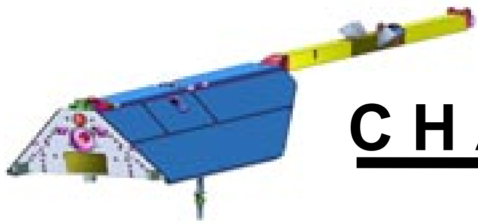
International Laser Ranging Service

Seventh General Assembly of the ILRS
April 25, 2002
Nice, France

Presentation Material

International Laser Ranging Service

Campaigns and Missions



Status SLR-Tracking CHAMP Mission

R. Schmidt, R. König, Ch. Reigber

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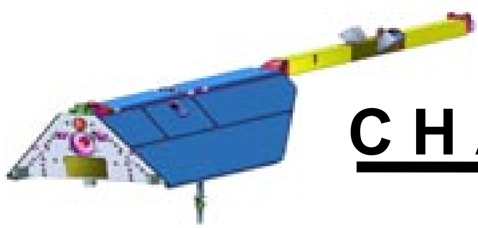
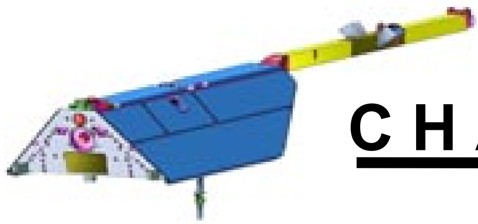
Division I: Kinematics and Dynamics of the Earth
Telegrafenberg
14473 Potsdam



C H A M P

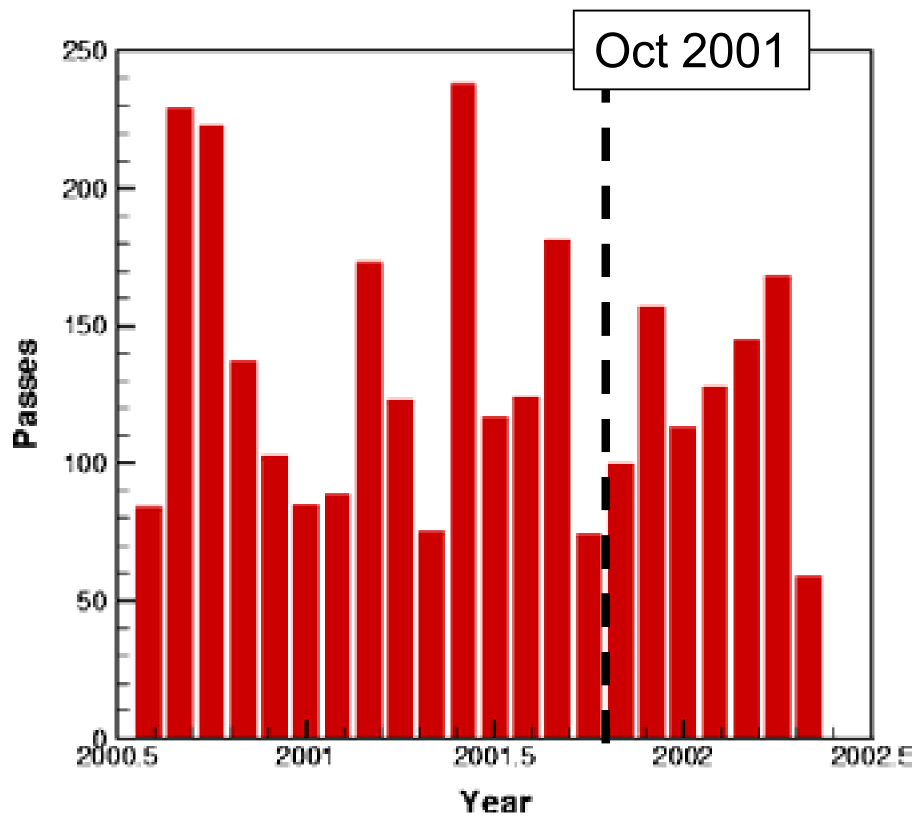
Status

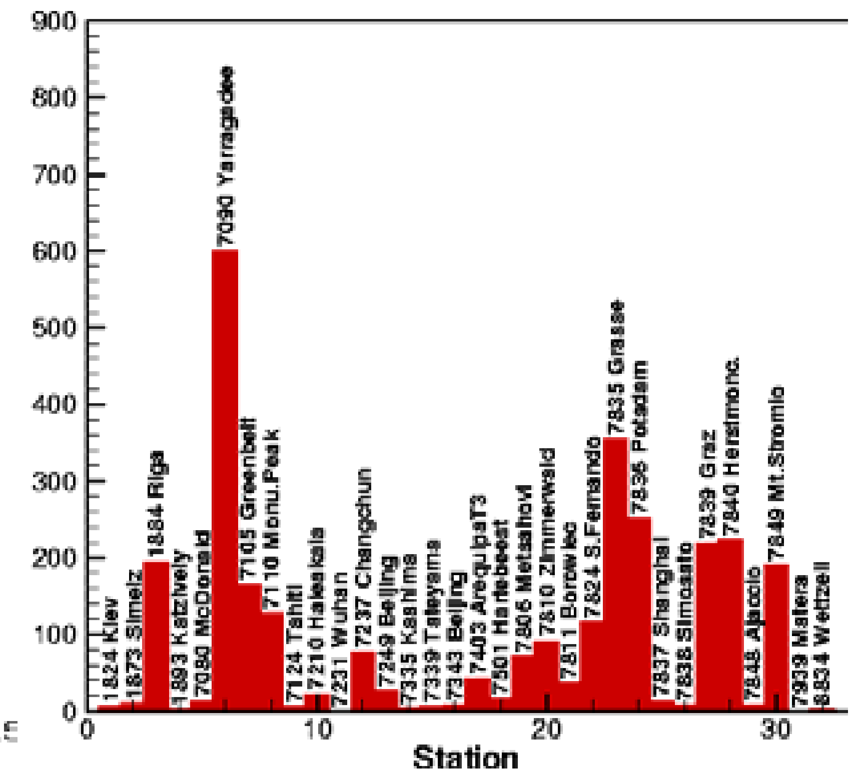
- automated operations of orbit predictions based on GPS navigation solution and SLR data; as of October 10th, 2001 updating frequency has been set to 3 predicts/per day improving SLR statistics
- SLR data amount collected (Jul. 2000 - Apr. 2002)
  - 2929 passes (69721 NPs) at 32 ILRS stations
  - mean number of passes/day is 5
- good latency of SLR data (hourly updating ILRS data centers)
- spatial and temporal coverage reflect capability of ILRS network of tracking LEO satellites
- usage of SLR data at GFZ for the validation of orbit determination



