LISA Pathfinder Status

S. Vitale

1st ELISA Consortium meeting

Layout of the talk

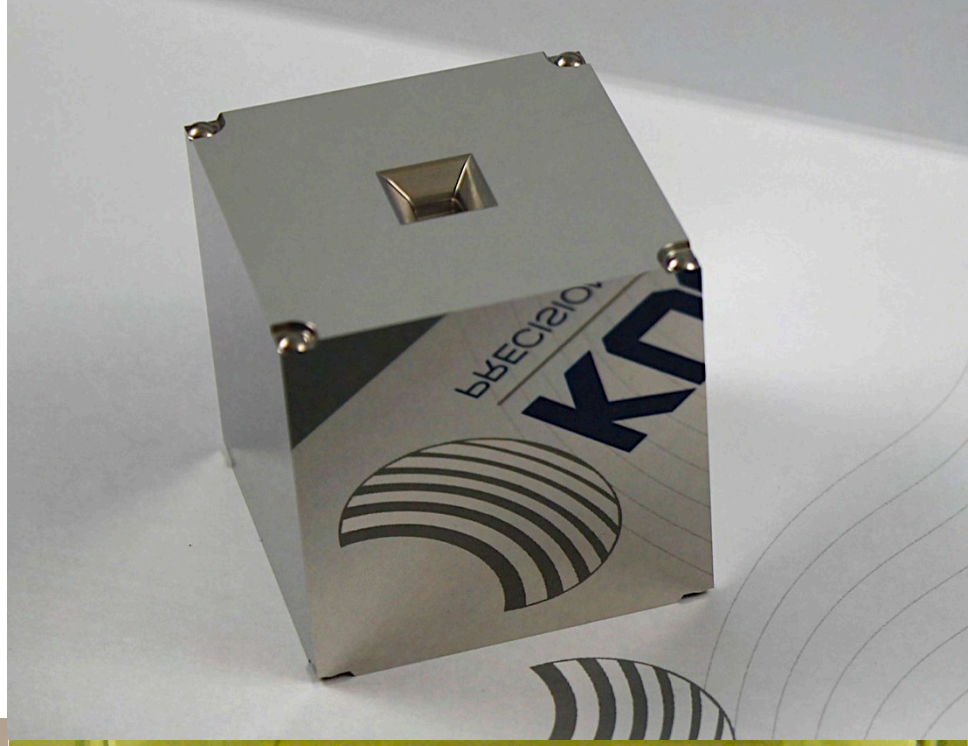
- Status of LTP
- Status of Mission
- Status of operation preparation

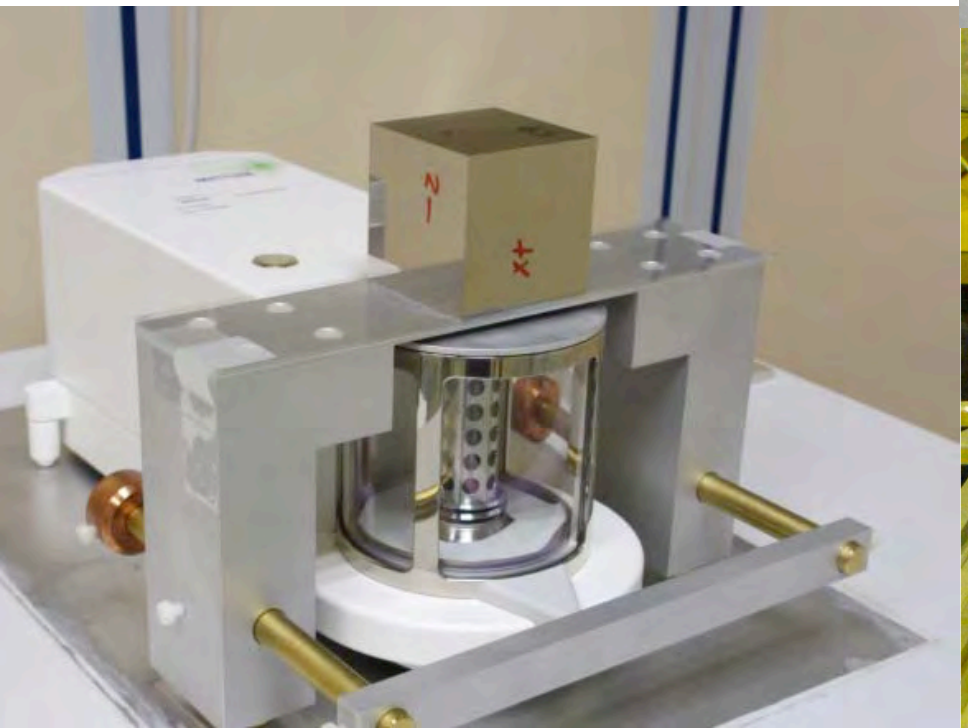
Status of LTP

- GRS most sensitive items:
  - Test-masses
  - Launch lock
  - Test-mass release
  - Discharging
  - Electrode housing
- Optical metrology
  - Diodes
  - End-to-end tests
- Integration

