ILRS Governing Board

Technical University of Vienna
Vienna, Austria

April 23, 2012
19:00-21:30

ILRS Governing Board Agenda

1.	Opening Remarks	G. Appleby
2.	Central Bureau Report	M. Pearlman
	1. Network Update and Performance	
	2. Bi-Annual Report	
3.	Missions Update	G. Appleby/S. Wetzel
4.	Data Formats and Procedures Update	R. Ricklefs/H. Mueller
	1. CRD Status	
	2. Stations Reporting procedures	
5.	Analysis and Data Products	E. Pavlis
6.	GPS Retroreflector Array	D. McCormick/S. Wetzel
7.	Task Force Reports	
	a. Spacecraft Center-of-Mass Corrections	G. Appleby/T. Otsubo
	b. Beam Divergence	M. Davis
	c. Normal Point Definition	M. Pearlman
8.	Lunar Laser Ranging	J. Mueller
9.	Website Development	C. Noll/R. Ricklefs
10.	ILRS Special Issue in Journal of Geodesy	E. Pavlis
11.	ILRS Workshop 2012 in Frascati	S. Dell'Agnello
12.	GGOS Activities	M. Pearlman
13.	Other Business	M. Pearlman

ILRS Central Bureau Report

Technical University of Vienna
Vienna, Austria

April 23, 2012
14:00-16:30

ILRS Governing Board 2011-2012

Director of the Central Bureau	Mike Pearlman (appointed)
Secretary of the Central Bureau	Carey Noll (appointed)
President of IAG Commission 1	Tonie Van Dam (appointed)
IERS Representative	Bob Schutz (appointed)
EUROLAS Network Representatives	Giuseppe Bianco, Francis Pierron
NASA Network Representatives	David Carter**, Jan McGarry
WPLTN Network Representatives	Ramesh Govind. Hiroo Kunimori
Data Center Representative	Horst Mueller
LLR Representatives	Juergen Mueller
Analysis Representatives	Cinzia Luceri, Erricos Pavlis
At-Large Representatives	Graham Appleby*, Georg Kirchner

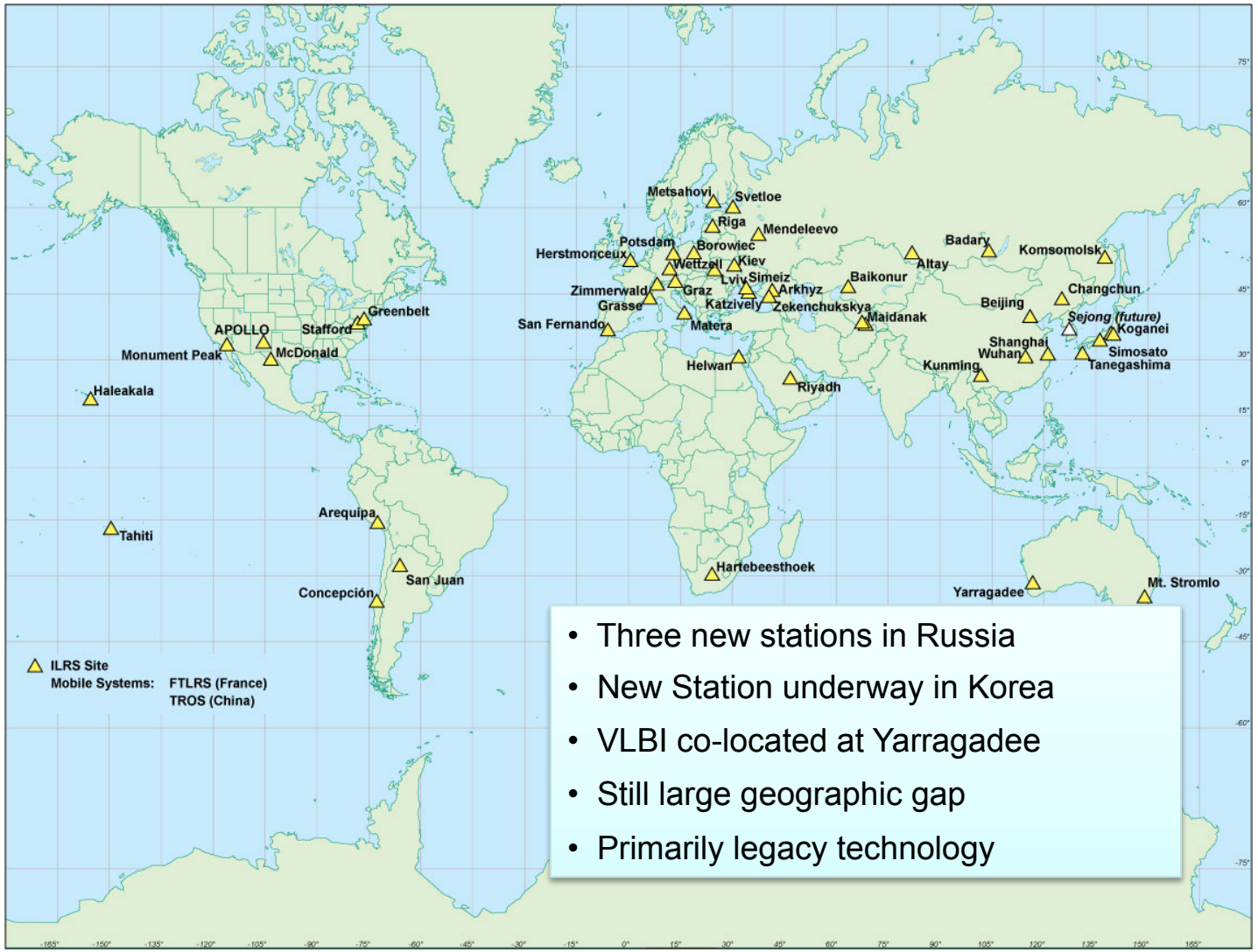
* Chair

** Being replaced by David McCormick

ILRS Working Groups

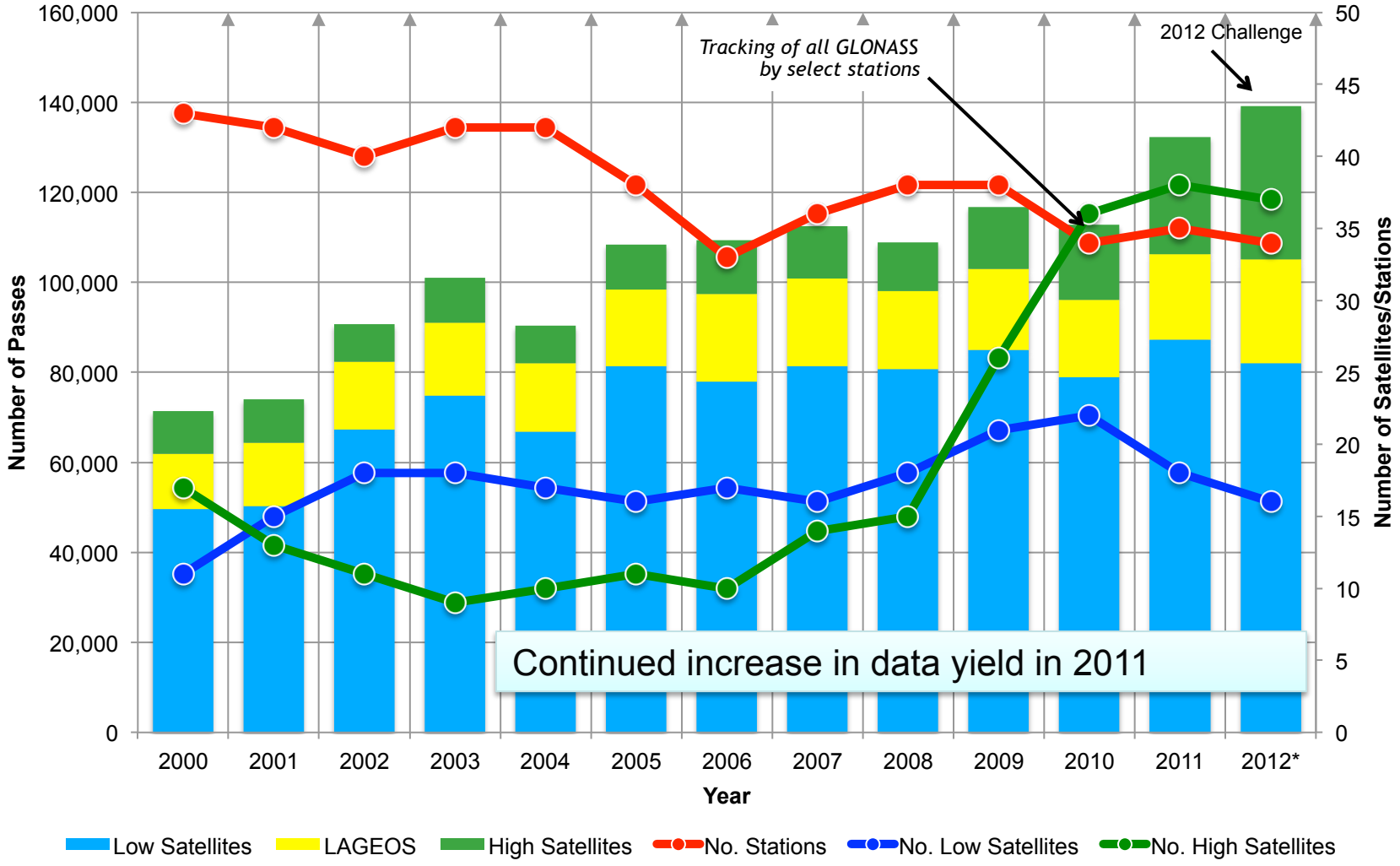
  - G. Appleby/S. Wetzel
- Analysis
  - E. Pavlis/C. Luceri
- Missions
- Data Formats and Procedures
  - H. Mueller/R. Ricklefs
- Networks and Engineering
  - G. Kirchner/M. Wilkinson
- Transponder
  - U. Schreiber/J. Degnan/J. McGarry

ILRS Network (April 2012)



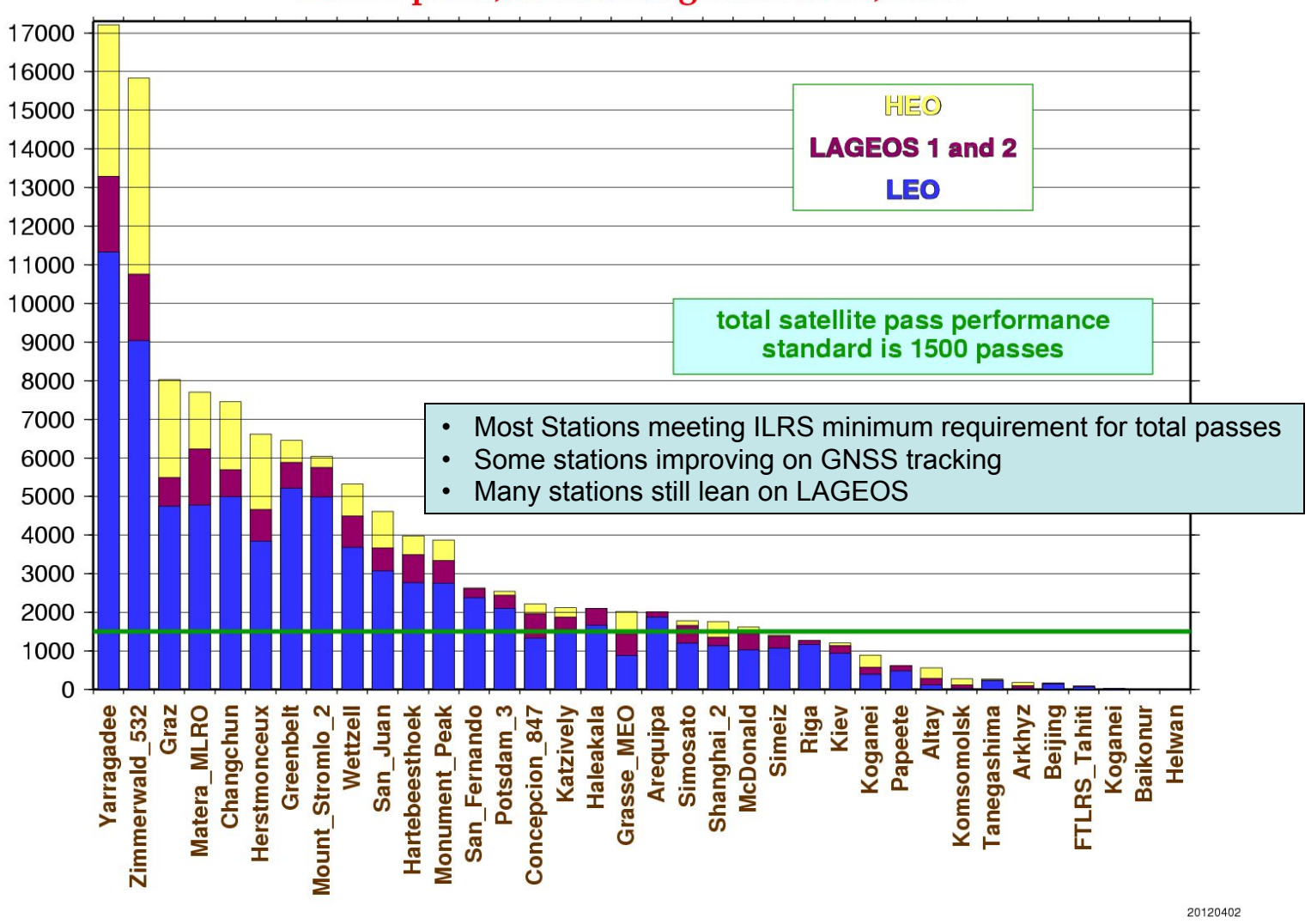
- Three new stations in Russia
- New Station underway in Korea
- VLBI co-located at Yarragadee
- Still large geographic gap
- Primarily legacy technology

Annual Data Yield

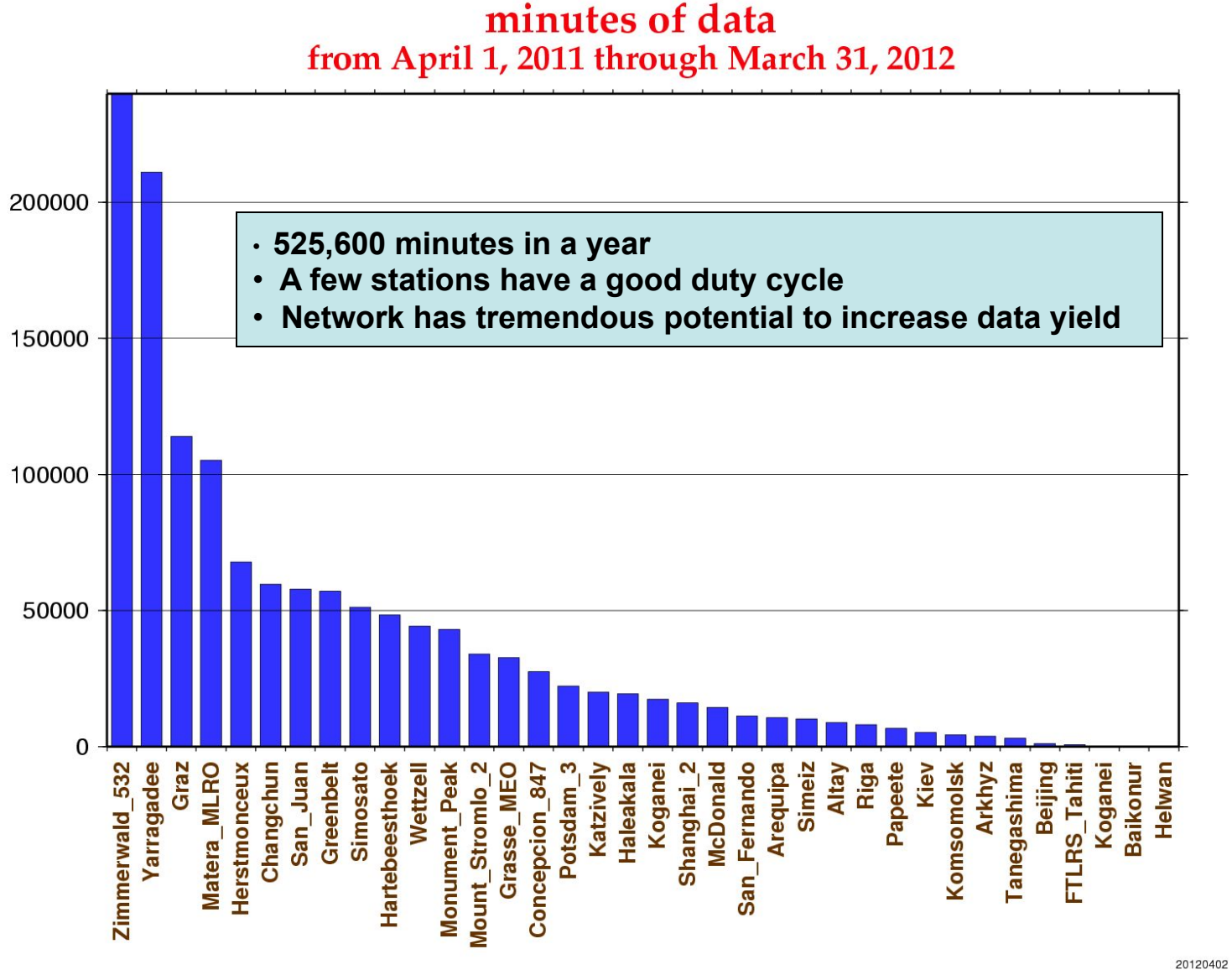


Note: 2012 totals pro-rated to full year

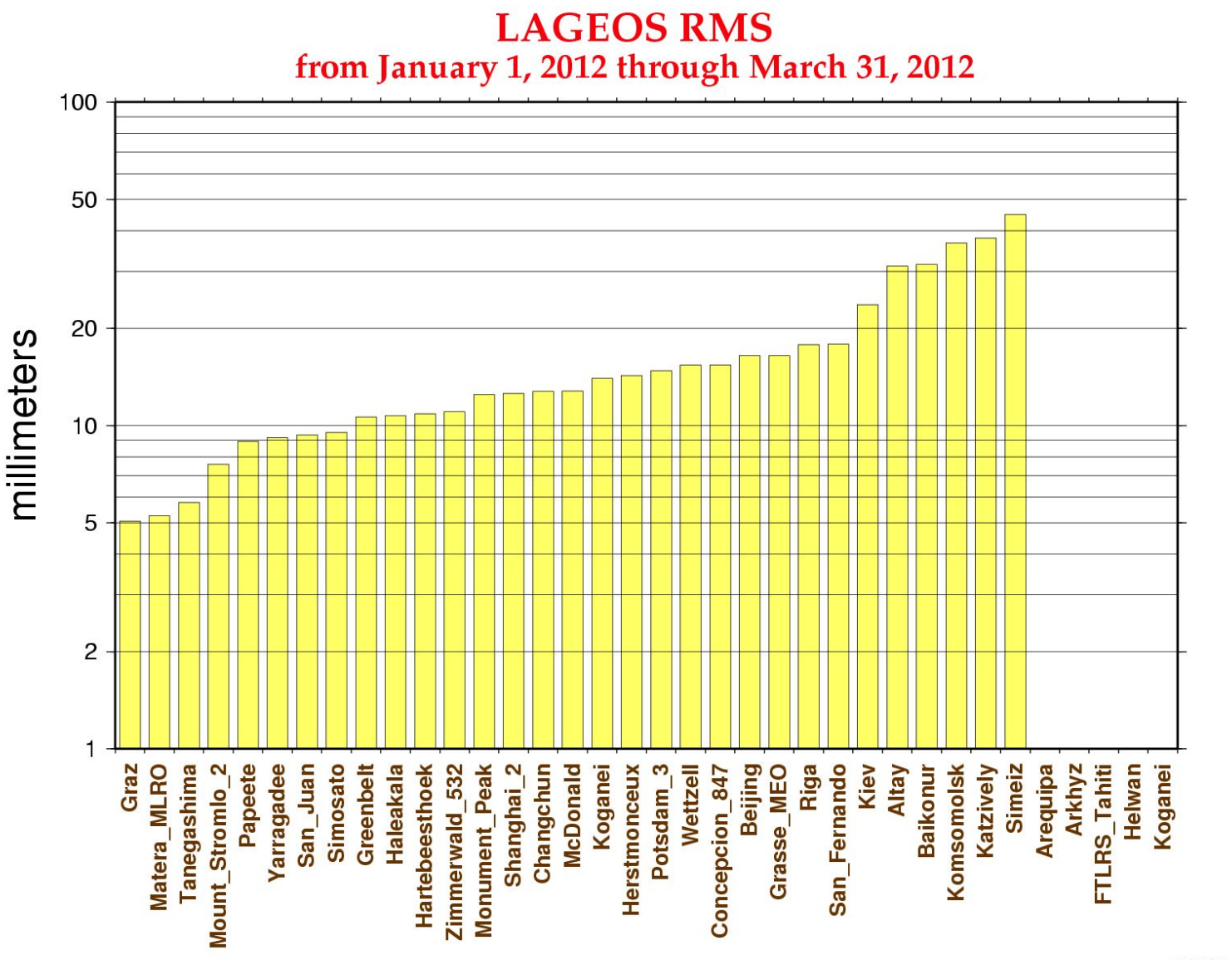
Station Performance (2012Q1)



