LASER OPTICAL TRACKING TECHNOLOGY FOR SPACE DEBRIS MONITORING

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German Aerospace Center (DLR)

Approx. 8000 employees across
33 institutes and facilities at 20 sites.

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Bundesministerium
für Wirtschaft
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aufgrund eines Beschlusses
des Deutschen Bundestages

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DLR Institute of Technical Physics – Sites & Topics

CBE Standoff Detection

Space Debris

Air Data

High-power cw lasers

Overview of talk

Motivation

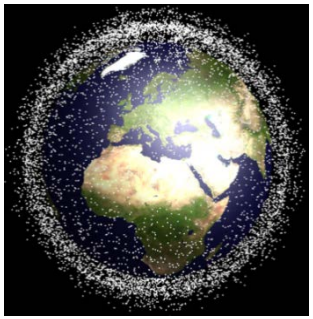
Laser tracking: procedure & results

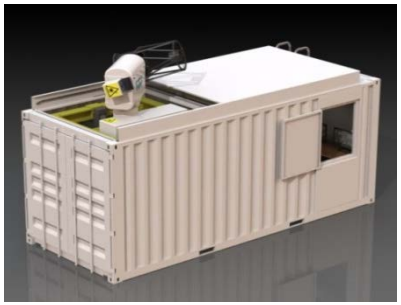
SLR ground station / containerized system

