Ninth General Assembly of the ILRS
April 11, 2003
Nice, France

Presentation Material

Central Bureau Report

ILRS Tracking Status

- **Mission items:**
  - Reflector campaign conducted from 12/2001-02/2003; total of 3,670 passes
  - Limited ADEOS-2 campaign conducted from 12/2002-01/2003; total of 175 passes
  - Etalon tracking changed from campaign to regular status in 10/2002
  - ICESat launched January 12, 2003; limited SLR tracking thus far
  - GP-B (Gravity Probe B) tentative launch date ~November 2003
  - STARSHINE-3 re-entered Earth's atmosphere on January 21, 2003
- **Station items:**
  - HOLLAS performance is much improved
  - MLRO now providing SLR and LLR data
  - Mt. Stromlo destroyed by fire and now being rebuilt
  - TIGO operational at Concepción
  - Lviv Ukraine station operational
  - Refurbished CRL station 7308 in Koganei joined ILRS in 11/2002
  - National Astronomical Observatory (China) mobile system joined ILRS in 02/2003; to be deployed to San Juan Argentina in mid-2003
  - FTLRS left Ajaccio, Corsica 09/2002; in setup in Chania, Crete
  - New station in Potsdam (7841) to replace station 7836; tracking started late 12/2002

LLR Network Report

The Stations

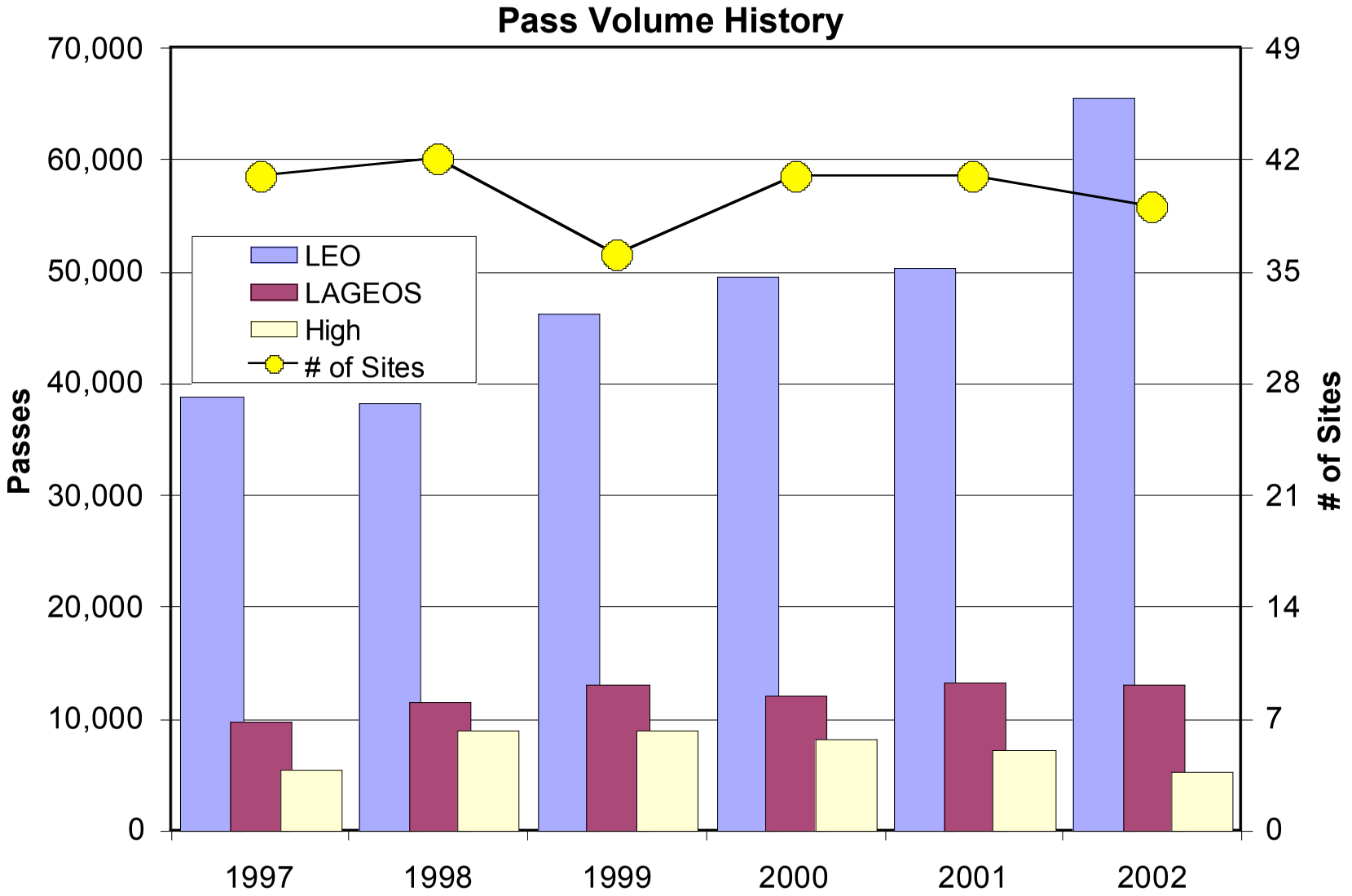
- OCA (France) and MLRS (USA)
- Routine LLR operations continue into 2003
- MLRS continues its SLR support
- OCA continues it high satellite support
- Other Stations (Matera, Wettzell)
- New Station
  - Apache Point (1st laser firing in Fall, 2003)

The Science

- Lunar Geophysics
  - Interior Structure
  - Physical Properties
  - Energy Dissipation
- Geodesy
  - Earth Rotation
  - Solid Body Tides
  - Station Location
- Dynamics
  - Orbit/Mass
  - Relativity/Gravitation

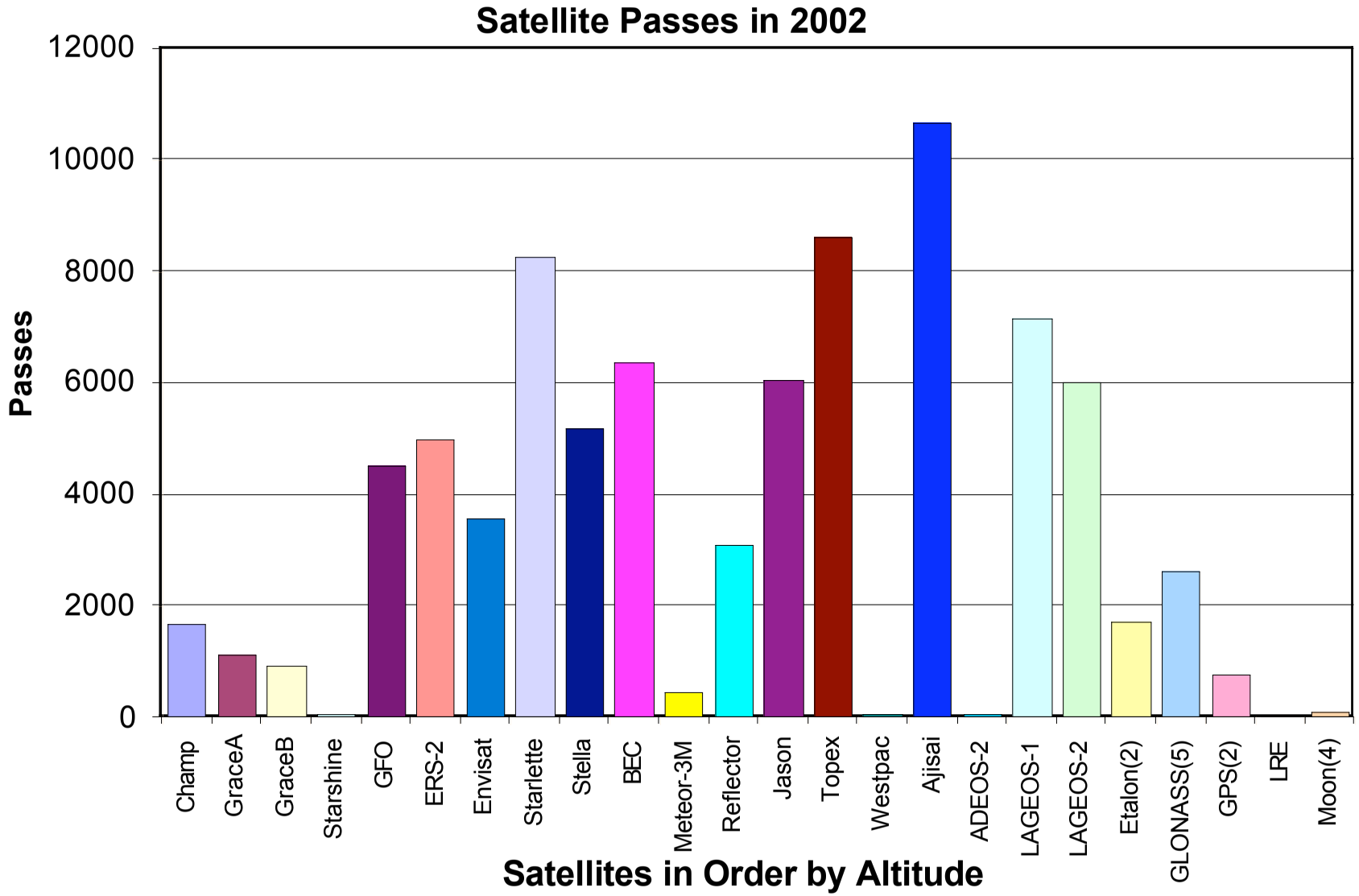
ILRS Tracking Statistics

(History)



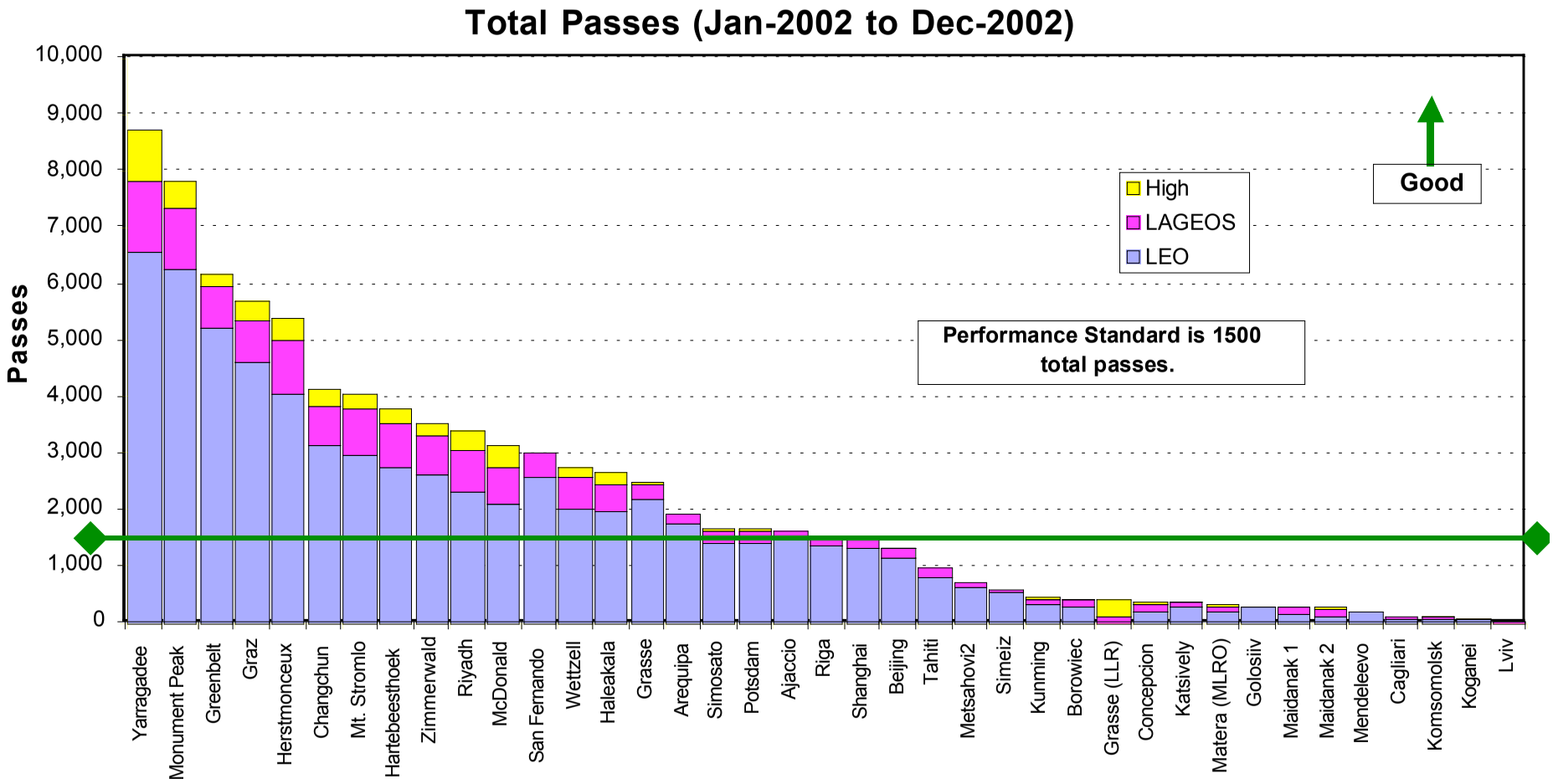
ILRS Tracking Statistics

(2002 by Satellite)

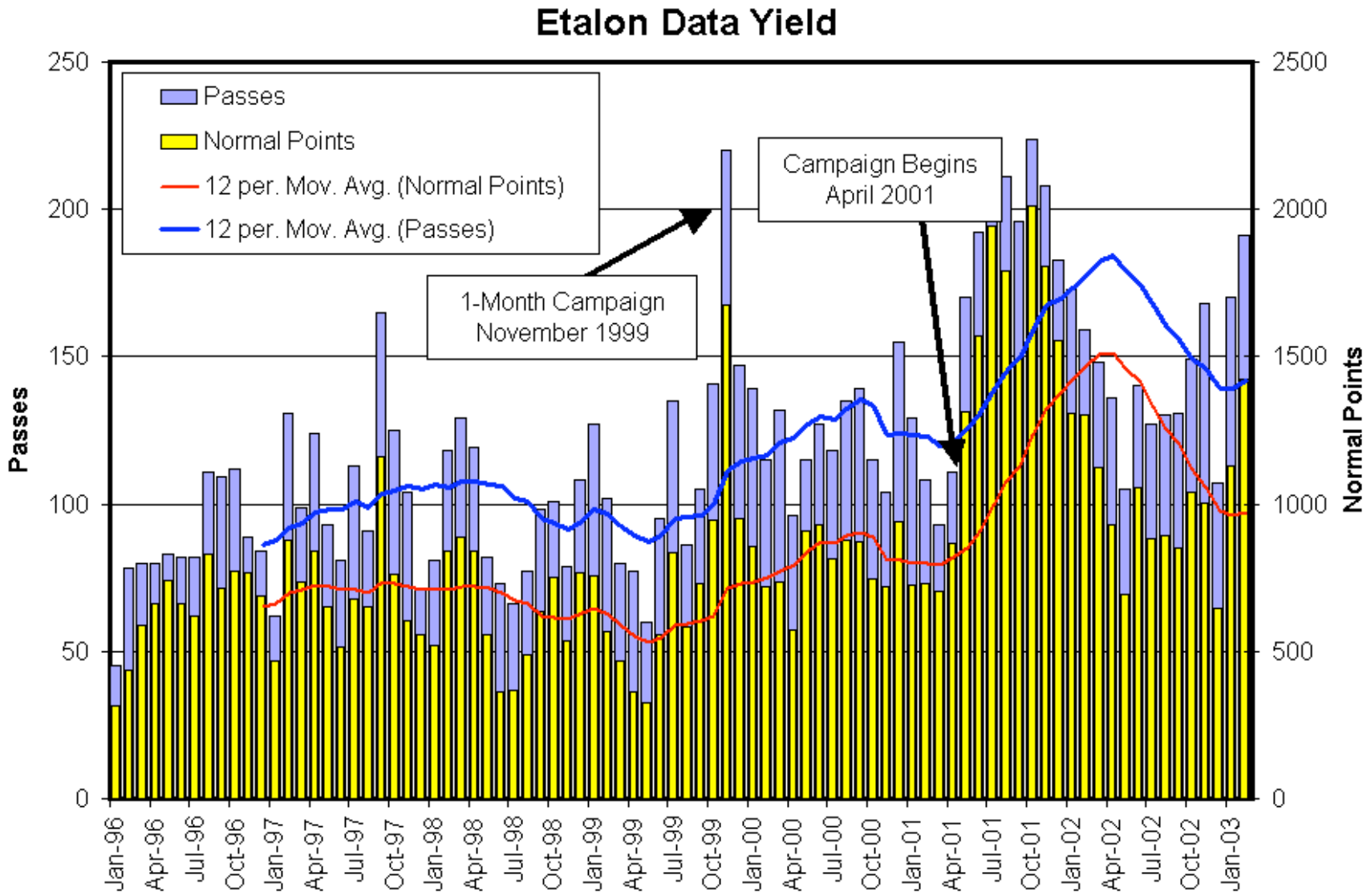


ILRS Tracking Statistics

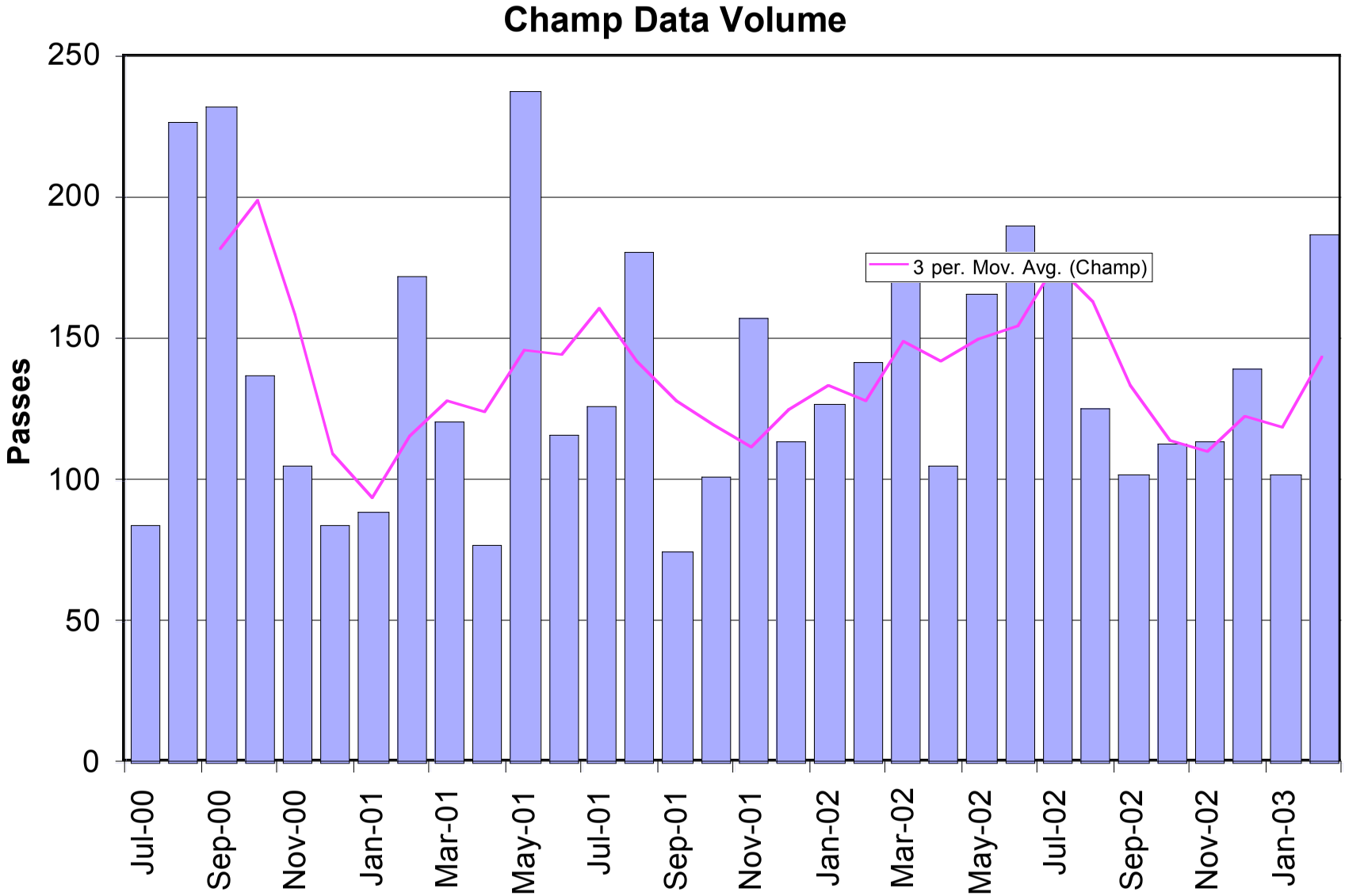
(2002 by Station)



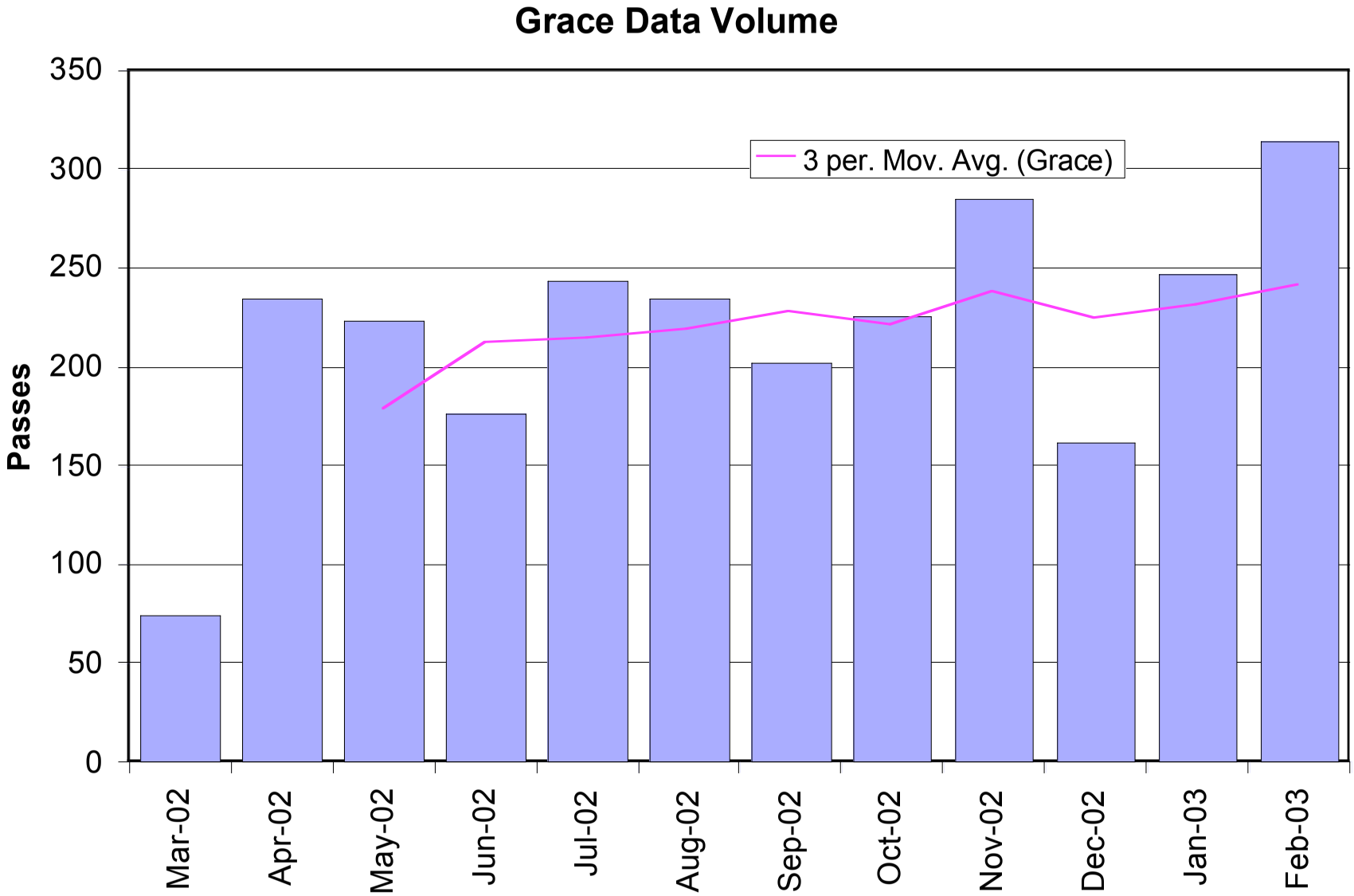
ILRS Tracking Statistics



ILRS Tracking Statistics



ILRS Tracking Statistics



ILRS Tracking Priorities

Priority	Mission	Sponsor	Altitude (km)	Inclination (degrees)	Comments
1	GRACE (A,B)	GFZ/JPL	485-500	89	tandem mission
2	CHAMP	GFZ	429-474	87.27	
3	GFO-1	US Navy	790	108.0	altimetry/no other tracking technique
4	ENVISAT	ESA	796	98.6	tandem with ERS-2 tracking to commence 40 days after launch
5	ERS-2	ESA	800	98.6	tandem with ENVISAT
6	Jason	NASA/CNES	1,350	66.0	tandem with Topex*
7	TOPEX/Poseidon	NASA/CNES	1,350	66.0	tandem with Jason*
8	Starlette	CNES	815-1,100	49.8	
9	Stella	CNES	815	98.6	
10	METEOR-3M	IPIE	1000	99.64	
11	Beacon-C	NASA	950-1300	41	upgraded from campaign to ongoing mission (Jan-02)
12	Ajisai	NASDA	1,485	50	
13	LAGEOS-2	ASI/NASA	5625	52.6	
14	LAGEOS-1	NASA	5850	109.8	
15	Etalon-1	Russian Federation	19,100	65.3	campaign extended to 01-Oct-02
16	Etalon-2	Russian Federation	19,100	65.2	campaign extended to 01-Oct-02
17	GLONASS-89	Russian Federation	19,100	65	replaced GLONASS-86 as of 20-Mar-03
18	GLONASS-87	Russian Federation	19,100	65	replaced GLONASS-88 as of 20-Feb-02
19	GLONASS-84	Russian Federation	19,100	65	replaced GLONASS-79 as of 22-Feb-01
20	GPS-35	US DoD	20,100	54.2	
21	GPS-36	US DoD	20,100	55.0	

ILRS Station Qualification

- Stations would be classified as Operational or Associate
- All current ILRS stations would be initially considered Operational
- New stations accepted as Associate by the Central Bureau upon submission of ILRS Station Response form
- Associate stations become Operational by:
  - Submitting valid site log
  - Delivering 10+ passes of data to CB
  - Passing format and data integrity validation by CB
  - Delivering 20+ LAGEOS passes over a consecutive 3-month period to ILRS operations center
  - Passing data evaluation by Analysis Working Group (see below)
  - Approval by Governing Board

ILRS Station Qualification

(Continued)

- Data evaluation:
  - 20+ LAGEOS passes in 3 months
  - Normal point RMS of 1 cm (Shanghai Criteria)
  - Short term range bias stability of 4 cm (twice Shanghai Criteria)
  - Normal point acceptance rate of 80%
- Starting January 01, 2004, any Operational Stations that have not submitted 50 LAGEOS passes within a 3-month period during previous 12 months or a valid site log will be assigned Associate status
- Stations designed for low-satellite tracking must fulfill criteria on Starlette/Stella (needs discussion)
- Operational/Associate status indicated on Quarterly Report Cards issued by ILRS CB

Shanghai Criteria

- Annual Data Yield
  - 1000 LEO passes
  - 400 LAGEOS-1, -2 passes
  - 100 HEO passes
- Data Quality
  - 2 cm LAGEOS precision
  - 1 cm LAGEOS normal point precision
  - 2 cm short term bias stability
  - 1 cm long term bias stability
- Operational Compliance
  - Data delivery within 12 hours
  - Specified data format
  - Current site log

Site Survey Activity

- Site Survey is a major problem impacting the space geodetic reference frame, especially related to collocation of techniques needed for TRF combination
- Problems include inconsistencies in the ground survey techniques used, the survey network geometries, the survey analysis, the documentation, discrepancies between site survey and TRF results, etc.
- An assessment of the local survey status for each station in the SLR and VLBI networks was made by the ISGN committee under John Bosworth; an action plan with priorities was developed
- A Joint Service team with IGN (Zuheir Altimimi), IVS (Chopo Ma) ILRS (Mike Pearlman), and NASA/Survey Team (Jim Long) are building on the earlier activity

Site Survey Activity
(Continued)

- This team will be placed somewhere in the new IAG organization, perhaps under the IERS
- Activities underway:
  - Jim Long is running tutorial survey sessions at major meetings
  - A survey standards document has been prepared and circulated
  - A complete survey report on GSFC is being issued as a teaching example
  - A joint team (IGN, NASA) is making arrangements visit Shanghai to participate in a site survey and to compare survey techniques
  - Discussions are underway with HartRAO on a planned site survey
- Additional people with survey experience are needed on the team to help educate others and to participate in the site surveys at critical stations

Operational Issues (April 2003)

Dynamic Priorities

- Simplified version presented to GB
- HTSI developing an intelligent scheduler

New Three Month Station Status Report on Web

Station Qualification

Data Corrections File in Process (1999 complete)

Local Ties

Operational Issues (April 2003)

Predictions

- HTSI incorporating GPS data into ICESAT predictions in collaboration with CSR

Laser Workshop Proceedings

2001 Annual Report is published and on-line

Minimum Obs. per Normal Point

Site Log Maintenance

Full-rate Data Flow Implemented

ILRS Web Site

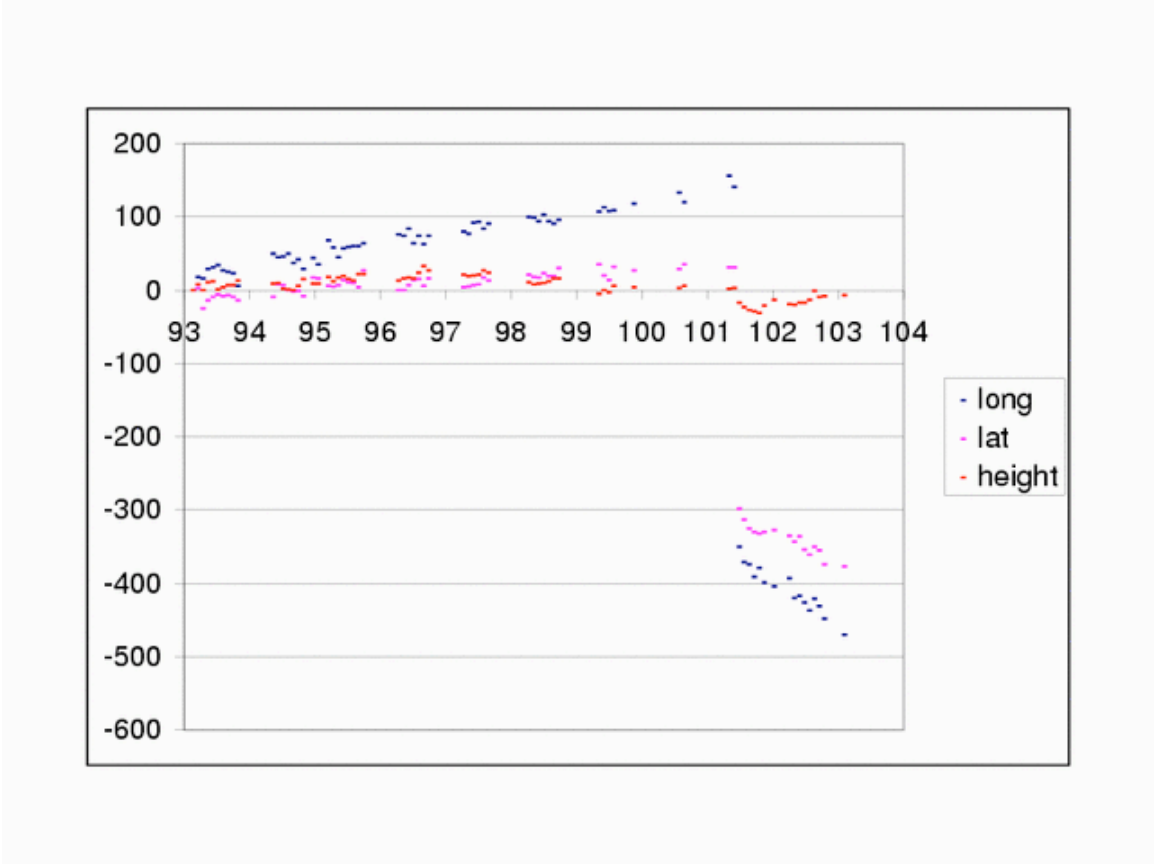
- New navigation scheme with breadcrumbs
- Bulletin Board
- 'Best Practices' for Timers
- Template for Satellite CoM
- Web Site statistics available at:

  http://ilrs.gsfc.nasa.gov/awstats
- Activities In Progress
  - Re-organize the station related web pages
  - MyStationPerformance.Com
    - Consolidated Bias Report

Science Coordinator Report

Science Coordinator's Report

Peter Dunn gave the CB Science Coordinator report, and provided an update on the motion of Arequipa, Peru after the June 23, 2001 earthquake and its aftershocks. He referred the participants to the wealth of science results now accessible in the proceedings of the recent Laser Workshop in Washington, D.C., and highlighted the renewed interest in modeling surface forces on SLR satellites evident in a session at the EGS/AGU Meeting.