C H A M P

SLR-Tracking Jul. 2000 - Apr. 2002





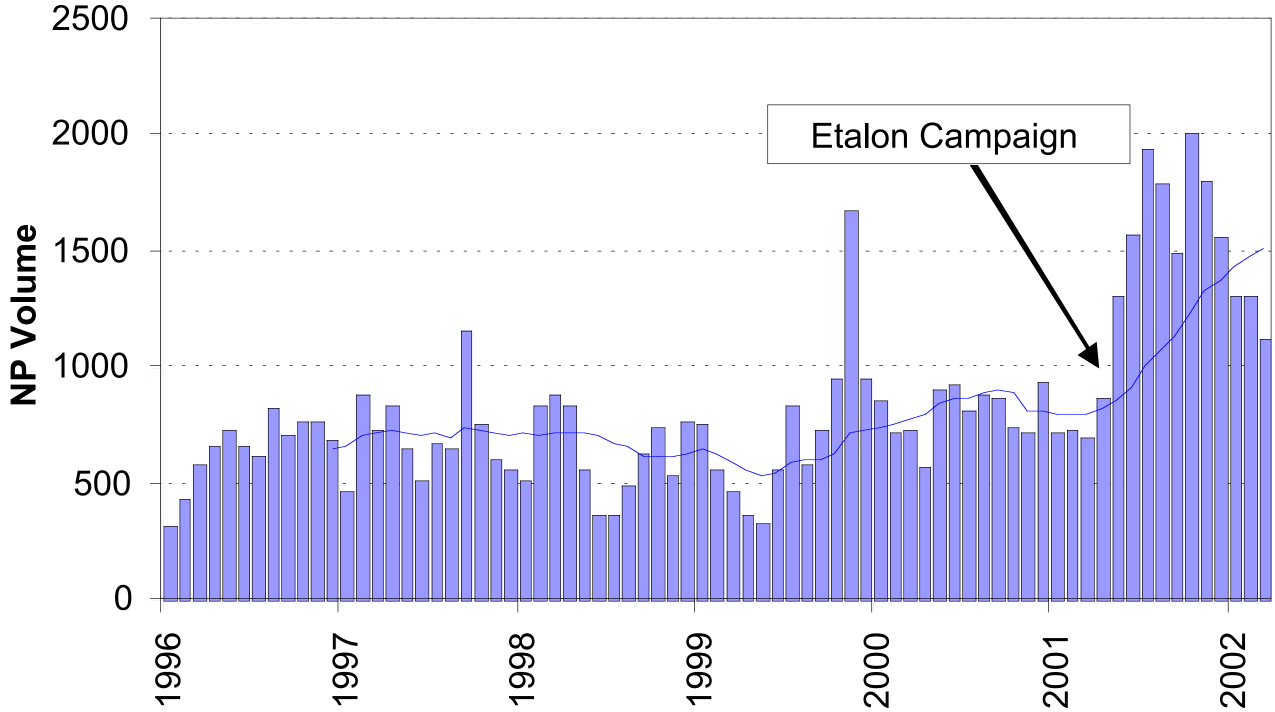
GFZ POTSDAM

ETALON campaign

- Purposes:
  Improve EOPS
  GM
  Station data characterization

- At request of ILRS AWG

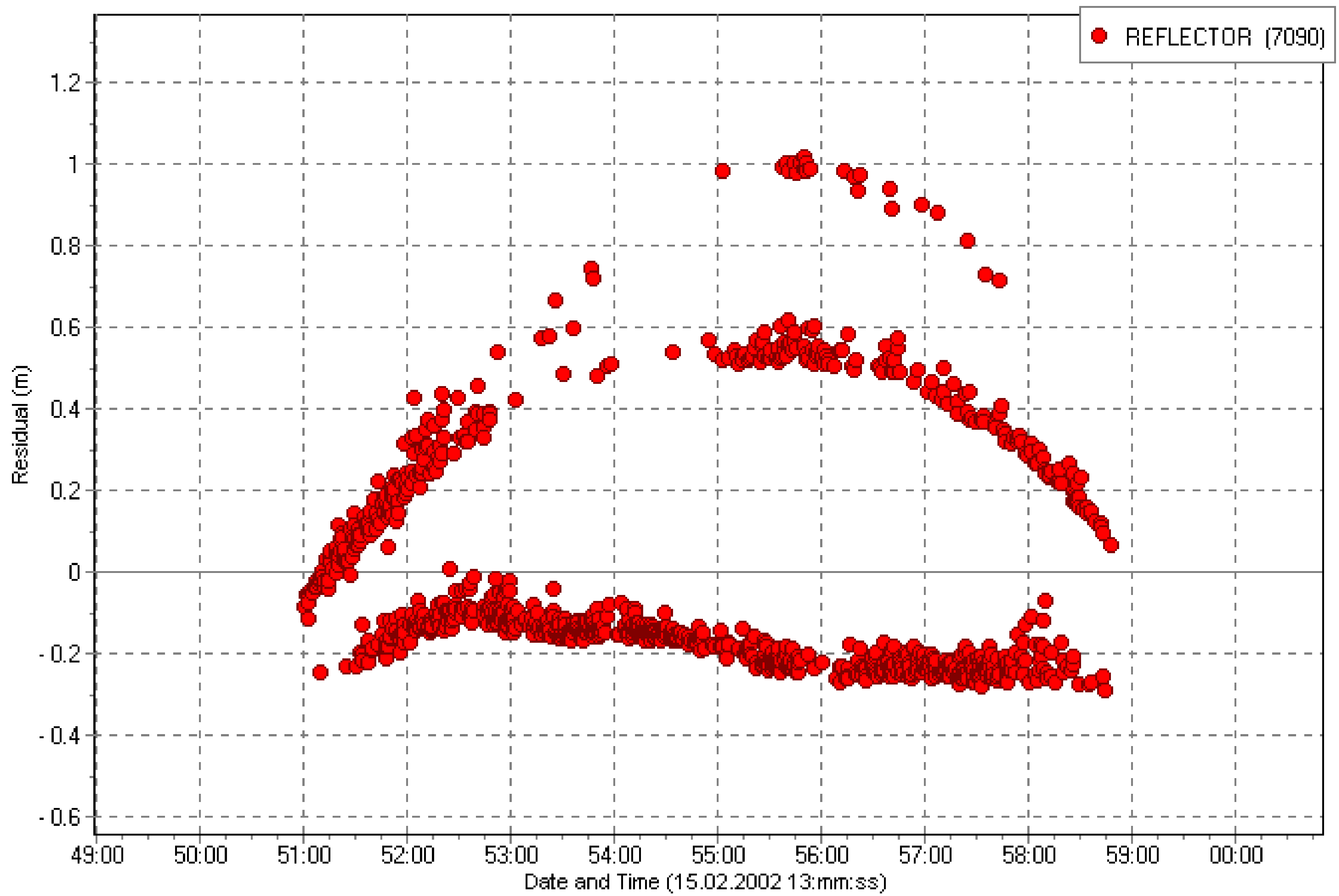
- April 2001 – April 2002

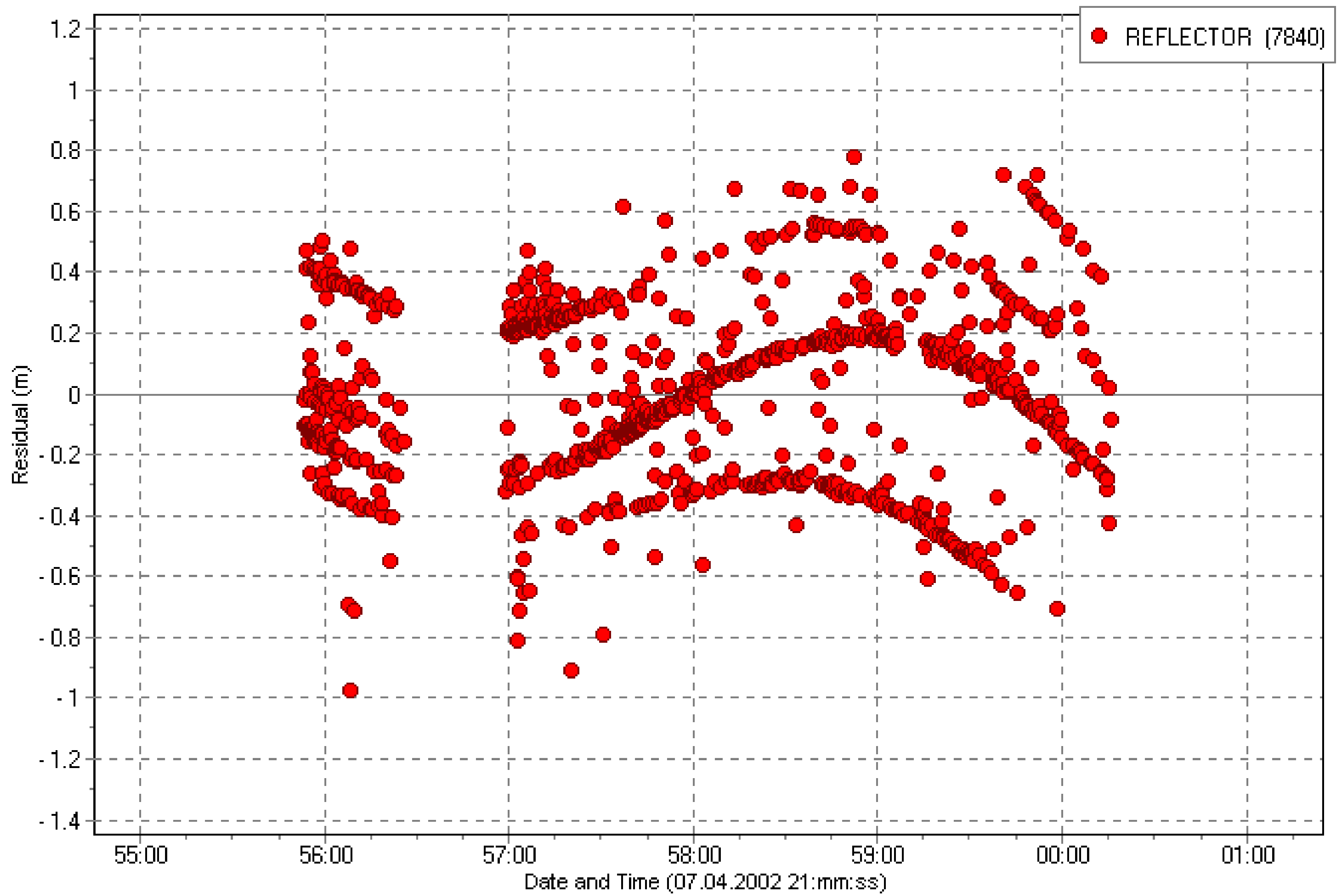


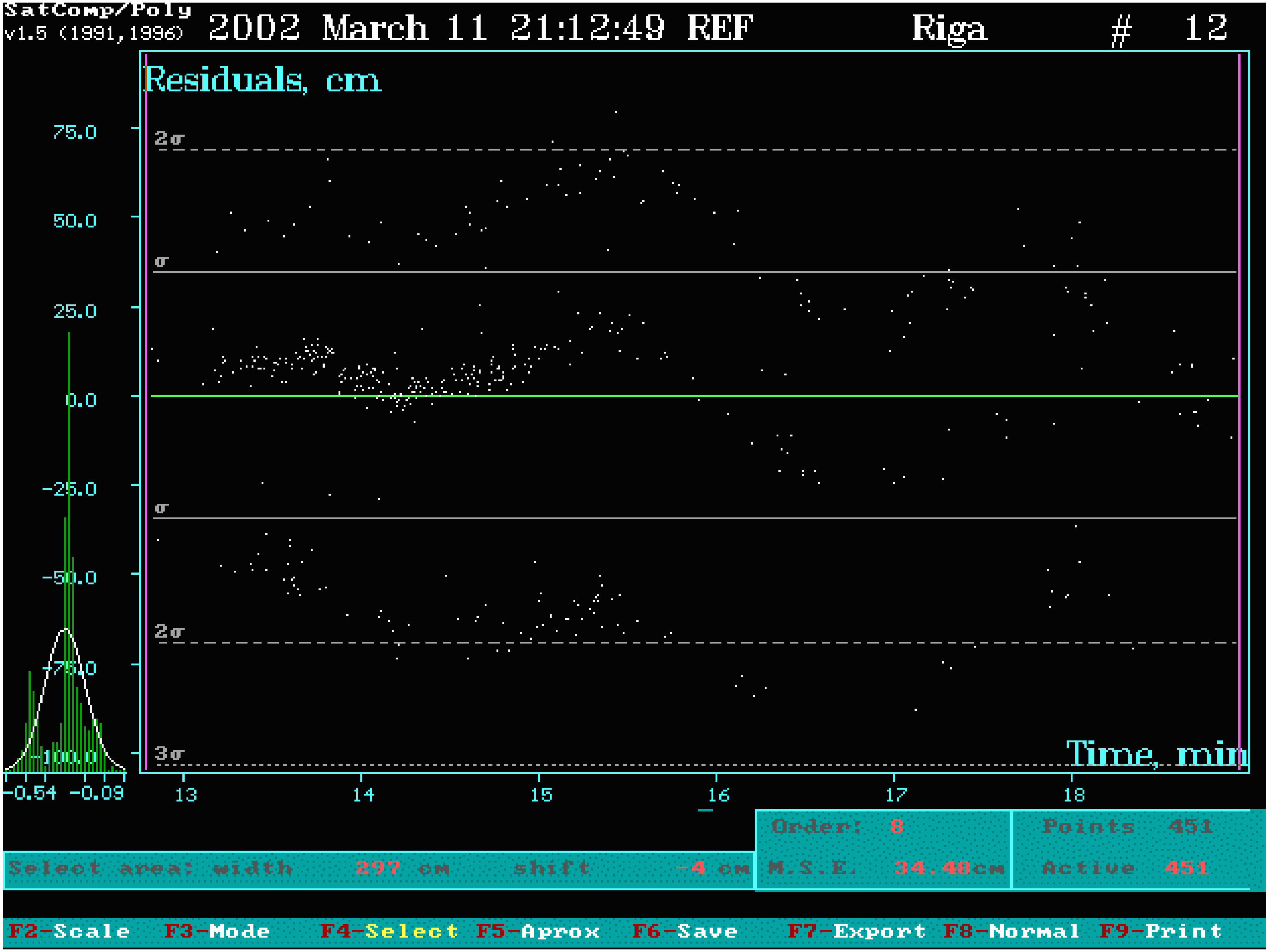
2500
2000
1500
1000
500
0
NP Volume
Etalon Campaign
1996
1997
1998
1999
2000
2001
2002

ETALON campaign: “conclusions”

- Improvement of EOPs marginal, but:
- Encouragement for improvement analysis
- Continue tracking at current level of intensity
- AWG -> development of official ILRS combination product


REFLECTOR (7090)
Residual (m)
1.2
1
0.8
0.6
0.4
0.2
0
- 0.2
- 0.4
- 0.6
49:00
50:00
51:00
52:00
53:00
54:00
55:00
56:00
57:00
58:00
59:00
00:00
Date and Time (15.02.2002 13:mm:ss)


REFLECTOR (7840)
Residual (m)
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
55:00
56:00
57:00
58:00
59:00
00:00
01:00
Date and Time (07.04.2002 21:mm:ss)


SatComp/Poly
v1.5 (1991,1996)
2002 March 11 21:12:49 REF
Riga
12
Residuals, cm
75.0
50.0
25.0
0.0
-25.0
-50.0
-75.0
-100.0
2σ
σ
σ
2σ
3σ
-0.54 -0.09
13
14
15
16
17
18
Time, min
Order: 8
Points 451
M.S.E. 34.48cm
Active 451
Select area: width 297 cm shift -4 cm
F2-Scale F3-Mode F4-Select F5-Aprox F6-Save F7-Export F8-Normal F9-Print

Report of LRE Launch Support

Maki MAEDA

Flight Dynamics Group
Office of Satellite Technology, Research and Applications
Satellite Mission Operations Department
National Space Development Agency of Japan

Launch Status

The launch of LRE/H-IIA was launched at 2001-08-29 07:00:00 (UTC) from Tanegashima Island,Japan

07:39:47 [L+39m47s]
The LRE has separated from Launch Viecle

The launch time had slipped about 3 hours. (04:00 -->07:00)

