Compact Q-Switched DPSS lasers

QS LASERS

International Laser Ranging Service

Profile

Manufacturer of compact, DPSS lasers for scientific and industrial applications. Our aim is to bring cost effective lasers to medical and industrial OEM markets

Accumulated experience in laser development, production and service over 35 years.

Advanced short pulse generation technology

Designing and adopting lasers for OEM needs

Series production

Employees – team of 34 professionals

Founded in April 2018

QS LASERS

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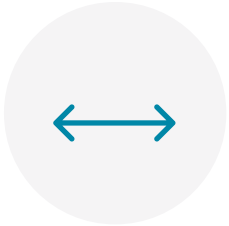
Field of expertise

Diode pumped Nd:YAG, Nd:YLF, Nd:YVO, Nd:YAP lasers + harmonic generators

01



Short pulse generation
(20 -50ps , 250-500 ps, <3 ns)

02

Pulse energy
(1uJ - 50 mJ)

03

Repetition rate
(single shot to 1000 Hz)

04

Custom laser systems
for specific applications

05

Products range

125 x 295 x 76 mm (W x L x H)

Passive Q-Switched laser **MPL2510/MPL2310**
Up to 2 mJ, 1-100 Hz, 250-500 ps,
1064 nm, 532 nm, 355 nm.

163 x 295 x 53.5 mm (W x L x H)

Active Q-Switched laser **MPL15100**
0.5 mJ, 1 kHz, < 700 ps,
1064 nm, 532 nm, 355 nm.

420 x 280 x 170 mm (W x L x H)

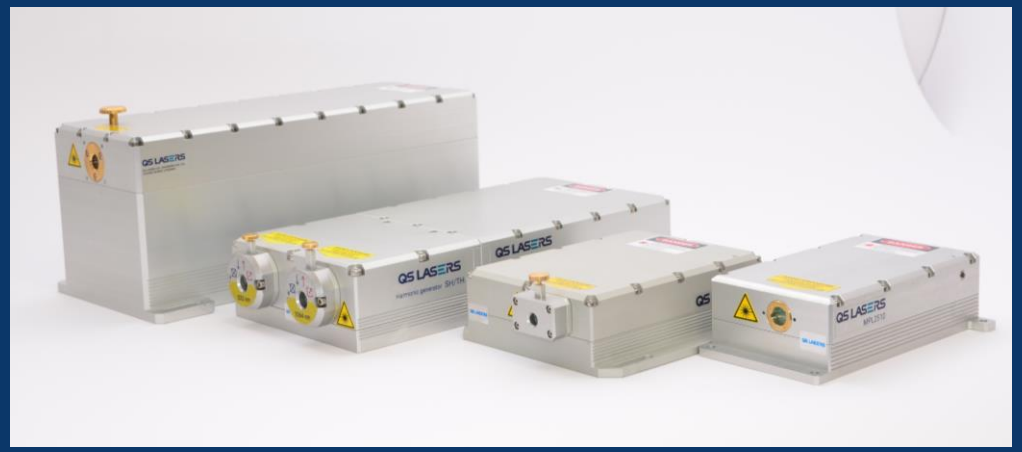
ANGIS
100 µJ, SS – 10 kHz, < 50 ps,
1064 nm, 532 nm, 355 nm.

Product Summary

Passive Q Switch Lasers
1064nm, 532nm, 355nm, 1-4mJ, 250-500ps, 1-100Hz

Active Q Switch Laser
1064nm, 532nm, 355nm, 0.5-0.15mJ, 700ps, 1-1000Hz

Gain Switch laser Angis
1064nm, 532nm, 355nm, 1-100uJ, 50ps, 10kHz



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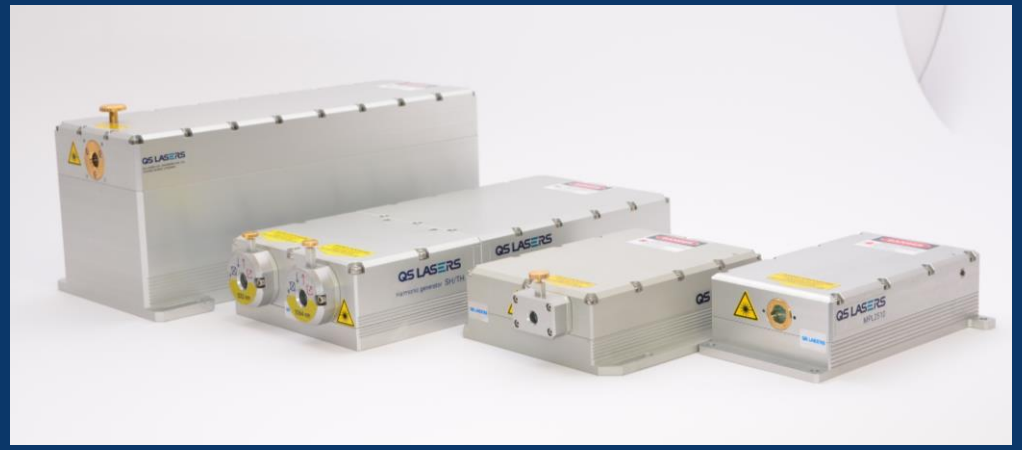
Applications of our lasers

- Remote Laser Ranging
- Seeder for amplifiers in the medical field
- Remote sensing
- OLED repair
- LIDAR
- Digital holography
- Laser Induced Breakdown Spectroscopy
- Non-linear spectroscopy
- Medical diagnostic systems
- Matrix-Assisted Laser Desorption/Ionization (MALDI)



QS LASERS

Benefits of our lasers

- Pulse energy stability
- Air Cooled
- Compact Size
- Available as OEM version
- Ambient Temperature: from 15°-30° C
- Hermetically sealed lasers
- Polarization: Linear
- Beam Diameter: 1.2mm – 1.5mm
- Beam Profile: Gaussian
- Relative Humidity: 10-80% (non-condensing)

QS LASERS

QS LASERS

Let’s talk!

Naujoji Riovoniu st. 25B, LT-03153, Vilnius, Lithuania

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Copernicus POD Service

SLR Yearly Report 2023

Presenter: Eva Terradillos (GMV)

2024 Networks & Engineering Standing Committee in the ILRS – 25th April 2024

Agenda

1. CPOD Service
2. Validation of Sentinel-3 and Sentinel-6 orbit solutions
3. CPF Predictions
4. Conclusions

CPOD Service

CPOD SERVICE

Copernicus is the European Union's Earth observation programme, looking at our planet and its environment to benefit all European citizens.

European Commission
esa
EUMETSAT
+ others

→ opernicus Europe's eyes on Earth →

COPERNICUS POD Service

More info about the CPOD Service may be found:

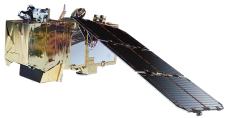
CPOD CONSORTIUM
gmv INNOVATING SOLUTIONS
PosiTIM
DLR GFZ Helmholtz-Zentrum Potsdam
TU Delft
TUM

QWG
CONSORTIUM
+
esa
EUMETSAT
cnes
AIUB
GRGS
TU Graz
JPL
NASA

The **Copernicus POD (CPOD) Service** is responsible for the operational generation of precise orbital and auxiliary products for the following Copernicus Sentinel missions.

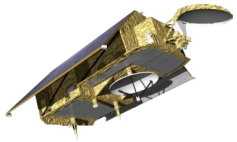
sentinel-1

sentinel-2



sentinel-3

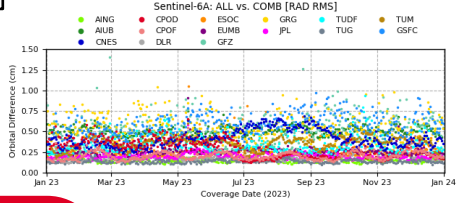
sentinel-6



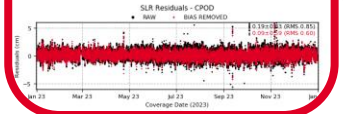
CPOD SERVICE – ACTIVITIES

Generation of **combined solution** (reference for QC)

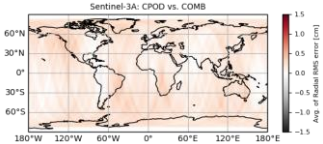
Accuracy & timeliness performance



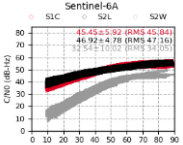
SLR Validation



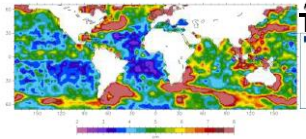
Geographic & Spectral Analyses



GNSS Signals/tracking performance



Altimetry Cross-over Analysis



TUDelft Delft University of Technology

TECHNISCHE UNIVERSITÄT MÜNCHEN

CPOD Service activities

Operational POD provision

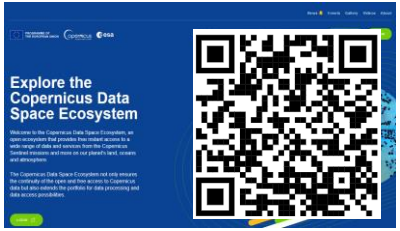
Quality Control & Validation

External user information & POD provision

Improvement of algorithms

Scientific communication

CPOD info



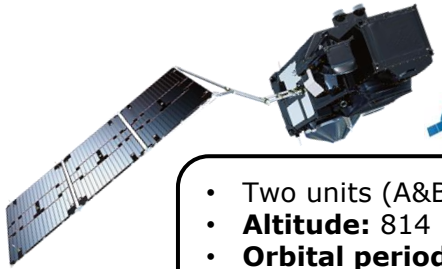
CPOD products

CPOD SERVICE – ILRS COMMUNITY

COPERNICUS POD Service

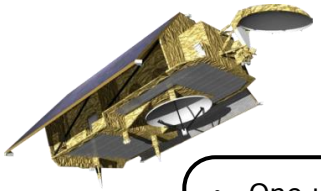
Predicted Orbit Products
Sentinel-3 CPF orbits are daily delivered to the ILRS community.

SLR Validation
Using COMB solution, a set of SLR stations, and only for Sentinel-3 and Sentinel-6 satellites.



sentinel-3

- Two units (A&B)
- **Altitude:** 814 km
- **Orbital period:** 101 min
- **Inclination:** 98.6° (polar)
- **Repeating cycle:** 27 days



sentinel-6

- One unit (A)
- **Altitude:** 1336 km
- **Orbital period:** 112 min
- **Inclination:** 66°
- **Repeating cycle:** 9.9 days

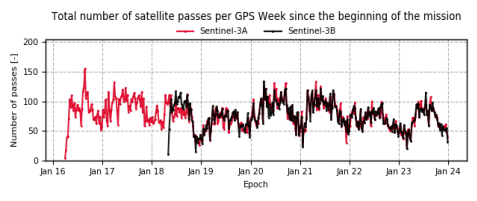
Set of SLR stations used in RSR and YSR reports

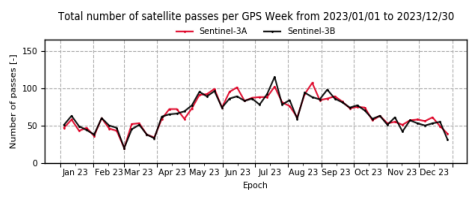
7090	YARL	**7810**	ZIML
7105	GODL	**7825**	STL3
7110	MONL	**7839**	GRZL
7119	HA4T	**7840**	HERL
7306	TKBL	**7841**	POT3
7501	HARL	**7941**	MATM
7701	IZ1L	**8834**	WETL

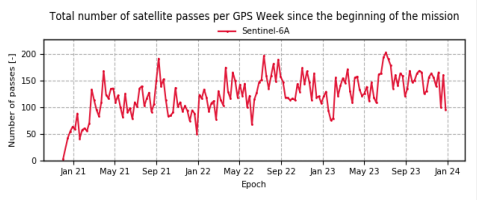
ILRS yearly report include all stations in:

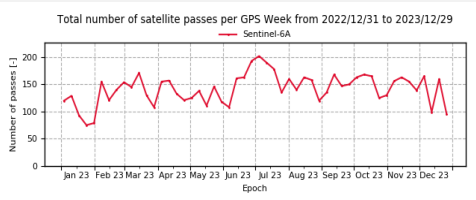
CPOD SERVICE – STATIONS

Total number of satellite passes per GPS Week

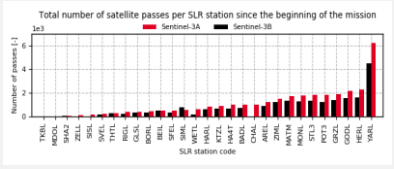


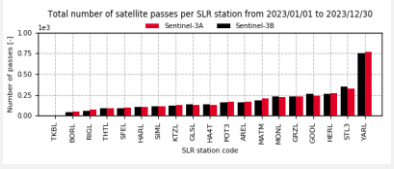


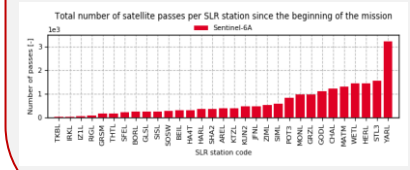


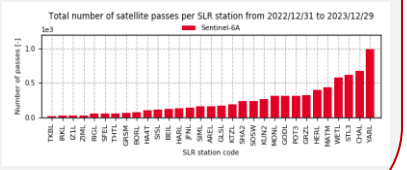


Total number passes per SLR station





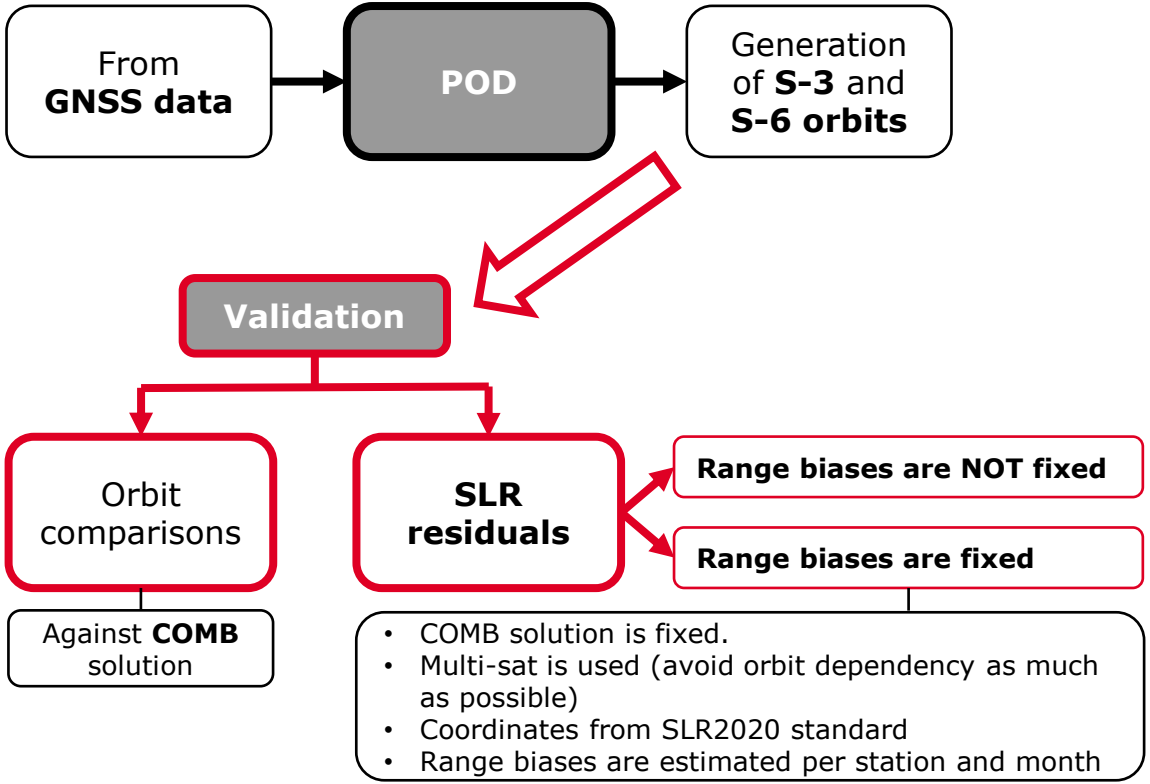




Statistics obtained from the np2 monthly files provided by SLR stations.

Validation of the Sentinel-3 and Sentinel-6 orbit solutions

PRODUCT VALIDATION

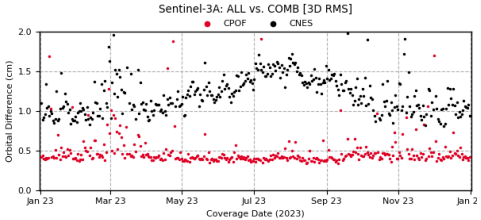


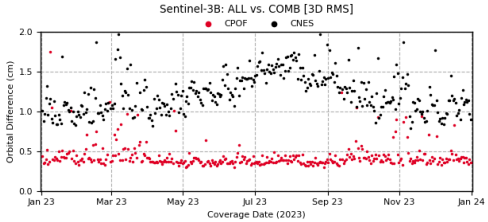
Considerations:

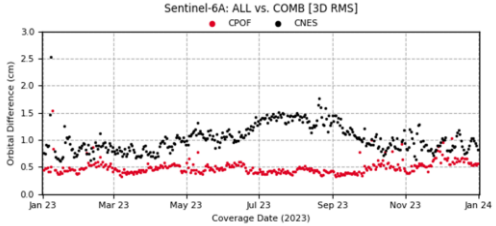
- **CNES**:
  - GPS data along with DORIS observations
  - **Own** seasonal geocenter motion mode
- **CPOF** (by CPOD):
  - **ITRF2020** seasonal geocenter motion model
  - COST-G model
  - Yaw bias correction for Sentinel-6A
- **COMB:**
  - Combination of orbits from AIUB, CNES, CPOD (operational orbit), DLR, ESOC, GFZ, JPL, TUD, TUG and TUM
  - Generated from orbits mostly in **CoM**.

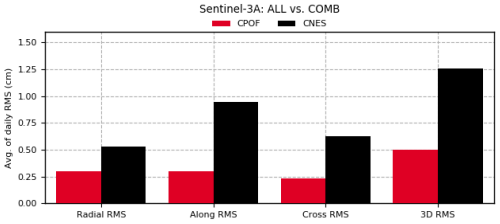
VALIDATION OF ORBIT SOLUTIONS

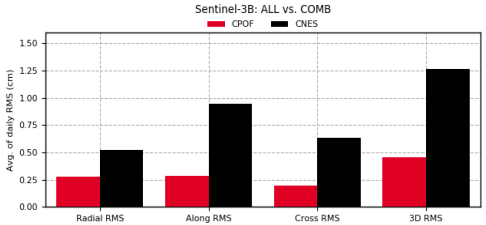
Sentinel-3 and Sentinel-6 combined orbit solution

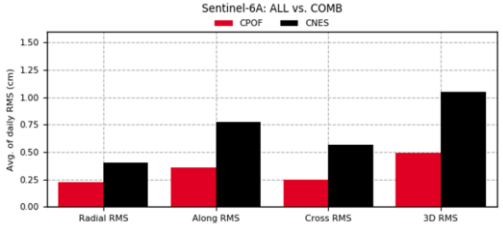












Orbit solution	Sentinel-3A [cm]			
	Radial RMS		3D RMS	
	Mean	STD	Mean	STD
CPOF	0.30	0.09	0.50	0.28
CNES	0.53	0.16	1.26	0.43

Orbit solution	Sentinel-3B [cm]			
	Radial RMS		3D RMS	
	Mean	STD	Mean	STD
CPOF	0.27	0.10	0.45	0.25
CNES	0.52	0.14	1.26	0.33

Orbit solution	Sentinel-6A [cm]			
	Radial RMS		3D RMS	
	Mean	STD	Mean	STD
CPOF	0.22	0.05	0.49	0.12
CNES	0.41	0.10	1.05	0.35

To keep in mind:

- **COMB** solutions is generated from orbits mostly in CoM.
- **CNES** applies different seasonal geocenter motion model, which is not removed for orbital comparisons or accounted for in the combination.

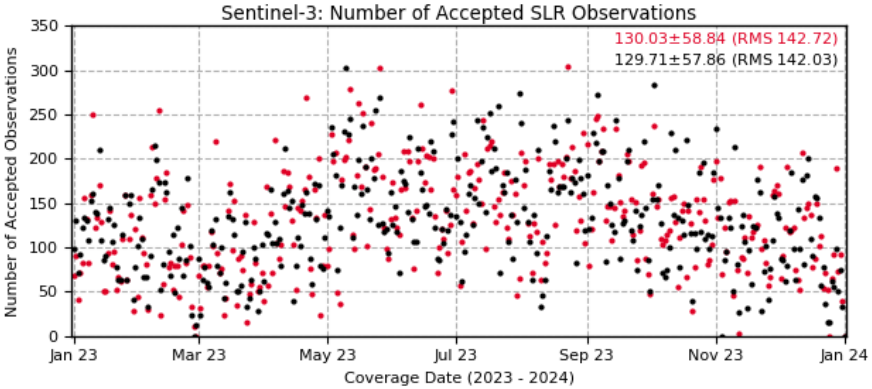
Conclusion: **CPOF** is more aligned to the COMB solution whereas **CNES** shows different centre of mass realisation due to their modelling.

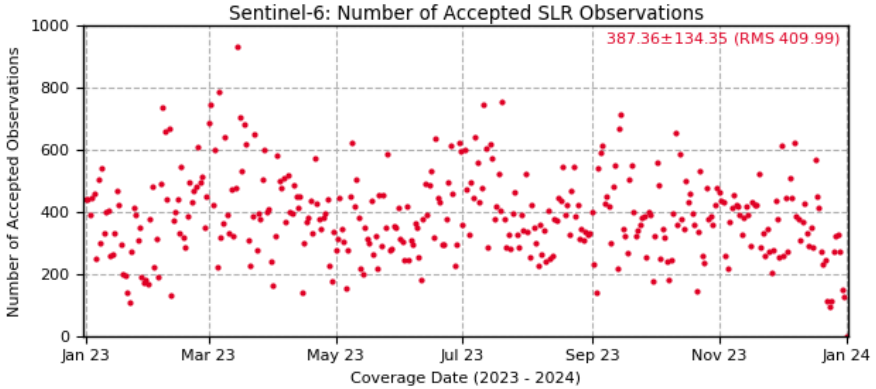
VALIDATION OF ORBIT SOLUTIONS

SLR Observations provided by the SLR stations

To keep in mind:

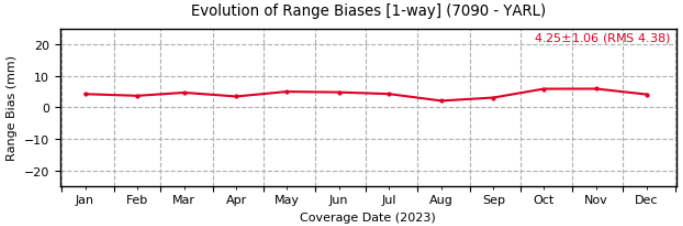
SLR observations are **NOT** used in the LEO POD process, only residuals are computed, to avoid influencing the orbit and to serve as external validation.

