LARES Mission

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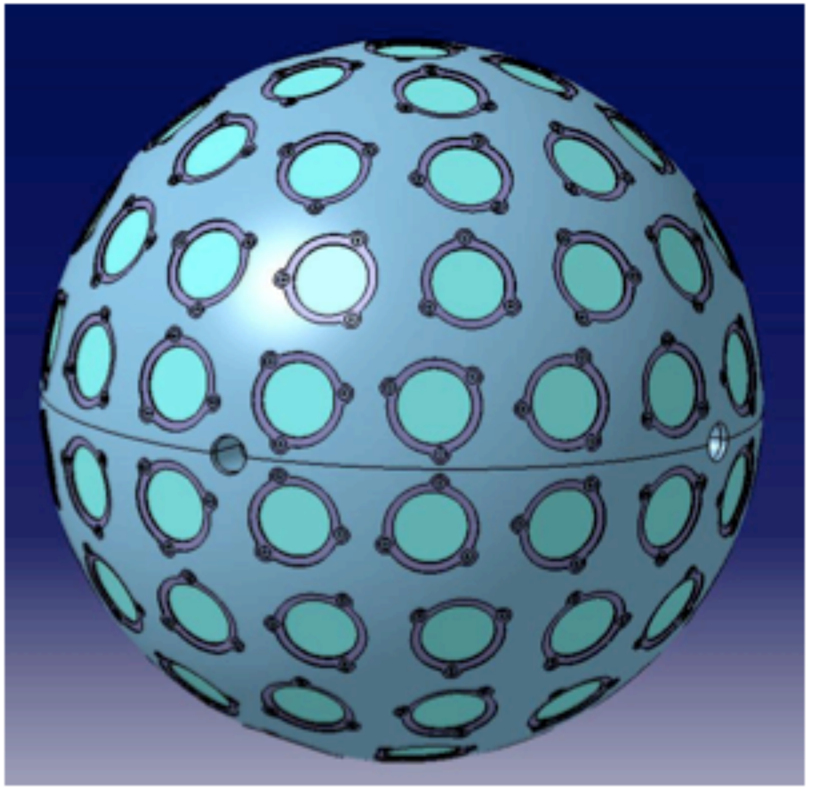
LARES Mission: Current status

- The orbital parameters chosen for LARES are:
  - inclination about 71.5 degrees,
  - semi-major axis about 7830 km (altitude ~1450 km)
  - eccentricity nearly zero;
- Final weight of LARES will be about 385 kg,
- Radius of about 18 cm and
- LARES will have 92 CCRs housed in conical cavities
- Launch set in early 2010 (tentative, dependent on VEGA)

PRESENT DESIGN

ALL COMPONENTS IN TUNGSTEN ALLOY

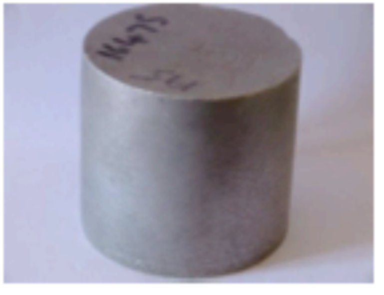
Excluding plastic rings and CCRs



- MATERIAL

  Tungsten alloy 95% **non magnetic**

  No Fe present in the alloy



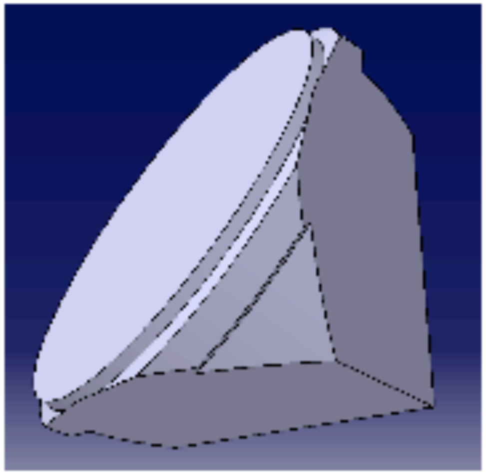
- Other elements:

