SWOT

NESC meeting – April 6th 2023

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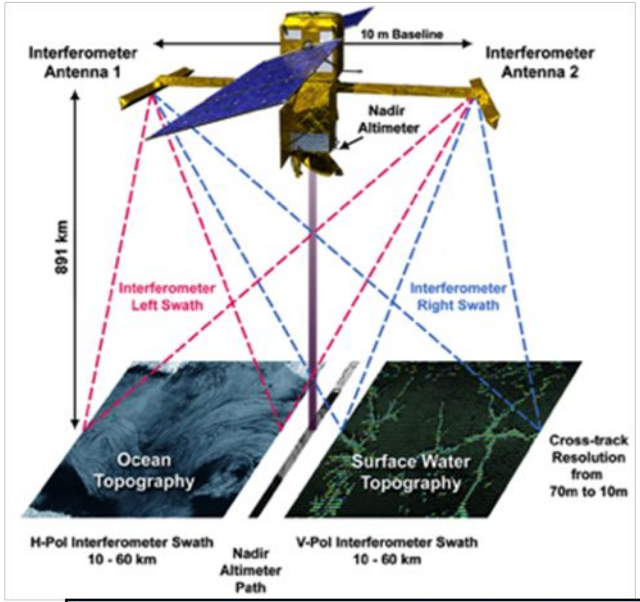
Mission Science

Oceanography: Characterize the ocean mesoscale and sub-mesoscale circulation at spatial resolutions of 15 km and greater.

Hydrology: To provide a global inventory of all terrestrial water bodies whose surface area exceeds $(250m)^2$ (lakes, reservoirs, wetlands) and rivers whose width exceeds 100 m (rivers).

- To measure the global storage change in fresh water bodies at sub-monthly, seasonal, and annual time scales.
- To estimate the global change in river discharge at sub-monthly, seasonal, and annual time scales.

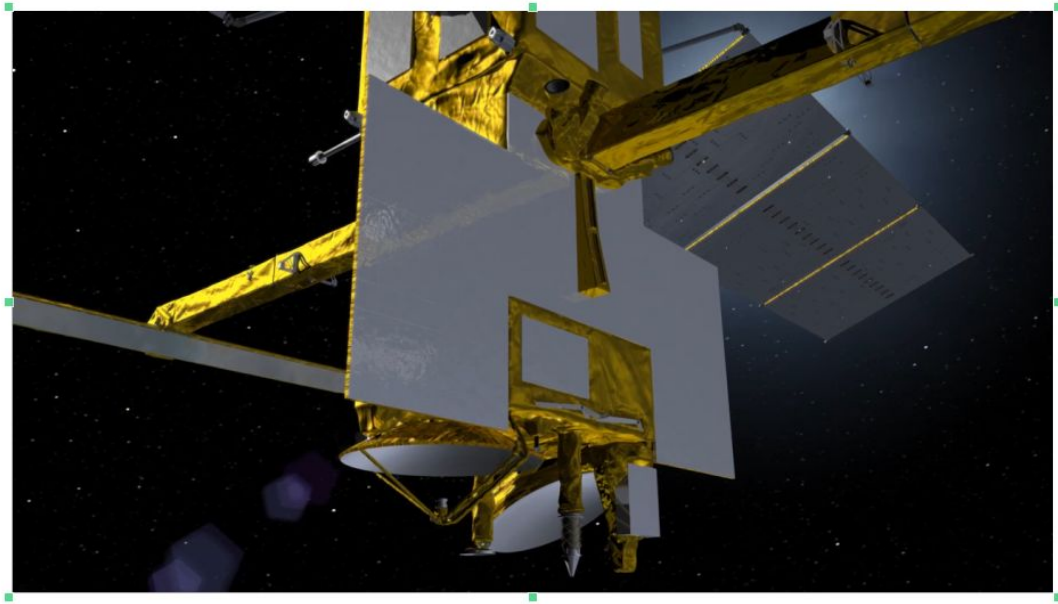


Mission Architecture

- Ka-band SAR interferometric (KaRIn) system with 2 swaths, 50 km each
- Produces heights and co-registered all-weather imagery
- Use conventional Jason-class altimeter for nadir coverage, radiometer for wet-tropospheric delay, and GPS/DORIS/LRA for POD.
- On-Board interferometric SAR processing over the ocean ($500m^2$ resolution) for data vol. reduction.

- Partnered mission : NASA/ JPL, CNES, UKSA & CSA
- Science mission duration of 3 years
- Calibration orbit: 857 km, 77.6º Incl., 1 day repeat
- Science orbit: 891 km, 77.6º Incl., 21 day repeat
- Flight System: ~2400kg, ~2100W
- Launch Vehicle: SpaceX Falcon 9
- Cat 2 Project, Risk Class: C
- Target Launch Readiness: November 22

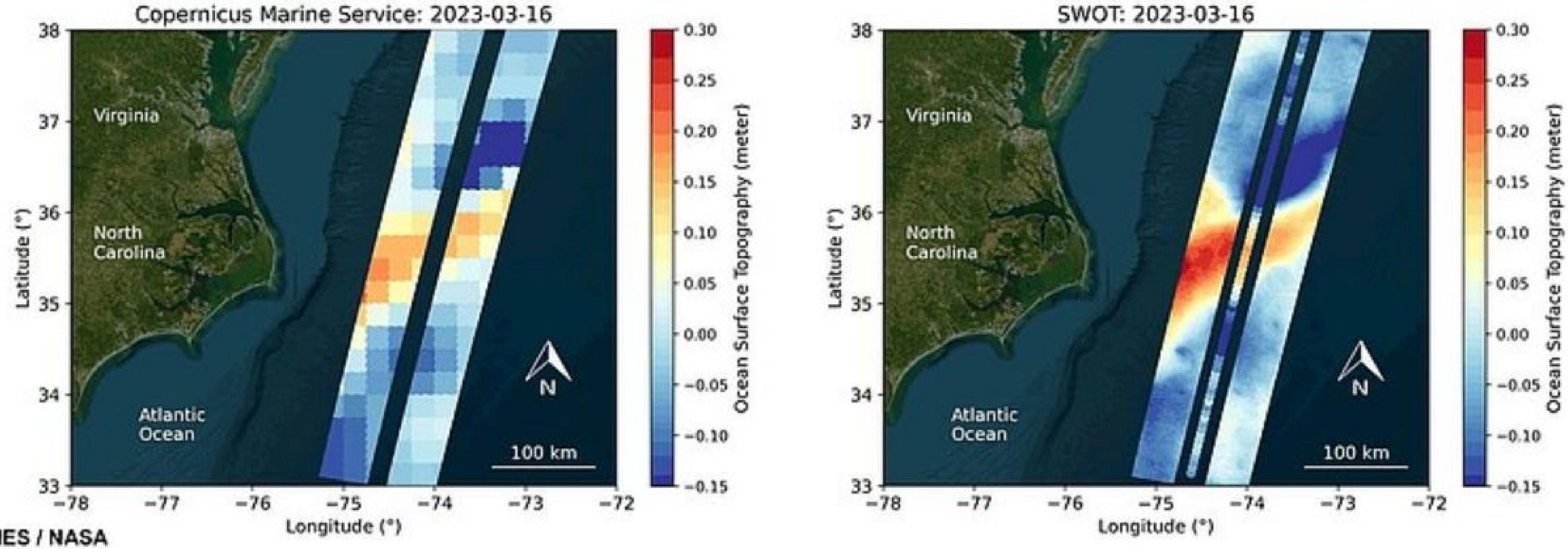
SWOT : a technological leap



Current NADIR altimeters measurements

SWOT measurements

The gulf stream, seen by Copernicus service and SWOT



Precision Orbit Ephemeris (POE) overview

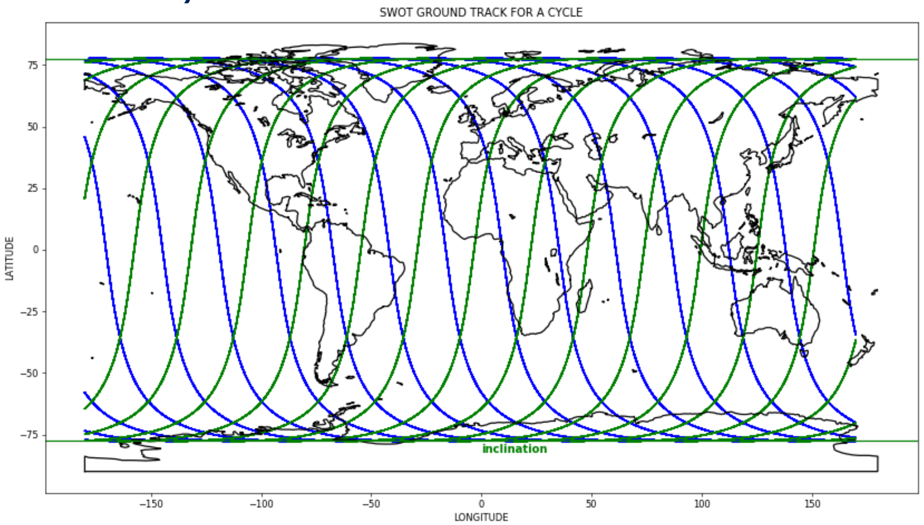
Time period for POD validation: January 15 – March 12, 2023.

Making use of all three tracking instruments:

- **CNES POE-F DORIS+GPS orbit solutions,**
- **SLR is saved for independent validations.**

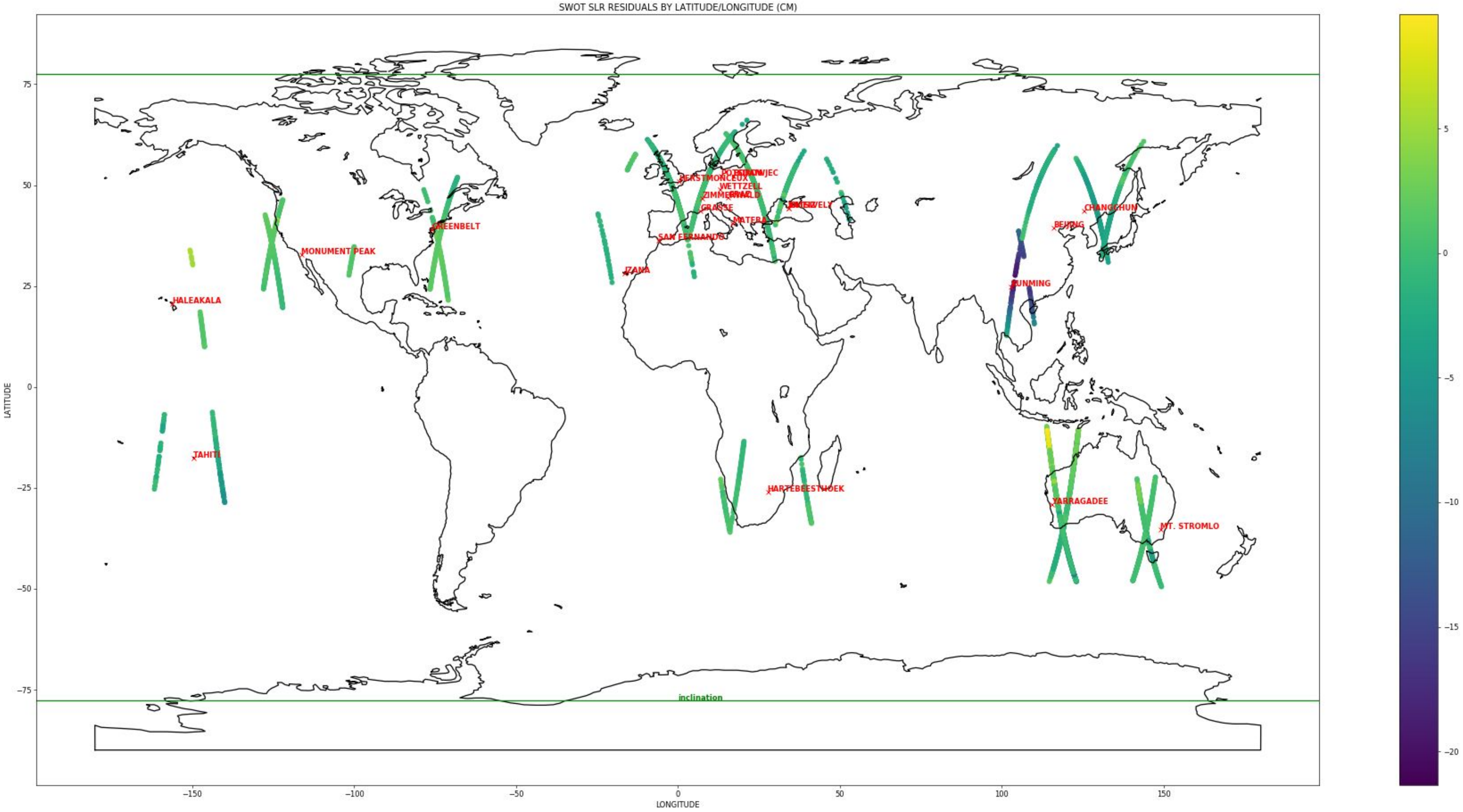
Reduced-dynamic parameterization to account for residual measurements/dynamic modeling errors:

- **Solve for daily constant cross-track, 30-min constant along-track, 1/rev along/cross-track empirical accelerations every orbital revolution.**



Calibration orbit (1-day repeat cycle).

Distribution of tracking SLR stations (high latitudes are blind)



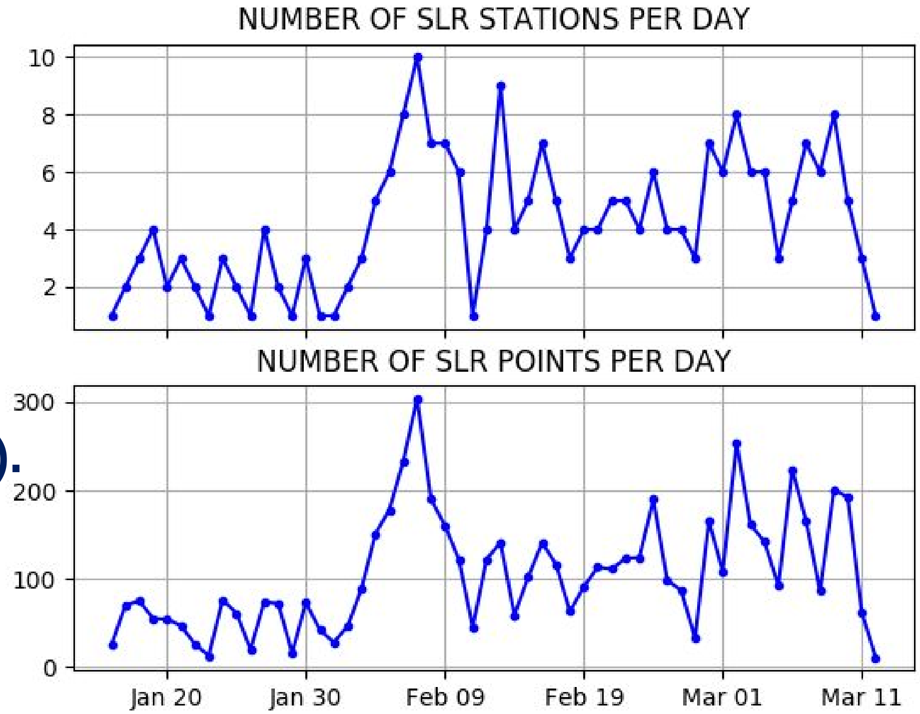
SLR availability

Tracking network:

- **~5 stations routinely track SWOT every day (21 in total).**
- **The top three stations with most tracking of SWOT are Yarragadee (Australia), Changchun (China), Mt. Stromlo (Australia).**

Normal points:

