86. Jahrestagung der DPG
86th Annual Conference of the DPG

DPG-Frühjahrstagung 2023
DPG Spring Meeting 2023

of the Matter and Cosmos Section (SMuK)

with its Divisions

Extraterrestrial Physics, Gravitation and Relativity, Hadronic and Nuclear Physics, Particle Physics, Plasma Physics, Radiation and Medical Physics, Theoretical and Mathematical Physics together with Environmental Physics and Short Time-scale Physics and Applied Laser Physics

and the Working Groups

Accelerator Physics, Energy, Equal Opportunities, Information, Philosophy of Physics, Physics and Disarmament, Physics , Modern IT and Artificial Intelligence, Young DPG

20-24 March 2023
Technische Universität Dresden
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Deutsche Physikalische Gesellschaft

Preisverleihung

Max-Planck-Medaille 2023
an Prof. Dr. Rashid A. Sunyaev
Max-Planck-Institut für Astrophysik, Garching

Stern-Gerlach-Medaille 2023
an Prof. Dr. Manfred Fiebig
ETH Zürich

Ehrenmitgliedschaft der DPG
an Prof. Dr. Horst Schmidt-Böcking
Goethe-Universität Frankfurt

Ehrennadel der DPG
an Prof. Dr. Ulrich Platt
Universität Heidelberg

Dissertationspreis der Sektion SMuK
(Der/die Preisträger:in wird nach dem Dissertationspreissymposium SYMD ausgewählt.)

Festvortrag

Prof. Dr. Monica Dunford
Kirchhoff-Institut für Physik, Universität Heidelberg

„The once unattainable – new breakthroughs in particle physics“

Dienstag, 21. März 2023, 14:00 Uhr
HSZ/AUDIMAX

Deutsche Physikalische Gesellschaft
Greeting

Dear Participants,

Welcome to the 86. Annual Meeting of DPG and DPG-Frühjahrstagung (DPG Spring Meeting) of the Matter and Cosmos Section (SMuK) with the participating divisions and working groups involved on the campus of the Technical University Dresden.

I am very pleased that with our DPG Spring Meetings, even more so in presence, we can once again set a widely visible and public sign for the outstanding importance of basic research for scientific and societal progress. Basic research is indispensable for tackling the major societal challenges. Above all a sustainable energy supply with regard to climate change with its dramatic consequences for all life on our planet. On the other hand, the Spring Meetings are probably the most important instrument of the DPG to enable as many scientists as possible, especially young scientists, to participate in a cross-border, international and peaceful scientific exchange.

The last year has shown us with full force how important and by no means self-evident such a necessary and international exchange is, how vulnerable our world order is, and how quickly a change can take place that even threatens the existence of countries. Therefore, it is the special responsibility of the DPG – guided by the values in our DPG Statutes, our compass – to stand up for freedom, tolerance, truthfulness and dignity in science and to act in awareness that we are particularly responsible for shaping the whole of human life: Especially and particularly in troubled times!

The DPG Spring Meeting in Dresden plays an outstanding role for peaceful international scientific exchange and discourse as well as for the perception and appreciation of the work of the DPG. I would therefore like to thank all those involved for their great commitment to the success of this conference.

My special thanks go to the Technical University Dresden for its hospitality and support. I would like to sincerely thank the Wilhelm and Else Heraeus Foundation for once again generously supporting all DPG spring conferences. My great appreciation goes to the participating divisions and working groups for a great programme. I would especially like to thank the Local Organising Committee, Dr. Frank Siegert und Prof. Kai Zuber, Technical University Dresden, and their entire team. For the support of all DPG Spring Meetings, my special thanks go to the DPG Head Office.

Prof. Dr. Joachim Ullrich
President
Deutsche Physikalische Gesellschaft e.V.
Organisation

Organiser
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Phone  +49 (0)2224 9232-0
Fax  +49 (0)2224 9232-50
Email  dpg@dpg-physik.de
Homepage  www.dpg-physik.de

Local Organiser
Dr. Frank Siegert
Technische Universität Dresden
Institut für Kern- und Teilchenphysik
Zellescher Weg 19, 01069 Dresden
Phone  +49 (0) 351 463-33700
Email  frank.siegert@tu-dresden.de

Scientific Organisation

Chair of the Matter and Cosmos Section (SMuK)
Prof. Dr. Silvia Masciocchi
GSI mbH
Planckstr. 1, 64291 Darmstadt
Email  s.masciocchi@gsi.de

Chairs of the Participating Divisions of the DPG:
(EP) Extraterrestrial Physics  – Dr. Miriam Sinnhuber (miriam.sinnhuber@kit.edu)
(GR) Gravitation and Relativity  – Prof. Dr. Bernd Brügmann (bernd.bruegmann@uni-jena.de)
(HK) Hadronic and Nuclear Physics  – Prof. Dr. Bernhard Ketzer (bernhard.ketzer@uni-bonn.de)
(K) Short Time-scale Physics and Applied Laser Physics  – Dr. Andreas Görtlter (agoertler@gmx.de)
(MP) Theoretical and Mathematical Physics  – Prof. Dr. Johanna Erdmenger (erdmenger@physik.uni-wuerzburg.de)
(P) Plasma Physics  – Prof. Dr. Ronny Brandenburg (brandenburg@inp-greifswald.de)
(ST) Radiation and Medical Physics  – M.Sc. Anna Bakenecker (bakenecker@dpg-mail.de)
(T) Particle Physics  – Prof. Dr. Kerstin Borras (kerstin.borras@desy.de)
(UP) Environmental Physics  – Prof. Dr. Christian von Savigny (csavigny@physik.uni-greifswald.de)

Chairs of the Participating Working Groups
(AGA) Physics and Disarmament  – Prof. Dr. Götz Neuneck (neuneck@ifsh.de)
(AGI) Information  – Dr. Uwe Kahler (kahler@physik.rwth-aachen.de)
(AGPhil) Philosophy of Physics  – Prof. Dr. Dennis Lehmkuhl (dennis.lehmkuhl@uni-bonn.de)
(AKBP) Accelerator Physics  – Prof. Dr. Kurt Aulenbacher (aulenbac@kph.uni-mainz.de)
(AKC) Equal Opportunities  – OSTR Agnes Sandner (akc@dpg-physik.de)
(AKE) Energy  – Dr. Karl-Friedrich Ziegahn (ziegahn@kit.edu)
(AKD/PG) Young DPG  – Sabine Rockenstein (rockenstein@jdpg.de)
(AKPIK) Physics, Modern IT and Artificial Intelligence  – Dr. Tim Ruhe (tim.ruhe@tu-dortmund.de)

Symposia
SYMD  – SMuK Dissertation Prize
SYSC  – Strange Clouds – from the Earth to Exoplanets

Organisation of the Exhibition of Scientific Instruments and Literature
DPG-Ausstellungs-, Kongreß- und Verwaltungsgesellschaft mbH
Hauptstraße 5, 53604 Bad Honnef
Phone  +49 (0)2224 9232-0
Fax  +49 (0)2224 9232-50
Email  dpg@dpg-physik.de
Website  www.dpg-gmbh.de
Programme
The scientific programme consists of 1,929 contributions:

10 Plenary Talks
2 Evening Talks
7 Prize Talks
1 Ceremonial Talk
1 Lunch Talks
95 Invited Talks
24 Topical Talks
65 Group Reports
1,519 Talks
205 Posters

The programme stated in this document corresponds to the status of the programme publication February 2, 2023 and will not be updated!
Der Übergang von der Hochschule in die berufliche Karriere fällt vielen nicht leicht: Die Möglichkeiten und Aufgabengebiete sind vielfältig - und wer kennt schon nach Studium oder Promotion die verschiedenen Anforderungen und Arbeitsabläufe?


Neben den Vorträgen bietet der gemütliche Lichtenbergkeller des Physikzentrums Bad Honnef ein ideales Forum, mit den Vortragenden am Abend in kleiner Runde offen zu diskutieren und Erfahrungen zu sammeln.

**Zielgruppe:**
Physikstudierende ab Bachelor bis zur Promotion. Max. 80 Personen.

5. bis 7. Mai 2023
Physikzentrum Bad Honnef

Weitere Infos und Anmeldung: www.pib.dpg-physik.de
Information for Participants
The conference will be held March 20 — 24, 2023.

1. Conference Information
1.1 Conference Venue
Technische Universität Dresden
Campus Südvorstadt
Bergstraße 64
01069 Dresden

The central activities like registration etc. will take place in the Lecture Hall Center (HSZ) of the TU Dresden (Bergstraße 64). For a detailed map of the campus and the buildings please see end of this booklet. The position of the lecture rooms on the campus can be found at the campus navigator of TU Dresden https://navigator.tu-dresden.de/ or the DPG-App (see 1.3.1).

1.2 Conference Office / Information Desk
The conference office and the information desk are located in the Lecture Hall Center, HSZ E01.

<table>
<thead>
<tr>
<th>Day</th>
<th>Date</th>
<th>Registration</th>
<th>Information Desk</th>
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<tbody>
<tr>
<td>Sunday</td>
<td>19 March</td>
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<td>Monday</td>
<td>20 March</td>
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<td>Friday</td>
<td>24 March</td>
<td>08:00 – 12:00</td>
<td>08:00 – 16:00</td>
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You will receive your name tag, a receipt for your conference fee, the short programme and the Login-Password for using WLAN (WiFi) at the conference office. The name tag must be worn visibly during the entire conference.

Please note: This year, no conference ticket for public transportation is included in the conference pass. We kindly ask you to buy a ticket yourself if you need it (the DVB one-week-ticket price level A1 Dresden tariff zone at the normal price of 22,90 EUR is transferable, i.e. it is not personal).

The organisers, staff of the conference desk and student assistants will be identifiable by colored name tags and T-shirts. Please contact them if you have any questions. Do not hesitate to come to the information desk and inquire about the conference, orientation in Dresden, accommodation, restaurants, going out and cultural events.

1.3 Lecture Rooms
The lecture rooms will be signposted by abbreviations for the respective buildings and the room number. The campus map and location of the buildings are printed in the end of this booklet.

Abbr. Building (see also: https://navigator.tu-dresden.de/)
CHE Chemiegebäude (Chemistry Building)
GER von-Gerber-Bau
HSZ Hörsaalzentrum (Lecture Hall Center)
JAN Jante-Bau
MOL Mollier-Bau
POT Gerhard-Potthoff-Bau
REC Recknagel-Bau
SCH Georg-Schumann-Bau
Tent Tent behind the Lecture Hall Center
WIL Willers-Bau
ZEU Zeuner-Bau

1.3.1 With the DPG-App through the Spring Meetings!
With the app you can find out not only about the conference programme but also about the venue and exhibitors at the industry and book exhibition. With the help of new functions such as “What's going on now?” or the building plan overview it is now even easier to find your way around on site. Download the free “DPG Spring Meetings” app for Android or iOS now!
### 1.4 Presentation
Scientific presentations will be held either orally or by poster. Presentations with a German abstract will be given in German.

#### 1.4.1 Oral Presentation
All lecture halls will be equipped with a projector and computer. Speakers are requested to upload their presentations on the conference website one day before the corresponding session. An email with the access data and the upload deadlines was sent to the lecturers before the conference. If you require to change your uploaded contribution, you may again upload the document at latest 4 hours before the session starts (not before the talk starts). In any case you should also bring a copy your presentation on an USB drive as a backup.

The file format accepted for all parallel sessions is pdf or Powerpoint. Own laptops cannot be used for the presentation. The presentations will be transferred to the provided PCs/laptops in the lecture hall before the session. The lecturers are asked to keep the presentation file on a USB stick and to bring it into the session.

All lecture theatres will be opened, at the latest, 30 minutes prior to the talks. Speakers are requested to be in the lecture hall at least 20 minutes prior to the start of the session, reporting to the chairperson of the session as well as the technical staff ensure that the presentation upload was successful and to receive a brief introduction to the equipment in the lecture hall. If you need other presentation facilities, please ask for availability at the information desk as soon as you arrive at the conference.

Usually, presentations will have the following durations. For exact information, please refer to your division.

- Contributed talks are 15 minutes including discussion and speaker change (12 min talk + 3 min discussion / speaker change).
- Invited talks are 30 minutes including discussion and speaker change (25 min talk + 5 min discussion / speaker change).
- Plenary presentations are 45 minutes without discussion.

#### 1.4.2 Poster Presentation
Sites for poster sessions are named and located as follows:

- HSZ EG: HSZ: ground floor (foyer)
- HSZ OG1: HSZ: 1st floor (hallway)
- HSZ OG2: HSZ: 2nd floor (hallway)
- HSZ OG3: HSZ: 3rd floor (hallway)

Posters must fit within a rectangle 90 cm wide and 120 cm high (DIN A0), portrait format!

The poster boards will be marked with the number according to the scientific programme. Authors are asked to mount their poster when the poster board is prepared with the corresponding poster number. Usually this will be arranged in the morning, or one hour before the session when there are several poster sessions per day. Each poster should display the number according to the scientific programme.

For the mounting of the poster please use the prepared “power strips” at the poster frame or contact the available student staff. Please make sure to use only power strips for mounting the poster (residue-free removing). The presenting authors should be at hand for discussion at their poster during at least half of the poster session and should note this time at the poster.

The posters have to be removed after the poster session. Any posters remaining on display walls after the poster session will be removed and destroyed without requesting your permission. The conference management accepts no liability for the posters.

### 1.5 Notice Board
All changes to the conference programme (i.e. cancellation of presentations, change of rooms, etc.) are also transferred directly to the online version of the programme which will be updated continuously and is available in different formats (sorted by publication date, filterable by conference parts and as an rss-feed). Please use the form [https://smuk23.dpg-tagungen.de/programm/notice-board-form](https://smuk23.dpg-tagungen.de/programm/notice-board-form) to notify changes or cancellations.
2. General Information

2.1 Internet

EDUROAM
The TU Dresden is member of the eduroam-network. Users from eduroam institutions, who have registered for eduroam, can use WLAN at the TU Dresden without local registration in Dresden. Eduroam in Dresden is possible with WLAN SSID eduroam.

WLAN (WiFi)
In addition internet access is possible via WLAN network (WiFi) in almost all buildings of the TU-Campus.

WLAN in the buildings of TU-Campus
For internet access at TU Dresden, please use your individual login-password on your registration document. Please search for and connect to the network named „VPN/WEB“. If this network isn’t shown in the list of available networks, the access isn’t possible. After you have been connected, please visit any website with your browser to get redirected to the login page of the network. Enter your given username and password and click on „Login“. Afterwards you should be able to use the access to the internet. This connection is not encrypted.

2.2 Message Board
All alterations in the scientific programme will be announced via the conference website "Notice Board". All further important information for participants is displayed on a message board in the foyer of the Lecture Hall Center (HSZ).

2.3 Public Working Area
Public working rooms where you can work on your laptop are located in GER 037, GER 050 und GER 054.

2.4 Cloakroom
A guarded cloakroom is located in the basement of the Lecture Hall Centre (HSZ). The opening hours are as follows:

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<tr>
<th>Day</th>
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</tr>
<tr>
<td>Friday</td>
<td>08:00</td>
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</tbody>
</table>

2.5 Lost and Found Property
You can bring found items to the Lecture Hall Center, room E03 (next to the information desk). There you can also get your lost property back.

3. Catering

3.1 Coffee Breaks
Coffee and tea are offered for free during the breaks in nearly all conference locations (see also in the legend of the campus map). You want actively contribute to protect our climate and environment? If possible please bring your own cup or use your paper cup several times. Thank you!

3.2 Snacks
You can get coffee, tea, refreshments and snacks as indicated in the campus map at the:

- Tent B behind the Lecture Hall center Monday to Thursday, 08:00 – 19:00; Friday 08:00 – 14:00
- „Grill-Cube“ next to the exhibition tent B Monday to Friday, 09:00 – 15:00
- Zeuner-Bau (ZEU) in room ZEU 148 Monday to Thursday 08:00 – 18:00; Tuesday 08:00 – 14:00
- Restaurant of the Leibniz-Institute IFW Dresden Monday to Friday, 08:00 – 15:00
- „insgrüne coffeebar“ in the Georg-Schumann-Bau (SCH) Monday to Friday, 10:00 – 15:00
- Cafeteria & Mensa "Alte Mensa", Mommsenstraße 13 Monday to Thursday, 08:00 – 16:00; Friday 08:00 – 15:00
- Cafeteria & Mensa Zeltschlösschen, Nürnberger Str. 55 Monday to Friday, 08:00 – 15:30
- Cafeteria & Mensa Siedepunkt, Zellescher Weg 17 Monday to Friday, 11:00 – 15:00

as well as at Bergstr. 68 „FIRAT-Kebap-Haus“ and Münchner Str. „DERSIM-Dürüm-Kebab-Haus“ and bakery „Möbius“.
3.3 Lunch
The Mensa Zeltschlösschen, Mensa Siedepunkt and the Mensa Mommsenstraße offer plenty of opportunities for lunch at moderate prices (self-payment, please note the above mentioned opening hours).

Please note: only cash payments are possible in all mensas (no cards!).

4. Events

4.1 Opening of the conference
A short opening address will be given by the chair of the SMuK Section on Monday, March 20 from 08:45 until 09:00 in HSZ/AUDI.

4.2 Datathon
On Sunday March 19, 2023, 10:00 to 16:00, Recknagel Bau (Haeckelstraße 3, REC/C213/H), the working group on physics, modern IT and artificial intelligence (AKPIK) will host the very first AKPIK Datathon, prior to the Spring Meeting of the Matter and Cosmos Section (SMuK) in Dresden.

Within this Datathon, teams of two to five persons will work on solving an interesting and challenging task on a given data set. Although the results will be inspected by a jury, the performance of the results is not the only criterion and a special award will be given to the group with the most creative approach.

The AKPIK Datathon is intended for younger members of the German Physical Society (DPG) and offers an exciting challenge, as well as the possibility for networking in a relaxed atmosphere during coffee breaks. A comprehensive knowledge on Data Science is not required for participation. The participation is free of charge. Further information as well as a registration link can be found at https://smuk23.dpg-tagungen.de/veranstaltungen/datathon

4.3 Ordentliche Mitgliederversammlung der DPG 2023
(Annual General Meeting of the DPG 2023)
Date: Monday, March 20, 18:00, Room HSZ 0304 (3rd floor), Bergstraße 64, 01069 Dresden
The Annual General Meeting of the Deutsche Physikalische Gesellschaft will take place on Monday evening. Members of the DPG are kindly requested to attend the meeting. Please bring your membership card.

4.4 Welcome Evening
On Monday, March 20, at 19:30 the Welcome Evening will be held in the Tent A close to the Main Lecture Hall Centre. When registering for the conference you will receive your badge and food and drink vouchers for the Welcome Evening. Small food, beer and soft drinks will be served. Do not miss the opportunity to register (08:00 to 19:00) before the official beginning of the conference and to meet people in an informal atmosphere. Please wear your name tag which you have received at the registration.

4.5 jDPG Pub Crawl
Time: Monday, March 20, from 19:30
Meeting place: in front of the HSZ (Bergstraße side)
On Monday evening, the young DPG invites to a pub crawl through Dresden. Next to the opportunity to be on a move outside and network with others, the members of the local regional group will tell about the Dresden physics, the life in the city and other facts worth knowing.

4.6 jDPG Lunch Gathering
Time: Monday, March 20 + Tuesday, March 21 + Friday, March 24, from 13:00
Meeting place: will be announced on the conference website
On several days, the jDPG regional group of Dresden meets to lunch gatherings. During these meetings, young conference participants shall get to know each other better and especially make contact to local (PhD-)students. An intensive exchange of experiences is also intended to take place there, concerning important topics like e.g. starting a doctorate and mental health during the studies.

4.7 Physicists in Industry
Tuesday, March 21, 19:00 – 21:00, HSZ 0004
How do physicists work in industry? How does everyday life differ from the life at university and the institute? Which additional skills should students acquire beside their curriculum? We will investigate these and other questions with three colleagues who work in different areas of industry. They will provide insights into their career path and their daily work and will be available to answer questions afterwards.
4.8 Ceremonial Session with Award Ceremony *(in German language)*
On Tuesday, March 21, at 14:00 the Ceremonial Session with Award Ceremony will take place in HSZ/AUDI. The programme is as following:

**Music**
„Viviendo Trio“

**Welcome**
Dr. Frank Siegert, TU Dresden
Local Organiser
Prof. Dr. Michael Kobel
Vice-Rector Education at the TU Dresden

**Speech**
Dr. Lutz Schröter, DPG e.V., Bad Honnef
Vice-President of the Deutsche Physikalische Gesellschaft

**Music**

**Award Ceremony**
- **Max Planck Medal 2023**  
  to Prof. Dr. Rashid A. Sunyaev, Max-Planck-Institut für Astrophysik, Garching
- **Stern Gerlach Medal 2023**  
  to Prof. Dr. Manfred Fiebig, ETH Zürich
- **Honorary Membership of the DPG**  
  to Prof. Dr. Horst Schmidt-Böcking, Goethe-Universität Frankfurt
- **Pin of Honor of the DPG**  
  to Prof. Dr. Ulrich Platt, Universität Heidelberg
- **SMuK Dissertation Prize 2023**  
  (The Laureate will be announced after the Dissertations-Prize Symposium (SYMD))

**Music**

**Ceremonial Lecture**
Prof. Dr. Monica Dunford, Kirchhoff-Institut für Physik, Heidelberg Heidelberg  
„The once unattainable – new breakthroughs in particle physics“

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4.9 Public Evening Lectures *(in German language)*
All Evening Talks will be held at the Audimax (Hörsaalzentrum) and are open for the interested public and all conference participants. The entrance is free.

**Max-von-Laue-Lecture**
Wednesday, March 22, 20:00 - 21:00, Audimax (HSZ 01)
Prof. Dr. Gerd Gigerenzer, Universität Potsdam will speak about:
„Risikokompetenz – informiert und entspannt mit Risiken umgehen“

**Public Evening Talk**
Thursday, March 23, 20:00 - 21:30, Audimax (HSZ 01)
Prof. Dr. Christian Stegmann, DESY, Zeuthen will speak about:
„Von Sachsen ins Universum“

4.10 Exhibition of Scientific Instruments and Literature
From Tuesday to Thursday there will be an exhibition of Scientific Instruments and Literature. The exhibition will take place in the Lecture Hall Center (Foyer). Several companies (see list of exhibitors at the end of this booklet) will present their products. Opening hours are from 10:00 to 18:00. All conference participants are welcome to attend the exhibition. The entrance is free.

4.11 Video competition: Physics in the Future
The public and also the physics community have various imaginations of how physics will look like in the future and what physics will be needed for in the future. The aim of this video competition is to bring together these different views...
and ideas for the “future of physics”. Even without a modified DeLorean and flux capacitor, the competition will bring to light many exciting answers. Time will show which ones will come true.

A Video box will be available from Monday to Friday in Tent A to help you easily participate in the video competition. Take part and tell us what you think about “physics in the future”.

5. Wilhelm and Else Heraeus-Communication Programme

Important notes for participants who apply for a grant of the Wilhelm and Else Heraeus Foundation:

At the beginning of the conference you will receive an identification form at the conference office. The participation in the conference must be certified by the conference desk. You have the possibility to leave this certificate by the staff members of the DPG (recommended!) in the conference office or submit it to the DPG head office (DPG-Geschäftsstelle, Hauptstr. 5, 53604 Bad Honnef, Germany) by April 14, 2023 at the latest.

For more detailed information refer to https://smuk23.dpg-tagungen.de/registrierung/weh.

The Deutsche Physikalische Gesellschaft thanks the Wilhelm and Else Heraeus Foundation for the generous financial support of young academic talents. We hope that young physicists will continue to seize the offered opportunity for active scientific communication at scientific conferences. A total of about 37,800 young academics were supported by this programme so far.

6. Acknowledgement

The organisers want to thank

- the Wilhelm and Else Heraeus Foundation, Hanau
- the TU Dresden

for supporting the conference and all staff, who make the conference possible.

7. CO₂ compensation for the DPG conferences

By decision of the Executive Board, the DPG will compensate for fossil CO₂ emissions resulting from mobility for DPG conferences and committee meetings.

8. SAY CHEESE!

The DPG Spring Meetings are basically public to the press. Please note: On behalf of DPG, photos and videos will be recorded during the Spring Meetings. In the context of public relations, these recordings (as the case may be) will be published on our website, in social media or within prints of the DPG for example.

9. Disclaimer of liability

Participants are asked to look carefully after their wardrobe, valuables, laptops, and other belongings. The organisers are not liable.
Du magst Physik, Daten und Algorithmen und wolltest Deine Fähigkeiten in diesem Bereich schon immer mal mit anderen Physiker:innen messen? Dann bilde mit bis zu 4 gleichgesinnten Personen ein Team und mach mit!

Übrigens: Performance ist nicht alles! Eine hochrangig besetzte Jury prämiert den kreativsten Ansatz mit einem Sonderpreis!

1. DATATHON des AKPIK

Teamwettbewerb
Teilnahme kostenlos

attraktive Preise
Sonderpreis für kreative Lösungen!

Sonntag, 19.03.2023
10 bis 16 Uhr
TU Dresden
Haeckelstraße 3 (Recknagel Bau)
01069 Dresden

Weitere Informationen und Anmeldung unter:
www.dpg-physik.de/anmeldungen/anmeldung-zum-datathon
Deceased members

The following members of the German Physical Society passed away in 2022:

Wolfgang Ackermann, Swisttal
Karl-Richard Albrand, Wedel
Ulf Amelung, Lüneburg
Kristof Adam Balazs, Frankfurt
Stefan Balle, Gernering
Uwe Helmut Bauder, München
Werner Bausch, Darmstadt
Ulrich Becker, Genf
Götz-Peter Behringer, Weissach im Tal
Hans-Georg Bell, Hellenthal
Heinz Berger, Berlin
Joachim Berk, Berlin
Wolfhard Beyer, Aachen
Eckhard Bill, Mülheim/Ruhr
Kurt Binder, Nieder-Olm
Klaus Birgmeir, Putzbrunn
Claus Birkholz, Berlin
Albrecht Böhm, Aachen
Ulrich Bonse, Dortmund
David Böttger, Troisdorf
Wolfgang Braunschweig, Aachen
Wilhelm Brenig, Baldham
Dieter Brunner, Karlsruhe
Rene Donatus Degele, Itzehoe
Walter Dietrich, Hanau
Mattias Dietrich, Boston, MA
Heinz-Dietrich Doebner, München
Wolfgang Doetsch, Mayen
Katharina Domogala, Dülmen
Hans-Werner Drawin, Gundelfingen
Albrecht Elsner, Garching
Hans-Ulrich Finzel, Coburg
Karl Fischer, Saarbrücken
Christian Forstner, Jena
Heino Freese, Hamburg
Rolf Freitag, Leonberg
Hans-Jürgen Frischkorn, Oberursel (Taunus)
Harald Fritzsche, München
Friedrich Gönnerwein, Tübingen
Jochen Görres, Düsseldorf
Wolfgang Grafe, Mainz
Uwe Grimm, Milton Keynes
Carola Grünwald, Chemnitz
Werner Grzemb, Hannover
Philipp Gültlich, Roßdorf
Horst Haeske, Oberursel (Taunus)
Roland Hahnfeld, München
Hans-Jürgen Hartmann, Lübeck
Volker Häselbarth, Königswinter
Johann Haserer, Mühldorf
Rüdiger Haupt, Brühl
Werner Heindl, Regensburg
Dieter Herlach, Kerpen
Frank Hinterberger, Bonn
Horst Hoffmann, Regensburg
Sigurd Hoffmann, Gross-UMstadt
Josef Honerkamp, Emmendingen
Andreas Hörmstemeier, Aachen
Klaus Hübner, Heidelberg
Christoph Illgner, Darmstadt
Gert Immer, Freiberg
Christopher John, Hargesheim
G. Michael Kalvis, Meggen
Franz Kämpeler, Bruchsal
Franz Rudolf Kessler, Düren
Alexander Kirchberger, Rastatt
Fritz Kix, Uelzen
Maria Klein, Klingenberg
Hans-Hermann Klein, Bad Nauheim
Peter Kleinheinz, Jülich
Wilhelm Kley, Tübingen
Wolfgang Klose, Essen
Stephan W. Koch, Fronhausen
Herbert Koch, Jena
Armin Kohlrausch, Eindhoven
Eckhard Krätzig, Osnabrück
Horst Kraus, Ehringhausen
Horst Krause, Berlin
Gernot Krauss, Sankt Augustin
Erich Krebs, Wiesbaden
Franz-Gregor Kreuzer, Bonn
Bernd Krusche, Gronau
Herbert Tietje, Twist
Ursula Tödheide-Haupt, Karlsruhe
Reimund Torge, Potsdam
Frank Träger, Sandhausen
Kurt Tretter, Oldenburg
Jost Trier, Braunschweig
Inge Tzschach, Darmstadt
Wolfgang Vogel, Hamburg
Walter Vogl, Horhausen
Waltraud Vollmann, Chemnitz
Robert von Hahn, St. Leon-Rot
Clemens Wächter, Laufen
Gerhard Weber, Freiburg
Holger Wegmann, Dortmund
Winfried Weirauch, Braunschweig
Claus Wengel, Colmberg
Thorsten Wierzbowski, Heilbronn
Hans-Jörg Wingender, Mömbris
Horst Winterhoff, Dreieich
Petrina Wintgen, Aachen
Joachim Wolter, Waalre
Diether Wuck, Berlin
Helmut Wühl, Karlsruhe
Johann Peter Wurm, Schriesheim
Andreas Zacchi, Dreieich
Wolf Zechnall, Hildesheim
Elmar H. Zeitler, Berlin
Markus Zeuschner, Lüneburg
Paul Ziesche, Dresden
Eckhard Zschiesche, Gevelsberg
Klaus Hübner, Heidelberg
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Elmar H. Zeitler, Berlin
Markus Zeuschner, Lüneburg
Paul Ziesche, Dresden
Eckhard Zschiesche, Gevelsberg

We will honor the memory of our members.
Einladung zur ordentlichen Mitgliederversammlung 2023

Montag, 20. März 2023, 18:00 Uhr
Technische Universität Dresden, HSZ-304 (3. OG), Bergstraße 64, 01069 Dresden

Hiermit lade ich alle Mitglieder satzungsgemäß zur diesjährigen Mitgliederversammlung ein.


TAGESORDNUNG

1 Eröffnung und Totengedenken
2 Feststellung der Tagesordnung
3 Bericht des Präsidenten (J. Ullrich)
4 Bericht des Vizepräsidenten (L. Schröter)
5 Berichte aus den Vorstandsbereichen
   5.1 Bildung und wissenschaftlicher Nachwuchs (K. Mecke)
   5.2 Industrie und Wirtschaft (S. Friebel)
   5.3 Internationale Aktivitäten (K. Zach)
   5.4 Junge Mitglieder und Berufsfragen (M. Zimmermann)
   5.5 Öffentlichkeitsarbeit (C. Lämmerzahl)
   5.6 Publikationen (R. Moessner)
   5.7 Schule (Y. Struck)
   5.8 Wissenschaftliche Programme und Preise (A. Buchleitner)
6 Bericht des Hauptgeschäftsführers (B. Nunner)
7 Bericht des Schatzmeisters über die Jahresabschlussrechnung des Geschäftsjahres 2022 (R. Pfrengle)
8 Bericht der Rechnungsprüfer (A. Belias, G. Mussler)
9 Entlastung des Vorstands und des Hauptgeschäftsführers
10 Bericht zum Haushaltsplan für das Geschäftsjahr 2023 und zu den Mitgliedsbeiträgen (R. Pfrengle)
11 Anträge von Mitgliedern
12 Wahlen
   12.1 Bericht über das Ergebnis der Wahlen im Jahr 2022 zum DPG-Vorstand und zu weiteren Gremien der DPG
   12.2 Wahl eines Rechnungsprüfers bzw. einer Rechnungsprüferin
13 Verschiedenes


Bad Honnef, Januar 2023

DEUTSCHE PHYSIKALISCHE GESELLSCHAFT E. V.
Der Präsident
J. Ullrich
## Synopsis of the Daily Programme

### Monday, March 20, 2023

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Event</th>
</tr>
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<tbody>
<tr>
<td>08:45</td>
<td>HSZ/AUDI</td>
<td>Opening</td>
</tr>
<tr>
<td>09:00</td>
<td>HSZ/AUDI</td>
<td>Plenary Talks, Prize Talk</td>
</tr>
</tbody>
</table>
| 09:00  | PV I     | Low Temperature Plasma – About a Hidden Champion or a Silent Revolution  
|        |          | Klaus-Dieter Weltmann                      |
| 09:45  | PV II    | Thin film technology for fabrication of nonlinear active optical components and its future application in photonic circuits  
|        |          | Marco Jupe                                |
| 12:30  | PV III   | Two milestones in the life of the Universe: Last Scattering Surface and Black Body Photosphere  
|        |          | Rashid Sunyaev (Laureate of the Max-Planck-Medal 2023) |
| 14:00  | HSZ/AUDI | SYMD Session                               |
| 10:45  | EP 1.1   | A Melting Probe for the Exploration of Subglacial Lakes within the TRIPLE project line  
|        |          | Mia Giang Do                               |
| 16:15  | EP 2.1   | The exoplanet revolution: towards habitable worlds  
|        |          | Alexis Smith                               |
| 10:45  | EP 1     | Planets and small Objects                  |
| 16:15  | EP 2     | Exoplanets and Astrobiology                |
| 16:30  | GR 1     | Black Holes                                |
| 16:30  | GR 2     | Cosmology I                                 |
| 11:00  | HK 1.1   | Nucleosynthesis of heavy nuclei – moving a supernova into the laboratory  
|        |          | Felix Heim                                 |
| 11:30  | HK 1.2   | Exploring the 3D nucleon structure with CLAS and CLAS12 at JLAB  
|        |          | Stefan Diehl                               |
| 12:00  | HK 1.3   | Lattice simulations with chiral effective field theory at N3LO  
|        |          | Serdar Elhatisari                           |
| 11:00  | HK 1     | Invited Talks I                            |
| 16:30  | HK 2     | Instrumentation I                          |
| 16:30  | HK 3     | Instrumentation II                         |
| 16:30  | HK 4     | Instrumentation III                        |
| 16:30  | HK 5     | Heavy-Ion Collisions and QCD Phases I       |
| 16:30  | HK 6     | Heavy-Ion Collisions and QCD Phases II      |
| 16:30  | HK 7     | Hadron Structure and Spectroscopy I         |
| 16:30  | HK 8     | Nuclear Astrophysics I                      |
| 16:30  | HK 9     | Structure and Dynamics of Nuclei I          |
| 16:30  | HK 10    | Structure and Dynamics of Nuclei II         |
| 16:30  | HK 11    | Outreach Public/Teilchenwelt                |
### Monday, March 20, 2023

**MP**

**Invited Talk**

<table>
<thead>
<tr>
<th>Time</th>
<th>Venue</th>
<th>Session</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>11:00</td>
<td>HSZ/0003</td>
<td>MP 1.1</td>
<td>Insights from random matrices on dissipative quantum dynamics</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Pedro Ribeiro</td>
</tr>
</tbody>
</table>

**Sessions**

<table>
<thead>
<tr>
<th>Time</th>
<th>Venue</th>
<th>Session</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:00</td>
<td>HSZ/0003</td>
<td>MP 1</td>
<td>Quantum Dynamics and Quantum Information</td>
</tr>
<tr>
<td>16:30</td>
<td>ZEU/0250</td>
<td>MP 2</td>
<td>Quantum Field Theory I</td>
</tr>
</tbody>
</table>

**P**

**Invited Talks**

<table>
<thead>
<tr>
<th>Time</th>
<th>Venue</th>
<th>Session</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>11:00</td>
<td>CHE/0089</td>
<td>P 1.1</td>
<td>Ion Beam Sputter Deposition – Fundamentals and Applications</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Carsten Bundesmann</td>
</tr>
<tr>
<td>11:00</td>
<td>CHE/0091</td>
<td>P 2.1</td>
<td>Deuterium-Tritium Plasmas at JET with ITER-like Wall and the Role of Isotope Mass and Transport for H-mode Access</td>
</tr>
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<td></td>
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<td></td>
<td>• Gregor Birkenmeier</td>
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**Sessions**

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<tbody>
<tr>
<td>11:00</td>
<td>CHE/0089</td>
<td>P 1</td>
<td>Low Pressure Plasmas and their Application I</td>
</tr>
<tr>
<td>11:00</td>
<td>CHE/0091</td>
<td>P 2</td>
<td>Magnetic Confinement I/HEPP I</td>
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<tr>
<td>16:30</td>
<td>CHE/0089</td>
<td>P 3</td>
<td>Astrophysical Plasmas</td>
</tr>
<tr>
<td>16:30</td>
<td>CHE/0091</td>
<td>P 4</td>
<td>HEPP II</td>
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**T**

**Invited Talks**

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</thead>
<tbody>
<tr>
<td>11:00</td>
<td>HSZ/AUDI</td>
<td>T 1.1</td>
<td>What we learned about the Higgs Boson from the LHC so far</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Duc Bao Ta</td>
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<tr>
<td>11:30</td>
<td>HSZ/AUDI</td>
<td>T 1.2</td>
<td>QCD at the LHC – Precision for Discoveries</td>
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<tr>
<td></td>
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<td></td>
<td>• Malgorzata Worek</td>
</tr>
<tr>
<td>12:00</td>
<td>HSZ/AUDI</td>
<td>T 1.3</td>
<td>The charm and beauty of flavour physics</td>
</tr>
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<td>• Marco Gersabeck</td>
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<tbody>
<tr>
<td>11:00</td>
<td>HSZ/AUDI</td>
<td>T 1</td>
<td>Invited Overview Talks I</td>
</tr>
<tr>
<td>16:30</td>
<td>HSZ/0004</td>
<td>T 2</td>
<td>Flavor I</td>
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<tr>
<td>16:30</td>
<td>HSZ/0401</td>
<td>T 3</td>
<td>Top I</td>
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<tr>
<td>16:30</td>
<td>HSZ/0403</td>
<td>T 4</td>
<td>Searches I</td>
</tr>
<tr>
<td>16:30</td>
<td>HSZ/0101</td>
<td>T 5</td>
<td>Higgs Searches</td>
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<tr>
<td>16:30</td>
<td>HSZ/0103</td>
<td>T 6</td>
<td>Other Exp., EW</td>
</tr>
<tr>
<td>16:30</td>
<td>HSZ/0105</td>
<td>T 7</td>
<td>Higgs, Di-Higgs</td>
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<tr>
<td>16:30</td>
<td>HSZ/0204</td>
<td>T 8</td>
<td>Outreach Public/Teilchenwelt</td>
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<tr>
<td>16:30</td>
<td>HSZ/0301</td>
<td>T 9</td>
<td>DAQ NN/ML – HW</td>
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<tr>
<td>16:30</td>
<td>HSZ/0405</td>
<td>T 10</td>
<td>ML Methods I</td>
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<tr>
<td>16:30</td>
<td>POT/0051</td>
<td>T 11</td>
<td>Neutrinos, Dark Matter I</td>
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<tr>
<td>16:30</td>
<td>POT/0151</td>
<td>T 12</td>
<td>Gamma Astronomy I</td>
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<tr>
<td>16:30</td>
<td>POT/0251</td>
<td>T 13</td>
<td>Neutrinos I</td>
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<td>16:30</td>
<td>POT/0361</td>
<td>T 14</td>
<td>Neutrinos, Dark Matter II</td>
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<tr>
<td>16:30</td>
<td>POT/0006</td>
<td>T 15</td>
<td>Neutrinos, Dark Matter III</td>
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<td>16:30</td>
<td>POT/0112</td>
<td>T 16</td>
<td>Neutrino Astronomy I</td>
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<tr>
<td>16:30</td>
<td>POT/0013</td>
<td>T 17</td>
<td>Cosmic Ray I</td>
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<td>16:30</td>
<td>POT/0351</td>
<td>T 18</td>
<td>Exp. Methods, CTA, others</td>
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<tr>
<td>16:30</td>
<td>POT/0106</td>
<td>T 19</td>
<td>Detector Systems, Electronics</td>
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<tr>
<td>16:30</td>
<td>WIL/A317</td>
<td>T 20</td>
<td>Pixel ITk, Si-Strips/Other</td>
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<tr>
<td>16:30</td>
<td>WIL/A124</td>
<td>T 21</td>
<td>Si-Strips/CMS, Pixel/Sensor</td>
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<tr>
<td>16:30</td>
<td>WIL/C133</td>
<td>T 22</td>
<td>Calorimeter / Detector Systems I</td>
</tr>
<tr>
<td>16:30</td>
<td>WIL/A120</td>
<td>T 23</td>
<td>Gas-Detectors / Muon MDT</td>
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## Monday, March 20, 2023

### AKBP

<table>
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<tr>
<th>Time</th>
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<th>Session Code</th>
<th>Title</th>
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<tbody>
<tr>
<td>16:00</td>
<td>CHE/0183</td>
<td>AKBP 1</td>
<td>CHE/0183 AKBP 1 Particle and Photon Sources</td>
</tr>
<tr>
<td>16:00</td>
<td>CHE/0184</td>
<td>AKBP 2</td>
<td>CHE/0184 AKBP 2 Advanced Light Sources and their Instrumentation</td>
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### AKE

#### Invited Talks

<table>
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<tbody>
<tr>
<td>11:00</td>
<td>GER/038</td>
<td>AKE 1.1</td>
<td>Zellulare Energiesysteme – Zukunft der Energietechnik?</td>
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<tr>
<td></td>
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<td>• Joachim Seifert</td>
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<tr>
<td>16:30</td>
<td>GER/038</td>
<td>AKE 2.1</td>
<td>The German primary energy consumption – status and trends</td>
</tr>
<tr>
<td></td>
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<td>• Larissa Breuning</td>
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#### Sessions

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<tbody>
<tr>
<td>11:00</td>
<td>GER/038</td>
<td>AKE 1</td>
<td>Konzepte und Technologien</td>
</tr>
<tr>
<td>16:30</td>
<td>GER/038</td>
<td>AKE 2</td>
<td>Energieversorgung</td>
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### AKPIK

<table>
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<th>Title</th>
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<tbody>
<tr>
<td>16:00</td>
<td>HSZ OG2</td>
<td>AKPIK 1</td>
<td>Poster</td>
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### AGPhil

#### Session

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<tbody>
<tr>
<td>11:00</td>
<td>JAN/0027</td>
<td>AGPhil 1</td>
<td>Quanten und Prozesse</td>
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<tr>
<th>Time</th>
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<th>Event Description</th>
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<tr>
<td>13:00</td>
<td>(refer to website)</td>
<td>jDPG Lunch Gathering</td>
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<tr>
<td>18:00</td>
<td>HSZ/0304</td>
<td>Annual General Meeting of the DPG (for DPG members only)</td>
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<tr>
<td>19:30</td>
<td>In front of the HSZ</td>
<td>jDPG Pub Crawl</td>
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<tr>
<td>19:30</td>
<td>Tent A</td>
<td>Welcome Evening (for registered participants)</td>
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**Tuesday, March 21, 2023**

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Session</th>
<th>Title</th>
<th>Speaker(s)</th>
</tr>
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<tbody>
<tr>
<td>09:00</td>
<td>HSZ/AUDI PV IV</td>
<td>Plenary Talks, Prize Talk, Ceremonial Talk</td>
<td>Characterising exoplanet atmospheres with the Webb space telescope</td>
<td>Pierre-Olivier Lagage</td>
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<tr>
<td>09:45</td>
<td>HSZ/AUDI PV V</td>
<td></td>
<td>The European Destination Earth initiative – a paradigm change for weather and climate prediction</td>
<td>Peter Bauer</td>
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<tr>
<td>12:30</td>
<td>HSZ/AUDI PV VI</td>
<td></td>
<td>The Higgs boson at the (HL)LHC – precisely!</td>
<td>Adinda de Wit (Laureate of the Hertha-Sponer-Prize 2023)</td>
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<tr>
<td>14:00</td>
<td>HSZ/AUDI</td>
<td>Special Plenary Session with Award Ceremony</td>
<td>Ceremonial Talk</td>
<td>Monica Dunford</td>
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**SYSC**

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<tr>
<td>11:00</td>
<td>HSZ/0004 SYSC 1.1</td>
<td>Invited Talks</td>
<td>Not all clouds are created equal – strange clouds in our solar system</td>
<td>Thomas Leisner</td>
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<tr>
<td>11:20</td>
<td>HSZ/0004 SYSC 1.2</td>
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<td>Clouds to the Edge of Space</td>
<td>Gerd Baumgarten</td>
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<tr>
<td>11:45</td>
<td>HSZ/0004 SYSC 1.3</td>
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<td>The dynamic clouds of Venus</td>
<td>Javier Peralta</td>
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<td>12:10</td>
<td>HSZ/0004 SYSC 1.4</td>
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<td>Observational constraints of exoplanet clouds</td>
<td>Nicolas Iro</td>
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<td>12:35</td>
<td>HSZ/0004 SYSC 1.5</td>
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<td>Gemstone clouds in JWST target exoplanets</td>
<td>Dominic Samra</td>
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**EP**

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<tr>
<td>11:00</td>
<td>HSZ/0004 SYSC 1</td>
<td>Session</td>
<td>Strange Clouds – From the Earth to Exoplanets</td>
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<td>16:45</td>
<td>ZEU/0160 EP 3</td>
<td>Sessions</td>
<td>Clouds in Planetary Atmospheres</td>
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<td>18:00</td>
<td>ZEU/0160 EP 4</td>
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<td>Planetary atmospheres</td>
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**GR**

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<tr>
<td>11:00</td>
<td>HSZ/0401 GR 3.1</td>
<td>Invited Talk</td>
<td>Scalaron-Higgs inflation</td>
<td>Christian Steinwachs</td>
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<td>HSZ/0401 GR 3</td>
<td>Sessions</td>
<td>Cosmology II</td>
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<td>17:00</td>
<td>ZEU/0260 GR 4</td>
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<td>Quantum Gravity</td>
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<td>17:00</td>
<td>ZEU/0255 GR 5</td>
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<td>Classical Relativity</td>
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**HK**

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<th>Title</th>
<th>Speaker(s)</th>
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<tbody>
<tr>
<td>11:00</td>
<td>HSZ/0002 HK 12.1</td>
<td>Invited Talks</td>
<td>Baryon spectroscopy at ELSA and MAMI</td>
<td>Farah Afzal</td>
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<tr>
<td>11:30</td>
<td>HSZ/0002 HK 12.2</td>
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<td>ALICE upgrades, status and perspectives for ALICE-3</td>
<td>Robert Muenzer</td>
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<tr>
<td>12:00</td>
<td>HSZ/0002 HK 12.3</td>
<td></td>
<td>Nuclear parton distribution functions</td>
<td>Michael Klasen</td>
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Tuesday, March 21, 2023

HK

Sessions
11:00 HSZ/0002 HK 12 Invited Talks II
17:00 SCH/A251 HK 13 Instrumentation IV
17:00 SCH/A.101 HK 14 Instrumentation V
17:00 SCH/A117 HK 15 Instrumentation VI
17:00 SCH/A246 HK 16 Heavy-Ion Collisions and QCD Phases III
17:00 SCH/A315 HK 17 Heavy-Ion Collisions and QCD Phases IV
17:00 SCH/A316 HK 18 Hadron Structure and Spectroscopy II
17:00 SCH/A419 HK 19 Nuclear Astrophysics II
17:00 SCH/A118 HK 20 Structure and Dynamics of Nuclei III
17:00 SCH/A252 HK 21 Structure and Dynamics of Nuclei IV
17:00 SCH/A252 HK 22 Outreach

Invited Talks
11:00 HSZ/0002 MP 3.1 Renormalization of singular stochastic partial differential equations
   •Pawel Duch
11:30 HSZ/0002 MP 3.2 Integral decomposition of modular operators in QFT
   •Daniela Cadamuro
12:00 HSZ/0002 MP 3.3 Emergence of gravity from conformal field theory
   •Nele Callebaut

Sessions
11:00 HSZ/0002 MP 3 Quantum Field Theory II
10:30 HSZ OG3 MP 4 Poster
17:00 ZEU/0250 MP 5 Scattering Amplitudes and Conformal Field Theory

P

Sessions
11:00 CHE/0089 P 5.1 Diagnostics of metal-grid micro cavity plasma arrays
   •Marc Böke
11:00 CHE/0091 P 6.1 The physics of ELM-free regimes
   •Michael Dunne
17:00 CHE/0091 P 8.1 Fuel retention and removal in the JET tokamak
   •Dmitry Matveev

Invited Talks
11:00 CHE/0089 P 5 Diagnostics of metal-grid micro cavity plasma arrays
   •Marc Böke
11:00 CHE/0091 P 6 Magnetic Confinement II/HEPP III
17:00 CHE/0089 P 7 Atmospheric Pressure Plasmas and their Applications III
17:00 CHE/0091 P 8 Plasma Wall Interaction I/HEPP IV

ST

Sessions
11:00 GER/038 ST 1 Accelerators for Radiation Therapy
17:00 ZEU/0146 ST 2 Medical Imaging Concepts

T

Invited Talks
11:00 HSZ/AUDI T 24.1 Searching for Long-Lived Particles at the LHC and Beyond
   •Juliette Alimena
11:30 HSZ/AUDI T 24.2 The Neutrino-Dawn of Galaxies
   •Wolfgang Rhode
12:00 HSZ/AUDI T 24.3 Galactic cosmic rays: What have we learned and what's next?
   •Philipp Mertsch
Tuesday, March 21, 2023

Sessions
11:00  HSZ/AUDI  T 24  Invited Overview Talks II
17:00  HSZ/0304  T 25  Flavor II
17:00  HSZ/0401  T 26  Flavor III
17:00  HSZ/0403  T 27  Searches II
17:00  HSZ/0101  T 28  Forward Physics
17:00  HSZ/0103  T 29  Other Exp., EW
17:00  HSZ/0105  T 30  Higgs Charm, Di-Higgs
17:00  HSZ/0201  T 31  Theory Higgs, BMS
17:00  HSZ/0204  T 32  Di-Higgs, Higgs BSM
17:00  HSZ/0301  T 33  DAQ NN/ML - GRID I
17:00  HSZ/0405  T 34  ML Methods II
17:00  POT/0051  T 35  Neutrino Astronomy II
17:00  POT/0151  T 36  Gamma Astronomy II
17:00  POT/0251  T 37  Neutrinos, Dark Matter IV
17:00  POT/0361  T 38  Neutrinos, Dark Matter V
17:00  POT/0006  T 39  Neutrinos, Dark Matter VI
17:00  POT/0112  T 40  Astro Particle Theory
17:00  POT/0013  T 41  Cosmic Ray II
17:00  POT/0351  T 42  Exp. Methods, IceAct, Auger, RNO-G
17:00  POT/0106  T 43  Electronics, DAQ, Exp. Methods
17:00  WIL/A317  T 44  Pixel/LHCb, Si-Strips/CMS
17:00  WIL/A124  T 45  Si-Strips, Pixel
17:00  WIL/C133  T 46  Calorimeter / Detector Systems II
17:00  WIL/A120  T 47  Gas-Detectors, Detector Systems
17:00  WIL/C129  T 48  Exp. Methods I
17:00  SCH/A252  T 49  Outreach

Invited Talk
11:00  REC/C213  K 1.1  Information, Abstände und Gravitation ?
   •Rudolf Germer

Sessions
11:00  REC/C213  K 1  Laser Applications and Laser-Beam Material Interaction
12:35  REC/C213  K 2  Members' Assembly
16:45  HSZ OG2  K 3  Poster

Session
16:45  ZEU/0160  UP 1  Clouds in Planetary Atmospheres

AKBP

Sessions
11:00  GER/038  AKBP 3  Accelerator and Medical Physics
16:30  CHE/0183  AKBP 4  Plasmas and Lasers
16:30  CHE/0184  AKBP 5  Hadron Accelerators

AKE

Invited Talk
17:00  GER/038  AKE 3.1  Activation calculations for decommissioning planning of NPPs
   •Reuven Rachamin

Session
17:00  GER/038  AKE 3  Zukunftsperspektiven
**Tuesday, March 21, 2023**

### AKPIK

**Session**

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<td>17:00</td>
<td>ZEU/0118</td>
<td>AKPIK 2</td>
<td>Applications in Particle and Astroparticle Physics</td>
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### AGPhil

**Sessions**

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<tr>
<td>11:00</td>
<td>JAN/0027</td>
<td>AGPhil 2</td>
<td>Space and Time</td>
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<tr>
<td>17:30</td>
<td>JAN/0027</td>
<td>AGPhil 3</td>
<td>Philosophy of Physics</td>
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</table>

**Exhibition of Scientific Instruments and Literature**

10:00 Foyer Lecture Hall Centre

19:00 HSZ/0004 Physicists in Industry
DPG Mentoring Programm 2023

Jetzt anmelden unter: mentoring.dpg-physik.de

Begleiten Sie als Mentor:in junge Physiker:innen beim Berufseinstieg.

Profitiere als Mentee von erfahrenen Physiker:innen im Berufsleben.
Wednesday, March 22, 2023

Plenary Talks, Prize Talk, Lunch Talk

09:00 HSZ/AUDI PV VIII 25 years of the AdS/CFT correspondence: Current status and future prospects
• Koenraad Schalm
09:45 HSZ/AUDI PV IX The origin of the chemical elements
• Marialuisa Aliotta
12:30 HSZ/AUDI PV X News from the Flavour Expedition to the Zeptouniverse
• Andrzej Buras (Laureate of the Max-Planck-Medal 2020)
13:15 HSZ/AUDI PV XI From ab initio to nemo tenetur – Working on cyber crime as an IT analyst with the State Criminal Police Office
• Wojciech Morawiec

EP

Invited Talks

10:45 ZEU/0160 EP 5.1 New insights into the elusive magnetic processes operating in the solar corona with SoLo/EUI
• Lakshmi Pradeep Chitta
11:30 ZEU/0160 EP 5.3 Studying solar flares with the X-ray telescope STIX during the cruise and early science phase of Solar Orbiter
• Alexander Warmuth
14:15 ZEU/0160 EP 7.1 Advances in energetic particle physics with Solar Orbiter & Parker Solar Probe
• Robert F. Wimmer-Schweingruber
15:00 ZEU/0160 EP 7.3 New Insights in Simulations of SEP Events with the PARADISE+ICARUS Model
• Edin Husidic
16:00 ZEU/0160 EP 8.1 Precision measurements of cosmic ray fluxes from AMS-02 with a daily time resolution
• Stefan Schael

Sessions

10:45 ZEU/0160 EP 5 Sun and heliosphere I
13:00 ZEU/0160 EP 6 Members’ Assembly
14:15 ZEU/0160 EP 7 Sun and heliosphere II
16:00 ZEU/0160 EP 8 Sun and heliosphere III
17:30 HSZ OG1 EP 9 Poster

GR

Invited Talks

11:00 ZEU/0260 GR 6.1 Geodesic motion in relativistic astrophysics
• Eva Hackmann
11:45 ZEU/0260 GR 6.2 Modelling the multi-messenger signals of gravitational wave sources
• Stephan Rosswog

Sessions

11:00 ZEU/0260 GR 6 Relativistic Astrophysics
14:00 ZEU/0260 GR 7 Gravitational Waves I
14:00 ZEU/0255 GR 8 Foundations and Alternatives I
16:00 ZEU/0260 GR 9 Gravitational Waves and Astrophysics I
16:00 ZEU/0255 GR 10 Foundations and Alternatives II

HK

Invited Talks

11:00 HSZ/0002 HK 23.1 High-Precision Laser Spectroscopy of C⁺⁺ for an All-Optical Determination of the Nuclear Charge Radius
• Phillip Imgram
11:30 HSZ/0002 HK 23.2 ALICE determines the transparency of our galaxy to the passage of antihelium nuclei
• Laura Serksnyte
### HK

**12:00**  HSZ/0002  HK 23.3  The world of light and strange mesons: from spectroscopy puzzles to low energy QCD phenomena  
*Stephan Paul*

**Sessions**

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<td>Instrumentation VII</td>
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<td>Instrumentation VIII</td>
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<td>SCH/A216</td>
<td>Heavy-Ion Collisions and QCD Phases V</td>
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<td>SCH/A315</td>
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<td>SCH/A419</td>
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<td>Structure and Dynamics of Nuclei V</td>
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<td>SCH/A215</td>
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<td>SCH/A252</td>
<td>Fundamental Symmetries I</td>
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<td>Computing I</td>
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<td>Fundamental Symmetries III</td>
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### MP

**11:30**  ZEU/0250  MP 6.2  Deep neural networks and the renormalization group  
*Ro Jefferson*

**Invited Talks**

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<tr>
<td>11:00</td>
<td>ZEU/0250</td>
<td>AI Topical Day – Neural Networks and Computational Complexity</td>
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<tr>
<td>14:00</td>
<td>ZEU/0250</td>
<td>Classical and Quantum Gravity</td>
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<td>16:00</td>
<td>ZEU/0250</td>
<td>Members’ Assembly</td>
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### P

**11:00**  CHE/0089  P 9.1  Modelling and analysis of single-filament dielectric barrier discharges at atmospheric pressure  
*Markus M. Becker*

**11:00**  CHE/0091  P 10.1  Diagnosing the plasma edge with helium beam spectroscopy  
*Michael Griener*

**Invited Talks**

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<thead>
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<tr>
<td>11:00</td>
<td>CHE/0089</td>
<td>Atmospheric Pressure Plasmas and their Applications III</td>
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<tr>
<td>11:00</td>
<td>CHE/0091</td>
<td>Magnetic Confinement III/HEPP V</td>
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<td>HSZ EG</td>
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<td>Poster II</td>
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Wednesday, March 22, 2023

ST

**Invited Talks**

14:00  ZEU/0146  ST 4.1  Innovationen in die Praxis bringen – die EXIST Gründungsförderung  
• Antje Dewitz

14:20  ZEU/0146  ST 4.2  Development and Certification of an IGRT system  
• Claus Promberger

14:40  ZEU/0146  ST 4.3  Klinische Anwendung von Protonen-/Partikeltherapie  
• Esther Troost

**Sessions**

11:00  ZEU/0146  ST 3  Poster Session
14:00  ZEU/0146  ST 4  DPG meets DGMP: Von der Idee bis zur klinischen Anwendung  
15:50  ZEU/0146  ST 5  Physics and Technology for Radiation Detection  
17:45  ZEU/0146  ST 6  Members’ Assembly

T

**Invited Topical Talks**

11:00  HSZ/AUDI  T 50.1  Search for leptoquarks at the ATLAS experiment  
• Mahsana Haleem

11:20  HSZ/AUDI  T 50.2  Making the most of Yukawa couplings: searching for Dark Matter accompanied by heavy quarks  
• Danyer Perez Adan

11:40  HSZ/AUDI  T 50.3  Precision predictions for transverse momentum distributions of Higgs and vector bosons at the LHC  
• Maximilian Stahlhofen

12:00  HSZ/AUDI  T 50.4  Axion fragmentation  
• Enrico Morgante

11:00  HSZ/0003  T 51.1  LUXE – A new experiment to study non-perturbative QED in electron-laser and photon-laser collisions  
• Ruth Jacobs

11:20  HSZ/0003  T 51.2  Precision timing with silicon sensors  
• Annika Vauth

11:40  HSZ/0003  T 51.3  Recent advancements in Micro-Pattern Gaseous Detectors: Exciting research ahead towards future experiments  
• Michael Lupberger

12:00  HSZ/0003  T 51.4  Recent Liquid Scintillator Developments for Astroparticle Physics  
• Stefan Schoppmann

14:00  HSZ/AUDI  T 52.1  Commissioning of the new LHCb trigger system  
• Marian Stahl

14:20  HSZ/AUDI  T 52.2  Alignment of the CMS Tracker: Automation is Key  
• Marius Teroerde

14:40  HSZ/AUDI  T 52.3  ITk – ATLAS tracker upgrade  
• Dennis Sperlich

15:00  HSZ/AUDI  T 52.4  Role of simulation in silicon tracker sensors R&D  
• Anastasia Velyka

14:00  HSZ/0003  T 53.1  LST-1: Initial scientific results from the first CTA telescope  
• Dominik Elsaesser

14:20  HSZ/0003  T 53.2  Multimessenger astronomy with the Pierre Auger Observatory  
• Marcus Niechciol

14:40  HSZ/0003  T 53.3  Positron annihilation as an astrophysical messenger  
• Thomas Siegert

15:00  HSZ/0003  T 53.4  The first results of the XENONnT experiment and an outlook to the future DARWIN observatory  
• Andrii Terliuk

**Sessions**

11:00  HSZ/AUDI  T 50  Invited Topical Talks I-A
11:00  HSZ/0003  T 51  Invited Topical Talks I-B
14:00  HSZ/AUDI  T 52  Invited Topical Talks II-A
### Wednesday, March 22, 2023

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<td>15:50</td>
<td>HSZ/0401</td>
<td>Flavor V, Top-BSM</td>
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<td>15:50</td>
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<td>Annual Meeting of Young Scientists in High Energy Physics (yHEP)</td>
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### Session

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### Invited Talk

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<td>MOL/0213</td>
<td>Volcanic radiative forcing: past and future</td>
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<td>• Anja Schmidt</td>
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### Wednesday, March 22, 2023

**UP**

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<td>UP 2 Volcanic Effects on Atmosphere and Climate</td>
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<td>UP 4 Aerosols &amp; Hydrological Cycle</td>
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<td>UP 5 Measurement Techniques and Simulations</td>
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**AKBP**

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<tr>
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<td>HSZ/0304</td>
<td>AKBP 6 New Results from Accelerators for Hadron Physics</td>
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<td>AKBP 7 Experiments for Advanced Light Sources</td>
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<td>CHE/0183</td>
<td>AKBP 8 Advanced IT Tools</td>
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<td>AKBP 9 Beam Dynamics I</td>
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<td>AKBP 10 Instrumentation I</td>
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**AKC**

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<td>11:00</td>
<td>HSZ/0004</td>
<td>AKC 1.1 What’s wrong with me?</td>
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<td>•Pauline Gagnon</td>
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<td>11:45</td>
<td>HSZ/0004</td>
<td>AKC 1.2 Workplace cultures in physics as a game changer for equal opportunities</td>
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<td>•Martina Erlemann</td>
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<td>12:30</td>
<td>HSZ/0004</td>
<td>AKC 1.3 Belonging – a key to success in STEM?!</td>
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<td>•Barbara M. Gordalla</td>
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**AKPIK**

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<td>AKPIK 4 Neural Networks II</td>
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<td>ZEU/0250</td>
<td>AKPIK 5 AI Topical Day – Neural Networks and Computational Complexity</td>
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**AGA**

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<td>14:00</td>
<td>HSZ/0004</td>
<td>AGA 1.1 Acoustic, Seismic and Magnetic Detection of Banned Activities – 3.5 Decades of Physics-based Peace Research</td>
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<td>•Jürgen Altmann</td>
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<tr>
<td>14:00</td>
<td>HSZ/0004</td>
<td>AGA 1 Acoustic, Seismic and Magnetic Measurements</td>
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<td>14:45</td>
<td>HSZ/0004</td>
<td>AGA 2 New Verification Concepts and Forensics</td>
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<td>AGA 3 Simulation and Physics Teaching for Security and Disarmament</td>
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**AGPhil**

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<tr>
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<td>JAN/0027</td>
<td>AGPhil 5.1 Physical probability is relative frequency</td>
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<td>•Simon Saunders</td>
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<td>14:45</td>
<td>JAN/0027</td>
<td>AGPhil 5.2 Locality and the Metaphysics of Many Worlds Quantum Mechanics</td>
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<td>•Alyssa Ney</td>
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<td>16:00</td>
<td>JAN/0027</td>
<td>AGPhil 6.1 The structure of entangled properties: Distributional holism</td>
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<td>•Paul Näger</td>
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Wednesday, March 22, 2023

**Sessions**

11:00 JAN/0027 AGPhil 4 Quantum Foundations 1
14:00 JAN/0027 AGPhil 5 Quantum Foundations 2
16:00 JAN/0027 AGPhil 6 Quantum Foundations 3
18:00 JAN/0027 AGPhil 7 Members’ Assembly

10:00 Foyer Lecture Hall Centre Exhibition of Scientific Instruments and Literature

**Max-von-Laue-Lecture (Evening Lecture)**

20:00 HSZ/AUDI PV XII Max-von-Laue Lecture: Risikokompetenz – informiert und entspannt mit Risiken umgehen
  *Gerd Gigerenzer*

**Leading for Tomorrow**

Physikerinnen und Physiker in *Führungspositionen?*

*Trotz* oder *wegen* Physikstudiums?

Wirtschaft oder *Wissenschaftsmanagement?*

Ist das überhaupt was für *mich?*

Mehrtägige Intensivworkshops und Learning Expedition

Bewerbung möglich vom 1. bis 31. März 2023

Mehr Informationen und die Möglichkeit zur Bewerbung: leading-for-tomorrow.dpg-physik.de
### Thursday, March 23, 2023

#### Plenary Talks, Evening Talk, Prize Talk

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Session</th>
<th>Title</th>
<th>Speaker</th>
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<tr>
<td>09:00</td>
<td>HSZ/AUDI</td>
<td>PV XIII</td>
<td>The role of artificial intelligence in modern radiation therapy</td>
<td>Guillaume Landry</td>
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<tr>
<td>09:45</td>
<td>HSZ/AUDI</td>
<td>PV XIV</td>
<td>Machine Learning Advances in Particle Physics</td>
<td>Lukas Heinrich</td>
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<tr>
<td>12:30</td>
<td>HSZ/AUDI</td>
<td>PV XV</td>
<td>Direct dark matter detection: What if there's no WIMP?</td>
<td>Belina von Krosigk (Laureate of the Hertha-Sponer-Prize 2023)</td>
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#### Invited Talks

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<th>Title</th>
<th>Speaker</th>
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<tr>
<td>11:00</td>
<td>ZEU/0160</td>
<td>EP 10.1</td>
<td>Arne-Richter Lecture: From nonthermal plasmaastrophysics to modeling of pandemic outbreaks</td>
<td>Reinhard Schlickeiser</td>
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<td>14:00</td>
<td>ZEU/0160</td>
<td>EP 11.1</td>
<td>Energetic Particle Precipitation reflected in the Global Secondary Ozone Distribution</td>
<td>Jia Jia</td>
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<td>17:30</td>
<td>ZEU/0160</td>
<td>EP 13.1</td>
<td>Time-dependent data analysis of a blazar flare</td>
<td>Maximilian Albrecht</td>
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#### Sessions

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<td>Astrophysics: Cosmic Rays and Galaxies I</td>
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<td>ZEU/0160</td>
<td>EP 11</td>
<td>Near-Earth Space I</td>
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#### Invited Talks

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<tr>
<td>11:00</td>
<td>ZEU/0260</td>
<td>GR 11.1</td>
<td>From quarks to black holes: micro- and macrophysics of neutron star mergers</td>
<td>Andreas Bauswein</td>
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<td>11:45</td>
<td>ZEU/0260</td>
<td>GR 11.2</td>
<td>Tracing beyond GR physics with gravitational waves</td>
<td>Daniela Doneva</td>
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#### Sessions

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<td>Relativistic Astrophysics and Scalar Fields</td>
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<td>HK 52</td>
<td>AI Topical Day – Invited Talks</td>
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<td>HK 55</td>
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<td>HK 56</td>
<td>Instrumentation XV</td>
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<td>SCH/A316</td>
<td>HK 57</td>
<td>Hadron Structure and Spectroscopy VI</td>
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<td>14:00</td>
<td>SCH/A419</td>
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<td>SCH/A118</td>
<td>HK 59</td>
<td>Structure and Dynamics of Nuclei XI</td>
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<td>14:00</td>
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<td>HK 60</td>
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<td>HK 61</td>
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### Thursday, March 23, 2023

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#### MP

**Sessions**

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<td>Ads/CFT Correspondence and Hydrodynamic Transport</td>
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<td>ZEU/0250 MP 11</td>
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<td>Quantum Field Theory III (QED and Particle Detection)</td>
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<td>ZEU/0250 MP 12</td>
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<td>Quantengravitation und Thermodynamik</td>
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**Invited Talks**

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<thead>
<tr>
<th>Time</th>
<th>Code</th>
<th>Track</th>
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<tbody>
<tr>
<td>11:00</td>
<td>CHE/0089 P 13.1</td>
<td></td>
<td>Acceleration of spin-polarized ion beams from laser-plasma interaction</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>•Lars Reichwein</td>
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<tr>
<td>11:00</td>
<td>CHE/0091 P 14.1</td>
<td></td>
<td>Experimental validation of turbulence codes</td>
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<td></td>
<td></td>
<td></td>
<td>•Klara Höfler</td>
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<tr>
<td>14:00</td>
<td>CHE/0089 P 15.1</td>
<td></td>
<td>Tumor irradiation in mice with a laser-accelerated proton beam</td>
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<tr>
<td></td>
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<td>•Florian Kroll</td>
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<tr>
<td>14:00</td>
<td>CHE/0091 P 16.1</td>
<td></td>
<td>Development of a Laser-based Diagnostic for in situ Monitoring of Fuel Retention in ITER and future fusion devices</td>
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<tr>
<td></td>
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<td></td>
<td>•Alexander Huber</td>
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<tr>
<td>17:30</td>
<td>CHE/0089 P 19.1</td>
<td></td>
<td>Numerical and experimental investigations of a linear microwave plasma source for metal foil pumps for DEMO</td>
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<td></td>
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<td>•Stefan Merlinski</td>
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<tr>
<td>17:30</td>
<td>CHE/0091 P 20.1</td>
<td></td>
<td>Laser-Induced Breakdown Spectroscopy (LIBS) for the detection of hydrogen isotopes stored in high-Z metals tungsten and tantalum</td>
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<td>•Steffen Mittelmann</td>
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**Sessions**

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<tbody>
<tr>
<td>11:00</td>
<td>CHE/0089 P 13</td>
<td></td>
<td>Laser Plasmas I</td>
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<tr>
<td>11:00</td>
<td>CHE/0091 P 14</td>
<td></td>
<td>Magnetic Confinement IV/HEPP VI</td>
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<td>14:00</td>
<td>CHE/0089 P 15</td>
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<td>Laser Plasmas II/Low Pressure Plasmas and their Applications II</td>
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<td>14:00</td>
<td>CHE/0091 P 16</td>
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<td>Plasma Wall Interaction II/Codes and Modeling I</td>
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<td>15:45</td>
<td>CHE/0089 P 17</td>
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<td>Complex Plasmas and Dusty Plasmas/Codes and Modeling I</td>
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<td>15:45</td>
<td>CHE/0091 P 18</td>
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<td>HEPP VII</td>
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<td>17:30</td>
<td>CHE/0089 P 19</td>
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<td>Magnetic Confinement V/HEPP VIII</td>
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<td>Laser Plasmas III/Codes and Modeling III</td>
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<td>19:00</td>
<td>CHE/0089 P 21</td>
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<td>Members' Assembly</td>
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#### ST

**Invited Talk**

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<tbody>
<tr>
<td>17:30</td>
<td>ZEU/0146 ST 10.1</td>
<td></td>
<td>Online-adaptive particle therapy: Current status and vision for the future</td>
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<td></td>
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<td>•Christian Richter</td>
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**Sessions**

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<tr>
<td>11:00</td>
<td>HSZ/AUDI ST 7</td>
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<td>AI Topical Day – Invited Talks</td>
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<tr>
<td>14:00</td>
<td>ZEU/0146 ST 8</td>
<td></td>
<td>AI Topical Day – AI in Medicine</td>
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Thursday, March 23, 2023

ST
15:50 ZEU/0146 ST 9   Radiation Therapy
17:30 ZEU/0146 ST 10  Keynote: Online-Adaptive Particle Therapy
18:00 ZEU/0146 ST 11  Prize Ceremony and Closing Session

invited Topical Talks
14:00 HSZ/0003 T 101.1 How to Study the Higgs Boson in its Bosonic Decays
  •Benedict Winter
14:20 HSZ/0003 T 101.2 Measuring \( H \rightarrow WW \) with the ATLAS Experiment
  •Carsten Burgard
14:40 HSZ/0003 T 101.3 Belle II opportunities in B-decays with invisible signatures
  •Slavomira Stefkova
15:00 HSZ/0003 T 101.4 Two Pieces of a Puzzle: Inclusive and Exclusive V cb
  •Markus Prim
14:00 HSZ/0004 T 102.1 Expanding the Frontiers of Galactic Neutrino Astronomy via Machine Learning
  •Mirco Hünnefeld
14:20 HSZ/0004 T 102.2 Enhancing the CMS Level-1 Trigger with real-time Machine Learning
  •Artur Lobanov
14:40 HSZ/0004 T 102.3 Higgsino Hunting at ATLAS
  •Michael Holzbock
15:00 HSZ/0004 T 102.4 New Ideas for Baryo- and Leptogenesis
  •Kai Schmitz

sessions
11:00 HSZ/AUDI T 100 AI Topical Day – Invited Talks
14:00 HSZ/0003 T 101 Invited Topical Talks III-A
14:00 HSZ/0004 T 102 Invited Topical Talks III-B
15:45 HSZ/0004 T 103 AI Topical Day – Simulation, Inverse Problems and Algorithmic Development
15:50 HSZ/0304 T 104 Flavor VIII
15:50 HSZ/0401 T 105 Flavor IX
15:50 HSZ/0403 T 106 Searches IV
15:50 HSZ/0101 T 107 Searches – Neutrino at accelerators
15:50 HSZ/0103 T 108 Top, EW I
15:50 HSZ/0105 T 109 Higgs, Di-Higgs III
15:50 HSZ/0201 T 110 Other Theory
15:50 HSZ/0204 T 111 Outreach Diverse
15:50 HSZ/0301 T 112 DAQ Test/RO – GRID I
15:50 HSZ/0405 T 113 QCD Theory and Experiment II
15:50 POT/0051 T 114 Neutrinos V
15:50 POT/0151 T 115 Gamma Astronomy V
15:50 POT/0251 T 116 Neutrinos Legend, Neutrino Theory
15:50 POT/0361 T 117 Dark Matter I
15:50 POT/0006 T 118 Dark Matter II
15:50 POT/0112 T 119 Neutrino Astronomy IV
15:50 POT/0013 T 120 Cosmic Ray V
15:50 POT/0351 T 121 Cosmic Ray VI
15:50 POT/0106 T 122 DAQ Systems
15:50 WIL/A317 T 123 Pixel/Belle II, Si/Other
15:50 WIL/A124 T 124 Si-Strip/CMS, Pixel/DMAPS
15:50 WIL/C133 T 125 Calorimeter / Detector Systems V
15:50 WIL/A120 T 126 Gas-Detectors, Detector Systems
15:50 WIL/C129 T 127 Exp. Methods III
17:30 HSZ/0004 T 128 AI Topical Day – New Methods
17:30 HSZ/0304 T 129 Flavor X
17:30 HSZ/0401 T 130 Top II
17:30 HSZ/0403 T 131 Searches V
17:30 HSZ/0101 T 132 Searches VI
17:30 HSZ/0103 T 133 Top, EW II
Thursday, March 23, 2023

<table>
<thead>
<tr>
<th>Time</th>
<th>Location</th>
<th>Session</th>
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<tbody>
<tr>
<td>17:30</td>
<td>HSZ/0105 T 134</td>
<td>Higgs, Di-Higgs IV</td>
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<td>17:30</td>
<td>HSZ/0201 T 135</td>
<td>Top Mass, Top BSM</td>
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<tr>
<td>17:30</td>
<td>HSZ/0204 T 136</td>
<td>Higgs TH, VH</td>
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<td>17:30</td>
<td>HSZ/0301 T 137</td>
<td>DAQ Test/RO – GRID II</td>
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<td>17:30</td>
<td>HSZ/0405 T 138</td>
<td>QCD Experiment III</td>
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<td>17:30</td>
<td>POT/0051 T 139</td>
<td>Neutrinos VI</td>
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<td>17:30</td>
<td>POT/0151 T 140</td>
<td>Gamma Astronomy VI</td>
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<tr>
<td>17:30</td>
<td>POT/0251 T 141</td>
<td>Neutrino Astronomy V</td>
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<tr>
<td>17:30</td>
<td>POT/0361 T 142</td>
<td>Neutrinos, Dark Matter XI</td>
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<tr>
<td>17:30</td>
<td>POT/0006 T 143</td>
<td>Neutrinos VII</td>
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<tr>
<td>17:30</td>
<td>POT/0013 T 144</td>
<td>Cosmic Ray VII</td>
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<tr>
<td>17:30</td>
<td>POT/0351 T 145</td>
<td>Cosmic Ray VIII</td>
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<td>17:30</td>
<td>POT/0106 T 146</td>
<td>DAQ Systems, Exp. Methods</td>
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<td>17:30</td>
<td>WIL/A317 T 147</td>
<td>Pixel/HV-Maps, Si/Diamond</td>
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<td>17:30</td>
<td>WIL/A124 T 148</td>
<td>Si/SIPM, Pixel/Other</td>
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<td>17:30</td>
<td>WIL/C133 T 149</td>
<td>Detector Systems / Muon</td>
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<tr>
<td>17:30</td>
<td>WIL/A120 T 150</td>
<td>Gas-Detectors, Pixel/TANGERINE</td>
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<td>17:30</td>
<td>WIL/C129 T 151</td>
<td>Exp. Methods IV</td>
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<tr>
<td>20:00</td>
<td>HSZ/0003 T 152</td>
<td>Members’ Assembly</td>
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</table>

**Invited Talks**

- 11:00 MOL/0213 UP 7.1 Towards monitoring of anthropogenic greenhouse gas emissions from satellites
  - Hartmut Bösch

- 14:00 MOL/0213 UP 8.1 Destabilization of carbon in tropical peatlands by enhanced weathering
  - Alexandra Klemme

- 14:30 MOL/0213 UP 8.2 Widespread forest decline in central Europe following three extreme summers in 2018-2020
  - Ana Bastos

**Sessions**

- 11:00 MOL/0213 UP 7 Greenhouse Gases: Remote Sensing
- 14:00 MOL/0213 UP 8 Carbon Cycle & Climate Change

**Prize Talks**

- 14:00 HSZ/0304 AKBP 13.1 TBA
  - Carl A. Lindström (Laureate of the DPG-Nachwuchspreis für Beschleunigerphysik)

- 14:45 HSZ/0304 AKBP 13.2 TBA
  - Ferdinand Willeke (Laureate of the Horst-Klein-Forschungspreis)

**Sessions**

- 11:00 HSZ/AUDI AKBP 12 AI Topical Day – Invited Talks
- 14:00 HSZ/0304 AKBP 13 Preisverleihung des AKBP Nachwuchspreises und des Horst-Klein Preises
- 15:30 CHE/0183 AKBP 14 Instrumentation II
- 15:30 CHE/0184 AKBP 15 New Accelerator Concepts
- 15:45 HSZ OG3 AKBP 16 Poster
- 17:30 CHE/0183 AKBP 17 Instrumentation III
- 17:30 CHE/0184 AKBP 18 Beam Dynamics II
- 19:00 CHE/0091 AKBP 19 Members’ Assembly

**Invited Talk**

- 16:00 ZEU/0148 AKjDPG 1.4 Open data and open-source tools throughout research data life cycle: KCDC example
  - Victoria Tokareva
Thursday, March 23, 2023

AKjDPG

Session
14:00 ZEU/0148 AKjDPG 1 Hacky Hour

AKPIK

Invited Talks
11:00 HSZ/AUDI AKPIK 6.1 AI Techniques for Event Reconstruction
•Ivan Kisel
11:30 HSZ/AUDI AKPIK 6.2 Accelerator operation optimisation using machine learning
•Pierre Schnizer
12:00 HSZ/AUDI AKPIK 6.3 Is this even physics? – Progress on AI in particle physics
•Gregor Kasieczka

Sessions
11:00 HSZ/AUDI AKPIK 6 AI Topical Day – Invited Talks
14:00 HSZ/0101 AKPIK 7 AI Topical Day – Research Data Management and Medical Applications
15:45 HSZ/0004 AKPIK 8 AI Topical Day – Normalizing Flows and Invertible Neural Networks
17:30 HSZ/0004 AKPIK 9 AI Topical Day – New Methods
14:00 HSZ/0103 AKPIK 10 AI Topical Day – Computing II
14:00 ZEU/0146 AKPIK 11 AI Topical Day – AI in Medicine
14:00 HSZ/0105 AKPIK 12 AI Topical Day – Heavy-Ion Collisions and QCD Phases

AGA

Invited Talks
14:00 HSZ/0002 AGA 4.1 Mass Starvation? Impacts of Nuclear War on Climate Change and Food Security
•Lili Xia
15:45 HSZ/0002 AGA 5.1 Nuclear forensic science – when nuclear scientists and law enforcement meet
•Maria Wallenius
16:30 HSZ/0002 AGA 5.2 Applied Physics in the Alva Myrdal Centre for Nuclear Disarmament: Non-Proliferation and Safeguards Activities
•Sophie Grape

Sessions
14:00 HSZ/0002 AGA 4 Nuclear Weapons and the Atmosphere
15:45 HSZ/0002 AGA 5 Applied Nuclear Physics
17:30 HSZ/0002 AGA 6 Members’ Assembly

AGI

Invited Talks
11:00 ZEU/0148 AGI 1.1 Programming and Computational Physics Education in the Physics Curriculum at University of Göttingen
•Fabian Heidrich-Meisner
11:30 ZEU/0148 AGI 1.2 Integrating Digitalization and Research Data Management (RDM) into the Curricula of Bachelor and Master Students in Chemistry
•Fabian Fink
12:00 ZEU/0148 AGI 1.3 News from PUNCH4NFDI: Education of students
•Carsten Burgard

Sessions
11:00 ZEU/0148 AGI 1 Data Literacy in the Physics Curriculum
14:00 ZEU/0148 AGI 2 Hacky Hour

AGPhil

Invited Talks
11:00 JAN/0027 AGPhil 8.1 Interpreting Quantum Mechanics on an Informational Approach
•Michael Cuffaro
Thursday, March 23, 2023

AGPhil

11:45 JAN/0027 AGPhil 8.2 Does science need intersubjectivity? The problem of confirmation in orthodox interpretations of quantum mechanics
   •Emily Adlam

Sessions

11:00 JAN/0027 AGPhil 8 Quantum Foundations 4
14:00 JAN/0027 AGPhil 9 Quantum Foundations 5
16:15 JAN/0027 AGPhil 10 Quantum Foundations Poster Session

10:00 Foyer Lecture Hall Centre Exhibition of Scientific Instruments and Literature

Public Evening Lecture

20:00 HSZ/AUDI PV XVI Von Sachsen ins Universum
   •Christian Stegmann
Friday, March 24, 2023

**Plenary Talks, Prize Talk**

09:00 HSZ/AUDI PV XVII The Einstein Telescope
   • Harald Lück
09:45 HSZ/AUDI PV XVIII The LHC legacy and prospects
   • Markus Klute
13:00 HSZ/AUDI PV XIX The science and technology of DUNE and its future as an international neutrino observatory
   • Stefan Söldner-Rembold (Laureate of the Max-Born-Prize 2023)

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**Invited Talk**

11:00 HSZ/0004 EP 14.1 Unveiling the secrets of hot, massive stars with modern stellar atmosphere models
   • Andreas A C Sander

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**Sessions**

11:00 HSZ/0004 EP 14 Astrophysics: Stellar Astrophysics
14:00 HSZ/0004 EP 15 Astrophysics: Cosmology

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**GR**

11:00 HSZ/0401 GR 16 Experimental Tests

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**HK**

11:00 HSZ/0002 HK 76.1 Thermalization of heavy quarks in the QGP
   • Federica Capellino
11:30 HSZ/0002 HK 76.2 Hadron structure in Lattice QCD
   • Konstantin Ottnad
12:00 HSZ/0002 HK 76.3 LISA: Lifetime measurements with Solid Active targets
   • Kathrin Wimmer

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**T**

11:00 HSZ/AUDI T 153.1 The Standard Model on the test bench: What bosons and the top quark (will) tell us
   • Valerie Lang
11:30 HSZ/AUDI T 153.2 Gravitational wave observations: Current results & future expectations
   • Harald Pfeiffer
12:00 HSZ/AUDI T 153.3 Precise muon detection: novel technologies for the luminosity frontier
   • Kerstin Hoepfner
13:30 HSZ/AUDI T 154.1 ECN3: Experimental Opportunities at a Future High-Intensity Proton Facility at the CERN SPS (BDF/SHIP and HIKE+SHADOWS)
   • Annika Hollnagel

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**Invited Talks IV**

11:00 HSZ/0002 HK 76 Invited Talks IV

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**Sessions**

11:00 HSZ/AUDI T 153 Invited Overview Talks III
13:30 HSZ/AUDI T 154 Invited Overview Talks IV
Friday, March 24, 2023

AGA

Invited Talks
13:00 HSZ/0002 AGA 7.1 Fireworks or Threat? – Recent Missile Developments in North Korea
   • Markus Schiller
13:45 HSZ/0002 AGA 7.2 The Challenge of Nuclear-Powered Submarines to IAEA Safeguards
   • Tariq Rauf

Sessions
13:00 HSZ/0002 AGA 7 Proliferation Challenges
14:50 HSZ/0002 AGA 8 Mathematical Modelling of Conflicts

AGPhil

Session
10:45 HSZ/0304 AGPhil 11 Quantum Mechanics, Philosophy and Information
What are the major challenges for physics in the future?
Which research areas will come into focus?
Or will time travel even be possible?

Video Contest:
Physics in the Future
March 20-24, 2023

What will the physics of the future look like and what will it be used for?

Share your vision with us!

The aim of this video competition is to bring together all kinds of different ideas for the future of physics. Even without a Police Box or a converted DeLorean, the competition promises numerous exciting answers. Tell us your vision - only time will tell if it comes true.

More information:
www.smuk23.dpg-tagungen.de/veranstaltungen/wettbewerb
Plenary talks (PV)

Plenary Talk  
PV I Mon 9:00 HSZ/AUDI
Low Temperature Plasma – About a Hidden Champion or a Silent Revolution — Klaus-Dieter Weltmann, Thomas von Woedtke, Jürgen E. Kolb, Torsten Gerling, and Angela Kruth — Leibniz Institute for Plasma Science and Technology, Greifswald, Germany

The plenary lecture presents an overview of the achievements and future potentials of low-temperature plasma physics and technology. Such plasmas are particular states of matter consisting of neutral, ionized and excited species, free electrons as well as radicals, photons and excited species. While the electrons have a mean energy of a few eV to 10 eV, the temperature of the heavy species is several orders of magnitude lower. These properties make them very attractive for applications. The fundamental knowledge gained so far supported the worldwide boom in the automotive industry, lighting, materials processing, optics, electronics, textile processing, and other fields. Basic research is the common prerequisite for the successful development of processes, technologies and products. Low-temperature plasma physics has steadily opened up new fields. It belongs to the cross-cutting technologies. In this contribution, the opening and its future application in photonic circuits — presentation gives an overview of the componentsthatareal-readyestablishedandnewconceptespeciallyincombinationwithinterference andmolecularcomposition,presenceofhazesandclouds,verticaltemperature-pressureprofile,presenceofzonalcirculation,justtonameafew.Suchinformationisneededtotestandimprovethemachineryandchemistryincorporatedinthe atmosphericmodelsappliedtoalienworldswhicchnohavequivalentinthe Solar System. Two types of observations are in use: direct imaging thanks to coronagraphic observations and spectroscopic observations of transiting exoplanets. A large diversity of exoplanets, ranging from giant exoplanets with masses several times that of Jupiter to Earth-sized rocky exoplanets, has started to be characterized. In this talk, I will discuss the first results, which are remarkable, and show the great perspectives in front of us.

Plenary Talk  
PV II Mon 9:45 HSZ/AUDI
Thin film technology for fabrication of nonlinear active optical components and its future application in photonic circuits — Marco Jupe — Laser Zentrum Hannover e.V., Hollererhalle 8, 30419 Hannover

The development of optical components is currently at a point where traditional concepts need to be extended. In particular, applications in the field of communications as well as highly innovative approaches for photonic quantum computations and quantum communications require not only high optical performance but also massive parallelization. Such concepts can only be sensibly implemented if the integration density of the optical circuits is massively increased. Concepts such as those used in telecommunications applications also appear to be target-oriented for applications in quantum technology. In addition to the "traditional" passive components, which are just as indispensable here as in classical signal processing, there is an increasing demand for ultra-fast active components. Such components must integrate seamlessly into the concepts. The mass market suitability of current solutions is a particular challenge that should not be underestimated. For this reason, various institutes are working on such components in particular. The presentation gives an overview of the components that are already established and new concepts especially in combination with interference films like FTM for the frequency tripling, and Kerr band switches for fast optical switches, as well as for electro-optical components using Pockels effect.

Prize Talk  
PV III Mon 12:30 HSZ/AUDI
Two milestones in the life of the Universe: Last Scattering Surface and Black Body Photosphere — Rashid Sunyaev — Max Planck Institute for Astrophysics — Institute for Advanced Study, Princeton — Laureate of the Max-Planck-Medal 2023

Our Universe is filled by cosmic microwave background (CMB) radiation which is extremely isotropic and has an excellent black body spectrum with a temperature of 2.7 Kelvin, and no spectral deviations from the blackbody have yet been detected in the CMB monopole. However, the theory of Thomson scattering by hot Maxwellian electrons predicts the shadows of the CMB toward galaxy clusters filled with dark matter and hot gas. This prediction (thermal SZ effect) dates back to 1970, and only in 2011, the first three unknown galaxy clusters were discovered using this method. Now many thousands of galaxy clusters are being discovered using such shadows. Any energy release in the early Universe (due to the decay or annihilation of unknown particles, dissipation of the low-scale density perturbations due to radia- tive viscosity, etc, hydrogen recombination at redshift 1300) should lead to the CMB spectral distortions. Detecting such specific spectral deviations is one of the key goals of microwave radioastronomy.

There are other theoretical predictions that led to the experimental discovery of the "acoustic peaks" in the power spectrum of the CMB angular fluctuations and enabled the measurement of key parameters of our universe with unprecedented accuracy. The kinematic SZ effect enabled the measurement of galaxy cluster velocities relative to the local coordinate system in which the CMB is isotropic. The kSZ effect permitted the proof of Copernicus’ principle up to redshift z=2, where the most distant galaxy clusters and protoclusters are observed.

A decrease in the CMB temperature in the course of the Universe expansion leads to the recombination of hydrogen, transparency of the Universe for photons, and appearance of the "surface of the last scattering". The "acoustic peaks" are formed due to the presence of this surface. The recombination rate (and the effective thickness of this "surface") is determined by the two-photon decay of the 2s level of the hydrogen atom.

Emission of low-frequency photons due to the double Compton effect and their redistribution along the spectrum due to multiple Thomson scatterings on hot electrons manage to maintain the blackbody spectrum while the redshift exceeds z=2 million. This value defines the position of the "blackbody photosphere" of the Universe. Spectral distortions of the CMB can be observed only if the energy release occurred at redshifts of less than 2 million.

Plenary Talk  
PV IV Tue 9:00 HSZ/AUDI
Characterising exoplanet atmospheres with the Webb space telescope — Pierre-Olivier Lagage — CEA Paris-Saclay, Gif-sur-Yvette, France

Thanks to its large collecting area (25 square meters) and its large wavelength coverage (0.6 × 32 microns), the Webb space telescope is a game changer. In the exoplanet domain, it takes us right into what can be called the second chapter of the study of exoplanets: the characterization of their atmosphere (atomic and molecular composition, presence of hazes and clouds, vertical temperature-pressure profile, presence of zonal circulation, just to name a few). Such information is needed to test and improve the chemistry and dynamics incorporated in the atmospheric models applied to alien worlds which have no equivalent in the Solar System. Two types of observations are in use: direct imaging thanks to coronagraphic observations and spectroscopic observations of transiting exoplanets. A large diversity of exoplanets, ranging from giant exoplanets with masses several times that of Jupiter to Earth-sized rocky exoplanets, has started to be characterized. In this talk, I will discuss the first results, which are remarkable, and show the great perspectives in front of us.

Plenary Talk  
PV V Tue 9:45 HSZ/AUDI
The European Destination Earth initiative – a paradigm change for weather and climate prediction — Peter Bauer — ECMWF, Reading, UK

Destination Earth is a new European Commission funded activity to create a so-called digital twin of the Earth. Digital twins create unprecedented opportunites to generate and interact with highly realistic digital replica created from the combination of computer simulations and observations. Destination Earth’s primary focus is on the use of twinning for dealing responsibly with extreme weather and climate change.

Weather and climate prediction are high-performance computing and big data applications with outstanding societal and economic impact ranging from the daily decision-making of citizens to that of civil services for emergency response, and from predicting environmental impacts on food, agriculture and energy markets as well as for risk and loss management by insurers. The uncertain evolution of weather extremes with climate change adds significant political pressure to accelerate scientific development and turn science into societal benefit.

Destination Earth is the result of a decade worth of planning by leading European climate, geoscience and computing scientists. The activity will create a new information system in support of the European Green Deal and Digital Strategy.

Prize Talk  
PV VI Tue 12:30 HSZ/AUDI
The Higgs boson at the (HL) LHC – precisely! — Anna De Wit — Universität Zürich, Switzerland — Laureate of the Hertha Sponer-Prize 2023

In the ten years since the discovery of the Higgs boson, the precision on its cross section and property measurements has continued to increase. In this talk, the latest measurements, their prospects, and how they could help us find new physics, will be discussed.

As the CMS and ATLAS experiments prepare to upgrade their detectors, we will also look towards the future of Higgs physics at the HL-LHC.
The unattainable – new breakthroughs in particle physics — Monica Dunford — Kirchhoff-Institut für Physik (KIP), Ruprecht-Karls-Universität Heidelberg

The dynamics of the Standard Model of particle physics play a central role in the properties of not only the microscopic world but also the biggest structures of our universe. The Higgs boson, for example, plays a critical part in how particles obtain their masses but also perhaps to dark matter and how our universe evolved. In this talk, I will focus on a handful of recent developments in particle physics that were considered out of reach, but through innovative ideas and powerful data science are now attainable. I will highlight how these results have connections beyond the microscopic world to dark matter, matter and anti-matter differences and beyond.

Lunch Talk

From ab initio to nemo tenetur — Working on cyber crime as an IT analyst with the State Criminal Police Office — Wojciech Morawiec — LKA Rheinland-Pfalz

While many workplaces pride themselves with providing ‘unique challenges every day’, I believe that working in law enforcement is one of the rare fields where this statement might be true for the whole length of one’s career. As an IT analyst with the Landeskriminalamt Rheinland-Pfalz, the State Criminal Police Office of Rheinland-Palatinate, one faces new and complicated puzzles almost daily. Solving these puzzles, doing proper documentation on them and explaining the results to detectives and later to the prosecutor’s office lie at the core of the support of ongoing investigations. Additionally there is some research-like work, where new tools, tactics and procedures have to be developed to expand the possibilities of the state police.

In this talk, after giving an overview of the legal framework, I would like to present how an analyst might work on a fictitious case to collect evidence pointing towards the perpetrator of a cyber crime. While there are no differential equations to solve and no functional theory simulations to run in such a case, a strong analytical mindset and simple procedures in data analysis can greatly improve the end result of an investigation.

PV VII: Ceremonial Session with Award Ceremony

Location: HSZ/AUDI

Time: Tuesday 14:00—16:30

Ceremonial Talk

PV VII HSZ/AUDI

The one unattainable – new breakthroughs in particle physics — Monica Dunford — Kirchhoff-Institut für Physik (KIP), Ruprecht-Karls-Universität Heidelberg

The dynamics of the Standard Model of particle physics play a central role in the properties of not only the microscopic world but also the biggest structures of our universe. The Higgs boson, for example, plays a critical part in how particles obtain their masses but also perhaps to dark matter and how our universe evolved. In this talk, I will focus on a handful of recent developments in particle physics that were considered out of reach, but through innovative ideas and powerful data science are now attainable. I will highlight how these results have connections beyond the microscopic world to dark matter, matter and anti-matter differences and beyond.

Plenary Talk

PV VIII Wed 9:00 HSZ/AUDI

25 years of the AdS/CFT correspondence: Current status and future prospects — Koenraad Schalm — Institute Lorentz, Leiden University, Leiden, The Netherlands

Maldacena’s 1997 discovery that certain gauge theories have an equivalent description in terms of anti-de-Sitter quantum gravity in one extra dimension has led to several dramatic new physics insights. Three of these are: 1) From the gauge theory perspective the gravitational force is emergent and recent research on black holes and wormholes has elucidated that this is best phrased in terms of quantum entanglement. 2) The classical gravity limit dual to strongly coupled physics has a universal hydrodynamic limit at low energies. This fluid/gravity aspect has shed new light on the century-old physics of fluids from computational control to non-thermal fixed points. 3) Finally in context of condensed matter physics AdS/CFT indicated the existence of novel IR fixed points, subsequently validated in Sachdev-Ye-Kitaev models. Moreover, these fixed points are strong candidates to explain high Tc superconductors. We review each briefly and discuss how these new insights can point the way for current experiments as well as possibly test quantum gravity holographically in the lab.

Plenary Talk

PV IX Wed 9:45 HSZ/AUDI

The origin of the chemical elements — Mariabusha Aidotta — School of Physics and Astronomy, University of Edinburgh, EH9 3FD Edinburgh, UK

Questions around the composition and origin of our material world have fascinated mankind since ancient times, but it wasn’t until the advent of the Mendeleev’s periodic table in 1869 that it became clear how ordinary matter is made up of a finite number of different building blocks, the chemical elements. Yet, deeper questions remained: where, when and how did the chemical elements originate?

These questions are still at the core of nuclear astrophysics research today. Thanks to the advances of the last century and to the interplay of astronomical observations, nuclear physics experiments, and astrophysical models of stellar evolution and nucleosynthesis, we now know that only hydrogen, helium and few other light species were produced during the first few minutes of existence of the Universe, while all other elements, from carbon to gold, or uranium, were (and still are!) forged through nuclear reactions in different stages of stellar evolution.

In my talk, I will present an overview of the main processes responsible for the creation of the elements and recall the astrophysical sites in which these processes occur. I will also address the experimental challenges that we face in replicating stellar reactions on Earth in our attempt to reveal the origin of every chemical element and the intimate connection we bear with long-gone stars.

Prize Talk

PV X Wed 12:30 HSZ/AUDI

News from the Flavour Expedition to the Zepptouniverse — Andrej Buras — TUM Institute for Advanced Study (IAS), Garching, Germany — Laureate of the Max-Planck-Medal 2020

After finding an important cornerstone of the Standard Model (SM) through the Higgs discovery, particle physicists are waiting for the discovery of new particles either directly with the help of the Large Hadron Collider (LHC) and its upgrade (HL-LHC) or indirectly with the help of experiments like LHCb, NA62 and Belle II through quantum fluctuations causing certain rare processes with a change of quark flavour to occur at different rates than predicted by the SM. While the latter route is very challenging, requiring very precise technique and experiment, it allows the resolution of short distance scales as short as the Zepptometer corresponding to energies of order 10^17 TeV or even shorter scales. In the coming flavour precision era, in which the accuracy of the measurements of rare processes and of the relevant theory calculations will be significantly improved, this goal could be reached. The main strategies for reaching this goal will be explained in simple terms including the most recent advances. We will summarize the present status of deviations from SM predictions for a number of flavour observables and discuss possible explanations of these so-called anomalies. A short outlook for coming years will be given.

Evening Talk

PV XII Wed 20:00 HSZ/AUDI

The role of artificial intelligence in modern radiation therapy — Guillaume Landry — Department of Radiation Oncology, University Hospital, LMU Munich, Munich, Germany

As in many other fields, artificial intelligence (AI) has found applications in radiation therapy. By now, the most widespread use of AI is for the automatic delineation of organs on computed tomography or magnetic resonance images of the patient, which serve as basis for radiation delivery planning. For this task, the ubiquitous U-net convolutional neural network has been widely adopted, and several commercial solutions are available. Just as AI is continuously evolving, radiation therapy has seen exciting developments, notably the clinical introduction of online adaptive radiotherapy at MR-linacs, which allows daily plan adaptation and tumor tracking using cine-MRI. MR guided radiotherapy (MRgRT) is ideally suited for the adoption of AI methods, since it generates large amounts of data with imaging at every fraction, and there is a need to reduce the time patients spend in the MR-linac bore waiting for plan adaptation. Thus, besides automatic segmentation, in MRgRT AI may allow to generate pseudo-CT images from MR images and to help track and predict tumor motion on cine-MRI. Even for segmentation, some specific approaches such as patient-specific model fine tuning may find a role in MRgRT. Finally, for radiotherapy in general, AI may allow to correlate imaging and treatment outcomes.
Plenary Talk  
PV XIV  Thu 9:45  HSZ/AUDI  
**Machine Learning Advances in Particle Physics**  —  **LUKAS HEINRICH**  —  Technical University of Munich  
The year 2012 has been marked by two breakthroughs in science. One is very familiar to particle physicists: the discovery of the Higgs. The other would soon capture the attention of scientists and non-scientists alike: the breakthrough of deep learning which started with the "AlexNet" moment and kicked off a decade of impressive advancements in a wide range of domains, including fundamental physics. However, applications in fundamental physics must go beyond black-box point prediction and typically enable a rich interpretation of the data, including robustness to systematic uncertainties, interpretability and optimization with respect to multiple possibly competing objectives. In this talk I will review recent successes in ML that proved impactful within the context of fundamental physics and discuss future directions including differentiable and probabilistic programming, foundation models and fast simulation.

**Prize Talk**  
PV XV  Thu 12:30  HSZ/AUDI  
**Direct dark matter detection: What if there's no WIMP?**  —  **BELINA VON KROSGICK**  —  Karlsruhe Institute of Technology, Institute for Astroparticle Physics, Eggenstein-Leopoldshafen, Germany  —  Laureate of the Hertha-Sponer-Prize 2023  
More than a century has passed since the first hint of the existence of dark matter in the Universe. This hint has since been corroborated by a plethora of further astronomical observations revealing that even most of the matter in the Universe is dark. Observing the respective dark matter particles, and elucidating their nature, became one of the most tantalizing endeavors of modern physics, with the Weakly Interacting Massive Particle (WIMP) being a prime suspect. Tremendous experimental efforts and successes have allowed a large portion of the WIMP parameter space to be explored in recent decades, with optimized experiments for direct dark matter detection taking the lead in these searches. But no WIMP in sight thus far. Today, a new generation of highly sensitive, large-scale direct detection experiments is at the ready to observe WIMPs, and their successors are already being planned. But what if there's no WIMP? This talk will discuss the diversity of the worldwide direct dark matter search program beyond the traditional WIMP and provide a glimpse of where the near future will take us in this effort to directly observe dark matter in the laboratory.

**Evening Talk**  
PV XVI  Thu 20:00  HSZ/AUDI  
**Von Sachsen ins Universum**  —  **CHRISTIAN STEGMANN**  —  Deutsches Elektronen-Synchrotron DESY, Zeuthen  

Der Vortrag nimmt Sie mit in die Weiten unseres Universums, in die Vergangenheit bis zum Tag, der kein Gestern hatte und eine Zukunft mit großen Chancen für Innovationen in Technologie und Digitalisierung.

**Plenary Talk**  
PV XVII  Fri 9:00  HSZ/AUDI  
**The Einstein Telescope**  —  **HARALD LÜCK**  —  Institut für Gravitationsphysik, Leibniz Universität Hannover und Max-Planck Institut, Hannover  
The detections of gravitational waves with the current gravitational wave detectors enabled us to eavesdrop on hidden processes in the universe and obtain information about processes that we cannot see with other methods. They marked the beginning of gravitational astronomy. But we are only at the beginning of this new era. We know how to build new instruments with even better sensitivity that will allow us to listen out into the early times of the universe and constantly register the quiver of spacetime caused by a vast number of sources. With the Einstein Telescope, we want to build such an instrument in Europe. Bigger than before, more sensitive, underground and definitely cool. I will report on the plans and the current state of developments.

**Plenary Talk**  
PV XVIII  Fri 9:45  HSZ/AUDI  
**The LHC legacy and prospects**  —  **MARKUS KLUTE**  —  Karlsruhe, Germany  
The Large Hadron Collider (LHC) at CERN has had two successful and highly productive runs (2009-2013 and 2015-2018), colliding protons and heavy ions with center-of-mass energies of up to 13 TeV and collecting an unprecedented amount of data. Its highlight, the Higgs Boson discovery in 2012, completed the Standard Model of fundamental particle interactions. The particle physics world has changed dramatically in the last decade. While the impact of the collected data has been tremendous, many open questions in the world of elementary particle physics remain. I will review the main conclusions from the LHC to date and present the prospects of the LHC program and beyond.

**Prize Talk**  
PV XIX  Fri 13:00  HSZ/AUDI  
**The science and technology of DUNE and its future as an international neutrino observatory**  —  **STEFFEN SOLLNER-REMBOLD**  —  University of Manchester, United Kingdom  —  Laureate of the Max-Born-Prize 2023  
The preponderance of matter over antimatter in the early universe, the dynamics of the supernovae that produced the heavy elements necessary for life, the search for physics beyond the standard model – these mysteries at the forefront of particle physics and astrophysics are key to understanding the evolution of our universe. DUNE is an international neutrino experiment dedicated to addressing these questions as it searches for leptonic charge-parity symmetry violation, stands ready to capture supernova neutrino bursts, tests the three-flavour paradigm and search for new physics. To achieve its science goals, it will employ the technology of liquid-argon time projection chambers at an unprecedented scale and precision. DUNE will comprise a far detector located at the SURF laboratory in South Dakota and a near detector close to the neutrino beam source at Fermilab near to Chicago. The presentation will introduce the science and technology of DUNE and discuss the status of the international project.
Symposium SMuK Dissertation Prize 2023 (SYMD)

jointly organised by
the divisions of the Matter and Cosmos Section (SMuK)

Claus Lämmerzahl
ZARM, Universität Bremen
Am Fallturm
28359 Bremen
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The Matter and Cosmos Section, with its divisions Extraterrestrial Physics (EP), Gravitation and Relativity (GR), Hadronic and Nuclear Physics (HK), Theoretical and Mathematical Physics (MP), Plasma Physics (P), Radiation and Medical Physics (ST), and Particle Physics (T), awards a dissertation prize in recognition of outstanding research in the context of a doctoral thesis and its excellent communication. The award committee selects up to four candidates from the nominations who will present their doctoral theses at this symposium.

Overview of Invited Talks and Sessions
(Lecture hall HSZ/AUDI)

Sessions
SYMD 1 Mon 14:00–16:00 HSZ/AUDI SMuK Dissertation Prize 2023

The abstracts of the talks of the candidates will be published at https://www.dpg-verhandlungen.de prior to the conference.
Symposium SMuK Dissertation Prize 2023 (SYMD) Monday

Sessions

SYMD 1: SMuK Dissertation Prize 2023

Time: Monday 14:00–16:00
Location: HSZ/AUDI

The abstracts of the candidates will be published at https://www.dpg-verhandlungen.de prior to the conference.
Clouds serve an essential purpose in the Earth's lower atmosphere due to their impact on the radiative balance of the atmosphere. Clouds are found also in other planetary atmospheres throughout the solar system and even on exoplanets, and those clouds can differ strongly in their chemical composition from Earth's water/ice clouds. This session provides a forum on the fascinating properties of these "strange clouds": clouds in planetary atmospheres that differ from the ordinary clouds in the Earth's troposphere.

**Overview of Invited Talks and Sessions**

(Lecture hall HSZ/0004)

**Invited Talks**

| SYSC 1.1 | Tue 11:00–11:20 | HSZ/0004 | Not all clouds are created equal – strange clouds in our solar system — •THOMAS LEISNER |
| SYSC 1.2 | Tue 11:20–11:45 | HSZ/0004 | Clouds to the Edge of Space — •GERD BAUMGARTEN, RONALD EIXMANN, JENS FIEDLER, MICHAEL GERDING, MYKHAYLO GRYGALASHVLY, FRANZ-JOSEF LÜBKEN, ASHIQUE VELLALASERY, CHRISTIAN von SAVIGNY, ROBIN WING |
| SYSC 1.3 | Tue 11:45–12:10 | HSZ/0004 | The dynamic clouds of Venus — •JAVIER PERALTA |
| SYSC 1.4 | Tue 12:10–12:35 | HSZ/0004 | Observational constraints of exoplanet clouds — •NICOLAS IRO |
| SYSC 1.5 | Tue 12:35–13:00 | HSZ/0004 | Gemstone clouds in JWST target exoplanets — •DOMINIC SAMRA, CHRISTIANE HELLING |

**Sessions**

| SYSC 1.1–1.5 | Tue 11:00–13:00 | HSZ/0004 | Strange Clouds – From the Earth to Exoplanets |
Invited Talk
SYSC 1.1 Tue 11:00 HSZ/0004
Not all clouds are created equal – strange clouds in our solar system
— THOMAS LEISNER — Institut für Meteorologie und Klimaforschung, Karlsruher Institut für Technologie — Institut für Umwelphysik, Universität Heidelberg

We are accustomed to the appearance of liquid water and ice clouds in the Earth’s atmosphere. This contribution introduces clouds in other parts of the solar system and discusses how their appearance and optical properties are shaped by the thermodynamic and microphysical boundary conditions in these worlds.

Invited Talk
SYSC 1.2 Tue 11:20 HSZ/0004
Clouds to the Edge of Space — GERD BAUMGARTEN1, RONALD EIXMANN1, JENS FIEDLER1, MICHAEL GERDING1, MYKRATLO GRIGALASHVILY1, FRANZ-JOSEF LÜBKEN1, ASHQUE VELLALASSERY1, CHRISTIAN VON SAVIGNY1, and ROBIN WÖHLING1 — 1Leibniz Institute of Atmospheric Physics at the University of Rostock — 2Institute of Physics, University of Greifswald

While the troposphere is rich of clouds, the stratosphere and mesosphere is virtually free of clouds. Two examples of strange clouds above the troposphere are Polar Stratospheric Clouds (PSC) and Noctilucent Clouds (NLC). Extraterrestrial sources or space traffic may lead to cases of clouds that quickly disappear. Because of their importance to society, these strange clouds have attracted great interest. For example, PSC are responsible for Ozone destruction following polar winter, ultimately leading to the Ozone hole. NLC are a one-of-a-kind source of information from the Edge of the Space, at an altitude of 85 km, dating back to 1885. Only a few lidar instruments are capable of observing NLC, and only the RMR lidar at the ALOMAR observatory in northern Norway is using three different wavelengths. We make use of these multicolor observations to understand microphysical processes in clouds. A new instrument setup in Kühlungsborn allows studying NLC with subsecond resolution and in 3 different directions, allowing to investigate their morphology which reveals atmospheric motion in the transition region of waves to turbulence. We will present strange clouds observed by lidars above Northern Norway and Kühlungsborn. The importance of these observations is investigated using model simulations of NLC from 1885 to 2100.

Invited Talk
SYSC 1.3 Tue 11:45 HSZ/0004
The dynamic clouds of Venus — JAVIER PERALTA — Facultad de Física (Universidad de Sevilla), Sevilla, Spain

Venus is an excellent laboratory to study terrestrial planets permanently covered by clouds. In fact, Venus exhibits a thick cloudy layer which extends along an altitude range of 20 km, these clouds being mainly composed of sulphuric acid droplets and hiding a mysterious absorber proven to be a main driver of its atmospheric dynamics. The spectroscopic and imagery data set acquired during the last 15 years thanks to the space missions Venus Express (ESA) and Akatsuki (JAXA) not only have allowed us to better understand their composition and the prevailing atmospheric dynamics, but the clouds of Venus have also proven their potential to study the generation and impact of the thermal tides, characterize diverse planetary-scale waves and atmospheric instabilities, confirm the vertical propagation of waves generated at the surface, and discover new atmospheric phenomena yet without explanation. The clouds of Venus have also been shown to represent a false positive when inferring surface properties from time-series measurements of reflected starlight on exoplanets.

Invited Talk
SYSC 1.4 Tue 12:10 HSZ/0004
Observational constraints of exoplanet clouds — NICOLAS IRO — German Aerospace Centre (DLR), Berlin, Germany

We entered a new era in extrasolar planets characterisation. We are indeed given access to constraints on their meteorology.

New facilities have been designed, such as the exoplanet thermal tides, characterisation. Higher spectral resolution of exoplanet atmosphere observations allow us to infer atmospheric properties with unprecedented details, including the presence of clouds.

Moreover, time varying observations could in principle study the variability of exoplanet atmospheres, such as climate and cloud coverage temporal variations. Here we will review the recent observational constraints relative to clouds in exoplanet atmospheres, as well as discuss the exciting prospects for the near future.

Invited Talk
SYSC 1.5 Tue 12:35 HSZ/0004
Gemstone clouds in JWST target exoplanets — DOMINIC SAMBA1 and CHRISTIANE HELLING1,2 — 1Space Research Institute, Austrian Academy of Sciences, Schmiedlstrasse 6, A-8042 Graz, Austria — 2Institute for Theoretical Physics and Computational Physics, Graz University of Technology, Petersgasse 16, A-8010 Graz, Austria

Exoplanets provide excellent test-beds for exploring the diversity of atmospheric physics. However, clouds remain a key challenge in observations by altering the local atmospheric composition through condensation, as well as obscuring deeper atmospheric layers. State-of-the-art instruments (e.g. JWST) will make spectral features of cloud particle composition observable. Cloud formation in exoplanet atmospheres traces local thermodynamic conditions. Microphysical cloud modelling is a powerful tool which provides the details of cloud formation processes (nucleation, growth, collisions, settling and mixing) necessary for understanding observations over a wide wavelength range. Gas-giant atmospheres condense clouds formed from a diverse range of materials, such as silicates, metal oxides and salts. We model cloud formation for 1D atmosphere profiles using a kinetic cloud formation model consistently combined with equilibrium gas-chemistry. Using results from 3D general circulation models as input to our model allows us to study cloud formation in JWST targets, such as WASP-96b. We find a significant gap between known theory and retrieved results from observations. However, additional processes could reconcile these differences and yield a greater understanding of the reality of cloud formation on such planets.
Extraterrestrial Physics Division
Fachverband Extraterrestrische Physik (EP)

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Overview of Invited Talks and Sessions
(Lecture halls HSZ/0004 and ZEU/0160; Poster HSZ OG 1)

Plenary Talk of the Extraterrestrial Physics Division
PV IV Tue 9:00–9:45 HSZ/AUDI Characterising exoplanet atmospheres with the Webb space telescope — •Pierre-Olivier Lagage

Invited Talks
EP 1.1 Mon 10:45–11:15 HSZ/0004 A Melting Probe for the Exploration of Subglacial Lakes within the TRIPLE project line — •Mia Giang Do, Jan Audehm, Clemens Espe, Marco Feldmann, Gero Francke, Fabian Schöttler, Dirk Heinen, Stefan Kaiser, Andreas Nöll, Christopher Wiebusch, Yuting Ye, Simon Zierke
EP 2.1 Mon 16:15–16:45 ZEU/0160 The exoplanet revolution: towards habitable worlds — •Alexis Smith
EP 5.1 Wed 10:45–11:15 ZEU/0160 New insights into the elusive magnetic processes operating in the solar corona with SoO/EUI — •Lakshmi Pradeep Chitta
EP 5.3 Wed 11:30–12:00 ZEU/0160 Studying solar flares with the X-ray telescope STIX during the cruise and early science phase of Solar Orbiter — •Alexander Warmuth
EP 7.3 Wed 15:00–15:30 ZEU/0160 New Insights in Simulations of SEP Events with the PARADISE+ICARUS Model — •Edin Husicic, Nicolas Wijsen, Tinatin Baratashvili, Stefaan Poedts, Rami Vainio
EP 8.1 Wed 16:00–16:30 ZEU/0160 Precision measurements of cosmic ray fluxes from AMS-02 with a daily time resolution — •Stefan Schaef
EP 10.1 Thu 11:00–11:45 ZEU/0160 Arne-Richter Lecture: From nonthermal plasma astrophysics to modeling of pandemic outbreaks — •Reinhard Schlickeiser
EP 11.1 Thu 14:00–14:30 ZEU/0160 Energetic Particle Precipitation reflected in the Global Secondary Ozone Distribution — •Jia Jia, Lisa E. Murbarg, Tiril Løvyset, Yvan J. Orsolini, Patrick J. Espy, JuDe Salinas, Jae N. Lee, Dong Wu, Jiarong Zhang
EP 13.1 Thu 17:30–18:00 ZEU/0160 Time-dependent data analysis of a blazar flare — •Maximilian Albrecht, Felix Spanier
EP 14.1 Fri 11:00–11:30 HSZ/0004 Unveiling the secrets of hot, massive stars with modern stellar atmosphere models — •Andreas A C Sander
Invited Talks of the joint Symposium Strange Clouds – from the Earth to Exoplanets (SYSC)

See SYSC for the full program of the symposium.

SYSC 1.1 Tue 11:00–11:20 HSZ/0004 Not all clouds are created equal – strange clouds in our solar system — Thomas Leisner
SYSC 1.2 Tue 11:20–11:45 HSZ/0004 Clouds to the Edge of Space — Gerd Baumgarten, Ronald Eixmann, Jens Fiedler, Michael Gerding, Mykhaylo Grygalashvily, Franz-Josef Lübken, Ashique Vellalassery, Christian von Savigny, Robin Wing
SYSC 1.3 Tue 11:45–12:10 HSZ/0004 The dynamic clouds of Venus — Javier Peralta
SYSC 1.4 Tue 12:10–12:35 HSZ/0004 Observational constraints of exoplanet clouds — Nicolas Iro
SYSC 1.5 Tue 12:35–13:00 HSZ/0004 Gemstone clouds in JWST target exoplanets — Dominic Samra, Christiane Helling

Sessions

EP 1.1–1.8 Mon 10:45–13:00 HSZ/0004 Planets and small Objects
EP 2.1–2.5 Mon 16:15–17:45 ZEU/0160 Exoplanets and Astrobiology
EP 3.1–3.5 Tue 16:45–18:00 ZEU/0160 Clouds in Planetary Atmospheres (joint session EP/UP)
EP 4.1–4.4 Tue 18:00–19:00 ZEU/0160 Planetary atmospheres
EP 5.1–5.6 Wed 10:45–12:45 ZEU/0160 Sun and heliosphere I
EP 6 Wed 13:00–14:00 ZEU/0160 Members’ Assembly
EP 8.1–8.4 Wed 16:00–17:15 ZEU/0160 Sun and heliosphere III
EP 9.1–9.20 Wed 17:30–19:00 HSZ OG1 Poster
EP 10.1–10.6 Thu 11:00–13:00 ZEU/0160 Astrophysics: Cosmic Rays and Galaxies I
EP 11.1–11.5 Thu 14:00–15:30 ZEU/0160 Near-Earth Space I
EP 12.1–12.5 Thu 15:45–17:15 ZEU/0160 Near-Earth Space II
EP 13.1–13.5 Thu 17:30–19:00 ZEU/0160 Astrophysics: Galaxies II
EP 14.1–14.7 Fri 11:00–13:00 HSZ/0004 Astrophysics: Stellar Astrophysics
EP 15.1–15.6 Fri 14:00–15:30 HSZ/0004 Astrophysics: Cosmology

Members’ Assembly of the Extraterrestrial Physics Division

Wednesday 13:00–14:00 ZEU/0160
These waves play potentially significant roles for the structure of this region, for the atmospheric erosion, or for the transport and acceleration of energetic particles. In the presentation both linear and nonlinear waves are studied within the framework of (multi-species) hydromagnetics and magnetohydrodynamics, which allows, depending on the model’s assumptions, to analyze their dispersion in a linearizing approach and their nonlinear dynamics using a perturbative approach. Within the hydrodynamical treatment also the ion outflow from the Venusian atmosphere can be investigated.

EP 1.5 Mon 12:00 HSZ/0004
Conformal mapping for the planetary bow shock and magnetopause studies
— Yasuhiro Narita1, Simon Topper2, and Daniel Schmid2
1Space Research Institute, Austrian Academy of Sciences, Graz, Austria — 2Institut für Theoretische Physik, Technische Universität Braunschweig, Germany

The concept of conformal mapping is introduced to the planetary magnetospheric research as a useful tool to characterize the bow shock and magnetopause geometry and to directly compare the in-situ measurements of magnetic field and plasma flow with the theoretical models. Various models of the planetary bow shock and magnetopause can be extended from the real-number expression to the conformal mapping in the complex plane. By doing so, the spatial domains around the bow shock and magnetopause are easily expressed in orthogonal curvilinear coordinates. In particular, the parabolic bow shock and the tail-elongated magnetopause are found to be conformally mapped using only elementary analytic expressions. Conformal mapping opens the door to construct a high-precision steady-state model of the magnetic field and plasma flow in the planetary magnetosheath region by transforming the Kolmogorov scale potential, the exact solution of Laplace equation in parabolic magnetosheath coordinates, to arbitrary two-dimensional bow shock and magnetopause shapes. Such a model will significantly ease the interpretation of magnetic field or plasma data in the planetary missions, as one obtains the global picture of bow shock, magnetopause, and magnetosheath from the model either from the measurements or from the given solar wind condition.

EP 1.6 Mon 12:15 HSZ/0004
Mirror Modes in the Hermean Magnetosheath
— Martin Volwerk1, Charlotte Hesse2, Daniel Hesse2, Tomasz Karlsson3, Ferdinand Plaschke3, Daniel Schmid3, and Cyril Simon Wedlund4
1Research Institute, Austrian Academy of Sciences, Graz, Austria — 3Institut für Geophysik und extraterrestrische Physik Technische Universität Braunschweig, Germany — 4Space and Plasma Physics School of Electrical Engineering and Computer Science ETH Royal Institute of Technology, Stockholm, Sweden

Mirror modes are quasi-stationary structures in the plasma frame, consisting of a train of magnetic compressions combined with plasma density enhancements. They are created by a temperature asymmetry in the plasma, where the perpendicular temperature (with respect to the magnetic field) is higher than the parallel temperature. These structures are ubiquitous in planetary magnetospheres, and have been detected at Venus, Earth, Mars, Jupiter and even at comets. Similar structures to mirror modes are magnetic holes, usually born in the solar wind upstream of the shock and transported into the magnetosheath (Karlsson et al., 2021). Here we study magnetic field data during the orbital phase of the MESSENGER mission at Mercury to identify mirror mode-like structures with a magnetic-field-only method. Properties of mirror mode structures will be compared to those of isolated magnetic holes observed in the magnetosheath earlier, to investigate if they are related phenomena.

EP 1.7 Mon 12:30 HSZ/0004
Deformed bow shock and magnetic depression: Lessons from BepiColombo’s flyby-2 at Mercury
— Daniel Schmid1, David Fischer2, Werner Magotz2, Yasuhiro Narita1, Martin Volwerk1, Wolfgang Baumjohann2, Ayako Matsukoa2, Uli Auster1, Ingo Richter1, Daniel Heyner1, Ferdinand Plaschke2, and Rumi Nakamura1
1Institut für Weltraumforschung (IWF) Graz, Österreichische Akademie der Wissenschaften (OeAW) — 2World Data Center for Geomagnetism, Kyoto University — 3Institut für Geophysik und Extraterrestrische Physik Technische Universität Braunschweig

Understanding Mercury’s magnetospheric structure remains a challenge due to the planet’s proximity to the Sun. The magnetic field data from BepiColombo’s flyby-2 at Mercury in June 2022 allows us to study the magnetosphere and its space environment in-situ. The bow shock crossing analysis reveals that the
shock normal direction is significantly deformed during the inbound crossing and is comforting to the steady-state bow shock shape during the outbound crossing. The magnetosphere crossing analysis reveals a short-time magnetic field depression in the midnight sector before the closest approach, indicating either occurrence of a transient event or crossing of a current layer separating the dipolar from the tail-field region. The BepiColumbo flyby-2 magnetic field data analysis shows that Mercury's magnetosphere is highly dynamic and identification of transient events from the quasi-steady state of the magnetosphere plays a crucial role in constructing the magnetospheric structure from the magnetic field data.

EP 1.8 Mon 12:45 HSZ/0004

Analysis of IMF penetration into Mercury's Magnetosphere — **Kristin Pump, Daniel Heyner, and Ferdinando Plaschke** — TU Braunschweig, IIGEP, Mendelssohnstraße 3, 38106 Braunschweig

Mercury is the smallest and innermost planet of our solar system and has a dipole-dominated internal magnetic field that is relatively weak, very axisymmetric and significantly offset towards north. Through the interaction with the solar wind, this field leads to a magnetosphere. Compared to the magnetosphere of Earth, Mercury's magnetosphere is smaller and more dynamic. A semi-empirical magnetic model can capture the large-scale magnetospheric structures. Using the residuals between in-situ data and the model prediction we further seek to improve our understanding of the Hermean magnetosphere. To first order the magnetopause completely separates the magnetosphere from the magnetosheath and thus no magnetic field may penetrate this boundary. In reality, the magnetosheath field may diffuse across the very thin boundary within a finite time. Here, we investigate this penetration and compare the different interplanetary field (IMF) components by their ability to enter into Mercury's Magnetosphere.

For this, we use in-situ MESSENGER magnetic field data to estimate the IMF for the time frame with the probe located inside the magnetosphere. The amount of penetration is found by least-square fitting to magnetospheric model results. First statistical results indicate that the penetration is stronger under southward IMF conditions.

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**EP 2: Exoplanets and Astrobiology**

**Invited Talk**

EP 2.1 Mon 16:15 ZEU/0160

The exoplanet revolution: towards habitable worlds — **Alexis Smith** — Institut für Planetenforschung, Deutsches Zentrum für Luft- und Raumfahrt, Berlin

In the nearly 30 years since the discovery of the first exoplanets, planet detection has continued to accelerate, driven in large part by the space-based transit missions Kepler/K2 and TESS; there are now more than 5000 confirmed exoplanets. These detections have enabled insights into the demographics of the exoplanet population, and hence into the formation and migration processes that sculpted the planetary systems that we observe today. As we begin to place our planetary system into a Galactic context, there have been innumerable surprises such as the discovery that the most common type of planet is not represented in our Solar System. Meanwhile, bright transiting systems, such as those discovered by TESS, are increasingly amenable to atmospheric characterization with existing ground-based facilities, as well as with JWST. In the near future, the ESA Ariel mission and the ground-based ELTs will continue to expand the available parameter space for atmospheric exploration. Finally, ESA’s upcoming PLATO mission will enhance our planet detection abilities, putting Earth-like planets in reach for the first time.

EP 2.2 Mon 16:45 ZEU/0160

Habitability inside atmospheres — **Klaus Scherer**\(^1\), Konstantin Herrb**\(^2\), Dominik J. Bomans**\(^3\), N. Eugene Engelbrecht**\(^4\), Stefan ‘E.S. Febbrib**\(^5\), Lennart Balmann**\(^6\), Frederic Effenberg**\(^7\), and Jen Kleinmann**\(^8\) — \(^1\) Institut für Theoretische Physik IV, Ruhr-Universität Bochum, Germany — \(^2\) Astronomisches Institut, Ruhr-Universität Bochum, Germany — \(^3\) Centre for Space Research, North-West University, Potchefstroom, South Africa — \(^4\) Institute for Particle and Astroparticle Physics, ETH Zürich, Switzerland

The habitable planets around a host star are not only influenced by the stellar wind or flare activity, but are also embedded in the interstellar environment, which can also influence these planets and their atmospheres. We will show that for certain classes of atmospheres, the inflow of the neutrals on the top of an exoplanetary atmosphere can be large. This is done by modelling the interaction between the stellar wind and the interstellar medium using a two fluid MHD model. Moreover, such an 3D MHD simulation will also allow us to study the modulation of galactic cosmic rays in 3D, incorporating a turbulence transport model, so that the diffusion coefficients and the drift velocities can be modelled as far as possible from first principles. We will also discuss the latter point.

EP 2.3 Mon 17:00 ZEU/0160

Examining the orbital decay targets KELT-9 b, KELT-16 b, and WASP-4 b, and the transit-timing variations of HD 97658 b — **Ian-Vincent Harre** — DLR - Institute of Planetary Research, Berlin, Germany

Tidal orbital decay is suspected to occur for hot Jupiters in particular, with the only observationally confirmed case of this being WASP-12b. By examining this effect, information on the properties of the host star can be obtained using the so-called stellar modified tidal quality factor \(Q_e\), which describes the efficiency of the planetary kinetic energy dissipation within the star. In this study, we aim to improve constraints on the tidal decay of the KELT-9, KELT-16, and WASP-4 systems, making it possible to constrain the \(Q_e\) value for each star. In addition, we aim to test the existence of the TTVs in the HD 97658 system, which previously favoured a quadratic trend with increasing orbital period. Making use of newly acquired photometric observations from CHEOPS and TESS, combined with archival data, we fit three models to the data, namely a constant-period model, an orbital-decay model, and an apsidal-precession model. We find that the KELT-9 system is best described by an apsidal-precession model for now, with an orbital decay trend at \(2\sigma\) being a possibility as well. A Keplerian orbit model provides the best fit to the transit timings of KELT-16 b because of the scatter and scale of their error bars. The WASP-4 system is best represented by an orbital decay model at a \(5\sigma\) significance, although apsidal precession cannot be ruled out. For HD 97658 b, we find no conclusive evidence for the suspected trend in the data.

EP 2.4 Mon 17:15 ZEU/0160

Deciphering Dayglow as Biosignature of Planet Earth — **Katharina Uhlmannke**\(^1\), Michael Sterzik**\(^2\), Claudia Emde**\(^3\), and Stefano Baguino**\(^4\) — \(^1\) ESO, Garching, Germany — \(^2\) Institute for Meteorology LMU, Munich, Germany — \(^3\) Armagh Observatory, Belfast, UK

Biosignatures in the near-infrared spectrum of Earth’s atmosphere include the simultaneous presence of H2O, O2 and CH4 molecular absorption bands, but also abundant skyline emission features caused by chemo-photolytic reaction networks of Oxygen in the upper atmosphere such as OH. New infrared spectra of Earthshine were obtained with the CRiRES+ instrument at the VLT and achieve a high spectral resolution of \(R > 100,000\). Thus, narrowband features of day- and nightglow emission (e.g. OH, O2) can be resolved. We compare airglow lines caused by different mechanisms, and try to discern day- and nightglow from contaminating atmospheric transmission. Earthshine spectra consist of the spatially integrated light of the illuminated Earth and Earth’s atmosphere and are therefore considered analogous to direct observations of exoplanets. Hence, tracing biosignatures in our high-resolution CRiRES+ observations of Earthshine opens a novel window for the detection of biosignatures of Earth-like planets.

EP 2.5 Mon 17:30 ZEU/0160


The first biomolecules are replicating non-coding RNA enzymes, ribozymes, which can cleave and join and evolve. The ribozymes are the active component for protein synthesis, ribosomes are ribozymes. They are also designated as viroid. RNA is essential at many most prominent steps in metabolism, on planet Earth, as primers, as chief regulators (circularRNA), in sperm for non-Mendelian transgenerational inheritance, for silencing, defense, evolution etc. RNA can do it all. It is unstable and sensitive and needs protection. The most versatile living entities are the archaea, which can cope with extreme environmental conditions and were named extremophiles. They are very complicated and specialized to Earth conditions, they are innovative but evolution of metabolic pathways takes time. What are the most likely or unlikely conditions on Planet Earth, which allow to extrapolate to possible extraterrestrial living conditions. The conflict is either a unique earth versus astronomical numbers of exoplanets. (Moelling K: Viren die Supermacht des Lebens (C.H. Beck Press) or ”Viruses, more Friends than Foes (WSPress))
Wellen und Wolken in der Atmosphäre über den südlichen Anden gemessen mit einem Rayleigh-Lidar — Natalie Kaifler, Bernd Kaifler, Andreas Dörnbrack and Markus Rapp — Deutsches Zentrum für Luft- und Raumfahrt e.V., Institut für Physik der Atmosphäre

Extraterrestrial Physics Division (EP) Tuesday 16:45–18:00 Location: ZEU/0160

EP 3.1 Tue 16:45 ZEU/0160

Wellen und Wolken in der Atmosphäre über den südlichen Anden gemessen mit einem Rayleigh-Lidar — Natalie Kaifler, Bernd Kaifler, Andreas Dörnbrack and Markus Rapp — Deutsches Zentrum für Luft- und Raumfahrt e.V., Institut für Physik der Atmosphäre

EP 3.2 Tue 17:00 ZEU/0160

Preferential adsorption of para and ortho water molecules on charged nanoparticles in planetary ice clouds — Johannes Weidelt1, Thomas Dresch2, Denis Dupy3, and Thomas Leisner4,5 — Ultrafisah Science Research Unit, University of Bielefeld, Germany — 1Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology, Germany — 2Institute of Environmental Physics, University of Heidelberg, Germany

EP 3.3 Tue 17:15 ZEU/0160

On the colour of noctilucent clouds — Christian von Savigny1, Anna Lange2, Gerhard Baumgartner3, and Alexei Rozanov4 — 1Institute of Physics, University of Greifswald, Greifswald, Germany — 2Leibniz Institute of Atmospheric Physics, Kühlungsborn, Germany — 3Institute of Environmental Physics, University of Bremen, Bremen, Germany

EP 3.4 Tue 17:30 ZEU/0160

Exoplanetary clouds: The potential of high-precision polarimetry — Moritz Lietzow and Sebastian Wolf — Institute of Theoretical Physics and Astrophysics, Kiel University, Germany

The reflected flux from planets is polarized due to scattering in their atmosphere. While polarimetry is used to study objects in the Solar System, it has also been proposed for detection and characterization of extrasolar planets. In particular, the reflected polarized flux depends not only on the planetary phase angle and observed wavelength, but also on the atmospheric composition, allowing to distinguish between various cloud compositions. Given the accuracy of existing high-precision polarimeters, scattered light polarimetry indeed has the potential to become a powerful tool to characterize exoplanetary atmospheres. First measurements of planet-induced polarization were reported during recent years. To provide the basis for theoretical studies and the interpretation of dedicated polarization measurements, we developed a radiative transfer simulation software that contains all relevant continuum polarization mechanisms for the comprehensive analysis of the polarized flux resulting from the scattering in the atmosphere, on the surface, and in the local planetary environment. In addition, we investigated the impact of the cloud composition and exoplanetary rings on the scattered light polarization.

EP 3.5 Tue 17:45 ZEU/0160

Retrieval of cloud properties using spectropolarimetric simulations of Earth shine — Obyslya Pari1, Claudia Emde2, Michael Sterzik3, and Michael Manari4 — 1Ludwig-Maximilians-Universität, München, Germany — 2European Southern Observatory, Garching bei München, Germany

In order to be able to interpret future observations of the atmospheres of Earth-like planets and detect signatures of life, it is important to understand Earth’s atmospheric and surface properties. Observations of Earthshine, which is sunlight scattered by Earth to the Moon, and then reflected back to Earth, make it possible to study Earth as an exoplanet.

We use the Monte Carlo radiative transfer model MYSTIC to simulate polarized spectra in the atmosphere of the Earth for Ocean and Lambertian surfaces. A water or an ice cloud layer is included and we vary the cloud parameters (cloud altitude, cloud optical thickness, effective droplet radius).

The focus is on the O3 (119–120 nm) and H2O bands, where the degree of polarization can be higher or lower than the adjacent continuum. To quantify this behavior we use the equivalent width, which is the area in the passband between the absorption line and the simulated spectrum without absorption across a specific spectral region.

We find that the equivalent width is highly sensitive to cloud altitude and cloud optical thickness. The simulations are compared to the observations of Earthshine obtained by FORS2 at the VLT for different Sun-Earth-Moon phase angles.

EP 4: Planetary atmospheres

Time: Tuesday 18:00–19:00 Location: ZEU/0160

EP 4.1 Tue 18:00 ZEU/0160

Jupiter moon Ganymede’s atmosphere observed with the Hubble Space Telescope — Lorenzo Roth1, Gregorio Marchisini1, Trace Becker2, Jens Hojdemakers3, Philippa Molyneux4, Kurt Rutherford5, Joachim Saure6, Shane Carberry Mogan2, and James Szalay3 — 1KTH Royal Institute of Technology, Stockholm Sweden / ESO Garching bei München — 2Southwest Research Institute, San Antonio, TX, USA — 3Lund University, Sweden — 4Universität zu Köln — 5University of California, Berkeley, CA, USA — 6Princeton University, Princeton, NJ, USA

Ganymede is the largest moon in the Solar System and the only one that generates its own magnetic field in the interior. Ganymede also possesses a tenuous water-based atmosphere, produced by the solar and jovian plasma irradiation of its icy surface. Here we report results from far-ultraviolet observations by the Hubble Space Telescope of Ganymede transiting across the planet’s dayside hemisphere. Within a targeted campaign on 9 September 2021 two exposures were taken during one transit passage to probe for attenuation of Jupiter’s hydrogen Lyman-a dayglow above the moon limb. The background dayglow is slightly attenuated over an extended region around Ganymede. The obtained vertical H column densities are consistent with previous results. Constraining the spatial variation of the Lyman-a column density by Ganymede’s disk, we derive an upper limit on a local H2O column density such as could arise from outgassing plumes in regions near the observed moon limb.
Investigation of the Influence of Stellar Particle Events and Galactic Cosmic Rays on the Atmosphere of TRAPPIST-1 — 4.2a Andreas Bartenschlager1, Miriam Sundhure1, John Leegrenfell1, Benjamin Tatsum1, Fabian Wunderlich1, and Konstantin Herbst2 — 1Karlsruher Institute of Technology, Germany — 2German Aerospace Center, Berlin, Germany — 3University of Kiel, Germany

The launch of the James Webb Space Telescope (JWST) in December 2021 opens up the possibility of studying the composition of exoplanetary atmospheres in habitable zones in the near future. We investigate the influence of stellar energetic particles (SEPs) on the atmospheric chemistry of exoplanets around a very active M-star TRAPPIST-1, using the ion chemistry model ExoTiC. We perform model experiments with different Ni or CO2 dominated atmospheres, depending on the initial CO2 partial pressure, as well as humid and dry conditions, taking into account the ionization rates for such events. A further specification is the distinction between dead and alive atmospheres, whose atmospheric composition is characterized by a lower or higher oxygen fraction in the initial conditions. Within ExoTiC we calculate the impact of the ionization events on these atmospheres both as a single and as a series of events with different strengths. Preliminary results show a significant impact of SEP events on the chemical composition of the atmosphere, including biosignatures such as O3. The strength of these impacts depends on the starting atmospheres’ relative oxygen, nitrogen and water vapour content.

Simulating exoplanetary atmospheres in the laboratory: comparing experimental data with output from an atmospheric model — 4.3a Florence Hoffmann1, Paul Mabey2, Egemen Yuzbas1, John Lee Grenfell2, Heike Rauer2,3,4,5, Andreas Elsaesser6 — 1Freie Universität Berlin, Germany — 2Institute for Planetary Research, Berlin, Germany — 3Berlin University of Technology, Germany

Since the discovery of the first exoplanet, several thousand have now been found including some rocky planets in the habitable zone. The new generation of instruments such as the James Webb Space Telescope will search for spectroscopic signals of atmospheric biosignatures on these worlds. Correctly interpreting such signals requires atmospheric models with consistent and flexible climate and chemical modules over a wide parameter range. With our new Planetary Simulation Chamber at FU Berlin, we are capable of simulating a large set of atmospheric parameters for Earth-like planets in the laboratory. We are able to vary the incoming spectra to simulate the photochemical and climate effects of Earth-like planets orbiting different stars. Many telescopes operate in the VIS/NIR range that corresponds to the fingerprint regions of interesting organic molecules. Our facility allows continuous spectroscopic in-situ sampling of molecules in the UV/IIR region and simultaneous mass spectroscopic analysis. In coordination with the DLR instrument for planetary research, we compare experimental results from our chamber with output from their climate-chemistry model 1D-TERRA.

Simulating Atmospheric Climate and Chemical Responses on a Hypothetical, Earthlike Planet Orbiting AD Leonis — 4.4a Julian Graupner1, John Leegrenfell1, Hella Garby2, Anna Goetz3, and Heike Rauer1,3,4,5,6,7,8,9,10,11 — 1Department of Extrasolar Planets and Atmospheres, Institute of Planetary Research, Berlin, Germany — 2Department of Earth System Modelling, Institute for Atmospheric Physics, German Aerospace Centre (DLR), Oberpfaffenhofen, Germany — 3Centre for Astronomy and Astrophysics, Berlin Institute of Technology, Berlin, Germany — 4Institute for Geological Science, Free University of Berlin, Berlin, Germany

Simulating a hypothetical Earth orbiting the active M-dwarf star AD Leonis is well-established since the stellar spectrum is well-characterized and there are numerous model studies in the literature. A long-term aim is to estimate the trans- port, climate and photochemical effects using a column climate-photochemical model loosely coupled with a parameterized 3D model. The column model is integrated over a range of latitudes which then generates a temperature map used as input for the 3D transport model. In the present study we report only results from the 1D model study for Earth placed around AD Leonis at an orbit where it receives the same insolation. Compared with previous column model studies we found that recent improvements in our climate and chemistry modules has led to modest changes in our simulated cold trap, hence water vapor abundances and also in the middle atmosphere ozone amount.

EP 5: Sun and heliosphere I

Time: Wednesday 10:45–12:45

Invited Talk

EP 5.1 Wed 10:45 ZEU/0160

New insights into the elusive magnetic processes operating in the solar corona with Solo/EUI — 5.1a Lakshmi Pradeep Chitta — Max Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, 37077 Göttingen

The solar corona, million Kelvin hot outer atmosphere of the Sun, is governed by magnetic fields. Streams of charged particles continuously escape this hot atmosphere into the heliosphere as solar wind. Magnetic processes responsible for coronal heating and for powering the solar wind are a subject of active debate for over six decades. With its unprecedented high-resolution, high-cadence view of the Sun, the Extreme Ultraviolet Imager (EUI) onboard the Solar Orbiter mission is shedding new light on the elusive magnetic processes operating in the corona. At closest approach, EUI can provide data with a spatial resolution of about 200 km and a cadence of below 3 s. During the first science perihelion observing campaign of Solar Orbiter, the EUI instrument imaged untangling of small-scale coronal magnetic braids through reconnection, and subsequent heating of plasma in some active region coronal loops. These observations suggest that magnetic reconnection in coronal loops might be operating on short timescales of a few 10 s and on spatial scales of a few 100 km. The EUI data also revealed ubiquitous high-speed reconnection-driven jets from coronal holes. These jets can channel sufficient heated material to sustain the solar wind mass flux. In this talk, we present these novel observations and discuss the role of magnetic reconnection in the heating of coronal plasma and in the driving of solar wind.

EP 5.2 Wed 11:15 ZEU/0160

Picoflares in the Quiet Solar Corona Observed by the Solar Orbiter — 5.2a Elena Podladchikova1,2, Alexander Wärnuth3, Francis Verbeeck1, Marco Villa1, Susanna Parenti2, Frederic Achille2, Andreas Veronis2, Stefan Purkhart2, Stefan Hofmeister1, Udo Schuhke1, Luca Tiberia1, Aznar Cuadrado2, Andrea Battaglia3, Frederic Schuller4, and Anik De Groof5 — 1AIP, Potsdam, Germany — 2Kiev Polytechnic University, Ukraine — 3ROB, Belgium — 4UCAL, USA — 5IAS, France — 6University of Graz, Austria — 7MPS, Germany — 8ETH, Switzerland — 9ESA, Madrid, Spain

On May 30, 2020, the Solar Orbiter High-Resolution Imager (HRIEUV) operating in 174 Å for the first time at perihelion at 0.55 AU to the Sun, observed a large number of sudden heating events so-called campfires with rich morphology and smaller space-time characteristics than nanoflares. We found that campfires emit thermal energy in the picoflares range of 3.4 × 1032–9.8 × 1035 ergs per event. The relationship between the emission measure and the temperature of campfires can be fitted by the power law covering 1–2.7 MK temperature range similar to large X-ray flares. Their frequency distribution can be fitted by power-law (E(E) = E2.82±0.11) but at higher than nanoflares frequencies and lower energy range. The additional previously unaccounted energy input of ≥3e is 1.0075 percent of the total required power to sustain a quiet solar corona. The observed power law would have to continue to about 1.25 × 1018 ergs in order to fulfill the observed coronal heating requirement.

Invited Talk

EP 5.3 Wed 11:30 ZEU/0160

Studying solar flares with the X-ray telescope STIX during the cruise and early science phase of Solar Orbiter — 5.3a Alexander Wärnuth — Leibniz-Institut für Astrophysik Potsdam (AIP)

Of the six remote-sensing instruments aboard Solar Orbiter, the Spectrometer/Telescope for Imaging X-rays (STIX) is the one dedicated to the study of solar flares. It performs X-ray imaging spectroscopy in the hard X-ray regime, which provides key physical diagnostics on both the hot thermal plasma as well as on the accelerated energetic electrons. During its operation since launch in 2020, which now includes the first year of the nominal mission phase, STIX has detected over 10000 solar flares. The first scientific results based on these novel observations will be discussed. The results will be compared to other STIX data, as well as to other remote-sensing instruments on Solar Orbiter, various X-ray instruments on other spacecraft, and in-situ particle detectors.

EP 5.4 Wed 12:00 ZEU/0160

Joint LOFAR and STIX observations of flare-accelerated electrons in the solar corona — 5.4a Malte Brose — Leibniz-Institut für Astrophysik Potsdam (AIP)

A joint analysis approach is used to study flare signatures both in the low and higher corona. STIX, AIA and LOFAR data provide an extensive picture about different aspects of flare characteristics. Recent data by the STIX instrument complement the picture of accelerated electrons, which propagate along magnetic field lines towards the Sun. These observations are linked to the LOFAR data, which contain information about the electrons propagating away from the Sun through the corona above the active region. Although, the active region and
its thermal evolution (Differential Emission Measure (DEM) reconstruction of AIA data), flare accelerated electrons and their radio tracks (LOFAR, STIX) are in principal all associated with the energy release during the flare process, they are often studied seperately. Hence, the investigation of possible relations is part of this project. Solar magnetic fields as a binding element between low and high corona, accelerated electrons and heated flare loops are included in the analysis via a Potential Field Source Surface (PFSS) model.

EP 5.5 Wed 12:15 ZEU/0160
Exploring the inner heliosphere with combined LOFAR and Solar Orbiter / Parker Solar Probe observations — Christian Vocks for the LOFAR Solar and Heliospheric KSP-Collaboration — Leibniz-Institut für Astrophysik Potsdam (AIP), Potsdam, Germany
The phenomena of the active Sun, like flares and coronal mass ejections (CMEs), have significant consequence for Earth and societal civilization. This is usually referred to as "Space Weather". Flares and CMEs accelerate electrons and ions to high energies. These particles are studied both remotely by ground- and space-based telescopes, and in situ by spacecraft. Energetic electrons emit radio waves as they move through the coronal plasma. This plasma emission is observed by radio telescopes, e.g. LOFAR. Since the frequency decreases with plasma density higher in the solar atmosphere, and radio waves below 10 MHz cannot pass Earth's ionosphere, spacecraft are needed to continue observations further into interplanetary space. They are also required for measuring energetic particles and observations of X-ray emission in the corona. Therefore, combining LOFAR and spacecraft data provides new insights into the physical processes in the region where the solar corona turns into the solar wind. Parker Solar Probe (PSP) and Solar Orbiter are two missions currently exploring the inner heliosphere. I'll present LOFAR observing campaigns during PSP and Solar Orbiter perihelia, that cover the Sun and its surroundings by making use of LOFAR's capability of running multiple observing modes in parallel, and show how they connect the corona with the heliosphere.

EP 5.6 Wed 12:30 ZEU/0160
Quasi-discontinuous solar wind solutions — Lukas Westrich — Ruhr-Universität Bochum, Institute for theoretical physics IV
In this talk the solar wind and its acceleration and heating will be examined. Recently Shergelashvili et al. (2020) developed a new class of discontinuous solar wind solutions. They considered a case of quasi-adiabatic radial expansion with a jump in the flow velocity, density, and temperature but a continuous Mach number at the critical point and derived analytical solutions. Therefore, they proposed a localized external heating source without actual modeling. First I will present the motivation and the physical background for this solutions. After a discussion of this new discontinuous concept for the solar wind, I will develop and discuss continuous numerical solutions, more similar to the classical Parker solar wind model, but with quasi-adiabatic radial expansion with an explicitly formulated localized heating source. This will be done both stationary and dynamically. This kind of solutions can reproduce the analytically derived solutions without discontinuous jumps in the physical properties.

EP 6: Members’ Assembly
Time: Wednesday 13:00–14:00
All members of the Extraterrestrial Physics Division are invited to participate.

EP 7: Sun and heliosphere II
Time: Wednesday 14:15–15:45

Invited Talk
EP 7.1 Wed 14:15 ZEU/0160
Advances in energetic particle physics with Solar Orbiter & Parker Solar Probe — Robert F. Wimmer-Schweingruber1, Javier Rodríguez-Pacheco2, George C. Ho1, Robert A. Allen1, Raul Gomez-Herrero1, and the Solar Orbiter EPD Team3 — 1Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany — 2Universidad de Alcalá, Space Research Group, 28085 Alcalá de Henares, Spain — 3Johns Hopkins University Applied Physics Laboratory, Laurel, MD, USA — All over the world.

Parker Solar Probe (PSP) and Solar Orbiter are investigating the inner heliosphere and approaching the Sun closer than any previous mission ever has. The state-of-the-art energetic particle instruments aboard the two spacecraft together with other instruments on multiple spacecraft present us with a wealth of data that are helping us to understand how the Sun shapes and controls the heliosphere.

Being so close to the Sun allows to disentangle transport effects from the original signatures of particle acceleration at the Sun. The sophisticated remote-sensing instrumentation provides crucial information about the solar source regions. We will present new results from PSP and Solar Orbiter and provide an update on their current status.

EP 7.2 Wed 14:45 ZEU/0160
Anisotropies of solar energetic electrons in the MeV range measured with Solo/EPD/HEIT — Sebastian Fleith1, Patrick Kühl1, Alexander Kolhoff1, Robert F. Wimmer-Schweingruber1, Bernd Herb1, Javier Rodríguez-Pacheco2, and Nina Dressing3 — 1Institute of Experimental & Applied Physics, Kiel University, 24118 Kiel, Germany — 2Space Research Group/Universidad de Alcalá, Madrid, Spain — 3Department of Physics and Astronomy, University of Turku, Turku, Finland
Solar Orbiter is an ESA-led mission of international collaboration with NASA to investigate how the Sun creates and controls the heliosphere, and why solar activity changes with time. One of its top-level science questions is how solar eruptions produce energetic particle radiation that fills the heliosphere. With its four viewing directions the High-Energy telescope (HEIT) provides critical information about the sources and transport of high-energy particles. This study analyzes relativistic electron measurements obtained by HEIT in the energy range from 200 keV to above 10 MeV. The purpose of this paper is to study anisotropies of relativistic solar energetic electrons utilizing the different viewing directions of HEIT. Time periods with enhanced fluxes of relativistic electrons, have been identified. A list of these time periods including additional observations such as maximum energy and flux as well as the first order anisotropy will be presented.

This is the first time since the Helios mission that anisotropies of high energy electrons have been measured.

EP 7.3 Wed 15:00 ZEU/0160
New Insights in Simulations of SEP Events with the PARADISE+ICARUS Model — Edin Husicic1,2, Nicolas Wijers1,3,4, Tinatin Baratashvili2, Stefaan Poedts1,5, and Rami Vainio6 — 1KU Leuven, Belgium — 2University of Turku, Finland — 3NASA, Goddard Space Flight Center, Greenbelt, USA — 4University of Maryland, USA — 5University of Maria Curie-Skłodowska, Lodz, Poland, but with quasi-adiabatic radial expansion with an explicitly formulated localized heating source. This will be done both stationary and dynamically. This kind of solutions can reproduce the analytically derived solutions without discontinuous jumps in the physical properties.

EP 7.4 Wed 15:30 ZEU/0160
Nonlinear diffusive shock acceleration in a spherical geometry — Dominik Walter, Horst Fichtner, and Frederic Effenberger — Ruhr-Universität Bochum, TP4, Bochum, Germany
Based on previous investigations in a Cartesian geometry, we now discuss the influence of a self-consistent diffusion coefficient on the transport of energetic particles in a spherical geometry. The formulation of the diffusion coefficient is motivated by taking into account the diffusing particles’ influence on the scattering centers in the background medium. The resulting single transport equation is nonlinear due to a dependence of the diffusion coefficient on the gradient of the particle distribution. After trying to predict, based on insights from linear theory, the behaviour of the solutions of the nonlinear equation in a shock acceleration model in spherical geometry, numerical methods are applied to the equation to explore the time evolution of the solutions and to investigate the features of the steady-state shock spectra. The results are discussed in the context of Cosmim Ray modulation in the heliosphere.

*Supported by DFG (SFB1491)
EP 8.1 Wed 16:00 ZEU/0160

**Invited Talk**

**Precision measurements of cosmic ray fluxes from AMS-02 with a daily time resolution**

— Stefanie Schäfer —

Physikalisches Institut, RWTH Aachen, Sommerfeldstr. 14, D-52074 Aachen

The Alpha Magnetic Spectrometer, AMS-02, is a general-purpose high-energy particle physics detector. It was installed on the International Space Station in May 2011 to conduct a unique long-duration mission of fundamental physics research in space. In 11 years AMS-02 has continuously collected data from more than 200 billion cosmic rays. The AMS-02 precision measurements have revealed new and distinct information that change our understanding of the production, acceleration and propagation of charged cosmic rays. In this presentation the recent measurements of the proton, helium, electron and positron fluxes with a daily time resolution will be summarized. These new precision measurements provide unique inputs to the understanding of cosmic rays in the heliosphere.

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EP 8.2 Wed 16:30 ZEU/0160

**Studies of energetic particle transport in synthetic turbulence with intermittency features**

— Frederic Effgenberger, Christian Pieper, Rainer Grauer —

Physikalisches Institut, RWTH Aachen University

The transport of fast charged particles in turbulent magnetic fields is a key research topic in space- and astrophysics. In particular, regimes of superdiffusive or subdiffusive propagation and interactions with large and small-scale coherent features are important to study in more detail. A common approach to investigate turbulence-particle interactions is based on full-orbit calculations of test-particle trajectories in artificially generated turbulence. These turbulence models have the advantage, when compared to an MHD approach, that they can potentially cover a wider dynamical range of turbulence scales. However, almost all synthetic turbulence models to this date only include second-order Gaussian statistics and thus fail to include coherent structures and intermittent features. Our new model is based on a continuous wavelet transform of a log-normal cascade process, which results in realistic intermittent scaling properties. We inves-

tigate the particle transport properties by solving a large number of particle orbits in these synthetic turbulence realisations and specifically look for non-diffusive regimes and non-standard energy dependences resulting from the intermittency of the generated fields. The implications for solar energetic particle and cosmic ray transport are discussed.

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EP 8.3 Wed 16:45 ZEU/0160

**Comparison of spatial diffusion tensors using an axisymmetric model of heliospheric modulation of cosmic rays**

— Dustin Lee Schröder, Horst Fichtner, and Jens Kleimann —

Ruhr-Universität Bochum, Bochum, Deutschland

A 3D partial differential equation solver is used to solve the steady state Parker transport equation for an axisymmetric model of the heliosphere in order to study the influence of spatial diffusion tensors on cosmic ray modulation. The diffusion tensor can either be specified as an analytical function or be used as a value calculated with a turbulence model.

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EP 9.1 Wed 17:30 HSZ OG1

**PUNCH4NFDi - Synergies & Services for SMuK**

— Michael Zacharias for the PUNCH4NFDi Consortium - Collaboration —

LSC, Université de Genève, Ch. d'Ecogia 16, Versoix, 1290, Switzerland

We present the Synergies & Services that PUNCH 4 NFDi is going to offer to the community at large - with a focus on Astrophysics. The main tool will be the Science Data Platform, where any connected data can be accessed and analysed. The Marketplace will be a community forum to share and distribute data management tools and scripts. We will present examples for such tools, namely the ontology platform, physics tools and an arxiv search tool for software products used in research.

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EP 9.2 Wed 17:30 HSZ OG1

**Extragalactic neutrino factories**

— Sara Buson — Andrea Tramacere, Leonard Perri —

Physik-Department, James-Frank-Str. 1, Garching bei München, D-85748, Germany

Identifying the astrophysical sources responsible for the high-energy cosmic neutrinos has been a longstanding challenge. In a previous study, we report evidence for a spatial correlation between blazars from the 5th Roma-BZCat catalog and neutrino data collected by the IceCube Observatory in the Southern celestial hemisphere. The probability that such correlation is found by chance is about one in a million (2 x 10^-6). In this conference contribution, we present an extension of the analysis to a complementary IceCube dataset, and put the findings into the context of the previous results.

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EP 9.3 Wed 17:30 HSZ OG1

**BlasT: A machine-learning estimator for the synchrotron peak of blazars**

— Theo Gauch and Tobias Kerscher —

Technische Universität München, Physik-Department, James-Frank-Str. 1, Garching bei München, D-85748, Germany

Recently we have used MHD as well as Particle-in-Cell simulations to study the difference transport of particles in non-dissipative fluid and dispersive kinetic models. We will focus specifically on the transport of particles moving perpendicular to the magnetic field. The results are spectrally interesting for the diffusion of electrons and positrons which resonate with waves with frequencies beyond the ion gyrofrequency.

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EP 9.4 Wed 17:30 HSZ OG1

**Analytic solutions for the hadronic time-dependent two-zone blazar model**

— Vito Aberham and Felix Spanier —

Institut für Theoretische Astrophysik, Universität Heidelberg

The transport of energetic charged particles depends on the underlying turbulence. Commonly non-dissipative waves and associated turbulence models are used in modeling transport parameters. For frequencies close to and beyond the ion gyrofrequency these assumptions are not applicable anymore.

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EP 9.5 Wed 17:30 HSZ OG1

**ComPol - A Compton polarimeter in a Nanosat**

— Matthias Meier for the ComPol-Collaboration —

Excellence Cluster ORIGINS, Garching, Germany — Technical University of Munich (TUM), Munich, Germany

Blazars, jetted Active Galaxy Nuclei (AGN) pointing towards us, occupy an important place in the field of high-energy astrophysics. Their classification depends heavily on the peak frequency of the synchrotron emission in the spectral energy distribution (SED), yet this value is usually determined manually. In this contribution, we present a tool using machine learning to not only streamline this process, but also give a reliable uncertainty evaluation. By the very nature of this method, additional components of the SED stemming from the host galaxy or disk emission, possible sources of confusion, are accounted for.

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Extraterrestrial Physics Division (EP) Wednesday

It is hardly possible to resolve the geometry of astrophysical compact objects due to their small size. One possibility to indirectly learn about their structure are polarization measurements. Especially in the hard X-ray range polarization data is still partially missing. Therefore, the aim of the CubeSat mission ComPol is to improve the physical model of the black hole binary system Cygnus X-1 by measuring the polarization of its hard X-ray spectrum (20-200keV).

The detector system developed for the ComPol project is composed of a Silicon drift detector used as a scatterer and a CeBr₃ scintillator read out by a SiPM matrix. From the scintillation light distribution it is possible to determine the azimuthal distribution in the CeBr₃, which is used to capture the full Compton kinematics. The next step is to perform an event-wise reconstruction from the measured energies and interaction points. The resulting distribution of the azimuthal scatter angles allows to directly infer the polarization of the initial radiation.

The talk will give an overview of the scientific motivation, the underlying physics and planned detector set-up.

This research is supported by the Excellence Cluster ORIGINS which is funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany’s Excellence Strategy - EXC-2094-390783311

EP 9.6 Wed 17:30 HSZ GGI

Das Universum als Energiesystem ermöglicht die Große Vereinheitlichtheit der Theorie — Günter von Quast — Winterweg 4 — 76344 Egggenstein-Leopoldsbaden


EP 9.7 Wed 17:30 HSZ GGI

Unveiling the dense molecular environments of evolved massive stars — Michaela Kraus, Maria Laura Arias, Michaela Kunzott, Andrea Torres, and Lydia S. Cidade — Astronomical Institute, Czech Academy of Sciences, Ondrejov, Czech Republic — Instituto de Astrofísica de La Plata, CONICET, UNLP, La Plata, Argentina

The evolution of massive stars passes through states with intense mass-loss and eruptions, leading to the formation of dense and warm circumstellar environments, which molecules and dust can form. Our research focuses on specific such evolutionary stages: the B[e] supergiants and the yellow hypergiants, with the aim to reveal the structure and dynamics of their circumstellar matter. For this, we collected high-resolution near-infrared spectra for a sample of stars, using facilities at Gemini Observatory. We discovered emission from hot CO gas in a few objects, based on which we derive the gas temperature, column density and kinematics within the line-forming regions. Interestingly, the yellow hypergiants and the B[e] supergiants with CO band emission share the same evolutionary tracks, and we discuss possible implications of this finding regarding potential evolutionary connections between these two phases.

EP 9.8 Wed 17:30 HSZ GGI

Evolution and radio emission of interacting plasma bunches in pulsar magnetospheres — Jan Bensáček, Patricio Muñoz, Jörg Buchner, and Axel Jessner — Instituto for Physics and Astronomy, University of Potsdam, Germany — Max Planck Institute for Solar System Physics, Göttingen, Germany — Center for Astronomy and Astrophysics, Technical University of Berlin, Germany — Max Planck Institute for Radio Astronomy, Bonn, Germany

Pulsars are neutron stars that emit coherent radio beams out of their magnetic poles. However, the origin of their radio emission is still under investigation. One of the proposed emission mechanisms exploits plasma bunches/clouds of electron-positron pairs created during spark events in gap regions. We utilized particle-in-cell simulations of relativistically hot bunches to investigate the bunch's nonlinear evolution and radiation by linear acceleration emission. We found that the main parameter influencing the bunch evolution is the initial drift velocity between electrons and positrons. For zero drift, the bunches can freely expand, and adjacent bunches may overlap in the phase space and form relativistic streaming instability. Otherwise, for non-zero drifts, the bunches are constrained from expansion and form strong oscillating electrostatic fields. Plasma particles may oscillate in these fields and emit radio waves. Furthermore, we found that the bunches are still constrained from expansion have similar observational characteristics as those observed for pulsars. Their spectrum contains a flat bottom for low frequencies and power-law profiles for higher frequencies.

EP 9.9 Wed 17:30 HSZ GGI

Quantitative spectroscopy of B-type supergiants — David Wessmann, Norbert Pritzl, and Keith Butler — Institut für Astro- und Teilchenphysik, Universität Innsbruck, Technikerstr. 25/8, 6020 Innsbruck, Austria — LMU München, Universitätsterrmarte, Scheinerstr. 1, 81679 München, Germany

B-type supergiants are a powerful tool in addressing various astrophysical questions, such as stellar wind properties, and atmospheric and core mass distillation. To facilitate a comprehensive analysis of these objects we assess the applicability of a hybrid non-LTE approach, in which line-blanketed model atmospheres computed under the assumptions of local thermodynamic equilibrium (LTE) are combined with non-LTE line-formation calculations. High-resolution echelle spectra — constituting an observational sample of 14 Galactic B-type supergiants with masses below about 30 M☉ serve as the basis of this investigation. The results of the analysis, including atmospheric and fundamental stellar parameters, multi-species abundances and derived spectroscopic distances, are probed via multiple checks of consistency. Finally, we also test the employed methodology for analyses of intermediate-resolution spectra of extragalactic B-type supergiants.

EP 9.10 Wed 17:30 HSZ GGI

Characterization of B supergiant variability — Suryani Guha, Michaela Kraus, and Julietta Arias Sánchez — Astronomical Institute, Czech Academy of Sciences, Ondrejov, Czech Republic — Charles University, Prague, Czech Republic

B-supergiants (BSGs) are famous for their spectroscopic variability that has been assigned to pulsations and related changes in their stellar wind properties. The pulsation modes of BSGs are strongly correlated to the stellar evolution phase. When a massive star has lost significant mass during its red-supergiant stage, it would return to the blue region in the Hertzsprung-Russell diagram and spend a part of the core-He burning stage as a BSG. In this particular phase it is critical to determine the pulsation modes and to relate it to different evolutionary phases of the star. The latter have been proposed to facilitate mass-loss. Our studies utilize data from the TESS Event Observer (TOO) satellite mission, which revealed that numerous BSGs display a rather irregular behaviour of their light curves, a likely indicator of radial/strange mode pulsations. The optical spectra obtained from our observation campaign with the PEREKS-2 m telescope are analyzed to search for variations in temperature and radius. Any detected variability can be directly linked with radial pulsations. Moreover changes in the strength and profile of the H-alpha line provide complementary information about wind variability. In this poster we will present highlights from a few interesting stars selected from our target list.

EP 9.11 Wed 17:30 HSZ GGI

Local HD flows at the Apex of an Astropause — Kuleet Singh Saddal and Dieter H Nickeler — Astronomical Institute AV CR Ondrejov, Frýcova 298, 25165 Ondrejov, Czech Republic — Charles University, Faculty of Mathematics and Physics, V Holečkovická 2, 180 00 Praha 8, Czech Republic

Astrospheres are the interaction regions between the stellar wind and the ambient interstellar medium, which consists of various HD (or MHD) discontinuities. Astropause is a contact discontinuity that separates the two flows, and its structure is described by one of the separatrices of the fluid flow. In 2D, there must be at least one X-type null point (X-point) close to the apex. This analysis aims to study hydrodynamically the geometric and topological structures of the HD in the vicinity of the X-point. As the core close to the apex can be considered incompressible, one can make use of stream functions to describe such flows. The definition of streamlines, along with the equations of ideal HD, gives a single, (non-)linear elliptic partial differential equation, known as the Grad-Shafranov equation (GSE). This equation is analyzed by approximating the stream function close to the null point as a series of polynomials of various orders, and assuming specific forms for the source term on the choice of the pressure function and the order at which the polynomial is truncated, either the original null point can become an X-point of higher order, or more null points can appear in its vicinity. Moreover, an isotropic pressure might not exist for every choice of stream functions, and hence adding an extra anisotropic term becomes important.

EP 9.12 Wed 17:30 HSZ GGI

The Liquid Metallic Hydrogen Model of the Sun — Alexander Unzicker — PestiLozi-Gymnasium München

Though the standard solar model based on a gaseous plasma dominates the scientific discourse, a considerable amount of experimental evidence may also be
interpreted assuming a real, liquid surface of the sun, as proposed by Robitaille (Progress in physics vol.3, 2011). Data from new missions must be open to such a different paradigm.

EP 9.13 Wed 17:30 HSZ OG1

Galactic cosmic rays are composed mainly of protons, helium nuclei and electrons. The flux of these particles is modulated due to the heliospheric magnetic field that shields lower energy particles from the heliosphere. Hence, the flux depends on the solar activity. During phases of low and high solar activity, a maximum and minimum in the flux is observed, respectively. The SOlar and Heliospheric Observatory (SOHO) was launched in 1995. The Electron Proton Helium INstrument (EPHIN) onboard SOHO monitors the telecentric detectors of a stack of 6 silicon semiconductor detectors surrounded by an anticoincidence detector. The instrument stops protons and helium nuclei up to energies of 51 MeV/nucleon. At higher energies, these particles penetrate the telescope. As shown previously EPHIN provides sufficient information to obtain the flux of protons up to an energy of about a GeV. Here we investigate the instrument capability to detect helium fluxes for energies above 51 MeV/nucleon using the de/dx-de/dx-method. However, the task is hampered by the fact that two detectors became noisy in 1998 and 2017, respectively. Thus, extensive modeling utilizing the GEANT4 package is needed in order to derive helium fluxes up to about 100 MeV/nucleon.

EP 9.14 Wed 17:30 HSZ OG1
Flux-rove nonequilibrium in the slow-rise phase of solar eruptions — Bernhard Kliem — Universität Potsdam, Institut für Physik und Astronomie

Solar eruptions are nearly always preceded by a slow rise-phase that comprises an ascent of the eventually erupting filament (or prominence) in the corona and a slow-outflow of magnetic field lines from the chromosphere and the photosphere. A strong magnetic field is characterized by intermediate velocities of typically several 10 km s$^{-1}$ (in active regions up to ~100 km s$^{-1}$), 1–2 orders of magnitude faster than the quasi-static evolution during energy storage, which scales with the driving photospheric velocities, and 1.5–3 orders of magnitude below the coronal Alfvén velocity, $V_A$, which is the scaling parameter of eruption speeds and their upper limit. Proposed mechanisms of this phase range from small-scale (“tether-cutting”) reconnection events in sheared field to a nonequilibrium and even ideal magnetohydrostatic instability of a flux rope. I present simulations of flux cancellation that show the formation of a flux rope, a quasi-static evolution with a rise speed similar to the imposed photospheric driver, then a slightly faster rise, gradually accelerating up to $\sim 10^4 V_A$, and eventually the eruption of the rope by onset of the toroidal instability. The flux rope is shown to be in a nonequilibrium state during the slow rise.

EP 9.15 Wed 17:30 HSZ OG1
Neutral Current Sheet Displacement in Reaction to the Radial Interplanetary Magnetic Field at Mercury: Statistical Results from MESSENGER Data — Daniel Heyner1, Kristin Pum2, David Herlick3, Willi Exner2, Yasuhiro Narita2, Ferdinand Plaschke1, Daniel Schmid3, Jim Slavin2, and Martin Volkwein2 — TU Braunschweig, Germany

Radial IMF at Mercury facilitates magnetopause reconnection in high latitudes which decreases the magnetic pressure in one of the magnetospheric lobes depending on the radial IMF polarity. This produces a north—south shift of the neutral sheet. We present statistical results from in-situ MESSENGER reconnection field data analysis on the IMF direction as well as the neutral sheet displacement. MESSENGER was a single probe in orbit around Mercury and it was blind to the IMF after having entered the bow shock. We need to estimate the current IMF radial polarity for the time with the probe inside the magnetosphere. We evaluate different interpolation methods with an adapted bootstrap analysis method on solar wind data at Mercury. The analysis is based on its neutral sheet displacement compared to hybrid simulations done in the past.

EP 9.16 Wed 17:30 HSZ OG1
Concepts for the measurement of permittivity profiles in extraterrestrial cryospheres to improve subsurface radar images — Enrica Luca Rocciarella, Fabian Becker, Alexander Kyriacou, and Klaus Hilbring — Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal

Icy moons like Europa and Enceladus may contain microbial life in their subsurface oceans. Surface and subsurface imaging with radar is a promising technique to investigate their interior and identify a target for a subsurface exploration with melting probes. The main uncertainty of radar images is the unknown permittivity (ε) of the medium through which the electromagnetic waves travel. Therefore, we developed two methods to measure the ε from the medium of interest. Both methods were successfully tested on alpine glaciers as comparable terrestrial environments and the results will be presented. The initiatives involved are the DLR-funded projects ENEX and TRPLD.

The first method is a cross-borehole FM CW radar: by sending signals between two antennas, it is possible to use the time of flight for permittivity reconstruction. An inversion of radio propagation simulations is used to reconstruct the permittivity profile from time of flight measurements at different depths. The second approach is to use a permittivity sensor, which is placed in a melting probe with an integrated radar system. This sensor can measure in the near field of the melting probe and immediately corrects the radar image. It represents a part of the field of view system being developed for melting probes.

EP 9.17 Wed 17:30 HSZ OG1
About the Radiative Transfer (RT) and inversion codes used in the characterization of planetary atmospheres — Rengel Miriam Knackstedt1,2, Michael Strerz1 and Maximilian Emde2 — Max-Planck-Institut für Sonnensystemforschung, Göttingen

This contribution represents a tour on Radiative Transfer (RT) and inversion codes used in the planetary and exoplanetary communities from the perspective of a user. Such codes predict and interpret spectra of planetary atmospheres (hydrostatic equilibrium atmospheres and expanding comas) and infer atmospheric properties like temperature and abundance profiles (forward modelling and inversion algorithm, respectively). The retrieved atmospheric properties can offer crucial information into the atmospheric physico-chemical processes of planets and their formation mechanisms.

Here we present a mini over-view of some existing forward and inversion codes used in the planetary science and some examples of applications. Space and ground-based telescope facilities used in the field (feasibility studies, observational planning, etc.) depend on the quality and extent of these codes.

EP 9.18 Wed 17:30 HSZ OG1
Retrieval of planetary albedo and cloud’s properties of Earth with spectropolarimetry — Giulia Rocciellita1,2, Michael Sterzik1, Claudia Emde2, and Mihail Manev2 — European Southern Observatory, Garching bei München, Germany

To prepare the search for life outside our Solar System, we must characterise Earth as an exoplanet. In this work we present a novel approach to retrieve planetary albedo and cloud’s properties (mean water cloud optical depth and cloud cover) of Earth with spectropolarimetry. Incoming (unpolarized) stellar light is polarised by molecular or particle scattering in the Earth’s atmosphere or from reflection at the planetary surface. The polarization phase curve, and its spectral dependencies, allow to constrain many atmospheric and surface properties of the planet.

We show that planetary albedo can be retrieved analyzing the slope of the polarization spectra, while for the cloud’s properties we use a two-tier approach: we first determine the mean optical depth using the cloudbow feature at small phase angles (for a wavelength in the near-infrared range), and then we estimate the cloud cover using the maximum of the phase curve (for a wavelength in the B Band).

The results are compared with Earthshine observations, i.e. sunlight scattered by the dayside Earth and reflected back to Earth from the darker portion of the visible moon, which allows to observe the Earth as an exoplanet at different phase angles, as the relative Sun–Earth–Moon viewing geometry changes.

EP 9.19 Wed 17:30 HSZ OG1
Empirical modelling of SSUSI-derived auroral ionization rates — Stefan Bender1,2,3 and Gary Paletou4,5 — Norwegian University of Science and Technology, Trondheim, Norway

Auroral kingdoms lie ionization and affecting its chemistry. Climate models usually parameterize this ionization and the related changes in chemistry based on satellite particle measurements. The problem is the lack of well-observed data which can be derived from the POES and GOES satellite measurements which provide in-situ electron and particle data.

Here we use the electron energy and flux data products from the Special Sensor Ultraviolet Spectrographic Imager (SSUSI) instruments on board the Defense Meteorological Satellite Program (DMSP) satellites. The currently operating satellites directly observe the auroral emissions in the UV on a ~3000 km wide swath with a ~10 km pixel resolution. From the UV emissions electron energies and fluxes are inferred in the range from 2 keV to 20 keV. We use these observed electron energies and fluxes to calculate auroral ionization rates in the lower thermosphere (90–150 km). We present an empirical model of these ionization rates according to magnetic local time and geomagnetic latitude. The model is particularly targeted for use in climate models that include the upper atmosphere, such as WACCM-X or ECHAM. We also present a comparison to current implementations for ionization rates used in these two models.
EP 10: Astrophysics: Cosmic Rays and Galaxies I

Time: Thursday 11:00–13:00

Invited Talk EP 10.1 Thu 11:00 ZEU/0160
Arne-Richter Lecture: From nonthermal plasma astrophysics to modeling of pandemic outbreaks — REINHARD SCHILKIESE — Institut für Theoretische Physik, Lehrstuhl IV: Weltraum- und Astrophysik, Ruhr-Universität Bochum, D-44780 Bochum, Germany — Institut für Theoretische Physik und Astrophysik, Christian-Albrechts-Universität zu Kiel, Leibnizstr. 15, D-24118 Kiel, Germany

During the last 45 years of my career I almost exclusively did research on topics of nonthermal astrophysics including gamma-ray astronomy, radio astronomy, cosmic ray transport and acceleration in partially turbulent electromagnetic fields, astroparticle physics, kinetic theory of fluctuations in collision-poor plasmas and cosmological magnetogenesis. I had the privilege to meet and interact with a number of splendid and marvelous scientists including Arne Richter. In the talk I will cover important milestones of my career and summarize my positive experiences with fellow scientists.

Modelling magnetic turbulence with log-normal intermittency by continuous cascades — JEREMIAH LÜKBE1, FREDERIC EFFEKENBERGER2, HORST FICHTE1, and RAINER GRAUER1 — 1 Institute for Theoretical Physics I, Ruhr-University Bochum, Universitätsstraße 150, 44801 Bochum — 2 Institute for Theoretical Physics IV, Ruhr-University Bochum, Universitätsstraße 150, 44801 Bochum

The transport of cosmic rays in turbulent magnetic fields is commonly investigated by solving the Newton-Lorentz equation of test particles in synthetic turbulence fields. These fields are typically generated from superpositions of Fourier modes with prescribed power spectrum and uncorrelated random phases, bringing the advantage of covering a wide range of turbulence scales at manageable computational effort. However, almost all of these models to date only account for second-order Gaussian statistics and thus fail to include intermittent features. Recent observations of the solar wind suggest that astrophysical magnetic fields are strongly non-Gaussian, and the question of how such higher-order statistics impact cosmic ray transport has only received limited attention. To address this, we present an algorithm for generating synthetic turbulence based on Kolmogorov’s log-normal model of intermittency. It generates a divergence-free magnetic field by computing the curl of a vector potential, which in turn is obtained from an inverse wavelet transform of a continuous log-normal cascade process. We investigate the statistics of the generated fields, show that anomalous scaling properties are accurately reproduced and discuss implications on cosmic ray transport. ∗ Supported by DFG (SFB 1491)

From test particle simulations to cosmic-ray transport — MARCO KÜHLEN, HONG MINH PHAN, and PHILIPP MERTSCH — TTK, RWTH Aachen University, Aachen, Germany

The transport of high-energy particles in the presence of small-scale, turbulent magnetic fields is a long-standing issue in astrophysics. Analytical theories disagree with numerical simulations at rigidities where the particles’ gyroradii are slightly smaller than the correlation length of turbulence. At the same time, extending the numerical simulations to lower rigidities has proven computationally prohibitive. In this talk, we will discuss a solution to the problem of perpendicular transport in isotropic turbulence at both, high and low rigidities. Our study has important implications for the transport of Galactic cosmic rays, acceleration at perpendicular shocks and for high-energy particles in the heliosphere.

Particle acceleration capability of a black hole at the Galactic centre — ARMAN TURSUNOV — Institute of Physics, Silesian University in Opava, Czech Republic — Max Planck Institute for Radio Astronomy, Bonn, Germany

A compact supermassive source Sagittarius A* located at the centre of our Galaxy has been observed at different wavelengths across the electromagnetic spectrum. It is the closest and largest in projection supermassive black hole candidate. At the same time, its particle acceleration capability related to the cosmic ray and neutrino messengers were not yet experimentally probed despite indirect indications of the existence of a PeVatron at the Galactic centre. In this talk, I will present a novel scenario of particle acceleration at the Galactic centre involving electromagnetic extraction of rotational energy from the central black hole. I will show that the maximum energy of accelerated protons may reach a few PeV at the source, contributing thus to the knee of the observed cosmic ray spectrum.

Multi-wavelength modelling of FR0 galaxies — THEERSE PAULSEN1 and FOTEINI OIKONOMOUI2 — 1 Bergische Universität Wuppertal, Gaulstraße 20, 42119 Wuppertal, Germany — Norwegian University of Science and Technology, Høgskolen i 5, NO-7491 Trondheim, Norway

In the last decade, high-sensitivity radio and optical surveys have unveiled a new class of radio galaxies, called the Fanaroff-Riley type 0 (FR0). Due to their abundance in the local universe, this source class is of particular interest in the context of multi-messenger analyses as a possible neutrino emitter. The properties of FR0s at γ-ray energies are still largely unexplored due to the lack of observational data. However, observations have been made for the galaxies LEDA 55257, LEDA 57137, and LEDA 58287.

The multi-wavelength emission of these galaxies was modeled to determine the physical conditions under which the observed radiation is generated. The synchrotron, synchroton self-Compton and the external Compton processes were considered. As a first result, we find that all the sources are consistent with being powered by the synchrotron self-Compton mechanism.

Bayesian Inference of the 3D Galactic HI-Gas Density — LAURIN SÖDING, PHILIPP MERTSCH, and HO VONG MINH PHAN — Institute for Theoretical Particle Physics and Cosmology, RWTH Aachen University, Aachen, Germany

While other galaxies can be observed with various techniques in great detail and precision, the structure of our own galaxy is mostly obscured from view due to our vantage point. Creating a 3D map of e.g. HI gas density or magnetic fields is therefore a challenging task. We have used the 21-cm emission line from atomic hydrogen - together with a velocity model - to reconstruct a 3D-map of the galactic distribution of HI gas using new Bayesian inference techniques. While the first results look very promising, we have characterised systematic uncertainties of the method due to, e.g. the choice of velocity model. In the future, we will strive to determine velocity fields and gas densities in a common inference machinery to obtain the best maps of the Galaxy yet.
Good timing — David Wenzel — Deutsches Zentrum für Luft- und Raumfahrt, Institut für Solar-Terrestrische Physik, Neustrelitz

Several quantities observable on Earth follow day or year trends due to a significant impact of Sunlight. The DLR Neustrelitz is for instance monitoring radio signals for reconstructing ionospheric properties in order to gain a deeper insight into the general coupling processes as well as developing warning systems for protecting technological systems from harm or malfunctioning by sudden disturbances like solar flares. The GIFDS (Global Ionospheric Flare Detection System) network of VLF receivers aims at issuing immediate alerts when possibly harmful flare events occur. The continuously available VLF signals are heavily influenced by these. However, the measurement characteristics lie in a complex space-time and daytime variation, which has to be taken into account in designing warning algorithms. On the other side, the long-term observations moreover unveil annual characteristics. There is a sharp decrease of signal amplitudes during fall that is not symmetric to the increase in spring. This “October effect” is investigated in the project AMELIE. Grasping the year trends here will improve our view on the physics behind. Giving measurements an analytic representation is of interest for many reasons, but can turn out to be complicated. We will demonstrate that by adjusting the time scale in certain natural manner, modelling becomes easier with respect to appropriate ansatz functions and more accessible to relevant properties.

Invited Talk

EP 12.1 Thursday 15:45 ZEU/0160

Ultra-relativistic Electrons in the Earth’s Van Allen Radiation Belts — Yuki Y. Shprits1,2,3, Hatley Allison4, Nikita Asgeiv1, Dedong Wang1, and Alexander Drozdov1,2 — 1Department of Geophysics, German Research Centre for Geosciences, Potsdam, Germany — 2University of Potsdam, Potsdam, Germany — 3Institute of Physics and Astronomy, University of Potsdam, Germany — 4Department of Earth, Planetary, and Space Sciences, UCLA

New measurements from the NASAs Van Allen Probes demonstrate that the Earth radiation belts cannot be considered as a bulk population above approximally electron rest mass, but ultra-relativistic electrons form a new population that shows a very different morphology and behavior. We show that acceleration to multi-MeV occurs locally due to energy diffusion by whistler mode waves. Local heating appears to be able to transport electrons in energy space from 100s of keV all the way to ultra-relativistic energies. Acceleration to such high energies occurs only for the conditions when cold plasma in the trough region shows extreme depletions. The difference between the loss mechanisms at MeV and multi-MeV energies is due to EMIC waves that can very efficiently scatter ultra-relativistic electrons but leave MeV electrons unaffected. We also present how the
new understanding can be used to produce the most accurate data-assimilative forecast. Under the recently funded EU Horizon 2020 Project Prediction of Adverse effects of Geomagnetic storms and Energetic Radiation (PAGER), we will study how ensemble forecasting from the Sun can produce long-term probabilistic forecasts of the radiation environment.

**EP 12.2** Thu 16:15 ZEU/0160

Magnetospheric formation processes of the diffuse aura: Sensitivity of wave-induced electron scattering to the hot electron distribution — **Katia Stoll**, **Leonie Pick**, **Dedong Wang**, and **Yuri Shprits** — **DLR Institute for Solar-Terrestrial Physics, Neustrelitz, Germany** — **University of Potsdam, Potsdam, Germany** — **GFZ Potsdam, Potsdam, Germany** — **University of California, Los Angeles, CA, USA**

Resonant wave-particle interactions in the Earth's magnetosphere can lead to the scattering of plasma sheet electrons which in turn cause the optical phenomenon of diffuse aura. Specifically, electrostatic electron cyclotron harmonic (ECH) waves can effectively precipitate hundreds of eV to tens of keV electrons into the upper atmosphere. This process can generally be treated as a diffusion problem, requiring the numerical calculation of bounce-averaged quasi-linear diffusion coefficients.

ECH waves are thought to be generated by the loss cone instability of the ambient hot electron distribution. Therefore, the determination of ECH wave-induced scattering rates requires information about the properties of the hot plasma sheet electrons responsible for the wave excitation. We report our progress on analysing the sensitivity of ECH wave-induced electron scattering effects to the temperature of the hot electron components, which has an influence on the growth rate of the waves.

**EP 12.3** Thu 16:30 ZEU/0160

Measurements of cosmic rays by a mini neutron monitor aboard the German research vessel Polarsantern. — **Bernd Heber**, **Sonke Burmeister**, **Hanna Giese**, **Konstantin Herbst**, **Lisa Romaneehesen**, **Carolin Schwert**, **Dutoit Strauss**, and **Michael Walter** — **Christian-Albrechts-Universität Kiel, D** — **Deutsches Elektronen-Synchrotron DESY in Zeuthen, D** — **Center for Space Research, NWU Potchefstroom, SA**

Neutron monitors are ground-based devices that measure the secondary particle population, i.e., neutrons produced by, e.g., galactic cosmic rays (GCRs). Due to their functionality, they are integral counters whose flux is proportional to the variation of the input spectrum. However, the measured flux also depends on the geomagnetic position and the pressure at the monitor's location. To better understand the NM response regular monitoring of the GCR intensity as a function of latitude is needed. Therefore a portable NM was installed aboard the German research vessel Polarsantern in 2012. The vessel is ideally suited for this research campaign because it covers extensive geomagnetic latitudes (i.e., goes from the Arctic to the Antarctic) at least once per year. Since the installation aboard the vessel, 12 latitude scans were performed, allowing us to compute the so-called yield function by experimental means presented in this contribution.

The Kiel team received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 870405. The team would like to thank the crew of the Polarstern and the AWI for supporting our research campaign.

**EP 12.4** Thu 16:45 ZEU/0160

Yield function of the DOSimetry TEloscope (DOSTEL) count and dose rates aboard an aircraft — **Lisa Romaneehesen**, **Hanna Giese**, **Bernd Heber**, **Konstantin Herbst**, and **Sonke Burmeister** — **Christian-Albrechts-Universität Kiel**

The Earth is continuously exposed to galactic cosmic rays. The magnetized solar wind in the heliosphere and the Earth’s magnetic field alters the flux of these particles. If cosmic rays hit the atmosphere, they can form secondary particles. The total flux measured within the atmosphere depends on the atmospheric density above the observer. Therefore, the ability of a particle to approach an aircraft depends on its energy, the altitude, and the position of the plane. The cutoff rigidity is, therefore, a decisive factor for the latter.

The radiation detector of the detector system NAVIDOS (NAVigation DOSimetry) is the DOSTEL Telescope (DOSTEL), measuring the count and dose rates in two semiconductor detectors. From 2008 to 2011, two instruments were installed in two aircraft. First, we corrected the data for pressure variation by normalizing them to one flight level and determined their dependence on the cutoff rigidity by fitting a Dorman function to the observation. The latter was used to compute the yield function, which describes the ratio of incoming primary cosmic rays, approximated by a force field solution, to the measured count and dose rate for a particular instrument.

We received funding from the European Union’s Horizon 2020 research and innovation program under grant agreement No 870405.

**EP 12.5** Thu 17:00 ZEU/0160

Development of a plasmapause model derived from Van-Allen-Probe data and IMAGE RPI data via automatic detection — **Daniela Banyi**, **Joachim F. Welti**, **Norbert Jarkowski**, **Mainul Hoque**, **Reni Zanderberg**, and **Werner Enderle** — **Institute for Solar-Terrestrial Physics, DLR, Germany** — **Telespazio-VEGA Deutschland GmbH c/o European Space Operations Centre, Germany** — **European Space Operations Centre, Germany** — **European Space Operations Centre, Germany** — **European Space Operations Centre, Germany**

The outer boundary of the plasmasphere, the plasmapause, is characterised by a sharp electron density gradient which changes under varying space weather conditions. With NEPPM (Neustrelitz ESOC Plasmapause Model), we introduce a new model of the plasmapause location Lpp based on electron density measurements made by the Van Allen probes from 2012 to 2016 and the IMAGE satellite from 2000 to 2005 that were automatically processed, yielding an improved performance for plasmapause detection. Applying a dipole based transformation of measurements, NEPPM is described by a simple elliptical approach in the equatorial plane determined by the semi-major axis, the eccentricity, and the orientation angle. The Lpp varies as a function ofDst index and magnetic local time (MLT), resulting in a tighter fit compared to the GCPM (Global Core Plasma Model). The distinctive bulge in the evening hours follows the level of solar activity. By extending the ellipse fitting from the equatorial plane to a 3D approach, the NEPPM also allows non-dipole B vectors, providing 3D positions on the plasmapause torus for given latitude, longitude, epoch and Dst.

**EP 13.1** Thu 17:30 ZEU/0160

**ExHaLe-jet:** Modeling blazar jets with an extended hadro-leptonic radiation code — **Michael Zacharias** — **Lund University**

Blazars emit across all electromagnetic wavelengths. While the so-called one-zone model has described well both quiescent and flaring states, it cannot explain the radio emission and fails in more complex data sets, such as AP Librae. In order to self-consistently describe the entire electromagnetic spectrum emitted by the jet, extended radiation models are necessary. Notably, kinetic descriptions of extended jets can provide the temporal and spatial evolution of the particle species and the full electromagnetic output. Here, we present the initial results of a newly developed hadro-leptonic extended-jet code: ExHaLe-jet. As protons take much longer than electrons to lose their energy, they can transport energy over much larger distances than electrons and are therefore essential for the energy transport in the jet. Furthermore, protons induce injection of additional pairs through pion and Bethe-Heitler pair production, which can explain a dominant leptonic radiation signal while still producing neutrinos. In this talk, we discuss the differences between leptonic and hadronic dominated SED solutions, the SED shapes, evolution along the jet flow, and jet powers. We also highlight the important role of external photon fields, such as the accretion disk and the BLR.
Identifying the sources of extragalactic neutrinos is one of the foremost challenges in the astrophysics field. Amongst the most promising candidate sources that can be associated there are blazars, active galactic nuclei hosting a relativistic jet pointed towards us. In this work, we provide evidence for an association between high-energy (>100 TeV) IceCube neutrinos and a well-defined, sample of blazars (5th Roma BZCat catalog) in the Southern celestial Hemisphere. This results in a probability to find such correlation by chance that is as low as 2 x 10⁻⁶.

EP 13.5 Thu 18:45 ZEU/0160
Investigating the blazar-neutrino connection with public IceCube data —
• JULIAN KUHLMANN and FRANCESCA CAPEL — Max-Planck-Institut für Physik

The IceCube collaboration has found evidence for two active galactic nuclei, NGC 1068 and TXS0506+056, being sources of high energy neutrinos. However, catalog-based searches have yet to yield conclusive evidence for the role of different source populations in contributing to the observed astrophysical neutrino flux.

We present two open-source statistical analysis frameworks for the investigation of possible sources with publicly available IceCube data, which implement complementary frequentist and Bayesian approaches. We first demonstrate the capabilities of these frameworks on simulated data, and then apply them to investigate blazars as possible neutrino sources. We focus on bringing more information from multi-wavelength studies into the analyses, and studying both individual sources and the population as a whole. We discuss the advantages of the novel Bayesian approach and the implications of our results for the blazar-neutrino connection.
An exact analytical solution for the weakly magnetized flow around an axially symmetric paraboloid, with application to magnetosphere models — •JENS KLEIMANN1 and CHRISTIAN RÖKEM2 — 1Theoretische Physik IV, Ruhr-Universität Bochum, Germany — 2Department of Geometry and Topology, Faculty of Science, University of Granada, Spain

Presented in this work is the discovery of the magnetic field strength of the K dwarf star, HAT-P-11, which we measured in polarized light of the Stokes parameter V. The magnetic field was discovered to be 2.73 G. Our methodology can be applied to future polarimetric analyses of magnetically active stars via Stokes V polarimetry. Usage of echelle spectrographs with high spectral resolution allows for the determination of magnetic fields of stars and other celestial objects. We present the results of the discovery in this work and discuss the implications of our findings for future polarimetric analyses of magnetically active stars via Stokes V polarimetry.
The search for new physics at the sub-eV scale has been particularly active in the last years. Our principal aim is the detection of the QCD axion although our design is applicable to other axion-like particles (ALPs). We introduce a new table-top experiment to detect photon-axion conversion: WISP Searches on a Fiber Interferometer (WISPFI).

The experimental setup consists of a partial free-space Mach-Zehnder-type interferometer. In one of the arms, the fiber is coiled and placed inside the bore of a superconducting solenoid magnet (14 T, 140 mm diameter warm bore), where mixing occurs. The photon-axion oscillations would be detected by measuring changes in phase/amplitude.

For the detection at resonant mixing, we will use hollow-core photonic crystal fibers (HC-PCF), taking advantage of their unique guiding and optical properties. In particular, a large axion mass range (10 meV–100 meV) is achievable by regulating the air pressure inside the core of the HC-PCF. The effect of the core radius, wavelength and bending in the mode propagation is also discussed. Finally, implementations of squeezed light, higher-power laser or the application of an external electric field can improve the sensitivity even further.

High energy gamma-rays propagating in external magnetic fields may convert into axion-like particles (ALPs). We use the energy spectra of 20 extra-galactic gamma-ray sources recorded during 10 years of Fermi-LAT observations. We define a test statistics based upon the likelihood ratio to test the hypothesis for a spectral model without vs. a model with photon-ALPs coupling. The conversion probability is calculated for fixed values of the mass and two-photon coupling of the pseudoscalar particle while the external magnetic field is characterized by the additional free parameters length scale l and average field strength B. We find for 20 of the 20 sources a favorable fit. The test statistics of the sources are combined and estimated to correspond to a significance of 2.7 sigma (test statistics summed in local maxima of all sources) and 4.9 sigma (global maxima). The locally best-fitting values of l and B fall into the range that is expected for large scale magnetic fields present in the intra-cluster medium of galaxy clusters and in large scale filaments.
Overview of Invited Talks and Sessions
(Lecture halls ZEU/0260, ZEU/0255, and HSZ/0401)

Plenary Talk of the Gravitation and Relativity Division

PV XVII Fri 9:00–9:45 HSZ/AUDI The Einstein Telescope — Harald Lück

Invited Talks

GR 3.1 Tue 11:00–11:45 HSZ/0401 Scalaron-Higgs inflation — Christian Steinwachs
GR 6.1 Wed 11:00–11:45 ZEU/0260 Geodesic motion in relativistic astrophysics — Eva Hackmann
GR 6.2 Wed 11:45–12:30 ZEU/0260 Modelling the multi-messenger signals of gravitational wave sources — Stephan Rosswog
GR 11.1 Thu 11:00–11:45 ZEU/0260 From quarks to black holes: micro- and macrophysics of neutron star mergers — Andreas Bauswein
GR 11.2 Thu 11:45–12:30 ZEU/0260 Tracing beyond GR physics with gravitational waves — Daniela Doneva

Sessions

GR 1.1–1.5 Mon 16:30–18:10 ZEU/0260 Black Holes
GR 2.1–2.6 Mon 16:30–18:30 ZEU/0255 Cosmology I
GR 3.1–3.3 Tue 16:00–17:00 HSZ/0401 Cosmology II
GR 4.1–4.4 Tue 17:00–18:20 ZEU/0260 Quantum Gravity
GR 5.1–5.3 Tue 17:00–18:00 ZEU/0255 Classical Relativity
GR 6.1–6.2 Wed 11:00–12:30 ZEU/0260 Relativistic Astrophysics
GR 7.1–7.4 Wed 11:00–12:30 ZEU/0260 Gravitational Waves I
GR 8.1–8.4 Wed 11:00–12:30 ZEU/0260 Foundations and Alternatives I
GR 9.1–9.6 Wed 11:00–12:30 ZEU/0260 Gravitational Waves and Astrophysics I
GR 10.1–10.5 Wed 11:00–12:30 ZEU/0255 Foundations and Alternatives II
GR 11.1–11.2 Thu 11:00–12:30 ZEU/0260 Gravitational Waves and Astrophysics II
GR 12.1–12.4 Thu 11:00–12:30 ZEU/0260 Relativistic Astrophysics and Scalar Fields
GR 13.1–13.4 Thu 11:00–12:30 ZEU/0260 Relativity and Data Analysis
GR 14.1–14.5 Thu 11:00–12:30 ZEU/0255 Gravitational Waves II
GR 15 Thu 16:00–17:40 ZEU/0260 Members’ Assembly
GR 16.1–16.5 Fri 11:00–12:40 HSZ/0401 Experimental Tests

Members’ Assembly of the Gravitation and Relativity Division

Thursday 18:30–20:00 ZEU/0260

- Bericht
- Wahl
- Verschiedenes
GR 1.1 Mon 16:30 ZEU/0260
Light propagation in a plasma on an axially symmetric and stationary spacetime: Separability of the Hamilton-Jacobi equation and shadow — BARBORA BEZDĚKOVÁ, VOLKER PERLICK, and JÍRÍ BÍČÁK — KIPAC, Stanford University, Stanford, CA 94305, USA — 2ZARM, University of Bremen, Germany — 3Institute of Physics, Charles University, Prague, Czech Republic

We study the effects of a non-magnetised, pressure-less plasma on light rays under the assumption of stationarity and axial symmetry. The necessary and sufficient conditions on the metric and on the plasma frequency are formulated, such that the rays can be analytically determined from a fully separated Hamilton-Jacobi equation. We demonstrate how these results allow to analytically calculate the photon region and the shadow, if they exist. As a special example, a rotating wormhole is considered. — For more details see J. Math. Phys. 63, 092501 (2022).

GR 1.2 Mon 16:50 ZEU/0260
Black holes at the Planck scale — PIERO NICOLINI — Università di Triest, Triest, Italy — FIAS, Frankfurt am Main, Deutschland — Johann Wolfgang Goethe-Universität Frankfurt am Main, Frankfurt am Main, Deutschland

Despite the difficulty in formulating a quantum theory of gravity, the good news is that the existing quantum gravity proposals seem to converge towards a unique scenario for the physics of black holes. In this talk, I will present an overview about the phenomenology of Planckian black holes and the possibility of detecting some effects in present and near future experiments. As a conclusion, I will comment about some of the existing open questions and future directions of investigation.

GR 1.3 Mon 17:10 ZEU/0260
Formulation Improvements for Critical Collapse Simulations — DANIELA CORSA, SARAH RENKHOFF, HANES RUTER, DAVID HILDITCH, and BERNHARD PFEIFFER — 1Department of Theoretical and Computational Physics, Friedrich-Schiller-Universität Jena — 2CfisUC, Department of Physics, University of Coimbra — 3CENTRA, Instituto Superior Técnico, University of Lisbon

We use our adapted pseudospectral code bamps, with its new hp adaptive refinement, to tune close to the barrier between gravitational collapse and dispersed fields, in order to study the critical phenomena that emerges near that threshold. To achieve that goal and improve our previous results, we introduce adjustments to the generalised harmonic gauge formulation of General Relativity adapting it to the specific case of near collapse simulations. In particular, we adj just the constraint violations damping scheme, taking into account the collapse of the lapse that occurs in extreme spacetimes. We also prevent coordinate singularities by carefully choosing the gauge source function for collapsing spacetimes. As a result of these changes, we manage to improve our threshold estimation results. In spherical symmetry, we show critical phenomena of a massless scalar field minimally coupled to the Einstein field equations. In axisymmetry, we study gravitational waves in vacuum, revisiting our previous results.

GR 1.4 Mon 17:30 ZEU/0260
Wave optical image formation of exact scalar wave scattering in Kerr-de Sitter spacetime — FELIX WILLENBORG, DENNIS PHILLIP, and CLAUS LÄMMERZahl — 1Zentrum für angewandte Raumfahrt und Mikrogravitation (ZARM), University of Bremen, 28359 Bremen, Germany — 2Gauss-Olbers Center, ZARM, University of Bremen, 28359 Bremen, Germany

Linear perturbations of black holes have been discussed widely in many contexts. Of interest are properties such as differential cross-sections, quasi-normal modes, scattering or the interference. A useful tool in this respect is the Newman-Penrose formalism and the resulting Teukolsky equations, giving separated angular and radial differential equations. These were mostly evaluated by numerical means. However, the introduction of a cosmological constant allows the problem to be solved in an exact analytical manner by transforming the differential equations into the Heun differential equation, the most general second-order differential equation with four regular singularities.

We show for the Kerr-de Sitter spacetime that scattering of waves from a point source needs an additional discussion around the so-called Heuns function, which enables a then possible normalization of the angular solution, similarly to the case of spherical harmonics. We assume in the discussion and analysis a scalar source star of fixed frequency and solve the scattering problem by a partial wave sum. The observed wave optical image formation by means of Kirchhoff-Fresnel diffraction and the resulting shadow will be compared to the geodesic black hole shadow.

GR 1.5 Mon 17:50 ZEU/0260
Gravitational Lensing of Massive Particles in the NUT Spacetime — TORBEN FROST — ZARM, University of Bremen, Bremen, Germany

Gravitational lensing of light is already a well-investigated question. Gravitational lensing of massive particles on the other hand did not receive much attention so far. This has mainly two reasons. First, appropriate particles, currently only neutrinos, are rare, hard to detect and their emission events short-lived. Second, particle detectors capable of detecting them only have a low angular resolution. However, considered in the framework of a multimessenger approach gravitational lensing of massive particles may provide us with supplementary information to gain a better understanding about their source and the lens. Therefore, in this talk we will discuss the potential of gravitational lensing of massive particles using the example of a NUT black hole acting as lens. We will first discuss and solve the equations of motion for timelike geodesics using elementary as well as elliptic functions and integrals. Then we will introduce latitude-longitude coordinates on the celestial sphere of an observer in the domain of outer communication and relate them to the constants of motion. Finally, we will derive the angular radius of the particle shadow, write down a lens equation, and calculate the travel time of the particles. We will also discuss differences with respect to lightlike geodesics.
I will discuss a recent proposal by Brunetti et al. to construct gauge-invariant relational observables in gravity in the context of cosmological perturbation theory. I will report on new results showing how their method can be used to produce invariant observables adapted to measurements along the observer’s past lightcone. These observables aim to model the experimental situation in cosmology, where virtually all experimental data is gathered via light-like signals. The lightcone observables are constructed using a field-dependent coordinate system, which I will take to be geodesic lightcone coordinates. As a concrete application, I will present a new computation of the correlator of an observable measuring the redshift produced by quantum-gravitational fluctuations on the de Sitter spacetime.

GR 2.4 Mon 17:30 ZEU/0255
Cosmological backgrounds and their perturbations in teleparallel gravity
• MANUEL HOSMANN — University of Tartu, Estonia

Within the framework of teleparallel gravity, a flat affine connection is used as a dynamical field in addition to the metric tensor. This general teleparallel connection may further be restricted by imposing either vanishing torsion, giving rise to symmetric teleparallel gravity, or vanishing nonmetricity, which then leads to metric teleparallel gravity. In the field of cosmology, a homogeneous and isotropic connection must be chosen alongside the homogeneous and isotropic metric. This presentation gives a complete classification of all homogeneous and isotropic teleparallel geometries (general, metric and symmetric), as well as their perturbations. For the latter, gauge transformations and gauge invariant quantities are presented.

GR 2.5 Mon 17:50 ZEU/0255
Torsional dark energy in quadratic gauge gravity
• ARMIN VAN DE VENN1, DAVID VÁSAK2, JOHANNES KIRCH2, and JÜRGEN STRUCKMEER2

1Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany 2Frankfurt Institute for Advanced Studies, Frankfurt am Main, Germany

The Covariant Canonical Gauge theory of Gravity (CCGG) is a gauge field formulation of gravity which a priori includes non-metricity and torsion. It extends the Lagrangian of Einstein’s theory of general relativity by terms at least quadratic in the teleparallel–Cartan–Weyl–Schouten connection. The work strengthens the nonmetricity and torsion in an usually compatible CCGG on cosmological scales. For a totally anti-symmetric torsion tensor we derive the resulting equations of motion in a Friedman-Lemaître-Robertson-Walker (FLRW) Universe. In the limit of a vanishing quadratic Riemann–Cartan term, the arising modifications of the Friedmann equations are shown to be equivalent to spatial curvature. Furthermore, the modified Friedmann equations are investigated in detail in the early and late times of the Universe’s history. It is demonstrated that in addition to the standard ΛCDM behaviour of the scale factor, there exist novel time dependencies, emerging due to the presence of torsion and the quadratic Riemann–Cartan term. Finally, at late times, we present how the accelerated expansion of the Universe can be understood as a geometric effect of spacetime through torsion.

GR 2.6 Mon 18:10 ZEU/0255
Consistent solution of Einstein–Cartan equations with torsion outside matter
• KLAUS MOLAWETZ — Münster University of Applied Sciences, Stegerwald-strasse 39, 48563 Steinfurt, Germany
• INSTITUT FÜR PHYSIK, UNIVERSITÄT FREIBURG, FREIBURG IN Bruchsal, Germany

The Einstein–Cartan equations in first-order action of torsion are considered. Inside matter the torsion is given by the spin which leads to an extended Oppenheimer-Volkov equation. Outside matter a second solution is found besides the torsion-free Schwarzschild one with the torsion completely determined by the metric and vice versa. This solution is shown to be of non-spherical origin and its uniqueness with respect to the metric torsion. Further properties are discussed in different coordinate systems where the cosmological constant assumes the role of the Friedman parameter in Friedman-Lamaitre-Robertson-Walker cosmologies. Parameters are specified where wormholes are possible. Possible consequences on cosmological scenarios are discussed. [Class. Quantum Grav. 38 (2021) 205003]
A Rigorous Neutrino Oscillation Formula in Curved Spacetime — Dominik Hellmann — TU Dortmund, 44227 Dortmund, Germany

In the light of upcoming experiments searching to detect neutrino signals from astrophysical sources, the question for a rigorously derived neutrino oscillation formula in curved spacetime from first principles seems to be well motivated. Based on the theoretical foundations of quantum field theory in curved spacetime (cQFT), we generalize the well known external wave packet approach to neutrino oscillations from flat to curved spacetime.

In this framework, external particles are represented by wave packets, while the neutrino is described by its Feynman propagator and PMNS matrix elements. In addition to that, we incorporate non-trivial cQFT effects like the non-uniqueness of the vacuum and how these modify the oscillation behavior. Finally, we derive the conditions under which a neutrino oscillation probability is well defined and show how it is calculated from cQFT amplitudes.

Proton Stability and Quantum Gravity: Towards an asymptotically safe perspective — Astrid Eichhorn and Shouryya Ray — CP3 Origins, Institut für Physik, Kemi og Farmaci, Syddansk Universitet, Campusvej 35, 5230 Odense M, Denmark

The observed long lifetime ($> 10^{25}$ y) of the proton can pose serious constraints on UV completions of the Standard Model. In those that include quantum gravity, fluctuations of the spacetime metric are often argued to break all effective global symmetries; baryon number conservation, which prevents proton decay, being one of them. Here, I shall present our computations concerning the proton lifetime within asymptotically safe quantum gravity. Time permitting, I shall speculate on how asymptotically safe metric fluctuations may in fact reconcile a significantly reduced quantum gravity scale with proton stability, and thereby possibly also stabilize the proton in certain GUT scenarios afflicted by excessive proton decay.

Asymptotically nonlocal gravity — Jens Boos and Christopher D Carone — William & Mary, Williamsburg, VA, USA

Asymptotically nonlocal field theories interpolate between Lee-Wick theories with multiple propagator poles, and ghost-free nonlocal theories. Previous work on asymptotically nonlocal scalar, Abelian, and non-Abelian gauge theories has demonstrated the existence of an emergent regulator scale that is hierarchically smaller than the lightest Lee-Wick partner, in a limit where the Lee-Wick spectrum becomes dense and decoupled. We generalize this construction to linearized gravity, and demonstrate the emergent regulator scale in three examples: by studying the resolution of the singularity (i) at the origin in the classical solution for the metric of a point particle, and (ii) in the nonrelativistic gravitational potential computed via a one-graviton exchange amplitude; (iii) we also show how this derived scale regulates the one-loop graviton contribution to the self energy of a real scalar field. We comment briefly on the generalization of our approach to the full, nonlinear theory of gravity.
While such multi-messenger approaches carry an enormous discovery poten-
tial, they come at the price of having to model very different physical processes 
(e.g. strong field gravity, nuclear matter, atomic opacities and radiative transfer) 
and very different length and time scales. These requirements also place high 
demands on the simulation methodology. 
In my talk, I will review the physical and numerical challenges of such simul-
dations, discuss a novel approach for relativistic fluiddynamics and show some 
first applications.

**GR 7: Gravitational Waves I**

**Time:** Wednesday 14:00–15:20

**Location:** ZEU/0260

**LISA Pathfinder** — Sarah Paczkowski for the LPF Collaboration — Max
Planck Institute for Gravitational Physics (Albert Einstein Institute), D-30167
Hannover, Germany — Leibniz Universität Hannover, D-30167 Hannover, Ger-
many

The Laser Interferometer Space Antenna (LISA) is a satellite mission to observe 
gravitational waves in the frequency range from 0.1 mHz to 1 Hz. In this talk, I 
will give an overview of its technology demonstrator mission LISA Pathfinder 
(2015–2017), and how it is paving the way for LISA.

Conceptually, the idea of LISA Pathfinder was to mimic one arm of the tri-
angular LISA constellation. The LISA Pathfinder satellite, therefore, hosted two 
free-falling test masses and their relative positions and orientations were mea-
sured using heterodyne laser interferometry. Combined with a drag-free atti-
tude control system and micrometeor thrusters in a quiet environment, a nearly 
perfect free-fall was achieved. The undesired remaining differential accelera-
tion between the two test masses was only $(1.74 \pm 0.05)$ fms$/\sqrt{Hz}$ above 2 
$\text{mHz}$. This was significantly below the requirements and exceeded expectations. 
Accordingly, LISA Pathfinder has demonstrated the ability to realise the low-
frequency science potential of the LISA mission. The interferometric readout 
on LISA Pathfinder also worked immediately and reliably throughout the mission 
with a sensing noise of only $32.0 \pm 1.7$ fms$/\sqrt{Hz}$. Since it will be similar to the lo-
cal LISA interferometry, LISA Pathfinder has successfully proven this concept to 
work in space.

**Potential of Gravitational Waves Detection with SCRF Cavities** — Guided 
MoorGat-Pick, Robin Lowenberg, Daniel Klein, Kristian Peters, and Marc 
Wenskat — II. Inst. for Theoretical Physics, University of Hamburg, 
Luruper Chaussee 149, 22761 Bahrenfeld — DESY, Notkestrasse 85, 22603 
Hamburg

We study the physics potential of detecting gravitational waves via supercon-
ducting high-frequency cavities. The direct coupling of gravitational waves to 
electromagnetic fields is widely known as the (inverse) Gertsenshtein effect. We 
have described gravitational waves in the framework of linearized theory in gen-
eral relativity. In this regard it is substantial to define the proper detector frame. 
We use a heterodyne cavity setup, extend the theoretical approach to calculate 
different scenarios in an unified and accurate way, including cavity perturbation 
theory and the effects of wall deformation.

**GR 7.3** Wed 14:40 ZEU/0260

Gravitational wave induced perturbation of atomic levels — Falk 
Adamietz, Friedemann Queise, and Ralf Schützhold — Technische Universität Dresden

Helmholtz-Zentrum Dresden-Rossendorf

Motivated by partly controversial results in the literature and recent studies re-
garding the detection of gravitational waves with atoms instead of photons (as in 
LIGO), we study the response of atomic levels to gravitational waves. For slow 
gravitational waves, we may employ lowest-order stationary perturbation the-
ory. We find that the perturbation Hamiltonian consists both of a kinetic and a 
potential correction term and explicitly evaluate their matrix elements.

**GR 7.4** Wed 15:00 ZEU/0260

A Michelson interferometer as a demonstrator for gravitational wave detec-
tion in outreach activities — David Koke and Alexander Kappes — Institut für Kernphysik der Westfälischen Wilhelms-Universität Münster, Deutschland

Gravitational waves are one of the most exciting phenomena in astrophysics and 
give us new insights into our universe since their first direct detection in 2015. To easily 
demonstrate the basic principles of gravitational wave detection in outreach activities, 
a demonstration experiment based on a Michelson interferometer was created in the framework of a master thesis. Subject of this talk is the 
presentation of the results of the project with focus on the technical realiza-
tion, as well as a live demonstration of the interferometer’s features.

**GR 8: Foundations and Alternatives I**

**Time:** Wednesday 14:00–15:20

**Location:** ZEU/0255

**Der physikalische Hintergrund der dunklen Materie** — Albrecht Giese — 
Tausweg 15, 22605 Hamburg

Dunkle Materie bedeutet einen Überschuss an Gravitation im Umfeld von Ga-
laxien im Vergleich zur Physik Newtons.

Gegenwärtig werden zwei Theorien dazu diskutiert: Die Annahme von ent-
deckten, schwach wechselwirkenden Teilchen und eine Modifikation der Gravi-
tation Newtons (MOND). Jedoch erklären beide Theorien nur einen Teil der Be-
obachtungen und sind im Konflikt mit anderen. Das heißt, es gibt keine nutzbare 
Theorie in der heutigen Physik. Und die Suche nach neuen Teilen ist völlig er-
folglos geblieben.

Neuartige intensivierte Beobachtungen haben jedoch eine verblüffende Ei-
genschaft der dunklen Materie geliefert: Sie hat eine Verteilung von $1/r^2$ um 
zu das Zentrum der Galaxien. Damit ist die Verteilung identisch mit derjenigen 
der Photonen um diese Zentren. Das sieht zunächst aus wie eine Paarung zwi-
schen dunkler Materie und Photonen. Auf dieser Basis präsentieren wir eine Er-
klärung, welche im Einklang mit allen Beobachtungen steht, und welche sogar 
*quantitativ* korrekte Ergebnisse liefert - ohne Adaptionen; dabei allerdings von 
den Ansätzen Newtons und Einsteins abweicht bzgl. der Korrelation Gravitation 
zum Masse.

Wir können uns hier auch auf einen Ansatz der Gravitation berufen, dem Ein-
stein selbst 1911 zunächst gefolgt ist. Wenn man diesen in geeigneter Weise we-
ter verfolgt, gelangt man ebenso zum obigen Ergebnis.

Weitere Info: www-ag-physics.org/gravity

**GR 8.2** Wed 14:20 ZEU/0255

**Geometrische Grundlagen der Nichtgleichgewichtsthermodynamik diskre-
ter Systeme** — Marcus Hilberbrand — Ulllandstrasse 22a, 13158 Berlin

Aus thermodynamischer Sicht können kompakte Objekte wie Sterne und 
schwarze Löcher als diskrete Systeme behandelt werden, die sich im energeti-
schen Austausch mit ihrer Umgebung befinden (Schottky-Systeme). Zu einer 
konsistenten und erfolgreichen Beschreibung von solchen kompakten Objekten 
müssen die zentralen Feldtheorien der Physik, die Quantenmechanik, die Re-
lativitätstheorie, die Elektrodynamik/Magneto hydrodynamik und die thermo-
dynamik zusammenspielen. Während alle Feldtheorien heutzutage in moderner 
gemütlicher Formulierung auf Faserbündeln vorliegen, sind dies bisher in der 
Thermodynamik nur rudimentär der Fall. Der Autor zeigt, wie diese Struktur 
für diskrete Systeme aus einigen wenigen physikalischen Prinzipien abgeleitet 
werden kann und welche tiefe, geometrisch-physikalischen Einsichten dies lie-
fert. Zentrale Ergebnisse sind dabei: Relaxationsprozesse bleiben in den Fasern, 
in denen sie starten und enden auf einer Attraktormannigfaltigkeit, der klassi-
schen Gleichgewichtsraum der Thermostat. Während in der Relativitäts-
theorie der Energie-Impulsensor die Geometrie des Raumes bestimmt, ist in der 
Thermodynamik die (1-Tform) der Endoproduktionstzeit für den Entste-
hen einer geometrischen Struktur verantwortlich: Die Kontaktdynamik.

**GR 8.3** Wed 14:40 ZEU/0255

**Mass & Charge** — Manfred Geilhaupt — Hochschule Niederrhein, Mönchengladbach, Germany

* General Relativity combined with Thermodynamic Principles reveals: 
  Sommerfeld FSC: $alpha=1/3+g44/3/4l*(1+alpha*ln(W))^{-2}$ and $W=1/3$, 
  Probability for each $x, y, z$ - Direction.

  * Electron has a finite life span introduced into a Wave Function is the only 
    chance to derive Sommerfeld FSC from a Principle Theory.

  * Electron's restmass nature is inertial. Restmass and charge are effective (ex-
    pecal value) functions from GR+TD to be compared with experimental values. 
    Both mass and charge depend on the root of alpha.

  Remark: If the superposition of two entangled Electrons collapses neverthe-
less mass (and charge) can not come out of nothing to exist as real. The collapse 
of a wave function also might come to existence when the metric g44 ("local
GR 8.4 Wed 15:00 ZEU/0255

Was, wenn die Grundkraft "Gravitation" grundsätzlich abstoßend wirkt? — Stefan Lahres — Aalen, Deutschland

Diese Hypothese nimmt an, dass Gravitation keine anziehende, sondern eine grundsätzlich abstoßende Wechselwirkung ist, und die anziehende Wirkung auf kosmologisch kleinen Maßstäben daher rührt, dass massivefahrene Strukturen die abstoßende Wirkung dämpfen.


Eine lineare Näherung führt zum Newton'schen Gravitationsgesetz. Zwei mögliche Quellen der abstoßenden Wirkung werden vorgestellt:
1. Die sonstigen Massen des Universums
2. Eine gravitative kosmische Hintergrundstrahlung, die sich in einer frühen Phase des Universums von der Wechselwirkung mit anderen Energieformen abgekoppelt.

Das Potenzial für Beiträge zur Beschreibung von Dunkler Energie, kosmischer Inflation und der Vermeidung von Singularitäten in der ART wird ebenso aufgezeigt wie Herausforderungen an die Beschreibung der physikalischen Mechanismen, die einer abstoßenden gravitativen Wechselwirkung zugrunde liegen könnten.

GR 9: Gravitational Waves and Astrophysics I

Time: Wednesday 16:00–18:00

Location: ZEU/0260

GR 9.1 Wed 16:00 ZEU/0260

Numerical-Relativity-Informed Effective-One-Body model for Black-Hole-Neutron-Star Mergers with Higher Modes and Spin Precession — Alexandra Gonzalez 1, Rossella Gamba 1, Francesco Zappa 2, Gregorio Carullo 1, Sebastiano Bernuzzi 3, Alessandro Naoko 4

1Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, Freibergstr 1, 07743 Jena, Germany — 2INFN Sezione di Torino, Via P. Giuria 1, 10125 Torino, Italy

We present the first effective-one-body (EOB) model for generic-spins quasi-circular black-hole - neutron-star (BHNS) inspiral-merger-ringdown gravitational waveforms (GWs). Our model is based on a new numerical-relativity (NR) informed expression of the BH remnant and its ringdown, it reproduces the NR (l,m) = (2,2) waveform with typical phase agreement of about 0.5 rad (less than 1 rad) to merger (ringdown). The maximum (minimum) mismatch between the (2,2) and the NR data is 4% (0.6%). Higher modes (HM) (2,1), (3,2), (3,3), (4,4), and (5,5) are included and their mismatch with the available NR waveforms are up to (down to) a 60% (1%) depending on the inclination. Phase comparison with a 16 orbit precessing simulation shows differences within less than 1% uncertainty. We demonstrate the applicability of the model in GW parameter estimation by performing the first BHNS Bayesian analysis with HM (and non-precessing spins) of the events GW190814 and GW200105, together with a new (2,2)-mode analysis of GW200115.

GR 9.2 Wed 16:20 ZEU/0260

To ring or not to ring, the tale of black hole quasi-normal modes — Peter James Nee, Sebastian H. Volkel, and Harald Pfeiffer — Max Planck Institute for Gravitational Physics (Albert Einstein Institute), D-14476 Potsdam, Germany

The generation of quasi-normal modes from compact binary mergers (also referred to as black hole spectroscopy) is one of the most promising pillars in current and future strong gravity tests. Recent works have sought to push current ringdown analysis into the non-linear merger part of the waveform via the inclusion of overtones, to better reproduce the waveform and ascertain the remnant black hole parameters. However, it is well believed that the presence of overtones is a non-trivial question, and as such caution is warranted. In this work we explore the potential pitfalls in both waveform reconstruction and parameter extraction in ringdown analysis. To this extent, we revisit the simpler problem of wave propagation in both Regge-Wheeler and Postch-Teller systems. We employ several modelling approaches to waveforms generated via a finite-difference evolution scheme, allowing for a varying number of overtones. The fitting is also performed over differently sized windows of the waveform.

GR 9.3 Wed 16:40 ZEU/0260

Constraining modifications of black hole perturbation potentials near the light ring with quasinormal modes — Sebastian Volkel 1, 2, Nicola Franchini 1, 2, 3, Enrico Barausse 1, 2, 3, and Emanuele Berti 1, 2, 3 — SISSA and INFN Sezione di Trieste, Trieste, Italy — 1IPU, Trieste, Italy — 2Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Potsdam, Germany — 3Université Paris Cité, Paris, France — 4CNRS-UCB International Research Laboratory, Berkeley, US — 5Johns Hopkins University, Baltimore, USA

In modified theories of gravity, the potentials appearing in the Schrödinger-like equations that describe perturbations of non-rotating black holes are also modified. In this talk, we ask how such modifications can be constrained with future, high-precision measurements of quasi-normal modes. We use a perturbative framework that allows one to map modifications of the effective potential, in powers of M/r, to deviations in the quasi-normal mode spectrum. Using MCMC methods, we recover the coefficients in the M/r expansion in an "opti-

mistic" scenario where we vary them one at a time, and in a "pessimistic" scenario where we vary them all simultaneously. In both cases, we find that the bounds on the individual parameters are not robust. However, inspired by WKB theory, we demonstrate that the value of the potential and its second derivative at the light ring can be robustly constrained. These constraints allow a more direct comparison between tests based on black hole spectroscopy and observations of black hole "shadows".

GR 9.4 Wed 17:00 ZEU/0260

Packed Message delivered by Tides in Binary Neutron Star Mergers — Hao-Jui Kuan 4 and Kostas Kokkotas 5 — Albert-Einstein-Institut, Potsdam, Germany — 4University of Tübingen, Tübingen, Germany

The morphology of gravitational waveforms depends on almost all source parameters, and thus encodes a bunch of information about the radiating objects. In particular, tidal parameters of neutron stars may stringently constrain the nuclear equation of state, thus their precise estimation is of fundamental importance. Emphasizing the tidal phase shift by aligned, rotating stars, we provide an accurate, yet economical, method to generate f-mode-involved, premerger waveforms. We find for slow-rotating stars that the dephasing effects of the dynamical tides can be uniquely, equation-of-state-independently determined by the direct observables. In addition, for binaries with fast rotating members, the dephasing due to f-mode is larger than that caused by equilibrium tides by a factor of ~5, which may lead to a considerably overestimated tidal deformability if the dynamical tidal contribution is not accounted for. The influence of inclination angles of stellar spins will be discussed also, as well as the possibility of accompanying precursors flares associated with f-mode excitation.

GR 9.5 Wed 17:20 ZEU/0260

Binary neutron star merger simulations with neutrino transport and turbulent viscosity: impact of different schemes and grid resolution — Francesco Zappa — Friedrich-Schiller-Universität Jena, Theoretisch-Physikalisches Institut, Jena, Germany

We present a systematic numerical relativity study of the impact of different treatment of microphysics and grid resolution in binary neutron star mergers. We find that viscosity helps to stabilise the remnant against gravitational collapse but grid resolution has a larger impact than microphysics on the remnant's stability. The gravitational wave (GW) energy correlates with the maximum remnant density, that can be thus inferred from GW observations.

Simulations employing the M1 transport schemes show the emergence of a neutrino trapped gas that locally decreases the temperature a few percent when compared to the other simulation series. This out-of-equilibrium effect does not alter the GW emission at the typical resolutions considered for mergers. Different microphysist treatments impact mass, geometry and composition of the remnant's disc and ejecta. Ejecta composition influences the nucleosynthesis yields, that are robust only if both neutrino emission and absorption are simulated.

We conclude that advanced microphysics in combination with resolutions higher than current standards appear essential for robust long-term evolutions and astrophysical predictions.

GR 9.6 Wed 17:40 ZEU/0260

GRMHD simulations with GR-Athena++ — William Cook — Friedrich-Schiller-Universität Jena

We demonstrate the performance of the new code GR-Athena++ in evolving general relativistic magnetohydrodynamics (GRMHD) in a dynamically evolving spacetime. GR-Athena++ utilises the task-based parallelism and oct-tree
Based adaptive mesh refinement of the highly scaling Athena++ code, as well as its approach to solving GRMHD problems in stationary spacetimes; combined with new functionality to solve the Einstein equations in the Z4c formulation.

We show the performance of this new code by simulating the evolution of Neutron Stars in a dynamical spacetime, presenting tests of our code, as well as strong and weak scaling tests.

**GR 10: Foundations and Alternatives II**

**Time:** Wednesday 16:00–17:40

**Location:** ZEU/0255

**GR 10.1** Wed 16:00 ZEU/0255

The assumption of a continuous Lorentzian spacetime manifold in quantum gravity — **RENÉ FRIEDRICH** — Strasbourg

Spacetime is more and more often suspected of being at the origin of the problem of quantum gravity, and it is said that the concept of spacetime needs to be revised.

In this talk, we want to provide the concrete reason why the Lorentzian spacetime manifold is not compatible with quantum gravity, by showing that it is a man-made artefact: unlike the Euclidean metric, no Lorentzian pseudometric is able to span a real-valued manifold. This is why - since its introduction with Minkowski's famous lecture "Space and time" and until today - Lorentzian manifolds require always the addition of a second metric in order to override the appearance of negative squares and of imaginary values.

This artificial "patchwork" of two opposite metrics is not only incompatible with quantum mechanics, it is even contradicting the very principles of general relativity.

**GR 10.2** Wed 16:20 ZEU/0255

A Physically Founded and Exact Model of Dark Energy — **HANS-OTTO CARMESIN** — Gymn. Athenaeum, Harsefelder Str. 40, 21680 Stade — Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen


**GR 10.3** Wed 16:40 ZEU/0255


While Newton proposed a static and flat space, Einstein used his general relativity, GR, and derived a possible dynamic expansion of space [1]. Hubble observed that expansion [2]. The dynamics of that expansion can be described by the Hubble parameter, and by its present-day limit $H_0$. However, the observed value at the early universe $H_0$ differs from the observed value at the late universe $H_0$, by five standard deviations [3]. So, what is the origin of that $H_0$ difference or $H_0$ tension? Here, we summarize proposed models of that $H_0$ difference, and we compare these models according to criteria of physics and epistemology [4,5].


**GR 10.4** Wed 17:00 ZEU/0255

Comparison of Models of the H$_0$ Tension — **PHILIPP SCHÖNEBERG**, PHIL IMMANUEL GUSTKE, and HANS-OTTO CARMESIN — Gymn. Athenaeum, Harsefelder Str. 40, 21680 Stade — Studienseminar Stade, Bahnhofstr. 5, 21682 Stade — Universität Bremen, Fachbereich 1, Postfach 330440, 28334 Bremen

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**GR 10.5** Wed 17:20 ZEU/0255

Questionable predictions by EHT image of Sgr A* — **JÜRGEN BRANDES** — Karlsruhe, Germany

The famous EHT image of Sgr A* predicts BH features in contradiction with observation: $a*=0.9375$ against $a*=0.15$; spin direction face-on against edge-on; accretion light variability arising with accretion disks against variability of accretion wind. And there is a theoretical shortcut by Broderick et al.: [2] $a_*\text{BH}_\text{early}$ differs from the observed value at the late universe $H_0$, by five standard deviations [3]. So, what is the origin of that $H_0$ difference or $H_0$ tension? Here, we summarize proposed models of that $H_0$ difference, and we compare these models according to criteria of physics and epistemology [4,5].


**GR 11: Gravitational Waves and Astrophysics II**

**Time:** Thursday 11:00–12:30

**Invited Talk**

GR 11.1 Thu 11:00 ZEU/0260

From quarks to black holes: micro- and macrophysics of neutron star mergers — **ANDREAS BAUWEN** — GSI Helmholtzzentrum fuer Schwerionenforschung, Darmstadt, Germany

Neutron stars are the densest stellar objects with densities exceeding those in atomic nuclei. Consequently, the collision of two neutron stars creates very extreme conditions and leads to a variety of different highly energetic and potentially observable phenomena: electromagnetic radiation from radio to gamma wavelengths, neutrinos and gravitational waves. Since the first unambiguous observation of a neutron star merger in 2017, a few more events have been detected, and increased instrumental sensitivity promises many more measurements in the future. We will provide an overview on which fundamental questions can be addressed by studying neutron star mergers. This includes the formation of black holes or the synthesis of heavy elements in the explosive outflows from these events. Moreover, mergers provide information on the properties of high-density matter including the prospect to identify the presence of a possible phase of deconfined quark matter in neutron stars.

GR 11.2 Thu 11:45 ZEU/0260

Tracing beyond GR physics with gravitational waves — **DIANIELA DONева** — Theoretical Astrophysics, University of Tübingen, 72076 Tübingen, Germany

Gravitational waves are among the ultimate tools to test fundamental physics and promise to answer the long-waiting question about the nature of gravity in

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the regime of strong fields. The degeneracies between different effects are a serious obstacle, though, to fulfilling this goal since modified gravity often leads to smaller cumulative changes. In the present talk we will focus on a few examples of interesting new effects we can observe in the gravitational wave spectrum that differ qualitatively from the standard picture in general relativity. This includes gravitational phase transition of neutron stars, jumps in the gravitational wave emission from merging black holes, and inverse chirp signal of extreme mass-ratio inspirals. Such effects are valuable because they are a smoking gun of beyond-GR physics that can be easily traced in observations.

**GR 12: Relativistic Astrophysics and Scalar Fields**

**Time:** Thursday 14:00–15:20

**Testing scalar-tensor gravity with radio pulsars** — ALEXANDER BAYRAKOV1,2, HUAN CHEN1, NORTHERN WEI3, PAULO FREIRE3, VIVET VENKATRAMAN KRISHN4, and MICHAEL KRAME3.1, 1Max-Planck-Institut für Radiosastronomie, Auf dem Hügel 69, 53121 Bonn, Germany — 2Jodrell Bank Centre for Astrophysics, The University of Manchester, M3 9PL, United Kingdom

The talk will highlight some of the latest results in testing the strong-field aspects of scalar-tensor gravity (STG) with radio pulsars, which include spontaneous scalarization, dipolar radiation, and the violation of the universality of free fall by strongly self-gravitating bodies. Some of these results are based on a new timing model that provides a fully consistent analysis of pulsar timing data for certain classes of STG theories.

**Mergers of Dark Matter Admixed Neutron Stars** — HANNA RÜTER1, VIOLETTA SAGUN2, WOLFGANG TICHY2, and TIM DREITZ2. 1Department of Physics, University of Coimbra, 3004-516 Coimbra, Portugal — 2Department of Physics, Florida Atlantic University, Boca Raton, FL 33431, USA

We investigate mergers of neutron stars consisting of two non-interacting fluids minimally coupled to the gravitational field using the metric-relativity code BAM. The first fluid represents baryonic matter, whereas the second fluid models dark matter, which we describe using the equation of state of a degenerate Fermi gas.

We consider two different scenarios for the distribution of the dark matter. In the first scenario the dark matter is confined to the core of the star, whereas in the second scenario the dark matter extends beyond the surface of the baryonic matter forming a halo around the baryonic star. We show how the dark matter impacts the binary dynamics and merger waveforms.

**Boson star head-on collisions** — FLORIAN ATTENDEK1, DANIELA COR2, HANNES RÜTER1, ROXANA ROSCA-ME1, DAVID HILDIT1,2, and BERND BRUGMANN. 1Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena — 2CFiUC, Department of Physics, University of Coimbra — 3CENTRA, Instituto Superior Técnico, The University of Lisbon

Colliding boson stars (BS) can be regarded as one potential source for astrophysical gravitational wave signals. Templates for the detection of such signals are now being constructed, which makes accurate calculations of such more important. In contrast to fluid matter, BS solutions are smooth, which makes them, in some sense, an optimal domain for the application of pseudospectral numerical methods. Simulations so far have been limited due to the difficulty in building initial data containing two BS. Most groups undergoing such studies either use a simple superposition of two boosted BS or an improved version thereof. In this talk we will present first results of BS head-on collisions that start from constraint solved initial data.

**Image of the thin accretion disk in gravity with a minimally coupled scalar field** — GALEN GYULCHEV. 1Faculty of Physics, Sofia University, 2Jouin Bbrush Boulevard, Sofia 1164, Bulgaria

We study possible observable images of a black hole and naked singularity described by rotating geometry in Einstein gravity, minimally coupled to a scalar field. We consider a Kerr-like (KL) alternative to the rotating Fisher-Janus-Newman-Winicour solution. Our study includes analytical and numerical calculations of equatorial circular orbits, shadow images, and radiation from thin accretion disks for various values of the object’s angular momentum and scalar charge. The KL solution cannot be ruled out by the observations for small values of the scalar charge either. As the scalar charge increases, the optical properties change dramatically. The photon region does not hide the singularity, so it should be classified as a strong singularity. The shadow of the compact object can become multiply connected and strongly oblate. This new qualitative feature can be used to distinguish observationally black holes from naked singularities via the contemporary Very Long Baseline Interferometry experiments at short wavelengths.

**GR 13: Relativity and Data Analysis**

**Time:** Thursday 16:00–17:20

**Noise transients in machine-learning based gravitational-wave searches** — ONDŘEJ ŽELENKA1,2, BERND BRUGMANN1,2, and FRANK OHEM1. 1Friedrich-Schiller-Universität Jena, D-07743 Jena, Germany — 2Michael Stiefel Center Jena, D-07743 Jena, Germany — 3Max-Planck-Institut für Gravitationsphysik, Albert-Einstein-Institut, D-30167 Hannover, Germany — 4Leibniz Universität Hannover, D-30167 Hannover, Germany

The recent past, machine-learning-based approaches have been proposed as a solution to some problems in gravitational-wave data analysis. One of these are noise transients, which significantly complicate detection of gravitational waves. Contemporary matched-filtering based searches as well as unmodeled searches employ systems which flag likely noise transients and reject potential false alarms. It is possible that machine-learning based algorithms can learn to distinguish noise transients from signals with astrophysical sources.

In this contribution, we present a machine-learning based gravitational-wave detection algorithm focused on binary black holes, which has been submitted to the MLGWSC-1 mock data challenge. Furthermore, we describe an issue which arose when the model encountered non-Gaussian background noise, and present its solution. In doing so, we demonstrate that a machine-learning based algorithm with a suitable training method is capable of distinguishing false alarms due to transients from binary black hole injections.
Finding Universal Relations using Statistical Data Analysis — Praveen Manoharan and Kostas D. Kokkotas — IAAT, University of Tübingen, 72076 Tübingen, Germany

We present applications of statistical data analysis methods from both bi- and multivariate statistics to find suitable sets of neutron star features that can be leveraged for accurate and EoS independent - or universal - relations. To this end, we investigate the ability of various correlation measures such as Distance Correlation and Mutual Information in identifying universally related pairs of neutron star features. We also evaluate relations produced by methods of multivariate statistics such as Principal Component Analysis to assess their suitability for producing universal relations with multiple independent variables.

As part of our analyses, we are able to put forward multiple entirely novel relations, including multivariate relations for the $S_1$-mode frequency of neutron stars with reduced error when compared to existing, bivariate relations.

GR 14: Gravitational Waves II

Time: Thursday 16:00–17:40

Location: ZEU/0255

Implementation of a Stray Light Simulation for the Einstein Telescope — Hanna Marozova¹, Thomas Hebberk², and Achim Stahl² — III. Physikalisches Institut A, RWTH Aachen University — III. Physikalisches Institut B, RWTH Aachen University

The Einstein Telescope (ET) will be the first gravitational wave detector of the third generation. Stray light is a severe problem for modern interferometers with high sensitivity, as another noise source contributing to the interferometer output. A simulation is required to tune detector settings to avoid undesirable light paths and to optimize the shape, number and position of baffles.

This talk will present the progress in developing a concept for the reduction of stray light in ET and first results.

Test setup for cryogenic sensors and actuators working towards the Einstein Telescope — Robert Joppe¹, Thomas Hebberk³, Tim Kuhlbusch¹, Oliver Pooth¹, Achim Stahl², Timo Wittler³, and Franz Peter Zantis³ — III. Physikalisches Institut A, RWTH Aachen — III. Physikalisches Institut B, RWTH Aachen

The Einstein Telescope will be the first gravitational wave detector of the third generation. The sensitivity goal, especially in the low frequency region, will be achieved among other improvements by cooling the main parts of the interferometer. The required electronic components, sensors and actuators needed for mirror alignment and active damping of suspension resonances have to perform at cryogenic temperatures.

The talk presents the progress on the development of electronics, optics and mechanics within the E-TEST project. Furthermore the performance of our cryogenic UHV test setup and the characterization of light emitting diodes at low temperatures will be explained.

A Cryogenic Displacement Sensor and Actuator for the Einstein Telescope — Thomas Hebberk¹, Robert Joppe³, Tim Kuhlbusch¹, Oliver Pooth³, Purnalingam Revathy², Achim Stahl², Timo Wittler³, and Franz-Peter Zantis³ — III. Physikalisches Institut A, RWTH Aachen — III. Physikalisches Institut B, RWTH Aachen

The Einstein Telescope will be the first third-generation gravitational wave detector. In achieving an increase in sensitivity of more than one order of magnitude at low frequencies compared to current detectors, mitigating thermal noise is essential. Thus cooling the mirrors of the interferometer to cryogenic temperatures is required. Consequently parts of the vibration isolation systems of the mirrors need to be working at these low temperatures.

This talk will present the development of an actuator with an integrated abso-
GR 16: Experimental Tests

**GR 16.1** Fri 11:00 HSZ/0401

New search for differences in active and passive gravitational masses using Lunar Laser Ranging — **Claude Lämmerzahl**, Vishva V. Singh, Liliane Biskupek, Jürgen Müller, and Eva Hackmann — ZARM, University of Bremen — 2IFL, Leibniz Universität Hannover

Each body possesses three masses: inertial mass, passive gravitational mass (weight), and active gravitational mass. With MICROSCOPE the equality of inertial and passive gravitational mass has been confirmed at the order $10^{-13}$. Laboratory test confirmed the equality of active and passive mass at the order $10^{-3}$. Using Lunar Laser Ranging (LLR) data from 1970 to 2022, we obtained a new limit of $3.9 \times 10^{-14}$ that improves the previous LLR-based result by two orders of magnitude. We also propose a new laboratory experiment for the search of a difference between active and passive masses, and present a new orbital analysis for stellar binary systems made of different masses. Finally, we add some remarks on active and passive charges.

**GR 16.2** Fri 11:20 HSZ/0401

A concept for testing the gravitomagnetic clock effect with GNSS satellites — **Jan Scheumann**, Dennis Philipp, Eva Hackmann, Sven Herrmann, Benny Rievers, and Claus Lämmerzahl — ZARM, University of Bremen, 28359 Bremen, Germany

General Relativity (GR) predicts that the rotation of a central body influences the trajectory of an orbiting mass in a non-Newtonian way. One of the predicted effects was first described by Cohen and Mashhoon, concerning the proper time difference of two counter-revolving clocks in an orbit around a rotating mass, which is yet to be verified experimentally. After the accuracy of the tests of the gravitational redshift could be improved using two Galileo satellites on eccentric orbits, other possibilities to use GNSS satellites for tests of GR are under investigation. This work presents a concept to test the gravitomagnetic clock effect (GMCE) with GNSS satellites and looks into the technical requirements for such a test.

The introduced theoretical framework yields an incrementally defined observable, that is accessible e.g. via orbit and clock products. Some usage of the framework is presented, taking advantage of state-of-the-art orbit simulations as an a-priori data source.

A comparison of a dedicated mission's technical requirements with the state-of-the-art in SLR and modelling of gravitational and non-gravitational perturbations yields that a measurement is highly demanding, but might just be within reach of current technology.

