Institute of
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SLR link budget and retroreflector optical cross section evaluation

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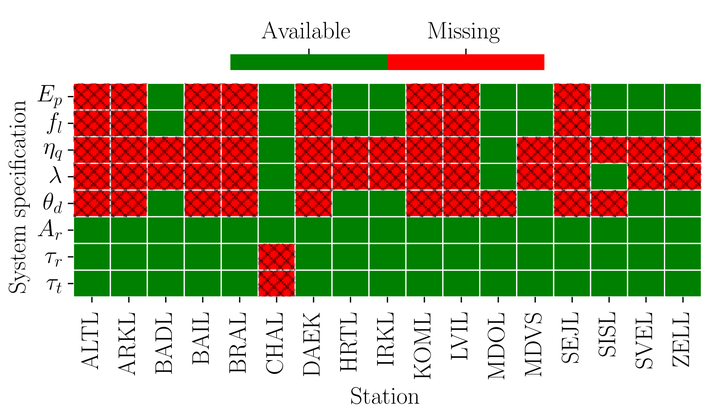
Motivation

- Link Budget is essential for signal estimation of an SLR ground segment and for designing new SLR stations.
- Optical cross sections (OCSs) are scarcely available

The miniSLR on the roof of the DLR, Stuttgart, Germany (Credit: Paul Wagner / DLR).

Methodology

Normal point measurements from a 15 year period (2007 to 2022) are obtained from the EUROLAS Data Center (EDC) [2].
In order to evaluate the signal strength, these are filtered, to solely ensure single photon operating stations, for which the Poisson distribution is known.
Unfortunately, some stations do not provide all necessary data for the link budget evaluation.



Stations that are missing information for the link budget evaluation

Link Budget

The utilised link budget accounts for the system specifications, the atmospheric transmission, and the orbital geometrics [1].
Large uncertainties arise from atmospheric conditions, beam divergence and tracking errors.

Key specifications of the miniSLR:

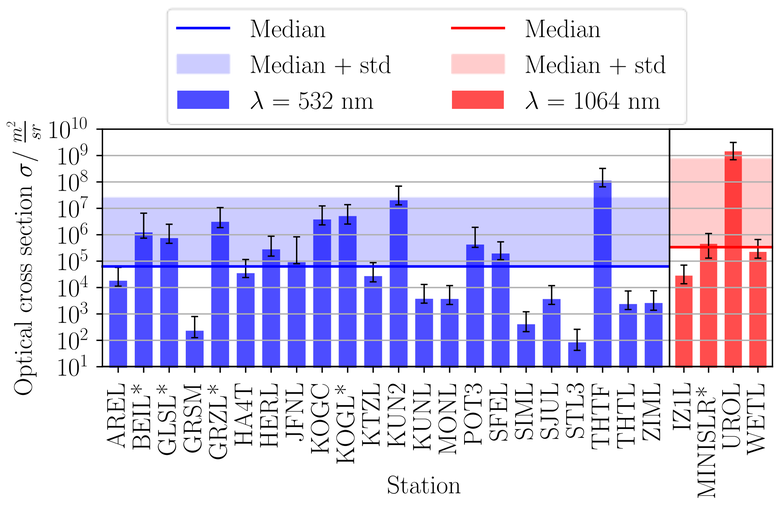
Ranging wavelength λ	1064 nm
Pulse energy E_p	110 µJ
Repetition rate f_l	27 kHz
Pulse duration	4 ns
Apertures A_r	20 cm / 7 cm
Beam divergence* θ_d	~50 µrad
Receiver efficiency τ_r	0.2
Transmitter efficiency τ_t	0.7
Tracking error*	~25 µrad

**Largest system specific uncertainties in the link budget*

Data selection

Optical cross sections (OCSs) measured with different SLR stations exhibit large variations due to systematic errors and return rate control.

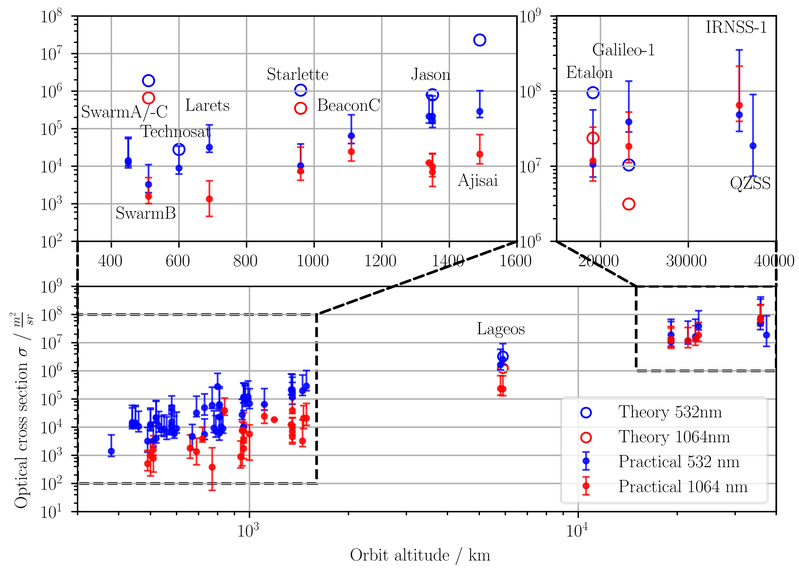
- 5 stations, including the miniSLR provide useful data for all orbit altitudes



*OCS for Lageos-1, derived from SLR measurements. *Used for further evaluation*

Results

- In total the OCS of 76 satellites and GSS constellations could be obtained
- Trend towards larger OCSs for increasing altitude apparent
- Link budget can only determine order of magnitude for return strengths
- Design of SLR stations needs to consider a margin (> factor 10) for link budget
- Derived values can be used for future signal estimations



OCSs derived from SLR measurements, including some theoretical values

[1] John J. Degnan, Millimeter Accuracy Satellite Laser Ranging: a Review, in: David E. Smith, Donald L.Turcotte (Eds.), Contributions of Space Geodesy
[2] EUROLAS Data Center (EDC), https://edc.dgfi.tum.de/en/

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