  Ni and Cu

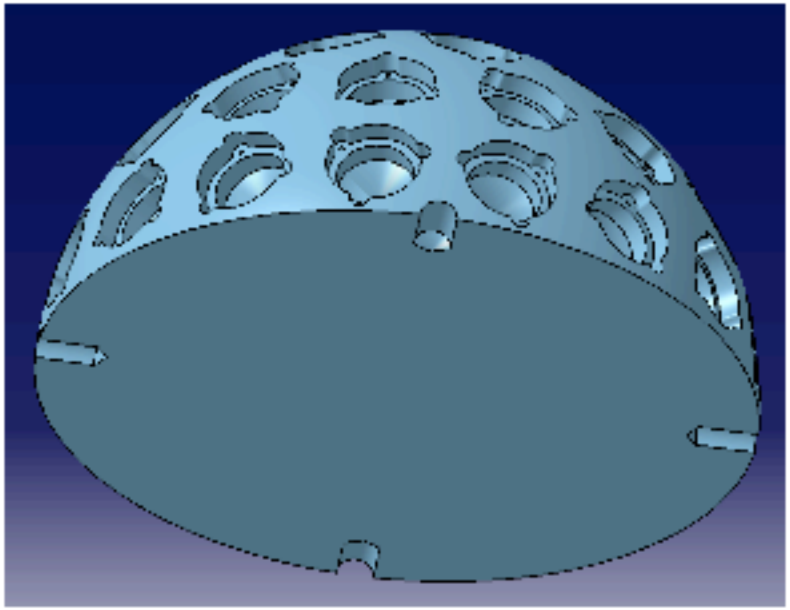
- Class 3 tungsten alloy

  Nominal density 18000 kg/m3

PRESENT DESIGN



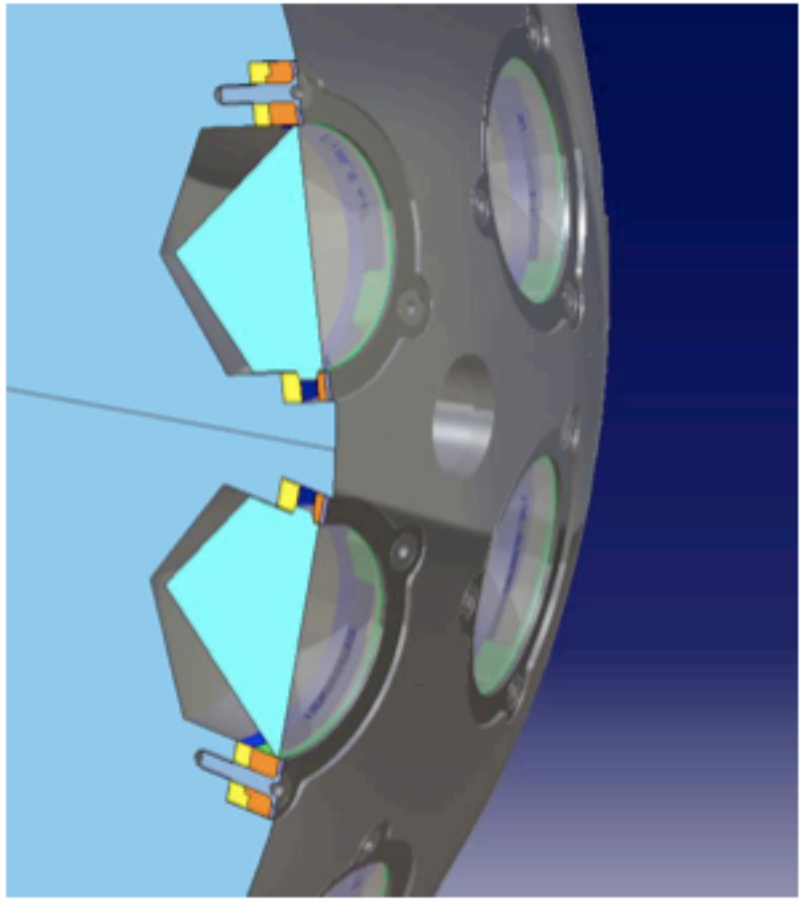
92 CUBE CORNER REFLECTORS (CCR)



- Satellite diameter 0.36m
- 4 Equatorial holes for handling and separation system interface
- CCR are evenly distributed on the surface and are organized in 8 parallel plus 2 polar CCRs

