The miniSLR® - A low-budget, high-performance satellite laser ranging system

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With: Felicitas Niebler, Nils Bartels, Luis Gentner, Robin Neumann, Tristan Meyer, and Wolfgang Riede

Long time no see

A few personal words…

- Great motto: Reconnecting the community
- During the last workshop, we were expecting our first child -
  Now a little mountain hiking lady! ➔ ➔ ➔
- Now: Expecting our second child
  Currently grounded in Stuttgart…

… and a new professional situation

- 50% continuing at German Aerospace Center (DLR) Stuttgart
- 50% DiGOS Potsdam GmbH

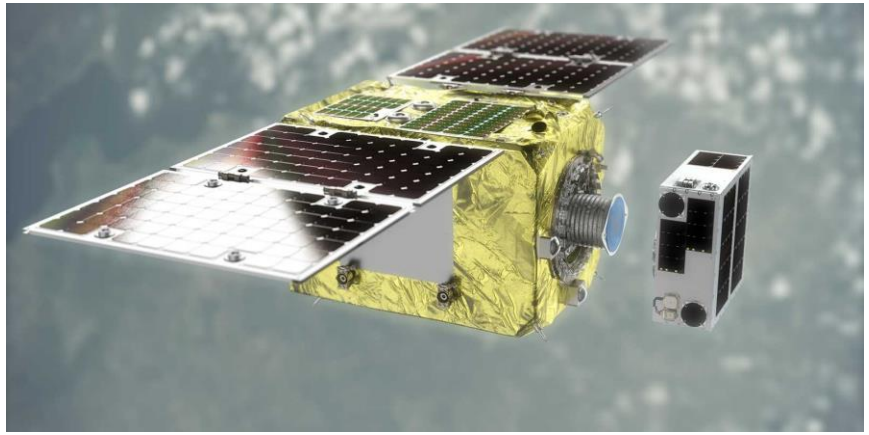
The miniSLR – why?

- SLR is still complex, expensive and features a sparse global coverage
- On the other hand, demand is constantly rising
  - More high-precision earth observation missions
  - Better theories and models
  - GNSS constellation support
  - Mission support
  - Space Traffic Monitoring

- Developing a simplified, less expensive, flexible SLR system can hopefully:
  - Enable new players to join the game
  - Facilitate new applications
  - Relief high-end station of routine observations

Lares-2

ELSA-D



The miniSLR – how?

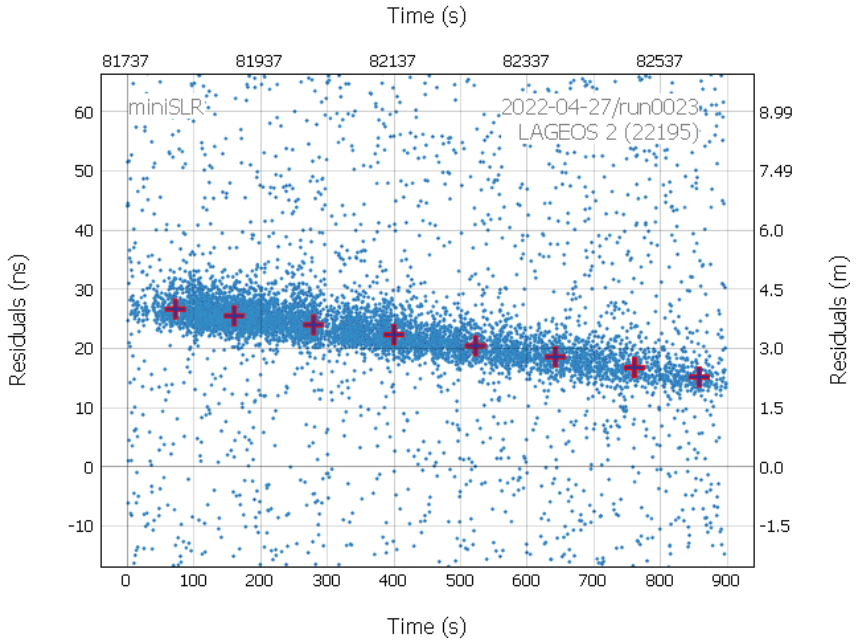
- Reduce complexity:
  - Small mount and telescope
  - High power / low energy laser
  - No dome, but fully encapsulated
  - No building
  - No “fancy” features, just SLR

