



Leading the way in photon-counting technology and applications

2024-06-20 - ILRS Networks & Engineering SC meeting

Micro Photon Devices



- Founded in 2004
- Located in Bolzano (Italy)
- R&D office near Milano (Italy)
- Mission: to be the leader in single photon counting technology



Facts and figures

- Annual Turnover: > 2 M€
- Average Annual Growth : 13% over the last 7 years
- Export: 93% of production
- Employees: 8 full time, up to 60 including parent company *Microgate s.r.l.*
- **Solid reputation** of high performance, reliable and robust products
- We make **OUR OWN SILICON** even if we are **fabless** (strong collaboration with Silicon -R&D and CMOS- and InGaAs/InP foundries)



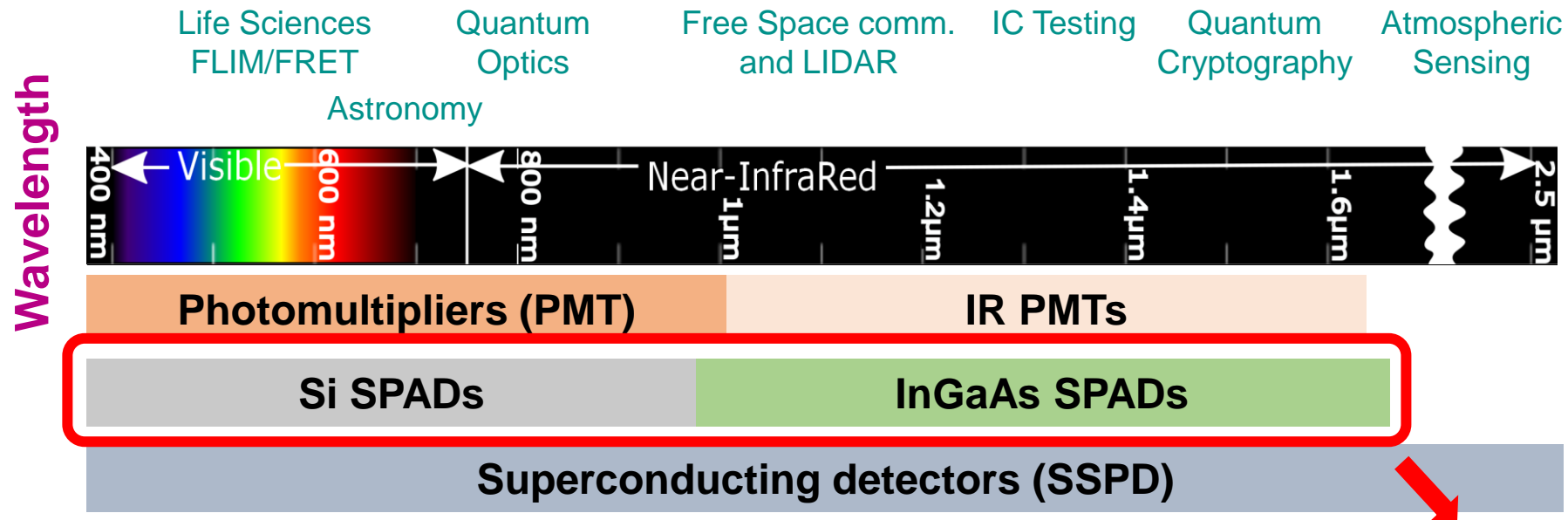
Our markets

Universities
R&D Facilities
OEMs

- **Biomedical**
 - DNA and Drug discovery
 - Confocal Microscopy
 - Fluorescence Lifetime Measurements
 - Fluorescence Correlation Spectroscopy
 - Time Resolved Spectroscopy
 - Light Tomography
 - Single Molecule Spectroscopy
- **Industrial**
 - Particle Sizing
 - Metrology by Time-of-Flight Measurements
 - LIDAR - LADAR
- **Quantum Cryptography**
- **Astronomy**
 - Adaptive Optics
- **Custom Applications**

Single-photon detectors & applications

Applications



Detectors

Single-pixel detectors



Photon Detection Module (PDM)

- LOW dark counting rates: down to **1 c/s**
- 20 μm , 50 μm and 100 μm active area diameter
- Ultrafast timing resolution (typ. **35 ps** FWHM)
- High quantum efficiency (up to **49% @ 550nm**)
- Robust, reliable and low power consumption



PDM

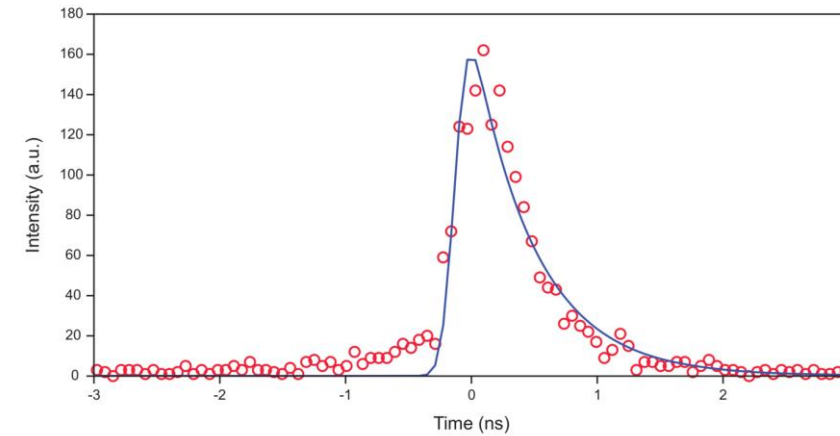
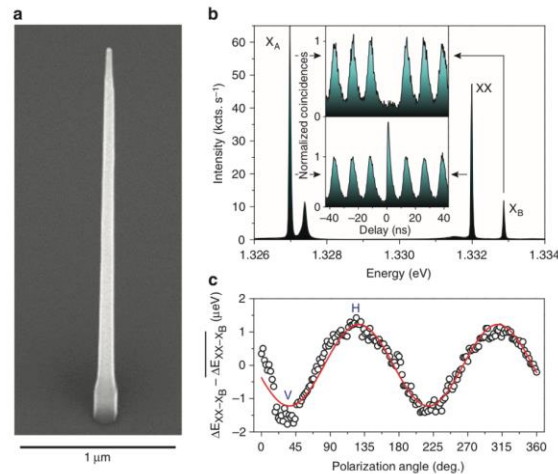


PDM-FC

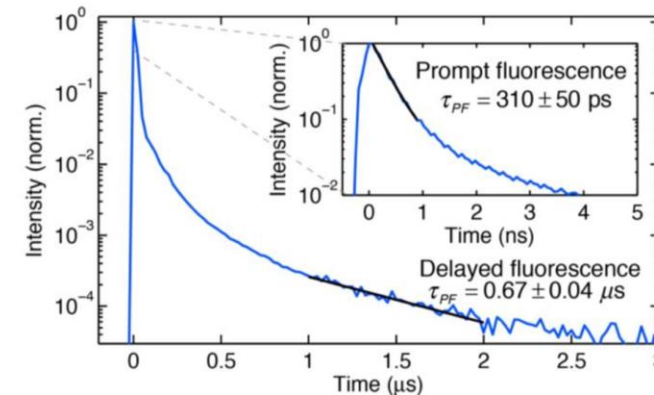
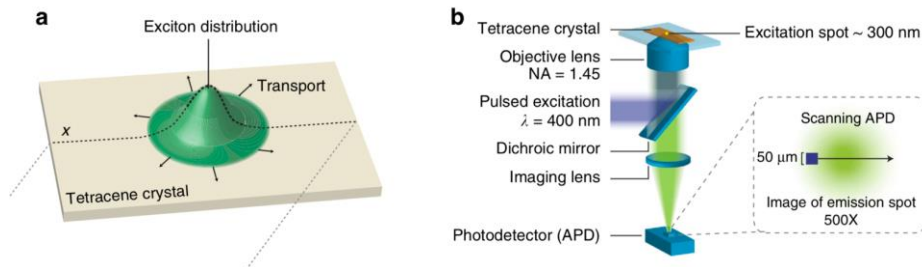
- HIGH Coupling Efficiency (> 80%)
- FC/PC fiber receptacle
- SM Fiber Coupling with 20 μm SPAD
- MM Fiber Coupling with 50 μm and 100 μm SPAD
- Extremely reliable assembly

PDM application: fast lifetime measurement

M. A. M. Versteegh, et al. "Observation of Strongly Entangled Photon Pairs from a Nanowire Quantum Dot." *Nature Communications* 5, no. 1 (December 2014).

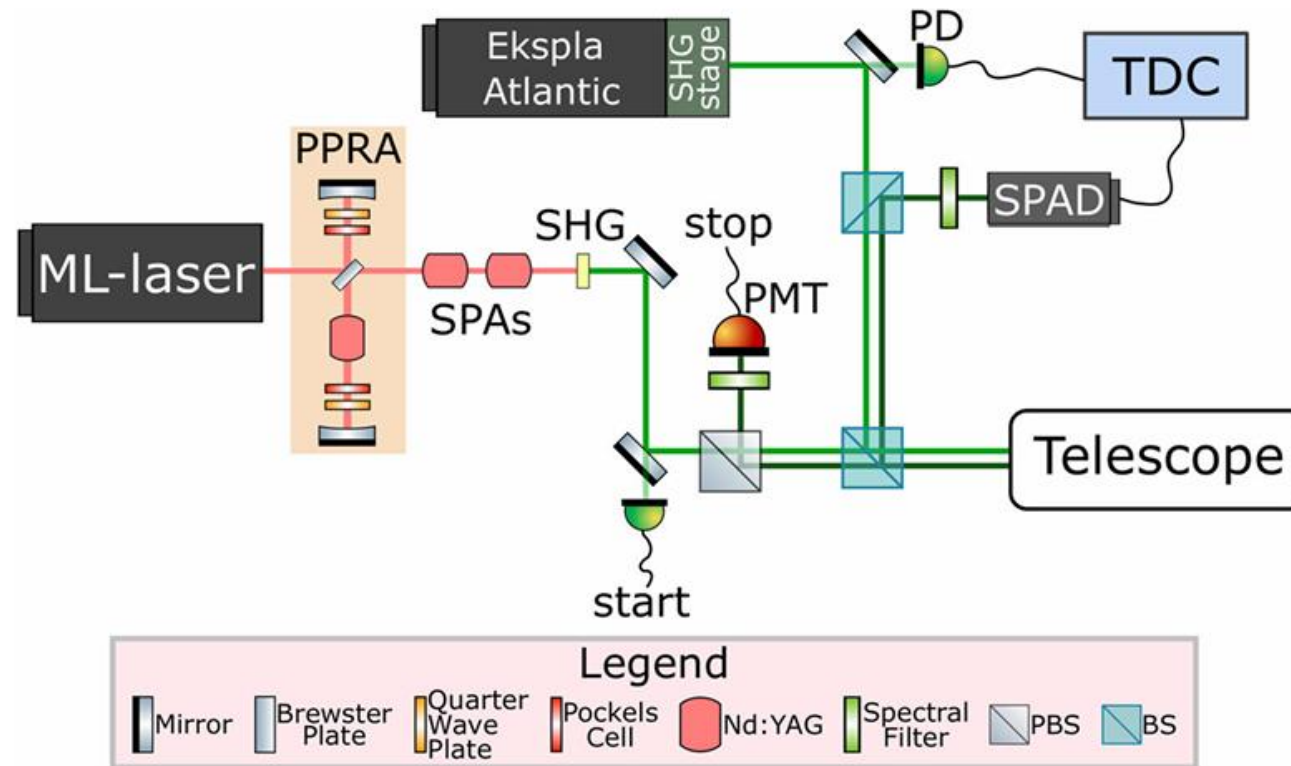


G.M. Akselrod, et al. "Visualization of Exciton Transport in Ordered and Disordered Molecular Solids." *Nature Communications* 5, no. 1 (December 2014).



PDM application: Diffuse Correlation Spectroscopy (DCS)

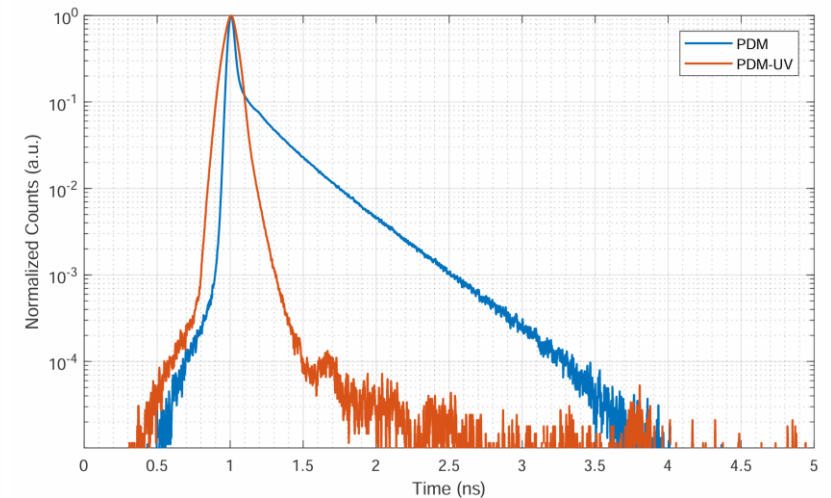
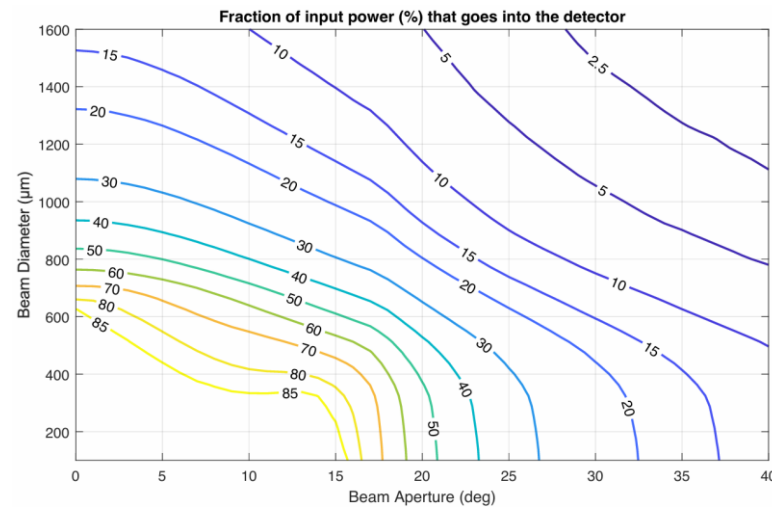
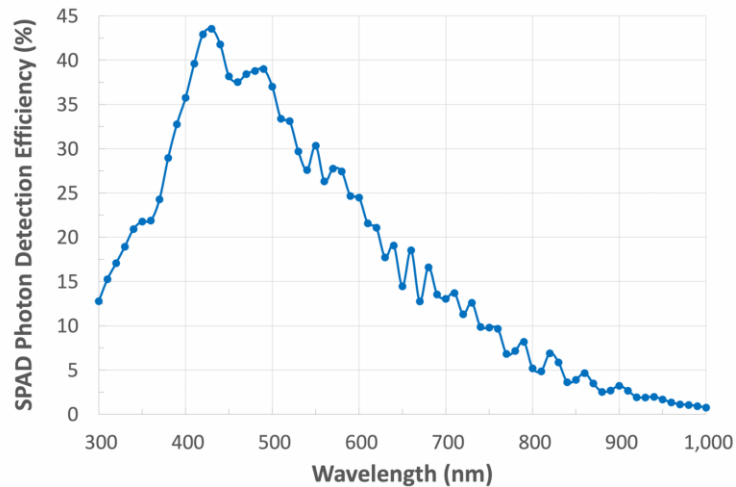
Daniele Dequal, et al. "100 kHz satellite laser ranging demonstration at Matera Laser Ranging Observatory."
Journal of Geodesy, (2021).