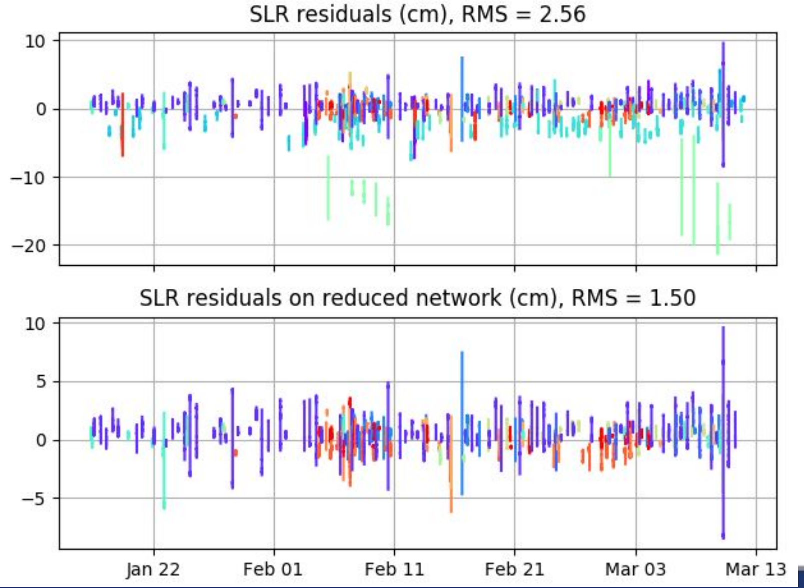
- **~110 daily SLR normal points for SWOT (200-300 for Sentinel-6 MF/Jason-3).**

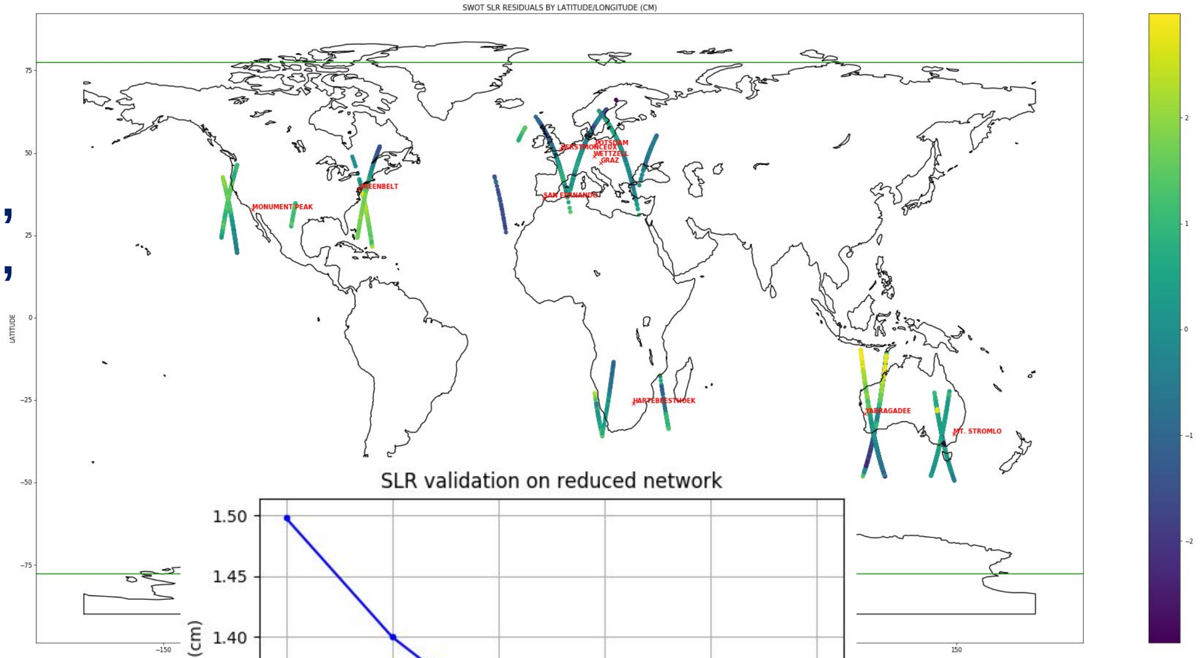


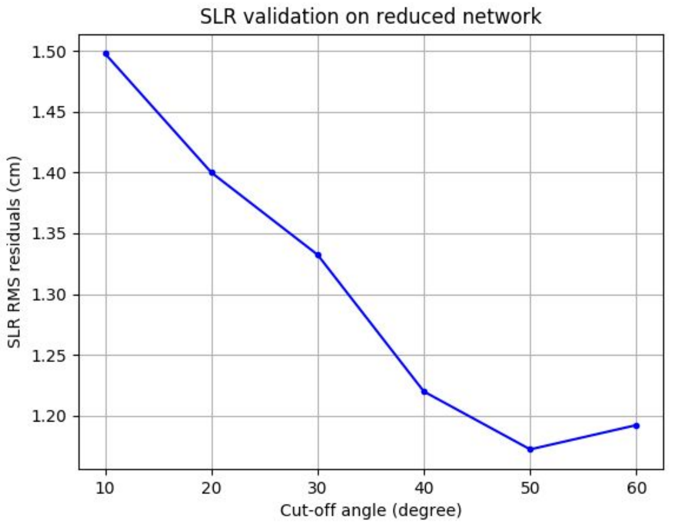
Independent orbit validation owing to SLR observations

Subset of ten SLR stations with residuals < 2 cm RMS:

- **8834 (0.9 cm), 7501-7825 (1.0 cm), 7839 (1.3 cm), 7105-7841 (1.4 cm), 7110 (1.5 cm), 7824 (1.6 cm), 7840 (1.7 cm), 7090 (1.8 cm).**







RMS of SLR residuals vs. time (left) & elevation angle (right).

Copernicus POD Quality Working Group SLR bias study

Use SLR observations to multiple active LEOs to address SLR station biases :

- **Article submitted to Advances in Space Research with AIUB, CLS, CNES, PosiTim.**

ELSEVIER
Available online at www.sciencedirect.com
ScienceDirect
Advances in Space Research xx (2022) xxx-xxx
Advances in Space Research (a COSPAR publication)
www.elsevier.com/locate/asr

Millimeter accuracy SLR bias determination using independent multi-LEO DORIS and GPS-based precise orbits

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[b] Centre National d'Etudes Spatiales, Toulouse, France
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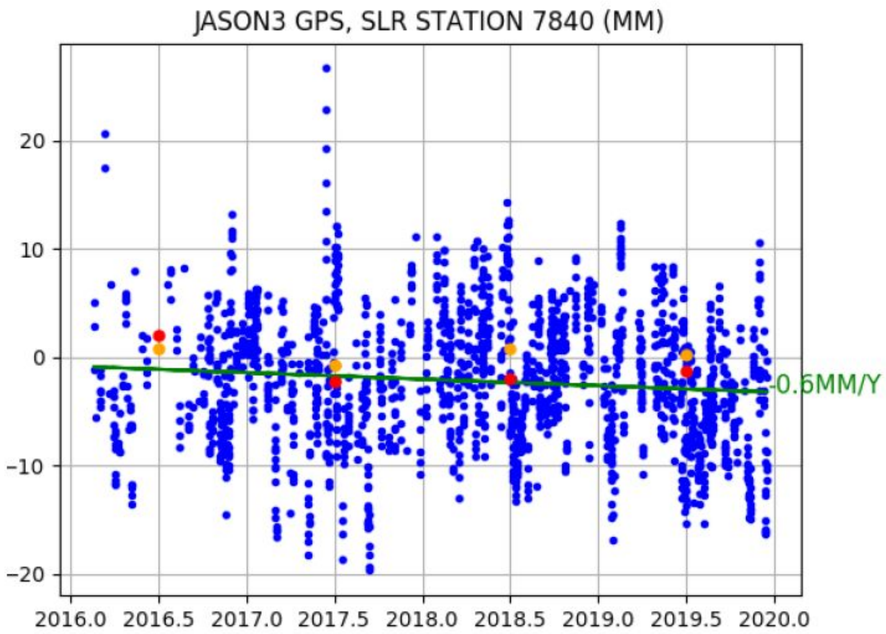
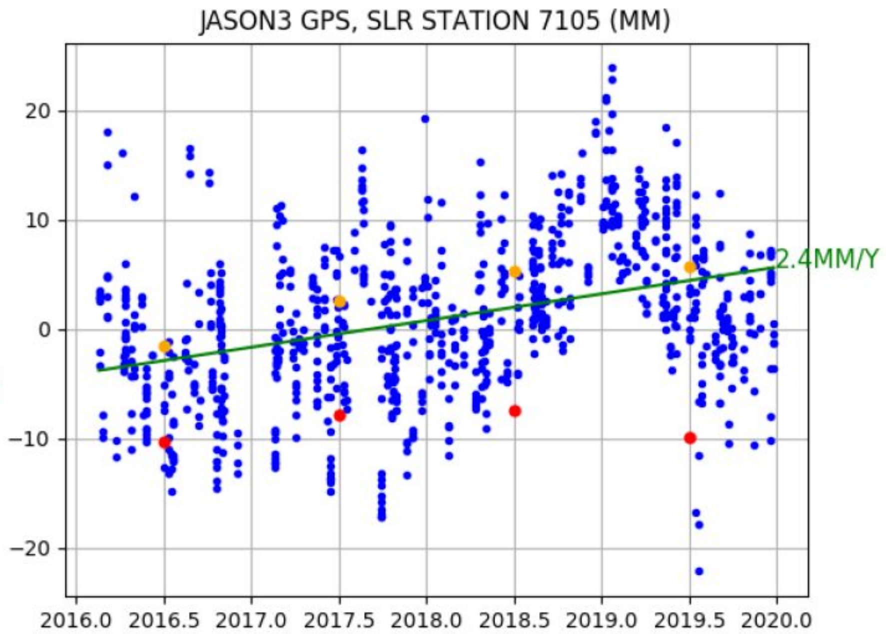
Header of the article of Saquet et al. (2023).

Future challenges in assessing the long-term regional radial orbit accuracy needed by demanding climate applications

Range biases and vertical ground motions mismodeling are seen:





Herstmonceux (left) and Greenbelt (right) high-elevation SLR residuals over Jason-3 GPS-based CNES POE-F reduced-dynamic orbits [Moyard and Mercier, 2023].

ILRS daily NP – network drop in March 2023

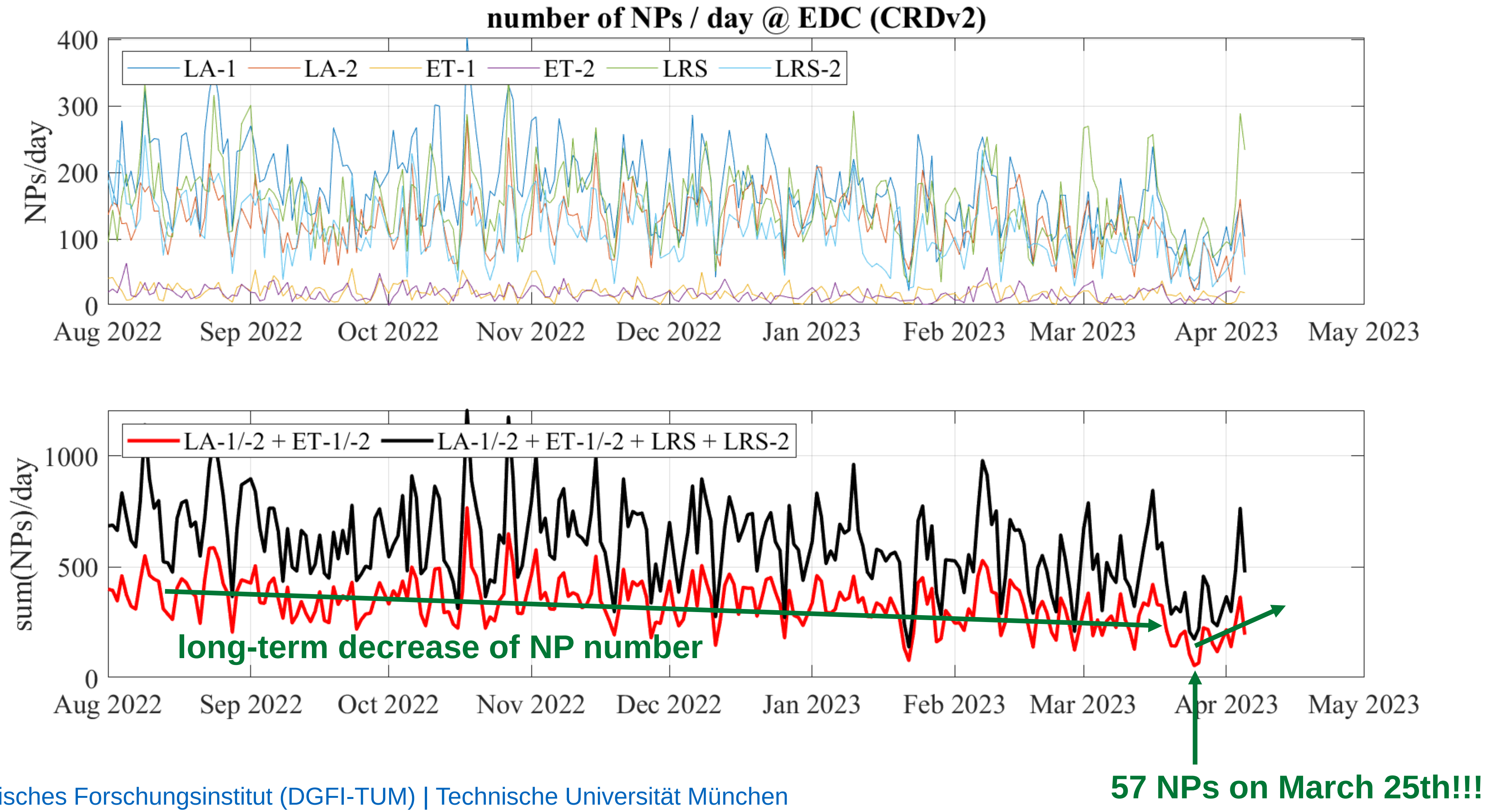
Mathis Bloßfeld

Deutsches Geodätisches Forschungsinstitut, Technische Universität München (DGFI-TUM)

ILRS NESC meeting (online) – 2023-04-05

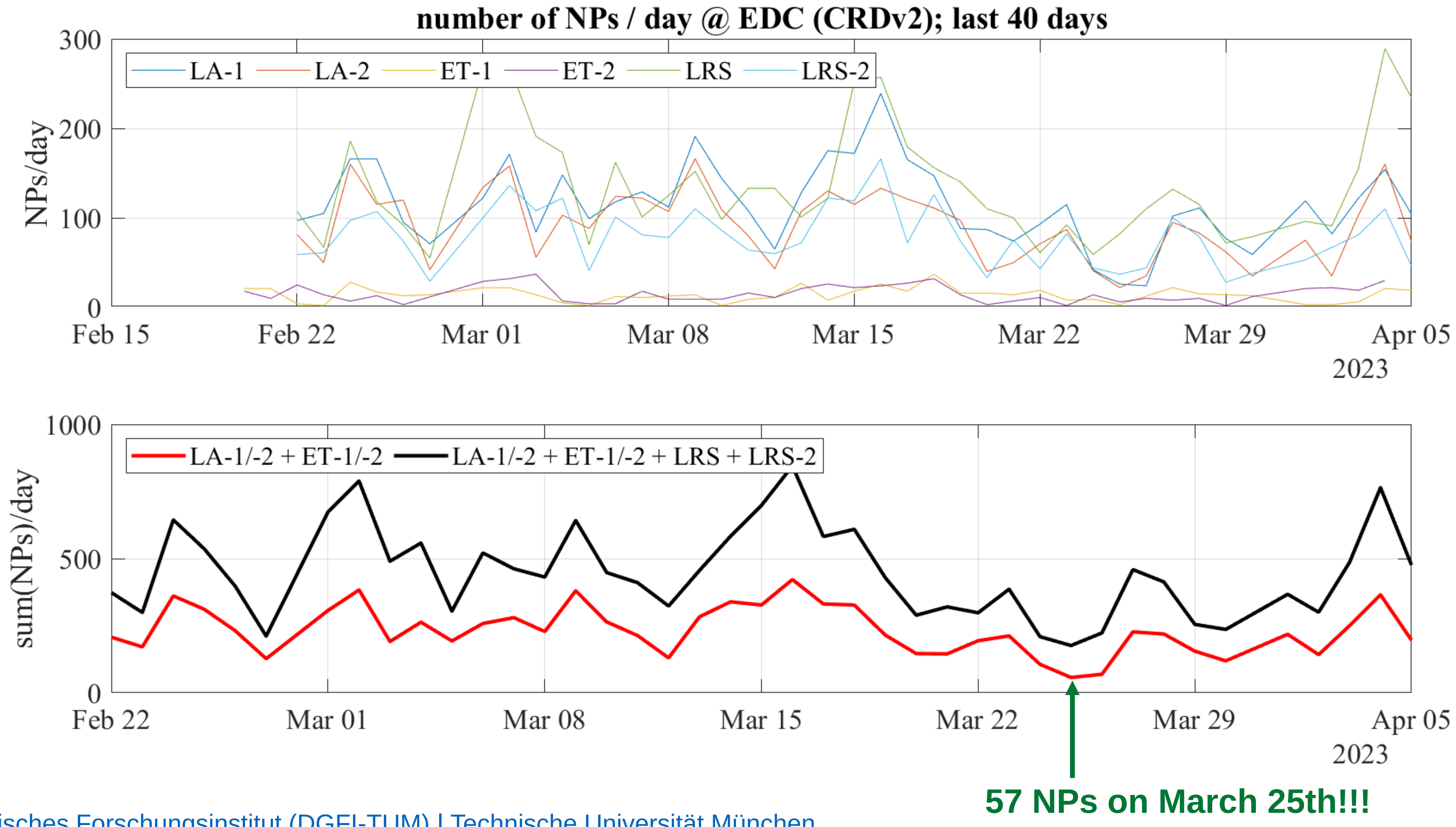
Daily number of NPs (4-sat. vs. 6-sat.)

