LaRCo (Laser Range Correction)

For hemi/spheres, spherical caps/domes like:
Genesis (ESA), LARES-2 (ASI), EO mission (ASI) …

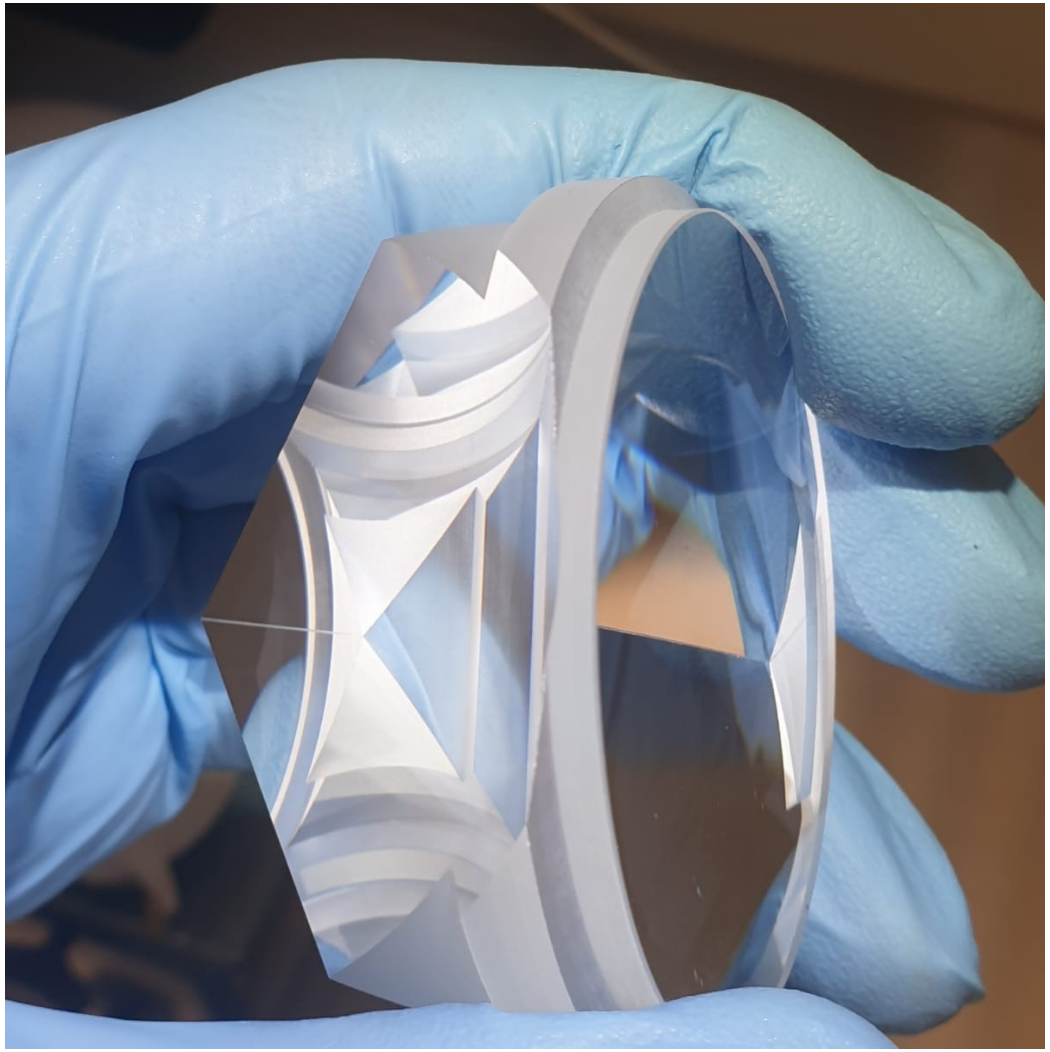
Goal: Service to ILRS and the SLR science community.

ILRS feedback / endorsement useful to inform ESA (and ASI)
ILRS: please give feedback in particular to slide (8 on Genesis)

ILRS NESC WG meeting, 13-03-2025

INFN – Frascati National Labs (INFN-LNF)
S. Dell'Agnello for the SCF_Lab Research Group
(simone.dellagnell0@lnf.infn.it)
Via E. Fermi 54, Frascati (Rome), 00044 – Italy

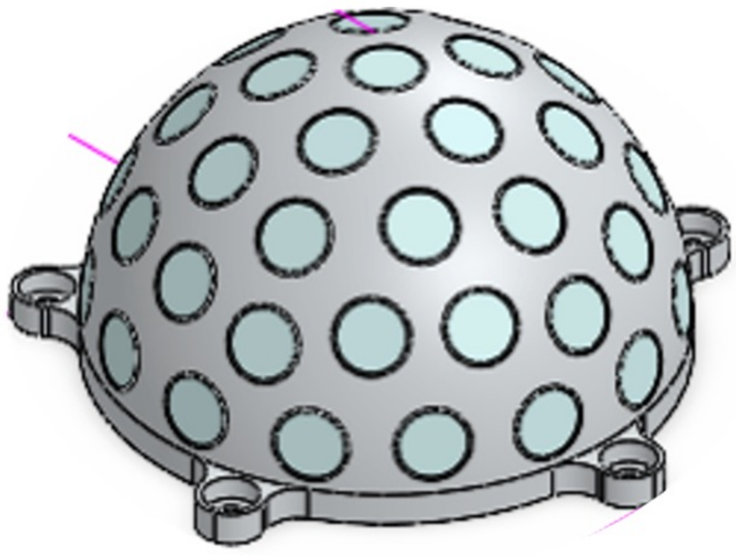
Cube Corner laser Retroreflectors (CCRs)



For flat Laser RetroReflectors (LRRs), for example GNSS LRRs, we know what range correction we are supposed to measure for normal laser incidence, and this can be used as a calibration of the LaRCo facility.

On the other hand, it will be interesting to verify how the GNSS LRR range correction changes vs laser incidence angle.

State-of-Art SLR Geometrodynamics



The GENESIS mission will contribute to a highly improved International Terrestrial Reference Frame (ITRF) with an accuracy of 1 mm and a long-term stability of 0.1 mm/year. The ITRF is the foundation for all space and ground-based observations in navigation and Earth sciences – monitoring the terrestrial environment and setting it within a set framework for mapping changes over time.

LARES-2 (LAser RElativity Satellite): 2022, ASI
LAGEOS-2 (LAser GEOdynamics Satellite): 1994, ASI

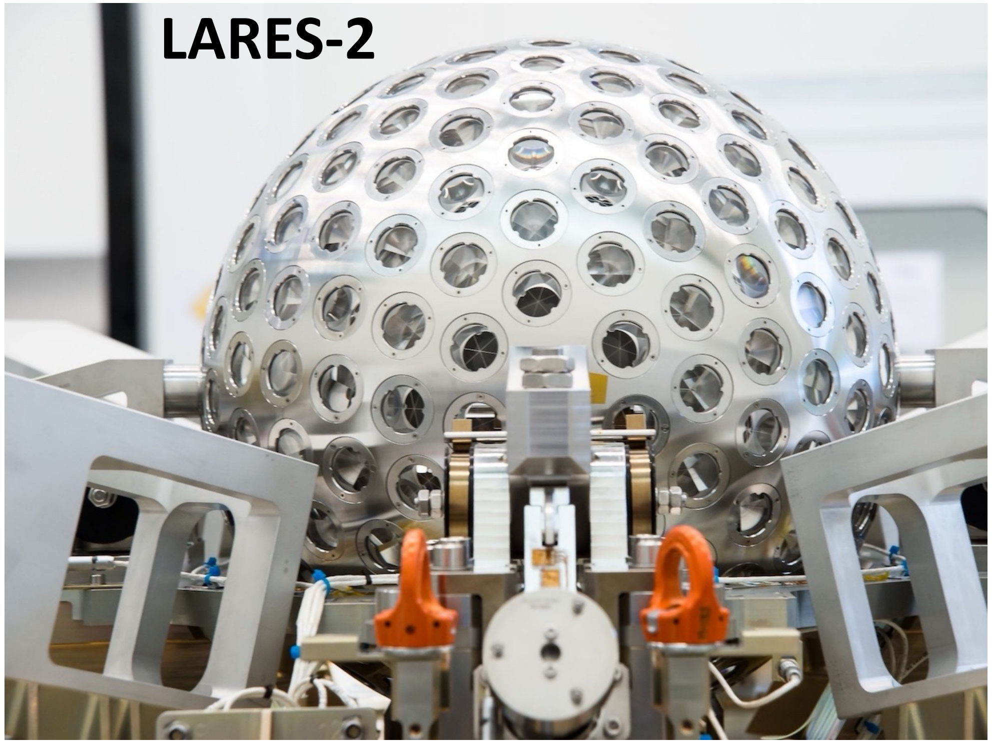
ASI's LARES-2 LRR made by INFN-Frascati & INFN-Padova launched on 13 July 2022 by ESA with the qualification flight of Vega C. 303 CCRs/sphere, 42cm diameter, 300 kg.

OHB-I, Milan: HDRM mechanism, quadrupod interfaces with Vega C.

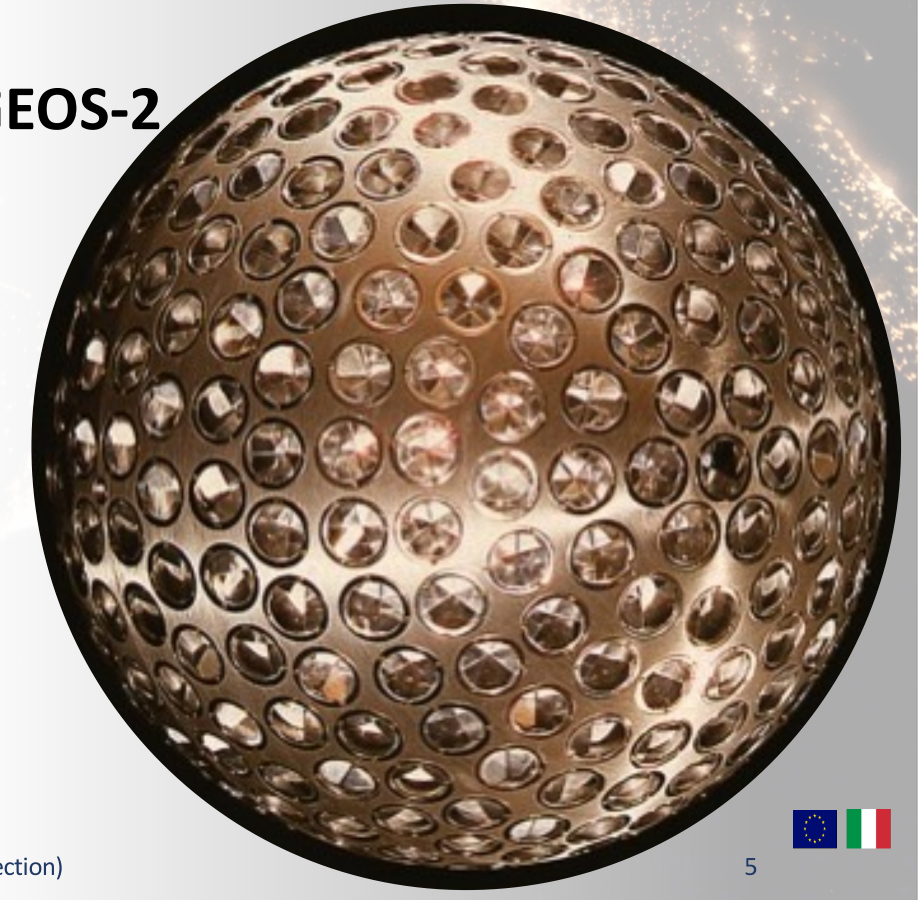
Best LRR, so far (**calculated 2 mm 1-STD/SIGMA accuracy of laser range correction**).

Premiere point-like test mass for General Relativity and Space Geodesy.

LARES-2

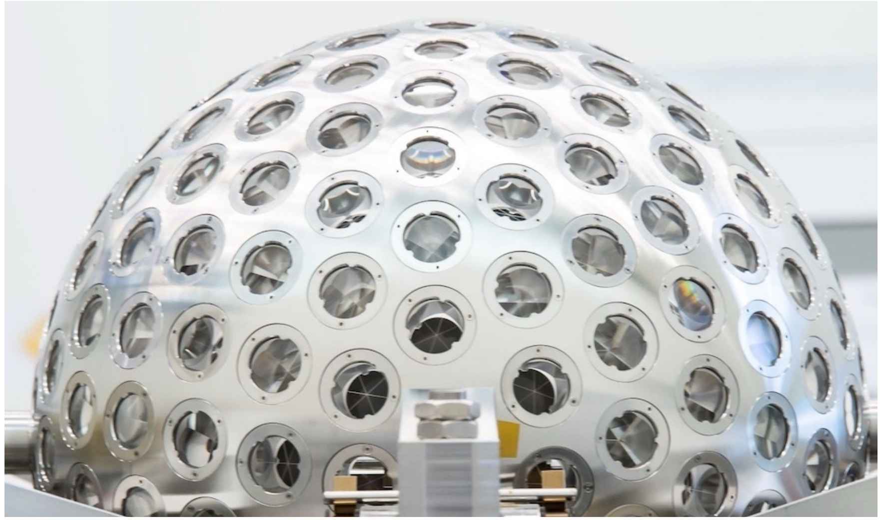


LAGEOS-2



LARES-2

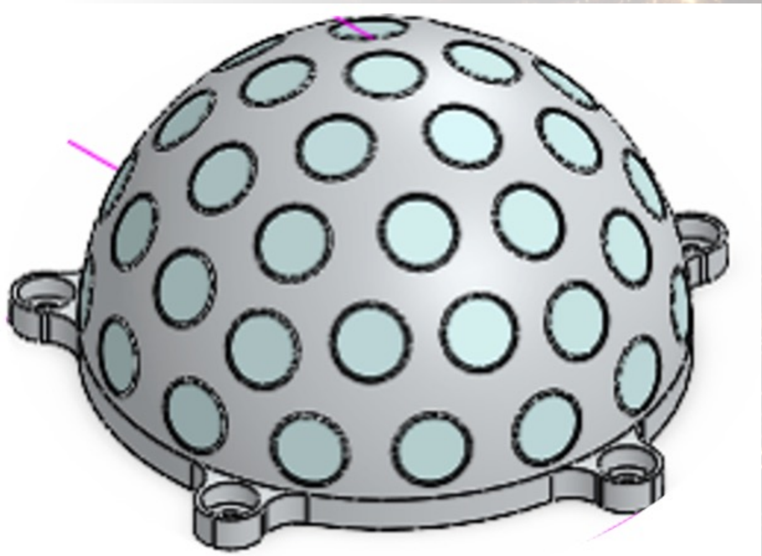
(~6000 km)



Genesis

(~6000 km)

Just notional drawing



GNSS

(~20000 km)

Flat LRRs

ASI EO mission

(~600 km)

Spherical LRRs but smaller than Genesis LRR

LaRCo = Laser Range Correction

- Service facility to measure in the lab the laser range correction.

- Sort of ultimate laser ranging calibration, relating geometrical centers of LRR hemi/spheres, spherical domes to the measured laser time-of-flight (ToF), **and reach/break the barrier of 1 mm of laser range accuracy.**

- **But for Genesis the optical barrier is actually at 0.5 mm at 1-STD / 1-SIGMA.**

- Measurement done twice in 60 years of laser ranging, for LAGEOS-1/2 in ~1974/1994. Now only calculated at 1-STD / 1-SIGMA (like for LARES-2).