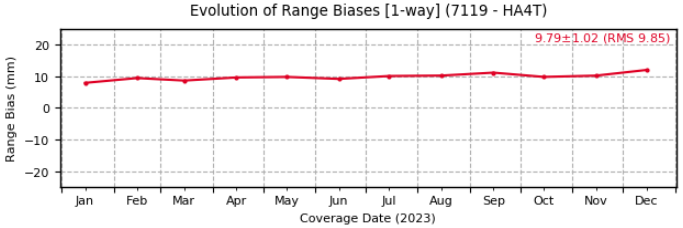


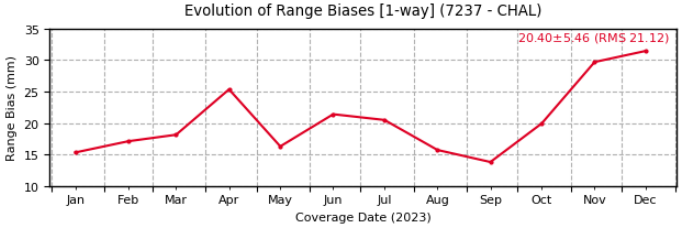


VALIDATION OF ORBIT SOLUTIONS

Estimation of the range biases for all SLR stations

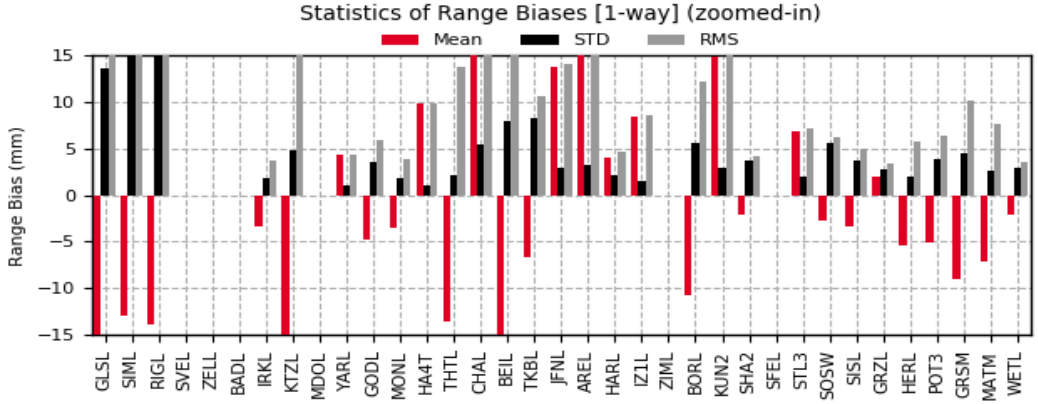






Particular behaviour:

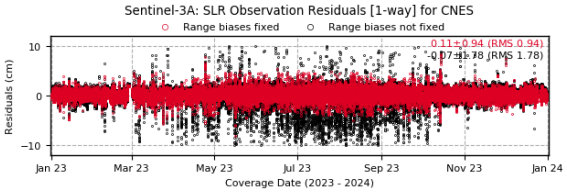
- **7306 – TKBL:** Not all observations have the same wavelength for the year 2023. Two different wavelengths were used:
  - **532 nm:** For most of the days
  - **1064 nm:** For a few observations. We discarded 1064 nm observations in order to obtain one bias.
- **7810 – ZIML:** All observations were rejected during the bias estimation process because of global rejection criteria. (Under evaluation)

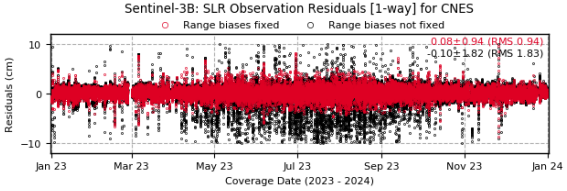


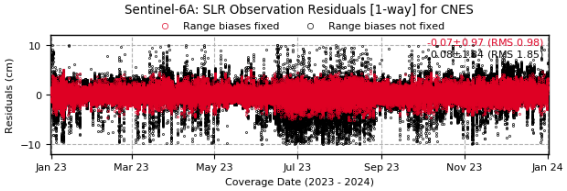
VALIDATION OF ORBIT SOLUTIONS

SLR residuals per orbit solution

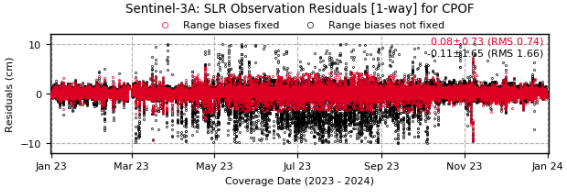
CNES

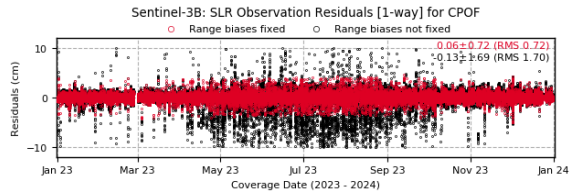


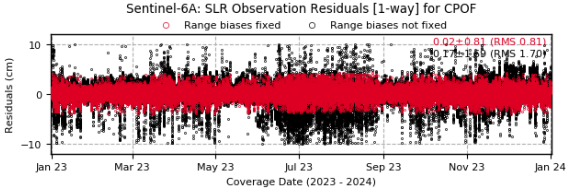




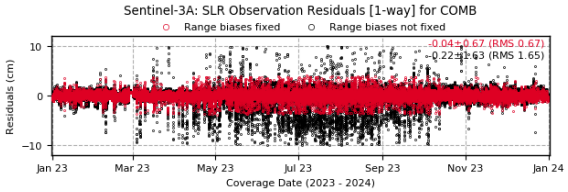
CPOF

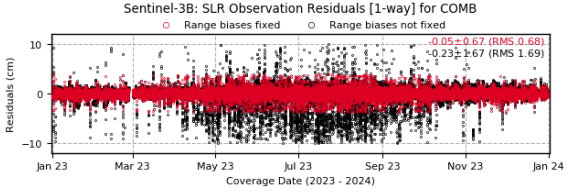


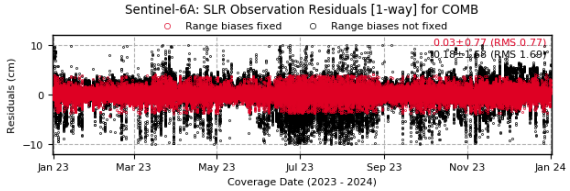




COMB







VALIDATION OF ORBIT SOLUTIONS

SLR residuals per orbit solution

Orbit solution	Sentinel-3A [1-way; cm]					
	Mean		STD		RMS	
	Range bias not fixed	Range bias fixed	Range bias not fixed	Range bias fixed	Range bias not fixed	Range bias fixed
CPOF	-0.07	0.11	**1.78**	**0.94**	1.78	0.94
CNES	-0.11	0.08	**1.65**	**0.73**	1.66	0.74
COMB	-0.22	-0.04	**1.63**	**0.67**	1.65	0.67

Orbit solution	Sentinel-3B [1-way; cm]					
	Mean		STD		RMS	
	Range bias not fixed	Range bias fixed	Range bias not fixed	Range bias fixed	Range bias not fixed	Range bias fixed
CPOF	-0.10	0.08	**1.82**	**0.94**	1.83	0.94
CNES	-0.13	0.06	**1.69**	**0.72**	1.70	0.72
COMB	-0.23	-0.05	**1.67**	**0.67**	1.69	0.68

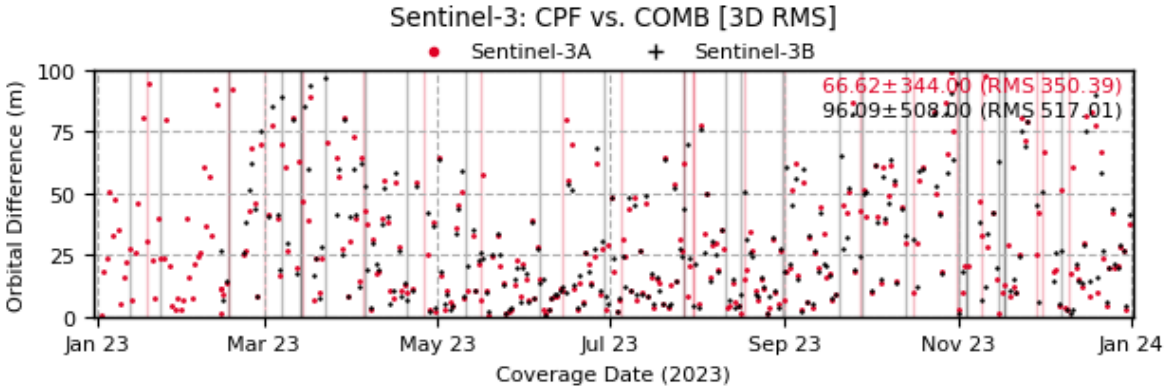
Orbit solution	Sentinel-6A [1-way; cm]					
	Mean		STD		RMS	
	Range bias not fixed	Range bias fixed	Range bias not fixed	Range bias fixed	Range bias not fixed	Range bias fixed
CPOF	0.08	-0.07	**1.84**	**0.97**	1.85	0.98
CNES	0.17	0.02	**1.69**	**0.81**	1.70	0.81
COMB	0.18	0.03	**1.68**	**0.77**	1.69	0.77

Conclusion: The validation of the different Sentinel-3 and Sentinel-6A orbit solutions improves if the range biases of the SLR stations are fixed.

CPF Predictions

CPF PREDICTIONS

Consolidated Prediction Files (**CPF**) daily delivered to ILRS community, to allow SLR tracking of Sentinel-3 satellites.



	3D RMS [m]		
	Mean	STD	RMS
Sentinel-3A	66.62	344.00	350.39
Sentinel-3B	96.09	508.00	517.01

	Product Accuracy	
	Percentage of fulfilment	
	Sentinel-3A	**Sentinel-3B**
< 1 m	0.55 %	0.31 %
< 5 m	10.11 %	9.01 %
< 10 m	22.95 %	21.12 %
< 50 m	71.04 %	67.39 %
< 100 m	88.80 %	85.09 %
< 200 m	95.36 %	92.55 %
< 400 m	98.91 %	97.52 %

Conclusions

CONCLUSIONS

- The ILRS stations cooperate with the Copernicus POD Service and its QWG by tracking both Sentinels-3 and Sentinel-6A and supplying ranging measurements. Due to the number of available stations, an overall good geographical coverage is attained.
- The total number of satellite passes during 2023 has shown values between 50 and 150 for both Sentinel-3 satellites and slightly higher for Sentinel-6A.
- The observations provided by the ILRS stations are used by the CPOD QWG as an independent means to validate the orbital accuracy of the POD orbits. The comparisons have revealed a good agreement between them (keeping the 3D RMS of the residuals below 1.5 cm in mean), which improves the reliability of the CPOD products.
- A monthly range bias has been calculated per each SLR station in order to improve the statistical outcome of the SLR residuals. It has been shown that the use of these range biases benefits the final outcome.
- The use of the seasonal geocenter motion ITRF20 is in progress in the QWG and in advanced it has shown to improve the stability of the monthly biases.