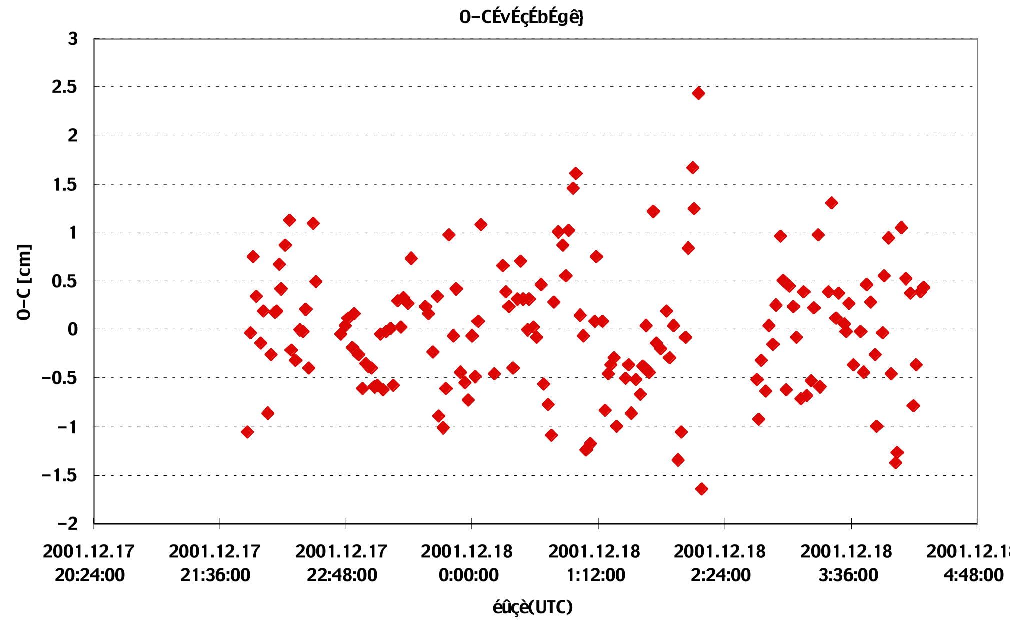
Because of the trouble of launch site

The relation between Sun and LRE visibility has changed

FIRST laser return from LRE

Dec 17 GRASSE/LLR station succeed SLR

	Start	End	NPs
2001/12/17	**21:51:33**	**22:08:10**	**10**
	22:09:45	**23:04:10**	**23**
	23:05:48	**00:04:35**	**28**
2001/12/18	**00:11:51**	**00:58:50**	**23**
	01:01:34	**01:58:32**	**28**
	02:01:36	**03:06:48**	**20**
	03:09:11	**04:02:14**	**26**
	04:04:58	**04:18:42**	**8**



Following GRASSE,
Yaragadee station (Dec 22) and
CRL station(Jan 28) also succeed SLR

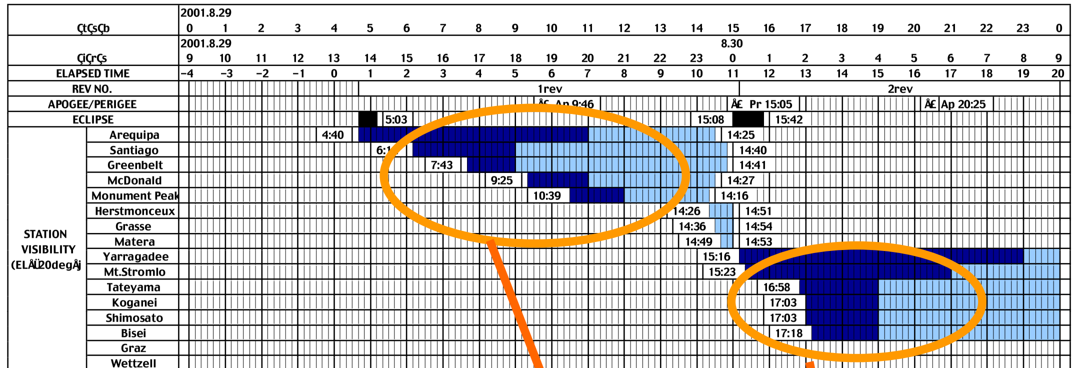
Difficulty of SLR to the transfer orbit

Interference with the SUN

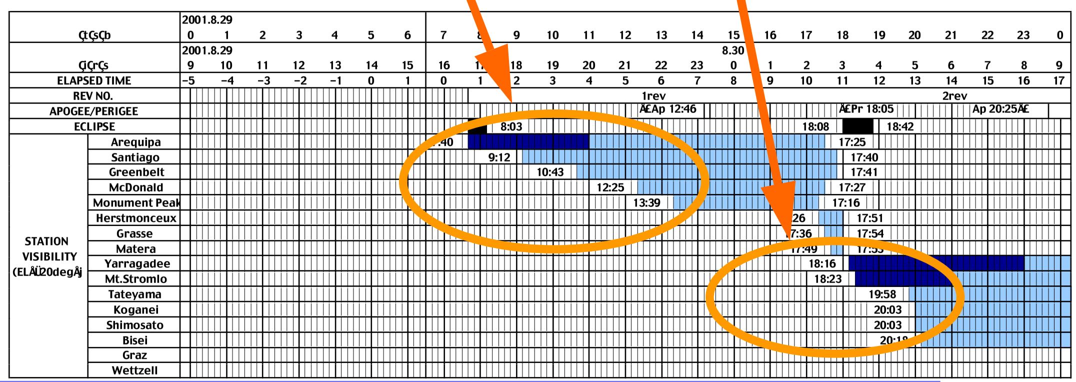
H-IIA launch was
Slipped about
3 hours

Day time

Night time



AFTER Launch Slip



The angle between sun and LRE had been small.
Difficult to target the telescope to LRE

Difficulty of SLR to the transfer orbit

Range Gate estimation

LRE flights eccentricity orbit
Slant range change during tracking pass

GRASSE station was modified software
to change range gate in short time.

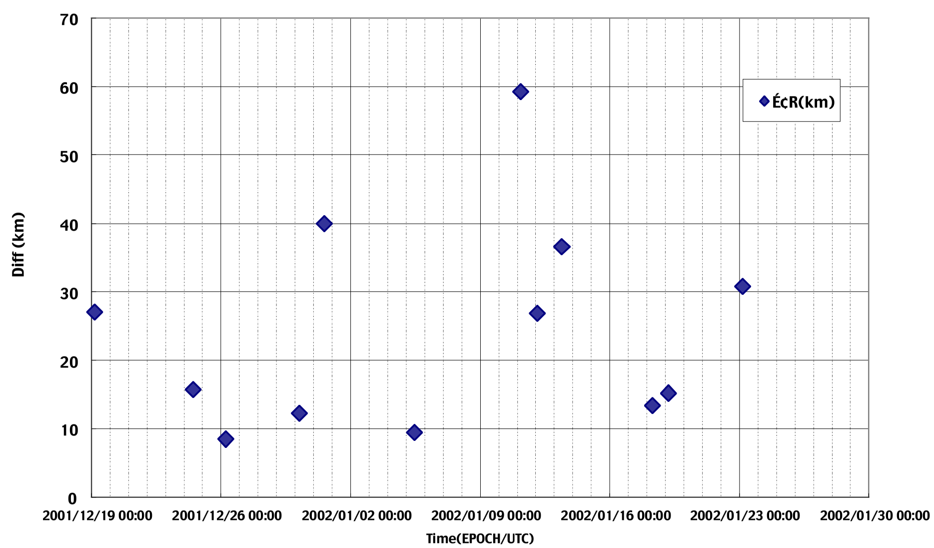
Very effective to success SLR of LRE

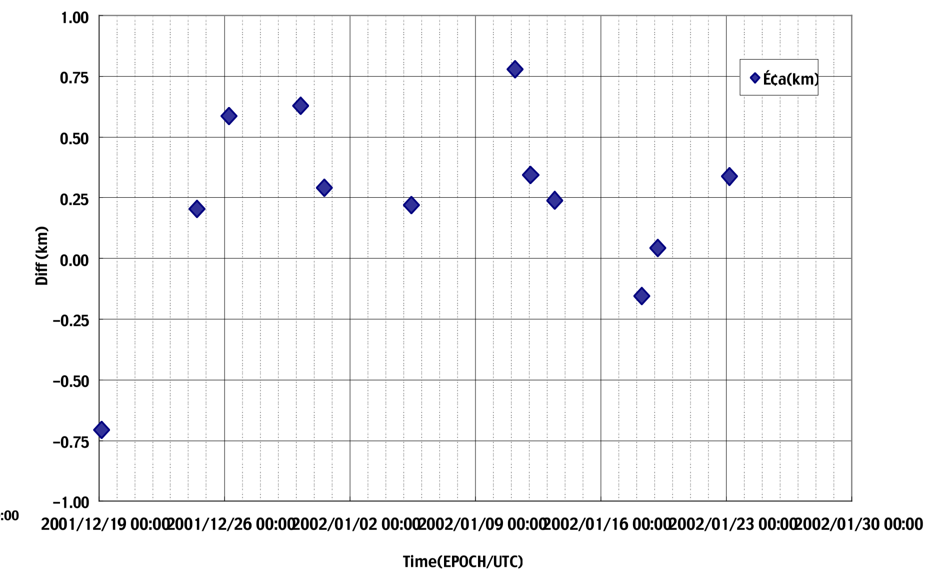
Difficulty of SLR to the transfer orbit

TIRV accuracy

Before the success of SLR, we delivered TIRVs based on NORAD TLE

only ONE information of LRE orbit





Compare with TLE and NASDA OD result

The accuracy of TLE was not enough for Laser ranging

Difficulty of SLR to the transfer orbit

Visibility in optical

Report from many station, It found that the visibility of LRE in optical was too bad condition.

WHY?

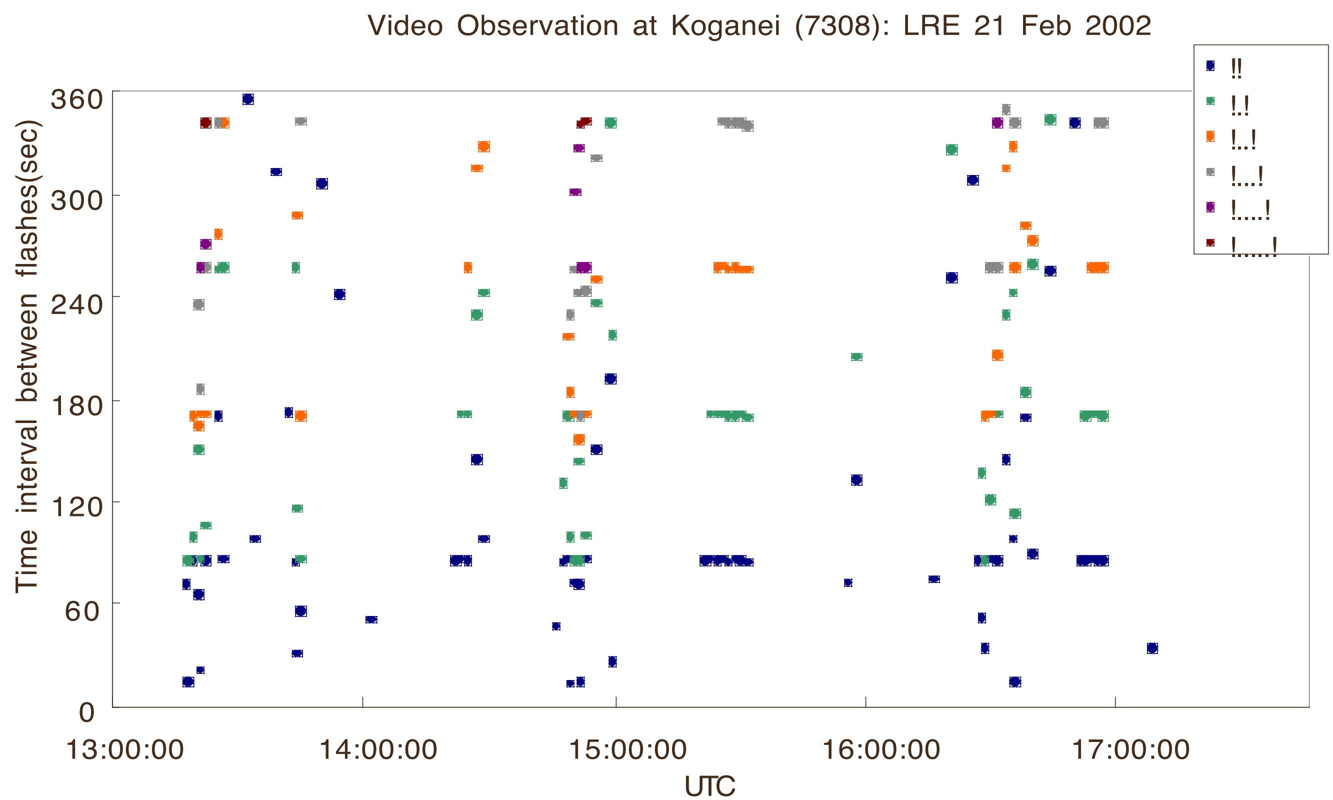
Estimated spin rate from the Video onboard H-IIA rocket was about 3rpm (EGS is 32rpm)

LRE was too small and not so good mirror Configuration to get enough optical sectional area

LRE: Video Observation at CRL

Probably reflected from mirrors. Many fall in 85±1 sec.