Total size	210 x 130 x 210 cm
Weight	~ 600 kg
Aperture	20 cm
Laser power	5 W (50 kHz / 100 µJ)
Wavelength	1064 nm
Pulse duration	500 ps (*)

(*) new laser, integrated in October 2022

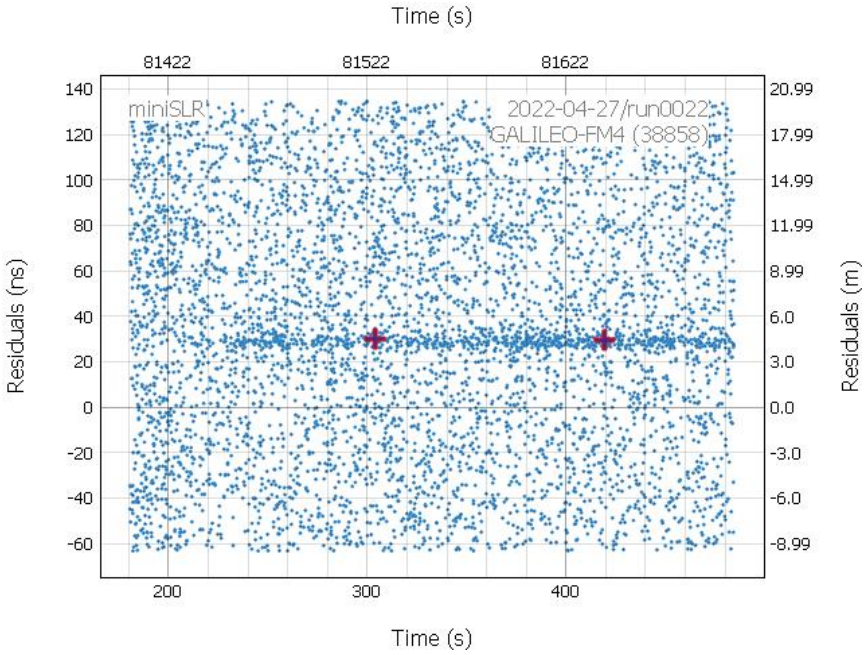
The miniSLR at DLR premises, summer 2022

Some early highlights



LAGEOS 2

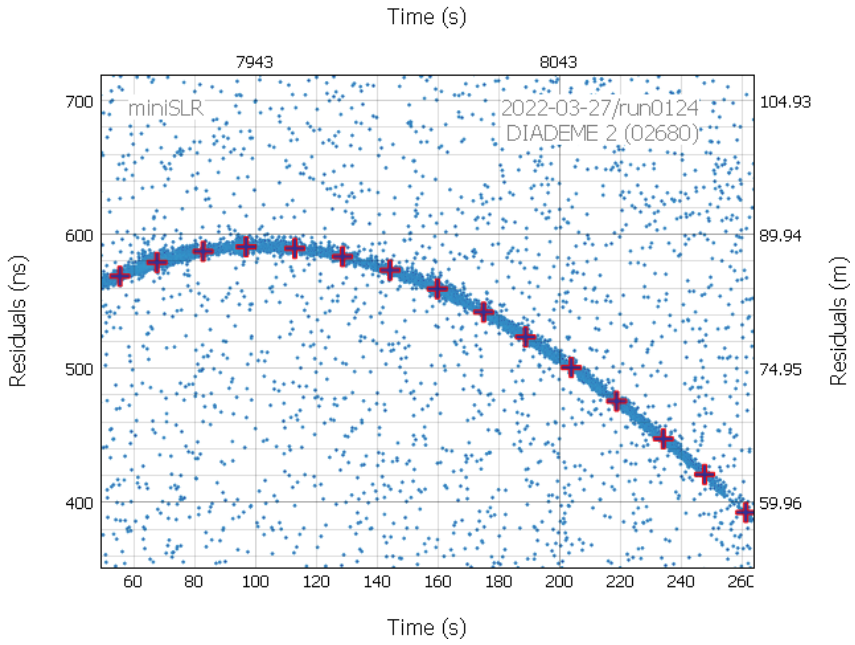
- 2000 to 7000 returns per Normal Point
- (Goal: 3000 data points)
- Return Quote: 0,1 bis 0,3 %