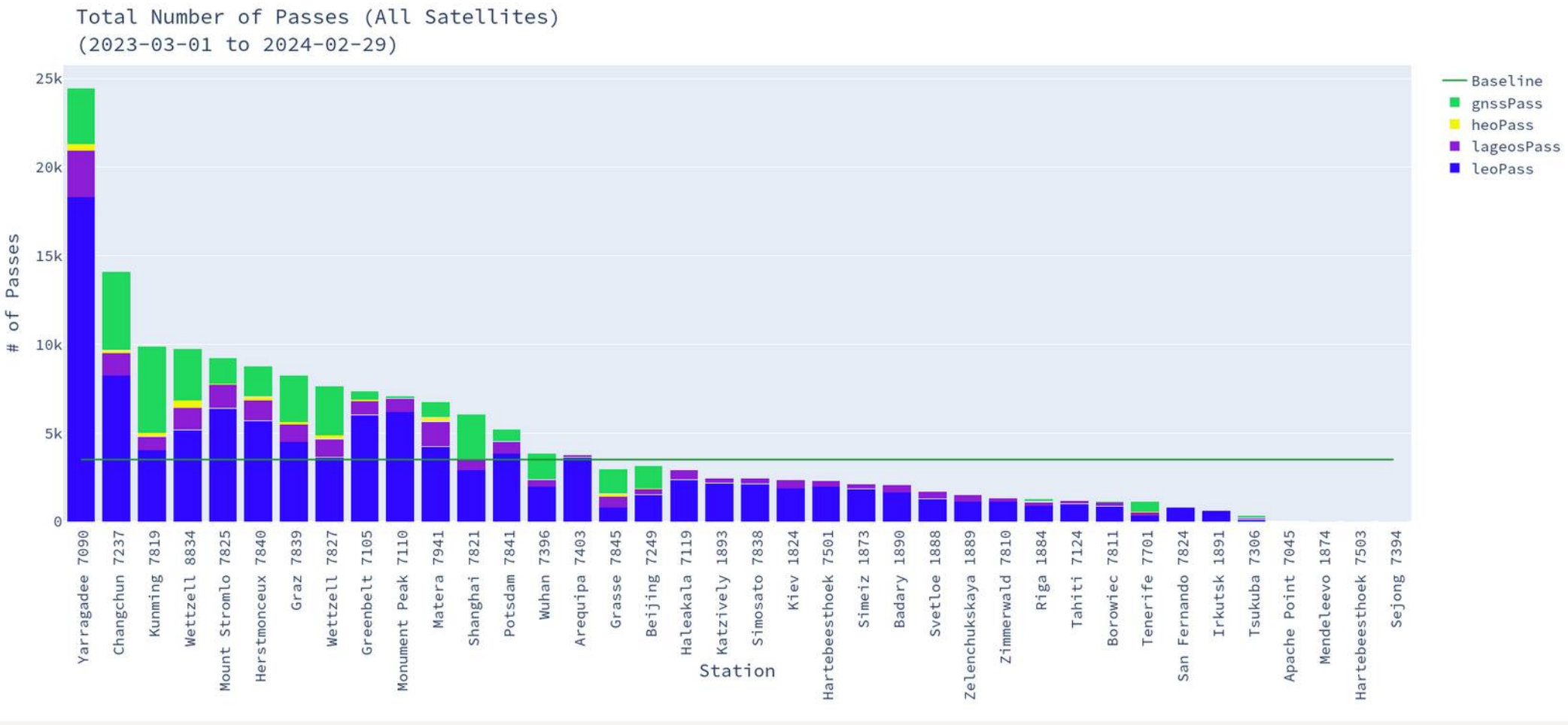
Sentinel-3 and Sentinel-6 missions are very important altimetry missions that count on the invaluable support of the ILRS community.
Thank you very much for your support!

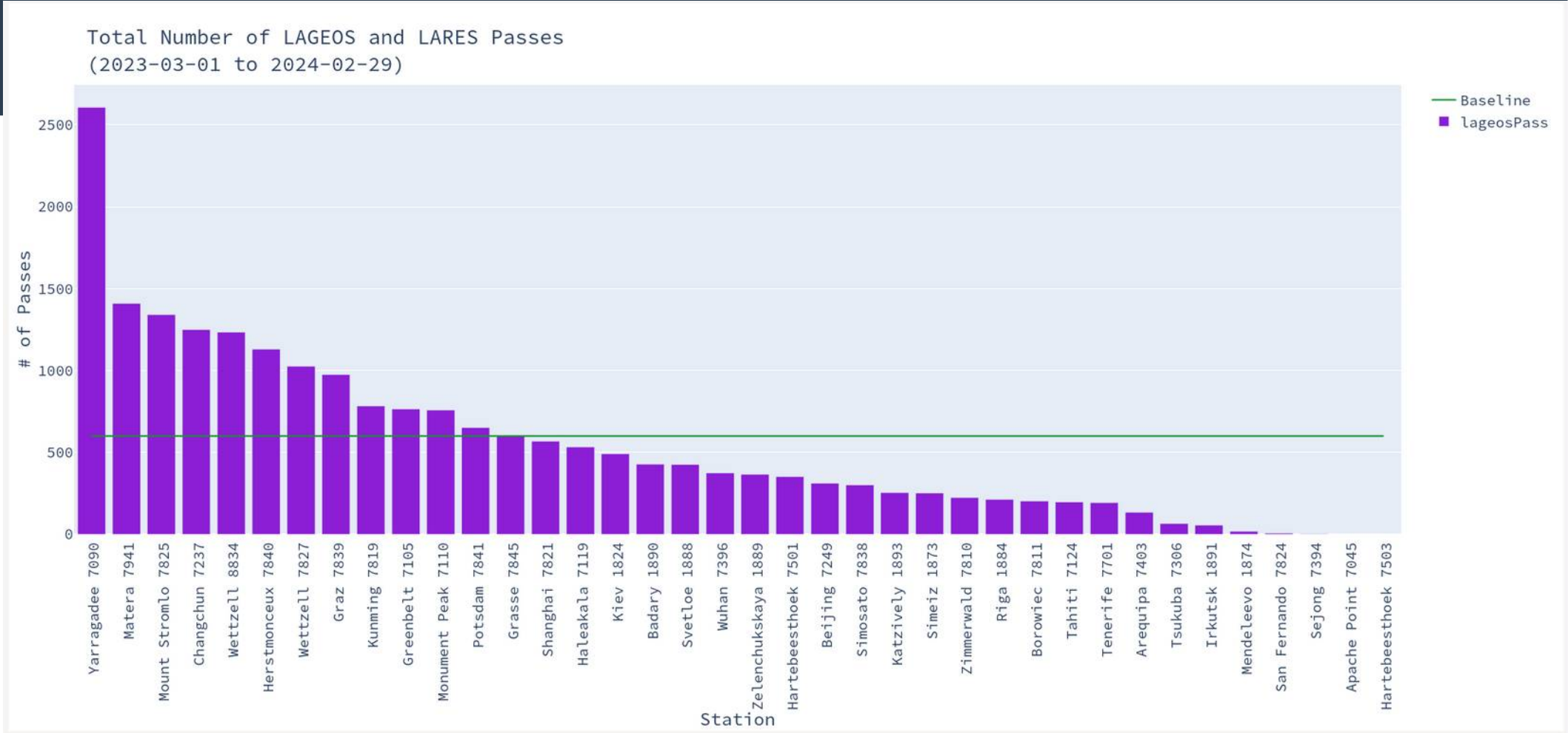
Thank you

Copernicus POD Service

ILRS Stations Survey & Plan

NESC Meeting 25th April 2024


Total Number of Passes (All Satellites)
(2023-03-01 to 2024-02-29)
# of Passes
25k
20k
15k
10k
5k
0
Baseline
gnssPass
heoPass
lageosPass
leoPass
Yarragadee 7090
Changchun 7237
Kunming 7819
Wettzell 8834
Mount Stromlo 7825
Herstmonceux 7840
Graz 7839
Wettzell 7827
Greenbelt 7105
Monument Peak 7110
Matera 7941
Shanghai 7821
Potsdam 7841
Wuhan 7396
Arequipa 7403
Grasse 7845
Beijing 7249
Haleakala 7119
Katzively 1893
Simosato 7838
Kiev 1824
Hartebeesthoek 7501
Simeiz 1873
Badary 1890
Svetloe 1888
Zelenchukskaya 1889
Zimmerwald 7810
Riga 1884
Tahiti 7124
Borowiec 7811
Tenerife 7701
San Fernando 7824
Irkutsk 1891
Tsukuba 7306
Apache Point 7045
Mendeleevo 1874
Hartebeesthoek 7503
Sejong 7394
Station


Total Number of LAGEOS and LARES Passes
(2023-03-01 to 2024-02-29)
# of Passes
0
500
1000
1500
2000
2500
Baseline
lageosPass
Yarragadee 7090
Matera 7941
Mount Stromlo 7825
Changchun 7237
Wettzell 8834
Herstmonceux 7840
Wettzell 7827
Graz 7839
Kunming 7819
Greenbelt 7105
Monument Peak 7110
Potsdam 7841
Grasse 7845
Shanghai 7821
Haleakala 7119
Kiev 1824
Badary 1890
Svetloe 1888
Wuhan 7396
Zelenchukskaya 1889
Hartebeesthoek 7501
Beijing 7249
Simosato 7838
Katzively 1893
Simeiz 1873
Zimmerwald 7810
Riga 1884
Borowiec 7811
Tahiti 7124
Tenerife 7701
Arequipa 7403
Tsukuba 7306
Irkutsk 1891
Mendeleevo 1874
San Fernando 7824
Sejong 7394
Apache Point 7045
Hartebeesthoek 7503
Station

Expectations for Stations

- Are under-performing SLR stations in the ILRS network expected to improve?
- What could the NESC do to help?
- Could the NESC identify stations for our focussed attention?
  - What questions do we ask these stations?
  - Could a plan be made?

Stations Survey

ILRS Survey and Station Plan

The ILRS relies upon the accurate measurements taken by the global SLR network in order to form its products. ILRS Stations must repeatedly observe the primary geodetic targets over many passes. Those stations that do not meet the minimum tracking requirement risk not contributing significantly to the scientific output of the ILRS.

Productivity can be improved with the right hardware or software developments or better funding support. ILRS stations not meeting the minimum tracking requirement are requested to identify the main factors limiting their performance and to make a development plan to meet the required productivity level in the near future.

Please answer the following questions with as much detail as possible. Completed forms will be kept by the ILRS Central Bureau and made available within the ILRS on request.

SLR Station

Email

Contact Name

Date dd/mm/yyyy

1. Is your SLR station operating at its full potential?

   a) Can your station track the full ILRS target list? ○ Yes ○ No

   b) Does your station track during the day and night? ○ Yes ○ No

   c) How many days a week does your station operate?

   d) How many hours per day does your station operate?

   e) Are there additional tracking priorities beyond SLR? ○ Yes ○ No

Please provide further information:

...

Stations Survey

2. How can your station improve its SLR tracking capability?

a) Which satellite targets are difficult to acquire?

...

b) What percentage of LAGEOS, LARES, LARES-2 and Etalon can you expect to track successfully?

...

c) Can you track the GNSS constellations at night ○ Yes ○ No

d) Can you track the GNSS constellations during the day? ○ Yes ○ No

e) Does your station have lunar laser ranging capability? ○ Yes ○ No

f) Does your system interleave quickly between targets? ○ Yes ○ No

g) Are there restrictions on SLR in azimuth and/or elevation? ○ Yes ○ No

h) Do temperature changes impact target acquisition rates? ○ Yes ○ No

i) What is currently limiting the acquired volume of data?

...

j) What would make a significant improvement to your station's tracking capability?

...

Please provide further information:

Stations Survey

3. Is your SLR station fully supported?

   a) Is your station funded to observe continuously? What times/days does your station not operate?

   ...

   b) How is your station funded? How often is the work of your station reviewed?

   ...

   c) How many full time and part time staff work at your station?

   ...

   d) Do staff have other duties that make them unavailable to observe? ○ Yes ○ No

   e) Is your tracking operations pattern likely to change soon? ○ Yes ○ No

Please provide further information:

...

Stations Survey

4. To your knowledge and based on analysis feedback you have received, is your SLR station stable and accurate?

   a) Is your ILRS Site Log up to date? ○ Yes ○ No

   b) What data quality checks does your station make on a regular basis?

   ...

   c) How regularly does your station calibrate using a fixed ground target to monitor the system delay?

   ...

   d) When was the date of your last local survey and was a report generated?

   ...

   e) How many meteorological devices collect data at your station? Are comparisons made?

   ...

   f) How could SLR accuracy and long-term stability be improved at your station?

   ...