- At INFN-Frascati we have a suited Clean Room, the SCF_lab2, co-funded by ASI & INFN, with a massive optical granite table (suitable for heavy 'cannon-ball' type of stand-alone satellites, like LAGEOS-12 and LARES-1/2).

The specific case of Genesis

- <u>Potential / Future Applications</u> of LaRCo in previous slides. Other missions?
  - ➢ INFN contracted to design, manufacture, qualify and deliver it with its calculated laser ranging correction. Under NDA (cannot avoid it).
  - ➢ For the calculation we intend to ask also for purchased services from expert analysists, inside/outside ILRS. We are doing this for the 2 ASI EO spheres.
    - Will try to make, refine, publish this as a shared, long-term ESA-ILRS work.
- <u>Practical challenges of **Genesis**</u> (**independent of LaRCo**):
  - ➢ OCS of 6 Msqm has been approved by ESA and the industrial consortium
  - ➢ We held LRR KO, but still have to do LRR SRR (System Reqs. Review) after Genesis meeting in Matera. **We ask for ILRS feedback on the following:**
  - ➢ Requested accuracy of calculated (purely optical) laser range correction is:
  - ➢ **1.0 mm (3D, 2-sigma) equivalent to 0.5 mm @1 standard deviation (1-std), to be compared to 5 mm @1-std for LAGEOS & 2 mm @1-std for LARES-2**
    - ➢ **Better than: x10 LAGEOS @1-STD and x4 LARES-2 @1-STD !**
- Compare requested laser ranging accuracy to accuracies of atmosph. corrections:
  - ➢ **For 10º / 15º / 20º elevations 5 mm / 2 mm / 1 mm**
    - ➢ See <u>Journal of Geodesy (2019) 93:1853–1866</u> https://doi.org/10.1007/s00190-019-01287
    - ➢ **Are these 1/2/5 millimeters @1-STD/2-sigma or @2-STD/2-sigma ?**

Ideas for implementation of LaRCo

- Direct involvement of the ILRS stations / SLR analysis Community !

We think that, in addition to the ILRS endorsement, an appropriate direct form of involvement in the project of some *representative, voluntary* ILRS *'partner'* stations would be crucial, not only useful. The range correction is FOR ILRS stations + SLR analysts. We also believe that this involvement in the project needs to be built together, getting feedback from stations' operators, analysts and taking time to discuss critical technical and programmatic details of the project. ILRS cannot get funding, but the single stations may and do get national, European funding, some also ESA funding. We foresee specific and focussed purchased support services not for ILRS as an organization (not possible), but for some *partner* ILRS stations and for some *partner* SLR analysts.

Ideas for implementation of LaRCo

- Facility instrumentation:
  - ➢ Technique of detection of the return signal?
    - Single photon, Multi photon; CFD? ...
  - ➢ What detector?
    - Streak camera, MC PMT, C-SPAD … What other detector or detector combinations (for start time) to measure the ToF?
  - ➢ What laser WL / repetition rate?
    - 532, 1064 nm / kHz ?
  - ➢ Laser pulse width and / or polarization type
  - ➢ Do all of the above categories map directly into separate corrections to be delivered to the funding agency / ILRS?
  - ➢ Flat LRRs: check range correction vs laser incidence angle
  - ➢ Clock options, …
- HW procurement and verification/validation
  - ➢ Share work (and associated funding) with *partner* stations
  - ➢ More sharing to be decided together. And come to Frascati, please.

Ideas for implementation of LaRCo

- <u>Execution of the measurements:</u>
  - Ask personnel of *partner* stations (representing detection techniques and/or detectors and/or laser characteristics of the previous points) to participate in the range correction measurements.
  - Participating means travel to Frascati, work there together, even in the preparation and then analysis of the results (this also remotely).
  - This will be TBD weeks of work for 1-2 people, which needs to be supported financially with LaRCo funding (if/when approved). It would be not only fair to the *partnering* stations, but also pragmatically effective.

GGOS Bureau of Networks and Observations Overview and Activities

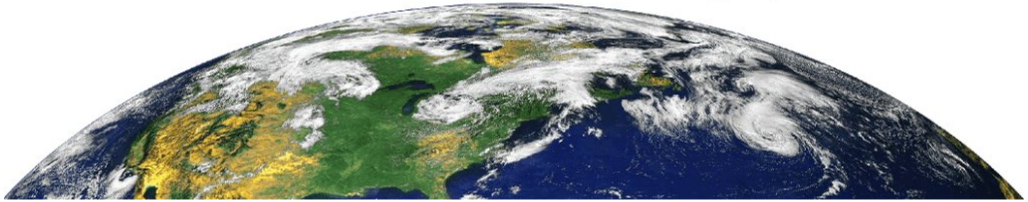
José C. Rodríguez, Martin Lidberg
Bureau of Networks and Observations

2025-03-13

The fundamentals

Recognising the fundamental need in geodesy for internation cooperation,

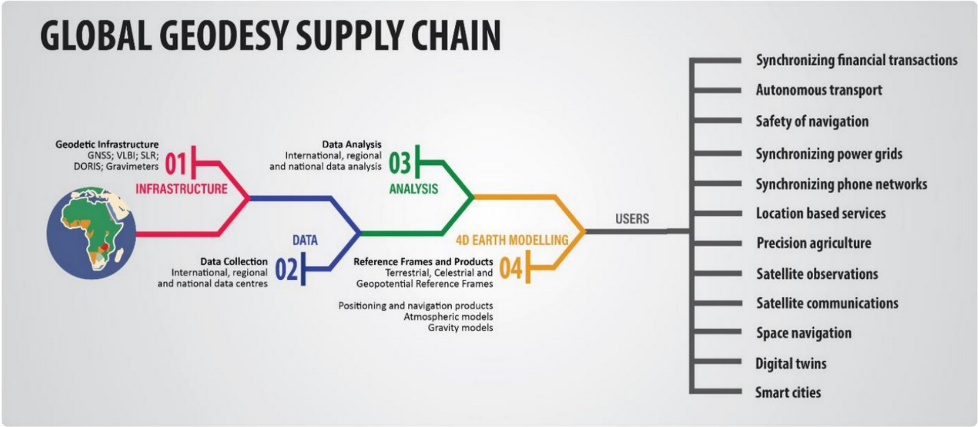
> “the Global Geodetic Observing System of the **IAG** is the proposed **unifying umbrella** for the IAG Services, which **integrates** the observing systems […] and **improves** internal consistency. It **links** the geodetic services into the global Earth observation systems in order to provide a consistent **service** to the users”.
>
> GGOS 2020



The fundamentals

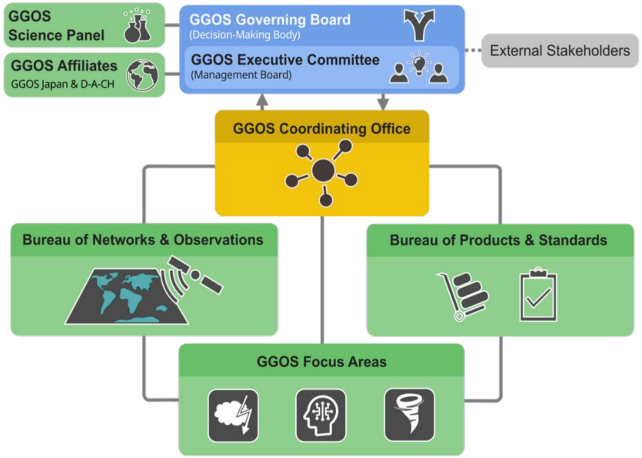
This ***service*** consists of a series of geodetic products that require:

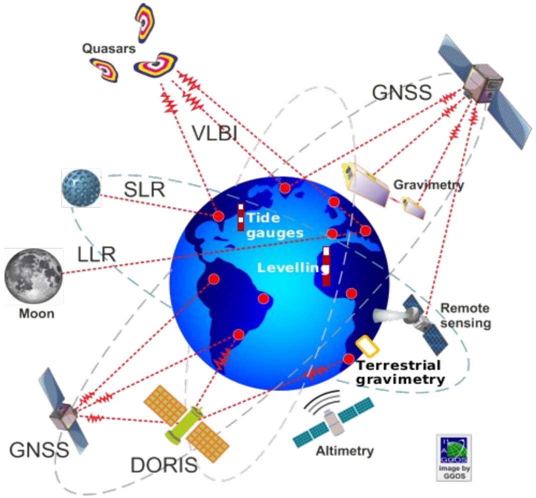
- Research & development
- Complex and costly material infrastructure (ground and space)
- Analysis and combination capabilities
- Infrastructure to handle the flow, storage and serving of data and products
- Standards, conventions, guidelines, protocols, quality control, coordination
- An army of highly specialised staff to do all this



The Global Geodetic Observing System

- **Integrates** the IAG Services into a global observing system.
- Geodesy contribution to GEOSS (Global Earth Observation System of Systems).
- Various components (Coordinating Office, Bureaus, Focus Areas, Affiliates...).





The Bureau of Networks and Observations

The operational component of the geodesy supply chain, and associated infrastructure, is essential for the provision of geodetic products.

The Bureau is tasked with overseeing this component, as it

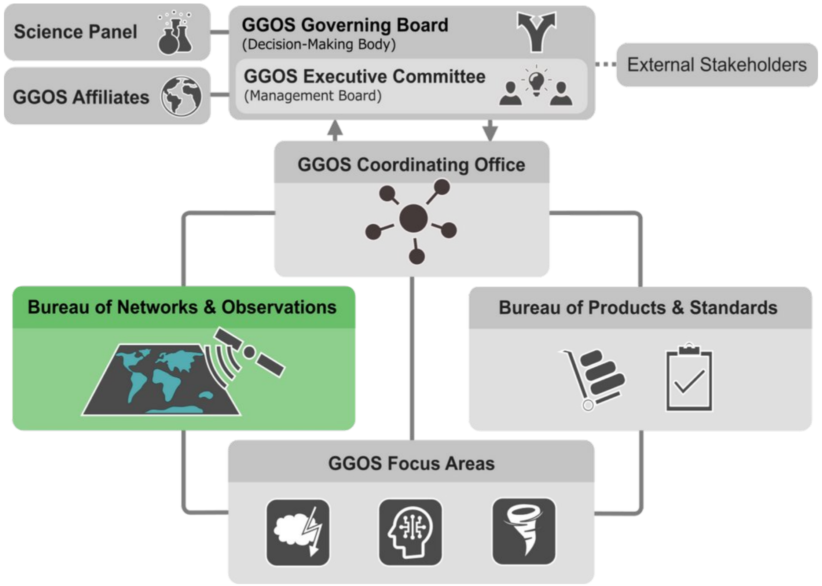
> “[…] develops a **strategy** to design, integrate and maintain the fundamental infrastructure in a sustainable way to satisfy the long-term (10–20 years) requirements identified by the GGOS Science Panel”.
>
> Geodesist Handbook 2024

Among its objectives:

- Monitor network status, projected network evolution, estimate performance capability
- Assess impact on key products from network configuration, system perf., technology mix, co-locations (ground and space)…

The Bureau of Networks and Observations

- Committees and working groups integrated to the BNO:
  - **PLATO** (simulations)
  - **C-SM** (satellite missions)
  - **C-DIS** (data and information systems)
  - **JWG Metrology** (with IERS)
  - **JWG Genesis** (with IAG and IERS)
  - Services: **IDS**, **IGS**, **ILRS**, **IVS**, **IGFS**, **PSMSL**



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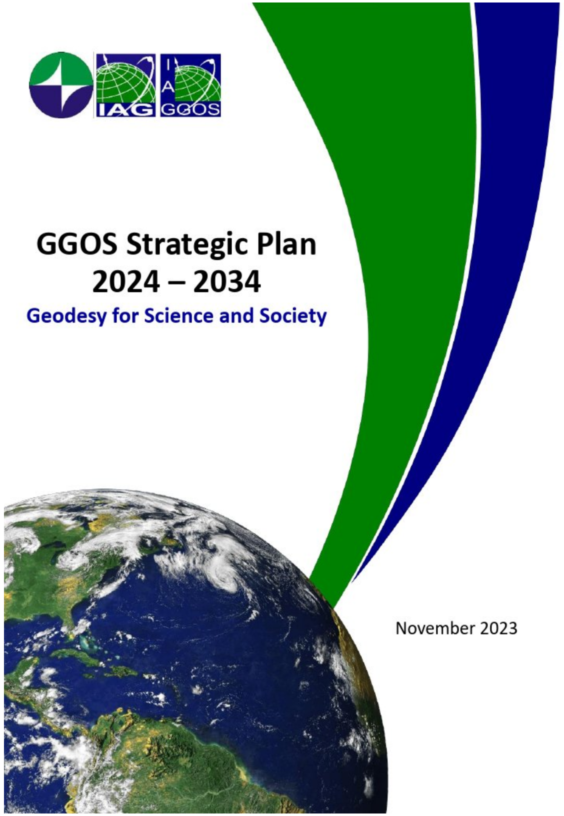
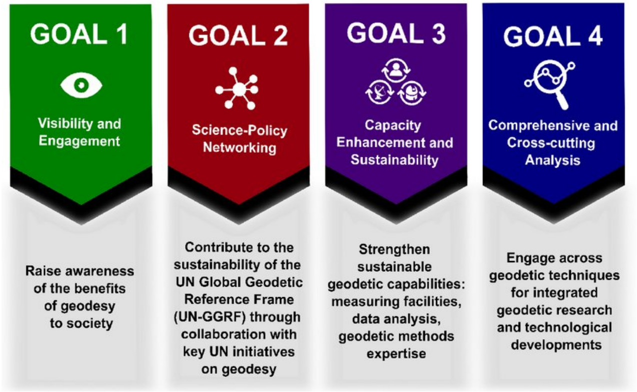
GGOS Strategic Plan



New GGOS strategic plan 2024–2034



Implementation Plan

- 2-year duration
- Single plan for the whole of GGOS
- Activities assigned to GGOS components
- SMART objectives

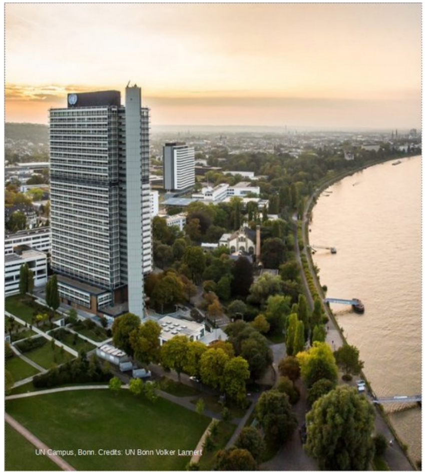
Relevant context for our activities

UN-GGCE

Operationalises 2015 UN resolution.

Excellent alignment with GGOS.

Evident avenues for collaboration.