- During March 2023, there was a "dramatic" drop in the daily number of NPs submitted to EDC/CDDIS from the entire ILRS tracking network



Daily number of NPs (4-sat. vs. 6-sat.) – zoom into last 40 days

- During March 2023, there was a “dramatic” drop in the daily number of NPs submitted to EDC/CDDIS from the entire ILRS tracking network



Daily number of NPs

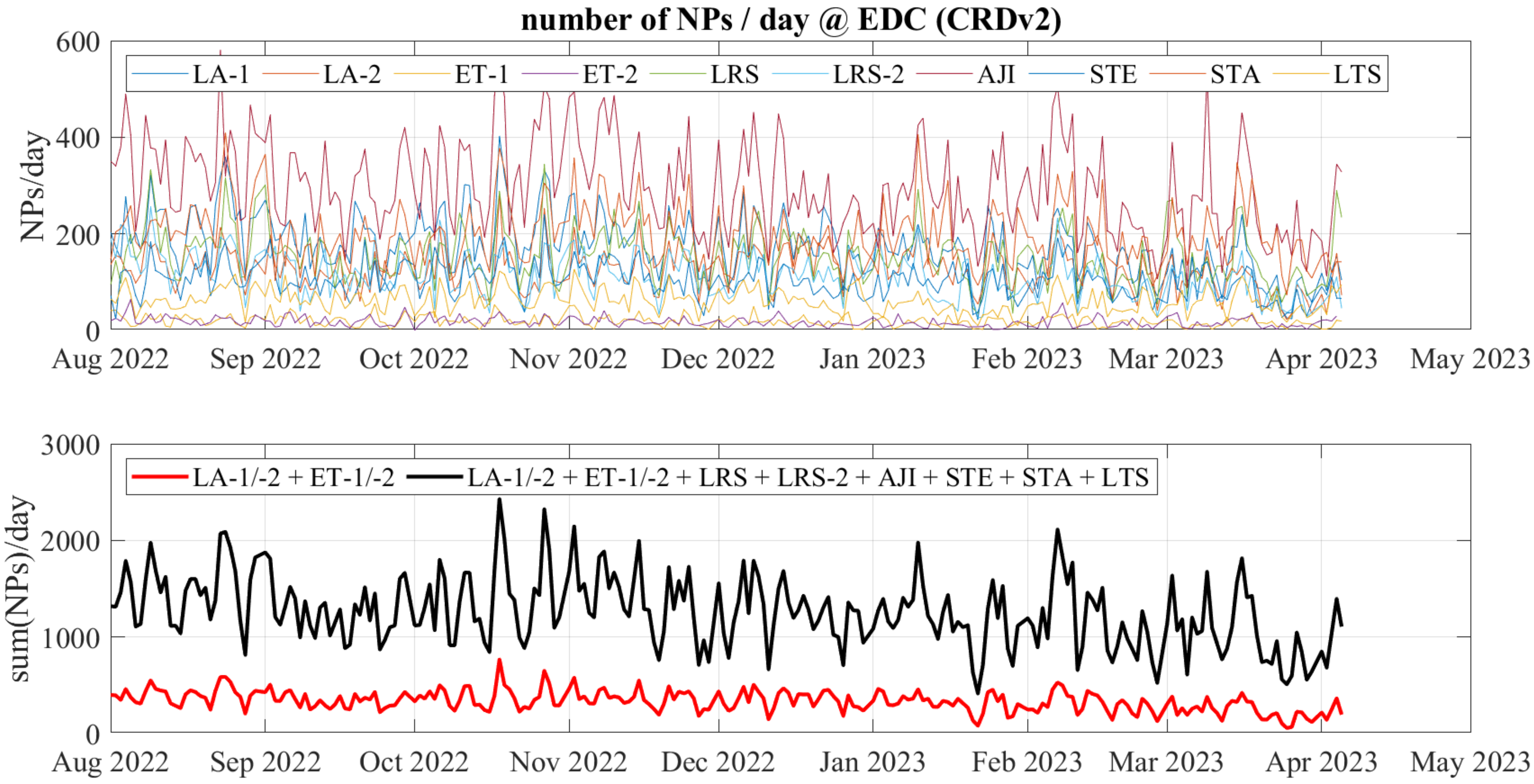
- During March 2023, there was a “dramatic” drop in the daily number of NPs submitted to EDC/CDDIS from the entire ILRS tracking network

- Situation demands attention since weekly ILRS ASC product quality will be affected (T. Springer from ESA mentioned quality criteria of ~2000 NPs/week

- Does anybody know why this happened?
  - **related to solar storm and reduced CPF quality? → not sure since also only few NPs of LA-1/-2 and ET-1/-2**
  - **Weather issues? → not sure since whole ILRS tracking network is affected**
  - **Any other ideas? How to investigate? → geographical correlation?**

Daily number of NPs (all spherical sat.)

- During March 2023, there was a “dramatic” drop in the daily number of NPs submitted to EDC/CDDIS from the entire ILRS tracking network



Main astronomikal observatory Ukraine NAS


SLR Station
1824

Our team

Mykhaylo Medvedsky

V’acheslav Semenenko

Viktor Pap

Vitalij Zhaborovsky

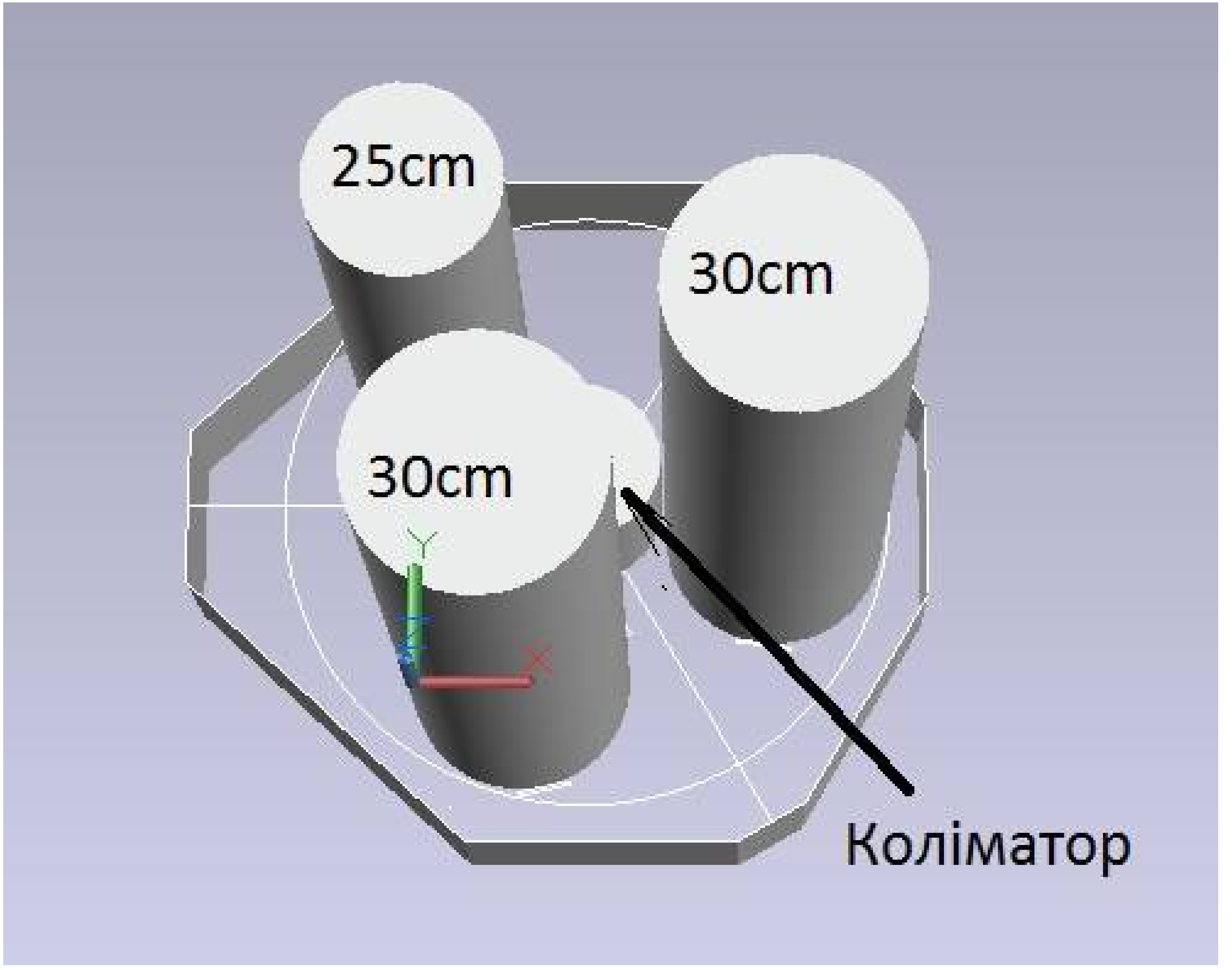
First reasons for modernization – bad main mirror!