PDM-UV-EC



- Enhanced collection efficiency thanks to **custom focusing optics**
- **100 times equivalent area improvement** (i.e. $50\ \mu\text{m} \rightarrow 500\ \mu\text{m}$ SPAD diameter) for nearly-collimated beams
- Timing jitter $< 100\ \text{ps}$ FWHM, DCR $< 100\ \text{cps}$



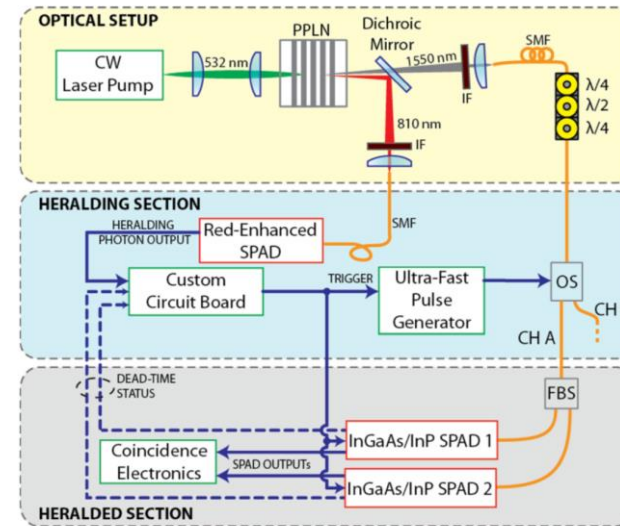
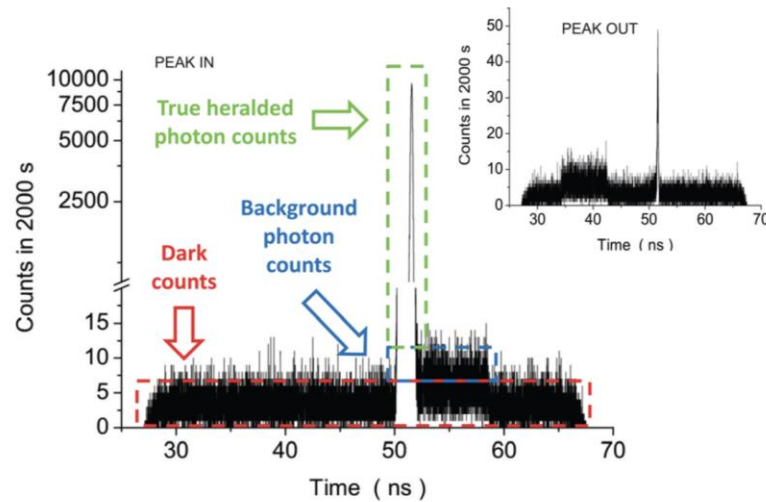
PDM-IR

- Cooled **InGaAs/InP SPAD** for detection up to 1700 nm
- Free-space, SMF-28 and MMF GI 50 μm fiber-pigtailed versions
- Includes a pulse generator for gating, a front-end circuit for avalanche sensing and fast circuitry for detector quenching and resetting.
- **PDE > 25%** at 1550 nm
- DCR as low as **400 cps** and timing jitter **<100 ps** FWHM
- Up to 100 MHz gating or free-running operation
- Fully programmable

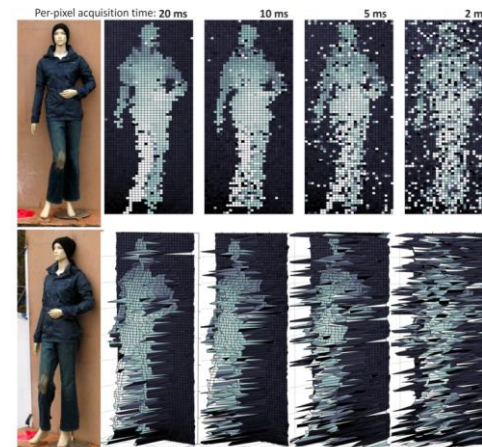
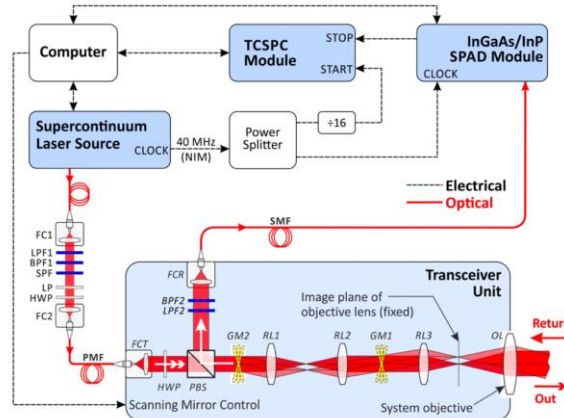


PDM-IR applications: quantum communications and km-range LIDAR

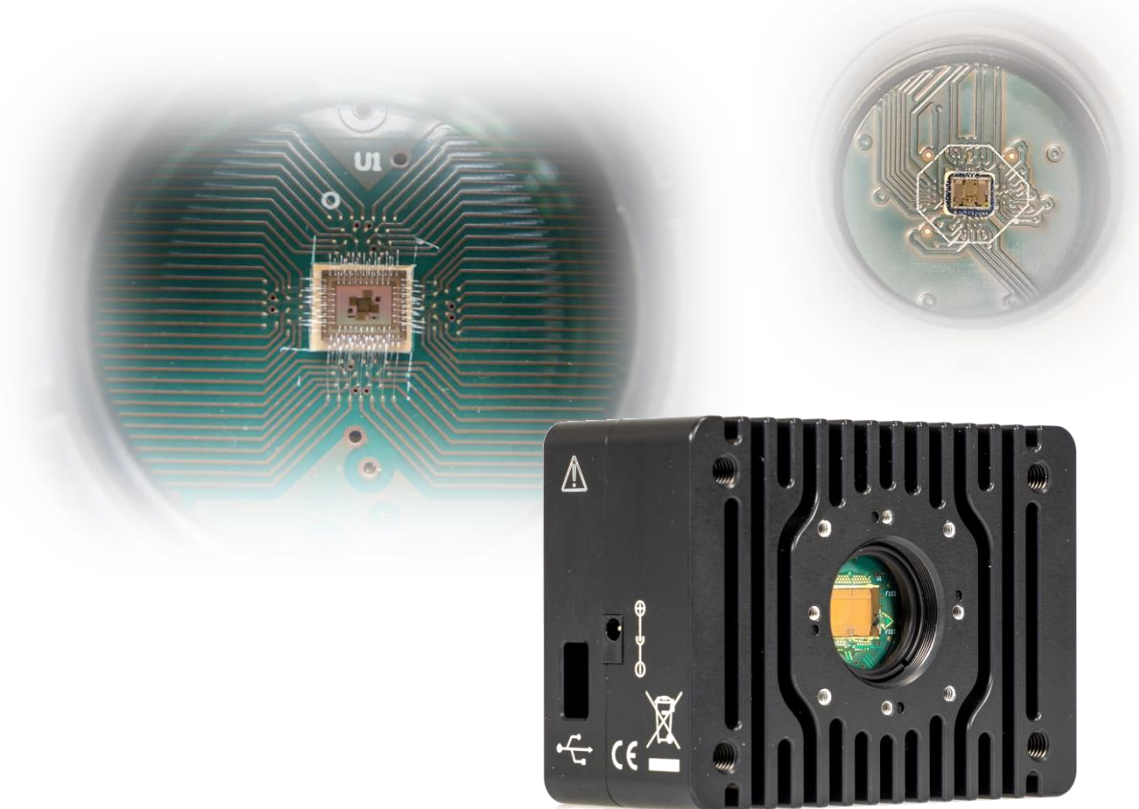
G. Brida, et al. "An Extremely Low-Noise Heralded Single-Photon Source: A Breakthrough for Quantum Technologies." *Applied Physics Letters* 101, no. 22 (2012)



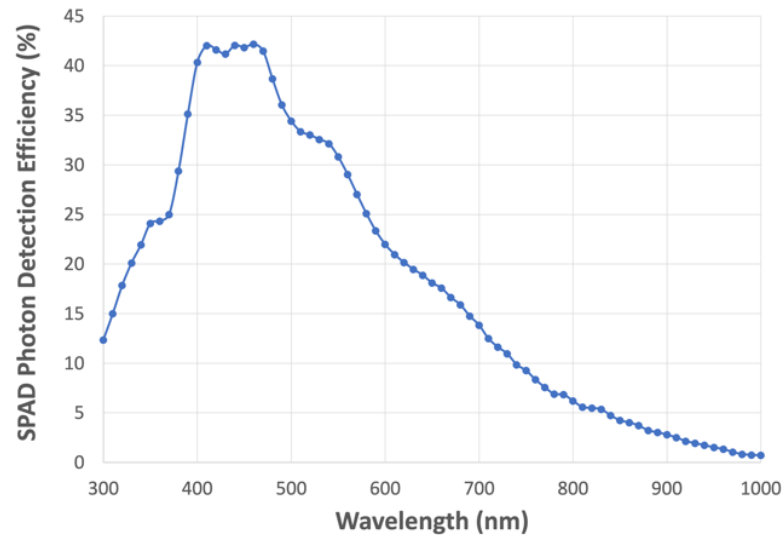
McCarthy, et al. "Kilometer-Range Depth Imaging at 1550 Nm Wavelength Using an InGaAs/InP Single-Photon Avalanche Diode Detector." *Optics Express* 21, no. 19 (2013)



CMOS imaging cameras



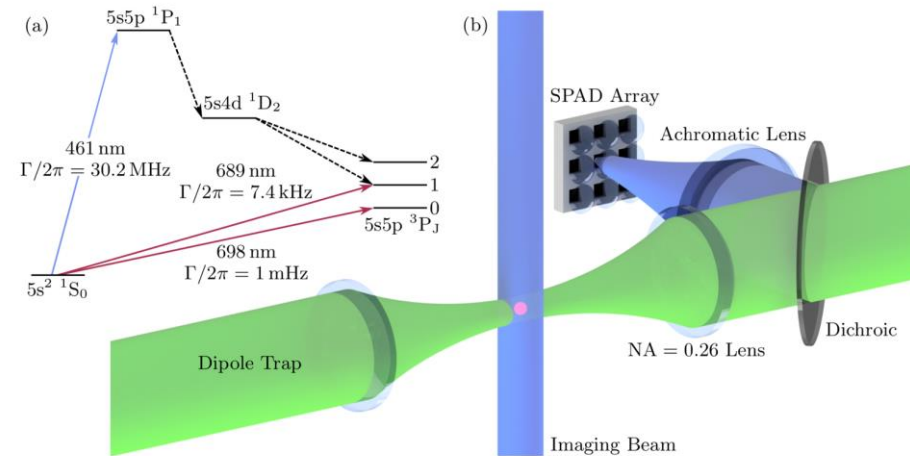
Hermes



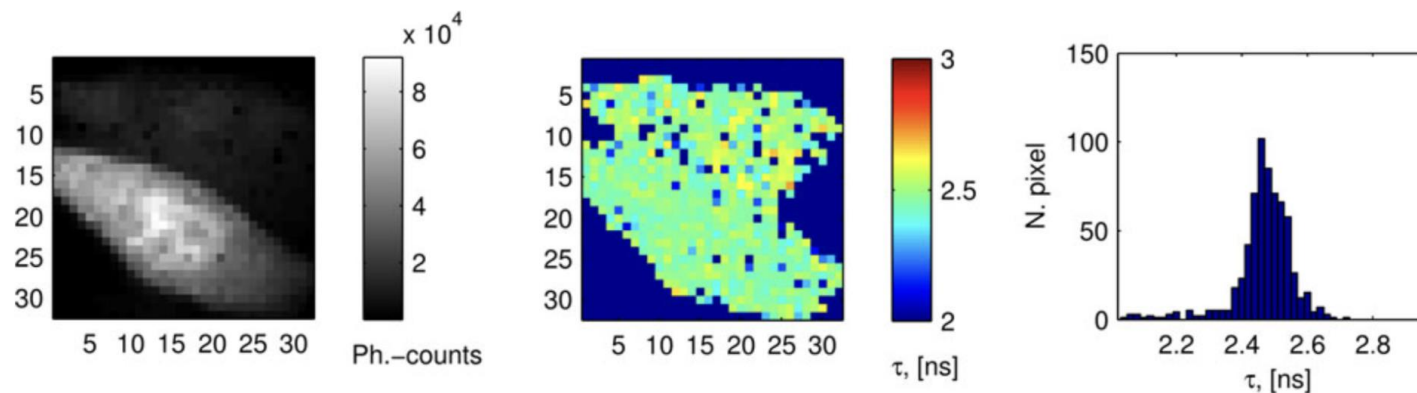
- **32 × 64 SPAD** pixels, fully parallel operation
- PDE: **36%** @ 400nm
- Version with **microlens** array available
- 3 counters (2 up/down) optimized for measuring phase shift and intensity
- Up to **96 kframes/s**
- Low noise: **~100 c/s** for 95% of the pixels
- 3 independent ultra short time gates (2 ns)
- Standard high speed “in-camera” FLIM-mode
- USB 3.0 interface, SDK provided

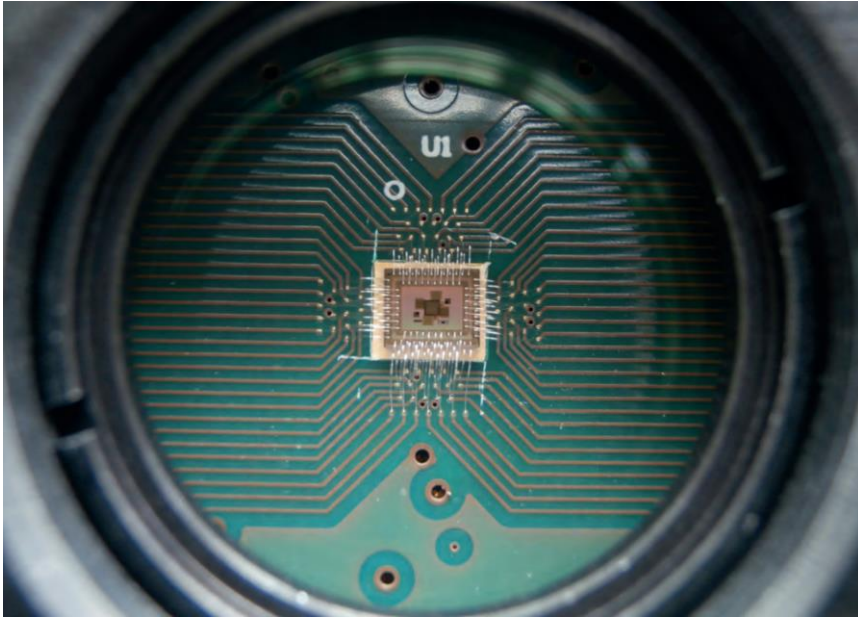
Hermes applications: physical experiments & FLIM

N. C. Jackson “Number-Resolved Imaging of ^{88}Sr Atoms in a Long Working Distance Optical Tweezer.” ArXiv:1904.03233 [Physics], 2019.

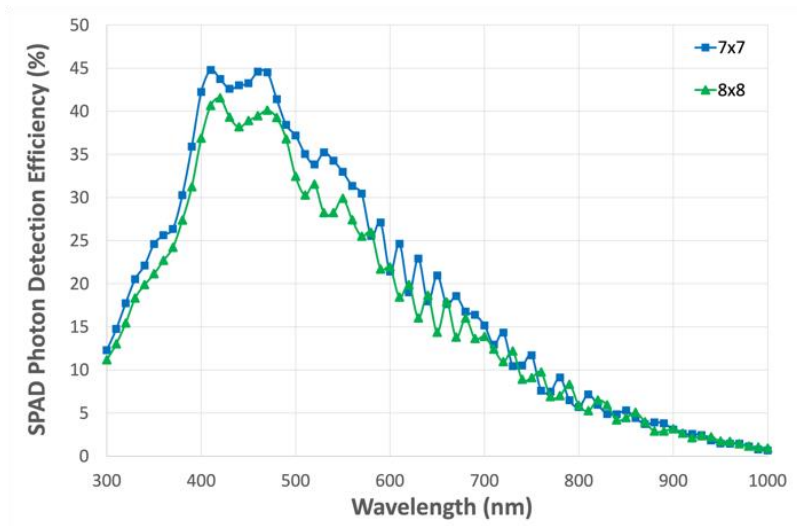


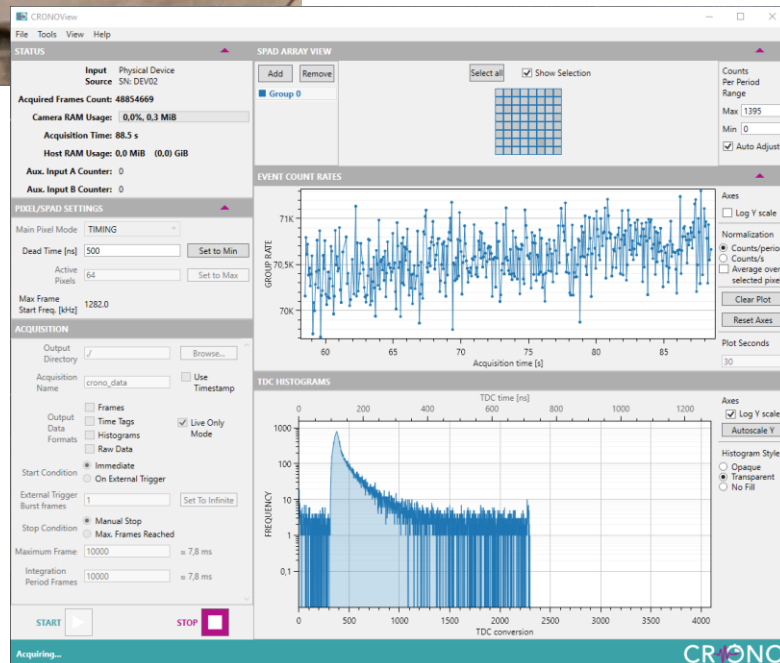
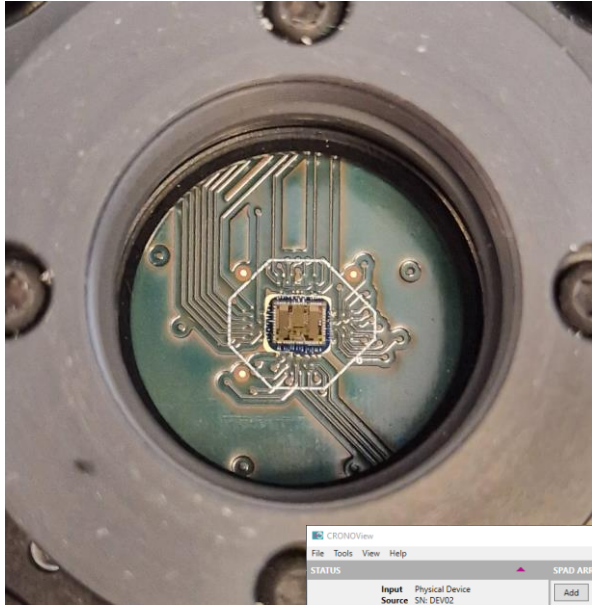
M. Vitali, et al. “A Single-Photon Avalanche Camera for Fluorescence Lifetime Imaging Microscopy and Correlation Spectroscopy.” IEEE Journal of Selected Topics in Quantum Electronics 20, no. 6 (2014)





- **7×7** or **8×8** SPAD pixels with direct outputs
- Timing jitter < **150 ps** FWHM – 7×7
- Timing jitter < **180 ps** FWHM – 8×8
- DCR < **500 c/s** for at least 85% of pixels
- LVDS timing outputs
- 12.6% native fill factor, **74%** with MLA





- **8×8** or **128×1** SPAD array with integrated TDCs
- 312.5 ps TDC resolution
- Frame rate > 1 Mframe/s
- PDE: **36 %** @ 400nm
- Fill factor ~10% and up to **78%** with MLA
- Internal or external hardware gating
- USB 3.0 interface, SDK provided

Other products



Quantum Random Number Generator (QNRG)

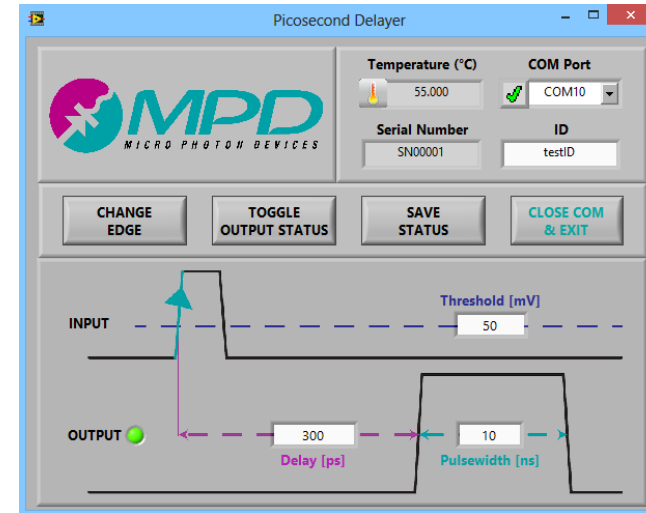


- Based on quantum physics
- Robust and low cost
- Up to 180 Mbps
- Low power consumption
- Easy to use