Data Center Report

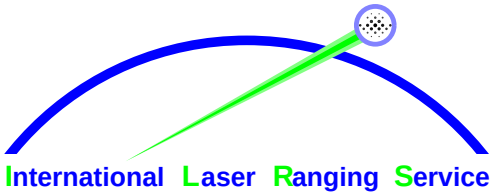
International Laser Ranging Service

ILRS Global Data Center Report

Wolfgang Seemüller

- **Remarks:**
  - **Backup procedures are installed at both global Data Centers (EDC replaced by Zimmerwald, CDDIS by EDC). The CDDIS replacement is still not tested, no data at EDC ftp server from Nasa stations since installation on Sep. 15, 2001 (for on-site normal points).**
- **New implementations:**
  - **Two wavelength ONPs (separate files) are accepted, archived and distributed at both Global Data Centers. Until now only some passes are received from Zimmerwald.**
  - **New quality check for data format and integrity is installed at EDC (still missing: automatic information of the responsible SLR station, and it is still not complete; it will be provided when finished)**
  - **Full-rate data delivery and archiving has started recently (Still some open questions, see DF&P WG Report)**

DGFI



ILRS Global Data Center Report (continued)

- **Full-rate data directories at CDDIS and EDC**
  - **At CDDIS:**
    /slr/slrfr/sname/yyyy/ **(monthly files)**
    /slr/slrfr/sname/daily/ **(daily files)**
  - **At EDC:**
    pub/laser/frdata/monthly/ **(monthly files)**
    pub/laser/frdata/daily/ **(daily files)**

- **Directories for deliveries of full-rate data**
  - **For deliveries to NASA/HTSI:**
    At HTSI: [fg_normpts.fullrate]
  - **For deliveries to EDC:**
    At EDC: incoming/laser/frdata/ **(user name and password can be asked at EDC)**

Working Group Reports

Missions Working Group Meeting

ILRS Missions Working Group

Nice, France

April 7, 2002

Agenda/Summary

- **MWG membership**
- **Past and Current Activity Since Last Meeting (October 2002 - Washington, DC)**
  - **Campaign/Mission Status**
    - **ICESat** **Update by Peter Shelus - CSR**
    - **LRE** **Update by Maki Maeda - NASDA**
    - **Reflector** **Update by Natalia Parkhomenko - IPIE**
  - **Mission/Satellite Data Base for Satellite Signature Study/ COM information - Update by Graham Appleby - NERC**
- **Continuing and Future Actions**
  - **Supporting current / future missions / campaigns**
  - **Satellite Tracking Priority List**
- **New Activity**
  - **Intelligent Scheduler Discussion**
    - **The need for starting parameters to drive scheduling criteria**
    - **Current software update - Update by Bart Clarke - HTSI**
    - **Proposed dynamic priorities - Update by Mike Pearlman - SAO**
- **Upcoming Missions**
    - **Within 2003**
      - **Gravity Probe B - NASA** **Late 2003**
    - **Beyond 2003**
      - **Cryosat - ESA** **2004**
      - **ANDE - NRL** **2004**
- **Other Issues**

MWG Membership

COORDINATOR

David Carter	NASA	USA

Deputy Coordinator

Hiroo Kunimori	CRL	Japan

New membership includes:

Bart Clarke	HTSI	USA

Retained membership include:

Wolfgang Schluter*	BKG	Germany	Giuseppe Bianco	ASI	Italy
Vladimir Vasiliev	IPIE	Russia	Urlich Schreiber	TUM	Germany
Scott Wetzel	HTSI	USA	Julie Horvath	HTSI	USA

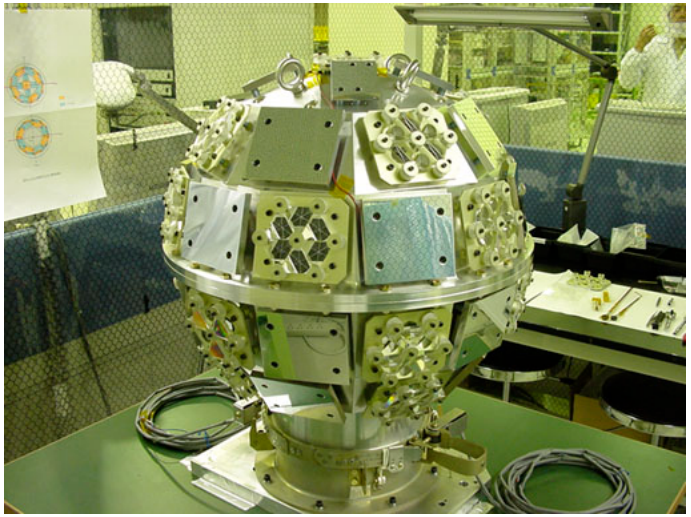
Membership action

- More active participation to be recruited for membership - in progress
- Change On-line Mission Request Form to reflect satellite name in message Subject line - in progress

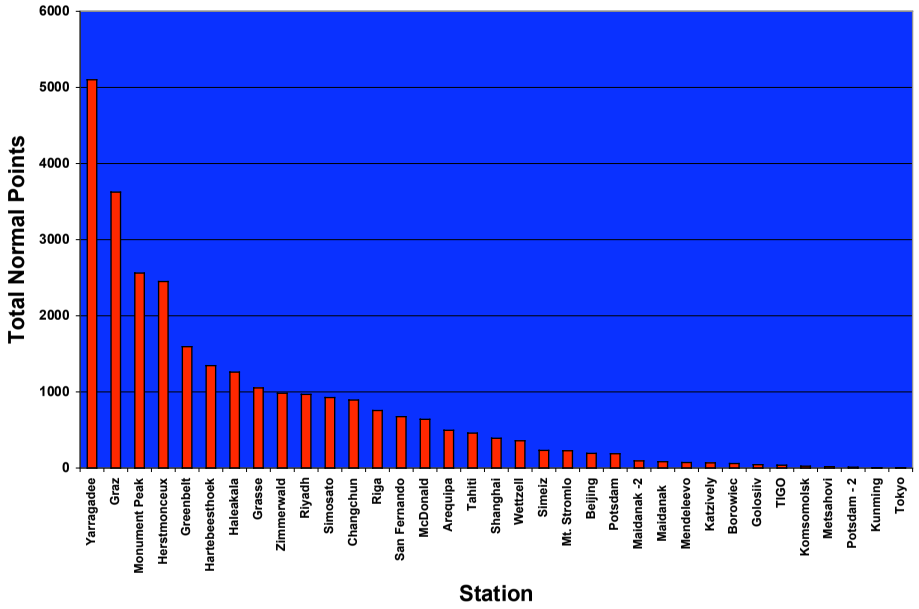
Past and Present Campaigns
LRE Campaign

LRE

- LRE was launched on a NASDA H2-A rocket on August 29, 2001
- Official campaign was 1 month in September 2001 and very difficult target to acquire due to 3 hour launch delay caused satellite to lose most of the terminator conditions for 3 months
- Only stations to have successful SLR are Grasse and Yarragadee
- No SLR tracking since March 28, 2002
- Kunimori proposes to keep LRE tracked on an "as available" basis
  - NASDA will provide TIRV routinely
  - LRE at bottom of priority list
- Maeda discussed possibility to track LRE as campaign in future
  - Looking toward May 2003 time period
  - More information is needed on when LRE is sunlit
  - Provide timeline for when LRE most probable for successful SLR tracking
- Awaiting further direction on campaign from NASDA

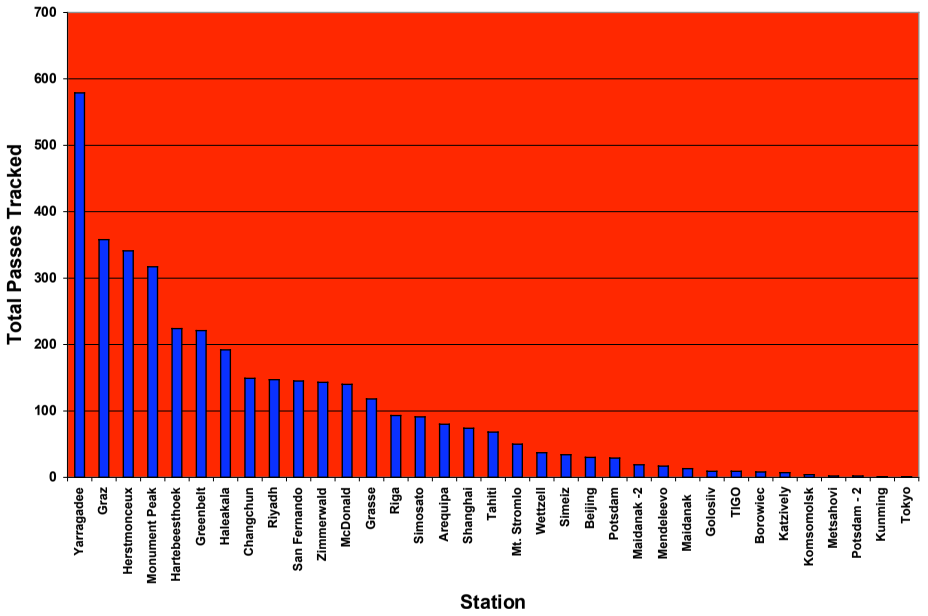


Past and Present Campaigns (2)
Reflector Campaign

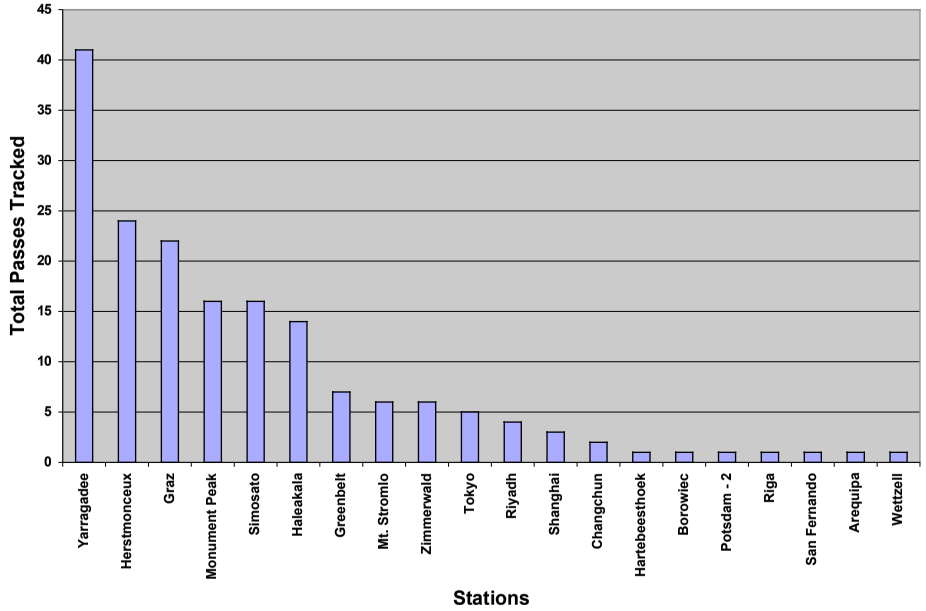


- **3 month campaign extension requested by IPIE**
- **IPIE notified ILRS CB to end campaign in March 2003**
- **SLR ended on March 10, 2003**
- **Tracking Statistics very good.**
  - **35 systems tracked Reflector**
  - **27,878 total normal points**
  - **3,752 total passes**
- **Campaign report by IPIE pending**

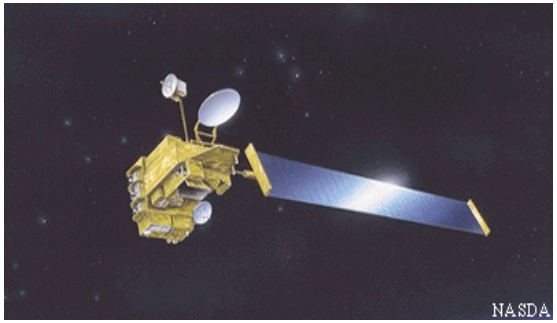
- **Used for POD research for space debris detection**
- **Sponsor is ROSAVIACOSMOS, Science Research Institute for Precision Instrument Engineering (IPIE)**
- **Launched December 10, 2001**
- **9 month SLR campaign began on December 21, 2001**
- **IPIE requested full-rate (F/R)data to study array response**
  - **F/R data was originally received from CDDIS for NASA only stations**
  - **F/R Study Group recommended direct full rate transmission from other systems to IPIE which began**



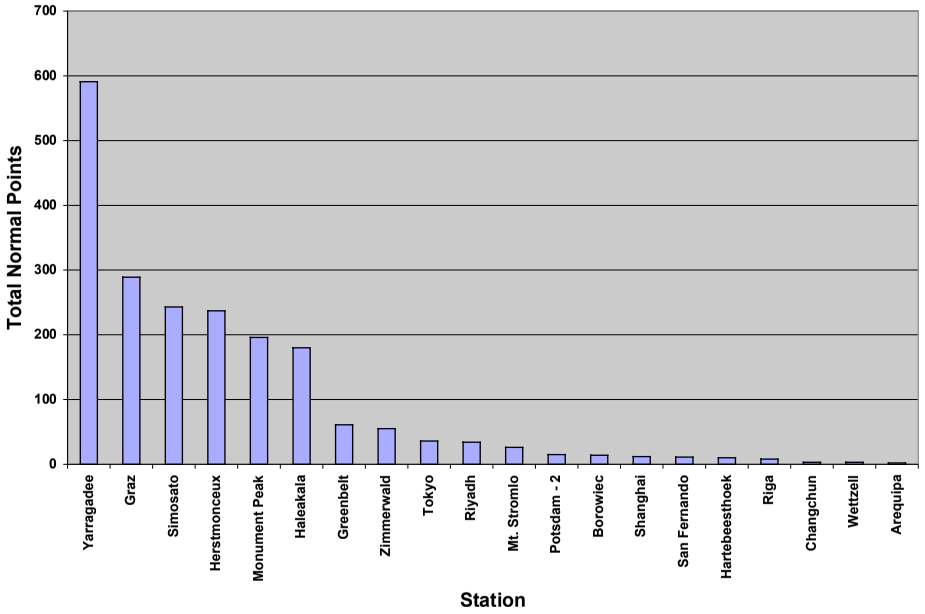
Past and Present Campaigns (3)
ADEOS-II (Advanced Earth Observing Satellite)



- **Follow-on tracking requested on an invitation basis for past Launch +34 day**
- **CRL, Simosato, Yarragadee currently supporting**
- **Follow-on tracking not ILRS approved due to safety concerns**



- **ADEOS-II is a NASDA Earth Sensing mission**
- **ADEOS-II was launched December 14, 2002**
- **SLR support performed from launch until L+34 days to support POD**
  - **GPS was turned off during this period**
  - **Issue with possible damage to GLI from SLR causing much problem with tracking**
- **Campaign ended on January 18, 2003**
- **Tracking Statistics very good.**
  - **20 systems tracked ADEOS-II**
  - **2,026 total normal points**
  - **173 total passes**



Continuing and Future Actions

Supporting current / future missions / campaigns

- Work with known satellite organizations to get Mission Request Forms and Support Plans completed and put on Web - ongoing
  - Currently working with GPB, CryoSat, NPOESS missions on mission planning activities
  - Working with NASDA to look at ways to include LRE and ADEOS-II into tracking schedule by either mission support or campaign support

Current Tracking priorities

Priority	Mission	Sponsor	Altitude (km)	Inclination (degrees)	Comments
1	GRACE A, B	GFZ/NASA	485-500	89	Gravity research (Two satellites tracked alternately)
2	CHAMP	GFZ	429-474	87.27	Gravity research
3	GFO-1	US Navy	790	108.0	Altimeter calibration / no other tracking technique available
4	Envisat-1	ESA	800	98.6	Altimeter calibration / DORIS backup
5	ERS-2	ESA	800	98.6	Altimeter calibration / PRARE backup
6	Jason	NASA/CNES	1,350	66.0	Altimeter / DORIS and GPS backup
7	TOPEX/Poseidon	NASA/CNES	1,350	66.0	Altimeter calibration / DORIS and GPS backup
8	Starlette	CNES	815-1,100	49.8	Geodetic / no other tracking technique available
9	Stella	CNES	815	98.6	Geodetic / no other tracking technique available
10	Meteor-3M	IPIE	1020	99.64	Retroreflector research / No other tracking technique available
11	BeaconC	NASA	950-1300	41	Gravity Research / upgraded to ongoing mission (Jan 2002)
12	Ajisai	NASDA	1,485	50	Geodetic / no other tracking technique available
13	LAGEOS2	ASI/NASA	5625	52.6	Geodetic / no other tracking technique available
14	LAGEOS1	NASA	5850	109.8	Geodetic / no other tracking technique available
15	Etalon1	Russian Federation	19,100	65.3	Geodetic / no other tracking technique available
16	Etalon2	Russian Federation	19,100	65.2	Geodetic / no other tracking technique available
17	GLONASS89	Russian Federation	19,100	65	Positioning POD enhancement / replaced G86 as of Mar. 2003
18	GLONASS87	Russian Federation	19,100	65	Positioning POD enhancement / replaced G88 as of Feb. 2002
19	GLONASS84	Russian Federation	19,100	65	Positioning POD enhancement / replaced G79 as of Feb. 2002
20	GPS35	US DoD	20,100	54.2	Positioning POD enhancement
21	GPS36	US DoD	20,100	55.0	Positioning POD enhancement

Other Targets of Opportunity:

ADEOS-II	NASDA	800	98.62	POD / GPS intercomparison / GPS backup
LRE	NASDA	250-36000	28.5	HEO Characterization / Spin evolution vs. BK7 degradation

April 7, 2003

New Activity

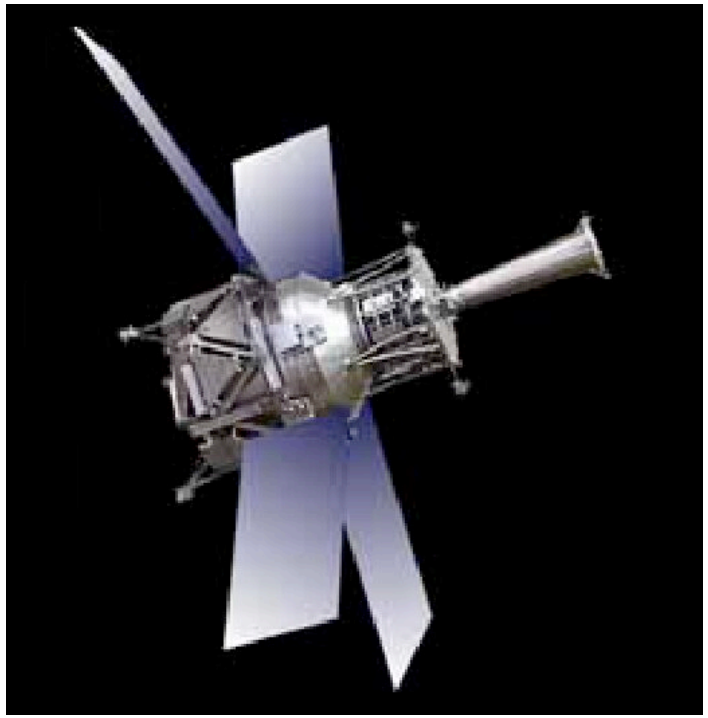
Intelligent Scheduler

- At Nice 2002 meeting Peter Shelus suggested dynamic tracking priorities with continuous monitoring of all satellites and systems and adjust tracking priorities to pick up on weak satellites
- Bart Clark presented paper in Washington 2002, “Intelligent Scheduler, Prioritize on the Fly” which will address many of these issues
- Mike Pearlman recently proposed a simplified model for adjusting tracking priorities
- Discussions regarding these two ideas of priorities and criteria to occur at this meeting
- Inputs from all Working Groups and all ILRS members and friends are desired

Upcoming Missions

GPB (Gravity Probe B)

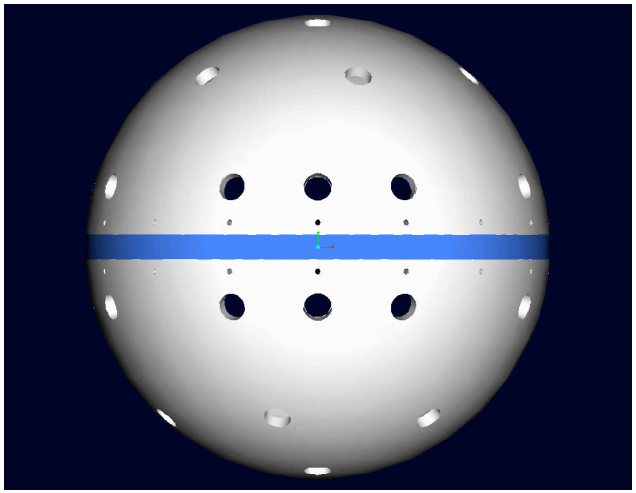
- GPB is a NASA / Stanford University relativity mission
- GPB is the relativity gyroscope experiment being developed by NASA and Stanford University to test two extraordinary, unverified predictions of Albert Einstein's general theory of relativity.
- Space vehicle is inertially pointed and spinning about its axis at approximately 0.3 rpm. Retroreflector is mounted axially with one cube pointing in the direction of the axis, and 8 cubes evenly distributed, pointing about 50 degrees away from axis
  - This will cause the array to be pointed away from stations at certain times
  - Model is to be provided for scheduling
- Coordination efforts between ILRS and GPB team on-going
  - GPB OD and Orbit Trim Review held in June 2002
  - Issues with the spacecraft continue to delay mission
- Mission Specifications include:
  - Altitude: 650 km
  - Eccentricity: 0.0
  - Inclination: 90°
  - Launch Date: Late 2003
  - Mission Duration: 16 months
  - Purpose of SLR: Establish POD then backup for GPS
  - Array information: 9 cube open hemisphere, same as MSTI-II



Upcoming Missions

Atmospheric Neutral Drag Experiment (ANDE)

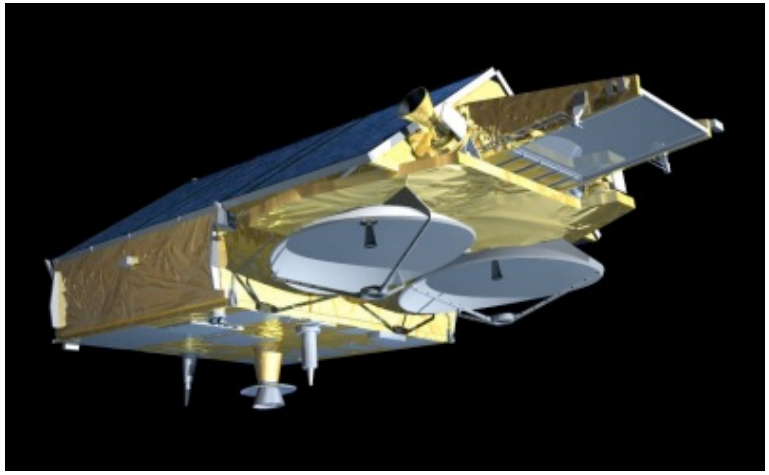
- ANDE is a NRL research satellite system which will provide a means to calibrate atmospheric drag effects on low earth orbiting satellites
- The program consists of two small spherical satellites
- Data about the position of the satellites can be used to calculate the drag on the satellite and the atmospheric density at that altitude
- The data will also be used to answer questions about the impact of spacecraft composition and thermal characteristics when computing theoretical ballistic coefficients
- No Mission Support Request provided as of yet
- Launch scheduled for 2004
- No mission specifications have been provided yet



Upcoming Missions
(beyond 2003)

CryoSat

- First satellite in ESA's Living Planet Program from the Earth Explorer Opportunity Missions
- A radar altimetry mission dedicated to observing the polar regions to study climate variability and trends by monitoring the variations in thickness of continental ice sheets and marine sea ice cover
- Mission Request form received, initial positive recommendations provided with questions
- Working with MWG on approvals following clarifications of certain items
- Mission Specifications include:
  - Altitude: 720 km
  - Eccentricity: 0.0
  - Inclination: 92°
  - Launch Date: 2004
  - Purpose of SLR: Establish POD then backup for DORIS
  - Tracking schedule: Commissioning + Routine Phase
  - Spatial coverage: Mediterranean for Commissioning Phase
    Global otherwise
  - Array information: 7 cubes, design to be provided
- MWG Status:
  - Need to coordinate this mission with CryoSat team.
  - Contact to be reestablished



Upcoming Missions

Satellite Name	Satellite Abbreviation	Owner	Mission Type	Planned Launch Date	Mission Duration	Received Mission Request Form	Received ILRS GB Approval
Gravity Probe B	GPB	NASA	Relativity research	Late 2003	1-2 years	Yes	Yes
Atmospheric Neutral Drag Experiment	ANDE	NRL	Drag research	2004	1 year	No	No
CryoSat	CryoSat	ESA	Ice flow monitoring	Mid 2004	3.5 years	Yes	Awaiting MWG Recommendation
Advanced Land Observing Satellite	ALOS	NASDA	Altimeter calibration	Mid 2004	3 years	No	No
Engineering Test Satellite number 8	ETS-VIII	NASDA	Time transfer experiment	Mid 2004	3 years	No	No
The National Polar-orbiting Operational Environmental Satellite System	NPOESS	NOAA	Earth Sensing	2013	7 years	Yes	No

Other Issues

- Questions, concerns and comments are appreciated...

Intelligent Scheduler Update

Missions Working Group
Nice, France
April 7, 2003

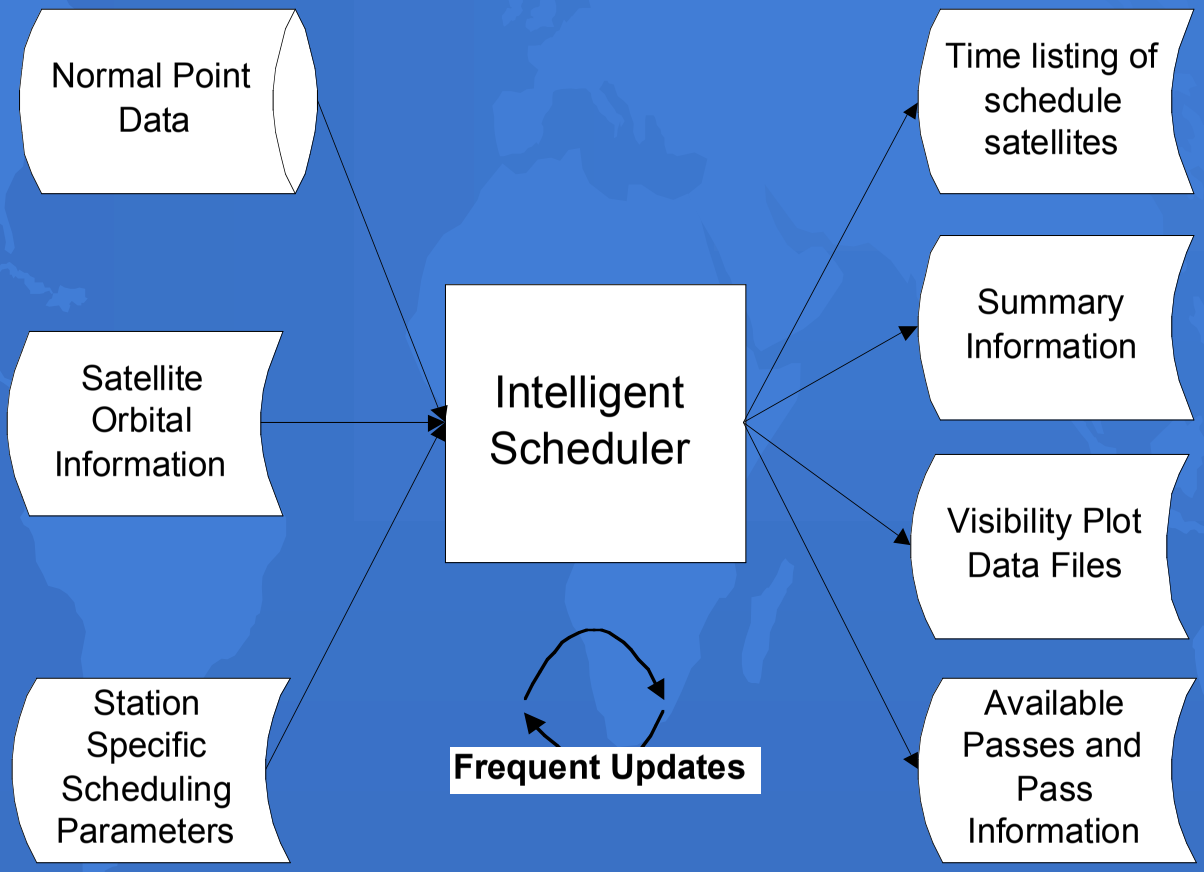
Christopher Clarke, Julie Horvath

NASA SLR/VLBI Program
Honeywell Technology Solutions Inc.
Honeywell International
7515 Mission Drive
Lanham, MD 20706 USA
Contact Information
E:mail: christopher.clarke@honeywell-tsi.com
E:mail: julie.horvath@honeywell-tsi.com

Introduction

- Current software schedules satellites according to static priorities
- New mission scheduling software in development
  - Based on the current scheduling software developed by HTSI for the Matera Laser Ranging Observatory
  - Features include
    - Dynamic prioritizing of satellites
    - Satellite position may be included in the scheduling criteria
    - Amount of recently tracked data may be included the scheduling criteria
    - Unique station criteria used in schedule optimization

Functional Diagram



Current Optimization

- Current optimization features implemented
  - AOS/PCA/LOS Optimization
  - Fine Interleaving Optimization
  - Geodetic (sky coverage) Optimization
  - Ascending/Descending Optimization
- Future optimization features
  - Schedule optimization based on station specific criteria
  - Other features will be added based on need.