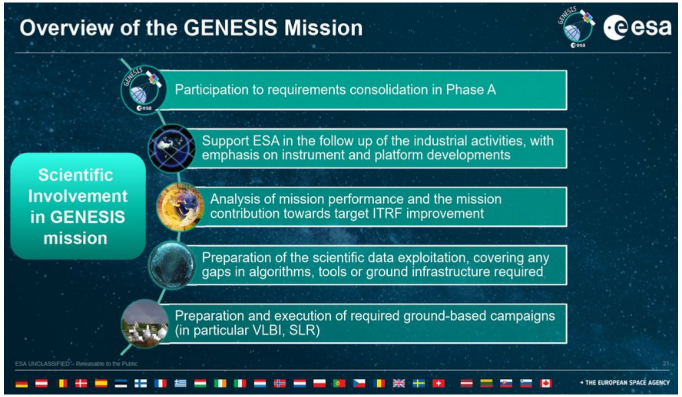
UN-GGCE

United Nations
Global Geodetic
Centre of Excellence

Genesis

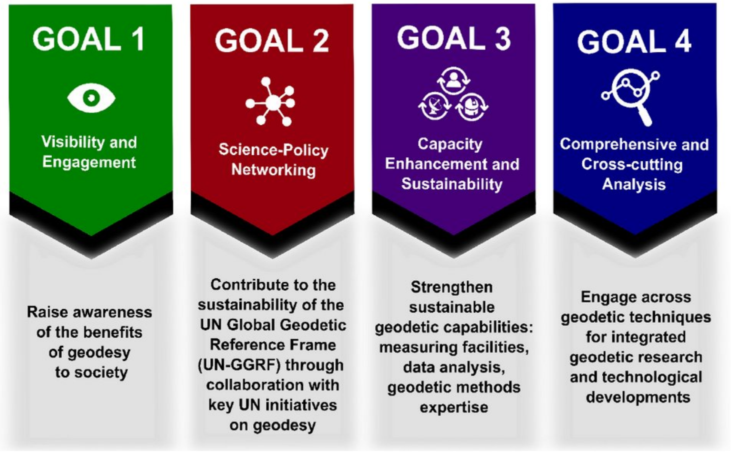
Fantastic opportunity for the community.

- BNO + PLATO: sharpen analysis, space ties, systematic errors, **product improvement.**
- BNO + IERS + JWG Metrology: renewed efforts to **update** local tie surveys.
- BNO + Services: networks readiness, **campaigns.**



GGOS Implementation Plan: BNO

- 4 main Goals, 4 actions each, for a total of 64 activities.
- BNO leads in 9 activities.
- BNO contributes to 24 additional activities.



GGOS Implementation Plan: BNO lead

GOAL 2 Science-Policy Networking	**2.2.c** Describe challenges and practices required to host and maintain fundamental geodetic stations.
GOAL 2 Science-Policy Networking	**2.3.b** Describe hierarchical framework of priorities for geodetic infrastructure needed to achieve 1 mm, 0.1 mm/yr TRF.

Contribute to the sustainability of the GGRF through collaboration with key UN initiatives on geodesy

GGOS Implementation Plan: BNO lead

GOAL 3 Capacity Enhancement and Sustainability	**3.1.e** Support/advocate new technologies to facilitate the expansion and improvement of the ground networks.
GOAL 3 Capacity Enhancement and Sustainability	**3.2.a** Simulations of ground network geometry and observation concepts.
GOAL 3 Capacity Enhancement and Sustainability	**3.2.b** Update the GGOS Requirements for Core Sites (2015) according to newest technological developments in the ITRF, IHRF and ITGRF.
GOAL 3 Capacity Enhancement and Sustainability	**3.2.c** Identify gaps, needs, and impact of changes in the ground and space segment.

Strengthen sustainable geodetic capabilities: measuring facilities, data analysis, geodetic methods, expertise

GGOS Implementation Plan: BNO lead

GOAL 4 Comprehensive and Cross-cutting Analysis	**4.3.c** Keep track of new analysis methods and product opportunities, e.g. missions not included yet in standard TRF products and all available co-locations.
GOAL 4 Comprehensive and Cross-cutting Analysis	**4.3.d** Benefits, opportunities, challenges, operational products of Genesis.
GOAL 4 Comprehensive and Cross-cutting Analysis	**4.3.e** Standardise local tie measurements, archiving and analysis procedures, up-to-date tie survey archive, encourage adoption of new techniques.

Engage across geodetic techniques for integrated geodetic research and technological developments

Some ongoing activities and plans

- Definition of GGOS **Core Site** → leading to the update of GGOS Requirements.
- Work withing Committee on Data and Information Systems to **include SLR** data in **GeodesyML**. Looking for volunteers: **o/**
- **Site Surveys**: status, difficulties faced by observatories?
- Work supporting the **UN-GGCE** to define what a robust set of networks should look like: analyses of current state, simulations.

Some ongoing activities and plans

- Definition of GGOS **Core Site** → leading to the update of GGOS Requirements.
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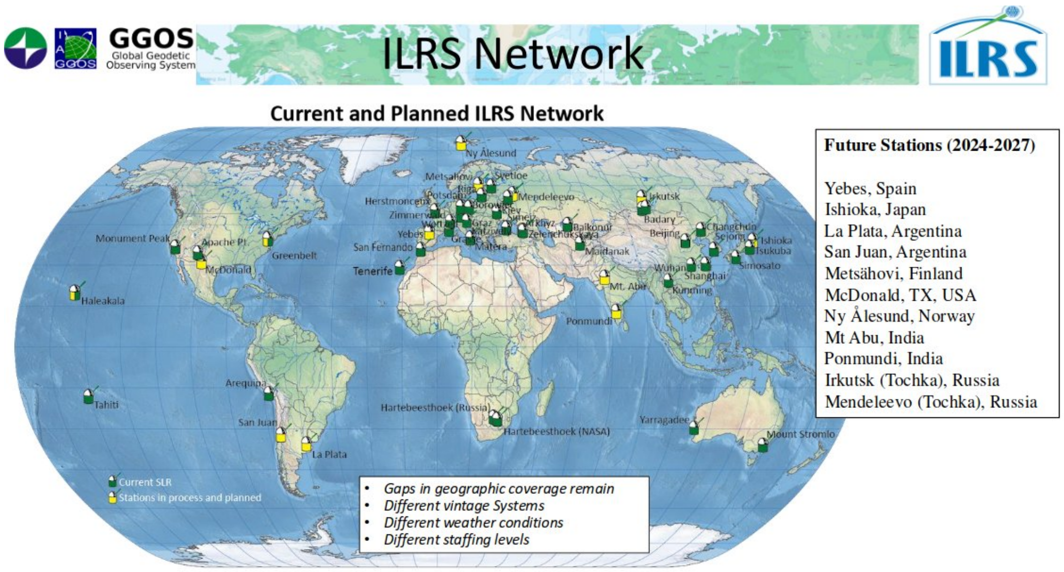
- **Site Surveys**: status, difficulties faced by observatories?
- Work supporting the **UN-GGCE** to define what a robust set of networks should look like: analyses of current state, simulations.

I will show some slides on the **state of the network** and on a recent **simulation** work.

ILRS current state and planned sites



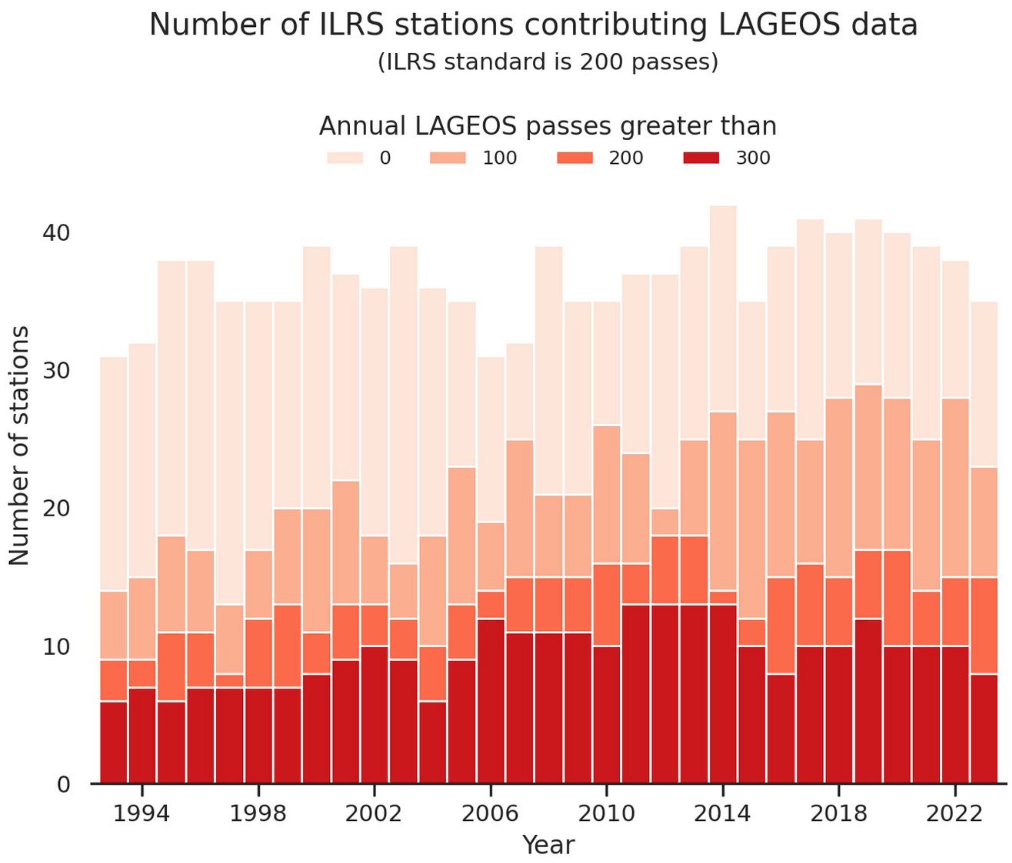
- Different degrees of uncertainty for the planned sites
- Africa and South America most obvious gaps
- No planned presence in Antarctica.

M. Pearlman. Presentation at the GGOS meeting, Bureau of Networks and Observations, Vienna (2024)

ILRS network evolution

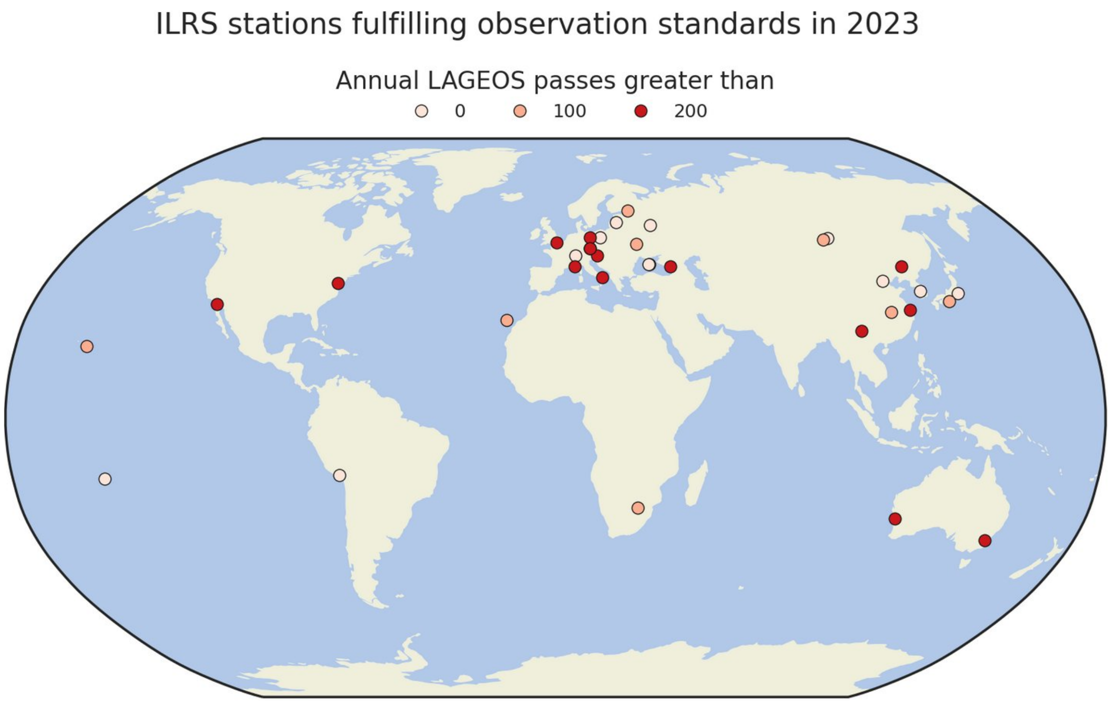
- The official ILRS products are based on the observations of satellites LAGEOS and LAGEOS-2 (mostly).
- Tracking LAGEOS and LAGEOS-2 (and LARES-2!) is the most **essential** contribution.
- The ILRS standard is **200 passes/yr** for these satellites.
- This is a **quite low:**
  - Six passes per week assuming observations made only 60% of the time (weather, outages, etc...)

ILRS network evolution



- The **overall number** of existing stations is roughly **constant** since the late 1990s.
- The number of stations with more than the bare minimum contribution, including those **not reaching** the ILRS standard, has **increased** steadily since the 1990s.
- Only **15 stations** deliver to the ILRS standard.
- Only **9-10 stations** of those provide a substantial contribution.

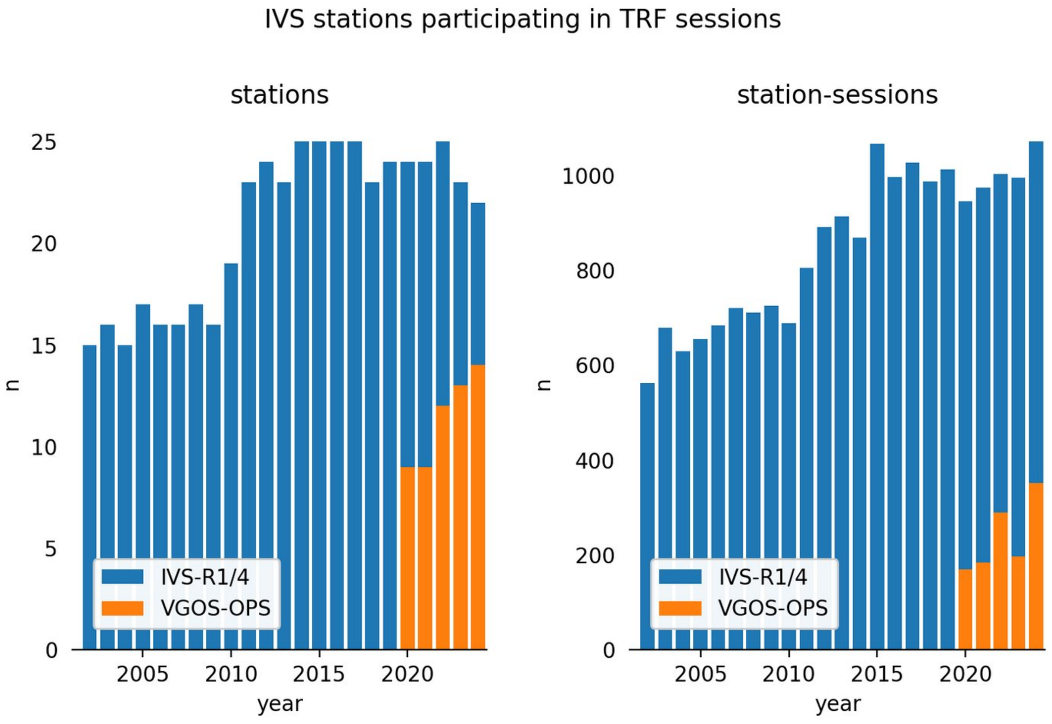
ILRS current state



The ILRS standard is a minimum of 200 passes of satellite LAGEOS per year

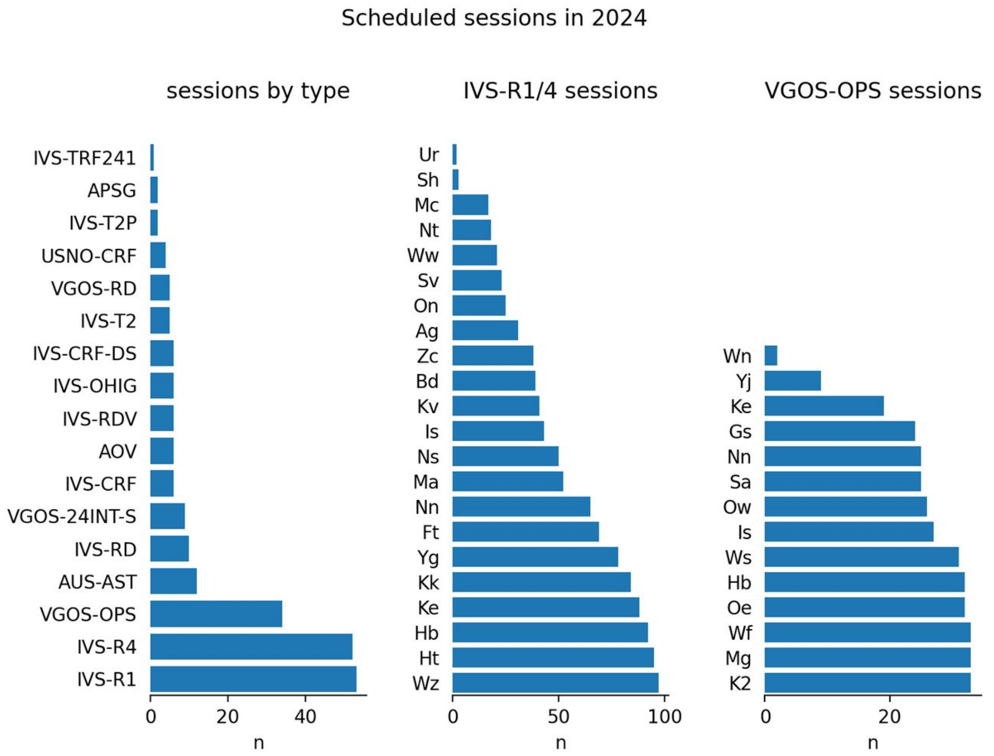
- The distribution of the network is **lopsided**.
- Presence in all continents but Antarctica.
- Huge gaps in the Southern Hemisphere.
- The core network that delivers up to ILRS standards is both **small** and very **poorly distributed**.
- Over **50%** of the sites are not operating as we wished.