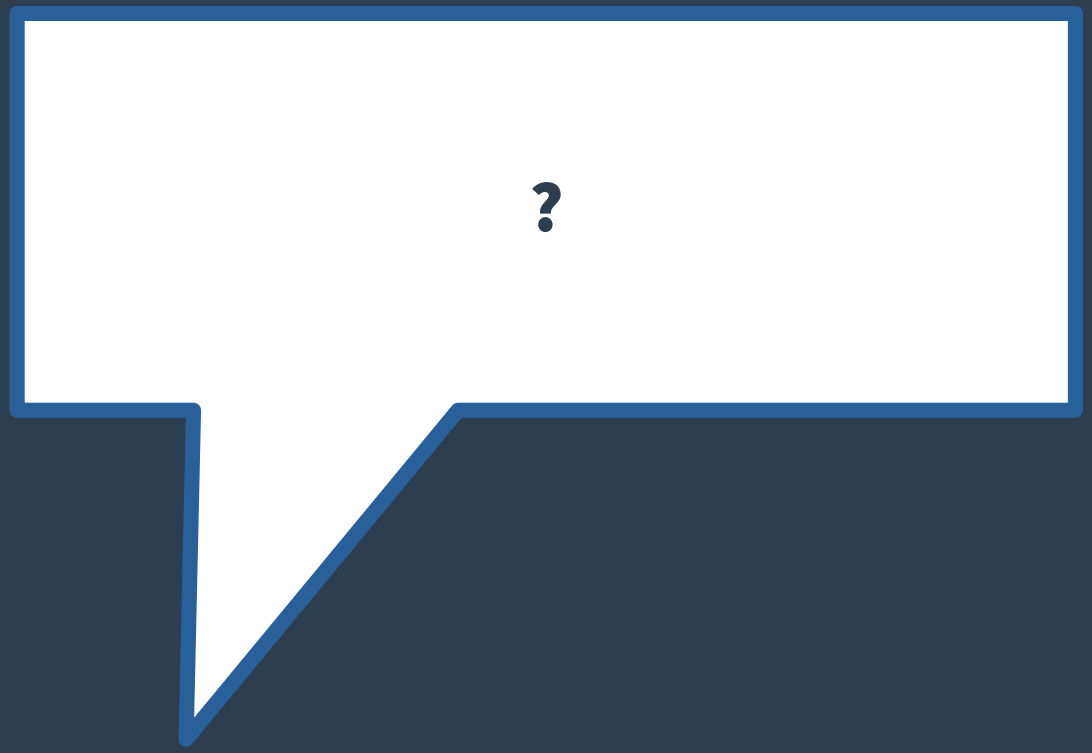
Please provide further information:

...

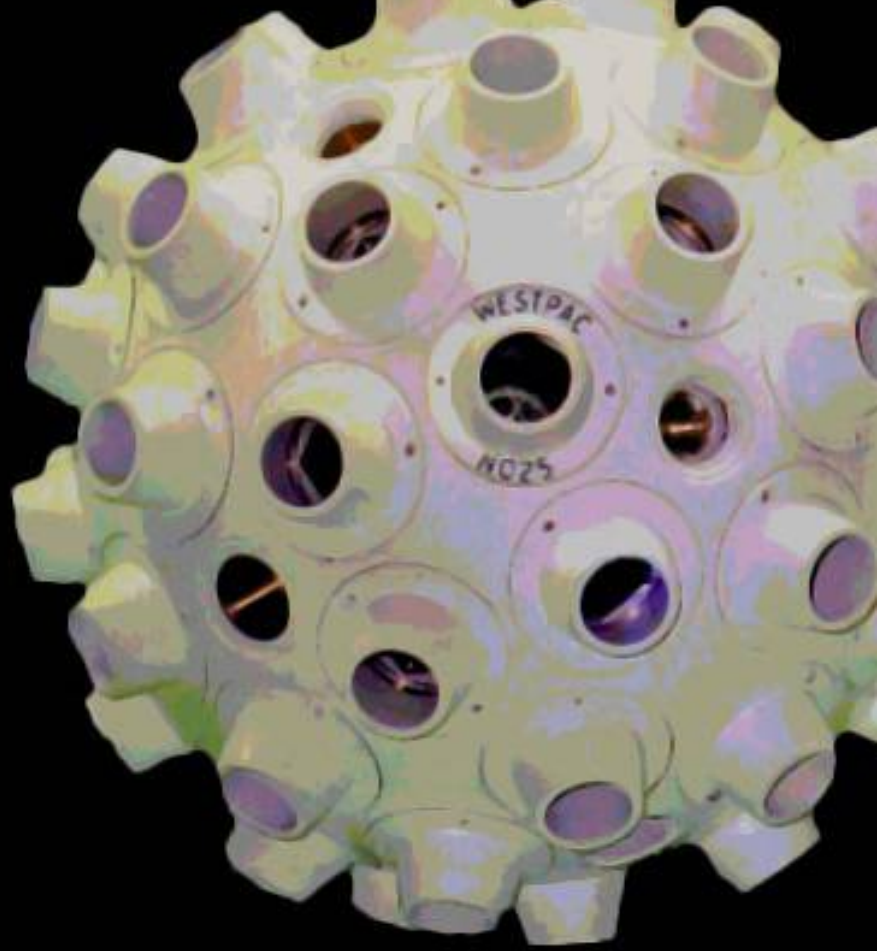
Stations Survey

5. Outline a plan for the next 2 years that will improve the overall performance of your SLR station. Break up the plan in to steps and include approximate time frames:

...



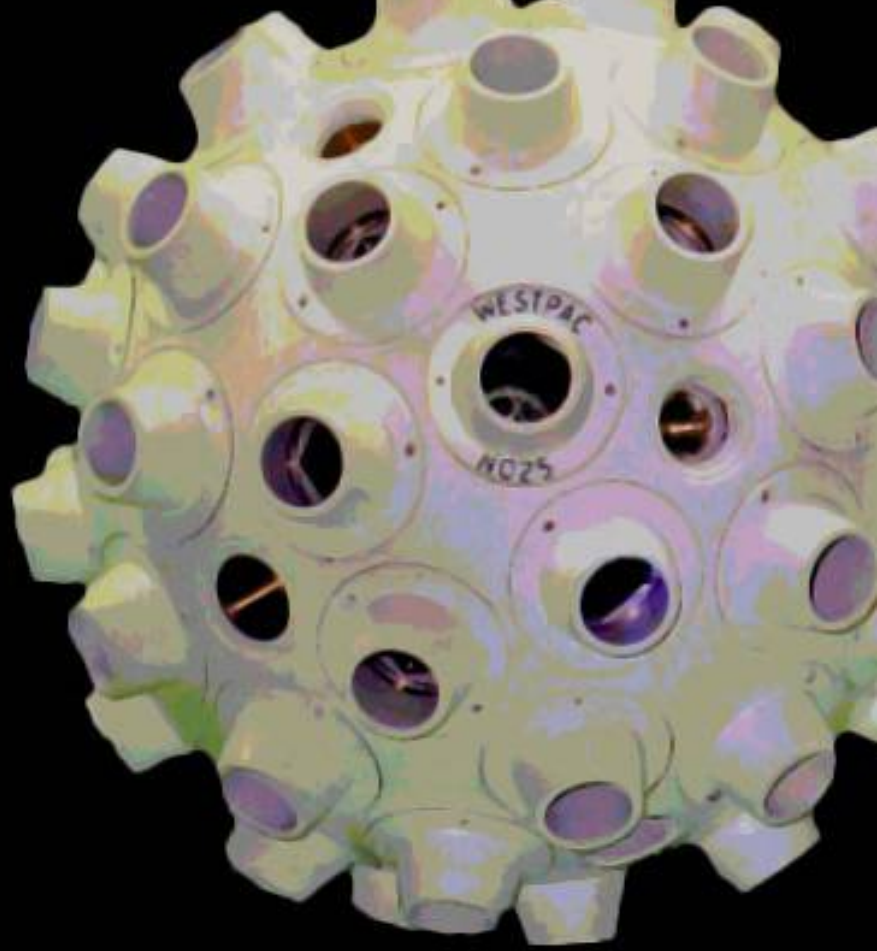
WESTPAC
-update



WESTPAC

Launch Date: **10 July 1998**
Orbit: **sun synchronous**
Inclination: **98 degrees**
Eccentricity: **0.0**
Perigee: **835 km**

End of ILRS Support: **1 Dec 2002**

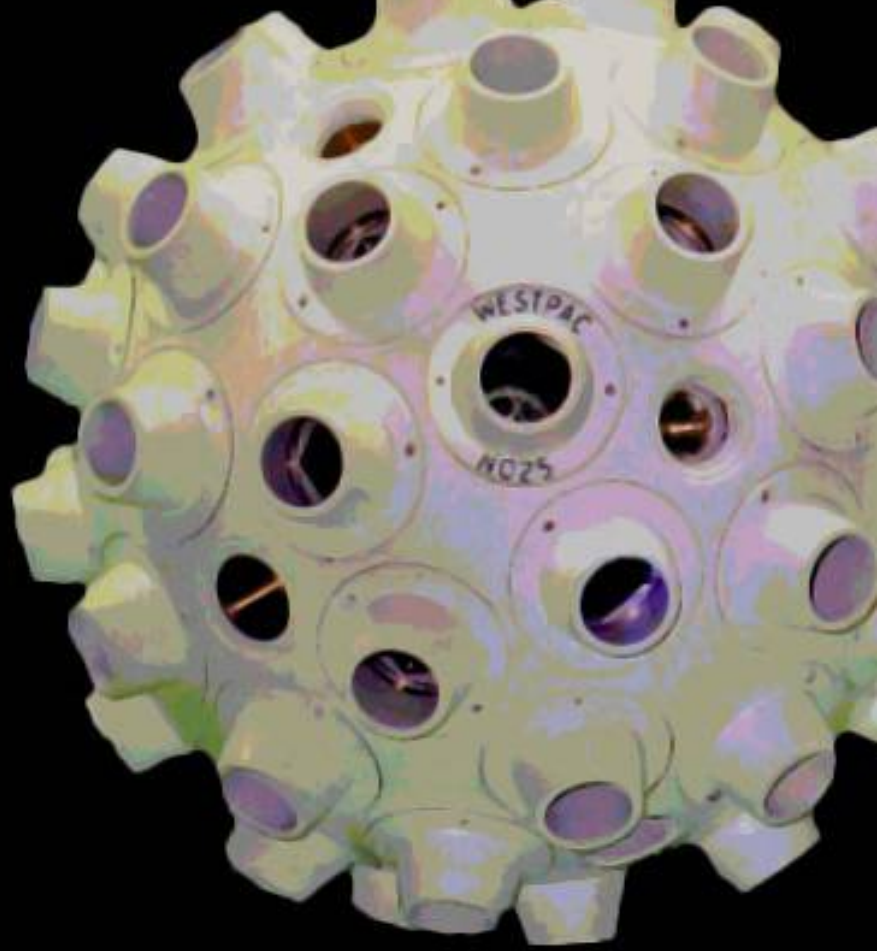


WESTPAC

Yarragadee
- *41 passes*
- *250 Normal Points*

Graz
- *3 passes*
- *? Normal Points*

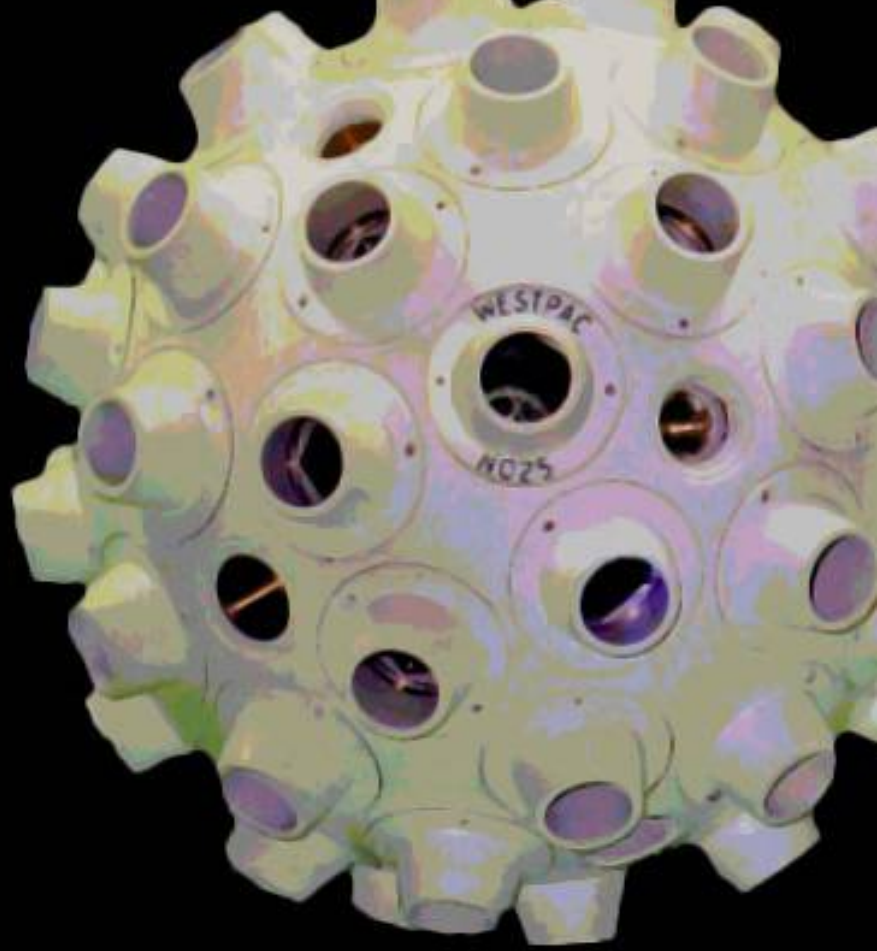
Other attempts
- *Herstmonceux*
- *Grasse*
- *Wettzell*



WESTPAC

NORAD number

- WESTPAC was originally given the NORAD number **25394**
- This was later reassigned due to a clash with RESURS-O 1N4, which is a Russian natural resources sensing satellite.
- It was given the new NORAD number of **25398**.