Performance modelling of small station network

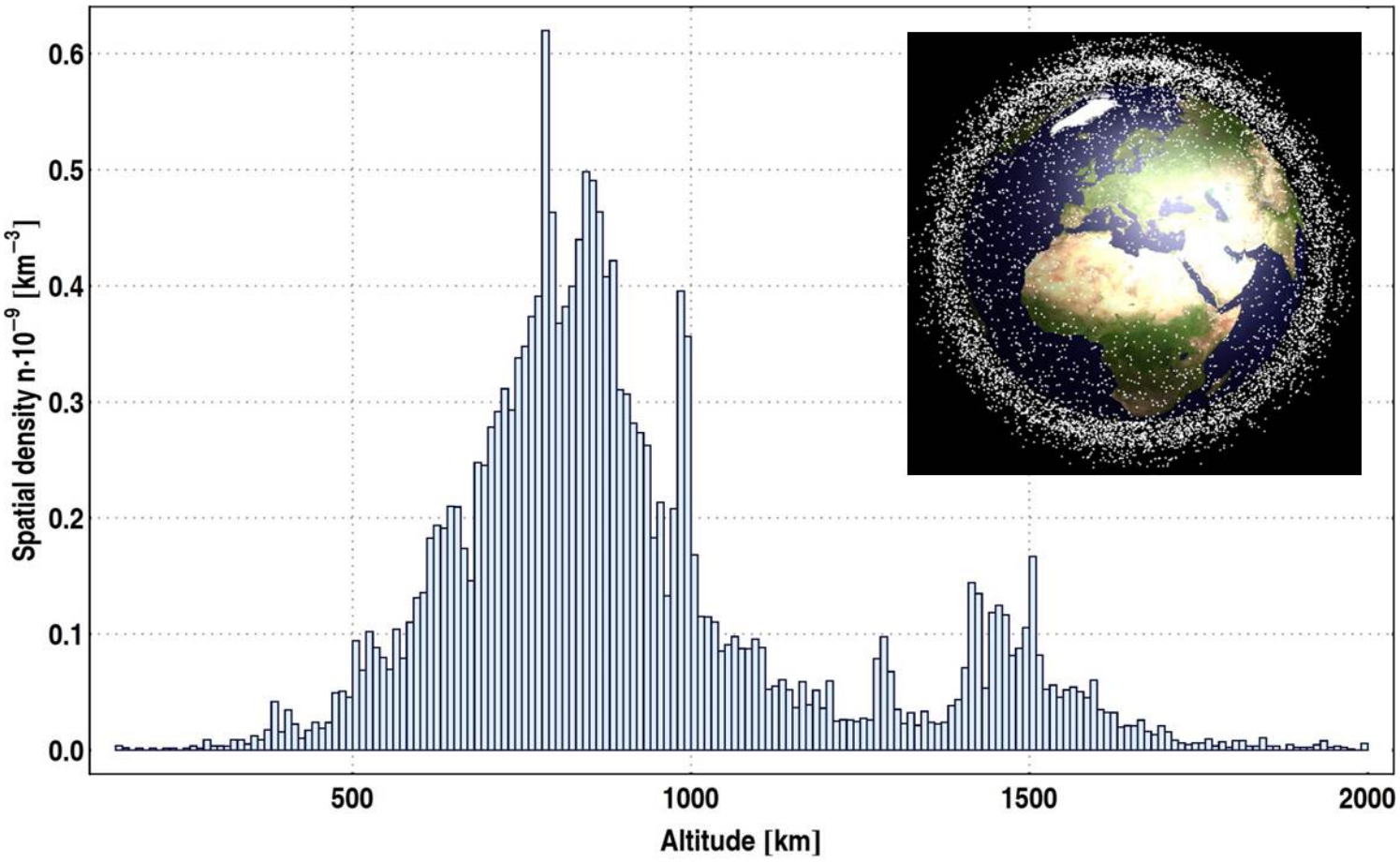
Use cases

Summary / outlook





Radial distribution of spatial density of LEO objects



Data from: http://celestrak.com, 04 / 2016

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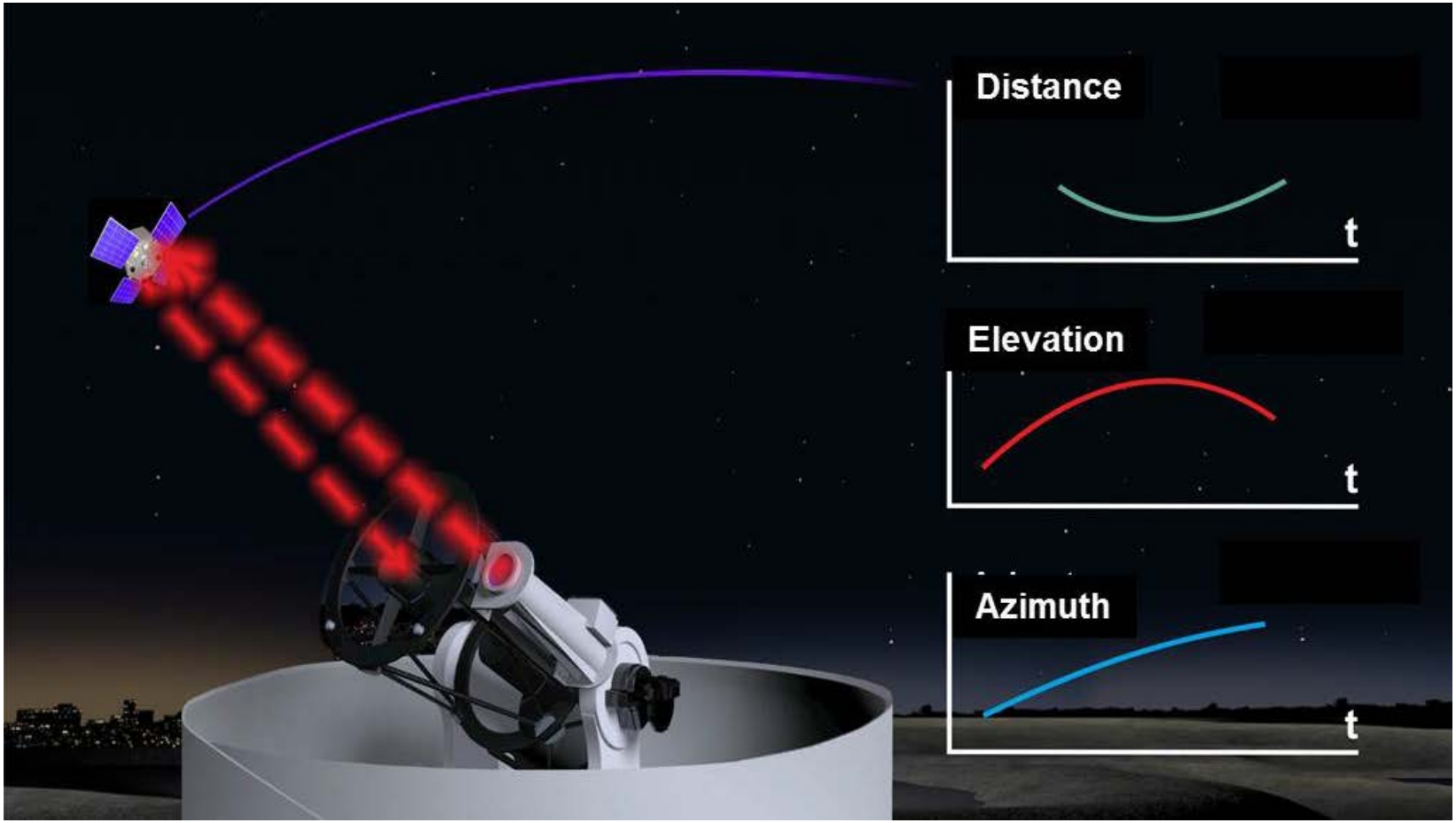
Scheme of three dimensional trajectory assessment of LEO orbital objects