Current Scheduling Parameters

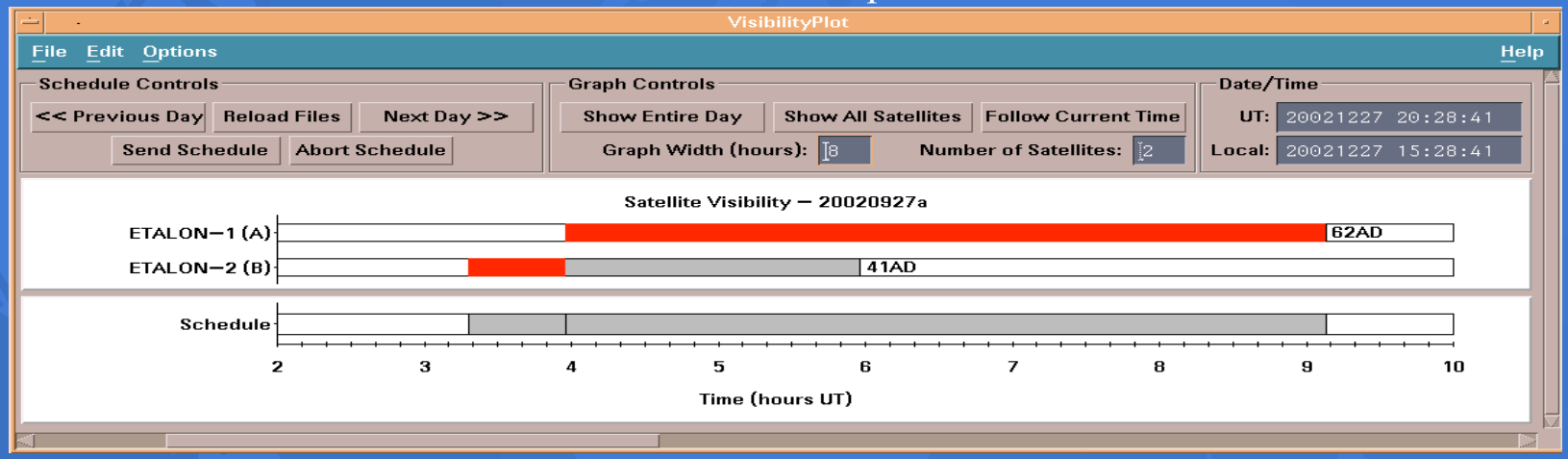
- Normal Operations
  - Priority
  - Min and Max Track Time
  - Min Elevation
  - Day/Night Restrictions
- Optimization Applications
  - AOS/PCA/LOS
    - Adjusted Priorities at AOS/LOS/PCA
  - Fine Interleaving
    - Fine Interleave Track Time
  - Sky Coverage
    - Minimum data per sky section
    - Previous data considered (variable)
  - Ascending/Descending
    - Minimum data per node
    - Previous data considered (variable)

AOS/PCA/LOS Optimization

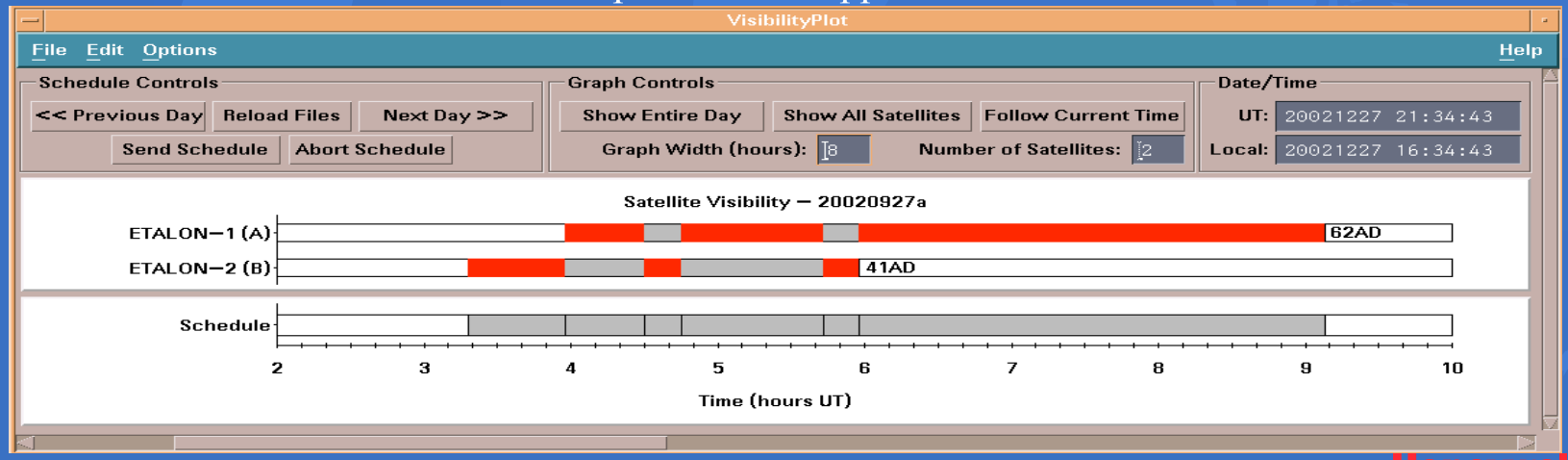
- Raises priority of a satellite at the AOS/PCA/LOS of a pass

AOS/PCA/LOS Example

No AOS/PCA/LOS Optimization



AOS/PCA/LOS Optimization Applied for Etalon-2

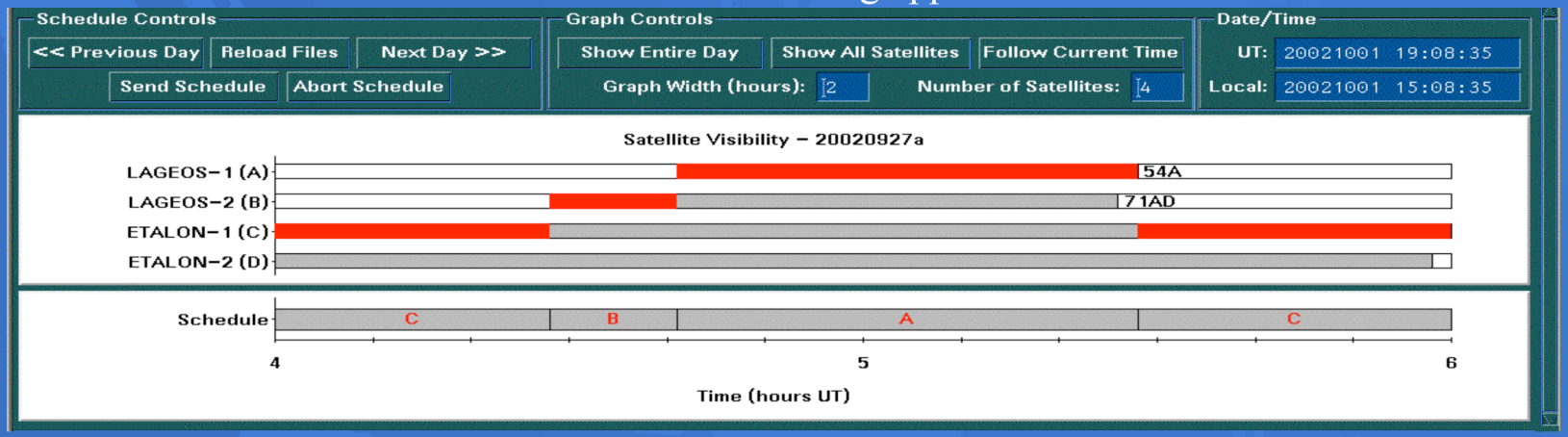


Fine Interleaving Optimization

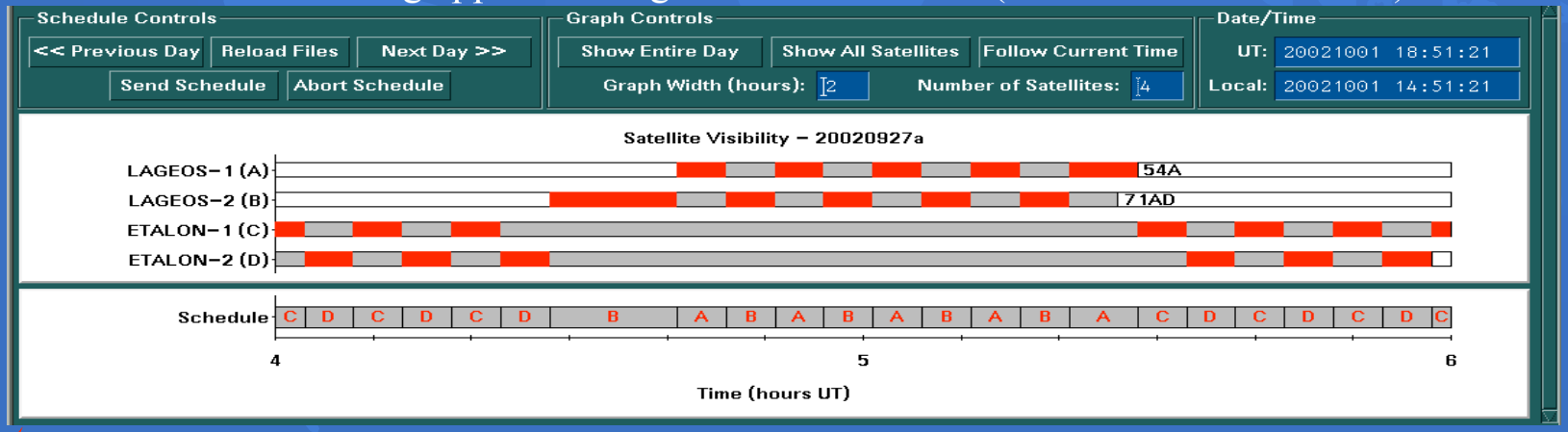
- Schedule will alternate between a satellite and lower priority satellites at given time intervals
- Avoids scheduling scenarios where one satellite of several similarly prioritized satellites is scheduled a disproportionate amount of time
- Gives flexibility to prioritize like-satellites equally (eg. GRACE A&B, Jason & TOPEX)

Fine Interleaving Example

No fine interleaving applied



Fine interleaving applied to Lageos-1 and Etalon-1 (time interval is variable)



Geodetic (Sky Coverage) Optimization

- Divides sky into sections based on azimuth and elevation
- Calculates amount of time satellite has been tracked in a section of the sky
- Raises the priority in a particular sky section where the amount of satellite data tracked does not reach a minimum threshold
  - Value defined by MWG and AWG or specific mission

Ascending/Descending Optimization

- Calculates the amount of time a satellite has been tracked in ascending and descending nodes
- Raises the priority of a satellite when in an ascending or descending node and the amount of data tracked in that node is less than the minimum threshold value
  - Value defined by MWG and AWG or specific mission

Additional Features

- Sun Zone Avoidance
  - Schedules other opportunities during sun zone times
- Ground target calibration and maintenance events optimize scheduling
  - Customize when calibrations or maintenance are to be performed for specific stations
- Special Satellite Passes
  - Raise priority for specific satellite passes

Summary File Information

- Information included
  - Total number of passes and minutes each satellite is available versus number of passes and minutes which the satellite is scheduled
  - Separated by ascending / descending node and section of the sky
  - Effects of the optimization
    - The schedule will be generated with and without the optimization applied
    - The net effects of the optimization are calculated and displayed

Possible Future Developments

- Multi-site optimization
  - Use groups of stations when optimizing schedules
- Web based application for displaying successful tracking and current schedules
- Increase frequency of updates to near-real-time

Conclusion

- New scheduler has enhanced capabilities
  - Dynamic prioritizing of satellites
  - Station specific criteria
  - Satellite position is available for entire visible arc
  - Recently tracked data is incorporated into scheduling criteria
  - Frequent updates to the schedule
- Several optimization applications have been developed utilizing these capabilities

Ascending/Descending Example

TOPEX and Jason summary with no ascending/descending optimization applied and TOPEX at a higher priority. Notice all available TOPEX is scheduled while only 63 % of available Jason is scheduled.

Satellite or Event Name	Passes Available	Passes Scheduled	%	Pass Segments Scheduled	Minutes Available	Minutes Scheduled	%
TOPEX	34	34	100	34	384	384	100
JASON	35	35	100	35	385	243	63

****
* JASON * SUMMARY *
****

Descript. of Row Sub-Total	Passes Available	Passes Scheduled	%	Pass Segments Scheduled	Minutes Available	Minutes Scheduled	%
Total	35	35	100	35	385	243	63
Ascending	18	18	100	18	194	124	64
Descending	17	17	100	17	191	119	62

Ascending/Descending Example (2)

TOPEX and Jason summary with ascending optimization applied to Jason (200 minutes minimum). Notice all ascending Jason is now scheduled

Satellite or Event Name	Passes Available	Passes Scheduled	%	Pass Segments Scheduled	Minutes Available	Minutes Scheduled	%
TOPEX	34	34	100	34	384	325	85
JASON	35	35	100	35	385	320	83

****
* JASON * SUMMARY *
****
ascending/descending optimization activated

Descript. of Row Sub-Total	Passes Available	Passes Scheduled	%	Pass Segments Scheduled	Minutes Available	Minutes Scheduled	%
Total	35	35	100	35	385	320	83
Ascending	18	18	100	18	194	194	100
Descending	17	17	100	17	191	119	62

NEWG

Network & Engineering Working Group

Notes of Nice Meeting, 8. April 2003

- Minimum Number of Returns per NP
  - Status: MOST Stations do NOT use this criteria;
  - It SHOULD be used, to avoid noise points, to improve data quality etc.
  - ILRS Governing board should sent 1 more notice to the stations, to implement it;
  - At the October meeting in Koetzting, this should be checked again, and – in case – some additional action started then ….

- Global Use of Real Time Time Bias Exchange, and Time Bias Prediction File:
  - Availability: YES : just implement it, enjoy it
  - Werner Gurtner will send another notice to SLR stations, to encourage implementation

- MyStationPerformance.Com:
  - Van Husson reported about the present status

- New Bias Detection Capabilities / 28 Day Solutions:
  - Van Husson reported about this new possibilities;
  - Seems to be a quite powerful new technique to detect problems …
  - Needs sufficient data, and for some cases a nearby core station, but allows significantly better results

- Engineering Data File (EDF)
  - Each CAL (and each pass) adds a line of parameters to the station EDF;
  - The list of parameters can be individual for each station; whatever they need and can …
  - The format has to be defined, but is not fixed; could be XML, or indexed, or …..
  - Goal: This allows for each station a complete history of hardware settings, parameters, CAL values, statistics, met values etc.etc.;
  - Expected advantages and output:
    - Each Station can (automatically) check for consistency, linearity, jumps etc.;
    - Analysis groups could easily cross-correlate any signatures;
    - Comparisons between EDF files of similar stations should identify possible improvement areas by simple comparisons ….
  - Some stations (Matera, RGO, Graz, NASA) agreed to check their possibilities, and to start with such recordings as soon as a first test format is defined; the goal is to have first results for the Koetzting meeting in October.

SLR Graz kHz Laser Project

Present Status: April 2003

- kHz Laser Ordered; Delivery: Summer 2003
  - 0.5 mJ @ 1 kHz (0.4 mJ @ 2 kHz)
  - 10 ps @ 532 nm
- Demo Laser Tests: Jan 2003; VERY successful
- Writing / Testing Software (now: > 500 Hz ...)
- Optical / Mechanical Adaption in Progress

<KG/KF, 2003-04-02>

SLR Graz kHz Laser Project

Demo Results

- Tests with Demo Laser / Jan 2003; Results:
  - 70 µJ per Shot only (no additional amp after reg. amp);
  - 125 Hz (due to Software limitations at that time)
- 17 Passes observed: From CHAMP to GLONASS 86
  - Champ: Down to 10° Elevation; G86: 111 Rets/Pass;
  - Ajisai: ≈ 50.000 Rets/Pass; Lageos: ≈ 5.000 Rets/Pass
- Excellent stability & RMS; near 100% Ret Rate from LEOs;

<KG/KF, 2003-03-20>

SLR Graz kHz Laser Project

Next Steps

- Software: 1 kHz until summer 2003 (Pentium 200 MHz);
  - 2 kHz final goal
- Upgrade of Range Gate Generator: Summer 2003;
  - New FPGA Device;FIFO buffers added;
  - 500 ps resolution, at least 2 kHz repetition rate;
- Mechanical / Optical Adaption: May 2003;
- Summer 2003: Delivery of Laser:
  - First results expected Autumn 2003

International Laser Ranging Service

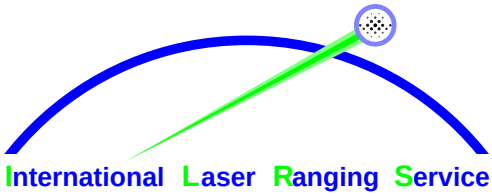
Data Formats & Procedures Working Group Report

Wolfgang Seemüller

- Two colour wavelength data submission is working but the analysis makes some problems
- New quality check for data format and data integrity now at both Global Data Centers (at EDC still not complete, new barometric pressure check algorithm proposed by Van Husson)
- Full-rate data delivering and archiving has started (March 31, 2003)
  Destination: global monthly files per satellite at CDDIS/EDC
  No time schedule adopted for:
  - Time of deliveries (next day, after 3 days, after one week latest)
  - updating of monthly files immediately, or e.g. at the tenth of the following month

  because real-time availability of full-rate data is not requested
- Backup of Urgent Mail at EDC in progress
- Refraction Study Group
  - see Report by Stefan Riepl
- Prediction Format Study Group
  - see Report by Randy Ricklefs

DGFI



Data Formats & Procedures Working Group Report

(continued, CB Activities)

CB Activities

- Normal Point Data Flow
  - hourly data flow working
  - Action item for sites: release flag
- Station Status
  - three month report based on NPs provided
  --> Station Qualification
- Predictions
  - HTSI incorporates GPS data
  - New prediction format
- Data Corrections File in Process
  - user friendly web based form for sites to enter data corrections
- Compliance Issues
  - NP Format and Data Integrity Checks
    -- NP bin formation
    -- Bin size
    -- Meteorological blunders
    -- Minimum number of observations in NP
    -- Midnight crossing (wrong date)
    -- New barometric pressure check algorithm

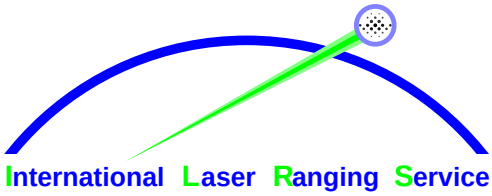
International Laser Ranging Service

Data Formats & Procedures Working Group Report

(continued, New Action Items for DF&P WG)

New Action Items for Data Formats & Procedures Working Group

- Encouraging stations for low elevation observations (request from Refraction Study Group)
- More frequent data exchange (e.g. every ten minutes) (request from Network & Engineering WG, action item for DCs)
- NP Format Change ? (request from Signal Processing WG)
- Full-rate data archiving
- Use of COSPAR or SIC number for satellites? (COSPAR No. at launch of new satellites not known)



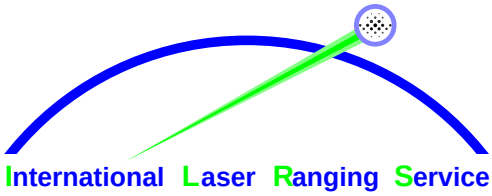
International Laser Ranging Service

Data Formats & Procedures Working Group

Agenda

Tuesday, April 08, 2003, 19:30-21:00
Nice, France
Lecture Room G5

1. Welcome and Introduction	**Wolfgang Seemüller**
2. Membership	**Wolfgang Seemüller**
3. Review of CB Activities	**Van Husson**
4. Refraction Study Group Report	**Stefan Riepl**
5. Formats Study Group Report	**Randy Ricklefs**
6. Two colour data submission and management, results?	**Werner Gurtner**
7. Working Group Charter/WG Activities	**W. Seemüller, all members**
8. FR data delivery	**Carey Noll, Van Husson, Werner Gurtner, W. Seemüller**
9. Normal Point data format and integrity check	**Van Husson, W. Seemüller**
10. Urgent Mail backup	**W. Seemüller**



International Laser Ranging Service

Data Formats & Procedures Working Group

Participants

Tuesday, April 08, 2003, 19:30-21:00
Nice, France
Lecture Room G5

Name	Institution	e-mail address
Wolfgang Seemüller	DGFI	seemueller@dgfi.badw.de
Werner Gurtner	AIUB	gurtner@aiub.unibe.ch
Stefan Riepl	BKG	stefan.riepl@bkg.bund.de
Georg Kirchner	OeAW	kirchner@flubpc04.tu-graz.ac.at
Van Husson	HTSI	Van.Husson@honeywell-tsi.com
Christopher Clarke	HTSI	Christopher.Clarke@honeywell-tsi.com
Julie Horvath	HTSI	Julie.Horvath@honeywell-tsi.com
Peter Shelus	CSR	PJS@ASTRO.AS.UTEXAS.EDU
Randy Ricklefs	CSR	RLR@ASTRO.AS.UTEXAS.EDU
Peter Dunn	RTSS	peter_j_dunn@raytheon.com
Graham Appleby	NERC SGF	graham.appleby@nerc.ac.uk
Ron Noomen	DEOS	RON.NOOMEN@DEOS.TUDELFT.NL
Rolf Koenig	GFZ	KOENIGR@GFZ-POTSDAM.DE
Nadia Shuygina	IAA	nvf@guasar.ipa.nw.ru
Leonid Petrov	GSFC	pet@leo.gsfc.nasa.gov

Data Formats and Procedures WG CB Report

ILRS Central Bureau

P. Dunn, J. Horvath, V. Husson, C. Noll, M. Pearlman, M. Torrence, S. Wetzel

International Laser Ranging Service

CB Activities

Normal Point Data Flow

- Hourly data flow working (occasional computer and network outages)
- Sites need to ensure the release flag is updated on resupplied data **(Action: sites)**

Station Status

- The CB has developed a 3 month report based on NPs provided.

Station Qualification under Review by GB

Predictions

- HTSI is incorporating GPS data into their prediction system
- Randy's team is progressing on the new predictions format
- Any need for another prediction's survey?

Maneuver Notifications

- No major problems

CB Activities (con't)

Data Corrections File in Process (1999 complete)

- This information is critical to the analysts
- Maintenance of this file is time consuming
- CB will develop a user friendly web based form for sites to enter data corrections
- Satellite Codes only exist for LAGEOS And Etalon

Compliance Issues

NP Format and Data Integrity Checks

- Most common compliance problem(s)
  - NP bin formation
  - Bin size violations (new satellites)
  - Meteorological blunders
  - Minimum number of obs in NP
  - Midnight Crossing (wrong date)
- Document un-correctable problem data vs deleting it from the data banks

New Recommended Barometric Pressure Check

- **Pressure -(1010-300*height in meters/3050)>=50**
- If TRUE, then delete the pass and notify the site

Prediction Formats Study Group
"Lynx Team"

Commissioned by:
The ILRS Data Formats and Procedures Working Group
at Matera, November 2000

Presentation prepared by
R. Ricklefs
University of Texas at Austin
McDonald Observatory and Center for Space Research
(rlr@astro.as.utexas.edu)

Purpose

Recommend a single laser ranging prediction format to encompass

- Earth satellites
- Lunar laser retro-reflectors
- Laser transponders on or orbiting other solar system bodies
- Laser transponders in transit

Format Features

- Tabular (grid) format (interpolation, not integration)
- State vectors spaced as required (fixed or variable)
- True body-fixed coordinates
- Multiple header and ephemeris record types
- Special record types to handle features of particular target classes
- Records short enough for e-mail
- Allows for integration beyond last record of file
- Some free format records
- Removes need for drag messages

Current Status

- Preliminary format has been distributed to the full slr community for comment.
- Sample code is being developed as a testbed for implementation of the format
- Sample interpolator tests have been completed
- Evaluating comments from the community

The Next Steps

- Revise format based on community comments
- Continue to develop sample code
- Document algorithms to convert ephemeris into point angles and range
- Develop and document metrics for prediction accuracy
- Conduct pilot projects using new format at several stations
- Make plans for general implementation
- Seek ILRS Governing Board's approval for implementation

Refraction Study Group
Minutes Nice 2003

1. Recent Activities

   1.1 Within the last months a contribution to IERS-Conventions concerning an update of the chapter for tropospheric refraction was furnished and submitted to Dennis McCarthy.

   1.2 As projected in the last RSG meeting at the Washington SLR workshop, a mapping-function analysis has been performed using 3 years of Lageos-2 normal point data (see appendix A and B at ILRS website). After orbit determination the normal point residuals were binned with respect to the elevation angle at which they have been recorded. The results reported by Cynthia Luceri and Erricos Pavlis show a clear improvement using the new mapping function, recently derived by Virgilio Mendes, instead of the Marini-Murray refraction model. Part of the analysis was also a test of the Saastomoinen zenith delay model applied to the Mendes' mapping function in it's original form and a modified form, enhancing the performance for other than 532nm wavelengths.

   1.3 Philip Ciddor provided his refractive index subroutines (coded by Jean Rueger) for the study and comparison of zenith delay models.

2. New Zenith Delay Model
   Concerning the modeling of the zenith delay the achievable accuracy as well as the limitations with respect to the input of surface meteorological data only remains to be determined. As it is not clear by now up to which extent non ideal gas behavior of the atmospheric constituents affects the zenith delay, statistics on this quantity have to be gathered out of numerical weather prediction (NWP) or radiosond data. As anomalous and nonlinear dispersion effects may play a role for certain wavelengths, such as 1064nm, at the millimeter level, a separate meeting with Yuri Galkin is scheduled for the end of July.

3. Horizontal Gradients
   As there have been reports on low elevation tracking data taken between 10 and 20 degrees elevation, showing deviations on the order of 10 centimeters with respect to the Marini-Murray refraction model, work remains to be done in the modeling and application of horizontal refractivity gradients. Statistical studies on the site dependent significance of horizontal refractivity gradients and their traceability in actual tracking data as well as surface meteorological data are underway. Global atmospheric models, data of satellite based remote sensing missions such as AIRS and limb sounding techniques are also considered as a data source for the determination of horizontal refractivity gradients, which has to be evaluated.

4. Combination Issues
   As presented within the Analysis Working Group meeting and projected in the IERS retreat the data gathered by the services supporting the IERS will be subject to two distinct modes of combination: a) Combination of technique specific solutions (Combination at solution level) b) Combination at observation level. Whereas mode a) is in favor of near real time data

processing (rapid availability of earth rotation parameters and station coordinates), which requires refraction data obtained in real time as well, mode b) permits the estimation of atmospheric refraction in the solution, since information of a vast multitude of observing techniques, i.e. different wavelengths, is accessible in the parameter estimation process. However mode a) imposes strict rules on how to obtain the refraction data: Combination at the solution level relies on uncorrelated solutions. Therefore a correlation of the ILRS solutions with the IGS solutions, e.g. by using refraction data obtained from GPS tomography, is to be avoided.

5. Governing Board Recommendations and Encouragements
   Once the open questions mentioned in paragraph 2) are completed, the Governing Board will be addressed formally in order to present recommendations for optimum procedures to improve refraction modeling, as foreseen by the study group charter. To improve the assessment of refraction and horizontal refractivity models, the SLR network is encouraged to gather more low elevation tracking data as well as to optimize two color satellite ranging techniques.