Galileo-FM4

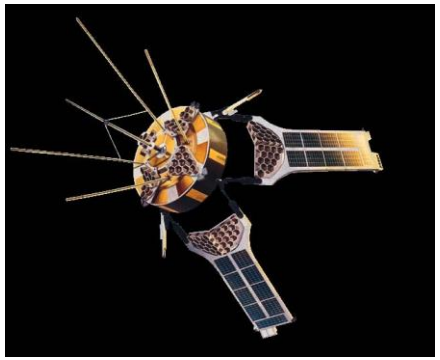
- 350 returns per NP
- (Goal: 300 data points)
- At the edge of capabilities of current set-up

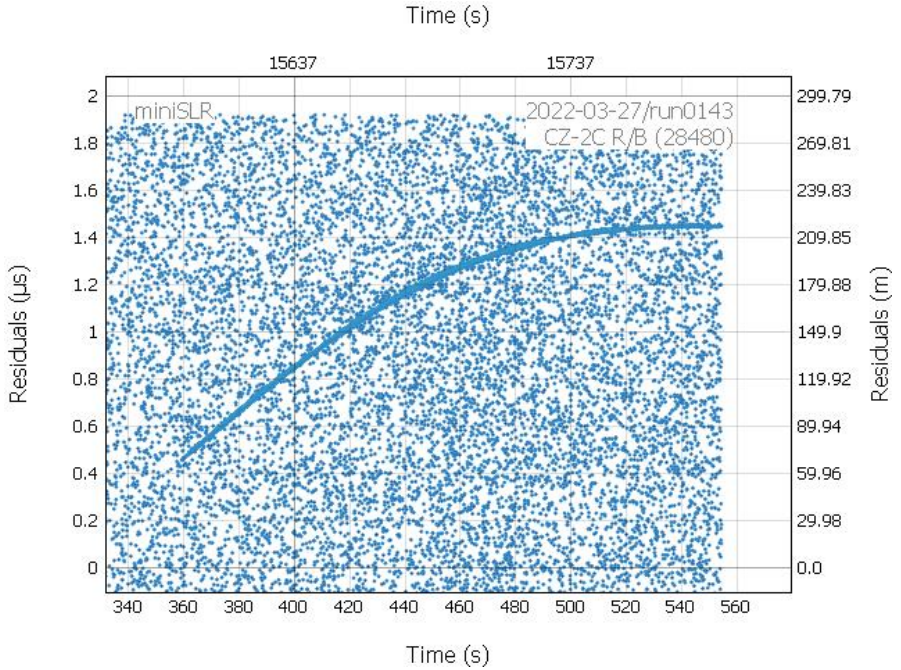
Ranging space debris (with retros)



DIADEME-2

- Launched Feb 1967
- Second oldest LR target (?)