Dieharder, TestU01

Statistical Test Suites: **PASSED!**

Picosecond Delayer



- 50 ns maximum delay range
- TTL and NIM output pulses
- Up to 380 MHz bandwidth (NIM output)
- Programmable output width from 1 ns to 250 ns
- Typ. INL between +50 ps and -50 ps over full-scale range
- 10 ps step
- Random jitter typ. 5 ps RMS
- < 1 ms programming time
- USB interface
- All solid state, no coax cables

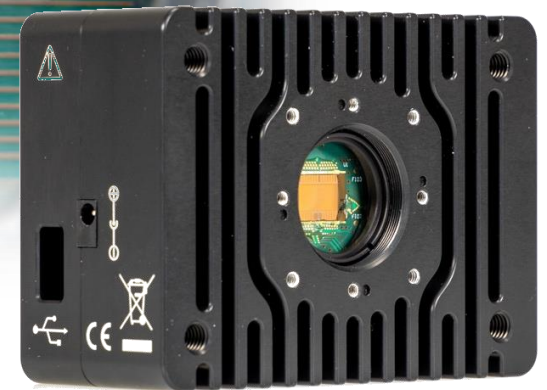
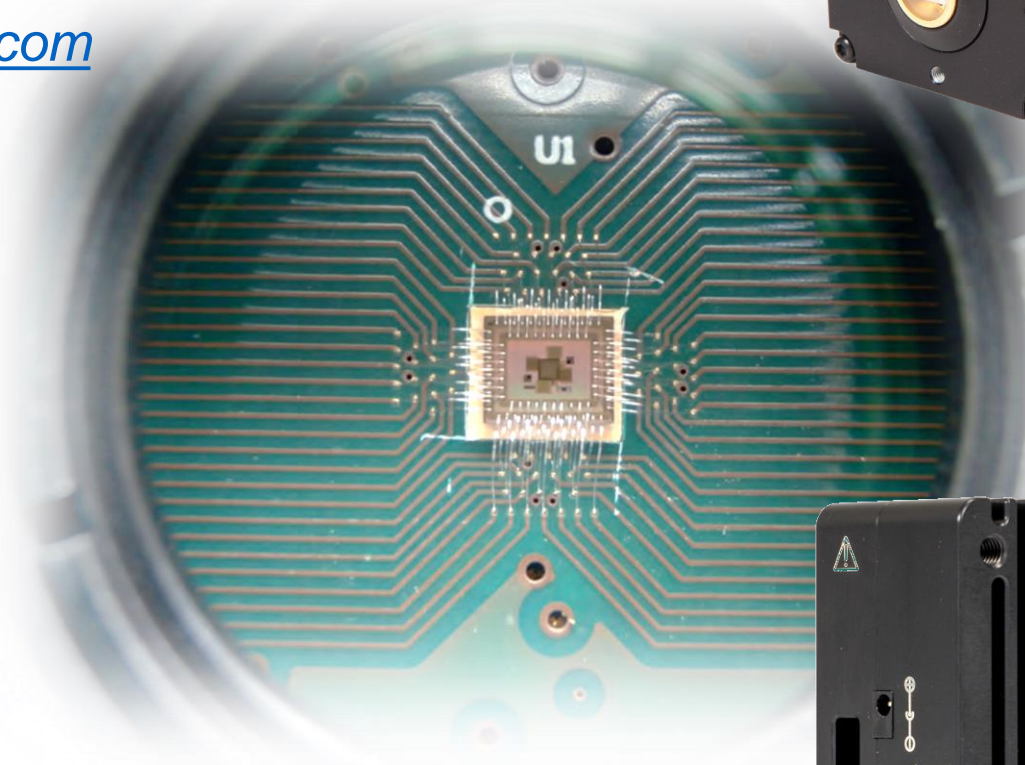
Contacts

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*ILRS NESC meeting
20th June*

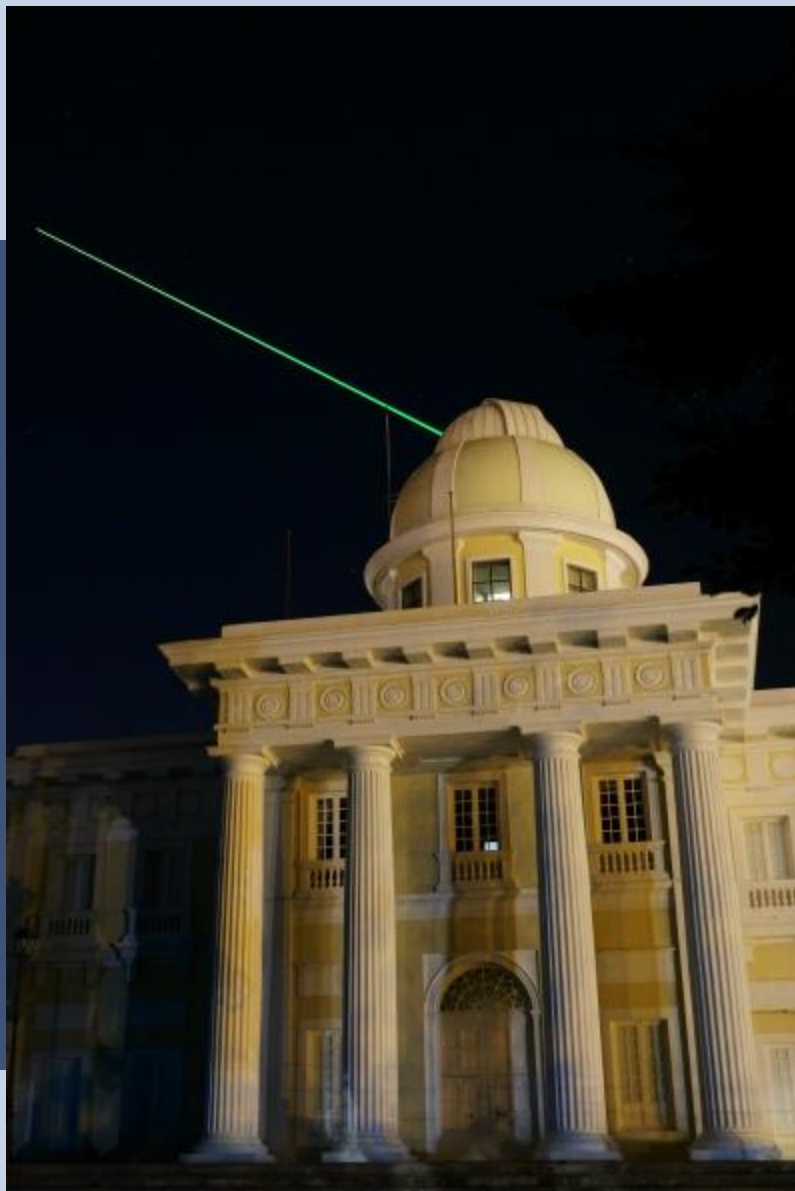


Improvements in the last 6 months at SFEL station

LT CDR Manuel Angel Sánchez Piedra



- 1. Introduction***
- 2. Infrastructure enhancements***
- 3. New Mount Project - AMELAS***
- 4. Improvements in other subsystems***
- 5. Future development projects***
- 6. Conclusions - objectives***



1. Introduction



Historical background



ESTACIÓN DE SEGUIMIENTO LÁSER
REAL INSTITUTO Y OBSERVATORIO DE LA ARMADA

Oldest astronomical observatory in Spain (1753).

Created at the initiative of Jorge Juan.

Training of Midshipmen in Fields of Science such as Navigation, Geodesy and Astronomy.

Participation in relevant international position astronomy projects (e.g. Carte du Ciel - 1887).

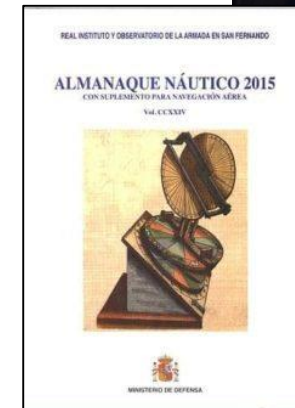
During its more than 250 years of operation, new missions for the Navy and for Spanish science were added to its original astronomical tasks.

The publication of the Annual Astronomical Ephemeris and the Nautical Almanac (1791).

The Deposit of Chronometers and Instruments of the Navy.

Meteorological (1811), magnetic (1879) and seismic (1898) observations

The scientific determination of time.



Historical background



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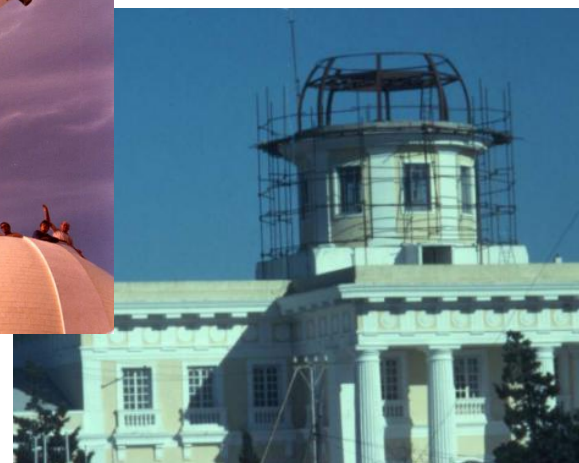
ROA has been a pioneer in Spain in the tracking of artificial satellites.

Photographic Techniques

- 1958. Baker-Nunn camera
- 2010. TFRM Robotic Telescope Modernization

SLR

- 1968. French Geodesic Campaign (CNES-GRGS)
- 1979. Transfer agreement to Spain



Overview of SFEL station



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MISSION

Both *collaborative object* and space *debris tracking*.

SFEL has participated with national and international tracking networks, for geodetic and SST purposes:

ILRS - EUROLAS

S3T - EU SST

ESA



It has also collaborated with companies in the space sector



Overview of SFEL station



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Space debris tracking

- LEO, 4 m²
- EKSPLA NL317 (25W @532 8ns)
- SAP500 detector



ILRS tracking tasks.

- LEO-MEO
- EKSPLA PL2251 (500mW @532 30ps)
- C-SPAD detector



FPGA-RGG

Event Timmer A032

PPS Synchronization with ROA Time Laboratory, Rubidium and Whitte Rabbit

Altazimuth mount

- 600 mm Cassegrain Telescope
- Launching Telescope - micrometric mechanical pointing
- Pointing Telescope - analogic camera + f12 telescope





2. Infrastructure enhancements



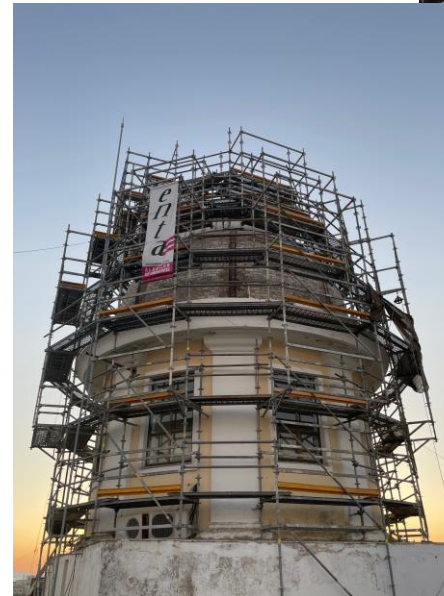
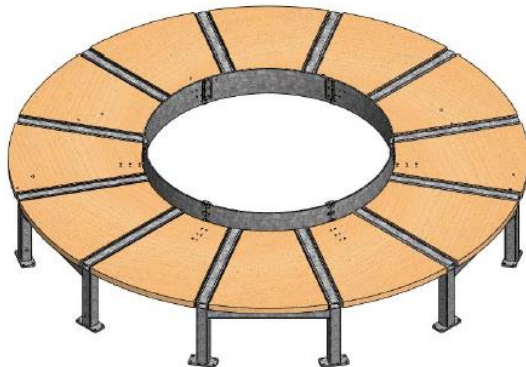


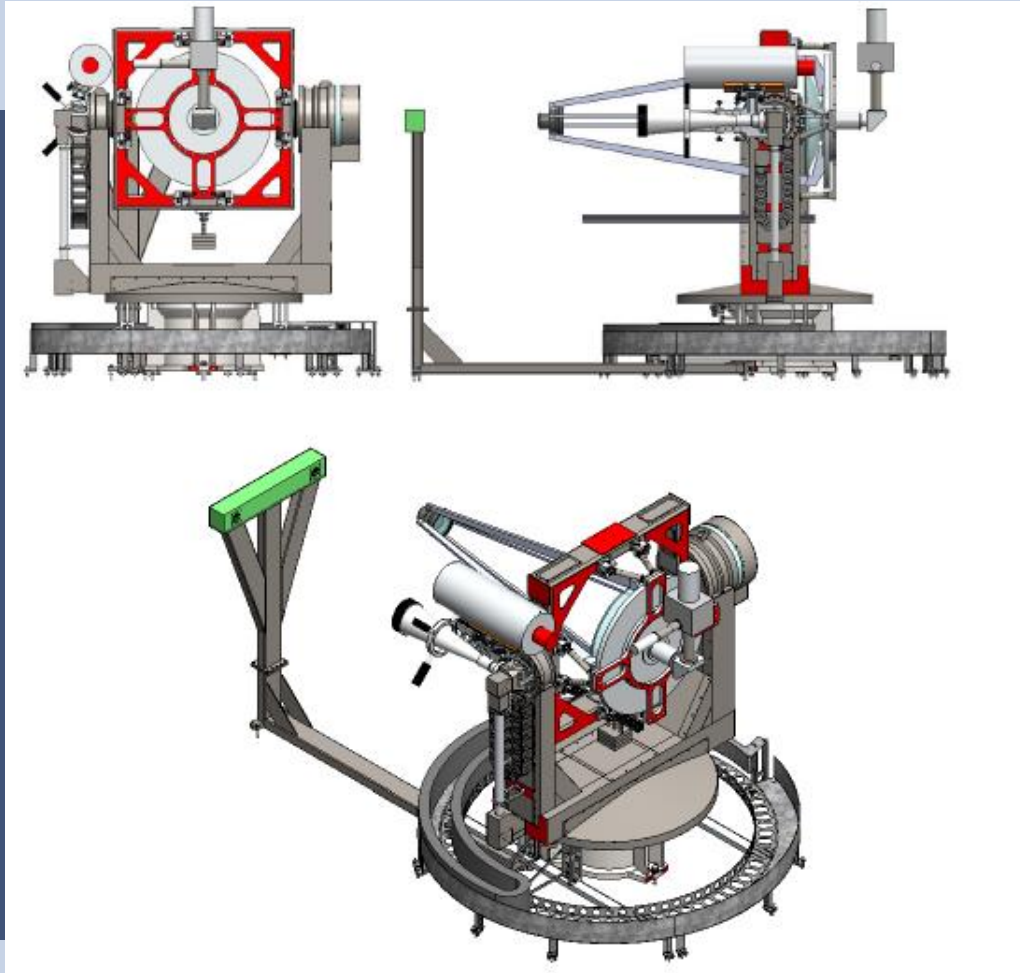
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Infrastructure enhancements

*Water leaks during the last two winters in the dome of the main building.
Maintenance work since November to February.*

*Conditioning of the laser and control rooms
Renewal of the electrical installation
Installation of a technical floor in the dome*





3. New mount project

New mount project



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Previous mount

- *Altazimuth mount*
- *From the project carried out by CNES (1979).*
- *Nominal accuracy (6 arcsec). Test: real accuracy (≈ 20 arcsec).*



Drawbacks

- *Servomotors with gear systems with limited precision*
- *Excessive vibrations due to mechanical transmission*
- *Gears have looseness due to wear*
- *Relative encoders. Homing to reset errors.*
- *Az & El cannot be used for complement observations*
- *Limited observational capacity for space debris.*
- *Highly coupled software*



New mount project



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New Altazimuth Mount – AMELAS project

Developed by the Spanish company AVS (Basque Country).

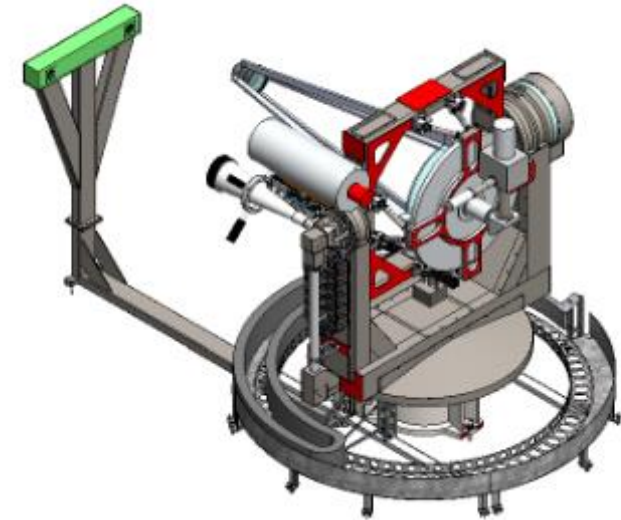
Current Project status:

- *FAT tests finished*
- *Installation in ROA and SAT tests (from 25 JUN)*

Main characteristics

- *Accuracy <1 arcsec (static 1/100 arcsec)*
- *Direct Drive technology (less vibration, wear and maintenance).*
- *High speeds and accelerations (>12°/s y >15°/s²).*
- *Invariant point precision < 1mm*
- *API design on demand*

Operating modes, security layers, tracking mode (CPF, TLE and stars-mount model), daylight use (exclusión área-sun), etc...