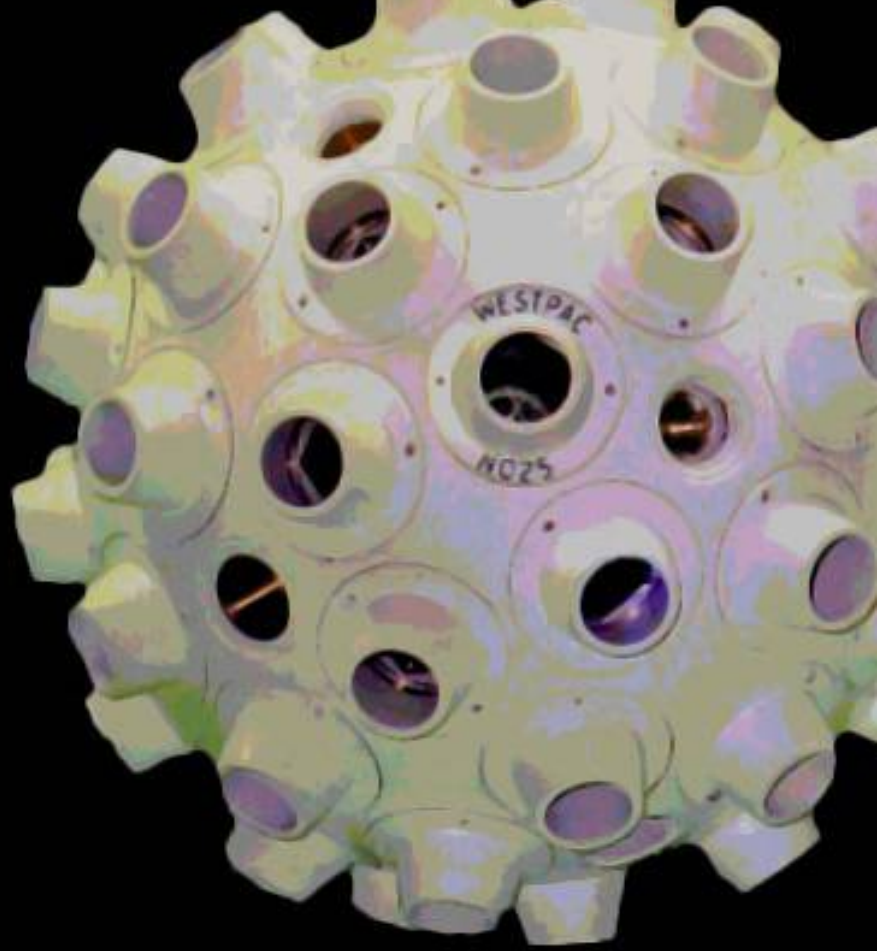


WESTPAC

Yarragadee has been using the updated NORAD number **25398** from the beginning.

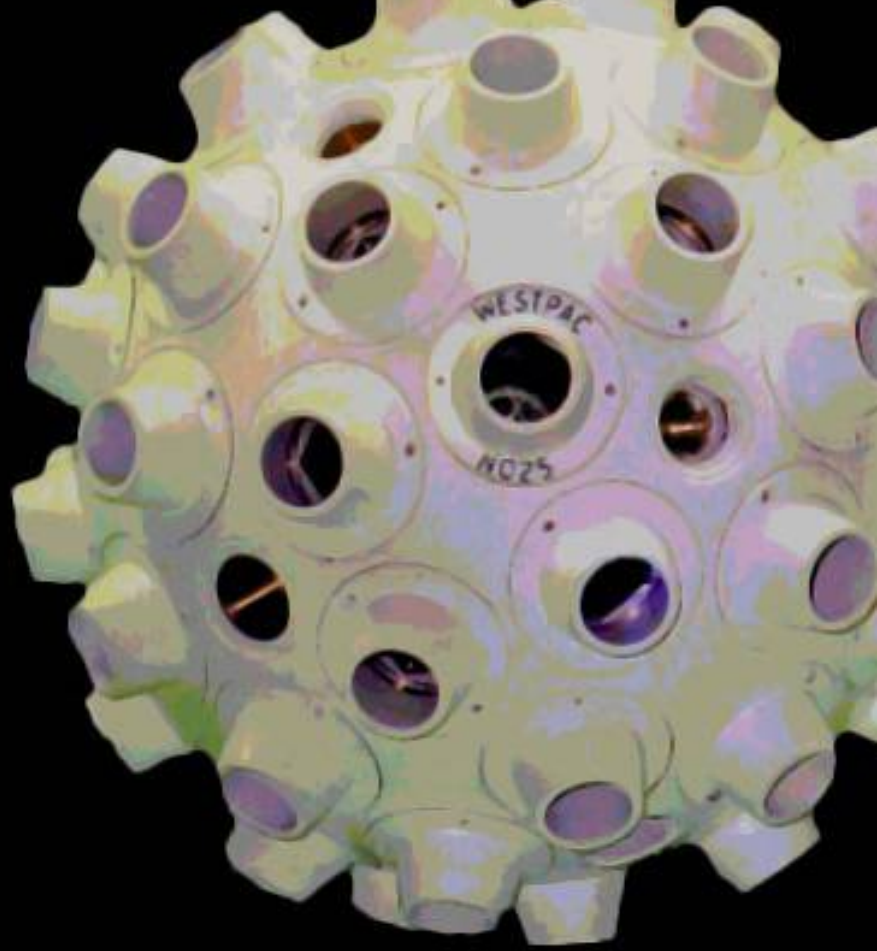
Graz switched from using the old number and then were successful.

Attempts at Herstmonceux were carried out using the old number.



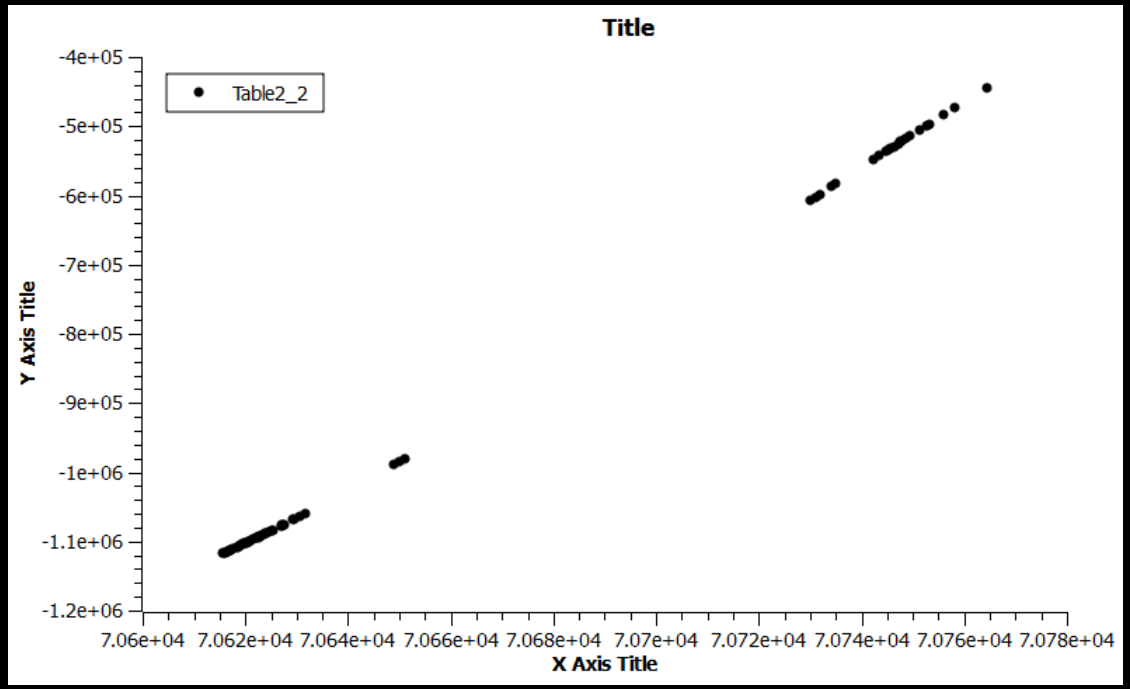
WESTPAC

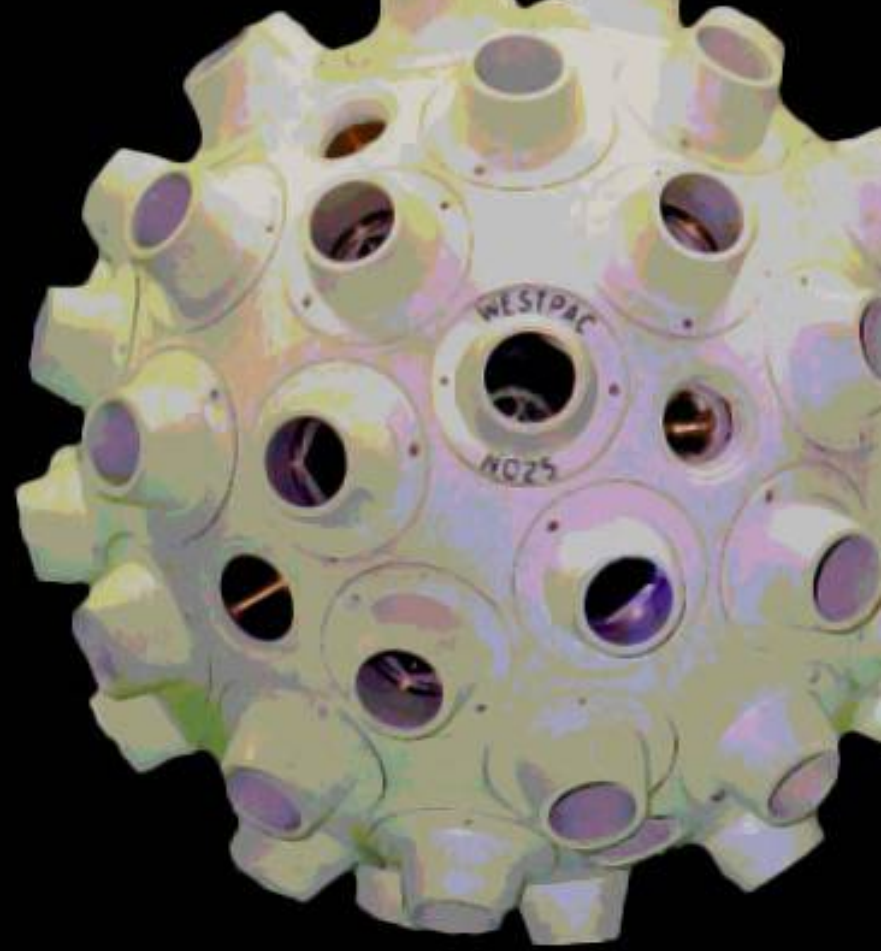
Are we certain that we are tracking the right target?