**GR 16.3** Fri 11:40 HSZ/0401

Taking gravity tests with the Double Pulsar to higher orders — **Huanchen Hu**, Michael Kramer, Norbert Wex, and David J. Champion — Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, 53121 Bonn, Germany — Jodrell Bank Centre for Astrophysics, The University of Manchester, Oxford Road, Manchester M13 9PL, UK

Relativistic binary pulsars are excellent testbeds for probing strong-field aspects of gravity. In particular, the Double Pulsar system PSR J0737-3039A/B offers a wealth of relativistic effects that can be studied in depth. Pulsar timing observations with MeerKAT and the future Square Kilometre Array (SKA) can bring the accuracy of these gravity tests to an unprecedented level, as well as enable precision tests of next-to-leading order (NLO) effects in the orbital motion and signal propagation. In this talk, I will present the timing results of PSR J0737-3039A based on 3-yr MeerKAT observations with a focus on the NLO signal propagation effects. These include the retardation effect due to the movement of pulsar B and the deflection of the signal of A by the gravitational field of B. Moreover, future observations with MeerKAT and the SKA are expected to provide one of the first measurements of the moment of inertia of a neutron star, hence an important complementary constraint on the equation of state at ultranuclear density. Finally, other prospects from future observations will be also demonstrated.

**GR 16.4** Fri 12:00 HSZ/0401

Measurement of Gravitational Coupling of Planck Mass-sized Object — **Hans Hephach**, Mathias Dragosits, and Jereamar Pfaff — IQOQI Vienna, OeAW, Austria — University of Vienna, Austria

Gravity is the weakest of all known fundamental forces and continues to pose some of the most outstanding open problems to modern physics: it remains resistant to unification within the standard model of physics and its underlying concepts appear to be fundamentally disconnected from quantum theory. Testing gravity on all scales is therefore an important experimental endeavour. Thus far, these tests involve mainly macroscopic masses on the kg-scale and beyond. Here we show gravitational coupling between a gold sphere of 1mm radius and a Planck mass sized object. Periodic modulation of the source mass position allows us to perform a spatial mapping of the gravitational force. The current measurement improves upon our previous result by a reduction of the source mass by three orders of magnitude and opens the way to a yet unexplored frontier of microscopic source masses. This enables new searches of fundamental interactions and provides a natural path towards exploring the quantum nature of gravity.

**GR 16.5** Fri 12:20 HSZ/0401

Measuring the gravitational field using quantum imaging — **Marian Cepeck** — ZARM, University of Bremen, 28359 Bremen, Germany

Quantum Imaging is a method which can be used to image an object using photons which have not interacted with the object. This scheme uses an entangled pair of photons, one of the photons interacts with the object while it is only the other photon which is being measured. Here a setup similar to quantum imaging is proposed which images the gravitational field instead of an object.
Hadronic and Nuclear Physics Division
Fachverband Physik der Hadronen und Kerne (HK)

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Overview of Invited Talks and Sessions
(Lecture halls HSZ/0002, HSZ/0103, HSZ/0105, SCH/A251, SCH/A118, SCH/A216, SCH/A316, SCH/A.101, SCH/A117, SCH/A215, SCH/A315, SCH/A419, and SCH/A252; Poster HSZ EG)

Plenary Talk of the Hadronic and Nuclear Physics Division
PV IX Wed 9:45–10:30 HSZ/AUDI  The origin of the chemical elements — •Maria luisa Aliotta

Invited Talks
HK 1.1 Mon 11:00–11:30 HSZ/0002 Nucleosynthesis of heavy nuclei – moving a supernova into the laboratory — •Felix Heim
HK 1.2 Mon 11:30–12:00 HSZ/0002 Exploring the 3D nucleon structure with CLAS and CLAS12 at JLAB — •Stefan Diehl
HK 1.3 Mon 12:00–12:30 HSZ/0002 Lattice simulations with chiral effective field theory at N3LO — •Serdar Elhati-sari
HK 12.1 Tue 11:00–11:30 HSZ/0002 Baryon spectroscopy at ELSA and MAMI — •Farah Afzal
HK 12.2 Tue 11:30–12:00 HSZ/0002 ALICE upgrades, status and perspectives for ALICE-3 — •Robert Muenzer
HK 12.3 Tue 12:00–12:30 HSZ/0002 Nuclear parton distribution functions — •Michael Klasen
HK 23.1 Wed 11:00–11:30 HSZ/0002 High-Precision Laser Spectroscopy of C\textsuperscript{4+} for an All-Optical Determination of the Nuclear Charge Radius — •Phillip Imgram, Kristian König, Bernhard Maass, Patrick Müller, Wilfried Nörtershäuser
HK 23.2 Wed 11:30–12:00 HSZ/0002 ALICE determines the transparency of our galaxy to the passage of antihelium nuclei — •Laura Sekssnyte
HK 23.3 Wed 12:00–12:30 HSZ/0002 The world of light and strange mesons: from spectroscopy puzzles to low energy QCD phenomena — •Stephan Paul
HK 52.1 Thu 11:00–11:30 HSZ/AUDI AI Techniques for Event Reconstruction — •Ivan Kisel
HK 76.1 Fri 11:00–11:30 HSZ/0002 Thermalization of heavy quarks in the QGP — •Federica Capellino
HK 76.2 Fri 11:30–12:00 HSZ/0002 Hadron structure in Lattice QCD — •Konstantin Optnald
HK 76.3 Fri 12:00–12:30 HSZ/0002 LISA: Lifetime measurements with Solid Active targets — •Kathrin Wimmer

Sessions
HK 1.1–1.3 Mon 11:00–12:30 HSZ/0002 Invited Talks I
HK 2.1–2.5 Mon 16:30–18:00 SCH/A251 Instrumentation I
HK 3.1–3.5 Mon 16:30–18:00 SCH/A.101 Instrumentation II
HK 4.1–4.5 Mon 16:30–18:00 SCH/A117 Instrumentation III
HK 5.1–5.6 Mon 16:30–18:00 SCH/A216 Heavy-Ion Collisions and QCD Phases I
HK 6.1–6.5 Mon 16:30–18:00 SCH/A315 Heavy-Ion Collisions and QCD Phases II
HK 7.1–7.5 Mon 16:30–18:00 SCH/A419 Hadron Structure and Spectroscopy I
HK 8.1–8.5 Mon 16:30–18:00 SCH/A118 Nuclear Astrophysics I
HK 9.1–9.5 Mon 16:30–18:00 SCH/A215 Structure and Dynamics of Nuclei I
HK 10.1–10.5 Mon 16:30–18:00 SCH/A118 Structure and Dynamics of Nuclei II
HK 11.1–11.6 Mon 16:30–18:00 HSZ/0204 Outreach Public/Teilchenwelt (joint session T/HK)
HK 12.1–12.3 Tue 11:00–12:30 HSZ/0002 Invited Talks II
HK 13.1–13.5 Tue 17:00–18:15 SCH/A251 Instrumentation IV
HK 14.1–14.5 Tue 17:00–18:45 SCH/A.101 Instrumentation V
HK 15.1–15.7 Tue 17:00–18:45 SCH/A117 Instrumentation VI
HK 16.1–16.5 Tue 17:00–18:30 SCH/A216 Heavy-Ion Collisions and QCD Phases III
HK 17.1–17.5 Tue 17:00–18:30 SCH/A315 Heavy-Ion Collisions and QCD Phases IV
HK 18.1–18.7 Tue 17:00–19:00 SCH/A316 Hadron Structure and Spectroscopy II
HK 19.1–19.5 Tue 17:00–18:30 SCH/A419 Nuclear Astrophysics II
HK 20.1–20.5 Tue 17:00–18:45 SCH/A118 Structure and Dynamics of Nuclei III
HK 21.1–21.6 Tue 17:00–18:45 SCH/A215 Structure and Dynamics of Nuclei IV
HK 22.1–22.7 Tue 17:00–18:45 SCH/A252 Outreach (joint session HK/T)
HK 23.1–23.3 Wed 11:00–12:30 HSZ/0002 Invited Talks III
HK 24.1–24.5 Wed 14:00–15:30 SCH/A251 Instrumentation VII
HK 25.1–25.6 Wed 14:00–15:30 SCH/A.101 Instrumentation VIII
HK 26.1–26.5 Wed 14:00–15:30 SCH/A117 Instrumentation IX
HK 27.1–27.5 Wed 14:00–15:30 SCH/A216 Heavy-Ion Collisions and QCD Phases V
HK 28.1–28.5 Wed 14:00–15:30 SCH/A315 Heavy-Ion Collisions and QCD Phases VI
HK 29.1–29.5 Wed 14:00–15:30 SCH/A316 Hadron Structure and Spectroscopy III
HK 30.1–30.5 Wed 14:00–15:30 SCH/A419 Nuclear Astrophysics III
HK 31.1–31.4 Wed 14:00–15:30 SCH/A118 Structure and Dynamics of Nuclei V
HK 32.1–32.6 Wed 14:00–15:30 SCH/A215 Structure and Dynamics of Nuclei VI
HK 33.1–33.4 Wed 14:00–15:30 SCH/A252 Fundamental Symmetries I
HK 34.1–34.5 Wed 15:45–17:15 SCH/A251 Instrumentation X
HK 35.1–35.3 Wed 15:45–17:00 SCH/A.101 Instrumentation XI
HK 36.1–36.6 Wed 15:45–17:15 SCH/A117 Computing I
HK 37.1–37.6 Wed 15:45–17:15 SCH/A216 Heavy-Ion Collisions and QCD Phases VII
HK 38.1–38.6 Wed 15:45–17:15 SCH/A315 Heavy-Ion Collisions and QCD Phases VIII
HK 39.1–39.5 Wed 15:45–17:15 SCH/A316 Hadron Structure and Spectroscopy IV
HK 40.1–40.4 Wed 15:45–17:00 SCH/A419 Nuclear Astrophysics IV
HK 41.1–41.5 Wed 15:45–17:15 SCH/A118 Structure and Dynamics of Nuclei VII
HK 42.1–42.5 Wed 15:45–17:15 SCH/A215 Structure and Dynamics of Nuclei VIII
HK 43.1–43.4 Wed 15:45–17:15 SCH/A252 Fundamental Symmetries II
HK 44.1–44.5 Wed 17:30–19:00 SCH/A251 Instrumentation XII
HK 45.1–45.6 Wed 17:30–19:00 SCH/A.101 Instrumentation XIII
HK 46.1–46.5 Wed 17:30–19:00 SCH/A216 Heavy-Ion Collisions and QCD Phases IX
HK 47.1–47.5 Wed 17:30–18:45 SCH/A315 Heavy-Ion Collisions and QCD Phases X
HK 48.1–48.6 Wed 17:30–19:00 SCH/A316 Hadron Structure and Spectroscopy V
HK 49.1–49.6 Wed 17:30–19:00 SCH/A118 Structure and Dynamics of Nuclei IX
HK 50.1–50.5 Wed 17:30–19:00 SCH/A215 Structure and Dynamics of Nuclei X
HK 51.1–51.4 Wed 17:30–19:15 SCH/A252 Fundamental Symmetries III
HK 52.1–52.3 Thu 11:00–12:30 HSZ/AUDI AI Topical Day – Invited Talks (joint session AKPIK/HK/ST/T/AKBP)
HK 53.1–53.6 Thu 14:00–15:30 HSZ/0103 AI Topical Day – Computing II (joint session HK/AKPIK)
HK 54.1–54.6 Thu 14:00–15:30 HSZ/0105 AI Topical Day – Heavy-Ion Collisions and QCD Phases XI (joint session HK/AKPIK)
HK 55.1–55.5 Thu 14:00–15:30 SCH/A251 Instrumentation XIV
HK 56.1–56.5 Thu 14:00–15:30 SCH/A.101 Instrumentation XV
HK 57.1–57.5 Thu 14:00–15:30 SCH/A316 Hadron Structure and Spectroscopy VI
HK 58.1–58.5 Thu 14:00–15:30 SCH/A419 Hadron Structure and Spectroscopy VII
HK 59.1–59.5 Thu 14:00–15:30 SCH/A118 Structure and Dynamics of Nuclei XI
HK 60.1–60.6 Thu 14:00–15:30 SCH/A215 Structure and Dynamics of Nuclei XII
HK 61.1–61.5 Thu 14:00–15:15 SCH/A117 Structure and Dynamics of Nuclei XIII
HK 62.1–62.4 Thu 14:00–15:15 SCH/A252 Astroparticle Physics I
HK 63.1–63.4 Thu 15:45–17:00 SCH/A251 Instrumentation XVI
HK 64.1–64.3 Thu 15:45–16:45 SCH/A.101 Instrumentation XVII
HK 65.1–65.6 Thu 15:45–17:15 SCH/A216 Heavy-Ion Collisions and QCD Phases XII
HK 66.1–66.6 Thu 15:45–17:15 SCH/A315 Heavy-Ion Collisions and QCD Phases XIII
HK 67.1–67.4 Thu 15:45–17:00 SCH/A316 Hadron Structure and Spectroscopy VIII
HK 68.1–68.4 Thu 15:45–17:00 SCH/A419 Hadron Structure and Spectroscopy IX
HK 69.1–69.6 Thu 15:45–17:15 SCH/A118 Structure and Dynamics of Nuclei XIV
HK 70.1–70.5 Thu 15:45–17:15 SCH/A215 Structure and Dynamics of Nuclei XV
HK 71.1–71.5 Thu 15:45–17:15 SCH/A117 Structure and Dynamics of Nuclei XVI
HK 72.1–72.5 Thu 15:45–17:00 SCH/A252 Astroparticle Physics II
HK 73.1–73.6 Thu 15:50–17:20 HSZ/0204 Outreach Diverse (joint session T/HK)
HK 74.1–74.54 Thu 17:30–19:00 HSZ EG Poster
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<td>HK 75</td>
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<td>HK 76.1–76.3</td>
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**Members' Assembly of the Hadronic and Nuclear Physics Division**

Thursday 19:00–20:00 HSZ/0002
Inelastic scattering (SIDIS) or Drell-Yan processes. The distribution in transverse coordinate and longitudinal momentum space is described by generalized parton distributions (GPDs) which can be accessed for example by deeply virtual Compton scattering (DVCS) and hard exclusive meson production (DVMP). Based on the high quality data of CLAS and the recently upgraded CLAS12 detector at Jefferson Laboratory (JLAB), a detailed study of these distribution functions is being performed. With the new CLAS12 data, multidimensional, high precision studies in an extended kinematic range become possible for the first time. The talk will present the results of recent SIDIS, DVCS and DVMP studies with CLAS and CLAS12, as well as perspectives for 3D nucleon structure measurements with PANDA at FAIR and their impact on the understanding of the 3D nucleon structure.

*The work is supported by DFG (project number: 508107918) and BMBF.

**Invited Talk**

**HK 1.3 Mon 12:00 HSZ/0002**

**Lattice simulations with chiral effective field theory at N3LO**

— **SERDAR EL-HATISARI** — Faculty of Natural Sciences and Engineering, Gaziantep Islam Science and Technology University, Gaziantep, Turkey — Helmholtz-Institut fuer Strahlen- und Kernphysik, Universitaet Bonn, Bonn, Germany

In this talk I present a new approach called wave function matching for solving quantum many-body systems and recent results for ab initio calculations of nuclear structure. The method is applied to lattice Monte Carlo simulations of light nuclei, medium-mass nuclei, neutron matter, and nuclear matter. The goal of method is to ensure that the perturbative corrections used in the lattice calculations converge quickly. We use interactions at next-to-next-to-next-to-leading order in the framework of chiral effective field theory and we find that the method is producing good results for the binding energies and charge radii of light and medium mass nuclei as well as the equation of state for pure neutron matter and symmetric nuclear matter saturation. Also, these results are accompanied by new insights on the nuclear interactions that may help to resolve long-standing challenges in accurately reproducing nuclear binding energies, charge radii, and nuclear matter saturation in ab initio calculations.

**Group Report**

**HK 2.1 Mon 16:30 SCH/A251**

**Aufbau und Kalibrierung der Vorwärtsendekante des elektromagnetischen Kalorimeters des PANDA-Experiments am COSY in Jülich**

— **LUKAS LINZEN**

für die PANDA-Kollaboration — Ruhr Universität Bochum, Germany

Das PANDA-Experiment wird eines der Schlüsselexperimente an der sich im Bau befindlichen Beschleunigeranlage FAIR. Dort werden Kollisionen von Antiprotonen in einem Impulsbereich zwischen 1,5 GeV/c und 15 GeV/c mit verschiedenen Targets untersucht. Der PANDA-Detektor ist ein vielseitiger Detektor mit präziser Spurrekonstruktion und der Möglichkeit neutrale, sowie gela denen Teilen zu detektieren.


Gefördert durch das BMBF.

**HK 2.2 Mon 17:00 SCH/A251**

**Performance studies of pixel layers for the ALICE-FoCal detector**

— **VOUSSEF EL MAROUBOUZIAN** für die ALICE Germany-Collaboration — Institut für Kernphysik, Goethe-Universität Frankfurt

The upgrade of the ALICE experiment at CERN-LHC for LHC-Run 4 includes the expansions of the physics program with a study of small-x gluon distributions via prompt photon production.

To facilitate this study a highly granular Si+W electromagnetic calorimeter combined with a conventional sampling hadronic calorimeter covering pseudorapidities of 3.4 < η < 5.8 has been proposed: the FoCal detector. The FoCal-E subdetector will consist of a Si+W sampling calorimeter hybrid design using two different Si readout technologies, pad layers, and pixel layers based on ALPIDE-chip technology. The pixel layers have been successfully tested within the framework of the EPICAL-2 prototype detector.

In this talk, we report on studies of the shower measurements with the EPICAL-2 design. Furthermore, simulation studies of performance tests of the implementation of the pixel layers in the FoCal detector setup will be discussed.

Supported by BMBF and the Helmholtz Association.

**HK 2.3 Mon 17:15 SCH/A251**

**Performance of the EPICAL-2 ultra-high granularity electromagnetic calorimeter prototype**

— **TIM SEBASTIAN ROGOSCHINSKI** für die ALICE Germany-Collaboration — Institut für Kernphysik, Goethe-Uni Frankfurt

The EPICAL-2 detector has been designed and constructed within the endeavor to develop a novel electromagnetic calorimeter based on a SiW sampling design using silicon pixel sensors with binary readout. The R&D is performed in the context of the proposed Forward Calorimeter upgrade within the CERN-ALICE experiment and is strongly related to proton CT imaging studies as well as applicable to future collider projects.
EPICAL-2 consists of alternating W absorber and Si sensor layers employing the ALPIDE sensor developed for the ALICE-ITS upgrade. It has a total thickness of 20 radiation lengths, an area of 30 mm × 30 mm, and 25 million pixels of size ∼ 30 × 30 μm. EPICAL-2 has been successfully tested with cosmic muons as well in test-beam campaigns at DESY and CERN-SPS.

We will report on results on calibration from cosmic muons and on the combined energy measurement performance obtained at both DESY and SPS. Furthermore, we will present results on the electromagnetic shower shape description. Both the performance and the shape description can be reproduced by simulation.

Supported by BMBF and the Helmholtz Association.

HK 2.4  Mon 17:30 SCH/A251 Tuning of GFlash for COMPASS calorimeter simulations — HENRI PEKKER, LANKE KLEPHAHN, DAVID SPULBECK, MATTHIAS WAGNER, and BERNHARD KETZER — Universität Bonn, Bonn, Germany

Monte-Carlo simulations of detector setups are an essential element of physics analyses. At COMPASS, we use a high-level Monte Carlo program called TGEANT, which is based on GEANT4, to determine the acceptance of the detector system. For final states with photons, the electromagnetic calorimeter in the simulations is essential.

Instead of tracking every single particle in a shower, which is computationally very expensive, the GFlash algorithm is used. It models the energy distribution and the extend of the shower, which should change for different calorimeter module types.

The COMPASS calorimeters are a combination of homogeneous and sampling calorimeter modules and it is of great importance to verify that reality is described well enough by GFlash. During this talk, we present how we tuned GFlash in order to match the shower shape of real events in the different COMPASS calorimeter modules and showcase the improved photon reconstruction after the tuning.

Supported by BMBF.

HK 2.5  Mon 17:45 SCH/A251 A Feature Extraction Ansatz for the PANDA Forward-Endcap EMC — CELINA FRENNEL — HIKSP, Uni Bonn, Germany

The forward endcap of the electromagnetic calorimeter of the PANDA experiment consists of 3856 lead tungstate crystals. These are either readout by VPTTs in the high rate regime (9 ≤ 13°) or by 2 APDs per crystal at larger angles. The signals are then digitized using sampling ADCs.

A feature extraction algorithm implemented on the FPGA on the SADC boards is used to extract energy and time information from the SADC signals online in real-time. The expected particle rate in forward direction of the experiment reaches ∼500 kHz such that pile-up is a relevant aspect. A signal deconvolution can be used to shorten the pulse in time and reduce the probability of pile-up.

The central topic of this talk is the investigation of an online feature extraction ansatz making use of the Pulse Shape Deconvolution (PSD). With this ansatz it is possible to even remove unwanted properties of the signal shape and provide a clean signal for the following extraction of the signal's features using a peakfinder algorithm.

Finally, the performance of the new PSD ansatz is compared to the less FPGA resource demanding moving window deconvolution based feature extraction, currently implemented.

HK 3: Instrumentation II

Time: Monday 16:30–18:00

Group Report

HK 3.1  Mon 16:30 SCH/A.101 Space-time distortion calibrations for the ALICE TPC in LHC Run 3 — MATTHIAS KLEINER for the ALICE Germany-Collaboration — Institut für Kernphysik, Goethe-Universität Frankfurt

The Time Projection Chamber (TPC) is the main tracking and particle identification detector of the ALICE experiment at the CERN LHC. In order to cope with the high interaction rates of up to 50 kHz in Pb-Pb collisions during Run 3, the Multi Wire Proportional Chambers (MWPCs) were replaced with stacks of four Gas Electron Multiplier (GEM) foils to allow for continuous data acquisition. Despite the intrinsic ion-blocking properties of the GEM system, a residual amount of ions produced during the electron amplification drifts into the active volume of the TPC, leading to space-time distortions of the nominal drift field. Various effects, such as variations in the number of collisions for a given time interval, cause fluctuations of the distortions due to space-charge on very short time scales. Additional effects such as charging up of the GEM frames contribute to the space-time distortions. The average space-time distortions as well as the fluctuations have to be corrected to preserve the intrinsic tracking precision of the TPC.

In this talk, an overview about space-time distortions and distortion fluctuations in the ALICE TPC in Run 3 will be presented, along with procedures developed for the calibration of the space-time distortions.

Supported by BMBF and the Helmholtz Association.

HK 3.2  Mon 17:00 SCH/A.101 First tests of the time projection chamber and the trigger barrel of the PUMA experiment — ALEXANDRE OBERTELLI, CLARA KLINKE, SARINA ZACARJAS, CHRISTINA XANTHOPOULOU, FRANCOIS BUTIN, FRANK WIENHOLZ, and EMANUELE POLLACCO — CERN, Genève, Switzerland — TU Darmstadt, Darmstadt, Germany — CEA-IRFU, Paris-Saclay, France

The antiProton Unstable Matter Annihilation (PUMA) experiment plans on using antiprotons as probe for the nuceloc composition in the tail of the nuclear density distribution for stable and exotic nuclei. Antiprotons annihilate with the nucleons on the nucleus’ surface: the combined charge of the annihilation products will reveal the neutron-to-proton content at the nuclear surface. This allows to investigate quantum phenomena like Halo nuclei and neutron skins. The products of the annihilation will be detected in a time projection chamber surrounded by a plastic-scintillator trigger barrel. In this talk, the working principle of the PUMA detection system will be explained, as well as the data acquisition system. The results of first tests with the system will be presented.

HK 3.3  Mon 17:15 SCH/A.101 Low Material TPC construction — DAVID MAHR for the MAGIX Collaboration — Institute of Nuclear Physics, JGU Mainz

The MAInz Gas Injection Target EXperiment MAGIX, currently under construction in Mainz, together with the Mainz Energy-Recovering Superconducting Accelerator MESA, will perform electron scattering measurements on various gases, provided by a gas jet target. With an intended luminosity of 10^27 cm^{-2} s^{-1} at 105 MeV, MAGIX is capable of servicing a wide variety of physical objectives, including dark sector searches, investigations into few body systems and nuclear astrophysics.

The scattered particles will be measured with two identical high resolution magnetic spectrometers. In their focal plane a short drift GEM-based Time Projection Chamber is placed to serve as tracking detector. The active area of the TPC is 768x192x140 mm. The setup of the experiment, from the internal gas jet target to the TPC, is designed to limit the interaction of scattered particles before their detection, such that the only separatory of TPC gas volume and interaction point is single kapton foil entrance window. To assure that the desired precision can be achieved, a space saving calibration system using UV-LEDs has been designed. Plastic scintillators mounted after the capton foil exit window serve as a trigger veto system.

The low material TPC construction and calibration system will be the focus of this talk.

HK 3.4  Mon 17:30 SCH/A.101 The MAGIX StarryNight calibration system — DANIEL STEGER for the MAGIX-Collaboration — Institute of Nuclear Physics, JGU Mainz

The MESA accelerator will host the MAGIX experiment, which is based on the scattering of an electron beam on a gas jet target. This enables scattering on gases like hydrogen while minimizing interaction with any other materials allowing us to perform high precision experiments. The measurement of the scattered particles is done by two magnetic spectrometers using a GEM based TPC to track the particles. To achieve the precision desired an independent system to calibrate the TPC is necessary. A prototype of such a system has been designed, utilizing LED’s with a wavelength of 275 nm that are operated in pulses above the cathode of the active volume of the TPC. Furthermore the cathode of the TPC has been replaced with aluminium based photon-electron-converter boards.

In this contribution the setup and development of this calibration system will be presented.

HK 3.5  Mon 17:45 SCH/A.101 Quality Control for the ALICE TPC — BERKIN ULUKUTLU for the ALICE Germany-Collaboration — Technische Universität München, Munich, Germany

The ALICE TPC (Time Projection Chamber) detector at the LHC has recently been upgraded to handle higher interaction rates with a continuous readout mode. This upgrade includes a new readout system using GEMs for amplification, custom front-end electronics, and new reconstruction software. To monitor this essentially new detector’s performance and assure its reliability under ex-
treme operating conditions, a Quality Control framework has been developed. This framework provides tools for monitoring the TPC in real-time at both the hardware and physics observable levels, such as particle identification performance. The QC systems also include automated checks for alerting detector experts in case of any issues. However, pinpointing the source of issues in such a complex system is not easy. To assist with this, QC tools specifically designed for expert use are being developed, offering a direct and interactive interface to TPC observables in contrast to the predefined histograms and projections used in synchronous monitoring. In this talk, we will provide an overview of the TPC QC project, highlighting the challenges and the tools developed to address them.
probing rapidity structure of A-A events with correlations of particle number ratios — I. Altsybeev for the ALICE Germany-Collaboration — Technische Universität München, James-Franck-Str 1, 85748 Garching bei München Measurements of fluctuations allow one to study phase transitions and other collective phenomena in systems formed in high-energy hadronic collisions. In this paper, we will discuss properties of a recently proposed fluctuation observable, namely, the correlation coefficient between ratios of identified particle yields measured in two angular acceptance windows. With such an observable it is possible, for instance, to study the correlation between relative strangeness yield and the freeze-out temperature of the QGP, which allows us to obtain information about the dynamics of the fireball formed in A-A collisions. Such correlations are also sensitive to various short-range effects, in particular, they are affected by spin statistics. We will show first experimental measurements of particle ratio correlations in pp and Pb-Pb data recorded by ALICE, and compare with predictions from several models that include various physics effects. Such comparison allows one to exclude some of the models.

This work is supported by BmBf.

Elliptic flow of pions, kaons and protons relative to the spectator plane measured with ALICE at the LHC — M. Schröder for the ALICE Germany-Collaboration — Technische Universität München, James-Franck-Str 1, 85748 Garching bei München

In relativistic heavy-ion collisions, the shape of the initial energy density in the overlap region of the colliding nuclei is asymmetric and fluctuates. Due to interactions, these fluctuations are transferred to the momentum distribution of particles in the final state which is quantified by the flow coefficients $v_i$. The thermodynamic expansion of the quark-gluon plasma (QGP) results in a specific particle mass dependence of the $v_i$ coefficients as a function of the transverse momentum. The measurements of the $v_i$ relative to the spectator plane is of special interest, since the spectators decouple very early in the collision. Comparison of the $v_i$ measured relative to the participant and the spectator plane with the corresponding eccentricities allows constraining the initial state models. The particle-type dependence of these differences is sensitive to the viscous effects in the QGP expansion.

ALICE measurements of the $v_2$ for pions, kaons and protons with respect to the spectator plane in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV are presented. The measurement of the particle-type dependent difference between $v_2$ relative to spectator plane and that of four-particle cumulants extends on previously published results for charged hadrons and allow to separate effects from QGP evolution and initial state fluctuations.

Equation of motion of the shear stress tensor in the momentum approximation — T. Füll for FIAS, Frankfurt am Main, Germany

One of the most prominent theories for the evolution of the hot quark gluon plasma is kinetic theory. The common equations of motion (EOM) by Israel and Stewart lack a method for consistently increasing accuracy, namely a power counting scheme. This is due to a truncation of the expansion of the distribution function before deriving the EOM. But in fact the equations of motion can be derived without closing the expansion leaving infinitely many moments of the Boltzmann equation and being able to decide on the order of the approximation afterwards. This work revises the EOM derived by Denicol et al. at the example of the shear stress tensor. The truncation will be done afterwards to arrive at the EOM of the 14-moment approximation with the incorporated power counting scheme in the Knudsen- and inverse Reynolds-number.

Collective flow at SIS energies within a hadronic transport approach: Influence of light nuclei formation and equation of state — J. Moehle and H. Elsner for the CBM-Collaboration — Goethe-Universität Frankfurt am Main

The CBM Collaboration study light nuclei in ultrarelativistic heavy-ion collisions, and the effects on the hadronic matter formed in these collisions. In this talk, we will discuss the current progress on the analysis of the data and the implications of the findings for the field.

Collective flow measurements with HADES in Au+Au collisions at 1.23 AGeV — F. Zuber for the HADES Collaboration — Goethe-Universität Frankfurt am Main

The HADES Collaboration has recently presented measurements of elliptic flow coefficients $v_2$ for protons, deuterons and tritons in Au+Au collisions at 1.23 AGeV. These results will be discussed in detail. In particular, the impact of the initial state is investigated using various models and the implications for the equation of state of the fireball will be presented.

Heavy-Ion Collisions and QCD Phases II

Time: Monday 16:30–18:00

Group Report

Dielectrons with ALICE - Past, Present, Future — Sebastian Schieß for the ALICE Germany-Collaboration — Goethe-Universität Frankfurt, Germany

The measurement of dielectrons is a fundamental piece in the understanding of hot and dense matter produced in ultra-relativistic heavy-ion collisions. The dielectron spectra yield information that pierce the veil of final-state hadronic interactions and give direct access to the early phases of the collision. ALICE recently started the LHC Run 3 data taking campaign after a major upgrade of the detector, which will significantly improve the capabilities to measure dielectrons. In this talk, we will give an overview of the dielectron measurements achieved so far with ALICE in different collision systems. Furthermore, the status of the Run 3 analyses together with the prospects for the Runs 3 and 4 will be presented. In particular, the impact of the detector upgrades installed during the long shut down will be explained. Finally, ultimate precision dielectron measurements in the context of the ALICE 3, a next-generation heavy-ion experiment at the LHC, will be discussed.


As dielectrons are radiated from the extreme states of matter created in heavy-ion collisions with negligible final-state interactions, they retain the information imprinted on them at the time of their creation. Multi-differential measurements of dielectron invariant mass, momentum, and angular distributions can therefore serve as a multi-messenger tool to characterize the properties of matter in the interior of the hot and dense fireball. To compute thermal dielectron spectra, we integrate in-medium dielectron rates over the space-time evolution of the collision zone using a microscopic approach. In this talk, we will present the results of recent calculations and discuss their implications for the understanding of the fireball.

Dielectron Analysis for the CBM Experiment — Adriaan Meyer-Ahrens for the CBM Collaboration — Institut für Kernphysik WWU Münster, Münster, Deutschland

This work has been supported by: VH-NF-823, Helmholtz Alliance HA216/EMMI, GSI, HHFF, and the DFG through grant CRC-TR21.
The Compressed Baryonic Matter (CBM) experiment is a fixed-target heavy-ion experiment currently under construction at FAIR in Darmstadt which will explore the QCD phase diagram at high net-baryon densities. Dielectrons serve as versatile probes for the properties of the hot and dense medium created in the collisions since they do not interact strongly and escape the fireball undisturbed. Dielectron physics relies on the efficient reduction of combinatorial background, dominated by misidentified hadrons as well as electrons from photon conversions in the target or detector material.

In this talk, simulation results concerning dielectron invariant mass spectra at CBM will be presented, focussing on background rejection using conventional cut-based selections as well as machine learning methods. This work is supported by BMBF grant 05P12P0FCC1.

**HK 6.4 Mon 17:30 SCH/A315**

Real-time methods for spectral functions — Jochen Streicher, Ralf-Arno Trojewska, Lorenz von Smekal, and Jochen Wambach — Technical University of Darmstadt, Germany — "GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany — Justus Liebig University Giessen, Germany — "Helmholtz Research Academy Hesse for FAIR (HHHF)

Dielectrons provide a unique way to access the properties of the fireball in heavy ion-collisions. While the bulk of the detected particles stemming from heavy ion collisions are hadrons, particles heavily influenced by final state interactions, dileptons do not suffer from this disadvantage and can leave the fireball undisturbed, probing the hot and dense matter before it freezes out. We use the microscopic transport model UrQMD to simulate heavy-ion collisions at SIS18 energies in different centrality classes. Employing a Coarse Graining approach, we are able to combine the simulated microscopic dynamics with in-medium spectral functions obtained from FRG methods at final momenta. This allows to study the impact of finite momentum effects of the spectral function on the dilepton spectral invariant mass spectra measured at SIS18 energies.

Supported by VH-NG-423, DFG CRC/TR 211 and GSI.

**HK 7: Hadron Structure and Spectroscopy I**

**Group Report**

**HK 7.1 Mon 16:30 SCH/A316**

A coupled channel analysis of + u * e * annihilation in the bottomonium region — Nils Husek, Ryan Mitchell, and Eric Swanson — 1Johannes Gutenberg-Universität Mainz — Indiana University Bloomington — 3University of Pittsburgh

In recent years, a large number of exotic hadron candidates have been discovered in the charmonium and bottomonium regions. Electron positron annihilation in experiments like BaBar, BESIII, Belle(II) and CLEO has played an important role in the discoveries of many of these charmonium- and bottomonium-like states, in particular of vector-states directly produced in the collision. Thus far, new resonances have regularly been studied using fits of simplified models to the cross sections of + u * e * to exclusive final states, leading to large model dependencies. Here, we will present the first global and unitary analysis of differential cross sections of + u * e * → b b final states having at least one + u * e * contribution. Our analysis approach is based on a non-relativistic quark model which is extended with a self-interacting scalar field. Inspired by the well-known Caldeira-Leggett model, we extend the classical Langevin dynamics for the coupling to an external heat bath to the corresponding Heisenberg-Langevin dynamics in the GSA. We furthermore use the latter to compute spectral functions which work particularly well in complementary temperature regimes.

Supported by VH-NG-423, DFG CRC/TR 211 and GSI.

**HK 7.2 Mon 17:00 SCH/A316**

Continuity Constraints for Partial-Wave Analyses — Florian Kaspar and Jakob Knollmuller for the COMPASS-Collaboration — 1Peking am Institut für Hochenergiephysik (IHEP) betrieben und zeichnet sich durch große Datasets mit Schwerpunktsenergien zwischen <3 TeV> aus, wodurch die Untersuchung seltener Charmonium-Zerfälle möglich ist. Auf Basis von QCD-Rechnungen wird ein 12%–Verhältnis zwischen den Verzweigungsverhältnissen von + u * e * und ψ(2S) in Hadronzerfällen mit drei Gluonen oder einem Photon vorausgesagt. Diese Vorhersage wird in einigen Zerfällen, beispielsweise dem Zerfall über + u * e *, nicht erfüllt. Die Ursache dieses sogenannten + u * e *-Puzzles, welches bereits seit 1983 erforscht wird, ist jedoch nicht vollständig bekannt. Durch die Bestimmung bisher nicht bekannter oder unge- nau vermesserter Verzweigungsverhältnisse von ψ(2S) → + u * e * und ψ(2S) → + u * e *
$\psi(2S) \rightarrow \phi \phi'$ soll ein Beitrag zum besseren Verständnis des $\rho \pi$-Puzzles geleistet werden. Die Analyse basiert auf einem Datensatz von über 22 - 10^6 $\psi(2S)$-Ereignissen. In diesem Beitrag werden vorläufige Ergebnisse für die Verzweigungsverhältnisse der Zerfälle von $\psi(2S)$ in $\phi \phi'$ und $\phi' \phi$ vorgestellt. Gefördert durch die DFG (CRC 110 / NSFC-DFG).

HK 7.5 Mon 17:45 SCH/A316
Untersuchung der Zerfallskanäle $\psi(2S) \rightarrow \omega \eta'$ und $\omega \eta''$ bei BESIII —
• LIU LI HU / Ruhr-Universität Bochum, Institut für Experimentalphysik I, 44780 Bochum

Die Quantenchromodynamik sagt ein Verhältnis von 12, 7 % zwischen hadronischen $J/\psi$- und $\psi(2S)$-Zerfällen voraus. Dies ist als "12 %-Regel" bekannt. Eine Abweichung wurde erstmals für den Zerfall in $\rho \pi$ festgestellt. Seitdem werden Zerfallskanäle, die diese Regel nicht erfüllen, unter dem $\rho \pi$-Puzzle zusammengefasst.

Um das Verhältnis zwischen $J/\psi$- und $\psi(2S)$-Zerfallsbreiten zu bestimmen, ist es erforderlich, die einzelnen Zerfallsbreiten genau zu vermessen. Die Zerfallsbreiten $\psi(2S) \rightarrow \omega \eta'$ sind mit großen statistischen Fehlern behaftet. Der Prozess $\psi(2S) \rightarrow \omega \eta'$ wurde bisher nicht beobachtet. Das BESIII-Experiment am Elektron-Positron Collder BEPCII in Peking hat Datensätze mit hoher Statistik für die $J/\psi$- und $\psi(2S)$-Resonanzen aufgezeichnet. Die Prozesse $\psi(2S) \rightarrow \omega \eta', \omega \eta''$ werden auf Basis von über 22 - 10^6 Ereignissen untersucht. Vorläufige Ergebnisse für die Bestimmung der Verzweigungsverhältnisse werden vorgestellt. Gefördert durch die DFG (CRC 110 / NSFC-DFG).

HK 8: Nuclear Astrophysics I

Time: Monday 16:30–18:00

Group Report

HK 8.1 Mon 16:30 SCH/A419
Activation experiments for $p$-process nucleosynthesis at the University of Cologne —
• MARTIN MÜLLER, FELIX HEIM, SVENJA WILDER, PÄNZA WÜNSTENBERG, and ANDREAS ZIEGES — University of Cologne, Institute for Nuclear Physics

For modeling the vast reaction networks involved in the production of heavy proton-rich isotopes in $p$-process nucleosynthesis, reaction cross sections for ten thousands of reactions are needed. It is impossible to measure all of these reactions in the laboratory because of which theoretical calculations of crossing sections are imperative. To verify and adjust these calculations a comprehensive experimental database is needed [1]. A powerful method for extending the available database is the activation technique, which has been applied in various forms at the University of Cologne utilizing its 10 MV FN tandem and 6 MV HVE tandetron accelerators as well as the Cologne Clover Counting setup consisting of two clover-type HPGe detectors. Experiments combining the activation technique with in-beam measurements or the stacked-target method will be reported on, a method for utilizing two-step decays will be introduced, and results for the $^{184}$Ir,$^{186}$Os,$^{188}$Re,$^{190}$Pt,$^{192}$Os,$^{194}$Pt,$^{196}$Pt,$^{198}$Pt,$^{200}$Pt decay, will be presented.

Supported by the DFG (GI 510/8-2).


HK 8.2 Mon 17:00 SCH/A419
New Cross Section Data for Radiative Proton Capture on Carbon for Nuclear Astrophysics at LUNA —
• ALEX BOETTELZIG and JAKUB SKOWRONSKI — LUNA-Collaboration —
\textit{a} Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — \textit{b} Universität des Studi di Padova and INFN Sezione di Padova, Padua, Italy

The observable ratio of $^{12}$C/$^{13}$C can be used as a probe for stellar nucleosynthesis as well as for mixing processes during hydrogen burning, provided that the reaction rates and $^{12}$C($p$, $\gamma$)$^{13}$N and $^{12}$C($p$, $p$)$^{13}$N are known. To obtain direct cross section measurements at low energies, which are required to better constrain these rates in astrophysical scenarios, both reactions were studied in a series of experiments at the LUNA-400 accelerator. Different targets and complementary detector setups were employed for a systematic study, and the sensitivity afforded by the low-background underground environment allowed for precise measurements at lower energies than previously available. We will present these experiments and their results for both reactions.

HK 8.3 Mon 17:15 SCH/A419
Cross section measurements of the $^{12}$C($p$, $\gamma$)$^{13}$N reaction in the energy range of 130 keV to 640 keV —
• SIMON RÜMMER — Helmholtz-Zentrum Dresden-Rossendorf, Institute of Radiation Physics —
TU Dresden, Institute of Nuclear and Particle Physics

The CNO-cycle is the dominant hydrogen burning process in stars over a temperature of 17 million Kelvin. The rate of this cycle in the initial phase and in the outer shells of the burning zone is dominated by the rate of the $^{12}$C($p$, $\gamma$)$^{13}$N reaction. Furthermore, this reaction affects the ratio of $^{12}$C to $^{13}$C abundances. Efforts are underway to re-measure the cross section of the $^{12}$C($p$, $\gamma$)$^{13}$N in the energy region of the 400 keV resonance, leading to an improved extrapolation to astrophysically relevant energies.

In 2017 the reaction was studied in inverse kinematics at the 3 MV Tandem accelerator at Helmholtz-Zentrum Dresden-Rossendorf in an energy range of 130 keV to 450 keV. Further measurements in the energy range of 330 keV to 640 keV with low background were done at the 5 MV Pelletron accelerator at the Felsenkeller shallow-underground laboratory in Dresden in 2022. The methods and results of these measurements, as well as a conclusion of the two campaigns, will be presented.

HK 8.4 Mon 17:30 SCH/A419
Analysis of the 3α-decay of the $^{20}$Ne state in $^{12}$C —
• JOE ROO1, PETER REITER2, KONRAD ARNSWALD2, MAXIMILIAN DROSTE2, PAVEL GOLUBEV2, ROUVEN HIRSCH1, HANNAH KLEIS1, NIKOLAS KÖNIGSTEIN1, MADALINA RAVAR1,3, DIRK RUDOLPH3, ALESSANDRO SALICE1 und LUIS SARMIENTO1 —
1 University of Cologne, Institute for Nuclear Physics, Cologne, Germany —
2 Lund University, Department of Physics, Lund, Sweden —
3 TU Darmstadt, Institute of Nuclear Physics, Darmstadt, Germany

The Eigenschaften des 3-Körper-Zerfalls der angeregten Zustände von $^{12}$C ermöglichen einen direkten Vergleich mit theoretischen Modellen zur Struktur von $^{12}$C. Er ermöglicht einen direkten Vergleich mit theoretischen Modellen zur Struktur von $^{12}$C.}

The 3α-decay of the $^{20}$Ne excited state at 22 MeV was studied with the help of a novel method, the so-called 3α-teaching method, which allows for an improved analysis of the 3α-decay of the $^{20}$Ne excited state. The method is based on the observation that the 3α-decay of the $^{20}$Ne excited state at 22 MeV is a three-alpha decay process, which is a rare and challenging process in nuclear physics. The method involves the use of a special detector setup, which is able to detect the three-alpha particles simultaneously. The observed energy spectrum of the 3α-decay of the $^{20}$Ne excited state at 22 MeV is consistent with the theoretical predictions of the 3α-teaching method. The results of this study will be presented.

HK 8.5 Mon 17:45 SCH/A419
Analysis of the 3α-decay of the $^{20}$Ne state in $^{12}$C —
• DAVID WERNER1, JOE ROO1,2, PETER REITER2, KONRAD ARNSWALD2, MAXIMILIAN DROSTE2, PAVEL GOLUBEV2, ROUVEN HIRSCH1, HANNAH KLEIS1, NIKOLAS KÖNIGSTEIN1, MADALINA RAVAR1,3, DIRK RUDOLPH3, ALESSANDRO SALICE1, LUIS SARMIENTO1 —
1 University of Cologne, Institute for Nuclear Physics, Cologne, Germany —
2 Lund University, Department of Physics, Lund, Sweden —
3 TU Darmstadt, Institute of Nuclear Physics, Darmstadt, Germany

The branching ratios between the direct and sequential three-alpha decay of the $^{20}$Ne excited state at 22 MeV, the 3α-state, are important for the probes of the new structure of $^{12}$C and provide insights into stellar nucleosynthesis. Two high-statistics experiments were performed at the 10 MeV FN-tandem accelerator of the Institute of Nuclear Physics of the University of Cologne. A $^{12}$C($a$, $\alpha$) re-action at a beam energy of 27 MeV was utilized to populate the state of interest. The Lund-York-College-Calorimeter (LYCCA) was used to study the three-particle decay branches of the 3α-state. The 8 segmented double-sided silicon strip detectors allowed individual detection of the reaction’s four α particles with high angular precision. Results from particle spectra are compared with Geant4 Monte-Carlo simulations. Latest analysis results, in particular Dalitz plots and the search for the direct 3α-decay will be presented.
Investigation of the low-lying dipole strength in $^{97}$Ni — T. Anja Schützler, Floriana Klug, Miriam Mäschler, Ronald Schwengner, and Andreas Zilges — University of Cologne, Institute for Nuclear Physics

Systematic studies within isotopic and isochronous chains are essential to investigate the properties of the low-lying dipole strength below and around the neutron-separation threshold. The nickel ($Z = 28$) isotopic chain is a well-suited candidate for this purpose because it consists of four stable, even-even isotopes covering a large range of N/Z ratios. Since photons just transfer small angular momenta, $(\gamma,\gamma'$) experiments are ideally suited to study the dipole response in atomic nuclei. [1]. The isotopes $^{56,60,64,68,70,74,78,82,86,90}$Ni have already been measured in $(\gamma,\gamma')$ experiments [2-5]. To complete the systematics, [1] Ni was investigated using energetically continuous bremsstrahlung with a maximal photon energy of $E_{\gamma,max} = 8.7$ MeV at the yELBE facility [6]. First results of this experiment will be presented.

This work is supported by the BMBF (05P21K09E9).


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HK 10.2 Mon 17:00 SCH/A215
The Charge Radius of $^{26,28m}_{+}$Al and its implication for CKM unitarity — Peter Plattner — Max-Planck-Institut fuer Kernphysik, Heidelberg, Germany
For the COLLAPS and IGISOL collaborations.

In the study of atomic nuclei, nuclear charge radii provide intriguing physics insights into the evolution of nuclear structure far away from stability. Furthermore, charge radii have been used as experimental input for the determination of $V_{ud}$ of the CKM quark mixing matrix from superallowed nuclear $\beta$-decays. In the Standard Model of particle physics, the CKM matrix is predicted to be unitary but recent reviews of the matrix values show a 2.2 deviation for one of its unitarity tests.

This contribution will present the recent work of combined measurements of the charge radii of $^{26,28m}_{+}$Al by means of Collinear Laser Spectroscopy (CLS) at the COLLAPS experiment/ISOLDE and at the IGISOL facility/Jyväskyla, Finland. CLS takes advantage of the transition between the atomic nucleus and its surrounding electrons giving rise to the hyperfine structure. Thus, properties of nuclear ground states and long-lived isomers, including nuclear charge radii, can be inferred from measured hyperfine spectra. Prior to the present work, the charge radius of the superallowed $\beta$ emitter $^{26m}_{+}$Al was not known experimentally but was extrapolated to evaluate the isospin symmetry breaking (ISB) correction required for the determination of $V_{ud}$.

The present measurements reveal a charge radius of $^{26m}_{+}$Al which differs by more than 4 standard deviations from the value assumed in previous ISB calculations.

HK 10.3 Mon 17:15 SCH/A215
$^{83m}_{+}$Kr N-line spectrum measurement at KATRIN — Matthias Böttcher¹, Moritz Machatschkie², Magnus Schlosser², and Jaroslav Stoker³ for the KATRIN-Collaboration — ¹Institute of Nuclear Physics, University of Münster — ²Institute for Astroparticle Physics, Karlsruhe Institute of Technology
The $^{83m}_{+}$Kr conversion electrons are used for calibration purposes of different (astro-)particle physics experiments due to the narrow $^{83m}_{+}$Kr line widths and short $^{83m}_{+}$Kr half-life. In the KARLNeU Tritium Neutrino experiment (KATRIN), that currently provides the best neutrino mass upper limit of 0.8 eV/c² at 90% C.L. in the field of direct neutrino-mass measurements, several systematic uncertainties are studied by a shape distortion of the quasi monoenergetic $^{83m}_{+}$Kr spectrum. This creates high demands on precise knowledge of the undistorted spectrum. In KATRIN we use the 32 keV N-lines lying in the high energy region of the spectrum including the weaker N$_1$ line. In this talk, results of a dedicated measurement of the $^{83m}_{+}$Kr electron N-spectrum with emphasis on N$_1$ line position and width conducted at unprecedented precision at KATRIN will be presented.

This work is supported by the Ministry for Education and Research BMBF (05A17PM3, 05A17PX3, 05A17K2, and 05A17W03) and the Doctoral School "Karlsruhe School of Elementary and Astroparticle Physics: Science and Technology (KSETA)" through the GSSP program of the German Academic Exchange Service (DAAD).

HK 10.4 Mon 17:30 SCH/A215
Implementation of silicon photomultipliers to detect single photons — Imke Lopp¹, Laura Rentzi¹, Bernhard Maass², Patrick Müller¹, Julian Palmes³, Julian Spahn³, and Wilfried Nörtershäuser⁴ — ¹Institut für Kernphysik, TU Darmstadt, Germany — ²Argonne National Laboratory, Chicago, IL, USA
Precise and sensitive measurements in collinear laser spectroscopy require detectors with a high detection efficiency for single photons. At the same time, the dark count rate of the detector and the generated background, e.g., from scattered light, should be as low as possible. Common systems use a combination of mirrors or lenses and photomultiplier tubes.

We investigated whether silicon photodiodes (SiPMs) are suitable for this application. Due to their detection area, the photodiodes can be better arranged to cover the optimal detection area than photomultiplier tubes with their circular detection area. Collinear laser spectroscopy on $^{125}_{+}$Ce and $^{131}_{+}$I ions was used to compare the detectors in the UV and optical region, respectively. Funded by BMBF, contract 05P21RDFN1.

HK 10.5 Mon 17:45 SCH/A215
Collinear Laser Spectroscopy on Neutron Rich Palladium — Laura Rentzi for the ATLANTIS-Collaboration — Institut für Kernphysik, Technische Universität Darmstadt, Darmstadt, Germany
Collinear laser spectroscopy gives access to isotope shifts and hyperfine parameters at high precision. From this, nuclear charge radii, nuclear magnetic and electric moments and nuclear spins can be determined. The LSEPEC beamline, originally designed for collinear laser spectroscopy at FAIR, has been connected to the Californium Rare Isotope Breeder Upgrade (CARIBU) and is now the central part of ATLANTIS (Argonne Tandem hall LAser beamNe for aTom and Ion Spectroscopy). Results from its commissioning and a first physics run on neutron-rich palladium isotopes will be presented. Short-lived $^{110}_{+}$Pd ions were delivered from CARIBU and neutralized to a fast atomic beam. Laser fluorescence spectroscopy was performed on the isotopes $^{110,112,114}_{+}$Pd. Spectra of all stable isotopes (even $^{102}_{+,+}^{110}_{+}$Pd and $^{105}_{+}$Pd) were taken for reference with ions delvered by a laser-ablation ion source. Further measurements will be performed on products of the CARIBU successor nuCARIBU.

This work was supported by DFG – Project Id 279384907/SPF 1245, and by BMBF 05P19DRDN1.

HK 11: Outreach Public/Teilchenwelt (joint session T/HK)
Time: Monday 16:30–18:00

HK 11.1 Mon 16:30 HSZ/0204
The german LHC-Office for outreach, transfer and promotion of young talents — Marius Hoffmann¹, Marie-Lena Dieckmann¹, Harald Appelhäsuer³, Johannes Haller², Stephanie Hansmann-Menzemer², and Arnulf Quarst³ — ¹Georg-August-Universität Göttingen — ²Universität Hamburg — ³Goethe-Universität Frankfurt — Universität Heidelberg
Communicating the scientific results to the public, fostering cooperation with partners in industry and the promotion of young talents are key tasks of the german LHC research groups. For this reason in 2020, the research focuses ("Forschungsschwerpunkte" short ErUM-FSPs) of the four LHC experiments have initiated a joint "LHC-Office" which is funded by the Federal Ministry for Education and Research (BMBF). Since then, the LHC-office has been active in a multitude of areas, including a common brochure, a new joint website, the participation at major industry fairs as well as several workshops and events to promote young researchers. This talk will give an overview of the work of the LHC-office's work of the last two years and present an outlook into future activities.

HK 11.2 Mon 16:45 HSZ/0204
KCETA event summer — Katrin Link — Karlsruhe Institute of Technology, KIT Center Elementary Particle and Astroparticle Physics KCETA, Karlsruhe, Germany
In the summer of 2022, the traveling exhibition "Code of the Universe" (code-oftheuniverse.eu) designed by CERN, was displayed for four weeks in the center of Karlsruhe. Accompanying this, the KIT Center for Elementary Particle and Astroparticle Physics (KCETA) organized a colorful program of events for a broad audience. The series of events included a vernissage, a lecture evening as part of the Karlsruhe EFFEKTE series and a panel discussion on the topic "Kommen großere Forschungsinfrastrukturen an ihre Grenzen? Neue Energieressourcen für die Forschung der Zukunft?". The main focus was on "Science Afternoons", during which the individual working groups of KCETA presented their research with a small exhibition, hands-on experiments and short lectures. Additionally a special programm for pupils was offered, including masterclasses and "Physik am Samstag". In this talk we want to present the different formats we used to interact with a broad audience and report from our experiences.

HK 11.3 Mon 17:00 HSZ/0204
Belle II - The Beauty goes public — Johanna Hausler and Thomas Kuehr — LMU, München, Deutschland
Public outreach is an element feature of modern science. In particular, the large and internationally organized particle physics experiments have great potential to raise public awareness of physics - both in terms of the physics questions themselves and the technological developments associated with fundamental research. The Belle II experiment is a rather novel experiment based in Japan and involving worldwide collaboration. The German Belle II institutes - in close cooperation with partner organizations and supported by a BMBF "Forschungsschwerpunkt" - are in the process of building a network and developing a strategy to present Belle II particle physics research to the German public. This is particularly interesting in view of the important scientific results that are expected from Belle II in the coming years. The outreach strategy includes a corporate design, a strategy to present the Belle II institutes, scientific results and staff both on Twitter and on the Belle II homepage, basic outreach activities in education (e.g., a course for primary school students) and the design of the "Belle II model" and industry transfer to promote technological development and human potential in the broad field of industry.
Hadronic and Nuclear Physics Division (HK)

Urknall unterwegs: eine mobile Ausstellung zur Teilchenphysik — Uta BLOW, MICHAEL KOBEL und PHILIPP LINDENAU for the Netzwerk Teilchenwelt-Kollaboration — TU Dresden, Institut für Kern- und Teilchenphysik


Nachwuchs für die Forschung gewinnen: Das Fellow-Programm von Netzwerk Teilchenwelt — ANDREA MAYER-HOUDELETT, UTA BLOW und MICHAEL KOBEL für die Netzwerk Teilchenwelt-Kollaboration — TU Dresden, Institut für Kern- und Teilchenphysik


The Network Teilchenwoche: active Teilhabe an der aktuellen Forschung für Jugendliche am CERN — UTA BLOW, NIKLAS HERFF, MICHAEL KOBEL, FRANZISKA RAUSCHER und SASCHA SCHMELING für die Netzwerk Teilchenwelt-Kollaboration — TU Dresden, Institut für Kern- und Teilchenphysik

Im Fünf-Schritten-Programm von Netzwerk Teilchenwelt bilden die Projektwochen am CERN eine äußergewöhnliche Möglichkeit für motivierte Jugendliche. Bis zu zehn Jugendliche, die durch ihr vorheriges Engagement bereits ein umfassendes Wissen und eine große Begeisterung für die "Physik der kleinsten Teilchen" mitbringen, bekommen die Chance, selbst einmal richtig in die Forschung einzutreten. Im Rahmen einer umfangreichen Forschungsarbeit, die von schulischem Unterricht über Beratung bis hin zur Teilnahme an Experimenten, und die individuelle Projekte in verschiedenen Bereichen am CERN statt. Betreut von Wissenschaftler:innen arbeiten die Jugendlichen zwei Wochen in einem Team an CERN, in dem sie beispielsweise Daten analysieren oder Detektorkomponenten vermessen und auswerten.

In einem gemeinsamen Vortrag von Niklas Herff (der verantwortlichen Person am CERN) und Franziska Rauscher (einer Teilnehmerin der Projektwochen 2022) werden die besonderen Chancen dieses Programms genauer vorge stellt.

Invited Talk

Baryon spectroscopy at ELSA and MAMI — FARAH AFZAL for the CBELSA/TAPS-Collaboration — HISKP, Uni Bonn

To improve our knowledge of the exact dynamics between the constituents of baryons and to better understand quantum chromodynamics (QCD) in the non-perturbative regime, the baryon excitation spectrum is investigated. Experimentally, it can be probed with a real photon beam by studying photoproduction reactions. Partial wave analyses are performed to extract the baryon resonance parameters from the experimental data. For an unambiguous solution it is not enough to only measure the unpolarized cross section, but several single and carefully chosen double polarization observables are essential as well.

Worldwide, various experimental facilities have dedicated programs to measure these polarization observables in different photoproduction reactions using polarized photon beams and polarized targets. Two of the leading experimental facilities are located in Germany, the CBELSA/TAPS experiment at the accelerator facility ELSA in Bonn and the Crystal Ball experiment at the accelerator facility MAMI in Mainz. Both experiments are excellent at measuring neutral mesons in the final states, using electromagnetic calorimeters covering almost the full angular range, while exploring complementary beam energy regions. This talk will give an overview about recent results in non-strange baryon spectroscopy at ELSA and MAMI.

Invited Talk

ALICE upgrades, status and perspectives for ALICE-3 — RObERT MEYNER for the ALICE Germany-Collaboration — Institut für Kernphysik, Goethe Universität Frankfurt, Deutschland

The ALICE experiment at CERN has undergone a major upgrade in preparation of LHCB Run 3. A new Inner Tracking System and a system of new trigger detectors were installed while the Time Projection Chamber was upgraded with GEM-based readout chambers. The muon system was extended by the Muon Forward Tracker. In addition, the readout of all detectors and the computing infrastruc-
HK 13: Instrumentation IV

Time: Tuesday 17:00–18:15

HK 13.1 Tue 17:00 SCH/A251
SiPM-characteristics after proton irradiation — Vincint Verhoeven, Det-Gryzonka, and James RITMAN — 1 GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany — 2 Ruhr-Universität Bochum, Institut für Experimentalphysik I, 44801 Bochum, Germany — 3 Institut für Kernphysik, Forschungszentrum Jülich, 52428 Jülich, Germany

SiPMs are frequently used for the photon read out of scintillation detectors as an alternative to a conventional photomultiplier. SiPMs exhibit a high photon detection efficiency in the order of 40%, achieve internal amplifications of 10^6 to 10^7, require rather low operating voltages, are insensitive to magnetic fields and, due to the small size, simplify the mechanical construction of detector components. A drawback is the sensitivity of SiPMs to irradiation resulting in a remarkable change of the behavior already at a rather low radiation dose.

In order to determine the effect of irradiation for the SiPM operation as photon sensors, the characteristics of SiPMs after irradiation with a 35 MeV proton beam have been studied. In addition to the basic properties, the performance as a photon detector at various photon numbers was investigated. With a bake-out at temperatures of up to 150 °C a regeneration to a certain degree was achieved.

The characteristics of SiPMs as a function of radiation dose and its possible regeneration at high temperatures will be presented.

HK 13.2 Tue 17:15 SCH/A251

Degradation of the optical transmission of lead tungstate (PWO) scintillation crystals in the luminescence spectrum under ionizing radiation leads to loss of the light output, which results in the deterioration of the energy resolution. Stimulated recovery allows to restore the optical transmission losses and is achieved by inducing photons of different wavelengths via external light sources (laser diode, LED). Here we report on new results of studies on the stimulated recovery and the radiation damage under gamma irradiation cooled down and at room temperature of lead tungstate crystals. It includes light output and transmittance degradation of PWO, correlations between variations of transmittance at 420 nm and the radiation induced absorption coefficient. Moreover, we present the first lab first experiment results of in-situ recovery of the PWO optical transmission during radiation period 1. We also propose the model of the radiation damage and the stimulated recovery of damaged PWO after gamma irradiation as well as spontaneous recovery.

This work is supported by BMBF, GSI and HFFF.

HK 13.3 Tue 17:30 SCH/A251
Pre production tests of the PANDA BARREL EMC Slice* — Thostben Erlen — 2 Physikalisches Institut, JLU Gießen, Deutschland

The Electromagnetic Calorimeter (EMC) of the future PANDA Experiment at the FAIR complex in Darmstadt will use lead tungsten scintillator crystals (PWO II) to convert energy into an according amount of light and in most parts two Large Area Avalanche Photo Diodes (LAAPD) per crystal are used to measure the amount of light created. Main characteristics of both the scintillator and the photosensors are temperature dependent. With decreasing temperature the light yield (photons per MeV) of the scintillators increases and the noise of the photosensors is reduced, while their gain-factor at a fixed voltage increases. The nominal operating temperature for the EMC is -25 degree celsius to meet the desired properties and allow the EMC to perform according to the needs of the experiment. Energy resolution and threshold depend on a system that is capable of achieving and maintaining stable crystal and photosensor temperatures. Topic of this talk will be the results of test measurements with the first in kind (slice of sixteen) for the barrel part of the calorimeter, using the latest (pre)production versions of the cooling, monitoring and front end electronic systems. Cooling and monitoring system design solutions will be presented in more detail.

HK 14: Instrumentation V

Time: Tuesday 17:00–18:45

Group Report

HK 14.1 Tue 17:00 SCH/A.101
A State-of-the-Art Cluster-Jet Target for the PANDA Experiment at FAIR — Philipp Brand, Daniela Bonaventura, Hanna Eick, Jost Froning, Lennart Halstenberg, Christian Mannweiler, Sophia Vestricks, Michael Weide, and Alfons Khoukaz for the PANDA Collaboration — Institut für Kernphysik, Westfälische Wilhelms-Universität Münster, 48149 Münster, Germany

The PANDA cluster-jet target that will be installed at the High Energy Storage Ring (HESR) at FAIR is the world’s leading target of its kind. It allows for hydrogen target thicknesses of more than 10^13 atoms/cm² at the interaction point, which is located more than 2 m below the nozzle. This is achieved by a complex machine that has been developed over the last year, including several systems for adjustment and diagnosis. Among them are special developments just for this purpose. This also includes the diagnostic systems that will be mounted into a modified version of the cluster-jet beam dump, which is the latest development.

Furthermore, the target has already been tested extensively in our institute but also at the COoler SYnchrotron (COSY) at FZ Jülich, where the interaction of a proton beam with the target in presence of the HESR stochastic cooling devices has been studied.

The target with all the technical developments that will be installed at its final version will be presented and some results of measurements with the PANDA target will be discussed.

This project has received funding from BMBF (05P2PMFP1), GSI FUE (MSKHOU2023) and the EU’s Horizon 2020 programme (824093).

Group Report

HK 14.2 Tue 17:30 SCH/A.101

The LHCspin project aims at unpolarized (SMOG2) and polarized fixed-target measurements by means of a gas target upstream of the LHCb detector, close to the vertex detector VELO. The forward geometry of the LHCb spectrometer
The internal and windowless cluster-jet targets from the WWU Münster are a key component of several experiments at various research facilities. One of them is the IHU Düsseldorf where the 200 TW ARCTURUS laser was used to investigate the laser-cluster interaction. In this context measurements are performed in order to study some important properties of the used hydrogen clusters, like the size of the clusters and their size distribution. To find out the size of the clusters, they are visualized by the shadowgraphy method. For this purpose, the ultra-short pulse ARCTURUS laser is illuminating the cluster beam and shadowgraphy images are taken. The evaluation of cluster diameters has to be automated due to the large number of recorded photos. This talk provides an overview of the results of the analyzed shadowgraphy measurements for various target settings and also for different positions in the cluster beam. By comparing the effective flow of material through the nozzle with the flow of clusters visible in these shadowgraphs, the amount of (invisible) gas embedded in the clusters can be estimated. This project has received funding from BMBF (05P2IPMFP1), GSI (MSKHOU2023) and the EU’s Horizon 2020 programme (824093).

HK 15.4 Tue 18:30 SCH/A.101
Transforming targets: Adapting a cluster-jet target for use as a droplet target — CHRISTIAN MANNWEILER, DANIEL BONAVENTURA, JOST FRONING, EVA-MARIA HAUSCH, ELENA LAMMERT, and ALFONSO KHOUKAZ — WWU, Münster, Deutschland
Internal targets such as H$_2$ cluster-jet targets and H$_3$ pellet targets have found widespread use in different fields of physics such as particle- and plasma physics. A prominent example is the future PANDA experiment at FAIR which will employ both target technologies for hadron physics experiments using antiproton annihilator beams.

Both types of target make use of cryogenic hydrogen in different forms. In the cluster-jet target it takes the form of a continuous beam made up of many small hydrogen clusters which achieve sizes from the nanometer scale up to several microns in diameter while a droplet target produces a stream of mono-sized, well separated hydrodynamic droplets at diameters in the tens of microns. Up until now, both target technologies were considered separately from each other, with a target device either creating cluster-jet beams or pellet beams. However, they remain closely related, which led us to initiate an R&D program on the development of a hybrid target which can produce both types of beam with only short downtime between swapping modes.

In our contribution we will present how we successfully transformed a cluster-jet target into a droplet target as well as first, encouraging results.

This project has received funding from the EU Horizon 2020 programme (824093).

HK 15.1 Tue 17:00 SCH/A117
Decelerating Antiprotons from 100keV to 4keV — JONAS FISCHER for the PUMA-Collaboration — IKP TU Darmstadt
The PUMA collaboration aims at trapping, storing and transporting $\bar{p}$ antiprotons in a cryogenic Penning trap to perform experiments with radioactive nuclei and investigate the nuclear density at the outermost part of the nucleus itself. To achieve this, antiprotons delivered from the ENELA storage ring at CERN need to be decelerated from 100keV to 4keV in a first step to be able to capture them in the Penning trap [1].

To minimise losses in the deceleration process, a Pulsed Drift Tube (PDT) was installed at a beam line connected to the ENELA storage ring (LNE51) at CERN. A vacuum of below 10$^{-10}$ mbar is necessary to avoid the annihilations of the antiprotons with the residual gas. This, and the required high voltage of about 100 kV, impose strict restraints on the design and operation of the pulsed drift tube. In this talk I will introduce the current setup and its major design considerations. Furthermore, the first successful tests of the setup with antiprotons will be presented.


HK 15.2 Tue 17:15 SCH/A117
The PUMA trap setup at ELENA — ALEXANDER SCHMIDT for the PUMA-Collaboration — IKP TU Darmstadt
The antiProton Unstable Matter Annihilation (PUMA) experiment at CERN will provide the ratio of protons and neutrons in the nuclear density tail as a new observable to test nuclear structure theories. To determine this ratio, the concept of antiprotonic atoms is used. After capture onto an antiprotonic orbital, the antiproton cascades towards the nucleus and eventually annihilates with a nucleon in the tail of the nuclear density distribution [1].

As there is no facility worldwide which provides both low-energy antiprotons and radioactive ions, PUMA uses a transportable setup which combines a cryogenic Penning trap for the long-term storage of antiprotons after accumulation at the ELENA ring and a detection system for the identification of pions originating from annihilations of antiprotons and ions of interest, which are either provided by the offline ion source of PUMA at ELENA, for experiments with stable nuclei, or the ISOLDE facility at CERN for investigating radioactive nuclei.

The first commissioning of a part of the PUMA beam line is currently performed at the Antimatter factory at CERN. This talk will give an status report of the trap and cryostat development and its foreseen implementation for the upcoming ELENA beam time starting in April 2023.

HK 15.3 Tue 17:30 SCH/A117
Recent developments at the sources for ultra-cold neutrons located at the TRIGA research reactor Mainz — SIMON KAUFMANN for the tauSPECT-Collaboration — Department of Chemistry, TRIGA site, Johannes Gutenberg University Mainz
Neutrons created by fission inside the TRIGA research reactor have kinetic energies in the range of MeV. When they are moderated in the range below kinetic energies of 350 neV, they are called ultra-cold neutrons (UCNs). Using materials with a larger Fermi potential than the kinetic energies allows to guide and trap these UCNs. This makes UCNs especially attractive for a variety of neutron based experiments.

In order to provide these UCNs, two UCN-sources are currently operated regularly at TRIGA’s beam ports C&D. While the source at beam port C is mainly operated in a continuous irradiation mode of the reactor, the one at beam port D is operated in a pulsed mode of the reactor. Both face the challenge of converting the kinetic energy of the neutrons from MeV down to neV with a solid deuterium crystal as the main converter. Their efficiency is strongly influenced by the structure of the crystal. This structure can be influenced by controlled thermal changes in order to increase the conversion efficiency.
This talk will present the latest measurements that were performed at beam port D with the aim to create a controlled thermal change sequence to increase and saturate the moderation efficiency.

A non-zero nEDM would break parity and time reversal symmetry and if large enough could explain observations like the matter-antimatter asymmetry of the universe. The standard model of particle physics predicts a neutron electric dipole moment (nEDM) on the order of \(10^{-26}\) e·cm. To probe the standard model of particle physics and constrain the parameter space for other theories, a more precise measurement of the nEDM is needed (current upper limit 1.8 - 10^{-26} e·cm). The aim of the n2EDM experiment is to measure or exclude an nEDM on the order of \(10^{-27}\) e·cm.

In the n2EDM experiment polarized ultra cold neutrons (UCNs) are stored in a vessel across which a combination of a constant electric and magnetic field is applied along the cylinder axis. The vessel consist of the high voltage and ground electrodes and the insulating ring. The Larmor precession frequency of the neutrons is determined by the external fields. If a shift in the Larmor precession frequency between parallel and antiparallel field orientation is measured, the nEDM is non-zero. To ensure long storage and long depolarization times of the UCNs which directly influence the sensitivity of the experiment, a special coating of the storage vessel is needed.

This talk gives an overview of the n2EDM experiment and the production and coating process of the insulating rings of the experiment.


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HK 15.4 Tue 17:45 SCH/A117
Simulations for the ultra-cold neutron lifetime experiment rSPECT —
• Niklas Pfeiffer for the tauSPECT-Collaboration — Institut für Physik, Mainz, Germany

The rSPECT experiment aims to measure the free neutron lifetime with an uncertainty goal of sub second by storing ultra-cold neutrons in a fully magnetic bottle. To study and understand systematic effects and reduce systematic uncertainties, simulations of neutron trajectories and their parameters during the whole measurement cycle are needed. For this we evaluate and use several software packages that can accurately simulate the trajectories of ultra-cold neutrons, protons, and electrons in complex electromagnetic fields as well as the precession of their spins.

This talk will present how the simulation for the rSPECT experiment is set up, challenges and limits of the simulation software and the latest results of the simulations.

A magnetic resonance magnetometer for position verification of a neutron spin-flipper —
• Victoria Ermutr for the tauSPECT-Collaboration — Institut für Physik, Johannes Gutenberg-Universität, Mainz

To measure the free neutron lifetime the rSPECT experiment stores ultra-cold neutrons fully using magnetic field gradients. By flipping the spin of spin-polarized neutrons and thereby transforming high-field-seeking neutrons, whose magnetic moments are aligned with the field, to the low-field-seeking state, where the magnetic moment is aligned opposite the field, the neutrons are filled into the magnetic trap. For the spin flip to be successful the frequency of the spin flipper has to be the Larmor frequency of the neutron at that point in the magnetic field. Therefore, it is necessary to know the magnetic field at the location of the spin flipper. The magnetic field is measured using a nuclear magnetic resonance (NMR) probe to monitor the stability of the magnetic field and provide a reference for the spin flip. Although the NMR probe does not sit directly at the spin flipper, conclusions about the field at the spin flipper can be made. Despite of environmental challenges, like cryogenic temperatures in vacuum, it is possible to measure the magnetic field with a high accuracy and a constant offset and temperature dependency.

This talk will show the construction and functionality of such an NMR probe as well as commissioning data.

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HK 16.1 Tue 17:00 SCH/A216
Hyperon and Hypernuclei Production in the High Baryon Density Region —
• Yue Hang Leung — Physikalisches Institut, Heidelberg University

Hyperon and hypernuclei have been suggested to be sensitive probes to the medium properties of the nuclear matter created in heavy-ion collisions. Measurements on the properties of hypernuclei can also give constraints to the hyperon-nucleon interaction, which is an essential ingredient in the equation of state of high baryon density matter, such as neutron stars. In this presentation, recent results on hyperon and hypernucleon production from intermediate to low energy heavy-ion collisions will be discussed. Future prospects at FAIR, including the ongoing mAQM project, will be discussed.

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HK 16.2 Tue 17:30 SCH/A216
Pining down the (anti-)hypertriton production with ALICE at the LHC —
• Michael Hartung for the ALICE Germany-Collaboration — Institut für Kernphysik, Goethe-Universität, Frankfurt, Germany

At the Large Hadron Collider at CERN, copious production of light (anti-)hypernuclei has recently become a topic of high interest, in particular since the properties of these objects are not measured to high precision. The most prominent example is the (anti-)hypertriton, which is a bound state of a proton, a neutron and a Λ hyperon. It is often discussed as a bound state of a deuteron and a Λ hyperon. If one uses the known Λ separation energy of the hyperon-nucleon interaction, which is an essential ingredient in the equation of state of high baryon density matter, such as neutron stars, one can estimate a size of about 10 fm of the state, which would be larger as a lead nucleus. The size has consequences for its probability to be formed in a coalescence process, which is not expected from a statistical-thermal model approach.
the $A = 4$ mass region, namely the hyperon-hydrogen-4 and the hyperhelium-4. Furthermore, first insights into the measurement of double-strange (anti-)$\psi$ hypernuclei will be shown.

HK 16.4 Tue 18:00 SCH/A216

Hypermultiplicities in heavy-ion collisions at CBM — *Susanne Glässel* and Christoph Blume — IKF Frankfurt

Under extreme conditions of relativistic heavy-ion collisions the creation of exotic matter like hypernuclei is possible. Hypernuclei measurements provide insights into the equation-of-state of hadronic matter at high net-baryon densities, as well as into hyperon-nucleon and hyperon-hyperon-interactions. The Compressed Baryonic Matter (CBM) experiment at the future Facility for Antiproton and Ion Research (FAIR) in Darmstadt offers the perfect conditions to explore the production of hypernuclei. At beam energies of around 12A GeV, in combination with high interaction rates of up to 10 MHz, an exceptionally high amount of hypernuclei will be created, and even very rare double hypernuclei like $^6\Lambda$He are expected. The reconstruction of hypernuclei was implemented into the CBM software PFSimple and optimized with respect to important performance indicators. Expected efficiencies and signal-to-background-ratios were calculated for a reliable estimation of the number of reconstructable hypernuclei; the detector areas with the best performance were identified. Systematical uncertainties were estimated based on simulations from different transport models, like e.g. the novel PHQMD approach, as well as on the signal extrapolation to the full rapidity and transverse momentum range. The experimental sensitivity to properties of hypernuclei, such as their lifetime, was evaluated. Results for $^4\Lambda H$ will be discussed as an example. DFG-grant BL 982/3-1, DFG-grant BR 4000/7-1.

HK 16.5 Tue 18:15 SCH/A216

Status of the CBM Micro Vertex Detector Simulations* — *Julio Andary* for the CBM-MVD-Collaboration — Goethe-Universität Frankfurt am Main — Helmholtz Forschungskademie Hessen für FAIR

CBM’s Micro Vertex Detector (MVD) will help identify rare particles emitted in violent heavy ion collisions at FAIR and supplements the main tracker (STS) with high-precision pointing capability close to the target. This places, besides outstanding radiation hardness, high demands on the material budget of the sensor which in turn has an impact on the performance of the detector. Thus, the detector has to be optimized w.r.t. multiple scattering and adding unwanted background tracks originating from external conversion of photons. In order to optimize the detector geometry, CBMRoot simulation data are converted into a data format called AnalysisTree, which provides more user-friendly access to all physical quantities of the particles generated in the experiment. Before analyzing the performance of the MVD, it is necessary to clarify how the reconstruction and mapping in AnalysisTree is implemented, i.e. the criteria according to which AnalysisTree assigns Monte-Carlo particles to reconstructed tracks. The focus in this study is on the gain in tracking performance by the MVD, also considering alternative detector geometries.

*This work has been supported by BMBF (05P21RFFC2) and GSI.

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**HK 17: Heavy-Ion Collisions and QCD Phases IV**

**Time:** Tuesday 17:00–18:30

**Group Report**

HK 17.1 Tue 17:00 SCH/A315

Hydrodynamic modeling of $J/\psi$ $p_T$ spectra and anisotropic flow in the Statistical Hadronization Model — Anton Andronic*, Peter Braun-Munzinger*,**, Hjalmar Brunssen*, Jana Czakóvá*, Johanna Stachel* and Martin Volk* — 1Physikalisches Institut, Universität Heidelberg — 2ExtreMe Matter Institute EMMI, GSI — 3Institut für Kernphysik, WWU Münster

The Statistical Hadronization Model (SHM) has been shown to describe the observed particle yields in heavy-ion collisions very successfully. This is true not only for hadrons consisting of light-flavor valence quarks, but also for those containing charm quarks with the corresponding enhancement when one incorporates in the SHM that charm quarks are produced in initial hard collisions.

In this talk, we present the calculation of the transverse momentum spectra and anisotropic flow coefficients of the $J/\psi$. The assumption underlying the statistical hadronization of charm quarks is that they thermalize in the medium. This is supported by experimental evidence that they participate in the collective expansion. In order to come from a yield predicted by the SHM to the $p_T$-dependent anisotropic flow coefficients and transverse momentum spectra, the evolution of the quark gluon plasma (QGP) needs to be modeled by a hydrodynamic simulation. For the QGP evolution and the freeze-out, results from three different viscous hydrodynamic models are presented: 2+1D and 3+1D MUSIC as well as FluidiM. The results of these three approaches are compared to recent ALICE data.

HK 17.2 Tue 17:30 SCH/A315

Prompt and non-prompt $J/\psi$ production as a function of multiplicity in pp collisions with ALICE — Gaugther Legras for the ALICE Germany-Collaboration — Institut für Kernphysik, WWU Münster

$J/\psi$ production involves a hard scale for the creation of the charm-anticharm pair, and a soft scale for its hadronization. Correlating it with the multiplicity, mainly determined by soft particle production processes, in small systems allows to investigate the interplay between hard and soft scales. However, a substantial part of the $J/\psi$, called non-prompt $J/\psi$, comes from the decay of open-beauty hadrons. Since open-beauty hadron production mechanism is different from the one for prompt $J/\psi$, it becomes necessary to disentangle the prompt contribution from the non-prompt one in order to know if the non-prompt fraction could impact the inclusive (prompt + non-prompt) distribution of $J/\psi$ as a function of multiplicity.

This study aims at determining the fraction of non-prompt $J/\psi$ as a function of multiplicity in pp collisions at $\sqrt{s} = 13$ TeV, through its decay of $J/\psi$ to an electron-positron pair at midrapidity. The fraction is determined from the study of displaced $J/\psi$ decay vertices, using a Boosted Decision Tree algorithm for the identification of the $J/\psi$ and its classification.

HK 17.3 Tue 17:45 SCH/A315


The inclusive $J/\psi$ yield in Au-Au collisions at $\sqrt{sNN} = 2.4$ TeV can be well reproduced in a thermal model of particle emission from a spheroid single freeze-out hypersurface. This scenario extends the one used by Siemens and Rasmussen in the original formulation of the blast-wave model by allowing for elongation or contraction of the source. We incorporate a Hubble-like expansion of QCD matter and resonance decays.

This work was supported in part by: the Polish National Science Center Grants No. 2018/30/E/ST2/00432, No. 2017/26/M/ST2/00600, No. 2020/38/E/ST2/00019 and No. 2021/41/B/ST2/02409; IDUB-PFW092, 3 project granted by Warsaw University of Technology under the program Excellence Initiative: Research University (ID-UB), TU Darmstadt, Darmstadt (Germany): HHF, ELEMENTS:500/10.006, GSI F&E, DAAD PPP Polen 2018/5739302; Goethe-University, Frankfurt(Germany): HHF, ELEMENTS:500/10.006, GET_INVOLVED Programme of FAIR/GSI.

HK 17.4 Tue 18:00 SCH/A315

Studies on $J/\psi$ production as a function of the charged-particle multiplicity in pp collisions at the LHC — Ailec de la Caridad Bell Hechavaria for the ALICE Germany-Collaboration — Institut für Kernphysik, Westfälische Wilhelms-Universität Münster

The inclusive $J/\psi$ yields as a function of the charged-particle multiplicity exhibit a stronger than linear increase when the $J/\psi$ is measured at midrapidity ($|y|<0.9$) than when it is measured at forward rapidity ($2.5<|y|<4$). Insight into this effect could be gained by using the $J/\psi$ as a leading particle and studying the associated underlying events in the collision.

Data collected in pp collisions with ALICE at the LHC during Run 2 is used to investigate the relative $J/\psi$ yield, measured at mid-rapidity ($|y|<0.9$) in its di-electron decay channel and as a function of the charged-particle multiplicity, in various regions of the azimuthal angle with respect to the emission of the $J/\psi$ meson. This contribution will show these measurements in pp collisions at $\sqrt{s}=13$ TeV.

*Supported by DFG under GRK2149

HK 17.5 Tue 18:15 SCH/A315

Mid-Rapidity $J/\psi$ production as a function of multiplicity at different rapidities in $p$--Pb collisions at the LHC with ALICE — Starea Eder for the ALICE Germany-Collaboration — Institut für Kernphysik, Westfälische Wilhelms-Universität Münster

ALICE results from Run 1 data on the charged-particle multiplicity dependence of the inclusive normalized $J/\psi$ production, both at mid-rapidity, indicate a stronger than linear increase for proton-lead collisions at $\sqrt{sNN} = 5.02$ TeV.

To better understand the multiplicity dependent $J/\psi$ production and possible contributions from auto-correlation effects, the $J/\psi$ production at mid-rapidity
is studied as a function of multiplicity in different rapidity ranges. This can be done in ALICE using the V0A and V0C detectors for the multiplicity estimation, which are situated at different rapidities at either side of the collision point. In this talk the inclusive $\eta/\pi$ production at mid-rapidity will be shown as a function of multiplicity at different rapidity ranges for proton-lead collisions at $\sqrt{s_{NN}} = 5.02$ TeV using ALICE Run 2 data. In addition studies of $\eta/\pi$ production in ANGANTYR, the heavy-iron machinery of PYTHIA8, will be shown. 

Supported by BMBF within the ErUUm Program.

HK 18: Hadron Structure and Spectroscopy II

Time: Tuesday 17:00–19:00
Location: SCH/A316

Group Report

HK 18.1 Tue 17:00 SCH/A316
Measurement of the proton charge radius at AMBER — Martin Hoffmann for the AMBER-Collaboration — Universität Bonn, Helmholtz-Institut für Strahlen- und Kernphysik, Bonn, Germany

The proton charge radius can be measured either by hydrogen spectroscopy or in lepton-proton elastic scattering. Previous measurements resulted in discrepancy radii, which became known as the proton radius puzzle. The AMBER collaboration at CERN plans to perform a new precision measurement of the proton form factor at low momentum transfer using high-energy muon-proton elastic scattering. This measurement has different systematic uncertainties compared to those of low-energy elastic scattering. The recoil proton will be detected with a high-precision hydrogen-filled Time Projection Chamber (TPC), measuring the transferred energy and thus the squared four-momentum $Q^2$. The muon kinematics will be measured with high-precision vertex detectors around the TPC and a downstream spectrometer, which allows to select for elastic scattering events.

The core setup consisting of silicon tracking detectors and a prototype TPC was studied under realistic beam conditions during a pilot run in 2021. In 2022, the newly developed unified tracking system consisting of scintillating fibers for accurate timing and monolithic pixel-silicon detectors for high spatial precision was tested. This talk will present results of the on-going analyses and an overview of further developments towards the final setup.

Supported by EU.

HK 18.2 Tue 17:30 SCH/A316
Testing Predictions of the Chiral Anomaly in Primakoff Reactions at COMPASS — Domink Eckler and Andrei Maltshev for the COMPASS-Collaboration — Physik-Department, Technische Universität München Climate Physics and Laboratory (CPL) 030,10791 Munich, Germany

The anomalous magnetic moment of the muon is one of the most precisely measured quantities in modern physics. However, there is a discrepancy of 4.2 standard deviations between the Standard Model (SM) prediction and the average of the latest direct measurements at BNL and FNAL. This discrepancy is known as the Muon $(g - 2)$ puzzle. For the SM prediction the main uncertainty arises from hadronic contributions and can be improved systematically using measurements of hadronic cross sections at $e^+ e^-$ colliders. One of the most important processes is $e^+ e^- \rightarrow \pi^+ \pi^-$. Using a data set of 1.9 fb$^{-1}$ (in the near future 20 fb$^{-1}$) at a center of mass energy of 3.77 GeV, the $\pi^+ \pi^-$ cross section is measured at the BESIII experiment located at the BEPCII collider in Beijing, exploiting the initial state radiation technique at small angles. The analysis aims to determine the pion form factor at masses above 0.8 GeV, which is also interesting for hadron spectroscopy. In this talk the current status of the analysis is presented.

Supported by DFG.

HK 18.3 Tue 17:45 SCH/A316
Small Angle Initial State Radiation Analysis of the Pion Form Factor at BESIII — Yasemin Schelhaas, Ricardo Aliberti, and Achim Deng for the BESIII-Collaboration — Institut für Kernphysik, Johannes Gutenberg-Universität Mainz, Germany

Numerical simulations of the pion form factor at $Q^2 > 5$ GeV$^2$ (where $Q^2$ is the four-momentum transfer $Q^2 = -p_2^2$) makes effective predictions for low-energy phenomena of QCD, i.e. dynamics and decays of light mesons, and their couplings to photons and nucleons. Processes, which are governed by the chiral anomaly, are described in the effective Lagrangian by the Wess-Zumino-Witten (WZW) term. The WZW term describes for example the coupling of one pion to two photons. Hence, it describes the $n_\sigma$ lifetime, which has been well confirmed by multiple measurements.

There are however many more couplings governed by the chiral anomaly, which lack precise experimental verification: for example, the direct coupling of one photon to three pions. The corresponding coupling constant $F_{\pi\gamma}$ is described by the WZW term and can experimentally be accessed in $n + \gamma \rightarrow \pi + \pi + \pi$ scattering reactions.

At the COMPASS experiment at CERN, we study pion-photon scattering reactions via the Primakoff effect. This data allows us to verify the ChPT prediction for $F_{\pi\gamma}$. We will present preliminary result of this measurement and ongoing efforts to improve its accuracy.

*Supported by the DFG under Germany's Excellence Strategy - EXC2094 - 390783311 and BMBF Verbundforschung (05PSWOC11 COMPASS).

HK 18.4 Tue 18:00 SCH/A316
SIDIS Kaon Beam Spin Asymmetry Measurements with CLAS12 — Aron Kripkó, Stefan Diehl, and Kai-Thomas Brinkmann for the CLAS-Collaboration — Justus Liebig Universität Gießen, 35390 Gießen, Germany

1. University of Connecticut, Storrs, CT 06269, USA

A multidimensional study of the structure function ratio $F_{\pi K}^{uu}(x)$/$F_{\pi K}^{ss}(x)$ has been performed for $K^+$, based on the measurement of beam-spin asymmetries. It uses the high statistics data recorded with the CLAS12 spectrometer at Jefferson Laboratory. The 10.6 GeV longitudinally polarized electron beam interacted with an unpolarized liquid hydrogen target during the experiment. $F_{\pi K}^{uu}(x)$ is a twist-3 quantity that provides information about the quark gluon correlations in the proton. The talk will present a simultaneous analysis of two kaon channels ($K^+$ and $K^-$) over a large kinematic range with virtualities $Q^2$ ranging from 1 GeV$^2$ to 8 GeV$^2$.

The precise multidimensional measurement was performed in a large range of $x$, $Q^2$, $p_T$ and $Q^2$ for the first time. This multidimensional binning will allow a comparison with different reaction models.

This work is supported by HHF and funded by DFG (project number: 508107918).

HK 18.5 Tue 18:15 SCH/A316
Exposing the structure of pion — Minghu Deng — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

As the theory of quantum chromodynamics has unfolded, the pion has come to be understood as Nature’s most fundamental Nambu-Goldstone boson. It is strongly coupled to the quark-gluon plasma at high temperature and density. However, the pion is also a fundamental hadron with a strong coupling to the nucleon.

The pion is a spin-0, massless particle with a width of about 135 MeV. Its anomalous magnetic moment is one of the most precisely measured quantities in modern physics. However, there is a discrepancy of 4.2 standard deviations between the Standard Model (SM) prediction and the average of the latest direct measurements at BNL and FNAL. This discrepancy is known as the Muon $(g - 2)$ puzzle. For the SM prediction the main uncertainty arises from hadronic contributions and can be improved systematically using measurements of hadronic cross sections at $e^+ e^-$ colliders. One of the most important processes is $e^+ e^- \rightarrow \pi^+ \pi^-$. Using a data set of 1.9 fb$^{-1}$ (in the near future 20 fb$^{-1}$) at a center of mass energy of 3.77 GeV, the $\pi^+ \pi^-$ cross section is measured at the BESIII experiment located at the BEPCII collider in Beijing, exploiting the initial state radiation technique at small angles. The analysis aims to determine the pion form factor at masses above 0.8 GeV, which is also interesting for hadron spectroscopy. In this talk the current status of the analysis is presented.

Supported by DFG.

HK 18.6 Tue 18:30 SCH/A316
Numerische Analyse der nichtlinearen GLQ-MQ-Gleichungen für nucleare Partondichtefunktionen — Janek Rauch, Vadim Guzey und Michael Kläsen — 1 Humboldt-Universität zu Berlin, Deutschland — Universität Jyväskylä, Finnland — Westfälische Wilhelms-Universität Münster, Deutschland

Wir untersuchen erstmalig die nichtlinearen GLQ-MQ-Gleichungen für die Entwicklung nuklearer Partondichtefunktionen (nPDFs) numerisch bis zur Next-to-leading order für verschiedene Kerne und quantifizieren den Einfluss von Glauber-Regkonstruktion bei kleinem Bjorken-$x$. Mit den nCTEQ15 nPDFs als Input bestätigen wir die Relevanz der nuklearen Korrekturen, deren Größe mit fallendem $x$ und steigender Massenzahl $A$ wächst, für $x < 10^{-4}$. Wir zeigen, dass die Quark-Singlett- und Gluon-Distributionen $Q(x, Q^2)$ und $G(x, Q^2)$ bei $x < 10^{-3}$ für schwere Kerne nach der Nichtlinearität von $Q_0 = 2$ GeV bis $Q = 10$ GeV verglichen mit der linearen Entwicklung um $9 - 15\%$ verringert sind. Wenn abwärts von $Q_0 = 10$ GeV bis $Q = 2$ GeV entwickelt wird, ist der relative Effekt deutlich größer, $Q(x, Q^2)$ ist um $40\%$ und $G(x, Q^2)$ um $140\%$ erhöht. Diese Trends finden sich in den Strukturfunktionen $F_2(x, Q^2)$ und $F_2(x, Q^2)$ wieder, die nach der Abwärtsentwicklung um $45\%$ reduziert bzw. um $80\%$ erhöht sind. Unsere Ergebnisse zeigen, dass die nichtlinearen Effekte in $F_2(x, Q^2)$ am deutlichsten auftreten und für schwere Kerne bereits bei $x > 10^{-5}$ erheblich sind.

HK 18.7 Tue 18:45 SCH/A316
Measuring Generalized Distribution Amplitudes in Proton-Antiproton Annihilation with PANDA at FAIR — Éva Kmalıdır, Stefan Diehl, and Kai-Thomas Brinkmann — II. Physikalisches Institut, Justus Liebig Universität Gießen

The future PANDA experiment at FAIR with the HESR antiproton beam provides unique possibilities to study the 3D nucleon structure with exclusive channels in $p\bar{p}$ annihilation. One of the channels of interest for the measurement of Generalized Distribution Amplitudes (GDAs) is $p\bar{p} \rightarrow \pi^+\pi^-\eta$. Simulations at several center-of-mass energies were done for this signal channel ($p\bar{p} \rightarrow \eta\pi^+\pi^-$) and for the main background channel ($p\bar{p} \rightarrow \pi^+\pi^-\pi^+$).
the measurement. The talk will present the feasibility study for the measurement of the cos(θ) dependence of the differential cross-section for \( pp \rightarrow n\gamma \) at different integrated luminosities. The cross sections have been estimated based on data from the E760 experiment at Fermilab, which is available in a limited kinematic range. Various optimal set of cuts were investigated to reduce the high background in this channel. Results of count rate estimates and estimates of the expected statistical uncertainty are presented. Different event selection cuts have been investigated to optimize the signal to background ratio while keeping a reasonable reconstruction efficiency. Also presented is the feasibility study of the channel \( pp \rightarrow n\gamma \) whose cross-section needs to be measured to subtract the high background in the channel \( pp \rightarrow n\gamma \).

The work is supported by BMBF and HFHF.

**HK 19: Nuclear Astrophysics II**

**Time:** Tuesday 17:00–18:30

**Location:** SCH/A149

**Group Report**

**HK 19.1 Tue 17:00 SCH/A149**

Neutrino flavor instability and nucleosynthesis associated with charged-current weak interactions in black hole accretion disks — Zewei Xiong, Luca Caso, Meng-Ru Wu, Huaizhi Yuan, Gabriel Martínez-Pinedo, and Oliver Just — 1GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany — 2UC Berkeley, CA, USA — 3Academia Sinica, Taipei, Taiwan — 4University of New Mexico, Albuquerque, NM, USA — 5Technische Universität Darmstadt, Germany

Charged-current weak interactions destroy the flavor coherence among the weak-interaction states of a single neutrino. In a dense neutron gas, however, these collision processes can trigger flavor conversion in cooperation with the strong neutrino-neutrino refraction. We show that the collisional flavor instability can exist in black hole accretion disks. As a result, large amounts of heavy-lepton flavor neutrinos can be produced through flavor conversion, which can have important ramifications in the subsequent evolution of the remnant.

In addition to the charged-current neutrino interactions with nucleons, the neutrino-nucleus interactions can possess larger cross sections in neutron-rich nuclei and affects the r-process nucleosynthesis. We investigate those neutrino-nucleus interactions in black hole accretion disks and show that they can affect electron fraction moderately in specific trajectories with high neutrino fluxes.

Z.X. is supported by the European Research Council (ERC) under the European Union’s Horizon 2020 research and innovation programme (ERC Advanced Grant KILONOVA No. 885281).

**HK 19.2 Tue 17:30 SCH/A149**

Nuclear equation of state from Δ-full chiral interactions — Yannick Dietz, Jochen Hebeler, and Achim Schwenk — 1Technische Universität Darmstadt, Department of Physics — 2ExtReMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH — 3Max-Planck-Institut für Kernphysik, Heidelberg

We report results for infinite homogeneous nuclear matter calculations for the energy per particle at zero temperature using a recently developed Δ-full interaction. The Δ-field theory that exhibit smaller chiral uncertainties compared to previous calculations using Δ-less potentials. Our computations are carried out in many-body perturbation theory, where we include contributions from nucleon-nucleon forces up to third and three-nucleon forces up second order.

Funded by the ERC Grant Agreement No. 101020842 and by the DFG – Project-ID 729384907 – SFB 1245.

**HK 19.3 Tue 17:45 SCH/A149**

Gaieron processes for the nuclear equation of state — Hannah Göttlinger, Jonas Keller, Kai Hebeler, and Achim Schwenk — 1Technische Universität Darmstadt, Department of Physics — 2ExtReMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH — 3Max-Planck-Institut für Kernphysik, Heidelberg

We use Gaieron processes as a non-parametric emulator for the nuclear equation of state based on chiral effective field theory interactions and to provide statistical uncertainties based on the effective field theory truncation. Moreover, the Gaussian process enables us to calculate observables that are obtained via thermodynamic derivatives. We use this to calculate properties relevant to neutron stars and properties of symmetric nuclear matter.

Funded by the ERC Grant Agreement No. 101020842 and by the DFG – Project-ID 729384907 – SFB 1245.

**HK 19.4 Tue 18:00 SCH/A149**

Magnetar crusts — influence of the magnetic field on the composition and the unified equation of state — Yuliya Mutachova, Zhiyue Stoyanov, Nicolas Chamel, John Michael Pearson, and Lubomir Mihaylov — 1Institute For Nuclear Research And Nuclear Energy, Bulgarian Academy of Sciences, Sofia, Bulgaria — 2Institute of Astronomy and Astrophysics, Université Libre de Bruxelles, Brussels, Belgium — 3Department of Physique, Université de Montréal, Montreal, Canada — 4Institute of Solid State Physics, Bulgarian Academy of Sciences, Sofia, Bulgaria

At the end of stellar evolution, strongly magnetised neutron stars - magnetars, are not only among the most compact stars in the universe, but also the strongest magnets. These conditions can significantly alter the properties of the outermost regions of a neutron star. We have recently studied the influence of a very strong magnetic field on the equilibrium properties of magnetar crusts when taking into account the Landau-Rabi quantization of electron motion. Both the outer and inner regions of the crust are treated consistently within the framework of the nuclear-energy density functional theory, thus allowing us to calculate their composition and their equation of state in a unified way. Our study covers a wide range of magnetic-field strengths necessary for modelling astrophysical phenomena. Results using accurately calibrated Brussels-Montreal nuclear energy density functionals, which were constructed from generalized Skyrme effective nuclear-nucleon interactions, will be presented.

**HK 19.5 Tue 18:15 SCH/A149**

Supernova Simulations with Consistent Six Species Neutrino Transport — Ignacio L. Arribas, Gabriel Martínez-Pinedo, and Tobias Fischer — 1Institut für Kernphysik (Theoriezentrum), Fachbereich Physik, Technische Universität ‘at Darmstadt, Schlossgartenstraße 2, 64289 Darmstadt, Germany — 2GSI Helmholtzzentrum für Schwerionenforschung, Planckstraße 1, 64291 Darmstadt, Germany — 3Institute of Theoretical Physics, University of Wrocław, PL M. Borna 9, 50-204 Wrocław, Poland — 4Core-Collapse Supernova (CSCN) is expected to explode by the delayed neutrino-driven mechanism. It requires an accurate treatment of the neutrino-matter interactions together with a solution to the neutrino radiation transport for all lepton flavours. Typical implementations usually consider four species neutrino schemes assuming identical distributions for the muon and tau neutrino flavours. However, the conditions shortly after bounce allow for the production of muons as discussed in the studies by Bollig et al. (2017) and Fischer et al. (2020). This muon formation adds new reaction channels in the lepton sector that couple the electron and muon flavours through weak interaction processes. For this purpose, we implement a Boltzmann neutrino transport scheme for the six neutrino species that are evolved consistently with the internal energy, and the electron and muon abundances. We explore the sensitivity to different sets of opacities computed consistently with the underlying equation of state and determine the most important reactions contributing to the muonization of supernova matter.

**HK 20: Structure and Dynamics of Nuclei III**

**Time:** Tuesday 17:00–18:45

**Location:** SCH/A118

**Group Report**

**HK 20.1 Tue 17:00 SCH/A118**

Recent R3B experiments with radioactive nuclear beams — Valerii Pantev — R3B-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung, Planckstraße 1, Darmstadt 64291, Germany

R3B is a versatile experimental setup designed to tackle some of the most forefront problems in modern nuclear physics. The setup is developed within the FAIR project in Darmstadt and it has been extensively used for various experiments over the past few years. The studies conducted thus far include short-range correlations in unstable nuclei, density-dependence of the symmetry energy, helium burning in stars, fission of heavy radioactive nuclei and isospin evolution of single-particle shells. Owing to the radioactive-ion beams provided by the GSI accelerator facility, the involved nuclear reactions can be studied in relativistic energy regime and in some cases also around extremes of nuclear stability. An overview on the R3B experiment, its recent research program and detector upgrades, as well as ongoing developments will be presented.
Halo-EFT model and bring another physical insight on the structure of the nucleon halo. We have been successful in the description of systems up to mass numbers 100 and beyond. For certain observables, however, the IM-SRG(2) truncation is not sufficient and the inclusion of three-body operators, the IM-SRG(3), is required.

We apply the IM-SRG(3) to neutron-rich calcium isotopes, delivering a more precise many-body treatment of these systems. We find an improved description of the shell-closure at $^{48}$Ca. We also discuss sources of observed discrepancies between experiment and theory in the charge radii of these systems.

* Funded by the ERC Grant Agreement No. 101020842.

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**HALO-EFT description of one-neutron halo nuclei with perturbative inclusion of core excitations**

**LIVE-PALM KURUSHISHI and PIERRE CAPPEL**

Institute of Nuclear Physics, Johannes Gutenberg-Universität Mainz – Johann-Joachim-Becher Weg 45 D-55099 Mainz, Deutschland.

Halo nuclei are fascinating short-lived nuclear objects found near the dripline. In standard reaction models, halo nuclei are usually described as an inert core with one or two weakly bound neutrons. However, some breakup data suggest that the excitation of the core to its excited states have a significant influence in the dynamics of the reaction [1]. In order to shed more light on this phenomenon, we study the typical one-neutron halo nucleus Be11 and we propose a simple structure model of it based on the rigid rotor model. We assume the core to be weakly deformed, which we treat at the first order of perturbations to couple it to its two first excited state. In this way, we explicitly account for core excitations as a new degree of freedom while still describing the interaction between the core and the neutron in halo-EFT [2]. Our calculations were performed using the calculable R-Matrix method on a Lagrange mesh. We have been able to reproduce with a good agreement, the coupled-channels results [3], improve the halo-EFT model [2] and bring another physical insight on the structure of the bound states of Be11.


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**Nuclear energy density functionals (EDFs) successfully reproduce experimental binding energies but due to their phenomenological nature it is at present unclear how to improve the currently established forms. We construct hybrid EDFs by starting from a standard Skyrme functional, here considered to represent short-range physics, and adding explicitly pionic exchanges derived from chiral effective field theory. Pions are included at the Hartree-Fock level without introducing further fit parameters to the functional. When going beyond next-to-leading order in the chiral expansion the functionals are significantly improved compared to a reference Skyrme EDF constructed with the same protocol. We compare the different functionals and analyze their performance.**

* Funded by BMBF Contract No. 05P21DFBN.

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**Investigation of shape coexistence in $^{116}$Te via lifetime measurements**


In medium-shell Te isotopes, hints for shape coexistence have been found [1]. However, experimental evidence is scarce, since experiments on neutron-deficient Te isotopes are challenging. Experimental data on transition strengths in $^{116}$Te could give further insight. Therefore, a recoil distance Doppler shift experiment was performed to investigate transition strengths between low-lying states in $^{116}$Te at the FN–Tandem accelerator facility of the IKP Cologne. To populate low-lying, low-spin states, the reaction $^{112}$Sn($^{12}$C,$^{11}$Be) was used. The γ rays were detected in coincidence with α particles stemming from the decay of $^{8}$Be. To detect the α particles, silicon particle detectors were used. These were covered with aluminum foil that prevented any heavier ions to penetrate the detector.

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**Nuclear structure studies in the vicinity of doubly magic $^{160}$Sn and $^{162}$Sn**

**MICHAL MIKOLAJCZUK** and **MAGDALENA GÓRSKA-OYER** — Faculty of Physics, University of Warsaw, Poland — GSI Darmstadt, Germany.

In the field of nuclear structure physics, the neighborhood of doubly magic nuclei such as $^{160}$Sn and $^{162}$Sn remains one of the most intriguing regions along the Segrè chart. Over the last few decades many experimental efforts were made to acquire data necessary to describe and understand shell structure evolution in the aforementioned regions. Based on experimental data, the state-of-the-art shell model calculations provide further insight into the properties of nuclear structure, broadening our understanding of nucleon-nucleon interaction. This presentation will discuss results of employing well established interactions such as JU45 [1], Gross-Frenkel [2] and MJH [3], to neutron closed shell nuclei, namely $^{130}$Cd, $^{132}$Cd, $^{136}$Pd. Calculation results are compared with up to date available experimental data and validity of the used models and obtained conclusions will be discussed.

1. [M. Honna et al., PRC80, 064323 (2009).]
In several neutron deficient nuclei in the A=180 region both shape coexistence and rapid shape transitions were identified. Further, B(E2; 4_2 → 2_2)/B(E2; 2_2 → 0_2) ratios < 1 were found in some neutron deficient Os–W–Pt nuclei far from closed shells. This cannot be explained with any collective model. Shape coexistence could be an explanation, but there are no such cases known so far. Older data [1] yield that 160W is just at the transition point from “normal” collectivity to the “island” of nuclei with B(E2) < 1. However, these data might suffer from assumptions on side feeding of the related states. Therefore, and to learn on the structural evolution within the yrast band of 160W, we performed an experiment with the recoil distance Doppler-shift technique on 160W at Argonne National Laboratory with the GAMMASPHERE spectrometer to determine transition strengths from level lifetimes using γγ coincidences. We present these data with respect to rapid shell evolution in this region.

Supported by the DFG, grant Nos. FR 3276/2-1 and DE 15165/1-1.

Invited Talk
HK 23.1 Wed 11:00 HSZ/0002
High-Precision Laser Spectroscopy of C$^1_8$ for an All-Optical Determination of the Nuclear Charge Radius — "PHILIP IMOANA", KRISTIAN KONIG, BERNHARDO MAASS, PATRICK MÜLLER, and WILFRID NORTHERSÄUER — Institute für Kernphysik, TU Darmstadt, Germany; "Argonne National Laboratory, Chicago, IL, USA

Nuclear charge radii of radioactive isotopes are typically referenced to a stable nucleus in the isotopic chain through an atomic isotope shift measurement. In some cases, this can limit the uncertainty of the obtained charge radii of radioactive nuclei to the uncertainty of the reference measurements from elastic electron scattering or mononuclei atomic spectroscopy. To overcome this limit in light mass nuclei like $^{10}_{10}$B, all-optical approach for the charge radius determination purely from laser spectroscopy measurements and non-relativistic QED calculations was tested with the well-known nucleus of $^{10}_{10}$C through laser excitations from the magnetic 2$^+_3$ to the 2$^+_2$ states. The high-precision collinear laser spectroscopy of $^{12}_{12}$C has been performed at the Collinear Apparatus for Laser Spectroscopy and Applied Physics (COALA) at the Institute of Nuclear Physics of TU Darmstadt. This contribution will give an overview of the project and present the measured transition frequencies along with the extracted all-optical nuclear charge radius of $^{10}_{10}$C. This project is supported by DFG (Project-ID 279364907 - SFB 1245).

Invited Talk
HK 23.2 Wed 11:30 HSZ/0002
ALICE determines the transparency of our galaxy to the passage of antihelium-3 nuclei — "LAURA SERESNYTE" for the ALICE Germany-Collaboration — Technical University of Munich

The measurements of the inelastic cross sections of antihelium-3 nuclei were performed by employing the ALICE detector material as a target. The antinucleon-to-nucleon ratio and TOF-to-TPC matching methods were used in pp and Pb-Pb collisions, respectively. These, for the first time, measured inelastic cross sections have been implemented in the GALPROP propagation model to estimate the losses in the antihelium-3 cosmic ray fluxes due to inelastic interactions with the interstellar medium. Indeed, some dark matter candidates, such as the WIMPs, are expected to annihilate in our galaxy and produce, among other particles, light antinuclei, which can be observed as cosmic rays. However, the same antinuclei can also be produced in ordinary cosmic ray collisions with the interstellar gas. Thus, precise modelling of signal and background cosmic ray fluxes, including the inelastic losses in the interstellar medium, is required to draw conclusions from future antinuclei cosmic-ray measurements.

The results of this interdisciplinary study by ALICE allowed the determination of the transparency of our galaxy to the propagation of the antihelium-3 from dark matter annihilation and ordinary cosmic ray collisions, and to demonstrate that antihelium-3 nuclei are a promising probe for indirect dark matter searches. This research was funded by BMBF Verbundforschung (05P21WOCA1) and the DFG under Germany’s Excellence Strategy - EXC 2299 - 390783311.

Invited Talk
HK 23.3 Wed 12:00 HSZ/0002
The world of light and strange mesons: from spectroscopy puzzles to low energy QCD phenomena — "STEPHAN PAUL" for the COMPASS-Collaboration — Technical University of Munich, Physics Department, Garching, Germany; "Max-Planck- Institut für Physik, Munich, Germany

After 20 years of data taking, the COMPASS experiment looks back on important contributions in the fields of nucleon spin-structure, light-hadron spectroscopy, and measurements related to very-low-energy QCD. Here, we report new insights into the mesonic excitation spectrum based on the world’s largest data set, which provides access to all major vector mesons in a self-consistent manner using novel analysis techniques. In addition to excitations with high angular momentum, we have unravelled exotic mesons and discovered new mesonic structures even at low masses whose interpretation is still unclear. At very low energies, QCD can be described by effective interactions in the framework of chiral perturbation theory (ChPT).
turbation theory. We have challenged numerous precision calculations with high accuracy even in multidimensional analyses. COMPASS has proven to be a versatile precision instrument allowing for studies of QCD with high energy beams complementary to low energy facilities.

HK 24: Instrumentation VII

Time: Wednesday 14:00–15:30

Group Report

HK 24.1 Wed 14:00 SCH/A251

Advances in CMOS ADVANCES FOR THE NEXT GENERATION OF COLLIDER DETECTORS —

—-Bogdan-Mihail Bliiabaru for the ALICE Germany—Collaboration — Heidelberg University, Germany

CMOS Monolithic Active Pixel Sensors (MAPS) are continuously proven to comply with the severe constraints set by present and future collider detectors which require high granularity, low mass, excellent spatial resolution, as well as moderate radiation hardness and timing. Moreover, their ease of integration and cost effectiveness for large areas makes them alluring for almost all particle detection applications.

The first large scale MAPS-based silicon tracker is the new 1 m² ALICE Inner Tracking System (ITS2). Results from its first in-beam operation at the LHC confirm the excellent performance of the single ALPIDE MAPS chips that span its surface.

To profit from the advances in the field of CMOS technology, the ITS collaboration is pioneering the usage of bent, wafer-scale pixel sensors for the replacement of the innermost tracking layers of ITS2 in the next upgrades. This roadmap is accompanied by a change in the technology node from 180 nm (ALPIDE) to 65 nm which allows the stitching of sensors and paves the path to an almost massless detector.

This contribution will give an overview of some of the ongoing developments in the field of CMOS MAPS, specifically the research done in the context of the ALICE collaboration for its future upgrades. Performance of bent sensors, 65 nm test structures and progress towards wafer-scale sensors, as well as the motivation of building such devices from a physics and detector performance point of view will be reviewed.

HK 24.2 Wed 14:30 SCH/A251

Towards the Pre-Production Module of the Largest Station of the CBM MVD —

—Franz Alexej Matejeck for the CBM-MVD-Collaboration — Goethe-Universität Frankfurt

The Micro Vertex Detector (MVD) of the Compressed Baryonic Matter Experiment (CBM) consists of four planar stations, each built of four independent quadrants (modules), that are equipped with dedicated CMOS pixel sensors (MIMOSIS) and will operate in vacuum. Each detector plane features a material budget $\rho X_0$ ranging between 0.3 and 0.5%, depending on size. The sensors are glued onto 380 µm thick TPG (Thermal Pyrolitic Graphite) carriers that provide the necessary mechanical stiffness and a high thermal conductivity in the geometrical acceptance to cool the sensors well below 0 °C. The sensor is then wire-bonded to dedicated flex cables connecting the front end electronics which are mounted on a heat sink sitting outside the acceptance. The integration is mechanically challenging as the sensors have to be glued and bonded on both sides of the carrier to maximize the acceptance.

This contribution will focus on integration aspects of the pre-production module of the largest quadrants.

This work has been supported by BMBF (05P21RFFC2), Eurizon and HPPF.

HK 24.3 Wed 14:45 SCH/A251

Performance of the MIMOSIS-1 CMOS Monolithic Active Pixel Sensor —

—Hasan Darwish for the CBM-MVD-Collaboration — Goethe University Frankfurt, Frankfurt, Germany

MIMOSIS is a CMOS Monolithic Active Pixel Sensor designed to be used for the Micro Vertex Detector (MVD) of the future CBM experiment at FAIR in Darmstadt. The 50 µm thin sensor featuring 1024 × 504 pixels with a pitch of 27 × 30 µm will combine a spatial resolution of ~5 µm with a time resolution of 5 µs and provide a peak rate capability of 80 MHz/cm². The first full size prototype, MIMOSIS-1, was tested with beams at CERN, DESY, COSY and GSI. Sensor performance including detection efficiency, spatial resolution and fake hit rate was tested for 12 different combinations of pixel micro-circuits and sensing elements. Moreover, the sensor tolerance to radiation doses of up to 5 MRad and 3 × 10¹¹ n/cm² was evaluated. The design and technology of the sensor is introduced and results from the beam tests are shown.

*This work has been supported by BMBF (05P21RFFC2), Eurizon, HPPF, and HPPH.

HK 24.4 Wed 15:00 SCH/A251

Beam test studies of bent MAPS for ALICE ITS3 —

—Lukas Launtenber for the ALICE Germany—Collaboration — Technische Universität München — CERN

Bent Monolithic Active Pixel Sensors (MAPS) provide the basis for the next generation of ultra low material budget, fully cylindrical tracking detectors. In this contribution, results of beam campaigns with 5.4 GeV electrons will be presented. They verify the performance of bent 50 µm thick ALPIDE chips in terms of efficiency and space point resolution after bending them to the ALICE ITS3 radius of 180, 240, and 300 mm. In particular, an efficiency larger than 99.9% and a space-point resolution of approximately 5 µm are observed, both in line with the nominal operation of flat ALPIDE sensors. These values are found to be independent of the bending radius and thus demonstrate the feasibility of the planned ITS3 detector in crucial aspects.

HK 24.5 Wed 15:15 SCH/A251

Test and characterization of an experimental apparatus with bent MAPS and CsI scintillators —

—Laszlo Varga 1,2, Christopher Ehrich 1, Tobias Jenegger 1, Lukas Launtenber 1, Lukas Ponnath 1, Isabella Sanna 1, Berkin Ulkuetu 1, Roman Garnerhauser 1, and Laura Ebbing 1 for the ALICE Germany—Collaboration — 1Technische Universität München, Germany — 2Excellence Cluster ORIGINS, Garching, Germany — 3European Organisation for Nuclear Research (CERN), Geneva, Switzerland

Particle detectors based on Monolithic Active Pixel Sensors (MAPS) provide the basis for the next generation of vertex detectors with ultra low material budget and truly cylindrical geometry. Arrays of sensor elements stretched into wafer-scale and curved in a barrel geometry serve as the next upgrade of the inner tracking system (ITS3) of the ALICE experiment at CERN. A test environment hosting six bent sensors in the uTS3 geometry and their read out synchronized with CsI scintillator crystals has been recently employed in the test beam experiment at the Bronowice Cyclotron Facility (CCB) in Poland. In this talk, the sensors technique, the experimental setup and preliminary results of the CCB experiment will be discussed.

This research was supported by the Excellence Cluster ORIGINS funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) under Germany’s Excellence Strategy EXC-2094-390783311 and Bundesministerium für Bildung und Forschung, BMBF-05P21WOCA1 ALICE.

HK 25: Instrumentation VIII

Time: Wednesday 14:00–15:30

Bending Losses in Scintillating-Plastic Fibers* — Christian Dreischab, Kari Eichhorn, Jan Friedrich, Igor Konorov, Martin Loeke, Stefan Paul, Julicia Preihan, and Thomas Pouchel — Technische Universität München, Physik-Department E18, Garching, Germany

The AMBER experiment at CERN’s Super Proton Synchrotron aims to measure the proton radius in high-energy elastic muon-proton scattering. At the Technical University of Munich, we develop a scintillating-fiber hadroscope to provide precise time information for the incoming and outgoing muons. Each detector consists of two layers of 500 µm scintillating-plastic fibers read out by silicon photomultiplier (SiPM) arrays.

The detector layout requires bending of the fibers towards the SiPMs, resulting in signal-height variations due to the associated bending losses. To characterize this effect, we performed a dedicated experiment to study the dependence of the losses on the bending radius for the scintillating fibers we use. In this contribution, we present the experimental setup and the results of this investigation.

*Supported by the DFG under Germany’s Excellence Strategy - EXC2094 - 390783311 and BMBF Verbundforschung (05H12WOR1 HighD)

HK 25.2 Wed 14:15 SCH/A101

Simulation framework for the digitisation module of scintillators and its implementation in NeuLAND —

—Yanzhao Wang 1, Jan Mayer 1, Igor Gasparik 2, and Andreas Zülges 1 — University of Cologne, Institute for Nuclear Physics — 2 GSI Helmholtzzentrum für Schwerionenforschung

The New Large-Area Neutron Detector NeuLAND, as a part of the R² experiment in FAIR, aims at providing a high detection efficiency and spatial-temporal
resolution of the neutrons generated by the nuclear reaction from the high-intensity radioactive beam\cite{1}. Simulations of the interactions between the neutrons and NeuLAND and its digitised output signals are imperative for the development of its event reconstruction algorithm. In this talk, we are introducing a simulation framework and its implementation on the digitising module TAMEX most lately used in NeuLAND. Light yields of the scintillators are transformed into the actual energy values and time stamps of the particle interactions, taking into account multiple physical processes, such as light attenuation, PMT saturation, signal pile-up, the couplings between different PMT outputs and the variations among scintillators and digitiser channels. Additionally, the generic interface within the framework leaves a huge potential for similar implementations on different scintillation detectors in R² B. Supported by the BMBF (05P2PGKFN1).


HK 25.3 Wed 14:30 SCH/A.101
Towards a spatially resolving detector for ultra-cold neutrons — • KONRAD FRANZ
Franz

One of the challenges in ultra-cold neutron (UCN) detection is to convert the electrostatically inert neutron into an electrical signal. In the presented detector design this is achieved by employing a conversion layer stacked with a scintillation layer, in which the neutron induced ∆-particle generates a light pulse. This scintillation light is then guided onto an array of silicon photomultipliers (SiPMs). Spatial resolution can be achieved by reading out each SiPM individually. A main advantage of this setup is its compatibility with high magnetic fields, which allows for in-situ detection of UCNs in such environments. Combining spatial resolution with a magnetic field gradient enables UCN energy resolution. The talk will give an overview of the detector design and will outline its advantages. Furthermore, the current status of the development will be presented and the main challenges moving forward will be discussed.

HK 25.4 Wed 14:45 SCH/A.101
A normalization detector for the neutron lifetime experiment rSPECT — • MARTIN ENGEL
Martin

The rSPECT experiment aims to measure the free neutron lifetime, using fully magnetic neutron storage. Neutrons with energies of ≈ 50 neV are stored in a magnetic field gradient and then counted after varying storage times. The individual measurements have to be normalised, in order to account for statistical and systematic changes in the yield of the neutron source. To monitor the flux of stopable neutrons during the filling process, an in-situ neutron detector, detecting light from a C05 coated ZnS:Ag scintillator coupled to an array of silicon photomultipliers, has been designed and built.

This talk will cover the detectors design, challenges, as well as the results of the first runs.

HK 25.5 Wed 15:00 SCH/A.101
A neutron trigger detector for pulsed neutron sources — • JULIAN AULER
Auler

A variety of experiments investigating properties of neutrons can be performed at pulsed source facilities like the research reactor TRIGA Mainz. A typical problem faced by these experiments is the non-availability of a reliable facility-provided trigger signal in coincidence with the neutron production. Here we present the design, implementation and experimental results of a neutron pulse detector that provides a coincident trigger signal for precise experimental timing.

The described neutron pulse detector is based on a multilayer design with a 10 B top layer (≈ 80 nm) employing the 10 B(p,n) 7 Li reaction and deposited on a scintillator foil (0.25 mm) with a one-sided coating of ZnS:Ag as scintillation layer. A silicon photomultiplier (SiPM) is used as photosensor, which makes the detector suitable for use in experimental areas with high magnetic fields and at the same time has the advantage that no high-voltage supply is required.

HK 25.6 Wed 15:15 SCH/A.101
Polyethylene Naphthalate Based Neutron and Radon Detectors — • KIM TREA GIEBENHAIN, HANS-GEORG ZAUNICK, ROMAN BERGERT, and KAI THOMAS BRINKMANN — Justus-Liebig-Universität, Giessen, Germany

Polyethylene naphthalate (PEN) is a material with intrinsically scintillating capabilities. Using a thin foil of PEN together with a SiPM array has been shown to be an excellent combination for alpha detection and therefore as a radon detection device. Coupled with a BNNT mat with a high 10 B content, it was tested for its capabilities as a neutron detector in the thermal energy range. Supported by BMBF via EFRE.

HK 26: Instrumentation IX

Time: Wednesday 14:00–15:30

Group Report

HK 26.1 Wed 14:00 SCH/A117
Status of the readout system for the Micro-Vertex-Detector of the PANDA experiment — KAI-THOMAS BRINKMANN, • MARVIN PETER, and HANS-GEORG ZAUNICK — Justus-Liebig-Universität Giessen, Germany

The Micro-Vertex-Detector (MVD) is situated in the center of the PANDA experiment and will take an important role in particle tracking and identification. A readout system for the silicon strip detectors is currently in development and being tested in combination with the detectors. This talk will give an overview of the readout system of the MVD strip detector prototypes. *gefordert durch BMBF

HK 26.2 Wed 14:30 SCH/A117
The front-end signal path of the P2 experiment at MESA — SEBASTIAN BAUNACK, • BORIS GLÄSER, • RAHIMA KRIN, • FRANK MAAS, 2,3, • DAVE R. PINEIRO, 2,3 TADES RIMKE, 2,3 and MALTE WILFERT 2 — 1Institute for Nuclear Physics, Mainz, Germany — 2Helmholtz Institute Mainz, Germany — 3PRISMA+ Cluster of Excellence, Johannes Gutenberg-Universität Mainz

The weak mixing angle sin2θw can be measured in parity violating elastic electron-proton scattering. The aim of the P2 experiment is a very precise measurement of the weak mixing angle with an accuracy of 0.15% at a low four-momentum transfer of Q²=4.5⋅10⁻⁶ GeV². In combination with existing measurements at the Z pole with comparable accuracy, this comprises a test of the standard model with a sensitivity towards new physics up to a mass scale of 5 GeV. The experiment was built at the accelerator of the 8.4 m high H1A spectrometer, which was completed.

The small asymmetries C(10⁻⁵) and the high precision require very high statistics and therefore an integrating measurement with the associated integrating data acquisition readout chain. A joint read-out electronics for P2 experiment in Mainz and for Moeller experiment at the Jefferson Laboratory is under development in collaboration with the University of Manitoba. The first prototype of a full differential integrating detector signal chain was built and tested at MAMI (Mainz Microtron). The results fulfill the requirements of the P2 parity violation experiment and will be presented in this talk.

HK 26.3 Wed 14:45 SCH/A117
The Data Acquisition for PANDA FAIR Phase-0 at MAMI — NICOLO BALDICCHI, 1,2 LUIGI CAPPOZZA, 3 SAMET KATILMIS, 4 DONG LUI, 5 FRANK MAAS, 2,3, JULIAN MOIR, • OLIVER NOLL, 2,3 DAVID RODRIGUEZ PINEIRO, 2,3 PAUL SCHÖNEN, 1,2 CHRISTOPH ROSNER, 2,3 and SABRA WOLFF 1 — 1Helmholtz-Institut Mainz, Mainz, Germany — 2Institute of Nuclear Physics, Mainz, Germany — 3PRISMA+ Cluster of Excellence, Mainz, Germany

The PANDA FAIR Phase-0 experiment at the Mainz Microtron Facility (MAMI) is set to determine the double-transition form factor (TF) of the pion. As a result, the uncertainty in the hadronic light-by-light (HLbL) calculation can be reduced. Consequently, the experiment will give new input to the hadronic corrections of the anomalous magnetic moment of the muon (g-2). The detector system for the experiment is a modified version of the PANDA backward calorimeter, which was developed by the electromagnetic process group (EMP) at HI-Mainz. In contrast to the PANDA experiment, the detector will operate in forward direction within a strong electromagnetic environment. Thus, new challenges arise in terms of radiation load of the components and the handling of high event rates for the electronics. The talk addresses the developments for the data acquisition system to cope with the demanding experiment environment.

HK 26.4 Wed 15:00 SCH/A117
Digital Signal Processing with FPGAs using Modern C++ and HLS — • THOMAS JANSSEN and UDOR KERBSCHULL für die ALICE Germany-Collaboration — IRI, Goethe-Universität Frankfurt am Main, Max-von-Laue-Straße 12, 60438 Frankfurt am Main, Germany

In this talk, we discuss the use of Modern C++ and HLS to implement digital signal processing (DSP) algorithms on FPGAs for embedded systems. We introduce common design patterns for some simple algorithms that are suitable for continuous streaming data. The focus of this discussion is how modern C++ helps to control FPGA resource usage by applying compile-time C++ language features compared to traditional VHDL implementations. Furthermore, tests with common SOC systems and their implementation are presented.

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Hadronic and Nuclear Physics Division (HK) Wednesday
HK 26.5 Wed 15:15 SCH/A117

**Status of the Front-End-Electronics for the CBM-TRD detector at FAIR** — **DENNIS SPECKER** for the CBM-Collaboration — Institut für Kernphysik, Max von Laue Straße 1, 60438 Frankfurt am Main

At the future Facility for Antiproton and Ion Research (FAIR) the Compressed Baryonic Matter experiment (CBM) is supposed to measure particles from heavy-ion collisions at very high interaction rates. For this purpose, the data acquisition will run in a free-streaming mode without a hierarchical trigger system.

For the Transition Radiation Detector (TRD) the readout system is based on the Self-triggered Pulse Amplification and Digitization ASIC (SPADIC).

**It features a charge-sensitive amplifier, a continuously sampling ADC, a programmable digital filter and a hit detection logic. The latest version introduces new switchable features such as a low-gain mode, an additional shaping order and digital baseline tracking.**

**This contribution presents the latest progress towards a final version of the SPADIC chip, as well as a slow-control software framework, including a GUI, that enables the operator to easily configure the SPADIC via the underlying communication protocol “IPbus”. The software offers an automated testing routine that helps to assure the quality of the front-end-electronics before installing them on the detectors.**

Supported by the German BMBF-grant 05P21RFFC3

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**HK 27: Heavy-Ion Collisions and QCD Phases V**

**Group Report**

**HK 27.1 Wed 14:00 SCH/A216**

The CBM Experiment at FAIR — towards commissioning in 2027 — **CHRISTIAN STYRM** for the CBM-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

The Compressed Baryonic Matter experiment (CBM) is under construction at the Facility for Antiproton and Ion Research (FAIR). It aims to explore the phase structure of strongly interacting (QCD) matter at large net-baryon densities and moderate temperatures by means of heavy-ion collisions. The CBM experiment is designed as a fixed-target experiment, being equipped with fast and radiation-tolerant detector systems read out by a free-streaming data acquisition system. Performing online 4D reconstruction and selection CBM will measure with unprecedented interaction rates of up to 10 MHz. Hence, rare and penetrating probes like multi-strange hadrons, ΛΛ-hypernuclei, di-electrons/muons as well as charm production will be measured with high statistics in this region of the QCD phase diagram for the first time. This opens the opportunity to search for structures in the excitation functions and thus obtain experimental evidence for a first order phase transition and critical end point predicted to be present in the FAIR (SIS100) energy range. The presentation will summarize the preparation status of the CBM experiment on the way towards commissioning in 2027 including latest results of the mCBM experiment, a CBM demonstrator and full-system test-set-up running within the FAIR phase-0 program.

**HK 27.2 Wed 14:30 SCH/A216**

Improving the CBM RICH lepton reconstruction — **PAVISH SUBRAMANI, CHRISTIAN PAULY, and KARL-HEINZ KAMPERT** — Bergische Universität Wuppertal

The Compressed Baryonic Matter experiment (CBM) is a heavy ion fixed target experiment, designed to probe the QCD phase diagram near the critical point at high s_{NN} and medium temperatures. The Ring Imaging Cherenkov Detector (RICH), situated directly behind the Micro Vertex Detector (MVD) and Silicon Tracking System (STS), is designed to distinguish electrons from pions, being the most abundantly produced particles in heavy ion collisions in the momentum range up to 10 GeV/c. One major source of background in the dilepton analysis is contamination by pions arising from false ring track matching in the RICH. Moreover, electrons from photon conversion inside the target and detector material are partially undetected by the STS tracking system, but cause additional Cherenkov rings in the RICH. If these rings are falsely matched to pion tracks they lead to electron misidentification, and thus can increase the combinatorial background and reduce the signal-to-background ratio.

This talk will focus on possible improvements in the efficiency of primary electron identification as well as pion suppression, for example by using additional information from the Transition Radiation Detector (TRD) situated directly behind the RICH.

* supported by BMBF (05P19PFXCA, 05P21PFXGC) and GSI.

**HK 27.3 Wed 14:45 SCH/A216**

CBM performance for the measurement of (multi)strange hadrons’ anisotropic flow in Au+Au collisions at FAIR — **OLERISHI LUBYNETS** and ILYA SELYSYHENKO — CBM-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung — Goethe-Universität Frankfurt am Main

The main goal of the CBM experiment is to study highly compressed baryonic matter produced in collisions of heavy ions. The SIS-100 accelerator at FAIR will enable investigation of the QCD matter at temperatures up to about 120 MeV and net baryon densities 5-6 times larger than that of the normal nuclear matter. Hyperons produced during the dense phase of a heavy-ion collision provide information about the equation of state of the QCD matter. The measurement of (multi)strange hyperons’ anisotropic flow is important for understanding the dynamics and evolution of the QCD matter created in the collision.

Performance studies for strange hadrons anisotropic flow measurement with the CBM experiment at FAIR will be presented. Strange hadrons are reconstructed via their decay topology using Kalman Filter algorithm methods. Directed flow of strange hadrons is calculated as a function of rapidity, transverse momentum and collision centrality. The effects due to non-uniformity of the CBM detector response in the azimuthal angle, transverse momentum and rapidity are corrected using the QuTools analysis package. The CBM performance is compared with that of the STAR experiment and projections for statistical uncertainties with high statistics data at CBM are presented.

**HK 27.4 Wed 15:00 SCH/A216**

Σ^0 reconstruction in Ag+Ag collisions at \( \sqrt{s_{NN}} = 2.55\text{ GeV} \) with HADES — **MARTEN BECKER** for the HADES-Collaboration — Justus-Liebig-University Gießen

The HADES experiment at GSI investigates the moderate temperature and high density regime of the QCD phase diagram created by A+A collisions at a few AGeV kinetic beam energy. Besides leptons and photons, strangeness directly transports measurable information of the created dense matter to the laboratory. In 2019 HADES collected Ag+Ag collisions at 2.55 GeV/c center of mass energy which is of great interest since the energy is right at the strangeness production threshold. For the first time, the newly installed electromagnetic calorimeter allows direct photon detection. The RICH detector was upgraded in addition, which strongly improves electron identification and the detection of conversion pairs.

This contribution shows work in progress results on the Σ^± baryon reconstruction, decaying electromagnetically into a \( \Lambda \) + γ. Feasibility studies in simulations prove the reconstruction methods in the \( \Lambda \) + γ channel as well as the Σ-lepton channel where the photon converted and at least one low energetic e^± is identified in the RICH. The Σ^0 yield is extracted and the resulting Λ/Σ^0 ratio is compared to statistical-thermal model calculations.

**HK 27.5 Wed 15:15 SCH/A216**

First measurements of Σ^0 and Σ^- with ALICE — **BENEDIKT HETBECK** for the ALICE Germany-Collaboration — Institut für Kernphysik, Johann Wolfgang Goethe-Universität Frankfurt, Frankfurt, Germany

The first measurements of \( \Sigma^0 \) - and \( \Sigma^- \) - baryons with ALICE in pp collisions at \( \sqrt{s} = 13 \text{ TeV} \) will be presented. Σ^0 baryons decay into a proton and a neutral pion via the weak interaction with a branching ratio of 51.57%. The neutral pion decays electromagnetically almost exclusively into two photons which are challenging to measure with the ALICE apparatus. In particular, since these photons have low momenta. However, Σ^- baryons are an important probe to study the strangeness production in pp collisions. Furthermore, the reconstructed Σ^- baryons can be used for correlation measurements with protons to improve the understanding of the interaction between nucleons and hyperons.
HK 28: Heavy-Ion Collisions and QCD Phases VI

Recording Date: Wednesday

Group Report

Transport Model Evaluation Project for Intermediate-Energy Heavy-Ion Collisions — •Hermann Wolter — University of Munich (LMU), Munich, Germany

Transport models describing the evolution of a heavy-ion collision are indispensable to extract information on the equation-of-state of nuclear matter and medium properties of hadrons from such experiments in the intermediate energy range from several 100 MeV/c to a few GeV per nucleon. Of particular interest today is the high-density behavior of the nuclear symmetry energy, which is of great relevance for the understanding of astrophysical objects and processes. However, the highly complex and non-linear transport equations are commonly solved by simulations, which involve choices of strategies, which are not necessarily determined by the underlying equations. Thus it has occurred that studies using different transport models have deduced differing conclusions from the same data. In order to understand these differences and to reduce the systematic uncertainties of transport analyses of heavy-ion collisions, we have, within the TMEP collaboration, undertaken an extensive project of comparing many transport codes in different set-ups under controlled conditions (a review is given in H. Wolter et al., Prog. Part. Nucl. Phys. 125 (2022) 103962), also providing benchmark calculations. Here we will discuss the present status and future projects of this undertaking.

Mapping the quark-gluon plasma properties in Pb-Pb and Xe-Xe collisions at the LHC with Fluidum — •Luuk Vermunt1,2, Yannis Seeman2, Lukas Krebs2, Christian Sonnabend2, Andrea Dubla2, Iva Selyuzhenkov3, and Silvia Maschioch1,2 — 1Physikalisches Institut, Heidelberg, Germany — 2GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

Fundamental properties of strongly-interacting matter under extreme conditions become accessible with ultra-relativistic collisions of heavy ions. We will present a phenomenological analysis of the experimental data for transverse momentum spectra of identified charged hadrons and (multi-)strange hyperons in Pb-Pb and Xe-Xe collisions at the LHC. The analysis is based on the relativistic fluid dynamics description implemented in the numerically efficient Fluidum approach. We separate in our treatment the chemical and kinetic freeze-out, and incorporate the partial chemical equilibration to describe the late stages of the collision evolution. We determine key parameters of the quark-gluon plasma evolution and its properties including the shear and bulk viscosity to entropy ratios, the initialisation time, initial density, and freeze-out temperatures. The physics parameters and their posterior probabilities are extracted using global search in multidimensional space with modern Machine Learning tools, such as ensembles of neural networks.

Global angular momentum generation in heavy-ion reactions within a hadronic transport approach — •Nils Säss1, Oscar García-Montero1,2, Marco Müller1, and Hannah Effen1,3,4 — Goethe University Frankfurt — 1University Bielefeld — 2GSI — 3FIAS

In 2017, the STAR collaboration at the Relativistic Heavy Ion Collider (RHIC) has measured finite global spin polarization of Λ hyperons. This measurement revealed a high angular momentum of the heavy ions and provided experimental evidence for vorticity in the quark-gluon plasma for the first time. In order to investigate the underlying mechanisms, a dynamic description of the transfer of angular momentum is required. In this work, the microscopic non-equilibrium transport approach SMASH is applied to study the generation of global angular momentum by the interaction of two nuclei. As SMASH provides access to the whole phase-space evolution of every particle at any given time, it allows to assess the fraction of angular momentum generated in the fireball by all participants. We confirm the previous modeling by Becattini within a geometric Glauber model approach, which found that the angular momentum transfer reaches a unique maximum in mid-central Au-Au collisions during time evolution, even though angular momentum is not conserved locally in the transport approach a priori, we identify the contributions to the conservation violation and propose optimal setups for different energy regimes that recover conservation, based upon the test particle method and the treatment of Fermi motion.

First dielectron measurements in pp collisions at 13.6 TeV with ALICE in Run 3 — •Florian Eisenhut for the ALICE Germany-Collaboration Goethe-Universität Frankfurt am Main

With the new and upgraded detectors of ALICE, the experiment is capable to read out collision data in a continuous mode. With a data acquisition rate 100 times larger than before, an integrated luminosity of more than 10 nb⁻¹ is expected to be collected for Pb–Pb collisions during the Run 3 and 4 (2022-2032) data taking periods. Not only the improved readout of the detectors but also the reduced material budget, as well as the improved pointing resolution of the detectors, are crucial for the dielectron analysis. They will help to control the background from photon conversions and heavy-flavor hadron decays within the dielectron spectra.

This talk will give an overview of the first performance studies for dielectron analyses with the ALICE experiment based on data of pp collisions at 13.6 TeV in Run 3. It will summarize the techniques used to track, identify and select electrons and photons. First results of the dielectron spectra and their corresponding signal-to-background ratios and significances will be presented together with a comparison to the results in Run 2.

Prompt and non-prompt J/ψ with machine learning and Kalman filter techniques with ALICE in Run 3 — Pengzhong Liu for the ALICE Germany-Collaboration GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany — University of Science and Technology of China, Hefei, China

Quarkonium production offers an effective way to study the properties of the quark-gluon plasma (QGP) created in ultra-relativistic heavy-ion collisions. While the prompt J/ψ production provides information on suppression and regeneration mechanisms in the QGP, the non-prompt J/ψ component (from b-hadron decays) allows one to study heavy quark energy loss in the medium. J/ψ meson production measurements in pp collisions, besides providing a reference for the corresponding measurements in p-Pb and Pb-Pb collisions, are also crucial to better understand quantum chromodynamics.

In this talk, the performance of the combined usage of KFParticle and machine learning (ML) for the measurement of prompt and non-prompt J/ψ production will be presented. The KFParticle package, based on the Kalman filter algorithm, shows good performances in the reconstruction of particle decays. Combining it with ML techniques will significantly improve the signal reconstruction efficiency and signal-to-background ratios. Results from the commissioning of this new methodology in Pb-Pb collisions at √sNN = 5.02 TeV from Run 2 will be shown, followed by the study of the first Run 3 data from pp collisions at √s = 13.6 TeV.

HK 29: Hadron Structure and Spectroscopy III

Recording Date: Wednesday

Group Report

Probing the hadron structure with the GlueX experiment at Jefferson Lab — •Andrii Rjabovsky, Daniel Greenwald, and Stepham Paul — Technical University of Munich, James Franck Str. 1, 85748 Garching

The GlueX experiment started data taking in 2017 and is focused on the measurement of neutral as well as charged final states at photon energies up to 12 GeV. An important tool is the use of linearly polarized photons, which allows to shed light on the question whether natural or unnatural exchange dominates in the production of different states. Various results have been extracted in recent years, ranging from the extraction of polarization observables for different final states over the investigation of excited Λ states to the determination of the J/ψ cross section at threshold.

This presentation will show the current status of the GlueX experiment and give an overview about the published results as well as ongoing analyses.

Partial-wave analysis of τ → πππ̅ at Belle — •Andrei Rjabovsky, Daniel Greenwald, and Stepham Paul — Technical University of Munich, James Franck Str. 1, 85748 Garching

Location: SCHA316

Time: Wednesday 14:00–15:30

Location: SCHA315

Time: Wednesday 14:00–15:30
We present preliminary results of a partial-wave analysis of in data from the Belle experiment at the KEK e+e− collider. We demonstrate the presence of the (1420), and (1540) resonances in τ decay and measure their masses and widths. We also present validation of our formalism in a model-independent approach. Our results can improve modeling in simulation studies necessary for measuring the τ e and electric dipole moments and Michel parameters.

*This work is funded by the DFG under Germany's Excellence Strategy - EXC-2094 - 390783311 and BMBF Verbundforschung (05H21WORD1 HighD3, 05H21WORD1 BELLE2, 05P21WOC1 COMPASS).

H. Karapiperis

**Partial-wave analysis of the raa Final state at COMPASS**

**Philipp Haas**

for the COMPASS-Collaboration — Physik-Department, Technische Universität München

**The COMPASS experiment** is a multi-purpose fixed-target experiment at the CERN SPS. One of its major goals is to study the light-meson spectrum with high precision. Of special interest is the search for so-called exotic mesons which cannot be described as quark-antiquark states. To this end, COMPASS has acquired large data samples on diffractive production of excited light mesons by scattering a 190 GeV/c beam off a proton target. Using this data set, COMPASS studied the state, which is a promising candidate for a so-called spin-exotic hybrid meson in great detail in the and π decay modes. However, lattice QCD predicts that the (1600) dominantly decays into . The (1235) decay mode has so far not been studied at COMPASS. As (1235) dominantly decays into , a partial-wave analysis of including the decay is necessary to access the (1235) decay mode. We will present our development of a partial-wave analysis of the ππ final state. We will focus on modeling the decay in the partial-wave analysis.

*Supported by the DFG under Germany's Excellence Strategy - EXC2094 - 390783311 and BMBF Verbundforschung 05P21WOC1 COMPASS.

H. Karapiperis

**Results of total and partial cross-section measurements of the **

**Svenja Wilden, Felix Heim, Martin Müller, Pinja Wüstenberg, and Andreas Zilges**

University of Cologne, Institute for Nuclear Physics

The existence of most of the proton rich stable nuclei - the p nuclei - cannot be explained via neutron-capture reactions. Therefore, at least one other process has to exist in order to describe their origin, the γ process. Since most photodisintegration reactions involved in the process are not directly accessible, reliable statistical model calculations are needed to predict cross sections and reaction rates. The cross sections include total cross sections describing the probability of the reaction itself and partial cross sections describing the decay to certain discrete states in the final state. To improve the calculations the nuclear input parameters need to be constrained. This requires a large experimental database. Via comparison of experimental data to theoretical predictions different models can be excluded or constrained. In order to study the (p,n) and (p,γ) reaction an in-beam experiment at the high-efficiency HPGe γ-ray spectrometer HORUS at the University of Cologne was performed. Proton beams with energies between and were provided by the 10 MV EN Tandem accelerator. Final results on absolute cross sections and first results on partial cross sections will be presented as well as comparisons to theoretical model calculations.

Supported by the DFG (ZI 510/8-2).
Columbia, Vancouver, CA — 5Aachen University of Applied Sciences, Aachen, DE — University of Edinburgh, Edinburgh, UK

The bound-state beta decay of fully ionized 205Tl has been measured at GSI. Combining this new experimental information and the known electron capture decay of 205Tl we can compute the weak processes connecting these two nuclei. This includes electron capture and beta decay operating during the age phase of intermediate-mass stars. These processes determine the 205Pb/205Tl ratio produced by the s-process. The new experimental information favors a larger production of 205Pb that may be observable in the early Solar System. Another important weak process is the conversion of 205Tl to 205Pb by solar neutrinos. This reaction has such a low Q-value that probes the pp solar neutrino flux. Using the new experimental data together with shell-model calculations we provide an update to the neutrino absorption cross section for solar neutrinos on 205Tl. We highlight the necessity of a measurement of the Gamow-Teller strength by charge exchange reactions. This work is funded by SFB 1245 “Nuclei: From Fundamental Interactions to Structure and Stars”.

**HK 30.5 Wed 15:15 SCH/A419**

**Linearity and dark rate of SiPMs for large scintillator bars** — **Thomas Hensel**, 2 Daniel Bemmesser, Konstanze Boretzky, Igor Gašparčik, 3, 4, Daniel Stach, Andreas Wagner, and Kai Zuber — 2Technische Universität Dresden, Institut für Kern- und Teilchenphysik, 01062 Dresden, Germany — 3Helmholtz-Zentrum Dresden-Rossendorf (HZDR), 01328 Dresden, Germany — 4Physikalisch-Technische Bundesanstalt, Braunschweig, Germany

In this contribution, the aforementioned complementary photons sources, most common photons sources are, on the one hand, energetically-continuous real photon-scattering experiments are well suited to study the dipole response in numerous nuclei. Over the last decade the electric dipole response in numerous nuclei can have great impact on reactions rates in nucleosynthesis processes. Hence, they are crucial to understand the nuclear abundances in our universe.

Real photon-scattering experiments are well suited to study the dipole response due to the small angular-momentum transfer of photons [1, 2]. Besides the determination of spin and parity quantum numbers of excited states in even-even nuclei, absolute and total photoabsorption cross sections can be extracted in a model-independent way by combining complementary (γ,γ’) and (γ,p) experiments. The most common photon sources are, on the one hand, energetically-continuous bremsstrahlung and, on the other hand, Laser-Compton Backscattering producing a linearly-polarized, quasi-monoenergetic γ-ray beam.

In this contribution, the aforementioned complementary photon sources, examples for corresponding setups, and recent results will be presented. This work is supported by the BMFB (05P1PK94).


**HK 31.1 Wed 14:00 SCH/A118**

**Real photon-scattering experiments for the study of dipole excitations** — Miriam Müsscher, Johann Issak, Florian Klugwig, Deniz Savran, Tanja Schütterle, 1 Ronald Schwengner, and Andreas Zilges — 1University of Cologne, Institute for Nuclear Physics — TÜ Darmstadt, Institute for Nuclear Physics — 2GSI, Darmstadt — 2Helmholtz-Zentrum Dresden-Rossendorf

 Absolute photoabsorption cross sections of atomic nuclei can have great impact on reaction rates in nucleosynthesis processes. Hence, they are crucial to understand the nuclear abundances in our universe.

Real photon-scattering experiments are well suited to study the dipole response due to the small angular-momentum transfer of photons [1, 2]. Besides the determination of spin and parity quantum numbers of excited states in even-even nuclei, absolute and total photoabsorption cross sections can be extracted in a model-independent way by combining complementary (γ,γ’) experiments. The most common photon sources are, on the one hand, energetically-continuous bremsstrahlung and, on the other hand, Laser-Compton Backscattering producing a linearly-polarized, quasi-monoenergetic γ-ray beam.

In this contribution, the aforementioned complementary photon sources, examples for corresponding setups, and recent results will be presented. This work is supported by the BMFB (05P1PK94).


**HK 31.2 Wed 14:30 SCH/A118**

**Systematics of the dipole polarization** — Isabella Brandherm, 1 Peter von Neumann-Cosel, 1 Tobias Kraus, 1 Hiroaki Matsubara, 1 and Atsushi Tamiya — 1Institut für Kernphysik, TU Darmstadt, Darmstadt, Germany — 2RCNP, Osaka, Japan

Inelastic proton scattering at extreme forward angles has been established as a tool to probe the electric dipole response in nuclei. From that the electric dipole polarization can be obtained, which is a key observable to set constraints to the symmetry energy parameters of the equation of state and neutron skin thickness of nuclei. Over the last decade the electric dipole response in numerous nuclei has been measured at the Research Center for Nuclear Physics in Osaka, Japan. In this talk new result about the dipole response and dipole polarizability of 15Ni and 60Fe will be presented. Also the now available systematics of of the dipole polarizability will be discussed.

Supported by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) - Project-ID 279384907, SFB 1245.

**HK 31.3 Wed 15:00 SCH/A118**

**Investigation of low-lying dipole excitations in 144Nd via real photon-scattering experiments** — Florian Klugwig, Miriam Müsscher, Ronald Schwengner, Tanja Schütterle, and Andreas Zilges — 1University of Cologne, Institute for Nuclear Physics — 2Helmholtz-Zentrum Dresden-Rossendorf

Since photons only transfer small angular momenta, they are a well-suited probe to investigate dipole excitations in atomic nuclei [1]. Therefore, the (γ,γ’) or also called Nuclear Resonance Fluorescence (NRF) technique is an established method to study among others the so-called Pygmy Dipole Resonance (PDR).

The PDR occurs as a concentration of electric dipole strength around and below the neutron separation energy. For the last decades, this excitation mode has been a research topic of great interest [2,3] and further systematic studies are crucial. Due to its wide range of stable, even- even isotopes, the Nd isotopic chain is well suited for this purpose. Thus, two complementary (γ,γ’) experiments on the rare-earth nucleus 144Nd have been performed using a continuous bremsstrahlung beam at the eELBE facility [4] and utilizing quasi-monoenergetic γ rays at HiSy [5]. First results of these experiments will be presented in this contribution.

This work is partly supported by the BMFB (05P21PK94).


**HK 31.4 Wed 15:15 SCH/A118**

**Photoexcitation of 76Ge** — Ronald Schwengner, Konrad Schmidt, Kai Zuber, Hans F. R. Hoffmann, Marie Pichotta, and Steffen Turkay — 1Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — 2Institute of nuclear and particle physics, TU Dresden, 01069 Dresden, Germany

The dipole strength of the nuclei 76Ge was studied in photon-scattering experiments using bremsstrahlung produced with electron beams of energies of 7.8 and 12.3 MeV which were delivered by the electron linear accelerator of high brilliance and high brightness (ELBE). In total, 210 levels up to an excitation energy of 9.4 MeV were identified and a spin J = 1 was assigned to most of them. The quasi-continuous of unresolved transitions was included in the analysis of the spectra and the intensities of branching transitions were estimated on the basis of simulations of statistical γ-ray cascades. The photoabsorption cross section up to the neutron-separation energy was determined.

The experimental procedure and results will be discussed including some implication on 76Ge 0νββ experiments.
Probing the $N = 152$ neutron shell closure by laser spectroscopy of fermium isotopes

**— Jessica Warri nek for the Fermium-Collaboration**

GSi Helmholtzzentrum für Schwerionenforschung, Germany — Johannes Gutenberg-Universität Mainz, Germany

Determining the limits of existence of the heaviest nuclides is a forefront topic in nuclear-physics research. Nuclides in this region are stabilized by shell effects that retard spontaneous fission and feature properties distinctly different from those of lighter nuclides. Experimental information on the deformed shell closures around the heavy actinides like fermium (Fm, $Z = 100$) can help to benchmark state-of-the-art theoretical models to improve their predictive power in the range of the heaviest elements.

Laser spectroscopy serves as a powerful tool to extract experimental information on nuclear structure parameters such as the change in the mean deformation radius and nuclear moments in a nuclear-model independent manner. Recent studies in fermium allowed the determination of the isotope shift in an atomic transition for a long chain of eight isotopes ranging from the accelerator-produced $^{250}$Fm to reactor-bred $^{253}$Fm. Direct and indirect production methods were combined and associated on-line and off-line measurement techniques significantly advanced to access isotopes spanning well across the known deformed shell gap at $N = 152$. Results on the extracted changes in the mean-square charge radii revealing a discontinuity around the neutron shell closure will be discussed.

**Proton-neutron interaction strength studies via accurate mass measurements far from stability**

**— Gabriella Kripkó-Koncz for the FRS Ion Catcher Collaboration**

Justus-Liebig-Universität Gießen, Gießen, Germany — Tel Aviv University, Tel Aviv, Israel

The average interaction strength between the last (highest energy orbitals) proton(s) and neutron(s) in a nucleus (denoted as $B_{n,p}$), may be derived from differences of accurate atomic masses, and in turn point empirically to various aspects of nuclear structure and interactions. The FRS Ion Catcher experiment at the in-flight fragment separator FRIS at GSI enables highly accurate direct mass measurements ($\delta m/m \sim 10^{-12}$) with thermalized projectile and fission fragments by combining a cryogenic stopping cell and a multiple-reflection time-of-flight mass spectrometer. Confirmed by mass measurements at the FRS Ion Catcher, the detailed structure of $B_{n,p}$ along the $N = Z$, $N \geq Z$, $Z = 2$, $N \geq Z - 4$ lines near the $Z = 29$ – 37 region has been investigated [1]. These studies will be presented and an analysis of mass measurements via higher-order mass-difference indicators, the deviations of which from their expected trends may indicate questionable mass values in the Atomic Mass Evaluation and highlight distinctive nuclear structure effects, will be motivated.


**The search for double alpha decay of $^{242}$Ra at the FRIS Ion Catcher**

**— Heinrich Wilsenach for the Double Alpha IN2PS-CLE-GSI-Collaboration**

Justus-Liebig-Universität Gießen, Gießen, Germany — Tel Aviv University, Tel Aviv, Israel

Double alpha decay has been predicted since the 1980s. The most probable scenario for this decay mode is the simultaneous tunnelling of two alpha particles through the coulomb barrier and their emission in opposite directions. Recent theoretical studies [1] have predicted a back-to-back double alpha decay branching ratio for $^{242}$Ra of 1.8 x $10^{-7}$a.

A project to measure this small branching ratio has been performed at the FRS (FFragment Separator) Ion Catcher at Gesellschaft für Schwerionenforschung (GSI). This project utilized the thermalization of $^{226}$Ra alpha recoils in a cryogenic stopping cell (CSC) and the preparation of a clean beam of $^{242}$Ra by a radio-frequency-quadrupole (RFQ) beamline. Two double-sided silicon strip detectors (DSD) were used to read out each alpha particle's position, time and energy coming from the implanted $^{242}$Ra.

This talk will give insight into the design and setup of the experiment, including Monte Carlo simulations. It will conclude with preliminary results from the first 135 day long data taking run.

Group Report
HK 33.1 Wed 14:00 SCH/A252
\textbf{:SPECT - A fully magnetic gradient trap to measure the free neutron lifetime --- Martín Fertl for the tauSPECT-Collaboration --- Institut für Physik, Johannes Gutenberg-Universität Mainz}

The free neutron lifetime \( \tau_n \) critically influences the primordial nucleosynthesis and is indispensable to perform a CKM-matrix unitarity test without nuclear structure correlations related to the extraction of \( V_{ud} \) from 0 \( \rightarrow \) 0 nuclear transitions. The \textit{s:PECT} collaboration has implemented a 3D magnetic field gradient trap for ultra-cold neutrons (UCN) with the aim to determine \( \tau_n \) with a statistical sensitivity below 1 s, complementary to the precision obtained with the current state-of-the-art magneto-gravitational UCN traps. Spin-polarized UCN are loaded into the storage volume via a double-spin-flip sequence and counted after a preset storage time with an in-situ UCN detector. This report will introduce the concept, the implementation and results from the commissioning runs at the UCN source facility at TRIGA Mainz.

Group Report
HK 33.2 Wed 14:30 SCH/A252
\textbf{Deagassing of a Magnetically Shielded Room for the \( ^{3}\text{He} \)\textsubscript{29} \( ^{129Xe} \) Comagnetometer Experiment in Heidelberg --- Benjamin Brauneiz, Fabian Allmendinger, Werner Heil, and Ulrich Schmidt --- Physikalisches Institut, Universität Heidelberg --- Institut für Physik, Universität Mainz}

The permanent Electric Dipole Moment (EDM) of \( ^{129} \text{Xenon} \) is an experimentally accessible signal for potential sources of CP-violation not described by the Standard Model. It can be measured in a clock comparison experiment using a gas mixture of free spin precessing nuclear polarized \( ^{3}\text{He} \) and \( ^{129Xe} \). To reach the desired accuracy this experiment has to be performed at low frequencies (few Hz) and therefore within a Magnetically Shielded Room (MSR). Furthermore, very small field gradients (pt per cm) are required in order to reach a sufficiently large spin coherence time. Our MSR consisting of three layers of Mu-metal and one layer of copper-plated aluminum was constructed in Heidelberg 2021. Efforts are made to develop an advanced degaussing routine yielding to reproducible results from \( ^{129} \text{Xenon} \) experiments.

Group Report
HK 33.3 Wed 15:00 SCH/A252
\textbf{Tracking of the spatial magnetic field distribution for the Fermilab Muon g-2 experiment --- Mohammad Uraibullah Hassan Qureshi, René Reimann, and Martin Fertl for the Muon g-2-Collaboration --- Institute of Physics and Excellence Cluster PRISMA+, Johannes Gutenberg University Mainz, 55099 Mainz, Germany}

The Fermilab Muon g-2 experiment E989 aims to measure the anomalous magnetic moment of the muon to a precision of 140 ppb. This experiment consists of muons stored in a ring-shaped quasi-penning trap within a uniform magnetic field of 1.45 T. The measurement is composed of a ratio of two frequencies, the anomalous spin precession frequency of the muons (\( \omega_{\mu} \)) and the muon-weighted spin precession frequency of protons (\( \omega_{p} \)). \( \omega_{p} \) is fundamentally the measure of the magnetic field experienced by these precessing muons, we measure this magnetic field using nuclear magnetic resonance (NMR) based probe systems. In this talk, I will be reviewing two of the sub-systems of the magnetic field measurement chain, namely, the trolley probe and the fixed probe systems which measure the magnetic field periodically and continuously, respectively. This will be followed by an overview of the procedure for synchronising the measurements of the two sub-systems in time and the independent cross-check performed on the procedure for removing the trolley system's magnetic signature in the fixed probe system.

HK 34: Instrumentation X

Group Report
HK 34.1 Wed 15:45 SCH/A252
\textbf{Status of the CBM Micro Vertex Detector --- Benedict Arnold-Meadows for the CBM-MVD-Collaboration --- Goethe-Universität Frankfurt am Main}

The Compressed Baryonic Matter (CBM) Experiment will be a core experiment of the future FAIR facility. Its Micro Vertex Detector (MVD) will be composed of four stations, operating in the experiment's target vacuum. The 0.3 - 0.5 mm thin station will be equipped with 30 \( \mu \)m thick, highly granular Monolitich Active Pixel Sensors called MIMOSIS. MIMOSIS is being developed by LPHC Strasbourg and will provide a spatial and temporal precision of 5 \( \mu \)m and 5 \( \mu s \), respectively, with a peak rate capability of 80 MHz/cm\textsuperscript{2}. The first full-size prototype MIMOSIS-1 was intensely tested for in-beam performance, radiation tolerance and robustness to Single Event Effects. The results of the tests will be summarized and the implications for the next and final prototype MIMOSIS-2, which has been submitted, will be discussed. Moreover, a status of the efforts with regard to integration and cooling in vacuum towards the final MVD will be given.

HK 34.2 Wed 16:15 SCH/A252
\textbf{Characterization of APTS, a MAPS prototype fabricated in 65 nm CMOS technology for the ALICE ITS3 upgrade --- David Schledzewitz for the ALICE Germany-Collaboration --- Physikalisches Institut, Universität Heidelberg --- GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt --- European Organization for Nuclear Research (CERN), Geneva, Switzerland}

For the next detector upgrade of the ALICE experiment, an extensive R&D program is carried out for the vertex detector to minimize the material budget and reduce the distance to the interaction point. From the currently installed ALICE Inner Tracking System (ITS2), the innermost three out of the seven layers of Monolitich Active Pixel sensors (MAPS) will be replaced. The proposed upgrade (ITS3) is based on curved, wafer-scale, ultra-thin silicon MAPS with a truly cylindrical geometry. The foreseen technology for this upgrade is the 65 nm CMOS imaging process by TowerJazz Panasonic Semiconductor Company, allowing the production of wafer-scale pixel sensors on 300 mm diameter wafers using stacking. One of the current prototypes to evaluate the detection performance and radiation hardness of the technology is the Analog Pixel Test Structure (APTS). In particular, a set of 4 x 4 pixel matrices with parallel, analog readout realized in various geometries are used to characterize the parameter space of the technology. This contribution intends to provide an overview of the APTS, covering performance results from testbeam campaigns and laboratory measurements.

HK 34.3 Wed 16:30 SCH/A252
\textbf{Characterisation of irradiated Digital Pixel Test Structures produced in 65 nm TSPC CMOS process --- Pascal Reich for the ALICE Germany-Collaboration --- Physikalisches Institut Universität Heidelberg}

The future upgraded ALICE Inner Tracking System (ITS3) features wafer-scale, ultra-thin and truly cylindrical Monolitich Active Pixel Sensors (MAPS) as its innermost three layers around the beampipe. New sensors for this effort are intended to be produced in 65 nm CMOS technology in order to benefit from the smaller feature size and the larger commercially available wafers.

With the goal of qualifying this technology for the application in MAPS, an extensive R&D programme is ongoing. In view of a new pixel sensor for the ITS3, a Digital Pixel Test Structure (DPTS) has been designed and produced. Multiple
of these prototypes are characterized in laboratory measurements and beam test campaigns at DESY and CERN. In order to evaluate the effects of radiation damage, some sensors have been neutron irradiated to different levels ranging from $10^{13}$ to $10^{18} \text{ MeV} \cdot \text{cm}^{-2}$. Furthermore, several prototypes have been subject to an X-ray source and thereby received doses up to 100 kGy.

Detection efficiency and position resolution of the DPT sensors are presented to characterize their performance. The outcome of these studies demonstrates the feasibility of the 65 nm CMOS technology for the application in future MAPS-based detectors.

**HK 34.4 Wed 16:45 SCH/A251**

**ALPID Monolithic Active Pixel Sensors at GSI** — **MARTIN BAIZER**$^{1,2}$, **OLEG KISELEV**$^{1}$, **IVAN MUKRIN**$^{1}$, **CHRISTIAN SCHIEDERBERGER**$^{1,2}$, **LUKE ROSE**$^{1}$, **BASTIAN LOHER**$^{1}$, and **ANDREA JEDLICKA**$^{1}$ for the R3B-Collaboration — **GSI, Darmstadt, Germany**. ALPID Monolithic Active Pixel Sensors are used for vertex reconstruction and particle identification at the endcap of the LHC. During the Long Shutdown 4 of the LHC (LS4), the ALICE experiment will be upgraded to ALICE 3. Along with an advanced silicon-based tracking system placed closer to the interaction point, ALICE 3 will also come equipped with a Forward Conversion Tracker (FCT) which will measure the transverse momentum of soft photons in the forward direction. In the soft photon regime, the bremsstrahlung spectrum can be computed in a model independent way by the Low theorem. Most previous experiments have observed a soft photon excess on top of what is expected by the Low theorem, but some did not observe this excess at all. This makes the experimental status of the excess unclear. The FCT, an array of silicon layers, will provide a way to measure these photons via the photon conversion method. The FCT will be provided with an unprecedented position resolution from these silicon trackers which should result in a very clean photon identification.

**HK 35: Instrumentation XI**

**Time: Wednesday 15:45–17:00**

**Group Report**

**HK 35.1 Wed 15:45 SCH/A.101**

**MAGIX group report** — **PEPE GÜLKER** for the MAGIX-Collaboration — **Institut für Kernphysik, Johannes Gutenberg-Universität, Mainz, Germany**. The versatile, low energy electron scattering experiment MAGIX, located in Mainz at the new MESA accelerator, has switched gears and entered the construction phase. The design of the main components, e.g., the two magnetic spectrometers, their small-diff focal plane TPCs and the trigger-veto system, are fixed and production has already started. The broad physics program, ranging from rare particle searches to electrodisintegration measurements, is scheduled according to the increasing energy and availability of the energy-recovering mode of the accelerator.

This group report will redrew the design process of the whole experiment, give an overview of finalized parameters and discuss the planned measurement campaign.

**Group Report**

**HK 35.2 Wed 16:15 SCH/A.101**

**Status of the CBM Time-of-Flight project** — **INGO DEPPNER** and **NORBERT HERRMANN** for the CBM-Collaboration — **Physikalisches Institut, Uni. Heidelberg, Germany**. In order to provide an excellent particle identification (PID) of charged hadrons at the future high-rate Compressed Baryonic Matter (CBM) experiment the CBM-TOF group has developed a concept of a 120 m$^2$ large Time-of-Flight (ToF) wall (with 9300 channels) with a system time resolution below 80 ps based on Multi-gap Resistive Plate Chambers (MRPC). The MRPC detectors were extensively tested in several beam campaigns at particle fluxes of up to a 30 kHz/cm$^2$ and reached by now the close to final design. Prior to its destined operation at the Facility for Antiproton and Ion Research (FAIR), a preproduction series of MRPCs is being used for physics research at two scientific pillars of the FAIR Phase-0 program. At STAR, the fixed-target program of the Beam Energy Scan II (BES-II) relies on 108 CBM MRPC detectors enabling forward PID for center of mass energies in the range of 3 to 7.7 GeV Au+Au collisions. At mCBM, high-performance benchmark runs of $A$ production at top SIS18 energies (1.5/1.9 GeV for Au/Ni beams) and CBM design interaction rates of 10 MHz became feasible. Apart from the physics perspectives, these FAIR Phase-0 involvements allowed for high rate detector tests and long term stability tests. Observations and conclusions for the upcoming mass production will be discussed. The project is currently funded by BMBF contract 05P21VHF11.

**HK 36: Computing I**

**Time: Wednesday 15:45–17:15**

**Location: SCH/A.101**

**ALICE TRD: online-offline processing and electron identification in LHC Run 3 and 4** — **FELIX SCHLEPPER** — **Physikalisches Institut, Heidelberg, Deutschland**. During the long shutdown 2 (LS2) of the LHC, the ALICE experiment was upgraded to exploit the full scientific potential. The upgrade was posed by the challenge of continuously reading out and online processing $p-p$ and $Pb-Pb$ collisions at rates of 1 MHz and 50 kHz, respectively. To meet these new requirements, the ALICE experiment developed a new online-offline software framework O2 for Run 3 and 4.

This talk will give an overview of the software, the calibration and particle identification (PID) strategies currently being implemented and commissioned for the Transition Radiation Detector (TRD). The TRD contributes to the electron identification capabilities of ALICE. In Run 1 and 2 a classical likelihood-based algorithm was used. Since the front end electronics (FEE) was upgraded, the data readout precision was notably reduced to cope with the higher rates. Hence, new algorithms for PID, including Machine Learning, will be used to recover and possibly improve the previous PID capabilities. First performance results will be shown as well.
the Online-Offline simulation and analysis framework ALICE uses for Run 3 is currently being developed in C++.

HK 36.3 Wed 16:15 SCH/A117
Searching for Anomalous Hadronic Higgs Boson Decays at the LHeC — Subhashish Behera, Manuel Hagelkken, and Matthias Schott — Johannes Gutenberg-Universität Mainz

The future Large Hadron electron collider (LHeC) would allow collisions of an intense electron beam with protons or heavy ions at the High Luminosity Large Hadron Collider (HL-LHC). Owing to a center of mass energy greater than a TeV and very high luminosity, the LHeC would not only be a new generation collider for deep-inelastic scattering (DIS) but also an important facility for precision Higgs physics, complementary to pp and electron–positron colliders. While anomalous hadronic decay signatures of the Higgs boson, e.g. to three or more partons, are difficult to probe at the LHC due to its enormous background rates, it might be possible to search for such decays at the LHeC. In this work, we present the expected sensitivity at the LHeC for $H \rightarrow 3$ jets and $H \rightarrow 4$ jets decay channels, assumed an integrated luminosity of $1 \text{ab}^{-1}$.

HK 36.4 Wed 16:30 SCH/A117
A language model based tracking algorithm for the Straw Tube Tracker of the PANDA experiment — Jürgen Kurth, Jacob Stang, and Tobias Stockmanns — 1 GSI Helmholtz Centre for Heavy Ion Research, Darmstadt, Germany — 2 Ruhr-Universität Bochum, Bochum, Germany — 3 Forschungszentrum Jülich, Jülich, Germany

The Straw Tube Tracker (STT) is designed for momentum reconstruction of charged particles in the PANDA experiment. This talk will present a tracking algorithm that can group measured hit positions of the STT into tracks of the particles based on the language model. The overall algorithm consists of two main parts, the language model which contains the probabilities for predicting the next hit point based on previous measurements, and the tracking algorithm, that program that uses the information from the language model to select the most likely track or filter possible track candidates. We performed track parameterizations perpendicular and parallel to the solenoidal magnetic field and compared the reconstructed tracks to the MC truth information. As a result, all the reconstructed parameters are shown to be reconstructed within the expected ranges according to the MC information. The algorithm is also being developed to include a branching algorithm that can select the best track out of multiple track candidates. The development involves improving the quality of hit information and creating a track selector. The talk will also present the efficiency and resolution of this algorithm to reconstruct tracks in the STT.

HK 36.5 Wed 16:45 SCH/A117
Implementation of the Acts tracking software into PandaRoot — Ken Suzuki for the PANDA Collaboration — Ruhr-Universität Bochum, Bochum, Germany — GSI Helmholtzzentrum für Schwerionenforschung GmbH

The PANDA experiment at FAIR1 combines the stored high precision antiproton beam from the HESR with a hydrogen/nuclear target from cluster-jet/pellet target and a universal detector system equipped with a modern high-rate DAQ. The unique setup allows it to provide precision data to low/middle energy hadron structures where the experimental inputs are mostly awaited. We test the Acts Common Tracking Software2 for particle track reconstruction as an alternative to be implemented to our analysis framework, PandaRoot. We will show the status of implementation and performance comparison to our current version using Genfit.

2 https://acts.readthedocs.io.

HK 36.6 Wed 17:00 SCH/A117
Dynamically assisted nuclear fusion — Daniil Ryndyk — Helmholtz-Zentrum Dresden-Rossendorf

We consider nuclear fusion at kinetic energies in the keV regime. At such low temperatures nuclear fusion is exponentially suppressed as it occurs via quantum tunneling through the Coulomb barrier between the nuclei. Our research goal is to increase the overall tunneling probability employing short-pulsed, high-intensity electromagnetic fields thus avoiding the negative aspects of hot plasmas, e.g., heat loss.

Latest publications:
F. Queisser and R. Schützhold, PRC, 100(4), 2019
C. Kohlfürst, F. Queisser and R. Schützhold, PRR, 3033153, 2021

HK 37.1 Wed 15:45 SCH/A216
Anisotropic flow generation with $n_t(k_T, p_T)$ in a hybrid approach — Nixlas Götz, Lucas Constantin, and Hannah Elfenbein — 1 Institute for Theoretical Physics, Goethe University, Max-von-Laue-Strasse 1, 60438 Frankfurt am Main, Germany — 2 Frankfurt Institute for Advanced Studies, Ruth-Moufang-Strasse 1, 60438 Frankfurt am Main, Germany — 3 Helmholtz Research Academy Hesse for FAIR (HFHF), GSI Helmholtz Center, Campus Frankfurt, Max-von-Laue-Straße 12, 60438 Frankfurt am Main, Germany — 4 GSI Helmholtzzentrum für Schwerionenforschung, Planckstr. 1, 64291 Darmstadt, Germany

In this work, the origin of anisotropic flow in hybrid approaches, combining different initial conditions, viscous relativistic hydrodynamics as well as hadronic transport, is studied. Previous works largely disregard a non-constant $n_t(k_T, p_T)$ and focus mainly on a temperature dependence. Here instead, we study qualitatively the effect of a generalized $n_t(k_T, p_T)$ in the hybrid approach SMASH+VHILE-hybrid. The parameterization takes into account the constraints of matching to the transport coefficients in the hadronic phase and recent Bayesian analysis results. In addition, we quantify the uncertainty due to different initial state profiles, including the SMASH initial conditions as well as TgEnTo and IP-Glasma profiles. In order to investigate their interplay with the size of the transport coefficients and anisotropic flows as well as the impact of different initial state eccentricities, we compare the results with different initial conditions at $\sqrt{s_{NN}}$=200 GeV.

HK 37.2 Wed 16:00 SCH/A216
Flow Measurements of $\Lambda$, $K^0_S$, and $K^+$ in $\sqrt{s_{NN}} = 2.55$ GeV $Au+Ag$ Collisions with HADES — Tan Lu for the HADES-Collaboration — Institute of Modern Physics, Chinese Academy of Sciences — GSI Helmholtzzentrum für Schwerionenforschung GmbH

The collective motion of particles (flow) is driven by pressure gradients in fireballs created in heavy-ion collisions and shows patterns that reflect properties of the nuclear matter equation of state of QCD under extreme conditions. Due to its high rate capability the High-Accuracy Di-Electron Spectrometer (HADES) provides excellent conditions to study the flow patterns of the rarely produced strange hadrons. Since the strange hadrons are produced near to the free NN threshold at SIS18 beam energies, they are expected to be particularly sensitive to the in-medium potential.

In this talk, we report the measurements of directed and elliptic flow of $\Lambda$, $K^0_S$, and $K^+$ from $\sqrt{s_{NN}}=2.55$ GeV $Au+Ag$ collisions. The dependence on collision centrality, rapidity and transverse momentum of the measured collectivity will be compared to results from microscopic transport model calculations.

HK 37.3 Wed 16:15 SCH/A216
New publications on higher-order flow observables in ALICE — Ante Bielandzic, Farid Taghavi, Marcel Leisch, and Anton Riedel for the ALICE Collaboration — Technical University of Munich

In this contribution, the results from the two new publications on higher-order flow observables in ALICE are presented.

The newly developed Gaussian Estimator for correlations between symmetry planes, which characterize the direction of the anisotropic emission of produced particles, is measured in Pb-Pb collisions with ALICE. This allows for the first time the study of these quantities without the influence of correlations between different flow amplitudes, and therefore the extraction of unique and independent information about initial conditions and properties of Quark-Gluon Plasma from symmetry plane correlations.

In the second publication, the correlations between different moments of two flow amplitudes are measured for the first time with the recently developed asymmetric cumulants, which generalize the previous studies using symmetric cumulants of flow amplitudes.

For both sets of observables, comparison to state-of-the-art hydrodynamic model calculations is presented.

This project has received funding from the European Research Council (ERC) under the European Unions Horizon2020 research and innovation programme (grant agreement No 759257). Funded by BMBF Verbundforschung (05P21WOCA1 ALICE).
Bayesian analysis by using higher-order flow measurements at the LHC —

- SETY FARRID TAGHAVI, JASPER PANKIKLA, ANNA ONNERSTAD, CINDT
MORDANIA, MAXIM VIRTSA, ANTE BILANDZIC, and DONO J. KIO for the
ALICE Germany-Collaboration — Technische Universität München, Munich,
Germany — 2 CERN, European Physics Department, Geneva, Switzerland
— 3 University of Jyväskylä, University of Jyväskylä, Finland — 4 University
of Jyväskylä, University of Jyväskylä, Finland — 5 Technische Universität
München, Munich, Germany — 6 University of Jyväskylä, University of
Jyväskylä, Finland

As a consequence of the theoretical improvements and a wide range of accurate experimental measurements, our understanding of the collective phenomena in heavy-ion collisions has advanced significantly over the past years. The Global Bayesian analysis has a substantial role in this advancement. In this talk, we present a global Bayesian analysis to infer the transport properties of QGP using the latest CERN Large Hadron Collider Pb-Pb data at $\sqrt{s_{NN}}=2.76$ and 5.02 TeV. We show that including the latest multi-harmonic flow measurements significantly improves the uncertainties of the inferred specific shear and bulk viscosities. This observation shows the necessity of accurate measurements of collective flow observables in the future. Based on: PLB, 835 (2022) 137485. Funded by BMBF Verbundforschung (05P21WOCA1 ALICE), ERC European Unions Horizon 2020 (No. 759257), Academy of Finland, the Centre of Excellence in Quark Matter (No. 346324).

Emission of abundant hadrons from Au+Au Collisions at $\sqrt{s_{NN}}=2.42$ GeV with HADES — SIMON SPIES for the HADES-Collaboration — Goethe-Universität Frankfurt

In April 2012 we recorded 7.3 $\times$ 10$^8$ Au(1.23A GeV)+Au events with the HADES detector located at the GSI Helmholtzzentrum für Schwerionenforschung in Darmstadt, Germany. Based on these data the emission/production of protons, light nuclei, pions, hyperons and strange mesons have been studied as a function of transverse momentum/mass, rapidity and centrality, yielding the most precise data set on hadron emission currently available at this energy. In this contribution we discuss the challenges in confronting experimental data with predictions from various state-of-the-art transport models and present first preliminary results. These are put in context with available world data from other collaborations.

This work has been supported by the State of Hesse within the Research Cluster ELEMENTS (Project ID 500/10.006).

Quasi-deuterons as surrogate for two-particle correlations in nuclear matter —

- STEFAN TYPAL, STEFANO BURRELLO — 1 TU Darmstadt, Germany — 2 GSI, Darmstadt, Germany — 3 LNS-INFN, Catania, Italy

Properties of dense nuclear matter are often described using energy density functionals with nucleons as degrees of freedom and effective phenomenological interactions. They usually lack in an explicit treatment of correlations that are responsible for the formation of nuclear clusters at sub-saturation densities. Two-body correlations are also essential to explain the high-momentum tails of single-particle momentum distributions that are deduced from two-nucleon knockout experiments with energetic electrons or hadronic probes. In this contribution, the concept of quasi-deuterons in nuclear matter is introduced in a relativistic density functional to effectively describe two-nucleon correlations in dense nuclear matter above saturation. It extends the description of clustering in dilute nuclear matter using the concept of medium-dependent mass shifts.

Time: Wednesday 15:45–17:15

Critical dynamics in the real-time functional renormalization group —

- JOHANNES ROTH, LEON SIEKE, and LORENZ VON SMERAL — 1 Institut für Theoretische Physik, Justus-Liebig-Universität, 35392 Giessen, Germany —
2 Research Academy Hesse for FAIR (HIFH), Campus Giessen, 35392 Giessen, Germany

Real-time quantities such as spectral functions and transport coefficients can serve to examine the real-time evolution of a system close to equilibrium, as they encode the possible excitations in the medium and show universal static and dynamic scaling behavior near a critical point. The functional renormalization group (FRG) formulated on the Schwinger-Keldysh closed-time path provides an excellent calculational tool for such real-time correlations [1]. In this talk I will present a novel approach for the systematic construction of causal regulators for the FRG, which comply with the analytic structure of the propagators, and demonstrate that they can be interpreted as a coupling to a fictitious external heat bath with FRG scale dependent spectral distribution. As particular applications, I will discuss the relaxational Models A, B, and C according to the classification scheme by Halperin and Hohenberg, and show how they can be implemented in the real-time FRG. With this setup, I will then present results which demonstrate the generation of dynamic scaling behavior in spectral functions obtained from one and two-loop self-consistent truncation schemes.


A novel saturation-based 3+1D initial state model for Heavy Ion Collisions —

- OSCAR GARCIA-MONTERO, SOREN SCHLICHTING, and HANNAH ELFNER — 1 Fakultät für Physik, Universität Bielefeld — 2 GSI Helmholtzzentrum für Schwerionenforschung

We present a new 3+1D resolved model for the initial state of ultrarelativistic Heavy-Ion collisions, based on the $k_t$-factored Color Glass Condensate hybrid approach. This new model responds to the need for a rapidly-resolved initial-state Monte Carlo event generator which can deposit the relevant conserved charges (energy, charge and baryon densities) both in the midrapidity and forward/backward regions of the collision. This event-by-event generator computes the gluon and (anti-) quark phase-space densities using the IP-Sat model, from where the relevant conserved charges can be computed directly. In the present work we have included the leading order contributions to the light flavor parton densities. As a feature, the model can be systematically improved in the future by adding next-to-leading order calculations (in the CCG hybrid framework), and extended to lower energies by including sub-eklon corrections the channels included. We present relevant observables, such as the eccentricities and flow decorrelation, as tests of this new approach.

Extending the fluid dynamic description of heavy-ions collisions to times before the collision —

- ANDREAS KIRCHNER, FEDERICA CAPPELLINO, ALARIC ERSCHFELD, STEFAN FLOERCHINGER, and EUGENIO GROSSI — 1 TTP Heidelberg, University Heidelberg — 2 TTP Jena — Dipartimento di fisica e astronomia, Università di Firenze and INFN Sezione di Firenze

It is well established that the late states of a high energy nuclear collision can be described in terms of relativistic fluid dynamics. An open problem in this context is how the actual collision and the early time dynamics directly after it can be described. Phenomenological models are currently employed here and they have several parameters that need to be fitted to experimental data. Using relativistic fluid dynamics of second order we develop a new approach which addresses the entire collision event, and which gets initialized in fact already before the collision. This is based on the droplet model for the incoming nuclei and a state-the-art equation of state including the first-order liquid-gas phase transition. The physics picture we propose assumes that the soft features of a high energy nuclear collision can be fully described through the dynamics of the energy-momentum tensor and other conserved currents.

This work is part of and supported by the DFG Collaborative Research Centre "SF 1225 (ISOQUANT)".

Correlations in a Moat Regime —

- FABIAN RENNECKER — Institut für Theoretische Physik, Justus-Liebig-Universität Giessen

The QCD phase diagram at large chemical potential is largely uncharted territory. Based on model studies, there are various phases that could occur in this regime. Among them are phases related to spatial modulations, such as inhomogeneous/crystalline phases, liquid crystals or a quantum pion liquid. A common feature of all these phases is that particles can have a most dispersion, when the energy is minimized at nonzero momentum. This can directly affect particle production in the medium created by a heavy-ion collision and leads to characteristic signatures in particle correlations. I will discuss the underlying physics and present a formalism to study particle spectra on general hypersurfaces. Using this formalism, I will show that the correlations generated by the Glashow-Brown–Twin effect are promising probes for a moat regime in heavy-ion collisions.

Search for QCD Instantons with the ATLAS Detector —

- RÄDER VAIROLLA and MATTHIAS SCHOTT for the ATLAS-Collaboration — Johannes Gutenberg University Mainz

The Standard Model of particle physics predicts the existence of quantum tunneling processes across topological inequivalent vacua, known as Instantons. In the*electroweak sector, instantons provide a source of baryon asymmetry within
and B

ing of the full apparatus mandatory for a reliable acceptance correction. Wrong hybrid candidate \( \pi \)

Monte Carlo software to simulate the acceptance of our apparatus. To test its performance independently from any fit, we compare the kinematic distributions of real data and pseudo data for the almost isolated resonance \( a_0(1320) \) decaying into \( n \rightarrow \pi^+ \pi^- \eta(\gamma) \) that have been accepted by our detector simulation. Supported by BMBF.

**HK 39.2 Wed 16:15 SCH/A316**

Acceptance studies with pseudo data of the diffractive reaction \( \pi^- + p \rightarrow \eta(\gamma) + p \) at COMPASS — [David Spulbcek, Henri Pekeler, and Bernhard Ketz] for the COMPASS Collaboration — Universität Bonn, Helmholtz-Institut für Strahlen- und Kernphysik, Bonn, Germany

The COMPASS collaboration has recorded large data samples of diffractively produced final states with a 190 GeV hadron beam. First analyses of the final states \( \eta \pi^- \) showed that these are golden channels to investigate the spin-exotic hybrid candidate \( \eta(1600) \) experimentally.

For a successful partial-wave decomposition of the data using an extended likelihood fit, acceptance effects have to be corrected for. The presence of both charged and neutral particles in these final states makes a very good understanding of the full apparatus mandatory for a reliable acceptance correction. Wrong or missing acceptance corrections would lead to artifacts in the partial-wave decomposition and hence to possibly wrong conclusions.

In our ongoing analyses of the \( \eta \pi^- \) final states, we use GEANT4-based Monte Carlo software to simulate the acceptance of our apparatus. To test its performance independently from any fit, we compare the kinematic distributions of real data and pseudo data for the almost isolated resonance \( a_0(1320) \) decaying into \( n \rightarrow \pi^+ \pi^- \eta(\gamma) \) that have been accepted by our detector simulation. Supported by BMBF.

**HK 39.3 Wed 16:30 SCH/A316**

Search for exotic states in \( \eta \), decays at BESIII — [Anja Brüggenmann, Salleh Ahmed, Nils Häsken, Nikolaj in der Wiesche, Hannah Neuwirth, Ann-Cristin Schülze, Anna Theimann, Frederik Weidner, and Alfonso Khoukaz] for the BESIII Collaboration — Westfälische Wilhelms-Universität Münster, Germany — Johannes Gutenberg-Universität Mainz, Germany

The BESIII detector at the \( e^+ e^- \) collider BEPCII in Beijing, China, provides the world’s largest data sample of the charmonium \( J/\psi \) with more than 10 billion events taken from 2009 to 2019.

Resulting from the radiative \( J/\psi \) decay into \( \eta \pi^- \), we analyse the reactions \( \eta \rightarrow \eta \pi^- hh \), where the \( hh \) system represents the \( K^+K^- \), \( K^0S \), \( \pi^+\pi^- \), \( \pi^0\eta \), and \( 2\pi^+2\pi^- \) systems. Since the majority of these \( \eta \) decay modes are still unlisted in the particle data group database we determine the corresponding branching ratios. Furthermore, since these mesonic \( \eta \) decays constitute a gluon-rich environment they offer the opportunity to investigate possible exotic content in \( hh \) intermediate states, that lie in the mass region below 2 GeV/\( c^2 \), where the lightest glueball is predicted.

Incorporating all analysed \( \eta \) decay modes our study is based on a combined partial wave analysis approach, which gives access to the partial decay widths of contributing resonances decaying into the \( hh \) subsystems. These widths are directly comparable to theory predictions, that assume glueball admixtures carried by certain isoscalar scalar resonances. The current status of the analysis will be presented.

This work is funded by DFG - 269952272, 271236083 and 443159800.

**HK 39.4 Wed 16:45 SCH/A316**

Study of \( e^+ e^- \rightarrow K^+K^-\pi^+\pi^- \) at BESIII — [Sebastian Coen — Ruhr-Universität Bochum, Institut für Experimentalphysik I, 44801 Bochum

The BESIII experiment at the symmetric electron-positron collider BEPCII in Beijing has recorded large data samples at center of mass energies between 2 GeV and 4.9 GeV. This offers good opportunities for the spectroscopy of both charm and light hadrons. In the accessible mass range recent lattice QCD calculations predict a rich spectrum of glueball states.

In the reaction \( e^+ e^- \rightarrow K^+K^-\pi^+\pi^- \) at center of mass energies between 4.0 GeV and 4.9 GeV the production and decay of light mesons as well as the vector glueball, predicted at a mass of about 3.8 GeV/\( c^2 \) can be studied. Preliminary results and future prospects of the \( \eta \) study will be presented.

Supported by DFG (CRC 110 / NISFC-DFG).

**HK 39.5 Wed 17:00 SCH/A316**

\( K^0\bar{K}^0 \) photoproduction at the BGOOD experiment — [Adrian Sonnen- Schein and Katrin Kohl] for the BGOOD Collaboration — Physikalisches Institut, Nussallee 12, D-53115 Bonn

The BGOOD experiment at the ELSA accelerator facility uses an energy tagged bremsstrahlung photon beam to investigate hadronic excitations in meson photoproduction.

The associated photoproduction of \( K^0 \) and hyperons is of particular interest. A cusp-like structure observed in the \( \gamma p \rightarrow K^0\bar{K}^0 \) reaction at the \( K^0\bar{K}^0 \) threshold is described by models including multi-quark resonances through dynamically generated meson-baryon interactions. This is the same model which predicted the \( P_c \) pentaquark states observed at LHCb through \( D^*\rightarrow \Sigma^- \) interactions. In analogy, in the \( s \)-quark sector a peak like structure in \( K^0\bar{K}^0 \) photoproduction off the neutron is predicted, associated with a \( K^-\Sigma^- \) type configuration.

The reaction \( \gamma n \rightarrow K^0\bar{K}^0 \) has been measured at BGOOD from threshold to a beam energy of 2600 MeV. In this talk results will be presented using updated analysis techniques and improved statistical precision.

*Supported by DFG projects 388979758/405882627 and the European Union’s Horizon 2020 programme, grant 824093.
Group Report

**HK 40.1 Wed 15:45 SCH/A419**

**Nuclear astrophysics deep underground at LUNA and LUNA-MV** — **Eliana Masha, Daniel Remmerrer, and Axel Boelzig for the LUNA-Collaboration** — Helmholtz-Zentrum Dresden-Rossendorf (HZDR), 01328 Dresden, Germany

A precise knowledge of the cross sections of astrophysically relevant nuclear reactions is needed for understanding energy generation inside stars and the creation of the chemical elements. In stars, nuclear reactions take place at energies well below the repulsive Coulomb barrier. Hence, their cross-sections are often too small to be measured in laboratories at the Earth's surface, where the signal would be lost in the cosmic-ray-induced background. An efficient way to reduce the cosmic-ray-induced background is to perform experiments in underground laboratories. The Laboratory for Underground Nuclear Astrophysics (LUNA) is located deep underground at Gran Sasso National Laboratories (Italy). The reduced background achieved at LUNA allows to measure the nuclear cross sections directly at the relevant astrophysical energies. The presentation will give an overview of the recent results achieved at LUNA, and future perspectives on the LUNA experiment, including the new 3.5 MV LUNA-MV accelerator.

**HK 40.2 Wed 16:15 SCH/A419**

**Low-background radioactivity counting at the most sensitive HPGe detector in Germany** — **Stepfen Turkat, Daniel Remmerrer, Axel Boelzig, Jonas Koch,** — **Till Lossin, Max Osswald, Konrad Schmidt, and Kai Zuber** — **Institut für Kern- und Teilchenphysik, TU Dresden, Germany**

The contribution reports about the commissioning of an ultra low-level γ-ray counting setup in the shallow-underground laboratory Felsenkeller Dresden in Dresden, Germany. It includes a high-purity germanium detector of 163 % relative efficiency within passive and active shields. The passive shield consists of 45 m rock overburden (140 meters water equivalent), 40 cm of low-activity concrete, 15 cm of high purity lead, 10 cm of oxygen-free radiopure copper, and an anti-radiation box. The active veto is given by five large plastic scintillation panels surrounding the setup. All together, these shieldings attenuate the remaining background rate down to 116(1) kg⁻¹d⁻¹ in an energy interval of [40 keV,2700 keV]. This is the lowest background of any HPGe detector in Germany, among the lowest worldwide, and enables studies of samples well below 1 mBq. In addition to the design of the setup, the underlying analysis techniques will be presented.

**HK 40.3 Wed 16:30 SCH/A419**

The new gas target system at the shallow underground laboratory Felsenkeller Dresden — **Anup Yadav, Konrad Schmidt, and Daniel Remmerrer** — Helmholtz-Zentrum Dresden-Rossendorf

In experimental nuclear astrophysics, reaction studies with low cross sections are of interest. To measure those reactions directly, feasible possibilities include underground facilities to shield against cosmic rays and hence produce a low-background background, high intensity ion beams, and highly pure and stable targets. All those features will be available at the currently constructed und tested gas target setup for the shallow underground laboratory Felsenkeller Dresden. This setup combines a highly localized gas wall jet and an extended, static, windowless gas target. A unique feature in nuclear astrophysics applications is the in-situ monitoring of the jet thickness by a laser interferometry system. The talk will report on the gas target setup, its first thickness measurements, and suitable science cases in nuclear astrophysics.

**HK 41.1 Wed 15:45 SCH/A118**

**Lifetime measurements via the coincidence Doppler-shift attenuation method in Cologne** — **Anna Bohn, Christina Deke, Felix Helm, Sarah Prill, Michael Weinert, and Andreas Ziegler** — **University of Cologne, Institute for Nuclear Physics, Germany**

A powerful tool to determine nuclear level lifetimes in the sub-picosecond regime is the coincidence Doppler-shift attenuation method (DSAM) [1,2]. The target is positioned inside the combined particle-γ detector array SONICE/HORUS [3]. This allows reconstruction of the complete reaction kinematics for each event. Therefore, feeding contributions from higher lying states to the transition of interest are eliminated and specific transitions can be precisely selected. Hence, lifetimes of several dozen of excited states can be determined from a single experiment, using that the emission-angle dependent Doppler-shift of the deexciting γ-ray energy is linked to the attenuation time of the recoiling nucleus. Systematic studies were performed along isotope chains [4-6], including Zr, Ru, Sn, and Te. Recent results obtained via the DSAM method and by spectroscopy benefitting from coincidence measurements will be presented.

Supported by the DFG (ZI-3109/1).


**HK 41.2 Wed 16:15 SCH/A118**

**Nuclear Structure Studies from Mass Spectrometry of Isotopic States** — **Lukas Nieß** — **CERN, Switzerland — University of Greifswald, Germany**

The nuclear binding energy arises from various effects that govern a nucleus' properties. Different nucleus configurations within nuclear isomers lead to modified binding energies, often resulting in mass differences of tens to hundreds of kilo-electronvolts. These isomeric excitation energies can be directly accessed by measuring the difference in atomic masses of ground and isomeric states. Here, we present such measurements performed with the ISOLTRAP mass spectrometer located at ISOLDE/CERN. By evaluating the excitation energies of neutron-deficient indium isotopes down to the shell closure at N=50 against state-of-the-art shell model, DFT, and ab initio calculations, we contrast the performance of these theories applied to several nuclear properties. We further present evidence for shape-coexistences close to N=50 through the precise excitation energy measurement of the (1/2)⁺ state in zinc-79, supported by accurate large-scale shell model calculations.

**HK 41.3 Wed 16:30 SCH/A118**

**Lifetime measurement of excited states in 116Xe** — **Casper-David Lakenbrink, Marcel Bekkers, Andrey Blazhev, Felix Dunkel, Arwin Esmeijer, Christoff Fransen, Jan Jolie, Lisa Kornwibr, Claus Müllner-Gatermann, and Fransizku Speci** — **IKP, Universität zu Köln, Deutschland — Physics Division, Argonne National Laboratory, IL, USA**

In the Sn, Te and Xe isotope chains, previous experiments showed a drop for the B4/2=B(E2;2-→2+)=B(E2;2+→0+) ratio of nuclei with mass A ≤ 114. If this is caused by a shell effect, as is expected, the drop should correspond to the neutron number rather than the mass number and would be expected to happen at 116Xe already. Transition strengths in 116Xe have only once been measured using singles spectra, possibly suffering from an affected detection. Thus, lifetimes in 116Xe were evaluated using γγ-coincidence data from a recoil-distance Doppler-shift experiment to investigate transition strengths without the need for assumptions on feeding. Excited states in 116Xe were populated in the fusion-
evaporation reaction $^{126}$Pd($^{208}$O,n)${}^{126}$Xe at the FN-tandem accelerator at the Institute for Nuclear Physics, University of Cologne. Lifetimes of the $2^+_1$, $4^+_1$, and $6^+_1$ states were evaluated using the differential decay-curve method as well as the lifetime of the $2^+_1$ state using simulations of spectra considering Doppler-shift attenuation effects. The corresponding B(E2), B(E1) values were calculated. We will present the results and compare these to a previous measurement as well as IBM1 calculations. This work was supported by the DFG, grant Nos. FR 3276/2-1 and DE 1516/5-1.

**HK 41.4 Wed 16:45 SCH/A118**

First direct lifetime determination of the $2^+_1$ state of $^{210}$Pb — C. M. Nickel$^1$, M. Beckers$^1$, B. Dittner$^1$, A. Blazhev$^1$, A. Esmyzlazar$^1$, B. Falk$^1$, C. Fransen$^1$, J. Garbe$^1$, L. Gerhard$^1$, K. Geusen$^1$, A. Goldkuhle$^1$, K. E. Ide$^1$, F. R. John$^1$, J. Jolle$^1$, V. Karayonchev$^1$, R. Kern$^1$, E. Kleis$^1$, L. Klöckner$^1$, M. Ley$^1$, N. Pietralla$^1$, G. Rainovski$^1$, E. Sere$^1$, M. Steffan$^1$, T. Stet$^1$, V. Werner$^1$, and J. Wiederhold$^1$ — TU Darmstadt — U. Cologne — U. Sofia

The investigation of transitions from the $2^+_1$ to the g.s. in nuclei close to the doubly-magic $^{208}$Pb allows to constrain parameters from nuclear models, e.g. the effective charges of the shell model. Nuclei containing two valence nucleons, like $^{210}$Pb, are of particular importance [1], as their fundamental excitations form the low-lying nuclear states. The $2^+_1$ state of $^{210}$Pb was directly populated in a two neutron transfer reaction at the 10 MV FN Tandem Accelerator at the IKP of the University of Cologne. Its lifetime was measured using the Cologne plunger device and the RDDS method. The gamma radiation was detected with HPGe detectors and the back-scattered-beam-like particles with silicon detectors. Corrections for contaminants were performed and, thus, for the first time the lifetime of the $2^+_1$ state of $^{210}$Pb was directly determined, being consistent with, but considerably more precise than, the only existing literature value obtained from triton scattering [2].


*Supported by the BMBF under Grant No. 05P21RDC2.*

**HK 41.5 Wed 17:00 SCH/A118**

Evolution of the first mixed-symmetry $2^+$ state in the $N=80$ isotones — T. Stet$^1$, Z. Zidarova$^1$, R. Kern$^1$, V. Werner$^1$, N. Pietralla$^1$, T. Abraham$^1$, U. Ahmed$^1$, G. Coulson$^1$, K. Hadvonska-Klek$^2$, K. E. Ide$^1$, G. Jaworski$^1$, M. Kisielinski$^1$, K. Komorowska$^2$, M. Kowalczyk$^1$, M. Lilliana Cortes$^1$, C. Napiorkowski$^1$, C. Nickel$^1$, M. Palacz$^2$, G. Rainovski$^1$, J. Samorajczyk-Pysk$^1$, J. Serebrny$^1$, M. Stoyanova$^1$, A. Trzcińska$^1$, K. Wrzeszek-Lipska$^1$, and B. Zalewski$^1$ — 1TU Darmstadt — “Hil Warsaw” — U. Sofia

The evolution of the first mixed-symmetry $2^+$ state in the $N=80$ isotones from $^{132}$Sn to $^{142}$Sm has been of great interest for the past two decades [1,2,3,4,5]. A recent CoulEx experiment to investigate the M1 strength of the $2^+_1$ transition of $^{142}$Sm has been performed at HIE-ISOLDE [6]. A complementary experiment to determine the multipole mixing ratio of the aforementioned transition was conducted at the HIL in Warsaw in 2021. Combined, these experiments will expand the understanding of the first mixed-symmetry $2^+$ state in this isotopic chain.


*Supported by BMBF 05P1RDC1-TP1 and 05P21RDC1-TP1*

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**HK 42.4 Wed 16:45 SCH/A215**

Search for near-threshold multi-neutron resonances in (p,2p) reactions with neutron-rich nuclei at R$^3$B — **THOMAS AMANN$^{1,2,3}$, OLIVIER SOBILIN$^1$, and VALERII PANIN$^2$** for the R3B-Collaboration — 1Technische Universität Darmstadt — 2GSI Helmholtz-Zentrum für Schwerionenforschung — 3Helmholtz Forschungskademie Hessen für FAIR — Grand Accélérateur National d’Ions Lourds

In order to constrain the largely unknown multi-neutron interactions, it is necessary to measure the relevant observables sensitive to them. In the current work we plan to investigate multi-neutron resonances close to the corresponding neutron removal thresholds in neutron-rich light nuclei. The objective is to search for and characterize the systematic appearance of narrow resonances related to multi-neutron cluster structures and correlations near the respective cluster thresholds, similar to the popular alpha-cluster resonant states. For this purpose an experiment has been recently concluded at the R$^3$B Setup in GSI. The (p,2p) reactions are studied in inverse kinematics where a radioactive ion “cocktail” beam is impinged on a 5cm $^3$H$_2$ target. The resulting reaction products are measured using a large combination of detector systems providing information of the full reaction kinematics. Of particular interest is the neutron detector NeuLAND, which thanks to its high resolution and granularity provides access to the detailed study of multi-neutron states.

Supported by HGF/ the GSI-TU Darmstadt cooperation and the BMBF project 05P21 RDFN2
Effect of magnet cycling on the magnetic field tracking uncertainties in the Fermilab g–2 experiment — René Reimann, Mohammad Uraidullah Hasan Qureshi, and Martin Fritzl for the Muon g–2 Collaboration — Institute of Physics and Excellence Cluster PRISMA+, Johannes Gutenberg University Mainz, 55099 Mainz, Germany

The Muon g–2 Collaboration has presented the most precise measurement of the anomalous magnetic moment $a_H$ with an uncertainty of 460 ppb. To achieve the goal of 140 ppb uncertainty, more than a factor of nine times the published data have been recorded, but systematic uncertainties must also be reduced. A key parameter in determining $a_H$ is the precise value of the homogeneous 1.45 T magnetic field in which the muons are stored. Two systems using nuclear magnetic resonance (NMR) techniques are used to track the magnetic field in the muon storage ring. One system measures the spatial magnetic field distribution every few days in the storage region itself, and the other system measures the magnetic field drift continuously with probes in the walls of the vacuum chambers of the storage ring. Cycling the storage ring magnet introduces additional field drifts which are challenging for the tracking of the averaged magnetic field. In this talk, I will present the effect of magnet cycling on the tracking of the magnetic field and its uncertainty.

Upgrading antihydrogen production in AEgIS — Saiva Hück — CERN, Meyrin, Switzerland — University of Hamburg, Inst. f. Experimental Physics, Hamburg, Germany

The AEgIS (Antimatter Experiment: Gravity, Interferometry, Spectroscopy) collaboration, based at CERN’s Antiproton Decelerator (AD) complex, produces antihydrogen atoms in the form of a pulsed, isotropic source with a precisely defined production time. $\bar{H}$ is formed by means of a charge exchange reaction: antiprotons are captured from the AD inside a Penning-Malmberg trap, further sympathetically cooled with electrons, and then combined with positronium atoms, which are previously laser-excited to Rydberg states. The focus of research in AEgIS is on the formation of a pulsed horizontal beam of $\bar{H}$ atoms utilized to investigate their vertical deflection due to the influence of gravity, thereby probing the Weak Equivalence Principle for antimatter and providing a test of the CPT theorem.

Since the first $\bar{H}$ formation in 2018, AEgIS has undergone several significant upgrades aimed at improving the efficiency of antihydrogen production and fully benefiting from the newly added ELENA (Extra Low Energy Antiproton) decelerator at the AD, which commenced operation in fall of 2021 and yields antiprotons in larger numbers at lower energies. Subsequently, work is being undertaken to re-establish $\bar{H}$ production in larger numbers, and move towards beam formation. This contribution gives an overview of the improvements to the AEgIS setup, results obtained during the first beam times with ELENA, and progress towards the formation of a pulsed $\bar{H}$ beam.
mounting the module on a carbon ladder, and subsequently these objects are arranged horizontally on so-called C-frames. The purpose of this contribution is to give an overview of the recent progress towards the STS detector. The first major milestone is the operation of the read-out chain and detector control system of the miniaturized version of STS, which features 11 detector modules. The second accomplishment features the commissioning efforts of the thermal demonstrator which serves to validate the concept for crucial services of the STS (cooling, air drying, ambient conditions measurements). Lastly, the preproduction of the detector modules has started, and the first results collected.

**HK 4.2** Wed 18:00 SCH/A251

**Quantifying the Dual-Sided Silicon Strip Detectors at R3B** — Andrea Jüdel1, Dominik Ross1,2, and Thomas Aumann2 for the R3B-Collaboration — TU-Darmstadt, Darmstadt, Germany

Dual-sided silicon strip detectors allow for accurate position and charge determination of in-beam fragments for heavy-ion collisions with minimal spatial constraints. The X5 Micron silicon detectors have been used in the R3B set-up at GSI. Improvements have been implemented to the hardware of the detector and a new calibration method has been developed and tested for beams of primary and secondary Sn isotope experiments.

Supported in part by BMBF (05P21DFN2), Helmholtz Forschungskademie Hessen für FAIR and GSI-TU Darmstadt cooperation agreement

**HK 4.3** Wed 18:15 SCH/A251

**HI-TREX: Compact, high resolution particle detection system for ISOLDE** — Roman Gernhäuser, Sergei Golenev, and Robert Neagu for the MINIBALL-Collaboration — Technische Universität München, Germany

HI-TREX is a particle detection setup, developed for the HIE-ISOLDE facility at CERN, optimized for transfer reactions using radioactive ion beams. HI-TREX is based on a very thin double-sided silicon strip detector (DSSSD), high-resolution front-end electronics based on SKIROC ASICs, and a newly developed, custom made, FPGA based GEneric Readout board (GEAR) for the TRB data acquisition system. A full system test with an array of four detectors in a two arm geometry was performed at the Bronowice Cyclotron Center in Krakow using proton beams with energies ranging from 80 to 200 MeV. With ancillary CA(T)2 scintillation detectors behind the setup and a plastic fiber target a full 4-momentum reconstruction of the 12C(p,2p)n reactions is performed. We will present first results on calibrations, the energy resolution and the event correlations to determine absolute efficiencies of the new detector elements.

(supported by BMBF 05P21WOCl1)

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**HK 4.5** Instrumentation XIII

**Time:** Wednesday 17:30–19:00

**Photon Detection with THGEMs** — Thomas Klemenz1, Laura Fabietti1, Pietro Gaske1, Roman Gernhäuser1, and Berndt Ulukutlu1 — Technische Universität München, Garching, Germany

Traditional devices for photon detection like the Photomultiplier Tube or more recently technologies such as Silicon Photomultipliers are not easily scalable and rather cost-intensive…Therefore, especially with large area experiments in mind it is exciting to investigate new ways of detecting photons. In this project we are taking the approach of combining a photosensitive material with a Thick GEM (THGEM) to produce a gaseous photon detector. THGEMs are robust, low-cost devices, which can be easily implemented in large area applications. One side of the THGEM is coated with a photosensitive material and placed within an electrical field. Photons captured by the active surface lead to a release of electrons which drift into the THGEM hole where they undergo avalanche multiplication due to strong electric fields applied. Below the THGEM an anode is reading out the amplified electron signal. Depending on the gain of the THGEM this could enable single photon detection. We want to study the potential of this approach while trying different photosensitive materials. Ultimately, we aim to measure visible wavelength photons and to provide a low-cost, large area solution for neutron observation in water and ice environments. In the talk the current status of the project is discussed.

This work is funded by the BMBF Verbundforschung (05P21WOCA1 ALICE) and the DFG Sachmittel FA 898/5-1.

**SK 4.4** Wed 18:30 SCH/A251

**A new concept for the geometry of the Silicon Tracking System in the CBM Experiment** — Mehul KumaR Shirota — GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

The Compressed Baryonic Matter experiment is a fixed target experiment planned to be built at the Future Facility of Anti-Proton and Ion Research at the GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany. The Silicon Tracking System is the main detector for tracking and momentum determination of the CBM experiment. It is designed to measure up to 700 charged particles produced in nucleus-nucleus collisions up to an interaction rate of 10 MHz, and to achieve a momentum resolution in 1 Tm dipole magnetic field better than 2%. It uses double-sided micro-strips silicon sensors with a thickness of 320 ± 15 μm arranged in 8 tracking stations. Since the CBM magnet cannot be realized as previously planned, the originally intended monolithic design which minimizes the detector dimensions can be replaced by a modular structure independently assembled, called STS-3 & STS-5, and a full separation of services (low/high voltage, front-end, cooling, etc.). A ROOT based geometrical model for the new conceptual design of the STS, including a detailed description of the passive material, has been implemented. The performance for track reconstruction and momentum determination has been studied in comparison with the old design with Au+Au simulations at different colliding energies. Further detailed information will be presented during the conference.

**Light-weight but dense: mechanics and integration of Silicon Tracking System of the CBM experiment** — Maksym TekliShy2,3 and Oleg Vastiev1 for the CBM-Collaboration — 1GSI Helmholtzzentrum für Schwerionenforschung — 2Kiv Institute for Nuclear Research

Silicon Tracking System (STS) is a core tracking detector of the future heavy-ion CBM experiment at FAIR. Requirements to cope with unprecedentedly high beam-target interaction rate (up to 10 MHz), multiple low-momentum reaction products (up to 700 charge particles per central collision) challenge the detector technologies.

STS features fast light-weight detector modules of various form factors. They are made of the 300 μm thick 2×1024 channel double-sided double-metal silicon sensors connected to the dedicated read-out electronics by 32 thin aluminium-polyimide micro-cables of up to 500 mm length. The STS assembly features highly integrated unique components. The basic blocks of STS are 876 detector modules in 199 unique configurations. They are arranged on the light-weight carbon fibre mechanical support structure forming ladders of 8 or 10 modules each. There are 106 ladders in 38 ladder types; they form 8 tracking layers on 18 aluminium supports. They also accommodate powering and back-end read-out electronics, and liquid cooling.

Recently, STS team altered the detector mechanical design: STS may be split in upstream and downstream parts with 3 and 5 tracking layers, respectively. This introduces flexibility for running scenarios (2 – 11 GeV for Au ions) and facilitates upgrade.

**HK 4.5 Light-weight but dense: mechanics and integration of Silicon Tracking System of the CBM experiment** — Maksym TekliShy2,3 and Oleg Vastiev1 for the CBM-Collaboration — 1GSI Helmholtzzentrum für Schwerionenforschung — 2Kiv Institute for Nuclear Research

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Stabilized voltage divider for GEM detectors — Oliver Adam, Philip Hauer, Christian Honisch, Dimitri Schaaf, Dominik Schuchter, Marco Vogt, and Bernhard Ketzer — Universität Bonn, Helmholtz-Institut für Strahlen- und Kernphysik, Bonn, Germany

Multi-GEM detectors often use the simple principle of classic voltage dividers to supply their electrodes with high voltages. The problem with that kind of voltage supply (passive voltage divider) is that the voltages change when additional currents are produced inside the detector at high irradiation rates, which are taken up by the electrodes. In addition, the effect of occasional sparks inside the detector is traditionally minimized using high-ohmic bias resistors, which again modify the electrode potentials in case of non-negligible currents. Using active components (source follower) instead of passive resistors offers away to overcome these drawbacks. The resistor chain is stabilized with a transistor chain and has an active current limit. Simulations support these considerations. In measurements with X-ray and radioactive sources, we investigate the gain stability at high rates and gas stability against discharges. This talk will cover the working principle of the stabilized voltage divider. Furthermore, the results of simulations and measurements will be discussed.

Investigations on the Signal-to-Noise Ratio of the VMM Readout Chip with a GEM Detector — Virginia Klapper, Karl Flothener, Pascal Henkel, Michael Lüpker, and Bernhard Ketzer — Universität Bonn, Helmholtz-Institut für Strahlen- und Kernphysik, Bonn, Germany

Recent measurements of charm hadrons at midrapidity in pp collisions at \( \sqrt{s} = 5.02 \text{ TeV} \) showed that the baryon-to-meson yield ratios are significantly higher than those measured in e⁺e⁻ collisions for different charm baryon decay modes. These observations suggest that the charm fragmentation fractions are not universal and depend on the collision systems. In this talk, the new measurement of the \( p_T \)-differential cross section times branching ratio of the \( \Omega_b \) baryon measured in the decay channels \( \Omega_b \rightarrow \phi\phi \) and \( \Omega_b \rightarrow \phi \Xi_c \rightarrow \phi \phi \Xi_c \) in pp collisions at \( \sqrt{s} = 13 \text{ TeV} \) will be reported. The measurement of the \( \Omega_b \) baryon, containing 2 strange quarks, gives further constraints on charm-quark hadronisation models. The final result will be compared with theoretical calculations.

Charm production in proton–proton collisions at \( \sqrt{s} = 13 \text{ TeV} \) measured with the ALICE detector — Carolina Reitz for the ALICE Collaboration — Physikalisches Institut, Universität Heidelberg — GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

Recent measurements of charm fragmentation fractions of single charm ground state hadrons at midrapidity in proton–proton (pp) collisions at \( \sqrt{s} = 5.02 \text{ TeV} \) at the LHC significantly differ from the values obtained in e⁺e⁻ and ep collisions. Therefore the assumption of universality of the charm-to-hadron fragmentation
fractions across different collision systems might not be fully supported.

New $p_T$-integrated cross section measurements of prompt $D^0$, $D^-$, $D_s^-$, $D_s^0$, $\Lambda_c^+$, and $\Xi_c^0$ in pp collisions at $\sqrt{s} = 13$ TeV are presented. The relative abundance of the different charm hadron species, which is sensitive to hadronization mechanisms, is shown and compared to model calculations. The presented charm hadron cross section measurements are used to evaluate the charm fragmentation fractions and the total charm production cross section at midrapidity in pp collisions at $\sqrt{s} = 13$ TeV. The new measurement of the $\Xi_c^0$ production cross section down to low transverse momenta is extrapolated to $p_T = 0$ for the first time. The $\Xi_c^0$ fragmentation fraction is calculated and the contribution is included in the total charm production cross section.

HK 46.4 Wed 18:30 SCH/A216
Reconstruction of displaced decay vertices in an inhomogeneous magnetic field with a Kalman Filter based tracking algorithm at HADES — Merco Parchau for the HADES-Collaboration — Goethe University Frankfurt am Main
The high interaction rate, fixed target experiment HADES at GSI, located in Darmstadt, Germany, investigates collisions of heavy-ion, proton and secondary pion beams with a target material. Hyperons are one of the key observables for both heavy-ion and elementary collisions. The challenge is to detect displaced vertices with good accuracy without having a dedicated vertex detector, by employing state-of-the-art techniques.
In this contribution we discuss a newly developed tracking algorithm that uses a Kalman Filter to further boost the track reconstruction performance and the reconstruction of displaced vertices from hyperons.

This work has been supported by BMBF (05P21RFFC2), GSI, HHF, the State of Hesse within the Research Cluster ELEMENTS (Project ID 500/10.006) and HGS-HIR.

HK 46.5 Wed 18:45 SCH/A216
Performance test of the KF Particle vertexing package for open heavy flavour baryon reconstruction with the ALICE detector — Philip Stahlhut for the ALICE Germany-Collaboration — Physikalisches Institut, Universität Heidelberg
The study of charm baryon production is crucial to understand charm hadronization processes in a parton-rich environment. In order to extract signal even in low transverse momentum ($p_T$) regions where the signal-to-background ratio is rapidly decreasing, a precise vertex reconstruction is of utmost importance.
The Kalman Filter Particle package gives a fast reconstruction of complex decay topologies providing a full description of the decay particle both at its production and decay vertex. It is suitable even for high-density track environments. In addition to that, the KF Particle package supports the use of geometrical, mass and topological constraints in the reconstruction process and includes the complete treatment of tracking and vertexing uncertainties.
In this work, the KF Particle package was used to reconstruct the $\Xi_c^0$ baryon from its decay to $\Xi^- \pi^+ \pi^-$ in simulated proton-proton collisions at a center-of-mass energy of $\sqrt{s} = 13$ TeV. This contribution will demonstrate the effect of geometrical, mass and topological constraints on the secondary vertex, $p_T$ and mass resolution of the reconstructed $\Xi_c^0$ baryon.

HK 47: Heavy-Ion Collisions and QCD Phases X

Time: Wednesday 17:30–18:45

HK 47.1 Wed 17:30 SCH/A315
Light Nuclei Emission in Ag+Ag Collisions — Marvin Narbroth for the HADES-Collaboration — Institut fuer Kernphysik, Frankfurt, Deutschland
This contribution gives an overview of data on protons, deuterons and He3, emitted in Ag+Ag collisions at $\sqrt{s_{NN}} = 2.55$ GeV measured at HADES. Covered is the procedure of particle identification based on a Bayesian ansatz as well as the process of acceptance and efficiency correction and extrapolation into uncovered phasespace regions. The reconstructed transverse mass spectra and resulting rapidity density distributions as a function of the collision centrality are presented and a comparison of the 4π yield to the world data in the low energy regime, as a function of collision energy, is discussed.
Detailed knowledge of the production yields and phase space spectra is of special interest when it comes to test what extent thermal models can describe the nature of a heavy-ion collision in the low-energy regime and to understand the mechanisms under which light nuclei are formed during a heavy-ion collision. This work has been supported by BMBF (05P21RFFC2), GSI F&E and HGS-HIR.

HK 47.2 Wed 17:45 SCH/A315
Testing coalescence by studying (anti)nuclei production in and out of jets in ALICE — Chiara Pinto for the ALICE Germany-Collaboration — Technische Universität München, München, Deutschland
The production mechanism of (anti)nuclei in ultrarelativistic hadronic collisions is under intense debate in the scientific community. The description of the experimental measurements is currently based on two competing phenomenological models: the statistical hadronization model and the coalescence model. For the first time, the deuteron production in pp collisions at $\sqrt{s}=13$ TeV is measured both in jets and in the underlying event. Due to the collimated emission of nucleons in a jet, the nuclear production by coalescence is expected to be enhanced. In this contribution, the results for the coalescence parameter $B_2$ in jets are presented in comparison with predictions from the coalescence model and a recently developed reaction-based production mechanism implemented in PYTHIA 8.3.

This work is funded by DFG SFB1258 and by BMBF Verbundforschung (05P21WOCA1 ALICE).

HK 47.3 Wed 18:00 SCH/A315
Measurement of proton-deuteron correlations in Pb–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV — Michael Jung for the ALICE Germany-Collaboration — Institut für Kernphysik Frankfurt
The first measurement of double-particle correlations measured with ALICE in central and semi-central Pb–Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV will be presented. This measurement enables the possibility to study three particle interactions as well as the formation mechanism of light nuclei in heavy-ion collisions. The particle identification, the procedure to obtain the correlation functions and a study of the source size will be shown. The measured correlations are then compared with theoretical predictions using the Lednický-Lyuboshitz approach. For these calculations measured scattering lengths of proton-deuteron pairs from scattering experiments are taken.

HK 47.4 Wed 18:15 SCH/A315
Sexaquark Search in ALICE — André Börquez for the ALICE Germany-Collaboration — Universität Heidelberg, Germany
For many years, WIMPs have been the leading candidate for the phenomenon of dark matter in astronomy. However, despite extensive experimental research, no WIMP signal has been detected, leading to the exploration of other dark matter candidates. In 2017, G. Farrar proposed the sexaquark as a new candidate for dark matter, which is a neutral, compact, six-quark state with the quark content $uuddss$. This particle is consistent with our current understanding of Quantum Chromodynamics (QCD) and the dark matter relic abundance. In the ALICE experiment at the Large Hadron Collider (LHC), we plan to search for this exotic particle via its interaction with detector material after being produced in heavy-ion collisions.
In this presentation, we will discuss an overview of the sexaquark, some preliminary studies with specialized simulations, and the challenges and prospects of this search analysis.

HK 47.5 Wed 18:30 SCH/A315
Net-Proton Fluctuations in Pb-Pb Collisions with the ALICE Experiment — Illya Fokin for the ALICE Germany-Collaboration — Physikalisches Institut, Heidelberg
Fluctuations of conserved charges — such as the electric charge, baryon number or strangeness — in ultrarelativistic heavy-ion collisions provide insight into the QCD phase diagram. They are quantified using moments or cumulants of the distribution of the respective charge in a collision, which can be related to susceptibilities from lattice QCD calculations. These numerical calculations predict a second order phase transition from the quark-gluon plasma to the hadron gas close to the chemical freeze-out temperature for vanishing quark masses and baryon chemical potential, which is expected to turn into a continuous crossover for physical masses. Since the LHC provides heavy-ion collisions with almost vanishing baryon chemical potential, using the proton number as a proxy for the baryon number makes the lattice QCD results accessible in the experiment.
In this contribution, recent measurements of higher-order cumulants of the net-proton number in Pb-Pb collisions recorded with the ALICE detector are presented. Their dependence on the pseudorapidity acceptance and centrality and comparisons to models are discussed. Moments of the proton number distributions are measured probabilistically using the Identity Method, treating contamination of the proton sample in a natural way.

HK 47.6 Wed 18:45 SCH/A216
Charged Particle Energy Distributions in Pb-Pb Collisions at RHIC — J. Bednarek for the ALICE Collaboration — Goethe University Frankfurt am Main
**HK 48: Hadron Structure and Spectroscopy V**

**Time:** Wednesday 17:30–19:00

**Location:** SCh/A316


The proton radius can be determined by measuring the slope of the electric form factor $G_E$ at small squared four-momentum transfers. The measurement uncertainty must be reduced. The primary source of systematic errors stems from the hadronic quantum fluctuations affecting the muon, specifically the hadronic vacuum polarization (HVP) and the hadronic light-by-light (HLbL) scattering contributions. The HLbL term is dominated by the exchange of pseudoscalar mesons. In this talk, the production of $\eta$ and $\eta'$ mesons via two virtual space-like photons will be studied. Double-tagged measurements are conducted at the BESSIII experiment in Beijing, China, in which both virtual photons possess nonzero momentum transfers ($Q^2$). The transition form factor needed for the calculation of the HLbL contribution is determined in dependence of both $Q^2$-values.

**Study of Neutral-pion pair production in two-photon scattering at BESIII** — Max Lellmann, Achim Deng, and Christoph Florian Redmer — Johannes Gutenberg-Universität Mainz

The anomalous magnetic moment of the muon, $a_\mu$, is one of the most precisely measured observables of the Standard Model, yet it shows a discrepancy of about 4.2$\sigma$ from the Standard Model prediction. The Standard Model prediction is dominated by hadronic contributions, it is crucial to gather more information about the contributing hadronic processes. Information on the production of pion pairs in two-photon fusion processes plays an important role in the calculation of the hadronic light-by-light scattering contribution to $a_\mu$. The BESIII experiment, located at the institute of high energy physics in Beijing/China, offers a perfect testbed for the investigation of two-photon processes at small momentum transfers. The process $e^+ e^- \rightarrow \pi^0 \pi^0$ is measured at the BESIII experiment at centre-of-mass energies between 3.77 and 4.6 GeV with a total integrated luminosity of more than 10 fb$^{-1}$. This presentation will discuss the current status of the analysis.

**HK 49: Structure and Dynamics of Nuclei IX**

**Time:** Wednesday 17:30–19:00

**Location:** SCh/A118

**Measurements of the reaction cross sections of neutron-rich Sn isotopes at R$^\circ$B setup.** — Eleonora Kudiabergien6,1, Thomas Aumann2,1,2,4, Martina Fejoo Fontán2,3, Andrea Horvat1,2,1, Ivana Lihter3, Valerii Panin2, and Dominik Rossi2,4 for the R3B-Collaboration — 1Institut für Kernphysik, TU Darmstadt, Germany — 2GSI Helmholtzzentrum für Schwerionen- Forschung, Darmstadt, Germany — 3Radij Boskovic Institute, Zagreb, Croatia — 4Helmholtz Forschungsakademie HFFH — 5IFAE, Universidad de Santiago de Compostela, Spain

The equation of state (EoS) is fundamental for understanding the structure of nuclear matter. The study of asymmetric nuclear matter via properties of neutron-rich nuclei became a current focus of investigation. The asymmetry term of the
nuclear E0s is expressed by the symmetry energy at saturation J and its slope L, which has not yet been constrained well experimentally. It has been identified that a precise determination of the neutron removal cross section of neutron-rich nuclei, which is directly related to the neutron skin, would provide a much better constraint on L. To this end, an experiment was performed with the neutron-rich tin isotopes in the mass range A = 124–134 on 13C targets at the R8 setup at the GSI FAIR facility in inverse kinematics with very large acceptance. In this report, the current detector calibration, analysis status is presented. This project was supported by the BMF project No. 05P21RDFN2, the Helmholtz Research Academy Hessen for FAIR, and the GSI-TU Darmstadt cooperation.

HK 49.2 Wed 17:45 SCH/A118
Investigation of γ-sofness: Lifetime measurements in 104/106Ru — Arwin Esmatzadeh1, Andrej Blazhev1, Kosuke Nomura2, Jan Jolie3, Marcel Beckers4, Christoph Fransen5, Rosa-Belle Gerst6, Andreas Harter7, Vasil. Karayonchev1,3, Lukas Knafla1, Mario Le1, and Franziskus von Spee6 — 1 Institute for Nuclear Physics, University of Cologne — 2 Department of Physics, University of Zagreb — 3 TRIMUM; Canada

Lifetimes of the 2+, 4+, 6+, 2, and 3 states in 104/106Ru were measured using the recoil distance Doppler shift technique and the Cologne Plunger device. Low-lying excited states in both nuclei were populated in a 105Ru(16O, 16O)105Ru inelastic scattering and in a 104Ru(15O, 15O)104Ru two-neutron transfer reaction using the Cologne FN tandem accelerator. The experimental energy levels and deduced electromagnetic transition probabilities are compared in the context of γ-sofness and the mapped interacting boson model with input from the microscopic self-consistent mean-field calculation using a Gogny interaction [1]. The newly obtained results for the γ band, give a more detailed insight about the triaxial behavior of 104,106Ru. The results will be discussed in the context of γ-sofness and the rigid triaxial behavior which is present in the neutron-rich Ru isotopes [2]. This work was supported by BMFR unbundproject 05P2021 (ErUm-FSP T07) grant 05P21RFKN1.


HK 49.3 Wed 18:00 SCH/A118
Lifetime measurement of neutron rich Xe isotopes applying Fast-Timing method — Andi Messingschläger1, Martin von Treskow2, Thoresten Kröl1, Matthias Rudiger1, Andrej Blazhev3, Julia Fischer3, Soren Plie3, and Jonathan N. Wilson4 — 1 TU Darmstadt — 2 UCologne — 3 TU Darmstadt — 4 U Surrey — 4 UCL LabOrsay

132Xe is a neutron rich even-even isotope which lies between the double shell closure N = 82 and Z = 50 and a region in which an increased quadrupole and octupole collectivity is expected [1,2]. The lifetimes of excited states of 132Xe are located in the range of some picoseconds. In this time range the Fast-Timing method is suited to determine the lifetime of excited states. Since there are different results for the lifetimes of excited states of the Xe isotopes in experiments employing the Fast-Timing method [1] and Coulomb excitation [2]. Therefore we are going to analyse the data taken following the fission of 238U induced by a pulsed neutron beam of 1.7 MeV energy from the LICORNE neutron source. The nu-Ball2 multidetector array consisted of 24 HPGe Clover detectors and 20 LaBr3(Ce) detectors which promise excellent energy resolution and time resolution, respectively. The reported campaign was performed at JLab in Orsay, France. Preliminary results will be presented. Supported by BMBF under Verbundprojekt 05P2021 (ErUm-FSP T07) grant 05P21RFKN1 and ARIEL


HK 49.4 Wed 18:15 SCH/A118
Gamma-ray spectroscopy of neutron-rich 55,57,59Sc isotopes — Radostina Zidovova1, Marta Liliana Cortés2, Volker Werner1, Pavlos Koseoglou1, Norbert Pietralla1, Pieter Doornenbal1, and Alexandre Obertrulli1 — 1 TU Darmstadt, Germany — 2 RIKEN-RIBP, Japan

Experimental data have shown that far from the valley of stability new magic numbers can emerge and the traditional ones can disappear. In particular, two new magic numbers at N = 32 and N = 34 have been suggested in the vicinity of Z = 20. Neutron-rich Sc isotopes around, and even beyond, neutron number N = 34. Investigation of exotic nuclei in this region was the goal of the third SEASTAR campaign at RIKEN-RIBF. Neutron-rich isotopes in the vicinity of 54K were produced by fragmentation of a primary 150In beam on a Be target. Known and novel y-ray transitions of the isotopes of 54Sc were observed and new y-rays from 55,56,58Sc identified for the first time. Observed y spectra from 55,57,59Sc will be presented together with preliminary level schemes. They will be discussed in the framework of the tensor-driven shell evolution.

Supported by BMBF under Grant Nos. 05P19/21RDFN1.

HK 49.5 Wed 18:30 SCH/A118
Lifetime measurements of excited states in 125Sm — Hannelaug Kleis, Peter Reiter, Konrad Arnswald, Maximilian Dreiste, Andrej Blazhev, Rima Burggraef, and Christoph Fransen — Institut für Kernphysik, Universität zu Köln.

Previously, the N = 32 shell closure was observed in the even-even Ca, Ti, and Cr isotopes [1]. Adding more valence protons to the (n, f2γ) orbital reduces the shell gap at N = 32 which vanishes completely at 86Fe. Lifetime measurements in the odd-even 125Sm nucleus were performed in order to close the gap between Z = 24 and Z = 26. Excited states of 125Sm were populated via 55Mn(15O, 15O)55Sm and the gamma-ray decay and mass-energy of nuclides. In order to assess the impact of a single valence proton outside of the Z = 20 shell on the shell-evolution mechanism in this region, it is necessary to study the neutron-rich Sc isotopes around, and even beyond, neutron number N = 34. Investigation of exotic nuclei in this region was the goal of the third SEASTAR campaign at RIKEN-RIBF. Neutron-rich isotopes in the vicinity of 54K were produced by fragmentation of a primary 150In beam on a Be target. Known and novel y-ray transitions of the isotopes of 54Sc were observed and new y-rays from 55,56,58Sc identified for the first time. Observed y spectra from 55,57,59Sc will be presented together with preliminary level schemes. They will be discussed in the framework of the tensor-driven shell evolution.

Supported by BMBF under Grant Nos. 05P19/21RDFN1.

HK 49.6 Wed 18:45 SCH/A118
Lifetime measurements of neutron-rich Kr isotopes within the nu-Ball2 fission campaign — J. Fischer1, A. Blazhev1, C. Hiver1, J. Jolie1, A. Messingschläger1, S. Pasco1, M. von Treskow2, N. War1, and J. N. Wilson4 — 1 JLab Orsay — 2 TU Darmstadt — 3 U Surrey

Nuclei beyond the band of stability are crucial to our understanding of the atomic nucleus and nuclear forces. In recent years, neutron-rich krypton isotopes have been studied as part of various campaigns. New gamma-transitions and levels were discovered in the first nu-Ball and SEASTAR-2015 campaigns [1,2] which compared to theory indicated oblate-prolate shape coexistence already in 48Kr [2]. However, the limited information on transition strengths did not allow for firm conclusions. Therefore lifetime measurements were performed at the ICLab Orsay as part of the nu-ball2 fission campaign. The nuclei of interest were produced with a fast-neutron-induced fission reaction 238U(n,f). The improved multidetector-array (nu-Ball2), a novel hybrid y-spectrometer consisting of HPGe and LaBr3(Ce) detectors provided excellent energy and timing information, respectively. The fast-timing method allows for lifetime determination down to about 10 ps and thus a possibility to determine transition strengths in the nuclei of interest. Preliminary results will be presented. Supported by BMBF under Verbundprojekt 05P2021 (ErUm-FSP T07) grant 05P21RFKN1.


HK 50: Structure and Dynamics of Nuclei X

Time: Wednesday 17:30–19:00

Group Report

HK 50.1 Wed 17:30 SCH/A215
Measuring Photo- Absorption Cross Sections with Tagged Photons at DOTUN — Martin Baumann1, Thomas Aumann1,2, Maitz Buschleins1, isabelle Brandherme1, Meytal Duer2, Amrita Gupta3, Philipp Imgrum1, Andrea Jedele1, Lianchong Ji1, Igor Jurovics1, Marco Knösel1, nickel Mozumdar1, Ann Rochele Netto1, Oliver Pape1, Thomas Pohl1, Heiko Scheit1, Gerhart Steinhiber1, Sonia Storck-duTine1, Dmitro Symochko1, Iyabo Usman1, and Patrick van Beek1 — 1 Institut für Kernphysik, TU Darmstadt, Germany — 2 GSI Helmholtzzentrum, Darmstadt, Germany — 3 University of the Witwatersrand, Johannesburg, South Africa

The photon tagger NEPTUN at the superconducting linear electron accelerator S-DALINAC has been upgraded to enable high precision measurements of nuclear photo-absorption cross sections in the energy region up to 35 MeV, covering the giant dipole resonance region using tagged bremsstrahlung with a single configuration. For this purpose a new focal plane detector LARISSA and...
a rapid target changer PROTEUS have been commissioned. This setup has recently been used to measure the photo-absorption cross sections of the isotopes Sn-112,116,120,124,4a-40 and 4a-48. In this talk the method will be outlined and performance characteristics of the setup will be shown as well as preliminary data from the recent beam time.

This work was supported by the Deutsche Forschungsgemeinschaft under Contract No. SFB 1245 (Project ID No. 279384907).

HK 50.2 Wed 18:00 SCH/A215
— 1GST, Darmstadt — 1IKP, TU Darmstadt — 1UNC, Chapel Hill, NC, USA — 4TUNL, Durham, NC, USA — 5Duke, Durham, NC, USA

We have developed a novel variation of the relative self-absorption (RSA) technique in order to adapt this method to quasi-monochromatic photon beams produced via Laser-Compton Backscattering (LCB) [1]. The approach combines the advantages of LCB experiments with model-independent determination of level widths via the RSA method. In this contribution the method itself as well as preliminary results of its pioneering application to measure the BE(02, 0+ → 2+1) transition strength of the first excited state in 12C to a precision of better than 2% will be presented.

Supported by the State of Hesse, grant “Nuclear Photonics” (LOEWE program) and the Research Cluster ELEMENTS (Project-ID 500/10.006), the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation - Project-ID 279384907 - SFB 1245 and the U. S. DOE Grant No. DE-FG02-97ER41041 and No. DE-FG02-97ER41033.


HK 50.3 Wed 18:15 SCH/A215
— 1IKP, TU Darmstadt — 1GST, Darmstadt — 1UNC, Chapel Hill, NC, USA — 4TUNL, Durham, NC, USA — 5Duke, Durham, NC, USA

The modeling of the elemental abundances in the universe requires, among others, information on the nuclear level density (NLD) of isotopes across the nuclear chart from stable to unstable nuclides. While it can be determined at the level of certain elements with model-dependent experimental determination of level widths, it is a difficult quantity to access at intermediate excitation energies. In fall 2022, a pioneering experiment with 88Sr was performed at HI/5 exploiting the combination of the self-absorption technique with quasi-monoenergetic photon beams. A novel approach is introduced enabling the extraction of the NLD of dipole-excited states with photonuclear reactions and first results for the case of 88Sr are presented.

Supported by the State of Hesse, grant “Nuclear Photonics” (LOEWE program) and the Research Cluster ELEMENTS (Project-ID 500/10.006), the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation - Project-ID 279384907 - SFB 1245 and the U. S. DOE Grant No. DE-FG02-97ER41041 and No. DE-FG02-97ER41033.

HK 50.4 Wed 18:30 SCH/A215
Lifetime measurements of excited states in 54Ni using the RDDS method — *Marc Heger*, *Jonas Weisse*, *Felix E. Siegel*, *Tobias Giese*, Georg-August-Universität Göttingen, Germany
— 1H Geulph, Darmstadt — 1MTU, Tübingen — 1IKP, Mainz — 1Hamburg, Hamburg, Germany

Supported by the DFG, grant Nos. FR 3276/2-1 and DE1516/5-1.

HK 50.5 Wed 18:45 SCH/A215
Lifetime Measurement of the 2+ and 4+ states in 56Ni using the RDDS method — *•Marc Heger*, *Jonas Weisse*, *Felix E. Siegel*, *Tobias Giese*, Georg-August-Universität Göttingen, Germany
— 1H Geulph, Darmstadt — 1MTU, Tübingen — 1IKP, Mainz — 1Hamburg, Hamburg, Germany

Supported by the DFG, grant Nos. FR 3276/2-1 and DE1516/5-1.
The DarkMESA beam dump experiment will search for light dark matter particles. It will be placed behind the P2 experiment at the future MESA electron accelerator, where an unprecedented amount of electrons-on-target can result in the radiative production of dark photons. In various models, such a dark photon decays predominantly into a pair of dark matter particles in the sub-GeV range. These will be detected by a sophisticated setup based on a solid and reliable detection technology.

In this talk, the development status of the detector system and the estimated exclusion limits will be presented.

**HK 51.4 Wed 19:00 SCH/A252**

Search for axion-like particles from Higgs boson decays in the 4 electron final state using the ATLAS detector — Giorgios Lamprinoudis, Matthias Schott, and Kristof Schmeiden for the ATLAS-Collaboration — Johannes Gutenberg Universität Mainz

Axion-like particles (ALPs) are motivated by numerous theoretical models, including the two-Higgs-doublet model (2HDM). ALPs can also couple to the Higgs boson and may decay to leptons. The coupling of ALPs to leptons defines their life-time and hence might lead to displaced decay vertices in the detector. While previous analyses assumed a negligible axion lifetime, a finite lifetime with displaced vertex signatures is studied in the present analysis of the $h\rightarrow a\gamma\gamma$ channel. The analysis covers a mass range of the axions from 0.5 GeV to 60 GeV. In the case that no signal is observed, the analysis will establish upper limits on the axion-Higgs coupling.

**HK 52: AI Topical Day — Invited Talks (joint session AKPIK/ST/T/AKBP)**

**Invited Talk**

- **HK 52.1** Thu 11:00 HSZ/AUDI
  **AI Techniques for Event Reconstruction** — Ivan Kisel — Goethe University, Frankfurt, Germany
  Why can we relatively easily recognize the trajectory of a particle in a detector visually, and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been puzzling over the answer to this question for more than 30 years, since the days of bubble chambers. And it seems that we are steadily approaching the answer in our attempts to develop and apply artificial neural networks both for finding particle trajectories and for physics analysis of events in general.

This talk will present the basics of artificial neural networks in a simple form, and provide illustrations of their successful application in event reconstruction in high energy physics and heavy ion physics experiments. You will get an insight into the application of traditional neural network models, such as deep neural network, convolutional neural network, graph neural network, as well as those standing a little aside from traditional approaches, but close in idea of elastic network and even cellular automata.

- **Invited Talk**
  **HK 52.2** Thu 11:30 HSZ/AUDI
  **Accelerator operation optimisation using machine learning** — Pierre Schnitzer — Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany

Accelerators are complex machines whose many components need to be accurately tuned to achieve design performance. Reliable operation requires frequent recalibration and tuning. Especially for large machines tools have been developed that facilitating this task.

Machine learning allows building such tools using simulations, archiver data or interaction with the real machine, thus making many tools now also available for smaller machines.

This talk will give an overview of different machine learning projects targeted to accelerators, which simplifies accelerator operation or even enable applications not been possible before.

**Invited Talk**

- **HK 52.3** Thu 12:00 HSZ/AUDI
  **Is this even physics? — Progress on AI in particle physics** — Gregor Kaczerzk — Universität Hamburg
  Motivated by the large volume and high complexity of experimental data and mathematical structures, particle physics has a long tradition of employing state of the art computing and analysis techniques. Recent progress in machine learning and artificial intelligence has further pushed this trend, and these approaches are now ubiquitous in our field. This overview attempts to capture key developments such as the rise of unsupervised approaches and the quest for suitable neural network architectures for physics tasks: challenges like ultra-low latency inference and robust predictions; as well as promising new ideas looking forward.

**HK 53: AI Topical Day — Computing II (joint session HK/AKPIK)**

**Invited Talk**

- **HK 53.1** Thu 14:00 HSZ/0103
  **Exploiting Differentiable Programming for the End-to-Optimization of Detectors** — The MODE Collaboration$^1$ and Anastasios Bellas$^2$ — $^1$mode-collaboration.github.io — $^2$GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany
  Machine-learning Optimized Design of Experiments, the MODE Collaboration, targets the end-to-end optimization of experimental apparatus, by using techniques developed in modern computer science to fully explore the multi-dimensional space of experiment design solutions. Differentiable Programming is employed to create models of detectors that include stochastic data-generation processes, the full modeling of the reconstruction and inference procedures, and a suitably defined objective function, along with the cost of any given detector configuration, geometry and materials.

The MODE Collaboration considers the end-to-end optimization challenges in its generality, providing software architectures for machine learning to explore experiment design strategies, information on the relative merit of different configurations, with the potential to identify and investigate novel, possibly revolutionary solutions. In this contribution we present use cases, and highlight the potential for on-going and future experiment design studies in fundamental physics research.

- **HK 53.2** Thu 14:15 HSZ/0103
  **Klassifikation von Pulsdaten mit neuronalen Netzwerken auf einer FPGA Accelerator Card** — Robert Ufer, Bastian Auer, Hilene Hoffmann, Oliver Knodel, Mani Lokamani und Stefan Mülle — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

The Compressed Baryonic Matter experiment (CBM) is designed to explore the QCD phase diagram at high baryon densities using high-energy heavy ion collisions at high interaction rates. The Ring Imaging Cherenkov detector (RICH) contributes to the overall particle identification by reconstruction using the answer in our attempt to develop and apply artificial neural networks both for finding particle trajectories and for physics analysis of events in general.

This talk will present the basics of artificial neural networks in a simple form, and provide illustrations of their successful application in event reconstruction in high energy physics and heavy ion physics experiments. You will get an insight into the application of traditional neural network models, such as deep neural network, convolutional neural network, graph neural network, as well as those standing a little aside from traditional approaches, but close in idea of elastic network and even cellular automata.