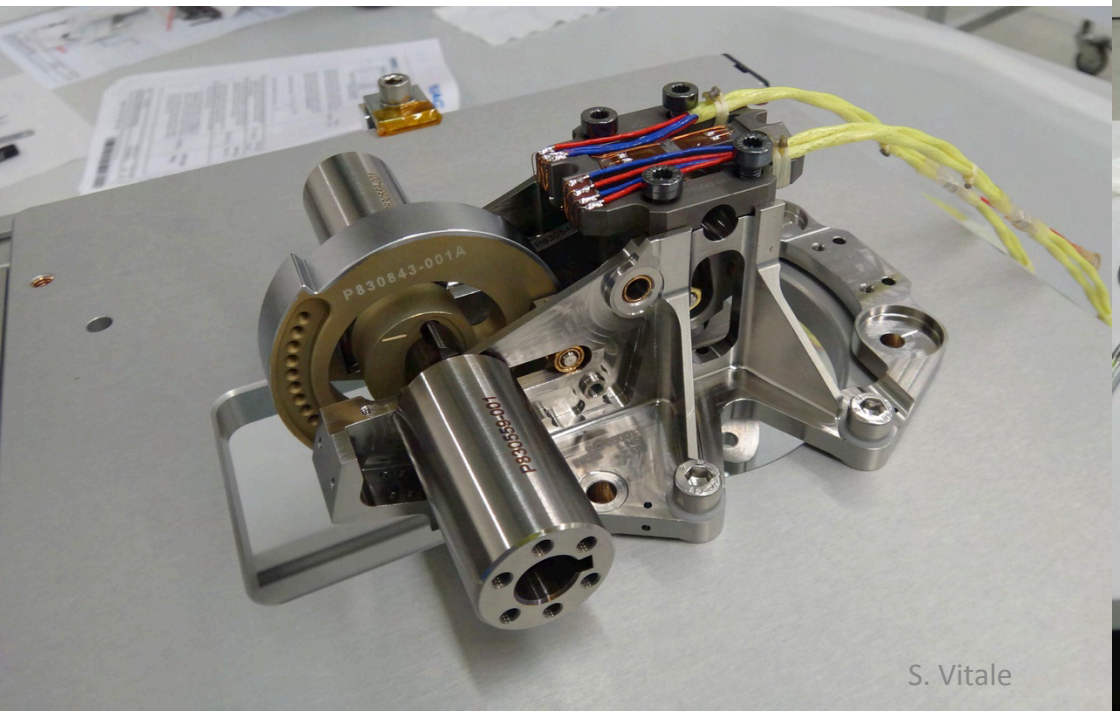
Test-masses

- 2×Flight test-masses (2 kg, 46 mm)
- Very high density homogeneity (<<1μm pores)
- CoG at geometrical center within ±2 μm
- Magnetic susceptibility at $\chi = -(2.3 \pm 0.2) \times 10^{-5}$
- Magnetic moment < 4 nAm^2