WESTPAC

Yarragadee

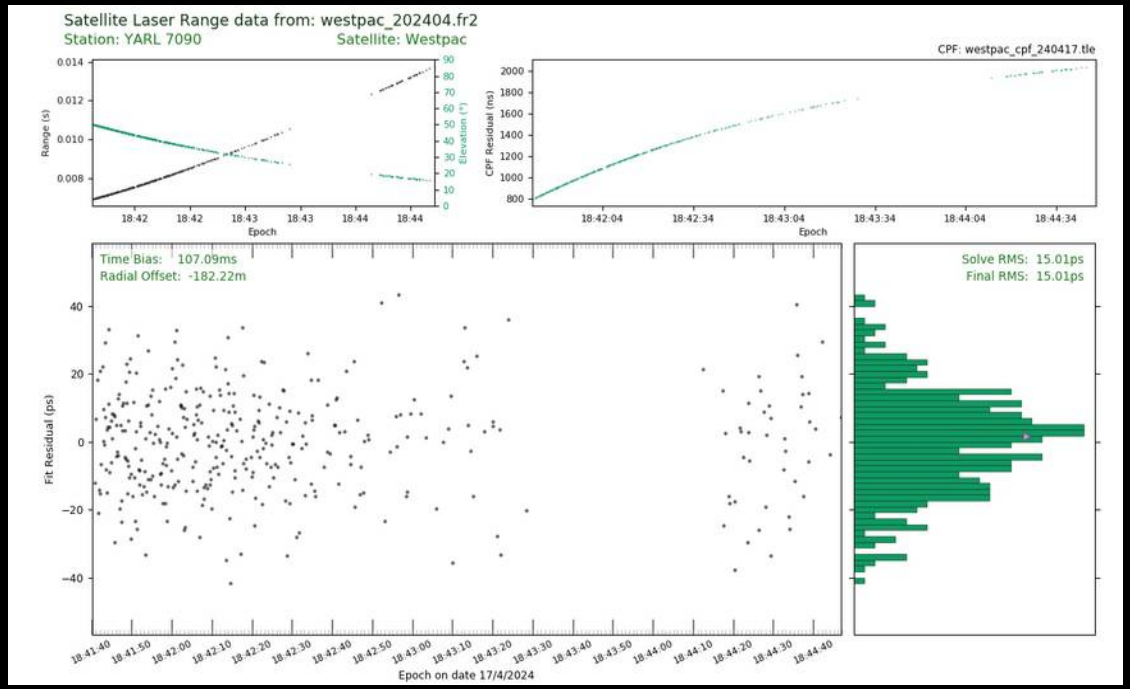


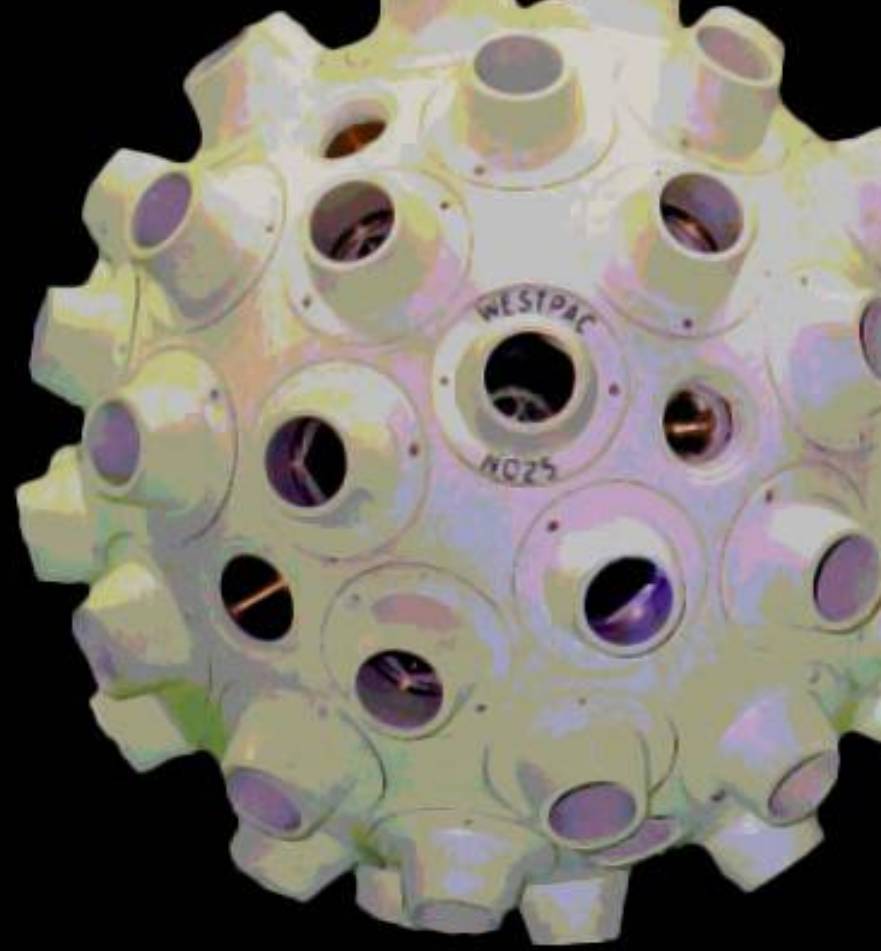


R. Carman

WESTPAC

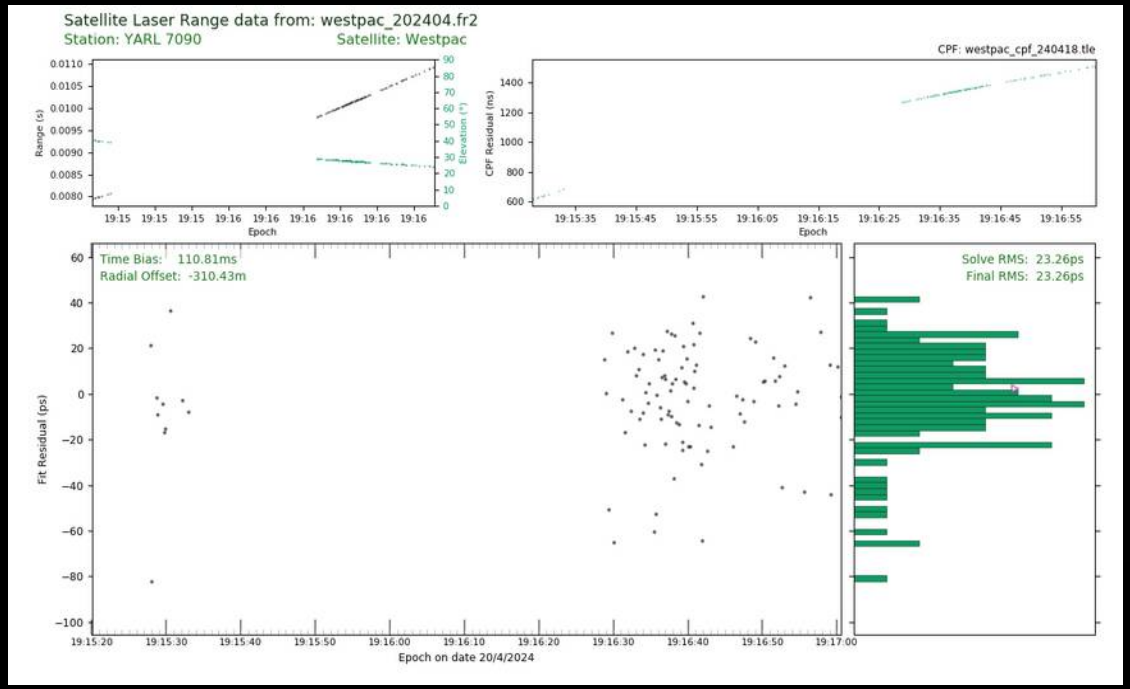
Yarragadee

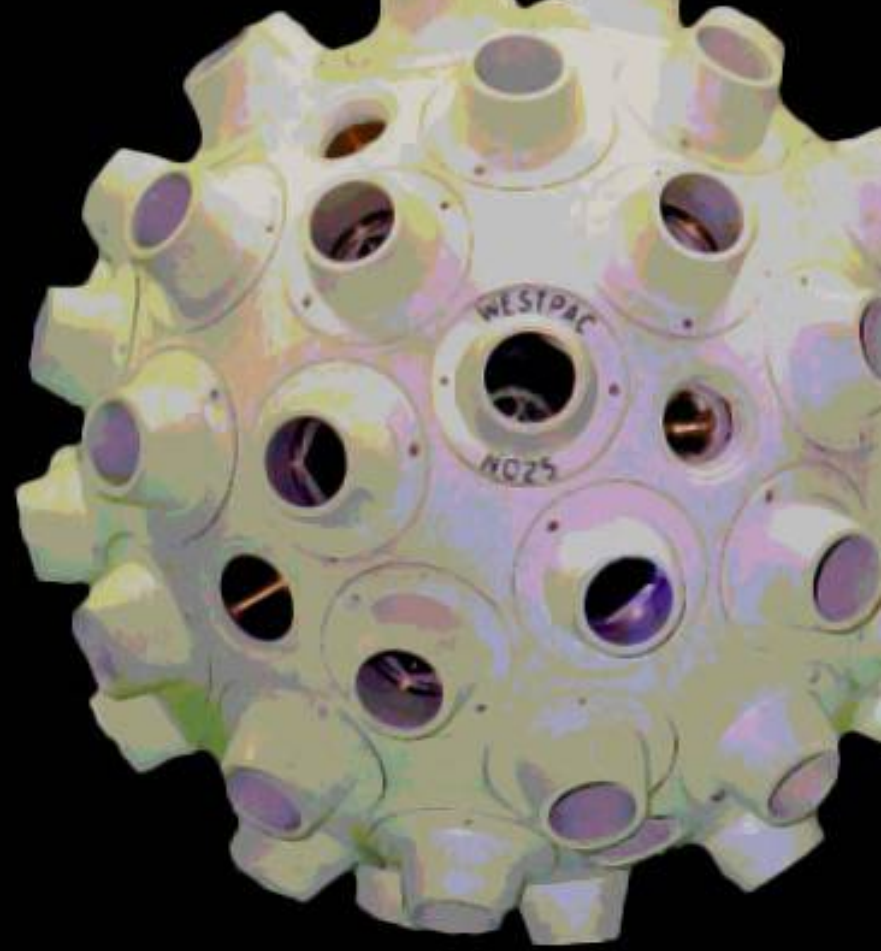




WESTPAC

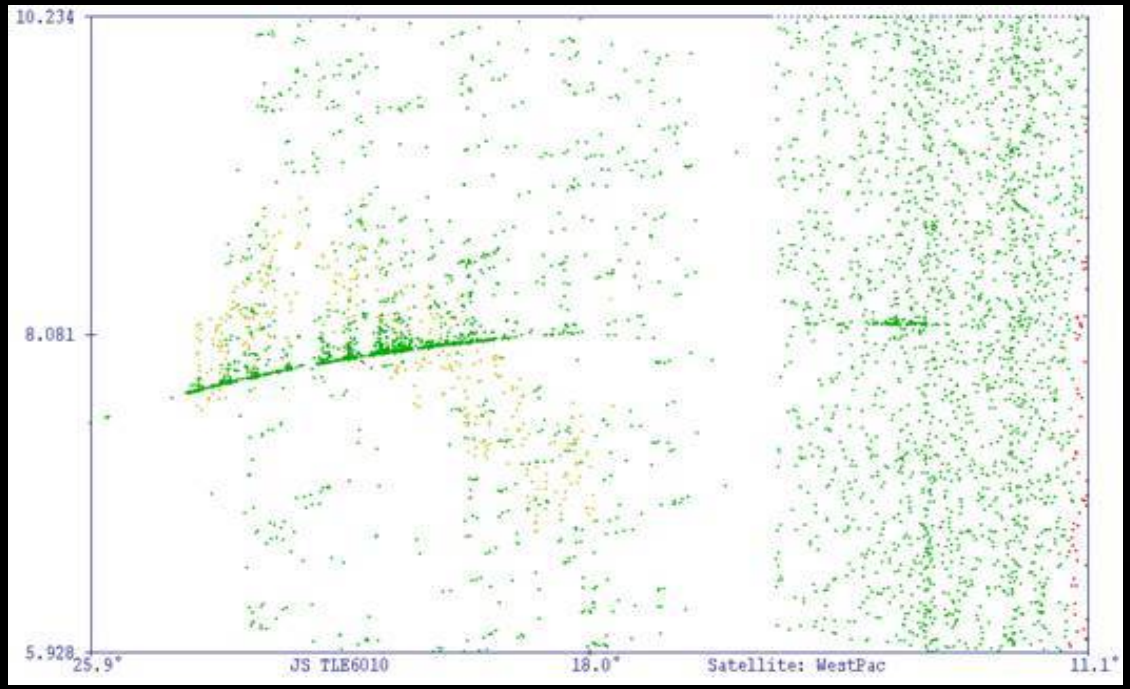
Yarragadee

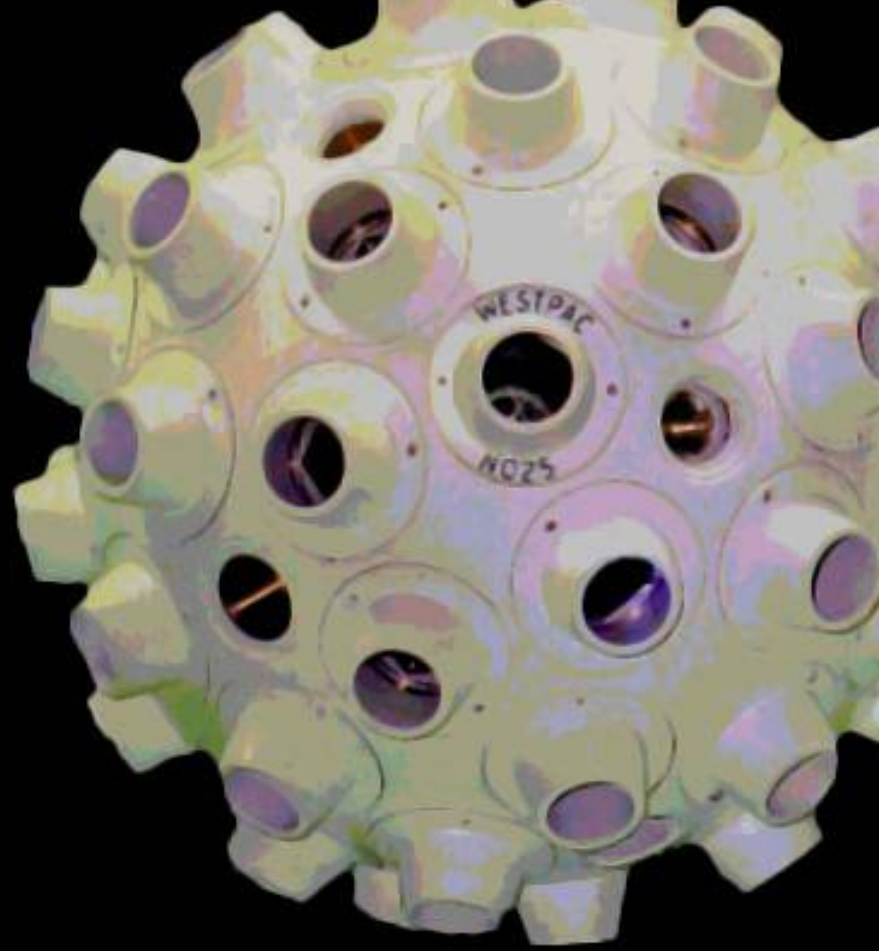




WESTPAC

Graz



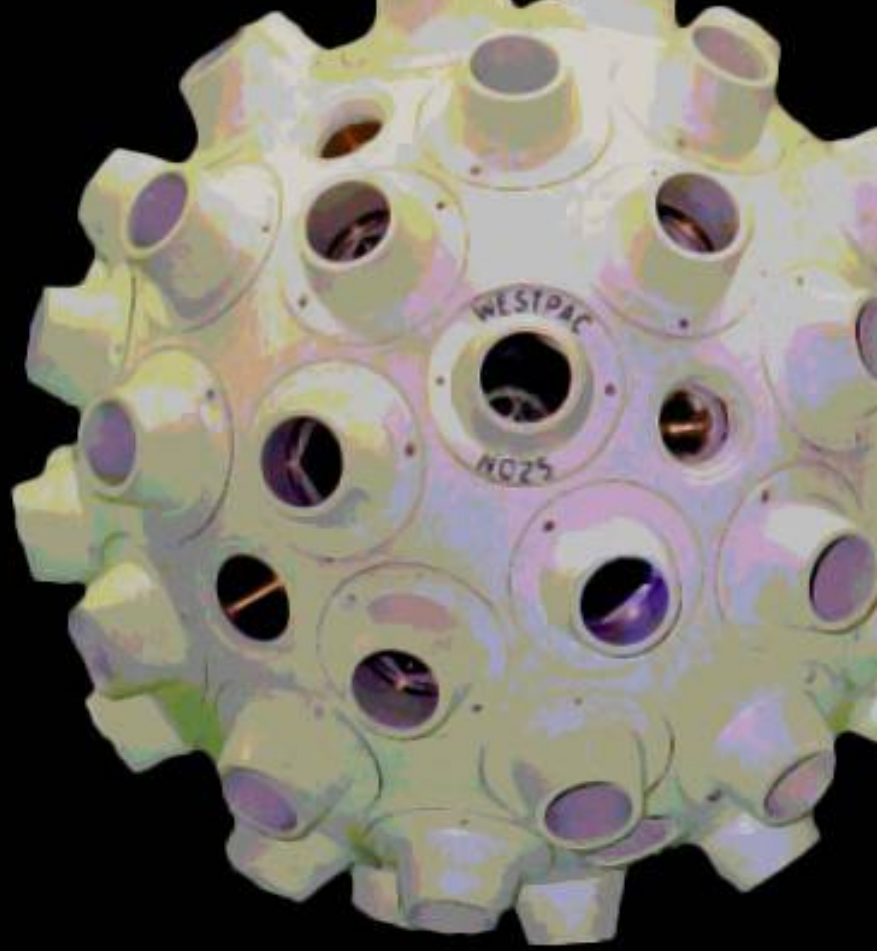


P. Wang

WESTPAC

What has changed?

- Consolidated Prediction Format (CPF) predictions were provided to ILRS stations after June 2008.
- New generation kHz stations began operating after 2003.

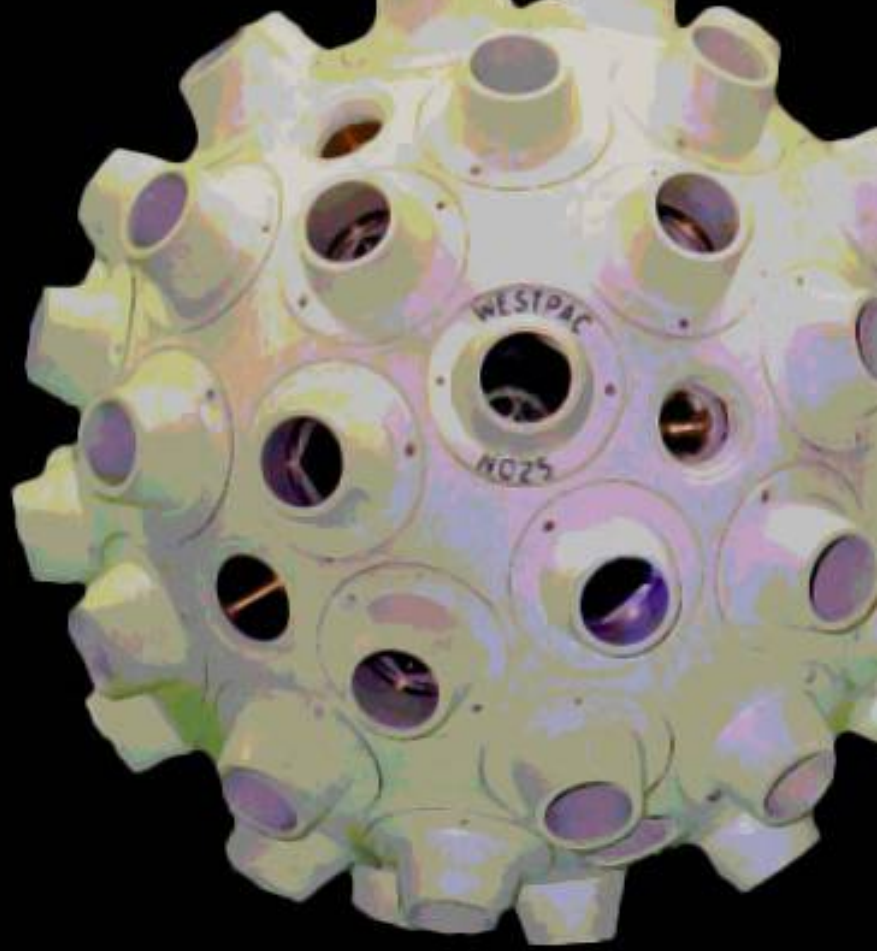


WESTPAC

Scientific Interest

WESTPAC SLR data can be used for:

- *Inclusion in multi-satellite SLR analysis*