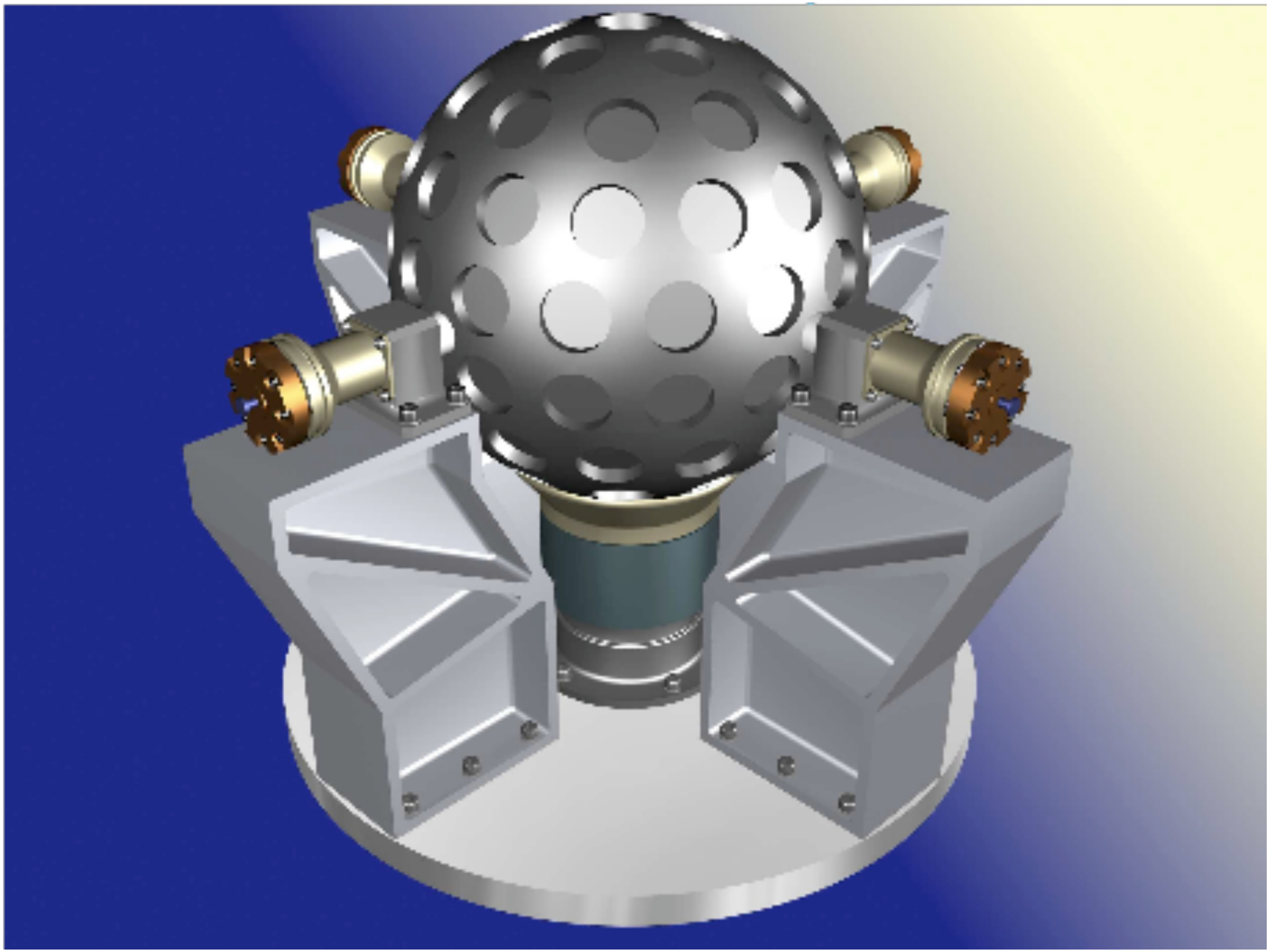
DETAIL OF NOMINAL CAVITY

maximize the mass to cross sectional area of the satellite.



- ISO_10642 M3X16
- HEXAGON SOCKET COUNTERSUNK SCREW

Separation Mechanism



Ref :		Date : 12 Avril2009
Rédigé par : P. Exertier	Signature :	

CURRENT STATUS

OF THE

JASON-2 / T2L2 MISSION

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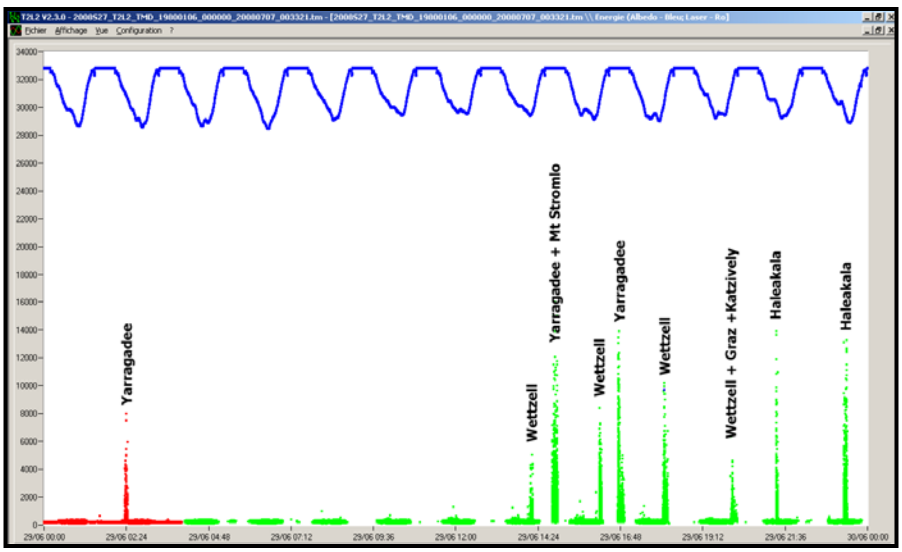
CURRENT STATUS OF THE JASON-2 / T2L2 MISSION

1. INTRODUCTION

T2L2 will permit to synchronize terrestrial and space clocks at a sub-anosecond level. This experience is based on the propagation of short laser pulses between a ground SLR system and a clock on-board the satellite Jason-2 (the DORIS Ultra Stable Oscillator, USO). The SLR system is supposed to be connected to a very stable clock (using a picosecond resolution), whereas the on-board instrumentation includes a detection system (with a photo-diode and an electronic device serving as timer with a resolution of one picosecond).

The T2L2 instrument, developed by OCA (Observatoire de la Côte d'Azur) and CNES (Centre National d'Etudes Spatiales) between 2005 and 2008, has been successfully launched with the Jason-2 space vehicule on the 20th of June 2008. It has been switched on 5 days later. First laser echoes have been detected a few days after : the first official SLR station clearly identified is Yarragadee (Australia). Since this date, the T2L2 instrument is fully operational and has recorded about 65 billion of events, including true laser shots, internal calibrations and noise events.



Detection of first SLR stations : CW background (sun albedo, higher value for penumbra, lower for daylight) in blue, energy of detected laser pulses in red and green (higher energy for "true" laser pulses, lower energy for noise events, mainly during daylight conditions)

The data flow and data processing have been developped by CNES and OCA, respectively. They are based on two « mission centers » ; the fisrt one (CMI) is dedicated to the on-board data and is working in CNES, Toulouse, whereas the second one (CMS) is dedicated to the scientific aspects of the mission and is working in OCA, Grasse.

1.1. CMI

The first operation which is realised daily, is to convey the raw data from the satellite to the CMI. T2L2 which has its own memory is delivering the raw data to Jason-2 using a low rate. Then, the satellite is transmitting the data every 2 hours to the ground (notably in Germany, in France, etc).

The CMI is processing the raw on-board data (second and picosecond given by the timer, and the measured energy of each in coming pulses) and is making the first calibrations. Because T2L2 is programed to acquire also 1-second pulses (PPS) coming from the on-board GPS, the CMI is computing a first estimation of the UTC date of on-board events at the ±1 µsec level.