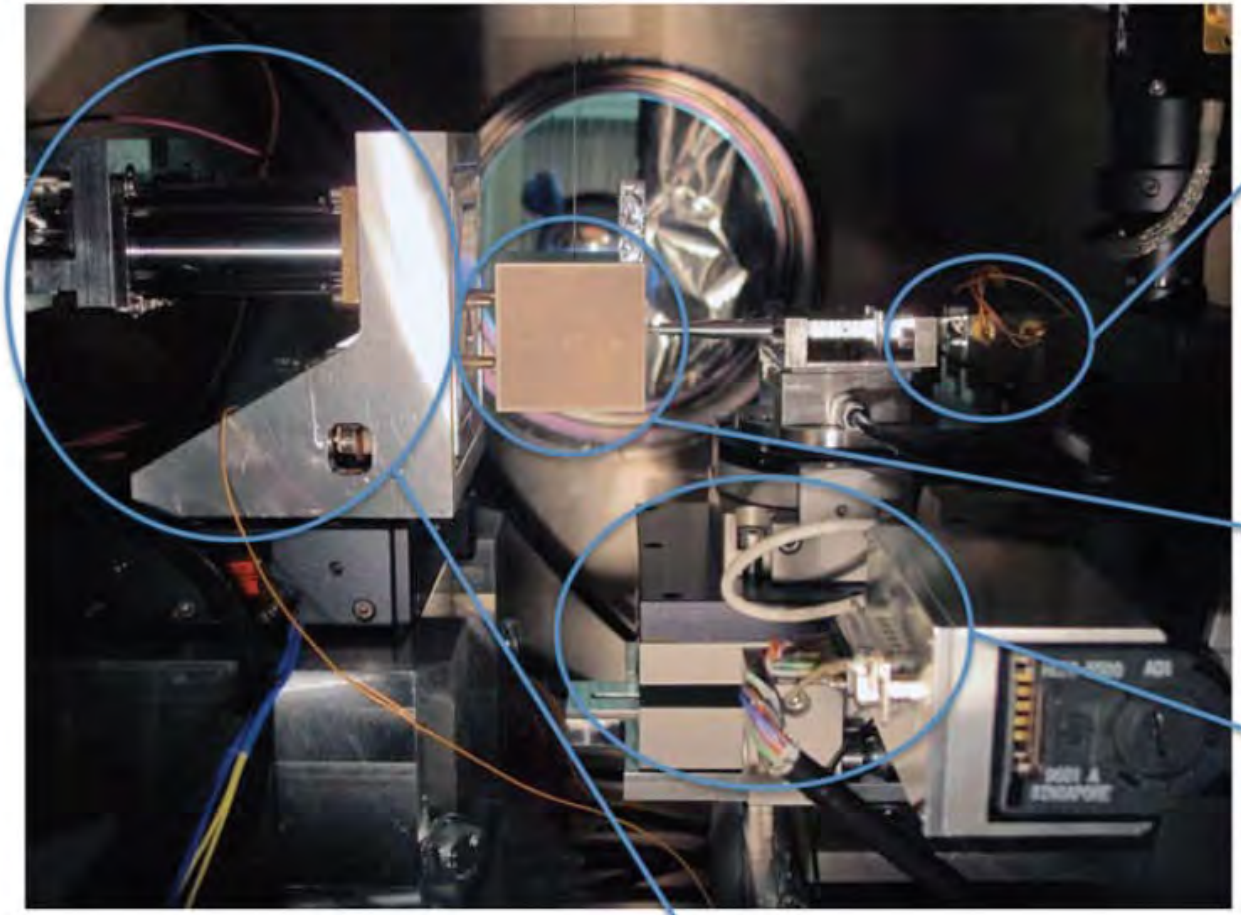


Qualification model under test (TRR and DRB successful)

