



New „face” of the Borowiec Satellite Laser Ranging Station

Paweł Lejba, Tomasz Suchodolski, Stanisław Schillak,
Jacek Bartoszak, Piotr Michałek, Stanisław Zapaśnik

Space Research Center PAS

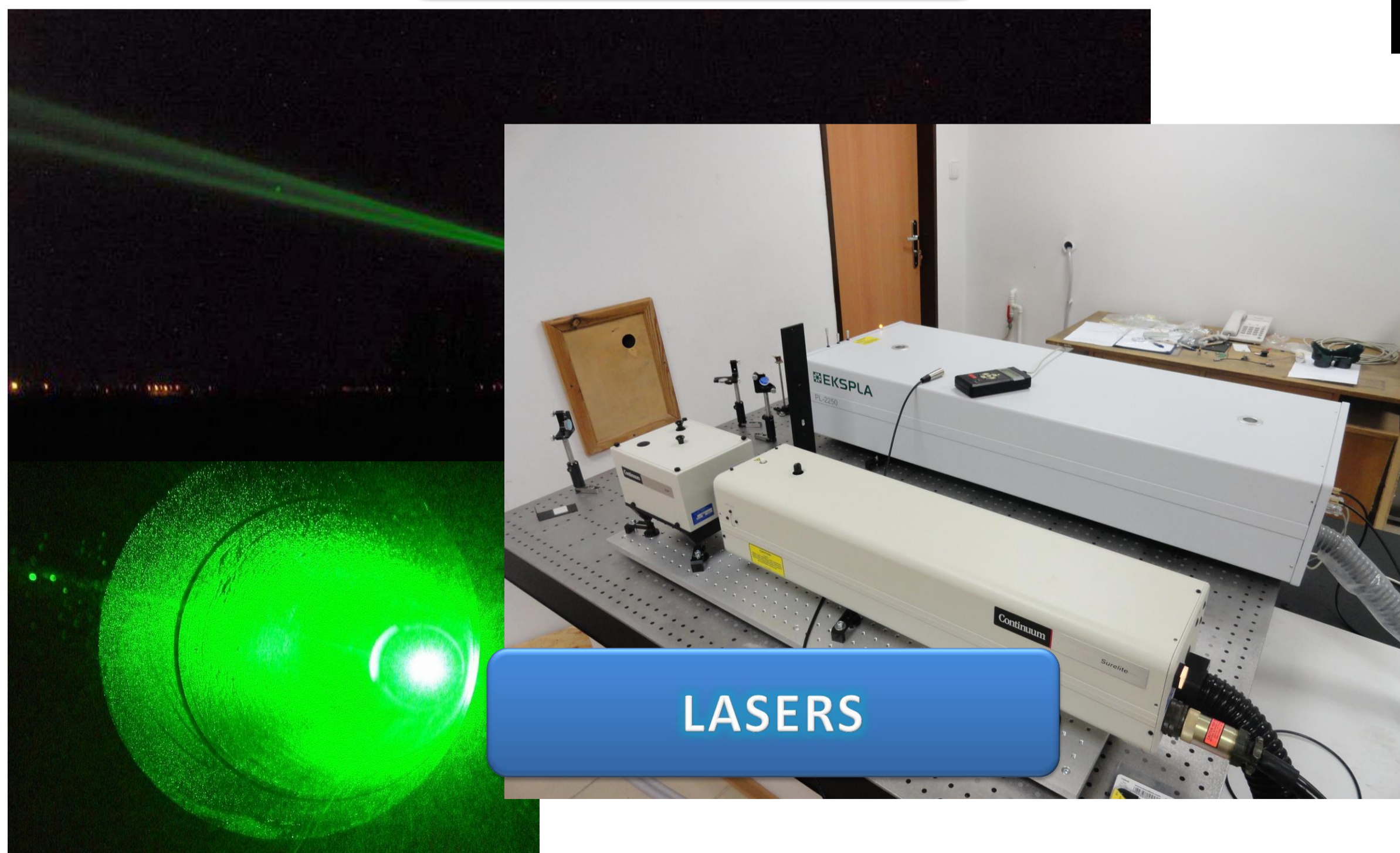
SRC Borowiec SLR



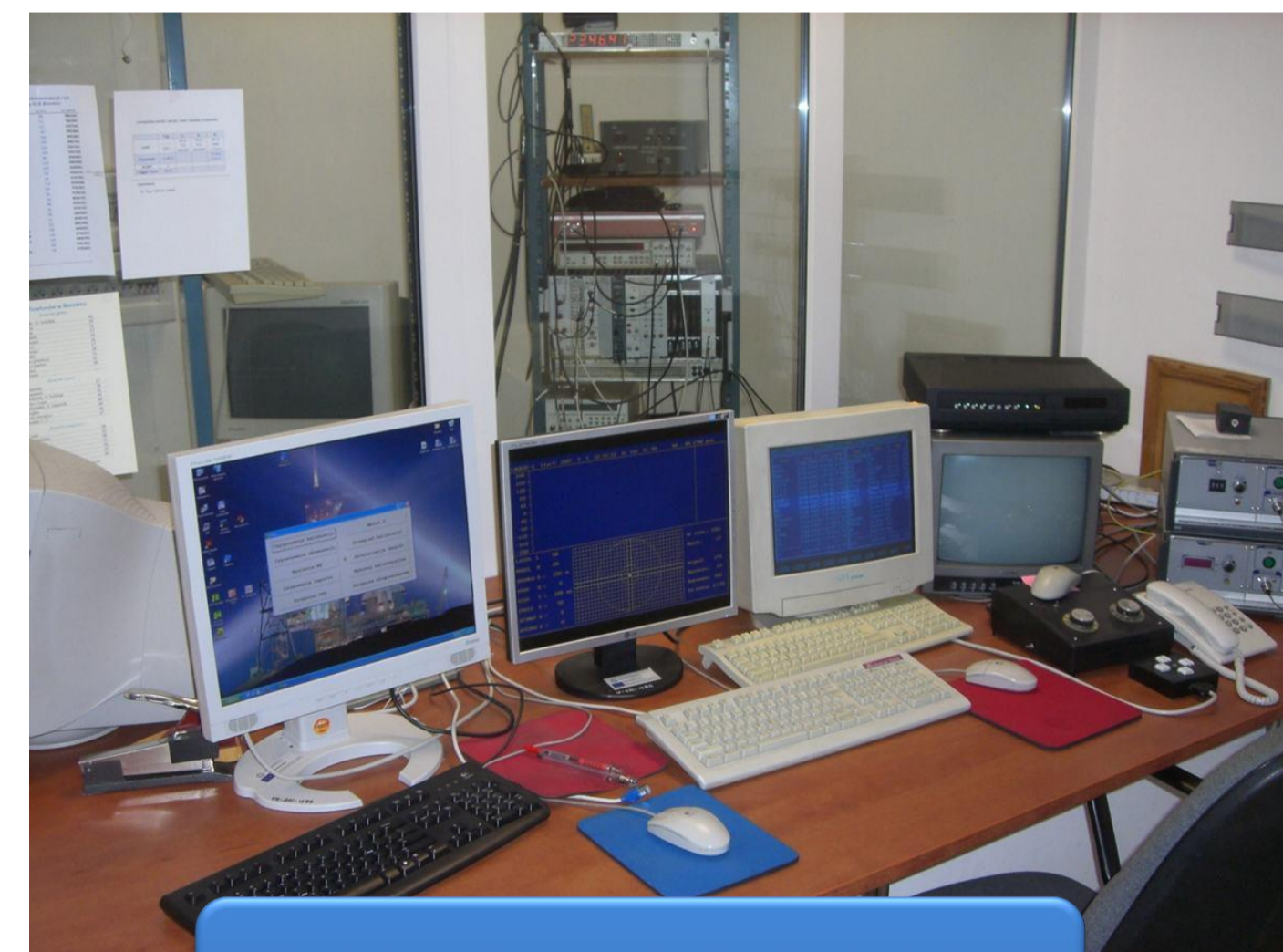
BUILDING



TELESCOPE



LASERS



OPERATOR ROOM

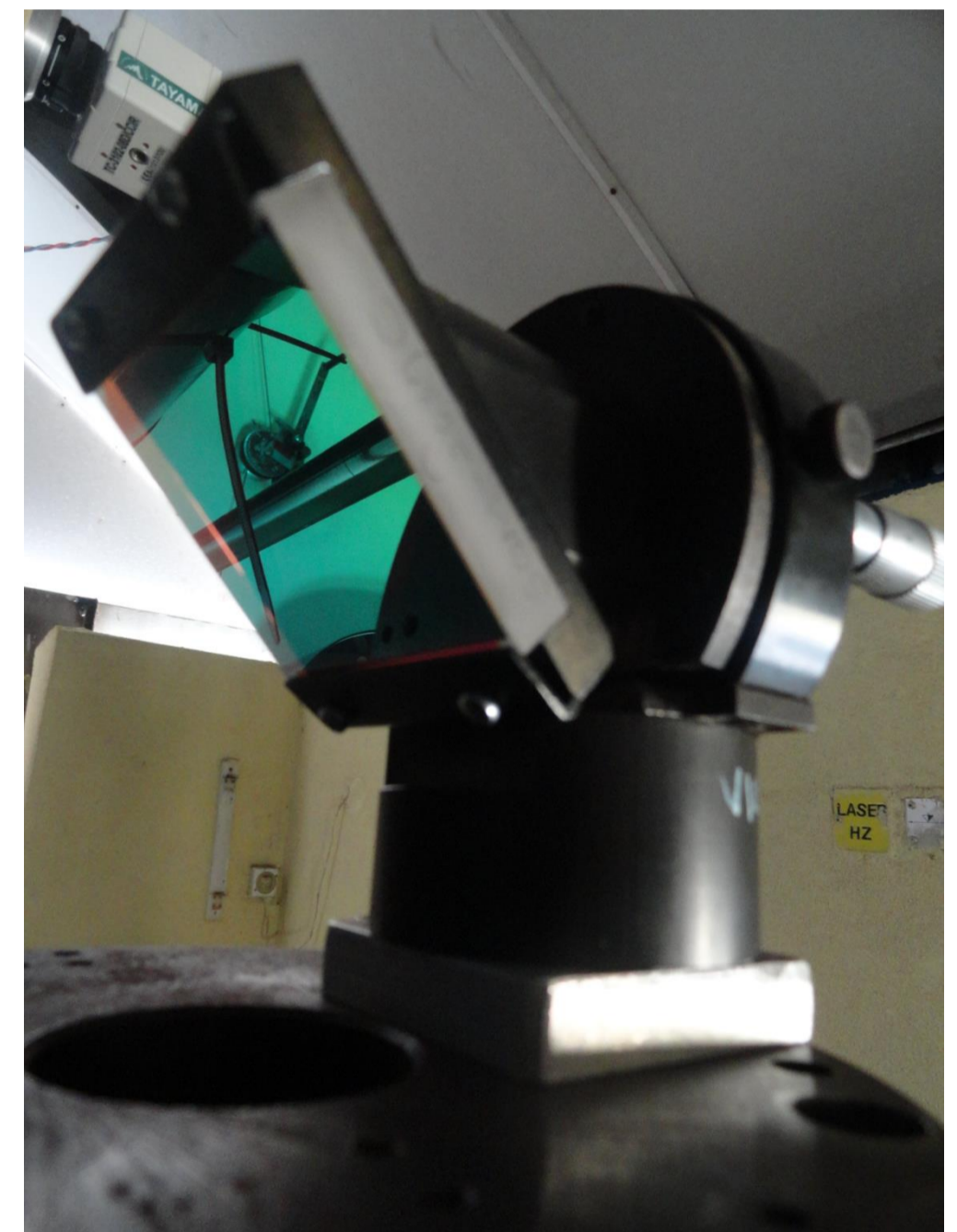
Laser station modernization

Optics exchange

Primary and secondary mirrors



dielectric mirrors coude path



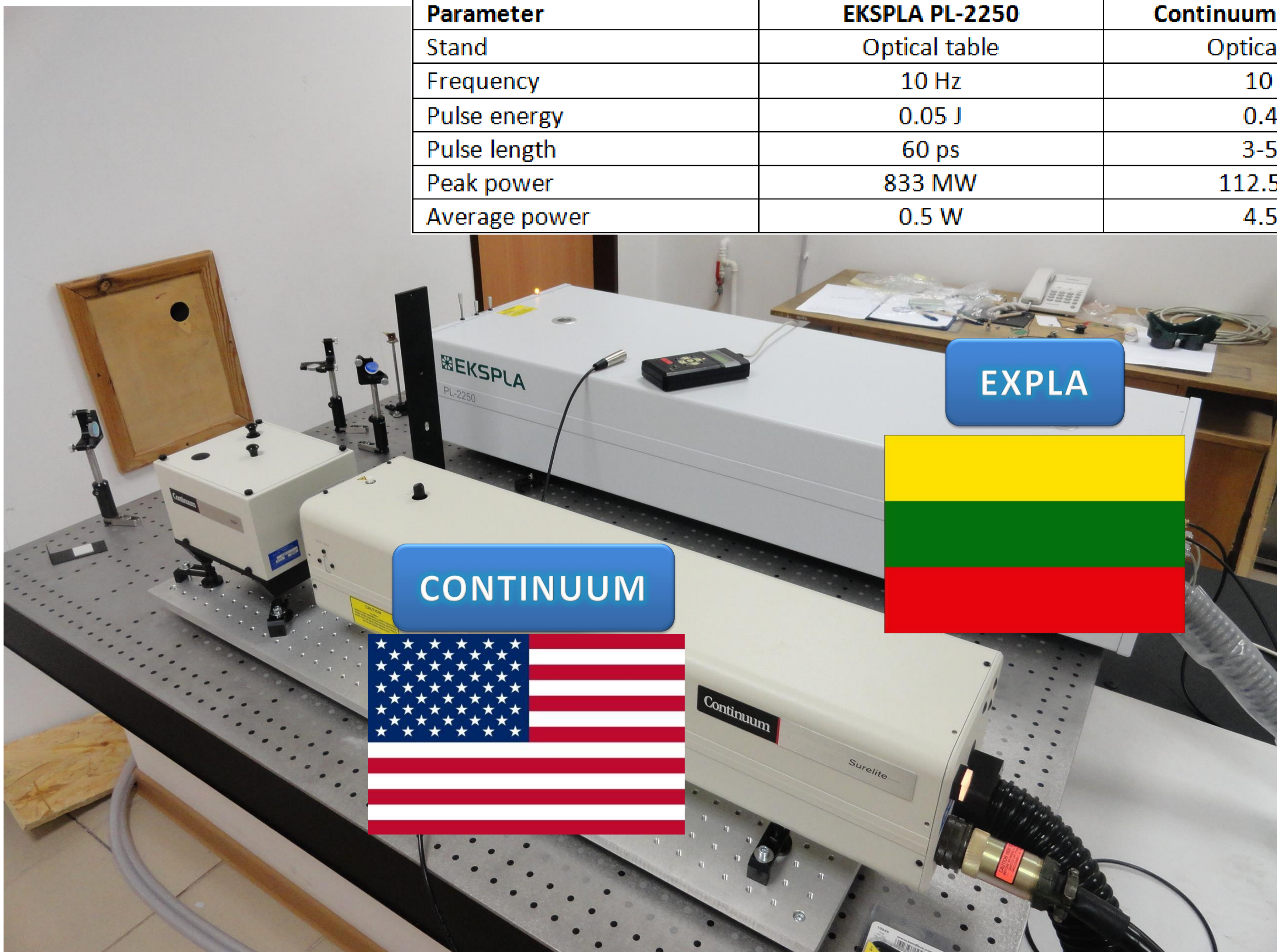
Telescope mount



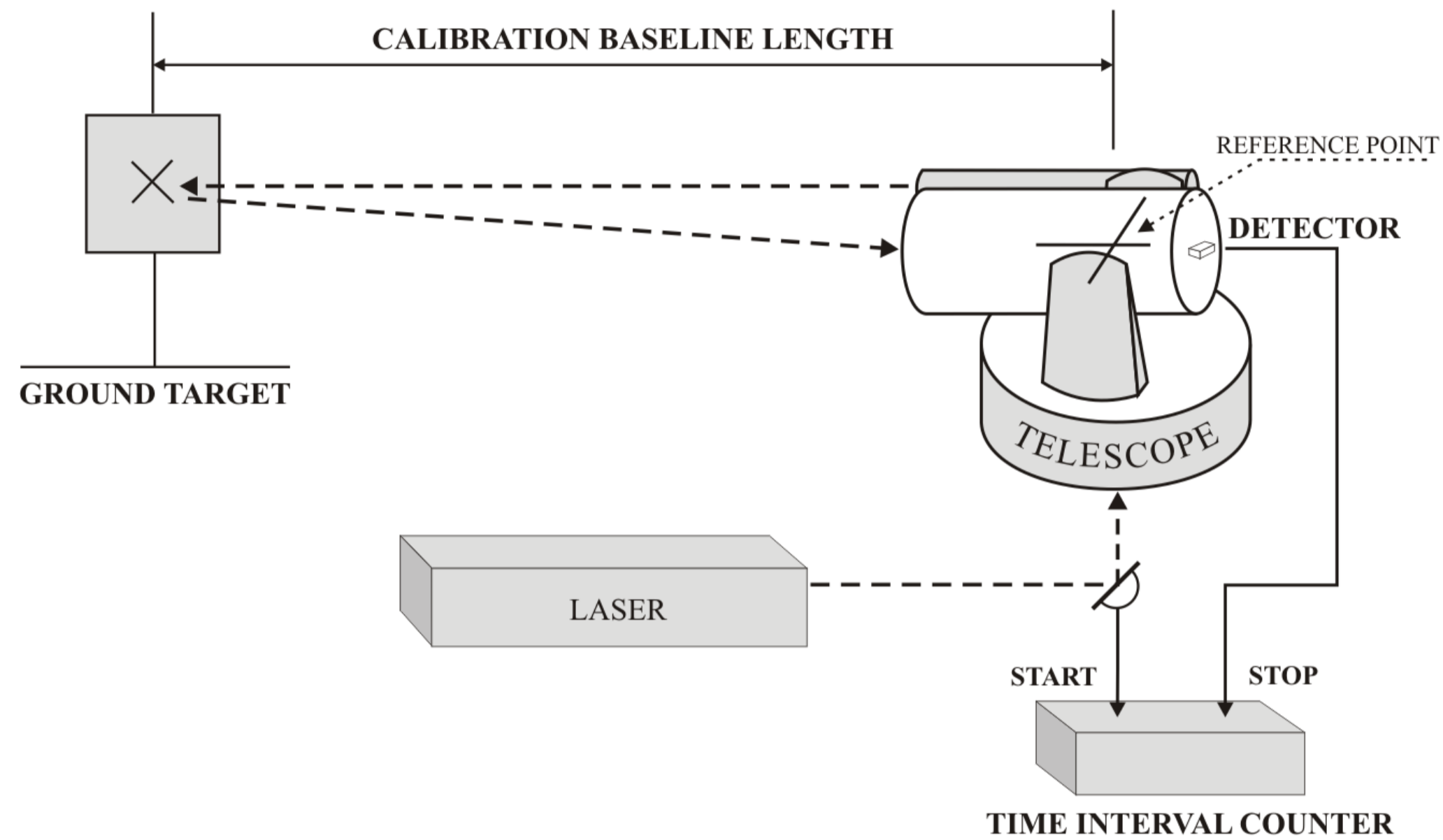
Mount	Azimuth – Elevation
Tracking	Step by step
Encoder resolution	1.8 arsec
Receiver	Cassegrain system
Diameter of the main mirror	65 cm
Diameter of the secondary mirror	20 cm
FOV	5 arcmin