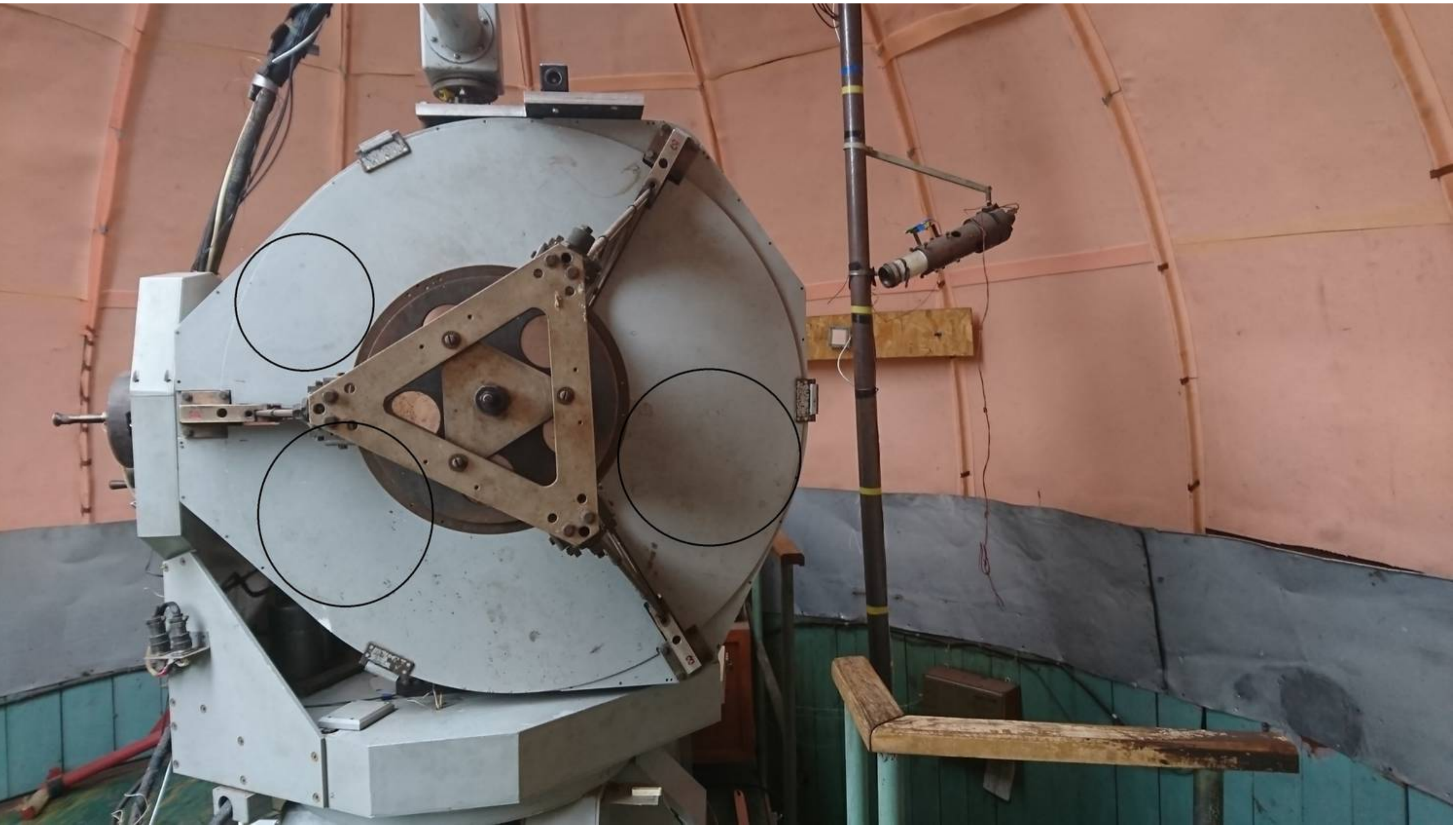
efficiency less than 50%

Rotating mirror

a lot of external noise

a concept was developed



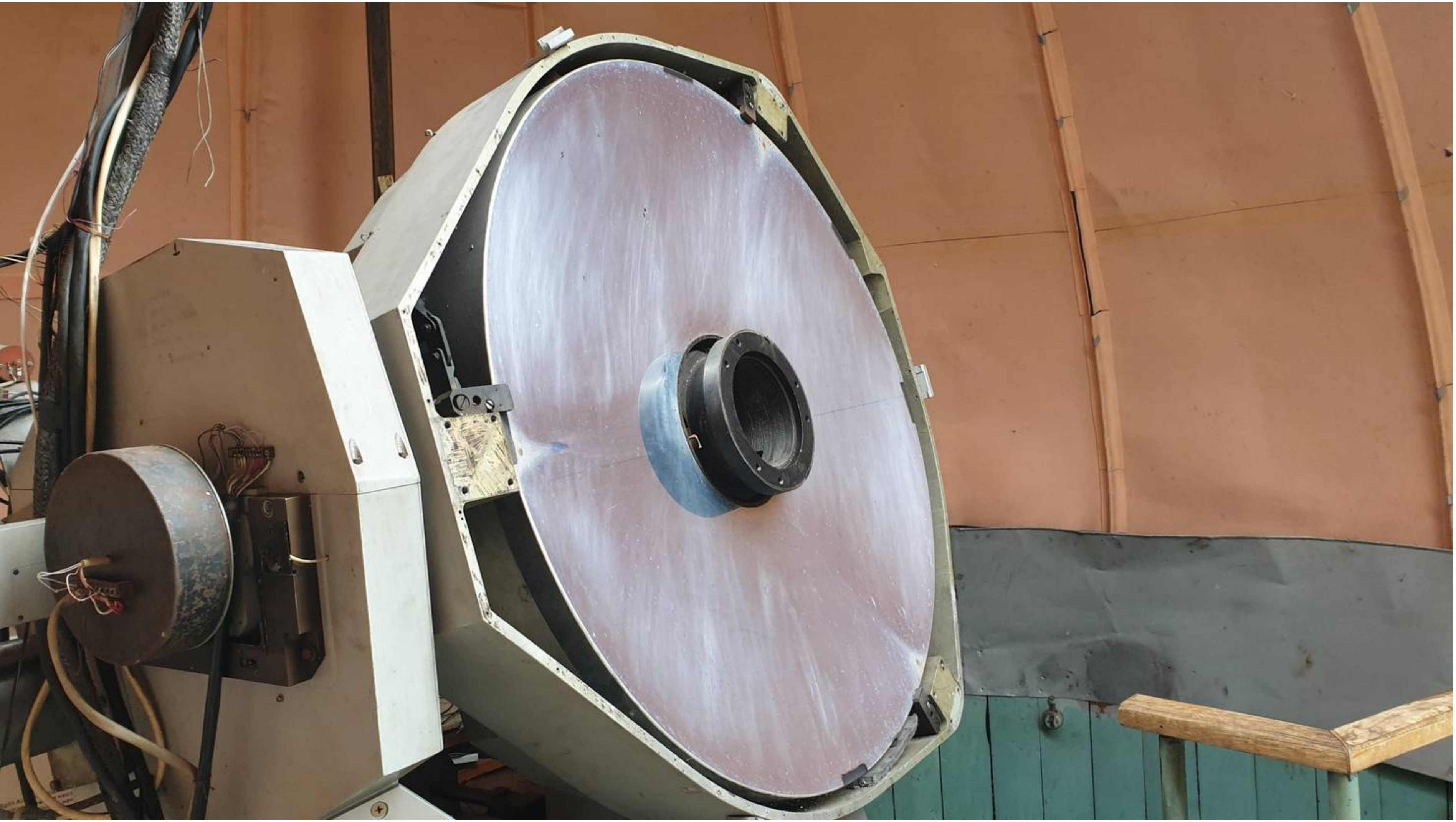


was bought Newtonian telescopes:
two 305mm (F=1500) & one 250mm (F=1200)

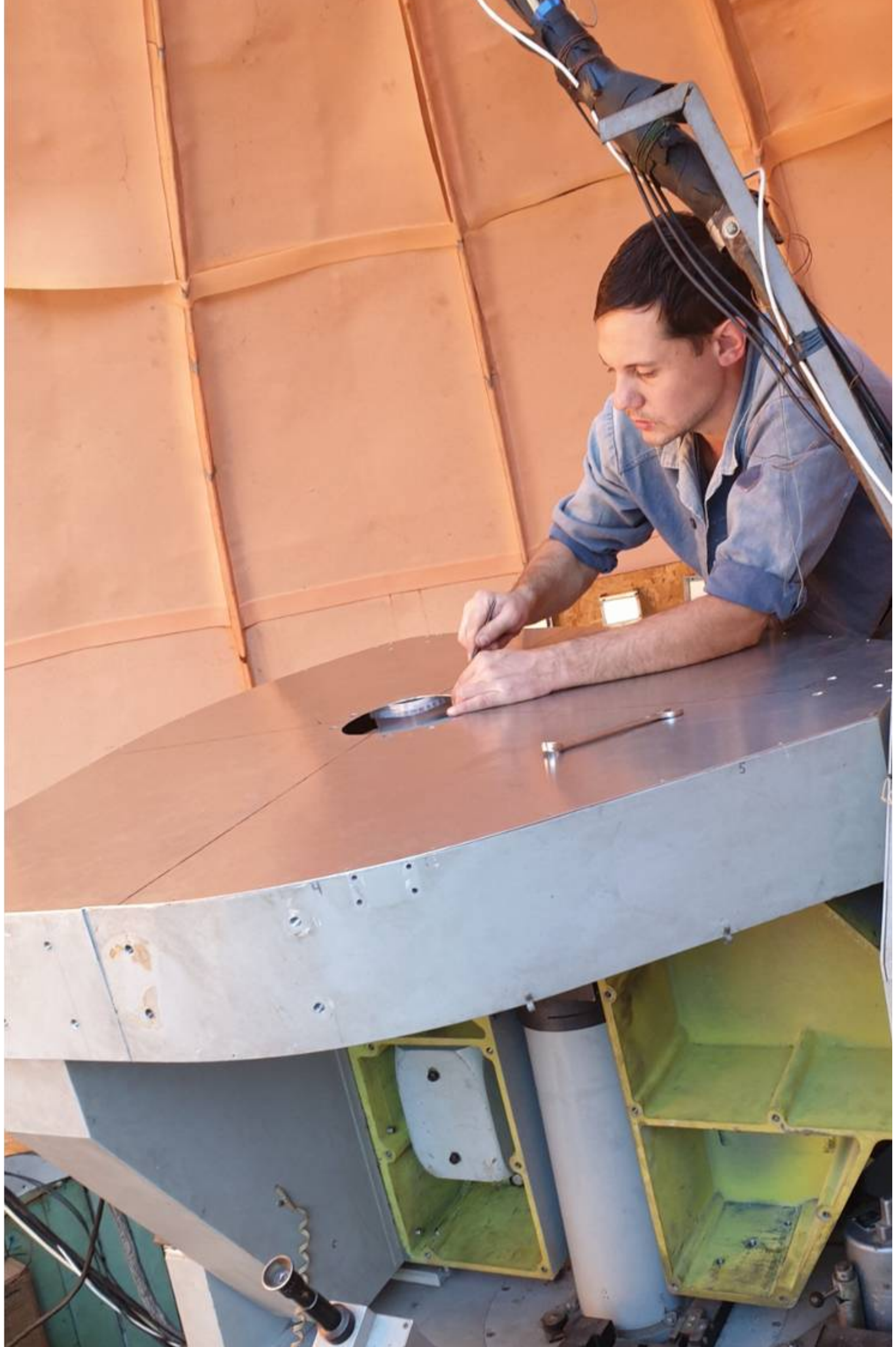
system of feeding cables to the telescope

a telescope mounting system was developed and manufactured independently!

after that, the main and secondary mirrors were removed



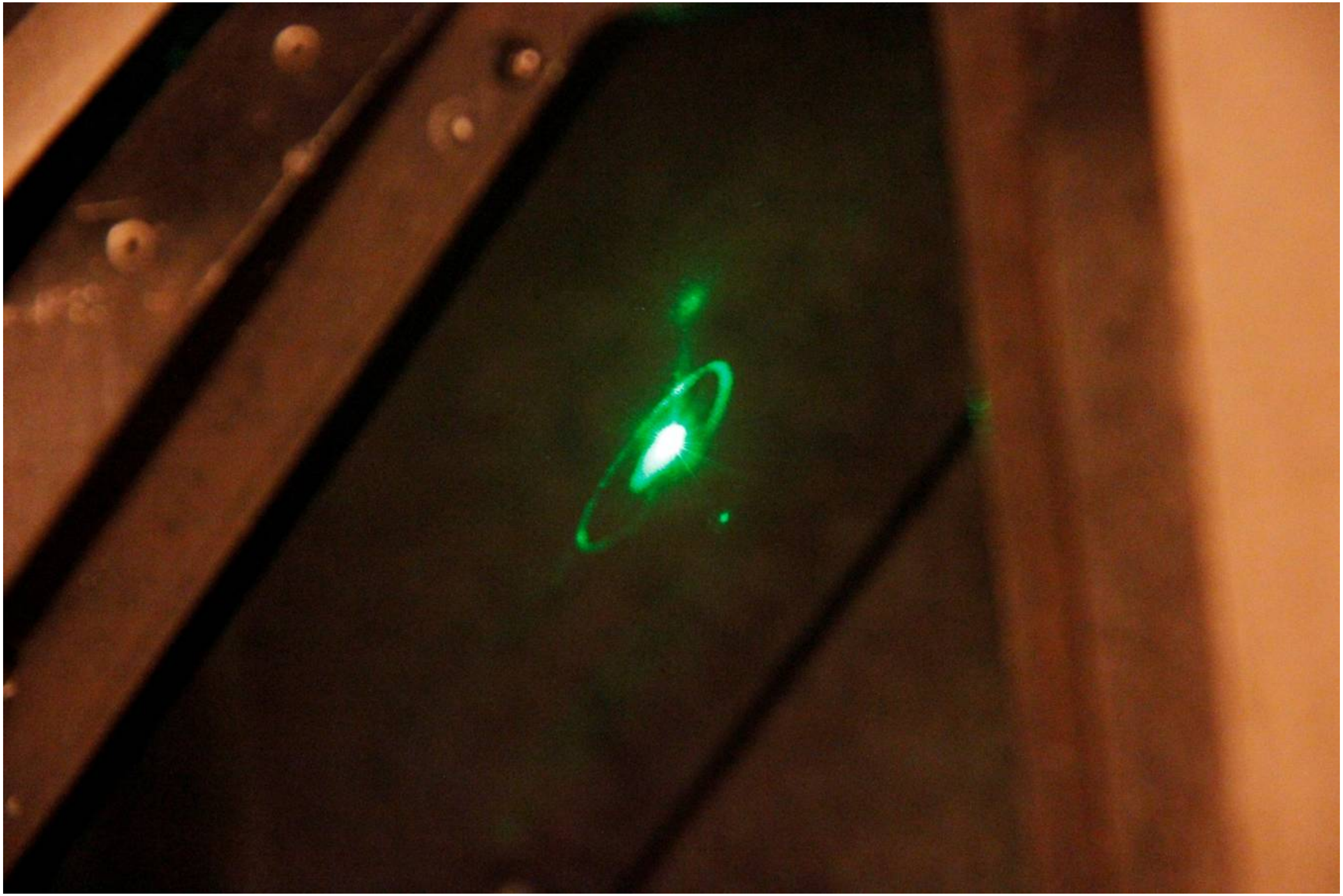
and installation of the new system has begun



installation of the first telescope

in the end
we got such
a system

Another problem was discovered during the Koude mirror alignment

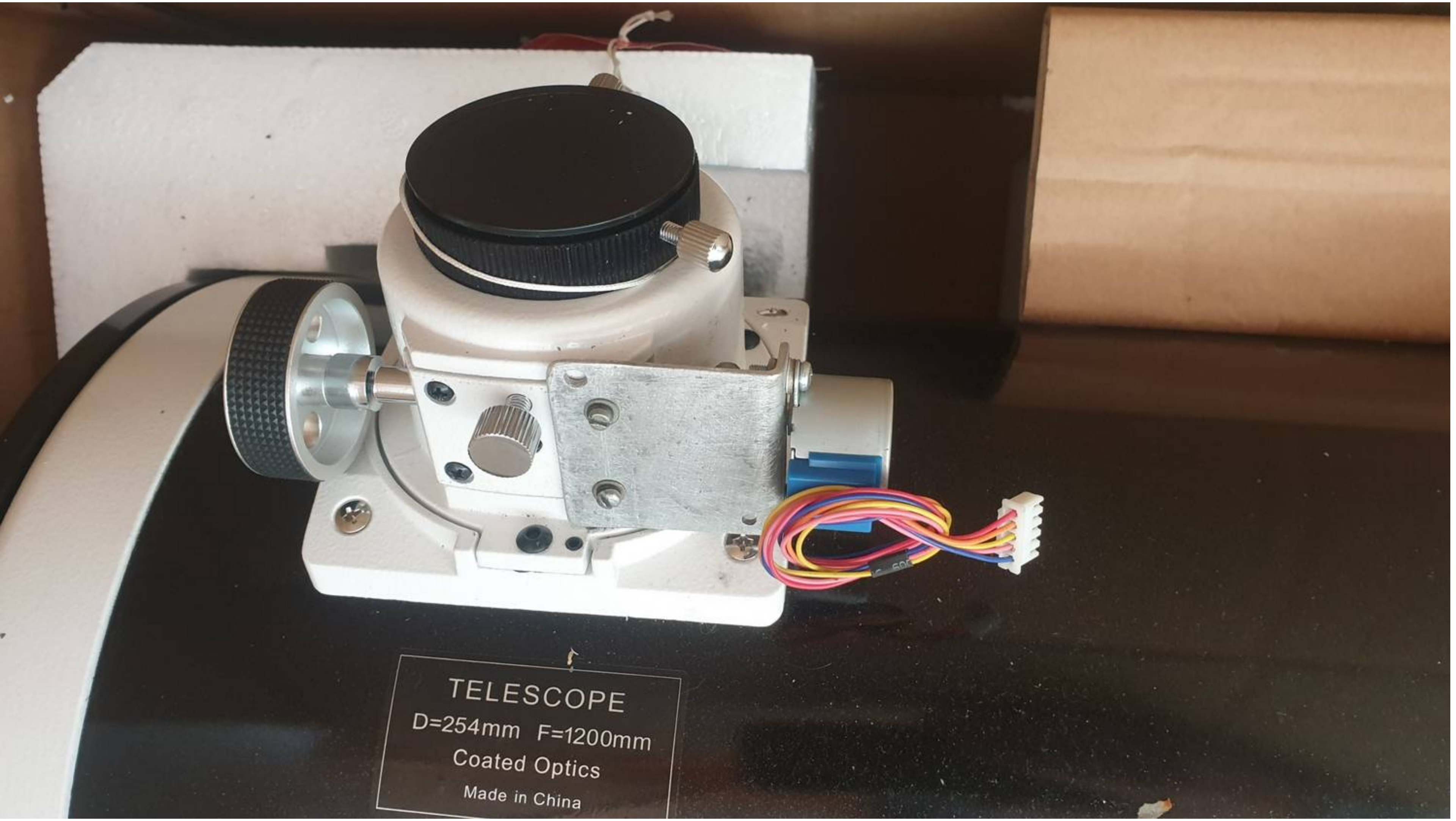


we use a 250mm telescope as a guide 15^m!