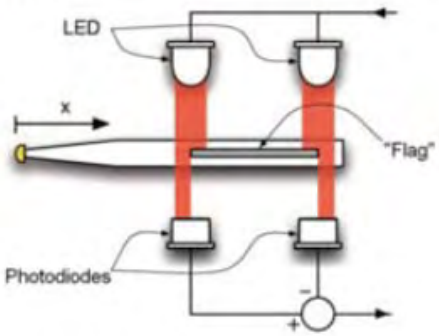


Test mass release

- New test-campaign with 1 kg test-mass



Differential optical shadow sensor



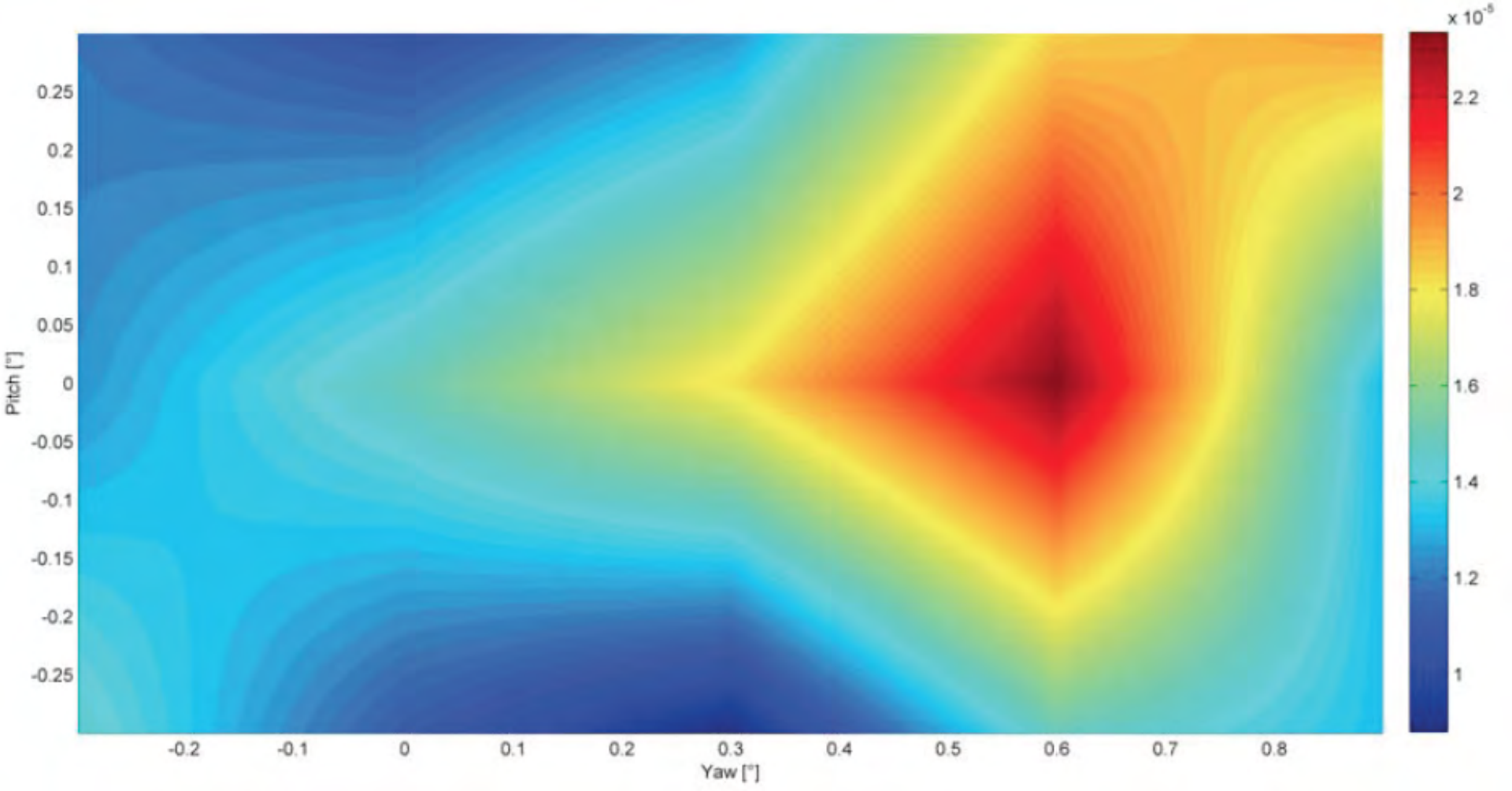
1 kg TM mock-up

Tip pitch positioner

yaw/pitch adjustable TM rear blocking system

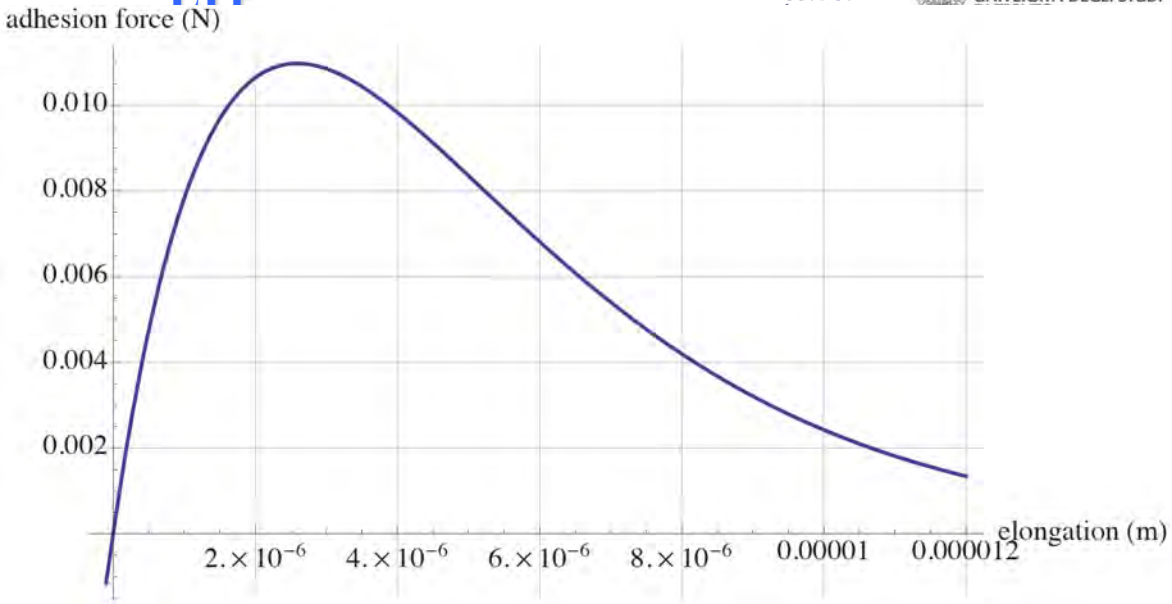
The transferred momentum

- Maximum momentum now stable (15 μNs).
- Results with 1 kg mass similar to those with 100 g

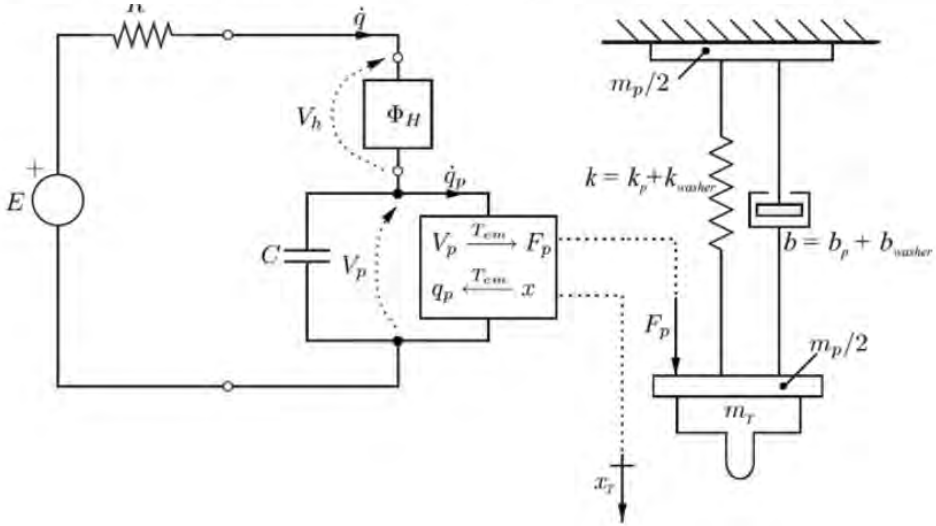


Extrapolating to flight

- Momentum measurement give force vs. elongation of adhered contact



- Extrapolated to flight via an electromechanical model



- Extrapolation (<4 μN s) compliant with factor 3 margin

Test with true GPRM