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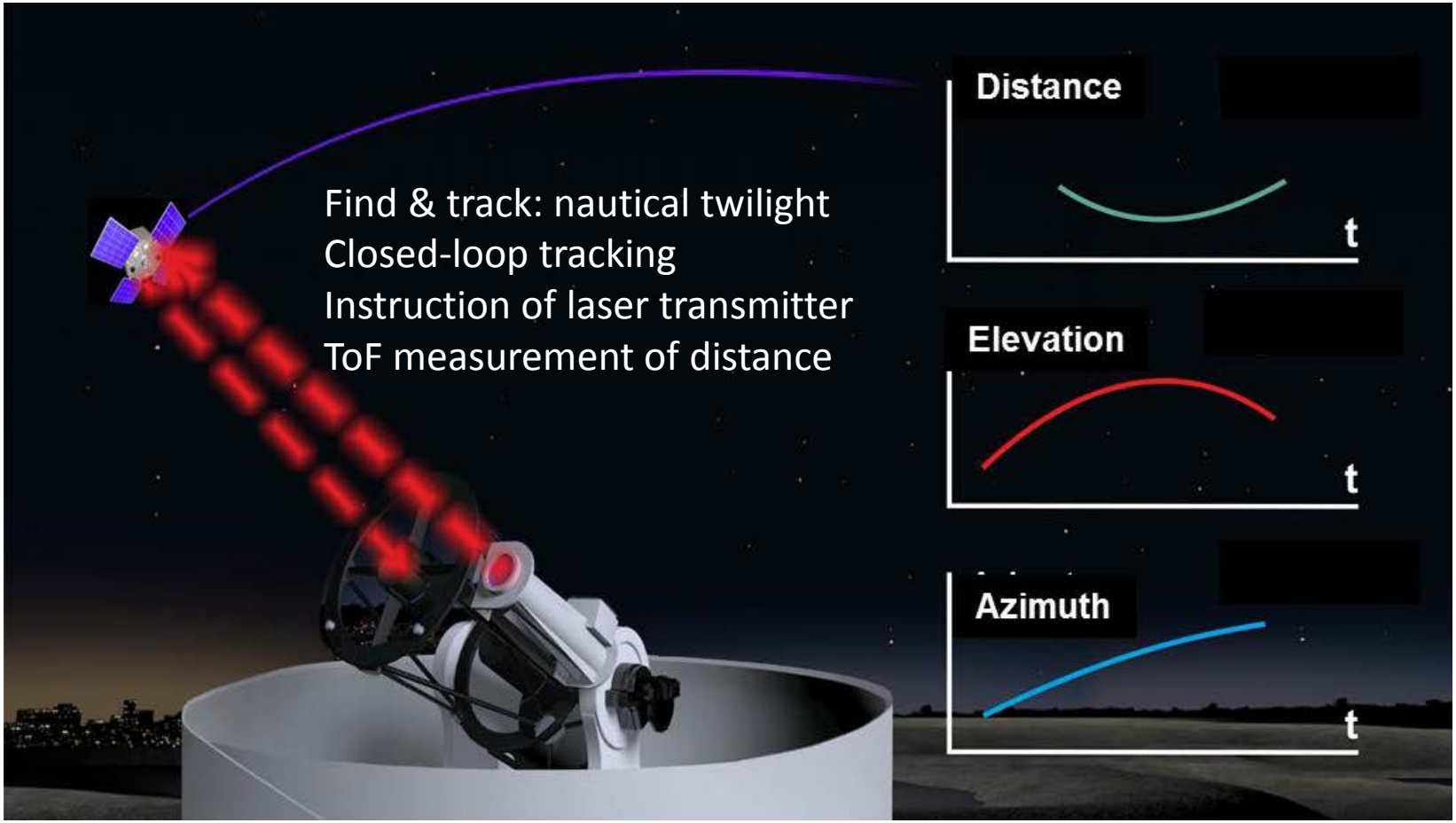
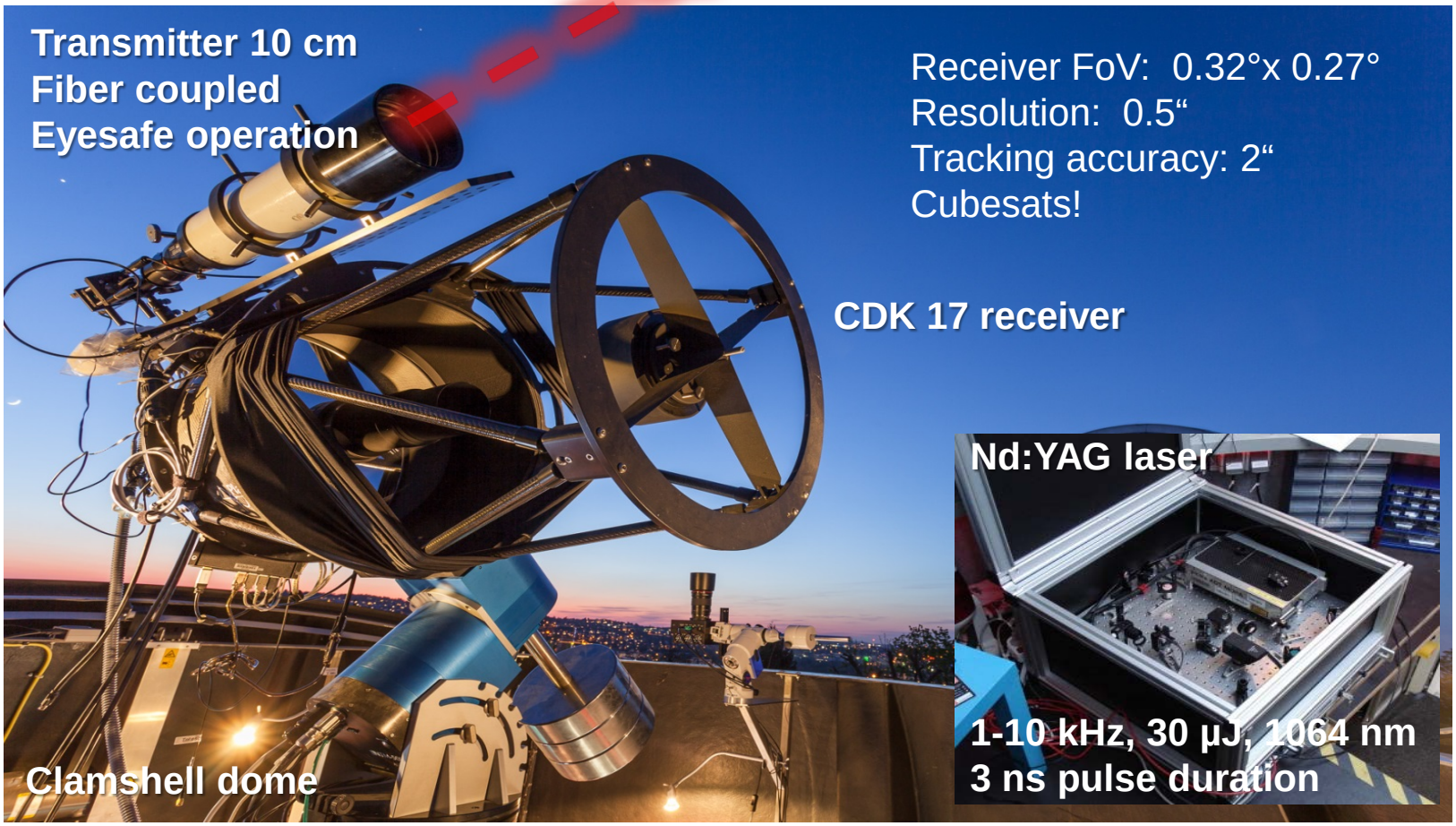


DLR tracking and laser ranging observatory: Technology testbed / engineering station (ILRS)