1.2. CMS

The CMS has been developped on a parallel way. Its first mission is to correlate SLR and T2L2 data in order to identify the origin of each SLR pulse which is recorded on-board by the system (via the non-linear detector – the photo-diode – and the timer). Its activities started the 30th of June, 2008. The first successful correlation which has been processed at that time concerns the Yaragadee SLR observations of the 29th of June, 2008.

During the first weeks of the T2L2 mission, the CMS made progress in improving the first estimation of the UTC date of on-board events, because the identification process is requiring a precision of 1 µsec to permit an unambigous correlation between on-board events and ground SLR pulses. In addition, because T2L2 is requiring a 1 picosec resolution for the SLR full rate data (to reach the mission goals), the CMS improved also the reading softwares of the new SLR format, the CRD one. Moreover, the « classical » MERIT format has been also programed, knowing its poor resolution of roughly ±100 nanosec.

The first results have been presented during the International Laser Ranging Workshop, 13-17 Oct., Poznan — Poland , and then during the OSTST meeting in Nice, Nov. 2008 (Samain et al., 2008 ; Exertier et al., 2008).

2. INSIDE THE CMS

The CMS is developing the overall programs and procedures needed (i) to convey and to merge SLR data given in both CRD and MERIT formats, (ii) to correlate SLR and T2L2 data, and (iii) to perform the outputs in terms of Time Transfer, comparisons with the DORIS data, etc. It has been separated in three levels :

- level I : the data reading and merging, and the correlation leading to the identification of on-board events
- level II : the computation of needed corrections and theoretical quantities, from the set of SLR station coordinates (given by ITRF2005), the Jason-2 MOE orbit (computed by the Jason-2 project), the attitude parameters of the spacecraft, and the models for atmospheric and relativistic effects (notably, Mendes&Pavlis 2001)
- level III : the estimaton of Time Transfers from ground to space and ground to ground, the offsets of the DORIS-USO frequency, etc.

Because the Grasse team is also involved in the CAL/VAL activities of Jason missions (since the TOPEX/Poseidon launch), the level II of the CMS-T2L2 data treatment takes advantage of the acquired knowledge (Bonnefond et al., 2008).

2.1. Files and data flow

2.1.1. Files

Data

The CMS is able to automatically make daily synchronization with the ILRS data centers (CDDIS and EDC), and is receiving every day the T2L2 data (1 file per day) from the CMI, Toulouse :

- the first SLR stations which sent their full rate data in the new CRD format were : Zimmerwald, Grasse and Ajaccio, and Herstmonceux in Europe and Changchun (CHIN) and Mt Stromlo (AUS).
- the first MERIT-II full rate data came from : Yaragadee, Greenbelt, Mt Peak, and then from Hartebeshoek, Arequipa, etc.