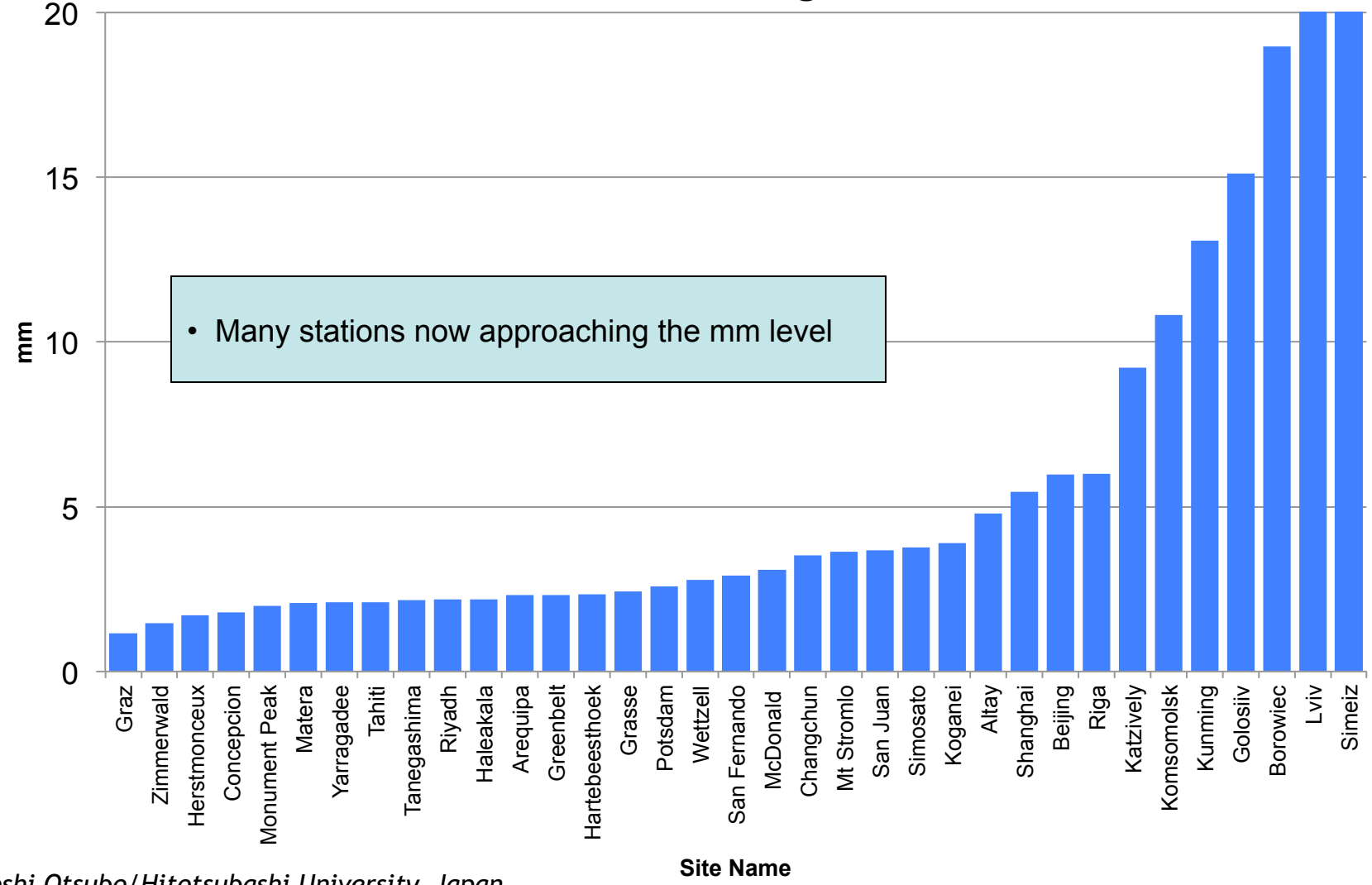
Station Performance (2012Q1)



Station Performance (2012Q1)



Station Performance
Estimated Range Bias

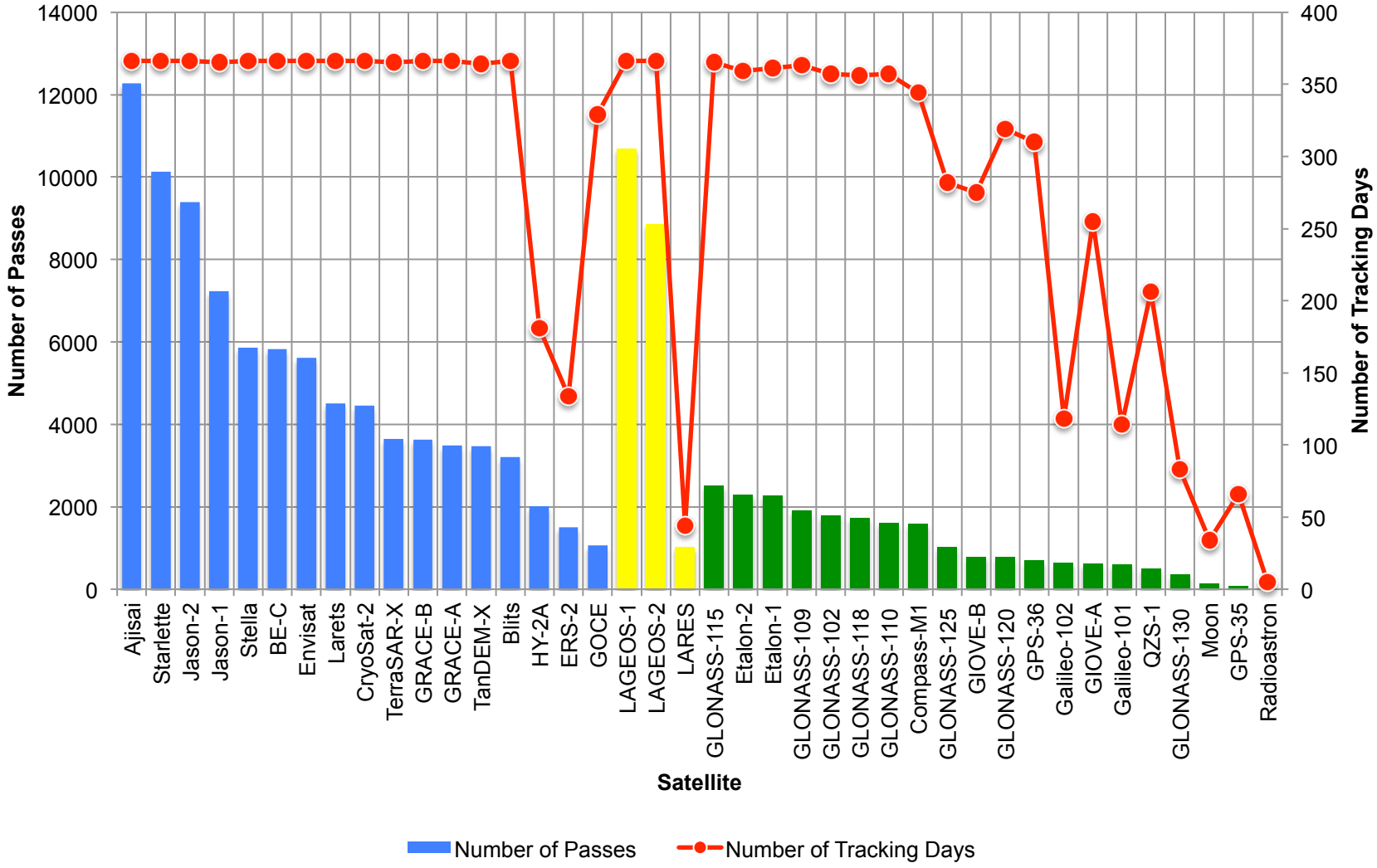


Toshi Otsubo/Hitotsubashi University, Japan

Mission Developments

- Currently supporting 56 missions (includes 26 GLONASS satellites) and lunar tracking
- Radioastron tracked by Grasse only; 11 passes since launch (18-Jul-2011)
- LRO-LR 20,260 minutes/2014.3 hours of data since launch
- Recent launches:
  - GLONASS-130 (28-Nov-2011)
  - ZY-3 (09-Jan-2012); still waiting on predictions
  - LARES (13-Feb-2012)
- Upcoming/Future:
  - COMPASS-M3, -G1, -I3 (approved)
  - IRNSS (ISRO): mid-2012 (awaits GB approval)
  - SWARM (ESA): Jul-2012
  - KOMPSAT-5 (KARI): 2012 (approved)
  - SARAL (CNES/ISRO): 2012

Satellite Tracking (2012Q1)



Central Bureau Items

- CDDIS and EDC data center structures, Q/C, and quarantining procedures supporting CRD-formatted data have been harmonized
- New normal point population recipe under review to take advantage of the high repetition systems
- Strengthen ILRS policies regarding station updates and quarantine of data following these updates
- All stations encouraged to submit full-rate data (including kHz) to be archived by the Data Centers
- Trying to strengthen the timely feedback and response procedures from the stations on maintenance, modification, and upgrades
- Adherence to processes for certification of new stations and requalification of stations after upgrading or significant downtime required
- Simplified algorithm to encourage stations to better distribute tracking efforts perhaps using the real-time web facility at AIUB needs to be developed
- ILRS 2009-2010 Report continues in preparation
- Proceedings from 17th International Laser Ranging Workshop in preparation
- Re-design of ILRS website underway to make it more responsive to user needs
- Deadline for CRD conversion has been pushed to May 9, but some stations have not answered our continuous inquiries

Revised Definition of the Normal Point
(Draft)

- Current Definition of the Normal Point specifies a standard normal point interval (SNPI) based on satellite altitude;
- Issue – some of the newer systems achieve plenty of FR data in far less time that the current FR interval;
- Task – New definition of the NP to accommodate this;
- Formula under discussion:
  - Target mm precision
  - The Normal Point is complete on Satellite 1 when either (1) 1000 **valid** FR points have been taken or (2) the SNPI has elapsed, whichever comes first;
  - Do not return to Satellite 1 until at least the SNPI has elapsed;
  - The “new normal points” can start at any time;
  - The epoch of the normal is that of a central FR data point.
- Task Committee: Georg Kirchner, Mike Pearlman, Jan McGarry, Graham Appleby, etc.

Satellite/lunar laser ranging Characterization Facility (SCF) Laboratory activities since June 2011

- SCF_LAB: SCF and its new, dedicated Clean Room infrastructure, 85 m^2, class 10000 or better
- Built and SCF-Tested 7 hollow retroreflector array for “ETRUSCO-2” ASI-INFN Project of technological development for GNSS. SCF-Test done in the Clean Room
- ETRUSCO-2 workshop on Nov. 7 2012, in conjunction with the ILRS ITLW-12 (5-9 Nov. 2012)
- SCF-Test of ESA’s Galileo In-Orbit Validation retroreflector published after ESA’s authorization. Paper on ILRS website
- LLR analysis: LNF performed preliminary measurement of lunar geodetic precession with J. Chandler of CfA
- LLR: 2nd Gen payload work making progress with D. Currie
- LLR: scientific agreement between Japan-US-Italy for SELENE-2 LLR: SCF-Test of Japanese hollow reflector; Currie/LNF lunar reflector as potential backup

NASA's Next Generation Satellite Laser Ranging System (NGSLR)

- High repetition rate single photon detection laser ranging system;
- Original concept by J. Degnan (GSFC, retired);
- Development continues at Goddard under the NASA Space Geodesy Project (SGP);
- Demonstrated tracking of Earth orbit satellites with altitudes from 300 km to 20000 km;
- Completion of the NGSLR prototype projected for early 2013;

Achievements & Status:

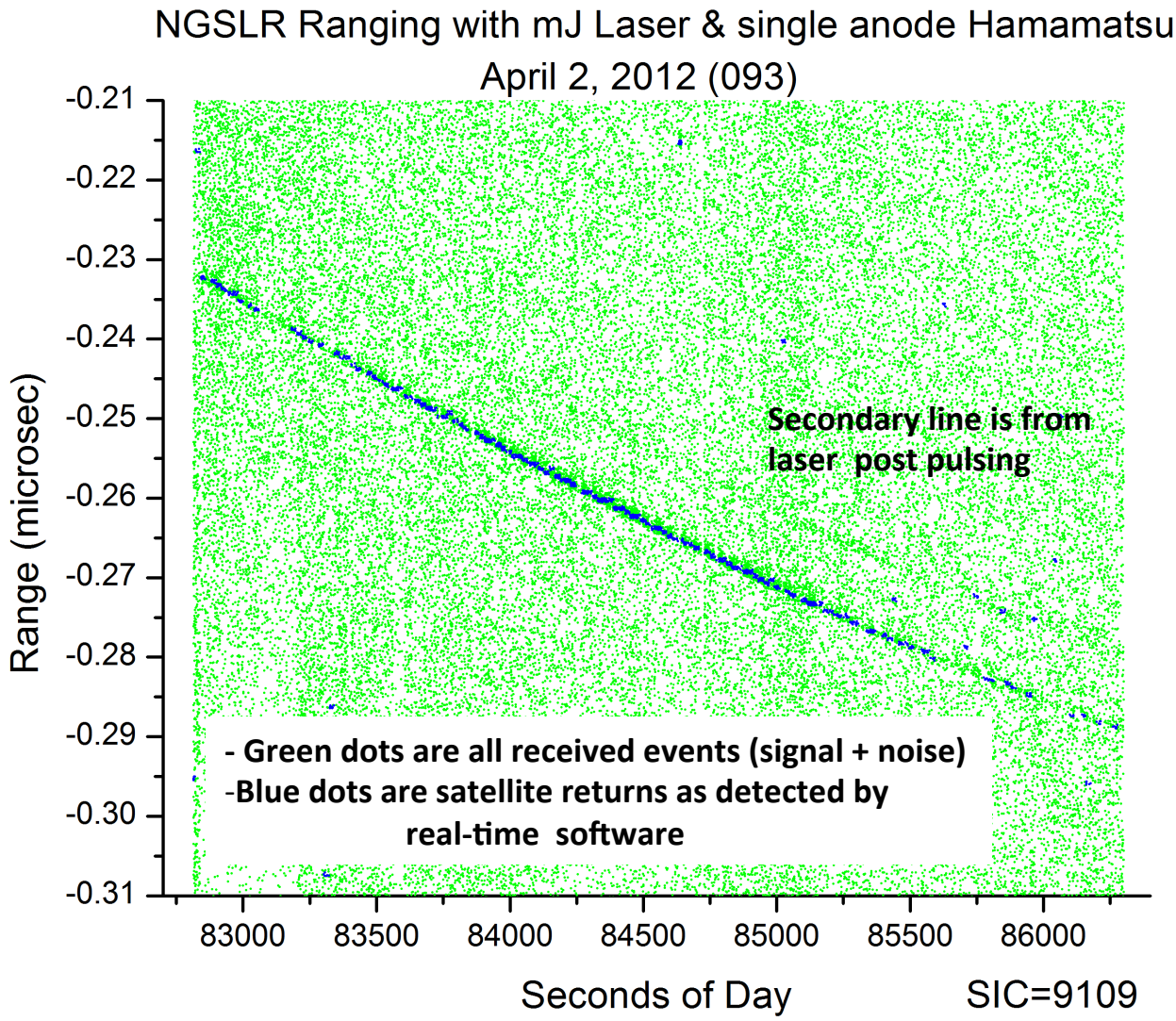
- **Daylight ranging to GLONASS-109 and -115**
- **Successfully tracked most of ILRS satellites.**
- **LEO, LAGEOS 1 & 2, and GNSS have all been successfully tracked in both daylight and night.**
- **New Photonics Industries laser in checkout**
- **Starting intercomparison testing with MOBLAS-7.**

System Features:

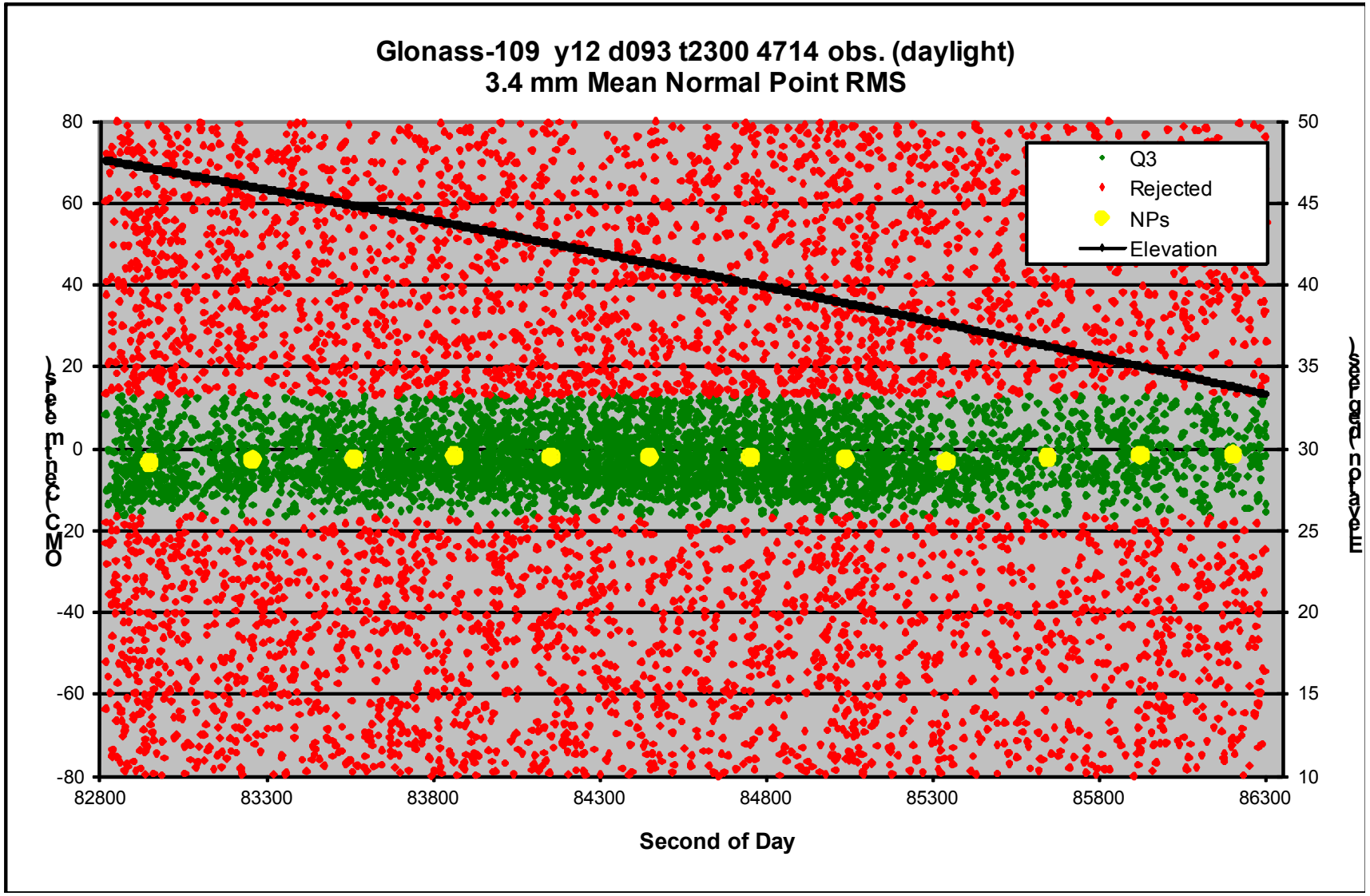
- 1 to 2 arcsecond pointing/tracking accuracy
- Track CCR equipped satellites to 20,000 km altitude, 24/7 operation
- Reduced ocular, chemical, electrical hazards
- Semi automated tracking features
- Small, compact, low maintenance, increased reliability
- Lower operating/replication costs

Daylight Ranging to GNSS

Measured Minus Station Predicted Ranges



Daylight Ranging to GNSS: Normal Pts



NASA mJ laser and Hamamatsu (40% QE) detector

Laser Ranging (LR) to the Lunar Reconnaissance Orbiter (LRO)

Status:

- Over 2000 hours of LRO-LR data in the 2.5+ years since launch;
- Nine stations supporting the program;
- Many 2, 3 and even 4-way simultaneous passes;
- Some days with almost complete 24 hour coverage;
- Precise orbit determination using LRO data underway;
- Preliminary analysis of 3-way geometric solution for orbit completed;
- Lasercom experiment successfully completed.