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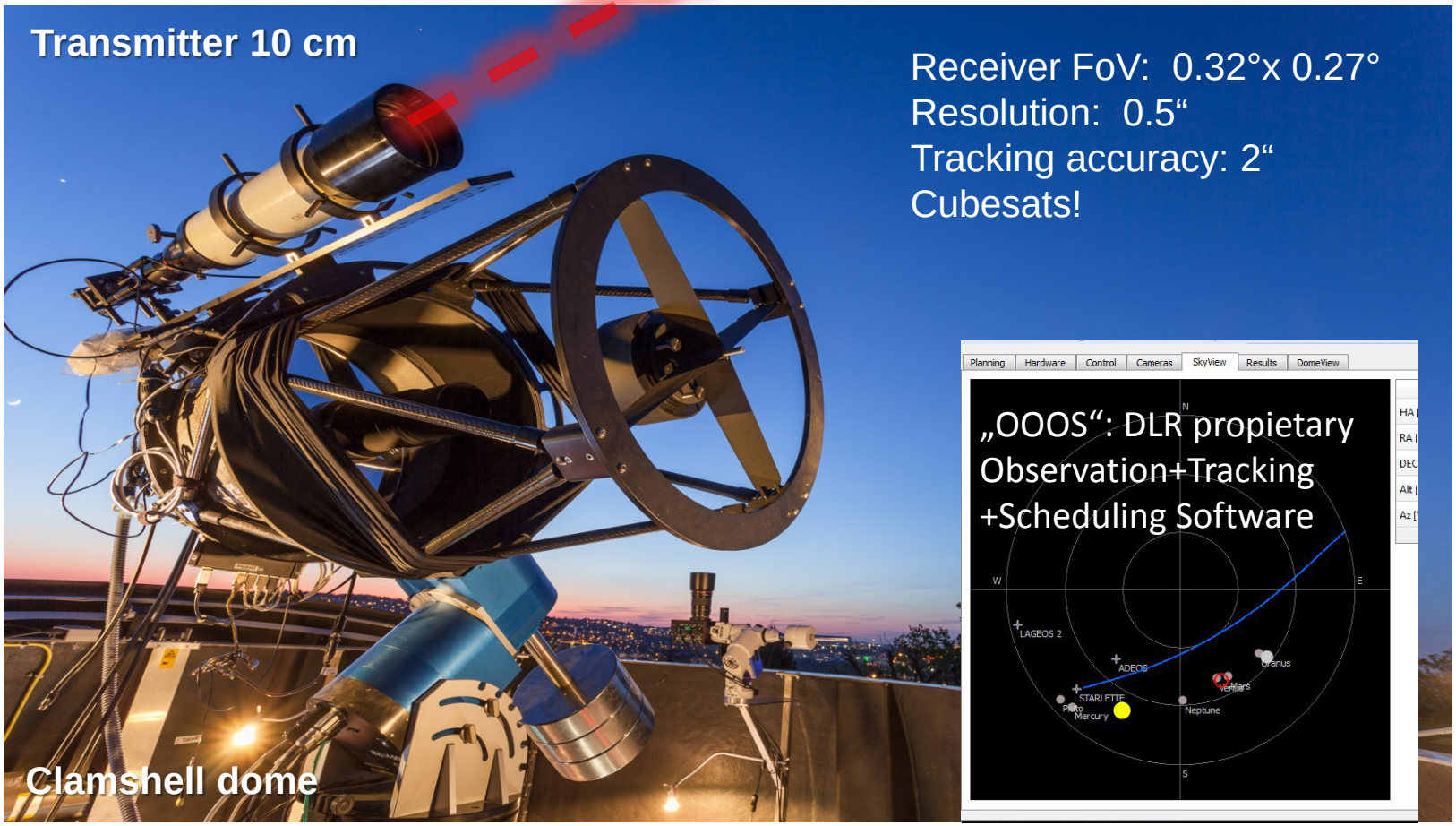
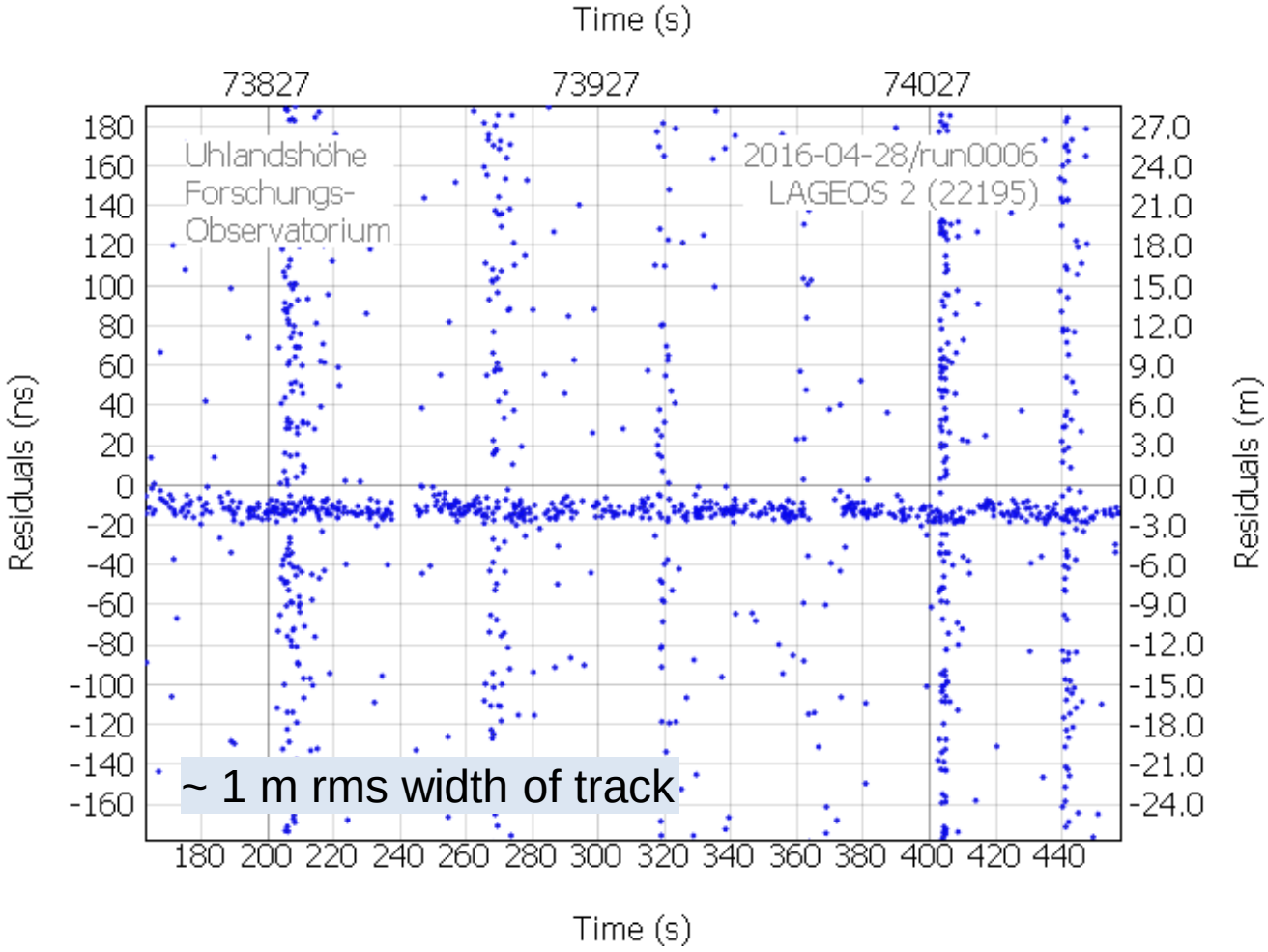