- *Additional target in an orbit similar to Stella could increase data yield that is sensitive to low degree harmonics of the gravity field.*
- *Zero-signature target*



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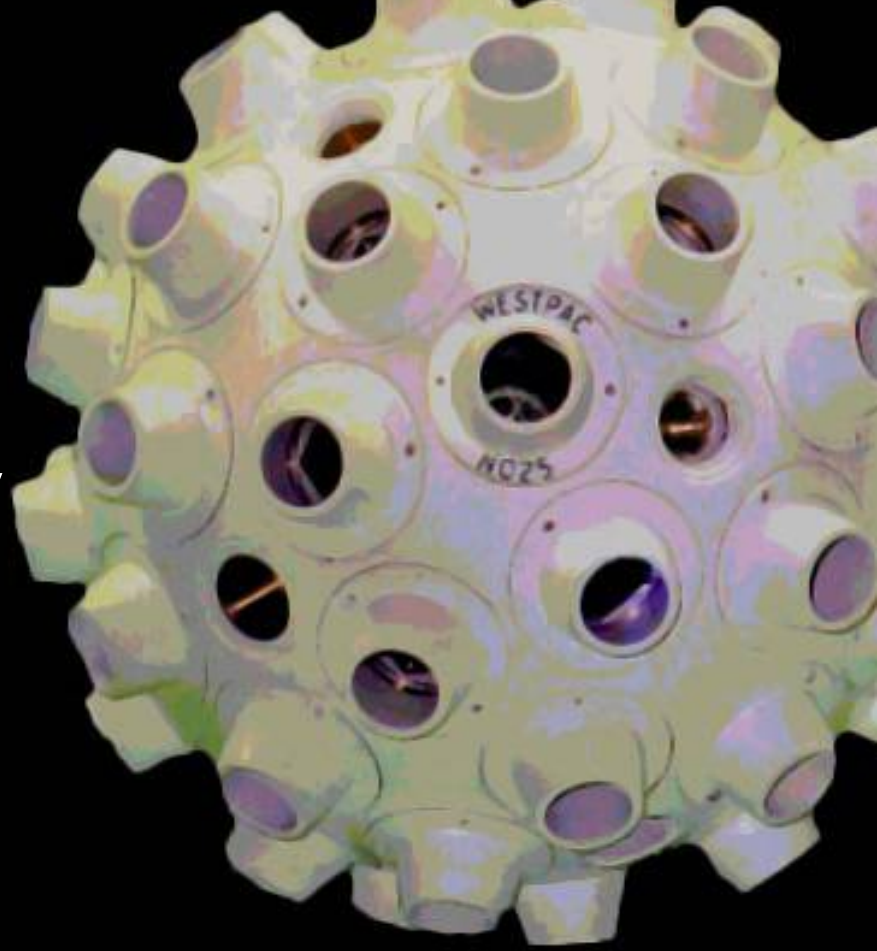
What's next?:

CPFs in production. 1st attempt was unsuccessful possibly due to data available only from one station.

Additionally, the incorrect NORAD number might have resulted in using the wrong TLE for initial conditions.

More tracking from stations and an assessment whether the target is viable for routine ILRS tracking.



WESTPAC

What’s next?:

Need to decide which NORAD number to write to CRD data.

- **25398** is the correct number
- EDC is rejecting data that has this number
- Yarragadee uses 25398 to observe but then writes 25394 to the CRD data.