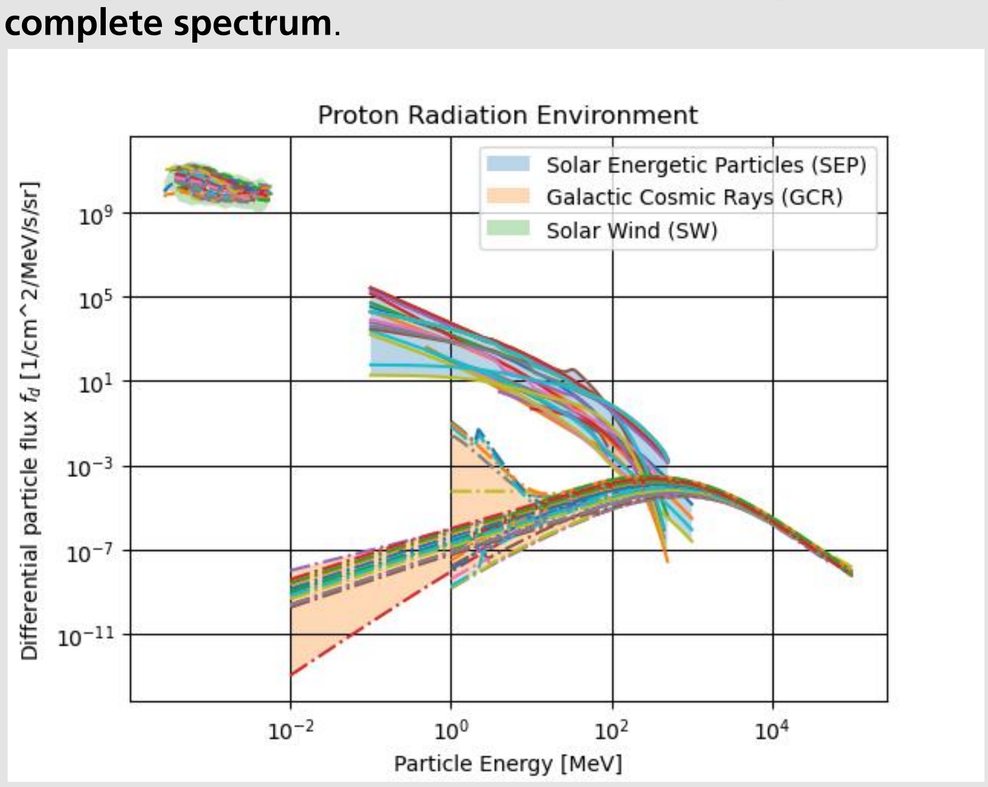
Development of In-Situ Measuring Techniques and Synergetic Radiation of Materials for Space Application – An Introduction.

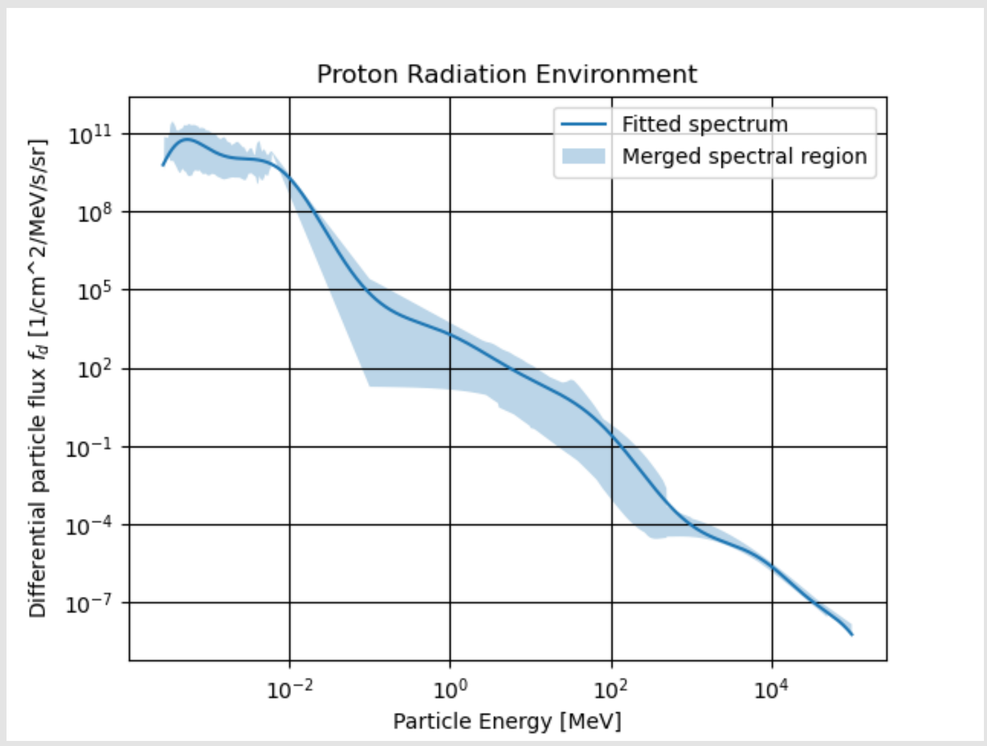
Humans try to reach further into interplanetary space. This makes the development of **novel technologies and materials** necessary to further **support life** outside of Earth's magnetosphere. At the Centre for Materials and Processes (MAPEX) Bremen, new materials to **shield, sense and possibly harvest space radiation** are developed, simulated and tested by three doctoral projects respectively. The latter, the here introduced project which includes the **testing**, will be conducted at and builds up on the already existing **Complex Irradiation Facility** (CIF) at DLR's Institute of Space Systems (IRS).
The work aims for the validation of the developed materials through testing under simulated space radiation environment since the actual environment is rarely directly accessible during a technical development phase. For this purpose, it is intended to **simultaneously** use different **corpuscular and electromagnetic radiation sources** of the CIF.