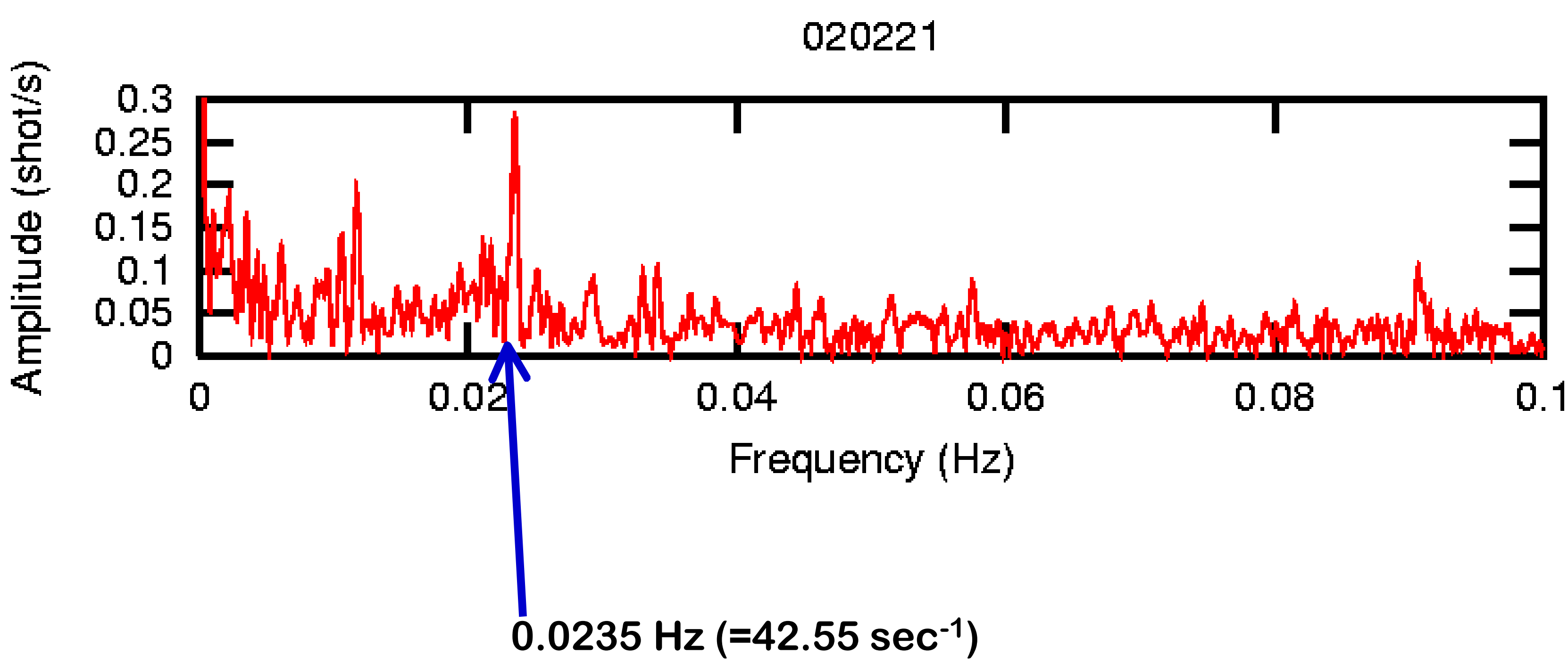
the spin period can be 85, 85x2, 85x3, 85x4 or 85x6 seconds



LRE: FR (Grasse) spectral analysis

Spectral analysis of post-fit full-rate data from Grasse.

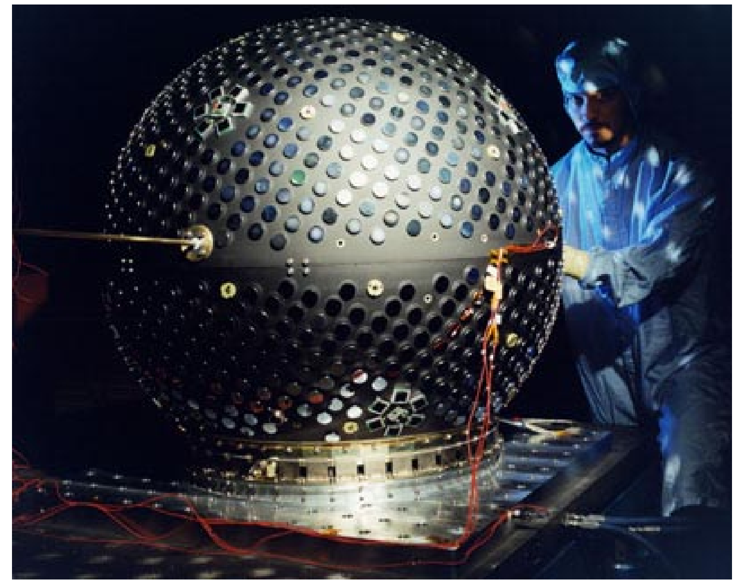
Time domain: number of returns per sec (not residuals!).



Starshine 3

- **Official Name**
  - Starshine 3
- **Sponsor**
  - Cooperative international organization
- **Primary Mission**
  - Thermospheric research, student experiments
- **Launch (September 30, 2001)**
  - Athena ELV from Kodiak, Alaska
- **Orbital Parameters**
  - Altitude: 470 km (at start)
  - Inclination: 67.048°
  - Eccentricity: 0.000066
- **Mission Duration**
  - 1 year
- **Array Characteristics**
  - 36 inch sphere, approximately 250 total pounds
  - 31 one cm cubes spaced around the sphere
  - 1000 student ground and polished mirrors

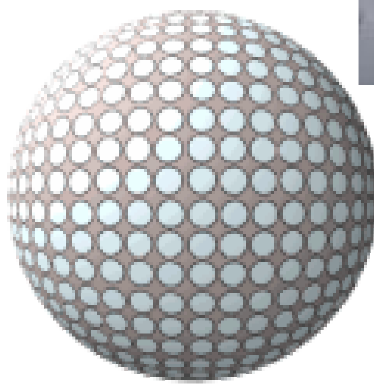
– **Tracking History (Oct. 3, 2001 - April 16, 2002)**
  - 9 systems (4 NASA, 3 EUROLAS, 2 WPLTN)
  - 33 total passes, came in spurts

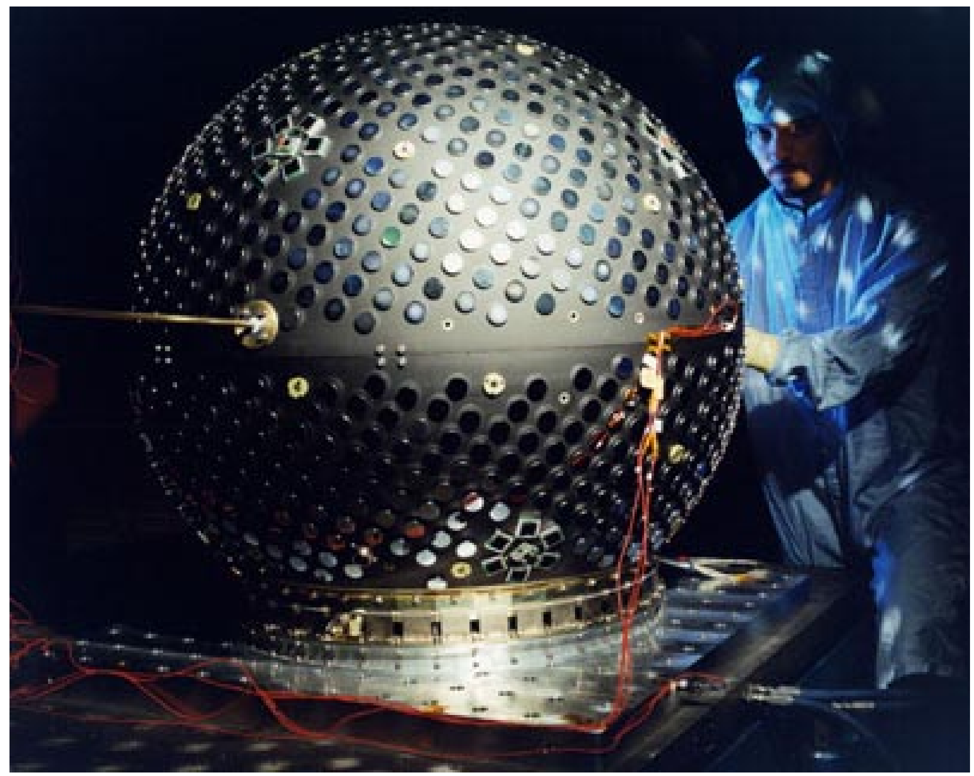


STUDENTS OF THE WORLD

STARSHINE 3

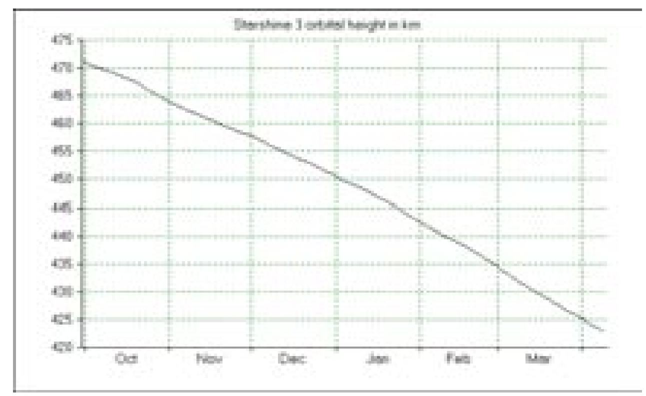
NASA·US NAVY·USAF SPACE GRANT·BATC·ADC PSC·OAI CC·SDSMT PSL·CFPPR·DW·CCG·RCBI





Starshine -2, -3

- Starshine 3
  - Starshine 3 launched on September 30, 2001 as part of first launch from Kodiak, Alaska
  - Starshine satellites were to be tracked by NASA stations and others if desired to determine utility of the retroreflectors - if viable then make a mission
    - First Starshine-3 pass received by Yarragadee on October 3, 2001
    - Tracking limited to NASA stations and anyone who wanted to try tracking (9 stations) - Sparse data
    - NRL provided high quality predictions to help support acquisition
- Starshine 2
  - Starshine 2 deployed from STS-108 on December 16, 2001
    - No tracking attempted attempting Starshine 3



The end of Starshine -2 & -3

- Starshine -2 will decay on or about April 26
- Starshine -3 will decay on or about October 30

- Starshine SLR data has significant impact on thermospheric research and applications impacted by variations in the thermosphere
- Currently, there are a limited number of thermospheric science missions
- Starshine satellites make excellent targets with the spherical shapes and SLR data