SLR reference measurements of geodetic satellites

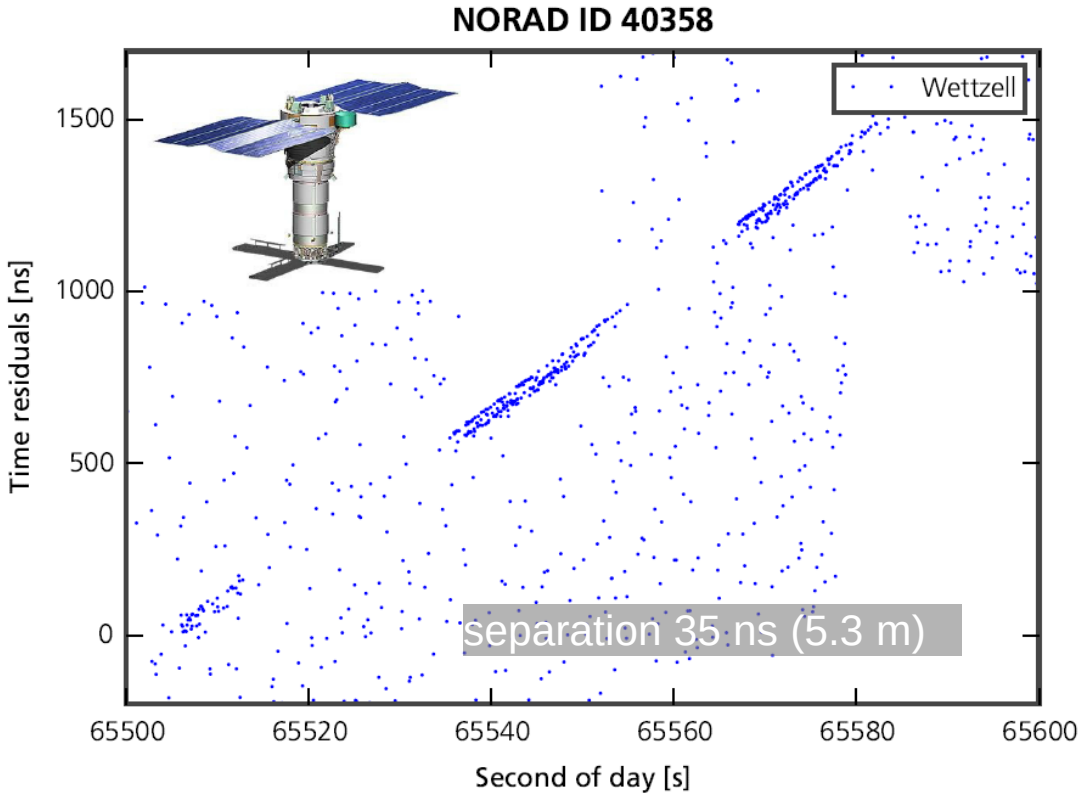


LAGEOS 2

MEO object
0.6 m diameter
426 retroreflectors

Upgrade of satellite laser ranging station
ESA project - space debris laser ranging

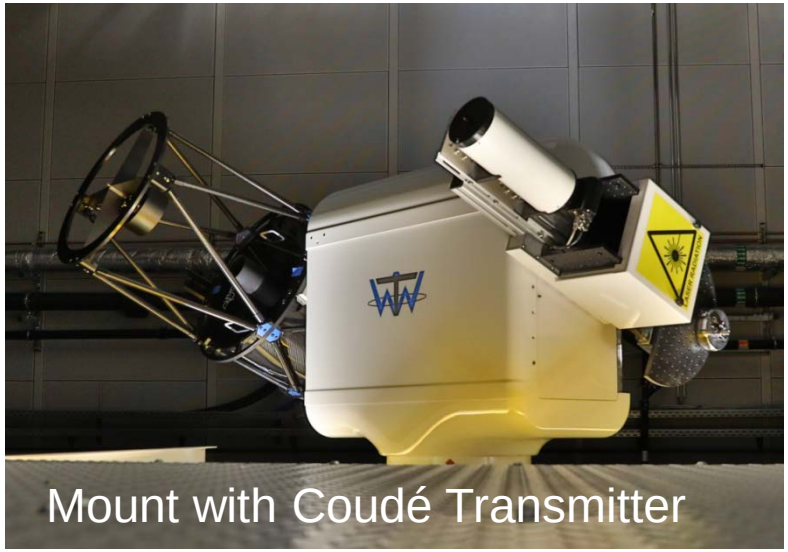
Wettzell SLR station
0.75 m transmitter/receiver
„Space debris laser“ specs:
20 Hz, 200 mJ, 1064 nm, 3 ns
Beam coupled in Coudé path



Laser ranging data can provide information about **structure** and **dimension** of objects

Containerized laser ranging system

Field evaluation (@ DWD*)