- Lab is preparing for test with EM of GPRM. Likely at end of 2013 (due to availability of GPRM)
- Results of test do not require extrapolation
- Test with uncoated test-mass-pin contact, likely to have lower adhesion, to be tested soon.

Discharging

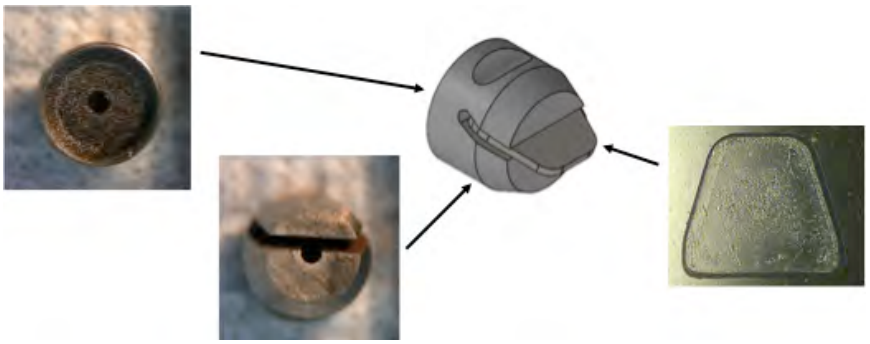
- Issue: bipolar discharge shown critical in torsion pendulum experiments
- Root causes:
  1. Photo-emissivity of surfaces variable by one order of magnitude or more depending on adsorbate
  2. Light aimed at test-mass (electrodes) is reflected off and ends on the electrodes (test-mass)extracting unwanted electrons from there
- Mitigation approach
  1. Stabilize photo-emissivity by appropriate treatment
  2. Redirect light with proper micro-mirrors