Planned

- 3-way simultaneous ranging between Europe, NGSLR and Hartebeesthoek;
- Time transfer experiments NGSLR to MOBLAS-7 and NGSLR to Wettzell.

ILRS LRO-LR NETWORK

Meetings

- **April 22-27, 2012: EGU General Assembly, TUW, Vienna**
- **April 20, ILRS AWG Meeting, TUW, Vienna**
- **April 23, ILRS GB Meeting, TUW, Vienna**
- **April 23, ILRS WG of Data Formats and Procedures, TUW, Vienna**
- **April 25, Joint IERS/Commission 1 Working Group on Ground Survey and Co-location, EGU**
- **April 27, GGOS Coordinating Board, TUW, Vienna,**
- July 23-27, 2012: IGS Analysis Center Workshop, Olsztyn, Poland
- August 13-17, 2012: AOGS-AGU Joint Assembly, Singapore
- August 20-31, 2012: XXVIII IAU General Assembly, Beijing, China
- September 25-26, 2012: IDS Workshop, Venice, Italy
- **November 5 – 9, 2012, SLR Workshop on Laser Ranging Space Segment, Frascati, Italy**
- **December 06-10, 2012: AGU Fall Meeting, San Francisco CA**
- **Fall 2013: 18th International Workshop on Laser Ranging, Japan**

ILRS Missions Working Group

Report to Governing Board
Monday April 23, 2012

Graham Appleby, Scott Wetzel

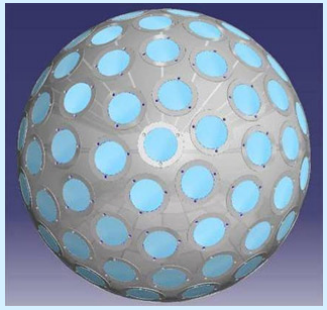
Mission support requests

- Mission sponsors fill in the ILRS web-based request forms
  - A general mission description, need for SLR, etc.
  - A detailed description of the LRA
- MWG then asked to comment via email
  - Includes AWG, SP, NEWG, DFPWG chairs
- Recommendation then to GB

Recent missions

- RadioAstron
  - In-space VLBI
  - Highly-elliptical, apogee at 350,000km
  - Link estimates (Davis) put returns in reach of several stations
  - Mission publishes regular station-schedules
    - Recent correspondence with mission to get better early warning of pass times
  - GRASSE-MEO so far only station to track successfully
  - LLR-capable stations in particular are still encouraged to track

Recent missions



- Recently Launched:
- LARES, (ASI, geodetic) – 13 Feb 2012
  - Successful target for whole network
- ZY-3, (China, topography, EO) - 9 Jan 2012
  - still waiting on predictions

- Recently approved:
- Swarm (ESA. magnetic field, three LEO satellites)
- Three new COMPASS satellites (1 MEO, 2 GEO)

- Under review:
- IRNSS (India, Regional GEO GNSS)

General remarks

- Quite a lot of new missions applying for support;
- MWG now very responsive
  - Full membership participation, timely
- General principle within MWG:
  - future open availability of mission data (e,g., onboard GPS) is an issue when ILRS is deciding whether or not to recommend tracking support:
    - Discussed at GB December 2011

ILRS DF&P WG

- WG charter
- Software Library
- Data QC consistency
- Data handling consistency
- CRD status
- Station reporting procedures

CRD status

- May 2 conversion data set
- New data only distributed In CRD format; non-CRD stations' data will be forward converted to CRD format
- Stations will be told to stop sending old format a couple weeks later
- Data status
  - Old format in Data Centers agree
  - CRD data in Data Centers agree after a couple days. (Possible station issues)

Station Change Reporting

- Clarified procedures to be posted to ILRS web site and sent to stations on occasion
- Requires stations to submit update plans to CB in advance, which will decide whether data needs to be quarantined
- Stations will notify and work with CB, OCs, AWG when data is sent after upgrade
- OCs will quarantine data until AWG says it has passed appropriate tests

ILRS Analysis Working Group Report to

ILRS Governing Board Meeting

Vienna, Austria, April 23, 2012

Erricos C. Pavlis and Cinzia Luceri

Analysis Coordinators

ILRS AWG News

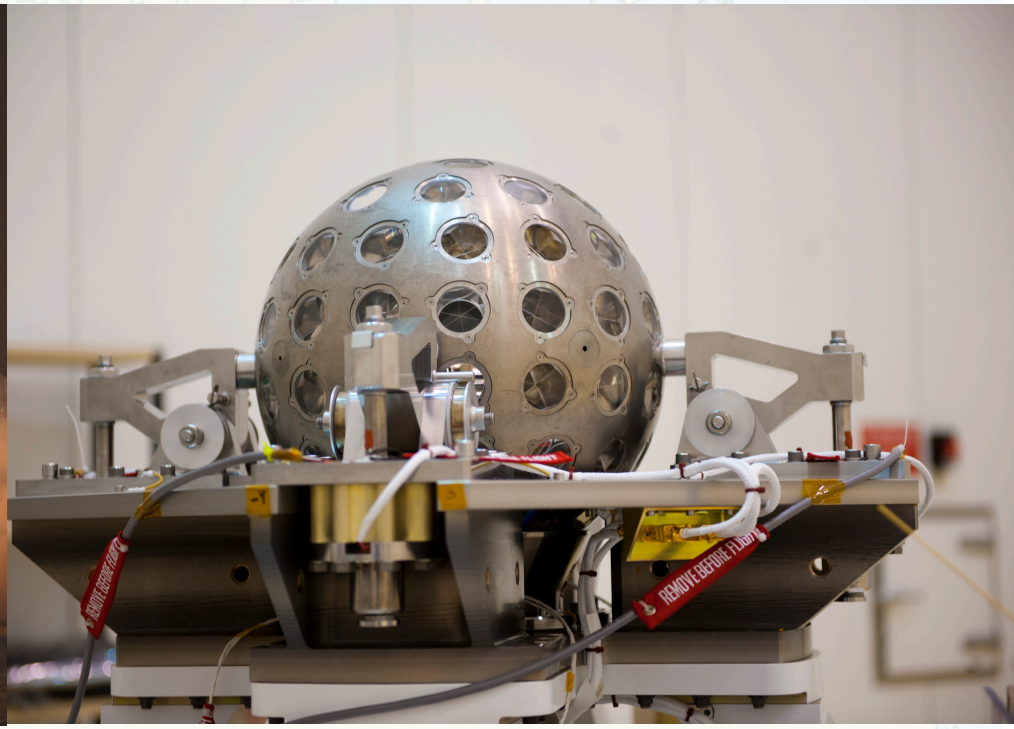
- **Analysis:**
- Operational products (weekly & daily) delivered routinely and on time from all nine ACs:
  - **ASI** (AC & CC), BKG, DGFI, ESA, GA, GFZ, GRGS, **JCET**(AC & CC), & NSGF
- New CoG model for LAGEOS & ETALON (*site- and time-dependent with ~2 mm accuracy*) tested in Pilot Project– **adoption postponed until further testing (*current results do not show clear improvement*)**
- ILRS AWG will switch official product on May 2:
  - **The DAILY product will become the official operational product (2-day latency)**
  - **The current WEEKLY product will be used as a test bed in PPs for modeling improvements, eventually to become the "definitive" product with a multitude of new features (e.g. atmospheric corrections, low degree harmonics, etc.)**
- PPs schedule shifted to accommodate ITRS/GGFC PP for testing atmospheric corrections at observation level (using GGFC input data) by July 1, 2012

ILRS AWG News – cont.

- **Analysis (cont.):**
- Re-analysis for 1983 to present to begin once all improvements have been tested and validated by all ACs (*Summer/Autumn of 2012*) and the ITRS
- As the ILRS is switching to the CRD format on May 2, the AWG plans to continue validating the implementation of CRD at existing sites which have not yet implemented it, e.g. Riyadh and Borowiec (their data will be reformatted to CRD by the OCs until they pass the validation tests), as well as entirely new sites that will join the network
- The AWG held its Spring meeting at TUW yesterday, April 21, 2012, and scheduled the Fall meeting to coincide with the ILRS Technical Workshop in Frascati, Italy, on Saturday, November 3, 2012.
- The ILRS AWG all-day meeting at TUW was attended by a large group of ILRS associates and several colleagues from other techniques

New Target: LARES

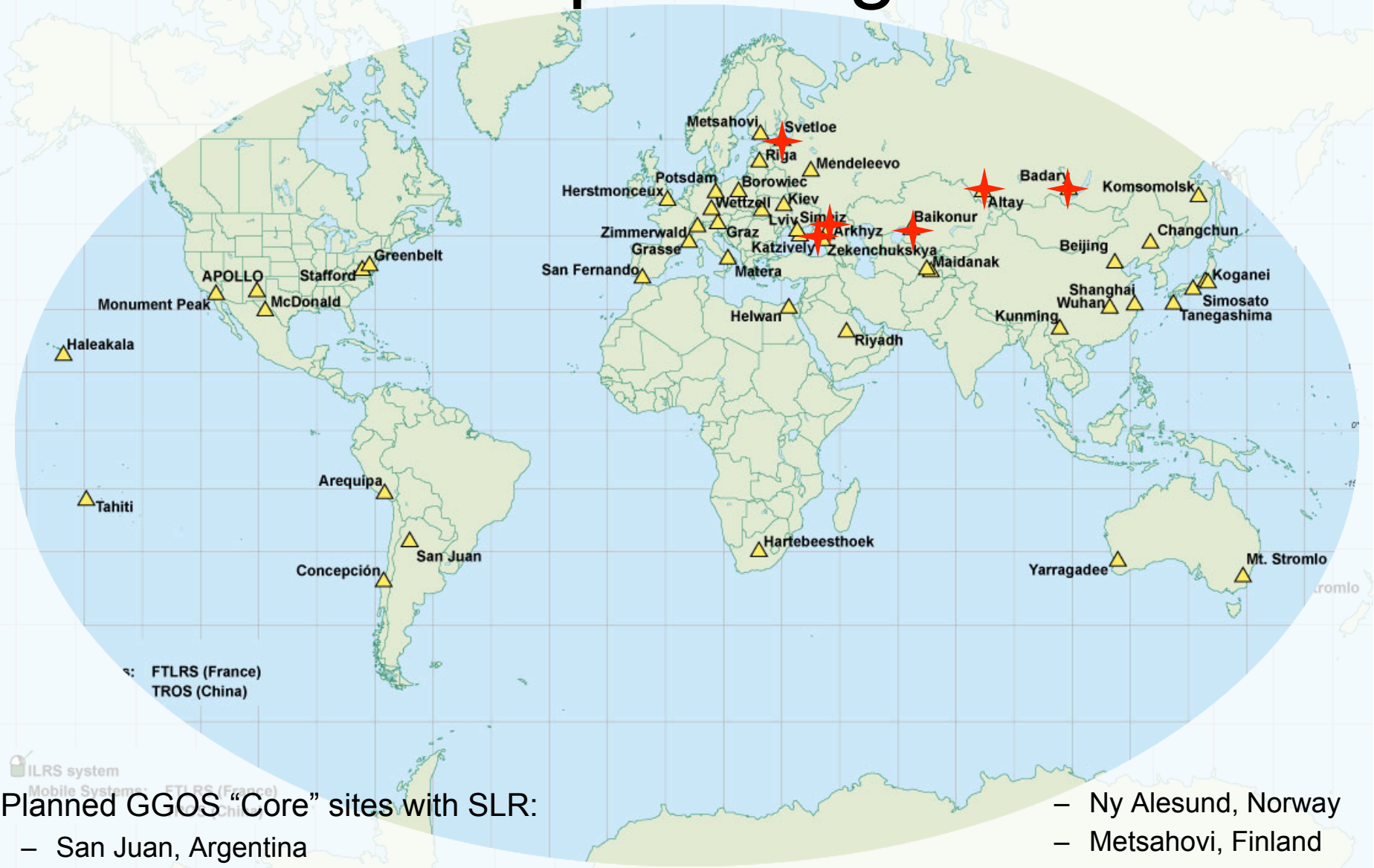
- ASI's LARES launched perfectly on February 13, 10:00 UTC 2012 from Kourou, Fr. G. on the inaugural launch of ESA's new launcher VEGA
- Cannonball constellation now has a new member – LARES!
- Initial data analysis indicates that LARES is much closer to a point mass particle than LAGEOS, requiring much smaller empirical accelerations in fitting the data



AWG – Operations Issues

- **Network and Operations:**
- DC harmonization much closer to 100% compared to last year
- Data flow problems are now resolved by and large
  - Online monitoring of data availability now at CDDIS and EDC
- **ILRS will finally switch to new data format on May 2: AWG is ready for this at all ACs**
- Stations undergoing repairs/upgrades resulted in poor data yield for a few months in 2011
- Several new and old international stations joined/returned to operations recently, improving network geometry and data yield:
  - **Returning:** *Mon. Peak, Arequipa, Haleakala, Potsdam, Tahiti, Riyadh, Koganei, Tanegashima, Beijing*
  - **New:** Arkhyz, Komsomolsk, Badari, Baikonur, Zelenchukskaya, and Svetloe

New & Upcoming Sites



- Planned GGOS "Core" sites with SLR:
  - San Juan, Argentina
  - Yebes, Spain
  - Ny Alesund, Norway
  - Metsahovi, Finland
  - Sejong, S. Korea

ILRS Publications

- **Annual Report:**
- The AWG contributions to the 2009-2010 Annual Report completed
- **ILRS Special Issue in the Journal of Geodesy:**
- Progressing slowly mainly due to the editors' limited amount of time for this task
  - Over 24 submissions, 3 abstracts pending finalization, selections this spring
  - Planning for a completed review process by end of 2012
- **Future Meetings:**
  - The AWG will meet again prior to the ILRS Technical Workshop in Frascati, Italy, (*November 5-9, 2012*), on Saturday, November 3, 2012
  - 18th International Workshop on Laser Ranging to be held in Tokyo, fall of 2013
  - The next Spring meeting of the AWG will take place on SUNDAY, April 7, 2013, at the TUW
  - The IERS is planning a "Retreat" on April 4-5, 2013 prior to the EGU where several ILRS associates will be required to represent ILRS with presentations (more on this in the near future)

ILRS SI @ JofG

#	TITLE	Lead Author(s)
0	Foreword	The Guest EB
1	The International Laser Ranging Service (ILRS): The First Decade and Beyond	Pearlman, Appleby, Noll, Pavlis, Torrence
2	Information Resources Supporting Scientific Research for the International Laser Ranging Service	Noll, Horvath, Ricklefs, Schwatke, Torrence
3	*Past, Present and Future of the ILRS Global Tracking Network*	*Wetzel, Horvath, Carter, Pierron, Bianco, Govind, ???* **Peter Dunn**
4	Next Generation Satellite Laser Ranging Systems	Degnan, McGarry, Kirchner, Appleby, Prochazka, Jäggi, Moore, Artyukh, Samain, Schreiber
5	Geodetic satellites: a high accuracy positioning tool	Pearlman, Arnold, Davis, Barlier, Biancale, Vasiliev, Paolozzi. Ciufolini, Pavlis
6	Satellite Laser Ranging to Global Navigation Satellite Systems	Thaller, Dell'Agnello, Fumin, Govind, Nakamura, Noda, Springer
7	Lunar Laser Ranging – A Tool for General Relativity, Lunar Geophysics and Earth Science	J. Müller, Murphy, Schreiber, Shelus, Torre, Williams, Boggs
8	Interplanetary Ranging	Degnan, Schreiber, McGarry, Sun, Zagwodzki, Murphy, Samain, Turyshev
9	Target Signature Systematic Errors for Geodetic Satellites and Novel LR Array Design	Appleby, Otsubo, Arnold, Kirchner, Neubert, Grunwaldt, Vasilliev
10	Data Quality Control Service for the ILRS Tracking Network	Otsubo, H. Müller, Pavlis, Torrence, Thaller, Glotov, Xiaoya, Appleby
11	Systematic errors in SLR Data: Documentation and Discussion of their Sources	Luceri, H. Müller, Vei, Appleby and Pavlis
12	Operational and Definitive Products of the ILRS Analysis Working [illegible]	Sciarretta, Luceri, Pavlis and Kelm
13	*Monitoring Mass Redistribution in the Earth System with SLR*	*Pavlis, König, Ries, Deleflie, Cheng, H. Müller, ???*
14	*The ILRS Contribution to the International Terrestrial Reference Frame (ITRF)*	*Pavlis and the AWG ACs and CCs*

We also have EIGHT (8) "un-solicited" abstracts so far

1) **BOLD** indicates working title from author(s) for a submitted abstract
2) RED indicates lead author
3) *Non-bold entries in italics are still pending!!!*

Report from Task Force – Spacecraft Centre of mass Corrections

Graham Appleby

Toshi Otsubo

NATURAL ENVIRONMENT RESEARCH COUNCIL

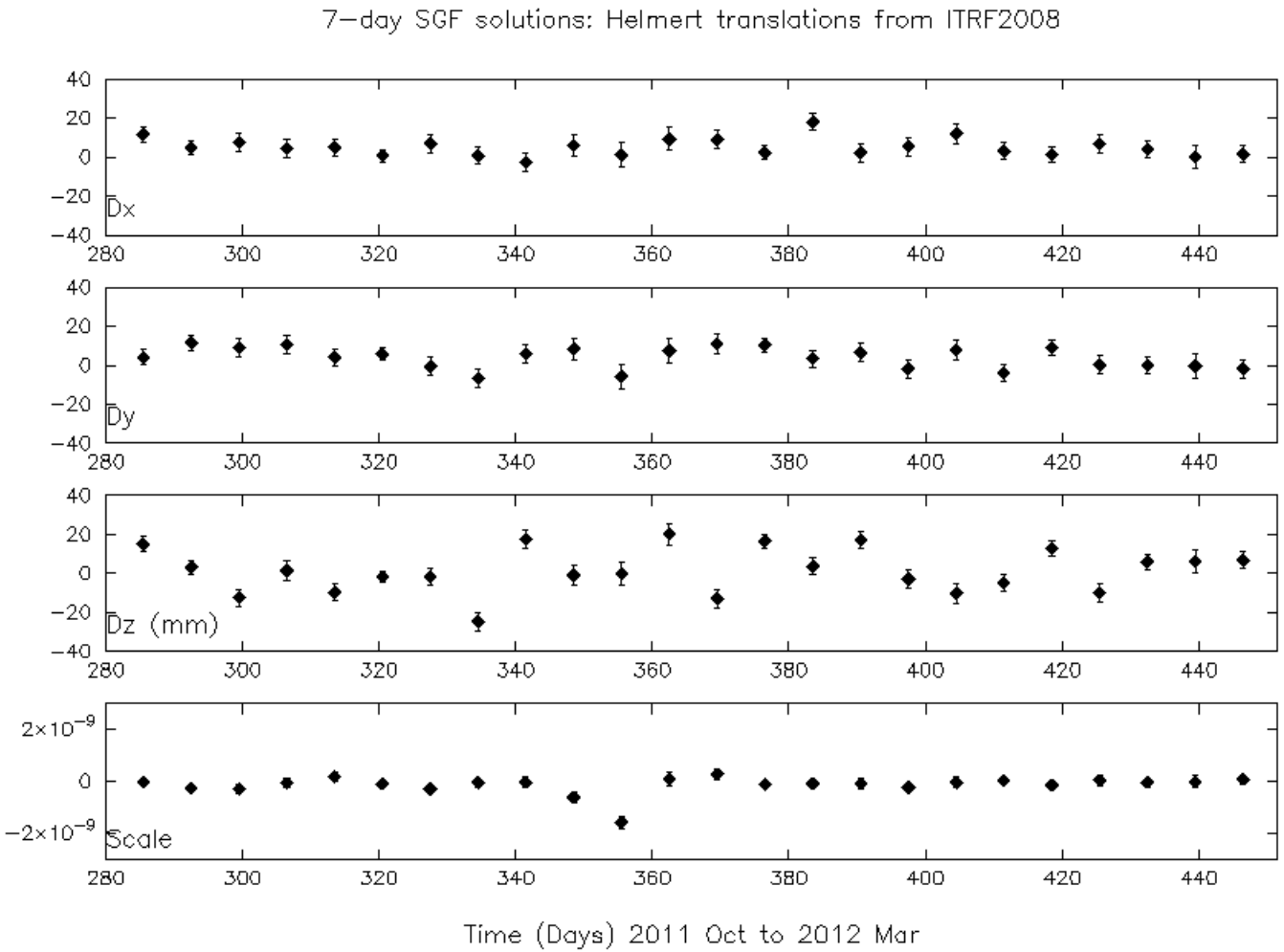
Detail from CoM table for LAGEOS

Station	Time-span		detector info	CoM min, max, adopted (mm)					
7838	01 04 2008	31 12 2050	20 MCP CSM	3.0	6	15	252	248	**250**
7838	01 07 1990	01 04 2008	100 MCP CSM	3.0	20	40	252	248	**250**
7839	01 01 1983	31 12 2000	300 PMT NC	3.0	120	150	245	241	**243**
7839	01 11 1981	08 10 2003	35 CSP NCM	2.2	3	9	255	250	**252**
7839	09 10 2003	31 12 2050	10 CSP NSF	2.2	3	9	255	250	**252**
7840	01 02 2007	31 12 2050	10 CSP CS	2.5	3	9	245	245	**245**
7840	31 03 1983	31 03 1992	100 PMT NCF	3.0	35	45	252	244	**248**
7840	31 03 1992	31 12 2050	100 CSP CS	3.0	6	15	246	244	**245**
7841	20 07 2001	31 12 2050	50 PMT CSF	2.5	10	18	254	248	**251**