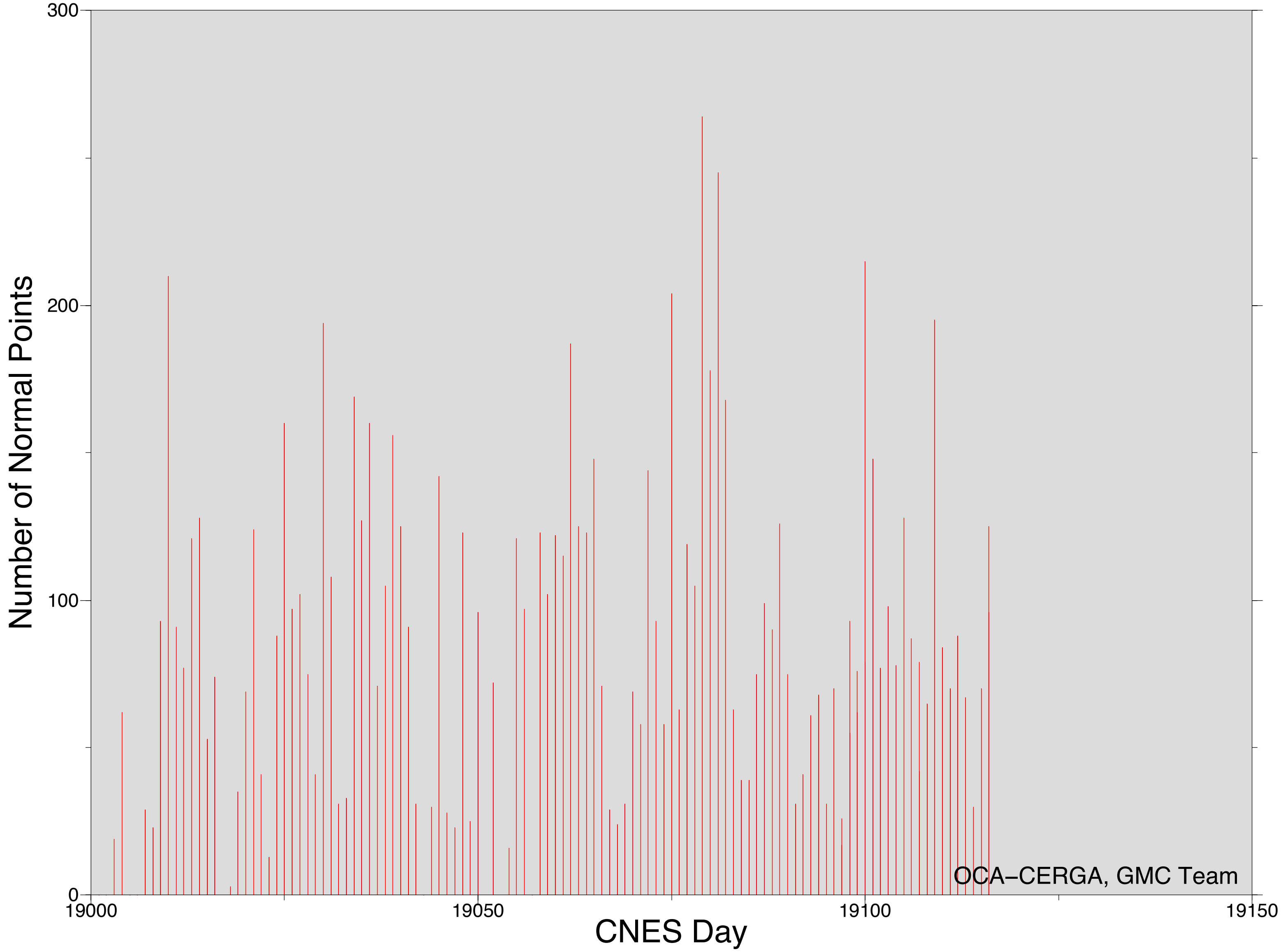
Starshine -4, -5 Underway

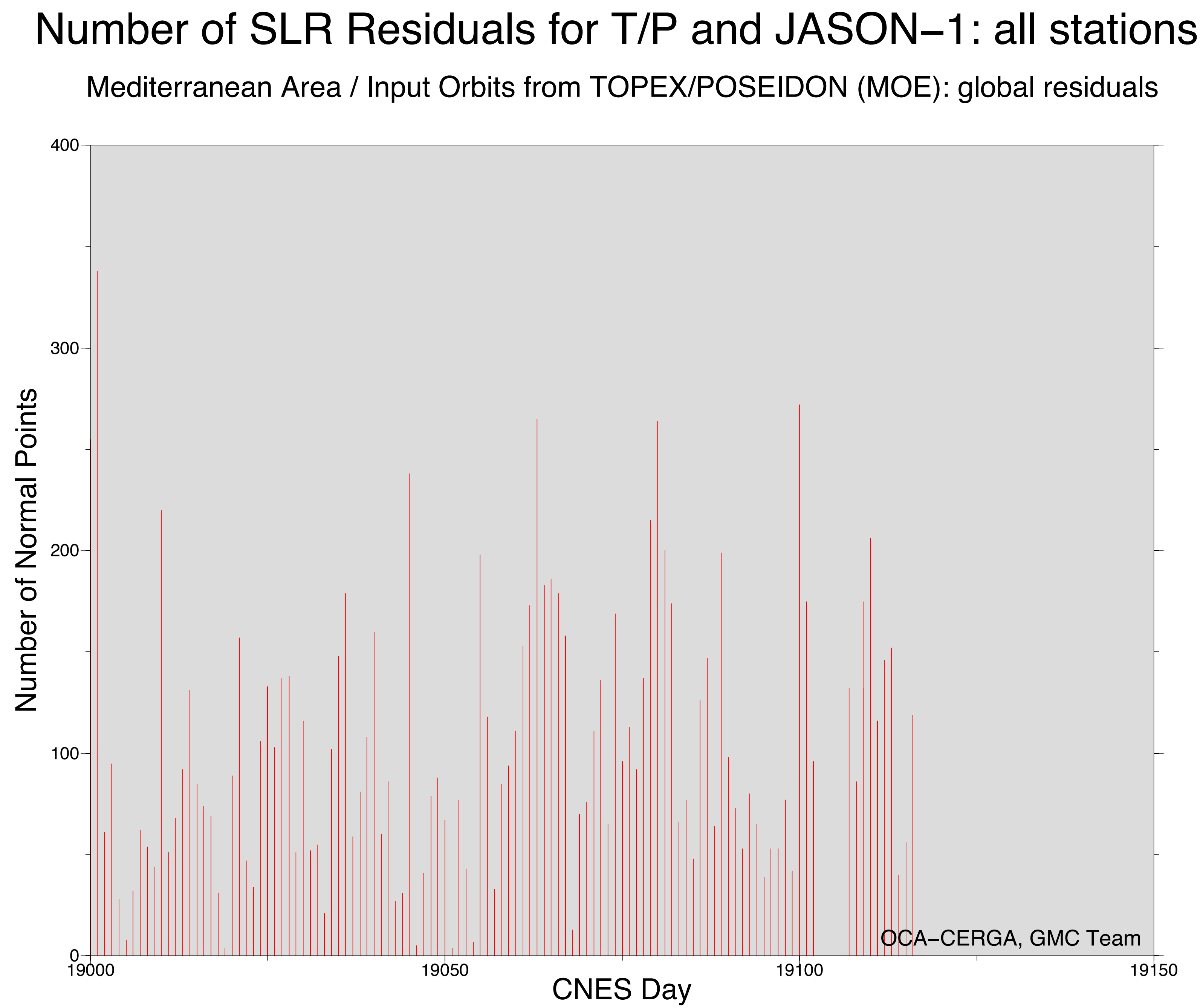
Starshine 4/5

- NASA has firmly manifested our Starshine 4/5 dual-satellite experiment on the STS-114 Shuttle mission to the International Space Station in January of 2003.
- Starshine 4/5 will have mounted 1000 mirrors and 31 laser retroreflectors on its external shell.
- Starshine 4/5 Mission Plan
  - Release from Starshine 4, a 4 inch (10 cm) hollow aluminum sphere, instead, which will be Starshine 5.
  - This small subsatellite will be released shortly after Starshine 4 is deployed from Space Shuttle Atlantis
  - Both Starshines 4 and 5 will carry 31 laser retroreflectors on their surfaces
  - Starshine 5 will have no mirrors and will thus not be naked-eye visible, so tracking will dependent totally on ILRS and Space Command tracking for orbit determination of this satellite.
  - By comparing the orbital decay rates of Starshine 4 and 5, it will possible for us to determine the density of the earth's atmosphere more precisely than we've been able to do on previous missions.

Number of SLR Residuals for T/P and JASON−1: all stations

Mediterranean Area / Input Orbits from JASON−1 (MOE): global residuals

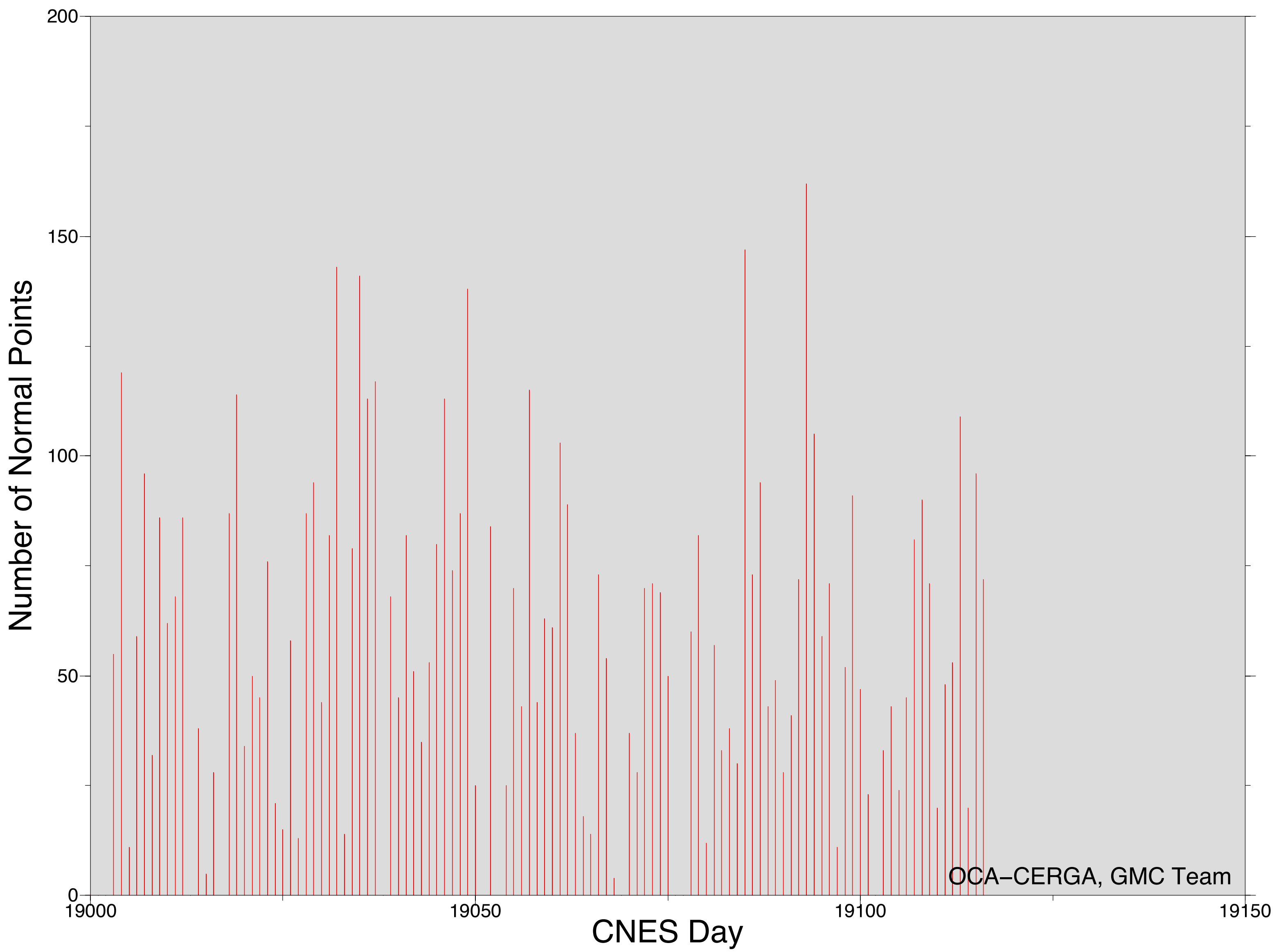




Number of SLR Residuals for T/P and JASON−1: all stations
Mediterranean Area / Input Orbits from TOPEX/POSEIDON (MOE): global residuals
Number of Normal Points
0
100
200
300
400
19000
19050
19100
19150
CNES Day
OCA−CERGA, GMC Team