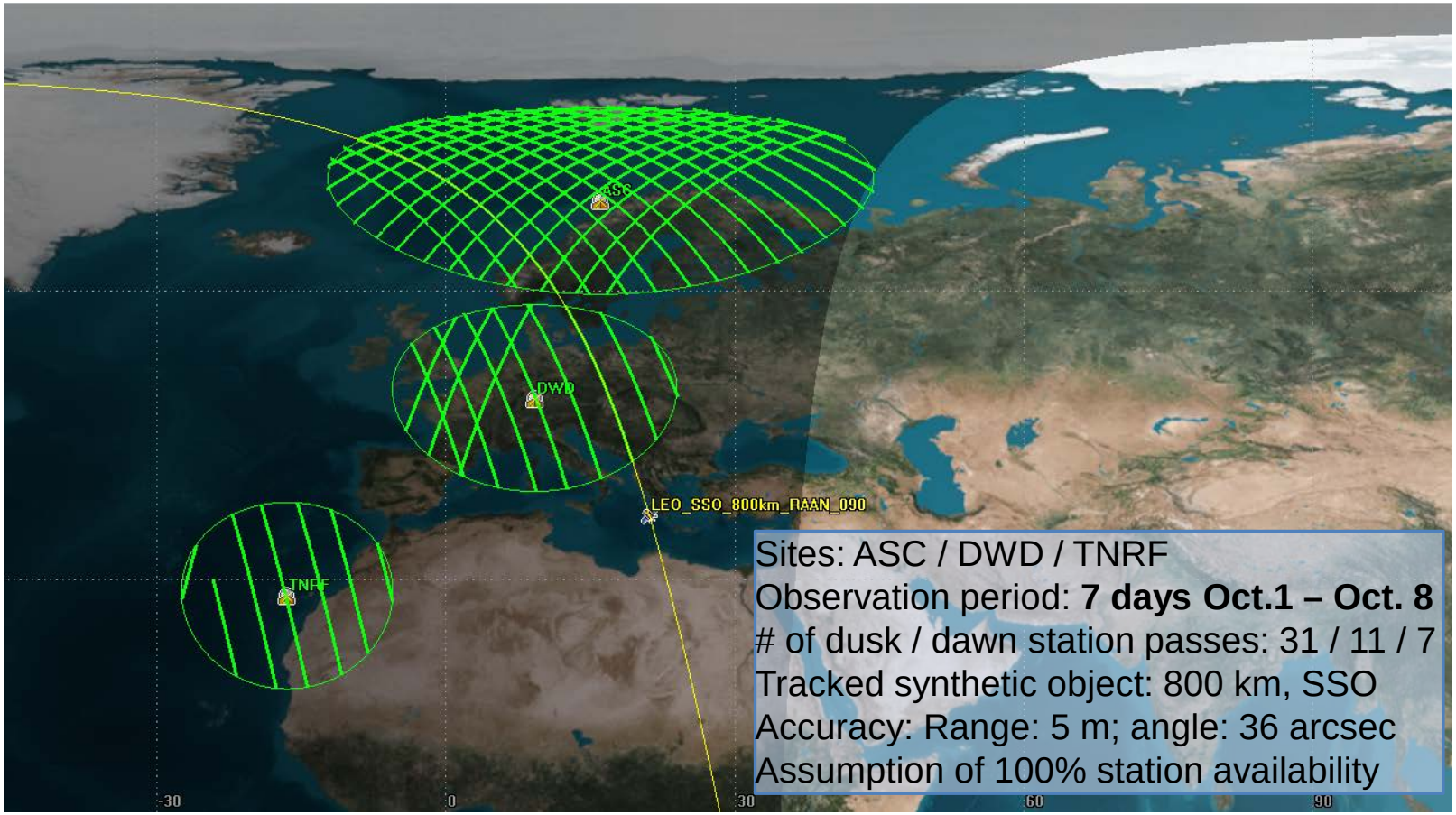

Mount with Coudé Transmitter

Characteristics

- Robust 20 ft ISO container, total weight of 10.5 t, easy shipping (truck/train)
- Heavy duty frame for raising and lowering a platform
- Short (2 m long) Coudé path with > 30 mm free aperture
- “High” energy Nd:YAG laser (50 mJ), 20 W average power, 5 ns pulses
- Full operation expected in 2018

* German Weather Service, Stuttgart

Initial performance modelling of small station network



Sites: ASC / DWD / TNRF
Observation period: **7 days Oct.1 – Oct. 8**