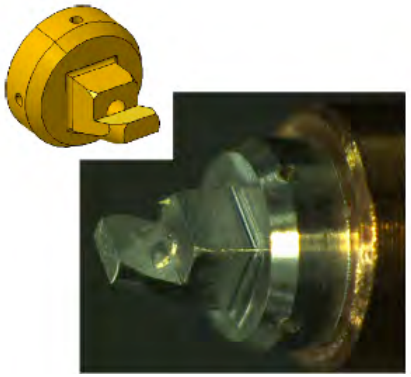
Stabilization of photoemissivity

- The main steps
  1. Plasma-clean surfaces before integration
     - Plasma-cleaning (oxygen) process under qualification. No damage to surfaces. Hydrocarbon adsorbate reduced by a factor 3-4
  2. Clean surfaces by UV light in oxygen atmosphere. Light is shone trough standard UV fibers but with more powerful lamp
     - Qualification on samples started, lamp procured, photo-emissivity measurement contract issued
  3. Bake-out surfaces after integration (already planned)

Light re-direction

- Light to electrode housing redirected to minimize stray reflection toward the test-mass
- Performed by means of a very small mirror on the tip of the fiber
- Two designs under prototyping





Light re-direction

- After measurement of true UV reflectivity predicted effectiveness of method has been reduced

	Baseline		Retro-Fit	
Discharge Direction	$\Delta\dot{Q}^{+}_{TM}$	$\Delta\dot{Q}^{-}_{TM}$	$\Delta\dot{Q}^{+}_{TM}$	$\Delta\dot{Q}^{-}_{TM}$
No DC bias voltages	*	1.88	*	3.71
DC bias voltages to support positive discharge rates	*	–	*	–
DC bias voltages to support negative discharge rates	–	10.65	–	13.62

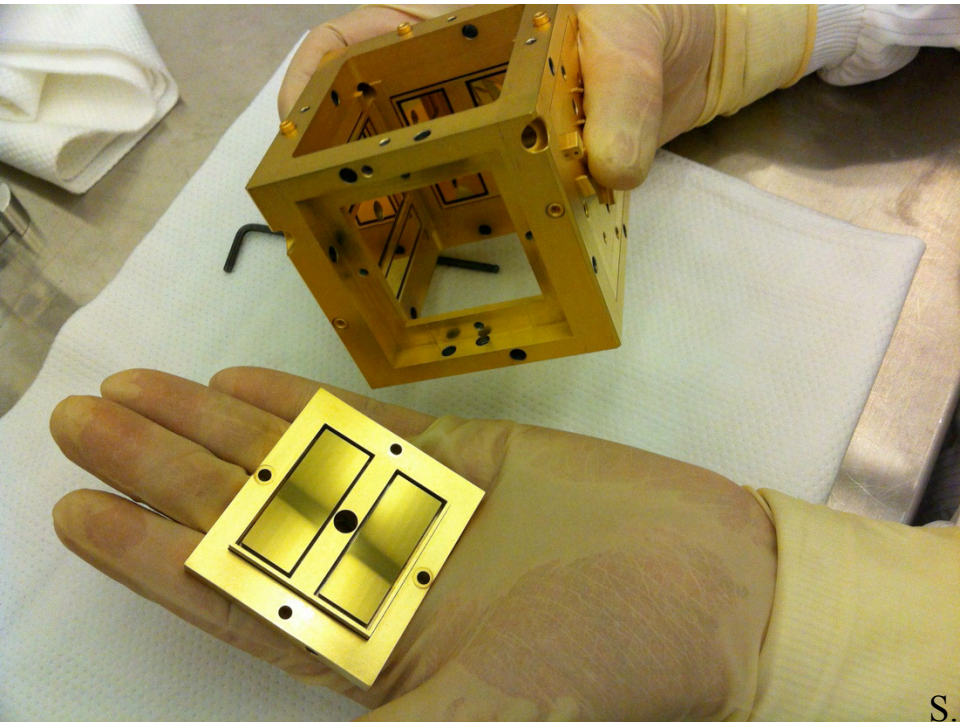
- However surface treatment is expected to reduce $|\Delta Q|<3$