Guide telescope	Maksutov system
Tracking	Visual (CCD camera)
Diameter of the mirror	20 cm
FOV	1°

New laser modules

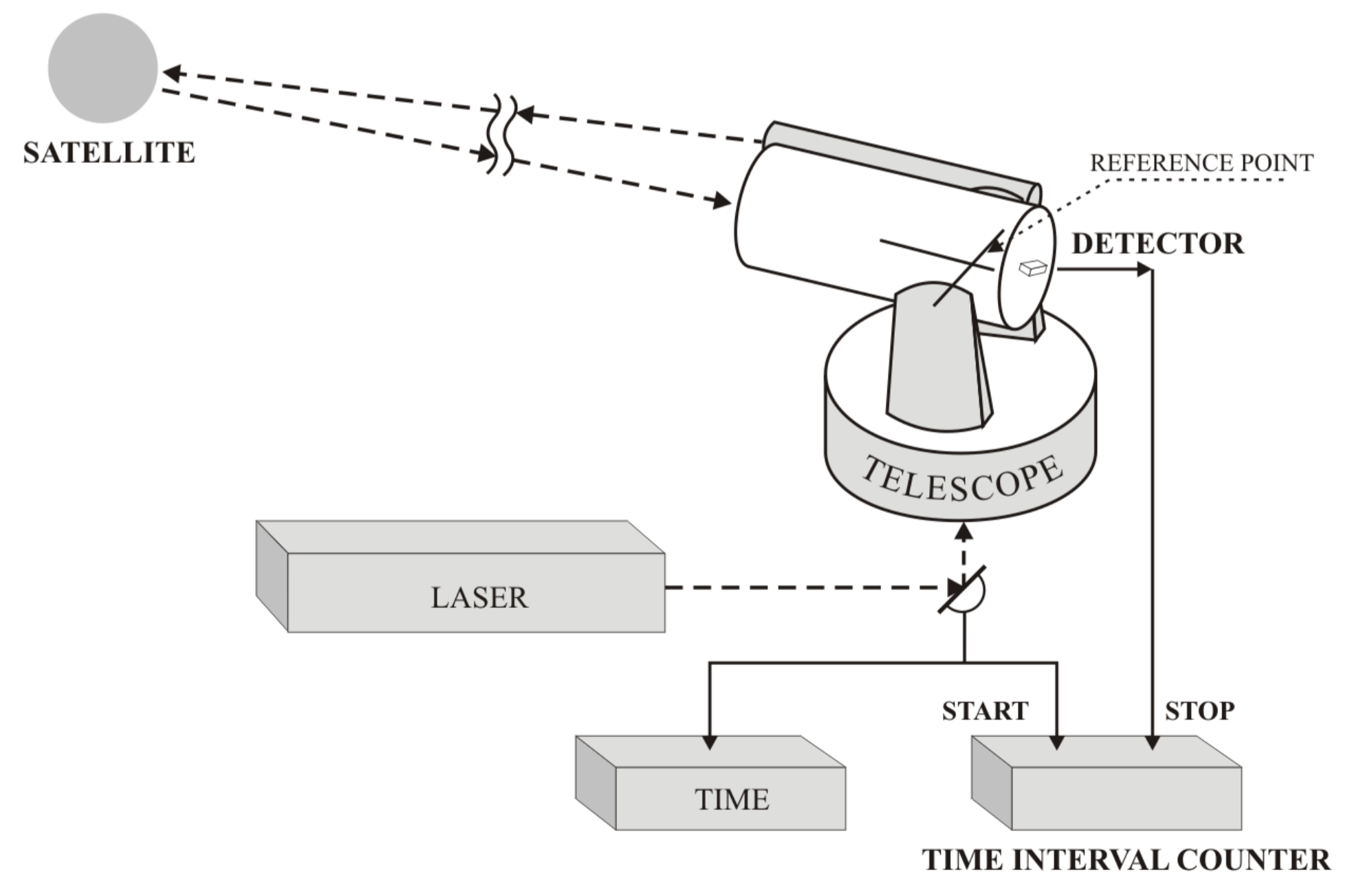
Parameter	EKSPLA PL-2250	Continuum Surelite III
Stand	Optical table	Optical table
Frequency	10 Hz	10 Hz
Pulse energy	0.05 J	0.45 J
Pulse length	60 ps	3-5 ns
Peak power	833 MW	112.5 MW
Average power	0.5 W	4.5 W



SRC Borowiec SLR

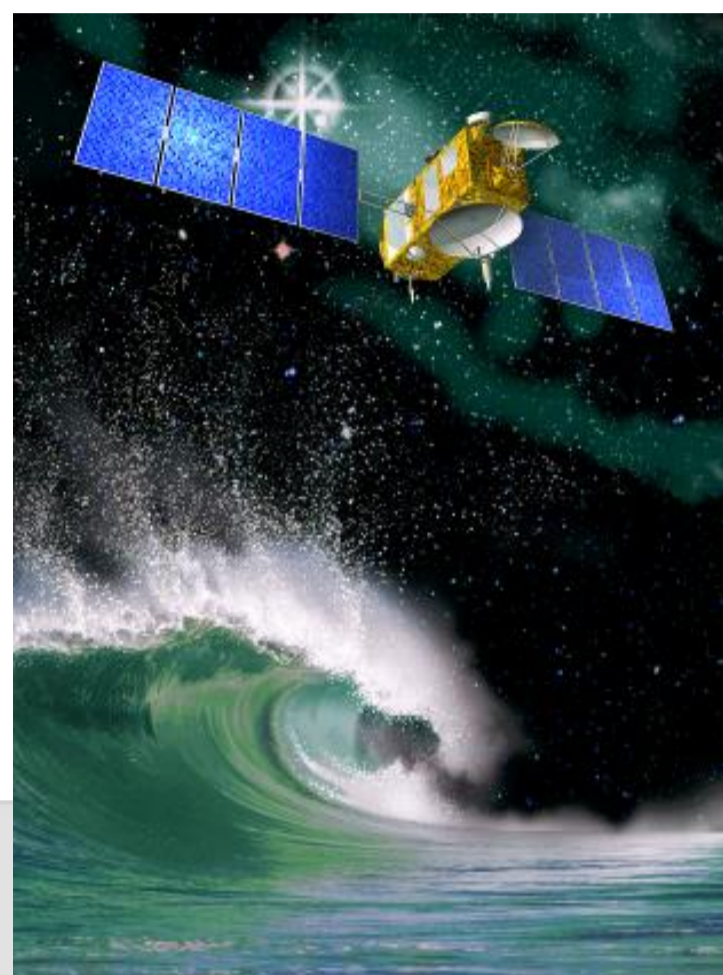


CALIBRATION MODE



OPERATION MODE

Time axis – last 2 years



2014
Station modernization

March 2, 2015
First returns from JASON-2

May 6, 2015
First good pass of CRYOSAT-2

July 10, 2015
START the quarantine
First good pass of LAGEOS2

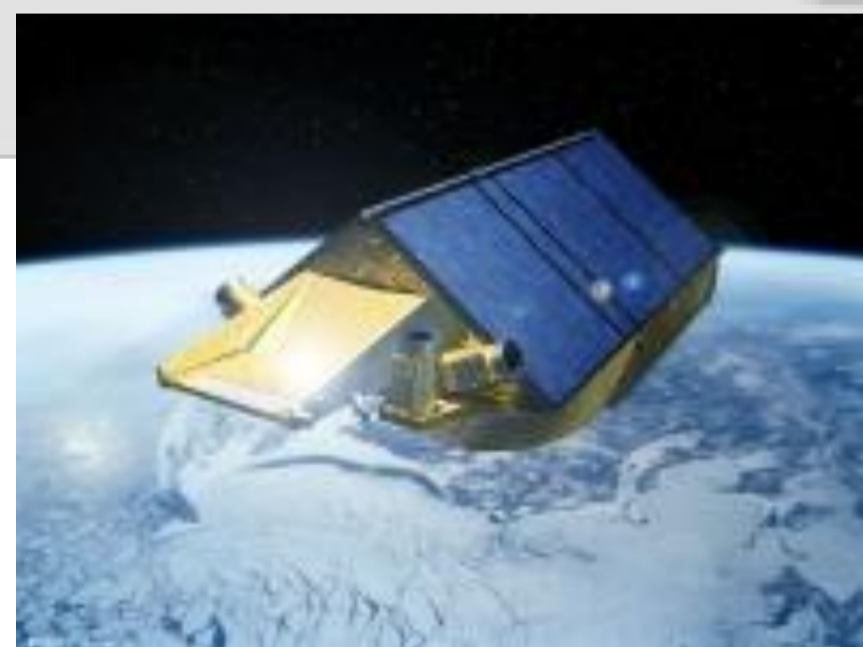
December 31, 2015
Quarantine status
6 passes of LAGEOS1
41 passes of LAGEOS2
47 passes of LARES