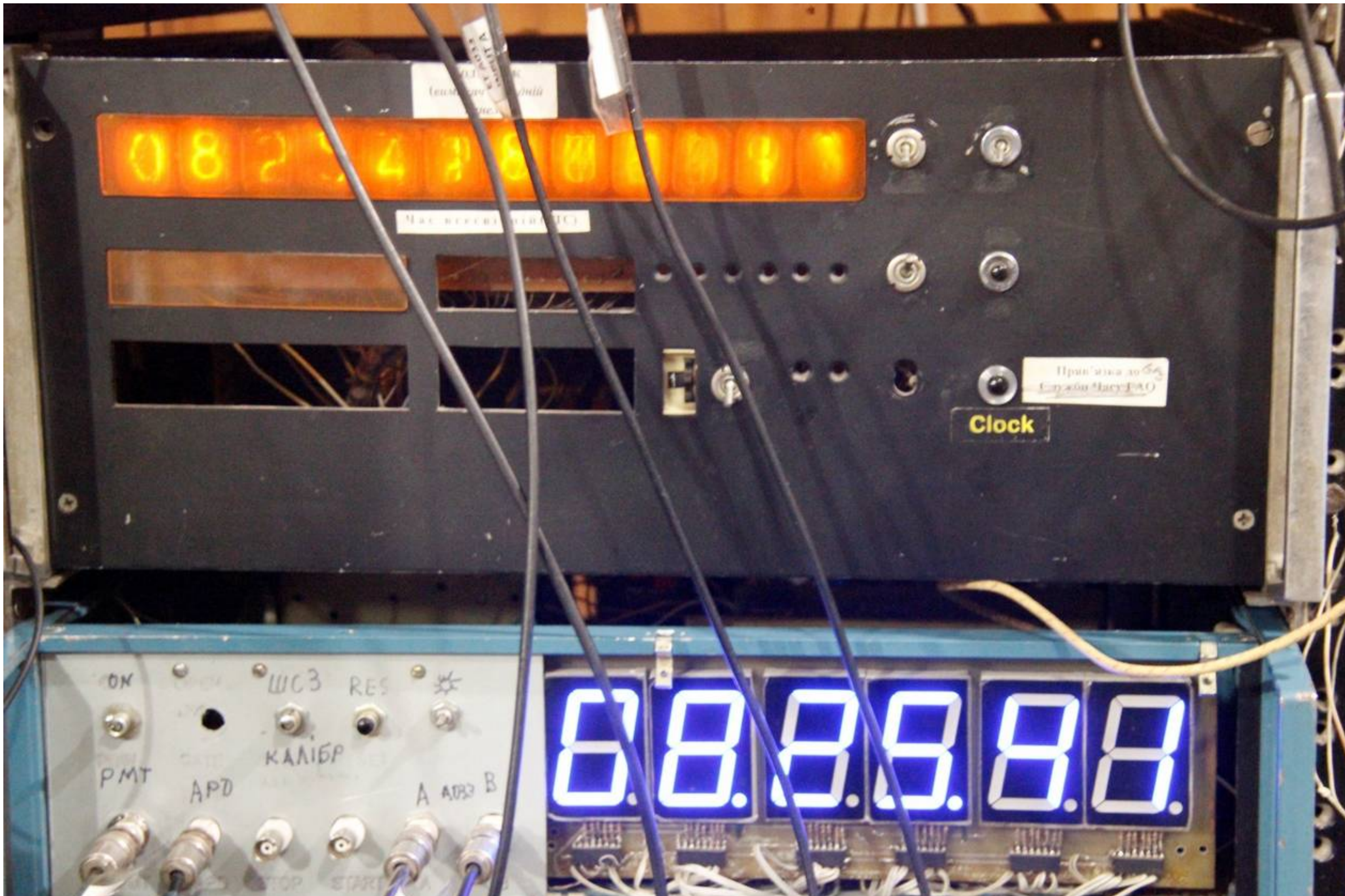
We can see all sunlight sat!

and two 305mm as a receiver

each one telescopes are equipped with stepper motors for remote focusing



we use two independent clocks
- for the telescope
- for time gates



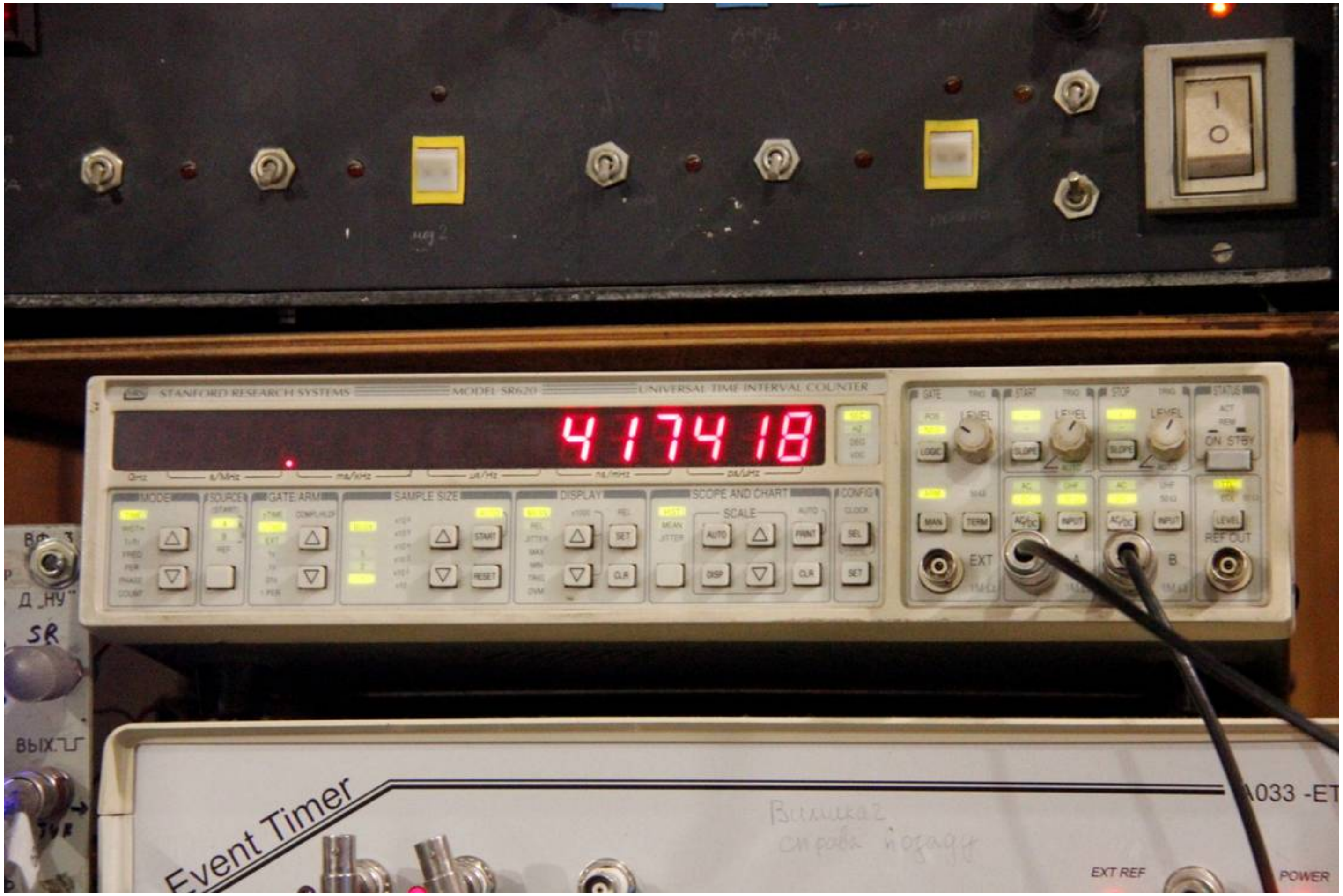
epoch

- These clocks & AT033 are synchronized

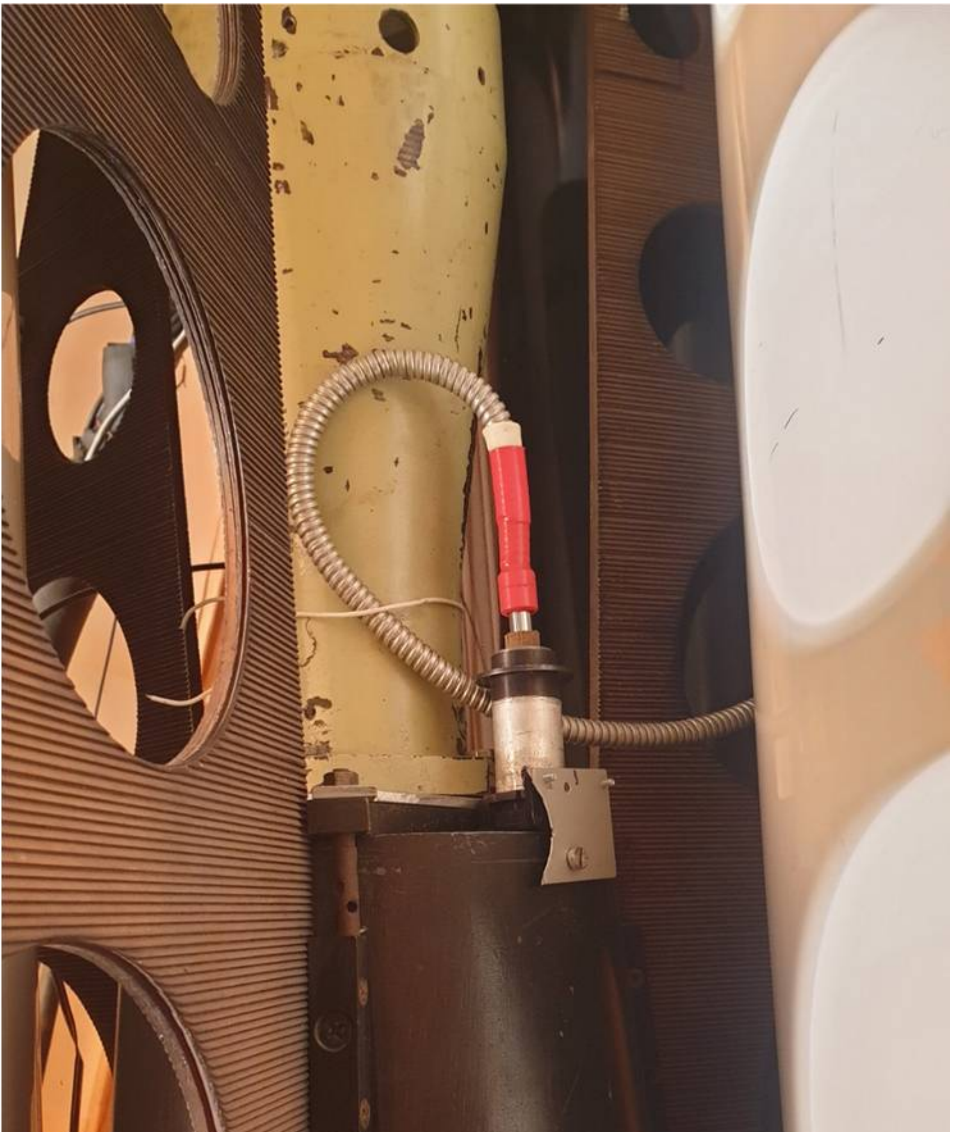
by GPS 1 pps

- Telescope clock use the GPS-control frequency
- The gate clock & AT033 use Rb standard frequency

the difference between 1pps is monitored by SR-620



a system for internal and external calibration was made

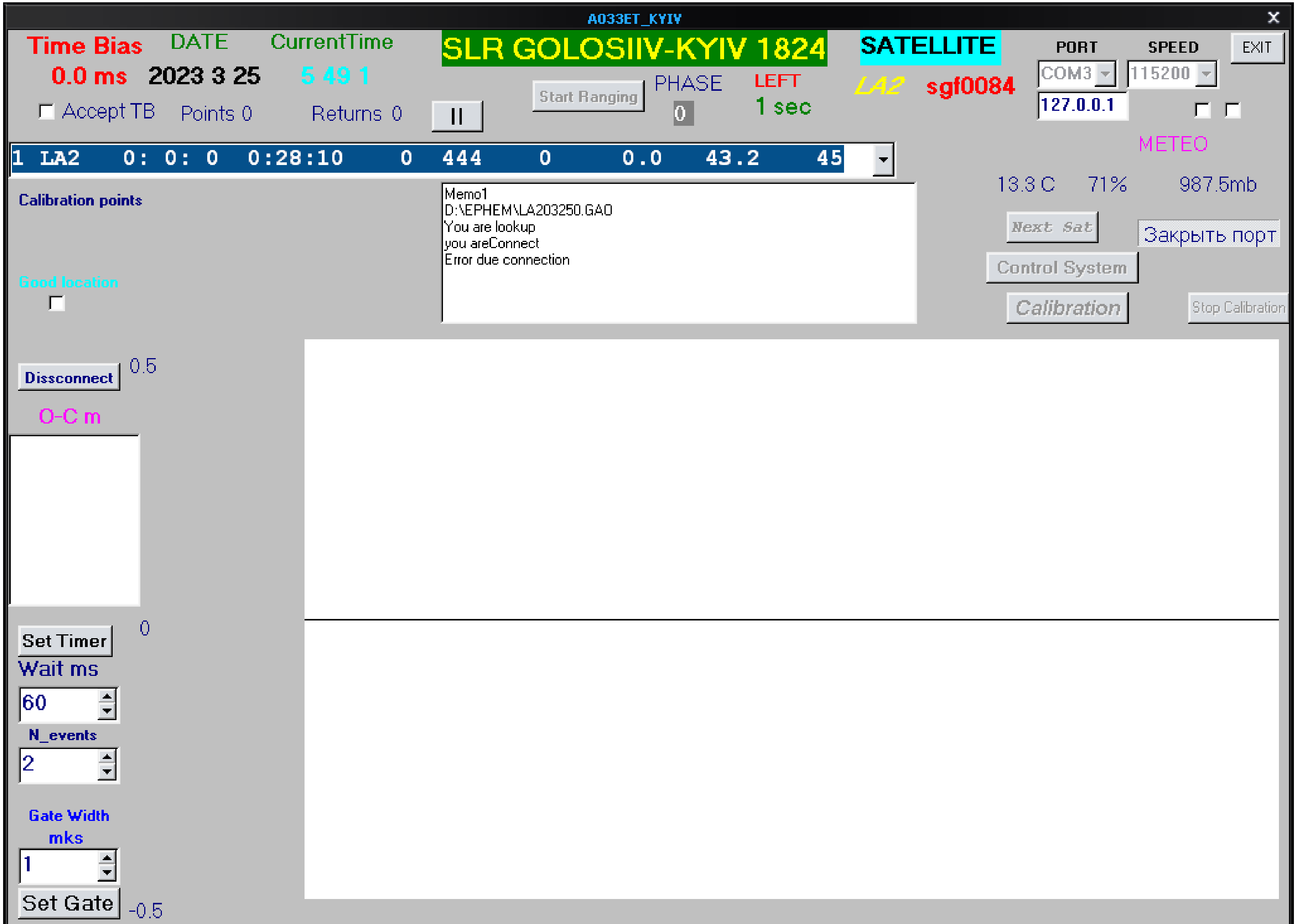


Laser
60ps 2mJ 10Hz (it can be 35mJ)

an epoch timer is installed (courtesy of **EVENTECH** (Riga))

an epoch gate generator with a discreteness of 20 ns was developed and manufactured

new software has been created to work with the new system



electronic remote control modules were developed and manufactured

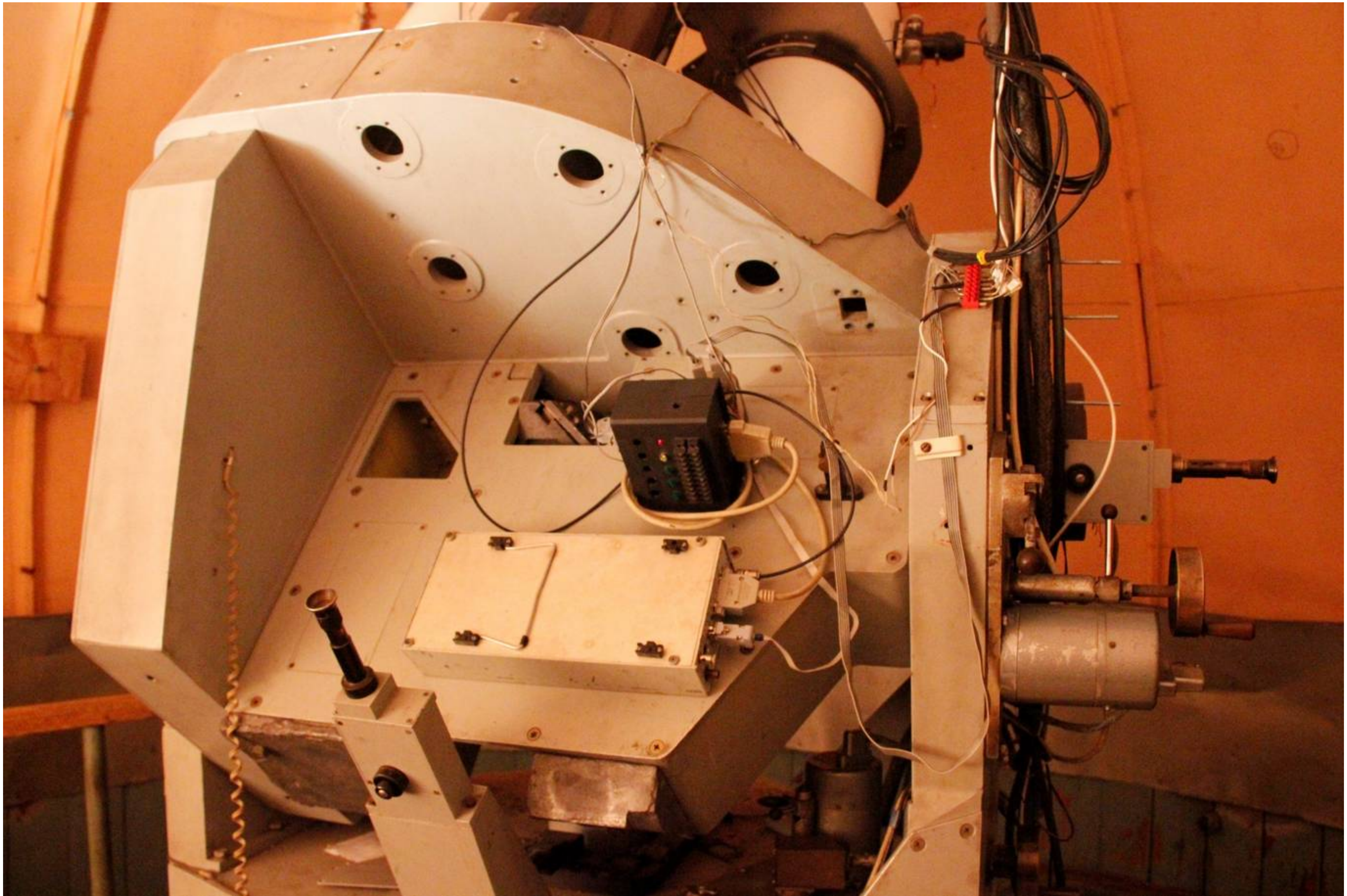


photo receiver module with PMT (drawing)