New mount project



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4. Improvements in other subsystems

Improvement in other subsystems



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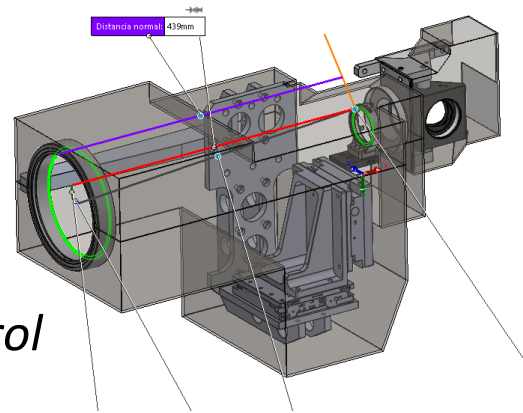
New ToF Measurement System

- Eventech ESST 7 Series
- Extremely precise & reliable time tagging device
- 1.5 ps RMS time-tag precisión



New launcher telescope

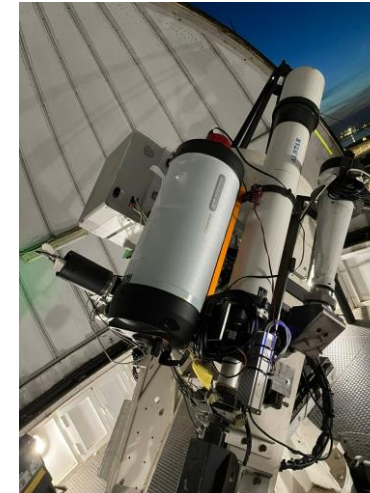
- Optomech based on COTS
- Beam pointing control and divergence control



New finder telescope

Celestron RASA 8 + CMOS ZWO ASI 2600

Already tested in GNSS – useful for space debris



Improvement in other subsystems



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WEEKDAY	DATE	NAME	NORAD	LR	DR	START TIME	MAX. ALT.	END TIME	PASS	AZIMUTHS
Monday	28-09-2023	TOPEX	22676	Yes	Yes	12:40h	24	12:54h	13:01h	50/NE 262.375 10
Monday	28-09-2023	AJDAI	10908	Yes	No	12:53h	40	13:02h	13:11h	50/NE 307 17 86
Monday	28-09-2023	LAGEOS1	8820	Yes	No	13:15h	35	13:40h	14:06h	50/NO 194 257 324
Monday	28-09-2023	ERS1	21174	Yes	Yes	13:24h	27	13:29h	13:32h	50/NE 118 65 15
Monday	28-09-2023	OKETS	28809	Yes	Yes	13:31h	47	13:30h	13:41h	NE/SE 24 99 175
Monday	28-09-2023	ADEOS2	27987	Yes	Yes	13:54h	87	13:59h	14:05h	SE/NO 166 271 348
Monday	28-09-2023	METEORIM	27001	Yes	Yes	14:17h	20	14:23h	14:26h	NE/SE 45 93 142

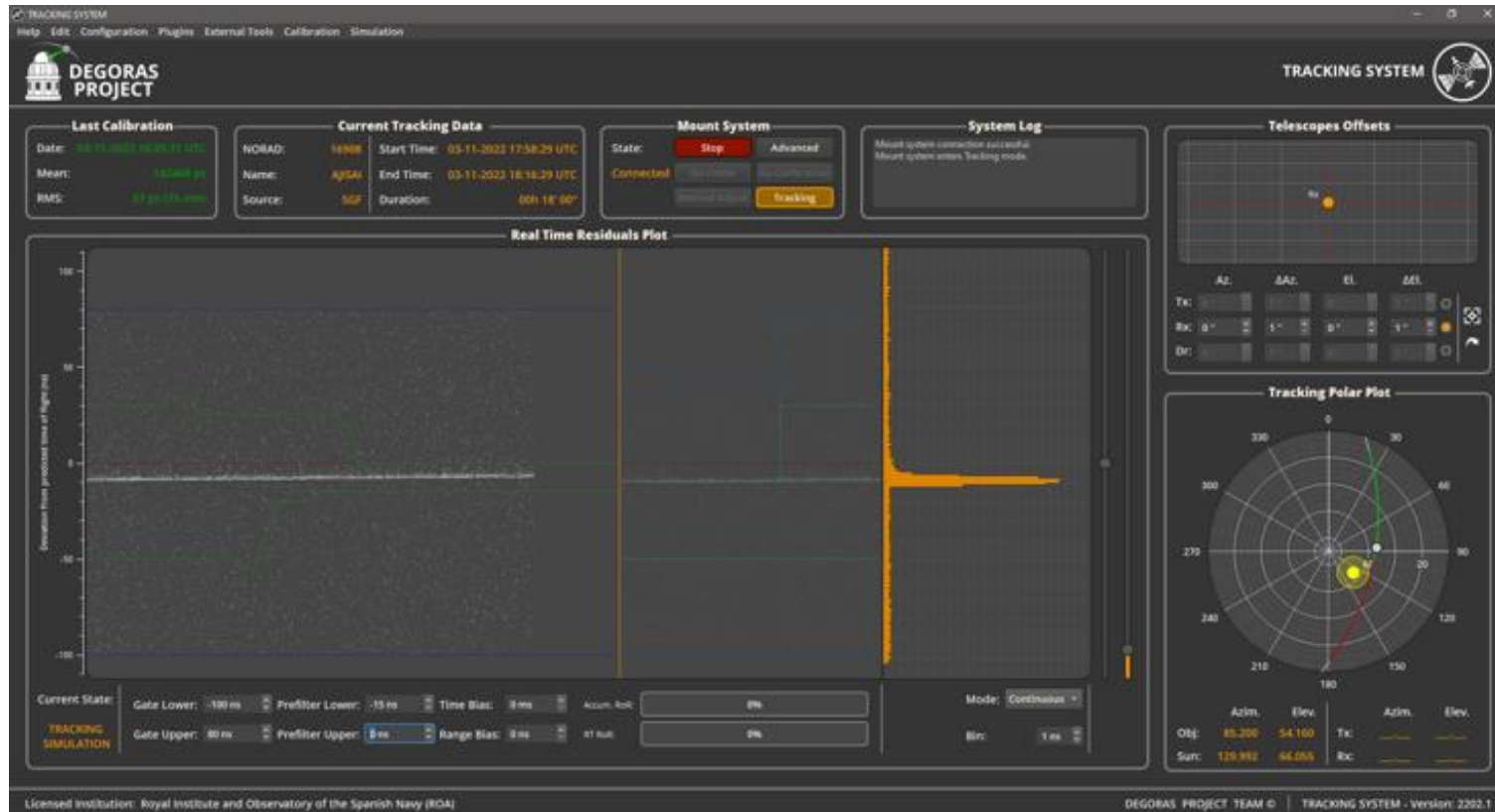
Software Development

- **Station Control**
- *Tracking programme*
- *Space Objects Database*
- *Prediction Generator*
- *Safety System and air warning*

Improvement in other subsystems



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Software Development

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Improvement in other subsystems



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SPACE OBJECTS MANAGER

Help Edit Configuration Plugins External Tools

DEGORAS PROJECT

SPACE OBJECTS MANAGER

Space Objects Data Table

EN. POLICY	NORAD	NAME	ILRS NAME	COSPAR	ILRS ID	SK	CLASSIFICATION	LR	DEBRIS	TRACK POLICY	PROR	CPF	ALTITUDE	RCS	NPI	RS
Disabled	40129	GALILEO	GALILEO01	2014-0508	1409002	7202	Satellite	Yes	No	Always	0	All	21665	0	300	0
Disabled	40128	GALILEO	GALILEO201	2014-0504	1409001	7201	Satellite	Yes	No	Always	0	All	21665	0	300	0
Disabled	38836	GALILEO104	GALILEO104	2012-0538	1305562	7104	Satellite	Yes	No	Always	0	All	23220	13.22	0	300
Disabled	38837	GALILEO103	GALILEO103	2012-0534	1305561	7103	Satellite	Yes	No	Always	0	All	23220	16.333	0	300
Disabled	37847	GALILEO102	GALILEO102	2011-0408	1194000	7102	Satellite	Yes	No	Always	0	All	23220	46.772	0	300
Disabled	37846	GALILEO101	GALILEO101	2011-0404	1194001	7101	Satellite	Yes	No	Always	0	All	23220	51.378	0	300
Disabled	29656	ETS	ETS	2004-0304	900001	1574	Geostationary	Yes	Yes	Always	0	All	36000	11	0	300
Disabled	29038	COSMOS2024	ETALON2	1889-030C	8902903	4146	Glossary Constellation	Yes	No	Always	0	All	19125	1.208	0	300
Disabled	18791	COSMOS1989	ETALON1	1889-001C	8901403	3525	Glossary Constellation	Yes	No	Always	0	All	19185	5.584	0	300
Enabled	22360	ERS2	ERS2	1990-021A	7502101	6175	Earth Resources, Brightest	Yes	Yes	Always	0	All	800	8.221	3	15
Enabled	21514	ERS1	ERS1	1991-030A	9100001	6177	Earth Resources, Brightest	Yes	Yes	Always	0	All	790	11.009	3	15
Enabled	27346	ENVISAT	ENVISAT	2002-008A	5200001	6179	Earth Resources, Brightest	Yes	Yes	Always	0	All	772	19.497	3	15
Enabled	2686	DIADEME2	DIADEME10	1967-014A	6701401	6704	Space & Earth Science	Yes	Yes	Always	0	All	585	0.427	3	15
Enabled	2674	DIADEME1	DIADEME1C	1967-011A	6701101	6703	Space & Earth Science	Yes	Yes	Always	0	All	345	0.527	3	15
Disabled	3658	CRYOSAT2	CRYOSAT2	2010-013A	1001301	8886	Space & Earth Science	Yes	No	Always	0	All	725	2.97	3	15
Disabled	41815	BEIDOU1	COMPASSM3	2010-006A	1800601	2011	Beidou Navigation System	Yes	Yes	Always	0	All	21300	0	0	300
Disabled	26792	BEIDOU2	COMPASSM3	2012-018A	1201801	2004	Beidou Navigation System	Yes	No	Always	0	All	21526	5.623	0	300
Disabled	31115	BEIDOU1	COMPASSM1	2007-011A	0701101	2001	Experimental...igation System	Yes	Yes	Always	0	All	21300	5.461	0	300
Disabled	40549	BEIDOU17	COMPASS10	2015-019A	1501901	2006	Beidou Navigation System	Yes	Yes	Always	0	All	25766	0	0	300
Disabled	41434	BEIDOU12	COMPASS08	2016-021A	1602101	2012	Beidou Navigation... Geostationary	Yes	No	Always	0	All	30677	0	0	300
Disabled	37948	BEIDOU15	COMPASS10	2011-073A	1107301	2003	Beidou Navigation System	Yes	No	Always	0	All	25766	7.943	0	300
Disabled	37768	BEIDOU9	COMPASSH	2011-030A	1103001	2009	Geostationary...gation System	Yes	Yes	Always	0	All	42181	7.943	0	300
Disabled	37364	BEIDOU8	COMPASS10	2011-013A	1101301	2003	Geostationary...gation System	Yes	No	Always	0	All	25766	25.118	0	300

Enablement Policy: All Enabled Disabled | Laser Retro Reflector: All With Without | Details: All N IS IS not | ILRS: All N IS IS not | Search:

Database | Name: ROWNR_Database_v2 | Date: 2020-08-31 12:28:14 UTC | Objects | Enabled: 28 | Loaded: 905 | Displayed: 905 | Default All | Select All

Space Object Picture

Sets Tools

System Set: DEBRIS ILRS + ROCKETS
Loaded Set: DEBRIS ILRS + ROCKETS
Selected Set: DEBRIS ILRS + ROCKETS

Set as System Set and Load

New Set Delete Selected

Load Selected Save Selected

Set En. Policy Disabled

Database Tools

Add Space Object

Edit Selected Delete Selected

Load Database

Open Database

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Software Development

- Station Control
- Tracking programme
- Space Objects Database
- Prediction Generator
- Safety System and air warning

Improvement in other subsystems



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Predictions Calculation Options

Sunset Start (UTC): 21:00 | Start Time (UTC): 25-09-2020 11:47 | Start Elevation (altitude > 15000 km) (%): 40
 Sunset End (UTC): 01:00 | End Time (UTC): 30-09-2020 00:00 | Start Elevation (altitude >= 15000 km) (%): 40
 Dawn Start (UTC): 06:00 | Calculation Time (days): 4.39 | Minimum Elevation With LLR (%): 30
 Dawn End (UTC): 08:00 | Interpolation %: 31 | Minimum Elevation Without LLR (%): 40

Current Predictions Summary

Creation Time: 25-09-2020 11:48:16 UTC | ILRS Normal: 13 --- Passes: 149
 Start Time: 25-09-2020 11:47:57 UTC | ILRS Debris: 0 --- Passes: 0
 End Time: 29-09-2020 23:13:16 UTC | With LLR: 13 --- Passes: 148
 Objects: 13 --- Passes: 149 --- Excluded: 0
 Without LLR: 0 --- Passes: 0

Generated Predictions And Space Objects Data

NORAD	NAME	WEEK DAY	DATE	START	MAX. ELE.	END	DUR.	PASS	AZIMUTHS	CFP SOURCE	Wpqs
38290	BEIDOU11	Friday	25-09-2020	11:47	16-12:01	13:45	1:11	NO/SO	294 261 183	38290_cpf_200919_7631.xlsx	false
22195	LAGEOS2	Friday	25-09-2020	12:41	14-13:14	13:48	47	NO/NE	236 323 55	22195_cpf_200925_7601.rgf	false
18998	EOS	Friday	25-09-2020	13:34	18-13:41	13:51	17	NO/NE	307 14 85	18998_cpf_200925_7601.jax	false
27944	LARES5	Friday	25-09-2020	13:39	32-14:03	14:08	8	NE/SE	32 98 162	27944_cpf_200925_7601.rgf	false
18998	EOS	Friday	25-09-2020	13:36	14-15:46	15:55	19	NO/SE	308 48 127	18998_cpf_200925_7601.jax	false
27944	LARES5	Friday	25-09-2020	13:37	21-15:46	15:44	7	NO/SO	341 293 246	27944_cpf_200925_7601.rgf	false
28451	SWARM8	Friday	25-09-2020	16:25	43-16:29	16:33	7	SE/NE	138 89 13	28451_cpf_200924_7601.xlsx	false
38077	LARES	Friday	25-09-2020	16:53	21-16:56	17:06	13	SE/NE	144 87 50	38077_cpf_200925_7601.rgf	false
22195	LAGEOS2	Friday	25-09-2020	16:54	63-17:28	18:04	69	NO/SE	295 21 136	22195_cpf_200925_7601.rgf	false
31490	TERRASAR-X	Friday	25-09-2020	17:37	42-17:41	17:45	7	SE/NE	146 75 1	31490_cpf_200925_7601.gfs	false
38885	SARISat-X	Friday	25-09-2020	17:37	42-17:41	17:45	7	SE/NE	146 75 1	38885_cpf_200925_7601.gfs	false
18998	EOS	Friday	25-09-2020	17:39	38-17:47	17:54	15	NO/SE	290 235 178	18998_cpf_200925_7601.jax	false
39096	SARAL	Friday	25-09-2020	17:54	31-17:58	18:04	9	NE/SE	34 98 166	39096_cpf_200924_7601.xlsx	false
38453	SWARM6	Friday	25-09-2020	18:22	41-18:26	18:29	6	NO/SO	332 276 189	38453_cpf_200924_7601.xlsx	false
38453	SWARM6	Friday	25-09-2020	18:23	54-18:28	18:29	6	NO/SO	349 271 192	38453_cpf_200924_7601.xlsx	false
38077	LARES	Friday	25-09-2020	18:47	34-18:56	19:05	18	NO/NE	209 295 20	38077_cpf_200925_7601.rgf	false
39096	SARAL	Friday	25-09-2020	19:34	27-19:38	19:43	8	NO/SO	349 293 231	39096_cpf_200924_7601.xlsx	false
36308	CRYOSAT2	Friday	25-09-2020	20:00	34-20:04	20:06	8	NE/NE	33 84 144	36308_cpf_200925_7601.xlsx	false
22195	LAGEOS2	Friday	25-09-2020	21:05	35-21:33	22:06	64	NO/SE	311 243 176	22195_cpf_200925_7601.rgf	false

Automatic notifications

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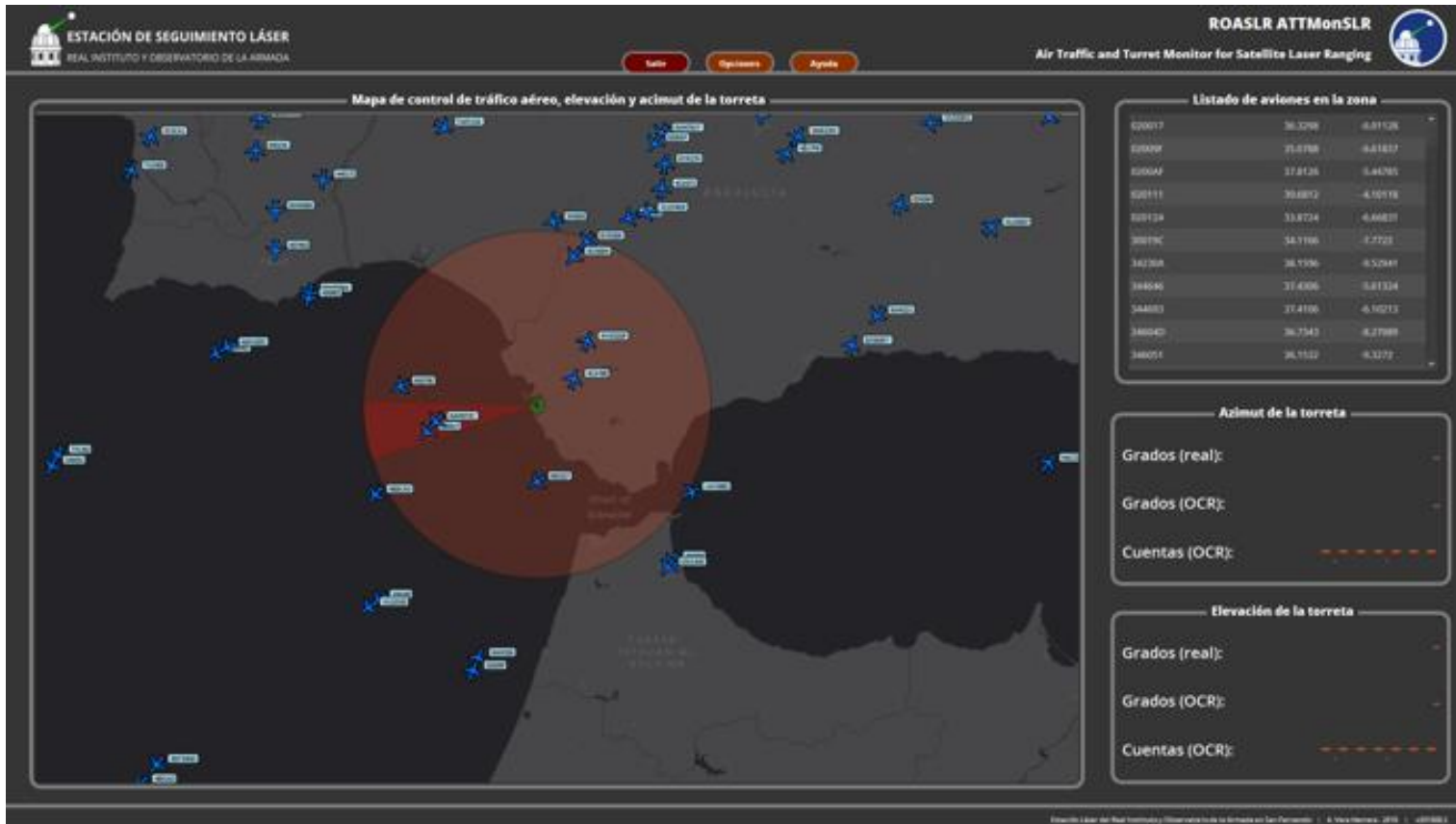
Software Development