August 2016
Laser observations of space debris
Laser observations of GNSS satellites

NEAR FUTURE
Second laser system
Timing experiments (T2L2 and ACES/ELT)
Laser observations at day

Stacja laserowa BOROWIEC

BUDYNEK
TELESKOP
LASERY
POKÓJ OPERATORA



Quarantine – April 26, 2016

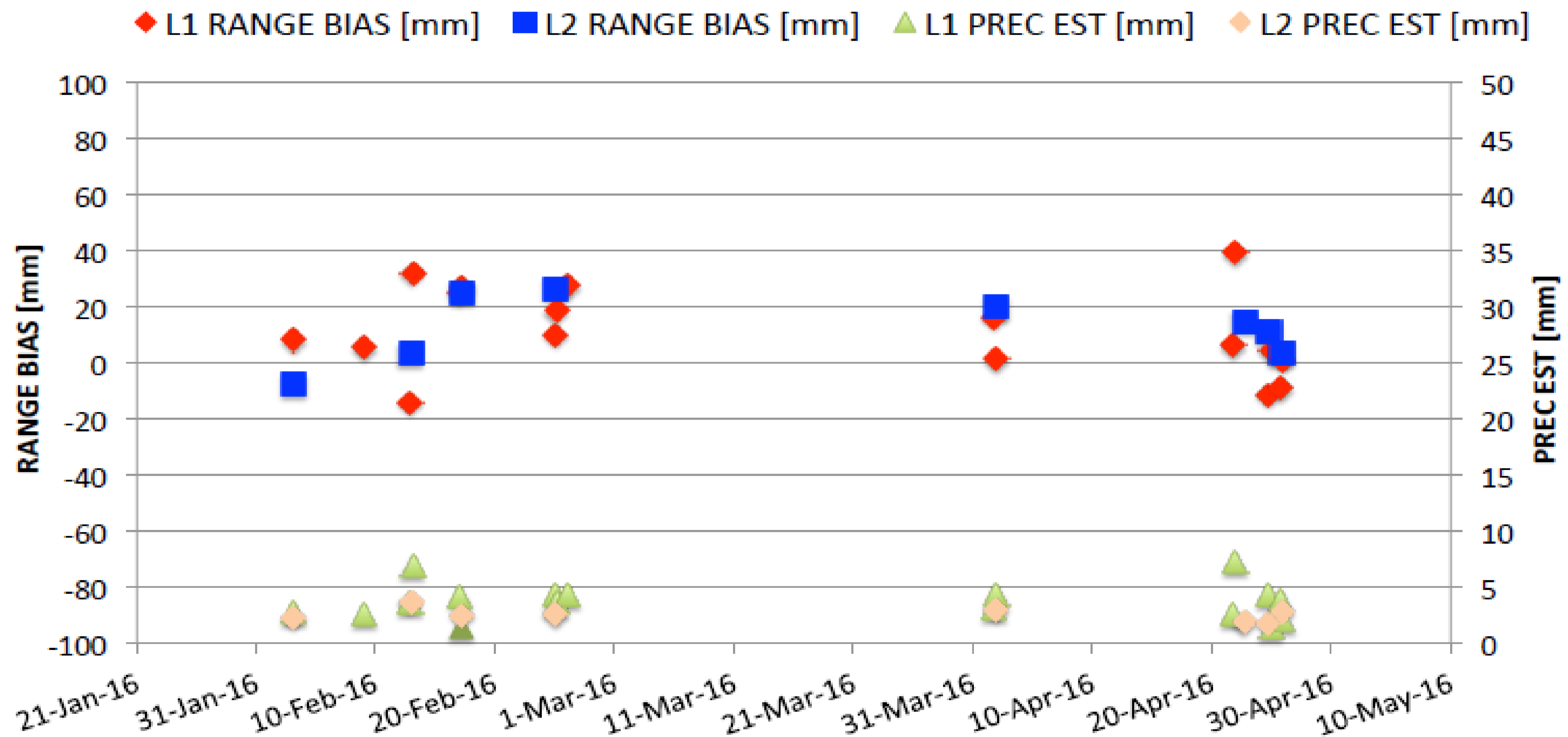
LAGEOS 1

&

LAGEOS 2

L1 78113802	PREC EST [mm]	RANGE BIAS [mm]
Mean	3.7	11.0
STD	1.6	15.6
RMS	4.0	18.7
Point	17	17

L2 78113802	PREC EST [mm]	RANGE BIAS [mm]
Mean	2.6	12.0
STD	0.6	11.9
RMS	2.6	16.3
Point	8	8



ILRS bias report – October 7, 2016

ILRS Combined Range Bias Report 1

2016-09-27 00:00 UT - 2016-10-07 00:00 UT

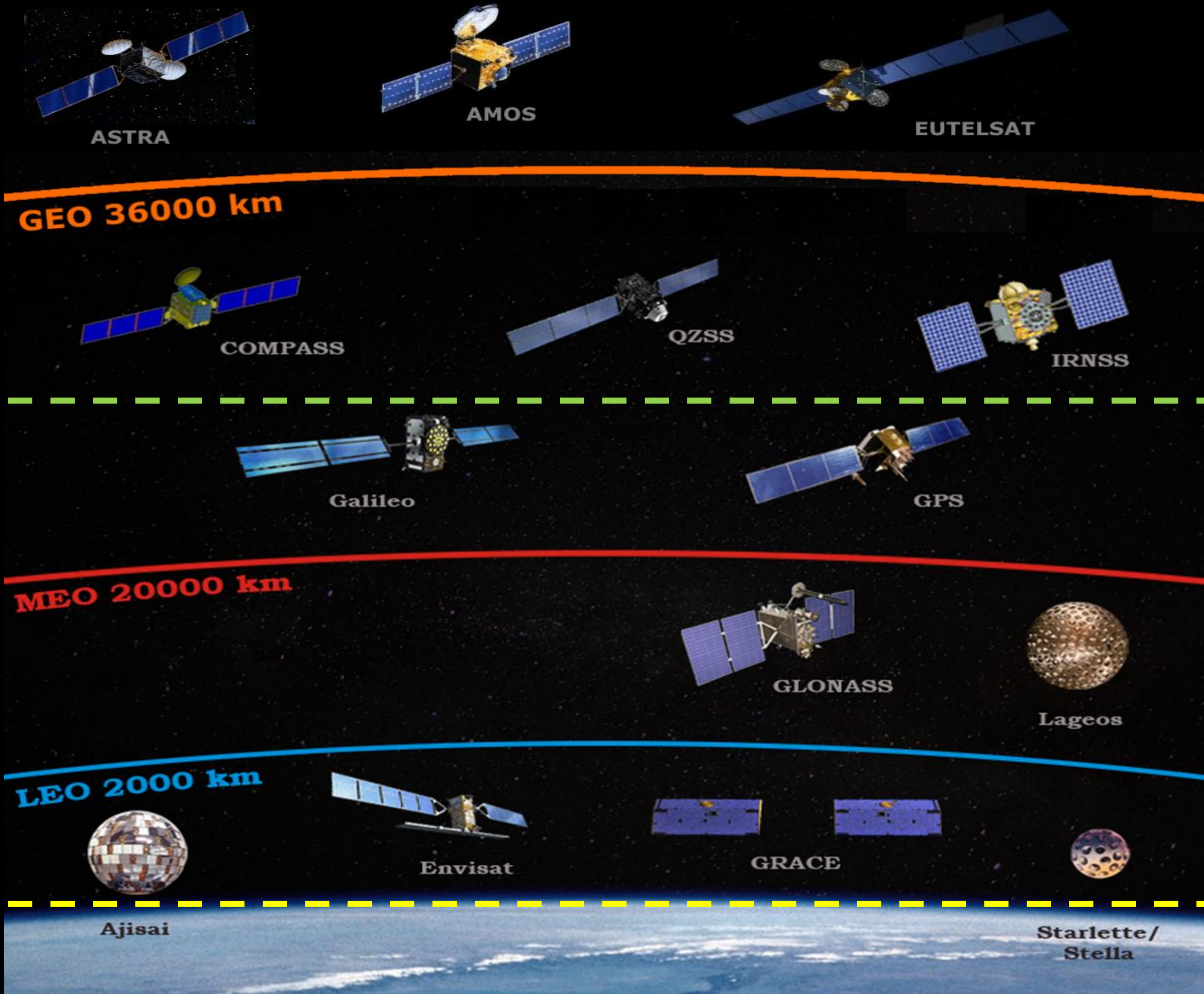
Compiled by: SLR Observatory Zimmerwald

Date : 2016-10-07 12:30 UT

E-Mail : martin.ploner@aiub.unibe.ch

7811 BORL Borowiec				DGFI		MCC		HIT-U		SAO		JCET	
	sat	wl		rb	pr	rb	pr	rb	pr	rb	pr	rb	pr
7811	2016-09-27	00:13	LAG1	532	-7	5	-1	5	-4	4		-1	5
7811	2016-09-27	01:20	LAG2	532	4	3	8	3	6	3		4	3
7811	2016-09-27	19:36	LAG1	532	14	4	5	4	-2	4		8	4
7811	2016-09-27	22:51	LAG1	532	-6	4	-8	4	-10	3		-4	4
7811	2016-09-27	23:27	LAG2	532	-5	5	-1	4	-1	4		6	4
7811	2016-09-29	23:36	LAG2	532	0	6	1	6	-8	5		7	6
7811	2016-09-29	23:53	LAG1	532	-15	4	-10	4	-7	3			
7811	2016-09-29	23:54	LAG1	0								*	*
7811	2016-10-04	20:31	LAG1	532	2	8	1	3	-3	7		23	7
7811	2016-10-04	22:16	LAG2	532	9	4	6	4	-10	4		-8	4
7811 Average				532	0	4	0	4	-4	4		4	4

Tracking capabilities



25 000 km

350 km

Borowiec results available at

http://www.cbk.poznan.pl/stacja_laserowa/lista_observacji_2016.php



CENTRUM BADAŃ KOSMICZNYCH PAN
OBSERWATORIUM ASTROGEODYNAMICZNE
Borowiec ul. Drapalka 4 62-035 Kórnik

$\varphi = 52^{\circ} 16' 37.2'' N$ $\lambda = 17^{\circ} 04' 28.56'' E$ $h = 123.4$ m
SERWER CZASU: vega.cbk.poznan.pl
9 Października 2016 r. 15:35:37 CEST



MENU GŁÓWNE
SŁUŻBA CZASU
STACJA IGS
STACJA LASEROWA
CENNIK

Stacja laserowa

Informacje ogólne

Charakterystyka systemu

Modernizacje stacji

ILRS Site Form

Results of grant N N526 231839

Lista obserwacji w 2016 roku

58316	2016-10-07 00:42	LAGEOS-1	58216	2016-10-06 23:17	GALILEO206
58116	2016-10-06 23:52	GLONASS-123	58016	2016-10-04 23:16	GLONASS-134
57916	2016-10-04 22:38	GLONASS-129	57816	2016-10-04 22:11	LAGEOS-2
57716	2016-10-04 21:47	AJISAI	57616	2016-10-04 21:29	SENTINEL3A

OBSERVATION 8316

ENVISAT

PASS DETAILS

DATA: 2016-04-19
MJD: 57497
GODZINA: 19:36
CZAS PRZELOTU: 5m12s
WYSOKOŚĆ: 27°:64°:30°
ODLEGŁOŚĆ: 1439:846:1354 km

WARUNKI METEO PRZED

TEMPERATURA: 6.9 °C
CIŚNIENIE: 1008.3 mbar
WILGOTNOŚĆ: 96 %
POGODA: GOOD+M0

KALIBRACJA PRZED

GODZINA: 19:34
STRZAŁY/ODBICIA: 379 / 285 / 75%
ŚREDNIA: 1547.506 ns
ODCHYLENIE: 0.074 ns / 1.10 cm
POPRAWKA: -61.323 ns

RESULTS

STRZAŁY/ODBICIA: 3760 / 476 / 12%
TIME BIAS: 0.21 msec
RANGE BIAS: -6.00 m
O-C (MIN-MAX): -8--3 m
RMS: 2.34 cm
PUNKTY NORMALNE: 17

WARUNKI METEO PO

TEMPERATURA: 7.5 °C
CIŚNIENIE: 1008.4 mbar
WILGOTNOŚĆ: 89 %
POGODA: GOOD+M0

KALIBRACJA PO

GODZINA: 19:56
STRZAŁY/ODBICIA: 393 / 268 / 68%
ŚREDNIA: 1547.511 ns
ODCHYLENIE: 0.070 ns / 1.05 cm
POPRAWKA: -61.317 ns



znau.pl/stacja_laserowa/obserwacje/L1668025.php

Safety and protection – SENTINEL-3A



March 30, 2016

SLR STATION AGREEMENT FOR LASER RANGING TO SENTINEL-3A

ILRS Governing Board Members:

Giuseppe Bianco, Italy,
Chairman
Wu Bin, Peoples Republic of China
Geoffrey Blewitt, USA
President IAG Commission I
Georg Kirchner, Austria
Vincenza Luceri, Italy
David McCormick, USA
Jon McGarry, USA
Horst Mueller, Germany
Juergen Mueller, Germany
Carey Noll, USA
Secretary, ILRS Central Bureau
Toshimichi Otsubo, Japan
Erricos Pavlis, USA
Michael Pearlman, USA
Director, ILRS Central Bureau
Ulrich Schreiber, Germany
Daniela Thaller, Germany
ILRS Representative
Matt Wilkinson, Great Britain

Station: **Borowiec, Poland**
Station No./Code: **7811/BORL**

We agree to support the SLR tracking of the Sentinel-3A. We understand that the campaign will start shortly and that the mission will provide predictions in a secure manner to be identified by the ILRS Central Bureau.