Evolution of the VLBI networks



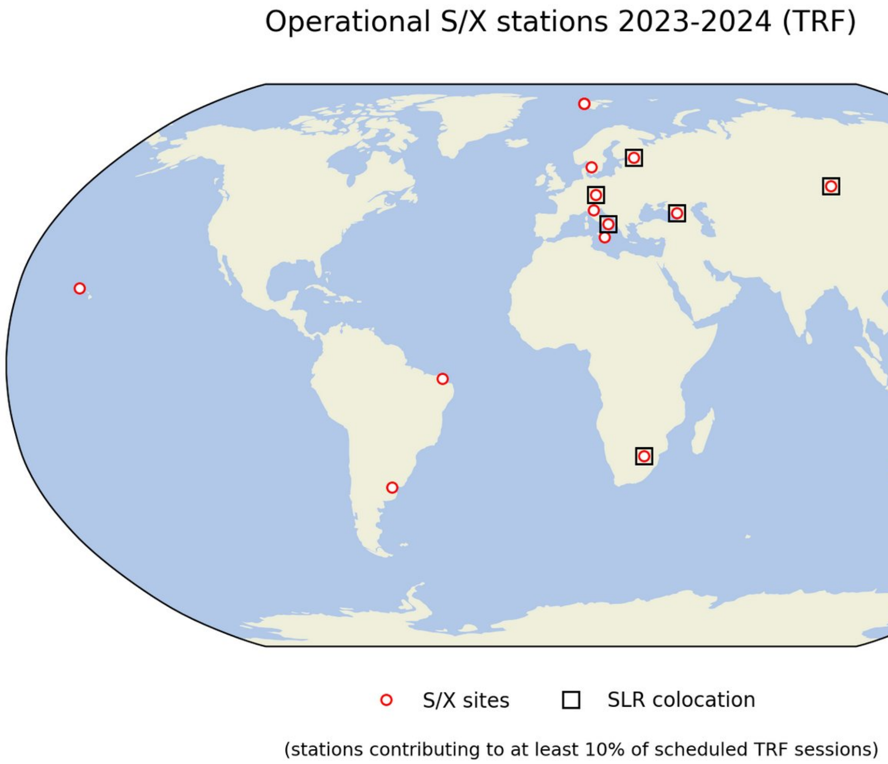
- Since ~2011 the **S/X** network has **stagnated.**
- The **VGOS** network is **growing** apace.
- In number of stations, the VGOS network is reaching the levels of the S/X at the beginning of the 2000s.
- In terms of sessions devoted to the TRF, the VGOS network is contributing less data because of **correlator bottleneck.**

Distribution of sessions



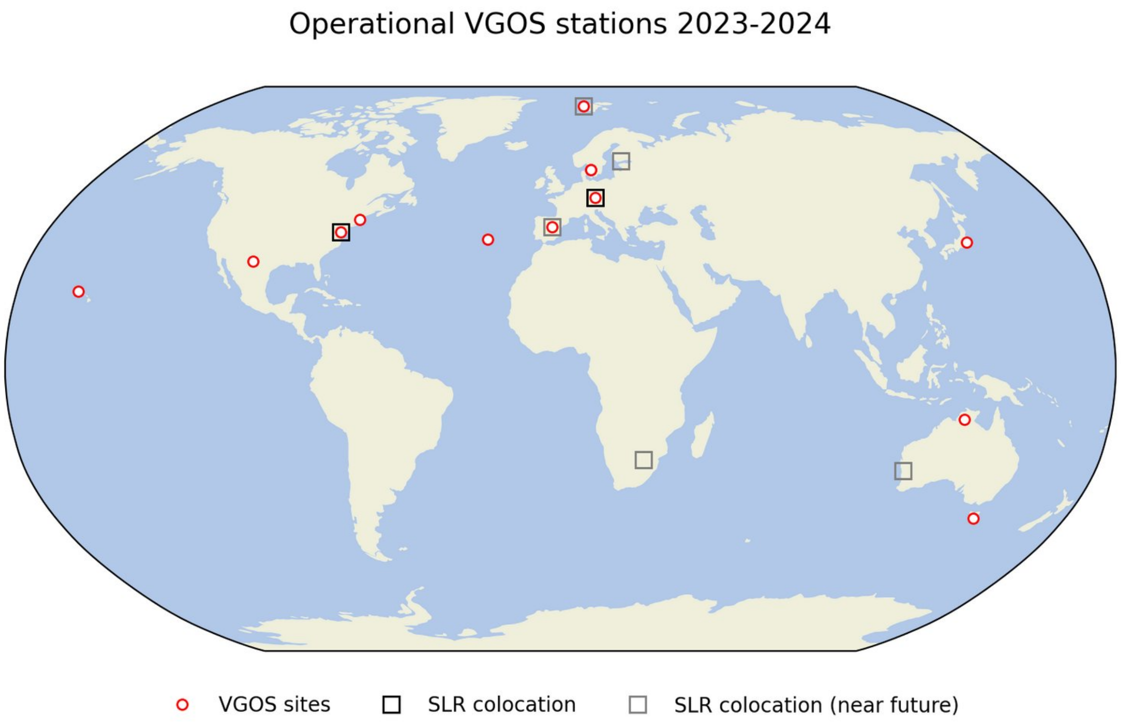
- The **S/X** network is scheduled **twice a week** for TRF observations (105 sessions in 2024).
- TRF **VGOS** sessions are **less than weekly** at the moment (35 sessions in 2024).
- The **S/X** network shows marked **differences** in the contributions from individual antennas, likely because of telescope time devoted to astronomy.
- The **VGOS** network is **dedicated** to geodesy, showing solid participation from all sites (except for downtime).

S/X current state



- The sites in the map are taken from the operational schedules for 2023 and 2024.
- Sites participating in less than 10% of the scheduled sessions were removed.
- A higher threshold would probably be more appropriate (20–30%?).
- The geographical distribution is not ideal, but not absolutely dreadful.

VGOS current state



- The sites in the map are taken from the operational schedules for 2023 and 2024.
- Some sites have a dual telescope setup.
- The geographical distribution is very poor.

Projections for VGOS future state

- Good outlook for VGOS in some regions, although the future sites shown will have different levels of uncertainty.
- Even the projected state of the network is very sparse, especially in Africa and South-America.
- No planned presence in Antarctica.

R. Haas. Presentation at the Expert Consultation on Strenthening the Geodesy Supply Chain, UN-GGCE, Bonn (2024)

Instituto Geográfico Nacional
CENTRO NACIONAL DE INFORMACIÓN GEOGRÁFICA

ILRS ground network simulations: the sans aus scenario.

José C. Rodríguez,[1,2] Liubov Poshyvailo-Strube,[3] Nicholas Brown[3]

[1]IGN, Spain; [2]GGOS BNO; [2]UN-GGCE

2024-12-17

GOBIERNO DE ESPAÑA MINISTERIO DE TRANSPORTES, MOVILIDAD Y AGENDA URBANA INSTITUTO GEOGRÁFICO NACIONAL

GGOS Global Geodetic Observing System

United Nations Global Geodetic Centre of Excellence

What’s this

The UN-GGCE has prepared, in consultation with experts from the geodetic community, the **1st Joint Development Plan for Global Geodesy** (JDP).

The JDP translates the geodetic needs of Member States and partners into strategic objectives and activities to **strengthen the global geodesy supply chain** (GGSC).

Three distinct phases:

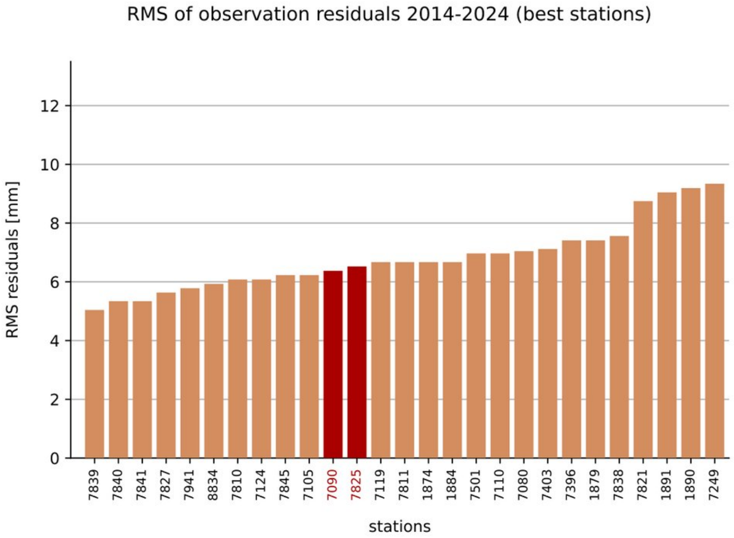
1. Avoid further degradation of the geodesy supply chain.
2. A robust global geodesy supply chain.
3. A next-generation global geodesy supply chain.

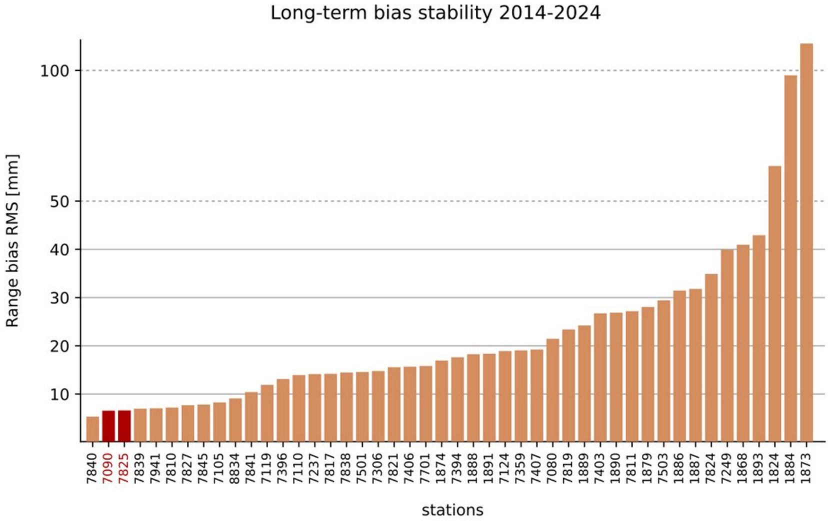
As part of the evidence gathering for the preparation of Phase 2, some tests were proposed to assess weaknesses of the current networks.

In this context, I simulated **what would happened if the Australian stations did not exist**.

The Australian stations

- Two SLR stations operate in Australia: Yarragadee (7090) and Mount Stromlo (7825).
- These are two of the best stations of the network according to all metrics.





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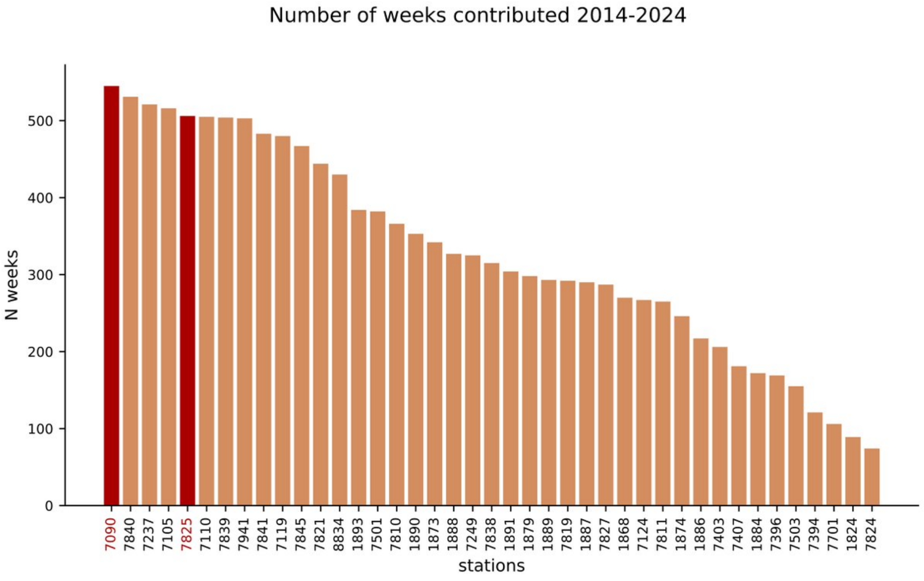
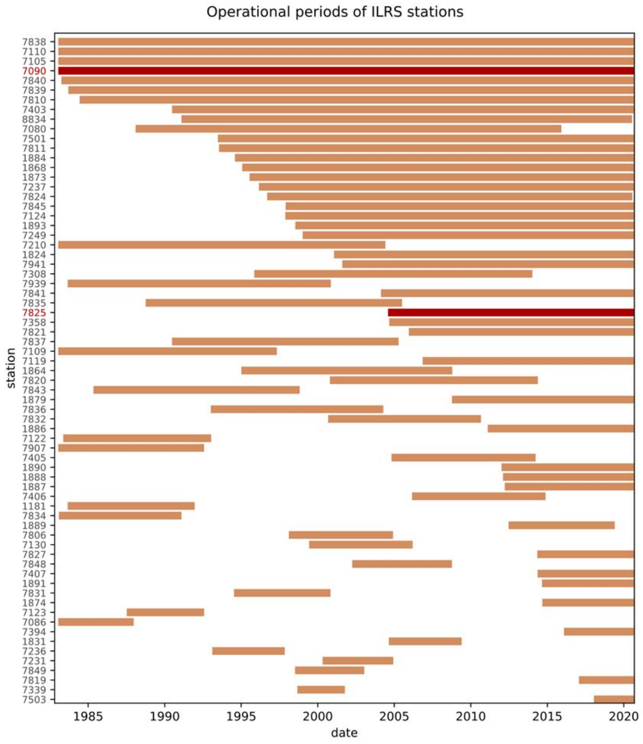




Test scenario: remove the Australian stations

What could be the effect on the ILRS products of losing just two stations?