ILRS AWG meeting Nice 2003: agenda

1. opening
2. minutes AWG Lanham
3. actions since AWG Lanham
   3.1. reports, presentations
4. annoucements
   4.1. ILRS related presentations, publications
   4.2. IERS Retreat
5. SINEX issues (Husson)
6. pilot project "harmonization" (Husson)
   6.1. status report
   6.2. future
7. pilot project "benchmarking and orbits" (Husson, Pavlis, Mareyen)
   7.1. status report
   7.2. future
8. pilot project "positioning + earth orientation"
   8.1. individual contributions
        . ASI
        . Geosciences Australia
        . DGFI
        . GFZ
        . IAAK
        . JCET
        . NERC
   8.2. comparisons and combinations
        . ASI
        . DGFI
        . JCET
        . NCL
   8.3. future of "positioning + earth orientation"
        . timeline?
9. miscellaneous
   9.1. atmospheric refraction
   9.2. station qualification
   9.3. analysis center qualification
   9.4. dynamic tracking priorities
10. next meeting
11. action items
12. closure

AWG activities

Pilot projects:

- Benchmarking and orbits
  Husson, Pavlis and Mareyen
  Blunders, software inconsistencies
  Orbit and parameter solution comparisons

- Harmonization
  Husson
  Unify analysis results (i.e. biases)
  Continuous development

- Positioning + earth orientation
  Noomen
  Developments of analysis technique, official ILRS combination product(s)

official ILRS product “pos+eop”

- Customer: IERS Bulletin A
- CFP released November 2002
- 8 groups responded:
  7 -> solutions
  4 -> combinations
- AWG workshop March 31 – April 1:
  = status reports on developments
  = update product: 7-day cycle
  = new milestones:
    - until May 31: software + proc. development
    - June 1 – Oct 1: analysis solutions in, combination centers fine-tune
    - Oct 1 – Oct 21: preparation for AWG evaluation
    - Oct 26-27: AWG evaluation
- Also:
    - until May 31: handing in “benchmark” solutions
    - June 15: establishment of criteria
    - June 30: pass/fail assessment

IERS Retreat: IERS Combination Pilot Project

(evolves from IERS SINEX combination campaign)

rigorous combination of networks + EOPs + quasars:

- rigorous
- weekly process
- input: weekly network solutions, daily EOPs
- contributions expected/solicited from:
  - IERS technique centers (combination product, or 1 individual solution)
  - combination solutions at measurement level
- 4-6 weeks delay
- timeline:
  - May 1, 2003: installation of Combination WG
  - end of June: release of CFP
  - Sep 15: deadline for proposals
  - beginning Oct: evaluation of proposals
  - Jan 1, 2004: start of pilot project
- eventually, combination product will replace (that of) IERS PCs
- eventually reprocess old SLR, VLBI, GPS, … data
- time-series of weekly solutions, evolve into multi-year solution

Signal Processing A/H Working Group

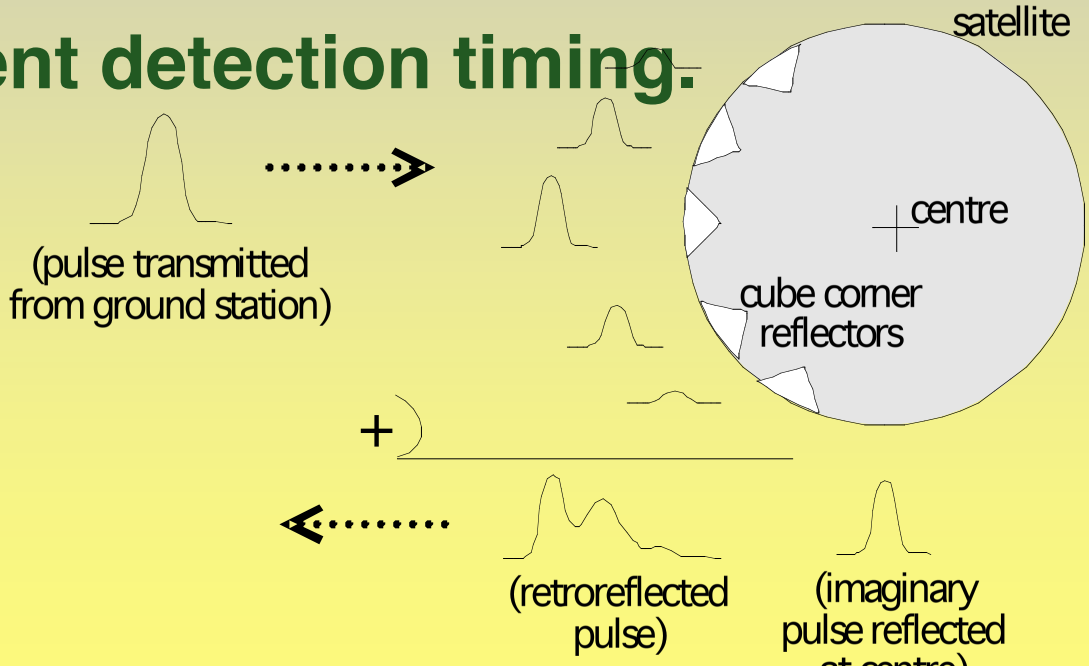
Report to ILRS General Assembly
Nice April 2003

Progress:

- CoM corrections derived for major geodetic satellites (T. Otsubo & G. Appleby);
- Working with ILRS CB to make LRA locations and characteristics available on ILRS website (M. Torrence & G. Appleby.

Satellite signature effect

- **Multiple reflectors contributing to the satellite response.**
- **System-dependent detection timing.**
  - **Single photon**
  - **C-SPAD**
  - **MCP-PMT**



- **Key error factor to achieve accurate GM and TRF scale.**

NATURAL ENVIRONMENT RESEARCH COUNCIL

CRL

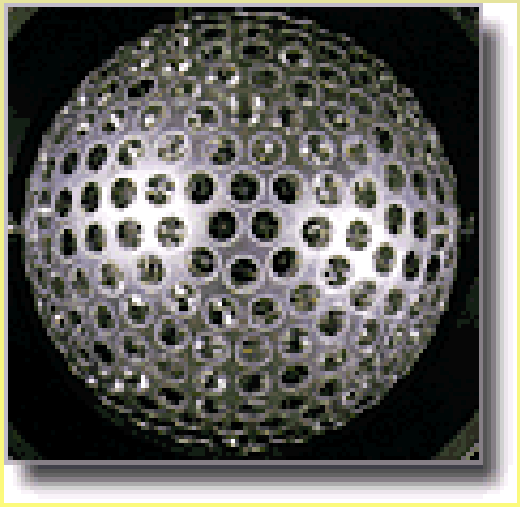
LAGEOS(1&2)

US+Italy 1976, 1992

Altitude 5900 km

Diameter 0.60 m

426 CCRs



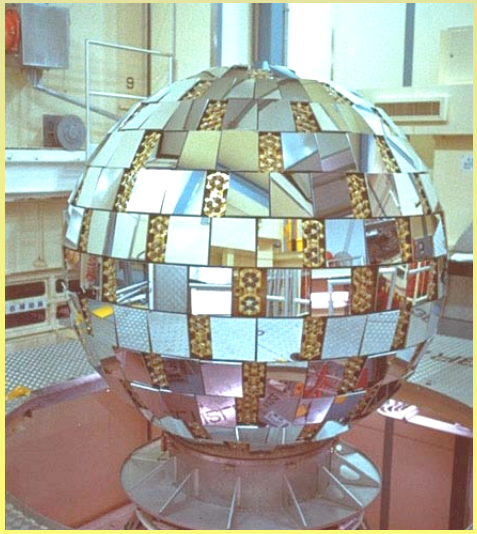
AJISAI

Japan 1986

Altitude 1500 km

Diameter 2.15 m

1436 CCRs



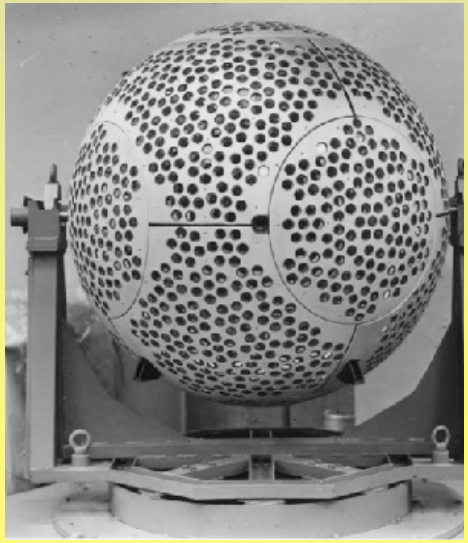
ETALON(1&2)

USSR 1989

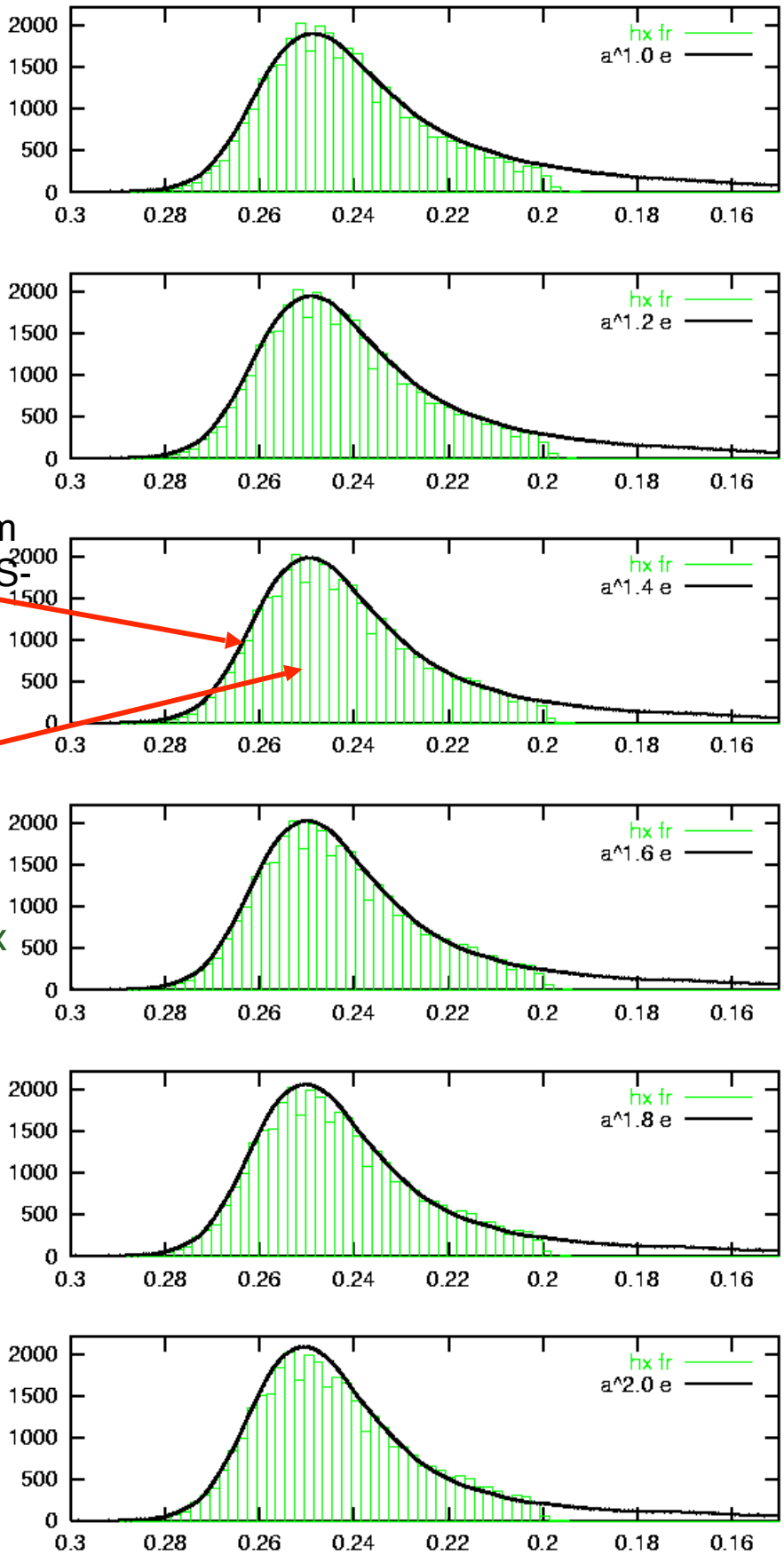
Altitude 19000 km

Diameter 1.294 m

2134 CCRs



Lageos n=1.1



Black curve:

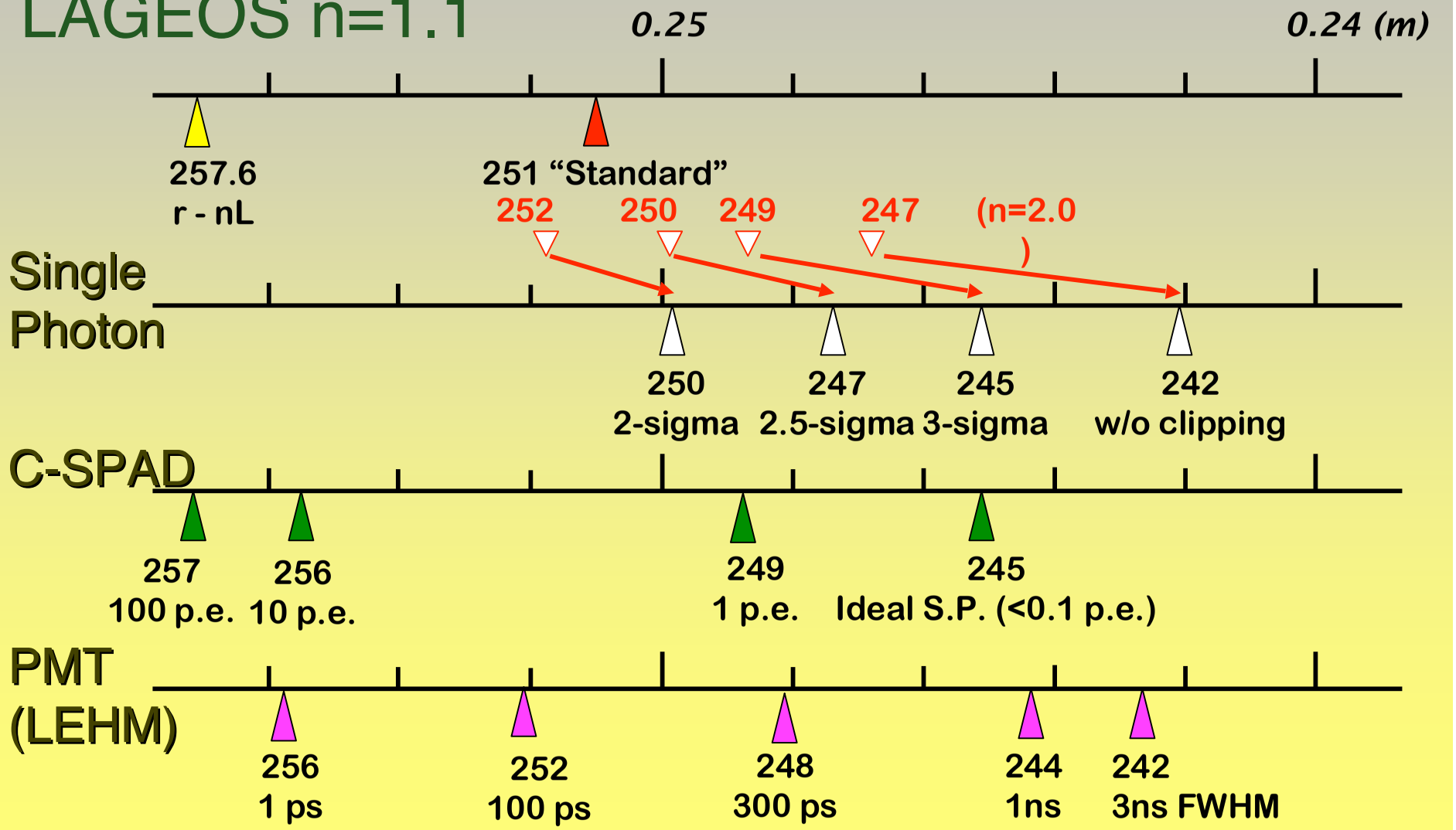
$a^n e$ convolved with Hx system response (ERS-2)

Green histogram:

Fullrate residuals of Hx single photon data

Centre of mass correction

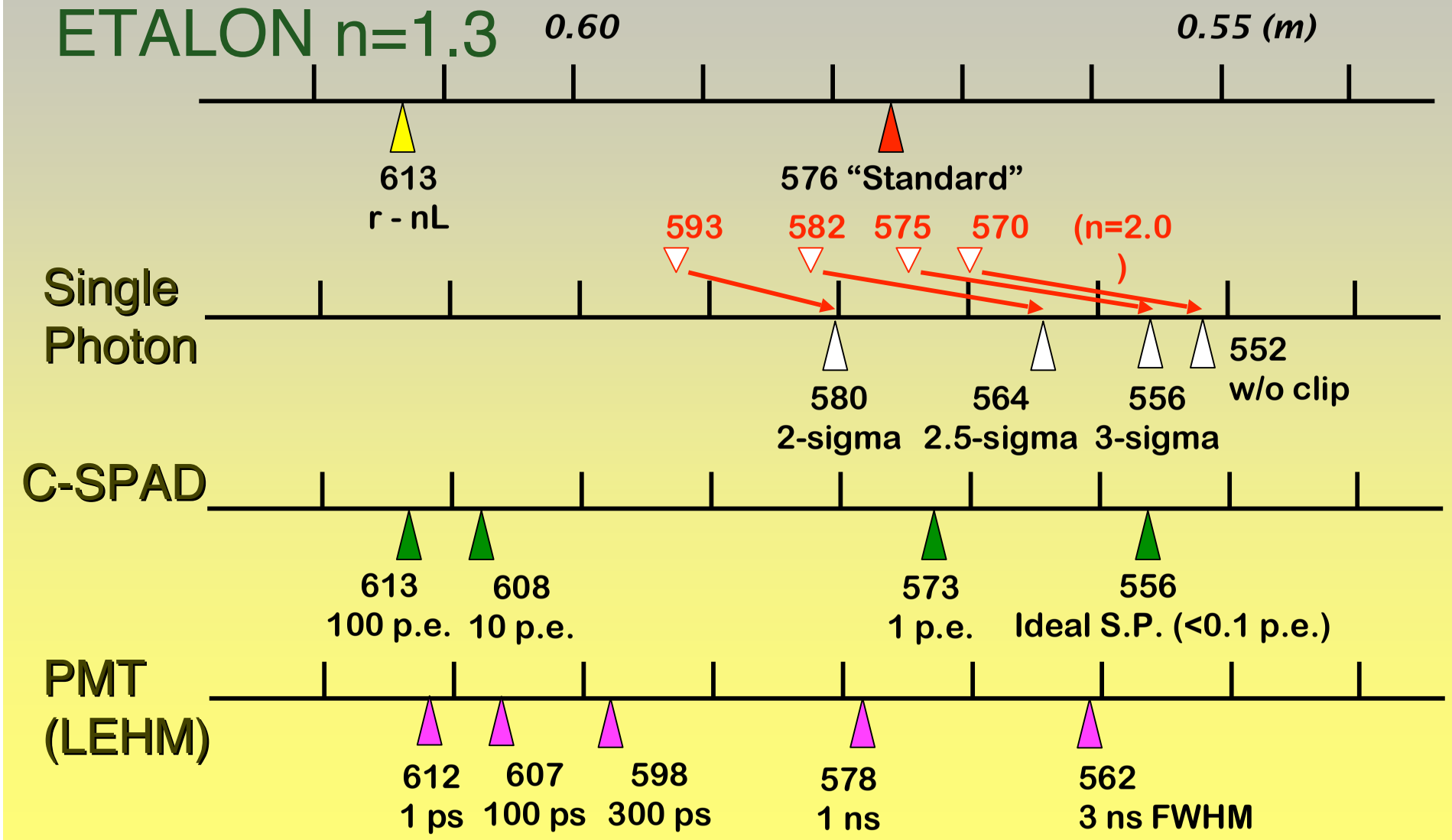
LAGEOS n=1.1



NATURAL ENVIRONMENT RESEARCH COUNCIL

CRL

Centre of mass correction



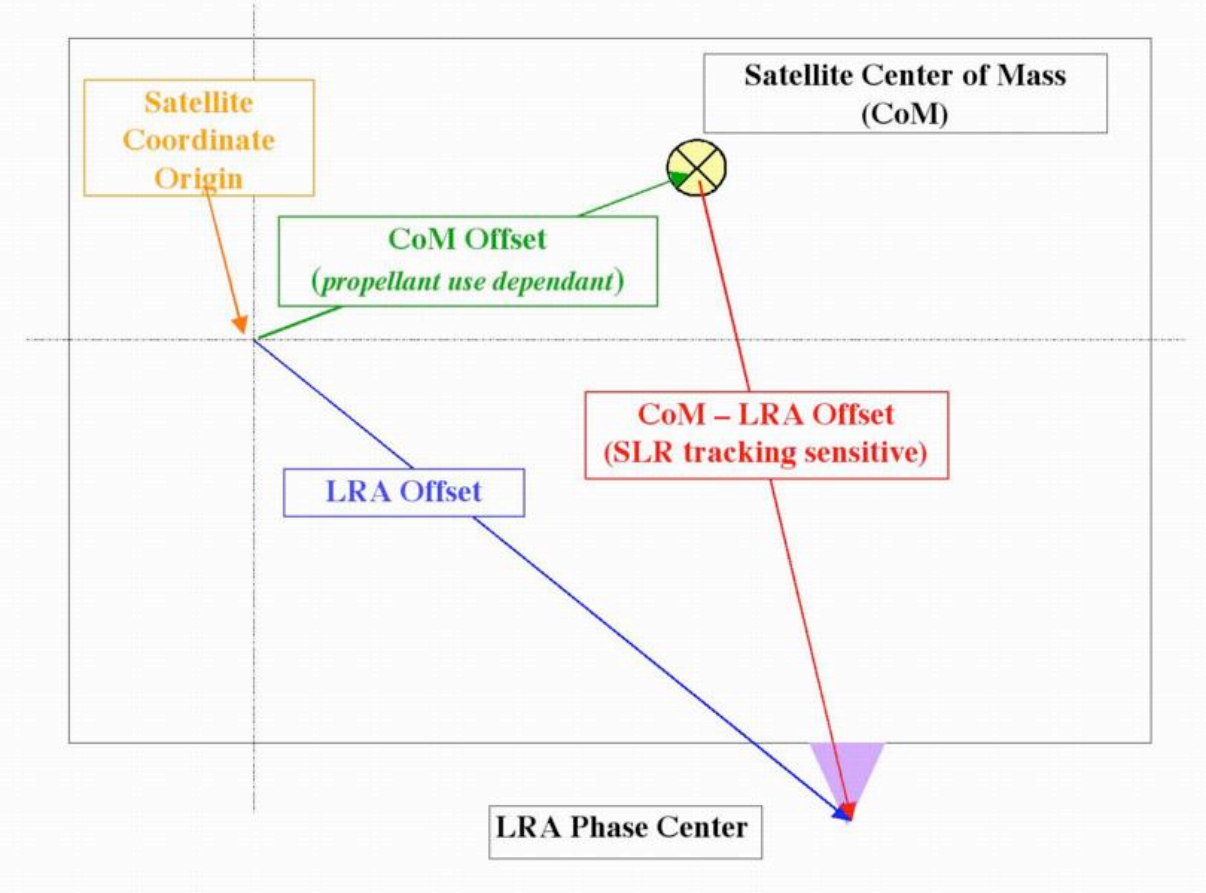
NATURAL ENVIRONMENT RESEARCH COUNCIL

CRL

Conclusions

- **Recovery of target response function.**
  - **LAG, AJI and ETA: using fullrate residuals from Herstmonceux single photon station.**
  - **n=1.1 to 1.3, not supporting the assumption in prev studies (n=2.0).**
- **System-dependent centre-of-mass correction.**
  - **Varies 1 cm for LAG, 4-5 cm for AJI and ETA.**
  - **Crucial for precise determination of Earth's scale (GM and TRF).**
  - **More details in the article recently accepted by JGR.**

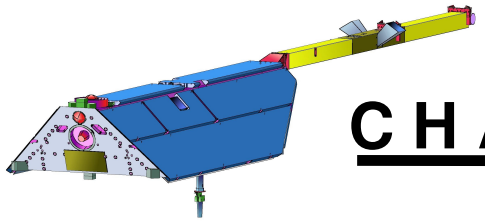
Spacecraft Laser Retroreflector Array (LRA) Offset: "Satellite Center of Mass Measurement Correction"



SLR Center of Mass offset information on ILRS website (under construction by SPWG +ILRS CB)

- Detailed CoM values for spherical satellites;
- Function of tracking station characteristics;
- LRA phase-centre vectors for some of the applications satellites;
- **More data required** (attitude algorithms, 3D location of LRA in spacecraft fixed reference frame) for:
  - GRACE; BEC-C; ADEOS; ?

Campaigns and Mission Reports

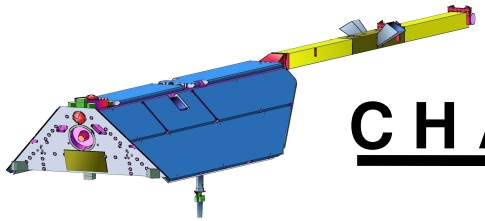


CHAMP

Status SLR-Tracking CHAMP Mission

R. König, R. Schmidt, Ch. Reigber

GeoForschungsZentrum Potsdam (GFZ)
Department 1 : Geodesy and Remote Sensing
Telegrafenberg
14473 Potsdam



CHAMP

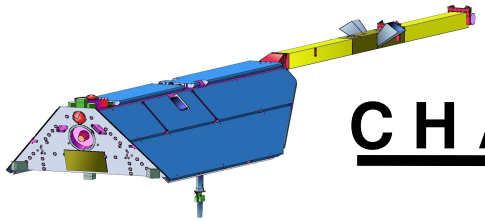
Status

- CHAMP is 1000 days in space on April 11th, 2003. All systems are running smoothly. The scientific instruments - except the radial channel of the accelerometer - perform nominally. All scientific instruments are in almost continuous science data collection mode (> 98%). No aging effects visible.

- Continued computation of static long-wavelength gravity field (EIGEN models) based on data from the onboard GPS receiver and precision accelerometer. Investigations of the temporal variability of the long-wavelength part of the gravity field are made from subset solutions. Intercomparisons (for the long-wavelength parts) of CHAMP-only and GRACE-only gravity models.

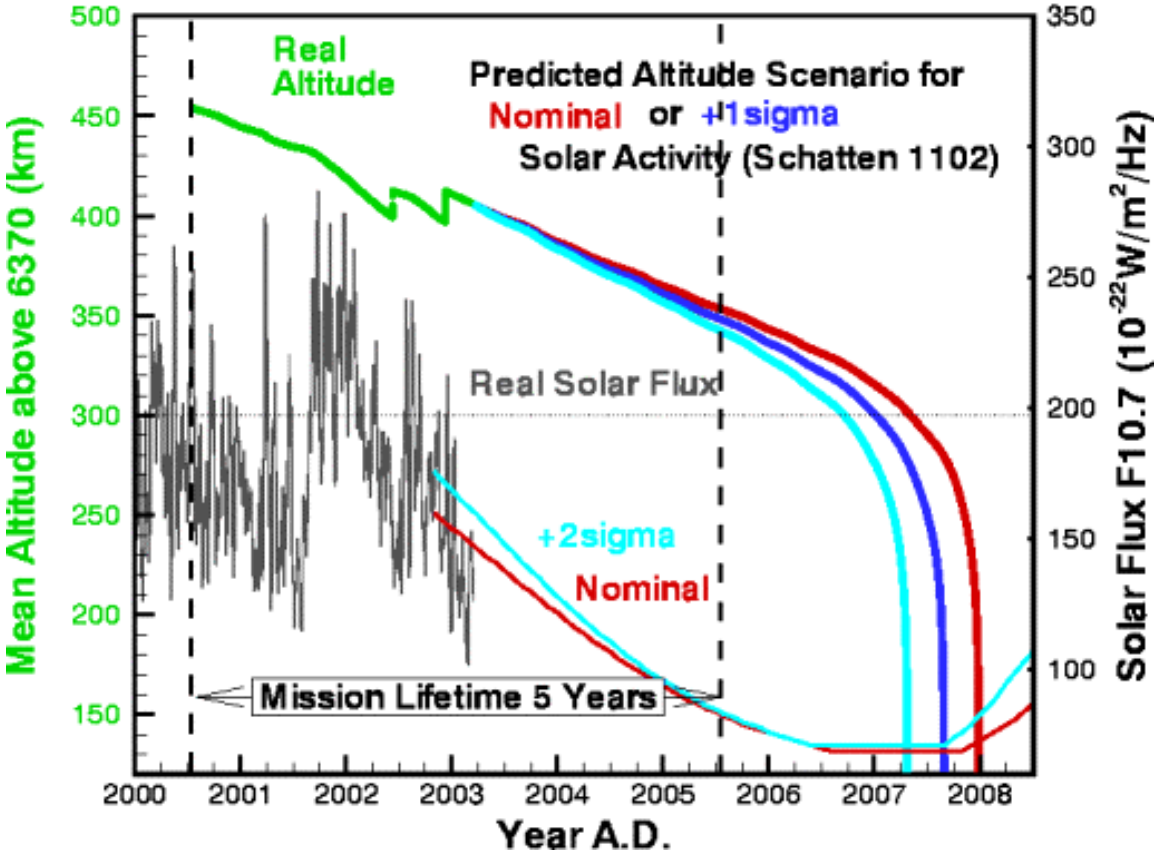
- Accurate globally distributed atmospheric profiles (temperature, humidity) are routinely generated from the GPS-SST data important for numerical weather prediction.

- Based on the data from the magnetometer instruments onboard CHAMP accurate and homogeneous maps of the Earth‘s magnetic field are generated.

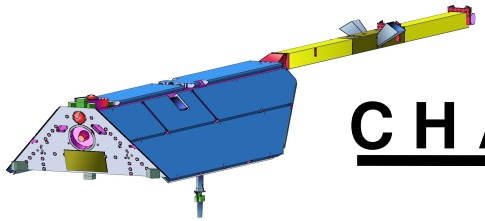


CHAMP

CHAMP Decay Scenario (Mid March 2003)



- Current altitude ~ 410 km.
- 2nd set of apogee thruster burns on Dec 09/10, 2002 (rise altitude by 20 km).
- Nominal lifetime of 5 years in reach.
- Current decay scenario even predicts extended lifetime to 2007/2008.



CHAMP

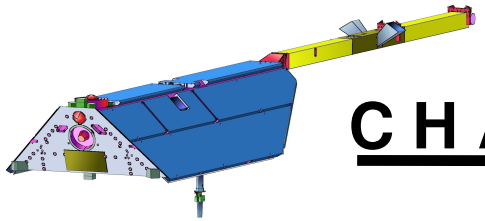
Role of SLR Data

- GFZ orbit predictions are based on ephemeris from GPS navigation solution **and** the more accurate SLR data.
- Routinely used for the validation of the data of the onboard GPS receiver in POD.
- SLR data is valuable data for the quality control of gravity field recovery from CHAMP microwave tracking data.