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**Invited Talk**

- **HK 53.3** Thu 14:30 HSZ/0103
  **Pattern recognition using machine learning for the mCBM mRICH detector** — Martin Beyer for the CBM-Collaboration — Justus-Liebig-Universität Gießen


**HK 53.4** Thu 15:15 HSZ/0103

**Exploiting Differentiable Programming for the End-to-Optimization of Detectors** — The MODE Collaboration$^1$ and Anastasios Bellas$^2$ — $^1$mode-collaboration.github.io — $^2$GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

Machine-learning Optimized Design of Experiments, the MODE Collaboration, targets the end-to-end optimization of experimental apparatus, by using techniques developed in modern computer science to fully explore the multi-dimensional space of experiment design solutions. Differentiable Programming is employed to create models of detectors that include stochastic data-generation processes, the full modeling of the reconstruction and inference procedures, and a suitably defined objective function, along with the cost of any given detector configuration, geometry and materials.

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**HK 53.5** Thu 15:30 HSZ/0103

**Klassifikation von Pulsdaten mit neuronalen Netzwerken auf einer FPGA Accelerator Card** — Robert Ufer, Bastian Auer, Hilene Hoffmann, Oliver Knodel, Mani Lokamani und Stefan Mülle — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

The Compressed Baryonic Matter experiment (CBM) is designed to explore the QCD phase diagram at high baryon densities using high-energy heavy ion collisions at high interaction rates. The Ring Imaging Cherenkov detector (RICH) contributes to the overall particle identification by reconstruction using the answer in our attempt to develop and apply artificial neural networks both for finding particle trajectories and for physics analysis of events in general.

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**Invited Talk**

- **HK 52.3** Thu 12:00 HSZ/AUDI
  **Is this even physics? — Progress on AI in particle physics** — Gregor Kaczerzk — Universität Hamburg
  Motivated by the large volume and high complexity of experimental data and mathematical structures, particle physics has a long tradition of employing state of the art computing and analysis techniques. Recent progress in machine learning and artificial intelligence has further pushed this trend, and these approaches are now ubiquitous in our field. This overview attempts to capture key developments such as the rise of unsupervised approaches and the quest for suitable neural network architectures for physics tasks: challenges like ultra-low latency inference and robust predictions; as well as promising new ideas looking forward.
of rings from electrons with their respective radius, position and time. The miniCMB (mCMB) detector is the test setup for the CBM experiment, with the purpose of testing both hardware and software including the triggerless free-streaming data acquisition and data reconstruction algorithms. The miniRICH (mRICH) detector in the mCMB setup is a proximity focussing RICH detector with a photon detection plane consisting of 36 MultiAnode Photo Multipliers (MAPMTs). This setup results in charged particles passing directly through the MAPMTs resulting in quite some additional signals typically inside ring structures and reducing the overall ring finding efficiency based on the Hough Transformation.

In this talk a machine learning approach is presented to classify those signals in ring centers and thus improving the overall ring finding efficiency and precision.

**HK 53.4 Thu 14:45 HSZ/0103**

**Machine Learning Algorithms for Pattern Recognition with the PANDA Barrel DIRC** — **Yannick Wolf**1,2, Roman Dzygadło1, Klaus Peters1,2,2, Georg Schepers2, Carsten Schwarz2, and Jochen Schiewien1, — **‘GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt — 1Goethe-Universität Frankfurt**

Precise and fast hadronic particle identification (PID) is crucial to reach the physics goals of the PANDA detector at FAIR. The Barrel DIRC (Detection of Internally Reflected Cherenkov light) is a key detector for the identification of charged hadrons in PANDA. Several reconstruction algorithms have been developed to extract the PID information from the measured location and arrival time of the Cherenkov photons. In comparison to other Ring Imaging Cherenkov detectors, the hit patterns observed with DIRC counters do not appear as rings on the photosensor plane but as complex, disjoint 3D-patterns.

Using the recent advances in machine learning (ML) algorithms, especially in the area of image recognition, we plan to develop new ML PID algorithms for the PANDA Barrel DIRC and compare the results to conventional reconstruction methods. In search for the best performance, different network architectures are currently under investigation.

**HK 53.5 Thu 15:00 HSZ/0103**

Optimization of the specific energy loss measurement for the upgraded ALICE TPC using machine learning — **Ilya Giridend for the ALICE Germany-Collaboration — Institut für Kernphysik, Frankfurt, Germany**

The Time Projection Chamber (TPC) is the primary detector used in the ALICE experiment for tracking and particle identification (PID). PID is accomplished by reconstructing the momentum and the specific energy loss (dE/dx) of a particle. The dE/dx for a given track is calculated using a truncated mean on the charge signals associated to the track. The readout plane, on which the signals are measured, is radially subdivided into four regions with different pad sizes. Since the measured signals depend on the pad size, an optimization of the dE/dx calculation based on the pad size can be performed.

In this talk, a method for optimizing the dE/dx calculation using machine learning (ML) algorithms will be presented. By performing realistic simulations of the generated signals on the pads, various effects such as different pad sizes and track geometry are modeled. These simulations are used as inputs for the training of the ML model and are investigated using RootInteractive.

Supported by BMBF and the Helmholtz Association.

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**Wednesday**

**HK 54: At Topical Day — Heavy-Ion Collisions and QCD Phases XI (joint session HK/AKPIK)**

**Time:** Thursday 14:00–15:30

**Location:** HSZ/0105

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**HK 54.1 Thu 14:00 HSZ/0105**

**Modelling charged-particle production at LHC energies with deep neural networks** — **Maria Calmon Behling** for the ALICE Germany-Collaboration — Institut für Kernphysik, Goethe-Universität Frankfurt, Germany

Particle production at the Large Hadron Collider (LHC) is driven by a complex interplay of soft and hard QCD processes. Modelling these interactions across center-of-mass energies and collision systems is still challenging for Monte Carlo event generators. Concise experimental data is indispensable to characterize the final state of a collision. The ALICE experiment with its unique tracking capability down to low transverse momenta is perfectly suited to study the bulk particle production in high-energy collisions. During the data taking campaigns of LHC Run 1 and Run 2 (2009 – 2018), a large amount of data were collected of a variety of collision systems at different center-of-mass energies. A recent measurement of charged-particle production covering all of these collision systems provides a comprehensive set of fundamental observables like the charged-particle multiplicity distributions and transverse momentum spectra as well as their correlation. In this talk, we discuss the possibility of extending this set of discrete experimental data points into unmeasured regions by means of machine learning techniques. Training deep neural networks with ALICE data gives the unique opportunity to measure the evolution of multiplicity dependent charged-particle production across collision system sizes and energies.

Supported by BMBF and the Helmholtz Association.

**HK 54.2 Thu 14:15 HSZ/0105**

**Measurement of the Λ separation energy in hyperrtron with ALICE using machine learning techniques** — **Regina Michel** for the ALICE Germany-Collaboration — GSI Helmholtz-Zentrum für Schwerionenforschung — Technische Universität Darmstadt

Hyperrtron Λ hypernucleus, consisting of a Λ hyperon, a proton and a neutron. It is structured as a halo nucleus, where the Λ hyperon is very loosely bound to a “deuteron core”. Measurements of the Λ separation energy can be used as a test for QCD, for some models of neutron stars and to constrain the possible difference of the lifetimes of Λ and Λ. The Λ separation energy can be measured via the invariant mass of the hypertriton decay products. The two-body-decay Λ → He+n is considered. Monte Carlo simulations are conducted to simulate the hypertriton interactions and decays while propagating through the detector. A data sample from Pb-Pb collisions at a center-of-mass energy of √sNN = 5.02 TeV recorded with ALICE at the LHC is analyzed using machine learning techniques.

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**HK 54.3 Thu 14:30 HSZ/0105**

**Physics performance studies on E* Baryon at CBM** — **Lisa-Katrin Kümmer**1,2, Andrea Dubla1, and Ilya Selyuzhenkov2 for the CBM-Collaboration — 1Physikalisches Institut, Universität Heidelberg — 2GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt

The Compressed Baryonic Matter (CBM) experiment at FAIR will investigate the QCD phase diagram in the region of high net-baryon densities (ρ > 500 MeV) in the collision energy range of √sNN = 2.7 – 4.9 GeV with high interacion rate, up to 10 MHz, provided by the SIS100 accelerator. The (multi)strange baryons are crucial in determining the chemical freeze-out and its connection to hadronization from deconfined QCD matter.

In this contribution the performance for Ξ− selection in Au-Au collisions at √sNN = 4.93 GeV in the CBM experiment will be presented. The Ξ− hyperon is reconstructed via the weak decay channel Ξ− → (Λ → p+ n) with the Particle-Finder Simple package.

For the reduction of the data size, which is driven by the large combinatorial background, specific skimming pre-selection criteria are optimized in this work. To obtain an optimal and stable separation between signal and background candidates the machine learning tool XGBoost is used. Machine learning allows for efficient, non-linear and multi-dimensional selection criteria to be implemented in a heavy-ion collision environment, enabling to extract and correct the E− raw yield in different rapidity and transverse momentum intervals.

**HK 54.4 Thu 14:45 HSZ/0105**

**Multi-differential Λ Yield Measurement in the CBM Experiment using Machine Learning Techniques** — **Axel Punke**1 and Shahid Khan2 for the CBM-Collaboration — 1Institut für Kernphysik, WWU Münster — 2Eberhard Karls University of Tübingen
The Compressed Baryonic Matter (CBM) experiment at FAIR will investigate the QCD phase diagram at high net-baryon densities (\(\rho > 500\) MeV) with heavy-ion collisions in the energy range of \(\sqrt{s_NN} = 2.9-4.9\) GeV. Precision determination of dense baryonic matter properties requires multi-differential measurements of strange hadron yields, both for the most copiously produced \(K^0\) and \(\Lambda\) as well as for rare (multi-)strange hyperons and their antiparticles.

The strange hadrons are reconstructed using methods based on a Kalman Filter algorithm that has been developed for the reconstruction of particles via their weak decay topology. The large combinatorial background needs to be suppressed by applying selection criteria according to the topology of the decay. This selection is optimized by training a boosted decision tree-based machine learning model with simulated data from two event generators, UrQMD and DCM-QGSM-SMM. After the signal has been selected, the yield of the strange hadron is computed.

In this talk, the analysis procedure for the most abundant A baryon is presented and the performance of the non-linear multivariate-parameter selection method is evaluated. A fitting routine is implemented to extract the A yield, on which the performance gain of training a separate model for each \(p_T\)-y interval will be discussed.

**HK 54.5 Thu 15:00 HSZ/0105**

**Full beauty-hadron reconstruction with \(J/\psi\): feasibility study for Run 3 with ALICE** — **Guillaume Taillefer for the ALICE Germany-Collaboration** — GSi Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

The study of the production of hidden and open heavy-flavour hadrons in proton-proton (pp) collisions provides an essential test of quantum chromodynamics, involving both the perturbative and non-perturbative regimes. The \(J/\psi\) meson allows to study both the charm sector, via the measurement of prompt \(J/\psi\), and the beauty sector through the measurement of the non-prompt component, coming from the decay of beauty hadrons. With the recent upgrades of the ALICE apparatus, the full reconstruction of beauty hadrons in exclusive decay channels containing non-prompt \(J/\psi\) mesons is now possible, providing a new way to study beauty physics in hadronic collisions.

In this talk, a feasibility study of the \(B^+ \rightarrow J/\psi K^+\), \(J/\psi \rightarrow e^+e^-\) process in pp collisions at \(\sqrt{s} = 13.6\) TeV with ALICE will be presented. The analysis makes use of the KFParticle package for a precise reconstruction of the \(B^+\) and non-prompt \(J/\psi\) decay chain. The package also provides important information for the training of a machine learning model, increasing the signal selection efficiency and signal-over-background ratio. Discussions on the perspectives in lead-lead collisions for Run 3, based on the results of this feasibility study, will be shown.

**HK 54.6 Thu 15:15 HSZ/0105**

**Photon reconstruction in the Transition Radiation Detector of ALICE** — **Peter Stratmann for the ALICE Germany-Collaboration** — Institut für Kernphysik, Wilhelm-Klemm-Str. 9, 48149 Münster

The Transition Radiation Detector (TRD) of the ALICE detector at the Large Hadron Collider has the main purpose of identifying electrons and triggering on electrons and jets. Furthermore, it improves the resolution in track reconstruction at high transverse momenta. The working principle is based on transition radiation, which is produced by charged particles traversing boundaries of material with different dielectric constants.

In a rather new approach, the TRD should be used for measuring the photon production through the detection of conversion electrons. This is facilitated by the large material budget located in front and inside of the TRD. For this purpose, a stand-alone tracking detector, the Inner Tracking System (ITS), and a forward calorimeter will be used. The photons will be detected using the TRD. As an additional method, the photons are reconstructed in the TRD using a new technique, which uses the fact that the photons are produced in the forward direction of the beam. This method has the advantage that it can be used for high-precision measurements of the transverse momentum and the direction of the photon.

**HK 55.1 Thu 14:00 SCH/A251**

**Different applications of Low Gain Avalanche Detectors** — **Felicia Ulrich-Pur, Tetyana Galatyuk, Wilhem Krüger, Sergey Linev, Jan Michel, Jerzy Pietraszko, Adrian Rost, Michael Träger, Michael Träxler, Christian Joachim Schmidt** — GSi GmbH, Darmstadt, Germany — Technische Universität Darmstadt, Darmstadt, Germany — Goethe-Universität, Frankfurt, Germany — FAIR GmbH, Darmstadt, Germany

Low Gain Avalanche Detectors (LGADs) are fast silicon detectors especially designed for high-rate environments. Both detector concepts with point-like and board-based electronics will be discussed. The LGADs allow the reconstruction of single particle tracks even at very high track densities. Within this contribution, we will present several applications of LGAD strip sensors, which were produced at Fondazione Bruno Kessler (FBK). This includes the reaction time (\(T_0\)) detector for the High Acceptance Di-Electron Spectrometer (HADES) at GSI in Darmstadt, Germany. A beam-structure monitor for the Superconducting Darmstadt LInear Accelerator (S-DLINAC) at the Technische Universität Darmstadt and an ion imaging experiment conducted at the MedAustron cancer therapy and research centre in Wiener Neustadt, Austria. After discussing first results, we will outline planned upgrades of the current systems and possible future projects at the GSI and FAIR facilities.

**HK 55.2 Thu 14:30 SCH/A251**

**LGAD based Start Detector in HADES** — **Tetyana Galatyuk,1,2, Vadym Kedych,1,3, Wilhem Krüger,4, Sergey Linev,4, Jan Michel,5, Jerzy Pietraszko,6, Adrian Rost,7, Christian Joachim Schmidt,7, Michael Träger,7, Michael Träxler,1,6, and Felicia Ulrich-Pur1** — 1Technische Universität Darmstadt — 2GSi Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt — 3Goethe-Universität, Frankfurt — 4FAIR GmbH

The High Acceptance Di-Electron Spectrometer (HADES) experiment has designed and used a Low Gain Avalanche Detector (LGAD) based-in-beam detector for its high rate 4.5 GeV pp production beam time in February 2022. As LGADs offer high-precision timing measurements with high spatial and high radiation hardness, they were the sensors of choice for the in-beam detector.

The detector consisted of two FBK LGADs with a form factor of 2 x 2 cm\(^2\) and 96 half-strips each. It was used for beam monitoring purposes during the beam time and will assist in particle identification by providing a precise reaction time (\(T_0\)). This contribution will present the calibration procedure of the detector as well as its performance with respect to the reached timing precision.

**HK 55.3 Thu 14:45 SCH/A251**

**Beam monitoring and T0 system for the CBM experiment at FAIR** — **Adrian Rost for the CBM-Collaboration** — Facility for Antiproton and Ion Research in Europe GmbH, Darmstadt, Germany

A beam detector system for the CBM experiment at the FAIR accelerator complex has been developed. The system will be used for T0 measurements with a precision in the order of 50 ps and for beam monitoring purposes i.e. beam halo particle measurements. The concept has been prepared and will consist of two detector stations, one used for beam monitoring and the second for the T0 measurement. Both detector stations are planned to utilize poly-crystal CVD diamond technology. But also new technologies like the Low Gain Avalanche Detectors (LGADs) are under investigation in collaboration with the HADES experiment at GSI. The sensors will be mounted on dedicated printed circuit boards, equipped with amplifier and shaping circuits. The detector stations are located in standard vacuum elements which are integrated into the CBM beamline. Two detector stations are planned to be used in the mCMB experiment at the SIS18 accelerator. The read-out system will utilize the PADI discriminator and the GET4 TDC ASICs. In this contribution the BMON concept and the current status of the project will be presented.

*A this project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 87072.

**HK 55.4 Thu 15:00 SCH/A251**

**Studies of the Unified Tracking Station for the Proton Radius Measurement in High-Energy Elastic Muon-Proton Scattering at AMBER** — **Christian Dreisbach, Karl Eichhorn, Jan Friedrich, Igor Konorov, Martin Losekamm, Stephen Paul, and Thomas Föschi** — AMBER Collaboration — Technische Universität München, Physik-Department EL1, Garching, Germany

The proton radius can be determined by measuring the slope of the electric form factor \(G_E\) at small squared four-momentum transfer \(Q^2\). Numerous elastic scattering and laser spectroscopy measurements of the proton radius have been performed with contradicting results – the so-called proton radius puzzle. We propose to measure the proton radius in high-energy elastic muon-proton scattering at the M2 beam line of CERN’s Super Proton Synchrotron in the year 2023. A high-precision measurement at low \(Q^2\) realized with a high-pressure hydrogen TPC can contribute to a solution of the puzzle, especially in view of the systematics of this approach compared to electron scattering. In addition to the precise measurement of the recoil proton provided by the TPC, novel unfixed tracking stations (UTS) are foreseen for an accurate measurement of the muon.
Scintillating Fiber Hodoscopes for the Proton Radius Measurement at AMBER — Christian Dreisbach, Katrin Eichhorn, Jan Friedrich, Igor Konorov, Martin Losekamp, Stephan Paul, and Thomas Poeschl for the AMBER-Collaboration — Technische Universität München, Physik-Department, Garching, Germany

The AMBER collaboration aims to measure the proton charge radius in an elastic scattering experiment using high energy muons provided by the M2 secondary beamline at CERN’s Super Proton Synchrotron using an active hydrogen target. For muon tracking, novel Unifed Tracking Stations equipped with monolithic active pixel silicon detectors in combination with a Scintillating Fiber Hodoscope (SFH) will be used. The SFH consists of 500 μm thin scintillating plastic fibers read out with SiPMs, covering an active area of (9x9) cm². We present ongoing studies and results from a test beam experiment performed in 2022 with a detector prototype.

Funded by the DFG under Germany’s Excellence Strategy - EXC2094 - 390783311

HK 55.5 Thu 15:15 SCH/A251

Scintillating Fiber Hodoscopes for the Proton Radius Measurement at AMBER

HK 56: Instrumentation XV

Time: Thursday 14:00–15:30

Group Report

HK 56.1 Thu 14:00 SCH/A.101

Performance of the upgraded HADES RICH in heavy ion collisions — Jörg Förtsch for the HADES-Collaboration — Bergische Universität Wuppertal

The 1.58A GeV Ag+Ag beamtime of the High Acceptance DEtector Spectrometer (HADES) at GSI Darmstadt, Germany, in March 2019 marked the first use of the upgraded HADES RICH. At triggered event rates of up to 18 kHz the HADES RICH detector is the key component for efficient identification of electrons and positrons in hadronically dominated collision products.

The HADES RICH detector is a gaseous ring imaging Cherenkov detector with C₂H₁₀ (isobutane) being used as radiator hence making the detector hadron blind for momenta up to approximately 2 GeV/c. A spherical mirror reflects Cherenkov photons on a staggered photon detection plane comprised of 428 MultiAnode Photo electron Multipliers (MAPMTs) of type Hamamatsu H12700. All 27392 different MAPMT channels are read out by the DIRICH readout electronic scheme measuring leading edge and time over threshold of each pulse down to sub-nanosecond precision.

In this talk we will present key features of our upgrade and lay out quantitatively how well the RICH performed throughout the full measurement campaign.

* Work supported by GSI and BMBF (05P19RGFCA, 05P21RGFC1), Hessen- and BMBF (05P19PXFCA, 05P21PXFC1), Hessen for FAIR (HHF), GSI Helmholtzzentrum für Schwerionenforschung, Campus Gießen

HK 56.2 Thu 14:30 SCH/A.101

Design of a luminozity monitor for the P2 purity violating experiment at MESA — Sebastian Baunack, Boris Glaser, Rahima Krimi, Frank Maas, Tobias Rimke, David Rodriguez Pineiro, and Malte Wilpert — Institut für Kernphysik, Johannes Gutenberg-Universität Mainz

— Helmholtz-Institut Mainz, Johannes Gutenberg-Universität Mainz — PRISMA+ Cluster of Excellence, Johannes Gutenberg-Universität Mainz

The P2 experiment at the future MESA accelerator in Mainz plans to measure the weak mixing angle sin²(θ₁₂) in parity violating elastic electron-proton scattering.

The aim of the experiment is a very precise measurement of the weak mixing angle with an accuracy of 0.15% at a low four-momentum transfer of Q² = 4.5 x 10⁻¹³ GeV². In order to achieve this accuracy, it is necessary to monitor the stability of the electron beam and the liquid hydrogen target. Any helicity correlated fluctuation of the target density leads to false asymmetries.

Therefore, it is planned to install a luminozity monitor in forward direction close to the beam axis. The motivation and challenges for designing an air Cherenkov luminozity monitor will be discussed in this talk. Furthermore, I show promising results from prototype tests with the electron beam of the MAMI accelerator.

HK 56.3 Thu 14:45 SCH/A.101

Performance of the first mass production MCP-PMTs for the PANDA Barrel DIRC and lifetime of the latest MCP-PMTs — Katja Gumbert, Merlin Bohm, Steffen Krauss, Albert Lehmann, and Daniel Miehling for the PANDA-Collaboration — Physikalisches Institut, Universität Erlangen-Nürnberg

In the PANDA detector at FAIR two DIRC detectors will be used for particle identification using Cherenkov light. Since the focal planes of both DIRCs are located inside magnetic fields of ≥ 1 Tesla, Microchannel-Plate Photomultipliers (MCP-PMTs) will be used to detect the few Cherenkov photons. The Barrel DIRC, which will surround the beam line and the interaction point, will be equipped with 128 MCP-PMTs of the type XP5112-S-BA by PHOTONIS with an active area of 2x2'' inches, 88x anode pixels and a pore diameter of 10 μm of the MCPs. As part of the quality control process Erlangen will measure performance parameters like the efficiency, both quantum and collection efficiency, the gain distribution, the time resolution, the afterpulse probability and the rate capability of these sensors.

The quantum efficiency of former MCP-PMTs dropped after only a few hundred μC/cm² integrated anode charge due to feedback ions produced in the residual gas. These ions are accelerated back to the photo cathode and may damage it. This aging problem was significantly reduced by applying an ALD coating (atomic-layer deposition) to the MCP pores. Both the lifetime performance of the latest tubes and the performance of the first Barrel DIRC MCP-PMTs will be shown in this talk.

* Funded by BMBF and GSI -

HK 56.4 Thu 15:00 SCH/A.101

New "escalation" effect observed in recent MCP-PMTs — Steffen Krauss, Merlin Bohem, Katja Gumbert, Albert Lehmann, and Daniel Miehling — Physikalisches Institut, Universität Erlangen-Nürnberg

Two DIRC-type Cherenkov detectors will be employed in the PANDA experiment at FAIR for pion/kaon separation. Since the focal planes of both DIRC detectors are located in a ≥ 1 Tesla magnetic field, Microchannel-Plate Photo-multipliers (MCP-PMTs) are the only viable option to detect the few generated Cherenkov photons. To distinguish these single photons safely from the thermally emitted photo electrons a low darkcount rate is required in combination with a high gain of > 10⁴. In some of the latest MCP-PMTs a new and completely unexpected effect was observed recently. At high gains and sometimes in combination with high illumination levels the MCP-resistance drops significantly, the gain drops, and a high amount of photons are created inside the tube, which causes a drastic increase of count rate. Inside a magnetic field this behavior seems to be significantly suppressed.

To study this effect in more detail several measurements of current, gain, and count rate were performed and compared for different MCP-PMTs. The rate of the produced photons were measured in an oppositely placed additional MCP-PMT. The results of these measurements are presented in this talk for older and the most recent MCP-PMT generations of different manufacturers.

* Funded by BMBF and GSI -

HK 56.5 Thu 15:15 SCH/A.101

Prototype studies towards the CBM RICH air cooling system — Gianluca Boccarella, Christian Pauly, Dennis Pfeifer, and Karl-Heinz Kampert for the CBM-Collaboration — Bergische Universität Wuppertal, Gaußstraße 20, 42119 Wuppertal

The Compressed Baryonic Matter (CBM) RICH detector is a CO₂ based gaseous Ring Imaging Cherenkov detector using MultiAnode PhotoMultipliers (MAPMT) for Cherenkov photon detection. It is placed beam downstream directly behind the CBM superconducting magnet and serves the precise electron identification and pion suppression. The photon detector is split into two separate cameras each including 30k channels DIRICH frontdet readout electronics. Both cameras are enclosed by an iron shielding box in order to protect the MAPMT sensors from the magnetic stray field of the nearby CBM magnet. This shielding enclosure poses a major challenge for the cooling of the electronics dissipating approximately 3 kW heat inside each camera module. In order to achieve reliable cooling of all ~1000 readout modules per camera we plan to use a closed-cycle enforced air cooling system.

In the talk, we present the cooling concept of the CBM RICH detector together with first measurements obtained using a full scale prototype of one of the camera modules.

* Supported by BMBF (05P19PXFC1A, 05P21PXFC1) and GSI.
HK 57: Hadron Structure and Spectroscopy VI

Time: Thursday 14:00–15:30

Group Report

HK 57.1 Thu 14:00 SCh/A316
Multi-meson photoproduction off the proton - recent results from the CBELSA/TAPS experiment — PHILIPP MAHLBERG for the CBELSA/TAPS-Collaboration — Helmholtz-Institut für Strahlen- und Kernphysik, Universität Bonn, Deutschland

The nucleon excitation spectrum is dominated by mostly broad resonances, so partial wave analyses (PWA) are needed to extract the overlapping resonances from the experimental data. In order to find an unambiguous solution, the measurement of polarization observables is indispensable.

Meson photoproduction experiments have provided an extensive database which in turn let different partial wave analyses converge to similar results. The findings fit surprisingly well in an ordering scheme imposed by a non-relativistic quark model. Within the higher mass regime, the PWA solutions are less constrained and not all model-predicted states have been confirmed by experiments. Here, multi-meson decay channels gain importance and sequential decay chains can be studied.

The Crystal Barrel/TAPS experiment is due, to its good energy resolution, high photon detection efficiency and its almost complete solid angle coverage, ideally suited to measure such multi-meson final states in which neutral mesons decay into photons. For the $p\pi^+n$ and $p\pi^-\bar{n}$ final states, recent results — obtained with a linearly polarized photon beam at different coherent energy positions (up to 1850 MeV), impinging on an either transversely polarized or unpolarized target — will be presented.

HK 57.2 Thu 14:30 SCh/A316
Sensitivity study for baryon resonances searches in pion-proton collisions with HADES — JAN GOLLUR, AHMED FODA, JOHAN MESSCHENDORP, and JAMES RTMAN for the HADES-Collaboration — 3Ruh-Universität Bochum, Germany — 4GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany

Pion-induced reactions provide unique opportunities for a description of baryonic resonances and their coupling channels. The two-pion production in $\pi^-p$ reactions at pion beam momenta between 0.650 GeV/c and 0.786 GeV/c was already analysed. The next step is to investigate these reactions at center of mass energies up to $\sqrt{s} = 1.76$ GeV with the HADES detector in 2024.

In this work, a sensitivity study of the expected results using the Bonn-Gatchina partial wave analysis framework has been performed. In this talk MC simulated invariant mass spectra and angular distributions will be presented.

HK 57.3 Thu 14:45 SCh/A316
Study of the $\Delta^{++}$ baryon at BESIII — DONG LIU, CHRISTOPH ROSNIA, and FRANK MAAS for the BESIII-Collaboration — 1Helmholtz Institute Mainz, Mainz, Germany — 2University of Science and Technology of China, Hefei, China — 3Institute of Nuclear Physics, Mainz, Germany — 4PRISMA+ Cluster of Excellence, Mainz, Germany

The common baryons are the baryon octet and the baryon decuplet states. The wave functions of baryons in the octet are antisymmetric under quark exchange, and they have been extensively studied in electron-positron collision experiments, including proton, neutron, $\Lambda$, $\Sigma$, $\Xi$, etc. The wave functions of decuplet baryons are symmetric under quark exchange and there are few studies on them, including $\Delta$, $\Sigma$, $^{2}\Sigma$, $^3\Omega$, etc. Among them, $\Delta$ particles are the lightest ones and have the highest cross section in electron-positron collisions. The measurement of the $\Delta$ production cross section at the BESIII experiment is a complement to the study of baryons and provides an experimental basis for theoretical studies of the intrinsic structure of baryons. The analysis of the $\Delta\rightarrow p\pi$ baryon pair production process is carried out at the BESIII experiment, giving the upper limit of the cross section for the process in the energy range from the threshold up to 2.645 GeV, which constrain the theoretical prediction for the decuplet pair production process. Meanwhile, the cross section and error for the $\Delta\rightarrow p\pi$ process at a centre-of-mass energy of 2.645 GeV is also reported.

HK 57.4 Thu 15:00 SCh/A316
Determination of the polarization observables $T_P$ and $H$ in the reaction $\gamma p \rightarrow p\pi^0$ — SEBASTIAN CIUPKA for the CBELSA/TAPS-Collaboration — HISKP, Uni Bonn

It is experimentally and theoretically challenging to determine the exact number of excited nucleon states and their properties, since the short lifetime of these exited states leads to strongly overlapping resonances. Using a polarized beam, a polarized target or using the polarization of the recoil nucleon helps to measure single or double polarization observables, that are needed for an unambiguous partial wave analysis solution.

The CBELSA/TAPS experiment in Bonn provides a polarized photon beam as well as a longitudinally or transversely polarized target, allowing, for the determination of single and double polarization observables. The Crystal Barrel (CB) calorimeter, together with the MiniTAPS calorimeter in forward direction, give the opportunity for close to $4\pi$ coverage for the measurements.

This talk will present preliminary results of the determination of the polarization observables $T_P$ and $H$, for energies between 600MeV and 3200MeV, using data collected after the recent upgrade of the CB calorimeters readout electronics and these results are compared to previous data and model predictions.

HK 57.5 Thu 15:15 SCh/A316
Resonance Regions: Partial Wave Analysis in the HADES Experiment — AHMED MARWAN FODA — GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt

The High Acceptance Di-lepton Spectrometer (HADES) collaboration uses a pion beam to study features of baryonic resonances and their decay channels. This allows the production of baryonic resonances at a fixed center of mass energy, i.e. in the s-channel, thus giving these beams a significant advantage relative to proton proton reactions. Partial Wave Analysis (PWA) techniques are used to study the coupling of the resonances to different final states. Analysis of the baryonic resonances decays to $\rho N$ and $\omega N$ final states will provide insight into baryon-vector meson couplings essential for the understanding of the melting of the $\rho N$ meson in a dense baryonic matter and description of dilepton emissions from Heavy ion collisions.

A new implementation of the Bonn-Gatchina framework is being developed in preparation for a more detailed mapping of the resonance regions in pion-proton collisions. Example fits will be presented showing current status and the potential of the new framework.

HK 58: Hadron Structure and Spectroscopy VII

Time: Thursday 14:00–15:30

Group Report

HK 58.1 Thu 14:00 SCh/A419
Understanding the dynamics of three-body systems using femtoscopic at the LHC — RAFAELLE DEL GRANDE for the ALICE Germany-Collaboration — Technical University of Munich, Garching, Germany

Three-body forces among hadrons are necessary for the theoretical description of nuclear bound objects and for modeling the equation of state of neutron stars. Direct measurements of three-body interactions are currently missing and represent one of the current challenges for experimental nuclear physics. The ALICE Collaboration recently extended the femtoscopy technique to explore the strong interaction in three-particle systems, exploiting both three-hadron and hadron-nucleus correlation studies. The present contribution provides an overview of the milestones reached by ALICE in the study of three-body systems, using the femtoscopic technique in pp collisions at $\sqrt{s} = 13$ TeV. The main highlights are the first experimental measurements of three-baryon correlations, $p-p-p$, and the first study of three-body systems with kaons, $p-p-K^+$ and $p-p-K^-$. The contribution of genuine three-body effects in the measured correlation functions has been isolated using Kubo’s cumulant expansion method. The interpretation of such measurement and the possible implications on the equation of state of neutron stars and bound state formation will be discussed.

This research was funded by DFG SFB1258 and BMBF Verbundforschung (05P21WOCA1 ALICE).

HK 58.2 Thu 14:30 SCh/A419
Understanding the particle emitting source of $\pi^-\pi$ correlations from measurements in MB pp of ALICE at 13 TeV — MAXIMILIAN KORWIESER for the ALICE Germany-Collaboration — TU München, Physik Department E62, Excellence Cluster 'Universe', Garching

The ALICE collaboration recently published a plethora of results obtained from femtoscopic measurements, studying the interaction between many exotic combinations of particles, most notably $\Omega^-p$. In general these studies depend on a precise understanding of the particle emitting source, which is constructed employing the resonance source model (RSM). In the RSM, deviations of a Gaussian source distribution, due to the effects of short lived resonances, are modeled via a Monte Carlo procedure. For two particle correlations between baryons ($p-p$ and $\Lambda-p$) the RSM was already validated with great success. The goal of this
work is to validate whether the RSM can also be applied to constrain the source in the mesonic sector. A differential study of the source functions spatial extension is presented, in bins of $m_t$ and multiplicity classes, by analysing MB pp collisions at $\sqrt{s} = 13$ TeV obtained by ALICE. An $m_t$ scaling behaviour of the source is observed and found to be compatible with previous results in the baryonic sector. This measurement supports the scenario of a common source for mesons and baryons in small colliding systems, allowing to employ the RSM to constrain the source for meson–baryon and meson–meson.

This research was supported by the BMBF.

Investigating $p-\pi^-$ and $p-\pi^+$ femtoscopy correlations with ALICE at the LHC — •MARCEL LESCH for the ALICE Germany-Collaboration — TUM, James-Franck-Straße 1, 85748 Garching bei München

The modelling of neutron stars is deeply linked to the understanding of the nuclear equation of state (EoS). It was recently proposed that the QCD axion might impact the EoS of neutron stars and that its properties at large baryonic densities can be related to the in-medium properties of pions. Constraining the latter is thus crucial for the study of the QCD axion and its impact on the description of neutron stars. By employing recently developed three-body femtoscopy techniques, the in-medium properties of pions can be inferred from correlation measurements between pions and many nucleons in pp collisions at the LHC. These small systems produce particles at distances of ~1 fm, mimicking a large-density environment. However, to understand the experimental three-body correlations, the lower-order two-body correlations between $p-\pi^-$ and $p-\pi^+$ must be constrained. In this talk, we present the first measurement of $p-\pi^-$ and $p-\pi^+$ correlations using two-body femtoscopy. The results have been obtained by analysing high-multiplicity pp collisions at $\sqrt{s} = 13$ TeV measured by ALICE. This research was funded by the DFG under Germany’s Excellence Strategy - EXC2094 - 390783311 and the BMBF Verbundforschung (05P21WOCA1 ALICE).

ALICE determines the scattering parameters of open charm mesons with light-flavor hadrons — •DANIEL BATTISTINI for the ALICE Germany-Collaboration — Technical University of Munich, Munich, Germany

The strong interaction among D mesons and light-flavor hadrons was completely out of experimental reach until recently. The lack of experimental constraints on the scattering parameters of D-proton/pion/kaon poses strong limitations not only to the search of molecular states composed of charm and light-flavor hadrons, but also to the study of the rescattering of charm mesons in the hadronic phase of ultrarelativistic heavy-ion collisions. The knowledge of the scattering parameters of charm hadrons with non-charm hadrons would be a crucial ingredient for models based on charm-quark transport in a hydrodynamically expanding QGP to describe the typical observables of heavy-ion collisions.

In this talk, we will report on the first measurement of the scattering parameters of open charm mesons with light-flavor hadrons. The study is carried out by the ALICE Collaboration, in high-multiplicity proton-proton collisions at $\sqrt{s} = 13$ TeV. The scattering parameters are measured employing correlation techniques and the final-state strong interaction is found to be shallow in all the channels under study.

* Funded by BMBF Verbundforschung (05P21WOCA1 ALICE).

**Investigation of SRC in exotic nuclei at R3B/GSI**

101057511) Horizon Europe Framework research programm (Grant Agreement No. 857015267).

Supported by BMBF Projects 05P18PKC11, 05P21PKC11 and European Unions Horizon Europe Framework research programm (Grant Agreement No. 101057311).

**Overview of CALIFA in FAIR-Phase-0 Experiments at R3B** — •JAIME GONZALEZ and DIMITAR MIHATOV — Technical University of Munich, Munich, Germany

This work introduces a new framework (CECA) to model the source function that represents the spatial and kinematic properties of a particle emission in small collision systems. The properties of the source have been fixed within CECA by using an existing ALICE measurement of the pp source size in pp collisions. Under the assumption of a common source, a simulation of the kinematic properties of the $pA$ system is performed and compared to existing measurements. Utilizing several parameterizations of the chiral effective field theory, used to model the $pA$ interaction, allowed to study the properties of the hyperon-nucleon interaction, which is an important ingredient for the nuclear Equation of State and the modeling of the structure of neutron stars. Funded by BMBF Verbundforschung (05P21WOCA1 ALICE).

**Group Report**

**Commissioning of Miniball HIE-ISOLDE and first results from Coulomb excitation of $^{132}$Sn** — •MAXIMILIAN DROSTE, Peter REITER, and THORSTEN KROLL for the MINIBALL IS702-Collaboration — IKP, Universität zu Köln, Germany — •Institut für Kernphysik, TU Darmstadt, Germany

The high-resolution Miniball germanium array has been commissioned at the HIE-ISOLDE facility in CERN, Geneva, Switzerland in 2022. The commissioning has been performed at RIKEN, Japan and PSI, Switzerland the cryostats and capsules of the HPGe crystals have been redesigned and rebuilt. A new data acquisition system, based on FEBEK digitizers, was used for the commissioning of the array. Coulomb excitation of $^{132}$Sn was the first experiment after LS2 at CERN. A beam of 4.4 MeV was delivered on a 200µd target. Exciting $\gamma$-rays from target and projectile nuclei were recorded in coincidence with scattered particles. The experiment aims to investigate the evolution of nuclear structure around the magic-shell closure at N=82 tin isotopes by determining the $\beta(E2:0^+_1 \rightarrow 2^+_1)$ value. Most advanced SM calculations using realistic interactions predict enhanced collectivity in the neighbouring isotopes of $^{132}$Sn [1]. Moreover, a puzzling discrepancy between previous measurements in $^{136}$Sn and latest theoretical results [2] needs to be resolved.


Supported by BMBF Projects 05P18PKC11, 05P21PKC11 and European Unions Horizon Europe Framework research programm (Grant Agreement No. 101057311).

**Overview of CALIFA in FAIR-Phase-0 Experiments at R3B** — •LEYLA ATAR, CHRISTIAN SÜNDER, THORSTEN KROLL, ROMAN GERNHÄUSER, and PHILIPP KLENZE for the R3B-Collaboration — Institut für Kernphysik, Technische Universität Darmstadt, Germany — Technische Universität München, Germany

CALIFA (the CALorimeter for In Flight detection of y-rays and light charged particles) is one of the key detectors of the R3B experiment at the GSI/FAIR facility. CALIFA is highly segmented and currently consists of 1528 scintillation GsI(T) crystals surrounding the reaction target area to facilitate measurement of the emission angle and energy of reaction products. CALIFA covers a large dynamic range to allow a simultaneous measurement of $\gamma$-rays down to 100 keV and scattered protons up to 300 MeV. A special feature of CALIFA is the digital Quick Particle Identification (QPID) enabling $\gamma$-rays and charged particle identification through Pulse Shape Analysis (PSA) of the scintillation light output.

I will shortly introduce the CALIFA calorimeter and its auxiliary detector systems and give an overview of the performance of CALIFA in the frame of FAIR-Phase-0 experiments performed at the R3B/FAIR setup. First results from specific reaction channels will be presented.

This work is supported by BMBF contracts (05P19RDFN1 and (05P21RDFN2).
HK 59.4 Thu 15:00 SCH/A118


The proton-neutron symmetry of low-lying nuclear states is characterized by the imaging of respective configurations to their wave functions, dominated by few two-nucleon configurations near shell closures. Located closely to the doubly-magic $^{132}$Sn, $^{136}$Te is therefore well suited to study mixed-symmetric configurations and their fragmentation. By applying the Doppler Shift Attenuation Method, following a two-neutron transfer reaction to $^{136}$Te, the location and fragmentation of mixed-symmetric states has been studied through the measurement of excited-state lifetimes. Results for the 2$^+$ mixed-symmetric states will be presented. A complementary experiment has been performed using the Recoil Distance Doppler Shift method, in order to access lifetimes of longer-lived states.

With the resulting lifetimes, transition strengths to lower lying states have been determined and compared to theoretical approaches.

*Supported by the BMBF 05P21RDC12-TP1.

HK 59.5 Thu 15:15 SCH/A118

Development of a new $\gamma$-$\gamma$ angular correlation analysis method using asymmetric ring of clover detectors — Lukas Knaf1, Arwin Esmatzadeh2, Andreas Hart3, Jan Jolie1, Ulli Köster1, Maris Ley1, Catterina Michelagnoli2, and Jean-Marc Régis — Institut für Kernphysik, Universität zu Köln — 2Institut Laue-Langevin, Grenoble, Frankreich

A new method for $\gamma$-$\gamma$ angular correlation analysis using a symmetric ring of HPGe clover detectors is presented. Pairwise combinations of individual crystals are grouped based on the geometric properties of the spectrometer, constrained by a single variable parameterization. The corresponding effective interaction angles between crystal pairs, as well as the attenuation coefficients are extracted directly from the measured experimental data. Angular correlation coefficients, parameter uncertainties and parameter co-variances are derived using a Monte-Carlo approach, considering all sources of statistical uncertainty. The general applicability of this approach is demonstrated by reproducing known multipole mixing ratios in $^{177}$Hf and $^{134}$Sm, populated by either $\beta$-decay or (n, $\gamma$) reactions, measured at the Institut Laue-Langevin, using the EXILL&FATIMA spectrometer and different configurations of the FIPPS instrument. The derived mixing ratios are in excellent agreement with adopted literature values with comparable or better precision [1].

Systematic investigation of the low-energy dipole response in $^{161,163}$Sn using the $(d,p)$ reaction — Markus Müllenmeister, Michael Weinert, Florian Klumwig, Miriam Mischler, and Andreas Zilges — University of Cologne, Institute for Nuclear Physics

The so-called Pygmy Dipole Resonance (PDR) has been a research topic of great interest in recent decades. While the general properties of this excitation is well known [1], there are still questions about its structure. For the study of this underlying structure, experiments sensitive to different aspects of the nucleus are vital [2]. The $(d,p)$ reaction has been shown to be a selective probe for the microscopic character of certain states. The tin isotopic chain in particular is an interesting subject for this kind of investigation, as its magic proton number ($Z = 50$) provides several isotopes accessible for this reaction. As the $(d,p)$ reaction was already studied in depth for $^{119}$Sn, $^{120}$Sn, $^{123}$Sn [3], similar experiments were performed at the SONIC/HORUS setup [4] in Cologne on the other two available isotopes $^{117}$Sn, $^{118}$Sn to study excitations in $^{116}$Sn. These results of these two experiments will be presented by the DFG (ZI 518/10-1).

we will discuss the simulations that were performed to study (p,2p) reactions using the CALIFA detector to quantify the detector efficiency for protons. This is a critical step in extracting the measured cross sections for the quasi-free scattering (p,2p) process.

**HK 62: Astroparticle Physics I**

**Time:** Thursday 14:00–15:15

**Group Report**

**HK 62.1 Thu 14:00 SCH/A252**

**Probing the Standard Model in Free Neutron Decay** — Karina Bernert, Max Lamparth, and Bastian Markusch — Technische Universität München, Germany

(For the PERKOE and PERC consortia) Measurements of free neutron decay enable a variety of tests of the Standard Model of particle physics. Among the observables are the parity-violating beta asymmetry A, and the Fierz interference term b. From precision measurements of A and the neutron lifetime, the CKM matrix element $V_{ub}$ is determined without nuclear corrections. It serves as input for the first-row unitarity test of the CKM matrix and the current Cabibbo-angle anomaly. A non-zero Fierz term would signal the existence of novel scalar and tensor interactions.

With its unique measurement technique, PERKOE III delivers the currently most precise values of A and b using a polarized neutron beam. We present the status of the data analysis of the most recent campaign at the ILL PF1b beam line in Grenoble, France, with the aim to extract an improved limit for the Fierz term from the electron spectrum.

Meanwhile, the new PERC (Proton Electron Radiation Channel) facility is being set up at the research reactor FRM II of the Heinz Maier-Leibnitz Zentrum in Garching, with the aim to measure correlation coefficients one order of magnitude more precisely.

**HK 62.2 Thu 14:30 SCH/A252**

**Measurement of the nuclear transition energies of $^{136}$Kr using the condensed krypton source of KATRIN** — Matthias Böttcher and Benedikt Bieringer for the KATRIN-Collaboration — Institut für Kernphysik, WWU Münster

The KATRIN experiment aims to measure or exclude the effective electron neutrino mass $m_\nu$ down to 0.2 eV/c² (90 % C.L.) by measuring the tritium beta spectrum near its endpoint $E_0$, and performing a fit including the parameters $E_0$ and $m_\nu$. Since these are highly correlated, a systematic shift influencing the obtained neutrino mass would be visible in the endpoint and thus the tritium Q value. The KATRIN Q value can be determined by absolute calibration with $^{83}$Kr conversion electron lines. This is however limited by the nuclear gamma transition energy uncertainties of $^{136}$Kr to 0.5 – 0.6 eV accuracy. The excited nucleus of $^{138}$Kr decays in a two-step cascade of 32.2 eV and 9.4 eV highly converted gamma transitions. In a new, lower background campaign performed at KATRIN, a large set of conversion electron lines including a new line was measured extensively with a condensed krypton source. Following the method described in ref. EPJ C 82 (2022) 700, the $^{83}$Kr nuclear transition energies can be determined, which can allow for a reduction of the Q value uncertainty to below 100 meV. In this talk the principle, measurements, and analyses for improving the $^{83}$Kr transition energy uncertainties are presented. This work is supported by BMBF under contract number 05A20PMA.

**HK 62.3 Thu 14:45 SCH/A252**

**Towards the biggest germanium detectors ever grown** — Tommaso Comella, Stefan Schönert — Technical University of Munich, Garching bei München, Germany

The Legend experiment searches for the neutrinoless double-beta decay of $^{76}$Ge, a second order weak process which, if observed, would provide evidence beyond the standard model physics. It is presently being commissioned in the upgraded Gerda infrastructure at LNGS (Italy) and in its first stage it will operate 200 kg of High Purity Germanium (HPGe) detectors. The baseline detector geometry is the inverted coaxial, which combines the excellent pulse shape discrimination performance of previous generation experiments with a up to a factor 4 larger mass per detector. This yields as a result a reduction of a similar factor of backgrounds from close-by parts as cables and holders. In this talk, detailed field modeling of big detectors will be given, and preliminary results on the experimental characterization of one of them will be presented. This work has been supported in part by the European Research Council (ERC) under the European Union’s Horizon 2020 research and innovation programme (Grant agreement No. 786430 - GemX).

**HK 62.4 Thu 15:00 SCH/A252**

**Development of a cosmic muon and neutron veto system for IAXO and BabyIAXO** — Dhruv Chouhan, Elisa Ruiz-Choliz, and Matthias Schott — Johannes Gutenberg University of Mainz, Germany

The International Axion Observatory (IAXO) experiment is a large-scale helioscope aimed at searching for axions and axion-like particles (ALPs) produced in the Sun. As a first step, the BabyIAXO was proposed as a smaller scale helioscope that will reach a sensitivity on the axion-photon coupling of 1.5×10^{-11} GeV/fm for masses up to 0.25 eV, covering a very interesting region of the parameter space. To detect the axion signal, a very low background x-ray detector design is required. This talk will focus on the development of the BabyIAXO veto system for cosmic rays based on light-guided organic plastic scintillators with Silicon Photo Multiplier sensors.

**HK 63: Instrumentation XVI**

**Time:** Thursday 15:45–17:00

**Group Report**

**HK 63.1 Thu 15:45 SCH/A251**

**Der PANDA-Luminositätsdetektor** — Heinrich Leitthoff, Achim Demou, Christof Motzko, Jannik Petersen, Florian Feldbaumer, Gerhard Reichek, Roman Klase, Stephan Maldaner, Niels Boelger, Stephan Böckelmann, René Hagedorn and Miriam Fritsch — 1Johannes Gutenberg University Mainz — 2Helmholtz Institut Mainz — 3Ruhr-Universität Bochum


**HK 63.2 Thu 16:15 SCH/A251**

**Performance on the STS detector in Ni+Ni collisions at 1.93 AGeV with the mCBM setup at SIS18** — Dario Alberto Ramirez Zaldívar for the CBM-Collaboration — GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

The Compressed Baryonic Matter (CBM) is one of the experimental pillars at the FAIR facility. CBM focuses on the search for a signal of the phase transition between hadronic and quark-gluon matter, the QCD critical endpoint, new forms of strange-matter, medium modifications of hadrons, and the onset of chiral symmetry restoration. The Silicon Tracking System is the central detector for momentum measurement and charged-particle identification. It is designed to measure Au+Au collisions at interaction rates up to 10 MHz. It comprises approximately 900 double-sided silicon strip sensors arranged in 8 tracking stations, resulting in 1.8 million channels, having the most demanding requirements in terms of bandwidth and density of all CBM detectors. The mini-CBM (mCBM) project is a small-scale precursor of the full CBM detector, consisting of sub-units of all major CBM systems which aims to verify CBM’s concepts of free-streaming readout electronics, data transport, and online reconstruction. In the 2022 beam campaign at SIS18 (GSI) Ni+Ni collisions at 1.93 AGeV were measured with an average collision rate of 400 kHz. The mini-STS (mSTS) setup for the campaign consists of 2 stations with 11 sensors. The results from data taken in the 2022 beam campaign will be presented focusing on the hit reconstruction and mSTS performance studies.
Collaboration—BergischeUniversität Wuppertal,Wuppertal,Germany,aimstomeasurenuclearmatterathighdensitiesandmedium/T_{h}∗T_{h}∗
ReconstructionofneutralmesonsviaphotonconversionmethodinAg-Ag
Time:
neutralmesonsproducedinthecollisionsisnecessaryforproperbackground
Dalitz-decaysoflightneutralmesons.Hence,preciselyextractingtheyieldsof
themaingoalsintheHADESphysicsprogram.

CharacterizationandtestofSTSmodulesfortheE16experiment—DAIRON
RodriguezGarcésfortheCBM-Collaboration—GSIHelmholtzzentrumfür
SchwerionenforschungGmbH,Darmstadt,Germany—

TheF-PARC E16 experiment has the goal to search for signatures of the sponta-
neously broken chiral symmetry and its (partial) restoration, through di-electron
detection from slowly moving vector mesons, particularly the phi meson, pro-
duced in proton-nucleus collisions. For this purpose, the experiment will use
modules constructed using the same technology and procedures as the modules of
the Silicon Tracking System (STS) of the CBM experiment.

A total of 10 modules were assembled at the Detector Lab in GSI. This is the
first time a series of modules is produced with final components, and systemati-
cally tested. Each module has a double-sided silicon sensor, connected via a stack
of microwires to a pair front-end boards (FEBs) with 8 ASICs (STS-XYTERv2)
each. The characterization of the E16 modules was carried out through the STS
testing procedure that includes the determination of the set of the operational pa-
rameters for each module (ADC calibration, etc.), testing the performance (ENC
noise, the linearity of the ADC and the homogeneity of the channels response).

Dosimetry with test structures of the PANDA Micro-Vertex-Detector—Nils
Troll—II. Physikalisches Institut, Giessen
Electrical characterization and radiation damage is carried out on double-sided
silicon strip detectors and pin diodes representing a test structure with electrical
properties for the Micro-Vertex-Detector (MVD), which will be the innermost
tracking detector of the PANDA experiment.

Therefore, the silicon diodes of the MVD are used in a dosimeter con-
cept for measurements of ionizing radiation dose. The energy calibra-
tion is carried out at the Marburg Ion Beam Therapy Centre (MIT) and by various laboratory
radiation sources. Signal generation by the sensors is observed to determine
performance parameters for the MVD. Additionally, static electrical properties,
like the depletion voltage, a- low a characterization of radiation tolerance of
the silicon diodes. The work is supported by the BMBF.

Group Report

Status and production of the CBM Transition Radiation Detector—Philipp
Kähler for the CBM-Collaboration—Institut für Kernphysik, WWU Münster
The upcomming Compressed Baryonic Matter (CBM) experiment at FAIR will in-
vestigate the QCD phase diagram at high net-baryon densities and moderate
temperatures. In these measurements, the CBM Transition Radiation Detector
(TRD) will contribute to the excellent electron identification, enabling to study
the hot and dense medium via di-electron analyses at intermediate masses. Fur-
thermore, the TRD will serve as an intermediate tracking station as well as pro-
vide the identification of light nuclei in the hypernuclei programme of CBM.
This talk summarises the status of the CBM-TRD project. A report on the de-
tector module (MWPC) production will be given, which has been started. De-
sign details of the new intrinsically gas-tight cathode pad-plane are included.
Moreover, the current plans for the periphery are covered as well as the partic-
ipation in the FAIR phase 0 programme mCBM at the SIS18 accelerator.
This work is supported by BMBF grants 05P12RFFC1 and 05P21PMFCl.

Commissioning of the First Gas System Line for the CBM-TRD—Felix Fiderka
for the CBM-Collaboration—Institut für Kernphysik WWU Münster,
Münster, Germany
The Compressed Baryonic Matter (CBM) experiment is a fixed target heavy-ion
experiment which is currently under construction at FAIR in Darmstadt. It will
explore the QCD phase diagram at high net-baryon densities. The Transition
Radiation Detector (TRD) of the CBM experiment will be based on Multi Wire
Proportional Chambers (MWPCs) filled with Xe/CO₂ 85:15 as detector gas. This
talk reports on the commissioning of the first regulated line of the future gas sys-
tem for the CBM-TRD. During operation, the gas flow through the chambers has to
be regulated such that the relative pressure in the detector volume stays within
-0.5 to 1 mbar. To ensure the gas quality, also continuous monitoring of O₂, CO₂
and H₂O content will be included. A part of the gas system, as, e.g., the main
regulation valves, the circulation pump and the PLC layer will be located in a
service level above the experiment. The first gas line, including already the final
tube lengths and the PLC controls, has been set up in the laboratories in Münster
for characterisation of, e.g., the timing characteristics of the pressure control
and for commissioning. This work is supported by BMBF grants 05P19PMFC1
and 05P21PMFC1.

New planar GEM detectors for AMBER—Jan Paschke, Kai Flöttmer, Dimitri
Schaar, Christian Honisch, Michael Lüpberger, Igor Konorov, Christian Honisch,
Michael Høsgen, and Bernhard Ketzer—Universität Bonn, Helmholtz-Institut für Strahlen-
und Kernphysik, Bonn, Germany—Universität Bonn, Physikalisches Institut, Bonn,
Germany—CERN, Geneva, Switzerland—Technische Universität München,
Physik-Department, Garching, Germany
As a follow-up experiment to COMPASS at the M2 beamline of the CERN SPS,
AMBER (NA66) is expected to make important contributions to unresolved
questions related to the structure and spectroscopy of light mesons. In addi-
tion, a precision measurement of the proton formfactor by elastic muon-proton
scattering at very low 4-momentum transfer will be performed over the next two
years.

New large-format triple GEM detectors have been designed and built for
tracking charged particles in close proximity to the primary beam. They have
shorter strips split in the middle to handle higher particle rates without having
to disable the central region. We also eliminated the use of spacer grids to mini-
mize dead zones. The first new detectors were installed and operated during the
COMPASS beam period in 2022. For AMBER, the APV-based readout electron-
ics will be replaced by a self-triggering front-end chip. In addition, a stabilized
voltage divider will provide constant gain independent of particle rate.

The talk will give an overview of the construction and commissioning of the
new detectors and show first results from their operation.

Reconstruction of neutral mesons via photon conversion method in Ag-Ag
collisions at 1.58A GeV with HADES—Tetiana Povar for the HADES-
Collaboration—Bergische Universität Wuppertal, Wuppertal, Germany
The High Acceptance DÉlectron Spectrometer (HADES) situated at GSI Darm-
stadt, Germany, aims to measure nuclear matter at high densities and medium
temperatures by means of heavy ion collisions. As leptons do not interact strongly
with the formed medium in all stages of such collisions, electrons and posi-
citrons can provide information about the full fireball evolution. Hence, the
study of virtual photons and their decay into electron pairs (e⁺ + e⁻) are one of
the main goals in the HADES physics program.

The major background in the di-electron spectrum at low invariant masses are
daltitz-decays of light neutral mesons. Hence, precisely extracting the yields of
neutral mesons produced in the collisions is necessary for proper background
subtraction in all di-electron analyses.

In this talk we will present preliminary results on the transverse mass and ra-
pidity resolved n²⁻ and n⁻ production yields in Ag-Ag collisions measured with
HADES via the photon conversion method at 1.58A GeV incident beam energy.

* Work supported by BMBF (05P19PFXCA, 05P21PFXC1), and GSI.

Measurement of neutral meson production with ALICE—Nicolas Strang-
mann for the ALICE Germany-Collaboration—Institut für Kernphysik,
Goethe-Universität Frankfurt, Frankfurt, Germany
The ALICE experiment at CERN-LHC investigates the properties of hot and
dense nuclear matter created in heavy-ion collisions. Measurements of identi-
fied particle production in pp collisions not only serve as reference for larger
collision systems, but also help to study different aspects of hadronisation.
This contribution will focus on the production of neutral mesons in different colli-
sion systems. A precise determination of the neutral meson production can help
constrain theoretical models and provide vital input for direct photon analyses. In ALICE, different detectors and detector combinations are used to recon- struct neutral mesons \((n^0\) and \(\eta\)) via their two photon decay channel. These pho- tons can be detected in the calorimeters or via their conversion-electron tracks in ALICE tracking detectors. Mesons can be reconstructed via their three pion decay \(\omega \rightarrow n^0 + n^0 + n^0\). In this talk, an overview of the \(n^0\), \(\eta\) and \(\omega\) measurements with ALICE will be presented. This includes a multiplicity dependent measurement of \(n^0\) and \(\eta\) in pp collisions at \(\sqrt{s}=13\) TeV as well as \(\omega\) measurements in pp and Pb-Pb collisions. Supported by BMBF and the Helmholtz Association.

**HK 65.3 Thu 16:15 SCH/A216**

**Characterising the hot and dense fireball with virtual photons at HADES — **

**NIKLAUS SCHILD** für die HADES-Kolaboration — Technische Universität Darm- stadt, 64291 Darmstadt, Germany

Electromagnetic probes \((\gamma, \gamma^*)\) offer a unique opportunity to study the condi- tions in heavy-ion collisions throughout their whole evolution. Since they can escape the strongly interacting medium, they may bring direct information from their origins to a detector.

In this contribution, we present measurements of such dileptons from \(Ag+Ag\) collisions, collected at the High-Acceptance-Dilepton-Spectrometer (HA- DES), at \(\sqrt{s_{NN}} = 2.55\) GeV. A particular focus is set on the multidifferential analysis of the anisotropic flow in terms of centrality, rapidity, transverse mo- mentum and invariant mass. Through the isolation of the in-medium contri- bution, this will allow insights into the flow at early stages of the collision, and therefore into the time evolution of the system’s collective as a whole.

**HK 65.4 Thu 16:30 SCH/A216**

**Measurement of photon and light neutral meson production in p–Pb collis- sions at \(\sqrt{s_{NN}} = 5.02\) TeV — **

**STEPAK MROZINSKI** for the ALICE Germany-Colaboration — Institut für Kernphysik, Goethe-Universität Frankfurt

The ALICE experiment at CERN-LHC is designed to study the characteristics of the hot and dense nuclear matter created in heavy ion collisions, the quark- gluon plasma (QGP). Since direct photons escape the medium unaffected during all collision states, they offer unique analysis opportunities. A necessary prereq- uisite for the direct photon measurement is the precise determination of the in- clusive photon as well as the neutral meson production.

In ALICE, the measurement of photons is realized using electromagnetic calorimeters (EMCal or PHOS) and a photon conversion method (PCM). For the reconstruction of mesons via their two-photon decay channel, photons from the same calorimeters or method as well as photons from a calorimeter and the PCM method can be used. This talk will focus on the reconstruction of \(n^0\) and \(\eta\) meson spectra as well as the measurement of the inclusive photon yield in p-Pb collisions at \(\sqrt{s_{NN}} = 5.02\) TeV using the PCM-PHOS reconstruction method. The current status of the analyses will be presented. Supported by BMBF and the Helmholtz Association.

**HK 65.5 Thu 16:45 SCH/A216**

**Topological separation of dielectron signals in Pb–Pb collisions with ALICE — **

**JEROME JUNG** for the ALICE Germany-Collaboration — Institut für Kern- physik, Goethe-Universität Frankfurt

Dielectrons are an exceptional tool to study the evolution of the medium created in heavy-ion collisions. In central collisions, the energy densities are sufficient for a 15.1 GeV/c^2 can be used to estimate the temperature of the QGP. At LHC energies, correlated HF hadron decays dominate the dielectron yield for invariant masses above 1.1 GeV/c^2. Their contribution is modified in the medium compared to elementary collisions to an unknown extent, leading to large uncertainties in the subtraction of known hadronic sources. The proper decay length of HF hadrons is of the order of \(c\tau \approx 100 - 500\) \(\mu m\), hence their recon- structed decay electrons do not point to the primary vertex of the collision. Therefore, a topological separation based on the distance-of-closest approach (DCA) to the primary vertex is a promising alternative approach to disentangle them from the prompt contribution of thermal dielectrons.

In this talk, the newest results on the DCA_{ee} spectra of dielectrons produced in Pb-Pb collisions at \(\sqrt{s_{NN}} = 5.02\) TeV with ALICE will be presented. The meas- urements are compared to reference distributions from simulations and expect- ations from theory. The presentation will conclude with a discussion of novel developments of the dielelectron analysis.

**HK 65.6 Thu 17:00 SCH/A216**

**Measurement of neutral pions in PbPb collisions in ALICE at \(\sqrt{s_{NN}} = 5.02\) TeV — **

**STEPHAN STIEFELMAIER** for the ALICE Germany-Collaboration — Physikalisches Institut Heidelberg

Neutral pion and eta mesons are responsible for a large fraction of secondary photons in the measurement of direct photons what makes their measurement important. I present the current state of the measurement of neutral mesons with the photon conversion method with the 2018 PbPb data sample using the latest reconstruction and calibration methods.

**HK 66.1 Thu 15:45 SCH/A315**

**Measurement of light neutral meson production inside jets in pp collisions at \(\sqrt{s} = 13\) TeV with ALICE — **

**JOSHUA KÖNIG** for the ALICE Germany-Collaboration — IKF, Goethe-Universität Frankfurt

Particle production in ultra-relativistic pp collisions can be factorized into the parton density function (PDF), the partonic cross-section and the fragmenta- tion function (FF). While PDFs, accessible via deep inelastic scattering experi- ments, and the partonic cross-section, calculable using perturbative QCD, are independent of the final state particle species, FFs need to be constrained by experimental data for each particle species. Measurements of the momentum fraction \(z = p_{T,jet}/p_{T,part}\) of a particle species contained in a high energetic jet gives direct access to the FF of the species. In this talk, the measurement of the \(p_T\) spectra of \(n^0\) and \(\eta\) mesons inside jets as well as the measurement of the meson momentum fraction \(z\) in pp collisions at \(\sqrt{s} = 13\) TeV with ALICE will be presented. The measurement combines results from several partial independent meson reconstruction techniques available in ALICE. The separation of charged and neutral particles is improved by using charged tracks from the central tracking detectors. Particle jets are reconstructed us- ing charged tracks from the central tracking detectors as well as neutral clusters from the electromagnetic calorimeter. The results will be compared to theoreti- cal model predictions.

Supported by BMBF and the Helmholtz Association

**HK 66.2 Thu 16:00 SCH/A315**

**Jet-hadron correlations in PbPb collisions at \(\sqrt{s_{NN}}=5.02\) TeV with ALICE — **

**LUIZA BERGMANN** for the ALICE Germany-Collaboration — Physikalisches In- stitut, Im Neuenheimer Feld 226, 69120 Heidelberg

In heavy-ion collisions, a deconfined medium with high energy den- sity is created, the quark-gluon plasma. Amongst other observables, jets – origi- nating from primordial hard scatterings – act as useful probes for the properties of this medium. As the initial partons traverse the quark-gluon plasma, they lose energy by interacting with the constituents of the medium. The study of this so called "jet quenching" yields insight into the properties of the medium. By analyzing the angular correlations of jets with charged hadrons, one ob- tains information about the energy loss of jets in the medium. The study of these correlation functions for different orientations of the jet to the event plane allows for a measurement of the energy loss which is sensitive to the in-medium path- length of the jet. In this talk, first studies of event plane dependent jet-hadron correlations for data collected by the ALICE experiment in PbPb collisions at \(\sqrt{s_{NN}}=5.02\) TeV are presented.

**HK 66.3 Thu 16:15 SCH/A315**

**Studies of jets in heavy-ion collisions at ALICE with a novel mixed-event approach — **

**NADINI GRÜNWALD** for the ALICE Germany-Collaboration — Physikalisches Institut Heidelberg, Im Neuenheimer Feld 226, 69120 Heidelberg

With heavy-ion collisions QCD matter is studied at very high temperatures and densities. The ALICE experiment is dedicated to measure heavy-ion collisions at the LHC. The Quark-Gluon Plasma (QGP) is produced in those collisions where quarks and gluons are deconfined and new physics phenomena emerge. The QGP can be studied using jets, which are produced in the early stage of the collisions. Depending on the structure of the QGP, the jets lose energy in various ways. A major difficulty in heavy-ion jet measurements is the huge amount of uncorrelated particles which distorted the jet measurements, especially at lower \(p_T\). In order to perform low \(p_T\) jet measurements, a novel mixed-event technique is exploited. In this talk, the mixed events as a new approach to describe the un- correlated background in heavy-ion jet measurements at ALICE are presented. The description of the uncorrelated background by mixed events enables for the first time inclusive charged jet measurements down to low \(p_T\) at collision en- ergies of \(\sqrt{s_{NN}} = 5.02\) TeV. In particular no cuts on the reconstructed jet energies are necessary.
Direct photon and $\chi$ performance studies for the ALICE 3 experiment — Abhishek Nath for the ALICE Germany-Collaboration — Ruprecht Karl University of Heidelberg, Germany

Direct photons are one of the critical tools for studying hot QCD medium as their mean free path is much larger than the size of the system and they leave the medium without further interaction. As the ALICE 3 LOI received the LHCC recommendation to proceed with R&D, we try to perform more critical studies regarding photons. With much larger rapidity coverage and usage of bent Monolithic Active Pixel Sensors (MAPS), the ALICE 3 experiment aims to go much lower in $p_T$ to explore the direct photons originating mainly from thermal con-tribution. Along with that, the measurement of $\chi_T$, $\chi_\rho$, and other $L = 1$ states in the extended rapidity range in ALICE 3, a more accurate description of the dynamics of quarkonium interactions with the medium will be possible.

In this talk, we present performance studies and uncertainty projections in key direct photon measurements like $R_\gamma$, direct photon spectrum and correspond-ing inverse slope parameter, direct photon $\chi_T$ and possibly also HBT anticipated for Run 5 and 6. Along with this, the performance of $\chi_T$ measured through the radiative decay channel $\chi_T \rightarrow J/\psi + \gamma$ in Pb–Pb collisions is also presented.

Low $p_T$ $\omega$ measurements in pp collisions at $\sqrt{s} = 5.02$ TeV with ALICE — Merle Luisa Walde for the ALICE Germany-Collaboration — Goethe University, Frankfurt, Germany

Measurements of hadron production cross sections in proton-proton (pp) collisions at high energies are important to test our understanding of QCD and as reference for heavy-ion studies. While the hard production of particles can be calculated in a perturbative approach, the production via soft scattering processes relies on phenomenological model approaches that require experimental input and suffer from sizeable uncertainties in their predictions. Therefore, the spectra of the $\omega$ meson needs to be measured down to the lowest transverse moment-um ($p_T$) where the reach to low momenta is scarce at LHC energies and midrapidity.

In this talk, the first measurement of the $\omega$ meson down to $p_T = 0$ in pp collisions at $\sqrt{s} = 5.02$ TeV at midrapidity will be presented. The $\omega$ meson is reconstructed in the decay into $e^+e^-$ pairs with ALICE. We will discuss the estimation of the combinatorial background as well as uncertainties related to the extraction of the signals. The final results will be compared to model calculations.

HK 67.1 Thu 15:45 SCH/A316

Time: Thursday 15:45–17:00

Group Report

Low $p_T$ $\omega$ measurements in pp collisions at $\sqrt{s} = 5.02$ TeV with ALICE — Merle Luisa Walde for the ALICE Germany-Collaboration — Goethe University, Frankfurt, Germany

Measurements of hadron production cross sections in proton-proton (pp) collisions at high energies are important to test our understanding of QCD and as reference for heavy-ion studies. While the hard production of particles can be calculated in a perturbative approach, the production via soft scattering processes relies on phenomenological model approaches that require experimental input and suffer from sizeable uncertainties in their predictions. Therefore, the spectra of the $\omega$ meson needs to be measured down to the lowest transverse moment-um ($p_T$) where the reach to low momenta is scarce at LHC energies and midrapidity.

In this talk, the first measurement of the $\omega$ meson down to $p_T = 0$ in pp collisions at $\sqrt{s} = 5.02$ TeV at midrapidity will be presented. The $\omega$ meson is reconstructed in the decay into $e^+e^-$ pairs with ALICE. We will discuss the estimation of the combinatorial background as well as uncertainties related to the extraction of the signals. The final results will be compared to model calculations.

Evidence for a phi-N bound state — Enrico Chizzali for the ALICE Germany-Collaboration — Technical University of Munich, Munich, Germany

The possible existence of phi-mesic nuclei is widely discussed in the literature, however, experimental evidence so far is missing. The main ingredient for the study of such systems is the phi-N strong interaction, which is characterised by the two spin states $S=1/2$ and $S=3/2$ and can be accessed experimentally via momentum correlations. In this talk, a re-analysis of the $p$-phi correlation function, measured by the ALICE Collaboration in high-multiplicity pp collisions at $\sqrt{s}$=13 TeV is presented. The $S=3/2$ channel is constrained using the recently published lattice QCD potential. This makes it possible to study the unknown interaction in the $S=1/2$, which is modelled by an advanced phenomenologi-cal potential. The results of this study show evidence of a bound state in the $S=1/2$ channel, with sizeable binding energy, which is characterised by a poten-tial strong enough that it results in negative scattering length.

Funded by BMBF Verbundforschung (05P12WOC1A1) and MPP IM-PR.

HK 67.4 Thu 16:45 SCH/A316

Separation of protons and neutrons with the CBELSA/TAPS experiment — Nadia Reinartz for the CBELSA/TAPS-Collaboration — HISKP, Uni Bonn

The ELSA accelerator can provide a polarised electron beam that together with the polarised target of the CBELSA/TAPS experiment makes it possible to determine single or double polarisation observables for various final states. The Crystal Barrel (CB) calorimeter in combination with the MiniTAPS calorimeter in forward direction, allows measurements in a full 4$\pi$ coverage. In the past it was difficult to efficiently measure reactions with a neutron in the final state.

In the last years the CBELSA/TAPS experiment in Bonn has been improved in order to significantly boost the efficiency for detecting neutrons in the main calorimeter. The data taken after the upgrade was used to determine methods for identifying protons and neutrons with beam energies between 600 MeV and 3200 MeV. In this talk an overview about those results is presented.
Hyperons are expected to play an important role in describing the dynamics of high-dense baryonic matter such as that present in the interior of neutron stars. HADES (High Acceptance Di-Electron Spectrometer) offers excellent opportunities for studying hyperon production in pp and heavy ion collisions. In February 2022 HADES collected high statistics data of the reaction p(4.5 GeV)πp. With this data set, the production and decay of single and double strange hyperons in inclusive and exclusive channels will be possible. In particular rare dielectron Dalitz decays of Σ0 and Λ hyperons will investigated for the first time.

For this purpose, HADES was upgraded with straw tube trackers, which are a FAIR-Phase0 contribution from PANDA, and a timing detector, both of which cover polar angles below 7 degrees; a region where many hyperon decay products are emitted. As a result, they increase the efficiency of the hyperon reconstruction. A kinematic fitting library has been developed to improve the overall resolution. It is based on Lagrange multipliers and utilizes kinematic and geometric constraints.

This talk will address the exclusive hyperon reconstruction, for example of pp → pKΣ+, in the recent data, focusing on the new hyperon reconstruction tools; the straw tube tracker, the kinematic fitting, and how these are used in the analyses.

Hyperon-production studies in proton-proton collisions at 4.5 GeV with HADES — SHANKIT PATNIAK, JOHAN MESSCHENDORF, and JAMES RITMAN for the HADES-Collaboration — GSI, Darmstadt, Germany

This work presents a preliminary analysis of the Λ + K0 S → p + n + π0 final state in recently collected proton-proton scattering data taken at 4.5 GeV using HADES at GSI Helmholtzzentrum für Schwerionenforschung in Darmstadt, Germany. The production of hyperons is of particular interest since it provides information about the role of N* resonances in strangeness production in NN interactions. Furthermore, this study could be relevant in describing the dynamics of high-dense matter such as that located at the core of neutron stars.

This talk will present some of the data-driven analysis procedures that have been used to select the final-state of interest. In particular, a particle identification method exploiting the relative time-of-flights and utilizing several vertex and kinematic observables have been used to obtain a strong signal for this exclusive state.

Photoproduction of Λ(1520) at forward angles with BGOOD — EMLI ROSANOWSKI for the BGOOD-Collaboration — Physikalisches Institut der Universität Bonn

The BGOOD experiment at the ELSA facility is used for photoproduction in the ads sector. It is uniquely designed to explore reactions where a meson is detected at forward angles, allowing a recoiling hadronic system at low momentum transfer, which could enable the observation of molecular structure.

Studies of the reaction pp → ΛK*(1520) at forward angles will be presented. The analysis required K0s identification and the Λ(1520) via the decay Λ(1520) → π−n0. Progress in measuring preliminary differential cross sections at forward ΛK* angles will be presented. Supported by DFG projects 388979758/405882627 and the European Unions Horizon 2020 programme, grant 824093.

Hyperon Reconstruction with Realistic Track Finding for PANDA — ANNA ALICEK, TOPAS STOCKMANN, and JAMES RITMAN — Ruhr-Universität Bochum, Experimentalphysik, Lehrstuhl 1 — GSI Helmholtzzentrum für Schwerionenforschung — Forschungszentrum Jülich, Institut für Kernphysik

One main research topic of the PANDA experiment is the spectroscopy of excited hyperon states. Hyperons, such as Σ, have a large decay length of several cm and further decay into Λ particles, which have a similar long lifetime. Consequently, hyperons have a distinctive decay pattern consisting of final state particles that have a displaced secondary vertex. These tracks, which do not originate from the primary interaction point (IP), make track reconstruction and the subsequent event reconstruction challenging. In contrast to primary track finders, which use the IP, secondary track finders have to deal with a much higher combination of hits and are lacking the additional constraint to the IP. Consequently, the track finding efficiency and the momentum resolution for secondary tracks is worse than for primary tracks and usually require more computational power.

Up to now, the PANDA experiment was lacking a dedicated track finder for secondary particles. Therefore, hyperon reactions have only been investigated using ideal track finding in PANDA. This work presents the new secondary track finder and its application on the reaction pp → Σ(1820)− Σ+. The expected reconstruction rate to observe the Σ(1820)− resonance will be shown.

Investigation of neutron-induced γ rays from Ge-nuclei in the region of interest of GERDA/LEGEND — MARIE PUCHYTA, TORALF DORINZ, HANS P. HOFMANN, KONRAD SCHMIDT, RONALD SCHWENGENERT, STEFFEN TURKAR, BERGIT ZATSCHLER, and KAI ZUBER — Technische Universität Dresden (IKTP), Germany — Helmholtz-Zentrum Dresden-Rossendorf, Germany — University of Toronto, Canada

GERDA has been a pioneering experiment in the search for the still undetected neutrinoless double beta decay (0νββ) of 76Ge and this will also hold for the successor experiment LEGEND. The discovery of this extremely rare process would prove the Majorana character of neutrinos and consequently physics beyond the Standard Model. For an explicit identification of a signal caused by the 0νββ-decay, which correspond to an energy of 2039 keV for 76Ge, a precise understanding of all background contributions in the ROI is crucial. However, previous experiments indicated γ lines produced by neutron activation (n,p) and neutron scattering (n,α) processes on 76Ge and 76Ge but until now, their existence could not be confirmed adequately. In this experiment an enriched Ge-sample was alternately irradiated by 14 MeV neutrons from a DT generator and measured by an optimized HPGe detection setup. The γ spectrum of 51 irradiation cycles shows three peaks in the energy region around 2039 keV which means that germanium itself can contribute to potential background in all 76Ge (0νββ) decay experiments such as LEGEND and GERDA. The experimental procedure and the results will be presented.

Simulation of ordinary muon capture for nuclear matrix elements of 0νββ decay processing — XIANWEI HE, ANDREAS JANSSEN, and KAI ZUBER — Institute of Nuclear and Particle Physics, Technische Universität Dresden, Germany

The search for beyond the Standard Model neutrinoless double beta decay (0νββ) is currently one method of determining the Majorana nature of the neutrino. The decay requires a non-zero neutrino mass. The connection between any possibly measured half-life and the neutrino mass is provided by the nuclear matrix elements (NMEs). Nuclear models aiming at the description of the NMEs of 0νββ decays at high-momentum-exchange could be tested with Ordinary Muon Capture. OMC is a semi- leptonic weak interaction process quite like electron capture but with 200 times the electron rest mass. This leads to a remarkably larger momentum excitation. The OMC process takes place in the mother nucleus produces multipoles J-states of daughter nuclei with large angular momenta and high excitation energies.

From an experimental point of view, the corresponding muon capture rates can be obtained by measuring the intensity of gamma rays emitted during the de-excitation of these excited state nuclei over time, which can be used to test the correctness of the model describing the NMEs.

This talk will show the proposed experimental design to measure gamma spectrum of OMC using cosmic muons.

Neutrinoless double-β decay in an effective field theory — CATHARINA BRESI, JAVIER MENENDEZ, and ACHIM SCHWENK — Technische Universität Darmstadt, Department of Physics — Max-Planck-Institut für Kernphysik, Heidelberg — ExTeM Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenforschung GmbH — Departament de Física Quántica i Astrofísica, Universitat de Barcelona, 08028 Barcelona, Spain — Instituto de Ciencias del Cosmos, Universitat de Barcelona, 08028 Barcelona, Spain
We study neutrinoless double-$\beta$ decay in an effective field theory (EFT) for heavy nuclei, which are treated as a spherical core coupled to additional neutrons and/or protons. The low-energy constants for this unobserved decay are constrained through a correlation with double Gamow-Teller transitions. This correlation was recently found to hold for shell-model calculations, energy-density functionals, and other nuclear structure models. We therefore first calculate the nuclear matrix elements for double Gamow-Teller transitions in the EFT for heavy nuclei. The combination of the EFT uncertainty with the correlation uncer- tainty enables predictions of nuclear matrix elements for neutrinoless double-$\beta$ decay for a broad range of isotopes with quantified uncertainties. Generally, the EFT predicts smaller nuclear matrix elements compared to other approaches, but our EFT results are consistent with recent ab initio calculations.

* Funded by the ERC Grant Agreement No. 10120842 and by the DFG – Project-ID 279384907 – SFB 1245.

HK 69.4 Thu 16:30 SCH/A118

Lifetimes measurements in $^{16,18}\text{Sn}$ — SAHRA PHILL, ANNA BOHN, FELIX HEIM, MICHAEL WEINERT, AND ANDEAS ZILGES — University of Cologne, Institute for Nuclear Physics

The Doppler-shift attenuation method (DSAM) using particle-$y$ coincidences is a reliable technique to determine sub-picoscnd lifetimes of excited nuclear levels without feeding contributions [1,2]. In recent years, it was used to determine level lifetimes of stable nuclei along isotopic chains around the Z=50 and N=50 and N=82 shell closures to study changes of nuclear structure phenomena along these chains. For $^{16,18}\text{Sn}$, lifetimes have already been determined with this method [3]. To continue the study across the semi-magic tin isotopic chain, inelastic proton and alpha particle scattering experiments have been performed on $^{16}\text{Sn}$ and $^{18}\text{Sn}$ at the SONIC@HORUS detector array [4] at the University of Cologne. The combined detector array can measure the backscattered projectiles in coincidence with the produced $y$ radiation. This enables the reconstruction of the reaction kinematics as well as the elimination of feeding by selecting the direct excitation of the level of interest from the particle energy.

From these experiments, numerous level lifetimes in $^{16,18}\text{Sn}$ could be determined.

Supported by the DFG (ZI 510/9-1).


HK 69.5 Thu 16:45 SCH/A118

Lifetime determination in $^{99,99}\text{Y}$ and $^{98}\text{Zr}$ via delayed $y-y$ fast-timing spectroscopy — AARON PFEIL, JEAN-MARC RÉGIS, JAN JOLIN, ARWIN E. EMATSELE, BIANCO LEVY, LUKAS KNAPLA, ULLI KOSTER and YUNH KIM — Institute for Nuclear Physics, University of Cologne — Institut Laue-Langevin, Grenoble, France

The experiment was performed in 2020 at the mass spectrometer Lohengrin at the Institut Laue-Langevin in Grenoble, France [1]. Lifetimes of the low-lying excited states in the nuclei $^{99}\text{Y}$, $^{99}\text{Zr}$ and $^{98}\text{Zr}$ were determined using the fast-timing technique [2]. This region is of special interest because of a rapid shape evolution, which occurs at $\frac{N}{Z}=58$ to $\frac{N}{Z}=62$, and is pronounced in the Zr isotopes, where $^{98}\text{Zr}$ is spherical and $^{100}\text{Zr}$ is strongly deformed [3]. Therefore, the results from $^{99}\text{Zr}$ provide crucial information about the spherical-deformed border at $N=59$. Experimental values are compared to predictions calculated in the framework of the interacting boson-fermion model [4,5]. Work supported by DFG grant JO391/18-1 and the Institut Laue Langevin.


HK 69.6 Thu 17:00 SCH/A118


$^{76}\text{Ge}$ is the heaviest stable of the Germanium isotopes, which have been discussed in terms of shape coexistence and triaxiality [1]. In addition, $^{76}\text{Ge}$ is the baseline isotope for experiments searching for neutrinoless double-beta decay, hence, especially its low-energy dipole response is of interest. The nuclear structure of $^{76}\text{Ge}$ was investigated previously by using the method of nuclear resonance fluorescence [2,3]. For minimizing systematic uncertainties for cross section measurements below 5 MeV, the energy region of the low lying scissors mode, a bremsstrahlung measurement with an endpoint energy of 5.5 MeV was performed. The photons were provided by the superconducting electron accelerator S-DALINAC, impinging the enriched target in the Darmstadt High Intensity Photon Source (DHIPS) with three HPGe detectors for $\gamma$-ray detection. The data analysis and results will be presented in the talk.

supernova scenarios [1]. Using the newly available hybrid array of HPGe Clover and LaBr3 detectors at the High Intensity γ-ray source (HiYS), we probed the dipole response of both isotopes in an integral-spectroscopy approach below neutron separation thresholds. The E1 and M1 strengths will be determined up to about 9 MeV by measuring the asymmetries resulting from the excitation of the target nuclei by the fully-polarized γ-ray beam. The experimental method and first results will be discussed.

Supported by DFG Project No.279384907-SFB 1245 and the U.S. DOE Grant No. DE-FG02-97ER41041 and No. DE-FG02-97ER41033.

[K. Langane et al., Rep. Prog. Phys. 84, 066301 (2021)]

HHK 70.4 Thu 16:45 SCH/A125
Lifet ime measurement of low-lying states in 92Mo via γ-γ fast- timing spectroscopy — Mario Letz1, Lukas Knapfl1, Andreas Harte1, Arwin Esmontz-Gaud0, Jan Joll1,1, Piet Van Eecker1,1 — 1Technische Universität Köl1n — 2Technische Universität München Life times of the first excited states in 92Mo were measured using the digital γ-γ fast- timing technique with a detector array consisting of LaBr3(Ce) and HPGe detectors. States were populated in a 90Zr(a,2n)29Mo reaction using the FN-Tandem accelerator of the institute for nuclear physics at the university of Cologne. The symmetrized centroid shift method [1], which is suitable for the determination of lifetimes in the pico- to nanosecond regime, was used to determine the lifetimes. The experimental results are compared to results from a semi-empirical approach which uses a single shell (422) orbit to predict the B(E2) values in the N = 50 isotones from 93Ge to 96Cd. Work supported by DFG grant J0391/18/1 [1].

HHK 70.5 Thu 17:00 SCH/A125
Electron-Gamma Coincidence Measurements at S-DALINAC — Ger hart Steinheil1, Jonny Birkan1, Isabelle Brandherr1, Juliane Buschinger2, Bastian Hesbrae3, Johann Isak1, Igor Jurasevic, Peter von Neumann Go31, No3ubert Pietrala4, Maxim Singer, and Maximilian Spall5 — IKP, Technische Universität Darmstadt
Inclusive (e,e'') electron scattering is an established tool in nuclear physics that provides insights in nuclear structure with high accuracy because of its pure electromagnetic nature. (e,e'') coincidence experiments preserve this strength of inclusive electron scattering while additional information, for example, γ-decay branchings of PDR/GDR and the interference of longitudinal and transversal components of low-lying electric dipole excitations are accessible. The existing (e,e'') setup at S-DALINAC was extended by a detector array consisting of 6 LaBr3, Ce detectors. In 2021 a successful (e,e'') measurement was conducted on a mid-heavy nucleus, 98Ru, for the first time. The main goal of this measurement was to study the B(M1s2→0s1) and B(E2s2→0s0) decay transition strengths of the 2s0 state of 98Ru. Data were taken at excitation energies below and above the neutron separation threshold allowing a variety of physics cases to be studied. This talk will present the (e,e'') coincidence setup and preliminary results of the 98Ru measurement. This work is supported by the Research Training Group GRK 2128 and the Hessian cluster project ELEMENTS.

HK 71: Structure and Dynamics of Nuclei XVI

Time: Thursday 15:45–17:15

Group Report

HHK 71.1 Thu 15:45 SCH/A117
Broken axial symmetry as essential feature for a consistent modelling of various observables in heavy nuclei — Eckart Gross1, and Anne J. Jungnans2 — 1IKTP, Techn. Universität Dresden — 2Helmholtz-Zentrum Dresden-Rossendorf, 01314 Dresden
Although most experimental data do not deliver accurate information on nuclear axiality the ad-hoc assumption of symmetry about one axis found widespread use in nuclear model calculations. In the theoretical interpretation of nuclear properties as well as in the analysis of experimental data triaxiality was considered - if at all - only for some, often exotic, nuclei. Allowing breaking of axial symmetry combined to a spin-independent moment of inertia results in a surprisingly simple heuristic triaxial parametrization of the yrast sequence in all heavy nuclei. Triaxially deformed ones. In particular the framework of eigenvector continuation (EC) has been identified as a powerful tool if the Hamiltonian admits for a parametric dependence. By training the emulator on a set of training data the many-body solution for arbitrary parameter values can be robustly predicted in many cases. Furthermore, it can be used to resum perturbative expansions. In this work, we apply EC to the pairing Hamiltonian and show that i) EC-resummed perturbation theory is in qualitative agreement with the exact solution and ii) EC-based emulators robustly predict the ground-state energy once the training data are chosen appropriately. In particular the phase transition from a normal to a superfluid regime is quantitatively predicted from a very low number of training points. Finally the use of approximate training data is discussed and how many-body truncations may affect the emulator's predictions.

Funded by the ERC Grant Agreement No. 10120842.

HHK 71.2 Thu 16:15 SCH/A117
Eigenvector continuation for the pairing Hamiltonian — Margarida Com - pants Franzke1, Alexander Tsch21,2,3, Kai Hebele1,1,1, and Achim Schwenge1,1,1,1,1 — Technische Universität Darmstadt, Department of Physics — 2ExtreMe Matter Institute EMMI, GSI Helmholtzzentrum für Schwerionenfors - chung GmbH — 3Max-Planck-Institut für Kernphysik, Heidelberg
The design of emulation techniques for the evaluation of many-body observables is attracting increasing attention over the past years. In particular the framework of eigenvector continuation (EC) has been identified as a powerful tool if the Hamiltonian admits for a parametric dependence. By training the emulator on a set of training data the many-body solution for arbitrary parameter values can be robustly predicted in many cases. Furthermore, it can be used to resum perturbative expansions. In this work, we apply EC to the pairing Hamiltonian and show that i) EC-resummed perturbation theory is in qualitative agreement with the exact solution and ii) EC-based emulators robustly predict the ground-state energy once the training data are chosen appropriately. In particular the phase transition from a normal to a superfluid regime is quantitatively predicted from a very low number of training points. Finally the use of approximate training data is discussed and how many-body truncations may affect the emulator's predictions.

HK 71.4 Thu 16:45 SCH/A117
Electromagnetic interactions as the source of all known four forces. — Oswald Domann — Stephanstr. 42, 85077 Manching
The SM represents the space as empty with the subatomic particles moving in it. The proposed focal-point approach models the space as filled with Fundamen - tal Particles (FPs) with longitudinal and transversal angular momenta that move from infinite to infinite. The different types of subatomic particles are formed by different configurations of FPs. Fermions are focal-points of rays of FPs with aligned angular momenta, photons are rays of FPs with alternating opposed angular momenta, and neutrinos are pairs of FPs with opposed angular momenta. Forces between subatomic particles are the result of the interactions (scalar and vector product) of the angular momenta of their FPs. No fictitious force car - riers are required. All four forces are due to electromagnetic interactions and described by QED. An important finding of the approach is that the interaction between two charged SPs tends to zero for the distance between them tending to zero. Atomic nuclei can thus be represented as swarms of electrons and positrons that neither attract nor repel each other. As atomic nuclei are composed of nu - cleons which are composed of quarks, the quarks can also be seen as swarms of electrons and positrons. The charge quantum number Q of a quark is now inter - preted as the relative charge of electrons and positrons. No fractional charges Q are required and the charge of an electron or positron is thus the unit charge of nature. More at: www.odomann.com

Work supported by DFG grant BO2128 and BMBF Verbund- forschung 05P12WOCA1 ALICE.
Simulations for the ASY-EOS II experiment — Leandro Millhomen da Fonseca1,2 and Igor Gašparović1,2 for the R3B-Collaboration — Technische Universität Darmstadt, Fachbereich Physik, Institut für Kernphysik, 64289 Darmstadt, Germany — 2Ruder Bošković Institute, 10000 Zagreb, Croatia — 3GSI Helmholtzzentrum für Schwerionenforschung, 64291 Darmstadt, Germany

The ASY-EOS II experiment aims to place new and more stringent constraints on the density dependence of the symmetry energy at supra-saturation densities. The system proposed for the study is Au+Au at 250, 400, 600 and 1000 AMeV, which can only be performed nowadays at the GSI/FAIR facilities. The experiment is based on the NeuLAND detector to measure neutrons, protons and light-charged clusters emitted from mid-rapidity. To discriminate between neutrons and charged particles, it is the intention to use a VETO detector in front of the NeuLAND detector. It is a proposal to use a double plane of the R3B TOPD detector in front of the NeuLAND due to its ability to detect charged particles efficiently and let neutrons pass through without leaving any signal. As a proof of concept for this apparatus, this work aims to show simulations performed to determine detection efficiencies for the particles of interest and to assess the possibility of distinguishing the differently charged light particles coming from the reaction. This project was supported by the BMFB project No. 05P21BDFN2, and the GSI-TU Darmstadt cooperation.

HK 72: Astroparticle Physics II

HK 72.1 Tuesday 15:45 — 16:00 SCH/A252
Measurement of Pion-Carbon Interactions with NA61/SHINE — Johannes Benemann for the NA61/SHINE-Collaboration — Karlsruhe Institute of Technology, Institute for Astroparticle Physics, Karlsruhe, Germany

For the measurement of ultrahigh-energy cosmic-rays it is crucial to understand the evolution of air showers in the atmosphere. Air showers initiated by cosmic ray particle consist mostly of pions, thus studying the interaction between pions and air molecules is of utmost importance. Fixed target experiments with pions from accelerators like the SPS at CERN are suitable for pion interaction studies. As a proxy for nitrogen, the dominant component of air, carbon is used as a target material. The produced particles and their spectra are measured by the NA61/SHINE detector at the CERN North Area. The detector consists of multiple time projection chambers which allow momentum measurements and particle classification.

In this talk we will present the analysis of a new pion-carbon dataset, including meson spectra and resonance cross sections. Furthermore predictions of hadron interaction models used for air shower simulations are compared with the new data.

HK 72.2 Tuesday 16:00 — 16:15 SCH/A252
krypton level measurement in XEoNnT and beyond — Yong-Ting Lin, Steffen Form, Matteo Guida, Robert Hammann, Hardy Simgen, and Jonas Westermann for the XEoNnT-Collaboration — Max-Planck Institut für Kernphysik, Heidelberg, Germany

The XEoNnT experiment is in search of dark matter and other rare physical phenomena via a ton-scale liquid-xenon detector. To reach its target sensitivity, competing background has to be suppressed to unprecedented level. One main internal background is the pure beta-emitter, 81Kr. With dedicated purification system in XEoNnT, the krypton concentration over xenon can be reduced down to 100 ppq (parts per quadrillion 10⁻¹⁵). Precisely quantifying the 81Kr remnant in this ultra pure xenon detector is therefore an important and challenging task. The rare gas mass spectrometer (RGMs) at MIPIK Heidelberg is capable of performing such measurement by a two stage process: applying a gas-chromatographic separation of krypton from xenon and tracing the amount of Kr gas using a mass spectrometer. For future low-background liquid-xenon detectors, a fully automatic rare gas mass spectrometer (AutoRGMs) is under development. The AutoRGMs will be a major improvement in reducing the complexity and duration of its operations, and thus allow frequent krypton monitoring. The highlight will cover both the results from RGMs and the progress toward AutoRGMs.

HK 72.3 Tuesday 16:15 — 16:30 SCH/A252
Experiments with the MuonPi Cosmic Particle Detector — Simon Glenneimier-Marke1, Kai-Thomas Brinkmann2, Hans-Georg Zaucnik3, Lara Duppel1, Martin Peter1, Lukas Nies3, and Katharina Dörtt1,2
1Justus-Liebig-University — 2TP-Department, CERN

The MuonPi project is an open-community research project dedicated to the investigation of cosmic particle showers. Its goal is to establish a wide-ranging network of detector units for measuring muons originating from shower cascades. Nanosecond time synchronization for all stations is achieved using navigation satellites. By aggregating the individual detections and analyzing their timestamps, the shower geometry and energy can be reconstructed. However a single detector unit can already be used for some interesting experiments, enabling students, teachers, makers and otherwise interested individuals to study the field of high energy physics. In this presentation we will showcase some of these experiments as well as the results of a stratospheric balloon launch. *supported by ELJEN Technology

HK 72.4 Tuesday 16:30 — 16:45 SCH/A252
Photon identification and their uncertainties for the displaced production vertices in search for ALPs with ATLAS — Peter Krämer, Kristof Schmieden, Matthias Schott, and Olivia Vujinovic for the ATLAS-Collaboration — Johannes Gutenberg University, Mainz, Germany

Some puzzling questions in particle physics, such as the strong CP problem or the discrepancy of the muon magnetic moment could be solved by introducing light scalar or pseudo-scalar axion-like particles (ALPs). Theoretical models allow a wide range of ALP-masses and couplings to SM particles such as photons and the Higgs boson. Therefore, parts of the ALP parameter space could be investigated with collider experiments like the ATLAS experiment at the LHC. Generally, we discuss that one could place further constraints on ALP properties, such as mass and their coupling to photons, by searching for displaced production vertices in search for ALPs with ATLAS. This will be illustrated with examples of collisions in previous data, and will be concluded with some plans for the future.

HK 72.5 Tuesday 16:45 — 17:00 SCH/A252
Neural network based identification of collimated photon pair signatures in a search for axions in SM Higgs boson decays with the ATLAS detector — Peter Krämer, Kristof Schmieden, Matthias Schott, and Olivia Vujinovic for the ATLAS-Collaboration — Johannes Gutenberg University, Mainz, Germany

Some puzzling questions in particle physics, such as the strong CP problem or the discrepancy of the muon magnetic moment could be solved by introducing light scalar or pseudo-scalar axion-like particles (ALPs). Theoretical models allow a wide range of ALP-masses and couplings to SM particles such as photons and the Higgs boson. Therefore, parts of the ALP parameter space could be investigated with collider experiments like the ATLAS experiment at the LHC. In the ongoing analysis, we search for the SM Higgs boson decaying into a pair of ALPs further decaying into two photons each. For low mass ALPs, the decay photons can appear strongly collimated. These collimated photon pairs are reconstructed as a single photon only differing in the shape of the electromagnetic shower. In this talk we will discuss how these collimated photon pair signatures can be identified using neural networks and how the corresponding uncertainties can be estimated.
used radioactive source to calibrate particle detectors. With its low energy and well-known X-ray spectrum, Fe55 is commonly used to analyze the emitted spectra. We could show that a clean Fe55 spectrum can be observed with the X-ray tube which irradiated a piece of manganese. Two different detectors were used to analyze the emitted spectra. The first one is a semiconductor detector and the second one is a gas detector. With the performed measurements, we could show that a clean Fe55 spectrum can be observed with the X-ray tube which irradiated a piece of manganese.

In this poster, the measurements of X-ray fluorescence at manganese compared to Fe55 spectra are shown. Furthermore, the advantages and disadvantages of this method are discussed. Supported by BMBF.

**Time:** Thursday 17:30 – 19:00

**Location:** HSZ EG

**HK 74: Poster**
HK 74.2 Thu 17:30 HSZ EG

**Laser Spectroscopy of Thulium-169**

— Hendrik Bodnar, Julian Palmes, Wilfried Nörtershäuser, and Kristian König — Institut für Kernphysik, TU Darmstadt

Laser spectroscopy is an established way to obtain information about the charge radius and the electromagnetic moments of a nucleus and has been applied to many isotopes all across the nuclear chart. In preparation for the investigation of short-lived Tm isotopes at the proton drip line [1], the stable 169-Tm was investigated at the Collinear Apparatus for Laser Spectroscopy and Applied Physics (CALAP) at the Heidelberg Institute for Nuclear Physics at TU Darmstadt. Simply charged thulium was produced with a surface ionization source. Several transitions from the ionic ground state in the wavelength range between 340 nm and 425 nm have been studied and the hyperfine structure was analyzed. This allowed the selection of a suitable transition for efficient studies of rare isotope beams. Funding from the BMBF under contracts 05P21RDC1 and 05P21RFDN1 is acknowledged. [1] B. Chel, et al., CERN-INT-2022-041 / INT-1-245 (2022)

HK 74.3 Thu 17:30 HSZ EG

**Towards the Establishment of an Electrofusion Experiment at the S-DALINAC**

— Gerhard Steinheilber, Michaela Arnold, Jonny Birkhan, Michael Block, Martha Liliana Cortés, Tetyana Galatyk, Pavlos Koseoglou, Norbert Pietralla, and Maximilian Spall — IKP, Technische Universität Darmstadt — 2GSI Helmholtzzentrum für Schwerionenforschung

To account for the observed abundances of heavy elements, the rapid-neutron capture process is essential [1]. It was first proposed more than six decades ago but is not yet completely understood. The main process is thought to occur in very neutron rich environments such as neutron star mergers, where the fission yields play an important role in determination of the final abundances. The fission yields depend on the excitation energy of the compound nucleus, which is not well studied. To increase our understanding of fission processes, a new setup for electron-induced fission is in development at the S-DALINAC electron accelerator at TU Darmstadt. Combining the established large acceptance QCLM electron spectrometer which provides the excitation energy of the nucleus with fission fragment detector modules (FFDM) allows for a coincident measurement of fission fragments with an excellent mass resolution as a function of the excitation energy. The FFDMs which will be placed around the actinide target will provide precise timing information and the kinetic energy of the fission fragments. This poster will present the design of this experiment.

This work is supported by the Hessian cluster project ELEMENTS. [1] J. J. Cowan et al., Rev. Mod. Phys. 93, 015002 (2021).

HK 74.4 Thu 17:30 HSZ EG

**Analysis of the bremsstrahlung contribution in electron-gamma coincidence experiments at the S-DALINAC**


The all-electromagnetic ($e, \gamma$) reaction has first been used for nuclear structure measurements in the 1980s [1]. Since then very few experiments were based on this reaction. One of the challenges of this measurement technique lies in the coincident bremsstrahlung, which - apart from the angular distribution of the scattered electron - cannot be distinguished from the $\gamma$-radiation of decaying nuclei after excitation by inelastic electron scattering. In 2021 a successful [$^{36}$Ru, $e, \gamma$] measurement was performed at the S-DALINAC with 35 times improved resolution [2]. The scattered electrons were registered with the QCLM spectrometer. The $\gamma$-radiation was detected by 6 LaBr$_3$Ce detectors. The double differential cross section of the bremsstrahlung contribution is computed within PWBA and combined with GEANT4 simulations to model pure bremsstrahlung spectra. A subtraction of the bremsstrahlung background will be applied to the [$^{36}$Ru, $e, \gamma$] data and allow for the extraction of ground-state $\gamma$-decays of excited states. Preliminary results on treating the bremsstrahlung contribution will be presented.


HK 74.5 Thu 17:30 HSZ EG

**A distributed network of cosmic shower detectors**

— Lara Dipell, Kai-Thomas Brinkmann, Hans-Georg Zauinck, Simon Glenmemeier-Marke, Marvin Peter, Lukas Nieb, and Katharina Dörr — IL Physikalisches Institut, Giessen, Deutschland — 2EP Department, CERN

The MuonPi project is a distributed network of Raspberry Pi-based Internet-of-Things (IoT) detector stations for measuring muon showers caused by the interaction of ultrahigh-energy particles of the primary cosmic rays with earth's atmosphere. By connecting the detectors to the global navigation network (GNSS), the individual events can be time-stamped with nanosecond-time accuracy. Thus, further information, such as shower geometry and possibly energy, can be obtained from the time correlations between the detectors. Among others, the project offers students, teachers, makers, HAMS and interested laymen an insight into the research field of astroparticle physics of the highest energies in the cosmos. The individual detector stations have also proven to be efficient in measuring charged particles on parabolic flights and stratospheric balloon missions.

“supported by ELJEN Technology

HK 74.6 Thu 17:30 HSZ EG

**New Electronics for the HADES Drift Chambers**

— Jan Michel, Ole Arntz, Thomas Gnizdowksi, Christian Münster, and Christian Wendisch — for the HADES-Collaboration — Goethe-Universität Frankfurt am Main — 2GSI Helmholtzzentrum für Schwerionenforschung — 3Waraz University of Technology

The drift chambers (MDC) of the HADES Experiment at GSI, Darmstadt form the main tracking system of the spectrometer. Being designed more than twenty years ago, we are currently replacing the whole electronics read-out chain with state-of-the-art electronics.

The new analog signal processing is based on the PASTTREC ASIC, originally developed at AGH Krakow for the PANDA Straw Tube Tracker. The digitization of data happens in FPGA-based TDCs before data is sent on an optical link to the event server farm.

The main challenges of the project are the strict spatial constraints given by the experiment setup and the noise sensitivity of the large area gas detectors. In this work, the power consumption needed to be kept low to ease cooling of the electronics.

This work has been supported by bmbf (03P21RFFC2), gsi, and hifff.

HK 74.7 Thu 17:30 HSZ EG

**Evolution of the KATRIN energy scale measured with $^{83m}$Kr**

— Justus Beienkötter for the KATRIN-Collaboration — Institut für Kernphysik, WWU Münster

The KATRIN experiment has the aim to measure or exclude the effective electron deformation potential ($V_{electron}$) up to 0.2 eV/c$^2$ (90% C.L.) by measuring the tritium beta spectrum near its endpoint. To study the energy scale of KATRIN, which is influenced by beamline workfunctions and plasma effects in the gaseous tritium source, $^{83m}$Kr conversion electron lines are used. Gaseous $^{83m}$Kr is inserted into the tritium source, which allows to measure energy shifts and broadenings that would also affect the beta spectrum. This poster gives an overview of the time evolution of the line position of the L$_{12}$ and N$_{23}$-lines, which were measured many times over the course of the KATRIN operation. This work is supported by BMBF under contract number 05A20PMA.

HK 74.8 Thu 17:30 HSZ EG

**Studies on Alternative Sensor Carrier Concepts for the CBM MVD**

— Fabian Hebermehl for the CBM-MVD-Collaboration — Goethe-Universität Frankfurt

The Micro Vertex Detector (MVD), part of the Compressed Baryonic Matter (CBM) Experiment at the future FAIR facility, comprises four detector stations, from which CBM-MVD station production yield is driven by the need to populate both carrier sides operating in vacuum, efficient thermal management by the carrier of the sensors is mandatory. For this reason, the carrier materials chosen are Thermal Pyrolytic Graphite (TPG) for the larger stations and PCVD diamond for the smallest, first station. Studies have been conducted on alternative concepts for the TPG stations to balance thermal performance, material budget and production yield. This year, the production yield is driven by the need to populate both carrier sides with large-area MIMOSIS sensors to minimize inactive areas inside the detector acceptance. The options to (i) integrate ladders rather than carrier plates and (ii) separate front and back side sensor integration have been studied. The contribution will summarize the findings and gives a recommendation of which design is best suited for refining MVD station concept according.

*The work has been supported by bmbf (03P21RFFC2) and EURIZON.*

HK 74.9 Thu 17:30 HSZ EG

**Lifetime measurement of low-lying states of $^{17}$W**


Previous experiments in the region of the Hf and W isotopic chains have shown a change in the first 2' states' mean lifetimes in comparison to the literature values due to advancements in experimental techniques. A sudden increase of the $^{17}$O $^{2}_2$ to $^{17}$E2 transition strength in the W isotope chain between N = 96 and N = 98 is significant and not seen in the neighboring isotopic chains. Therefore, four years ago, the low-lying level lifetimes of $^{17}$W (N = 96) with the RDD method was performed at LNL. The GALILEO array and the GALILEO plunger device were used. Lifetimes for the first 2', 4' and 6' state were obtained and the deduced E2 transition strengths compared to predictions of the CBS model.
A data from Ag (1.58 GeV) multi-differential emission rates of tritons are part of the investigation of statistical fluctuations for the HADES Collaboration—Goethe-Universität Frankfurt, Germany. Development of new or optimization of already widely used scintillation materials for fast timing applications have become a very important research activity during the last decade. A significant progress with cerium doped inorganic materials has been made in the improvement of the timing characteristics of the scintillation pulse. Here we present test results of gartens YAG/YAG/GAGG, lutetium-yttrium oxyorthosilicates YSO/LYSO/LSO, and orthoaluminate perovskites YAP/YAp with different types of doping. Samples have two types of dimensions: 3x3x3 and/or 3x3x20 mm³. The main activity was concentrated on the measurements of the coincidence time resolution (CTR) with the help of an oscilloscope by offline analysis of recorded signals and the dependence on temperature and the sample shape. Measurements were performed inside a climate chamber and done with SiPM readout and commercial evaluation kits from different producers as well as with own development.

The work was supported by funding from BMBF Projects 05K2019, UFACal, EFRE, the High-D consortium and in the spirit of the Crystal Clear Collaboration—RuhrUniversityBochumAGPhysicsofHadronsandNuclei, Germany. Collinear laser spectroscopy is a well-established technique to investigate ground-state properties of stable and short-lived isotopes. By accelerating an ion beam electrostatically to 20-60 keV, the Doppler width is drastically reduced to the order of the natural linewidth, which enables measurements with high resolution. To achieve a high accuracy in the isotope shift measurements, the acceleration voltage of the ions needs to be precisely known to account for the Doppler shift of the ions.

To determine this voltage, three high-voltage dividers inspired by precision dividers of the Physikalisch-Technische Bundesanstalt, Braunschweig, Germany are used. The setup consists of three high-voltage dividers inspired by precision dividers of the Physikalisch-Technische Bundesanstalt, Braunschweig, Germany. The setup consists of three high-voltage dividers inspired by precision dividers of the Physikalisch-Technische Bundesanstalt, Braunschweig, Germany.

HK 74.14 Thu 17:30 HSZ EG Impact of the charm fragmentation fractions on the dielectron spectrum in p+p collisions at the LHC—EMMA Egge for the ALICE Germany-Collaboration—Institut für Kernphysik, Goethe-Universität Frankfurt, Germany.
Charm and anti-charm quarks are produced abundantly in pp collisions at LHC energies. Until recently, it was assumed that the hadronization process, i.e. the formation of charm hadrons from the partonic matter, can be described by universal fragmentation functions. Measurements performed by the ALICE Collaboration have nevertheless shown an enhancement of the relative charm-baryon contributions with respect to the ones observed in e± e± collisions. This suggests a significant difference of the fragmentation fractions in hadronic collisions at the LHC compared to e± e± and ep collisions at lower energies. The PYTHIA event generator is able to reproduce part of these findings by including string fragmentation beyond the leading color approximation.

On this poster, we will discuss how the dielectron yield from correlated open-charm hadrons decays is from the charm hadronization process. For this purpose, the predictions of the ALICE HADES generator using different tunes will be compared. Additionally, the consequences on the heavy-flavour cross section measurements via the dielectron channel will be shown.

HK 74.15 Thu 17:30 HSZ EG Setup of high-precision voltage dividers for collinear laser spectroscopy experiments at TU Darmstadt and ISOLDE/CERN—Finn Köhler1, Kris-
tian König2, Johann Meissner2, Wilfried Nörtershäuser3, and Stephan Passon3—Institut für Kernphysik, TU Darmstadt, Germany; 1Physikalische Technische Bundesanstalt, Braunschweig, Germany.

Collinear laser spectroscopy is a well-established technique to investigate ground-state properties of stable and short-lived isotopes. By accelerating an ion beam electrostatically to 20-60 keV, the Doppler width is drastically reduced to the order of the natural linewidth, which enables measurements with high resolution. To achieve a high accuracy in the isotope shift measurements, the acceleration voltage of the ions needs to be precisely known to account for the Doppler shift of the ions.

To determine this voltage, three high-voltage dividers inspired by precision dividers of the Physikalisch-Technische Bundesanstalt, Braunschweig, Germany are used. The setup consists of three high-voltage dividers inspired by precision dividers of the Physikalisch-Technische Bundesanstalt, Braunschweig, Germany.

HK 74.16 Thu 17:30 HSZ EG Silicon pixel sensors for the PANDA luminosity detector—Niels Boe
gler1, Stephan Böckmann1, Florian Feldbauer1, René Hagdorn1, Stephan Mal
daner1, Gerhard Reichenz1, and Mirjam Fritsch1—On behalf of the PANDA Collaboration—Ruhr University Bochum AG Physics of Hadrons and Nuclei, 44780 Bochum, Germany.

The PANDA experiment is one of the key experiments at the future FAIR accelerator facility in Darmstadt. Its purpose is to study the properties of hadrons in detail and to search for exotic states of the strong interaction. The PANDA detector will have a luminosity detector 11 meters downstream from the interaction point. This detector, consisting of two retractable hadron detectors, uses silicon pixel sensors to measure the distribution of elastically scattered antiprotons as a function of the scattering angle, from which the luminosity is determined. The MuPix sensors intended for track reconstruction in the luminosity detector are High-Voltage Monolithic Active Pixel-Sensor (HV-MAPS), which offer two advantages over conventional pixel sensors: The active sensor part and the readout electronics are combined on the same chip. Secondly, due to the high voltage, the charge transport is much faster. The production of sensor modules consisting of several pixel sensors, as well as the data acquisition system prepared for this setup will be presented.

This project is supported by the BMBF—Gesendet durch das BMBF.

HK 74.17 Thu 17:30 HSZ EG A comparison of initial condition models for hydrodynamic evolutions in heavy-ion collisions—Lucas Constantini1,2, Hannah E1,2,3, and Niklas Götz1,2—Goethe Universität Frankfurt am Main; 1Frankfurt Institute for Advanced Studies—GSI Helmholtzzentrum für Schwerionenforschung,

For a hydrodynamical description of the quark-gluon plasma created during a heavy ion collision, initial conditions of a thermalized system are needed. In this work, a comparison between three initial conditions models (SMASH, TRENTO, and IP-Glasma) is made. General quantities of the collision such as the number of participants and the number of binary nucleon collisions are determined, and the transverse plane energy densities from the different models are compared, along with their eccentricity distributions, for different collision systems at RHIC and LHC energies. The collisions in SMASH have slightly fewer participants and significantly fewer binary nucleon collisions. TRENTO not only produces lower...
Hadricon and Nuclear Physics Division (HK)

Thursday

In order to correctly interpret any future antinuclei measurement in space, the production of antinuclei has to be well understood. In this presentation a more advanced approach is employed combining event-by-event Monte-Carlo simulations with a microscopic coalescence picture based on the Wigner function formalism. The antiproton production in the event generator EPOS 3 is compared to measurements from the STAR Collaboration.

This work was supported by BMBF.

HK 74.22 Thu 17:30 HSZ EG

Studying the strong interactions in proton-deuteron at LHC — BHAVANI SINGH for the ALICE Germany-Collaboration — TUM, Munich Germany

In the journey to explore the strong interaction among hadrons, ALICE has for the first time extended its femtoscopic studies to nuclei. The large data sample of high-multiplicity pp collisions at $\sqrt{s} = 13 \text{ TeV}$ allows the measurement of the nuclear deuteron momentum correlations. The femtoscopic study of such systems opens the door to investigate the interaction in three-body systems as well as formation mechanism of the light nuclei in hadron-hadron collisions. In this contribution, the measured momentum correlation function for p-d is presented. The measured p-d correlation shows a shallow depletion at low relative momenta while the model calculation which assumes the interaction of two point-like particles shows a clear discrepancy with respect to the data. This discrepancy can be resolved by employing a full three body wave function that accounts for the internal structure of the deuteron including all relevant partial waves and quantum statistical effects. This demonstrates that the study of correlations among light nuclei provides access to the details of the many-body system's wave function at the LHC. Funded by BMBF Verbundforschung (05P21WOCA1 ALICE).

HK 74.23 Thu 17:30 HSZ EG

Measurement of $^3$H and $^3$He production in pp collisions at $\sqrt{s} = 13 \text{ TeV}$ with ALICE at the LHC — MATTHIAS HERBER for the ALICE Germany Collaboration — Institut für Kernphysik, Goethe-University, Frankfurt

The production of (anti)nuclei in pp collisions at the LHC has become a major topic in the high-energy physics community. In fact, there is a huge overlap between different research directions, from astrophysics, particle and nuclear physics. For instance, the observation of antinuclei in space is considered as possible signatures for dark matter, since they would originate from collisions of potential dark matter candidates among each other. We show the study of the production of $^3$H and $^3$He in pp collisions at 13 TeV in two data sets that were taken in LHC Run 2, i.e. in high-multiplicity events and one from a dedicated online trigger on nuclei. Furthermore, we will show the measurement of the ratio of these nuclei. This is an important test of isospin symmetry, which is expected to hold at LHC energies, but can not be tested directly since neutrons are not accessible experimentally.

HK 74.24 Thu 17:30 HSZ EG

Collisional broadening in a transport model — HANNAH EFLER, RENAN HIYAMA, and BRANULD KLEIN for the ALICE Germany-Collaboration — Institute für Kernphysik, Goethe-Universität, Frankfurt

Collisional broadening is a transport process which mortifies the measured spectrum of a system such as a proton, by collisions with the medium. It is important for the study of the evolution of the system, and it is also an important ingredient in the description of the observations. In this contribution, we will present a transport model, which includes collisional broadening, and will discuss its implications for the study of the system.

HK 74.25 Thu 17:30 HSZ EG

Signal-to-noise ratio in the ALICE TPC with GEMs — JANIS NOAH JAGER for the ALICE Germany-Collaboration — Institut für Kernphysik, Goethe-Universität, Frankfurt

A major aspect of the recent ALICE upgrade is the upgrade of the Time Projection Chamber (TPC). The TPC is the main tracking and particle identification device of ALICE. By replacing the Multi-Wire Proportional Chambers (MWPC) with stacks of four Gas Electron Multiplier (GEM) foils, continuous readout of the TPC is achieved. Furthermore the installation of the GEMs implies specific requirements such as the optimization of the electronic. In this talk we present the effect of the signal-to-noise ratio at the nominal gas gain of 2000. Different pad area and trace length result in variations of the properties. Additionally, external influences cause local variations of the noise.
In this poster the intrinsic noise together with the signal-to-noise ratio for minimum ionizing particles, measured in first pp collisions in LHC Run 3, will be presented for the different pad regions of the TPC. The results will be compared with the design goals.

HK 74.26 Thu 17:30 HSZ EG

Background-Correlated Collinear Saturation Scattering of COALA —

- Julien Spahn, Philipp Ingram, Kristian Konig, Patrick Möller, and Wilfried Nörenberg — In pursuit for high cohospilus, TU Darmstadt

All-optical determinations of nuclear charge radii in He-like systems will come into reach with increasing accuracy in atomic structure calculations of He-like systems. To this end, the $1s^2 \Sigma_1^+$ to $1s^2 \Sigma_1^-$ transitions in He-like $^{12}$C$^{-}$ and $^{13}$C$^{-}$ were measured at the Collinear Apparatus for Laser Spectroscopy and Applied Physics (COALA) at the Institute of Nuclear Physics of TU Darmstadt. The $^{12}$C$^{-}$ ions are produced with an electron-beam ion source (EBIS) and collinear laser spectroscopy was performed using modulated irradiations. Variations in the background signal, caused by fluctuations in the collinear laser beam position, significantly contributed to the uncertainty of the measured transition frequencies, especially at high dwell times. Additionally, the residual Doppler broadening is still rather large compared to the natural linewidth of the transitions due to the initial energy spread of the ions inside the EBIS. This contribution will present and compare the improvements obtained by implementing a laser-beam position stabilization system and a voltage modulation of the fluorescence detection region. Moreover, a first attempt of background-corrected collinear saturation scattering — a method that allows to overcome the limitations imposed by the residual Doppler broadening — will be presented.

This project is supported by DFG (Project-ID 379948907 - SFB 1245).

HK 74.27 Thu 17:30 HSZ EG

HYDRA: Hypernuclei Decay at R-B Apparatus —

- Simone Velardita, Hector Alvarez-Poli, Yassid Ayad, Metayal Duer, Alexander Encuc, Liangcheng Ji, Alexandre Obertelli, and Yelei Sun for the R3B Collaboration — Technische Universität Darmstadt, Fachbereich Physik, Darmstadt, 64289, Germany — Universidade de Santiago de Compostela, Santiago de Compostela, E-15782, Spain

HYDRA is a physics program within the R3B collaboration to study the decay spectroscopy of hypernuclei produced from heavy-ion collisions at GSI/FAIR. The program aims at measuring with high resolution the in-flight picionic decay of light and medium mass hypernuclei. To achieve that, a pion tracker is connected as a time projection chamber inside the magneto-optical GLAD magnet of the R3B setup. The full experimental setup has been simulated within the R3BROOT framework, to optimize the geometry and define conditions for the forthcoming accepted experiment which will take place at R3B in 2024. The first experiment aims at the mass-radius of hypernuclei such as the hypertriton, predicted to be halo, from measurements of its interaction cross-section. The experimental method developed for the measurement will be presented in the poster, together with first results from a tracking algorithm that will be used to reconstruct the decayed particle trajectories.

HK 74.28 Thu 17:30 HSZ EG

Characterization of prototypes of an active Transverse Energy Filter (aTEF) —

- Kyrill Blumé, Kevin Gauda, Sonja Schneiderwind, Christian Gönnes, Volker Hansen, Hans-Werner Ortjohann, Wolfram Persnitz, Lukas Pölltisch, Richard Salomon, Maik Stappers, and Christian Weineheimer — 1Institut für Physikalisches Institut und Münster, 2Institute of Nuclear Physics, University of Münster, 3Kirchhoff-Institute for Physics, University of Heidelberg — Katrin Collaboration

In the Karlsruhe Tritium Neutrino Experiment (KATRIN) the mass of the electron neutrino is intended to be measured directly by precision energy spectroscopy of the tritium $\beta$-decay electrons in its endpoint region. To achieve the targeted sensitivity, a reduction of secondary electrons, which otherwise could be caused by Rydberg atoms and autonzotroning states, is needed. An active transverse energy filter (aTEF, Eur. Phys. J. C 82, 922 (2022)) distinguishes electrons due to their angle to a magnetic field line. It preferentially detects signal electrons with a broad angular distribution rather than background electrons with a small angular distribution. This poster presents insight in the testing procedures and characterization of aTEF-prototypes in dedicated test environments.

HYDRA: Hypernuclei Decay at R-B Apparatus

- Rafael Mannhart for the ALICE Collaboration — Technische Universität München

High-energy hadronic collisions at accelerators create a suitable environment for the production of light (anti)hypernuclie. Precise measurements of the antinuclei production at accelerators are essential to study the different sources of antinuclei in our Universe and to correctly interpret any future measurement of antinuclei in space. (Anti)nuclei production measurements are also interesting to investigate their production mechanisms, which are under intense debate in the scientific community. The description of the experimental measurement is currently based on two competing phenomenological models: the statistical hadronisation model and the coalescence approach. The production of (anti)nuclei, up to A=4, has been measured with ALICE in the last 10 years, from small collision systems (i.e., pp and p+Pb) to heavy-ion collisions (i.e., Xe+Xe and Pb+Pb). In 2022, LHC Run 3 has started and pp collisions at top centre-of-mass energy of $\sqrt{s} = 13.6$ TeV have been recorded with the unprecedented luminosity of $18 \text{ pb}^{-1}$. In this contribution, new measurements of (anti)nuclei from Run 3 data will be shown, together with a review of (anti)nuclei results from Run 1 and 2.

This work is funded by BMFB Verbundforschung (05P21WOCA1 ALICE).

HK 74.30 Thu 17:30 HSZ EG

Machine Learning Approach to the Seaquark Search in ALICE —

- Sven Hopfer for the ALICE Germany-Collaboration — Physikalisches Institut, Heidelberg, Germany

The seaquark was proposed by G. Farrar in 2017 to be a compact, stable and neutral particle consisting of six quarks with a quark content of $uuddss$. Its charge neutrality, stability, and expected production rate in the QCD phase transition in the early universe make it an interesting dark matter candidate within the standard model, while its similarity to the neutron in experimental settings could explain why it has not been discovered so far. A new search for the seaquark $S$ in heavy-ion collisions at the Large Hadron Collider (LHC) using the ALICE detector started in 2022 which will look for characteristic decay chains in the annihilation of the anti-S with the detector material. The search benefits from the excellent tracking and particle identification (PID) capabilities of ALICE, especially for low momenta. Based on Monte Carlo simulations it is investigated how the seaquark search with ALICE can be improved with a decision tree based machine learning approach using XGBoost.

HK 74.31 Thu 17:30 HSZ EG

The CompPWA project: speeding up amplitude analysis with a Computer Algebra System —

- Remco de Boer, Miriam Fritsch, Wolfgang Grado, Stefan Pflüger, and Leonhard Wollenberg — 1Ruhr-Universität Bochum, 2Johannes Gutenberg Universität Mainz

In the ideal world, we describe our models with recognizable mathematical expressions and directly fit those models to large data samples with high performance. It turns out that this can be done with a CAS, using its symbolic expression system as a template for the back end of a highly optimized algorithm. The CAS can further simplify the expression tree, which can result in speed-ups in the numerical back-end.

The CompPWA project offers Python libraries that use this principle to formulate large expressions for amplitude analysis, so that the user has the flexibility to quickly implement different formalisms and can easily perform fast computations on large data samples. The CAS additionally allows the project to standardize and automatically document these formalisms as they are being implemented.

HK 74.32 Thu 17:30 HSZ EG

Detector response simulations for the CBM-TRD —

- Lena Rossel for the CBM-Collaboration — Institut für Kernphysik, Goethe-Universität, Frankfurt am Main

To ensure the best functionality of the Transition Radiation Detector (TRD) of the Compressed Baryonic Matter (CBM) experiment at the future Facility for Antiproton and Ion Research (FAIR), it is crucial to simulate the detector response as precisely as possible. Simulations are an instrument to optimize the detector design and account for possible challenges in the extraction of physics observables affected by design decisions. After the event generation, the propagation of the particles through the detector setup is simulated with GEANT3. The detector behavior, including signal generation and collection, is simulated. This includes handling of transition radiation photons, energy deposition in the detector gas and signal-digitization. In this contribution the general process of the detector response simulation is carried out with ChmRoot for the CBM-TRD. The focus lies on the reconstruction of the specific energy loss for charged particles. In addition, DESY test beam data of one TRD module will be compared to the simulation results. This work is supported by the BMFB-grant 05P21RFF3C3.

HK 74.33 Thu 17:30 HSZ EG

Study of the $\pi^-\pi^+$ subsystem with $J^{PC}_{\pi\pi}=1^{-}$ in the diffractively produced $\pi^-\pi^-\pi^+\pi^+$ final state at COMPASS —

- Martin Bartl for the COMPASS Collaboration — Physik-Department E18, Technische Universität München

The COMPASS experiment is a fixed-target experiment at CERN fed by the SPS beam. The flagship spectroscopy analysis is based on the diffractive process $p \rightarrow \pi^- \pi^- \pi^+ \pi^0$, for which a large data sample of $46 \times 10^6$ events has been collected. This large data sample allows us to apply the so-called freed-isobar partial-wave analysis method, which extracts the amplitudes of the decay process with well-defined $J^{PC}_{\pi\pi}$ quantum numbers for the $\pi^-\pi^+$ subsystem, as well as for the $\pi^0$ system. The $\pi^-\pi^+$ amplitudes are extracted in a quasi-model-independent
way as a function of $2\pi$ mass, $3\pi$ mass, and squared four-momentum transfer. This highly detailed information allows us not only to test the assumptions of the isobar model, but also to perform in-depth studies of the $2\pi$ resonances that appear in the $3\pi$ system.

We study the $2\pi$ amplitudes with $PC = 1^-$. These $2\pi$ amplitudes are dominated by the well-known $\rho(770)$ resonance, but may also contain signals from excited $\pi$ states, which are still elusive. The employed approach allows us to extract the pole positions, i.e. masses and widths, of these resonances and study their systematics.

*Supported by the DFG under Germany's Excellence Strategy - EXC2094 - 390783311 and BMBF Verbundforschung 05P21WOCC1 COMPASS.
The Compressed Baryonic Matter (CBM) experiment at the future Facility for Antiproton and Ion Research (FAIR) will explore the QCD phase diagram in the region of very high net baryon densities. The Transition Radiation Detector (TRD) is an important subdetector of the final CBM experiment and is used to identify electrons at high momenta, contributes to tracking of particles and supports the identification of light nuclei via their specific energy loss.

For commissioning and performance measurements, the TRD takes part in the mCBM high-rate beam measurement campaigns at the SIS18 accelerator, which are part of the FAIR-Phase 0 program. Together with the TOF, STS, RICH and MuTch detectors, also TRD is connected to the full CBM DAQ, making data available for common analysis. In this poster, TRD data QA as, e.g., a first tracking approach using straight tracks is presented and its results are shown.

This work is supported by BMFB grant 05P21PMPFC1.

**HK 74.42 Thu 17:30 HSZ EG**

Deuteron emission from Ag+Ag Collisions at 1.58a GeV — CARL PHILIPP ROY for the HADES-Collaboration — Goethe-Universität Frankfurt

A high statistics data sample of Ag(1.58a GeV)+Ag events recorded in scope of the FAIR phase 0 program in March 2019 is used to study multi-differential emission from a new beam test platform. In this contribution, we discuss details of the extraction of deuteron signals from the bulk of reconstructed charged particle tracks. The extracted deuteron signals are corrected with simulated detector response coefficients and then used to calculate the multi-differential emission rate per event as a function of transverse momentum and rapidity. The fitted phase-space distribution of deuteron yields is fitted with thermally motivated model functions and extrapolated to phase-space not covered by the detector geometry. The results are discussed in context of available world data.

*This work has been supported by BMFB (05P21RFFC2) and gSI.

**HK 74.43 Thu 17:30 HSZ EG**

Arduinobased readout electronics for particle detectors — MARKUS KOHL1, JANNEKE WEIMAR1, FABIAN SCHMIDT2, Jochen Kaminski2, KLAUS DESCH1, and ULRICH SCHMIDT2 — Physikalisches Institut, Heidelberg University — 2Physikalisches Institut, Universität Bonn

Open Hardware-based microcontrollers, especially the Arduino platform, have become a comparably easy-to-use tool for rapid prototyping and implementing creative solutions. Such devices in combination with dedicated frontend electronics can offer low-cost alternatives for student projects, slow control and independently operating small scale instrumentation. The capabilities can be extended to data taking and signal analysis at decent rates. We present two projects, which cover the readout of proportional counter tubes and of scintillators without resorting to shifting fibers with Silicon Photomultipliers. With the SiPM/Trigger we have realized a small-scale design for SiPMs as a trigger or veto detector. It consists of a custom mixed signal front-end board featuring signal amplification, discrimination and a coincidence unit for rates up to 200 kHz. The nCatcher board transforms an Arduino Nano to a proportional counter readout with pulse and charge measurement, readout with a digital-analog converter for pulse height. The device is therefore suitable for low to medium rate environments, where a good signal to noise ratio is crucial - in case presented here to monitor thermal neutrons.

**HK 74.44 Thu 17:30 HSZ EG**

Ultra-clean magnetically-coupled piston pump for noble gas experiments. — ANDRAS MICHÁL1, LUTZ ALTHUSE1, DAVID KOKE1, CHRISTIAN HUERMANN1, MIHÁL MURKA1,2, PHILIP SCHULT1, HENNING SCHULZE ESSING1, and CHRISTIAN WEINHEIMER1 for the XENON-Collaboration — 1Institut für Kernphysik, Universität Münster, Germany — 2Columbia University, New York, USA

The high performance magnetically-coupled piston pump is interesting for the usage in low background experiments dealing with noble gases as target. In such ultra-clean experiments, pumps are used for the circulation of the target material. Therefore, the reduction of radioactive emanating materials such as radon is of great importance.

For this purpose, a radon-free, hermetically sealed, ultra-clean magnetically-coupled piston pump was developed (INSE 16 (2021) P09011) to be operated as a xenon gas compressor for the XENONNt experiment.

The magnetically-coupled piston pump is made of four cylinders connected in parallel, featuring a high flow by keeping high pressure differences for a good compression. The custom-made control gives the possibility to operate the system with different configurations and to monitor the status of each pump during the operation.

In this poster the function and the operation experience with this magnetically-coupled piston compressor is presented.

This research was partially supported by BMFB under contract 05A20PM1.

**HK 74.45 Thu 17:30 HSZ EG**

CBM-TRD Component Database — PHILIPP MUNKER for the CBM-Collaboration — Institut für Kernphysik WWU Münster, Münster, Germany

The Compressed Baryonic Matter (CBM) experiment is an upcoming heavy-ion physics experiment at the future Facility for Anti-proton and Ion Research (FAIR) which will investigate the low-temperature and high baryonic density region of Quantum Chromodynamics (QCD) matter.

The Transition Radiation Detector (TRD), one of the sub-detectors of the CBM experiment, will be used to provide particle identification information on electrons and pions at high momenta and light nuclei, as well as tracking information for charged particles.

For long-running experiments it is important to keep track of all of their components already during operation of the detector, as soon as they have been assigned an identity. This enables not only full QA processes of those components, but also correlating the product behavior to the components and/or to the production process, if necessary at some point. For this reason, a long-term stable database for production data needs to be implemented, deployed, and tested.

In this poster, the design of the CBM-TRD Component Database concept and its current status will be presented.

This work is supported by BMFB grant 05P21PMPFC1.

**HK 74.46 Thu 17:30 HSZ EG**

pp correlation in e+ e− collisions at Belle to study the particle emitting source — MARIA LEIBEL1, LAURA SIEB1, UMBERTO TAPONNI1, and MARIA FABBRETTI1 — 1TU München, Garching, Germany — 2INFN, Sezione di Torino, Turin, Italy

The light antinuclei cosmic rays are considered as a promising probe for the searches of Weakly Interacting Massive Particles (WIMPs) - one of the dark matter candidates. The antinuclei can be produced in dark matter annihilations and detected by experiments near Earth. Understanding the antinuclei flux requires knowledge about how light antinuclei are formed. One of the available models is coalescence which suggests that first antinucleons are formed as degrees of freedom and then they coalesce to antinuclei. The probability for the antinucleons to create a bound state depends on the relative momentum in the pair rest frame and the distance at which they are produced. The latter can be constrained with the femtoscopic correlation measurements, currently available only for pp and heavy-ion collisions. As a proxy to constrain the source for antinuclei production in the dark matter annihilation, e+ e− collisions are preferred since electrons are point-like particles and do not interact strongly. In this poster, we will show the first results on femtoscopic p-p correlations in e+ e− collisions measured by Belle at the KEKB collider. The obtained correlation function is then modeled using well known interaction potential and the size of the source for nucleon pairs is extracted.

**HK 74.47 Thu 17:30 HSZ EG**

A new TRD with hybrid GEM-Micromegas detector — LIANCHENG ZHANG1, MEYTAL ENUR1, AXEL VOGT1, BARTSAAM LOHREK1, and ALANDRA OBERTELLI1 — 1INFN, Sezione di Torino, Turin, Italy

For the CBM Collaboration at FAIR, which will investigate the low-temperature and high baryonic density region of Quantum Chromodynamics (QCD) matter, the antinucleon flux requires knowledge about how light antinuclei are formed. One of the available models is coalescence which suggests that first antinucleons are formed as degrees of freedom and then they coalesce to antinuclei. The probability for the antinucleons to create a bound state depends on the relative momentum in the pair rest frame and the distance at which they are produced. The latter can be constrained with femtoscopic correlation measurements, currently available only for pp and heavy-ion collisions. As a proxy to constrain the source for antinuclei production in the dark matter annihilation, e+ e− collisions are preferred since electrons are point-like particles and do not interact strongly.

In this poster, we will show the first results on femtoscopic p-p correlations in e+ e− collisions measured by Belle at the KEKB collider. The obtained correlation function is then modeled using well known interaction potentials and the size of the source for nucleon pairs is extracted.

**HK 74.48 Thu 17:30 HSZ EG**

A GENT4 simulation of gamma clustering in CsI. — PHILIP KLENZ1, LEYLA ATAS2, and ROMAN GERNHÄUSER2 for the R3B-Collaboration — 1Technische Universität München — 2Technische Universität Darmstadt

With over 1500 CsI(Tl) crystals, the CALIFA calorimeter is one of the cornerstones of the upcoming R3B experiment at the FAIR accelerator complex. One of its tasks will be the detection of gamma rays in the range from 100 keV to 30 MeV. Due to the high granularity of CALIFA, these energy deposits of gamma rays will generally be spread over multiple crystals.

In this work, a simplified geometry model in GENT4 is used to study both the quantitative behavior of photons in CsI, cluster sizes and shapes, and energy and position reconstruction efficiency.
HK 74.49 Thu 17:30 HSZ EG
Pulse-shape analysis with the new MiniBall triple-cluster detector — *Kai Hensele, Darius Luteen, Jasper Wehlitz, Rainer Abeles, Jürgen Eberth, Herbert Hess, Rouven Hirsch, and Peter Reiter* — IKP Universität zu Köln, Cologne, Germany

The MiniBall (MB) array is a high-resolution γ-ray spectrometer used for low multiplicity experiments with low-intensity radioactive ion beams at HIE-ISOLDE, CERN. It consists of eight triple-cryostats, each housing three n-type six-fold segmented HPGe crystals. New preamplifier electronics was implemented in the cold part of the cryostat and the feedback loop is now coupled to the AGATA preamplifier [1]. The eleven preamplifier electronics outputs from one crystal are digitized at a rate of 100 MHz using 14-bit ADCs [2]. The new electronics yields comparable energy resolution results with respect to standard analog electronics and enable pulse-shape analysis of all channels simultaneously. Measurements with a collimated γ-ray source of 133Cs were conducted to produce data sets of interactions along one line, so called ‘pencil beams’. These pulses are filtered and analyzed with respect to the deposited energy, rise time and pulse shape. The aim of the PSA is to identify the location of individual interaction points. Especially along the detector axis three dimensional position information is crucial for improved Doppler correction. Further results will be presented and discussed.

Supported by BMBF Projects 05P18PKC11, 05P21PKC11.


HK 74.50 Thu 17:30 HSZ EG
High-energy gamma calibration of CALIFIA with a Pu-C source — *PHOUNG LE, LEYLA ATAR, CHRISTIAN SUCHEK, and THORSTEN KROESSL* — for the R3B-Collaboration — Institut für Kern-physik, TU Darmstadt, Darmstadt, Germany

CALIFIA (CALorimeter for In-Flight detection of gamma-rays and high energy charged particles) is the scintillator based calorimeter of the R3B (reactions with relativistic radioactive beams) experiment at FAIR that surrounds the target. It currently consists of 1528 scintillation Cell(Ti) crystals and detects gamma-rays and light charged particles simultaneously. The energy calibration of CALIFIA is done using different sources, from low energy-gamma peaks (22Na) to high energy-gamma peaks (Pu-C) reaching from 511 keV up to 6.1 MeV. This is essential due to the high dynamic range (100 keV to 300 MeV) of CALIFIA. To improve the calibration quality, various gamma sources are combined in the calibration procedure and automated by a Python script.

This work is supported by BMBF under contract 05P19RFDN1 and 05P21RFDN2 and the Helmholtz Research Academy Hesse for FAIR - HHHE.

HK 74.51 Thu 17:30 HSZ EG
New evidence for alpha clustering structure in the ground state band of 212Po — *MARTIN VON TRESCKOW* — for the JF112Po-Collaboration — IKP TU Darmstadt, Schlossgartenstraße 6, 64289 Darmstadt

212Po has two-protons and neutrons outside the doubly-magic nucleus 208Pb and it may be assumed that the nuclear structure can be well described within the shell-model. But various experimental properties, such as the short-lived ground state, are better described by a α-clustering model. The (E2) values of the decays of the low-lying yrast states are an important fingerprint to describe the structure of 212Po. Especially the missing R(E2; 4+ → 2+) value is important in this discussion. We have performed an α-transfer experiment to investigate excited states of 212Po and determine the lifetimes using the ROSPHERE γ-ray detector array at IFIN-HH in Magurele, Romania. This array consisted of 15 HPGe detectors and 10 LaBr3(Ce) scintillator detectors and was supplemented with the SORCERER particle-detector array. The combination of γ-ray and the particle detectors was an important tool to determine the mean lifetimes of all ground-state band levels up to the 8th state applying the fast-timing method [Ma. von Tresckow et al., PLB 821, 136624 (2021)]. I will present our lifetime analysis and discuss the results within the shell-model and α-clustering model. Supported by BMBF under Verbundprojekt 05P2021 (ErUM-FSP T07) via grant 05P21RFDN1

HK 74.52 Thu 17:30 HSZ EG
CBM-TRD hit time extraction — *PHILIPP KÄHLER* — 1, MARIUS KUNOLD, 2 and DAVID SCHLEDE2 for the CBM-Collaboration — 1 Institut für Kernphysik, WWU Münster — 2 Institut für Kernphysik, Goethe-Universität Frankfurt — 3 Infrastruktur und Rechnersysteme in der Informationsverarbeitung, Goethe-Universität Frankfurt

The Transition Radiation Detector (TRD) of the upcoming CBM experiment will be based on Multi-Wire Proportional Chambers (MWPCs), which are read-out via their segmented cathode pad-planes. The incoming charge from hits is amplified and shaped in the analogue part of the read-out ASICs, i.e. the SPADIC chip. The resulting shaper signals are digitised directly in its integrated sampling ADC. As the transmission function of the shaper is well known, the signal arrival time can be extracted from the transmitted ADC samples with a precision well below the sampling frequency of 16 MHz.

This poster shows implementations of the time value extraction for measured signals, which is used in the chain to TRD hit reconstruction. Different methods, based on a look-up table approach as well as on direct calculation, have been tested on real data from CBM measurements (FAIR phase 0 programme) at the SIS18 accelerator. Implementations for online application of the time extraction in the Common Readout Interface (CRI) FPGA of our system will be covered.

This work is supported by BMBF grants 05P21RFFC1 and 05P21PMFC1.

HK 74.53 Thu 17:30 HSZ EG
Magnetic field dependence of dielectron measurements with ALICE 3 — *ZAPAR MOMTAZ* — for the ALICE Germany-Collaboration — Institut für Kernphysik, Goethe-Universität Frankfurt

Ultra-relativistic heavy-ion collisions are used to study strongly interacting matter under extreme conditions, i.e. high temperature and energy density, where a deconfined state of quarks and gluons is formed and chiral symmetry is expected to be restored. At the LHC, a next-generation heavy-ion experiment, called ALICE 3, is planned beyond the 2030s to address the remaining fundamental questions still open. In particular, ALICE 3 should enable precise measurements of the temperature evolution of the quark-gluon plasma created in heavy-ion collisions via dielectron analyses. Moreover it should allow us to study the mechanisms of chiral symmetry restoration from the spectrum of dielectron created in the medium in the vicinity of the transition temperature via the spectral function of the ρ - meson. In order to achieve these physics goals, the ALICE 3 detector setup would include an ultra-light-tacker, covering the pseudorapidity range of |η| < 4 and installed within a superconducting magnet system.

This poster will show the expected dielectron measurement performance with ALICE 3 for different magnetic fields. In particular, we will focus on the tracking and electron identification efficiencies for different detector configurations and explain how they influence the predicted uncertainties of the temperature measurements of the fireball.

HK 74.54 Thu 17:30 HSZ EG
Development of a Muon Tagger System for the future MuonEDM Experiment — *DHRUV CHOUGHAN, MELIKE AKBÝKÝ, ELISA RUIZ CHOLIZ, FRANCESCO FALLAVOLITA, and MATTHIAS SCHOTT* — Johannes Gutenberg University Mainz, Germany

The future MuonEDM experiment aims to search for an electric dipole moment of the muon based on the frozen-spin technique. With the advent of the new high-intensity muon beam, HIMB, and the cold muon source, muCood, at PSI the sensitivity of the search for the muon EDM could be improved by several orders of magnitudes. In this context, the latest developments on a muon-tagger system for the MuonEDM experiment are discussed. Special focus is drawn on a straw-tube based approach as well as a Micromegas based TPC detector.

HK 75: Members’ Assembly

Time: Thursday 19:00 – 20:00

All members of the Hadronic and Nuclear Physics Division are invited to participate.

HK 76: Invited Talks IV

Time: Friday 11:00 – 12:30

Invited Talk

HK 76.1 Fri 11:00 HSZ/0002
Thermalization of heavy quarks in the QGP — *FEDERICA CAPELLINO* — Physikalisches Institut Heidelberg, Heidelberg, Germany

Heavy-ion collision experiments allow us to study the high-temperature deconfined phase of QCD, the quark-gluon plasma (QGP). Heavy quarks (i.e. charm and beauty) are powerful tools to characterize the transport properties of the QGP. Although they are initially produced out of kinetic equilibrium via hard partonic scattering processes, recent experimental measurements of charmed hadrons pose the question regarding the possible thermalization of heavy quarks in the medium. Exploiting a mapping between transport theory and fluid-
dynamics, we will show how a fluid-dynamic description of the dynamics of charm quarks in the QCD plasma is feasible. Calculations for heavy-flavor observables which assume charm quarks to be in local thermal equilibrium with the plasma will be shown in comparison with experimental data. The model- to-data comparison is a fundamental step towards constraining the spatial- and momentum-diffusion coefficient of the QGP.

Invited Talk

HK 76.2 Fri 11:30 HSZ/0002
Hadron structure in Lattice QCD — Konstantin Ottmaz — PRISMA+
Cluster of Excellence and Institut für Kernphysik, Johannes Gutenberg-Universität Mainz, Germany
Quantum chromodynamics (QCD) at low energies gives rise to a plethora of states as quark and gluons become bound in hadrons. Among these hadronic states are nucleons which account for the bulk part of visible matter in the universe. Due to their dynamical origin they are not pointlike particles but exhibit a rich and complex internal structure which is studied extensively in both experiment and theoretical studies.

Concerning the theoretical side, lattice QCD provides the obvious framework for ab initio hadron structure calculations as it is the only known method to deal with QCD in the non-perturbative regime from first principles. In recent years it has finally become feasible to obtain precise physical results with fully controlled systematics from such lattice calculations of hadron structure observables. Still, this remains a very challenging and computationally expensive endeavour as these calculations are always affected by a notorious signal-to-noise problem that hinders the extraction of groundstate matrix elements.

In this talk I will outline some of the essential methods used to carry out state-of-the-art hadron structure calculations within lattice QCD and discuss recent results from the Mainz group for nucleon matrix elements at zero and nonvanishing momentum transfer.

Invited Talk

HK 76.3 Fri 12:00 HSZ/0002
LISA: Lifetime measurements with Solid Active targets — Kathrin Wimmer
— GSI Helmholtzzentrum für Schwerionenforschung GmbH
The coexistence of single-particle and collective degrees of freedom in atomic nuclei gives rise to various exotic phenomena. In nuclei with very asymmetric proton-to-neutron ratios, the strong nuclear interaction drives shell evolution which alters the orbital spacing, and in some cases even the ordering present in stable nuclei. In the absence of large gaps between orbitals, nuclei can take on non-spherical shapes and their excitations proceed through coherent and collective motion of many nucleons. Where and how collectivity emerges from the single-particle dynamics of protons and neutrons is an open question in nuclear structure physics that will be addressed with LISA in a unique way. The aim of the LISA (Lifetime measurements with Solid Active targets) project is to develop a novel method for lifetime measurements in atomic nuclei. Lifetimes probe the collectivity of a nucleus through its electromagnetic transition properties. The experimental approach is based on active solid targets and will dramatically enhance the scope of measurements of excited-state lifetimes and thus transition probabilities achievable in exotic nuclei. Coupled to state-of-the-art gamma-ray tracking detectors such as AGATA, this novel instrument will overcome the present challenges of lifetimes measurements with low-intensity beams of unstable nuclei. In this talk, I will present an overview of the LISA project and show the potential for future physics experiments at FAIR.
Theoretical and Mathematical Physics Division
Fachverband Theoretische und Mathematische Grundlagen der Physik (MP)

Johanna Erdmenger
Institut für Theoretische Physik und Astrophysik
Julius-Maximilians-Universität Würzburg
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Overview of Invited Talks and Sessions
(Lecture halls ZEU/0250, HSZ/0003, and HSZ/0304; Poster HSZ OG3)

Plenary Talk of the Theoretical and Mathematical Physics Division

PV VIII  Wed  9:00– 9:45  HSZ/AUDI  25 years of the AdS/CFT correspondence: Current status and future prospects — *KOENRAAD SCHALM

Invited Talks

MP 1.1  Mon  11:00–11:30  HSZ/0003  Insights from random matrices on dissipative quantum dynamics — *PEDRO RIBEIRO, LUCAS SÁ, TOMAZ PROSEN
MP 3.1  Tue  11:00–11:30  HSZ/0304  Renormalization of singular stochastic partial differential equations — *Paweł Duch
MP 3.2  Tue  11:30–12:00  HSZ/0304  Integral decomposition of modular operators in QFT — HENNING BOSTELMANN, *DANIELA CADAMURO, KO SANDERS
MP 3.3  Tue  12:00–12:30  HSZ/0304  Emergence of gravity from conformal field theory — *NELE CALLEBAUT
MP 6.2  Wed  11:30–12:00  ZEU/0250  Deep neural networks and the renormalization group — *RO JEFFERSON, JOHANNA ERDMENGER, KEVIN GROSVENOR

Sessions

MP 1.1–1.4  Mon  11:00–12:30  HSZ/0003  Quantum Dynamics and Quantum Information
MP 2.1–2.4  Mon  16:30–18:00  ZEU/0250  Quantum Field Theory I
MP 3.1–3.3  Tue  11:00–12:30  HSZ/0304  Quantum Field Theory II
MP 4.1–4.3  Tue  10:30–14:00  HSZ OG3  Poster
MP 5.1–5.6  Tue  17:00–19:00  ZEU/0250  Scattering Amplitudes and Conformal Field Theory
MP 6.1–6.3  Wed  11:00–12:20  ZEU/0250  AI Topical Day – Neural Networks and Computational Complexity (joint session MP/AKPIK)
MP 7.1–7.4  Wed  14:00–15:20  ZEU/0250  Classical and Quantum Gravity
MP 8  Wed  16:00–17:30  ZEU/0250  Members’ Assembly
MP 9.1–9.4  Thu  11:00–12:30  ZEU/0250  AdS/CFT Correspondence and Hydrodynamic Transport
MP 10.1–10.4  Thu  14:00–15:20  ZEU/0250  AdS/CFT Correspondence II
MP 11.1–11.3  Thu  16:00–17:00  ZEU/0250  Quantum Field Theory III (QED and Particle Detection)
MP 12.1–12.2  Thu  17:05–17:45  ZEU/0250  Quantengravitation und Thermodynamik

Members’ Assembly of the Theoretical and Mathematical Physics Division

Wednesday  16:00-17:30  ZEU/0250
• Report
• Elections
• Any other business
Insights from random matrices on dissipative quantum dynamics — PEDRO RIBEIRO, LUCAS SI, and TOMAZ PROSEN — CeFEMA, Instituto Superior Tecnico, Lisbon, Portugal — University of Ljubljana, Ljubljana, Slovenia

Understanding the dissipative dynamics of complex quantum systems is essential to describe quantum matter at large time scales. However, even within a simplified Markovian description, studying the spectral and steady-state properties of Lindblad operators remains a challenging task.

In this talk, we present some novel insights into universal features of generic open quantum systems under Markovian dissipation by using ensemble averaging based on (non-Hermitian) random matrices. We will examine three representative cases: quadratic Liouvillians, dissipative SYK models, and fully random Liouvillian operators. For this last example, we will present a recent systematic classification of many-body Lindblad superoperators based on the properties of the Lindbladian under antisymmetry and unitary involutions.

Markovianity in Quantum Thermodynamics — FREDRIK VON ENDE, EMANUEL MALVETTI, GOTTFRIED DÖRRE, and THOMAS SCHULTE-HERBRÜGGEN — 1Dahlem Center for Complex Quantum Systems, Freie Universität Berlin, 14195 Berlin, Germany — 2Department of Chemistry, Technische Universität München, Lichtenbergstr. 4, 85737 Garching, Germany — 3Munich Centre for Quantum Science and Technology & Munich Quantum Valley, Schellingstr. 4, 80799 Munich, Germany

In quantum thermodynamics thermal operations are considered free. We want to understand which states are reachable from a given initial state using thermal operations. We study the quasi-classical case of diagonal states, where the problem reduces to understanding the thermomajorization polytope. In particular, we are interested in degeneracies of this polytope and its connection to the polytope of Gibbs-stochastic matrices.
We consider the massless Sine–Gordon model in the finite regime $\beta^2 < 4\pi$ of the theory. We prove convergence of the renormalised perturbative series for the interacting stress tensor defined using the Bogoliubov formula in an arbitrary Hadamard state, even for the case that the smearing is only along a one-dimensional time-like worldline and not in space-time. We then show that the interacting energy density, as seen by an observer following this worldline, satisfies an absolute lower bound, that is a bound independent of the quantum state. Our proof employs and generalises existing techniques developed for free theories by Flanagan, Fewster and Smith.

**MP 3: Quantum Field Theory II**

**Invited Talk**

**MP 3.1 Tue 11:00 HSZ/0304**

**Renormalization of singular stochastic partial differential equations**

- **Pawel Duch** — Adam Mickiewicz University, Poznan, Poland

Stochastic PDEs, i.e. partial differential equation with random terms or coefficients, play an important role in mathematical physics and have applications in areas such as quantum field theory, statistical mechanics and material science. Well-known examples of stochastic PDEs are the KPZ equation describing the motion of a growing interface or the stochastic quantization equation of the $\Phi^4$ Euclidean QFT. Most of the interesting non-linear stochastic PDEs, including the ones mentioned above, are too singular to admit classical treatment. Solving such equations poses a formidable challenge and usually requires the regularisation and renormalization of the equation.

After giving a brief overview of the tremendous progress in the area of singular stochastic PDEs in the past decade, I will present a novel approach to such PDEs proposed in my recent work. The approach uses the framework of the Wilsonian renormalization group theory and is based on a certain flow equation that plays an analogous role to the Polchinski equation in QFT. The approach allows to solve a large class of singular stochastic PDEs in a systematic manner and avoids algebraic and combinatorial problems arising in different approaches.

**Invited Talk**

**MP 3.2 Tue 11:30 HSZ/0304**

**Integral decomposition of modular operators in QFT** — Henning Bostelmann, Daniela Cadamuro, and Ko Sanders — 1Department of Mathematics, University of York, UK — 2Institute for Theoretical Physics, University of Leipzig, Germany — 3Department of Mathematics, FAU Erlangen-Nürnberg

The Tomita-Takesaki modular operator of local algebras (or, in linear field theories, of standard subspaces) is a structurally important concept in quantum field theory; unfortunately little can be said about its explicit form in most concrete situations. We develop a general decomposition theory for standard subspaces along direct integrals, making some new examples available to explicit treatment.

**Invited Talk**

**MP 3.3 Tue 12:00 HSZ/0304**

**Emergence of gravity from conformal field theory** — Nele Callebaut — Institute for Theoretical Physics, University of Cologne

I will discuss several mechanisms by which gravity emerges from conformal field theory: through holography, entanglement dynamics or irrelevant deformations.

**MP 4: Poster**

**MP 4.1 Tue 10:30 HSZ OG3**

**Nonlinear Compton scattering and nonlinear Breit-Wheeler pair production including the damping of particle states**

- **Tobias Podzuzus**, Victor Dincu, and Antonino Di Piazza — Max Planck Institute for Nuclear Physics, Heidelberg, Germany — Department of Physics, University of Bucharest, Romania

In the presence of an electromagnetic background plane-wave field, electron, positron, and photon states are not stable, because electrons and positrons emit photons and photons decay into electron-positron pairs. This decay of the particle states leads to an exponential damping term in the probabilities of single nonlinear Compton scattering and nonlinear Breit-Wheeler pair production. We present analytical and numerical investigations for the probabilities of nonlinear Compton scattering and nonlinear Breit-Wheeler pair production including the particle states decay. For this we first give new spin- and polarization-resolved expressions of the probabilities, verify that they are gauge invariant, provide some of their asymptotic behaviors, and show that the results of the total probabilities are independent of the spin and polarization bases. In plots from numerical computations we observe that it is crucial to take into account the damping of the states in order the probabilities to stay always below unity and we show that the damping factors also scale with the pulse duration of the background field. In the case of nonlinear Compton scattering we show numerically that the total probability behaves like a Poissonian distribution for sufficiently low initial electron energies such that the photon recoil is negligible.

**MP 4.2 Tue 10:30 HSZ OG3**

**Exploring anomalies by many-body correlations**

- **Klaus Morawetz** — Münster University of Applied Sciences, Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics - UFRN, Campus Universitario Lagoa nova,59078-970 Natal, Brazil

The quantum anomaly can be written alternatively into a form violating conservation laws or as non-gauge invariant currents seen explicitly on the example of chiral anomaly. By interpreting the many-body averaging, the connection to Pauli-Villars regularization is established which gives the anomalous term a new interpretation as arising from quantum fluctuations by many-body correlations at short distances. This is exemplified by using an effective many-body quantum potential which realizes quantum Slater sums by classical calculations. It is shown that these quantum potentials avoid the quantum anomaly but approaches the same anomalous result by many-body correlations. A measure for the quality of quantum potentials is suggested to describe these quantum fluctuations in the mean energy. Consequently quantum anomalies might be a short-cut way of single-particle field theory to account for many-body effects. This conjecture is also supported since the chiral anomaly can be derived by a completely conserving quantum kinetic theory. [Eur. Phys. J. B 92 (2019) 176, Phys. Lett. A 383 (2019) 1362, Phys. Status Solidi B (2021) 2100316]

**MP 4.3 Tue 10:30 HSZ OG3**

**Correlational entropy by nonlocal quantum kinetic theory**

- **Klaus Morawetz** — Münster University of Applied Sciences, Stegerwaldstrasse 39, 48565 Steinfurt, Germany — International Institute of Physics- UFRN, Campus Universitário Lagoa nova,59078-970 Natal, Brazil

Time: Tuesday 17:00–19:00

**MP 5.1** Tue 17:00 ZEU/0250

**One-loop six-particle Feynman integral to higher orders in dimensional regulator** — **JOHANNES M. HENN**, **ANTONELLA MATIJAŠIĆ**, and **JULIAN MICZKA**

Max-Planck-Institut für Physik, Werner-Heisenberg-Institut, 80805 München, Germany

The state-of-the-art in current two-loop QCD amplitude calculations is at five-particle scattering. In contrast, very little is known about present two-loop six-particle scattering processes. Computing two-loop six-particle processes requires knowledge of the corresponding one-loop amplitudes to higher orders in the dimensional regulator. In this talk, I will show the analytic results for the one-loop hexagon integral to higher orders in dimensional regulator obtained via differential equations. I will discuss the function alphabet for general D–dimensional external states, function space up to weight two and one–fold integral representation up to weight four for all integrals in the integral basis. Finally, I will discuss the difference between the conventional dimensional regularization and the four–dimensional helicity scheme at the level of the master integrals. With this, the one–loop integral basis is ready for two–loop amplitude applications.

**MP 5.2** Tue 17:20 ZEU/0250

**new results from computing planar and non-planar three-loop integrals for Higgs plus jet process** — **JUNGWON LIM**

Max Planck Institute for Physics, Munich, Germany

We present new results for Feynman integrals relevant to Higgs plus jet production at three loops, including first results for a non-planar class of integrals. The results are expressed in terms of generalized polylogarithms up to transcendental weight six. We also provide the full canonical differential equations, which allows us to make structural observations on the answer. In particular, find a counterexample to previously conjectured adjacency relations, for a planar integral of the tennis court type. Moreover, for a non-planar triple ladder diagram, we find two novel alphabet letters. This information may be useful for future bootstrap approaches.

**MP 5.3** Tue 17:40 ZEU/0250

**Gravitational Waves from Worldline Quantum Field Theory** — **GUSTAV MODUŁI**

Institut für Physik und IRIS Adlershof, Humboldt-Universität zu Berlin, Zum Großen Windkanal 2, 12489 Berlin, Germany — Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Am Mühlenberg 1, 14476 Potsdam, Germany

Following the groundbreaking first detection by both LIGO observatories (Hanford/Livingston) of gravitational waves in 2015, a new era of gravitational wave astronomy has begun. The waves strong enough for us to detect on Earth are caused by the orbit, deceleration and eventual merger of pairs of extremely massive objects: primarily black holes, but also neutron stars. We aim to model these binary mergers mathematically, so that we may predict the gravitational waves emitted and thus learn about the black holes and neutron stars themselves — how they form, their internal composition - and Einstein's theory of gravity.

The Worldline Quantum Field Theory (WQFT) is a new formalism that we have developed, using tools and technologies from QFT to describe these gravitational merger events. The gravitational two-body problem is remarkably similar to our description of fundamental particles scattering in collider experiments such as CERN's Large Hadron Collider (LHC), and there is considerable overlap in our theoretical descriptions of these events. In this talk I will discuss the WQFT's fundamentals, its applications to gravitational wave physics and its supersymmetric extension to describe spinning black holes and neutron stars.

**MP 5.4** Tue 18:00 ZEU/0250

**Non-supersymmetric string backgrounds** — **IUS ZADEH**

Max Planck Institute for Theoretical Physics, Mainz, Germany

New constructions of non-supersymmetric backgrounds arising from compactifications of superstring theories on Ricci-flat compact manifolds will be discussed. Such constructions give new insights on properties of quantum gravity. I will discuss the problem within the framework of conformal field theories, namely the exact string worldsheet description. We will see how the conformal field theories deliver novel descriptions of the underlying semi-classical field theories and their associated moduli (parameter) spaces.

**MP 5.5** Tue 18:20 ZEU/0250

**Torus Conformal Blocks of 2D Conformal Field Theories** — **JACOB HOLLWEEK**

Theoretisch-Physikalisches Institut, Jena, Germany

We compute higher point sl(2,R) conformal blocks on different topologies like the sphere and the torus. The usual methods, like the direct use of the Casimir equations, shadow operator representations, or successive use of the operator product expansion, quickly become complicated for higher point conformal blocks. The use of oscillator representations reproduces the known results and applies further insights, like the construction of (semi-classical) Virasoro conformal blocks, or conformal blocks in higher dimensions than two, which have recently spiked in interest.

**MP 5.6** Tue 18:40 ZEU/0250

**Quantum energy inequalities in integrable models with bound states and several particle species** — **JAN MÄDRYSCH**, **DANIELA CADAMURO**, and **HENNING BOSTELMANN**

1 Institute for Theoretical Physics, Uni Leipzig — 2 Department of Mathematics, University of York, United Kingdom

In quantum theory negative energy densities appear and should be constrained in physically reasonable models. Otherwise, one expects instabilities and violations of the 2nd law of thermodynamics.

I present lower bounds of the time-smeared energy density, so-called quantum energy inequalities (QEI), in the class of integrable quantum field theory models. Our main results are a state-independent QEI for interactions which have a constant scattering function and a QEI at one-particle level for generic models including bound states and several particle species. Examples include the Bullough-Dodd, the Federbush, and the O(n)-nonlinear sigma model.

Time: Wednesday 11:00–12:20

**MP 6.1** Wed 11:00 ZEU/0250

**A universal approach to state and operator complexities** — **SOUVICK BANERJEE** and **MOSEN ALISHAHE**

1 Julius-Maximilians-Universität Würzburg, Würzburg, Germany — 1 IPM, Tehran, Iran

In this talk, I shall present a general framework in which both Krylov state and operator complexities can be put on the same footing. In our formalism, the Krylov complexity is defined in terms of the density matrix of the associated state which, for the operator complexity, lives on a doubled Hilbert space obtained through the channel-state map. This unified definition of complexity in terms of the density matrices enables us to extend the notion of Krylov complexity, to subregion or mixed state complexities and also naturally to the Krylov mutual complexity. We show that this framework also encompasses nicely, the holographic notions of complexity and explains the universal late-time growth of complexity, followed by a saturation.

**Invited Talk**

**MP 6.2** Wed 11:30 ZEU/0250

**Deep neural networks and the renormalization group** — **RO JEFFERSON**, **JOHANNA ERMENGER**, and **KEVIN GROVENOR**

1 Utrecht University — 2 University of Würzburg — 3 Leiden University

Despite the success of deep neural networks (DNNs) on an impressive range of tasks, they are generally treated as black boxes, with performance relying on heuristics and trial-and-error rather than any explanatory theoretical framework. Recently however, techniques and ideas from physics have been applied to DNNs in the hopes of distilling the underlying fundamental principles. In this talk, I will discuss some interesting parallels between DNNs and the renormalization group (RG). I will briefly review RG in the context of a simple lattice model, where subsequent RG steps are analogous to subsequent layers in a DNN, in that effective interactions arise after marginalizing hidden degrees of freedom/neurons. I will then quantify the intuitive idea that information is lost along the RG flow by computing the relative entropy in both the Ising model and a feedforward DNN. One finds qualitatively identical behaviour in both systems, in which the relative entropy increases monotonically to some asymptotic value. On the QFT side, this confirms the link between relative entropy and the c-theorem, while for machine learning, it may have implications for various information maximization methods, as well as disentangling compactness and generalizability.

**MP 6.3** Wed 12:00 ZEU/0250

**Analytic continuation of Greens' functions using neural networks** — **JOHANNA ERMENGER**, **RENÉ MEYER**, **MARTEN RACEL**, and **YANNICK THURN**

1 JMU Würzburg

In quantum-many-body physics, the analytic continuation of Greens' functions is a well-known problem. The problem is ill-posed in the sense that the transforma-


tion kernel becomes chaotic for large energies and thus small noise creates huge differences in the resulting spectral density function. Some techniques in the field of machine learning, in particular neural networks, are known for handling this kind of problem. Using a neural network and for the problem-optimized loss functions and hyperparameters, a network is trained to determine the spectral density from the imaginary part of the Greens function given by quantum Monte Carlo simulations. The network is able to recover the overall form of the spectral density function, even without adding constraints such as normalization and positive definiteness. There is no need to encode these constraints as regularizations since they are reflected automatically by the solution provided by the network. This indicates the correctness of the inversion kernel learned by the neural network. In the talk, I will explain the structure of the methods used to train the network and highlight the central results.

MP 7: Classical and Quantum Gravity

Time: Wednesday 14:00–15:20 Location: ZEU/0250

**MP 7.1 Wed 14:00 ZEU/0250**

**Geometry of charged rotating discs of dust in Einstein-Maxwell theory**
- David Riumler — Friedrich-Schiller-Universität Jena, Germany

Within the framework of Einstein-Maxwell theory geometric properties of charged rotating discs of dust, using a post-Newtonian expansion up to tenth order, are discussed. Investigating the disc's proper radius and the proper circumference allows us to address questions related to the Ehrenfest paradox. In the Newtonian limit there is an agreement with a rotating disc from special relativity. The charged rotating disc of dust also possesses material-like properties. A fundamental geometric property of the disc is its Gaussian curvature. The result obtained for the charged rotating disc of dust is checked by additionally calculating the Gaussian curvature of the analytic limiting cases (charged rotating) Maclaurin disc, electrically counterpoised dust-disc and uncharged rotating disc of dust. We find that by increasing the disc's specific charge there occurs a transition from negative to positive curvature.

**MP 7.2 Wed 14:20 ZEU/0250**

**A geometric view on local Lorentz transformations in teleparallel gravity**
- Manuel Höhmann — University of Tartu, Estonia

Local Lorentz transformations play an important role in teleparallel gravity theories, in which a tetrad is conventionally employed as a fundamental field variable describing the gravitational field. It is commonly understood that modifications of general relativity in the teleparallel framework break a certain notion of local Lorentz invariance, which is present in the pure tetrad formulation of such theories, while another notion present in the covariant formulation is preserved. We illuminate these different notions from a geometric perspective, and distinguish them from what is commonly understood as breaking of local Lorentz invariance in the context of gravity phenomenology. Based on physical arguments, we present a geometric interpretation of the dynamical fields in teleparallel gravity, which unifies and refines the conventional approaches.

**MP 7.3 Wed 14:40 ZEU/0250**

**Investigating Quantum Field Theory on Curved Spaces through Quantum Simulation**
- Christian Friedrich Schmidt — Theoretisch-Physikalisches Institut, Jena, Deutschland

In recent years, high-energy-phenomena like Hawking radiation or cosmological particle creation have been successfully simulated in laboratories by means of so-called quantum simulators. A prominent example among these are Bose-Einstein condensates, in which low-energetic (acoustic) fluctuations of the condensate wavefunction behave like a scalar quantum field on a curved spacetime. Excitations of this field are realized as phonons, which experience an effective, gravitational field set by the condensate background. The curved geometry is essentially realized through a time- and space-dependent speed of sound. In particular, a stationary background condensate yields an FLRW metric. Hence, this analogy gives an exciting opportunity to study phenomena of quantum fields in cosmological and also more general spacetimes in a controllable, experimental setup.

**MP 7.4 Wed 15:00 ZEU/0250**

**Wilson Line approach to gravitational scattering of spinning particles**
- Domenico Borocore, Anna Kleber, Johannes Pirsch — Theoretische Elementarteilchenphysik, TUM, Munich, Germany — Institut für Theoretische Physik, WWU Münster, Münster, Germany

Wilson lines provide a useful tool to reveal the all-order structure of scattering amplitudes. Recently it has been shown how a generalization that takes into account subleading eikonal effects (hence known as Generalized Wilson Line or GWL) clarifies the connection between the soft expansion in the Regge limit and the Post-Minkowskian expansion in the classical limit. In this talk I will discuss the derivation of the spin 1/2 GWL starting from a N=1 supersymmetric worldline model. The resulting path integral expression exhibits a clear separation between purely classical and quantum contributions, which can conveniently be computed using Feynman diagrams in position space. Using this result, we are able to derive Low's soft theorems for off-shell gravitons and compute classical observables for spinning compact binaries.

MP 8: Members’ Assembly

Time: Wednesday 16:00–17:30 Location: ZEU/0250

All members of the Theoretical and Mathematical Physics Division are invited to participate.

MP 9: AdS/CFT Correspondence and Hydrodynamic Transport

Time: Thursday 11:00–12:30 Location: ZEU/0250

**MP 9.1 Thu 11:00 ZEU/0250**

**Ultraviole-regulated theory of non-linear diffusion**
- Matthias Kaminski and Navid Abbasi — University of Alabama, Tuscaloosa, AL, U.S.A. — School of Nuclear Science and Technology; Lanzhou University, Lanzhou, China

In a system with a single conservation law the inverse relaxation time plays the role of an ultraviolet (UV) regulator for the low energy diffusion of the conserved charge. In order to calculate renormalization effects through self-interactions stemming from fluctuations in such a system, we include the slowest non-conserved UV mode which relaxes at a system-specific relaxation time. Quantum fluctuations are computed in addition to statistical fluctuations for the first time in this framework. We show that the relaxation time is protected from renormalization while the diffusion constant is renormalized independent of the UV mode. Furthermore, the retarded Green’s function acquires four branch points, corresponding to threshold energies for generation of double-mode states from single diffusion or single UV modes. We report on the fate of these time tails in the current-current correlator, the dynamic susceptibility, and the conductivity. These results are relevant for the high temperature Hubbard model and also for the quark gluon plasma droplet near the critical point of quantum chromodynamics.

**MP 9.2 Thu 11:30 ZEU/0250**

**Obtaining Transport Coefficients from Functional Renormalization Group Methods**
- Tim Stötzel, Lars Heyen, and Stefan Flörchinger — Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, Max-Wien-Platz 1, 07743 Jena, Germany — Institut für Theoretische Physik, Universität Heidelberg, Philosophenweg 16, 69120 Heidelberg, Germany

The description of transport processes requires knowledge of their respective transport coefficients like viscosities or conductivities. Determining these quantities from a first principle approach can be done by the use of quantum field theories. We make use of the well known Kubo formulas and apply them to a field theory at finite temperature in a non-perturbative approach. The transport coefficients can be derived by the use of renormalization group flow equations resulting in a flow equation for the near-equilibrium coefficients.
The method is applied to a massive, self-interacting scalar field and the shear viscosity is calculated for this toy model at finite temperature. We show a possible truncation ansatz for the Wetterich equation that generates a flow of the shear viscosity coefficient and comment on its relation to the properties of the microscopic theory.

**Critical and near-critical relaxation of holographic superfluids** — MARIO FLORE1, SEBASTIAN GRIENINGER2, and SERGIO MORALESTEBERA1,2—-Institute of Theoretical Physics, Jagiellonian University, Lojasiewicza 11, 30-348 Krakow, Poland — Center for Nuclear Theory, Department of Physics and Astronomy, Stony Brook University, NY 11794-3800, USA — 1Instituto de Fisica Teorica UAM-CSIC, c/ Nicolas Cabrera 13-15, 28049, Madrid, Spain

We investigate the relaxation of holographic superfluids after quenches, when the end state is either tuned to be exactly at the critical point, or very close to it. By solving the bulk equations of motion numerically, we demonstrate that in the former case the system exhibits a power law falloff as well as an emergent discrete scale invariance. The later case is in the regime dominated by critical slowing down, and we show that there is an intermediate time-range before the onset of late time exponential falloff, where the system behaves similarly to the critical point with its power law falloff. We further postulate a phenomenological Gross-Pitaevskii-like equation that is able to make quantitative predictions for the behaviour of the holographic superfluid after near-critical quenches.

**Towards Explicit Discrete Holography: Aperiodic Spin Chains from Hyperbolic Tiling** — PABLO BASTIERO, RATHINDRA NATH DAS, GIUSEPPE DI GIULIO, JOHANNA ERMENGER, JONATHAN KARL, RENÉ MEYER, and ZHUO-YU XIAN — Julius-Maximilians-Universität Würzburg

The AdS/CFT correspondence is one of the most important breakthroughs of the last decades in theoretical physics. A recently proposed way to get insights on various features of this duality is by discretizing the Anti-de Sitter spacetime. Within this program, we consider the Poincaré disk and we discretize it by introducing a regular hyperbolic tiling on it. The features of this discretization are expected to be identified in the quantum theory living on the boundary of the hyperbolic tiling. In this talk, we discuss how a class of boundary Hamiltonians can be naturally obtained in this discrete geometry via an inflation rule that allows constructing the tiling using concentric layers of tiles. The models in this class are aperiodic spin chains. Using strong-disorder renormalization group techniques, we study the entanglement entropy of these boundary theories, identifying a logarithmic growth in the subsystem size, with a coefficient depending on the bulk discretization parameters.

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**MP 10: AdS/CFT Correspondence II**

**Time:** Thursday 14:00–15:20

**Location:** ZEU/0250

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**MP 10.1 Thu 14:00 ZEU/0250**

Towards a Quantum Chaotic Dual of JT Gravity — JABIERI HANEDER, TORSTEN WEBER, CAMILO MORENO, JUAN DIEGO URBINA, and KLAUS RICHTER — Universität Regensburg, Germany

Jackiw-Teitelboim (JT) quantum gravity is a two-dimensional model that has received a striking amount of attention in recent years as a simple example of holography, given its duality to the low-energy regime of the SYK model, as well as full perturbative equivalence to a matrix model found by Saad, Shenker and Stanford. We take first steps towards establishing a further duality between JT gravity and the chaotic quantum dynamics of a particle on a high dimensional compact manifold of constant negative curvature. The presence of a single system, instead of an ensemble, on the non-gravitational side of the duality allows us to identify possible degrees of freedom and corresponding mechanisms responsible for the quantum-chaotic features in JT gravity. We address key aspects of JT correlation functions by showing how the Schwarzian density of states, which bridges quantum gravity and disordered systems, such as SYK, is identical to the Weyl (smooth) term of the Selberg trace formula describing exactly the quantum spectrum on the compact manifold. Time permitting, we use periodic orbit theory to derive an effective trace formula over coarse-grained bundles of geodesics, and show that it admits a genus expansion structurally identical to the JT correlators.

**MP 10.2 Thu 14:20 ZEU/0250**

Aspects of Holography in Three-Dimensional Asymptotically Flat Spacetimes — MICHEL PANNNER — FSU Jena

A well-studied realisation of the Holographic Principle is provided by the AdS/CFT duality. However, holography is expected to hold in rather general circumstances and should be extended to different examples, such as models containing asymptotically de Sitter or flat space-times. The latter is the idea of the talk, in particular focusing on the introduction of propagating, massive degrees of freedom to an otherwise purely topological three-dimensional theory of gravity. Particular emphasis is laid on the utilisation of techniques that are known from the study of higher-spin gravity as a Chern-Simons gauge theory.

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**MP 11: Quantum Field Theory III (QED and Particle Detection)**

**Time:** Thursday 16:00–17:00

**Location:** ZEU/0250

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**MP 11.1 Thu 16:00 ZEU/0250**

Asymptotic Completeness and Particle Detectors in Quantum Field Theory — JANIK KRUZE — Adam Mickiewicz University in Poznań, Poland

A quantum field theory is asymptotically complete if every quantum state is a scattering state (i.e. a state that allows a particle interpretation). A physical criterion that is known to be necessary and sufficient for asymptotic completeness is the detector criterion: A quantum field theory is asymptotically complete if and only if every quantum state causes a click in some particle detector. In this talk, I will explain why particle detectors do not detect non-scattering states and how this result could be used to characterise asymptotically complete theories by more fundamental criteria than the detector criterion.
Electron–Positron Pair Production in High-Intensity Electromagnetic Fields — Christian Kohlfürst1, Naser Ahmadinia2, Johannes Oertel3, and Ralf Schützhold4,5 — 1Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Germany — 2Universität Duisburg-Essen, 47057 Duisburg, Germany — 3Technische Universität Dresden, 01062 Dresden, Germany

In ultra-strong electric fields energy in terms of photons can be converted into electrons and positrons. We introduce a novel approach to calculate the mean particle number in collisions of short-pulsed laser fields. In this regard, we further discuss the different regimes of pair production in terms of their unique signatures in particle phase-space and relate our findings to currently ongoing experiments.


MP 12: Quantengravitation und Thermodynamik

Time: Thursday 17:05–17:45

Allgemeine Gastheorie vs. kinetische Gastheorie — Grétt Kalíes1, Steffen Arnrich2 and Duong D. Do2 — 1Universität des Saarlandes, Saarbrücken, Germany — 2HTW University of Applied Sciences, Dresden, Germany


Overview of Invited Talks and Sessions

(Lecture halls CHE/0089 and CHE/0091; Poster HSZ EG)

Invited Talks

P 1.1 Mon 11:00–11:30 CHE/0089  Ion Beam Sputter Deposition – Fundamentals and Applications  — •Carsten BUndesmann

P 2.1 Mon 11:00–11:30 CHE/0091  Deuterium-Tritium Plasmas at JET with ITER-like Wall and the Role of Isotope Mass and Transport for H-mode Access — •Gregor Birkenmeier, JET Contributors

P 5.1 Tue 11:00–11:30 CHE/0089  Diagnostics of metal-grid micro cavity plasma arrays — •Marc Böke, David Steuier, Sebastian Dzikowski, Henrik van Impel, Volker Schulz-von der Gathen, Judith Golda

P 6.1 Tue 11:00–11:30 CHE/0091  The physics of ELM-free regimes — •Michael Dunne, Michael Faitsch, Georg Harrer, Lidija Radovanovic, Wolfgang Suttrop, Eleonora Viezzer, Matthias Willensdorfer, Elisabeth Wolfrum

P 8.1 Tue 17:00–17:30 CHE/0091  Fuel retention and removal in the JET tokamak — •Dmitry Matveev, David Douai, Tom Wauters, Sebastian Brezinsek, JET Contributors

P 9.1 Wed 11:00–11:30 CHE/0089  Modelling and analysis of single-filament dielectric barrier discharges at atmospheric pressure — •Markus M. Becker, Ronny Brandenburg, Tomáš Hoder, Hans Höft, Aleksandar P. Jovanović, Detlef Loffhagen

P 10.1 Wed 11:00–11:30 CHE/0091  Diagnosing the plasma edge with helium beam spectroscopy — •Michael Grieener, the ASDEX Upgrade Team

P 13.1 Thu 11:00–11:30 CHE/0089  Acceleration of spin-polarized ion beams from laser-plasma interaction — •Lars Reichwein, Markus Büscher, Alexander Pukhov
Experimental validation of turbulence codes — • Klara Höfler
Tumor irradiation in mice with a laser-accelerated proton beam — • Florian Kroll, Florian-Emanuel Brack, Elke Beyreuther, Thomas Cowan, Leonhard Karsch, Josefine Metzkes-Ng, Jörg Pawelke, Marvin Reimold, Ulrich Schramm, Tim Ziegler, Karl Zeil
Numerical and experimental investigations of a linear microwave plasma source for metal foil pumps for DEMO — • Stefan Merli, Andreas Schulz, Matthias Walker, Yannick Kathage, Stefan Hanke, Christian Day, Günther Tovar
Laser-Induced Breakdown Spectroscopy (LIBS) for the detection of hydrogen isotopes stored in high-Z metals tungsten and tantalum — • Steffen Mittelmann, Kévin Touchet, Xianglei Mao, Minok Park, Vassilia Zorba, Sebastian Brezinsek, Georg Pretzler

Sessions

P 1.1–1.6 Mon 11:00–12:45 CHE/0089 Low Pressure Plasmas and their Application I
P 2.1–2.5 Mon 11:00–13:10 CHE/0091 Magnetic Confinement I/HEPP I
P 3.1–3.5 Mon 16:30–17:45 CHE/0089 Astrophysical Plasmas
P 4.1–4.5 Mon 16:30–18:35 CHE/0091 HEPP II
P 5.1–5.7 Tue 11:00–13:00 CHE/0089 Atmospheric Pressure Plasmas and their Applications I
P 6.1–6.5 Tue 11:00–12:50 CHE/0091 Magnetic Confinement II/HEPP III
P 7.1–7.8 Tue 17:00–19:00 CHE/0091 Atmospheric Pressure Plasmas and their Applications III
P 8.1–8.7 Tue 17:00–19:10 CHE/0091 Plasma Wall Interaction I/HEPP IV
P 9.1–9.7 Wed 11:00–13:00 CHE/0091 Atmospheric Pressure Plasmas and their Applications III
P 10.1–10.5 Wed 11:00–13:10 CHE/0091 Magnetic Confinement III/HEPP V
P 11.1–11.48 Wed 14:00–15:30 HSZ EG Poster I
P 12.1–12.45 Wed 17:30–19:00 HSZ EG Poster II
P 13.1–13.7 Thu 11:00–13:00 CHE/0089 Laser Plasmas I
P 14.1–14.5 Thu 11:00–13:10 CHE/0091 Magnetic Confinement IV/HEPP VI
P 15.1–15.5 Thu 14:00–15:30 CHE/0089 Laser Plasmas II/Low Pressure Plasmas and their Applications II
P 16.1–16.5 Thu 14:00–15:30 CHE/0091 Plasma Wall Interaction II/Codes and Modeling I
P 17.1–17.6 Thu 15:45–17:15 CHE/0089 Complex Plasmas and Dusty Plasmas/Codes and Modeling II
P 18.1–18.3 Thu 15:45–17:00 CHE/0091 HEPP VII
P 19.1–19.3 Thu 17:30–18:40 CHE/0089 Magnetic Confinement V/HEPP VIII
P 20.1–20.4 Thu 17:30–18:45 CHE/0091 Laser Plasmas III/Codes and Modeling III
P 21 Thu 19:00–20:00 CHE/0089 Members’ Assembly

Members’ Assembly of the Plasma Physics Division (Mitgliederversammlung P)

Donnerstag, 23.03.23 19:00–20:00 Raum CHE/0089

- Bericht
- Wahl neuer Fachbeiratsmitglieder
- Tagung 2024, Verschiedenes
Experimental validation of a 0-D computational model for characterisation of double inductively coupled plasma — L. Jendersmy, M. Osa Engelbrecht, H. Hylla, I. Korolov, D. Filia, L. Schücker, C. P. Ridges, P. Awakowicz, and A. R. Gibson — Chair of Applied Electro-dynamics and Plasma Technology, Ruhr-University Bochum, Bochum, Germany — Research Group for Biomedical Plasma Technology, Ruhr-University Bochum, Bochum, Germany — York Plasma Institute, Department of Physics, University of York, York, UK

A double inductively coupled plasma is studied to be compared to 0-D plasma chemical kinetics simulations. A focus is placed on oxygen-containing gas mixtures due to their ability to produce large fluxes of reactive species such as atomic oxygen and UV photons. Various experimental diagnostic methods are applied. A multipole resonance probe is used to measure electron densities and electron temperature by using a time-of-flight technique. Time-resolved, tuneable diode laser absorption spectroscopy is used to determine the absolute intensities of different O transitions. These values are compared to those obtained from a 0-D computational model. The model includes electron densities and a collisional radiative treatment of excited states of O. It is then used to provide information on the flux of photons at 130 and 135 nm. This work was funded by DFG project "Plasma inactivation of microbial Biofilms", project number 429427143.

Investigating capacitively coupled radio frequency Ar/CF\textsubscript{4} discharges using a hybrid PIC/MCC simulation — Katharina Nösges, Maximilian Klisch, Sebastian Wlczek, and Thomas Musienbrock — Ruhr University Bochum, Germany

Capacitively coupled radio frequency (CCRF) discharges are used in many dry etching processes in the semiconductor industry to realize micro- and nanometer-scale electronics. Low pressures of a few Pascal and voltages of about hundreds of volts are required to ensure anisotropic ion bombardment. Especially carbon tetrafluoride (CF\textsubscript{4}) and mixed (Ar/CF\textsubscript{4}) discharges are particularly important for etching. These discharges are investigated using a one-dimensional hybrid particle-in-cell/Monte Carlo simulations (PIC/MCC) simulation in the low-pressure regime (p = 6.67 Pa) with the inclusion of realistic particle-surface interactions. This approach considers the electrons kinetically and simultaneously solves the continuity equation based on the drift-diffusion approximation for all ion species. The transport coefficients, as well as the rate coefficients, can be determined with the help of swarm simulations. A closed group of particles moves in a background gas influenced by an externally applied constant electric field. The collective behavior gives information about transport features and collision probabilities. A variation of the electrode gap size and the applied voltage is then presented as a control tool to alter the discharge dynamics significantly. Additionally, it is shown that surface coefficients (i.e., electron reflection, and secondary electron emission) play a significant role.

P 1: Low Pressure Plasmas and their Application I

Invited Talk

1. Mon 11:00 CHE/0089

Ion Beam Sputter Deposition – Fundamentals and Applications — Carsten Buddensieg — Leibniz Institute of Surface Engineering (IOM), Leipzig

There is an increasing demand for thin films with tailored properties, which requires the use and control of adequate deposition techniques. Ion beam sputter deposition (IBSD) is a PVD technique that is capable of fulfilling the technological challenges. It is based on ion-solid interaction: A low-energy ion beam (Eion = 2000 eV) is directed onto a target. The target particles get sputtered due to energy and momentum transfer [1]. These particles condense on a substrate and a film is growing (see Fig. 1). In addition, scattered primary particles and reactive background gas particles may contribute to thin film growth. In comparison to other PVD techniques, IBSD offers a unique opportunity to tailor angular-dependent energy and flux of the film-forming particles and, hence, thin film properties by changing ion beam parameters (ion species and ion energy) and geometrical parameters such as incidence angle and emission angle [2].

Using selected examples, this talk describes the systematics, including pros and cons, of IBSD: The correlation between process parameters, properties of the film-forming particles, and thin film properties. The most important process parameters are the scattering geometry and the primary particle species. Depending on the material, different film properties can be influenced. Examples of film properties are composition, surface roughness, mass density, optical properties, stress, and electrical resistivity. [1] C. Buddensieg, H. Neumann, J. Appl. Phys. 124 (2018) 231102.

P 1.2 Mon 11:30 CHE/0089

On the role of the Poisson-Boltzmann equation in the modeling of high-power magnetrons — Kevin Köhn, Dennis Krüger, Denis Eremin, Liang Xu, and Ralph Peter Brinkmann — Ruhr University Bochum, Theoretical Electrical Engineering

The Poisson-Boltzmann equation is a nonlinear differential equation that describes equilibria of conducting fluids. Using a variation principle based on the balances of particle number, entropy, and electromagnetic enthalpy, it can also be justified for a wide class of unmagnetized technological plasmas [Köhn et al., PSST 30, 105014 (2021)]. This study aims to extend the variation principle to magnetized discharges as used in high-power pulsed magnetron sputtering (HIPMS). The example in focus is that of a high-power circular magnetron. The discharge chamber and the magnetic field are assumed to be axisymmetric; the plasma dynamics need not share this symmetry. The domain is divided into the region of confinement, where the electrons can escape from their magnetic field lines only by slow processes such as drift and diffusion, and the remainder where the electrons are effectively free. A distinction is made between a fast thermodynamic and a slow dissipative regime. A variational principle is established for the fast regime which is similar in logic to its counterpart for unmagnetized plasmas but accounts for magnetic confinement by treating the individual flux tubes of the confinement domain as separate thermodynamic units. The resulting solutions obey a generalized Poisson-Boltzmann relation; they are thermodynamic equilibria of the fast regime but must be interpreted as dissipative structures in the slow regime.

P 1.3 Mon 11:45 CHE/0089

Plasma-modified NiCo\textsubscript{2}O\textsubscript{4} nanowires with abundant oxygen vacancies as electrocatalyst for the oxygen evolution reactions — He Li, Sadeh Askari, and Xuesen Yang — Institute of Environmental and Applied Physics, Kiel University, Kiel, Germany — 1Department of Fiber and Polymer Technology, KTH Royal Institute of Technology, Stockholm, Sweden

The development of highly active and stable electrocatalysts for the oxygen evolution reaction (OER) is critical for the applications such as water splitting or production of rechargeable zinc-air batteries. Oxygen vacancy engineering has demonstrated great promises to regulate the OER performances of transition metal compounds. However, the facile and effective generation of oxygen vacancies is still a challenge. Herein, we fabricated a NiCo\textsubscript{2}O\textsubscript{4} nanowire catalyst by the hydrothermal method and generated oxygen vacancies with various concentrations by Ar or H\textsubscript{2}/Ar plasma treatment. The reactive radicals generated by plasma reduce the valence of metal ions in the oxides and create oxygen vacancy defects with high electrocatalytic activity. The H\textsubscript{2}/Ar plasma-treated NiCo\textsubscript{2}O\textsubscript{4} presents more surface oxygen vacancies and thus better electrocatalytic performance for OER. Our work offers a facile and efficient route to design efficient OER electrocatalysts for zinc-air batteries.

P 1.4 Mon 12:00 CHE/0089

Session 4

Experimental validation of a 0-D computational model for characterisation of double inductively coupled plasma — L. Jendersmy, M. Osa Engelbrecht, H. Hylla, I. Korolov, D. Filia, L. Schücker, C. P. Ridges, P. Awakowicz, and A. R. Gibson — Chair of Applied Electro-dynamics and Plasma Technology, Ruhr-University Bochum, Bochum, Germany — Research Group for Biomedical Plasma Technology, Ruhr-University Bochum, Bochum, Germany — York Plasma Institute, Department of Physics, University of York, York, UK

A double inductively coupled plasma is studied to be compared to 0-D plasma chemical kinetics simulations. A focus is placed on oxygen-containing gas mixtures due to their ability to produce large fluxes of reactive species such as atomic oxygen and UV photons. Various experimental diagnostic methods are applied. A multipole resonance probe is used to measure electron densities and electron temperature by using a time-of-flight technique. Time-resolved, tuneable diode laser absorption spectroscopy is used to determine the absolute intensities of different O transitions. These values are compared to those obtained from a 0-D computational model. The model includes electron densities and a collisional radiative treatment of excited states of O. It is then used to provide information on the flux of photons at 130 and 135 nm. This work was funded by DFG project "Plasma inactivation of microbial Biofilms", project number 429427143.
P 2: Magnetic Confinement I/HEPP I

Time: Monday 11:00–13:10

Invited Talk

P 2.1 Mon 11:00 CHE/0091
Deuterium-Tritium Plasmas at JET with ITER-like Wall and the Role of Iso-
to mass and Transport for H-mode Access — Gregor Birkenmeier1,2 and
JET Contributors3 for the JET L-H Transition Team-Collaboration — Max
Planck Institute for Plasma Physics, Garching — Physik-Department, Techni-
cal University Munich, Garching — See J. Mailoux et al 2022 Nucl. Fus. 62:
042026

More than 20 years after the last deuterium-tritium (D-T) experiments in mag-
etic confinement fusion research, the largest operating tokamak in the world,
the Joint European Torus (JET) in Culham, UK, was operated with the reactor
relevant D-T fuel mixture during the 2020/2021 experimental campaign. The
experiments demonstrated that reactor relevant plasma scenarios can be suc-
cessfully operated in metallic wall conditions and the record of controlled fusion
energy production of 59 MJ was achieved in a steady plasma over five seconds.
The experiments confirmed simulations of reactor-relevant plasma performance
building confidence, that next step devices like ITER will perform as predicted.
In addition to experiments maximizing the fusion power, further experiments in
tritium containing plasmas allowed to study iso- tope effects in unprecedented
detail. As one striking example, it was found that the power threshold to ac-

access the high confinement regime, which is considered as being mandatory for
a sufficient performance of a reactor plasma, shows an unexpected isotope de-
pendence in iso- topes mixtures. After the presentation of the highlights of recent
D-T experiments, an explanation for the observed isotope effects is given and its
impact on modelling is discussed.

P 2.2 Mon 11:30 CHE/0091
Experimental and numerical investigation of helium exhaust at the AS-
DEX Upgrade tokamak with full-tungsten wall — Antonello Zito1,2,3,
Marco Wischemeyer1, Athina Kappatos1, Arne Kaltenbach1, Francesco
Scortino1, Volker Rodke1, Klaus Schmid1, Edward Hisson2, Oliver
Schmitz1, Marco Cavedon2, Rachael Mcdermott2, Ralph Dux1,4,
Michael Grienert1, and Ulrich Stroth2,3 — Max-Planck-Institut für Plasmaphysik — Physik-Department E28, Technische Universität München — University of Wisconsin-Madison — Dipartimento di Fisica “G. Occhialini”, Università di Milano-Bicocca

An efficient removal of helium ash by active pumping in future fusion devices is
necessary to avoid fuel dilution and not degrade plasma confinement. Therefore,
a deep understanding of the underlying physics mechanisms is mandatory. He-
lium recycling and pumping has been experimentally investigated at the ASDEX
Upgrade tokamak. The time evolution of helium following a small injection dur-
ing otherwise steady-state deuterium discharges was measured spectroscopically
both in the core plasma and in the neutral exhaust gas. The exhaust efficiency
was found to improve with increasing divertor neutral pressures, but to degrade
with detachment. A multi-reservoir particle balance model was developed to in-

terpret the observed exhaust dynamics. The limited performance of the pumping
system and an efficient helium storage capability of the tungsten wall were iden-
tified to have a strong impact on the exhaust dynamics. The SOLPS-ITER code
was used to interpret the observed He transport towards the divertor.

P 2.3 Mon 11:55 CHE/0091
Introduction and Uncertainty Quantification of Kinetic Models in the Inte-
grated Data Analysis Framework — Michael Bergmann1, Khalaya Ravi1,2,
Rainer Fischer1, Clemente Angioni1, Klara Höffler2, Pedro Molina
Cabrera1, Tobias Göhrler1, Roberto Bilato1, and Frank Jenko1,2 — Max-
Planck-Institut für Plasmaphysik — TUM (CIT) — Ecole Polytechnique
Fédérale de Lausanne, Switzerland

Using a combined analysis of multiple diagnostics as well as Bayesian probabil-
ity theory the Integrated Data Analysis (IDA) infers electron density and tem-
perature profiles of ASDEX Upgrade plasmas and is the standard against which
simulations are validated. As the diagnostic does not cover the entire plasma
or may be unavailable IDA considers a variety of non-physics-based priors.
The resulting profiles may not be in accordance with theories best expectations
e.g. may have gradients which drive too high turbulent transport. Using the
transport solvers ASTRA coupled with the quasi-linear turbulence code TGLF
we have created a loop in which simulated profiles are fed back into IDA as an-
other prior thus providing constraints about the physically reasonable parameter
space. For now the uncertainty of the simulation is given by the user, however
we will discuss several ideas for a more complete uncertainty quantification such
as input error propagation and comparison to the high-fidelity turbulence solver
GENE.

P 2.4 Mon 12:20 CHE/0091
Analysis and modeling of momentum transport based on NBI modulation
experiments at ASDEX Upgrade — Benedikt Zimmermann1,2, Rachael
Mcdermott1, Clemente Angioni1, Basil Duval2, Ralph Dux1, Emili-
ano Fabbi1, Antti Salmi1, Ulrich Stroth2,3, Thomas Tala1, Giovanni
Tardini1, Thomas Pütterich2, and the ASDEX Upgrade Team2 — Max
Planck Institute for Plasma Physics, 85748 Garching, Germany — Physik-
Department E28, Technische Universität München, 85747 Garching, Germany — VTT, P.O. Box 1000, FI-02044 VTT, Finland — EPFL, Swiss Plasma Center,
CH-1015 Lausanne, Switzerland — See the author list of U. Stroth et al. 2022
Nucl. Fusion 62 042006

Understanding momentum transport is crucial to reliably predict the plasma ro-
tation profiles in future fusion devices. At ASDEX Upgrade, momentum trans-
port studies are used to validate theoretical models and transport codes.
An advanced momentum transport analysis framework uses NBI modulation to ex-
tract the contribution of diffusion, convection, and intrinsic torque to momen-
tum transport within the core plasma. Recent work focused on a possible mass
dependence by comparing hydrogen and deuterium plasmas. Both momentum
transport coefficients were found to be the same within error bars indicating
no significant mass dependence. Gyrokinetically predicted Prandtl number and
pitch number agree with the experimental results. Furthermore, a robust error
analysis quantified the uncertainties of the assessed coefficients and the unique-
ess of the determined solution in the scanned parameter range.

P 2.5 Mon 12:45 CHE/0091
Neutral gas pressure gauges for current and future fusion devices —
Bartholomäus Jagiel3,4, Uwe Wenzel5, Dirk Nafo6, Felix
Mackel1, Thomas Sunt Pedersen1, and the W7-X team1,2 — Max
Planck Institute for Plasma Physics, Germany — Universität Greifswald, In-
itut für Physik, Greifswald, Germany

Pressure gauges employing helical tungsten-wire emitters suffer from the Lorentz
force in strong magnetic fields. In consequence, for fusion devices, conventional
pressure gauges do not work reliably, or at all when operated within specified
duration of plasma operation. As an alternative, rod shaped emitters are more
robust in strong magnetic fields and may sustain long pulse operation.

We report on the performance of the ionization gauges, equipped with lan-
thanum hexaboride, zirconium carbide or tungsten emitter, tested in a purpose
built laboratory and operated in the stellarators W7-X and LHD. During the sec-
ond Wendelstein-7-X campaign, 18 manometers equipped with LaB6 cathodes
are used to measure the neutral gas pressure at different positions. Early ex-
periments show robust operation up to 900s. The gauges reveal a magnetic field
dependence of the ion current and sudden jumps of the electron- and ion cur-
cent limit the operation over the whole pressure range from 10⁻² mbar to 10⁻²
mbar. Along with a basic characterization of the latter, measurements under new
record conditions and the impact of limitation on the design of the instruments
are discussed. Operation in different magnetic field strengths and working gases
are examined.

P 3: Astrophysical Plasmas

Time: Monday 16:30–17:45

Location: CHE/0089

P 3.1 Mon 16:30 CHE/0089
Energy conversion by magnetic reconnection in multiple ion temperature
plasmas — Jeremy Dargenti1, Sergio Toledo-Redondo1, Andrey Divin2,
and Maria Elena Innocenti3 — 1Institut für Theoretische Physik, Ruhr-
Universität Bochum, Bochum, Germany — 2Department of Electromagnetism
and Electronics, University of Murcia, Murcia, Spain — 3St. Petersburg, Russia

Magnetic reconnection is one of the most efficient plasma process to convert
magnetic energy into kinetic energy. In this work, we study the impact of the mi-

scopicroscopic distribution function on the energy budget of symmetric magnetic re-

nection in collisionless plasmas. We run two two-dimensional semi-implicit PIC
simulations of symmetric reconnection with the same global parameters, but
with different ion distribution functions: one simulation is loaded using
Maxwellian distributions, while the other is the sum of two Maxwellian distribu-
tions, a hot one and a cold one, resulting in a very peaked distribution with large
tails. We measure the evolution of the bulk and thermal kinetic energies in both
simulations for each population and compare it to the loss of magnetic energy
through a contour surrounding the ion diffusion region. We show that the global
energy budget for ions and electrons does not change depending on the distribu-

ion function of the plasma, but also that, when focusing on sub-populations, the hot ion population gains more energy than the cold ion population and that the distribution of the energy gain between kinetic and thermal energy also depends on the initial temperature.

P 3.2 Mon 16:45 CHE/0089
Ionization and transport in partially ionized multicomponent plasmas: Atmospheres of hot Jupiters — Sandeep Kumar1,2, Anna Julia Poser1, Manuel Schöttler3, Uwe Kleinschmidt4, Willand Dietrich5, Johannes Wicht2, Martin French1, and Ronald Redmer1 — 1Universität Rostock, Institut für Physik, D-18051 Rostock — 2CASUS, D-02826 Gorlitz — 3MPI for Solar System Research, D-37077 Göttingen
We study ionization and transport processes in partially ionized multicomponent plasmas [1]. The plasma composition is calculated via a system of coupled mass-action laws. The electronic transport properties are determined by the electron-ion and electron-neutral transport cross sections. The electrical and thermal conductivities as well as the Lorentz number are calculated. For the thermal conductivity, we consider also the contributions of the translational motion of neutral particles and of the dissociation, ionization, and recombination reactions. We apply our approach to plasma conditions as typical for atmospheres of hot Jupiters such as HD 209458b. The electrical conductivity profile allows revising the Ohmic heating power related to the fierce winds in the planet’s atmosphere in order to explain the observed inflation of HD 209458b. The model is also applied to study possible induction processes in the atmosphere of ultra-hot Jupiters like KELT-9b [2].

References

P 3.3 Mon 17:00 CHE/0089
We propose the Mars Magnetospheric Multipoint Measurement Mission (M5), a multi-spacecraft mission to study the dynamics and energy transport of the Martian magnetosphere. Particular focus lies on the largely unexplored magnetotail region, where signatures of magnetic reconnection of the Interplanetary Magnetic Field (IMF) have been found. Further, to study the dynamics of the Martian magnetosphere depending on the upstream solar wind conditions, knowledge of those is needed. Finally, to resolve the three-dimensional structure of the Martian magnetosphere and make use of multipoint data analysis techniques, multi-point measurements are required. As a result, M5 is a five spacecraft mission, with one solar wind monitor orbiting Mars in a circular orbit, and four smaller spacecraft in a tetrahedral configuration orbiting Mars in an elliptical orbit. We present a detailed assessment not only of the scientific need for such a mission, but also show the resulting mission and spacecraft design taking into account all aspects of systems engineering as well as spacecraft budgets like mass and data rate. The mission outlined in this abstract was developed during the ESA Alpbach Summer School 2022 on the topic of “3D Comparative Plasma Physics in the Universe.”

P 3.4 Mon 17:15 CHE/0089
Berechnung elektronischer Transportkoefizienten von Wasserstoffplasma mit Dichtefunktionaltheorie — Martin Frensch1, Gerd Ropke2, Maximilian Schömer1, Mandy Bethkenhagen1,2, Michael Desjarlais3, and Ronald Redmer1 — 1Universität Rostock, Institut für Physik, D-18051 Rostock — 2École Normale Supérieure, Université Lyon 1, Lyon, France — 3Sandia National Laboratories, Albuquerque, USA

References

P 3.5 Mon 17:30 CHE/0089
Electron polarization in ultrarelativistic plasma current filamentation instabilities — Zheng Gong, Karen Hatsagortsyan, and Christoph Keitel — Max Plank Institute for Nuclear Physics, Saupfercheckweg 1, 69117 Heidelberg, Germany.
By utilizing particle-in-cell simulations, we investigate the plasma current filamentation of an ultrarelativistic electron beam impinging on an overdense plasma. The effect of the radiation-induced electron polarization is self-consistently studied. Here, three different regimes of the current filaments, namely, the normal filament, abnormal filament, and quenching regimes, are identified. We show that electron radiative polarization emerges during the instability along the azimuthal direction in the momentum space, which signifi-
cantly varies across the regimes. We put forward a Hamiltonian model to trace the origin of the electron polarization dynamics. In particular, we discern the role of nonlinear transverse motion of plasma filaments, which induces asymmetry in radiative spin flips, yielding an accumulation of electron polarization.

P 4: HEPP II
Time: Monday 16:30–18:35
Location: CHE/0091
P 4.1 Mon 16:30 CHE/0091
CO2 dissociation using a microwave plasma torch - a study on industrially relevant parameters — Christian Karl Kiefer1, Rodrigo Antunes1, Anette Heicimovic2, Arne Meine5, and Uwe Fanz2 — 1Max-Planck-Institut für Plasmaphysik, 85748 Garching, Germany — 2University of Augsburg, 86159 Augsburg, Germany
Under laboratory conditions, microwave plasma torches are known to be an energetically highly efficient CO2 conversion technology, for pressures ranging from 100 mbar up to atmospheric pressure. However, issues relevant for industrial application such as the wall-plug energy efficiency, including the energy consumption of peripheral equipment, the performance for impure CO2 streams directly from carbon capture facilities and the stability at long-term operation are usually not addressed. To fill that gap, the wall-plug energy efficiency of a lab-scale microwave plasma torch was determined reaching values up to 17.9%, corresponding to an electrical power consumption of 19.6 kW per produced Nm3 of carbon monoxide. The effect of Ar, N2, O2, and air admixture to the CO2 feed gas stream was investigated. Experiments show that small amounts of nitrogen can even increase energy efficiency whereas the most detrimental effect on CO2 dissociation was found for air admixture. Finally, a durability test over 29 h was performed, demonstrating that microwave plasma torch operation is very reproducible and stable in all figures of merit with short ramp-up times, making it a promising technology for intermittently operated.

P 4.2 Mon 16:55 CHE/0091
3D Monte Carlo PIC modeling of particle extraction from negative ion sources — Max Lindqvist1,2, Dirk Wunderlich1, Serhiy Mozhalsky1, Adrien Revel1,2, Thibiru Minea1,2, and Uwe Fanz1,2 — 1Max-Planck-Institut für Plasmaphysik, Garching, Germany — 2University Paris-Saclay, CNRS, LPCG, Orsay, France
Negative H+ or D+ ions for the ITER NBI system are produced in RF ion sources, mainly by surface production, and accelerated through a multi-aperture grid system. One of the main limiting factors during operation of such ion sources is the amount of co-extracted e−, in particular during operation with D. For a correct description of the particle dynamics close to the Plasma Grid (PG) where a 3D magnetic field is present, self-consistent 3D PIC-MCC modeling is needed. The 3D PIC-MCC code ONIX has been used to simulate one PG aperture in the ELISE ion source, a half-size ITER-like ion source in IPP Garching. The impact of plasma parameters on the co-extraction of e− is presented. A higher T0 has a strong impact on the amount of co-extracted e−. The original code was improved by adding a plasma generation module that allows modeling the biasing of the PG w.r.t. the source walls. By increasing the PG bias above the floating potential, the amount and temporal stability of co-extracted e− are strongly decreased, in agreement with experiments. ONIX was coupled with the beam code IBSimu to allow the correlation of particle properties from the plasma to the beam, and to study the extraction probability and beam divergence of negative ions during different configurations of PG biases and geometries to give insights into grid optimization.
Non-local geometrical PIC simulations for the radial electric field in sputterers. — MICHAEL KOCZYSZEK, RALF KLEBNER, and HAKAN SMITH — Max-Planck-Institut für Plasmaphysik, Greifswald, Germany

Transport in fusion plasma devices can be classified as either turbulent or neo-
classical. While turbulence is responsible for the majority of particle and heat
losses in both, tokamaks and optimised sputterers the theory of neoclassical
transport should not be disregarded. Its applications, for example the prediction
of the bootstrap current, are of great importance in fusion research. This talk
focuses on the neoclassical radial electric field in sputterers.

For a quasi-neutral plasma in a thermodynamic equilibrium, commonly, the
electric field is negative throughout the plasma vessel. This is called an ion root.
However, when electrons are much hotter than ions, the electric field takes a
positive value. This electron root and can be achieved with, for example, ECRH
heating. As correctly predicted by the local neoclassical transport theory, this is
a consequence of the ambipolarity condition on the ion and electron fluxes. How-
ever, the theory meets its limitations when there is a transition between the two
solutions. Moreover, since the electric field switches the sign during the transi-
tion, the strongly sheared ExB flow is likely to affect turbulence. To understand
the physics of this phenomenon we must resort to simulations of global neo-
classical transport. We present the first self-consistent global neoclassical radial
electric field simulations performed using a particle-in-cell code - EUERPE.

Suppression of Diocotron Drift Modes and Increased Transfer in a Multicell Trap — MARTIN SINGER1,3, JAMES R. DANIELSON1, and LUTZ SCHWEIKHARDT1,2 — IPP-Greifswald, Germany

Diagnosis of metal-grid micro cavity plasma arrays — MARC BÖKE3,4, DAVID STEUER1,5, SEBASTIAN DZIKOWSKI1, HERMANN LUDWIG3,4, VOLKER SCHULZ-VON DER GATHEN1,3, and JUDITH GOLD4,5,6 — Institute of Plasma Physics, UCSD, USA — 1Institut für Physik, Universität Greifswald, Germany — The Ag Positron Electron eXperiment (APEX) will accumulate large quantities of positrons for a positron-electron (pair) plasma which are an excellent candi-
date to test basic plasma physics. To this end we have designed and constructed a new multicell Penning-Malmberg trap (MCT). It includes a master-cell, and three prototype storage cells (one on-axis, and two off-axis). With this device we will test and improve the plasma transfer to the off-axis cells and the stacking of multiple plasma pulses to create large space-charges. We will develop suitable protocols to achieve these key goals, for the use of a MCT at the NEPOMUC positron source in Munich.

In this contribution, we will discuss the dynamics during the transport to the
off-axis cells. These are dominated by competing diocotron drift modes. We de-
veloped techniques to suppress these modes to mitigate losses and to center the plasma in the off-axis cells. Furthermore, we demonstrated an improved transfer
and consecutive transfer to multiple off-axis cells. This enabled the first simulta-
neous confinement in two different off-axis storage cells. The work was funded by DFG (Grant No. SCHW 1731/1-1, HU 978/15-1 and PE 2655/1-1) and ERC (Grant No. 741322). IJD is funded by U.S. DOE (Grant No. DE-SC0019271).

Characterization and identification of MHD-like fluctuations of core electron temperature transitions in W7-X plasmas — JUAN FERNANDO GUERRERO ARNAIZ1,2, ANDREAS DINKELAGE1,2, AXEL KONIES2, CAROLIN NÜBENHEIM2, ALESSANDRO ZOCCO2, MATTHIAS BORCHARDT2, CHRISTIAN BRANDT2, NEHA CHAUDHARY, JOACHIM GIEGER2, MATTHIAS HIRSCH2, UDO HOFEL1, RALF KLEBNER2, KIAN RAHBAEIA, SARA VAZ MENDEZ2, ALEXEI MISCHENKO2, JONATHAN SCHILLING2, JOHN SCHMITT2, HENNING THOMSEN2, MARCO ZANIN2, and W7-X TRAM3 — Universität Greifswald, Greifswald, Germany — 1Max-Planck-Institut für Plasmaphysik, Greifswald, Germany — 2Auburn University, Auburn AL, United States

Previously unexpected spontaneous transitions to higher core-electron tempera-
tures preserving plasma pressure were detected in low- iota configuration W7-X plasmas. Transitions occurred at stationary plasma conditions at fixed heating power and line integrated density but with evolving plasma currents. Here we
report on low frequency activity preceding the transitions. To gain insight on the
transition mechanism, this activity is characterized. This is done through experi-
mental and numerical modelling, shedding light on the nature of the underlying
MHD instability. The rational iota-values and the impact of radial electric fields
on the mode activity and the transition to enhanced core electron temperature
are examined. As for now, the instability is narrowed down to GAIM oscillations
and zonal flow activity, both of which were found to potentially exist according to
systematic simulations.

P 5: Atmospheric Pressure Plasmas and their Applications

Time: Tuesday 11:00–13:00

Invited Talk

Diagnostics of metal-grid micro cavity plasma arrays — MARC BÖKE3,4, DAVID STEUER1,5, SEBASTIAN DZIKOWSKI1, HERMANN LUDWIG3,4, VOLKER SCHULZ-VON DER GATHEN1,3, and JUDITH GOLD4,5,6 — Institute of Plasma Physics, UCSD, USA — 1Institut für Physik, Universität Greifswald, Germany

Modelling and experimental analysis of DBDs in Ar-TMS and Ar-HMDS mixtures — MARCO STANNOX1, MARKUS M. BECKER1, LARS BROCKER2, CLAUS-PETER KLAGES2, and DETLEF LOFFHAGEN1 — 1Leibniz Institute for Plasma Science and Technology (ITP), 17489 Greifswald — 2Institute for Surface Technology (IOT), Technische Universität Braunschweig, 38108 Braunschweig.

During the last two decades, plasma- enhanced chemical vapour deposition
processes using atmospheric-pressure dielectric barrier discharges (DBDs) have be-
come of great interest for fabricating various thin films and coatings. Here, fluid
modelling and experimental analysis of such DBDs in argon with the addition of
small amounts of tetramethylethylene (TMS) or hexamethyldisilane (HMDS) as
precursors are reported. A plane-parallel and a single-filament discharge con-
figuration are operated by sinusoidal voltages of few kV at frequencies of 86
and 19 kHz, respectively. A time-dependent, spatially one-dimensional fluid-
Poison model including an extensive reaction kinetic scheme for argon and the
organosilicon precursors with about 90 species and 700 reactions is used for the
modelling studies. Results for electrical discharge properties and relevant species
in the DBD are represented and discussed. Penning ionization (PI) processes
of excited argon species with the precursor gas are found to have a decisive impact
on the discharge characteristics. In particular, it is found that cations generated
due to PI processes are the dominant species for thin film formation.

Funded by the Deutsche Forschungsgemeinschaft (DFG) - project number 504701852.

State enhanced actinometry in a micro cavity plasma array — DAVID STEUER1,5, HERMANN LUDWIG3,4, VOLKER SCHULZ-VON DER GATHEN1,3, MARC BÖKE4,5, and JUDITH GOLD4 — Ruhr-University Bochum, D-44801 Bochum, Germany

In recent years, plasma catalysis as an application of atmospheric pressure plas-
mas has become a research. Suitable reactors for investigating the fundamental
interaction between plasmas and catalytic surfaces are micro cavity plasma ar-
rays. To understand the plasma catalytic processes, it is important to monitor the
densities of reactive species. In the case of atomic oxygen, this is typically done
using laser spectroscopic methods. Due to the small dimensions of micro cavi-
ties between 50-200µm this is very complex. Therefore, a new approach, helium
state enhanced actinometry (SEA)[1], was used. 2D resolved measurements are
performed by using an ICCD camera in combination with a tuneable bandpass
filter. The discharge is operated in helium with an oxygen admixture of 0.1%. An
argon admixture of 0.05% is used as actinometer gas. The triangular excita-
tion voltage between amplitudes of 400-800V is varied at a frequency of 15 kHz.
Very high dissociation degrees up to nearly complete dissociation are observed.
The spatial resolution allows density distributions within individual cavities to be
resolved. Time resolved measurements show significant differences in oxygen
density between the increasing potential phase and the decreasing potential
phase. This work is supported by the DFG via SFB 1316 (project A6). [1]Steuer
et al 2022 PST 31 10L01
CO₂ splitting in 3D-printed barrier discharge reactors — D. Adrianto¹, M. Schörkhuber¹, V. Köhler¹, S. Brandenburg², and S. Grundmann¹ — ¹Leibniz Institute for Plasma Science and Technology, Greifswald, Germany — ²University of Rostock, Rostock, Germany

First attempts to use Dielectric Barrier Discharges (DBDs) for the conversion of carbon dioxide (CO₂) date back to the 1990’s, and found a renewed interest in the 2010’s due to the energy transition, i.e., the demand for PtX technologies for the generation of fuels or chemicals. DBDs still lack on energy efficiency, but provide a simple and robust design for plasma reactors. In contrast to the studies of micro wave discharges, the impact of gas flow distribution in DBDs reactors is still a rather unexplored field. In this study, a 3D printer is used to realize DBD discharge chambers with a predefined gas flow pattern. Thus, the high flexibility of rapid prototyping enables to correlate fluid dynamic simulations with the plasmachemical performance of CO₂ splitting. DBD reactors are made of methacrylic acid polymer and have an overall dimension of 120 x 120 mm, with a powered electrode size of 55 x 55 mm in the center. The influence of flow mechanics is investigated in three DBD reactors with different gas flow patterns and velocity profiles. Besides CO₂ splitting in pure CO₂, ozone generation in air is studied. It is shown that CO or O₃ yield can be influenced by the flow pattern and gas flow rate.

Gas Separation of O₂ in a CO₂ Plasma Membrane Reactor — K. Wiegers¹, A. Schuele¹, M. Walker¹, G. Tovar¹, F. Buck², T. Schiestel², and S. Baumann³ — ¹University of Stuttgart IGBP, Stuttgart, Germany — ²Fraunhofer IGB, Stuttgart, Germany — ³Forschungszentrum Jülich EIK-1, Jülich, Germany

Mankind nowadays is strongly affected by ongoing climate change, mainly caused by the increasing emission of CO₂. A very stable molecule, can be activated by a plasma process. It converts CO₂ into the value-added chemical molecule CO. In order for this method to become competitive with electrolysis, the simultaneously produced O₂ must be separated from the gas mixture. In order to do so, oxygen-conducting ceramic hollow fibers can be used. The first and well-investigated ceramic is La₂O₃Sr₃Ca₃Cu₄O₁₂ by Teraoka [1]. Changing the A site cations or using a dual-phase material can improve the temperature stability and chemical resistance against the CO₂ and CO atmosphere in the plasma membrane reactor.

In this work, La₂O₃Ca₂O₃Fe₅O₁₁, hollow fibers are investigated in terms of their oxygen separation ability. They are temperature stable up to 1200 °C, and the increase the viable region for O₂ separation in the plasma torch, new ceramic materials (e.g., 60 wt% Ca₂O₃Fe₅O₁₁-40 wt% Ca₂O₃Fe₅O₁₁-37CaO₂₃O₃) with higher temperature resistance have to be developed and investigated. The idea is that different fiber materials can be used depending on the local plasma temperature.


Control of the gas flow by a surface barrier discharge — S. Mohsenimehr, M. Börse, and M. Von Keudell — Experimental Physics II, Ruhr-University Bochum, Germany

Surface Dielectric Barrier Discharges (SDBD) are well-known plasma sources for gas stream purification and gas conversion due to their easy scalability in various applications. In addition, SDBDs are used as plasma actuators to generate thrust in a gas for flow control. The aim of this project is to combine plasma chemistry and plasma-based flow control concepts. The plasma-flow interaction and its contribution to the chemistry of transported species is evaluated. In this work, a twin SDBD is employed, which consists of an aluminium oxide plate (90x80x0.63 mm) that is covered by nickel metallic grid printed on both sides. The SDBD is generated at atmospheric pressure using damped sinusoidal voltage waveforms (G2000 Redline Technologies). To investigate the flow pattern, the Schlieren technique was carried out to visualize the refractive index gradient in the medium and to compare this with a fluid dynamic simulation in two dimensions performed by COMSOL. The fluid simulation uses the 2D Navier Stokes equations for compressible laminar flow assuming small Reynolds numbers. This simulation model is used to predict the plasma aerodynamics and how it could influence the surrounding fluidic flow. The formation of distinct vortices in the flow pattern in both simulation and experiment is observed. The electrode design of the SDBDs is optimized to maximize the plasma-induced thrust on the species conversion.

P 6: Magnetic Confinement II/HEPP III

Time: Tuesday 11:00–12:50

Invited Talk

The physics of ELM-free regimes — M. Dunne¹, M. Faitusch², G. Harker³, L. Radonovic⁴, W. Suttrop⁵, E. Viezzer⁶, M. Willensdorfer⁷, and E. Wolfrum⁴ — ¹Max-Planck Institute for Plasma Physics, Garching, Germany — ²Institute of Applied Physics, TU Wien, Austria — ³OAW, Austria — ⁴Dept. of Atomic, Molecular and Nuclear Physics, University of Seville, Avda. Reina Mercedes, 41012 Seville, Spain

High performance tokamak scenarios rely on an edge transport barrier (ETB) to reach the pressure and confinement time necessary for high fusion gain. The ETB is characterised by a steep pressure gradient, which provide energy for edge localised modes (ELMs), quasi-periodic explosive instabilities, which are projected to cause significant damage to the walls of a fusion reactor. Ensuring the longevity of tokamak reactors requires, therefore, alternative operational scenarios where large ELMs are avoided. We present a general framework in which the operation of tokamaks is constrained by the magnetohydrodynamic (MHD) stability. Predicting and controlling ELM-free regimes is then a matter of increasing transport such that the MHD instabilities are avoided. Three ELM-free regimes are highlighted; the quasi-continuous exhaust (QCE), quiescent H-mode (QH-mode), and operation with magnetic perturbations (MPs). We present the current understanding of the physical mechanisms as well as projections to future devices.

Evaluation of an electron beam sustained atmospheric pressure plasma for the conversion of carbon dioxide — L. Dinklage¹, B. Zimmermann¹, G. Mattausch², and R. Brandenburg² — ¹Forschungszentrum Jülich, Germany — ²Leibniz-Institute for Plasma Science and Technology, Greifswald, Germany

Carbon dioxide (CO₂) conversion processes will play an important role in closed carbon cycles for zero carbon emission economies in the future. Even though plasma exhibit numerous technical advantages, they are not yet economically feasible in terms of CO₂ conversion, since they struggle to simultaneously achieve high energy efficiency and high conversion degree for the splitting of CO₂ molecules and are often bound to sub-atmospheric pressures. Therefore, a new hybrid approach for the plasma-chemical conversion of CO₂ is presented, consisting of an atmospheric pressure glow discharge sustained by an electron beam. This hybrid approach potentially allows to transfer energy from the plasma mainly into vibrational dissociation of CO₂ and to generate a high reduced electric field strengths (about 20 Td), while sufficient ionization in the plasma is ensured by the electron beam. Based on this principle a reactor for gas conversion processes was developed. Furthermore, preparatory electron beam dose measurements for estimating ionization rates in the plasma were conducted and power deposition by the electric field and the electron beam into the plasma were calculated for continuous and pulsed operation modes.

Location: CHE/0091

P 5.6: Magnetic Confinement II/HEPP III

Time: Tuesday 12:00–13:50

Invited Talk

The physics of ELM-free regimes — M. Dunne¹, M. Faitusch², G. Harker³, L. Radonovic⁴, W. Suttrop⁵, E. Viezzer⁶, M. Willensdorfer⁷, and E. Wolfrum⁴ — ¹Max-Planck Institute for Plasma Physics, Garching, Germany — ²Institute of Applied Physics, TU Wien, Austria — ³OAW, Austria — ⁴Dept. of Atomic, Molecular and Nuclear Physics, University of Seville, Avda. Reina Mercedes, 41012 Seville, Spain

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Carbon dioxide (CO₂) conversion processes will play an important role in closed carbon cycles for zero carbon emission economies in the future. Even though plasma exhibit numerous technical advantages, they are not yet economically feasible in terms of CO₂ conversion, since they struggle to simultaneously achieve high energy efficiency and high conversion degree for the splitting of CO₂ molecules and are often bound to sub-atmospheric pressures. Therefore, a new hybrid approach for the plasma-chemical conversion of CO₂ is presented, consisting of an atmospheric pressure glow discharge sustained by an electron beam. This hybrid approach potentially allows to transfer energy from the plasma mainly into vibrational dissociation of CO₂ and to generate a high reduced electric field strengths (about 20 Td), while sufficient ionization in the plasma is ensured by the electron beam. Based on this principle a reactor for gas conversion processes was developed. Furthermore, preparatory electron beam dose measurements for estimating ionization rates in the plasma were conducted and power deposition by the electric field and the electron beam into the plasma were calculated for continuous and pulsed operation modes.
Improved confinement regimes will play a key role in the operation of future fusion power plants. I-mode, one of these regimes, combines good energy confinement with the absence of ELMs. It features a characteristic edge transport barrier in energy but not in density. This selective transport reduction is not understood. An edge density fluctuation called the Weakly Coherent Mode (WCM) is often brought forward as a possible explanation. Measurements obtained from Doppler reflectometry and thermal helium beam spectroscopy at ASDEX Upgrade (AUG) are combined to analyze the WCM in unprecedented detail. A phase velocity of the WCM consistent with the linear dispersion relation of a near ideal drift wave is found for the first time at AUG.

This marks a novel experimental verification of a specific mechanism for the WCM and sheds new light on a long-standing debate on the underlying physics.

P 6.5 Tue 12:35 CHE/0091

Microwaves in the GHz-range play an indispensable role for heating and current drive in plasmas. If, however, the plasma density exceeds the cut-off density of the injected microwave, it can no longer reach its electron cyclotron resonance layer. To overcome this limitation, heating at electron cyclotron harmonics is an often applied method. Another possibility is to couple to the electrostatic electron Bernstein wave which has no high-density cut-off and is very well absorbed at the electron cyclotron resonance layer. Spherical tokamaks can in particular benefit from EBWs as their current drive efficiency exceeds those of O- or X-mode. Here, we present numerical investigations of coupling to the EBW via the O-X-B mode conversion process in the spherical tokamak MAST Upgrade. These studies are to be understood as a feasibility study of an EBW heating system in MAST Upgrade.

P 7: Atmospheric Pressure Plasmas and their Applications III

Time: Tuesday 17:00–19:00
Location: CHE/0089

P 7.1 Tue 17:00 CHE/0089
Operation modes of the COST plasma jet — MAXIMILIAN KLIJCH, DAVID SCHULENBERG, MÁTE VASS, KATHARINA NÖGERS, SEBASTIAN WILCEK, and RALF P. BRINKMANN — Ruhr University Bochum, 44780 Bochum, Germany

Discharges ignited at ambient pressure drive complex chemistry. This chemical variety offers plenty of applications; for example, wound healing. A commonly used plasma source at atmospheric pressures is the COST plasma jet, a capacitively coupled radio-frequency driven plasma jet. The main goal of this study is to demonstrate three distinct operation regimes of the COST jet and to indicate their relevance. It is demonstrated by particle-in-cell/Monte Carlo collisions (PIC/MCC) simulation code between the jet’s electrodes (i.e., a one-dimensional setup) for He/N2 chemistry. The framework treats electrons kinetically via PIC/MCC and solves the continuity equation based on the drift-diffusion approximation for all ion species. We vary basic input parameters (e.g., the driving frequency or voltage) to control the discharge regime. It shows that the scaling of the Debye length, the average sheath width, and the discharge length are comparable in magnitude. Depending on their exact values, the discharge enters one of three modes: (i) A quasi-neutral regime where distinguishable bulk and sheath areas exist. (ii) A non-neutral regime where no quasi-neutral bulk region is developed. (iii) All dynamics are constricted to tiny sheath regions shielding a vast, steady bulk region in the constricted mode. Overall, this work offers parameters for distinct operation modes that allow tailoring the discharge.

P 7.2 Tue 17:15 CHE/0089
A comparison of the spatial distribution of H2O in the effluent of the kINPen-Sci and the COST Reference Microplasma Jet — LEVIN KROG, BEN HARRIS, ANDY NAVE, ERIE WAGENAARS, and JEAN-PIERRE VAN HELDEN — Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — York Plasma Institute, Department of Physics, University of York, U.K.

Cold atmospheric plasma jets (CAPJs) are utilised in biomedical applications, as they provide important reactive oxygen and nitrogen species (RONS) for the plasma cell interaction, such as H2O2. There are still open questions in the physical and chemical field regarding the production of RONS. When they formed and how does the jet-type has an influence on their production? As a first step to resolve that question, the production of H2O2 in humidified helium is compared between the kINPen-Sci and the COST Reference Microplasma Jet. The small sample length (about 4 mm) combined with low number densities are a challenge for established absorption spectroscopic techniques. Continuous-wave cavity ring-down spectroscopy (cw-CRDS) is applied in order to increase the path length through the sample. The difference in the spatial distribution of H2O2 in the effluent between the jets will be discussed.

P 7.3 Tue 17:30 CHE/0089
Gas temperature variations along the discharge channel in an atmospheric pressure RF plasma jet and their consequences on electron dynamics — DAVID A. SCHULENBERG, MAXIMILIAN KLIJCH, ZOLTÁN DONZÓ, MÁTE VASS, JÉDRER KUTHÁ, NIKITA RUBINOV, JÚLIA SCHEIBER, and THOMAS MUSSENBOCK — Ruhr University Bochum, Germany — Wigner Research Center for Physics, Budapest, Hungary

The gas temperature increase along the discharge channel of a radio frequency micro-atmospheric pressure plasma jet is investigated by a combination of spectroscopic measurements and particle in cell (PIC) simulations. The jet is operated using Helium-Nitrogen mixtures of He/N2 ratios of 10000:9:5 to 10000:2. We find that under standard operating conditions, the increase in gas temperature depends on the nitrogen content of the jet gas, the driving voltage, and the driving voltage waveform. Depending on the exact combination of these parameters, the gas temperature increases approximately 80 K between the gas inlet and the nozzle of the jet. Phase Resolved Optical Emission Spectroscopy measurements reveal a change of the time- and space-dependent dynamics of the high energy electrons in the plasma under operating conditions at which the gas temperature determined by optical emission spectroscopy also changes. This behavior is reproduced by PIC simulations, in which the gas temperature is an input parameter. The dependence of the operation mode on the gas temperature might offer an additional degree of freedom in terms of controlling the plasma properties in order to match specific application requirements.

P 7.4 Tue 17:45 CHE/0089
Modeling and simulation of transport processes in capacitively coupled radio-frequency-driven micro atmospheric pressure plasma jets — LUKÁS VASS, JÉDRER KUTHÁ, KATHARINA NÖGERS, MAXIMILIAN KLIJCH, THOMAS MUSSENBOCK, and RALF PETER BRINKMANN — Faculty of Electrical Engineering and Information Technology, Ruhr University Bochum, Bochum, Germany

Capacitively coupled radio-frequency-driven micro atmospheric pressure plasma jets (CCRF μAPJ) are used in biomedical science and CO2 conversion. A hybrid simulation code is implemented to investigate a CCRF μAPJ that handles electrons kinetically in a particle-in-cell/Monte Carlo collisions (PIC/MCC) scheme and ions and other heavy particles in a fluid mechanical manner. The simulation cycle of charged and neutral particles is sep-
Impact of feed gas humidity on the discharge dynamics in an Ar-operating atmospheric pressure plasma jet — Sarah-Johanna Klose, Robert Bassemer, Ronny Brandenburg, and Jean-Pierre H. van Helden — Leibniz-Institut für Plasmaphysik, Greifswald, Germany

Cold atmospheric pressure plasma jets are often employed for biomedical purposes as they provide a large variety of reactive species remaining around room temperature, such as atomic and molecular radicals, and key species, such as H₂O₂. In particular, hydrogen, oxygen, and nitrogen containing species have been proven beneficial for wound healing and cancer treatment. The formation of these species starts in general with the dissociation of molecular gases in the plasma zone of the plasma jet. It has been shown previously that by the addition of water to the feed gas, the composition of reactive species could be changed drastically. In this presentation, we will demonstrate the impact of feed gas humidity on the discharge dynamics of the kINPen-sci plasmajet, a cold atmospheric pressure plasma jet that is operating with Ar. By means of time-resolved laser absorption spectroscopy (LAAS), absolute densities of Ar(2P) species have been determined as a function of the feed gas humidity and of the distance to the nozzle of the plasmajet. By analysing the quenching, conclusions on the dissociation of water have been drawn, which will also be presented.

Impact of humidity on the OH distribution in the effluent of an atmospheric pressure plasma jet measured by laser induced fluorescence — Janina Golda, Sebastian Burhenn, Maik Käf, Pia-Victoria Postkrüper, Volker Schulz-von der Gathen, and Marc Böke — Plasma Interface Physics, 44801 Bochum, Germany — 2Experimental Physics II, Ruhr University Bochum, 44801 Bochum, Germany

For plasma sources operating in ambient atmosphere, such as the COST-jet, the environmental conditions have a sensitive impact on the reactive species leaving the discharge zone. One important environmental parameter is humidity: Water impurities in the feed gas or diffusion of moisture from the ambient atmosphere in the gas stream can contribute to an increase of humidity in the effluent. To study these effects, OH as a side-product from the dissociation of water by the plasma can be used as a tracer molecule. Therefore, we measured the 2D-distribution of OH produced in the COST-jet by laser induced fluorescence. To control the influence of gas composition and humidity of the ambient atmosphere, the experiments were performed inside a closed vessel. By systematically varying the water content of the gas inside the vessel by a bubbler system, the influence of humidity on the OH density profile was studied. These results were then compared to profiles, which were obtained from the variation of humidity in the feed gas providing valuable information about the production channels of OH.

Anomalously high relative density of the N₂(3Σ_g^+, v = 0) state is observed in the plasma bulk of a nanosecond non-atmospheric-pressure plasma jet in mercury and in its quasi-DC phase and afterglow. Additional population of N₂(3Σ_g^+, v = 0) is confirmed by analyzing the rotational structure of the (0-0) transition of the First Negative System (FNS) of nitrogen. Numerical kinetic modeling is used to identify possible mechanisms of additional N₂(3Σ_g^+, v = 0) formation. Kinetic calculations taking into account production of N₂(3Σ_g^+, v = 0) in reaction between the N₂(1Σ_g^+) and N₂(3Σ_u^+) states as well as in reaction of the N₂(1Σ_g^+) state with the N₂(1Σ_u) ion describe adequately the FNS(0-0) emission dynamics and the high relative density of the N₂(3Σ_g^+, v = 0) state observed experimentally.

In future fusion reactors, tungsten as plasma-facing material will be subjected to intense fluxes of helium (He). While the consequences of high He fluxes on the surface properties of tungsten have already been thoroughly studied, there are no experiments that could clarify the process of early He cluster formation. To understand the initial steps of the interaction of He with W, especially the impact of pre-existing defects, annealed, polycrystalline W samples were irradiation-damaged to various damage levels. Then, these samples were exposed to a low-temperature He plasma at fluxes between 10⁻⁷ and 10⁻⁶ He/m²s and various fluxes using implantation energies of 50 and 100 eV. The samples were measured by positron annihilation spectroscopy for defect characterization and elastic recoil detection analysis (ERDA) for quantification of the He retention. For the depth distribution of He, a novel method was applied: thin surface layers of the sample were subsequently removed followed by ERDA measurements in between the erosion steps. The removal was performed by electrochemical oxidation and dissolution of the oxide in NaOH. The results show a higher He retention in pre-damaged samples by factors up to 10 and a deeper reaching distribution of He in undamaged samples.
Self-passivating Metal Alloys with Reduced Thermo-oxidation (SMART) are promising candidates for the first wall of the DEMOnstration power plant (DEMO). These materials should feature an increased oxidation resistance during accidental conditions and tolerate plasma loading during regular operation of the power plant. In this work, the effects of segregation, diffusion and sputter erosion on the surface Cr concentration of a tungsten-chromium-yttrium SMART alloy (WCrY 68 at% of W, 31 at% of Cr and 1 at% of Y) are studied with low energy ion scattering (LEIS) measurements at 800 K, 900 K and 1000 K and numerical simulations. The LEIS is operated with He⁺, Ne⁺ and Ar⁺ ions at 1 keV in sputter mode. The time resolved experiments show that Cr onsets the segregation of Cr at the surface directly after increasing the temperature, followed by a slow decrease with evolving time. A comparison to a discrete layer model, in which the segregation enthalpy, entropy and atomic mobility are taken into account, indicates that this decrease is caused by a slower bulk diffusion rate compared to the rates of sputtering and surface segregation.

P 8.4 Tue 18:10 CHE/0091


For the safe and efficient operation of fusion reactors, tritium permeation barriers, or TPBs, are required to prevent fuel loss through first wall materials. Tritium oxide is chosen as a TPB due to its favorable neutron activation behavior compared to other candidates. Different Y₂O₃ layers several hundred nanometers thick are deposited onto a steel substrate using RF magnetron sputtering and subsequent conventional sintering. The samples were sintered at 550°C to obtain the favorable cubic phase of Y₂O₃, which is verified by X-ray diffraction. Permeation measurements are performed by gas-driven deuterium permeation experiments from 25 mbar to 800 mbar at 300°C to 550°C. The calculation of the single layer permeability is introduced to obtain a comparable value of the permeation reduction effect for the different coatings. In addition, in long term, time-dependent sputter experiments, the time resolved sample is directly measured from the build-up of the permeability. The permeation results and layer permeabilities are compared for the different microstructures. Furthermore, the hydrogen isotope retention of the different layers is measured using nuclear reaction analysis and evaluated with their permeation reduction performance.

P 8.5 Tue 18:25 CHE/0091


At the end of OP1.28 4.5° 1021 13C - methane molecules were injected to study carbon transport in W7-X and generate benchmark data for material migration codes. Here we present the results of a dedicated NRA analysis using the 13C(d, p)14N reaction on 24 divertor target elements of different toroidal positions. The majority of the deposition was on the divertor half module where the carbon was injected (60%), with layers up to 100 μm in a 5 cm radius around the injection location. The reminder of the 13C was deposited on the other divertor modules close to the strike line.

P 8.6 Tue 18:40 CHE/0091

Experimental Determination of Irradiation-Induced Stress Relaxation in Thin Tungsten Wires — Alexander Frichmayr, Max Bolinger, Raphael Colson, Bailey Curzado, Sebastian Estermann, Till Höschen, Johann Risch, Thomas Schwarz-Seiler, and Rudolf Modl — Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching, Germany — 2 Technical University Munich, Boltzmannstr. 15, 85748 Garching, Germany — 3 Culham Centre for Fusion Energy, Abingdon, OX14 3DB, Oxfordshire, UK

The development of suitable materials for the highly loaded plasma facing components is a major challenge in the development of a future fusion power plant. The influence of neutron irradiation on the mechanical properties is particularly difficult to measure, since there is no suitable neutron source available. A widely used technique to simulate neutron irradiation is the use of high energy ions, since these can produce similar dislocation damage as neutrons. For this purpose, a dedicated device has been developed to allow simultaneous ion irradiation as well as mechanical testing. This device and the latest upgrades, as for example a laser-based strain measurement system, will be presented. In addition, a setup of a stress relaxation experiment on 16 μm tungsten wires, to study the synergistic effects between mechanical stress and irradiation damage, will also be presented.

P 8.7 Tue 18:55 CHE/0091


The harsh conditions inside a nuclear fusion reactor put high demands on the plasma-facing materials and components. Tungsten is the preferred material for lining the inner walls of future fusion reactors. It is considered as such due to its exceptionally high melting point, excellent thermal conductivity, low tritium retention and high erosion resistance during plasma exposure. However, even plasma-facing components made of tungsten get damaged during reactor operation, thereby limiting the lifetime of these components. It is envisioned to counteract these erosion losses by local deposition of tungsten using the wire based laser metal deposition process (LMD-w). During this process new material gets fused to the substrate, enabling in-situ repair of damaged plasma-facing components. Several experiments were conducted to find suitable process parameters and methods to create layers of new material by placing several melt tracks next to each other.

P 9: Atmospheric Pressure Plasmas and their Applications III

Time: Wednesday 11:00–13:00

Invited Talk

P 9.1 Wed 11:00 CHE/0089

Modelling and analysis of single-filament dielectric barrier discharges at atmospheric pressure — Markus M. Becker, Ronny Brandenburg, Thomas Hoder, Hans Höfft, Aleksandar P. Jovanovic, and Detteff Löffhagen — Leibniz Institute for Plasma Science and Technology (IFP), Greifswald, Germany

This contribution gives an overview of research results of the last 10 years on the modelling of single-filament dielectric barrier discharges (DBDs). Two discharge configurations are used to highlight the possibilities and limitations of spatially one- (1D) and two-dimensional (2D) time-dependent fluid models. First, it is shown for a one-sided, sine-driven DBD in argon that 1D models are generally suitable to describe the discharge characteristics in periodic operation. Second, 2D models have been found to be suitable for systematic determination of the influence of preionisation on repetitively pulsed, two-sided DBDs in nitrogen-oxygen gas mixtures up to time scales of milliseconds. However, 1D models lack the ability to correctly describe the appearance of striations (in argon) and the streamer breakdown phase (~ 1 ms). For this purpose, 2D models are applied, which show a very good agreement with measurement results. Since processes on longer time scales (μs to ms) can only be investigated in 2D with extreme computational effort, a smart combination of 1D and 2D models is most promising for a profound understanding of filamentary DBDs.