We understand that the mission payload is optically vulnerable and that the operating parameters of our station should be:

Wavelength (nm): **532**
Pulse Repetition Rate (Hz): **10**
Ranging System Output energy (mJ): **50 mJ**
Beam Divergence (arcsec FWHM): **30**

We agree that our station will operate with these parameters; we will cease tracking and inform the ILRS Central Bureau immediately if the following happens:

1. Output energy exceeds that above value;
2. Beam divergence is less than the above value;
3. Laser output wavelength or pulse repetition is changed

Since stations are approved individually, we agree not to share the predictions with anyone other than those who need them for the operation of the **Borowiec, Poland** station.

Signed: *Stanislaw*
Printed Name: prof. dr hab. Iwona Stanislawka
Position: Director
Organization: Space Research Centre of the Polish Academy of Sciences

This signed agreement should be returned to the ILRS Central Bureau c/o Carey Noll (carey.noll@nasa.gov).

Thank you for your support,

Dr. Michael R. Pearlman
Director, ILRS Central Bureau
Harvard-Smithsonian Center for Astrophysics
Cambridge MA 02138
USA

Central Bureau
International Laser Ranging Service
NASA Goddard Space Flight Center
Code 690
Greenbelt, MD 20771
USA

Tel: 301-614-6542
Fax: 301-614-6015
Internet: ilrs-cb@lists.nasa.gov
<http://ilrs.gsfc.nasa.gov>

SENTINEL-3A
Current passes
(October 4, 2016):
Number of passes: 44
Single shots (accepted): 38549
AVG RMS: 2.64 cm

Space Debris Study Group (SDSG)

ILRS
International Laser Ranging Service
A service of the International Association of Geodesy

Search
IAG | GGOS

About ILRS | Network | Missions | Science | Data & Products | Technology

Network
Home » Network » Networks and Engineering Working Group » Space Debris Study Group

List of Stations
Site Information
Site Procedures
System Performance
Network and Engineering Working Group
Space Debris Study Group

Quick Links

- Network Map
- List of Stations
- Monthly Report Card
- Quarterly Report Card
- Network Status Page
- Procedure for estimating laser beam divergence
- Recent Station Upgrades

ILRS Space Debris Study Group (SDSG) Members

ILRS email exploder: ilrs-sdsg@lists.nasa.gov
Member listing: [ilrdsdsg_userlist.txt](#)
Exploder message archive: <https://lists.nasa.gov/pipermail/ilrs-sdsg/>

Chairman: Georg Kirchner
Co-Chairman: Ludwig Grunwaldt

James Bennett/Space Environment Research Centre
Dr. Giuseppe Bianco/Agencia Spaziale Italiana (ASI)
Mark Blundell/Electro Optic Systems Pty Limited
Tommaso Cardona/Sapienza/Universita di Roma
Dr. Manuel Catalan/Instituto y Observatorio de Marina
Eunjung Choi/KASI
Luis M. Cortina/Real Instituto y Observatorio Armada
Jose Martin Davila/Real Instituto y Observatorio Armada
Johann Eckl/BKG/Geodaetisches Observatorium Wettzell
Tim Flohrer/ESA/ESOC Space Debris Office
Dr. Ben A. Greene/Electro Optic Systems Pty Limited
Jake Griffiths/Naval Center for Space Technology
Dr. Ludwig Grunwaldt/Helmholtz Centre Potsdam/GFZ
Xingwei Han/Jing Yue Tan Xi Shan
Gunther Harold/BKG/Geodaetisches Observatorium Wettzell
Dr. Makram Ibrahim/NRIAG
Young-Rok Kim/KASI
Dr. Georg Kirchner/Space Res. Inst., Austrian Acad. of Sci.
Andre Kloth/DIGOS Potsdam GmbH
Franz Koidl/Space Res. Inst., Austrian Acad. of Sci.
Daniel Kucharski/KASI
Pawel Lejba/Space Research Centre of PAS
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Hyung-Chul Lim/KASI
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Dr. Chris Moore/Electro Optic Systems Pty Ltd
Jyri Naranan/Finnish Geospatial Research Institute
Giuseppe Nicoletti/e-GEOS S.p.A
Dr. Natalia Parkhomenko/SRI for Precision Instrument Engineering
Fabrizio Piergentili/Sapienza/Universita di Roma
Jonathan Poenpol/Electro Optic Systems Pty Limited
Feng Qu/Beijing Station
Manuel Quijano/Real Ins. y Observatorio de la Armada
Arttu Raja-Halli/Finnish Geospatial Research Institute
Wolfgang Riede/DLR
Stefan Riepl/BKG/Geodaetisches Observatorium Wettzell
Kalvis Salmish/Institute of Astronomy, Univ. of Latvia
Prof. Thomas Schildknecht/Astronomical Institute, Univ. of Bern
Dr. Stanislaw Schillak/Space Research Centre of PAS
Dr. Ulrich Schreiber/BKG/Geodaetisches Observatorium Wettzell
Jens Steinborn/DIGOS Potsdam GmbH
Linda Thomas/NRL, Code 8123
Anatoliy Vid'machenko/Main Astronomical Observatory of the NAS
Felyuan Wang/Inst. of Seismology, CEA
Matthew Wilkinson/NERC Space Geodesy Facility
Zhongping Zhang/Shanghai Data Center

Updated: 11-Dec-2015 23:00:04

NASA Official: Carey Noll
Web Curator: Lori J. Tyshis
Contact Us

Last modified date: Nov 12, 2014
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NASA
Goddard
SPACE FLIGHT CENTER

WORLD DATA SYSTEM
ICSU
IAG
GGOS

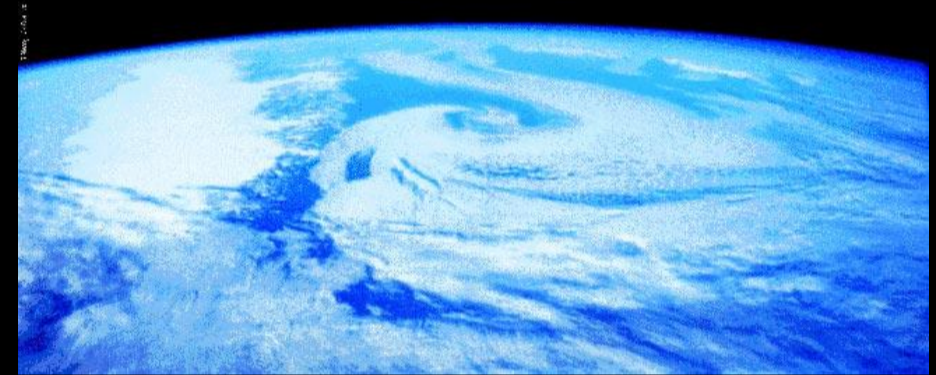
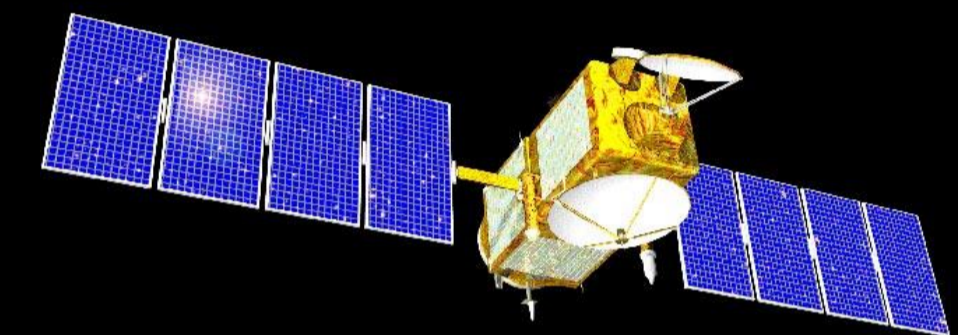
SRC Borowiec