# of dusk / dawn station passes: 31 / 11 / 7
Tracked synthetic object: 800 km, SSO
Accuracy: Range: 5 m; angle: 36 arcsec
Assumption of 100% station availability

Station passes with observable tracks of LEO object

(Passes over the stations with elevations >30 deg are shown as green lines)

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Observable station passes of LEO object

station passes: 31

station passes: 11

station passes: 7

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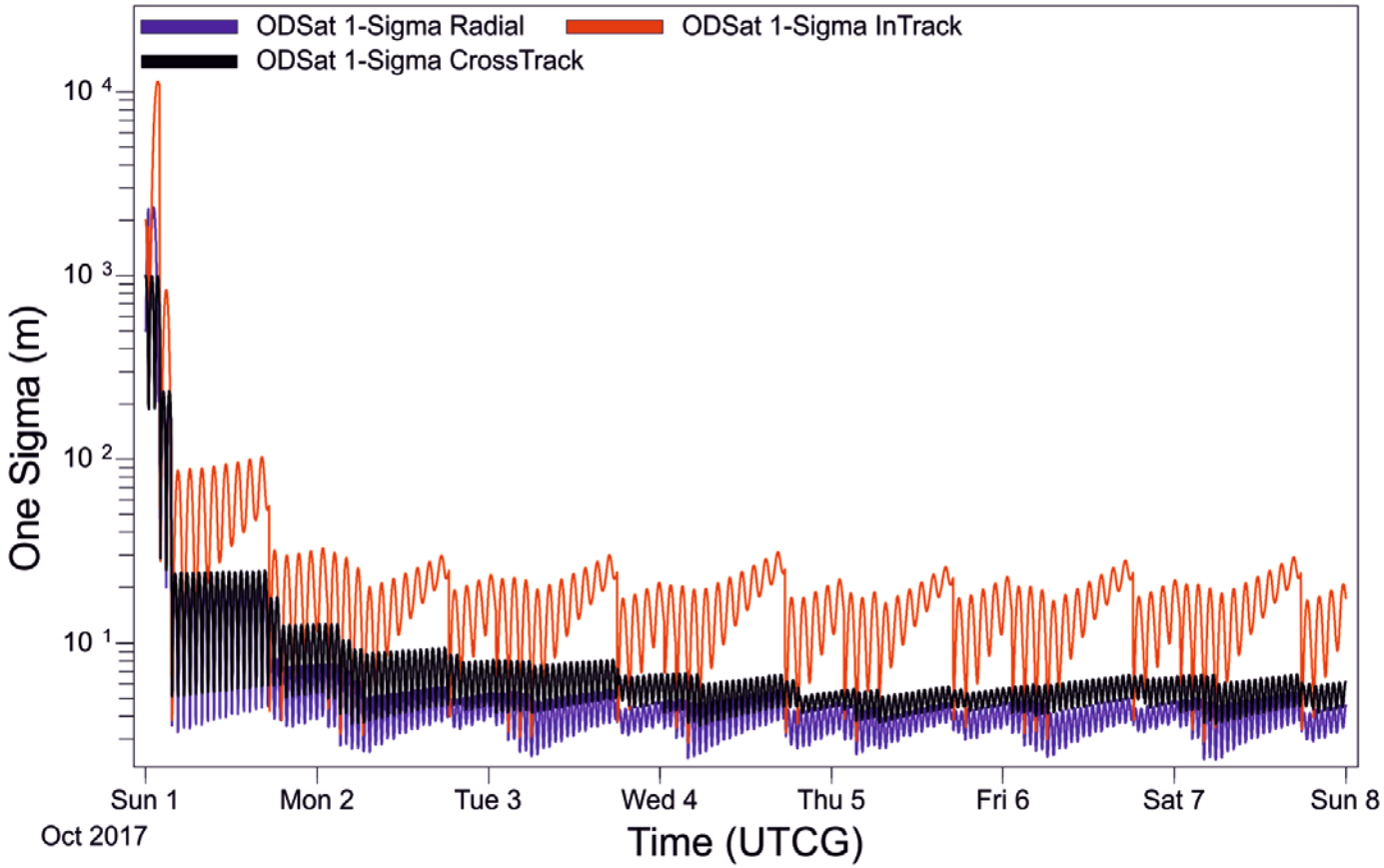
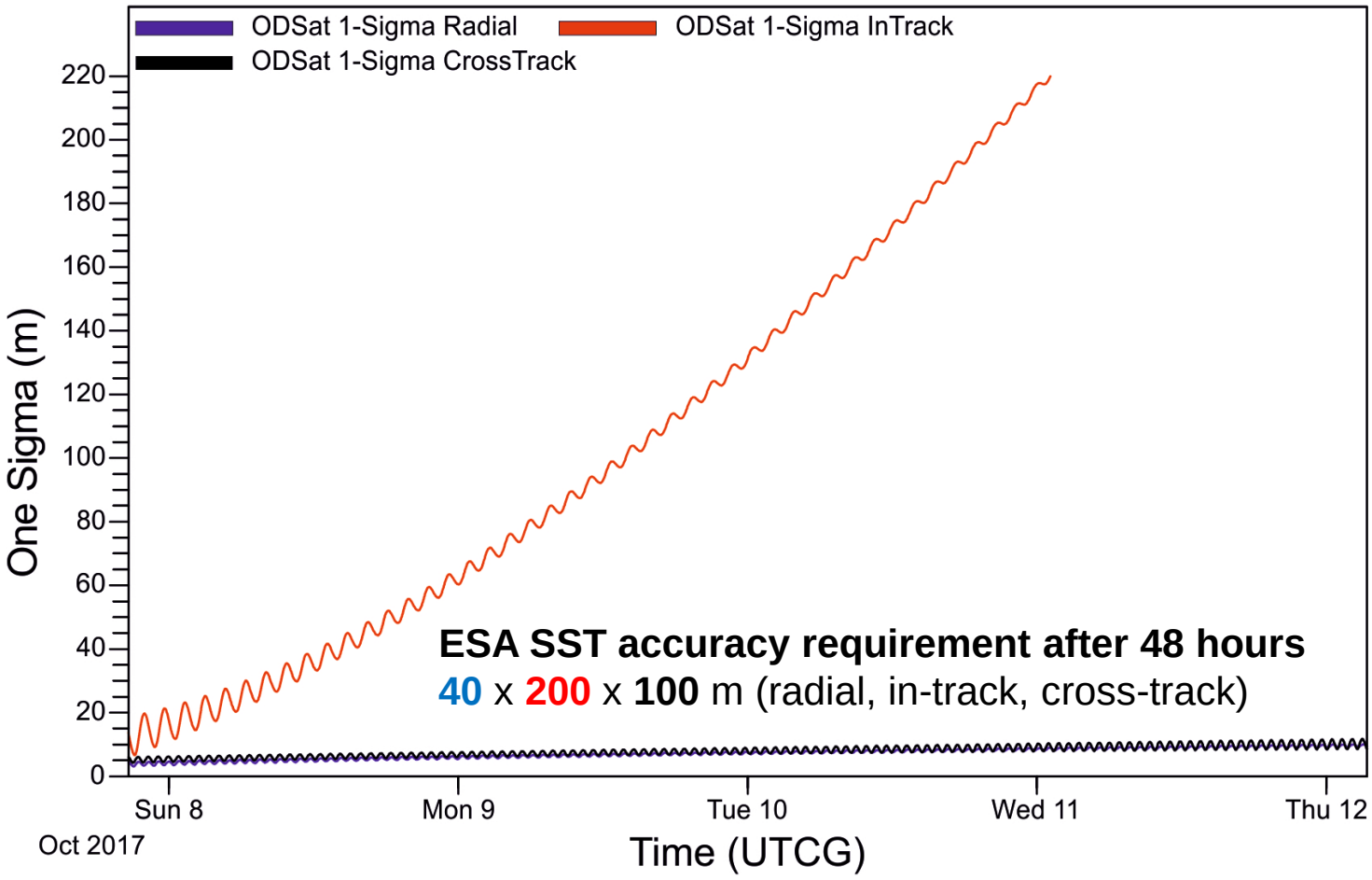
Position uncertainty during observation period