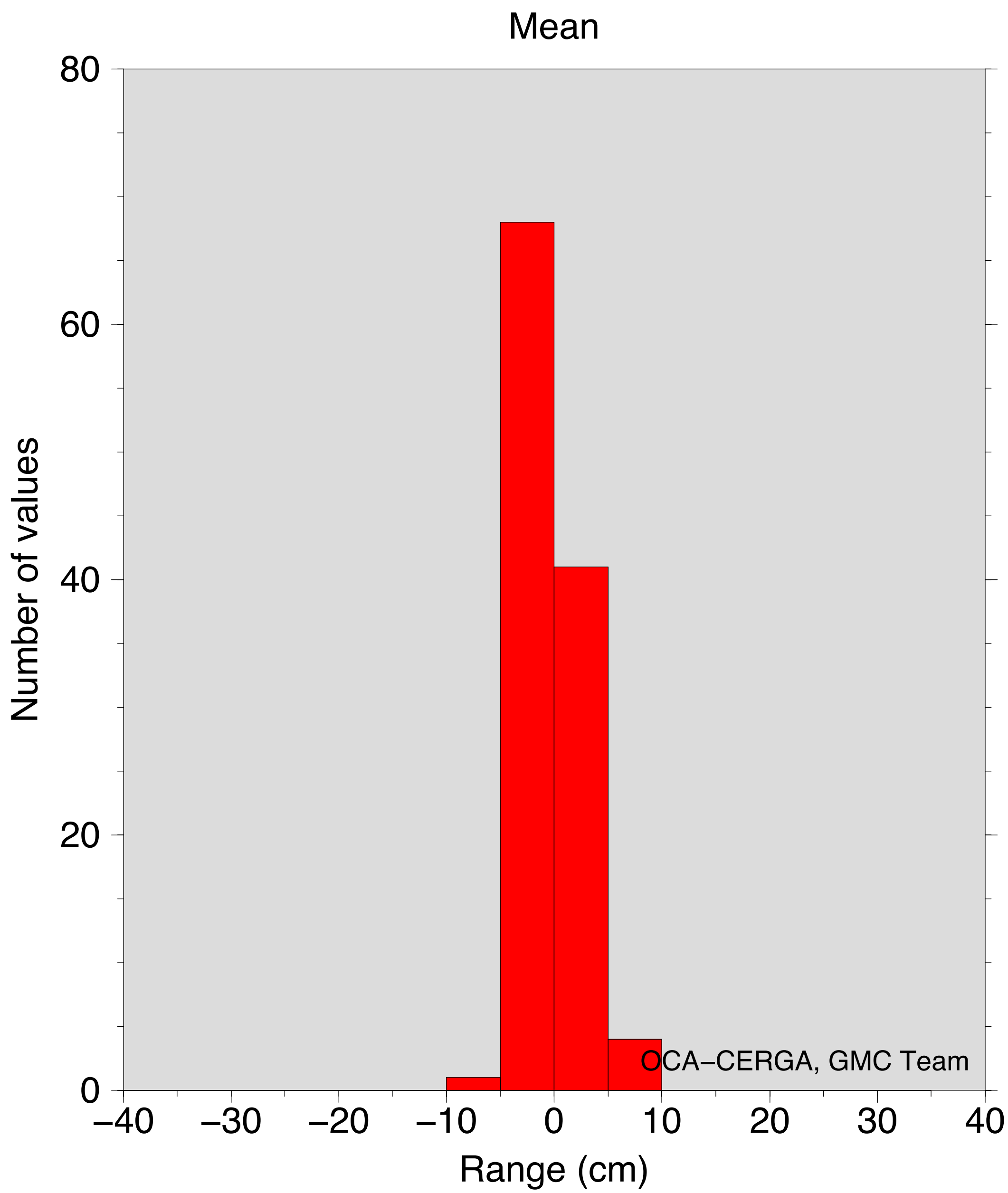
Number of SLR Residuals for T/P and JASON−1: all stations

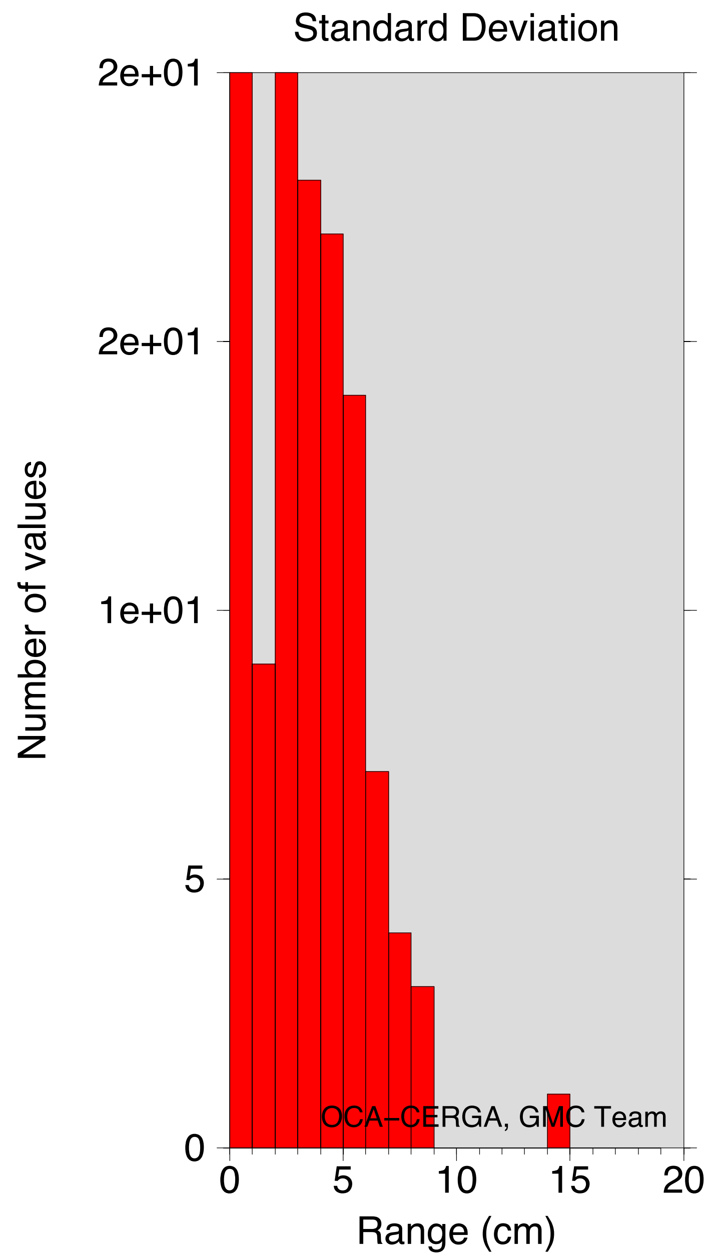
USA Area / Input Orbits from JASON−1 (MOE): global residuals



Histogram of SLR Residuals for T/P and JASON−1: all stations

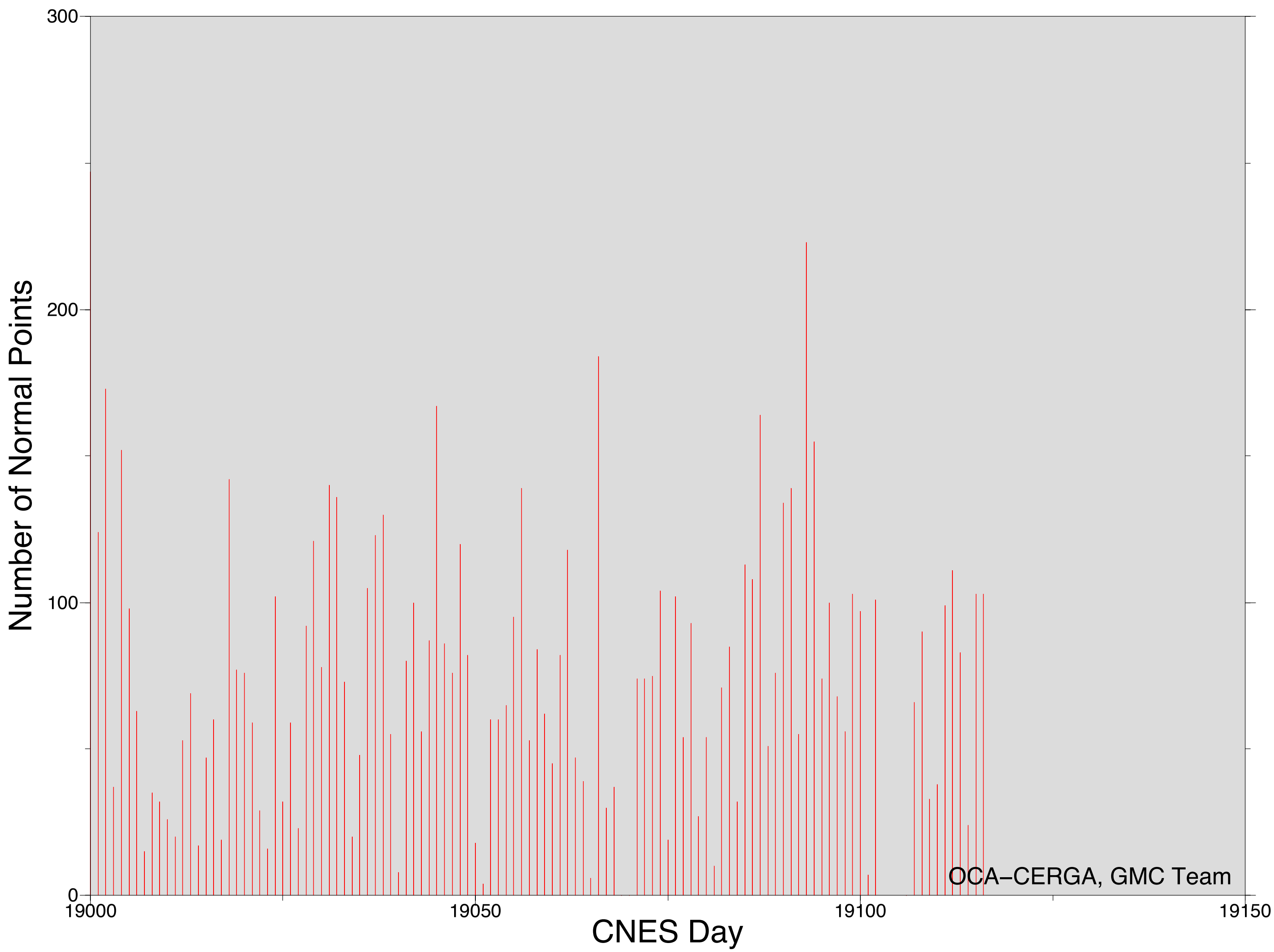
USA Area / Input Orbits from JASON−1 (MOE): global residuals