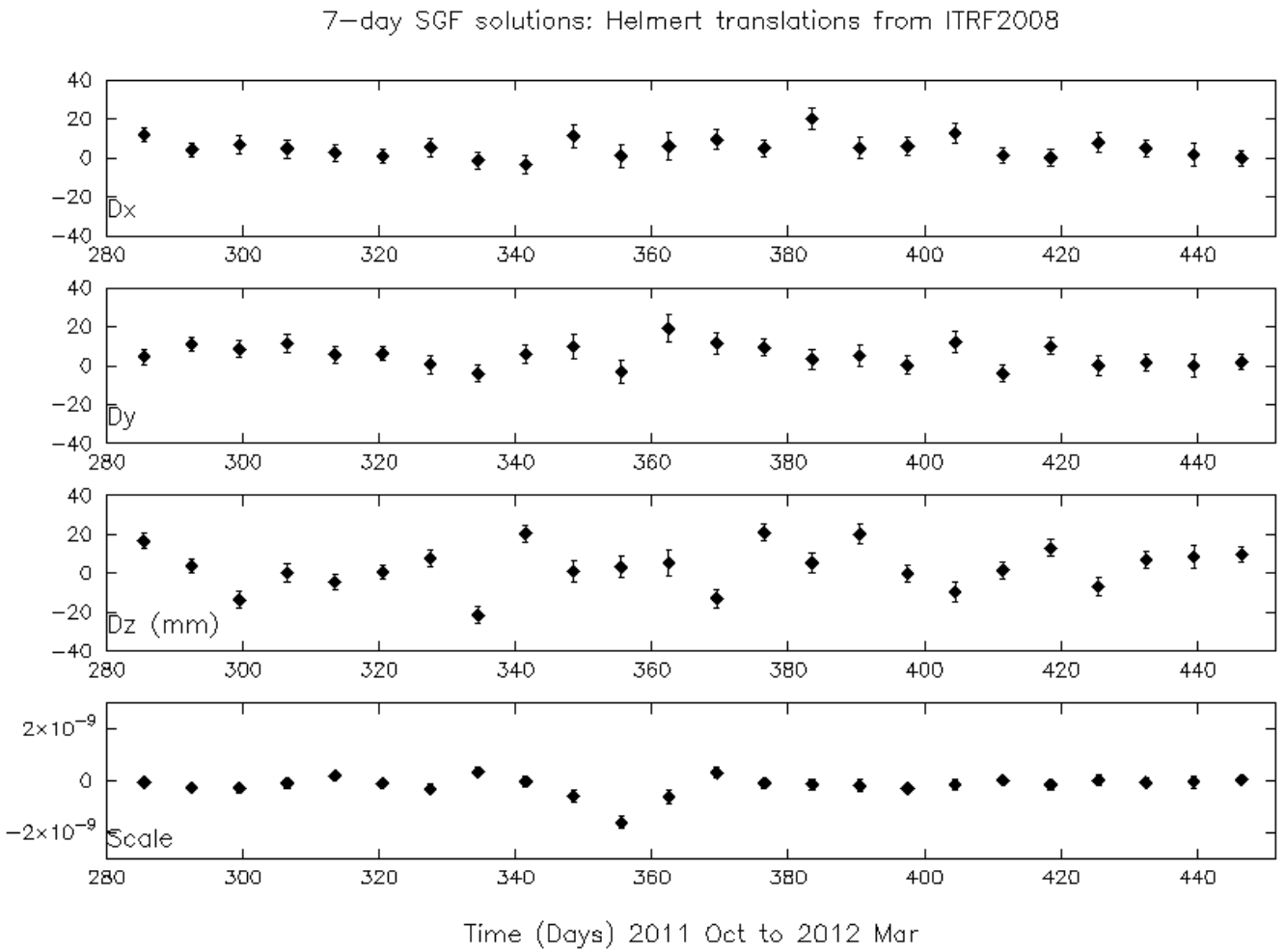
AWG Pilot Study CoM

- In common with all ACs, SGF carried out two weekly solutions, from October 2011:
- One (v30) the standard pos+eop
- Two (v35) using the new CoM correction tables, epoch and station-dependent
- Then Helmert (7-parameter) mapping of each weekly solution onto SLRF2008

‘Standard’ v30 solutions



New-CoM v35 solutions



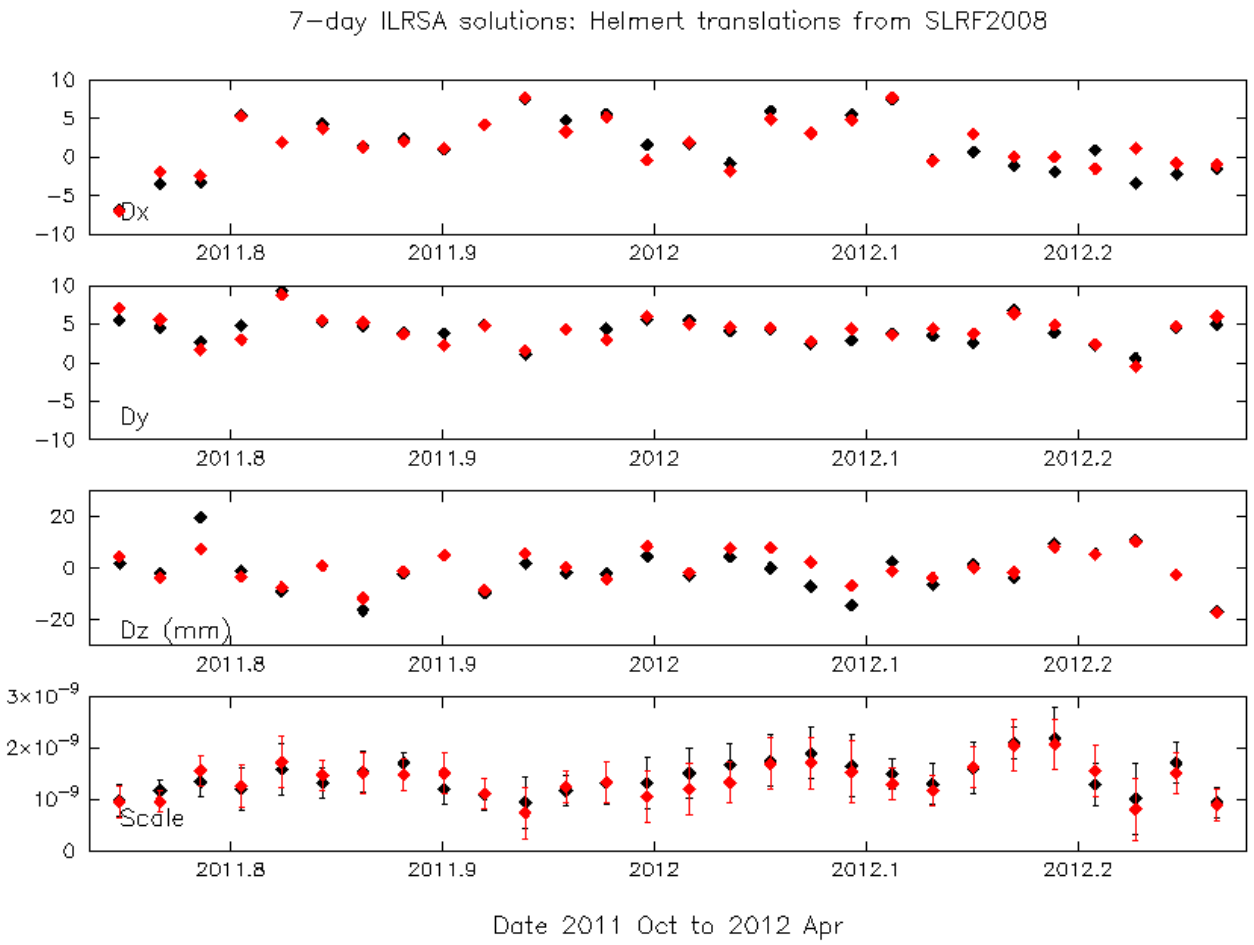
Summary of v30-v35 differences

- V30 mean scale difference from SLRF2008:
  - -0.13±0.05ppb
- V35 mean scale difference from SLRF2008:
  - -0.16±0.05ppb
- Difference in scale driven by more careful use of CoM values is only 0.03ppb

AWG Pilot Study CoM

- Also took weekly Helmert parameters from ILRSA summaries
- Primary CC maps ILRSA weekly combined v30 and combined v35 solutions each onto SLRF2008
- V30 average scale is 1.44ppb
- V35 average scale is 1.38ppb
  - Difference of 0.06ppb
- But of course GM is not a free parameter

Differences between ILRSA v30 and v35 combined solutions



CoM conclusions

- Not major issue?
- But important to model as well as possible
- Must consider CoM effects in context with those of poor site-ties and range measurement error issues
- Can we really say that some sites are range-error free?

Progress with updates to SATAN

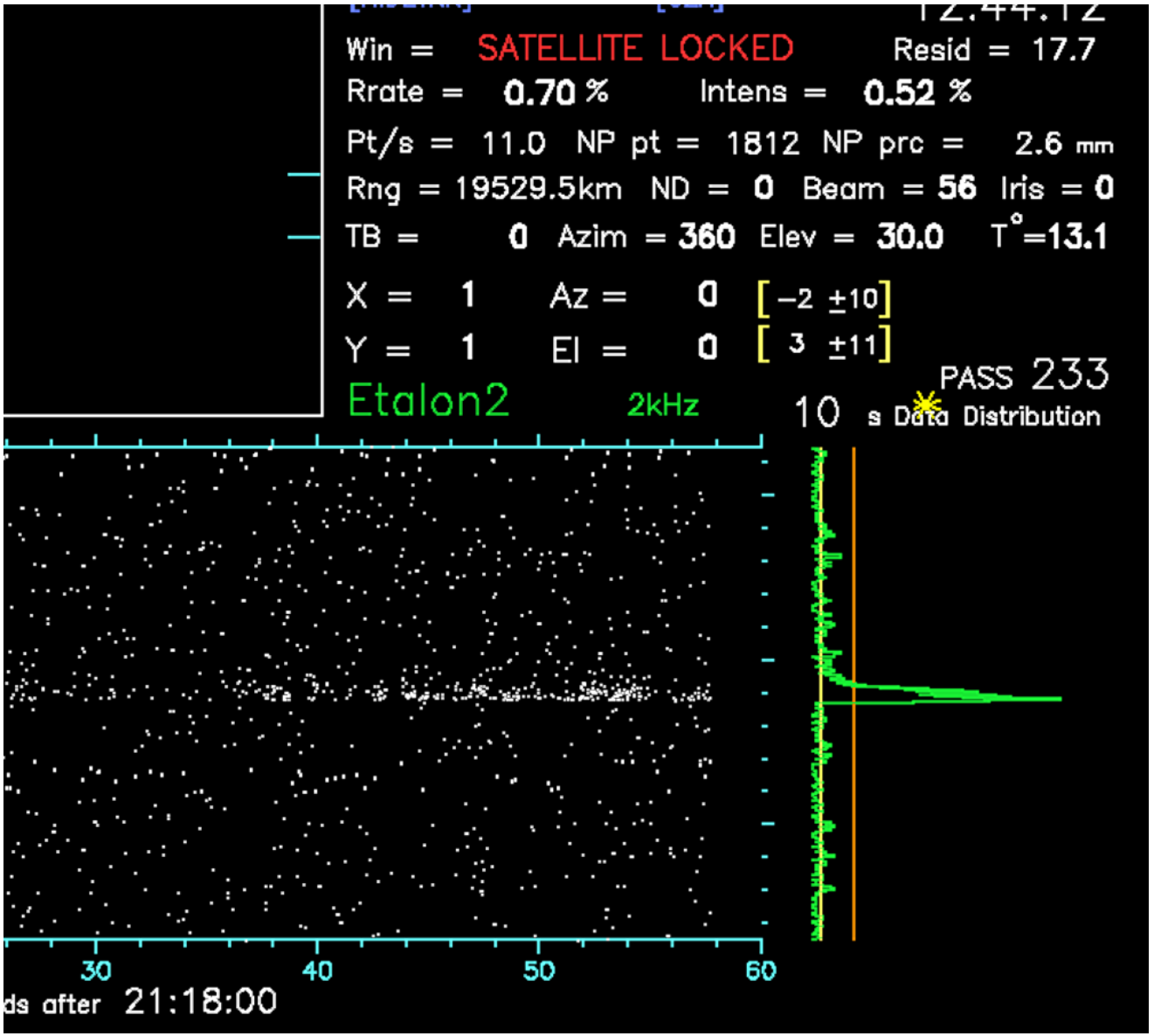
- Some tests done on APL, as part of standard weekly solutions;
- Very little change in post-fit residual WRMS;
- Implementation working, needs full test

- No orbit SP3 files available yet – a priority
  - New team member at SGF getting involved

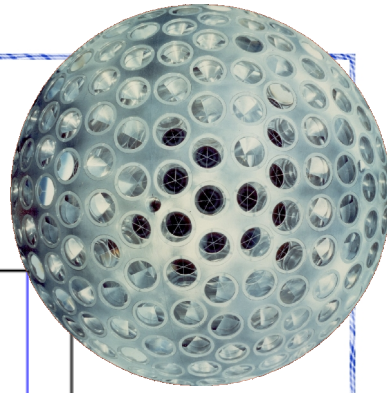
Progress with updates to SATAN

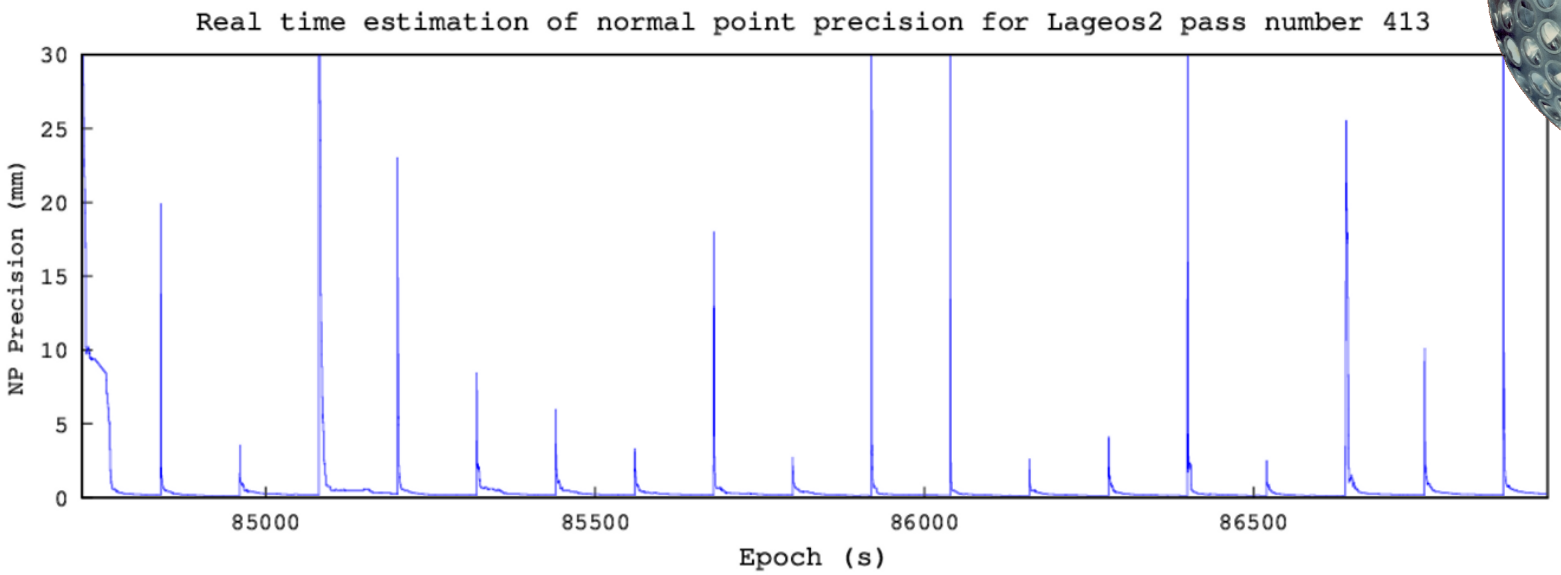
- Using ITRF2008 coordinates and IERS08_c04 as a-priori for daily and weekly ILRS coordinate and EOP solutions;
  - No progress with LoD problem
- Daily LAGEOS and Etalon QC web-based solutions also use ITRF2008.
- Atmospheric loading at observation level:
- Scheme devised to use Vienna APL V2 data:
- Interpolation in 6-hourly data to NP epochs during a data pre-processing stage

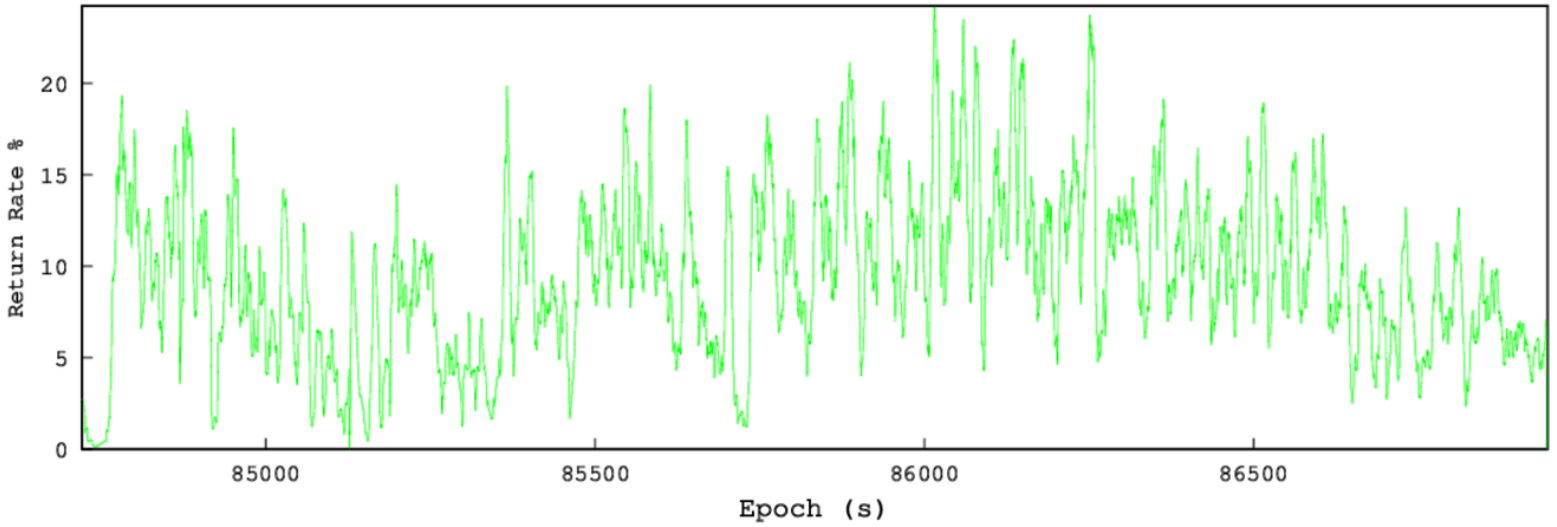
Real time estimation of Normal Point precision



Lageos 2 pass







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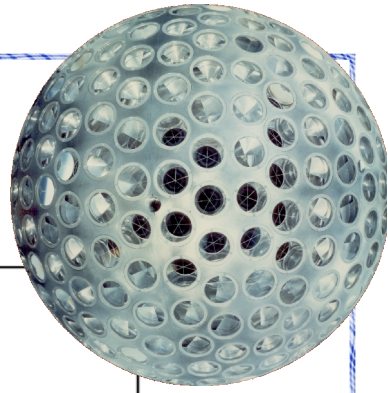