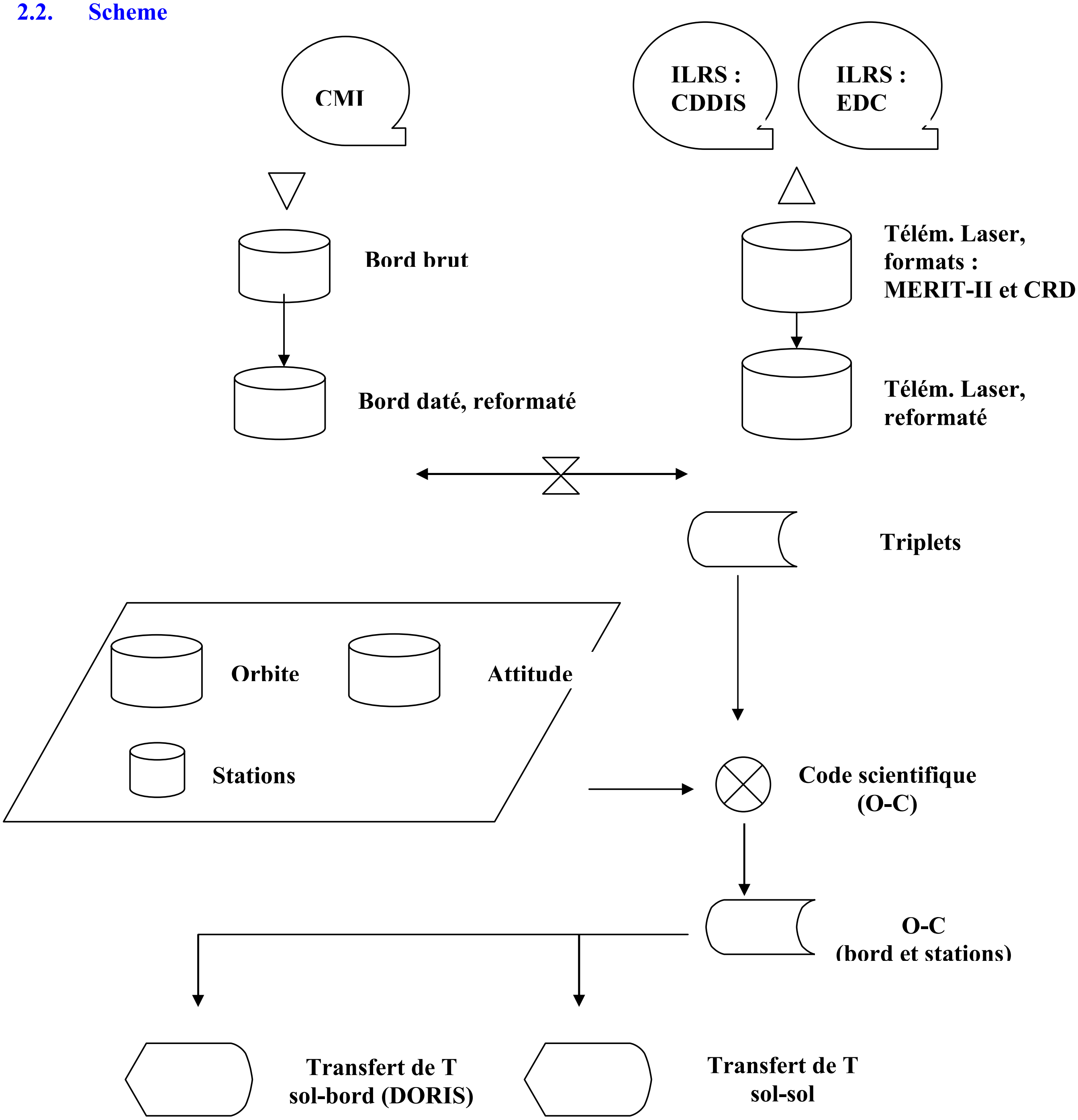
2.1.2. Data flow

During the first months of the T2L2/Jason-2 mission, it has been difficult both to improve the reading of CRD files and, in the same time, to provide an « up to date » data processing. Nevertheless, the situation has been improved by each SLR stations, thanks to the collaboration of ILRS. Now, the identification of on-board events is running at Day+7 ; the goal being to process data at Day+1 or +2 in order to be re-active during the upcoming Time Transfer campaigns (in 2009).

Concerning files volumes :

- current raw files :
  - on-board data : around 1 Go / month
  - ground SLR data : 15 Mo / month
- in the futur, this will give around 30-40 Go of raw files and 30-40 Go for processed files, considering the first 3 years of the mission.

2.2. Scheme



3. DATA TREATMENT

3.1. First results and validations

3.1.1. Board

All the available on-board data have been processed since the 29th of June ; it represents around 65 billion of events.

Thanks to the on-board PPS-GPS, we estimate 1µsec UTC date of events, and Δf/f frequency offsets of the USO DORIS (see Fig.1). This contributes to the long term monitoting of the USO, with a low precision (around 10-11).

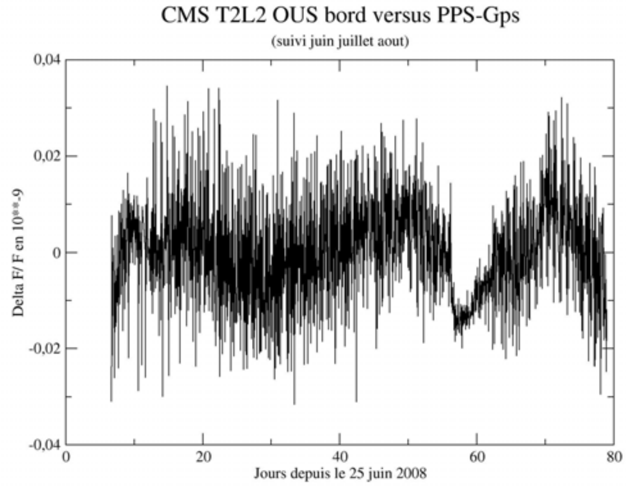


Figure 1. USO monitoring from the PPS-GPS acquired by T2L2

3.1.2. Ground

The SLR stations providing full rate data are the following :

- Europe :
  - Herstmonceux : format CRD
  - Zimmerwald : format CRD
  - FTLRS (Grasse, then Ajaccio from July to Dec. 2008, and then Grasse) : format CRD
  - MeO, fixed SLR, Grasse : format CRD
  - Wettzell (from June to Sept.) : format MERIT-II
  - Wettzell (since Oct.) : format CRD
  - Matera (only few passes during Nov. and Dec. 2008) : format CRD
  - We have contacts with the following SLR stations :
    - Matera : CRD
    - Graz (Aut) : internal format for few passes only
    - San Fernando (E) :
    - Borowietz (P) :
- America / Africa :
  - Mac Donald : format MERIT-II
  - Monument Peak : id
  - Greenbelt : id
  - Arequipa : id
  - Hartebeeskoek : id
  - 1873 : id
- China :
  - Changchun (since Sept.) : format CRD
- Australia :
  - Yaragadee : format MERIT-II
  - Mt Stromlo (since Sept.) : format CRD

Around 150 laser passes per month are accumulated by the CMS, but this number has great variatons from a period to another (from 100 to 300). We have at our disposal the following full rate SLR passes and/or files :

months in 2008	MERIT-II	CRD
June	11 (_a)	0
July	72 (_a) 4 (_b)	55
Aug.	63 (_a) 3 (_b)	117
Sept.	82 (_a) 6 (_b)	235
Oct.	66 (_a) 4 (_b)	207
Nov.	75 (_a) 4 (_b)	193
Dec.	65 (_a) 4 (_b)	196
months in 2009	MERIT-II	CRD
Jan.	74 (_a) 11 (_b)	260
Feb.	79 (_a) 7 (_b)	162
Mar.	87 (_a) x (_b)	210

There are around 500 SLR measurements per pass whereas the pass duration are in average of 600 sec. The laser rate is of 10Hz generally, but some SLR systems use a 100Hz rate and a kiloHz for Hx (few passes) and Graz (few passes with internal format).

