Orbital Debris Laser Ranging Station Stuttgart

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DLR Institute of Technical Physics

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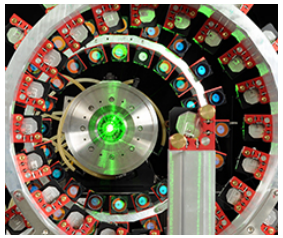
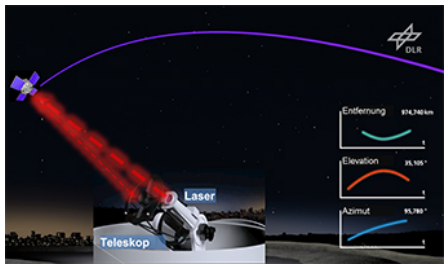
- Long tradition in development and application of lasers
  - Development of disk lasers
  - Standoff detection of dangerous materials
  - Laser-powered micro drives for satellites
  - Damage tests and qualification for space optics
  - …



- New application idea (~2010):
  - Observation and removal of space debris



- But: No experience in satellite tracking / laser ranging

Orbital debris research station @ Uhlandshöhe

- Main goal:
  - Gain experience with satellite laser ranging

- 2013: First light (passive)
- 2014: Satellite tracking and astrometry
- 2015: First ranging to terrestrial targets
- 2016: Satellite laser ranging

Orbital debris research station @ Uhlandshöhe

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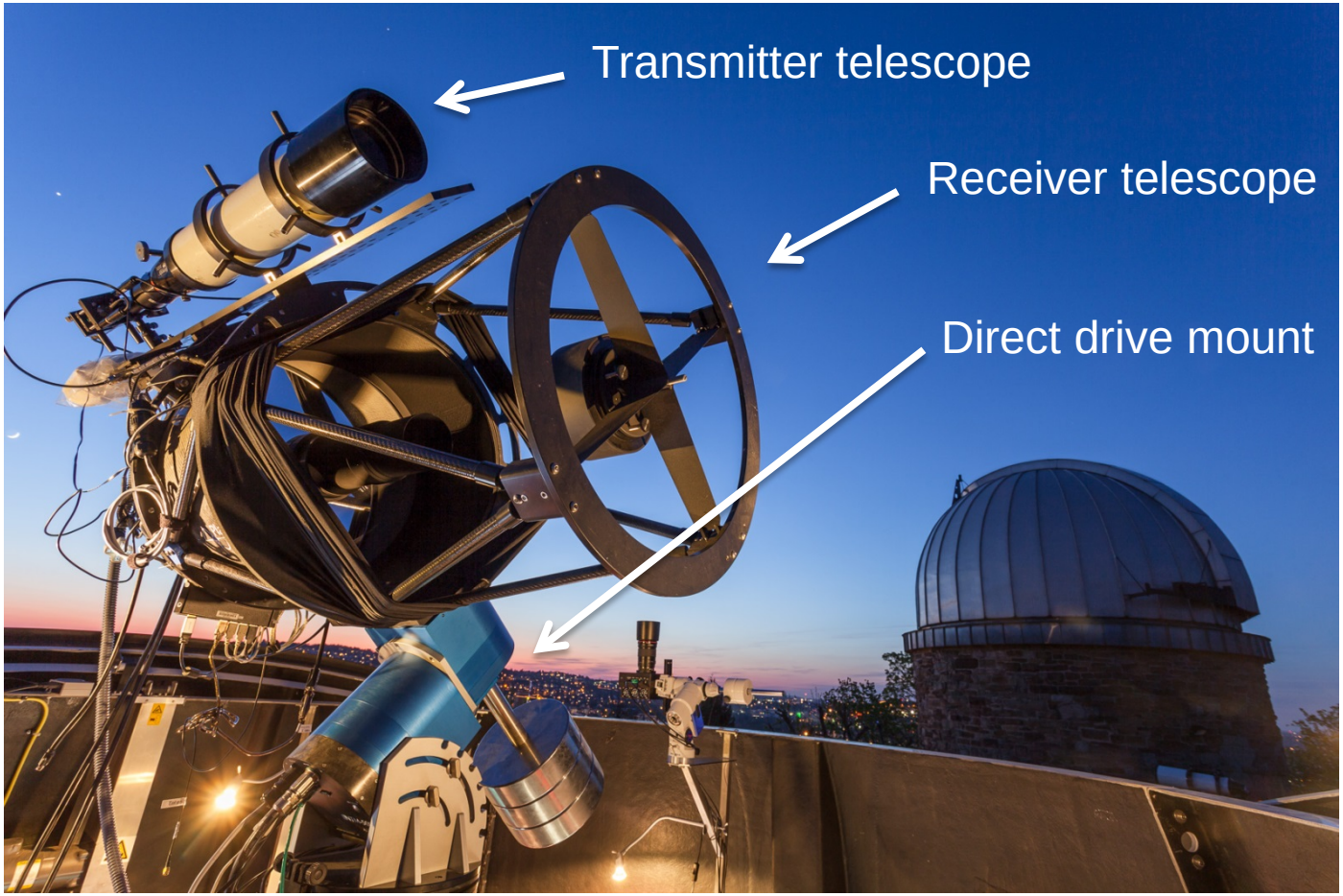
The telescope