Example: orbital fit of SLR data for 26 14-h CHAMP arcs in April, 2002

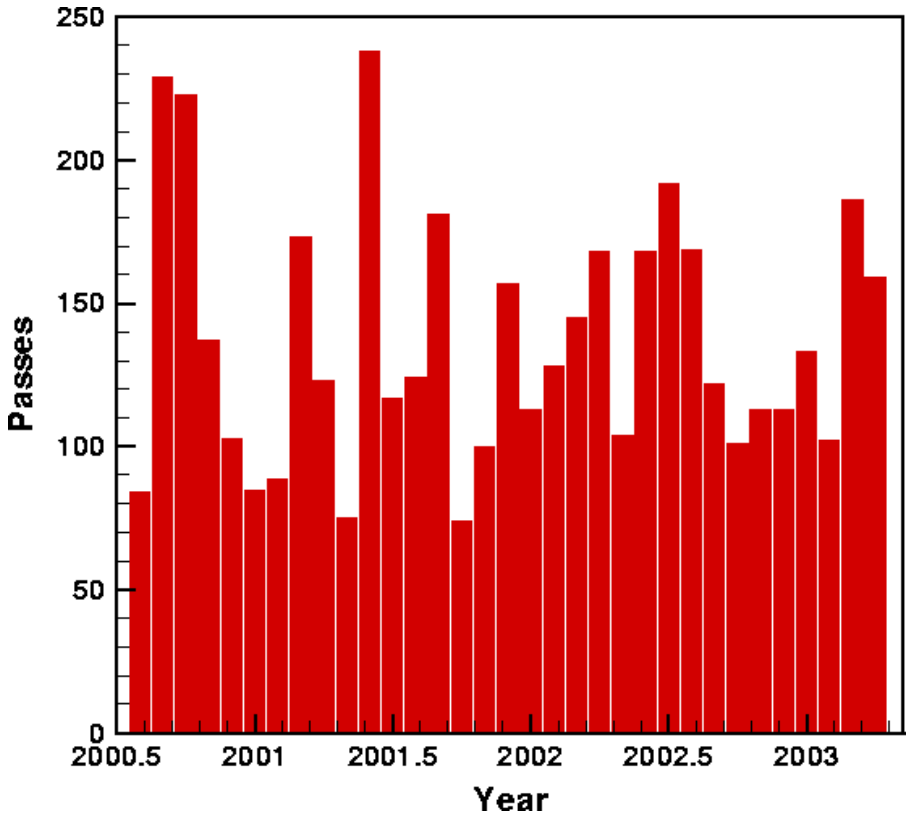
Model		SLR-RMS [cm]
EIGEN-2S *)	(70 x 70)	6.3
EIGEN-2S	(120 x 120)	6.1

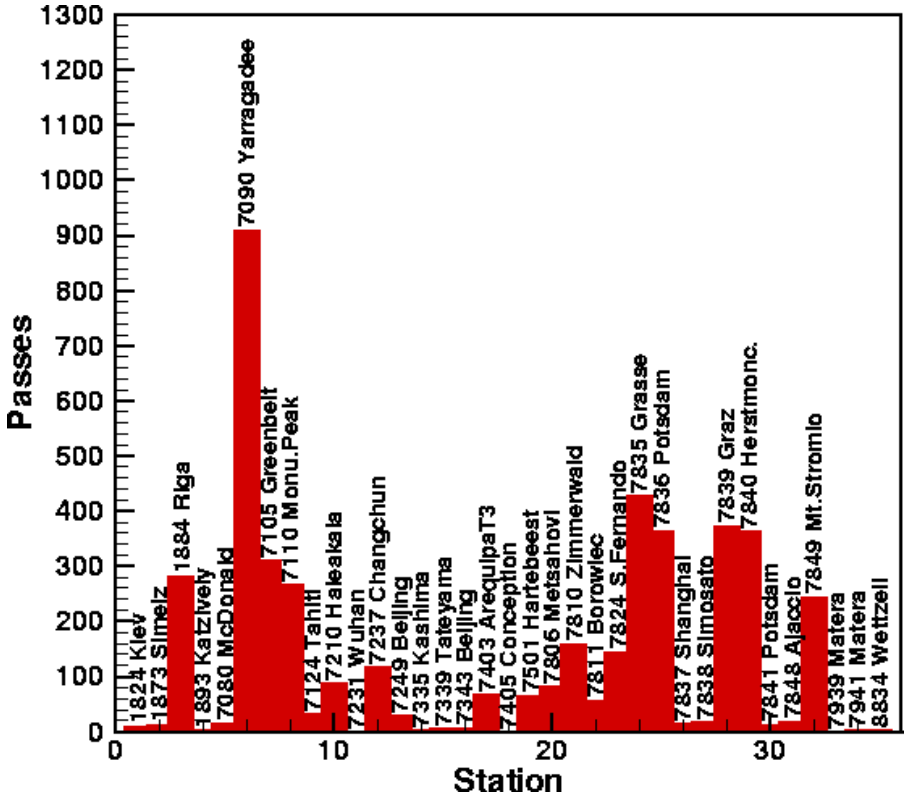
*) EIGEN-2S = iterated version of the official EIGEN-1S model (satellite-only), i.e CHAMP plus Lageos-I/II, Ajisai, Starlette, Stella in 2000, GRIM5-S2 normal equation

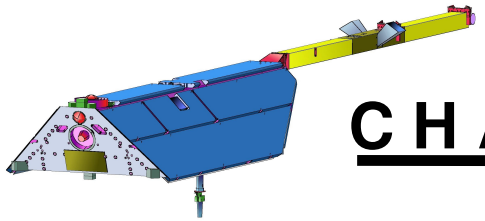


CHAMP

SLR-Tracking Jul. 2000 - Mar. 24, 2003







CHAMP

Summary

- Overall tracking statistics quite satisfactory for the CHAMP mission - in particular in view of the low altitude of CHAMP.

- Overall tracking statistics indicate adequate accuracy of GFZ orbit predictions. Also, the update frequency at 3 predictions/days seems to be sufficient. With further decreasing altitude an increased update rate may become necessary.

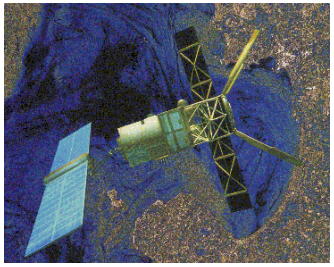
- SLR data plays an important role:

  - for the generation of accurate orbit predictions,

  - for the continuous validation of the microwave tracking systems onboard the CHAMP satellite and

  - for the quality control of gravity field modeling.

= > continued intensive SLR support is requested

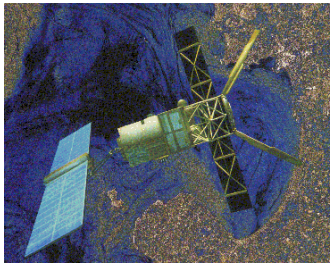


E R S - 2

Status SLR-Tracking ERS-2 Mission

F.-H. Massmann, Ch. Reigber, *R. Koenig*

GeoForschungsZentrum Potsdam (GFZ)
Department I: Geodesy and Remote Sensing
Telegrafenberg A17
14473 Potsdam, Germany



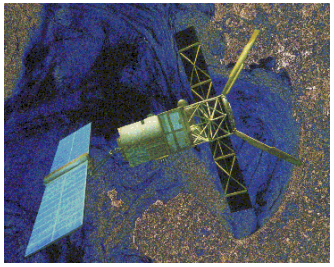
E R S - 2

Mission Status

- ERS-2 is now in orbit for about 8.0 years.
- In general the satellite and the payload are in good condition.
- ESA plans to operate ERS-2 till mid of 2004.

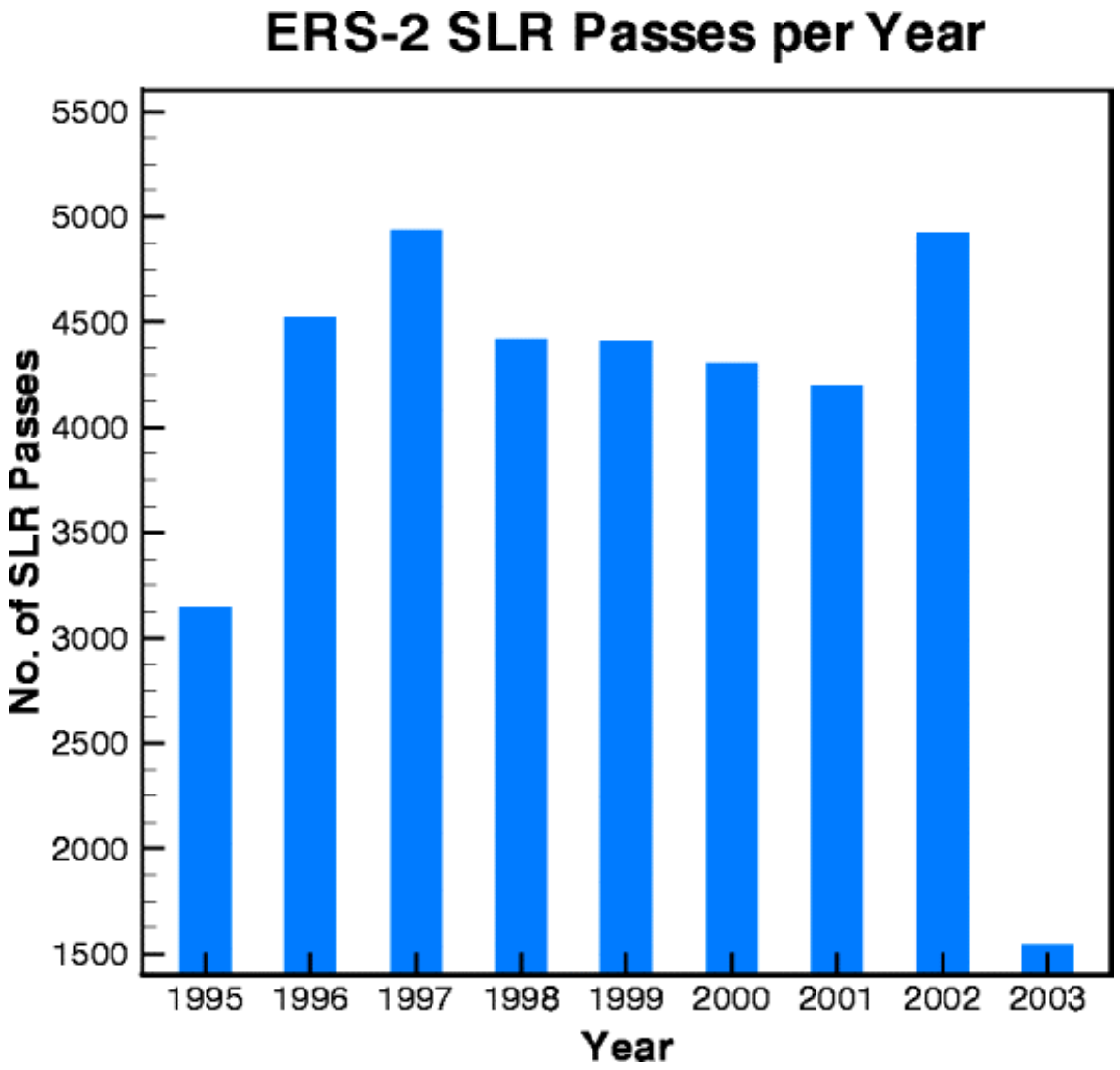
Role of SLR

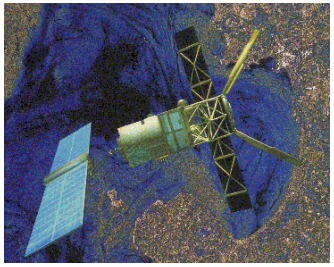
- SLR is the secondary tracking system, while PRARE is the primary one.
- Since 2003 the PRARE system is operated by GFZ on best effort basis due to stop of funding by DLR. This results in an increasing importance of SLR.
- ERS-2 SLR tracking will be required until approximately mid 2004.



E R S - 2

SLR Data Quantity

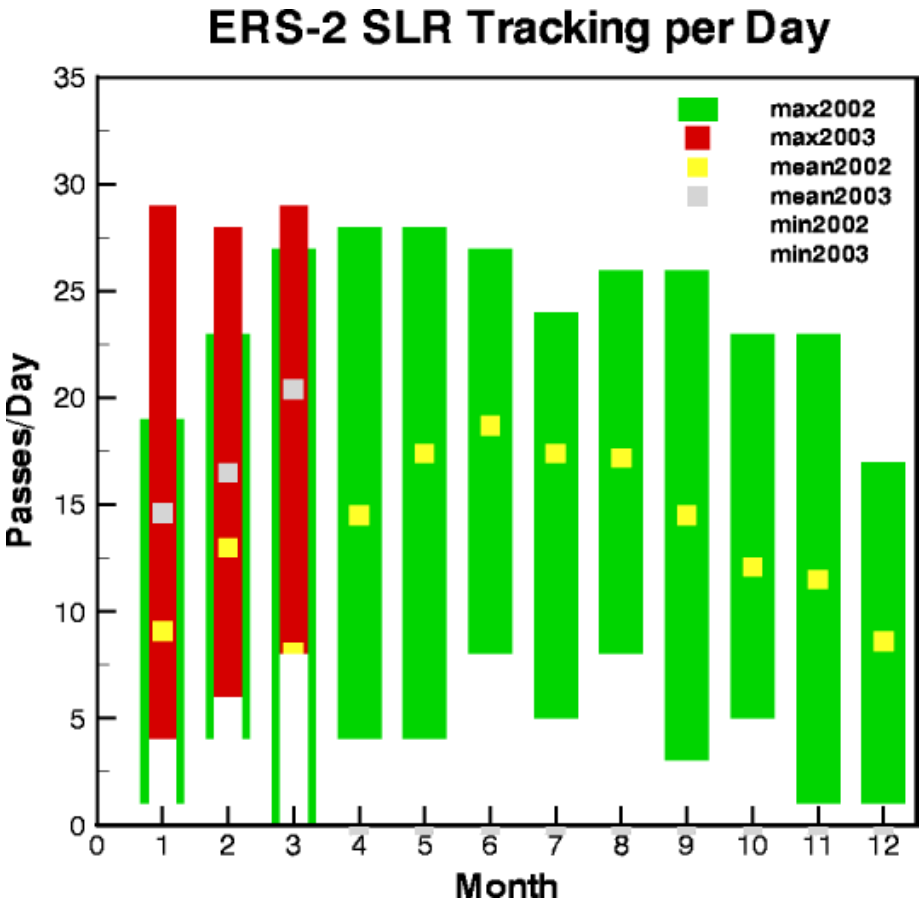


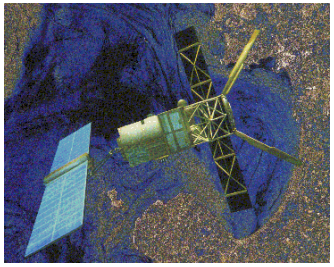


E R S - 2

SLR Data Quantity and Quality

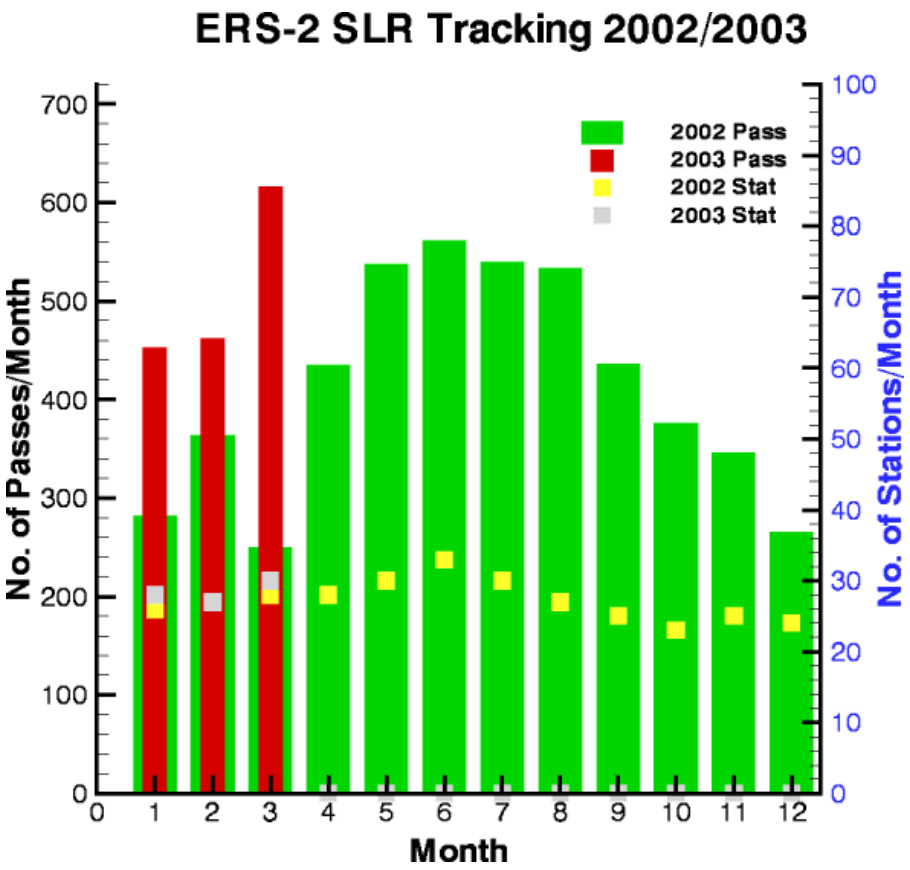
- In 2002 in average 13.5 passes have been tracked per day
- Jan. to Mar. 2003 SLR passes are the record since start of the mission
- Contribution of stations very different
- The data quality is in general very good
- Still sometimes large outliers when the normal point has been formed from one full-rate observation only

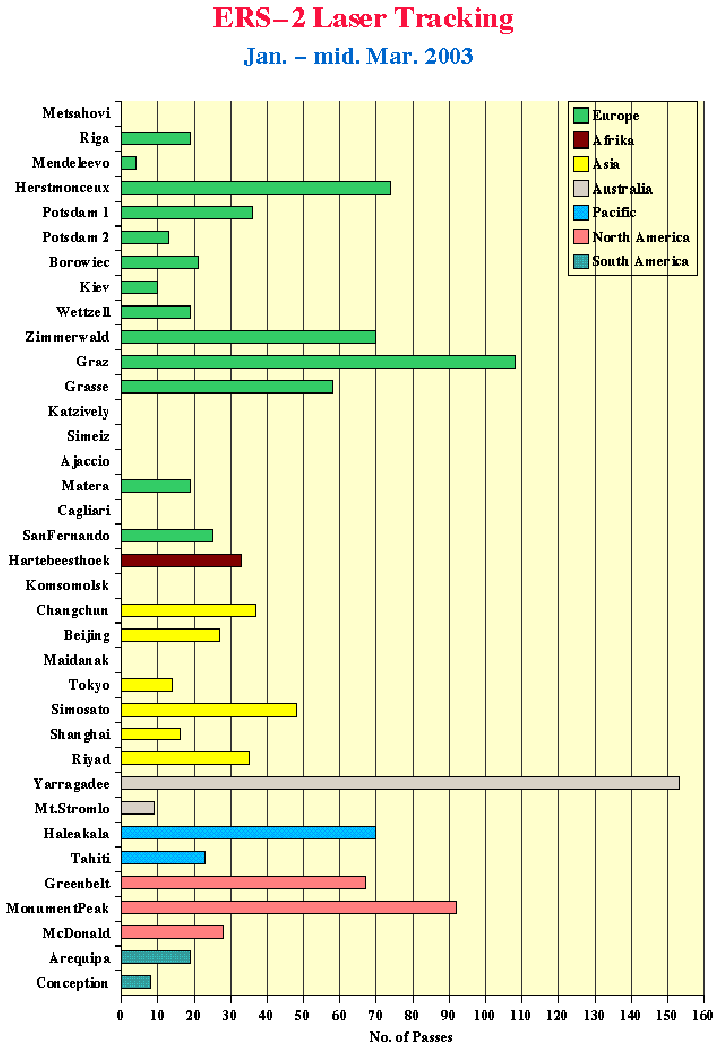


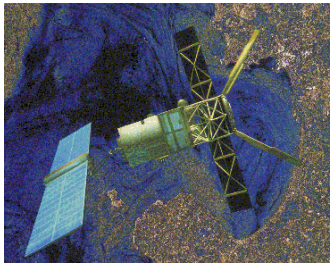


E R S - 2

SLR Data Quantity and Quality







E R S - 2

Achieved Results

Based on SLR and PRARE tracking data predicted and precision orbits have been generated, which are used for

- **Geolocation of SAR data**
- **Antenna steering**
- **Mission planning**
- **Interferometric SAR processing (DEM, deformation analysis)**
- **Sea surface monitoring**
- **Ice mass monitoring**
- **High resolution gravity modelling from radar altimeter data**

ERS-2 SLR and PRARE data are also incorporated in recent gravity models (TEG3p, EIGEN-1, EIGEN-2)

Status SLR Tracking GRACE Mission

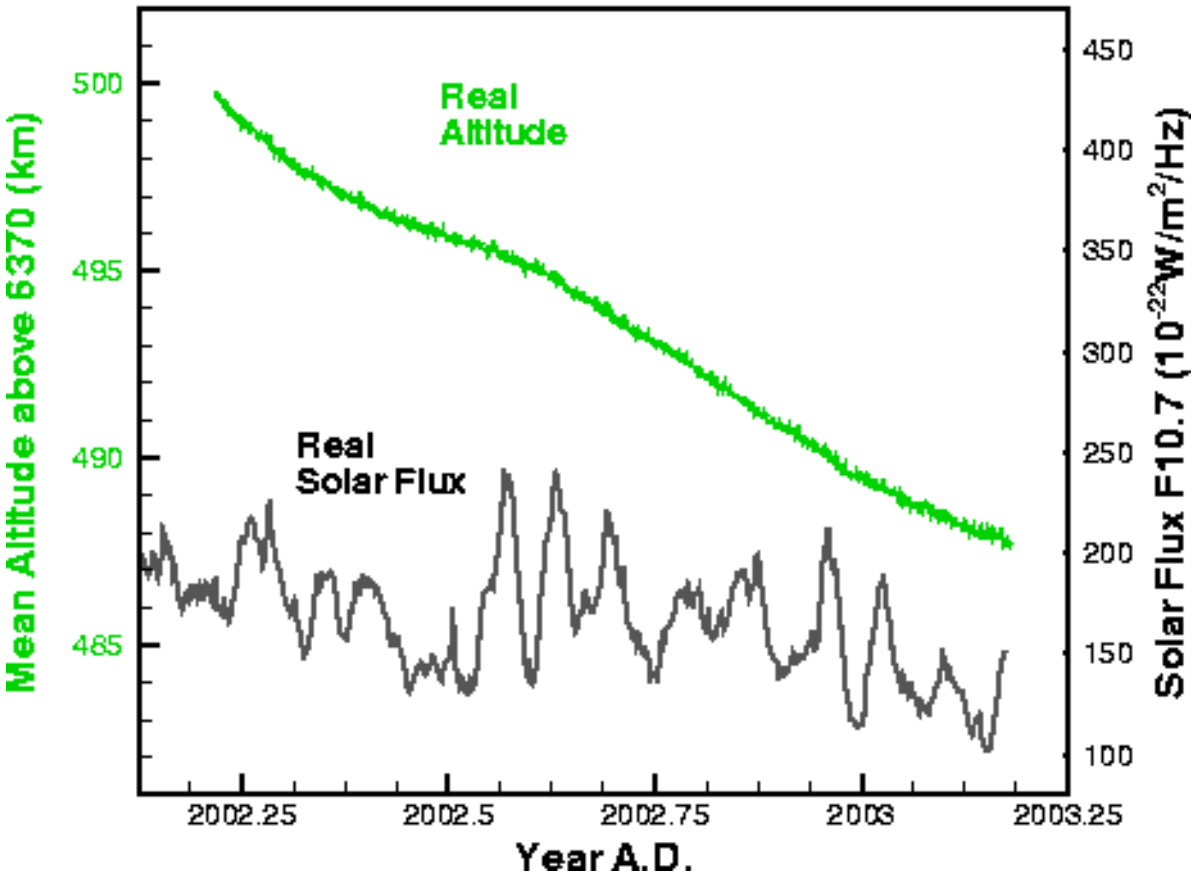
R. König, R. Schmidt, Ch. Reigber

GeoForschungsZentrum Potsdam (GFZ)
Department 1: Geodesy and Remote Sensing
Telegrafenberg
14473 Potsdam

Status

- The twin GRACE satellites are more than one year in space.
- All sensors and instruments - except the intertial measurement unit on GRACE-1 - are operating in the science data collection mode.
- All scientific instruments (accelerometers, star cameras, GPS receivers, K-Band-Ranging system, Laser Ranging Reflector) are performing nominally.
- The Science Data System teams at JPL, UT-CSR and GFZ have generated preliminary static gravity fields based on multi-months of GRACE science data. The capability of the micrometer-precise K-Band-Ranging system for gravity recovery is revealed in the determination of the static field with unprecedented accuracy.
- At GFZ the generation of standard GRACE orbit predictions based on GPS navigation solution and SLR data is operational in automatic mode (2 predicts/day).

GRACE Decay Scenario (Mid March 2003)



- Current altitude ~ 487 km.
- Current separation of the twin satellites about 180 km.
- With the current decay of about 13 km/year nominal mission lifetime of 5 years in reach.
- From time to time (> 1 month) orbit manoeuvres in order to keep separation distance at 220 km ± 50 km.

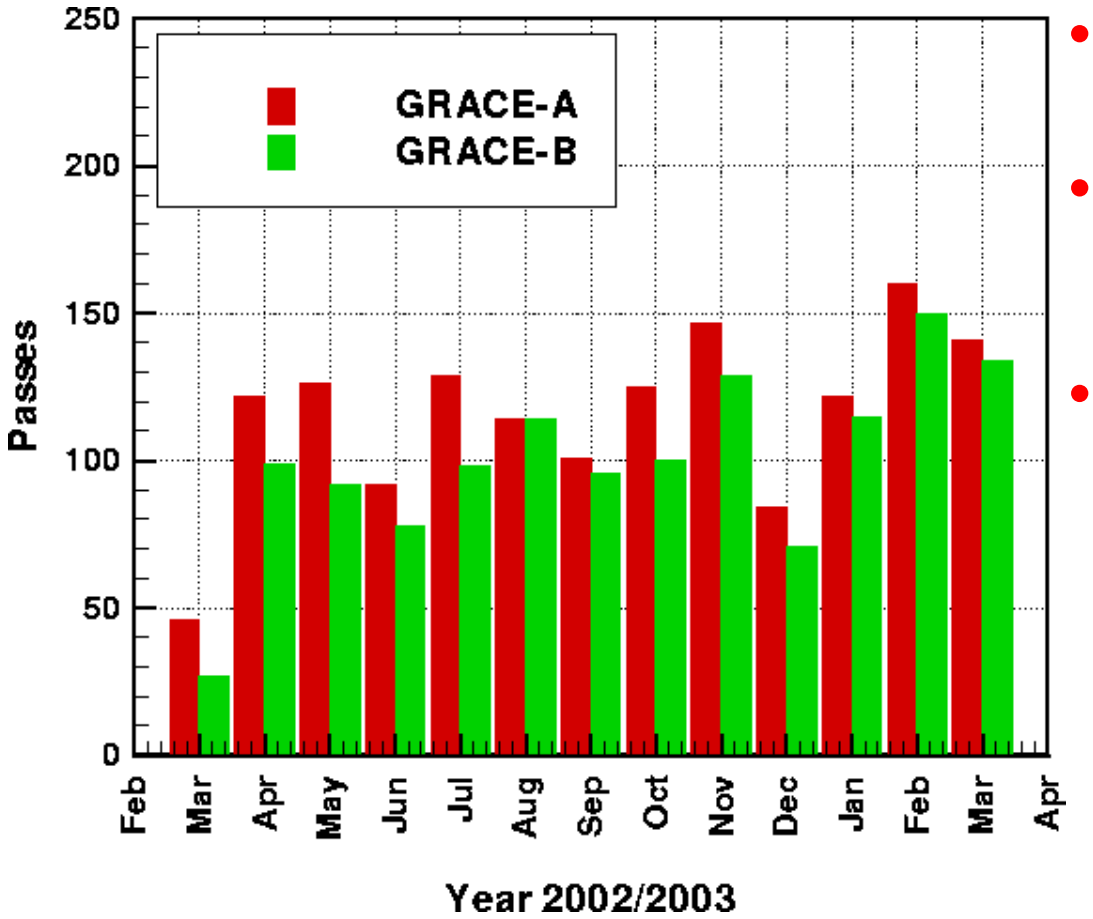
Role of SLR data

- At GFZ precise orbit predictions are generated from GPS navigation solution **and** the more accurate SLR data.
- Routinely used for the validation of the data of the onboard GPS receivers and K-Band-Ranging instrument in POD.
- SLR data is valuable data for the quality control of gravity field recovery from GRACE microwave satellite-to-satellite tracking data.

  Example: 8 arcs (length 1 - 1.5 days) for GRACE-A&B in September (arcs not included in gravity field solution).