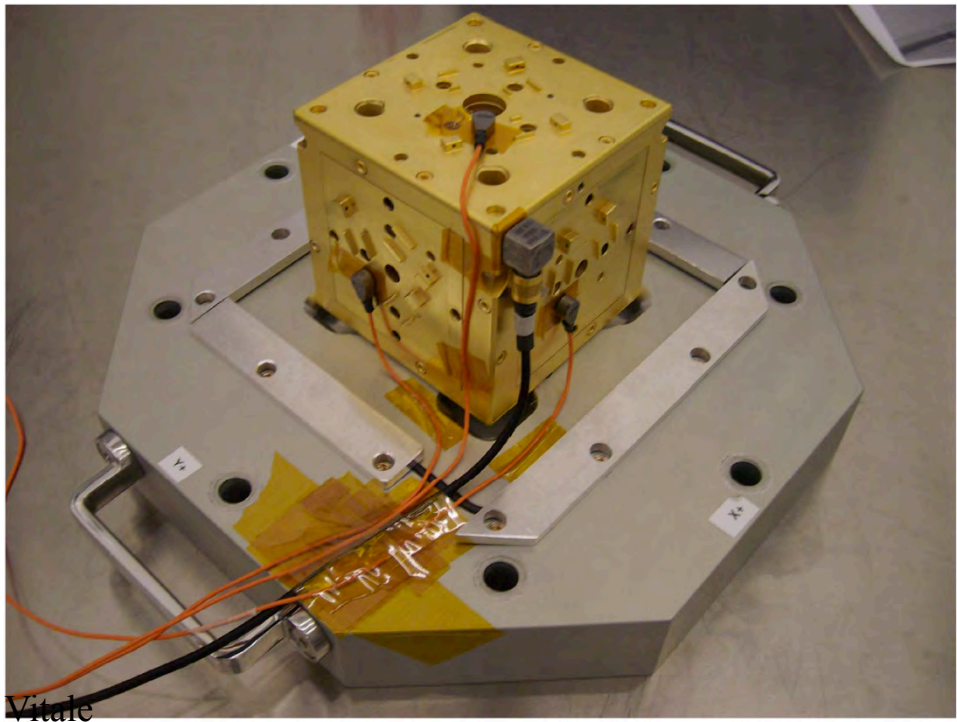
Discharging

- GRS after bake-out has shown bipolar discharge in all cases, though only with properly selected electrode bias configuration
- Re-grabbing test-mass has been shown to leave it in an acceptable charging status

The Electrode Housing

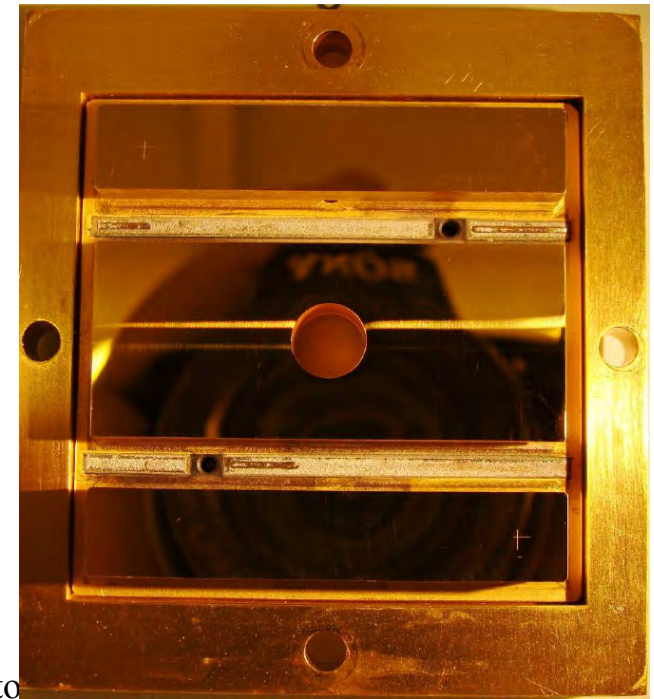
- GRS electrode housing FM1
- Vibration qualification performed