Space Debris Tracking

Space debris – research, safety and protection



ENVISAT, 800 km

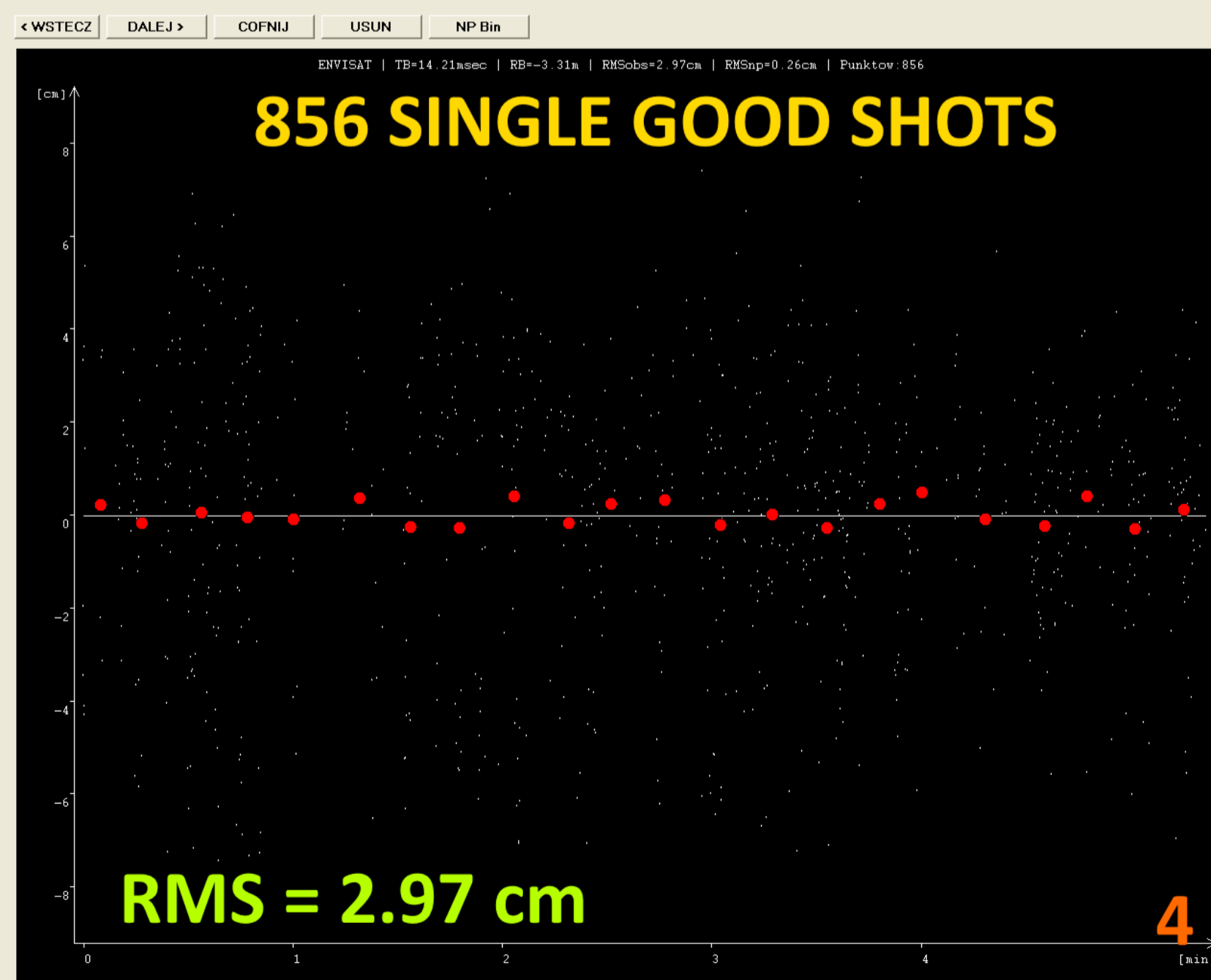
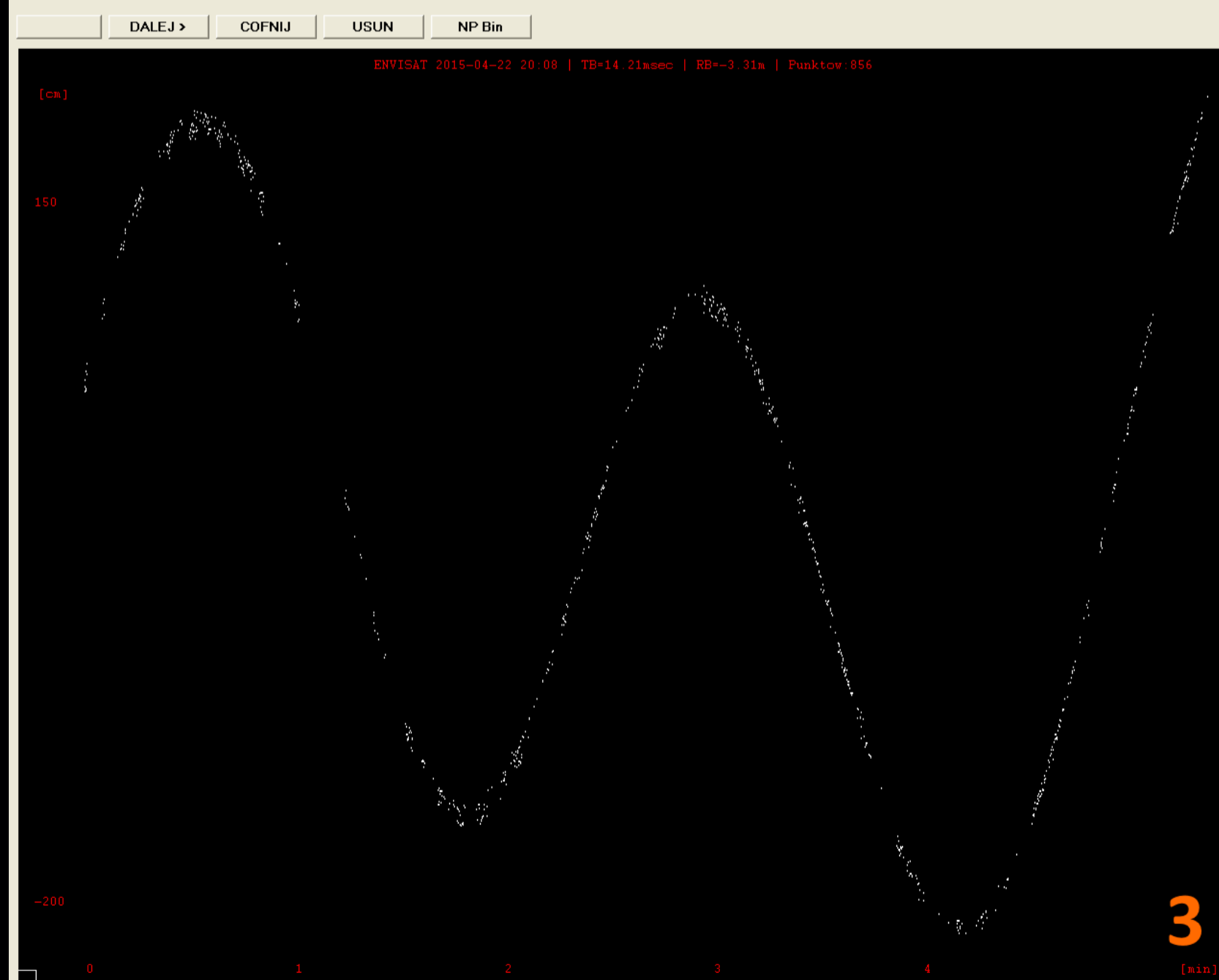
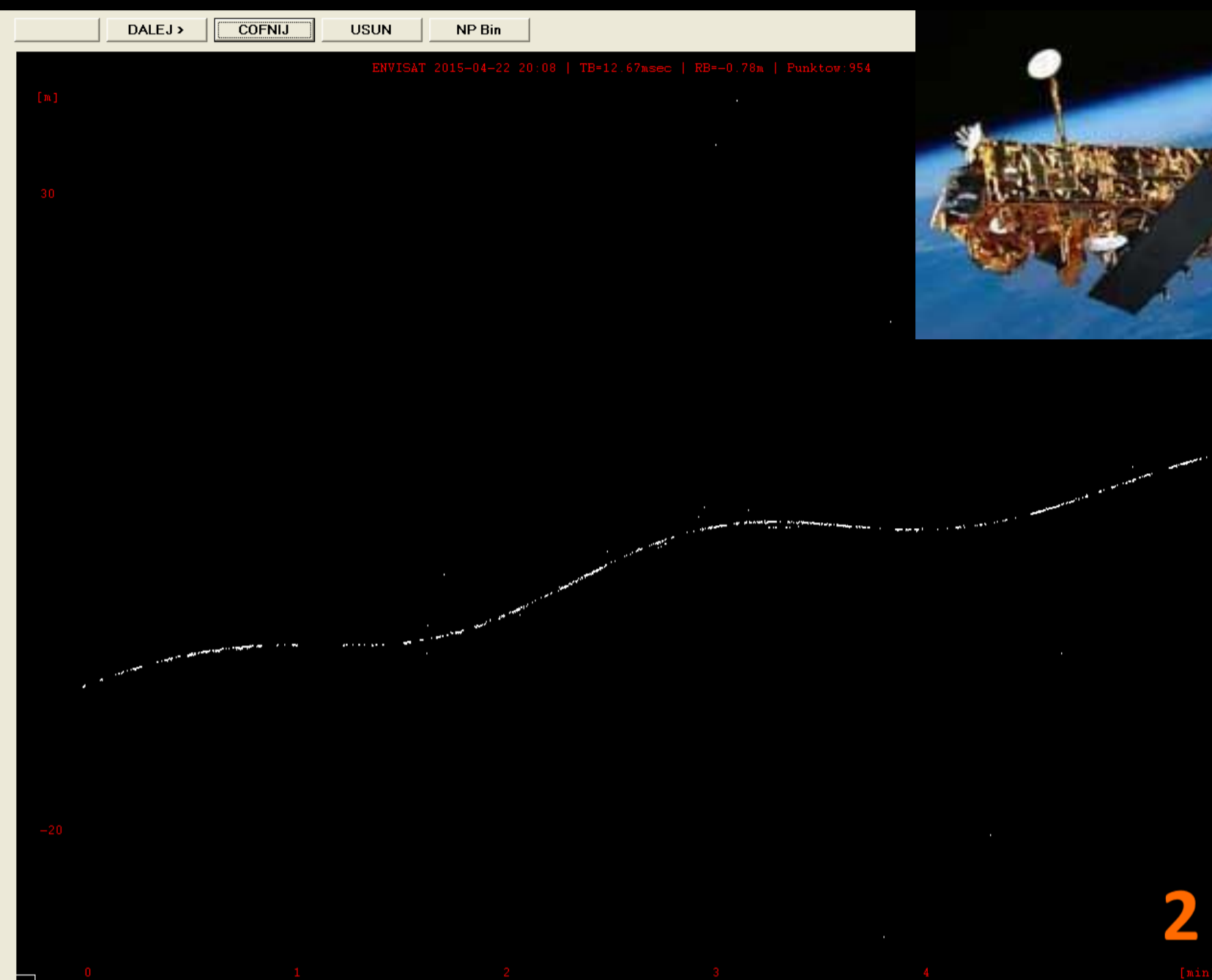


JASON-1, 1300 km

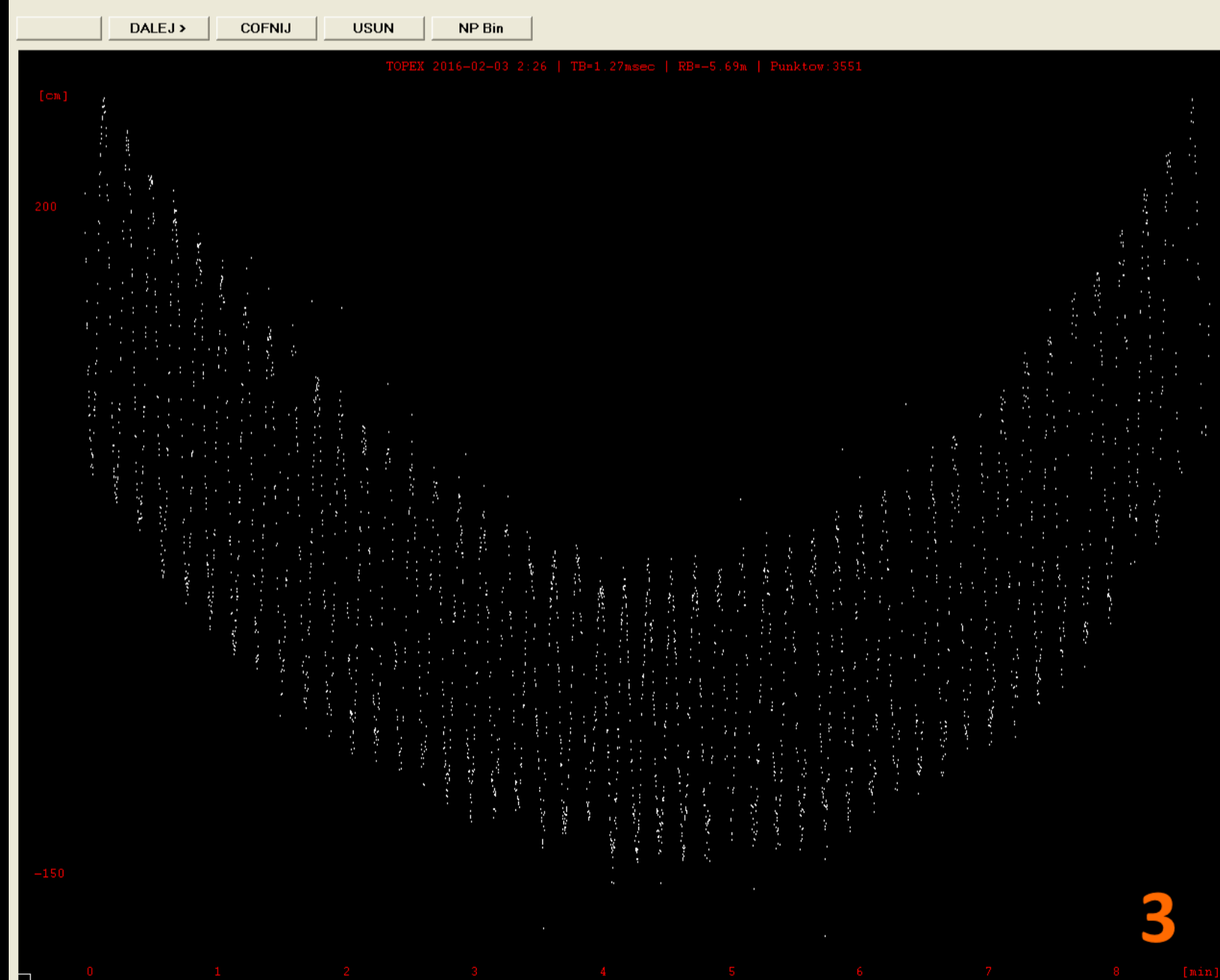
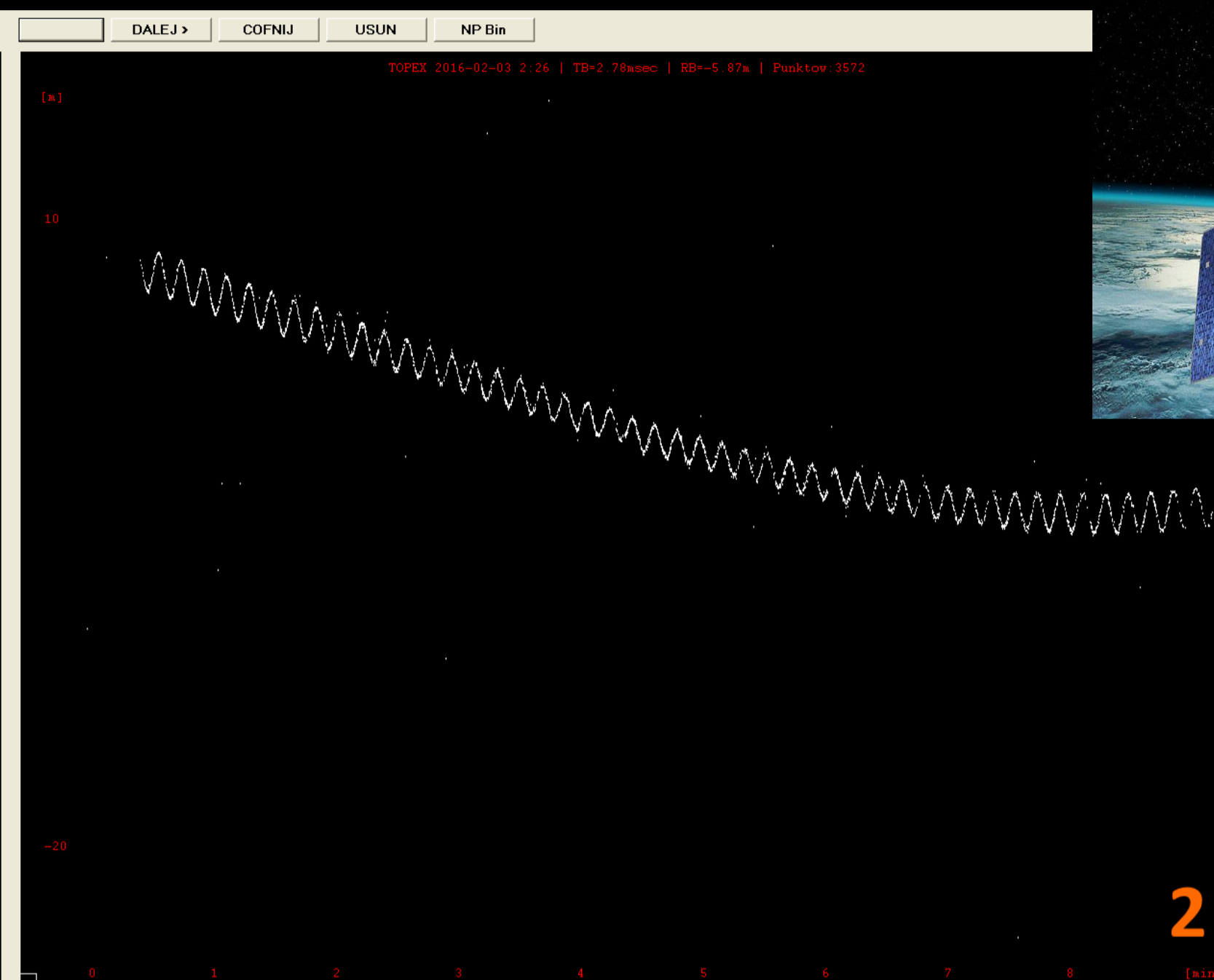
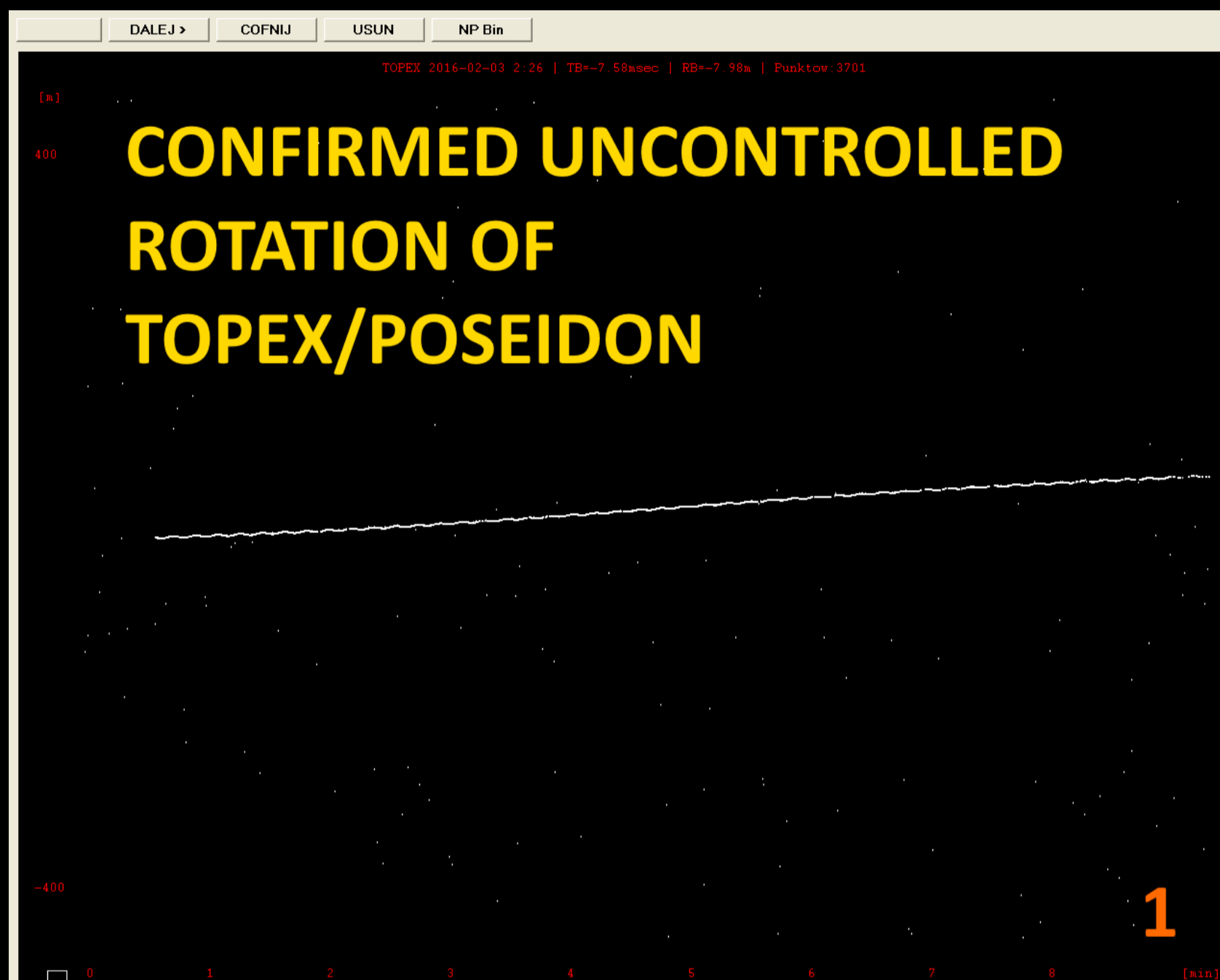