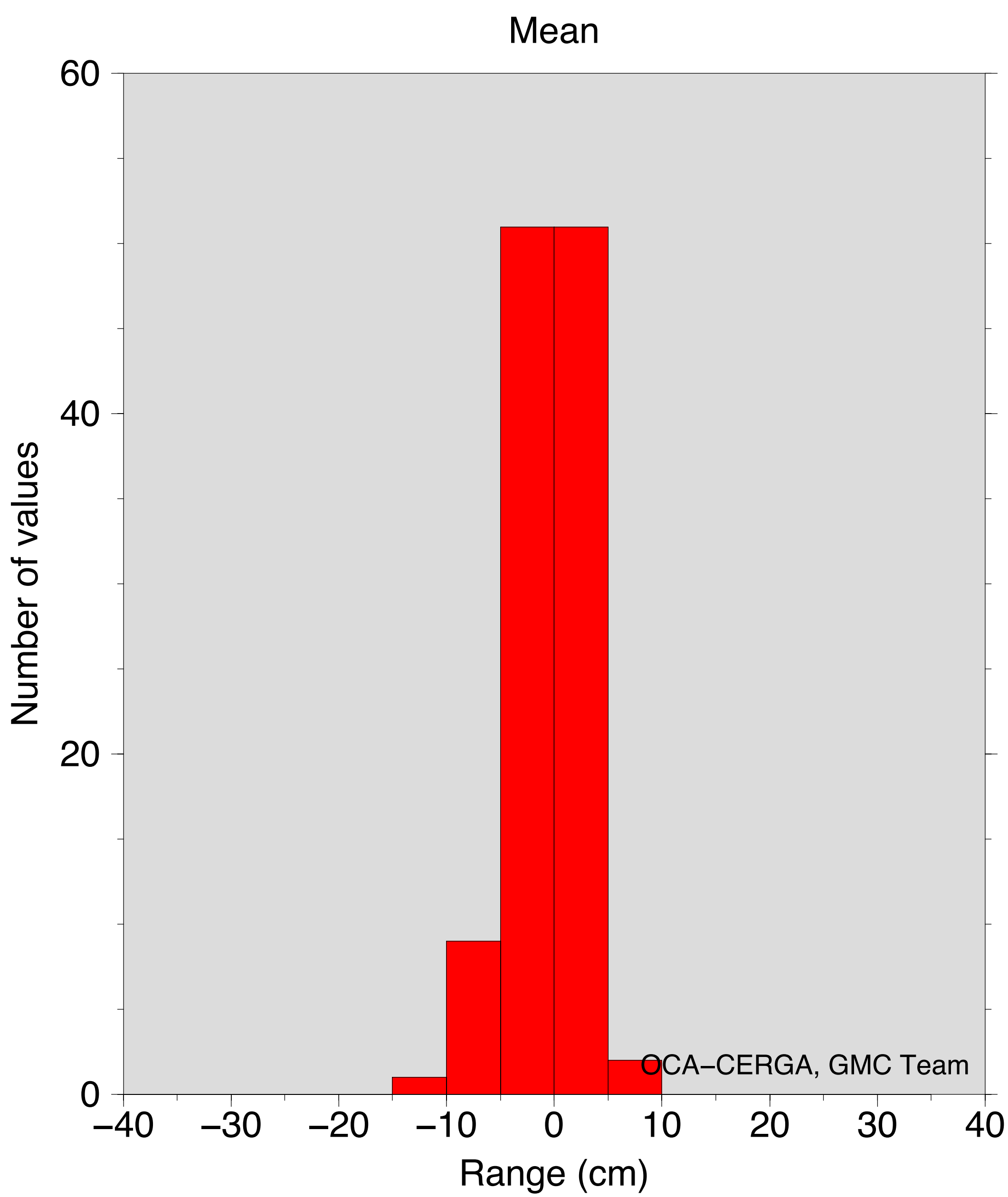
Number of SLR Residuals for T/P and JASON−1: all stations

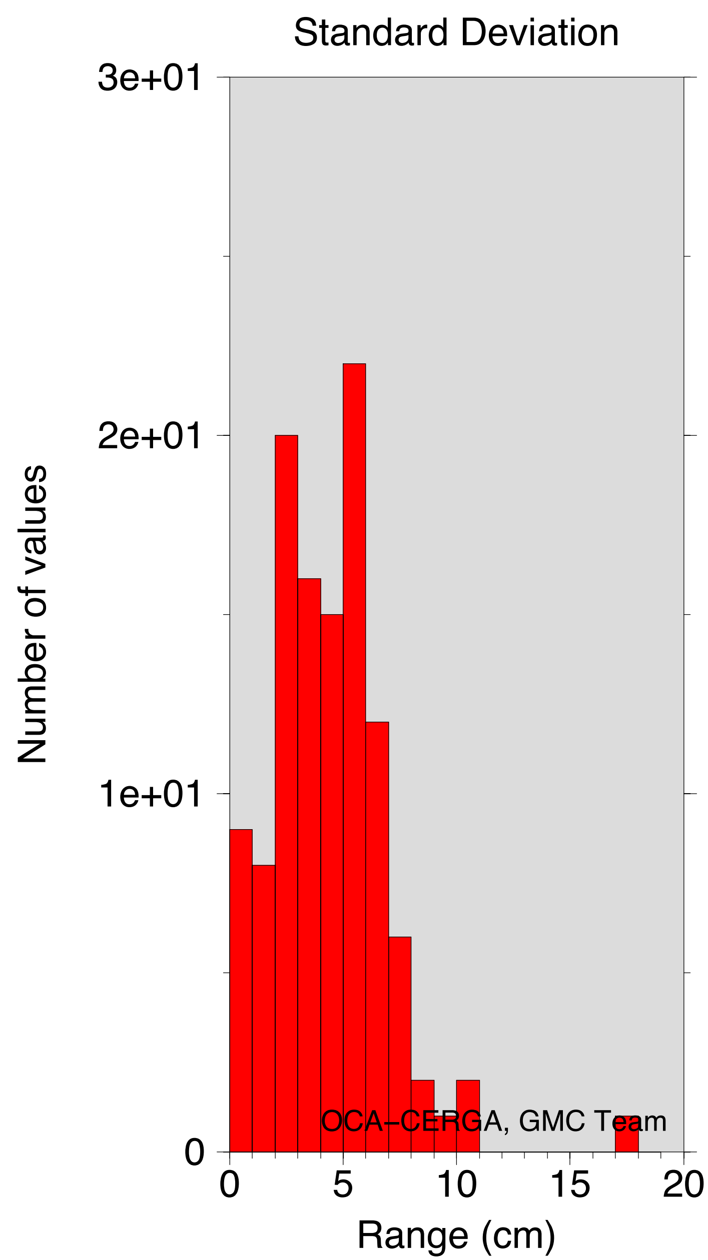
USA Area / Input Orbits from TOPEX/POSEIDON (MOE): global residuals



Histogram of SLR Residuals for T/P and JASON−1: all stations

USA Area / Input Orbits from TOPEX/POSEIDON (MOE): global residuals



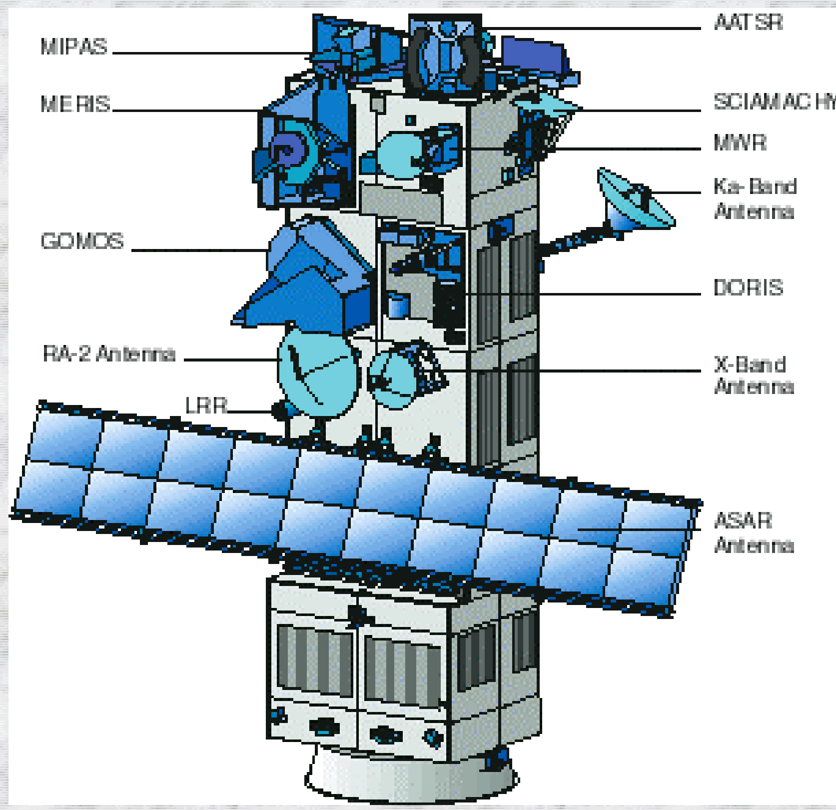


ENVISAT STATUS

Mission Status

SATELLITE SUCCESSFULLY LAUNCHED ON 1 MAR 2002 (CET)

ENVISAT STATUS/Instruments



Satellite Status

NOMINAL LEOP

Switch-on and Initial Verification: complete (except AATSR and SCIA that require a longer stabilisation)

Altimeter switch-on: successful
DORIS Switch-on: successful
MWR switch-on:successful
All other instruments:successful

ENVISAT STATUS/Orbit

ENVISAT ORBIT: SSO, 10 am solar time at descending node
ERS ORBIT: SSO, 10:30 am solar time at descending node

TANDEM : ENVISAT AND ERS on the same track at 30 mins

Reaching of the Tandem Configuration required a drift phase for several weeks

FINAL ORBIT REACHED ON 4 APRIL 2002

esa

ENVISAT Next Steps

Cal-Val for Altimeter, MWR and DORIS, incl. POD

Successful tracking by 17 stations

Intense Laser tracking will be needed until the end of the Commissioning (Sep 2002).

Laser Tracking will also be required during the Routine Phase, planned from Sep 2002

CONCLUSION

ESA ACKNOWLEDGES THE LONG-STANDING EFFORTS OF LASER STATIONS TO CONTRIBUTE TO THE SUCCESS OF ERS AND ENVISAT AND EXPECTS THAT TO CONTINUE WITH THE UPCOMING MISSIONS CRYOSAT (2004) AND GOCE (2006)

esa

Status SLR Tracking GRACE Mission

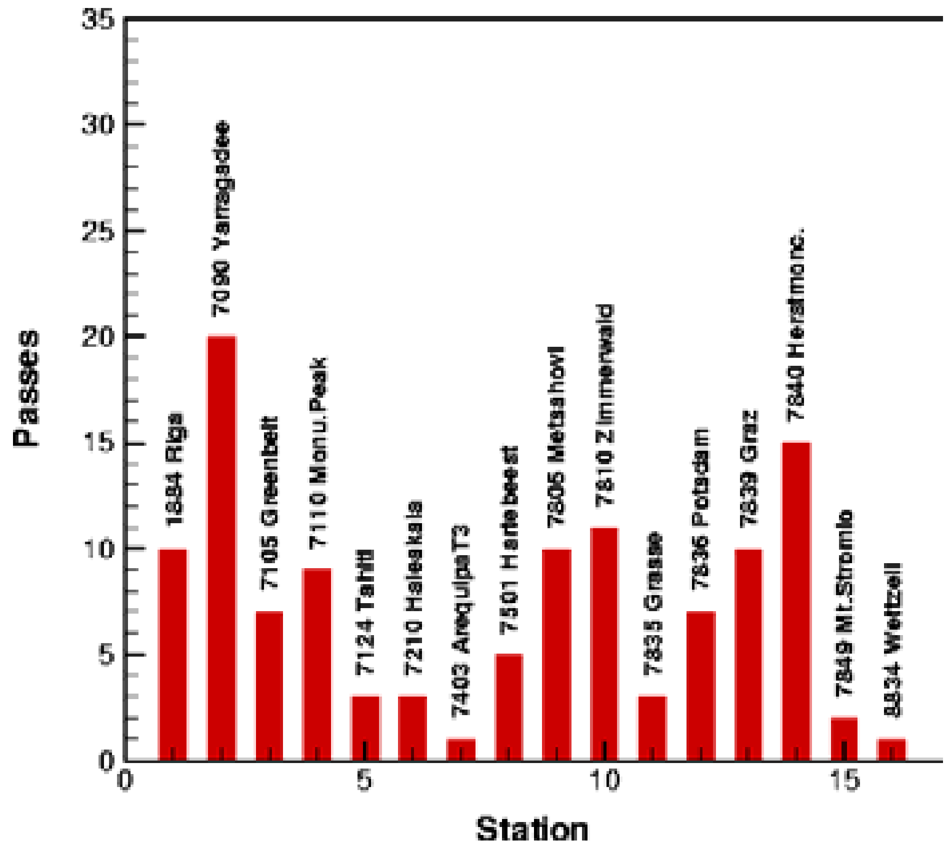
R. Schmidt, R. König, Ch. Reigber

GeoForschungsZentrum Potsdam (GFZ)
Division I: Kinematics and Dynamics of the Earth
Telegrafenberg
14473 Potsdam