- Station Control
- Tracking programme
- Space Objects Database
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- Safety System and air warning

Improvement in other subsystems



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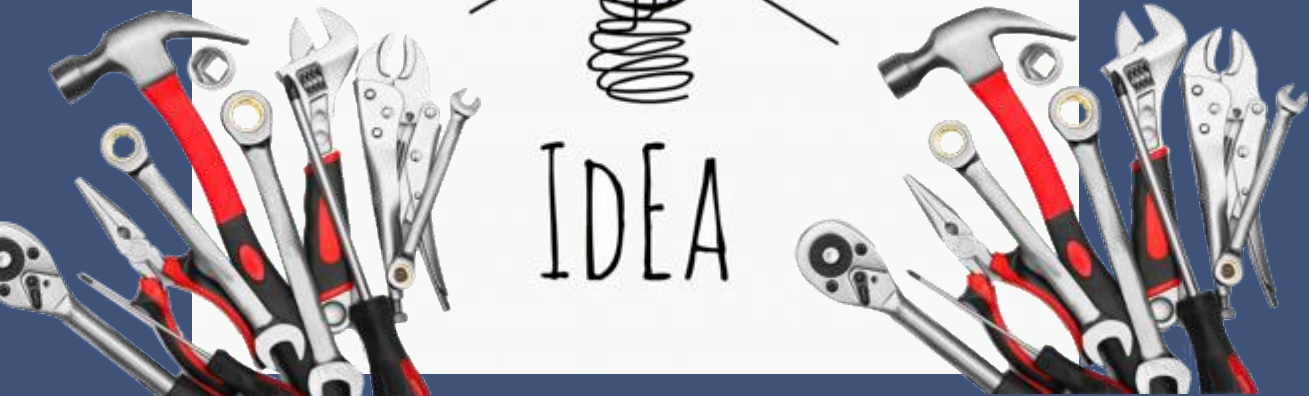


Software Development

- *Station Control*
- *Tracking programme*
- *Space Objects Database*
- *Prediction Generator*
- ***Safety System and air warning***



IDEA



5. Future development projects





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Future development project

TERELAS

New Cassegrain telescope 800 mm
1 arcsec star image
Lighter and with greater reflectivity
Space debris

$$n_{pe} = \eta_q \left(E_T \frac{\lambda}{hc} \right) \eta_t G_t \sigma \left(\frac{1}{4\pi R^2} \right)^2 A_r \eta_r T_a^2 T_c^2$$

KIROA

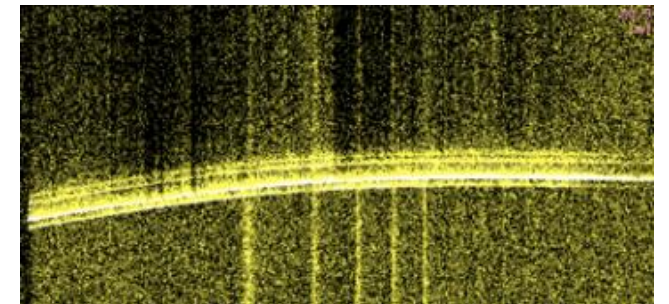
New KHz laser
Combine in the same device characteristics required by ILRS and SST
532 nm, 1-5 KHz, 20 W, < 75 ps

$$\sigma_{Total}^2 = \sigma_{Pulso\ láser}^2 + \sigma_{Detector}^2 + \sigma_{Contador}^2 + \sigma_{Satélite}^2$$

$$\Delta R_{NP} = \frac{\sigma_{Total}}{\sqrt{N}}$$

CUPROA

Minimun speed 15°/s (re-entries)
Slit dome according to TERELAS
Integrated in station control SW





7. Conclusions



Conclusiones



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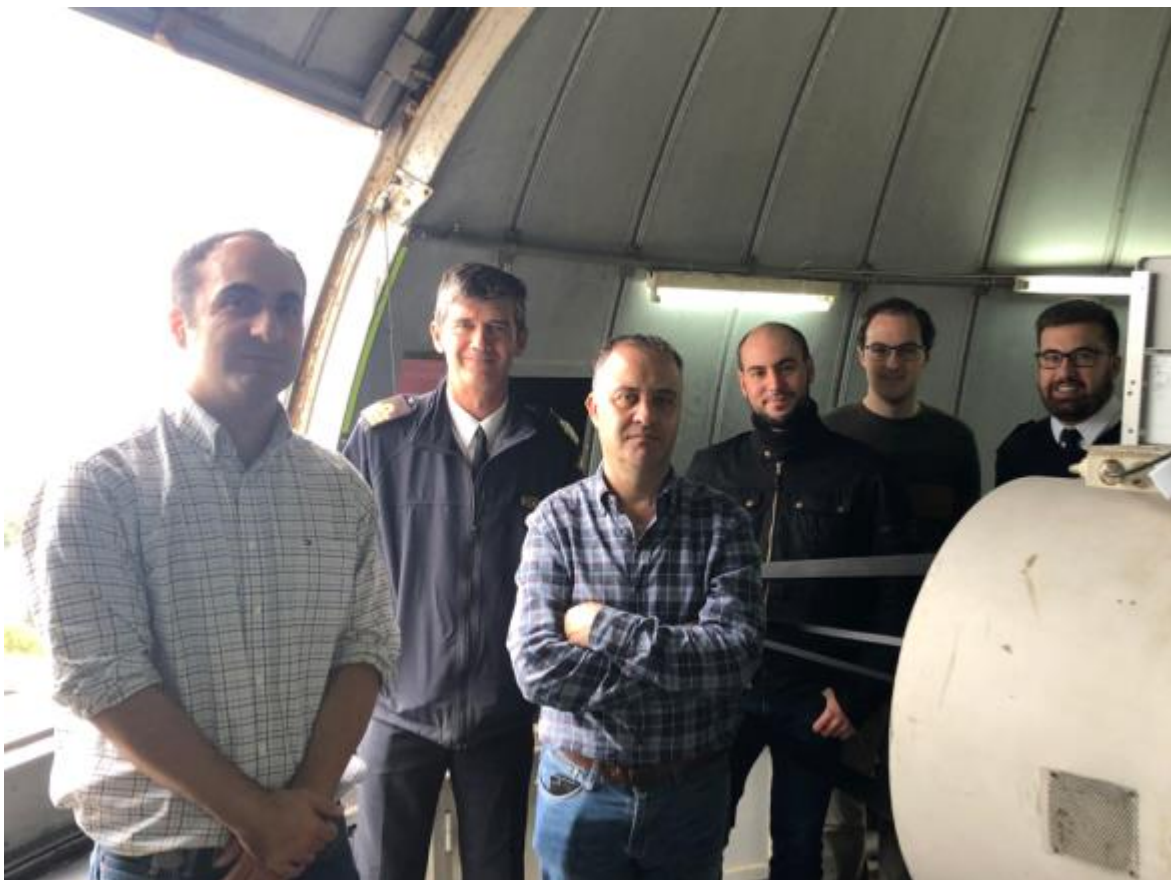
Conclusiones

- *After more than 40 years of life, SFEL has the experience acquired in this field and continues to be operational and with new functionalities.*
- *It maintains its own development capabilities and the ability to track collaborative objects and space debris.*
- *It has participated in both national (S3T) and international organizations (ILRS, EU SST, ESA) and the intention is to recover these collaborations as soon as possible.*
- *Currently, immersed in a profound modernization to bring it to the forefront of the state of the art*

Objective - In memory of Dr. Manuel Catalán



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Staff is the most valuable resource

- *Cohesive group that works with enthusiasm to carry out all the projects we face.*
- *2 Navy officers (PhD students)*
- *4 engineers (different disciplines)*
- *2 observers*



LT CDR Manuel Ángel Sánchez Piedra
Head of San Fernando Laser Station

msanpie@roa.es

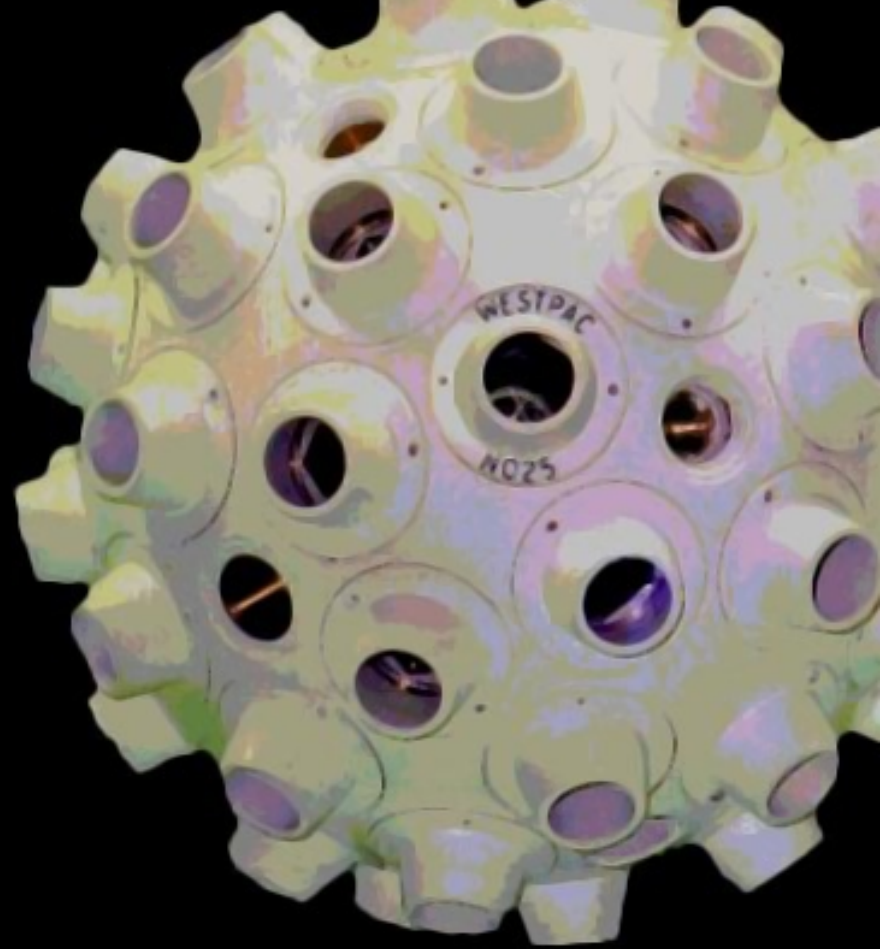


¡Thanks for your attention!



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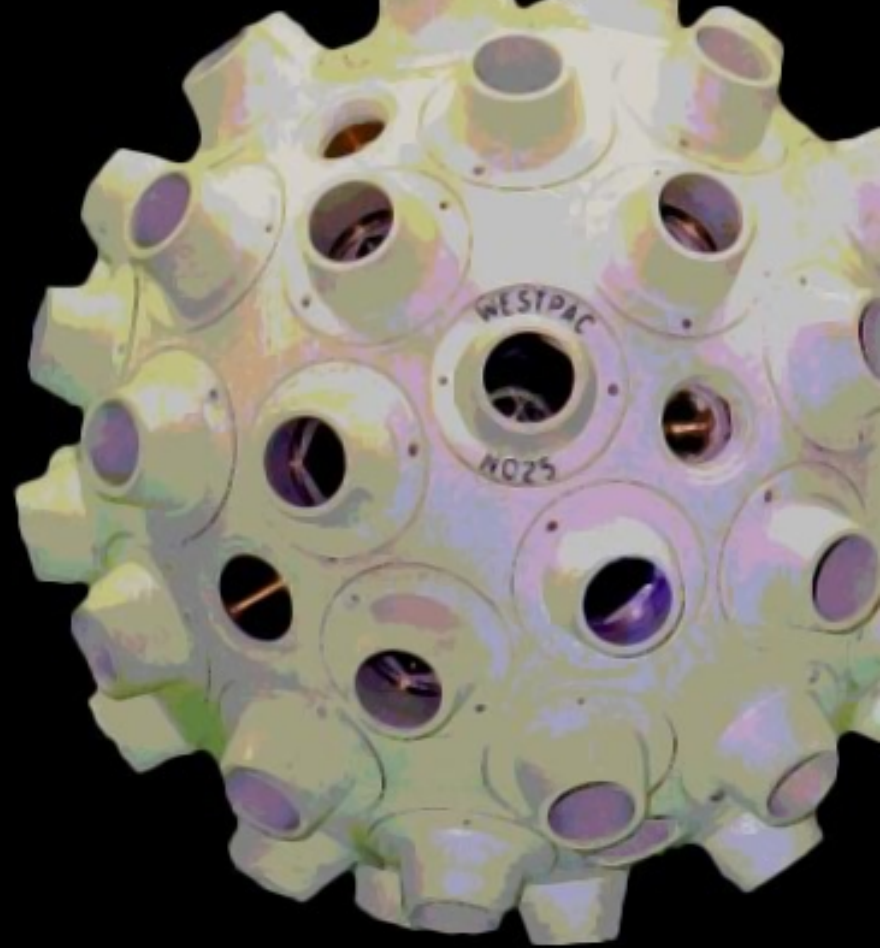
WESTPAC -update



WESTPAC

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

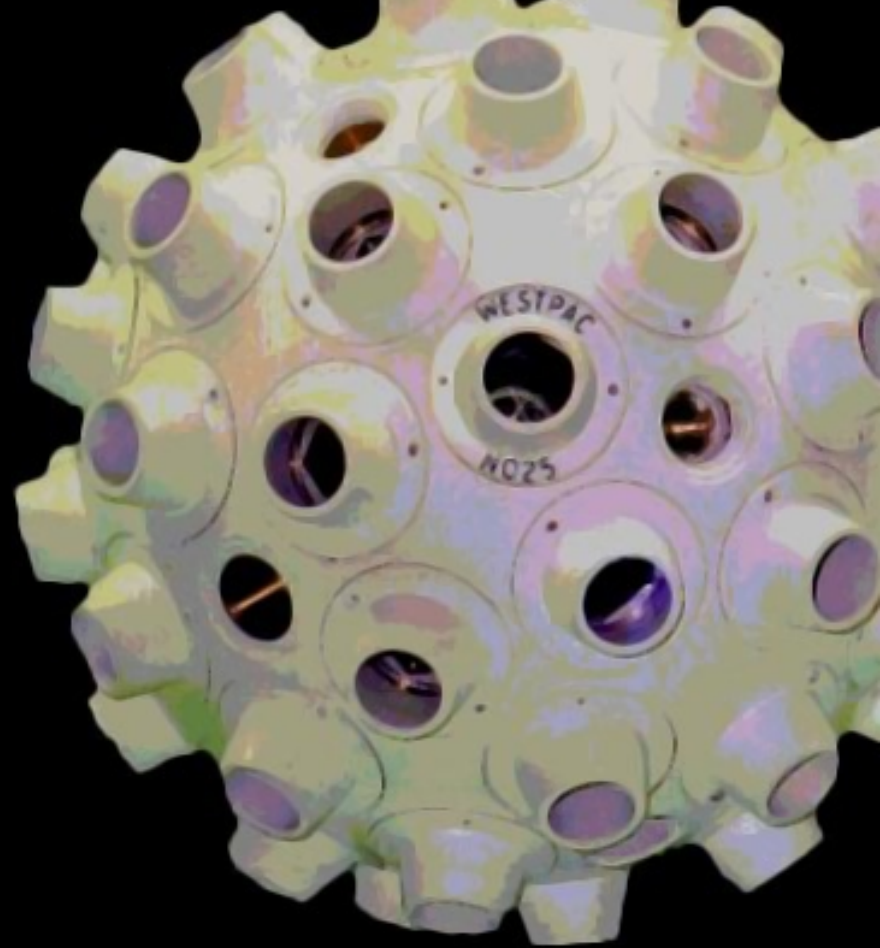
End of ILRS Support: **1 Dec 2002**



WESTPAC

NORAD number

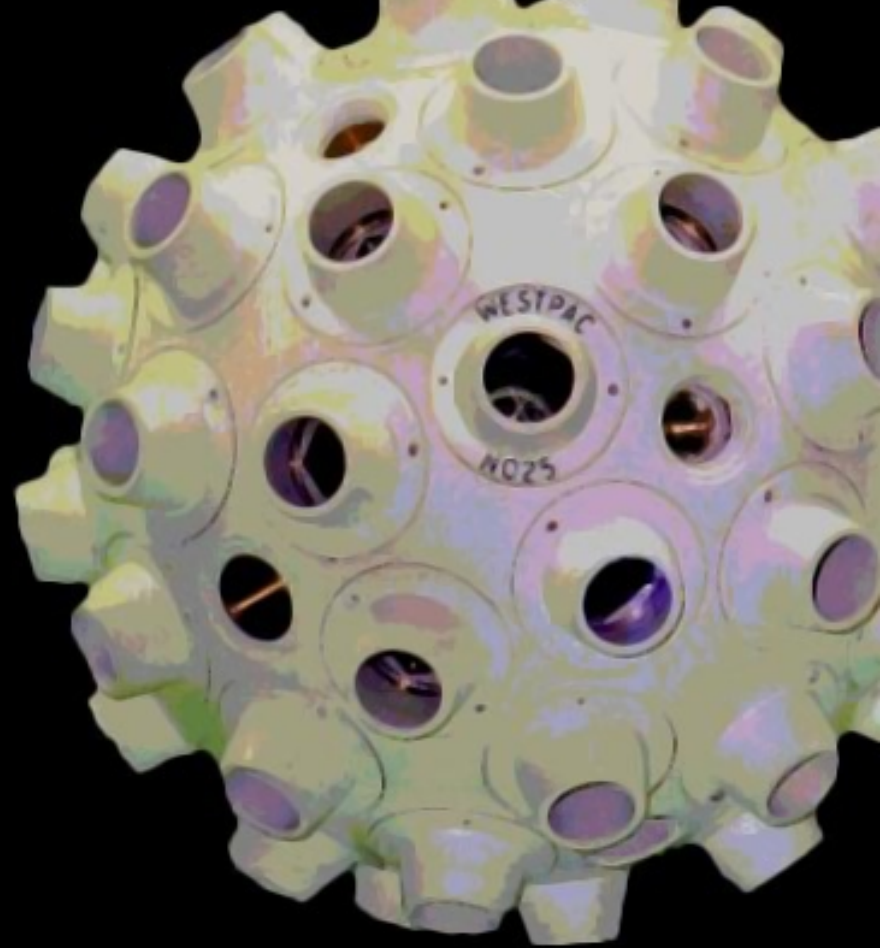
- WESTPAC was originally given the NORAD number **25394**
- This was later reassigned due to a clash with RESURS-O 1N4, which is a Russian natural resources sensing satellite.
- It was given the new NORAD number of **25398**.