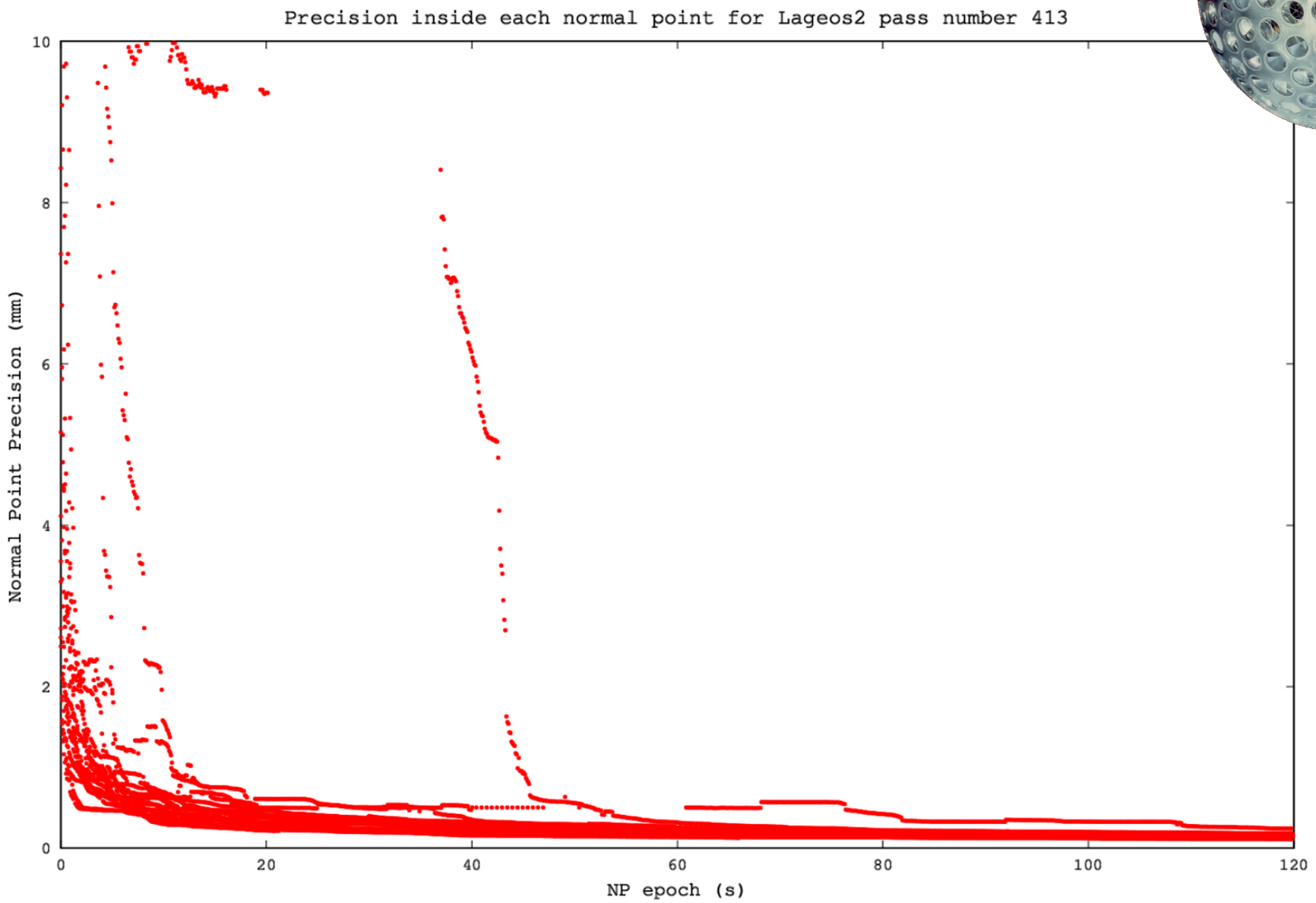

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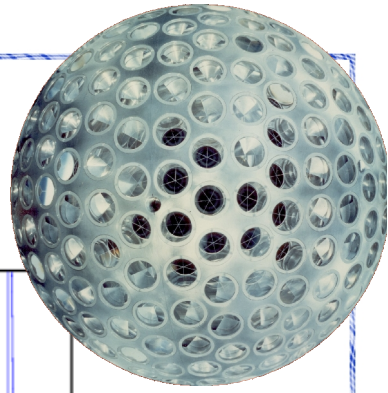

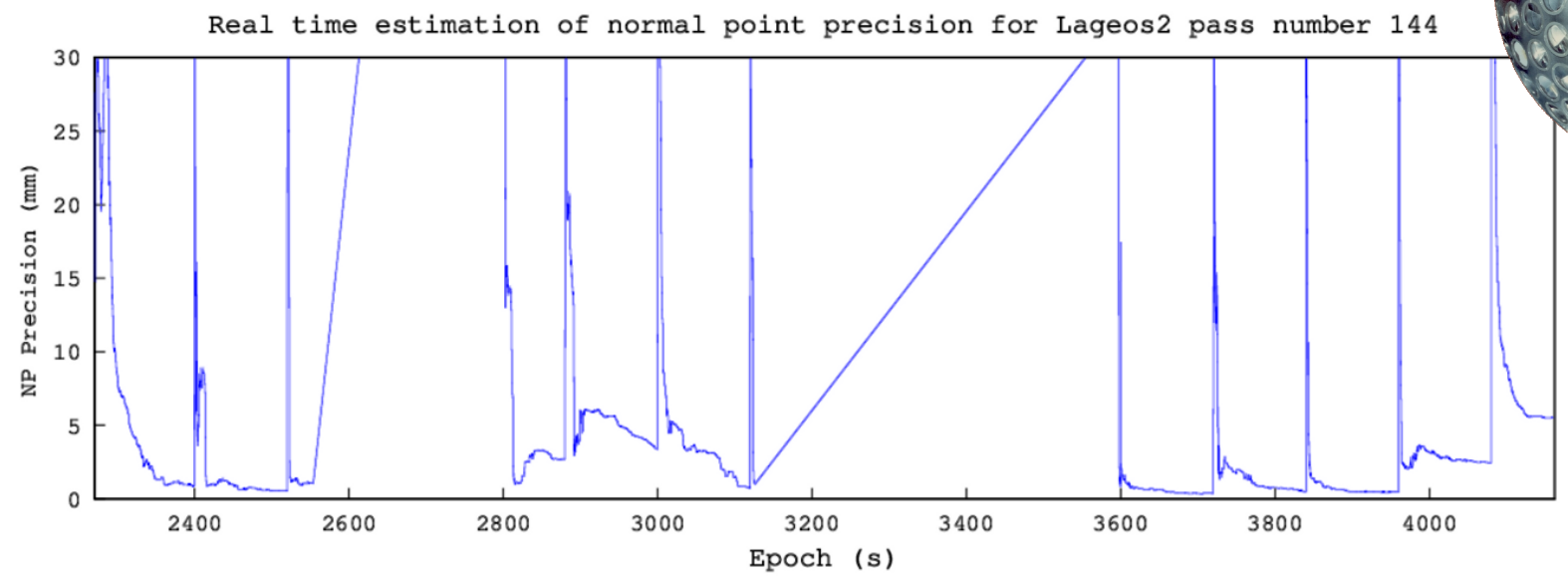

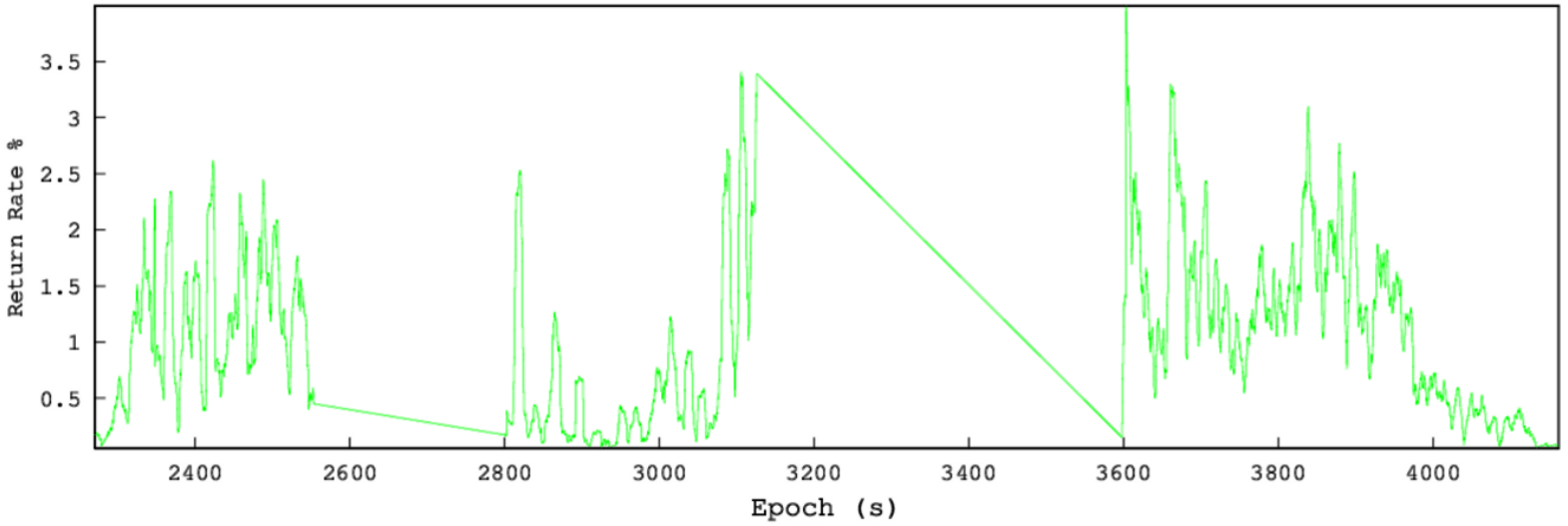

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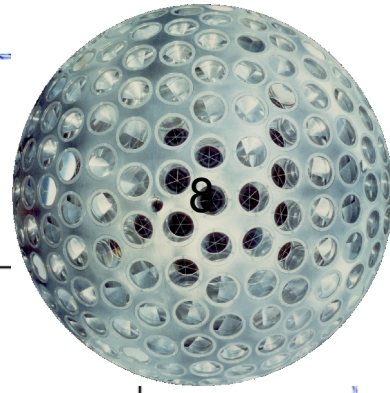

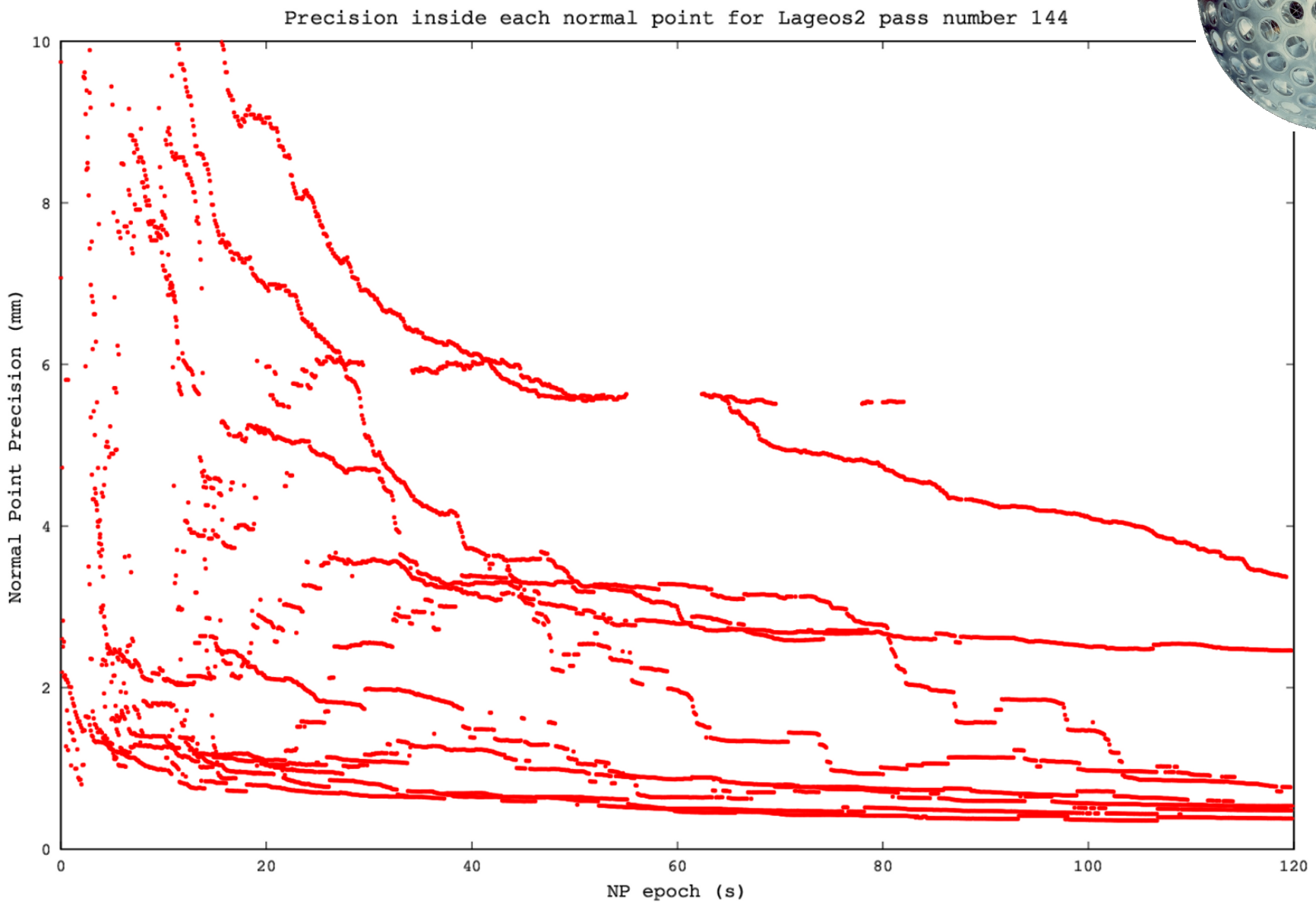

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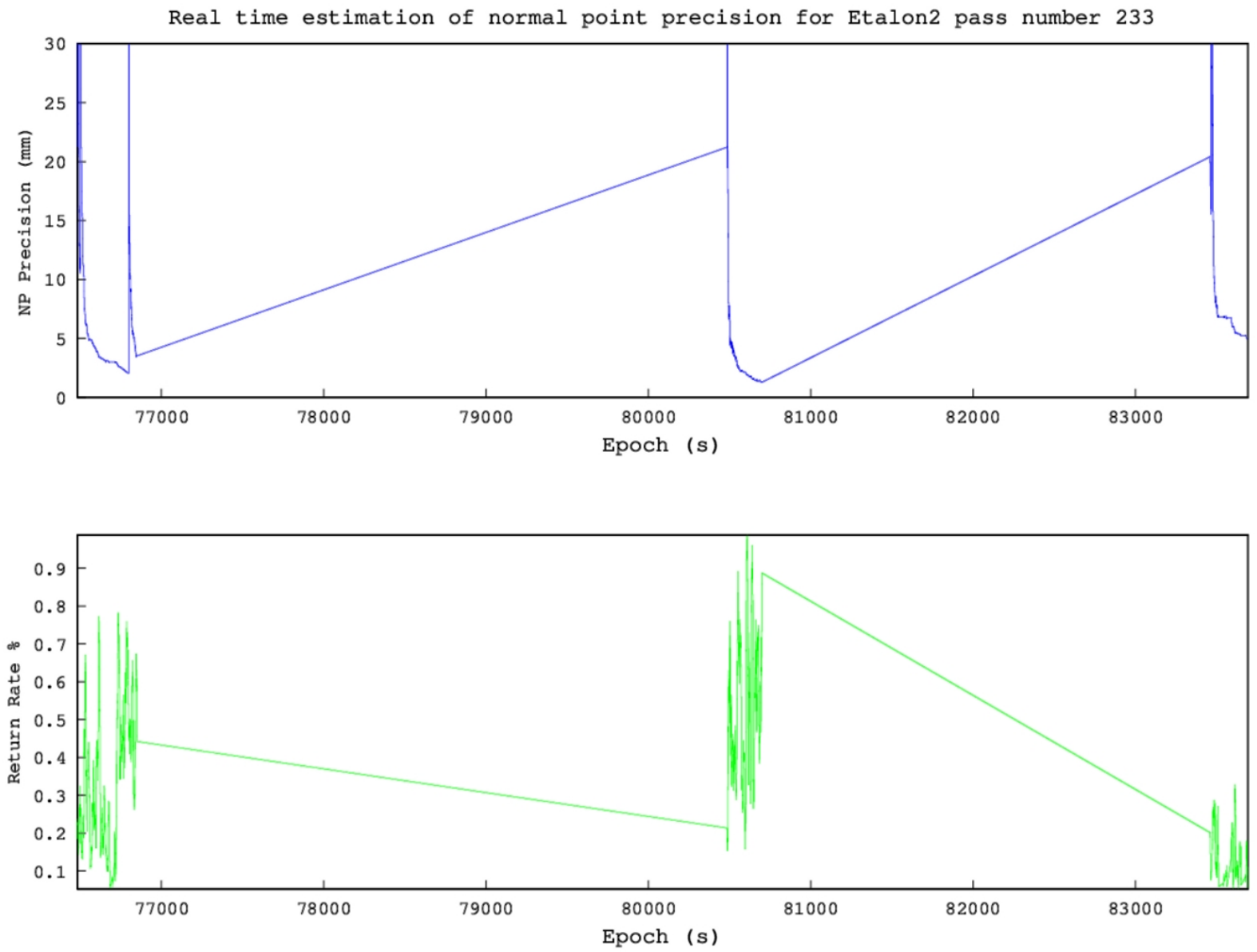