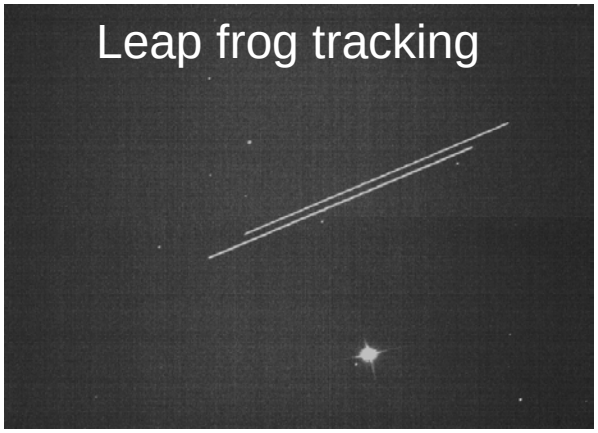
Hardware design

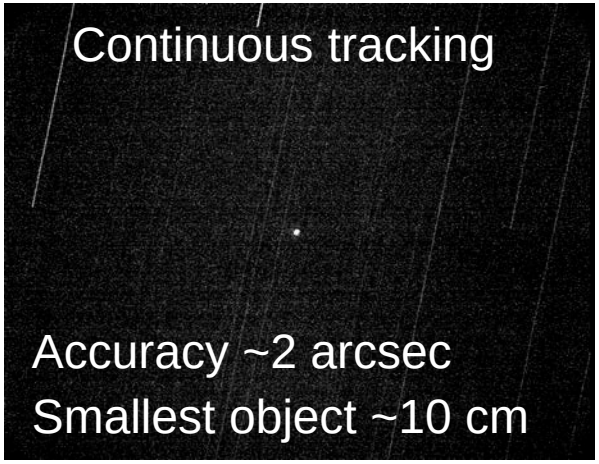
- Inexpensive hardware
- COTS components
- Can be set up independently of external partners

Mount	Astelco	35 K€
Telescope	Planewave	25 K€
Camera	Andor sCMOS	10 K€
Laser	Innolas	20 K€
SP Detector	idQuantique	10 K€
Gating and synchro	CERN White Rabbit	10 K€
Event Timer	PicoQuant	20 K€
Optical components	various	10 K€
Auxilary hardware	various	10 K€
		150 K€

Passive optical channel

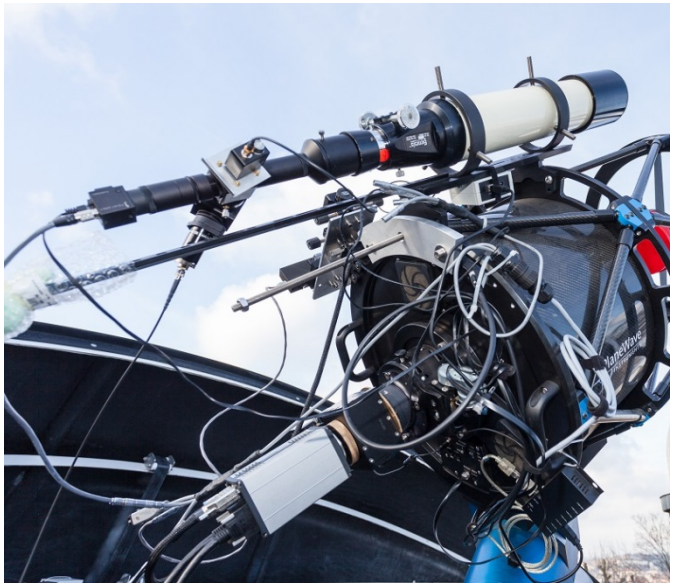
Focal length	2939 mm
Aperture	432 mm
Camera resolution	2560 x 2160
Pixel size	6.5 µm
Field of view	0.32° x 0.27°
Camera scale	0.45 arcsec / pixel
Frame rate	Up to 50 Hz