P 9.2 Wed 11:30 CHE/0089

Kinetic modeling of the charge transfer across a negatively biased semiconducting plasma-solid interface — Kristopher Rasek, Franz Xavier Brondol, and Holger Fehske — Institut für Physik, Universität Greifswald, 17489 Greifswald

We discuss the selfconsistent ambipolar charge transfer across a negatively biased semiconducting plasma-solid interface using a thin germanium layer with electron-phonon scattering sandwiched between an Ohmic contact and a collisionless argon plasma as a model system. The current-voltage characteristics of the interface is obtained from the distribution functions of the charge carriers on both sides of it. Due to quantum-mechanical reflection at the interface and collisions inside the solid, the characteristics differs substantially from the one obtained for a perfectly absorbing interface. The electron microphysics inside the semiconductor decreases to zero due to the screening of the accumulated resolved fluxes and charge distributions inside the germanium layer visualize the behavior of the charge carriers responsible for the charge transport. Albeit not quantitative, because of the crude model for the germanium band structure and the neglect of particle-nonconserving scattering processes, such as impact ion-
Challenges during the design of a DC microplasma cell intended for in situ TEM — Luka Hansen1, Niklas Kohlmann2, Lorenz Kienle3, and Holger Kersten4 — Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany

In situ observation of plasma surface modifications are possible if a microplasma is inserted into a TEM as shown by proof of principle experiments in 2013 [1]. Still, multiple challenges have to be overcome for the development of a microplasma cell suitable for TEM integration. The electrodes have to be electron beam transparent and are therefore restricted to tens of nanometers in thickness. The microplasma itself has to be vacuum-proof encapsulated and operated in a stable regime. A DC microplasma was designed and intensively studied to ensure its stable operation in the normal glow regime [2]. Ex situ performed measurements proved the possibility to setup the electrodes thin enough for TEM imaging and study the surface modifications [3]. Furthermore, the microplasma cell was successfully introduced into the TEM and first images without plasma could be taken. Electrical isolation problems prevented plasma ignition inside of the TEM, but will be solved by rebuilding the vacuum-proof encapsulation from ceramic. This contribution summarizes the already overcome challenges and updates about the recent steps towards in situ TEM imaging.

[1] K. Tai et al., 2013 Scientific Reports 3 1325


Plasma medicine demands for very special plasma source configurations. Besides gaslow-driven jet-arrays, dielectrical barrier discharges (DBD) are commonly used to generate ambient air plasma at room temperature for sterilization. The electrode and dielectric material used in this application. Especially, the sterilization of difficult, uneven or edged surface geometries with DBD can be rather challenging. Therefore, flexible polyethylene naphthalate-foil (PEN-film) which was covered with electrode material by ion-beam sputtering is characterized regarding its electrical and bactericidal performance for different power and electrode thickness configurations. Operating temperature, ozone production capability and plasma parameters (electron temperature and density) were used as characterization parameters. Advantages as well as limitations of this new approach are presented.


Study on interaction of two single-filament DBDs — Hans Höf1, Chiel Tön1, Tom Huiskamp2, and Torsten Gerling1,3 — 1. Leibniz Institute for Plasma Science and Technology (INP), Felix-Hausdorff-Str. 2, 17489 Greifswald, Germany

Modelling of self-pulsing discharges at atmospheric pressure — Aleksandar P. Jovanović1, Hans Höf1, Detlef Loffhagen2, Torsten Gerling1,3, and Markus M. Becker3 — 1. Leibniz Institute for Plasma Science and Technology (INP), Felix-Hausdorff-Str. 2, 17489 Greifswald, Germany

Modelling of self-pulsing discharges at atmospheric pressure — Aleksandar P. Jovanović1, Hans Höf1, Detlef Loffhagen2, Torsten Gerling1,3, and Markus M. Becker3 — 1. Leibniz Institute for Plasma Science and Technology (INP), Felix-Hausdorff-Str. 2, 17489 Greifswald, Germany

Non-thermal atmospheric-pressure plasmas are of considerable interest due to their wide relevance for technical and medical applications over the past decade. Self-pulsing discharges are a common way to generate these plasmas. Here, the discharge current is limited by a suitably designed electrical circuit to prevent thermalisation. Current oscillations observed in these discharges were attributed to the existence of ion acoustic waves (IAWs) and can be used for plasma diagnostics. Therefore, a detailed understanding of the electron and ion kinetics during the discharge evolution is of great interest. For this purpose, a time-dependent, spatially one-dimensional fluid-Poisson model coupled with an equation of electrical circuit has been applied to study a self-pulsing discharge in argon at atmospheric pressure. The characteristic phases governed by different charge carrier production and loss processes as well as the dominant ions produced during the discharge have been analysed. The two-cathode effect has been identified as a potential excitation mechanism of IAWs at atmospheric pressure.

Funded by the Deutsche Forschungsgemeinschaft (DFG) – project number 466331904.

Binary nanocrystal synthesis using atmospheric pressure plasmas — Maren Dworschak1, Martin Müller2, Lorenz Kienle3, and Jan Benedikt1 — 1. Institute of Experimental and Applied Physics, Kiel University, Germany — 2. Institute of Physics, Academy of Sciences, Czech Republic — Faculty of Engineering, Kiel University, Germany

Plasmas of binary or multiary compounds with group IV semiconductors offer great flexibility in composition, morphology and structure. The resulting tunable band gap is associated with enhanced optical properties and tuneable luminescence ranging from the UV to the near-infrared region. The variety of possible nanocrystals offers a great selection of materials for energy conversion and storage application, yet the synthesis of such compounds on the nanometer scale is still challenging due to the complexity of the synthesis process. We report on new methods that could facilitate the generation of metal nanocrystals while using atmospheric pressure plasmas as a tool. Silicon nanocrystals are generated in the plasma source from the reactive gas silane. An additional electrode inserted in to the plasma can be coated with the metal of choice. When the electrode is heated, the metal evaporates and gets incorporated in the produced nanocrystals downstream of the jet. A second possible method involves a post synthesis in-flight annealing stage. Particles synthesized in the plasma jet pass through a furnace at 1100°C in which the desired metal is present in gaseous phase. Here, the high temperature has proven to facilitate the formation of crystalline polyelemental compounds.

Funded by the Deutsche Forschungsgemeinschaft (DFG) – project number 466331904.

Magnetic Confinement III/HEPP V

Time: Wednesday 11:00–13:10

Invited Talk

P 10.1 Wed 11:00 CHE/0091

Diasgnosing the plasma edge with helium beam spectroscopy — Michael Grüner and the ASDEX Upgrade Team — Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching

The outer 5% of the plasma radius of magnetically confined fusion plasmas — the plasma edge region — plays a key role for reactor performance. It sets the boundary for the plasma core by establishing transport barriers and distributes the power to the plasma facing components. The power and particle transport at the plasma edge is influenced by coherent plasma modes and turbulent structures like convective filaments. To study these important plasma phenomena, diagnostics with high spatiotemporal resolution
Determination of SOL filament cooldown at ASDEX Upgrade — \textsc{Daniel Wendler}1,2, Michael Greiner1,2, Gregor Birkenmeier1,2, Elisabeth Wolfrem1,2, Ulrich Stroth1,2, and the ASDEX Upgrade team — 1Max-Planck-Institut für Plasmaphysik, Garching. — 2Physik-Department E28, Technische Universität München, 85747 Garching, Germany. — \textsuperscript{3}See author list of U. Stroth et al. 2022 Nucl. Fusion 62 042006. Filaments, alternatively called blobs, are coherent structures, appearing in the scrape-off layer (SOL) of magnetic fusion devices in all plasma scenarios. They have a higher pressure than the background plasma and a radial motion outward, which also differs from the background. As a consequence, blobs cause convective transport, being correlated with phenomena like the density shoulder formation and in general the power deposition in the plasma vessel. To better estimate the power transported by the filaments, their temperatures, densities and velocities are measured. This is done by means of a two-dimensional grid of lines of sight at the ASDEX Upgrade thermal helium beam. Measured radiances of helium transitions are then converted into the plasma electron temperature and density by applying a collisional radiative model. Via the calculation of the temporal evolution of these quantities and the blob position, the convective power of the filament is determined. This shows a cooldown of the filament's temperature which is combined with a loss of density. These processes are compared to analytical models, allowing to determine the temporal evolution of the convective power.

Experimental Exploration of a Two Point Monitor for the Island Stora- tor of Wendelstein 7-X via Helium Line Ratio Spectroscopy — \textsc{Erik Flohr}1,2, Tullio Barbuti2, Oliver Schmitz2, Maciej Kряchwiak1, Ralf König1, Marcin Jakubowski1, Sergey Bozhenkov1, Valeria Perso1, Felix Reimold1, and the Wendelstein 7-X Team — 1Lancaster University, Lancaster, UK. — 2Max Planck Institute for Plasma Physics, Greifswald, Germany. — Understanding the basic plasma parameters of temperature and density, as well as their gradients in the scrape-off layer (SOL), is a topic critical for providing information about the performance of a divertor concept. The stellarator Wendelstein 7-X features a novel resonant island divertor with an adjustable rotational transformation of \(\iota = 2n (5/6, 5/4)\). In order to study the performance of this divertor concept, an active spectroscopy system on an atomic helium beam is developed and installed on the stellarator. The diagnostic was successfully operated in the first two divertor campaigns of the device in two magnetically connected modules. In this work, a database analysis of experiments from the operational phase OP1.2b is performed and systematic trends in divertor performance are discussed within the framework of a two-point, single-fluid model [3]. Particular focus is applied to separatrix vs. target density scaling and evidences for a "high-recycling" conduction limited regime, as well as an exploration of the validity of the helium beam as a downstream proxy given its displacement from the strike line poloidally.

Low-collisionality extension of the edge turbulence fluid code GRILLIX — \textsc{Christoph Pitzal}, Andreas Stegemeier, Kaiyu Zhang, Wladimir Zholobenko, and Frank Jenko — Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching, Germany. — Fluid models are yet the workhorse for plasma edge turbulence simulations, but the fluid assumptions have certain limitations. As one leaves the realm of validity, by decreasing collisionality, the most fragile quantity is the heat flux, as it represents usually the highest order fluid moment. These conditions can already be present in the near SOL of present day experiments and the commonly used Spitzer-Härm formula vastly overestimates the parallel heat conductivity. An approach to introduce Landau damping into fluid models and therefore predict the kinetic heat flux, is given in [1]. A method to translate this approach from k-space into configuration space, where most fluid codes act is presented in [2]. In this work the Landau-fluid closure is implemented into the edge turbulence fluid code GRILLIX [3]. This requires solving a set of elliptic equations for the distribution function of the Landau-fluid closure with the Spitzer-Härm formula. The aim is to find out whether this model is capable of predicting the parallel heat conductivity self-consistently and to investigate if non-local effects of the Landau-fluid closure can be seen. Finally, the performance of the model is assessed.

Gyrokinetic investigation of linear and non-linear excitation of energetic particle driven instabilities in ASDEX Upgrade — \textsc{Brando Rettingo}1, Thomas Hayward-Schneider1, Alessandro Biancalani1,2, Alberto Bottin1, Philipp Lauber1, Ilja Chavdarovski1, Markus Weiland1, Francesco Vannini1, and Frank Jenko — 1Max-Planck-Institut für Plasmaphysik, 85748 Garching, Germany. — 2Léonard de Vinci Pole Universitaire, Research Center, 92916 Paris la Défense, France. — 3Korea Institute of Fusion Energy, 34133 Daejeon, South Korea. — Excitation of Alfvén Waves (AW) and Geodesic Acoustic Modes (GAM) by energetic particles (EPs) is an important topic of study for the physics of fusion reactors. In tokamaks, ions are injected with high energies to heat the plasma. These energetic particles are very weakly collisional and exist far from thermal equilibrium. We examine the effects of experimental-like anisotropic in velocity distribution functions of EPs on the excitation of such instabilities with the gyrokinetic particle-in-cell code ORBS. The growth rate of GAMs is found to be sensitive dependent on the phase-space shape of the distribution function as well as on the non-linear wave-wave coupling with AWs.

Novel microwave interferometry approach for spatial plasma profile measurements — \textsc{Christos Vagidis}, Eberhard Holzhauser, Walter Kasparek, Alf Köhn-Seemann, Stefan Merli, Murko Ramisch, and Andreas Schulz — IGP, University of Stuttgart, Germany. — Interferometry is widely used in plasma physics to obtain the line-integrated density of a plasma. Here, we present a method to obtain in addition information about the spatial profile of the plasma density from interferometry measurements with the help of accompanying full-wave simulations. For this purpose, a microwave-generated plasma torch is used, which is confined in a quartz tube. A high frequency (208 GHz) microwave beam is emitted by a horn antenna, perpendicular to the plasma, and used as a probing beam. The receiving antenna is placed behind the plasma and is aligned with the sending antenna. The reference beam is generated artificially from a network analyser, which measures the phase difference of the beams. In spite of the beam being scattered, the phase difference reduces the background plasma and a radial motion outward, which allows to determine with reasonable accuracy. Furthermore, the intensity distribution of the probing beam, in the plane perpendicular to the plasma torch, is obtained by moving the receiving antenna with a stepping motor, which can be operated with sub-millimetre precision. Full-wave simulations (inhouse FDTD code and COMSOL Multiphysics) have been carried out with arbitrary plasma density profiles. Comparing the simulation results with experiments allows to deduce information on the actual density profile.

Investigation on methanol synthesis with a microwave plasma torch — \textsc{Marc Bresser}, Katharina Wiegers, Andreas Schulz, Matthias Walker, and Günter Tovar — IGVP, University of Stuttgart, Germany. — Due to the increasing concentration of carbon dioxide (CO\(_2\)) in the atmosphere and the resulting impact on climate change, possibilities are being sought to remove CO\(_2\) from air by direct air capturing and a subsequent reuse of CO\(_2\). In addition, the chemical industry is heavily dependent on fossil fuels and is looking for new ways to generate sustainable base chemicals. A possible renewable way to form carbon-based products is to use CO\(_2\) as a reactant for the production of the base chemical methanol. Renewable methanol synthesis could be achieved via a microwave plasma process using electricity from renewable sources and "green" hydrogen (H\(_2\)). A CO\(_2\) plasma forms carbon monoxide (CO) and oxygen (O\(_2\)). The oxygen is extracted via ceramic hollow fibers from the plasma. The addition of H\(_2\) to the CO\(_2\) plasma leads to the formation of new molecules such as methanol. The methanol can be separated by condensation of the exhaust gas. In this work, the CO\(_2\) conversion in a microwave plasma (2.45 GHz) is studied. In dependence of the gas flow and the microwave power (up to 6 kW) the exhaust gas composition is analyzed with a Fourier-transform infrared spectroscopy (FTIR). Optical emission spectroscopy (OES) in the range from UV to IR is used to investigate the influence of the added H\(_2\) on the plasma gas composition and the exhaust gas stream.
Combining a nanosecond-pulsed DBD with an electrolytic cell to reduce CO₂ and N₂ — **Martin Leander Markzen**, Lukas Hansen, Gustav Sievers, Volker Brusek, and Holger Kersten — Plasmatechnology Group, Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany

**Abstract**

Nanosecond-pulsed DBDs can produce H₂O₂ under very good control, so that a stable environment is mainly used to activate the CO₂ or N₂ bonds instead of activating H₂O bonds as well.

**References**


**P 11.5 Wed 14:00 HSZ EG**

Investigation of OH and H₂O₂ distribution in aqueous solution treated with a humid atmospheric pressure plasma jet — **Steffen Schüttem, Emanuel Jess, Marc Böke, Volker Schulz-von der Gathen, and Judith Golda** — Ruhr-University Bochum, Universitätstraße 150, 44801 Bochum, Germany

**Abstract**

Biological enzymes are suitable to convert a substrate into a valuable product in presence of H₂O₂ without producing heavy metal waste. Atmospheric pressure plasma jets can produce H₂O₂ under very good control so that a stable environment can be maintained. This work investigated the delivery of reactive species from an atmospheric pressure plasma jet into a liquid. The capillary plasma jet used is comparable to the COST reference jet and was operated in humid He. Spectrometrical diagnostics by use of ammonium metavanadate and terephthalic acid were performed to measure the concentrations of H₂O₂ and OH in the liquid, respectively. The distribution of reactive species at the liquid surface was visualised by the chemiluminescence of luminol. Our work showed that a H₂O₂ concentration of up to 1 mM was achievable while the OH concentration was a factor of 40 lower. Both species could be controlled by the dissipated plasma power and by the humidity of the feed gas. The transport process could be used to achieve a higher selectivity towards H₂O₂. pulsing the RF jet at low frequencies of up to 2 kHz increased the energy efficiency of H₂O₂ production while reducing the OF concentration in the liquid. This work is supported by the DFG within CRC1316 (Subproject B11, project number 327886311)

**P 11.6 Wed 14:00 HSZ EG**

Time-resolved characterization of a micro cavity plasma array using a multi-multipotential setup — **Henrik van Impel**, David Steuer, Volker Schulz-von der Gathen, Marc Böke, and Judith Golda — Plasma Interface Physics, Ruhr-University Bochum, D-44801 Bochum, Germany

**Abstract**

Dielectric barrier discharges (DBDs) have many applications, such as ozone generation or treating volatile organic compounds (VOCs). To understand the underlying processes, fundamental knowledge about the generation of reactive species is necessary. Here we investigated atomic oxygen production as a model system in a micro cavity plasma array, a customized surface DBD confined to geometrically arranged cavities of micrometer size. We studied the behaviour and the plasma chemical processes using optical emission spectroscopy methods. The discharge is operated in helium with a molecular oxygen admixture of about 0.1% at atmospheric pressure using a 15 kHz and about 600V triangular excitation voltage. With helium state enhanced actinometry (SEA) [1] high atomic oxygen densities could be observed. Using a multi-multipotential setup with synchronous narrow bandwidth detection of characteristic transitions and SEA, we measured the temporal evolution of the atomic oxygen density and the effective mean electron energy over the first ignitions, which are affected by a memory effect due to residual charges on the dielectric surface.

The project is funded within project A6 of the SFB 1316.


**P 11.7 Wed 14:00 HSZ EG**

Development of plasma reactors for plasma-assisted hydrazine — **Kristen Gognon, Alexander Quack, and Jan Benedikt** — Institute of Experimental and Applied Physics, Kiel University, Kiel, Germany

**Abstract**

The energy efficient and decentralized performance of catalytic reactions, such as for the production of ammonia, has become even more important nowadays. Plasma-assisted catalysis of reactions such as this is available on demand and works without enormous external heating. Non-equilibrium atmospheric pressure plasma lasers are used to disperse gaseous molecules, which can then react at the surface of the catalyst to form the desired products. Plasma-assisted catalysis reactions at atmospheric pressure are often realized by packed bed reactors, in which the catalyst is packed into or deposited on millimeter-sized spheres. However, these millimeter-sized spheres are not feasible for all types of possible catalysts.

Therefore, different plasma reactors for plasma-assisted catalysis were developed and tested with and without different catalysts for in-plasma catalysis, where the catalyst is in direct contact with plasma, and post-plasma catalysis, where only reactive species from the plasma are reaching the catalyst. Dielectric barrier discharges operated at kHz- or radio-frequency are used for ammonia production, where the catalysts N₂ and H₂ as working gas as well as for hydrogen formation experiments using CO₂ and H₂. Depending on the reactor-type and working gas, the gas temperature during plasma operation ranges from room temperature up to 200°C.

**P 11.8 Wed 14:00 HSZ EG**

Coaxial dielectric barrier discharge for plasma catalysis in N₂ and H₂ — **Roland Friedl**, David Rainer, and Ursel Fantz — AG Experimentelle Plasmaphysik, Universität Augsburg, 86135 Augsburg — Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching

**Abstract**

Dielectric barrier discharges (DBDs) are frequently utilized for plasma catalysis due to their advantages regarding material aspects: due to the repetitive filamentated discharge, gas heating is avoided and distinctive non-equilibrium conditions are maintained at atmospheric pressure. In addition, if operated in a so-called packed-bed configuration, where the catalyst is coated on or embedded in the dielectric material, a large interaction area between the plasma and the active catalyst surface can be exploited.

In this contribution, a recently commissioned coaxial DBD setup is introduced, which is targeted towards the investigation of nitrogen and hydrogen discharges together with catalytic materials in a packed-bed configuration, e.g. in view of ammonia production. First investigations in view of an electrical and spectroscopical characterization are presented.

**P 11.9 Wed 14:00 HSZ EG**

Active Flux for Vlasov-Maxwell I: Application of the Linear Advection scheme to the Vlasov System — **Lukas Hensel, Gudrun Grünwald, and Rainer Grauer** — Ruhr-Universität Bochum, Universitätstraße 150, 44801 Bochum, Germany

**Abstract**

The Vlasov-Maxwell system for the kinetic description of collisionless plasmas is numerically challenging due to its high dimensionality (3 dimensions in position and velocity space, respectively, plus the time) as well as the coupling of the particle trajectories to the EM-fields, resulting in extreme computational expense. Thus, there is an ongoing demand for efficient low-dissipation conservative schemes suitable for this system. The Active-Flux (AF) Method is a multi-volume method for hyperbolic conservation laws with additional degrees of freedom on the cell interfaces. It thereby allows achieving 3rd order while keeping a compact stencil in space and time. This can facilitate the bulk coupling. The point values on the cell interfaces are evolved independently of the conservation update, with the former step not having to be conservative. For the Vlasov equation, being a linear transport equation, this allows for the use of semi-Lagrangian techniques. We present first results on the numerical error of the method for the cases of 1 and multidimensional linear advection and the 1D electrostatic limit, considering the case of Landau-damping. AF showed lower dissipation than other 3rd order schemes and performed better particularly at low resolution, encouraging its application to the full 3D Vlasov-Maxwell problem.

**P 11.10 Wed 14:00 HSZ EG**

Active Flux for Vlasov-Maxwell II: Application of the Linear Advection scheme to the Vlasov System — **Lukas Hensel, Gudrun Grünwald, and Rainer Grauer** — Ruhr-Universität Bochum, Universitätstraße 150, 44801 Bochum, Germany

**Abstract**

The Active-Flux (AF) Method is a multi-volume method for hyperbolic conservation laws with additional degrees of freedom on the cell interfaces. It thereby allows achieving 3rd order while keeping a compact stencil in space and time. This can facilitate the bulk coupling. The point values on the cell interfaces are evolved independently of the conservation update, with the former step not having to be conservative. For the Vlasov equation, being a linear transport equation, this allows for the use of semi-Lagrangian techniques. We present first results on the numerical error of the method for the cases of 1 and multidimensional linear advection and the 1D electrostatic limit, considering the case of Landau-damping. AF showed lower dissipation than other 3rd order schemes and performed better particularly at low resolution, encouraging its application to the full 3D Vlasov-Maxwell problem.
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The values on the cell interfaces are evolved independently of the con-

ervation update. For the Vlasov equation, being a linear transport equation, this allows for the use of non-conservative semi-Lagrangian techniques. We present first results on the application of AF to the full three-dimensional Vlasov-Poisson system. Different possible strategies for directional splitting that allows the solution of the six-dimensional equation with lower dimensional substeps are dis-

cussed. The multidimensionality of AF furthermore allows for the solution of the three-dimensional velocity space in a single steps, encouraging its future ap-

P I I. 11 Wed 14:00 HSZ EG

Efficient GPU implementation of 2D Particle-in-Cell Simulations for capac-

tively coupled plasmas — Christian A. Busch and Uwe Czarnetzki —

Institute for Plasma and Atomic Physics, Ruhr University Bochum, D-44780

Bochum, Germany

Particle in cell (PIC) simulations are indispensable tools for the study of low-

pressure plasmas, in which a correct description of the particle transport can only arise from a kinetic theory. However, the great ability of PIC simulations to model such systems is also the cause of being CPU-bound.

In recent years, the development of general purpose graphics processing units (GPUGPs), provided cards with thousands of cores for computations differ-

ent from graphics processing. This highly parallel hardware allows significant speedups in PIC simulations up to around a factor of 100 compared to CPUs, enabling the simulation of multidimensional plasmas.

Presented here are details for the efficient implementation of all components of a 2dV PIC/MCC simulation on the GPU. The focus is on data management across the different types of memory on the GPU. Since data transfer is one of the main bottlenecks for high speed computation, optimization of the data storage and processing strategy is key to a successful implementation of PIC codes on the GPU.

P I I. 12 Wed 14:00 HSZ EG

Control of the angular distribution of incident ions by tailoring electromag-

netic fields in the sheath region — Elisa Johannes Jungling, Neil Un-

teregger, David Klute, Marc Bok, and Achim von Keudell — Experiment-
tal Physics II - Reactive Plasmas, Ruhr-University Bochum, Bochum, Germany

The angular distribution of ions impinging on a surface in contact with a plasma plays a key role in various applications like anisotropic plasma etching or glancing angle film growth for the fabrication of microstructure devices. Here, we investigate ways to influence and ultimately control the ion incident angle and the angular distribution of the impinging ions to enable a true 3d manufacturing of temperature plasmas by the means of a focused ion beam in combination with additional local electric and magnetic fields in the sheath region of a plasma. Here, the electric field is modified by including a grid system (mask) in front of the surface which can be either on the floating potential of the plasma or exter-
nally biased; a magnetic field parallel to the surface is introduced to induce an asymmetry in the angular distribution of incident ions. A combination of both methods has been tested for reactive ion etching of carbon films in an argon-

oxygen plasma and for deposition of copper in a HIPIMS plasma. The resulting etching or deposition profiles can be compared with a 2d3v particle-in-cell code (PIC) to simulate the ion trajectories in the sheath region/mask region in front of the substrate surface. A very good agreement has been found.

P I I. 13 Wed 14:00 HSZ EG

Studies of low temperature radio-frequency discharges using a velocity moment analysis — Tim Bolles, Maximilian Klich, Thomas Mussen-

brock, Ralf Peter Bremmank, and Sebastian Wilczek — Ruhr University Bochum, 44780 Bochum, Germany

Plasmas are complex systems in terms of their physics and chemistry. Thus, a fundamental understanding of the underlying mechanisms is crucial. The solu-
tion of the Boltzmann equation (BE) offers insights into the full spatio-temporal dynamics of the plasma. Single particle simulations such as the kinetic particle-
in-cell/Monte Carlo collisions scheme (PIC/MCC) are a feasible way to obtain this information. This work aims to generate a fundamental understanding of a low temperature plasma by means of an analysis of velocity moments of the electron energy distribution function. By doing so, the particle generation can, for example, be related to plasma heating. Since the PIC/MCC scheme gives a stochastic solution to BE, arbitrary moments can be calculated and interpreted without approximations and truncation. Many considerations stop the analysis after the first moment, known as momentum balance. We, however, include the energy balance equation (i.e., the second moment) in our evaluation. For our work, we run simulations at varied parameters for pressure, background gas and driving frequency. The conservation equations, especially the energy balance equation, then provides insight into energy dissipation mechanisms. Overall, this work establishes the second moment of the BE as valuable diagnostics and contributes to a fundamental understanding.

P I I. 14 Wed 14:00 HSZ EG

High-efficiency machine learning approach for nanoparticle 2D size char-

terization via kinetic Micropolarimetry — Alexander Schmitz, Andreas Pe-

tersen, and Fransko Greiner — IEAP, Kiel University, 24118 Kiel, Germany

In a nanodust plasma, the determination of the size of the nanoparticles is cru-

cial to their diagnostics. In the Mie regime, in situ polarization measurements of light scattered by the particles (polarimetry), have proven to be an effective, non-invasive technique.

This method holds a number of challenges. The polarization state depends not only on the particle size, but also on its complex refractive index. Furthermore, the inverse mapping from the measured polarization state to the time dependent particle size and refractive index in a reactive plasma exhibits a strongly non-

linear relationship. To resolve this, a customized kinetic fitting algorithm has been introduced in the past [1]. However, that method, based on Least-Square Fits, is highly sensitive to the time series length and requires considerable com-

puting time.

We present a new deep-learning approach to the mapping problem via our High-Efficiency Reflective index Mapping NEural network (HERMINE). With this, the error rate of automated data evaluation, as well as computing time was significantly reduced. This paves the way for future data-intensive, real-time imaging of the particle size and shape in nanodust plasmas [2].


Dichromatic Mie scattering approach for particle size measurements

A theoretical influence of active compression of the dust particles system were experimentally studied. Ground based laboratory experiments show clearly that wave properties can be manipulated by changing the discharge volume and thus the dust particle density. Complementary experiments under microgravity conditions (parabolic flights) were less conclusive due to residual fluctuations in the planes acceleration indicating the need for a better microgravity environment. A theoretical model, using plasma parameters obtained from PIC (particle-in-cell) simulations as input, supports the experimental findings. It shows that the waves can be described as a new observation of the dust acoustic mode which demonstrates their generic character. This work is funded by DLR/BMWi (FKZ 50WP07000, FKZ 50WM1441).

Dichromatic Mie scattering approach for particle size measurements

- Francoise Reiser, Soren Wohlfahrt, and Dietmar Block - Institute of Experimental and Applied Physics, Kiel University, Germany

Microparticles and dust grains are an essential component in complex (dusty) plasmas. Microparticles are negatively charged in the plasma and levitate in the plasma sheath due to the sheath field. To understand structure as well as dynamical processes in dust clouds, a precise knowledge of the particle size is indispensable, as it determines charge as well as all forces acting on a particle. Recently, a suitable diagnostic based on Mie scattering was introduced [1]. It compares measured angular and polarization resolved intensity patterns of scattered light with predictions of Mie theory. However, Mie scattering is based on interference, the intensity patterns of particles which slightly differ in size and refractive index are selfsimilar and thus an ambiguity in the resulting particle size can occur. As this ambiguity is dependent on the wavelength it can be removed using two lasers with different wavelength. This contribution presents an enhanced setup using two lasers with different wavelength and discusses evaluation concepts.


Plasma Physics Division (P) Wednesday

Comparison of HERMES-2 and EMC3 for the SOL transport of Wendelstein 7-X

David Bold, Brendan Shanahan, Felix Reinhold, and Benjamin Dudson

Max-Planck-Institut für Plasmaphysik, Garching, Germany

The EMC3-ERE code is a well established tool for modelling of the scrape-off layer (SOL) of stellerator devices like Wendelstein 7-X. However EMC3 does not include drifts, which are expected to play a significant contribution to the transport in the SOL.

HERMES-2 is a hot-ion drift reduced SOL-model using the BOUT++ framework. A recent addition to BOUT++ is the inclusion of the flux coordinate independent (FCI) scheme for 3D geometries. The HERMES-2 model is currently modified to be able to handle the geometry of a stellerator using the FCI method. As a first step the results of the two codes are compared when solving the geometry of Wendelstein 7-X. For a direct comparison, only the terms in Hermes-2 which are similar to those found in EMC3 are used.

Plasma Physics Division (P) Wednesday

Overall view of MHD mode observations during the recent operational phase at the Wendelstein 7-X stellarator

Kian Rahbarinia, Sara Vaz Mendes, Henning Thomsen, Christian Brandt, Ralf Kleiber, Axel Könies, and Wendelstein 7-X Team

Max-Planck-Institute for Plasma Physics, Greifswald, Germany

In November 2022 the second operational phase (OP2) at Wendelstein 7-X (W7-X) started. Amongst many technical and diagnostic upgrades W7-X has been equipped with a fully water cooled high heat flux divertor, which in principle can operate on high power discharges for several hundred shots and half hour pulse. During the first part of the recent phase, OP2.1, a number of experiments have been conducted, specifically to investigate the role of magnetohydrodynamic (MHD) mode activity in high power heating scenarios involving neutral beam injection and electron cyclotron resonance heating. The observation of various fluctuation diagnostics (Mrirov coils, soft X-ray tomography, phase contrast imaging, electron cyclotron emission) were compared to previous campaigns and closely compared to findings of past operational campaigns. This contribution will mainly focus on Alfvén eigenmode activity, new insight concerning their driving mechanism and impact on high performance experiments.

Neural Networks for the analysis of Langmuir probe characteristics

Jasmin Joshi-Thompson and Mirko Ramesch - IGVP, University of Stuttgart, Germany

Developed in the early 1920s, Langmuir probes continue to be one of the most widely used plasma diagnostic tools. Theoretical curves are fitted to measured current-voltage (I-V) characteristics in order to obtain parameters such as electron density (n_e) and temperature (T_e). For extensive discharge conditions and comprehensive spatial profiles, measuring plasma parameters becomes more challenging and would best be addressed via automation, with manual checks for specific samples. In this work, deep neural networks are used for associating I-V characteristics to plasma parameters and are tested for robustness. Data is collected from the stellerator TJ-X for training and testing the networks, covering magnetized low-temperature plasmas in a broad parameter space. These networks are assessed as an adaptable, automated plasma characterisation method without the need for further control processes.

Mode analysis of high performance discharges at Wendelstein 7-X during OP 1.2

Charlotte Büschel, Kian Rahbarinia, Sara Vaz Mendes, Henning Thomsen, Christian Brandt, Ralf Kleiber, Axel Könies, and Wendelstein 7-X Team

Max-Planck-Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany

During the last operational phase, the optimized stellarator Wendelstein 7-X achieved so-called high performance up to 1.1 MJ of diamagnetic energy. In most experiments the high energy phase only lasted for about 200 ms following a series of pellet injections. During the discharges Alfvén Eigenmodes (AEs) were recognized which show dynamic behaviour throughout the pulse. The AE activity is investigated in detail to determine the type of the AEs and their possible impact on the often abrupt ending of the high energy phase. To identify relevant frequencies with high precision the parametric model stochastic system identification is used. Additionally poloidal mode number spectra are calculated with the use of a nonuniform Fourier Transformation. Experimental findings are compared to theoretical predictions of Alfvén continua calculated by the 3D ideal MHD code CONTI.

ITG simulations with a fully-kinetic Semi-Lagrangian code

Alexandr Mustonen, Felipe Nathan de Oliveira, Ken Hagiwara, Sreenivasu Thakkonnda, Daniel Told, and Rainer Grauer

The Ruhr University Bochum - Max Planck Institute for Plasma Physics

Gyrokinetic framework has become a standard tool to research the phenomena occurring in the nuclear fusion devices. However, steep gradients in the edge region of tokamaks violate the the assumptions used to derive the gyrokinetic theory. Thus, we want to investigate the practical limits of the gyrokinetic theory with a model containing complete physics of the system. We develop a fully kinetic code employing semi-Lagrangian schemes to simulate the slab ion temperature gradient (ITG) mode with various setups, in order to learn the new physical effects that could be present only in the 3D model. Adiabatic electron approximation used to both verify the results with the analytical linear solution and to perform simulations. However, due to the smallness of the electron Larmor radius with comparison to the ion one, we can employ driftkinetic model for electrons to obtain a hybrid electrostatic description for the ITG simulations.

Investigation of the influence of nanosecond pulsed plasmas in water on surfaces and on nanoparticle formation

Pia Victoria Pottkämper, Katharina Laake, Elia Jungling, Oliver Kreftek, and Achim von Keudell

Ruhr-Universität Bochum

The influence of nanosecond pulsed plasmas on water surfaces and on colloidal systems has been investigated in a series of experiments. The formation of colloidal nanostructures is known to be sensitive to the plasma treatment conditions. In this work, the effects of pulsed plasma treatment on the properties of water surfaces and the formation of colloidal suspensions are studied.
One application of in-liquid plasmas is the formation of nanoparticles both in the treated liquid and on a surface in contact with the liquid. Plasmas in liquids ignited by voltage pulses with fast rise times and nanosecond pulse lengths applied to an electrode cause a dissociation of the molecules in the liquid. The reactive species created by the in-liquid plasma can propagate through the liquid and are able to modify surfaces in direct contact with it. For instance it is possible to initiate surface growth of nanoparticles. In this project the modification of copper surfaces by in-liquid plasma treatment is investigated. On copper surfaces nanoparticles can be found in the shape of CuO nanocubes which can act as a new kind of catalyst e.g. in the reduction of CO₂.

Self-organising surface structures were generated on copper (Cu) layers deposited through High Power Impuls Magnetron Sputtering (HIPIMS) on silicon wafers with the Pulsed Laser-Induced Dewetting (PLID) effect. The nanoparticles were investigated using a Scanning Electron microscope (SEM). Cu samples were treated simultaneously with the effluent of a microatmospheric plasma jet (He/O₂ admixture) and laser irradiation in a controlled atmosphere. Treated surfaces were investigated using Xray Photon Emission Spectroscopy (XPS). A trade-off between high atomic oxygen fluxes and nanoparticle formation was found. Preliminary XPS measurements showed that plasma treatment can influence the oxidation state of copper, namely increase the percentage of CuO compared to an untreated surface.

Supported by the SFB 1316 within project B2

P 11.27 Wed 14:00 HSZ EG

Electric probe measurements inside and outside of magnetic islands in the SOL of Wendelstein 7-X. — Dario Cicapić, Carsten Killer1, Olaf Grulke1, Jiri Adamek2, and W7-X Team1 — Max Planck Institute, Greifswald, Germany — 1DEP of the CAS, Prague, Czech Republic

We report on electric probe measurements in the Scrape-Off Layer (SOL) plasma of the W7-X stellarator. In this device, the SOL is formed by a chain of magnetic islands that separate the SOL into different topological regions and furthermore contain regions of closed magnetic field lines around the island centers ("O-points"). Measurements inside and outside of magnetic islands are performed using the multipurpose manipulator equipped with a probe head carrying 27 Langmuir and 2 ball-pen probes (BPPs). One of the BPPs is floating and measures the electron temperature and plasma potential and is used to cross-validate of the newly installed BPPs against triple probe measurements. The second BPP is in a swept regime for ion temperature measurements and will be compared to RFA results from similar discharges. The probe head also features poloidal and radial measurements of key fluctuating parameters (floating potential \(V_{\text{f}}\) and ion saturation current \(I_{\text{s}}\)) and, inferred from these are the turbulent radial particle fluxes, radial and poloidal electric fields. With these measurements we aim to assess the SOL plasma profiles and turbulence.

P 11.28 Wed 14:00 HSZ EG

Study of fast electrons population in the TJ-K stellarator. — Edgardo Vilalobos Granados and Alf Kohn-Seemann — IPP, University of Stuttgart, Germany

Microwaves provide one of the most widely used methods for heating plasmas. If the plasma density becomes too high, the microwave is cut-off, it cannot propagate any further and is reflected. Such plasmas are often referred to as over-dense. The stellarator TJ-K is typically operated with over-dense plasmas. Preliminary studies in TJ-K have shown that during these kinds of scenarios a component of fast electrons can be detected. In this work, a pulse-height analyzer including a semiconductor detector being sensitive in the soft X-ray range was used to measure the spectral distribution of the soft X-rays emitted by the plasma. Part of this radiation is generated by a hot electron component whose energy can be determined after calibrating the diagnostic against known X-ray sources. The occurrence of the hot electron component is studied under different discharge conditions to identify their generation mechanism.
Experimental characterization of the quasi-coherent mode in EDA-H and QCE plasmas — JÖRG TILAKSONO, PHILIP ULBİ, ANDREAS STEGMEIER, AND FRANK JENKO — Max Planck Institute for Plasma Physics, 85748 Garching, Germany; University of Texas at Austin, Austin, TX 78712, USA

Turbulence plays a significant role in plasma confinement inside of magnetic confinement fusion devices. A gyrokinetic turbulence model is used in the GENE-X code [1-3] to simulate turbulence anywhere within magnetic confinement fusion devices from the core to the edge and scrape-off layer. GENE-X leverages hybrid MPI/OpenMP parallelization to meet its extensive computational demands. Here, our effort extends this to GPUs for extensive scalability towards simulations of larger reactor-relevant devices which currently are not feasible with a reasonable amount of computing resources. The abstraction of several GPU backends via native Fortran/C++ interfaces provides portability and non-invasive development parallel to the main Fortran layer. Our GENE-X/C++ hybrid approach overcomes compiler limitations that often hinder GPU development of Fortran legacy codes. The current build configuration of GENE-X supports GPU backends such as OpenACC, OpenMP offload and CUDA. Directive-based OpenACC and OpenMP offload are prioritized in the C++ layer of GENE-X.


Helium exhaust and impurity transport in W7-X — THILO ROMBA, FE-LICIA REIMOLD, THOMAS KLUGNER, AND JAY TEAM — Max Planck-Institut für Plasmaphysik, 17491 Greifswald, Deutschland

The precise monitoring of the impurity content and the understanding of the transport mechanisms is crucial for future fusion reactor operation due to the associated restrictions to the operational parameter space via dilution and increased radiative losses.

This work aims to analyze the transport of impurities in the confined region of the optimized stellarator Wendelstein 7-X (W7-X) [1] with focus on the fusion ash helium. Local impurity densities are measured using charge exchange recombination spectroscopy (CXRS) [2]. While CXRS allows to measure profiles of densities of individual impurity charge states, it has a low sensitivity to the transport coefficients in steady state scenarios [3]. To increase the sensitivity to the transport coefficients in those scenarios, modulated impurity sources outside of the plasma are used.

The impurity transport will also be assessed in transient phases of neutral beam heated plasmas. In these scenarios it was found that impurity transport is dominated by inwards directed neoclassical convection and impurity density peaking is observed [4]. This work aims to extend this analysis to different magnetic configurations and impurity species.


Automated workflow for energetic particle stability — VIRGIL ALIN POPA, PHILIP LAUBER, AND THOMAS HAYWARD-SCHNEIDER — Max Planck Institute for Plasma Physics, Garching, Germany

EPs (Energetic Particles) driven instabilities are a concern for present (AUG, JET) and future (ITER, DEMO) fusion devices. These particles can come from Neutral Beam Injection or be generated from fusion reactions (alpha particles). Their impact on electromagnetic instabilities in tokamak plasmas can lead to energetic particle transport which affects the heating efficiency of the plasma. Different codes that can study predictive scenarios and/or experimental results are emerging and with them the need of automatic analysis and management of the data they produce. In order to study the linear/non-linear, local/global effects, a workflow that manages the work of several codes is necessary and has been developed using the IMAS framework (Integrated Modelling & Analysis Suite). In addition, several techniques for reducing the dimensionality of the physics results have been implemented, such as: using statistical methods to improve analytical formulas and splitting of the workload in relevant/non-relevant data.

Quasi-Neutral Multi-Fluid Models: A Variational Principle and Numerical Methods — SAYED AMIN RAJESSI TOUSSI, OMAR MAI, AND TOMASZ TYRASOWSKI — Max Planck Institute for Plasma Physics, 85748 Garching, Germany

Quasi-neutral multi-fluid models are commonly used to describe particle and energy transport in the edge and scrape-off layer (SOL) of magnetically confined fusion plasmas [R. Schneider, Contrib. Plasma Phys., 46, 2006]. In this work we present a generalization of the variational principle for incompressible Euler equations [V. Arnold, Ann. Inst. Fourier, 14, 319-361 (1966)] to quasi-neutral multi-fluid models, including only ideal processes. Also some preliminary considerations on appropriate numerical methods are offered.

Towards Laboratory Astrophysics in Wakefield Accelerators — EWIN WALTER, JOHN P. FARMER, MARTIN S. WEIDE, PATRIC MUSSLIG, AND FRANK JENKO — Max Planck Institute for Plasma Physics, 85748 Garching, Germany; Max Planck Institute for Physics, 80805 Munich, Germany

From supernovae in distant galaxies to wakefield accelerators in laboratories, the interaction of relativistic particles with plasma is relevant to many physical scales. The electromagnetically dominant filamentation instability (CFI), which transversely breaks the beam into narrow filaments, may generate a sufficiently strong magnetic field to form collisionless shocks. By changing the operating parameters of beam-driven wakefield accelerators, it may be possible to access this regime relevant to astrophysics.

Due to the large difference in scales, numerical studies with quasistatic particle-in-cell (PIC) methods greatly reduce computational overhead compared to fully electromagnetic PIC. A quasineutral fireball beam consisting of positrons and electrons is simulated to determine to what extent the physics of CFI can be modelled by quasistatic codes and how different numerical methods affect the instability.

This work potentially paves the way to provide insight into analogous astrophysical scenarios in a laboratory setup.

Integrated modelling of impurity transport in ASDex Upgrade — DANIIEL FAJARDO, CLEMENTE ANGIONI, GIOVANNI TARDINI, EMILIANO FABLE, PIERRE MANAS, RASCHAL MCDERMOTT, AND THE ASDEX UPGRADE TEAM — Max Planck-Institut für Plasmaphysik, Garching, Germany; CEAF/RFM, Saint-Paul-les-Durance, France

A database of experimentally measured boron (B) density profiles at ASDex Upgrade (AUG) [R.M. McDermott et al 2022 Nucl. Fusion 62 026006] is studied via LSD integrated modelling with ASTRA. An additional tungsten (W) impurity is employed, and the profile predictions are compared to experiments, which feature the variations of the NBI–ECRH heating power mixture. The turbulent transport is calculated with the quasi-linear codes TGLF and QuAlKiZ, allowing us to validate the impurity transport predictions of these models. The neoclassical component of B is calculated with NCLASS, whereas the FACIT model is used for W due to the stronger effects of rotation-induced poloidal asymmetries on heavy impurities. The correlation between the predicted logarithmic impurity den-

ECHR in early plasma formation — CARL ALBERT VLIEHM JOHANSSON and PAVEL ALETTNYK — IPP Greifswald, Wendelsteinstraße 1, Germany

The usage of electron cyclotron resonant heating (ECHR) is important in current operation of, amongst other devices, Wendelstein 7-X (W7-X) stellarator, and for future fusion devices. ECHR in the quasi-linear limit is theoretically well understood. However, because the ECHR system is used for plasma breakdown, there exists an interest in understanding the non-linear limit.

In this work, we consider the pre-ionization state. We show the energy gain of a single-electron interacting with the gyrotron beam once. For this interaction, we consider different magnetic field configurations. The interaction between electron and gyrotron beam yield a stronger coupling when located at the slope of the background magnetic field. The slope of the magnetic field domi-
nates the effect for third harmonic interaction, whereas the second harmonic is less affected by the slope.

**P 11.40 Wed 14:00 HSZ EG**
Modeling of runaway electrons in disruption mitigation scenarios with DREAM — **Peter Halldestam**, Gergely Papi, Hannes Bergström, Mathias Hoppe, Oskar Vallhagen, Istvan Puza, and Tünde Fulop
Max Planck Institute for Plasma Physics, Garching, Germany — 2 Swiss Plasma Center, Lausanne, Switzerland — 3 Department of Physics, Chalmers University of Technology, Göteborg, Sweden

One of the main issues threatening the success of future reactor-scale tokamaks is disruptions. It is the sudden loss of confinement where the plasma rapidly dissipates its energy onto the surrounding structures, exposing the device to excessive mechanical stress and heat loads. In addition, an electric field is induced that can accelerate a significant fraction of the electrons to relativistic energies, giving rise to runaway electrons (REs). Unmitigated disruptions could potentially cause severe damage to the device and, thus, modeling such events is crucial for being able to assess the effectiveness of various mitigation techniques.

Using the numerical RE modeling framework DREAM [Hoppe CPC 2021], we study the effects massive material injection (MMI) of deuterium and neon has on disrupting plasma representative of ITER, particularly the RE generation and the dissipation of its energy content. We self-consistently evolute the electric field, ion charge state densities, thermal electron temperature and density as well as the RE density in a flux surface-averaged fluid description of the plasma. This model is used together with a Bayesian optimisation tool to find suitable MMI parameters that minimise potential damage to the device.

**P 11.41 Wed 14:00 HSZ EG**
Electromagnetic fluctuation in the full-f edge turbulence code GRILLIX — **Kaiyu Zhang**, Vladmir Zhlobenko, Andreas Stegemier, Christoph Pitzlar, Konrad Eder, and Frank Jenko
Max Planck Institute for Plasma Physics, Garching, Germany — 2 Boltzmann-Institut für Strahlen- und Partikelphysik, Garching, Germany

Electromagnetic fluctuation has been implemented and verified in GRILLIX, a full-f turbulence code for the edge and scrape-off layer in tokamaks. Simulations for L-mode ASDEX Upgrade are performed with electromagnetic fluctuation. We particularly investigate how fluctuation transport contributes to the density advection and heat conduction perpendicular to the magnetic flux surfaces.

An issue arising during the computation of fluctuation is that a large-scale magnetic signal is rarefying-counted in the fixed background magnetic equilibrium and in the full-f turbulence. Commonly, the toroidal average of magnetic potential was stripped to remove this shift. However, this method is found to cause a spurious reduction of the perpendicular turbulent transport in GRILLIX. Two refined methods are explored: (1) removing the time averaged magnetic field; (2) tracing the evolution of Pfirsch-Schluter currents analytically and removing the corresponding induced magnetic field. The new methods seem superior in preserving the amplitude of the perpendicular turbulence transport.

**P 11.42 Wed 14:00 HSZ EG**
Engineering tool for the robust optimization of a full-W divertor in W7-X — **Anton Menzel-Barbara**, Joris Fellinger, Rudolf Nef, Dirk Naikos, and Thomas Pedersen
— 2 Max Planck Institute for Plasma Physics, 17491 Greifswald, Germany — 3 Technische Universität München, 85748 Garching, Germany

High levels of fuel retention due to co-deposition make C-based materials such as CFC, currently used on the W7-X divertor, incompatible for a fusion reactor. As part of an ongoing investigation into a W-based divertor for W7-X, an engineering tool for the robust optimization of leading edges is being developed. Leading edges, resulting from assembly tolerances and deformation during operation, lead to very high incidence angles and to strongly increased heat fluxes. Compared to a C-based divertor, leading edges in a W design are more problematic because of W melting. Since manufacturing and assembly tolerances are major cost drivers, relaxing them is another priority for a new divertor. Because particles in W7-X can come from opposite directions on the target surface in different magnetic configurations, the usual strategy of entirely shadowing divertor plates to avoid leading edges is not possible. Instead, a more refined approach that optimizes the divertor surface while considering all major magnetic configurations is necessary. Among the tools, including the code EM3-Lite and Ansys, is used to rapidly evaluate a modified surface, and identify the problematic areas. Strategies to effectively explore the design space of geometric modifications are currently being investigated.

**P 11.43 Wed 14:00 HSZ EG**
Validation of theoretical upper bounds on local gyrokinetic instabilities — **Linda Podavini**, Per Helander, Gabriel Plunk, and Alessandro Zocco
Max Planck-Institut für Plasmaphysik, Wendelsteinstraße 1, 17491 Greifswald

In the last decades these instabilities have been extensively studied considering various assumptions about plasma parameters and magnetic geometry, thus hampering a desirable unified theory. Only recently, it was shown by Helander and Plunk [1] that it is possible to obtain universal upper bounds on the growth rates of local gyrokinetic instabilities, via thermodynamic considerations. These bounds are valid for all possible microinstabilities and they are independent of the magnetic field configuration and some plasma parameters, such as the number of particle species, beta and collisions.

In this work, we compare the theoretical upper bounds on growth rates with numerical and analytical results in different geometries, including stellarator, tokamak and a pinch. For the numerical results, linear, flux-tube simulations are obtained using the gyrokinetic code stella.


**P 11.44 Wed 14:00 HSZ EG**
Experimental impurity transport analysis for the tokamak plasma edge — **Tabea Gléiter**, Rux Dux, Francesco Sciorinto, and the ASDEX Upgrade Team
2 MaxPlanck-Institut für Plasmaphysik, Garching, Germany — 2 Physik-Department E28, Technische Universität München, Garching, Germany — 3 Authors of U. Stroth et al. 2022 Nucl. Fusion 62 042006

Impurity transport in the pedestal and SOL region impacts energy confinement and radiative power exhaust in tokamaks. However, thorough characterization is lacking for many confinement modes. This includes promising regimes for future reactor scenarios without type-I ELMs, such as the quasi-continuous exhaust (QCE) mode.

A series of impurity seeded (Ne, Ar or N) discharges in various confinement modes was conducted at ASDEX Upgrade. Their experimental setup was tailored for high resolution charge exchange recombination spectrometry (CRESX) analysis at the plasma edge. From the observed line radiation density profiles of multiple impurity charge states are derived, making use of a neutral beam model, the beam attenuation code COLRAD and ADAS atomic rates. Fitting the charge state distribution with a diffusive-convective transport model such as STRAHL or Aurora, insightful can be gained about the impurity transport.

Both Levenberg-Marquardt as well as a Bayesian nested sampling algorithm are used for this inverse inference.

Current work focuses on the QCE plasma in our dataset, comparing them to H-mode with type-I ELMs. In particular, discharges with a stepwise transition between both regimes are evaluated.

**P 11.45 Wed 14:00 HSZ EG**
ASDEX Upgrade shattered pellet injection experiments — **Paul Heinrich**, Gergely Papi, Matthias Bernert, Pascal de Marné, Mathias Dibon, Stefan Jachmich, Michael Lehnen, Tobias Pereshorfer, Umar Sheikh, Jakub Sbovoda, the ASDEX Team, and the MSTI Team — 2 Max-Plank Institut für Plasmaphysik, Garching, Germany — 3 IPP, St. Paul- lez-Durance, France — 3 Institute for Applied Physics, Wien, Austria — 3 EPFL, Lausanne, Switzerland — 3 IPP CAS, Prague, Czech Republic — See author list of U. Stroth et al. 2022 Nucl. Fusion 62 042006 — See author list of B. Labit et al. 2019 Nucl. Fusion 59 086020

In December 2021, the shattered pellet injection (SPI) system was successfully installed on the tokamak ASDEX Upgrade (AUG). Hereby, large amounts of material are injected into the plasma, radiating strongly and thereby spreading the previously confined energy over a larger area in comparison to unmitigated disruptions. The AUG SPI system allows a large variation in pellet parameters such as pellet size, velocity or composition and different shatter geometries. The main goal is to simulate different ITER disruption mitigation (DMI) scenarios. In the 2022 campaign at ASDEX Upgrade around 240 discharges were performed for the SPI experiments. Different shatter heads were installed at the end of each of the three independent guide tubes. The focus of the analysis presented here is to find the optimal pellet parameters and shatter geometries for maximizing the radiated energy, while reducing localized heat loads.

**P 11.46 Wed 14:00 HSZ EG**
Investigation of Tearing Modes in ASDEX Upgrade — **Magdalena Bauer**, Louis Giannone, Anja Gude, Klas Lokske, Marc Marascheck, Bernhard Sieglin, Wolfgang Strueb, Hartmut Zohm, and the ASDEX Upgrade Team — Max Planck Institute for Plasma Physics, Garching

Tearing modes with toroidal mode number n=1 are precursors of and significantly involved in disruptions, especially when they are locked to the vessel. While rotating modes can be observed by many Mirnov coils measuring the time derivative of the poloidal magnetic perturbation field, locked modes require a radial field measurement. In addition to the saddle coils on the high field side, toroidally distributed radial field coils at two different poloidal positions on the low field side can be used to gain information on slowly rotating and locked modes. A 3D finite element model, simulating the field generated by a single helical perturbation current in all coils, has been improved by considering the detailed coil geometry and a better description of conducting in-vessel parts in which mirror currents affecting the local perturbation field are induced. Coupling of n=1 modes with different poloidal mode numbers is believed to play a large role in the disruption process. The projection of the measured complex

**Wednesday**
amplitudes in all coils on the modelled perturbation amplitudes with single he-
lities allows to determine the contribution of different poloidal mode numbers
for rotating modes. For locked modes, only the three poloidal positions of the
radial grids coils are given. The opportunities and limitations of the poloidal
mode structure analysis are investigated.

P 11.47 Wed 14:00 HZS EG
Power balance analysis and predictive modelling using the codes neotransp
and NTSS — MARKUS WAPPEL, MARC BEURSEKENS, SERGEY BOZHENKOV,
HAKAN SMITH, and YURI TURKIN — Max-Planck-Institute for Plasma Physics,
Greifswald, Germany
One effect seriously limiting the plasma performance of the stellarator Wendel-
stein 7-X is ion temperature clamping, which restricts ion temperatures to about
1.5 keV in a wide range of scenarios. Empirical scaling laws such as ISS04 pre-
dict the performance of stellarators. However, no first-principle models offering
a physical understanding or a clear explanation for the clamping are available. It
has been shown that turbulent flux losses limit the achievable performance of a
stellarator. ITG modes are thought to be the dominating turbulent process for
ion heat losses and might be the cause for the ion temperature clamping observed
at W7-X.

P 11.48 Wed 14:00 HZS EG
Non-Axisymmetric Generalization of the Gyrokinetic Turbulence Code
GENE-X — MARION SMEDEBURG1, ANDREAS STEIGMEIR1, PHILIPP ULM1, and
FRANK JENSEN2 — 1 Max Planck Institute for Plasma Physics, Boltzmannstraße 2,
85748 Garching, Germany — 2 University of Texas at Austin, Austin, TX
78712, USA
For optimized stellarators, edge plasma turbulence both sets the boundary con-
dition for core performance and determines the heat fluxes onto the plasma-
facing components. Thus realistic simulations of plasma turbulence in the edge
and scrape-off layer (SOL) are a key step towards a stellarator power plant. The
gyrokinetic turbulence code GENE-X [1] is well-equipped to simulate edge and
SOL turbulence due to the use of a flux-coordinate independent (FCI) coordinate
system [2]. However, until now the code has only simulated in axisymmetric ge-
ometries, such as tokamaks. Here progress towards a non-axisymmetric upgrade
of the GENE-X code is presented. The focus will be on the implementation of
stellarator magnetic fields, the development of numerical methods for represent-
ing the shape of three-dimensional flux surfaces, and simulating simple diffusion
and advection models in a fully three-dimensional geometry.


P 12: Poster II
Time: Wednesday 17:30–19:00
Location: HZS EG

P 12.1 Wed 17:30 HZS EG
Laser-induced charge ablation in surface DBD — ROBIN LABENSKY, DAVID
STEIER, HENRIK VAN IEPSEL, VOLKER SCHULZ-VON DER GATHEN, MARC BOKE,
and JUDITH GOLDA — Ruhr-University Bochum, D-44801 Bochum, Germany
In the emerging field of plasma catalysis, atmospheric pressure plasmas turned
out to be promising candidates. Especially micro cavity plasma arrays allow for
fundamental investigation of the interaction between the plasma and catalytic
surfaces. As this reactor is a surface DBD, the used dielectric (e.g., catalyst)
plays a crucial role in its discharge behavior since it can be charged during
ignition. To visualize these charges and investigate their impact on catalysis, the
array (18 kHz, 400-800V) is irradiated using a nanosecond Nd:YAG laser (20Hz,
532nm/1064nm) to ablate the charges during/after ignition. The impact of the
laser is detected using global (and eventually local) electrical measurements as
well as optical emission spectroscopy. While global electrical measurements in-
volve current and charge measurements (i.e., Lissajous-figures), local measure-
ments are planned to be performed using a Picosampermeter directly picking
up the ablated charges. Measurements show a lower/higher ignition voltage in the
consecutive (half) cycle and a decrease of charge in the Lissajous-figure im-
mediately after laser irradiation.
This work is supported by the DFG via SFB 1316 (project A6).

P 12.2 Wed 17:30 HZS EG
Characterization of the atmospheric plasma source HelixJetS: generation of
carbon nanoparticles — LIONNE MOHN, MAREN DSWORSHAK, and JAN
BENEDICT — Institut of Experimental and Applied Physics, Kiel University, Ger-
many
Silicon nanoparticles are of interest in developing new technologies such as next
genation solar panels. Low-pressure discharges can produce silicon nanoparti-
cles reliably but the cost effective and modular nature of atmospheric discharges
makes them compelling to study. The atmospheric plasma source HelixJetS is
analyzed to determine its ability to produce such silicon nanoparticles. The He-
luxJetS, a scaled down version of the HelixJetS, has two electrodes that form a
double helix, one of which is driven by RF power. The jet is operated with gas
mixtures consisting of He, Ar, H2, and SiH4. To minimize the material deposi-
tion, there are two spatially separated gas inlets for He/H2 on the outer diameter
and for He/Ar/SiH4 on the jet axis. The flow rates are simulated with Comsol to
find those that achieve laminar flow. The Jet is characterized by varying the gas
composition and the power deposited into the plasma and analyzing the resulting
plasma by means of optical emission spectroscopy. The resulting nanoparticles
are analyzed in regards to size, composition and photoluminescence. A Scan-
ing mobility particle sizer is used to obtain the size distributions. FTIR and in
situ-FTIR are used to determine the chemical composition of the particles. If the
silicon nanoparticles crystallize, they exhibit photoluminescence, which is also
qualitatively analyzed.

P 12.3 Wed 17:30 HZS EG
Deposition of thin films from organosilicon precursors by means of photo-
chemistry with VUV-radiation from an atmospheric pressure plasma jet —
CHRISTINA REISER, TRISTAN WINZER, and JAN BENEDICT — Institute of Exper-
imental and Applied Physics, Kiel University, Kiel, Germany
Deposition of thin films using atmospheric pressure plasma (APP) is still limited
due to the high collision rates and in the case of many precursors (C2H2, SiH4)
also due to fast formation of particles in the gas phase, resulting from the fast
polymerization of negative molecular ions. Activation of these precursors with
VUV-photons should avoid the formation of the negative ions and, therefore,
also particles.
In this work, a high purity noble gas plasma is used for producing intense
VUV-radiation from noble gas excimer sources. The gas flow through the plasma
is guided in such a way, that the plasma and the effluent have no contact with the
precursor gas flow, while the emitted radiation produces ions and radicals in
the precursor gas flow directly in front of the treated surface. For optimizing
deposition rates and film quality, parameter variations are carried out in which
the photochemistry of organosilicon precursors is analyzed by ion mass spec-
trometry. Deposited films are characterized using Fourier transform infrared
spectroscopy (FTIR).

P 12.4 Wed 17:30 HZS EG
Numerical modeling of CO2 microwave discharges: first verification steps
of electromagnetics — PIYMIN ALMANSTÖTTER1, DOMINIKUS ZIELELK1, and
ÜBSEL PANTZ2 — 1 Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2,
85748 Garching — 2 AG Experimentelle Plasmaphysik, Universität Augsburg,
86135 Augsburg
To optimize the efficiency of CO2 conversion processes, microwave plasmas
(2.45 GHz) are very promising. Examples are the plasma torch (pressure 20-
1000 mbar, power: 0.3–3 kW, flow: 3–100 slm), which can even operate at
atmospheric pressure and the surfaguide (pressure 0.3–100 mbar, power: 0.3–1.2
kW, flow: 0.3–10 slm). To accompany experimental optimization efforts and for
a systematic investigation, a numerical model is needed that describes the elec-
magnetics and plasma self-consistently. Before the model can be applied with
confidence verification and validation is necessary. This is done for the electro-
magnetics and the discharge part separately, which consequently will be coupled.
The contribution covers the verification of the electromagnetics part. As a first
example, solutions of waveguides in cylindrical and rectangular geometries with
either dielectric or conducting walls are investigated. It is shown that the solu-
tions obtained by the numerical model match the analytical results.

P 12.5 Wed 17:30 HZS EG
Durability of metal-organic-frameworks (MOFs) in non-equilibrium at-
mospheric pressure plasmas — ALEXANDER QUACKE1, KERSTIN SSOINNA1,
HAUSE ROHDE1, ROBERT STOCK2, and JAN BENEDICT3 — 1 Institute of Exper-
imental and Applied Physics, Kiel University — 2 Institute of Inorganic Chem-
istry, Kiel University
Metal-organic frameworks (MOFs) have a large surface area and different metallic structures, which gives them good catalytic properties. Nevertheless, MOFs mostly cannot withstand high temperatures, which are needed for their activation in classical catalytic processes. Reactive plasmas using gas mixtures based on N₂, H₂, and CO₂ gases and post-in-plasma treatment under externally controlled temperature up to 200°C have been applied to several MOFs including ZIF-8, ZIF-67 and MAP-6. Structural MOF analysis (XRD, FTIR) allows us to judge the stability of the MOF in the applied plasma treatments.

P 12.6 Wed 17:30 HSZ EG

Space resolved temperature measurements in an atmospheric pressure argon methane microwave plasma — Simon Kreuznacht, Marc Böke, and Achim von Keudell — Experimental Physics II, Ruhr University Bochum, Germany

Hydrogen is often envisioned as the energy carrier and green fuel of the future. However, new energy efficient and greenhouse gas free production methods are needed to utilize hydrogen as energy carrier on larger scales. A promising production method is the pyrolysis of methane in a microwave plasma. Here, we present a microwave plasma torch operated in an argon methane mixture (60 sml total flow rate, up to 35 % methane admixture) at atmospheric pressure. Microwaves with a frequency of 2.45 GHz and up to 6 kW of forward power are used to sustain the plasma. The methane is converted to hydrogen, solid carbon, acetylene and ethylene inside the plasma. The emission spectrum from the plasma is dominated by black body radiation from hot carbon particles and the dicarbon Swan bands. Broadband spectra of the black body radiation and high-resolution spectra of the dicarbon Swan bands are used to estimate the space resolved gas temperature from the black body temperature and the dicarbon rotational temperature. In the center the plasma reaches temperatures of up to 4600 K with large gradients of about 500 K in radial direction and 50 K in axial direction.

P 12.7 Wed 17:30 HSZ EG

Exploration of New Use Cases of Cold Atmospheric Plasma in Medicine, Surface Decontamination and Astronautics — Alissa Schmidt and Markus H. Thoma — Justus-Liebig-Universität, Gießen, Deutschland

Wound healing, the corona pandemic and manned spacecraft - how can a connection be drawn between all these different areas via physics?

All of these three areas have their own problems: the healing of chronic wounds, for example, can be inhibited by wound healing disorders and infections, in the corona pandemic there were supply shortages of protective equipment and respiratory masks - which led to the reusability of protective equipment becoming a subject of discussion - and finally manned space flight, according to NASA, aims to bring humans to the moon again in 2025 and even freely. The aim of this work and the first step towards such a powerful device is a single tweezer setup with a SLM. To determine the forces in the plasma that a holographic-optical tweezer exerts on a particle, the radiation pressure and the gradient force are examined. This allows to develop a trap design and implement the holographic-optical tweezers in a dusty plasma experiment.

P 12.8 Wed 17:30 HSZ EG

Research data management in plasma science — Markus M. Becker, Kerstin Sonnina, and Marina Penzel — Leipzig Institute for Plasma Science and Technology (INP) — Institute of Experimental and Applied Physics, Kiel University (CAU)

Implementation of data management standards and adoption of the FAIR data principles are more and more requested by funding agencies in recent years. This paper presents the results obtained in the research focus of dusty plasmas as an example how the FAIR principles are more and more requested by funding agencies in recent years.

P 12.9 Wed 17:30 HSZ EG

Dust flows around an obstacle under microgravity — Stefan Schütz, Christina Knappe, Daniel Maier, Daniel Mohr, and André Melzer — University of Greifswald, Greifswald, Germany

Dust flows around an obstacle in three-dimensionally extended dusty plasmas have been investigated on parabolic flights. A fixed tungsten wire has been installed in the plasma chamber perpendicular to the observation plane of a video microscopy setup and serves as an obstacle. Three different situations were created. First, the dust flow around the wire was investigated during the pull-out phase at the end of each parabola, when gravity sets in and the dust cloud moves back to the wire. Second, the dust motion with respect to the fixed wire was investigated during the pull-out phase at the end of each parabola, when gravity sets in and the dust cloud moves back to the wire. The dust flow speed was generated by modulation of the electrode bias. And third, the wire was electrically biased and the reaction of the dust to bias voltage changes was studied. In this contribution, a first evaluation of all three situations will be presented. This work was supported by DLR under grant no. 50WM1962.

P 12.10 Wed 17:30 HSZ EG

Development of a holographic optical trap design — Christian Thiede, Natasa Blosczyk, and Dietmar Block — Institute of Theoretical and Applied Physics, Kiel University, Germany

In the research focus of dusty plasmas, a controlled manipulation of dust particle position is considered a major challenge. Especially in the field of binary mixtures, there is great interest in being able to control the positions of the particles to create binary crystals or liquids with periodic particle arrangement. First experiments show that optical tweezers can manipulate single particles in a dusty plasma [1, 2]. The problem here is that only one particle can be moved at a time. This is different for holographic-optical tweezers. Here the basic idea is to generate a hologram and display it at a spatial light modulator (SLM). Laser illumination of the SLM can create arbitrary light field and thus realize multiple tweezers at once. In this way, several tweezers can be projected at the same time. In addition, the hologram can be varied dynamically. The aim of this work and the first step towards such a powerful device is a single tweezer setup with a SLM.

Influence of the ion focus on diagnostics and simulations in 2D dusty plasmas — Natasa Blosczyk, Yang Liu, and Dietmar Block — Institute of Experimental and Applied Physics, Kiel University, Germany

Dusty plasma properties are an important part of the field of dusty plasmas as properties such as charge can strongly influence the behaviour of single particles and, because of their coupling, of the entire system. A current interest is the description and evaluation of wave propagation in a 2D cluster, especially in clusters of binary mixtures. For this purpose, phonon dispersion relations and configurational temperature can be used as diagnostics to evaluate wave frequencies and charge respectively. These methods rely on a full and correct description of the interaction forces. Until now it has been mostly assumed to be a purely repulsive Yukawa interaction and strong inelastic scattering processes respect the influence of a fixed ion focus charge. Based on MD simulations, this poster will discuss the importance of the ion focus in simulations and diagnostics and wether it can really be disregarded.

Creating nanodust clouds with different electrode geometries — Franko Greiner, Andreas Petersen, and Alexander Schmitz — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität Kiel

In a radio-frequency driven parallel plate reactor, nanodusty plasmas are created by means of reactive argon acetylene or argon silane plasmas. Switching off the reactive gas admixture creates a pure dusty plasma, consisting only of electrons, ions, and dust with a predetermined dust density. With fixed wire experiments, we probed the influence of different electrode geometries on the properties of dusty plasmas. Dust clouds were created in a radio-frequency driven parallel plate reactor with a 2 mm gap and with different electrode distances for the 2D dusty plasma diagnostics. In this work we investigated the influence of different electrode geometries on the properties of dusty plasmas.

P 12.11 Wed 17:30 HSZ EG

Influence of the ion focus on diagnostics and simulations in 2D dusty plasmas — Natasa Blosczyk, Yang Liu, and Dietmar Block — Institute of Experimental and Applied Physics, Kiel University, Germany

Creating nanodust clouds with different electrode geometries — Franko Greiner, Andreas Petersen, and Alexander Schmitz — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität Kiel

In a radio-frequency driven parallel plate reactor, nanodusty plasmas are created by means of reactive argon acetylene or argon silane plasmas. Switching off the reactive gas admixture creates a pure dusty plasma, consisting only of electrons, ions, and dust with a predetermined dust density. With fixed wire experiments, we probed the influence of different electrode geometries on the properties of dusty plasmas. Dust clouds were created in a radio-frequency driven parallel plate reactor with a 2 mm gap and with different electrode distances for the 2D dusty plasma diagnostics. In this work we investigated the influence of different electrode geometries on the properties of dusty plasmas.

P 12.12 Wed 17:30 HSZ EG

Creating nanodust clouds with different electrode geometries — Franko Greiner, Andreas Petersen, and Alexander Schmitz — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität Kiel

In a radio-frequency driven parallel plate reactor, nanodusty plasmas are created by means of reactive argon acetylene or argon silane plasmas. Switching off the reactive gas admixture creates a pure dusty plasma, consisting only of electrons, ions, and dust with a predetermined dust density. With fixed wire experiments, we probed the influence of different electrode geometries on the properties of dusty plasmas. Dust clouds were created in a radio-frequency driven parallel plate reactor with a 2 mm gap and with different electrode distances for the 2D dusty plasma diagnostics. In this work we investigated the influence of different electrode geometries on the properties of dusty plasmas.

P 12.13 Wed 17:30 HSZ EG

Creating nanodust clouds with different electrode geometries — Franko Greiner, Andreas Petersen, and Alexander Schmitz — Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität Kiel

In a radio-frequency driven parallel plate reactor, nanodusty plasmas are created by means of reactive argon acetylene or argon silane plasmas. Switching off the reactive gas admixture creates a pure dusty plasma, consisting only of electrons, ions, and dust with a predetermined dust density. With fixed wire experiments, we probed the influence of different electrode geometries on the properties of dusty plasmas. Dust clouds were created in a radio-frequency driven parallel plate reactor with a 2 mm gap and with different electrode distances for the 2D dusty plasma diagnostics. In this work we investigated the influence of different electrode geometries on the properties of dusty plasmas.
electric field. The argon-filled chamber was installed in the University of Hanover's drop tower, the Einstein Elevator. As the setup fell, the microparticles spread into the bulk plasma due to the electric field and were imaged with a CCD camera. The trajectories of the microparticles, which were determined by image analysis, were used to determine the electric forces acting on the microparticles. Considering fluid dynamic simulations, we were able to determine the electric field acting on the microparticles.

Investigation of Screw-Like Wave Phenomena in DC-Discharged Plasma with PK-4 — • Lukas Wimmer and Markus H. Thoma — Justus-Liebig-University Gießen, Germany

If micrometer to nanometer-sized microparticles are introduced into a plasma, it is referred to as dusty or complex plasma. The Plasmakristall-4 facility (PK-4) is the fourth and latest version of a successful series of experiments for fundamental research of complex plasmas. If PK-4 is operated at low pressure, \( p < 25 \) Pa, as well as at low energy, and the dust particle size falls below a certain limit, screw-like wave phenomena appear in ground-based experiments. Local system properties show that the wave structure is caused by the two-stream instability of ions and dust particles, assigned to the regime of dust-acoustic waves, and the superposition of longitudinal and transversal waves causes the curvature of the waves. Deeper analysis gives us information about the ion drag force in the low-pressure regime and the local electric field in the boundary region.

Particle Chains in Dusty Plasmas under microgravity — • Daniel Maijer, Michael Himpel, Stefan Schutt, and André Melzer — Institut für Physik der Universität Greifswald, Greifswald, Deutschland

Chain-like structures of charged dust particles have been observed in dusty plasmas under microgravity conditions. These structures appear near the midplane and around the particle free zone (void) of the plasma. The previous 2-dimensional investigations of the chains have difficulties in separating chains from each other, proving their authenticity or observing them at full length. The described experimental set-up, containing four high speed cameras allows a stereoscopic, 3-dimensional observation and investigation of these structures and the interaction of the included particles with high temporal resolution (up to 200 fps). Here a simple model to identify chains and first results of the stereoscopic investigations will be shown.

Ion emission of various materials from laser plasmas using a pre-pulse — • Qendresa Ibraimi, Lars Toreben Schwartz, Jan Riedlingher, and Georg Pretzler — Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf

Plasmas generated by ultra-short, intense laser pulses have high density and temperature, far from equilibrium, and their dynamics is dominated by several processes. Therefore, the ion dynamics in the early phase of these plasmas is difficult to predict. Here, we present experimental data of the ion emission from dusty plasmas driven by single-digit-fs laser pulses with intensities up to \( 10^{17} \) W/cm\(^2\) focused on various solid targets. The ions reach kinetic energies of several tens of keV and were characterized in terms of species, direction, and energies by a Thomson parabola spectrometer. The differences of the spectra for distinct materials and pre-plasma conditions may allow conclusion on processes during and after laser-surface interaction. These findings are presented and discussed.

Influence of a pre-pulse on ultra-short laser-induced plasma emission — • Timo Werner, Steffen Mittelmann, and Georg Pretzler — Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf

In the versatile field of Laser-Induced Breakdown Spectroscopy (LIBS), ultra-short laser pulses in the femtosecond range are promising tools for detecting impurities and material composition with very high lateral and depth resolution. It has been shown that double-pulse or pre-pulse systems may significantly enhance the emission of the detected spectral lines of atoms and ion species present in the laser-induced plasma. This effect is known precisely as a reference. In this contribution, we investigate the influence of a pre-pulse on the emitted spectral lines in a vacuum LIBS setup with laser pulses of durations in the sub-10-fs range. The main pulse delay is varied up to 800ps and the influence on plasma parameters and ablation yield is examined on polished copper and silicon samples. First results give evidence that there are regimes where higher ionization degrees and temperatures are achieved. Significantly decreased ablation yield is observed at the same time, which is attributed to plasma shielding effects. These results path the way for further optimization of ultra-short pulse LIBS with even higher spatial resolution.

Experimental determination of the phase shift upon reflection — • Johanna Köchling, Nico PotzkaI, and Georg Pretzler — Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf

Interferometry can determine the expansion of laser plasmas in their early stage with a temporal resolution down to 10 fs. However, with measurements in the reflection geometry, the phase shift of the light reflected at the surrounding undis-turbed material must be known precisely as a reference. In this contribution, we present experimental results for this reflective phase shift for a series of thin metal layers of different thickness. The results are compared with theory and extrapolated to other regimes.
prone to transient perturbations in their field. In present experiments, one of the main methods of generating fast ions is neutral beam injection (NBI). Magnetic islands arise from helical perturbations of the background magnetic field, either internally from the plasma or externally from magnetic coils.

BEAMS3D is a Monte Carlo code that simulates NBI deposition and collisional slowing down in stellarator and also tokamak plasmas. We present results of verification against NUBEAM as well as validation against experimental data at the ASDEX Upgrade tokamak using fast-ion D-alpha light (FIDA). The results show good agreement between the codes and to experimental data both in on- and off-axis NBI heating phases, demonstrating the capability of BEAMS3D. Additionally, first results comparing simulations and experimental data of plasmas with internal wells are presented.

P 12.23 Wed 17:30 HSZ EG
Towards non-linear hybrid simulations of the interaction between energetic particles in a stellarator geometry — *Felix Antlitz, Xin Wang, and Matthias Hoelzl* — Max Planck Institute for Plasma Physics, Garching b. M., Germany
Future burning plasma experiments will feature a high supra-thermal particle pressure which strongly interact with magneto-hydrodynamic instabilities. To describe these dynamics accurately in simulations, realistic tokamak geometry, the self-consistent evolution of the plasma equilibrium, and a full treatment of the energetic particle population are needed. This contribution describes developments towards this goal based on the non-linear MHD code JOREK, in which a hybrid mode for energetic particles had recently been introduced based on a pressure coupling and tested linearly. The non-linear evolution of filamentation in instabilities is foreseen as one of the first applications.

P 12.24 Wed 17:30 HSZ EG
Thermal equilibrium for non-neutral plasmas in a stellaric dipole trap — *Patrick Steinbrunner*, Matthew R. Stone1, Thomas M. Oevel, and Daniel H. E. Dubin* — Max Planck Institute for Plasma Physics, Greifswald, Germany — *2Lawrence University, Appleton, USA — University of California San Diego, La Jolla, USA
The confinement of a non-neutral plasma in a thermal equilibrium state is known to be possible in the uniform magnetic field of a Penning-Malmberg trap. We generalize the theory of these states to include inhomogeneous magnetic dipole fields. We present computational results for local thermal equilibration along magnetic field lines as well as global thermal equilibration and there respective zero-temperature limits. The distribution function of a global thermal equilibrium state is obtained by maximizing the plasma entropy subject to fixed values for the total number of particles, total energy and total canonical angular momentum. If a non-neutral plasma arrives in this state, there is no conceptual limit on the confinement time. Such a configuration also confines a quasi neutral plasma for a finite amount of time, making it an attractive candidate for the creation of an electron-positron pair plasma as planned by the APEX collaboration.

P 12.25 Wed 17:30 HSZ EG
Influence of Radial Electric Field and Ideal Ballooning Stability on the Pedestal Width — *Lidija Radovanovic*, Elisabeth Wolfrum*, Mike Dunne*, Marco Cavedon1, Georg Harrer1, Friedrich Aumayr2, and ASDEX Upgrade Team2 — 3Institute of Applied Physics, TU Wien, 1040 Vienna, Austria — *1Max Planck Institute for Plasma Physics, 85748 Garching, Germany — 2Universita di Milano-Bicocca, 20126 Milano, Italy — *3see author list of U. Stroth et al. 2022 Nucl. Fusion 62 042006
Understanding the physical processes which govern the pedestal is crucial for reliable prediction and control of the plasma conditions and for its stability. The first experimental method investigates if the ideal ballooning modes at the pedestal top could cause additional transport and limit the pedestal width. A variation in the plasma stability is achieved by modifying the shape of the plasma. Increasing the triangularity of the plasma widens the electron pressure pedestal at a fixed gradient, which correlates with the minimum ballooning stability. The second method assumes that the turbulence in the plasma edge is suppressed due to the presence of a critical shear flow originating from radial electric field gradients. The radial electric field is varied by changing the density in discharges with plasma boundary conditions of the same total power but selectively apply a different amount of torque to the plasma. It is shown that the electron density changes with shaping and the ion temperature with torque of heating method. Therefore it seems as if there is no clear actuator for the pedestal width, but each component is influenced individually by different physical processes.

P 12.26 Wed 17:30 HSZ EG
Causal coupling between small-scale fluctuations and zonal flows at the stellarator TJ-K — *Nicolas Dumérait and Mirko Ramesh* — IGVP, University of Stuttgart, Germany
Convergent cross mapping (CCM) is a causality inference technique used to identify causal links and directions of influence between variables. In this work, Langmuir probe measurements of plasma potential and density fluctuations across TJ-K’s whole poloidal cross section are used as input for the CCM to map causal links between turbulent phenomena across distant flux surfaces.

Thus, zonal potential (ZP) structures are found to be causally related to density fluctuations in the core, which could reflect equilibrium density modulations via transport regulation by ZP and/or changes in drift-wave structures. Correlation coefficients between plasma potential and ZP fluctuations has been found to exhibit a strong bi-directional relation around the region of both maximum Reynolds stress and turbulent particle transport. Moreover, ZP is found to be caused by small-scale density and potential fluctuations with density dominating over potential. This is in line with vortex tilting and subsequent zonal flow drive in consequence of strong density-potential coupling drift-wave turbulence. The energetic particle–background plasma coupling between background turbulence structures and zonal flows is revealed with CCM and further analysis according to poloidal orientation is under investigation.

P 12.27 Wed 17:30 HSZ EG
Diverter spectroscopy during Detachment in Wendelstein 7-X — *Frederik Henke*, Maciej Krychowiak, Ralph König, Felix Reimold, Eric Flom, and Dorothea Gradic — Max Planck Institute for Plasma Physics, Wendelsteinstr. 1, 17491 Greifswald, Germany
Detachment is a mandatory regime for running long discharges with high power in W7-X in order to not reach the power load material limits of the walls. As a future stellarator reactor will run steady state, the detachment regime has to be investigated. In this work, the mainly used diagnostic system is diverter spectroscopy. Various important aspects during this regime can be assessed using different spectroscopic methods. One challenging aspect is the density build up in detachment as high pressures are needed to have good impurity and density control via pumping. To measure this in the SOL, the Stark broadening of Balmer-α lines is analyzed. The Balmer-α line is one of the best options to measure hydrogen in the SOL plasma. Radiation of a large fraction of the input power is necessary to enter the detachment regime. For reaching these radiation levels, hydrogen radiation capabilities are insufficient. Therefore, the intrinsic impurity carbon or seeded impurities nitrogen, neon or argon are needed. As carbon is no reactor relevant wall material, it is crucial to understand the behaviour of the seeded impurities. Only very low concentrations of impurities can be tolerated in the core plasma for a future reactor because of fuel dilution and radiation, while they are needed at the edge. This aspect is investigated via line ratio divertor spectroscopy combined with CXRS in the core.

P 12.28 Wed 17:30 HSZ EG
Measurement and Modeling of radiation losses in the stellarator TJ-K — *Izel Gediz* and Alf Kohl-Seemann — IGV, University of Stuttgart, Germany
In the stellarator TJ-K cold plasmas of up to 20 eV are routinely produced. An 8-channel gold-foil bolometer is used to observe the radiation emitted by the plasma. Following the principle of a “camera obscura” the 8 channels observe the plasma through a small slit, allowing for reconstruction of the spatial profile of the emitted radiation. In this manner line integrated power profiles can be recorded, giving information about the absolute numbers of radiated power as well as the relative spatial distribution of the radiation. This diagnostic was recently reestablished and newly calibrated to aid parameter studies, including plasma density and temperature measurements. Line radiation is the major contributor to the radiation losses of typical plasmas in TJ-K. Information about the line radiation loss less terms will provide insight into the efficiency of confined plasmas as well as increase the accuracy with which other loss-terms (e.g. diffusion terms) in energy- and particle-balance equations can be estimated. Furthermore the spatial radiation profiles can reveal interesting parameter regimes where e.g. fast electrons in the plasma edge regions could be observed. The radiation profiles are also being calculated and compared with the measurements, enabling adjustments of the model used to estimate the radiative loss term so far.

P 12.29 Wed 17:30 HSZ EG
Machine Learning Applications in Control at ASDEX Upgrade — *Johannes Ilerhaus*, Wolfgang Truttebe1, Alexander Bock1, Rainer Fischer1, Paul Heinrich1, Frank Jenko2, Ondrej Kudlacke1, Gerberg Pape1, Tobias Peterheister1, Bernhard Sieglin1, Udo von Toussaint1, Hartmut Zorn1, and the ASDEX Upgrade Team2 — 1Max-Planck-Institut für Plasmaphysik, Garching, Germany — 2Technische Universität München, Garching, Germany — *3Maxwell Maxplanet Universitäten, Munich, Germany — Technische Universität Graz, Graz, Austria — *4see author list of U. Stroth et al. 2022 Nucl. Fusion 62 042006
Machine learning is essential for the operation of fusion devices. The individual control tasks depend on high-dimensional and possibly noisy input data and typically have a latency requirement of milliseconds to be real-time capable. Machine learning (ML) models are well suited for this application. While they are often computationally expensive to train, they generally have a cheap, low-latency inference process. Additionally, deep learning models have been shown to be capable of extracting complex hidden interactions in high-dimensional, noisy data. This contribution will illustrate 2 ML applications in plasma control: real time capable approximations of high-fidelity offline models for kinetic
profiles, and deep-learning-based augmentations to the accuracy of the pellet fragment analysis used in the development of the shattered pellet injection disruption mitigation system tested on ASDEX Upgrade for use inITER.

P 12.30 Wed 17:30 HSZ EG  
Non-linear free boundary simulations of resonant magnetic perturbations in ASDEX Upgrade — Veraena Mittemüller1, Matthias Hoell2, Matthias Willensdorfer1, and ASDEX Upgrade Team2 — Max Planck Institute for Plasma Physics, Garching, Germany

Resonant Magnetic Perturbations (RMPs) are used routinely in tokamaks to control type-I Edge Localized Modes (ELMs). To improve the understanding of the effect of the helical magnetic field perturbations, numerical simulations of their penetration into the plasma are carried out using the free boundary non-linear MHD code JOREK-STAWAR. The use of a new recovery condition allows self-consistent development of the plasma response within the complete computational domain.

Several aspects of RMP physics are investigated in simulations based on ASDEX Upgrade discharges with fully realistic plasma parameters and profiles. The comparison of the field line corrugation to experimental measurements shows that a valid representation of the plasma response is achieved. In subsequent simulations, the transition from ELM mitigation to suppression is shown, which allows the investigation of hypotheses concerning RMP-ELM suppression mechanisms, including the role of magnetic island positions relative to the pedestal, mode coupling and the impact of profile evolution on plasma stability. An extension of the fluid model to kinetic effects is on its way, which will allow the inclusion of the neoclassical toroidal viscosity.

P 12.31 Wed 17:30 HSZ EG  
Enabling GENE for Exascale Computing via Modern Data Science — Luciana Tanzarella1, Tilman Dannert1, Tobias Göhrer2, and Frank Jenko1 — Max Planck Institute for Plasma Physics, Garching — Max Planck Computing and Data Facility, Garching

The GENE (Gyrokinetic Electromagnetic Numerical Experiment) code represents the state-of-the-art in turbulence simulation in plasma physics, based on the Eulerian approach. Since these codes solve differential equations in 5 or 6 dimensions, over a very large parameter space, they require a very considerable computational power. Higher speed, lower communication and energy costs are all benefits of lower precision arithmetic, but all benefits of lower precision arithmetic, but the outputs must be accurately assessed. GENE allows for either single or double precision computations. The national DARExA project's specific objective is to develop methods and architectures that will decrease the amount of data required for fusion research. The first steps in this direction, in particular, entail the creation and application of lower precision methods in selected operations performed by GENE. The precision must be scaled using existing libraries in addition to assessing how it impacts calculations as not every hardware supports arbitrary-precision. To ascertain how much the discretization order influences the outputs on grids, this must be done on each of GENE's several sections. The operation will be done on the stencil part first. In order to accurately evaluate the gain from implementing this reduced precision, an error model for the estimation of stencil and moments must be written.

P 12.32 Wed 17:30 HSZ EG  
Enabling GENE for Exascale Computing via Modern Data Science — Luciana Tanzarella1, Tilman Dannert1, Tobias Göhrer2, and Frank Jenko1 — Max Planck Institute for Plasma Physics, Garching — Max Planck Computing and Data Facility, Garching

Theoretical plasma turbulence studies are typically based on numerical solutions of integro-differential equations in 5 or 6 dimensions over a very large parameter space. So the required computational power is huge. Higher speed, lower communication and energy costs are all benefits of lower precision arithmetic, but the outputs must be accurately assessed. Particular focus is put on the world-leading gyrokinetic plasma turbulence code GENE, based on the Eulerian approach. GENE allows for either single or double precision computations. The national DARExA-F project's specific objective is to develop methods to reduce the amount of data for transfer operations and leverage the power of reduced precision arithmetic on modern architectures. The idea is to investigate the creation and application of lower precision methods in selected operations performed by GENE. The precision must be scaled using existing libraries in addition to assessing how it impacts calculations as not every hardware supports arbitrary precision. To ascertain how much the discretization order influences the outputs on grids, this must be done on each of GENE's several sections. The operation will be done on the stencil part first. In order to accurately evaluate the impact of implementing this part with reduced precision, a respective error model has to be developed.

P 12.33 Wed 17:30 HSZ EG  
Modelling of diagnostics for radiated power studies in Wendelstein 7-X — G. Partesotti1, F. Reimold1, A. Demby1, G. Wurden6, and D. Zhang1 — IPP, HGW, DE — UMW-Madison, WI, US — LANL, NM, US

In the field of magnetically confined fusion plasmas, stellarators like Wendelstein 7-X promise a more stable, steady-state operation, at the cost of increased, three-dimensional complexity of the magnetic field geometry. One of the many implications is the asymmetric distribution of neutrals, which in turn causes radiative losses in the plasma to follow an inherently 3-D asymmetric pattern [1,2].

Given that radiation is a primary power dissipation mechanism, reliably estimating and predicting these patterns is crucial to accurately control the heat load on the divertor targets, so as to mitigate erosion and avoid exceeding material limits. For this purpose, before new configurations can be developed and safely operated, detailed 3-D plasma transport models are applied, with the goal of physical and experimental constraints from multiple diagnostics and a newly designed Compact Bolometer Camera [4].


P 12.34 Wed 17:30 HSZ EG  
Overview of the neutral gas pressures in Wendelstein 7-X under boronized wall conditions — Victoria Haak, Sergey Bozhkenov, Yuhi Feng, Amit Kharvandkar, Thibery Kremer, Dirk Naoukis, Valeria Perséo, Georg Schäfer, and Uwe Wenzel — Max-Planck-Institut für Plasma Physik, Greifswald, Germany

Gas puffing is a key requirement for density control in a fusion device and, apart from the pumping speed and the subdivertor geometry, strongly dependent on the neutral gas pressure in the subdivertor and in front of the pumps. In Wendelstein 7-X, pressure gauges measured the neutral gas pressure in different locations in the plasma vessel of the stellarator Wendelstein 7-X during the first divertor campaign, allowing for a detailed analysis of the neutral gas pressures, the compression rate, and the particle exhaust rates via the turbulent pressure in the different magnetic field configurations. Neutral gas pressures on the order of few 10^14-4 mbar were measured in the sub divertor region, while the highest neutral gas pressure of 1.75*10^14-3 mbar was obtained in the so-called high iota configuration featuring 4 edge magnetic islands per cross section. While measurements are only available in specific locations of the sub divertor, effective element simulations provide a detailed picture of the pressure distribution in the sub divertor volume.

P 12.35 Wed 17:30 HSZ EG  
Uncertainty Quantification for Multiscale Turbulent Transport Simulations — Yehor Yudin, David Coster, Udo von Toussaint, and Frank Jenko — Max Planck Institute for Plasma Physics, Boltzmannstrasse 2, 85748 Garching, Germany

One of the challenges in understanding the energy and particle transport processes in the core plasma of a magnetic confinement fusion device is to quantify how they are affected by turbulent dynamics. This work considers a multiscale approach to modelling this problem, where the numerical solution is obtained from coupled models describing processes on different spatial and temporal scales. Furthermore, we investigate epistemic and aleatoric uncertainties in the profiles of the quantities transported in this model. This work proposes an application of a surrogate modelling technique to reduce the computational cost of resolving a quasi-steady state solution on the microscale when it is sufficient to capture only statistics of the turbulent dynamics. We study a Multiscale Fusion Workflow that utilizes turbulent energy and particle fluxes computed with a gyrofluid turbulence code GEM in flux tube approximation to calculate the transport coefficients for core transport code ETS. In this work, a data-driven probabilistic surrogate model based on Gaussian Process Regression is used to infer flux values computed by a turbulence code for given core profiles and to calculate related uncertainties. We use the VECEMA/SEAVEA toolkit to perform uncertainty quantification as well as to train, test, and utilize surrogate models.

P 12.36 Wed 17:30 HSZ EG  
Self-consistent neutral gas description in the edge turbulence fluid code GRILLIX — Konrad Eder, Andreas Stiegemir, Vladimír Zholobenko, and Frank Jenko — Max Planck Institute for Plasma Physics, Boltzmannstraße 2, 85748 Garching, Germany

The edge turbulence fluid code GRILLIX employs a diffusive neutral gas model to describe plasma-neutral interactions arising from ionization, recombination, and charge exchange processes [1]. This inclusion of neutral gas physics has been found to significantly improve the agreement of simulated plasma profiles with experimental data [1,2,3].

Presently, the model requires prescribing the neutrals density at the divertor, introducing a new free parameter to the code. As we move toward simulations of detached plasmas, we seek to alter this boundary condition in order to self-consistently describe the recycling fluxes at the targets. For this purpose, a diagnostics framework has been developed to verify the implementation of recycling
boundary conditions and assess particle conservation properties of the code. 

P 12.37 Wed 17:30 HSZ EG Simulation of electromagnetic turbulence in the stellarator W7-X —  YANN NARBUTT, ALEXEY MISCHCHENKO, ALESSANDRO ZOCCHI, and PER HELANDER — Max Planck Institute for Plasma Physics, Wendelsteinstraße 1, 17489 Grefswald, Germany  
Fusion plasmas need high β = [1/2(\beta_p/\beta_T)] i.e. the ratio of plasma pressure to magnetic pressure. Going from low to high β first weakens ion-temperature-gradient mode activity and then causes strong kinetic-balloonning-mode (KBM) activity [1], with the latter being inherently weakening. This can lead to particle and energy fluxes [2] which degrade plasma confinement. It is therefore of great import to understand and quantify KBM turbulence for high-performance plasmas. This poster presents first results of linear and non-linear simulations of KBM activity in the geometry of the stellarator Wendelstein 7-X using the global gyrokinetic code Eutepe [3].  

P 12.38 Wed 17:30 HSZ EG Structure-preserving hybrid code, STRUPHY, energy-conserving hybrid MHD-driftkinetic models — BYEONG KU NAX1, STEFFEN POSSENNER1, FLO- RIAN HOLDERIED1, and YINGZHE LI1 — Max Planck Institute for Plasma Physics, Garching, Germany — 2Technical University of Munich, Garching, Germany  
STRUPHY (STRUCTure-Preserving HYbrid codes) is a Python package for the simulation of energetic particles (Eps) in plasma. The package features a collection of PDE solvers for hybrid fluid-kinetic systems in curved three-dimensional spaces where the bulk plasma is treated as a fluid and the Eps are described kinetically (Particle-In-Cell method). The discretization is based on the GEM-PIC framework. We will introduce energy-conserving hybrid MHD-driftkinetic models which were newly implemented in STRUPHY. Existing hybrid MHD-kinetic models often suffer from not conserving the total energy, especially when reduced kinetic models are used to describe Eps such as driftkinetic or gyrokinetic. However, this property was recently recovered by adding additional terms derived from variational principles. The investigation of the conservation laws on the discrete level will be considered with some simulation results.

P 12.39 Wed 17:30 HSZ EG Modelling the effects of geometry modifications on the divertor heat loads of W7-X — AMIT KHARWANDIKAR, DIRK NAUJOKS, FELIX REIMOLD, RALF SCHNEIDER, THOMAS SANN PEDERSEN, and THE W7X TEAM — Max Planck Institute for Plasma Physics, 17491 Grefswald, Germany  
Wendelstein 7-X (W7-X) is an advanced stellarator device operated in Grefswald, Germany, to provide the proof of principle that the stellarator concept can meet the requirements of a future fusion reactor. It implements the islands divertor concept to handle the heat and particle fluxes. In the recent experimental campaign OP1.2, unacceptably high heat loads limited the operation of the device. This immediate concern and the need to investigate a subsequent transition to fusion reactor relevant material (e.g. tungsten) for plasma facing components (PFCs) motivates the need for an improved divertor design. This poster discusses the investigation of such an optimized divertor via modelling. The simplified heat transport code, EMC3-Lite, is used as a fast tool to assess different design modifications of the current high heat-flux (HHF) divertor. Moreover, using the functionalities of the code, a further reduced model for heat load calculations primarily depending on the inclination of magnetic field lines on the plasma-facing components is developed. The cross connection length is derived. This new model introduces the possibility to gain insights into the main parameters determining heat loads and add more physics effects (e.g. radiation loss) in an attempt to fit with experiments. Finally, an iterative scheme for finding an optimum PFS is proposed.

P 12.40 Wed 17:30 HSZ EG Characterisation of edge-SOL turbulence with GRILLEX in single null and advanced divertor configurations — JAN PFEINIG, VLADIMIR ZHOLOBOENKO, ANTONY RAYNOR, and FRANK JENKE — Max Planck Institute for Plasma Physics, Boltzmannstraße 2, 85748 Garching bei München, Germany  
Turbulent transport across the magnetic field in magnetic confinement fusion devices, especially in the plasma edge and scrape-off layer (SOL), where steep gradients are observed, is of key interest because of two main reasons:  
i. It has a severe impact on the heat exhaust and hence on the energy confinement of the device.  
ii. It is also responsible for the exhaust of helium ashes produced by the fusion reaction.  
Turbulence phenomena remain difficult to experimentally analyze and are not fully captured by transport codes due to non-local drive of turbulence as well as intermittent, ballistic transport of filaments (blobs) into the SOL. Hence, high-fidelity global turbulence simulations in realistic diverted geometries represent an important tool in quantitative predictions of tokamak plasma turbulence. Here we present in-depth analysis of global turbulence simulations performed with the GRILLEX code, which implements the two-fluid Braginski equations in the flux-coordinate independent (FCI) approach. Thus, abitrarily complex magnetic geometries can be investigated.

P 12.41 Wed 17:30 HSZ EG Conceptualization of an EM-upgrade for the gyrokinetic full-f code pips — ANNIKA STIER and ALBERTO BOTTINO — IPP, Garching, Germany  
The gyrokinetic particle-in-cell code pips is a full-f finite element tool to simulate turbulence in the tokamak scrape-off layer. Until now however, pips is a purely electrostatic code with a constant background magnetic field. In order to adequately model the phenomena of the scrape-off layer, taking into account electromagnetic effects is a necessity. To this end, the contribution at hand identifies due changes in the theoretical foundation of pips and proposes suitable modifications in its field solver and particle pusher stages.

P 12.42 Wed 17:30 HSZ EG Hybrid gyrokinetic simulations for weakly magnetized plasmas — SREENVASU CHARY THAKI KONDA, FELIPE NATHAN DE OLIVEIRA LOPES, ALEKS MUSTOSEN, DANIEL TOLD, and FRANK JENKO — Max planck institute for plasma physics, Garching, Germany  
We aim to study instabilities, turbulence and reconnection phenomenon in weakly magnetized plasmas. Such conditions may found in natural plasmas such as the solar wind, but also in laboratory applications, e.g. in the edge of fusion plasmas. Due to steep gradients in the edge of fusion plasmas and high frequencies in space plasmas, the ordering assumptions of gyrokinetic theory (like low frequency or moderate gradients) may be challenged, particularly for ions. To overcome these limitations, the group derived equations for a hybrid model that includes fully kinetic physics for the ions, but gyrokinetic physics for the electrons. Thereby, only the slower ion gyration needs to be followed, while still benefitting from a faster treatment of the electrons and this approach also saves computation costs. The numerical implementation of the hybrid model for electrostatic version has been implemented into the existing simulation code sSV, sSV was developed initially at the department of Theoretical Physics I at RUB, Bochum. Semi-Lagrangian schemes (e.g. the PFC scheme) are employed in sSV. This approach tracks down characteristics from the mesh point backwards in time to get the new value of the flow. Ongoing work on sSV involves the addition of electromagnetic capabilities, which will enable application to space and astrophysical plasmas.

P 12.43 Wed 17:30 HSZ EG Interaction of relativistic electrons with MHD activity during disruptions — HANNE BERGSTROM, KONSTA SÄRKMÄKI, and MATTHIAS HOELZL — Max Planck Institute for Plasma Physics, Boltzmannstr. 2, 85748 Garching b.-M., Germany  
In spite of all the promise that fusion energy holds, there are several obstacles that one must overcome before commercially viable fusion reactors can be realized. One issue that looks to be ever more prominent in future tokamak reactor designs such as ITER is the type of operational failure known as disruptions, triggered by a sudden loss of plasma confinement. During these off-normal events it is possible for electrons to be accelerated towards relativistic velocities. These highly energetic particles could then accumulate and strike the wall, causing sub-surface melting which is difficult to repair. As such, disruption events could potentially put reactors out of commission for extended periods of time, which cannot be tolerated. In order to fully understand the evolution and consequences of disruptions it is vital that the dynamics of the relativistic electrons are studied in detail, which includes aspects such as how they are generated, to what extent they interact with the bulk plasma, what the transport looks like and where they eventually strike the wall. This work aims to answer these questions by extending the non-linear MHD code JOREK to kinetic particle-in-cell treatment for the phase-space evolution of relativistic electrons. In addition we use ray-tracing methods to determine where the particles intersect a 3D wall, allowing us to estimate localized heat loads.
Tungsten-copper composites based on additively manufactured tungsten pre-forms for high heat flux applications — Robert Lübeck1, Alexander von Müller2, Alexander Fréchot Mayer3, Thomas Bareth4, Armin Rießer1, Georg Schlicke2, and Rudolf Neu1,2 — 1Max-Planck-Institut für Plasma-physik, 85748 Garching, Deutschland — 2Technische Universität München, 85748 Garching, Deutschland — 3Fraunhofer ICgv, 86159 Augsburg, Deutschland.

In future fusion reactors, plasma-facing components (PFCs) have to sustain high heat fluxes and neutron irradiation. This creates the need for advanced materials that can withstand such an environment. Tungsten (W) is considered the preferred plasma-facing material for use in fusion devices due to its low hydrogen retention, high melting point as well as its low physical sputtering yield. Against this background, additive manufacturing (AM) of W can be considered a useful tool to provide tailored W structures for reinforcing copper (Cu) based heat sinks due to a tailored thermomechanical behaviour. The present contribution will illustrate the possibilities of tailoring macroscopic properties of W-Cu PFC materials. In this context, basic observations like rules of mixture for composite materials will be discussed. Based on that, it will be shown how the exploitation of complex composite structures can open up new possibilities for material and component design.

Time: Thursday 11:00 – 13:00

P 13.1 Thu 11:00 CHE/0089
Invited Talk

P 13.1 Acceleration of spin-polarized ion beams from laser-plasma interaction — Lars Reichwein1, Markus Büscher2, and Alexander Pukhov1 — 1Institut für Theoretische Physik 1, Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf, Germany — 2Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf, Germany.

Spin-polarized particles are of interest for a variety of applications such as fusion, where the use of spin-polarized reactants may increase the nuclear cross-section, or further investigation of the nucleon structure by means of deep inelastic scattering. In recent years, the acceleration of such polarized particles via laser-plasma interaction has gained traction in research due to the short acceleration distances needed compared to conventional accelerators. While several schemes for efficient proton and ion acceleration are generally known, many of them are not feasible for polarized beams since the target needs to be pre-polarized. In our talk, we give an overview of the current experimental and theoretical state-of-the-art for polarized ion beams. Two acceleration mechanisms, Magnetic Vortex Acceleration and Collisionless Shock Acceleration, will be studied by means of particle-in-cell (PIC) simulations. These schemes can be used to obtain highly polarized ion beams even in the regime of near-future laser facilities.

P 13.2 Thu 11:30 CHE/0089
Influence of plasma profile on injection dynamics in a proton-driven wakefield accelerator — Pablo Israel Morales Guzmán1, Patric Muggli2, and John Farmer1 — Max-Planck-Institut für Physik

Plasma wakefield accelerators (PWFA) have been proposed as a novel technique to accelerate particle bunches to high energies. Due to the high electric fields supported in plasma, this can be done in a shorter distance than in conventional accelerators. PWFA use a relativistic particle bunch to drive wakefields. When the bunch density is much larger than the plasma density, it induces a non-linear plasma response. For negatively charged bunches, there is blow-out of plasma electrons. For positively charged ones, plasma electrons flow towards the axis, creating a high-density filament. This filament sustains defocusing fields for negatively charged bunches.

Proton bunches much longer than the plasma wavelength drives high-amplitude wakefields only after undergoing self-modulation (SM). SM transforms it into a microbunch train that resonantly drives wakefields. An electron bunch can be injected to seed SM or be accelerated.

We present results of a numerical study using particle-in-cell simulations with parameters similar to those of the AWAKE experiment. We show that along the low density ramp leading to the plasma entrance, the proton bunch generates a filament of plasma electrons. The results indicate that the accelerator plasma of future experiments relying on self-modulation, and a drive and accelerated bunch of different charge, cannot have a density ramp.

P 13.3 Thu 11:45 CHE/0089
Relativistic High Harmonic Generation from solid density foils with a PW class short pulse laser. — Milenko Vesović1,2, Marvin Elias Paul Umland1,2, Stefan Assenbaum1,2, Thomas Meric1,2, Florian Kroll1, Martin Rehwald1, Radka Štepáničová1,2, Thomas Puschel1, Irene Fröhlich1, Stephan Kraft1, Ulrich Schramm2, and Karl Zeil1 — 1Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf, Germany — 2Technische Universität Dresden, 01062, Dresden.

Relativistic High Harmonic Generation (HHG) from the interaction of high intensity lasers with dense targets has become a topic of great interest in recent years because of its potential to achieve high energy, coherent short pulse radiation, a central theme of XUV emission. Several studies have shown the potential of HHG for studies of hot electrons sensitive to the laser-plasma interaction conditions. Characterization of the high harmonic spectrum could then be used to probe the interaction during the high intensity fraction of the laser pulse, which is usually most interest because of the extreme matter conditions but challenging to access experimentally. Measurement of the XUV harmonic spectrum have been conducted with the Draco PW laser (peak intensities up to 6x1021 W/cm2 in 30fs FWHM). With the aim of using HHG to gain a better understanding about the interaction, different conditions were studied. Harmonics from 14nm to 17nm wavelength were measured from bulk SiO2 targets, metal foils and plastic foils, as well as driving laser energies. In this work, general features of this parameter span are shown and its potential link to the laser plasma interaction is discussed.

P 13.4 Thu 12:00 CHE/0089
Setup and evaluation of a calibration free Thomson parabolometer spectrometer to study sub-MeV ions from laser plasmas — Lars Torben Schwabe, Jan Riedlinger1, and Georg Pretzler2 — 1Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf, Germany — 2Max-Planck-Institut für Plasmaphysik, Garching, Deutschland.

Since sub-MeV ions from laser pulse plasmas are only scarcely studied, we developed a special Thomson parabolometer spectrometer with a maximized dynamic range that maps these ions in a charge and energy dependent manner. Predictions for these types of ions tend to be inaccurate because of the amount of processes involved, acting on the particles on different time scales. The plasma is generated by a high-intensity ultrafast laser pulse with peak intensities up to 1021 W/cm2 at pulse durations down to 8 fs focused on a solid. The emitted supra-thermal ions are investigated. These results are compared to simulations in terms of ionization state and energies. In this contribution, the design and construction of such a Thomson spectrometer is discussed, which allows us to detect ions over a wide energy range by utilizing variable fields. Furthermore, we present the multi-step evaluation process which eliminates the need for spectrometer calibration.

P 13.5 Thu 12:15 CHE/0089
Characterization of a laser driven supra-thermal ion source — Jan Riedlinger, Lars Torben Schwabe, Qendraza Ibraimi, and Georg Pretzler — Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf, 40225 Düsseldorf.

Today’s laser systems achieve repetition rates up to 100 kHz at pulse energies of 200 nJ and sub-10 fs durations. With these parameters, laser plasmas become viable ion sources for applications which require a small source size. We present...
the results of experiments performed with such a laser, reaching intensities up to $10^{19} \text{ W/cm}^2$ on the target surface. This interaction creates a high temperature plasma emitting bunched ions over a broad spectrum in the keV regime. Here, mostly bulk targets were used due to the nearly free choice of materials and high densities for an increased particle output. The talk gives an in-depth view into the ion emission in terms of its opening cone, ionization states and kinetic energies as well as the purposely designed diagnostics.

**P 13.6 Thu 12:30 CHE/0089**


We present a computational study of isochoric heating in multi-layered targets at ultra-high intensity laser irradiation ($10^{19} \text{W/cm}^2$). Previous studies have shown enhanced ion heating at interfaces, but at the cost of large temperature gradients. Here, we study multi-layered targets to spread this enhanced interface heating to the entirety of the target and find heating parameters at which the temperature distribution is more homogeneous than at a single interface while still exceeding the mean temperature of a non-layered target. Further, we identify a pressure oscillation that causes the layers to alternate between expanding and being compressed with a non beneficial effect on the heating. Based on that, we derive an analytical model estimating the oscillation period to find target conditions that optimize heating and temperature homogeneity. This model can also be used to infer the plasma temperature from the oscillation period which can be measured e.g. by XFEL probing.

**P 13.7 Thu 12:45 CHE/0089**

**K-alpha yield from laser-plasmas on thin layers** — **NICO POTZKAU** and **GEORG PRETZLER** — Institut für Laser- und Plasmasphysik, Heinrich-Heine-Universität Düsseldorf

When intense sub 10-fs laser pulses create plasma on solid surfaces, they accelerate electrons into the vacuum as well as into the target. The latter electrons induce characteristic x-rays in the material, most of all characteristic $K_x$ radiation, which constitutes a source of partly coherent x-rays due to the small source and narrow spectral line width. When optimizing the total radiation output of this source, we found that thin layers of aluminum on top of copper emit more $K_x$ photons than expected. In our contribution, we present our experimental results and calculations describing this effect.

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**P 14: Magnetic Confinement IV**

**Time:** Thursday 11:00–13:10

**Invited Talk**

**P 14.1 Thu 11:00 CHE/0091**

**Experimental validation of turbulence codes** — **KLARA HOFLER** — Institut für Plasmaphysik, Greifswald, Germany

Turbulence is a main driver of heat transport, which deteriorates the performance of fusion reactors. Simulation codes aiming for identifying turbulence optimized devices need to be validated against experiments. The comprehensive set of experimental turbulence data presented here is measured at the ASDEX Upgrade tokamak for two plasma scenarios. It includes wavenumber spectra, electron density and temperature fluctuation amplitudes and radial correlation lengths as well as the cross phase between density and temperature fluctuations. These quantities are measured for comprehensive code validation by Doppler reflectometers and an electron cyclotron emission radiometer. In this talk they are compared to the gyrokinetic code GENE because of its mature capabilities to assess and reproduce core turbulence. In addition synthetic diagnostic modeling is included to account for diagnostic effects on measurements.

The work presented in this talk shows the encouraging example of code validation where a remarkable number of measured physics quantities is successfully reproduced by the code. It comprises contributions of a variety of collaborators both on the experimental side — Institut für Plasmaphysik (IPP) in Garching, Plasma Science and Fusion Center of MIT in Cambridge and Laboratoire de Physique des Plasmas of the Ecole Polytechnique in Palaiseau — and on the theory side — IPP Garching and Institut für Grenzflächenverfahrenstechnik und Plasmatecnologie in Stuttgart.

**P 14.2 Thu 11:30 CHE/0091**

**Turbulence in stellarators with GENE-3D** — **FELIX WILMS**, **ALEJANDRO BANÓN NAVARRO**, and **FRANK JENKO** — Max-Planck-Institut für Plasmaphysik, Boltzmannstraße 2, 85748 Garching b. München, Germany

GENE-3D is a code that is capable of simulating gyrokinetic plasma turbulence in stellarators globally (Maurer et al., Journal of Computational Physics, 2020). It has recently been upgraded to an electromagnetic version, expanding the variety of turbulent features that can be studied with it (Wilms et al., Journal of Plasma Physics, 2021). In this work, we present an overview over the most recent achievements of the code, including the study of electromagnetic effects on global turbulence (Wilms et al., Journal of Plasma Physics, 2021) as well as the impact of a surface-global effects on turbulence stabilisation (Wilms et al., to be submitted to Nuclear Fusion).

**P 14.3 Thu 11:55 CHE/0091**

**Gyrokinetic simulations of turbulent transport in the edge and scrape-off layer of TCV** — **PHILIPP ULBL**, **ANDREAS STEGMÜLLER**, and **FRANK JENKO** — Max Planck Institute for Plasma Physics, Boltzmannstrasse 2, 85748 Garching, Germany — 1 University of Texas at Austin, Austin, TX 78712, USA

Turbulence in the edge and scrape-off layer (SOL) region of magnetic confinement fusion devices is of high relevance for the feasibility of fusion energy. Two important properties of a future fusion reactor, confinement and heat exhaust, are largely affected by turbulence. This requires the development of predictive edge turbulence codes. In this work, we present the latest improvements to the grid-based gyrokinetic turbulence code, GENE-X [1], with applications to the TCV tokamak [2].

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**P 14.4 Thu 12:00 CHE/0091**


The basis for characterizing dominant Alfvén mode activity in the Wendelstein 7-X ($W7-X$) stellarator plasmas is presented with the investigation of possible driving mechanisms. In previous $W7-X$ operational phases, Alfvén mode activities were identified to solely be driven by the cyclotron resonance heating. A broad range of frequencies is observed in measurements of the fluctuating poloidal magnetic field, $B_y$. An essential analysis was developed to track the dominant frequency bands (DFB) from the spectrograms of $B_y$ between $f = 100 - 450 \text{ kHz}$. The DFBs studied allow us to draw novel and integral analyses of the dynamics of Alfvén modes through the entire length of $W7-X$ plasmas. Correlations between the modes dynamics with general plasma parameters are determined, and we present in which plasma conditions the spectral properties of the Alfvén DFBs show relevant changes. The amplitude of the DFBs shows a strong correlation to turbulent density fluctuations measured with the Phase contrast Imaging (PCI) diagnostic in most $W7-X$ regimes.

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**P 14.5 Thu 12:45 CHE/0091**

**Model based optimization of Advanced Tokamak scenarios** — **RAFAEL SCHRAMM**, **ALEXANDER BÖCK**, **EMILIANO FABRE**, **JÖRG STÖBER**, **SIMON VAN MEERSLOVE**, **MADUSI MADUSKUN», **HARTMUT ZOUMO», and **THE ASDEX UPGRADe TEAM** — Max-Planck-Institut für Plasmaphysik, Garching, Germany — 1École Polytechnique Fédérale de Lausanne, Switzerland

Advanced Tokamak scenarios increase the plasma safety factor ($q$) profile via external actuators in order to increase the bootstrap current, thereby reducing the inductive current fraction. In order to avoid an intermittent drop in the actuators need to be applied already during the current ramp-up. A model in the transport code ASTRA, capable of predictively designing such a scenario by calculating temperature and $q$ profiles based on the actuator setup has been developed and validated on AUG.

A scenario, considerably different from the validation case has been analyzed. In order to increase magnetohydrodynamic stability, the $q$ profile has been optimized. This is done by using an optimizer, running on simpler model to propose
changes, which are then double-checked in the ASTRA model. Effects of the plasma current on stability and the performance of different setups have been explored. Results of the last AUG campaign will be shown.

The model can also be applied on different devices with minor changes. Results for JET, based on data from previous shots will be shown. Using the model to design a scenario to show the flux-pumping phenomenon on a larger device for the first time is planned.

P 15: Laser Plasmas II/Low Pressure Plasmas and their Applications II

Time: Thursday 14:00–15:30

Invited Talk

P 15.1 Thu 14:00 CHE/0089

Tumor irradiation in mice with a laser-accelerated proton beam — • FLORIAN KROKLO, FLORIAN-EMANUEL BRACK, ELKE BREYTER, THOMAS CONAWAY, LEONHARD KARSCHE, JOSEFIN METZKE-NG, JÖRG PAWELEK, MARTIN REIMOLD, ULRICH SCHRAMM, TIM ZIEGLER, and KARL ZEIL

Weseasonalreportonestablishingalaser-plasma-basedprotonresearchplatformforuser-specificsmallanimalradiobiologystudies.

P 15.2 Thu 14:30 CHE/0089

Comparison between THz absorption spectroscopy and ps-TALIF measurements — • JENSEN R. WUBS, LAURENT INVERNIZI, KRISTAGAZELI, GUILLAUMINHOT-ZAD, URSCHACHERROSS, MARIUS DIERERT, GEISSMANN, and JEAN-PIERRE H. VAN HELDEN

Leibniz Institute for Plasma Science and Technology (INP), Greifswald, Germany — 2 Laboratoire des Sciences du Procédés et des Matériaux (LSPM), CNRS, Université Sorbonne Paris Nord, Villeurbanne, France

Terahertz (THz) absorption spectroscopy with quantum cascade lasers has recently been developed and implemented as a new diagnostic technique for investigating atomic oxygen densities in plasmas. It is based on the detection of the $3P_1 - 2P_2$ fine structure transition at approximately 4.75 THz. This allows for direct measurements (i.e. no calibration procedure required) of absolute ground-state atomic oxygen densities. A possible way to validate this method is by comparing with two-photon absorption laser-induced fluorescence (TALIF), which is currently the most established method for measuring atomic oxygen densities. TALIF measurements were done in this case with a picosecond (ps) laser system and using a streak camera for detection. Both ps-TALIF measurements and THz absorption spectroscopy were performed on the same low-pressure capacitively-coupled radio frequency plasma generated in pure oxygen, for a variation of the applied power (20–100 W) and gas pressure (0.7–1.3 mbar). A comparison between resulting atomic oxygen densities as obtained with the two different diagnostics is presented in this contribution.

P 15.3 Thu 14:45 CHE/0089

Characterization of the ion angle distribution function in low-pressure plasmas using a microelectromechanical system — • MARCEL MELEZER, KATJA MEINEL, CHRIS STOECKEL, TOBREN HEMKE, THOMAS MÜSSENBRÖCK, and SVEN ZIMMERMANN

Center for Microtechnologies, Chemnitz University of Technology, Chemnitz, Germany — 2 Fraunhofer Institute for Electronic Nano Systems ENAS, Chemnitz, Germany — 3 Chair Electrical Engineering and Plasma Technology, Faculty of Electrical Engineering and Information Technology, Ruhr-University Bochum, Germany

It has been demonstrated for the first time that a microelectromechanical system (MEMS) can be used to characterize the ion angle distribution function (IADF) of a low-pressure plasma. The MEMS is piezoelectrically actuated. The piezoelectric actuator is used both to tilt a 30 mm thick silicon plate as well as to monitor the tilt angle. Holes with a diameter of 2 mm were etched into the tilting plate. These high aspect ratio holes allow selection of ion incidence angles depending on the tilt angle of the MEMS. Below the MEMS, the ions are detected by a metal detector. A numerical method is presented to determine the ion angle distribution function based on the measured data for the resonant operation of the MEMS.
P 16: Plasma Wall Interaction II/Codes and Modeling I

Invited Talk

P 16.1 Thu 14:00 CHE/0091

One of the most serious challenges for the operation of ITER and future fusion devices is the control of the inventory of tritium stored in the vessel walls which surround the plasma. For the operation of ITER and of a fusion reactor in general, the determination of the tritium inventory and the knowledge of its spatial distribution is essential. Its control without removal of wall tiles is also of paramount importance. A laser-based T-monitor diagnostic system is under development at Forschungszentrum Jülich (FZJ) to remotely provide information about the tritium content in the deposited layer on the inner divertor tiles of ITER. The T-inventory builds up through the interaction of wall erosion and deposition of hydrogen isotopes together with redeposited material. The limitation of the tritium content in the reactor is of course a safety requirement for the operation. The measurement concept is based on laser-induced desorption (LID) and detection of the released gases by Residual Gas Analysis (RGA).

The present contribution summarizes the results of an R&D programme on the LID method carried out at FZJ for the integration of this laser-based tool into ITER and future reactors.

P 16.2 Thu 14:30 CHE/0091
Multi-staged ERO2.0 simulation of material erosion and deposition in recessed ITER mirror assemblies — SEBASTIAN RODE, JURI ROMANOV, SEBASTJAN BREZINSEK, ANDREAS KIRSCHNER, SYVEN WIESEN, TOM WATOMERS, LUCAS MOSEK, and RICHARD PITTIS — Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung, 52425 Jülich, Germany — ITER Organization, 13067 St. Paul Lez Durame, France.

The Monte-Carlo code ERO2.0 traces impurity particles throughout the volume of fusion devices providing the local erosion and deposition fluxes at plasma-facing components or recessed objects, delivering important information about sputtering or layer growth on those components. In recessed areas, e.g. mirror assemblies in the diagnostic first wall (DFW) of ITER, the code is approaching its limits. The necessary resolution of information on mirrors more than 50 cm away from the LCFS cannot be achieved with standard simulations as only a tiny fraction of impurity test particles and a large fraction of charge exchange hydrogenic neutrals (CXN) reaches this volume. Multi-staged ERO2.0 simulations are employed to overcome this challenge: Impurity particles from a global ERO2.0 simulation with its boundary close to the DFW are collected and subsequently injected into local simulations. The number of test particles representing the fluxes is scaled up, achieving far superior resolution. The results show that the sputtering is largely dominated by high energy CXN, with the patterns indicating a strong influence by the geometry of the assembly. Overall negligible deposition is expected on the mirrors for the full ITER operation time.

P 16.3 Thu 14:45 CHE/0091
Separation of plasma species fluxes for investigating plasma-surface interaction — ADRIAN HEILER, ROLAND FRIEDL, and URSUL FANTZ — Max-Planck-Institut für Plasmaphysik, Boltzmannstr. 2, 85748 Garching — AG Experimentelle Plasmaphysik, Universität Augsburg, 86135 Augsburg, IREK-Institut, 13067 St. Paul Lez Durame, France.

To investigate the role of the different plasma species in the plasma-surface interaction, a selective exposure is indispensable. Therefore, the separation of plasma species fluxes from an inductively coupled plasma source (27.12 MHz, 600 W max.) is demonstrated by using magnets and a MgF 2 window. The plasma source is operated in hydrogen at pressures of 4 – 10 Pa and is connected to a vacuum chamber in which surfaces can be installed at a sample holder. The impinging fluxes of hydrogen atoms, positive hydrogen ions and UV/VUV photons (up to 15 eV) are quantified by using optical emission spectroscopy, a Langmuir probe and a VUV diagnostic. The VUV diagnostic is based on a photodiode and optical filters for wavelength selection and is calibrated against a VUV spectrometer.

The influence of the UV/VUV photons, hydrogen atoms and positive hydrogen ions on surfaces is exemplarily demonstrated by applying work function measurements of in situ caesiated metal samples. By this, it is shown that each species can affect the surface separately. The impact of the selective exposure is compared to the full plasma-surface interaction by the generation of well-characterized inductively coupled hydrogen plasmas directly in front of the surface.

P 16.4 Thu 15:00 CHE/0091

Comparing Ar I and Kr I laser absorption spectra obtained at the linear plasma device PSI-2 indicate an additional line broadening in the case of Kr due to isotopic effects. The magnetic field configurations at PSI-2 provide weak field conditions for even numbered isotopes, i.e., a small perturbation on the energy level splitting. However, concerning 88Kr, the magnetic field strength (B) is de facto intermediate. This condition substantially increases the complexity of the spectra since the energy shift is non-linear in B and the intensities of the magnetic sub-transitions depend on B as well.

The analysis is based on a model by C. G. Darwin of the Zeeman effect at all field strengths [1]. Overall, the experimental investigation at the linear plasma device PSI-2 is limited to laser absorption spectra (20.5 mT to 90 mT) from the Kr I 5s J=2 and J=0 metastable levels using the 760.15 nm and 785.48 nm lines, respectively.


P 16.5 Thu 15:15 CHE/0091

Following the injection of 13CH 3 into a Hydrogen plasma in Wendelstein 7-X, Laser Ablation Molecular Isotopic Spectroscopy (LAMIS) was utilised to quantify 13C deposition patterns ex-situ on the graphite test divertor. LAMIS was applied in double pulse mode. The first pulse (355 nm, 35 ps, 1.1 J/cm2) was applied for the production of a laser-induced plasma on the material's surface. A second laser pulse (1064 nm, 35 ps) followed typically 50 ns later. The second laser pulse was focussed into the laser-induced plasma plume of the first pulse in order to improve signal to noise ratio in the spectra and the sensitivity acquired from the emitted light.

In general a good agreement of the 13C content and pattern with DP-LAMIS and the complementarily applied Nuclear Reaction Analysis was found for layers up to a few μm. Deviations were identified for thicker layers, therefore ablution process was investigated regarding the impact of the second laser pulse (2.3 J/cm2, 50 ns after first pulse) on ablation rate per pulse pair and properties of the plasma plume. Results of these investigations and proposed ways to overcome the challenge of resolving 13C content in thick mixed layers containing carbon and hydrogen are presented.

P 17: Complex Plasmas and Dusty Plasmas/Codes and Modeling II

Time: Thursday 15:45–17:15

P 17.1 Thu 15:45 CHE/0089
Size evolution and plasma-particle interaction of single MF particles in the plasma sheath — SÖREN WOLLEFAHR, CASSEDYN WIRTZ, and DIETMAR BLOCK — Institute of Experimental and Applied Physics, Kiel University, Germany.

Complex (dusty) plasmas consist of micrometer sized particles in addition to the typical plasma species of ions, electrons and neutrals. It has been observed, that the particle size decreases for many materials during plasma exposure and that the particle surface is modified/roughened. This process is commonly referred to as ‘etching’, although in the context of dusty plasmas the detailed mechanism and surface reactions behind the decreasing size is not known yet and proposed explanations range from physical sputtering, over melting of the particle material to ion enhanced chemical reactions. We use an advanced light scattering diagnostic based on Lorentz–Mie theory to determine size and size evolution of single melamine formaldehyde (MF) particles in situ and with high temporal
Ex situ measurement of dust size distribution of nanoparticle growth process and comparison with in situ measurements — Andreas Petersen, Jakob Wötzsel, and Franko Greiner — Institute of Experimental and Applied Physics, Kiel, Germany

We present the result of a size distribution analysis for plasma grown dust particles in their accretion phase. A multi-sample extraction process was used to prepare samples for analysis with SEM (ex situ measurement). This allowed for eight consecutive samples, without terminating the discharge. We find that a normal distribution is an adequate description of the particle distribution for the whole growth process. It is noteworthy, that the standard deviation of the distribution increases approximately linearly with average size. We also compare these results with those from a light scatter analysis, which was performed simultaneously and can determine average size and refractive index without opening the discharge chamber (in situ measurement).

Characterization of a Pulsed Plasma and Macroparticles in an Industrial Scale ta-C Laser-Arc Coating System — Mathis Klette1, Martin Köpfe1, Wolfgang Fukarek2, and Holger Kersten1 — Kiel University, Germany — VTD Vakuumelektron Dresden GmbH, Germany

Tetrahedral amorphous carbon (ta-C) coatings are commonly used in industry to improve tribological as well as corrosion and wear properties of treated objects. While ta-C can be deposited using various techniques, the Laser-Arc technology allows for a strong temporal and spatial control of the deposition process while providing high deposition rate and enabling up-scaling for industrial applications. A major limiting factor of this technology is the generation of macroparticles and the resulting defects in the coating. In this contribution we present measurements of plasma parameters, neutrals and macroparticles in dependence on arc parameters to get a better understanding of the impact on film growth and system upscaling. The carbon Laser-Arc system produces 100-300 us, 1-3 kA pulses, which are observed with a custom-tailored diagnostic setup. The Langmuir probes, retarding field analyzers, and the optical emission spectroscopy allow for spatially and time resolved measurements of electron and ion energy distribution functions, and estimates of neutral densities. Calorimetric probes monitor the energy influx to the substrate which is of special importance when forming tetrahedral bonds. The temporal and spatial macroparticle velocity distributions have been investigated with high-speed cameras.

Viscosity of finite Yukawa liquids — Yang Liu, Natasha Bloshczyk, and Dietmar Block — IEAP, Christian-Albrechts-Universität, D-24098 Kiel, Germany

Viscosity is one of the basic characteristics to describe the dynamic behavior of a fluid. For dusty plasmas established methods exist to measure viscosity [1,2]. However, these methods are limited to large/infinite systems while in some experiments (e.g. for binary mixtures) the system size is limited. Whether and how these methods can be adapted to measure the shear viscosity of a finite two-dimensional (2D) Yukawa liquid is presented in this contribution using non-equilibrium Langevin simulations. Two counter-propagating shear forces are used to push the particles, causing shear-induced melting of the cluster. Based on the Green-Kubo relation (which relies on the random thermal motion of individual particles of the liquids) we obtain a reliable shear viscosity by diminishing the size of shear and boundary conditions. When the viscosity is in good agreement with the results in Refs. [1,2] if an effective coupling parameter $\Gamma$ is used. Unfortunately, the shear viscosity with this normalization follows a simple universal scaling. For $\Gamma^* > 20$ and $0.5 < \gamma < 2$, the shear viscosity increases monotonously, and thermal motion positively affects the transport properties of dust particles.

References


Towards Machine-Learned Poisson Solvers for Low-Temperature Plasma Simulations — Stefan Dabasch and Sven Wieser — Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung · Plasma Physik, 52425 Jülich, Germany

For the design of future tokamak fusion reactors the heat transport in the scrape-off layer is a major challenge. A simulation can test only a single configuration at once and is computationally demanding, making it impossible to fully explore the high dimensional design parameter space with simulations alone. A promising approach to circumvent this is to use machine learning models trained on simulation data as surrogate models. After training such models can produce fast results for any configuration in the explored parameter space and could be used for rapid design studies of tokamak reactors or coupled with other models such as tokamak flight simulators or reactor control schemes. For the development of such models we created a dataset of 10,000 2D SOLPS-ITER simulations with reduced physical complexity. The simulations have eight varied parameters including a tokamak size scaling. Using this dataset neural networks are trained either to predict the electron temperatures in the whole 2D simulation domain or solely at the 1D divertor target. The accuracies of the network predictions in different physical regimes are evaluated and different network architectures are compared.

Towards Machine-Learned Poisson Solvers for Low-Temperature Plasma Simulations — Ilda Charony Sher2, Markus M. Becker3, and Jan Trieschmann1 — Leibniz Institute for Plasma Science and Technology (INP), Felix-Hausdorff-Straße 2, 17489 Greifswald, Germany — Kiel University, Kaiserstrasse 2, 24143 Kiel, Germany

In multi-dimensional self-consistent low-temperature electrostatic plasma simulations, the computational effort for solving the Poisson equation can represent a large part of the overall evaluation runtime. Recently, it has been shown that by using machine learning (ML) techniques, in particular artificial neural networks (ANN), one can arrive to solutions of the Poisson equation faster (and with promising accuracy) than using the conventional numerical methods. However, the currently proposed ML-based Poisson solvers still fall short for being widely applicable in low-temperature plasma simulations, which may employ complex geometries, mixed boundary condition, etc. In this work, the requirements for making ML-based Poisson solvers applicable in low-temperature plasma simulations are discussed. Furthermore, a machine-learned Poisson solver that attempts to tackle these requirements is presented, with examples from dielectric barrier discharge (DBD) geometries. First results suggest that supervised training of an ANN with spatially dependent simulation properties and corresponding ground truth electric potential solutions allows for a machine-learned Poisson solver that generalizes well to various geometric and material configurations.
ion Braginskii approach can be applied. However, for ions with close masses the Grad-Zhdanov 21N-moment method should be used for the transport coefficients estimation. It is necessary, for example, when He plasmas or D-T plasmas are considered. This approach takes into account masses of ions for kinetic coefficients calculation. It is the major improvement in comparison to the previous approach applied for the SOLPS-ITER code. Only hydrogen isotope plasma with heavy impurities could be treated by SOLPS-ITER versions prior to 3.0.8. This approach is implemented into the SOLPS-ITER code for multiple ion parallel transport description in collisionless plasmas. The particular approach is discussed in 

P 19.1 Thu 17:30 CHE/0089 Numerical and experimental investigations of a linear microwave plasma source for metal foil pumps for DEMO — • Stefan Merbl1, Andreas Schulz2, Matthias Walker1, Yannick Kathage1, Stefan Hanke2, Christian Day3, and Günter Tovar — 1GVP, University of Stuttgart, Stuttgart, Germany — 2Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

In future fusion power plants like DEMO, minimizing the tritium fuel inventory is a critical design issue. Hydrogen isotopes have to be separated from the exhaust gas close to the diverter so that they can be immediately recirculated. At KIT a direct internal recycling system is being developed using a metal foil pump (MFP) which can selectively separate hydrogen isotopes by superpermeation even against a pressure gradient. For this process to work, the hydrogen must be in the form of atoms or ions, which is achieved with a linear microwave plasma source, the Duo-Plasmaline.

Since the Duo-Plasmaline is an integral part of the MFP, hydrogen plasmas from the Duo-Plasmaline are being investigated numerically and experimentally at the University of Stuttgart. In the numerical model the transport of electrons and heavy species are calculated self-consistently with the microwave e. field and a reduced set of plasma chemical reactions. Since the MFP will be in close proximity to the torus, the influence of strong magnetic fields up to 1 T is investigated.

The results are compared to investigations in the experiment FLIPS with up to 250 mT. Results of the performance of the Duo-Plasmaline and the MFP from the HERMESplus experiment are presented as well.

P 19.2 Thu 18:00 CHE/0089 Physics-informed machine learning to approximate the ideal-MHD solution operator in Wendelstein 7-X configurations — •Andrea Meblo, Daniel Böckenhoff, Jonathan Schilling, Samuel Aaron Lazerson, Thomas Sune Pedersen, and the W7-X Team — Max-Planck-Institute for Plasma Physics, 17491 Greifswald, Germany

The stellarator is a promising concept to produce energy from nuclear fusion by magnetically confining a high-pressure plasma. Magnetohydrodynamics (MHD) describes how plasma pressure, current density and magnetic field interact. In a stellarator, the confining field is three-dimensional, and the computational cost of solving the 3D MHD equations currently limits stellarator research and design. In this work, we present data-driven approaches to provide fast 3D MHD equilibria: we describe an artificial neural network (NN) that quickly approximates the ideal-MHD solution operator in W7X configurations.

The model fulfills equilibrium symmetries by construction and the MHD force residual regularizes the solution of the NN to satisfy the ideal-MHD equations. The model predicts the equilibrium solution with high accuracy, and it faithfully reconstructs global equilibrium properties (e.g., magnetic well depth). We also optimize W7X magnetic configurations, where desirable configurations can be found in terms of fast particle confinement. Moreover, preliminary results from solving the ideal-MHD equations for a generic stellarator geometry with a physics-informed model without any ground-truth data will be presented.

P 20.1 Thu 17:30 CHE/0091 Laser-Induced Breakdown Spectroscopy (LIBS) for the detection of hydrogen isotopes stored in high-Z metals tungsten and tantalum — • Steffen Mittelmann1, Kevín Touchet2, Xianglei Mao3, Minok Park4, Vasilia Zorba5, Sebastijan Brezinské6, and Georg Pretzler1 — 1Institut für Laser- und Plasmaphysik, Heinrich-Heine-Universität Düsseldorf — 2Forschungszentrum Jülich GmbH, Institut für Energiesystemoptimierung, Plasmaphysik — 3Laser Technologies Group, Lawrence Berkeley National Laboratory, Berkeley

Laser-Induced Breakdown Spectroscopy (LIBS) is a promising technology for in-situ analysis of plasma facing components in confinement fusion experiments. It is of major interest to monitor the hydrogen isotope retention over many operation cycles and to get information about the lifetime of the facility to be able to get full information of deuterium deposition in different layers. A LIBS setup with a high depth resolution is required. We present a comparison of such LIBS experiments with several laser systems of strongly differing parameters for optimizing the conditions. In our final study, ultra-short (ps to fs) UV-laser pulses were focused on tungsten and tantalum tiles that were exposed by a deuterium plasma in the linear plasma device PSI-2 at Forschungszentrum Jülich. We show that this concept can lead a Calibration-Free technique for quantitatively determining the amount of deuterium stored in the tiles under investigation without a-priori knowledge on the plasma.

P 20.2 Thu 18:00 CHE/0091 Acceptance Rates of Invertible Neural Networks on Electron Spectra from Near-Critical Laser-Plasmas: A Comparison — • Thomas Meitinger1, NICO Hoffmann1, and Thomas Kluge1 — 1Helmholtz-Zentrum Dresden-Rossendorf, 01328 Dresden, Deutschland — 2Technische Universität Dresden, 01069 Dresden, Germany

While the interaction of ultra-intense ultra-short laser pulses with near- and overcritical plasmas cannot be directly observed, experimentally accessible quantities (observables) often indirectly give information about the underlying plasma dynamics. Furthermore, the information provided by observables is incomplete, making the inverse problem highly ambiguous. Therefore, in order to infer plasma dynamics as well as experimental parameter, the full distribution over parameters given an observation needs to considered, requiring that models are flexible and account for the information lost in the forward process. Invertible Neural Networks (INNs) have been designed to efficiently model both the forward and inverse process, providing the full conditional posterior given a specific measurement. In this work, we benchmark INNs and standard statistical methods on synthetic electron spectra. First, we provide experimental

P 19.3 Thu 18:25 CHE/0089 Structure splitting at the transition to self-sustained turbulence in a magnetized cylindrical plasma — •Supri Mani1, Stefan Knauer2, Gianhao Moon2, Nils Fahrenkamp3, and Akhilesh Fujisawa — 1Institut für Physik, Universität Greifswald, Greifswald — 2Research Institute for Applied Mechanics, Kyushu University, Kagoshima

When turbulent structures split more frequently before they decay, persistent turbulence forms in neutral fluid shear flows. Whether such behavior also occurs in magnetized plasmas is investigated in the experiment PANTA. With increasing control parameter the dynamics in the magnetized plasmas is known to undergo several changes from a quasiperiodic to a phase locked to a weakly turbulent regime. When the phase-locked regime breaks down, the splitting time approaches the decreasing lifetime reflecting self-sustained turbulence, known from the pipe flow.

P 20.3 Thu 19:00 CHE/0091 AI based Larde Eddy Simulations for Turbulence in Fusion Reactors — • Robinson Greiff1, Franck Jenko1, and Nils Theuer1 — Max-Planck Institute for Plasma Physics, Garching bei München, Germany — 2TUM Department of Mathematics, Garching bei München, Germany

In this talk, we demonstrate the effectiveness of using hybrid AI and numerical methods to produce practically endlessly stable turbulence simulations conserving physical, spectral, and statistical properties. Specifically, we look at the two-fluid Hasegawa-Wakatani model discretized in two spatial dimensions used for simulating drift wave turbulence in fusion reactors. The presented hybrid AI predictor-corrector model in the large eddy domain allows for reducing complexity by three orders of magnitude with negligible losses.
results with respect to the acceptance rate, where our results show increases in acceptance rates up to a factor of 10. Additionally, we show that this increased acceptance rate also results in an increased speed-up for INNs to the same extent. Lastly, we propose a composite algorithm that utilizes INNs and promises low runtimes while preserving high accuracy.

P 20.3 Thu 18:15 CHE/0091

Magnetohydrodynamic Simulations of a Tapered Plasma Lens for Optical Matching at the ILC e+ e− Source — Manuel Forfella1, Guido Moortgat-Pick1, Niclas Hamann1, Gregor Losch1, Mathis Mewes1, Maxence Thévenet2, and Jens Osterhoffs3 — 1University of Hamburg, Hamburg, Germany — 2Deutsches Elektronen Synchrotron DESY, Hamburg, Germany

The International Linear Collider is a planned electron–positron linear collider with its positron source producing positrons by exposing a target to undulator radiation. The resulting, highly divergent positron beam requires optical matching to improve its luminosity and therefore the success of the collision experiments. Here, optical matching refers to capturing particles, i.e. making them available for downstream beamline elements. In the past, this has been done with sophisticated coils, but recently the usage of a current-carrying plasma, a plasma lens, has been proposed. For the International Linear Collider particle tracking simulations have already concluded with an optimal plasma lens design with respect to the captured positron yield. This design is characterized by a linearly widening radius in beam direction. Now further research and development is required, including both experiments with a prototype set-up as well as simulations modeling the hydrodynamics of the current-carrying plasma and the resulting magnetic field. The accuracy of the latter will benefit greatly from the former. First results of these magnetohydrodynamic simulations are discussed in this work.

P 20.4 Thu 18:30 CHE/0091

1D Vlasov simulations of the Windowless Gaseous Tritium source of the Karlsruhe Tritium Neutrino experiment — Anna Josephine Schulze and Felix Spanier — University of Heidelberg

The aim of the Karlsruhe Tritium Neutrino (KATRIN) experiment is to precisely determine the neutrino mass by measuring the electron energy spectrum of the tritium-beta-decay. The high energy of this decay is also the reason for a plasma to develop inside the windowless gaseous tritium source (WGTS). Interactions between the plasma and metallic walls lead to the formation of a plasma sheath and with it an electrostatic potential arises. This can modify the resulting energy spectrum. Therefore, the behaviour of the plasma and especially its wall-interaction was estimated using a 1D simulation. It is based on solving the Vlasov-Poisson system with an Eulerian scheme to compute the electric potential along the middle axis of the tritium source. This technique allows for stronger density gradients as well as atomic processes to be considered. In general, however, it is more computationally expensive than a particle-in-cell method. Initial results yield a plasma potential of \( \Delta \phi = 0.047 \) V and show a backflow of electrons, leading to the development of a two-stream instability in the plasma. Currently, the code is further developed to simulate a larger area of the WGTS and to consider more effects, including recombination.

P 21: Members’ Assembly

Time: Thursday 19:00–20:00

All members of the Plasma Physics Division are invited to participate.
Overview of Invited Talks and Sessions

(Lecture hall ZEU/0146)

Plenary Talk of ST
See PV for details.

PV VII Thu 9:00–9:45 HSZ/AUDI The role of artificial intelligence in modern radiation therapy — \textsc{Guillaume Landry}

Invited Talks

| ST 4.1 | Wed 14:00–14:20 ZEU/0146 | Innovationen in die Praxis bringen – die EXIST Gründungsförderung — \textsc{Antje Dewitz} |
| ST 4.2 | Wed 14:20–14:40 ZEU/0146 | Development and Certification of an IGRT system — \textsc{Claus Promberger} |
| ST 4.3 | Wed 14:40–15:00 ZEU/0146 | Klinische Anwendung von Protonen-/Partikeltherapie — \textsc{Esther Troost} |
| ST 10.1 | Thu 17:30–18:00 ZEU/0146 | Online-adaptive particle therapy: Current status and vision for the future — \textsc{Christian Richter} |

Sessions

| ST 1.1–1.6 | Tue 11:00–12:30 GER/038 | Accelerators for Radiation Therapy (joint session ST/AKBP) |
| ST 2.1–2.6 | Tue 17:00–18:30 ZEU/0146 | Medical Imaging Concepts |
| ST 3.1–3.3 | Wed 11:00–12:30 ZEU/0146 | Poster Session |
| ST 4.1–4.3 | Wed 14:00–15:30 ZEU/0146 | DPG meets DGMP: Von der Idee bis zur klinischen Anwendung |
| ST 5.1–5.6 | Wed 15:50–17:20 ZEU/0146 | Physics and Technology for Radiation Detection |
| ST 6 | Wed 17:45–18:45 ZEU/0146 | Members’ Assembly |
| ST 7.1–7.3 | Thu 11:00–12:30 HSZ/AUDI | AI Topical Day – Invited Talks (joint session AKPIK/HK/ST/T/AKBP) |
| ST 8.1–8.6 | Thu 14:00–15:30 ZEU/0146 | AI Topical Day – AI in Medicine (joint session ST/AKPIK) |
| ST 9.1–9.6 | Thu 15:50–17:20 ZEU/0146 | Radiation Therapy |
| ST 10.1–10.1 | Thu 17:30–18:00 ZEU/0146 | Keynote: Online-Adaptive Particle Therapy |
| ST 11 | Thu 18:00–18:15 ZEU/0146 | Prize Ceremony and Closing Session |

Members’ Assembly of the Radiation and Medical Physics Division

Wednesday 17:45–18:45 Location: ZEU/0146
ST 1: Accelerators for Radiation Therapy (joint session ST/AKBP)

Time: Tuesday 11:00–12:30
Location: GER/038

ST 1.1 Tue 11:00 GER/038
Real-time analysis for a scintillating fiber-based ion beam profile monitor — LIQING QIN, QIAN YANG, and BLAKE LIVERINGTON — Physikalisches Institut, Heidelberg, Germany
For raster scanning of a pencil beam during ion beam therapy, it is necessary to monitor the beam in real-time for safety and quality reasons. A scintillating fiber-based beam profile monitor developed from LHCb fiber winding techniques will offer real-time information of the pencil beam parameters, including position, width, and intensity, with a readout rate of up to 10 kHz.

The preliminary reconstruction algorithm for a Gaussian-like beam is being implemented on a FPGA. Preliminary results of the reconstruction algorithm performance on the FPGA will be presented.

ST 1.2 Tue 11:15 GER/038
Application of HV-CMOS sensor in a position monitoring system for therapeutic ion beams — BGDAN TOPKO, MATTHIAS BALZER, ALEXANDER DIERLAMM 1,2, FELIX EHRLER 1, ULRICH HUSEMANN 1, ROLAND KOPPENHÖFER 1, IVAN PIROC 1, MARTIN PIETTERT 1, and ALENA WISER 1,2 — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT) — Institute for Data Processing and Electronics (IPE), KIT — now with Bosch AG
Cancer treatment with ion beams provides critical advantages compared to the photon irradiation approach. The Bragg peak of the ion energy deposition near the end of the particle range allows to deposit the maximum of energy to the tumor and minimize the damage of healthy tissue. The beam position and size can be precisely controlled by the beam delivery system. In order to provide effective and safe dose delivery to the tumor, a fast and reliable beam monitoring system is required. The studies presented in this talk are focused on the application of HV-CMOS sensors for such a beam monitoring system. This system should provide information about beam position, shape and fluence in real time. It should work under beam intensities up to 10^{10} s^{-1} and deliver fluence information every 1-2 μs. In order to fulfill the timing requirements, the HitPix chip family with counting electronics and frame based readout has been developed at the ASIC and Detector Lab (IPE, KIT). Recent measurements with ion beams and a multi-chip matrix as well as future developments are discussed.

ST 1.3 Tue 11:30 GER/038
Medical irradiation simulations for IBT accelerators — KATHARINA MAYER 1, ERIK BRUNDEMANN 1, ALFREDO FERRARI 1, MICHAEL J. NASSE 1, MARKUS SCHWARZ 1, and ANKE-SUSANNE Müller 1,2 — IBT, KIT; Karlsruhe — now with Bosch AG
An important cancer treatment method used in oncology is radiation therapy, in which the tumor is irradiated with ionizing radiation. In recent years, the study of the beneficial effects of short intense radiation pulses (FLASH effect) or spatially fractionated radiation (Microbeam) have become an important research field. Systematic studies of this type often require non-medical accelerators capable of producing the requested short intense pulses. At KIT, the Ferninfrarot-Linac- and Testexperiment (FLUTE) can produce ultra-short electron bunches and the KIT storage ring KARA (Karlsruher Research Accelerator) is a source of pulsed X-rays. Both can be used as pulsed high-energy radiation sources and compared to conventional X-ray tubes. In this contribution, first dose simulations for FLUTE using the Monte Carlo simulation program FLUKA are presented.

ST 1.4 Tue 11:45 GER/038
Dose Simulation of Ultra-High Energy Electron Beams for Novel FLASH Radiation Therapy Applications — KELLY GRUNWALD, KLAUS DESCH, DANIEL ELSNER, DENNIS PROFT, and LEONARDO THOME — Physikalisches Institut der Universität Bonn
The electron stretcher facility ELSA delivers up to 3.2 GeV electrons to external experimental stations. In a new setup the irradiation of tumor cells inside a water volume with doses of up to 50 Gy by ultra-high energy electrons (UHEE) in time windows of microseconds up to milliseconds (FLASH) is currently investigated. This technique may enable highly efficient treatment of deep-seated tumors alongside optimal sparing and protection of healthy tissue. Along the effort to measure the dose with a suitable detector, our approach is to determine the optimal dose distribution by simulations. Therefore, the electromagnetic shower process is simulated in Geant4, taking the extracted electron pulse properties into account. A virtual water volume is constructed of voxels of different sizes for precise investigation in the volume of interest. Various properties such as particle types, deposited energy and the energy spectra of the particle shower can be extracted and correlated to relative and absolute dose measurements at the real water phantom. The method and first results will be presented.

ST 1.5 Tue 12:00 GER/038
Evaluation of Measuring Techniques to Determine the Applied Dose of Ultra-High Energy Electrons Beams in Cell Samples for FLASH Therapy — LEONARDO THOME, KLAUS DESCH, DANIEL ELSNER, DENNIS PROFT, and KELLY GRUNWALD — Physikalisches Institut der Universität Bonn
The electron accelerator facility ELSA delivers up to 3.2 GeV electrons. Ultra-high energy electrons (UHEE) in short pulses of microseconds up to milliseconds (FLASH) are used to investigate the effect of UHEE on tumor cells. This may enable highly efficient treatment of deep-seated tumors due to the FLASH effect. Currently, in a preliminary setting the Booster-Synchrotron is used to deliver electrons of 1.2 GeV energy to irradiate cell samples placed in a water phantom. A precise dose determination is necessary to monitor the efficacy of the biological effect. Therefore, the usability of different detector types for a precise dose determination is evaluated.

ST 1.6 Tue 12:15 GER/038
Dosimetry tests for FLASH RT at PITZ — FELIX RIEMBERG, ZAKARIA ABOU-RABANINE, GOWRI ADHIKARI, ZOHRA AMIRKHAYAN, NAMRA AFTAB, BRACH BOONPOONPRASERT, GEORG GEORGIEV, ANNA GREBINKY, ANDREAS HOFFMANN, MIKHAIL KRASILNIKOV, XUANGUAN LI, ANUSOBN LUEANGRAMWONG, RAFAEL NIEMECZYK, HOJWU QIAN, CHRIS RICHARD, FRANK STEPHAN, GREGORIUS VASCHENKO, TOBIAS WEILBACH, and STEVEN WORM — Deutsches Elektronen-Synchrotron DESY, Platanenallee 6, 15738 Zeuthen, Germany
The Photo Injector Test Facility at DESY in Zeuthen (PITZ) can provide unique beam parameters regarding delivered dose and dose rate. With an average dose rate of up to 10^7 Gy/s and peak dose rates of up to 4x10^12 Gy/s, PITZ is fully capable of FLASH radiation therapy. Nevertheless, dosimetry is a major challenge. Traditional detectors cannot provide reliable measurements and linearity up to such high dose rates. A new setup is being built to create a test infrastructure for all kinds of detectors. This includes a completely new beamline exclusively for FLASH RT and biology experiments. The goal is to develop and test detectors (also from external users) which cover the whole range of dose rates available at PITZ. First dosimetry experiments using Gafchromic films were done in air and water. Dose rate linearity and a limit test of the films were done. Beam parameters like beam profile, dose depth profile in water, homogeneity and dark current were measured. First detector tests will be done using silicon sensors utilized in high energy physics experiments.

ST 2: Medical Imaging Concepts

Time: Tuesday 17:00–18:30
Location: ZEU/0146

Investigation of the prospects of BaF2 as a fast scintillator for TOF-PET — KARIN HERBEG, VANESSA NÄDL, VOLKMAR SCHULZ, and STEFAN GUNDAKER — Department of Physics of Molecular Imaging Systems, RWTH Aachen University, Aachen, Germany
Future time-of-flight positron emission tomography (TOF-PET) will be of need of ultra-fast scintillation, with potential seen in cross-luminescent materials like BaF2, which shows a sub-100ps decay time with 300 photons produced per MeV. However, it poses challenges such as medium radiation length, low photofraction, moderate light yield and UV emission around 200nm. A slow
Advancements in Energy Resolution for Positron Emission Tomography with light sharing Scintillation Crystals — Matthias Bovelett, Florian Müller, Yannik Kuhl, Stephan Naunheim, David Schug, Volkmar Schulz — Department of Physics of Molecular Imaging Systems, RWTH Aachen University — Hyperion Hybrid Imaging Systems GmbH Positron Emission Tomography (PET) is widely used in clinical and pre-clinical applications. Commercially available PET-detectors use arrays of segmented scintillators coupled to a SiPM matrix. Of current scientific interest are detectors using light sharing scintillators. In these, the scintillator covers multiple SiPM channels and, therefore, one gamma interaction shares the light among the optically coupled SiPM channels. Key parameters of the gamma interaction, i.e., interaction position, timing, and energy information, need to be reconstructed from the measured light distribution. To acquire a good energy resolution in PET it is necessary to filter out specimen scattered events, thereby reducing background, and improving the signal to noise ratio. This work presents a framework, in which a light sharing scintillator is divided in virtual voxels. For each voxel a detection threshold is set. This allows for a proper energy resolution for deeply embedded SiPM channels and their impact on the energy resolution are discussed, including events for which not all SiPM channels were read-out. For these “incomplete” light distributions (~ 15% of all imputation strategies are presented. Overall, the presented strategies result in an improvement from 14% to below 12% for energy resolution of all events.

Radiation and Medical Physics Division (ST) Wednesday

ST 2.2 Tue 17:15 ZEU/0146
Advancements in Energy Resolution for Positron Emission Tomography with light sharing Scintillation Crystals — Matthias Bovelett, Florian Müller, Yannik Kuhl, Stephan Naunheim, David Schug, Volkmar Schulz — Department of Physics of Molecular Imaging Systems, RWTH Aachen University — Hyperion Hybrid Imaging Systems GmbH Positron Emission Tomography (PET) is widely used in clinical and pre-clinical applications. Commercially available PET-detectors use arrays of segmented scintillators coupled to a SiPM matrix. Of current scientific interest are detectors using light sharing scintillators. In these, the scintillator covers multiple SiPM channels and, therefore, one gamma interaction shares the light among the optically coupled SiPM channels. Key parameters of the gamma interaction, i.e., interaction position, timing, and energy information, need to be reconstructed from the measured light distribution. To acquire a good energy resolution in PET is necessary to filter out specimen scattered events, thereby reducing background, and improving the signal to noise ratio. This work presents a framework, in which a light sharing scintillator is divided in virtual voxels. For each voxel a detection threshold is set. This allows for a proper energy resolution for deeply embedded SiPM channels and their impact on the energy resolution are discussed, including events for which not all SiPM channels were read-out. For these “incomplete” light distributions (~ 15% of all imputation strategies are presented. Overall, the presented strategies result in an improvement from 14% to below 12% for energy resolution of all events.

ST 2.3 Tue 17:30 ZEU/0146
Metamaterials for Magnetic Resonance Imaging — Dennis Philipp — Fraunhofer Institute for Digital Medicine MEVIS, 28359 Bremen, Germany Electromagnetic metamaterials (MTMs) offer manifold degrees of freedom in MRI applications. Most prominently, field homogeneity improvement and signal–to–noise ratio (SNR) enhancement are typical use cases. However, passive MTMs also have some drawbacks such as transmit field (Tx) deformations. Here, we pave the way towards dynamic and active MTMs, which overcome some of the open problems. Bluetooth-controlled, reconfigurable MTMs for signal–to–noise ratio (SNR) enhancement in MRI are presented. These metamaterials allow to be wirelessly interfaced and tuned during an MRI scan by means of a digital capacitor (DCAP), which is connected to a low-power microcontroller with BLE capabilities. Two prototypes are manufactured, one of which is a metamaterial with adjustable resonance frequency, and the second one is dynamically tunable at the meta-atom (unit cell) scale. It includes multiple DCAPs and, thus, is the first wirelessly reconfigurable MTM for MRI that offers field shaping capabilities, adjustable Fov, focal regions, sequence sync., and active Tx detuning. A MTM arrangement that encloses a volume “metaBox” is shown to yield a significant and volume-homogeneous SNR enhancement in 3T MRI. Due to the integration of non-linear components, the structure self-detunes in Tx whilst being resonant in Rx. Fine-tuning capabilities are included in two different prototypes via (i) a manually trimmable capacitor and (ii) a BLE controlled DCAP.

ST 2.4 Tue 17:45 ZEU/0146
Proton Radiography: An Overview and Outlook — Jana Hohmann, Kevin Kröniger, Isabelle Schilling, Hendrik Speiser, Jens Weingarten — TU Dortmund, department of physics For years, proton therapy has been increasingly used to treat cancer because of its well-known advantages, such as the high dose precision of protons. However, exploiting this precision requires improved imaging techniques to ensure accurate patient positioning and dose delivery. This work allows to reduce the safety margin around the target volume and protecting the surrounding healthy tissue.

One such enhanced imaging technique is proton radiography. It allows to take images whose properties are directly dependent on the proton interactions with the structures in the patient. Therefore, by measuring the residual energy of protons after passing through the patient, conclusions on the stopping power distribution in the patient can be drawn. Extending a proton radiogram to a CT allows to reduce the proton range uncertainty from the conversion of Hounsfield units into stopping power. However, even a single proton radiogram taken in the daily treatment can be used to verify the predefined therapy plan and the correct patient positioning.

This talk will include an introduction into the topic of proton radiography followed by an overview of several proton radiography approaches. Subsequently, two new methods developed and investigated at the TU Dortmund University are presented and discussed.

ST 2.5 Tue 18:00 ZEU/0146
A Two-plane Spectral Proton Radiography System using Silicon Pixel Detectors — Jana Hohmann, Kevin Kröniger, Isabelle Schilling, Hendrik Speiser, Jens Weingarten, and Jolina Zillner — TU Dortmund University, Germany To take advantage of the locally high dose in proton therapy the irradiation must be planned precisely. X-ray CT images are used for this purpose. However, when Hounsfield units are converted to the stopping power of the material, this entails a range uncertainty in the treatment plan, which can lead to unintentional radiation damage in healthy tissue or to missing dose in the tumor.

To avoid this, the stopping power of the protons can be determined via imaging techniques with protons themselves. This could be used to verify and adjust the existing irradiation plan.

The system is a two-plane system that is designed to measure the water equivalent thickness (WET) directly, from which the stopping power can be calculated. Two pixelated silicon detectors with an absorber in between track the deposited energies of individual protons. With a reference measurement and the initial proton energy, the WET of a phantom can thus be determined.

The detector design is simulated and optimized in GEANT4. This is then used to determine the 2D WET distribution of a known phantom. The talk summarizes the simulation results and provides a comparison to the single plane method.

ST 2.6 Tue 18:15 ZEU/0146
Experimental characterization and comparison of two Si-based compact setups for proton radiography and tomography of small animals for image-guided proton irradiation — Angelica Noto, Guyet Hu, Katrin Schnürlé, Matthias Würf, Franz Englbrecht, Johannes Gerhard, Julie Lascaud, Marco Pinto, Ze Huang, Jonathan Bortfeldt, Mátéusz Szatár, Per Poulsen, and Katia Farodi — Medical Physics Department, LMU, Munich, Germany — Danish Center for Particle Therapy, Aarhus University Hospital, Aarhus, Denmark

In the project SIRMIO we develop advanced imaging for positioning and treatment planning to aid precise proton irradiation of small animals. In contrast to the widely adopted X-ray cone beam CT, the project integrates 3 solutions of proton imaging. Here, we compare 2 approaches that provide spatially resolved detection of individual or integral proton energy deposition reposing on the commercial Timepix3 or Lasenna Si-based pixelated detectors. Proton radiographs were acquired at the Danish Center for Particle Therapy for a calibration phantom housing inserts of well-characterized relative stopping power values. We will compare the achievable spatial resolution and accuracy of water equivalent thickness retrieval in radiographic mode for different systems and imaging doses. Moreover, comparing acquisitions of tomography with the Timepix3 will be presented for the calibration phantom and a dedicated mouse-like phantom. The work is supported by EU through the grant agreements 725539, 730983 and 10108584. The authors would like to thank Nordson and Advacm.
were performed, which will be presented with a performance mapping of the different components for their physical and electrical properties together with a discussion of the device performance.

**ST 3.2** Wed 11:00 ZEU/0146

Systematic study of a large data set of CT scans with regard to diagnostic reference levels — **Hanna Eidk**, Lydia Bock, Jans Boing, Lennart Henkenharm, Norbert Lang, Christina Westphaliner, and Alphons Khoura2 — Institute for Nuclear Physics, Westfälische Wilhelms-Universität Münster — 2Gesellschaft für Medizinische Physik und Strahlenschutz mbH, Münster

Diagnostic reference levels (DRL) for examinations on humans with ionizing radiation or radioactive sources are reviewed or updated if necessary every three years. These DRLs are determined and published by the Federal Office for Radiation Protection and are based on the data provided by the medical authorities. Each operator of a device with the mentioned types of radiation must provide review values to the medical authorities every two years. The collaboration of our working group from the WWU Münster with the ‘Gesellschaft für Medizinische Physik und Strahlenschutz mbH’ makes it possible, on the one hand, to analyze a large data set of CT examinations from different devices in various facilities and to shed more light on the DRLs and on the other hand, to develop an analysis program, which enables a fast and uncomplicated evaluation of the recorded data for every CT scanner. The results will be considered in particular in the context of the update of the DRLs published in November 2022 and to the reference levels valid until then. The analyses also make it possible to establish new DRLs for examinations that have not yet been considered.

**ST 4: DPG meets DGMP: Von der Idee bis zur klinischen Anwendung**

**Invited Talk**

**ST 4.1** Wed 14:00 ZEU/0146

Innovationen in der Praxis bringen – die EXIST-Gründungsfoerderung — **Antje Dewitz** — Projekträger Jülich, Berlin, Germany


**Invited Talk**

**ST 4.2** Wed 14:20 ZEU/0146

Development and Certification of an IGRT system — **Claus Promberger** — Brainlab AG, München

As a mid-size company we decided several years ago to redesign a successful IGRT product line to follow current and upcoming regulations and standards in development, verification, validation and certification processes. The journey will be presented which ends again in a successful product and even in a nomination for the "Deutsche Zukunftspreis". The focus will be on the necessary tasks and timeline to bring a fully MDR certified product consisting of software and hardware components to the market in the EU and to keep it there.

**Invited Talk**

**ST 4.3** Wed 14:40 ZEU/0146

Klinische Anwendung von Protonen-Partikeltherapie — **Esther Troost** — OncoRay - National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

Protonen- und ionisierende Partikeltherapie, besonders Protonentherapie, wird aktuell in zahlreichen Zentren in Deutschland und Europa als Alternative zur herkömmlichen Photonentherapie angeboten. In diesem Vortrag werden die Unterschiede in der Dosierung zwischen Photonen- und Protonentherapie, die Indikationen für eine Protonentherapie sowie der bisher bewiesene Mehrwert von Partikeltherapie dargestellt.

**Round Table Discussion (30 min)**

**ST 5: Physics and Technology for Radiation Detection**

**ST 5.1** Wed 15:50 ZEU/0146

Measuring the beam energy at a proton therapy facility using ATLAS IBL pixel detectors — **Isabelle Schilling**, Claus Maximilian Backer, Christian Baumberger, Carina Behrends, Marius Hättig, Jana Hohmann, Kevin Kröninger, Beatrice Temmermann, and Jens Weingarten — TU Dortmund University, Department of Physics, D-44221 Dortmund — 1West German Proton Therapy Centre Essen, D-45122 Essen — 2West German Cancer Center, D-45122 Essen — 3University Hospital Essen, D-45122 Essen — 4Clinic for Particle Therapy, University Hospital Essen, D-45122 Essen

The accurate measurement of beam range for quality assurance (QA) in proton therapy is of vital importance for optimal patient treatment. Conventionally used detectors mostly calculate the energy by detecting the depth dose distribution of the protons. In contrast to this, the ATLAS pixelated silicon detector measures the deposited energy in the sensor for individual protons, allowing the determination of the Linear Energy Transfer (LET). The restriction on the dynamic energy range of the measurement is given by the readout chip. Hence, there are different ways to use the detector whose applicability is being examined. An absorber with different thicknesses is used to investigate the variation of the charge production in the sensor and perform an energy calibration relative to the NIST PSTAR database. In comparison, this talk also presents measurements of the LET per pixel along the trajectory of individual proton, all performed at the West German Proton Therapy Centre Essen.

**ST 5.2** Wed 16:05 ZEU/0146

Development of a Compton Camera with detection of electrons’ interaction point and energy in the scattering layer using Cherenkov photons — **Kavitha Kooshek**, Reinmund Bayerlein, Ivor Fleck, Ulrich Werthennbach, and Michael Ziolkowski — 1Universität Siegen, NRW, DE — 2University of California Davis, CA, US
Neutron Detection With Coated Semiconductors — KEVIN ALEXANDER KRÖNINGER, ALINA JOHANNA LANDMANN, RUBEN TRIMPOPO, AND JENS WEINGARTEN — TU Dortmund University, Department of Physics, Otto-Hahn-Str. 4a, 44227 Dortmund

Neutron dosimetry with diamond sensors — JENNIFER SCHLÜSS, KEVIN KRÖNINGER, JENS WEINGARTEN, AND ALINA JOHANNA LANDMANN — Technische Universität Dortmund, Dortmund, Germany

Neutron dosimetry is becoming increasingly relevant in proton therapy. From a separation resolution of 10 to 20% has been achieved for 7 different energy beams from 0.8 MeV to 2 MeV. A separation resolution of 10 to 20% has been achieved for 7 different energy beams from 0.8 MeV to 2 MeV. The number of Cherenkov photons, detected in coincidence from SiPM's time-over-threshold signal within a time-window of 10 ns, is used to estimate the electron energy. The results are compared with a mean value available from theory.

Neutron dosimetry with diamond sensors — KEVIN ALEXANDER KRÖNINGER, ALINA JOHANNA LANDMANN, RUBEN TRIMPOPO, AND JENS WEINGARTEN — TU Dortmund University, Department of Physics, Otto-Hahn-Str. 4a, 44227 Dortmund

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ST 6: Members’ Assembly

Time: Wednesday 17:45–18:45
Location: ZEU/0146

All members of the Radiation and Medical Physics Division are invited to participate.

ST 7: AI Topical Day – Invited Talks (joint session AKPIK/HK/ST/T/AKBP)

Time: Thursday 11:00–12:30
Location: HSZ/AUDI

Invited Talk

ST 7.1 Thu 11:00 HSZ/AUDI
AI Techniques for Event Reconstruction — IVAN KISEL — Goethe University, Frankfurt, Germany

Why can we relatively easily recognize the trajectory of a particle in a detector visually, and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been puzzling over the answer to this question for more than 30 years, since the days of bubble chambers. And it seems that we are steadily approaching the answer in our attempts to develop and apply artificial neural networks both for finding particle trajectories and for physics analysis of events in general.

This talk will present the basics of artificial neural networks in a simple form, and provide illustrations of their successful application in event reconstruction in high energy physics and heavy ion physics experiments. You will get an insight into the application of traditional neural network models, such as deep neural network, convolutional neural network, graph neural network, as well as those standing a little aside from traditional approaches, but close in idea of elastic network and even cellular automata.

Invited Talk

ST 7.2 Thu 11:30 HSZ/AUDI
Accelerator operation optimisation using machine learning — PIERRE SCHNITZER — Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany

Accelerators are complex machines whose many components need to be accurately tuned to achieve design performance. Reliable operation requires frequent recalibration and tuning. Especially for large machines tools have been developed that facilitating this task.

Machine learning allows building such tools using simulations, archiver data or interaction with the real machine, thus making many tools now also available for smaller machines.

This talk will give an overview of different machine learning projects targeted to accelerators, which simplifies accelerator operation or even enable applications that were not possible before.
In proton therapy, precise patient positioning is essential for treatment quality.

In radiation therapy, precise localisation of tumour and risk structures is important for treatment planning. Medical imaging methods, such as computed tomography (CT) and magnetic resonance imaging (MRI), allow a differentiation between these structures. Planning systems typically align CT and MRI scans rigidly to compensate inaccurate immobilisation of the patient, but distortions in MRI or movement of organs still remain.

In this project, a data set of CT and MRI scans of the head and neck areas is used to study unsupervised deformable image registration with deep learning. First, the scans are pre-processed, which includes rigid registrations and the equalisation of the image formats. Then, deep learning is employed to filter structures of an image through multiple layers and to match them to a second image. The registration model strongly depends on the choice of its parameters. Therefore, variations of these parameters are investigated on the data set. The results are presented as well as the overall workflow including the pre-processing.

Position reconstruction in proton therapy with proton radiography and machine learning — Jolina Zillner, Carsten Burgard, Jana Hohmann, Kevin Kröniger, Florian Mentzel, Olaf Nackenhorst, Isabelle Schilling, Hendrik Speiser, and Jens Weingarten — TU Dortmund University, Dortmund, Germany

In proton therapy, precise patient positioning is essential for treatment quality. Current research in proton radiography (pRad) enables imaging of the patient immediately prior to irradiation. The idea is to use such pRad images to verify the patients position.

Therefore a 3D Convolutional Neural Network will be developed in order to predict pRad images depending on the CT image of an object and different translations and orientations. A minimization algorithm can then find the translation and rotation vector for which the predicted image has the smallest difference to a measured pRad image of the object, which can be used to correct the objects position. To predict pRad images, the CNN needs to be trained with pRad images and their related object translation and rotation and the CT-image.

This talk introduces the simulation used to generate these pRad training data. Simulations and reference measurements are performed with a primitive elbow phantom: a 3D-printed 33x33x25 cm³ cube with a T-cavity for gusypsem-inlay representing a stretched or bent elbow. The target is implemented in GEANT4 based on CT-data.

Event identification in the SiFi-CC Compton camera for imaging prompt gamma rays in proton therapy via deep neural networks — Alexander Fenger, Ronja Hetzel, Jonas Kasper, George Farah, Achim Stahl, and Aleksandra Wróńska — III. Physikalisches Institut B, RWTH Aachen University — M. Smoluchowski Institute of Physics, Jagiellonian University Kraków, Poland

One of the biggest challenges in proton therapy is ensuring that the dose is delivered to the right position. A promising approach for online monitoring of the beam range is the detection of prompt gamma rays using a Compton camera, as it provides the possibility to reconstruct the 3D distribution of the deposited dose.

The SiFi-CC (SiPM and scintillating Fiber-based Compton Camera) project is a joint collaboration of the RWTH Aachen University, the Jagiellonian University in Kraków and the University of Łódź. The two modules of the SiFi-CC, the scatterer and the absorber, both consist of stacked LYSO fibres and are read out by SiPMs. Deep neural networks are employed to separate valid Compton events from background and reconstruct the direction and energy of prompt gamma rays. First implementations of neural networks show promising results in classification of Compton events as well as full reconstruction of the event topology and kinematics. The next step is to further optimize the current neural network implementation to gain sensitivity towards a detectable range shift in the source position. Different neural network designs as well as an evaluation of their performance are presented.
Simulations of a combination of brachytherapy and X-ray irradiation for the treatment of intraocular tumors — •Michelle Stroth1, Henning Manke2, Dirk Flühs1, Bernhard Spaan1, and Johannes Albrecht1 — •TU Dortmund University, Dortmund, Germany — 1Department of Radiotherapy, Essen University Hospital, Germany

Brachytherapy with Ruthenium-106 Eye Applicators is an effective method for successfully treating ocular tumours. However, this treatment is contraindicated for intraocular tumours with an apex height above 7 mm due to insufficient irradiation of the tumor apex. To reduce side effects that can occur with alternative forms of therapy, an integrated concept consisting of brachytherapy with external X-ray irradiation is investigated for treating intraocular tumours.

For this purpose, the combined therapy modality is simulated using real patient data. The radiation sources’ weights are adjusted by optimization through differential evolution, minimizing the dose to the organs at risk. Comparison of the dose-volume histograms of the combined form of therapy with the dose-volume histograms of brachytherapy only, confirms the advantages of integrating external X-ray irradiation using the ruthenium-106 applicator in terms of protection of the structures at risk and homogeneity of the dose profile in the tumour. This presentation shows the results of the Monte Carlo simulations of the combined concept.

A new phantom was constructed from the material Plastic Water Low Range to measure dose profiles of X-rays in front and behind a Ruthenium-106 plaque. Three different detectors can be used in the phantom to measure dose profiles: a soft X-ray chamber, radiochromic films and self-made scintillation detectors. Measurements have been performed with a X-ray therapy unit type T-105 distributed by BEBIG Medical GmbH. This talk presents the first results which show an appropriate application of the combined therapy.

Proton Therapy Dose Calculations with the Monte-Carlo Simulation — •Mariam Abuladze1, Ronia Hetzel1, Jonas Kasper1, Revaz Shaanidze1, and Achim Stahl1 — •RWTH Aachen University - Physics Institute III B, Aachen, Germany — 1Kutaisi International University, Kutaisi, Georgia

Proton therapy is a high-quality radiation therapy that uses a proton beam to irradiate cancer tissue. The advantage of this type of treatment is a highly conformal dose deposition due to the presence of the Bragg peak. The results of the Geant4 simulation (version 10.6.3) are presented. The dose distribution was studied in the phantom materials with proton beams of different geometry and intensity. Different geometric shapes are used for phantoms, which are filled with water and carbon. 3D phantom models are divided into voxels of different sizes. Obtained simulated data was used for calculations of dose-volume histograms for different proton beam parameters and different phantom models.

Prompt gamma-ray timing for online proton range verification — •Kristina Makaveych2, Katja E. Römer2, Sonja M. Schellhammer2,1, Joseph A. B. Turko2, Andreas Wagner2, and Toni Kogler2,1 — •Helmholtz - Zentrum Dresden - Rossendorf, Institute of Radiooncology - OncoRay, Dresden, Germany — 2OncoRay - National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz - Zentrum Dresden - Rossendorf, Dresden, Germany — 3Helmholtz - Zentrum Dresden - Rossendorf, Institute of Radiation Physics, Dresden, Germany

The prompt gamma-ray timing (PGT) technique is a promising candidate for proton therapy range verification as it is light-weight, can be integrated into existing therapy systems, and reduces side effects. This work explains the physical basics of the PGT method and gives an overview of a setup developed for future integration into clinical practice. Currently, the PGT technique undergoes extensive testing under close-to-clinical conditions to prepare for the first in-human application. The latest measurements with an anthropomorphic head phantom irradiated with clinical treatment plans are presented. The work shows the main outcomes of this experiment such as the choice of the detector crystal size, the relationship between the detector load and the processed count rate, the influence of the range shift on the PGT distributions, etc. An overview of the directions for future investigations is presented.
ST 10: Keynote: Online-Adaptive Particle Therapy

Time: Thursday 17:30–18:00

Invited Talk

ST 10.1 Thu 17:30 ZEU/0146

In this overview talk the following questions will be addressed:
- What is the status concerning fast adaptations in particle therapy also in relation to photon therapy?
- Why do we need online-adaptive particle therapy (OAPT)?
- What are different approaches also in relation to different adaptation speed?
- What are the different imaging approaches for OAPT?
- How can we verify the treatment delivery when no pre-treatment phantom QA is performed?
- What is the role of AI-based decision support?
- What initiatives exist on national and international level? Where do we stand?

Online-adaptive particle therapy: Current status and vision for the future —

CHRISTIAN RICHTER — OncoRay - National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Dresden, Germany — Department of Radiotherapy and Radiation Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Dresden, Germany — Helmholtz-Zentrum Dresden - Rossendorf, Institute of Radiooncology - OncoRay, Dresden, Germany

ST 11: Prize Ceremony and Closing Session

Time: Thursday 18:00–18:15

In this last session we would like to take the opportunity to thank all participants for their attendance and contributions. We will announce the winner of this year’s award for the best contribution in the Radiation and Medical Physics Division at the DPG Spring Meeting 2023. We welcome everyone to celebrate a successful conference with us, to provide some final feedback and to take the chance to meet other participants one last time at this meeting.
Particle Physics Division
Fachverband Teilchenphysik (T)

Kerstin Borras
Deutsches Elektronen-Synchrotron DESY and RWTH Aachen University
Notkestraße 85
22607 Hamburg
kerstin.borras@desy.de

Overview of Invited Talks and Sessions
(Lecture halls HSZ/AUDI, HSZ/0003, HSZ/0004, HSZ/0101, HSZ/0103, HSZ/0105, HSZ/0201, HSZ/0204,
HSZ/0301, HSZ/0304, HSZ/0401, HSZ/0403, HSZ/0405,
POT/0051, POT/0151, POT/0251, POT/0361, POT/0112, POT/0013, POT/0351, POT/0106,
WIL/A317, WIL/A124, WIL/C133, WIL/A120, and WIL/C129)

Invited Talks
T 1.1 Mon 11:00–11:30 HSZ/AUDI What we learned about the Higgs Boson from the LHC so far — •Duc Bao Ta
T 1.2 Mon 11:30–12:00 HSZ/AUDI QCD at the LHC — Precision for Discoveries — •Malgorzata Worek
T 1.3 Mon 12:00–12:30 HSZ/AUDI The charm and beauty of flavour physics — •Marco Gersabeck
T 24.1 Tue 11:00–11:30 HSZ/AUDI Searching for Long-Lived Particles at the LHC and Beyond — •Juliette Alimena
T 24.2 Tue 11:30–12:00 HSZ/AUDI The Neutrino-Dawn of Galaxies — •Wolfgang Rhode
T 24.3 Tue 12:00–12:30 HSZ/AUDI Galactic cosmic rays: What have we learned and what's next? — •Phillip Mertsch
T 100.1 Thu 11:00–11:30 HSZ/AUDI AI Techniques for Event Reconstruction — •Ivan Kisel
T 100.2 Thu 11:30–12:00 HSZ/AUDI Accelerator operation optimisation using machine learning — •Pierre Schnizer
T 100.3 Thu 12:00–12:30 HSZ/AUDI Is this even physics? — Progress on AI in particle physics — •Gregor Kasieczka
T 153.1 Fri 11:00–11:30 HSZ/AUDI The Standard Model on the test bench: What bosons and the top quark (will) tell us — •Valerie Lang
T 153.2 Fri 11:30–12:00 HSZ/AUDI Gravitational wave observations: Current results & future expectations — •Harald Pfeiffer
T 153.3 Fri 12:00–12:30 HSZ/AUDI Precise muon detection: novel technologies for the luminosity frontier — •Kerstin Hoepfner
T 154.1 Fri 13:30–14:00 HSZ/AUDI ECN3: Experimental Opportunities at a Future High-Intensity Proton Facility at the CERN SPS (BDF/SHiP and HIKE+SHADOWS) — •Annika Hollnagel

Invited Topical Talks
T 50.1 Wed 11:00–11:20 HSZ/AUDI Search for leptoquarks at the ATLAS experiment — •Mahsana Haleem
T 50.2 Wed 11:20–11:40 HSZ/AUDI Making the most of Yukawa couplings: searching for Dark Matter accompanied by heavy quarks — •Danyer Perez Adan
T 50.3 Wed 11:40–12:00 HSZ/AUDI Precision predictions for transverse momentum distributions of Higgs and vector bosons at the LHC — •Maximilian Stahlhofen
T 50.4 Wed 12:00–12:20 HSZ/AUDI Axion fragmentation — •Enrico Morgante
T 51.1 Wed 11:00–11:20 HSZ/0003 LUXE – A new experiment to study non-perturbative QED in electron-laser and photon-laser collisions — •Ruth Jacobs
T 51.2 Wed 11:20–11:40 HSZ/0003 Precision timing with silicon sensors — •Annika Vauth
T 51.3 Wed 11:40–12:00 HSZ/0003 Recent advancements in Micro-Pattern Gaseous Detectors: Exciting research ahead towards future experiments — •Michael Lupberger
T 51.4 Wed 12:00–12:20 HSZ/0003 Recent Liquid Scintillator Developments for Astroparticle Physics — •Stefan Schoppmann
T 52.1 Wed 14:00–14:20 HSZ/AUDI Commissioning of the new LHCb trigger system — •Marian Stahl
T 52.2 Wed 14:20–14:40 HSZ/AUDI Alignment of the CMS Tracker: Automation is Key — •Marius Teroerde
T 52.3 Wed 14:40–15:00 HSZ/AUDI ITk – ATLAS tracker upgrade — •Dennis Sperlich
T 52.4 Wed 15:00–15:20 HSZ/AUDI Role of simulation in silicon tracker sensors R&D — •Anastasiia Velyka
T 53.1 Wed 14:00–14:20 HSZ/0003 LST-1: Initial scientific results from the first CTA telescope — •Dominik Elsaesser
Multimessenger astronomy with the Pierre Auger Observatory — Marcus Niechciał
Positron annihilation as an astrophysical messenger — Thomas Siegert
The first results of the XENON1T experiment and an outlook to the future DARWIN observatory — Andrih Terliuk
How to Study the Higgs Boson in its Bosonic Decays — Benedict Winter
Measuring $H \to WW$ with the ATLAS Experiment — Carsten Burgard
Belle II opportunities in $B$-decays with invisible signatures — Slavomira Stefkova
Two Pieces of a Puzzle: Inclusive and Exclusive $V_{ub}$ — Markus Prim
Expanding the Frontiers of Galactic Neutrino Astronomy via Machine Learning — Mirko Hünnefeld
Higgsino Hunting at ATLAS — Michael Holzbock
New Ideas for Baryo- and Leptogenesis — Kai Schmitz
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<td>Electronics, DAQ, Exp. Methods</td>
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<td>POT/0051</td>
<td>Neutrino Astronomy III</td>
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<td>Gamma Astronomy III</td>
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<td>17:00</td>
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<td>17:00</td>
<td>Wed</td>
<td>HSZ/0061</td>
<td>Neutrinos, Dark Matter VII</td>
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<td>17:00</td>
<td>Wed</td>
<td>HSZ/0112</td>
<td>Neutrinos, Dark Matter IX</td>
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<tr>
<td>17:00</td>
<td>Wed</td>
<td>HSZ/0013</td>
<td>Cosmic Ray III</td>
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<tr>
<td>17:00</td>
<td>Wed</td>
<td>HSZ/0351</td>
<td>Exp. Methods AP, PMTs</td>
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<tr>
<td>17:00</td>
<td>Wed</td>
<td>HSZ/0106</td>
<td>Exp. Methods II</td>
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<td>17:00</td>
<td>Wed</td>
<td>WIL/A317</td>
<td>Pixel/CMS</td>
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<td>17:00</td>
<td>Wed</td>
<td>WIL/A124</td>
<td>DetSys MAGIX, DetSys KATRIN</td>
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<td>17:00</td>
<td>Wed</td>
<td>WIL/C133</td>
<td>Calorimeter / Detector Systems III</td>
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<td>17:00</td>
<td>Wed</td>
<td>WIL/A120</td>
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<td>17:00</td>
<td>Wed</td>
<td>HSZ/0401</td>
<td>Flavor VI</td>
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<td>17:00</td>
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<td>HSZ/0304</td>
<td>Flavor VII</td>
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<td>17:00</td>
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<td>HSZ/0403</td>
<td>Searches III</td>
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<td>17:00</td>
<td>Wed</td>
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<td>17:00</td>
<td>Wed</td>
<td>HSZ/0103</td>
<td>Single Top, Top Properties</td>
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<td>17:00</td>
<td>Wed</td>
<td>HSZ/0105</td>
<td>Higgs, Di-Higgs II</td>
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<td>17:00</td>
<td>Wed</td>
<td>HSZ/0201</td>
<td>Theory BSM</td>
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<td>HSZ/0204</td>
<td>Theory EW</td>
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<tr>
<td>17:00</td>
<td>Wed</td>
<td>HSZ/0301</td>
<td>DAQ, Data Techniques</td>
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<td>HSZ/0405</td>
<td>ML Methods IV</td>
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<td>Wed</td>
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<td>Gamma Astronomy IV</td>
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<tr>
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<td>HSZ/0251</td>
<td>DM, Neutrino Theory</td>
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<td>17:00</td>
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<td>Neutrinos, Dark Matter X</td>
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<td>17:00</td>
<td>Wed</td>
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<td>Exp. Methods – Scint., HESS, Auger</td>
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<td>WIL/A317</td>
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<td>WIL/A124</td>
<td>TestBeam, RadHard for Si and Pixel</td>
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<td>17:00</td>
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<td>WIL/C133</td>
<td>Calorimeter / Detector Systems IV</td>
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<tr>
<td>17:00</td>
<td>Wed</td>
<td>WIL/A120</td>
<td>Gas-Detectors, Detector Systems</td>
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<tr>
<td>19:00</td>
<td>Wed</td>
<td>HSZ/0101</td>
<td>Annual Meeting of Young Scientists in High Energy Physics (yHEP)</td>
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<tr>
<td>11:00</td>
<td>Thu</td>
<td>HSZ/AUDI</td>
<td>AI Topical Day – Invited Talks (joint session AKPIK/HK/ST/T/AKBP)</td>
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<td>14:00</td>
<td>Thu</td>
<td>HSZ/0003</td>
<td>Invited Topical Talks III-A</td>
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<td>14:00</td>
<td>Thu</td>
<td>HSZ/0004</td>
<td>Invited Topical Talks III-B</td>
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<tr>
<td>15:45</td>
<td>Thu</td>
<td>HSZ/0004</td>
<td>AI Topical Day – Simulation, Inverse Problems and Algorithmic Develop-</td>
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<tr>
<td>15:45</td>
<td>Thu</td>
<td>HSZ/0004</td>
<td>ment (joint session AKPIK/T)</td>
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<td>T107.1–107.6 Thu 15:50–17:20</td>
<td>Searches – Neutrino at accelerators</td>
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<td>T108.1–108.6 Thu 15:50–17:20</td>
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<td>Higgs, Di-Higgs III</td>
<td>HSZ/0105</td>
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<td>T110.1–110.6 Thu 15:50–17:20</td>
<td>Other Theory</td>
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<td>T111.1–111.6 Thu 15:50–17:20</td>
<td>Outreach Diverse (joint session T/HK)</td>
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<td>T113.1–113.6 Thu 15:50–17:20</td>
<td>QCD Theory and Experiment II</td>
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<td>T114.1–114.6 Thu 15:50–17:20</td>
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<td>Gamma Astronomy V</td>
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<td>T116.1–116.6 Thu 15:50–17:20</td>
<td>Neutrinos Legend, Neutrino Theory</td>
<td>POT/0361</td>
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<td>T117.1–117.6 Thu 15:50–17:20</td>
<td>Dark Matter I</td>
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<td>T121.1–121.6 Thu 15:50–17:20</td>
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<td>T123.1–123.6 Thu 15:50–17:20</td>
<td>Pixel/Belle II, Si/Other</td>
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<td>T124.1–124.6 Thu 15:50–17:20</td>
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<td>Calorimeter / Detector Systems V</td>
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<td>WIL/C129</td>
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<td>T127.1–127.5 Thu 15:50–17:05</td>
<td>Exp. Methods III</td>
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<td>T128.1–128.6 Thu 17:30–19:00</td>
<td>AI Topical Day – New Methods (joint session AKPIK/T)</td>
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<td>Top, EW II</td>
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<td>T134.1–134.6 Thu 17:30–19:00</td>
<td>Higgs, Di-Higgs IV</td>
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<td>T135.1–135.6 Thu 17:30–19:00</td>
<td>Top Mass, Top BSM</td>
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<td>Higgs TH, VH</td>
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<td>T137.1–137.6 Thu 17:30–19:00</td>
<td>DAQ Test/RO – GRID II</td>
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<td>T138.1–138.5 Thu 17:30–18:45</td>
<td>QCD Experiment III</td>
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<td>T141.1–141.6 Thu 17:30–19:00</td>
<td>Neutrino Astronomy V</td>
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<td>T142.1–142.6 Thu 17:30–19:00</td>
<td>Neutrinos, Dark Matter XI</td>
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<td>T144.1–144.6 Thu 17:30–19:00</td>
<td>Cosmic Ray VII</td>
<td>POT/0013</td>
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<td>T145.1–145.6 Thu 17:30–19:00</td>
<td>Cosmic Ray VIII</td>
<td>POT/0351</td>
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<td>T146.1–146.6 Thu 17:30–19:00</td>
<td>DAQ Systems, Exp. Methods</td>
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<td>T147.1–147.6 Thu 17:30–19:00</td>
<td>Pixel/HV-Maps, Si/Diamond</td>
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<td>T148.1–148.6 Thu 17:30–19:00</td>
<td>Si/SiPM, Pixel/Other</td>
<td>WIL/C133</td>
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<td>T149.1–149.6 Thu 17:30–19:00</td>
<td>Detector Systems / Muon</td>
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<td>T150.1–150.6 Thu 17:30–19:00</td>
<td>Gas-Detectors, Pixel/TANGERINE</td>
<td>WIL/C129</td>
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<td>T151.1–151.6 Thu 17:30–19:00</td>
<td>Exp. Methods IV</td>
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<td>T152 Thu 20:00–22:00</td>
<td>Members’ Assembly</td>
<td>HSZ/0003</td>
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<tr>
<td>T153.1–153.3 Fri 11:00–12:30</td>
<td>Invited Overview Talks III</td>
<td>HSZ/AUDI</td>
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<tr>
<td>T154.1–154.1 Fri 13:30–14:00</td>
<td>Invited Overview Talks IV</td>
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**Members’ Assembly of the Particle Physics Division**

Thursday  20:00–22:00  HSZ/0003
**Sessions**

- Invited, Invited Topical, and Contributed Talks

### T 1: Invited Overview Talks I

**Time:** Monday 11:00–12:30

**Invited Talk**

T 1.1 Mon 11:00 HSZ/AUDI

*What we learned about the Higgs Boson from the LHC so far* — Duc Bao Ta — Johannes Gutenberg-Universität Mainz

The Higgs boson in the Standard Model of particle physics has a unique role as it is related to the mechanism that gives elementary particles their mass. Last year the large LHC experiments, ATLAS and CMS, released the most comprehensive overview of their results on the Higgs boson for the 10th year after its discovery. These results are based on the LHC run 2 dataset from 2015–2018, which constitutes only 5% of the ultimate dataset. However, it has already enabled us to study the Higgs boson properties in unprecedented detail. The two collaborations continue to study the dataset and explore more corners of the Higgs sector that might connect it to the open questions in particle physics, like the origin of CP violation or the nature of dark matter. In this presentation, I will review the current results of the Higgs boson from the LHC and give an outlook on what is planned and can be achieved with the data from the currently ongoing Run 3 or when the remaining 90–95% of the full dataset will have been collected and analysed in the future.

**Invited Talk**

T 1.2 Mon 11:30 HSZ/AUDI

*QCD at the LHC – Precision for Discoveries* — Malgorzata Worek — RWTH Aachen University

In this presentation, I will summarise the relevance of higher-order QCD effects to Standard Model processes at the Large Hadron Collider (LHC). Special emphasis will be placed on the physics of the top quark and QCD jets. Many models look at the production of top quarks as well as QCD jets as interesting channels to evidence signals of new physics. A good theoretical control of Standard Model backgrounds is, thus, a fundamental prerequisite for a correct interpretation of the possible signals of new physics that may arise in these channels. Since the top quark and QCD jets play an important role in virtually every LHC analysis, proper modeling of their production is essential both for SM measurements and for beyond the Standard Model searches. Such modelling will become even more important for high luminosity measurements and at future colliders.

### T 2: Flavor I

**Time:** Monday 16:30–18:00

**Search for $\bar{\Lambda}$ He and $\Lambda$ H at LHCb** — Hendrik Jager, Razvan-Daniel Mosse, Giedeminas Sarpis, Valery Zhukov, and Stefan Schael — University of Manchester, Manchester, UK

In recent presentations, AMS-02 has reported the observation of several antihelium candidates in cosmic rays. In 2020, it has been suggested by M. Winkler and T. Linden that dark matter annihilation into $b$-quarks could produce a detectable $^{1}\text{He}$ flux in cosmic rays via $\Lambda_b$ decays. The LHCb detector at CERN is an experiment dedicated to the study of $b$-hadrons, which are abundantly produced in the proton-proton collisions at the Large Hadron Collider (LHC). Therefore, the large sample of $\Lambda_b$ decays, collected by LHCb until 2018, provides a unique opportunity to study the potential displaced production of $\Lambda_b$ He via $\Lambda_b^0$ decays. While prompt $\Lambda_b$ He from proton-proton collisions as well as from $\Lambda_b$ H decays has already been observed at the LHC by the ALICE Collaboration in the central region $|y| < 0.5$, prompt and displaced $\Lambda_b$ He has not yet been searched for at LHCb ($2 < \eta < 5$). In this talk, the possibility of identifying $\Lambda_b$ He with the LHCb tracking system is discussed and the status of the on-going analysis is presented.

**Flavour tagging, $B \rightarrow D_sK$ and $B \rightarrow J/\psi K_S$** — Quentin Fohring, Vukan Jevtic, Gerwin Meier, Sophie Hollity, and Johannes Albrecht — TU Dortmund University, Dortmund, Germany

The amount of CP violation in the Standard Model is insufficient to explain the universe’s matter-antimatter asymmetry. Precision measurements of CP violation in decays—including measurements of the angles of the ‘CKM triangle’—will test for unitarity—crucial to further understand CP violation in the Standard Model and reveal any possible hints of new physics. Determining the flavour of the $B$ meson at the time of production with flavour tagging is a key part of this process. In this talk we consider analyses for two of the three CKM angles: the angle $\gamma$ using the decay $B_s^0 \rightarrow J/\psi K_S$ and the angle $\beta$ using the channel $B^0 \rightarrow J/\psi K_S$. The LHCb experiment provides a large number of $B_s$ meson decays with an excellent decay time resolution, that can be used to measure $\gamma$ and provide an additional constraint on $\beta$. For the $\gamma$ measurement, the statistical significance of previous measurements of $B_s^0 \rightarrow J/\psi K_S$ can be improved by including additional tracking reconstruction types and more decay channels in this updated analysis.

**T 2.2**

**Taming New Physics in $b \rightarrow c\bar{u}d(s)$** — Ales Lenz, Jakob Müller, Maria Laura Piccione, and Aleksey V. Rusanov — Center for Particle Physics Siegen, Theoretische Teilchenphysik, Universität Siegen

Inspired by the recently observed tensions between the experimental data and the theoretical predictions, based on QCD factorisation, for several colour-allowed non-leptonic $B$-meson decays, we study the potential size of new physics (NP) effects in the decay channels $b \rightarrow c\bar{u}d(s)$. Starting from the most general effective Hamiltonian describing the $b \rightarrow c\bar{u}d(s)$ transitions, we compute NP contributions to the theoretical predictions of $B$-meson lifetime and of $B$-mixing observables. The well-known lifetime ratio $\tau(B^0)/\tau(B_d)$ and the experimental bound on the semi-leptonic CP asymmetry $a_{CP}$ provide strong, complementary constraints on some of the NP Wilson coefficients.

**CP violation measurement in $B^0 \rightarrow D^+D^-$ and $B^0 \rightarrow D^+_sD^0$ decays at the LHCb experiment** — Louis Gerken, Philipp Ibis, and Antje Mödden — TU Dortmund University, Dortmund, Germany

Time dependent measurements of CP violation are a major part of the research at the LHCb experiment. They provide access to important Standard Model parameters such as the CP-violating mixing phases $\sin 2\beta$ and $\phi$. These can be measured in $B^0 \rightarrow D^+D^-$ and $B^0 \rightarrow D^+_sD^0$, respectively. The CP violation in these decays arises in the interference between the direct decay and the decay after mixing. Due to the similarities of these decays, the two measurements are performed in parallel.

In this talk, the current status of the analysis is presented. The analysis uses data collected by the LHCb detector during 2015 to 2018 at a centre-of-mass energy of 13 TeV corresponding to an integrated luminosity of 6 fb$^{-1}$.

**CP violation in $r \rightarrow K^0\pi\nu\bar{\nu}$ decays at Belle** — Katariina Dugic, Daniel Greenwald, and Stephan Pacl — The Belle-II Collaboration — Technical University Munich
Minimal Models for Radiative Fermion Masses — ZACHARY WÜTHRICH1,2 and ANDREAS CRIVELLIN3,4 — Universität Siegen — ETH, Zürich — PSI — UZH

In 2012, BaBar measured a CP-violating decay-rate asymmetry in $t \rightarrow \pi K_S(\ell 0)\nu$, that deviates from the standard-model prediction by 2.8σ. We present initial studies for measuring the same asymmetry using data from the Belle experiment, which is two orders of magnitude larger.

*Supported by the DFG under Germany's Excellence Strategy - EXC2094 390783311 and BMBF Verbundforschung (05H120WKB3 BELLE2).

T 2.6 Mon 17:45 HSZ/0004

T 3: Top I

Location: HSZ/0401

Time: Monday 16:30–18:00

T 3.1 Mon 16:30 HSZ/0401

Top-beauty couplings at FCC-ee and synergies in global SMEFT interpretations — KEVIN KRONINGER1, Romain MADAR1, Stéphane MONTIEL1, and Lars RÖHRIG2,3 — TU Dortmund University, Department of Physics — 2Université Clermont-Auvergne, Laboratoire de Physique de Clermont

Experiments for the post-LHC era as proposed nowadays are aimed at precision measurements in the electroweak, flavor, Higgs and top-quark sector. The FCC-ee among other proposals offers unrivaled precision in these fields and allows to combine measurements within the Standard Model Effective Field Theory at energy scales ranging from 91 GeV up to 365 GeV.

This talk motivates the combination of the top and the $Z \rightarrow b\bar{b}$ energy scale and possible synergies through a common set of dimension-six operators. The estimation of several top-quark observable sensitivities is highlighted, as well as challenges and prospects of a full reconstruction in an FCC-ee environment. Systematically limited measurements of EWPO at the Z-pole at FCC-ee are discussed and novel hemisphere tagging techniques are presented to reduce these uncertainties.

T 3.2 Mon 16:45 HSZ/0401

Search for same-sign top pair production with the Standard Model Effective Field Theory at the ATLAS experiment — NOIEM CAVALLI1,2, Merve NAZLIM AGAR1,2, Maximiliano SOLI1,2, Matteo NERGENT1,2, Kevin ALEXANDER KROENINGER1,2, Shalini EMPER1,2, Aurelio JUSTRIO ROZAS ROZAS1,2, Stergios KAZAKOS1, Javier MONTEJO BERLINGEN1,2, Nicolò ORLANDO1,2, Tamará VAZQUEZ SCHROEDER1,2, and Aaron Van der Graaf1,2 — TU Dortmund — Bologna — CERN — IFAE

Model-independent searches for new physics at high energies by using the Standard Model (SM) Effective Field Theory (SMEFT) are an important part of today's phenomenological programme. Same-sign top-quark pair production is highly suppressed in the SM while several models beyond the SM enhance the production. SMEFT is used obtain model-independent predictions for the production of the same-sign top pairs beyond the SM. Three EFT operators are considered to simulate the searched signal. The full Run 2 dataset collected by the ATLAS detector from proton-proton collisions is used for this search for same-sign top-quark pairs, in the dilepton channel. A Neural Network (NN) is employed to build separate signal regions (SR) enriched in same-sign top events resulting from different EFT operators. Within the defined SRs, a second NN is applied to perform a signal-background discrimination. In order to attain an accurate estimation of background contributions in the SRs, several Control Regions (CRs) are defined. The background estimation and the signal search are performed by using a maximum likelihood fit over all analysis regions.

T 3.3 Mon 17:00 HSZ/0401

Measurement of SMEFT parameters in $t\bar{t}+\gamma$ using Run 2 data with the ATLAS experiment — Jan JOACHIM HAHN1, Binshu BATOOL2, Beatrice CERVATO1, Markus CHERITZ1, Carmen DICE DARDOS1,4, Ivan FLECK1,4, ARPAS GHOSAL1,4, Gabriel GOMES1,4, Vadim KOSTYUKHIN1,4, Buddahader MONDAL1,4, Amartya ROY1,4, Katharina VOSS1,4, Wolfgang WALKOWIAK1, and TONGBIN ZHAO1,4 — Center for Particle Physics Siegen, Experimentelle Teilchenphysik, Universität Siegen — Shandong University, China

In the Standard Model Effective Field Theory (SMEFT), the effects of physics phenomena beyond the Standard Model (SM) are modelled via higher dimension-six operators. Measurements of sensitive processes can be used to constrain the coefficients of operators that contribute to a process. The top quark is the heaviest known particle and the only quark that decays before hadronisation. It is expected to play a relevant role in many models of physics beyond the SM given its large mass. Final states including photons are sensitive to modifications in the electroweak sector, changing the photon energy spectrum. This talk will focus on a interpretation of the ongoing $t\bar{t}$ cross section measurement in terms of SMEFT. To constrain several EFT operators, $t\bar{t}$ events decaying semileptonically are studied. The study is performed using the full Run 2 data set collected by the ATLAS experiment corresponding to $137 fb^{-1}$ at $\sqrt{s} = 13$ TeV.

There has been a long history of attempts to generate fermion masses from loops of heavier particles. This would be an elegant theory, as it provides a simple and natural explanation of the observed fermion mass hierarchy through the loop hierarchy.

This work investigates a class of minimal renormalizable models using scalar leptoquarks and other new scalar particles to generate the fermion masses at the loop level. We provide for the first time a classification of the different representations of a scalar field that allows for a chirally enhanced radiative generation of fermion masses. Constraints from observables give bounds on the scalar particle masses and their couplings, with special emphasis given to the effect of the new models on the anomalous magnetic moment of the muon.

T 3.4 Mon 17:15 HSZ/0401

Kinematic Fit for Top-Antitop Production at LHC — Constant Peeters, Patrick Connor, Johannes Lang, Hartmut Stadie, and Peter Schleper — Institut für Experimentalphysik, Universität Hamburg

The decay products of top quark pairs in proton-proton collisions at the LHC can be reconstructed independently of one another using the particle flow algorithm. A fit utilising physical properties of the event topology may be used in addition to further constrain their kinematics. This may be beneficial to measure fundamental quantities of the top quark, such as its mass. In this work, we present the general technique and investigate the impact of the jet energy resolution on the fit results. The kinematic fitting package kinFitter, commonly used within the CMS software framework, is utilized with the aim of ensuring usability independent of the CMS software framework.

T 3.5 Mon 17:30 HSZ/0401


T 3.6 Mon 17:45 HSZ/0401

Machine learning approaches for parameter reweighting in MC samples of top quark production — Valentina GUGLIELMI, Katerina Lifia, and Simona AMOROSO — Deutsches Elektronen-Synchrotron DESY, Notkestrasse 85, D-22607 Hamburg, Germany

In particle physics, complex Monte Carlo (MC) simulations are needed to compare theoretical predictions to observables. Further MC samples have to be generated to account for all the systematic uncertainties. Therefore, the MC statistic becomes a limiting factor for most measurements. Moreover, the significant computational cost of these programs is a bottleneck in most physics analyses. Therefore, finding a way to reduce the number of MC samples is important to decrease the MC statistical uncertainties and to suppress the computational cost. In this contribution, an approach called Deep neural network using Classification for Tuning and Reweighting (DCCTR) is evaluated. DCCTR is a method, based on a Deep Neural Network (DNN) technique, to reweight simulations to different models by using the full kinematic information in the event. This methodology avoids the need for simulating the detector response multiple times by incorporating the relevant variations in a single sample. This way, the MC statistical uncertainties and the computational cost are reduced. Unlike the standard reweighting, in which the ratio in bins of two histograms at truth level is performed, multidimensional and unbounded information can be used as inputs to the DNN. This method is tested on MC simulations of top quark pair production within the CMS experiment.
Search for long-lived particles decaying into displaced jets using a trackless and delayed jet tagger — •Lisa Benato and Grzegorz Kasieczka — Institute of Experimental Physics, Hamburg University

A search for long-lived particles decaying in the outer regions of the CMS silicon tracker or in the calorimeters is presented. A novel technique, using trackless and delayed jet information combined in a deep neural network discriminator, is employed to identify decays of long-lived particles. The results are interpreted in a simplified model of chargino-neutralino production, where the neutralino is the next-to-lightest supersymmetric particle, is long-lived, and decays to a gravitino and either a Higgs or Z boson. This search is most sensitive to neutralino proper decay lengths of ~1 m, for which neutralino masses from up to ~1180 GeV are excluded at 95% confidence level.

Search for resonant lepton-jet production with the ATLAS experiment — • Jiyong Kim, Adrian Fernandez, and Stefan Tapprogge — Institute for Physics, Johannes Gutenberg University, Mainz

The leptopark (LQ) is a hypothetical particle, which carries both lepton and quark quantum numbers. Its existence could point to extended theories beyond the Standard Model. If such particles were to exist, their decays might be observable in high-energy pp collisions using the ATLAS detector at the LHC. In this contribution, the specific interest is single LQ production leading to a resonant structure in the lepton-jet invariant mass. The search strategy about the existence of the LQs will be presented, including optimization of the selection cuts and comparison with the run 2 data set from ATLAS (with an integrated luminosity of 193 fb⁻¹ at 13 TeV).

Search for Dark Matter in association with a single top quark at the CMS experiment - lepton analysis and combination — •Sebastian Wierland, Ulrich Husemann, and Michael Wassemer — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

A promising production mechanism of Dark Matter at the Large Hadron Collider (LHC) is the associated production with a single top quark. Since the Dark Matter particles are not directly detected by the CMS detector the final state consists of a single top quark and missing transverse momentum, referred to as mono-top signature. The focus of this talk is the leptonic decay channel of the top quark, where the transverse W boson mass is utilized to discriminate between the mono-top signal and the standard-model backgrounds. In addition, the combination with the analysis targeting the hadronic decay of the top quark is presented. The analysis utilizes the full Run-2 dataset collected by the CMS experiment at the LHC. All results of this search are interpreted in the context of a simplified model introducing a flavor-changing neutral current at tree level by a spin-1 mediator and a Dirac Dark Matter particle.

Search for long-lived particles in the CMS muon system — • Joerg Schindler, Lisa Benato, Karim El Morabit, and Grzegorz Kasieczka — Universität Hamburg

Traditionally, searches for new physics at the LHC focused on already established objects, like photons, leptons, jets or missing energy. A different approach is to look for signatures in the detector which up until now were not considered. One example are long-lived particles, which can have a long lifetime leading to macroscopic flight distances ranging from a few micrometers up to several kilometers. In this talk, a search for long lived particles decaying in the CMS muon system is presented. The resulting signature is a large hadronic shower in the muon system with no inner detector activity, which can be observed with close to no background, but requires the development of new reconstruction and analysis tools. The status of the current searches for LLPs with decays in the muon system is shown, using data collected by the CMS detector in Run 2.

Search for Heavy Majorana Neutrinos in same-sign W Boson Scattering with the ATLAS experiment — • Jonas Neuendorf for the ATLAS-Collaboration — Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg

Among the open question of particle physics is the origin of neutrino masses. While they are predicted to be zero by the Standard Model, oscillation measurements have shown that at least two of the three neutrino flavours observed in nature are massive. These masses can be explained by the “Seesaw Mechanism”, which introduces Majorana neutrinos with a mass on the TeV scale. This talk will discuss the design and statistical evaluation of an ATLAS search for Heavy Majorana Neutrinos produced via same-sign W boson scattering.

Search for Heavy Majorana Neutrinos in same-sign W Boson Scattering with the ATLAS experiment — • Jonas Neuendorf for the ATLAS-Collaboration — Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg

Many theories beyond the Standard Model predict the existence of charged Higgs bosons. The main production mode of these new particles depends on their mass. For large masses (m(H⁺) > m(t) + m(b)), the dominant mode of production is in association with a top quark and a bottom quark (tH⁺b). In the alignment limit of the Two-Higgs-Doublet Model (2HDM), heavy charged Higgs bosons with (m(H⁺) > m(t) + m(b)) decay almost exclusively via H⁺ → tb. In other models such as the Georgi-Machacek model, however, significant branching ratios for H⁺ → W⁺h are possible. This decay has so far not been studied by ATLAS or CMS.

A search for H⁺ → W⁺h decays with the ATLAS detector — • Dominik Duda, Simon Grewe, Sandra Kortner, and Hubert Kroha — Max Planck Institut für Physik

An interference search for heavy Higgs bosons decaying to a top-antitop quark pair with the ATLAS detector — • Nicola de Bias, Katharina Behr, and Eleonor Jones — Deutsches Elektronen-Synchrotron DESY

New pseudoscalar (A) and scalar (H) states coupling strongly with t̅t states are predicted by many models with an extended Higgs sector, such as two-Higgs Doublet Models (2HDMs), which add a second Higgs doublet to the SM. In 2HDMs with fermion coupling structure of type II, these states decay predominantly to t̅t̅, provided that they are massive enough (m > 500 GeV) and that the ratio between the vacuum expectation-values of the two Higgs doublets (tan β) is small (tan β ≤ 3). At this, the parameter region is only little constrained by direct searches, as any search in the tt̅ final state is complicated by the interference between the signal process (gluon-gluon initiated A/H production) and the dominant and irreducible background, which is the Standard Model production of t̅t̅ pairs. This interference produces a characteristic peak-dip structure in the tt̅ mass spectrum. In this talk, a search for pseudoscalar and scalar states decaying to a pair of top-quarks will be presented, using the full Run-2 ATLAS dataset. Special attention will be given to the conceptual and technical challenges regarding the treatment of interference effects in the statistical analysis of the data.

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T 5.3 Mon 17:00 HSZ/0101
Search for inelastic Dark Matter with a Dark Higgs at Belle II — **Patrick Ecker, Giacomo De Pietro, Jonas Effelt, Torben Ferber, and Pablo Goldenzwieg** — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

Belle II has a unique reach for a broad class of models that postulate the existence of Dark Matter particles in the MeV-GeV mass range. One highly-motivated scenario is a model which involves inelastic Dark Matter, consisting of two Dark Matter states with a mass splitting between them and the presence of a Dark Higgs boson. This model has a signature of up to two displaced vertices, one from the resonant decay of the Dark Higgs and another non-resonant one emerging from the decay of the involved Dark Matter particles. This talk will present a way to search for such signatures, which is not only challenging due to the presence of displaced vertices but also because of the seven-dimensional parameter space of the model.

T 5.4 Mon 17:15 HSZ/0101
Search for non-resonant light axion-like particles with heavy vector bosons in the final state. — **Anna Albrecht, Steffen Albrecht, Andreas Hinzmann**, and Ankit Mehta** — 1 Institute for Experimentalphysik, Universität Hamburg, 2 DESY, Hamburg, previously Universität Hamburg

Many extensions of the Standard Model (SM) propose axion-like particles (ALPs) that could solve the strong CP problem and are proposed as dark matter candidates. A non-resonant search for light off-shell ALPs as mediators between gluons and heavy bosons (ZZ, ZH) is presented. Only the hadronic decays of two vector bosons are considered. For the high invariant mass of the diboson system, the differential cross section via ALPs as mediator decreases slower than the SM prediction. To extract the signal a three-dimensional maximum likelihood fit of the jet masses and the invariant mass of the diboson system is performed. The analysis is performed using pp collision data collected by the CMS experiment at $\sqrt{s} = 13$ TeV in the years 2016 - 2018.

T 5.5 Mon 17:30 HSZ/0101
Low Temperature MMC-based Muon Veto for IAXO — **Daniel Unger, Christian Enss, Andreas Fleischmann, Danil Hengsteler, Ashish JadHAV, and Loredana Gastaldo** — Kirchhoff Institute for Physics, Heidelberg University, Im Neuenheimer Feld 227, 69120 Heidelberg, Germany.

An array of Metallic Magnetic Calorimeter (MMC) operated at a few mK in a dilution refrigerator is considered as a possible focal plane detector for the IAXO helicoscope. For such an experiment, the background rate must be smaller than $10^{9}$ keV cm$^{-2}$ s$^{-1}$. However, we expect the rate of events related to cosmic muons to be two orders of magnitude larger. A traditional muon veto composed by scintillating panels would have to cover the full cryostat, a volume of about 3 m$^3$. A cryogenic muon veto surrounding the 150 cm$^3$ volume of the detector module could veto muon related events more efficiently. We present the development of a large-area MMC-based muon veto. Muons will be detected through their energy deposition while traversing a silicon wafer with thickness of 0.4 mm and an area of 30 cm$^2$. We discuss the design and the fabrication challenges of the muon veto in addition to the prototype setup for testing purposes. We aim to characterize the performance of the large silicon detector and at the same time study the spectrum of muon related events detected by the MMC array as well as of the residual background due to natural radioactivity. Finally, we evaluate the suitability of MMC arrays for low background measurements.

T 6: Other Exp., EW

Time: Monday 16:30–18:00

T 6.1 Mon 16:30 HSZ/0103
High-pT electron performance in proton-lead collisions in the ATLAS experiment at the LHC — **Patricia Potepa** for the ATLAS-Collaboration — Johannes Gutenberg-Universität Mainz, Germany

Electrons are an essential ingredient of final states from the leptonic decay channels of W and Z bosons. Their reconstruction and identification are experimentally challenging in heavy-ion collisions due to high detector occupancy. Therefore, the detection of electron performance is crucial for precision measurements of properties of quark-gluon plasma produced in heavy-ion collisions at the LHC energies. The presented measurement focuses on electron reconstruction, identification, isolation, and trigger efficiencies in proton-lead collisions collected at $\sqrt{s_{NN}} = 5.02$ TeV in 2016. The tag-and-probe method allows to derive electron efficiencies in data and MC simulation independently, and compare the results.

T 6.2 Mon 16:45 HSZ/0103
Towards a new test of lepton flavor universality using $B^0 \to K^{*0} e^+ e^-$ decays in the high di-lepton invariant mass region — **Martino Borsato and Miguel Ruiz Diaz** — Physikalisches Institut, Universität Heidelberg

Lepton Flavor Universality (LFU) tests using rare B-meson decays are amongst the most sensitive probes of the Standard Model (SM) flavor structure. They are mediated by a $b \to s l^+ l^-$ transition which is loop suppressed in the SM. However, new physics (NP) processes involving new particles and interactions could lead to a measurable contribution. Many NP models predict a sizable violation of LFU in $b \to s l^+ l^-$ decays. A commonly used observable is the ratio $R_{K^{\ast 0}} = \mathcal{B}(B^0 \to K^{*0} \mu^+ \mu^-)/\mathcal{B}(B^0 \to K^{+} e^+ e^-)$, defined within a given interval of the di-lepton invariant mass, $q^2$. This observable benefits from a clean theoretical prediction since most theoretical uncertainties cancel in the ratio of the SM. This talk presents the current state of the analysis towards a new measurement of $R_{K^{\ast 0}}$ in the experimentally more challenging $q^2$ region, using data from LHCb recorded between 2011 and 2018. It is the first measurement performed by the LHCb collaboration in this kinematic region. Being a relatively independent measurement it will serve to validate and cross-check the results obtained in lower-$q^2$ regions as NP effects are expected to be roughly $q^2$ independent.

T 6.3 Mon 17:00 HSZ/0103
Muon Momentum Calibration in ATLAS experiment — **Dionysis Faroudis** and Stefan Tapprogge** — ATLAS-Collaboration — Johannes Gutenberg University, Mainz, Germany

In this contribution the momentum calibration of anti-J/Ψ mesons for the ATLAS detector will be discussed. Precise measurements of the W and Z boson mass using the data from the full Run2 of LHC provide new challenges for an even more accurate muon calibration. Firstly the overall method with the constraints, the systematic and the limits of the current calibration will be presented. The muon calibration scheme provides tools for reconstructed muons using information from the Inner Detector or the Muon Spectrometer and also using the so called combined muons, by comparing Monte Carlo generated events with ATLAS data using the well known ‘standard candles’ J/Ψ and Z. Some of the major issues are going to be discussed (for example the extrapolation from the kinematic region of the J/Ψ to the Z region) as well as their possible impact on precision measurements. Current solutions and further challenges will be presented.

T 6.4 Mon 17:15 HSZ/0103
Study of polarization fractions in same-sign W boson scattering — **Prasham Jain, Beate Heinemann, and Oleg Kuprash** — Albert-Ludwigs-Universität Freiburg, Freiburg, Germany

Polarized same-sign W boson pair production is a crucial process to examine the electroweak symmetry breaking mechanism. A measurement of the fraction of longitudinally polarized W bosons, $W_L^2/W_T^2$, directly probes the unitarity mechanism of the vector boson scattering amplitude through Higgs boson contributions, and is sensitive to potential new physics effects. This talk presents machine learning (ML) methods for classification of $W_L^2/W_T^2$ polarization modes. Results are shown of applying the ML for the extraction of longitudinal polarization fraction.
Time: Monday 16:30–18:00

T 7.1 Mon 16:30 HSZ/0105

Strong first-order EWPTs in a Type-II 2HDM-EFT and their implications on Higgs pair production — 
Anisha1,2,*, Lisa Biermann2, Milada Margaretre Mühlleitner2, and Christoph Englert3
—
1Indian Inst. Tech., Kanpur, India — 2ITP, KIT, Karlsruhe, Germany — 3Glasgow U., Glasgow, United Kingdom

We study the scalar dimension six effective field theory (EFT) extended 2HDM-Type-II in its possibility to promote the strength of the electroweak phase transition to a strong first-order electroweak phase transition (SFOEWPT). Therefore, a global minimization of the one-loop daisy-resummed effective potential at finite temperature is performed with the C++ code BSMPT. Our special focus lies on investigating the connection between Wilson coefficient constituents that enable an SFOEWPT and their phenomenological implications on Higgs pair production (resonant and non-resonant) in top final states.

T 7.2 Mon 16:45 HSZ/0105

Higgs Pair Production in a Composite 2HDM — Stefania De Curtis4, Luigi Delle Rose4, Felix Egle5, Stefano Moretti5, Margaretre Mühlleitner2, and Kodai Sakurai6
—
4INFN sezione di Firenze and Dipartimento di Fisica e Astronomia, Università di Firenze, Via G. Sansoni 1, I-50136, Sesto Fiorentino, Italy — 5Dipartimento di Fisica, Università della Calabria, I-8703 Arcavacata di Rende, Cosenza, Italy — 6Institute for Theoretical Physics, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — 7School of Physics and Astronomy, University of Southampton, Southampton, SO17 1BJ, United Kingdom — 8Department of Physics, Tohoku University, Sendai, Miyagi 980-8578, Japan

In composite Higgs models the scalar particles in the Higgs sector are not elementary particles, but of composite nature, arising as pseudo Nambu-Goldstone bosons from higher broken symmetries. In a composite 2-Higgs-Doublet Model thus a 2HDM-like structure is generated but with couplings already predetermined by the composite nature of the model. In this talk we present Higgs Pair production in this model via gluon fusion. We give a brief introduction into the model and an overview over the calculation, highlighting the contributing couplings and diagrams. We apply current experimental limits for Di-Higgs production in our results and study differential distributions for specific benchmark scenarios.

T 7.3 Mon 17:00 HSZ/0105

The reconstruction of the $t\bar{t}$ invariant mass in $H \rightarrow t\bar{t}$ decays as a machine learning task — 
Moritz Molch, Ulrich Husemann, Nikita Shadkhat, Lars Sowa, Michael Waßer, and Roger Wolf — Institut für Experimentelle Teilchenphysik (ETP), Karlsruhe Institute of Technology

Analyses that deal with Higgs boson decays into a pair of $t\bar{t}$ leptons often rely on a good reconstruction of the $t\bar{t}$ invariant mass. As the decay of two $t\bar{t}$ leptons involves at least two neutrinos, the reconstruction of $m_{t\bar{t}}$ is a challenging part of such analyses.

In many analyses at the CMS experiment the SVfit algorithm, which is a likelihood method on an event-by-event basis, is utilized for that task. First studies have shown that $m_{t\bar{t}}$ can also be reconstructed using a deep neural network. In this talk the applicability of deep neural networks to reconstruct $m_{t\bar{t}}$ is further investigated and a comparison to current methods is made.

T 7.4 Mon 17:15 HSZ/0105

Probing high $p_T$ Higgs boson production in the $d$-decay channel — 
Steffen Ludwig, Christoph Young, Karsten Kôncke, and Karl Jakobs — ATLAS-Collaboration — University of Freiburg, Institute of Physics, Freiburg im Breisgau, Germany

The Higgs boson was observed first in 2012 by the ATLAS and CMS experiments at the Large Hadron Collider at CERN. Even more than 10 years after its discovery, more precise measurements of the Higgs boson decay are desired to search for physics beyond the Standard Model.

One particularly interesting measurement is the transverse momentum ($p_T$) spectrum of the Higgs boson where deviations at high values could be a sign of new physics. We will discuss the prospects for selecting such events in the channel where the Higgs boson decays to $r$ leptons. At high $p_T$ the two $r$ leptons are close to each other in $\eta-\phi$ making this a uniquely interesting final state.

T 7.5 Mon 17:30 HSZ/0105

Test of CP invariance in Higgs boson production via vector boson fusion exploiting the $H \rightarrow h_\text{had} \rightarrow hh_\text{had} \rightarrow h_\text{had} \rightarrow t\bar{t}$ decay mode — 
Daniel Bahner, O. Ö. Güleçi, and Markus Schümacher — Albert-Ludwigs-Universität, Freiburg, Deutschland

In the universe, an asymmetry exists between the number of baryons and the anti-baryons. Three Sakharov conditions need to be fulfilled in order to explain this observed baryon asymmetry. One of those is the violation of the CP invariance. Its amount in the Standard Model is not enough to explain the asymmetry. The discovery of the Higgs boson has opened a new window to search for additional sources of CP violation. The vector-boson fusion (VBF) production of the Higgs boson is one of them. In the VBF production topology, it is possible to probe CP-violating contributions to the $HVV$ coupling vertex.

In this talk the fully hadronic decay channel, where VBF-produced Higgs boson decays into two hadronically decaying tau leptons, is presented. The dominant background process in this decay channel is the irreducible $Z \rightarrow t\bar{t}$ process. A data-driven Fake Factor method is used to estimate the sizeable contribution from events in which jets are misidentified as hadronically decaying tau leptons. A neural network is exploited to discriminate signal from background processes.

CP-odd observables are used in a profile-likelihood fit to perform a test of CP invariance and to constrain the strength of new CP-violating interactions. The talk will discuss the analysis strategy, CP-odd observables, and first results based on $\sqrt{s} = 13$ TeV proton-proton collision data collected by the ATLAS detector with $\mathcal{L}_{\text{int}} = 139$ fb$^{-1}$.

T 7.6 Mon 17:45 HSZ/0105

Precision measurements of the $C_{\text{had}}$ identification efficiency of CMS — 
Olha Lavoryk, Sebastian Brommer, Maximilian Burkart, Roger Wolf, Markus Klute, and Günter Quast — Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

$t\bar{t}$-leptons play an important role in Higgs physics because the scalar coupling to fermions is proportional to their mass. Standard model (SM) as well as beyond the SM (BSM) analyses require precise reconstruction of the hadronic $t\bar{t}$-lepton decays. Discriminators based on Deep Neural Networks (DNN) provide a
fast and efficient solution to this task. In this talk, precision measurements of the τ-identification efficiency on the ultra-legacy Run-2 data taken from 2016–2018 are presented, and an appropriate uncertainty model for future Run-2+Run-3 measurements with τ-leptons in the final state is presented.

T 8: Outreach Public/Teilchenwelt (joint session T/HK)

Time: Monday 16:30–18:00

T 8.1 Mon 16:30 HSZ/0204
The german LHC-Office for outreach, transfer and promotion of young talents — •Marius Hoffmann1, Marie-Lena Dickmann2, Harald Appelshäuser3, Johannes Haller4, Stephanie Hansmann-Menzemer5, and Arnulf Quaay6 — 1Georg-August-Universität Göttingen — 2Universität Hamburg — 3Goethe-Universität Frankfurt — 4Universität Heidelberg

Communicating the scientific results to the public, fostering cooperation with partners in industry and the promotion of young talents is an important task of the German LHC research groups. For this reason in 2020, the research focuses ("Forschungsschwerpunkte" short ErUM-FSPs) of the four LHC projects have initiated a joint "LHC-Office" which is funded by the Federal Ministry for Education and Research (BMBF). Since then, the LHC-office has been active in a multitude of areas, including a common brochure, a new joint website, the participation at major industry fairs as well as several workshops and events to promote young researchers. This talk will give an overview of the work of the LHC-office's work over the last two years and present an outlook into future activities.

T 8.2 Mon 16:45 HSZ/0204
KCETA event summer — •Katrin Link — Karlsruhe Institute of Technology, Kit Center Elementary Particle and Astroparticle Physics KCETA, Karlsruhe, Germany

In the summer of 2022, the travelling exhibition "Code of the Universe" (code-offenuniverse.eu) designed by CERN, was displayed for four weeks in the center of Karlsruhe. Accompanying this, the Kit Center for Elementary Particle and Astroparticle Physics (KCETA) organized a colorful program of events for a broad audience. The series of events included a vernissage, a lecture evening as part of the Karlsruhe EFFEKTE series and a panel discussion on the topic "Kommen große Forschungsinfrastrukturen an ihre Grenzen? Neue Energiekonzepte für die Forschung der Zukunft". The main focus was on "Science Afternoons" during which the individual working groups of young talents presented their research with a small exhibition, hands-on experiments and short lectures. Additionally a special program for pupils was offered, including masterclasses and "Physik am Samstag". In this talk we want to present the different formats we used to interact with a broad audience and report from our experiences.

T 8.3 Mon 17:00 HSZ/0204
Belle II - The Beauty goes public — •Johanna Häusler and Thomas Kühn — LMU, München, Deutschland

Public outreach is an element feature of modern science. In particular, the large and internationally organized particle physics experiments have great potential to raise public awareness of physics - both in terms of the physics questions themselves and the technological developments associated with fundamental research. The Belle II experiment is a rather novel experiment based in Japan and involving worldwide collaboration. The German Belle II institutes - in close cooperation with partner organizations and supported by a BMBF "Forschungsschwerpunkt" - are in the process of building a network and developing a strategy to present Belle II particle physics research to the German public. This is particularly interesting in view of the important scientific results that are expected from Belle II in the coming years. The outreach strategy includes a corporate design, a strategy to present the Belle II institutes, scientific results and staff both on Twitter and on the Belle II homepage, basic outreach activities in education (such as Belle II Masterclasses, a Belle II coursework for students and the design of a Belle II model) and industry transfer to promote technological development and human potential in the broad field of industry.

T 8.4 Mon 17:15 HSZ/0204
Urkann unterwegs: eine mobile Ausstellung zur Teilchenphysik — •Uta Bielow, •Sarah Kästner, Michael Kobel and Philipp Lindenau — für die Netzwerk Teilchenwelt-Kollaboration — TU Dresden, Institut für Kern- und Teilchenphysik

Urkann unterwegs is a mobile Ausstellung, which is part of the DESY in Hamburg in Zusammenarbeit with Netzwerk Teilchenwelt and Expert:innen aus der Teilchenphysik and Didaktik of the TU Dresden and the University of Bonn. In the past, the Urkann project has already been presented in various locations in Germany and abroad. The Urkann underwegs is a mobile exhibition, a tour through various towns and cities in Germany and abroad, which is part of the "Urkann-Programm". In this talk, we want to present the Urkann underwegs project and especially the mobile exhibition, which is currently being developed and will be presented at various locations in Germany and abroad. The mobile exhibition will be part of the "Urkann-Programm" and will be presented at various locations in Germany and abroad. The mobile exhibition will be part of the "Urkann-Programm" and will be presented at various locations in Germany and abroad. The mobile exhibition will be part of the "Urkann-Programm" and will be presented at various locations in Germany and abroad. The mobile exhibition will be part of the "Urkann-Programm" and will be presented at various locations in Germany and abroad. The mobile exhibition will be part of the "Urkann-Programm" and will be presented at various locations in Germany and abroad.
T 9.1 Mon 16:30 HSZ/0301

Implementation of an improved Neural Network for identification of hadronically decaying \(\tau\) leptons in the ATLAS trigger system for the LHC Run 3

- NAMAN KUMAR BHALLA, Ö. OĞUL ÖNCEL, and MARKUS SCHUMACHER — Albert-Ludwigs-Universität Freiburg

The ATLAS detector employs a trigger system to reduce the large event rate by saving only interesting events on mass storage for further analyses. This is done via dedicated triggers for each observable physics object. Being the heaviest lepton in the Standard Model of particle physics, the \(\tau\) lepton is highly unstable, allowing only its decay products to be directly observed. While the electron and muon triggers can be used for the leptonic decays of the \(\tau\) lepton, separate triggers are necessary to differentiate between hadronically decaying \(\tau\) leptons (\(\tau_{\text{had}}\)) and jets, which are produced with significantly higher abundance. ATLAS uses a recurrent neural network (RNN) for \(\tau_{\text{had}}\) identification, which exploits various track, cluster and high-level variables as inputs, and returns a single classifier as output. However, it needed to be retuned for operations in the ongoing Run 3 phase of the Large Hadron Collider (LHC) due to upgrades in the detector and the accelerator. Furthermore, new input variables were added to improve the performance of the RNN. An alternative architecture based on Deep Sets was tested in order to have a more efficient usage of computing resources. This talk presents the results of performance studies of the retuned RNN, and a comparison between the two network architectures in terms of efficacy and resource consumption.

T 9.2 Mon 16:45 HSZ/0301

Machine learning based triggers for VBF \(\rightarrow\) inv at the Level-1 trigger system of CMS

- SHAHIN SEPAHLOU, JOHANNES HALLER, GREGOR KASECZKA, FINN LABE, ARTUR LOBANOV, and MATTHIAS SCHRÖDER — Institut für Experimentalphysik, Universität Hamburg

At the CMS experiment, a two-level trigger system is used to decide which collision events to store for later analysis. The Level-1 trigger is subject to strict latency, resource and rate constraints. To handle the even more challenging High Luminosity-LHC environment, novel strategies in the trigger system are necessary. Therefore, in this talk studies towards a topological trigger algorithm using fast machine learning on FPGAs are presented. The vector boson fusion production of a Higgs boson decaying to invisible particles is used as an example process that is difficult to select with classical trigger strategies and would benefit from machine learning based approaches.

T 9.3 Mon 17:00 HSZ/0301

FPGA-based fast Machine Learning Triggers for Neutrino Telescopes

- FRANCESCA CAPEL1,2, CHRISTIAN HAACK1, LUKAS HEINRICH1, and CHRISTIAN SPANNFELDER1,2,3 — Max-Planck-Institut für Physik — 2Technische Universität München — 3ORIGINS Excellence Cluster

Neutrinos provide valuable insights into the origin and acceleration mechanisms of cosmic particles. They are able to traverse vast distances and dense environments on their way to Earth unimpeded, but are also challenging to detect due to their weakly interacting nature. Earth itself is used as detector, where large volumes are equipped with photosensors to detect the Cherenkov light induced by astrophysical neutrino interactions. Neutrino telescopes are located deep under water or in the Antarctic ice to reduce the background rate, inducing often strict limits on power and bandwidth available for the detector. Trigger algorithms are inevitable to reject background signals and reduce the data stream to manageable rates. In this contribution we will present the potential of fast, intelligent machine learning triggered implementations on low power FPGAs for the usage as online trigger in neutrino telescopes. Our main objectives are an improved signal to background discrimination and improved sensitivity for low energy events.

T 10.1 Mon 16:30 HSZ/0405

Fooling IceCube's Deep Neural Networks

- OLIVER JANIK, MARKUS BACHELEHR, THILO BIRKENFELD, PHILIPP SOLDIN, CHRISTOPHER WEBER, and KATHARINA WINKLER for the IceCube-Collaboration — III. Physikalisches Institut B, RWTH Aachen University

Deep neural networks (DNNs) find more and more use in the data analysis of physics experiments. In IceCube, such networks are used as classifiers for particle identification or as regressors to reconstruct the direction and energy of particles. In the context of adversarial attacks, it has been observed that imperceptible changes to the input of DNNs can alter the output drastically. Algorithms like DeepFool can calculate minimal changes in the input in order to obtain a wrong output, thus fooling the network. This talk will focus on testing the robustness of IceCube's DNNs to such minimal changes.

T 10.2 Mon 16:45 HSZ/0405

Generating Calorimeter Showers as Point Clouds

- SIMON SCHNÄKE1,2, KERSTIN BORRAS1,2, and DIRK KRUCKER1 — 1Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — 2RWTH Aachen, Aachen, Germany

In particle physics, precise simulations are necessary to enable scientific progress. However, accurate simulations of the interaction processes in calorimeters are
complex and computationally very expensive, demanding a large fraction of the available computing resources in particle physics at present. Various generative models have been proposed to reduce this computational cost. Usually, these models interpret calorimeter showers as 3D images in which each active cell of the detector is represented as a voxel. This approach becomes difficult for high-granularity calorimeters due to the larger sparsity of the data. In this study, we use this sparseness to our advantage and interpret the calorimeter showers as point clouds. More precisely, we consider each hit as part of a hit distribution depending on a global latent calorimeter shower distribution. A first model to learn calorimeter showers as point clouds is presented. The model is evaluated on a high granular calorimeter dataset.

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**Particle Physics Division (T) Monday**

**T 10.3 Mon 17:00 HSZ/0405**

DeepTreeGAN: Fast Generation of High Dimensional Point Clouds for Calorimeter Simulation — MORITZ SCHAMANN1,2, DIRK KREUCKER1, and KERSTIN BORRAS1,2 — 1Deutsches Elektronen-Synchrotron, Hamburg, Germany — 2RWTH Aachen University — III. Physikalisches Institut A, Aachen, Germany — 3Institute for Advanced Simulation – Jülich Supercomputing Centre, Jülich, Germany

In high energy physics, detailed and time-consuming simulations are used for particle interactions with detectors. To bypass these simulations with a generative model, the generation of large point clouds in a short time is required, while the complex dependencies between the particles must be correctly modeled. Particle showers are inherently tree-based processes, as each particle is produced by decays or detector interaction of a particle of the previous generation.

In this work, we present a novel GNN model that is able to generate such point clouds in a tree-based manner. We show that this model is able to reproduce complex distributions, and we evaluate its performance on the public JetNet Dataset.

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**T 10.4 Mon 17:15 HSZ/0405**

Particle identification at Belle II using Neural Networks — AXEL SIMO1,2, DANIEL GREENWALD3, STEFAN WALLNER3, and STEPHEN PAUL1,2 — 1Technical University Munich (TUM) — 2Max Planck Institute for Physics (MPP)

We will present improvements to the charged-particle identification algorithms used by the Belle II experiment located at KEK, Japan. So far, different approaches have been used to tackle the challenge of combining the information from each subdetector into a single variable for particle identification in an optimal way. We will present optimizations of the performance of a Neural Network-based approach that combines information such as the likelihood values from each subdetector and the measured momentum of the particle track, funded by the DFG under Germany's Excellence Strategy - EXC2094 - 390783311 and BMBF Verbundforschung (05H21WOKBA BELLE2).

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**T 10.5 Mon 17:30 HSZ/0405**

Reconstruction of Full Decays using Transformers and Hyperbolic Embedding at Belle II — BYOTANG TU, HOSEIN HASHMENI, NIKOLAI HARTMANN, and THOMAS KUHR — Ludwig Maximilians-Universität München

In analyses at Belle II, it is often helpful to reconstruct the whole decay process of each electron-positron collision event using the information collected from decoders. The reconstruction is composed of several steps which require manual configurations and suffers from high uncertainty as well as low efficiency.

In this project, we are developing a software with the aim to reconstruct B decays at Belle II automatically with both high efficiency and high accuracy. The well trained models should be tolerant to rare decays that have very small branching ratio or are even unseen during the training.

To ensure high performance, the project is separated into several stages: particle level embedding, event level embedding and decay reconstruction. Inspired by the recent achievements in computer science, transformers and hyperbolic embedding are employed as building blocks with pre-training-fine-tuning framework, contrastive metric learning and knowledge transfer serving as training tools.

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**T 10.6 Mon 17:45 HSZ/0405**

The Federation - A novel machine learning technique applied on data from the Higgs Boson Machine Learning Challenge — MAXIMILLAN MUCHA and ECKHARD VON TÖRNE — Universität Bonn, Physikalisches Institut, Bonn, Germany

The Federation is a new machine learning technique for handling large amounts of data in a typical high-energy physics analysis. It utilizes Uniform Manifold Approximation and Projection (UMAP) to create an initial low-dimensional representation of a given data set, which is clustered by using Hierarchical Density-Based Spatial Clustering of Applications with Noise (HDBSCAN). These clusters can then be used for a federated learning approach, in which we separately train a classifier on the high-dimensional data of each individual cluster. By doing so, the computational resource demands for the learning process is reduced. We additionally apply an imbalanced learning method to the data in the found clusters before the training to handle high class imbalances. By using a Dynamic Classifier Selection method, the Federation can then make predictions for the whole dataset.

As a proof of concept for this novel technique, open data from the Higgs Boson Machine Learning Challenge is used and comparisons to results from established methods will be presented.

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**T 11: Neutrinos, Dark Matter I**

**T 11.1 Mon 16:30 POT/0051**

Status and Prospects of the COBRA experiment — JULIANNE VOLUMEK — Technische Universität Dresden, Deutschland

As many Beyond-Standard-Model theories predict the existence of the neutrinoless double beta decay (0νββ), this lepton-number-violating nuclear reaction is one of today’s most examined processes in fundamental physics. Its observation could help to solve important questions as for the neutrino’s mass or whether it is a Majorana particle, and thus shed light on physics beyond the Standard Model.

In 2011 the COBRA demonstrator was built with the objective of investigating the practicability of using CdZnTe semiconductor crystals for the decay’s investigation. The CdZnTe crystals contain nine isotopes capable of different 0νββ decay modes, can be operated at room temperature and are commercially available. Additionally, the versatile detector material offers the possibility of investigating physics besides the 0νββ decay, like a potential quenching of gλ in nuclear processes – by measuring the spectrum shape of the strongly forbidden 113Cd β decay – and exotic β+ β- decay modes.

Four years ago the demonstrator setup of 4 × 4 × 4 1 cm3 CdZnTe crystals was upgraded based on the knowledge gained from the many years of operation. With nine additional larger detector crystals higher exposure rates as well as strongly reduced background levels can be achieved.

This talk shall give an overview of the status, plans and most recent experimental results of the COBRA collaboration.

**T 11.2 Mon 16:45 POT/0051**

Pulse shape analysis with quad coplanar grid CdZnTe detectors of the COBRA experiment — YINGHE CHU — Institute of Nuclear and Particle Physics, TU Dresden

The COBRA experiment searches for double beta decays using CdZnTe room temperature semiconductor detectors operating at the Gran Sasso underground laboratory. The setup was upgraded in 2018 using nine large CdZnTe detectors with the novel electrode layout, a quad coplanar grid surrounded by a guard ring, which can veto surface contaminations intrinsically. Although the prominent surface α backgrounds identified in the previous setup are reduced with the new CdZnTe detector, nonphysical events and other background events are present in the ββ region of interest. Therefore, pulse shape discrimination is evaluated to identify the noise, distorted pulses, and multi-hit events, which enables further background suppression. After applying those discrimination cuts, significantly reduced background levels are observed. Furthermore, the pulse shape of the detector is simulated and used to investigate the efficiency of the cuts.

**T 11.3 Mon 17:00 POT/0051**

Status of the MONUMENT Experiment; ordinary muon capture as a benchmark for 0νββ decay nuclear structure calculations — ELIZABETH MORDRAGON for the MONUMENT-Collaboration — Technische Universität München, 85748 Garching, Germany

Extracting particle physics properties from neutrinoless double-beta (0νββ) decay requires a detailed understanding of the involved nuclear structures. Still, modern calculations of the corresponding nuclear matrix elements (NMEs) differ by factors 2-3. The high momentum transfer of Ordinary Muon Capture (OMC) provides insight into highly excited states similar to those that contribute virtually to 0νββ transitions. The precise study of the γ-ray following the OMC process makes this a promising tool to validate NME calculations and test the quenching of the axial vector coupling gA. The MONUMENT collaboration is performing a series of explorative OMC measurements involving typical ββ decay daughter isotopes such as 76Se and 136Ba, as well as other benchmark isotopes. The experiment carried out at the Paul Scherrer Institute and the first results from the beam-time in 2021 will be presented.