Development/Status

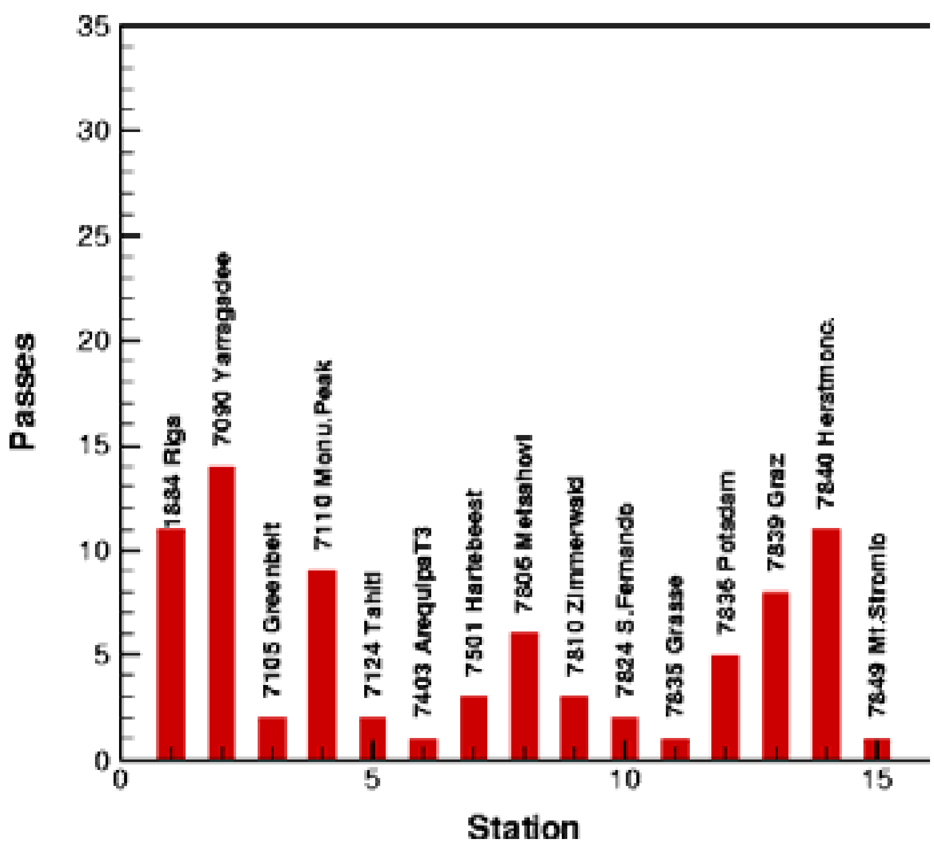
- successfull launch on March 17th, 2002, 09:21 UTC; nominal separation on March 17th, 2002, 10:46 UTC
- initial orbit determination and orbit predictions based on angle- and RADAR-tracking; after the switch-on of onboard GPS receivers standard orbit predictions derived from GPS navigation solution initiated (March 18th, 2002)
- first NPs for GRACE-A/B observed by Yarragadee on March 18th, 15:55 UTC in one pass
- generation of standard GRACE orbit predictions based on GPS navigation solution and SLR data turned to automatic mode
- prediction cycle at the moment set to 2 preditcs/day
- good quality of the GPS navigation solution data; rms in orbit determination 6 - 8 [m]

GRACE-A SLR-Tracking Mar./Apr. 2002



- 117 passes (Mar. 46 passes, Apr. 71 passes)
- 16 ILRS stations
- mean number of passes per day is 3 - 4; max. 9 passes on Apr. 4th
- in March two days of zero tracking due to orbit manoeuvres (calibration and stop/drift manoeuvres)
- tracking statistics in April shows stronger tracking of GRACE-A than of GRACE-B

GRACE-B SLR-Tracking Mar./Apr. 2002



- 79 passes (Mar. 27 passes, Apr. 52 passes)
- 15 ILRS stations
- mean number of passes per day is 2 - 3; max. 5 passes on several days in Apr.
- in March several days of zero tracking due to orbit manoeuvres (calibration and stop/drift manoeuvres)
- tracking statistics in April shows weaker tracking of GRACE-B than tracking of GRACE-A

Summary

- successfull SLR tracking initiated early in the beginning of the GRACE mission; rather quick transistion to automated operations
- tracking statistics reflect in general good quality of the standard GRACE orbit predictions based on GPS navigation solution and SLR data
- improvements of the orbit predictions are expected from a reduced latency of GPS navigation solution data and improved gravity field modelling from GRACE data
- unbalanced tracking statistics for GRACE-A and GRACE-B
- calibration/validation of the GPS tracking system using SLR data is ongoing

In case of questions/suggestions/comments feel free to contact us under:
rschmidt@gfz-potdam.de

GLONASS –Satellite System
(IGS and ILRS Tracking Status in 2002)

Between January 1 and May 31, 2002, there have been 7-8 healthy, operational GLONASS satellites. They are all in planes 1 and 3 of the constellation. The first new GLONASS-M satellite, GLONASS No. 711 in Plane 1/Slot 5, has not yet been designated as operational. It is not clear what if any problems may have been encountered after launch.

Microwave Technique / Tracking Status

The number of "permanent" IGLOS microwave tracking stations has grown slightly since December 2001. There are now 50 stations in the network, continuously tracking the GLONASS satellites and transmitting their data to the IGS Data Centers. Forty-five or more of these stations have been sending data to the data centers each week. Most of the receivers are Ashtech Z18 or JPS Legacy models. New stations that came on-line during the last three months include Frankfurt, Germany (FFMJ), Kourou, French Guyana (KOU1), and Zimmerwald, Switzerland (ZIMZ).

Satellite Laser Ranging / Tracking Status

The ILRS has agreed to continue to track three GLONASS satellites as part of their standard tracking protocol. In February 2002, the IGLOS Project Committee requested the ILRS to track two of the satellites in orbit plane 1 and one satellite in plane 3: Plane 1/Slot 1, Plane 1/Slot 3, Plane 3/Slot 24. A few weeks later Slot 1 has been set unhealthy, so this satellite was replaced by Plane 1/Slot 6.

Orbit Determination

BKG, ESA and the Russian Mission Control Center (MCC) continue to compute and make available GLONASS orbits on a routine basis. The MCC orbits are based on SLR data. A combination orbit is produced by Robert Weber, the IGS Analysis Center Coordinator, from the orbits of these three centers. Figure 1 below demonstrates the daily coordinate rms. of the center submissions with respect to the combined orbit (1998.8-2002.2). The consistency among all contributed orbit submissions is at the 20cm level, regardless of the basic observable. MCC orbit rms. numbers are of course somewhat noisier, caused by the low number of satellites tracked by ILRS. The visible bump in figure1 in summer 2001 is related to a mis-modelling of radiation pressure for satellite slot 8 by ESA. Just after fixing that problem the rms. numbers went down below the 20cm level.

Outlook

In May 2002 the IGS-CB integrated all combined GPS/GLONASS tracking sites within their official data site pool, which was a long lasting request of the IGLOS-Pilot Project. This step should encourage all IGS Analysis Centers to make increased use of the GLONASS data in their processing schemes and come up with a number of new or improved products. In the first place precise GLONASS orbits with an increased orbit accuracy of 1-3 cm in the radial direction should be sufficient to study in detail the reason of the remaining bias of a few centimetres between microwave and laser tracking observations. Moreover, in case of a new GLONASS launch to plane II (elevation of sun above the orbital plane up to 88 degree) we are looking forward to learn more about reliable radiation pressure models for the GLONASS satellites Thus, the ILRS is kindly asked to continue the tracking of GLONASS satellites and to provide laser based precise orbits.

James A. Slater (IGLOS-PP Chair)
Robert Weber (IGS Analysis Coordinator)

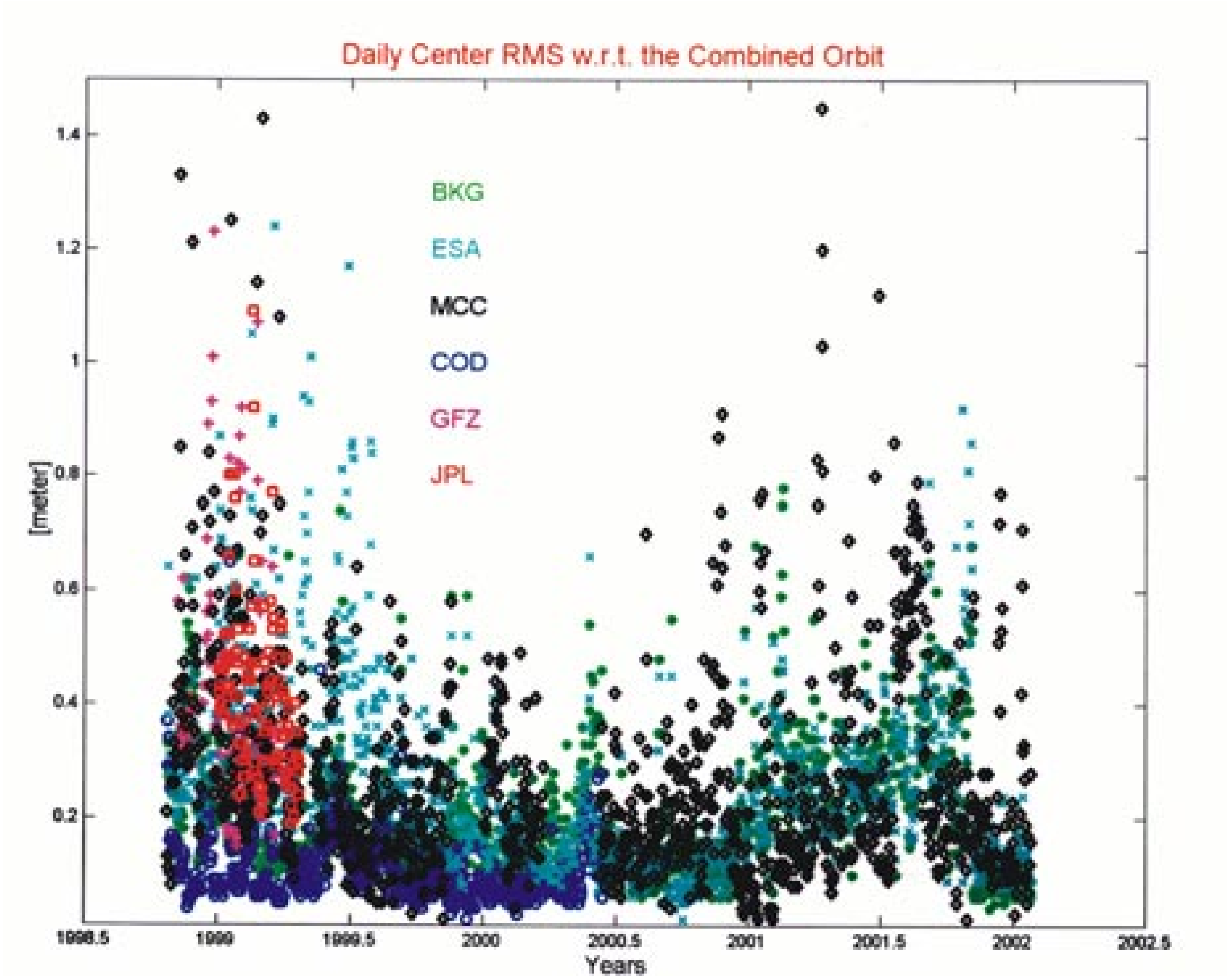


Figure 1