WESTPAC

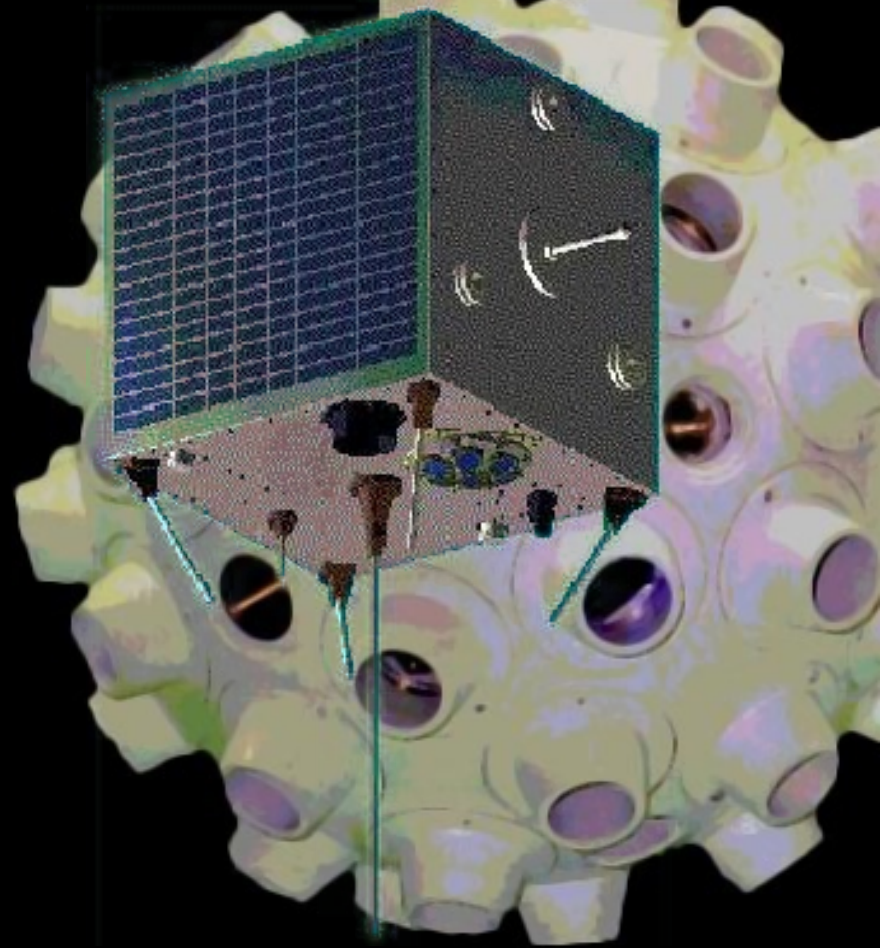
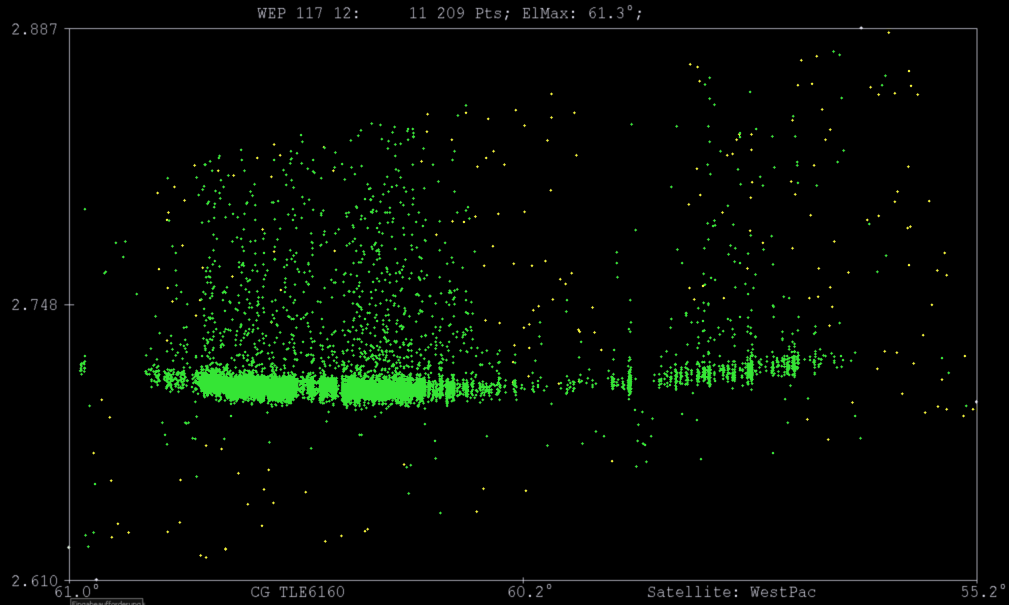
Some uncertainty remained:

- Which NORAD number is WESTPAC?
- Which NORAD number was used to observe the older WESTPAC SLR data?
- When did the NORAD number change from **25394** to **25398**?



WESTPAC

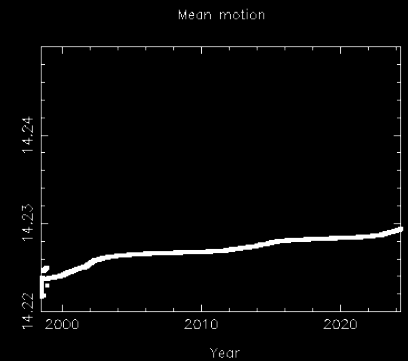
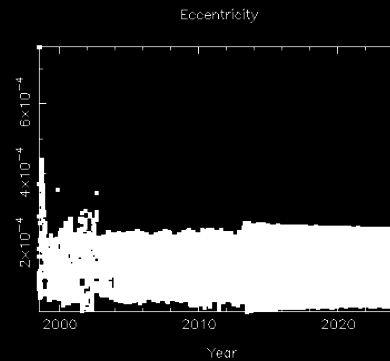
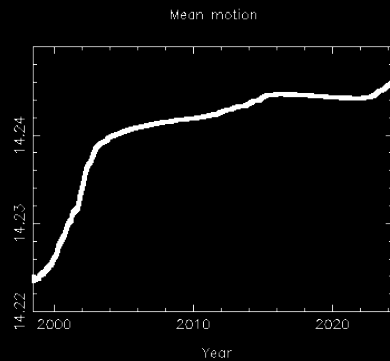
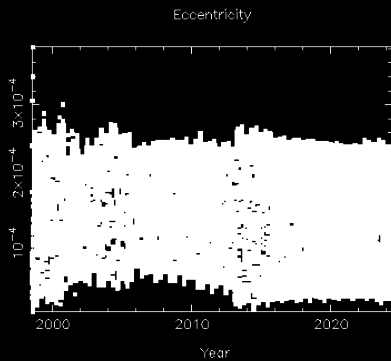
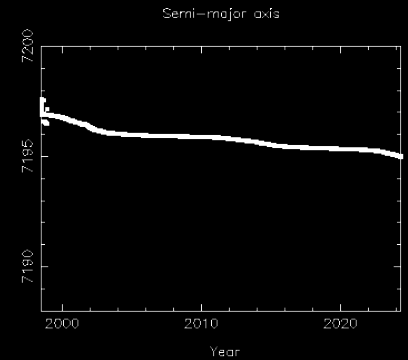
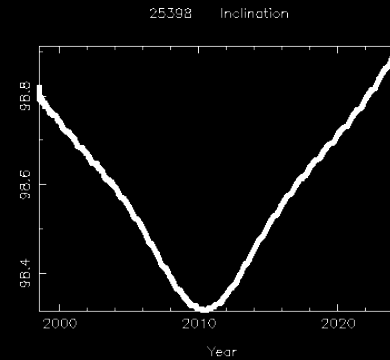
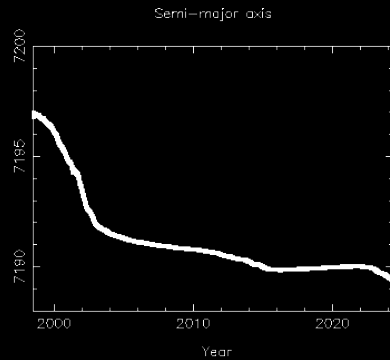
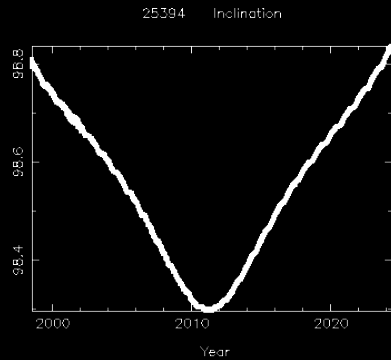
Stations have been successfully tracking an object using TLEs with NORAD number **25398**.



WESTPAC

Are we certain that we are tracking the right target?

- Rob Sherwood took a look at the TLE history

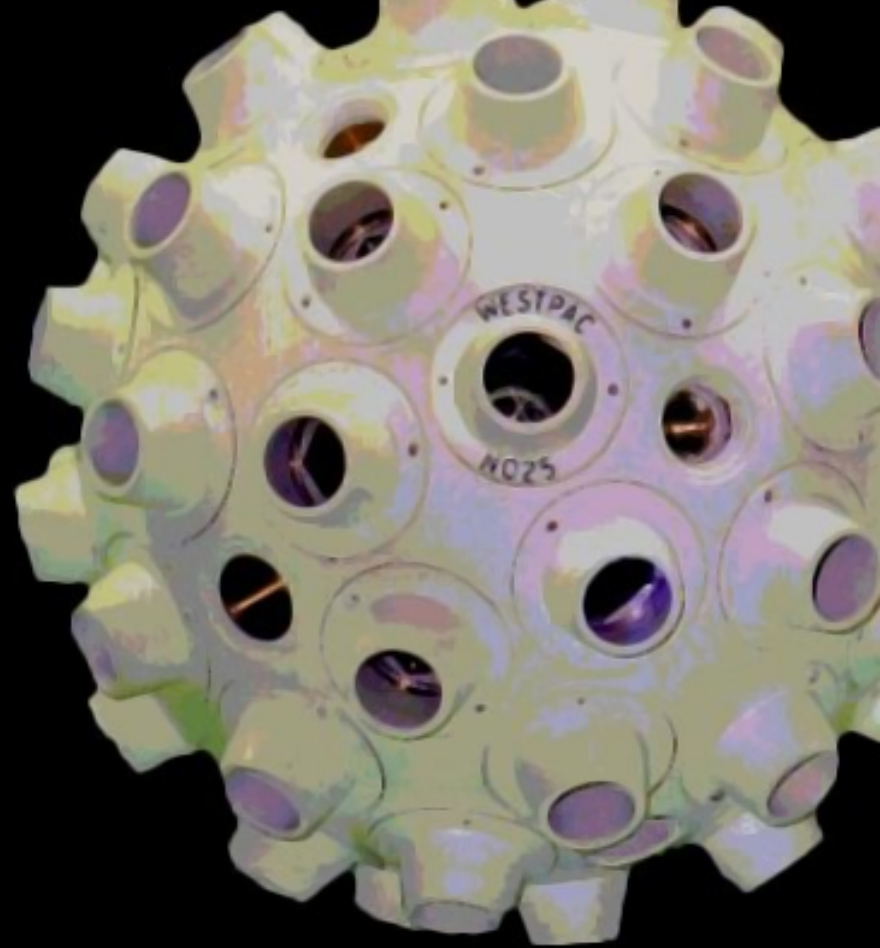


R. Sherwood

WESTPAC

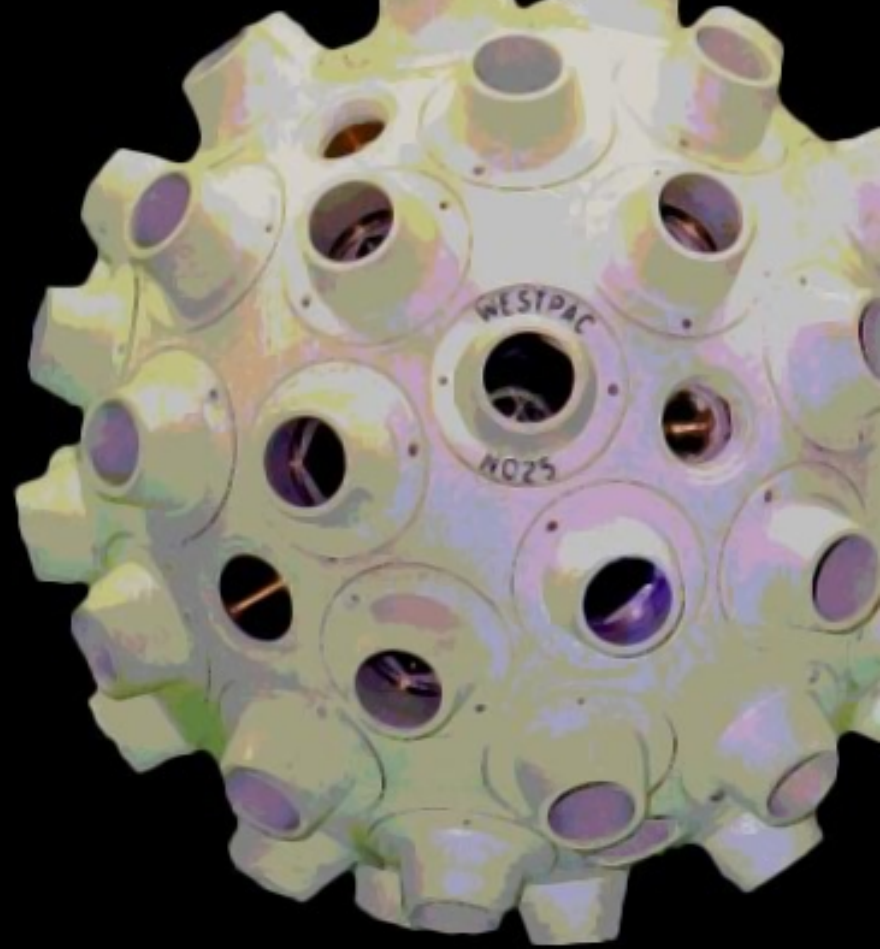
What about the archive SLR data?

- It was possible to process the SLR data observed in 1998 and 1999 by:
 - 1) Converting TLEs to CPFs
 - 2) Converting MERIT II full-rate data to CRD data, using the sample code by R. Ricklefs available on the ILRS website.