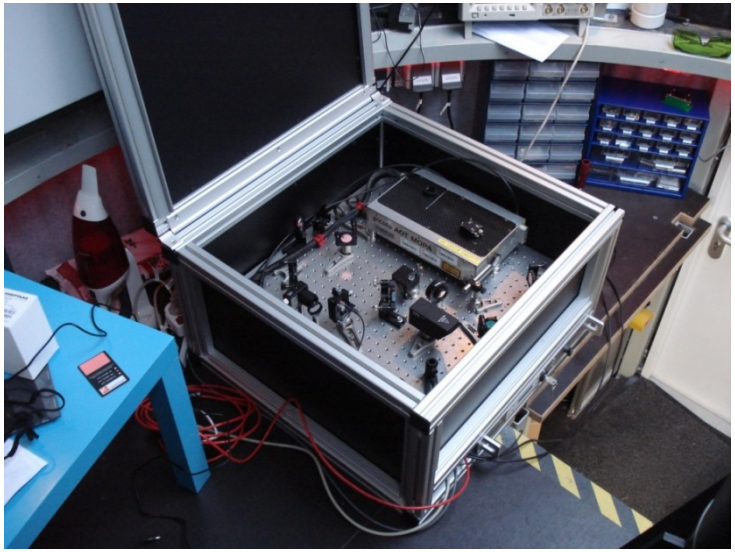




Transmitter

- Small diode-pumped Nd:YAG laser
- Fibre transmission from base to telescope
- Automatic beam control and steering
- 10 cm aperture, 50 µrad divergence

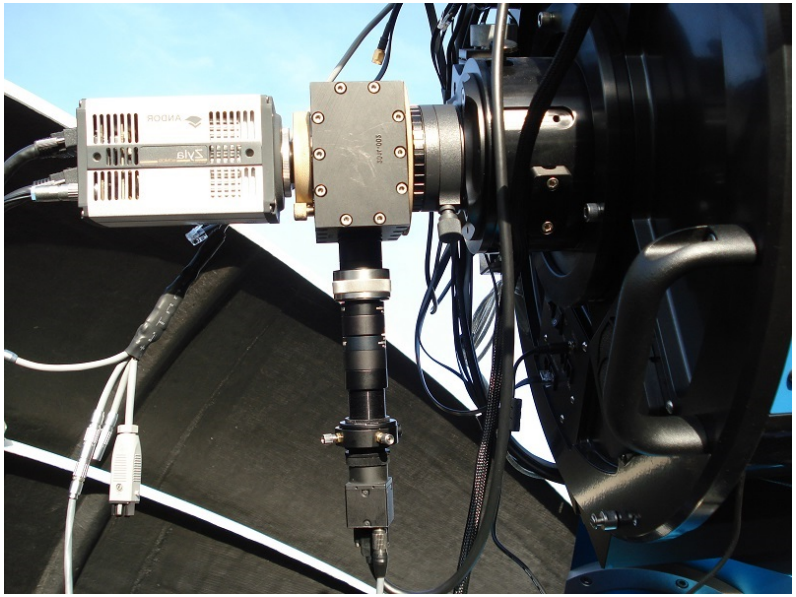




Innolas AOT 1-YAG	
Wavelength	1064 nm (IR)
Puls duration	< 3 ns
Repetition rate	1 kHz (to 10 kHz)
Pulse energy	300 µJ