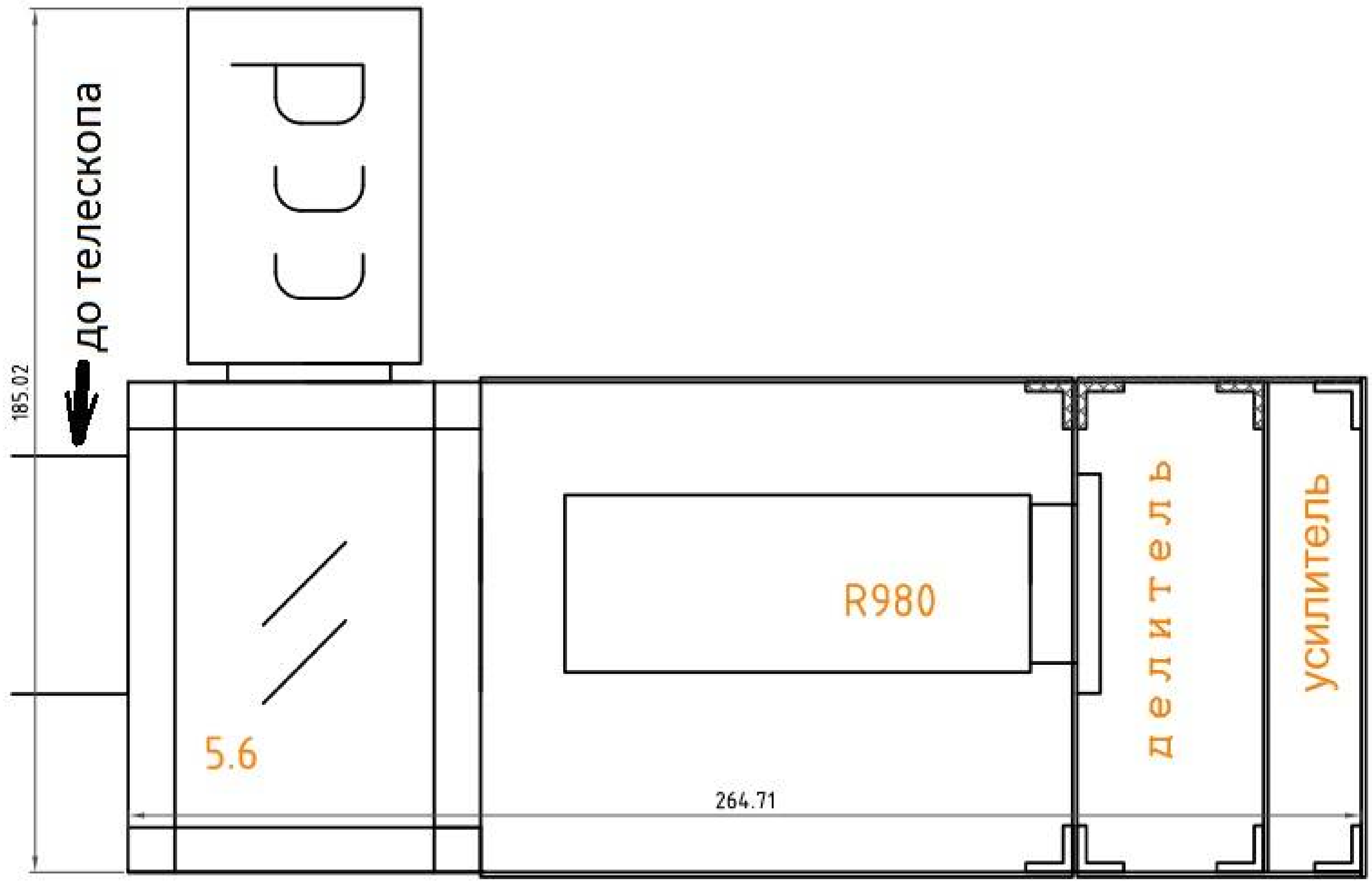
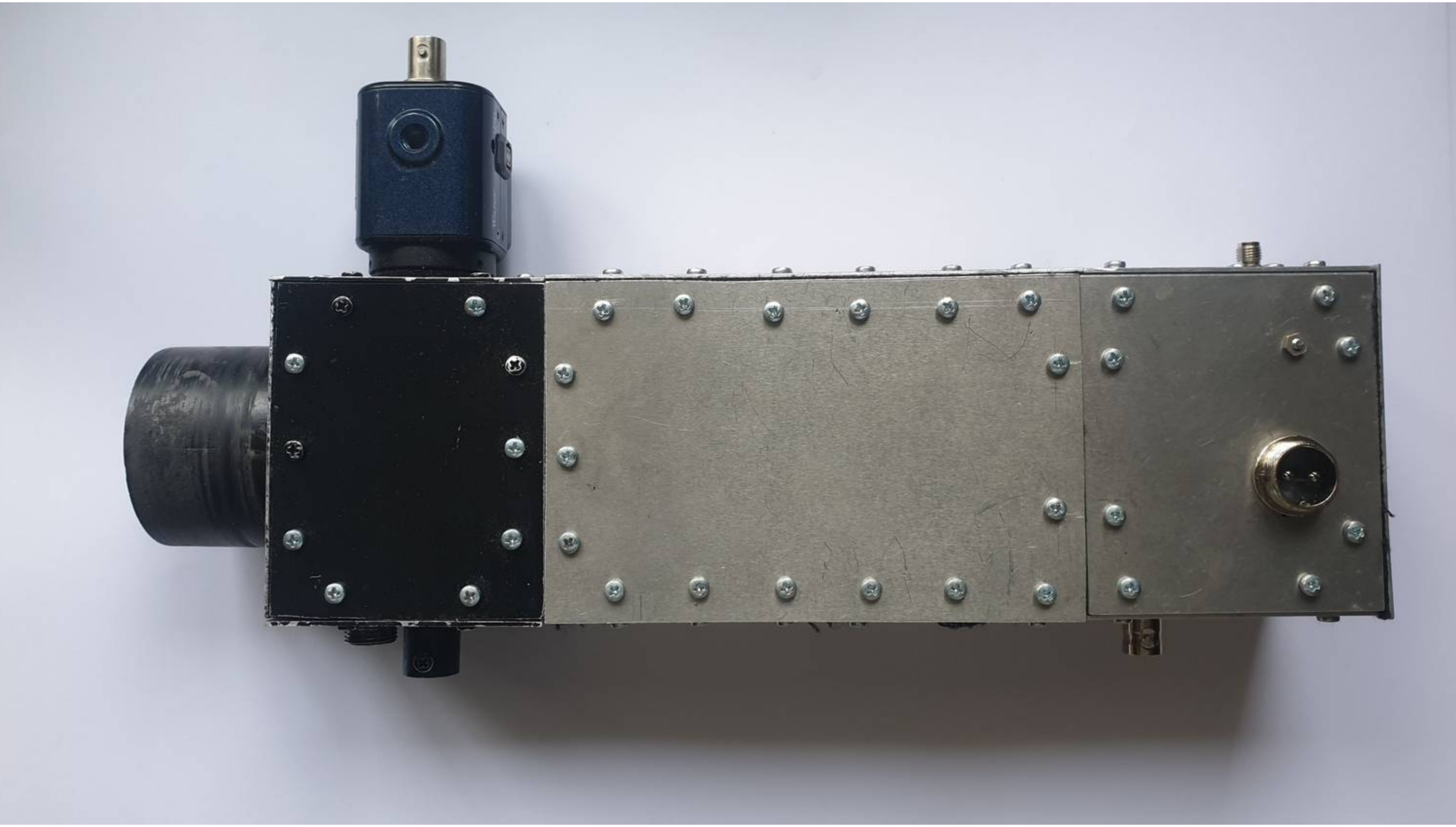
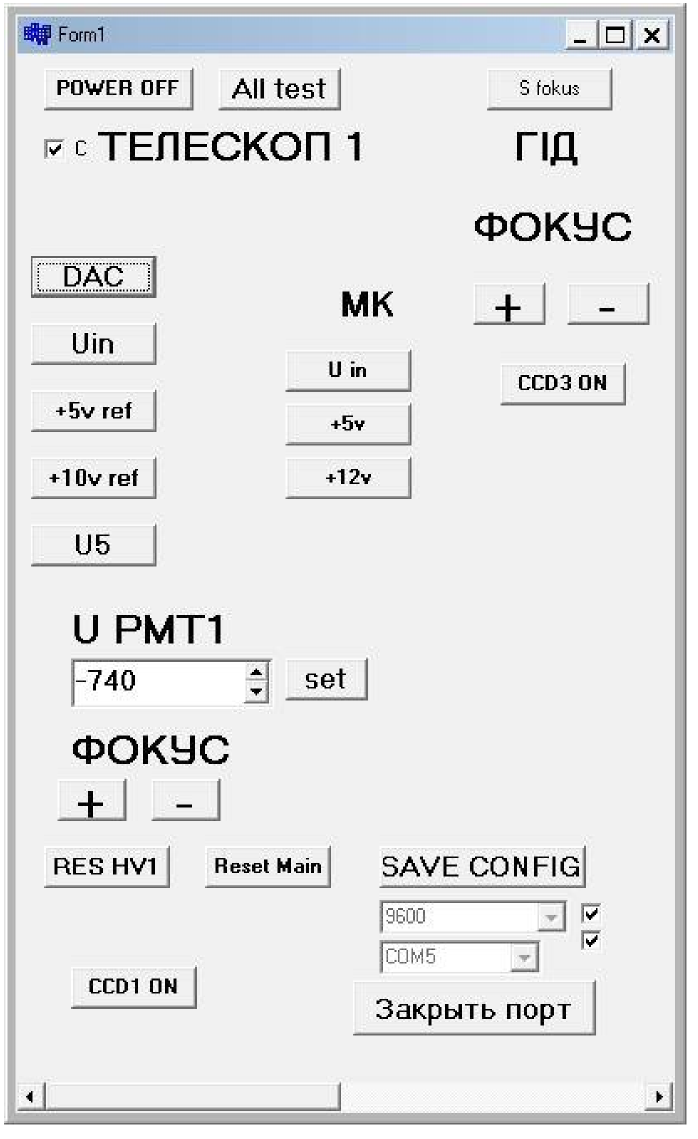


photo receiver module with PMT (made)