Factors suggesting that this would be a severe loss for the whole network:

- **Geography**: two southernmost stations, no nearby sites in the area, covering a region of the globe that would otherwise remain unobserved.
- **Performance**: the precision and stability of the orbservations provided are of top quality. Both stations are part of the ILRS *core network*, used by analysts to determine the SLR reference frame.
- **Data volume**: consistently among the top performers of the network.

Results I. Data volume, observation precision.

Loss of 21% and 24% of LAGEOS and LAGEOS-2 observations, respectively.

Huge numbers, disproportionate with the size of the network. A **major contribution** to the observational efforts of the ILRS comes from Australia.

No significant differences in the post-fit RMS of the observation residuals.

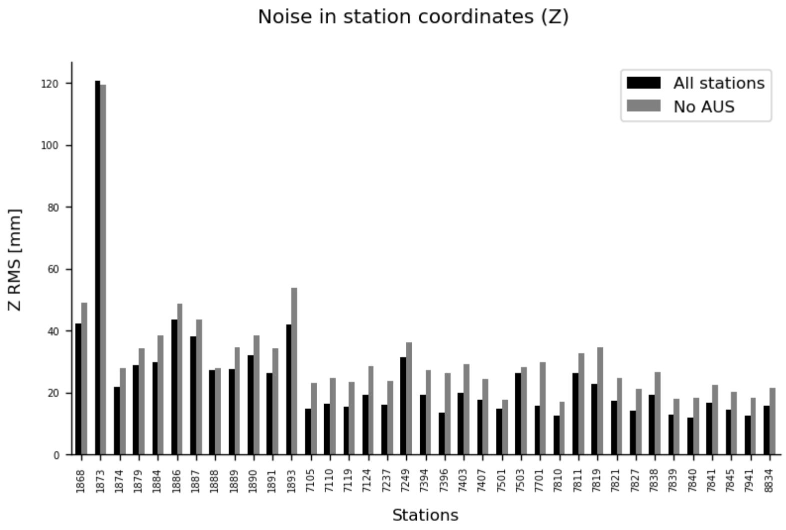
	# obs LG-1 [k]	# obs LG-2 [k]	RMS LG-1 [mm]	RMS LG-2 [mm]
All, no RB	734	637	7.4	7.0
All, RB	730	634	7.0	6.5
No AUS, no RB	578	483	7.3	6.8
No AUS, RB	580	483	6.8	6.4

Results II. Coordinates precision.

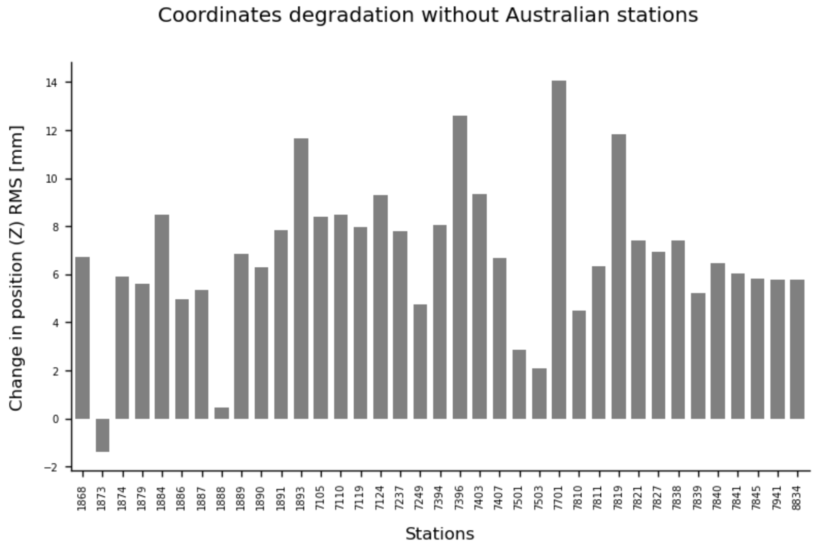
Significant **degradation** of the **Z** component of the station positions.

About 6.8 mm higher RMS on average, and up to over 1 cm in several cases.

The ILRS network quality is noticeably affected without the Australian contribution.



RMS values



RMS difference No Aus – All

Degradation

(+)

Improvement *(?)*

(-)

Results III. Frame stability.

Significant differences in the offsets and rates of defining parameters of the reference frame, some of which beyond the GGOS goal of 1 mm and 0.1 mm/y.

(epoch: 19:001)	**ΔX** [mm, mm/y]	**ΔY** [mm, mm/y]	**ΔZ** [mm, mm/y]	**Δs** [mm, mm/y]
All – No AUS, no RB	**2.7** – 0.05t	**-2.5** + **0.46**t	0.59 + **0.59**t	**-1.36** – 0.05t
std. errors	(0.15 , 0.05)	(0.19 , 0.06)	(0.41 , 0.13)	(0.14 , 0.05)
All – No AUS, RB	0.58 – 0.02t	**-1.29** – **0.23**t	0.84 + **0.51**t	-0.50 + 0.01t
std. errors	(0.23 , 0.07)	(0.27 , 0.09)	(0.69 , 0.23)	(0.17 , 0.06)

Results V. Orbits.

Worse consistency of the orbits when the Australian observations are included: higher dispersion of the orbit differences in all components (radial, across- and along-track).

x5 increase in the radial direction relative to the standard solutions.

	RMS of orbit component [mm]		
	ΔR	**ΔS**	**ΔW**
All stations (RB vs No RB)	1.0	8.2	12.8
All vs No aus (no RB)	5.1	20.7	22.8
All vs No aus (RB)	5.3	19.5	22.7
No Aus (RB vs no RB)	3.0	12.0	10.7

Conclusions II

- We have found significant differences in the standard products of the ILRS that would arise from the loss of the Australian contribution.
- The differences are found in the orbits, the Earth rotation parameters, the coordinates of the rest of the network, and hence in the quality of the SLR frame.
- Through the estimated orbits and Earth rotation parameters, all stations define and share a common frame.
- Lacking the quantity and quality of these observations, the estimated positions of the rest of the ILRS network and global products deteriorate.
  - Noisier station coordinates
  - Less precise global frame
  - Frame deformations
  - Less precise ERP

Conclusions IV

- With the loss of just two (carefully selected) stations causing so much damage, it seems clear that the ILRS network is far from being robust.
- No regional redundancy for the global SLR network to be robust.
- The required redundancy is contingent on the specifics. For instance, likely the poor coverage and performance in the southern hemisphere makes the Australian stations more important.
- All this highlights how much we are missing from the lack of good quality and productive stations in the South.

Thank you

SLR activities at GFZ

Julian Rodriguez, Stefan Weisheit, Frank Flechtner

Overview

- Improvement of Operations at POT3 in 2024
- European Laser Time Transfer
- GRACE-C Laser Retroreflectors
- Future POT4

Improvement of Operations @ POT3 in 2024

- <u>**HighQ Laser check and improvement**</u>
- Enhanced transmission in Tx & Rx
- <u>**New TEC for old HighQ laser**</u>
- Replacement of diode (seeder) or fiber laser (regen)? / Passat laser
- <u>**New telescope mount models**</u>
- Enhancement of data processing chains
- Effort acquiring observations: <u>Thanks to all our observers</u>

HighQ laser check and improvement

Problem: Given an undocumented, unsupported, upgraded in 2017 laser system, ensure its operations plus strategy for the future.

Solution:

- Collect evidence: output power, beam shape, contrast ratio, voltage level of PC, current for the regen, working hours of pumping sources, etc.
- When you cannot explain certain abnormal patterns (magnitude and shape of pre- and post-pulses): seek for help (Dr. Gabor Kulcsar).

Take away: laser system was optimized aiming to extend the lifetime of the most critical components: pumping sources, while keeping a decent output power (GNSS → no problem).

New TEC for old HighQ laser

Problem: TEC controller provided with HighQ was one of the most frequent reasons of system failure.

$$\frac{R}{R_0} = e^{B\left(\frac{1}{T}-\frac{1}{T_0}\right)} \rightarrow \text{PID}$$

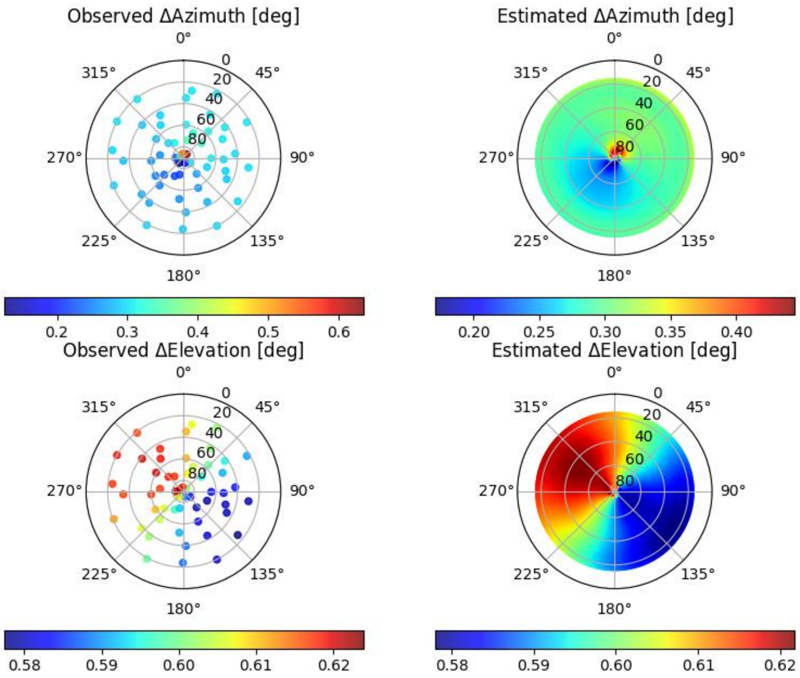
https://www.ibrtses.com/products/tecmanual2006.html

Solution:

The reference values for HighQ were not longer valid for the new TEC. We had to:

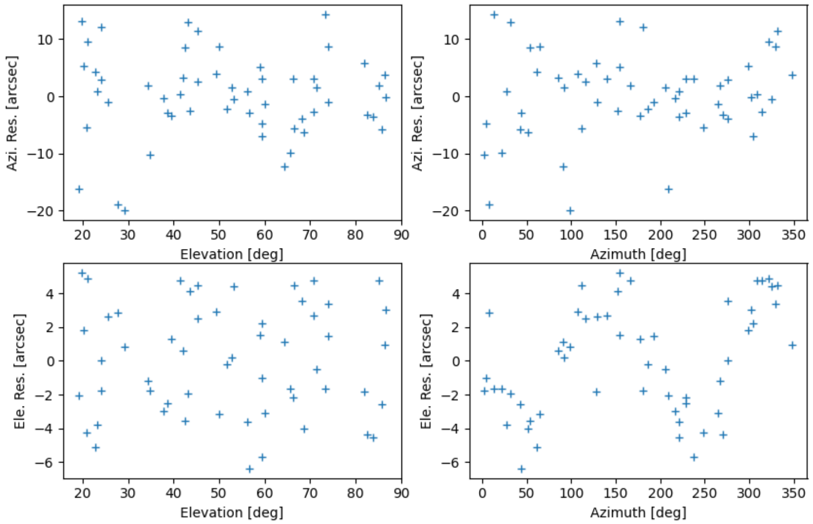
1. Find out the right values for the new TEC for *setpoint*, *beta(B)*, *base resistor* and *LED voltage*.
2. Optimize the temperature values for the SHG aiming at maximum output power avoiding depletion i.e., spread of pulse width.
3. Check the single-shot RMS & output power.

New Mount Models (Rx example)



- Mount model available from the legacy of the station seems to fit the observations
- Mind the behavior of the telescope in azimuth for large elevations
- Critical distribution of measurements over the sky
- Regular estimation of the model to improve pointing
- But…

New Mount Models (Rx Example)

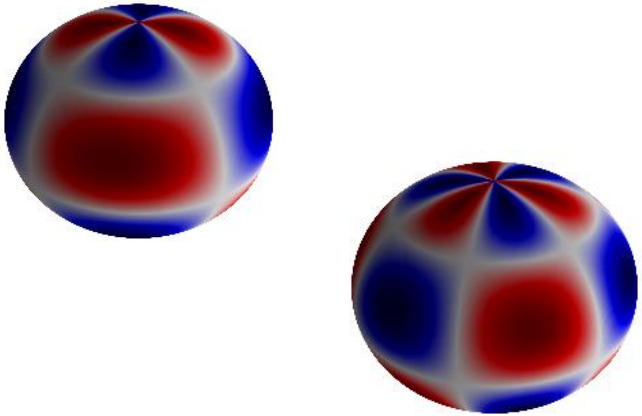


- Residuals seem to indicate that there is room for improvement, but how?
  - Extend the existing models using 2D-Fourier
  - Explore alternative parametrizations

New Mount Models

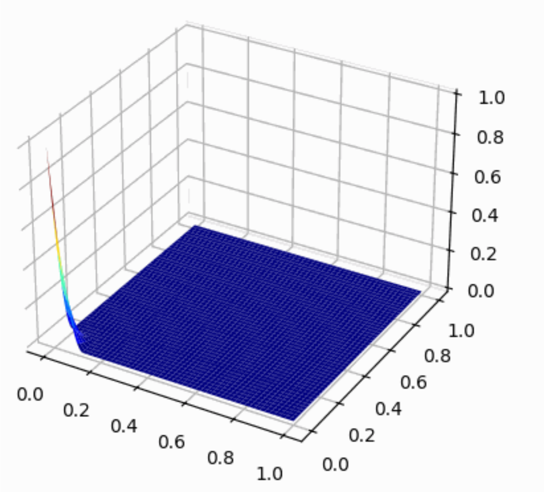
2D-Fourier

$$f(Az, El) = \sum_{i=0}^{\infty} \sum_{j=0}^{\infty} (a_{i,j} sin(jAz) sin(iEl) + b_{i,j} cos(jAz) sin(iEl) + c_{i,j} sin(jAz) cos(iEl) + d_{i,j} cos(jAz) cos(iEl)).$$



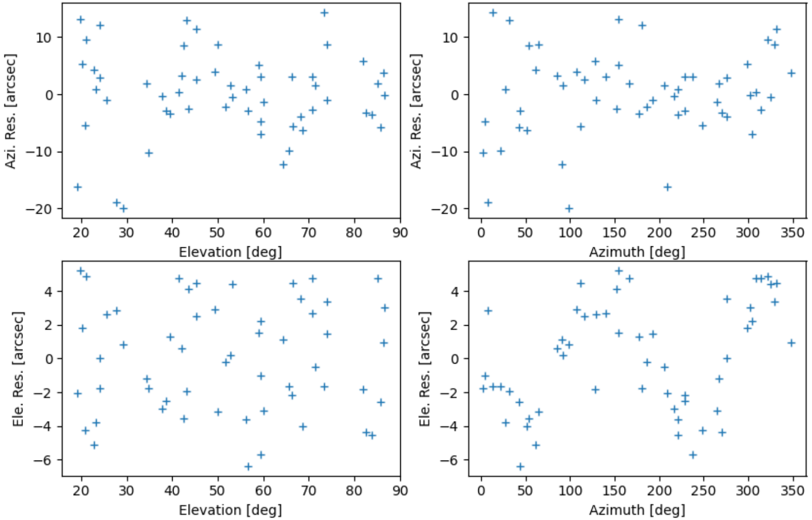
Tensor Product of Trig. B-Splines

$$s(x_1, x_2) = \sum_{k_1=1}^{K_1} \sum_{k_2=1}^{K_2} d_{k_1,k_2}^{J_1,J_2} \Psi_{1_{k_1}}^{J_1}(x_1) \Psi_{2_{k_2}}^{J_2}(x_2).$$