TOPEX/Poseidon, 1300 km

Space debris – ENVISAT



Space debris – TOPEX/POSEIDON



Space Debris Tracking

New Campaigns

SRC Borowiec space debris campaigns



ERS-2



ERS-1



OICETS

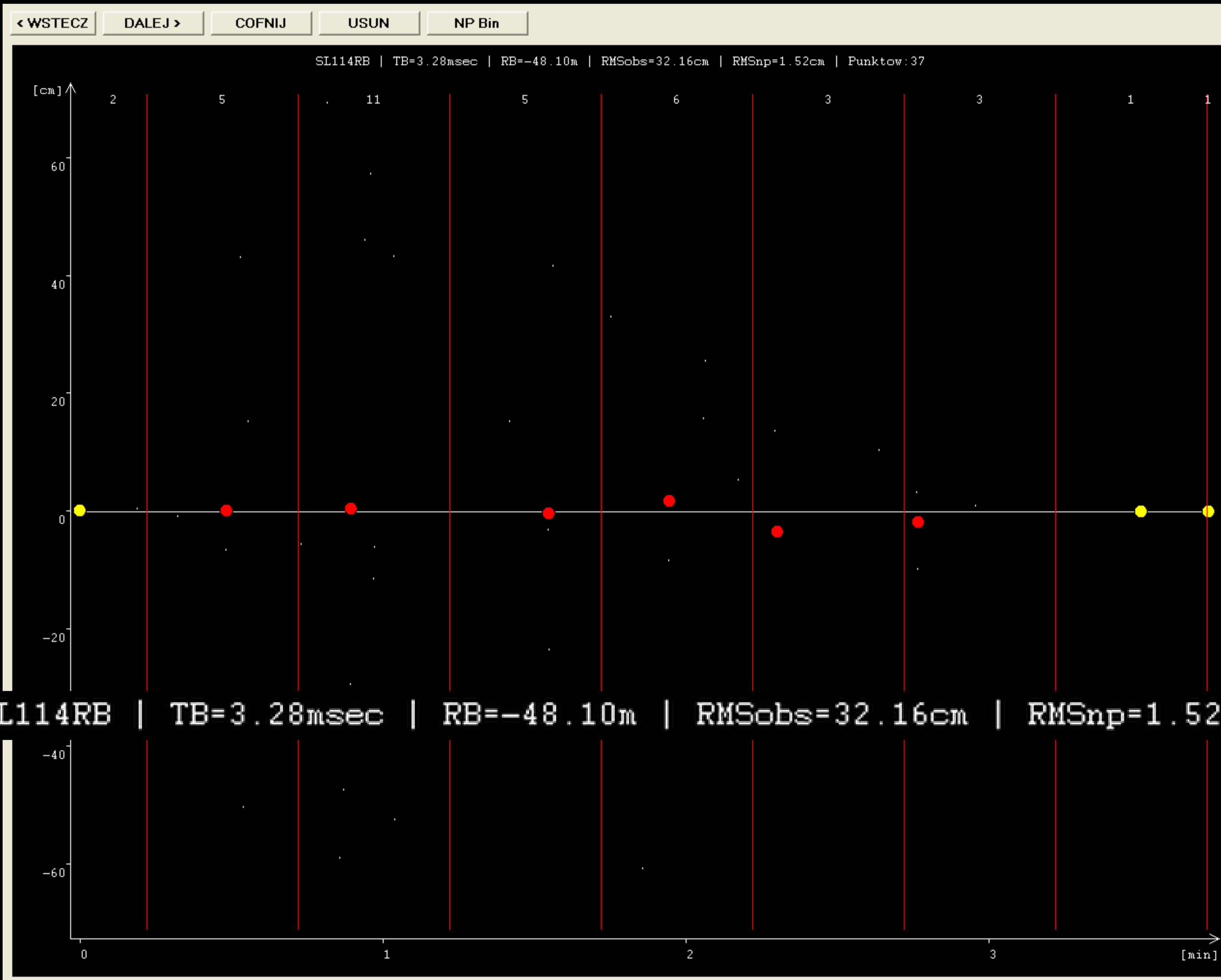


ADEOS-2

Space Debris Tracking (*rocket bodies*)

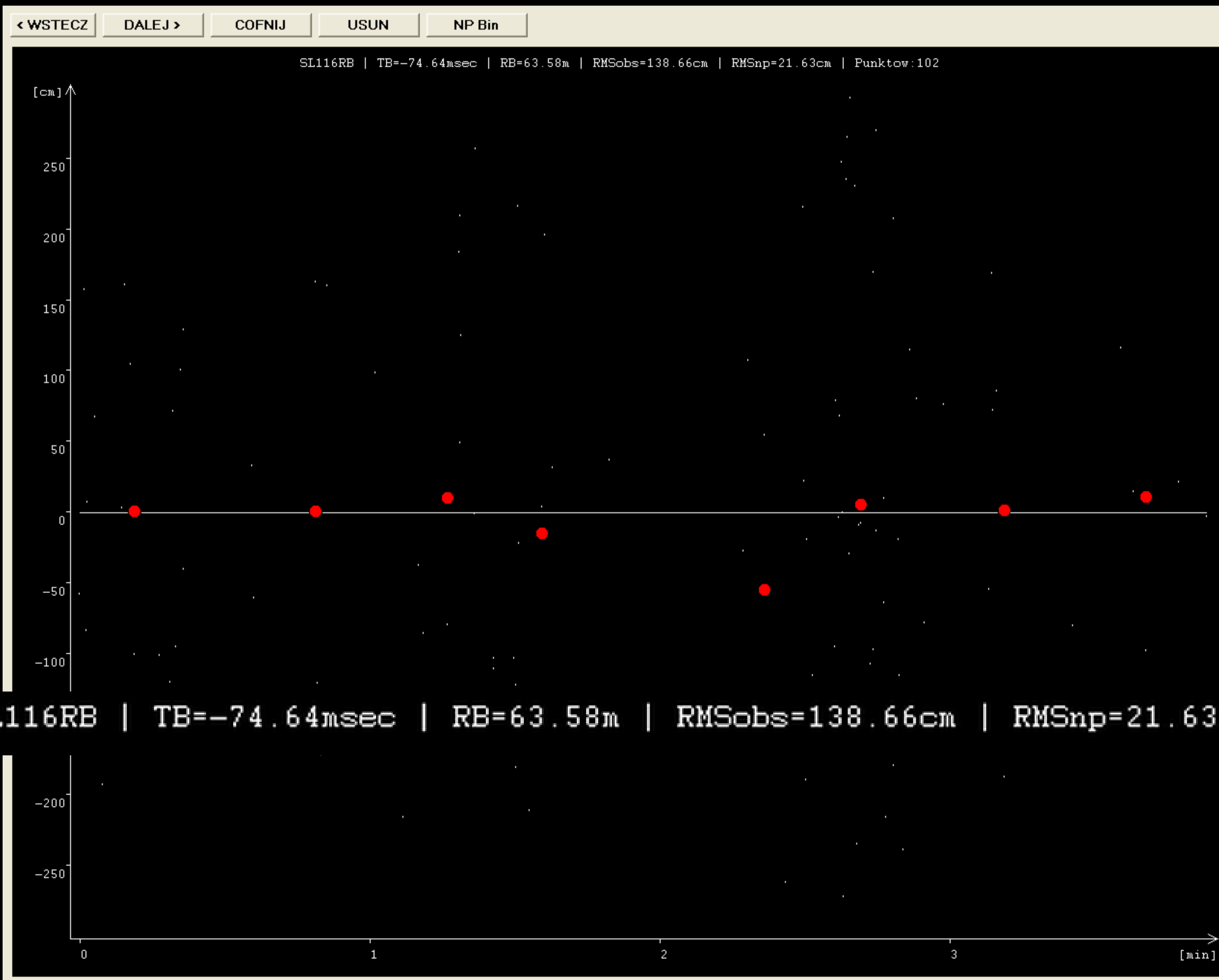
SL14RB (17912)