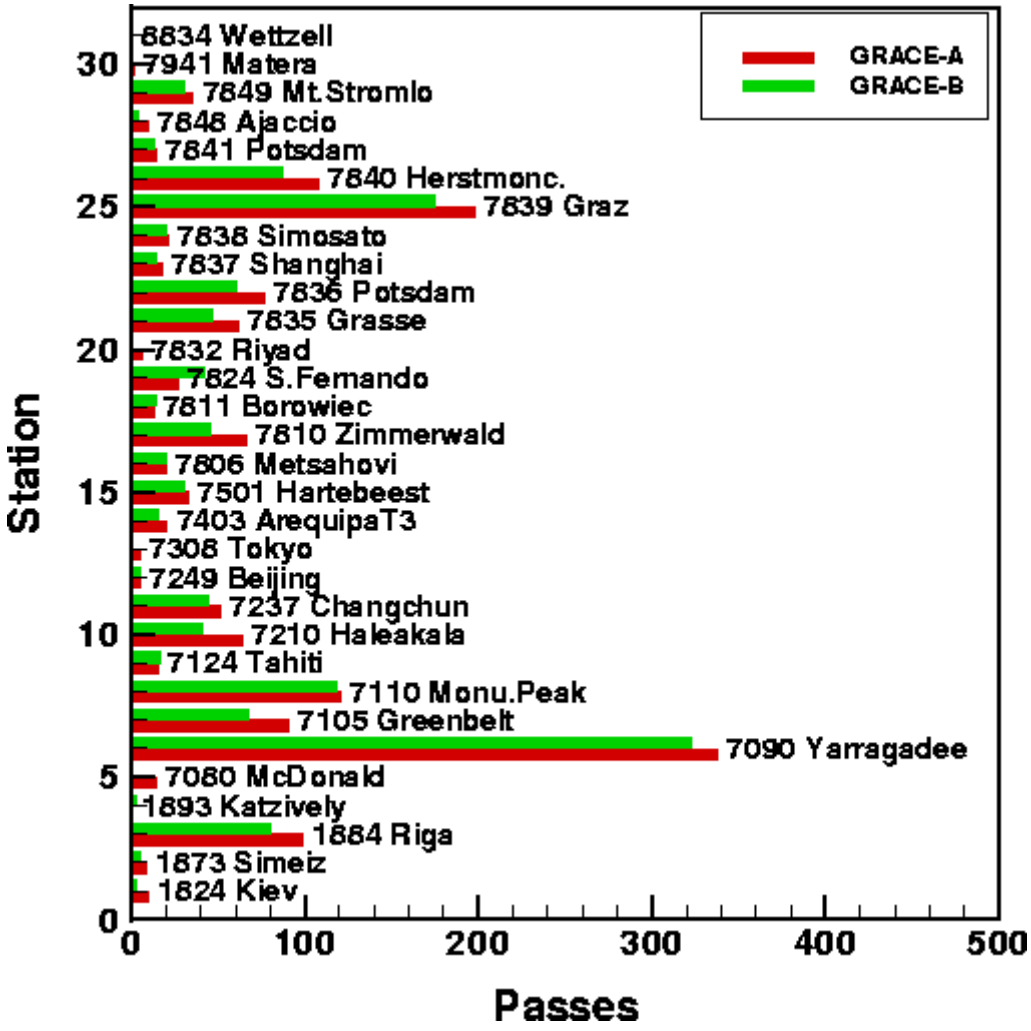
		RMS
SLR (σ = 50 m)	[cm]	6.2

GRACE SLR-Tracking March 2002- March 2003



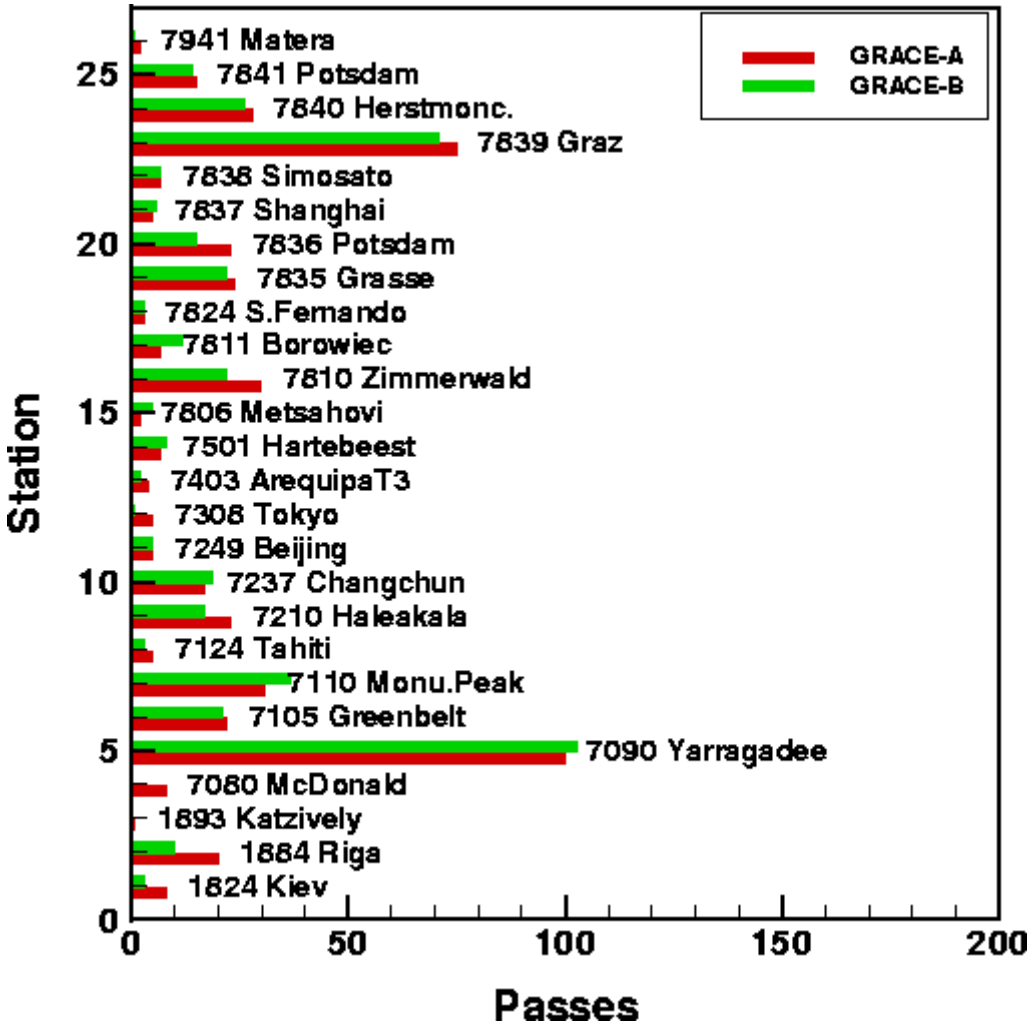
- Total 2812 passes (GRACE-A: 1509, GRACE-B: 1303).
- Good amount of data per month and per satellite (as of Apr. 2002 in general >= 100 pass/month).
- In general stronger tracking of GRACE-A (except Aug. 2002). Differences vary from month to month from 40 % (initial orbit phase) to about 5 % less data for GRACE-B (as of Jan. 2003). Some part is due to degraded predicts during orbit maintenance manoeuvres mostly performed on GRACE-B

GRACE SLR-Tracking March 2002- March 2003



- Total 30 ILRS stations (for GRACE-B only 28 stations; Riyad and Wettzell delivered some passes for GRACE-A but not for GRACE-B)
- Summary statistics per station for about one year of SLR data also reflects stronger tracking of GRACE-A for almost all ILRS stations. **However ...**

GRACE SLR-Tracking January - March 2003



- ... e.g. the current SLR tracking of 25 ILRS stations in the first 3 months of 2003 shows an almost balanced statistic for the majority of the observing stations.
- Some stations seem to focus on GRACE-A. Why ?
- The overall difference between GRACE-A and GRACE-B data of about 5 % is satisfactory, however.

Summary

- Overall tracking statistics quite satisfactory for the GRACE mission. History of SLR tracking shows in general stronger tracking of GRACE-A. Tracking statistics per stations shows that majority of contributing ILRS stations obtain almost balanced data sets. The efforts taken are highly appreciated.

- Overall tracking statistics indicate adequate accuracy of GFZ orbit predictions. Current update rate of 2 predicts/day seems to be sufficient.

- SLR data plays an important role:

  - for the generation of accurate orbit predictions,

  - for the calibration/validation of the microwave tracking systems onboard the GRACE satellites and

  - for the quality control of gravity field recovery.

= > continued intensive SLR support is requested

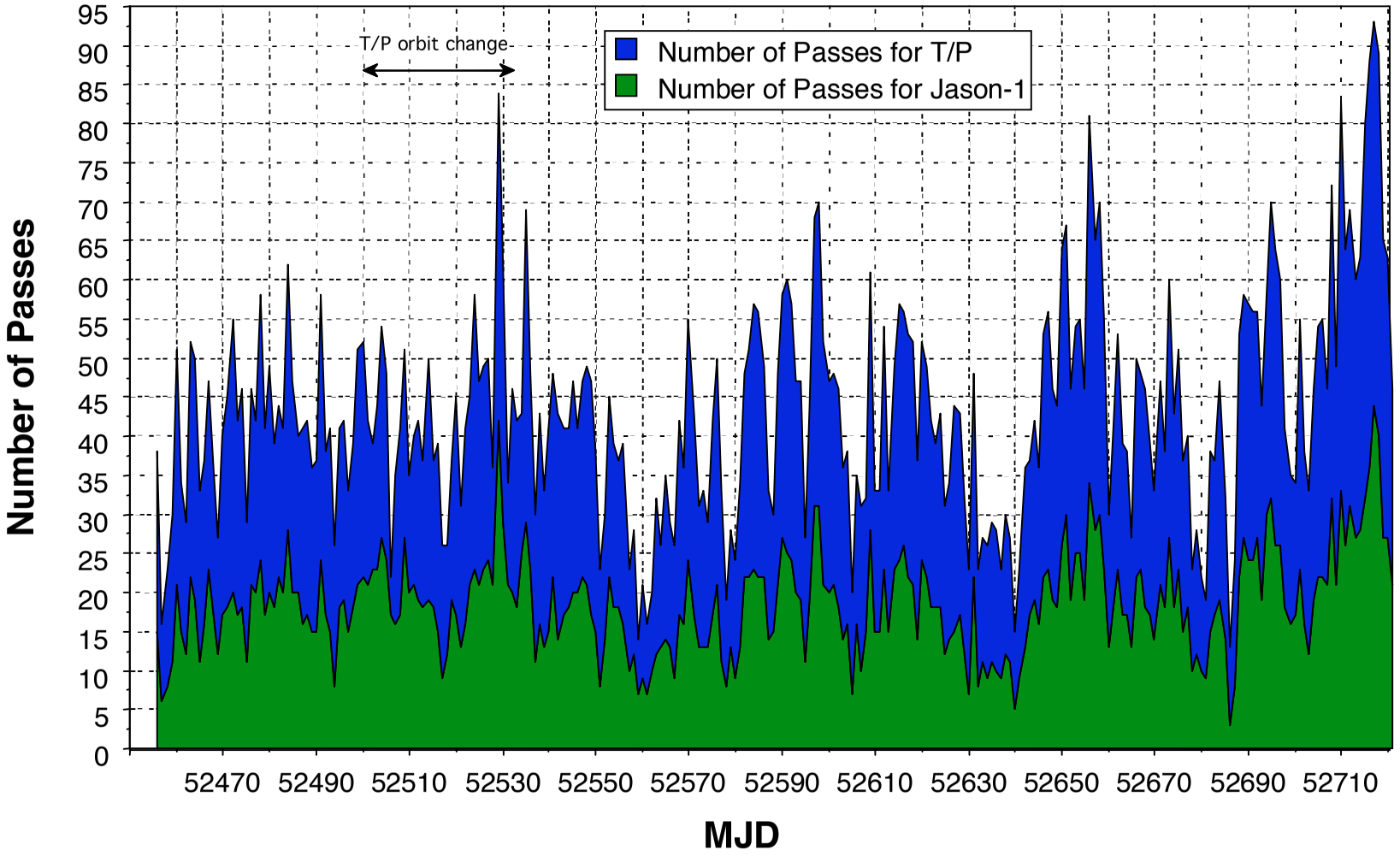
SLR Performance on TOPEX/Poseidon and Jason-1

- **Tracking of T/P and Jason-1 continues to meet mission goal of 15 good passes/day**

	TOPEX/Poseidon		Jason-1	
	# obs	# passes	# obs	# passes
Before editing	535	24	369	19
After editing	441	21	326	16

- **Coverage is good in spite of close proximity of T/P and Jason-1**
- **Bias of tracking in favor of T/P likely due to much larger LRA on T/P**
- **Jason-1 LRA design supports higher precision ranging**
  - **Jason-1: 18 mm fit RMS, 4 mm precision, -2 mm bias (248 day average)**
  - **T/P: 24 mm fit RMS, 7 mm precision, -2 mm bias (200 day average)**

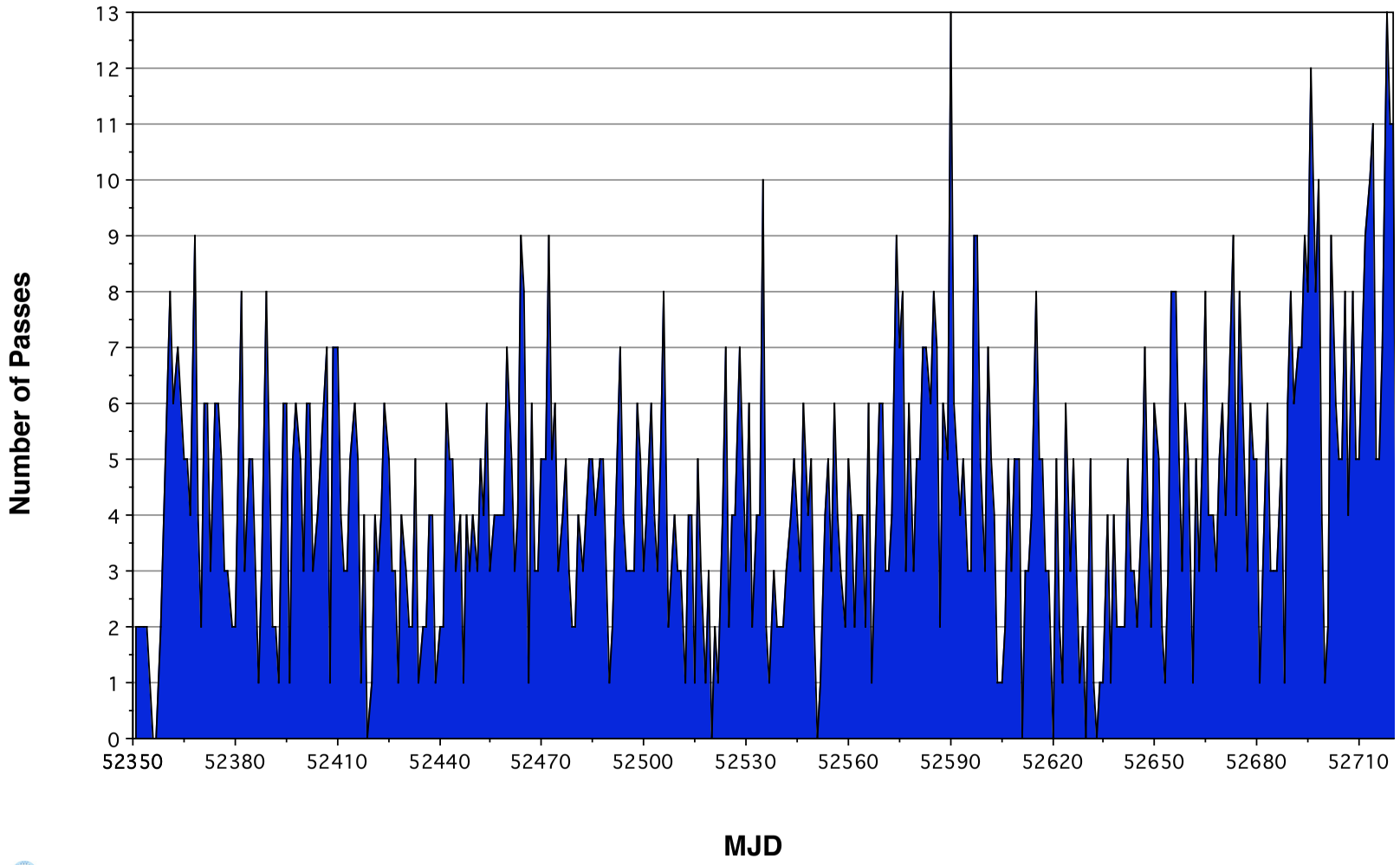
SLR Tracking of T/P and Jason-1



SLR Performance on GRACE

- GRACE-A and GRACE-B tracked 4 times per day on average (~80 observations/day)
- 6-7 cm SLR RMS consistent with expected orbit error using GRACE gravity model
  - Adequate for post-fit orbit quality assessment
- ~6 cm Z-bias apparent in center-of-mass offset correction currently accommodated by empirical adjustment of phase center coordinates

GRACE SLR Tracking

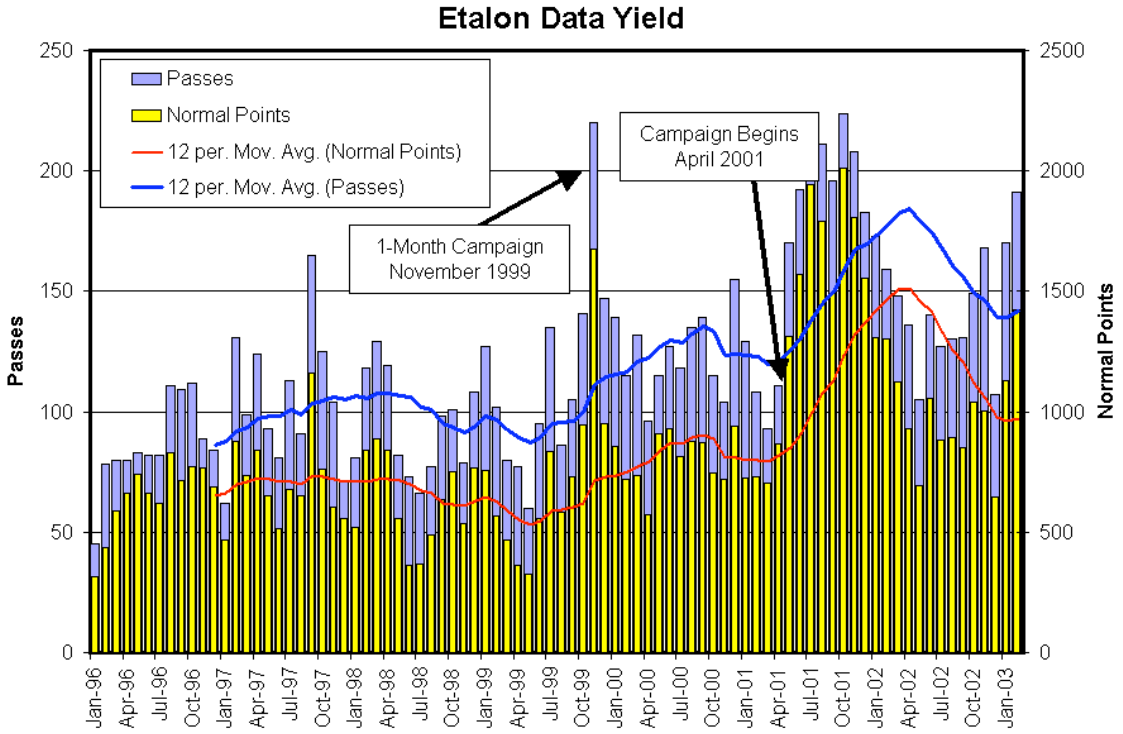


Summary

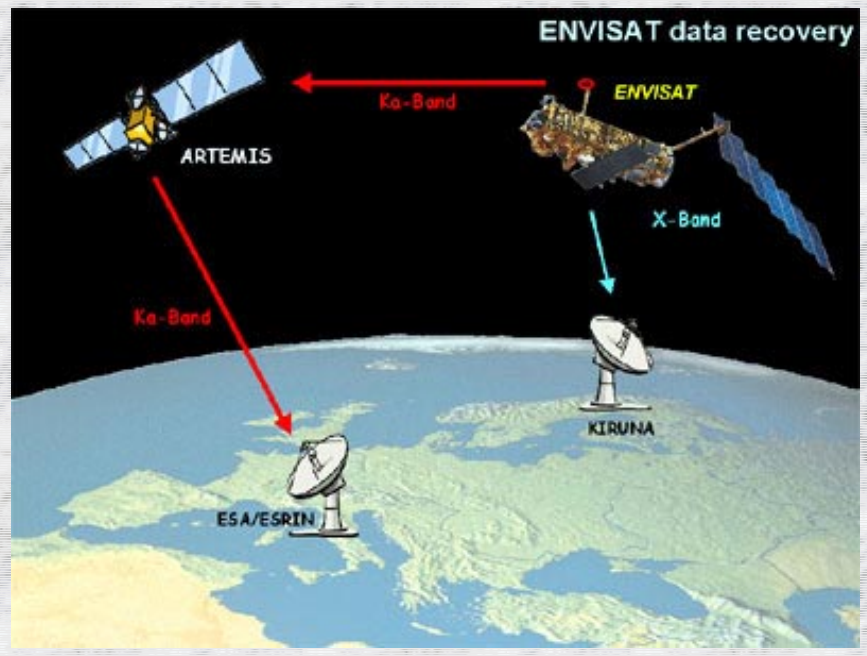
- SLR remains a important component of radar altimeter satellite POD, for both accurate orbit centering (where used for orbit determination) and radial orbit accuracy assessment
  - Tracking on T/P and Jason-1 remains good in spite of proximity of two satellites
- Orbit accuracy assessment particularly critical for missions such as GRACE and ICESat where no other independent, absolute orbit error assessment is available

ETALON campaign: “conclusions”

- Marginal improvements of x/y-pole
- Significant contribution for LOD
- Continue tracking at current level of intensity
- AWG -> development of official ILRS combination product


Etalon Data Yield
Passes
Normal Points
12 per. Mov. Avg. (Normal Points)
12 per. Mov. Avg. (Passes)
1-Month Campaign
November 1999
Campaign Begins
April 2001
Passes
Normal Points
250
200
150
100
50
0
2500
2000
1500
1000
500
0
Jan-96
Apr-96
Jul-96
Oct-96
Jan-97
Apr-97
Jul-97
Oct-97
Jan-98
Apr-98
Jul-98
Oct-98
Jan-99
Apr-99
Jul-99
Oct-99
Jan-00
Apr-00
Jul-00
Oct-00
Jan-01
Apr-01
Jul-01
Oct-01
Jan-02
Apr-02
Jul-02
Oct-02
Jan-03

ENVISAT STATUS



Mission Status

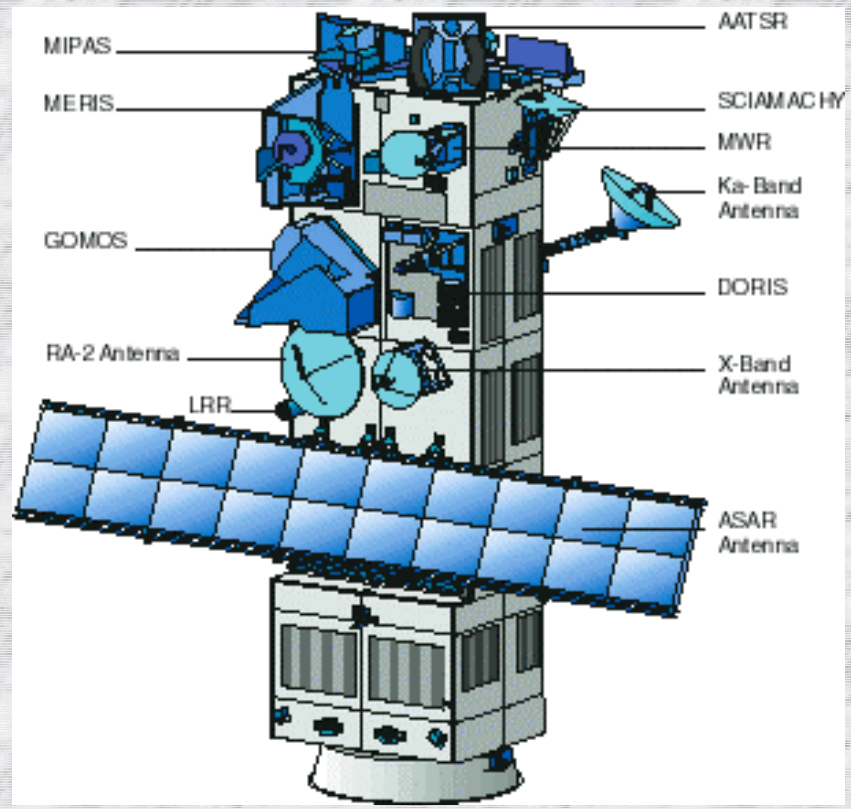
Payload commissioned

Data relay via Artemis nearly commissioned

Pre-operations ongoing since

Full ops imminent

ENVISAT STATUS/Instruments



Mission Status

NOMINAL ORBIT: 35-Day repeat (same as ERS-2)

Reached on: 4 April 2002

Sensor Calibration: Calibr Workshop held 9-13 Sep 2002

Validation: Validation Workshop: 9-13 Dec 2002

ENVISAT STATUS/Calibration

Altimeter performing nominally. Range calibration performed
Absolute calibration of σ_0 (world premiere) performed

MWR performance nominal. Precision around 1 K

DORIS: very good, as the other DORIS systems

ALTIMETRY MISSION IN PERFECT SHAPE
MORE PARAMETERS AVAILABLE WRT ERS

ENVISAT Orbit Validation

Several institutes (ESA, CNES, DEOS/Delft, GFZ…)

Different computation procedures for orbit validation

DORIS and SLR data used

Orbit radial component at the 3 cm level!

Laser data are fundamental for orbit validation

ENVISAT Orbit Routine Validation

POD work based on DORIS, but laser data are a vital complement

Laser tracking has been really good from the beginning

Continuation over the entire mission duration necessary to ensure highest level science return

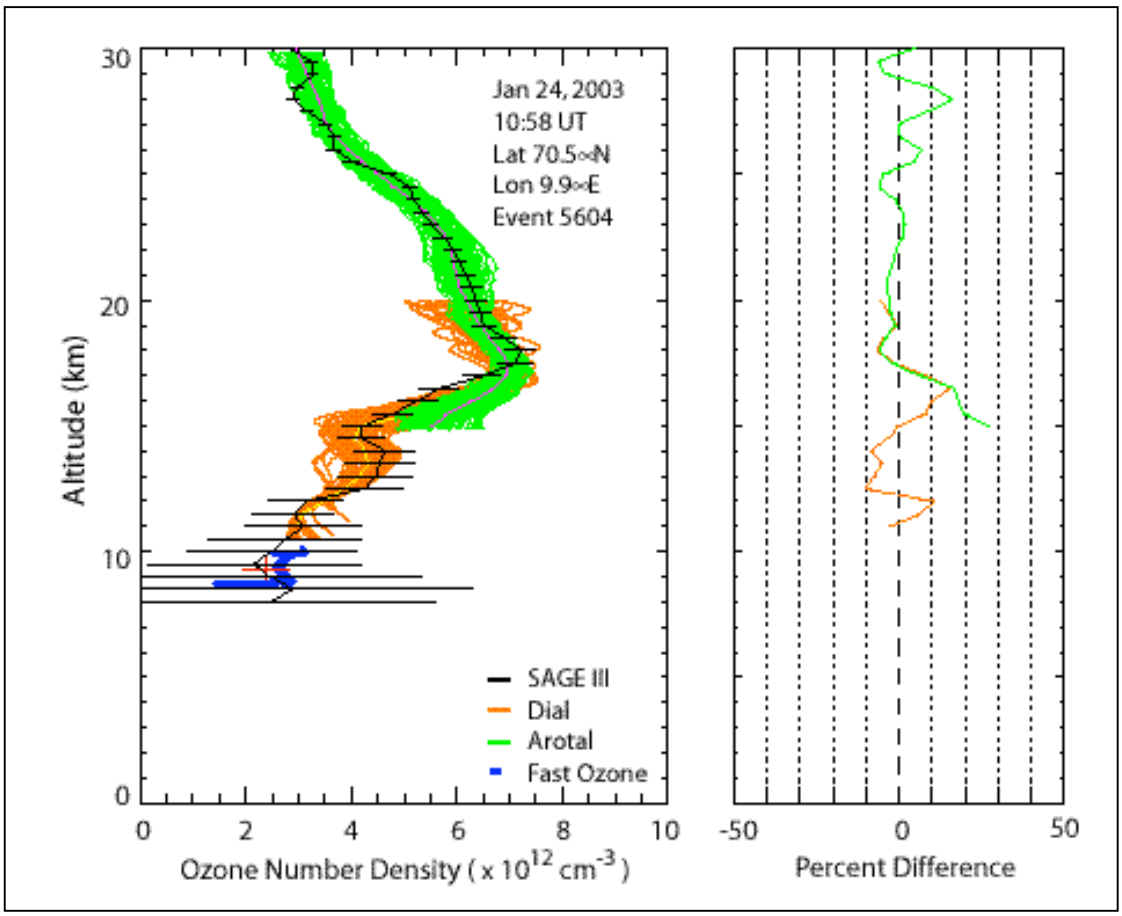
CONCLUSION

The Laser support has been very good.

Continuation during routine operations of utmost importance

ESA is thankful to all laser stations for their essential contribution to the ENVISAT scientific success

NEXT ESA MISSION: CRYOSAT (Sep 2004)



Preliminary ozone measurement results made by the NASA SAGE III experiment operating on the Russian Meteor 3M spacecraft and instruments taking part in the SOLVE-2 mission operating from Kiruna Sweden in January 2003.

As you can see, the measurement agreement is very good and SAGE III captures the fine ozone structure very well. These excellent results are not possible without the precise ephemeris data we receive from the ILRS.