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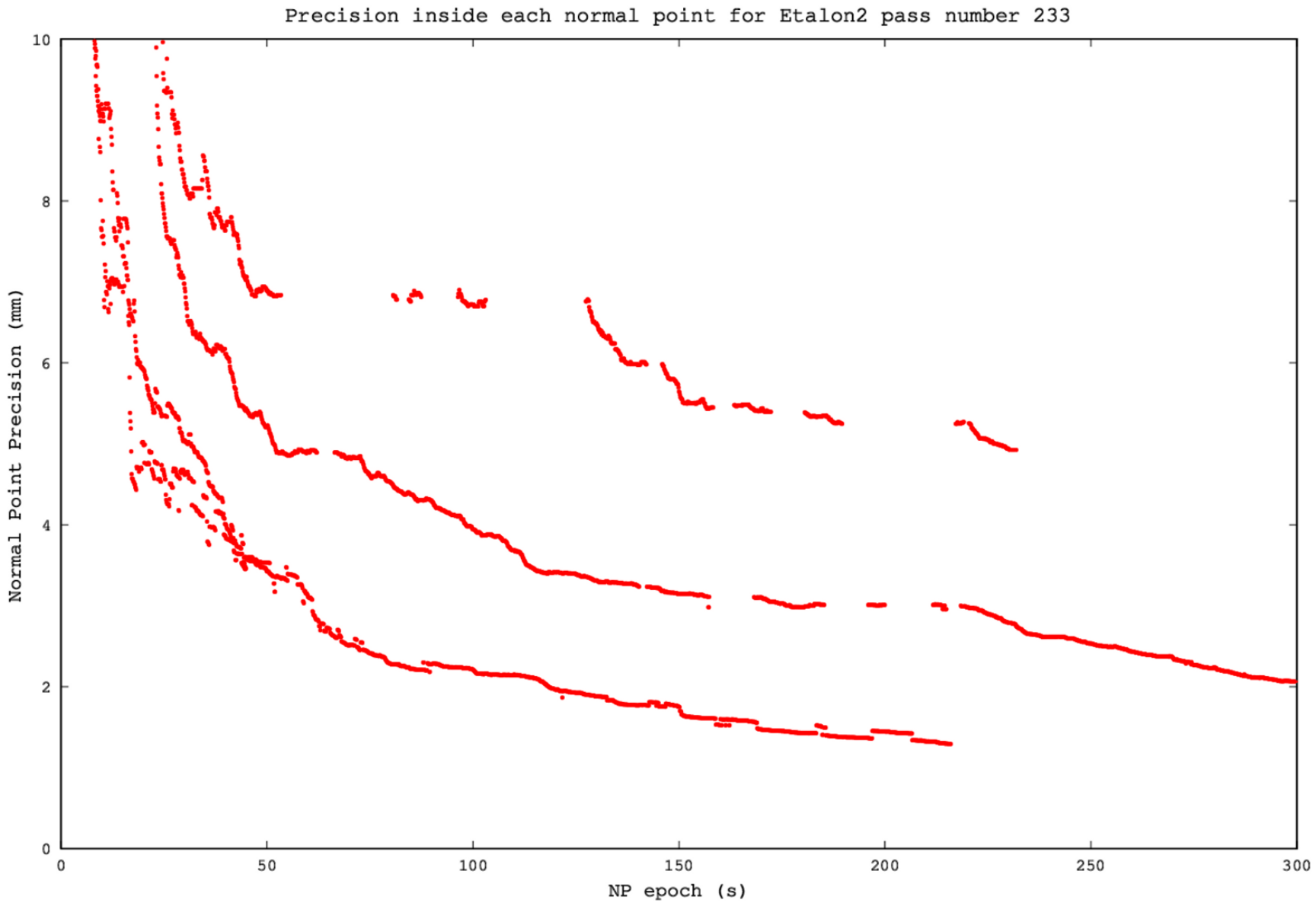
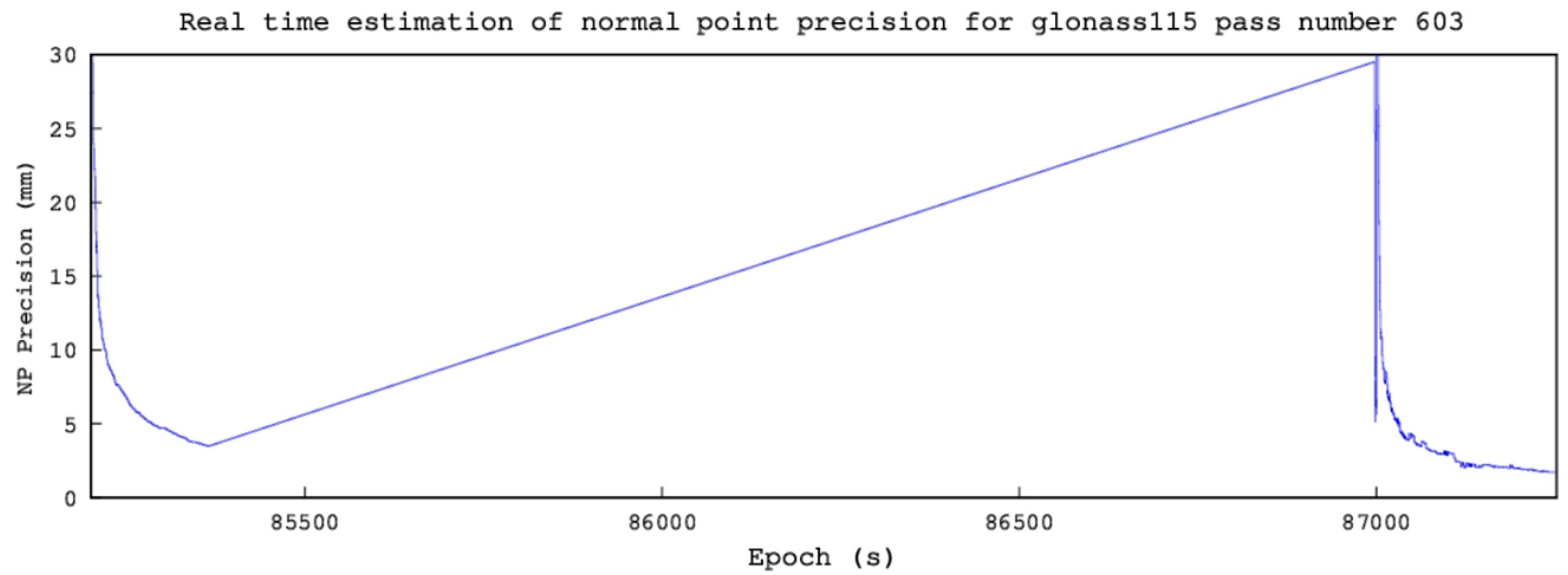
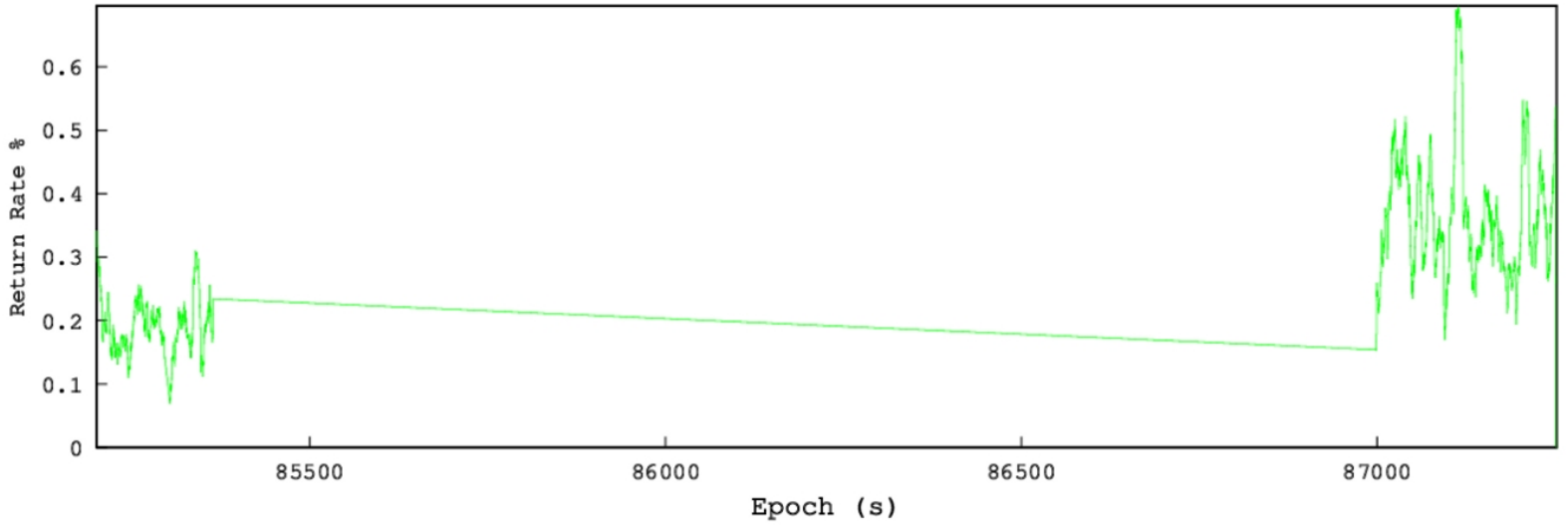
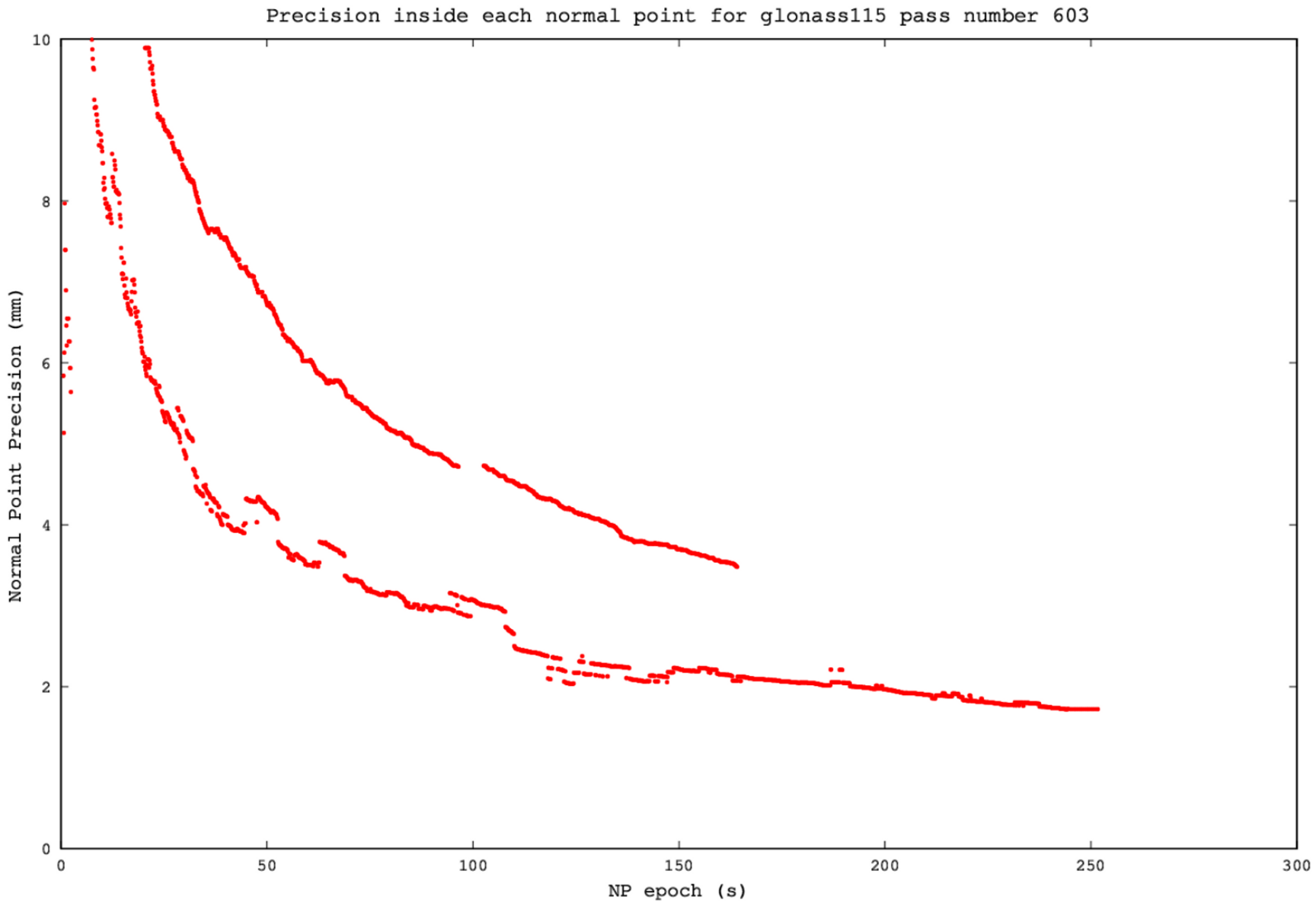


GLONASS 115 pass

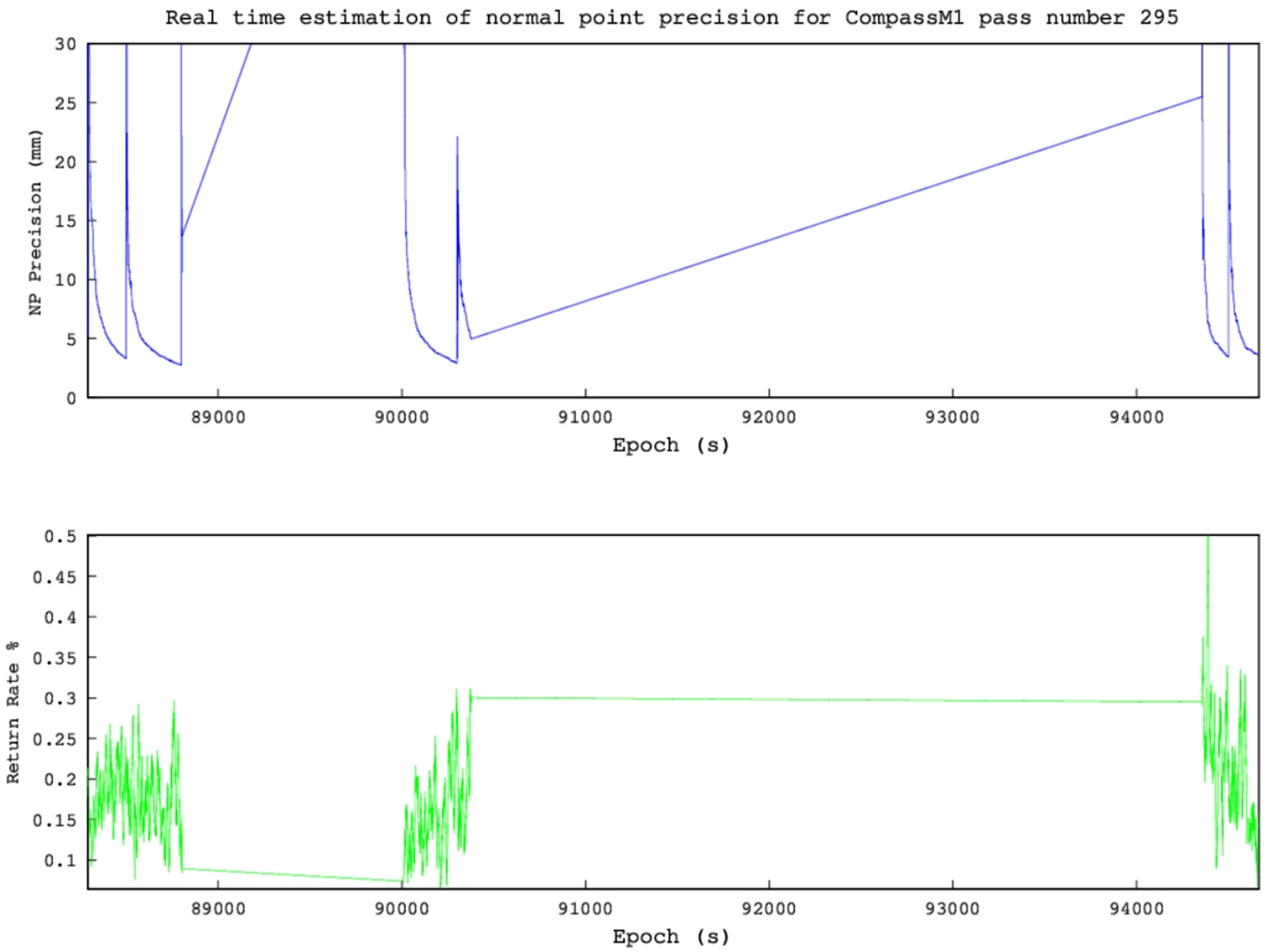




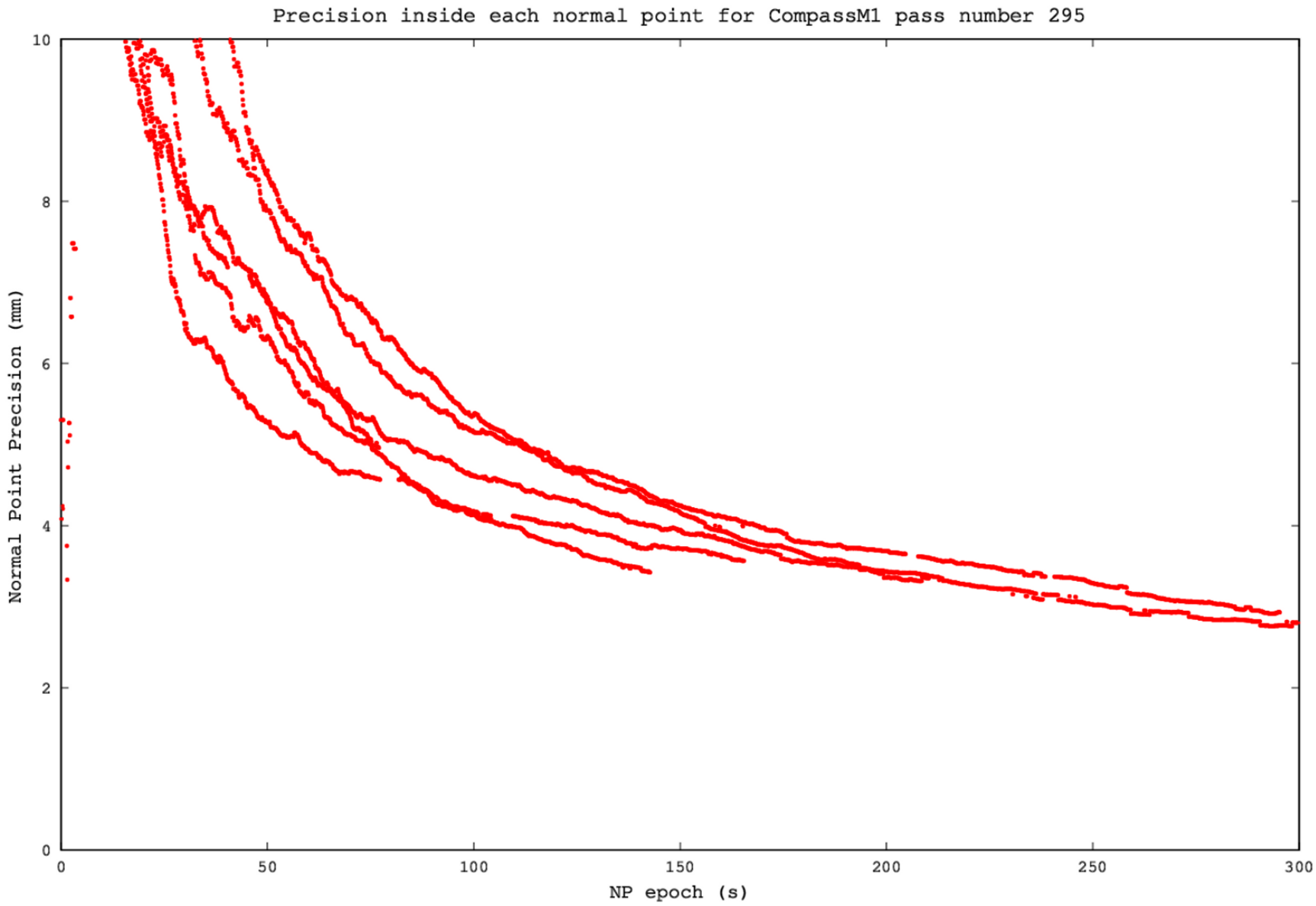
GLONASS 115 pass



Compass-M1 pass



Compass-M1 pass



International Laser Ranging Service

LLR Status Report
- ILRS 2012 -

Jürgen Müller

Institut für Erdmessung (Institute of Geodesy) and

Center of Excellence QUEST
(Quantum Engineering and Space-Time Research)

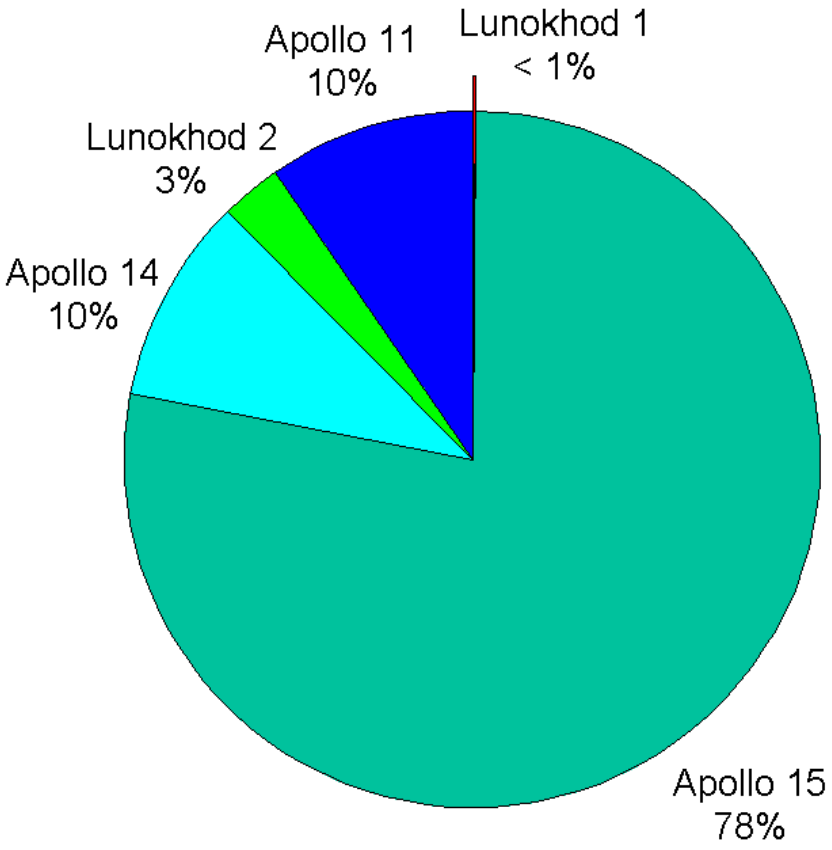
Leibniz Universität Hannover (University of Hannover)