10.08.2016, 01:10:50



SL16RB (23088)

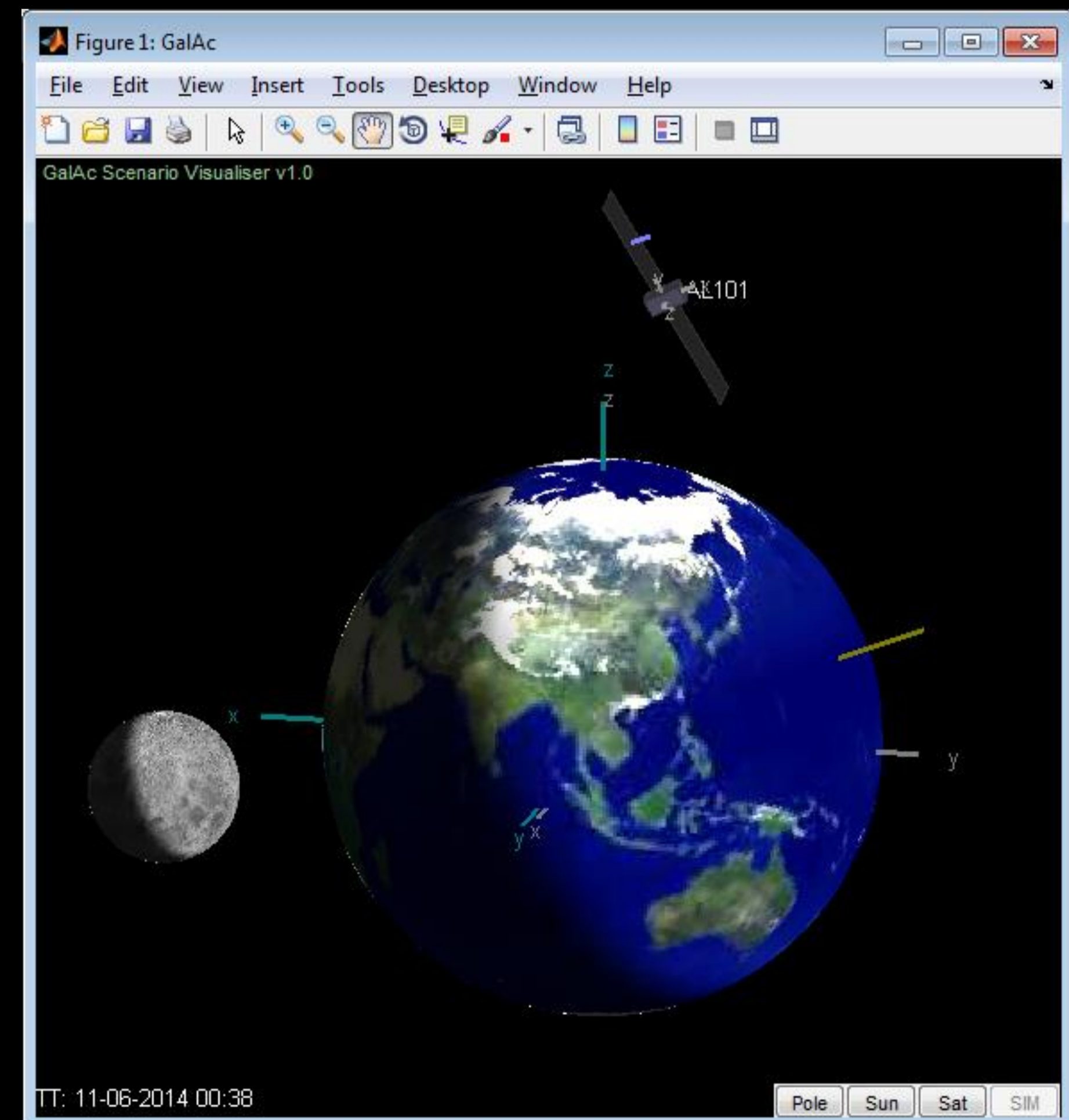
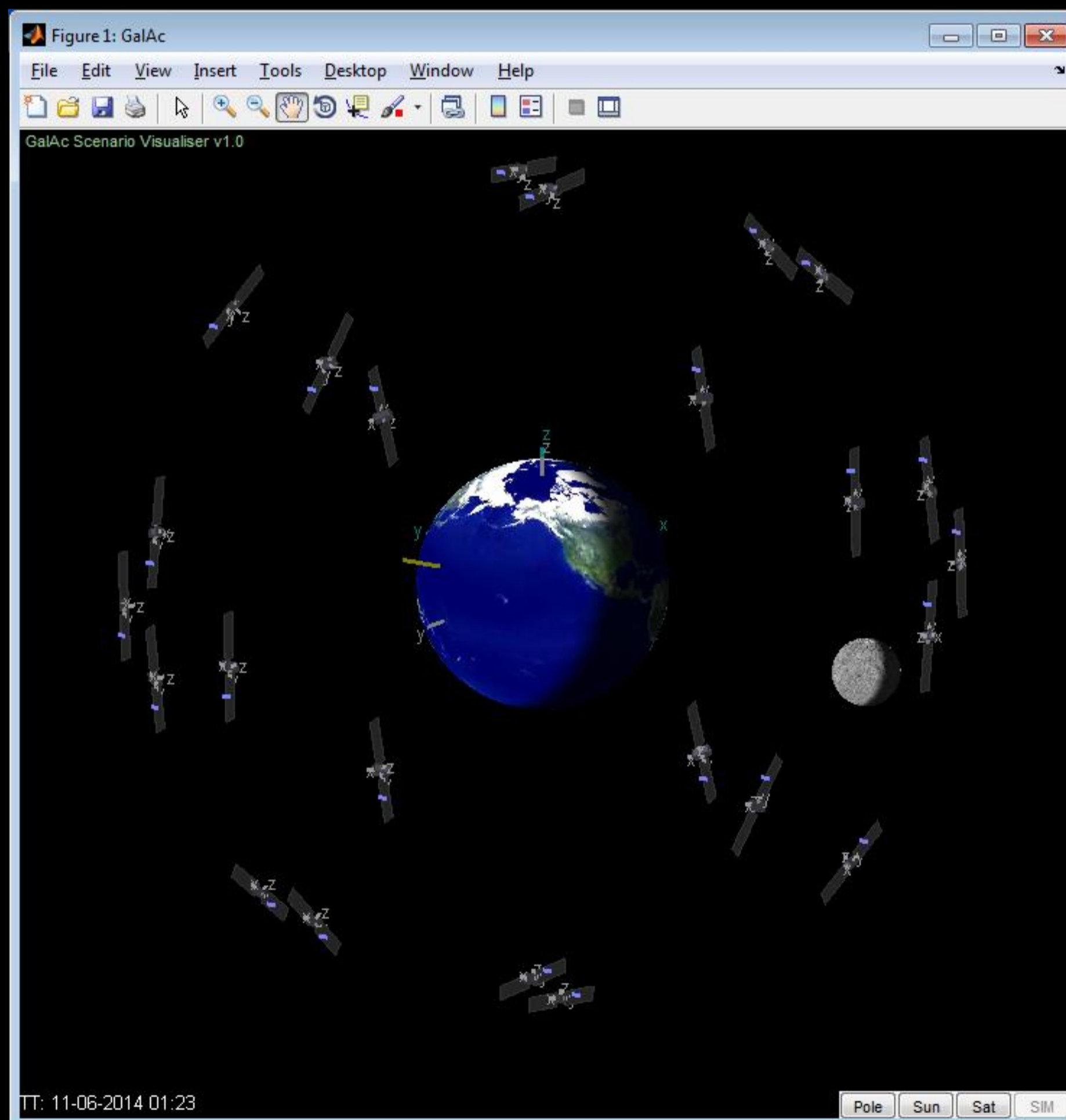
15.08.2016, 00:57:30



**Own orbital
software development**

GALAC – ESA contract

advanced orbital propagator (compatible with IERS 2010 Conventions)



Near future...

Time Transfer – ACES/ELT

Time flies on the
International Space Station



Atomic Clock Ensemble in Space (ACES)
European Laser Transfer (ELT)



Second independent laser system

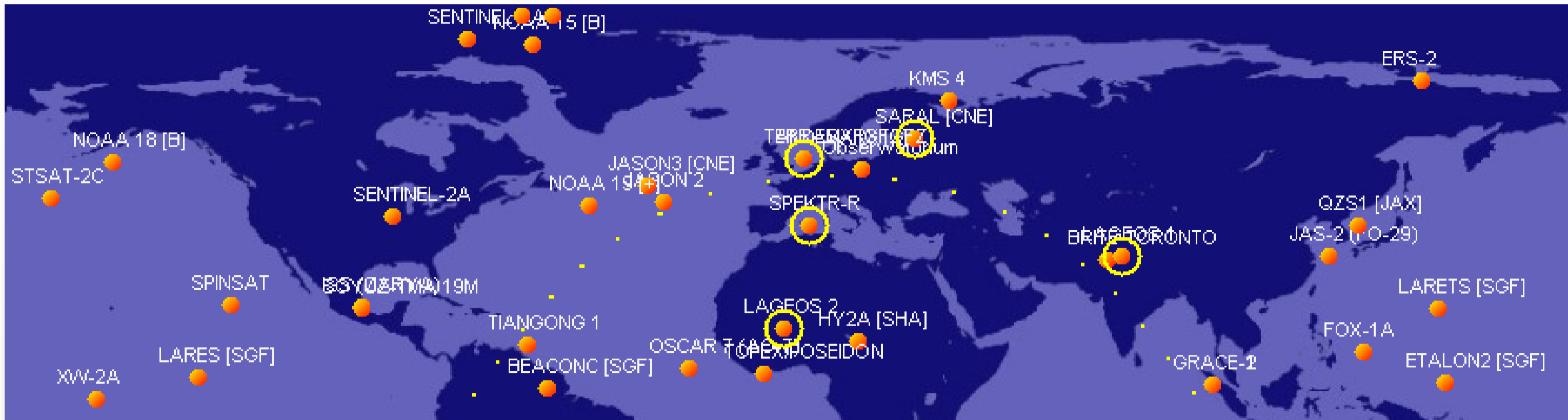
Space Surveillance and Tracking programme



Second independent laser system new software

2016-04-19 17:02:21 UTC, dzień roku: 110 Do następnego przelotu: brak obserwowanych satelitów

Wizualizacja Import TLE, CPF Dane orbitalne Planowanie Obserwacje Ustawienia



AJISAI [EGS]
 BEACONC [SGF]
 BRITE-AUSTRIA
 BRITE-PL
 BRITE-PL 2
 BRITE-TORONTO
 CRYOSAT 2
 ENVISAT
 ERS-2
 ETALON1 [SGF]
 ETALON2 [SGF]
 FOX-1A
 FUNCUBE-1 (A0-73)
 GRACE-1
 GRACE-2

SAT Radio Inne

AJISAI (EGS)

Czas [UT]: 17:02:21
Czas [LT]: 19:02:21

Długość: 105,29 E
 Szerokość: 36,55 S
 Azymut: 268,0634°
 Elewacja: -66,3055°▲

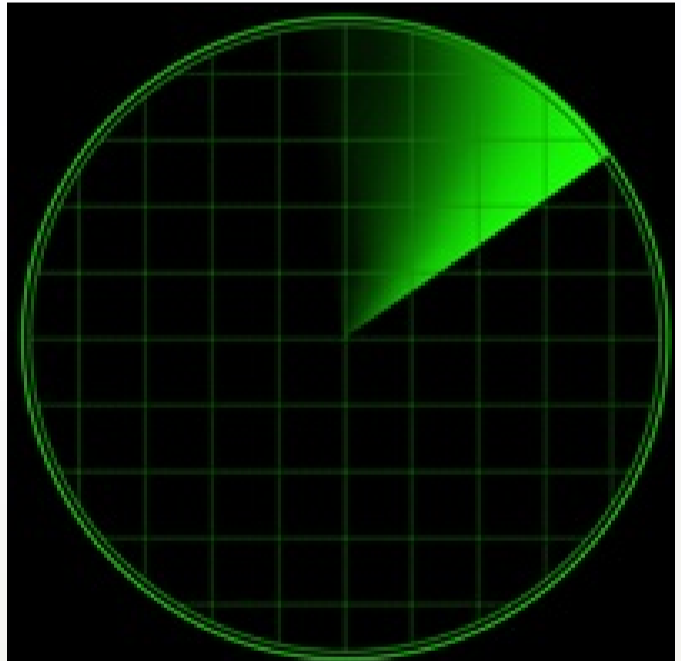
Odległość: 13278▼ km
 Zbliżanie: -2,197 km/s

Obieg: 1h 55m 43s
 Apogeum: 1497 km

2016-04-19 16:03:29 UTC, dzień roku: 110 Do następnego przelotu: 22 minut - Satelita: XW-2A_20162519_162523.txt