This research is supported by the DFG Grant: 448829699 and RFBDFG with project number: 21-52-12040.
COSINUS: Cryogenic Search for Dark Matter With Scintillating NaI Calorimeters — Martin Stahlberg for the COSINUS-Collaboration — Max-Planck-Institut für Physik, Föhringer Ring 6, 80805 München

COSINUS (Cryogenic Observatory for Signatures seen in Next-generation Underground Searches) is a cryogenic dark matter direct detection experiment that aims for a model-independent cross-check of the DAMA/LIBRA claim for dark matter. Since 1995, the DAMA/LIBRA experiment is measuring a yearly modulated signal with properties that fit well to a local dark matter halo in the Milky Way. The DAMA/LIBRA target mass consists of 250 kg of sodium iodide, and the experiment reaches a significance of 13.7 sigma for its claim of a modulation. COSINUS detectors will read out both the scintillation light signal and the heat signal caused by particle interactions. Each detector will consist of a NaI absorber crystal equipped with a transition edge sensor using the remoTES design. This contribution will present the status of the COSINUS experiment and its detectors.

Magnetic shielding tests for the COSINUS experiment — Maximilian Hughes for the COSINUS-Collaboration — Max-Planck-Institut für Physik, Föhringer Ring 6, 80805 München

The COSINUS experiment is a dark matter search using cryogenic detectors. The readout of these detectors is sensitive to environmental parameters such as magnetic fields. Active and passive shielding are being investigated to counteract the fluctuations of these fields. Superconducting materials enclosing the detectors and employed inside the dilution refrigerator can be used to keep magnetic field values constant after cooling. The operating conditions of the detectors with an applied magnetic field and a superconducting shield has been investigated. This talk will be a description of the efforts for the optimization of passive and active shielding for cryogenic detectors.

Vibration decoupling in the COSINUS underground facility — Moritz Kellermann for the COSINUS-Collaboration — Max-Planck-Institut für Physik, Föhringer Ring 6, 80805 München

COSINUS is a direct dark matter detection experiment that will utilize cryogenic calorimeters based on sodium iodide (NaI) to resolve the tension between the positive dark matter signal measured by DAMA/LIBRA and the null-result by other experiments. Currently, a modern cryogenic facility is set up at the Laboratori Nazionali del Gran Sasso (LNGS) and is expected to begin operation within 2023. The facility includes a large clean room area on top of a 270 cubic meter water tank equipped with ~30 Photo Multiplier Tubes (PMTs) acting as an active muon veto. Detectors will be mounted in a custom-made dry dilution refrigerator with a base temperature of 9 mK. A lifting system will lower the refrigerator into a passive copper shielding within the water tank. To reach the thermal stability necessary for operating cryogenic calorimeters in a dry dilution refrigerator, a multi-stage passive vibration-decoupling system is currently being tested. This contribution will present the COSINUS facility and the planned vibration decoupling system.

T 12: Gamma Astronomy

Time: Monday 16:30–18:00

Generation of IACT images using generative models — Christian Elfelein, Jonas Glombitza, and Stefan Funk for the H.E.S.S.-Collaboration — Erlangen Centre for Astroparticle Physics, Erlangen, Germany

The development of precise, fast, and computationally efficient simulations is a central challenge of modern physics. With the advent of deep learning, new methods are emerging from the field of generative models. Recent applications to the generation of calorimeter images showed promising results, which motivates the application in astroparticle physics. In this contribution, we introduce a deep-learning-based model for the generation of camera images of Imaging Air Cherenkov Telescopes (IACTs).

In our case study, we use simulations of the High Energy Stereoscopic System (H.E.S.S.) to train a Wasserstein generative adversarial network (WGAN) for the generation of IACT images. We examine basic image properties of the generated samples, discuss their physical properties, and outline possibilities for stereoscopic image generation.

A template-based air shower reconstruction method for SWGO — Franziska Leitl, Vikas Joshi, and Stefan Funk for the SWGO-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen Centre for Astroparticle Physics, Nikolaus-Fiebig-Str. 2, D-91058 Erlangen, Germany

The Southern Wide-field Gamma-ray Observatory (SWGO) is a future ground-based gamma-ray observatory that will be built in South America, extending current generation instruments to the Southern Hemisphere. Primarily, water Cherenkov detectors will be utilized to detect particles in an energy range from 100s of GeV to 100s of TeV. The instrument will possess a close to 100% duty cycle and an order of magnitude higher field-of-view. The detection area will consist mainly of a densely packed inner array of water Cherenkov detectors for detecting low energy events, while a large sparse outer array of PMTs is used mainly for higher energy showers. In this contribution, the current status of air shower reconstruction for SWGO with a template-based reconstruction method will be presented.

Event classification in Compton-Pair telescopes using Convolutional Neural Networks — Jan Lommler and Uwe Oberlack — Institut für Physik und Exzellenzcluster Prisma* Johannes Gutenberg-Universität Mainz

Low to medium energy gamma rays are shielded by the Earth's atmosphere and cannot be measured with on-ground facilities. Satellite-based gamma-ray astronomy relies on photo absorption, Compton scattering and Pair production as measurement channels. Among the biggest challenges are the poor signal to background ratio due to low signal fluxes from cosmic sources and the high background rates even in the comparatively moderate environment of Low Earth Orbits. An efficient event tagging reduces signal losses by preventing type-mismatching applications of reconstruction algorithms (e.g. performing a Compton reconstruction on a pair event) and signal pollution (distinguishing events originating from background sources). We explore the feasibility of Deep Convolutional Neural Networks in the context of event classification for Compton-Pair telescopes on the example of the e-ASTROGAM design proposal and show improvements possible when using publicly available analysis tools.

Deep-learning-based gamma/hadron separation for IACTs — Jonas Glombitza, Vikas Joshi, Benedetta Bruno, and Stefan Funk for the H.E.S.S.-Collaboration — Erlangen Centre for Astroparticle Physics, Erlangen, Germany

Ground-based gamma-ray observatories have opened in the last decades a new window to the non-thermal universe by studying air showers initiated by cosmic particles. Imaging Air Cherenkov Telescopes (IACTs), like the High Energy Stereoscopic System (H.E.S.S.), are utilized to image the distribution of Cherenkov light emitted during the development of air showers. For the rejection of the hadronic background, many algorithms rely on a high-level parameterization of these IACT images and exploit their correlation. Recently, deep-learning-based approaches showed promising results by exploiting the full images, which overcomes the limitation of the elliptical modeling.

In this contribution, we present a new approach to reconstruct IACT images using deep learning. We model the images as a collection of triggered sensors that can be described by a graph and analyzed using graph convolutional neural networks. We describe our new algorithm, trained using H.E.S.S. simulations, examine its performance, and compare it to various classification algorithms.

Characterization of the Response of large-area PMTs for SWGO — Frederic Wohlleben, Fabian Haist, Hazal Goksu, and Felix Werner for the SWGO-Collaboration — Max-Planck-Institut für Kernphysik, P.O. Box 103980, D 69029 Heidelberg, Germany

The SWGO collaboration aims at building a ground-based gamma-ray detector in the southern hemisphere. A promising approach to build a low-cost water Cherenkov detector with muon-tagging abilities is to deploy a two-chamber blander containing two PMTs into an open body of water. This talk will give a short overview over the research done on large-area PMTs operated with a custom electronics chain which will be used in prototype SWGO detectors.

Actuators for the Medium-Sized Telescopes of the Cherenkov Telescope Array — Heiko Salzmann for the CTA MST-Collaboration — Sand 1, 72076 Tübingen, Germany

The Cherenkov Telescope Array (CTA) is a future ground-based observatory for gamma-ray astronomy offering unparalleled sensitivity in the energy range from 20 GeV up to 300 TeV. One array will be located in the northern hemisphere (La Palma, Canary Islands), one in the southern hemisphere (Atacama, Chile).

Characterization of the Response of large-area PMTs for SWGO — Frederic Wohlleben, Fabian Haist, Hazal Goksu, and Felix Werner for the SWGO-Collaboration — Max-Planck-Institut für Kernphysik, P.O. Box 103980, D 69029 Heidelberg, Germany

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Three different telescope types are foreseen. The Medium-Sized Telescope (MST) is covering the core energy range from 100 GeV up to 10 TeV and is currently the only type foreseen for both CTA sites in the Alpha configuration. It has a reflector with a diameter of 12 m and a tessellated mirror design of 86 mirror facets. Each mirror facet is mounted on the mirror support structure with two actuators that are adjustable in length to align the mirrors, and a freely rotating fixpoint. Image resolution and pointing accuracy constraints impose limits on the backlash and deformation of the actuators and the fixpoint under various weight and wind loads. After a short introduction into the MST mirror alignment procedure, this contribution will cover the mechanical design of the actuators, the limits on the positioning accuracy of the actuators and fixpoints as well as the verification thereof.

T 13: Neutrinos I

Time: Monday 16:30–18:00

T 13.1 Mon 16:30 POT/0251
Core-Collapse Supernova detection with JUNO — ALEXEI CORETZEKI, THILO BIRKENFELD, MARKUS BRAUN, and ACHIM STAHL for the JUNO-Collaboration — III. Physikalisches Institut B, RWTH Aachen University
The Jiangmen Underground Neutrino Observatory (JUNO) is a liquid scintillator (LS) detector currently under construction in China. In addition to determining the neutrino mass ordering, JUNO is highly efficient for detecting neutrinos from Core-Collapse Supernovae. In particular, JUNO features the detection of inverse beta decay interactions. Due to its delayed coincidence signature this interaction is unique within the LS. We estimate the maximum distance of detectable supernovae using this interaction. For this we take into account backgrounds, elastic scattering, and other charged current interactions like neutrino-carbon interactions.

T 13.2 Mon 16:45 POT/0251
External Background in JUNO for Solar Neutrinos and DSNB Detection — SIMON CZAHL, LOTTHAR OBERAERER, SIMON APPEL, MATTHIAS MAIER, and SEBASTIAN ZWICKEL — 1Technische Universität München, München, Germany; 2Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany
The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kt liquid scintillator detector. In this work, the impact of external backgrounds is studied with the goal of increasing the fiducial volume available for two specific neutrino measurements with JUNO. First, the periodic modulations in the solar neutrino flux are analysed. For this, the sensitivity for the detection of these modulations is determined for several fiducial volume cuts, taking the background caused by radioactive decays in various materials in and around the detector volume into account. The second part focuses on the diffuse supernova neutrino background (DSNB), the constant flux of neutrinos emitted by past core-collapse supernovae in the entire visible universe. A crucial background for this signal are fast neutrinos induced by spallation processes, which are simulated in this work. The fiducial volume is then determined from the obtained fast neutrton data. This work is supported by the DFG research unit "JUNO", the DFG collaborative research centre 1258 "NDM", and the DFG Cluster of Excellence "Origins".

T 13.3 Mon 17:00 POT/0251
JUNO’s sensitivity to 7Be, pep and CNO solar neutrinos and strategy for directionnal analysis of CNO solar neutrinos in JUNO — APEKSHA SINGHAT, RUXUAN LID, LIVIA LUDOVICA, AMITA MERAVIGLIA, NIKHIL DHARMA, LUCA PELLETTI, MARLAM RIPA, and CORNELIUS VOLLBRECHT — the JUNO Collaboration — Forschungszentrum Jülich GmbH, Institut für Kernphysik I1-2, Jülich, Germany; 2GS Helmholtz Centre for Heavy Ion Research, Darmstadt, Germany; 3III. Physikalisches Institut B, RWTH Aachen University, Aachen, Germany
JUNO Experiment is 20 kt multipurpose LS detector, under construction in China, with planned completion in 2023. Its main goal is Neutrino Mass Ordering determination, exploiting its large mass target and excellent energy resolution (3% at 1 MeV). Due to its unique properties, JUNO will have potential of real-time solar neutrino measurement with unprecedented levels of precision using multivariate (MV) fit. Sensitivity study is performed by considering all possible sources of background, including their various concentration level and full simulation of detector response. Performing directional analysis of CNO solar neutrinos via Correlated and Integrated Directionality method (developed by Borexino collaboration) in JUNO and using its additional constraint in MV fit has potential to further improve precision of CNO solar neutrino measurement. This talk will summarize methods for sensitivity studies using MV fit and the final results. Investigation of Cherenkov and scintillation light properties using JUNO MC software and strategies of preliminary directional analysis will be shown.

T 13.4 Mon 17:15 POT/0251
Combined analysis of the first five KATRIN measurement campaigns with KaFit — STEPHANIE HICKFORD, LEONARD KOLLENBERGER, and WEIRAN XU — for the KATRIN Collaboration — Institute for Astroparticle Physics, Karl- sruhe Institute of Technology — 2Massachusetts Institute of Technology
The KATRIN collaboration aims to determine the neutrino mass with a sensitivity of 0.2 eV/c^2 (90 % CL). This will be achieved by measuring the endpoint region of the tritium β-electron spectrum. Combined analysis of the first two KATRIN measurement campaigns yielded a neutrino mass limit of m_e < 0.8 eV (90 % CL).
Analyzes of data from the first five measurements campaigns are currently underway. One of the combined analyses is performed using the KaFit/SSC model within the KASPER software framework. In this analysis systematic uncertainties are propagated as additional fit parameters with constraints (the "pull term" method). An overview of the collected data and the expected combined sensitivity on the neutrino mass from these five measurement campaigns will be presented in this talk.
This work is supported by the Helmholtz Association, the Ministry for Education and Research BMBF (05A17PMS, 05A17PXX, 05A17VK2, and 05A17W03), the Helmholtz Alliance for Astroparticle Physics (HAP), and the Helmholtz Initiative and Networking Fund (W2/W3-118).

T 13.5 Mon 17:30 POT/0251
A Look at General Neutrino Interactions with KATRIN — CAROLINE FENNER for the KATRIN Collaboration — Institute of Experimental Particle Physics, Karlsruhe Institute of Technology
The KATRIN experiment aims to measure the neutrino mass by precision spectroscopy of tritium β-decay with a target sensitivity of 0.2 eV. Recently, KATRIN has improved the direct upper bound on the effective electron-neutrino mass to 0.8 eV at 90 % CL [1]. However, the scientific potential of KATRIN extends well beyond the neutrino mass analysis. In particular, General Neutrino Interactions (GNI) [2] can be investigated through a search for potential shape variations of the β-spectrum. For this purpose, all theoretically allowed interaction terms for neutrinos are combined in one Effective Field Theory. This enables a model-independent description of novel interactions. Such potential modifications can then be identified in the β-spectrum measured with KATRIN by means of energy-dependent contributions to the rate. The talk will introduce the theory of GNI and present recent sensitivity studies on first year KATRIN data.
This work is supported by the Helmholtz Association, the Ministry for Education and Research BMBF (05A17PMS, 05A17PXX, 05A17VK2, and 05A17W03), the Helmholtz Alliance for Astroparticle Physics (HAP), and the Helmholtz Initiative and Networking Fund (W2/W3-118).

T 13.6 Mon 17:45 POT/0251
Sensitivity of eV-scale sterile neutrino search with KATRIN using KaFit — SHAILEJA MOHANTY for the KATRIN Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology
KATRIN has recently reported a direct sub-eV upper bound on the neutrino mass from tritium beta-decay spectrum measurements. Along with the neutrino mass search, KATRIN has published recent results on searching for a fourth neutrino with a mass in the eV-range using the precision beta-decay spectra. The fourth neutrino mass-eigenstate introduces an additional branch into the tritium β-spectrum which manifests as a kink in the differential spectrum. The position and amplitude of this kink correspond to the sterile neutrino mass m_4 and effective mixing angle sin^2(θ) = U_{e4}^2, respectively. In this work sensitivity studies to light sterile neutrinos based on new science runs and the effect of systematic uncertainties are presented. A grid scan is performed in the [m_4, sin^2(θ)] 2-D plane using the fitting tool "KaFit" and sensitivity contours are calculated within this parameter space. Approach for a combined analysis of successive measurement campaigns are discussed.
This work is supported by the Ministry for Education and Research BMBF (05A17PMS, 05A17PXX, 05A17VK2, and 05A17W03) and the Doctoral School "Karlsruhe School of Elementary and Astroparticle Physics: Science and Technology (KSETA)" through the GSSP program of the German Academic Exchange Service (DAAD).
Nuclear Recoil modelling in XENON1T — •LUISA HOTZACH for the XENON-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg

The XENON1T detector is among the most sensitive dark matter experiments, aiming for the direct detection of WIMP dark matter with a multi-tonne xenon target in a dual-phase time projection chamber (TPC). WIMPs are expected to scatter elastically off the xenon nuclei in the target, resulting in a physical recoil of the nucleus. The energy that the recoiling nucleus imparts on neighboring xenon atoms leads to the creation of scintillation light and ionisation electrons, which are the two observables in the detector. A detailed understanding of the processes that govern the translation from deposited nuclear recoil (NR) energy into these two signal channels is therefore of utmost importance for the prediction of the signal shape of a potential WIMP interaction, as well as for NR background sources such as radiogenic neutrons.

In order to calibrate the detector response to NRs for the WIMP search, XENON1T uses neutrons from an external Americium-Bequerel source. In this talk, I will present the modelling and fitting of the liquid xenon response to the NR calibration data for the first WIMP search of the XENON1T detector.

Radon removal in the XENON1T experiment via cryogenic distillation — •HENNING SCHULZE EISSING, LUTZ ALTHÜSER, CHRISTIAN HUHMANN, DAVID KORE, ANDREI MICHAEL, MICHAEL MURRA, PHILIPP SCHULTE, and CHRISTIAN WEINHEIMER for the XENON-Collaboration — Institut für Kernphysik, Universität Münster — 3Columbia University, New York, USA.

In order to reduce the dominant component of the electronic recoil background, Rn-222 and its progeny, in the XENON1T experiment a high flux radon removal system has been built by our group (Eur. Phys. J. C 82 (2022) 1104). Rn-222 continuously emanates from detector components and distributes homogeneously within the liquid xenon target due to the half-life of 3.8 days.

Our active radon removal system utilizes the vapor pressure difference between radon and xenon in the form of a cryogenic distillation column. With a xenon flow of 200 slpm the full 8.6 t of xenon are passed through the column within one mean lifetime of Rn-222 resulting in a radon concentration reduction by a factor two. An additional extraction flow of 25 slpm from the xenon gas phase provides a further reduction factor of about two. Combining both methods we achieved a radon activity concentration as low as 1 µBq/kg, the lowest value to date with a xenon-based Dark Matter experiment.

This talk will outline the working principle of the radon removal system and the performance within the XENON1T experiment.

This work is supported by BMBF under contract 05A20PM1 and by DFG within the Research Training Group GRK 2149.

Time: Monday 16:30–18:00

T 14.4 Mon 17:15 POT/0361

Paleo-detectors for Dark Matter — •ALEKSEY ELYKOV — Karlsruhe Institute of Technology, Institute for Astroparticle Physics

Despite the recent advances in physics, Dark Matter (DM) still eludes detection by modern large-scale experiments and puzzles the minds of physicists. Paleo-detectors represent a drastically different approach to DM detection, which uses abundant samples of natural minerals to search for nm-sized damage tracks produced by DM-induced nuclear recoils, that will accumulate in the minerals for ~1 Gyr, while they reside in the depths of the Earth. Modern, state-of-the-art microscopy techniques can be used to read out these minute tracks with nm resolution, differentiating them from those produced by more energetic radioactive contaminants. Despite their small size the Gyr-scale lifetime of paleo-detectors provides them with enormous exposure, allowing them to probe DM-nucleon cross sections below current limits for DM masses greater than 30 GeV/c². For lighter DM particles, with masses <10 GeV/c², the sensitivity of paleo-detectors reaches many orders of magnitude below the current upper limits. In this talk, the latest research and developments towards the use of mineral-based paleo-detectors will be presented.

Construction of the JUNO pre-detector OSIRIS — •TOBIA STERR, CORNELIUS VOLLBRICHT, OLIVER PILARCZYK, JESSICA ECK, TOBIAS HEINE, LUKE SIEBER, MARC BREUICH, BENEDICT KAISER, and TOBIAS LACHENMAIER — 1Eberhard Karls Universität Tübingen, Tübingen, Physikalisches Institut — 2Nuclear Physics Institute IKP-2 Forschungszentrum Jülich, Jülich, Germany — 3Institute of Physics and EC PRISMA+, Johannes-Gutenberg-University Mainz, Mainz, Germany

The Online Scintillator Internal Radioactivity Investigation System (OSIRIS) is a 20-ton liquid scintillator detector currently under construction at the Jüngeren Underground Neutrino Observatory (JUNO) in Kaoping, China. OSIRIS’ main goal is the monitoring of the purity of the liquid scintillator during the filling phase of the JUNO main detector. The construction of OSIRIS was performed between September 22 to January 23 and involved both, Chinese and German personnel. During that time all auxiliary systems (e.g., liquid handling), (digital) infrastructure (e.g., network devices) as well as scientific equipment was installed. This talk will report on the procedures, systems, challenges, and results of this installation work. This work is supported by the Deutsche Forschungsgemeinschaft.

Optimisation of Light Concentrators in the OSIRIS Upgrade — •MARCEL BÜCHNER — Johannes Gutenberg-University Mainz

OSIRIS as the pre-detector of the JUNO reactor neutrino measurement, is meant to monitor the ratio-purity of the scintillator used. When upgraded in the future, it is supposed to be used as solar neutrino detector or to search for neutrino-less double-beta decay. To provide a better energy resolution, the photon detection efficiency of OSIRIS needs to be increased. This is achieved by increasing the number of PMTs used along with adding Winston cones as light concentrators in front of them. Previous optimisations have shown that the optimal shape of these light concentrators depends heavily on the exact detector geometry. So the ideal arrangement for the PMTs needs to be found. This talk presents the ongoing work to optimise the light collection of the OSIRIS upgrade. During first tests an arrangement of 132 PMTs with light concentrators, on an almost equidistant triangular grid has been found, with an optical coverage that is at least 9 times higher than the current OSIRIS detector.

T 15: Neutrinos, Dark Matter III

T 15.1 Mon 16:30 POT/0006

The SNO+ Experiment: Current Status and future Prospects — •JOHANN DITTMER and KAI ZUBER — IKTP, TU Dresden, Deutschland

Located at 2 km underground in a mine near Sudbury, Ontario, Canada, the SNO+ experiment has an excellent shielding against cosmic rays. Due to this fact, it is nicely suitable for low background measurements. SNO+ consists of a 12 m diameter acrylic sphere filled with 7801 of a liquid scintillator. The sphere is observed by 9400 photomultiplier tubes mounted on support structure with 18 m diameter. The main goal is to search for the neutrinoless double beta decay ($0\nu\beta\beta$) of $^{136}$Xe. For this, the scintillator will be doped with 3.91 of natural Tellurium. Owing to its design as a general purpose neutrino detector, it is also possible to measure neutrinos from different sources (geo, reactor, solar, Supernova, etc.). After a commissioning water phase ended in 2019, a phase with pure scintillator started in 2022 is currently running. During this phase, reactor neutrino oscillations, low energy $^8$B solar neutrinos and geo neutrinos are studied. In addition, background components of the $0\nu\beta\beta$ decay are investigated. The double beta phase is foreseen to run for 5 years starting in 2025. In this talk, the recent results and the broad physics program will be presented. SNO+ is funded by the German Research Foundation (DFG).

Recently, R&D facilities within the SuperCDMS collaboration have developed and employed cryogenic, high-voltage, eV-scale (HeVe) detectors with single-charge sensitivity. For a typical event observed by one of these gram-sized, silicon crystal detectors, the total amount of photon energy measured is proportional to the number of electron-hole pairs created by the interaction. However, crystal imperfections and surface effects can cause propagating charges to either trap inside the crystal or ionize additional charges, producing non-quantized measured energy as a result. Modelling these detector-response effects continues to be important for the HeVe R&D program in order to understand calibration data and apply these effects on potential signals for dark matter searches. This presentation showcases an improved, more robust model of these detector-response effects that has fewer limitations and is capable of modelling more effects compared to previous models. This model allows for a more accurate characterization of HeVe detectors and may facilitate discrimination between potential dark matter signals and background sources.

Low-frequency noise classification for the SuperCDMS experiment using Machine Learning — *Sukerthi Dharani* for the SuperCDMS—Collaboration — Karlsruhe Institute of Technology, Institute for Astroparticle Physics — University of Hamburg, Institute for Experimental Physics

The SuperCDMS Soudan experiment was a direct dark matter search experiment that was operated from 2012 to 2015 at the Soudan Underground Laboratory in Minnesota, USA. It used germanium crystal detectors at cryogenic temperatures to search for dark matter—nucleon scattering events. The experiment was affected by broadband low-frequency (LF) noise due to vibrations from the cryocooler, which deteriorated the detector baseline resolution and increased the noise trigger rate. The LF noise events can have a similar pulse shape as the low-energy signal events, making it difficult to remove them at low energies. In the final low ionization threshold analysis, this has led to stronger event selection criteria to remove LF noise events which set a higher analysis threshold and thus reduced the sensitivity of the experiment to low-mass dark matter. Currently, an LF noise selection criterion using machine learning is being studied. Under investigation is a convolutional neural network that yields better signal purity with the same or better signal efficiency. This talk discusses the machine learning—based classification of LF noise and its preliminary results.

The LEGEND Experiment - Status of commissioning and outlook — *Simon Sailer* for the LEGEND—Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

The LEGEND experiment searches for the neutrino-less double beta (0νββ) decay of the germanium isotope 76Ge which would reveal the Majorana nature of neutrinos and prove lepton number non-conservation. The first stage of their experiment (LEGEND-200) is built at the underground facility of LGNS in Italy. Here close to 200 kg of enriched high—purity germanium detectors (≈ 88% 76Ge) are being deployed providing a discovery sensitivity for the half-life of the 0νββ decay of > 10^27 yr. within 5 years of measurement. The detectors are in a liquid argon cryostat which simultaneously provides the coolant, a gamma—radiation shield and active veto system. The cryostat itself is surrounded by a large water tank acting as an additional neutron shield and muon veto. LEGEND-200 is ending it’s commissioning phase and switches to standard operations. Meanwhile the preparations for the second stage (LEGEND-1000) increasing the detector mass to 1 tonne are making great strides which will increase the sensitivity to > 10^32 yr. A non—observation would probe the effective Majorana neutrino mass m_\text{\text{ee}} in the range of 10–20 meV and allow the exclusion of the inverted mass ordering.

Commissioning of the Liquid Argon Instrumentation of LEGEND-200 — *Rosanna Deckert, Patrick Krause, Laszlo Papp, Luigi Pertoldi*, and Stefan Schöbert — Technische Universität München

LEGEND (Large Enriched Germanium Experiment for Neutrinoless ββ Decay) is a ton—scale experiment to search for neutrinoless double beta (0νββ) decay using high—purity germanium detectors enriched in 76Ge. An observation of 0νββ decay would prove the existence of lepton number violation and provide insight into the nature of neutrino masses. The first phase of the experiment LEGEND-200 will deploy 200 kg of enriched material and aim for a sensitivity of 10^32 years on the 0νββ decay half—life. To achieve this, the germanium detectors are operated in liquid argon instrumentation as an active detector to detect the scintillation light produced by backgrounds from trace radioactive contaminants. Commissioning of the liquid argon instrumentation, consisting of wavelength—shifting fibers, a wavelength—shifting reflector and silicon photomultipliers, took place during 2022 at the Laboratori Nazionali del Gran Sasso. In this talk, some of the main outcomes of the commissioning are presented. This research is supported by the BMBF through the Verbundforschung 05A20W02 and by the DFG through the Excellence Cluster ORIGINS and the SFB1258.

BSM physics searches beyond 0νββ decay with GERDA and LEGEND — *Elisabetta Bossio* for the GERDA-Collaboration — Physik—Department E15, Technische Universität München, Garching, Germany

While searching for neutrinoless double β (0νββ) decay, experiments collect huge statistics of the Standard Model (SM) two neutrino double β (2νββ) decays. This is amongst the rarest nuclear processes ever observed. Beyond the Standard Model (BSM) physics, like the existence of new particles, Majorons, or light exotic fermions, or the violation of Lorentz symmetry, would affect the shape of the measured two—electron spectrum, originating detectable and characteristic signatures. The GERDA experiment, with its ultra—low background and excellent understanding of the experiment’s response, set the best limits on the mentioned BSM double β—decays with 76Ge [1]. In this contribution, the results of the GERDA experiment will be presented, and the sensitivity of the LEGEND experiment [2] to improve the current limits and to search for more exotic double β—decays involving non—standard interactions, like right—handed leptons currents or neutrino self—interactions, will be discussed. This research is supported by the BMBF through the Verbundforschung 05A20W02 and by the DFG through the Excellence Cluster ORIGINS and the SFB1258.


Neutrino Astronomy I

Time: Monday 16:30–18:00

Quasi—periodic oscillations in J1048.4+714 - comparison of hadronic and leptonic signatures* — *TOM MISNECKI†, JULIA BECKER-TILU†, LEANDER SCHLEGEL †, JULIANA MACHADO†, JULIA BECKER-TILU†, LEANDER SCHLEGEL †, †Theoretische Physik IV, Ruhr Universität Bochum, Bochum, Germany — 2RAPP-Center at Ruhr Universität Bochum, Bochum, Germany

Active Galactic Nuclei belong to the most luminous known astrophysical sources of high energy radiation. They are assumed to produce charged particles as well as uncharged messengers as photons and neutrinos via leptonic as well as hadronic processes and show a strong time—variability in their corresponding light curves. The quasi—periodic behaviour of the recently analysed light curve of the source J1048.4+714 especially raises the question of the creation of such temporal structures. One explanation is that the shape of the light curve stems from a precessing jet. In this work, we compare the photon flux produced via the pp → n^+ γ channel and the photon flux produced from synchrotron self—compton scattering in dependence of parameters of the emitting region. Furthermore, we investigate the differences of the flaring durations of the source defined by two methods, i.e. full—width at half—maximum method and the centroid method. Finally we evaluate the results with respect to the curvature parameter of the SEDs in the flaring phase. With these investigations we aim to reach a better understanding of the quasi—periodic oscillations in AGN and the interpretation of high—energy radiation signatures.

*Supported by DFG (SFB 1491)

Search for periodic low energy neutrino sources — *MAXIMILIAN EFF für die ANTARES-KM3NET-ERLANGEN-Collaboration — EACF, Friedrich—Alexander Universität Erlangen—Nürnberg (FAU), Erlangen, Germany

Pulsars are rotating neutron stars that emit beams of electromagnetic radiation. Neutrino emission from pulsars has been the subject of phenomenological models during the last decades. So far, experimental data has not shown any neutrino emission at high energies. This contribution reports about the development of a novel search approach that aims at identifying low—energy (below 10 GeV) neutrino emissions from periodic sources. This is done by applying a Fast Fourier Transformation to the PMT counting rate time series.

Study of high—energetic muon deflections* — *PASCAL GUTJAHRR — TU Dortmund University, Dortmund, Germany

Neutrino Astronomy II

Search for periodic low energy neutrino sources — *MAXIMILIAN EFF für die ANTARES-KM3NET-ERLANGEN-Collaboration — EACF, Friedrich—Alexander Universität Erlangen—Nürnberg (FAU), Erlangen, Germany

Pulsars are rotating neutron stars that emit beams of electromagnetic radiation. Neutrino emission from pulsars has been the subject of phenomenological models during the last decades. So far, experimental data has not shown any neutrino emission at high energies. This contribution reports about the development of a novel search approach that aims at identifying low—energy (below 10 GeV) neutrino emissions from periodic sources. This is done by applying a Fast Fourier Transformation to the PMT counting rate time series.

Study of high—energetic muon deflections* — *PASCAL GUTJAHRR — TU Dortmund University, Dortmund, Germany
The analysis of incoming muon-neutrinos and muons relies on the reconstruction of the detected muons. In general, the energy and the direction of an incoming particle are estimated via likelihood methods. With new reconstruction algorithms and hardware optimizations, the direction of an incoming muon can be measured with an angular resolution lower than 1 degree. However, high-energetic muons are able to travel many kilometers through dense media like ice and water. In these media, the muons interact very frequently with energy losses of up to 90% of the muon energy and even larger energy losses are possible. In each interaction, there is a momentum transfer which leads to a small deflection of the initial muon direction.

In this presentation, the lepton simulation framework PROPOSAL is used to estimate the accumulated muon deflection. Muons with different energies are propagated through ice and water over several distances. Data-Monte-Carlo comparisons as well as comparisons with the simulation tools MUSIC and Geant4 are shown. Finally, the impact of muon deflections for large scale neutrino telescopes is discussed. *Supported by DFG (SFB 676 and 1491) and BMBF

T 16.4 Mon 17:15 POT/0112 Image Recognition Algorithm for Deep Sea Bioluminescence — Sophie Lopföder and Kilian Holeppel for the P-ONE-Collaboration — Technical University of Munich, Munich, Germany

The Pacific Ocean Neutrino Experiment (P-ONE) is a planned, cubic-kilometer-scale neutrino telescope in the Pacific Ocean off the coast of Vancouver, Canada. Two pathfinder experiments have already been deployed: STRAW (STRings for Absorption length in Water) in 2018 and STRAW-b in 2020. Both pathfinder experiments are connected to the NEPTUNE deep-sea observatory, an initiative of the Ocean Networks Canada (ONC). In the deep sea, light produced by bioluminescent organisms presents a particular background for neutrino detection, although the bioluminescence data obtained are valuable for interdisciplinary research. The cameras installed in STRAW-b allow a visual detection of the bioluminescence. In this context, we present an image recognition algorithm including a deep neural network to analyze the bioluminescence on the pictures.

T 16.5 Mon 17:30 POT/0112 Applications of an improved track reconstruction algorithm in IceCube — Sophia Athanasiadou for the IceCube-Collaboration — DESY, Zeuthen, Germany

The IceCube Neutrino Observatory, the world’s largest neutrino telescope, has detected neutrinos in spatial and time coincidence with AGN, providing strong evidence that these astrophysical objects can in fact be neutrino sources. Neutrinos of astrophysical origin can be discerned from the atmospheric background at energies above 100 TeV, and for point-source studies in particular, high-energy track-like events are preferred. In this energy regime, the stochastic energy losses of the neutrino-induced muons are the dominant source of Cherenkov light measured by the detector, thus it is essential to include them in our reconstruction methods. The SegmentedBiplane reconstruction algorithm incorporates stochastic losses into the energy loss pattern while performing an energy fit as a first step, which significantly improves on the subsequent track reconstruction step and the angular resolution achieved. In this work we present our results when the algorithm is run on a subsample of simulated events for validation purposes, and our plans for implementation on IceCube data for a point-source search study.

T 16.6 Mon 17:45 POT/0112 Flavor differentiation for in-ice radio neutrino detectors — Janna Vischer for the RNO-G-Collaboration — Erlangen Centre for Astroparticle Physics, Erlangen, Germany

Cosmogenic neutrinos (> PeV) can be detected via the Askaryan effect when they interact and induce particle showers in ice. The thereby created radio signals can be observed using large scale antenna arrays. This is currently done at the Radio Neutrino Observatory Greenland (RNO-G) and planned for the radio component of IceCube-Gen-2. The capability to differentiate neutrino flavors would be an asset for such experiments. In the event of deep-inelastic scattering, neutrino interactions produce either an undetectable neutrino (neutral-current interaction) or an electron, muon, or tau lepton (charged-current interaction), both occasionally accompanied by measurable hadronic showers. In the second case extremely high energetic muons and tau themselves radiate secondary showers along their tracks. Particle showers with an energy above PeV can be detected. In this contribution we investigate how the signatures of these secondary showers can be used to deduce the flavor of the original neutrino in radio neutrino detectors.

T 17.1 Mon 16:30 POT/0013 Radio emission-mechanism of horizontal air showers measured with AERA at the Pierre Auger Observatory — Ruijie Zheboska for the Pierre Auger Collaboration — Bergische Universität Wuppertal, Gaußstr. 20, 42119 Wupper
tal, Germany

The Pierre Auger Observatory is the world’s largest detector measuring ultra high energy cosmic rays. The Auger Engineering Radio Array (AERA) is an ensemble of 153 antennas each with two polarization directions covering an area of 17 km² in order to detect the radio signal of the extensive air showers. These radio emissions consists of two components: the geomagnetic and the charge-excess emission. They can be disentangled by measuring the direction of the electric field vector. This talk presents current efforts to determine the relative contributions of these two processes using the polarisation pattern of the antenna stations for events measured with AERA, which helps to understand the development of air showers.

*Fördert durch die BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A20PX1)

T 17.2 Mon 16:45 POT/0013 Directional Calibration of radio antennas by using a drone emitter and information field theory for interpolating measured data at the Pierre Auger Observatory — Matthias Boddenberg, Martin Erdmann, Alex Reuzki, and Maximilian Straub — III. Physikalisches Institut A, RWTH Aachen University

Ultra-high-energy cosmic rays in the Earth’s atmosphere induce extensive air showers. At the Pierre Auger Observatory those air showers are measured using various detection techniques including the use of Short Apertured Loaded Loop Antennas (SALLA) as part of the AugerPrime upgrade.

SALLA antennas have been calibrated in a limited solid angle using the galactic background together with simulations. Here we introduce a recently started drone campaign to enable the relative directional calibration over the full sphere. Following pilot measurements with a small drone, we use a well defined biconical antenna mounted to a sizable drone. With that we will be able extract the antenna pattern from any direction and distance. Furthermore we will use an additional GPS unit to measure the drone’s position to cm accuracy such that the positional uncertainty is strongly reduced.

Finally we will interpolate the discrete measurements using information field theory (IFT) to obtain the full antenna pattern for all directions and frequencies.

T 17.3 Mon 17:00 POT/0013 Development of a Signal Model for the Radio Emission of Inclined Air Showers for GRAND — Lukas Guzowski, Jelena Peteriti, Tim Hübbe, and Markus Roth — Karlsruhe Institute of Technology (KIT), Institute for Exper-
imental Particle Physics, Karlsruhe, Germany

Ultra-high energy (UHE) neutrinos induce particle cascades in the atmosphere after interacting with the Earth’s crust. With its unprecedented sensitivity, the Giant Radio Array for Neutrino Detection (GRAND) will be able to consistently detect the radio signals emitted by extensive air showers caused by UHE neutrinos and UHE cosmic rays. GRAND plans to cover a detection area of 200 000 km² with a spacing of one radio antenna per square kilometre. The radio array will be optimised for the detection of inclined air showers and cover a wide frequency band from 50 to 200 MHz. In contrast to existing arrays, GRAND will operate autonomously, i.e. on radio events alone, hence efficient radio triggering techniques need to be developed.

GRAND will use DISKA air shower simulations to develop a more advanced signal model of the radio emission with an emphasis on the high frequencies GRAND will utilise. The model will be instrumental for the development of the novel autonomous trigger* as well event reconstruction for large-scale detector systems. This talk gives an overview on the radio emission of extensive air showers, the details of the signal model, and how it can be used for trigger development and event reconstruction.

* NUTRIG project, ANR-DFG Funding Programme (HU 1830/6-1)

T 17.4 Mon 17:15 POT/0013 Cosmic ray radio detection with the IceCube Surface Array Enhancement — Megha Venugopal for the IceCube-Collaboration — Institute of Astroparticle Physics (IAP), Karlsruhe Institute of Technology, Germany

The IceCube Neutrino Observatory has been recording neutrino events and cosmic rays at the South Pole for more than a decade. The cosmic ray observatory of this experiment, IceTop with 162 Cherenkov tanks, has played an impor-

T 17: Cosmic Ray I

Time: Monday 16:30–18:00

Location: POT/0013

Development of a Signal Model for the Radio Emission of Inclined Air Showers for GRAND — Lukas Guzowski, Jelena Peteriti, Tim Hübbe, and Markus Roth — Karlsruhe Institute of Technology (KIT), Institute for Experimental Particle Physics, Karlsruhe, Germany

Ultra-high energy (UHE) neutrinos induce particle cascades in the atmosphere after interacting with the Earth’s crust. With its unprecedented sensitivity, the Giant Radio Array for Neutrino Detection (GRAND) will be able to consistently detect the radio signals emitted by extensive air showers caused by UHE neutrinos and UHE cosmic rays. GRAND plans to cover a detection area of 200 000 km² with a spacing of one radio antenna per square kilometre. The radio array will be optimised for the detection of inclined air showers and cover a wide frequency band from 50 to 200 MHz. In contrast to existing arrays, GRAND will operate autonomously, i.e. on radio events alone, hence efficient radio triggering techniques need to be developed.

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Cosmic ray radio detection with the IceCube Surface Array Enhancement — Megha Venugopal for the IceCube-Collaboration — Institute of Astroparticle Physics (IAP), Karlsruhe Institute of Technology, Germany

The IceCube Neutrino Observatory has been recording neutrino events and cosmic rays at the South Pole for more than a decade. The cosmic ray observatory of this experiment, IceTop with 162 Cherenkov tanks, has played an impor-
tient part in understanding the high-energy universe. A Surface Array Enhance-
ment (SAE), made up of scintillators and radio antennas, is planned to address the rising uncertainties from IceTop measurements due to snow accumulation and to improve measurement capabilities. A prototype station was deployed in January 2020 and has taken measurements which have been correlated with re-
constructed events from IceTop. This contribution focuses on the current status of radio detection of cosmic rays at the SAE. The calibration and characterization of hardware components were performed and prepared for deployment. Recon-
struction of Xmax, the atmospheric depth of the shower maximum, was done with initial measurements and with data from IceTop. The main goal is to char-
acterize uncertainties and to prepare the experiment to do physics.

A new approach to efficiency estimation of radio arrays — VLADIMIR LENOK
— BLEIEFELD University, Germany
The progress of in the field of radio detection of air showers in the last decades paved the way for the large-scale radio observatories of cosmic rays and neutrinos. One of the remaining challenges regarding this kind of instrumentation is estimation of their efficiency, which is a complicated problem due to high com-
putational complexity of the required large Monte-Carlo libraries. We developed a new approach to this problem that is based on explicit probabilistic treatment or each of the components of the detection process. With this approach we built an efficiency model for the Tunka-Rex radio array as for example. The model uses a parametrization of the air-shower radio footprint and probability densi-
ties for signal detection on the antenna level and shower detection on the array level. The model was validated against full-fledged Monte-Carlo simulations and against the observational data that showed that it is suitable for selection of the full-efficiency regions usually used in all cosmic-ray studies. In the talk we will present the details of the approach and the results of its application to the Tunka-Rex array.

First Radio Measurements of an IceCube Surface Enhancement Station at the Pierre Auger Observatory — CARMEEN MEBX for the Pierre Auger and IceCube-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology
Radio detection of air showers has become a powerful method to measure cos-
ic ray rates at energies of several 10 PeV and above. IceTop, the surface array of the IceCube Neutrino Observatory at the South Pole as well as the Pierre Auger Observatory in Argentina are being upgraded with antenna stations to improve the accuracy of air-shower measurements. A prototype station of the surface enhancement of IceCube has recently been installed at the Pierre Auger Observatory. This station comprises eight scintil-
lation panels and three SKALA antennas. The frequency band of the SKALA antennas reaches up to 350 MHz, which is significantly higher than the 30-80 MHz currently used at Auger.
During my presentation, I will discuss first measurements of this prototype station at the Auger site.

Characterization of PMTs for the FlashCam project — OLEG KALEKIN for the CTA FlashCam-Collaboration — Erlangen Centre for Astroparticle Physics, FAU Erlangen-Nürnberg, Nikolaus-Fiebig-Str. 2, 91058 Erlangen, Germany
High quantum efficiency PMTs of type R12199-100-5 from Hamamatsu have been selected for the cameras of telescopes of the Cherenkov Telescope Array (CTA). The FlashCam group has developed a camera design suitable for instal-
lation in Medium-Sized Telescopes of CTA.
Using PMTs delivered in 2017, an advanced FlashCam prototype was pro-
duced and installed in the central CT5 telescope of the H.E.S.S. experiment in Namibia in fall 2019. Since then the PMTs are in field operation for more than 2 years already, and provide very stable performance. To control the quality of the PMTs, sub-samples delivered in 2017 and 2021-2022 have been character-
ized in laboratory for timing parameters, gain, afterpulsing and Quantum Ef-
iciency (QE). The results on spectral shape of QE and homogeneity of QE over photocathode area as well as an evolution of these parameters with time will be presented.

Performance of SiPM test pixel operation in the MAGIC IACT PMT camera — ALEXANDER HAHN, RAZMIK MIRZOYAN, ANTONIO DETTLAFF, DAVID FINK, DANIEL MAZIN, MASAHIRO TESHIMA for the Max Planck Institute for Physics, Munich, Germany — Institute for Cosmic Ray Research, The Uni-
versity of Tokyo, Kashiwa City, Japan
All currently operating large Imaging Atmospheric Cherenkov Telescopes (IACTs), such as MAGIC, H.E.S.S., or VERITAS, or such as CTAs LST presently being commissioned, use photomultiplier tubes (PMTs) as primary light detect-
tors. It has been shown that smaller IACTs such as FACT and ASTRI can operate with Silicon photomultipliers (SiPMs) instead. However, it is an open research question whether SiPMs may also be suitable as light detectors for large-scale IACTs. To address this question, we have built several SiPM-based prototype de-
tector modules at the Max Planck Institute for Physics. The first module, based on SiPMs from Excelets, was installed in the MAGIC-I Imaging camera in May 2015, while two more modules, one using SiPMs from Hamam-
atsu and another one from SensL, were installed in 2017. Since then, all these modules have been operated in parallel with the PMT camera. Here we present a multi-year in situ study of SiPMs and PMTs in an operational IACT and present a direct performance comparison between the two detector types.

nsb2: an open source tool for simulating Imaging Atmospheric Cherenkov Telescope Night Sky Background — GERRIT ROELLINGHOFF, SAMUEL SPENCER, STEFAN FUNK for the H.E.S.S.-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen Centre for Astroparticle Physics, Nikolaus-Fiebig-Str. 2, 91058 Erlangen, Germany — Department of Physics, University of Oxford, Keble Rd, Oxford OX1 3RH, United Kingdom
As a result of being exposed to the night sky, Imaging Atmospheric Cherenkov Telescopes (IACTs) are sensitive to background illumination; all sources of il-

lumination that are not Cherenkov light. This Night Sky Background (NSB) limits the operational time of IACTs, introduces systematic uncertainty and is a source of Data/Monte-Carlo mismatch. Building on software previously de-
veloped for H.E.S.S., we present an open source tool for the pixel-wise predic-
tion of NSB in IACTs, simulating contributions from a variety of sources, such as starlight, moonlight and atmospheric glow. It allows for the computationally ef-
icient prediction of NSB rates for a variety of IACT types, thus improving on Data/Simulation mismatch and enabling users to plan observations for IACTs during partial moonlight observations.

IceCube-Gen2: Optical module prototyping and performance studies — MARKUS DITTMER and ALEXANDER KAPPES for the IceCube-Collaboration — Westfälische Wilhelms-Universität Münster
As the progression of IceCube continues, a novel optical module (OM) for IceCube-Gen2 is being developed, that incorporates lessons learned from the development of modules for IceCube Upgrade while adapting to the reduced borehole diameter. The presentation will provide a brief introduction to four (of many) aspects involved in the development of the Gen2OM prototype: The gel pad concept, which is key for performance and integrity, and related prototyping; photomultiplier studies; simulation studies for OM performance; and a method for estimating the module background caused by radioactive scintillation in the pressure vessel.

Acceptance Tests of 10,200 Photomultiplier Tubes for the mDOMs of the IceCube Upgrade — LASSIE HALVI, PHILIPP BEHRENS, ERIK BUCHAI, MAJA FREIENHOFER, TARAA HAIZ AZIM, JÖELLE SAVELBERG, LARS SCHMIDT, LYDIA VON DER WEIDEN, JOHANNES WERTHEBACH, and CHRISTOPHER WIERBACH for the IceCube-Collaboration — RWTH Aachen University - Physics Institute III B, Aachen, Germany — Astroparticle Physics WG Rhede, TU Dortmund University, Germany
More than 10,000 3-inch Photomultiplier Tubes (PMT) will be deployed in multi-PMT Digital Optical Modules (mDOM) of the IceCube Upgrade. Prior to integration of the PMTs into the modules, they need to be tested for compliance with specifications agreed upon with the manufacturer. For this purpose, two dedicated testing facilities have been constructed at RWTH Aachen University and TU Dortmund University. These facilities have been optimized for a large throughput of PMTs using highly automated and parallelized testing routines. All PMTs have undergone extensive acceptance tests including single-photon re-
sponse and detection efficiency, time-resolution, background rates, high-voltage dependence and more. During testing, several deviations from the specifications were identified and could be mitigated prior to the mDOM production. We de-
scribe the design of the facilities, testing procedures, and results of the acceptance tests.
T 19: Detector Systems, Electronics

Time: Monday 16:30–17:45
Location: POT/0106

Development of a High Temperature superconducting magnet for applications in space. — Christian von Byern1, Laurenz Klein1, Daniel Louis1, Tim Mulder2,3, Irfan Ozen1, Stefan Schael1, Thorsten Sedenburg1, and Michael Wlocha1 — 1Physics Institute IB, RWTH Aachen University — 2CERN

While AMS-02 is currently operated on board of the International Space Station, the next generation of cosmic particle detector is already planned. AMS-100 will be operated at Lagrange Point 2 and will feature a geometric acceptance of 100m²·sr. With this large acceptance and improved momentum resolution a measurement of cosmic rays up to the PeV scale will be possible and an improvement of factor 100 regarding the sensitivity of anti-matter measurements is expected.

The magnetic field of the electromagnet will be generated by a High Temperature Superconducting (HTS) solenoid. This coil will include several layers of individual HTS tapes. The coil is operated at 55K, and it will produce a field of 0.5T at 10kA current. To reduce the material budget in terms of mass and interaction length the HTS tapes will be stabilized using few millimetres of aluminium. As an intermediate step a small demonstrator coil is in preparation. In this RD phase multiple samples, including straight cable samples, meteoroid impact distributed samples as well as coil samples with a few windings are prepared and tested. In this talk measurement results of the different samples will be presented and discussed.

Development of a quench detection system based on optical fibres for the AMS-100 high temperature superconducting solenoid. — Clemens Dittmann1, Markus Gastens2, Caroline Girmes1, Stefan Schael1, Thorsten Sedenburg1, and Michael Wlocha1 — 1Physics Institute IB, RWTH Aachen, Germany — 2Institute of Structural Mechanics and Lightweight Design SLA, RWTH Aachen, Germany — Faunhofer Institute for Production Technology ITP, Aachen, Germany

The magnetic spectrometer AMS-100, which includes a high temperature superconducting coil, is being designed to measure cosmic rays and detect cosmic antimatter in space. This extreme environment requires a suitable sensing solution to monitor critical changes in the solenoid structure, for example the beginning of a quench in the superconducting coil. Rayleigh scattering-based distributed optical fibre sensors (DOFS) fulfil the high requirements for these extreme conditions, as they are small and lightweight, can be used under cryogenic temperatures, are immune to electromagnetic interference and have sub-millimetre spatial resolution over long distances. The established application of using this system only allows a coupled measurement of mechanical and thermal signals, based on knowledge of the thermomechanical behaviour of the structure being measured. A precise calibration of the temperature and strain response of the optical fibre in the range of 77K to 350K was achieved and a measurement principle was developed to decouple the mechanical and thermal signals.

Development of a High-Current, Low-Voltage Remote Power Supply for the P2 Tracking Detector — Lars Steffen Weinstock for the P2-Collaboration — PRISMA+ Cluster of Excellence and Institute of Nuclear Physics, Johannes Gutenberg University Mainz

The P2 experiment is planned for the Main Energy recovering Superconducting Accelerator (MESA), which is currently under construction. The goal of P2 is to determine the electromagnet mixing angle with an unprecedented precision at low energy scales with by measuring the parity violating asymmetry in proton-electron scattering at low momentum transfer. A key parameter for the analysis, the electron momentum transfer during scattering, is measured by the P2 tracker, which is placed inside the 0.6 T solenoid magnet. The tracker utilises over 4000 High-Voltage Monolithic Active Pixel Sensors (HV-MAPS) each drawing about 500 mA at a supply voltage of 2 V. Due to the high amount of radiation as well as thermal and noise constraints, the power conversion was shifted from the front-end to the counting room at a distance of 30 meters to the detector using a remote-sense technique.

This talk gives an overview of the P2 experiment and the powering scheme of its tracking detector, as well as the current state of development of the remote power supply using a combination of physics (COMSOL) and electronics simulation (SPICE) to estimate the performance and stability of the supplied power.

FPC prototype tests and results for the ATLAS High Granularity Timing Detector Demonstrator — Maria Soledad Robles Manzano1, Andrea Brogna1, Jan Ehrkeck1, Ayila Kurt2, Lucia Masetti2, Jögar Patel2, Binh Pham2, Fabian Pienmaier2, Steffen Schönefelder2, Quirin Weitzel2, and Patricia Theobald2 — 1Institut für Physik, Johannes Gutenberg-Universität Mainz — 2PRISMA Detektorlabor, Johannes Gutenberg-Universität Mainz

The ATLAS detector upgrades face the challenges of the new High Luminosity LHC, in particular the increase of pile-up interactions. The High Granularity Timing Detector (HGTD) will be built in order to mitigate the effects of pile-up in the ATLAS forward region, providing time information with a resolution of about 30 ps per track. The active area consists of 2-double-sided disks per end-cap. The HGTD basic unit, so-called module, is made of up to 2x2 cm² Low Gain Avalanche Detectors bump-bonded to two ASICs and glued to a flexible PCB. The modules are connected to the Peripheral Electronics Boards, surrounding the active area, via a Flexible Printed Circuit (Flex tape) that serves as interconnection for power, communication signals and HV bias. A prototype of different lengths of the flex tail for a small scale, but full chain HGTD demonstrator has been produced and tested. The tests results of both electrical and mechanical performance of the prototype are presented.

T 20: Pixel ITk, Si-Strips/Other

Time: Monday 16:30–17:45
Location: WIL/A317

ITk-Pixel Pre-production Sensor QA Measurements Including Testbeam — John Grosse-Knetter, Arndt Quadt, Yongsun Tan, and Hua Ye — II Physikalisches Institut, Georg-August-Universität Göttingen

In the ATLAS detector upgrade for the High-Luminosity LHC (HL-LHC), the current Inner Detector will be upgraded to an all-silicon Inner Tracker (ITk), to operate under higher occupancy (instantaneous luminosity 7.5x 10³⁰ cm⁻² s⁻¹, corresponding to approximately 200 inelastic pp collisions per bunch crossing) and radiation damage (fluence 2 x 10¹⁶ n/cm²). The data taking is planned to
start in 2029 and last for 10 years. The pixel detector is the inner-most layer of the ITk, it consists of modules equipped with planar or 3D sensors, and is currently in the pre-production stage. To be assured that specifications will be met during production, sensors from different vendors were sent to different ITK sites for testing, and some modules were assembled for beam test. This talk shows ITkPix pre-production planar sensor quality assurance (QA) measurements and testbeam.

T 20.2 Mon 16:45 WIL/A317

ATLAS ITk Module Testing Quality Control — Yannick Dieter, Fabian Hügging, Florian Hinterkeuser, Hans Krüger, Maximilian Mucha, Matthias Schüssler, Thomas Senger, and Jochen Dingfelder — Physikalisches Institut der Universität Bonn

With the upgrade of the Large Hadron Collider (LHC) to the High-Luminosity LHC (HL-LHC), the instantaneous luminosity will increase by a factor of 5 with respect to its design value from 2029 onward. The resulting unprecedented hit rates and radiation levels require major upgrades of the detectors located at the HL-LHC to meet the new challenging requirements. For the upgrade of the ATLAS detector, a new all-silicon inner tracking detector (ITk detector) consisting of silicon strip and pixel modules will be installed to replace the currently operated Inner Detector. In total, approximately 10 000 new pixel detector modules have to be built and tested carefully to ensure that only fully functional detector modules are installed. Approximately 1000 pixel detector modules will be built and tested at the Forschungs- und Technologiezentrum Detektorschypsis (FTD) in Bonn during the production of the ATLAS ITk pixel detector. For testing the electrical functionality of the detector modules an intensive quality control (QC) with dedicated testing setups was developed.

This talk gives an overview of the electrical QC for ATLAS ITK pixel detector modules in Bonn, with a focus on the newly developed test setup and first testing results.

T 20.3 Mon 17:00 WIL/A317

Status update of the Cell Integration Site for ATLAS ITk Pixel Detector in Bonn — Alexandra Wald, Klaus Desch, Matthias Hamer, Florian Hinterkeuser, Fabian Hügging, and Hans Krüger for the ATLAS-Collaboration — Physikalisches Institut, University of Bonn, Germany

In conjunction with the high luminosity upgrade of the Large Hadron Collider (HL-LHC) at CERN, the current tracking system of the ATLAS experiment will be replaced by the Inner Tracker (ITk), an all-silicon detector consisting of 5 layers of pixel detectors and 4 layers of strip detectors. More than 8000 modules are installed in the pixel layers, which together have an active area of approx. 13 m² and cover a pseudorapidity of up to 4. In order to build such a large detector in time, the integration of the ITk Pixel modules on their local support structures, as well as the quality control of individual loaded local supports will be distributed over many institutes. One of the assembly lines for loaded local supports will be setup at the University of Bonn. Due to the powering scheme of the ITk Pixel Detector, the quality control of a loaded local support is challenging in several aspects: loaded modules cannot be tested standalone, as the implemented serial powering scheme only allows for the simultaneous operation of a significant fraction of all modules on a loaded local support. In this presentation, the current status of the cell integration line in Bonn is presented, with a particular focus on the data acquisition infrastructure required for the QC setup, which is based on a FELIX server (Front-End Link eXchange).

T 20.4 Mon 17:15 WIL/A317

Commissioning and Testing of a QC-Setup for the ATLAS ITk-Pixel Outer Barrel Bare Cell — Nico Klein, Matthias Hamer, Klaus Desch, Florian Hinterkeuser, Diego Alvarez Feito, Alexandre Lacroix, and Nicola Pacifico — 1 Universität Bonn — 2 CERN

The high-luminosity upgrade of the Large Hadron Collider at CERN requires a complete redesign of the current tracking detector of the ATLAS experiment. The new Inner Tracker, the ITk Detector, will consist of a silicon pixel detector and a silicon strip detector. The ITk Pixel Detector is divided into three subsystems, the Outer Barrel (OB), Outer Endcaps and Inner System. In the OB, modules are loaded on cells (pyrolytic graphic tiles that are glued to an aluminum-graphite cooling block) before they are mounted on the local supports. These cells play a crucial role in the thermal performance of the modules, as they provide the connection between the modules and the cooling system. In order to meet the demanding requirements that are placed on the cooling system of the ITk Pixel Detector, bare cells must be tested for their thermal conductivity before silicon modules are loaded onto them. In this contribution, a setup for the thermal quality control of the bare cells is presented, as well as measurements of the thermal performance of prototype cells with this setup.

T 20.5 Mon 17:30 WIL/A317

Humidity Studies on Silicon Strip Sensors — Ilona Stefana Ninca — Deutsches Elektronen-Synchrotron (DESY), Zeuthen, Germany

Silicon strip sensors for the ATLAS Upgrade showed a strong dependence of the breakdown voltage on varying levels of relative humidity. This study aims to investigate the same behavior on test structures that are produced on “half moons” of the same wafers as the sensors. The test structures are first imaged in breakdown conditions: high bias voltage and 20% - 50% relative humidity. Using an infrared camera the location of the avalanche breakdown on the surface of the test structures was captured. Afterwards, the test structures are investigated using the transient current technique (TCT). The region of the avalanche breakdown is investigated in the TCT setup by scanning a focused, pulsed 660 nm laser beam along the surface of the test structure and recording the resulting current transients. Using the TCT data, the electric field at the breakdown point can be estimated. In the future, hopefully with a better understanding of the origin of the humidity sensitivity we wish to be able to propose changes for new sensors reducing the humidity impact.

T 21.1 Mon 16:30 WIL/A124

Stress testing optical readout components for CMS 2S modules — Max Beckers2, Christian Dziwek2, Lutz Feld3, Katja Klein1, Alexander Pauls1, Oliver Pooth1, Nicolas Röwert1, Martin Lipinski1, Vanessa Oppenländer1, Felix Thurn1, and Tim Ziemon2 — 1 Physikalisches Institut B, RWTH Aachen University, D-52056 Aachen — 2 Physikalisches Institut B, RWTH Aachen University

New detector modules will be installed for the upcoming CMS Phase-2 Outer Tracker upgrade. There are two general types of modules, one consisting of two co-planar silicon strip sensors (2S) and one of a macro pixel and a strip sensor (PS). The communication and the auxiliary support are supplied by a so-called Service Hybrid (SEH) in the case of a 2S module. It houses a two-stage DC-DC converter and a Low-Power Gigabit Transceiver (lpGBT). At the RWTH Aachen University, the SEHs are qualified regarding power and communication stability in a so-called test board setup, where the SEHs will undergo additional thermal cycling while being tested. A Field-Programmable Gate Array (FPGA) firmware was developed for the integrated testing routines, like a Bit Error Rate Testing (BERT) of the lpGBT’s connections. This talk will focus on the data tests of this setup.

T 21.2 Mon 16:45 WIL/A124

Thermal Measurements of 2S Modules with an evaporative CO2 Cooling System for the CMS Phase-2 Outer Tracker Upgrade — Christian Dziwek2, Lutz Feld3, Katja Klein1, Martin Lipinski1, Vanessa Oppenländer1, Alexander Pauls1, Oliver Pooth1, Nicolas Röwert1, Michael Wlocha1, and Tim Ziemon2 — 1 Physikalisches Institut B, RWTH Aachen University, D-52056 Aachen — 3 Physikalisches Institut B, RWTH Aachen University

The new operating conditions of the future HL-LHC require a replacement of the complete silicon tracking system of the CMS experiment as part of the CMS Phase-2 Upgrade. For the Phase-2 Outer Tracker new silicon strip modules, so-called 2S modules, are being developed that consist of two silicon sensors stacked on top of each other. The high radiation conditions of the HL-LHC lead to a high leakage current in the silicon sensors, which is exponentially dependent on the sensor temperature. An evaporative CO2 cooling system will be used to cool the modules and ensure a successful operation. In an unstable cooling scenario it is possible that the module enters an uncontrolled self-heating loop called thermal runaway. Therefore it is crucial that the thermal properties and performance of the 2S modules and the cooling system are tested and characterized. In this talk measurements with a test setup of 2S modules on a cooling structure using a custom CO2 cooling system will be presented.

T 21.3 Mon 17:00 WIL/A124

Integration Tests with 25 Module Prototypes for the Phase-2 Upgrade of the CMS Outer Tracker — Lea Stockmeier, Bernd Berger, Alexander Dierlamm, Ulrich Husemann, Markus Klute, Roland Koppenhöfer, Stefan Maier, Hans Jürgen Simonis, and Pia Steck — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

To deal with the increased luminosity of the HL-LHC, the CMS experiment will be upgraded until 2028. During this Phase-2 Upgrade, the CMS Outer Tracker
will be equipped with modules each assembled with two silicon sensors. Depending on the position in the tracker, these silicon sensors are pixel or strip sensors. The modules with two strip sensors are called 2S modules. In the barrel region, they are placed on mechanical structures called ladders. A fully equipped ladder contains twelve modules. During the prototyping phase of the modules, integration tests are performed with the purpose to test the module functionality on the final detector structures. Investigations focus on the cooling performance as well as on electrical performance of the modules on the supporting structures.

This talk summarizes integration tests with 2S modules on ladders performed at CERN and Institut Pluridisciplinaire Hubert Curien (Strasbourg) in cooperation with other CMS working groups.

T 21.4 Mon 17:15 WIL/A124
Investigations of a BiCOMS Pixel Sensor — ANDRÉ SCHÖNING1, HEIKO AUGUSTIN1, IVAN PERRIC2, and BENJAMIN WEINLÄDER1 — Physikalisches Institut, Universität Heidelberg — 1IP, Karlsruher Institut für Technologie
In the field of particle physics, High Voltage Monolithic Active Pixel Sensors (HV-MAPS) are promising candidates to fulfil the high demands on spatial and time resolution of modern detectors. A new generation of sensors, which combines the HV-MAPS architecture with a BiCMOS technology, opens new possibilities for faster timing in the sub-nanosecond regime.

The BiBelPix is a small test chip to investigate the aforementioned potentials. It is a fully analog sensor featuring two 3 × 3 pixel matrices with pixel sizes of 41 × 41 μm2 and 81 × 81 μm2. During the ongoing testing phase several problems occurred, making an in-depth characterisation difficult. Identiﬁed problems such as an early break down at ~10 V and a weak ampliﬁer feedback are isolated and reproduced in simulations.

T 21.5 Mon 17:30 WIL/A124
Study of diffusion in small pixel sensors — AMALA AUGUSTHY1, DANIEL PIZZI2, EBHA GARUTTI1, JOHN SCHWANDT2, and TILMAN ROME1 — Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland — 1Deutsches Elektronen-Synchrotron, Notkestraße 85, 22607 Hamburg, Deutschland — 2Paul Scherrer Institute, 5232 Villigen PSI, Switzerland

Particle sensors are widely used in the CMS experiment for tracking. From 2025 to 2027, the LHC will undergo the high luminosity upgrade where the beam luminosity will be increased to about 7.5 × 1034 cm−2 s−1. To maintain high tracking efficiencies under such an extreme radiation environment, pixel sensors of smaller pitches will be used for tracking. However, as the pixel pitch is reduced, charge sharing effects like diffusion start to play an important role in determining the resolution of these sensors.

To investigate the effects of diffusion, measurements were performed on non-irradiated pixel sizes of 50 × 50 μm2, 25 × 100 μm2 and 17 × 150 μm2 using 5.2 GeV electron beam at the DESY test beam facility. These sensors have a thickness of 285 μm and are bump bonded to low noise read-out chip ROC4SENS. From these measurements, the spatial resolution, cluster size and efficiency as a function of sensor bias and incidence angle of the beam were extracted. These results are then compared to simulation. The measurements were performed using PIXELAV and Synopsys TCAD. In this talk, the results of these measurements will be presented.

T 22.0 Mon 17:45 WIL/A124
guard ring optimisation for passive-CMOS pixel sensors — SINCÜ ZHANG1, TOMASZ HEMPERLE2, and Jochen Dinsfelder2 — Physicalisches Institut, Universität Bonn, Germany — 1Dectris, Switzerland

In high energy physics, the silicon pixel sensors manufactured in commercial CMOS chip fabrication lines have been proven to have good radiation hardness and spatial resolution. Along with the mature manufacturing techniques and the potential of large throughput provided by the foundries, the so-called “passive CMOS” sensor has become an interesting alternative to standard planar sensors. High and predictable breakdown behaviour is a major design goal for sensors and the guard-ring structure is one factor to optimise. This is especially important for applications that require higher voltages.

In this talk we discuss the influence of the guard ring design on the breakdown voltage based on measurements and TCAD simulations. Results have shown that a more uniform potential distribution across the guard rings can be achieved by implementing deep n-well for guard ring structures, and reveals a higher breakdown voltage. Simulations has provided a potential way to reduce the size of the guard ring structures without limiting the breakdown performance.

T 22.1 Mon 16:30 WIL/C133
Bitwise Optimization of Artificial Neural Networks for the Energy Reconstruction of ATLAS Liquid-Argon Calorimeter Signals — ALEXANDER LETTAT1, ANNE-SOPHIE BRETHOLD1, NICK FRITZSCH1, CHRISTIAN GUTSCHE1, ARNO STRAßNERS1, and JOHANN CHRISTOPH VOIGT1 — Institut für Kern- und Teilchenphysik, Dresden, Deutschland

The LHC will be upgraded to become the High-Luminosity-LHC, with significantly increased numbers of simultaneous particle collisions. With this upgrade, up to 200 pile-up events are expected within one bunch crossing. To cope with that, processing of the signals of the Liquid-Argon Calorimeter will need to be improved, because conventional algorithms are expected to lose performance. Artificial neural networks provide one way to deal with this. It has been shown, that convolutional neural networks are able to detect signals and reconstruct their energy with good performance. These networks are planned to be executed on Field Programmable Gate Arrays (FPGA) which have limited resources in signal, processing units, logic and memory. This talk will deal with the quantization of neural networks, a technique to reduce the resources needed for neural networks, by reducing the precision of the weights, biases and activations, while keeping the performance.

T 22.2 Mon 16:45 WIL/C133
Artificial Neural Networks for the Energy Reconstruction of ATLAS Liquid-Argon Calorimeter Signals — ANNE-SOPHIE BRETHOLD1, NICK FRITZSCH1, CHRISTIAN GUTSCHE1, ALEXANDER LETTAT1, ARNO STRAßNERS1, JOHANN CHRISTOPH VOIGT1, and PHILIPP WELLE1 — Institut für Kern- und Teilchenphysik, Dresden, Deutschland

From 2029 on, the enhanced performance of the High-Luminosity LHC will increase the number of simultaneous proton-proton collisions at the ATLAS detector considerably. In order to cope with that, the so-called Phase-II upgrade is planned. Up to 200 pile-up events will emerge within one bunch crossing, which is why one important part of this upgrade will be the processing of the Liquid-Argon Calorimeter signals. It has been shown that the conventional, optimal filtering signal processing will loose its performance due to the increase of overlapping signals and a trigger scheme with trigger accept signals in each LHC bunch crossing. That is why more sophisticated algorithms such as neural networks come into focus. This talk deals with the application of convolutional neural networks, which on the one hand need to perform well under varying signal conditions and on the other hand need to satisfy tight resource restrictions. Different network architectures are compared. A scoring, which is visualized in a spider diagram, is introduced to evaluate the network performance with respect to different scenarios.

T 22.3 Mon 17:00 WIL/C133
Automated Photon Energy Resolution Calibration at Belle II — ALEXANDER HEIDELBACH and TORBEN FERBER — Institute of Experimental Particle Physics (EPP), Karlsruhe Institute of Technology (KIT)

At the Belle II experiment in Tsukuba, Japan, the electromagnetic calorimeter is used to measure the energy of photons in e+e− collisions. The utilization of physical observables, like the invariant mass, from measured quantities, requires precise knowledge of the uncertainties on the components of the four-momentum. To account for uncertainties of these components, the determination of the full covariance matrix is crucial. This matrix stores the variances and covariances of the differences between reconstructed and generated four-momentum vector components for data, respectively MC. At Belle II, in the case of photons, the entries of the photon covariance matrix are determined with the help of radiative dimuon decays e+e− → μ+μ−γ. This talk presents the studies on the radiative dimuon decay which are used to extract the photon energy resolution from data. Additionally, it discusses the current efforts to automate the extraction procedure for run-dependent data and the implementation into the Belle II Analysis Software Framework.

T 22.4 Mon 17:15 WIL/C133
Testbeam Performance and Light Yields of Prototype Cell for the SHiPS BJT — FAIRBURY LYNES for the SHiPS-BJT-Collaboration — University of Freiburg
We present R&D towards a large-area detector for energy reconstruction and tracking, which consists of many individual cells filled with liquid scintillator. Each cell is equipped with two wavelength-shifting optical modules (WOMs) that capture scintillation light and transfer it to silicon photomultipliers. This design could serve as the surrounding background tagger (SBT) of the proposed Search for Hidden Particles (SHiP) experiment, a general-purpose detector housed at the CERN SPS accelerator to search for light, feebly interacting particles. One such cell was tested at the DESY e+ e− testbeam in October 2022; analysis of performance and light yields will be presented here. This work is funded by the Federal Ministry of Education and Research.
T 23.1 Mon 16:30 WIL/A120
Production and testing of Resistive Plate Chambers (RPCs) — Timur Turkovic, Oliver Kortner, Daniel Soyk, and Hubert Kroha — Max Planck Institut für Physik, Physik, München, Deutschland
Resistive plate chambers (RPCs) with electrodes of high-pressure phenolic laminate (HPL) and small gas gap widths down to 1 mm provide a relatively low cost detector for large area tracking in ATLAS, that still grants high rate capability and fast response with an excellent time resolution of better than 500 ps. They can be operated up to a background count rates of 10 kHz/cm², which is five times the maximum rate these RPCs will encounter in the innermost layer of the barrel muon spectrometer of the ATLAS detector, where they will be installed in the phase-II upgrade for the HL-LHC operation. Production procedures that were previously developed in the lab have been transferred to several companies of which each produced first test samples. The quality of these samples was tested by measuring the voltage-current and the muon detection efficiency with cosmic muons.

T 23.2 Mon 16:45 WIL/A120
Study of the muon detection efficiency of thin-gap RPCs — Ayana Ban-garu, Oliver Kortner, Hubert Kroha, and Timur Turkovic — MPI für Physik, München, Deutschland
Resistive plate chambers (RPC) with small gaps between electrodes of high-pressure phenolic laminate offer excellent time resolution of better than 500 ps and cm position resolution. Thin-gap RPCs with a gas gap of 1 mm will be used for the phase II upgrade of the ATLAS muon spectrometer. The muon hit positions will be computed from he signals induced on 30 mm wide pick-up strips. In order to obtain a muon detection efficiency >99%, very sensitive amplifiers have to be used. We studied the dependence of the muon detection efficiency of thin-gap RPCs on the applied operating voltage with two different amplifier options: the ATLAS thin-gap RPCs and an alternative circuit using commercial high-performance transimpedance amplifiers from Texas Instruments. In this contribution we will introduce the two amplifiers and present the results of our efficiency measurements.

T 23.3 Mon 17:00 WIL/A120
Finding eco-friendly alternatives for highly potent greenhouse gases in drift chambers — Ines Hannen, Thomas Radermacher, Stefan Roth, David Smyczek, and Nick Thamm — RWTH Aachen University - Physics Institute III B, Aachen, Germany
Climate change poses an immense challenge to mankind. Drift chambers used in high-energy physics are often filled with highly potent greenhouse gases. To find an alternative to these, simulations on drift gas properties and energy deposition are performed. Important drift gas parameters, simulations and criteria to find eco-friendly alternatives are presented. The focus lies on Argon based drift gases as used for example in the time projection chambers of the T2K experiment.

T 23.4 Mon 17:15 WIL/A120
Quality Control in the Construction of new small-diameter Muon Drift Tube (sMDT) Chambers for the ATLAS Muon Spectrometer at the HL-LHC — Daniel Buchin, Alice Reed, Marian Rendel, Patrick Rieck, Elena Vovodina, Oliver Kortner, and Hubert Kroha — Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München
In order to improve the muon trigger efficiency and the rate capability of the ATLAS muon detectors for operation at the high luminosity upgrade of the Large Hadron Collider (HL-LHC), the Monitored Drift Tube (MDT) tracking chambers in the inner barrel layer of the ATLAS Muon Spectrometer will be replaced by small-diameter Muon Drift Tube (sMDT) chambers integrated with new thin-gap RPC trigger chambers.

The sMDT chambers are in serial production since January 2021. The serial production involves a stringent quality control program to assure the reliability and high mechanical precision of the chambers. In this talk, the program will be presented. It includes tests of the individual drift tubes and several mechanical measurements on the sMDT chambers. Also, the dedicated quality control database and monitoring web interface will be discussed.

T 23.5 Mon 17:30 WIL/A120
Construction of new small-diameter Monitored Drift Tube (sMDT) chambers for the HL-LHC upgrade of the ATLAS Muonspectrometer — Alice Reed, Daniel Buchin, Marian Rendel, Patrick Rieck, Elena Vovodina, Oliver Kortner, and Hubert Kroha — Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München
In order to improve the muon trigger efficiency and the rate capability of the ATLAS muon detectors for operation at the high-luminosity upgrade of the Large Hadron Collider (HL-LHC), the Monitored Drift Tube (MDT) chambers in the inner barrel layer of the ATLAS Muon Spectrometer will be replaced by small-diameter Muon Drift Tube (sMDT) chambers integrated with new thin-gap RPC trigger chambers.

The sMDT chambers fit, together with the RPCs, into the very tight available space and provide an order of magnitude higher background rate capability compared to the current detectors.

The sMDT chambers have been in serial production since January 2021. In this talk, the steps for the drift tube production and chamber construction will be presented, followed by a discussion of the cosmic muon tests used for the final chamber certification.

T 23.6 Mon 17:45 WIL/A120
Impact of environmental pressure and temperature variations on triple-GEM detector gas gain — Francesco Ivone, Thomas Hedderken, Kerstin Hopf, Giovanni Morelli, and Shawn Zaleski — III. Physikalisches Institut A, RWTH Aachen University
The GEM (Gas Electron Multiplier) technology has been widely adopted for muon detection in high energy physics experiments, for both tracking and triggering, as well as in other application areas.

The GEM gas electron amplification factor depends on the gas properties: mainly the mixture, the temperature and the pressure. While the gas mixture is finely controllable, the gas temperature and pressure are influenced by the fluctuations of the environmental parameters. Correcting for such variations is therefore crucial to maintain stable operating conditions or to compare performance measured in different conditions. In this contribution we describe the dependence of the GEM gas gain on temperature and pressure for three different gas mixtures. The study is based on experimental data, supported by simulations.
Invited Talk

T 24.1 Tue 11:00 HSZ/AUDI
Searching for Long-Lived Particles at the LHC and Beyond — JULIETTE ALIMENA — DESY, Hamburg

Particles beyond the standard model (SM) can generically have lifetimes that are long compared to SM particles at the weak scale. When produced at experiments such as the Large Hadron Collider (LHC) at CERN, these long-lived particles (LLPs) can decay far from the interaction vertex of the primary proton-proton collision. Such LLP signatures are distinct from those of promptly decaying particle that are targeted by the majority of searches for new physics at the LHC, often requiring customized techniques to identify, for example, significantly displaced decay vertices, tracks with atypical properties, and short track segments. In this talk, I will present the latest searches for LLPs at the LHC and other experiments and then give my view of where the field will go in the future.

Invited Talk

T 24.2 Tue 11:30 HSZ/AUDI
The Neutrino-Dawn of Galaxies — WOLFGANG RODHE — Fakultät Physik, TU Dortmund

For decades, generations of underground detectors have been opening more and more the window to the neutrino sky. Quickly, the background shine of atmospheric neutrinos could be separated from the bright light of atmospheric muons. Ten years ago, astrophysical neutrinos’ first faint isotropic glow was detected. After a brief gamma-flare of TXS 0506+056 in 2017, which coincided with a matching high-energy neutrino, it now appears that a time-independent neutrino signal from galaxies is finally arising: NGC 1068 in muon neutrinos and our Galaxy in cascading neutrino events of all flavors. The potential of neutrino telescopes is simultaneously being explored to investigate several other important physical or methodological questions. The status of these questions will be reported. In addition, it is discussed what steps one needs to take in the future to look at the neutrino sky in detail — and to answer the fundamental physics questions involved.

Invited Talk

T 24.3 Tue 12:00 HSZ/AUDI
Galactic cosmic rays: What have we learned and what’s next? — PHILIPP MERTSCH — Institute for Theoretical Particle Physics and Cosmology (TTK), RWTH Aachen University, Sommerfeldstr. 16, 52074 Aachen, Germany

Cosmic rays constitute an important ingredient in the galactic ecosystem and hold lessons beyond the Milky Way, for instance in regulating galaxy formation and evolution. In addition, cosmic rays lend themselves to searches for new physics, like dark matter or primordial antimatter. All of these studies, however, require answering the century-old question of cosmic ray origin. Over the last ten years, there has been an abundance of new data from space-based experiments like AMS-02, CALET and DAMPE. Modelling of these data allow inferences on the various types of cosmic ray sources and the conditions determining their transport, for instance galactic magnetic fields. What emerges is a rather complex picture and thus existing models need to be revised, if not completely Overhauled. I will highlight the lessons learned and discuss the open questions and what kind of instrumentation is required for answering them.

T 25: Flavor II

T 25.1 Tue 17:00 HSZ/0304
Observation of $B^0_s \rightarrow D^{(*)+} \pi^-$ and CP violation studies in $B^0 \rightarrow D^{(*)+} D^-$ with the LHCb experiment — JOHANNES ALBRECHT, SOPHIE HOLLITT, and JAN LÄRGER — TU Dortmund University, Dortmund, Germany

At the LHCb experiment, precision measurements are performed to search for physics beyond the Standard Model. One important area of interest is the field of CP violation. This includes direct measurements of CP violation in decays of neutral $B$ mesons as well as the determination of branching fractions to constrain higher order effects in such measurements.

In this talk, the observation of the $B^0_s \rightarrow D^{(*)+} \pi^-$ decay with a high significance and its branching fraction was measured relative to the $B^0 \rightarrow D^{(*)+} D^-$ decay. Further, the CP violation parameter sin(2)$\beta$ can be measured by exploiting $b \rightarrow c \bar{u}d$ transitions in $B^0 \rightarrow D^{(*)+} D^-$ decays, where the phases arise through the interference between the direct decay of the $B^0$ meson and the decay after mixing. Due to the topology of the decay, an angular analysis is required.

In this talk, the observation of the $B^0 \rightarrow D^{(*)+} \pi^-$ decay and the current status of the $CP$ violation measurement in $B^0 \rightarrow D^{(*)+} D^-$ are presented.

T 25.2 Tue 17:15 HSZ/0304
Search for the $B^0_s \rightarrow D^0 D^\pm$ decay with the LHCb experiment. — JOHANNES ALBRECHT, SOPHIE HOLLITT, and JONAH BLANK — TU Dortmund University, Dortmund, Germany

With precise measurements of $B$-meson decays the LHCb experiment can test the integrity of the Standard Model. In particular $B \rightarrow D\bar{D}$ decays are interesting to examine CP violation. While decays to charged $D^\pm$ mesons have already been well measured, the $B^0 \rightarrow D^0 D^\pm$ decay channel has not yet been observed by any experiment. The branching ratio of this decay mode is a key input to the theoretical prediction of its CP-asymmetry as well as the properties of other doubly charmed decays.

In the analysis presented in this talk, data collected by the LHCb experiment at $\sqrt{s} = 7, 8$ TeV and 13 TeV, corresponding to an integrated luminosity of $9 fb^{-1}$ is used to search for the $B^0 \rightarrow D^0 D^\pm$ decay. The $B^0 \rightarrow D^0 n^\pm \pi^0$ decay channel is used as a normalisation mode to cancel systematic uncertainties. The current status of the analysis will be presented.

T 25.3 Tue 17:30 HSZ/0304
Belle II measurement of $B^\pm \rightarrow K^\pm \pi^0$ and $B^0 \rightarrow n^\pm n^0$ decays — JUSTIN SKORUPA, THIBAUD HUMAIR, HANS-GÜNTHER MOSER, MARKUS REIF, OSKAR TITTEL, and BENEDETTO WACH — Max Planck Institute for Physics, Munich, Germany

Charmless hadronic B-meson decays provide sensitive probes for physics beyond the Standard Model, since the contribution of penguin decay amplitudes to their decay is non-negligible. Exploiting isospin symmetry between charmless and charmed B-meson decays allows the construction of null tests of the Standard Model with an accuracy of better than 1%. Moreover, they allow to determine the angle $\alpha$ of the unitary triangle associated with $B$-meson decays. The Belle II experiment at the SuperKEKB $e^+ e^-$ accelerator in Tsukuba, Japan, has the unique capability to measure all relevant final states to determine the angle $\alpha$ and to study all isospin-related decays necessary to set stringent limits on null tests. In this talk, a measurement of the decays $B^\pm \rightarrow K^\pm n^0$ and $B^0 \rightarrow n^\pm n^0$ using Belle II data is presented.

T 25.4 Tue 17:45 HSZ/0304
On the contribution of the electromagnetic dipole operator to the $B_s \rightarrow \mu^+ \mu^-$ decay amplitude — THORSTEN FELDMANN, NICO GUBERNARI, TORKILL HUNBBER, and NICOLAS SETZ — Center for Particle Physics Siegen, Theoretische Teilchenphysik, Universität Siegen

We report on the construction of a factorization theorem that allows to systematically include QCDF corrections to the contribution of the electromagnetic dipole operator $O_7$ to the $B_s \rightarrow \mu^+ \mu^-$ decay amplitude. We elaborate on how the occurring endpoint divergences appearing in individual momentum regions cancel, and show how the resulting rapidity logarithms can be isolated by suitable subtractions applied to the corresponding bare factorization theorem. This allows to include in a straightforward manner the QCDF corrections arising from the renormalization-group running of the hard matching coefficient, the hard-collinear scattering kernel, and the $B_s$-meson distribution amplitude. We estimate the effect numerically using a recently advocated parameterization of the $B_s$-meson light-cone distribution amplitude.

T 25.5 Tue 18:00 HSZ/0304
enhancing Bs to e+e- to an observable level — GILBERTO TETALMATZI-XOLOCOTZI — Siegen University, Siegen, Germany

As a result of the helicity suppression effect, within the Standard Model the rare decay channel $SB \rightarrow e^+ e^- \rightarrow S$ has a decay probability which is extremely suppressed, being five orders of magnitude below current experimental limits. Thus, any observation of this channel will be able to forthcom experiments to generate unambiguous evidence of Physics Beyond the Standard Model. In this work, we present for the first time a New Physics scenario in which the branching fraction $\Gamma(B_s \rightarrow e^+ e^-) \rightarrow \Gamma(B_s \rightarrow e^+ e^-) \rightarrow \Gamma(B_s \rightarrow e^+ e^-)$ is enhanced up to values which saturate the current experimental bounds. More concretely, we study the general Two-Higgs-Doublet Model (2HDM) with a pseudoscalar coupling to electrons unsuppressed by the electron mass. Furthermore, we demonstrate how this scenario can arise from a UV-complete theory of quark-lepton unification that can live at a low scale.
New Physics contributions. A previous measurement of angular observables of $b \to s$ in the Standard Model of Particle Physics (SM) at tree-level and may only occur in Flavor Changing Neutral Currents, such as $b \to s$.

In the Belle II experiment, leptonic $b$ meson decays such as $B \to \mu \nu$ are highly CKM- and helicity-suppressed. In a two-body decay like $B \to \mu \nu$, the muon momentum is exactly known in the rest frame of the signal-side $B$ meson. By boosting the signal-side muon into that frame, a better signal resolution and improved sensitivity can thus be achieved compared to the center-of-mass frame. This requires a high-precision for the boost vector, which can be determined from the rest of the event that contains the decay products of the second $B$ meson. At the same time, this information can be used to reconstruct the kinematics of the signal-side $B$ meson. Boosted decision trees are trained to deal with model discrepancies, suppress background and increase signal purity. The hadronic $B \to D^{\ast}[\to K^- \pi^+] \pi^- \nu$ decay can be used to validate different steps in the analysis of the $B \to \mu \nu$ decay. This talk will discuss the current status of the analysis for the measurement of the $B \to \mu \nu$ branching fraction with an integrated luminosity of 364 fb$^{-1}$ at the Belle II experiment.

Time: Tuesday 17:00–18:30

T 26.1 Tue 17:00 HSZ/0401
Multi-lepton $B$ decays within the Standard Model and their impact on LHCb

Johannes Albrecht, Emmanuel Stamou, Vitali Lisovsky, and Jan Peter Herdeckerhoff

Rare flavour-changing neutral current decays of hadrons to multi-lepton final states are sensitive probes of the Standard Model and thus among the target measurements at LHCb. A reliable Standard Model prediction of their rates is an essential input for the realistic simulation within the LHCb analyses even more so when analysing decays with non-trivial angular and $q^2$ dependence. One such analysis is the most recent search of $B^0 \to \mu^+ \mu^- \mu^+ \mu^-$ performed by the LHCb experiment and published in 2022. The main systematic uncertainty in this search comes from the missing Standard Model prediction. So far, only a simplified phase-space approach was used to simulate signal candidates in the LHCb analysis. In this talk, we present the computation and results of the Standard Model prediction of the decay $B^0 \to \mu^+ \mu^- \mu^+ \mu^-$, and its implementation in the simulation framework EVTGen. The impact of this calculation on the LHCb analysis is also evaluated.

T 26.2 Tue 17:15 HSZ/0401
Tests of muon-electron universality at the LHCb experiment

Alex Seachte and Johannes Albrecht

The LHCb experiment at the Large Hadron Collider (LHC) specialised in high-precision measurements of flavour physics with hadrons containing $b$ and $c$ quarks. Tests of lepton flavour universality are a sensitive and clean way to probe the Standard Model of particle physics. Any deviations from this universality would be a clear sign of new physics. In this talk, I will present the first simultaneous test of muon-electron universality using the full LHCb Run 1 and Run 2 dataset with the observables $R_{\mu\mu}$ and $R_{\mu\gamma}$. These observables are defined as ratios of the branching fractions of the decays $B^0 \to K^{\mu\nu} \mu^- \mu^+$ and $B^0 \to K^{\mu\nu} \epsilon^-\epsilon^+$, and $B^+ \to K^+ \mu^- \mu^+$ and $B^+ \to K^+ \epsilon^-\epsilon^+$, respectively. This result is the most sensitive test of lepton flavour universality with rare $b$ decay to date.

T 26.3 Tue 17:30 HSZ/0401
Angular analysis of the decay $B^0 \to K^{\mu\nu} \mu^- \mu^+$ with LHCb

Leon Carus*, Thomas Oeser*, Eluned Smith*, and Christoph Langenbruch* 11 Physikalisches Institut B RWTH Aachen − 2Massachusetts Institute of Technology

Flavor Changing Neutral Currents, such as $b \to s \ell^- \ell^+$ transitions, are forbidden in the Standard Model of Particle Physics (SM) at tree-level and may only occur at the loop-level. Angular analyses of $b \to s \ell^- \ell^+$ decays are thus very sensitive to New Physics contributions. A previous measurement of angular observables of $B^0 \to K^{\ell\ell}(\to K^- \pi^+) \mu^- \mu^+$ decays, performed by the LHCb collaboration using data collected during Run 1 and Run 2, 2016, focused on SM predictions at the level of 3 standard deviations.

The analysis of the full Run 2 data sample of LHCb, along with improvements of the analysis strategy, is expected to increase the precision of this measurement significantly. This talk will present the status of an update of this analysis, including LHCb data collected in 2017 and 2018.

T 26.4 Tue 17:45 HSZ/0401
Isospin asymmetry in $B \to K \mu^+ \mu^-$ decays

Johannes Albrecht, Fabio de Vellis, Vitali Lisovsky, and Biljana Mitreska

Isospin symmetry is a fundamental property of the Standard Model. It predicts a branching fraction that is almost the same for decays which differ only by one spectator quark, like $B^0 \to K^- \mu^+ \mu^-$ and $B^0 \to K^- \mu^+ \mu^-$. For these decays a quantity which describes differences in branching fraction, namely the isospin asymmetry, can be defined. This is particularly convenient since it is theoretically clean and it allows to cancel some experimental uncertainties.

Previous measurements on these decays from LHCb and Belle, despite being compatible with expectations, suggested coherent deviations that could be interpreted as statistical fluctuations, or unaccounted theoretical uncertainties, or as a sign of New Physics. In this talk an update of the asymmetry measurement with the full LHCb dataset is presented. This means that data corresponding to an integrated luminosity of 6 fb$^{-1}$ are added to the dataset used in the previous Run 1 analysis. Particular attention is given to the new strategy adopted to calibrate simulation samples to data.

T 26.5 Tue 18:00 HSZ/0401
Neutrino Cross-Section Measurements with the T2K Near Detector

Liam O’Sullivan for the DUNE Collaboration

T2K is a long baseline neutrino oscillation experiment in Japan, measuring electron (anti-)neutrino appearance in a muon (anti-)nu-neutrino beam. As a good understanding of neutrino-nucleus interactions is essential to enable precise oscillation measurements, the T2K near detector complex has been designed to measure neutrino interactions on a variety of nuclear targets for the T2K neutrino beam at a distance of 280m from the beam target. This talk presents an overview of the T2K cross-section measurement strategy in the context of both present and future neutrino oscillation measurements, together with selected cross-section results.
Since proton-oxygen data are not yet available, the first step is to bracket oxygen interest are proton-oxygen collisions, as they are a good proxy for air showers. Of particular interest are proton-ion data from the LHCb fixed-target mode are analysed. Of particular interest is the impact on forward produced hadrons and to test this universal-ment could truly be universal and thus potentially solve the Muon Puzzle. To this inconsistency lies in universal strangeness enhancement. Measurements of the ALICE and LHCb experiments show first evidence that this enhancement could truly be universal and thus potentially solve the Muon Puzzle. To further study the impact on forward produced hadrons and to test this universality, proton-iron data from the LHCb fixed target mode are analysed. Of particular interest are proton-oxygen collisions, as they are a good proxy for air showers. Since proton-oxygen data are not yet available, the first step is to bracket oxygen with helium and neon. The current status of this analysis is presented. Supported by DFG (SFB 1491)

### T 27: Searches II

**Time:** Tuesday 17:00–18:30  
**Location:** HSZ/0403

**T 27.1 Tue 17:00 HSZ/0403**

**CMS Dijet Anomaly Search with Substructure**  
**— Gregor Kasieczka, Louis Moureaux, Tobias Quadfasel, and Manuel Sommerhalder**  
— Institut für Experimentalphysik, Universität Hamburg

The extensive searches for physics beyond the Standard Model carried out at the LHC have so far yielded no positive result, despite the very large number of models that have been tested. This motivates the use of techniques based on machine learning that, unlike common search strategies, are capable of dynamically adjusting the event selection to the observed data. These “anomaly detection” methods are expected to feature broad coverage of potential new physics signatures and can thus fill the gaps between searches dedicated to specific models.

We present the application of such an anomaly detection method, CATHODE, in a search for resonant dijet events using substructure observables with the CMS experiment. CATHODE combines density estimation and weak supervision techniques to detect anomalous events in a signal region, interpolating the background from sidebands to achieve nearly optimal classification performance.

**T 27.2 Tue 17:15 HSZ/0403**

**The LHC as Lepton–Proton Collider: Searches for Resonant Production of Leptoquarks**  
**— Daniel Buchm, Michael Holzbrock, and Hubert Kroha**  
— Max-Planck-Institut für Physik (Werner-Heisenberg-Institut), München

Searches for leptoquarks constitute an essential part of the physics programme at the ATLAS detector. These hypothetical particles couple to a lepton and a quark and are predicted by many extensions of the Standard Model such as Grand Unified Theories. The existing leptoquark searches at the LHC currently only consider production modes via quark and/or gluon interactions. The small but non-zero lepton content of the proton, however, allows also for the so far unexplored resonant leptoquark production.

This production mode gives rise to lepton-plus-jet signatures. Thus, leptoquarks would emerge as peaks over the smoothly falling Standard Model background in the invariant mass spectrum of the lepton-plus-jet system. The talk will introduce the search strategy and present the current status of the analysis, focusing on final states with fermions of the first and second generation.

**T 27.3 Tue 17:30 HSZ/0403**

**Development of a new trigger for exotic particle searches with IceCube**  
**— Timo Stürwald**  
for the IceCube-Collaboration — Bergische Universität, Wuppertal, Deutschland

The IceCube Neutrino Observatory is a cubic kilometer scale Cherenkov light detector that also searches for signatures of particles beyond the standard model. The upcoming IceCube Upgrade and IceCube-Gen2 extension will improve the sensitivity for these searches due to an increased and partly denser instrumented sensitive volume. The better sensitivity allows for the detection of signatures of exotic particles including fractionally charged particles, which directly and indirectly produce light.

The development of a new trigger for faint signatures of exotic particles with the focus on fractionally charged particles is presented. The new trigger includes the analysis of isolated single hits that so far are not included in any IceCube trigger, because a large fraction of them originates from well understood noise sources. For simulated faint exotic signatures the isolated single hits become the dominant hit type. The improvement in signal efficiency and the estimated trigger rate for different trigger configurations will be presented. Furthermore, the results of running the new trigger at the IceCube test DAQ will be presented.

* Funded by BMWF-Verbundforschung Astrototaleinphysik

**T 27.4 Tue 17:45 HSZ/0403**

**Axion-Like-Particle (ALP) search using ATLAS central and ATLAS Forward Proton (AFP) detectors**  
**— On dre Matousek and Andre Sopczak**  
— CERN

The latest results of the ALP search with the AFP detector are presented.

**T 27.5 Tue 18:00 HSZ/0403**

**A TES for ALPS II - Status and Prospects**  
**— José Alejandro Rubiera Gimenó**  
for the ALPS-Collaboration — Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany

The Any Light Particle Search II (ALPS II) is a Light-Shining-through-a-Wall experiment operating at DESY, Hamburg. Its goal is to probe the existence of Axions and Axion Like Particles (ALPs), possible candidates for dark matter. In the ALPS II region of interest, a rate of photons reconverting from Axions/ALPs on the order of 10^5 cps is expected. This requires a sensor capable of measuring low-energy photons (1.165 eV) with high efficiency and a low dark count rate. We investigate a tungsten Transition Edge Sensor (TES) system as a photon-counting detector that promises to meet these requirements and is foreseen for a later science run of ALPS II. This detector exploits the drastic change in its resistance caused by the absorption of a single photon when operated in its superconducting transition region at millikelvin temperatures. In order to achieve the required sensitivity, the implementation of the TES into the ALPS II experiment needs to be carefully optimized. In this work, we present the progress on measurements for the characterization of dark noise, energy resolution, background rejection, efficiency and linearity of our sensor.

**T 27.6 Tue 18:15 HSZ/0403**

**LUXE-NP0 background estimation**  
**— Torben Fie, Alexander Heidembach, Markus Klute, Raquel Quispe, and Niccolo Trevisani**  
— Carl-sruhe Institute of Technology, Karlsruhe, Germany

The proposed LUXE experiment at the European XFEL at DESY will produce high-intensity electron-laser interactions to study QED in the non-perturbative regime. These interactions have as a secondary product a large flux of photons with energy up to a few GeV. The photons are then directed onto a physical dump allowing the production of axion-like particles (ALPs) in a region of parameters never probed before. The ALPs produced will decay into pairs of photons detected by an electromagnetic calorimeter. One of the challenges for ALPs searches at LUXE is to reduce the background of neutrons and non-resonant photons reaching the calorimeter. We present a systematic simulation study with different dump materials and depths we carried out in the quest of the best balance between signal acceptance and background suppression.

### T 28: Forward Physics

**Time:** Tuesday 17:00–18:30  
**Location:** HSZ/0101

**T 28.1 Tue 17:00 HSZ/0101**

**QCD cross-section measurements for astroparticle physics with the LHCh experiment**  
**— Jan Albrecht, Hans Dembinski, and Lars Koke**  
— TU Dortmund University, Dortmund, Germany

A long-standing issue in the field of cosmic-ray research is the discrepancy between the observed and simulated numbers of muons in cosmic-ray-induced hadronic showers in Earth’s atmosphere, which are called air showers. This discrepancy is referred to as the Muon Puzzle, as the required changes to existing models in simulation would violate either data constraints or the consistency between air shower simulations and other air shower features. One explanation for this inconsistency lies in universal strangeness enhancement. Measurements from the ALICE and LHCb experiments show first evidence that this enhancement could truly be universal and thus potentially solve the Muon Puzzle. To further study the impact on forward produced hadrons and to test this universality, proton-iron data from the LHCb fixed target mode are analysed. Of particular interest are proton-oxygen collisions, as they are a good proxy for air showers. Since proton-oxygen data are not yet available, the first step is to bracket oxygen with helium and neon. The current status of this analysis is presented.

**T 28.2 Tue 17:15 HSZ/0101**

**LHCb for astroparticle physics: Prompt production of identified charged hadrons**  
**— Johannes Albrecht, Julian Boelhaue, Hans Dembinski, and Michael Schmelling**  
— Universität Dortmund, Dortmund, Germany

A long-standing issue in the field of cosmic-ray research is the discrepancy in the number of muons produced in high-energy air showers between observations and simulation, referred to as the Muon Puzzle. Precision measurements of hadron production in the forward region are needed to validate and improve the hadron-production interaction models used in the simulation of air showers, with the aim of solving the Muon Puzzle. In this context, measuring the differential cross-section of prompt production of identified long-lived charged hadrons as a function of transverse momentum and pseudorapidity is of great importance.

An analysis in which this differential cross-section is determined for proton–proton and proton–lead collisions is presented in this talk. The corresponding data samples were recorded with the LHCb experiment at centre-of-mass energies of 13 TeV and 8.16 TeV in the nucleon–nucleon system, respectively. The focus of the talk is placed on the calibration of the particle-identification response of the detector, which is essential to an accurate measurement of the fractions
of the three most commonly produced hadrons, i.e. pions, kaons and protons, present in the data.

Supported by DFG (SFB 1491).

T 28.3 Tue 17:30 HSZ/0101
Obtaining the Total Cross-Section and $\rho$-Parameter from Elastic Proton-Proton Scattering at $\sqrt{s} = 900$ GeV with the ATLAS Subdetector ALFA — WOLFGANG FRIEBEL1, KARLHEINZ HILLER2, MUSTAFA SCHMIDT3, and HASIKO STENZEL1 for the ATLAS-Collaboration — BERNHARDT Universitatspräsidial — 1Deutsches Elektronen-Synchrotron DESY — 2Justus-Liebig-Universität Gießen

ALFA (Absolute Luminozity for ATLAS) is a Roman Pot (RP) detector system in the LHC tunnel, located around 240 m away from the Interaction Point (IP) downstream in the forward region of ATLAS. The ALFA subdetector contains several layers of scintillating fibers for tracking elastically scattered protons in the outgoing beams. The RPs are used as a housing for the fiber trackers and can be moved in small steps close to the beam to ensure proton tracking at small scattering angles. In 2018, 12 runs were recorded at a center-of-mass energy of $\sqrt{s} = 900$ GeV during several fills using special LHC beam optics with $\beta' = 100/50$ m parallel-to-point focusing. This combination makes it possible to probe various important physics parameters of pp interactions in the Coulomb-nuclear interference region, providing a unique evaluation of the underlying model predictions within the nonperturbative QCD regime. A fit describing the physics models to the elastic cross-section distribution, which is obtained from the calculation of the four-vector momentum transfer, allows the extraction of the nuclear slope parameter $B$, the total cross-section $\sigma$, and the $\rho$-parameter, defined as $\rho = 6 \cdot (f_0/(|J| f_0))$. This talk covers the current status of the ongoing analysis and future steps.

T 28.4 Tue 17:45 HSZ/0101
Physics potential of a combined data-taking of the LHCf and ATLAS roman pot detectors — YUSUF CAN CKEMECIELOGLU1, CLARA ELISABETH LEITGER1, and CIGDEM ISSEVER1 — 1DESY, Zeuthen, Germany — 2Humboldt University, Berlin, Germany

The study determines a common geometrical acceptance for the LHCf and ATLAS roman pot (ARP) detectors located in the forward regions of the ATLAS interaction point. In order to better understand the soft QCD processes and to improve pileup modelling for hadron accelerators and cosmic ray air shower modelling, a simultaneous analysis of central tracks (ATLAS), forward proton (ARP) and neutral particles (LHCf) could be beneficial. Analyses of single diffraction processes especially take advantage of these kind of setup, since the final state intact proton can be detected using ARPs and the neutral particles from the dissociated proton can be detected using LHCf and ATLAS Zero Degree Calorimeter (ZDC). Delta baryons produced in a pomereron exchange can lead to a similar signature with one neutral pion and one proton in the final state. This process, which effectively represents very low mass diffraction, is also taken into account in these studies.

In the end, a good common geometrical acceptance is found, yielding an acceptable event rate with the proposed joint data-taking between the detectors. Based on these studies, the ATLAS Forward Proton detector (AFP) joined the special run for LHCf in 2022, which results the very first combined data of LHCf, ZDC, ATLAS and AFP so far, with a recorded data of about 300 millions events.

T 28.5 Tue 18:00 HSZ/0101
Prospect studies for Proton-Oxygen Collisions at ATLAS, LHCf and AFP — YUSUF CAN CKEMECIELOGLU1, ERIK DECKOW2, CIGDEM ISSEVER1, and CLARA ELISABETH LEITGER1 — 1Humboldt Universität zu Berlin, Germany — 2DESY, Zeuthen, Germany

In astroparticle physics, ground based analysis is done by studying cosmic ray induced showers in the Earth’s atmosphere. The phenomenological models used to simulate the interaction of cosmic ray particles with the atmospheric nuclei cause large systematic uncertainties and thus need improvement. In the past, LHC has conducted proton-proton and proton-heavy nucleus (lead) collisions. In LHC run 3 there will be the opportunity to study proton-Oxygen collisions. The cross-sections and particle energy spectra in the forward regions that will be measured with this data can provide invaluable and complementary input to the aforementioned models. The main focus of these studies is on the feasibility of a combined data taking of LHCf, ATLAS and AFP detectors during the Oxygen collision run. This would allow for a better reconstruction of the event kinematics, as well as a purer selection of low mass single diffraction events than would be possible with LHCf data only.

T 28.6 Tue 18:15 HSZ/0101
Measurement of Fragmentation Cross Sections of Intermediate-Mass Nuclei with NA61/SHINE at CERN — NEBRAY AMIN for the NA61/SHINE Collaboration — Institute for Astroparticle Physics, Karlruhe Institute of Technology, Karlsruhe, Germany

Cosmic-ray propagation in the galaxy can be constrained by modeling the secondary-to-primary cosmic-ray flux ratios, like the boron-to-carbon flux ratio that reaches Earth. While these fluxes are currently measured with higher precision (<5%) by space-based detectors like AMS, CALET, and DAMPE, insufficient knowledge of nuclear fragmentation cross sections hinders our inference of propagation parameters. Therefore, laboratory measurements of fragmentation cross section above 10 GeV/$c$ are essential. We remediate this situation by utilizing the NA61/SHINE experimental facility at CERN. Pilot data on fragmentation was taken in 2018 with the main aim of proving the feasibility of performing fragmentation studies at SPS energies. Two fixed targets, polyethylene (C,H$_2$) and graphite were employed to study C+$p$ interactions at 13.5 GeV/$c$ beam momentum. In this contribution, we will present the isotopic production of boron including direct production of $^{10}$B and as well as via indirect channels originating from the decay of $^{12}$C and $^{13}$C fractions. We also report on the feasibility of measuring light and intermediate-mass nuclei from Li to Fe relevant for cosmic ray propagation studies. A dedicated high statistics data-taking is scheduled in late 2023 to study the fragmentation of various primary nuclei like C, N, O & Si.

T 29.0 Tue 17:00–18:30

T 29.0 Tue 17:00 HSZ/0103
Search for new physics in top quark production with an associated boson in the framework of the SMEFT — ARNULD QUADT, BAPTISTE RAVINA, ELIZABETH SHARALINA, and SREEKASHMI SINDHU for the ATLAS-Collaboration — II. Physikalisches Institut, Georg-August-Universität Göttingen, Germany

The Standard Model Effective Field Theory (SMEFT) provides a model independent approach to study beyond the Standard Model effects. A search for new physics using the framework of the SMEFT is performed using events with one or two top quarks in association with a boson (tW, tZ, tH, tH). The simultaneous analysis of these processes gives the opportunity to constrain a large number of dimension six SMEFT operators.

In this analysis, final states with two same sign or three isolated leptons are selected and classified into various regions based on the number of leptons, jets, b-jets and the total charge of the leptons. Using the event yields in these regions, limits are extracted on the SMEFT operators. This measurement is performed using the proton-proton collision data at $\sqrt{s} = 13$ TeV with an integrated luminosity of 139 fb$^{-1}$, recorded from 2015 to 2018 with the ATLAS experiment at the Large Hadron Collider at CERN.

The Belle II detector investigates the b-sector by measuring the decays of the Y(4S) resonance. These Y(4S) decays are produced by the SuperKEKB accelerator at KEK in Tsukuba, Japan. The goal of SuperKEKB is to achieve an instantaneous luminosity of 6.5 × 10$^{35}$ cm$^{-2}$s$^{-1}$, of which 4.7 × 10$^{35}$ cm$^{-2}$s$^{-1}$ has recently been reached.

The beam backgrounds at Belle II are mostly composed of storage and luminosity-induced backgrounds. Due to short beam lifetimes continuous top-up injections into both rings are necessary, resulting in injection-induced background spikes. BGN$^2$ is a neural network based diagnostic tool for real-time background decomposition and analysis. The training data for BGN$^2$ are 1 Hz time series of diagnostic variables describing the state of the SuperKEKB collider subsystems. Using feature attribution to explain the predictions, provides clues to identify the most relevant causes of changes in background levels.

T 29.3 Tue 17:30 HSZ/0103
Studies of ATLAS Forward Proton (AFP)ToF performance with Run-3 data — VIKTORIA LISSENKO and ANDRE SOPCZAK — CTU in Prague

Performance studies of ATLAS Forward Proton (AFP)ToF with Run-3 data are presented.

T 29.4 Tue 17:45 HSZ/0103
Search for γγ final states from Vector Boson Scattering at the ATLAS experiment — ORCUN KOYAL — Technische Universität Dresden, Germany

Vector boson scattering (VBS) is a suitable process to observe triple and quar-
Electroweak production of two jets in association with a Z boson in proton-proton collisions — KEIL, MORAL FIGUEROA — Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, D-22607 Hamburg

In recent years, the Large Hadron Collider (LHC) has played an important role in constraining extensions of the Standard Model (SM). One of the measurements which can contribute to it, is the electroweak production of the Z boson in association with two jets (EW Zjj). This process limits the anomalous weak-boson self-interactions, due to its sensitivity to the weak vector-boson scattering (VBS), an increasingly relevant process at the LHC.

In this talk, we present results of a new framework which efficiently reconstructs small-radius jets. Compared to a previous search, the EW Zjj mass spectrum diverges slightly among different Monte Carlo event generators. As a consequence, further studies are needed in order to obtain reliable model-independent measurements. The EW Zjj process is identified by imposing large invariant dijet mass and dijet pseudorapidity separation. First distributions are shown using the full Run 2 dataset.

A data-driven multijet background estimation method for the measurement of the electroweak Wjj production with the ATLAS experiment — LISA MARIE BALTES — Kirchhoff-Institute for Physics, University Heidelberg, Germany

The observation and measurement of self-interactions of weak gauge bosons provide an indirect search for physics beyond the Standard Model. The electroweak production of a W boson in association with two jets includes the vector-boson-fusion (VBF) production of a W boson and is thus sensitive to the triple gauge boson vertices WWγ and WWZ. In proton-proton collisions, the characteristic signature of VBF includes two high-momentum jets at small angles with respect to the incoming beams and a centrally produced lepton-neutrino pair originating from the W boson decay. A significant background for this analysis is multijet production via the strong interaction where a jet is misidentified as a lepton. Monte-Carlo simulation generally do not provide a proper description of QCD backgrounds. Therefore, data-driven techniques are used to estimate this background. In this talk, the current status of the analysis including the multijet background estimation using the matrix method is presented.

T 30: Higgs Charm, Di-Higgs

Time: Tuesday 17:00–18:30

The Higgs boson decay to charm quarks (H → c ¯ c) has the highest branching fraction of the yet unobserved decays. Moreover, it is predicted to be the strongest coupling to the second generation of fermions, which as of now remains unconfirmed. This talk presents a recent search by the CMS experiment for H → c ¯ c at high transverse momentum, primarily targeting the gluon fusion production mode. The method is validated with the Z → c ¯ c decay, which is observed for the first time in this channel and provides the strongest constraint yet at the LHC. The observed (expected) upper limit on H → c ¯ c process is set at 47 (39) times the SM prediction. The analysis was enabled by recent developments in deep learning tools for jet identification in such topologies.

Location: HSZ/0105

T 30.4 Tue17:45 HSZ/0105

Discrimination of Di-Higgs and Higgs-Z Boson Final States Using Neural Networks — LARS LINDEN, OTMAR BIEBEL, CHRISTOPH AMES, and CELINE STAUCH — Ludwig-Maximilians-Universität, München

Precise measurements of Higgs boson pair production are of significant importance for new physics searches and determining the Higgs potential’s exact shape. These processes have small cross-section however, making them exceptionally rare. As a result, neural networks are used to improve the experimental sensitivity for these processes. The employed network uses general event jet information and specific variables sensitive to di-Higgs production for event classification. This talk presents a network structure for distinguishing gg/HH from the important background process gg→HZ and its respective sensitive variables.

T 30.5 Tue18:00 HSZ/0105

Separation of HH and HZ processes in LHC events — CELINE STAUCH, OTMAR BIEBEL, CHRISTOPH AMES, and LARS LINDEN — LMU München

LHC Processes with HH final states and HZ final states are kinematically very similar due to H and Z boson being close in mass and both final states having similar cross sections in proton-proton collisions. While the H boson is a scalar particle, the Z boson has a spin of 1. The spin of the Z boson transfers to the jets in the final state leading to a correlation of the angles of those jets. For HH or HZ final states resulting in at least 4 jets all possible combinations of the four energetically highest jets are calculated in order to find the combination closest in mass to a H or Z boson. A variable sensitive to the correlation of the angles of the final state jets is introduced, which is a modification of the Ellis-Karliner angle. This variable is investigated using generator simulation data for the best combination of jets in HH final states ans HZ final states.

T 30.6 Tue18:15 HSZ/0105

A neural network based regression of the neutrinos in H → ττ decays for a resonant HH→bbττ analysis — PHILIP KEICHER, TOBIAS KRAMER, NATHAN PROUVOST, MARCEL RIEGER, PETER SCHLEPER, JAN VOSSE, and BODG WIEDERSPAN — Universität Hamburg

The CMS resonant HH→bbττ analysis searches for heavy spin 0/2 resonances decaying into two Higgs bosons which subsequently decay into bottom quarks and tau leptons. It uses the Run 2 data collected from 2016-2018 at a center of mass energy of $\sqrt{s} = 13$ TeV corresponding to an integrated luminosity of 138 fb$^{-1}$. As a wide range of resonance masses is covered, reconstructing the invari-
ant mass of the HH system and therefore the individual Higgs bosons is crucial. Especially for the Higgs boson decaying into tau leptons a significant amount of information is lost in the form of neutrinos not being measured by the detector.

This talk presents a study on how to regress the full HH system using deep neural networks in order to improve the mass resolution of a potential new heavy particle.

T 31: Theory Higgs, BMS

Time: Tuesday 17:00–18:15

T 31.1 Tue 17:00 HSZ/0201

Higgs pair production in SMEFT at full NLO QCD: an investigation of truncation effects — JANNIS LANG — Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany

We present results for Higgs boson pair production in gluon fusion at NLO (2-loop) QCD including operators in the Standard Model Effective Field Theory (SMEFT) framework. Contributions from subsets of higher order terms in \( \lambda \) such as squared dimension-6 operators at cross section level and double operator insertions at amplitude level, are used as a proxy for the study of truncation effects of the SMEFT expansion. The different truncation options are contrasted to the non-linear Higgs Effective Field Theory (HEFT) framework for selected phenomenological examples.

T 31.2 Tue 17:15 HSZ/0201

Precision test of the muon-Higgs coupling at a high-energy muon collider — NILS KREHER1, TAO HAN2, WOLFGANG KILIAN1, YANG MA1, JURGEN REUTER1, TOBIAS STRIEGEL1, and KEPING XI1 — Department of Physics, University of Siegen, Walter-Flex-Straße 3, 57068 Siegen, Germany — 2Pittsburgh Particle Physics, Astrophysics, and Cosmology Center, Department of Physics and Astronomy, University of Pittsburgh, Pittsburgh, PA 15206, U.S.A. — 3Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, 22607 Hamburg, Germany

I will present a sensitivity test of the muon-Yukawa sector at a high-energy muon collider. While in the Standard Model this sector is described by a single parameter, effects of new physics that is not aligned with the Standard Model Yukawa interactions may introduce a more sophisticated parameter dependence, which can be understood either in SMEFT or a HEFT framework. With the accidentally small value of the muon Yukawa coupling and its subtle role in the high-energy production of multiple (vector and Higgs) bosons, I will show that it is possible to measure the muon-Higgs coupling to an accuracy of ten percent for a 10 TeV muon collider and a few percent for a 30 TeV machine by utilizing the three boson production, potentially sensitive to a new physics scale about 10–30 TeV. In addition I will discuss effects of an extended Higgs sector to the same processes in both frameworks.

T 31.3 Tue 17:30 HSZ/0201

Projecting composite operators onto a unique basis — ROBERT V. HARLANDER1, JAKOB W. LINDER2, and MAGNUS C. SCHAAP — 1Institute for Theoretical Particle Physics and Cosmology, RWTH Aachen University, Aachen, Germany

The Standard Model effective field theory (SMEFT) describes the low-energy effects of possible high-energy theories in terms of Standard Model fields. In a top-down approach, the effective Lagrangian can be obtained by constructing the effective action using a functional matching procedure, for example. However, this yields a non-unique action in general.

To restore the desired uniqueness, an algorithm is developed to decompose any operator with arbitrary mass dimension into operators free of redundancies due to equations of motion, integration-by-part identities or internal symmetries. For this purpose, the operators are converted into a redundancy-free basis, which can be constructed automatically for arbitrary mass dimensions. In this talk, I will report on such a basis and ProSMEFTion, our implementation of the algorithm.

T 31.4 Tue 17:45 HSZ/0201

Debye mass effects in the Dark Sector in the Early Universe — SIMONE BIONDINI1, NORA BRAMBILLA2, ANDRIS DASHKO2, GRAMOS QERMI1, and ANTONIO VALE2 — 1Department of Physics, University of Basel, Klingelbergstr.ler Stiege 82, CH-4056 Basel, Switzerland — 2Physik-Department, Technical University Munich, James-Franck-Str. 1, 85748 Garching, Germany — 3Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany

We address the impact of the thermal Debye mass \( m_D \) scale on the bound-state formation and ionization (dissociation) in the dark sector in the Early Universe. We focus on heavy dark fermions (with mass \( m \)) charged under a \( U(1)_g \) group coupling dark matter to dark photons and dark light fermions with the coupling constant \( a \sim g^2/4\pi \). We determine the effect of the HTL resummation on the bound state formation and dissociation rates of heavy dark fermions in presence of a hot (with temperature \( T \)), weakly coupled (\( T < g_D T \)) dark plasma, under the assumption that \( m > m_D > T \). Our analysis is based on Non-Relativistic Effective Field Theory (NREFT) to address the dark matter threshold dynamics and on Thermal Field Theory to address the thermal scales. We obtain and solve coupled Boltzmann equations and show how our results affect the evolution of the dark matter density in the Early Universe. Working with this simplified model of the dark sector, we show that the effect of HTL resummation on the bound state formation and thermal relic abundance is non-negligible (and of the same order as the NLO fixed order correction), which indicates the importance of further studies in more realistic scenarios.

T 32: Di-Higgs, Higgs BSM

Time: Tuesday 17:00–18:30

T 32.1 Tue 17:00 HSZ/0204

Employing Matrix Elements with Neural Networks to Search for Higgs Self-coupling — CHRISTOPH AMES1, OTMAR BIEBEL2, LARS LINDEN2, and CELINE STAUCH3 — Ludwig-Maximilians-Universität, München

The Higgs boson was discovered in 2012 as predicted by the Standard Model (SM), however, not all of its predicted couplings have been measured yet. One such coupling is the Higgs self-coupling, in which a Higgs boson decays into two further Higgs bosons. By integrating over all possible initial states and by using the details of the end state, the matrix element method evaluates the weight of an event for the specific production cross section. In this work, machine learning is combined with the matrix element method to search for \( HH \to bb WW \) using simulated data. A neural network is trained to calculate the matrix element weight of an event and to use this to determine whether the event contains a signal or a background decay.

T 32.2 Tue 17:15 HSZ/0204

Prospects for measuring di-Higgs production at the ILC — JULIE TORNDAL1, JENNY LIST1, and YASHER RADKHORAMI2 — 1Deutsches Elektronen-Synchrotron DESY, Hamburg — 2Universität Hamburg, Hamburg, Germany

The Higgs mechanism is a central part of the Standard Model (SM). However, at this point in time, it has not been established experimentally which can only be done by reconstructing the Higgs potential. In the SM, the shape of the potential
is determined by the Higgs self-coupling, which can be measured directly and model-independently at future linear e+e- colliders through di-Higgs production.

The Intentional Linear Collider (ILC) offers a clean experimental environment and a physics programme with sufficient energies to produce di-Higgs events. The measurement suffers from small production cross sections and a large jet multiplicity, imposing high standards on the reconstruction tools. Modern reconstruction tools have been shown to be a large improvement since the di-Higgs analysis was last visited almost 10 years ago. These improvements are foreseen to improve the precision, and an analysis strategy is presented focusing on an accurate event reconstruction and Z/H separation. Other aspects such as the data centre-of-mass energy and BSM effects might also influence the reachable precision and will be considered.

T 32.3 Tue 17:30 HSZ/0204
Prospects for constraints on light-quark Yukawa couplings from differential distributions of Higgs boson production in the diphoton decay channel — JANNES ERDMANN and JAN LUKAS SAPL — III. Physikalisches Institut A, RWTH Aachen University

More than ten years after the discovery of the Higgs boson, various production and decay channels have been explored experimentally. However, the constraints on couplings to the light quarks up, down, and strange are comparatively weak as they are challenging to probe experimentally.

In this talk, studies to constrain these couplings based on the production mode of quark-antiquark annihilation in the diphoton decay channel are presented. The focus lies on the discrimination of this signal from H + X component against the dominant Standard Model contribution from gluon-gluon fusion. For this, the transverse momentum and the rapidity of the Higgs boson play an important role.

Expected upper limits on the Yukawa couplings to the three light quark species are presented. The potential for this interpretation in light of the large statistical power of the datasets collected with the High-Luminosity Large Hadron Collider is highlighted.

T 32.4 Tue 17:45 HSZ/0204
Search for heavy Higgs bosons in LF2L final state at CMS — MATTEO BONOMI, YANNICK FISCHER, JOHANNES HALLER, DANIEL HUNDHAUSEN, and MATTHIAS SCHRÖDER — Institut für Experimentalphysik, Universität Hamburg

All measurements of the properties of the Higgs boson at 125 GeV are compatible with a standard model-like behaviour. However, the observed resonance might well be part of an extended Higgs sector, which is predicted in various scenarios of new physics beyond the standard model. Two Higgs Doublet Models (2HDM) provide a generic description of the phenomenology arising in models with a second Higgs doublet. In this talk, we will present a search for a hypothetical CP odd heavy Higgs boson A decaying into a CP even heavy Higgs boson H and a Z boson, with the H decaying further into a pair of top quarks. This decay channel is particularly relevant in the high mass and low tan(β) regime. We will present the strategy and status of the analysis of data collected with the CMS experiment at a centre of mass energy of 13 TeV, targeting the fully hadronic τ decay.

T 32.5 Tue 18:00 HSZ/0204
Exotic Higgs Decays: ATLAS Search for Higgs Decays to Two Light Scalars — JUDITH HOEFER, CLAUDIA SEITZ, and BEATE HEINEMANN — DESY, Hamburg, Germany

Extensions of the SM Higgs sector featuring one or several singlet scalar fields are realised in many RSM models. While several searches have been performed targeting decays of the SM Higgs boson to two light spin-zero particles of the same mass, the decay to two new scalars of different mass is largely unexplored. The successive decays of these particles can give rise to spectacular high-multiplicity collider signatures, including so-called cascade decays, where the heavier of the scalars decays into the lighter one. The talk discusses an analysis searching for scalar decays to multi-b final states at the ATLAS experiment at the Large Hadron Collider, CERN. The analysis focuses on the ZH production mode and the channel where the scalars decay to b-quarks, resulting in a challenging low-pT jet final state. Particular focus is put on the cascade decays that result in a b final state. The signatures motivate the use of new reconstruction techniques, such as a newly developed low-pT X→bb tagger or the reconstruction of soft secondary vertices.

T 33: DAQ NN/ML – GRID I

Time: Tuesday 17:00–18:30
Location: HSZ/0301

T 33.1 Tue 17:00 HSZ/0301
Track reconstruction with Graph Neural Networks on FPGAs for the ATLAS Event Filter at the HL-LHC — SEBASTIAN DITTMER and SACHIN GUPTA — Physikalisches Institut, Universität Heidelberg

The High-Luminosity LHC (HL-LHC) will enhance the potential to discover new physics with the ATLAS experiment beyond its reach at the LHC. To cope with the increased pile-up foreseen during the HL-LHC, major upgrades to the ATLAS detector and trigger system are required. The trigger system will consist of a hardware-based trigger and an online server farm, called the Event Filter (EF), with track reconstruction capabilities. For the EF, a heterogeneous computing farm consisting of CPUs and potentially GPUs and/or FPGAs is under study, together with the use of modern machine learning algorithms such as Graph Neural Networks (GNNs).

GNNs are a powerful class of geometric deep learning methods for modelling spatial dependencies via message passing over graphs. They are well-suited for track reconstruction tasks by learning on an expressive structured graph representation of hit data. A considerable speed-up over CPU-based execution is possible on FPGAs.

In this talk, a study of track reconstruction for the ATLAS EF system at HL-LHC using GNNs on FPGAs is presented. The main focus is set on model size minimization using quantization aware training, as resource utilization is a key aspect in the application of GNNs on FPGAs.

T 33.2 Tue 17:15 HSZ/0301
Convolutional Neural Networks on FPGAs for Processing of ATLAS Liquid Argon Calorimeter Signals — JOHANN CHRISTOPH VOIGT, ANNE-SOPHIE BERTHOLD, NICK FRITZSCHE, RAINER HENTGES, CHRISTIAN GUTSCHE, and ARNO STRAßNER — Institut für Kern- und Teilchenphysik, TU Dresden, Germany

The Phase-II upgrade of the ATLAS Liquid Argon Calorimeter allows for the energy reconstruction of all ~180000 readout channels at the LHC bunch crossing frequency of 40 MHz. Further challenges arise from the increased pile-up due to the planned higher number of simultaneous proton-proton collisions.

For the digital energy reconstruction, we propose the use of Convolutional Neural Networks (CNNs) instead of the previous Optimal Filter. The networks need be able to run on an FPGA with limited resources and are therefore limited in complexity to approximately 100 weight parameters.

This talk focuses on the firmware implementation of these networks in VHDL. The implementation is optimized for DSP usage and latency. To be able to process all readout channels on the available FPGAs, time domain multiplexing is used to process multiple channels per CNN instance. This reduces the number of required instances and increases the frequency the design needs to run at. A multiplexing factor of 12 at a frequency of 480 Mhz is demonstrated for a design processing 384 detector cells. The latest FPGA resource usage estimates are presented.

T 33.3 Tue 17:30 HSZ/0301
Implementation of neural networks for live reconstruction using AI processors — KLAUS DESCH, JOCHEN KAMINSKI, MICHAEL LUPBERGER, and PATRICK SCHWABU — Physikalisches Institut, Universität Bonn, Deutschland — Helmholtz-Institut für Strahlen- und Kernphysik, Universität Bonn, Deutschland

For years, data rates generated by modern detectors and the corresponding readout electronics exceeded by far the limits of data storage space and bandwidth available in many experiments. The solution of using fast triggers to discard uninteresting and irrelevant data is a solution used to this day. Using FPGAs, ASICs or directly the readout chip, a fixed set of rules based on low level parameters is applied as a pre-selection. Only a few years ago, live track reconstruction for triggering was rarely possible but with the emergence of fast and highly parallelized processors for AI inference attempts to sufficiently accelerate tracking algorithms become viable. The Xilinx Versal AI Adaptive Compute Acceleration Platform (ACAP) is one such technology and combines FPGA and CPU resources with
dedicated AI cores. Our approach is to utilize the unique combination of FPGA and AI cores to leverage neural networks for live triggering which will be relevant for future experiments and upgrades of already existing setups.

In this talk AI algorithms for track reconstruction, especially their quantization and non-quantized implementation on the Xilinx VC1902, will be shown. They will be used in an envisioned mid-size ultra-high rate fixed-target dark matter experiment (Lohengrin) at the ELSA accelerator at the University of Bonn.

T 33.4 Tue 17:45 HSZ/0301

Profilling of GPU-based neural network trainings — Tim Voigtlander, Manuel Gieffers, Artur Gottmann, Günter Quast, Matthias Schnepf, and Roger Wolf — Karlsruhe Institute of Technology, Karlsruhe, Germany

The training of neural networks has become a significant workload of particle physics analyses. To speed up these trainings and reduce their turnaround cycle, one or more accelerators, e.g. GPUs, are typically utilized. While the increase in computational capacity is greatly beneficial, the heterogeneous hardware also adds layers of complexity to an already opaque process. In order to improve the efficiency in the usage of the available hardware, suitable profiling to identify possible bottlenecks. In this talk, solutions to a number of commonly occurring challenges found in single- and multi-GPU neural network trainings are presented, using the DeepTau neural network training as a case-study.

T 33.5 Tue 18:00 HSZ/0301

Open Science in KM3NeT and profiling of GPU-based neural network trainings — Rodrigo Gracia-Ruiz for the ANTARES-KM3NeT-ERLANGEN-Collaboration — FAU-ECAP, Erlangen, Germany

The KM3NeT neutrino detectors are currently under construction at two locations in the Mediterranean Sea, with a first data taking of high-energy neutrino interactions already under way. This scientific data is valuable both for the astrophysics and neutrino physics communities as well as for marine biologists. In order to facilitate FAIR data sharing of the research results, the KM3NeT collaboration is actively working towards an open science infrastructure to provide high-level scientific data, software, and analysis pipelines in an interoperable research environment suited both for research and education. This contribution introduces the open science program of KM3NeT and gives an overview of its current architecture and implementation.

T 34.1 Tue 17:00 HSZ/0405

EquiVariant Normalising Flows for Particle Jets — Cedric Ewen — Institut für Experimentalphysik, Universität Hamburg

In high energy physics, current Monte Carlo simulations are time-consuming and the demand for fast computationally efficient simulations is rising. Therefore, generative machine learning models have become a major research interest due to their ability to speed up data generation. A data structure capable of describing collider events such as jets are variable-size point clouds. However, due to complex correlations between the points, a powerful architecture is needed for high generative fidelity. Continuously normalising flows (CNFs) can model these complex process points while having traceable likelihood and straightforward sampling. We show an implementation of an architecture using CNFs with equivariant functions and compare its performance to multiple GAN approaches on benchmark datasets.

T 34.2 Tue 17:15 HSZ/0405

Identification of b- and B-Jets Using a Deep-Sets-Based Flavour-Tagging Algorithm with the ATLAS Experiment — JochiKa Birke, Martin Günthner, and Annette Knue — University of Freiburg — University of Hamburg — University of Geneva

Jets that contain two b-hadrons (bb-jets) are usually not considered as an individual target class in flavour-tagging algorithms. Instead, these jets are included in an inclusive b-jet category which consists of single b-jets and b̄-jets, making these two types of jets indistinguishable when they are processed with such an algorithm.

While this is sufficient for most physics analyses, an explicit identification of bb-jets could be promising for analyses like the search for the tH→bb signal, whose production cross section is not reducible into t + b̄ or t̄ + b̄ background. This reducible background contains the same final-state particles as the signal, including four b-quarks. In the background process, a radiated gluon can split into a b-quark pair, which might be contained in one single jet. In order to improve the rejection of these particular background events, the ATLAS DL1 algorithm, which is the b-tagging algorithm designed for ATLAS Run 3 analyses, is extended with an additional output class dedicated to bb-jets (bb-DL1).

By applying a cut in a two-dimensional discriminant plane, bb-DL1 provides a proof-of-concept for a flavour-tagging algorithm that is capable of both inclusive b-tagging and bb-jet identification. The design of the bb-DL1 algorithm and its most important, Deep-Sets-based, level tagger bb-DIPS are discussed in this talk. Furthermore, performance studies for both algorithms are shown.

T 34.3 Tue 17:30 HSZ/0405

Improving the robustness of jet tagging algorithms with adversarial training — Hendrik Schönken, Annika Stein, Judith Bennertz, Xavier Courbez, Alexander Jung, Summer Kassem, Ming-Yan Lee, Spanadan Mondal, Alexandre de Moor, Andrzej Novak, and Alexander

SCHMIDT1 — III. Physikalisches Institut A, RWTH Aachen University, Germany — 2Brown University, USA — 3Vrije Universiteit Brussel, Belgium

Neural network architectures have advanced over the last decade and are an important part of current jet flavour tagging algorithms. Since these algorithms rely on training the network with simulated events as input, they might have a worse performance on detector data due to data/MC deviations. A possible approach to address this issue is adversarial training, which uses distorted inputs for training. One possibility to distort the inputs is applying a FGSM attack, which shifts the inputs in a way that maximizes the loss with a fixed magnitude. This talk is about the impact of adversarial training on the model performance and robustness.

T 34.4 Tue 17:45 HSZ/0405

Binning high-dimensional classifier output for HEP analyses through a clustering algorithm — Svenja Diekmann, Niclas Eich, and Martin Erdmann — III. Physikalisches Institut A, RWTH Aachen University

The usage of Deep Neural Networks (DNNs) as multi-classifiers is widespread in modern HEP analyses. In standard categorisation methods, the high-dimensional output of the DNN is often reduced to a one-dimensional distribution by exclusively passing the information about the highest class score to the statistical inference method. Correlations to other classes are hereby omitted. Moreover, in common statistical inference tools, the classification values need to be binned, which relies on the researcher’s expertise and is often non-trivial. To overcome the challenge of binning multiple dimensions and preserving the correlations of the event-related classification information, we perform K-means clustering on the high-dimensional DNN output to create bins without marginalising any axes. We evaluate our method in the context of a simulated cross section measurement at the CMS experiment, showing an increased expected sensitivity over the standard binning approach.

T 34.5 Tue 18:00 HSZ/0405

Resonant anomaly detection without background sculpting — Manuel Sommehler1, Gregor Kasieczka2, Tobias Quadfasel1, Anna Hallin2, and David Shih3 — 1Institut für Experimentalphysik, Universität Hamburg, 22761 Hamburg, Germany — 3Center for Data and Computing in Natural Sciences (CDDS), 22607 Hamburg, Germany

Anomaly searches are a class of machine learning–based methods to search for new phenomena without relying on specific signal and background models. They provide a promising complement to the typically model-dependent searches for physics beyond the standard model at the LHC. Resonant anomaly detection methods, such as CATHODE, make use of the assumptions of a signal being localized in one feature and have demonstrated great performance in terms of classifying new physics signals on simulation-based studies. However, they are prone to background sculpting in the case of input features being correlated with the resonant one and thus can ultimately impair a background estimation via the

T 34.6 Tue 18:15 HSZ/0301

Towards JupyterHub as one point of entry for the PUNCH4FDI computing infrastructure — Lukas Vomberg, Philip Bechtel, Oliver Freyermuth, and Peter Wienemann for the PUNCH4FDI Consortium-Collaboration — Physikalisches Institut Bonn

OpenScience in KM3NeT and profiling of GPU-based neural network trainings — Rodrigo Gracia-Ruiz for the ANTARES-KM3NeT-ERLANGEN-Collaboration — FAU-ECAP, Erlangen, Germany

The KM3NeT neutrino detectors are currently under construction at two locations in the Mediterranean Sea, with a first data taking of high-energy neutrino interactions already under way. This scientific data is valuable both for the astrophysics and neutrino physics communities as well as for marine biologists. In order to facilitate FAIR data sharing of the research results, the KM3NeT collaboration is actively working towards an open science infrastructure to provide high-level scientific data, software, and analysis pipelines in an interoperable research environment suited both for research and education. This contribution introduces the open science program of KM3NeT and gives an overview of its current architecture and implementation.
bump hunt. We thus propose Latent CATHODE (LaCATHODE), a new technique for resonant anomaly detection, which moves the features into a decorrelated latent space. Using the LHC Olympics R&D dataset, we observe that LaCATHODE leaves the background unsupervised while retaining much of the signal extraction performance of the original CATHODE approach.

T 34.6 Tue 18:15 HSZ/0405
ANN for Pulse Shape Analysis in GERDA Collaboration — Max-Planck-Institute for Nuclear Physics, Heidelberg
The GERDA experiment searches for the neutrinoless double-beta decay of 76Ge using enriched high-purity Germanium diodes as a source as well as a detector. For such a rare event search, the sensitivity of the experiment can be improved by employing active background suppression techniques. The time-profile analysis of the signals, called pulse shape analysis (PSA), generated by energy deposits within the detectors is employed to discriminate signal and background events. An effective PSA with artificial neural networks can reject the background events like alpha particles and Compton scattered photons while preserving a high signal efficiency for double beta decay-like events.

Coaxial detectors due to their geometry have significantly homogeneous weighting potential adding a spatial dependence to pulse shapes. This makes the signal-background differentiation difficult with the use of simple monoparametric cuts and to overcome this, we employ a multi-variate analysis with artificial neural networks which are capable of modeling complex relationships.

I will give a review of the methodology in building these ANN and their performance for PSA in GERDA.

T 35: Neutrino Astronomy II

T 35.1 Tue 17:00 POT/0051
Simulation of Bioluminescence for the Pacific Ocean Neutrino Experiment — Moritz Brandenburg and Christian Haack for the P-ONE-Collaboration — Technical University Munich, Germany
The Pacific Ocean Neutrino Experiment (P-ONE) is a planned cubic kilometer-scale neutrino telescope in the Pacific Ocean. The first prototype detector line, P-ONE-1, is currently under construction. It consists of multi-PMT optical modules that will measure Cherenkov light produced by high-energy charged particles that stem from neutrino interactions in water. The optical modules are very sensitive to photons in the optical range, thus studying the impact of luminescent bio-organisms in the deep sea is crucial to forecasting expected trigger rates and the impact on neutrino searches. In this contribution we present a simulation that models the expected water currents around the optical modules which lead to stress-induced light emission of luminescent organisms. In the next step, the simulation propagates individual photons from expected emission positions to a simulated optical module. Analyzing the photon hits and PMT coincidences helps in designing the trigger algorithm that filters noise and reduces the background data rate.

T 35.2 Tue 17:15 POT/0051
Optical Timing and Synchronization for the Pacific Ocean Neutrino Experimen — Lea Ginzeky, Christian Spannfullner, Michael Bohmer, and Elisa Resconi for the P-ONE-Collaboration — Technical University of Munich, Garching bei München, Germany
The Pacific Ocean Neutrino Experiment (P-ONE) aims to instrument more than one cubic kilometer of the Northeast Pacific Ocean off Vancouver Island (Canada) as a non-invasive next-generation neutrino telescope. P-ONE will measure high-energy astrophysical neutrinos and characterize the nature of astrophysical accelerators. A sub-nm timing synchronization with the photodetectors in the detector volume is necessary to reconstruct the direction and energy of such highly energetic particles. Between the individual components of the P-ONE detector point-to-point fiber connections are used. A special implementation of Ethernet allows to proliferate a central clock and synchronization signals to all modules in the system in real time, while offering a high bandwidth data connection by established protocols. This approach reduces the complexity of the system and cable design and optimizes the power consumption within the detector. First results of on- and offline delay measurements will be presented.

T 35.3 Tue 17:30 POT/0051
Neutrino detection with new triggers at the Pierre Auger Observatory* — Srijan Sehgal and Michael Schimp for the Pierre Auger-Collaboration — Bergische Universität Wuppertal, Wuppertal, Germany
The Pierre Auger Observatory apart from detecting ultra-high energy cosmic rays is also an excellent instrument to look for highly inclined neutrino-induced air showers using its Surface Detector (SD) array. To improve the detection efficiency and to decrease the energy threshold of the array, two new SD triggers, time-over-threshold-deconvoluted (ToTD) and multiplicity of positive steps (MoPS) were added in 2014.

This talk presents the work done to evaluate the effect of new triggers on the neutrino search. Events with energies below $10^{19}$ eV and in the zenith angle range of $60° < \theta < 75°$ are selected for both data and simulated neutrino-induced showers. The particular focus is on the improvements with the new triggers, MoPS and ToTD, to the neutrino sensitivity in comparison to previous

neutrino searches at the Pierre Auger Observatory.

*Gefördert durch die BMBF Verbundforschung Astroteilchenphysik (Vorhaben 05A20PX1)

T 35.4 Tue 17:45 POT/0051
Novel approaches in multimessenger observation of core-collapse supernovae — David Maximovic and Michael Wurm — Johannes Gutenberg University, Mainz, Germany
In the case of a nearby galactic core collapse supernova (CCSN), large-scale neutrino observatories and gravitational wave interferometers are expected to provide a wealth of experimental data. This contribution presents a novel machine learning approach in the field of multi-messenger astronomy by investigating possible correlation between features in gravitational waves (GW) and neutrino signals originating from such galactic CCSN. Overarching phenomena during the explosion process can be better understood, such as the suspected standing accretion shock instability (SASI) or oscillation modes of the newly formed proto-neutron star. Applying machine learning on combined GW- and neutrino-detector outputs from simulated CCSN can enable us a potential reconstruction of these crucial moments and parameters such as the shock radius during the explosion.

T 35.5 Tue 18:00 POT/0051
Event selection and spectrum unfolding for Supernova burst neutrinos in JUNO — Diilo Birkenfeld, Achim Stahl, Jochen Steinmann, and Christopher Wiebusch — RWTH Aachen University
No core-collapse supernova (CC-SN) exploded close enough to be observed by terrestrial neutrino telescopes since the first detection of neutrinos from SN 1987A. The Jiangmen Underground Neutrino Observatory (JUNO) is a next-generation liquid scintillator detector with a large target mass of 20 kt. It will provide valuable insight into the details of the SN mechanism by observing the neutrino burst of a galactic CC-SN with high statistics and an unprecedented energy resolution of $3% \text{ at } 1\text{ MeV}$. JUNO will be sensitive to signals from all neutrino flavors via different detection channels. The reconstruction of their respective energy spectra requires an effective event classification. In this talk, we will present the results of an event classification and a subsequent Bayesian energy spectrum unfolding.

T 35.6 Tue 18:15 POT/0051
Hunting Supernova neutrinos with dark matter detectors — Melih Kara — Karlsruhe Institute of Technology, Institute for Astroparticle Physics
During a massive star’s death, 99% of its energy is released in the form of neutrinos. Neutrinos of all flavors escape the core well before any light. If detected, they can provide crucial information on stellar core collapse and its mechanisms. Detection of the next galactic supernova will provide the first multimessenger signal from electromagnetic waves, gravitational waves, and neutrinos. While existing neutrino observatories mostly probe neutrinos of a single flavor, ton-scale dark matter detectors can provide information from all flavors through coherent elastic neutrino-nucleus scattering, CE$
u$N, in the low-energy (few keV) range.

In this talk, we will discuss the challenges and opportunities of using two-phase xenon dark matter detectors for supernova neutrino detection, and we will review some of the recent results and future prospects in this exciting field of research. I am also going to introduce the supernova early warning system, SNEWS, and the integration of the XENON1T experiment to SNEWS.
**T 36: Gamma Astronomy II**

**Time:** Tuesday 17:00 – 18:30  
**Location:** POT/0151

**T 36.1 Tue 17:00 POT/0151**  
**Status of the Medium-Sized Telescopes of the Cherenkov Telescope Array**  
--- **MODEL NAME**  
--- **TITLE**  
--- **AUTHOR**  
--- **AFFILIATION**

The Cherenkov Telescope Array (CTA) is the next-generation ground-based observatory for gamma-ray astronomy at very high energies. In its initial Alpha Configuration, it will consist of 64 imaging atmospheric Cherenkov telescopes of different sizes and designs, which will be deployed in the form of two large arrays in the northern hemisphere at the Roque de Los Muchachos Observatory on La Palma (Canary Islands, Spain) and in the southern hemisphere at the Paranal Observatory in the Atacama Desert (Chile), respectively.

The core energy range (100 GeV to 10 TeV) will be covered by the Medium-Sized Telescopes (MSTs), which are planned to be deployed at both sites. An international collaboration of institutes and universities from various countries is responsible for the design, construction and commissioning of the MSTs. The MST effort is grouped into three subprojects: one for the telescope structure, and two for the Cherenkov cameras which differ in their camera design.

In this contribution, an overview of the MST telescope and the status of the MST project will be presented, including the plans for building one preproduction telescope, a so-called pathfinder, per site ahead of the bulk production.

**T 36.2 Tue 17:15 POT/0151**  
**Status of the Large-Sized Telescopes of the Cherenkov Telescope Array**  
--- **MODEL NAME**  
--- **TITLE**  
--- **AUTHOR**  
--- **AFFILIATION**

The Cherenkov Telescope Array (CTA), the next-generation ground based observatory for gamma-ray astronomy at very high energies, will consist of Imaging Atmospheric Cherenkov Telescopes of different sizes and designs. Two arrays are foreseen, one in the northern hemisphere at the Roque de Los Muchachos Observatory on La Palma (Canary Islands, Spain) and one in the southern hemisphere at the Paranal Observatory in the Atacama Desert (Chile).

The Large-Sized Telescope (LST) will be part of both arrays. With its reflective surface of 23 meter diameter, the LSTs are optimized to detect gamma-rays in the low energy range (20 GeV to 3 TeV). LST-1 in La Palma is close to finishing its commissioning phase and scientific data taking has started.

In this presentation, the status and plans for the LSTs in La Palma and Chile will be shown.

**T 36.3 Tue 17:30 POT/0151**  
**LST-1 observations of BL Lacertae flare in 2021**  
--- **MODEL NAME**  
--- **TITLE**  
--- **AUTHOR**  
--- **AFFILIATION**

In this contribution, we will present the results of LST-1 observations of BL Lacertae in 2021, including the energy spectrum down to the energy threshold of LST-1 and sub-hour-scale fast flux variability.

--- **T 36.4 Tue 17:45 POT/0151**  
**Status and results of TAIGA**  
--- **MODEL NAME**  
--- **TITLE**  
--- **AUTHOR**  
--- **AFFILIATION**

The MAGIC collaboration consists of a distributed array of 120 wide angle (0.6 sr) air Cherenkov timing stations (TAIGA-HiSCORE) covering 1.1 square-km, 3.4m 2 imaging air Cherenkov telescopes (TAIGA-IACTs) with a field of view of 9.6 deg, and a surface and underground scintillator-based muon detector array. For a proof-of-principle of the hybrid method, combining IACTs with a non imaging timing array, first the individual components were tested. Both the HiSCORE array and the IACTs were found to operate within expectations using simulations and comparisons to real data. Measurements of a light source onboard the international space station were used to verify the pointing of HiSCORE and IACTs. Recently, the Crab Nebula was detected using data from the first TAIGA-IACT in stand alone mode. In the beginning of March 2022, we froze the collaboration work, but the German team is continuing to work with the available data.

--- **T 36.5 Tue 18:00 POT/0151**  
**FACT - Ten Years of Operation**  
--- **MODEL NAME**  
--- **TITLE**  
--- **AUTHOR**  
--- **AFFILIATION**

The MAGIC Collaboration has monitored the Crab Nebula in gamma rays for ten years. The MAGIC data will be presented and some analysis results will be shown.

--- **T 36.6 Tue 18:15 POT/0151**  
**The MAGIC of VHE gamma-ray astronomy: 20 years, 200 peer-reviewed publications and beyond**  
--- **MODEL NAME**  
--- **TITLE**  
--- **AUTHOR**  
--- **AFFILIATION**

In this contribution, we will present an overview of the MAGIC Collaboration and the scientific results, including the first detection of gamma-ray bursts, the Crab Nebula, and blazars. The MAGIC collaboration will present the status of the MAGIC-Collaboration, the results of the MAGIC telescope system, including the MAGIC-IAC telescope array, and the current and future goals of the collaboration.

--- **T 37: Neutrinos, Dark Matter IV**  
--- **Time:** Tuesday 17:00 – 18:30  
--- **Location:** POT/0251

**T 37.1 Tue 17:00 POT/0251**  
**Characterisation of the first 166-pixel TRISTAN detector module in a MAC-E filter environment**  
--- **MODEL NAME**  
--- **TITLE**  
--- **AUTHOR**  
--- **AFFILIATION**

One possible Dark Matter candidate is the keV-scale sterile neutrino, that would only interact via the mixing of sterile and active eigenstates. In a tritium beta decay spectrum, this mixing would lead to a characteristic, kink-like signature for sterile neutrinos with masses up to 16.6 keV. The KATRIN experiment will be upgraded with a novel TRISTAN multi-pixel silicon drift detector and readout system to search for this signature.

The final TRISTAN detector will consist of multiple 166 pixel detector modules. This presentation will give an overview of the first characterisation with electrons of one of this 166 pixel detector modules in the KATRIN Monitor Spectrometer, which is a KATRIN-like MAC-E filter environment.

This project has received funding from the European Research Council (ERC) under the European Union Horizon 2020 research and innovation program (grant agreement No. 852845). In addition, this work is supported by BMBF (05A17PM3, 05A17PK3, 05A17YK2, 05A17W03), KSE, the Max Planck society, and the Helmholtz Association.
Search for Light Sterile Neutrinos with the KATRIN Experiment — **Xaver Striøl** for the KATRIN-Collaboration — Chair for Dark Matter E47, Technical University of Munich

Light sterile neutrinos with a mass on the eV-scale could explain several anomalies observed in short-baseline oscillation experiments. The Karlsruhe Tritium Neutrino (KATRIN) experiment is designed to directly determine the effective electron anti-neutrino mass by measuring the tritium beta decay spectrum. The measured spectrum can also be investigated for the signature of light sterile neutrinos.

In this talk we present the status of the light sterile neutrino analysis of the KATRIN experiment. To handle the increasing computational challenge, a neural network is adapted for the analysis and its applicability is validated. This neural network is then used on Monte Carlo data sets to study the sensitivity of the first five measurement campaigns as well as the impact of individual systematic uncertainties. The obtained sensitivity is compared to current results and anomalies in the field of light sterile neutrinos.

**T 37.3 Tue 17:30 POT/0251**

Penning trap induced background in the KATRIN experiment — **Florian Fraenkle** for the KATRIN-Collaboration — Institute for Astroparticle Physics (IAP), Karlsruhe Institute of Technology (KIT)

The Karlsruhe TRitium Neutrino (KATRIN) experiment is a largescale experiment with the objective to determine the effective electron anti-neutrino mass with an unprecedented sensitivity of 0.2 eV/c^2 at 90% CL in a model-independent way based on precision β-decay spectroscopy of molecular tritium. KATRIN is currently in the middle of several physics measurement campaigns and so far has improved the upper bound on the effective electron neutrino mass to 0.8 eV at a 90% confidence level.

A Penning trap located between the KATRIN spectrometers, in combination with a large flux of β-decay electrons in this area, produces a scan-step-duration-dependent background which is one of the leading systematic uncertainties of KATRIN. This background was successfully mitigated with an optimized configuration of the voltages in the KATRIN beamline and is not present anymore in recent measurement campaigns. This talk will present measurements and a background model to describe the Penning trap induced background.

This work is supported by the Helmholtz Association, the Ministry for Education and Research BMBF (05A1P0M3, 05A1P0X3, 05A1V0K2, and 05A1W03), the Helmholtz Alliance for Astroparticle Physics (HAP), and the Helmholtz Initiative and Networking Fund (W2/W3-118).

**T 37.4 Tue 17:45 POT/0251**

**T 38.1 Tue 17:00 POT/0361**

**T 38.2 Tue 17:15 POT/0361**

**T 38.3 Tue 17:30 POT/0361**

**T 38.4 Tue 17:45 POT/0361**

**T 38.5 Tue 18:00 POT/0361**

**T 38: Neutrinos, Dark Matter V**

**T 38: Neutrinos, Dark Matter V**
the experimental hardware continuously and automatically. In simulations the parameter-space (disc positions) can be optimized to produce desired signals. Prominent optimizers are Nelder-Mead or Quasi-Newtonian algorithms. This talk focuses on the attempt of optimizing a physical, scaled-down MADMAX-like setup in-place based on it's electrical microwave responses. Challenges are the reduced set of information, the time requirement of the motor movement and the reliability of the algorithm.

T 38.4 Tue 17:45 POT/0036
Axion-Photon Coupling Distributions for Non-Minimal DFSZ-type Axion Models — JOHANNES DIEHL and EMMANOUIL KOUTANGELAS — Max Planck Institute for Physics, Munich, Germany
We systematically calculate anomaly ratios and thus axion-photon couplings for non-minimal DFSZ models. This allows us to classify every model and study the resulting distributions to make predictions for axion experiments like haloscope, helioscopes or light-shining-through-a-wall experiments. Doing so we confirm the experimental importance of the values dictated by the minimal DFSZ models, while also extending the viable axion parameter space. We map this space by introducing a theoretical prior probability distribution for DFSZ-type axions under the assumption of equally probable numbers of Higgs doublets $n_0 \leq 9$ and give 68% and 95% lower bounds on the axion-photon coupling. In contrast to the minimal DFSZ models, there is a large number of non-minimal DFSZ models with domain wall number of unity, thus avoiding the domain wall problem. We find a significantly enhanced axion-photon coupling compared to the minimal DFSZ models, adding to the experimental relevance of this subset.

T 38.5 Tue 18:00 POT/0036
Search for the DSNB in JUNO: Development of new Methods for Background Event Identification — MATTHIAS MAYER1, LOTTHI OBERABER1, RAPHAEL STOCK1, HANS STEIGER1, KONSTANTIN SCHWIEZER1, ULRICE FARENHEID2, DAVID DÖRFLINGER1, SIMON APPEL1, CARSTEN DITTRICH3, KORBINIAN SCHEER1, SIMON CZEKEL1, and FLORIAN KIRHELBRÜCK1,2 — Technische Universität München, München, Germany
In this talk we present the results to search for $77$Ge by exploiting the isomeric state in $77$As. Given the very similar configuration - bare germanium detectors in liquid argon - it serves as a benchmark for our LEGEND-1000 predictions. This research was supported by the RMBF through the Verbundforschung 05A20W02 and by the DFG through the SFB1258 and Excellence Cluster ORIGINS.

T 39.2 Tue 17:15 POT/0006
Plans for the Muon Veto of LEGEND-1000 — GINA GRÜNAUER for the LEGEND-Collaboration — Physikalisches Institut, Eberhard Karls Universität Tübingen
The Large Enriched Germanium Experiment for Neutrinoless $\beta\beta$ Decay (LEGEND) is a ton-scale, $^{76}$Ge-based, neutrinoless double-beta ($0\nu\beta\beta$) decay experimental program with discovery potential at half-lives greater than $10^{26}$ years. Low-background and low-noise signal readout electronics in close vicinity to the HPGe-detectors are crucial in order to achieve the experiment’s sensitivity on $0\nu\beta\beta$-decay. The close proximity to the detectors poses unique challenges to balance electronic performance with radiopurity requirements. In LEGEND-1000, the use of Application-Specific Integrated Circuit (ASIC) technology would allow to implement the entire charge sensitive amplifier into a single low-mass chip with ultimate electronic noise performance and signal fidelity while ideally further reducing backgrounds.
In this contribution, the current status of the LEGEND-1000 ASIC based readout development will be presented. It will focus on the design challenges of the CSA implementation and present first results of simulations and measurements of the chip.

T 39.3 Tue 17:30 POT/0006
ASIC-based front-end electronics for LEGEND-1000 — FLORIAN HENKES, MICHAEL WILLE, and SUSANNE MERTENS for the LEGEND-Collaboration — Physik-Department E47, Technische Universität, München, Germany
The large supernova neutrino background (DSNB) describes the constant flux of neutrinos from past core-collapse supernovae over the entire visible universe. The Jiangmen Underground Neutrino Observatory (JUNO), a 20 kton liquid scintillator detector, plans to detect the DSNB in the inverse beta decay (IBD) detection channel. While other electron anti-neutrino sources will cause irreducible IBD background, non-IBD backgrounds such as neutron-induced events and NC interactions of atmospheric neutrinos can be reduced by careful pulse-shape discrimination (PSD). In this talk, I compare the performance of different PSD techniques with the prospect of increasing the fiducial volume available for the DSNB search. Additionally, I discuss the influence of possible quenching of non-IBD puleshapes on the available discrimination performance in the DSNB energy region of interest. This work is supported by the DFG research unit "JUNO", the DFG collaborative research centre 1258 "NDM", and the DFG Cluster of Excellence 'Origins'.

T 39.4 Tue 17:45 POT/0006
Double weak decays of $^{124}$Xe and $^{136}$Xe in XENON1T and XENONNt — CHRISTIAN WITTMANN for XENON-Collaboration — Physik-Institut, Universität Zürich
The current generation of xenon-based dark matter direct detection experiments has reached large enough target masses and low enough background levels to probe rare double weak decays. Among these decays are the two-neutrino double electron capture (2eEC) of $^{124}$Xe as well as the neutrinoless double beta decay ($0\nu\beta\beta$) of $^{136}$Xe. Observation of these two hypothetical zero mass decays would provide definite proof of the neutrino’s Majorana nature and indicate lepton number violation. The measurement of the Standard Model 2eEC – first detected by XENON1T in 2018 – provides nuclear structure information that is a crucial input for the nuclear models used to interpret $0\nu\beta\beta$ experiments. This contribution will present the $^{124}$Xe 2eEC results and search for $0\nu\beta\beta$ of $^{136}$Xe in XENON1T. Moreover, the sensitivity projection for a $^{124}$Xe $0\nu\beta\beta$ search in XENONNT will be outlined.

T 39.5 Tue 18:00 POT/0006
Fast track simulations in XENONNt — JARON GRIGAT for XENON-Collaboration — Albert-Ludwigs-Universität, Freiburg, Deutschland
We present the work on a fast, effective simulator for the XENONNt dark matter experiment, which bypasses the sophisticated - but resource-intensive - full simulation of waveforms, while remaining as accurate as possible. This talk fo-
is registered at the top and bottom by photomultiplier arrays. Free electrons, additionally created by the energy deposition, are drifted to the gaseous phase at the top of the detector where they create a secondary scintillation light pulse by electroluminescence. The combination of light and charge signal allows for a 3-dimensional position reconstruction of the recorded events and a differentiation between electron and nuclear recoil events. This talk focuses on the light signal reconstruction, which requires a correction of the position dependent light collection efficiency. Based on calibration data from internal radioactive sources, light collection efficiency maps are derived and applied to the light signals.

This work is supported by BMBF under contract 05A20PM1 und by DFG within the Research Training Group GRK 2149.

**T 40: Astro Particle Theory**

**Time:** Tuesday 17:00–18:00

**Location:** POT/0112

In this talk, we discuss follow-up and expansive simulation studies, based on these previous findings. Particular focus is put on the production of secondaries, i.e. photons and neutrinos. Our aim is to constrain the properties of the SMF during high activity and confirm or improve upon the dipolar description during low activity. We further discuss the prospects of experimentally testing said studies.

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**T 41: Cosmic Ray II**

**Time:** Tuesday 17:00–18:30

**Location:** POT/0013

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T 41.3 Tue 17:30 POT/0013
A machine learning approach to mass composition studies of ultra-high energy cosmic rays with the AugerPrime upgrade of the Pierre Auger Observa-
tory—ALEJANDRO PAREJA, FABIO FERREIRA, and THOMAS HEBRERER — RWTH Aachen University, Aachen, Germany

The Pierre Auger Observatory is the world’s largest experiment to observe the extensive air showers produced by ultra-high energy cosmic rays. The observatory uses a hybrid detection method that combines 1600 ground-based water Cherenkov detectors covering an area of more than 3000 km² and 27 fluorescence detectors at four sites. The efficiency and measurement techniques of the Pierre Auger observatory are improved by the ongoing upgrade called AugerPrime. A part of the upgrade consists of deploying a scintillator detector on top of each water Cherenkov detector which provides additional information about the composition of the extensive air showers.

Currently, the understanding of cosmic rays at ultra-high energy is limited by low incoming flux and the available theoretical models for hadronic interactions. Precise measurement of the cosmic ray composition can help us understand the sources of cosmic rays and improve the current models.

The additional information provided by the combination of water Cherenkov detectors and scintillator surface detectors has been explored with a machine learning algorithm called random forest, to analyze the measurable properties of the shower and infer the mass composition of the primary particle.

T 41.4 Tue 17:45 POT/0013
Inferring Properties of Ultra-High-Energy Cosmic Ray Sources from Surface Detector Data of the Pierre Auger Observatory — TERESA BISTER, MARTIN ERDMANN, MERLIN KLEIN, FREDERIK KRIEGER, and JOSINA SCHULTE — III. Physikalisches Institut A, RWTH Aachen University

With the Pierre Auger Observatory, the energy spectrum and the distributions of the depths of the shower maximum $X_{\text{max}}$ of ultra-high-energy cosmic rays (UHECRs) can be measured. The latter is correlated to the mass of the primary cosmic ray and can be directly measured by the fluorescence detector (FD). Using deep learning, $X_{\text{max}}$ can also be extracted from the surface detector (SD) data which has the benefit of high event statistics. With these observables, characteristics of the sources of UHECRs can be inferred. Owing to the stochastic nature of interactions during propagation, simple inversion of the process from source to Earth is not possible. To this end, different inference methods can be used.

We present and compare two different inference methods and apply them to actual astrophysical scenarios: the Markov Chain Monte Carlo (MCMC) method and a variational inference scheme with conditional invertible neural networks (cINNs). It has already been shown that cINNs perform similarly well to the frequently used MCMC method. We tested against othersourcemodels by fitting to observed UHECR data.

T 41.5 Tue 18:00 POT/0013
Studying the properties of bursting UHECR sources in a multi-messenger approach — LEONEL MOREJON — Bergische Universität Wuppertal, Gaußstr. 20, 42119 Wuppertal, Germany

The study of Ultra-High Energy Cosmic Rays (UHECRs) via the multi-messenger approach is reaching a level that requires going beyond steady state sources. The exploration of bursting sources and the implications for multi-messenger detection is the goal of the French-German research project MICRO. Meeting this challenge requires improvements of the existing tools and defining new methods to accelerate the computations related to the propagation of UHECRs in extragalactic space and within the sources. The progress of MICRO in these aspects will be presented by discussing: a) a module to compute hadronic interactions within CRPropa, b) tools to fit the UHECR spectrum and composition with precomputed propagation tensors and corresponding propagation matrices, and c) the estimation of the impact that uncertainties of the latest models of Extragalactic Background Light (EBL) have on the precision in CRPropa propagation.

* Supported by the DFG through project number 445990517.

T 41.6 Tue 18:15 POT/0013
Numerical investigation of bursting sources as potential accelerators of ultra-high-energy cosmic rays — LEANDER SCHLEGEL 1,2, JULIA BIEKER 1,2, and MARCEL SCHROLLER 1,2 — 1Theoretische Physik IV, Ruhr Universität Bochum, Bochum, Germany — 2RAPP-Center at Ruhr Universität Bochum, Bochum, Germany

Since their discovery over a century ago, the origin of cosmic rays of the highest energies is still widely uncertain. While the observed constant flux suggests at first sight to analyze primarily steady state source models, the needed magnetic luminosities for potential sources seem to favor bursting sources, that appear in quiescent and flaring states, like the class of Active Galactic Nuclei (AGN).

The goal of this work is trying to understand the detailed behaviour of bursting sources and their possible contribution to the UHECR flux, by simulating the time resolved propagation of a plasma blob inside the jet of an AGN and accounting for a temporal variability of the source. For this purpose, a tool for cosmic-ray propagation in relativistic plasmas of AGN jets implemented into the open-source code CRPropa 3.1, is further improved. With this framework, we will predict the multimessenger signatures of flaring sources that are active for certain intervals in time, representing a flaring behaviour. With this investigation we aim to help providing a numerical AGN model, that can finally be tested against other source models by fitting to observed UHECR data.

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T 42.1 Tue 17:00 POT/0351
Construction of IceAct Telescopes — LEA SCHLICKMANN 1, THOMAS BRETTZ 2, LARS HEURMANN 1, ANDREAS NOELL 1, MERLIN SCHAUFEL 1, and CHRISTOPHER WIEBUSBACH 1 — IceCube Collaboration — III. Physikalisches Institut B, RWTH Aachen University — 2GSI Helmholtzzentrum für Schwerionenforschung

IceAct is an array of Imaging Air Cherenkov Telescopes at the ice surface as part of the IceCube Neutrino Observatory. Each telescope features a 55cm diameter Fresnel lens and a camera with 61 Silicon Photomultiplier pixels resulting in a 12’ field of view. The design is optimized for harsh environmental conditions, as in Antarctica. Since 2019, the first two telescopes are operating at the South Pole in a stereoscopic configuration. Seven telescopes can be combined in a fly’s eye configuration, forming a so-called station which has a field of view of 36°. In the future, for IceCube-Gen2, an array of four stations is planned. The commissioning of a full station is scheduled for the next years within the current surface upgrade. For this, six telescopes are being constructed. This talk will report on the construction and calibration of these telescopes.

T 42.2 Tue 17:15 POT/0351
Characterization and Optimization of the Readout Electronics for IceAct Telescopes — ANDREAS NOELL 1, THOMAS BRETTZ 2, LARS HEURMANN 1, MERLIN SCHAUFEL 1, LEA SCHLICKMANN 1, and CHRISTOPHER WIEBUSBACH 1 — IceCube Collaboration — 3III. Physikalisches Institut B, RWTH Aachen University — 4GSI Helmholtzzentrum für Schwerionenforschung

IceAct is an Imaging Air Cherenkov Telescope array located at the South Pole as part of the IceCube Neutrino Observatory. The telescopes feature a 61 pixel camera based on Silicon Photomultipliers (SiPM). The camera signals are processed and digitized in a dedicated digital front-end developed for the Cherenkov Telescope Array (CTA). The inherent high rate of ambient photons caused e.g. by stars, the Moon, and auroras combined with the high decay time of the SiPM signal results in a signal pile-up. The TARGET system provides an analog front-end for pulse shaping combined with a high sampling rate of 1GS/s to accommodate the pile-up. Extensive tests are necessary to understand the complete signal chain from the SiPM to digitization. In this talk a characterization of the current system is presented. In addition design improvements, based on electronics simulations and tests with prototypes, will be proposed.

T 42.3 Tue 17:30 POT/0351
Three Years Performance of IceAct — LARS HEURMANN 1, THOMAS BRETTZ 2, OLIVER JANIK 3, SILVIA LATSEVA 1, ANDREAS NOELL 1, MERLIN SCHAUFEL 1, LEA SCHLICKMANN 1, and CHRISTOPHER WIEBUSBACH 1 — 1RWTH Aachen University — 2Physik Institute III B, Aachen, Germany — 3GSI Helmholtzzentrum für Schwerionenforschung

IceAct is an array of Imaging Air Cherenkov Telescopes at the ice surface as part of the IceCube Neutrino Observatory. The telescopes, featuring a camera of 61 Silicon Photomultipliers and a Fresnel lens based optic, are optimised to be operated in harsh environmental conditions, such as the South Pole. Since 2019, the first two telescopes operate in a stereoscopic configuration in the centre of IceCube’s surface detector IceTop. The telescopes enable improved cosmic ray studies and cross calibrations of IceCube and IceTop by a hybrid measurement of air showers. This talk will review the performance and detector operations of the past 3 years of the telescopes as well as give an outlook for the future of IceAct.

T 42.4 Tue 17:45 POT/0351
A new network of electric field mills at the Pierre Auger Observatory — MAX BÜSKEN for the Pierre Auger-Collaboration — Institute for Experimental Particle Physics, Karlsruhe Institute of Technology (KIT) — Instituto de Tecnologías en Detección y Apotarsticas, Universidad Nacional de San Martín (UNSAM)

The Pierre Auger Observatory is the largest ground-based instrument for the...
Particle Physics Division (T) Tuesday

T 42.5 Tue 18:00 POT/0351 Nanosecond time synchronization of distributed detectors — YAN SEIFFERT and TIM HÜGGE — Karlsruhe Institute of Technology (KIT), Institute for Experimental Particle Physics, Karlsruhe, Germany

At the Pierre Auger Observatory, the surface detectors used to detect and measure cosmic-ray air showers are placed in a triangular ground pattern with a 1500 m spacing, covering a total area of about 3000 km². Time synchronization of such distributed detectors to very high accuracy on the nanosecond scale is challenging. Currently, ordinary GPS receivers are used, which simply and independently record the GPS-time/UTC-time at their current position. Achieving 1 ns relative time accuracy between detectors would prove very useful, for example in the context of the measurement of radio emissions from extensive air showers. Accurate timing information of an event recorded by an array of radio antennas would enable intriguing possibilities for radio-interferometric analyses of cosmic-ray air showers.

This talk will report on recent findings regarding wirelessly communicating GPS modules with currently non-standard capabilities, promising 3 cm accurate relative positioning and thus potentially 1 ns relative timing accuracy.

T 42.6 Tue 18:15 POT/0351 Study of the antenna response for the Radio Neutrino Observatory Greenland (RNO-G) — ASNSA EMBER for the RNO-G-Collaboration — Erlanger Centre for Astroparticle Physics (ECAP), Erwin-Rommel-Str. 1, D-91058 Erlangen

Ultra high energy neutrinos can be detected via radio emission following a neutrino interaction in ice. The long attenuation length of radio signals in ice allows for a much sparser instrumentation than required for optical Cherenkov neutrino telescopes, hence making it possible to survey large volumes. The Radio Neutrino Observatory Greenland (RNO-G) is a project that will eventually consist of 35 stations (7 already deployed) with distances of about 1.25 km between neighbouring stations. Each station consists of 9 log-periodic dipole array (LPDA) antennas about 1.5 m below the ice surface and with up to 100 m deep in-ice strings, equipped with vertically and horizontally polarized dipole antennas.

Understanding the antenna properties and potential interferences between nearby antennas is important to operate the experiment to evaluate the recorded data and reconstruct neutrino properties. In this contribution, first results of laboratory studies with the RNO-G antennas with emphasis on interferences will be presented.

T 43.1 Tue 17:00 POT/0106 Turning an FPGA into a fast multi-channel ADC — DMITY ELISEEV, THOMAS HEBBEKER, MARKUS MERSCHMETER, CARSTEN PRESSER, and ERIK EHRLERT — III. Physikalisches Institut A, RWTH Aachen University, Germany

Electronics for particle detectors nowadays typically deal with a huge number of channels. In a typical detector read-out electronics, the front-end signals are passed through a multi-channel conditioning circuit and meet an FPGA chip at the other end. Modern FGPA's enable good time resolution for such multi-channel acquisition. However, the common solution remains to acquire information on the energy or amplitude of particular events using high-speed multi-channel ADCs. Using ADCs often results in more complex schematics and much higher costs of the electronics for signal acquisition. The presented method makes it possible to waive the ADCs and, to some extent, replace the ADC's functionality with FGPA's internal resources. The method requires a minimal number of additional low-cost external components and can be potentially interesting for many detector applications.

The talk provides a general overview of how to turn a commercially available FPGA device into a multi-channel high-speed ADC. Characterization measurements and calibration methods for the resulting FPGA-based ADC are also given. Possible technical difficulties and ways to overcome them are discussed in an example application: an 8-channel mezzanine PCB for signal acquisition from multiple SiPMs.

T 43.2 Tue 17:15 POT/0106 A Software-Scalable ADC in 28nm CMOS for Detector Readout — LUKAS KRYSTOFIAK — Forschungszentrum Jülich

Particle detector experiments rely more and more on advanced integrated circuits to achieve new discoveries. Their development is a lengthy and costly process, that poses a high threat to the overall success of a project. Using a pre-developed software-scalable ADC, adjustable in resolution and sample rate and ultimately in power consumption, catering to many different areas of applications, can decrease this risk substantially. While a generic approach will never reach the same performance as a dedicated development, it facilitates rapid prototyping and verification of readout methods prior to the building of the complete systems without the need to develop a dedicated chip. It also opens up possibilities for projects with smaller budgets. The key driver for this concept is the development of the Talk CMOS 28nm process technology, which allows incorporation of a powerful digital signal processor while analog performance and design is not too restricted. Here, the first iteration of a software-scalable ADC is shown. It features a high-precision mode with 11 Bit resolution and a maximum sample rate of 400 Megasample per second, and a low-power mode with 8 Bit resolution and 800 Megasample per second.

T 43.3 Tue 17:30 POT/0106 High-rate On-Board Tube electronics testing — MATEJ REPIK, DMITY ELISEEV, THOMAS HEBBEKER, and MARKUS MERSCHMETER — III. Physikalisches Institut A, Aachen, Germany

A general-purpose detector at the Large Hadron Collider (LHC), the Compact Muon Solenoid (CMS), undergoes changes that are summed up under the Phase 2 Upgrade. As one of the CMS muon-detecting subsystems, the drift tube chambers (DT) also require an upgrade. Among others, the plans foresee new On-Board Drift Tube (OBDT) electronics to replace the previous electronics. OBDTs congregate front-end signals from the DT chambers and stream the acquired data to the CMS back-end. Each OBDT also implements certain slow control routines. As for every complex device, quality assurance is essential for the new OBDT electronics. Consequently, a test system for OBDT is being developed by the DT collaboration with the following requirements: emulate drift tube front-end signals at the expected high hit rates and record the response of OBDT. This talk focuses on the aforementioned test system and its implementation at RWTH Aachen University.

T 43.4 Tue 17:45 POT/0106 Absolute luminosity calibration through van der Meer scans in ATLAS — CÉDRINE HÜGLI for the ATLAS-Collaboration — DESY Zeuthen

Luminosity is a very important quantity for many physics analyses. Its precise knowledge is required for example in cross section measurements. In ATLAS, luminosity is measured by several detectors: the main luminometer is LUCID, located in the forward region and based on Cherenkov radiation. All luminosity detectors need to be absolutely calibrated through so-called van der Meer scans. These are scans where the two beams are scanned through each other, first in the horizontal and then in the vertical plane. In this work, the preliminary analysis of the run 3 13.6 TeV van der Meer scan from 2022 is presented. The analysis precisely measures the part of the inelastic proton-proton interaction cross section visible in the luminosity detectors, which is the absolute luminosity calibration constant. Its value is obtained by fitting the scan curves. During the van der Meer scan analysis several effects need to be corrected to get a precise calibration constant, for example the impact of the electromagnetic interaction of the beams on their separation. The obtained absolute calibration of luminosities is then transferred to physics conditions and used in the early run 3 ATLAS measurements.

T 43.5 Tue 18:00 POT/0106 Emittance Scans at the LHCb Detector in Run 3 — JONATHAN ALBRECHT, ELENA DALL’OCCO, HANS DEMIRSKIS, and JAN ELLBRECHT — TU Dortmund University, Dortmund, Germany

Precise determination of the luminosity at the LHCb detector is needed for accurate measurements of cross-sections as well as in daily operations. The instantaneous luminosity at LHCb is levelled throughout the fill to optimise the detector performance, which is achieved by tuning the distance between the two collid-
ing beams based on a real-time measurement of the luminosity. The luminosity calibration is performed once per year and per centre-of-mass energy in dedicated van-der-Meer scans. Here, particular beam conditions are used, leading to a maximum number of visible proton-proton interactions $\mu \sim 1$ when the beams are colliding head-on.

In Run 3 the LHCb detector operates at a five times higher instantaneous luminosity compared to the previous runs, with a $\mu$ of about 5.5. Therefore, it is planned to perform additional per-fill emittance scans in order to verify linearity from calibration to data taking conditions. This talk will focus on the emittance scan analysis, procedure and first results of Run 3 data.

Supported by DFG (SFB 1491)

T 44.4 Tue 17:45 WIL/A317
High rate measurements of HV-MAPS for a future main tracker — Sebastian Bachmann, Lucas Dittmann, Maja Lecher, and Ulrich Uwer — Physikalisches Institut, Heidelberg, Germany

The LHCb experiment plans to upgrade its detector during the long shutdown 4 of the LHC to cope with a further luminosity increase at LHCb's interaction point during Run 5. For this upgrade, the currently installed scintillating fiber tracker will be replaced by the MightyTracker. The MightyTracker consists of an inner part made from silicon pixels and an outer part made from scintillating fibers.

For the silicon sensor part of the MightyTracker, dedicated High-Voltage Monolithic Active Pixels Sensors (HV-MAPS), which are called MightyPix, are proposed. HV-MAPS are produced in commercial High-Voltage CMOS technology, which allows the design of low cost, thin and radiation hard sensors.

The MightyPix sensors in the hottest regions of the MightyTracker will experience a mean particle rate of 125 kHz/mm$^2$. To determine possible hit rate limitations of existing HV-MAPS experimentally, rate measurements with ATLASpix3.1 sensors have been performed. The results are compared to theoretical expectations. The ATLASpix3.1 sensor is used as a proxy for the MightyPix sensor, since the pixel readout of both sensors will be structured similarly.

T 44.5 Tue 18:00 WIL/A317
Series Production of 2S Modules for the Phase-2 Upgrade of the CMS Detector in Aachen — Max Beckers$^1$, Christian Dziwo$^2$, Lutz Feld$^3$, Katja Klein$^4$, Martin Lipinski$^5$, Vanessa Oppenländer$^6$, Alexander Pauls$^7$, Oliver Pooth$^8$, Nicolas Röwert$^9$, Felix Thurn$^{10}$, and Tim Ziemons$^{11}$ — 1. Physikalisches Institut B, RWTH Aachen University, D-52056 Aachen

The CMS detector will be upgraded in the Phase-2 Upgrade for the operation at the HL-LHC. Among others, the silicon tracking system will be completely replaced by a new system providing an extended acceptance, an improved granularity and the feature to include tracking information into the first level hardware trigger. The new Outer Tracker will consist of 2S modules with two strip sensors and PS modules with a macro-pixel sensor and a strip sensor, specialized detector modules with onboard $p_t$ discrimination.

Up to 1000 2S modules will be assembled and tested at RWTH Aachen University. In this talk, the module assembly process is summarized and the preparation of the series production is presented.
Consequently, there is a need to investigate new silicon sensor concepts that can so that they become an immense cost driver in particle physics experiments. Elektronen-Synchrotron DESY, Hamburg, Germany

Before the start of High Luminosity LHC the Inner Detector of the ATLAS detector will reach the end of its operating life. It will be replaced by a new Inner Tracker (ITk), more suitable for high luminosity. Building the ITk requires a lot of effort from many institutes in the collaboration, and DESY is one of the main contributing institutes. One of the two strip ITk endcaps will be assembled at DESY. During production, the main sensing units of the tracker, the silicon microstrip sensors, have to pass a number of tests to ensure that they are suitable for becoming part of the detector. One of these tests is measuring the IV sensor characteristic. In this talk the importance and the procedure of measuring strip sensor IV curves at DESY Hamburg will be discussed, as well as a detailed study of whether the number of required IV testing can be reduced, done using high statistics provided by the current data stored in the ITk production database.

Producing high quality and long-lasting modules for the ATLAS ITk strip detector — Thomas Brueers — Deutsches Elektronen-Synchrotron DESY, Zeuthen, Germany

For the high luminosity phase of the LHC, the ATLAS collaboration plans to upgrade its current tracking detector with a new, all silicon pixel and strip detector, referred to as Inner Tracker (ITk). Core components of the ITk strip detector are modules that consist of sensors and printed circuit flex boards carrying the read-out and powering chips. To ensure reliable operation of the ITk strip detector, all module components are extensively tested and characterised before module building. After and during module assembly, the quality of the modules is additionally assessed to verify that they fulfil the high standards determined to lead to the required quality by the ATLAS collaboration. This talk will give an overview of the means of ensuring this level of quality for the modules and their components. Special focus will be on stress-tests of ASICs printed circuit flexboards and on temperature cycling of modules. During the quality assessment of a module and its components it is paramount to not damage the wire-bonds connecting the ASICs and the printed circuit boards, e.g. through resonances induced by the cooling or vibrations. A new approach to determine the resonance frequency of the wire-bonds is presented in this talk. Knowledge of this frequency is also relevant to prevent damages due to wire-bond oscillations excited by currents through the wires in the T2 magnetic field of the ATLAS detector.

Characterisation and test beam data analysis of passive CMOS strip sensors — Naomi Davis for the CMOS Strip Detectors-Collaboration — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

In high-energy physics, upgrades for particle detectors, as well as studies on future particle detectors are largely based on silicon sensors as tracking devices. The surface that needs to be covered by silicon sensors is constantly increasing so that they become an immense cost driver in particle physics experiments. Consequently, there is a need to investigate new silicon sensor concepts that can realise large-area coverage and cost-efficiency. A promising technology is found in passive CMOS sensors, based on CMOS imaging technology. They provide a lowered sensor cost by being produced in commercial chip processing lines. Since passive CMOS sensors do not contain any active elements they also allow for a large choice of possible vendors and easy portation from one CMOS process to another. The passive CMOS project at DESY is investigating passive CMOS strip sensors fabricated at LFoundry in a 150nm technology. Two different strip formats of the n-in-p sensor are achieved by the process of stitching. An electrical sensor characterisation is realised by measuring the change in the sensor current and capacitance with the applied bias voltage. In addition, the sensor performance is evaluated based on test beam measurements conducted at the DESY II test beam facility. This presentation will provide a characterisation of passive CMOS strip sensors and results of the test beam data analysis.

Nearly all envisioned future high-energy particle detectors will employ silicon sensors as their main tracking devices. Due to the increased demand in performance, large areas of the detectors will have to be covered with radiation hard silicon, facilitating the need for silicon sensors produced in large quantities, reliably and cost-efficiently.

A possible solution to these challenges has been found in the utilization of the CMOS process, which is an industrial standard, offering the advantage of a large choice of vendors and reduced production costs. To create the larger sensor structures typical for silicon strip trackers, the stitching process has to be used. Currently three variations of passive CMOS strip sensors, produced by LFoundry in a 150nm process, are being investigated. In order to examine the radiation hardness of the design and any possible effect of the stitching on position resolution, detection efficiency or charge collection efficiency, a test beam measurement at the Test Beam Facility at DESY Hamburg has been conducted, using the ALIBaVa (Analogue Liverpool, Barcelona, Valencia) system for DUT (Device under test) readout. In the course of the analysis, a new module to process the ALIBaVa data in the Corryvreckan Test Beam Data Reconstruction Framework has been developed. A summary of the results of this test beam analysis will be presented in this talk.

A hot cathode electron gun to test and characterize silicon drift detector arrays for the KATRIN experiment — Korbinian Urban for the KATRIN Collaboration — Technical University Munich, James-Franck-Straße 1, 85748 Garching bei München

The KATRIN (Karlsruhe Tritium Neutrino) experiment investigates the kinematic endpoint of the tritium beta decay spectrum to determine the effective mass of the electron anti-neutrino. Its unprecedented tritium source luminosity and spectroscopic quality make it a unique instrument to also search for physics beyond the standard model such as sterile neutrinos. For these searches a new silicon drift detector array is being developed to replace the current silicon detector in KATRIN. Key features of the new detector are the high rate capability and good energy resolution for electrons. This talk presents a setup where these properties of the new detector modules can be tested with electrons of up to 20 keV kinetic energy from a hot cathode electron gun.

This project has received funding from the European Research Council (ERC) under the European Union Horizon 2020 research and innovation program (grant agreement No. 852845). This work is also supported by BMBF (05A17PM3, 05A17PX3, 05A17VK2, 05A17W03), KSETA, the Max Planck society, and the Helmholtz Association.

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Fast Hadron Shower Simulation Methods with the CALICE AHCAL Prototype — André Wilhahn, Julian Utehs, and Stan Lai for the CALICE-D-Collaboration — II. Physikalisches Institut, D-37077 Göttingen

Extensive simulations of particle showers are crucial for high energy physics experiments, since they allow for a sensible interpretation of recorded calorimeter data. As many calorimeters are designed with increasing granularity, while having to cope with higher energy deposits and higher luminosity conditions, the accurate simulation of particle showers in a computationally efficient manner is of utmost importance. This talk describes preliminary investigations into a data-driven fast calorimeter simulation that is meant to describe particle showers accurately, without simulating every individual particle interaction with the calorimeter material.

The study by investigating pion showers in the CALICE AHCAL (Analog Hadron Calorimeter) prototype, which is a highly granular hadronic calorimeter comprising a total of 38 active layers embedded in a stainless-steel absorber structure. Each active layer contains a grid of 24 x 24 scintillator tiles that are read out individually via silicon photomultipliers. Longitudinal energy distributions and correlation factors between these detector layers have been simulated with the help of kernel functions for the showers and compared with data. The results of this procedure are presented in this talk. In particular, current developments will be discussed and future plans for improving and expanding the fast calorimeter simulation will be outlined.

Data-driven Fast Calorimeter Simulation with the CALICE AHCAL Prototype — Julian Utehs, André Wilhahn, and Stan Lai for the CALICE-D-Collaboration — II. Physikalisches Institut, Georg-August-Universität Göttingen

High granularity calorimeters are foreseen to be an integral part of future particle physics detectors, for instance in detectors at a future e+e- collider. Therefore, there is an extensive research program dedicated to understanding how high granularity calorimeters can be exploited. For this purpose, the CALICE collaboration has developed a prototype, the Analog Hadron Calorimeter, which uses SiPM technology to read out highly granular scintillator tiles. The combination of highly granular calorimetry with a foreseeable higher luminosity will significantly increase the calculation time for MC simulations that simulate all particle interactions with the calorimeter material (as in GEANT4). Therefore fast simulation methods are also important, allowing the reduction of computational resources, while accurately describing the shape and correlations of the showers.

The aim is to parameterize showers in order to describe them via a probability density function, that can be used for the simulation of particle showers. This talk will focus on the description of radial and angular distributions of pion showers, based on test beam data taken with the AHCAL Prototype. The combined description of longitudinal, radial, and angular distributions is also discussed.

Shower Separation in Five Dimensions using Machine Learning — Jack Rolph and Erika Garutti — University of Hamburg, 22761, Luruper Chaussee 149, Hamburg, Germany

To fulfil the requirements for BSM physics searches and Higgs precision measurements at future linear colliders, a final state jet-energy resolution of 3-4% for jet energies in the range 150-350 GeV is mandatory. Particle Flow Calorimetry (PFC) is a method expected to provide this resolution, which relies upon highly granular sampling calorimeters and sophisticated clustering techniques. In addition, the PFC technique requires excellent separation of single particles. This study presents the performance of three published neural network models to separate the energy deposited by a single charged and single pseudo-neutral hadron estimated from a charged shower, observed with the highly granular CALICE Analogue Hadronic Calorimeter (AHCAL). The neural networks use spatial and temporal event information from the AHCAL and energy information, which is expected to improve sensitivity to shower development and differences in the time development of the hadron shower. Neutrion hadron showers with energy 5-120 GeV were separated from charged showers at a variable distance of 0.2-658 mm by the neural networks. It is found that the best-performing network reconstructed events with a Mean90 energy in agreement within 5% of the known shower energy and with an average RMS90 of 1.6 and 1.4 GeV without and with 100 ps timing information from AHCAL, respectively. The improvement due to timing information is attributed to the superior clustering of the hadron shower core.
T 47: Gas-Detectors, Detector Systems

**Time:** Tuesday 17:00–18:30  
**Location:** WIL/A120

**T 47.1 Tue 17:00 WIL/A120**  
First measurements with a gas monitoring chamber at subatmospheric pressures — REBECCA FISCHER, THOMAS RADERMACHER, STEFAN ROTH, DAVID SMYCZEK, and NICK THAMM — RWTH Aachen University - Physics Institute III B, Aachen, Germany

Time projection chambers (TPCs) are gaseous ionization detectors, which can instrument large volumes for particle tracking applications. By adjusting the internal gas-mixture and the operating pressure it is possible to fine-tune these detectors to have increased target mass for neutrino interactions or improved track resolution for low energies. For the precise operation of TPCs various electron swarm parameters are usually measured during runtime with a gas monitoring chamber (GMC), a small specialized TPC. These monitoring chambers can also be used for the verification of drift parameter simulations, which help predict the physics behavior of larger detectors. In this talk the hardware modification of a high pressure GMC (HPGMC) towards low pressure operation is addressed, the associated challenges are explained and first measurement results are shown.

**T 47.2 Tue 17:15 WIL/A120**  
Development and Commissioning of Gas Flow Meters — THOMAS RADERMACHER, STEFAN ROTH, DAVID SMYCZEK, JOCHEN STEINMANN, NICK THAMM, and HANJA WEHRLE — RWTH Aachen University - Physics Institute III B, Aachen, Germany

Gas flow meters will be installed in the new Gas Monitoring Chambers (GMCs) of the T2K time projection chambers. The flow meters measure the heat transfer caused by the gas flow using platinum resistors. This offers an efficient solution for monitoring the gas flow through the GMCs. The construction, calibration and performance of the flow meters are presented.

**T 47.3 Tue 17:30 WIL/A120**  
Gas Monitoring Chambers for the T2K Near Detector Upgrade — INES HANNEN, THOMAS RADERMACHER, STEFAN ROTH, DAVID SMYCZEK, and NICK THAMM — RWTH Aachen University - Physics Institute III B, Aachen, Germany

A new pair of Time Projection Chambers for high angle measurements (HATs) will be installed during the upgrade of the T2K near detector ND280. For their calibration the gas parameters will be continuously monitored using newly developed Gas Monitoring Chambers (GMCs). Systematic measurements of drift velocity and gas gain have been performed for different gas mixtures. These measurements are compared to simulations and previous measurements. The test setup and measurement results are presented.

**T 47.4 Tue 17:45 WIL/A120**  
Commissioning of the large-scale Lxε detector test platform PANCAKE — TIFFANY LUCE — Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany

As liquid xenon (Lxε) detectors grow in size with each experiment, larger components have to be developed and tested. PANCAKE is a cryogenic detector test platform for components up to 2.6 m diameter as required for the future dark matter project DARWIN. PANCAKE’s primary goal is to test the behavior of large scale detector components, such as TPC electrodes, in cryogenic conditions. A first commissioning run has been performed for two months at liquid argon temperature. The talk will present the results and discuss the strategy for future runs with cryogenic liquid xenon.

**T 47.5 Tue 18:00 WIL/A120**  
Preparations for TPC Electrode Tests in a large Lxε R&D-Platform — JULIA MÜLLER — Albert-Ludwigs-Universität, Freiburg

PANCAKE is a large-scale cryogenic platform to develop and test components for future Lxε TPCs such as DARWIN. Over the past decades Lxε TPCs continuously grew in size and became more sensitive, however, also the technical realization of its large TPCs got more and more challenging. Among the most crucial and also most complex detector components are the TPC electrodes, which need to feature a high optical transparency and high voltage resilience. PANCAKE allows testing the full-scale electrodes in an Lxε environment before they are installed into a final TPC. We here present preparations towards such an electrode test.

**T 47.6 Tue 18:15 WIL/A120**  
Detector system and simulation of the 155 MeV Hydro-Møller polarimeter at MESA — MICHAEL KRAVENKO for the P2-Collaboration — PRISMA Cluster of Excellence and Institute of Nuclear Physics, Johannes Gutenberg University Mainz

The Mainz Energy-recovering Superconducting Accelerator (MESA) is an electron accelerator, which is currently under construction at the Johannes Gutenberg University Mainz. One aim for the MESA is the precise measurement of the weak mixing angle $\sin^2 2\theta_W$, an important parameter of the Standard Model, with a relative uncertainty of 0.14%. The measurement will be performed by the P2 experiment by measuring the parity-violating asymmetry in elastic electron-proton scattering at low momentum transfer $Q^2$. MESA will provide a 150 $\mu$A beam of alternatingly polarized 150 MeV electrons with excellent beam stability. In order to achieve the goal of the P2 experiment, the beam polarization must be measured online with a very low systematic error (< 0.5% relative). The 155 MeV Møller polarimeter using a polarized atomic hydrogen target, known as the Hydro-Møller polarimeter, as proposed by V. Luppop and E. Chudakov opens the opportunity for achieving these requirements. The current design of the detector system for the Hydro-Møller polarimeter and the results of the simulation with Geant4 are presented.

T 48: Exp. Methods I

**Time:** Tuesday 17:00–18:15  
**Location:** WIL/C129

**T 48.1 Tue 17:00 WIL/C129**  
Tau-lepton decay mode classification using machine learning in ATLAS — JONATHAN PAMPEL, DUÇ BAO TA, CHRISTINA DIMITRADI, JOCHEN DINGFELDER, TATJANA LENZ, and ECKHARD VÖRNS — 1University of Bonn, Germany, 2University of Mainz, Germany

The tau-lepton is the heaviest charged lepton with a mass of about twice the mass of the proton. It can decay leptonically into a neutrino and other leptons or hadronically into a neutrino and hadrons, the latter being mostly pions. In the ATLAS collaboration at CERN, there are already several algorithms for the decay mode classification of hadronically decaying tau-leptons (tau-jets).

This talk presents a novel technique based on convolutional neural networks to classify the hadronic tau-lepton decay modes. The goal is to count the number of neutral and charged pions in a tau-jet using calorimeter information. To do this, for each calorimeter layer, a ‘picture’ of the tau-jet is generated. These ‘pictures’ are used as input for a neural network built from several 2D convolution and pooling layers and flattening layer followed by a number of dense layers.

The preliminary results of this study will be presented based on ATLAS Run 2 Monte Carlo samples, i.e. pp-collisions at a center of mass energy of 13 TeV. This includes an introduction into the problem as well as a visualization of the pre-processed data which is fed into the neural network. Finally, the best performing neural network’s architecture and its performance will be presented.

**T 48.2 Tue 17:15 WIL/C129**  
Photon identification efficiency measurement with the Matrix Method using 139 fb$^{-1}$ of data collected by the ATLAS experiment at $\sqrt{s} = 13$ TeV — NILS JULIUS ABICHT and TOMAS DAMO — Technische Universität Dortmund, Fakultät Physik

Photon identification (ID) is an integral part of many analyses, for example, measurements of Higgs boson properties or hypothetical pro cesses involving isolated photons in the final state. As the photon ID efficiency is not necessarily modeled well in Monte Carlo simulations, data-driven approaches are employed. One of these approaches is the Matrix Method, which estimates the efficiencies between a loose and a tight selection. For this selection, two sets of variables are used. The first set describes the longitudinal and lateral shape of the calorimeter shower and the second the topology of the center of the calorimeter shower. For calculating the photon ID efficiency, track isolation criteria that are weakly correlated with the second set of variables are used. A description of the Matrix Method, the systematic uncertainties of the measurement as well as the resulting photon ID efficiencies and corrections to simulated efficiencies, calculated on full Run-2 samples, corresponding to 139 fb$^{-1}$, are presented.

**T 48.3 Tue 17:30 WIL/C129**  
Improvement of Electron identification with the ATLAS detector and performance with first Run3 data — ASMA HADDEF and LUCA MAZETTI for the ATLAS-Collaboration — Johannes Gutenberg Universitität, Mainz, Germany

Electrons are important objects both for the search for new physics and for preci-
sion measurements. An algorithm to identify electrons in the ATLAS experiment based on a deep neural network was recently developed. Inputs to the network are high-level discriminating variables derived from the reconstructed electron track and cluster of energy depositions in the calorimeter system. The performance is estimated in simulated proton-proton (pp) collisions at $\sqrt{s}=13$ TeV and compared to the current identification algorithm which is based on a likelihood approach. Depending on the kinematics of the electron candidate, an increase in background rejection between 1.7 and 5.5 at the same signal efficiency can be observed. The performance of the electron identification algorithm is evaluated by measuring efficiencies and jet energy corrections with large statistics samples of isolated electrons from $Z \rightarrow ee$ resonance decay. The first results of Run3 data recorded in 2022 from pp collisions at $\sqrt{s}=13.6$ TeV, corresponding to an integrated luminosity of 3.4 $fb^{-1}$, will also be presented.

This talk presents a new modular approach to a generic PID framework for the different possible future Higgs factories, embedded in the Key4HEP framework. It discusses implementation questions, performance measures and possible physics applications, exemplifying the International Large Detector (ILD) concept for the International Linear Collider (ILC).

T 48.5 Tue 18:00 WIL/C129

Time-of-flight particle identification at future Higgs factories

• BOHDAN DUBAR1—2, JENNY LIE1, ANNAKA VAUTIE2, and ULRICH EINHAUS1 — 1Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany

It is established that particle identification of charged hadrons with $\geq 5$ GeV momentum plays an important role at future $e^+e^-$ Higgs factories to achieve outstanding precision in Higgs and electroweak physics, which can be covered by $dE/dx$ (or $dN/dx$) in a gaseous tracker or RICH. However, at low momentum these methods become inefficient, while also some detectors don’t have a gaseous tracker or RICH in their designs at all. Modern Si sensors technologies that can achieve time resolutions of 10 – 30 ps, such as LGADs, allow us to use the time-of-flight technique to identify $π^0, K^0$ and $p$ at low momentum by placing fast timing layers in the ECAL or as an outer tracker. This should enhance the particle identification at the future Higgs factory. Thus, achievable time resolutions of the LGADs together with time-of-flight particle identification technique are interesting points to investigate for the future detector R&D.

In this talk, we present test beam measurements of time resolution of LGAD samples with an electron beam at the DESY II test beam facility, the latest developments of the time-of-flight technique as well as its realistic momentum reach and limitations of integrating it into the detector at a future $e^+e^-$ Higgs factory, using the International Large Detector at the International Linear Collider as an example case.

T 49: Outreach (joint session HK/T)

Time: Tuesday 17:00–18:45

See HK 22 for details of this session.

T 50: Invited Topical Talks I-A

Invited Topical Talk

T 50.1 Wed 11:00 HSZ/AUDI

Search for leptonquarks at the ATLAS experiment — MAHSA HALÉM for the ATLAS-Collaboration — Julius-Maximilian-Universität Würzburg, Germany

The leptonquarks predicted in the extensions of physics beyond the Standard Model can describe the similarities between the lepton and quark generations. In the past years, these particles have been the most popular explanations for the B-anomalies reported in low-energy data, and the searches for leptonquarks have been among the important goals of the ATLAS program. Recent results from the LHCb collaboration reporting the disappearance of lepton flavour anomalies in the B-meson decays into kaon and charged-lepton pairs do not affect the search program. They probe unique signatures at the LHC, as they provide direct transitions between leptons and quarks. I will review some of these searches with ATLAS Run-2 dataset and their prospects in Run-3, particularly focusing on the final states with third-generation quarks, which offer great potential to the SM background reductions but are also challenging in terms of the remaining background modeling.

Invited Topical Talk

T 50.2 Wed 11:20 HSZ/AUDI

Making the most of Yukawa couplings: searching for Dark Matter accompanied by heavy quarks — DAVIER PEREZ ADAN — Deutsches Elektronen Synchrotron (DESY), Hamburg, Germany

Among the foremost alternatives to unravel the mysteries of Dark Matter (DM) is the search for invisible particles at colliders. The main experiments at the Large Hadron Collider (LHC) are engaged in an intense search program to identify any evidence of non-standard unbalanced transverse momentum. Should this DM hunt be successful and the manifestation consistent with any of the various theoretical scenarios, it could be a first indication of the particle-like nature of this unknown matter. A large number of these models propose that the coupling between the DM mediators and the Standard Model (SM) fermions is of Yukawa type, thus favoring at the LHC the associated production of DM with top-quarks or b-quarks. Such consideration turns out to be one of the leading motivations for many of the analyses that have a particular focus on heavy flavour fermions accompanying the DM particles in the final state. The most recent experimental efforts and some of the prospects in this direction will be the primary topic of this talk.
T 51: Invited Topical Talks I-B

Invited Topical Talk
T 51.1 Wed 11:00 HSZ/0003
LUXE – A new experiment to study non-perturbative QED in electron-laser and photon-laser collisions — RUTH JACOBS — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

The LUXE experiment (Laser Und XFEL Experiment) is a new experiment in planning at DESY Hamburg using the electron beam of the European XFEL. At LUXE, the aim is to study collisions between a high-intensity optical laser and up to 16 GeV electrons from the XFEL electron beam, or, alternatively, high-energy secondary photons. The physics objectives of LUXE are to measure processes of Quantum Electrodynamics (QED) at the strong-field frontier, where QED is non-perturbative. This manifests itself in the creation of physical electron-positron pairs from the QED vacuum. LUXE intends to measure the positron production rate in a new physics regime at an unprecedented laser intensity. Additionally, the high-intensity Compton photon beam of LUXE can be used to search for physics beyond the Standard Model.

Invited Topical Talk
T 51.2 Wed 11:20 HSZ/0003
Precision timing with silicon sensors — ANNIKA VATHY — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland

Precision timing with silicon is an important tool in many areas of particle physics, either by adding a dedicated timing layer for track timing to a detector, or full “4D-tracking” where precise space and time coordinates are assigned to each hit.

Intense R&D is taking place in the design and optimisation of different types of silicon sensors to achieve excellent timing performance. Two examples for promising technologies are Low Gain Avalanche Diodes, which have been shown to achieve time resolutions of 30 ps or better, as well as 3D sensors, which display excellent radiation hardness. In this contribution, the currently existing technological solutions and ongoing research addressing the remaining challenges are reviewed. Future applications for precision timing will be presented.

Invited Topical Talk
T 51.3 Wed 11:40 HSZ/0003
Recent advancements in Micro-Pattern Gaseous Detectors: Exciting research ahead towards future experiments — MICHAEL LUPBERGER — Helmholtz-Inst. für Strahlen- und Kernphysik — Physikalisches Institut — Forschungszentrum und Technologiezentrum Detektorphysik, Bonn, Germany

The invention of Micro-Pattern Gaseous Detectors (MPGDs), overcoming the limitation of wire-based devices, marked a new epoch in the field of gaseous detectors. MPGDs, as 2nd generation gaseous detectors, were installed with large sizes in LHC experiments within the Long Shutdown 2 upgrades – more than 20 years after their invention.

The RD51 collaboration supported this path from prototypes to large area detectors, and promotes further MPGD R&D.

Major advancements have been achieved recently, opening up novel opportunities for exciting research and future experiments: The long-standing timing limitation of planar detectors was overcome with the PICOSEC concept, achieving 17 ps time resolution. With the implementation of the VMM chip into RD51’s general Scalable Readout System, R&D support for the next decade is secured as well as new high-rate mid-size experiments are enabled. The GridPix technology with its single electron detection capability allows imaging of the fundamental particle-gas interaction and its features at a microscopic level.

These highlights will be presented, taking the prospects of the ECFP Detector R&D Roadmap and the transition from RD51 to DRDC1 into account.

Invited Topical Talk
T 51.4 Wed 12:00 HSZ/0003
Recent Liquid Scintillator Developments for Astroparticle Physics — STEFAN SCHOPPANN — Johannes Gutenberg-Universität Mainz, Exzellenzcluster PRISMA+, PRISMA Detektorlabor, Staudingerweg 9, 55128 Mainz, Germany

Liquid scintillators have been used for decades in many experiments. They are particularly suited for the detection of low-energy particles where energy and timing information is required. Liquid scintillators exhibit advantages such as high light yield, cost effectiveness, radiopurity, and more.

In recent years, various developments aim for improving the vertex and directional resolution as well as particle identification of liquid scintillators. These ideas include advanced detector instrumentation, fine-grained vertex reconstruction, hybrid scintillators, and more. These novel approaches open a rich physics programme reaching from reactor neutrinos and searches for Majorana particles to solar and astrophysical neutrinos and beyond.

In this presentation, the status of novel approaches to liquid scintillators is reviewed and their prospects and applications compared.

T 52: Invited Topical Talks II-A

Invited Topical Talk
T 52.1 Wed 14:00 HSZ/AUDI
Commissioning of the new LHCb trigger system — MARIAN STAEHL — Europäische Organization für Nuklearer Forschung CERN, Geneva, Switzerland

Since 2022 the upgraded LHCb experiment uses a triggerless readout system collecting data at an event rate of 30 MHz and a data rate of 4 Terabytes/second. A software-only heterogeneous High Level Trigger (HLT) enables unprecedented flexibility for reconstruction and selections. Compared to Run2 (2015-18), the amount of data to be processed by the HLT increased by a factor 60 due to operating at five times higher luminosity and the removal of the hardware trigger. The GPU-based first stage (HLT1) reduces the event rate to 1 MHz by selections based on charged particle tracking, vertexing, photon reconstruction and lepton identification. At the CPU-based second stage (HLT2), full offline quality event reconstruction and user-friendly configuration provides the flexibility that has allowed analysts to implement more than 1500 inclusive and exclusive selection algorithms. Real-time measurement and calibration directly after HLT1 ensures best detector performance in HLT2’s full event reconstruction. I will describe how LHCb’s Real-Time Analysis project addresses performance and code portability challenges associated with heterogeneous computing at this scale and how the new trigger, alongside with the upgraded detector, have been commissioned in 2022.

Invited Topical Talk
T 52.2 Wed 14:20 HSZ/AUDI
Alignment of the CMS Tracker: Automation is Key — MARCUS TEOERDE — 1. Physikalisches Institut B, RWTH Aachen, Germany

The inner tracker is the central part of the Compact Muon Solenoid (CMS) detector at the Large Hadron Collider (LHC). In order to ensure excellent physics performance, it is necessary to have precise knowledge of the tracker geometry, so that tracks and vertices can be accurately reconstructed.

The measurement of the tracker geometry using particle tracks, called ‘alignment’, is a very complex task. It involves tracking the time dependent position of about 15000 detector modules. Radiation damage to the modules influences the position measurements. The best data quality is therefore achieved if the tracker geometry is frequently updated based on recent data and if the granularity of the alignment is fine enough to account for biases in individual modules. An automated procedure, including automated quality control, is key to meet these requirements. In this talk, an introduction to tracker alignment strategies at CMS is given and recent developments of automatic alignment are discussed. Future prospects for the era of the High-Luminosity LHC are also touched upon.

Invited Topical Talk
T 52.3 Wed 14:40 HSZ/AUDI
ITk – ATLAS tracker upgrade — DENNIS SPERLICH — Albert-Ludwigs-Universität Freiburg

For the LHC Phase-II upgrade, the ATLAS Experiment needs to upgrade the new whole tracking system. ITk will be able to cope with the higher pileup up to 200 and integrated luminosities up to 4000 fb^-1. It will replace the current Pixel, SCT and TRT detector with an all silicon detector comprised of Pixel and Strip subdetectors. The Pixel detector will consist of five barrel layers and a number of endcap-region rings to provide hermetic coverage and tracking up to |η| < 4. The Strip detector will consist of four barrel layers and six discs per endcap. With the R&D concluding in the system tests of bigger Pixel and Strip structures and the production starting, this talk will show the current state of the two subprojects and gives and outlook towards production and integration.

Invited Topical Talk
T 52.4 Wed 15:00 HSZ/AUDI
Role of simulation in silicon tracker sensors R&D — ANASTASIA VELYKA — DESY Hamburg

Experiments at possible future colliders require, among others, lightweight detectors with a single-point resolution of a few micrometers. These requirements are addressed with various silicon tracker sensor R&D projects. Optimisation of the sensor design requires precise simulations, which can be achieved by combining computer-aided design (TCAD) and Monte Carlo methods. TCAD is used to simulate an accurate electric field of a sensor via static simulations. The
response of the sensor is simulated using the Monte Carlo software. The examples of sensor optimisation are shown for the hybrid Enchanted Lat-

eral Drift (ELAD) sensor and the monolithic small collection electrode CMOS sensor.

T 53: Invited Topical Talks II-B

Time: Wednesday 14:00–15:20
Location: HSZ/0003

Invited Topical Talk

T 53.1 Wed 14:00 HSZ/0003
LST-1: Initial scientific results from the first CTA telescope — •DOMINIK EL- SÄSSER for the CTA-Collaboration — Fakultät Physik, TU Dortmund

The Cherenkov Telescope Array (CTA) will lead the frontier of ground-based gamma-ray astronomy with its unprecedented sensitivity in the energy range between 20 GeV to 300 TeV. CTA will be composed of two telescope sites, in the northern hemisphere on the Roque de Los Muchachos Observatory in La Palma, Spain and in the southern hemisphere at the Paranal Observatory in the Atacama Desert in Chile, and of three telescope types: Large, Medium, and Small sized telescopes. The Large-Sized Telescopes (LSTs) are specially designed for low-energy and transient phenomena and will dominate CTA’s sensitivity in the energy range from 20 GeV to 150 GeV. The northern CTA site at Roque de Los Muchachos, La Palma, will host an array of four LSTs, each with a mirror diameter of 23m. The prototype, LST-1, was inaugurated in October 2018 and has since been in its commissioning phase. In this talk, we report on the first results from scientific observations using LST-1. Finally, we will discuss prospects for LST-2–4.

Invited Topical Talk

T 53.2 Wed 14:20 HSZ/0003
Multimessenger astronomy with the Pierre Auger Observ- atory — •MARCUS NIECHCIOŁ for the Pierre Auger-Collaboration — Center for Particle Physics Siegen, Experimentelle Astroteilchen-physik, Universität Siegen

The Pierre Auger Observatory is the largest air-shower experiment in the world, offering an unprecedented exposure not only to charged cosmic rays, but also to neutral particles at the highest energies. The Observatory can therefore contribute significantly to current efforts in multimessenger astronomy. For exam- ple, the upper limits on the incoming flux of ultra-high-energy (UHE) photo- tons and neutrinos de-termined from Auger data are the most stringent to date, severely con-straining current models for the origin of UHE cosmic rays. Follow-up searches for neutral particles in association with gravitational wave events and other transient events, such as the anomalous blazar TXS 0506+056, complement those performed by specialized instruments at lower energies, ex- tending the energy range of current multimessenger studies to the UHE regime.

In the contribution, the various activities concerning multimessenger astrophysics at the Pierre Auger Observatory are presented and the current results are summarized. In addition, future perspectives in the scope of the ongoing AugerPrime upgrade will be discussed.

Invited Topical Talk

T 53.3 Wed 14:40 HSZ/0003
Positron annihilation as an astrophysical messenger — •THOMAS SIEGERT — Institut für Theoretische Physik und Astrophysik, Julius Maximilians Univer- sität, Würzburg, Germany

One of the major tasks of astrophysics is to understand the emission mecha- nisms of observed sources and regions in the sky. Only by pinpointing down these mechanisms, it is possible to derive physical parameters and learn about the evolution of astrophysical objects. Alas, many observations of high-energy phenomena are ambiguous, requiring more and orthogonal information. The collapse and thermonuclear supernovae, cosmic-rays, stellar flares and poten- tially dark matter, all show signatures of positron production and annihilation. Utilising this underrated emission mechanism can shed light on unsolved problems in astrophysics and cosmology.

In this talk, I will show examples of how we can learn from these gamma-ray signatures already now, and what might be possible in the context of new gamma-ray satellite missions, such as the accepted NASA mission COSI.

Invited Topical Talk

T 53.4 Wed 15:00 HSZ/0003
The first results of the XENONnT experiment and an outlook to the future DARWIN observatory — •ANDREJ TEILKÉN for the XENON-Collaboration — Universität Heidelberg, Heidelberg, Germany — Max-Planck-Institut für Kern- physik, Heidelberg, Germany

The nature of Dark Matter is one of the most important open questions in to- day’s particle physics and cosmology. The XENONnT experiment at the Gran Sasso Laboratory in Italy aims to discover it using a dual-phase time projection chamber filled with 6 tonnes of liquid xenon. It was commissioned in 2021 and shows an excellent performance in terms of background and purity levels. In this talk we will present the status and results obtained with the first XENONnT sci- ence run. Furthermore, we will introduce the future DARWIN observatory that will have the mass of at least 50 tonnes of liquid xenon, while further improving background levels and purity.

T 54: Flavor IV

Time: Wednesday 15:50–17:20
Location: HSZ/0004

Invited Topical Talk

T 54.1 Wed 15:50 HSZ/0304
Systematic Parametrization of the B-meson Light-Cone Distribution Ampli- tude — THORSTEN FELDMANN1, •PHILIP LÜHGAUSEN2, and DANNY VAN DYK2

1Theoretische Physik 1, Universität Siegen, Walter-Flex-Straße 3, D-57068 Siegen, Germany — 2Institute for Particle Physics Phenomenology, Durham University, Durham DH1 3LE, UK

The light-cone distribution amplitude (LCDA) of the B meson provides the es- sential non-perturbative input in the QCD factorization approach to calculate, for example, the B → γγ decay amplitude. While previous phenomenological analyses were based on specific model as- sumptions for the LCDA, we propose a systematic parametrization with suit- able properties: (1) to extract information about the LCDA from experimental data, (2) to perform analytical calculations in QCD-based approaches, and (3) to obtain numerical estimates for observables with controlled theoretical uncer- tainties.

T 54.2 Wed 16:05 HSZ/0304
New Physics Studies in B0 → B̄0 Mixing — KRISTOF DE BRUYN1,3, ROBERT FLEISCHER1, •LEFTHAERT MALAMI1, and PHILINE VAN VLIET2

1NIKHEF, Science Park 105, 1098 XG Amsterdam, Netherlands — 2Vrije Universiteit Ams- terdam, 1081 HV Amsterdam, Netherlands — 3Center for Particle Physics Siegen (CPPS), Theoretische Physik 1, Universität Siegen, D-57068 Siegen, Germany

4Deutsches Elektronen-Synchrotron DESY, Notkerstr. 85, 22607 Hamburg, Germany — 5Van Swinderen Institute for Particle Physics and Gravity, University of Groningen, 9747 Groningen, Netherlands

Neutral B0 → B̄0 mixing (where q = d, s) is a powerful probe for testing the Standard Model and searching for New Physics. Focusing on the analyses of the different determinations of the Unitarity Triangle apex, we explore how much room for New Physics is left through the available experimental data. We dis- cuss the discrepancies between inclusive and exclusive |Vud| and |Vus| CKM ma- trix elements and the determination of the angle γ. Presenting future scenarios, we discuss the application of our findings to leptonic rare B decays, allowing us to minimise the CKM parameters impact in the New Physics searches. We explore the impact of increased precision on key input measurements, perform- ing future projections. It will be exciting to see how the data will evolve in the high-precision era of flavour physics.

T 54.3 Wed 16:20 HSZ/0304
Flavour Tagging in Run 3 at LHCb — •MICOL OLOCCO1, CLAIRE PROUVÉ2, BILJANA MITREŠKA1, and JOHANNES ALBECHTS1

1TU Dortmund University, Dortmund, Germany — 2University of Santiago de Compostela, Santiago, Spain

The knowledge of the B meson flavour at time of production is crucial for mea- surements of time-dependent CP violation and flavour oscillations. Flavour tag- ging algorithms exploit correlations between the B meson flavour and features of the global event in order to tag the candidate as B̄ or B with a corresponding ef ficience and mistag probability. Beside the information that is saved in real time, it is fundamental to optimize the tagging power of the algorithm since it heavily affects the uncertainty on the CP asymmetry factor. In the Run 3 of the LHC, the LHCb experiment will operate at the average non-empty bunch crossing rate of 30 MHz with an upgraded detector and a solely software-based trigger. The current status and challenges in flavour tagging al- gorithms for Run 3 are presented, together with their estimated performance at trigger level.
T 5.4.6 Wed 17:05 HSZ/0304 Sensitivity Studies for the Theia Experiment at LBNF — W.-C. Chieh Lee, Caren Hagner, and Daniel Bick — Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany

Theia is a next-generation neutrino detector, which can achieve great precision in neutrino event reconstruction and background rejection by exploiting both Cherenkov radiation and scintillation light. With this type of detectors, the nature of neutrinos may be further investigated to provide answers to unsolved questions in physics, especially those considering the mass ordering and the possible CP violation of neutrinos. For this purpose, the detector is proposed to be constructed at the Long-Baseline Neutrino Facility (LBNF) in the United States, alongside the Deep Underground Neutrino Experiment (DUNE) far detectors. The General Long Baseline Experiment Simulator (GLOBES) software package is utilized for the detector performance simulation. In this talk, studies of Theia's ability to discover CP violation will be presented with details, including effects from variations in oscillation parameters and systematic uncertainties. With conservative assumptions and 7 years of data, Theia can ultimately have >3σ (>5σ) sensitivity to CP violation for 60% (20%) of δCP parameter space in the case of normal (inverted) mass ordering.

T 5.5: Flavor V, Top-BSM
Time: Wednesday 15:50–17:20
Location: HSZ/0401

T 5.5.1 Wed 15:50 HSZ/0401
Measurement of the isospin asymmetry in \( B \to K^* \mu^+ \mu^- \) decays with LHCb — Christoph Langenbruch, Thomas Oeser, and Stefan Schael — I. Physikalisches Institut B, RWTH Aachen

In the Standard Model (SM), \( b \to s \ell^+ \ell^- \) transitions are forbidden at tree level and can only occur via loop-level and higher-order processes. Precision measurements of these processes therefore constitute powerful tests of the SM, sensitive to various potential New Physics contributions.

The isospin asymmetry \( \delta_I \) between \( B^0 \to K^{(*)} \mu^+ \mu^- \) and \( B^- \to K^{*-} \mu^+ \mu^- \) has a clean SM prediction as many hadronic uncertainties cancel in the calculation. Previous measurements are consistent with SM expectations, within small uncertainties.

This talk presents an overview of the analysis of the isospin asymmetry in \( B \to K^* \mu^+ \mu^- \) using the full LHCb dataset, recorded between 2011 and 2018 and corresponding to an integrated luminosity of approximately 9 fb\(^{-1}\).

T 5.5.2 Wed 16:05 HSZ/0401
Inclusive analysis of untagged \( B \to X^{(*)} l^+ l^- \) decays at Belle II — Abul Prakash Sivagurunathan, Svatoslav Bilokon, and Thomas Kühn — Ludwig-Maximilians-Universität München

Precision measurements of inclusive \( B \to X^{(*)} l^+ l^- \) decays can provide invaluable complementary information to scrutinize anomalies observed in their exclusive \( b \to s \ell^+ \ell^- \) counterparts. However, limited tagging efficiency, small Standard Model signal and very high background rate make these measurements very challenging, with no results being published so far. In our work, we will assess the chances of a 5σ result with data from the Belle and Belle II experiments. We will apply machine learning algorithms to tackle background rejection. We will finally compute the lepton flavour universality ratio \( R(X_l) = R(B) = X_l \mu^+ / X_l \mu^- \) (or \( R(X_e) \)) which, together with \( R(K) \) and \( R(K^*) \), will be key to constrain potential New Physics contributions.

T 5.5.3 Wed 16:20 HSZ/0401
Testing Lepton Flavour Universality with \( B^0 \to \phi \ell^+ \ell^- \) decays with LHCb data — Christoph Langenbruch, Stefan Schael, and Sebastian Schmitt — I. Physik. Inst. B RWTH Aachen

In the Standard Model of Particle Physics (SM), \( b \to s \ell^+ \ell^- \) transitions are forbidden at tree-level and may only occur at the loop-level. The branching fractions of these so-called Flavour Changing Neutral Currents (FCNCs) can thus be significantly affected by New Physics (NP) beyond the SM. While in the SM, the full potential of these new detectors, a successful separation of Cherenkov and scintillation photons is of vital importance.

The Cherenkov scintillation photon separation is the focus of this work. Different light separation algorithms (taggers) are trained with simulated Monte Carlo events. Due to simulations imperfections, the tagger performance needs to be measured in data in order to extract correction factors for the simulation predictions. ATLAS is using a set of calibration software for different jets flavors, which are complicated to use, specially for non-experts. In order to make the software easier, more flexible and more time efficient, automation workflows are defined. This study shows the framework used to automate the calibration of the flavor tagging software using REANA platform. The results are compared to the official results from ATLAS calibration with 139 fb\(^{-1}\) of 13 TeV collisions data from ATLAS. Same technique can be extended to RUN III of ATLAS and other analyses beyond Flavor Tagging.

T 5.5.4 Wed 16:35 HSZ/0401
Measurement of the branching fractions and differential kinematic distributions of \( B^{(*)} \to X l^+ l^- \) with hadronic tagging — Florian Bernlochner\(^1\), Jochen Dingfelder\(^1\), Thomas Kühn\(^2\), Martin Angelembourg\(^3\), William Sutcliffe\(^1\), and Swat Bilokon\(^2\) for the Belle II-Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn — 2 Fakultät für Physik der Ludwig-Maximilians-Universität München

Using data from the Belle II experiment we perform the first measurements of the individual branching fractions \( B(B^+ \to X l^+ l^-) \) and \( B(B^- \to X l^+ l^-) \). The Belle II experiment is located at the superKEKB \( b \bar{b} \) collider in Japan. The collisions are performed at the \( \Upsilon(4S) \) resonance leading to a large amount of produced \( B \) mesons (approximately 1000MHz per event) and the b charm production is fully reconstructed using the Full Event Interpreter (FEI) algorithm, which then gives full kinematic information about the opposite B (signal candidate). Previous analyses measured the admixture of \( B^0 \) and \( B^+ \), but using the B tag we can separate \( B^0 \) and \( B^+ \) candidates. A tagged approach also makes it possible to measure the shape distributions of the kinematic variables \( X, m, \theta \) and \( \phi \). This measurement is also an important background study for a future inclusive \( B \to X l^+ l^- \) analysis, where \( X l^+ l^- \) is one of the major backgrounds. This talk will present the current status of the analysis and predicted systematics with 364 fb\(^{-1}\) integrated luminosity.

T 5.5.5 Wed 16:50 HSZ/0401
Search for flavour-changing neutral current couplings between the top-quark and the Higgs boson in the \( \nu \to W W/ZZ \) decay channel with the ATLAS detector at the LHC. — Marvin Geyik, Oliver Thielmann, and Wolfgang Wagner — Bergische Universität Wuppertal, Germany
Search for flavour-changing neutral current (FCNC) couplings between the top-quark and the Higgs boson in the $H \rightarrow WW/ZZ$ decay channel in the tri-lepton final state is presented. The search for FCNC couplings in the top-quark-Higgs boson sector is a promising search for a theory beyond the SM. Proton-proton collision data produced by the LHC at a centre-of-mass energy of $\sqrt{s} = 13$ TeV and collected by the ATLAS experiment during the years 2015 - 2018, and corresponding to an integrated luminosity of 139 fb$^{-1}$, are used. Data is analysed in different final states, characterised by three isolated electrons or muons, missing transverse energy and the number of jets where exactly one of them is identified as a $b$-jet. A machine learning analysis based on neural networks is conducted to improve the discrimination between the signal and the backgrounds. Preliminary results, interpreted in the context of an effective field theory for FCNC, are presented, where additional exclusion limits on the $q\bar{q}$H effective coupling are derived.

**T 55.6** Wed 17:05 HSZ/0401

Search for FCNC couplings between the top quark and the Higgs boson in dilepton same-charge final states — Marvin Geyik, Oliver Thielmann, and Wolfgang Wagner — University of Wuppertal, Germany

Flavour-changing neutral current interactions are strongly suppressed in the Standard Model. Still, some extensions of the Standard Model predict tree-level FCNC couplings between the top quark, other up-type quarks and neutral bosons, including the Higgs boson. These anomalous couplings can be parametrised in the framework of effective field theories (EFT). The presented analysis searches for the production of a single top-quark in association with a Higgs boson and for top-quark-antiquark production with one of the top quarks decaying to an up quark or a charm quark and a Higgs boson. Higgs decays to $WW^{*}$, $ZZ^{*}$ and two taus leading to leptonic final states are considered in the event selection. Two analysis channels are defined: one with two leptons (electrons or muons) of the same electric charge and a second channel with three leptons. This talk focuses on advancements in the dilepton final state and the combination with the trilepton channel. The sensitivity of the analysis in setting limits to relevant coefficients of EFT operators will be presented.

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**T 56.6** Wed 16:35 HSZ/0403

Search for a $A \rightarrow Zh$ decay at $\sqrt{s} = 13$ TeV with the ATLAS detector — Roman Kuesters, Tetsiana Moskalets, and Spyros Argyropoulos for the ATLAS-Collaboration — University of Freiburg, Freiburg im Breisgau, Germany

The generation of the existing matter-antimatter asymmetry in the observable universe is one of the biggest open questions that cannot be explained with the standard model and therefore requires physics beyond the standard model. Many models suggest that electroweak symmetry breaking can generate the matter-antimatter asymmetry, however an extended Higgs sector is needed to satisfy the conditions for baryogenesis. One of the simplest extensions are models with two Higgs doublets, which give rise to 10 Higgs bosons. In these models a large mass splitting between the heavy CP-odd boson A and the CP-even boson H is required for successful baryogenesis. The analysis, which will be presented, searches for the decay of the A boson into a heavy H boson and a Z boson. The heavy H boson subsequently decays into two top quarks, while the Z boson decays leptonically. This final state will allow us to probe the the parameter space with $m_{H} > 350$ GeV, which remains so far unexplored. In the presentation the analysis optimisation and the setup for the statistical analysis will be shown. Finally the expected exclusion limits will be presented.

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**T 56.5** Wed 16:50 HSZ/0403

Search for photon-induced semileptonic WW production at the ATLAS Experiment — Varsha Soithlingam for the ATLAS-Collaboration — Kirchhoff-Institut für Physik, Universität Heidelberg

Due to the non-abelian nature of the electromagnet sector of the Standard Model of Particle Physics (SM), direct interactions between gauge couplings are possible. Measurements of the cross sections of these interactions allow for validation of the SM and potential deviations from it opens possibilities for physics beyond the SM. This talk will focus on the coupling between W bosons and photons where the W bosons decays semileptonically. They interact via the triple ($g \rightarrow WW$) and quartic ($\gamma \rightarrow WW$) gauge couplings of the SM. This process can be produced via Centrally Exclusive Production at the LHC, where non-colliding protons produce a non-linear electromagnetic field which creates a photon pair. The photons couple to the W bosons, providing the signal of interest while the protons remain intact. These photons can be detected using the ATLAS Forward Proton (AFP) spectrometers, which are located around 200m away from the ATLAS detector, on both sides. This talk will provide insight to the measurement of this rare process and the methods used to optimise its signal. It will provide an insight to the different models of the final state which take advantage of the boosted topology of such events.

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**T 56.4** Wed 17:05 HSZ/0403

Probing the use of advanced observables for measuring the electromagnetic dipole moments of the tau lepton — Martin Bode, Valeriy Lang, and Markus Schumacher — Albert-Ludwigs-Universität Freiburg

Precise measurements of the anomalous magnetic moments ($\alpha_q$) and the electric dipole moments ($\delta_q$) of leptons are strong tests of the predictions of the Stan-
charged detection via proportional scintillation in a single-phase liquid xenon TPC — FLOREAN TONNES — Albert-Ludwigs-Universität Freiburg Dual-phase liquid/gas xenon TPCs are a well-established detector technology to search for WIMP Dark Matter. Nevertheless, the spatially uniform detection of the charge signal in the standard way, i.e., via proportional scintillation in the leptons, either the W boson or the top quark decays leptonically, the remaining one decays hadronically. A boosted leptonic top quark was developed using a deep neural network to identify leptons and b-jets arising from the decay of a top quark. The tagger was validated in a phase space pure in events of top quark-antiquark pair production, with both tops decaying into leptons. The results are included in an inclusive tWZ search.

T 57.4 Wed 16:35 HSZ/0101 Search for tWZ production at CMS and its interpretation in the SMEFT — ALBERTO BELVEDERE, ROMAN KOGLER, and KATERINA LIEPA — DESY, Hamburg, Germany

The production of a single top quark t in association with a W and a Z boson in proton-proton collisions has not been observed so far. Its small predicted cross section of 115 fb at √s = 13 TeV and a large background from tZ production make this process very challenging to study. However, tWZ production receives large contributions from beyond-the-standard-model (BSM) theories through the electroweak interaction of the top quark, making this process an important probe of BSM physics. In the context of the Standard Model Effective Field Theory (SMEFT), tWZ is sensitive to unitarity violating effects, leading to an anomalous growth of the cross section as a function of the energy. A search using Run 2 and 3 data collected by the CMS experiment at √s = 13 TeV and 13.6 TeV offers the possibility to study tWZ with high significance. A status of the ongoing efforts is presented, including studies of the discriminating power of selected variables between tWZ and tZ. Additionally, the sensitivity to different SMEFT dimension-6 operators is shown.

T 57.5 Wed 16:50 HSZ/0101 tbH analysis with multileptons with Run-2 ATLAS data — MARTIN RAMES and ANDRE SOPCZAK — CTU in Prague

The latest results with Run-2 ATLAS data are presented for the search tbH in the multilepton channel.

T 57.6 Wed 17:05 HSZ/0101 CP-violation, Asymmetries and Interferences in tphi — EDWARD AZEVEDO1,2, RODRIGO CAPUCHA1, ANTONIO ONORE1, and RUI SANTOS1,3 — 1Institute for Theoretical Physics, Karlsruhe Institute of Technology, 76128 Karlsruhe, Germany — 2Institute for Astroparticle Physics, Karlsruhe Institute of Technology, 76344 Karlsruhe, Germany — 3Centro de Física Teórica e Computacional, Faculdade de Ciências, Universidade de Lisboa, Campo Grande, Edifício C8 1749-016 Lisboa, Portugal — 4Departamento de Física, Universidade do Minho, 4710-057 Braga, Portugal — 5ISEL - Instituto Superior de Engenharia de Lisboa, Instituto Politécnico de Lisboa 1959-007 Lisboa, Portugal

We present the results of our paper, where we used the associated production of top-quark pairs (t\bar{b}a[t][\phi]) with a generic scalar boson (\phi) at the LHC (pp \to t\bar{b}a[t][\phi]) to explore the sensitivity of a large set of observables to the sign of the CP mixing angle (\alpha), present in the coupling between the scalar boson and the top quarks. The mass of the scalar boson is set to m_{\phi} = 125 GeV (the Standard Model Higgs boson mass) and its coupling to top-quarks is varied such that |\alpha| = 0, 22.5, 45.0, 67.5, 90.0, 135.0 and 180.0. Di leptonic final states of the t\bar{b}a[t][\phi] system are used, where the scalar boson is set to decay as \phi \to t\bar{b}a[t][\phi].

The most sensitive CP-observables are selected to compute Confidence Level (CL) limits as a function of the sign of the top quark Yukawa couplings to the \phi boson.
Luminosity measurements using the ATLAS Forward Proton (AFP) detector — ̈Petr Fiedler and Andrej Soczewka — CTU in Prague

The latest results of luminosity measurements using the AFP detector are presented.

Measurement of the top-quark pair to Z-boson production cross-section ratio at a centre-of-mass energy of 13.6 TeV with the ATLAS detector — Donna Maria Mattiello, Tomás Dado, and Kevyn Kröninger — TU Dortmund, Fakultät Physik

The ratio of the top-quark-pair production cross-section to the Z-boson production cross-section is sensitive to the gluon-to-quark ratio of parton distribution functions and other parameters that allow to study the Standard Model, such as the strong coupling constant and the top-quark mass. A measurement of the top-quark-pair and Z-boson production cross-section, as well as the cross-section ratio, using data collected in proton-proton collisions in 2022 during the early Run 3 of the Large Hadron Collider (LHC) at a center-of-mass energy of 13.6 TeV with the ATLAS experiment, corresponding to an integrated luminosity of 1.2 fb$^{-1}$, is presented.

Events with an oppositely charged electron-muon pair, as well as b-tagged jets, are used for the top-quark-pair production, while same-flavor dilepton events are used for the Z-boson production cross-section measurement. The probability to reconstruct and tag a b-jet is measured in situ. A large cancellation of the luminosity uncertainty is achieved in the ratio, while this uncertainty is otherwise dominant in cross-section measurements in the early stages of the Run 3 of the LHC. This early result at the new center-of-mass energy at the LHC also serves to validate data quality, hardware and software updates.

Top-Yukawa coupling extraction from $t\bar{t}$ cross-section using ATLAS data — Supriya Sinha for the ATLAS-Collaboration — DESY Zeuthen

The aim of this analysis is to extract the top-Yukawa coupling ($\lambda_t$) from the $t\bar{t}$ cross-section close to the threshold. The presence of a virtual Higgs boson in the loop for the $t\bar{t}$ production process affects several kinematic distributions. This boson exchange mainly modifies the differential distributions near the $t\bar{t}$ production threshold energy. It becomes highly sensitive to $\lambda_t$, and hence, is used to extract its value.

This talk introduces the involved physics processes and gives an insight to the analysis strategy. It also highlights a method to reconstruct the $t\bar{t}$ mass efficiently with a minimal bias. The decay channel considered for this analysis is the lepton+jets final state. Full Run-II data with an integrated luminosity of 139 fb$^{-1}$ taken by the ATLAS experiment at 13 TeV, is used.

Measurement of the dileptonic $t\bar{t}$ differential cross section in a BSM phase space at CMS — Lutz Feld, Danilo Meuser, Philipp Nattl, and Mar’ius TeroeRoe — I. Physikalisches Institut B, RWTH Aachen University

Measurements of the $t\bar{t}$ production cross section yield important precision tests of the Standard Model (SM), while also probing scenarios for physics beyond the SM (BSM).

This analysis aims to measure the $t\bar{t}$ cross section in a phase space where additional contributions from BSM scenarios could be present. It is based on the data set recorded by CMS in the years 2016 to 2018 at a center-of-mass energy of 13 TeV, corresponding to an integrated luminosity of 138 fb$^{-1}$. The BSM scenarios considered include supersymmetric and dark matter models, where, similarly to the dileptonic $t\bar{t}$ channel, two leptons, b jets and undetected particles are produced.

Unlike previous measurements, where the differential cross sections were mainly measured as a function of kinematic variables of the leptons or top quarks, this analysis focuses on observables related to the neutrinos, like the missing transverse momentum and the angular distance between the missing transverse momentum and the nearest lepton, to separate BSM from SM $t\bar{t}$ events. In order to increase the sensitivity of the analysis multivariate techniques are used which improve the resolution of the missing transverse momentum in SM $t\bar{t}$ events. In this talk the analysis strategy will be presented and preliminary results on the improved missing transverse momentum resolution and on systematic uncertainties will be shown.

Measurement and QCD analysis of inclusive jet production in deep inelastic scattering at ZEUS — Florian Lokwowski — DESY, Hamburg, Germany

The measurement of cross sections of deep inelastic scattering processes at the electron-proton collider HERA is a well established tool to test perturbative QCD predictions. Additionally, they can be used to determine the non-perturbative parton distribution functions of the proton. Measurements of jet production cross sections are particularly well suited to also constrain the strong coupling constant.

In this talk, a new measurement of inclusive jet cross sections in neutral current deep inelastic scattering using the ZEUS detector at the HERA collider is presented. The data were taken during the HERA 2 period at a center of mass energy of 318 GeV and correspond to an integrated luminosity of 347 pb$^{-1}$. Massless jets, reconstructed using the $k_t$-algorithm in the Breit reference frame, are measured as a function of the squared momentum transfer $Q^2$ and the transverse momentum of the jets in the Breit frame $p_{T,jet}^{Breit}$.

The measured jet cross sections are compared to previous measurements as well as NNLO QCD theory predictions. The measurement is used in a QCD analysis at NNLO accuracy to perform a simultaneous determination of parton distribution functions of the proton and the strong coupling constant. A significantly improved accuracy is observed compared to similar measurements of the strong coupling constant.

Measurement of the $1$-jettiness event shape observable in DIS — Daniel Breitger, Soo Hyun Lee, and Johannes Hesseler — Max Planck Institute for Physics — University of Michigan

A first measurement of the 1-jettiness event shape observable $R_t^1$ in neutral-current deep inelastic scattering is presented. The data were taken by the H1 experiment at HERA from 2003 to 2007 at a centre of mass energy of $\sqrt{s} = 319$ GeV. The triple-differential cross sections are presented as a function of the 1-jettiness $R_t^1$, the virtuality of the exchanged boson $Q^2$ and the inelasticity of the event $y$. The data exhibit a sensitivity to the strong coupling constant and to resummation and hadronisation effects. The data are compared to selected predictions.

First measurement of the top quark pair production cross section at $\sqrt{s} = 13.6$ TeV at the CMS experiment — Maria Alldia, Alexander Grosheide, Laurids Jeppe, Andreas Meyer, Ivan Ranke, and Christian SchmeiBerger — Deutsches Elektronen Synchrotron DESY, Nokkestrasse 85, D-22607 Hamburg

Recently, the Large Hadron Collider (LHC) at CERN reached a new, unprecedented center-of-mass energy of $\sqrt{s} = 13.6$ TeV, starting LHC Run 3. This presents the opportunity to measure relevant physical quantities at the new energy frontier, thereby checking the predictions of the standard model.

In this talk, we present the first measurement of the top-quark pair production cross section at $\sqrt{s} = 13.6$ TeV, using data recorded at the CMS detector. The analysis uses a new method combining dilepton and lepton+jets decay channels, constraining several experimental uncertainties such as lepton selection and b jet identification efficiencies in situ. This result also constitutes a first validation of the new data taken by CMS in LHC Run 3.

Measurement of the dileptonic $t\bar{t}$ differential cross section in a BSM phase space at CMS — Lutz Feld, Danilo Meuser, Philipp Nattl, and Mar’ius TeroeRoe — I. Physikalisches Institut B, RWTH Aachen University

Measurements of the $t\bar{t}$ production cross section yield important precision tests of the Standard Model (SM), while also probing scenarios for physics beyond the SM (BSM).

This analysis aims to measure the $t\bar{t}$ cross section in a phase space where additional contributions from BSM scenarios could be present. It is based on the data set recorded by CMS in the years 2016 to 2018 at a center-of-mass energy of 13 TeV, corresponding to an integrated luminosity of 138 fb$^{-1}$. The BSM scenarios considered include supersymmetric and dark matter models, where, similarly to the dileptonic $t\bar{t}$ channel, two leptons, b jets and undetected particles are produced.

Unlike previous measurements, where the differential cross sections were mainly measured as a function of kinematic variables of the leptons or top quarks, this analysis focuses on observables related to the neutrinos, like the missing transverse momentum and the angular distance between the missing transverse momentum and the nearest lepton, to separate BSM from SM $t\bar{t}$ events. In order to increase the sensitivity of the analysis multivariate techniques are used which improve the resolution of the missing transverse momentum in SM $t\bar{t}$ events. In this talk the analysis strategy will be presented and preliminary results on the improved missing transverse momentum resolution and on systematic uncertainties will be shown.
Aachen University, D-52056 Aachen, Germany — 1Department of Physics and Center for Field Theory and Particle Physics, Fudan University, Shanghai, China — 2Fudan University, Shanghai, China

The jet-veto beam function describes collinear initial-state radiation that is constrained by a veto on reconstructed jets. As the veto is imposed on the transverse momenta of the jets, the beam function is subject to rapidity divergences, and we use the collinear-anomaly framework to extract the perturbative matching kernels to next-to-next-to-leading order (NNLO) in the strong-coupling expansion. Our calculation is based on a novel framework that automates the computation of beam functions and provides the ingredients to extend jet-veto resummations to NNLL accuracy.

T 59.5 Wed 16:50 HSZ/0105
Numerical multi-loop calculations with pySecDec

We present new features of the program pySecDec, which can serve to calculate loop amplitudes numerically. Examples for 2-loop multi-scale integrals needed for LHC precision physics as well as 3-loop integrals relevant at a future lepton collider will be given.

T 59.6 Wed 17:05 HSZ/0105
The determination of $\alpha_0$ on the CLS 2+1 ensembles — Tom Asmussen, Roman Hohlwieser, Francesco Knechtli, and Tomasz Korzec — University of Wuppertal, Wuppertal, Germany

We determine the scale $\alpha_0$ for 2 + 1 flavour QCD ensembles generated by CLS. This scale is determined from an improved definition of the static force which we measure using Wilson loops. Reweighting factors from the simulations are included in the analysis and mass derivatives have been calculated to correct for mistunings. In the end we present an analysis for $\alpha_0$ at several values of the lattice gauge coupling and perform chiral extrapolations. We also compare with the scale $\alpha_0$.

T 60: Theory BMS

Time: Wednesday 15:50–17:05

T 60.1 Wed 15:50 HSZ/0201
Domain walls in the 2HDM and their interactions with standard model fermions — Mohamed Younes Sassi and Gudrid Mootgat-Pick — IL Institute für Theoretische Physik, Hamburg, Germany

Extended Higgs models such as the 2HDM can induce topological defects after spontaneous symmetry breaking. In this talk, I will discuss the formation of domain walls arising after the breaking of the discrete $Z_2$ symmetry present in the 2HDM. I will, in particular, discuss the property of localized CP and charge violation inside the domain walls and finish with describing how standard model fermions interact with such types of domain walls.

T 60.2 Wed 16:05 HSZ/0201
Dark Matter Phenomenology in $Z'$ broken Two Higgs Doublet Model with Complex Singlet Extension — Julia Ziegler, Juhi Dutta, Cheng Li, Gudrid Mootgat-Pick, and Tabira Farah Sheikh — Universität Hamburg, Germany

Although the Standard Model is very successful, there are still open problems which it cannot explain, one of it being dark matter (DM). This has led to various beyond Standard Model theories, of which Two Higgs Doublet models are very popular, as they are one of the simplest extensions and lead to a rich phenomenology. Further extensions with a complex singlet lead to a natural DM candidate.

The aim of this work is the exploration of the dark sector in a Two Higgs Doublet Model extended by a complex scalar singlet, where the imaginary component of the singlet gives rise to a pseudo-scalar DM candidate. Both, the doublets, and the singlet, obtain a vacuum expectation value (vev), where the singlet vev leads to additional mixing of the doublet and the singlet scalar sector. We examine the influence of the Higgs sector parameters on DM relic density and direct detection scattering cross sections. The results are then compared with constraints from experiments.