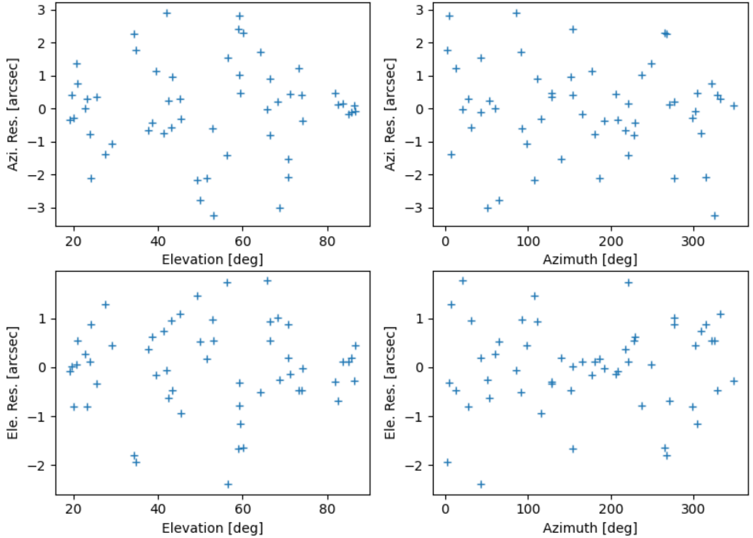


New Mount Models (Rx)

Before

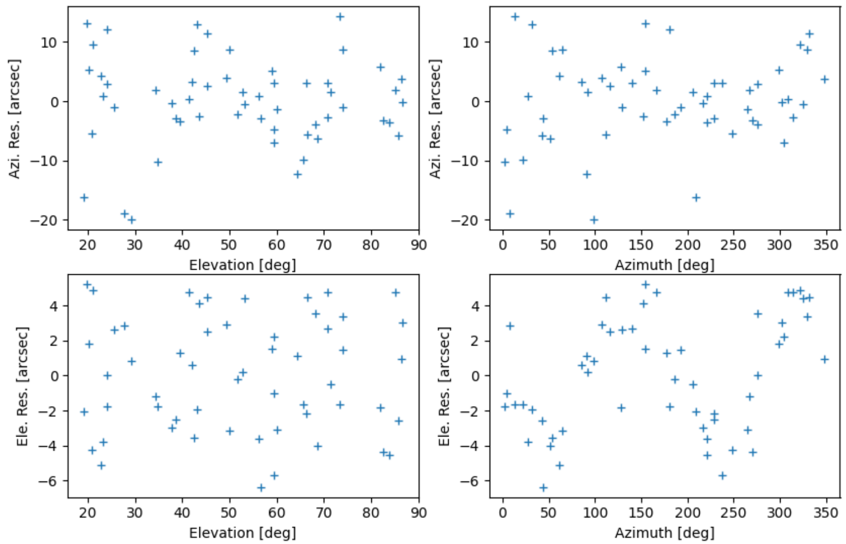


After 2D-Fourier

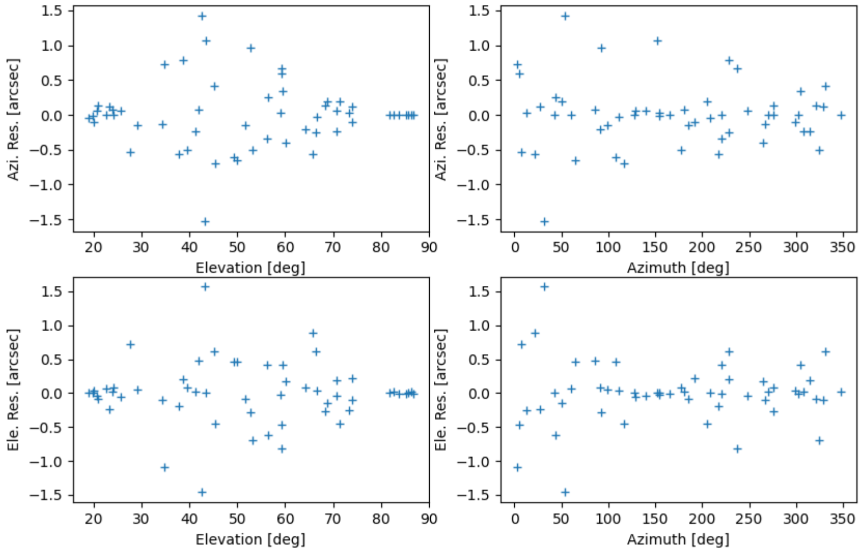


New Mount Models (Rx)

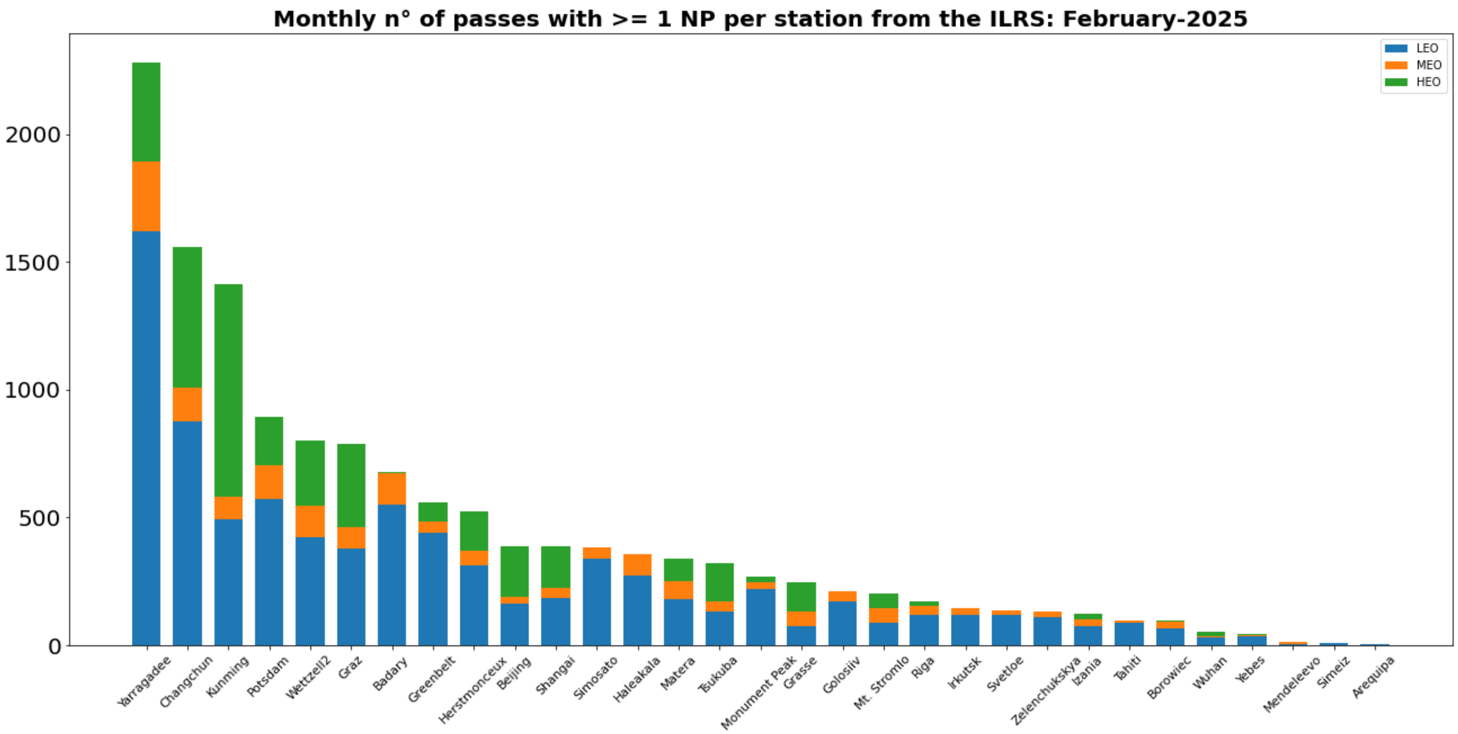
Before



After Tensor Product Trig. B-splines



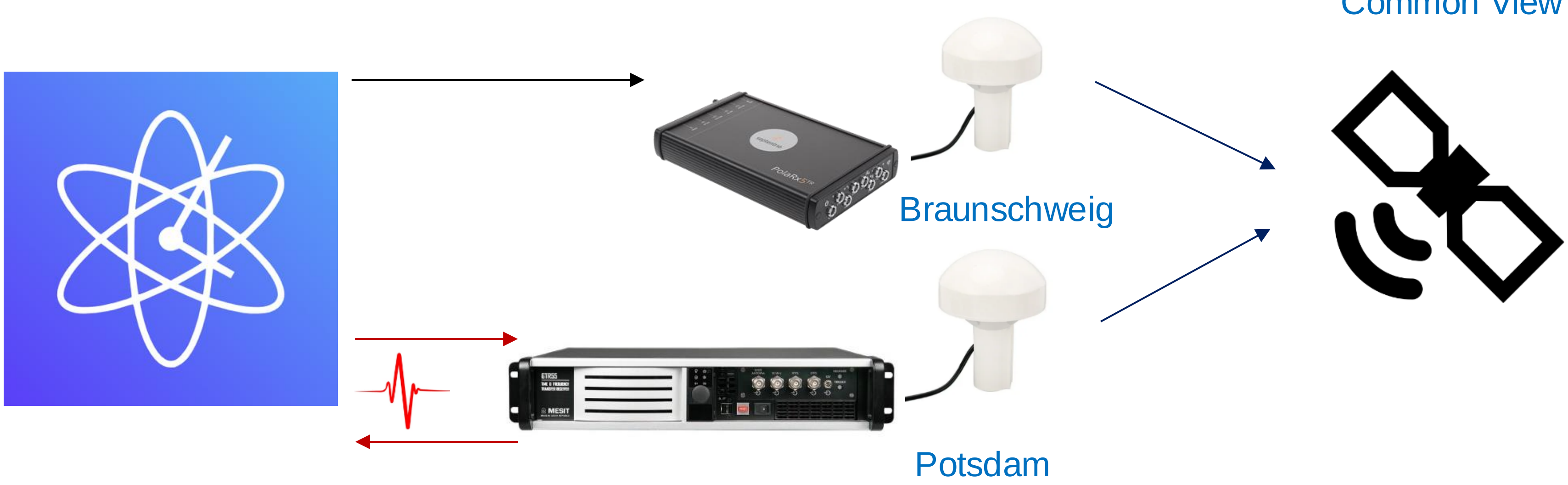
Overall Results



European Laser Time Transfer Experiment

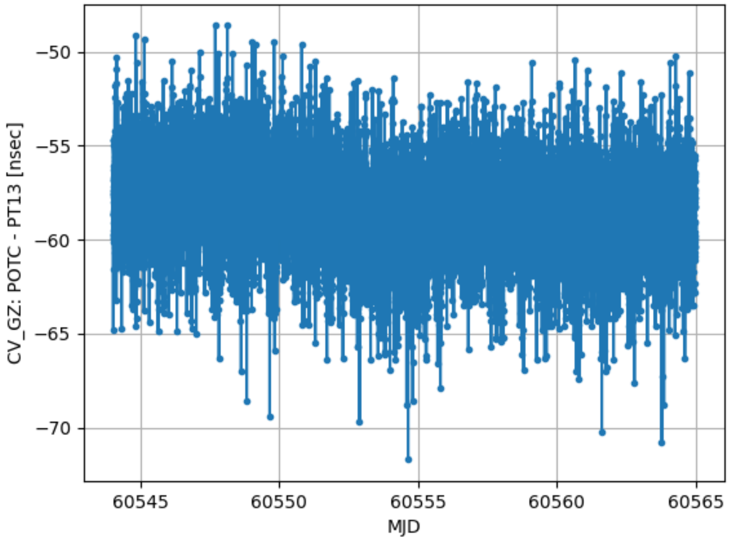
Time link with UTC(PTB) via 1PPS & 10 MHz

How to monitor the one –way 1PPS?



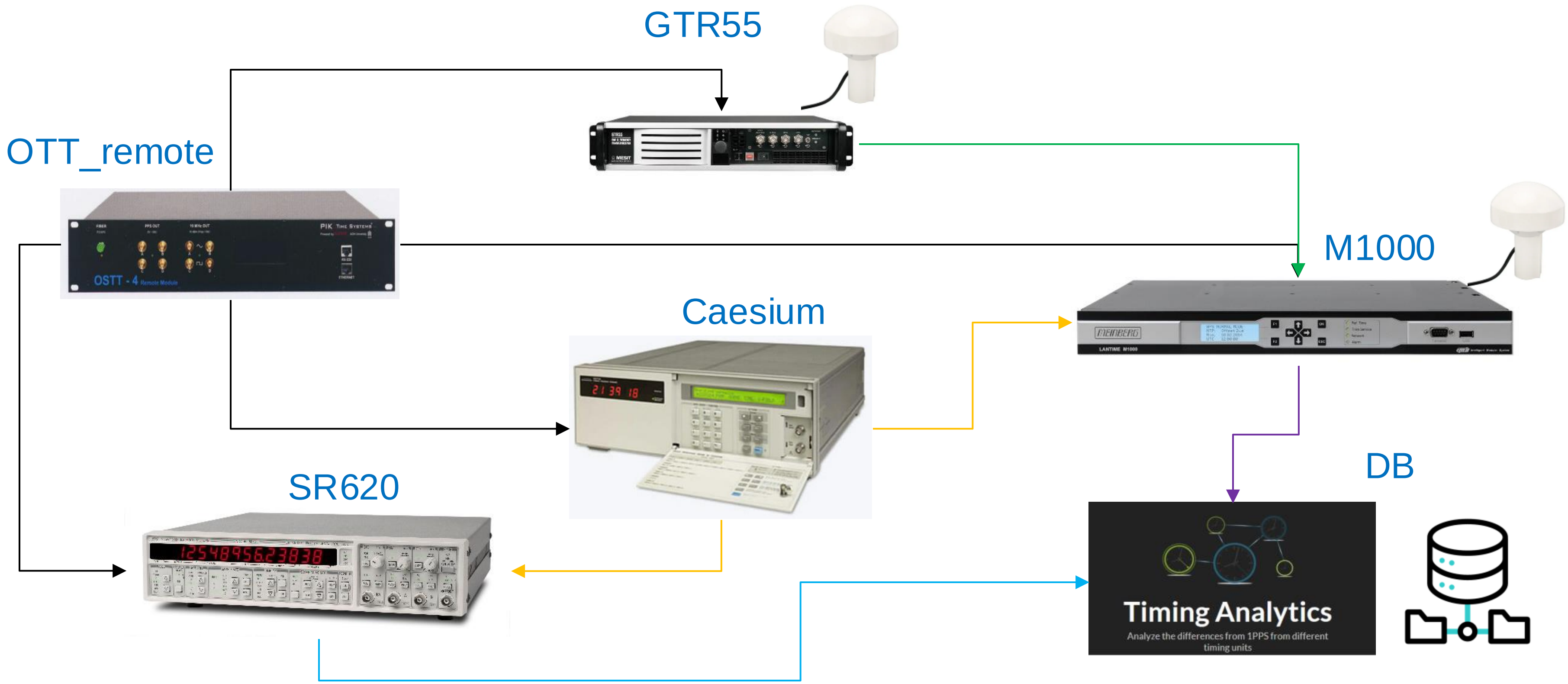
Time link with UTC(PTB) via 1PPS & 10MHz

Common View POTC – PT13



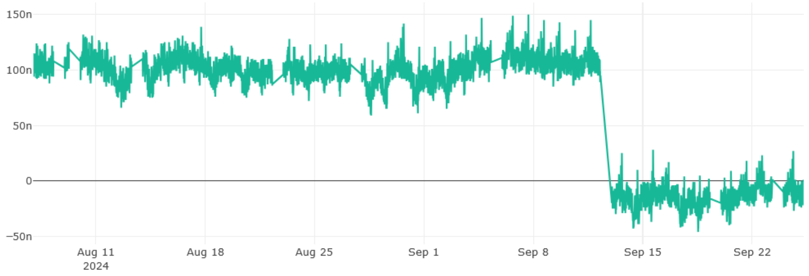
- Issues with the 1PPS from UTC(PTB) → 43.6 nsec
- Remaining offset and nonlinear behaviour remains unexplained. Visit to PTB to calibrate our receiver in their facilities
- Should we trust only the GTR55?