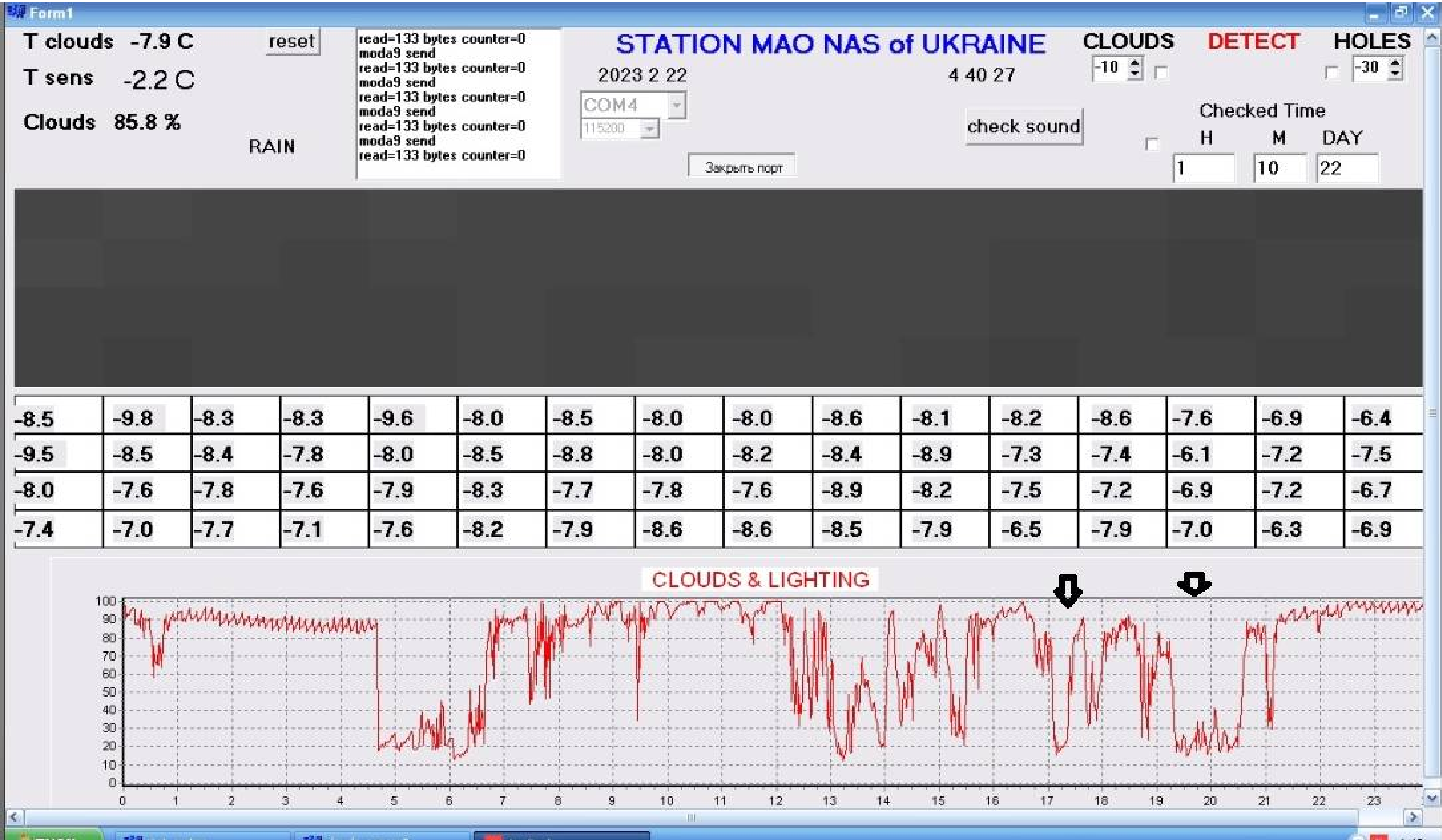


Control receivers panel

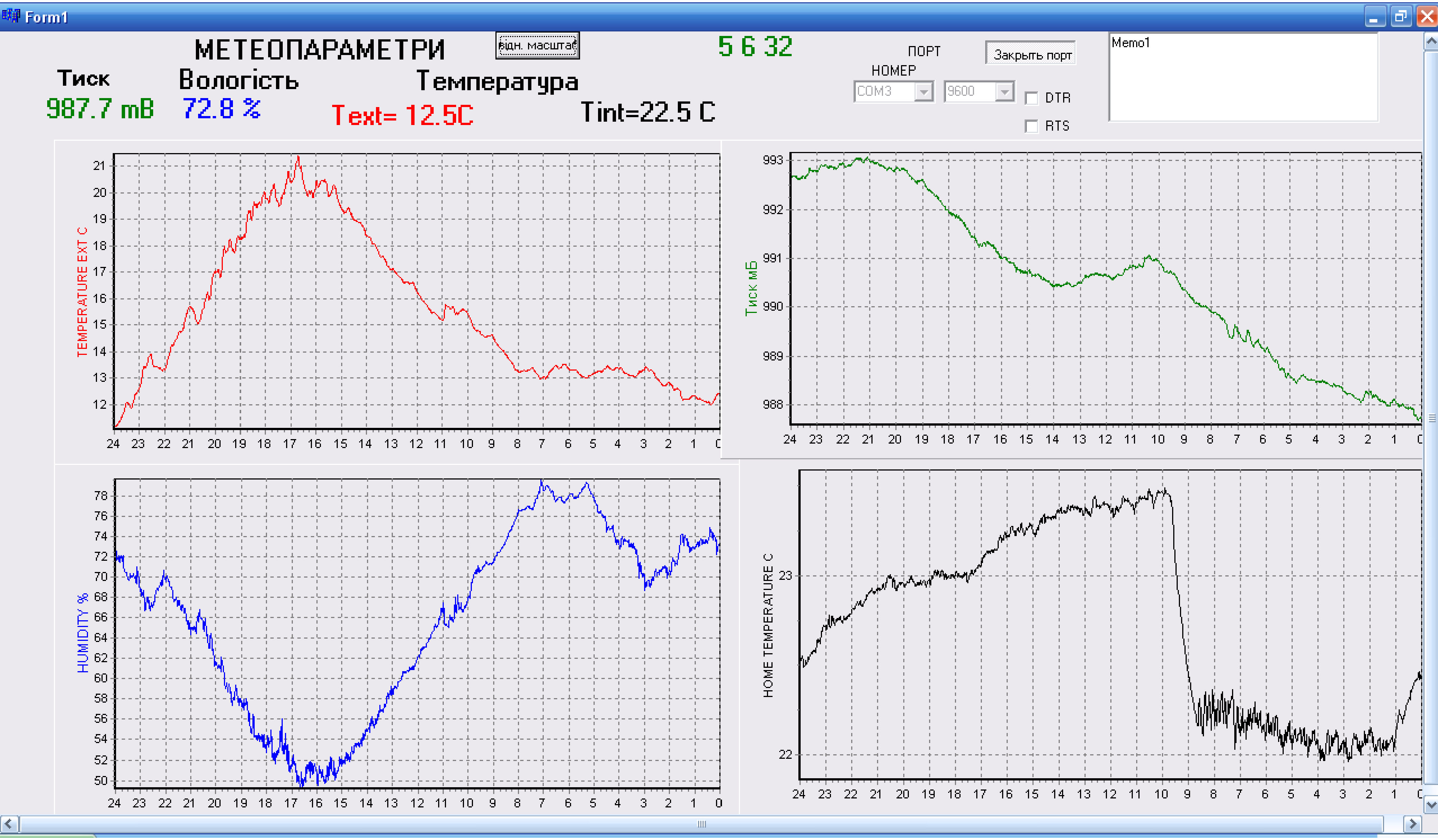


Clouds observing

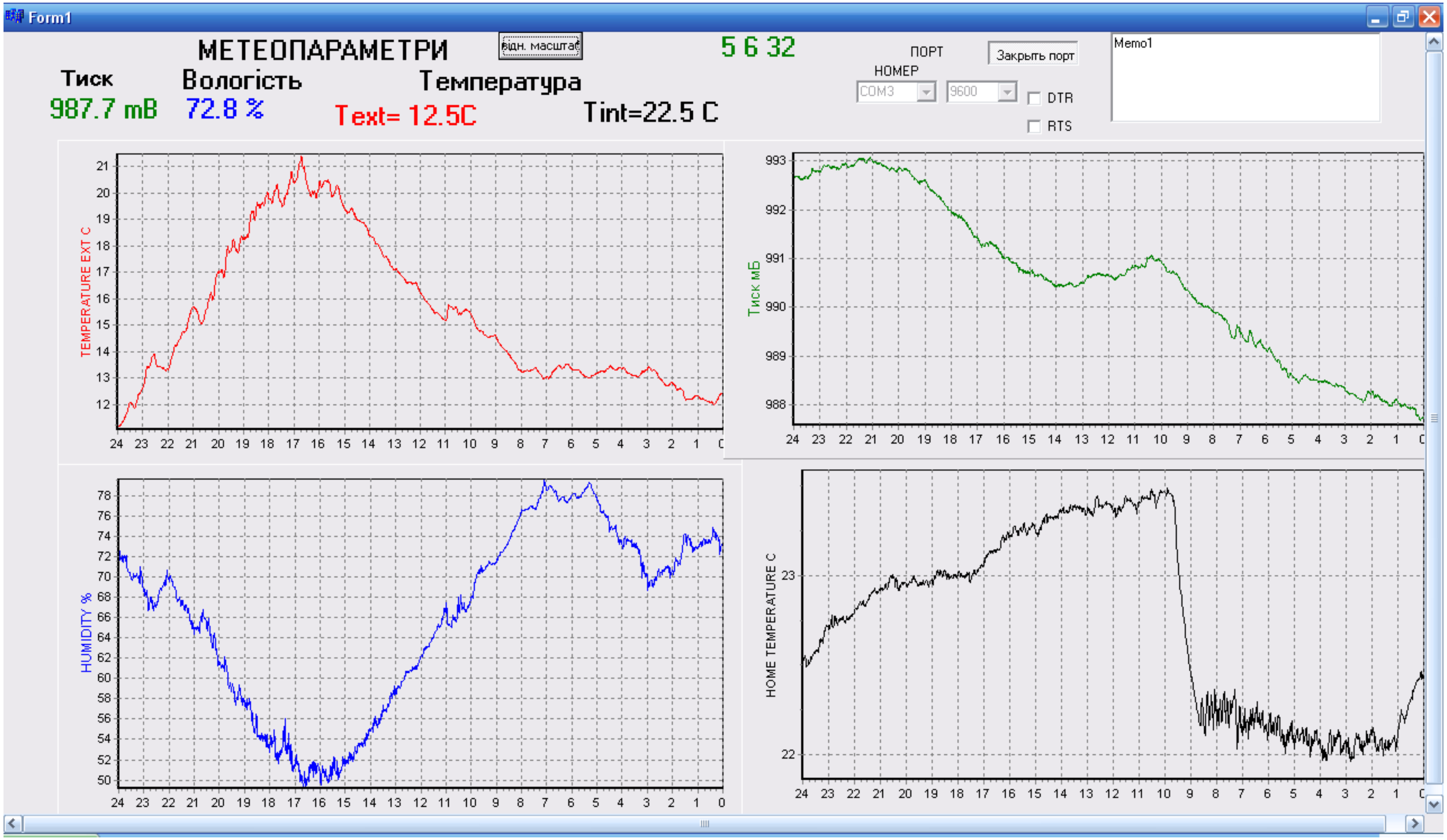
Clouds control software



Meteo station

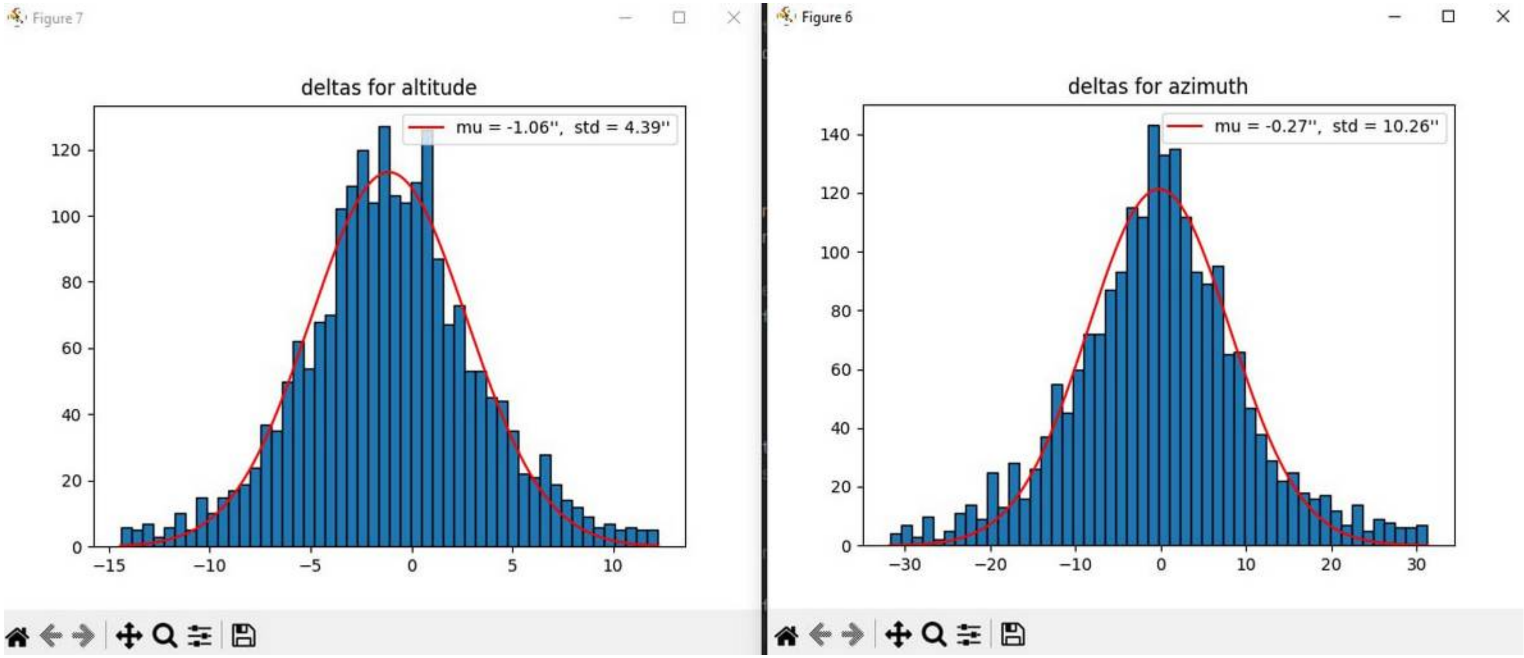


The operation room temperature are stabilized on 1C accuracy



Pointing the telescope

- a telescope pointing error model was built using the machine learning method (neural networks) this made it possible to observe "invisible" satellites!



Working place

- Most of the created software and hardware allows remote control via the Internet

real improvements of the modernized system

- The modernized system turned out to be much more effective than the previous one!
- The number of received answers from satellites has increased!
- The penetrating ability of the guiding telescope has increased (better than 15 magnitudes!)
- The level of external noise has decreased!

plans for the nearest future

- new telescope control software (for Win OS)
- a new telescope drive power unit
- a new receiving module on the PMT H5783/H6780 Series (courtesy of Kalvis (Riga station))
- A new CFD for this PMT
- new telescope control hardware
- A new version epoch gate

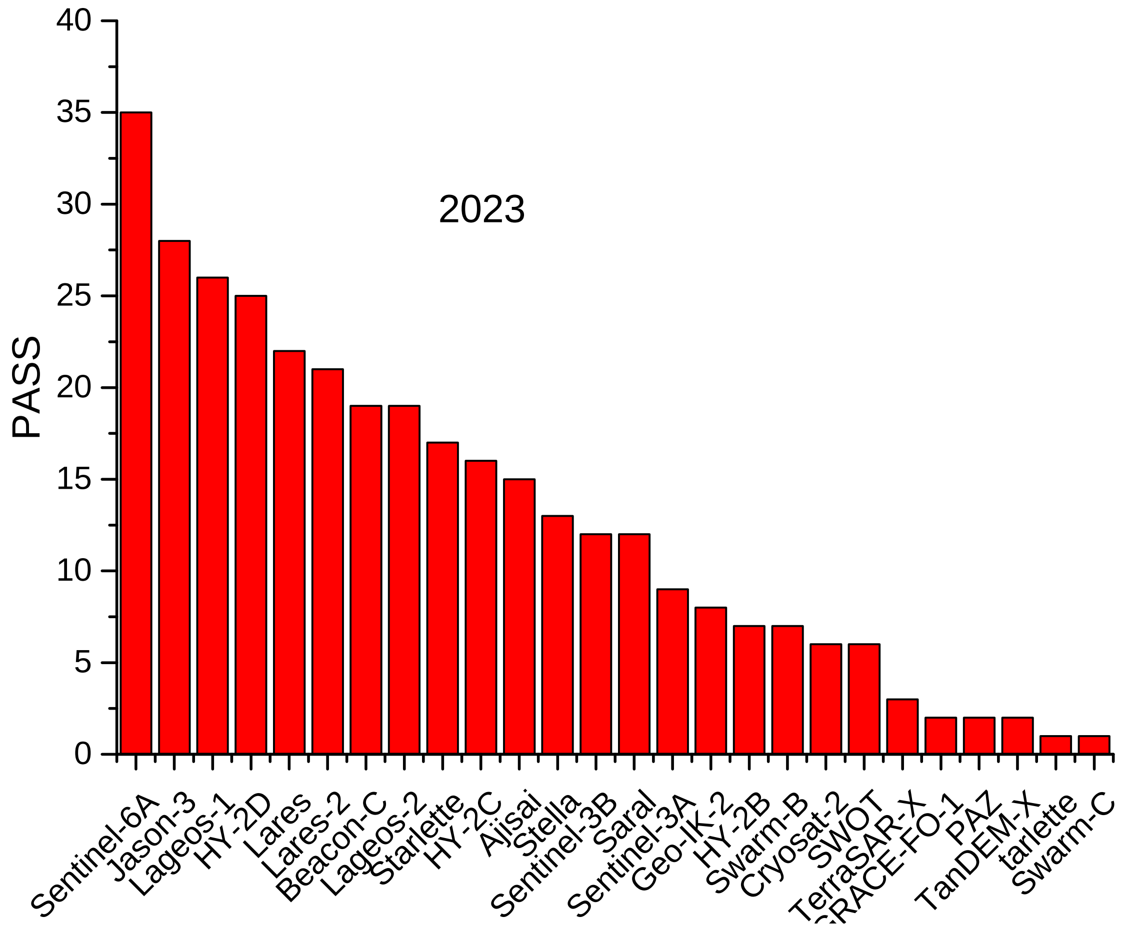
The main difficult

- laser lamps are required
- replacement of Pockels cells is necessary

problems with getting out of quarantine

- Weather * schedule!