Format CRD, mois en 2008	06	07	08	09	10	11	12
7237 Changchun		0	4	56			
7810, Zimmerw., CH		13	84	50	40		
7829, FTLRS Calern		5	0	0			
7825, Mt Stromlo, AUS		0		24	5		
7840, Hx, RU		28	25	55	3		
7845, MeO, F		3	0	2			
7848, FTLRS, Ajaccio		6	4	23	**		
Format CRD, mois en 2009	01	02	03	04			
1893			4				
7237 Changchun	49	39	14				
7825	43	30	49				
7840	48	20	57				
7845	12		19				
7829				4			
7810	44	47	42				
8834	64	26	26				

3.1.3. Triplets

The passes are selected using the ratio « nb of on-board detected pulses / nb of ground SLR measurements ». Generally, the MOBLAS type SLR systems have a ratio of 90-100%, whereas « european » SLR systems have between 15% and 55% due to a lower laser energy.

Overall performances per pass ; examples of ground to space Time-Transfers :

	USO model.	MERIT-II Yaragadee	Hx CRD	FTLRS CRD	MeO CRD	Changch CRD
1-sec (PPS-GPS)	286.	100.				
5000 sec (id)	80.-120.					
Board - ground /pass		55.	1-2.	20.	1.-0.6	1.
Board – ground /100 sec						

TABLE 1. Performances (RMS) in **nano sec** ($\Delta f/f = 3\text{-}4.10^{-12}$ to $3\ 10^{-11}$)

An example if identified triplets :

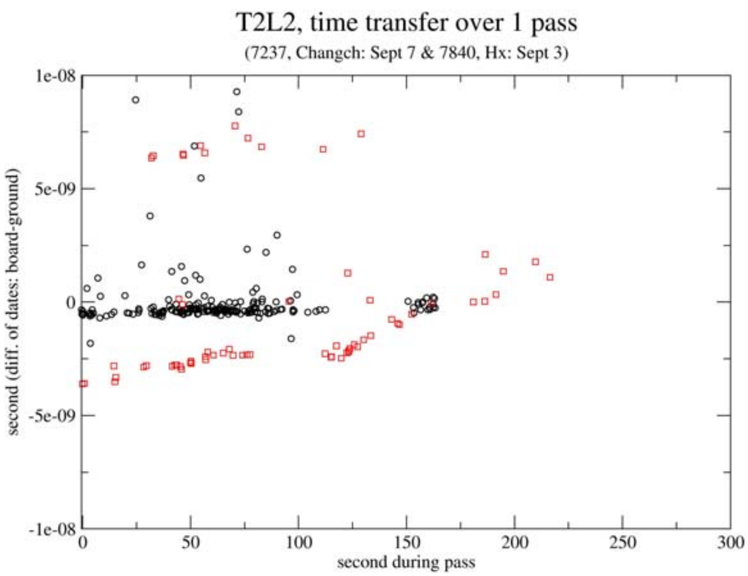


Figure 2. Triplets Laser for Changchun and Herstmonceux

4. CONCLUSION

In 2009, we plan to deploy the FTLRS system at the Observatoire de Paris, in order to make Time Transfer (TT) experiences between Paris and Grasse. In addition, we plan to work with Hx, Wettzell and Matera for making additional TT experiences based on passes with a common view ; of course, Borowiecz (Poland) and San Fernando (Spain) will be welcome to participate to campaigns, notably in order to make comparisons with the existing GPS and Two-Way TT systems.

Concerning long passes, that is with a non-common view, we plan to make TT experiences with Eastern Europe (SLR 1893) and Changchun (7237), notably.

We need more regular discussions with these SLR stations in order to exchange informations about laser energy, local time stability, observations conditions, etc. The goal is to reduce the time between the acquisition period and the first data processing in order to discuss about improvements and changes and then to re-iterate the TT experiences.

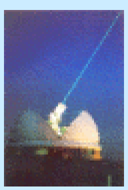
We also need other SLR data with a picosecond resolution, notably over America in order to better monitor the DORIS USO via T2L2.