Wizualizacja Import TLE, CPF Dane orbitalne Planowanie Obserwacje Ustawienia

	Obserwacja	Predykcja	Efemeryda	Efemeryda (dni)	NC-Code	Satelita	Początek przelotu (UTC)	Koniec przelotu (UTC)	Czas przelotu	Elewacja min.	El m	
▶	<input type="checkbox"/>	1181	17059	6382	0	XW-2A_20162519_162523.txt	XW-2A	2016-04-19 16:25:23	2016-04-19 16:32:12	00:06:49	10	6
	<input type="checkbox"/>	1182	17045	6388	0	SENTINEL-1A_20164719_16471...	SENTINEL-1A	2016-04-19 16:47:18	2016-04-19 16:56:12	00:08:54	10	3
	<input type="checkbox"/>	1183	17060	6382	0	XW-2A_20160119_180103.txt	XW-2A	2016-04-19 18:01:03	2016-04-19 18:03:11	00:02:08	10	1
	<input type="checkbox"/>	1184	17050	6370	1	SENTINEL-2A_20162019_18203...	SENTINEL-2A	2016-04-19 18:20:32	2016-04-19 18:23:08	00:02:36	10	1
	<input type="checkbox"/>	1185	17055	6389	0	SENTINEL-3A_20160119_19011...	SENTINEL-3A	2016-04-19 19:01:18	2016-04-19 19:10:42	00:09:24	10	3
	<input type="checkbox"/>	1186	17051	6370	1	SENTINEL-2A_20165519_19551...	SENTINEL-2A	2016-04-19 19:55:10	2016-04-19 20:05:10	00:10:00	10	4
	<input type="checkbox"/>	1187	17056	6389	0	SENTINEL-3A_20164019_20403...	SENTINEL-3A	2016-04-19 20:40:34	2016-04-19 20:50:42	00:10:08	10	4
	<input type="checkbox"/>	1188	17052	6370	1	SENTINEL-2A_20163519_21351...	SENTINEL-2A	2016-04-19 21:35:18	2016-04-19 21:44:24	00:09:06	10	2
	<input type="checkbox"/>	1189	17046	6388	0	SENTINEL-1A_20163920_04395...	SENTINEL-1A	2016-04-20 04:39:58	2016-04-20 04:48:40	00:08:42	10	3
	<input type="checkbox"/>	1190	17061	6382	0	XW-2A_20161520_051554.txt	XW-2A	2016-04-20 05:15:54	2016-04-20 05:22:21	00:06:27	10	3
	<input type="checkbox"/>	1191	17047	6388	0	SENTINEL-1A_20161720_06173...	SENTINEL-1A	2016-04-20 06:17:38	2016-04-20 06:26:15	00:08:37	10	3
	<input checked="" type="checkbox"/>	1192	17062	6382	0		XW-2A	2016-04-20 06:49:07	2016-04-20 06:54:41	00:05:34	10	2
	<input type="checkbox"/>	1193	17057	6389	0	SENTINEL-3A_20164920_08491...	SENTINEL-3A	2016-04-20 08:49:15	2016-04-20 08:59:23	00:10:08	10	4
	<input type="checkbox"/>	1194	17053	6370	1	SENTINEL-2A_20164120_09411...	SENTINEL-2A	2016-04-20 09:41:12	2016-04-20 09:51:36	00:10:24	10	6
	<input type="checkbox"/>	1195	17058	6389	0	SENTINEL-3A_20162920_10291...	SENTINEL-3A	2016-04-20 10:29:15	2016-04-20 10:38:39	00:09:24	10	3



Otwórz / zamknij dach

Załącz / wyłącz napędy

Montaż na spoczynkową

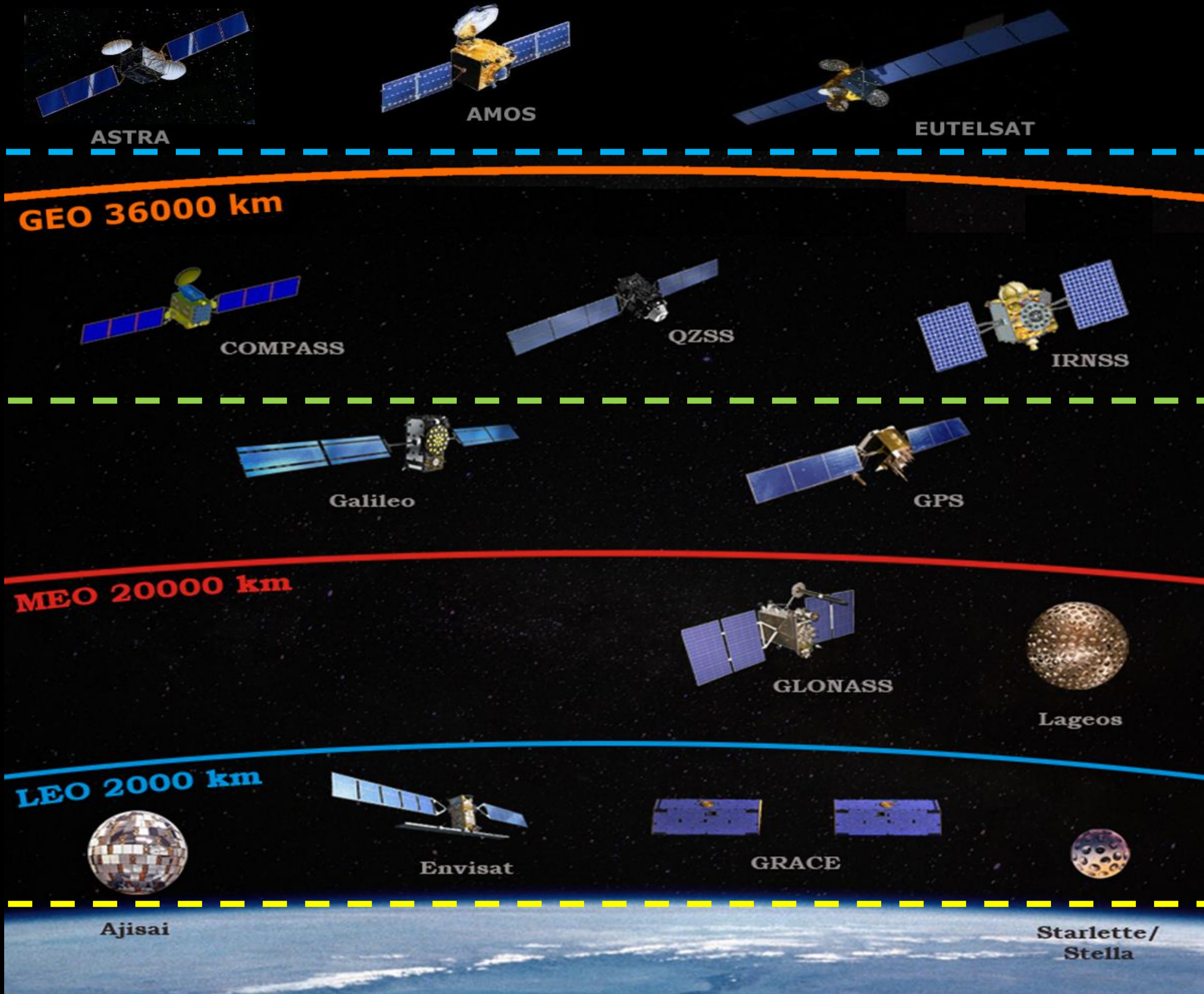
Montaż na polarną

Montaż na TARGET

Kalibracja na żądanie

label42

Tracking capabilities



GOAL
38 000 km

25 000 km

350 km



Day observations



to reach
3500
passes/year
treshold

Efficiency \approx 33 %



**IGS BOR1 point
modernization**

IGS BOR1 – SLR BORL



New GNSS receiver – IGS BOR1



GNSS receiver installed on February 5, 2015

Satellites - Skypilot

2016-10-07T14:15:00Z (UTC)

Satellites - General Information

System	# Satellites	Constellation
GPS	11	1, 2, 3, 5, 32 Unhealthy 4 Ignore Health 1, 32
GLONASS	8	5, 6, 7, 14, 15, 20, 21, 22 1, 24 Ignore Health 1, 24
Galileo	4	9, 11, 12, 19 Unhealthy 1, 2, 8, 14, 18, 20 Ignore Health 1, 5, 7, 36 Disabled 6
QZSS	0	
BeiDou	5	2, 5, 7, 9, 10 Unhealthy 103 Ignore Health 103 Disabled 194, 197
SBAS	2	127 GAGAN - GSAT 8 136 EGNOS - SES-5 Ignore Health 1, 30

2016-10-07T14:17:04Z (UTC)

Satellites - Tracking Information

C/N0 vs. SV

Receiver Status - Activity

Satellites Tracked: 29

GPS (11): 1, 3, 8, 11, 14, 17, 19, 22, 23, 31, 32
 GLONASS (8): 5, 6, 7, 14, 15, 20, 21, 22
 Galileo (4): 9, 11, 12, 19
 BeiDou (5): 2, 5, 7, 9, 10
 SBAS (2): 127, 136

Data Logging:
 Web Services: /Internal/BOR2281o.T02
 Data Logging: /Internal/BOR2281a.T02
 Receiver Configuration: /Internal/BOR2281oB.T02

Input/Output:
 Output: TCP/IP (5011) - RT27 (1Hz)
 Output: TCP/IP (5012) - RT27 (1Hz)

Temperature: 33.92°C
 Runtime: 03:20:20
 Power Source: Part 2

Disk: [SMB:8192MB]
 Port 2: [100% / 19.54V]
 Ethernet: [9%]
 Battery 1: [100% / 8.28V]
 Battery 2: [0% / 100%]

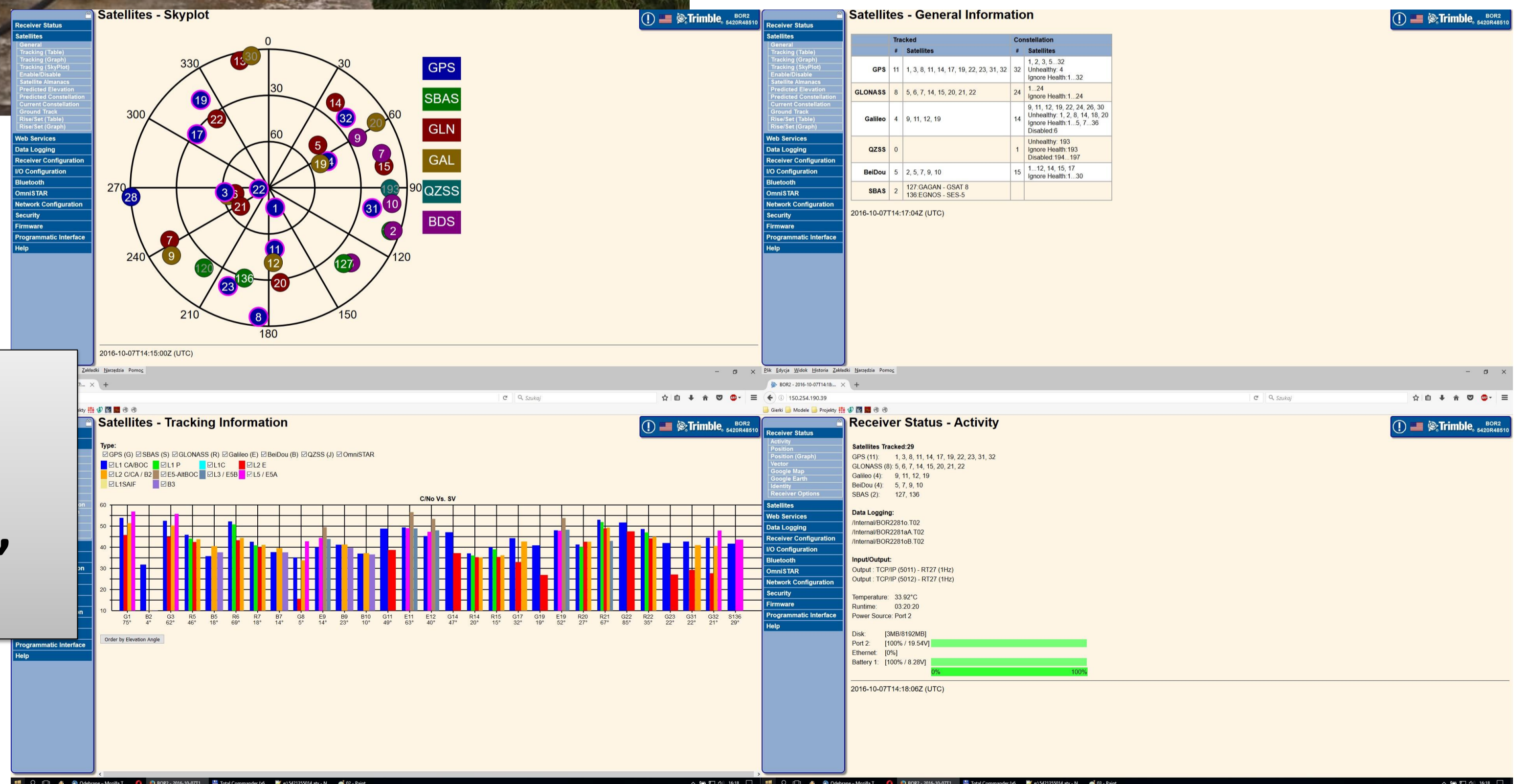
2016-10-07T14:18:06Z (UTC)

**Sample screens
GPS, GLONASS,
GALILEO, BEIDOU,
SBAS**

New GNSS antenna – IGS BOR1



**GNSS antenna
installed on October 5, 2016**



**Sample screens
GPS, GLONASS,
GALILEO, BEIDOU,
SBAS**

SUMMARY

- high quality observations of satellites (results confirmed by AC's)
- AVG RMS from 1.19 cm to 5.54 cm (ILRS satellites)
- second SLR system under construction
- space debris observations (LEO regime)
- ACES/ELT experiment is underway
- observations of GNSS satellites
- KHz direction
- Better contribution to the GGOS (IGS BOR1, SLR BORL)