Long-March Rocket Body

- Launched in Nov 2004
- Equipped with retro-reflector

First estimation of accuracy

- First data analysis kindly provided by Prof Toshimichi Otsubo (August 2022)

- Pass to pass jitter: ~10 cm
- Precision: ~3 cm

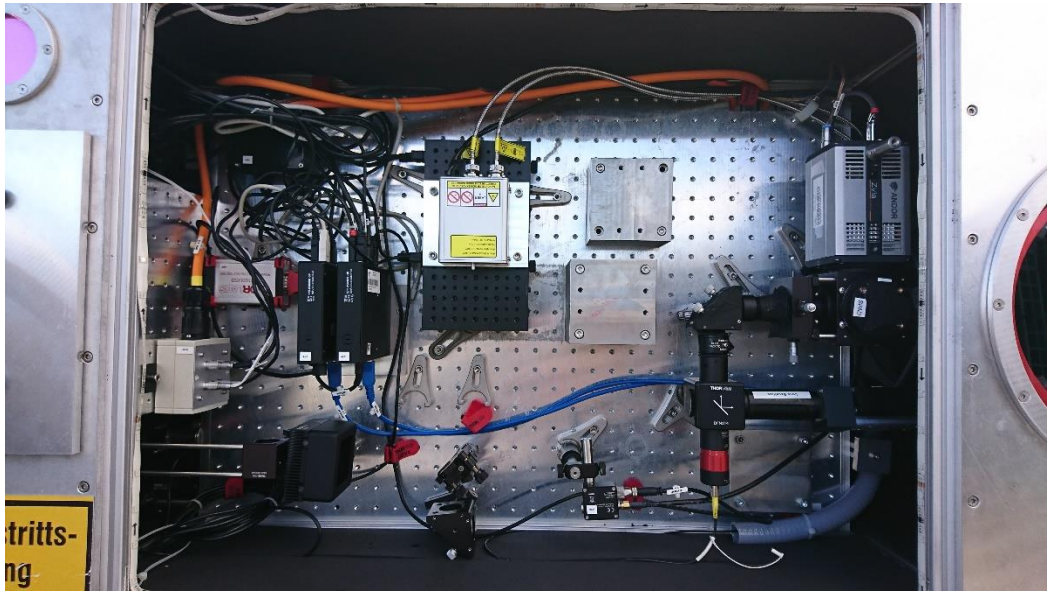
➔ These values should improve with sub-ns laser (5 ns ➔ 500 ps)

sat	date	time	dur	rb mm	error	tb us	error	prec	bad	total	rms
AJI1	2022/08/12	21:15	6	32	(36)	-8.8	(11.7)	16	0	/ 14	588
STRL	2022/08/12	22:47	1	18	(23)	-------.-	(----.-)	11	0	/ 4	297
LARS	2022/08/12	23:07	0	53	(28)	-------.-	(----.-)	33	0	/ 3	1130
LAG1	2022/08/12	23:16	3	-16	(15)	-------.-	(----.-)	4	0	/ 3	392
STRL	2022/08/13	00:30	7	-22	(13)	-2.3	(2.7)	16	0	/ 14	346
LARS	2022/08/13	01:06	2	-29	(18)	-------.-	(----.-)	30	0	/ 7	926
LARE	2022/08/13	01:40	0	-52	(31)	-------.-	(----.-)	12	0	/ 3	558
STRL	2022/08/13	02:19	7	-38	(13)	2.5	(2.6)	40	0	/ 14	382
LAG1	2022/08/13	02:33	11	29	(18)	-3.5	(15.8)	14	0	/ 7	365
STRL	2022/08/16	22:13	2	35	(18)	-------.-	(----.-)	19	0	/ 7	326
LARS	2022/08/16	22:45	7	-29	(15)	9.8	(4.1)	16	0	/ 11	332

The miniSLR – quo vadis?