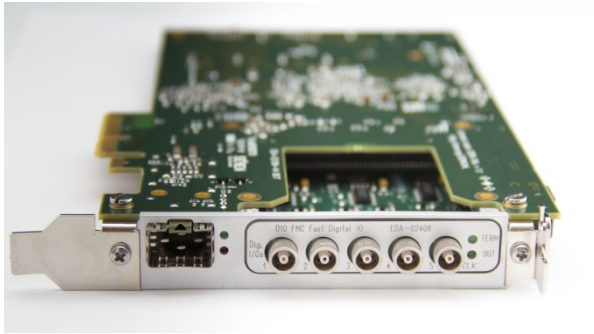
Receiver

- Dichroic beam splitter near focal place
- idQuantique single photon detector
  - InGaAsP APD
  - 30% efficiency @ 1064 nm
  - 80 µm diameter
  - Dark noise ~ 2 kHz
- Can be used gated or free running
- Alignment done via software (no moving parts)

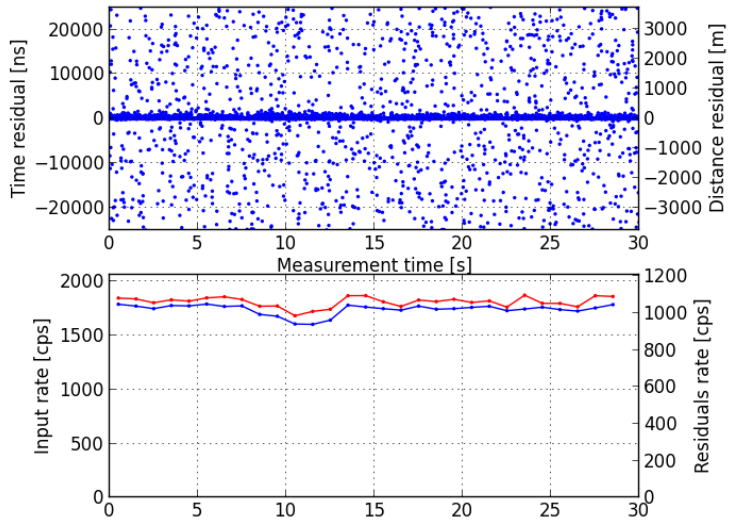


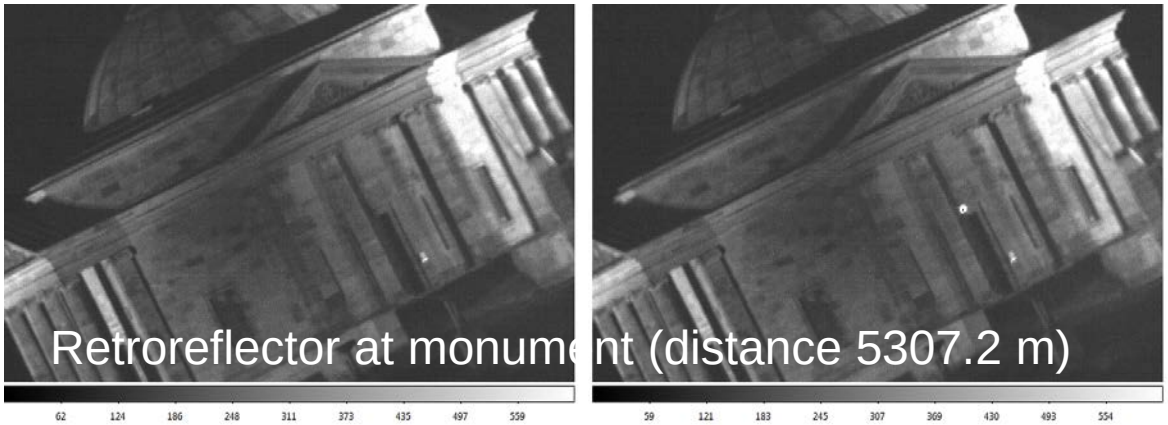
Instrument control and DAQ

- Event Timer: PicoHarp 300
  - 4 ps resolution
  - Timing 12 ps + 10^{-8} dT
  - Max. data rate: 5 MHz
- GPS clock: Jackson Labs Fury GPS
  - Motorola M12+ timing receiver
  - 20 ns (1 sigma) to UTC
- Gating and synchronisation: CERN White Rabbit
  - 5 inputs / outputs
  - Sub-ns synchronisation between devices
  - Pulse generation and timetagging
  - Synchronisation to UTC