Resilient Time Monitoring

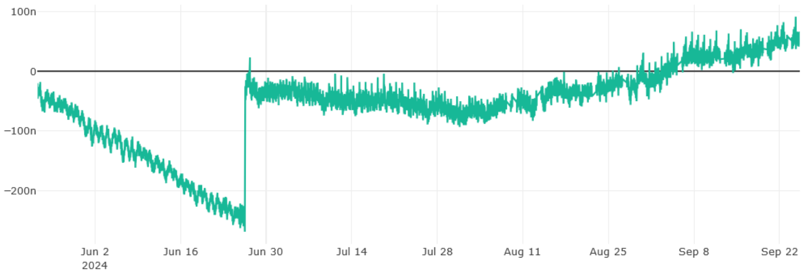


What is the outcome?

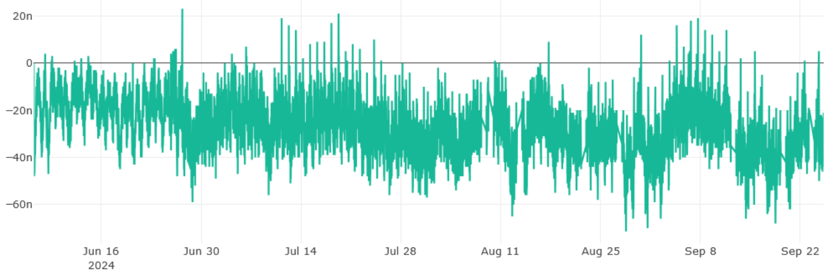
GTR55 vs. M1000



Caesium vs. M1000

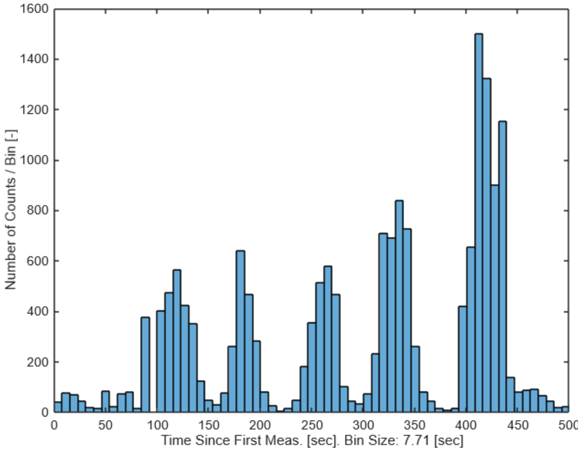


OTT_remote vs. M1000

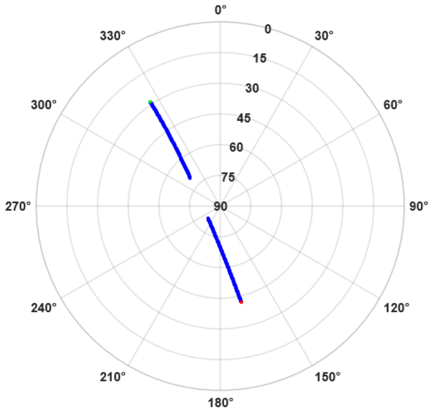


Laser System: Safety First

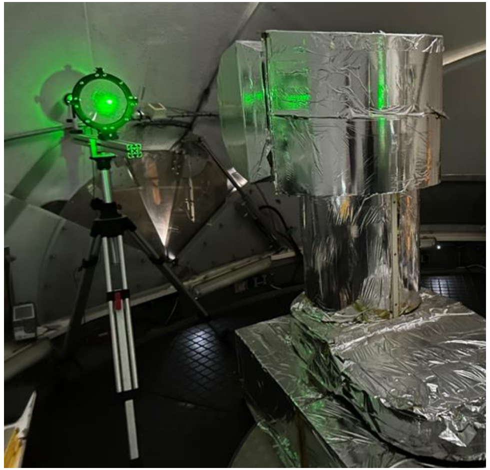
Minimum Divergence: 20 arcseconds



Example Lares-2 HC pass

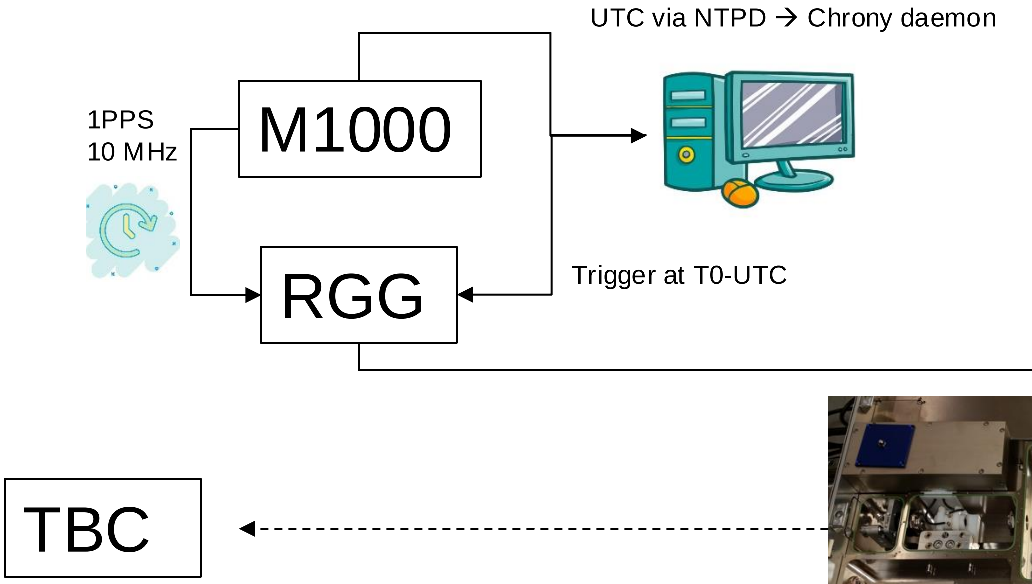


Energy per pulse 183 uJ



We are eye safe only when working at max divergence: 40 arcsec!

Laser System: Ensuring the 100 nsec firing accuracy



- Many open questions
- Many configuration changes
- Many tests to be done

2kHz +- (?)
FO to avoid pulse collision

Laser System: what comes next?

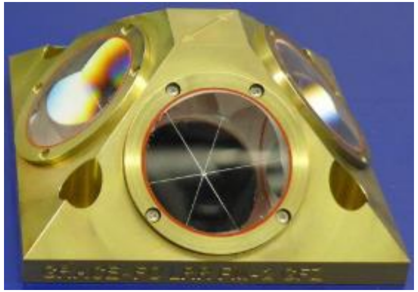
- Tests with the fast optical detector (start diode)
- Test the new NPET
- One-way calibration delay estimation
- Setup FTP for Go/NoGo flag
- …

Special thanks to Horst Ender from Telekom, Andreas Bauch (PTB), Florian Heimbach (PTB), Johann and Jan from Wettzell. We appreciate a lot your support! ☺

GRACE-C Laser Retroreflectors

Context:

- Successor of GRACE-FO → GRACE-C (launch end of 2028)
- We follow the traditional GFZ design, but…

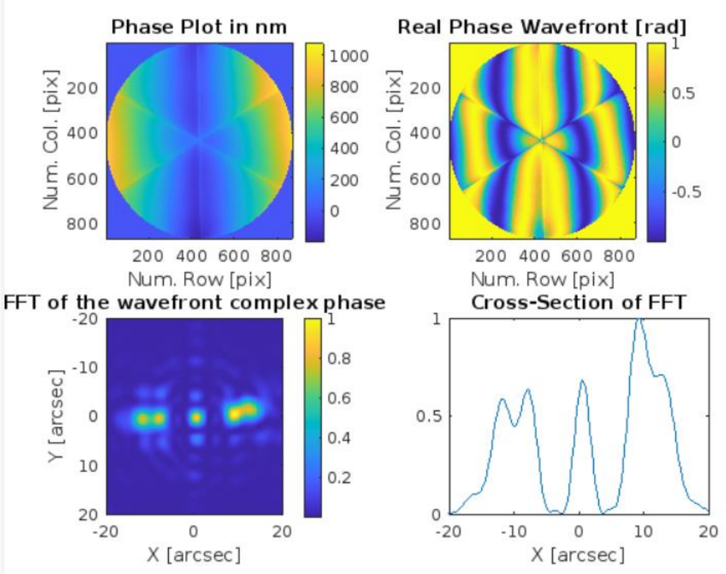


Example of LRR for the GOCE mission

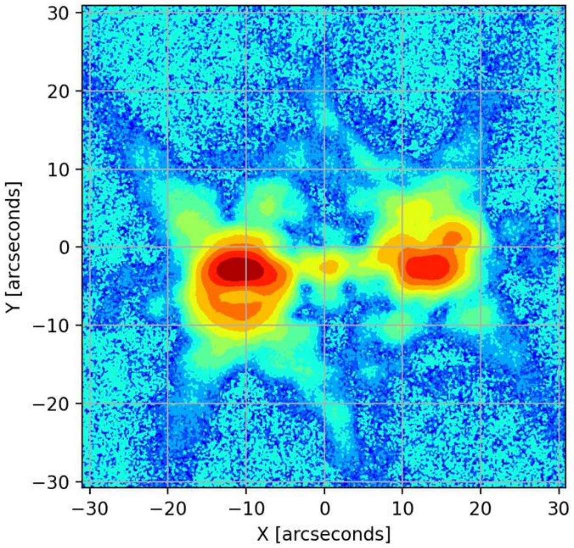
- New regulations regarding chromatation procedures
- Classic screw types are not longer supported (DIN 912 M2 x 8 A4/80)
- New personnel handling the provision of corner cube prisms at Zeiss
- Critical deadline on our side

Examples of FFDP

Zygo Interferometer



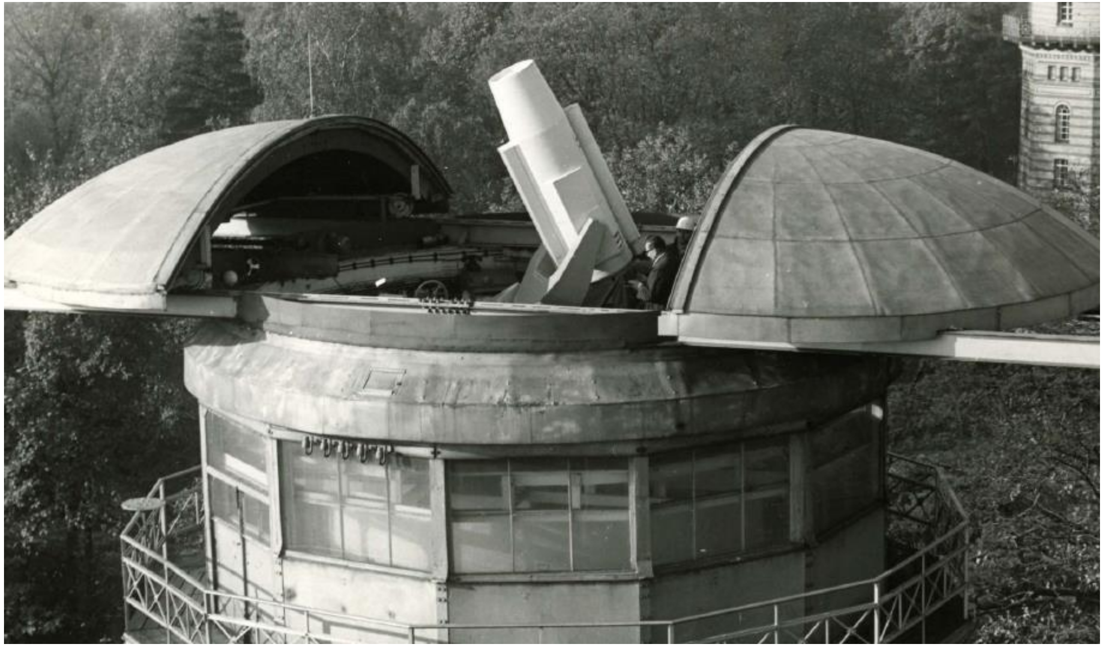
GFZ’s Optical Lab



Color coded normalized logarithmic scale

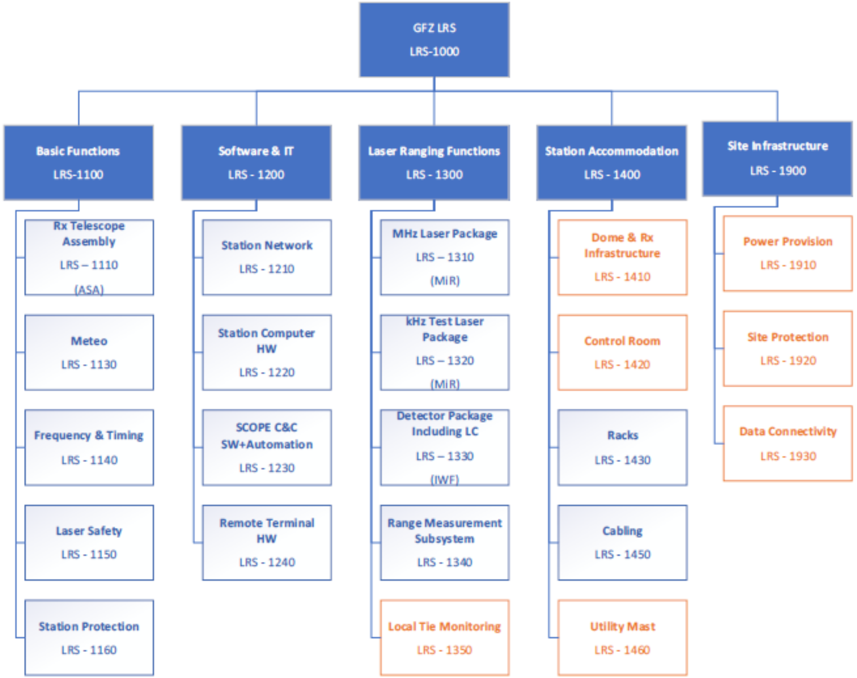
Future POT4

Back to the Roots



First Generation Laser Ranging System 1968

Embracing New Technologies: MHz



Images generated by DiGOS

Discussion

- 1 laser package (Tx) + 2 laser units (MHz & kHz) → Swapping between laser heads as needed (ONLY 1064 nm)
- 2 laser packages (Tx) co-mounted on the telescope + 1 MHz laser unit (1064 nm & 532 nm) kHz laser provided by GFZ
- Pros & Cons?