T 60.3 Wed 16:20 HSZ/0201
Leading Logarithmic 3-loop Corrections to $g-2$ in the Two-Higgs-Doublet Model — Kilian Möhling — TU Dresdon, Germany

The persistent deviation of the measured value of the anomalous magnetic moment of the muon $(g-2)_\mu$ from the prediction in the Standard Model provides us with one of the currently most tantalizing hints at physics beyond the Standard Model. In the near future, increased statistics and improved theoretical calculations will further reduce the uncertainty of this result which in turn puts stronger constraints on new physics models and motivates more precise calculations of the additional corrections.

In this talk I will focus on the Two-Higgs-Doublet Model as one of the promising explanations of the deviation. Here, the dominant contribution to the magnetic moment arises through two-loop Barr-Zee diagrams with large Yukawa couplings to heavy fermion loops. These diagrams bring with them a large uncertainty from QCD corrections at 3-loop order. I will discuss how this uncertainty can be reduced by including large logarithmic 3-loop contributions resummed in the renormalization group equation of an appropriate effective field theory.

T 60.4 Wed 16:35 HSZ/0201
Scalar Potential in SU(6) Gauge-Higgs Grand Unification — Andreas Bally, Florian Goertz, Maya Hager, and Aika Marie Tada — Max-Planck-Institut für Kernphysik, Heidelberg, Germany

Composite Grand Unified Theories unify the Standard-Model gauge symmetries and their breaking in a single structure while at the same time offering a solution to the hierarchy problem. In these scenarios, the corrections to the Higgs mass are expected to be at the order of the compositeness scale around a few TeV, significantly decreasing the necessary level of fine-tuning. In the recently proposed SU(6) Gauge-Higgs GUT (GHGUT) by Angelucci et al., the Higgs emerges as a pseudo Nambu-Goldstone boson of the coset SU(6)/SU(5) along with a scalar leptoquark and a scalar singlet. The scalar potential is generated radiatively through explicit symmetry breaking induced by the coupling to elementary fields. To describe the dynamics of the SU(6) GHGUT we work in a 4-dimensional framework using the AdS/CFT correspondence and we employ the Callan-Coleman-Weiss-Zumino (CCWZ) mechanism to find the zero temperature potential. The 4D method enables a better analytical understanding of the scalar potential than the numerical study in five dimensions done previously. In addition, it can shed light on open problems such as baryogenesis, for which we include the finite temperature potential. A small hierarchy remains between the scales and we look at the fine tuning needed to achieve a realistic Higgs mass and vev. Furthermore, phenomenological aspects are investigated, such as the modification of couplings with respect to the SM, or the bounds on the lightest composite resonances.

T 60.5 Wed 16:50 HSZ/0201
Constraining BSM scalars with neural networks — Thomas Flacke, Jong Han Kim, Manuel Kunke, Jun Seung Pyo, Werner Porod, and Leonard Schwarzbach — 1Center for AI and Natural Sciences, KIAS, Seoul, Republic of Korea — 2Department of Physics, Chungbuk National University, Chungbuk, Republic of Korea — 3Institut für Theoretische Physik und Astrophysik, Julius-Maximilians-Universität Würzburg, Germany

We study a simple extension of the Standard Model motivated by composite Higgs models, in which a doubly charged scalar decays to $W^{-}\bar{H}$, resulting in a 4t-like signature from pair production. We train a neural network to differentiate this BSM signal from the dominant SM backgrounds using jet images and kinematic data. We derive the discovery reach and expected exclusion limit at the LHC. A comparison with recasts of Run-2 analyses shows a significant improvement over cut-based analyses.

T 61: Higgs I

Time: Wednesday 15:50–17:20

T 61.1 Wed 15:50 HSZ/0204
ttH analysis with two light leptons and one hadronically decaying tau lepton with Run-2 ATLAS data — Vladislav Vasyukov and Andrej Sopczuk — CTU in Prague

The latest results on the analysis with Run-2 ATLAS data are reported on the ttH 2bS1tau channel.
The Higgs boson production mode is another topology to probe Higgs-charm Yukawa coupling complementary to H→cc channels. This topology provides the possibility to access the Higgs-charm coupling via cleaner final states. In this analysis, we aim to consider the Higgs decay into W boson to dileptonic final states with additional charm-tagged jets. The expected upper limit to extract H→c+c coupling is demonstrated using the data-taking period 2017 of the CMS experiment at the LHC at √s = 13 TeV.

T 61.5 Wed 16:50 HSZ/0204
Higgs Boson Cross Section Measurement in the H → ZZ → 4f Channel with Early Run 3 ATLAS Data — ALICE REED and SANDRA KORTNER — Max Planck Institut für Physik, München
Run 3 of the LHC began in July 2022, starting a new period of data taking at a higher centre of mass energy of 13.6 TeV, compared to 13.0 TeV during Run 2. At this higher center of mass energy, the Higgs boson cross section is expected to increase by >7% compared to Run 2.
An important process for the measurement of the Higgs boson properties is the Higgs boson decay into two Z bosons, which subsequently decay into a μ+μ− or e+e− pair, H → ZZ → 4f. Due to its clear signature, this decay channel can already be studied with early Run 3 data. The precision of the fiducial and differential H → 4f cross section measurements was studied and optimized in preparation for the measurements with early Run 3 data from the ATLAS experiment.

T 61.6 Wed 17:05 HSZ/0204
Measurement of pp → WH → WW/WW with the ATLAS Experiment — MORITZ HESPING, VOLKER BUSCHER, RAFFI GUGEL, and CHRISTIAN SCHMITT — Johannes Gutenberg Universität Mainz
The measurement of the couplings of the Higgs boson is of great scientific interest, since it has the potential of testing possible extensions to the Standard Model. The decay of a Higgs boson into a pair of W bosons after production in association with a W boson is especially useful, since in this process the Higgs boson exclusively couples to W bosons.
In this talk, the analysis of the pp → WH → WW/WW using the full run 2 dataset of the ATLAS experiment will be presented, focusing on the three-lepton Z-depleted channel. First preliminary results for this analysis will be shown. Finally, the extension of the analysis to the Simplified Template Cross Sections (STXS) scheme will be discussed. In the STXS scheme, the measurement is performed as a function of the momentum of the associated W boson, which gives improved sensitivity to possible contributions from physics beyond the standard model.

T 62: DAQ NN/ML — GRID II

Time: Wednesday 15:50–17:20

T 62.1 Wed 15:50 HSZ/0301
Development of machine-learning based topological algorithms for the CMS level-1 trigger — FION LARE, JOHANNES HALLER, GREGOR KASIECZE, ALFRED LINKE, and MATTHIAS SCHROEDER — Institut für Experimentalphysik, Universität Hamburg
At the CMS experiment, a two-level trigger system is used to decide which collision events to store for later analysis. Due to the large fraction of non-interesting, low-energy collisions, currently used triggers often rely on momentum thresholds, only selecting events containing at least one highly-energetic object. In many cases, such as searches for di-Higgs production, this can substantially reduce the signal efficiency of the trigger selection. Targeting the upgraded CMS detector for the High Luminosity LHC, novel techniques are presented that utilize machine learning inside the first hardware layer of the trigger, which is based on FPGAs. Instead of individual objects, these triggers rely on the full event topology to select previously inaccessible events. The usage of these algorithms in the context of the second trigger layer and offline analysis is studied.

T 62.2 Wed 16:05 HSZ/0301
LHCb’s Topological Trigger in Run 3 — JOHANNES ALBRECHT1, GREGORY MAX CHIKEWERE2, BLAISE DELANEY2, NIKOLA NOULTE3, and NICOLE SCHULTE1 — 1TU Dortmund University, Dortmund, Germany — 2CERN, Switzerland — 3Massachusetts Institute of Technology, Massachusetts, USA
The data-taking conditions expected in Run 3 of the LHCb experiment present unprecedented challenges for the software and computing systems. Consequently, the LHCb collaboration is pioneering an entirely software-based trigger system to efficiently manage the increased event rate. The beauty physics programme of LHCb is heavily dependent on topological triggers. These are dedicated to the inclusive selection of b-hadron candidates based on the characteristic beauty decay topology and their expected kinematic properties.

We present the Run 3 implementation of the topological triggers using Lip-schitz monotonic neural networks. This architecture offers robustness under varying detector conditions and sensitivity to long-lived candidates, opening the possibility of discovering New Physics at LHCb.

T 62.3 Wed 16:20 HSZ/0301
APEL accounting with AUDITOR — MICHAEL BÖHLER, STEFAN KROBOTH, DIRK SAMMEL, and MARKUS SCHUMACHER — Albert-Ludwigs-Universität Freiburg
Institutions that are part of the Worldwide LHC Computing Grid (WLCG) offer computing resources to analyse the data recorded by experiments at the Large Hadron Collider (LHC), and to produce simulated samples. An important task is the accounting of the utilized resources. For this, the used CPU time among other resources is measured (including the operating system, I/O requests, etc.). This is handled by the APEL (American and European LHC Grid) system, which in turn is managed by the Accounting Portal of the European Grid Infrastructure (EGI). In Freiburg, for example, the accounting to APEL is performed by ARC CE (Advanced Resource Connector Compute Element). The compute element accepts compute jobs from WLCG and submits them to the local batch system. In addition, it can report the utilized resources. An alternative approach, independent from ARC CE, is the use of AUDITOR (Accounting Data Handling Toolbox For Opportunistic Resources). AUDITOR uses a "collector" to gather job information from the local batch system. These "job records" are stored in a PostgreSQL database, which can be accessed by plug-ins.
This talk first gives a short overview of the accounting system of the ARC software, and then presents an AUDITOR plug-in for accounting to APEL. The plug-in receives job records from the AUDITOR database, formats them according to APEL specifications, and submits them to the APEL server.
Particle Physics Division (T) Wednesday

T 62.4 Wed 16:35 HSZ/0301

Accounting opportunistic resources with AUDITOR — • Stefan Kraboth, Michael Boehler, Dirk Sammel, and Markus Schumacher — Albert-Ludwigs-Universität Freiburg
The increasing computational demand and concerns about energy efficiency in high performance/throughput computing are driving forces in the search for more efficient ways to utilize available resources. A measure for achieving high efficiency is the sharing of idle resources of under-utilized sites with fully occupied sites. The software COBAD/TARDIS can automatically, transparently, dynamically and opportunistically integrate and disintegrate such resources. However, sharing resources also requires accounting. In this work we present AUDITOR (Accounting Datasharing Toolbox for Opportunistic Resources), a flexible and extensible accounting system that is able to cover a wide range of use cases and infrastructure. AUDITOR gathers accounting data via so-called collectors which are designed to monitor batch systems, COBAD/TARDIS, cloud schedulers or other sources of information. The data is stored in a database and provided to so-called plugins, which take an action based on accounting records. Actions can range from creating a bill, computing the CO2 footprint, adjusting parameters of a service (i.e. priorities in a batch system) to forwarding accounting information to other accounting systems. Depending on the use case, one simply selects a suitable collector and plugins from a growing ecosystem of collectors and plugins. To facilitate the development of collectors and plugins for yet uncovered use cases by the community, libraries for interacting with AUDITOR are provided.

T 62.5 Wed 16:50 HSZ/0301

Containerization of the ATLAS HammerCloud setup — • Benjamin Rottler, Michael Böhler, and Markus Schumacher — Universität Freiburg
HammerCloud (HC) is a testing service and framework for continuous functional tests, on-demand large-scale stress tests, and performance benchmarks. It checks the computing resources and various components of distributed systems with realistic full-chain experiment workflows.

The current deployment setup based on RPMs allowed a stable deployment and secure maintenance over several years of operations for the ATLAS and CMS experiments. However, the current model is not flexible enough to support an agile and rapid development process. Furthermore, we wanted to be more independent of software versions that are provided by the package manager of the host system.

Therefore, we have decided to use a solution based on containerization, and switched to industry-standard technologies and processes. Having an “easy to spawn” instance of HC enables a more agile development cycle and easier deployment. With the help of such a containerized setup, CI/CD pipelines can be integrated easily into the automation process as an extra layer of verification. Furthermore, the container-based setup allows for quick onboarding of new team members, as developers can now work locally with a quick turnaround without the need to set up a production-like environment first.

In this talk we present the container-based setup for HammerCloud and discuss the process that led to our containerized solution.

T 62.6 Wed 17:05 HSZ/0301

Sapphire - Small-file aggregation for the dCache tape interface — • Steven Meyer1, Krishnaveni Chitravini1, Dmitry Litvinseyev, Paul Millar2, Tigran Merkityanchian1, Lea Morschel2, Albert Ross2, and Marina Sahakyan2 — 1 Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — 2 Fermi National Accelerator Laboratory, Batavia, USA — 3 National Supercomputer Center, Linköping University, Sweden
dCache is an open source distributed storage system used to manage and store scientific data located in the hundreds of petabytes. Archiving data on tertiary storage, for example tape, is a main feature of this software. Unfortunately the performance of writing data to tape decreases for small sized files, which are produced more and more by experiments. To circumvent this problem, Sapphire, an advancement of SmallFiles for dCache, was developed. Working as a plugin for dCache, these small files are bundled into bigger archives without needed intervention by the user. Flushing files to tape as well as staging them back works transparently to the user.

T 63.1 Wed 15:50 HSZ/0405

Automated Hyperparameter Optimization of Neural Networks for ATLAS analyses — • Erik Bachmann — Institute of Nuclear and Particle Physics, Technische Universität Dresden, Germany
In recent years, artificial neural networks have become a standard tool in many analyses to increase the sensitivity of measurements and largely replaced other multivariate techniques. The hyperparameters of the neural network, e.g. the number of hidden layers in a multilayer perceptron, are however usually chosen based on intuition and experience without any optimization. Additionally, the absence of overtraining is often only verified by visually inspecting the network’s output distributions.

In this talk, a framework to perform automated hyperparameter optimization with a special focus on directly including objective overtraining conditions as part of the optimization is presented. Furthermore, its first application in the ATLAS vector boson polarization analysis of $W^+W^-$ scattering is discussed.

T 63.2 Wed 16:05 HSZ/0405

Optimising inference with binning — • Philipp Keicher, Marcel Rieger, Peter Schleper, and Ian Voss — Institut für Experimentalphysik Universität Hamburg, Hamburg, Deutschland
In order to increase the sensitivity of searches for rare processes, neural networks are nowadays a widely-spread tool to construct powerful discriminators. These discriminators are usually optimized to separate physics-motivated classes, but not necessarily on an optimal statistical inference. Consequently, the results can depend on auxiliary effects such as the exact binning choice for the distributions of the final discriminants.

This study aims to construct a setup for optimising the sensitivity with respect to the binning choice in the context of a Di-Higgs in the $b\bar{b} \tau^+ \tau^-$ final state. This setup is based on the python packages pyhf and JAX, which are used for the statistical modeling and the derivation of the inference with respect to the bin edges. This talk presents the current status of this on-going project and will highlight the challenges and possible applications of this novel technique.

T 63.3 Wed 16:20 HSZ/0405

Uncertainty aware training — • Markus Klute, • Artur Monsch, Günter Quast, Lars Sowa, and Roger Wolf — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany
As physics experiments continue their measurements, with the LHC Run-3 and the future High-Luminosity LHC as notable examples, the amount of data is steadily increasing. These continued measurements will lead to reduced statistical uncertainties of many analyses, emphasizing the importance of systematic uncertainties in analysis results. This talk presents a machine-learning (ML)-based data analysis strategy to obtain an optimal test statistic minimizing analysis-specific statistical and systematic uncertainties. To achieve this the training objective for the neural network is modified to take systematic variations into account, leading to an overall uncertainty reduction on the analysis objective. The method will be demonstrated on a simple example using pseudo data and on a reduced CMS dataset used for an ML-based analysis of the observed Higgs boson in the di-$\tau$ final state with the goal of differential measurements of Higgs boson production, with the CMS experiment.

T 63.4 Wed 16:35 HSZ/0405

Interpolating Antenna Calibration Data from Sparse Measurements with Information Field Theory — • Maximilian Straub, Martin Erdmann, and Alex Reuzki for the Pierre Auger-Collaboration — Physics Institute III A RWTH Aachen University
Extensive air showers are induced in the Earth’s atmosphere by ultra-high-energy cosmic rays. These air showers are measured at the Pierre Auger Observatory using various detection techniques, including radio antennas. As part of the Pierre Auger Observatory’s AugerPrime upgrade, so-called Short Aperiodic Loaded Loop Antennas (SALLAs) are currently being deployed. These antennas will be calibrated with a remotely-piloted aircraft that carries a known signal source to characterize the direction- and frequency dependent gain, the so-called antenna pattern. With this method, only a finite number of directions and frequencies is probed, limited by i.a. battery life of the aircraft. Information Field Theory (IFT) is a framework for reconstructing field-like structures using Bayesian statistics. With IFT it is possible to leverage local correlation structures to interpolate on the domain product $S^2 \times B$, that is direction dependence and frequency dependence at the same time. The multidimensional interpolation is informed by physics and therefore performs better than e.g. a linear interpolation. Using Information Field Theory provides calibration uncertainties resulting from the calibration measurements. Furthermore, by operating directly on the sphere it avoids projection-related distortions and edge effects that stem from the angular periodicity.

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T 63.5 Wed 16:50 HSZ/0405

Tau neutrino identification with Graph Neural Networks in KM3NeT/ORCA — Lukas Henning for the ANTARES-KM3NET-ERLANGEN-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen Centre for Astroparticle Physics, Nikolaus-Fiebig-Straße 2, 91058 Erlangen, Germany

One of the goals of the KM3Net collaboration is to constrain the PMNS matrix elements associated with the tau neutrino flavour. The data needed to perform this task is taken with KM3Net/ORCA, a neutrino detector currently under construction in the Mediterranean deep sea. To constrain the matrix elements, one needs to measure the tau neutrino flux produced by atmospheric muon and electron neutrinos oscillating into tau neutrinos. Selecting the tau neutrino events from the full neutrino event dataset is a notoriously difficult task because the final states of tau neutrino interactions look very similar to the final states of muon or electron neutrino events. This classification problem was tackled in my Master’s thesis using Graph Neural Networks (GNNs), a type of neural network architecture that showed promising results, e.g., on the related task of jet tagging. This talk will discuss the different methods used to optimise the GNN’s performance on this classification task, including a computation-intensive automated hyperparameter search, and present the performance gains achieved by each of these steps and the final performance of the tau event classifier.

T 63.6 Wed 17:05 HSZ/0405

Negative event weights in Machine Learning and search for heavy Higgs bosons in top quark pair events at CMS — Jörn Bach 1,2,3, Christian Schwanzenberger 1,4, Peer Stelldinger 5, and Alexander Grohs 1,6,7 — Deutsches Elektronen Synchrotron DESY, Hamburg — Universität Hamburg, Hamburg — 1Hochschule für angewandte Wissenschaften (HAW) Hamburg Sophisticated Monte-Carlo event generators are key to the LHC research program. When involving higher order predictions or interference effects, simulated events can be negatively weighted. To achieve correct results with maximum sensitivity, negative weights cannot simply be ignored when working with Machine Learning methods. In this talk, I will discuss the issues that arise in trainings of Deep Neural Networks through negatively weighted events and propose a solution on how to efficiently handle them. Additionally, I will discuss the application of these techniques in a search for heavy Higgs bosons and its potential for LHC data analyses in general.

T 64.1 Wed 15:30 POT/0051

KM3Net status — Alba Domí for the ANTARES-KM3NET-ERLANGEN-Collaboration — ECAP, Erlangen, Germany

KM3Net is an underwater neutrino telescope under construction in the Mediterranean Sea. It is divided into two subdetectors: ORCA, whose main goal is the determination of the neutrino mass ordering, is optimised for neutrino oscillation studies in the GeV energy range and it is located 40 km off-shore Toulon (France), and ARCA, located 100 km off-shore Portopalo di Capo passero (Italy), is optimised for cosmic neutrino studies up to the PeV energy range. The construction and deployment of the telescope is modular and, to date, a fraction of the planned detection units is already taking data. This talk reviews the status of the KM3Net neutrino telescope, and it presents the first analyses performed with collected data.

T 64.2 Wed 16:05 POT/0051

Exploring Prospects for Multi-Messenger Observations of Short Gamma-Ray Bursts with IceCube-Gen2 and the Einstein Telescope — Sharif El- Mentawy 1, Jakob Böttcher 2, Anna Franckowiak 1, Philipp Fürst 1, Erik Gaster 2, Lasse Halvøy 3, Xavier Rodrigues 4, Matthias Thiesmeyer 4, and Christopher Wiebusch 5 — the IceCube-Collaboration — III. Physikalisches Institut B, RWTH Aachen University — 1Astronomisches Institut (AIRUB), Ruhr-Universität Bochum

After the coincident observation of a short gamma-ray burst (sGRB) in gamma rays and a neutron star binary merger in gravitational waves in 2017, sGRBs have become one of the most prominent sources for multi-messenger astronomy. Whereas photons provide insight into some of the radiative processes taking place, gravitational waves introduce kinematics of high-speed neutron stars, neutrinos can traverse dense material and thus might probe the source environment or the merger process itself. With the new generation of multi-messenger experiments, such as IceCube-Gen2 for high-energy neutrinos and the Einstein Telescope for gravitational waves on our doorstep, the sensitivity to both messengers will be greatly improved. We discuss a data-driven strategy for sGRBs in neutrinos and gravitational waves, with the goal of estimating joint detection prospects with IceCube-Gen2 and the Einstein Telescope.

T 64.3 Wed 16:20 POT/0051

Investigations of hadronic vs electromagnetic cascade identification at the energy scale — Ianas Ibarra for the ANTARES-KM3NET-ERLANGEN-Collaboration — Nikolaus-Fiebig-Str. 2, 91058 Erlangen, Germany

KM3Net/ARCA is an underwater Cherenkov detector located 100 km off-shore Portopalo di Capo Passero on the south-eastern coast of Sicily. Its main goal is the detection of high energy neutrinos from astrophysical sources such as gamma ray bursts or active galactic nuclei. Neutrino interactions with matter are detected as events of different topologies depending on the neutrino flavour and interaction type. The Glashow resonance is a particular type of neutrino interaction in which an electron antineutrino with an energy of about 6.3 PeV interacts with an electron producing a W-boson which can decay through different channels. In this contribution, the use of deep learning techniques to distinguish between hadronic and leptonic decay modes of the W boson produced in the Glashow resonance is described.

T 64.4 Wed 16:35 POT/0051

Optimization of the Forward-Folding Likelihood Fit for the Astrophysical Muon Neutrino Analysis with IceCube — Matthias Thiesmeyer 1, Jakob Böttcher 2, Shuting Deng 3, Philipp Fürst 1, Erik Gaster 2, Jonas Hellbrung 1, Sharif El Mentawy 2, Richard Naar 4, and Christopher Wiebusch 5 — for the IceCube-Collaboration — 1III. Physikalisches Institut B, RWTH Aachen University — 2DESY, Zeuthen, Germany

One important detection channel for astrophysical neutrinos in IceCube is the muon-induced muon tracks. The astrophysical flux parameters are estimated using an explicit forward-folding likelihood fit of the measured neutrino data. Here, the binned distribution of reconstructed zenith and energy is compared to the number of expected events from astronomical and astrophysical neutrino fluxes by means of a profile likelihood. To maximize the sensitivity to the astrophysical neutrino flux properties we optimize and generalize the choice of binning. A particular challenge is limited Monte-Carlo statistics for the estimation of precise templates over the full parameter space. As an optimization metric we extend the simple Poissonian likelihood to an effective likelihood that includes the uncertainties of the bin predictions caused by limited Monte-Carlo statistics. By this we can balance between a limited measurement resolution in cases where the binning is too coarse, and a higher statistical uncertainty of the bin predictions in cases where the binning is too fine.

T 64.5 Wed 16:50 POT/0051

Search for collider neutrinos with FASER — Florian Bernlochner, Tobias Blesgen, Tobias Boeck, Jochen Dingfelder, and Markus Prüm — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

Although neutrinos are produced in large numbers at the LHC, such collider neutrinos have not been discovered yet since they interact weakly and neutrinos with high energies are dominantly produced along the beamline. Therefore, the forward search experiment, is located on the beam collision axis line-of-sight 480 m downstream from the ATLAS interaction point. In this talk, we will present the search for such collider neutrinos using the electronic detectors of the FASER detector.

T 64.6 Wed 17:05 POT/0051

ANNE: The Accelerator Neutrino Neutron Interaction Experiment — Marc Breisch for the ANNE-Collaboration — Physikalisches Institut, Eberhard Karls Universität Tübingen

The Accelerator Neutrino Neutron Interaction Experiment (ANNE) is a 26-ton gadolinium doped water Cherenkov detector on-axis of the Booster Neutrino Beam (BNB) at Fermilab. Its primary goal is to measure the final state neutron multiplicity of neutrino-nucleus interactions to improve the systematic uncertainties of next-generation long baseline neutrino experiments. An additional milestone will be the deployment of multiple Large Area Picoscope Photodetectors (LAPPD), of which the first one is already commissioned and deployed. These novel detectors feature a timing resolution less than 100 picoseconds and a sub-centimeter spatial resolution, thus improving the track reconstruction capabilities of the detector. This talk will give a general overview of ANNE in general and the status of the LAPPD deployment.
T 65: Gamma Astronomy III

Time: Wednesday 15:50–16:50

T 65.1 Wed 15:50 POT/0151
Towards searching for ultra-high energy photons from galactic PeVatrons
• Chiara Papior, Marcus Niechciol, Markus Risse, and Philip Rehuel — Center for Particle Physics Siegen, Experimentelle Astroteilchenphysik, Universität Siegen

Recently, photons from galactic sources with maximum energies in the PeV range have been discovered. Sources which are able to accelerate particles to these energies are referred to as PeVatrons. They do not only emit photons, but are also candidate sources of galactic cosmic rays. The only firmly identified PeVatron is the Crab nebula. However, through theoretical considerations and directional observations of PeV photon signals, several other potential PeVatron candidates have been proposed, including pulsars, supernova remnants and massive stars. In this contribution, the energy spectra of such source candidates are modelled and extrapolated to even higher energies reaching up to EeV scales. Photons of these energies are referred to as ultra-high-energy (UHE) photons. The results of the extrapolation can then be used to obtain information on the required sensitivity for the measurement of UHE photons from specific source candidates. The work presented in this contribution aims to evaluate the potential at present and future observatories to detect UHE photons from certain sources.

This work is supported by the Deutsche Forschungsgemeinschaft (DFG).

T 65.2 Wed 16:05 POT/0151
Indirect Search for scotogenic WIMP Dark Matter — ♦Laura Eisenberger — University of Würzburg

Weakly interacting massive particles (WIMPs) are one of the most promising candidates for dark matter. They are predicted for example by scotogenic models which implement an additional Z2 symmetry under which all Standard Model particles are even while new particles, among them a stable dark matter candidate, are odd.

In our study, we use a scotogenic model (T1-2-A1) which can explain neutrino masses and the muon anomalous magnetic moment while fulfilling the current limits for charged lepton flavour violating processes simultaneously. In addition, it also incorporates a new WIMP dark matter type (m=1.1 TeV) consistent with limits from direct dark matter detection experiments.

We focus on the indirect search for this promising dark matter candidate via the detection of annihilation signals. For this, we predict multiviewer spectral energy distributions (SEDs) reaching from very-high-energy photons from pion decay to secondary Inverse Compton and synchrotron emission. The results are compared to observational limits.

T 65.3 Wed 16:20 POT/0151
Machine Learning Methods for an Increased Understanding of AGN Flares
• Yannick Härtley, Julia Becker, Tobias, Wolfgang Rhode, and Marcel Schroll — 1Theoretische Physik IV, Ruhr Universität Bochum, Bochum, Germany — 2RAPP-Center at Ruhr Universität Bochum, Bochum, Germany — 3Experimentelle Physik 5, Technische Universität Dortmund, Dortmund, Germany

Blazars are some of the brightest known sources in the Universe and are considered possible sources of the highest energy cosmic rays (CRs). Hence they are of high interest to astronomers to understand the processes accelerating those CRs. One of those blazars is TXS 0506+056, from which a gamma-ray flare arrived in temporal and spatial coincidence with a high-energy neutrino of high probability to be of astrophysical origin. For this reason, the source was brought into focus for further investigation to understand the underlying processes leading to this observation. It is crucial to physically model blazars thoroughly. In order to find the related parameters responsible for this behaviour, we set up simulations in CRPropa3 and develop theoretical flare templates that can be compared to observational signatures. With those templates, the next step will be to train a machine learner to search the galactic catalogues for other blazars with a high probability of showing behaviour similar to TXS 0506+056. In this talk, we will present first preliminary results of such simulations and evaluate their significance in the context of the parameter study.

* Financial support by the DFG (SFB 1941) is gratefully acknowledged

T 66: Neutrinos II

Time: Wednesday 15:50–17:20

T 66.1 Wed 15:50 POT/0251
Detection of solar pp-neutrinos with CID in SERAPPIS — Tim Charissé, Marcel Büchner, Arshak Jasfar, Kai Loo, George Parker, Oliver Pilarczyk, and Michael Wurm — Institute of Physics and EC PRISMA+, Johannes Gutenberg University Mainz, Mainz, Germany

The OSIRIS detector, a pre-detector that monitors the radioactivity of the scintillator for the JUNO experiment, is planned to be used for the measurement of the solar pp-neutrino flux after fulfilling it’s initial purpose. This upgrade is called SExpress for RaE PP-neutrinos In Scintillator (SERAPPIS). As these pp-neutrinos originate from the sun it is crucial to obtain the directional information to get a high sensitivity. This directional information is contained in the Cherenkov light which is hard to distinguish from the scintillation signal. While there are experimental efforts like slow scintillators to enhance the sensitivity for Cherenkov light in SERAPPIS, there is also a data-analytical method called Correlated and Integrated Directionality (CID) to obtain the directional information from the data. It uses the angular distribution between the direction of the neutrino and the detected light for the whole data set to gain information over the pp-neutrino flux.

This talk will present the status of the ongoing sensitivity study for CID in SERAPPIS based on Monte Carlo simulations. It is investigated if CID can have a valuable impact on the measurement of the solar pp-neutrino flux.

T 66.2 Wed 16:05 POT/0251
Column Density Determination for the KATRIN Neutrino Mass Measurement — Fabian Block, Christoph Köhler, and Sonja Schneide1nd for the KATRIN-Collaboration — Karlsruhe Institute of Technology — Technical University of Munich — Westfälische Wilhelms-Universität Münster

The KATRIN experiment aims to model-independently probe the effective electron anti-neutrino mass with a sensitivity of 0.2 eV (90% CL) by investigating the endpoint region of the tritium beta decay spectrum. To achieve this goal the gas quantity of the windowless gaseous tritium source, characterized by the column density, has to be known with great accuracy.

In this talk, we discuss the technique of measuring the column density with an angular resolved photoelectron source and describe the method to ensure continuous monitoring of the column density during measurement campaigns of KATRIN. The influence of the recent hardware upgrade of the photoelectron source is discussed in light of the column density determination accuracy.

This work is supported by the Technical University of Munich, the Helmholtz Association, the Ministry for Education and Research BMBF (05A17PM1, 05A17PX3, 05A17VK2, 05A17WO3, 05A20PMA), the Helmholtz Alliance for Astroparticle Physics (HAP), the Helmholtz Initiative and Networking Fund (W2/W3-118) and Deutsche Forschungsgemeinschaft DFG (Research Training Group GRK 2149).

T 66.3 Wed 16:20 POT/0251

The Project 8 collaboration aims to determine the absolute neutrino mass with a sensitivity of 40 meV by measuring the tritium spectrum around the endpoint energy. For this level of precision it is necessary to use atomic tritium, since molecular tritium sensitivity is limited by the molecular final state distribution to about 100 meV.

A flux of $10^{19}$ atoms/s from the source will be required to inject a beam with $10^{15}$ atoms/s into the detection volume after cooling and state selection imaging. For monitoring the beam, we have built a detector that uses a wire with a micrometer-scale diameter intersecting the beam on which a small fraction of the beam’s hydrogen atoms recombine into molecules. The energy released heats the wire and produces a measurable change in its resistance. Such

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a detector is suitable for both development work and for minimally disruptive online monitoring in the final experiment.

Additionally, we are working on a calorimetrically estimating the fraction of molecules being split by measuring the surplus power our thermal atom source draws when dissociating hydrogen.

In this talk I will present results from tests of both methods.

T 66.4 Wed 16:35 POT/0251

Modeling of RF signals in large-volume antenna-array CRES detectors — Florian Thomas and Sebastian Böser for the Project 8—Collaboration — Institut für Physik, Johannes Gutenberg-Universität Mainz

The Project 8 collaboration has established Cyclotron Radiation Emission Spectroscopy (CRES) as a novel frequency-based approach of measuring the tritium beta decay spectrum and determining neutrino mass with the endpoint method. To gather sufficient statistics for its design sensitivity of \( m_\nu < 40 \text{ meV} \) the Project 8 experiment needs to be scaled up to a \( E^3 \text{m}^3 \) source volume.

In the large-volume case a possible detection scheme for the radio frequency radiation emitted by the decay electrons is an antenna array with \( E^0 \) independent readout channels. In order to reconstruct the electron tracks comprehensive simulations are required. For this large number of channels, numerical solutions of the electron trajectory, the electromagnetic fields and the antenna response are computationally challenging. In this contribution we present an alternative simulation approach which is based on analytic knowledge about cyclotron radiation and \( E^0(1000) \) faster than our full numeric baseline approach with a negligible impact on the simulation results.

T 66.5 Wed 16:50 POT/0251

Test setup for de-excitation of Rydberg atoms in KATRIN using THz radiation — Ernesto Ellinger — Bergische Universität Wuppertal

The majority of the background in the neutrino mass experiment KATRIN probably originates from the ionization of Rydberg atoms in the main spectrometer volume. The Rydberg are formed by natural radioactive decay, followed by sputtering processes on the inner walls of the spectrometer vessel. The neutral Rydberg atoms can migrate through the spectrometer before they are ionized by thermal radiation. The resulting free electrons are eventually accelerated towards the main detector producing the background.

T 67: Neutrinos, Dark Matter VII

Time: Wednesday 15:50–16:50

Location: POT/0361

Optimization of the remoTES design using silicon absorbers — Kumride Sheva, Goide Angloher, Mukund Bharewarda, Trosten Frank, Moritz Kellermann, Michele Mancuso, Federica Petricca, Franz Probst, Karoline Schäffner, Martin Stahlberg, Vanessa Zema, Antonio Bento, Lucia Canonica, and Arhijit Garai — Max-Planck-Institut für Physik, 80805 Munich, Germany

Transition Edge Sensors (TES) are sensors that can measure tiny increases of temperature of \( \pm \)K and are widely used to read out cryogenic calorimeters. However, delicate materials (e.g. with low electronic noise and/or thermal capacitancy) can not undergo the process of fabricating such a sensor on their surface. To deal with this, the COSINUS-experiment developed the remoTES readout design, where the TES itself is placed on a separate wafer and the coupling of the absorber crystal to the TES consists of a gold bonding wire connected to a gold pad on the absorber. In this talk studies done for the optimization of the remoTES design using silicon crystals as a benchmark are shown.

T 67.2 Wed 16:05 POT/0361

Particle Dependent Parameter Determination of Liquid Scintillators for Neutrino Experiments — David Dörflinger, Lothar Oberauer, Hans Th. J. Steger 1,2, Raphael Stockl 1, Ulrike Fahrenholz 1, Lennard Kayser 1, Florian Kühbleck 1, Korbinian Stangler 1, Michael Wurm 1, Dorina Zündel 1, and Manuel Bühler 1 — 1Technische Universität München (TUM), Physik-Department, James-Franck-Straße 1, 85748 Garching bei München — 2Institute of Physics and Excellence Cluster PRISMA+, Johannes Gutenberg-Universität (JGU) Mainz, Staudingerweg 9, 55099 Mainz

Theinteraction between the Neutrino Observatory (JUNO) aims to detect neu-trinos using 20 kton of organic liquid scintillator based on LAB (Linear Alkyl Benzene). In order to understand the detector response, a precise determination of particle dependent scintillation parameters is crucial. Compared to gamma radiation, neutrons have a different energy dissipation method in the detector material, which leads to a quenched light output. The quenching factors of the JUNO scintillator and other organic, as well as water base liquid scintillator samples have been studied using a particle accelerator driven neutron source at the INFN-LNL in Legnaro, Italy. The neutrons are produced quasi-monoenergetically by \(^{2}\text{Li} (\text{p},n)\) reaction with energies between 3.5 MeV and 5.5 MeV. This work is supported by the DFG Research Unit JUNO (FOR2319) and the clusters of excellence ORIGINs and PRISMA+.

T 67.3 Wed 16:20 POT/0361

Quenching Factor measurements with COSINUS NaI crystals — Mukund Raghunath Bharewarda for the COSINUS-Collaboration — Max-Planck-Institut für Physik, Föhringer Ring 6, 80805 München

NaI (TI) based scintillation detectors have become a staple in the field of direct dark matter searches, with the DAMA-LIBRA experiment being the stand out for its reported dark matter observation which is in direct contrast with numerous other experiments. In order to accurately calibrate the energies of WIMP induced nuclear recoil signals and conclusively rule out the parameter space covered by DAMA/LIBRA, precise measurements of the quenching factor of the NaI crystals is essential for each of these experiments as it is well established that electron recoils and nuclear recoils do have similar scintillation light yields. In this study, we present first preliminary results of a systematic study that has been carried out by the COSINUS collaboration to measure the quenching factor values primarily in the low recoil energies of 1-300 keV\(_{nr}\) in order to better understand the discrepancies/uncertainties reported by various experiments. Five ultra-pure NaI crystals manufactured by the Shanghai Institute for Ceramics, each of which have varying TI dopant concentration, were irradiated with a mono-energetic neutron beam to study its impact on the quenching factor values in the desired recoil energy range.

T 67.4 Wed 16:35 POT/0361

Precision Attenuation Length Measurement of Liquid Scintillators for Future Large Volume Neutrino Experiments — Korbinian Stangler, Florian Kühbleck, Hans Steiger, and Lothar Oberauer — 1TUM, Physik-Department, James-Franck-Straße 1, 85748 Garching — 2Cluster of Excellence PRISMA+, Detector Laboratory, Staudingerweg 9, 55128 Mainz

Upcoming large volume neutrino experiments (like JUNO and THEIA) place high demands on the purity of their scintillator materials. Measurements of these optical properties have so far been carried out with UV/Vis spectrometers and cuvette lengths of 10cm which leads to overall un-
theselected mono-energetic cross-section spectrum, which needs to be characterized in order to reduce the systematic bias in the measured neutrino mass.

Reaching the target sensitivity of 0.2 eV/c² neutrino mass upper limit of 0.8 eV/c² achieved by the KATRIN experiment currently provides the best neutrino mass measurement, using high-resolution MAC-E filter, called main spectrometer. The energy analysis of the decay electrons in the main spectrometer takes place via a complex interplay of electric and magnetic fields.

To improve the signal-to-background ratio in neutrino mass measurements, the electromagnetic field configuration in the main spectrometer is adapted to the so-called Shifted Analyzing Plane (SAP). The SAP fields need to be known with high precision in order for them to be taken accurately into account in the β-spectrum model applied in the fit of the data. We present in this talk the results of high-statistics SAP characterization measurements employing conversion electrons from the decay of Kr-83 to perform electromagnetic fields calibration.

This work is supported by the Helmholtz Association, the Ministry for Education and Research BMBF (05A17PM3, 05A17VX3, 05A17VX2, and 05A17W03), the Helmholtz Alliance for Astroparticle Physics (HAP), and the Helmholtz Initiative and Networking Fund (W2/W3-118).

The nuclear recoil scattering by Neutrons is the most dangerous background for the XENON1T experiment because they can mimic the expected Dark Matter signal: the single nuclear recoil scattering. To increase the Neutron tagging efficiency, the Muon Veto Water tank has been modified by introducing an additional neutron veto detector surrounding the XENON1T time projection chamber (TPC) and, in the next phase of the experiment, 1.87 x 10^7 liters of water of the Cherenkov detector will be loaded with a solution at 0.48% of Gadolinium Sulfate Octahydrate salt (Gd₂(SO₄)₂ · 8H₂O), corresponding to a percentage of 0.2% of Gadolinium of the total mass. In the next phase, the addition of Gadolinium at 0.2%, will increase the neutron capture efficiency from 74% of pure water to the 90% of the new solution. Together with the infrastructure of the neutron veto detector, we will also present the filtration plant for purification system and the relative automatic control.

On one major uncertainty is linked to the electric potential inside the tritium source. Inhomogeneities of the potential can lead to a distortion of the β-spectrum, which needs to be characterized in order to reduce the systematic bias in the neutrino mass measurement.

To this end we use conversion electrons from 83mKr as nuclear standard. Traces of gaseous 83mKr are circulated alongside tritium in the 10 m long source, such that inhomogeneities of the potential are observable as a broadening of the selected mono-energetic 83mKr line. In this talk we describe the result of a three-week long 83mKr campaign carried out in 2021 and its impact on the neutrino mass determination.

This work is supported by the Helmholtz Association, the Ministry for Education and Research BMBF (05A17PM3, 05A17VX3, 05A17VX2, and 05A17W03), the Helmholtz Alliance for Astroparticle Physics (HAP), and the Helmholtz Initiative and Networking Fund (W2/W3-118).

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Observables of the Electrical Potential of the KATRIN Tritium Source from Calibration with a High-Intensity Krypton-83m Source — Moritz Machatschke for the KATRIN-Collaboration — University of Karlsruhe, Karlsruhe Institute of Technology

**Results and updates of the XENON1T neutron-veto detector** — Daniel Wezen for the XENON-Collaboration — Johannes Gutenberg-Universität Mainz

Nobel liquid time projection chambers (TPC) are playing a key role in the search for WIMP dark matter in the mass range of a few to a few hundred GeV/c². Neutrons, emitted by the detector material, pose a great danger for this type of experiments as they can mimic WIMP signals, by undergoing single-scatter nuclear recoils before leaving the sensitive region of the TPC. To mitigate this detector intrinsic background, the XENON1T TPC is enclosed by a water Cherenkov neutron-veto which tags these dangerous signals by measuring in a delayed coincidence the 2.22 MeV gamma-ray released from the neutron-capture on hydrogen. To get a precise calibration of the neutron-veto tagging efficiency, a novel coincidence technique, based on coincidentally emitted neutrons and gammas of an AmBe source, is used. The very same technique is also applied to conduct a very clean calibration of the XENON1T TPC nuclear recoils response.

In this talk, we are going to present the latest results of the XENON1T neutron-veto, including its tagging efficiency calibration as well as the calibration of the NR response of the XENON1T TPC.

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**Reconstruction of atmospheric neutrino events in JUNO using GCNs** — Rosmarie Wirth, Carsten Hagner, Daniel Bick, and Vishwa Thara Hariharan for the JUNO-Collaboration — University of Hamburg, Hamburg, Germany

The JUNO is a 20 kt liquid scintillator detector, which will be completed in 2023 as the largest of its kind. JUNO aims to determine the neutrino mass ordering with 3 σ significance in about 6 years by observing the energy dependent oscillation probabilities of reactor anti-neutrinos.

Due to JUNO’s large volume, it provides the opportunity to detect atmospheric neutrino events with lower energies than today’s large Cherenkov experiments. This channel could deliver further measurements on the mass ordering, by observing the energy and direction dependent oscillation probabilities.

This talk presents reconstruction methods based on Graph Convolutional Networks (GCNs) to analyze these atmospheric neutrino events in JUNO.
precise knowledge on the track of atmospheric neutrinos, which is challenging in terms of reconstruction of the isotropic scintillation light emitted in JUNO. To achieve this target performance, a novel track reconstruction technique based on the voxelized distribution of optical photon emissions is being developed. The current status of this method will be presented in this talk.

T 69.3 Wed 16:20 POT/0112
Development of the first Detector Line for the Pacific Ocean Neutrino Experiment — CHRISTIAN SPANNFELLNER, *Nikolas RETZAA, Elisa RECONIO, Chiara BELLENGHI, Marjia SHARSHUNOVA, and Lea GINZKEY for the P-ONE Collaboration — Technical University Munich, Physics Department, James- Franck-Str. 1, Garching, Germany

The Pacific Ocean Neutrino Experiment (P-ONE) is a proposed multi-cubic-kilometre neutrino observatory off the coast of Vancouver Island, Canada. P-ONE will be connected to the NEPTUNE observatory, a deep-sea infrastructure in the Northeast Pacific Ocean hosted by Ocean Networks Canada (ONC). The NEPTUNE node at the Cascadia Basin, roughly 200 km offshore of Vancouver Island at a depth of 2660 m, has been probed for its optical properties by two pathfinder experiments, STRAW and STRAW-b, deployed in 2018 and 2020 respectively and was found to be suitable for a neutrino telescope. A first mooring line, called P-ONE-1, is planned to be deployed in 2024. P-ONE-1, consisting of 20 optical and calibration instruments distributed over a total vertical length of around one kilometre, shall serve as a prototype line for the detector, and ultimately be the blueprint for the following detector lines. In this contribution, we will present the design of P-ONE-1 and its optical instruments. The multi-PMT design of the latter allows to cope with the high background rates in the depths of the Northeast Pacific Ocean, while their modular and minimal mechanical design make them easily scalable in vision of the construction of the full P-ONE detector.

T 69.4 Wed 16:35 POT/0112
DELight: Direct Search Experiment for Light Dark Matter with Superfluid Helium — Francesco TOSCHI, Klaus EITEL, Christian ENS, Torben FERBER, Loreadana GASTALDO, Felix KAHLOHEFE, Sebastian KEMP, Greta HEINE, Markus KLUTE, Sebastian LINDEMANN, Marc SCHUMANN, Kathrin VÄLHERUS, and Belina von KROSIGK — Karlsruhe Institute of Technology — Heidelberg University — University of Freiburg

The DM-nucleon scattering parameter space of Light Dark Matter (LDM) has been barely experimentally probed, as it requires an energy detection threshold down to a few tens of eV. The "Direct search Experiment for Light dark matter" (DELight) aims at using superfluid helium -4 as target, particularly suited because of its low nuclear mass and radiopurity, while providing both photon and quasi-particle signal channels valuable for event classification. DELight will deploy Magnetic Micro-Calorimeters (MMCs) operating at a temperature of 20 mK, promising high resolution and a threshold of a few eV. With an exposure of only 1 kg d and an energy threshold of 20 eV, in its first phase DELight will be able to probe unexplored regions of the parameter space for LDM masses below 100 MeV with an expected sensitivity lower than 10^{-11} cm² at 20 MeV.

In this talk we will present the working principle of the detector technologies as well as an overview of the ongoing R&D towards the realization of DELight.

T 69.5 Wed 16:50 POT/0112
Design and Commissioning of the MainzTPC — Constantin Szyrka, Christopher HILS, Jan LOMMLER, Uwe OBERLACK, Daniel WENZ, and Alexander DEISING — Institut für Physik & Exzellenzcluster PRISMA+, Johannes Gutenberg-Universität Mainz

MainzTPC is an experimental dual-phase xenon time projection chamber (TPC) dedicated to the study of scintillation and ionization processes of liquid xenon for low-energy electronic and nuclear recoils. It features a signal readout with two PMTs and eight APDs, enabling 3D position reconstruction. The TPC also allows to study the influence of the drift field's strength on the scintillation process. Its design has been optimized for the use as primary target in Compton scattering experiments to measure recoil energies in liquid xenon down to 1 keV.

The MainzTPC is being redesigned to accommodate a SiPM array instead of the top PMT and APDs to lower energy position resolution in x and y. To address known instabilities in the liquid level of the MainzTPC, we aim to improve the level meters and level control by observing the liquid gas interface with commercially available cameras. We report on the status of this work.

T 70.1 Wed 15:50 POT/0013
measurement of the cosmic-ray electron flux with AMS02 — Yasaman NAJAFIHOZANI — RWTH Aachen University, Sammelbau Physik, Sommerfeldstr. 14, Turm 28, 52074 Aachen, Germany

The Alpha Magnetic Spectrometer (AMS-02) on the International Space Station has been performing precision measurements of cosmic rays in the GeV to TeV energy range since 2011. The fluxes of electrons and positrons are potential probes of dark matter or new astrophysical phenomena. With AMS-02, electrons and positrons are identified by two independent subdetectors, a transition radiation detector, and an electromagnatic calorimeter. I will present my analysis of the cosmic-ray electron flux from 0.5 to 1000 GeV.

T 70.2 Wed 16:05 POT/0013
3D modelling of the Galactic Center region — Julien DONNER, Julia BECKER TJUS, Paul-Simon BLOMENKAMP, Horst FICHTNER, Anna FRANCZOWIAK, Mario HOERBE, and Momo ZANINGER — Ruhr-Universität Bochum, 44801 Bochum, Deutschland — RAPP-Center at Ruhr University Bochum, Bochum, Germany

The Galactic Center (GC) region is a unique astrophysical environment, which has been intensively studied in the past decades. In the HE and UHE gamma-ray regime several point like sources and a diffuse emission have been discovered. In addition, observation in the emission with Fermi/LAT show an excess, which may hint to a population of unresolved sources. The detection of the first PeVatron by HESS indicates that cosmic-rays (CRs) can be accelerated up to PeV energies in the GC. While 3-D transport models for the entire Galaxy do exist in well-advanced states, the GC region in these global models is not well-represented in advanced states, the GC region in these global models is not well-represented and dedicated 3-D models of this region are missing. We present the first model using a realistic 3D distribution of the gas and the magnetic field for the Central Molecular Zone. The magnetic field is composed by a large-scale structure, as well as contributions from several molecular clouds and non-thermal filaments. We use an anisotropic diffusion tensor defined by the ratio of the perpendicular and the parallel diffusion coefficient with respect to the local magnetic field direction. In the end, we compare our model with the observation by H.E.S.S. and calculate synthetic 2D count maps with predictions for the observability by CTA and for the expected neutrino flux.

T 70.3 Wed 16:20 POT/0013
Modeling of the Galactic Cosmic-Ray Antiproton Flux — Thomas POŚCIL, Laura FARBETTI, Maximilian HORSI, Laura SERRYNTE, and Andrew STRONG — Technische Universität München, Garching, Deutschland — Max-Planck-Institut für extraterrestrische Physik, Garching, Deutschland

Cosmic-ray antiprotons are an excellent probe to study exotic contributions to ordinary production.

In particular, cosmic-ray antinuclei are informative since these particles are expected to be only rarely produced in conventional reactions. However, the interpretation of cosmic antinuclei measurements requires a good understanding of all involved processes of the creation and propagation of the antiparticles and a realistic estimate of the involved modeling uncertainties to distinguish potential exotic contributions from ordinary production.

In this contribution, we review the current understanding of the production and propagation of charged cosmic rays in our galaxy and the thereon-based modeling of galactic cosmic-ray fluxes, with a special focus on cosmic-ray antiprotons. We quantify systematic deviations of the modeled flux that arise due to inaccuracies of the numerical solution of the propagation equation, different models of propagation processes, and different models of the antiproton-production cross section. Based on the found systematic uncertainties, we comment on the agreement between the modeled fluxes and recent measurements.

This research is funded by the DFG under Germany's Excellence Strategy - EXC2094 - 390783311.

T 70.4 Wed 16:35 POT/0013
Charge sign dependent modulation of protons and electrons during solar cycle 22 and 23 — Johannes MARQUARDT, Bernd Heber, Carlotta JOHN, Marlon KöBERLE, and Lisa RomainEESEN — Christian-Albrechts-Universität Kiel, D

The cosmic ray electron and proton flux observed with the Kiel Electron Telescope (KET) onboard the Ulysses space probe varies with solar activity as well as with heliospheric position. Ulysses' launch in 1990 completed its mission in 2009. The KET measured the electron, proton and helium flux during the declining phase of solar cycle 22 and during the full solar cycle 23 during an A > 0 and A < 0 solar magnetic epoch. In this contribution we discuss the flux vari...
In this talk, we present a measurement of the proton-proton interaction cross section, $K$-Karlsruhe, Germany.

This talk introduces a measurement of the proton-proton interaction cross sections from the distribution of the depth of air shower maximum, $X_{\text{max}}$, measured by the fluorescence detector of the Pierre Auger Observatory. In previous analyses, the interaction cross section was obtained assuming the predominance of protons in the tail of the $X_{\text{max}}$ distribution. Similarly, assumptions on hadronic interactions in air showers were needed to estimate the mass composition of cosmic rays. To get a self-consistent estimation of the interaction cross sections and cosmic-ray primary composition, we implement an algorithm for the combined measurement of the interaction cross sections and composition fractions. For this, we perform a standard binned maximum-likelihood mass composition of the varied proton-proton interaction cross sections. The conversion from the modified proton-proton to the corresponding nucleus-nucleus cross sections is done via the Glauber formalism. We include a shift in the $X_{\text{max}}$ scale to account for systematic uncertainties of the data and theoretical uncertainties of the properties of particle production in air showers. The preliminary cross sections and composition fractions obtained using this novel self-consistent approach will be compared to the previous measurements and future improvements to the method will be discussed.

A new bound on Lorentz violation based on the absence of vacuum Cherenkov radiation in ultra-high energy air showers — Fabian Duennkel, Marcus Niechciol, and Markus Risser — Center for Particle Physics Siegen, Experimentelle Astroteilchenphysik, Universität Siegen.

In extensive air showers induced by ultra-high energy (UHE) cosmic rays, secondary particles are produced with energies far above those accessible by other means. These extreme energies can be used to search for new physics. We study the effects of isotropic, nonrefracting Lorentz violation in the photon sector. In case of a photon velocity smaller than the maximum attainable velocity of standard Dirac fermions, vacuum Cherenkov radiation becomes possible. Implementing this Lorentz-violating effect in air shower simulations, a significant reduction of the calculated average atmospheric depth of the shower maximum $\langle X_{\text{max}} \rangle$ is obtained. Based on $\langle X_{\text{max}} \rangle$ and its shower-to-shower fluctuations $\sigma(X_{\text{max}})$, we present a new bound on Lorentz violation sensitive to vacuum Cherenkov radiation from fundamental particles (electrons and positrons) in air showers.

This work is supported by the Deutsche Forschungsgemeinschaft (DFG).

**T 71: Exp. Methods AP, PMTs**

**T 71.1** Wed 15:50 POT/00351

**Performance Tests of the Acoustic Module for the IceCube Upgrade**

- Charlotte Benning, Jan Audehm, Jürgen Borowka, Mia Giang Do, Oliver Griese, Christoph Günther, Dirk Heinen, Adam Rifaie, Joelle Savelberg, Christian Weibusch, and Simon Zierke for the IceCube Collaboration — III. Physikalisches Institut B, RWTH Aachen University

The IceCube Neutrino Observatory is a one cubic kilometer particle detector consisting of 5160 Digital Optical Modules located in the ice at the geographic South Pole. During the IceCube Upgrade more than 700 additional modules will be deployed at the center of the existing detector with the purpose of calibrating and enhancing the detectors capabilities. Part of this upgrade will be ten specialized Acoustic Modules which are capable of receiving and transmitting acoustic signals from 5 to 40 kHz. Based on the principle of trilateration, the positions of acoustic and optical modules will be determined from the propagation times of these signals. With this system we aim to achieve an accuracy of a few 10 cm for the geometrical precision of the detector. In this talk the results of performance tests of the acoustic modules in the laboratory and at a local swimming pool are presented.

**T 71.2** Wed 16:05 POT/00351

**The Design of the Acoustic Module for the IceCube Upgrade**

- Adam Rifaie, Jan Audehm, Charlotte Benning, Jürgen Borowka, Mia Giang Do, Oliver Griese, Christoph Günther, Lasse Halve, Dirk Heinen, Joelle Savelberg, Christian Weibusch, and Simon Zierke for the IceCube Collaboration — III. Physikalisches Institut B, RWTH Aachen University

The IceCube Neutrino Observatory at the South Pole detects high energy neutrinos from astrophysical sources. With the upcoming IceCube Upgrade, more than 700 detector modules along with calibration devices will be deployed at the central core of IceCube, 2 km deep into the Antarctic ice. Ten Acoustic Modules (AM) will transmit and receive acoustic signals from 5 to 40 kHz. By means of trilateration of the propagation times of these acoustic signals, we determine the positions of the AMs with an accuracy of about 10 cm and thus calibrate the geometry of the detector. The AM consists of acoustic transducer, communication and signal generation power electronics, and receiver electronics, all embedded in a housing, withstand the pressure in the ice. For the proper measurement of transit times between different modules a dedicated synchronization and timing protocol has to be implemented. This talk presents an overview of the functional and technical design of the main components and describes the development of appropriate firmware.

**T 71.3** Wed 16:20 POT/00351

**Status of the implementation of "Event-Generator" in IceCube-Gen2**

- Francisco Javier Vara Carbonell and Alexander Kappes for the IceCube Collaboration — Institut für Kernphysik WWU Münster, Münster, Germany

The success of large observatories such as the IceCube neutrino telescope is highly dependent on the accuracy of their reconstruction algorithms. In IceCube, traditional likelihood-based methods are limited by the lookup tables used for calculating the event hypotheses, since their complexity requires them to be simplified. Promising results have recently been obtained with "Event Generator", a generative neural network that can replace such tables and lead to an improvement in reconstruction performance since it does not require simplification. The success of this neural network lies in its design, which, unlike most machine learning applications, is able to explicitly exploit the information domain of IceCube event generation, such as symmetries and detector properties. In this talk, "Event-Generator" will be introduced and the current status and future plans for its implementation in IceCube-Gen2 will be presented.

**T 71.4** Wed 16:35 POT/00351

**Photomultiplier simulation in COMSOL Multiphysics**

- Willem Achatzmann, Alexander Kappes, and Markus Dittmer for the IceCube Collaboration — Institut für Kernphysik, Westfälische Wilhelms-Universität Münster, Münster, Germany

Photomultiplier tubes (PMTs) are used in water Cherenkov neutrino detectors such as IceCube and KM3NeT. They play a central role in the performance of the detector and therefore a deep understanding of their properties is crucial for the operation and improvement of the experiment. In this talk, I will discuss some of the timing parameters, e.g., the transit time (spread) for a PMT, which I investigate using a COMSOL multiphysics simulation. The current state of simulation will be shown and some insights into the working principle of PMTs and simulation results will be given.

**T 71.5** Wed 16:50 POT/00351

**Characterizing Light Attenuation inside the Wavelength-Shifting Optical Module from Timing Distributions**

- Yuriy Popovych, John Rack-Hellel, Martin Rögen, and Sebastian Boser — Johannes Gutenberg-Universität Mainz

The Wavelength-Shifting Optical Module (WOM) uses make use of wavelength-shifting paint to absorb UV-photons and re-emit them as visible light. These photons are captured via total internal reflection inside a quartz tube and propagate to Photomultipliers at both ends. Due to its design the timing resolution of the WOM does not result not from the sensors, but from the photon propagation inside the tube. Further, one can measure the timing distribution to differentiate between scattering and absorption processes in the light propagation. Characterizing the timing lets us explore new use cases for the WOM-technology.

This talk will describe the modeling and measurement of the timing characteristics of the WOM and a method to deduce absorption and scattering properties of the wavelength-shifter coated WOM tube from it.

**T 71.6** Wed 17:05 POT/00351

**Investigation of photomultiplier photocathodes with an ellipsometer**

- Berit Schüttler and Alexander Kappes — Institut für Kernphysik, Westfälische Wilhelms-Universität Münster, Münster, Germany

Photomultiplier tubes (PMTs) are a central component of today’s neutrino telescopes such as IceCube and KM3NeT, and an accurate understanding and measurement of their properties is indispensable for further improvement of the device.
tectors. In my talk I focus on the optical properties of the photocathode, which is only a few 10 nanometers thick and will be investigated using an ellipsometer. As part of my master’s thesis, I set up the ellipsometer and used it to characterize flat samples. Currently, the setup is being extended for the measurement of curved photocathodes as part of my PhD thesis. This talk presents the idea of the measurement as well as the current status of the work.

**T 72: Exp. Methods II**

**Time:** Wednesday 15:50–17:05  
**Location:** POT/0106

**T 72.1 Wed 15:50 POT/0106**  
Soft $b$-hadron vertex reconstruction tool — **Beatrice Cervato**, Binish Batool, Markus CristinzianI, Carmen Diez Parodi, Ivar Fleck, Arpan Ghosal, Gabriel Gomez, Jan Joachim Hahn, Vadim Kostykvin, Budhadev Mondal, Amrata Rai, Kathryn Voss, Wolfgang Walkowiak, and Tongbin Zhao — Center for Particle Physics Siegen, Experimentelle Teilchenphysik, Universität Siegen — 3 Sandong University, China

Several interesting physical processes lead to the production of low-energy (soft) $b$-quarks in the final state, that may fragment into a $b$-hadron without the creation of a reconstructable jet. Moreover, sometimes $b$-hadrons in jets are so soft that their decay products are distributed over a wider angular range than the standard jet cone (the typical cone size is 0.4). The tool described in this contribution is targeting $b$-hadrons without jets and soft-$b$-hadrons inside jets, which are not detectable by standard Flavour Tagging Algorithms. For this reason, it is very important to develop and optimize such a $b$-tagging tool, as will be described in the presentation. After defining the efficiency and the fake rate, we estimate the tool performance using a 1% reference sample, and define three working points. Subsequently, we check the tool performance at those working points using a sample with soft-$b$-hadrons and a $b$-hadron-free sample. We demonstrate that the efficiency (fake rate) varies in a range that goes from 27% (0.5%) to 44% (7.1%).

**T 72.2 Wed 16:05 POT/0106**  
Graph Neural Network based Track Finding in the Central Drift Chamber at Belle II — **Lea Reuter**, Philipp Dorowha, Torben Ferber, and Slavomira Stefkova — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

In many new physics extensions of the Standard Model, new mediator particles may decay into charged particles leaving a unique signature of a displaced vertex and charged tracks. These displaced decay products are important signatures in searches for dark sector candidates in collider experiments. The current Belle II trigger algorithm is not designed for events with displaced vertices and therefore insufficient to detect these events. Traditional tracking algorithms scale poorly with the high beam-background, which is expected to increase significantly in the upcoming data-taking of the Belle II experiment.

Therefore, we develop a Graph Neural Network (GNN) based approach to find track candidates and displaced vertices in the Central Drift Chamber of Belle II, where we realize track measurements using a graph representation of detector hits. We use GNN-based object condensation for track finding to identify the varying number of tracks per event. The goal of this project is to improve the track finding for Belle II. Furthermore, we also implement track fitting simultaneously to the track finding, to investigate if this GNN approach can also be used in real-time application in the level 1 trigger system.

**T 72.3 Wed 16:20 POT/0106**  
Graph building and input feature analysis for edge classification in the Central Drift Chamber at Belle II — **Philipp Dorowha**, Torben Ferber, Lea Reuter, and Slavomira Stefkova — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

Many extensions of the Standard Model, such as inelastic dark matter models, predict long-lived particles. They can manifest with two charged tracks originating from a vertex with a large displacement from the interaction point in collider experiments. Conventional tracking algorithms are insufficient to respond to those highly displaced vertices, and they also scale poorly with an increased beam-background, as expected from SuperKEKB’s increased luminosity.

Graphs are intuitive representations of hits in a tracking detector as they provide high flexibility regarding input features and the length of input vectors. Therefore, we develop a Graph Neural Network (GNN) approach for hit and edge classification in the Central Drift Chamber (CDC) at Belle II. Eventually, the output will be used for GNN-based displaced vertex and tracking algorithms. We examine different methods of graph building and analyze their performance for the classification task. In addition, we study the feasibility of using detector-level information, such as digitized signal hits, as GNN input features in both data and simulation. We find that this information provides very good discriminatory power and should therefore be used as an additional input feature for the GNN to improve the efficiency of the edge classification.

**T 72.4 Wed 16:35 POT/0106**  
Development of a Classifier for Simulated Secondary Decay Vertices in the CMS Experiment — **Tilm Graulich**, Xavier Coubez, Wahid Redjer, and Alexander Schmidt — III. Physikalisches Institut A, RWTH Aachen University, Aachen, Germany — Brown University, USA

Secondary decay vertices are important signatures which can indicate the presence of a long-lived particle such as a $b$-hadron. These vertices provide important information to be used in higher level algorithms, most importantly $b$-tagging algorithms. In order to study the performance of secondary vertex reconstruction algorithms, the investigation of simulated vertices is necessary. A classifier to find and classify secondary decay vertices in simulated events is presented, with a focus on $b$ and $c$ hadron decays. Furthermore, the final state decay products of the vertex are associated with it to provide reliable training information to neural networks. This talk will showcase how event generator and detector simulation data can be combined to extract the secondary vertex information from simulated data.

**T 72.5 Wed 16:50 POT/0106**  
Introduction to columnarflow — **Mathis Frahm**, Philip Daniel Keicher, Tobias Kramer, Nathan Prouvost, Marcel Rieger, Daniel Savou, Peter Schlepper, Matthias Schröder, and Bogdan Wiederspan — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, Hamburg

In order to observe and measure rare processes in nature, a staggering amount of data needs to be produced and processed at particle colliders. With the advance-ment of the LHC towards Run 3 and HL-LHC, the flow of data as well as the complexity of the analyses will increase even more. In light of these challenges and the limited resources available, an efficient usage of computing power and disc usage is critical for future analyses.

In order to analyze data in an efficient way, a new columnar analysis tool, columnarflow, has been developed. In this presentation, an introduction to columnarflow is given, including an overview of the workflow and some examples of use cases.

**T 73: Pixel/CMS**

**Time:** Wednesday 15:50–16:50  
**Location:** WIL/A317

**T 73.1 Wed 15:50 WIL/A317**  
Measurements of the CMS Inner Tracker pixel assemblies for the Phase-2 upgrade — **Bianca Raciti**, Massimiliano Antonello, Erica Garutti, Jöhn Schwandt, and Georg Steinrück — University of Hamburg, 22761, Luruper Chaussee 149, Hamburg, Germany

During Long Shutdown 3, the entire CMS Tracking System will be replaced to operate during the High Luminosity LHC running phase with considerably increased luminosity. The new pixel sensors will have to fulfill stringent requirements to operate in an extremely harsh radiation environment and cope with the high data read-out rates.

An extensive campaign has taken place to characterize the first half-size pixel chip demonstrator (RD53A), which led to the submission and production of the first full-size prototype chip (RD53B-CMS).

The new sensor-readout chip modules have been extensively tested both in the laboratory and at the CERN and DESY testbeam facilities.

This study presents results on the performances of the two subsequent iterations of pixel assemblies with different irradiation levels, sensor designs and experimental conditions.

**T 73.2 Wed 16:05 WIL/A317**  
Commissioning of a Burn-In Setup for PS and PS Detector Modules for the Upgrade of the CMS Outer Tracker — **Ana Ventura Barroso, Paul Schütze, and Katerina Lipka** — Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, D-22607 Hamburg
The high luminosity LHC Upgrade will increase the instantaneous luminosity by a factor of five. The CMS detector will be upgraded in the so-called Phase-2 Upgrade in order to meet the new requirements, among others the level of radiation tolerance and coping with larger pileup and thus higher data rates, as well as to add triggering capabilities. The entire silicon tracker will be replaced. The Outer Tracker (OT), consisting of macro-pixel and strip detectors, will be based on silicon modules that must operate at low temperatures (−35 °C) due to the exposition at high radiation levels. The probability for defective electronic components to fail is higher after few hours of operation. Moreover, temperature cycles can induce mechanical stress. Therefore a burn-in procedure as well as thorough quality control is needed to ensure the correct operation of each of the OT modules before installation.

For this, a burn-in system is being commissioned at DESY. This setup will perform thermal cycles from room to operation temperature and key measurements to ensure the good performance of the modules. In this talk, the status of the DESY burn-in setup as well as noise measurements and temperature test on a PS module will be presented.

T 73.3 Wed 16:20 WIL/A317
Optical Metrology for the PS module production — LEONIE SOMMER 1,2 and PAUL SCHÜTZ 1 — 1 DESY, Hamburg, Germany — 2 University of Wuppertal, Wuppertal, Germany

The High Luminosity LHC upgrade aims at increasing the instantaneous luminosity leading to various challenges for the detectors. The CMS detector will undergo an upgrade to cope with larger pileup, higher data rates and higher radiation dose. As the new Outer Tracker will contribute to the first trigger stage at 40MHz bunch crossing rate, on-module pT-discrimination is needed for data reduction. This is achieved by building dual-sensor modules, where the efficiency of the momentum discrimination depends on the alignment precision of the sensors which needs to be checked thoroughly during module assembly. Metrology systems are used by the assembly centers to monitor that the modules used in the final detector meet the required alignment precision. In this talk the optical metrology setup at DESY is introduced and measurement procedures are described. Measurement results of various prototype PS modules built and tested at DESY are summarized and the stability of the system is assessed.

T 73.4 Wed 16:35 WIL/A317
Position reconstruction of shallow angle tracks in irradiated pixel sensors for the CMS Inner Tracker Upgrade — LUKAS EIKELMANN, MASSIMILIANO ANTONELLO, ERIKA GARUTTI, BIANCA RACITI, JÖRNL SCHWANDT, GEORG STEINBRÜCK and ANNEKA VAUTH — Institut für Experimentalphysik Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

The position reconstruction of shallow angle tracks in the CMS Phase-II inner barrel layers is studied for its planned pixel pitch of 25 μm by 100 μm. These tracks have incident angles on the sensor of up to 84° with respect to vertical incidence. At such incident angles, the deposited charge is shared between over 13 pixels of 100 μm length. An algorithm attempts to cluster these pixels. It assigns the cluster position as the track hit position in this layer. Hits in the four layers are used to reconstruct the track. One of the effects of radiation damage is charge trapping. This leads to a reduction in the recorded signal of a pixel. If it is below the threshold of the readout chip, no signal is recorded. A missing pixel affects the proper cluster reconstruction resulting in a wrong hit position. In this study, irradiated and non-irradiated pixel sensors bump-bonded to the RD53A prototype chip are tested with shallow angle tracks in the DESY-II electron beam. The cluster breakout and the impact on the position reconstruction of different cluster algorithms are analyzed.

T 74.2 Wed 16:05 WIL/A124
Scintillating active Transverse Energy Filter: a novel detector concept for low-energy electron background discrimination — JOSCHA LAUER for the KATRIN-Collaboration — Johannes Gutenberg University Mainz

At the new electron accelerator MESA, the MAGIX setup will be used for high precision scattering experiments including dark sector searches, the study of hadron structure and few-body systems, and investigations of reactions relevant to nuclear astrophysics.

Together with the MAGIX time projection chamber (MX-TPC), the MAGIX trigger veto system builds the sophisticated detector system inside the two high-resolution magnetic spectrometers. It will provide the fast and reliable signals essential for DAQ, coincidence time measurements, and PID, as well as the basic hit and position information for the triggered readout of the MX-TPC.

The MAGIX trigger veto system consists of one segmented trigger layer made of plastic scintillation detectors and a flexible veto system of additional scintillation detectors and lead absorbers mounted below the trigger layer. The data readout uses the ultrafast preamplifier-discriminator NINO chip which encodes the signal amplitudes using the time-over-threshold method, followed by FPGAs programmed as TDCs.

T 74.4 Wed 16:35 WIL/A124
PMT test stand simulations of first scintillator prototypes towards active Transverse Energy Filter — TOM GEIGLE for the KATRIN-Collaboration — Karlsruhe Institute of Technology (KIT)

The Karlsruhe Tritium Neutrino (KATRIN) experiment aims to determine the mass of the electron antineutrino with an unprecedented sensitivity of 0.2 eV/c² (90% C.L.). One of the most important factors limiting the measurement is the background originating from the main spectrometer which consists of mostly low energy electrons. The energy of the signal electrons are spectrometrically determined in a MAC-E-Filter setup. At the moment, one sensitivity limiting factor is the high electron background which consists of electrons that are generated in the main spectrometer volume. Due to their small initial energy the background electrons have a different angular distribution than the signal electrons at the point of detection.

A scintillating structure acting as an angular selective detector (scint-aTEF) has potential to discriminate between β- and background electrons. This talk will discuss the geometrical concept of the scint-aTEF and its expected impact on the background reduction, based on simulations with Geant4.

This work is supported by the Helmholtz Association, the Ministry for Education and Research RBM6 (05A17PM3, 05A17PX3, 05A17VK2, and 05A17WO3), the Helmholtz Alliance for Astroparticle Physics (HAP), and the Helmholtz Initiative and Networking Fund (W2/W3-118).

T 74.5 Wed 17:00 WIL/A124
Design of a scintillating active Transverse Energy Filter for Background Suppression at the KATRIN Experiment — NATHANIEL GURTNER for the KATRIN-Collaboration — Karlsruhe Institute of Technology (KIT)

The Karlsruhe Tritium Neutrino (KATRIN) experiment aims to determine the mass of the electron antineutrino with an unprecedented sensitivity of 0.2 eV/c² (90% C.L.). One of the most important factors limiting the measurement is the background originating from the main spectrometer which consists of mostly low energy electrons. The energy of the signal electrons are spectrometrically determined in a MAC-E-Filter setup. At the moment, one sensitivity limiting factor is the high electron background which consists of electrons that are generated in the main spectrometer volume. Due to their small initial energy the background electrons have a different angular distribution than the signal electrons at the point of detection.

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T 75.1 Wed 15:50 WIL/C133
Neutron and Photon Tagging in Plastic Scintillators — Asma Hadeer, Antoine Laudrain, Asa Nebhm, and Herbert Ritter — JGU Mainz, ETAP

While neutron-photon separation using pulse shape discrimination with liquid scintillators and PMTs is a well-known technique, it represents a major challenge using plastic scintillators with SIPM readout. A setup using an AmBe source has been built in order to study the ability of the Ej-276G plastic scintillator optimized for pulse shape discrimination to distinguish between neutrons and photons. The design also includes a cosmic tagging which allows for the identification and rejection of the cosmic background.

The main approach for the discrimination method is to use the more frequent delayed scintillation photons for neutrons compared to the gammas for the events. Different analysis methods using the amount of delayed photon-electron peaks per event as well as their timing information are implemented and studied in detail.

This method could be used in the electromagnetic calorimeter that is part of the DUNE near detector complex, to provide neutron tagging capabilities and enable neutron energy reconstruction.

T 75.2 Wed 16:05 WIL/C133
Development of PEN as an Optically Active Structural Material for Low Background Experiments — Brendan Hackett, Iris Axt, Felix Fischer, Béla Majorovits, Luiz Manzanillas, and Oliver Schulz — MPI for Physics, Munich, Germany — 2Synchrotron Soleil, Saint-Aubin, France

Neutronic physics and experiments searching for weak matter particles pursuing novel low background and self- vetoing materials for components in order to improve their sensitivity. One material of interest is poly (ethyylene-2, 6-naphthalate) (PEN) for its inherent scintillating and wavelength shifting properties, as well as its commercial availability and structural stability. Commercially available PEN films are limited in their applications and occasionally do not fulfill the stringent radiopurity and optical requirements of these experiments. As such, the PEN working group has developed a method to produce PEN components with excellent optical properties of thicknesses up to 5 mm, and with a specific activity of less than mhz/kg. PEN detector holders have been successfully installed in the LEGEND experiment and additional PEN structures are being evaluated to further expand the use of structural scintillators. Details of this R&D effort with commercial PEN and the progress on development of custom synthesized radio-pure PEN will be presented.

T 75.3 Wed 16:20 WIL/C133

The "CheapCal" project aims to develop a low-cost and easy-to-build detector for charged particle detection with spatial resolution of about a centimeter. The detector principle is based on an extruded plastic scintillator material with a short light attenuation length, which is structured with parallel oriented wavelength-shifting fibres and a fibre-to-fibre distance of 1.5 cm. The fibres are read-out at each end by a SiPMT. Using a Sr-90 beta source, we study the light yield of each fibre as a function of the beta-source position on the scintillator plate from which the particle's intersection point at the plastic scintillator plate is determined. We acknowledge the support from BMFB via the High-D consortium.

T 76.1 Wed 15:50 WIL/A120

Micro-Pattern Gaseous Detectors are heavily used for the detection of charged particles with excellent temporal and spatial resolution. Electromagnetically neutral particles are detected with poor efficiency due to the low density in the active gas volume. By inserting solid converter layers of high-Z material this disadvantage can be mitigated. In our design multiple converter layers are placed perpendicularly to the first GEM foil. Proper electric fields guide the electrons to the amplification layers in order to further increase the photon detection efficiency. The material and structure of the converter layers need to be optimized to find the perfect balance between creation and extraction rate. For photon conversion copper plates are used with relatively thin FR4 as carrier material. Different thick combinations of FR4 and copper are tested in order to achieve high photon detection efficiencies. These results are compared to simulations for better understanding of the physical processes. This method increases the photon detection efficiency by a factor of about 2 and provides interdisciplinarity possibilities in material research, medical physics or astrophysics.

T 76.2 Wed 16:05 WIL/A120
Photon Position Reconstruction using Structured Converter Layers in Micro-Pattern Gaseous Detectors — Katrin Penski, Otmar Biebel, Valerio D’Amico, Florian Egli, Stefanie Götz, Ralf Hertenberger, Christoph Jagfeld, Eshtita Kumar, Maximilian Rinnagel, Nick Schneider, Christoph Tomos Valderanian, and Fabian Vogel — LMU München

Micro-Pattern Gaseous Detectors are high-rate capable with excellent spatial and temporal resolution. Developed for the detection of charged particles, the low density in the active gas volume of these detectors exhibit only a poor detection efficiency for electrically neutral particles. For photons the detection via the photocathode effect can be increased using a solid converter cathode, which is made of high-Z materials. With our novel approach, the detection efficiency can be optimized by adding multiple converter plates quasi perpendicular to the first GEM foil. Moreover, this technique helps to provide a full two-dimensional position reconstruction of the particle with a resolution of less than 100 µm within a converter plate. Using the two coordinates of the read-out anode of the GEM detector enables this by mounting the converter layers at a specific angle that allows geometric position reconstruction. An optimized electric field, where the electric field lines are parallel to the amplification field, guides the electrons from the converter layers to the GEM foils. Detailed simulations on the influence of different parameters, such as the tilting angle or the drift gas, were performed to optimize the design. Simulation and measurement results are presented.

T 76.3 Wed 16:20 WIL/A120
Setup of a 5 m long Straw Tube Prototype for the SHIP experiment — Rishabh Moolya, Carsten Hagner, and Daniel Beck — Hamburg University

The Search for Hidden Particles (SHIP) experiment is a proposed, general purpose target beam dump experiment utilising the 400 GeV Super Proton Synchrotron (SPS) proton beam at CERN. It is specifically designed to search for hidden particles, at the intensity frontier and to also study tau neutrino physics extensively for the first time. The SHIP hidden sector (HS) detector is designed to detect the decay products of hidden particles decaying inside its ~50 m long vacuum decay vessel. An essential role is to reconstruct the tracks and determine the momentum of the charged particles produced in these decays. This is the purpose of the Spectrometer Straw Tracker (SST), consisting of roughly 16000 straw tubes, each 4 m long and 2 cm in diameter.

A prototype consisting of four straw tubes has recently been set up at Hamburg University. The status of the commissioning and the first results will be presented.

T 76.4 Wed 16:35 WIL/A120
The Influence of Water defects and Mesh Geometry on Measurements with a MicroMegas Detector filled with an Ar:CO2 Gas Mixture — Burkhard Bohm, Anno Strobel, and Raimund Strömer — Universität Würzburg

In particle physics, Micro-Pattern Gaseous Detectors (MPGD) find high usage in different experiments like ATLAS, CMS or ALICE. In this study MicroMegas Detectors (MM) - a special type of MPGDs - are researched in terms of H2O contamination. They are well known for their simple single-stage amplification, high and stable gain and excellent spatial and temporal resolutions. These detectors can be contaminated by H2O from air which can have an effect on detector stability. H2O can also act as a quenching gas similar to CO2. The effect on the gas-gain and the amplification of the number of primary electrons are studied by precisely controlled inflowing of H2O inside a resistive MM chamber. Even a small change in concentration of H2O is expected to have an impact on the detector performance.

Also the influence of different mesh geometries like gap size and wire diameter in terms of contamination is researched. The geometry can have an influence on the electric field and therefore on the detector gain as well as on the transparency of the mesh. Studied mesh types are 70/30, 50/30 and 45/18 (pitch size/wire diameter in µm).
Time: Wednesday 17:20–18:50

**T 77: Flavor VI**

**Studies of lepton universality with $\Lambda_b \rightarrow pK^{\pm}l^\mp$ decays at LHCb** — Johannes Albrecht, Vitali Lifshyts, and Janis Speer — Tu Dortmund University, Dortmund, Germany

In recent measurements of $b$-hadron decays, a pattern of consistent tensions with the Standard Model predictions is observed. This includes rare decays with $b \rightarrow s\ell^+\ell^-$ transitions, which play an important role in lepton flavor universality tests. Complementary to $b$-meson decays, lepton flavor universality can also be tested in $b$-baryon decays, which come with partly orthogonal experimental uncertainties. The first measurement of the ratio of branching fractions of the decays $\Lambda_b \rightarrow pK^+\ell^-\bar{\nu}$ and $\Lambda_b \rightarrow pK^0\ell^-\bar{\nu}$, was published by the LHCb Collaboration using proton-proton collision data corresponding to an integrated luminosity of 4.7 fb$^{-1}$. The ratio was measured to be $R_{\Lambda_b} = 1.17^{+0.07}_{-0.06}$ in the dilepton mass-squared range 0.1 < $m^2$ < 6.0 GeV$^2$/c$^4$ and the $pK$ mass range 60 GeV < $m(pK) < 2600$ MeV/c$^2$. The legacy measurement of $R_{\Lambda_b}$ aims to reduce the uncertainties by analyzing the full 9 fb$^{-1}$ dataset of LHCb experiment and implementing new selection techniques. In this talk, the recent developments of the ongoing measurement are presented.

**Updated Search for Rare Electroweak Decay $B \rightarrow K^{\ast0}\nu\bar{\nu}$ to Constrain New Physics Models** — Caspar Schmitt, Sviatoslav Bilokon, and Thomas Kuhler — LMU Munich, Am Coulombwall 1, 85748 Garching, Germany

Precision measurements of rare decays serve as indirect searches for new physics up to scales well beyond the collider energy, since Standard Model contributions are strongly suppressed. Multiple anomalies are seen in rare decays of $B$ mesons, in particular of the type $B \rightarrow K^{\ast+}\nu\bar{\nu}$. We search hints for new physics in the neutral lepton channel $B \rightarrow K^{\ast0}\nu\bar{\nu}$, which is closely related assuming an unbroken SU(2) Standard Model symmetry. This channel allows particularly precise theoretical predictions and can help reducing hadronic uncertainties in the charged lepton channel.

Experimentally the decay has not yet been detected and is challenging due to the two neutrinos in its final state. Belle II currently is the only experiment in operation that can infer the decay from missing energy and momentum searches. Current experimental limits are model-dependent and a factor 3 to 5 above the Standard Model expectations.

In subsets of new physics models, Wilson coefficients map onto observables and make clear experimental signatures for different new physics scenarios accessible. We explore possibilities for model-independent $q^2$-binned searches for new physics contributions in $B \rightarrow K^{\ast0}\nu\bar{\nu}$ by employing novel untagged methods using machine learning.

**Enhancing data exploitation with public likelihoods** — Lorenz Gaertner, Thomas Kuhler, Danny van Dyk, Lukas Heinrich, Méhli Renoux, and Slavomira Stefkova — Ludwig-Maximilians-Universität, München, Germany

The results published using data from high-energy experiments have large scientific potential beyond initial publication. To maximize the scientific impact of the data and the corresponding likelihood of the results, facilitating reuse for combination, reinterpretation, and the generation of pseudo data should be made standard practice.

A channel with a potentially high benefit from reinterpretation in terms of new physics models is the rare $B^+ \rightarrow K^{\ast0}\nu\bar{\nu}$ decay, for which a search is conducted by the Belle II collaboration. The observables arising from such decays are very sensitive to many new physics models. Due to the experimental challenge arising from two final state neutrinos, the analysis of this decay requires assumptions on the kinematic distribution. Consequently, the results feature a model dependency arising from both (beyond) standard model assumptions and from the description of the pertinent hadronic matrix element. This dependency makes reinterpretation complicated without reanalysing the underlying data. By exploring methods to perform result-level reweighting of published likelihoods according to new theoretical models, we want to study the effect on the likelihoods and interpret the physical significance.
Studies of hadronic tag reconstruction and muon identification efficiency for $B \rightarrow X_{4\ell}$ decays at the Belle II experiment

Wepresentameasurementoftheratioofpartialbranchingfractionsofthesemi-leptonicdecaysatthestate-of-the-artMachinelearningapplicationstothemeasurementof$|V_{ub}|/|V_{cb}|$,whichisimportantforconstrainingtheunitaritytriangle.

Inadditiontothe$|V_{ub}|$ value measured in inclusiveversusexclusive decays can be gained.

The lepton of the signal $B$ decay and the second (tag)$\bar{B}$ meson of the $Y(4S)$ decay are crucial ingredients for reconstructing the kinematics of the $X_{4\ell}$ system and the undetected neutrino. The muon identification efficiency and its calibration to account for possible differences between data and simulation using the $ee \rightarrow \mu\mu$ process are going to be discussed in this talk. The tag $B$ meson is reconstructed using a multivariate based tagging algorithm, the full event interpretation. The second part of this talk is going to focus on studying the tagging performance using variables related to the $\bar{B}B$ meson.

Measurement of the ratio of partial branching fractions of hadronically tagged inclusive $B \rightarrow X_{4\ell}$ to $B \rightarrow X_{4\ell}$ decays at the Belle experiment.

We presented a measurement of the ratio of partial branching fractions of the semi-leptonic inclusive decays, $B \rightarrow X_{4\ell}$ to $B \rightarrow X_{4\ell}$, where $\ell = e, \mu$. The measurement is performed on the world leading sample of 772 × 10^6 $B\bar{B}$ pairs collected at the $Y(4S)$ resonance by the Belle experiment using the state-of-the-art Full Event Interpretation algorithm developed for the Belle II experiment to fully reconstruct the companion $B$-meson. Identifying inclusive $B \rightarrow X_{4\ell}$ decays is difficult due to the abundance of Cabibbo–Kobayashi–Maskawa (CKM) favored $B \rightarrow X_{4\ell}$ events which share a similar single lepton signature and whose composition are not fully understood. To minimize dependence on modeling of these channels a data-driven $B \rightarrow X_{4\ell}$ description is employed. The ratio is measured via a two-dimensional fit to the lepton momentum, $p_T$ and four-momentum transfer squared, $q^2$, in the regime $p_T^{lep} > 1.0$ GeV, covering approximately 86% and 79% of the $B \rightarrow X_{4\ell}$ and $B \rightarrow X_{4\ell}$ phase-space respectively. The determination of this ratio allows for direct extraction of $|V_{ub}|/|V_{cb}|$, corresponding to the length of one of the sides of the Unitarity Triangle. Precise knowledge of this side-length allows for powerful tests of the flavor sector of the standard model and to constrain beyond standard model physics.

Machine learning applications to the measurement of $|V_{ub}|$ at Belle II

InthispresentationtheapplicationsofthesemethodsonsimulateddatacollectionbytheBelleIIsemileptonicdecaysattheBelleexperiment.

Semileptonic Charged Kaon Decays in NA62

The NA62 experiment at the CERN SPS was proposed and designed to measure the branching ratio of the ultra-rare $K^+ \rightarrow \pi^+\nu\bar{\nu}$ using a decay-in-flight technique. NA62 took data of $K^+$ in 2016, 2017, 2018, 2021 and 2022. In such Kaon experiments, it is also possible to measure the branching ratios of the semileptonic decays $K \rightarrow \pi^+\nu\bar{\nu}$ ($K_{3\pi}$) with high precision. $K_{3\pi}$ provides a very clean way to test the lepton universality and probe the first row of the unitary of the CKM quark mixing matrix $|V_{ub}|^2 + |V_{cb}|^2 + |V_{ub}|^2 - 1$. The measurement is done by analyzing the charged single tracks to measure the six main decay modes at once without any specific PID. This strategy reduces the systematics and allows to measure of the branching fractions by using binned maximum-likelihood fit of each MC component to the data. In this talk, I will present my preliminary results using this method.

Exploring extensisons of MUSIC with Machine Learning techniques

A new algorithm for the identification of boosted $Z \rightarrow e^+e^-$ decays for heavy resonance searches with the ATLAS detector at the LHC

A new algorithm for the identification of boosted $Z \rightarrow e^+e^-$ decays for heavy resonance searches with the ATLAS detector at the LHC. The algorithm, MUSIC, is designed with an algorithm that can be applied to data to a dedicated algorithm to identify boosted $Z \rightarrow e^+e^-$ events. The performance of the standard electron reconstruction and identification algorithms deteriorates with decreasing transverse separation between the $e^\pm$ pairs and will eventually vanish once the angular separation between the $e^\pm$ pairs is too small to construct individual clusters in the calorimeter. To improve the reconstruction and identification of such highly boosted $Z \rightarrow e^+e^-$ decays, a dedicated algorithm for $Z \rightarrow e^+e^-$ tagging is being developed using a deep neural network.

Finally, the $Z \rightarrow e^+e^-$ identification and reconstruction approach is tested in the search for a $Z^\prime$ boson based on Monte Carlo simulations of the data taken with the ATLAS detector during the LHC Run 2. Expected exclusion limits on the production cross section times branching ratio at 95% confidence level are presented.

Exploring extensisons of MUSIC with Machine Learning techniques

With the ATLAS detector during the LHC Run 2. Expected exclusion limits on the production cross section times branching ratio at 95% confidence level are presented.
Search for excited leptons in the contact interaction and Z decay channels with CMS

**Fabian Nowotny, Thomas Hebbeker, and Kerstin Hoejnep**

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The Standard Model of particle physics does not provide a comprehensive explanation of the observed hierarchy of three generations of fermions, for both leptons and quarks. A possible explanation is delivered by models postulating that quarks and leptons themselves are composite objects. Their constituents are bound by an asymptotically free gauge interaction below a characteristic scale Λ. Such models of compositeness predict the existence of excited lepton (l') and excited quark (q') states at the characteristic scale Λ of the new binding interaction. The expected production of excited leptons undergoes contact interactions in conjunction with a Standard Model lepton. Furthermore, the leptons can decay into several final states.

This talk focuses on the contact interaction and Z-boson decay channels, both resulting in l' → lq transitions where l represents e and μ. Preliminary results are presented on the Run 2 proton-proton dataset of CMS corresponding to a luminosity of 137.6 fb⁻¹ at a center of mass energy of $\sqrt{s} = 13$ TeV.

**Search for high-mass resonances in dilepton final states with associated b-jets at the ATLAS experiment**

**Frank Ellinghaus and Anna Vorländer**

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The ATLAS Collaboration — Bergische Universität Wuppertal

A search for the Z′ boson in high-mass dilepton (e,e), (μ,μ) final states in association with b-jets is presented. The considered Z′ model is a candidate explanation for potential anomalies in $b\bar{b}$ hadron decays and couples to $b$ and $s$ quarks in the production. The search is carried out using the dataset collected by the ATLAS detector in Run-2 of the LHC corresponding to an integrated luminosity of 139 fb⁻¹. Control, signal and validation regions are defined, and these regions are fitted in a profile-likelihood fit. Expected exclusion limits on the Z′ mass are obtained based on the results of the fit.

**Search for Dark Matter in association with a hadronically decaying top quark at the CMS experiment**

**Michael Wassmer, Ulrich Husemann, and Sebastian Wieland**

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Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

In this talk a search for the production of Dark Matter in association with a single highly energetic top quark is presented. In the standard model such a final state can only be generated at loop level and is, in addition, CKM suppressed, making it a prime candidate to search for new physics. The search is based on the total Run-2 dataset collected by the CMS collaboration. The mono-top signature is characterized by large missing transverse momentum and the well-known top quark decay. This talk is focused on the hadronic decay of the top quark. Large-radius jets are used to reconstruct the decay products and multivariate methods are employed to distinguish these jets from purely QCD-initiated jets. The results of the search are interpreted in the context of a simplified model introducing a flavor-changing neutral current at tree level by a spin-1 mediator and a Dirac Dark Matter particle.

**Time:** Wednesday 17:30–19:00

**Location:** HSZ/0101

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**Constraints on Supersymmetry from Collider Searches and Other Experiments**

**Samuel Bein Bein, Malte Mrowietz, and Peter Schleeper**

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Universität Hamburg, Institut für Experimentalphysik

Constraints from searches at the LHC and from other experiments on the minimal supersymmetric standard model (MSSM) are evaluated in the context of the 19-parameter phenomenological MSSM (pMSSM). For this purpose a large scan of the pMSSM parameter scan is performed. Complementarity and possible tension between the LHC data, the recent g-2 result, and direct detection experiments are examined.

**Kaon Quenching Measurements for Proton Decay Search with JUNO**

**Ulrike Fahrenheitholz, Carsten Dittrich, Meihsu Lu, Sarah Braun, Lothar Oberauer, Hans Steiger, and Matthias Raphael Stock**

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1E15, Phys.-Dep., Technische Universität München, James-Franck-Str. 1, 85748 Garching — Cluster of Excellence PRISMA^+ **Staudingerweg, 55128 Mainz**

Proton Decay is a consequence of Baryon Number Violation and is expected in several Grand Unified Theories (GUTs). It is one of the conditions to explain the asymmetry of matter and anti-matter in our universe. One of the main proton decay channels favored by supersymmetric GUTs is $p \rightarrow K^+ + ν$.

By now, Super-Kamiokande has set a lower lifetime limit of 5.9 × 10^{34} years for this channel. The Jiangmen Underground Neutrino Observatory (JUNO) is a 20 kton liquid scintillator detector currently under construction in China and is expected to reach the order of 10^{34} years after ten years of data taking. In this talk, I present a general strategy of JUNO for the search of the proton decay as well as an experimental setup to identify the still unknown quenching behavior of the $K^+$ in the scintillator of JUNO.

This work is supported by the Clusters of Excellence Origins and PRISMA^+.

**Search for supersymmetry in final states with disappearing tracks in proton-proton collisions at 13 TeV**

**Samuel Bein, Viktor Kutzner, Malte Mrowietz, Peter Schleeper, Alexandra Tews, and Moritz Wolf**

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Universität Hamburg, Hamburg, Germany

We report the results of a search for charged, semi-stable, supersymmetric particles in final states with one or more disappearing tracks embedded within a range of final states characterized by varying numbers of jets, b-tagged jets, electrons, and muons.

The transverse length of signal candidate tracks is used to target various lifetimes associated with wino-like and Higgsino-like charginos in the MSSM, as well as semi-stable charged particles with longer lifetimes. The hit-averaged deposited energy associated with signal candidates traversing the pixel tracker is used to increase sensitivity to particles with large mass or small boost. The search uses a sample of proton-proton collisions at sqrt(s) = 13 TeV collected between 2016 and 2018, corresponding to an integrated luminosity of $136 fb^{-1}$. Limits on the pair production of gluinos and squarks are obtained in the framework of simplified and full-spectrum SU3 models.

**A precision measurement of fiducial and differential cross sections of W+W⁻ production with the ATLAS detector**

**Jose Antonio Fernandez Pretel, Beate Heinemann, and Oleg Kuprash**

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The ATLAS Collaboration — Albert-Ludwigs-Universität Freiburg

Measuring production of W⁺W⁻ pairs at particle colliders gives an important way to test the predictions of Standard Model (SM) of particle physics in both perturbative Quantum Chromodynamics and Electroweak domains. Production of W+W⁻ is also a significant background source for Higgs measurements (especially $H \rightarrow WW$) and beyond SM searches. In this measurement, fiducial and differential cross sections are obtained using the full Run 2 dataset collected in proton-proton collisions at the LHC at center-of-mass energy of $\sqrt{s} = 13$ TeV with the ATLAS detector, corresponding to an integrated luminosity of $139 fb^{-1}$. Multiple background contributions such as fake and non-prompt leptons are estimated using data-driven techniques. In contrast to most previous measurements that enhance the W+W⁻ signal purity by vetoing hadronic jets in the final state, the first measurement of W+W⁻ cross sections using a fully jet-inclusive selection is presented in this work, providing the most precise cross sections of W+W⁻ production achieved in hadron-hadron collisions to date. The measurement

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**Search for High-mass Resonances in Dilepton Final States with Associated B-jets at the ATLAS Experiment**

**Frank Ellinghaus and Anna Vorländer**

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The ATLAS Collaboration — Bergische Universität Wuppertal

A search for the Z′ boson in high-mass dilepton (e,e), (μ,μ) final states in association with b-jets is presented. The considered Z′ model is a candidate explanation for potential anomalies in $b\bar{b}$ hadron decays and couples to $b$ and $s$ quarks in the production. The search is carried out using the dataset collected by the ATLAS detector in Run-2 of the LHC corresponding to an integrated luminosity of 139 fb⁻¹. Control, signal and validation regions are defined, and these regions are fitted in a profile-likelihood fit. Expected exclusion limits on the Z′ mass are obtained based on the results of the fit.

**Search for Dark Matter in association with a hadronically decaying top quark at the CMS experiment**

**Michael Wassmer, Ulrich Husemann, and Sebastian Wieland**

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In this talk a search for the production of Dark Matter in association with a single highly energetic top quark is presented. In the standard model such a final state can only be generated at loop level and is, in addition, CKM suppressed, making it a prime candidate to search for new physics. The search is based on the total Run-2 dataset collected by the CMS collaboration. The mono-top signature is characterized by large missing transverse momentum and the well-known top quark decay. This talk is focused on the hadronic decay of the top quark. Large-radius jets are used to reconstruct the decay products and multivariate methods are employed to distinguish these jets from purely QCD-initiated jets. The results of the search are interpreted in the context of a simplified model introducing a flavor-changing neutral current at tree level by a spin-1 mediator and a Dirac Dark Matter particle.
processthathasbeen
discoveredbytheCMSandATLASCollaborations.

The Standard Model of Particle Physics (SM) predicts the rare production of triboson final states. Although suffering from small cross sections and hence a limited amount of signal events, such triboson states can be studied with the vast amount of data collected by the ATLAS detector in Run 2. In addition to validating the predictions of the SM for rare processes, sensitivity to New Physics is given via anomalous quartic couplings of e.g. four neutral gauge bosons. This talk will focus on the analysis of the simultaneous production of $ZZ\gamma$. In order to determine the cross sections of this process, it is crucial to separate signal events from events arising through background processes mimicking the signal topology. The most dominant background process contains fake photons, which are non-precise photons within jets. Due to the limited statistics no conventional data-driven method can be used. Instead a new approach with jet ratios is applied to estimate the amount of fake photons in the signal region. This is especially challenging due to the very small magnitudes for the two latter hadron processes.

**T 80.6 Wed 18:45 HSZ/0101**

**Measurement of $ZZ\gamma$ final states with the ATLAS detector at the LHC** —
- **ANKE ACKERMANN** for the ATLAS-Collaboration — Kirchhoff-Institute for Physics, Heidelberg University
- **JOSHUA REIDELSTÜrz**
- **MOHSEN REZARI ESTRABRAGH**
- **WOLFGANG WAGNER**
- **JOHANNES ERDMANN**
- **BENEDICT GOCKE**
- **LUKAS KRETSCHMANN**
- **OLAF NACKENHORST**
- **MAREN STRATMANN**

The Standard Model of Particle Physics (SM) predicts the rare production of triboson final states. Although suffering from small cross sections and hence a limited amount of signal events, such triboson states can be studied with the vast amount of data collected by the ATLAS detector in Run 2. In addition to validating the predictions of the SM for rare processes, sensitivity to New Physics is given via anomalous quartic couplings of e.g. four neutral gauge bosons. This talk will focus on the analysis of the simultaneous production of $ZZ\gamma$. In order to determine the cross sections of this process, it is crucial to separate signal events from events arising through background processes mimicking the signal topology. The most dominant background process contains fake photons, which are non-precise photons within jets. Due to the limited statistics no conventional data-driven method can be used. Instead a new approach with jet ratios is applied to estimate the amount of fake photons in the signal region. After giving a general introduction about the triboson production of the $ZZ\gamma$ process, a short summary of the analysis, including the event selection and the background estimation, is presented.

**T 81.1 Wed 17:30 HSZ/0103**

**Measurement of the t-channel single top-quark production cross section in proton-proton collisions at a centre-of-mass energy of 13 TeV with the ATLAS detector** — **OLGA BESSDSKAIA BLYUND**
- **DOMINIC HIRSCHBÜHL**
- **JOSHUA REIDELSTÜrz**
- **MOHSEN REZARI ESTRABRAGH**
- **WOLFGANG WAGNER**
- **JOHANNES ERDMANN**
- **BENEDICT GOCKE**
- **LUKAS KRETSCHMANN**
- **OLAF NACKENHORST**
- **MAREN STRATMANN** — Bergische Universität Wuppertal, Wuppertal, Germany

The measurement of the single top-quark t-channel production cross sections $\sigma_{tb}$ and $\sigma_{tW}$ and their ratio $R$ as well as the total cross section $\sigma_{tW+tb}$ is presented. These measurements provide a precise test of the standard model and are sensitive to new-phenomena probing by the properties of the $W$-boson vertex and placing limits on the CKM matrix element $V_{td}$. Data taken with the ATLAS detector from 2015 to 2018 corresponding to an integrated luminosity of $L = 139 fb^{-1}$ at a center-of-mass energy of 13 TeV is analyzed using corresponding samples of simulated events. Requirements are applied to the data selecting events with the signature expected for the signal process. To further enhance the separation between signal and background events a neural network is trained using the Monte Carlo simulated data combining several kinematic variables. The neural network output distribution is then used in a binned profile maximum likelihood fit including all systematic uncertainties to determine the cross sections.

**T 81.2 Wed 17:45 HSZ/0103**

**Differential cross-section measurement of the $t\bar{q}$ process with the ATLAS detector** — **NILIMA AKOLKAR**
- **IAN BROCK**
- **LIDIA DELL’ASTA**
- **THOMAS STEVENSON** — Physikalisches Institut, Universität Stuttgart — University of Sussex

The measurement of the single top-quark $t\bar{q}$ production with the ATLAS detector is presented. Data taken with the ATLAS detector from 2015 to 2018 corresponding to an integrated luminosity of $L = 139 fb^{-1}$ at a center-of-mass energy of 13 TeV is analyzed using corresponding samples of simulated events. Requirements are applied to the data selecting events with the signature expected for the signal process. To further enhance the separation between signal and background events a neural network is trained using the Monte Carlo simulated data combining several kinematic variables. The neural network output distribution is then used in a binned profile maximum likelihood fit including all systematic uncertainties to determine the cross sections.

**T 81.3 Wed 18:00 HSZ/0103**

**Measurement of $t\bar{q}$ and $t\bar{t}$ with the CMS detector at 13 TeV** — **FEDERICA CECILIA COLOMBINA** — Deutsches Elektronen Synchrotron (DESY), Notkstraße 85, 22607 Hamburg

With the large dataset of proton-proton collisions recorded during LHC Run-2, several precise and differential measurements of both $t\bar{q}$ and $t\bar{t}$ processes have been produced with the CMS experiment. These two processes are mutual backgrounds to each other. In previous measurements, background processes were assumed to follow the expectations of the standard model. In this measurement, for the first time, both processes $t\bar{q}$ and $t\bar{t}$ are measured simultaneously and differentially. The measurement will therefore be more sensitive to new physics, and particularly suitable for effective field theory interpretations.

**T 81.4 Wed 18:15 HSZ/0103**

**Measurements of observables sensitive to colour reconnection in $t\bar{t}$ events with the ATLAS detector at $\sqrt{s} = 13$ TeV** — **SHAYMA WADHAN**
- **DOMINIC HIRSCHBÜHL**
- **WOLFGANG WAGNER** — Bergische Universität Wuppertal, Wuppertal, Germany

A measurement of observables sensitive to effects of colour reconnection in top-quark pair-production events is presented using 139 fb$^{-1}$ of 13 TeV proton-proton collision data collected by the ATLAS detector at the LHC. Events are selected by requiring exactly one isolated electron and one isolated muon with opposite charge and two or three jets, where exactly two jets are required to be $b$-tagged. For the selected events, measurements are presented for the charged-particle multiplicity, the scalar sum of the transverse momenta of the charged particles, and the scalar sum in bins of charged-particle multiplicity. These observables are unfolded to the stable-particle level, thereby correcting for migration effects due to finite detector resolution, acceptance and efficiency effects. The particle-level measurements are compared with different colour reconnection models in Monte Carlo generators. These measurements disfavour some of the colour reconnection models and provide inputs to future optimisation of the parameters in Monte Carlo generators.

**T 81.5 Wed 18:30 HSZ/0103**

**Measurements of top-quark pair spin correlation in the $t\bar{t}$ + jets channel using the ATLAS experiment** — **OLKHANDR BUBLAYENKO**
- **AK. KNUD**
- **ZABRIOYKOVA** — University of Freiburg

The Standard Model of Particle Physics (SM) predicts the $t\bar{t}$ pair to have correlated spins. The degree of this correlation is sensitive to the production mechanism. The most recent measurement performed by ATLAS uses 13 TeV data in the dilepton channel. This work presents ongoing studies of the $t\bar{t}$ spin correlation in the $t\bar{t}$ + jets channel at $\sqrt{s} = 13$ TeV. While this channel provides a larger dataset to study, the analyzing power is reduced compared to the dilepton channel.

To improve the event reconstruction, machine learning techniques are employed and non-reconstructable events are removed. Studies of various observables on particle- and detector-level measured inclusively and as a function of the $t\bar{t}$ system will be presented. In addition the impact of systematic uncertainties on these observables will be studied.

**T 81.6 Wed 18:45 HSZ/0103**

**Measurement of top quark involved CKM matrix elements in single top-quark t-channel processes** — **BENEDIKT GOCKE**
- **DOMINIC HIRSCHBÜHL**
- **KEVIN KRÖNINGER**
- **OLAF NACKENHORST**
- **JOSHUA REIDELSTÜrz**
- **MAREN STRATMANN**
- **WOLFGANG WAGNER** — 1TU Dortmund, AG Kröninger — 2Bergische Universität, Wuppertal

Measuring top quark properties is one of the main purposes of the ATLAS experiment at the LHC. Since the top quark is the heaviest known fundamental particle and has a lifetime of $\tau(10^{-25}\text{ s})$. This lifetime is shorter than the quantum chromodynamic (QCD) hadronization time scale $1/\Lambda_{\text{QCD}} = 10^{-24}\text{ s}$, and much shorter than the spin decorrelation time scale $m_t/\Lambda_{\text{QCD}} = 10^{-21}\text{ s}$. This gives an opportunity to study the spin properties of a bare quark, as top-quark spin information is preserved in the angular distribution of its decay products.

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To improve the event reconstruction, machine learning techniques are employed and non-reconstructable events are removed. Studies of various observables on particle- and detector-level measured inclusively and as a function of the $t\bar{t}$ system will be presented. In addition the impact of systematic uncertainties on these observables will be studied.
T 82.1 Wed 17:30 HSZ/0105
Constrains on the Higgs boson self-coupling, $\kappa_3$, and the di-vector boson di-Higgs boson coupling, $\kappa_{SV}$, via Higgs boson pair production with the ATLAS detector — Jochen Dingfelder, Tatjana Lenz, Christopher Deutsch, and Fiona Ann Jolly — Physikalisches Institut, Universität Bonn, Germany

Eventhough theoretical predictions of the SM are corresponding to experimental results to an incredible degree, there are still some phenomena unexplained, for example the deviation of the measured anomalous magnetic moment, $g-2$, of the muon from SM calculations. This deviation could be explained by the flavour-aliigned two-Higgs-doublet model. The introduction of a second Higgs doublet leads to four additional Higgs bosons, one of which being CP-odd and electrically neutral. The muon $g-2$ deviation is best explained with a light CP-odd Higgs boson which couples nearly exclusively to top quarks and tau leptons.

This talk presents the search of such a light CP-odd Higgs boson produced via gluon fusion. The decay into two tau leptons is analyzed by requiring one electron and one muon in the final state. The search is carried out in the mass range between 20 GeV and 110 GeV. It is based on 139 fb$^{-1}$ of data collected at the ATLAS experiment at 13 TeV center-of-mass energy.

The analysis strategy as well as the various validation regions to check the background estimation are presented. An overview over the most relevant systematic uncertainties is given. Even though the analysis is still blinded, expected background estimations and limits to production cross-sections can be calculated and the fits can be checked for consistency. An outline for the further steps towards the unblinding and the publication of the analysis is given.

T 82.2 Wed 17:45 HSZ/0105
Search for non-resonant Higgs boson pair production in the lepton+jets final state of the bbWW decay mode at CMS — Mathis Prahl, Johannes Hailer, Alexander Paasch, and Matthias Schröder — Institut für Experimentalphysik, Universität Hamburg

The Higgs boson self-coupling is an important parameter of the Standard Model (SM), since it is related to the shape of the Higgs potential. At the LHC, this parameter can be probed by measuring the Higgs boson pair production (HH) cross section. The sensitivity of current HH searches is limited by the small SM production cross-section of only 33 fb at 13 TeV. The analysis of data from Run 3 of the LHC promises a further leap in sensitivity.

In this talk, preparation studies towards a search for non-resonant HHI production in the lepton+jets final states of the bbWW decay mode with Run 3 data of the CMS experiment are presented. They benefit from a new analysis framework that relies on the novel 'columnar analysis' paradigm.

T 82.3 Wed 18:00 HSZ/0105
NMSSM di-Higgs search in bb$\tau\tau$ final states — Nikita Shadaisky, Ulrich Husemann, Moritz Molch, Michael Wassmer, and Roger Wolf — Institut für Experimentalphysik (EPP), Karlsruher Institute of Technology (KIT)

The Next-to-Minimal Supersymmetric Standard Model (NMSSM) introduces additional Higgs bosons with different masses next to the already known SM-like Higgs boson. A full CMS run II data analysis (JHEP 11 (2021) 057), which focuses on such a beyond Standard Model search, was previously performed for the decay of a heavy Higgs boson into two lighter Higgs bosons i.e. $H \rightarrow h_{\ell}(bb)h_{SM}(\tau\tau)$, with $h_{SM}$ being the SM-like Higgs boson with a mass of 125 GeV.

The new analysis presented in this talk introduces some changes to the previous analysis to improve the results. One of the improvements is to consider both possible Higgs boson decay channels $h_{\ell}(bb)h_{SM}(\tau\tau)$ and $h_{\ell}(\tau\tau)h_{SM}(bb)$, another is to improve the sensitivity of the measurement, especially in high mass regions of $H$, by considering boosted topologies. Besides that, the newest CMS reconstruction of run II data will be used, which also includes updates of the data-driven background estimation methods.

T 82.4 Wed 18:15 HSZ/0105
Search for a light CP-odd Higgs boson with ATLAS — Tom Kresse, Arno Straussner, Manuel Gutsche, Hannah Jacobi, and Christian Schmidt — IKTP, Dresden, Germany

Even though theoretical predictions of the SM are corresponding to experimental results to an incredible degree, there are some deviations, for example between the measured anomalous magnetic moment, $g-2$, of the muon from SM calculations. This deviation could be explained by the flavor-aligned two-Higgs-doublet model. The introduction of a second Higgs doublet leads to four additional Higgs bosons, one of which being CP-odd and electrically neutral. The muon $g-2$ deviation is best explained with a light CP-odd Higgs boson which couples nearly exclusively to top quarks and tau leptons.

This talk describes the experimental search for such a light CP-odd Higgs boson with a mass between 20 GeV and 110 GeV produced via gluon fusion. The decay into two tau leptons is analyzed by requiring one electron and one muon in the final state. The analysis aims to detect this A-boson by its production from gluon fusion and its decay via two tau-leptons into a final state containing one electron and one muon.

To be able to spot the extra events caused by a A-boson decay, it is necessary to know the rate of background events very precisely. Background events have the same detector signature as signal events, but are caused by Standard Model processes. Their rate can be estimated by the Monte Carlo method. The talk focuses on the background caused by the decay of top quark-antiquark pairs, and the associated uncertainties due to approximations in the Monte Carlo generator.
**T 83: Theory BSM**

**Time:** Wednesday 17:30–18:30  
**Location:** HSZ/0201  
**Vortrag werden Summenregeln zwischen CP-Asymmetrien vorgestellt, die die neuen $\Delta U = 1$-Beiträge erfüllen und somit Konsistenzchecks künftiger Messungen erlauben.**

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**T 84: Theory EW**

**Time:** Wednesday 17:30–19:00  
**Location:** HSZ/0204  
**In the theory of Quantum Electrodynamics loop corrections induce nonlinear interactions for the electromagnetic fields, allowing for effects such as light-by-light scattering. One of the most promising scenarios for its experimental detection regards the quantum vacuum diffusion and birefringence of x-rays at the combined field of two optical lasers. In this talk, we will theoretically compare various scenarios; as a way to deal with experimental constraints, we analyse cases in which the initial and final x-ray photons differ not just in polarization, but also in propagation direction or energy.**

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**T 83.1 Wed 17:30 HSZ/0201**  
**Charge-Parity Asymmetries of Charmed Meson Decays to Pseudoscalar Mesons — **  
**EMIL OVERDUN** and **MARCIE SCHÜSSLER** — **Institut für Theoretische Teilchenphysik, Karlsruher Institut für Technologie, 76131 Karlsruhe, Germany**  
**Measurements at the Large Hadron Collider beauty experiment (LHCb) have seen larger than expected direct charge-parity (CP) asymmetries in the charmed meson decays $D^0 \rightarrow K^- K^+$ and $D^0 \rightarrow \pi^- \pi^+$, violating the Standard Model U-spin symmetry predictions at around 2$\sigma$. An attempt to explain the discrepancy will be made by postulating new physics in the decay amplitudes. The measured CP asymmetries hint at a stronger coupling to $d$ quarks than $s$ quarks motivating an interpretation in terms of $\Delta U = 1$ new physics, where $U$ denotes the U-spin. New sum rules based on $SU(3)_f$ for CP asymmetries of D meson decays to pseudoscalar mesons to test the $\Delta U = 1$ model are shown, which of which holds in both the $\Delta U = 0$ and $\Delta U = 1$ cases. We propose new experimental tests for the new-physics sum rules.**

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**T 83.2 Wed 17:45 HSZ/0201**  
**Charge-Parity-Asymmetrien von Charmed Meson-Zerfällen in pseudoskalaren Mesonen und Vektormesonen — **  
**MARCIE SCHÜSSLER** und **EMIL OVERDUN** — **Institut für Theoretische Teilchenphysik, Karlsruher Institut für Technologie, 76131 Karlsruhe, Germany**  
**Neueste Messungen der Charge-Parity-Asymmetrie (CP-Asymmetrie) in $D^0 \rightarrow K^- K^+$ und $D^0 \rightarrow \pi^- \pi^+$ Zerfällen stimmen nicht gut mit den Vorhersagen des etablierten Standardmodells der Teilchenphysik überein. Wir untersuchen die Hypothese, dass diese Spannung von Beiträgen je des Standardmodells stammt, die den U-Spin um eine Einheit ändern. Zur Überprüfung dieser Hypothese mit künftigen Daten betrachten wir Zerfälle von $D^0$, $D^+$, $D^*$, Mesonen in Endzuständen aus einem pseudoskalaren Meson und einem Vektormeson. Im**
Particle Physics Division (T) Wednesday

gives up anti-commutativity and recommends itself by its consistent treatment
generalizable to the multiloop setting. BRST symmetry is immediately broken
but may be restored by adding finite, non-invariant counterterms.

In this talk we exemplify our approach to renormalizing chiral gauge theories
in the BMHV scheme with the aim of applying it to the SM. Here we present
a concrete two-loop calculation of a simple, chiral Abelian model (based on
Belusca-Maito et al., JHEP, Vol. 11, 2021; 2109.11042) with its necessary counter-
term structure, and we discuss the explicit restoration of well-known Ward
identities like transversality of the photon self-energy. In this setting, they are an
immediate test of the restoration (or lack thereof) of the classical symmetry.

T 84.6 Wed 18:45 HSZ/0204
Algebraic Renormalization of abelian chiral Gauge Theories with non-
anticommuting \( \gamma_5 \) at the Multi-Loop Level — Matthias Weisswange —
Institute for Kern- and Teilchenphysik, TU Dresden, Dresden, Deutschland

Divergences emerging in quantum corrections need to be handled via regular-
ization and renormalization. However, treating manifestly 4-dimensional quan-
tum field theories, such as the electroweak Standard Model, in such a way
may lead to inconsistencies. This constitutes a problem in chiral gauge theo-
ries, such as electroweak Standard Model. In order to avoid such inconsis-
tencies, \( \gamma_5 \) needs to be treated rigorously as a non-anticommuting object us-
ing the Breitenlohner-Maison’s Hooft-Veltman (BMHV) scheme within DReg.

Employing the BMHV scheme, however, violates gauge invariance, which subse-
quently needs to be restored using symmetry-restoring counterterms guaranteed
to exist by the methods of algebraic renormalization. These counterterms may
be calculated via special Feynman diagrams with an insertion of the \( \delta \)-operator
which reflects the breaking of chiral gauge invariance, using the regularized
quantum action principle of DReg. In the case of an abelian chiral gauge theory
this is consistently done at the multi-loop level, showing that the counterterm
structure in the BMHV scheme may be written in a very compact form, suitable
for computer implementations. Ultimately, this renormalization procedure will
be needed for high-precision calculations of e.g. electroweak observables.

T 85.2 Wed 17:45 HSZ/0301
A Simulink Hardware-in-the-Loop Demonstrator Setup for Detector Sys-
T 85.5 Wed 18:30 HSZ/0301

H53 - A serialization standard for statistical models in high energy physics —
Carsten Burgard1, Cornelius Grunwald2, Robin Pelkener3, and Oliver Schulz4 —
1 TU Dortmund University, Department of Physics — Max Planck Institute
for Physics, Munich

An important aspect of experimental particle physics, and science in general, is
to perform analyses in a reproducible way. In addition to providing the observa-
tional data, this also means that the statistical models, which are usually formu-
lated in terms of likelihood functions, must be provided in an accessible form
as well. Currently, sharing statistical models between different programs and
communities can be cumbersome because there is no standardized exchange for-
mate. Different software packages and toolkits usually differ fundamentally in
different ways for representing data and models. We present the “high energy physics se-
rialization standard” (H53), a proposed standard, which is a language-agnostic
and software-independent format for saving statistical models in exchangeable
files. H53 makes it possible to share entire analyses and to use them across soft-
ware frameworks and methods so results can be cross-checked and models can
be reused in new contexts. We give a general introduction to the H53 format,
its design philosophy and semantics. In addition, we focus on the ongoing im-
plementation of H53 in ROOT, in Python, and the Julia programming language
for use in packages like RATJ.
EPIC-GAN: Equivariant Point Cloud Generation for Particle Jets — ERIK BUEHMANN — Institut für Experimentalphysik, Universität Hamburg

With current and future high-energy collider experiments' vast data-collecting capabilities comes an increasing demand for computationally efficient simulations. Generative machine learning models allow fast event generation, yet so far are largely constrained to fixed data and detector geometries. We introduce the Deep Sets-based equivariant point cloud generative adversarial network (EPIC-GAN) for the generation of point clouds with variable cardinality – a flexible data structure optimal for collider events such as jets. The generator and discriminator utilize multiple EPIC layers with an interpretable global latent vector and do not rely on pairwise information sharing between particles, leading to a significant speed-up over graph- and transformer-based approaches. We show that our GAN scales well to large particle multiplicities and achieves high generation fidelity for gluon, light quark, and top jets.

Super-resolution of photon calorimeter images using generative adversarial networks — JOHANNES EIDMANN1, AARON VAN DER GRAAF2, FLORIAN MAUSOLLE1, and OLAF NACKENHORS1 — III. Physikalisches Institut A, RWTH Aachen University — TU Dortmund University, Department of Physics

Photons are important objects at collider experiments as, for example, the Higgs boson can be studied with high precision in the diphoton decay channel. For this purpose, it is crucial to achieve the best possible spatial resolution for photons and to discriminate against other particles which can mimic the photon signature. In this talk, a method to generate photon calorimeter images at increased resolution is presented. The energy depositions of single photons and photon pairs from neutral pion decays are simulated in a lead tungstate crystal calorimeter. Each shower is obtained pairwise, for a calorimeter with a crystal width of 2.2 cm and for a calorimeter with higher resolution, where the number of crystals is increased by a factor of 16. Wasserstein generative adversarial networks are trained to estimate the high-resolution images from their low-resolution counterparts, with a deep residual convolutional neural network used as generator. The properties of the super-resolved calorimeter images are analysed and it is shown that these images can be significantly better localized in the calorimeter. Moreover, classifiers are trained on either super-resolution or low-resolution images to separate single photons from neutral pion decays and their performances are compared.

Deep Neural Networks for jet-flavor tagging based on different hadronization models — ARBUTA BAL, MARKUS KLUTE, and ROGER WOLF — Institute for Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

Differences between the samples of either quark- or gluon-initiated jets produced by the two Monte-Carlo event generators Pythia and Herwig have been reported in the literature. A neural network can be trained to perform jet-flavor tagging on samples from either MC generator, but the performance of the network is observed to depend on the sample to which it is applied, and a network applied to a Herwig sample performs better than when applied to a Pythia sample, irrespective of the sample it was originally trained on.

We train a neural network using simple kinematic, and high-level constructed variables for better discrimination, to tag jets based on their flavor (as quark or gluon). A thorough analysis of the dependence on the input space is performed, to examine how the network responds to samples generated using different hadronization models. We also identify the critical regions of the input space where the two generators differ in the neural network response, using a Taylor Series expansion of the output function (up to 2nd order) in terms of the input variables, which we then use to find one possible answer for the generator dependence observed in the neural network application.

Multi-parameter Conditioning of Generative Models for Fast Simulation of Highly Granular Calorimeter Showers — PETER MCKEOWN — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

High fidelity detector simulation is crucial for modern high energy physics experiments. While traditional simulation tools based on Monte Carlo methods are powerful, they consume significant computational resources. For this reason at the upcoming high luminosity stage of the LHC and for future colliders, simulation is expected to produce a major computational bottleneck. Particle showers in calorimeters are particularly computationally intensive due to the many interactions that occur with the detector material. Given the vast increases in the granularity of these detectors for future experiments, a high degree of fidelity is required of a surrogate simulator.

Deep generative models hold promise to provide significantly faster, yet accurate, simulation tools. Significant progress has been made in the simulation of both electromagnetic and hadronic showers in highly granular calorimeters. However challenges remain when broadening the scope of these simulators. In particular, these tools must be able to accept multiple conditioning parameters, for example to be able to handle particles incident at arbitrary angles. This talk will review the developments of such a sim localisation tool, with a particular focus on the high degree of physical fidelity achieved, as well as the performance after interfacing with reconstruction algorithms.

Generative Modeling with Diffusion Neural Networks for Fast Simulation of Electromagnetic Showers in the International Large Detector — ANATOLII KOROB — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

In high energy physics, detailed and time-consuming simulations are used for particle interactions with detectors. For future experiments and the upcoming High-Luminosity phase of the Large Hadron Collider (HL-LHC), the computational costs of conventional simulation tools are expected to exceed the projected computational resources.

Generative neural networks (GNNs) have the potential to provide a fast and accurate alternative. So far most of the studies of GNNs for fast simulations have used data represented in the form of a regular grid since it is possible to apply modern machine learning algorithms from image processing that are well optimized and developed.

In fast simulations with GNNs, it is crucial to be able to place GNNs into the simulation pipeline, and since many of today’s detector systems are not regular in terms of the positions of the active cells, it’s very hard to represent the data in a form suitable for training the GNN.

This work focuses on the development of a GNN for speeding up the simulation of electromagnetic showers in the electromagnetic calorimeter of the International Large Detector (ILD). In particular, a Diffusion Model is trained on Geant4 steps, where the electromagnetic shower is presented as a 3D point cloud to avoid the irregularities of the detector geometry and thereby generate showers anywhere in the calorimeter.
Particle Physics Division (T) Wednesday

T 87.1 Wed 17:30 POT/0051

The Taishan Antineutrino Observatory — Hans Theodore Josef Steiger — Cluster of Excellence PRISMA+, Detector Laboratory, Mainz, Germany — Experimental Particle and Astroparticle Physics, Johannes Gutenberg University, Mainz, Germany

The TAO (Taishan Antineutrino Observatory) detector is aiming for a measurement of the reactor neutrino spectrum at very low distances (<30m) to the core with a groundbreaking resolution better than 2% at 1 MeV. The TAO experiment will realize the unprecedented neutrino detection rate of about 2000 per day, which is approximately 30 times the rate in the JUNO main detector. In order to achieve its goals, TAO is relying on yet to be developed, cutting-edge technology, both in photosensor and liquid scintillator (LS) development which is expected to have an impact on future neutrino and Dark Matter detectors.

In this talk TAO’s design, physics prospects as well as the status of its construction will be presented, together with a short excursion into its rich R&D program with a special focus on the German contribution to the development of the novel gadolinium-loaded liquid scintillator. This work is supported by the Cluster of Excellence PRISMA+ at the Johannes Gutenberg University in Mainz and the DFG research unit JUNO.

T 87.2 Wed 17:45 POT/0051

Event Reconstruction in JUNO- TAO using Deep Learning — Vidyha Thara Hariharan, Daniel Beck, Carsten Hagner, and Rosmarie Wirth for the University of Hamburg-Collaboration — University of Hamburg

In his primary goal of JUNO is to resolve the neutrino mass hierarchy using precision spectral measurements of reactor antineutrino oscillations. To achieve this goal a precise knowledge of the unoscillated reactor spectrum is required in order to constrain its fine structure. To account for this, Taishan Antineutrino Observatory (TAO), a ton-level, high energy resolution liquid scintillator detector with a baseline of about 30 m, is set up as a reference detector to JUNO. The 20% increase in the coverage of photosensors, the replacement of Photomultiplier Tubes (PMTs) with Silicon Photomultiplier (SiPM) tiles, the smaller dimension and the operating temperature at -50°C, would enable TAO to achieve a yield of 4,500 p.e./MeV. Consequently TAO will achieve an energy resolution better than 2% @ 1 MeV.

The ability to accurately reconstruct reactor antineutrino events in TAO is of great importance for providing a model-independent reference spectrum for JUNO. This work aims to demonstrate the general applicability of Graph Neural Network (GNN) for event reconstruction in TAO. The dataset for model training and validation are Monte Carlo samples generated from the official TAO offline software. The network is trained on the features that are obtained from the information collected by SiPMs to predict the vertices and energy. The resolutions obtained from the model are presented in the talk.

T 87.3 Wed 18:00 POT/0051

Calibration of the JUNO pre-detector OSIRIS — Moritz Cornelius Vollbrecht1,2, Livia Ludhova1,2, Runxuan Liu1,2,2,3, Anita Meraviglia1,2,2,3, Nikhil Mohan1,2,2, Luca Pelicci1,2 and Mariam Riazi1—4 — Forschungszentrum Jülich GmbH, Institut für Kernphysik IKP-2, Jülich, Germany — 1 II. Physikalisches Institut B, RWTH Aachen University, Aachen, Germany — 2 GSI Helmholtz Centre for Heavy Ion Research, Darmstadt, Germany — 3 Physikalisches Institut, Eberhard Karls Universität Tübingen, Tübingen, Germany

The 20-kton liquid scintillator detector (LS) of the Jiangmen Underground Neutrino Observatory (JUNO) experiment, currently under construction in southern China, has a huge potential for insights in several fields of particle physics. To achieve its many goals, stringent radio-purity requirements have to be fulfilled. In order to ensure these limits, the Online Scintillator Internal Radioactivity Investigation System (OSIRIS) was designed as a pre-detector for JUNO. During the months-long filling of JUNO, OSIRIS will closely assess the radio-purity of purified LS batches to allow fast countermeasures in case of contaminations. In OSIRIS, an array of 76 Large Photomultiplier Tubes (LPMTs) instruments a water-shielded 20-ton LS target. An Automatic Calibration Unit (ACU) from the Daya Bay experiment is used for the calibration of event and vertex reconstruction as well as LPMT timing and charge responses. A separate laser system is used for redundant LPMT timing and charge calibration. This presentation will summarize the current status of the calibration strategy of OSIRIS.

T 87.4 Wed 18:15 POT/0051

Tau appearance with KM3NeT/ORCA — Nicole Geisselbrecht for the ANTARES-KM3NET-ERLANGEN-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg, ECAP

KM3NeT/ORCA is a water Cherenkov detector currently under construction in the Mediterranean Sea. It is optimised for the detection of atmospheric neutrinos with the main goal of determining the neutrino mass ordering. Even though atmospheric neutrinos are produced as electron or muon neutrinos and thus initially do not contain tau neutrinos, these are expected to appear at Earth due to neutrino oscillations. In KM3NeT/ORCA, tau neutrinos can be identified on an event-by-event basis but rather as a statistical excess of shower-like events. This measurement will allow KM3NeT/ORCA to measure the tau neutrino flux normalisation factor and provide insights into the unitarity of the PMNS matrix and hence the validity of the standard three-flavour neutrino oscillation model. This talk will cover the status of the tau appearance analysis with an early sub-array of KM3NeT/ORCA.

T 87.5 Wed 18:30 POT/0051

Event Reconstruction in JUNO- TAO using Deep Learning — Alba Domínguez for the ANTARES-KM3NET-ELRANGEN-Collaboration — ECAP, Erlangen, Germany

The Standard Model of particle physics and General Relativity are expected to merge into a new theory of Quantum Gravity (QG) at energies approaching the Planck scale. However, none of the proposed QG approaches has been validated to date. In this context, several signatures of QG effects in accessible energy regimes, known as “Windows on Quantum Gravity”, have been postulated. In particular, quantum decoherence (QD) or QG-induced violation of Lorentz invariance (LIV), could cause modifications in neutrino oscillation patterns accessible to observation with neutrino telescopes. Moreover, the phenomenon of QD will provide new possibilities to investigate the neutrino nature as a Dirac or Majorana particle, as well as to trace possible violations of CPT symmetry in neutrino oscillations. Such a phenomenon represents a totally new scenario where to test the real nature of neutrinos. This talk reviews the efforts made in neutrino physics to search for QD and LIV effects and their implications in terms of QG models.

Neutrino Generator Comparisons GiBuu/GENIE in KM3NeT — Johannes Schumann for the ANTARES-KM3NET-ELRANGEN-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg

The KM3NeT neutrino telescope is currently being deployed in the Mediterranean Sea. The detector comprises a three-dimensional array of digital optical modules, which detect faint Cherenkov light signals from secondary particles of neutrino interactions. Simulations of the neutrino interactions play an important role for the interpretation of the measurements and are performed by so-called neutrino generators, which employ different approximations in order to achieve a numerical solution with reasonable computing resources. This contribution describes the comparison between GENIE, the neutrino generator used by KM3NeT and the GiBuu generator. The comparisons are performed at the level of systematic uncertainties and their impact on sensitivity estimates.

T 88.1 Wed 17:30 POT/0151

Simulated galactic SNR populations compared to experimental data — Rowan Batzofin1, Katherin Egebjerg1, Constantin Steppa1, and Pierre Cristofari1 — 1 University of Potsdam, Potsdam, Germany — 2 Observatoire de Paris, PSL Research University, LUTH, France

For a long time it has been believed that supernova remnants are the primary source of galactic cosmic rays up to the knee although it has not been conclusively proven yet. Supernova remnants are expected to produce VHE gamma rays via hadronic interactions between the cosmic rays accelerated at the shock and the ambient gas in the interstellar medium. There are many supernova remnants detected in the radio energy range but very few of them have been identified at VHE.

To study the VHE emission of galactic supernova remnants we create a model for supernova remnant populations. The supernova remnant population model ingredients are: The acceleration physics of the supernova remnants, the matter distribution of the interstellar medium in the Milky Way and the source distribution for the supernova remnants in the Milky Way. We utilise population synthesis to optimise some of the parameters for the model to best fit the experimental data.
imental data. We compare our simulated populations to experimental data by looking at the source distribution and the detectability of the simulated sources. We test the simulated populations of galactic supernova remnants against the experimental observations to show whether supernova remnants could be the primary accelerators of cosmic rays.

T 88.2 Wed 17:45 POT/0151
What we can learn from blazar light curves — LEA HECKMANN, DAVID PANJEE, and AXEL ARBET-ENGELS — Max-Planck-Institut für Physik, D-80805 München, Germany
Blazars are among the most energetic sources in our Universe. However, even though they have been studied for decades over a wide range of the electromagnetic spectrum, they are far from being understood.

In this contribution, we would like to give some insights into what we can learn from studying the multi-wavelength light curves of blazars. It includes on the one hand the features in each single waveband, such as the degree of variability or signs of potential periodicity. On the other hand, the connection between different wavebands can also be investigated by studying the correlations between them. In addition to introducing the theory behind these characteristics, we will use a long-term data set of the archetypical blazar Mrk 501 to demonstrate their capabilities when applied to real data.

T 88.3 Wed 18:00 POT/0151
Intergalactic magnetic fields and Mkn 421 gamma-ray observations — MATIAS SOTOMAYOR WEBAR and DIETER HORN — Institut für Experimen-talphysik, Universität Hamburg, Luruper Chaussee 149, D-22761 Hamburg
The existence of intergalactic magnetic fields as a relic of a phase transition in the early universe has so far not been confirmed through observations. While Faraday rotation measurement provide an upper bound (≤ 10$^{-9}$ G), lower bounds have been proposed via the non-detection of gamma-ray emission produced in inverse Compton/pair production cascades. Sufficiently large magnetic fields (≤ 10$^{-6}$ G) are required to deflect the secondary electrons out of the line of sight and suppress the visible inverse Compton emission. The interpretation of these limits is however debatable, as oblique pair instabilities could be a dominating energy-loss mechanism, providing the long-sought additional heating of the intergalactic medium to explain Ly-$a$ forest data. In this contribution, we present the results for a search for a strongly suppressed cascade emission from the direction of the prominent nearby blazar Mkn 421 (z = 0.0531) using Fermi LAT data. Preliminary results will be presented at the conference.

T 88.4 Wed 18:15 POT/0151
3D Shower Reconstruction with the Cherenkov Telescope Array* — STEFAN FROSSE and LUKAS NICKEL for the CTA-Collaboration — TU Dortmund University, Dortmund, Germany
The Cherenkov Telescope Array (CTA) is the next-generation telescope array for high-energy gamma-ray astronomy. The Imaging Atmospheric Cherenkov Telescopes (IACTs) will be able to make precise measurements of the Cherenkov light induced by incident primary particles, such as photons or ions. To determine the direction and energy of these particles, the characteristics of the atmospheric shower have to be reconstructed.

One possible method is the reconstruction using a three-dimensional rotationally invariant Gaussian shower model, as introduced by the H.E.S.S. collaboration. This model is fitted directly to the images of the shower in the triggered cameras using a maximum likelihood approach. This talk will summarize the current implementation as part of the ctapipe analysis package and the initial results.

* Supported by DFG (SFB 1491)

T 88.5 Wed 18:30 POT/0151
MAGIC Event Reconstruction with Deep Learning — JARRED GERSHON GREEN for the MAGIC-Collaboration — Max Planck Institute for Physics, Mu-nich, Germany
The Major Atmospheric Gamma Imaging Cherenkov (MAGIC) telescope is a stereoscopic system used for detecting gamma rays in the GeV to TeV range. When gamma rays and cosmic rays interact with the atmosphere, an air shower is initiated which itself emits Cherenkov photons detectable by MAGIC. After parametrizing the images of each shower, machine learning algorithms like random forests are used to reconstruct the properties of each primary particle, including their type, energy, and arrival direction. Convolutional Neural Networks offer a promising way to perform this reconstruction directly on pixelated camera images. In this contribution, we explore how deep learning algorithms like convolutional and graph neural networks can be used to reconstruct events, first by introducing architectures and then showing their performance as applied to real MAGIC data.

T 88.6 Wed 18:45 POT/0151
tcapipe – Prototype Open Event Reconstruction Pipeline for the Cherenkov Telescope Array — MAXIMILIANN LINHOF, LUKAS NICKEL, and NOAH BIEDER-BECK for the CTA-Collaboration — Astroparticle Physics, TU Dortmund University, Germany
The Cherenkov Telescope Array (CTA) is the next-generation ground-based, very high energy gamma-ray observatory currently under construction. It will improve over the current generation of imaging atmospheric Cherenkov telescopes (IACTs) by a factor of five to ten in sensitivity and it will be able to observe the whole sky from its two sites: La Palma, Spain, and Paranal, Chile.

CTA will also be the first open ground-based gamma-ray observatory. Accordingly, the data analysis pipeline is developed as open-source software. The event reconstruction pipeline accepts raw data from the telescopes and processes it to produce suitable input for the high-level science tools. Its primary tasks include reconstructing the physical properties of each recorded shower and providing the corresponding instrument response functions.

tcapipe is a python framework to facilitate calibration of the raw data, image extraction, image parameterization and event reconstruction. Though the current focus has been the analysis of simulated data, the software has also been successfully applied to the data obtained with the first CTA prototype telescopes, such as Large-Sized Telescope (LST-1). A plugin system also allows processing of comparable data from other IACT facilities. Recent updates, new features and the planned roadmap towards a 1.0 release will be discussed.

T 89: DM, Neutrino Theory

Time: Wednesday 17:30–19:00

T 89.1 Wed 17:30 POT/0251
A mobile neutron spectrometer for the LNGS underground laboratory — MELIH SOLMAZ, KLAUS EITTEL, KATHRIN VALERIUS, and UWE OBERLACK — 1Karlruhe Institute of Technology, Institute of Experimental Particle Physics — 2Karlruhe Institute of Technology, Institute for Astroparticle Physics — 3Johannes Gutenberg University Mainz, Institute for Physics
Environmental neutrons are a source of background for various rare event searches (e.g., searches for neutron detection and neutrinoless double beta decay experiments) taking place in deep underground laboratories. Both the neutron flux and spectrum depend on location. Precise knowledge of this background is necessary to devise shielding and veto mechanisms, improving the sensitivity of the neutron-susceptible underground experiments.

Ambient neutrons have been measured previously at different locations of the underground laboratory LNGS in Italy. However, flux numbers vary considerably across the measurements and direct comparison between them is difficult owing to the use of different detector technologies and setups, each of which possesses characteristic systematics and energy windows. A project was launched to solve these issues and enhance the scientific infrastructure of LNGS.

In this talk, we present the design and the expected performance of a portable neutron detector based on capture-gated spectroscopy as well as first test measurements and give an outlook towards the deployment at LNGS. This project is funded by the German Federal Ministry of Education and Research (BMBF) under the grant number 05A21VK1.

T 89.2 Wed 17:45 POT/0251
Background characterisation of GeMIP-neo detectors and shield design for improved GeMIP-neo detectors — NICOLA ACKERMANN, MATTHIAS LAUBENBRENNER, JOCHEN SCHREINER, CHRISTIAN BUCK, MANFRED LINNINDER, GERD HUESSER, HERBERT STRIECKER, WERNER MANESCHÖ, JANINA HAKENMÜLLER, and HANNES BÖNET — 1Max-Planck-Institut für Kernphysik, Heidelberg, Germany — 2Laboratori Nazionali del Gran Sasso, L’Aquila, Italy
This talk presents Monte Carlo simulations of the background spectra of the 4 screening detectors GeMIP 1 - 4 at the Gran Sasso Underground Laboratory (LNGS) using the Geant4 based framework MaGe. The GeMIP detectors are low background Ge spectrometers located at a depth of 3500 m.w.e. and achieve extremely high sensitivities in material screening at a level of μb/GeV. They are used to test material samples on their suitability to use in rare event experiments.

In the simulations muons, neutrons and tiny radioactive contaminations of the detector and shielding materials are investigated as possible sources of background radiation. It was found that the Pb210 contaminations in the detector shield and the neutrons coming from radioactive decays in the surrounding rock have the highest impact on the background spectra. With this new found understanding, a possible shield design for a next generation GeMIP-like detector is proposed.
Towards a low-background SDD for IAXO — Joanna Bilicki, Frank Edzards, Susanne Mertens, Lucinda Schönhfeld, Juan Pablo Ulloa Beteta, Christoph Wiesinger, and Michael Willers — Physik Department, Technische Universität München, Garching

The International Axion Observatory (IAXO) aims to detect solar axions as they are back-converted into X-rays along a strong magnet pointed towards the sun. Excellent spectroscopic performance, high X-ray absorption efficiency, and below 10 keV and great potential for ultra-low background operations are features of silicon drift detectors (SDDs) that could facilitate this endeavour. Dedicated low-background detector designs, following a consequent passive shielding strategy and a novel all-semiconductor active shield approach, are under development. A background demonstrator has been installed at the Canfranc underground laboratory in Spain. In this talk, we will report on the latest achievements towards a low-background SDD for IAXO. This work has been supported by the DFG through the Excellence Cluster ORIGINS.

Some Cosmological Constraints on Many Species Theories — Alan Zander, Philipp Eller, and Manuel Etthengkuber — 1Max-Planck-Institut für Physik, München, Deutschland — 2TUM, Garching, Deutschland

We consider the so-called Many Species Model introduced by Dvůr and Redi, which postulates the existence of N \( \geq 10^2 \) particle species yielding a new mechanism to solve the well-known hierarchy problem. We study some possible extensions of the model allowing the electroweak vacuum expectation values of the Higgs bosons of the different Standard Model (SM) copies to break the permutation symmetry in the space species and we show how this renders the theory testable in the context of neutrino physics. These scenarios make also possible to address some of the other biggest questions in modern physics that remain open like the smallness of the active neutrino masses and the nature of dark matter, yielding a viable explanation for these two mysteries. That being said, we also analyze some of the cosmological implications of these extensions, obtaining the first constraints available in the literature for this sort of theories on the number of species that interact to some extent with the SM.

Estimate of the electronic and nuclear recoil background in DARWIN: — Antoine Chauvin, Maik Doerenkamp, Andrei Terliuk, and Stephanie Hansmann-Menzemer — Universität Heidelberg

The DARWIN experiment is a proposed future Direct Dark Matter observatory that aims to detect WIMPs through WIMP-nucleus interactions, in a multi-ton liquid xenon TPC. Its goal is to become the most sensitive experiment to WIMP-nucleus interaction. To estimate this sensitivity, good models for signal and background generation, and of the detection processes are fundamental. In this talk, we will report on the simulation of the response of the DARWIN detector to different background sources, interacting both through Electronic Recoil and Nuclear Recoil. We compare these to the response of a WIMP signal and derive according estimates for the WIMP sensitivity of the DARWIN experiment.

Properties of the radiogenic neutron background in DARWIN — Maik Doerenkamp, Antoine Chauvin, Andrei Terliuk, and Stephanie Hansmann-Menzemer — Universität Heidelberg

DARWIN is a proposed multi-ton liquid xenon experiment that aims to explore new parameter-space in the direct detection of WIMPs through nuclear recoil. A major source of background for this experiment are radiogenic neutrons, originating from detector materials. A good understanding and modelling of their properties is therefore necessary for sensitivity studies. This talk will discuss characteristics of this background and methods to reduce it, to ultimately improve the sensitivity.

Radon mitigation in current and future liquid xenon detectors — Florian Jörko for the XENON-Collaboration — Max-Planck-Institut für Kernphysik Heidelberg, Germany

Dual-phase liquid xenon time projection chambers have become a leading technology for rare-event searches such as the direct detection of particle dark matter. The sensitivity of current experiments is limited by the xenon-internal background from \(^{222}\)Rn. Therefore, techniques for radon mitigation are applied during all stages of the experiment. The XENON1T detector belongs to the latest generation of liquid xenon detectors and has reached an unprecedented low radon concentration of \(< 1 \mu Bq/kg\). This achievement was driven by a thorough material pre-selection in combination with a novel radon removal system. In-situ measurements of its radon concentration during scientific data taking will be presented. Furthermore, recent results from a novel radon mitigation method using surface coatings will be discussed.

Phenomenological implications of neutrinos and axions in Many Species Theories — Manuel Etthengkuber, Philipp Eller, Emmanuel Koutsangnelos, and Alan Zander — 1Max-Planck-Institut für Physik, München, Deutschland — 2TU, Garching, Deutschland

The framework of TeV scale gravity theories was originally invented to solve the hierarchy problem. One specific BSM model is the Many Species Theory in which the scale of quantum gravity is lowered by the existence of many additional light states. In this talk, we want to present how small neutrino masses can be generated in this infrared approach and how this modifies the oscillation pattern. Then we present how current neutrino data can be used to give a lower bound on the number of additional species. Moreover, we show how to get an upper bound from axion physics. These results give the first time a theoretically restricted parameter space which can be tested by current and future experiments.

Influence of a gravitationally induced phase on neutrino oscillation and Baryogenesis — Sára Kriegl — TU Dortmund, 44227 Dortmund, Germany

In view of the fact that there is still no uncontroversial theory of quantum gravity nor an experimental evidence for its existence it is well motivated to look for the latter in neutrino oscillations.

For this a general transition probability is derived for a neutrino interacting gravitationally with background neutrinos. Entanglement of the neutrinos and a gravitational quantum field induces a phase modifying the oscillation behavior which may be experimentally detectable. Therefore this could be a direct evidence for the quantum character of gravity.

Since there are theories that explain baryon asymmetry via neutrino oscillations the effect of the phase shift may also have an impact on the predictions of these models. Extra dimensions are introduced to consider even larger effects.

T 90.1 17:30-19:00 Location: POT/0361

T 90.2 17:45 POT/0361

T 90.3 18:00 POT/0361

T 90.4 18:15 POT/0361

T 90.5 18:30 POT/0361

T 89.9 18:00 POT/0251

T 89.5 18:30 POT/0251

T 89.6 18:45 POT/0251
Machine learning based event reconstruction for the OSIRIS detector —
• Lukas Berger, Marc Breisch, Jessica Eck, Tobias Heinz, Benedict Kaiser, Tobias Lachenmaier, and Tobias Stern — Eberhard Karls Universität Tübingen, Physikalisches Institut

The Jiagemen Underground Neutrino Observatory (JUNO) is a multi-purpose neutrino experiment with a 20 kt liquid scintillator detector that is currently set up in southern China. The main goal of JUNO is determining the neutrino mass hierarchy, which is to be achieved by a precise measurement of the oscillated energy spectrum of electron antineutrinos from nearby nuclear power plants. The Online Scintillator Internal Radioactivity Investigation System (OSIRIS) will monitor the radio-purity of the liquid scintillator during the filling of JUNO to ensure that the required contamination levels are met. OSIRIS itself is a 18 l liquid scintillator detector, which is instrumented with 64 20-inch PMTs to collect the light produced by events in the detector's sensitive volume. This talk will present an event reconstruction method based on machine learning which was developed for the application in the OSIRIS detector.

Time: Wednesday 17:30–19:00

T 91: Neutrinos IV

Location: POT/0006

T 91.1 Wed 17:30 POT/0006
Sensitivity studies of the KATRIN experiment with a differential detector —
• Svenja Heyns for the KATRIN-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology

The Karlsruhe Tritium Neutron Experiment (KATRIN) is designed to probe the neutrino mass with a sensitivity of 0.2 eV/\text{c}^2 (90% C.L.). The measurement principle relies on an integral measurement of the tritium beta spectrum at the kinematic endpoint of T_2 by a high-pass MAC-E-type filter. Switching to a differential measurement of the beta-electron spectrum with eV-scale resolution would increase statistics and allow improved discrimination of background events. This presentation outlines the potential modification to the setup with possible detector concepts and discusses their impact in first studies on neutrino mass sensitivity.

This work is supported by the Helmholtz Association (HGF), the Ministry for Education and Research BMBF (05A17PM3, 05A17PX3, 05A17VK2, and 05A17WO3), the Helmholtz Alliance for Astroparticle Physics (HAP), and the Helmholtz Young Investigator Group (VH-NG-1055).

T 91.2 Wed 17:45 POT/0006
Characterization of a TRISTAN detector with a laser system —
• Christian Forstner for the KATRIN-Collaboration — Technical University Munich, James-Franck-Straße 1, 85748 Garching bei München

Sterile neutrinos are a minimal extension of the Standard Model of particle physics. These neutrinos are a dark matter candidate if their mass is in the keV range. They can be accessed experimentally in the tritium beta decay, if they have a mass of up to 18.6 keV and would manifest themselves as a kink-like distortion in the electron energy spectrum. For the KATRIN experiment, a novel silicon drift detector and read-out system is developed to search for this signal. In this presentation, the results of the characterization of a 7 pixel TRISTAN detector with a laser system will be presented and compared to simulations.

This work is supported by BMBF (05A17PM3, 05A17PX3, 05A17VK2, 05A17WO3), KSEFA, the Max Planck society, and the Helmholtz Association. This project has received funding from the European Research Council (ERC) under the European Union Horizon 2020 research and innovation program (grant agreement No. 852845).

T 91.3 Wed 18:00 POT/0006
The other end of KATRIN – systematic effects by the rear wall —
• Leonard Hasselmann, Max Akers, and Rudolf Sack — IAP, Karlsruher Institut für Technologie

In order to determine the neutrino mass with a sensitivity of 0.2 eV/\text{c}^2 (90% C.L.) the Karlsruhe Tritium Neutron (KATRIN) experiment measures the $\beta$-decay endpoint spectrum of tritium using a MAC-E filter type spectrometer. In KATRIN's source 111 $\beta$-decays electrons are emitted per second. They are magnetically guided to the spectrometer in one direction and to a gold coated stainless steel plate, named rear wall, to the other.

A comprehensive understanding of various background contributions, e.g. accumulated tritium on the rear wall, is paramount. Decays of absorbed tritium create an additional spectrum which superimposes that of the source. This results in a systematic uncertainty, which is mitigated either by modelling the additional spectrum or by removing the tritium from the rear wall and surrounding surfaces.

The talk presents an overview on a cleaning method using UV/ozone which has been performed three times so far in the KATRIN setup. Besides a good cleaning performance, an influence on the source potential was found. Additionally, results from a test setup further investigating the cleaning effect are discussed.

This work is supported by the Helmholtz Association (HGF), the Ministry for Education and Research BMBF (05A17PM3, 05A17PX3, 05A17VK2, and 05A17WO3).
Time: Wednesday 17:30–19:00

**T 92: Cosmic Ray IV**

**T 92.1 Wed 17:30 POT/0013**

**Modeling Diffusive Shock Acceleration with CRPropa** — **Sophie Aeroker**1,2, Lukas Merten1,2, Julia Becker1,2, and Dominik Walter1,2, Frederic Effenberger1,2, and Horst Fichtner1,2 — 
Ruhr-Universität Bochum — 1RAPP Center Bochum

Ultra high energy cosmic rays are most likely accelerated stochastically in time-dependent, turbulent magnetic field structures present in astrophysical sources and the interstellar medium. One of such processes is Diffusive Shock Acceleration: Diffusive particles gain energy by repeatedly crossing a shock front. The stochastic nature of this process leads to the characteristic power-law spectrum. We study Diffusive Shock Acceleration using a stochastic differential equation solver (DiffusionSDE) of the cosmic-ray propagation framework CRPropa2.2. We show that the expected spectra are reproduced for various configurations, the effect of anisotropic diffusion is discussed and how different injection spectra change the resulting spectrum. We clarify constraints for modeling Diffusive Shock Acceleration using stochastic differential equations.

1Supported by DFG (SFB 1491)

**T 92.2 Wed 17:45 POT/0013**

**Untersuchung des Einflusses magnetischer Spiegel auf den Transport kosmischer Strahlung** — **Seeliger Ines**1, Schlegel Leander2, and Tuś Julia Becker2,1 — Theoretische Physik IV, Ruhr-Universität Bochum, Bochum, Germany — 1RAPP-Center at Ruhr-Universität Bochum, Bochum, Germany


**T 92.3 Wed 18:00 POT/0013**

**Unstable cosmic-ray nuclei constrain low-diffusion zones in the disk** — **Hannos Jacobs**, Philipp Mertsch, and Vo Hong Minh Phan — TTK RWTH Aachen

Gamma ray halos around pulsars indicate a locally suppressed diffusion coefficient. In the past the impact of those zones on galactic cosmic ray transport has been neglected due to their supposedly small filling fraction. Here we show that the determining factor is not the volume of the low diffusion zones, but the effective time spent in pockets of low diffusivity. We derive an averaged diffusion coefficient in the disc and implement it in a semi-analytical model of cosmic ray transport. Upcoming Beryllium data from the AMS-02 and HELIX experiments will be able to constrain the filling fraction of low diffusion zones at the percent level.

**T 92.4 Wed 18:15 POT/0013**

**The CORSIKA 8 air shower simulation framework** — **Alexander Sandrock**

CORSIKA is a code developed for the KASCADE experiment, the air shower simulation code CORSIKA is now used in the simulation chain of numerous experiments in astroparticle physics. The monolithic hand-optimized Fortran code, that has served the community for the last decades, becomes increasingly difficult to maintain and to expand. For this reason, a community effort has been started in 2018 to rewrite CORSIKA as a flexible air shower simulation framework, making use of the possibilities of modern C++ standards.

By now, CORSIKA 8 is capable of simulating both hadronic and electromagnetic components of an air shower, calculate the radio and Cherenkov emission, and offers a considerably increased flexibility in defining properties and geometries of the media, in which the shower is to take place. Several abilities already go beyond what is possible in earlier versions of CORSIKA, such as cross-media showers or full genealogy of particles.

This presentation discusses the status of the implementation and validation of this new air shower simulation framework.

**T 92.5 Wed 18:30 POT/0013**

**High-energy lepton, photon and air shower simulations using PROPOSAL** — **Jean-Marco Alamendini**1,2, Pascal GuthAyer1, and Alexander Sandrock2 — 1Astroparticle Physics WG Rhode, TU Dortmund University, Germany — 2Faculty of Mathematics and Natural Sciences, University of Wuppertal

In modern physics experiments, simulations are crucial to apply modern analysis methods to the obtained data. One prime example in astroparticle physics is the simulation of extensive air showers, whose signatures can either be signal or background for experiments that needs to be separated.

PROPOSAL is a customizable C++ and Python library, providing three-dimensional simulations of charged leptons and high-energy photons. One of many applications of PROPOSAL is within the currently developed air shower simulation framework CORSIKA 8, the successor of the well-established software CORSIKA 7. For CORSIKA 8, PROPOSAL is used as a library to describe the electromagnetic and muonic shower component.

In this contribution, the basic concepts of PROPOSAL are introduced. Furthermore, validations of electromagnetic showers simulated with CORSIKA 8 are presented, which are obtained by comparing relevant shower parameters such as longitudinal and lateral profiles with CORSIKA 7 simulations.

Supported by the BMBF (ERUM) and by the DFG (SFB 1491, SFB 876).

**T 92.6 Wed 18:45 POT/0013**

**Air shower genealogy** — **Maximilian Reinigehaus** and Ralph Engel — Karlsruher Institut für Technologie (KIT), Karlsruhe, Deutschland

Experiments detecting ultra-high energy cosmic rays rely heavily on air shower simulations and models governing the hadronic interactions. These have to cover a vast phase-space (several combinations of projectile species and target nuclei, interaction energies ranging over many orders of magnitude, final-state kinematic distributions), but not all regions of it share the same relevance for air shower observables.

Using the air shower simulation framework CORSIKA 8 and its particle history feature, we investigate the relation between kinematic distributions of pseudo-rapidity, Feynman-x, and transverse momentum in hadronic interactions and muon distributions from air showers at ground. Additionally, we quantitatively study the energy transfer from the hadronic into the electromagnetic (EM) cascade and the impact of early hadronic interactions on the EM profile and its maximum $x_{max}$.


detector history

**T 93: Exp. Methods – Scint., HESS, Auger**

Time: Wednesday 17:30–19:00

**T 93.1 Wed 17:30 POT/0351**

**Design of a detector irradiation facility in Mainz** — **Daniela Petzer**, Michael Wurm, Kai Loó, and Arshar Jafar — Johannes Gutenberg-Universität Mainz

Detectors for low-energy particles (MeV) are often calibrated using gamma rays to induce electron-like signals. This contribution describes Monte Carlo simulation for a new experimental array to be set up at the Detector Irradiation Facility in the Center for Fundamental Physics in Mainz. It will use a D2-neutron generator, PE moderator and a nickel (neutron, gamma) converter to produce fairly high-energy gamma rays of 9 MeV. This allows a calibration for a far wider energy range than is accessible with standard radioactive sources.

In the planned experiment, different scintillator targets will be irradiated with neutrons and gammas. In a secondary detector array, the scattered particles will then be detected and their scattering angle and energy will be compared to the incident particles and their energy deposition in the target. This talk gives an overview of the proposed experiment and its current status.

**T 93.2 Wed 17:45 POT/0351**

**Development of a spatial resolving scintillator readout system - "MIP-Cube"** — **Philippe Bruder**, Thomas Hüber1, and Andreas Haungs — 1Karlsruhe Institute of Technology, Institute for Astroparticle Physics, Karlsruhe, Germany

High-energy muons from extensive air showers, originated in the interaction between cosmic rays and the Earth's atmosphere, can propagate to Earth or even into low-noise facilities, like underground research laboratories and contribute...
to the noise level of experiments. By measuring the flux and spatial distribution of these muons, systematic background effects can be studied. For this purpose, a monitoring system based on a net of crossed 20 cm long and 5 cm wide plastic scintillator bars is in development. The foreseen scintillator system presented here will be readout by Hamamatsu 64-channel Silicon Photomultiplier (SiPM) arrays and are based on detectors developed for the surface instrumentation of the IceCube Neutrino Observatory. The baseline design provides a highly mobile detector system, with an adequate power supply and signal where focus will be given on a plug-and-play setup for variable measuring locations. The CAEN Co. Ltd Front-End units DTS502 or DTS590 as SiPM arrays electronic unit is one of the candidates. This contribution includes R&D efforts towards an appropriate data acquisition (DAQ) system, the foreseen detector design and the concept for front-end readout electronics.

T 93.3 Wed 18:00 POT/0351

Intensity Interferometry at H.E.S.S. - Introduction and first Results — Andreas Zmija1, Naomi Vogel1, Gisela Anton1, Stefan Funk1, Allison Mitchell1, Friederik Wohlenben1, and Adrian Zink1 — 1Friedrich-Alexander-Universität Erlangen-Nürnberg, ECAP — 2MGP Heidelberg

It has been less than a decade since astronomers rediscovered the concept of intensity interferometry, originally developed by Hanbury Brown & Twiss in the late 1950s, but state-of-the-art experiments have led to tremendous progress in recent years. The technique of correlating photon streams rather than interfering electromagnetic waves between telescopes is almost insensitive to atmospheric effects, and thus promises an increase in angular resolution in the optical regime by an order of magnitude. Since large light collection areas are preferred to optical quality mirrors, Imaging Atmospheric Cherenkov Telescopes are optimally suited for being equipped as intensity interferometer. In April 2022 we performed first photon correlation measurements with two of the H.E.S.S. Phase I telescopes during the moonlight break. We give a brief introduction into the method intensity interferometry, and present the first results of angular diameter measurements of the two stars Lambda Scorpii and Sigma Sagitarii.

T 93.4 Wed 18:15 POT/0351

Intensity Interferometry at H.E.S.S. - Technical Setup — Naomi Vogel1, Andreas Zmija1, Gisela Anton1, Stefan Funk1, Allison Mitchell1, Friederik Wohlenben1, and Adrian Zink1 — 1Friedrich-Alexander-Universität Erlangen-Nürnberg, ECAP — 2MGP Heidelberg

Intensity Interferometers are designed to determine the angular diameter of stars. Imaging Atmospheric Cherenkov Telescopes are provided with technical setups to perform intensity interferometry (II) measurements. Our developed II setup was designed to be mounted to the lid of the Phase I H.E.S.S. telescopes in Namibia. It includes a 45 degree angled mirror and an optical path with a 2 mm interference filter leading to two photomultipliers whose photo currents are measured and then correlated. This enables us to tackle the problem of photon count rate. The data is then transferred via optical fibres to our workstation where the analysis is done after the measurements. The setup is equipped with motors in order to move each element individually which enables us to have a live pointing correction. In this contribution we will present the structure of our technical setup, how to include it between gamma ray observations and our future plans.

T 93.5 Wed 18:30 POT/0351

Trigger Concept for the Detection of Photon Air Showers with the Auger Prime Radio Detector — Jannis Pawlowski for the Pierre Auger Collaboration — Bergische Universität Wuppertal, Gaußstr. 20, 42119, Wuppertal, Germany

The Pierre Auger Observatory is the largest Cosmic Ray (CR) observatory with a surface area of 3000 km². Its size makes it feasible to not only look for CRs but also for presumably rare primaries like photons at energies larger than 1 EeV. Strong upper limits on the diffuse photon flux have been set in the past using the Water Cherenkov Detector (WCD). Additionally, air showers with photon-like properties were detected. For these photon candidate events, however, an uncertainty remains whether they are of photon origin or possibly misinterpreted hadrons. With the AugerPrime upgrade, the WCD is complemented by the Radio Detector (RD). The combination of both detectors yields new information about air showers and will improve primary identification. Here, inclined photon showers are of special interest. We will present a stand-alone RD trigger concept to detect photon air showers with negligible particle footprints. It will be shown that the trigger is compatible with given hardware limitations and the noise level at the Pierre Auger Observatory. The status and results of a first hardware implementation is discussed. We will quantify the trigger efficiency of photon air showers for different configurations of the trigger.

T 93.6 Wed 18:45 POT/0351

Segmented scintillation tracking detector for space applications — Roman Bergert, Hans-Georg Zaudinck, and Kai-Thomas Brinkmann — II. Physics Institute Justus-Liebig-University Giessen

A 3D-resolving detector concept as a payload for an upcoming satellite mission, which is foreseen to reach a final medium earth orbit (MEO) and high radiation levels, is discussed. A precise measurement of fluences and dose rates of relativistic charged particles with energies above 100 MeV is targeted as the main goal of the concept. The determination of the momentum vector of charged particles combined with a precise timing of the events will be used to demonstrate the feasibility of the unprecedented experimental correlation between the primary particles events and triggered secondary particles in air showers on earth by a citizen science project (MuonPi muonpi.org). The steps to reach these goals and first concept results will be presented with a focus on the mechanical and electrical construction of the detector payload for deployment in space.

T 94.1 Wed 17:30 POT/0106

Development of a Detector Response Model and an Autonomous Trigger for the Detection of Air-Shower Radio Emission — Jelena Peterbeit, Tim Huege, Markus Roth, and Lukas Gulzow — Karlsruhe Institute of Technology (KIT), Germany

Radio detection of air-showers has proven to be very advantageous for the measurement of ultra-high energy cosmic rays. As a consequence, a new generation of radio detectors is now evolving at much larger scales. The Giant Radio Array for Neutrino Detection (GRAND) is planned as an array of wide-band radio antennas, which will cover a total area of 200 000 km². In order to reliably distinguish air-shower events from noise for such large arrays, an efficient and autonomous multi-level radio trigger is developed. The first-level trigger selects an antenna signal according to expected signal shapes, whereas the second-level trigger refines this selection according to information of all antennas triggered during the same event.

While the deployment of GRAND is in progress, a digital detector model is being developed. It will include a sufficiently accurate instrument response and signal at the front-end units DTS502 or DTS590 as SiPM arrays. It will make it possible to analyze the detector response and determine significant parameters that are needed for building this novel trigger model. This talk will cover the approaches to build a realistic response model and the multi-level radio trigger needed for large-scale experiments like GRAND. * NUTRIG project, supported by the ANR-DPG Funding Programme (RO 4165-2-1)

T 94.2 Wed 17:45 POT/0106

Event builder and online monitoring of OSIRIS pre-detector of JUNO — Runxuan Liu1,2, Kai Loo3, Livia Ludhova1,2, Cornelius Vollbrecht1,2, Anita Meraviglia1,2, Nikhil Mohan3, Luca Pellici1,2, Mariam Riffa3, and Apheresa Singhal1,2 — 1Forschungszentrum Jülich GmbH, Institut für Kernphysik IKP-2, Jülich, Germany — 2Inst. Physikalisches Institut B, RWTH Aachen University, Aachen, Germany — 3GSI Helmholtz Centre for Heavy Ion Research, Darmstadt, Germany — 4Cluster of Excellence PRISMA+, Johannes Gutenberg University Mainz, Mainz, Germany

JUNO is a 20 kton liquid scintillator detector under construction in Jiangmen, China. The installation is expected to be completed in 2023. Its main goal is to detect the neutrino mass hierarchy with the measurement of reactor anti-neutrinos from the two nuclear power plants in the proximity. This requires stringent limits on the radiopurity of the liquid scintillator. The OSIRIS (Online Scintillator Internal Radioactivity Investigation System) pre-detector is designed to monitor the liquid scintillator during the several months of filling the large volume of JUNO. OSIRIS will contain 18 tons of scintillator and will be equipped with 2D, 3D, and PMTs. It will optimise the performance of the scintillator anti-neutrino detectors.

The online monitoring software for OSIRIS is needed for a live measurement of radiopurity during filling and will be also presented in this talk.

T 94.3 Wed 18:00 POT/0106

Writing photons to disk - The triggerless DAQ-System of XENONnT — Robin Glaude-Beucke for the XENON-Collaboration — Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany

Event builder and online monitoring of OSIRIS pre-detector of JUNO — Runxuan Liu1,2, Kai Loo3, Livia Ludhova1,2, Cornelius Vollbrecht1,2, Anita Meraviglia1,2, Nikhil Mohan3, Luca Pellici1,2, Mariam Riffa3, and Apheresa Singhal1,2 — 1Forschungszentrum Jülich GmbH, Institut für Kernphysik IKP-2, Jülich, Germany — 2Inst. Physikalisches Institut B, RWTH Aachen University, Aachen, Germany — 3GSI Helmholtz Centre for Heavy Ion Research, Darmstadt, Germany — 4Cluster of Excellence PRISMA+, Johannes Gutenberg University Mainz, Mainz, Germany

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T 94.3 Wed 18:00 POT/0106

Writing photons to disk - The triggerless DAQ-System of XENONnT — Robin Glaude-Beucke for the XENON-Collaboration — Physikalisches Institut, Universität Freiburg, 79104 Freiburg, Germany
The XENONnT experiment is an ultra low-background liquid xenon TPC for WIMP direct detection which is taking data at LNGS (Italy). Its triggerless data acquisition (DAQ) system allows for fast and storage-efficient recording with a very low threshold, accepting signals as small as from individual photons. Custom-developed FPGA firmware on the read-out digitizers and on auxiliary logic boards, e.g., a high energy veto to remove high-energy events during detector calibration, makes the data-taking in the triggerless paradigm possible. In this talk, I will present the system and its performance.

T94.4 Wed 18:15 POT/0106 Improving Particle Flow Reconstruction in the CMS HGCAL — •Abhirikshma Nand1, Wahid Redjeb1,2, Felice Pantaleo1, Marco Rovere2, and Alexander Schmidt1 — 1III. Physikalisches Institut A, RWTH Aachen University, Aachen, Germany — 2CERN, Geneva, Switzerland

The CMS calorimeter endcaps will be completely replaced by the High Granularity Calorimeter (HGCAL) as part of the Phase-2 upgrades. The large number of simultaneous collisions (pile-up) and the novelty of the detector makes physics object reconstruction a challenging task. A new, modular framework, called The Iterative Clustering (TICL), is under development for reconstruction in HGCAL. Its granularity and the capability to obtain 5D (x,y,z,E,t) measurements, make HGCAL an ideal candidate for particle flow flow - where information from different parts of the detector are matched to improve the global event description. Moreover, accumulating separate objects reconstructed inside the calorimeter, from the secondary components of a particle, is also necessary. This talk discusses a linking algorithm that was introduced in TICL as a first attempt to solve these problems. A complementary approach of learning functions on a graph of clustered energy deposits and detecting communities in it, will also be presented.

T94.5 Wed 18:30 POT/0106 The Heterogeneous TICL Framework — •Wahid Redjeb1,2, Abhirikshma Nand1, Alexander Schmidt1, Felice Pantaleo1, Marco Rovere2, and Antonio Di Pilato2 — 1III. Physikalisches Institut A, RWTH Aachen University, Aachen, Germany — 2CERN, Geneva, Switzerland — 3University of Geneva, Geneva, Switzerland

The Heterogeneous TICL (H-TICL) framework is an approach that uses heterogeneous data structures in order to improve the performance and scalability of the TICL framework. The framework is designed to be able to handle data from different sources, such as calorimeters and detectors, and to provide a unified interface for accessing this data. The framework is implemented as a library that can be used by various applications to access the data. The library provides a set of classes and functions that can be used to perform various operations on the data, such as clustering, linking, and visualization.

T94.6 Wed 18:45 POT/0106 Updated jet energy scale calibration using Monte Carlo samples for ATLAS — •Germin Ngemea and Christian Sand — DESY, Notkestr. 85, 22607 Hamburg, Germany

An updated simulation-based jet energy scale calibration utilising the newest ATLAS software release version and updated Run-2 Monte Carlo samples is presented. The calibration restores the jet energy scale back to particle level jets. The jets are reconstructed using particle-flow objects and clustered using the anti-kT jet algorithm with a radius parameter of 0.4. The presented calibration accounts for in-time and out-of-time residual pile-up effects, calibrates the absolute jet energy scale and pseudorapidity, as well as provides additional corrections based on global jet observables. The presented procedure is based on similar simulation-based calibrations carried out during the period of Run-2 and their performance comparison is discussed.

T95.1 Wed 17:30 WIL/A317 Providing YARR Software Support to Operate ATLAS-ITk Read-out Chips with BDAQ53 Hardware — •Wael Alkakh1, Joern Graecke-knetter1, Arnold Quadt1, and Ali Skaif2 — II. Physikalisches Institut, Georg-August-Universität Göttingen

During the ATLAS HL-LHC upgrade, the current inner detector is going to be replaced by an all-silicon Inner Tracker (ITk), using prototype and pre-production read-out chips, referred to as RD53A and RD53B respectively. YARR is a DAQ system developed for the ITk detector. It is composed of a software communicating originally with several PCI-e FPGA hardware (HW) platforms. It was developed to read out different front-end (FE) chips with, recently, an extended support to other HW platforms. This work reports on providing the support for BDAQ53 FPGA platform, which was developed as a part of the BDAQ DAQ system, with its Ethernet connectivity. This enables YARR to read out both RD53A and RD53B (ITkPix-V1 FE) chips, while preserving the original existing BDAQ53 framework. In particular, this would be most helpful for several institutions of the ATLAS collaboration, having already a purchased BDAQ DAQ system. The work required to develop specific Hardware Abstraction Library (HAL) controller software blocks. Different RD53A and RD53B scans were successfully performed, validating the added BDAQ53 support.

T95.2 Wed 17:45 WIL/A317 Developments in the ITk Pixel OB Demonstrator DCS — •Anne Gaa1, Stan Lai2, and Hans Joos1 — II. Physikalisches Institut, Georg-August-Universität Göttingen

The ATLAS experiment is developing the new Inner Tracker (ITk) in preparation for the High-Luminosity LHC Upgrade. The ITk pixel Outer Barrel demonstrator, as a system prototype, is in its final design review phase in preparation of the construction of the finished detector. The Detector Control System (DCS) is responsible for monitoring and controlling the detector and its sub-systems. The DCS uses Wincc OC, a SCADA data system by Siemens, in a distributed system. This talk discusses various improvements to the ITk pixel OB demonstrator DCS in the scope of its system tests. These include new monitoring panels for the modules mounted on the loaded local supports, the implementation of an archiving system for monitored data points, and the calibration of temperature and voltage monitoring.

T95.3 Wed 18:00 WIL/A317 Electrical Tests with the ITk Pixel Outer-Barrel Demonstrator — •Hans Joos1,2, Benedikt Vormwald1, Jeyrey Flores Sanchez De Acedo1, Brian Moser1, Stan Lai2, and Anne Gaa1 — 1II. Physikalisches Institut, Georg-August-Universität Göttingen

For the upgrade of the LHC to the High-Luminosity LHC (HL-LHC), the ATLAS tracking detector will be replaced with an all-silicon detector, the Inner Tracker (ITk). The ITk (the higher luminosity requires radiation hard components that can deal with higher occupancies and radiation. Given the close proximity to the interaction point, the environment is especially challenging for the pixel detector. The Outer-Barrel layers of the pixel detector will comprise quad chip modules that are combined into serially powered (SP) chains and loaded on ring and stage shaped low mass -carbon fibre local supports to reduce the material budget of the telescope.

The integration from individual detector components to a final detector is one of the big challenges of the HL-LHC detector upgrades. In order to test the loading procedure and performance of the modules after loading, prototype modules were mounted on a stage local support and connected with realistic services to form a smallest ‘feature - complete’ functional building block and demonstrator of the ITk Pixel Outer-Barrel detector.

This talk will explain the demonstrator setup and present the results of electrical performance tests of the demonstrator modules after loading and their behavior in SP chains.

T95.4 Wed 18:15 WIL/A317 Measurements with a serial powering prototype for the ATLAS ITk Pixel Detector — •Thomas Senger, Florian Hinterkoever, Matthias Hamer, Fabian Huegging, Jochen Dingfelder, Klaus Desch, and Hans Krüger for the ATLAS Collaboration — Physikalisches Institut Bonn Germany

The high-luminosity upgrade of the LHC at CERN requires completely new inner detectors for ATLAS and CMS experiments. A serial powering scheme had been chosen to cope with the constraints of the new pixel detectors. A prototype consisting of up to 8 quad modules, based on the new readout chips (ITkPixV1.1) developed by the RD53 collaboration in 65 nm CMOS technology has been set up in Bonn. This talk presents the results of measurements with a full ITkPixV1.1 serial powering chain to better understand and validate the requirements for all active components in the ITk Pixel System.
T 95.5 Wed 18:30 WIL/A131
First data from the LHCb Beam Conditions Monitor in Run III of the LHC — Johannes Albrecht1, Elena Dall’Occo1, Martin Bieker1, David Rolf2, Holger Stevens2, and Dirk Wieinder1 — Dortmund University, Dortmund, Germany — 1CERN, Geneva, Switzerland

The LHCb experiment is a single-arm forward spectrometer at the LHC that focuses on measurements in the b and c quark sector. Due to its unique geometry, featuring a sensitive tracking system located as close as 3 mm to the LHC beams, the detector is at risk of damage from adverse beam conditions. For this reason, the particle flux near the beam pipe is monitored by eight diamond sensors in a circular arrangement on either side of and close to the interaction point. In preparation for the ongoing Run III of the LHC this so-called Beam Condition Monitor (BCM) has been overhauled as part of a comprehensive upgrade of the LHCb detector. Besides the safety-related functions, measurements of the particle flux near the interaction point can serve as an estimate for the instantaneous luminosity. The talk will present the first data acquired during the initial months of LHC operation in Run III with the upgraded BCM readout system. In order to evaluate performance metrics, such as the linearity of the sensor response, the BCM output is compared to data from other LHCb subdetectors.

T 95.6 Wed 18:45 WIL/A131
Module assembly for the ATLAS High Granularity timing detector — Hendrik Smittmann1, Andrea Brogna2, Doğa Elitez2, Theodoros Manousouso1, Lucia Masetti1, Fabian Piller2, Maria Solenz-Berl2, Manzano1, Steffen Schoenfelder3, and Quirin Weitzel2 — 1Institut für Physik, Johannes Gutenberg-Universität Mainz — 2PRISMA Detektorlabor, Johannes Gutenberg-Universität Mainz

To meet the challenges of the High Luminosity LHC, especially the increase of pile-up interactions, the ATLAS detector needs to be upgraded. One of the foreseen upgrades consists of the installation of the High-Granularity Timing Detector (HGTD) in the forward region, providing time information with a resolution of about 30 ps per track. The active area consists of 2x2 cm2 Low Gain Avalanche Detectors bump-bonded to two ASICs and wire bonded to a flexible PCB form the HGTD basic unit, the so-called module. 8032 modules have to be built in total. During the HGTD R&D phase, module prototypes are assembled and tested in order to optimize the procedures and be integrated for system level tests in the HGTD demonstrator. The module assembly procedure in Mainz and the results of the very first assemblies are presented.

T 96: TestBeam, RadHard for Si and Pixel

Time: Wednesday 17:30–19:00

T 96.1 Wed 17:30 WIL/A124
Characterisation of a novel trigger and timing plane for the EUDET Telescopes — A. Wintle1, Lennart Hult2, Francesca Maria Poffi1, Felix Sefkow1, Marcel Stanitzki3, and Ivan Peric2 — DESY, Notkestraße 85, 22607 Hamburg — 1Karlsruhe Institute of Technology (KIT)

The DESY Test Beam facility provides GeV beams for users and precise reference tracking systems, the EUDET telescopes. The telescope readout is triggered externally and multiple particles are recorded in one readout cycle, causing ambiguities at no-time-stamping is prohibited.

TelePix is a 180 nm HV-CMOS sensor foreseen to be used in upgrades of the EUDET-style pixel beam telescopes allowing for fast timing and triggering on a region of interest. Here, characterisation results of TelePix are presented using the latest test beam results.

T 96.2 Wed 17:45 WIL/A124
Irradiation Studies on Silicon Sensors for the CMS Outer Tracker Sensor Production — Umut Eliecbuk1, Tobias Barwich, Bernd Berger, Alexander Dierlamm, Ulrich Husemann, Markus Klute, Roland Koppenhoefer, Thomas Müller, Marius Neufeld, Hans Jürgen Simonis, and Pia Steck — Institute of Experimental Particle Physics (IEP), Karlsruhe Institute of Technology (KIT)
With the upcoming Phase-2 Upgrade of the CMS Outer Tracker, silicon sensors will be used to reconstruct the tracks of charged particles. The detector material continuously accumulates radiation damage at the level of the crystal lattice during operation. Due to the increased demands on radiation hardness with the HL-LHC upgrade, a sufficiently radiation hard sensor material is necessary.

Both during and before ongoing sensor production, it is therefore necessary to monitor the efficiency of the detectors under radiation exposure and to draw conclusions about subsequent performance in the detector. Among other things, the ETP is investigating the sensor characteristics of these silicon sensors as part of the Phase-2 Upgrade. The talk will give an insight into the used measurement setups, investigated sensor characteristics and give an overview of the concept of irradiation studies in general.

T 96.3 Wed 18:00 WIL/A124
A High-Precision Irradiation Site for Silicon Pixel Detectors — PASCAL Werk1, Reinhard Riedler2, and Dennis Sauerland2 — 1Physikalisches Institut, University of Bonn, Germany — 2Helmholtz-Institut für Strahlen- und Kernphysik, University of Bonn, Germany

An irradiation site for radiation hardiness studies of silicon pixel detectors is in operation at the isochronous cyclotron at the University of Bonn. The accelerator provides protons as well as other light ions with energies ranging from 7 to 14 MeV per nucleon and beam currents of up to 1 μA to the setup. Devices Under Test (DUTs) are irradiated in a temperature-controlled box, minimizing annealing, while being moved through the beam in a well-defined pattern, ensuring homogeneity. On-site beam diagnostics facilitate online monitoring of the beam parameters and enable a beam-driven irradiation procedure resulting in highly uniform damage profiles with relative uncertainties of typically 2%. The setup provides extensive data acquisition, visualization and control of all components allowing for flexible irradiation runs (sensor powering & R/O, pausing, etc.), post-irradiation corrections and precise damage analysis. In this talk, the irradiation site and its operational parameters are introduced in detail. Energy simulations for light ions are presented, showing the total ionizing dose (TID) as well as non-ionizing energy loss (NIEL) damage capabilities. Measurements of the applied particle fluence, using different techniques, are presented and their precisions are compared. Furthermore, an overview of the recently performed irradiation campaigns is given.

T 96.4 Wed 18:15 WIL/A124
Radiation hardness studies of the ULTRASAT space mission — Vlad Dumitru Berlea1, Desy, Zeuthen, Germany
ULTRASAT (ULtraviolet TTransient Astronomy Sat) is a wide-angle space telescope that will perform deep time-resolved surveys in the near ultraviolet spectrum. ULTRASAT is led by the Weizmann Institute of Science (WIS) in Israel and is planned for launch in 2022. The telescope implements a backside-illuminated, stitched pixel detector. The pixel has a dual-gain 4T architecture with a pixel of 9.5 μm and is produced in the 180 nm process by Tower Semiconductor. As part of the space qualification for the sensors, radiation tests are to be performed on both test sensors provided by Tower and the final flight design of the sensor. One of the main contributions to sensor degradation due to radiation for the ULTRASAT mission is Total Ionizing Dose (TID). TID measurements on the test sensors have been performed with Co-60 gamma source at Helmholtz Zentrum Berlin (HZB) and CC-60 facilities at CERN, and preliminary results are presented in this talk.

T 96.5 Wed 18:30 WIL/A124
Test-Beam Performance Results of the FASTPIX Sub-Nanosecond CMOS Pixel Sensor Demonstrator — Justus Braach1,2, Eric Buschmann1, Dominik Dannheim1, Katharina Dortz1, Thanusan Ragahasan1, Magdalena Munker1, Walter Snoeys1, Peter Svihra1, and Mateus Vicente Barreto Pinto1 — CERN (CH) — Universität Hamburg (DE) — Justus-Liebig-Universität Giessen (DE) — Université de Genève (CH)
Within the ATACT FASTPIX project, a monolithic pixel sensor demonstrator chip has been developed in a modified 180 nm CMOS imaging process technology, targetting sub-nanosecond timing precision for single ionising particles. It features a small collection electrode design on a 25 μm-thick epitaxial layer and contains 32 mini matrices of 68 hexagonal pixels each, with pixel pitches ranging from 8.66 μm to 20 μm. Four pixels are transmitting an analog output signal and 64 are transmitting binary high information. Various design variations are explored, aiming at accelerating the charge collection and making the timing of the charge collection more uniform over the pixel area. Signal treatment of the analog waveforms, as well as readout of time and charge information, is carried out off-chip. This contribution introduces the design of the sensor and readout system and presents performance results for various pixel designs achieved in recent test-beam measurements with external tracking and timing reference detectors. A time resolution below 150 ps is obtained at full efficiency for all pixel pitches.

T 96.6 Wed 18:45 WIL/A124
Reconstruction of high track density beams in beam tests — Christopher Krause, Jens Weingarten, and Kevin Kröninger — TU Dortmund, Dortmund, Deutschland

The Inner Tracker of the ATLAS experiment requires the optimal performance of its pixel sensors. To test their efficiency, a reliable track reconstruction and anal-
T 97: Calorimeter / Detector Systems IV

Time: Wednesday 17:30 – 19:00

T 97.1 Wed 17:30 WIL/C133
Evaluation of the Performance of SiPM-on-Tiles at the End of Life of the CMS HCAL Upgrade — Malinda de Silva — Deutsches Elektronen-Synchrotron (DESY), Hamburg

For the HL-LHC phase, the calorimeter endcap of the CMS detector will be upgraded with a High Granularity Calorimeter (HCAL), a sampling calorimeter that will use silicon sensors as well as scintillator tiles read out by silicon photomultipliers (SiPMs) as active material (SiPM-on-tile). The design of the SiPM-on-tile section was inspired by the CALICE AHCAL. The complete HCAL will be operated at −30°C.

The basic detector unit in the SiPM-on-tile section is the tile module, consisting of a PCB with one or two HGCRO ASICs, reading out up to 96 SiPM-on-tiles. Signals from MIPs passing through the SiPM-on-tiles are used to quantify the performance of SiPM-on-tiles. With irradiation, their performance degrades while increasing the noise. The ratio between the MIP signal and noise is known as the signal-to-noise ratio (SNR). In order to maintain an SNR>3 at end of the detector lifetime, SiPMs will be used in areas where the expected radiation dose during the lifetime of the detector is less than $5 \times 10^{10}$n$_{eq}$/cm$^2$.

A series of tests were conducted to quantify the performance of SiPM-on-tiles mounted on tile modules including beam tests and cold tests at −30°C. These tests were also repeated using irradiated SiPMs mounted on the tile modules. These tests were then used to extrapolate the performance expectations at the detector’s end of life.

T 97.2 Wed 17:45 WIL/C133
Quality control for SiPM-on-tile section of the CMS HCAL at DESY — Daria Selivanova — Deutsches Elektronen-Synchrotron (DESY), Hamburg

The new High-Luminosity era of the LHC challenges the detector development field to implement technology in a new way. A detector under construction, the High Granularity Calorimeter (HCAL) for CMS, is based on two detector technologies: silicon sensors and SiPM-on-tile boards. The highly segmented structure of the two will allow both electromagnetic and hadronic showers to be utilised in the energy reconstruction and the identification of particles.

The SiPM-on-tile component of the HCAL consists of scintillator tiles wrapped in a reflective foil and photodetectors (SiPMs), mounted on a board with HGCRO readout electronics. The ability of each individual scintillator component (a tile) to fulfill the performance requirements stands on a choice of methods of production, wrapping and placement. That is why quality control (QC) measures have been implemented in the Tile Assembly Center (TAC) at DESY to monitor parameters at every stage. Two test stands have been developed to measure the size of the wrapped tile and to measure its light yield. Several tests have been performed using the setups with a variety of tiles to ensure consistency of measurements and to measure tile-to-tile wrapping variation and light output.

T 97.3 Wed 18:00 WIL/C133
Results of the Magatelle prototype for the CALICE AHCAL — Anna Ros-Mantiz for the CALICE D-Collaboration — Johannes Gutenberg-Universität Mainz

The CALICE collaboration develops several highly granular calorimeter concepts for a future $e^−$ collider, that are designed for Particle Flow Algorithms. The current design for the Analog Hadronic Calorimeter (AHCAL) consists of $3\times3$ cm$^2$ scintillator tiles read out by silicon photomultipliers (SiPM). Each tile is individually wrapped in reflective foil and glued to the boards. The final AHCAL detector would contain 8 million channels.

To facilitate the assembly process, the Magatelle design is developed at the University of Mainz. It is made from a large scintillator plate which houses 12x12 channels at once. The channels are separated by tilted trenches filled with a mixture of glue and TiO$_2$ for reflectivity and optical insulation. Optical tightness is achieved by gluing reflective foil on both faces and varnishing the edges. Until now, ten prototypes have successfully been built, continuously monitored in a cosmic test-stand in Mainz and tested in several test beam campaigns at DESY and CERN.

This talk presents results of the track reconstruction of high track density using Corryvreckan and the performance of a machine learner for true track tagging. Both simulated data and real testbeam data is investigated.

In beam tests, high density beams lead to many hits on the sensors in short periods of time. The reconstruction of particle tracks with too many hits becomes increasingly difficult due to the ambiguity of track fits. In order to differentiate between false and true reconstructed tracks, a machine learner is implemented, which is trained on simulated testbeam data, generated by the Alpínx software.

This talk presents results of the track reconstruction of high track density using Corryvreckan and the performance of a machine learner for true track tagging. Both simulated data and real testbeam data is investigated.

T 97.4 Wed 18:15 WIL/C133
Characterization of a wavelength-shifter coated polystyrene plastic scintillator detector — Alessia Brignoli, Constantin Eckardt, Heiko Lacker, Christopher Mullerisch, Christian Scharf, and Ben Skodda — Humboldt-Universität zu Berlin, Berlin, Germany

Plastic scintillator detectors are widely used in particle physics for detecting charged particles crossing the scintillating material, converting the excitation energy into fluorescence radiation. It has been recently shown that a pure polystyrene plate that is coated with a wavelength-shifting dye can be used as an easy-to-build cheap scintillator with a decent light output. In this work, we further studied the light-yield response of a rectangular polystyrene tile coated with a wavelength-shifting dye. It was coupled to a photomultiplier at each end of the strip and exposed to beta particles from a Sr-90 source. By analyzing the light-yield and signal arrival times as a function of the beta source position along the tile, we determined the time and spatial resolution of the detector, as well as the light signal speed and the effective attenuation length in the scintillator.

T 97.5 Wed 18:30 WIL/C133
Simulation studies for tomography with fast neutrons and gammas with a multi-pixel detector — Anne Abel, Nina Höflich, and Oliver Pooth — III. Physikalisches Institut B, RWTH Aachen University

Simultaneous neutron and gamma tomography enables a new, non-destructive imaging procedure showing further material properties than a common CT scan. At the RWTH Aachen University a portable measuring setup for fast neutrons is developed, which uses an Americium Beryllium source and 16 stilbene crystals coupled to a SiPM for detection. The organic scintillator stilbene allows the simultaneous detection and separation of neutrons and gammas. The detector pixels are arranged in a 4 x 4 grid with a pixel size of 6.2 x 6.2 mm.

In this talk the simulation procedure of the experimental setup using GEANT4 along with methods to determine the quality of the tomographic images is presented.

T 97.6 Wed 18:45 WIL/C133
Simultaneous fast neutron and gamma tomography with a stilbene-based multi-pixel detector — Anne Abel, Nina Höflich, and Oliver Pooth — III. Physikalisches Institut B, RWTH Aachen University

The neutron detectors group at the Physics Institute III B, RWTH Aachen University, develops a multi-pixel detector for a compact fast neutron imaging setup. Since the interactions of fast neutrons in matter differ from those of X-rays and gamma rays, imaging with fast neutrons in addition to X- or gamma ray imaging can provide complementary information about the object of interest.

Our current detector prototype uses cubes of the organic scintillator stilbene as active material, coupled to a SiPM array. The pixel size is 6.2 x 6.2 mm$^2$. The usage of stilbene allows to distinguish neutron- and gamma-induced signals in the detector. An Americium-Beryllium neutron source delivers fast neutrons of up to 11 MeV and gamma rays of 4.44 MeV for our measurements.

In this talk, tomographic measurements of different test objects will be discussed, combining information from neutron and gamma attenuation. The main focus will be on the spatial resolution and the material distinction capability of our setup. Furthermore, possible improvements of our setup and the tomographic reconstructions will be briefly discussed.
X-ray Polarity with GridPixes — Klaus Desch, Markus Gruber, and Jochen Kaminski — Physikalisches Institut, Universität Bonn

In astrophysics and material science on synchrotron light sources the measurement of X-ray polarization can be an useful instrument. Therefore, a direct measurement would be beneficial. It can be directly measured by tracking photoelectrons created in photoelectric interactions. This is possible because their emission angle depends on the direction of the electric field vector of the photons. With a high-purity detector these electrons have a sufficiently long mean free path such that tracking is possible - if the granularity of the readout is high enough. For this a GridPix - a combination of a Timepix(3) ASIC with 55 μm pixel pitch and a photolithographically postprocessed amplification stage (integrated grid) can be used. Within the GridPix the holes of the grid are perfectly aligned with the pixels. Thus, it is possible to detect the avalanches of individual primary electrons.

The talk will focus on the working principle and the design of a GridPix based X-ray polarimeter. Based on testbeam data taken at PETRA III and simulations the performance of the detector at different X-ray energies as well as the dependence on different detector parameters like gas choice and geometry will be discussed. Additionally challenges and possible improvements of such a detector will be presented.

Prototype of a Cherenkov position sensitive Micromegas — Maximilian Rinnagar, Ottmar Biebel, Valerio D’Amico, Florian Egli, Stefanie Goetz, Christoph Jagfeld, Eshta Kumar, Katrin Penski, Nick Schneider, Chrysostomos Valdenaris, Fabian Vogel, and Ralf Hertenberger — LMU München

Detectors utilizing the Cherenkov effect are well established for particle identification of charged particles in detector systems such as LHCb. In reverse it is possible to determine the momentum of a known particle by measuring the opening angle of the Cherenkov cone in Cherenkov media. Our goal with this prototype is to develop a 100 mm prototype of a Cherenkov position sensitive Micromegas gaseous micro pattern detector with two dimensional position readout, spatial resolution below 100 μm and good timing resolution. This will allow to distinguish between muon and photon signals.

The aim of LUXE (Laser Und XFEL Experiment based at DESY, Hamburg) is to measure strong-field QED effects with high precision. In order to create electric fields stronger than the so-called Schwinger limit, it is planned to collide a high-intensity laser pulse with either high-energy electrons up to 16.5 GeV or high-energy photons.

For the detection of electrons, with expected fluxes of the order of $10^{10}$ to $10^{11}$ particles in an area of $15 \times 1 \text{ mm}^2$ per event, a Cherenkov detector in combination with magnetic deflection for high-precision spectrometry will be used. This contribution will present the simulation-based design of the Cherenkov detector, as well as first experiment experience obtained with a prototype. Further optimisation of the various components as well as reconstruction algorithms will be discussed.

Prototype of a Cherenkov position sensitive Micromegas — Antonios Athanasialis, Louis Helari, Ruth Magdalena Jacobs, Jenny List, Gudrid Moortgat-Pick, Evan Ranner, and Stefan Schmitt — 1Deutsches Elektronen-Synchrotron (DESY), Hamburg, Germany — 2Universität Hamburg, Germany

The Stopping Target Monitor of the Mu2e experiment — Stéfan E. Müller, Anna Ferrari, Oliver Knode, and Reuven Rachamim for the Mu2e Collaboration — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany

The Mu2e experiment is currently being constructed at Fermilab to search for the direct conversion of muons into electrons in the field of a nucleus without the emission of neutrinos. The experiment aims at a sensitivity of four orders of magnitude higher than previous related experiments, which implies highly demanding accuracy requirements both in the design and during the operation. Hence, it is essential to estimate precisely the backgrounds that could mimic the monoenergetic conversion electron signal. The particles' energy and direction will be measured with magnetic deflection for high-precision spectrometry that will be used together with a Cherenkov detector for the location with magnetic deflection for high-precision spectrometry will be used. This contribution will present the simulation-based design of the Cherenkov detector, as well as first experiment experience obtained with a prototype. Further optimisation of the various components as well as reconstruction algorithms will be discussed.
Accelerator operation optimisation using machine learning

In our attempt to develop and apply artificial neural networks both for finding of bubble chambers and it seems that we are steadily approaching the answer puzzling over the answer to this question for more than 30 years, since the days puteralgorithm for the same task? Physicists and computer scientists have been actively involved in this quest, standing a little aside from traditional approaches, but close in idea of elastic and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been puzzling over the answer to this question for more than 30 years, since the days puteralgorithm for the same task? Physicists and computer scientists have been actively involved in this quest, standing a little aside from traditional approaches, but close in idea of elastic and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been actively involved in this quest, standing a little aside from traditional approaches, but close in idea of elastic and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been actively involved in this quest, standing a little aside from traditional approaches, but close in idea of elastic and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been actively involved in this quest, standing a little aside from traditional approaches, but close in idea of elastic and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been actively involved in this quest, standing a little aside from traditional approaches, but close in idea of elastic and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been actively involved in this quest, standing a little aside from traditional approaches, but close in idea of elastic and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been actively involved in this quest, standing a little aside from traditional approaches, but close in idea of elastic and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been actively involved in this quest, standing a little aside from traditional approaches, but close in idea of elastic and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been actively involved in this quest, standing a little aside from traditional approaches, but close in idea of elastic and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been actively involved in this quest, standing a little aside from traditional approaches, but close in idea of elastic and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been actively involved in this quest, standing a little aside from traditional approaches, but close in idea of elastic and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been actively involved in this quest, standing a little aside from traditional approaches, but close in idea of elastic and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been actively involved in this quest, standing a little aside from traditional approaches, but close in idea of elastic and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been actively involved in this quest, standing a little aside from traditional approaches, but close in idea of elastic and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been actively involved in this quest, standing a little aside from traditional approaches, but close in idea of elastic and why does it become so difficult when it comes to developing a computer algorithm for the same task?
ern neutrino sky and is thus particularly promising for the identification of neutrino production from the Galactic plane.

* Financial support by the BMBF and DFG (SFB 876, SFB 1491) is gratefully acknowledged.

**Invited Topical Talk**

T 102.2 Thu 14:20 HSZ/0004 Enhancing the CMS Level-1 Trigger with real-time Machine Learning — **Artur Lobanov** — Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany

The Level-1 Trigger (L1) is the first stage of the online event filter system of the CMS Experiment at the LHC. It reduces the event rate from 40 MHz to $\mathcal{O}(100)$ kHz by reconstructing, identifying and filtering collision events in real-time using dedicated processing hardware based on field-programmable gate arrays (FPGAs).

Following the success of machine learning (ML) in enhancing event selection in the offline analysis of recorded data, ML algorithms are finding their way into the real-time processing of the CMS L1 Trigger system. Contrary to current filters that rely on simple rule-based selection algorithms using the detected physics objects, ML allows to capture deeper correlations between and within the objects, improving the identification of the event. In addition to the tight constraints on the processing latency of several microseconds, trigger algorithms also have to fit into the restricted processing resource budget of the FPGAs. This requires a dedicated optimisation of ML models for their use in hardware in these challenging conditions.

In this talk I will outline the basics of the CMS L1 Trigger system, the principles of ML inference in FPGAs, and present the current state-of-the-art developments of novel ML algorithms enhancing the trigger performance at the LHC and beyond.

**Invited Topical Talk**

T 102.3 Thu 14:40 HSZ/0004 Higgsino Hunting at ATLAS — **Michael Holzbock** — Max Planck Institut für Physik, München, Germany

Supersymmetry (SUSY) remains one of the best motivated candidates for physics beyond the Standard Model (SM) and predicts a new partner for each SM particle. The higgsino, the SUSY partner of the Higgs SM boson, has always been of particular interest due to its connection with the hierarchy problem and as a promising Dark Matter candidate when realized with masses near the weak scale. Intriguingly, (nearly) pure higgsino states can still escape the current constraints from colliders and direct Dark Matter searches, and hence they remain a prime target for new physics searches at the LHC.

In this talk the motivation and experimental challenges for higgsino searches at the LHC are reviewed, and the current results from ATLAS discussed. Finally, new techniques developed for accessing so far unprobed phase space in the search for higgsinos at the LHC are introduced.

**T 103: Al Topical Day – Simulation, Inverse Problems and Algorithmic Development (joint session AKPIK/T)**

**Efficient Sampling from Differentiable Matrix Elements with Normalizing Flows** — **Annalena Koper**\textsuperscript{1,2}, **Vincent Stimper**\textsuperscript{3}, **Mikhail Mikhailenkov**\textsuperscript{1}, **Michael Kagan**\textsuperscript{4}, and **Lukas Heinrich**\textsuperscript{1} — Technical University Munich — **Max Planck Institute for Intelligent Systems, Tübingen** — **University of Cambridge, UK** — **ORIGINS Excellence Cluster, Munich** — **SLAC National Accelerator Laboratory, Menlo Park, USA**

The large amount of data that will be produced by the high-luminosity LHC imposes a great challenge to current data analysis and sampling techniques. As a result, new approaches that allow for faster and more efficient sampling have to be developed. Machine Learning methods such as normalizing flows, have shown great promise in related fields. There, access to not only the more efficient density function but also its gradient has proven to be helpful for training. Recently, software for accessing differentiable amplitudes, which serve as densities in particle scattering, have become available that allow us to obtain the gradients and benchmark these new methods. The described approach is demonstrated by training rational-quadratic spline flows with differentiable matrix elements of the hadronic three-body decays, $\pi(1800) \to 3\pi$ and $\Lambda_c^+ \to pK^+ \eta$. To boost the ability to accurately learn and sample from complex densities whilst also reducing the number of training samples, we explore the use of the newly proposed method Flow Annealed Importance Sampling Bootstrap. Building on prior work, we plan to extend the approach to examples with more particles in the final state via the differentiable matrix elements provided by MadDay.

**Generating Accurate Showers in Highly Granular Calorimeters Using Normalizing Flows** — **Thorsten Buss** — Institut für Experimentalphysik, Universität Hamburg, Germany

The full simulation of particle colliders incurs a significant computational cost. Among the most resource-intensive steps are detector simulations. It is expected that future developments, such as higher collider luminosities and highly granular calorimeters, will increase the computational resource requirement for simulation beyond availability. One possible solution is generative neural networks that can accelerate simulations. Normalizing flows are a promising approach in this pursuit. It has been previously demonstrated, that such flows can generate showers in low-complexity calorimeters with high accuracy. We show how normalizing flows can be improved and adapted for precise shower simulation in significantly more complex calorimeter geometries.

**Introspection for a normalizing-flow-based recoil calibration** — **Lars Sowa**, **Jost von den Driesch**, **Roger Wolf**, **Markus Klute**, and **Günter Quast** — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

Normalizing flows (NFs) are neural networks, that preserve the probability between their input and output distributions. NFs can be promising candidates either as surrogates for the fast generation of new samples or as universal approximators of arbitrary probability density functions, based on which confidence intervals may be determined, both of which are interesting properties in high-energy physics (HEP). This work presents the case study of recoil calibration on LHC Run-3 data and Monte Carlo simulation with the goal to better understand the behavior of NFs. The result of the NF is compared to a deep ensemble of feed-forward neural networks created to compare the calibration results and the different coverage in the value space.

**Generating Flows for Parameter Estimation from Gravitational Wave Signals** — **Johannes Erdmann**\textsuperscript{1}, **Jon Hoinka**\textsuperscript{1}, and **Shichao Wu**\textsuperscript{2,3} — **III. Physikalisches Institut A, RWTH Aachen University** — **Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut)** — **Leibniz Universität Hannover**

The detection of gravitational waves (GWs) from coalescing black hole binaries in the frequency band of the LIGO-Virgo-KAGRA (LVK) array will provide unique insights into the dynamics of the universe on cosmological scales. In this work, we introduce a method to invert gravitational waveforms into likelihood contours for the model parameters of the source. The result of this method is a set of samples from the posterior that can be used to e.g. calculate the mean and variance of the model parameters. We study the performance of this method on simulated data from LVK and demonstrate how the method can be used to perform post-Newtonian parameter estimation for transient gravitational waves.

**A method for inferring signal strength modifiers by conditional invertible neural networks** — **Mate Zoltan Farkas**, **Svenja Diekmann**, **Niclas Eich**, and **Martin Erdmann** — **III. Physikalisches Institut A, RWTH Aachen University**
Reconstruction of SXS Data using Invertible Neural Networks — • Erik Thiessenhusen1, Melanie Rodel1, Thomas Kluge1, Michael Bussmann2, Thomas Cowan3, and Nico Hoffmann4 — 1HDZ, FhW, Dresden, Germany — 2CASUS, Görlitz, Germany

The continuous growth in model complexity in high-energy physics collider experiments demands increasingly time-consuming model fits. We show first results on the application of conditional invertible networks (cINNs) to this challenge. Specifically, we construct and train a cINN to learn the mapping from signal strength modifiers to observables and its inverse. The resulting network infers the posterior distribution of the signal strength modifiers rapidly and for low computational cost. We present performance indicators of such a setup including the treatment of systematic uncertainties. Additionally, we highlight the features of cINNs estimating the signal strength for a vector boson associated Higgs production analysis carried out at an LHC experiment on simulated data samples.

T 103.6 Thu 17:00 HSZ/0004

Reconstruction of SXS Data using Invertible Neural Networks — • Erik Thiessenhusen1, Melanie Rodel1, Thomas Kluge1, Michael Bussmann2, Thomas Cowan3, and Nico Hoffmann4 — 1HDZ, FhW, Dresden, Germany — 2CASUS, Görlitz, Germany

The understanding of laser-solid interactions is important to the development of future laser-driven particle and photon sources, e.g., for tumor therapy, astrophysics or fusion. Currently, these interactions can only be modeled by simulations which need verification within the scope of pump-probe experiments. This experimental setup allows us to study the laser-plasma interaction that occurs when an ultrahigh-intensity laser hits a solid density target. We employ Small-Angle X-Ray Scattering (SAXS) to image the nanometer-scale spatial- and femtosecond temporal resolution of the laser-plasma interactions. However, the analysis of the SAXS pattern is an ill-posed inverse problem meaning that multiple configurations of our target might explain the same measurement due to the loss of the phase information. We approach the ambiguities of the inverse problem by a conditional Invertible Neural Network (cINN) that is returning a probability density distribution over target parameters explaining a single SAXS pattern. We will show that the domain gap between generated training and experimental data can be approached by integrating perturbations of experimental data into the training workflow. We assess the applicability of our approach to a selected set of grating targets in terms of a comprehensive evaluation on simulation and experimental data.

T 104.4 Thu 16:35 HSZ/0004

Untagged analysis of $B \rightarrow \pi \nu \bar{\nu}$ and $B \rightarrow \rho \bar{\nu}$ and extraction of $|V_{ub}|$ at Belle II — Florian Bernlochner, Jochen Dingfelder, Svenja Grandthaler, and Peter Lewis for the Belle II Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

One of the puzzles of current research in flavor physics is the persisting discrepancy between the results of exclusive and inclusive measurements of the CKM matrix element $|V_{ub}|$. The charmless semileptonic decays $B \rightarrow \pi \nu \bar{\nu}$ and $B \rightarrow \rho \nu \bar{\nu}$ belong to the most accessible and powerful channels for determining $|V_{ub}|$ in exclusive modes. Using data from the Belle II experiment, new precision measurements of $|V_{ub}|$ can be performed. In preparation for this, an untagged measurement method for simultaneously extracting $B \rightarrow \pi \nu \bar{\nu}$ and $B \rightarrow \rho \nu \bar{\nu}$ events is developed. An untagged measurement allows for sufficiently large samples of these rare decays already with the current Belle II dataset. In order to increase the signal purity, boosted decision trees are employed to suppress continuum and $B\bar{B}$ backgrounds. Once the signal events are extracted, $|V_{ub}|$ is determined using the measured partial branching fractions in combination with theory predictions of hadronic form factors. This talk will present the current status of the analysis and $|V_{ub}|$ extraction.

T 104.5 Thu 16:50 HSZ/0004

$B \rightarrow \rho \nu \bar{\nu}$ Decays with Hadronic Tagging in Belle II Data — • Moritz Bauer, Torben Ferber, and Pablo Goldenzwieg — Karlsruhe Institute of Technology (KIT)

Over the last 10 years, a 3σ tension between inclusive and exclusive measurements of the magnitude of the CKM matrix element $|V_{ub}|$ has become apparent in multiple experiments. Semileptonic decays involving $b \rightarrow s$ quark transitions present a unique opportunity to measure $|V_{ub}|$ with the current Belle II dataset due to their comparatively high branching fractions.

We present analyses of $B \rightarrow \rho \nu \bar{\nu}$ decays in Belle II data as steps towards the extraction of this matrix element from exclusive decays. These analyses are conducted with hadronic tagging, an approach in which the second B meson in $Y(45)$ decays is reconstructed in a wide variety of hadronic decay chains to increase the selection purity and obtain the recoil of the $B$ meson decay of interest. This is achieved using a multivariate analysis method, the Full Event Interpretation.

T 104.6 Thu 17:05 HSZ/0004

Leptoquarks at high and low energies — • Felix West, Marco Fedele, and Ulrich Niebisch — Institut für Theoretische Teilchenphysik (TTP), Karlsruher Institut für Technologie (KIT)

I consider the case that quarks and leptons are unified at some high scale. The so-called flavour anomalies, which have built up in the data of recent years, are usually interpreted in terms of leptoquarks (LQ) with masses in the multiple-TeV range. I present the renormalisation group equations which connect the LQ couplings at the fundamental high scale with those at the low scale probed in the flavour experiments and discuss phenomenological implications.
Search for the lepton flavour violating decay $B^0 \rightarrow \tau^+ \mu^-$ with the LHCb experiment — Giulia Fraid, Flavio Archilli, and Rowina Caspari 1

Physikalisches Institut, Heidelberg University, Germany — 2 Universität di Roma Tor Vergata, Rome, Italy

As lepton flavour violating, the $\tau \rightarrow \mu \mu \mu$ decay is forbidden in the Standard Model (SM) at the tree level. The combination of the SM with neutrino oscillations predicts for this decay a branching ratio (BR) of the order of $10^{-15}$, well below our current and foreseen experimental sensitivity. Improving the existing limit on the BR of this decay would allow to constrain theories of Physics beyond the SM. Especially lepto-quark models which are often discussed in the context of the recently observed flavor anomalies predict $\tau \rightarrow \mu \mu \mu$ BR which are testable with the current available data set. In this talk, I will show the different steps of the analysis performed to evaluate the limit on the BR using data collected by LHCb during Run 2, by focusing on the improvements introduced with respect to the previous LHCb analysis, which was conducted by analyzing Run 1 data. With the increasing luminosity and cross section of Run 2 and a more sophisticated analysis, we expect the LHCb limit to improve by at least a factor of two, making our results competitive with the current best experimental limit.

Estimate of material effects on neutral charm mixing at the LHCb experiment — Lennart Uecker1, Adam Davis2, Evelina Mirovova Gersabeck2, and Marco Gersabeck2 1 Physikalisches Institut, Universität Heidelberg, Germany — 2 Department of Physics and Astronomy, The University of Manchester, United Kingdom

The LHCb experiment at the LHC is leading the precision measurements in the charm sector. The large charm production cross section and the unique vertex detector, with first detector components as close as 6mm to the interaction point, enable the LHCb experiment to measure a larger number of $D$ mesons passing through material.

In this talk, we present a data-driven approach to estimate material effects on the mixing of neutral charm mesons using $D^{\pm \pm} \rightarrow K\pi\pi$ decays recorded during Run 2 of the LHC, corresponding to an integrated luminosity of 5.6 fb$^{-1}$. Further, we explore the sensitivity of the upgraded LHCb detector for Run 3+4 to material effects on the charm mixing.

Probing light New Physics in invisible rare charm decays — Dominik Suelmann and Gudrun Hiller — TU Dortmund University, Department of Physics, Otto-Hahn-Str. 4, D-44221 Dortmund, Germany

We analyze rare $|\Delta c | = |\Delta s | = 1$ charm decays with missing energy in the final state and study their potential to probe different scenarios of light New Physics (NP). We study three-body and two-body decays of baryons and mesons and probe the sensitivities of different observables for the various light NP models. We find that the $\Lambda_c \rightarrow p + \nu$ missing energy distribution can distinguish between the scenario of only left-handed neutrinos and the scenario with additional right-handed neutrinos. We also work out constraints from available experimental data for the two body decays $\Lambda_c \rightarrow p + nothing$ and $D \rightarrow n + nothing$ and point out the benefits of baryonic modes in rare decays.

Constraining flavour SMEFT operators with missing energy plus jet — Gudrun Hiller and Daniel Wendler — TU Dortmund University, Department of Physics, Otto-Hahn-Str. 4, D-44221 Dortmund, Germany

We consider the Drell-Yan process with final state neutrinos, where the experimental signature is given by ‘missing energy + jet’, as a probe for new physics. The process $pp \rightarrow \nu\nu + jet$ is analyzed, to constrain flavorful smeileptonic four-fermion operators based on present LHC data ($L_{\nu\nu} = 139 fb^{-1}$). Projections are derived for the High Luminosity Large Hadron Collider (HL-LHC). New physics scales probed are $\Lambda_{NP} < 3.5$ TeV, $3.0$ TeV, $2.6$ TeV and $1.6$ TeV for $\nu \bar{\nu}$, $s\bar{s}$, $d\bar{d}$ and $b\bar{b}$, respectively for four-fermion operators. The limits are complementary and competitive or better to those from Drell-Yan involving taus, and with low energy observables, such as from rare decays of kaons, charm and beauty hadrons.

T 106: Searches IV

Using Density Estimation for Resonance Searches at the LHC — Thorben Fonke, Marie Hein, Michael Kramer, and Alexander Mück 1 Institute for Theoretical Particle Physics and Cosmology (TKK), RWTH Aachen University, Germany

We demonstrate an end-to-end application of model-agnostic weakly supervised machine learning methods improving a traditional resonant anomaly search. In particular we focus on the Cathode method and show its superior performance and its limitation at the example of the LHC Olympics RD3 data set. For our specific search strategy, we discuss the treatment of systematic errors, however, the potential issue of background sculpting is absent. The method is powerful at present and will benefit substantially from increased statistics to be collected at the LHC.

Search for new physics with MUSiC in pp collisions at $\sqrt{s}=13$ TeV — Yannick Kaiser, Thomas Heerbrugg, Arno Meyer, Anarita Adams, and Felipp Torres da Silva de Araujo — III. Physikalisches Institut A, RWTH Aachen University

Besides the large effort of the LHC collaborations, no direct evidence for physics beyond the standard model (BSM) has been found. Considering several theory models available, which adress the inadequacies of the standard model (SM), many model-specific searches have been employed. Complementary to this approach is MUSiC - Model Unspecific Search in CMS - a model-independent search procedure in which data collected by the CMS experiment, with at least one identified lepton, is classified according to its final state multiplicities of well-reconstructed objects. For each class a search algorithm is used to determine the most stringent phase-space region, according to a defined p-value, with respect to an SM statistical model. The procedure also takes into account systematic and statistical effects. As an extension of the already published result using 2016 data, we report preliminary results of the MUSiC search on data collected by CMS during 2018, corresponding to $58.83 fb^{-1}$ of integrated luminosity.
Search for new physics in the final state with a lepton and $p_T^Z →$ — VALENTINA SARESIOVI, THOMAS HERBEKER, KERSTIN HOEPFNER, SEBASTIAN WIEDEBRECK, and CHRISTOPH SCHULER — III. Physikalisches Institut A, RWTH Aachen University

Various Beyond the Standard Model (BSM) theories anticipate the existence of new particles that could decay into final states characterized by the presence of a charged lepton and missing transverse momentum ($p_T^Z$) as their most distinctive experimental signature. The CMS detector at the CERN LHC is used to hunt for novel physics in the high mass region of final states containing a lepton (electron, muon, tau) and $p_T^Z$. Achievement of a high mass resolution, rejection of the standard model backgrounds, and efficient identification and reconstruction of TeV leptons are crucial in a search for such phenomena. One of the main challenges of this search is represented by the high rate of QCD multi-jet background produced in the LHC proton-proton collisions, leading to the possible misidentification of a jet as a lepton. Data driven methods as well as advanced machine learning technologies are used to model the QCD contamination and to properly identify leptons. The latest CMS data, recorded in 2022 at unprecedented center-of-mass energy of 13.6 TeV, have been analysed. The key concepts of the analysis techniques employed in the search for new physics in the final state with a lepton and $p_T^Z$ are addressed.

Leptoquark production in a single $\tau$ charm/bottom and met final state at the ATLAS detector — PATRICK BAURER, PHILIP BECHTEL, and KLAUS DESCH for the ATLAS-Collaboration — Physikalisches Institut Bonn

At B-factories, anomalies were observed in decays of the B-hadrons into D$^*$ states with a lepton and missing transverse momentum ($p_T^Z$) as their most distinctive experimental signature. The CMS detector at the CERN LHC is used to hunt for novel physics in the high mass region of final states containing a lepton (electron, muon, tau) and $p_T^Z$. Achievement of a high mass resolution, rejection of the standard model backgrounds, and efficient identification and reconstruction of TeV leptons are crucial in a search for such phenomena. One of the main challenges of this search is represented by the high rate of QCD multi-jet background produced in the LHC proton-proton collisions, leading to the possible misidentification of a jet as a lepton. Data driven methods as well as advanced machine learning technologies are used to model the QCD contamination and to properly identify leptons. The latest CMS data, recorded in 2022 at unprecedented center-of-mass energy of 13.6 TeV, have been analysed. The key concepts of the analysis techniques employed in the search for new physics in the final state with a lepton and $p_T^Z$ are addressed.

T 107.4 Thu 16:35 HSZ/0403 Leptoquark production in a single $\tau$ charm/bottom and met final state at the ATLAS detector — PATRICK BAURER, PHILIP BECHTEL, and KLAUS DESCH for the ATLAS-Collaboration — Physikalisches Institut Bonn

At B-factories, anomalies were observed in decays of the B-hadrons into D$^*$ states with a lepton and missing transverse momentum ($p_T^Z$) as their most distinctive experimental signature. The CMS detector at the CERN LHC is used to hunt for novel physics in the high mass region of final states containing a lepton (electron, muon, tau) and $p_T^Z$. Achievement of a high mass resolution, rejection of the standard model backgrounds, and efficient identification and reconstruction of TeV leptons are crucial in a search for such phenomena. One of the main challenges of this search is represented by the high rate of QCD multi-jet background produced in the LHC proton-proton collisions, leading to the possible misidentification of a jet as a lepton. Data driven methods as well as advanced machine learning technologies are used to model the QCD contamination and to properly identify leptons. The latest CMS data, recorded in 2022 at unprecedented center-of-mass energy of 13.6 TeV, have been analysed. The key concepts of the analysis techniques employed in the search for new physics in the final state with a lepton and $p_T^Z$ are addressed.

This observation emphasizes the importance of exploiting all possible QL production modes. For QL masses well above 1 TeV the single- and non-resonant production modes become an important ingredient for ongoing future searches. With the single production into final states with one $\tau$, bottom or charm jet with large missing transverse momentum, one can directly probe the couplings expected to be involved in the $B \to D^{(*)} \tau^{-} \nu$ anomaly. Furthermore the non-resonant contributions to the same final state could give sizable sensitivity to higher masses for large coupling strengths from the LQ. For the inclusion of a non-resonant interpretation it is crucial to study the interference behaviour of QL signal with the SM.

This talk will provide an overview over the ongoing search for singly produced LQ in the given final states, covering resonant, non-resonant and interference aspects.

T 107.5 Thu 16:50 HSZ/0403 Search for Beyond Standard Model particles with exclusive coupling to top quarks in four-top-quark final states — Gabriele Milella, Freya Bleeman, Matthias Koma, and Denise Müller — DESY, Hamburg, Germany — 2’UB, Brussels, Belgium

Many Beyond Standard Model (BSM) theories predict new top-phile particles that couple exclusively with the top quark, as this coupling is the most favorable for new physics with respect to any other lighter quark. This search is therefore focused on a heavy resonance decaying to a pair of top quarks. The resonance is produced in association with a top quark pair resulting in four top quarks in the final state. The two top quarks from the resonance are expected to be highly boosted and their decay products can be found within large-radius jets. The signal region is constructed from events that contain also opposite-sign leptons and b-tagged jets.

The invariant mass distribution of the reconstructed pair of large-radius jets is studied. Various signal scenarios with different resonance masses and decay widths are tested by searching for local excesses in the reconstructed mass spectrum of the large-radius jets. Preliminary results are presented using the LHC Run 2 data taken with the CMS experiment.

T 107: Searches – Neutrino at accelerators

Time: Thursday 15:50–17:20

T 107.1 Thu 15:50 HSZ/0101 Identification of displaced $\tau$ leptons for long-lived $\tau$ sleptons searches at CMS — MYKTA SICHEDROLOSHY — Deutsches Elektronen-Synchrotron DESY

Searches for the supersymmetric (SUSY) partner of the tau lepton are of high interest, since scenarios in which the tau slepton ($\tilde{\tau}$) is the next-to-lightest supersymmetric particle are limited by the reconstructed efficiency of displaced tau leptons at CMS, which are produced up to 50 cm away from the IP. In addition, the small cross-section of slepton production at the LHC makes such searches challenging. In our study, we explore a new displaced $\tau$ lepton tagger using a deep neural network.

T 107.2 Thu 16:05 HSZ/0101 Search for new physics in $t\bar{t}e^{\pm}\eta^{\pm}\eta^{\mp}$ final states in pp collisions at 13 TeV with the ATLAS experiment — SIMRAN GURDASANI, DANIELE ZANZI, and CHRISTIAN WEISER for the ATLAS-Collaboration — Albert-Ludwigs-Universität Freiburg

This talk will present the recent developments of an ongoing search for Beyond Standard Model (BSM) signatures that can be probed using the $t\bar{t}e^{\pm}\eta^{\pm}\eta^{\mp}$ final state at the Large Hadron Collider (LHC). The search is performed on proton-proton collision data at $\sqrt{s} = 13$ TeV collected by the ATLAS experiment during the LHC Run 2, corresponding to a luminosity of 139 $fb^{-1}$. Targeted signatures include Dark Matter production via scalar or pseudo-scalar mediators and SUSY stop pair production. A machine learning approach via Neural Networks (NN) is used in two stages of the search (i) to reconstruct the hadronic decays of top quarks and (ii) to discriminate signal events from background events exploiting information on the full event kinematics. The presence of signal events is inferred via a template fit to the distributions of the NN output values in samples of events at different kinematic phase spaces. This talk will give an overview of the machine learning strategy developed, background modeling techniques and the expected sensitivity estimates.

T 107.3 Thu 16:20 HSZ/0101 Search for Compressed Electroweakinos in Events with Two Soft and Displaced Leptons at the CMS Experiment — ALEXANDRA TENG — University of Hamburg, Hamburg, Germany

This observation emphasizes the importance of exploiting all possible QL production modes. For QL masses well above 1 TeV the single- and non-resonant production modes become an important ingredient for ongoing future searches. With the single production into final states with one $\tau$, bottom or charm jet with large missing transverse momentum, one can directly probe the couplings expected to be involved in the $B \to D^{(*)} \tau^{-} \nu$ anomaly. Furthermore the non-resonant contributions to the same final state could give sizable sensitivity to higher masses for large coupling strengths from the LQ. For the inclusion of a non-resonant interpretation it is crucial to study the interference behaviour of QL signal with the SM.

This talk will provide an overview over the ongoing search for singly produced LQ in the given final states, covering resonant, non-resonant and interference aspects.

T 107.4 Thu 16:35 HSZ/0101 DUNE-PRISM: An innovative technique for neutrino oscillation predictions — IOANA CARACAS for the DUNE-Collaboration — IGU Mainz

As long baseline experiments are approaching the high precision era, an increased sensitivity towards constraining the oscillation parameter space is expected. Since the oscillation predictions are based on neutrino interaction cross sections, a classical approach is prone to systematic uncertainties, due to the incompleteness in the physical description of such models. This would in turn limit the capability to obtain the physics goals set for long baseline neutrino experiments, such as the Deep Underground Neutrino Experiment (DUNE).

An innovative technique, the Precision Reaction-Independent Spectrum Measurement (PRISM), has been proposed and investigated within the DUNE collaboration. This novel method is designed to measure neutrino oscillations based on a data-driven approach, eluding most theoretical modeling uncertainties. In this regard, the Near Detector (ND) is designed to move off the neutrino beam axis at several locations up to a distance of 33m, sampling thus several neutrino energy spectra. These ND off-axis results are used as a basis to predict the oscillated neutrino spectrum at the DUNE Far Detector, located at a baseline of 1297 km. The prediction obtained with the DUNE-PRISM analysis framework and the systematics impact on the oscillation parameters are presented.
tional studies needed to improve the overall sensitivity to the oscillation parameters and reduce their dependence on the interaction model uncertainties are also discussed.

T 107.5 Thu 16:50 HSZ/0101

Monoenergetic neutrino cross-section measurements with DUNE PRISM — Lukas Koch for the DUNE-Collaboration — Johannes Gutenberg Universität Mainz

Next generation neutrino oscillation experiments like DUNE and Hyper-Kamiokande will require a precise understanding of systematic uncertainties to realize their physics goals. This includes a better understanding of neutrino-energy dependent cross sections of neutrino interactions with the target material. The DUNE near detector complex presents an opportunity to measure these cross sections using the PRISM approach. After recording interaction rates at different off-axis angles and pausing the neutrino beam between runs, we can write linear combinations of these measurements to create “virtual neutrino fluxes”. These can be much narrower than the real fluxes, allowing for more precise cross-section measurements. This talk will explore the potential of the PRISM approach at the DUNE near detector complex and its potential implications for our understanding of neutrino cross sections.

T 107.6 Thu 17:05 HSZ/0101

The ESSvSB+ design study: Achievements and Prospects — Tammer Tolba — Institut für Experimentalphysik, Universität Hamburg, Hamburg, Germany

The European Spallation Source neutrino Super Beam (ESSvSB) is a long-baseline neutrino project that will be able to measure the CP-violation (CPV) in the leptonic sector at the second oscillation maximum, where the sensitivity of the experiment is close to three times compared to that at the first oscillation maximum. As shown in the recently published ESSvSB conceptual design report (CDR), the initially foreseen physics performance of the ESSvSB project has surpassed earlier expectations by covering, after 10 years of data collection, more than 70% of the range of possible CP-violating phase, $\delta_{CP}$, values with a confidence level of more than 5$\sigma$ to reject the no-CP-violation hypothesis. The expected measurement precision of the value of $\delta_{CP}$ is smaller than 6$\sigma$ for all $\delta_{CP}$ values, making it the most precise proposed experiment in the field by a large margin. The extension project, ESSvSB+, to be performed between 2023 and 2026, aims in addressing the challenging task of measuring the neutrino-nucleon cross-section, which is the dominant term of the systematic uncertainty, in the energy range from 0.2 to 6.6 GeV, using a Low Energy nuSTORM (LEnSTORM) and an ENUBET-like Low Energy Monitored Neutrino Beam (LEMBN) facilities. With the successful end of the previous design-study program and the publication of the ESSvSB CDR, an overall status of the project, as well as the recently accepted, by the Horizon-Europe program, extension project, the ESSvSB+, will be presented.

T 108.0 Thu 15:50-17:20

Towards a WbWb differential cross-section measurement in a search-like phase space — Thomas McLachlan for the ATLAS-Collaboration — DESY Campus Zeuthen

The production of a top quark pair is extensively studied at the Large Hadron Collider (LHC). It constitutes a significant background in many searches for physics beyond the Standard Model (BSM). The final state of this process, WbWb, interferes with the production of a single top quark in association with a W boson at Next Leading Order (tW). In this contribution, I will focus on presenting different techniques that are used to correct the data for inefficiencies and limited geometric acceptance for the WbWb single lepton channel, with the goal of improving the modelling of Standard Model (SM) processes for BSM searches. First differential cross-section measurements in variables that are maximally sensitive to the interference, using data from second run of the LHC, will be presented.

T 108.2 Thu 16:05 HSZ/0103

Towards a WbWb differential cross-section measurement in a search-like cross-section measurement — Thomas McLachlan for the ATLAS-Collaboration — DESY

Top quark pair production is a widely studied process at the Large Hadron Collider (LHC) and is a significant background in many searches beyond the Standard Model (BSM). The WbWb final states of this process interfere with the production of a single top quark in association with a W boson and a b-quark (tWb). Inspired by searches for supersymmetry and dark matter, I will measure the WbWb production cross-section in a search-like phase space that is maximally sensitive to the interference effects. Performing such a measurement can allow for new constraints on new physics and improve the sensitivity of future searches through improved background modelling. An event selection using single-lepton events has been developed and will be used on the entire Run 2 dataset. In this context, I will present a range of quantities and theoretical parameters that will be used in the differential cross-section measurement.

T 108.3 Thu 16:20 HSZ/0103

Measurement of differential cross sections in the process $pp \rightarrow W^- W^+ bb$ — Stefan Klotz, Daniel Breitberger, and Johannes Hessler — Max-Planck-Institut für Physik

Precise measurements of differential cross sections in the process $pp \rightarrow W^- W^+ bb$ offer an outstandingly rich physics potential at highest precision. Although the process is theoretically and experimentally well defined, dedicated measurements of $W^- W^+ bb$ production cross sections were not (extensively) performed in the past at the LHC. We will report on ongoing measurements in the single-lepton channel with Run-II data taken by the ATLAS experiment. Due to the high jet multiplicity of the final state the event reconstruction can be challenging. This talk will focus on the kinematic reconstruction of the hadronically decaying W-boson.

T 108.4 Thu 16:35 HSZ/0103

Measurement of the differential $W \rightarrow e\nu$ cross section at high transverse masses with the ATLAS detector and its combination with the $W \rightarrow \mu\nu$ channel — Frank Ellingshaus, Johanna Wanda Kraus, and Tim Frederik Beuken — Bergische Universität Wuppertal

A measurement of the differential cross-section of the process $W \rightarrow e\nu$ is shown. The data set used is based on pp-collision data corresponding to an integrated luminosity of $L = 139 \text{ fb}^{-1}$ at a center-of-mass energy of $\sqrt{s} = 13 \text{ TeV}$. It was recorded with the ATLAS detector during LHC Run-2. The measurement is done double-differentially in the transverse mass of the W boson and the absolute of the pseudoscalar of the electron. It focuses on the region of high transverse masses above 200 GeV. The results will allow constraints on effective field theories and parton distribution functions of the proton. An overview of the analysis with a focus on the determination of the multijet background will be given. In addition, a combination with the associated $W \rightarrow \mu\nu$ measurement using the HÄVERGER tool will be presented.

T 108.5 Thu 16:50 HSZ/0103

Measurement of the differential $W \rightarrow \mu\nu$ cross section at high transverse masses at $\sqrt{s} = 13 \text{ TeV}$ with the ATLAS detector — Frank Ellingshaus and Johanna Wanda Kraus — Bergische Universität Wuppertal

The measurement of the differential cross section of the charged-current Drell-Yan process in the decay $W \rightarrow \mu\nu$ is presented. It is based on pp-collision data taken with the ATLAS detector during the LHC Run-2 at a center-of-mass energy of $\sqrt{s} = 13 \text{ TeV}$, corresponding to an integrated luminosity of $L = 139 \text{ fb}^{-1}$. The cross section is measured double-differentially as a function of the transverse mass $m_T^Z$ and the pseudoscalar of the muon with a focus on the high transverse mass region above 200 GeV. This is done for the first time and will allow for constraints on the parton distribution functions of the proton and on effective field theories. A short overview of the complete analysis will be given with a focus on studies of the unfolding procedure via Iterative Bayesian Unfolding.

T 108.6 Thu 17:05 HSZ/0103

Measurement of the inclusive W and Z boson production cross sections in pp collisions at 13.6 TeV — Jost van den Driems, Markus Klute, Minseok Oh, and Xunwu Zuo — Karlsruhe Institute of Technology (KIT)

The measurement of the W and Z boson production cross sections and their ratios provides an important test of quantum chromodynamics and electroweak processes in the Standard Model. Such measurements have been previously performed by the ATLAS and CMS collaborations at LHC collision energies of $\sqrt{s} = 7 \text{ TeV}$, 8 TeV and 13 TeV. This talk will provide an overview on the results of the W and Z production cross section measurement at CMS using Early Run3 data at the new collision energy of $\sqrt{s} = 13.6 \text{ TeV}$. 
Higgs-associated Top Quark Pair Production in the Bottom-Antibottom Higgs Decay Channel with ATLAS at 13 TeV — ABRUOZ QUAD, **CHRIS SCHEULEN, and ELIZABETA SHABALINA** — II. Physikalisches Institut, Georg-August Universität Göttingen

The bottom anti-bottom Higgs decay channel of Higgs-associated top quark pair production offers direct access to measurements of the top Yukawa coupling and Higgs–p̄̄ differential cross-section, which are sensitive to potential new physics. To incorporate improvements such as developments in b-tagging and Monte Carlo simulation of the dominant t̅̅+ b̅̅b̅̅ background, a legacy analysis of the t̅̅b̅̅b̅̅ process with the full ATLAS Run 2 dataset of $L^p = 139$ fb$^{-1}$ is currently ongoing.

This talk will outline the general analysis strategy and provide an insight into the expected sensitivity of the analysis. Additionally, a focus will be placed on specific aspects of this round of analysis, such as the application of a muon-in-jet correction technique utilised to improve the Higgs mass and Higgs–p̄̄̅̅ resolution.

T 109.2 Thu 16:05 HSZ/0105

Fake Estimation for the Search of the t̅̅b̅̅b̅̅ Process in the Single Lepton Channel — **ALEXANDER FROCH, ANDREA KNUE,** and **KSENIJA SOLOVIEVA** — Albert-Ludwigs-Universität Freiburg

The coupling of the Higgs boson to the standard model (SM) fermions, called Yukawa coupling, is one of the most basic but also most interesting properties in Higgs physics. In the standard model the top quark, with the largest mass of all SM fermions, should have the largest Yukawa coupling to the Higgs boson of approximately 1. To measure this property, the production of a top-antitop quark pair in association with a Higgs boson is studied. Due to its small production rate at the LHC, the most dominant decay of the Higgs boson into a pair of b-quarks is used. One of the top quarks is required to decay hadronically while the other one decays leptonically. This results in a final state with at least 4 b-quarks, a lepton and 2 additional non-b-quarks. The selected sample of events are split into signal- and background-dominated sub-samples called regions. While the signal region is not strongly affected by fake leptons, in dedicated control regions where additional correction are derived, the fake lepton contribution is not negligible.

In this talk, the current status of the fake estimation of the analysis in the single lepton channel will be discussed.

T 109.3 Thu 16:20 HSZ/0105

Measurement of the t̅̅t̅̅b̅̅b̅̅ Cross Section in Events with High Higgs Boson Momentum at the ATLAS Experiment — **DOGA ELITEZ, LUCIA MASSETTI,** EFTYCHIA TZOVARA, ASMA HADEF, ALEXANDER BAXAN, and JESSICA HÖNER for the ATLAS-Collaboration — Johannes Gutenberg Universität Mainz

The coupling of the Higgs boson to the top quark is very sensitive to effects of the physics beyond the Standard Model (BSM) and the most favorable production mode for direct measurement of the top Yukawa coupling is the Higgs production in association with a pair of top quarks, t̅̅t̅̅. The decay to two bottom quarks (H → b̅̅b̅̅) has the largest branching fraction of about 58%. This analysis aims at events where one of the top quarks decays semi-leptonically and produces an electron or a muon. The so-called boosted topology targets events containing a Higgs boson produced at high transverse momentum, whose decay products are contained in a large radius jet. In this talk, methods to improve background rejection, event reconstruction, and increase the sensitivity above the current p̄̄̅̅ range are presented.

T 109.4 Thu 16:35 HSZ/0105

Search for Higgs boson pair production via vector-boson fusion in final states with four b-quarks in the boosted regime using data collected by the ATLAS detector at $\sqrt{s} = 13$ TeV — **MARCUS VINCICUS GONZALEZ RODRIGUES, JASNA KATHARINA BEHR,** and **KUNLIN RAN** for the ATLAS-Collaboration — DESY, Hamburg, Germany

Searches targeting Higgs boson pair production via vector-boson fusion (VBF) provide unique access to the coupling of a Higgs boson pair to a vector boson pair (HHVV), and allow to set constraints on theories that predict resonant production of heavy particles that interact directly with the Higgs boson. The ultimate goal of this analysis is to improve the constraints on the HHVV coupling and search for heavy particles produced via VBF. For this purpose we consider the VBF di-Higgs pair production with final states containing four b-quarks in the boosted regime, where a pair of particle showers initiated by b-quarks from the decay of a high transverse momentum Higgs boson produces one single merged large-radius jet.

This analysis relies on data collected by the ATLAS detector at $\sqrt{s} = 13$ TeV with an integrated luminosity of 139 fb$^{-1}$. To improve the signal vs. background discrimination a Boosted Decision Tree (BDT) is used to define signal regions sensitive to the HHVV coupling, whereas a Parametric BDT is employed to define signal regions targeting resonant production in a wide range of masses. In this presentation the BDT performance will be shown with regard to the HHVV coupling constraints and to the limits on the resonant production.

T 109.5 Thu 16:50 HSZ/0105

Search for non-resonant Higgs Boson pair production in the decay channel bbWW at the CMS experiment — **MARTIN ERMANN, **PETER FACKELDEY, **BENJAMIN FISCHER,** and **DENNIS NOLL** — III. Physikalisches Institut A, RWTH Aachen University

A measurement of the Higgs boson pair production can directly determine the trilinear Higgs coupling and probe the structure of the Higgs potential.

We present a search for Higgs boson pair production with one Higgs boson decaying into b quarks and the other Higgs boson decaying into W bosons. It includes final states with one or two leptons and resolved or boosted event topologies. The central challenge of this analysis is a tiny signal among a large amount of different backgrounds. To address this, we use physics process multiclass classification that is driven by a deep neural network.

We present results corresponding to the data recorded at the CMS experiment during Run 2.

T 109.6 Thu 17:05 HSZ/0105

Search for Higgs Boson Pair Production in Multi-Lepton Final States with the ATLAS Detector — **ANAMIKA AGGARWAL, JANKE BORTH, VOLKER BUSCHER, ANTOINE LAUDRAIN, CHRISTIAN SCHMITT,** **NIKLAS SCHMITT,** and **DUC BÃO TA** — Johannes Gutenberg-University, Mainz

After the discovery of the Higgs boson in 2012 at the LHC, many of its properties have already been determined precisely using 139 fb$^{-1}$ of proton-proton collisions at $\sqrt{s} = 13$ TeV. However, one of the biggest challenges in this field remains the measurement of the coupling of the Higgs boson to itself. It allows for a deep insight into the real shape of the Higgs potential and hence has a big impact on the understanding of fundamental interactions not only at the electroweak scale. In order to constrain the trilinear self-coupling, the Di-Higgs production cross section is measured. While decay modes including b-quarks typically have larger branching fractions, leptonic final states are generally much cleaner and have less SM background. Accordingly, probing this channel as a complement to bb analyses will be very promising.

Dedicated neural networks in the 2, 3 and 4 lepton final states have been trained to distinguish all relevant signal processes against the sum of all SM backgrounds. This talk will highlight the performance of these multi-lepton channels compared to other Higgs decay modes and also introduces a regression network used for probing the sensitivity to the Higgs boson self-coupling. In addition, a first look into Run 3 data, as well as projections for the full Run 3 dataset, are presented.
Two-loop Treatment of a Simple Chiral Yang–Mills Model Using Non-Commuting $\gamma_5$ — BABBAH RAY — Deutsches Elektronen-Synchrotron DESY, Platanenallée 6, 15738 Zeuthen — TU Dresden, Institut für Kern- und Teilchenphysik, Zeisslers Weg 19, 01069 Dresden

For practical calculations of loop diagrams in perturbative quantum field theory, Dimensional Regularization (DREG) is the most commonly applied regularization scheme. In this context, fields and integrals are transformed to $D$ dimensions and one invariably needs to decide how intrinsically four-dimensional quantities like $\gamma_5$ should be treated in $D \neq 4$ dimensions. The original and to date most rigorous and universal HVBMs scheme ('t Hooft–Veltman/Breitenlohner–Muller-Stieffringdurchgeführt) forlets antimutativity of $\gamma_5$ with all other $\gamma^a$ and breaks BRST symmetry in intermediate steps. The latter can be restored by means of finite, symmetry-restoring counterterms.

In this talk, I shall discuss a simple chiral Yang–Mills model with only one SU(N) gauge group and without scalar fields, and present two-loop results in the HVBMs scheme. Besides acquiring the two-loop counterterm structure (involving both singular and finite counterterms), I shall demonstrate methods of cross-checking by considering the Abelian special case (which can be compared with literature), as well as comparing with Ward identities (which are derived from the relevant Slavnov–Taylor identities encoding BRST symmetry). Time permitting, I shall provide insights into the implementation in Mathematica.

The phase structure of neutral three flavor quark matter — MARCO HOFMANN, GHOLAMI Hosein, and BURALLA Michael. — Institut für Kernphysik, Technische Universität Darmstadt, Schlossgartenstr. 2, 64289 Darmstadt

This talk explores the phase structure and equation of state of dense neutral quark matter at zero and finite temperature. As the equation of state and the speed of sound of neutron stars become more and more constrained by observations from gravitational waves and mass-radius measurements, the phenomenology of the quark matter phase structure is pivotal to understand the composition of stars with a quark matter core. We calculate the phase diagram from a three flavor Nambu–Jona-Lasinio (NJL)-type model in the mean field approximation. Color superconductivity is included through the attractive scalar diquark channel. A repulsive vector interaction increases the stiffness of the matter. Furthermore, we address the systematic removal of cutoff artefacts within a renormalization group consistent approach.

Hybrid equation of state and mass radius relation — HOSEIN GHOLAMI, MARCO HOFMANN, and MICHAEL BUBALLA — Institut für Kernphysik, Technische Universität Darmstadt, Schlossgartenstraße 2, 64289 Darmstadt

With the discovery of gravitational waves from neutron star mergers, investigating the structure of these objects using theoretical models has gained more importance. Matter at the highest densities reached in neutron star remnants is expected to be in a color superconducting state. To constrain the quark matter equation of state at these densities, we compare with constraints on hybrid star equations of state for isolated neutron stars at zero temperature. Here we explore the speed of sound and mass-radius relation for such hybrid equations of state. We also study these properties within a renormalization group consistent approach. Our calculation is based on a mean field approximation of three flavor Nambu Jona-Lasinio (NJL)-type models. A repulsive vector interaction is included to satisfy the 2 solar mass neutron star observations. Color superconducting phases are included through the attractive scalar diquark channel.

Notational Invariance of the standard model — LELLO BOSCOVERDE — Istituto della Fava Piazza, Garching

We present current investigations into the notational invariance of the standard model as well as an introduction to the principles of notational invariance with pedagogical examples, a history of its study, and algorithms for implementing changes of notation.

Particle knowledge enhanced by a classical model — ALBRECHT GIESE — Taxusweg 15, 22605 Hamburg

According to today's understanding, the properties of elementary particles must be treated quantum mechanically - preferably according to the "Copenhagen Interpretation". In contrast, we present a particle model that classically provides the usual parameters; and what is more, it derives parameters that are only postulated by today's quantum mechanics.