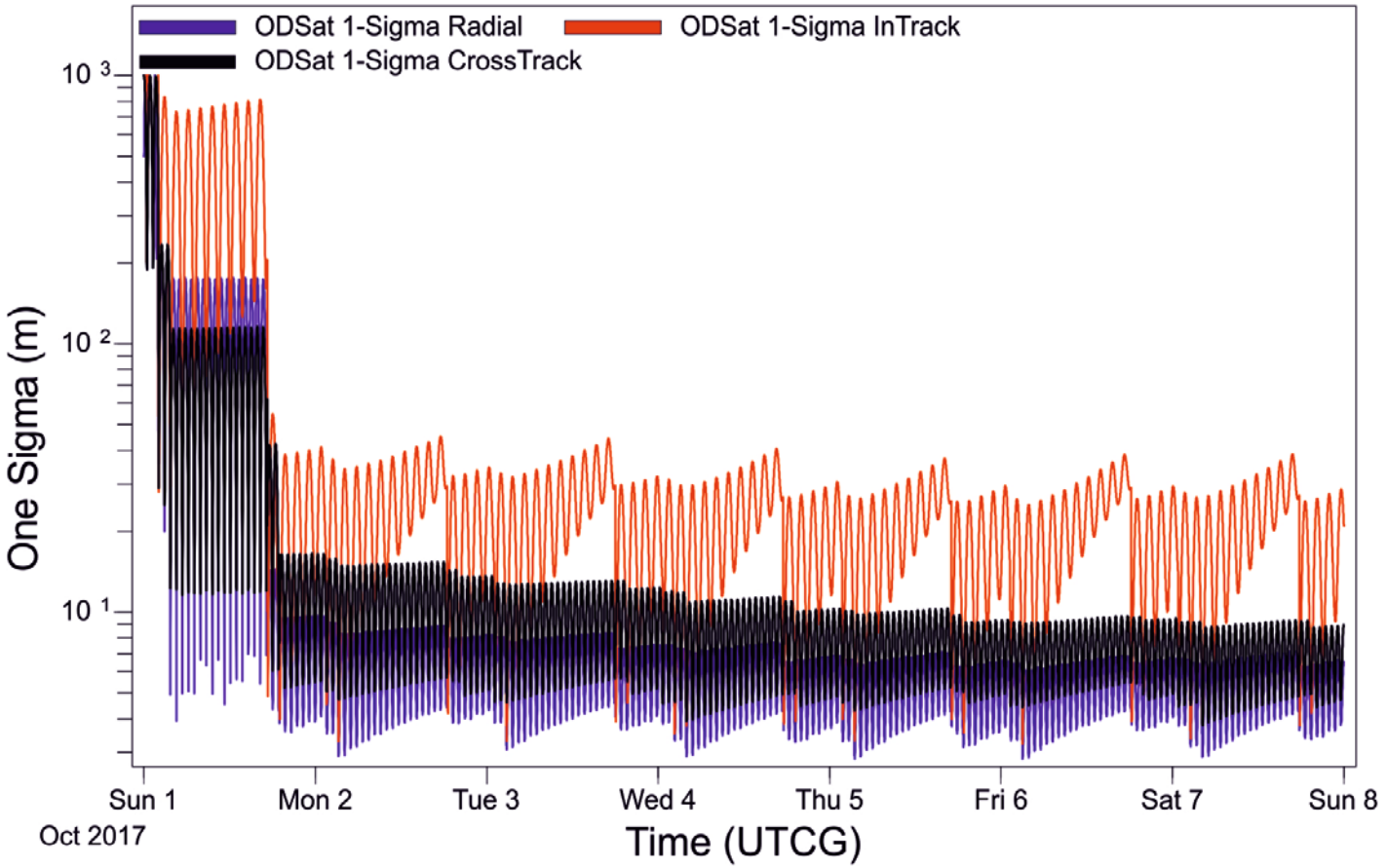


Contributing observations by ASC, DWD, TNRF

Propagation - absence of measurements



Position uncertainty during observation period



Contributing observations by ASC

Addressable use cases by laser optical tracking

Maintenance of a space object catalog

Initial analysis with small local station network
Network of laser optical tracking stations is mandatory

On-demand mission support

Inherent high accuracy achievable by laser ranging is the key factor
Network of laser optical tracking stations is mandatory

Stare and laser chase for uncatalogued objects

Uncued detection of objects
Handover to laser optical tracking telescope for range measurements
Precise orbit determination (measurements from current / subsequent passes

Summary and outlook

- DLR is developing and operating laser optical tracking sensors
  - Cooperative objects: SLR station operational
  - Containerized, transportable system for space debris monitoring functional in 2018

- Laser optical tracking sensors complement radar sensors for LEO

- Availability restrictions (weather/visibility...) can be circumvented by operation in a distributed sensor network

- Initial performance modelling (using ODTK) of a small station network promising

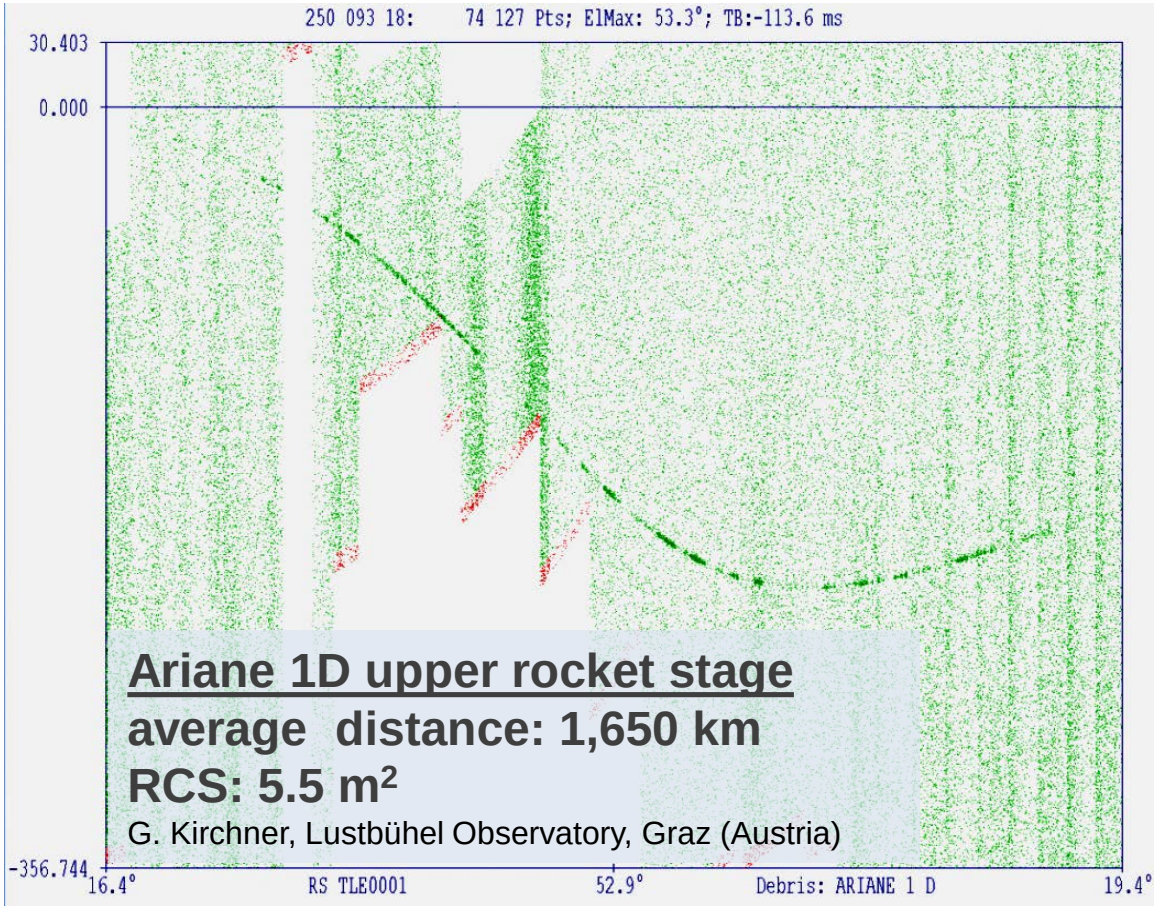
- Extension of modelling to extended station network

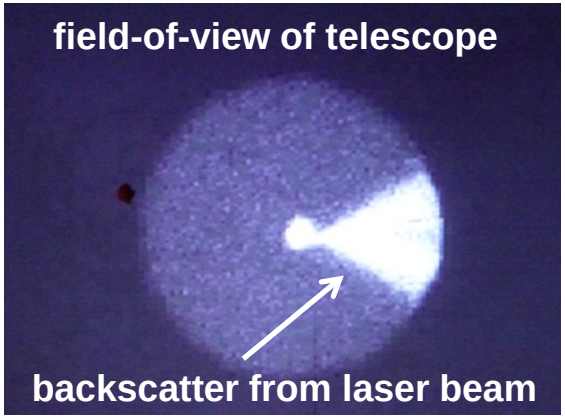
Thank you for your attention

Questions?

View from our observatory site of downtown Stuttgart

Laser ranging of space debris with Graz SLR station
First succesful demonstration in Europe





- 150 tracked station passages
- 59 different objects
- 600 km ≤ r ≤ 3,300 km
- RCS: 0.2 m^2 – 19 m^2
- avr. accuracy (rms): 0.8 m
- **laser source:**

  532 nm, 200 mJ, 100 Hz, 3 ns

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