Thank you for your attention!

NESC - ILRS

news

Upcoming meeting

https://space-debris-conference.sdo.esoc.esa.int/

Welcome

9th European Conference on Space Debris

World Conference Center Bonn, Germany | 1 - 4 Apr 2025

Organiser: Space Debris Office (OPS-SD)
ESA-ESOC | Darmstadt, Germany

Meeting of the ILRS Space Debris Study Group (SDSG):
Wednesday, April 2nd 2025, between 14:00 and 15:00 CEST (12:00-13:00 UTC).

Contacts: Michael Steindorfer, Daniel Kucharski

Upcoming meeting

Genesis Science Workshop 2025
3-4 April 2025 | Matera | Italy

esa

Home Calendar of Events Programme Registration Venue Accommodation Contact Details

Genesis Science Workshop

3rd-4th April 2025

A two-day scientific workshop is organised by ESA on 3rd-4th of April 2025 at Matera, Italy in collaboration with ASI Centre for space geodesy. The event aims to bring together the Genesis scientific community and ESA project team for valuable exchanges on Genesis mission.

The event will feature presentations from ESA Project Team on Genesis project development, including industrial contributions, keynote speakers, discussions on Genesis Science Exploitation Team (GSET) activities, and Genesis science objectives. ESA sees this as an opportunity to refocus the Genesis GSET working groups objectives for 2025. Additionally, it will offer interactive sessions for each working group to facilitate exchange and collaboration on mission-related topics, as well as networking opportunities.

The workshop is free of charge. Participation online is possible but participation in person would be highly appreciated.

We look forward to welcoming you at the event,

ESA Genesis Team

CALENDAR OF EVENTS

Event	Date
REGISTRATION OPEN	End of Feb 2025
FINAL PROGRAMME	Early March 2025
REGISTRATION CLOSES	20th March 2025
DAY OF THE EVENT	3rd-4th April 2025

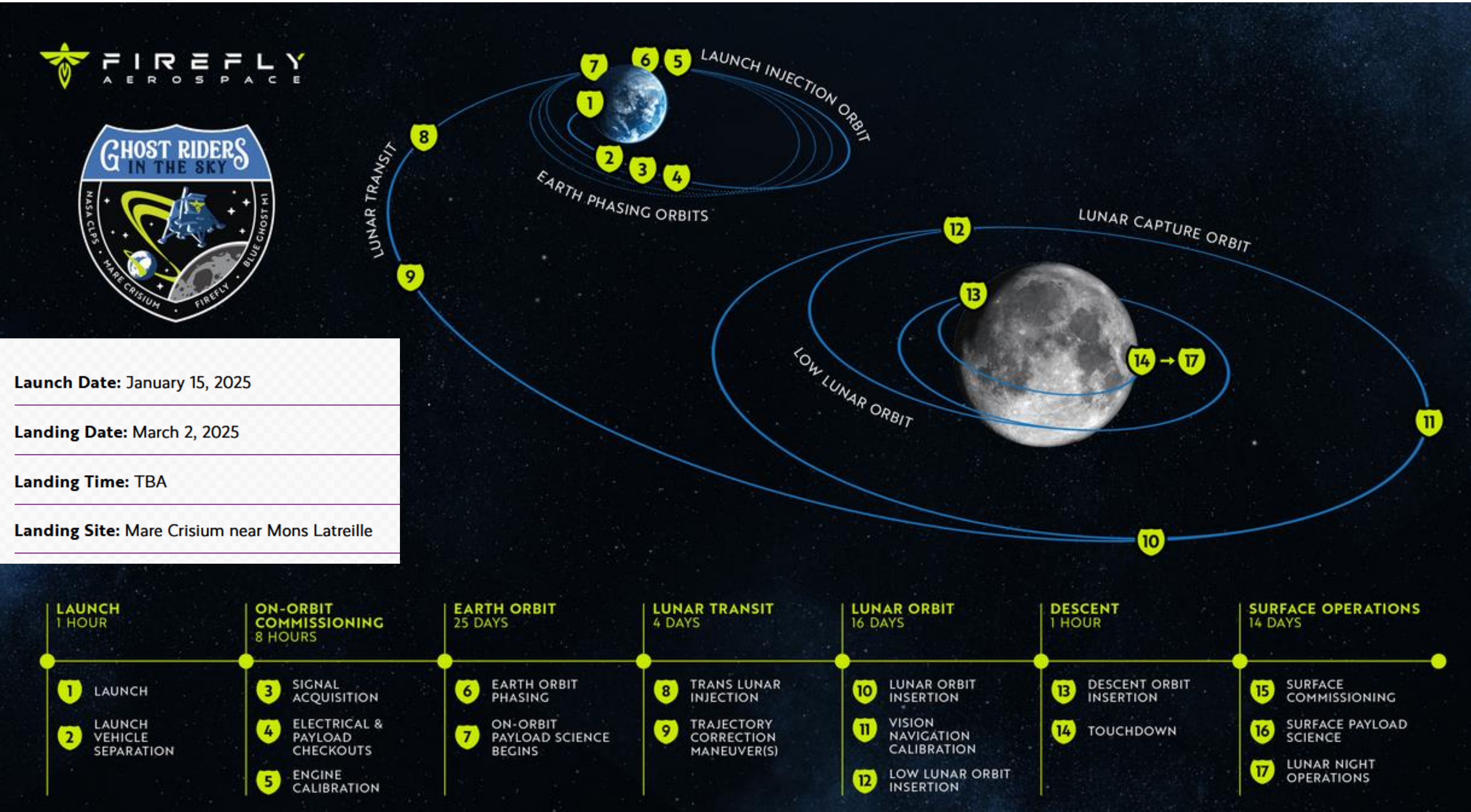
PROGRAMME

Day 1	3rd April 2025	Day 2	4th April 2025
8:00 - 9:00	Registration	09:00-11:00	Morning Session 1
09:00 - 11:00	Morning Session 1	11:00-11:30	Coffee break
11:00 - 11:30	Coffee Break	11:30-12:30	Morning Session 2
11:30 - 12:30	Morning Session 2	12:30-13:30	Lunch break
12:30 - 13:30	Lunch break	13:30-16:30	Matera Geodesy Space centre tour
13:30 - 15:00	Afternoon Session 1		
15:00 - 15:30	Coffee Break		
15:30 - 17:00	Afternoon Session 2		
19:00 – 22:00	Networking Dinner (optional)		

https://atpi.eventsair.com/genesis-science-workshop-2025/

NGLR-1

- https://fireflyspace.com/missions/blue-ghost-mission-1/



NGLR-1 : on the Moon March 2^{nd} 2025

Congratulations to Firefly & NASA & INFN for this achievement

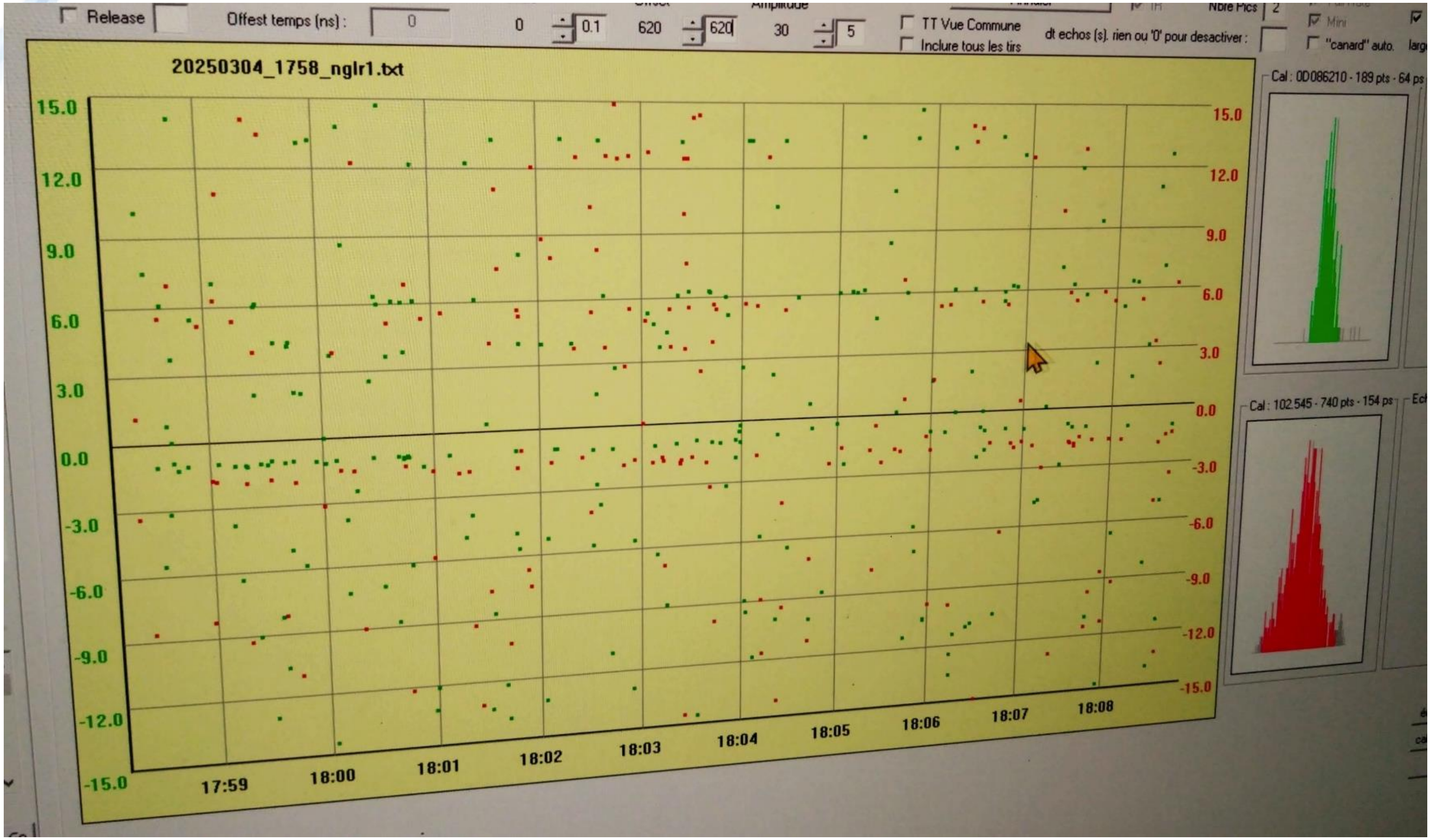
And thank you for giving all the LLR stations the opportunity to try range measurements on this new laser reflector.

NGLR-1 : First echoes at GRSM / MéO March 3rd 11H30 TU in IR

With POLAC prediction
⇒ offset of +620 ns
⇒ (~less than 100 meters regarding the initial coordinates)
shared with ILRS CB and Wettzell

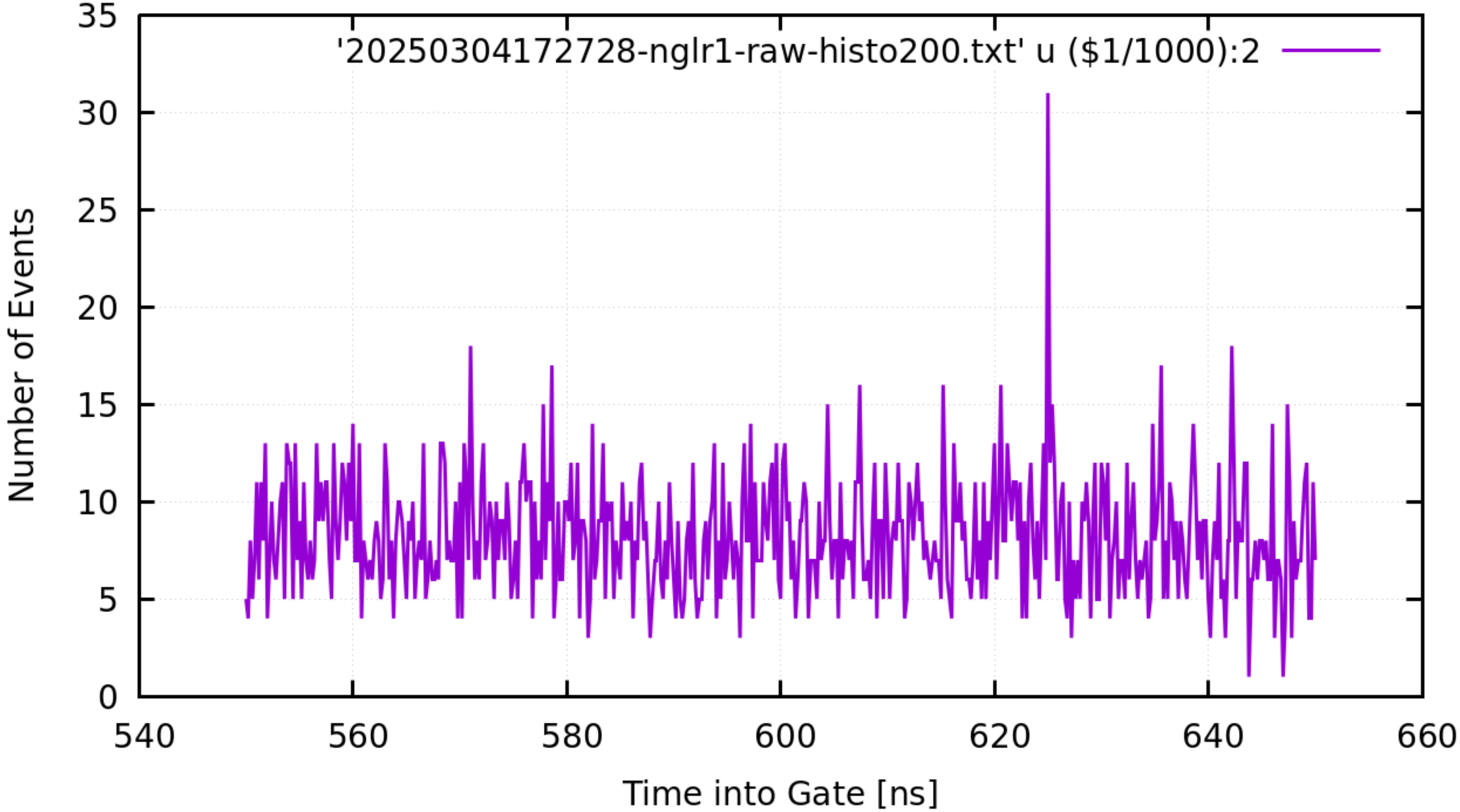
March 3rd: 19 NPs in IR

NGLR-1 : First echoes at GRSM / MéO March 4th in 2-colors



March 4th : 28 NPs including 10 in 2-colors.
Ranging up to 20° of elevation

NGLR-1 : First echoes at Wettzell March 4th in IR



Congratulations WLRS !!

NGLR-1 : perspectives

- Help the other LLR stations to succeed (on going discussion with MLRO)