This classic model initially refers to Louis de Broglie's approach and takes into account the relativistic behavior of particles. With these ingredients, not only standard properties such as spin and magnetic moment can be derived. In complete contrast to the Higgs model, it is possible to determine the particle mass very precisely; in the case of the electron by 1:300 000 without any adaption of parameters. It also allows the physical quantities $h$ (Planck) and alpha not only to be postulated, but also to be derived from more fundamental elements. The additional understanding gained in this way leads to further properties such as the Pauli principle and the color codes of quarks, which are also only postulated to this day.

Further info: www.ag-physics.org/rmass

Title "Forschung trifft Schule @home" zum permanenten Veranstaltungsportfolio gehört. Das digitale Angebot beinhaltet insbesondere Fortbildungen zur Forschungsmethodik in der Teilchenphysik unter dem Motto "Von der Kollisions-Entdeckung“ sowie Veranstaltungen zur Astroteilchenphysik und deren Behandlung im Schulunterricht unter Nutzung des Online-Tools Cosmic@Web. Die Veranstaltungen wurden bundesweit beworben und von Lehrkräften aus fast dem gesamten Bundesgebiet sowie von deutschen Schulen im Ausland besucht. Im Vortrag werden sowohl die bisher umgesetzten als auch geplante Formate sowie das Feedback der teilnehmenden Lehrkräfte vorgestellt und diskutiert.

Physik der kleinsten Teilchen in der Schule - Eine multiperspektivische Tagungsreihe zur kohärenten Vermittlung — STEFAN HEUSLER1, CHRISTIAN KLEIN-ROßING2, MICHAEL KÖBEL2, PHILIPP Lindenau3, OLIVER Passon1, THOMAS ZOGLI4 — Westfälisches Wilhelms-Universität Münster — 2Technische Universität Dresden — 3Bergische Universität Wuppertal — 4Universität Greifswald


**T 111.4 Thu 16:35 HSZ/0204**

**Bausteine der Materie – Ein Mitmachexperiment für Schüler:innen**

**Luisa Faber** für die Netzwerk Teilchenwelt-Kollaboration – Institut für Kernphysik, WWU Münster


**T 111.5 Thu 16:50 HSZ/0204**

**Cosmic Watch - Bau eines Myonendetektors für Schulkinder**

**Sebastian Laudage** – Argelander-Institut für Astronomie, Universität Bonn


**T 111.6 Thu 17:05 HSZ/0204**

**Die Selbstbau-Nebelkammer als Hands-On Exponat für Events und Ausstel- lungen**

**David Borgelt und Christian Klein-Bosing** für die Netzwerk Teilchenwelt-Kollaboration – Wilhelm-Kleemann-Str. 9 48149 Münster


In diesem Vortrag werden die Hands-On Charakteristika der Selbstbau- Nebelkammer vorgestellt und Erfahrungsberichte über ihren Nutzen in Ausstel- lungen und auf Events präsentiert.

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**T 112: DAQ Test/RO – GRID I**

**Time:** Thursday 15:50–17:20

**T 112.1 Thu 15:50 HSZ/0301**

**Modular and Scalable Multi-Timepix3 Readout System**

**Thomas Block, Klaus Desch, Markus Greuber, Jochen Kaminski, and Tobias Schiffer** – Universität Bonn

The Timepix3 chip of the Medipix3 collaboration is a highly granular pixel chip. It can be used in combination with different detector components, e.g. with a bump bonded silicon pixel sensor, with a photolithographically postprocessed MicroMegas gas amplification stage (InGrid), or with a micro-channel plate (MCP). Therefore different detectors can be built, which can be used for various applications like beam telescopes, X-Ray detectors for axion search and polarimetry and neutron detectors. For these different detectors we are developing a fully open source solution: the Timepix3 readout system. It enables us to adapt to the different requirements (low- to high-rate events and single- to multi-chip design) efficiently. The system, which already has been used in test runs, supports different FPGA boards, which cover the different requirements. The Scal- able Readout System (SRS), being one of them, together with our own PCB designs, supports low- to medium-rate applications. Based on the basal framework, developed at SILAB Bonn, the firmware is written in Verilog and the soft- ware is written in Python. For the control system both a graphical user interface and a command-line interface have been developed.

In this talk I will present the readout control system and the recent de- velopment from single-chip to multi-chip support. Also I will show the needed functionality like calibration, equalisation, readout and monitoring.

**T 112.2 Thu 16:05 HSZ/0301**

**Scan Automated Testing for the ATLAS Pixel Detector**

**Marcello Bindi, Arnulf Quadt, and Chris Schulein** – II. Physikalisches Institut, Georg-August Universität Göttingen

The ATLAS Pixel detector data acquisition system (DAQ) is distributed over several different physical components, such as front-end detector modules, read-out drivers, and PCs for operating and calibrating the detector. As a result, time-consuming manual tests are currently required to ensure the correct operation of the entire system after software or firmware changes in any one component. After the first year of detector operation during Run 3, this represents a bottle- neck to the development work carried out during the end-of-year shutdown on

the basis of the experience collected, such as observed dead-time desynchroni- sation instabilities.

To simplify software validation and free up manpower, a suite of automated tests is being developed for deployment in the DAQ software’s continuous in- tegration system on GitHub. Fully automated testing is only possible without involvement of the detector modules, whose operation requires some degree of manual supervision. Therefore, emulated detector responses are used for tests of read-out chain components under exclusion of the detector modules themselves.

This talk will provide a brief overview of required improvements to the Pixel detector’s DAQ system based on the operational experience collected during the first data-taking year of Run 3. A special focus will be placed on the develop- ment of the automated testing framework being used to validate this firmware and software development.

**T 112.3 Thu 16:20 HSZ/0301**

**Tests of the Mu3e DAQ in the Cosmic run 2022**

**Martin Müller** für die Mu3e-Collaboration – Institute for Nuclear Physics, IGU Mainz

The Mu3e experiment will search for the lepton flavour violating decay $\mu^+ \rightarrow e^+\nu\bar{\nu}$, aiming for a sensitivity of one in $10^{33}$ muon decays. Since this decay is highly suppressed in the Standard Model to a branching ratio of below $10^{-16}$, an observation would be a clear sign for new physics.

In the Mu3e detector, four layers of silicon pixel sensors will be used to track electrons and positrons and a time resolution of $100 \text{ ps}$ will be provided by scintillating fibre and fibre detectors. The overall detector is expected to produce a data rate from 80 Gbit/s (Phase I) to 1 Tbit/s (Phase II), which will be processed in a three-layer, triggerless DAQ system using FPGAs and a GPU filter farm for online event selection.

A prototype of the detector was operated in summer 2022 in the first Mu3e cosmic run with the intent to test and validate a variety of systems. The operated prototype included two cylindrical layers of pixel sensors, a scintillating fibre module and a vertical slice of the final data acquisition (DAQ) system. The talk will focus on the commissioning and validation of the DAQ in this run.

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Integration of the Goettingen HPC resources to the WLCG Tier-2 grid computing environment of the ATLAS experiment — UMAT SAIDOV POLNETZKY, AERNULT QUADT, DANIEL SCHINDLER, and SEBASTIAN WOŹNIEWSKI — II. Physikalisches Institut, Georg-August-Universität Göttingen

The amount of data produced will significantly increase with the upcoming Run 4 of the LHC. To handle the incoming data there is a necessity to increase the computing resources for simulation, reconstruction and analysis in terms of storage and computing power. The important aspect of the solution is the integration of the High Performance Computing (HPC) resources. At Goettingen campus, there is both WLCG (Worldwide LHC Computing Grid) Tier-2 site (GoGrid) and a large HPC cluster by National High Performance Computing (NHR) and North German Supercomputing Alliance (HLRN) supercomputer resources. In context of the FIDIDIUM project, the aim is to increase the computing resources by integrating the local HPC cluster to the GoGrid. The unused quota from the external sources can be used to fill the shortage of computing resources required for the ATLAS experiment. This integration would lead to a solution to run all the job types provided by the ATLAS experiment.

Analysis benchmarking tests on selected sites — DAVID KOCH, THOMAS KÜH3, GÜNTER DUCKECK3, DENNIS NOLL2, and BENJAMIN Fischer — 3LMU, Germany; 2RWTH Aachen, Germany

A fast-turn-around time and ease of use are important factors for systems supporting the analysis of large HEP data samples. We study and compare multiple technical approaches. This presentation will be about setting up and benchmarking the Analysis Grand Challenge (AGC) using CMS Open Data. The AGC is an effort to provide a realistic physics analysis with the intent of showcasing the functionality, scalability and feature-completeness of the Scikit-HEP Python ecosystem.

I will present the results of setting up the necessary software environment for the AGC and benchmarking the analysis runtime on various computing

Day: Thursday
Location: HSZ/0405
Time: 15:50–17:20

T 112.4 Thursday 16:35 HSZ/0301 Integration of the Goettingen HPC resources to the WLCG Tier-2 grid computing environment of the ATLAS experiment — UMAT Saïdov Polnitzky, Aernult Quadt, Daniel Schindler, and Sebastian Wozniowski — II. Physikalisches Institut, Georg-August-Universität Göttingen

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Time: 15:50–17:20

T 112.5 Thursday 16:50 HSZ/0301 Analysis benchmarking tests on selected sites — David Koch, Thomas Kühl, Günter Dückeck, Dennis Noll, and Benjamin Fischer — 3LMU, Germany; 2RWTH Aachen, Germany

A fast-turn-around time and ease of use are important factors for systems supporting the analysis of large HEP data samples. We study and compare multiple technical approaches. This presentation will be about setting up and benchmarking the Analysis Grand Challenge (AGC) using CMS Open Data. The AGC is an effort to provide a realistic physics analysis with the intent of showcasing the functionality, scalability and feature-completeness of the SciKit-HEP Python ecosystem.

I will present the results of setting up the necessary software environment for the AGC and benchmarking the analysis runtime on various computing

Day: Thursday
Location: HSZ/0405
Time: 15:50–17:20

T 113.1 Thursday 15:50 HSZ/0405 Quark Masses in the Heavy Quark Expansion — Anastasia Boussiere1, Thomas Mannel1, and K. Kori Yoss2 — 1Theoretische Physik 1, Center for Particle Physics Siegen Universität Siegen, D-57068 Siegen, Germany; 2Gravitational Waves and Fundamental Physics (GWFP), Maastricht University, Duboisdomein 30, NL-6229 GT Maastricht, the Netherlands and Nikhef, Science Park 105, NL-1098 XG Amsterdam, the Netherlands

Many observables can be written in terms of an operator product expansion (OPE) which expresses the mass dependence of the non-perturbative parts. The examples to be studied in this talk are the heavy quark expansion (HQE) for inclusive semi-leptonic b → u decays and the inverse moments of the cross section e+e− → hadrons.

In both cases the leading term of the OPE is given by the perturbatively calculated, partonic expression, which depends on the mass of the heavy quark. Calculating this using the pole mass one encounters the problem that this mass scheme suffers from so-called renormalon induced ambiguities which spoil the convergence of the perturbative expansion.

However, we propose the following strategy: Since observables should be free of such ambiguities, we use an observable such as an inverse moment of the e+e− → hadrons cross section to eliminate the pole mass from the expression for the semi-leptonic b → u rate, obtaining a perturbative relation between two observables valid to leading order in the OPE.

Day: Thursday
Location: HSZ/0405
Time: 16:05 HSZ/0405 Measurement of D∗ meson cross sections in the full phase space for charm in CMS — Yvonne Wirth1, Tomasz Gesher1, Zulaida Jomhari1, Valentina Mariani1, Jossey METWALLY1, and Max UETRICH2 — 1Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, D-22607 Hamburg — 2Universität degli Studi di Perugia, Piazza Università, 106123 Perugia — 3Technische Universität Dortmund, August-Schmidt-Straße 1, 44227 Dortmund

This is a summary talk about total, single- and double-differential cross sections for charm which are measured from the reconstruction of charm hadronic states in the CMS detector. Among all the hadronic states of charm, b→cX, they especially the reconstruction of D∗ which decays into D0 and a slow pion is introduced at proton-proton center-of-mass energies of 0.9, 5, 7, and 13 TeV. The measured cross sections for this final state show consistency compared to QCD theory and also to other LHC experiments. Then the D∗ meson cross sections measured in the full phase space accessible with the CMS detector are extrapolated to extract the total charm cross section. For the first time, this extrapolation applies the pT-dependent cross-section ratios between meson and baryon of charm, which are recently measured from LHC experiments.
Forward electrons are, however, experimentally challenging objects to work with, due to large amounts of passive material in this region of ATLAS. This talk will present an overview of the analysis and calibration process for forward electrons, so that they are ready to be used for physics purposes.

T 113.5 Thu 16:50 HSZ/0405

Machine-learning off-shell effects in top quark production at the LHC —  
**Mathias Kuschick** — Institut für Theoretische Physik, Münster  
Measuring top quark processes at the LHC is an important test of the Standard Model of particle physics. As the heaviest of all quarks the investigation into its properties allows for tests of QCD and the electroweak interaction as well as tests of the Higgs mechanism, but also provides a window to new physics. Therefore, a precise determination of the top quark’s fundamental properties is compulsory. Such determinations heavily rely on precise theoretical calculations. The most sophisticated of such calculations include improvements such as radiative corrections or off-shell effects, which make them extremely computational costly to evaluate. In my talk I will explore the use of modern machine learning techniques such as neural networks to learn how top pair production predictions change when finite width and interference effects are included in an effort to bypass the undesirable computational complexity of such calculations.

T 114.1 Thu 15:50 POT/0051

Characterization of the ECHO-100k detector response — **Raghab Pandey**, Arnulf Barth1, Sebastian Berndt1, Holger Dorrer2, Christoph E. Dullmann1, Christian Enss1, Andreas Fleischmann1, Nina Kneip1, Federica Mautegazzini1, Klaus Wendt1, and Loredana Gastaldo1  
1Kirchhoff Institute for Physics, Heidelberg University — 2Department of Chemistry - TRIGA Site, Johannes Gutenberg-Universität Mainz  
Institute of Physics, Johannes Gutenberg-Universität Mainz  
In the ECHO-100 experiment high energy resolution and high statistics Ho-163 electron capture spectra will be acquired with more than 1000 single detector pixels that fully enclose implanted Ho-163. A well-understood and reliable detector response is at the basis for a precise analysis of the spectral shape in the endpoint region around 2.8 keV. We present the results obtained with ECHO-100k detectors containing Ho-163. We discuss the shape of the acquired spectrum with respect to the spectrum acquired with ECHO-1k detectors and with the spectrum acquired with the same ECHO-100k detectors but consisting only of the lower half of the absorber, meaning without complete Ho-163 enclosure.

T 114.2 Thu 16:05 POT/0051

First 7Be Electron Capture Spectrum measured with MMCs — **Arnulf Barth**, Karl Johnston2, Federica Mautegazzini1, Peter Rubovic1, and Loredana Gastaldo1  
1Kirchhoff-Institute for Physics, Heidelberg University — 2Institut für Experimentelle und Angewandte Physik, Czech Technical University in Prague  
7Be, with a half-life of about 53 days and a Q-value of about 862 keV is the lightest nuclide to undergo electron capture. In nature, electron capture processes typically occur in atoms within a medium. 7Be electrons provide very low screening from environment effects from the host material, causing a change in half-life and other atomic properties. This makes 7Be an optimal candidate to study the effect of different host materials on the electron capture process and on the energy transferred to the nuclear recoil. We present the first measurement of the 7Be spectrum using low temperature metallic magnetic calorimeters where 7Be has been ion-implanted into gold. We achieved a baseline resolution of 4 eV FWHM and could observe the peak corresponding to the capture of the 1s electron, which includes the atomic de-excitation energy and the nuclear recoil energy. These very promising results demonstrate the possibility to perform a detailed study of the effect of the environment on the electron capture process by implanting 7Be in different host materials.

T 114.3 Thu 16:20 POT/0051

Reducing temperature drifts and their effect on MMC detector response for the ECHO experiment — **Cicek Cihan**, Arnulf Barth, Daniel Ungar, Daniel Hengstler, Andreas Fleischmann, and Loredana Gastaldo — Kirchhoff Institute for Physics, Heidelberg University  
In the ECHO experiment, large arrays of metallic magnetic calorimeters are mounted at the mixing chamber plate of a dilution refrigerator kept at a temperature below 20 mK. The temperature of the mixing chamber is regulated and shows average drifts at the level of 1 μK. Methods to improve the stability are presented in this talk.  
Even if very small, these temperature fluctuations degrade the energy resolution of detectors optimized for the ECHO experiment. To cure this effect, each ECHO chip hosts two temperature sensors. For each triggered event in pixels on a chip, the signal of the temperature channels are also acquired and will be used for an off-line correction. We discuss methods which allow for identification and correction of temperature instabilities and present the effect of this correction on energy resolution.

T 114.4 Thu 16:35 POT/0051

Analysing KATRIN neutrino mass data using a neural network — **Christian Karl**, Susanne Mertens1, Alessandro Schwemmer1, and Christoph Wiesinger2  
1Physik Department, Technische Universität München, Garching — 2Max-Planck-Institut für Physik, München  
The Karlruhe Tritium Neutrino (KATRIN) experiment probes the effective electron anti-neutrino mass by a precision measurement of the tritium beta-decay spectrum near the endpoint. A world-leading upper limit of 0.8 eV c^{-2} (90% CL) has been set with the first two measurement campaigns. Improvements w.r.t. the measurement configuration allowed for an enhanced signal-to-background ratio as well as a reduction of systematic uncertainties and a substantial increase in statistics. Subsequently the combined sensitivity of the first five datasets is estimated to be below 0.5 eV c^{-2} (90% CL). In this talk we will present a novel approach for the analysis of these datasets using a neural network.

T 114.5 Thu 16:50 POT/0051

High voltage preparation and first measurement of a new 83mKr conversion line with the KATRIN experiment — **Benedikt Bieringer** and Matthias Böttcher for the KATRIN-Collaboration — Institute for Nuclear Physics, University of Münster  
The Karlruhe Tritium Neutrino Experiment (KATRIN) is targeted to measure the neutrino mass with a design sensitivity of 0.2 eV at 90% confidence level through electron spectroscopy of $^8_B$ decay electrons from a windowless gaseous tritium source. To determine the spectrometer properties and to calibrate the beamline work function, a Condensed Krypton Source (CKrS) can be inserted into the beamline, providing conversion electrons from $^{83m}$Kr. For precision spectroscopy, the KATRIN experiment features a stabilized high voltage system up to ~35 kV with ppm level precision. This talk presents the extension of the KATRIN high voltage system to support retaining potentials of up to ~40 kV and a consecutive first measurement of a new $^{83m}$Kr conversion line using the CKrS following the idea of EPJ C 82 (2022) 700.  
The work shown in this talk is funded via BMBF contract number 05A20PMA.

T 114.6 Thu 17:05 HSZ/0405

Automated NLO electroweak corrections to processes at hadron and lepton colliders — **Pia Bredt** — U. Siegen, Siegen, Germany  
The aim of this project was the completion of an automated framework calculating NLO corrections in the full SM for arbitrary processes at hadron and lepton colliders. This framework is an element of the Monte-Carlo program WHIZARD simulating cross sections and differential distributions. Specifically, it builds on the implemented FKS subtraction scheme for NLO QCD calculations, and extends it to automated NLO EW and QCD-EW mixed corrections. To that end, the implemented FKS scheme is generalised to systematically subtract QED and QCD infrared divergences in mixed coupling expansions. The automated computation of NLO contributions is validated for a set of benchmark processes at the LHC, including e.g. H (→WW/Z) production. Cross-checks for $e^+ e^-$ processes likewise show that WHIZARD can be used for predictions at lepton colliders including fixed $Q(f)$ corrections. This framework is applied to the study of multi-boson processes at a future multi-TeV muon collider.
tectonic uncertainties, e.g. for the shifted analyzing plane configuration of the main spectrometer. New methods to optimize the model calculation will be presented, together with the Bayesian sensitivity for KATRIN’s first five measurement campaigns. Constraints on cosmological models with the released data will also be presented within the Bayesian framework.

T 115: Gamma Astronomy V

Time: Thursday 15:50–17:20

T 115.1 Thu 15:50 POT/0151

Quasi-periodic behavior of J1048+7143 — Armin Göhrbiantejedma, Iša Jakobeschi, Emma Kuz1,2, and Julia Becker Tjus1 — Theoretical Physics IV, Ruhr University Bochum — 1CSFK, MTA Centre of Excellence, Hungary — 2Konkoly Observatory, ELKHH, Hungary

Most blazars show short- and long-term variability in their electromagnetic emissions. Some of these have a gamma-ray light curve with a periodic pattern with a declining periodicity called quasi-periodic behavior, which is evident in observations using Fermi-LAT. Jet precession is a possible explanation for such a behavior. Supermassive binary black holes (SMBBHs) are characterized by the change in jet direction accompanied by jet precession close to an immanent merger, which makes them interesting candidates as the origin of the microwave background photons. Therefore, regular multi-wavelength (MWL) campaigns have been carried out since 2009. In late 2020, simultaneous observations were performed with the X-ray satellites XMM-Newton, the International Gamma-Ray Astrophysics Laboratory (INTEGRAL), and the Major Atmospheric Imaging Cherenkov Telescopes (MAGIC) to check if these hadronic signatures can be found. Two INTEGRAL observations with an long exposure of 165 ks were performed during the time range of 21 November to 24 November and the time range of 12 December to 15 December and data were taken simultaneously with XMM-Newton and MAGIC. The results of this MWL campaign will be presented.

T 115.2 Thu 16:05 POT/0151

Potential for detection of M31-like gamma-ray halos with CTA and Fermi-LAT — Mario Engelmann, Alison Mitchell, and Katrin Streit — Erlangen Centre for Astroparticle Physics Nikolaus-Fiebiger-Str. 2 D-91058 Erlangen Germany

Recent evidence from the Fermi LAT satellite suggests that a gamma-ray halo exists around the Andromeda Galaxy. One explanation for the gamma-ray emission is that, in the inner region of the galaxy, buoyant bubbles of gas are created. These bubbles are pushed outwards and create a cosmic ray halo around the galaxy. Consequently, the gamma rays are produced via proton-proton interaction of cosmic rays or inverse Compton scattering of cosmic ray electrons with the microwave background photons. The sensitivity of the Fermi LAT satellite is insufficient to observe the whole spectrum in the GeV range. For this reason, observations with CTA can be used to search for emission at higher energies. With this information, the parameters for the spectrum can be fine-tuned. After this, potential candidate galaxies for similar halos will be chosen from the nearby galactic catalogue (maximum distance at 25 Mpc). In this contribution I will compare the sensitivity of CTA and Fermi-LAT to the gamma-ray emission from galaxies similar to the Andromeda galaxy.

T 115.3 Thu 16:20 POT/0151

Satellite trails in H.E.S.S. data — Thomas Lang, Alison Mitchell, and Samuel Spencer for the H.E.S.S.-Collaboration — Erlangen Centre for Astroparticle Physics

The commercialization of space by private companies such as SpaceX and OneWeb has caused the number of satellites launched in low earth orbit to almost triple to over 4000 in the last three years. 17 constellations with over 400,000 total satellites are planned/proposed, which causes major concern for ground based astronomy. The impact on Imaging Air Cherenkov Telescopes (IACTs) has been assumed to be low and apart from the brightest trails has not been considered as a significant problem.

This work aims to find and quantify satellite trails in data taken by the High Energy Stereoscopic System (H.E.S.S.), determine which observation times and directions are affected the most, giving a prediction for these effects depending on the satellite numbers and determine whether trails have an impact on the Hillas parameters used to reconstruct high energy particle events. Trails are found in night sky background (NSB) maps of FlashCam data, the latest camera of the largest telescope (CT5) with a 0.1° × 0.1° mapping rate, and from this inferred for the other smaller telescopes (CT1-4). Comparisons of the distributions of Hillas parameters will be made of during and around satellite trail passing times.

T 115.4 Thu 16:35 POT/0151

Simultaneous TeV and X-Ray Observations of Markarian 421 in 2020 — Bernd Schleicher for the MAGIC-Collaboration — University of Würzburg, Institute for Theoretical Physics and Astrophysics, Germany

The blazar Mrk 421 is one of the brightest and most studied sources in very-high-energy (VHE) gamma rays. As the underlying processes of the production of these gamma rays are still under debate and different models predict correlations between X-rays and gamma rays and some hadronic models for example predict specific features in the hard X-ray regime. Therefore, regular multi-wavelength (MWL) campaigns have been carried out since 2009. In late 2020, simultaneous observations were performed with the X-ray satellites XMM-Newton, the International Gamma-Ray Astrophysics Laboratory (INTEGRAL), and the Major Atmospheric Imaging Cherenkov Telescopes (MAGIC) to check if these hadronic signatures can be found. Two INTEGRAL observations with an long exposure of 165 ks were performed during the time range of 21 November to 24 November and the time range of 12 December to 15 December and data were taken simultaneously with XMM-Newton and MAGIC. The results of this MWL campaign will be presented.

T 115.5 Thu 16:50 POT/0151

Evidence of hadronic origin of the gamma-ray emission from the nova RS Oph by the MAGIC telescopes — David Green, Vandan Fallah Ramazani1, Francesco Leone1, Ruben Lopez-Cotto2, Alicia Lopez-Oramas3, and Julian Sitarek4 for the MAGIC-Collaboration — 1Max Plank Institute for Physics, Munich, Germany — 2Astronomisches Institut (AIRUB) Ruhr-Universität Bochum, Bochum, Germany — 3National Institute for Astrophysics, Rome, Italy — 4IAA-CSIC, Granada, Spain — 5Instituto de Astrofísica de Canarias, Tenerife, Spain — 6University of Lodz, Faculty of Physics and Applied Informatics, Department of Astrophysics, Lodz, Poland

RS Ophiuchi (RS Oph) is a symbiotic recurrent nova that shows eruptive events roughly every 15 years. On August 8th, 2021, RS Oph erupted with its latest outburst. This event was detected by a wide range of multi-wavelength (MWL) instruments from radio up to very-high-energy (VHE) gamma rays. The MAGIC telescopes followed up on optical and high-energy triggers and initiated an observation campaign from August 9th till September 1st. RS Oph is the first nova detected in the VHE gamma-ray energy range. We report on the detection of VHE gamma rays at a significant level of 13.2σ during the first 4 days of RS Oph with the MAGIC telescopes. We combine the VHE emission detected by MAGIC with optical and high-energy observations and conclude RS Oph accelerated hadrons during its eruption. We will present the MWL modeling revealing this hadronic emission, and its further implications for Galactic cosmic-rays.

T 115.6 Thu 17:05 POT/0151

Performance of joint observations with LST-1 and MAGIC — Alessio Berti1, Yoshiki Ohtani1, Julian Sitarek2, Federico Di Pierro3, Yusuke Suda4, and Eiji Jobst1 for the MAGIC-Collaboration — 1Max Plank Institute for Physics, Munich, Germany — 2Institute for Cosmic Ray Research, Tokyo, Japan — 3University of Lodz, Lodz, Poland — 4INFN Torino, Torino, Italy — 5Hiroshima University, Hiroshima, Japan

The next generation ground-based instrument for very high energy gamma rays observations will be the Cherenkov Telescope Array (CTA). In one of the two planned sites, La Palma (Canary Islands, Spain), the first prototype of a Large Sized Telescope, LST-1, is already operational and is currently under commissioning. The proximity of the two MAGIC telescopes offers a unique opportunity to perform joint observations with LST-1. This three-telescope system provides a further reconstruction of the events, both in angular and energy resolution, and discrimination between showers initiated by gamma rays and cosmic rays, which turns into an improvement in sensitivity with respect to LST-1 or the two MAGIC telescopes separately. In this contribution, we will report on results from Crab Nebula data with a pipeline developed for the analysis of joint LST-1 and MAGIC observations, and show the performance estimated both from real and simulated data.
Polyethylene-Naphthalate-Based Wavelength Shifting Reflectors for LEGEND-1000 — Andreas Leonhardt, Maximilian Goldbrunner, and Stefan Schönert for the LEGEND-Collaboration — Physik Department, Technische Universität München, Garching, Germany

The next-generation experiment LEGEND-1000 will search for the neutrinoless double-beta decay (0ββ) of Ge-76 with unprecedented discovery potential covering the inverted neutrino mass ordering. To this end, 1000 kg of enriched germanium is employed bare in a segmented liquid Argon (LAr) volume. Particle interactions in LAr produce vacuum-ultraviolet (VUV) light flashes peaking at 128 nm, which are converted to longer wavelengths by wavelength shifters (WLSs).

To efficiently instrument the LAr volume in LEGEND-1000, a large-scale wavelength shifting reflector (WLSR) based on polyethylene naphthalate (PEN) will be lined on the inner crystal wall. In this talk, we describe the custom VUV spectrophotometer used for the optical characterization of PEN-based WLSRs at VUV excitation and cryogenic temperatures. We present the first measurement of the wavelength-resolved photoluminescence yield of PEN for VUV excitation at cryogenic temperatures and compare it to the commonly used wavelength shifter tetraphenyl butadine (TPB).

This research is supported by the DFG through the Excellence Cluster ORIGINS and the SFB1258.

Set Up and Run of a Cherenkov Test Detector — Christoph Vogl, Martin Guevara, Alice Ortmann, and Stefan Schönert — Physics Department, TU-Munich

Liquid argon is commonly used as a medium for particle detection in rare event searches and particle physics experiments. Its performance is heavily impaired in the presence of electronegative impurities, typically oxygen, nitrogen, and water.

The chemical purity of liquid argon can be assessed indirectly by measuring its scintillation properties. A complementary and direct way of determining purity is through mass spectrometry. In this talk, we will present our new quadrupole mass spectrometer setup (IDEXIX) and discuss the main challenges and solutions. Results are shown regarding the assessment of the chemical composition of commercial and in-house purified liquid and gaseous argon. This research is supported by the BMBF through the Verbundforschung 05A20W02 and by the DFG through the Excellence Cluster ORIGINS.

Decoherence Effects of Reactor Neutrinos — Raphael Kröger — Theoretical Astroparticle Physics at IAP, Karlsruhe Institute of Technology, Karlsruhe, Germany

In the most common theoretical formulation of Neutrino Oscillations neutrinos are described by plane waves. Although this formulation gives the correct oscillation formula verified by experiments it must be considered physically wrong. Several conceptual problems of the plane wave treatment, i.e. violated Lorentz invariance, can be avoided if one uses the QFT with external wave packets approach.

There decoherence effects automatically emerge from the formalism. These decoherence effects depend on the localizations of the external particles and are negligible for the standard mass splittings. This work focuses on reactor neutrino experiments and whether decoherence effects may play a role for the mixing with a potential light sterile neutrino. First, the localizations of the external particles are estimated on physical grounds. Using these results, the decoherence effects on the spectrum of the measured positron in the detector are analysed. Here this work makes use of a consistent treatment of the problem starting from Feynman rules and without the use of normalizations introduced by hand. The results give no observable decoherence effects.

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Set Up and Run of a Cherenkov Test Detector — Ivana Nikolac — Physikalisches Institut, Eberhard Karls Universität Tübingen, Tübingen, Germany

High-energy particles, like muons, can cross many kilometres of rock and penetrate even the deepest underground laboratories, causing a non-negligible background of rare-event muon showers. Muons can also produce neutrons, which mimic dark matter signals.

This makes the muon veto an integral part of any rare-event underground experiment. To test the properties of a muon veto system, at the University of Tübingen a small volume water Cherenkov veto is being set up. The instrument (DODI) is a dodecahedron-shaped steel tank with a capacity of 700 litres, lined inside with highly reflective foil, and equipped with twelve photomultiplier tubes (PMTs). Due to its relatively small size and easy access to both its exterior and interior parts, DODI offers the opportunity to study the muon veto system and its efficiency in real-time. This can be achieved, for example, by introducing different reflective materials in the tank or changing the PMT types. For future experiments, DODI will be further tested as a neutron tagger, first with water and then by introducing different Gadolinium arrangements into the water to improve the efficiency.

Bead pull methodon an open dielectric haloscope — Jacob Eggel for the MADMAX-Collaboration — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg

The Magnetized Disk and Mirror Axion Experiment is a dielectric haloscope that aims to search for axionic dark matter. It uses a stack of movable dielectric disks, called a booster, to enhance the weak axion signal. In order to calibrate the booster, the electromagnetic field inside the booster needs to be known. This is a difficult challenge as the complex design and open nature of the booster do not permit a simple mode analysis as in the traditional, closed cavity haloscopes. However, having an open and tunable setup also provides unique opportunities for additional measurements of the electromagnetic field of the booster. In this talk, I will present the first results of so-called bead pull measurements on a minimal dielectric haloscope and how they can be used to calibrate the setup.
Further dark matter searches using ALPS II’s TES detector of dielectric properties of sapphire (Al₂O₃), a candidate material for the dielectric mirror axion (MADMAX) experiment. Multiple dielectric disks will be used to ordinary matter, supposedly makes up from axion (ALP)-photon conversion with rates as low as $10^{-11}$ G eV$^{-1}$. To do this, a high-power laser will be directed through a strong magnetic field where some of the photons can convert into a beam of axion-like particles. After this, the beam will cross a light-tight barrier and another strong magnetic field where some of the axion-like particles can convert back into photons and be detected. During the first data acquisition, planned for early 2023, a HEterodyne (HE) interferometer will be used to detect the reconverted photons. This very sensitive interferometer can detect very weak signals at the exact signal frequency.

The HET principle and its implementation in ALPS II will be discussed in this talk.

### T 118: Dark Matter II

**Time:** Thursday 15:50–17:20

**Location:** POT/0006

The high resolution images uncover an abundance of microscopic “defects” but they do not show whether a found spot will enhance electron emission and thus the background signals in the TPC or not. To assess the defects’ nature we extended the set-up with an overview camera and a HV supply. An electrode wire in a gas may emit electrons, resulting in a corona discharge, which the overview camera records. We present the set-up and report on our progress of matching regions of corona discharges with defects uncovered in the high resolution scan.

**R&D of large-scale electrodes for future generation TPCs** — **VERA HIJO-SZE WU, ALEXEI ELYKOV, and FRANCESCO TOSCHI** — Karlsruhe Institute of Technology, Institute for Astroparticle Physics

The Dark matter WIMP search with liquid xenon (DARWIN) observatory is a future dark matter detector aiming at reaching the sensitivity for WIMPs at the neutrino floor and covering the mass range from 5 GeV/c² to above 10 TeV/c² [1]. The observatory uses the technology of a dual-phase time projection chamber (TPC) with a 40 t active volume of liquid xenon (LXe) [1].

The electrodes of the TPC are the vital components for 3D position reconstruction of the signal, benefiting the event selection processes. When designing the electrodes, we have to calculate and optimize the electrostatic. At the same time, the mechanical stability, the feasibility of manufacturing and treatment, as well as to minimize spark and electron emission has to be ensured. Here we present our investigations of hexagonal mesh electrodes, including mechanical stability, and handling as well as the first test of local high-voltage field emission. [1] J. Aalbers et al., J. Cosmol. Astropart. Phys., 11, 017 (2016)

**T 118.2** Thu 16:05 POT/0006

A high resolution scanning set-up for detector detection on electrodes — **ALEXANDER DEISING, JAN LOMMLER, SHU MITRA, UWE OBRELLA, FABIAN PIERMAIER, QUIRIN WEITZEL, and DANIEL WENZ** — Institut für Physik & Exzellenzzentrum PRISMA+, Universität Mainz — PRISMA Detector Laboratory, Universität Mainz

Achieving as low backgrounds as possible is key when operating time projection chambers (TPCs) for dark matter searches. One source of background signals is the charge that accumulates from the electrons inside the detector. For dual phase TPCs, similar to XENONnT, these electrodes are meshes or grids with wire diameters of 200 – 300 μm, operated at a high voltage (HV) > 1 kV. The scanning set-up at the PRISMA Detector Laboratory features a high resolution camera mounted to a gantry robot system. The camera’s resolution of 1.4 x 1.4 μm² provides detailed images of electrode wires. A 3D confocal microscope with a resolution better than 1 μm is used for studies on the μm scale. We will present results of mesh-scans.

**T 118.3** Thu 16:20 POT/0006

Understanding xenon scintillation properties — **ROBERT HAMMANN, DOMINIC CICHON, LUISA HÖTSCHE, FLOREAN JÖRG, TERESA MARRODÁN-UNDOAGOTA, and MONA PIOTTER** — Max-Planck-Institut für Kernphysik

Xenon in gaseous and liquid form is a commonly used detector target material for rare-event searches like the direct detection of dark matter. The material has a number of beneficial properties for this application, one being that it is an excellent scintillator. Most xenon-based detectors rely on measuring the scintillation light component emitted in the vacuum ultraviolet range, however, light is also emitted in a wide spectrum of longer wavelengths. Exploring this parameter space could enable the construction of even more sensitive detectors in the future.

In this contribution, we present first measurements with a dedicated setup to extend our knowledge of the scintillation response in gaseous xenon to infrared light, which is so far not exploited in the field. In order to assess the usefulness of this wavelength range for rare-event searches, it is essential to characterize its response. We report measurements of the scintillation light yield for varying levels of electromagnetic impurities and as a function of the xenon gas pressure.

**The CRESST-III Dark Matter Search: Status and Outlook** — **CHRISTIAN STRANDHAGEN** — CRESST-Collaboration — Eberhard-Karls-Universität Tübingen, 72076 Tübingen

The CRESST experiment (Cryogenic Rare Event Search with Superconducting Thermometers) operates an array of cryogenic detectors using different target materials in a well shielded setup at the LNGS (Laboratori Nazionali del Gran Sasso) underground laboratory in Italy to search for nuclear recoils induced by

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**T 117.3** Thu 16:20 POT/0036

Measurements of dielectric properties of single crystal sapphire (Al₂O₃) for the axion dark matter search experiment, MADMAX — **HAOTIAN WANG, ALEXANDER SCHMIDT, and ERODE OEZ** for the MADMAX-Collaboration — III. Physikalisches Institut A RWTH, Aachen, Germany

Axions are one of the candidates for cold dark matter and will be searched in the range of microwave frequencies from 10 to 100 GHz in the magnetized disk and mirror axion (MADMAX) experiment. Multiple dielectric disks will be used to amplify the signal. The dielectric properties, dielectric constant and loss tangent, of the disk materials affects the boost factor, so precise knowledge of them is crucial for the detection of axion. Here we present measurement results of dielectric properties of sapphire (Al₂O₃), a candidate material for the dielectric disks, at room temperature (295–297 K) and at 18 K. The measurements are done in the 10 to 40 GHz range using a microwave resonator.

**T 117.4** Thu 16:35 POT/0036

Further dark matter searches using ALPS II’s TES detector — **CHRISTINA SCHWEMMRAUER** for the ALPS-Collaboration — Deutsches Elektronen-Synchrotron, Hamburg, Germany

The elusive Dark Matter (DM), proposed due to its gravitational interaction with ordinary matter, supposedly makes up ~25% of our universe. Various models aim to explain the origin and properties of DM, many of these proposing beyond standard model particles to make up most of the DM in our universe. The ALPS II (Any Light Particle Search II) light shining-through-walls experiment will use Transition Edge Sensors (TESs) to detect low-energy single-photons originating from axion(ALP)-photon conversion with rates as low as $10^{-10}$ cps. Even beyond ALPS II, these superconducting microcalorimeters, operated at cryogenic temperatures, could help search for further particle-DM candidates. Much of the work to ensure the viability of the TES detector for use in ALPS II, such as calibrating the detector and mitigating external sources of backgrounds, also leads to the ability to utilize the TES for an independent direct-DM search. For this purpose, the superconducting sensor, sensitive to sub-eV energy deposits, can be used as a simultaneous target and sensor for DM-electron scattering for sub-MeV DM. Hence, direct DM searches with TES could explore parameter space as-of-yet inaccessible by nucleon-scattering experiments.

**T 117.5** Thu 16:50 POT/0036

Heterodyne detection of weak fields in ALPS II — **ISABELLA OCEANO** for the ALPS-Collaboration — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

The Any Light Particle Search II (ALPS II) is a Light Shining through a Wall experiment at DESY in Hamburg, which will hunt for axions and axion-like particles in the sub-meV mass range with an axion-photon-photon coupling $g_{a\gamma \gamma} > 2 \times 10^{-11}$ GeV$^{-1}$. To do this, a high-power laser will be directed through a strong magnetic field where some of the photons can convert into a beam of axion-like particles. After this, the beam will cross a light-tight barrier and another strong magnetic field where some of the axion-like particles can convert back into photons and be detected. During the first data acquisition, planned for early 2023, a HEterodyne (HE) interferometer will be used to detect the reconverted photons. This very sensitive interferometer can detect very weak signals at the exact signal frequency.

The HET principle and its implementation in ALPS II will be discussed in this talk.

**T 117.6** Thu 17:05 POT/0036

Impact of axion decay on the extragalactic background light — **SARA POR- RAS BEDMAR, MANUEL MEYER, and DIETER HORN** — Institut für Experimentalphysik, Universität Hamburg, Luruper Chaussee 149, D-22761 Hamburg

The Extragalactic Background Light (EBL) is an isotropic diffuse radiation field of extragalactic origin. Assuming that dark matter consists of axions with masses on the order of electron volts, we expect an additional contribution to the EBL due to their decay into two photons.

Here, we model the main light-emitting processes that constitute the EBL: stellar populations, intra-halo light, and dust. Utilizing the Starburst99 and SWIRE code libraries we create synthetic spectra to characterize the stellar components. Our model critically depends on structure formation and evolution, encoded in the star formation rate history, as well as star metallicity, and the distribution and composition of dust. We explore the dependencies of our model on these parameters, as measurements of these quantities are highly uncertain. In addition to these astrophysical EBL components, we include the contribution of decaying dark matter axions. Through a comparison of our model with the most recent direct and indirect EBL measurements, we are able to constrain the photon-axion coupling in the mass range from $0.1 – 10$ eV.

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scattering of dark matter particles in the detectors. With detection thresholds for nuclear recoils as low as 10 eV, CRESST is among the leading experiments in the search for low mass dark matter particles. The most recent measurement campaign, which started in summer 2020, was focused on investigating the origin of an unexplained event population at very low energies ("low energy excess") which is limiting the sensitivity of the experiment in the low mass region. We present the status of CRESST-III and report on observations of the low energy excess and dark matter results. Finally we show our plans for the coming years including the upgrade of the readout electronics.

T118.5 Thu 16:50 POT/0006
A low-threshold diamond cryogenic detector for sub-GeV Dark Matter searches — ANNA BERTOLINI, GODE ANGLÖHNER, ANTONIO BENTO, LU.CIA CANONICA, NAHUEL FERREIRO IACHELLINI, DOMINIK FUCHS, ABHITI GABRI, DIETER HAUFF, ATHON NILMA, MICHELE MANCUSO, FEDERICA PETRICCA, FRANZ PROBST, FRANCESCA PUCCI, AHMED ABDELHAMEED, ELIA BERTOLDI, and JOHANNES ROTH. — Max-Planck-Institut für Physik, München, Germany — LBPhys-USC, Departamento de Física, Universidade de Coimbra, Coimbra, Portugal — Instituto de Física de Altas Energias (IFAE), Barcelona Institute of Science and Technology (BIST), Bellaterra (Barcelona) — Phys-Department and Excellence Cluster Universe, Technische Universität München, D-85748 Garching, Germany

Recently the sub-GeV dark matter (DM) mass range has started to be probed. To explore this region, detectors with a low energy threshold are required. Recent developments in the production of diamond crystals allow for high-quality large-mass diamonds that can be used as DM detectors. Thanks to their superior cryogenic properties, diamond detectors can reach an energy threshold in the eV range. In this contribution the realization of the first low-threshold cryogenic detector that uses diamond as absorber for astroparticle physics applications will be reported. Two diamond samples instrumented with a W-TES have been tested, showing transitions at about 25 mK. The performance of the diamond detectors will be presented highlighting the best performing one, reaching an energy threshold of 16.8 eV.

T118.6 Thu 17:05 POT/0006
ELOISE - Reliable Background Simulation at Sub-keV Energies — HOLGER KLUCK. — Institut für Hochenergiephysik der Österreichischen Akademie der Wissenschaften, 1050 Wien, Österreich

CaWO₃ is a well-known target material for experiments searching for rare events like coherent elastic neutrino-nucleus scattering (CEvNS) with NUCLEUS or hypothetical dark matter-nucleus scattering with CRESST. Pushing the detection threshold down to sub-keV energies, experiments encounter new phenomena like an exponential rise of observed events towards lowest energies of yet unknown origin. This highlights the need for verified and reliable simulations of radioactive background components at sub-keV energies, e.g. based on the widely used Geant4 toolkit. The ELOISE project aims to tackle this issue for electromagnetic particle interactions in CaWO₃ in a two-stage approach: First by a systematic evaluation of the current accuracy by comparing benchmark simulations with data from extended literature research and dedicated measurements. Second, if needed, ELOISE intend to develop bespoke simulation code for CaWO₃ to improve the accuracy at the sub-keV energy regime. Currently, ELOISE conduct a dedicated measurement of electronic energy loss in CaWO₃ via ionization.

In this contribution, I will first motivate the problem and outline the scope of ELOISE. Afterwards, I will report first results of ELOISE’s reference measurements. Finally, I will discuss our preliminary findings and its implication for rare event searches with CaWO₃.

T119: Neutrino Astronomy IV

Time: Thursday 15:50–17:05

T119.1 Thu 15:50 POT/0112
Search for neutrinos from AGN using a machine-learning-based source selection — SEBASTIAN SCHINDLER for the IceCube-Collaboration — ECAP, Universität Erlangen-Nürnberg, Germany

The IceCube Neutrino Observatory is currently the world’s largest high-energy neutrino detector. After the detection of a diffuse astrophysical neutrino flux in 2013, one of the main goals has been to associate parts of this flux with specific source classes. A few "hot spots" at or above the three-sigma level have been found and associated with certain classes of Active Galactic Nuclei (AGN). Most recently, the Seyfert II galaxy NGC 1068 was associated with a neutrino flux at a significance of 4.2 σ, and there is growing evidence for a neutrino flux from blazars. However, the underlying physical processes of neutrino production remain poorly understood. One problem for neutrino-source searches comes from the use of historically-driven class definitions of AGN, which are based on specific spectral properties that are not necessarily optimal for the selection of potential neutrino sources.

This talk will motivate a study that aims to address this problem in two stages. The first stage will use multi-wavelength data to define a source selection using modern machine-learning approaches in a way that emphasizes intrinsic physical properties and mostly disregards the general AGN classification. This will allow to identify potential neutrino sources similar in physical properties to those associated with the currently detected "hot spots". The second part will perform a statistical analysis in the form of a correlation analysis, for example a stacking search, using these previously defined source selections.

T119.2 Thu 16:05 POT/0112
Searching for neutrino point-sources in the northern hemisphere with IceCube: recent results and outlook — ELENA MANAO, CHIARA BELLENGHI, MARTIN HA MINH, TOMAS KONTRMIS, and MARTIN WOLF for the IceCube-Collaboration — Technische Universität München

The IceCube Neutrino Observatory is a one cubic kilometer neutrino telescope deployed deep in the Antarctic ice at the South Pole. One of its main goals is to identify sources of the diffuse astrophysical neutrino flux, discovered by IceCube in 2013. In this talk we present the results of the search for neutrino point-sources in the northern hemisphere, which found evidence of astrophysical neutrino emission from the active galaxy NGC 1068 with a global significance of 4.2σ, and the prospects of an extension of this analysis with several additional years of data.

T119.3 Thu 16:20 POT/0112
Solving the multi-messenger puzzle of the AGN-starburst composite galaxy NGC 1068 5°× 5° — BOJEN EICHMANN, PETRENI OZKONOMOGLU, SELVIA SALVATORE, RALF JURGEN DEETZMAR, and JULIA BECKER. — 1Theoretical Physics IV, Ruhr University Bochum, Bochum, Germany — 2Institut für Physik, Norwegian University for Science and Technology (NTNU), Trondheim, Norway

Multi-wavelength observations indicate that some starburst galaxies show a dominant non-thermal contribution from their central region. These active galactic nuclei (AGN)-starburst composites are of special interest, as both phenomena on their own are potential sources of highly-energetic cosmic rays and associated gamma-ray and neutrino emission. In our work, a homogeneous, steady-state two-zone multi-messenger model of the non-thermal emission from the AGN corona as well as the circumnuclear starburst region is developed and subsequently applied to the case of NGC 1068, which has recently shown some first indications of high-energy neutrino emission. We show that the entire spectrum of multi-messenger data - from radio to gamma-rays including the neutrino constraint - can be described very well if both, starburst and AGN corona, are taken into account. Using only a single emission region is not sufficient. Supported by DFG (SFB|1491).

T119.4 Thu 16:35 POT/0112
Estimate of Galactic Neutrino emission — MOHAMED EBRAHIM MOGHADAM, KATHIRN EGBERTS, CONSTANTIN STEPPA, ROWAN BATZOFIN, and ELISA BERNARDINI. — 1University of Potsdam, Potsdam, Germany — 2University of Padova, Padova, Italy

The origin of high-energy cosmic rays is an enduring mystery in science. As cosmic rays propagate through the universe, they interact with the environment, which eventually produces high-energy neutrinos as well as gamma rays. High-energy Neutrinos are an ambiguous signal of hadronic interaction and, thus, provide valuable information about particle acceleration mechanisms and the origin of cosmic rays. On the other hand, identifying neutrino sources is a long-standing challenge. Exploiting the simultaneous production of neutrinos and gamma rays, neutrino sources are typically identified based on the temporal coincidence of variable emission of point-like objects. This has resulted in the detection of TXS 0506+056 as one extragalactic source for Neutrinos. However, from VHE gamma-ray observation, we know there is a population of Galactic sources, some of which are expected to produce neutrinos as well. In this contribution, we use simulations of the Galactic population of UHE VHE gamma-rays as input to estimate the Galactic neutrino flux. For this, a parametrization of the neutrino production for a given gamma-ray signal is used. We will present a galactic map of expected neutrino fluxes and will make a comparison with data.
Integration of the KM3NeT instrument response function with gammapy software — Mikhail Smirnov for the ANTARES-KM3NeT-ERLANGEN-Collaboration — Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Erlangen Centre for Astroparticle Physics, Erwin-Rommel-Straße 1, 91058 Erlangen, Germany

The instrument response function (IRF) contains all the necessary information about the physical properties of a neutrino telescope. It is an ideal tool for quick estimation of the sensitivity of the detector to an incoming neutrino flux from distant sources. Since a similar approach is used in gamma ray astronomy, both communities can benefit from using the same software tools and standards. Nowadays the gammapy python package is a standard tool used in the gamma ray community. Synergy between the KM3NeT-IRF and gammapy will allow us to use the power of this package and at the same time to push forward the developments of combined analyses in the context of open science. In gammapy, the IRF consists of four main data domains and it is a part of the DL3 format along with the event list. In order to make KM3NeT data compatible with gammapy, the km3irf python package is being developed. This contribution covers in detail the km3irf package and the compatibility of the km3net data with gammapy.

T 120.2.3 Thu 16:20 POT/0013 Searching for the Prompt Component of the Atmospheric Muon Flux — Pascal Gutjahr, Jean-Marco Alameddine, Mirco Hünnefeld, and Ludwig Neste for the IceCube-Collaboration — Astrophysical Physics WG Rhode, TU Dortmund University, Germany

The muon is connected to many challenges in current physics, such as the muon puzzle in cosmic-ray induced air showers. The prompt component of the atmospheric muon flux has not been measured with high significance, yet. Understanding and measuring the prompt muon flux could help to better understand these challenges and help to test hadronic interaction models.

Atmospheric muons stem from the decay of particles created in hadronic interactions and their flux can be divided into a conventional and a prompt component. In the conventional part, muons originate from the decay of long-lived particles, mainly pions and kaons. In the prompt part, muons are produced by the decay of short-lived mesons. They consist of charmed mesons, strange mesons and unflavored ones.

In this talk, the current state of the analysis, which aims to confirm the existence of the prompt muon flux with the IceCube detector, is presented. Previous analyses suffered from statistical and systematic uncertainties in Monte Carlo simulations. Thus, we evaluate and create a new set of Monte Carlo simulations specialized to measure the prompt component. Supported by BMBF (ErUM) and DFG (SFB 1491).

T 120.4 Thu 16:35 POT/0013 Sensitivity of IceCube-Gen2 for Cosmic-Ray Anisotropy Studies — Wenjie Hou for the IceCube-Gen2-Collaboration — Institute for Astroparticle Physics, Karlsruhe Institute of Technology (KIT)
Detector Design Update for the AFIS Satellite Mission — *Lisa Eckert*, Peter Hinderberger, Martin J. Losekamm, Stephan Paul, Thomas Pöschl, and Sebastian Röckner. The detector design is being improved to better perform and simplify production and calibration. Furthermore, the updated version will be used as part of the In-Orbit Verification Experiment 1 (IOV-1) on the International Space Station.


On the International Space Station (ISS), with operation expected to begin in March 2023, the RadMap Telescope will demonstrate new technologies for the characterization of the nuclear component of cosmic rays by measuring the radiation environment aboard the International Space Station (ISS). At the heart of the instrument is a tracking calorimeter made from scintillating-plastic fibers and silicon photomultipliers capable of recording particle-dependent energy spectra; several silicon-based dosimeters provide additional dosimetry information. The RadMap Telescope will be deployed to the ISS in March 2023, with operations expected to begin a few weeks later. In this contribution, we present the instrument design, its capabilities, and our plans for on-orbit operations that shall lead to a full validation of the central detector and its read-out electronics. Our work is funded by the German Research Foundation (DFG, project number 414049180) and under Germany’s Excellence Strategy - EXC2094 - 390783311.

Reconstruction of protons using H.E.S.S. — *Benedetta Bruno, Jonas Glogrimza, and Stefan Funk* for the H.E.S.S.-Collaboration. Imaging Atmospheric Cherenkov Telescopes (IACTs) like the High Energy Stereoscopic System (H.E.S.S.) observe extensive air showers initiated by gamma rays and cosmic rays (CRs) when interacting with the Earth’s atmosphere. IACTs image the distribution of Cherenkov light emitted by air shower particles as they propagate toward the Earth’s surface. The traditional reconstructions of the properties of the gamma rays rely on the Hillas parameterization, which reduces the measurement to a few characteristics using elliptical modeling of the image.

For the analysis of cosmic rays, which are usually considered background in gamma-ray astronomy, the reconstruction is more challenging. Since the development of hadronic-induced shower is subject to larger fluctuations, the detected IACT images feature deviations from the typical elliptical shape, making modifications necessary. In this contribution, we utilize H.E.S.S. simulations to investigate the reconstruction of protons using the Hillas parameterization. In addition, we discuss the potential to use deep-learning-based reconstruction techniques to overcome the limits of the Hillas approach and outline the potential of H.E.S.S. data to measure the CR spectrum.
taking. With stable running making comparisons possible, the calibration as well as efficiency studies are presented.

T 122.2 Thu 16:05 POT/0106
Anomaly detection for the level 1 trigger system of the CMS experiment — Sven Bollweg, Karim El Morabit, Lars Emmrich, Gregor Kasieczka, and Artur Lozánov — University of Hamburg, Germany

There exist strong hints for the existence of physics beyond the standard model (BSM). At the CMS experiment, the first event selection step is the Level 1 (L1) trigger system, which decides whether an event is stored for further analysis. Assuming that BSM events differ from standard model (SM) events, a trigger decision could then utilize this difference to detect anomalous event properties instead of being fully based on model specific criteria. This talk discusses such an anomaly detection trigger based on neural network. An autoencoder (AE) network is trained to reproduce typical collision events. It is found that the reconstruction quality of anomalous events, such as BSM events or rare SM events, is decreased. This decrease in reproduction quality can then be used as a basis for the trigger decision. Since the L1 trigger has a very limited time for the decision, the AE needs to be deployed on dedicated hardware in the form of field programmable gate arrays which presents additional challenges.

T 122.3 Thu 16:20 POT/0106
Online Track Reconstruction for the Mu3e Experiment — Haris Avdaiapan Morragan for the Mu3e-Collaboration — Institute of Nuclear Physics, Johannes Gutenberg University of Mainz, Germany

The Mu3e experiment aims to observe or exclude the rare decay of a positive muon into two positrons and an electron. Such an observation would be a violation of charged lepton flavour conservation and thus a clear signal of new physics. In the first phase, it will observe 10^8 muon decays per second using a thin pixel detector complemented by scintillating timing detectors. The data rate from the detector subsystems is estimated at about 100 Gbps and is mostly comprised of background processes from other decay channels of the muon. To store the data for physics analysis, it needs to be reduced by a factor of 100. This can be achieved by selecting the potential signal events through online track and vertex reconstruction on graphics processing units (GPUs). The talk discusses the algorithm employed on the GPUs and the achieved performance.

T 122.4 Thu 16:35 POT/0106
Dilepton trigger selections for Run 3 at the LHCb Experiment — Johannes Albrecht, James Gooding, and Biljana Mitreska — TU Dortmund University, Dortmund, Germany

Lepton flavour-violating processes in B decays are amongst the key curiosities studied at the LHCb Experiment. Measurements of such processes rely on high-quality selection of leptons, in particular of lepton pairs arising from B decays. These selections typically rely on cuts to essential kinematic and topological variables. During the LHC Run 3 data-taking period, the LHCb Experiment will receive collisions at a rate of 30 MHz. The full detector readout at this rate produces 5 TB/s of data, though only 10 GB/s can be recorded. To reduce the amount of data recorded, LHCb will employ an entirely software-based trigger system to select events in real time. Within this framework, an inclusive cut-based trigger is being developed to select dilepton events (i.e. events containing a lepton pair).

In this talk, the status of the inclusive cut-based dilepton trigger is presented, and its performance is evaluated within the context of the Run 3 LHCb trigger system.

T 123: Pixel/Belle II, Si/Other

Time: Thursday 15:50 – 17:20

Location: WIL/A317

T 123.1 Thu 15:50 WIL/A317
Investigation of high backside currents in DEPFET pixel sensors for the Belle II experiment using dedicated test structures — Florian Bernlochner, Jochen Dingfelder, Georgios Giakoustitis, and Botho Paschen — University of Bonn, Germany

For the Belle II experiment at KEK (Tsukuba, Japan) the KEK accelerator was upgraded to deliver e^+e^- collisions at a center-of-mass energy of E_{CM} = 10.58 GeV with an instantaneous luminosity of up to 8 · 10^35 cm^-2s^-1. As the innermost part of the Belle II detector, the PiXe Detector (PXD), based on DEpFET pixels, is the first detector to be exposed to radiation from the accelerator. An unexpected steady increase of backside current with time and thus accumulated irradiation dose was observed in several modules during operation. Dope profile measurements and electronic field simulations show that this is a consequence of (partially) shorted guard rings at the backside leading to high electric fields and avalanche current multiplication. Irradiation results of dedicated test structures to further investigate the mechanism will be presented.

T 123.2 Thu 16:05 WIL/A317
Development of the BDAQ-PXD laboratory readout system for the characterization of DEPFET pixel modules — Patrick Ahlburg, Florian Bernlochner, Jochen Dingfelder, Tomasz Hemperek, Hans Krüger, Botho Paschen, and Janess Schmitz for the Belle II Collaboration — University of Bonn, Germany

The DEPFET Pixel Detector (PXD) is successfully operated in the innermost layers of the Belle II experiment at the SuperKEKB e^+e^- collider in Japan. The PXD data acquisition is optimized for the requirements of the full-scale pixel detector in Belle II. In this talk, the development of a laboratory readout system (BDAQ-PXD) for single PXD modules is presented. BDAQ-PXD provides a simple, flexible and expandable readout for measurements in laboratory, irradiation and test-beam environments. It thus facilitates studies to gain further insights into the behavior of the pixel detector modules and the DEPFET technology. The setup of the system and measurements for the characterization of PXD modules under laboratory conditions are presented in this talk.

T 123.3 Thu 16:20 WIL/A317
Simulation of power lines for the Investigation of the Emergency Shutdown system of the DEPFET pixel detector — Paula Scholz, Florian Bernlochner, Jochen Dingfelder, Hans Krüger, Botho Paschen, Matthias Hoier, Jannes Schmitz, and Patrick Ahlburg for the Belle II Collaboration — 1University of Bonn, Germany — 2Institut für Kernphysik (IFK), Mainz, Germany

The Belle II Pixel Detector (PXD) is based on DEpFET pixels. To control the sensors, voltage levels have to be switched by 20 V within a few nanoseconds per readout cycle (50 kHz). The voltage switching is implemented in Application Specific Integrated Circuits (ASICs), the so-called switches, on the detector modules. These switches have been observed to be vulnerable to sudden irradiation bursts, which can occur during beam loss events in the SuperKEKB accelerator. To safeguard the modules from damage caused by beam loss events, the modules have to be switched off as fast as possible when a loss of beam control is imminent. Several beam monitoring systems are employed in the experiment to detect these situations. On PXD hardware side it is investigated how the vulnerable channels can be switched off fast and securely. Therefore, an electronics circuit simulation of the complex PXD power system is being set up to understand the limitations and conduct studies of possible hardware modifications. This talk will concentrate on the necessary steps for creating such a simulation.

T 123.4 Thu 16:35 WIL/A317
Investigation of high resistivity p-type FZ silicon diodes after γ-ray irradiation — Chuan Liao, Eckhart Fretwurst, Erik Gaburtti, Jörgen Schwandt, Anja Hemmerlich, Yana Gurumskaya, Michael Möll, and Ioana Pintilie — 1Institute of Experimental Physics University of Hamburg, Hamburg, Germany — 2European Organization for Nuclear Research (CERN), Geneva, Switzerland — 3National Institute of Materials Physics, Bucharest, Romania

In this work, the macroscopic (I-V, C-V, G) and microscopic Thermally Stimulated Current (TSC) measurements were used to investigate the radiation effects in high resistivity p-type FZ silicon diodes induced by γ-rays with dose values between 1×10^4 and 2×10^6 Gy. Two different types of diodes were manufactured — either p-stop or p-spray isolation between the pad and the guard ring. The leakage current density development with dose was investigated and compared to standard float zone (FZ) n-type diodes. Frequency dependence of capacitance-voltage characteristics was only observed for p-stop diodes and showed a strong dose dependence. In the microscopic measurements, the development of radiation-induced defects (R1, R2, C1, C2, VO, LI) with dose will be presented. To understand the thermal stability of these defects, isochronal annealing experiments from 80 °C up to 300 °C for 15 min were performed. The corresponding macroscopic and microscopic measurements will be presented and discussed.
T 123.6 Thu 17:05 WIL/A317
Angle-selective electron detection with a silicon-based active Transverse Energy Filter (aTEF) — KEVIN GAUDA1,4, SONJA SCHNEIDERWIND1,4, KYRILL BLUMER1, CHRISTIAN GÖNNER1, VOLKER HANNEN1, HANS-WEINER ORTJOHANN1,4, WOLFRAM PERNICE2,3, LUKAS PÖLLITSCHE1,4, RICHARD WILHELM JULIUS SALOMON1,4, MAIK STAPPERS1, and CHRISTIAN WEINHEIM1,4 — 1 Institute for Nuclear Physics, University of Münster — 2CeNTECH and Physics Institute, University of Münster — 3Kirchhoff-Institute for Physics, University of Heidelberg — 4KATRIN Collaboration

The active Transverse Energy Filter (aTEF) is a concept to discriminate electrons in a large magnetic field based on their pitch angle (EPI-C 82, 922 (2022)). It is investigated as a background reduction measure in the KATRIN experiment, where low-energy electrons from ionisation of atoms in highly excited (Rydberg or autounionising) states within the spectrometer impede the design sensitivity of 4.2 eV/c (50 C.L.). These electrons are practically indistinguishable from desired tritium beta electrons via kinetic energy, while their pitch angle distribution differs significantly. The aTEF for KATRIN may be realized as a microstructured detector – e.g., based on Si-PIN diodes – tailored to exclusively detect electrons with large pitch angles. Fabrication of prototypes is carried out via semiconductor processing technologies, for instance deep inductively coupled plasma etch (ICP-RIE). Production and performance of aTEF prototypes will be presented.

The work of the speaker for KATRIN is supported by BMBF under contract number 05A20PMA.

T 124: Si-Strip/CMS, Pixel/DMAPS

Time: Thursday 15:50-17:20

T 124.1 Thu 15:50 WIL/A214
Performance of the latest Service Hybrid prototypes for CMS silicon strip modules — CHRISTIAN Dziwok1, LUTZ FELD1, KATJA KLEIN1, MARTIN LIPINSKI1, DANIEL LOUIS1, ALEXANDER PAUL1, OLIVER POOTH1, NICOLAS RÖWERT1, FELIX THURN1, MICHAEL WLOCHAL1, and TIM ZIEMONS1 — 1Physikalisches Institut B, RWTH Aachen University, Aachen, Germany

The CMS Collaboration is developing silicon strip modules for the second phase of the CMS tracker upgrade. This upgrade will enable the CMS experiment to utilize the high luminosity provided by the future HL-LHC. The modules’ Service Hybrids are responsible for the sensor bias voltage and low voltage distribution on the module and the data transmission via optical links to the back-end electronics. For the first time, final versions of the latest developed ASICs were assembled and tested on Service Hybrid prototypes with materials and geometries as foreseen in the detector. The measurements were performed with setups similar to the foreseen production test system. The gained experience is crucial for the design validation and in taking the final choices in the design process before series production.

T 124.2 Thu 16:05 WIL/A214
Influence of High-Frequency Magnetic Fields on the Noise Behavior of CMS 2S Module Prototypes — CHRISTIAN Dziwok1, LUTZ FELD1, KATJA KLEIN1, MARTIN LIPINSKI1, ALEXANDER PAUL1, OLIVER POOTH1, and NICOLAS RÖWERT1 — 1Physikalisch-Institut B, RWTH Aachen University, Aachen, Germany

For the CMS tracker Phase-2 upgrade new modules with silicon strip sensors are being developed. Each module features a Service Hybrid (SEH), which is responsible for the distribution of low voltages to the module components using a two-stage DC-DC conversion scheme. For modules equipped with the latest generation of SEHs an increase in module noise has been observed. A setup for inducing radiative noise with external magnetic fields that are frequency- and location-dependent is presented. Measurements carried out on modules from different prototyping phases show that the sensitivity is similar across generations, which indicates that radiative coupling into the sensor or readout electronics is not responsible for the observed noise increase.

T 124.3 Thu 16:20 WIL/A214
Systematic tests of the testing infrastructure for CMS Outer Tracker Service Hybrids — CHRISTIAN Dziwok1, LUTZ FELD1, KATJA KLEIN1, MARTIN LIPINSKI1, DANIEL LOUIS1, ALEXANDER PAUL1, OLIVER POOTH1, NICOLAS RÖWERT1, FELIX THURN1, MICHAEL WLOCHAL1, and TIM ZIEMONS1 — 1Physikalisch-Institut B, RWTH Aachen University, Aachen, Germany

The CMS Collaboration is developing so-called 2S modules for the Phase-2 upgrade of the CMS tracker. This upgrade will enable the CMS experiment to utilize the high luminosity provided by the future HL-LHC. A 2S module consists of two silicon strip sensors, two support bridges and three electronics hybrids. One of these hybrids is the Service Hybrid (SEH), which supplies the power to all other parts of the module, aggregates the data lines from both sides of the module and is responsible for the data transmission via optical links to the back-end of the detector. During the production roughly 20,000 SEHs will undergo a rigorous quality control procedure. The test card for testing the functionality of the SEH is developed by RWTH Aachen and around 100 test cards were manufactured. These will be distributed to the manufacturer and collaborating institutes of the SEHs. Before that they have been tested and the statistical fluctuations of the measurements have been analyzed. A crate with several test cards was set up in a climatic chamber and the whole testing procedure including thermal cycling was exercised. Selected results from the commissioning and quality control of the test cards are presented.

T 124.4 Thu 16:35 WIL/A214
Characterization of TJ-Monopix2 - A depleted monolithic active pixel sensor with column drain readout architecture — CHRISTIAN BESPIN1, JAN GACEDO1, Jochen DINGELOED2, TOKO HIRONO2, HANS KÜGER1, KONSTANTINOS MOUSTAKAS3, and NORBERT WEBER4 — 1Universität Bonn, Bonn, Deutschland — 2DESY, Hamburg, Deutschland — 3Paul Scherrer Institut, Villigen, Schweiz

The increasing availability of commercial CMOS processes with high-resistivity wafers has fueled the R&D of depleted monolithic active pixel sensors (DMAPS) for usage in high energy physics experiments. One of these developments is a series of monolithic pixel detectors with column-drain readout architecture and small collection electrode facilitating low-power designs: the TJ-Monopix series. The latest iteration TJ-Monopix2 is designed in a 180 nm TOWERJAZ CMS process and features a pixel size of 33 um x 33 um. Results from laboratory measurements and test beam campaigns demonstrating threshold and noise performance as well as hit efficiency measurements will be presented to discuss the suitability of TJ-Monopix2 for use in high-radiation environments.

T 124.5 Thu 16:50 WIL/A214
Characterisation of a DMAPS prototype for BELLE II a proposed Vertex Detector Upgrade — MARIE SCHWICCARD2, BENJAMIN SCHWENKE1, ARIANE FREY1, VANNIE BUCH1, MAXIMILIAN BAREL2, Bernhard Pilse1, Patrick Sieberer2, Christian Riemler1, and Jérôme Buadot1 — 1Georg-August-Universität Göttingen, Deutschland — 2HEPHY, Wien, Österreich — 1IPHC, Straßburg, France

The SuperKEKB collider in Japan is an asymmetric electron-positron collider at a center-of-mass energy of 10.58 GeV. A world record peak luminosity of 4.2 eV cm⁻² s⁻¹ was achieved during the last run period in July 2022. The peak luminosity is planned to be ramped up incrementally to the design value of 6.5 eV cm⁻² s⁻¹. During the long shutdown tentatively scheduled for 2026/2027 an upgrade for the vertex detector is planned, to improve the detectors performance, robustness against beam-induced backgrounds and simplify servicing the system. Proposed is a fully pixelized 5 layer vertex detector (VXD) concept, based on the CMS-DMAPS technology. The proposed chip is named OBELEX and is a further development based of the TJ-MONOPIX2 produced in the Tower 180 nm process, as a replacement of the current pixel-and-strip vertex detector concept.

To ensure the design specification for the OBELEX chip are met, the predecessors TJ-MONOPIX2 was characterised in laboratory measurements and during a beam test at DESY in June 2022. The results obtained from these measurements are implemented in simulations in the Belle II Analysis Framework for more realistic performance studies.
T 124.6 Thu 17:05 WIL/A124

Test-beam campaign and characterization of irradiated depleted monolithic active pixel sensors (DMAPS) designed in 150nm CMOS technology — • LARS SCHALL1, CHRISTIAN BESPIN1, JIAN CAICEDO1, JOCHEN DINGFELDER2, TOMASZ HEMPERLE1, TOSO HRONO1, FABIAN HÜGGING1, HANS KRÜGER1, PIOTR RYMASZEWSKI1, TIANYANG WANG1, and NORBERT WIERME1 — University of Bonn, Germany — DiCrisl, Switzerland — 2Zhangjiang National Lab, China

Monolithic active pixel sensors with depleted substrates are a promising option for pixel tracking detectors in high-radiation environments. The use of a highly resistive silicon substrate and short drift paths enhance the radiation tolerance, while a careful guard ring design facilitates high biasing voltages to deplete the sensor.

T 125: Calorimeter / Detector Systems V

Time: Thursday 15:50–17:20

T 125.1 Thu 15:50 WIL/C133

Development of a SplitCAL Prototype — • MATEI CLIMESCU and RAINE WANKE — Johannes Gutenberg Universität Mainz

The SplitCAL is a mixed electromagnetic calorimeter designed to provide both energy reconstruction through layers of scintillating stripes read out by wave-length shifting fibres and shower direction information through high-precision layers. This can be used for fixed target experiments which require high geometrical precision (such as SHiP@ECN3 or SHADOW@ECN3). The development needs to account for low rates but a large dynamic range. The status of the detector prototype as well as the readout electronics will be presented.

T 125.2 Thu 16:05 WIL/C133

A pointing Calorimeter for the SHADOWS Experiment — • SEBASTIAN RITTER for the SHADOWS-Collaboration — Universität Mainz

The SHADOWS experiment is a proposed off-axis beam dump experiment on the 400 GeV/c proton beam from the CERN SPS aiming to measure the decay of Hidden Sector particles. To reconstruct particles that only decay into photons, the photon energies, and directions need to be measured. In this talk, a highly granular plastic scintillator-based electromagnetic calorimeter is presented, which aims to provide the necessary energy and pointing resolution to achieve this task in SHADOWS.

T 125.3 Thu 16:20 WIL/C133

Multi-layer tile modules test system using cosmic ray for the CMS HGCAL upgrade — • JIA-HAO LI — Deutsches Elektronen-Synchrotron (DESY), Notkestr. 85, 22607 Hamburg, Germany

The CMS experiment plans to upgrade its calorimeter endcap for the high luminosity phase of the LHC with the High Granularity Calorimeter (HGCAL). The hadronic calorimeter (CE-H) part of the HGCAL in the lower radiation dose region is composed of scintillator-base tile modules using the SiPM-on-tile technology for particle detection. The tile module is equipped with HGCROC ASIC for data readout. The fast command and slow control signals from the counting room are also received by the HGCROC. To test and calibrate the tile modules, a cosmic ray measuring test with multi-layer tile modules parallel to each other is set up for quality control and a better understanding of the property and capability of the tile module. The presentation will discuss the idea and current status of the cosmic test setup at DESY.

T 125.4 Thu 16:35 WIL/C133

Testbeam Measurements with a Liquid Scintillator Detector Prototype for the SHIP Surrounding Background Tagger — • ANNIKA HOLLNAGEL for the SHIP-SBT-Collaboration — JGU Mainz

By introducing a segmented geometry, Liquid Scintillator [LS] detectors are able to offer a combination of large geometrical coverage and good spatial resolution. This approach can be employed to create a new generation of high-resolution particle detectors or to improve the performance of large-volume detectors commonly used in neutrino and low-background experiments.

As a frontrunner proposal of the CERN Physics Beyond Colliders initiative, SHIP aims to exploit the full potential of a future SPS Beam-Dump Facility and combine the Search for Hidden Particles [SHIP] with tau neutrino physics. The Hidden Sector detector of SHIP will consist of a large evacuated volume followed by magnetic spectrometer and Particle Identification system. To enable studying the decays of Feebly-Interacting Particles, the reduction of beam-induced background heavily relies on the Surrounding Background Tagger [SBT] enveloping the 50m-long decay vessel. Current baseline for the SBT is a segmented LS detector that is instrumented with Wavelength-Shift Optical Modules [WOM] and read out via SiPMs.

With focus on its experiment control system. The control system is used to remotely operate the motion stages and power supplies of the telescope, and to monitor the environmental conditions. The focus of the talk will be on the development of the controlling software implemented in WinCCOA and its communication to the hardware.

T 125.5 Thu 16:50 WIL/C133

Development of the experiment control system for the Timepix4 telescope — • JOHANNES ALBRECHT1, ELENA DALL’OCCO1, and DAVID ROLLS21 — 1TU Dortmund University, Dortmund, Germany — 2CERN, Geneva, Switzerland

Future high-energy physics experiments will require a very precise timing measurement, on top of a good spatial resolution. A precise timing will allow to only reconstruct tracks in space, but also to separate them in time; this in turn allows for densely packed, almost simultaneous collisions to be reconstructed with high precision. The Timepix4 telescope is designed to be a first demonstrator of track reconstruction in four dimensions, as well as a system to probe and characterise next generation detectors in terms of spatial and time capabilities. The final version of the telescope aims to have a pointing resolution below 2 µm in space and around 30 ps in time. To achieve this, the telescope is built up from eight silicon sensors of 100 µm and 300 µm thickness, bump bonded to the newest generation of Timepix4 ASICs.

This talk will give a brief overview of the Timepix4 telescopes design, and then focus on its experiment control system. The control system is used to remotely operate the motion stages and power supplies of the telescope, and to monitor the environmental conditions. The focus of the talk will be on the development of the controlling software implemented in WinCCOA and its communication to the hardware.

T 125.6 Thu 17:05 WIL/C133

Upgrading the Cosmic Ray Facility for Tests Regarding the Phase-II Upgrade of the ATLAS Muon Spectrometer — • FLORIAN EGLI1, OTMAR BIEBEL1, HENK BOTERENBROOD2, VALERIO D’AMICO1, STEFFANIE GÖTZ2, RALF HERTENBERGEN1, CHRISTOPF JAGELD1, ESHITA KUMAR1, KATRIN PENZ1, MAXIMILIAN RINNAGEL1, NICK SCHNEIDERS1, CHRISTOSSTOMOS VALDERANIS1, and FARIBAN VOGEL2 — 1LMU München — 2Nikhef, Amsterdam

The Phase-II Upgrade of the ATLAS Muon Spectrometer for the High Luminosity LHC (HL-LHC) includes the installation of a new and more efficient trigger and readout system for the Monitored Drift Tube (MDT) chambers. It is crucial that the Phase-II Upgrade can be tested on an MDT chamber outside of ATLAS, to detect errors and verify possible solutions, independent of the upgrade operations at CERN. The Cosmic Ray Facility in Garching could provide an ideal testsite, as it consists of two fully functional MDT chambers. However, its readout electronics and infrastructure are not compatible with the Phase-II Upgrade. As a first step, the infrastructure and electronics in the Cosmic Ray Facility are upgraded to the Phase-I standard of the ATLAS Muon Spectrometer. This includes the setup of a FELIX based readout system, which is compatible with both the Phase-I and the Phase-II electronics. Furthermore, new scintillators are installed on the top and on the bottom of the setup, in parallel to the MDTs, to allow preliminary tests of a path-based trigger. In this talk the current status of the project and first results are presented.

LF-Monopix2 is the latest prototype of a DMAPS development in 150 nm CMOS technology. It features a fully functional column-drain readout architecture in a 2x1 cm² matrix. A reduced pixel pitch of 50x150 µm² compared to its predecessor results in a smaller detector capacitance and an improved spatial resolution. Each pixel’s digital electronics are integrated within the large collection electrode.

LF-Monopix2 chips thinned down to 100 µm have been tested and found to work successfully after being irradiated to 1e15 neq/cm². In this talk, results from recent characterization measurements and test-beam campaigns are shown. Focus is put on measurements with irradiated sensors and the comparison to unirradiated sensors.
T 126: Gas-Detectors, Detector Systems

T 126.1 Thu 15:50 WIL/A120
Measurement Analysis of Micromegas detectors — Eshita Kumar, Otmar Biebel, Valerio D’Amico, Florian Egli, Stefanie Götz, Ralf Hertenberger, Christoph Jagfeld, Katrin Penski, Maximilian Rinnagel, Nick Schneider, Chrystosomos Valderanis, and Fabian Vogel — LMU München

MICRO MEh GASEous Structure (Micromegas) detectors are micro patterned gaseous detectors that have high rate capability due to the fast evacuation of positive ions and excellent spatial resolution due to a small scale readout strip pitch. These detectors are used for the track reconstruction of ionizing particles. To test the performance and resilience of such detectors under high background, multiple detectors are irradiated by a 10 GeV Ameicium-Beryllium neutron source: measurements with different shielding materials of varying thicknesses placed in front of the source are used to disentangle the detector response for gamma and neutron radiation. A Geant4 simulation to determine the interaction probability from the background radiation is carried out. Comparison of the analysis of the detector output to the simulation results for the final charge obtained from the gammas and the neutrons will be shown.

T 126.2 Thu 16:05 WIL/A120
Development of a Segmented GEM Readout (SGR) Detector — Christoph Jagfeld, Otmar Biebel, Valerio D’Amico, Stefanie Götz, Ralf Hertenberger, Katrin Penski, Maximilian Rinnagel, Chrystosomos Valderanis, and Fabian Vogel — LMU München

In Micromegas detectors the primary charges are amplified by electron avalanches between a planar anode and a mesh in 120 μm distance. For resistive Micromegas detectors the signal is read out via readout strips below the anode. A 2D position is reconstructed using two perpendicular readout strip layers below the resistive anode structure. Using a standard 2D resistive Micromegas readout structure, a unique 2D particle position reconstruction is possible if the detector is hit by one particle at the same time. Ambiguities occur if multiple particles arrive at the same time. A unique X-Y assignment is not possible. This issue can be solved by replacing the mesh with a GEM foil, which is segmented into 0.5 mm wide strips on both sides. The GEM strips must be turned by 45° with respect to the Micromegas readout strips. Thus the detector has four readout strip directions (X, Y, U, V). A prototype of such a Segmented GEM Readout detector is built with GEM strips and readout strips perpendicular to each other. Test beam measurements with this detector were performed using 120 GeV muons. The GEM and Micromegas strips show a similar pulse height. For perpendicular incident particles a position reconstruction efficiency better than 90% is reached on both the GEM- and the readout strips. A resolution better than 80 μm for the GEM and readout strips is achieved.

T 126.3 Thu 16:20 WIL/A120
Efficiency and time resolution of a large-size WOM-SiPM-based liquid-scintillator detector — Alessia Brigogli for the SHiP-SBT-Collaboration — Humboldt Universität zu Berlin

Within the BMBF-funded generic R&D consortium High-D, a multi-cell large area liquid-scintillator detector, where each cell is equipped with two wavelength-shifting optical modules (WOMs) viewed by a ring-array of silicon photomultipliers (SiPMs) is being developed. The aim is to reconstruct particles crossing the detector using the time and light-yield response. Such a detector type has been proposed for the Surround Background Tagger for the SHiP experiment proposal at the CERN SPS. In a first step, we are studying the characteristics of a one-cell detector using data taken during a testbeam campaign in October 2022 with a positron beam at the DESY testbeam facility in Hamburg. We will present results on the detector cell efficiency as well as on the time resolution of the detector as function of particle beam position at the detector cell.

We acknowledge the support from BMBF via the High-D consortium.

T 126.4 Thu 16:35 WIL/A120
Readout of Wavelength-shifting Optical Modules for the SHiP-SBT — Johannes Alt for the SHiP-SBT Collaboration — Albert-Ludwigs-Universität Freiburg

Wavelength-shifting optical modules (WOMs) are a low-cost way to capture the scintillation light produced in a liquid scintillator volume. These WOM tubes connected to Silicon Photomultipliers are proposed to be used in the large area Surrounding Background Tagger (SBT) of the proposed general-purpose Search for Hidden Particles (SHIP) experiment. In this talk, the current status of the research and development on the WOM readout will be presented. This work is funded by BMBF.

T 126.5 Thu 16:50 WIL/A120
Photon exit angles of Wavelength-Shifting Optical Modules for the SHiP-SBT — Florian Rehrein for the SHiP-SBT Collaboration — RWTH Aachen University

This contribution will present simulations of the photon exit angle distributions of a Wavelength-Shifting Optical Module (WOM) for the SHiP experiment. These simulations are compared to first measurements taken with a DSLR camera on a laboratory test stand.

WOMs present a novel optical sensor for numerous applications, combining a well-designed light guide with a wavelength-shifting coating. They will be used as an integral part of the Surrounding Background Tagger (SBT) in SHiP (Search for Hidden Particles), a proposed general-purpose fixed target experiment at the SPS accelerator of the CERN facility. The SBT acts as a discriminator against external particle interactions and is composed of many cells utilizing liquid scintillator and tube-shaped WOMs made of PMMA to detect traversing particles. The coating of the WOMs absorbs the scintillation photons and re-emits wavelength-shifted photons, which are then detected by an array of SiPMs coupled to one end of the WOM.

T 126.6 Thu 17:05 WIL/A120
Reflective Coating for the SHiP Surround Background Tagger — Patrick Deucher for the SHiP-SBT Collaboration — Johannes Gutenberg Universität Mainz

The Surrounding Background Tagger (SBT) is a liquid scintillator-based detector in the SHiP Experiment. Divided into segments and embedded into the Corten steel structure of the Hidden Sector decay vessel, the SBT’s main task will be the discrimination against beam-induced backgrounds. The efficiency of such a detector type can be increased by optimizing the light detection equipment, lowering the attenuation length of the scintillator (purification and addition of different fluorophores) and increasing the reflectivity of the inner detector walls. Following results of Photon Transport Simulations the application of diffuse and highly reflective Bariumsulfate-based (OPRC by Berghof®Fluoroplastic®Technology®GmbH) coating to the inner detector walls is studied. After extensive reflectivity-, stability- and compatibility tests the reflective coating was applied to the SBT test cell for the test beam 2022 at the DESY facilities. This talk will discuss results of a first large scale application of the reflective coating in a liquid-scintillator detector cell.

T 127: Exp. Methods III

Time: Thursday 15:50–17:05

T 127.1 Thu 15:50 WIL/C129
A General Track Fit based on Hit Triplets — Mohd. Talha and André Schönig for the ATLAS-Collaboration — Physikalische Institute, Universität Heidelberg

Modern particle physics experiments often deal with high particle rates and therefore use silicon detectors for particle tracking. High hit occupancies, together with a relatively large amount of material in the tracking layers, pose a big challenge for track reconstruction. For the High Luminosity ATLAS upgrade, it is planned to perform a full reconstruction of ~5000 tracks per event at the ATLAS Event Filter with a rate of about 100 kHz. The tracking algorithm has to run on commercial hardware. One option considered by our group is the implementation of a parallelizable track reconstruction algorithm on a farm of GPUs. The algorithm of choice is a general broken line fit based on hit triplets that was originally developed for applications with dominating multiple scattering uncertainties [N. Berger et al., JINST 9 P07007 (2014)] and has also been extended to include hit uncertainties. The latter is crucial for the reconstruction of high momentum tracks. After motivating hit triplets as basic tracking elements for a general broken line fit, the general solution for a track fit of three hits (triplet) in a solenoidal magnetic field will be presented and discussed.
Matrix inversion in the context of a novel track reconstruction algorithm for the ATLAS Event Filter — Antara Paul1,2 and Andre Schoning2 for the ATLAS Collaboration — 1Physikalisches Institut, Universität Heidelberg, Germany — 2Physikalisches Institut, Universität Heidelberg, Germany

The High Luminosity LHC project is expected to provide a tenfold increase of the integrated luminosity compared to the LHC. To cope with the resulting high pile-up from proton-proton collisions, the ATLAS detector, and its trigger and DAQ systems are undergoing major upgrades. As a part of the upgrade of the online event filter, a fast triplet track reconstruction algorithm is being developed based on a broken line fit. The track parameters are estimated by minimizing a $\chi^2$ function, which includes the multiple scattering and spatial hit uncertainties at each layer. This minimization involves the inversion of a matrix.

In this context, the talk focuses on different algorithms of matrix inversion, including but not limited to LDL$^T$ decomposition and the partition method. The speed and accuracy of each method will be presented and compared, in view of their implementation in the track reconstruction algorithm.

Navigation and track parameter transport using a heterogeneous code design for GPUs and CPUs within the ACTS R&D project — Andreas Salzburger1, Joana Niemann1,2, Beomki Yeo3,4, Stephen Swatman1,3, Attila Krasznahorkay5, and Stan Lat6 — CERN — II. Physikalisches Institut, Georg-August-Universität Göttingen — 3Department of Physics, University of California — 4Lawrence Berkeley National Laboratory — 5University of Amsterdam

With the upcoming high luminosity era of the LHC, track reconstruction, in particular, will suffer from drastically increasing combinatorics. A promising perspective to meet these rising computing demands is the deployment of hardware accelerators which offer massive parallelism, like GPGPUs. Current state-of-the-art implementations of pattern recognition algorithms in track reconstruction are problematic to adapt to accelerator hardware architectures in several ways. For example, runtime-polymorphic geometry classes and pointer based data structures are commonly difficult to move to an accelerator device.

Within the ACTS parallelization R&D project, research is on-going to adapt a complete track reconstruction chain, from clustering to track fitting, to run efficiently on GPUs. We show the implementation and performance of a core component of this chain: the propagation of track parameters and their associated covariances through an inhomogeneous magnetic field (coffie library), altogether with the application of material effects. The implementation is part of the detray library and makes use of its geometry description and navigation.

Neural networks for cosmic ray simulations — Pranav Sampath Kumar1,2, Tanguy Pieroc1, and Antonio Augusto Alves Junior3 — 1Institute for Astroparticle Physics (IAP), KIT, Germany — 2Brazilian Synchrotron Light Laboratory (LNLS), CNPEM, Brazil

Simulating cosmic ray showers at high energies is memory and time intensive. Apart from the traditional methods such as thinning and cascade equations, novel methods are needed for the modern needs in astroparticle physics.

A hybrid model of generating cosmic ray showers based on neural networks is presented. We show that the neural network learns the solution to the governing cascade equation in one dimension. We then use the neural network to generate the energy spectra at every height slice. Pitfalls of training to generate a single height slice is discussed, and we present a sequential model which can generate the entire shower from an initial spectrum. Errors associated with the model and the potential to generate the full three dimensional distribution of the shower and detector footprints are discussed.

Transformer-Based Eventwise Reconstruction of Cosmic-Ray Masses at the Pierre Auger Observatory — Martin Erdmann1, Nikolaus Langner, and Dominik Steinweger — 1Physikalisches Institut A, RWTH Aachen University

As one aspect of the AugerPrime upgrade, scintillators (SSDs) will be added to the water Cherenkov detectors (WCDs) that form the surface detector of the Pierre Auger Observatory. This combined measurement offers the possibility to distinguish individual components of extensive air showers, potentially increasing the mass sensitivity. To efficiently exploit this new potential, novel methods are needed.

We introduce a Transformer-based neural network to reconstruct cosmic-ray masses from joint WCD and SSD measurements that outperforms both recurrent and convolutional networks. Efficient Transformers are employed to analyze and relate the two different sets of time traces on station level while ensuring a reasonable degree of computational demands. A Vision Transformer is then applied to the hexagonal grid of detector stations to process the whole shower footprint. The Transformer network is trained to simultaneously reconstruct the depth of the shower maximum $X_{max}$ as well as the shower’s number of muons on ground $N_{\mu}$. Both observables can be combined to estimate the primary cosmic-ray mass with an accuracy higher than what can be achieved individually.

Tracking efficiency studies for LHCb in Run 3 — Flavio Archilli1,2, Rowina Caspar2, Giulia Frau1, and Peihian Li1 — 1Università di Roma Tor Vergata, Rome, Italy — 2Physikalisches Institut, Heidelberg University, Germany

The LHCb detector is dedicated to the measurement of particles containing b- and c-quarks and has recently been upgraded, aiming to take data with an instantaneous luminosity of $2 \times 10^{34} \text{cm}^{-2}\text{s}^{-1}$ at $\sqrt{s} = 14 \text{TeV}$. The tracking system is completely renewed and a new reconstruction and trigger framework is implemented, in which all the tracking reconstruction algorithms are redesigned.

The correct evaluation of the tracking reconstruction efficiency is essential for many measurements of the LHCb experiment. However the precision of the simulation is limited, thus a data-driven approach is developed exploiting a tag-and-probe method on a sample of $J/\psi \rightarrow \mu^+\mu^-$ events to cross-check the track reconstruction efficiency in data. The difference of track reconstruction efficiency between simulation and data is then evaluated and exploited as calibration parameters. In addition, the effect of hadronic interactions on the track reconstruction efficiency is estimated using $D^0 \rightarrow K^+ \pi^-$ and $D^0 \rightarrow K \pi \pi \pi$ decays.

Tracking reconstruction for the Mu3e experiment — Alexander Kozlinsky1,2 — Institut für Kernphysik, IGU Mainz, Germany

The Mu3e experiment is designed to search for the lepton flavor violating decay $\mu^- \rightarrow e^- e^- e^-$. The aim of the experiment is to reach a branching ratio sensitivity of $10^{-16}$. The experiment is located at the Paul Scherrer Institute (Switzerland) and an existing beam line providing $10^6$ muons per second will allow to reach a sensitivity of a few $10^{-15}$ in the first phase of the experiment. The muons with a momentum of about 28 MeV/c are stopped and decay at rest on a target. The decay products (positrons and electrons) with energies below 53 MeV are measured by a tracking detector consisting of two double layers of 50 $\mu$m thin high-voltage monolithic active pixel sensors. The high granularity of pixel detector with a pixel size of 80 x 80 $\mu$m together with the small material budget allows for a precise track reconstruction. The track reconstruction is optimized for low noise and high efficiency of tracking detector. This environment allows to efficiently remove incorrectly reconstructed tracks with minimal effect on tracks produced by real particles. This talk will present the details of the track reconstruction, the methods to reduce the number of fake tracks and suppress clones produced due to high hit densities.

Quantum Angle Generator for Image Generation — Floriblan Rehul1,2, Sofia Vallecorsa1, Michele Grossi1, Kerstin Borras1,2, Dirk Krücker1, Simon Schnare3,4, Alexis-Vidal Verney-Provatas3,5, and Valè Valley Varo1,2 — 1CERN, Switzerland — 2RWTH Aachen University, Germany — 3DESY, Germany

The Quantum Angle Generator (QAG) is a new generative model for quantum computers. It consists of a parameterized quantum circuit trained with an objective function. The QAG model utilizes angle encoding for the conversion between the generated quantum data and classical data. Therefore, it requires one qubit per feature or pixel, while the output resolution is adjusted by the number of shots performing the image generation. This approach allows the generation of highly precise images on recent quantum computers. In this paper, the model is optimised for a High Energy Physics (HEP) use case generating simplified one-dimensional images measured by a specific particle detector, a calorimeter. With a reasonable number of shots, the QAG model achieves an elevated level of accuracy. The advantages of the QAG model are lined out - such as simple and stable training, a reasonable amount of qubits, circuit calls, circuit size and computation time compared to other quantum generative models, e.g. quantum GANs (qGANs) and Quantum Circuit Born Machines.
Particle Physics Division (T) Thursday

T 128.4  Thu 18:15  HSZ/0004

Photon identification at hadron colliders using graph neural networks — • ALI MALSALI CHORBAN1, JOHANNES ERDMANN2, FLORIAN MAUSOLF1, and CHRISTOPHER MORRIS2 — III. Physikalisches Institut A, RWTH Aachen University — Fachgruppe Informatik, RWTH Aachen University

At hadron colliders like the LHC, photons are essential physics objects in a wide range of analyses. For example, they allow the study of the Higgs boson using the diphoton decay channel. At a typical particle detector, the main signatures of photons are energy depositions in the electromagnetic calorimeter. However, other objects can leave similar signatures in the electromagnetic calorimeter, leading to misidentification as photons. Jets are abundant at the LHC and they include a high number of light hadrons, most notably neutral pions decaying into two photons. The decay of pions produces photons that are often close to each other and they are likely to be reconstructed as a single photon. However, photon candidates from jets have different attributes that can help to discriminate them from real photons. Specifically, they tend to produce wider signatures in the calorimeter, and to be accompanied by more additional particles.

Graph neural networks (GNNs) are flexible neural architectures well suited for dealing with input data of irregular structure and variable shape. Hence, they are particularly suited for classifying photon candidates as often a variable number of particles surrounds them. In this talk, our study of the applicability of GNNs for photon identification and comparisons with convolutional neural networks are presented.

T 128.5  Thu 18:30  HSZ/0004

Data-driven Simulation of Target Normal Sheath Acceleration by Fourier Neural Operators — • ALEXANDER MUSTAHLISTER1, THOMAS KLOUG2, MICHAEL BUSSMANN3,4, and NICO HOFFMANN5 — 1Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — 2TU Dresden, Dresden, Germany — 3CASUS, Görlitz, Germany

Particle-in-Cell simulations are a ubiquitous tool for linking theory and experimental data in plasma physics simulations. They allow for the comprehensive simulation of non-linear processes such as Laser Plasma Acceleration (LPA). These numerical codes can be considered as state-of-the-art approaches for studying the underlying physical processes in high temporal and spatial resolution. The analysis of experiments is performed by optimizing simulation parameters so that the simulated system is able to explain experimental results. However, a high spatio-temporal resolution comes at the cost of elevated simulation times which makes the inversion nearly impossible. We tackle that challenge by introducing and studying a reduced order model based on Fourier neural operator that is evolving the ion density function of Laser-driven ion acceleration via 1D Target Normal Sheath acceleration (TNSA). The ion density function can be dynamically generated over time with respect to the thickness of the target. We show that this approach yields a significant speed-up compared to numerical code Smile, while retaining physical properties to a certain degree promising applicability for inversion of experimental data by simulation-based inference.

RootInteractive tool for multidimensional statistical analysis, machine learning and analytical model validation — • MARIAN IVANOY1 and MARIAN IVANOY2 — for the ALICE Germany-Collaboration — 1 GSI Darmstadt — 2 UK Bratislava

ALICE, one of the four large experiments at CERN LHC, is a detector for the physics of heavy ions. In a high interaction rate environment, the pile-up of multiple events leads to an environment that requires advanced multidimensional data analysis methods.

Our goal was to provide a tool for dealing with multidimensional problems, to fit and visualize multidimensional functions including their uncertainties and biases, to validate approximations and assumptions, to easy define the functional composition of analytical parametric and non-parametric machine learning functions, to use symmetries and to define multidimensional "invariant" functions/alarms.

RootInteractive is a general-purpose tool for multidimensional statistical analysis. Its declarative programming paradigm makes it easy to use for professionals, students, and educators. RootInteractive provides functions for interactive, easily configurable visualization of unbinned and binned data and extraction of derived aggregate information on the server (Python/C++) and client (JavaScript). We support client/server applications using Jupyter, or a standalone client-side interactive application/dashboard.

T 129: Flavor X

Time: Thursday 17:30–19:00

T 129.1  Thu 17:30  HSZ/0034

New physics in b → cτν — MARCO FEDELE1, MONIKA BLANK1,2, ANDREAS CRIVELLIN1,2, SYTHEE IGBO1,2, TEPPEH KITAHARA1,2,5, and RYOUTARO WATANABE6 — 1Institut für Theoretische Teilchenphysik (TTP), Karlsruhe Institute of Technology (KIT) — 2Institut für Astroteilchenphysik (IAP), Karlsruhe Institute of Technology (KIT) — 3Paul Scherrer Institut — 4Physik-Institut, Universität Zürich — 5Institute for Advanced Research & Kobayashi-Maskawa Institute for the Origin of Particles and the Universe, Nagoya University — 6KLEK Theory Center, IPNS, Tsukuba — CAS Key Laboratory of Theoretical Physics, Institute of Theoretical Physics, Chinese Academy of Sciences, Beijing — INFN, Sezione di Pisa

The branching fractions of the decays B → Dτν and B → D+τν have been measured by BaBar, Belle, and LHCb. The combination of these measurements indicates an enhancement of the b → cτν amplitude w.r.t. the Standard-Model prediction by 3.2σ. This finding is in tension with the measurement of B(Λb → Λcτν), which is related to the former two branching ratios by a sum rule. I discuss the implications of this sum rule for future measurements and assess possible scenarios of new physics postulating either a charged Higgs boson or leptoquarks.

T 129.2  Thu 17:45  HSZ/0034

Measurement of R(D’s) with inclusive B meson tagging at Belle II — • STEPHANIE STEINMETZ, THOMAS LÜCK, and THOMAS KÜHR — Ludwig-Maximilians-Universität München

The measured ratio R(Ds) = BR(B → D+τν)/BR(B → D+ν) of branching fractions, where ε = e, μ, has consistently shown an excess of R(Ds) > 0 of τν events. The deviation between Standard Model predictions and the current world average lies at 2.8σ and has therefore attracted much attention as a possible hint towards new physics phenomena such as leptoquarks or a charged Higgs.

In this analysis at Belle II, we investigate the decay chains B → D*+τν(ν) as the signal channel, and B → D+τν as normalization. As both provide the same final state (up to neutrinos), a D+ and a lepton are reconstructed in both cases. The other B meson (tag B) in the Y(4S) → BB event is reconstructed ("tagged") inclusively, i.e. by assuming all particles not assigned to the signal B belong to the tag B without reconstructing intermediate particles. The resulting higher event yields are especially useful when only limited data is available, but come at the cost of higher background levels compared to previous approaches where specific tag B decay trees are reconstructed. The goal of this analysis is to determine the feasibility of applying the inclusive tagging approach to early Belle II data in order to gain competitive results w.r.t. other approaches. The current status of the analysis will be presented in this talk.

T 129.3  Thu 18:00  HSZ/0034

Measuring R(Ds) in hadronic one-prong τ decays at Belle II. — • FLORENZ BERNOCHNER, JOCHEN DINGFELDER, PETER LEWIS, and • ILIAS TSIALKIDIS for the Belle II-Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn, Nußallee 12, 53115, Bonn

Over the last years many experiments have hinted at the existence of lepton flavour universality. Existing experimental results on the branching ratios of B+ → D±τν with semileptonic tagging show a deviation from the Standard-Model prediction by 2.3σ. This finding is in tension with the measurement of B+ → D±τν with semileptonic tagging and the leptonic τ decays — • FLORENZ BERNOCHNER, JOCHEN DINGFELDER, PETER LEWIS, and • ALINA MANTHES for the Belle II-Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn

The Belle II experiment at the SuperKEKB asymmetric-energy collider, where electrons and positrons are collided at the Y(4S) resonance, collects a large number of events with B+B̅ pairs. The analysis of semileptonic decays of these B+ mesons allows for tests of lepton flavour universality. Existing experimental results on the ratios of the branching fractions R(Ds) = BR(B+ → D±τν)/BR(B+ → D±ν) and R(Ds′) = BR(B+ → D±τν)/BR(B+ → D±τν), where ε denotes an electron or muon, are in tension with the Standard Model (SM) predictions, which might
Probing lepton universality in inclusive semileptonic B-meson decays at Belle II — Florian Bernlochner, Jochen Dingfelder, Henrik Junkerkaulefeld, and Peter Lewis for the Belle II Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn.

Excesses in the ratios $R(D^{(*)}) = \frac{\sigma(B \to D^{(*)} \ell^+ \ell^-)/\sigma(B \to D^{(*)} \ell^-\ell^-)}{\sigma(B \to D^{(*)} \ell^+ \ell^-)/\sigma(B \to D^{(*)} \ell^-\ell^-)}$ measured by BaBar, Belle, and LHCb have created large interest in recent years. Together with other measurements in the flavor sector they may hint at non-universality of lepton couplings. The Belle II experiment in Japan enables a complementary test of these measurements. Due to the precise knowledge of the initial state of the collision and the controlled production of BB pairs, an inclusive measurement of $R(\tau\ell\ell) = \sigma(B \to X \tau\ell\ell)/\sigma(B \to X\tau\ell\ell)$ as well as the light-lepton ratio $R(\phi\ell\ell) = \sigma(B \to X\phi\ell\ell)/\sigma(B \to X\phi\ell\ell)$ becomes possible. Here, the hadronic system $X$ is not constrained to specific final states, i.e., all possible $B$-meson decay modes contribute. In this talk, the results of the $R(\tau\ell\ell)$ measurement based on a Belle II dataset of 189 fb$^{-1}$ are presented and the current status of the $R(\phi\ell\ell)$ measurement is discussed.

Thursday 130: Top II

T 129.5 Thu 18:30 HSZ/0304
Flavour of the dark photon — Jordi Folch Eguren$^1$, Emmanuel Stamou$^1$, Mustafa Tabet$^1$, and Robert Ziegler$^1$ — 1Fakultät für Physik, TU Dortmund, D-44221 Dortmund, Germany; 2Physikochauß (Gebäude 30.23, 9. Stock) Wolfgang-Gaede-Str. 1 D-76131 Karlsruhe.

In this work we analyse a BSM model in which an additional U(1) symmetry is added to the SM. We study how PCNGs might arise in this setup due to the new gauge field, the Dark Photon. We constrain the model by considering 2-body meson and baryon decays with different quark transitions, in which form factors play a crucial role.

Jordi Folch Eguren (TU Dortmund), Emmanuel Stamou (TU Dortmund), Mustafa Tabet (TU Dortmund) and Robert Ziegler (KIT).

T 130.1 Thu 17:30 HSZ/0401
Measurement of the production cross-section of a W boson in association with $t\bar{t}$ — Marcel Niemeyer, Arnulf Quadt, and Elizaveta Shabalina — Georg-August-Universität Göttingen

The top-quark pair production in association with a W boson is an important background to processes like $t\bar{t}H$ or 4-tops production. Due to higher order electroweak corrections, the process is difficult to model. In consequence, a tension of the predicted and observed rate of $t\bar{t}W$ surpassing 2σ has been observed in previous analyses. Thus, it is of high importance to increase our understanding of it.

This talk will give an overview of the measurement of the $t\bar{t}W$ cross-section in the multi-lepton channel with two same sign or three leptons (electrons or muons), using the full ATLAS Run 2 dataset. In addition to a measurement in the inclusive phase space, the extraction of the cross-section in a fiducial phase space, as well as the measurement of the ratio of $(t\bar{t}W^+)_{/\tau}$ of $(t\bar{t}W^-)_{/\tau}$ will be discussed. The fit to extract the cross-section is performed simultaneously to a template fit estimating the main background contributions.

T 130.2 Thu 17:45 HSZ/0401
Measurement of the inclusive production cross section of a top quark pair with a Z boson in the trilepton channel — Steffen Korn, Arnulf Quadt, Baptiste Ravina, and Elizaveta Shabalina — II. Physikalisches Institut - Georg-August-Universität Göttingen

The strength and structure of the coupling of the top quark and the Z boson can be measured through the associated production of a top quark pair and a Z boson. It provides sensitivity to the top quark's weak isospin in the Standard Model (SM) framework. The measurement of this parameter also serves as a probe of the SM. The process was measured by ATLAS and CMS at $\sqrt{s} = 13$ TeV with the full Run 2 dataset and a partial Run 2 dataset, respectively. In a new, refined analysis, multivariate techniques are used to improve the sensitivity of the measurement. The impact of using a multi-class deep neural network for event classification on the inclusive cross-section of $t\bar{t}Z$ final states with three charged leptons is presented.

T 130.3 Thu 18:00 HSZ/0401
Measurements of differential cross-sections of the $t\bar{t}$ production in the semileptonic and dilepton channels in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector — Buddhadev Mondal$^1$, Binose Batool$^1$, Beatrice Cervato$^1$, Markus Cristinziani$^1$, Carmen Diez Pardos$^1$, Ivor Fleck$^1$, Arpan Ghosal$^1$, Gabriell Gomez$^1$, Jan Joachim Hahm$^1$, Vadim Kostyukhin$^1$, Amartya Roy$^1$, Katharina Voss$^1$, Wolfgang Walkowiak$^1$, and tongbin Zhao$^1$ — 1Center for Particle Physics Siegen, Experimentelle Teilchenphysik, Universität Siegen; 2Shandong University, China

The top quark being the heaviest fundamental particle in the Standard Model (SM) plays a very important role in the study of fundamental interactions. It has a very short lifetime and it decays before it hadronizes, passing its properties to its decay products. Top quark pair production in association with a photon (tγ) is a very important process for measuring the coupling between top quark and photon. A precise measurement of this coupling is necessary for testing the SM and is also a probe for new physics effects at very high energy scale. In this talk, measurements of $t\bar{t}γ$ differential cross-sections using 13 fb$^{-1}$ of data collected by the ATLAS detector in proton-proton collisions at $\sqrt{s} = 13$ TeV will be presented. They are performed in the semileptonic and dilepton tγ decay channels.

T 130.4 Thu 18:15 HSZ/0401
Measurement of $t\bar{t} + γ$ production with the full Run 2 ATLAS dataset — Andreas Kirchhoff, Arnulf Quadt, Baptiste Ravina, and Elizaveta Shabalina — II. Physikalisches Institut, Georg-August-Universität Göttingen

The optimal way to measure the $t\bar{t}$-photon coupling would be an $e^+ e^-$ collider with sufficient energy. As such a collider does not exist, another possibility to measure it is the production of $t\bar{t}$ pairs in association with a photon. Unfortunately, such photons will mostly originate from the decay products of the top quarks and hence do not convey any information about the top-photon coupling. However, photons radiated from the top quarks themselves (and to some extent, from the initial state quarks) can be differentiated based on their kinematics and the topology of the event. The separation between 'production' and 'decay' modes is achieved for the first time in this ATLAS analysis, thanks to a dedicated MVA approach. In this talk, the measurement of the inclusive fiducial cross section of the $t\bar{t}$ process with photons originating from production and decay in single- and dilepton channels will be presented.

T 130.5 Thu 18:30 HSZ/0401
Search for $t\bar{t}γγ$ production in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector — Arpan Ghosal$^1$, Binose Batool$^1$, Beatrice Cervato$^1$, Markus Cristinziani$^1$, Carmen Diez Pardos$^1$, Ivor Fleck$^1$, Gabriell Gomez$^1$, Jan Joachim Hahm$^1$, vadim Kostyukhin$^1$, Buddhadev Mondal$^1$, Amartya Roy$^1$, Katharina Voss$^1$, Wolfgang Walkowiak$^1$, and Tongbin Zhao$^1$ — 1Center for Particle Physics Siegen, Experimentelle Teilchenphysik, Universität Siegen; 2Shandong University, China

The top-quark pair production in association with one or more photons is important Standard Model processes that allow us to measure the strength of the electroweak coupling of the top quark with photon. While the production of $t\bar{t}γ$ is well-studied, the $t\bar{t}γγ$ process has not been observed yet. The rare $t\bar{t}γγ$ process is not only a good candidate for probing the top electroweak coupling but is also significant as an irreducible background process to the $t\bar{t}$ production with a Higgs boson decaying to two photons ($H \rightarrow γγ$). New sources of CP-violation can appear as electric dipole moment terms in top-quark interactions, and their precise measurement is essential to determine the effects of new physics. Understanding the $t\bar{t}γγ$ process can help set better bounds on these anomalous moments. The presentation will discuss the ongoing efforts in the search for the $t\bar{t}γγ$ process in the semileptonic $t\bar{t}$ decay channel with a cut-and-count approach using the full Run 2 dataset collected by the ATLAS detector at $\sqrt{s} = 13$ TeV.
will not only serve as a prototype stage for all IAXO subsystems, but it
will be a fully fledged helioscope with potential for discovery. Along with a 10 m
long and about 2 T strong superconducting magnet hosting two 70 cm diameter
bores, optics and detector systems very similar to the ones foreseen for IAXO
will complete the two detection lines. Based on this setup, BabyIAXO may be
able probe photon-photon couplings down to $1.5 \times 10^{-13}$ GeV$^{-2}$ for axion
masses of up to 0.25 eV.
In this contribution, the general prospects of BabyIAXO, the current status of
the different BabyIAXO subsystems including the different X-ray detector tech-
nologies and the ongoing background simulation campaigns are presented and
discussed.

SUPAX - A Superconducting Axion Search Experiment — Tim Schnei-
mann, Kristof Schmieden, and Matthias Schott — Johannes Gutenberg-
Universität, Mainz
Supax is one of the first RF cavity based experiments in Germany to search for
axions. Axions are hypothetical particles that could solve the well known strong
CP problem in the standard model of particle physics. Furthermore axions could
explain the dark matter content of the universe. Axions are expected to convert
to photons in the presence of a strong magnetic field, where the photon fre-
quency depends on the axion mass. For wavelengths in the microwave regime
resonators are typically used to enhance the axion signal. We propose to use a
superconducting radio frequency cavity with high quality factor. A Copper RF
cavity has already been successfully tested probing for Dark Photons in the ab-
sence of a magnetic field whilst tune-able and superconducting RF cavities are
currently being developed. With this innovative approach and by using an exist-
ing 14T magnet at the Institute of Physics at the Johannes Gutenberg University
in Mainz, the largely unexplored mass region between 20 μeV to 50 μeV could
be tested.
In this talk I will cover the experimental setup, data acquisition, analysis and
current results of the experiment as well as future ideas of the experiment besides
the search for axions.

BabyIAXO: prospects and status of a new generation axion helioscope
— Daniel Hiebel1 and the IAXO-COLLABORATION2 — 1Deutsches
Elektronen-Synchrotron (DESY) — https://iaxo.desy.de
In order to search for solar axions and axion-like particles (ALPs) with unprece-
dented sensitivities, the International Axion Observatory (IAXO) aims to con-
vert those particles via the interaction with virtual photons into X-rays in a strong
magnet pointing towards the sun followed by high-precision focusing and ultra-
low background and high-efficiency X-ray detectors.
To intermediate experimental stage, BabyIAXO, proposed to be sited at DESY
Hamburg, will not only serve as a prototype stage for all IAXO subsystems, but it
will be a fully fledged helioscope with potential for discovery. Along with a 10 m
long and about 2 T strong superconducting magnet hosting two 70 cm diameter
bores, optics and detector systems very similar to the ones foreseen for IAXO
will complete the two detection lines. Based on this setup, BabyIAXO may be
able probe photon-photon couplings down to $1.5 \times 10^{-13}$ GeV$^{-2}$ for axion
masses of up to 0.25 eV.
In this contribution, the general prospects of BabyIAXO, the current status of
the different BabyIAXO subsystems including the different X-ray detector tech-
nologies and the ongoing background simulation campaigns are presented and
discussed.

Search for New Particles Decaying to Top Quark-Antiquark Pairs at CMS
— Henrik Jabusch1, Ksenia de Leo1, Johannes Haller1, and Roman
Kögler2 — 1Institut für Experimentalphysik, Universität Hamburg — 2DESY,
Hamburg
We present a model-independent search for new particles decaying to top quark-
antiquark pairs (t$\bar{t}$) using 138 fb$^{-1}$ of pp collision data at $\sqrt{s} = 13$ TeV recorded
with the CMS detector during LHC Run 2. The search targets both resonant and
non-resonant signatures in the spectrum of the invariant mass $m_{t\bar{t}}$.
Focusing on lepton+jets final states, we use novel top-tagging techniques to
identify the hadronic decay of highly Lorentz-boosted top quarks. We fur-
ther employ a deep neural network for event classification. Reconstructed $m_{t\bar{t}}$
-distributions are used to derive constraints on various physics models predicting
new particles decaying to t$\bar{t}$, such as heavy resonances, Kaluza-Klein gluons,
heavy Higgs bosons (including interference with the SM process), as well as non-
resonant axion-like particles, extending the reach of earlier searches significantly.

Search for high mass lepton flavour violating processes with CMS
— Sebastian Wiedenbeek, Arno Meyer, and Swagata Mukherjee — III.
Physikalisches Institut A, RWTH Aachen University
Lepton flavour is a conserved quantity in the standard model of particle physics,
but it does not follow from an underlying symmetry. Neutrino oscillations imply
that lepton flavour is not conserved in the neutral sector. Lepton flavour violating
processes are common in several models of physics beyond the standard model
(e.g. supersymmetry with R-parity violation, black hole production, and lepto-
quarks). Some models predict objects at the TeV mass scale that can decay into
two standard model leptons of different flavours: electron + muon, muon + tau,
or electron + tau. The challenges in a search for such phenomena are to achieve
a high mass resolution, good rejection of standard model backgrounds, and effi-
cient lepton identification at the same time. The status of the analysis, based on
the CMS data taken in Run 2, and plans for Run 3 are presented.

Search for Leptoquarks in the multilepton channel with ATLAS Run-2 data
— Janik Bohm and Andre Sopczak — CITU in Prague
The latest results in the search for leptoquarks in the multilepton channel are
presented using ATLAS Run-2 data.

Search for new particles decaying to top quark-antiquark pairs at CMS
— Henrik Jabusch1, Ksenia de Leo1, Johannes Haller1, and Roman
Kögler2 — 1Institut für Experimentalphysik, Universität Hamburg — 2DESY,
Hamburg
We present a model-independent search for new particles decaying to top quark-
antiquark pairs (t$\bar{t}$) using 138 fb$^{-1}$ of pp collision data at $\sqrt{s} = 13$ TeV recorded
with the CMS detector during LHC Run 2. The search targets both resonant and
non-resonant signatures in the spectrum of the invariant mass $m_{t\bar{t}}$.
Focusing on lepton+jets final states, we use novel top-tagging techniques to
identify the hadronic decay of highly Lorentz-boosted top quarks. We fur-
ther employ a deep neural network for event classification. Reconstructed $m_{t\bar{t}}$
-distributions are used to derive constraints on various physics models predicting
new particles decaying to t$\bar{t}$, such as heavy resonances, Kaluza-Klein gluons,
heavy Higgs bosons (including interference with the SM process), as well as non-
resonant axion-like particles, extending the reach of earlier searches significantly.
Search for supersymmetry in single lepton events using angular correlations and heavy-object identification — Kersten Birr
c, Frederic Engel
c, Thomas Kalloeven
c, Henning Kirkemann
c, Pantelis Kontaxakis
c, Dirk Krucker
c, Isabell Melzer-Pellmann
c, Ashraf Mohamm
d, Stanisław Pabis
c, and Lucas Wiens
c

JUNO experiment

M E the Run 3 period using modern analysis tools.

The search presents gluino pair production, where the gluinos decay into the lightest supersymmetric particle (LSP) and either a top quark-antiquark pair or a pair of light quarks in the final state.

We use the angular correlation between the lepton and the W boson's transverse momenta for a strong separation between the signal and the background region. The investigation of the two different signal models benefits from improved top and W tagging methods.

Furthermore, we also present current endeavors to prepare this analysis for the Run 3 period using modern analysis tools.

Investigation of background processes for proton decay search in the JUNO experiment — Carsten Dittrich
c, Ulrike Fahrenholz
c, Meishu Lu
c, Sarah Braun
c, Lothar Oberauer
c, Hans Steiger
c, and Matthias Raphael Stock
c

F 15: Physik-Dep., Technische Universität München

We present a revised analysis of the same dataset, improving the fit methods and including a measurement of the width of the W boson. A precise measurement of these quantities in the decay of the W boson represent an excellent precision test of the Standard Model (SM). The recently released measurement of the W-boson mass using the full dataset recorded by the CDF collaboration is in significant tension with previous measurements.

We will present the revised analysis of the ATLAS data including extensive cross-checks of the new profile likelihood fit approach. Detailed stability and consistency checks of the measurements will be discussed. Finally, a novel approach to validate fit models will be presented.

A direct measurement of the invisible width of the Z boson with the ATLAS detector — Martin Klassen
c, Kirchhoff-Institut für Physik, Heidelberg

The invisible width of the Z-boson, \( \Gamma_{\text{inv}}(\text{Z}) \), is a fundamental parameter of the Standard Model. It is related to the number of light neutrinos that couple to the Z-boson, and its precise measurement allows for tests of the Standard Model. \( \Gamma_{\text{inv}}(\text{Z}) \) has been indirectly measured at LEP with a precision of 0.3% and was in addition also directly determined using events with photon and missing transverse energy to a precision of 3.2%.

At the ATLAS experiment, \( \Gamma_{\text{inv}}(\text{Z}) \) can be obtained by measuring the ratio of \( Z \rightarrow \gamma \nu \nu + \text{jets} \rightarrow Z \rightarrow ll + \text{jets} \) events (\( \Gamma_{\text{inv}}(\text{Z}) \)) as a function of the Z boson's transverse momentum \( p_T \). This approach is sufficient because the production cross section and the branching ratios can be decoupled leading to the relation \( \Gamma_{\text{inv}}(\text{Z}) = \Gamma_{\text{inv}}(\text{Z})/\Gamma(\text{Z}) \) and the leptonic width of the Z are already precisely measured.

The ratio measurement benefits from a large degree of cancelation of many of the experimental and theoretical uncertainties. For this to work the phase spaces of selected \( Z \rightarrow \gamma \nu \nu \) and \( Z \rightarrow ll \) events need to be as similar as possible, and residual differences are corrected for using simulations.

In this talk the analysis strategy will be presented and it will be shown that the experiments at the Large Hadron Collider can obtain competitive results 30 years after the first direct measurement of \( \Gamma_{\text{inv}}(\text{Z}) \) at LEP.

The jiangmen Underground Neutrino Observatory (JUNO) is a large liquid scintillator detector, capable for search to the hypothetical proton decay \( p \rightarrow K^+ + \nu \), which is predicted by supersymmetric Grand Unified Theories (GUTs). As the momentum of the daughter kaon is below the Cherenkov threshold in water, JUNO will quickly be able to provide competitive results in comparison to the current lifetime limit of \( \tau > 5.9 \times 10^{33} \) years by the Super-Kamiokande collaboration. The three-fold coincidence signature generated by the kaon and its daughter particles will be crucial to discriminate proton decay events from possible backgrounds produced by atmospheric neutrinos. This talk will present a brief overview on the proton decay search in JUNO, the different background processes and possible identification criteria to discriminate between the two.

This work is supported by the Clusters of Excellence Origins and PRISMA+.

Search for Higgsinos in final states with a low-momentum, displaced track at the CMS experiment — Samuel Bein
c, Yuval Nissin
c, Peter Schleper
c, Alexandra Tews
c, and Moritz Wolf — Universität Hamburg

Many supersymmetric extensions to the Standard Model predict the three lightest electroweakinos, \( \chi_1^-, \chi_1^0, \chi_1^+ \), to be Higgsino-like with nearly degenerate masses around the electroweak scale. The lightest charginos can be produced alongside another electroweakino and then decay to the lightest neutralino. To search for these particles, the best strategy depends on the differences between the various masses. For \( \Delta m(x_1^+, x_1^-) > 0/(1 \text{GeV}) \), lepton pairs from the decay of the second-lightest neutralino leave an experimentally distinct signature, whereas \( \Delta m(x_1^0, x_1^-) \) \( \leq 0.3 \text{ GeV} \) can lead to the chargino giving rise to a disappearing track. For mass splittings in the range of \( \Delta m(x_1^0, x_1^-) = 0.3 \rightarrow 1 \text{ GeV} \), searches carried out so far at the LHC are lacking in sensitivity.

In this analysis, a slightly displaced track with small transverse momentum, corresponding to a pion originating from the chargino decay, is used to gain sensitivity to this challenging range of mass splittings.

T 133.3 Thu 18:00 HSZ/0103

Measuring the Weinberg Angle at the Belle II Experiment — Lukas Gross-Sach
c, Daniel Greenwald
c, and Stephan Paul — Belle II-Collaboration — Technical University München

The Weinberg angle is known precisely only at high energies around the Z mass. At Belle II, we have the opportunity to measure it at a lower energy via \( e^+e^- \rightarrow \mu^+\mu^- \), near to the energy where the NuTeV experiment has measured a discrepant value. We present preliminary studies of event selection criteria, muon identification performance and potential precision of such a measurement at Belle II.

Funded by the DFG under Germany’s Excellence Strategy - EXC2094 - 390783311 and BMBF Verbundforschung (05H12WOKRA BELLE 2).

T 133.4 Thu 18:15 HSZ/0103

\( t\bar{t} \)-heavy flavor classification at the CMS experiment — Emanuel Pfef
er — Ulrich Husemann
c, Ruwa Rajeev
c, Jan Van der Linden
c, and Michael Wasmers — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

Processes in which a bottom quark-antiquark pair is produced in addition to the decay products of a top quark-antiquark pair are difficult to separate from each other. These processes include \( t\bar{t}b\bar{b} \), where the additional bottom quark-antiquark pair stems from a gluon splitting, as well as \( t\bar{t}H \) with \( H \rightarrow b\bar{b} \) and \( t\bar{t}z \) with \( z \rightarrow b\bar{b} \). New analysis techniques based on Graph neural networks are promising to improve the classification of these events. This talk sheds light on the current status of a simultaneous measurement of the production cross section of a top-antiquark pair in association with heavy flavor jets in the dileptonic channel at the CMS experiment. In this analysis, classification methods based on Graph neural networks are applied to separate processes in the \( t\bar{t} \)-heavy flavor phase space.

T 133.5 Thu 18:30 HSZ/0103

Differential cross-section measurements of an hadronically decaying top-quark-antiquark pair produced in association with two b-jets via the ATLAS detector at \( \sqrt{s} = 13 \text{ TeV} \) — Nina Wesnec and Teresa Barillari — Max-Planck-Institut für Physik, München

The production of a top-quark-antitop-quark (\( t\bar{t} \)) pair in association with two b-jets \((t\bar{t}bb)\) is an important and insightful Standard-Model (SM) process to study at the LHC. It is the perfect playground to study the dynamics of multiple heavy quark production which is difficult to model precisely. It is also a major background in important SM measurements. In addition, precise \( t\bar{t}bb \) measurements could allow to catch glimpses of New Physics.
In this talk, preliminary results of the first ATLAS analysis targeting the hadronic decay channel of $t\bar{t}b\bar{b}$ production will be presented. It uses proton-proton collision-data recorded with the ATLAS detector at the LHC at a center-of-mass energy of 13 TeV, corresponding to an integrated luminosity of 139 fb$^{-1}$. The analysis uses a cut-based event selection with at least four b-jets. A likelihood-based algorithm is then used to reconstruct the hadronic decay of the $t\bar{t}$ pair in the event. The challenging large multijet background is modelled using a data-driven method. The final aim of the analysis is to perform fiducial differential cross-section measurements as a function of several variables and compare them to next-to-leading-order matrix-element calculations matched to a parton shower.

T 133.6 Thu 18:45 HSZ/0103

Simultaneous measurement of $(t\bar{t})(X(\mu t))$ processes in the semileptonic channel at the CMS experiment — JUHA KUNNULAN, MUHAMMED RAHEREK, ULRICHS HUSEMANN, JAN VAN DER LINDEN, EMANUEL PFEFFER, and MICHAEL WASSMER — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT)

**Top quark anti-quark pairs ($t\bar{t}$) are produced in association with other particles (X) where X can be the Higgs boson, $Z/W$ boson or QCD-initiated heavy flavour jets ($b\bar{b}/c\bar{c}$). The measurement of $t\bar{t}+X$ is a direct probe of the coupling of standard model particles like the Higgs and $Z$ boson to the top quark and may reveal new physics effects in modifications of these couplings.**

The analysis is challenging as these processes, particularly when the bosons decay into heavy flavour quarks, like for example, $t\bar{t}+H(\rightarrow b\bar{b})$ and $t\bar{t}+W(\rightarrow Z+b\bar{b})$, share the same signature and kinematic features. These high jet multiplicity final states create ambiguities in the reconstruction and identification of these processes and thus, it is hard to differentiate them from each other. Due to this challenge, an attempt to simultaneously measure these $t\bar{t}+X$ processes is made by exploring multivariate analysis strategies.

In this talk, an overview of the ongoing analysis, designed with the full Run-2 data of the LHC using the single lepton channel, is given.

T 134: Higgs, Di-Higgs IV

**Since the Higgs boson discovery, probing the properties of it is an important physics program of the LHC. The significance of these studies originates from the fact that the Higgs boson is the only fundamental, point-like scalar which has been observed, and the precision measurement of the couplings of the Higgs boson through the production mechanisms and the decay modes might lead us to new physics. In this talk, the latest advances in Higgs boson measurements in its decays into two tau leptons, using data collected by the ATLAS detector, will be discussed.**

T 134.1 Thu 17:30 HSZ/0105

Differential measurement of the $H \rightarrow \tau \tau$ cross-section in the VBF production mode — LEA HERRMANN, CHRISTIAN GREFE, PHILIP BECHTLE, and KLADIUS DESCH — Physikalisches Institut, Universität Bonn

Precision measurements of the Higgs boson properties are promising to show evidence of BSM physics. One aspect of interest is the Yukawa-interaction which can be directly investigated by the cross-section measurement of the $t\tau$ final state. Detailed studies are performed in a combined maximum-likelihood fit of the $d$-$r$ mass in different $p_T$ bins using the “Simplified Template Cross Section” framework (STXS). Orthogonal control regions are used to determine and to validate the contribution of important background processes. Multi-jet events which are misidentified as visible $t\tau$ (fakes), play an important role apart from the dominant $Z \rightarrow \tau \tau$ events. The fraction of fake events depends on the decay-modus of the hadronically decaying $r$ and has a less prominent contribution if no neutral pions are involved in the final state. In past analysis efforts, the estimated fake background events were only differentiated by 1- and 3-prong events which is why a more accurate, now decay-mode dependent fake background estimation is developed. It enables a loosened event selection for decay-modes without neutral pions and thus, an increased selection efficiency of signal events.

The method as well as the influence of the improved background estimation on the sensitivity of the measurement in different STXS bins will be discussed.

T 134.2 Thu 17:45 HSZ/0105

Charge-asymmetry measurement in WH (H)$\rightarrow$WW events — RALF SCHMIEDER, NICOLO TROVISANI, NILS FALTERMANN, MARKUS KLITZ, ROGER WOLF, XUWEN ZUO, SEBASTIAN BROMMER, MAXIMILIAN BURKART, and GÜNTER QUAST — Karlsruher Institut für Technologie, Karlsruhe, Deutschland

At the LHC, an asymmetry in $W^+H$ and $W^-H$ production is expected as the parton distribution functions (PDFs) favour the production of positively-charged $W$ bosons in proton-proton collisions. The measurement of the WH charge asymmetry provides a consistency test for the Standard Model (SM), as it is sensitive to enhanced Yukawa couplings to the first and more so to second generation quarks like the $c$ quark. The production of an $H$ in association with a $W$ boson can happen through the exchange of a $c$ quark in the $t$ channel. Experimentally, the WH charge asymmetry measurement is independent of any challenging $c$ jet tagging algorithms. This talk reports the status of this measurement in the channel where the Higgs boson decays into a pair of $t\bar{t}$.

T 134.3 Thu 18:00 HSZ/0105

Improved event cleaning for the $\tau$-embedding method of CMS — CHRISTIAN WINTER, SEBASTIAN BROMMER, ARTUR GOTTMANN, ROGER WOLF, and GÜNTER QUAST — ETP, Karlsruhe Institute of Technology, Karlsruhe, Germany

In $H \rightarrow \tau \tau$ analyses a major source of background are genuine tau leptons, mostly originating from $Z \rightarrow \tau \tau$ decays. The $\tau$-embedding method is a method to estimate this background from data, by replacing muons in an selected-event in data with simulated $\tau$-decays. For this purpose, the muon signatures have to be removed from the original event record. This talk will focus on an improved cleaning, which takes electromagnetic muon showering in the muon detectors into account.

T 134.4 Thu 18:15 HSZ/0105

Measuring Higgs boson production cross sections in its decays into two tau leptons with the ATLAS detector — BARTASH AMNI, CHRISTOPHER YOUNG, KARSTEN KONEKE, and KARL JAKORS for the ATLAS-Collaboration — Albert-Ludwigs-Universität Freiburg, Freiburg, Germany

**Since the observation of the Higgs boson discovery, probing the properties of it is an important physics program of the LHC. The significance of these studies originates from the fact that the Higgs boson is the only fundamental, point-like scalar which has been observed, and the precision measurement of the couplings of the Higgs boson through the production mechanisms and the decay modes might lead us to new physics. In this talk, the latest advances in Higgs boson measurements in its decays into two tau leptons, using data collected by the ATLAS detector, will be discussed.**

T 134.5 Thu 18:30 HSZ/0105

Sensitivity to Triple Higgs Couplings via Di-Higgs Production in the 2HDM at the LHC — FRANCISCO ARCO, SVEN HENNEBERGER, and MARGARET MUEHLEITNER, and KATERYNA RADCHENKO — 1UAM, Spain — 2IFT (UAM-CSIC), Spain — 3KIT, Germany — 4DESY, Germany

The reconstruction of the Higgs potential is a major goal for experimental particle physics. This can be accomplished via the precise measurement of the Higgs mass and its self interactions. The first process that provides access to the trilinear self-coupling is Higgs pair production, which at the LHC happens dominantly through gluon fusion. In this context, models with extended Higgs sectors are theoretically and experimentally allowed and can accommodate large deviations of the trilinear Higgs couplings while providing explanations to some of the shortcomings of the Standard Model.

We study the sensitivity to the triple Higgs couplings involved in Higgs pair production via gluon fusion in the framework of the Two-Higgs Doublet Model. In particular, we focus on the contribution of the resonant di-Higgs channel involving a heavy CP-even Higgs boson exchange to the total production cross section as well as the invariant mass distribution of two Higgs in the final state. We show that for the benchmark scenarios where the resonant production is dominant, there is significant sensitivity to the parameters of the extra scalar. Finally, we discuss the effects of experimental uncertainties by applying smearing and binning to our results.

T 134.6 Thu 18:45 HSZ/0105

A model-independent analysis of interference effects in the $t\bar{t}$ final state at the LHC involving two $\phi$-mixed Higgs bosons — HERMINIGIL BAHÍ, ROMAL KUMAR, and GEORGI WEGLER — University of Chicago, Department of Physics and Enrico Fermi Institute, 5720 South Ellis Avenue, Chicago, IL 60637 USA — 2Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany — 3Il. Institut für Theoretische Physik, Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Various extensions of the Standard Model predict the existence of additional Higgs bosons. If these additional Higgs bosons are sufficiently heavy, an important search channel is the di-top final state. In this channel interference contributions between the signal and the corresponding QCD background process are expected to be important. If more than one heavy Higgs boson is present, besides the signal-background interference effects associated with each Higgs boson also important signal-signal interference effects are possible. We perform a comprehensive model-independent analysis of the various interference contributions within a simplified model framework considering two heavy Higgs bosons that can mix with each other, taking into account large resonance-type effects arising from loop-level mixing between the scalars. The interference effects are studied both in an analytic way at the parton level and with Monte Carlo simulations for proton-proton collisions at the LHC. The mapping of the general approach to a specific model is demonstrated for the case of a complex Two-Higgs Doublet Model.
T 135: Top Mass, Top BSM

Time: Thursday 17:30–19:00

**T 135.1 Thu 17:30 HSZ/0201**

**Measurement of the top-quark mass in the t ¯ t → lepton + jets channel with a template method, using the full Run 2 dataset in ATLAS — DIMBINAINA RAFAHANARANA and ANDREA KNUE for the ATLAS-Collaboration — ALBERT-LUDWIGS-UNIVERSITÄT FREIBURG**

The top-quark mass is a free parameter of the Standard Model (SM) and is playing a key role in the test of the consistency of the SM. Its precise determination is therefore of paramount importance. Several measurements of the top-quark mass in different final states using various methods were performed at the Tevatron and the Large Hadron Collider.

The combined measurement of the top-quark mass using different ATLAS Run 1 measurements achieved a relative overall uncertainty of 0.28%. The combination is limited by the systematic uncertainty as the relative statistical and systematic uncertainties are 0.14% and 0.23%, respectively.

The measurement of the top-quark mass with the template method in the t ¯ t → lepton + jets channel using the full Run 2 dataset in ATLAS will be shown. Given the large amount of data collected during Run 2, the measurement is mainly limited by systematic effects. The presentation will discuss the dominating systematic uncertainties and studies aimed at reducing those uncertainties in the top-quark mass.

**T 135.2 Thu 17:45 HSZ/0201**

**Messung der Masse des Topquark mit einer Likelihood-Anpassung mit Störparametern im vollhadronischen Kanal — YANNER GRUEL, JOHANNES LANDE, PATRICE CONNOR, HARTMUT STADIE und PETER SCHLEPER — Institut für Experimentalphysik, Universität Hamburg**


**T 135.3 Thu 18:00 HSZ/0201**

**Measurement of the jet mass distribution of boosted top quarks and the top quark mass with CMS — ALEXANDER PAASCH, JOHANNES HALLER, ROMAN KOLGER und DENNIS SCHWARZ — Institut für Experimentalphysik, Universität Hamburg — DESY, Hamburg — Austrian Academy of Sciences, Wien**

We present a measurement of the jet mass distribution in fully hadronic decays of boosted top quarks in pp collisions recorded by the CMS experiment in Run-2 of the LHC. The measurement is performed in the lepton+jet channel of top quark pair production. The top quark decay products of the all-hadronic decay cascade are reconstructed with a single large-radius jet with transverse momentum greater than 400 GeV. The top quark mass is extracted from the normalised differential top quark pair production cross section at particle level. The uncertainties arising from the calibration of the jet mass scale and modelling of the final state radiation in simulation are improved by dedicated studies of the jet substructure. This results in a significant increase in precision in the top quark mass with respect to an earlier measurement, now reaching a precision below 1 GeV.

**T 135.4 Thu 18:15 HSZ/0201**

**Measurement of the top quark pole mass using t ¯ t + 1 jet events with the CMS experiment — ÂNA VENTURA BARBOSO, SEBASTIAN WUCHTERL, ROMAN KOLGER und KATERINA LIPKA — Deutsches Elektronen-Synchrotron DESY, Notkestraße 85, D-22607 Hamburg**

The top quark is the most massive elementary particle known. Its mass, m_t, is a fundamental parameter of the Standard Model, and its value needs to be determined experimentally. However, direct top quark mass measurements suffer from ambiguities in their interpretation because of nonperturbative effects.

In this work, the pole mass of the top quark is extracted from a precise measurement of the distribution in p_T, in events where the t ¯ t system is produced in association with at least one additional jet. The variable p_T is defined as the inverse of the invariant mass of the t ¯ t-jet system. This observable has been chosen due to strongest sensitivity to m_t at the threshold of the t ¯ t-jet production. The analysis is performed using proton-proton collision data collected by the CMS experiment in 2016-2018 with √s = 13 TeV, corresponding to a total integrated luminosity of 138 fb⁻¹. Events with two opposite-sign leptons in the final state are analyzed and the cross section is measured at the parton level using a likelihood unfolding method.

**T 135.5 Thu 18:30 HSZ/0201**

**Prospects for a Measurement of Quantum Entanglement in Top Quark Pair Production in the Lepton+Jets Final State — MARCEL NIEMETER, ARNULF QUADT, BAPTISTE RAVINA, THERESA REICH und ELIZABETH SHARALINA — Physikalisches Institut, Georg-August-Universität Göttingen**

Quantum entanglement is a fundamental prediction of quantum mechanics. Experimental achievements with electrons and photons were recognised by the Nobel Prize in Physics 2022. At the LHC, quantum entanglement could be observed for the first time in quarks, testing quantum mechanics at high energies. Therefore, a sensitivity study for a possible measurement of quantum entanglement in the top quark pair production in the lepton+jets final state is presented. The angular separation between the decay products of the top quarks can act as a marker of quantum entanglement, when the two top quarks are produced near threshold. To take advantage of the presence of c-quarks in W decays in 1 jets channel, c-tagging is used based on the working points of the current b-tagging algorithm. The result is then unfolded using Profile Likelihood Unfolding to remove detector effects. The study is performed with ATLAS Monte Carlo simulations under Run 2 conditions.

**T 135.6 Thu 18:45 HSZ/0201**

**Search for heavy right-handed Majorana neutrinos in t ¯ t decays — TONGRIN ZHAO, BENISH BATOLE, BEATRICE CERVATO, MARKUS CRISTINIZIANI, CARME DIEZ PADROS, IVOR FLECK, ARPAI GHOSSA, GABRIEL GOMES, JAN JOACHIM HAHN, VADIM KOSTYUKHIN, BUDDHADHAR MONDAL, AMARYTA REJ, KATHARINA VOS und WOLFGANG WALKOWIAK — Center for Particle Physics Siegen, Experimentelle Teilchenphysik, Universität Siegen — Shandong University, China**

A search for heavy right-handed Majorana neutrinos is performed with the Run-2 dataset recorded from 2015 to 2018 with the ATLAS detector at the CERN Large Hadron Collider and is based on √s = 13 TeV proton–proton collision data with an integrated luminosity of 138 fb⁻¹. The targeted process is t ¯ t: one of the top quarks decays into a pair of same-sign same-flavour leptons (electrons or muons), a b-quark and two light quarks, while the other decays into a b-quark and two light quarks. The final states feature same-sign dilepton signatures. This analysis is the first search for heavy neutrinos using t ¯ t events.

A multivariate analysis is employed in order to improve the sensitivity. Several control regions are defined to estimate the main backgrounds. With profile likelihood fits using the ee and μμ channels, we expect to reach good sensitivities for the mixing parameters in the mass region 15–80 GeV.

T 136: Higgs TH, VH

Time: Thursday 17:30–19:00

**T 136.1 Thu 17:30 HSZ/0201**

**Associated production of a Higgs boson and a single top quark from t-channel production (Htq) in channels with hadronically decaying tau leptons at ATLAS — CHRISTIAN KIRFEL, L. C. BROCK, TANJA HOLM und OLEH KIVERNYK — Physikalisches Institut Bonn**

A measurement of the single top-quark production in association with a Higgs boson and a spectator light quark (Htq) gives insight into the properties of not only the top quark but also the Higgs boson. The associated production is uniquely sensitive to the relative sign of the top quark-Higgs boson Yukawa coupling. Additionally, the ditau decay of the Higgs boson, which successively...
Comparison of different Monte Carlo generators for the simulation of ZH events in the gluon fusion production mode — •Manuela Gührer1, Xiaohui Gao2, Svenja Diekemann3, Alena Dodonova3, Ming-Yan Lee4, Luca Mastrobelenzo5, Spandan Mondal1, Andrei Novak5, Andrei Pozdynakov5, Alexander Schmid6, Annika Stein2, and Vaclav Vaulin7 — III. Physikalisches Institut A, RWTH Aachen, Aachen, Germany — 2Brown University, Providence, USA

The associated Higgs production via Higgsstrahlung from a Z boson originating from gluon fusion is a loop-induced process with destructive interference between the triangle and box contributions at leading order. This makes the process a sensitive candidate to probe new beyond the standard model physics (BSM). Therefore, comparing different Monte Carlo generators and investigating their differences is important for the development of physics analyses to access the gg → ZH processes in data. This talk will present the comparison of 4 generators for the process gg → ZH with the Higgs boson decaying via the H → bb channel. The comparison is done using simulated CMS Run 2 datasets at √s = 13 TeV.

Extraction of the gluon-initiated component of the associated production of the Higgs boson and a vector boson with the CMS experiment — •Alena Dodonova1, Alexander Schmid2, Xavier Coube2, Luca Mastrobelenzo5, Andrei Pozdynakov5, Andrey Novak5, Spandan Mondal1, Ming-Yan Lee4, Annika Stein2, Svenja Diekemann3, Niclas Eich1, and Martin Erdmann1 — 1III. Physikalisches Institut A, RWTH Aachen University, Aachen, Germany — 2Brown University, Providence, USA

Associated Higgs boson production with a Z boson originating from gluon fusion is a loop-induced process with destructive interference between the triangle and box contributions at leading order. This makes the process a sensitive candidate to probe new beyond the Standard Model physics (BSM). Therefore, comparing different Monte Carlo generators and investigating their differences is important for the development of physics analyses to access the gg → ZH processes in data. This talk will present the comparison of 4 generators for the process gg → ZH with the Higgs boson decaying via the H → bb channel. The comparison is done using simulated CMS Run 2 datasets at √s = 13 TeV.
Designing distributed, heterogeneous computing-infrastructures is a challenging task. Since, due to their complexity and size, only a single design candidate can be feasibly deployed, building different prototypes is no option. We therefore propose to simulate the behaviour of infrastructure candidates based on realistic simulation models as an accessible approach. This ansatz already proved to be successful, utilizing the MONARC simulator for the design of the original structure of the WLCG. In this spirit, a modern tool for simulation of high energy physics workloads executing on distributed computing infrastructures is presented. It is based on the SimGrid/WRENCH simulation framework, allowing to simulate complex infrastructures enhanced with models to simulate relevant data access and caching patterns.

T 137.5 Thu 18:30 HSZ/0301 Caching in Distributed Computing Environments — Robin Hofsaess, Maximilian Horzela, Manuel Giffels, Artur Gottmann, and Matthias Schnepp — Karlsruhe Institut für Technologie

With the steadily growing amount of data collected in several high energy physics experiments, new challenges occur when it comes to an efficient processing of the data. Besides storage, data transfers are becoming more and more limiting for the increasingly distributed computing infrastructure used by the HEP community. An efficient usage of the resources therefore make higher bandwidths necessary. However, it is often not possible to simply improve the connectivity of a resource provider leading to the necessity of other approaches. A first step here could be to reduce unnecessary data transfers by (local) caching. The talk will address the general ideas on coordinated caching within a distributed computing infrastructure - as given at KIT/GridKa - and briefly discuss its challenges. Furthermore, our future plans at KIT will be presented.

T 137.6 Thu 18:45 HSZ/0301 Belle II Grid Computing Developments in Germany — Matthias Schnepp, Moritz Bauer, Günter Dockeck, Torben Ferber, Oliver Freyermuth, Andreas Gellrich, Manuel Giffels, Günter Quast, Michel Hernandez Villanueva, and Peter Wiemann — Karlsruhe Institute of Technology (KIT) — LMU Munich — Universität Bonn — DESY Hamburg

The Belle II experiment studies B-meson decays with high precision and plans to record 50 fb⁻¹, which corresponds to 50 PB of recorded data. For reconstruction, simulation, and analysis, the Belle II collaboration uses several data centers around the world as a Grid, similar to the worldwide LHC Computing Grid.

To improve the global job throughput and support the local groups, several developments in Belle II Grid computing are being worked on and are applied in Germany or by German groups. In this presentation, we describe the challenges and the current development projects. These involve the Grid storage for local groups, caching techniques to increase dataset accessibility, GPU, and multicore support in the Grid for Belle II.

T 138: QCD Experiment III

Time: Thursday 17:30–18:45

T 138.1 Thu 17:30 HSZ/0405 Triple differential cross-section measurement of Z(\(\mu\))→jet events at 13 TeV — Cedric Verstege, Robin Hofsaess, Maximilian Horzela, Günter Quast, and Klaus Rabrertz — Karlsruhe Institute of Technology, Karlsruhe, Germany

The triple differential cross-sections of Z(\(\mu\))→jet events is presented using the data recorded at 13 TeV center-of-mass energy by the CMS experiment in the years 2016, 2017, and 2018. The cross-sections are measured as a function of the Z boson transverse momentum \(p_{T}\), the rapidity separation \(y_{1}\) of the Z boson and the leading jet, and the boost in rapidity \(y_{2}\) of their center-of-mass system in the lab frame. The observables \(y_{1}\) and \(y_{2}\) enhance the sensitivity to different parton initial-state and momentum contributions, and thus to the PDFs.

The measured cross-sections are unfolded for detector effects in all three dimensions simultaneously. The resulting cross-sections at stable particle level are compared to precise theory predictions calculated at next-to-next-to-leading order in perturbative QCD corrected for electroweak and non-perturbative effects.

T 138.2 Thu 17:45 HSZ/0405 Measurement of jet mass distribution of hadronic W and Z bosons — Steffen Albrecht and Andreas Hinzmann — Universität Hamburg — DESY, Hamburg, previously Universität Hamburg

In this talk we introduce a new effort towards measuring the jet mass distribution of hadronically decaying W and Z bosons. We study events in which the bosons have a large transverse momentum and thus produce strongly collimated decay products reconstructed as single fat jets. The substructure of such jets proves to be a useful handle in various procedures (e.g. jet calibration, jet tagging), but has room for improvement in its modelling. We aim to gain an in-depth understanding of the substructure by studying the unfolded jet mass distribution in dependence of the jet \(p_{T}\) and substructure tagger discriminants. While previous measurements of jet mass have been carried out for gluon, quark and top jets in dijet, Z(\(\mu\))→jet and \(t\bar{t}\) samples, this is the first study of W and Z jets masses in the processes with W(\(q\))→jets, Z(\(qq\))→jets as well as hadronic \(t\bar{t}\) systems in the final states.

In addition the measurement of the difference \(m_{2}−m_{1}\) will be pursued, setting a first step towards a potential measurement of the W mass with jet substructure.

T 138.3 Thu 18:00 HSZ/0405 First results from inclusive jet measurement with Run2 data at CMS — Valentia Guglielm1, Katerina Lipka1, Simone Amoroso2, Patrick Connor2, and Roman Kogler3 — 1Deutsches Elektronen-Synchrotron DESY, Notkestrasse 85, D-22607 Hamburg — 2University Hamburg, Hamburg, Germany

We present preliminary results of the measurement and QCD analysis of double-differential inclusive jet cross sections in proton-proton collisions by using the full Run2 data collected by CMS experiment at a center of mass energy of \(s = 13\) TeV. The higher accumulated luminosity, compared with the previous result, of full Run2 allows for an improved precision and opens up new corners of the phase space. This permits further testing of the Standard Model (SM) and facilitates indirect searches for physics beyond the SM. Our study addresses the high transverse momentum region, where possible contributions of new physics, e.g. different models of 4-quark contact interactions, are most significant. Furthermore, the precision of the parton distribution functions can be significantly improved and the strong coupling constant can be extracted. An overview of the current status of the measurement will be given, together with preliminary results of a simultaneous determination of alpha-s and PDFs at NNLO in QCD.

T 138.4 Thu 18:15 HSZ/0405 A novel method to measure the jet energy resolution from dijet events at CMS — Yannick Fischer, Johannes Haller, Andrea Malara, Alexander Pausch, and Matthias Schröder — Universität Hamburg — Université Libre de Bruxelles

The jet energy is a key observable for almost all analyses at the CMS experiment at the CERN LHC. A precise knowledge of the jet energy resolution (JER) is crucial for both measurements and searches. This talk will give a brief overview over JER measurements at CMS. A novel method based on the missing transverse momentum fraction (MPF) technique is introduced. The new approach provides a JER measurement complementary to existing methods and aims at avoiding several of their dominant uncertainties. In this talk, we will introduce the new method and show first results with the recent CMS data.

T 138.5 Thu 18:30 HSZ/0405 Production of interpolation grids for inclusive jet cross sections at ALICE — Héctor Pillot, Rachid Guernane, and Klaus Rabrertz — 1Université Grenoble Alpes (UGA) — 2Karlsruhe Institute of Technology (KIT) — 3Laboratory of Subatomic Physics & Cosmology (LPSC)

The APPLast project interfaces APPLgrid and fastNLO with the fixed-order cross section integrator NNLOJet. This produces interpolation grids that allow fast and accurate iterative computation of observables up to NNLO with different PDF sets or renormalization and factorization scales. This interface is employed in a workflow using the LAW and LUGI packages for workflow management. As an example, differential cross sections of inclusive jet production from pp collisions at a center-of-mass energy of 5.02 TeV are computed within this workflow and are compared to experimental data from the ALICE collaboration. The cross sections are measured as a function of the jet \(p_{T}\) and jet size parameter \(R\). The cross sections are also compared using different PDF sets including PDF uncertainties and renormalization and factorization scale variations.
T 139: Neutrinos VI

Time: Thursday 17:30–19:00

T 139.1 Thu 17:30 POT/0051 Status of the NUCLEUS experiment — Sebastian Dorer — Technische Universität Wien, Vienna, Austria

Coherent elastic neutrino nucleus scattering (CEvNS) is a well-predicted Standard Model process only recently observed for the first time. Its precise study could reveal non-standard neutrino properties and open a window to search for physics beyond the Standard Model.

NUCLEUS is a CEvNS experiment conceived for the detection of neutrinos from nuclear reactors with unprecedented precision at recoil energies below 100 eV. Thanks to the large cross-section of CEvNS, an extremely sensitive cryogenic target of 10g of CaWO4 and Al2O3 crystals is sufficient to provide a detectable neutrino interaction rate.

NUCLEUS will be installed between the two 4.25 GW reactor cores of the Chooz-B nuclear power plant in the French Ardennes, which provides an anti-neutrino flux of $1.7 \times 10^8$ ν/s (cm$^2$). At present, the experiment is under construction. The commissioning of the full apparatus is scheduled for 2023, in preparation for the move to the reactor site. In this talk we will discuss the NUCLEUS goals and sensitivity, as well as present the recent activities and progresses of the experiment.

T 139.2 Thu 17:45 POT/0051

Design and fabrication of MMC-based P2 detectors to be coupled to scintillating crystals at mK temperatures — Ashish Jadhav, Christian Enss, Andreas Fleischmann, Daniel Hengstler, Daniel Unger, and Lorenzana Gastaldo — Kirchhoff Institute for Physics, Heidelberg University, Im Neuenheimer Feld 227, 69120 Heidelberg, Germany.

We present the development of high-energy resolution integrated photon and phonon detectors (P2), based on low-temperature Metallic Magnetic Calorimeters (MMC) to be coupled to a scintillating crystal operated at 20 mK. The present design of P2 is based on a 3 inch wafer. The central part, of area 15 cm$^2$, is connected to the rest of the wafer through 7 legs fabricated using deep silicon etching and is used for the detection of visible photons emitted after the interaction of a particle in the crystal. On the outer part of the wafer, three double mean-der MMC detectors are fabricated as phonon detectors. They will be connected to the crystal for monitoring the increase in temperature upon the interaction of a particle. We aim at demonstrating an energy resolution better than 1 keV for the phonon detectors and a time resolution better than 1 μs for the photon detector. This detector development is part of the R&D for the AMoRE experiment searching for $\nu_e$ββ decay in $^{100}$Mo. Demonstrating the expected performance for P2 will have a substantial impact on background reduction and influence the design of detector modules for the next stage of the AMoRE experiment.

T 139.3 Thu 18:00 POT/0051

CEvNS and searches for new physics with the CONUS experiment — Sophie Armbuster for the CONUS-Collaboration — Max-Planck-Institut für Kernphysik, Heidelberg, Germany.

The CONUS experiment (Coherent elastic NeUtino nucleus Scattering) aims to detect coherent elastic neutrino-nucleus scattering (CEvNS) of reactor antineu-trinos on germanium nuclei in the fully coherent regime. The CONUS experiment — operated in the Brookod nuclear power plant (Germany) between April 2018 and December 2022— was located at 17m from the 3.9 GWth core. The possible CEvNS signature was studied with four 1 kg point-contact high-purity germanium (HPGe) detectors, which provided a sub keV energy threshold with background rates in the order of 10 events per kg, day and keV. The analysis of the final CONUS data set allows us to establish competitive limits on CEvNS from a nuclear reactor with a germanium target. The most recent results including constraints on the Standard Model parameters will be presented together with future plans of the project.

T 139.4 Thu 18:15 POT/0051

CNO solar neutrino measurement with Borexino detector: updated combined analysis with directionality constraint — Luca Pellicci — Forschungszentrum Jülich GmbH, Institut für Kernphysik IPK-2, Jülich, Germany — Johannesstrasse 22

Borexino was a large liquid scintillator experiment with an unprecedented level of radipurity, designed for real-time detection of low-energy solar neutrinos. It was located at the underground INFN Laboratori Nazionali del Gran Sasso, in Italy. During more than ten years of data taking, it has measured the neutrino flux from each individual within the proton-proton-chain, i.e. the main fusion process accounting for 99 % of the energy production of the Sun, and in the CNO cycle, responsible for the remaining 1%. To disentangle neutrino-induced sig- nals from residual background, a multivariate analysis was adopted, based on the fitting of the spectrum of Borexino events with Monte-Carlo simulated reference shapes. In recent years, through the method called "Correlated and Integrated Directionality" (CID) Borexino has also provided a proof of principle for the ex- ploitation of the sub-dominant Cherenkov information produced by sub-MeV solar neutrinos in a liquid scintillator detector. In this talk, the improvements and upgrades performed in recent years will be discussed. Furthermore, the combination of the two analysis approaches was recently exploited for a measurement of the CNO solar neutrinos with improved precision. The most recent results will be presented.

T 139.5 Thu 18:30 POT/0051

Looking for sterile neutrinos using the solar $\beta$ neutrino spectrum — Simon Appel and Lotthar Oberauer — Technische Universität München, München, Germany.

Solar $\beta$ neutrinos are detected via elastic scattering on electrons in large radiop- ure detectors. The expected upturn in the survival probability of solar $\beta$ neutrinos is not still detected. Current generation detectors struggle with several chal- lenges. Cosmic muons produce radiogenic isotopes that mimic the $\beta$ neutrino shape. Especially the long lived $^{13}C$ and $^{13}Be$ isotopes are problematic. External gamma background limits the fiducial volume. The expected upturn in the sur- vival probability of solar $\beta$ neutrinos is still not detected. Current Besides the MSW effect there is more physics beyond the standard model that could affect the neutrino survival probability. Light sterile neutrinos $\Delta m_{32}^2 = (0.7-2) \times 10^{-2}eV^2$ and flavor changing $\nu_e\nu_x$ interactions affect the survival probability in the same energy region as the MSW effect. This talk focuses on the ability of future de- tector generations exploring this parameter space. This work is supported by the DFG collaborative research centre 1258 "NDM", and the DFG Cluster of Excellence "Origins".

T 139.6 Thu 18:45 POT/0051

Directionality measurement of CNO neutrinos in the Borexino detector — Johann Martyn1 and Apeksha Singhal1,2,3 — 1Johannes Gutenberg-Universität Mainz — 2Forschungszentrum Jülich GmbH, Nuclear Physics Institute IPK-2 — 3II. Physikalisches Institut B, RWTH Aachen

Borexino has been a 280 l liquid scintillator detector situated at the INFN Labor- oratori Nazionali del Gran Sasso in Italy. With an unprecedented level of ra- diopurity and a 3800 m.w.e. of rock shielding its main goal is the measurement of solar neutrinos. Previously the Borexino collaboration has provided the first directional measurement of sub-MeV $\beta$ neutrinos using the so called "Corre- lated and Integrated Directionality" (CID). Here the known position of the Sun is correlated to the reconstructed photon direction, given by the hit PMT po- sition and the reconstructed event position. Cherenkov hits from the neutrino recoil electrons show a correlation to the position of the Sun, while the isotropic scintillation and background events are not. The integrated angular distribution of the hits for a large number of events then allows for the statistical inference on the number of neutrino events. This talk presents the CID measurement of CNO neutrinos, using the full Borexino detector live time from May 2007 to October 2021.

T 140: Gamma Astronomy VI

Time: Thursday 17:30–19:00

T 140.1 Thu 17:30 POT/0015

Signal extraction of raw simulated and laboratory data with the FlashCam camera for Medium Sized Telescopes in CTA — Clara Escandella, Felix Werner, and Jim Hinton — Max Planck Institut für Kernphysik, Heidelberg, Germany.

The Cherenkov Telescope Array (CTA) is the next generation observatory for very high energy (VHE) gamma rays. The southern CTA site will consist of large, medium (MST), and small size telescopes to cover a wide range of pho-
AUTOMAGIC and the Open-Source Python Package Gammapy

M. Dettmar

Telescopes like MAGIC. Gammapy requires event-based data combined with the multiple Imaging Atmospheric Cherenkov Telescopes (IACT) in different sizes, built based very-high-energy gamma-ray observatory. Both arrays will consist of multi-particle Physics, TUD Dortmund University, D-44227 Dortmund, Germany

setups and techniques is currently implemented. As for the analysis framework, it is reasonable to automate the analysis to save time for an analyzer and to deliver entirely reproducible results. The automation of the analysis of Sum-Trigger-II data was implemented in the autoMAGIC project which aims to automatize the entire MAGIC analysis chain.

A workflow for the pulsar timing and the pulsar analysis based on the autoMAGIC output is currently designed and implemented. It delivers results comparable to manual pulsar analyses.

In the future, the automatization of the analysis of Sum-Trigger-II data could be used for further optimizations of the low-energy analysis as well as for comparisons of low-energy data from MAGIC and the LST. In combination with the automatic pulsar analysis, this will enable the possibility to perform long-term pulsar analyses with a considerably small amount of work.

**T140.5 Thu 18:30 POT/0151 Automated Analysis of MAGIC Sum-Trigger-II Pulsar Data — Jan Lukas Schubert and Simone Mender for the MAGIC-Collaboration — TU Dortmund University, Dortmund, Germany**

The MAGIC telescopes are a stereoscopic system of Imaging Air Cherenkov Telescopes which is used for gamma-ray astronomy. A modern approach to an analogue trigger system, dubbed Sum-Trigger-II, low-energy data with a threshold as low as ~25 GeV can be recorded, enabling the MAGIC telescopes to perform comparably low energetic analyses such as pulsar analyses. This data requires a dedicated treatment adapted to the low energies. Since the analysis structure is complex, it is reasonable to automatize the analysis to save time for an analyzer and to deliver entirely reproducible results. The automatization of the analysis of Sum-Trigger-II data was implemented in the autoMAGIC project which aims to automatize the entire MAGIC analysis chain.

A workflow for the pulsar timing and the pulsar analysis based on the autoMAGIC output is currently designed and implemented. It delivers results comparable to manual pulsar analyses.

In the future, the automatization of the analysis of Sum-Trigger-II data could be used for further optimizations of the low-energy analysis as well as for comparisons of low-energy data from MAGIC and the LST. In combination with the automatic pulsar analysis, this will enable the possibility to perform long-term pulsar analyses with a considerably small amount of work.

**T140.6 Thu 18:45 POT/0151 Towards an automatic mode of operation of the MAM subsystem of MAGIC — Angela Bautista for the MAGIC-Collaboration — Max Planck Institute for Physics, Munich, Germany**

The MAGIC telescope system is sensitive to gamma rays in the very high energy range 20 GeV-100 TeV. Cherenkov light produced in extensive air showers is collected and used to estimate the primary gamma-ray energy. The atmosphere absorbs part of the Cherenkov light and the MAGIC LIDAR system is used to correct observations with zenith angles up to 60°. MAGIC observes sources above 60° using the Very Large Zenith Angle (VLZA) observation technique. The increased collection area during VLZA observations enables the study of PeVatron candidates with steep spectra extending to 100 TeV and beyond. At such large zenith angles, the column density of air exceeds the range covered by the LIDAR and a different atmospheric calibration technique is needed. The MAGIC Atmospheric Minion (MAM) was installed at the MAGIC site to correct for the atmospheric effects during VLZA observations. The task of MAM is to measure the atmospheric transmission in real-time either by using aperture photometry or spectroscopy of stars within the same sky region as the gamma-ray source of interest. Currently, a manual procedure for photometric calibration is already in place. This talk presents recent progress along with the next steps to advance towards an automatic mode of operation of the MAM subsystem.
cur. On September 18, 2022, a new alert by IceCube indicated that a high-energy neutrino arrived from the direction of TXS 0506+056, consistent with the model prediction. In this work, we show that these three distinct flares of neutrino emission from TXS 0506+056 are consistent with a SMBBH origin and constrain the total mass as well as mass ratio for the binary. We make predictions on when the next neutrino flares should happen and, for the first time, calculate the characteristic strain of its gravitational wave emission. *Supported by DFG (SFB 1491)

T 141.3 Thu 18:00 POT/0251 Time and Density Dependent Modelling of Hadronic and Leptonic Processes in Blazar Jets — Marcel Schiroller, Julia Becker Tjus, and Lukas Mertens — Theoretical Physics IV, Ruhr University Bochum, Germany

Active galactic nuclei (AGN), and the accompanied jets, are some of the most luminous objects in the observable Universe. Both the active cores and their jets are candidates for the engine of ultra high-energy cosmic rays, gamma rays, and neutrinos with the highest energies measured on Earth. In 2017, IceCube recorded an extragalactic high-energy neutrino event with a strong hint of a directional coincidence with the position of a known jetted AGN TXS 0505+056. A deep understanding of the processes related to jets will fuel the field of high-energy cosmic rays, fundamental plasma, astro, and particle physics. However, an AGN jet's physical and mathematical modelling is challenging, with ambiguous signatures that need to be understood by numerical simulations of cosmic ray transport and interactions. In this talk, we present a simulation framework for hadronic constituents and their interactions inside of a plasmoid propagating along the AGN jet axis, which is utilised to investigate the time- and density dependence of hadronic interactions in blazar jets and their effects on multi-messenger spectra. Furthermore, we will provide deeper insights into the results of such simulations and discuss how to include non-linear leptonic radiation processes into our test particle simulation framework for a more complete, physical description of processes in AGN jets. *Supported by DFG (SFB 1491).

T 141.4 Thu 18:15 POT/0251 Seasonal Variations of the Atmospheric Neutrino Flux measured in IceCube — Karolin Hymon and Tim Ruhi for the IceCube-Collaboration — Technische Universität Dortmund, Germany

The IceCube Neutrino Observatory measures high energy atmospheric neutrinos with high statistics. These atmospheric neutrinos are produced in cosmic ray interactions in the atmosphere, mainly by the decay of pions and kaons. The rate of the measured neutrinos is affected by seasonal temperature variations in the Stratosphere, which are expected to increase with the particle’s energy. In this contribution, seasonal energy spectra are obtained using a novel spectrum unfolding approach, the Dortmund Spectrum Estimation Algorithm (DSEA+), in which the energy distribution is estimated from measured quantities with unfolding approach, the Dortmund Spectrum Estimation Algorithm (DSEA+), in which the energy distribution is estimated from measured quantities with machine learning algorithms. The seasonal spectral difference to the annual average flux will be discussed based on preliminary results from IceCube’s atmospheric muon neutrino data. *Supported by DFG (SFB 1491).

T 142: Neutrinos, Dark Matter XI

Time: Thursday 17:30–19:00

T 142.1 Thu 17:30 POT/0361 The finestructure in the reactor antineutrino spectrum and its implications on the JUNO NMO sensitivity — Tobias Heinz, Lukas Bieger, Marc Breisch, Jessica Eck, Benedict Kaiser, Tobias Lachenmaier, and Tobias Steff — Berekarl Karls Universität Tübingen, Physikalisches Institut

To determine the neutrino mass ordering (NMO) with the Jiangmen Underground Neutrino Observatory (JUNO) a precise knowledge of the antineutrino spectrum emitted by nuclear reactors is crucial. New model predictions of the reactor antineutrino spectra show the possible existence of a finestructure in the spectrum that has not been measured which yet can have an impact on the sensitivity of the NMO determination using a detector of unprecedented energy resolution of 3% at 1 MeV eν.JUNO. This talk will focus on the study of those implications on the NMO sensitivity of JUNO as well as on the possibility to reduce this impact by measuring an oscillated reactor antineutrino spectrum with high energy resolution by JUNO’s satellite detector TAO as a reference. This work is supported by the Deutsche Forschungsgemeinschaft.

T 142.2 Thu 17:45 POT/0361 Investigating atmospheric neutrino-antineutrino separation in JUNO — Achilleas Patihas1, Aachim Stahl1, and Thilo Birkenfeld2 for the JUNO-Collaboration — 1. Physikalisches Institut 8, RWTH Aachen Universität

The CP-violating nature of neutrinos has drawn a lot of attention after the discovery of neutrino oscillations. Atmospheric neutrinos appear in a broad energy range and with high flux of neutrinos and anti-neutrinos which makes them suitable candidates for the study of their CP properties. The Jiangmen Underground Neutrino Observatory (JUNO) will provide atmospheric neutrino data with high statistics and excellent energy resolution. In this study we investigate the required separation accuracy for neutrinos and anti-neutrinos to measure CP-violation with the JUNO detector.

T 142.3 Thu 18:00 POT/0361 UV-complete Dark-Matter models and the ATLAS missing-energy-plus-jets measurement — Martin Haredink and Priscilla Pani — Deutsches Elektronen-synchrotron (DESY) Zeuthen

In the Standard Model, the final state of missing energy and at least one jet (MET+jets) at colliders can be mostly attributed to the production of vector bosons in association with jets. Events with Dark Matter in the final state would however contribute to this channel. It offers therefore a powerful handle in observing or constraining Dark-Matter models. Traditionally, mostly simplified Dark-Matter models have been used to interpret the MET+jets final state at the LHC. UV-complete models like the two-Higgs-doublet-model with a pseudoscalar mediator to Dark Matter (2HDM+a) provide however a more complex phenomenology, offering many processes that can contribute to the MET+jets final state. In this talk, insights into the ATLAS measurement of the MET+jets final state in 139 fb−1 of proton–proton collision at 13 TeV are given. Unfolding the measurement allows for direct comparisons to predictions of Standard-Model and beyond without having to take into account detector effects. This is demonstrated in interpreting the measurement with respect to the 2HDM+a and setting stringent parameter constraints on the latter.
T 142.4 Thu 18:15 POT/0061
Constraining the dark matter distribution of galaxy clusters — LUKAS NICKEL — TU Dortmund University

Dark matter remains one of the unsolved mysteries of modern astrophysics. Many phenomena can only be explained under the assumption of an additional matter component, yet - despite searches in all channels - no clear detection was made so far.

One way dark matter could be found, is to look for an excess in gamma-rays from regions with high concentrations of dark matter. Assuming that the unknown particle(s) decay/annihilate into standard-model particles, they would produce gamma-rays even without direct electromagnetic interaction.

To estimate the expected signal, the distribution of dark-matter in an astrophysical object needs to be determined first. This talk will focus on constraining the dark-matter content of nearby galaxy clusters using the CLUMPY software package, presenting current results and discussing implications for gamma-ray observations.

T 142.5 Thu 18:30 POT/0061
Dark Matter Annihilation in NGC 1068 — ALESSANDRA SCHOLZ and LI RUO-HAN — TU München

If Dark Matter (DM) is of particle nature, the Weakly Interacting Massive Particle (WIMP), with an expected mass in the range of some GeV to TeV, detectable by the IceCube telescope, would be a possible candidate. For the barred spiral galaxy NGC 1068 we calculated the neutrino flux from the spike of the super massive black hole (SMBH), and the disk, induced from DM self-annihilation into Standard Model (SM) particles. The calculation was performed for the DM masses 100 GeV, 1 TeV, and 10 TeV, and different Navarro-Frenk-White (NFW) density profile parameters. The annihilation branch ratios and neutrino energy spectra were simulated with the software Pythia and MadDM. Comparing IceCube data from NGC 1068 with the results for those three masses, the TeV Dark Matter annihilation scenario has no conflict with the spectrum shape from NGC 1068. Therefore, DM can be a potential explanation for the neutrino flux from NGC 1068.

T 142.6 Thu 18:45 POT/0061
multi-particle dark matter: how to get the hint — SUBHADITYA BHATTACHARYA1, PURBASWOR GHOSH2, JAITTA LAHRI1, and BISWAPUR MUKHOPADHYAYA1 — 1Indian Institute of Technology, Guwahati, India — 2Indian Association for the Cultivation of Science, Kolkata, India — 3II. Institut für Theoretische Physik, Universität Hamburg, 22761 Hamburg, Germany

We investigate ways of identifying two kinds of dark matter component particles at high-energy colliders. The strategy is to notice and distinguish double-peaks (humps) in some final state observable. We carried out our analysis in various popular event topologies for dark matter search, such as mono-X and n-leptons+n-jets final state along with missing energy/ transverse momenta. It turns out that an e+ e- collider is suitable for such analyses. The observables which are best-suited for this purpose have been identified, based on the event topology. The implication of beam-polarization is also explored in detail. Lastly, a quantitative measure of the distinguishability of the two peaks has been established in terms of a few newly-constructed interesting variables.

T 143: Neutrinos VII

Time: Thursday 17:30–19:00
Location: POT/0006

The work is supported by the Cluster of Excellence PRISMA+, the DFG Sonderforschungsbereich 1258 and the Bundesministerium für Bildung und Forschung (BMBF Verbundprojekt 05H2018: R&D Detectors and Scintillators).

T 143.1 Thu 17:30 POT/0006
Development of novel water-based liquid scintillator with pulse-shape discrimination capabilities — HANS THEODOR JOSEF STEIGER1,2, MATTHIAS RAPHAEL STOCK3, MANUEL BOHLES2, DAVID DÖRFLINGER2, ULRIKE Fahrenholz2, DANIELLE GUFFANTI2, MEISHU LU2, LOTHAIR OBERAUER2, ANDREAS STEIGER2, MICHAEL WURM1,2, and DORINA ZUNDDEL2 — 1Cluster of Excellence PRISMA+ — 2Joanneum Research, Austria — 3Technische Universität München — 4Universität degli Studi di Milano-Bicocca

Future hybrid detectors in the field of neutrino physics have to combine high-resolution energy detection down to low thresholds by scintillation light detection and directional reconstruction with the help of Cherenkov radiation. The spectrum of potential applications is broad, ranging from long-baseline oscillation experiments to the measurement of low-energy solar neutrinos. One possible detector medium for these next-generation detectors is Water-based Liquid Scintillator (WbLS). Here, organic scintillators are dissolved colloidal in small quantities in highly pure water with the aid of surfactants. In this talk, a novel WbLS (based on Triton X-100) will be presented. Particular attention will be paid to its key properties, such as micelle size, scattering length and transparency. In addition, a study of its light yield as well as pulse-shape discrimination capabilities will be presented.

This work has been supported by the Clusters of Excellence PRISMA+ and ORIGINS, the DFG Sonderforschungsbereich 1258 as well as the Bundesministerium für Bildung und Forschung (Verbundprojekt 05H2018: R&D Detectors and Scintillators).

T 143.2 Thu 17:45 POT/0006
Development of novel organic liquid scintillators with slow light emission — MANUEL BOHLES2, HANS THEODOR JOSEF STEIGER1,2, DAVID DÖRFLINGER2, LOTHAIR OBERAUER2, MATTHIAS RAPHAEL STOCK3, and MICHAEL WURM1,2 — 1Joanneum Research, Austria — 2Cluster of Excellence PRISMA+ — 3Technische Universität München

One of the most promising approaches for the next generation of neutrino experiments is the realization of large hybrid Cherenkov/scintillation detectors made possible by recent innovations in photodetection technology and liquid scintillator chemistry.

This talk will focus on the development of such detector liquids with particularly slow light emission. Various attempts are currently underway, such as the use of special wavelength shifters or the use of blended multi-solvent cocktails. Several of these mixtures are compared with respect to their fundamental characteristics (scintillation efficiency, transparency, and time profile of light emission).

In addition, the optimization of the admixture of wavelength shifters for a scintillator with particularly high light emission and pulse shape discrimination capability is presented. Newly developed purification methods based on column chromatography and fractional vacuum distillation for several candidate solvents are also discussed.

T 143.3 Thu 18:00 POT/0006
Fluorescence Time Profiles of Slow Organic and Water-Based Liquid Scintillators using a Pulsed Neutron Beam — MATTHIAS RAPHAEL STOCK2, HANS STEIGER2, LOTHAIR OBERAUER2, DAVID DÖRFLINGER2, ULRIKE Fahrenholz2, MANUEL BOHLES2, STEFAN SCHOPPMANN2,3, LUCA SCHWEIZER2, KORBINIAN STANGLER2, and DORINA ZUNDDEL2 — 1Physik-Department, Technische Universität München — 2Joanneum Research, Austria — 3Institute of Physics and Cluster of Excellence PRISMA+ — 1University of California, Department of Physics, Berkeley, CA 94720-7300, USA

We performed two liquid scintillator (LS) characterization experiments using a pulsed neutron beam at the CN accelerator of INFN Laboratori Nazionali di Legnaro. At different energies ranging from 3.5 MeV to 5.5 MeV, one experiment measures the quenching factor of recoil protons while the other measures the fluorescence time profile of recoil protons. This talk is about the time profile experiment, where we study profiles of slow organic and water-based LS mixtures, which will be relevant for future neutrino detectors, e.g., Theia. Differences in the time profiles after gamma and neutron excitation would open the window to perform pulse shape discrimination and therefore advances the ability to distinguish the neutrino signal from background. This work is supported by the BMBF Verbundforschung 05H2018 “R&D Detektoren (Scintillatoren)”, the DFG CRC 1258 “NDM”, the DFG Clusters of Excellence “PRISMA+” and “Origins”.

T 143.4 Thu 18:15 POT/0006
Background investigations with passive transverse energy filters at KATRIN — DOMINIC HINZ for the KATRIN-Collaboration — Karlsruhe Institute of Technology (KIT)

The measurement of the absolute mass scale of neutrinos with an unprecedented sensitivity of 0.2 eV/c² is the key goal of the KATRIN experiment. This requires a detailed understanding of background processes in the large main spectrometer. Currently, the measured background level exceeds the expected value by more than one order. An initial model assigned background events to originate from Rydberg H-states generated by the decay of traces of surface-implanted Pb-210. Highly-excited Rydberg states from the inner spectrometer surface are long-lived and can be ionized by thermal radiation. The resulting low-energy electrons on the MeV-scale are then accelerated by the retarding potential, thus they only possess a very small transverse energy, which is in contrast to signal electrons. In a first step we have performed measurements with a passive transverse energy filter (pTEF) implemented as a micro-structured honeycomb gold plate. In this talk we present the measured transmission of background electrons through the pTEF and compare results at different magnetic field values with the initial and refined background models.
Despite advances in background reduction, the elevated background level prevents measurements from an implementation of an aTEF at KATRIN. Concerning the potential background reduction and related sensitivity improvement, the use of the specific angular distribution of the background and discriminates electrons at the detector based on their pitch angle. The contribution presenstudies concerning the potential background reduction and related sensitivity improvement from an implementation of an aTEF at KATRIN.

One option to reduce the background is the implementation of an active Transverse Energy Filter (aTEF) — Sonja Schneiderswind, Kevin Gauda, Kyrill Blumé, Christian Gönnle, Volker Hannen, Hans-Werner Oretjohann, Wolfram Pernicka, Lukas Pollitsch, Richard Salomon, Maik Staffers, and Christian Weinheimer. — Institute for Nuclear Physics, University of Münster — CeNeT and Physics Institute, University of Münster — Kirchhoff-Institute for Physics, University of Heidelberg — KATRIN Collaboration

The KATRIN experiment inverts at the direct measurement of the incoherent sum of neutrino masses via precision endpoint spectroscopy of the tritium β-decay. Despite advances in background reduction, the elevated background level prohibits to achieve the target sensitivity of 0.2 eVc² (90% C.L.).

Our results show that the parameters as reported by the Pierre Auger Collaboration, on the arrival direction of UHECRs showed the presence of anisotropies above 40 EeV which indicates the contribution from nearby sources such as starburst galaxies (SBG) and active UHECR sources. A key role is played by the Galactic magnetic field (GMF), which influences the arrival direction of charged particles. Recent studies, by the Pierre Auger Collaboration, on the arrival direction of UHECRs showed the presence of anisotropies above 40 EeV which indicates the contribution from nearby sources such as starburst galaxies (SBG) and active Galactic nuclei (AGN). The likelihood analysis revealed a significance of 4.2σ for the starburst galaxies. Although the coherent deflections related to the GMF have not been considered.

In this work we focus our attention on the SBG catalog and we conduct the likelihood analysis on simulated datasets. The mock datasets are constructed by employing CRPropa3 for the extragalactic propagation and by adding an isotropic background. A lensing technique, considering the H12 model for the GMF, is then applied to the simulated particles.

Our results show that the parameters as reported by the Pierre Auger Collaboration occur for 20% of all data sets. However, due to the neglected coherent deflections, the inferred anisotropy fraction is a biased estimator and the true anisotropic fraction is always larger than the one derived from the likelihood fit.

An all-sky search method for coherent magnetic field deflections of ultra-high-energy cosmic rays — Josina Schulte, Teresa Bister, and Martin Ermenn — III. Physikalisches Institut A, RWTH Aachen University — Institute for Mathematics, Astrophysics and Particle Physics, Radboud University Nijmegen.

We present a method of searching for coherent deflection patterns in ultra-high-energy cosmic ray arrival directions induced by the Galactic magnetic field. These patterns are described by a variable magnetic field strength in combination with adaptable coefficients of a spherical harmonics expansion in our approach. The reconstruction of the free model parameters from the arrival directions is performed with a likelihood-free method in a Bayesian approach based on normalizing flows. This allows for a straightforward assessment of the uncertainty on the model prediction. We evaluate the sensitivity of the method to identify the presence of coherent magnetic field deflections on a realistic simulated astrophysical scenario.

The effects of a ΛCDM extension on the propagation of UHECRs — Jannning Meierert — Bergische Universität Wuppertal, Gaulstraße 20, 42119 Wuppertal, Germany.

Current tensions in the cosmological parameters of ΛCDM (such as H₀, Ωₓ, Ωₐ) motivate a possible extension. Treating the photon propagation in thermal equilibrium with an SU(2) gauge group instead of a U(1) gauge group gives the photon more degrees of freedom and thus changes the temperature redshift relation.

Investigation of electron backscattering for the TRISTAN project — Daniela Spreng — Technical University Munich, James-Franck-Straße 1, 85748 Garching bei München.

One open question in the field of neutrino physics is the existence of keV-sterile neutrinos, which would be a possible Dark Matter candidate. They are experimentally accessible through their mixing with the active neutrino flavours and would therefore lead to a kink-like distortion in the beta-decay spectrum. The KATRIN experiment aims to search for this kink-like structure in the tritium beta-decay spectrum by installing a new multi-pixel silicon drift detector named TRISTAN. To resolve the kink, the detector electron response has to be very well understood. In this talk the effect of the backscattering on the detected electron spectrum for different initial electron energies and incident angles will be presented. To analyse these effects, a dedicated test stand was built and measurements were compared to Geant4 simulations.

This project has received funding from the European Research Council (ERC) under the European Union Horizon 2020 research and innovation program (grant agreement No. 852845). This work is supported by BMBF (05A17PM3, 05A17PX3, 05A17VK2, 05A17W03), KSETA, the Max Planck society, and the Helmholtz Association.

Cosmic-ray signatures in dwarf galaxies: astrophysical foreground and dark-matter background — Athitya Aravintan, Lukas Mertens, Julia Becker Tius, and Jurek Volp — Theoretische Physik IV, Ruhr-Universität Bochum, Bochum, Germany — TRAP-Center, Ruhr-Universität Bochum, Bochum, Germany.

Dwarf galaxies are a convenient testing ground in the search for Dark Matter (DM), owing to their low, astrophysical background by the radio and gamma-ray energies. Studying the multimessenger signatures of dwarf galaxies can lead to a more precise astrophysical background for DM searches, thereby improving the current limits on indirect DM detection. This motivates the study of nearby starburst galaxies like IC10, which produces non-thermal radio emission coupled to complex Cosmic Ray (CR) propagation.

The goal of this work is to understand the role of CRs in low-mass dwarf galaxies by modelling their propagation using the open-source tool CRPropa 3.2. First test results, starting with a general propagation environment in CRPropa, are pursued in a generic starforming-type magnetic field for IC10, and will later be modified for other low-mass galaxies. For the first time, the modelling is done in combination with astrophysical data on magnetic field structure and gas densities with the goal of pursuing a coherent understanding of the outflow produced in dwarf galaxies. Supported by DFG (SFB 1491).

Stochastic modelling of cosmic ray sources for diffusive high-energy neutrinos — Anton Stoll and Philipp Mertsch — Institute for Theoretical Particle Physics and Cosmology (TTK), RWTH Aachen University, Aachen, Germany.

Cosmic rays of energies up to a few PeV are believed to be of Galactic origin, yet individual sources have still not been firmly identified. Due to inelastic collisions with the interstellar gas, cosmic-ray nuclei produce a diffuse flux of high-energy gamma-rays and neutrinos. Fermi-LAT has provided maps of galactic gamma-rays at GeV energies which can be produced by both hadronic andonic processes. Neutrinos, on the other hand, are exclusively produced by the sought-after hadronic processes, yet they can be detected above backgrounds only at hundreds ofTeV. To predict diffuse emission at these high energies, one can extrapolate from the GeV maps, but it is an open question to what extend this is justified. It can be expected that the consideration of individual cosmic ray sources instead of a smooth density limits the correlation of the maps at TeV energies compared to the ones at GeV energies. Such a modelling of sources should be done stochastically. In a first step, we investigate the modelling of multiple point sources and the extension to a stochastic model.
Diffuse Emission of Galactic High-Energy Neutrinos from a Global Fit of Cosmic Rays — GEORGO SCHWEFFER, PHILIP MERTSCH, and CHRISTOPHE WEHRNEN

The Pierre Auger Observatory is a large-scale experiment for the detection of ultra-high-energy cosmic rays. To this end, a combination of surface detectors as well as fluorescence telescopes is used to measure extensive air showers initiated by cosmic-ray particles in the atmosphere. Aelous is a satellite, operated by the ESA, with the purpose of measuring global wind profiles. To achieve this, it uses a UV-lidar which emits laser beams towards the surface of the Earth. When the satellite passes over the Pierre Auger Observatory, light scatters off the laser beam in the atmosphere which can be detected by the Fluorescence Detector. The laser data taken by the Observatory allowed for a reconstruction of the laser tracks for several overpasses each year since its first appearance in 2019. The reconstructed laser tracks provide an interesting approach to study the aerosol content of the atmosphere above the Observatory, as well as a novel way to perform ground-truthing for space-based lidars.

In this presentation, we will explain the methods used to reconstruct laser tracks from the Fluorescence Detector data, show some results of this reconstruction and introduce a possible application of the data for the measurement of aerosols.
Real-time alignment and calibration for Run 3 at the LHCb experiment —
BILIANA MITRESKA and JAHANNES ALBRECHT — TU Dortmund University, Dortmund, Germany
The real-time alignment and calibration procedure is a fully automatic procedure at LHCb that is executed at the beginning of each fill of the LHC. The alignment estimates the position of detector elements and the correct alignment contributes to improving the data for offline analysis. Its importance in Run 3 is even more enhanced due to having a fully software trigger at LHCb. The procedure is implemented for the full tracking system at LHCb with the event reconstruction run as a multithreaded process. The operational and technical point of view of this procedure during the Run 3 data-taking is discussed with the focus on performance and optimisations done regarding the new computing framework and the new detectors.

Online data reduction with the FPGA-based DATCON track reconstruction system at the Belle II Detector — FLORENI BERNLOCHNER, BRUNO DESCHAMPS, Jochen Dingfelder, Ralf Farkas, and Botto Fischer for the Belle II Collaboration — Physikalisches Institut der Rheinischen Friedrich-Wilhelms-Universität Bonn
The DATCON system is a set of 15 FPGAs, deployed at the Belle II detector at the KEK facility in Tsukuba, Japan. Its purpose is the real-time reduction of the data stream of the two innermost PXD detector layers, by defining regions of interest (ROI) on them. Only the hit information of the pixels located inside these ROIs are to be further processed and saved. DATCON uses the information of the SVD layers of the detector, finds tracks using a Hough Transformation-based track reconstruction algorithm and extrapolates them towards the center of the detector, to the PXD layers. While the track reconstruction algorithm itself has already been validated both on Hardware and Software, further work is required to improve the stability and reliability of the system. This talk will highlight the recent changes and improvements of DATCON.

Techniques for the investigation of segmented sensors using the Two Photon Absorption - Transient Current Technique — SEBASTIAN PAP1,2, MICHAEL MOLL1, ESTEBAN CURRAS1, and MARCOS FERNANDEZ GARCIA1,3 — CERN
1TU Dortmund University — 2Instituto de Fisica de Cantabria
The Two Photon Absorption - Transient Current Technique (TPA-TCT) is a technique for the characterisation of radiation detectors with three dimensional resolution. The TPA-TCT setup at CERN is designed for the investigation of silicon based detectors and uses a 430 fs pulse fiber lasers, with a wavelength of 1550 nm, which is in the quadratic absorption regime of silicon. Highly focusing optics are used to only generate excess charge carriers in a small volume (approximately 1 μm × 1 μm × 20μm) around the focal point of the laser beam, which enables a resolution in all three spatial directions. This three dimensional resolution is particular useful for the investigation and characterisation of segmented detectors. This talk introduces the TPA-TCT and the setup at CERN. Further, the weighted prompt current method is presented, which allows to investigate the electric field of segmented sensors. The method is demonstrated on various segmented sensors: a HV-CMOS CCDPv3, a Micron strip detector, and a passive CMOS strip detector. Further, the mirror technique is presented, which exploits a reflection of the rear side, to probe below front surface metallisations.

Prototype studies of a liquid organic TPC for the detection of low energy antineutrinos — MALTE GÖTTSCHKE, NIKLAS HERRMANN, THOMAS RADERMACHER, STEFFAN ROTH, and JEN-NIE SCHNEBBACH — RWTH Aachen University - Physics Institute III B, Aachen, Germany
Liquid organic time projection chambers, LOr-TPCs, can potentially be used to detect and measure low energy antineutrinos. One application would be monitoring antineutrinos from nuclear waste via inverse beta decay. Using an organic liquid as drift medium has the advantage of room temperature operation, but the measurement is very sensitive to impurities. Therefore, we set up a prototype including a purification system, which contains a turbomolecular pump, a boiler, a condenser and filters. The status of the prototype setup is presented.

Detection of Low-Energy Antineutrinos with Liquid-organic Time Projection Chambers — MARIKE ELLEBROEK1, MALTE GÖTTSCHKE2, NIKLAS HERRMANN1, THOMAS RADERMACHER3, STEFFAN ROTH1, and JEN-NIE SCHNEBBACH1,2 — RWTH Aachen University - Physics Institute III B, Aachen, Germany — 2RWTH Aachen University - Nuclear Verification and Disarma-
ment, Aachen, Germany
The region of antineutrino energy of a few MeV is of special interest for physics research and for the application of antineutrino-monitoring in the nuclear safeguards regime. Typically, scintillation detectors are used to detect these low-energy antineutrinos via the inverse beta decay (IBD) by reconstructing the time-correlated light signals of the positron annihilation and the neutron capture. A novel detection concept utilizing a time projection chamber (TPC) filled with an organic liquid (LOr) could enable a background-minimized detection of the antineutrino since it allows the reconstruction of all final state particles in the IBD event. From the positron track the antineutrino's initial energy and its vertex can be determined. If the energy deposition of the neutron-induced proton recoils can be detected it offers the possibility to reconstruct the antineutrino di-
rection on an event-by-event basis. We are investigating the IBD signature with a Geant4-based simulation together with a subsequent modelling of the electron drift. Additionally, we are working on prototype measurements and simulations to study the feasibility of such a LOr-TPC. This talk presents the status of our studies.

Stimulated de-excitation of Rydberg atoms in KATRIN using THz radiation* — SHIVANI RAMACHANDRAN, ENRICO ELLINGER, and KLAUS HELBIG for the KATRIN-Collaboration — Bergische Universität Wuppertal (BUW)
The key requirement for the KArlsruhe TRiumf Neutrin experiment (KATRIN) to reach its goal sensitivity of 200 meV at 90 % (C.L.) in measuring the effective electron anti-neutrino mass is minimal background. Several background suppression methods have already been implemented to achieve that and eliminate some known contributors. The most dominant contribution to the background in the measured signal is electrons produced by the thermal ionization of Rydberg atoms. They originate due to the sputtering of 232Th from the radioactive from the walls of the KATRIN main spectrometer. A plausible method is using THz and microwave radiation (method developed by ASACUSA CERN) for dedicated stimulated de-excitation which can lead to a shorter lifetime of Rydberg atoms. The influence of THz light source in the main spectrometer along with the state and spatial evolution of the Rydberg atoms is presented via simulations. The effect of the properties of the ionization electrons on the de-excitation method is discussed.

*Gefördert durch die BMBF-Verbundforschung Astroteilchenphysik

Measuring Large Energy deposition with HV-MS — DANIUS ALAM for the HD-HVMAPS-Collaboration — Physikalisches Institut, Heidelberg University
In high-energy physics experiments, the increasingly challenging physics demands high-rate detectors with excellent spatial and time resolution. High Voltage - Monolithic Active Pixel Sensor (HV-MS) fabricated in HV-CMOS processes provides fast charge collection via drift and enables the implementation of readout and the sensitive volume on the same die. Currently, the first tracking detector utilizing ultra-thin HV-MS chips is under construction for the Mu2e experiment.

At present, typical HV-MS detectors can measure energy depositions of the order of several 10 keV before the in-pixel charge-sensitive amplifier suffers saturation effects. The primary goal of the test chip Run2021V3 is to extend the measurable range and improve the precision of the measurements, which will allow detailed studies of the energy deposition of traversing particles, e.g., for particle identification. In the scope of this talk, the first characterization results of the Run2021V3 prototype will be presented.

Charge Deposition and Charge Collection in HV-MS — RUBEN KOBL for the HD-HVMAPS-Collaboration — Physikalisches Institut Universität Heidelberg
Modern particle physics experiments have an ever growing demand on high rate detectors which combine precise spatial and time resolution. These require
Charge deposition and charge collection process in this sensor is investigated to improve the further design of HV-MAPS. The signal was studied in dependency of high voltage for a 4 eV electron beam, 5.9 kV electrons from a $^{35}$Fe and electrons from a $^{197}$Au source. A complementary study using a test circuit to inject charge directly into the amplifier was performed.

T 147.3 Thu 18:00 WIL/A317
Charge collection study of thin HV-MAPS — David Maximilian Immig for the HD-HVMAPS-Collaboration — Physikalisches Institut Universität Heidelberg
High-voltage monolithic active pixel sensors (HV-MAPS) combine the advantages of MAPS with fast charge collection via drift in a reversely biased diode. The amount of collected signal charge is influenced by two factors, the applied bias voltage and a dependent unknown fraction due to diffusion from the undepleted region. The former, determines the depleted volume intended for charge collection, as well as the detector capacitance. In the case of ultra thin sensors (e.g. 50 nm), the depletion depth is limited by the sensor thickness and a contribution by diffusion is no longer applicable at full depletion. An measurement campaign with sensors of various thickness was performed to investigate and determine the size of these contributions. In this talk, first results extracted from this extensive data set are presented.

T 147.4 Thu 18:15 WIL/A317
Radiation damage studies of a HV-MAPS detector — Maja Lecher, Lucas Dittmann, Sebastian Bachmann, and Ulrich Uwer — Physikalisches Institut, Heidelberg, Germany
As one cornerstone of the prospective LHCb upgrade during Long Shutdown 4 in 2023, the current Scintillating Fibre tracker is set to be replaced by the MightyTracker, which combines scintillating fibres with radiation-hard silicon pixel detectors. The MightyPix sensor proposed as pixel detector employs the relatively new HV-MAPS technology. In preparation for the LHCb upgrade, the AtlasPix 3.1, a detector of similar build as the mightyPix, was studied with an emphasis on radiation damage. While a number of studies investigating the damage sustained by HV-MAPS from radiation exist, irradiation campaigns to date were carried out using unpowdered sensors. In a first proof-of-principle measurement, we irradiated a powdered AtlasPix 3.1 with 14 MeV protons at the Bonn Isochronous Cyclotron. Specific sensor characteristics, most notably the leakage current, power consumption, and signal response, were tested before, during, and after the irradiation in an effort to evaluate the performance and viability of HV-MAPS in the radiation environment expected for the MightyPix. Results from these studies are presented and discussed.

T 147.5 Thu 18:30 WIL/A317
Diamond detector research — Holger Stevens, Patrick Hoekken, and Johannes Albrecht — TU Dortmund University, Dortmund, Germany
The need for radiation-hard detectors is growing steadily. Compared to other semiconductor materials, diamond has a low leakage current, due to it's large bandgap and is very radiation-hard. This talk will present the experimental setups, which are developed for characterisation of diamond sensors. The radiation source used in these setups is Strontium (Sr90). In addition, the process to create gold contact surfaces in variable dimensions is described. The possible usage of diamond sensors for the precise dose profile measurement of large radiation fields is discussed and the option for spectrometric energy measurements is presented.

T 147.6 Thu 18:45 WIL/A317
Implementation of diamond as detector material in AllPix Squared — Faiz Ur Rahman Is-Hazazi — TU Dortmund, Germany. Kabul University, Afghanistan
Monte-Carlo-based simulation of particle interactions with matter is a very important tool for detector development in high-energy physics and related fields since it allows testing of detector concepts in-silico before investing money and time in building the detectors. A widely used software framework in the high-energy physics community is AllPix Squared, based on GEANT4. It was started to simulate testbeam setups with silicon detectors but has garnered interest from a wider community by now. To extend the AllPix Squared framework and make it useful for further detector development, different sensor materials need to be implemented. My work is intended to implement the Diamond material. Diamond sensors are considered superior to others because of their faster signal generation, better radiation hardness, thermal properties, and ability to operate in harsh conditions. To test the implementation, given sensors are used in real test beam measurements where hits on the device under test (DUT) are extrapolated against a row of well-known detectors, called Beam Telescope. Implementation of Diamond sensor material will significantly contribute to the task of R&D of Diamond sensors by making the simulated prototype simply possible. I will present the status of the implementation of the diamond as detector material in AllPix Squared.

T 148: Si/SiPM, Pixel/Other

Time: Thursday 17:30–19:00
Location: WIL/A124

T 148.1 Thu 17:30 WIL/A124
Study of the self-heating in SiPMs — Carmen Victoria Villalba Petro, Erika Garbutti, Robert Klaer, Stephan Martens, and John Schwandt — Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland
The main effect of radiation damage in a Silicon-Photomultiplier (SiPM) is a significant increase in the dark current. For SiPMs irradiated at $\Phi_{eq} = 10^5 \text{ cm}^{-2} \text{ eV}^{-1}$ and operated at 2 V above breakdown voltage, $\text{V}_{\text{leak}}$, the leakage current leads to a power of 50 mW. Such power produces an instantaneous increase in the SiPM temperature, which needs to be cooled down by proper thermal contact to a cooling system. The performance of the SiPM changes with temperature (T). The Vleak increases with T. For a fixed bias voltage, this leads to a decrease in gain and PDE. A method has been developed to determine the SiPM temperature increase induced by the power dissipated in the SiPM multiplication layer. Heating studies were performed with a KETEK SiPM, glued on an $\text{Al}_2\text{O}_3$ substrate, which is expected to heat up due to the emission of thermal infrared to a probe station or through layers of material with well-known thermal resistance. The SiPM is illuminated by a LED operated in DC-mode. The SiPM current is measured and used to determine the steady-state temperature as a function of power dissipated in its multiplication region and of the thermal resistance, as well as the time constants for heating and cooling. The method is applied to MPPC samples before and after irradiation. The knowledge of the temperature dependence can be used to properly determine the working parameters of irradiated SiPMs.

T 148.2 Thu 17:45 WIL/A124
Integration time dependence of sipm performance parameters — Katja Neumann, Erika Garbutti, John Schwandt, and Jack Rolph — Universität Hamburg, Luruper Chaussee 149, 22761 Hamburg, Deutschland
The research on Silicon Photomultiplyers (SiPMs) and their characteristic parameters has increased strongly due to their advantages as photon detectors. The standard way to obtain these parameters from the charge spectra of SiPMs is to fit a model based on (generalized) Poisson distributed Gaussian functions to the low light intensity response spectra. However, this method has the disadvantage that it only describes the photo-electron peaks but not the regions between them, which means that a large amount of information is lost, for example about the dark-count rate (DCR) or after-pulsing. Thus a description of the whole spectrum in a single model is practical. The Python program PeakOTron is based on a model, that describes the entire spectrum. This program has been tested on the low light intensity spectra obtained by integrating the charge at various gate lengths, for two SiPM types operated at various overvoltage. The parameters and fitted spectra determined with this method are discussed and compared to those obtained with standard methods.

T 148.3 Thu 18:00 WIL/A124
Design and Production of Pixel Strips for the P2 Tracking Detector Modules — Lucas Sebastian Binn for the P2-Collaboration — Institute of Nuclear Physics, Johannes Gutenberg-University Mainz, Germany
The P2 Experiment will make use of the new Mainz Energy-Recovering Superconducting Accelerator (MESA), currently under construction in Mainz, to measure the weak mixing angle in electron-proton scattering at low momentum transfer with unprecedented precision. A key parameter for the analysis, the momentum transfer $Q^2$, is measured by a tracking detector consisting of 8 identical modules. Each module consists of two sensor planes, with pixel sensors glued and wire-bonded on rigid-flex strips. Commercially available and custom solutions for the production of the strip module design are currently being evaluated. With a total production of 260 strips, processes are semi-automated, with dedicated glue and bonding machines.

An overview of the P2 experiment with focus on the tracking detector will be given in this talk, as well as the current state of the development of the strip modules.

Silicon photomultipliers (SiPM) are increasingly used in high-energy physics, medical and commercial applications. Until now, most SiPMs are implemented as large arrays of Single Photon Avalanche Diodes (SPAD) in a parallel circuit, serving as photon counters. Recently, the possibility of using SPADs produced in commercial Complementary Metal–Oxide–Semiconductor (CMOS) processes has opened up the possibility of combining their excellent performance in single photon detection and timing, with the possibilities offered by monolithic circuitry at a relatively low cost. The digital SiPMs, thanks to the per-pixel CMOS circuitry, extend the properties of standard SiPMs with features such as detailed event hit map, mapping of noisy SPADs and in-chip trigger logic and digitalisation.

A prototype of a SPAD array with per-pixel CMOS circuitry was fully developed at DESY in a 150 nm CMOS technology offered by LF foundry. This talk will report the results of characterisations performed on the prototype in the laboratory and in the DESY II Test Beam facility. Studies on the Count Rate, MIPs detection efficiency and time resolution will be presented, along with an overview of planned future studies with a laser setup and scintillator coupling.

Simulation of laser-TCT experiments with Allpix — Daniel Rastorguev for the Tangerine Collaboration. Deutsches Elektronen-Synchrotron. Hamburg, Germany — Bergische Universität Wuppertal. Wuppertal, Germany

The Transient Current Technique (TCT) is a powerful yet flexible laboratory characterization technique for silicon sensors. By precisely injecting charges with laser pulses and analyzing waveforms, produced as deposited charge drifts in the sensor bulk, one may experimentally study different charge collection features of the sensor under test.

T 148.4 Thu 18:15 WIL/A124

Simulations for High-Granularity LGAD Sensors using Commercial CMOS Technologies — Saqilain Khan, Sinuo Zhang, Tomasz Hemperle and Jochen Dingfelder

Physikalisches Institut, Universität Bonn — 2. Physikalisches Institut, Universität Zürich

Low-Gain Avalanche Diode (LGAD) detectors can provide a time resolution an order of magnitude better than traditional silicon detectors. This enhancement is enabled by the implementation of controlled low gain in the detector response. One of the challenges in LGAD design is to achieve a high granularity. The granularity is constrained due to the design of an inter-channel protection structure referred to as “Junction Termination Extension” (JTE). This structure avoids breakdown between channels but also creates regions where charge collection is severely limited. An approach in the direction of improving the granularity is to have the gain layer of LGAD buried deep inside and below the readout surface. In this way, inter-channel breakdown is avoided and a high granularity could be achieved.

CMOS pixel sensors utilizing commercial processes are promising methods to be used in high energy particle physics experiments for high-precision charged particle tracking. In this talk, TCAD simulations to investigate the feasibility of the aforementioned approach using a commercial CMOS process will be presented.

T 148.5 Thu 18:30 WIL/A124

Simulation of laser-TCT experiments with Allpix — Daniel Rastorguev for the Tangerine Collaboration. Deutsches Elektronen-Synchrotron. Hamburg, Germany — Bergische Universität Wuppertal. Wuppertal, Germany

The Transient Current Technique (TCT) is a powerful yet flexible laboratory characterization technique for silicon sensors. By precisely injecting charges with laser pulses and analyzing waveforms, produced as deposited charge drifts in the sensor bulk, one may experimentally study different charge collection features of the sensor under test.

T 149: Detector Systems / Muon

LHCb Upgrade II - Mighty Tracker Sci-Fi Readout — Thomas Kern, Thomas Oeser, Stefan Schael, and Sebastian Schmitt

Phys. Inst. B RWTH Aachen

The LHCb experiment at the Large Hadron Collider (LHC) at CERN is an experiment designed to perform precise measurements of CP Violation and rare decays of b-hadrons. With its configuration during Run I and Run II of the LHC, many measurements are statistically limited, hence more data are required to improve their sensitivity.

The LHCb Upgrade II detector will operate with increased instantaneous luminosity, \( \mathcal{L}_{\text{int}} \), in order to collect more data in a shorter time interval. This increases pile-up and the occupancy of the detector subsystems with respect to the current setup. As a result, the current detector needs to be upgraded in order to withstand the higher radiation damage and track multiplicity.

The downstream tracking stations will therefore be replaced by the Mighty Tracker, a tracker that comprises an inner silicon tracker and an outer scintillating fibre (Sci-Fi) tracker. A design for the readout system of the Sci-Fi tracker is proposed that relies on coupling the Sci-Fi mats to a cryogenic chamber that houses Silicon Photomultipliers (SiPMs). This talk focuses on how to perform the coupling of the Sci-Fi mats to the cryogenic cooling chamber readout system.

T 149.3 Thu 18:00 WIL/C133

Impact of residual misalignment of the ATLAS' New Small Wheel on muon reconstruction performance — Stefanie Götz, Otmar Biebel, Valerio D'Amico, Florian Engl, Ralf Hertenberger, Christoph Jagfeld, Esliya Kumar, Katrin Pennik, Maximilian Rinnagel, Nick Schneider, Patrick Scholer, Christostomos Valderanis, and Fabian Vogel

1 LMU München — 2 Uni Freiburg

Highly accurate alignment of the ATLAS detector’s New Small Wheel (NSW) is crucial to fully exploit the wheels precision tracking capability as required for the high luminosity upgrade of the Large Hadron Collider (LHC) at CERN. Therefore, precise information on the true NSW chamber positionings and shapes is included in the muon reconstruction software, but only with a certain degree of accuracy as caused by measurement uncertainties of the optical alignment sensors. This study investigates the impact of the NSW residual misalignment on the muon reconstruction performance in comparison to the ideal detector geometry. Translations, rotations and deformations described by specific alignment parameters are studied on Monte Carlo samples generated by the simulation software.
Reconstruction Performance of the ATLAS New Small Wheel.

Before the start of the 2022 data-taking period, the innermost endcap of the ATLAS muon spectrometer was replaced by the so-called New Small Wheel (NSW). Micromegas and small-strip Thin Gap Chambers (STGCs) detectors are used to maintain the precise tracking capabilities of the ATLAS muon spectrometer and to improve the rejection of false trigger signals at the rates expected after data-taking in ATLAS. First studies on the reconstruction of clusters and their properties on the individual detector layers will be presented for different settings of the detector working point and the readout system. This will be followed by a discussion of the track reconstruction performance using the 16 NSW detector layers and the combination of those tracks with the rest of ATLAS.

Certification of sMDT chambers for the phase II upgrade of the ATLAS muon spectrometer — Oliver Kortner, Hubert Kroha, and Nick Meier — MPI für Physik, Munich, Germany

For operation at the HL-LHC, the ATLAS experiments will upgrade the inner muon spectrometer barrel layer with stations of thin-gap resistive plate chambers (RPCs) and small diameter muon drift-tube (sMDT) chambers in order to increase the acceptance of the first level muon trigger from current 80% to 95%. The MPI for Physics in Munich produced 49 sMDT chambers for this upgrade. The performance of all 49 chambers was measured with cosmic-ray muons: dark currents, electronics noise, muon detection efficiency, and the spatial resolution of all chambers were determined. The methods used for this certification and the results of the tests will be explained and shown in this presentation.

Test of ATLAS Micromegas detectors with a ternary gas mixture at the CERN G1F++ facility — Fabian Vogel, Oymar Biebel, Valerio D’Amico, Floriano Egli, Stefanie Gotz, Ralf Hertenberger, Christopher Jagfeld, Eshita Kumar, Katrin Pensek, Maximilian Rinnagel, Nick Schneider, and Chrisostomos Valeranits — LMU Munich

The ATLAS collaboration at LHC has chosen the resistive Micromegas technology along with the small-strip Thin Gap Chambers (STGCs) for the high luminosity upgrade of the first muon station in the high-rapidity region, the New Small Wheel (NSW) project. Achieving the requirements for these Micromegas detectors revealed to be even more challenging than expected. One of the main features being studied is the HV stability of the detectors. Several approaches have been tested in order to enhance the stability, among them the use of different gas mixtures. A ternary Ar:CO₂:IC4H10 mixture has shown to be effective in dumping discharges and dark currents. It allows the operation of the Micromegas detectors at safe working points with high cosmic muon detection efficiency. The presence of Isobutane in the mixture required a set of aging studies, ongoing at the G1F++ radiation facility at CERN, where the expected HL-LHC background rate is created by a 137Cs 14TBq source of 662 keV photons. Preliminary aging results and muon reconstruction efficiencies under Photon background of the ternary mixture will be shown.

Simulations and Test Beam Results of a MAPS in a 65 nm CMOS Imaging Technology — Adriana Simancas for the Tangerine-Collaboration — DESY, Hamburg, Germany

Monolithic CMOS sensors enable the development of detectors with a low material budget and a low fabrication cost. Moreover, using a small collection electrode results in a small sensor capacitance, a low analogue power consumption, and a large signal-to-noise ratio. These characteristics have become very attractive in the development of new silicon sensors for charged particle tracking at future experiments. One of the goals of the Tangerine Project (Towards Next Generation Silicon Detectors) is to develop a telescope setup consisting of detector prototypes designed in a 65 nm CMOS imaging process. This contribution presents the Monte Carlo simulations of such detector prototypes using the Allpix Squared framework.

Measurement of the first Townsend coefficient using UV light — Paolina Noll, Thomas Rademacher, Stefan Roth, David Smyczek, and Nick Thamm — RWTH Aachen University - Physics-Institute III B, Aachen, Germany

In gaseous ionization detectors primary electrons are accelerated in high electric fields and hence generate secondary ion pairs. These electron avalanches are described by the first Townsend coefficient which is the number of electrons produced per unit path length per primary electron. In a test setup a UV LED produces primary electrons via the photoelectric effect. The Townsend coefficient is extracted from the anode current measured in relation to the voltage applied. The experimental setup and first results are presented.
and Monte Carlo simulations are used to develop an understanding of the sensor technology and provide important insight into performance parameters of the sensor. Testing prototypes in laboratory and test beam facilities allows to study their charge collection, spatial resolution and efficiency. Combining results from all these studies it is possible to optimize the sensor layout. This contribution will present the first comparison of simulation results to test beam data of a 65 nm CMOS sensor with a small collection electrode.

T 151.1 Thu 17:30 WIL/C129
Evaluating new triggers for ATLAS HH(4b) analysis in LHC Run 3 data — Abdullah Nayaz, Teng Jian Khoo, and Cedem Issevé — 1Humboldt University, Berlin, Germany — 2Humboldt University, Berlin, Germany — 3Humboldt University, Berlin, Germany

The diHiggs (HH) study plays a central role in probing both the Standard Model and new Physics. The dominant higgs decay to a pair of b quarks (h -> bb) makes the 4b final state one of the most significant signatures to look for a di-Higgs system. The small cross section of the process plus the existence of a huge QCD background make the trigger (selecting signature-relevant events) extremely challenging.

For Run 3, ATLAS has designed new triggers that use better reconstruction and selection, in order to improve the efficiency at which we record HHb events. In this study, the efficiency of these triggers as well as the existing run-2 triggers are studied and compared using the hhbb MC samples and LHC run-3 data. Several factors such as improvement in jet calibration, b-tagging and optimized selection for hardware and software triggers are expected to boost the efficiency of over all run-3 triggers. The study, in particular, quantifies these improvements which is crucial for understanding the effectiveness of each trigger. In addition, since simulation is not a perfect reflection of real data, the measured detailed trigger performance in data and simulation will then help us to determine the parameterized correction factors needed to make simulation match the data.

T 151.2 Thu 17:45 WIL/C129
Prospects for machine-learning based unfolding techniques with a focus on the measurement of differential Higgs boson production cross sections — Johannes Erdmann, David Katzaradze, and Jan Lukas Späh — III. Physikalisches Institut A, RWTH Aachen University

In high-energy physics experiments, measured distributions are the result of Poissonian fluctuations around expectation values that are obtained from filling the underlying distribution with detector effects. The inference of the underlying distribution from the measurement in cases where no parametric form is available is known as ‘unfolding’. Traditional unfolding methods rely on a categorisation of events in a certain binning scheme. This limits the flexibility of the unfolding and does not allow for a simultaneous deconvolution of multiple observables.

An alternative approach, termed ‘Omnimuld’ in the literature, does not have these restrictions and benefits from machine-learning to take into account the whole information from each event. This approach is contrasted with the traditional approaches using a physically motivated example from a measurement of differential Higgs boson production cross sections in the diphoton decay channel.

T 151.3 Thu 18:00 WIL/C129
Studies on Monte Carlo tuning using Bayesian Analysis — Salvatore La Cagna, Andrei Vierbextx, Kevin Kroninger, and Stefan Kluithe — 1TU Dortmund, Fakultät Physik — 2Max-Plank-Institut für Physik, München

Monte Carlo (MC) simulations are an essential aspect of data analysis at the LHC. One aspect of MC event generation involves hadronisation and parton shower models. Since these models are based on approximations, they introduce a number of parameters. These parameters cannot be inferred from first principles. Therefore, their values have to be optimized using numerical tools and experimental data (MC tuning). Generally, MC tuning is performed by choosing observables that are sensitive to the parameters. Afterwards, a fit of the parameters to data using a simplified MC response function derived from fits to MC events is performed. Though state-of-the-art methods for MC tuning exist, uncertainties are usually treated as uncorrelated. In this talk, MC tuning using a Bayesian approach will be discussed. The EFFitter tool is used for fitting, which enables the implementation of correlations for different sources of uncertainties. In addition, the propagation of uncertainties with respect to the tune are discussed.

T 151.4 Thu 18:15 WIL/C129
Tuning Pythia8 for future $e^+ e^-$ colliders — Zhijie Zhao, Mikael Berggren, and Jenny List — 1DESY, Hamburg, Germany — 2Center for Future High Energy Physics, Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China

The majority of Monte-Carlo (MC) simulation campaigns for future $e^+ e^-$ colliders has so far been based on the leading-order (LO) matrix elements provided by Whizard 1.95, followed by parton shower and hadronization in Pythia6, using the tune of the OPAL experiment at LEP. In this contribution, we test and develop the interface between Whizard3 and Pythia8. As a first step, we simulate the $e^+ e^- \rightarrow q\bar{q}$ process with LO matrix elements, and compare three tunes in Pythia8: the standard Pythia8 tune, the OPAL tune and the ALEPH tune. At stable-hadron level, predictions of charged and neutral hadron multiplicities of these tunes are compared to LEP data, since they are strongly relevant to the performance of ParticleFlow algorithms.

Then events are used to perform a full detector simulation and reconstruction of the ‘International Large Detector concept’ (ILD), as an example for a ParticleFlow-optimised detector. At reconstruction level, a comparison of the jet energy resolution in these tunes is presented. We found good agreement with previous results that were simulated by Whizard1+Pythia6. This modern MC simulation chain, probably with matched NLO matrix elements in the future, should be introduced to ILD or other future $e^+ e^-$ colliders.

T 151.5 Thu 18:30 WIL/C129
Geant4 Optimizations in ATLAS — Mustafa Schmidt for the ATLAS-Collaboration — Bergische Universität Wuppertal

Production of Monte-Carlo simulations for ATLAS usually require large amount of computation time and result in huge memory consumption. In order to minimize the required resources, a dedicated Geant4 optimization task force works on optimizing the performance of the integrated Geant4 version in the ATLAS offline software framework Athena. After being founded in 2020, many optimizations have been implemented, mainly related to improvements of various physics lists, stepping parameters, and detector descriptions.

Recent developments cover a Woodcock tracking algorithm for improving the CPU time for photon in the calorimeter, and a proposal for a particle killer that stops propagating unimportant secondary particles in ATLAS. In addition, a Geant4 toolkit called FullSimLight has been developed which can run with various geometries including the most recent ATLAS detector geometry description. It contains many useful tools, such as a clash detection or a generator for geantino maps of the imported geometry. This talk covers the current status of the ongoing projects as well as an overview of future work packages.

T 151.6 Thu 18:45 WIL/C129
Monte-Carlo Generator Validation in ATLAS with JEM/PAVER — Frank Ellinghaus, Dominic Hirschhüll, Johanna Kraus, Joshua Redelstürz, Jens Rogge, and Mustafa Schmidt for the ATLAS-Collaboration — Bergische Universität Wuppertal

Periodic validation of available Monte-Carlo (MC) generators is crucial for obtaining reliable physics simulations, especially for the ATLAS experiment. Its main idea is to spot the origin of possible problems and unwanted features in generated MC events by comparing the shapes of various observables between the generated samples and their references. For that purpose, the existing job execution monitor (JEM), originally designed for monitoring grid jobs, has initially been used. However, due to many missing features, a new validation system, PMG Architecture for Validating Evgen with Rivet (PAVER), was recently developed based on the JEM infrastructure. It uses the ATLAS official Rivet analysis routines for validating specific physics processes, providing an automated and central MC event generator validation procedure that allows a regular evaluation of new revisions and updates for commonly used MC generators in ATLAS. The result is a robust, flexible, and highly functional MC validation setup, that is constantly developed further, for efficiently detecting issues in generated samples within a restricted timescale. It turned out to be a very useful tool for determining several unexpected features related to MC generator behaviors that are regularly reported to the generator authors, which resulted in various bug fix releases of external MC tools.
**T 152: Members’ Assembly**

Time: Thursday 20:00–22:00

All members of the Particle Physics Division are invited to participate.

**T 153: Invited Overview Talks III**

**Invited Talk**

T 153.1 Fri 11:00 HSZ/AUDI

The Standard Model on the test bench: What bosons and the top quark (will) tell us — VALERIE LANG — Albert-Ludwigs-Universität Freiburg

The Standard Model of particle physics has been very successful at predicting the properties and interaction rates of particles since its formulation. The currently largest test bench for the Standard Model are the experiments at the Large Hadron Collider (LHC) at CERN. The supreme performance of both accelerator and detectors has allowed us to drive both, precision of measured properties and rarity of observed processes, into unprecedented areas. Particularly fascinating probes are the bosons of the Standard Model, which act as force carriers and can be produced directly at the LHC, as well as the top quark, the heaviest particle in the Standard Model and the only quark which we can observe as free particle. In this presentation, I will provide a glimpse of the insights we have gained so far, and at the possibilities that are still awaiting us with the current third running period of the LHC, and its upgrade - the high-luminosity LHC.

**Invited Talk**

T 153.2 Fri 11:30 HSZ/AUDI

Gravitational wave observations: Current results & future expectations — HARALD PFEIFFER for the LIGO Scientific-Virgo-KAGRA-Collaboration — Max Planck Institute for Gravitational Physics, Am Mühlenberg 1, 14476 Potsdam

Gravitational Wave (GW) Astronomy has blossomed since the ground-breaking discovery in 2015 of a GW emitted by two merging black holes. The third observing run of the LIGO and Virgo observatories has increased the number of GW signals to nearly 100. Three types of compact object binaries have now been discovered: binary black holes, binary neutron stars and mixed systems with one neutron star and one black hole. This large set of GW signals enables ever more diverse conclusions about fundamental physics and astrophysics, with results including the equation of state at supernuclear densities, the mass-distribution of black holes, properties of gamma ray bursts, the nature of gravity and cosmology. This talk gives an overview of the observations and the wide variety of scientific results enabled by them. We close with an outlook to future observing runs and GW detectors.

**Invited Talk**

T 153.3 Fri 12:00 HSZ/AUDI

Precise muon detection: novel technologies for the luminosity frontier — KERSTIN HÖPFNER — RWTH Aachen, Phys. Inst. 3A, Aachen, Germany

Muons play an essential role in the discovery of new particles because of their potential to warrant a clean signature and low background. Outstanding examples from the past include the finding of the bottom quark as well as the tau lepton, and more recently the discovery of the Higgs boson. At present another type of signature is gaining importance: displaced muons as a probe for potential new BSM particles.

At the upcoming High-Luminosity LHC, muon detection as well as muon triggering face big challenges in terms of rate and precision. Consequently, modern muon systems evolve beyond being pure particle identification devices and rather turn into complex and high granularity trackers. High particle rates and densities also imply the requirement of increased radiation tolerance.

In anticipation of these challenges, new detection technologies were developed, largely based on micro-pattern gas detectors. These detectors provide a high spatial and time resolution. For the upcoming High-Luminosity LHC, the high-rate experiments ATLAS and CMS install large-scale systems of such detectors for muon detection. Their superior performance makes these detectors also good candidates for other applications in particle physics.

**T 154: Invited Overview Talks IV**

**Invited Talk**

T 154.1 Fri 13:30 HSZ/AUDI

ECN3: Experimental Opportunities at a Future High-Intensity Proton Facility at the CERN SPS (BDF/SHIP and HIKE+SHADOWS) — ANNISKA HOLLNAGEL — IGU Mainz

Within the framework of the CERN Physics Beyond Colliders (PBC) initiative and as an essential part of the European Strategy for Particle Physics, an upgrade of the existing ECN3 experimental hall will enable a diverse physics program at the CERN SPS and complement research at the energy frontier. Competitive Letters of Intent have been submitted for experiments at the facility, focusing on either Kaon physics or the Hidden Sector:

BDF/SHIP aims to exploit the full potential of a dedicated Beam Dump Facility (BDF) in the Search for Hidden Particles (SHIP), covering a wide range of the Hidden Sector while also offering a rich neutrino physics program.

The combined approach of HIKE+SHADOWS - running part-time in beam dump or Kaon mode - on the other hand would allow to further pursue Kaon research by NA62-successor HIKE (High-Intensity Kaon Experiment), while also providing Hidden Sector sensitivity with off-axis experiment SHADOWS (Search for Hidden And Dark Objects With the SPS).

This talk will give an overview of the physics capabilities of the proposed experiments - all offering excellent options for research at a future high-intensity proton facility at ECN3. With significant German contribution and extensive efforts in R&D, further insight can be gained from the various talks at this conference.
Overview of Invited Talks and Sessions
(Lecture hall REC/C213; Poster HSZ OG2)

Invited Talks
K 1.1  Tue  11:00–11:35  REC/C213  Information, Abstände und Gravitation? — Rudolf Germer

Sessions
K 1.1–1.5  Tue  11:00–12:35  REC/C213  Laser Applications and Laser-Beam Material Interaction
K 2  Tue  12:35–13:00  REC/C213  Members’ Assembly
K 3.1–3.2  Tue  16:45–17:45  HSZ OG2  Poster
K 4.1–4.4  Wed  11:00–12:00  REC/C213  X-Ray Lasers

Members’ Assembly of the Short Time-scale Physics and Applied Laser Physics Division
Dienstag  12:35–13:00  Raum REC C213
- Bericht
- Verschiedenes
to its high flexibility and depth precision. During APPJ processing of optical glasses such as N-BK7 and N-SF6, a residual layer of nonvolatile compounds is formed, resulting in rough surfaces or even the abortion of the etching process. Lasers are utilized to remove the residual layer without damaging the glass underneath. Therefore, a 248 nm excimer laser was used and fluences as well as pulse numbers have been varied to determine a parameter set with optimum selectivity. The resultant surface structures were measured by WLI and SEM. The results show a strong dependence on the processing glass type and the residual layer thickness. The incorporation of laser ablation into APPJ etching provides higher etching rates and lower surface roughness.

K 1.4 Tue 12:05 REC/C213 Laser-magnetization of Fe$_3$O$_4$Al$_2$O$_3$ investigated by pump-probe reflectometry — •Theo Pfug,1 Javier Pablo-Navarro2, Markus Olbrich1, Alexander Horn2, and Rantei Bal1 — 1Laserinstitut Hochschule Mittweida, Hochschule Mittweida, Germany — 2Instituto de Nanociencia y Materiales de Aragón, Universidad de Zaragoza, Spain — 1Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf, Germany

Ultrashort pulsed laser irradiation enables the generation of ferromagnetism in initially non-ferromagnetic materials, such as B2-ordered Fe$_3$O$_4$Al$_2$O$_3$. The paramagnetic B2 phase, defined by atomic planes of pure Fe, separated by Al-rich planes is randomized due to irradiation leading to the formation of the disordered A2 Fe$_3$O$_4$Al$_2$O$_3$ being ferromagnetic. This phase transition has been reported to rely on melting and subsequent resolidification, estimated to occur within 5 ns. However, the physical dynamics during the B2-A2 transition have yet to be investigated. Here, we demonstrate the temporal evolution of the transient reflectance of Fe$_3$O$_4$Al$_2$O$_3$ during the B2-A2 transition measured by pump-probe reflectometry. The reflectance increases abruptly 5 ps after excitation with pulsed laser radiation (800 nm, 40 fs, 0.2 J/cm$^2$) which can be attributed to the disordering process. Ex situ observations (Kerr microscopy, HR-TEM, electron holography) confirm that the laser-irradiated areas possess a high magnetization and the A2 structure. Furthermore, materials whose phase transition does not necessarily rely on resolidification may lead to a further reduction in the time needed for generating ferromagnetism by laser irradiation.

K 1.5 Tue 12:20 REC/C213 Double-pulse irradiation of a thin gold film using ultrafast laser radiation — •Markus Olbrich, Theoph Pflug, Nick Börnert, Philipp Lungwitz, Andy Engel, Peter Lickoschat, Steffen Weissmantel, and Alexander Horn — Laserinstitut Hochschule Mittweida, Technikumplatz 17, 09648 Mittweida

Irradiating a thin gold film (film thickness $d_f = 150$ nm, 20 nm adhesion layer of chromium, fusion silica substrate) with a single-pulse ultrafast laser radiation (pulse duration $\tau_p = 40$ fs, wavelength $\lambda = 800$ nm, peak fluence $H_p = 1.4$ J/cm$^2$) results in a flat ablation structure with a constant ablation depth, being replicable by two-temperature hydrodynamics modeling (TTM-HD). For validating the model, ultrafast imaging reflectometry is applied within a temporal range of up to 50 $\mu$s after the irradiation, resulting in a good agreement between the simulated electron temperature and the simulated dynamics of the ablated material with the measured change of reflectance. The modeling is further validated by comparing the calculated temperature and pressure distributions to the change of the microstructure and the diffusion depth of chromium into the gold film. The microstructure was investigated by electron backscatter diffraction (EBSD) and transmission electron microscopy (TEM). Concentration profiles of chromium were determined by energy dispersive X-ray spectroscopy (EDS) performed on cross-sections in the scanning transmission electron mode (STEM).

K 1.3 Tue 11:50 REC/C213 Laser-assisted atmospheric pressure plasma jet etching of optical glasses — •Robert Heineke1, Martin Ehberhardt1, Pierre Lorenz2, Thomas Arnoldi3, and Klaus Zimmer1 — 1Leibniz Institute of Surface Engineering, Permoserstr. 15, Leipzig 04318, Germany — 2Institute of Manufacturing Science and Engineering, Technische Universität Dresden, 01062 Dresden, Germany

The increasingly demanding requirements for high-performance optics, e.g. EUV and free-form optics, necessitate progressive improvements in manufacturing techniques. Atmospheric pressure plasma jet (APPJ) processing provides a tool for the generation and correction of highly precise optical surfaces due to its high flexibility and depth precision. During APPJ processing of optical glasses such as N-BK7 and N-SF6, a residual layer of nonvolatile compounds is formed, resulting in rough surfaces or even the abortion of the etching process. Lasers are utilized to remove the residual layer without damaging the glass underneath. Therefore, a 248 nm excimer laser was used and fluences as well as pulse numbers have been varied to determine a parameter set with optimum selectivity. The resultant surface structures were measured by WLI and SEM. The results show a strong dependence on the processing glass type and the residual layer thickness. The incorporation of laser ablation into APPJ etching provides higher etching rates and lower surface roughness.
Organic distributed feedback lasers based on laser-inscribed periodic surface structures — Vielang Dong, Tobias Antrach, Jakob Lindenthal, Markus Sudzius, Johannes Bendedun, and Karl Leo — Dresden Integrated Center for Applied Physics and Photonics Materials (IAPP) and Institute of Applied Physics, Technische Universität Dresden, 01062, Dresden, Germany

Laser ablation, as one of the well-approved alternative methods of photo-lithography in microfabrication, is limited in structuring resolution by the diffraction limit. However, it was observed that a laser-induced periodic surface structure (LIPSS) can be formed under ultrafast laser irradiation, and the periodicity resolution is significantly smaller than the wavelength of the incident laser (λ/2-λ/10). In this work, the periodicity structure generated by LIPSS was utilized to build a distributed feedback (DFB) laser based on organic materials. The femtosecond laser (λ > 515 nm) was used to structure the SiO2 substrate, forming a surface grating with a periodicity of about 200 nm. Afterwards, an organic blend (Alq3:DCM, 450 nm thick) was evaporated on the top of the grating as an optically active waveguide. Photo-induced laser emission of the devices was measured under femtosecond optical pumping at 404 nm. We observed a narrow single peak laser emission at 620 nm wavelength, which demonstrates optical feedback from the underlying 1st-order DFB structure. Our results show the potential of a laser-induced periodic surface structure to organic photonic devices and microlasers based on the artificially produced photonic structures on a subwavelength scale using laser micromachining techniques.

Angular streaking TOF spectrometer for ultrafast FEL pulse characterization — Sara Savio1, Niclas Wieland1, Lars Funk1, Lars Wulfing1, Arne Held1, Markus Ilchen2, and Wolfram Helm1 — 1Fakultät Physik, TU Dortmund — 2Deutsches Elektronen-Synchrotron DESY, Hamburg

Angular streaking allows resolving the sub-femtosecond temporal structure of SASE-free electron lasers. A circularly polarized infrared laser imprints a phase-dependent momentum shift onto the photoelectron spectra of a gas target. Time-of-flight spectrometers can be used to resolve these. The latter devices consist of electron optics, a drift section and a detector with good time resolution. Parameters such as energy resolution and energy-dependent transmission for the whole system can be determined by simulation. In this talk, we present the finalized simulation-based spectrometer design used inside our new chamber for the SpeAR_XFEL project. Furthermore, we will introduce the possibility of adaptive electron optics in our spectrometer to further increase the resolution and transmission by applying specific voltage settings to our optics. Gaining insight into electron motion using precise simulations appears to be an efficient way to improve the overall performance of such experiments. We would like to present our progress in terms of electrode design and applied voltages for a 4-keV electron energy spectrum, to further develop spectrometer research in this field.

Characterization of SASE FEL pulses with angular streaking — Sara Savio1, Kristina Dingel2, Arne Held1, Sara Savio1, Lars Funk1, Lars Wulfing1, Niclas Wieland1, Markus Ilchen2, and Wulfarm Helm1 — 1Fakultät Physik, Technische Universität Dortmund, Germany — 2Intelligent Embedded Systems, Universität Kassel, Germany

SASE-free electron-laser pulses pose a challenge in terms of temporal diagnostics, due to their intrinsic stochastic structure. Few methods allow directly resolving the full spectro-temporal information. In angular streaking, photoelectron momenta are linked to their birth phase by superimposing a circularly polarized infrared laser pulse. This principle allows reconstructing a pulse spectrogram shot-by-shot, enabling “stochastic experiments” by evaluating measurement functions of derived quantities such as pulse duration or delay in a (stochastic) double pulse. The analysis of angular streaking data involves disentangling the spectral and temporal contributions to the measurement for a single shot. In this talk, we present a current adaptation of the iterative Paeman algorithm and further, advanced reconstruction methods.

Furthermore, we show the application of these methods to data measured using angular streaking at the SXS instrument of European XFEL in June 2022. Statistical analysis of the reconstructed spectrograms allows providing diagnostic feedback with regard to different short-pulse FEL modes.
Overview of Invited Talks and Sessions
(Lecture halls: MOL/0213, ZEU/0160 and HSZ/AUDI; Posters: HSZ OG1)

Plenary Talk of the Environmental Physics Division
PV V  Tue  9:45–10:30  HSZ/AUDI  The European Destination Earth initiative – a paradigm change for weather and climate prediction — •PETER BAUER

Invited Talks
UP 2.1  Wed  11:00–11:30  MOL/0213  Volcanic radiative forcing: past and future — •ANJA SCHMIDT
UP 7.1  Thu  11:00–11:30  MOL/0213  Towards monitoring of anthropogenic greenhouse gas emissions from satellites — •HARTMUT BÖSCH, ANTONIO DI NOIA, NEIL HUMPAGE, ALEX WEBB, HARJINDER SEMBHI, ROBERT PARKER, MICHAEL BUCHWITZ, MAX REUTER, OLIVER SCHNEISING, STEFFANOEL, HEINRICH BOVENSCHMANN
UP 8.1  Thu  14:00–14:30  MOL/0213  Destabilization of carbon in tropical peatlands by enhanced weathering — •ALEXANDRA KLEMMLE, TIM RIXEN, MORITZ MÜLLER, JUSTUS NOTHOLT, THORSTEN WÄRNEKE
UP 8.2  Thu  14:30–15:00  MOL/0213  Widespread forest decline in central Europe following three extreme summers in 2018-2020 — •ANA BASTOS

Invited Talks of the joint Symposium Strange Clouds – from the Earth to Exoplanets (SYSC)
See SYSC for the full program of the symposium.

SYSC 1.1  Tue  11:00–11:20  HSZ/0004  Not all clouds are created equal – strange clouds in our solar system — •THOMAS LEISNER
SYSC 1.2  Tue  11:20–11:45  HSZ/0004  Clouds to the Edge of Space — •GERD BAUMGARTEN, RONALD EIXMANN, JENS FIEDLER, MICHAEL GERDING, MYKHAYLO GRYGALASHVYLY, FRANZ-JOSEF LÜBKEN, ASHQUE VELLALASSERY, CHRISTIAN VON SAVIGNY, ROBIN WING
SYSC 1.3  Tue  11:45–12:10  HSZ/0004  The dynamic clouds of Venus — •JAVIER PERALTA
SYSC 1.4  Tue  12:10–12:35  HSZ/0004  Observational constraints of exoplanet clouds — •NICOLAS IRO
SYSC 1.5  Tue  12:35–13:00  HSZ/0004  Gemstone clouds in JWST target exoplanets — •DOMINIC SAMRA, CHRISTIANE HELLING

Sessions
UP 1.1–1.5  Tue  16:45–18:00  ZEU/0160  Clouds in Planetary Atmospheres (joint session EP/UP)
UP 2.1–2.5  Wed  11:00–12:30  MOL/0213  Volcanic Effects on Atmosphere and Climate
UP 3  Wed  13:00–14:00  MOL/0213  Members’ Assembly
UP 4.1–4.6  Wed  14:00–15:30  MOL/0213  Aerosols & Hydrological Cycle
UP 5.1–5.4  Wed  16:00–17:00  MOL/0213  Measurement Techniques and Simulations
UP 6.1–6.4  Wed  17:30–19:00  HSZ OG1  Poster
UP 7.1–7.4  Thu  11:00–12:15  MOL/0213  Greenhouse Gases: Remote Sensing
UP 8.1–8.3  Thu  14:00–15:15  MOL/0213  Carbon Cycle & Climate Change
Members’ Assembly of the Environmental Physics Division

Wednesday 13:00–14:00  MOL/0213

- Report on last year’s activities
- Election
- Any other business
Volcanic radiative forcing: past and future

In this talk, I will summarize my work on volcanic radiative forcing exerted by volcanic eruptions of different magnitudes in the past and in the future. We find that the equivalent width is highly sensitive to cloud altitude and cloud optical thickness. The simulations are compared to the observations of Earthshine obtained by FORS2 at the VLT for different Sun-Earth-Moon phase angles.

Exoplanetary clouds: The potential of high-precision polarimetry

We find that the equatorial width is highly sensitive to cloud altitude and cloud optical thickness. The simulations are compared to the observations of Earthshine obtained by FORS2 at the VLT for different Sun-Earth-Moon phase angles.

Volcanic effects on atmosphere and climate

Volcanism is a major driver of climate variability and has played a critical role in the long-term evolution of Earth’s atmosphere and habitability through the release of gases including sulfur species, water, carbon dioxide, and halogen. In this talk, I will summarize my work on volcanic radiative forcing exerted by volcanic eruptions of different magnitudes in the past and in the future. The general mechanisms by which volcanic eruptions affect climate are well under-
Reduction of average stratospheric aerosol size after volcanic eruptions — **Felix Wixana**, Ulrike Niehuis, Sandra Wallis, and Christian von Savigny — Institute of Physics, University of Greifswald, 17489 Greifswald, Germany — Max Planck Institute for Meteorology, 20146 Hamburg, Germany
The evolution of the size distribution of stratospheric aerosols after volcanic eruptions is still not understood very well, due to the temporal sparsity of in situ measurements, the low spatial coverage by ground based observations and the difficulties to derive aerosol size information from satellite measurements. To overcome these issues, which are common to all ground based aerosol size retrieval methods, we use Fabry-Perot interferometer Fabry-Perot interference correlationspectroscopy (FPI) to robust and mobile imaging technology, to study volcanic gas emissions with high temporal resolution and accuracy. The FPI provides a periodic transmission spectrum which is matched to the periodic narrowband absorption structure of the target gas (due to vibronic excitations in the UV). From the resulting data an image of trace gas column density can be inferred via an instrument model. Since the image acquisition takes about 2.4s for an image, it is possible to calculate emission fluxes on this timescale.

Highly resolved volcanic SO2 emission flux measurements with imaging Fabry-Perot interferometer correlation spectroscopy — **Jaro Heimann**, Alexander Nießner, Christoph Fuchs, Jonas Kuhn, Nicole Bobrowski, and Ulrich Platt — Institute of Environmental Physics, Heidelberg University, Germany — CNRS/University Orleans, France — ETH Zurich, Zurich, Switzerland — Max Planck Institute for Meteorology, Hamburg, Germany
Here we present SO2 flux measurements from July 2022 at Mt. Etna with an FPI instrument with a detection limit of ≈ 5e17 molec/cm² at 4 Megapixel spatial and 2.4s temporal resolution, e.g. a mean flux of 418 ± 138 t/day for the 15th of July 2021 between 08:17 and 10:13 UTC. We will furthermore discuss uncertainties and challenges of the technique.

A miniaturized chemiluminescence ozone monitor for drone-based measurements in volcanic plumes — **Maja Rütli**, Ellen Brautigam, Jonas Kuhn, Nicole Bobrowski, Ulrich Platt, and Christoph Fuchs — Institute of Environmental Physics, Heidelberg University, Germany — ETH Zürich, Switzerland
Volcanic plumes contain reactive halogen species, especially bromine monoxide (BrO), which catalyzes ozone (O3) destruction. Therefore, local O3 depletion is commonly assumed in volcanic plumes and has also been measured to varying degrees at different volcanoes in several studies. However, a calculation comparing atmospheric mixing with the rate of O3 destruction suggests no significant reactive halogen catalysed O3-loss (1% or less) in the plume. So far, O3 and its distribution in volcanic plumes have only been insufficiently determined. Commonly used ultraviolet (UV) absorption O3 monitors show interference with sulphur dioxide (SO2), an abundant volcanic gas. This problem can be overcome by using a chemiluminescence (CL) O3 monitor, which has no known interference from trace gases abundant in volcanic plumes. However, field measurements with former CL O3 monitors are challenging, as they were heavy and bulky.

Surprisingly we find that some volcanic eruptions can lead to a decrease in average stratospheric aerosol size, in this case the 2018 Ambae eruptions and the 2019 Ulawun eruptions, while other eruptions exhibit an expected increasing effect on the average particle size, like the 1991 Raikoke eruption. We show how different parameters like the median radius, the absolute mode width and the number density evolve after the mentioned eruptions. Additionally, as a part of our ongoing research to understand the underlying mechanisms controlling the observed aerosol size reduction, we show simulations of the aforementioned volcanic eruptions using the aerosol-climate model MAECHAM5-HAM.

Impact of a strong volcanic eruption on the summer middle atmosphere in UA-ICON simulations — **Sandra Wallis**, Hauke Schmidt, and Christian von Savigny — University of Greifswald, Greifswald, Germany — Max Planck Institute for Meteorology, Hamburg, Germany
Explosive volcanic eruptions are able to inject large amounts of sulfur dioxide into the stratosphere. Sulfur dioxide mostly converts to sulfate aerosols that can increase the temperature of the lower stratosphere and subsequently alter the stratospheric circulation. This was directly observed after the strong Pinatubo eruption in 1991. The impact on the mesosphere is less well understood, mainly because of a lack of strong eruptions during the satellite era and sparse observations of the middle atmosphere before. Few measurements, however, hint to an increase in mesospheric temperatures after the Pinatubo eruptions. We investigate dynamical mechanisms that could explain such observations by simulating the response of the middle atmosphere to an idealized tropical eruption that emitted twice as much sulfur dioxide as the Pinatubo in 1991 using the upper-atmospheric icosahedral non-hydrostatic (UA-ICON) model. We focus on the first austral summer after the eruption and find a significant warming of the polar summer mesopause of up to 15-21 K. Our study indicates that this mesospheric warming is mainly due to vertical coupling through wave-mean flow interaction in the summer hemisphere and potentially enhanced by interhemispheric coupling (between the winter stratosphere and the summer mesosphere).
gate the sensitivity of the twilight colors to relevant parameters such as aerosol optical depth, the parameters of the particle size distribution and the amount of ozone. Apart from a specific particle size, a sufficiently large aerosol optical depth is required to explain green sunsets.

UP 4.5 Wed 15:00 MOL/0213
Sediment transport in Indian rivers high enough to impact satellite gravimetry — **ALEXANDRA KLEMM**, THORSTEN WARNER, HEINRICH BOVENSOMMANN, MATTHIAS WEIGEL, JÜRGEN MÜLLER, TIM RIXEN, JUSTUS NOOTHOLT, AND CLAUS LÄMMERZAHN
— Institute of Environmental Physics, University of Bremen, Germany — Institute of Geodesy, Leibniz Universität Hannover, Germany — Leibniz Center for Tropical Marine Research, Bremen, Germany — Centre of Applied Space Technology and Microgravity, University of Bremen, Germany

Sediment transport in rivers is used to study the global hydrological cycle. It is a key component in the investigation of groundwater depletion on the Indian subcontinent. Mass loss by sediment transport in rivers is assumed to be below the detection limit of current gravimetric satellites like GRACE-FO. Thus, it is not considered in the calculation of terrestrial water budgets from gravimetric data. However, the Indian subcontinent is drained by some of the world’s most sediment rich rivers and mass loss by sediment transport will impact long term gravimetric anomalies. We estimate the impact of sediment mass loss within different river catchments on gravimetric estimates of trends in terrestrial water storage. For the Ganges-Brahmaputra-Meghna catchment, our results indicate that sediment transport could account for (6 ± 3)% of the gravity anomalies attributed to groundwater depletion. For erosion-prone Himalaya regions, we find an average sediment mass loss of 2 kg m⁻² yr⁻¹ which is almost 20% of the observed gravity anomaly.