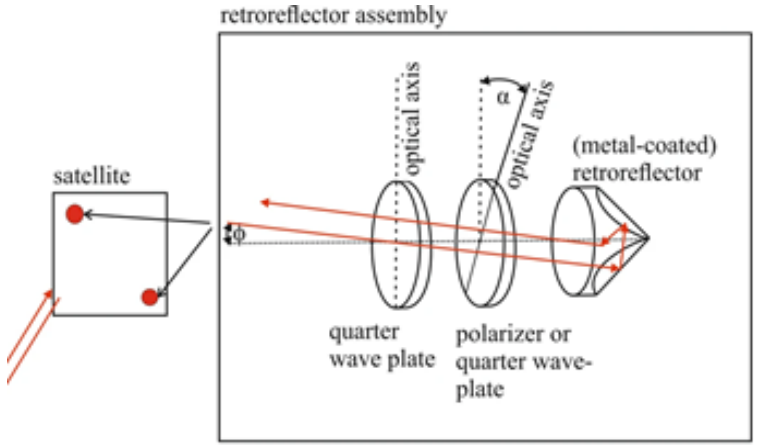
- First tests with new laser pending
- Plan to submit data to ILRS from January (or so)
- Using the system for studies and testing of technologies

- Cooperation with DiGOS to develop a commercial system
  - First platform system already sold, to be delivered in Q3 2023

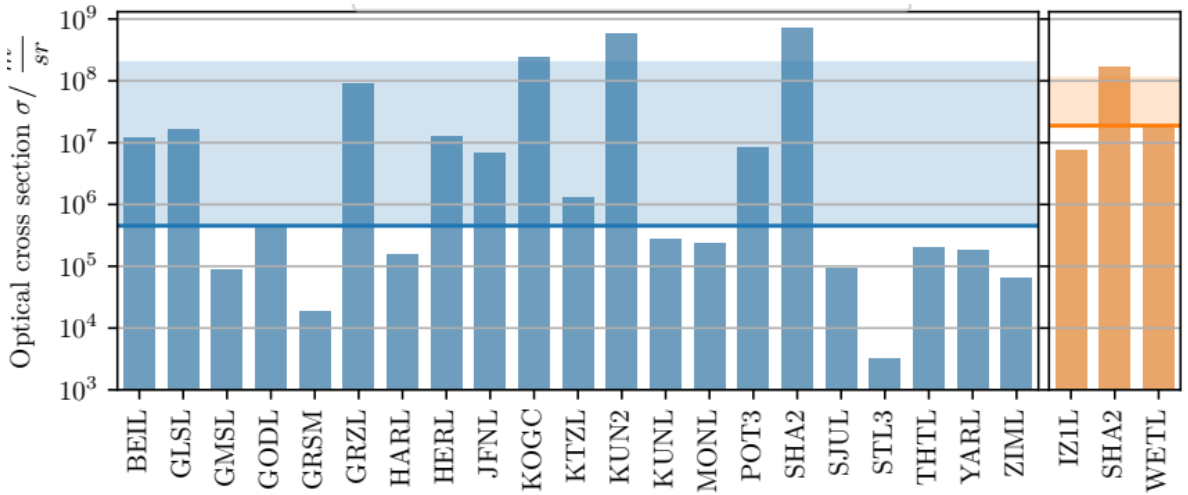


Other projects

- Nils Bartels:
  - Identify satellites by retro-reflector signature
  - Develop commercial retro-reflector arrays
- Tristan Meyer:
  - Calculate OCS of satellites from CRD archive
  - Compare theory of link budget and OCS calculation with experiment



Wavelength	OCS 532 nm / $m^2\,sr^{-1}$		
Satellite	Q1	Median	Q3
AJISAI	31156	96331	258520
ANDEC	15	64	105
BEACONC	19783	49376	119875
BLITS	393	701	2070
CRYOSAT2	1815	5281	13591
…		…	



Conclusion

- The miniSLR® offers a cost-effective alternative to traditional SLR systems
- First tests show good performance
- Data will be delivered to ILRS for public validation
- System will be available commercially in the near future

The presented results have been made possible by great team work with:
Felicitas Niebler, Nils Bartels, Luis Gentner, Tristan Meyer, Robin Neumann, Wolfgang Riede, Paul Wagner (now at DLR Institute of Communication and Navigation), Ewan Schafer (now at Lumi Space, UK), DLR IT department, mechanical and electronics workshop, and many others

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