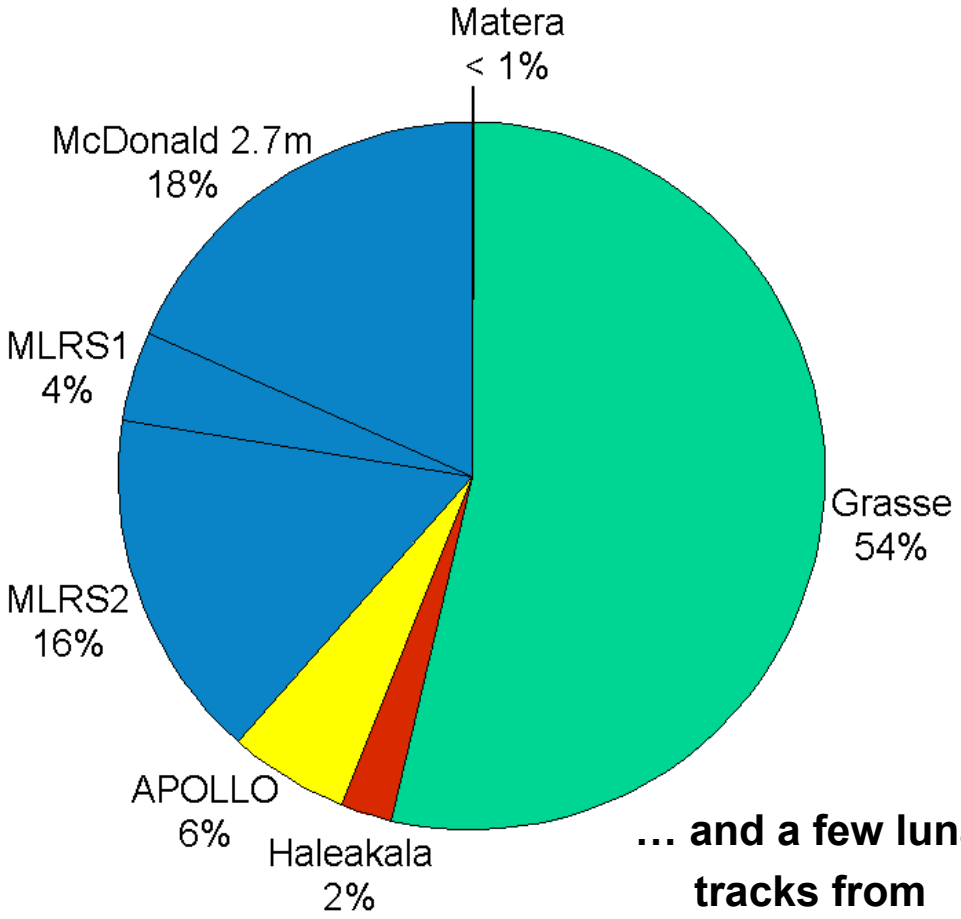
ife

Leibniz Universität Hannover

Statistics – retro-reflectors and observatories

Time span **1970-2011**





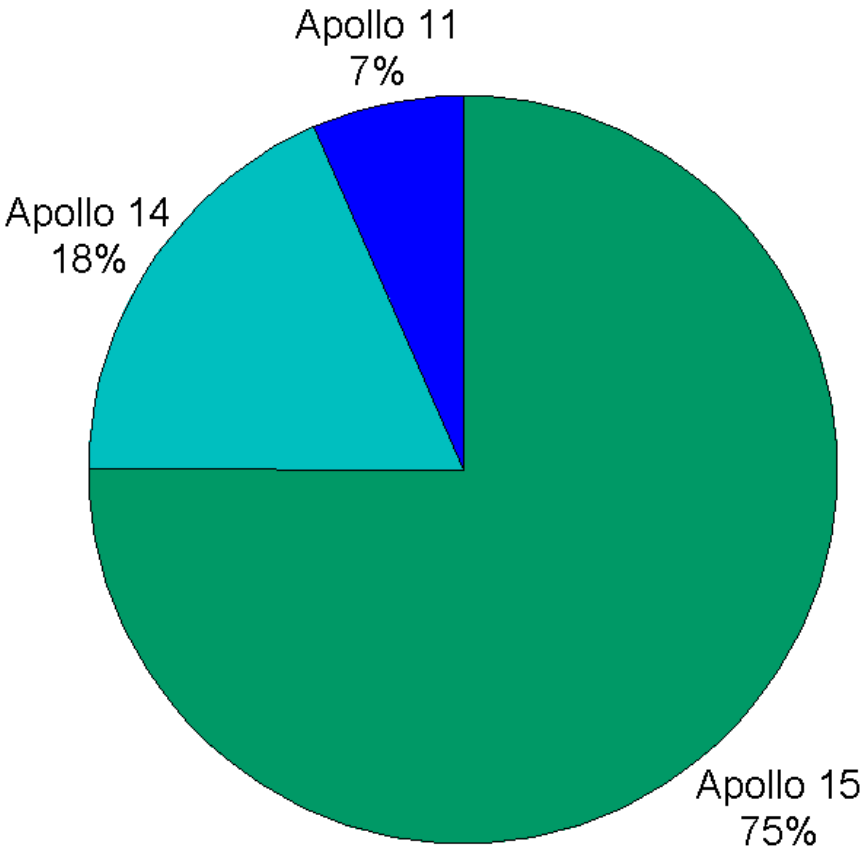
about 17.000
normal points

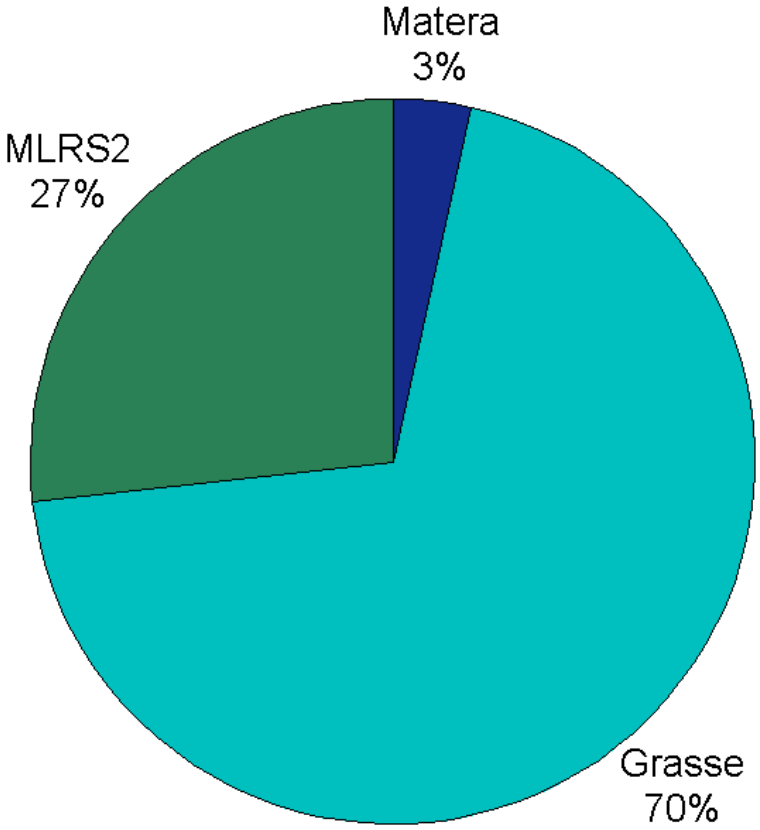
… and a few lunar tracks from

- **Orroral**
- **Wettzell**

Statistics – retro-reflectors and observatories

Only **2011**



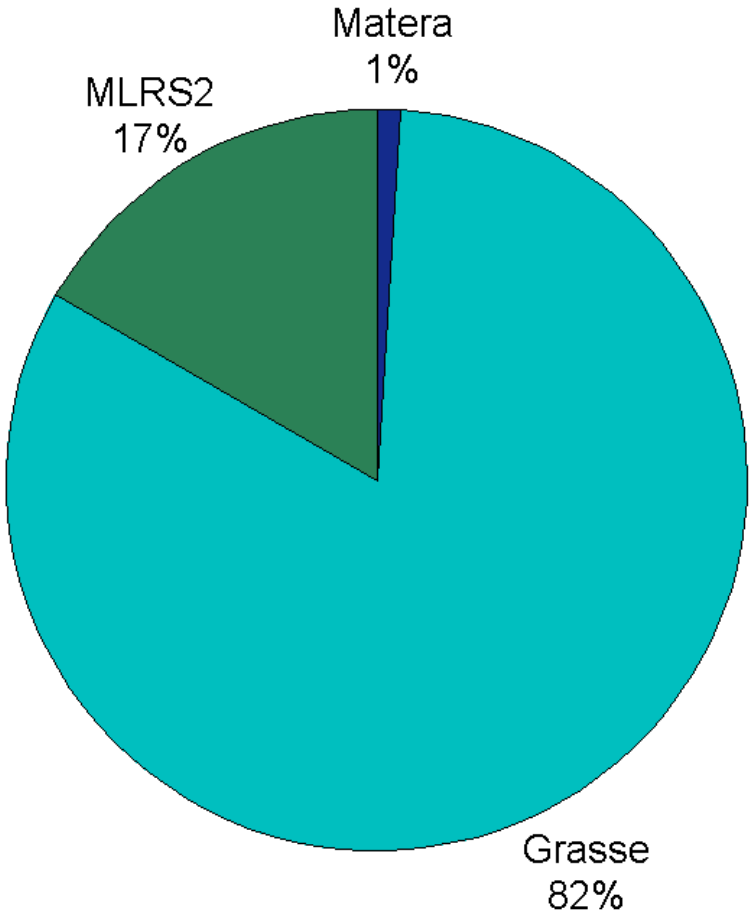


- no APOLLO normal points, as new detector (end of 2010) requires refined pre-processing
- no tracks to Lunokhod 1 and 2

Statistics – observatories 2012

Only **2012** (until April)

Normal points	**2011**	**2012**
McDonald	23	16
Grasse	60	79
Matera	3	1
In total	**86**	**96**



Status, perspective at the LLR sites

- McDonald - lunar tracking at low level
- APOLLO - good LLR data, but no normal points since end of 2010, no “official archiving”
- Grasse re-started lunar tracking by end of 2009, less returns in 2010/2011, good performance since end of 2011
- Matera re-started lunar tracking in spring 2010, routine operation is difficult
- Wettzell will soon resume – first attempts have been made (but problems with the new SLR system have to be resolved first)

Major LLR-related activities

- ISSI workshop series on LLR modelling and analysis (start 2009), final meeting in spring 2012
- Boston workshop 2010 on comparison of LLR software packages
- ILRS initiative on LLR data qualification (“French website”)
- Joint LLR paper in ILRS JoG special issue (subm., 2012)
- In Germany: New DFG Research unit “Reference systems” (speaker A. Nothnagel, Bonn) with **2 LLR related projects**
  - Moon-related systems
  - Barycentric ephemeris

  has begun on 1 March 2012.

Main research at lunar analysis centers

- Jet Propulsion Laboratory (JPL)
  - lunar interior, lunar core
  - relativity
- Paris Observatory Lunar Analysis Center (POLAC)
  - libration theory
  - reference frames
- Institute of Geodesy (IfE)
  - relativity
  - Earth orientation
  - lunar interior
- Others: special topics ...

LLR tests of general relativity

Equivalence Principle (Nordtvedt effect)

$$\eta = (3.0 \pm 3.6) \times 10^{-4}$$

$$\left[\frac{M_G}{M_I}\right]_{SEP} - 1 = (-1.4 \pm 1.6) \times 10^{-13}$$

Müller et al., CQG 2012

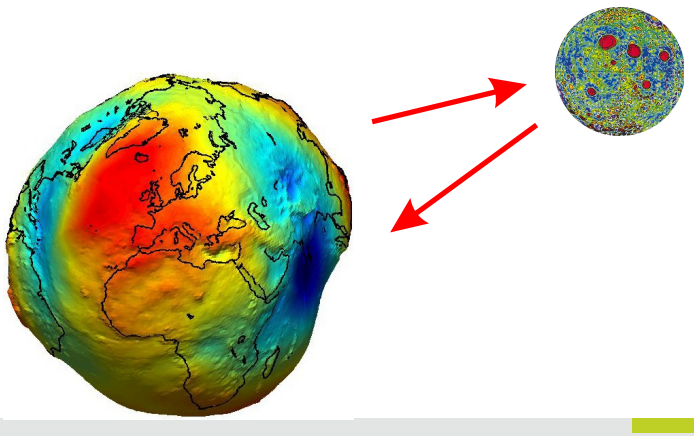
EP test with LLR is a combination of weak and strong EP test
(different compositions and additional gravitational self energy)

Temporal variation of the gravitational constant

$$G = G_0\left(1 + \frac{\dot{G}}{G}\Delta t + \ldots\right)$$

$$\frac{\dot{G}}{G} = (1 \pm 2.5) \times 10^{-13}\ \mathrm{yr}^{-1}$$

Müller et al., IAG Springer 2012

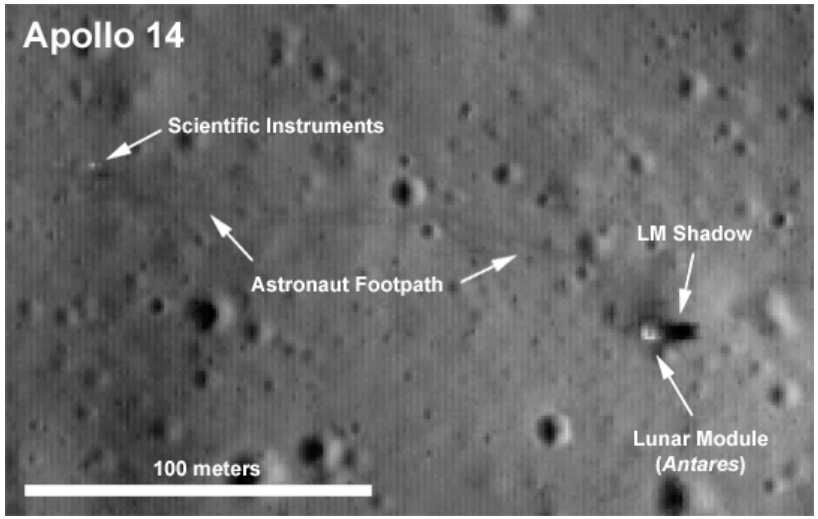


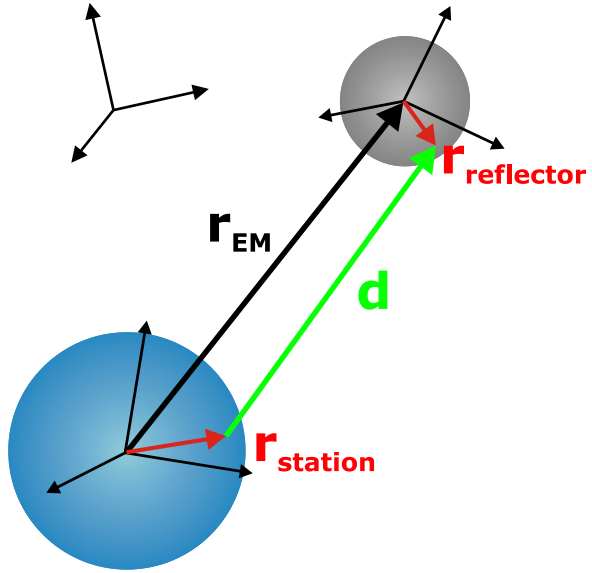
Project „Moon-related systems“

Moon-related reference systems are indispensable

- to link terrestrial and celestial reference systems and
- to advance lunar science and space exploration

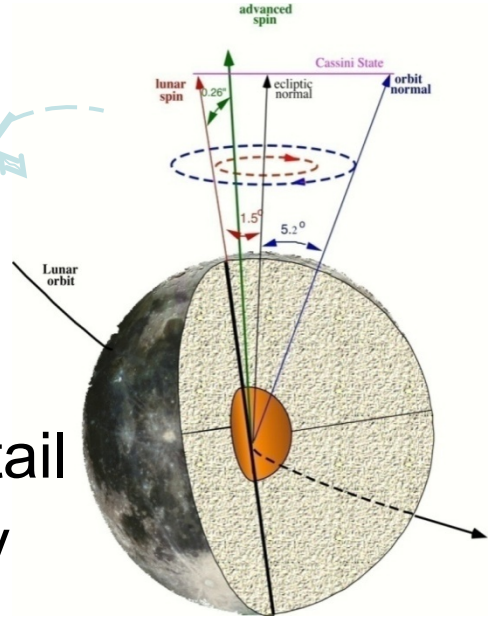
This project prepares the application of established methods for mapping and surveying the Earth to extra-terrestrial bodies.





Objectives

Provide next-generation lunar reference systems for geodesy, astronomy, and exploration.

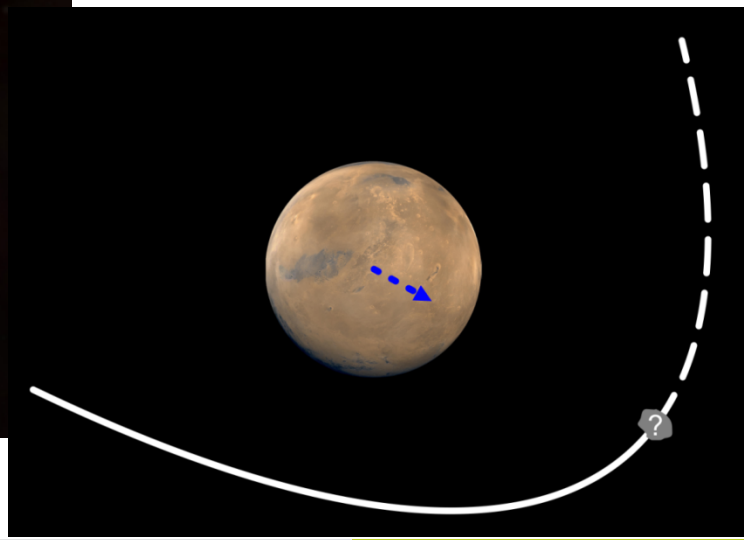


To achieve this:

- improve lunar models (lunar rotation, interior)
- integrate novel data sets in available s/w
- determine (new) parameters (e.g., tidal)
- realize the Moon-fixed coordinate system in detail
- deliver control point networks and geometrically accurate base maps
- carry out sensitivity studies and simulations of future geodetic experiments
- tie the stable Moon orbit into the inertial and terrestrial reference systems (realized by space geodetic techniques)

Project „Barycentric ephemeris“

Special aspects of an improved solar system ephemeris (additional forces and torques, lunar librations, asteroid perturbations, different timescale, solar mass loss, etc.)



Objectives

- Extension of existing LLR code to a full solar-system ephemeris
- Improvements of the force/torque model
  - additional figure-figure and relativistic interactions in the Earth-Moon system
  - librations: considering the full internal structure of the Moon (solid inner core)
  - considering effects from (unseen) asteroids
- work towards an independent fit to observational data

Beyond the first 3 years → high precision ephemeris by

- better data combination strategy
- long-term stability, e.g. for palaeo-climate studies, by means of
  - new integrators (symplectic, ...),
  - optimization w.r.t. computing time (parallelization, ...)