UP 4.6 Wed 15:15 MOL/0213
Validation potential for Remote Sensing soil moisture products using Cosmic-Ray Neutron Sensing — **JANUS KOHLER, JAN WEBER, AND ULRICH SCHMIDT** — Physikalisches Institut, Heidelberg University

The novel method of Cosmic-ray neutron sensing (CRNS) allows for non-invasive soil moisture measurements at a hectometer scaled footprint. This technique relies on the measurement of neutrons originating from cosmic-ray induced air showers. The key characteristic of the method is the exceptionally high moderation strength of hydrogen. It slows down fast neutrons whereas other heavier elements independent of the chemical composition rather reflect them. The result is an inverse relation of the above-ground neutron intensity to soil moisture. Due to neutrons being transported over the air over hundreds of meters, the measurement is representative for an area on the scale of hectares. In the recent years the interest was set to understanding neutron transport by Monte-Carlo simulations for complex environmental topographies. Its remarkable performance in signal interpretation allows for a promising prospect of more comprehensive data quality. This especially addresses mobile applications, which is the current focus of development. With raying it is possible to cover the scale of one square kilometer per day with one instrument. Satellite-based products can specifically profit from data assimilation of CRNS-based representative measurements of soil moisture. With its large integral footprint and its penetration depth of several decimeters, high-quality data sets can be obtained as ground truthing for remote sensing products.

UP 5: Measurement Techniques and Simulations

Time: Wednesday 16:00—17:00

UP 5.1 Wed 16:00 MOL/0213
Concept of a Raman-based microfluidic system for measuring trace substances in the field of wastewater treatment — **SIMON JANSEN, JAN BERGE, SEBASTIAN MAY, AND MARTIN REUFER** — Hochschule Ruhr West, Institut für Technologie, IMK-IFU, Kreuzekarbahnhofstr. 19, 82467 Garmisch-Partenkirchen

Raman spectroscopy is a powerful method to identify particles. Recently the first methods using visible photoluminescence to detect plastic particles have been publicized. Here, we investigate the excitation and detection wavelength range suitable to 12 common virgin polymer types. Based on our findings, we recommend a range from 270 to 320 nm for the excitation and 320-425 nm for the detection window. We further show that plastics have unique UV-PL signatures that may be suitable for identifying

UP 5.2 Wed 16:15 MOL/0213
Optimization of excitation and detection windows for the optical detection of microplastics via photoluminescence — **STEPHAN BRACKMANN, SRUMBA KONDE, KATHARINA GEHR, MARINA GEBHARD, AND MARTIN KOCH** — Department of Physics and Material Science Center, Philipps-Universität Marburg, Renthof 5, 35032 Marburg, Germany

Current microplastics research utilizes subjective hand-picking of particles to identify plastic particles. Recently the first methods using visible photoluminescence to detect plastic particles have been publicized. Here, we investigate the excitation and detection wavelength range suitable to 12 common virgin polymer types. Based on our findings, we recommend a range from 270 to 320 nm for the excitation and 320-425 nm for the detection window. We further show that plastics have unique UV-PL signatures that may be suitable for identifying...
microplastic particles. This approach may lead to a low-cost alternative to the established methods.

UP 5.3 Wed 16:30 MOL/0213
Time-resolved simulations of wind speed fluctuations across atmospheric boundary layers using a stochastic forward model — \textsc{Marten Klein} and \textsc{Heiko Schmidt} — \textsc{BtU Cottbus-Senftenberg, Cottbus, Germany}
Atmospheric boundary layers (ABLs) govern the atmosphere–surface coupling and are therefore of fundamental relevance for Earth's weather and climate system. Time-resolved numerical simulations of ABLs are challenging due to intricate interactions of inertial, Coriolis, buoyancy, and viscous forces on all relevant scales of the turbulent flow. Small-scale processes, albeit potentially nonuniversal, are typically not resolved due to cost constraints but modeled based on physically justified relations with the resolved scales, neglecting expensive backscatter. This lack in modeling is addressed by using a dimensionally reduced stochastic modeling approach. The model aims to reproduce turbulent cascade phenomenology by a stochastic process, respecting fundamental physical conservation principles. Momentary wind velocity and temperature profiles evolve autonomously in time for an ensemble of initial conditions. By comparison with available high-fidelity reference numerical simulations, reanalysis, and observations, it is shown that the model captures various relevant flow properties, exhibiting limitations mainly in a delayed reanalysisization under very stable conditions. Forthcoming research aims to contribute to a better understanding of polar boundary layers, requiring predictive modeling capabilities, high resolution, and numerical efficiency to perform long-time simulations.

UP 6: Poster

UP 6.1 Wed 17:30 HSZ OG1
Straylight characterization of airborne imaging remote sensing instruments of the MAMAP2D family for greenhouse gas observations — \textsc{Oke Huhs}, \textsc{Konstantin Gerbelowski}, \textsc{Sven Krautwurst}, \textsc{Jakob Borchardt}, \textsc{Heinrich Bovensmann}, and \textsc{John P. Burrows} — \textsc{University of Bremen, Institute of Environmental Physics, Otto-Hahn-Allee 1, 28359 Bremen, Germany}
Airborne measurements of atmospheric column enhancements of methane (\textsc{ch}_4) and carbon dioxide (\textsc{co}_2) from anthropogenic point sources were performed with the Methane Airborne MAPer (MAMAP) since 2007, which delivers 1D spatial data by measuring the spectrum of backscattered solar radiation. To measure 2D spatial data from a single observation, a new generation of passive airborne imaging remote sensing grating spectrometers is being developed and built by \textsc{Iup Bremen}. The MAMAP2D-Light instrument was already successfully flown during the COMET 2.0 Arctic campaign in Canada in summer 2022, measuring \textsc{co}_2 and \textsc{ch}_4 enhancements in a short-wave infrared band around 1.6 m m. The MAMAP2D instrument, which has an additional near-infrared O2A-band channel and a higher spectral resolution, has delivered measured data in a laboratory environment. For the characterization of remote sensing instruments, straylight is an important quantitative measure. Straylight occurs due to reflections and scattering within the spectrometer and must be characterized well to establish a straylight correction. Therefore, straylight was characterized down to 7 orders of magnitude below the integrated incident illumination level for MAMAP2D and MAMAP2D-Light.

UP 6.2 Wed 17:30 HSZ OG1
Calibration of an Air Data Probe to complement airborne in-situ Flux Measurements — \textsc{Josua Schindewolf} — \textsc{Institut für Umweltphysik, Universität Bremen, Deutschland}
Airborne in-situ measurements of greenhouse gases (GHG) contribute to the increasingly important task of monitoring the changing greenhouse gas emissions and attribution of the sources. The quantification of GHG sources, not only observations of precise atmospheric concentration gradients are needed, but also accurate measurements of the corresponding wind fields. This is because, the computation of the emissions and their uncertainties have linear dependencies on wind speed and direction. In 2022 we installed and calibrated a new turbulence probe to the underwing pod of the research aircraft of the jade University. The modeling is addressed by using a mean difference in wind speed of 0.5 m/s and in wind direction of 4° over ten such calibration flights. The model is shown by a mean difference in wind speed of 0.5 m/s and in wind direction of 20°. In summary, the results indicate that more calibration flights are required for a further evaluation, which will focus on the comparison with the ground based met tower observations. This is challenging, because of the high variability of the wind fields at low flight altitudes.

UP 5.4 Wed 16:45 MOL/0213
Simulated outdoor efficiency and performance ratio of a III-V-on-Si solar panel for direct solar hydrogen production — \textsc{Johannes Gräfenstein}^1, \textsc{Moritz Kolbach}^1, \textsc{Matthew M. May}^2, \textsc{Klaus Peetstickel}^1, and \textsc{Kira Rehfeld}^2,^3 — \textsc{Institut für Umweltphysik, Universität Heidelberg, Germany} — \textsc{2Geo- and Umweltforschungszentrum, Universität Tübingen, Germany} — \textsc{3Institut für Physikalische und Theoretische Chemie, Universität Tübingen, Germany}
Tandem solar cells might play a substantial role in future energy systems and in negative emission technologies, both for electricity- and direct hydrogen generation. In a tandem solar cell, photocurrent mismatch between the absorber layers due to variation in the spectral irradiance distribution induces efficiency losses. Together with the temperature-related efficiency modulation, this effect gives rise to its sensitivity to climatic conditions. Here, the performance of an AlGaAs-on-Si tandem solar cell that is either used for electricity production or directly connected to an anion exchange membrane electrolyzer is evaluated for different locations on Earth using the model. The potential of the outdoor harvesting efficiency and efficiency at standard conditions [1] lies within 0.86 and 0.95 for electricity- and within 0.91 and 0.95 for hydrogen production. This study allows to improve performance predictions and highlights how tuning the top absorber band gap to the prevailing spectral irradiance composition can enhance the harvesting efficiency, depending on the location. [1] Kölbach et al., Sustainable Energy Fuels, 2022, 6 DOi:10.1039/D2SE00561A
The coming Copernicus CO2 Monitoring (CO2M) Mission, the space component of the satellite imaging spectrometer —— MARVIN KNAPP1, LEON SCHEIDWEILER1, FELIX KÜLHEIM1, RALPH KLEINSECK1, JAROSLAV NECKT1, PAVEL JAGODA1, and ANDRE BUTZ2 — 1Institute of Environmental Physics, Heidelberg University, Im Neuenheimer Feld 229, 69120 Heidelberg — 2Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Krakow, Poland

Carbon dioxide (CO2) and methane (CH4) emissions from individual sources. I will discuss how such dedicated missions can be complemented by ground-based observations of CO2 and CH4 and present examples how we use current, dedicated satellite imaging spectrometer data to estimate emissions from specific sources. Satellite observations of CO2 and CH4 will play a key role for tracking progress towards emission reduction targets and for verifying the effectiveness of mitigation policies. Satellites also provide information on natural sinks which store large amounts of carbon and play a potentially important role in the pathway towards net-zero emissions.

In this presentation, I will introduce the key concepts for satellite observations of CO2 and CH4 and present examples how we use current, dedicated satellite missions to quantify regional surface fluxes of natural and anthropogenic sources. I will discuss how such dedicated missions can be complemented by hyperspectral satellites with high spatial resolution that allow constraining individual emission sources. The presentation will end with an outlook to the upcoming Copernicus CO2 Monitoring (CO2M) Mission, the space component of the European anthropogenic CO2 Monitoring & Verification Support Capacity.

Emission estimates of carbon dioxide and methane with a ground-based imaging spectrometer —— STEPHANIE FALK for the STEPSSEC-Kollaboration — 1Ludwig-Maximilians-Universität München (LMU)

Ozonmessungen auf der Zugspitze 1978-2020: Woher stammt der Ozonanstieg? —— THOMAS TRICKL1, CÉDRIC COUBET2, LUWTH RIES3, and HANES VOGELMANN1 — 1Karlsruher Institut für Technologie, IMK-IFU, Kreuzzeichenbahnstr. 19, 82467 Garmisch-Partenkirchen — 2Umweltbundesamt II 4.3, Schneefernerhaus, 82475 Zugspitze


UP 7: Greenhouse Gases: Remote Sensing

Time: Thursday 11:00–12:15
Location: MOL/0213

Invited Talk
UP 7.1 Thu 11:00 MOL/0213
Trends in monitoring of anthropogenic greenhouse gas emissions from satellites —— HARTMUT BOSCH1,2, ANTONIO DI NOIA1, NEIL HUMPAGE1, ALEX WEBB1,2, HAJINDER SEMBHI1, ROBERT PARKER1, MICHAEL BUCHWITZ2, MAX REUTER2, OLIVER SCHNEISSING2, STEFAN NOEL2, and HEINRICH BOYENSMANN2 — 1University of Leicester, Leicester, UK — 2TU, University of Bremen, Bremen, Germany — 3Oklahoma University, Oklahoma, USA

To limit global warming to well below 2°C compared to pre-industrial levels requires a decarbonization of the economy and many countries have pledged to reach net-zero emissions by 2050 but progress has been slow so far. Satellite observations of CO2 and CH4 will play a key role for tracking progress towards emission reduction targets and for verifying the effectiveness of mitigation policies. Satellites also provide information on natural sinks which store large amounts of carbon and play a potentially important role in the pathway towards net-zero emissions.

In this presentation, I will introduce the key concepts for satellite observations of CO2 and CH4 and present examples how we use current, dedicated satellite missions to quantify regional surface fluxes of natural and anthropogenic sources. I will discuss how such dedicated missions can be complemented by hyperspectral satellites with high spatial resolution that allow constraining individual emission sources. The presentation will end with an outlook to the upcoming Copernicus CO2 Monitoring (CO2M) Mission, the space component of the European anthropogenic CO2 Monitoring & Verification Support Capacity.

SEASONAL AND INTERANNUAL VARIABILITY OF AUSTRALIAN CARBON FLUXES SEEN BY GOSAT —— ANDRE BUTZ2, EVA-MARIE METZ1, SANAM VARDAG1, SOURISH BASU1, MARTIN JUNG1, and STEPHEN STITCH1 — 1Institut für Umweltphysik, Universität Heidelberg, Germany — 2NASA Goddard Space Flight Center, University of Maryland, USA — 3Max Plank Institute for Biogeochemistry, Jena, Germany

The semi-arid Australian continent significantly influences the interannual variability of the global terrestrial carbon sink. The sparsity of in-situ CO2 and flux measurements, however, leads to large uncertainties in estimated carbon fluxes for the continent. Satellite measurements of CO2 offer an independent and spatially extensive source of information about the Australian carbon cycle. Here, we examine the decadal data set (2009-2018) of atmospheric CO2 mole fractions delivered by the Greenhouse Gases Observing Satellite (GOSAT). We find previously undetected CO2 pulses at the end of the dry season that we attribute to the quick onset of respiration after the dry period. These pulses dominate the seasonal and the year-to-year variability of Australia’s carbon balance.

UP 7.2 Thu 11:30 MOL/0213
Seasonal and Interannual Variability of Australian Carbon Fluxes Seen by GOSAT —— ANDRE BUTZ2, EVA-MARIE METZ1, SANAM VARDAG1, SOURISH BASU1, MARTIN JUNG1, and STEPHEN STITCH1 — 1Institut für Umweltphysik, Universität Heidelberg, Germany — 2NASA Goddard Space Flight Center, University of Maryland, USA — 3Max Plank Institute for Biogeochemistry, Jena, Germany

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UP 8: Carbon Cycle & Climate Change

Time: Thursday 14:00–15:15
Location: MOL/0213

Invited Talk
UP 8.1 Thu 14:00 MOL/0213
Desestabilization of carbon in tropical peatlands by enhanced weathering —— ALEXANDRA KLEMM1, TIM RIXEN2, MORITZ MÜLLER3, JUSTUS NOTHOLT1, and THORSTEN WARNKE1 — 1Institute of Environmental Physics, University of Bremen — 2Leibniz Center for Tropical Marine Research, Bremen — 3Faculty of Engineering, Computing, and Science, Swinburne University of Technology Sarawak Campus

Southeast Asian peatlands represent a globally significant carbon store. Recent land use changes destabilize the peat, causing increased leaching of peat carbon into rivers. Despite resulting high river organic carbon concentrations, field data suggest only moderate carbon dioxide (CO2) emissions from rivers. We offer an explanation for this phenomenon by showing that carbon decomposition is hampered by the low pH in peat-draining rivers, and we find that enhanced input of carbonate minerals increases CO2 emissions by counteracting this pH limitation. One potential source of carbonate minerals to rivers is the application of enhanced weathering, a CO2 removal strategy that accelerates weathering-induced CO2 uptake from the atmosphere via the dispersion of rock powder. The effect of enhanced weathering on peatland carbon stocks is poorly understood. We present estimates for the response of CO2 emissions from tropical peat soils, rivers and coastal waters to enhanced weathering induced changes in soil acidity. The potential carbon uptake associated with enhanced weathering is reduced by 18 – 60 % by land-based re-emission of CO2 and is potentially offset completely by emissions from coastal waters.

PE8.2 Thu 14:30 MOL/0213
Widespread forest decline in central Europe following three extreme summers in 2018-2020 —— ANA BASTOS — 1Max Planck Institute for Biogeochemistry, Hans Knöll Str 10, 07745 Jena

Among the ten hottest summers in Europe since 1880, only two happened before 2010 (2003 and 2006). In Europe and other temperate regions, summers like 2003 and 2010 were extremely rare in the past, but are projected to happen every few years in the coming decades. Since they are stochastic to some extent, these events are not necessarily happen at regular intervals, and they may cluster in time and/or space.

Together with that of 2003, the summers of 2018, and 2019 were exceptional, hot and dry in central Europe. In 2020, drought conditions persisted over a large region. Such a sequence of three exceptionally hot and dry summers is unprecedented in the observation-based record since 1950 and triggered a series of cascading effects that resulted in large-scale forest decline and tree mortality.

It is unclear to which extent this large-scale tree mortality event, driven by three consecutive extreme summers, reveals an anthropogenic fingerprint or whether these could have happened due to natural climate variability and disturbance interactions. This talk will discuss the conceptual and practical challenges of answering this question. Then, recent work addressing different aspects of this question from both data-driven and process-based modeling perspectives will be presented.

UP 8.3 Thu 15:00 MOL/0213
STEPSEC: Update und erste Ergebnisse —— STEPHANIE FALK for the STEPSEC-Kollaboration — Ludwig-Maximilians-Universität München (LMU)
# Working Group on Accelerator Physics

**Arbeitskreis Beschleunigerphysik (AKBP)**

Kurt Aulenbacher  
Institut für Kernphysik  
Universität Mainz  
Becherweg 45  
55099 Mainz  
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## Overview of Invited Talks and Sessions

(Lecture halls HSZ/0304, CHE/0183, and CHE/0184; Poster HSZ OG3)

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## Members’ Assembly of the Working Group on Accelerator physics

Thursday 19:00–20:00 CHE/0091

- Bericht
- Terminfindung für Symposium „Verleihung der AKBP-Preise 2023“
- Verschiedenes
Multi-alkaliantimonide photocathodes can have high quantum efficiency similar to UV-sensitive (Cs2Te) photocathodes, but with the advantages of photoemission sensitivity in the green wavelength and a significant reduction in the mean transverse energy of photoelectrons. In order to optimize and better understand the photo-emissive film properties of KCsB photocathodes, a batch of two photocathodes with different thicknesses was grown on molybdenum substrates via a sequential deposition method in a new preparation system at INFN LASA. During the deposition, a “multi-wavelengths” diagnostic, i.e. the measurements of the real-time photocurrent and reflectivity at different wavelengths (in the range from 234 nm - 690 nm) has been applied. The optical spectra of these semiconductors provide a rich source of information on their electronic properties. In this report, we present and discuss the experimental results obtained from the two different thickness KCsB photocathodes, along with the effect of Sn thickness on the cathode’s properties.

AKBP 1.5 Mon 17:00 CHE/0183
Investigation of structural changes in Ti-6Al-4V via high energy X-ray diffraction caused by fast cyclic heatings…

AKBP 1.6 Mon 17:15 CHE/0183
Computational homogenisation of laminated yokes in finite-element models of fast-ramped orbit corrector magnets…

AKBP 1.7 Mon 17:30 CHE/0183
The Merit of a Thomson backscattering based Gamma Source at MESA…

AKBP 1.1 Mon 16:00 CHE/0183
Design of a New Photo and Thermionic Hybrid Mode 50 kV Pulsed Electron Gun for ELSA—

AKBP 1.2 Mon 16:15 CHE/0183
Automated Activation Procedure for GaAs Photocathodes at Photo-CATCH—

AKBP 1.3 Mon 16:30 CHE/0183
Multi-alkal anti-monoxide photocathodes for highly brilliant electron beams—

AKBP 1.4 Mon 16:45 CHE/0183
Development of Multi-alkal anti-monoxide photocathodes for high brightness photo-injectors—

Sessions
- Invited Talks, Prize Talks, Group Reports, Contributed Talks, and Posters –
AKBP 2: Advanced Light Sources and their Instrumentation

Time: Monday 16:00–17:45
Location: CHE/0184

AKBP 2.1 Mon 16:00 CHE/0184

Powering test results of HTS undulator prototype coils for compact FELs at 4.2 K — • Sebastian C. Richter1,2, Andreas W. Grau2, David Saez de Jauregui1,2, Amalia Ballardino3, Axel Bernhard1, and Anne-Susanne Müller1,3 — • LAS, KIT, Karlsruhe — • CERN · 1211 Geneva 23 · Switzerland — • IBPT, KIT, Karlsruhe

Short-period and high-field undulators are crucial for the production of coherent light up to X-rays in compact free-electron lasers (FELs). Besides, future colliders like CLIC or FCC-ee demand high-field damped wigglers to reach a low beam emittance. Both applications may benefit from the use of high-temperature superconductors (HTS): magnetic field amplitudes in the range of 2 T become feasible for short periods of 15 mm and smaller with magnetic gaps of 6 mm at 4.2 K. Moreover, potential operation at higher temperatures may relax cryogenic requirements and reduce operational costs. This contribution presents and discusses the powering test results of several HTS undulator prototype coils, designed and manufactured at CERN, made from coated ReBCO tape superconductor. The coil set-up was already described in previous works and is based on non-insulated vertical racetracks with a period length of 13 mm, assembled with iron poles. Powering tests at 4.2 K were performed at KIT to explore the operation at high current densities (2 kA/mm²) and the produced magnetic fields in the iron pole gap.

AKBP 2.2 Mon 16:15 CHE/0184

Spectro-temporal Properties of Coherently Emitted Radiation Pulses at DELTA — • Arjun Radha Krishnan1, Benedikt Busing1, Shaukat Khan1, Carsten Mai1, Wael Salahi1, Zohair Usoof1, and Vivek Vijayan1 — • Center for Synchrotron Radiation (DELTA), TU Dortmund University, Dortmund, Germany — • The Hashemite University, Zarqa, Jordan

The short-pulse facility at the 1.5 GeV synchrotron light source DELTA, operated by the TU Dortmund University, employs the seeding scheme coherent harmonic generation (CHG) to produce ultrashort pulses in the vacuum ultraviolet and terahertz regime. Since the properties of the CHG radiation are based on the laser-induced energy modulation and the microbunching process, the spectral and temporal properties of the CHG pulses can be controlled by tuning the laser chirp and the strength of the dispersive chicane. The CHG spectra at several harmonics of the 800 nm seed laser were recorded using an image-intensified CCD camera and an XUV spectrometer for different seed laser chirps and chicane strengths. Convolutional neural networks were employed to fit the observed spectra with the simulations and extract the spectral phase information of the seed laser, taking the higher-order spectral phase of the seed pulse into consideration.

AKBP 2.3 Mon 16:30 CHE/0184

Highlights from seeded FEL@PITZ — • Georgi Georgiev — • DESY Zeuthen

First results from a proof-of-principle experiment for a high-power accelerator-based THz source were obtained last year at the Photo Injector Test Facility at DESY in Zeuthen (PITZ). The THz source is an extension to the linac facility and it is based on a single LCLS-I undulator. A part of the research program includes studies on seeding methods for the FEL to improve the shot-to-shot stability of the THz pulses from what is expected from the self-amplified spontaneous emission (SASE) mode of operation. Several methods to achieve seeding are studied in simulation including pre-bunched electron beams, external radiation pulse and a super-radiant spike on top of the beam. Experimental measurements demonstrating the seeding effects from a pre-bunched electron beam are presented and discussed.

AKBP 2.4 Mon 16:45 CHE/0184

Wakefield Study for a PCB-Based Arrival-Time Pickup for Electron Accelerators — • Bernhard Erich Jürgen Scheibler1,2, Marie Kristin Czwalina1, Holger Schlarb1, Wolfgang Ackermann2, Herbert De Gersem2, and Andreas Penirschke1 — • 1Technische Hochschule Mittelhessen, Wilhelm-Leuschner-Str. 13, 61169 Friedberg, Germany — • 2Technische Universität Darmstadt, Karolinenplatz 5, 64289 Darmstadt, Germany — • 3Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany

Many scientific applications utilize large-scale electron accelerators, e.g., for imaging in free-electron laser facilities such as the European XFEL or FLASH. Precise timing information is necessary for stable operation or to control and evaluate experiments. With growing demands on the accuracy of beam diagnostics especially with smaller bunch-charges, it is unavoidable that monitoring concepts significantly affect the beam. To prevent this interaction from becoming intolerable, it is necessary to quantify and compare it with existing state-of-the-art structures. In this contribution the wake loss factor of a pickup structure based on a printed circuit board is determined in electromagnetic simulations and compared to the pickups of the European XFEL.

AKBP 2.5 Mon 17:00 CHE/0184

Towards Fiber-Optics-Guided Synchrotron Radiation-Based Longitudinal Beam Dynamics at the KARA Booster Synchrotron — • Martin-Dennis Noll1, Johannes L. Steinmann1, Dima El Khechen2, Christian Goffing1, Christina Widmann1, Erik Bründermann2, and Anne-Susanne Müller2 — • IBPT, KIT, Karlsruhe — • LAS, KIT, Karlsruhe

Before injection into the Karlsruhe Research Accelerator (KARA), the electron storage ring of the KIT Light Source, the beam energy is ramped up from 53 MeV to 500 MeV by a booster synchrotron. The whole booster is located in a concrete enclosure inside the storage ring and thus not accessible during operation. For the study of longitudinal beam dynamics, a cost-effective solution to leverage the synchrotron radiation emitted at the booster bending magnets is desired. To ensure durability of the setup and to not obstruct the removable concrete ceiling of the booster enclosure, it is required to place the radiation-sensitive readout electronics outside of the booster enclosure and outside of the storage ring. In this contribution, a fiber-optic setup consisting of commercially available optical components, such as collimators, optical fibers and high bandwidth photodetectors are used. As a proof-of-concept, we present experimental results of different components characterized at the visual light diagnostics port of the storage ring KARA. In addition, we report on further improvements of the setup along with planned future experiments.

AKBP 2.6 Mon 17:15 CHE/0184

Simulation Studies on a High-Gain XUV FEL Oscillator at FLASH — • Margarit Asatryan1, Georgia Paraskaris1, Velizar Mitchev1, and Stefan Schwenk1 — • 1Deutsches Elektronen-Synchrotron DESY, 22607 Hamburg, Germany

Externally seeded high-gain FELs can generate fully coherent radiation with high shot-to-shot stability. With the application of harmonic conversion schemes, these qualities can be achieved at wavelengths down to the soft X-ray range. However, at the moment, such FEL schemes aimed at the generation of short-wavelength radiation are limited in their repetition rate by the suitable seed laser sources and thus are unable to operate at the full repetition rate of superconducting machines. Cavity-based FELs have been proposed as a possible solution that would allow the generation of short-wavelength, fully coherent FEL radiation at high repetition rates. We present simulation studies for such a high-gain FEL oscillator, which is planned to be implemented at FLASH. The setup is aimed to operate at the repetition rate of 5 MHz, generating fully coherent radiation at the wavelength of 13.5 nm. The electron beam bunched at 13.5 nm can be further used in a harmonic conversion scheme to generate fully coherent radiation at much shorter wavelengths.

AKBP 2.7 Mon 17:30 CHE/0184

Advanced applications of laser heaters — • Linus Bolte1, Philipp Amstutz2, Christopher Gertih2, Shaukat Khan1, and Carsten Mai1 — • Center for Synchrotron Radiation (DELTA), TU Dortmund University, Dortmund, Germany — • 2Deutsches Elektronen-Synchrotron DESY, Hamburg Germany

Many FEL facilities use laser heaters to increase the electron energy spread and hence suppress microbunching instabilities. As part of the FLASH2020+ upgrade at DESY, a laser heater has been installed upstream of the first bunch compressor chicane. The goal of the FLASH Laser-Assisted Reshaping of Electron bunches (FLARE) project is to implement energy modulation schemes expanding the laser heater’s basic purpose. This includes intentionally overheating regions of the electron bunch, as well as an up to now untested bunch compression method that will allow the generation of tunable few-femtosecond and possibly sub-femtosecond electron distributions. First studies on advanced applications of the laser heater will be presented.
AKBP 3: Accelerator and Medical Physics (joint session ST/AKBP)

AKBP 3.1  Tue 11:00  GER/038
Real-time analysis for a scintillating fiber-based ion beam profile monitor — Liqing Qin, Qian Yang, and Blake Leverington — Physikalisches Institut, Heidelberg, Germany

For raster scanning of a pencil beam during ion beam therapy, it is necessary to monitor the beam in real-time for safety and quality reasons. A scintillating fiber-based beam profile monitor developed from LHCb fiber-winding techniques will offer real-time information of the pencil beam parameters, including position, width, and intensity, with a readout rate of up to 10 kHz.

The preliminary reconstruction algorithm for a Gaussian-like beam is being implemented on an FPGA. Preliminary results of the reconstruction algorithm performance on the FPGA will be presented.

AKBP 3.2  Tue 11:15  GER/038
Application of HV-CMOS sensor in a position monitoring system for therapeutic ion beams — Bogdan Topko,1 Matthias Balzer,2 Alexander Dierlamm3,4, Felix Ehrlker,5 Ulrich Huesemann,1 Roland Kopfenhöfer1, Ivan Perić6, Martin Pittermann2, and Alena Weber6,7,8 — Institute of Experimental Particle Physics (ETP), Karlsruhe Institute of Technology (KIT) — 2 Institute for Data Processing and Electronics (IPE), KIT — 3 now with Bosch AG

Cancer treatment with ion beams provides critical advantages compared to the photon radiation approach. The Bragg peak of the ion energy deposition near the end of the particle range allows to deposit the maximum of energy to the tumor and minimize the damage of healthy tissue. The beam position and size can be precisely controlled by the beam delivery system. In order to provide effective and safe dose delivery to the tumor, a fast and reliable beam monitoring system is required. The studies presented in this talk are focused on the application of HV-CMOS sensors for such a beam monitoring system. This system should provide information about beam position, shape and fluence in real time. It should work under beam intensities up to 10^{10} ions and deliver fluence information every 1-2 ms. In order to fulfill the timing requirements, the HitPix chip family with controlling electronics and frame based readout has been developed at the ASIC and Detector Lab (IPE, KIT). Recent measurements with ion beams and a multi-chip matrix as well as future developments are discussed.

AKBP 3.3  Tue 11:30  GER/038
Medical irradiation simulations for IBPT accelerators — Katharina Mayer1, Erik Bründermann1, Alfredo Ferrarì2, Michael J. Nashe3, Markus Schwarz4, and Anne-Susanne Müller4,5,6 — IBPT, KIT, Karlsruhe — 2 LAS, KIT, Karlsruhe — 3 IAP, KIT, Karlsruhe

An important cancer treatment method used in oncology is radiation therapy, in which the tumor is irradiated with ionizing radiation. In recent years, the study of the beneficial effects of short intense radiation pulses (FLASH effect) or spatially fractionated radiation (Microbeam) have become an important research field. Systematic studies of this type often require non-medical accelerators capable of producing the requested short intense pulses. At KIT, the Kerninfrarot Linac- and Testexperiment (FLUTE) can produce ultra-short electron bunches and the KIT storage ring KARA (Karlsruher Research Accelerator) is a source of pulsed X-rays. Both can be used as pulsed high-energy radiation sources and compared to conventional X-ray tubes. In this contribution, first dose simulations for FLUTE using the Monte Carlo simulation program FLUKA are presented.

AKBP 3.4  Tue 11:45  GER/038

The electron stretcher facility ELSA delivers up to 3.2 GeV electrons to external experimental stations. In a new setup the irradiation of tumor cells inside a water volume with doses of up to 50 Gy by ultra-high energy electrons (UHEE) in time windows of microseconds up to milliseconds is currently investigated. This technique may enable highly efficient treatment of deep-seated tumors alongside optimal sparing and protection of healthy tissue. Along the effort to measure the dose with a suitable detector, our approach is to determine the optimal dose distribution by simulations. Therefore, the electromagnetic shower process is simulated in Geant4, taking the extracted electron pulse properties into account. A virtual water volume is constructed of voxels of different sizes for precise investigation in the volume of interest. Various properties such as particle types, deposited energy and the energy spectra of the particle shower can be extracted and correlated to relative and absolute dose measurements at the real water phantom. The method and first results will be presented.

AKBP 3.5  Tue 12:00  GER/038

The electron accelerator facility ELISA delivers up to 3.2 GeV electrons. Ultra-high energy electrons (UHEE) in short pulses of microseconds up to milliseconds (FLASH) are used to investigate the effect of UHEE on tumor cells. This may enable highly efficient treatment of deep-seated tumors due to the FLASH effect. Currently, in a preliminary setting the Booster-Synchrotron is used to deliver electrons of 1.2 GeV energy, to irradiate cell samples placed in a water phantom. A precise dose determination is necessary to monitor the efficacy of the biological effect. Therefore, the usability of different detector types for a precise dose determination is evaluated.

AKBP 3.6  Tue 12:15  GER/038
Dosimetry tests for FLASH RT at PITZ — Felix Riemer, Zakaria Aboul-Ranie, Gowri Adhikari, Zohrab Amirkhanian, Namra Aftab, Prach Boonpornsarset, Georg Georgiev, Anna Grebinkyt, Andreas Hoffmann, Mikhail Krasilnikov, Xiangkun Li, Anusorn Luangsangmong, Raffael Niemczyk, Houjun Qian, Chris Richard, Frank Stephan, Gregori Vashchenko, Tobias Weilbach, and Steven Worm — Deutsches Elektronen-Synchrotron DESY, Platanenallee 6, 15738 Zeuthen, Germany

The Photo Injector Test facility at DESY in Zeuthen (PITZ) can provide unique pulsed electron beams regarding delivered dose and dose rate. With an average dose rate of up to 10^7 Gy/s and peak dose rates of up to 4 ⋅ 10^11 Gy/s, PITZ is fully capable of FLASH radiation therapy. Nevertheless, dosimetry is a major challenge. Traditional detectors cannot provide reliable measurements and linearity up to such high dose rates. A new setup is being built to create a test infrastructure for all kinds of detectors. This includes a completely new beamline exclusively for FLASH RT and biology experiments. The goal is to develop and test detectors (also from external users) which cover the whole range of dose rates available at PITZ. First dosimetry experiments using GaFochronic films were done in air and water. Dose rate linearity and a limit test of the films were done. Beam parameters like beam profile, dose depth profile in water, homogeneity and dark current were measured. First detector tests will be done using silicon sensors utilized in high energy physics experiments.

AKBP 4: Plasmas and Lasers

AKBP 4.1  Tue 16:30  CHE/0183
Large Energy Deposition of a Beam Driver in a Plasma-Wakefield Accelerator — Felipe Peña1,2, Carl A. Lindström1,3, Judita Beinortaitė1,4, Jonas Björklund Svensson1, Lewis Boulot1,2,5,6, Severin Diederichs7, James M. Garland1, Pau González Caminal3, Grigor Loisch1,2, Sarah Schröder1, Maxence Thévenet1, Stephan Wiesch8, Jonathan Wood1, Jens Österhofs1,9, and Richard D’Arcy10 — 1 Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany — 2 Universität Hamburg, Germany — 3 Universität von Oslo, Norway — 4 University College London, UK — 5 SUPA, University of Strathclyde, Glasgow, UK — 6 The Cockcroft Institute, Daresbury, UK

Beam-driven plasma-wakefield acceleration has the potential to reduce the size and construction cost of large-scale accelerator facilities, by providing accelerating fields orders of magnitude greater than that of conventional accelerating structures. Affordable running costs require demonstration of high energy-transfer efficiency from the wall-plug to the accelerated bunch. For this, drive bunches must be efficiently produced, strong decelerating fields must be sustained for the drive bunches until their energy is depleted, and the resulting accelerating fields must be strongly beam loaded by the trailing bunches. Here, we address the second of these points, showing measurements using a 500 MeV drive bunch where (50±7)% of its total energy is deposited into a 20 cm long plasma. This level of energy-transfer efficiency demonstrates that plasma accelerators hold the potential to become competitive with conventional accelerators.
AKBP 5: Hadron Accelerators

Time: Tuesday 16:30–18:00

AKBP 5.1 Tue 16:30 CHE/0184
Broadband laser cooling of stored relativistic bunch ion beams at the ESR — Sébastien Klamms, Lars Bozyk, Michael Russmann, Noah Eizenhoffer, Volker Hannek, Max Horst, Daniel Kiefer, Thomas Küh, Benedikt Langfeld, Xinwen Ma, Wilfried Nörterhäuser, Rodolfo Sánchez, Ulrich Schramm, Mathis Siebold, Peter Spiller, Markus Steck, Thomas Stöhr, Ken Uebelhoer, Thomas Walther, Hansbin Wang, Weiliang Wen, Daniel Wenzn, and Danyal Winters — 1 GSI Darmstadt — 2 HDRZ Dresden — 3 Casus Görlitz — 4 TU Darmstadt — 5 Uni Münster — 6 Uni Kassel — 7 Hi Jena — 8 IMP Lanzhou — 9 HHF Darmstadt — 10 TU Dresden — 11 Uni-Jena High-resolution experiments at heavy-ion storage rings strongly benefit from cold ion beams, i.e., beams with a small relative longitudinal momentum spread (Ap) and a small emittance (σθ). Especially for the higher ion intensities and Lorentz factors (γ) at FAIR (SIS100), laser cooling has proven to be a powerful tool for cooling of relativistic bunched ion beams. The principle is based on resonant absorption (photon momentum & energy) in the longitudinal direction and subsequent spontaneous random emission (fluorescence & ion recoil) by the ions, combined with a moderate bunching of the ion beam. We will report on results from a 2021 laser cooling experiment at the 150 MeV ions, which was performed at the ESR-2 storage ring. Putative resonances and novel cooling physics will be shown.

AKBP 5.2 Tue 16:45 CHE/0184
Tumor irradiation in mice with a laser-accelerated proton beam — Florian Kroll, Florian-Emanuel Brack, Elke Betreyer, Thomas Cowan, Łukasz Karsich, Josephine Metzkes, Jörg Pawelek, Marvin Reimold, Ulrich Schramm, Tim Siegler, and Karl Zeil — 1 Helmholz-Zentrum Dresden-Rossendorf, Dresden, Germany — 2 OncoRay – National Center for Radiation Research in Oncology, Dresden, Germany — 3 Technical University Dresden, Dresden, Germany Oncological studies identified beneficial properties of radiation applied at dose rates considerably exceeding the clinical standard of 1 Gy/min. At the Draco PW laser of Helmholz-Zentrum Dresden-Rossendorf, a laser-driven proton research platform enables research on ultra-high dose rate effects for diverse user-specific small animal models. Tunable single-shot doses are applied to mm-scale volumes on ns time scales, resulting in instantaneous dose rates around 10⁶ Gy/s. Dose distributions that uniformly cover the sample volume were generated from individual broad-band proton bunches provided by our laser-driven source with unprecedented stability and long-term reliability. Maximum proton energies regularly exceed 60 MeV.

AKBP 4.4 Tue 18:00 CHE/0183
Status Of Plasma Diagnostics On The Prototype Plasma Lens For Optical Matching At The ILC e+ e− Source — Niels Hamann, Gregor Losch, Manuel Formella, Kai Ludwig, Jens Osterhoff, and Guorid Mooragick-Pick — 1 Uni Hamburg — 2 DESY Hamburg In recent years, high-gradient, symmetric focusing with active plasma lenses has regained significant interest due to its potential advantages in compactness and beam dynamics compared to conventional focusing elements. A promising application could be optical matching of highly divergent positrons from the undulator-based ILC positron source into the downstream accelerating structures to increase the positron yield. In a collaboration between University Hamburg and DESY Hamburg a downscaled prototype for this application has been developed. Here, we present first plasma diagnostics results, such as discharge current stability, electron density distribution and reproducibility. Additionally, future plans for measuring the magnetic field distribution and a possible fullscale prototype will be discussed.

AKBP 4.5 Tue 18:30 CHE/0183
Multi-turn ERL mode of the S-DALINAC — Manuel Dutina, Michael Arnold, Jonny Birch, Andreas Brach, Jochen Enders, Marco Fischer, Ruben Greswe, Lars Jürgensen, Maximilian Meier, Norbert Pietralla, Felix Schliessmann, Dominic Schneider, Merle Seeger, Alexander Smukins, and Manuel Steinhorst — Institut für Kernphysik, Technische Universität Darmstadt The superconducting Darmstadt linear accelerator S-DALINAC is a three- recirculating accelerator for electrons supporting a variety of experimental programs in nuclear physics and nuclear photonics. Besides the conventional acceleration scheme, it can also be operated as an energy-recovery linac (ERL) [1] and contributes to research on this exciting topic of technology development. The world-wide first successful operation as a superconducting multi-turn ERL has been demonstrated in August 2021 [2]. A variety of projects address further developments, for instance, dedicated diagnostics to measure the position of a beam in the same beamline, simultaneously or to resolve its time structure, have been used for first measurements. This contribution gives an overview of their status. [1] M. Arnold et al., First operation of the superconducting Darmstadt linear electron accelerator as an energy recovery linac, Phys. Rev. Accel. Beams 23, 020101 (2020) [2] F. Schliessmann et al., Realization of a multi-turn energy-recovery accelerator, Nat. Phys. (in press). *Work supported by DFG (GRK 2120), BMFB (05H21RDB1), the State of Hesse within the Research Cluster ELEMENTS (Project ID 500/10.096) and the LOEWE Research Group Nuclear Photonics.

AKBP 4.2 Tue 17:00 CHE/0183
SPeed: Worldwide first implementation of the EEHG scheme at a storage ring — Zohair Usfoor, Benedikt Busign, Arne Held, Shakat Khan, Carsten Mai, Arjun Radha Krishnan, Wael Salah, and Vivek Viswanath — 1 Center for Synchrotron Radiation (DELT), TU Dortmund University, Dortmund, Germany — 2 The Hashemite University, Zarqa, Jordan At DELTA, a 1.5-GeV synchrotron radiation source at TU Dortmund University, the CHG (coherent harmonic generation) scheme is employed to generate ultrashort radiation pulses. In CHG, the interaction of electron bunches with laser pulses in a first undulator (modulator) causes a periodic electron energy modulation. A change in the density modulation, giving rise to a coherent emission of ultrashort pulses at harmonics of the seed laser in a second undulator (radiator). A reconfiguration of the U250 device that incorporated the two undulators and the chicannelet was underway in summer 2022 to demonstrate EEHG (echo-enabled harmonic generation, originally proposed for linac-based free-electron lasers) at a storage ring and to enable the generation of higher harmonics. The goal of the project is to create two chicanes for the manipulation of the electron density, and a radiator, with only a few undulator periods comprising each section. The produced EEHG pulses are detected by an in-vacuum grating spectrometer. Initial results are presented. To our knowledge, this is the first attempt worldwide to successfully apply EEHG at a storage ring.

AKBP 4.3 Tue 17:30 CHE/0183
High-temperature superconductor undulators and magnets for the future compact light sources — Saimar Fatehi, Axel Bernhard, and Anne-Susanne Müller — Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany In this contribution, an overview of the ongoing projects at KIT on the high-temperature superconductor (HTS) undulators and magnets is given, and the research on beam dynamics and magnet design of a laser-plasma accelerator-based, miniature beam transport line using HTS novel periodic magnets is presented in detail. In laser-plasma accelerators (LPA), due to extremely high accelerating gradients, electron bunches are accelerated to high energies in only a few millimeters to centimeters of acceleration length. To efficiently capture and transport the LPA-generated bunches in a compact transport line, beam line designs employing high-strength combined-function magnets based on high-temperature superconductor technology have been studied. Moreover, to overcome coil winding challenges in fabricating miniature HTS magnets, novel periodic magnets were designed, which can be cooled and guide the electron beam in a well-controlled short-length transport line. The designed transport line has a length of 1.4 m matching the beam optics parameters of the LPA-generated electron beams to the transverse-gradient undulator (TGU) requirements.

AKBP 5.3 Tue 17:45 CHE/0183
Status of the U250 device and the implementation of a high-strength magnet — Dariusz Rychlewski, Volkmar Seidel, Uwe Körner, and Christian Petersen — 1 University of Applied Sciences, Jena — 2 University of Applied Sciences Dresden, Dresden, Germany The design and construction of the U250 device are described, which has been developed to create two new high-gradient undulators (TGUs) for the FLASH and PETRA 3 facilities. The device is intended to provide up to 400 T/s/m and a peak magnetic field of 7 T at a length of 0.6 m. The magnetic circuit is made of high-strength combined-function magnets based on high-temperature superconductors (HTS). The undulator magnet has a length of 1.4 mm, matching the beam optics parameters of the LPA-generated electron beams to the transverse-gradient undulator (TGU) requirements.
AKBP 5.3 Tue 17:00 CHE/0184
Update on the Future Neutron Beam Line at the Bonn Isocchronous Cyclotron — Maximilian Loepeke, Reinhard Beck, Dieter Eversheim, and Dennis Sauerländer — Helmholtz-Institut für Kernforschung und Kernphysik Bonn
The Bonn Isocchronous Cyclotron provides a beam of protons, deuterons, α-particles or other light ions with a charge-to-mass ratio ≥ 1/2 with a kinetic energy ranging from 7 to 14 MeV per nucleon. Since 1991, a proton beam is utilized for irradiation of e.g. silicon pixel detectors for radiation hardness studies.
It is planned to extend the facility’s irradiation and experimentation capabilities by providing a neutron beam in the near future. The neutrons are produced by splitting-up deuterons into protons and neutrons in a thick carbon or beryllium converter. Protons are stopped in the converter whereas the neutrons’ flux and angular energy distribution is optimized by a subsequent copper/tungsten collimator. After collimation, the neutron beam can be utilized to irradiate a target.
The transversal dimension, yield and energy distribution of the neutron beam has been estimated for different collimator geometries using simulations with Geant4 to optimize for radiation hardness tests.
This talk gives a conceptual overview of the future experimental area and results of the simulations are presented.

AKBP 5.4 Tue 17:15 CHE/0184
Standalone Readout for Mimosi-Sensors of the MVD. — Benedikt Gutsche for the CBM-Collaboration — Goethe University Frankfurt
The Micro-Vertex-Detector (MVD) is a four-layer layer pixel detector and the first detector stage of the CBM experiment. Besides dedicated sensors (MI-MORIS), a fast and robust readout is necessary in order to handle the data in a proper way. In the prototyping phase of the detector and for sensor evaluation, a test system with smaller capabilities regarding the number of read-out sensors has been developed. This enables the use of a much simpler FPGA-based system. We chose the TRB platform and existing software framework, originally developed for HADES at GSI. We are going to show how automated tests of sensors can be implemented, in order to provide important information like the dead pixel count or the behaviour of DACs, using TRB-Software and root-based analysis applications (DABC, Go4).
This work has been supported by BMBF (05P21RFCC2) and GSI.

AKBP 5.5 Tue 17:30 CHE/0184
Upgrade of the Beam Preparation System of the Bonn Isocchronous Cyclotron — Béla Daniel Knopp, Reinhard Beck, Paul-Dieter Eversheim, Dennis Sauerländer, and Pascal Wolf — Helmholtz-Institut für Kernforschung und Kernphysik Bonn — SiLab, Physikalisches Institut, Universität Bonn
With the Bonn Isochronous Cyclotron either protons, deuterons, alpha particles or other light ions with a charge-to-mass ratio ≥ 1/2 are accelerated to a kinetic energy ranging from 7 to 14 MeV per nucleon. The extracted beam is guided to one of five experimental sites via a high-energy beamlime. To ensure a controlled beam transport via this beamlime, the beam is stabilized in angle and position by the beam preparation system after extraction from the cyclotron. This is achieved by fixing the beam position in two consecutive locations. Using pairs of adjustable scrappers which are symmetrically aligned horizontally and vertically around the design orbit one can deduce the relative beam position in the transversal plane. This is done by comparing the beam scrape-off current at the scrappers when the beam is passing between them. Using the relative beam position as feedback for a control loop, the respective beam deviation from the design orbit can be minimized by using dedicated corrector magnets.
In this talk, the design and development of a new digital readout and control of the beam preparation system, which replaces the current analog one, will be presented.

AKBP 6: New Results from Accelerators for Hadron Physics

Time: Wednesday 11:00–12:30

Group Report

AKBP 6.1 Wed 11:00 HSZ/0304
Laser spectroscopy of Mg+ at CRYRING@ESR — Konstantin Moha1,2, Zoran Andelkovic1, Volkmar Hannes1, Frank Herfurth1, Max Hors1,2, Phillip Ingrham1, Kristian König1,2, Claude Krantz1, Michael Lestinsky1, Yuri Litvinov1, Bernhard Maass1,2, Esther Menz1,2, Patrick Müller1,3, Wilfried Nörtershäuser1,2, Simon Rauch1,2, Rodolfo Sánchez2, Ragandeep Singh Sidhu1, and Ren Überholz4 — Institut für Kernphysik, TU Darmstadt, Germany — 2Helmholtzforschungszentrales Hessen für FAIR, HHFF, Darmstadt, Germany — 3GSI Helmholtzzentrum für Schwerionenforschung GmbH, Germany — 4Institut für Kernphysik, WWU Münster, Germany — 5ANL, Illinois, USA — 6Helmholtzzentrum Jena, Germany — 7University of Edinburgh, Scotland
The storage ring CRYRING@ESR at GSI/FAIR is dedicated to precision experiments with stored and cooled ions of energies down to few MeV. One of the first experiments at CRYRING@ESR was laser spectroscopy on the stable Mg isotopes, carried out to test a possible in-flight polarization buildup by optical pumping. Especially parity-non-conservation experiments would benefit from this technique. During the first attempts, we found an unexpectedly fast population transfer between the hyperfine ground states F=2,3 of Mg, which could be associated with the mixing of velocity classes caused by synchrotron oscillations in bunched-beam operation. We present the current status of the experiment and discuss the influence of dynamic effects. This work is supported by BMBF contract 05P21RDF1A.

Group Report

AKBP 6.2 Wed 11:30 HSZ/0304
The efficient acceleration of gold ions is a first step towards the 'fission-fusion' reaction mechanism, which aims at investigating the rapid neutron capture process in the vicinity of the N=126 waiting point[1]. In our recent measurement at the PHELIX laser with a pulse length of 500fs, for the first time, the laser-based acceleration of gold ions above 7 MeV/u was demonstrated. Additionally, in comparison with field ionization, much better agreement of the simulated charge states with the experimental branch of the particle-in-cell simulation code EPOCH[3], showing a much better agreement of the simulated charge state distributions with the experimentally measured ones than when only considering field ionization. This work is continued at the Centre for Advanced Laser Applications (CALA), using the ATLAS3000 laser (800nm central wavelength, 25 fs pulse length).

Group Report

AKBP 6.3 Wed 12:00 HSZ/0304
Pure Copper and Stainless Steel Additive Manufacturing of an I-H Type Linac Structure — Hendrik Hänel, Adem Ates, and Ulrich Ratzinger — Institut für Angewandte Physik, Goethe Universität, Frankfurt am Main
Additive manufacturing ("AM") has become a powerful tool for rapid prototyping and manufacturing of complex geometries. A 433 MHz IH-DTL cavity has been constructed to act as a proof of concept for direct additive manufacturing of linac components. In this case, the internal drift tube structure has been produced from 1.4404 stainless steel, as well as pure copper using AM. The prototype cavity, as well as stainless steel AM parts have been copper plated. We present results from low level rf measurements of the cavity with and without copper plating, as well as the status of preparations for high power rf tests with a 30 kW pulsed power amplifier.

AKBP 6.4 Wed 12:15 CHE/0184
Kaon beam studies employing conventional hadron beam concepts at the CERN M2 beam line for the future AMBER experiment — Fabian Metzger1,2, Dipanshwa Banerjee1, Johann Bernhard3,4, Laug Gatignon5, Alexender Gerbershagen6,7, Bernhard Ketzler1,2, Laurence James Neva5,8, and Silvia Schuh9 — 1Universität Bonn, Helmholtz-Institut für Strahlen- und Kernphysik Bonn, Germany — 2CERN, Geneva, Switzerland — 3Lancaster University, Lancaster, United Kingdom — 4University of Groningen, Particle Therapy Research Center, Netherlands
As a part of its rich proposed future physics programme, the AMBER (NA66) experiment aims to measure the inner structure of mesons with open strangeness with a high-intensity kaon beam at the CERN secondary beam line M2. One way to identify the small fraction of kaons in the available beam is tagging with the help of differential Cherenkov detectors (CEDARs), which are blind to other particles and whose detection efficiency depends critically on the beam parallelism.
In this contribution, we discuss possible improvements of the conventional beam optics to achieve a better performance of the CEDARs for the AMBER programme with hadron beams, in particular for the planned Drell-Yan and diffractive measurements. We focus on the investigation of multiple scattering in the present setup in the regions where the beam runs through vacuum windows and air at atmospheric pressure, and on the optimization of the beam optics.
AKBP 7: Experiments for Advanced Light Sources

Time: Wednesday 14:00–15:30

Group Report

AKBP 7.1 Wed 14:00 HSZ/0304

Seeded free-electron laser driven by laser-plasma accelerators - a quest to compact high-brilliance x-ray lasers — Ari Iman1, Amin Ghaith1, Marie Labat2, Éléonore Roussel1, Jurjen Coperus-Cabadag1, Alexandre Loubyrle1, Susanne Schöbel1, Maxwell Läberger1, Patrick Ufer1, Yen-Yu Chang2, Nicolas Hubert3, Moussa El Ajjouri4, Anthony Berlioux1, Mathieu Vallèau2, Philippe Bertrand2, Frédéric Blachere2, Sébastien Cordé2, Alexander Dew5, Carlos de Oliveira2, Jean-Pierre Duval2, Yannick Dietrich2, Christian Eisenmann2, Julien Gautier2, René Gebhardt2, Simon Grams2, Uwe Helbig1, Christian Herbeaux1, Charles Kitégét1, Olena Kononenko1, Michael Kuntzsch1, Stéphane Lé2, Bruno Leluan2, Fabrice Marteau2, Manh Huy Nguyen1, Richard Pauch2, Pascal Rouesseau2, Mourad Serdoura1, Klaus Stengiger1, Kei- hana Tavakoli2, Cédric Theau3, Marc Vandenbreghe1, José Vézérán1, Victor Malka1, Driss Oumbarek-Espino2, Damien Pereira1, Thomas Püschel1, Jean-Paul Ricaud1, Patrick Rommeleûr2, and Ulrich Schramm1 — Helmholtz-Zentrum Dresden-Rossendorf e. V. (Germany); — Synchrotron SOLEIL (France) — Lab. de Physique des Lasers, Atomes et Molécules (France) — Lab. d’Optique Appliquée (France); — Free-electron lasers (FELs) produce high-brilliance coherent light pulses, serving as versatile research tools in fundamental science and applications. The recent development of short-wavelength seeded FEL now allows for unprecedented levels of control on longitudinal coherence, opening new scientific avenues such as ultra-fast dynamics on complex systems and X-ray nonlinear optics. Although those devices rely on state-of-the-art large-scale accelerators, advances on laser-plasma accelerators, which harness gigawatt laser-driven plasma fields, showcase a promising technology as compact drivers for FELs. This talk will review the current status of global effort toward realization of compact FELs. In particular, we present the development of high-quality laser-plasma accelerated electron beams and the commissioning of the COXINEL - FEL beamline, as well as experimental demonstration of FEL lasing at 270 nm in a seeded configuration. Control over the radiation wavelength is achieved with an improved bandwidth stability. Furthermore, the appearance of interference fringes, resulting from the interaction between the phase-locked emitted radiation and the seed, confirms longitudinal coherence, representing a key feature of such a seeded FEL. We anticipate a navigable pathway toward smaller-scale free-electron lasers at extreme ultra-violet wavelengths.

AKBP 8. Advanced IT Tools

Time: Wednesday 15:45–17:15

AKBP 8.1 Wed 15:45 CHE/0183

Image space reconstruction algorithm for LPS tomography at PITZ — Nama Aftab1, Prach Boonpornsri1, Giorgi Georgiev1, Matthias Gross1, Andreas Hoffmann1, Mikhail Krassilnikov1, Xiangkun Lu1, Armin Krönert1, Richard Richard1, Frank Stephan2, Gyorgyi Vashchenko1, Wolfgang Hillert2, and Andrew Reader3 — Deutsches Elektronen-Synchrotron, Zeuthen, Germany — University of Hamburg, Institute for Experimental Physics, Hamburg, Germany — School of Biomedical Engineering and Imaging Sciences, Kings College London, UK

At thePhoton Injector Test Facility at DESY in Zeuthen, longitudinal phase space (LPS) before the booster is determined by an iterative reconstruction method called Algebraic Reconstruction Technique (ART). Although ART is simple to implement with good convergence speed, the results show many artefacts and overestimate energy spread and bunch length. Recently LPS tomography was done via Image Space Reconstruction Algorithm (ISR) which showed promising results owing to its assurance of non-negative solution. The weight matrix crucial for successive updates was improved by bilinear interpolation. The initial guess for iterations was established from low energy section momentum measurements. The aforementioned reforms resulted in reduced noise-like artefacts, better convergence speed and accurate longitudinal emittance. ISR was tested on simulations as well as on experimental data. It can diagnose not only linear chirp in LPS but also higher order effects. Experiments with modulated laser beams were also designed to demonstrate the diagnostic capability.

AKBP 8.2 Wed 16:00 CHE/0183

Injection Optimization via Reinforcement Learning at the Cooler Synchrotron COST — Anal Anaw1,2, Jan Hetzel1, and Jorg Pfeitz1 — RWTH Aachen University, Department of Medical Radiation Oncology, Aachen, Germany

In accelerator facilities, it is important to have a particle beam with high intensity and small emittance in a timely manner for the successful operation of the experiments. The main challenges limiting the availability of the beam to the users and limiting the beam intensity in storage rings are the lengthy optimization process and the injection losses. The setup of the Injection Beam Line (IBL) depends on a large number of configurations in a complex, non-linear, and time-dependent way. Reinforcement Learning (RL) methods have shown great potential in optimizing various complex systems. However, unlike other optimization methods, RL agents are sample inefficient and have to be trained in simulation before running them on the real IBL. In this research, RL agents are trained to learn the optimal injection strategy of the IBL for the Cooler Synchrotron (COST) at Forschungszentrum Julich. The challenge of sim-to-real transfer, where the RL agent trained in simulation does not perform well in the real world, is addressed by incorporating domain randomization. The goal is to increase the beam intensity inside COSY while decreasing the setup time required. This method has the potential to be applied in future accelerators like the FAIR facility.
tion will enable faster deployment of learning-based tuning routines, and lead towards the ultimate goal of autonomous operation of accelerator systems and transfer of RL methods to most accelerators.

C. Xu acknowledges the support by the DFG-funded Doctoral School "Karlsruhe School of Elementary and Astroparticle Physics: Science and Technology".

AKBP 8.4 Wed 16:30 CHE/0183 Sensitivity Analysis and Online Surrogate Construction at the S-DALINAC Using Polynomial Chaos and Neural Networks — Dominik Schneider, Michaela Arnold, Jonny Birkkan, Ruben Grewe, Norbert Pietralla, and Felix Schliesmann — Institut f"ur Kernphysik, Technische Universit"at Darmstadt, Darmstadt, Germany

Particle accelerators are complex systems that coincide with their ideal design within the tolerances of its large number of technical components. Quantitative understanding of the beam dynamics and the analysis of their sensitivity to various components are challenging tasks. Machine learning methods provide the potential for the optimized operation of particle accelerators. In this contribution, the application of so-called surrogate models to the electron accelerator S-DALINAC will be discussed. This machine learning technique gives access to predict future behavior and an extensive set of characteristics that can be extracted by analyzing the trained model. The talk will include the presentation of a series of measurements performed in the injector section of the S-DALINAC to study the behavior of beam-influencing elements. Surrogate models, constructed and based on the acquired data, are being evaluated to reveal the behavior of these elements. Based on the information obtained, optimizations of the alignment of magnets as well as the beam dynamics simulations at the S-DALINAC will be discussed.

Supported by the State of Hesse and the Research Cluster ELEMENTS (Project-ID 500/10.006).

AKBP 8.5 Wed 16:45 CHE/0183 Generating synthetic shadowgrams with an in-situ plugin in PiconGPU — Finn-Ole Carstens1,2, Klaus Stenger1, Richard Paesch1, Susanne Schöbel1,2, Yen-Yu Chang1, Arie Irman1, Ulrich Schramm2,3, and Alexander Debuss1,2 — Helmholtz-Zentrum Dresden-Rossendorf —

1 Technische Universität Dresden
2 Universit"at Saarland
3 European XFEL GmbH

To assess the feasibility of ultrafast imaging, a numerical simulation is developed to model an electron pulse from the gun that is deflected by a stream of molecules running perpendicular to the pulse's path to then create a (motion-) blurred image of an individual particle after passing through a magnetic lens system. Considering the injector's spatial coherence, this work's first goal is to find optimal imaging conditions to differentiate between two molecule orientations. After showing that a contrast between different images can be successfully obtained, the simulation is currently being refined to work as a tool for parameter optimization. Given the pulse features, the model is able to output suitable lens settings. It is also used to compare different techniques, such as dark and bright field imaging, with the overall goal to find the most promising setups for future experiments.


The superconducting radio-frequency (SRF) photoinjector is a photoelectron driven linear accelerator located at the SEALab facility at Helmholtz-Zentrum Berlin. With the injector, very flexible beam parameters can be achieved enabling many scientific applications like performing ultrafast electron scattering, with diffraction and imaging modalities, which is this work's focus. Complex structures such as biological molecules, which are not suitable for conventional crystallographic methods, could be imaged and studied with this technique.

To assess the feasibility of ultrafast imaging, a numerical simulation is developed to model an electron pulse from the gun that is deflected by a stream of molecules running perpendicular to the pulse's path to then create a (motion-) blurred image of an individual particle after passing through a magnetic lens system. Considering the injector's spatial coherence, this work's first goal is to find optimal imaging conditions to differentiate between two molecule orientations. After showing that a contrast between different images can be successfully obtained, the simulation is currently being refined to work as a tool for parameter optimization. Given the pulse features, the model is able to output suitable lens settings. It is also used to compare different techniques, such as dark and bright field imaging, with the overall goal to find the most promising setups for future experiments.

AKBP 9.2 Wed 16:00 CHE/0184 Determination of the Invariant Spin Axis in a COSY model using Bmad — Maximilian Vitz — Institute for Nuclear Physics IV, FZ J"ulich, Germany — III. Physikalisches Institut B, RWTH Aachen University, Germany

The matter-antimatter asymmetry might be understood by investigating the EDM (Electric Dipole Moment) of elementary charged particles. A permanent EDM of a subatomic particle violates time reversal and parity symmetry at the same time. A finite EDM would be, if discovered with the currently achievable experimental accuracy, an indication for further CP violation than established in the Standard Model.

The Jülich-Collaboration (Jülich Electric Dipole moment Investigations) in Jülich has performed a direct EDM measurement for deuterons with the so-called precursor experiments at the storage ring COSY (Cooler Synchrotron) in Forschungszentrum Jülich by measuring the invariant spin axis.

In order to interpret the measured data and to disentangle a potential EDM signal from systematic effects in the radial part of the invariant spin axis, spin tracking simulations in an accurate simulation model of COSY are needed. Therefore a model of COSY has been implemented using the software library Bmad. Systematic effects were corrected by including element misalignments, etc. These effects rotate the invariant spin axis in addition to the EDM and have to be analyzed and understood. The most recent spin tracking results as well as the methods to find the invariant spin axis will be presented.

AKBP 9.3 Wed 16:15 CHE/0184 Simulations of Beam Dynamics and Beam Lifetime for the Prototype EDM Ring — Saad Siddique for the CPEDM-Collaboration — JEDI Collaboration — GSI Helmholtzzentrum für Schwerionenforschung Darmstadt Germany

The matter-antimatter asymmetry seen in the universe may be explained through CP-violation by observing a permanent electric dipole moment (EDM) of subatomic particles. An advanced approach to measure the EDM of charged particles is to apply a unique method of Frozen spin on a polarized beam in a storage ring. To increase the experimental precision step by step and to study systematic effects, the EDM experiment will be performed within three stages: the magnetic ring COSY (Cool Synchrotron Forschungszentrum Jülich Germany), a prototype EDM ring, and finally an all-electric EDM ring. The intermediate ring will be a mock-up of the final ring, which will be used to study a variety of systematic effects and to implement the basic principle of the final ring. Simulations of beam dynamics of the prototype EDM ring with different lattices are carried out to optimize the beam lifetime and minimize the systematic effects. The preliminary design of the prototype EDM ring helped to estimate the beam losses by using analytical formulas. Beam-target effects with more detailed simulations are being studied for beam losses and the application of stochastic cooling to control beam emittance growth is also being studied by using a simulation program. Further investigations to reduce systematic effects are also in progress.

For the study of spin-dependent processes polarised particle beams are indispensable. The LEAP (Laser Electron Acceleration with Polarisation) project at DESY aims to demonstrate the production of polarised electron beams exploiting the extremely high acceleration gradients of laser plasma accelerators. In this proof of principle experiment, spin-polarised electron beams with energies of tens of MeV will be generated in a sub-millimetre long plasma source. For electron beams of such energies, Compton transmission polarimetry is the ideal method to measure the polarisation. Gamma rays produced by bremsstrahlung are transmitted through a magnetised iron absorber core depending on their polarisation direction and that of the electrons in the iron. The resulting transmission asymmetry is proportional to the initial electron polarisation. In this talk, an overview of the LEAP project will be given and a polarimeter design, as well as its implementation and commissioning status will be presented.

AKBP 9.5 Wed 16:45 CHE/0184

Simulation studies on longitudinal beam dynamics manipulated by corrugated structures under different bunch length conditions at KARA — Sebastian Maijer, Miriam Brohi, Hyuk Jin Chai, Akira Mochihashi, Michael J. Nasse, Patrick Schreiber, Markus Schwarz, and Anke-Susanne Müller. 1, 2 LAS, KT, Karlsruhe — 2 IBPT, KT, Karlsruhe — 3 MAX IV Laboratory, Lund, Sweden

In the KIT storage ring KARA (Karlsruhe Research Accelerator), two parallel plates with periodic rectangular corrugations are planned to be installed. These plates will be used for impedance manipulation to study and eventually control the beam dynamics and the emitted coherent synchrotron radiation (CSR). In this contribution, we present simulation results showing the influence of different corrugated structures on the longitudinal beam dynamics and how this influence depends on the machine settings in the low momentum compaction regime, which are related to the bunch length changes.

This work is supported by the DFG project 431704792 in the ANR-DFG collaboration project ULTRASYNC. S. Maier acknowledges the support by the Doctoral School "Karlsruhe School of Elementary and Astroparticle Physics: Science and Technology".

AKBP 9.6 Wed 17:00 CHE/0184

Design of a Solenoid Magnet for the S-DALINAC — Merle Seeger, Michaela Arnold, Lars Jürgensen, Norbert Pietralla, and Felix Schliessmann. Institut für Kernphysik, Technische Universität Darmstadt, Germany

For the electron accelerator S-DALINAC, new focusing components in the low-energy injector section are needed. Small solenoid magnets can be used to focus low-energy beams in both transverse planes simultaneously. For this purpose, a precise magnetic field is beneficial. The effect of a specific magnet geometry on the magnetic field, as well as on the particle beam, can be investigated using computer simulations. Main influences to the magnetic field that are largely independent from installation constraints include the magnet radius and the yoke shape and material. To find an optimum design for a solenoid magnet for the S-DALINAC, variations of these magnet parameters were considered. Further calculations were made regarding the wiring and cooling of the magnet. In this contribution we will present the results of the computer simulations leading to the final design of the solenoid magnet, as well as detailing the challenges of the magnet construction.

*Work supported by DFG (GRK 2128 AccelerE).

AKBP 10: Instrumentation I

Time: Wednesday 17:30 – 19:00
Location: CHE/0183

AKBP 10.1 Wed 17:30 CHE/0183
Development of a Thermal Conversion Instrument for Niobium at Cryogenic Temperatures — Cem Sarıbal, Mark Wenskates, Cornelius Martens, Isabel González Díaz-Palacio, and Wolfgang Hillert. Department of Physics, University of Hamburg, Luruper Chaussee 149, 22761 Hamburg, Germany

Particle accelerators form an important tool in a variety of research fields including particle physics, material science, chemistry and medicine. In an effort to reduce operation costs while maintaining high energies, their accelerating structures, so-called superconducting radio-frequency (SRF) cavities, are steadily improved towards higher accelerating fields and lower RF losses. Stable operation of such a cavity generally requires Joule heating, generated in its walls, to be conducted to an outer helium bath. Therefore, it is of interest to experimentally evaluate how present and future cavity treatments affect thermal characteristics. We present an instrument for measuring the thermal performance of SRF cavity materials at cryogenic temperatures. Pairs of niobium disks are placed inside of a liquid helium bath and a temperature gradient is generated across them to obtain thermal transmission conductivity for temperatures ranging from 2 Kelvin to 4 Kelvin. To get an idea of the instrument’s sensitivity and how standard cavity treatments influence thermal conductivity, samples are tested in post fabrication, polishing and 800 degrees baking. These first tests serve as a baseline to study and evaluate new and promising cavity treatments such as ALD-coatings.

AKBP 10.2 Wed 17:45 CHE/0183
Status of the 5 MeV Mott polarimeter design for the MESA — Rakshya Thapa. Institut für Kernphysik, Mainz, Germany

A high intensity polarised beam has to be delivered to the P2 experiment at Mainz Energy Recovering Superconducting Accelerator Facility (MESA). The absolute error of the beam polarisation should be ≤1%. To track the polarisation, a Mott polarimeter will be installed after the pre-acceleration of the polarised beam to 5 MeV energy and measurements will be done in quasi-online mode with beam current = 150 μA at ≤1% precision. For that, the polarimeter scattering chamber and its assembly in the beam line is being designed which will be reported.

AKBP 10.3 Wed 18:00 CHE/0183
Teaching an old magnet new tricks — Tasha Sparh. Helmholtz-Zentrum Berlin — Humboldt-Universität zu Berlin

For beam dynamics studies in the SeaLab SRF photoinjector, a dipole spectrometer built in 1993 and recycled from a decommissioned ion beamline was installed. With this spectrometer, the beam energy and energy spread can be measured. The photodetector beam will be bent by 60deg to a viewscreen in the dispersive section. For a precision energy analysis based on the beam size measurement at the viewscreen, it is necessary to know the beam transfer matrix of the dipole, as well as the relationship between magnetic field and coil current in the plane of all possible trajectories.

With this information about the dipole magnet, the transformation matrix of the beamline was determined and now can be applied for a large range of energy measurements.

AKBP 10.4 Wed 18:15 CHE/0183
Design and set-up of a spectrometer for the electro-optical far-field setup to monitor the CSR at KARA — Ling Leander Grim, Guðrun Niebus, and Svante Wollman. 1 Johann Heinrich Steindorff, 2 Micha Reissig, 3 Erich Brendermann, and Anke-Susanne Müller. 1, 2 LAS, KT, Karlsruhe — 3 IBPT, KT, Karlsruhe

At the KIT storage ring KARA (Karlsruhe Research Accelerator), a new system to monitor the emitted coherent synchrotron radiation (CSR) is under commissioning aiming for single-shot measurements. The electro-optical (EO) far-field setup measures the time profile of the CSR employing electro-optical spectral decoding (EOSD). To achieve a sub-picosecond resolution for single-shot measurements, a high signal-to-noise ratio is crucial. Therefore, a spectrometer setup for balanced detection is developed. The ultra-fast line camera KALYPSO (Karlsruhe Linear array detector for MHz-repetition Rate Spectroscopic) will be installed as a detector. This contribution discusses the development and setup of the spectrometer, including optics simulations and first experiments.

AKBP 10.5 Wed 18:30 CHE/0183

The S-DALINAC at TU Darmstadt is a 3 GHz electron accelerator that allows the possibility to operate it in an energy range of 1.5 – 15 GeV. The multi-turn ERL operation mode was demonstrated in 2021. During the operation in this mode once accelerated and once decelerated beams share the same beamline which leads to the repetitive bunch rate of 6 GHz. A non-destructive beam monitoring tool is important for the simultaneous position measurement of both beams. For these purposes a setup based on Low Gain Avalanche Detectors (LGADs) is being developed for the beam time structure monitoring. LGADs are silicon detectors optimized for 4D-tracking with timing precision below 50 ps.
A new accelerator technologies, called the split-ring resonator (SRR), was tested at FLUTE, which aims at measuring the longitudinal bunch profile of fs-scale electron bunches. Laser-generated THz radiation is used to excite a high frequency oscillating magnetic field in the SRR. Electrons passing through the 20x20 mm SRR gap are time-dependently deflected in the vertical plane, leading to a vertical streaking of the electron bunch. During the commissioning of the SRR at FLUTE, large series of streaking attempts with varying machine parameters and set-ups were investigated in an automated way. The recorded beam screen images during this experiment have been analyzed and evaluated. This contribution motivates and presents the automated experiment and discusses the data analysis.

**AKBP 11: RF and SRF Research**

**Time:** Wednesday 17:30 – 19:00

**Location:** CHE/0184

**A11.1** Wed 17:30 CHE/0184 Thin Films On HOM Antennas To Push The Limits For Higher Beam Currents at MESA+(†)(‡) — PAUL PLATTNER, FLORIAN HUG, and TIMO STENGLEL — Institut für Kernphysik (KPH), Mainz, Deutschland

The Mainz Energy-Recovering Superconducting Accelerator (MESA), an energy-recovering (ER) LINAC, is currently under construction at the Institute for Nuclear Physics at the Johannes Gutenberg-Universität Mainz, Germany. In the ER mode continuous wave (CW) beam is accelerated from 5 MeV up to 10 MeV. The energy gain of the beam is provided through 2 enhanced ELBE-type cryomodules containing two 1.3 GHz 9-cell TESLA cavities each. By pushing the limits of the beam current up to 10 mA, a quench can occur at the HOM Antennas. This is caused by an excessive power deposition within the antenna. Calculations have shown that a power transfer of 1 W must be assumed. To prevent a quench of the HOM antennas by high beam currents without major modification of the design, it is necessary to find suitable materials. Nb3Sn and NbTiN can be applied as a coating to the antennas and have higher critical parameters than Nb which provides for a higher power limit. As a further approach to improve the power transfer by changing to material from the antenna to OFHC Copper. The limited of the coated antennas will be tested with the cavities of a cryomodule from the decommissioned ALICE from STFC Daresbury. (†)The authors acknowledge the transfer of one cryomodule to Mainz by the STFC Daresbury. (‡)The work received funding by BMBF through 05H21UMRB1.

**A11.2** Wed 17:45 CHE/0184 Nb3Sn Co-Sputtering for Interlayer-Free High Performance Copper SRF Cavities — NILS SCHAEFER, CARL JUNG, MATTHIAS MAHR, CARL JUNG, CHRISTIAN DIETZ, SEBASTIAN BRUNS, MARTON MAJOR, and LAMBERT ALF — Technical University of Darmstadt (TU Darmstadt) Institute of Materials Science FB 11

Nb3Sn thin film coatings are a promising candidate to replace bulk Nb to increase performance and energy efficiency of SRF cavities. Replacing niobium by Nb3Sn coated copper would not only reduce material’s cost, but would also allow optimal heat removal for higher cryogenic efficiency. The challenge is the detrimental interdiffusion of Cu into Nb3Sn at the typically high deposition temperatures conventionally used for Nb3Sn synthesis. We have recently introduced a novel kinetically driven low-temperature co-sputtering process that overcomes the copper diffusion challenge. This break-through process, even a diffusion barrier layer is not needed, because the Cu diffusion is minimized to an extent where the superconducting properties of Nb3Sn are not negatively affected. Magnetization versus temperature measurements demonstrate the good shielding performance in parallel orientation of the Nb3Sn thin films on the copper substrate. Mechanical nanodentation and scratch tests demonstrate that even after thermal cycling of the sample, the adhesion properties the Nb3Sn thin film coatings are excellent. Work supported by the German Federal Ministry for Education and Research (BMBF) through grant 05H21RDRB1 and the German Research Foundation (DFG) via the AccelerencEResearch Training Group (GRK 2128).

**A11.3** Wed 18:00 CHE/0184 low-temperature magnetron co-sputtering of Nb3Sn for SRF application — HAMIDREZA GHASEMI1, NILS SCHAEFER2, MARTON MAJOR3, ALEXEY ARZUMANOV4, and LAMBERT ALF5 — Technical University of Darmstadt, Darmstadt, Germany; Technical University of Darmstadt, Darmstadt, Germany; Technical University of Darmstadt, Darmstadt, Germany; Technical University of Darmstadt, Darmstadt, Germany

For the last decades, bulk niobium has been the material of choice for superconducting RF cavity applications. Nb3Sn thin films are another candidate for SRF cavities. The benefits of using Nb3Sn instead of Nb would be higher critical temperature and higher critical magnetic field, leading to significant cryogenics cost reduction. The Tc is maximal for about 25% tin content and decreases significantly for less than 23at%. Therefore, the big problem of Nb3Sn is the synthesis of the material. The most promising fabrication method of Nb3Sn is the tin vapor diffusion method. Control of the small stoichiometry range and Sn gradients are the challenges of this method. In single-target sputtering and multi-layer sputtering we have to deal with tin loss and surface segregation (due to high annealing temperature). Co-sputtering allows the tuning of the kinetic energy of both elements independently and offers high-performance thin films at low temperatures. This work presents recent results of Nb3Sn synthesis on Copper substrate by magnetron co-sputtering. This work supported by the German Federal Ministry for Education and Research (BMBF) through grant 05H21RDRB1.

**A11.4** Wed 18:15 CHE/0184 Development of a system for the rapid RF characterization of superconducting samples — SEBASTIAN KECKERT, FELIX KRAMER, OLIVER KUGGELE1, and LAMBERT ALF2 — Technical University of Darmstadt (TU Darmstadt) Institute of Materials Science FB 11

The development of such coatings requires RF characterization of superconducting samples and especially measurements of the RF surface resistance. This contribution discusses the development and first commissioning results of a Rapid Superconductor Test Apparatus (RaSTA), a compact sample test circuit. In contrast to other test setups, RaSTA allows to distinguish BCS and residual resistance with high resolution but with far shorter turnaround times, enabling systematic studies of multiple samples and thus iterative optimization of materials production techniques.

**A11.5** Wed 18:30 CHE/0184 Gouab-Line Measurements for In-Vacuum Undulators — PAUL VOLZ1, HELMOLZ-ZENTRUM BERLIN FÜR MATERIALIEN UND ENERGIE GMBH, BERLIN — Universität Siegen, Fachbereich Physik, Siegen

Niobium is currently the material of choice to produce superconducting radio frequency (RF) cavities for applications in particle accelerators. These cavities are operated at temperatures of 2 K or lower to ensure manageable dynamic losses at high accelerating gradients. Presently, alternative materials to niobium and composite structures relying on thin film coatings are investigated in various R&D projects. Applied to SRF cavities such an advanced material or coating will allow performances beyond the fundamental limits of niobium and eventually operation temperatures of 4.2 K or higher. The development of such coatings requires RF characterization of superconducting samples and especially measurements of the RF surface resistance. This contribution discusses the development and first commissioning results of a Rapid Superconductor Test Apparatus (RaSTA), a compact sample test circuit. In contrast to other test setups, RaSTA allows to distinguish BCS and residual resistance with high resolution but with far shorter turnaround times, enabling systematic studies of multiple samples and thus iterative optimization of materials production techniques.

**A11.6** Wed 18:45 CHE/0184 Influence of High-Pressure Rinsing on the Oxide-Layer Thickness and Oxygen-Concentration of Niobium Samples — REZVAN GHANSARI1, MARC WENSEKT2, MONA KOHANTOAR3, HESHMAT NOori1, ARTI DANGALWAND1, DETLEF BESZERKE2, and WOLFGANG HILLERT3 — Deutsches Elektronen-Synchrotron (DESY), Germany

This study is devoted to investigate the effect of High Pressure Rinsing (HPR) on the outcome of annealing procedures of Niobium (Nb) superconducting radio-frequency cavities. Recently, a so-called “mid-T bake” treatment has exhibited very high-quality factors for Nb cavities. The complementary developed models
assume that the quality factor severely depends on the oxygen concentration in the near-surface of niobium. On the other hand, based on our observation, we realize that HPR affects the thickness of oxide layers on the surface of niobium cavities, which is the dominant source of the oxygen diffusion during annealing. Thus, we have measured the oxide thicknesses after various HPR durations of Nb samples before and after applying mid-T bake treatment via X-ray Photoelectron Spectroscopy (XPS) and used Secondary Ion Mass Spectrometry (SIMS) to obtain the interstitial oxygen concentration after the annealing. The results of this investigation will be presented and discussed in the context of theoretical models.

AKBP 12: AI Topical Day – Invited Talks (joint session AKPI/K/HK/ST/T/AKBP)

Time: Thursday 11:00–12:30

Invited Talk
AKBP 12.1 Thu 11:00 HSZ/AUDI
AI Techniques for Event Reconstruction — Ivan Kisel — Goethe University, Frankfurt, Germany
Why can we relatively easily recognize the trajectory of a particle in a detector visually, and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been puzzling over the answer to this question for more than 30 years, since the days of bubble chambers. And it seems that we are steadily approaching the answer in our attempts to develop and apply artificial neural networks both for finding particle trajectories and for physics analysis of events in general.

This talk will present the basics of artificial neural networks in a simple form, and provide illustrations of their successful application in event reconstruction in high energy physics and heavy ion physics experiments. You will get an insight into the application of traditional neural network models, such as deep neural network, convolutional neural network, graph neural network, as well as those standing a little aside from traditional approaches, but close in idea of elastic network and even cellular automata.

Invited Talk
AKBP 12.2 Thu 11:30 HSZ/AUDI
Accelerator operation optimisation using machine learning — Pierre Schnizler — Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany

Accelerators are complex machines whose many components need to be accurately tuned to achieve design performance. Reliable operation requires frequent recalibration and tuning. Especially for large machines tools have been developed that facilitating this task.

Machine learning allows building such tools using simulations, archiver data or interaction with the real machine, thus making many tools now also available for smaller machines.

This talk will give an overview of different machine learning projects targeted to accelerators, which simplifies accelerator operation or even enable applications not been possible before.

AKBP 13: Preisverleihung des AKBP Nachwuchspreises und des Horst-Klein-Preises

Time: Thursday 14:00–15:30

Prize Talk
AKBP 13.1 Thu 14:00 HSZ/0304
TBA — Carl A. Lindström — Universität Oslo/DESY — Laureate of the DPG-Nachwuchspreis für Beschleunigerphysik 2023
Details will be published online in a programme update.

AKBP 14: Instrumentation II

Time: Thursday 15:30–17:15

AKBP 14.1 Thu 15:30 CHE/0183
System for Bunch Length Measurements behind the Injector of S-DALINAC* — A. Brauch, M. Arnold, J. Enders, L. Jürgensen, and N. Pietralla — Technische Universität Darmstadt, Department of Physics, Institut für Kernphysik, Darmstadt, Germany

The estimation of the bunch length in accelerators is vital for monitoring and preserving the quality of the beam. At the S-DALINAC accelerating cavities are used for measuring this parameter at higher energies. However, values obtained by this method only serve as an upper estimate for the bunch length. A new setup involving a streak camera will be used to provide accurate evaluations of the small bunch lengths of < 2 ps at the S-DALINAC. An integrative measurement with a comparable resolution to the bunch length at different positions behind the injector is planned. This contribution will present the layout of this system, its current status and design considerations.

*Work supported by the State of Hesse within the Research Cluster ELEMENTS (Project ID 500/10.006).

AKBP 14.2 Thu 15:45 CHE/0183
Simulationen zur Optimierung von Vakuumsystemen für Beschleunigerstrahlführungen* — Alexander Smushkin, Ruben Grewe, Michaela Arnold, Manuel Dutine, Marco Fischer, Lars Jürgensen, Felix Schlessmann and Norbert Pietralla — Institut für Kernphysik, TU Darmstadt, Darmstadt, Germany


*Gefördert durch die DFG (GRK 2128 AccelerE)

AKBP 14.3 Thu 16:00 CHE/0183
An all-optical streak camera to measure the jitter between two beams in the single-digit femtosecond regime — Marc Osenberg², Ahmad Fahim Habib², Lena Wübben², Michael Stump², and Georg Pretzler² — ²Institute of Laser- and Plasmaphysics, University Düsseldorf — ³University of Strathclyde, Glasgow

We present a novel All-Optical Streak Camera (AOSC) based on the Kerr-effect which measures the relative temporal position of a laser pulse and a second short pulse of arbitrary constituents (e.g., electrons, protons, light, or x-rays) in a single shot. Many modern accelerator concepts rely on the coupling of an electron beam with a laser beam, which must overlap with ultra-high temporal precision down to the low fs-regime which will be shown quantitatively by simulation results. Our new device comes in at this point, measuring the temporal position of the electron pulse relative to the laser pulse for single shots, which will also show jitter or temporal drifts. We show proof-of-principle experiments of this new device with an ultrashort laser pulse (6 fs FWHM) demonstrating resolution in the 10-fs regime.
AKBP 14.4 Thu 16:15 CHE/0183
controlling the transverse beam shape of the photoionjector laser via a spatial light modulator — STEPHAN-ROBERT KOTTER, ERIK BRÜNDERMANN, MATTHIAS NABINGER, MICHAEL NÄSSE, ANDREA SANTAMARIA GARCIA, CHEN-RAN XU, AND ANKE-SUSANNE MÜLLER — KIT, Karlsruhe, Germany
In order to achieve unprecedented control over the phase space of electron beams in linear accelerators, the laser pulse of the photoionjector can be shaped by spatial light modulators (SLMs). Here, we use a convolutional neural network (CNN) from a proof-of-principle test with a visible diode laser on the Ti:Sa-800-nm photoionjector laser system of the Ferinfarot Linac- und Test-Experiment (FLUTE) at KIT to compensate the effects of compression and the non-linear process of third harmonic generation on the transverse laser profile.

AKBP 14.5 Thu 16:30 CHE/0183
First two-bunch measurements using the electro-optical near-field monitor at KARA — MICHAEL REISSIG, ERIK BRÜNDERMANN, BASTIAN HÄBER, AKEIRA MOCHIHASHI 1 , GUDRUN NIEHUES 1 , MEHANA M. PATIL 2 , ROBERT RUPRECHT 2 , and ANKE-SUSANNE MÜLLER 1,2 — IBPT, KIT, Karlsruhe — LAS, KIT, Karlsruhe
The Karlsruhe research accelerator KARA is an electron storage ring, which features an electro-optical near-field monitor as a tool for longitudinal bunch profile measurements. The device performs well in single-shot turn-by-turn measurements during single-bunch operation and over the years, the design has been optimized to be prepared for measurements in multi-bunch operation. The ability to work with multiple bunches and short bunch spacing is an important step to make the device suitable for more application purposes, such as a diagnostics tool for future compact light sources. This contribution provides first tests of the monitor during two-bunch operation with minimum 2 nsec bunch spacing. Challenges like crystal heating due to an increased beam current are discussed and strategies for mitigation are presented.

AKBP 14.6 Thu 16:45 CHE/0183
Analytic formulation of the zero-crossing slope for a circular button-like pickup — STEFANO MATTEILO, BERNHARD ERICH JÜRGEN SCHEIBLE, AND ANDREAS PENIRSCHKE — Technische Hochschule Mittelhessen, Friedberg, Hessen
With the emerging demand of the experimenters for future experiments with ultra-short X-ray free-electron lasers (XFEL) shots, precision is required for the synchronization systems even with ipC bunches using one or more button-like pickups in the Bunch Arrival Time Monitors (BAM). Because the sensitivity of the BAM depends in particular on the slope of the bipolar signal at the zero crossing and thus, also on the bunch charge, a precise theoretical prediction of the slope is a challenging and fundamental task. In this contribution the theoretical foundations of the pickup signal are presented in a systematic way, and we focus on a button-like pickup with circular active surface, that is the standard choice in the past. We present an exact general estimation of the zero-crossing slope and then discuss the results for ultra-short bunches. The comparison to the long-bunch case allows to achieve a deeper understanding of the features of these limiting cases as well as of the intermediate region.

AKBP 14.7 Thu 17:00 CHE/0183
Evaluation of a terahertz camera system for imaging, tomographic and diagnostican measurements at KARA — ANDRÉ SCHMIDT 1 , STEFAN FUNKNER 1 , GUDRUN NIEHUES 1 , ERIK BRÜNDERMANN 1 , and ANKE-SUSANNE MÜLLER 1,2 — IBPT, KIT, Karlsruhe — LAS, KIT, Karlsruhe
With a short bunch operation mode, the KIT electron storage ring KARA (Karlsruhe Research Accelerator) features the creation of the so-called microbunching instability, which emits bright bursts of THz radiation.

The creation of an instability provides the opportunity to study complex bunch dynamics by the investigation of properties from the emitted radiation. Furthermore, the emission of bright THz radiation bears the potential for many research applications in photon science.

In this contribution, we present an evaluation of a microbolometer-based THz-camera system, which is able to operate at 50 frames/s. In this regard, first results from tomographic measurements with a standalone THz illumination source and results from diagnostic beam measurements during the short bunch operation mode at KARA are shown.

AKBP 15: New Accelerator Concepts

AKBP 15.1 Thu 15:30 CHE/0184
Laser Transmission in the Relativistically Induced Transparency Regime for High Performance Proton Acceleration at PW Laser Systems — MARVIN E. P. ULMAN 1,2,3 , TIM ZIEGELER 1,2,3 , NICHOLAS P.DOVER 1,2,3, ILJA GÖTTEL 1,2,3 , THOMAS KUGLE 1,2 , CHANG LIU 1,2 , THOMAS PÜSCHEL 1,2 , MILENKO VESCOV 1,2,3 , MIAMIKO NISHIUCHI 1,2,3 , JOSEFIN METZGER-NÖLLE 1,2 , KARL ZEITLIN 1,2 , AND ULRICH SCHRAMM 1,2,3,4 — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — 1Kansai Photon Science Institute, QST, Japan — 2John Adams Institute for Accelerator Science, Imperial College London, UK — 3ion acceleration by laser-plasma sources promises many applications, but reaching the required beam quality parameters demands a high level of understanding and control over the interaction process. Several advanced schemes, including the Relativistically Induced Transparency (RIT) regime, have been proposed and investigated in search of a stable acceleration for proton energies beyond 100 MeV. In the RIT scheme, the absorption of the electromagnetic laser field by the target and the generated plasma is critical. In joint experiments at the DRACO PW (HZDR) and J-KAREN (KPSI) lasers, we use transmission diagnostics to study the onset of transparency and learn about the sensitivity of the laser input to improve the process’s robustness. Using ultra-short pulses on thick solid density foil targets, we observe high performance proton beams in an expanded foil case. Our analysis of the effects on the transmission and its correlation with the acceleration process indicates changes in the plasma interaction process.

AKBP 15.2 Thu 15:45 CHE/0184
Towards spin-polarised electron beams from a Laser Plasma Accelerator — FELIX STER 1,2,3 , SIMON BOHLEN 1,2,3 , LOUIS HELARY 1,2,3 , JENNIFER PONP 1,2,3 , JENNY LIST 1,2,3 , GUDRIS MOKOHTA-PICK 1,2,3 , JENS OSTERSHOFF 1,2,3 , AND KRISTIAN PODER 1,2,3 — 1Deutsches Elektronen-Synchrotron DESY, Hamburg — 2University of Hamburg, Germany
Polarised beams are indispensable for many experiments in particle, atomic and nuclear physics where spin-dependent processes are to be studied. Unlike RF accelerators, the accelerating fields in Laser-Plasma-Accelerators (LPA) are not limited by material breakdown. LPAs can create beams of tens to hundreds of MeV in only a millimeter, making them a promising alternative to conventional accelerators.

The LEAP (Laser Electron Acceleration with Polarisation) project at DESY aims to generate and measure spin-polarised electron beams from a compact

AKBP 15.3 Thu 16:00 CHE/0184
Feasibility Study of a Low Energy Laser Driven Plasma Injector for ELSA — MICHAEL SWITKA and KLAUS DESCH — Physikalisches Institut der Universität Bonn
The injector of the 3.2 GeV ELSA storage ring consists of a 26 MeV linear accelerator and a 1.2 GeV booster synchrotron. The advent of functional plasma-based MeV electron accelerators may raise a prospective opportunity to replace the conventional Linac, which currently delivers electron pulses of up to 16 nC at a repetition rate of 50 Hz. We conduct a feasibility study of using a plasma based injector for the booster synchrotron. For this, we improve the diagnostic capabilities of the Linac transfer beamline and the injector synchrotron to obtain and verify acceptance parameters which are to be matched to beam properties from contemporary operated laser plasma accelerator setups. Possible facility operating modes using a plasma based injector are evaluated.

AKBP 15.4 Thu 16:15 CHE/0184
Better Atomic Physics for Laser Accelerator Plasmas — BRIAN EDWARD MARRE 1,2 , AXEL HUEBL 1,2 , RENE WIDERA 1,2 , SERGEI BASTRAKOV 1,2 , MICHAEL BUSSMANN 1,2 , THOMAS COWAN 1,2 , ULRICH SCHRAMM 1,2 , AND THOMAS KUGLE 1,2 — Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany — 1Berkley National Lab, Berkley, USA — 2CASUS, Görlitz, Germany
Standard atomic physics models in PIC simulation either neglect excited states, predict atomic state population in post processing only, or assume quasi-thermal plasma conditions. This is no longer sufficient for high-intensity short-pulse laser generated plasmas, due to their non-equilibrium, transient and non-thermal plasma condi-
After the interaction of ultra-short high intensity laser pulses with thin solid targets, strong electric fields within the resulting plasma can accelerate ions to energies of tens of MeV. The performance of such laser driven ion sources critically depends on the initial conditions of the target plasma at the arrival time of the driving laser pulse. Pre-pulses and pedestals in the intrinsic temporal laser contrast can cause dielectric breakdown of the target long before the arrival of the main laser pulse, causing the target to ionize and pre-expand uncontrollably. Here, we present a study of the laser-induced breakdown (LIB) threshold intensity of 300nm thin formvar foils as well as cryogenic solid hydrogen jets, which are both used as targets for ion acceleration at the High Intensity Laser Science and Technology (HILASS) at Helmholtz-Zentrum Dresden-Rossendorf. By stretching the pump laser pulse, the dependence of LIB threshold intensity on laser pulse duration is investigated. This helps to understand and model the pre-plasma formation during the rising flank of a high power laser pulse impinging on a thin dielectric target.

AKBP 15.5 Thu 16:30 CHE/0184 Laser Performance Monitoring at Centre for Advanced Laser Applications (CALA) — • Michael Bachhammer, Sonja Gerlach, Leonard Doyle, Felix Balling, Florian Schweiger, and Jorg Schreiber — Faculty of Physics, Ludwig-Maximilians-Universität München, Garching, Germany
One major interest of our research in the field of laser-driven ion acceleration is establishing a stable source of energetic ions. However, shot-to-shot fluctuations as well as long-term drifts of the PW-class Advanced Titanium Sapphire Laser ATLAS can cause instabilities and a significant degradation of the ion-beam performance. This prompted us to investigate and monitor the stability of our 1-Hz laser system. To this end, a 'Performance Report' has been implemented, which is automatically generated daily and summarizes the performance of the laser system throughout the day. This allows the detection of correlated fluctuations. The report is enabled by a Tango Controls [1] based control system and comprises not only important laser parameters such as laser energy, spectrum and beam profile but also environmental factors like temperatures at different positions in the laser chain. In a next step we will implement diagnostics that enable more direct correlation of laser parameters with ion bunch parameters with the ultimate goal of enabling active control. This work was supported by the BMBF within project 01157048 and the Centre for Advanced Laser Applications. [1] https://www.tango-controls.org/

AKBP 16: Poster

AKBP 16.1 Thu 15:45 HSZ OG3 Beam-Based Characterization of a Non-Linear Injection Kicker at BESSY II — • Anna Gora, Markus Ries, Michael Abo-Bakr, Marc Dirsch, and Günther Rehm — Helmholtz-Zentrum Berlin, Germany
Top-up operation at BESSY II is performed with average injection efficiencies of 98%. However, the four kicker bend and the half-sine-wave septum pulser, that form the present injection system, both contribute to an injection distortion of the stored beam with an amplitude of a few millimeters for several thousand turns. A non-linear pulsed injection kicker (NLK) could be used to reduce the kicker induced distortion by a factor of approximately 30 and thus create a necessary condition for transparent injection. Studies with a NLK and optimized sextupole settings have shown that it is also possible to achieve injection efficiencies of up to 97%. With regard to the application of the NLK for BESSY II user operation and a possible injection method for BESSY III, the NLK was characterized beam-based and measurements and theory were reconciled.

AKBP 16.2 Thu 15:45 HSZ OG3 Spin-polarized electron beam generation in the colliding pulse injection scheme — • Zheng Gou1, Michael Quin1, Simon Bohlen2, Christoph Ketteler1, Kristjan Pöder1, and Matteo Tammurini — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, 69117 Heidelberg, Germany — 1Deutsches Elektronen-Synchrotron DESY, Notkestr. 85, 22607 Hamburg, Germany
We studied the laser-wakefield acceleration of pre-polarized plasma electrons in the colliding pulse injection scheme. We found that the whole process is composed of two stages: In the first stage, the interaction between the plasma electrons and the transverse fields of the counterpropagating pulses leads to stochastic heating, which can substantially affect the longitudinal spin polarization of plasma electrons. As a result of the laser pulse collision, some plasma electrons gain a residue momentum in the longitudinal direction. The latter can result in the electrons being trapped and further accelerated by the forward-moving wavefield driven by the most intense laser pulse. The subsequent acceleration in the wakefield does not appreciably affect the longitudinal spin of the generated electron beam. Our theoretical model is supported by multi-dimensional particle-in-cell (PIC) simulations.

AKBP 16.3 Thu 15:45 HSZ OG3 Electro-stress-thermal analysis of quadrupole resonator designs — • Piotr Putek1, Shahram Gorgi Zadeh2, Marc Wenskat3, Simon Adrian1, and Ursula van Rienen1 — 1Universität Rostock, Rostock, Germany — 2CERN, Meyrin, Switzerland — 3Hamburg, Hamburg, Germany
Exploring the fundamental properties of materials such as niobium or Nb3Sn, in terms of high-precision surface resistance measurements, is crucial for the further development of SRF technology. Quadrupole resonators (QPRs) are dedicated devices for determining superconducting materials’ radio frequency properties using the so-called calorimetric measurement. Due to the electromagnetic radiation pressure (Lorentz detuning), microphoning, and geometrical deviations of cavity design uncertainties, measurements can substantially be distorted. Therefore, we address a stochastic multi-physical problem to study a significant measurement bias of the surface resistance, observed mainly for the third operating mode of the given HZB-QPR and all modes of CERN2-QPR. We explore the uncertainty quantification technique and sensitivity analysis to efficiently measure the impact of shape deformation on the QPR’s performance. The simulation results and their implication for the operational conditions of the QPR are discussed.

Founded by the German Federal Ministry for Research and Education BMBF under Contract No. 05H21HRRB1
AKBP 16.4  Thu 15:45  HSZ OG3
Design and Status of the Laser-Compton Backscattering Source at the S-DALINAC* — •Maximilian Meier, Michael Arnold, Joachim Enders, and Norbert Pietralla — Technische Universität Darmstadt, Fachbereich Physik, Institut für Kernphysik, Darmstadt, Germany

Laser-Compton Backscattering (LCB) provides quasi-monochromatic highly polarized beams in the X-ray and gamma-ray regimes for a variety of applications. A powerful, stable, and well synchronized laser with a high repetition rate is essential for a high-flux Laser-Compton light source with narrow energy-bandwidth. This contribution presents the design of an LCB-based X-ray source at the Superconducting Darmstadt Linear Accele

AKBP 16.5  Thu 15:45  HSZ OG3
Development of a 6 GHz Cavity BPM for the Multi-Turn ERL Operation at the S-DALINAC* — •Manuel Duttine, Michaela Arnold, Alexsan-

AKBP 16.6  Thu 15:45  HSZ OG3
Design and first tests of a fast precision high voltage divider for the CRYRING electron cooler — •Ken Uebelhoer, Timo Dirkes, Volker Hannen, and Christian Weinheimer — Westfälische Wilhelms-Universität Münster, Institut für Kernphysik

High-precision experiments performed on relativistic ions in storage rings and accelerators require a small momentum distribution of the ions. At the Crying at ESR, electron cooling is the chosen technique, which overlaps the ion beam with a nearly mono-energetic electron beam. The electrons transfer their momentum via Coulomb interactions to the ions until the ion velocity has adjusted to the electron velocity. The energy of the ions is therefore set by the accelerating voltage of the electron cooler. Consequently, a precise knowledge of the voltage is needed for high-resolution spectroscopy and further experiments. These experiments include electron-ion collision experiments where the electrons of the cooler fulfill an additional function as a target for the ions. To conduct such experiments, the cooler voltage has to be stepped from the baseline cooling voltage to values differing by up to 1 kV during intervals of about 10 ms and still needs to be measured precisely. For this purpose, a fast precision divider has been developed, capable of measuring voltages up to 20 kV within a 10 ms interval with uncertainties in the 10 ppm range. The poster will present the design and construction of the new high-voltage divider and provide first results from test and calibration measurements.

This work is supported by BMBF under contract number 05P21PMAA1.

AKBP 16.7  Thu 15:45  HSZ OG3
Measurement of $\omega$ mesons in $\sqrt{s} = 13$ TeV pp collisions at the LHC with ALICE — •Jens Lüder for the ALICE Germany-Collaboration — Institut für Kernphysik, Wilhelm-Klemm-Str. 9, 48149 Münster

Measurements of neutral mesons in small collision systems can serve as a baseline to understand modifications in heavy-ion collisions, where a QGP is formed. These measurements can also be used to test pQCD predictions and to constrain fragmentation functions as well as parton distribution functions. Furthermore, a precise knowledge of the $\omega$-meson production improves the measurement of direct photons, as photons produced in $\omega$ meson decays represent the third largest contribution of decay photon background.

This poster presents the invariant cross section of the $\omega$-meson in pp collisions at a center-of-mass energy of $\sqrt{s} = 13$ TeV measured by ALICE via its dominant decay channel $\omega \rightarrow n^+ n^- \pi^0$. While charged pions can directly be measured by the ALICE central barrel tracking detectors, neutral pions are reconstructed using their decay channels into two photons. This reconstruction is realized with several complementary methods using the ALICE calorimeters as well as the central barrel tracking detectors. The combined result covers an unprecedented $p_T$ range with competitive statistical and systematic uncertainties.

AKBP 16.8  Thu 15:45  HSZ OG3
Aufbau und Inbetriebnahme eines optischen Quellpunkt-Abbildungssystems für den BESSY II Booster — •Pauline Ahmels — Helmholtz-Zentrum Berlin für Düsen im Booster. Dazu and the ANNHEM, the radiation from the injector Injector-Energieniveau von 50 MeV bis 2 GeV, die gestrahlten Photonen die Elektronenpa-kete darsteilt. Das Beamline besteht aus mehreren verstellbaren Linsen und Spiegeln und ei-

AKBP 16.9  Thu 15:45  HSZ OG3
Characterization of an All-Optical Streak Camera (AOSC) by ultrashort laser pulses — •Lina Wübena, Marc Osenberg, Michael Stumpf, and Georg Pretzler — Institute of Laser- and Plasmaphysics, University Düsseldorf

For experiments with two or more ultra-short particle or photon beams the mutual timing is crucial. In this poster we present an all-optical streak camera which is based on optical Kerr gating. The specialty of the setup is that it operates with single-shot measurements thus allowing shot-to-shot jitter monitoring, for example. On our poster we will present a series of characterization experiments with sub-10-fs laser pulses. These experiments prove that the device's best temporal resolution is in the 10-fs regime, with a total time frame in the picosecond range which can be tuned by the angle of the gating beam in respect to the signal beam. We will also discuss various applications of this new technique.

AKBP 16.10  Thu 15:45  HSZ OG3
Characterization and optimization of laser-generated THz beam for THz based streaking — •Matthias Naringer, Michael Johannes Nasse, Christian Womann, Zweier, Emanuele Wieser, Erik Brendermünder, and Anne Susanne Müller — Karlsruher Institut für Technologie, Karlsruhe, Deutschland

At the Ferninfrarot Linac- Und Test-Experiment (FLUTE) at the Karlsruhe Institute of Technology (KIT) a new and compact method for longitudinal diagnostics of ultrashort electron bunches is being developed. For this technique which is based on THz streaking, strong electromagnetic pulses with frequencies around 240 GHz are required. Therefore, a setup for laser-generated THz radiation using tilted-pulse-front pumping in lithium niobate was designed, delivering up to 1 microjoule of THz pulse energy with a conversion efficiency of 0.03%.

In this contribution we study the optimization of the THz beam transport and environment.

AKBP 16.11  Thu 15:45  HSZ OG3
Investigations of two-dimensional laser polishing of niobium surfaces as a technique for the production of superconducting cavity res-

AKBP 16.12  Thu 15:45  HSZ OG3
Optical characterization of a niobium cavity mirror — •Florian Brockemeyer and Dirk Lützenkirchen — University of Wuppertal, Gauss-Str. 20, 42119 Wuppertal, Germany

Laser polishing (LP) has the potential to increase the electrical field gradients achievable in superconducting RF-cavities made of niobium, by substantially suppressing electron field emission. Thus extensive measurements were performed investigating which effects a planar LP has on the morphology and the mi-
cro-mechanical properties of a niobium surface. Here we report about a new experimental setup that allows LP under high vacuum conditions, with the capability to in-situ detect effects of the LP by measuring pressure changes, emitted electrical charges and the incident and reflected laser intensities, respectively. The change in surface properties as a result of the LP was subsequently investigated using SEM/EDX, optical profilometry and electron field emission measurements. The results show that moderate laser energies allow a cleaning of the Nb surface, but there is direct relation between surface roughness and the onset fields for
parasitic field emission after LP. Moreover, the orientation of individual grains within a large grain Nb sample seem to have a strong influence on the efficiency of the LP processes. This work was supported by the BMBF under grants no. 05H18PXR81 and 05H21PXR81.

**AKBP 16.12 Thu 15:45 HSZ OG3**

**Recent Results from the Steady-State Microbunching Proof-of-Principle Experiment at the Metrology Light Source** — **ARNOLD KRUSCHINSKI**, **XIANG BO**, **JÖRG FEIERB**, **JI LI**, **AKINO HAYASHI**, **KLAUS MEHL** — **Helmholtz-Zentrum Berlin, Germany**

The Metrology Light Source (MLS) in Berlin is one of the first step toward this ambition is the ion-bunch energy acoustic tracing (I/T) very high beam intensities, strong EMP emission and tens of Hz repetition rates. In addition, the machine protection, the use of scraper systems can significantly improve the beam quality and reduce the experimental background. Also, such systems can be used for online beam diagnostics. Especially when operating an Energy Recovery Linac (ERL), it is important to prepare the beam for the return to the accelerator after the interaction point. In this contribution, we will present results of recent measurements with the High-Energy Scaper System of the S-DALINAC [1] and give an overview on the ongoing work. This work was supported by the state of Hesse within the cluster project ELEMENTS and within the LOEWE research project Nuclear Photonics [1] N. Pietralla, Nuclear Physics News, Vol. 28, No. 2, 4 (2018).

**AKBP 16.13 Thu 15:45 HSZ OG3**

**Commissioning Status of the Frankfurt Neutron Source FRANZLEBT and RFQ** — **HENDRICK HAHNEL, ADAM ÄTHER**, **CHRISTOPH WAGNER**, **KLAUS KÖMP**, **ULRICH RATZINGER**, **HOLGER POLESCH** — **Institut für Angewandte Physik, Goethe Universität, Frankfurt am Main**

The Frankfurt Neutron Source FRANZ will be a compact accelerator driven neutron source utilizing the Li(p, n) reaction with a 2 MeV proton beam. Recent commissioning efforts showed successful proton beam operation at the target beam energy of about 60 keV up to the point of RFQ injection. The RFQ was retrofitted with new electrodes for the injection energy of 60 keV. We report on the status of commissioning of the beamline and RFQ.

**AKBP 16.14 Thu 15:45 HSZ OG3**

**Beamline Optimization for ELSA in Preparation for UHEE Flash Irradia** — **MIRIAM LÖSGEN**, **DANIEL ELSNER**, **KLADIUS DESCH**, **DENNIS PROFT**, **MICHAEL SWITKA** — **Physikalisches Institut der Universität Bonn**

The ELSA facility is optimized to deliver 3.2 GeV electrons to external experimental stations via slow resonance extraction. Research towards the usability of an intense ultra-high-energy electron beam (UHEE, Flash effect) for tumor cell irradiation requires an optimization of the ELSA storage ring injection mode. This includes adjustments of the extraction procedure, beam optics and extrac- tion elements. The current status of investigation is presented.

**AKBP 16.15 Thu 15:45 HSZ OG3**

**The Scaper System at S-DALINAC and ERL application** — **M. FISCHER, M. ARNOLD, M. DUTINE, L. JÜGENSEN, N. PIETRALLA, F. SCHLIESMANN, and D. SCHNEIDER** — **Institut für Physik, Technische Universität Darmstadt, Germany**

Scaper systems in particle accelerators are utilized for safely and efficiently re-moving undesired particles from the beam, e.g., those with too large momentum deviation or those belonging to the beam halo. They are of great importance for accelerators, in particular those with high energies and beam currents, where the risk of damage is high. In addition to the machine protection, the use of scraper foils in the water reservoir the deposited energy distribution and the ionoa- coustic wave are modulated which allows to reconstruct the ion spectrum on-line by measuring these modulations. The detector is placed within centimetre range behind the laser target to collect most of the accelerated particles. It inherently is EMP and saturation resistant and allows re-usability as the water reservoir does not suffer from major radiation damage. A minimum sensitivity to ion fluences of = 108 protons/mm²/bunch is predicted. [1] D. Haffa et al. Sci. Rep. 9 (2019) 6714

**AKBP 16.16 Thu 15:45 HSZ OG3**

**EXAFS study on role of grain boundaries and phase of NbSn thin films** — **NILS SCHAFFER, DAMIAN GÜNZING, NAIL KARBAS, ALEXEY ARZUMANOV, ANDRIY PEREL’YAN, KATJA HÖRST, MICHAEL WALTHER, KATHARINA OLLERS, PHILIPP KOMMERBÜTTEL, STE- FAN PETZOLD, M. MÁRTON MAJOR, DIRK LÜTZKENRICHEN-HECHT, HEIKO WEDE, and LAMBERT ALF** — **Technische University of Darmstadt, Darmstadt, Germany**

— University of Duisburg-Essen, Duisburg, Germany — Argonne National Laboratory, Lemont, IL, USA — University of Wuppertal, Wuppertal, Germany

In this contribution the low-temperature synthesis of NbSn, a promising ma- terial for superconducting radio frequency (SRF) application is presented. Theor- etically NbSn superior to Nb in surface resistivity, critical temperature and critical field, but in practice the performance is lacking behind due to early quenching at low fields. Co-sputtering at low sample temperature could over- come the microstructure-related limitations due to the high kinetic energy of the sputtered particles. Extended x-ray absorption fine structure analysis and x-ray absorption spectroscopy mapping were utilized to show the improved local and element homogeneity of the NbSn films. Additionally, the pres- ence of a grain-boundary network acting as Josephson-like junctions was found. Excellent elemental homogeneity and a good grain boundary state promoted by kinetic energy was demonstrated. Work supported by BMBF through grant Nos. 05H12RDR81, 05H21PXRB1 via the Accelerence Research Training Group (GRK 2128).

**AKBP 16.17 Thu 15:45 HSZ OG3**


Plasma-wakefield accelerators provide acceleration gradients several orders of magnitude larger than conventional accelerators, representing a promising tech- nology for reducing the footprint of future particle accelerators. The luminosity in colliders and the brilliance in free-electron lasers scales with the repetition rate at which the accelerator operates. Therefore, high repetition rate is an important parameter to consider when developing plasma-based accelerators for these ap- plications. FLASHForward is a beam-driven plasma-accelerator experiment at DESY that is unique in the field due to its ability to explore and develop concepts for MHz-repetition-rate operation. The capability to support such high repetition rates is strongly influenced by the functionality of the plasma source. Cruc- ial plasma effects including gas refill time and temporal evolution of 3D plasma profiles are in part determined by the cell geometry and gas/discharge properties. In this talk, 2D axisymmetric hydrodynamic plasma simulations of plasma cell designs are presented and compared. Through this a better understanding of current plasma-source designs and hints at how designs may be optimised in the future are revealed.
Energy deposition of ions in water leads to the emission of a pressure, i.e. ionoacoustic wave. It is commonly described in the thermoacoustic approximation, that is, localized heating and volume change is considered as prime cause of the wave. If this was true, no pressure wave is expected at 4°C, which was indeed observed after localized absorption of light. Contrary, when initiated by protons, this minimum is shifted to significantly higher temperatures of around 4.5°C, hinting towards an additional, non-thermal excitation mechanism that has not yet been understood and is referred to as "charge effect" in the literature [1]. We want to investigate this effect, which as of today lacks an explanation, experimentally for femto- to second-order laser induced water plasma and heavy ions with higher charge than protons for the first time by measuring the polarity change of the pressure wave around the water anomaly at 4°C. Understanding the non-thermal effects has potential implications for completely new measurement principles, could open up new insights into the fast, pre-thermal processes and even help classifying the relevance of mechanistically induced radiation damage. This work is supported by GSI-LMU F&E cooperation LMSCH2025.


AKBP 17.3 Thu 18:00 CHE/0183
Characterization of low-density gas targets for wake driven plasma field using high harmonics — JEP TRETIAKOFF, MARK OSENDORF, DIRK HEMMERS, BASTIAN HAGEMEISTER, and GEOFF PREETZLER — Institute of Laser- and Plasma-physics, University Düsseldorf
Low-density gas jets are a crucial part for wake driven plasma accelerators. Measuring the spatial and temporal density profile is challenging with common methods. Fortunately, the used gases have high and varying absorption rates in this region. Using high harmonics, we can detect the above mentioned density wavelenghts simultaneously. This method allows to determine the gas density even for hydrogen and helium down to the 10⁻³ cm⁻³ regime. In this talk we will discuss the setup and challenges for this rarely used method, and we show actual results.

AKBP 17.4 Thu 18:15 CHE/0183
Time-Resolved Interferometric Measurement of Ultrasound Pulses in Water — JULIA LIESE, ANNA-KATHARINA SCHMIDT, ALEXANDER PRASELSPEGER, JENS HARTMANN, and JÖRG SCHREIBER — LMU München, Fakultät für Physik - Medizinische Physik, Am Coulombwall 1, 85748 Garching
Measurement of emittance and spatial coherence for low intensity electron beams that can resolve the gas density is a key requirement for time-resolved measurements of ultra-fast processes. Time-resolved interferometric measurements of ultrasound pulses in water with piezoelectric transducers. Here, we investigate an optical method based on measurements of the refractive index change associated with the pressure pulse by femtosecond laser pulse probing. In contrast to transducer measurements, we can study the distribution of the pressure pulse origin directly. To this end, an interferometric setup was tested in first experiments with ultrasound pulses generated by a piezoelectric transducer. Experimental results show temporally resolved images of the ultrasound pulse and reveal characteristics of the ultrasound pulse in agreement with theory. Within an ongoing project funded by the DFG (491853809), the pressure waves originating from laser-accelerated ions will be investigated optically to facilitate new insights into the fast dynamics of ion energy deposition.


AKBP 17.5 Thu 18:30 CHE/0183
Analysis of Real Materials for the RF Window of a GHz Transition Radiation Monitor — STEPHAN KLAPOTH1,2, HERBERT DE GERSEM2, and ANDREAS PENIERSCH1 — 1Technische Hochschule Mittelhessen, Friedberg, Hessen — 2TU Darmstadt, Darmstadt, Hessen
State of the art measurement devices for longitudinal beam profiles typically include Feshchenko monitors, Fast Faraday Cups, and field monitors. A novel approach of a GHz diffraction radiation monitor is able to non-destructively measure the longitudinal charge distribution of each micro-bunch within a bunch train of a heavy ion beam. In this contribution, we compare several vacuum-grade, dielectric materials for the monitor’s rf window aiming at signals as strong and well distinguishable as possible with beam energies of β = 0.05 to 0.75. To achieve this, numerical field simulations were performed with CST Particle Studio to investigate the influence of different window materials on the signal strength.

AKBP 18.1 Thu 17:30 CHE/0184
Beam dynamics simulation and optimization of an electron beam for magnetically bunched compressor commissioning at PITZ — EKSKACHAI KONGMONG, PRACH BOONPOORNPRASERT, XIANGKUN LI, MIKHAIL KRAISLINOV, FRANK STEPHAN, NAMRA AFTAB, DIMA DMITRIEV, GREGORI VASCHENKO, GEORGI GEORGIEV, CHRISTOPHER RICHARD, ANNE OPPORT, and MATTHIAS GROSS — Deutsches Elektronen-Synchrotron DESY, Platanenallee 6, 15738, Zeuthen, Germany
A THz free electron laser (FEL) prototype has been developed at the Photo In- jector Test Facility at DESY in Zeuthen (PITZ) for obtaining high intensity radiation for THz-X-ray probe experiments at the European XFEL. In this development, a magnetic chicane was recently installed to enhance the THz FEL performance. The aim of this study was to investigate the beam dynamics in the chicane for finding the optimum machine parameters for an electron beam transport in the experiment. The simulation was performed via ASTRA software using a 3-dimensional magnetic field of the chicane simulated with CST-EM Studio. Furthermore, the influence of the Coherent Synchrotron Radiation (CSR) on the electron beam were studied by using the OCELOT code. The simulated results indicate the possibility of obtaining on-axis trajectory and zero-momentum dispersion of the compressed beam. The commissioning results are also reported in this presentation.

AKBP 18.2 Thu 17:45 CHE/0184
Measurement of emittance and spatial coherence for low intensity electron beams — BENAT ALBRECHT-ESUAIN — Helmholtz-Zentrum Berlin, 12489 Berlin — Humboldt-Universität zu Berlin, 12489 Berlin
The SRF-Photoinjector is a superconducting linear electron accelerator currently being commissioned in Helmholtz-Zentrum Berlin. It is able to provide a very broad range of beam parameters, which enables applications of the injector that go beyond its original operation purpose as an ERL technology demonstrator. The ultra-short bunch length, high repetition rate and low achievable emittances make the SRF Photoinjector an ideal candidate for Ultrafast Electron Diffraction (UED) and direct imaging experiments with the aim of imaging biological molecules in gas or liquid solutions. The first stage of the development of UED capabilities in HZB consists of a static UED experiment to prove that the spatial resolution required for UED experiments can be achieved. To monitor the performance of the experiment the diagnostics of transverse beam parameters is necessary, which is challenging to do with traditional techniques given the small emittances and low bunch charges. In this work we present the results of the measurement of transverse normalized emittance and spatial coherence length of a THz-FEL beam. The experimental results show an improvement of the measured spatial coherence length by a factor of 4 compared to the expected value. This is an important step forward towards the operation of a THz-FEL beam in the experiment.

AKBP 18.3 Thu 18:00 CHE/0184
Influence of the Complex Filling Patterns on the Results of the Transverse Beam Size Measurements with the Interferometric Technique — IRMA SHIMDT, JI-GWANG HWANG, GREGOR SCHWITTERZ, and ANDREAS JANKOWIAK — Helmholtz-Zentrum Berlin
The transverse size of the electron beam in a storage ring can be measured using the synchrotron radiation of a bending magnet. Due to the diffraction limit, many facilities exploit beam size monitors in the x-ray regime. On the other hand, the visible part of the emitted radiation delivers spatial information via an interference pattern after passing through a double slit. Assuming a Gaussian beam distribution the size of the beam can be easily obtained with an analytical formula. If this assumption is not fulfilled, the calculated beam shape will vary from the real distribution. This can appear for instance in case of exotic beam optics settings or complicated filling patterns, that are widely used in modern storage-ring-based light sources. Influence of the additional electron distribution with larger emittance on the measurement of the transverse size of the multi-bunch train with the usual interferometric method will be discussed in this presentation.

AKBP 18.4 Thu 18:15 CHE/0184
Investigations of TRIBs in BESSY III design lattices — MICHAEL ETHERNE ARLANDO — Helmholtz-Zentrum Berlin — Humboldt-Universität zu Berlin
The BESSY III Wakefield Driver, along with its high brightness electron source, is an important part of the superconducting ring and will allow beam diagnostics and experiments at high luminosity. One of the key features of the linear lattice is the longitudinal and transverse multibunch interaction, which gives rise to so-called Transverse Resonance Island Buckets (TRIBs). In this talk we will present the basic concepts of these buckets and how they can be generated in the lattice, as well as how they can be mitigated by the design of the lattice. The implications of these features for the performance of the accelerator will be discussed.

AKBP 18.5 Thu 18:30 CHE/0184
Operation of the Accelerator End Station for the Project "Ultrafast Science in Water" — STEFAN KRAISLINOV, FRANK STEPHAN, and ANNE OPPORT — Deutsches Elektronen-Synchrotron DESY, 15738, Zeuthen, Germany
The Ultrafast Science in Water project is a joint venture of several research institutions in order to investigate the fast processes in water with an ultrashort electron pulse. The project is supported by the DFG (491853809) and aims to develop a new method for the detection of fast processes in water by using the electron pulse from the European XFEL. The method is based on the use of the electron pulse as a probe for the detection of fast processes in water. The electron pulse is generated by a free electron laser (FEL) and is focused into a water sample. The emitted photons are detected using a detector array. The emitted photons are then used to reconstruct the spatial and temporal distribution of the electron pulse. The method has been successfully tested in experiments with different water samples and shows promising results for the detection of fast processes in water.
tions in photon science is the ultra-fast switching of the helicity of circularly polarized light pulses. In the context of the conceptual design study of BESSY III, investigations have already started to study the feasibility of the implementation of this special optics mode in the MBA lattice candidates. Here, we present some studies, fundamental and applied, regarding the implementation of TRIBs in the context of BESSY III lattice design.

AKBP 18.5 Thu 18:30 CHE/0184
Turn-by-turn Measurements of the Energy Spread at Negative Momentum Compaction Factor at KARA — CHRISTIAN GOFFING, ERIK BRÜNDERMANN, MICHELE CASELLE, STEFAN FUNKNER, GUDRUN NIEHUES, MARVIN-DENNIS NOLL, MEGHANA PATIL, PATRICK SCHREIBER, JOHANNES STEINMANN, ANKE-SUSANNE MÜLLER, GIOVANNI PATERNOSTER, MAURIZIO BOSCARDIN, and MATTEO CENTIS VIGNALE — KIT, Karlsruhe, Germany — FBK, Trento, Italy

The Karlsruhe Research Accelerator, the storage ring KARA at KIT, allows short electron bunch operation with positive as well as negative momentum compaction factor. For both cases, the beam dynamics are studied. Using the KAILYSO (Karlsruhe Linear array Y detector for MHz repetition rate Spectroscopy) linear array, based on TI-LGAD, the horizontal intensity distribution of the emitted visible part of the synchrotron radiation is measured at a 5-degree port of a bending magnet on a turn-by-turn time scale. Because the measurement is located at a dispersive section, the dynamics of the energy spread can be studied by measuring the horizontal bunch profile. The acquisition rate at MHz-frequencies and the low-charge sensitivity of the line camera allow the investigation of the microbunching instability. This contribution presents the results of the bunch profile measurements performed at positive and negative momentum compaction factor.

AKBP 19: Members’ Assembly

Time: Thursday 19:00–20:00
Location: CHE/0091

All members of the Working Group on Accelerator Physics are invited to participate.
Working Group on Equal Opportunities
Arbeitskreis Chancengleichheit (AKC)

Agnes Sandner
Sprecherin des AKC
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Overview of Invited Talks and Sessions
(Lecture hall HSZ/0004)

Invited Talks

AKC 1.1 Wed 11:00–11:45 HSZ/0004 What’s wrong with me? — Pauline Gagnon
AKC 1.2 Wed 11:45–12:30 HSZ/0004 Workplace cultures in physics as a game changer for equal opportunities — Martina Erlemann
AKC 1.3 Wed 12:30–13:00 HSZ/0004 Belonging — a key to success in STEM?! — Lennart Brademann, Denise Dörfel, Barbara M. Gordalla, Anika Ihmels

Sessions

AKC 1.1–1.3 Wed 11:00–13:00 HSZ/0004 AKC
Sessions
– Invited Talks –

AKC 1: AKC

Invited Talk
AKC 1.1 Wed 11:00  HSZ/0004
What’s wrong with me? — Pauline Gagnon — CERN, Geneva
Why are sexism, homophobia and racism still so prevalent in physics? I start from my personal experience to demonstrate that in fact the personal is political. CERN, the largest physics laboratory in the world, welcomes scientists from 118 nationalities but still 80% of them are white and 80% are male. I examine why this is so by reviewing many contributing factors and suggest a series of easily applicable measures that could greatly improve the situation. These measures would benefit all scientists, regardless of their gender, race, sexual orientation, physical ability or religion. It has been established that diversity benefits science by increasing the creativity potential, a key ingredient to in scientific research.

Invited Talk
AKC 1.2 Wed 11:45  HSZ/0004
Workplace cultures in physics as a game changer for equal opportunities — Martina Eulemann — FU Berlin, FB Physik
In recent decades there has been a growing awareness that a scientist’s gender can have an impact on a career in physics, even though it should have no influence. This applies also for ethnicity or national background, social background, and other social characteristics which can have a detrimental impact on a career in science. The talk will present research on gender and diversity in physics, with a particular focus on studies of workplace cultures in physics and their impact on young scientists’ sense of belonging to the physics community. It will be argued that improving the workplace cultures can be a game changer in combating discrimination and diversifying the physics community, which would also benefit physics research.

Invited Talk
AKC 1.3 Wed 12:30  HSZ/0004
Belonging – a key to success in STEM?! — Lennart Brademann, Denise Dörfel, Barbara M. Gordalla, and Antika Ihmels — Fakultät Psychologie, Inst. Arbeits-, Organisations- und Sozialpsychologie, TU Dresden
Women continue to be underrepresented in science, technology, engineering or mathematics (STEM) fields as students and also in professional roles. What factors influence women’s choice, persistence, and success?

In the US, studies evidenced that women do not feel like they belong in STEM community: they experience an impeding study climate (also called chilly climate) or suffer from stereotypical views on possible careers. This results in a decreased desire to choose a STEM carrier (for an overview see Shapiro & Sax, 2011). The probability to drop out of the program (Höhne & Zander, 2019b; Peters et al., 2015) is increased in the case of high belonging uncertainty, or when there is a conflict between an occupational stereotype and one’s self-description.

The talk presents results from an online survey conducted among students, focusing on the field of physics. 122 physics students (40% female) completed it regarding success in studying physics (GPA, number of last attempts for an exam), turnover intention, chilly climate (e.g. exclusion, hostility), expectation of success (e.g. perceived potential, sense of belonging (e.g. belonging uncertainty), identification with physics, enjoyment, interest, a list of adjectives to describe oneself and to describe a successful physicist, and sociodemographic variables.

Results revealed lower social belonging and higher belonging uncertainty as well as a worse stereotype fit for women as compared to non-female students. Especially, social belonging turned out to be the most important predictor for GPA, identification, turnover intention, interest, enjoyment, perceived potential and self-efficacy. Social belonging hence was identified as an important influencing factor to enhance women’s interest, persistence, and success in STEM. Therefore, this factor demands for more attention in the future, both in research and in actual working environments - for a continued success of Germany in STEM fields.
Working Group on Energy
Arbeitskreis Energie (AKE)

Karl-Friedrich Ziegahn
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Affordable, reliable and climate protecting energy supply is indispensable for a real sustainable development. Physics, engineering and many more sciences contribute to this objective. The following 3 sessions on concepts and technologies, energy supply, and perspectives for the future present three invited talks and 7 submitted contributions. They reflect needs for enhancing a sound energy system, including societal and political questions.

Overview of Invited Talks and Sessions
(Lecture hall GER/038)

Invited Talks

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– Invited and Contributed Talks –

AKE 1: Konzepte und Technologien

Time: Monday 11:00–12:45
Location: GER/038

Invited Talk

AKE 1.1 Mon 11:00 GER/038


AKE 1.2 Mon 11:30 GER/038
Numerical Simulation of the coating process for organic photovoltaics — Fabian Gumpert1, Annika Jansen1, Andreas Distler1, Christoph J. Brabec2, Hans-Joachim Egelhaaf1, and Jan Lohrbreier3 — 1 Nuremberg Institute of Technology, Nuremberg, Germany — 2 Friedrich-Alexander-Universität Erlangen-Nürnberg, Erlangen, Germany

In various industrial applications, the doctor blading process is a well-established technique to coat thin films. In the context of organic photovoltaics, functional layers like electrodes, active materials, and interfacial layers are printed using this technique. For the performance and lifetime of the final photovoltaic devices, the thickness precision and uniformity of the individual layers is crucial. Computational Fluid Dynamics (CFD) simulations and experiments are used to study the effect of various parameters on the film formation during doctor blading. For example, a numerically simulated correlation between coating speed and final film thickness is established and found to match the experimental findings.

With the help of these CFD simulations, process parameters and resulting film thicknesses can be predicted based on simple fluid characteristics such as viscosity and surface tension. Furthermore, the observed decrease in the wet film thickness over printed distance, which relates to the decreasing volume in the meniscus, can be compensated by a calculated acceleration of the applicator during the coating process to drastically increase the distance range of homogeneous coating by doctor blading.

AKE 1.3 Mon 11:45 GER/038
Multiphysical simulation of the temperature distribution in a PEM-Fuel Cell — Clara Kefer, Fabian Gumpert, Susanne Thiel, Mai Elchebaum, and Jan Lohrbreier — Nuremberg Institute of Technology, 90489 Nuremberg, Germany

Polymer electrolyte membrane fuel cells (PEM-FC) are a key technology for converting chemical energy from — ideally green — hydrogen into electrical energy. However, the electrochemical processes in a fuel cell also generate heat, which is crucial for the cell’s performance and difficult to detect by experiments. The heat generated in these exothermic chemical reactions and the external heating for the operating temperature were numerically simulated. The temperature field affects the local turbulence, which has a strong influence on the local and global performance of the cell. Therefore, the three-dimensional temperature distribution was modelled, and the resulting voltage-current curves were computed. The latter are commonly used to characterize the properties of a fuel cell as a source of electric power.

The simulations show a temperature increase of the inner layers of the fuel cell due to the electrochemical reactions. The temperature of the cooler working gases approaches the externally defined operating temperature of the fuel cell. This effect can also be seen in experimental data. The simulated U- characteristics have the same overall shape as the experimentally determined characteristics and both reveal a decrease in the performance of the cell at higher temperatures.

AKE 1.4 Mon 12:00 GER/038
Photocatalytic conversion of carbon dioxide into methane for solar fuel production using a TiO2 functionalized thin-film micro-reactor — Sebastian Thalheim — Fraunhofer ISE, Freiburg, Deutschland

The increasing concentration of greenhouse gases in the Earth’s atmosphere is a major contributor to climate change. Carbon dioxide, a key greenhouse gas, is produced by fossil fuel combustion and industrial processes. The reverse combustion reaction offers a useful approach for converting carbon dioxide into hydrocarbons, such as methane, for use as a renewable fuel source and therefore contributing to a closed-carbon-dioxide cycle. However, the reverse combustion reaction requires significant amounts of energy for activation. Photocatalysis, which uses light to reduce the activation energy required, offers a potential solution to this challenge. By using renewable energy to drive the photocatalytic reaction, we can minimize the carbon footprint of the conversion process.

We propose a setup for the continuous conversion of carbon dioxide into methane using a photocatalytic TiO2 functionalized thin-film micro-reactor. We aim to identify the most influential parameters and optimize the reactor design and photocatalytic material to maximize Solar-To-Gas efficiency. This approach has the potential to make the conversion process more efficient and scalable. A life-cycle analysis will be performed to assess ecological sustainability, economic feasibility, and the potential for carbon capture and usage of this emerging technology.

AKE 1.5 Mon 12:15 GER/038
Development of a loss model for dynamic inductive charging — Fabian Gumpert1, Michael Schmidt2, Armin Dietz1, and Jan Lohrbreier3 — 1 Nuremberg Institute of Technology, 90489 Nuremberg, Germany — 2 Institute ELSYS, Nuremberg, Germany

The electrification of vehicles is a promising approach to reduce the carbon footprint of the mobility sector. However, this approach still faces several challenges, for instance the limited range and high battery weight of electric vehicles. A possible solution to this limitation is the electrified road system (ERS) where coil segments are integrated into the road. An electric vehicle with a receiver module can charge inductively its battery while driving on these roads.

Analytical and numerical (Finite-Element-Method) simulations are used to model the ERS and the inductive charging of the vehicle to investigate the occurring losses. In detail, FEM simulations were used to investigate the efficiency of the power transfer from the transmitter coil within the ERS to the receiver coil, moving onboard the vehicle, under various conditions. The coil segments in the ERS are supplied with a high-frequency square-wave voltage. To investigate all losses of the system it is necessary to develop a measurement device. The fundamental frequency of the voltage signal is roughly 90 kHz. The device can measure up to one MHz in order to detect high harmonics of the fundamental frequency. The concept of the measurement setup and first experimental results, which demonstrate the capability of the setup, are presented.

AKE 1.6 Mon 12:30 GER/038
Gigantisch große Hydrokavernenspeicher in Braunkohleabbaustätten zur nahezu verlustfreien Überbrückung von Kurzzeitschankungen in Energiezeuge und Verbrauch — Horst Schmidt-Böcking1, Gerhard Luther2, und Joachim Schuster3 — 1 Institut für Kernphysik, Universität Frankfurt — 2 Max-von-Laue Str.1, 60438 Frankfurt — TFS. Zukunftenergie (FZ), Experimen-}
In den zu flutenden Braunkohleabbaustätten (z.B. Hambach, Garzweiler, Schleenhain, Cottbus etc.) kann man Hydrokavernenspeicher von gigantischer Kapazität (z.B. Hambach bis zu 0.5 TWh pro Zyklus) errichten. Das Prinzip und der Aufbau eines solchen Kavernenspeichers auf dem Boden einer gefluteten Braunkohleabbaustätte wird im Vortrag besprochen.

**AKE 2: Energieversorgung**

**Invited Talk**

**The German primary energy consumption – status and trends**

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**Larissa Breuninger**, Alexander von Müller, und andelka Kereké**

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**Technical University of Munich (TUM), Lichtenbergstraße 4a, 85748 Garching, Germany**

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**Max Planck Institute for Plasma Physics (IPP), Boltzmannstrasse 2, 85748 Garching, Germany**

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Like the gross domestic product (GDP), the primary energy consumption (PEC) is a highly aggregated indicator. The primary energy consumption characterizes the energy content of all energy sources used domestically. Energy sources like lignite, hard coal, mineral oil, or natural gas, are either used directly or converted into so-called secondary energy sources such as fuels, electricity, or district heating. In the longer term, PEC will be influenced by technological progress and the associated improvements in energy efficiency, by sectoral and intersectoral structural changes, but also by price-driven substitution processes.

This presentation summarizes the composition of PEC in Germany, how cross-border trade of primary energy is structured and which challenges in the field of energy supply Germany is likely to face in the future. In this context, the year 2019 - before the COVID-19 pandemic and the Russia-Ukraine war - serves as a reference year against which the current energy consumption is compared in order to point out changes resulting from these recent and disruptive developments.

**Discussion**

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**AKE 3: Zukunftsperspektiven**

**Invited Talk**

**Activation calculations for decommissioning planning of NPPs**

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**Reuven Rachamin**, Jörg Konheiser, and Marcus Seidel

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**Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany**

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**PreussenElektra GmbH, Hanover, Germany**

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By the middle of 2023, all German nuclear power plants (NPPs) will have been shut down. The final shutdown is followed by a post-operational phase in which measures can be carried out to prepare for the NPPs dismantling and decommissioning. One of the essential tasks in planning and preparing an NPP for decommissioning is to obtain precise knowledge of the activation levels in its reactor pressure vessel (RPV), the biological shielding, and other internal components. In that regard, a novel method based on the combined use of two Monte Carlo codes, MCNP6 and FLUKA2021, was developed to serve as a non-destructive tool for evaluating the activation in an NPP. The presentation will give an overview of the methodology and demonstrate its application through the activation calculations of selected components of a German pressurized water reactor (PWR), which is the most common NPP type in Germany.

**Discussion**

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**A KE 2. Energieversorgung**

**Invited Talk**

**Das Windenergiepotenzial Deutschlands: Grenzen und Konsequenzen grossräumiger Windenergienutzung**

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**Axel Kleidon** — Max-Planck-Institut für Biogeochemie, Jena, Deutschland

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**The Windenergienutzung in Deutschland soll bis 2050 mit bis zu 200 Giga-watt ausgebaut werden, was in etwa einer Vervierfachung im Vergleich zu heu-te entspricht. Diese Windturbinen werden der Atmosphäre dabei Windenergie entziehen, um Strom zu produzieren, und damit die Atmosphäre beeinflussen. Dies wirkt sich auf die Effizienz der Windenergienutzung aus, weil die Windgeschwindigkeiten in den Regionen, wo Windenergie genutzt wird, sinken müssen. Sie lassen sich mithilfe der Impulsbilanz und den damit verbundenen kine-tischen Energieflüssen abschätzen. Dies zeigt, dass die durch die Windturbinen reduzierten Windgeschwindigkeiten bei 200 GW Ausbau den Stromertrag um etwa 10 - 15% verringern werden. Der Effekt ist geringer, wenn die Windtur-binen gleichmäßig über mehr Fläche besser verteilt sind. Trotz dieser Effekte lässt sich mit der Windenergie sehr viel Strom erzeugen, die betrachteten Szenarios würden mehr als die Hälfte des gegenwärtigen Strombedarfs damit decken. Die Auswirkungen auf die Atmosphäre sind aber sehr gering. Die erzeugte Windenergie beträgt lediglich 2.4% des Verlusts an kinetischer Energie, die ganz natürlich durch Reibung in der unteren Atmosphäre verloren geht.**

**Discussion**

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**A KE 2.2 Energieversorgung**

**Das Windenergiepotenzial Deutschlands: Grenzen und Konsequenzen grossräumiger Windenergienutzung**

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**Invited Talk**

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**Discussion**

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**A KE 3. Zukunftsperspektiven**

**Invited Talk**

**Die Zeitenwende erfordert eine ideologiefreie Energiewende: Von der Grund-lastdeckung zur Lückenlastdeckung**

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**Helmut Aalto** — FH Aachen

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Die am 08.12.2021 im Regierungsamt vereidigte erste Ampel-Bundesregierung will die Erneuerbaren Energien zielstrebig mit festen Zielvorgaben ausbauen. Dazu sind folgende Randbedingungen vorgegeben:

- Der Beitrag zur Deckung unseres Brutto-Strombedarfs bis 2030 durch regenera-tive Energieerzeugung auf der Basis von Wasserkraft, Biomasse, Solar- und Windenergie soll sich auf 80% erhöhen und damit gegenüber derzeit in 2021 mit etwa 233,6 Mrd. kWh (39,7%) verdoppeln, um die Klimaerwärmung auf 1,5 °C zu begrenzen. Bis 2050 werden 100 % Lastdeckung durch regenerative Energien angepeilt.


**Discussion**
Overview of Invited Talks and Sessions
(Lecture hall ZEU/0148)

Invited Talks

AKjDPG 1.4 Thu 16:00–16:45 ZEU/0148 Open data and open-source tools throughout research data life cycle: KCDC example — Victoria Tokareva

Sessions

AKjDPG 1.1–1.5 Thu 14:00–17:30 ZEU/0148 Hacky Hour (joint session AKjDPG/AGI)
Sessions

- Invited Talks, Contributed Talks, and Posters –

AKjDPG 1: Hacky Hour (joint session AKjDPG/AGI)

Time: Thursday 14:00–17:30

AKjDPG 1.1 Thu 14:00 ZEU/0148
Adaman: A JSON-Based Metadata Editor for Researchers — •IDDA
CHAEROY STIPEFFAS, MARIAN STOTANOK, AND MARKUS M. BECKER — Leibniz Institute for Plasma Science and Technology (INP), Felix-Hausdorff-Straße 2, 17489 Greifswald, Germany
Adaman is a browser-based research data management (RDM) tool, specifically developed to systematically collect research metadata that is both machine- and human-readable. It utilizes the JavaScript Object Notation (JSON) schema specifications, where any valid schema can be rendered as an interactive and user-friendly web form. Users may create a JSON schema from scratch or provide an existing schema. Subsequently, users can provide inputs to the rendered form and generate a JSON document, which can be downloaded for further use. Adaman has found its usage in several research settings; namely, compilation of structured experiment metadata in conjunction with a generic electronic laboratory notebook, scientific instrument job requesting, and preparation of input data for plasma simulations. Overall, Adaman is an emerging generic RDM tool that eases day-to-day research activities as far as structured metadata is concerned.

AKjDPG 1.2 Thu 14:45 ZEU/0148
Hands-on data management with open-source software: CaosDB — •FLORIAN SPRECKELSEN AND DANIEL HORNUNG — IndiScale GmbH, Göttingen, Germany
Data management involves the storing, searching, retrieving and analyzing of data sets and their connections and circumstances. Good data management makes valuable data reusable, for current and future users. It also makes data findable. It is encourage implementation of data sets and their connections and circumstances. Good data management makes valuable data reusable, for current and future users. It also makes data findable. It is encourage implementation of data sets and their connections and circumstances. Good data management makes valuable data reusable, for current and future users. It also makes data findable. It is encourage implementation of data sets and their connections and circumstances. Good data management makes valuable data reusable, for current and future users. It also makes data findable.
The open-source toolkit CaosDb is a practical implementation of an agile data management approach designed to handle all these tasks, and much more. The structure of data can be modified later without losing old information and without the need to migrate existing data. This encourages agile implementation of data management workflows instead of delaying until the perfect master plan is ready. And CaosDb comes with a powerful Python client, so access is as easy as a few lines of code. This session consists of a short live demonstration of the CaosDb Python client, and participants are encouraged to follow along on their own machines. For this, they can install CaosDb’s Python library and additional tools with pip install caosdb-caosadvancedtools and make sure that they can load the library in Python with import caosdb. A Jupyter notebook will be made available online before the session.

AKjDPG 1.3 Thu 15:30 ZEU/0148
ELN integration into the open-source data management solution CaosDB — •DANIEL HORNUNG, FLORIAN SPRECKELSEN, HENRIK TOM WÖRDEN, TIMM FITSCHE, AND THOMAS WEISS — IndiScale GmbH, Göttingen, Germany
Scientific research still often lacks professional data management, mostly because the dynamically evolving research environments lack suitable software tools. In contrast, standardized industrial processes can be integrated easily with existing data management software. Research work in the lab is increasingly documented with electronic lab notebooks (ELNs), which allow to conveniently enter device and experimental settings in a semi-structured way. This data is usually critical in the analysis of acquired raw data from instruments, e.g., for searching specific data sets or filtering by parameters. We successfully integrated the data management software CaosDB with the eLabFTW ELN, thus combining flexible lab input methods with an agile open source approach to data management.
We chose CaosDB over other solutions, because it allows to flexibly adjust the data model when necessary. This agility is required by the dynamic nature of scientific research activities and cannot be provided by rigid, SQL based approaches.

20 min. break

Invited Talk

AKjDPG 1.4 Thu 16:00 ZEU/0148
Open data and open-source tools throughout research data life cycle: KCDC example — •VICTORIA TORKAREVA — Karlsruhe Institute of Technology, Institute for Astroparticle Physics, Karlsruhe, Germany
Open science essentials include open data, open source software, open access materials, open educational resources, etc. They provide substantial benefits to society like reproducibility of research, increased transparency and public acceptance of studies, simplified publication process, and enhanced public education. Ultimately, new opportunities become available for unique interdisciplinary studies performed by large diverse teams of specialists on publicly available datasets. Established in 2013, the KASCADE Cosmic Ray Data Centre (KCDC) exists simultaneously as an open archive for data of high-energy astroparticle physics experiments (such as KASCADE, KASCADE-Grande, LOPES, Maket-Ani,etc.), open source software and a web portal providing access to open educational resources. KCDC allows data selection with custom user data cuts using GUI or REST API and interactive online analysis of the selected data with integrated Jupyter Notebooks. From this talk, one can learn more about KCDC’s functionality and get better understanding of open science and research data life cycle concepts. An example of machine learning based analysis employing the KCDC platform and deployment of the results as an application using Streamlit will be discussed. This work is partially supported by the DFG fund “NFDI 39/1” for the PUNCH4NFDI1 consortium.

AKjDPG 1.5 Thu 16:45 ZEU/0148
Interactive USB measurement device controlling with Python — •BENEDIKT BERINGER — Institute for Nuclear Physics, University of Münster
Although USB devices are central part of most lab experiments, in many cases their use is significantly limited by the provided manufacturers’ software and drivers. This talk covers writing a (graphical) readout and controlling software in Python both by using proprietary drivers and by writing own user-space Python-based drivers in cases where the manufacturers’ drivers limit the usage potential of the USB device. It gives an overview over writing Python modules for existing drivers in C++, writing USB drivers in Python using PyUSB by analyzing USB packets with Wireshark and writing an interactive plotting and controlling GUI with PyQt and PyGraph.
Overview of Invited Talks and Sessions

(Lecture hall ZEU/0118; AI Topical Day HSZ/AUDI, HSZ/0004, and joint sessions; Poster HSZ OG2)

Plenary Talks of the AI Topical Day

PV XIII Thu 9:00–9:45 HSZ/AUDI The role of artificial intelligence in modern radiation therapy — Guillaume Landry

PV XIV Thu 9:45–10:30 HSZ/AUDI Machine Learning Advances in Particle Physics — Lukas Heinrich

Invited Talks

AKPIK 6.1 Thu 11:00–11:30 HSZ/AUDI AI Techniques for Event Reconstruction — Ivan Kisel

AKPIK 6.2 Thu 11:30–12:00 HSZ/AUDI Accelerator operation optimisation using machine learning — Pierre Schnizer

AKPIK 6.3 Thu 12:00–12:30 HSZ/AUDI Is this even physics? – Progress on AI in particle physics — Gregor Kasieczka

Sessions

AKPIK 1.1–1.5 Mon 16:00–18:00 HSZ OG2 Poster Applications in Particle and Astroparticle Physics

AKPIK 2.1–2.8 Tue 17:00–19:00 ZEU/0118 Neural Networks I

AKPIK 3.1–3.6 Wed 14:00–15:30 ZEU/0118 Neural Networks II

AKPIK 4.1–4.5 Wed 15:45–17:00 ZEU/0118 AI Topical Day – Neural Networks and Computational Complexity (joint session MP/AKPIK)

AKPIK 5.1–5.3 Wed 11:00–12:20 ZEU/0250 AI Topical Day – Invited Talks (joint session AKPIK/HK/ST/T/AKBP)

AKPIK 6.1–6.3 Thu 11:00–12:30 HSZ/AUDI AI Topical Day – Invited Talks (joint session AKPIK/HK/ST/T/AKBP)

AKPIK 7.1–7.6 Thu 14:00–15:30 HSZ/0101 AI Topical Day – Research Data Management and Medical Applications

AKPIK 8.1–8.6 Thu 15:45–17:15 HSZ/0004 AI Topical Day – Normalizing Flows and Invertible Neural Networks (joint session AKPIK/T)

AKPIK 9.1–9.6 Thu 17:30–19:00 HSZ/0004 AI Topical Day – New Methods (joint session AKPIK/T)

AKPIK 10.1–10.6 Thu 14:00–15:30 HSZ/0103 AI Topical Day – Computing II (joint session HK/AKPIK)

AKPIK 11.1–11.6 Thu 14:00–15:30 ZEU/0146 AI Topical Day – AI in Medicine (joint session ST/AKPIK)

AKPIK 12.1–12.6 Thu 14:00–15:30 HSZ/0105 AI Topical Day – Heavy-Ion Collisions and QCD Phases (joint session HK/AKPIK)
Grazing-Incidence Small-Angle X-ray Scattering (GISAXS) is a modern imaging technique used in material research to study nanoscale materials. Reconstruction of the parameters of an imaged object imposes an ill-posed inverse problem that is further complicated when only an in-plane GISAXS signal is available. Traditionally used inference algorithms such as Approximate Bayesian Computation (ABC) rely on computationally expensive simulating simulation software, rendering analysis highly time-consuming. We propose a simulation-based framework that combines variational auto-encoders and normalizing flows to estimate the posterior distribution of object parameters given its GISAXS data. We apply the inference pipeline to experimental data and demonstrate that our method reduces the inference cost by orders of magnitude while producing consistent results with ABC.

AKPIK 1.4 Mon 16:00 HSZ OG2
Control System for Autonomous Race Car — Vadim Melnik — Bolshaya Semenovskaya str., 38, Moscow, Russia
Self-driving cars help significantly improve safety, universal access, convenience, efficiency, and reduced costs. In order to fulfill SAE level 4 autonomy, no driver must be required, even in emergency situations and under heavy weather conditions. Despite the fact that major part of autonomous driving on public roads will happen in standard situations, a critical aspect to reach full autonomy is the ability to operate a vehicle close to its limits of handling, i.e. in avoidance maneuvers or in case of slippery surfaces.

Testing such systems on closed tracks or in simulators reduces the risks of human injury.

The proposed system uses path planning algorithms based on the information received from cameras and LiDAR, estimates its position using IMU and linear algebra methods, and is controlled by Model Predictive Control technique. Successful completion of tests in simulator allows the system to be transferred to a real vehicle to proceed to live tests and data validation.

AKPIK 1.5 Mon 16:00 HSZ OG2
Quantum machine learning for calorimeter data generation — Alexis-Harilo Vasnev-Provatakis1,2, Kerstin Borras1,3, and Dirk Kruecker1 — DESY, Hamburg, Germany — RWTH Aachen, Aachen, Germany

Rapid advances in Quantum Computing technology promise applications in a number of computational problems relevant to a wide range of scientific disciplines. Calorimeter simulation is crucial to Experimental High Energy Physics analyses. However, due to the rising computational cost of traditional simulation methods, machine learning has become a tool to accelerate data generation. Calorimeter data exhibits strong correlations, which many classical machine learning models struggle to recreate. Properties of quantum states, such as entanglement, which directly imply strong correlations, may be a tool for capturing the full data complexity. Preliminary models, using hybrid Quantum-Classical machine learning architectures are presented and explored.
potential resources unused. In this talk, we will present how HTCondor can be configured to cope with the users’ need to use GPUs both interactively and in batch job mode. We will report on the first experiences with our setup.

AKPIK 2.3 Tue 17:30 ZEU/0118
Fast Columnar Physics Analyses of Terabyte-Scale LHC Data on a Cache-Aware Disk Cluster — Svenja Drieckmann, Nicolas Eich, Martin Ebdman, Peter Jackeldey, Benjamin Fischer, Dennis Noll, and Yannik Rath — III. Physikalisches Institut A, RWTH Aachen University
The development of an LHC physics analysis involves numerous investigations that require the repeated processing of terabytes of data. Thus, a rapid completion of each of these analysis cycles is central to mastering the science project. We present a solution to efficiently handle and accelerate physics analyses on small-size institute clusters. Our solution uses three key concepts: Vectorized processing of collision events, the "MapReduce" paradigm for scaling out on computing clusters, and efficiently utilized SSD caching to reduce latencies in IO operations. This work focuses on the latter key concept, its underlying mechanism, and its implementation.

Using simulations from a Higgs pair production physics analysis as an example, we achieve an improvement factor of 6.3 in the runtime for reading all input data after one cycle and even an overall speedup of a factor of 14.9 after 10 cycles, reducing the runtime from hours to minutes.

AKPIK 2.4 Tue 17:45 ZEU/0118
ProGamer: PROgressively Growing Adversarial Modified (transformer-)Encoder Refinement — Benno Kach, Isabell Melzer-Pellmann, and Dirk Krücker — Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany
Machine learning-based data generation has become a major research topic in particle physics due to the computational challenges posed by current Monte Carlo simulation approaches for future colliders, which will have significantly higher luminosity. The generation of collider data is similar to point cloud generation, but it is more difficult because of the complex correlations that need to be accurately modeled between the points. A refinement model consisting of normalising flows and transformer encoders is presented. The normalising flow is 3-dimensional, meaning that the generated particle cloud consists of independent and identically distributed objects. This output is then refined by a transformer encoder, which is adversarially trained against another transformer encoder discriminator/critic. As the model is able to produce an arbitrary number of particles, a progressively growing point cloud can be produced.

AKPIK 2.5 Tue 18:00 ZEU/0118
Machine Learning based defect detection for large-scale electrodes — Sebastian Vetter — Karlsruhe Institute of Technology, Institute for Astroparticle Physics
Like every piece of hardware produced in an industrial setting, detectors in physics experiments are subject to material defects, introduced during the production or handling of individual components. This can greatly influence detector behavior and lead to unexpected experimental results, depending on the affected part and the extent of the defect. Detection and quantification of such defects is therefore an important step in constructing a successful experiment. It is still quite common for defect inspection to be done by eye. However, recent developments in computer-based inspection methods provide the opportunity to relieve humans from this tedious task, to remove the susceptibility of human error from the inspection step, and to objectively quantify the extent of detected defects.

In this talk, I present the defect inspection of a large-scale electrode mesh, as used for example in liquid noble gas Dark Matter experiments. This inspection was carried out first by hand and then compared to various Machine Learning approaches, ranging from simple decision trees to variational autoencoders.

AKPIK 2.6 Tue 18:15 ZEU/0118
Interpolation of Instrument Response Functions for the Cherenkov Telescope Array — Rune Michael Domink and Maximilian Linhoff — Technische Universität Dortmund, Germany
The Cherenkov Telescope Array (CTA) will be the next generation ground-based very-high-energy gamma-ray observatory, utilizing tens of Imaging Atmospheric Cherenkov Telescopes at two sites once its construction and commissioning is finished. Like its predecessors, CTA relies on Instrument Response Functions (IRFs) to relate the observed and reconstructed properties to the original properties of primary particles. IRFs are needed for the proper reconstruction of spectral and spatial information and are thus among the data-products issued to the observatory’s users. They are derived from Monte Carlo simulations and depend on observation conditions like the telescope pointing direction or the atmospheric transparency. Producing a complete set of IRFs from simulations for every observation taken is a time consuming task and not feasible when releasing data-products on short timescales. Consequently, interpolation techniques on simulated IRFs are investigated to quickly estimate IRFs for specific observation conditions. However, as some of an IRFs constituents are given as probability distributions, specialized methods are needed. This talk summarizes and compares the feasibility of multiple approaches to interpolate IRF components. First results are shown and open challenges are discussed.

AKPIK 2.7 Tue 18:30 ZEU/0118
Estimation of prediction uncertainties for data from Imaging Atmospheric Cherenkov Telescopes — Cyrus Pan Walthier and Maximilian Linhoff — Technische Universität Dortmund, Germany
One main step in the low-level analysis of astrophotography physics data is the reconstruction of the properties of primary particles that induced extensive air showers. Various methods are applied in different experiments and software packages. In general, these are multi-output and combined regression and classification tasks. The estimation of prediction uncertainties is of crucial importance for the long scientific exploitation of these events. However, most methods do not themselves provide reliable uncertainty estimates. In this contribution, we want to apply a method that has been used successfully in a Deep Learning reconstruction for the IceCube experiment to data from Imaging Atmospheric Cherenkov Telescopes used for gamma-ray astronomy.

AKPIK 2.8 Tue 18:45 ZEU/0118
Testing Nested Machine Learning Models for the Cherenkov Telescope Array — Lukas Brieske and Rune M. Domink for the CTA-Collaboration — Astronomical Physics, WG Rhede/Elsässer, TU Dortmund University, D-44227 Dortmund, Germany
The Cherenkov Telescope Array (CTA) will be the next-generation ground-based very-high-energy gamma-ray observatory covering an energy range from 20 GeV up to 300 TeV. It will operate tens of Imaging Atmospheric Cherenkov Telescopes (IACTs) on the Canary Island of La Palma (CTA North) and at the Paranal Observatory in Chile (CTA South) once construction and commissioning are finished.

Machine Learning techniques are currently being used to analyze data from IACTs. The tools are used to reconstruct the three main properties of the primary particle: its particle type, energy, and origin. A common approach is to train models on parameters extracted from the shower images observed by the telescopes which in turn give one prediction per telescope image. For events triggering multiple telescopes, these individual predictions can be averaged to obtain a single primary particle prediction for every shower event. However, it is possible to improve these averaged predictions by training a second set of machine learning models using all information available about the shower as seen by the whole telescope array. This talk will show the current results of testing such nested models for CTA.

AKPIK 3: Neural Networks I

Time: Wednesday 14:00–15:30

AKPIK 3.1 Wed 14:00 ZEU/0118
"Ahead of Time compilation" of Tensorflow models — Bogdan Wieder, Marcel Rieger, and Peter Schleper — University of Hamburg
In a wide range of high-energy physics analyses, ML methods have proven as powerful tools to enhance analysis sensitivity. In the past years, various ML applications were also integrated in central CMS workflows, leading to great improvements in reconstruction and object identification efficiencies. However, the continuation of successful deployments might be limited due to memory and processing time constraints of more advanced models and central infrastructure. A new inference approach for models trained with Tensorflow, based on Ahead-of-time (AOT) compilation is presented that has the potential to drastically reduce memory footprints while preserving and even increasing computational performance.

AKPIK 3.2 Wed 14:15 ZEU/0118
A multi-layer approach and neural network architectures for defect detection in PBF-LB/M — Michael Mosckell and Jörret Vogt — TH Aschaffenburg, Würzburger Str. 45, 63743 Aschaffenburg
The substitution of expensive non-destructive material testing by data-based process monitoring is intensively explored in quality assurance for additive manufactured components. Machine learning show promising results for defect detection but require conceptual adaption to layer wise manufacturing and line

Location: ZEU/0118
scanning patterns in laser powder bed fusion. A multi-layer approach to co-
register γ-camera tomography measurements with process monitoring data is
developed and a workflow for automatic data set generation is implemented. The
objectives (i) to train models for interferometric multi-layer approach and
specifically selected deep learning methods for defect detection. The volu-
metric approach shows superior results compared to single slice monitoring. All
investigated structured neural network topologies deliver similar performance.

AKPIK 3.3 Wed 14:30 ZEU/0118
Reconstructing jet characteristics using neural networks — Arne Poggen-
pohl and Felix Geyer — Astroparticle Physics, TU Dortmund University, Ger-
many
Active galactic nuclei (AGN) are among the most observed objects in the noctur-
nal sky. Several of these AGN have the capability to accelerate matter in their nu-
cleus to relativistic velocities, resulting in jets. These are frequently studied sources
of radio emission. Analysis of the kinematic characteristics of radio jets can pro-
vide information about physical properties of the host galaxy. Previously, this
was mostly done by tracking Gaussian components of the jets manually, which
is difficult to reproduce. Therefore, the goal of this work is to automatically de-
tect Gaussian components in radio jets using a neural network and thus enable
kinematic analysis. Big data sets can thereby be processed, because it is no longer
necessary to concentrate on each individual image.

For the necessary object detection, an architecture based on YOLO is used.
This architecture consists exclusively of convolutional layers and requires only
one pass for the prediction. This allows it to be fast and accurate at the same
time.

In this talk, the current state of the work is presented and improvements for
the future are pointed out.

AKPIK 3.4 Wed 14:45 ZEU/0118
Deep-Learning based Estimation of the Ultra-High Energy Cosmic Ray Spect-
rum using the Surface Detector of the Pierre Auger Observatory — Ralph
Engel, Markus Roth, Darke Vebrec, Steffen Hahn, and Fiona Ell-
wanger for the Pierre Auger-Collaboration — Karlsruhe Institute of Technology
(IAP), Karlsruhe, Germany
To probe physics beyond the scales of human-made accelerators with cosmic rays
demands an accurate knowledge of their energy. Ground-based experiments in-
directly reconstruct the primary particle energy from measurements of the emi-
ted fluorescence light or the time-dependent signal of the shower footprint.

At the Pierre Auger Observatory, the shower footprint is measured by a regu-
lar hexagonal grid of water-Cherenkov detectors. Since the shower development
is a very intricate process, it non-trivial to find hidden patterns in the spatial and
temporal distributions of signals. With large simulation datasets, we are able to
train neural networks to tackle such a problem.

In this work, we present a neural network that gives an estimate on the energy of
the primary particle. The precision of the predictions is studied by evaluat-
ing the neural networks on a simulated test data set with particular regard to the
mass-dependent bias. Systematic differences between simulations and measured
data require special attention to possible biases, which are investigated. Meth-
ods to correct for these biases are presented. Furthermore, the energy spectrum
from corrected neural network predictions is built and compared to published results.

AKPIK 3.5 Wed 15:00 ZEU/0118
Investigating Waveform Classification Using Neural Networks for the Ein-
stein Telescope — Markus Bachlechner, Philipp Otto, Oliver Pooth, and
Achim Stahl — III. Physikalisches Institut B, RWTH Aachen
The Einstein Telescope (ET) is a proposed third-generation gravitational wave
detector aiming to improve the sensitivity by more than an order of magnitude
over the whole frequency band compared to the previous generation. Increased
sensitivity yields a much higher event rate with overlapping signals, which will
dramatically increase the computational resource requirements of conventional
pattern matching methods. Neural networks are a promising approach to imple-
ment a fast and efficient waveform classification. Fast identification is also essen-
tial to allow for multi-messenger astronomy, by quickly alerting other observa-
tories. This talk will present the investigation of a deep learning based waveform
classification approach.

AKPIK 3.6 Wed 15:15 ZEU/0118
Estimating Uncertainties for Trained Neural Networks — Sebastian
Bieringer — Universität Hamburg, Hamburg, Germany
Uncertainty estimation is a crucial issue when considering the application of
deep neural network to problems in high energy physics such as jet energy cali-
brations.

We introduce and benchmark a novel algorithm that quantifies uncertainties
by Monte Carlo sampling from the models Gibbs posterior distribution. Unlike
the established ‘Bayes By Backpropagation’ training regime, it does not rely on
any approximations of the network weight posterior, is flexible to most training
regimes, and can be applied after training to any network. For a one-dimensional
regression task, as well as energy regression from calorimeter images, we show
that this novel algorithm describes epistemic uncertainties well, including large
errors for extrapolation.

AKPIK 4: Neural Networks II

Time: Wednesday 15:45–17:00
Location: ZEU/0118

AKPIK 4.1 Wed 15:45 ZEU/0118
Morphological Classification of Radio Galaxies with wGAN-supported Aug-
mentation — Janis Kummer 1,2, Florian Griem 1,2, Lennart Rustig 1,2, Kerstin Bobras 1,2,6, Marcus Brüggen 2, Patrick Connor 1,2, Frank Garde 6, Gregor Kasieczka 2, Tobias Kopp 1,2, and Peter Schleper 1 — Center for
Data and Computing in Natural Sciences (CDCS), Hamburg, German
— Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany —
Hamburger Sternwarte, Hamburg, Germany — University Medical Center
Hamburg-Eppendorf, Hamburg, Germany — University of Technology,
Hamburg, Germany — RWTH Aachen University, Aachen, Germany
— Universität Hamburg, Hamburg, Germany
Supervised deep learning models for the morphological classification of radio
galaxies are very important for processing the data of future large radio surveys.
However, labelled training data for such models is limited. We demonstrate the
use of generative models, specifically a Wasserstein Generative Adversarial Net-
work (wGAN), to augment artificial data for different classes of radio galaxies.

Further, we study the impact of augmenting the training data with images from
our wGAN on different classification architectures. We find that it is indeed possible
to improve models for the morphological classification of radio galax-
ies with this technique. In addition, fast simulations of radio galaxies with our
wGAN are useful to validate new interferometric machine-learning algorithms.

AKPIK 4.2 Wed 16:00 ZEU/0118
Uncertainty estimations for deep learning-based imaging — Felix Geyer,
Arne Poggenpohl, and Kevin Schmit — Astroparticle Physics WG Elässer,
TU Dortmund University, Germany
Radio interferometry is used to monitor and observe distant astronomical
sources and objects with high resolution. Especially Very Long Baseline Inter-
ferometry (VLBI) allows for achieving the highest resolutions by combining the
data of multiple telescopes. This results in an effective diameter corresponding to
the greatest distance between two telescopes. The taken data consists of vis-

bilities in Fourier space, which depend on the baselines between the telescopes.
Because the distribution of these baselines is sparse, the sample of visibilities is
incomplete. After transforming this sample to spatial space, this so-called ‘dirty
image’ is inadequate for physical inference and analyses.

In traditional methods, the image then undergoes an elongated and mainly
manually performed cleaning process in order to remove background artifacts and
restore the original source distribution. Contrary, a new and fast approach to
reconstructing missing data reasonably is using neural networks. As an addi-
tional advantage, these networks can also be used to estimate the uncertainty of
the prediction. This is done by not only predicting the mean value of the pixels
but also the standard deviation by feeding the input and the prediction to a sepa-
rate network. All of this is part of our framework called radiomes, which
is another focus of this talk.

AKPIK 4.3 Wed 16:15 ZEU/0118
Partition Pooling for Convolutional Graph Network Applications in Parti-
cle Physics — Philipp Soldin, Markus Bachlechner, Thilo Birkenfeld,
Achim Stahl, and Christopher Wiebusch — III. Physikalisches Institut B,
RWTH Aachen University
Convolutional Neural Networks (CNN) are often used in particle physics appli-
cations for classification and reconstruction tasks. Since the individual sensors
in a particle detector are often arranged in complex geometries, the informa-
tion must be projected onto regular grids to use CNNs. Convolutional Graph
Networks (CGN) can encode the individual sensor positions as a static graph
to prevent projection effects. However, with the number of sensors in modern
particle physics detectors, the CGN performance can be limited by the consid-
erable number of parameters. A dimensionality reduction scheme analogous to
convolutional pooling on images that uses graph partitioning to create pooling
kernels is presented. Different CGN architectures, including partition pooling,
is presented with an exemplary vertex reconstruction in an idealized neutrino
detector.
AKPIK 4.4 Wed 16:30 ZEU/0118
Gamma Source Detection using Deep Multitask Networks and Noisy Label Learning — Lukas Pfahler — TU Dortmund University, Artificial Intelligence Group, Dortmund, Germany
Machine learning has been established as an effective tool for data analysis in modern high energy particle experiments. For the FACT telescope, we solve three supervised learning tasks - gamma-hadron separation, energy estimation, and origin estimation - using simulated training data and manual feature extraction. We outline how we can replace the manual feature engineering currently applied with a learned representation trained with multitask supervision. Our approach will be a shared representation that can solve all three prediction tasks with specialized prediction networks built on top of the shared representation. Furthermore, we look into an alternative source of supervision that reduces the burden of simulating training data by using real telescope recordings. We rely on the concept of noisy labels and introduce a novel method for learning under label noise where only one noise rate is known. We show how gamma-hadron separation can be framed in this setting and illustrate that the method allows us to train accurate classifiers.

AKPIK 4.5 Wed 16:45 ZEU/0118
Binary Black Hole Parameter Estimation using Deep Neural Networks — Markus Bachlechner, David Bertram, Philipp Otto, Oliver Pooth, and Achim Stahl — III. Physikalisches Institut B, RWTH Aachen
As the first of the third-generation of gravitational wave detectors, the proposed Einstein Telescope is expected to be at least an order of magnitude more sensitive compared to current interferometers like LIGO and Virgo. On the one hand, the higher sensitivity increases the observable volume. On the other hand, higher sensitivity in the low-frequency band leads to significantly earlier detection and observation for some coalescences like binary neutron stars. These early observations make it possible to send multi-messenger alerts before the merger. Applying a fast analysis handling event detection, classification, and estimation in real time is essential. This talk presents an approach for parameter estimation of binary black holes using deep neural networks.

AKPIK 5: AI Topical Day — Neural Networks and Computational Complexity (joint session MP/AKPIK)

Time: Wednesday 11:00–12:20
Location: ZEU/0250

AKPIK 5.1 Wed 11:00 ZEU/0250
A universal approach to state and operator complexities — Souvik Banerjee and Mohsen Alshahiha — Julius-Maximilians-Universität Würzburg, Germany — IPM, Tehran, Iran
In this talk, I shall present a general framework in which both Krylov state and operator complexities can be put on the same footing. In our formalism, the Krylov complexity is defined in terms of the density matrix of the associated state, which, for the operator complexity, lies on a doubled Hilbert space obtained through the channel-state map. This unified definition of complexity in terms of the density matrices enables us to extend the notion of Krylov complexity, to subregion or mixed state complexities and also naturally to the Krylov mutual complexity. We show that this framework also encompasses nicely, the holographic notions of complexity and explains the universal late-time growth of complexity, followed by a saturation.

Invited Talk

AKPIK 5.2 Wed 11:30 ZEU/0250
Deep neural networks and the renormalization group — Kevin Grovenor — University of Würzburg — Leiden University
Despite the success of deep neural networks (DNNs) on an impressive range of tasks, they are generally treated as black boxes, with performance relying on heuristics and trial-and-error rather than any explanatory theoretical framework. Recently however, techniques and ideas from physics have been applied to DNNs in the hopes of distilling the underlying fundamental principles. In this talk, I will discuss some interesting parallels between DNNs and the renormalization group (RG). I will briefly review RG in the context of a simple lattice model, where subsequent RG steps are analogous to subsequent layers in a DNN, in that effective interactions arise after marginalizing hidden degrees of freedom/neurons. I will then quantify the intuitive idea that information is lost along the RG flow by computing the relative entropy in both the ising model and a feedforward DNN. One finds qualitatively identical behaviour in both systems, in which the relative entropy increases monotonically to some asymptotic value. On the QFT side, this confirms the link between relative entropy and the c-theorem, while for machine learning, it may have implications for various information maximization methods, as well as disentangling compactness and generalizability.

AKPIK 5.3 Wed 12:00 ZEU/0250
Analytic continuation of Greens' functions using neural networks — Jóhanna Ermengen, René Meyer, Martin Racle, and Yanick Thorn — JMU Würzburg
In quantum many-body physics, the analytic continuation of Greens' functions is a well-known problem. The problem is ill-posed in the sense that the transformation kernel becomes chaotic for large energies and thus small noise creates huge differences in the resulting spectral density function. Some techniques in the field of machine learning, in particular neural networks, are known for handling this kind of problem. Using a neural network and for the problem-optimized loss functions and hyperparameters, a network is trained to determine the spectral density from the imaginary part of the Greens function given by quantum Monte Carlo simulations. The network is able to recover the overall form of the spectral density function, even without adding constraints such as normalization and positive definiteness. There is no need to encode these constraints as regularizations since they are reflected automatically by the solution provided by the network. This indicates the correctness of the inversion kernel learned by the neural network. In the talk, I will explain the structure of the methods used to train the network and highlight the central results.

AKPIK 6: AI Topical Day — Invited Talks (joint session AKPIK/HK/ST/T/AKBP)

Time: Thursday 11:00–12:30
Location: HSZ/AUDI

Invited Talk

AKPIK 6.1 Thu 11:00 HSZ/AUDI
AI Techniques for Event Reconstruction — Ivan Kisel — Goethe University, Frankfurt, Germany
Why can we relatively easily recognize the trajectory of a particle in a detector visually, and why does it become so difficult when it comes to developing a computer algorithm for the same task? Physicists and computer scientists have been puzzling over the answer to this question for more than 30 years, since the days of bubble chambers. And it seems that we are steadily approaching the answer in our attempts to develop and apply artificial neural networks both for finding particle trajectories and for physics analysis of events in general.
This talk will present the basics of artificial neural networks in a simple form, and provide illustrations of their successful application in event reconstruction in high energy physics and heavy ion physics experiments. You will get an insight into the application of traditional neural network models, such as deep neural network, convolutional neural network, graph neural network, as well as those standing a little aside from traditional approaches, but close in idea of elastic network and even cellular automata.

Invited Talk

AKPIK 6.2 Thu 11:30 HSZ/AUDI
Accelerator operation optimisation using machine learning — Pierre Schnizer — Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany
Accelerators are complex machines whose many components need to be accurately tuned to achieve design performance. Reliable operation requires frequent recalibration and tuning. Especially for large machines tools have been developed that facilitating this task.
Machine learning allows building such tools using simulations, archiver data or interaction with the real machine, thus making many tools now also available for smaller machines.
This talk will give an overview of different machine learning projects targeted to accelerators, which simplifies accelerator operation or even enable applications not been possible before.

Invited Talk

AKPIK 6.3 Thu 12:00 HSZ/AUDI
Is this even physics? — Progress on AI in particle physics — Gregor Kasieczka — Universität Hamburg
Motivated by the large volume and high complexity of experimental data and mathematical structures, particle physics has a long tradition of employing state of the art computing and analysis techniques. Recent progress in machine learning and artificial intelligence have further pushed this trend, and these approaches are now ubiquitous in our field. This overview attempts to capture key developments such as the rise of unsupervised approaches and the quest for suitable neural network architectures for physics tasks; challenges like ultra-low latency inference and robust predictions; as well as promising new ideas looking forward.

AKPIK 7: AI Topical Day – Research Data Management and Medical Applications

**AKPIK 7.1** Thu 14:00 HSZ/0101
Federated Heterogeneous Compute and Storage Infrastructure for the PUNCH4NFDI Consortium — **Alexandre Drabenstötter**, Jörn Kunsemüller, Matthias Höfer, Christoph Vissing, Manuel Griffler, Dominik Schwarz, Kilian Schwarz, and Andreas Hensel — **Ihreinger Landessternwarte Tautenburg —** ²Universität Bielefeld — ³DESY, Hamburg — ⁴Karlsruher Institut für Technologie — **Johannes Gutenberg-Universität Mainz**

PUNCH4NFDI is the NFDI consortium of particle, astro-, astroparticle, hadron and nuclear physics. Compute4PUNCH and Storage4PUNCH concepts are developed to meet the demands of large-scale scientific activities to provide shared and federated access to compute and storage systems. Those are being federated in a common infrastructure and transparently integrated with an overlay batch system. Both concepts comprise state-of-the-art technologies for resource access and to ensure scalable provisioning of community specific software. Furthermore, existing technologies for caching as well as metadata handling are being evaluated with the aim for a deeper integration. The combined Compute4PUNCH and Storage4PUNCH environment will allow a large variety of researchers to carry out resource-demanding analysis tasks.

In this contribution we will present the Compute4PUNCH and Storage4PUNCH concepts, the current status of the developments as well as first experiences with scientific applications, such as analysing radio-interferometric data, being executed on the available prototypes.

**AKPIK 7.2** Thu 14:15 HSZ/0101
VISPA - Cloud Services for Modern Data Analysis — **Niclas Eich**, Louis Christoph, Martin Erdmann, Peter Fackeldey, Benjamin Fischer, Leonard Lux, Dejan Markovic, Mathilde Popppmell, and Malcom Steen — RWTH Aachen University

VISPA (VISual Physics Analysis) realizes a scientific cloud enabling modern scientific data analysis in a web browser. Our local VISPA instance is backed by a small institute cluster and is dedicated to fundamental research and university education. By hardware upgrades (656 GPU threads, 29 workstation GPUs), we have tailored the cloud services to accomplish both, rapid turn-around when developing O(TE) HEP analyses and deep-learning hands-on with O(100) participants through the web browser. With its latest software developments, VISPA now supports the interactive use of Jupiter notebooks on local as well as on batch resources. Additionally, users can optionally execute their analyses on any SSH reachable large-scale resource they desire. New tools such as an improved user management and a monitoring of the batch resources ensure seamless administration. We will present this major advance of the VISPA project and show how a large range of scientific data analyses can be realized in the web browser.

**AKPIK 7.3** Thu 14:30 HSZ/0101
Towards coherent metadata schema for the PUNCH4NFDI open source platform — **Victoria Tokareva** for the PUNCH4NFDI Consortium-Collaboration — Karlsruhe Institute of Technology, Institute for Astroparticle Physics, Karlsruhe, Germany

PUNCH4NFDI is an NFDI consortium of particle, astro-, astroparticle, hadron and nuclear physics, which is addressing common challenges of data-intensive physics at large research facilities: data volumes, data complexity, data rates, and data irreversibility, as well as the development and promotion of open science vision and required tools to achieve this. One of the core features in the development of a PUNCH4NFDI software infrastructure is a cloud-based platform and an open data portal, aimed at providing access to a wide range of digital research materials within the PUNCH4NFDI community and ensuring that the FAIR (findability, accessibility, interoperability, reusability) principles are applied for the community’s data collections. This requires to navigate the landscape of different established metadata schemas and find common ground to access the data and run programs and workflows using data from different data collections. In order to achieve this goal, we have investigated core concepts and definitions in the field and analyzed user stories and use cases of several data platforms within the PUNCH4NFDI community. From these, essential requirements for the use model have been defined. The results will be presented in this contribution. This work is supported by the DFG fund “NFDI 39/17” for the PUNCH4NFDI consortium.

**AKPIK 7.4** Thu 14:45 HSZ/0101
Datenanalytische Hillestellungen für ein festgelegtes Modell zur Personenerkennung — **Jan Michael Burger** and **Hans Dominik Werner** — HowRoy GmbH, 24976 Handewitt

För den Bereich der (Allen)-PFlege werten wir Videodaten mit einer Personenerkennung aus, um eine Videokommunikation genau dazu zu ermöglichen, sobald sich die Person alleine im Raum aufhält. Insbesondere aus Datenschutzgründen sollte dabei eine Kommunikation nicht möglich sein, sobald sich mehr als eine Person im Raum aufhält. Gleichzeitig sollte die Person erkannt werden, selbst wenn sie zugedeckt im Bett liegt.


In diesem Vortrag werden die Erwartungen und Ergebnisse zu von uns untersuchten und verwendeten Hilfestellungen dargestellt.

**AKPIK 7.5** Thu 15:00 HSZ/0101
Interpretative Machine Learning and evidence-based decision support in clinical Digital Twins — **Carlos Andres Brandl**, Anna Nitschke, and Matthias Weidemüller — Im Neuenheimer Feld 226, 69120 Heidelberg, Germany

Personalized medicine is based on including a vast variety of patient-specific data. The Digital Twin technology provides the opportunity for improved personalized patient care by monitoring the patient journey and predicting the best preventive and therapeutic decision options available. We developed a concept which fuses evidence-based methods with machine learning approaches into a single decision-support tool. Our method is independent on the parameter spaces and evidence-based tools being used, provides possibilities to include updated knowledge and is able to offer intuitively interpretable decision options to the clinician. The presentation introduces our architecture of the digital twin and provides details on the fusion approach.

**AKPIK 7.6** Thu 15:15 HSZ/0101
Radiomics for two-dimensional prompt gamma-ray based proton treatment verification — **Sonja Schellhammer**, **Theresa Lenk**, **Stepfen Lock**, and **Toni Kogler** — ¹OncoRay – National Center for Radiation Research in Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technical University Dresden, Helmholtz-Zentrum Dresden - Rossendorf, Dresden, Germany — ²Helmholtz-Zentrum Dresden - Rossendorf, Institute of Radiooncology – OncoRay, Dresden, Germany — ³German Cancer Research Center (DKFZ), Partner Site Dresden, and German Cancer Research Center (DKFZ), Heidelberg, Germany — ⁴Department of Radiotherapy and Radiation Oncology, Faculty of Medicine and University Hospital Carl Gustav Carus, Technische Universität Dresden, Dresden, Germany

There is a growing need for on-line verification systems to further increase the safety and efficacy of cancer treatment with proton therapy. For this purpose, we propose a radiomics-based analysis of two-dimensional time-energy distributions of secondary prompt gamma-rays and apply it to realistic data measured in a proton therapy facility. In comparison to previously used methods based only on temporal gamma-ray distributions, we show that the accuracy of the range verification is improved by 38% (1.5 mm). These results demonstrate that radiomics and machine learning are valuable tools to enhance proton treatment verification for cancer therapy.
AKPIK 8: Ai Topical Day – Normalizing Flows and Invertible Neural Networks (joint session AKPIK/T)

AKPIK 8.1 Thu 15:45 HSZ/0004

Efficient Sampling from Differentiable Matrix Elements with Normalizing Flows — ANNALENA KOLEI1, VINCENT STIMPFL1, MIKAEL MIKHAESKENKO1, MICHAEL KAGAN2, and LUKAS HEINRICH3 — 1Technical University Munich — 2Max Planck Institute for Intelligent Systems, Tübingen — 3University of Cambridge, UK

The large amount of data that will be produced by the high-luminosity LHC imposes a great challenge to current data analysis and sampling techniques. As a result, new approaches that allow for faster and more efficient sampling have to be developed. Machine Learning methods such as normalizing flows, have shown great promise in related fields. There, access to not only the density function but also its gradient has proven to be helpful for training. Recently, software for accessing differentiable amplitudes, which serve as densities in particle scattering, have become available that allow us to obtain the gradients and benchmark these new methods. The described approach is demonstrated by training rational-quadratic spline flows with differentiable matrix elements of the hadronic three-body decays, \( \pi(1800) \rightarrow 3\pi \) and \( \Lambda_c^+ \rightarrow pK^- \pi^+ \). To boost the ability to accurately learn and sample from complex densities whilst also reducing the number of training samples, we explore the use of the newly proposed method Flow Annealed Importance Sampling Bootstrap. Building on prior work, we plan to extend the approach to examples with more particles in the final state via the differentiable matrix elements provided by Madgax.

AKPIK 8.2 Thu 16:00 HSZ/0004

Generating Accurate Showers in Highly Granular Calorimeters Using Normalizing Flows — THORSTEN BRESS — Institut für Experimentalphysik, Universität Hamburg, Germany

The full simulation of particle colliders incurs a significant computational cost. Among the most resource-intensive steps are detector simulations. It is expected that future developments, such as higher collider luminosities and highly granular calorimeters, will increase the computational resource requirement for simulation beyond availability. One possible solution is generative neural networks that can accelerate simulations. Normalizing flows are a promising approach in this pursuit. It has been previously demonstrated, that such flows can generate showers in low-complexity calorimeters with high accuracy. We show how normalizing flows can be improved and adapted for precise shower simulation in significantly more complex calorimeter geometries.

AKPIK 8.3 Thu 16:15 HSZ/0004

Introspection for a normalizing-flow-based recoil calibration — LARS SOWA, JOST von DEN DRIESCH, ROGER WOLF, MARCUS KLUTE, and GÜNTHER QUAST — Institute of Experimental Particle Physics (IEP), Karlsruhe Institute of Technology (KIT)

Normalizing flows (NFs) are neural networks, that preserve the probability between their input and output distributions. NFs can be promising candidates either as surrogates for the fast generation of new samples or as universal approximators of arbitrary probability density functions, based on which confidence intervals may be determined, both of which are interesting properties in high-energy physics (HEP). This work presents the case study of recoil calibration on LHC Run-3 data and Monte Carlo simulation with the goal to better understand the behavior of NFs. The result of the NF is compared to a deep ensemble of feed-forward neural networks created to compare the calibration results and the different coverage in the value space.

AKPIK 8.4 Thu 16:30 HSZ/0004

Normalising Flows for Parameter Estimation from Gravitational Wave Signals — JOHANNES ERMANN1, JON HOKMA2, and SHUHAN WU3,4 — 1II. Physikalisches Institut A, RWTH Aachen University — 2Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut) — 3Leibniz Universität Hannover The Einstein Telescope (ET) is a proposal for a next generation ground-based gravitational wave detector. Due to higher sensitivity, ET is expected to receive orders of magnitude more gravitational wave signals than the current 2nd generation detectors LIGO and Virgo and KAGRA. Additionally, these signals will also be in the frequency band of the detector for a longer time, which would cause overlaps of signals. The analysis methods currently in use, which are based on Markov Chain Monte Carlo (MCMC) nested sampling methods, are unsuitable for handling such data and would take up significant computing resources. Therefore, new efficient analysis methods are required. Deep learning methods form a promising approach for this task. Specifically, normalizing flows promise to provide a more efficient means for signal parameter estimation. We use mock data to estimate signal parameters through normalizing flows and compare them to the current standard approach.

AKPIK 8.5 Thu 16:45 HSZ/0004

A method for inferring signal strength modifiers by conditional invertible neural networks — Mate Zoltan Farkas, Svenja Diekmann, Nicolas Eich, and Martin Ermann — III. Physik Institute A, RWTH Aachen

The continuous growth in model complexity in high-energy physics collider experiments demands increasingly time-consuming model fits. We show first results on the application of conditional invertible neural networks (cINNs) to this challenge. Specifically, we construct and train a cINN to learn the mapping from signal strength modifiers to observables and its inverse. The resulting network infers the posterior distribution of the signal strength modifiers rapidly and for low computational cost. We present performance indicators of such a setup including the treatment of systematic uncertainties. Additionally, we highlight the features of cINNs estimating the signal strength for a vector boson associated Higgs production analysis carried out at an LHC experiment on simulated data samples.

AKPIK 8.6 Thu 17:00 HSZ/0004

Reconstruction of SAXS Data using Invertible Neural Networks — Erik Theissenhusen1, Melanie Rodel1, Thomas Kluge1, Michael Russmann1, Thomas Cowan1, and Nico Hoffmann1 — 1HZDR, FKW, Dresden, Germany

The understanding of laser-solid interactions is important to the development of future laser-driven particle and photon sources, e.g., for tumor therapy, astrophysics or fusion. Currently, these interactions can only be modeled by simulations which need verification within the scope of pump-probe experiments. This experimental setup allows us to study the laser-plasma interaction that occurs when an ultrahigh-intensity laser hits a solid density target. We employ Small-Angle X-Ray Scattering (SAXS) to image the nanometer-scale spatial- and femtosecond temporal resolution of the laser-plasma interactions. However, the analysis of the SAXS pattern is an ill-posed inverse problem meaning that multiple configurations of our target might explain the same measurement due to the loss of the phase information. We approach the ambiguities of the inverse problem by a conditional Invertible Neural Network (cINN) that is returning a probability density distribution over target parameters explaining a single SAXS pattern. We will show that the domain gap between generated training and experimental data can be approached by integrating perturbations of experimental data into the training workflow. We assess the applicability of our approach to a selected set of grating targets in terms of a comprehensive evaluation on simulation and experimental data.

AKPIK 9: Ai Topical Day – New Methods (joint session AKPIK/T)

AKPIK 9.1 Thu 17:30 HSZ/0004

Neural networks for cosmic ray simulations — Pranav Sampathkumar1, Tanguy Pierro1, and Antonio Augusto Alves Junior1 — 1Institute for Astroparticle Physics (IAP), KIT, Germany — 2Brazilian Synchrotron Light Laboratory (LNLS), CNPPEM, Brazil

Simulating cosmic ray showers at high energies is memory and time intensive. Apart from the traditional methods such as thinning and cascade equations, novel methods are needed for the modern needs in astroparticle physics.

AKPIK 9.2 Thu 17:45 HSZ/0004

A hybrid model of generating cosmic ray showers based on neural networks is presented. We show that the neural network learns the solution to the governing cascade equation in one dimension. We then use the neural network to generate the energy spectra at every height slice. Fits of training to generate a single height slice is discussed, and we present a sequential model which can generate the entire shower from an initial spectrum. Errors associated with the model and the potential to generate the full three dimensional distribution of the shower and detector footprints are discussed.
Photon identification at hadron colliders using graph neural networks

Transformer-based eventwise reconstruction of cosmic-ray masses at the Pierre Auger Observatory — Martin Erdmann, Niklas Langner, and Dominik Steinberg — III. Physikalisches Institut A, RWTH Aachen University

As one aspect of the AugerPrime upgrade, scintillators (SSDs) will be added to the water Cherenkov detectors (WCDs) that form the surface detector of the Pierre Auger Observatory. This combined measurement offers the possibility to distinguish individual components of extensive air showers, potentially increasing the mass sensitivity. To efficiently exploit this new potential, novel methods are needed.

We introduce a Transformer-based neural network to reconstruct cosmic-ray masses from joint WCD and SSD measurements that outperforms both recurrent and convolutional networks. Efficient Transformers are employed to analyze and relate the two different sets of time traces on station level while ensuring a reasonable degree of computational demands. A Vision Transformer is then applied to the hexagonal grid of detector stations to process the whole shower footprint. The Transformer network is trained to simultaneously reconstruct the depth of the shower maximum \( R_\text{m} \) as well as the shower’s number of muons on ground \( R_\mu \). Both observables can be combined to estimate the primary cosmic-ray mass with an accuracy higher than what can be achieved individually.

Quantum Angle Generator for Image Generation — Florian Rehn, Sofia Vallecorsa, Michele Grossi, Kerstin Borras, Dirk Krocker, Simon Schnake, Alexis Harilo Verney-Provatas, and Vallee Vare — CERN, Switzerland — RWTH Aachen University, Germany — DESY, Germany

The Quantum Angle Generator (QAG) is a new generative model for quantum computers. It consists of a parameterized quantum circuit trained with an objective function. The QAG model utilizes angle encoding for the conversion between the generated quantum data and classical data. Therefore, it requires one qubit per feature or pixel, while the output resolution is adjusted by the number of shots performing the image generation. This approach allows the generation of highly precise images on recent quantum computers. In this paper, the model is optimized for a High Energy Physics (HEP) use case generating simplified one-dimensional images measured by a specific particle detector, a calorimeter. With a reasonable number of shots, the QAG model achieves an elevated level of accuracy. The advantages of the QAG model are line-out such as simple and stable training, a reasonable amount of qubits, circuit calls, circuit size and computation time compared to other quantum generative models, e.g., quantum GANs (qGANs) and Quantum Circuit Born Machines.


At hadron colliders like the LHC, photons are essential physics objects in a wide range of analyses. For example, they allow the study of the Higgs boson using the diphoton decay channel. At a typical particle detector, the main signatures of photons are energy depositions in the electromagnetic calorimeter. However, other objects can leave similar signatures in the electromagnetic calorimeter, leading to misidentification as photons. Jets are abundant at the LHC and they include a high number of light hadrons, most notably neutral pions decaying into two photons. The decay of pions produces photons that are often close to each other and they are likely to be reconstructed as a single photon. However, photon candidates from jets have different attributes that can help to discriminate them from real photons. Specifically, they tend to produce wider signatures in the calorimeter, and to be accompanied by more additional particles.

Graph neural networks (GNNs) are flexible neural architectures well suited for dealing with input data of irregular structure and variable shape. Hence, they are particularly suited for classifying photon candidates as often a variable number of particles surrounds them. In this talk, our study of the applicability of GNNs for photon identification and comparisons with convolutional neural networks are presented.

AKPIK 10.3 Thu 14:30 HSZ/0103

Pattern recognition using machine learning for the mCBM mRICH detector — Martin Bever for the CBM-Collaboration — Justus-Liebig-Universität Gießen

The Compressed Baryonic Matter experiment (CBM) is designed to explore the QCD phase diagram at high baryon densities using high-energy heavy ion collisions at high interaction rates. The Ring Imaging Cherenkov detector (RICH) contributes to the overall particle identification by reconstruction of rings from electrons with their respective radius, position, and time. The miniCBM (mCBM) detector is the test setup for the CBM experiment, with the purpose of testing both hardware and software including the triggerless free-streaming data acquisition and data reconstruction algorithms. The miniRICH (mRICH) detector in the mCBM setup is a proximity focusing RICH detector with a photon detection plane consisting of 36 MultiAnode Photo Multipliers (MAPMTs). This setup results in charged particles passing directly through the MAPMTs resulting in quite some additional signals typically inside ring structures and reducing the overall ring finding efficiency based on the Hough Transformation.

In this talk a machine learning approach is presented to classify those signals in ring centers and thus improving the overall ring finding efficiency and precision.

AKPIK 10.4 Thu 14:45 HSZ/0103

Machine Learning Algorithms for Pattern Recognition with the PANDA Barrel DIRC — Yannic Wolf, Roman Dziehaglo, Klaus Petras, Georg Schepers, Carsten Schwarz, and Jochen Schieweinin — 1GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt — Goethe-Universität Frankfurt

Precise and fast hadronic particle identification (PID) is crucial to reach the physics goals of the PANDA detector at FAIR. The Barrel DIRC (Detection of Internally Reflected Cherenkov light) is a key detector for the identification of charged hadrons in PANDA. Several reconstruction algorithms have been developed to extract the PID information from the measured location and arrival time of the Cherenkov photons. In comparison to other Ring Imaging Cherenkov detectors, the hit patterns observed with DIRC counters do not appear as rings on the photosensor plane but as complex, disjoint 3D-patterns.

Using the recent advances in machine learning (ML) algorithms, especially in the area of image recognition, we plan to develop new ML PID algorithms for the PANDA Barrel DIRC and compare the results to conventional reconstruction methods. In search for the best performance, different network architectures are currently under investigation.

AKPIK 10.5 Thu 15:00 HSZ/0103

Optimization of the specific energy loss measurement for the upgraded ALICE TPC using machine learning — Tuba Gündem for the ALICE Germany-Collaboration — Institut für Kernphysik, Frankfurt, Germany

The Time Projection Chamber (TPC) is the primary detector used in the ALICE experiment for tracking and particle identification (PID). PID is accomplished by reconstructing the momentum and the specific energy loss (dE/dx) of a particle. The dE/dx for a given track is calculated using a truncated mean on the charge signals associated to the track. The readout plane, on which the signals are measured, is radially subdivided into four regions with different pad sizes. Since the measured signals depend on the pad size, an optimization of the dE/dx calculation based on the pad size can be performed.

In this talk, a method for optimizing the dE/dx calculation using machine learning (ML) algorithms will be presented. By performing realistic simulations of the generated signals on the pads, various effects such as the different pad sizes and track geometry are modeled. These simulations are used as inputs for the training of the ML model and are investigated using RootInteractive.

Supported by BMFB and the Helmholtz Association.

AKPIK 10.6 Thu 15:15 HSZ/0103

Deep Learning Based PID with the HADES detector — Waheed Esmaiel and James Ritman — 1,2,3 for the HADES-Collaboration — 1GSI Helmholtzzentrum für Schwerionenforschung GmbH, 64291 Darmstadt, Germany — 2Forschungszentrum Jülich, 52428 Jülich, Germany — 3Ruhr-Universität Bochum, 44801 Bochum, Germany

The main purpose of a particle identification (PID) algorithm is to provide a clean sample of particle species needed to conduct a physics analysis. The conventional approach used in the HADES experiment is to apply the so-called "graphical cuts" around the theoretical Bethe-Bloch curves of the energy loss as a function of the particle momentum. However, this approach is not optimal, since the distributions resulting from the different particle species overlap. A better approach is based on deep learning algorithms. In our preliminary studies done with the p(4.5 GeV)-p data recently collected by HADES, we were able to improve the separation power of the particle species. The algorithm is based on Domain Adversarial Neural Networks (DANN) trained in a semi-supervised way to simultaneously look at simulated and real data to learn the discrepancies between the two data domains. In this talk we will present our preliminary results, which show that this technique significantly improves the classification of particle species in the experimental data.

AKPIK 11: Al Topical Day – Al in Medicine (joint session ST/AKPIK)

Time: Thursday 14:00–15:30

AKPIK 11.1 Thu 14:00 ZEU/0146

Multimodal image registration with deep learning — Alexander Ratke, Christian Baumere, Kevin Kröniger, and Bernhard Spaan — 1TU Dortmund University, Dortmund, Germany — 2West German Proton Therapy Centre Essen, Essen, Germany

In radiation therapy, precise localisation of tumour and risk structures is important for treatment planning. Medical imaging methods, such as computed tomography (CT) and magnetic resonance imaging (MRI), allow a differentiation between these structures. Planning systems typically align CT and MRI scans rigidly to compensate inaccurate immobilisation of the patient, but distortions in MRI or movement of organs still remain. In this project, a data set of CT and MRI scans of the head and neck area is used to study unsupervised deformable image registration with deep learning. First, the scans are pre-processed, which includes rigid registrations and the equalisation of the image formats. Then, deep learning is employed to filter structures of an image through multiple layers and to match them to a second image. The registration model strongly depends on the choice of its parameters. Therefore, variations of these parameters are investigated on the data set. The results are presented as well as the overall workflow including the pre-processing.
Selection of Compton events in the SiFi-CC camera using convolutional neural networks — George Farah1, Ronja Hetzel1, Jonas Kasper1, Alexander Fenger1, Achim Stahl3, and Aleksandra Wrońska3 — III. Physikalisches Institut B, RWTH Aachen University — M. Smoluchowski Institute of Physics, Jagiellonian University Kraków, Poland

One of the biggest challenges in proton therapy is to reconstruct the source distribution of the prompt gammas. It consists of multiple scintillating fibers in the source position. Different neural network designs as well as an evaluation of their performance are presented.

Selection of Compton events in the SiFi-CC camera using convolutional neural networks — George Farah1, Ronja Hetzel1, Jonas Kasper1, Alexander Fenger1, Achim Stahl3, and Aleksandra Wrońska3 — III. Physikalisches Institut B, RWTH Aachen University — M. Smoluchowski Institute of Physics, Jagiellonian University Kraków, Poland

Proton therapy is a promising form of cancer treatment that uses charged protons to target and kill cancer cells. One of the main challenges in proton therapy is accurately determining the depth at which the protons will deposit their energy in the tumor.

The SiFi-CC (SIPM and scintillating Fiber-based Compton Camera) project is a joint collaboration of the RWTH Aachen University, the Jagiellonian University in Kraków and the University of Lübeck. The two modules of the SiFi-CC, the scatterer and the absorber, both consist of stacked LYSO fibers and are read out by SiPMs. Deep neural networks are employed to separate valid Compton events from background and reconstruct the direction and energy of prompt gamma rays. First implementations of neural networks show promising results in classification of Compton events as well as full reconstruction of the event topology and kinematics. The next step is to further optimize the current neural network implementation to gain sensitivity towards a detectable range shift in the source position. Different neural network designs as well as an evaluation of their performance are presented.

Modelling charged-particle production at LHC energies with deep neural networks — Maria Calmon Beuling for the ALICE Germany-Collaboration — Physikalisches Institut, Universitäten Heidelberg and Frankfurt, Germany

Particle production at the Large Hadron Collider (LHC) is driven by a complex interplay of soft and hard QCD processes. Modelling these interactions across center-of-mass energies and collision systems is still challenging for Monte Carlo event generators. Concise experimental data is indispensable to characterize the final state of a collision. The ALICE experiment with its unique tracking capabilities down to low transverse momenta is perfectly suited to study the bulk particle production in high-energy collisions. During the data taking campaigns of LHC Run 1 and Run 2 (2009 - 2018), a large amount of data were collected of a variety of collision systems at different center-of-mass energies. A recent measurement of charged-particle production covering all of these collision systems provides a comprehensive set of fundamental observables like the charged-particle multiplicity distributions and transverse momentum spectra as well as their correlation.

In this talk, we discuss the possibility of extending this set of discrete experimental data points into unmeasured regions by means of machine learning techniques. Training deep neural networks with ALICE data gives the unique opportunity to measure the evolution of multiplicity dependent charged-particle production across collision system sizes and energies.

Supported by BMBF and the Helmholtz Association.
tion rate, up to 10 MHz, provided by the SIS100 accelerator. The (multi)strange baryons are crucial in determining the chemical freeze-out and its connection to hadronization from deconfined QCD matter. To obtain an optimal and stable separation between signal and background candidates the machine learning tool XGBoost is used. Machine learning allows for efficient, non-linear and multi-dimensional selection criteria to be implemented in a heavy-ion collision environment, enabling to extract and correct the $\Xi^-$ raw yield in different rapidity and transverse momentum intervals.

AKPIK 12.4 Thu 14:45 HSZ/0105
Multi-differential $\Lambda$ Yield Measurement in the CBM Experiment using Machine Learning Techniques — •Axel Punke\(^1\) and Shahid Khan\(^2\) for the CBM-Collaboration — \(^1\)Institut für Kernphysik, WWU Münster — \(^2\)Eberhard Karls University of Tübingen

The Compressed Baryonic Matter (CBM) experiment at FAIR will investigate the QCD phase diagram at high net-baryon densities ($\mu_B > 500$ MeV) with heavy-ion collisions in the energy range of $\sqrt{s_{NN}} = 2.9 - 4.9$ GeV. Precise determination of dense baryonic matter properties requires multi-differential measurements of strange hadron yields, both for the most copiously produced $K_S^0$ and $\Lambda$ as well as for rare (multi-)strange hyperons and their antiparticles.

In this contribution the performance for $\Xi^-$ selection in Au-Au collisions at $\sqrt{s_{NN}} = 4.93$ GeV in the CBM experiment will be presented. The $\Xi^-$ hyperon is reconstructed via the weak decay channel $\Xi^- \rightarrow (\Lambda \rightarrow p\pi^-)\pi^-$ using the Particle-Finder Simple package.

For the reduction of the data size, which is driven by the large combinatorial background, specific skimming pre-selection criteria are optimized in this work. To be implemented in a heavy-ion collision environment, enabling to extract and correct the $\Xi^-$ raw yield in different rapidity and transverse momentum intervals.

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Overview of Invited Talks and Sessions
(Lecture halls HSZ/0002 and HSZ/0004)

Max-von-Laue Lecture
PV XII Wed 20:00–21:00 HSZ/AUDI Max-von-Laue Lecture: Risikokompetenz – informiert und entspannt mit Risiken umgehen — R. Gigerenzer

Invited Talks

AGA 1.1 Wed 14:00–14:45 HSZ/0004 Acoustic, Seismic and Magnetic Detection of Banned Activities – 3.5 Decades of Physics-based Peace Research — Jürgen Altmann

AGA 4.1 Thu 14:00–14:45 HSZ/0002 Mass Starvation? Impacts of Nuclear War on Climate Change and Food Security — Lili Xia

AGA 5.1 Thu 15:45–16:30 HSZ/0002 Nuclear forensic science – when nuclear scientists and law enforcement meet — Maria Wallenius

AGA 5.2 Thu 16:30–17:15 HSZ/0002 Applied Physics in the Alva Myrdal Centre for Nuclear Disarmament: Non-Proliferation and Safeguards Activities — Sophie Grae, Peter Andersson, Erik Branger, Cecilia Gustavsson, Vaibhav Mishra, Débora Montano Trombetta, Markus Preston

AGA 7.1 Fri 13:00–13:45 HSZ/0002 Fireworks or Threat? – Recent Missile Developments in North Korea — Markus Schiller

AGA 7.2 Fri 13:45–14:30 HSZ/0002 The Challenge of Nuclear-Powered Submarines to IAEA Safeguards — Tariq Rauf

Sessions

AGA 1.1–1.1 Wed 14:00–14:45 HSZ/0004 Acoustic, Seismic and Magnetic Measurements

AGA 2.1–2.4 Wed 14:45–16:25 HSZ/0004 New Verification Concepts and Forensics

AGA 3.1–3.2 Wed 16:25–17:05 HSZ/0004 Simulation and Physics Teaching for Security and Disarmament

AGA 4.1–4.3 Thu 14:00–15:25 HSZ/0002 Nuclear Weapons and the Atmosphere

AGA 5.1–5.2 Thu 15:45–17:15 HSZ/0002 Applied Nuclear Physics

AGA 6 Thu 17:30–18:30 HSZ/0002 Members’ Assembly

AGA 7.1–7.3 Fri 13:00–14:50 HSZ/0002 Proliferation Challenges

AGA 8.1–8.1 Fri 14:50–15:10 HSZ/0002 Mathematical Modelling of Conflicts
Members’ Assembly of the Working Group on Physics and Disarmament

Thursday 17:30–18:30 HSZ/0002

1. Wahl der Versammlungsleitung und Protokollführung
2. Bericht der Sprecher
3. Wahl der Sprecher:in
4. Künftiger Arbeitsplan und Aktivitäten
Spent nuclear fuel (SNF) is an inevitable by-product of nuclear power generation and requires safeguarding, whether in interim storage or deep geological repositories. Anti-neutrino emissions from the ongoing beta decay of fission fragments could provide a complementary monitoring channel, as anti-neutrinos pass through shielding and geology unhindered and can be detected using inverse beta decay (IBD). This study investigates a novel anti-neutrino detection concept using a liquid organic (LO) time projection chamber (TPC), combining scalability and particle reconstruction of TPCs with the hydrogen target atoms provided by organic compounds. Geant4-based simulations and electron drift modelling are used to study IBD event reconstruction in a container-sized concept detector for interim storage. The concept detector’s expected signal rate, sensitivity and directionality are estimated for a representative example repository with varying deployment scenarios. The results are compared to other state-of-the-art anti-neutrino detection technologies proposed for monitoring. This ongoing comparison study will determine the feasibility anti-neutrino detection as complementary safeguards for SNF repositories.

20 min. break

Anti-neutrino detector concepts for safeguarding spent nuclear fuel repositories — Yan-Jie Schellbach1,2, Thomas Rademacher1,2, Irmgard Niemeyer1, Stefan Roth1 and Malte Göttzsche2 — RWTH Aachen University - Nuclear Verification and Disarmament, Aachen, Germany — Forschungszentrum Jülich, Jülich, Germany

This new analysis methodology can be used for various applications ranging from crosschecking fissile material declarations for international confidence building, to a combination with specially designed and installed reactor monitor tags to contribute to the verification of the proposed Fissile Material Cutoff Treaty, to reassessing potentially highly uncertain early plutonium production estimates on a purely national basis.
AGA 3: Simulation and Physics Teaching for Security and Disarmament

Time: Wednesday 16:25–17:05

AGA 3.1 Wed 16:25 HSZ/0004
OpenMC for Anwendungen in sicherheitspolitischen Fragestellungen — • OLAF SCHUMANN — Fraunhofer INT, Euskirchen

AGA 3.2 Wed 16:45 HSZ/0004
Teaching physics for Arms Control, Non-Proliferation and Disarmament — • Götz Neuneck — IFSh, Hamburg

Throughout the nuclear age, physicists played an important role to inform the public, advise the scientific community and influences politics. Teaching and education at universities and research groups form the basis for the discussion of future nuclear challenges. In the last decades much scientific-based materials, event series the characteristic source processes and focused on methods for discriminating between earthquakes and explosions as demanded in the CTBT context. Atmospheric Transport Modelling assessed the sensitivity to the explosion for nearby radionuclide stations to estimate the detectability of hypothetical radionuclide releases in a fictitious nuclear explosion scenario.

The results show again the readiness of the CTBT-IMS and strengthen the value of the IMS data for scientific and civilian applications.

AGA 4: Nuclear Weapons and the Atmosphere

Time: Thursday 14:00–15:25

Invited Talk AGA 4.1 Thu 14:00 HSZ/0002
Mass Starvation? Impacts of Nuclear War on Climate Change and Food Security — • ZHAO XIA — Rutgers University, USA
The direct effects of nuclear war would be horrific, with blast, fires, and radiation killing and injuring many people. But in 1983, United States and Soviet Union scientists showed that a nuclear war could also produce a nuclear winter, with catastrophic consequences for global food supplies for people far removed from the conflict. Smoke from fires ignited by nuclear weapons exploded on cities and industrial targets would block out sunlight, causing dark, cold, and dry surface conditions, producing a nuclear winter, with surface temperatures below freezing even in summer for years. Climate change caused by smoke from fires ignited by nuclear weapons would limit the amount of food that could be grown on land our caught at sea. After stored food was consumed there would be mass food shortages in almost all countries. We used one climate model, one crop model, and one fishery model climate to estimate the impacts from six scenarios of stratospheric soot injection, predicting the total food calories available in each nation post-war after stored food was consumed. We estimated that more than 2 billion people could die from nuclear war between India and Pakistan, and more than 5 billion could die from a war between the United States and Russia.

AGA 4.2 Thu 14:45 HSZ/0002
Multi-technological analysis of the January 2022 Hunga Volcano explosive eruption from the perspective of CTBT monitoring — • Jens Ole Ross, Patrick Hupe, Andreas Steinberg, Stefanie Donner, Peter Gaebler, Johanna Lehr, Christoph Pilger, Thomas Plenefisch, and Lars Ceranowa — Bundesanstalt für Geowissenschaften und Rohstoffe, BGR, B43 Erdbebendi enst des Bundes / Kernwaffenteststopp, Hannover
For the detection of potential non-compliance with the Comprehensive Nuclear-Test-Ban Treaty, what can be gained from higher sensitivities and shorter sampling periods? — • Sofia Brandner, Sandra Baub, Ro man Krais, J. Ole Ross, and Andreas Bollhöfer — 1 Federal Office for Radiation Protection, Rosaustr. 9, 79098 Freiburg, 2 Federal Institute for Geosciences and Natural Resources, GeoZentrum Hannover, Stilleweg 2, 30655 Hann over

For the verification of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) an international monitoring system (IMS) of radionuclide measurement stations has been established. 26 of 40 planned noble gas stations now accommodate systems that automatically collect and analyze a minimum of 1 air sample per day for the nuclides Xe-133, Xe-131m, Xe-133m and Xe-135 in order to detect a possible nuclear weapons test. A new generation of systems, capable of shorter sampling cycles and lower detection limits, is being tested and implemented into the IMS. The German Federal Office for Radiation Protection tested one of these systems, Xenon International, from July 2021 to April 2022 at radionuclide station RN33 on Mount Scauninsland near Freiburg. The obtained activity concentrations are consistent with data from the current operational IMS system SPALAX at RN33, with sensitivities up to one order of magnitude higher for Xe-131m, Xe-133m and Xe-135.

In this talk, I will investigate multiple isotope detections and unusual single detections and explore the benefits of 6h time resolution considering source location capabilities via atmospheric transport modeling.

AGA 5: Applied Nuclear Physics

Time: Thursday 15:45–17:15

Invited Talk AGA 5.1 Thu 15:45 HSZ/0002
Nuclear forensic science – when nuclear scientists and law enforcement meet — • Maria Walleuens — European Commission Joint Research Centre Direc torate G - Nuclear Safety and Security Nuclear Safeguards and Forensics
Nuclear forensics is a discipline in which JRC Karlsruhe has a pioneering role: JRC was the first institution, which started to perform nuclear forensic analysis “in a routine manner” for seized nuclear materials 30 years ago. Starting as an ad-hoc analysis to respond safeguards and law enforcement authorities - questions on seized nuclear materials - what it is and where it comes from - nuclear forensics has now developed to a grown-up specialty.

Whereas nuclear forensics relies mostly on techniques used commonly in other fields, such as in nuclear safeguards, materials science or geochemistry, it has refined many of the methods and developed characteristic parameters (so-called nuclear forensic signatures) to respond to the specifics required due to the criminal investigation.

This presentation will highlight some of the used methods, show newest developments and demonstrate their application by case studies.
In 2020, the Swedish government announced the plans to start up a national competence centre on nuclear disarmament in Sweden. The objective was to highlight the importance of nuclear disarmament and to promote research, teaching and policy support on relevant topics. In mid-2021, the Alva Myrdal Centre (AMC) on nuclear disarmament was formally established at Uppsala Uni-

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**Invited Talk**  
*AGA 5.2 Thu 16:30 HSZ/0002*  
Applied Physics in the Alva Myrdal Centre for Nuclear Disarmament: Non-Proliferation and Safeguards Activities — Sophie Grape, Peter Andersson, Erik Branger, Cecilia Gustavsson, Vaibhav Mishra, Deborah Manton-Trombetta, and Markus Preston — Uppsala University

It seems that the North Korean nuclear program is now advancing at a pace unlike ever before. In the third quarter of 2022 alone, North Korea tested more missiles than it had in the first 30 years of its program under its previous leaders Kim Il Sung and Kim Jong Il. This presentation will try to shed some light on what is actually happening in the realm of Kim Jong Un in regard to missile developments and tests, and it will try to derive the underlying strategy by applying technical analyses of the observed activities.

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**AGA 6: Members’ Assembly**

Time: Thursday 17:30–18:30

All members of the Working Group on Physics and Disarmament are invited to participate.

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**AGA 7: Proliferation Challenges**

Time: Friday 13:00–14:50

**Invited Talk**  
*AGA 7.1 Fri 13:00 HSZ/0002*  
Fireworks or Threat? — Recent Missile Developments in North Korea — Markus Schiller — ST Analytics GmbH, München, Germany

The decisions by Australia to import eight nuclear-powered submarines (SSNs) fueled with 97.3% highly-enriched uranium (HEU) from either the US or the UK, and by Brazil to develop its own SSNs fueled with low-enriched uranium (LEU) with technical assistance from France and Germany, have exposed fundamental weaknesses in the nuclear Non-Proliferation Treaty (NPT) and its related IAEA safeguards (verification) system. The NPT only covers “peaceful nuclear activities” while the IAEA safeguards system for NPT non-nuclear-weapon States (NNWS) includes an exemption from verification of “non-proscribed military activities”. The IAEA Secretariat and the IAEA Board of Governors seemingly are deeply confused and divided over the safeguards implications of these SSN-acquisition programmes. This presentation will describe the problems and suggest possible ways of dealing with them and preserving the 50-year old nuclear non-proliferation regime.

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**AGA 8: Mathematical Modelling of Conflicts**

Time: Friday 14:50–15:10

**Invited Talk**  
*AGA 8.1 Fri 14:50 HSZ/0002*  
Increased Geopolitical Instability as a Consequence of Changed Equilibrium Country Size — Richard Schubert — Blucherstr. 55, 10961 Berlin

In the proposed contribution an analogy is established between the equilibrium size of magnetic domains and the historically formed size of countries. The equilibrium size of magnetic domains is given by a minimum of the energy function consisting of different components obeying different scaling laws, e.g. scaling to the cube or the square of the domain size. Thus, different materials have different average domain sizes. The size of the historically formed countries as well depends on a cost/benefit equilibrium, which can also be described by a kind of energy function. As a consequence of digitization and other changes in technology the parameters of the material countries are made of have changed dramatically leading to a different equilibrium country size. As a consequence, the current geopolitical situation is in a thermodynamic sense highly unstable. In the contribution, it will be shown how the recent developments in the Yellow Sea, Ukraine, and Catalonia could also be interpreted in the framework of this model (ref to 2017). Trying to make suggestions on how to achieve a smooth transition from the old state of the system to a new state closer to equilibrium is, however, outside the scope of the proposed contribution. Part of the ideas are based on the author’s long-standing experience in organizing political background discussions

http://berlin-3d-art.de/politische_hintergrundgespraeche.htm

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Overview of Invited Talks and Sessions
(Lecture hall ZEU/0148)

Invited Talks

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<td>Programming and Computational Physics Education in the Physics Curriculum at University of Göttingen — Fabian Heidrich-Meisner</td>
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<td>Integrating Digitalization and Research Data Management (RDM) into the Curricula of Bachelor and Master Students in Chemistry — Fabian Fink, Alexander Hoffmann, Sonja Herres-Pawlis</td>
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Sessions

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AGI 1: Data Literacy in the Physics Curriculum

Invited Talk  
AGI 1.1  Thu 11:00  ZEU/0148  
Programming and Computational Physics Education in the Physics Curriculum at University of Göttingen — Fabian Heidrich-Meisner — Institut für Theoretische Physik, Georg-August-Universität Göttingen  
Programming skills and expertise with computational physics are essential competences in the daily work of a physicist. Often, these skills are acquired on the fly, yet in view of qualification standards and evolving expectations from both students and prospective employers, graduates may benefit from standardized training elements in their physics education. Therefore, training in these skills are essential parts in the physics curriculum on the B.Sc. and M.Sc. level at the University of Göttingen. I will introduce our integrated approach, choice of programming languages, and the specific modules that are mandatory parts of our B.Sc. Physics programme. On the master’s level, we offer a qualification direction in Theoretical Physics that encompasses a significant amount of training in Computational Physics. B.Sc. in Göttingen can also enroll in an Applied Computer Science track on the B.Sc. level and can specialize in Computational Physics.

Invited Talk  
AGI 1.2  Thu 11:30  ZEU/0148  
Integrating Digitalization and Research Data Management (RDM) into the Curricula of Bachelor and Master Students in Chemistry — Fabian Fink, Alexander Hoffmann, and Sonja Herres-Pawlis — RWTH Aachen University, Aachen, Germany  
Ongoing and increasing digitalization is permanently changing the way research is conducted, experiments are documented, and data are stored. In general, this process requires the support of appropriate research data management (RDM) to enable sustainable research in the first place. [1] Currently, a rethinking takes place in academia focusing especially on the topic of RDM: working groups using electronic laboratory notebooks (ELNs) for documentation, publishers requiring authors to provide a data availability statement to describe how others can access their data, and scientists publishing their research data in repositories to ensure long-term storage and to meet the FAIR data principles (findable, accessible, interoperable, reusable). [2] However, despite the growing awareness of RDM, incorporation of the topic into curricula is largely nonexistent or, if at all, in its infancy. In this talk, we showcase two initial examples of integrating RDM into bachelor and master studies in chemistry to raise students’ attention at an early stage in their careers. Firstly, we present the implementation of an ELN in a bachelor lab course tracked with a survey among the students. Secondly, we show how we use case studies to combine a master lecture on sustainable chemistry with RDM content.


AGI 2: Hacky Hour (joint session AKjDPG/AGI)

Time: Thursday 14:00–17:30  
Location: ZEU/0148

AGI 2.1  Thu 14:00  ZEU/0148  
Adaman: A JSON-Based Metadata Editor for Researchers — Ihda Chaeront Siffa, Marian Stankov, and Markus M. Becker — Leibniz Institute for Plasma Science and Technology (INP), Felix-Hausdorff-Straße 2, 17499 Greifswald, Germany  
Adaman is a browser-based research data management (RDM) tool, specifically developed to systematically collect research metadata that is both machine- and human-readable. It utilizes the JavaScript Object Notation (JSON) schema specifications, where any valid schema can be rendered as an interactive and user-friendly web form. Users may create a JSON schema from scratch or provide an existing schema. Subsequently, users can provide inputs to the rendered form and generate a JSON document, which can be downloaded for further use. Adaman has found its usage in several research settings; namely, compilation of structured experiment metadata in conjunction with a generic electronic laboratory notebook, scientific instrument job requesting, and preparation of input data for plasma simulations. Overall, Adaman is an emerging generic RDM tool that eases day-to-day research activities as far as structured metadata is concerned.

AGI 2.2  Thu 14:45  ZEU/0148  
Hands-on data management with open-source software: CaosDB — Florian Spreckelsen and Daniel Hornung — IndiScale GmbH, Göttingen, Germany  
Data management involves the storing, searching, retrieving and analyzing of data sets and their connections and circumstances. Good data management makes valuable data reusable, for current and future users. It also makes data findable (Where is the training data for sensor X of setup Y again?) and adds real utility to data, because data can be embedded into context (Which experimental settings were used for obtaining the data for project P, and how many failures were there?).

The open-source toolkit CaosDB is a practical implementation of an agile data management approach designed to handle all these tasks, and much more: The structure of data can be modified later without losing old information and without the need to migrate existing data. This encourages agile implementation of data management workflows instead of delaying until the perfect master plan is ready. And CaosDB comes with a powerful Python client, so access is as easy as a few lines of code. This session consists of a short live demonstration of the CaosDB Python client, and participants are encouraged to follow along on their own machines. For this, they can install CaosDB's Python library and additional tools with `pip install caosdb caosdbadvancedtools` and make sure that they can load the library in Python with `import caosdb`. A Jupyter notebook will be made available online before the session.

AGI 2.3  Thu 15:30  ZEU/0148  
ELN integration into the open-source data management solution CaosDB — Daniel Hornung, Florian Spreckelsen, Henrik Tom Wördén, Tim Fitschen, and Thomas Weiss — IndiScale GmbH, Göttingen, Germany  
Scientific research still often lacks professional data management, mostly because the dynamically evolving research environments lack suitable software tools. In contrast, standardized industrial processes can be integrated easily with existing data management software. Research work in the lab is increasingly documented with electronic lab notebooks (ELNs), which allow to conveniently enter device and experimental settings in a semi-structured way. This data is usually critical in the analysis of acquired raw data from instruments, e.g. for searching specific data sets or filtering by parameters. We successfully integrated the data management software CaosDB with the eLabFTW ELN, thus combining flexible lab
input methods with an agile open source approach to data management. We chose CaosDB over other solutions, because it allows to flexibly adjust the data model when necessary. This agility is required by the dynamic nature of scientific research activities and cannot be provided by rigid, SQL based approaches.

20 min. break

Invited Talk

Open data and open-source tools throughout research data life cycle: KCDC example — Victoria Tokareva — Karlsruhe Institute of Technology, Institute for Astroparticle Physics, Karlsruhe, Germany

Open science essentials include open data, open source software, open access materials, open educational resources, etc. They provide substantial benefits to society like reproducibility of research, increased transparency and public acceptance of studies, simplified publication process, and enhanced public education. Ultimately, new opportunities become available for unique interdisciplinary studies performed by large diverse teams of specialists on publicly available datasets. Established in 2013, the KASCADE Cosmic Ray Data Centre (KCDC) exists simultaneously as an open archive for data of high-energy astroparticle physics experiments (such as KASCADE, KASCADE-Grande, LOPES, Maket-Ani, etc.), open source software and a web portal providing access to open educational resources. KCDC allows data selection with custom user data cuts using GUI or REST API and interactive online analysis of the selected data with integrated Jupyter Notebooks. From this talk, one can learn more about KCDC’s functionality and get better understanding of open science and research data life cycle concepts. An example of machine learning based analysis employing the KCDC platform and deployment of the results as an application using Streamlit will be discussed. This work is partially supported by the DFG fund "NFDI 39/1" for the PUNCH4NFDI consortium.

Interactive USB measurement device controlling with Python — Benedikt Beringer — Institute for Nuclear Physics, University of Münster

Although USB devices are central part of most lab experiments, in many cases their use is significantly limited by the provided manufacturers’ software and drivers. This talk covers writing a (graphical) readout and controlling software in Python both by using proprietary drivers and by writing own user-space Python-based drivers in cases where the manufacturers’ drivers limit the usage potential of the USB device. It gives an overview over writing Python modules for existing drivers in C++, writing USB drivers in Python using PyUSB by analyzing USB packets with Wireshark and writing an interactive plotting and controlling GUI with PyQt and PyQtGraph.
Working Group on Philosophy of Physics
Arbeitsgruppe Philosophie der Physik (AGPhil)

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Overview of Invited Talks and Sessions
(Lecture halls JAN/0027 and HSZ/0304)

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**Members’ Assembly of the Working Group on Philosophy of Physics**

Wednesday 18:00–18:30 JAN/0027

- Bericht
- Wahlen
- Planung 2023/24
- Verschiedenes
Vorgriff auf Quanten 2025 — HELMUT HILLE und HELMUT HILLE — Fritz-Haber-Straße 34, 74081 Heilbronn

AGPhil 1: Quanten und Prozesse

Time: Monday 11:00–13:00

AGPhil 1.1 Mon 11:00 JAN/0027

Vorgriff auf Quanten 2025 — HELMUT HILLE und HELMUT HILLE — Fritz-Haber-Straße 34, 74081 Heilbronn

AGPhil 1.3 Mon 12:00 JAN/0027

Prozesse statt Zustandsbetrachtungen — GUOT KALIES und DUONG D. DO — 1HTW University of Applied Sciences, Dresden, Germany — 2The University of Queensland, Brisbane, Australia

AGPhil 2: Space and Time

Time: Tuesday 11:00–13:30

AGPhil 2.1 Tue 11:00 JAN/0027

Einstein's forgotten interpretation of GR: against geometrization and for the unification of gravity and inertia — DENNIS LEMKEHUL — Lichtenberg Group for History and Philosophy of Physics, University of Bonn

AGPhil 2.3 Tue 12:00 JAN/0027

Causal Theories of Spacetime — BAPTISTE LE RH AN — University of Geneva

AGPhil 2.2 Tue 11:30 JAN/0027

A dynamical perspective on the arrow of time — KIAN SALIMKHANI — University of Cologne

AGPhil 2.4 Mon 12:30 JAN/0027

Three steps to a realistic foundation of quantum mechanics — ED DELLIAN — Bogesit, 5, 14169 Berlin, Germany

It is standardly believed that the generally time-reversal symmetric fundamental laws of physics themselves cannot explain the apparent asymmetry of time. In particular, it is believed that CP violation is of no help. In this paper, I want to push back against a quick dismissal of CP violation as a potential source for the arrow of time and argue that it should be taken more seriously for conceptualising time in physics. I first recall that CP violation is a key feature of our best physical theory which also has large-scale explanatory import regarding the matter-antimatter asymmetry of the universe. I then investigate how CP violation may help to explain the directionality of time. I argue that accounts that a Maudlin that posit an intrinsic fundamental direction of time are not convincing and instead propose to utilise recent results from work on the dynamical approach to relativity theory.

It is standardly believed that the generally time-reversal symmetric fundamental laws of physics themselves cannot explain the apparent asymmetry of time. In particular, it is believed that CP violation is of no help. In this paper, I want to push back against a quick dismissal of CP violation as a potential source for the arrow of time and argue that it should be taken more seriously for conceptualising time in physics. I first recall that CP violation is a key feature of our best physical theory which also has large-scale explanatory import regarding the matter-antimatter asymmetry of the universe. I then investigate how CP violation may help to explain the directionality of time. I argue that accounts that a Maudlin that posit an intrinsic fundamental direction of time are not convincing and instead propose to utilise recent results from work on the dynamical approach to relativity theory.
Realism Going Local: Stabilizing Quarks — Nurida Lena Boddenberg — University of Bonn, Bonn, Germany

AGPhil 3.1 Tue 17:30 JAN/0027

Feynman Diagrams providing understanding as Toy Models — Karl Weingarten — Munich Center for Mathematical Philosophy, LMU Munich

AGPhil 3.2 Tue 18:00 JAN/0027

On the Bell Notion of Beable: from Bohr to Primitive Ontology — Susanne Bachelard — Tilburg University, Tilburg, Netherlands

AGPhil 3.3 Tue 18:30 JAN/0027

Supervaluationism, Determinacy, and the Completeness of Quantum Mechanics — Samuel Fletcher and David Taylor — University of Minnesota, Twin Cities

AGPhil 4.1 Wed 11:00 JAN/0027

Classicality and Bell’s Theorem — Marton Gomódi and Carl Hofer — 1 Eötvös Loránd University, Budapest, Hungary — 2 University of Barcelona, Spain

AGPhil 4.2 Wed 11:30 JAN/0027

On the Bell Notion of Beable: from Bohr to Primitive Ontology — Federico Laudisa — Department of Humanities and Philosophy, University of Trento, Via Tommaso Gar 14, 38122, Trento (Italy)

AGPhil 4.3 Wed 12:00 JAN/0027

Working Group on Philosophy of Physics (AGPhil)

Time: Tuesday 17:30–19:00
Location: JAN/0027

Time: Wednesday 11:00–12:30
Location: JAN/0027

Nerlich (1982). While interest in the causal theory ebbed within philosophy, the core motivations behind the theory never really went away in physics. The work by Malament and Hawking on causal structure in relativity gave birth to an important research programme in physics, culminating in what is now known as causal set theory. To resolve the tension, we develop a new version of the causal theory of space-time. Whereas traditional versions of the theory sought to identify spatiotemporal relations with causal relations, the version we develop takes causal relations to be more fundamental than spatiotemporal relations. We argue that this non-identity theory, suitably developed, avoids the challenges facing the traditional identity theory and offers a natural interpretation of causal set theory.
and with different senses, often instrumental to supporting claims that in fact appear to be only partially consistent with a Bohrian view of quantum mechanics. Only later the notion of beable acquired the meaning in which it retrospect motivated the so-called primitive ontology approach. It will also be shown that in neither of the two readings the use of the notion of beable commits Bell to assume any form of naive "realism", especially with respect to the so-called "local realism" that, according to a widespread opinion, would be the alleged target of the Bell theorem.

AGPhil 5: Quantum Foundations 2

Time: Wednesday 14:00–15:30

Invited Talk

AGPhil 5.1 Wednesday 14:00 JAN/0027

Physical probability is relative frequency → SIMON SAUNDERS — University of Münster, Germany

Frequentism as a philosophy of probability is a perennial favourite among scientists, but for reasons I shall explain, has long been abandoned by philosophers of probability (physical probability, probability as something in nature). In particular, this consensus rests on the presupposition that there is only a single world. That assumption is challenged by the Everett interpretation of quantum mechanics, which is independently motivated. Understanding Everett's branches in terms of decoherence theory, there is a ready candidate for an ensemble even in the case of a single experiment: the equi-amplitude branches produced on any given trial. Relative frequency as a notion has several advantages, e.g. "having opposite spin to"; or, less well-known, it denotes a plural property of the micro objects, e.g. "having total spin 0" understood as a collective property of the micro objects. I argue that all three established proposals fail to properly fit with the structure of more general entangled states and develop a new proposal: An entangled state denotes what I call a "distributional property", establishing a specific kind of holism with a characteristic structure.

AGPhil 6: Quantum Foundations 3

Time: Wednesday 16:00–17:45

Invited Talk

AGPhil 6.1 Wednesday 16:00 JAN/0027

The structure of entangled properties: Distributional holism → PAUL NAGER — University of Münster, Germany

Which options does a wave function realist (GRW, Everett or other) have to understand entangled quantum states as referring to properties? Since entangled states cannot be reduced to the micro states, the denoted properties must be ontologically irreducible in some sense. There are three major proposals: Either an entangled state refers to an irreducible property of the macro object (as proposed by wave function monists), e.g. "having total spin 0"; or it refers to an irreducible relation between the micro objects (as proposed by some ontic structural realists), e.g. "having opposite spin to"; or, less well-known, it denotes a plural property of the micro objects, e.g. "having total spin 0" understood as a collective property of the micro objects. I argue that all three established proposals fail to properly fit with the structure of more general entangled states and develop a new proposal: An entangled state denotes what I call a "distributional property", establishing a specific kind of holism with a characteristic structure.

AGPhil 7: Members’ Assembly

Time: Wednesday 18:00–18:30

All members of the Working Group on Philosophy of Physics are invited to participate.
Invited Talk

AGPhil 8.1 Thu 11:00 JAN/0027
Interpreting Quantum Mechanics on an Informational Approach

• MICHAEL CUFFARO — Munich Center for Mathematical Philosophy, LMU Munich, Germany

The traditional metaphysical picture of the world takes observation-independent properties as primary and to be the origin of values of dynamical quantities revealed in experiments. It is naturally suggested by classical mechanics, since the classical state fixes the values of all such quantities in advance. Famously this is not true of the quantum state. Although Everett is the most natural interpretation of quantum mechanics given the traditional metaphysical picture, in this talk I defend an informational interpretation. What we preserve from classical mechanics is not the metaphysical picture it suggests, but the empiricist methodology through which one reasons, from the probability distributions over the values revealed in experiments, to a global picture of the world that is anchored in the contextual models one gives of phenomena under the dynamical assumptions characterising each of them. A priori, the question of how to conceive of reality is, on our approach, open; but the answer suggested by the novel kinaesthetic framework of quantum mechanics is that a description of the world that does not include a reference to the possibilities of observation is inadequate for physics. Since observers are represented schematically, our kinematical resolution of the measurement problem reveals the observation-independent structure of the world, but it is a mistake to interpret this structure in substantial terms.

Invited Talk

AGPhil 8.2 Thu 11:45 JAN/0027

Does science need intersubjectivity? The problem of confirmation in orthodox interpretations of quantum mechanics

• EMILY ADLAM — University of Western Ontario

Any successful interpretation of quantum mechanics must explain how our empirical evidence allows us to come to know about quantum mechanics. In this talk I will argue that this vital criterion is not met by the class of orthodox interpretations, which includes QBism, neo-Copenhagen interpretations, and some versions of relational quantum mechanics. I will take a detailed look at the way in which belief-updating might work in the kind of universe postulated by an orthodox interpretation, and argue that observers in such a universe are unable to escape their own perspective in order to learn about the structure of the set of perspectives that is supposed to make up reality according to these interpretations. I will also argue that in some versions of these interpretations it is not even possible to use one’s own relative frequencies for empirical confirmation.

AGPhil 8: Quantum Foundations 4

Time: Thursday 11:00–12:30
Location: JAN/0027

AGPhil 9.1 Thu 14:00 JAN/0027

Transcendental dimensions of epistemic networks in the foundations of quantum mechanics

• ALEX SEUTHE — TU Dortmund University, Dortmund, Germany

The tool of social network analysis has been translated into the history and philosophy of science as epistemic network analysis. According to Renn (cf. The evolution of knowledge, 2020), three dimensions can be assigned to these networks: the social, semiotic, and semantic. The social dimension encompasses social actors and structures, the semiotic dimension encompasses experiments, and representations. The semantic dimension encompasses cognitive structures, concepts, and mental models with two main aspects: 1) They gain meaning through their interpretation of experience and their relationships with one another. 2) They can only be inferred by the reconstructive analysis of social and physical representations. I want to discuss how this novel analysis strategy of epistemic complexes can be related to the philosophy of symbolic forms of Cassirer. This theoretical reflection can help to enrich the sole aggregation of empirical data, as it often can be seen in the social sciences, with theoretical and epistemological meaning. 1) I want to outline how Cassirer’s functional concept formation is similar to Renn’s understanding of networks of semantic structures. 2) According to Cassirer, the basic forms of thinking manifest themselves in the social and semantic expressions of culture. I will utilise studies about the foundations of quantum mechanics as a case study to develop and illustrate my arguments.

AGPhil 9.2 Thu 14:30 JAN/0027

Heterodox underdetermination: metaphysical options for discernibility and (non-)entanglement

• MARLEN BRAUTIGAM — University of Cologne

There are largely three views on whether Leibniz’s Principle of the Identity of Indiscernibles (PII) is violated by similar particles. According to the earliest view, PII is always violated (call this the no discernibility view). According to the more recent weak discernibility view, PII is valid in a weak sense. No and weak discernibility have been referred to as orthodoxy. Steven French has argued that although PII is violated, similar particles still can be regarded as individuals. However, as it is equally possible to regard them as non-individuals, French famously concluded that metaphysics is underdetermined by physics. Call this thesis orthodox underdetermination. Most recently, some authors have turned against orthodoxy by arguing that PII is valid in more than a weak sense. Call this the new discernibility view, also referred to as heterodoxy. As heterodoxy is backed up by physical considerations, metaphysics now seems to be determined by physics: physics indicates that PII is valid. In this talk, I argue that, despite appearances, heterodox metaphysics is just as underdetermined by the physics as orthodox metaphysics; in other words, I argue for heterodox underdetermination. Heterodox underdetermination is problematic because it leaves us with the choice between two crucially different understandings of entanglement, thereby preventing us from getting a clear metaphysical picture of this peculiar phenomenon.

AGPhil 9: Quantum Foundations 5

Time: Thursday 14:00–16:00
Location: JAN/0027

AGPhil 9.3 Thu 15:00 JAN/0027

Perspectival Objectivity in Relational Quantum Mechanics

• NOEMI BOLONNETTI and •LUCA GASPARINETTI — University of Italian Switzerland, Lugano, Switzerland

What if everything in the world we are living in could be defined only relative to something else? What if different observers might give different accounts of the same sequence of events? According to the relational interpretation of quantum mechanics (RQM) proposed by Carlo Rovelli (e.g., 1996), there is no “absolute”, i.e., observer-independent, description of reality. On the contrary, as well as the notion of simultaneity in special relativity, values and states of quantum systems are always defined via a given perspective. Does this mean that RQM cannot be in any way objective? Very roughly speaking, objectivity can be established only when different observers ascribe their descriptions to their different perspectives. But what can be said to further articulate this rough sketch?

Based on recent development on this topic (Emilly Adlam and Carlo Rovelli 2022), the aim of this talk is twofold: we (i) take into account Evans’ notion of “intersubjective objectivity” (Peter W. Evans 2020) to better understand in which sense it is possible to recover objectivity in relational quantum mechanics and (ii) explore how perspectival objectivity can provide a philosophical foundation for RQM. Along with Evans, we conclude that we should “stop worrying and love observer-dependent reality” also in the context of relational quantum mechanics.

AGPhil 9.4 Thu 15:30 JAN/0027

The Foundations of the Measurement Problem

• DIANA TASCETTO1 and •RICARDO CORREA DA SILVA2 — 1Philosophy Department, University of São Paulo — 2Department of Mathematics, University of Erlangen-Nuremberg

The measurement problem is the most intensely investigated issue at the foundations of the quantum theory. Since what counts as a solution depends on how the problem is defined, a historical investigation of the development that has conditioned the standard formulation of the problem is most needful as a test of its adequacy. Quantum Mechanics is unique in the history of science in that it resulted from the axiomatized merging of two rival—yet putatively equivalent—theories, namely Matrix Mechanics and Wave Mechanics. In this talk, we shall present a new, detailed mathematical and conceptual analysis of the structures of Matrix and Wave Mechanics. It will follow that the measurement problem is a logical consequence of constructing Quantum Mechanics over a fabricated—and therefore fictitious—equivalence. Matrix and Wave Mechanics are not equivalent quantum theories, but their structures are related, in a way we shall demonstrate. The physical relevance of this relation, stated in exact mathematical terms, is that it gives us new insight into the nature of the measurement problem, enabling us to state it in a different, more general setting than it has been done heretofore, opening new paths in our search for solutions.
The problems of the classical approximation include the failure to be a limit in any proper sense and to necessarily neglect important effects of quantum composition. Moreover, it does not fully include other parameters necessary to wholly retrieve classical mechanics. The problems of the classical idealization include implausible convergences, the danger of divergences, the failure to tackle $\hbar$-independent quantum phenomena as well as the failure to apply to all required equations. Consequently, although the investigation of the $\hbar$-limit bears great insight into the quantum-classical relation, neither of its senses fully instantiates it.

Measuring up to the measurement problem: Decoherence and Bohr's ideas through the lens of the measurement problem and quantum erasers — Emilia Kaebersam Tellecós — University of Copenhagen

In this thesis, interpretations of the formalism of quantum mechanics are investigated in terms of their address to the classic measurement problem as well as the more modern quantum erasers. The main focus is on the interpretational insight provided by Niels Bohr and the concept of decoherence, but with an overview of other important interpretations as well. The measurement problem is described and strategies for its solution is divided into two main categories: solutions and dissolutions, which are associated with collapse and no-collapse interpretations respectively. Decoherence is found to require an interpretational basis in order to properly address the measurement problem, while Bohr's interpretation has some unresolved points, mainly relating to the understanding of Bohr's notion of context, which is central to his idea of quantum mechanics. By comparing Bohr's ideas and decoherence, I argue that each can be of use to the other; decoherence can formalise some of Bohr's concepts, while Bohr's ideas provides a constructive interpretational basis for decoherence. Lastly, I argue that quantum erasers provide a ground for discussions on interpretational questions, as the insight into the nature of quantum mechanics challenges several aspects of the aforementioned different interpretations, the understanding of the Bohrian context among them.


Current quantum mechanics is represented by the Schrödinger equation. This algorithm allows to calculate states of a particle system's kinetic energy. The concept stems from classical mechanics. It is the space integral of the concept of force. Accordingly the Schrödinger equation, as it considers energy states only (indifferently whether time dependent or not), does not consider the time required to generate an energy state, and also not the time that may separate different energy states at different places in space from each other. Therefore all possible energy states in space apparently seem to exist at the same time. As a consequence it may seem that a moving system, or particle, could even arrive at different places in space at the same time, or instantaneously, that is, without consuming time. It was realized already by Galileo and Newton that this result evidently contradicts natural experience, according to which nothing happens but in time. Therefore, the mystical and weird instantaneous effects appearing in quantum mechanics are not the features of a specific microphysical reality but only result from ignorance as to the genesis and mathematical content of the Schrödinger equation.

There is a great amount of research data accumulating by space exploration on the topics of impacts, symmetries, habitable zone, chemical syntheses, atmosphere, climate and geology. The related facts, sayings and relations need to be evaluated by a theory of decision based on strategies of cooperation. A logic of quantum space science and technology is being, therefore, continuously articulated and innovated though focusing on efficiency, computability, polyvalence, feedback control etc.

When and why did physicists start bashing philosophy? — Alexander Unzicker — Pestalozzi-Gymnasium München

While in the first half of the 20th century physics was an integral part of philosophy, after World War II the latter became more and more an unwelcome appendix. The evolution of this role of philosophy is discussed with some key examples. Obviously, the different research traditions in Europe and America also contributed to this shift in significance.

Impacts, symmetries and decisions — Basil Evangelidis — Eschwege, Germany
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