Mike Cisewski
SAGE III Mission Manager
NASA Langley Research Center
Radiation Aerosols Branch (REB)
Building 1250, Room 200M, Mail Stop 420
21 Langley Boulevard
NASA Langley Research Center
Hampton, VA 23681-2199
Phone +1 757 864-1861
Fax +1 757 864-1232

ADEOS-II Status

Maki MAEDA / GUTS SLR team
National Space Development Agency of Japan (NASDA)

Launch Time : 2003-12-14 01:31:00.212 (UTC)

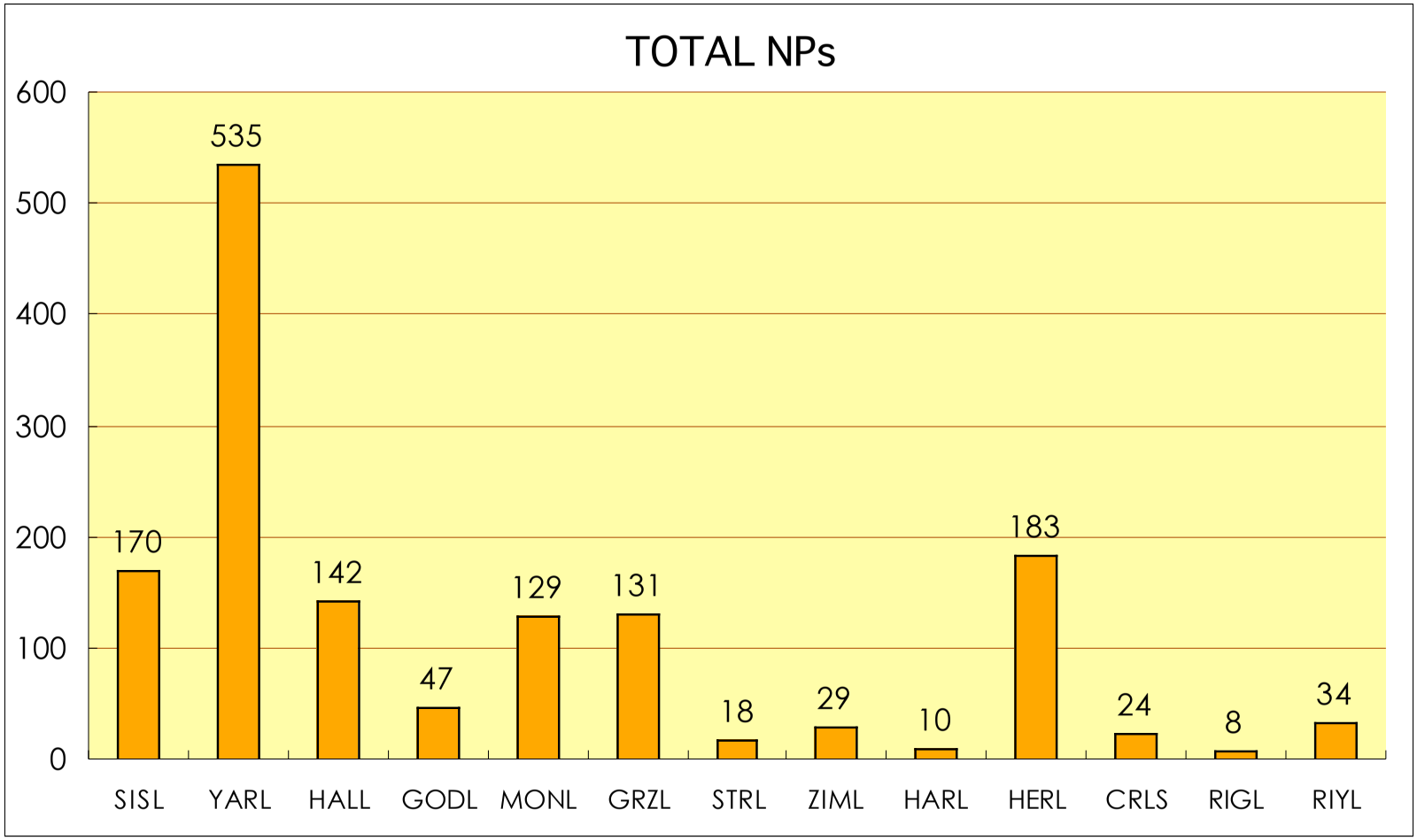
Vehicle : H-IIA Launch vehicle No.4

The Tracking Mission Objectives of ADEOS-II

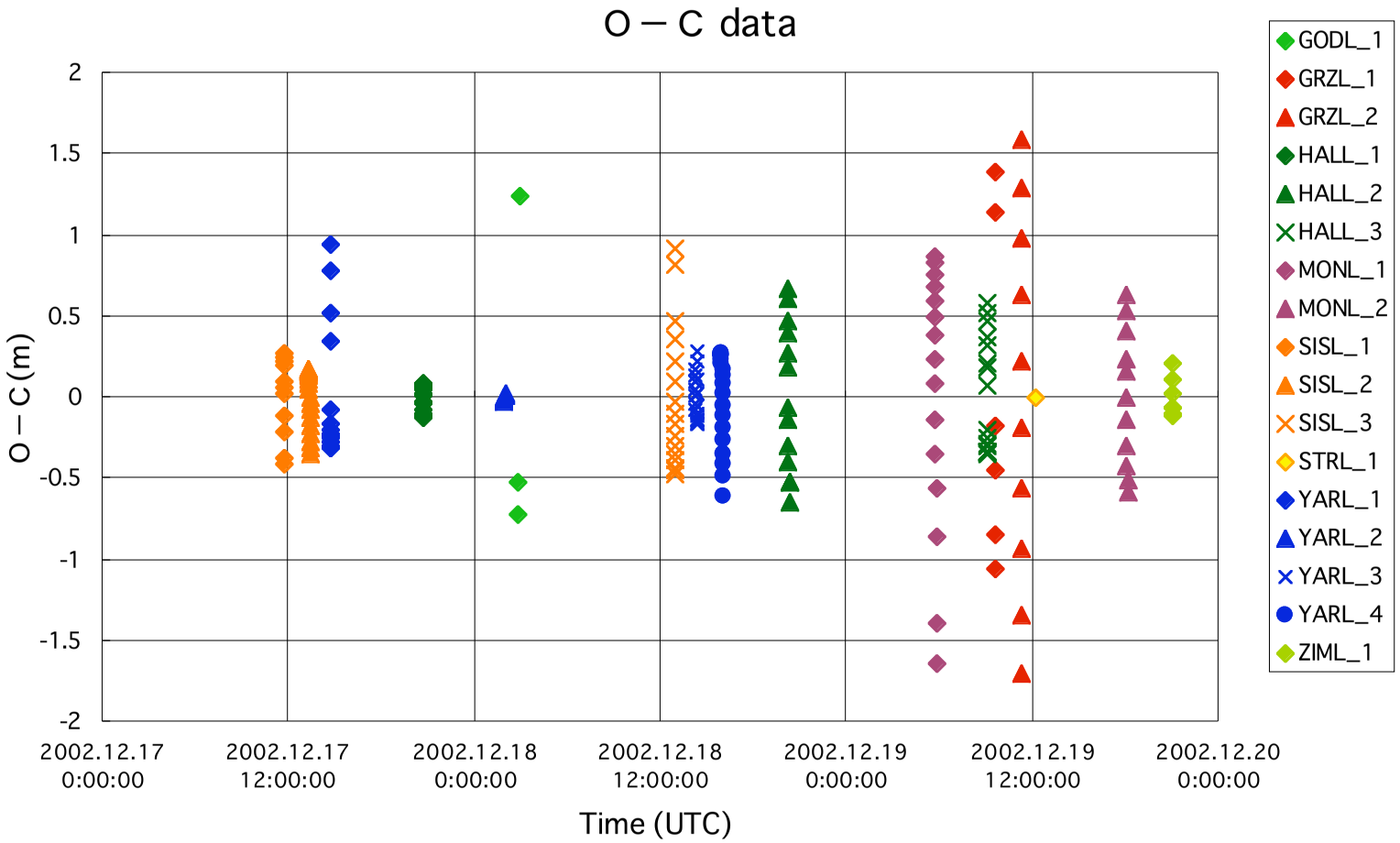
- To develop precise orbit determination techniques using GPS and SLR
- To provide precise orbit information with SLR stations and ADEOS-II user from NASDA routinely.
- Update the earth's gravitational model using SLR and GPS data.
- To verify the tracking accuracy and operational procedures of SLR during high solar activity periods.
- ADEOS-II orbit determination accuracy in short arc tracking.

Campaign RESULT

Campaign: Dec.14, 2002 - Jan.18, 2003

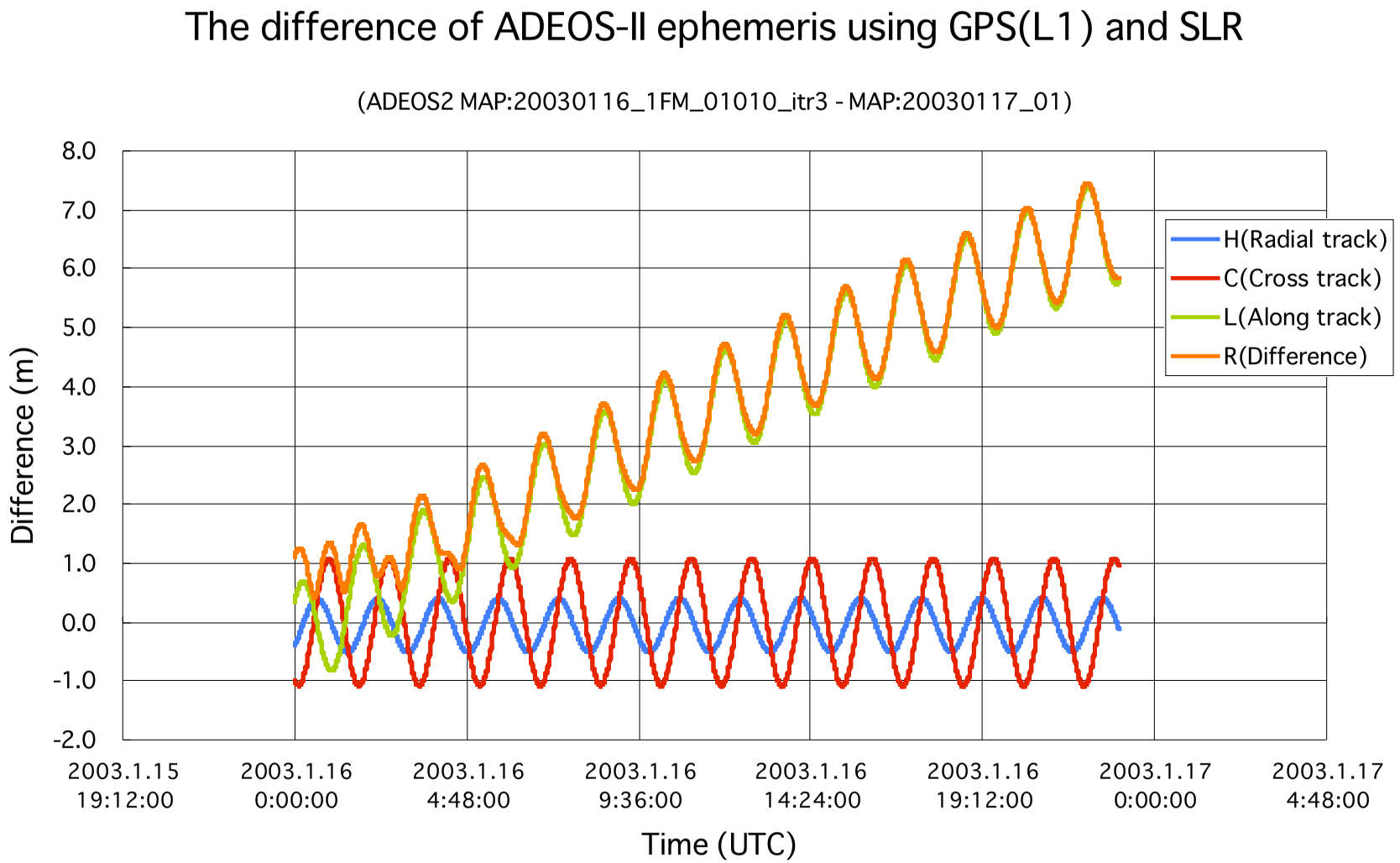


Precise orbit determination(SLR)



The orbit determination O-C is in a few meters

Orbit determination using on-board GPS (L1 only)



April 7-11/2003

ADEOS-II operation plan

NASDA would like to continue ADEOS-II tracking only with the restrictive stations* until the end of June, 2003.

- ADEOS-II GPSR could not gather enough on-board data during ILRS campaign

  ADEOS-II on-board GPS has stopped its observation from the end of February intermittently.
  But from April 1st, ADEOS-II started GPS observation and GUTS started to receive on-board GPS data again.

*:*the restrictive stations Shimosato, Yarragadee and CRL.*
If there is other station that will support ADEOS-II, please contact NASDA.

NASDA are extremely grateful for ILRS generous support to ADEOS-II tracking campaign.
We look forward to the continuing this relationship in our future projects as well as ADEOS-II.

NASDA GUTS-SLR Team
Mikio SAWABE
Takashi UCHIMURA
Maki MAEDA

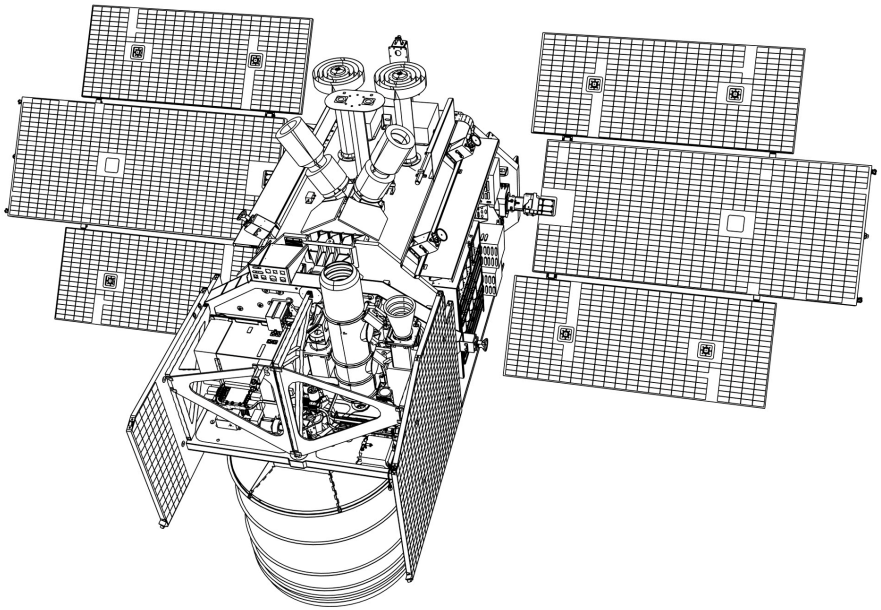
ICESat Status

Bob E. Schutz
Center for Space Research
University of Texas at Austin
schutz@csr.utexas.edu

ICESat

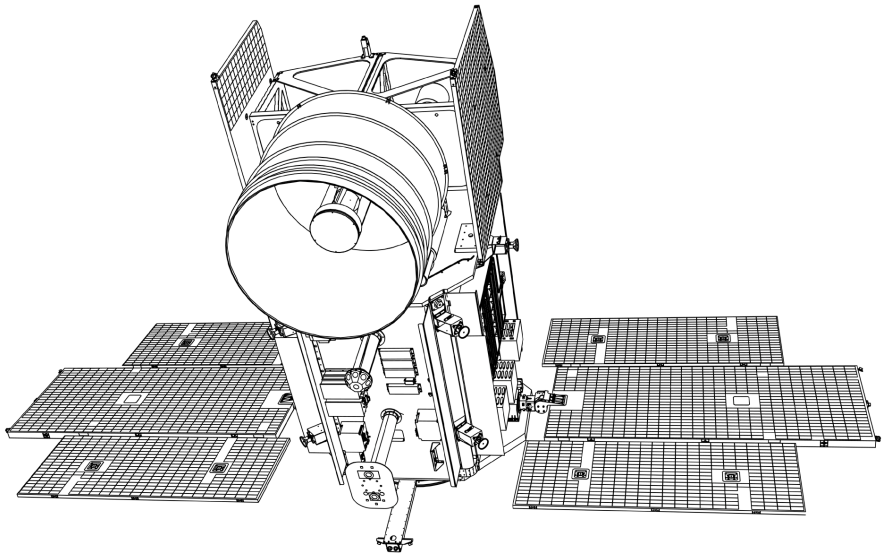
- Ice, Cloud and land Elevation Satellite (ICESat) launched January 13, 2003 00:45 UTC from Vandenberg (CA) on Delta-II
- Primary instrument on ICESat is GLAS (Geoscience Laser Altimeter System)
- NASA Earth Science Enterprise mission
  - GLAS is a NASA Goddard instrument
  - Spacecraft built by Ball Aerospace
  - Mission operations at LASP/University of Colorado

Position and Pointing

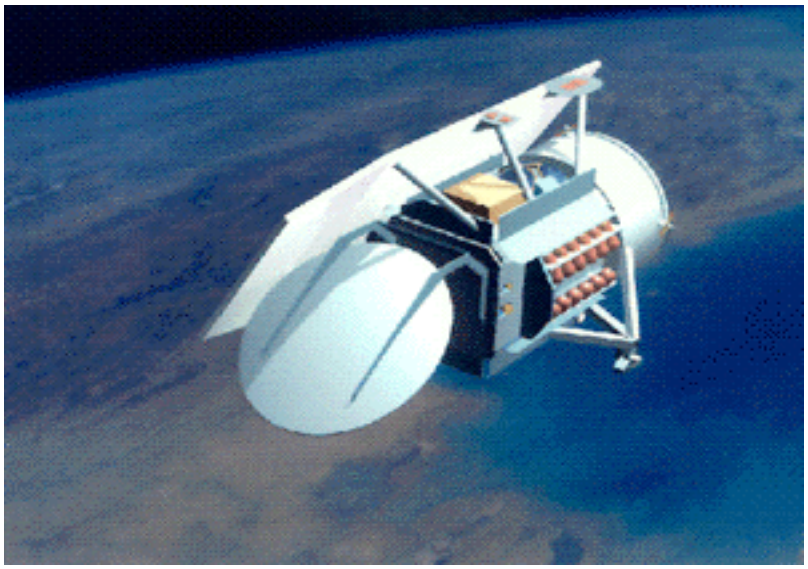


- Laser altimetry requires accurate knowledge of position and laser pointing
- Position:
  - Two BlackJack GPS receivers
  - SLR array
- Pointing:
  - System of star cameras, gyros, and cameras to monitor the 40 Hz laser performance

SLR Tracking Status



- GLAS instrument team placed restrictions on SLR tracking
  - Concern about GLAS detector damage from SLR
  - Restrict SLR ranging to elevations less than 70° (~20° incident angle to GLAS boresight)
- SLR test ranges began March 5 from Goddard and McDonald
- Plan under discussion to add stations
- SLR very important for POD validation
- GLAS cal/val period interrupted with laser anomaly; return to operations soon



GEOSAT Follow-On (GFO) Radar Altimeter Satellite

Satellite Laser Ranging (SLR)

Tracking and Analysis Overview

GSFC Report

ILRS Workshop; Nice France

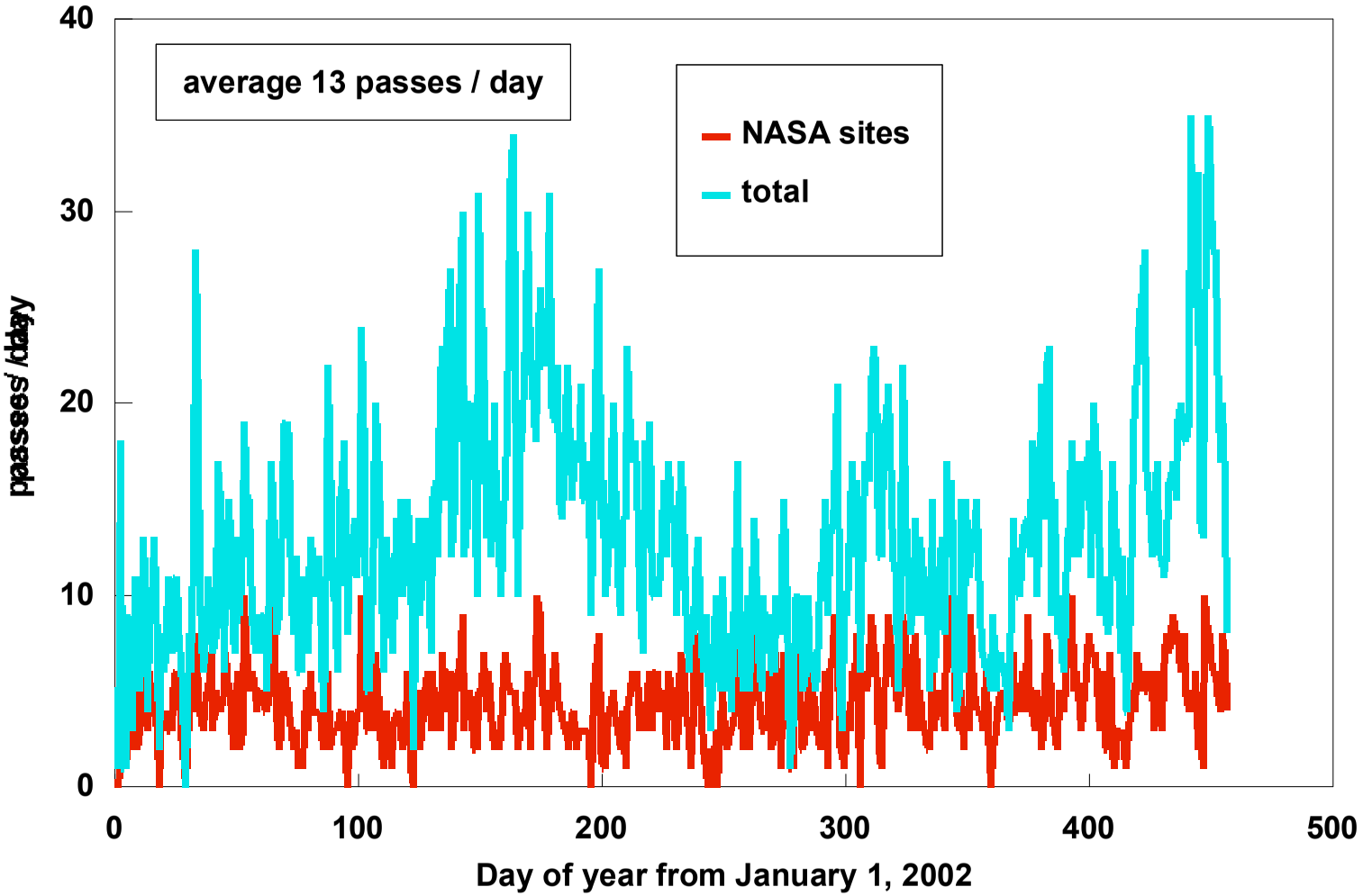
April 2003

Altimeter Error Budget

Component	Information source	Error (cm)
Altimeter		
Instrument noise	Ball	1.9
Biases	Ball	3.0
Sea surface (EM and skewness)	TOPEX	2.3
Troposhpere	Ball	2.6
Inonsphere	Ball	1.7
SLR POD (radial orbit error)	GSFC	5.0
Total RSS		7.1

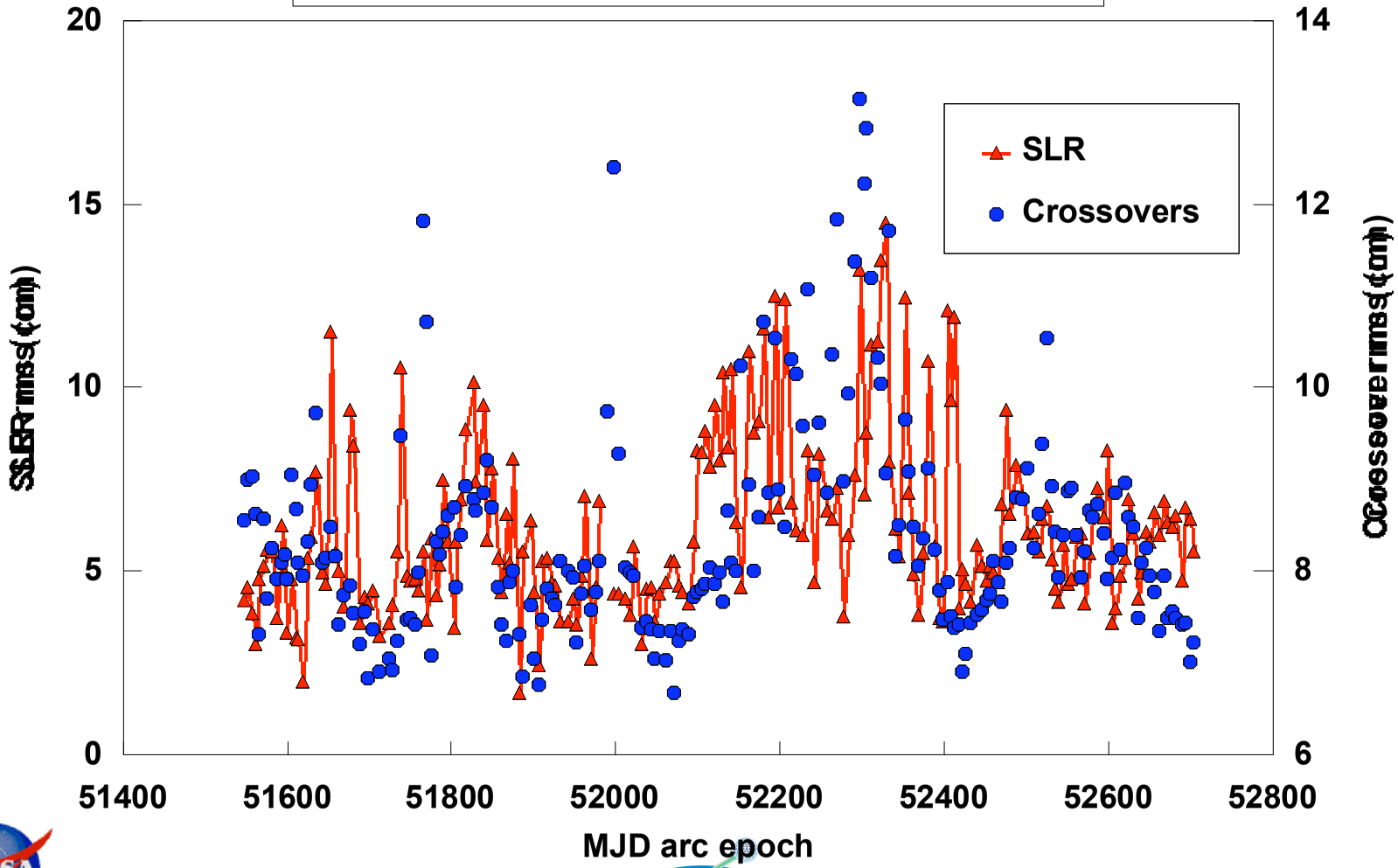
International Laser Ranging Service

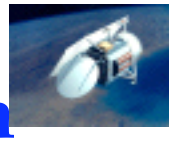
SLR Tracking History: Jan 2002 - Mar 2003



Tracking Data Residuals

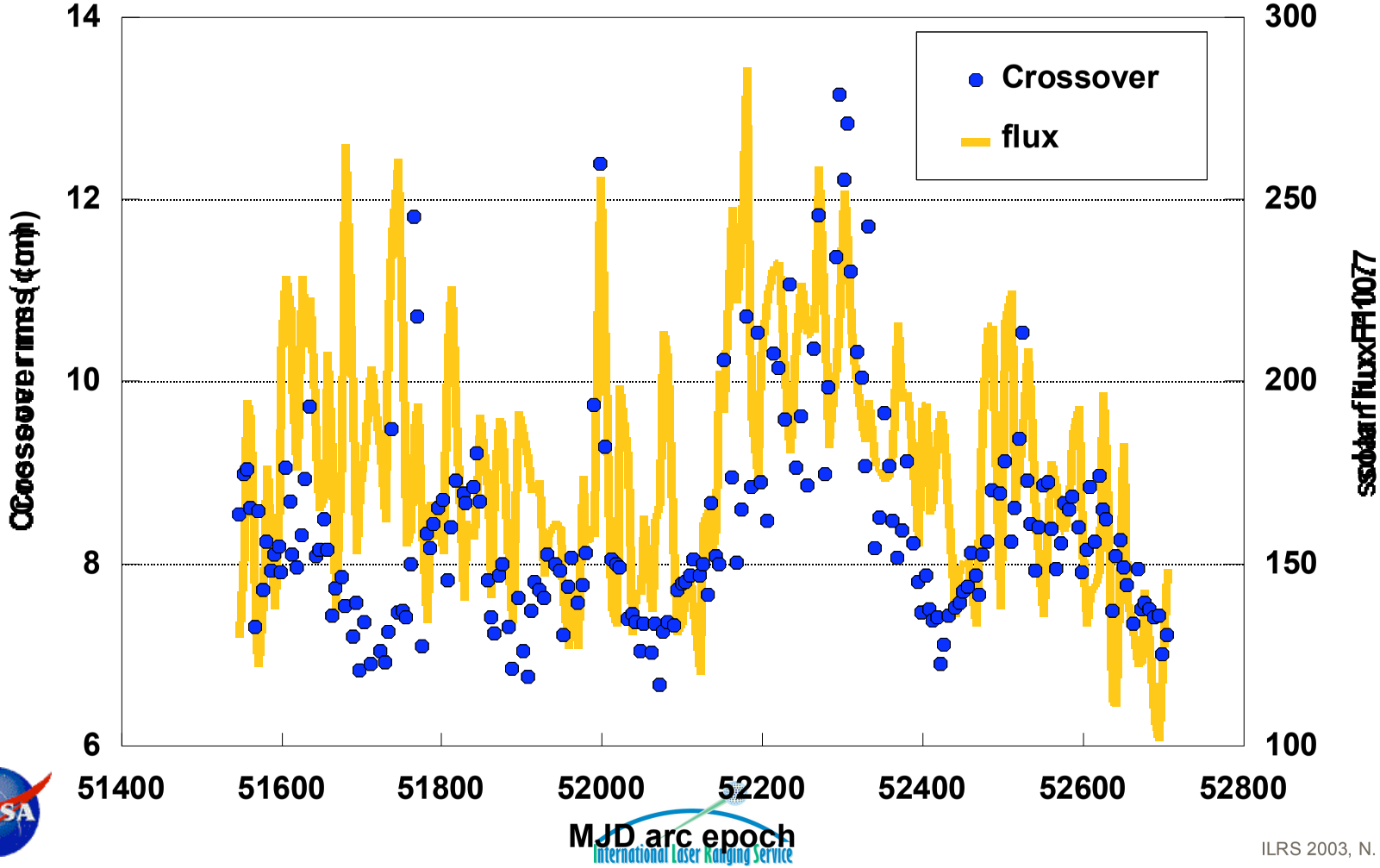
204 6-day arcs spanning Jan 1 '02 - Mar 10 '03