Links to other projects

INPOP: J. Laskar, A. Fienga (Paris, Besancon)
DE: W. Folkner (JPL)
EPM: E. Pitjeva (St. Petersburg)

The GAIA community (S. Klioner …)

ILRS Website Update
Carey Noll

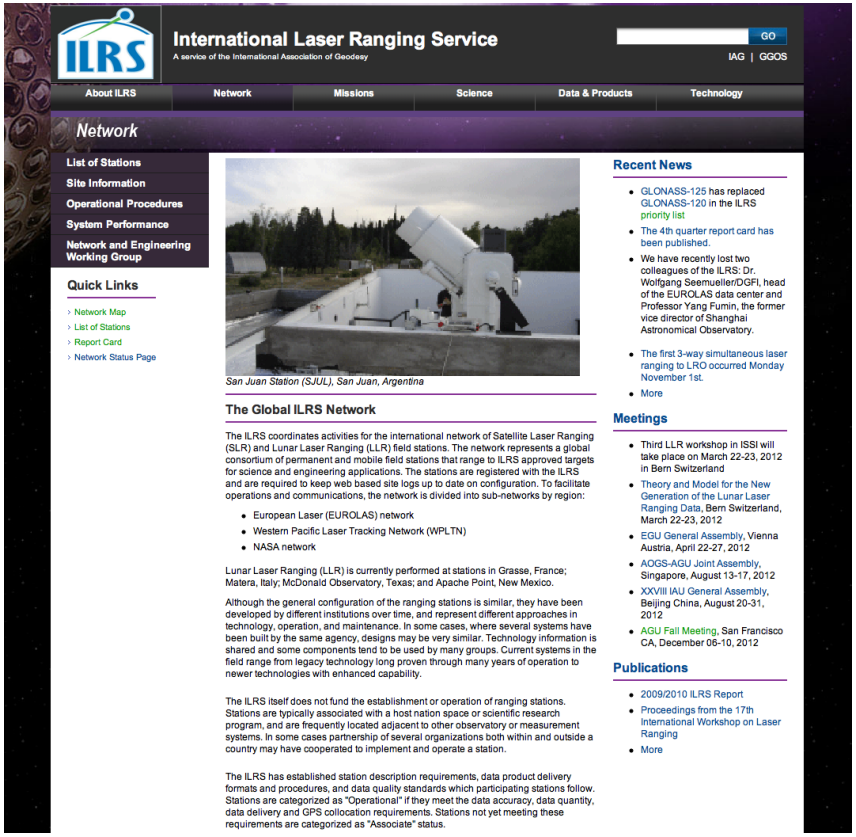
Technical University of Vienna
Room Seminarroom 124
Vienna, Austria

April 23, 2012
14:00-16:30

ILRS Website Update

- New website uses same major structure:
  - About, Network, Missions, Science, Data&Products, Technology
- Currently porting old content to new format
- Reviewing and updating content
- Website available for review:
  - http://ilrs-test.gsfc.nasa.gov
- Encourage all to review, comment, and let staff know if items are missing/confusing/needed

Sample Pages



International Technical Laser Workshop 2012 (ITLW-12)

"Satellite, Lunar and Planetary Laser Ranging: Characterizing the Space Segment"

Frascati National Laboratories of the INFN-LNF,

Frascati (Rome), Italy (http://www.lnf.infn.it/user.html)

in conjunction with a one-day Workshop on

"ASI-INFN ETRUSCO-2 Project of Technological Development on SLR Payloads of GNSS"; November 8, 2012

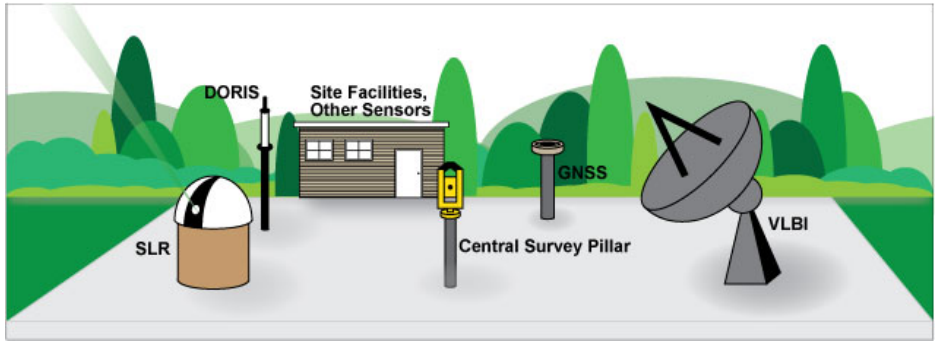
November 5 – 9, 2012

Program Concept

- To meet our challenging technical requirements this workshop will focus on the critical design issues and on the characterization of payload performance for missions in operation and in preparation. Such characterization is based on:
  - SLR/LLR tracking experience of stations of the International Laser Ranging Service (ILRS) distributed worldwide
  - Ground testing of as-built and newly developed payload at dedicated facilities (like the SCF and SCF-G in operation at INFN-LNF, Frascati)
  - Specialized optical, thermal, structural and orbital software modeling.
  - Optimization approaches and integration.

- The previous edition of this workshop, dedicated to "SLR tracking of GNSS Constellations" and held in Greece in 2009, can be consulted at http://www.ntua.gr/MIRC/ILRS_W2009/.
- Opportunities for ILRS working groups meetings will be held before or during the workshop.

GGOS Bureau for Networks and Communications Report



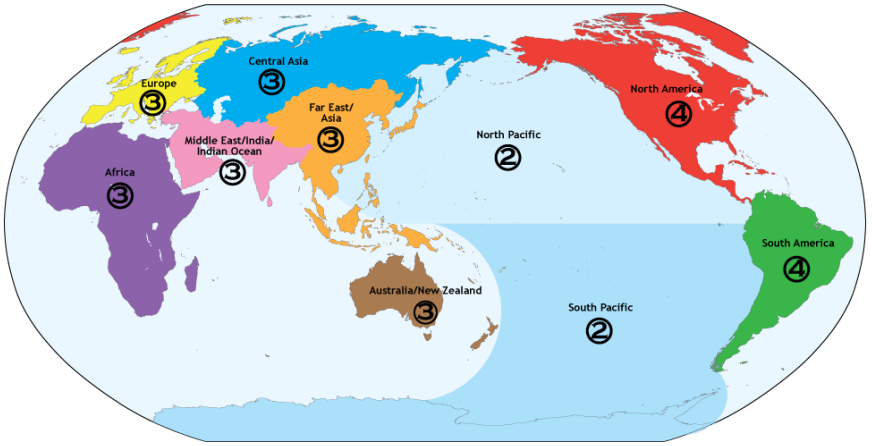
ILRS Governing Board Meeting
Technical University of Vienna

GGOS Bureau for Networks and Communications Action Plan

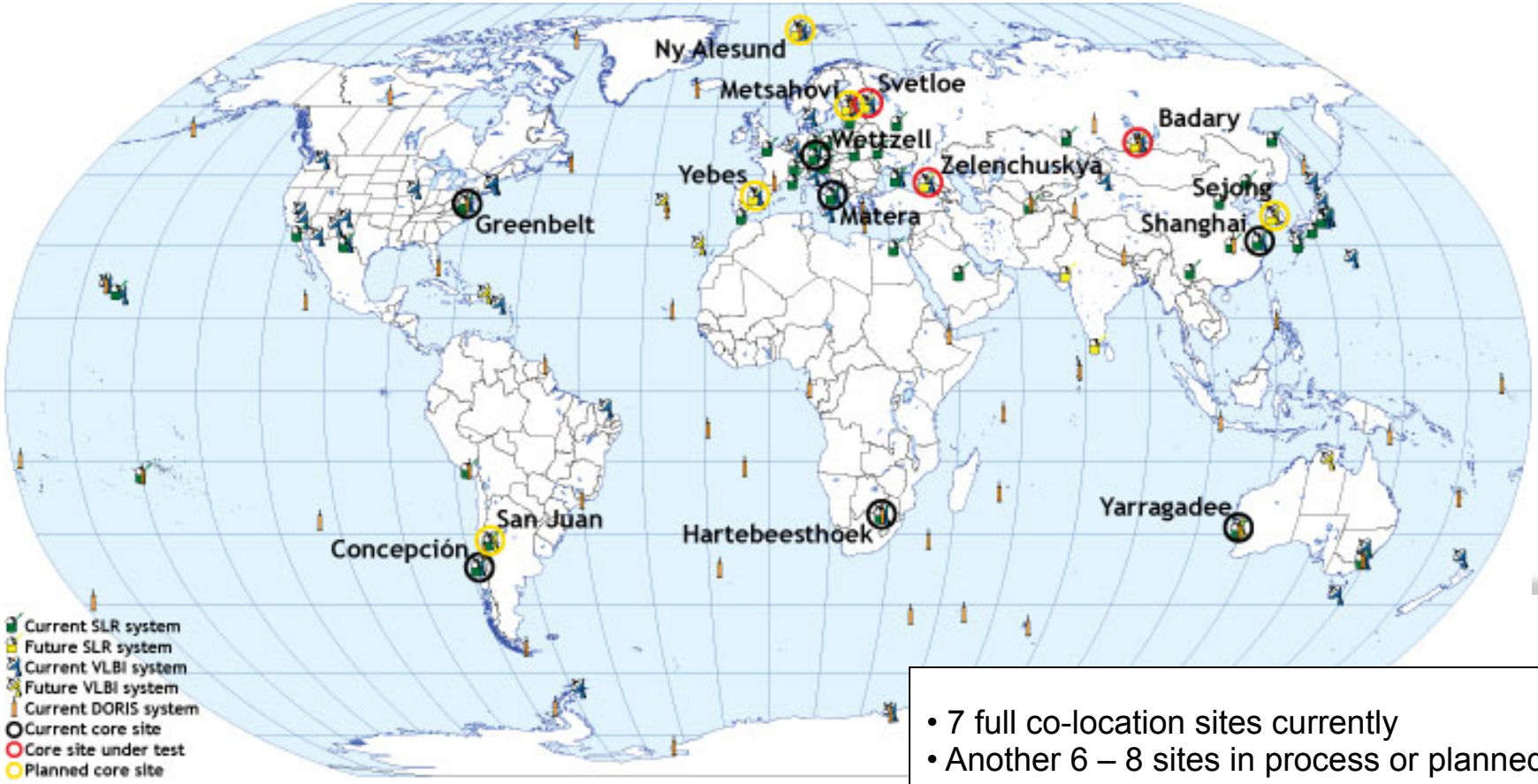
- **Complete Simulations:**
  - Examine sensitivity of data products to intersystem vector accuracy;
  - Compare data product quality from idealized network to network projected to be place in 5 years, 10 years;
- **Complete Site Specification Document:**
  - Develop Next Level version of the Site Specification Document;
  - Add description of the component systems and the site
- **Call for Participation;**
  - Issue responses
  - Encourage more participation
- **Intersystems Vectors**:
  - Work with IERS WG on Inter-system vectors (co-location);
- **Working Group for Network Communications and Automation (A. Neidhardt):**
  - Establish a Bureau Working Group on Network Communication and Automation:
- **Continue Outreach (All Bureau Members):**
  - Meet with potential participants in the GGOS network of Core Sites
  - Presentations at Scientific Meetings

Simulation Studies to Scope the Network
(Erricos Pavlis)

- **First Phase completed**
  - **~30 globally distributed, well positioned, co-location Core Sites with proper conditions;**
  - **16 of these Core Sites must track GNSS satellites with SLR to calibrate the GNSS orbits;**
- **Follow-on Phases (Impact on the ITRF)**
  - **Sensitivity to intersystem vector accuracy**
  - **Phased deployment; evolution of the products**
  - **Impact of errors and outages;**
  - **Additional space objects**
  - **Tracking scanarios**
  - **Impact of GRASP**



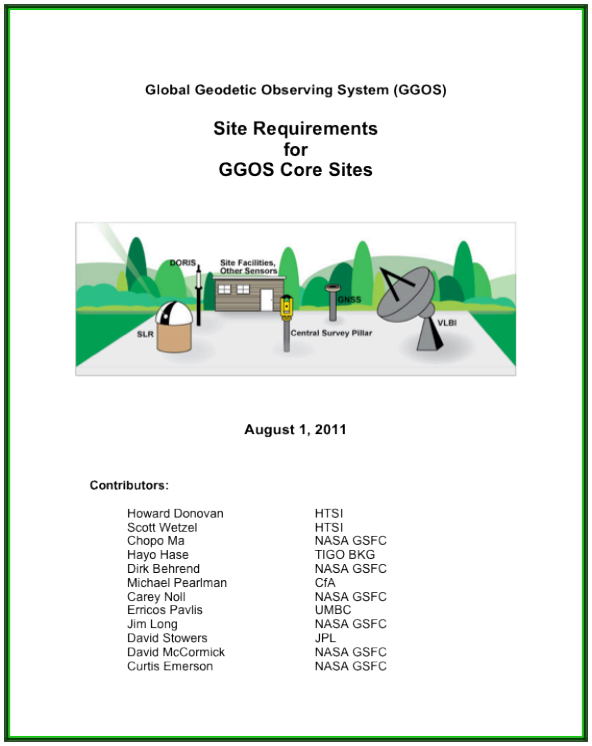
Co-located VLBI, SLR, GNSS
(Some with DORIS)



- 7 full co-location sites currently
- Another 6 – 8 sites in process or planned
- Many regional voids in the network
- Many site have older less reliable technology

GGOS Site Requirements Document

(http://cddis.gsfc.nasa.gov/docs/GGOS_SiteReqDoc.pdf)



Global Geodetic Observing System (GGOS)

Site Requirements
for
GGOS Core Sites

August 1, 2011

Contributors:

Howard Donovan	HTSI
Scott Wetzel	HTSI
Chopo Ma	NASA GSFC
Hayo Hase	TIGO BKG
Dirk Behrend	NASA GSFC
Michael Pearlman	CfA
Carey Noll	NASA GSFC
Erricos Pavlis	UMBC
Jim Long	NASA GSFC
David Stowers	JPL
David McCormick	NASA GSFC
Curtis Emerson	NASA GSFC

- **Introduction and Justification**
  - **What is a Fundamental Station?**
  - **Why do we need the Reference Frame?**
  - **Why do we need a global network?**
  - **What is the current situation?**
  - **What do we need?**
- **Site Conditions**
  - **Global consideration for the location**
  - **Geology**
  - **Site area**
  - **Weather and sky conditions**
  - **Radio frequency and optical Interference**
  - **Horizon conditions**
  - **Air traffic and aircraft Protection**
  - **Communications**
  - **Land ownership**
  - **Local ground geodetic networks**
  - **Site Accessibility**
  - **Local infrastructure and accmmodations**
  - **Electric power**
  - **Site security and safety**
  - **Local commitment**

GGOS Call for Participation;
The Global Geodetic Core Network:
Foundation for Monitoring the Earth System

We seek proposals from organizations that would participate in the development, implementation and maintenance of the GGOS Global Geodetic Core Network:

- **To implement and operate core space geodesy stations including:**
  - **existing stations that already have the four techniques implemented and plan for upgrade to the next generation systems;**
  - **existing stations that have one or more techniques operational, are planning for upgrade to the next generation systems and for the implementation of the remaining techniques;**
- **To support the network design and planning activity with analysis, simulations, site research (geology, weather, logistics, personnel, etc). To help design and develop the inter-technique vector systems and operational procedures.**
- **To provide applicable space geodetic instruments for implementation at a GGOS Global Geodetic Core Site in cooperation with a local organization.**
- **To implement and operate core stations offered by others;**
- **Call for Participation has been issued through the Services and the IAG.**

GGOS Bureau for Networks and Communications
Call for Participation
Issues and Steps Forward

- Issued Call for Participation;
- Organized the Review Team
- Completed the Review Process for the First Round

- 14 Submissions covering 36 sites
- Submissions;
  - Legacy Core Sites
  - Legacy/New Technology Technique Sites
  - Core and Technique Sites being developed
  - Sites offered
- Summary posted on the GGOS Website
- Other Groups being approached.

GGOS Bureau for Networks and Communications
Call for Participation
Responses so far

Agency (Country)	Sites
BKG/FESG (Germany)	Wettzell
NERC (UK)	Herstmonceux
IRA (Italy)	Medicina, Noto, Sardinia
OSO (Norway)	Onsala
FGI (Finland)	Metsahovi
IGN Spain)	Yebes
SPC (Poland)	Borowiec
SHAO (China)	Shanghai, Beijing, Changchun, Wuhan, Kunming, Urumuqi, Sanyo, (San Juan)
GA (Australia)	Yarragadee, Mt. Stromlo, Katherine, Hobart
NASRDA (Nigeria)	Toto

GGOS Bureau for Networks and Communications
Call for Participation
Responses so far

Agency (Country)	Sites
NASA (US)	GSFC, Westford, Kokee Park, Monument Peak,Fortaleza, McDonald, Mt. Haleakala, Hartebeesthoek, Papeete, Arequipa
RIG (Czech Republic)	Pecny
NRF (South Africa)	Harttebeesthoek,
ASI (Italy)	Matera

Techniques are all Making Progress

- **Satellite Laser Ranging**
  - **Several systems working in the Khz regime;**
  - **Increased data yield and daylight ranging on the GNSS satellites**
  - **Steady progress on the new SLR prototype at GSFC;**
  - **Progress on the GPS-3 arrays;**
- **VLBI**
  - **Prototype VLBI 2010 in testing at GSFC**
  - **New Systems Systems**
    - **Tasmania, Katherine, Yarragadee Stations**
    - **Wettzell twin telescopes are being constructed;**
- **GNSS**
  - **Multiple constellations**
  - **Additional frequencies**
  - **New ground stations**
- **DORIS**
  - **Nearly complete network already**
  - **Additional satellites**
  - **New beacons**
- **Calibration**
  - **GRASP Concept**

NASA Space Geodesy Project

- Provide NASA's contribution to a worldwide network of modern space geodesy Core Sites;
- Phase 1 Proposal developed for a 2–year activity staring in October 2011:
  - Complete network simulations to scope the network and examine geographic, operational and technical tradeoffs based on LAGEOS and GNSS tracking with SLR;
  - Complete the prototype SLR (NGSLR) and VLBI (VLBI 2010) instruments;
  - Co-locate these instrument with the newest generation GNSS and DORIS ground stations at GSFC;
  - Implement a modern survey system to measure inter-technique vectors for co-location;
  - Develop generalized station layout considering RFI and operations constraints;
  - Undertake supporting data analysis;
  - Begin site evaluation for network station deployment;
  - Develop a full network implementation plan;
- Follow-on phase for deployment for up to 10 stations;

NASA Space Geodesy Project
Network Site Criteria/Evaluation Task

- Develop Site Selection Requirements Document
- Evaluate current NASA Sites as candidate

  Core Sites;
- Begin discussions with existing and possible new partners on Core Sites
- Work with GGOS (IAG) and other international organizations to develop plans for international participation and partnerships;
- Current Action: Evaluation of Kokee Park, Mt. Haleakala, and GSFC (basis of comparison)

Establishment of the

GGOS Inter-Agency Committee (GIAC)

- GGOS has established a GGOS InterAgency Committee to provide coordination and support for the development, implementation and operation of those components of the IAG's Global Geodetic Observing System (GGOS), whose infrastructure is operated by governmental institutions.
- GIAC lead is John LaBrecque from NASA
- The GIAC supports the IAG Services, particularly those involved in the establishment, maintenance and enhancement of the geodetic infrastructure, observing systems and the International Terrestrial Reference Frame (ITRF) in a sustainable and a cost-efficient way. Furthermore,
- GIAC members underpin geodetic research activities coordinated by the GGOS Science Committee by providing world class geodetic infrastructure.
- The GIAC is a forum that seeks to generate a unified voice to communicate with Governments and Intergovernmental organizations (GEO, UN bodies) in all matters of global and regional spatial reference frames and GGOS research and applications.

GIAC Members to date

- Geoscience Australia
- Natural Resources Canada
- Shanghai Astronomical Observatory
- Finnish Geodetic Institute
- Institut Géographique National, France
- Federal Agency for Cartography and Geodesy, Germany
- Italian Space Agency
- National Geodesist Land Information, New Zealand
- Norwegian Mapping Authority
- Institute of Applied Astronomy/Russian Academy of Sciences
- Hartebeesthoek Radio Astronomy Observatory, South Africa
- National Facility of the National Research Foundation
- Instituto Geográfico Nacional, Spain
- Federal Office of Topography, Switzerland
- National Aeronautics and Space Administration
- National Geodetic Service, USA

Meetings with Partners at GSFC
In cooperation with GIAC

Country	Organization	Contact	Meetings	Site
Colombia	Instituto Geografico Agustin Codazzi (IGAC)	William Martinez Diaz Elena Posada Dora-Ines Rey Martinez	11/10/10 Pachuca Mex. 9/26/11 GSFC	Three options suggested in NE Colombia
Brazil	Instituto Nacional de Pesquisas Espaciais(INPE)	Eduardo W. Bergamini	8/13/10 Sao Paulo 11/8/11 GSFC	
Korea	Korea Astronomy and Space Science Institute (KASI)	James Park Hyung-Chul Lim	11/5/11 Korea 11/18/11 GSFC	Sejong
Norway	Norwegian Mapping Authority (NMA)	Ina Elsrud Line Langkaas Leif-Morten Tangen Per Erik Opseth	12/6/11 GSFC	Ny-Alesund
Finland	Finnish Geodetic Institute (FGI)	Markku Poutanen Jarkko Koskinen	2/13/12 GSFC	Metsahovi
Taiwan	Institute of Earth Sciences Academia Sinica	Benjamin Chao Cheinway Hwang	8/9/11 Taipai	Two sites visited but drawbacks to both;
France	Centre National d'Etudes Spatiales. (CNES)	Richard Biancale Mandea Miora Andre Laurens	4/4-5, 2012	Papeete

Working Group for Communications and Automation

Chair: Alexander Neidhardt
First Meeting: April 25, 18:00
TUW Seminar Room 124

- Introduction to the Working Group
  - Motivation for the Working Group
  - Charter and Objectives; what do we expect to get out of this?
  - Who should participate?
  - Final product:
    - Forum for discussions to help the community keep abreast of techniques and new ideas;
    - Information base for practitioners and new entrants to the field.
    - Opportunity for industry to keep us informed about new products and services;
    - Opportunity for us to let industry know what we need.
- Automation
  - What is automation and what tasks should we consider;
  - What tasks do techniques have in common;
  - What are we doing now? What are people planning to do?
  - What have been the real issues and obstacles?
  - How should we trade configuration, technical, and operation information and experience?
  - Should we writer a position paper as a guide?
- Communication
  - What are the requirements for each technique, core site?
  - Quality Control and workflow roundtrip monitoring;
  - Services available; what has been the experience?
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