Test targets





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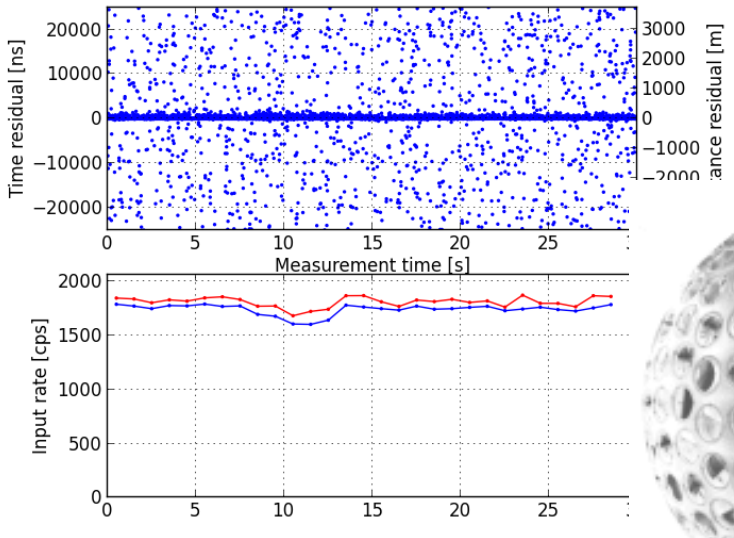

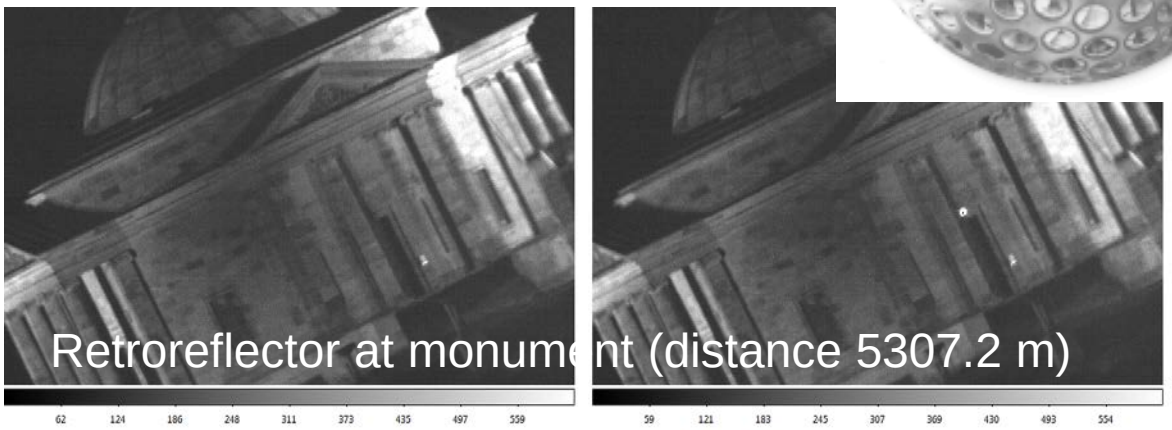

What can we do with this design?

- For „standard“ satellite laser ranging:
  - This design can be an inexpensive alternative to traditional SLR stations

  ➔Need to push picosecond pulses through the fibre

- For space debris laser ranging:
  - Need stronger fibres, and high repetition rate

  ➔Currently, space debris laser ranging still needs a Coudé system

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- DLR Stuttgart will start building a Coudé system in 2016

Collaborations & current projects

- ESA project with Graz and Wettzell
  - 1064 nm laser ranging to space debris
  - Calculate orbits from observations
- DLR project with other institutes:
  - BACARDI database for 1M objects incl. data management, conjunction warning etc.
    - ➔Planned to be „open“
- Other projects for EU, German defense department etc.

Summary & Outlook

- DLR Stuttgart is building up space debris observation hardware
- Facilities are dedicated 100% to space debris research (no routine tasks)
- SLR planned for 2016
- SDLR facility in preparation