Thoughts on the application of Stanford corrections

Report to ILRS NEWG as reported to GB

2009 April 22

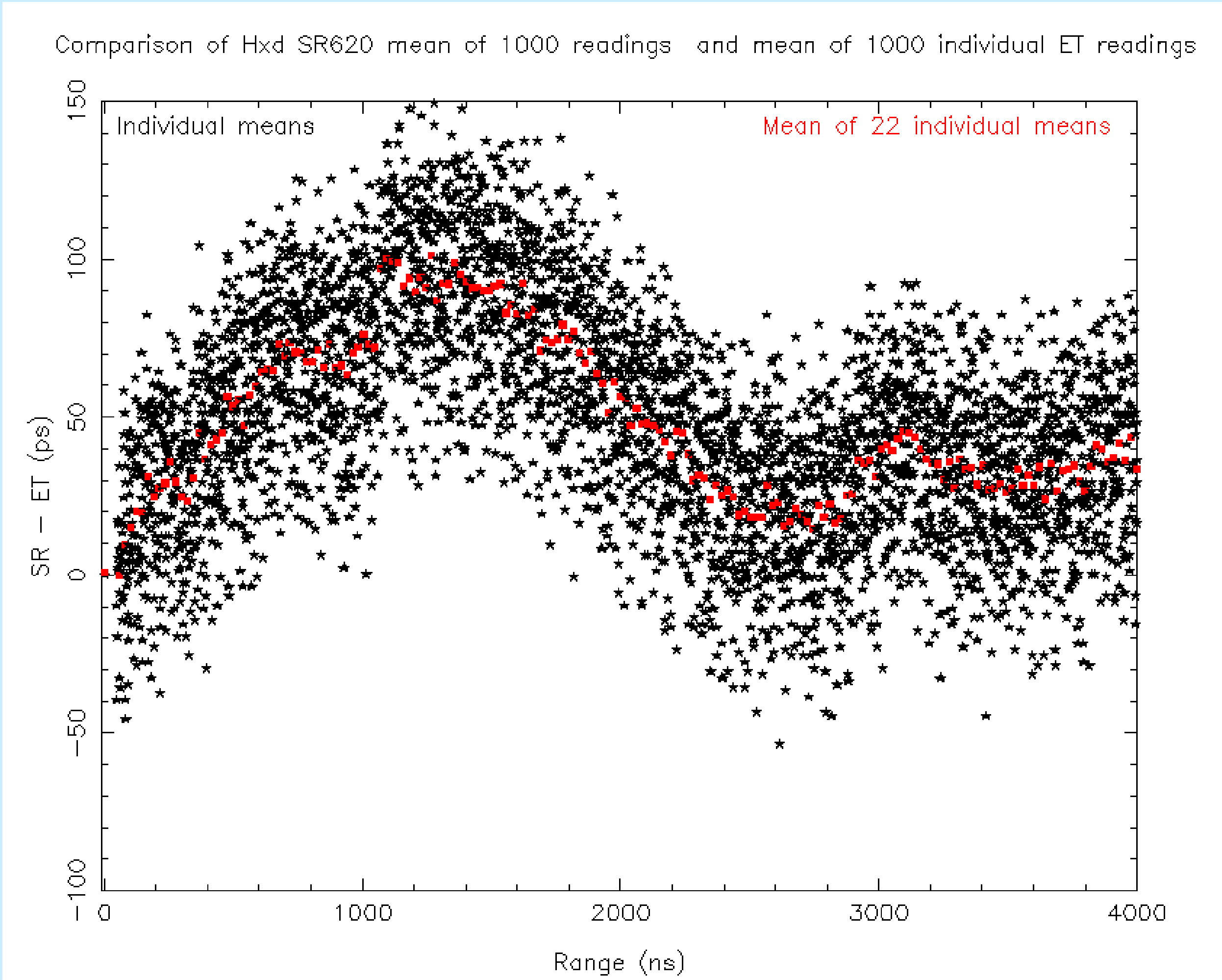
G Appleby, Philip Gibbs, NERC SGF



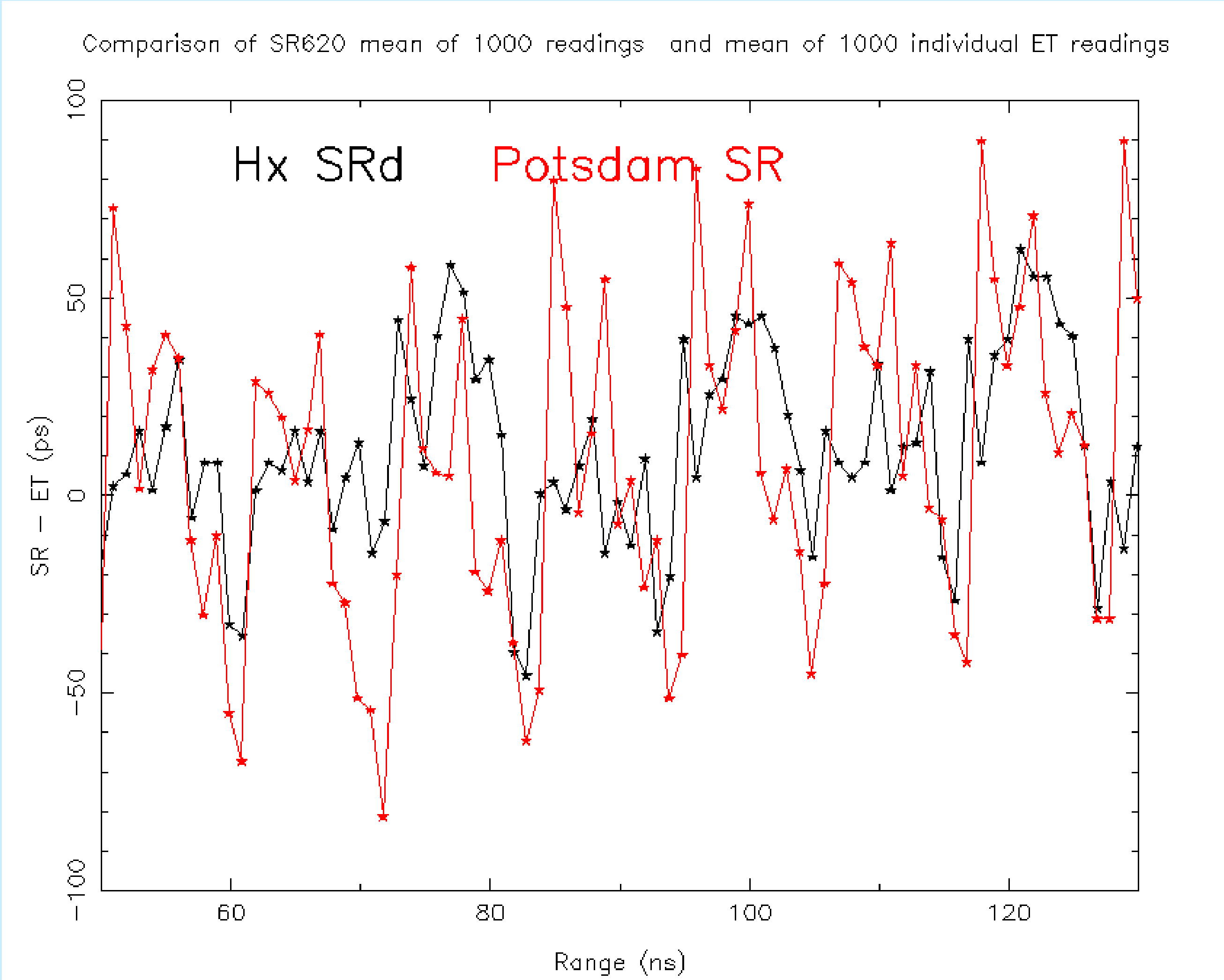
NATURAL ENVIRONMENT RESEARCH COUNCIL

Stanford ‘calibration’