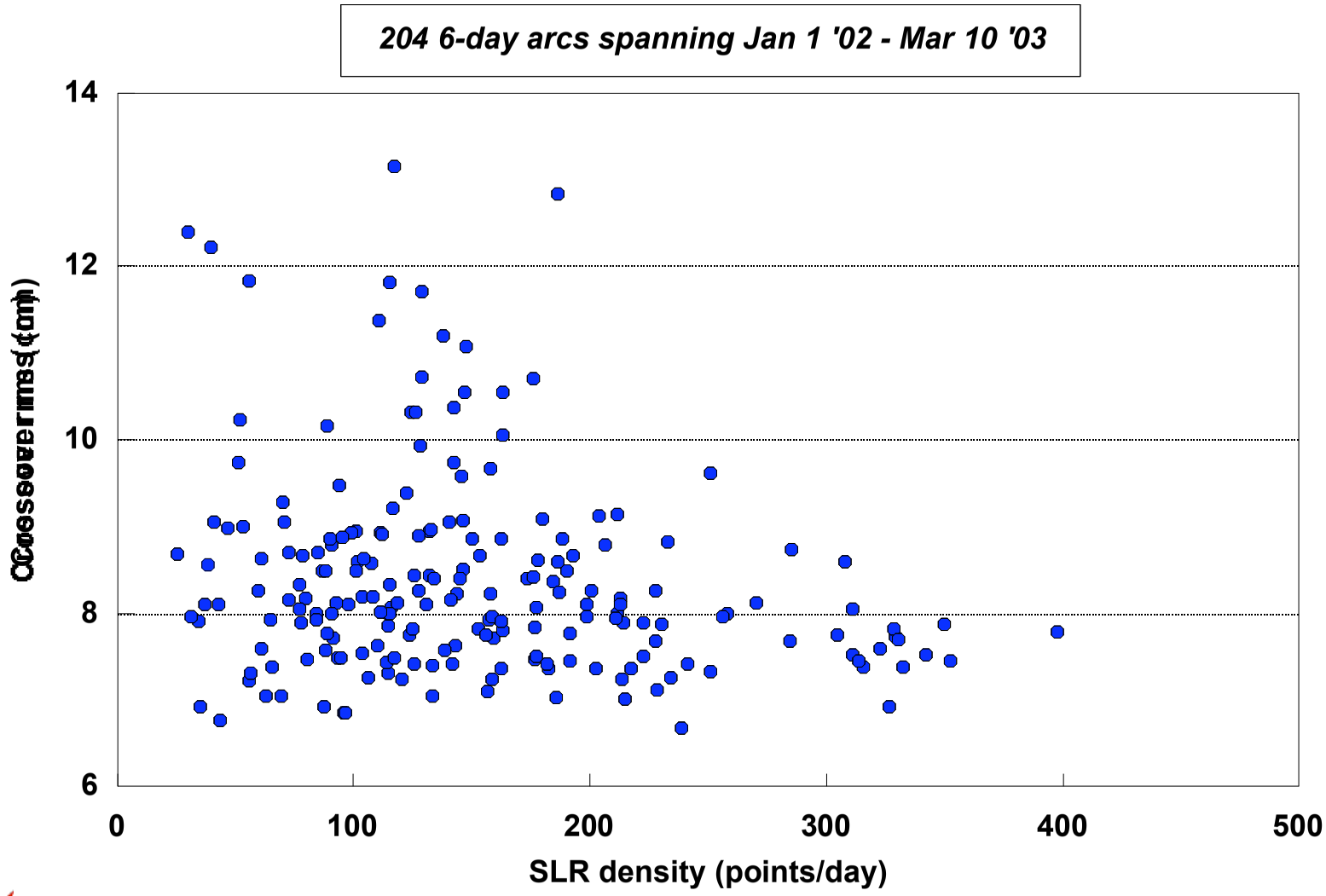


Orbit quality degrades over periods of high solar activity due to Drag error

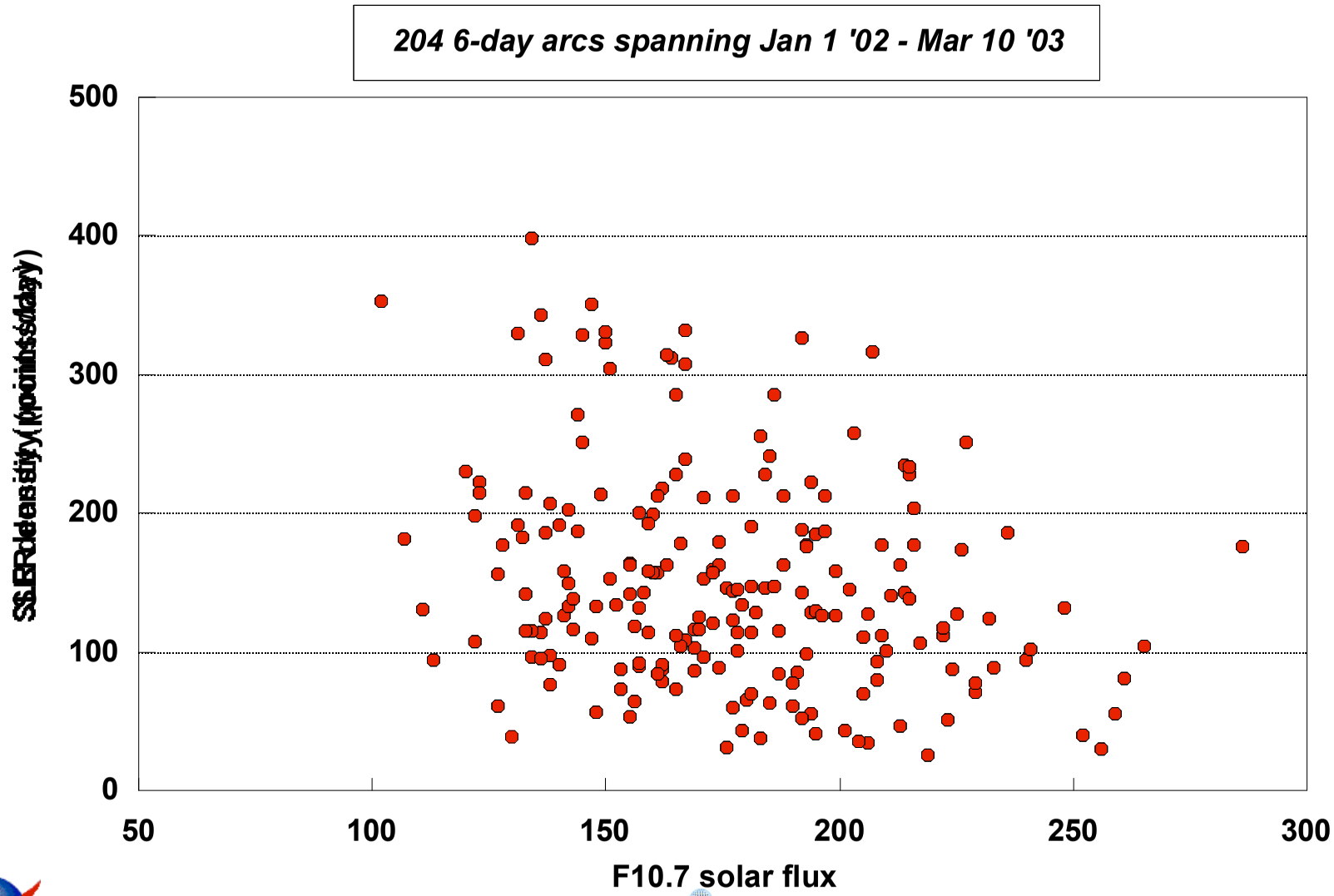
204 6-day arcs spanning Jan 1 '02 - Mar 10 '03



Orbit quality varies with SLR tracking density



SLR tracking density varies with solar activity



GFO POD GSFC Points of Contact

- **Frank Lemoine**

  flemoine@geodesy2.gsfc.nasa.gov

- **Nikita Zelensky**

  nzelensk@geodesy.gsfc.nasa.gov

IGLOS Pilot Project

The International GLONASS Service - Pilot Project (IGLOS-PP) is a pilot service of the International GPS Service (IGS) to track and analyse data from the Russian GLONASS satellite constellation. The products from the Service should facilitate the use of combined GLONASS and GPS observations for scientific and engineering applications, and allow users to experiment with the combined systems as a prototype Global Navigation Satellite System.

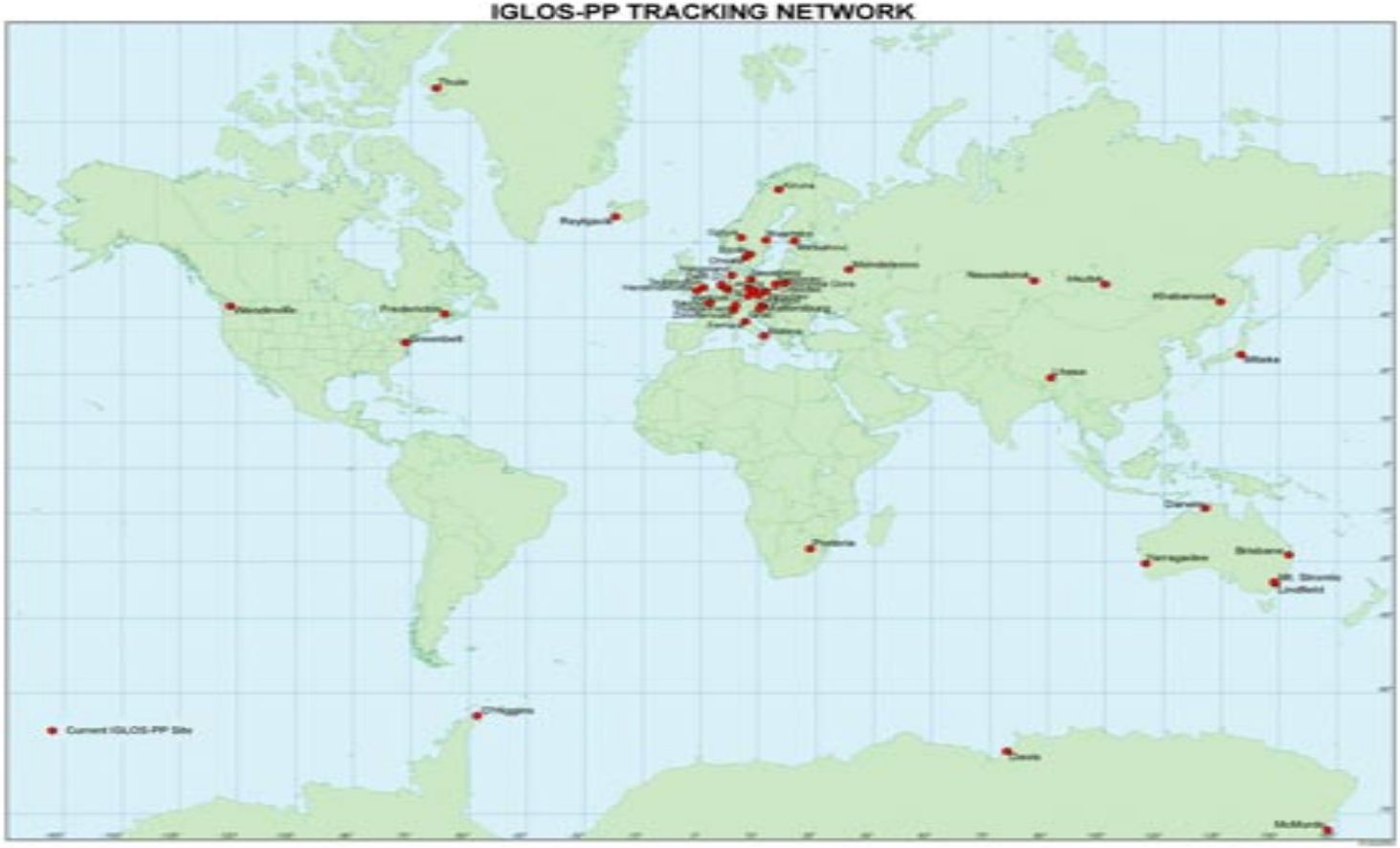
The ILRS supports this effort by a continuous tracking of three GLONASS satellites as part of their standard tracking protocol and by delivering precise GLONASS orbits through one of its Analyses Centers (MCC)

Tracking Network

In support of the GLONASS stations and to improve the geophysical information available in the site logs, the IGS switched to a new GNSS site log format in June 2002. At the same time, combined GPS/GLONASS stations have become an integral part of the IGS network.

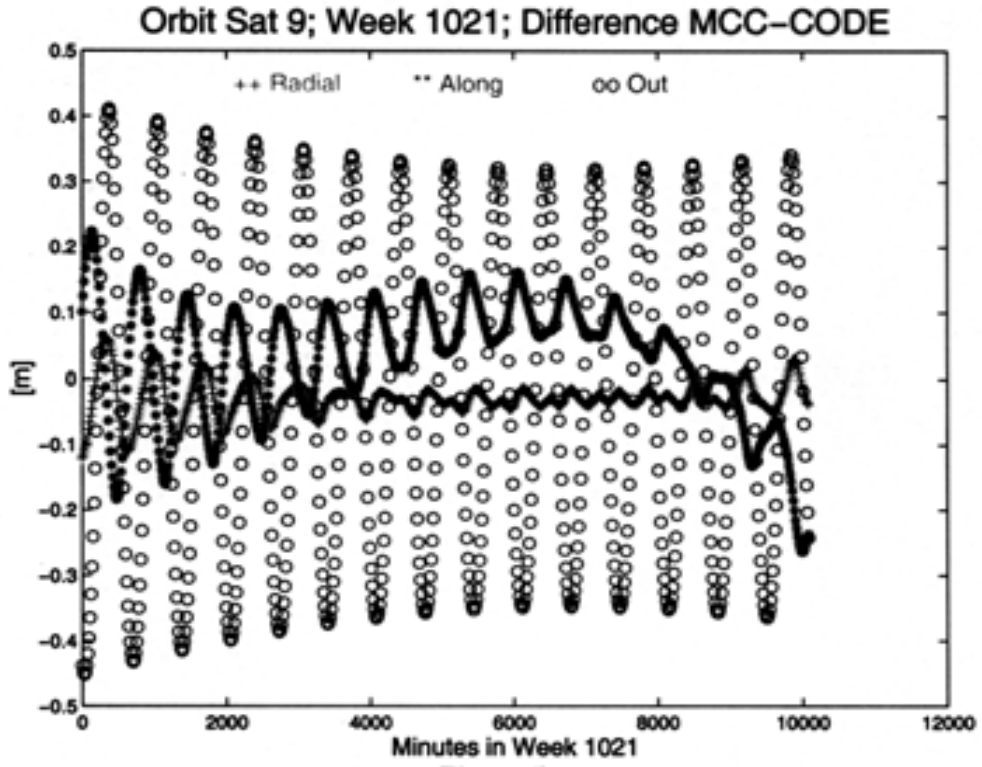
The number of permanent IGLOS microwave tracking stations has grown slightly to 50 stations in the network. New stations that came online include Frankfurt, Kourou and Zimmerwald.

IGLOS-PP TRACKING NETWORK

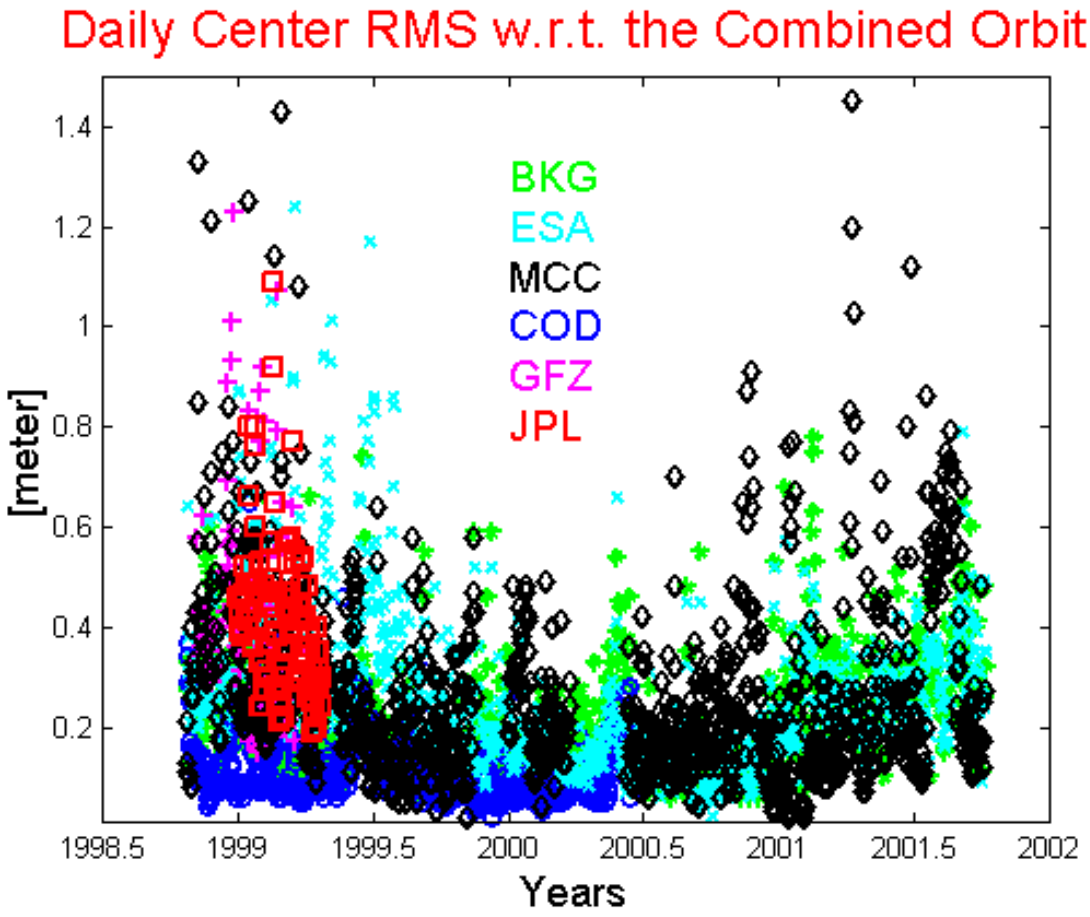


Data Analysis

From end of 1998 till June 2000 up to five IGS-AC and one ILRS Analyses Center processed GLONASS observation data. As an example Figure 1 shows the consistency of the best microwave solution at this point in time and the laser solution in the satellite coordinate system over a whole week (GLONASS slot 9, end of 2000). The consistency between the best microwave solutions was usually better in out of plane (about 15 cm) but worse in along track



Unfortunately ILRS had to decrease the number of tracked GLONASS satellites (from 9 down-to 3). The same time the number of microwave ACs went down to two. This situation is stable since end of 2000. Currently BKG , ESA and MCC provide precise GLONASS orbits on a regular basis. A combination orbit is produced by the IGS Analysis Center Coordinator from the orbits of these three centers.



Scientific Outcome

Combined precise GLONASS orbits in regular intervals (weekly).
(consistency of the Analysis Center contributions about 15 cm per coordinate)

Mis-modelling of solar radiation pressure at high elevation of the sun above plane II by ESA and BKG during GPS weeks 988, 1014,1039. (Problem / Model corrected)

Mis-modelling of satellite 8 in summer 2001 and begin of 2002 by ESA (corrected)

Various publications and presentations at international meetings

GLONASS satellites currently tracked by ILRS stations

	GLONASS-87	**Plane 1**	**Slot 3**
	GLONASS-84	**Plane 3**	**Slot 17**
New:	**GLONASS-89**	**Plane 3**	**Slot 22 (=Cosmos 2394)**

Reasons to continue/increase tracking of GLONASS satellites

- **The number of active GLONASS satellites became stable and could be slightly increased over the past 2 years.**

- **GLONASS satellite tracking**
  Precise GLONASS orbits with an increased orbit accuracy of 1-3 cm in the radial direction shoul be sufficient to study in detail the reason of the remaining bias of a few centimetres between laser tracking and microwave observations.

- **Invaluable contribution : Collocation in space**

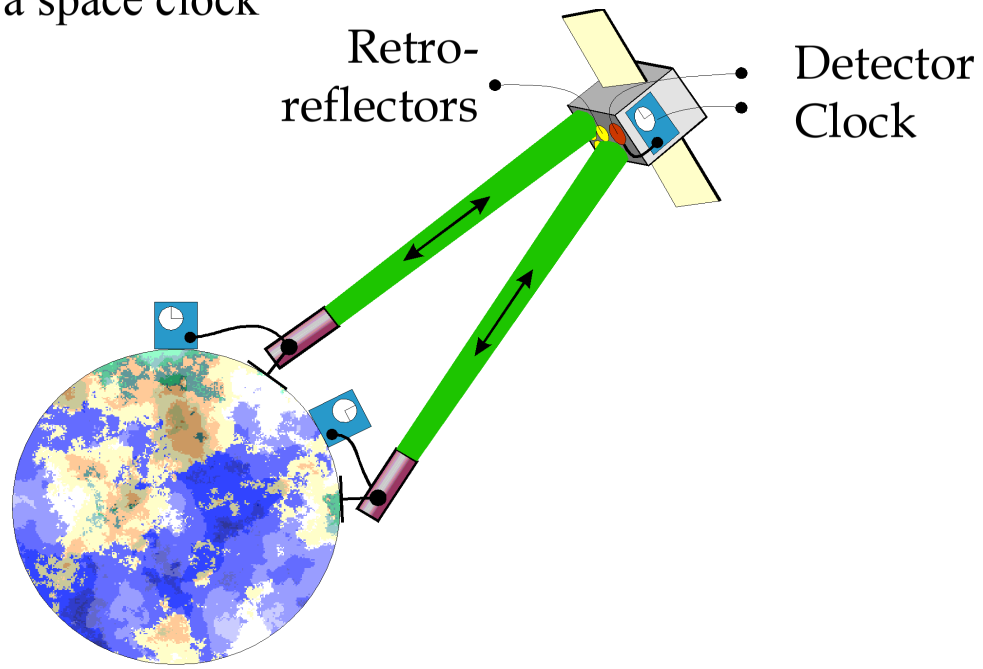
- **MCC GLONASS orbit determination**
  MCC asks for intensified tracking of GLONASS satellites to process and deliver improved precis satellite orbits.

- **GLONASS data processing**
  Intensify the ability to process data from combined GPS/GLONASS tracking sites. ACs and A are encouraged to provide orbit and clock submissions in order to ensure a reliable combined GLONASS orbit and clock product.
  (Recommendation agreed at the IGS Workshop in Ottawa 2002)

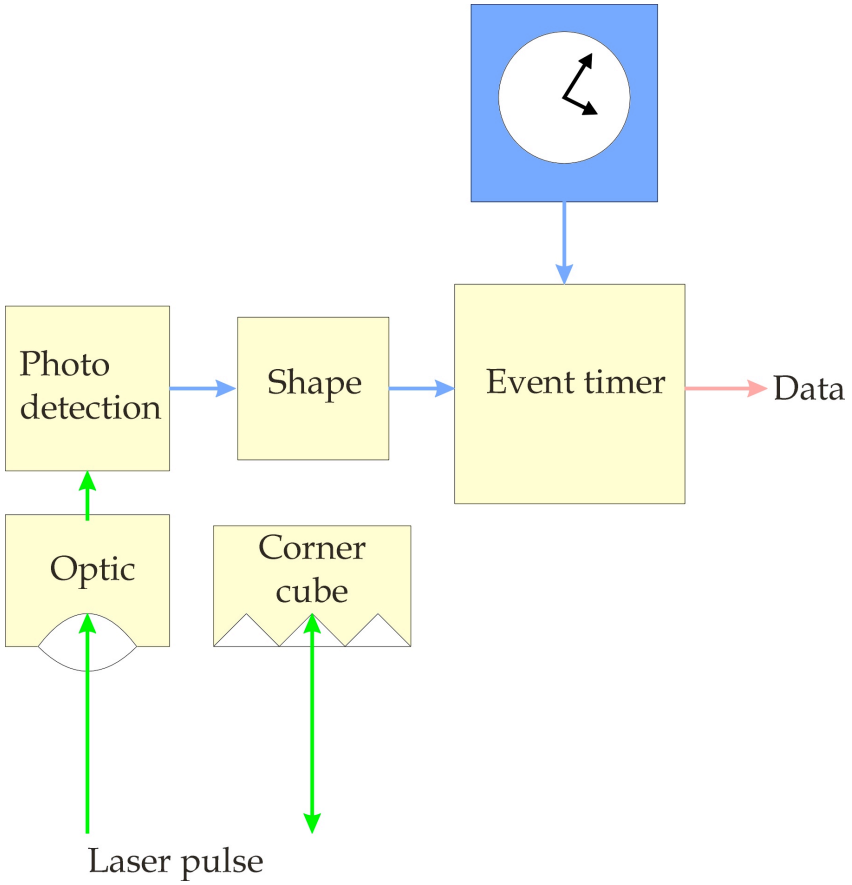
Upcoming Missions

T2L2 (Time Transfer by Laser Link) OCA/CNES

- Goals :
  - Time transfer between remote ground clocks via a space equipment
  - Time transfer between ground clocks and a space clock
  - One way laser ranging validation
- Missions
  - T2L2 on board ISS : Scrapped in 2001
  - T2L2 on board Micro satellite Myriade
  - T2L2 on board Galileo prototype
  - T2L2 on board a Chinese platform

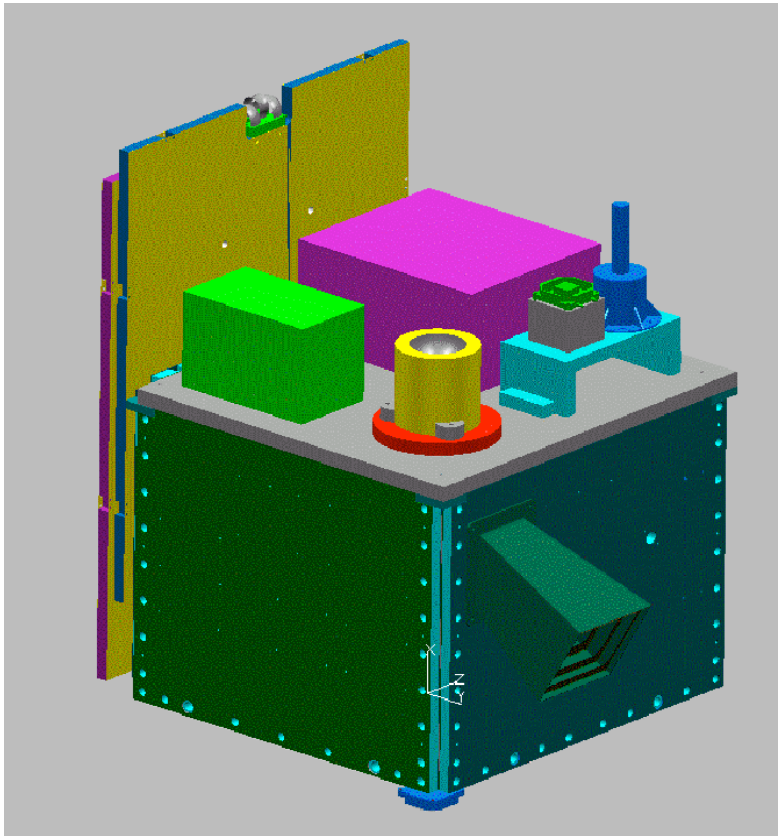


Space segment

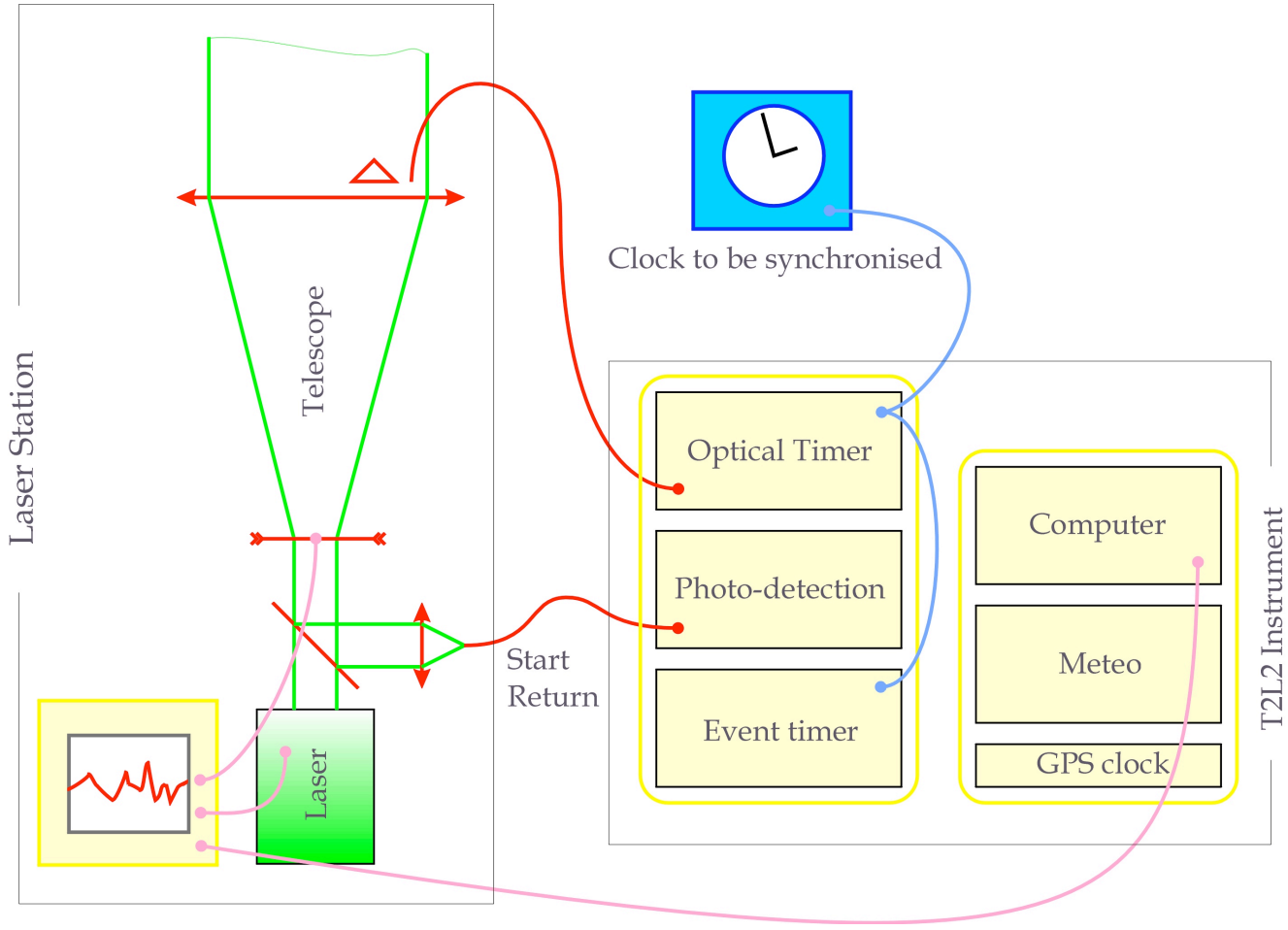


Space segment

- Characteristics
  - » Volume : 6 l
  - » Masse 10 kg
  - » Power 40 W - 28 V
- End of Phase B : Dec. 2003
- Phase C/D : 2 years



Ground segment



Ground segment

ILRS Annual Report Series

- 2001 ILRS Annual Report on web; hardcopy also distributed
- Call for input to 2002 ILRS Annual Report to be issued in April 2003
- Contributions due to C. Noll by May 09, 2003
- Plans:
  - Shorter report
  - No individual center reports
  - Sections by subject rather than organizational element

International Laser Ranging Service

2002 ILRS Annual Report

Outline

ILRS Organization (2 pages) Brief Overview, New Governing Board, Contributing Organizations	M. Pearlman/C. Noll/W. Gurtner
SLR Tracking Network (2 pages) Changes in the network, Site surveys	P. Stevens
Satellites and Campaigns (1 page) New missions, Retired missions	S. Wetzel/J. Horvath
Infrastructure (2 pages) Web Site developments, Site log file, Bias reports	V. Husson/C. Noll/W. Seemueller
Tracking Procedures and Data Flow (2 pages) Priorities, Improvements in data flow, Improvements in predictions, Expanded prediction format	J. Horvath/P. Stevens
Emerging Technologies (3 pages) Autonomous operations, SLR 2000, Transponders	J. Degnan
Analysis Pilot Projects; progress toward a consolidated product (2 pages)	R. Noomen
Modeling (2 pages) Satellite center of mass correction, Refraction	G. Appleby/S. Reipl/E. Pavlis
Science Coordination (2 pages) Role in the ITRF, Synergy with other techniques, Bibliography, Science Applications	S. Klosko/M. Torrence/P. Dunn
Meetings (1 page) Thirteenth International Workshop on Laser Ranging, Seventh and Eighth ILRS General Assembly	C. Noll
Bibliography	M. Torrence

International Laser Ranging Service

ILRS Meetings — Fall 2003

- Location: Wettzell
- Schedule: October 27 - 30, 2003
- Plan:
  - More specialized Working Group Sessions
  - Address specific topics and try to bring them to closure
  - As examples:
    - Refraction Model
    - Prediction Format
    - Station Qualification
    - Spacecraft Center of Mass Correction
    - Dynamic Priorities
    - Local Survey Issues
    - Hardware characterization
    - Data Flow
- Sessions could be scheduled in tandem so everyone can participate
- Working Groups would each pick a couple of topics to work on
- No formal General Assembly, but a General Meeting to allow some discussion
- Governing Board Meeting