Thus, as initial step, it is of high interest to **characterize the interplanetary radiation environment** and that of possible human exploration missions, e. g. to Mars. The radiation environment for various scenarios can be accessed via a full variety of available models and measurements of the particle flux published and taken during the previous decades. Yet, these usually **only cover a certain energetic range and aggregate particles from only one source**, e.g. Galactic Cosmic Rays (GCR), which are particles coming from outside the solar system. Gathering these models, patching them together and eventually fitting these, results in an **complete spectrum**.



The three main radiation sources: SEP and SW, emitted from the sun, and GCR emerging from outside the solar system. Each line plot represents another model.

Adding, connecting, and interpolating.

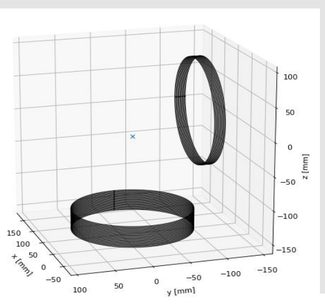


After connecting, appropriate weighting and eventually interpolating the merged radiation models, one joint spectrum can be found.

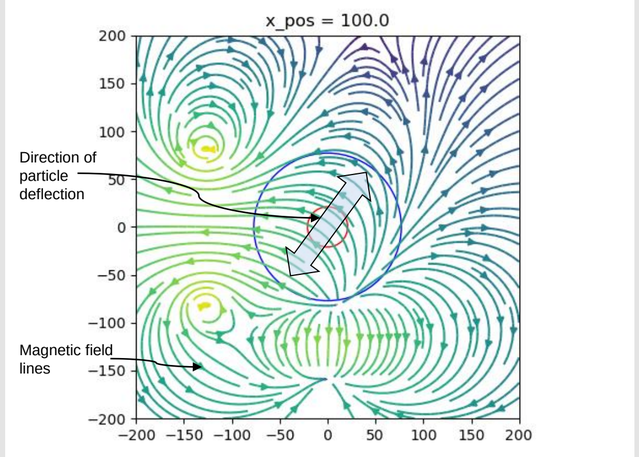
Outlook on succeeding work packages of this doctoral project

Simulation of the CIF

The Complex Irradiation Facility is to be simulated not only as whole but also individual parts such as used electromagnets, capacitors and passive elements.



Solenoid arrangement of the high-energy steerers of the CIF



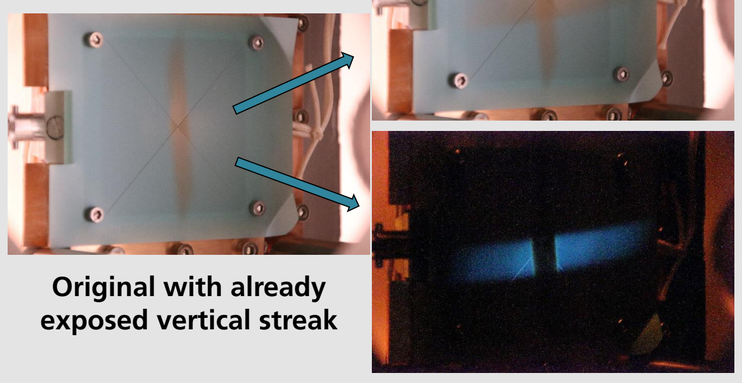
Simulated magnetic field lines at high-energy steerer of CIF

Beam Profile Visualisation

To reduce adjustment times of the particles beams, it is of high interest to quickly image beam shape and position. Therefore new approaches for the visualisation of the particles beams are explored.
First trials gave promising results, but will have to be improved in order to be sufficient for long-term operationality inside the CIF.

Beam profile visualisation

Additional traditionally exposed horizontal streak



Original with already exposed vertical streak

Using luminescent properties to make the same streak visible

Further Work Packages

- **New In-Situ measuring techniques** of material properties are to be explored. This is to minimize the possible influence of the atmosphere on the samples after exposure to radiation.
- **Full Synergetic Radiation**, not only of electromagnetic and one corpuscular source, but also from both, electrons and protons simultaneously, shall be implemented by employing knowledge gained from the simulation of the CIF.
- **Irradiation Testing** will take place once prototypes of the novel materials have been manufactured. These are than to be tested for their shielding, sensing and harvesting capabilities.
- **Post-processing** of the irradiation tests includes among others proof of functionality of the novel materials, comparison of expected and measured behaviour, possibly extending the measured results towards higher particle energies. Further e.g. the long-term performance of newly implemented techniques shall be accessed.

Erik M. Klein, University of Bremen and DLR, Institute of Space Systems
erik.klein@uni-bremen.de

Deutsches Zentrum für Luft- und Raumfahrt
MAPEX Bremen Material. Process. Excellence.
University of Bremen