- Work reported at Canberra (2006), EGU (2007) based on measurement of non-linear behaviour of Stanford counters;
- Effects at close (calibration) and far (satellite) ranges
- Optimistic that correction tables could be applied to several ILRS stations



Close-range non-linearity – note high-frequency signal:

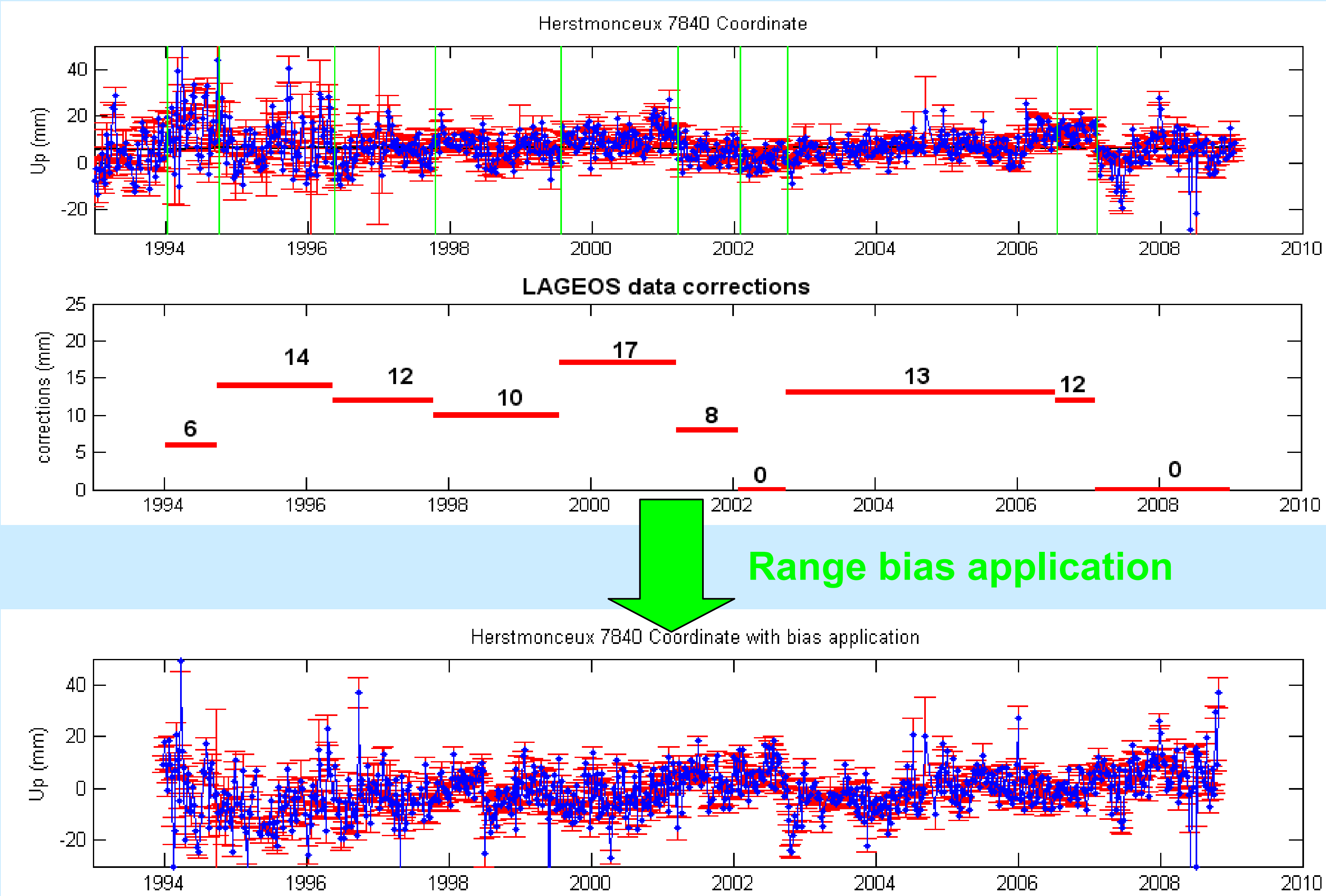


High-frequency signal (P=11ns) from two Stanford counters- note vertical scale –> 70ps=10mm

Problem

- The high-frequency signal often destroys attempts to determine range corrections in historical data:
- Care has been taken to re-construct the electronic delay-circumstances pertaining at the times;
- But error function changes radically in few nsecs, and is a function of the actual device;
- Hence some success but also some extra problems are induced –
  - Following is result from Luceri *et al*, EGU 2009

The Herstmonceux case



Conclusion

- Problem with post-determination of total Stanford errors in 1993-2006 era, ‘even’ at Herstmonceux;
- Validity of applying technique to other stations’ counters must be questioned
- ‘Better’ route is solution for satellite-dependent, constrained RB during dynamic solutions?