Statistics for 2023



Thank you for your attention

SLR Tsukuba Station

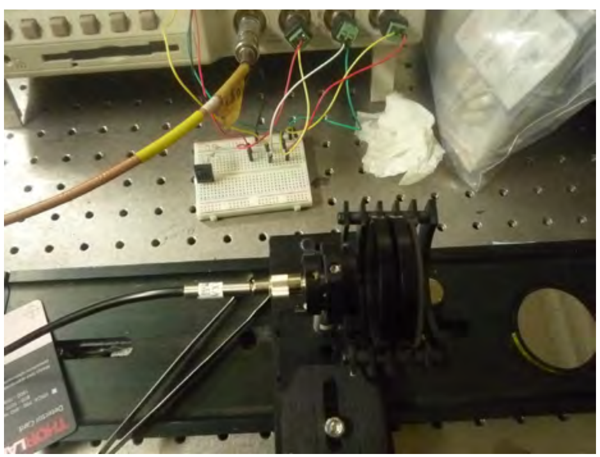
JAXA
Shinichi Nakamura
Takehiro Matsumoto
Ayano Nakajima
Kiyoshi Hamada

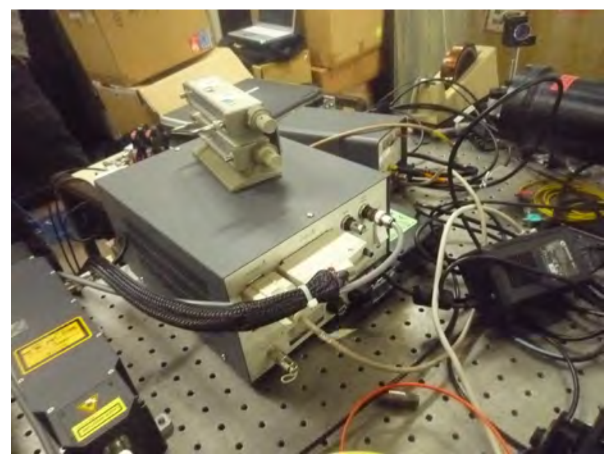
Once upon a time

April 2005　SLR Tanegashima station begins operations.
The Tanegashima station contributed to the mission with ALOS, OICETS, ETS-8, QZS-1, SOLAR-1 and AJISAI ranging.

2016　JAXA recognized that the global generation of SLR systems had changed. Specifically, kHz pulses, infrared ranging, photodetectors and electronics have become more sophisticated.

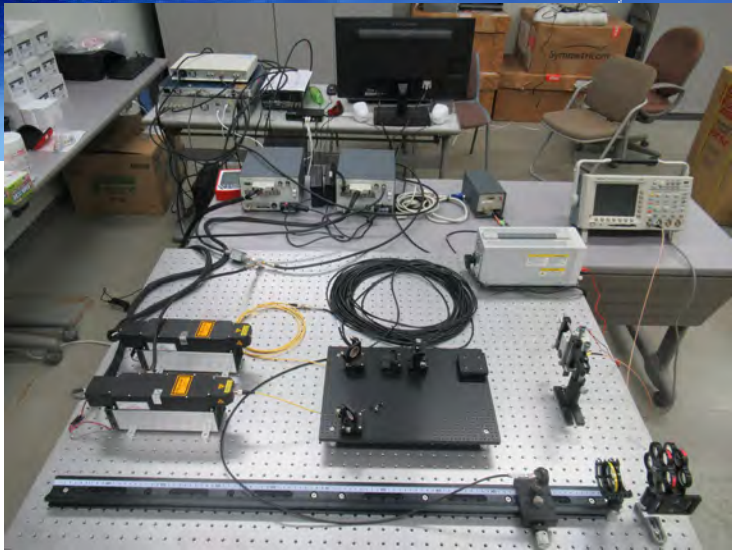
2017　JAXA staff with no background in Optics or Electronics learned from scratch at NICT, even though they were shamed.

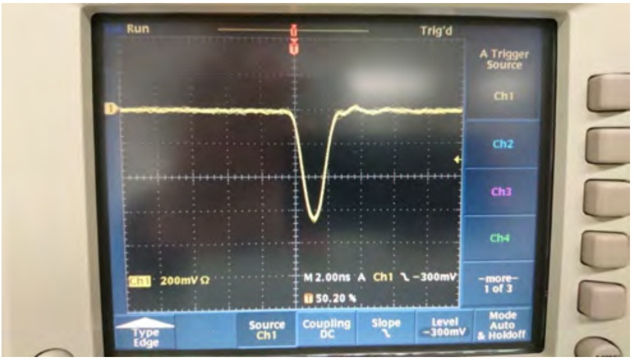


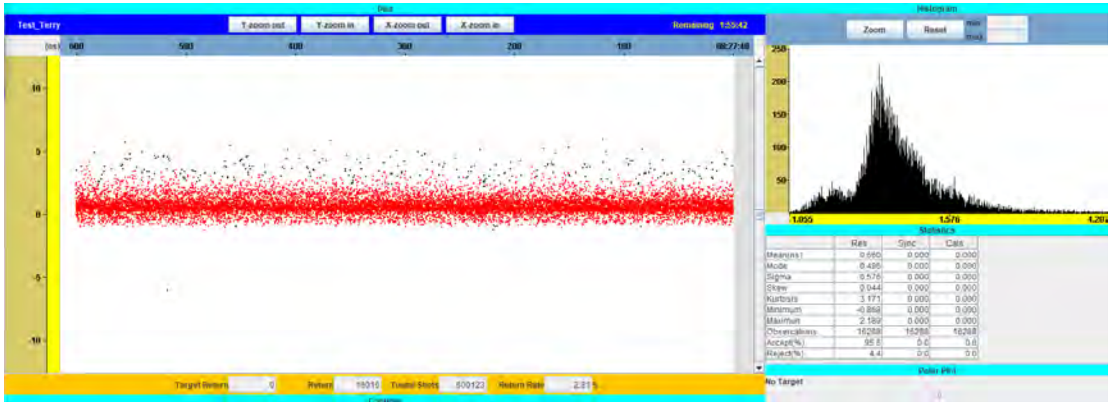


Heartfelt thanks to Kunimori-san, NICT.
The spirit of NICT has been passed on to the Tsukuba station.

2018 Mock-up of JAXA SLR station based on what was learnt at NICT

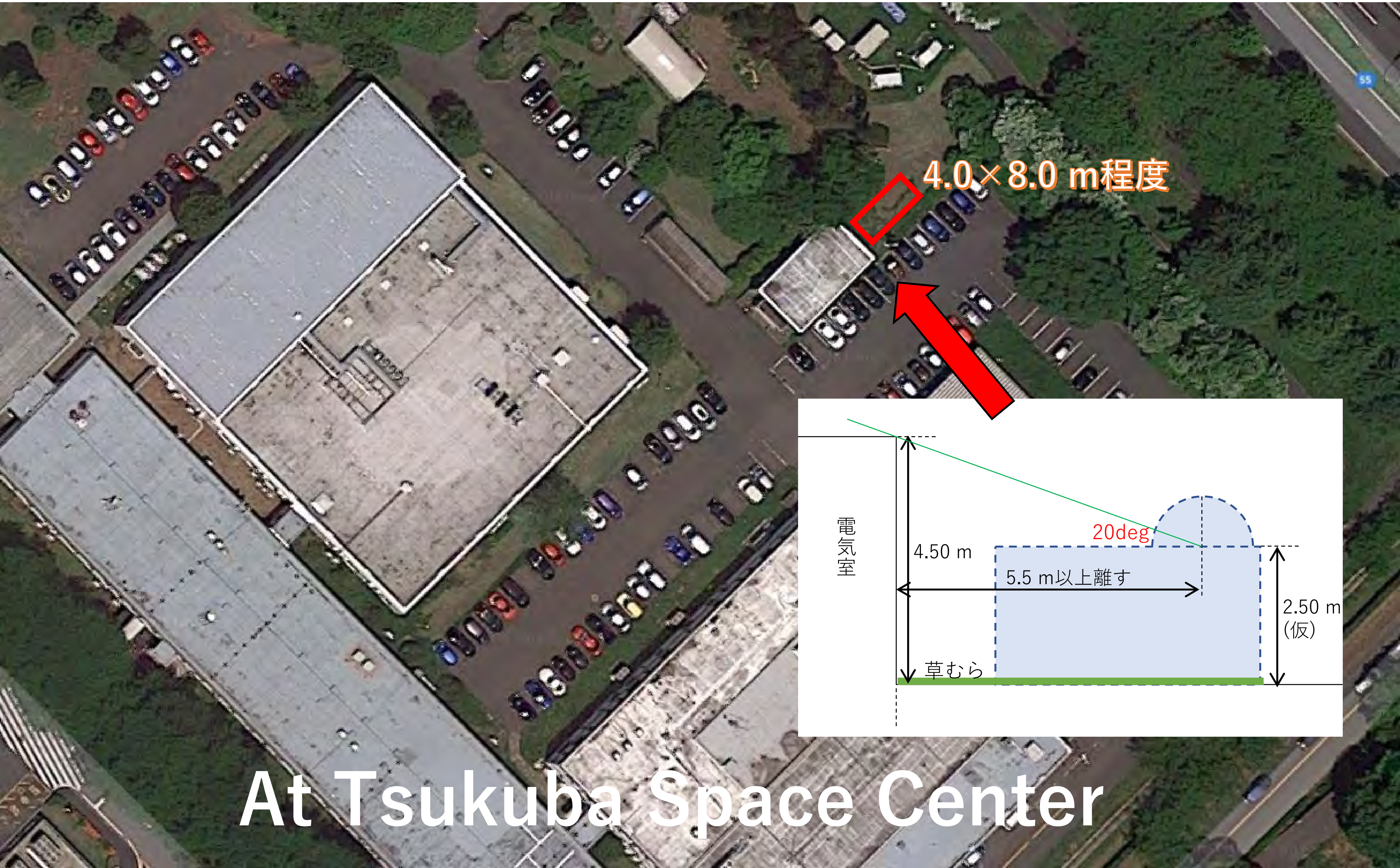






JAXA staff have mastered the principle of operation of SLR stations.
→The level of JAXA staff being able to prepare the specifications for SLR Tsukuba stations themselves has been reached.
Successfully obtained budget for FY2018!
First contract signed in March 2019.
Started to move towards the development of the SLR Tsukuba station!

Finding a place to install（2018/8/15）



At Tsukuba Space Center


電気室

Start of construction


2020/10/02

So far, things have been going well!

COVID-19 caused a two-year standstill.
Unexpected!We had to struggle in non-technical areas, such as the carry-over of funds from one year to the next.

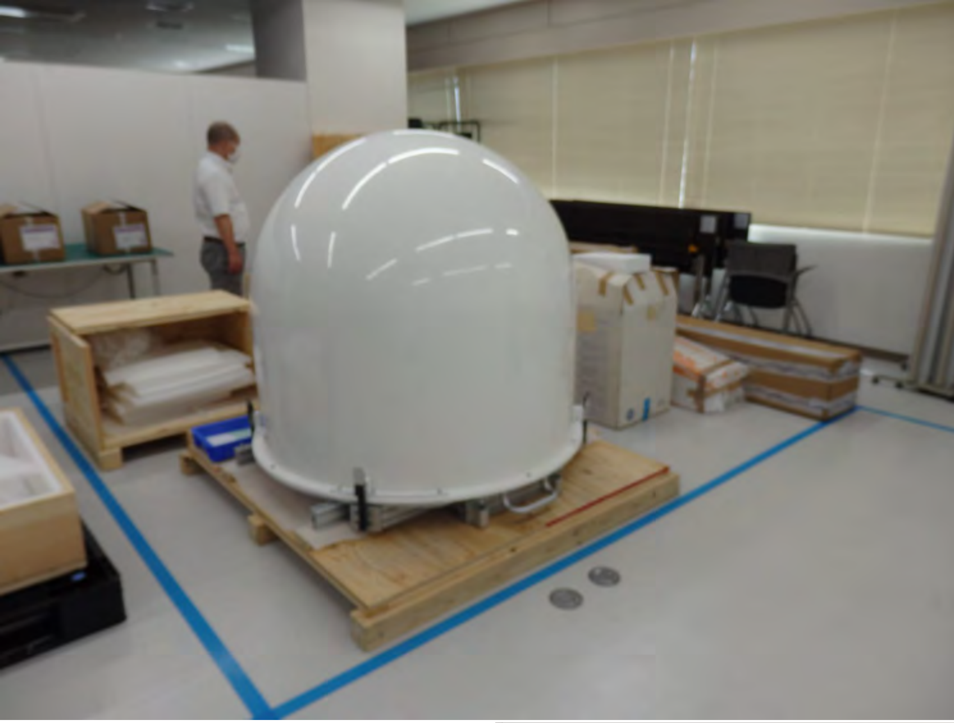
Every day we had to manage the storage conditions etc. Photo shows the warehouse.


TAL
tek
CA

A+
AluCoating

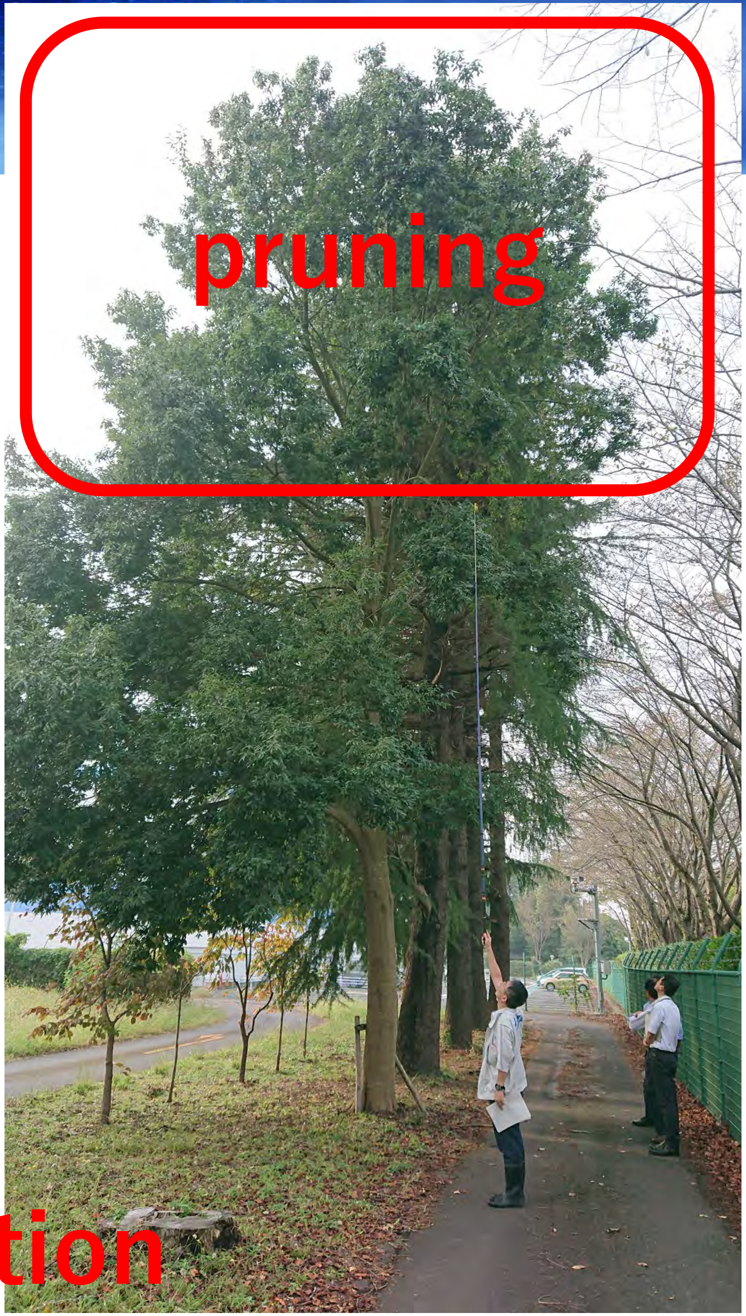
A+
AluCoating

A+




TRUSCO


pruning


pruning


deforestation

Establish a rest area for each company (COVID-19 infection control).)




KATO


KATO



Diameter 60 cm Telescope
RIGA Event Timer
Safety :Aircraft Detection Radar & ADSB

1 kHz Ranging
532nm & 1064nm

Trivia of the Day.
Which satellite was the first to be ranging by the SLR Tsukuba station?

GLONASS