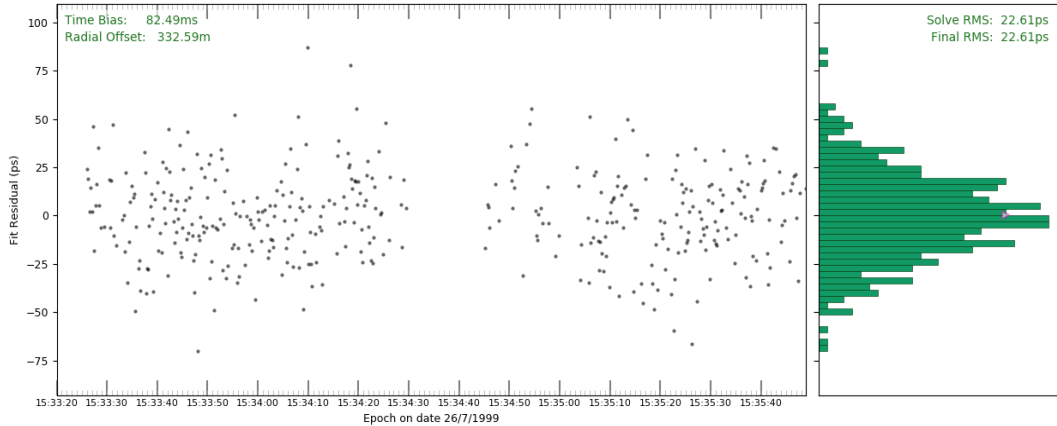
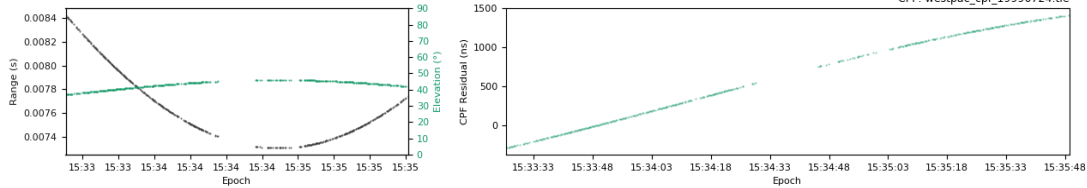
WESTPAC

Yarragadee



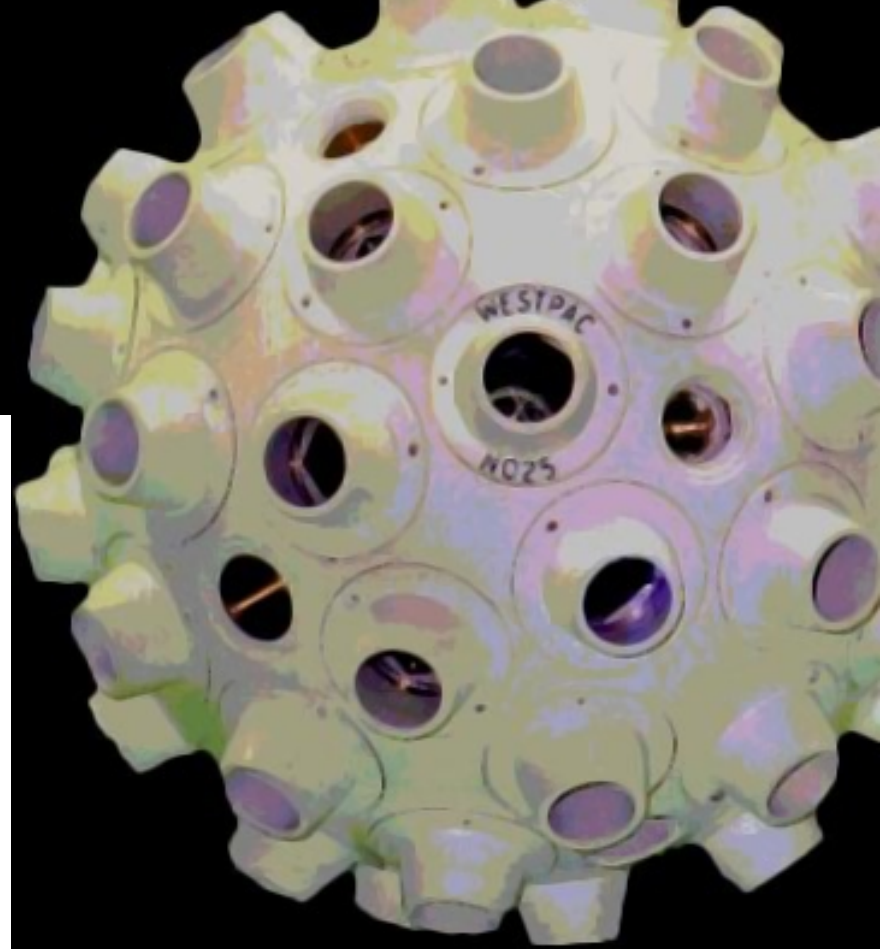
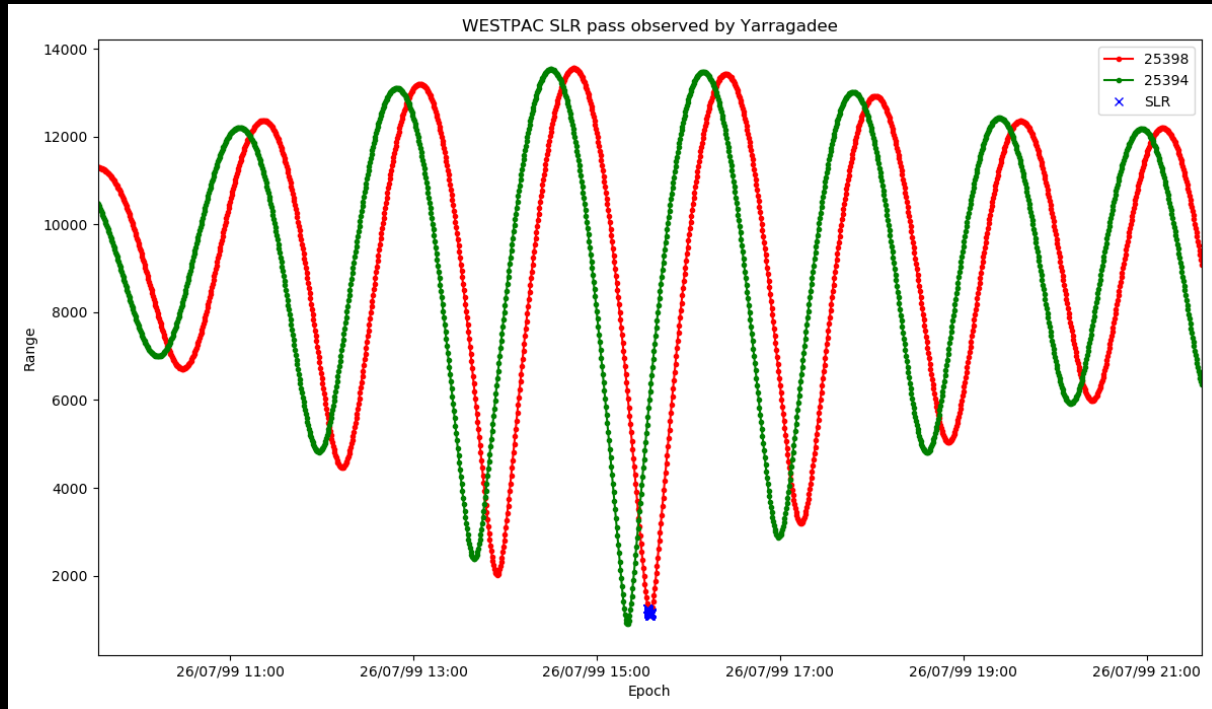
Satellite Laser Range data from: crd_westpa1.199907
Station: YARL 7090 Satellite: Westpac

CPF: westpac_cpf_19990724.tle



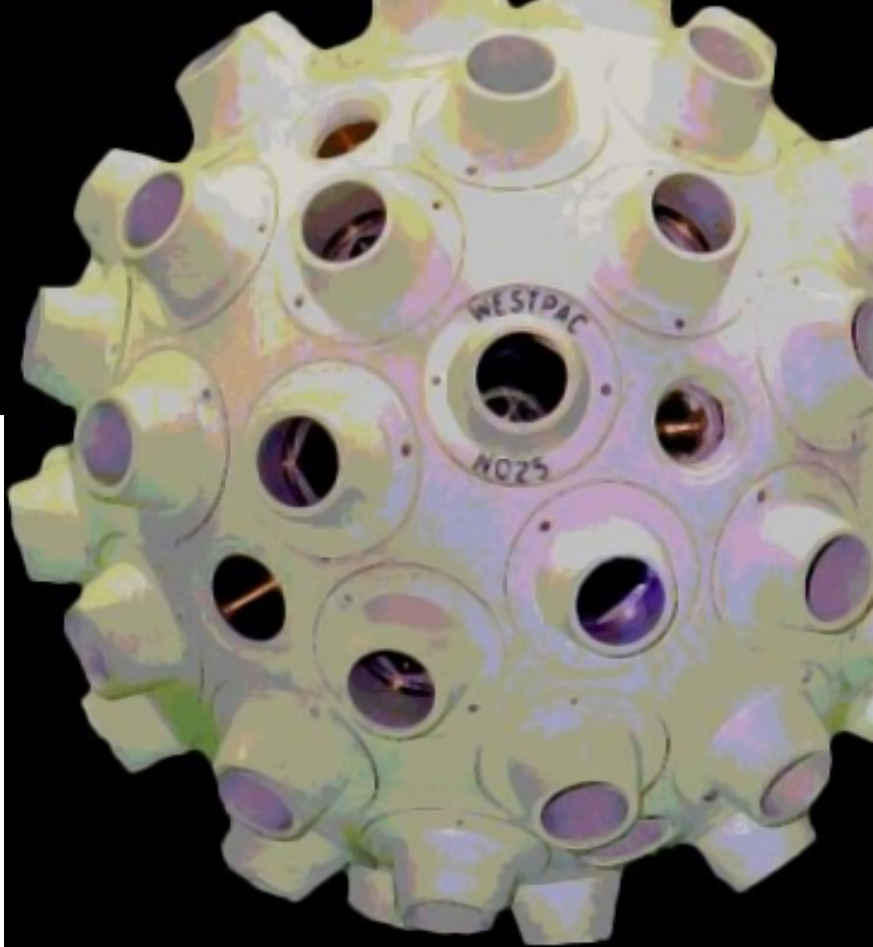
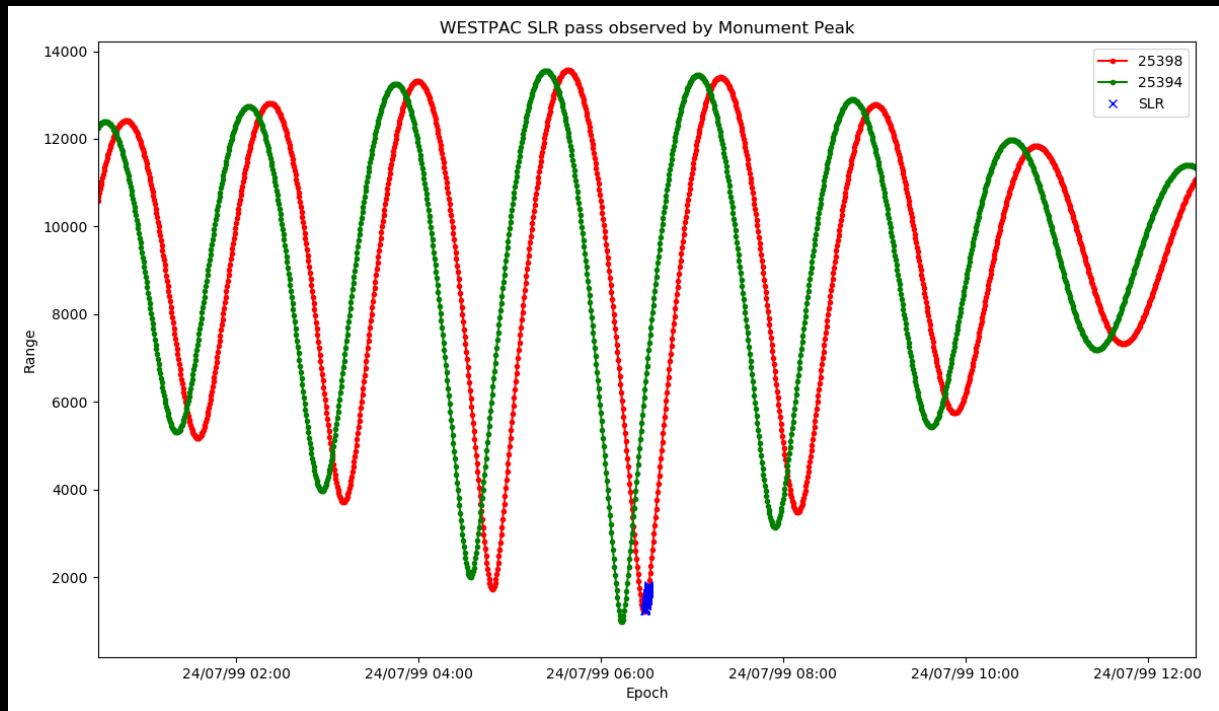
WESTPAC

Yarragadee



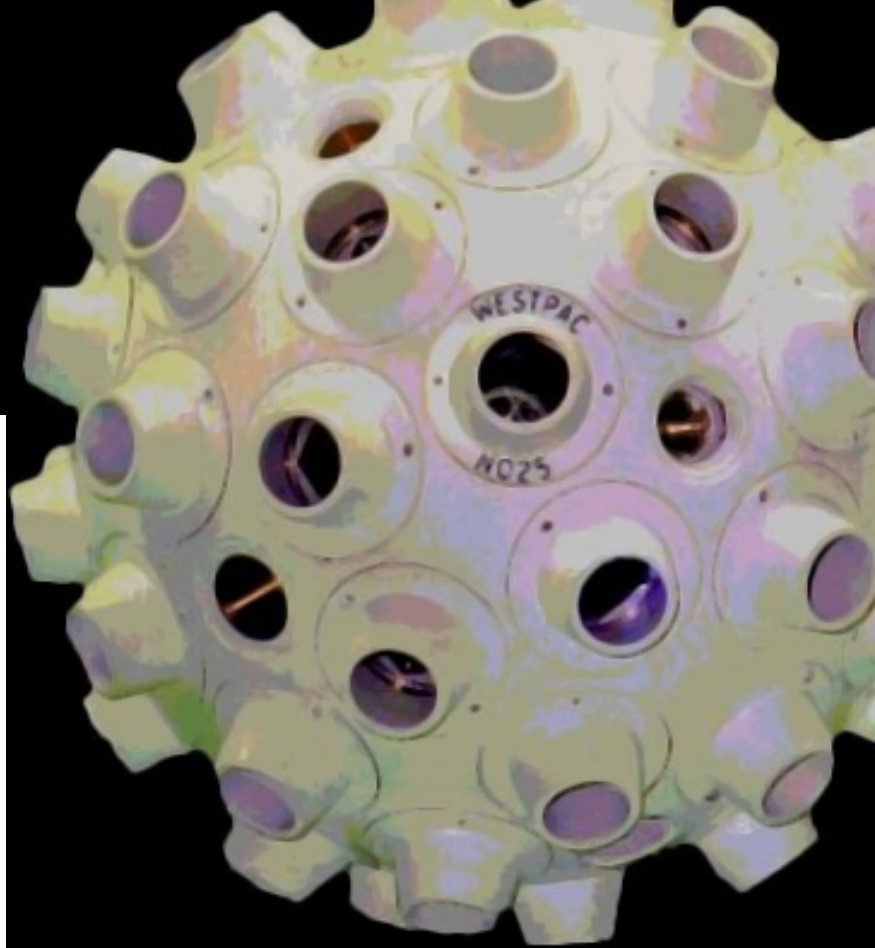
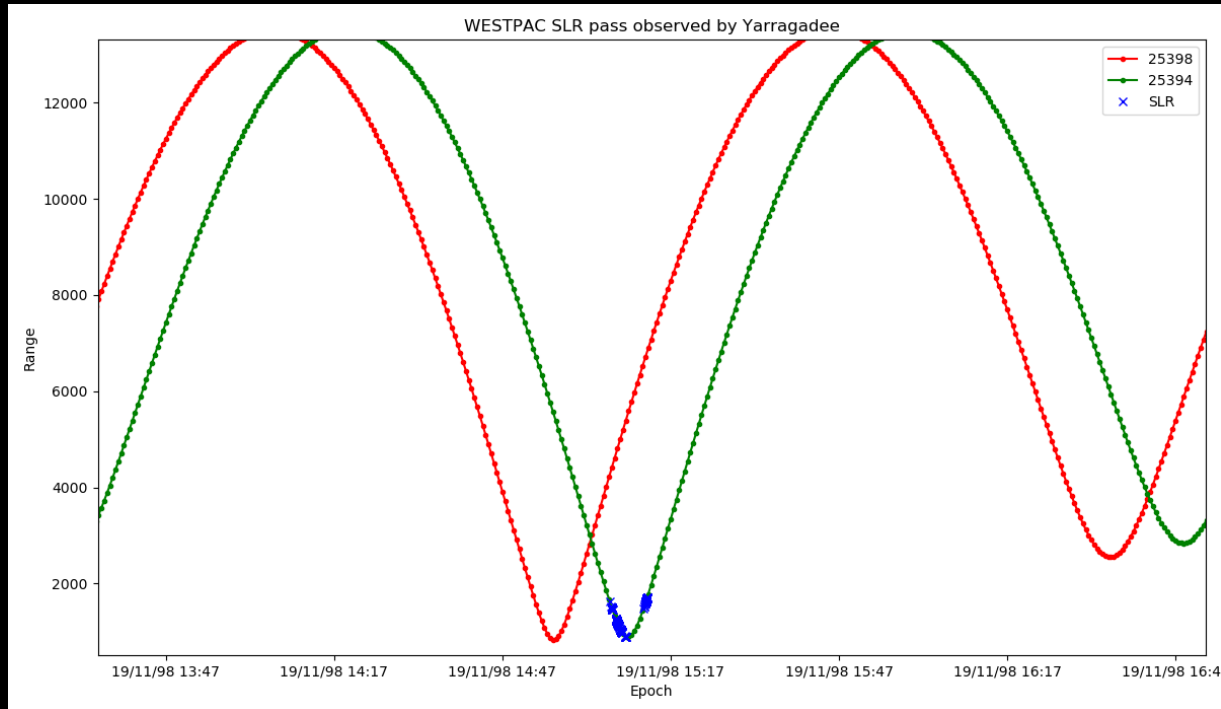
WESTPAC

Monument Peak



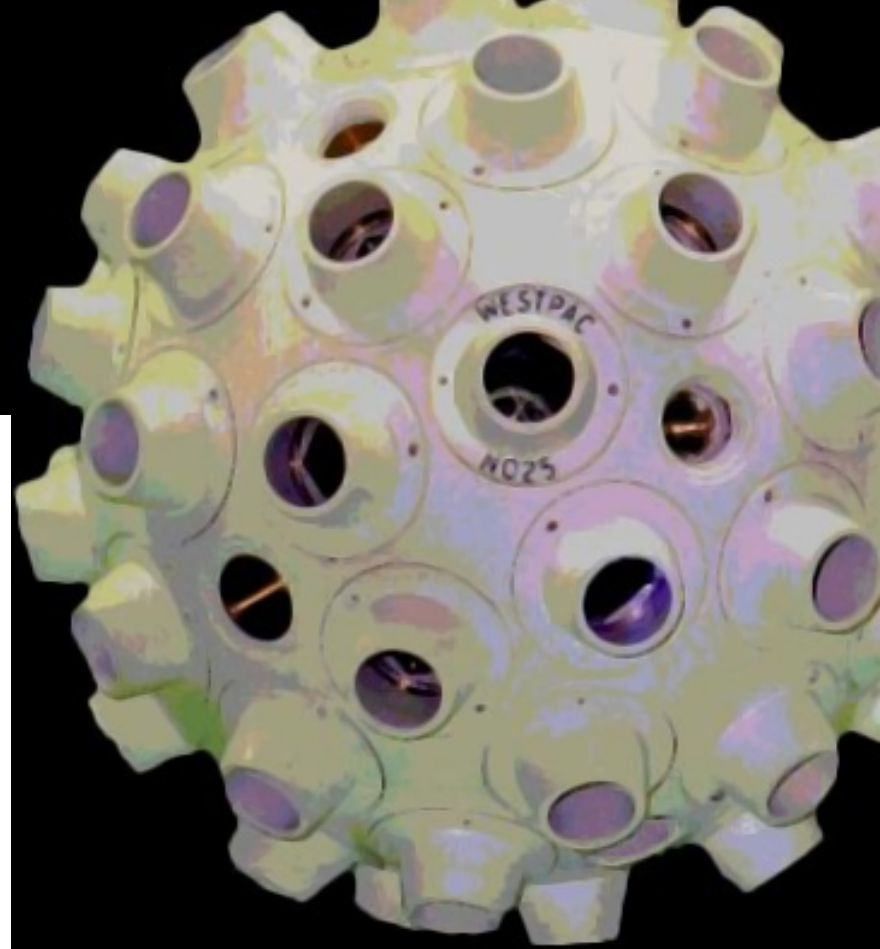
WESTPAC

Yarragadee

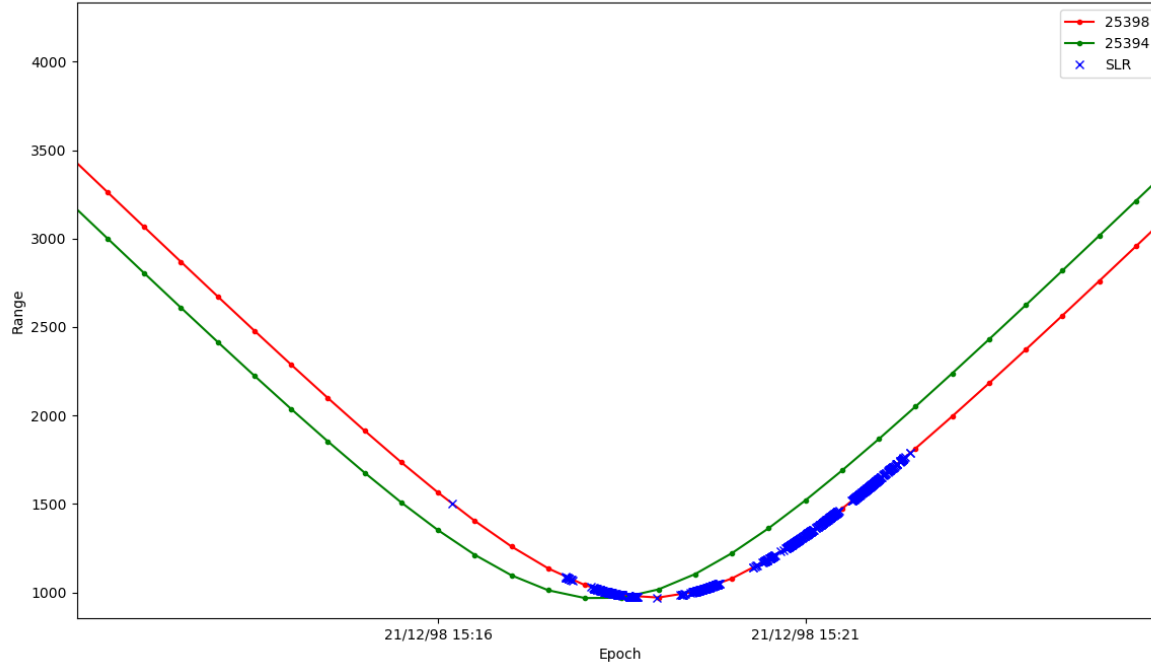


WESTPAC

Yarragadee



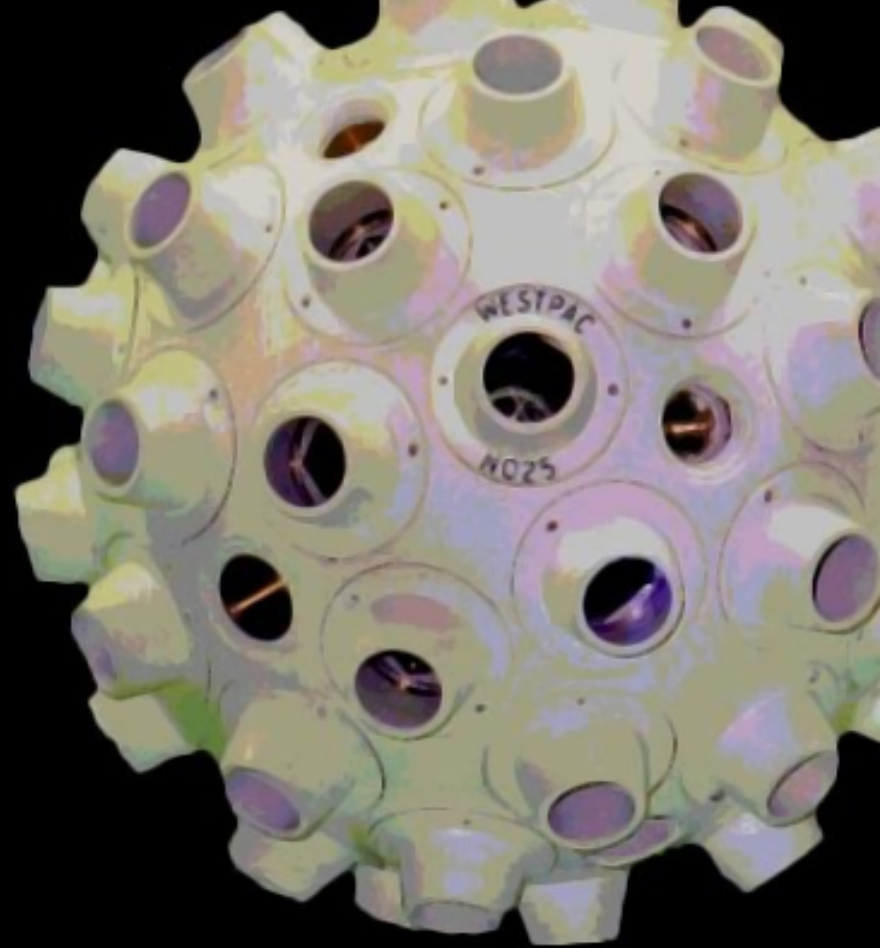
WESTPAC SLR pass observed by Yarragadee



WESTPAC

NORAD Number

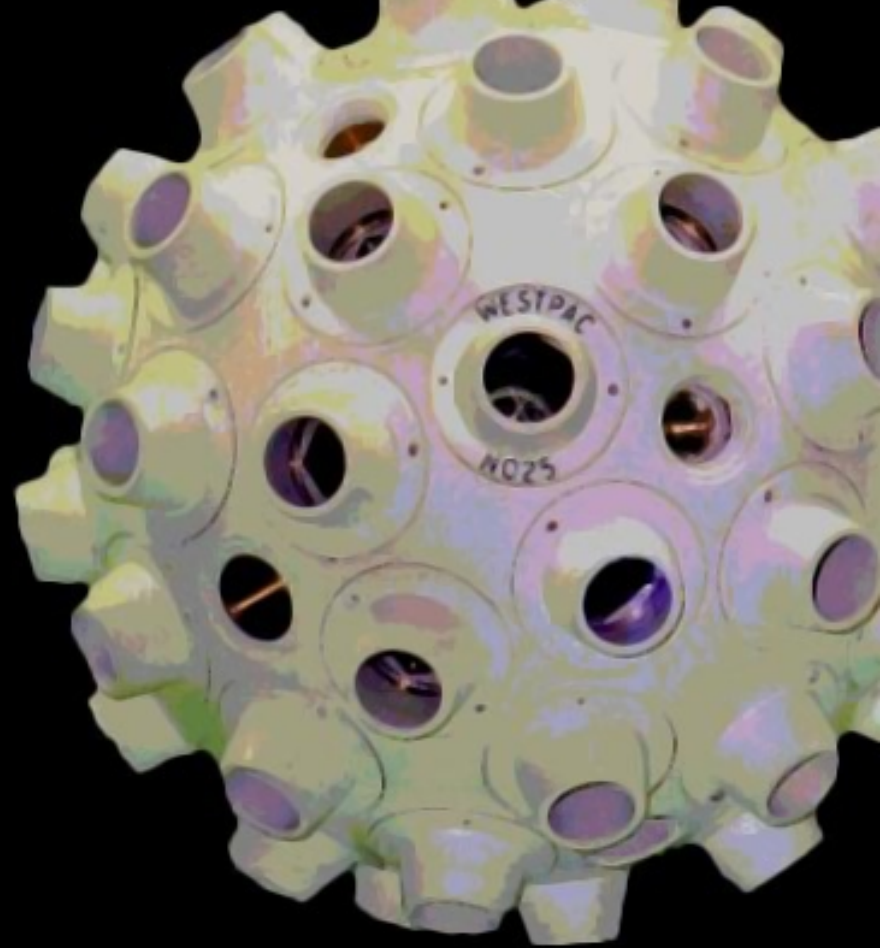
- The WESTPAC NORAD number was 25394 but changed to **25398** in December 1998.
- This object can be observed by SLR and shows a history of stable orbits.



WESTPAC

CPFs are now available

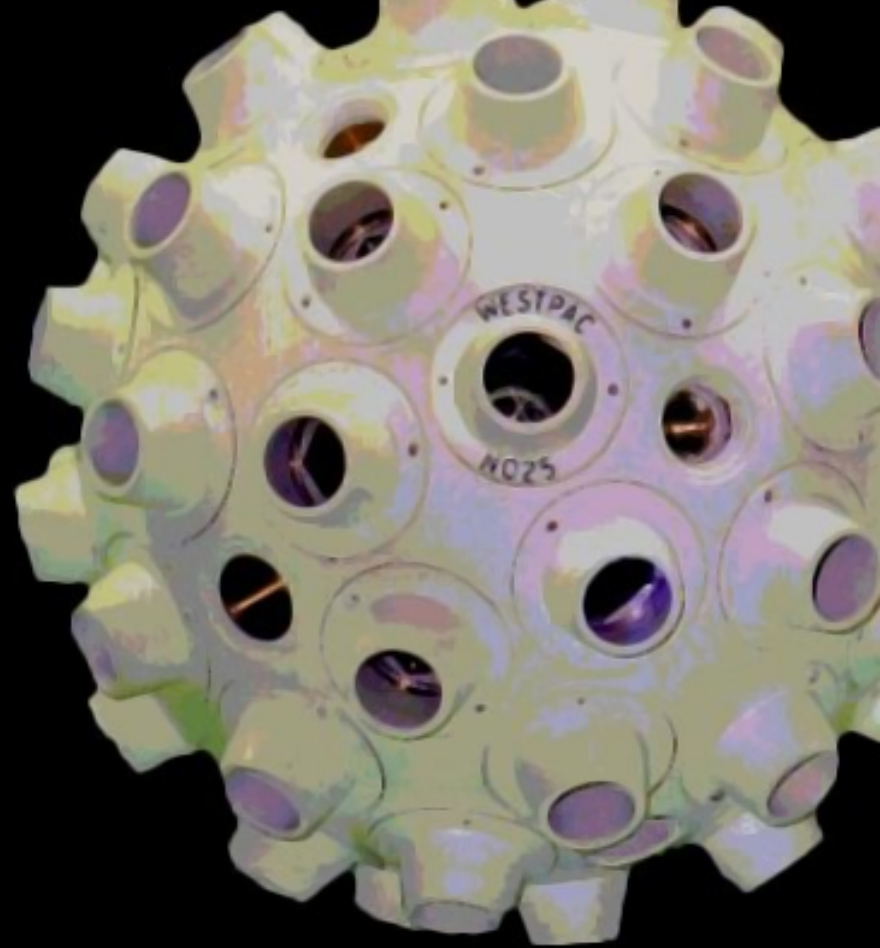
- Graham Appleby has included WESTPAC in the routine orbit prediction service at the SGF, Herstmonceux.
- These are produced daily and are available from EDC.
- They currently have a NORAD number of 25394, but this will soon be changed.



WESTPAC

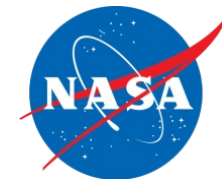
What's next?:

- We are now confident in the target.
- Future data needs to be submitted with the correct number, 25398.
- The quality of the CPFs should be assessed.
- Daylight passes can be attempted with the CPFs.



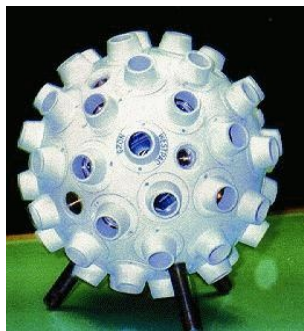


WESTPAC News



- Since last meeting we are confident which satellite is WESTPAC and SGF (NERC) is providing daily predicts
- We have been using a COSPAR and NORAD IDs of 9804301 and 25394; respectively, but the correct ILRS COSPAR and NORAD IDs are 9804305 and 25398; respectively
- How far back in time do we correct for erroneous COSPAR and NORAD IDs? And who should fix the data?
- Should WESTPAC be added to the priority list?
- WESTPAC is not easy to track. Will there be adequate WESTPAC data set to generate meaningful scientific results?

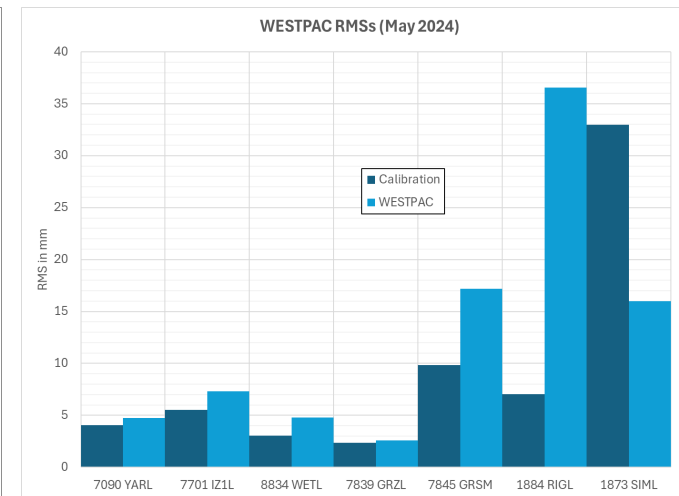
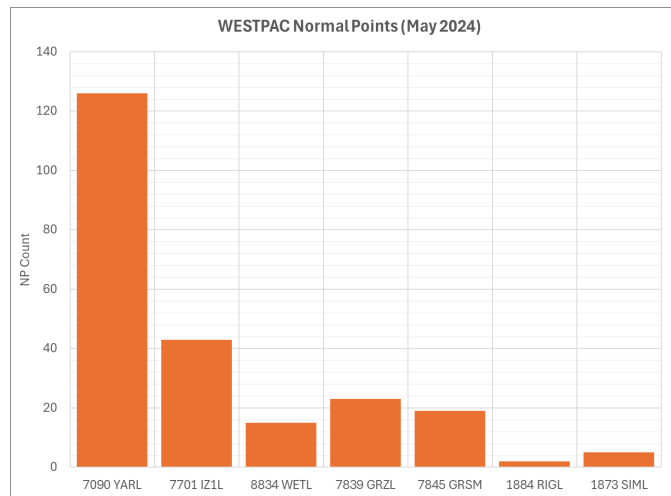
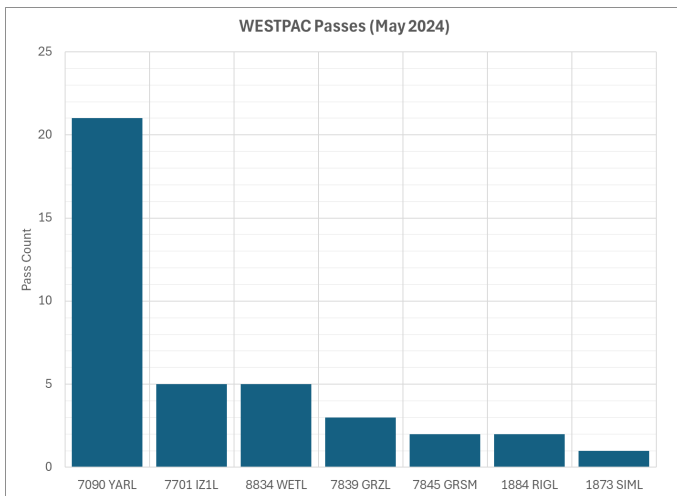
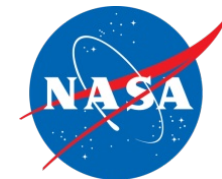
Name	NORAD ID	Int'l Code	Launch date (YYYY-MM-DD)
RESURS O1-N4	25394	1998-043A	1998-07-10
FASAT B	25395	1998-043B	1998-07-10
TMSAT	25396	1998-043C	1998-07-10
TECHSAT 1B	25397	1998-043D	1998-07-10
WESTPAC	25398	1998-043E	1998-07-10
SAFIR 2	25399	1998-043F	1998-07-10



Date Type	COSPAR ID	NORAD ID	SIC
CSTG Normal Points	9804301	N/A	N/A
CSTG Sampled Data	9804301	N/A	N/A
MERIT II Fullrate Data	9804301	N/A	N/A
Predicts (Tuned IRV)	N/A	N/A	8801
CRD Normal Points	9804301	25394	8801
CRD Fullrate	9804301	25394	8801
Predicts (CPF)	9804301	25394	8801



WESTPAC May 2024 Tracking Statistics



Station	Pass Count	NP Count	Cal RMS in mm	WESTPAC RMS in mm	Min NP Range in km	Max NP Range in km	NP Return Rate Min in %	NP Return Rate Max in %	Bin Size in Seconds	Comments
7090	21	126	4.1	4.7	833	2117	0.7	66.7	15	
7701	5	43	5.5	7.3	860	1740	2.3	76.1	8, 15	return rate was 76% in one NP bin
7839	3	23	2.4	2.6	976	1746	0.6	3.4	8	Standard ILRS Bin Size is 15 seconds
8834	3	15	3.0	4.8	861	1225	0.2	1.7	15	2 of 3 passes were at dual wavelengths
7845	2	19	9.8	17.2	1162	2664	6.0	64.7	15	WESTPAC RMS 2x their Calibration RMS
1884	2	2	7.0	36.6	1638	1687	7.8	12.5	15	WESTPAC RMS 5x their Calibration RMS
1873	1	5	33.0	16.0	1092	1340	2.0	8.7	15	WESTPAC RMS 0.5x their Calibration RMS

❑ Should all stations use the ILRS standard 15 second bin size?