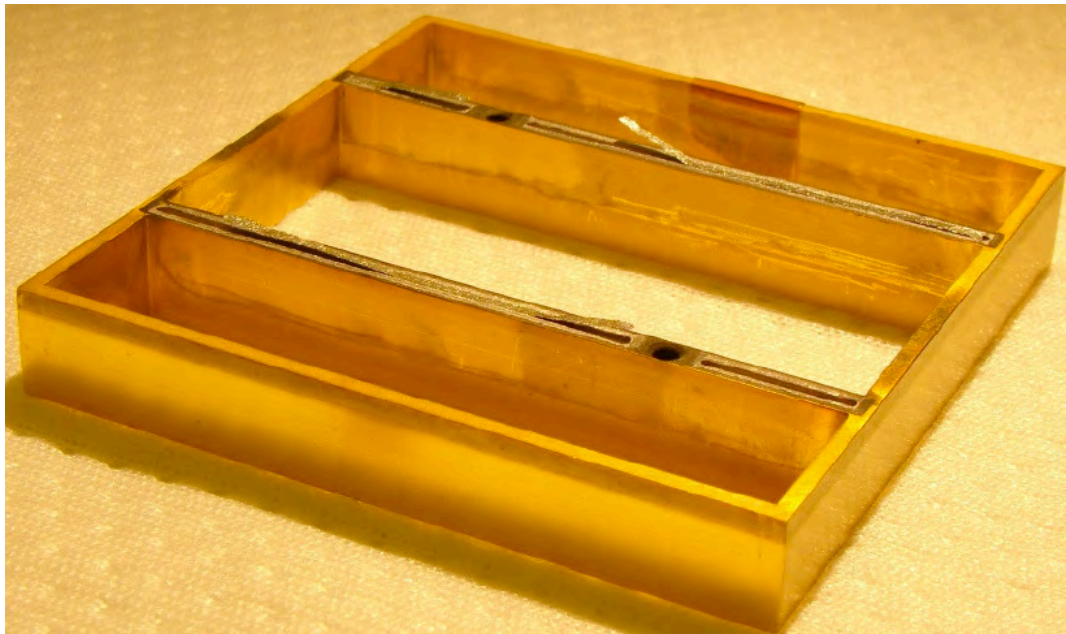




Failure of one of the brazed joints

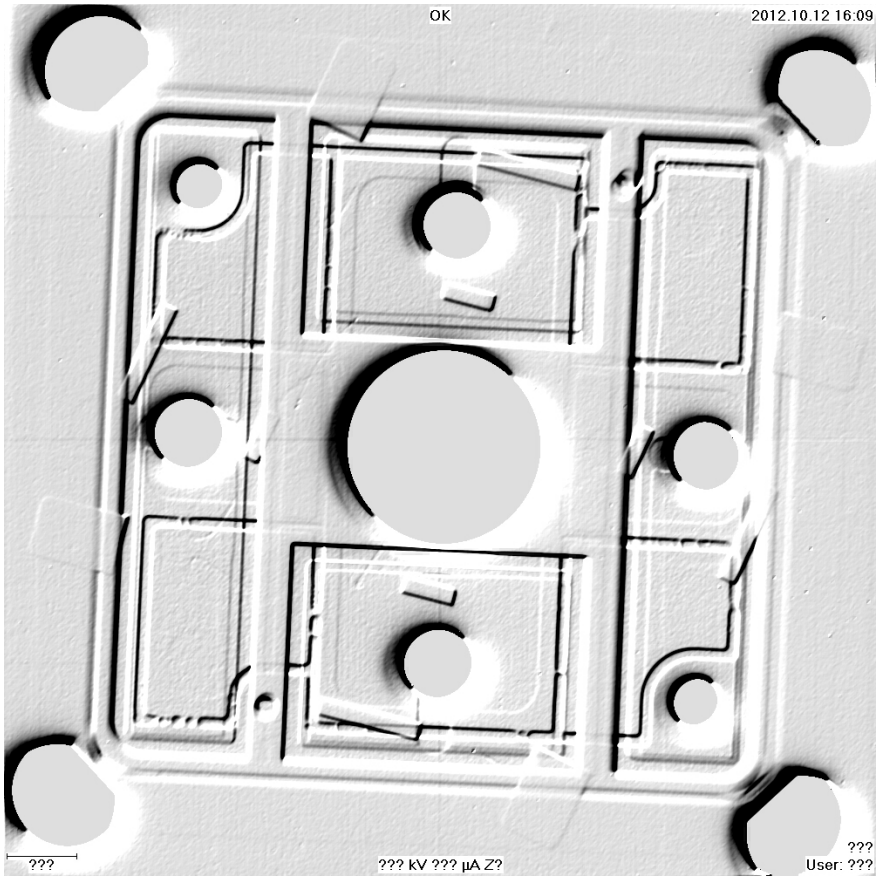
- Failure casted doubt over the brazing process
- NRB was not able to identify a way forward with acceptable schedule impact
- A “Tiger Team” formed. Schedule is driving requirement. Report due on October 24. Various options identified
- October 30 a review board meets in Rome and decides the way forward to minimize schedule impact





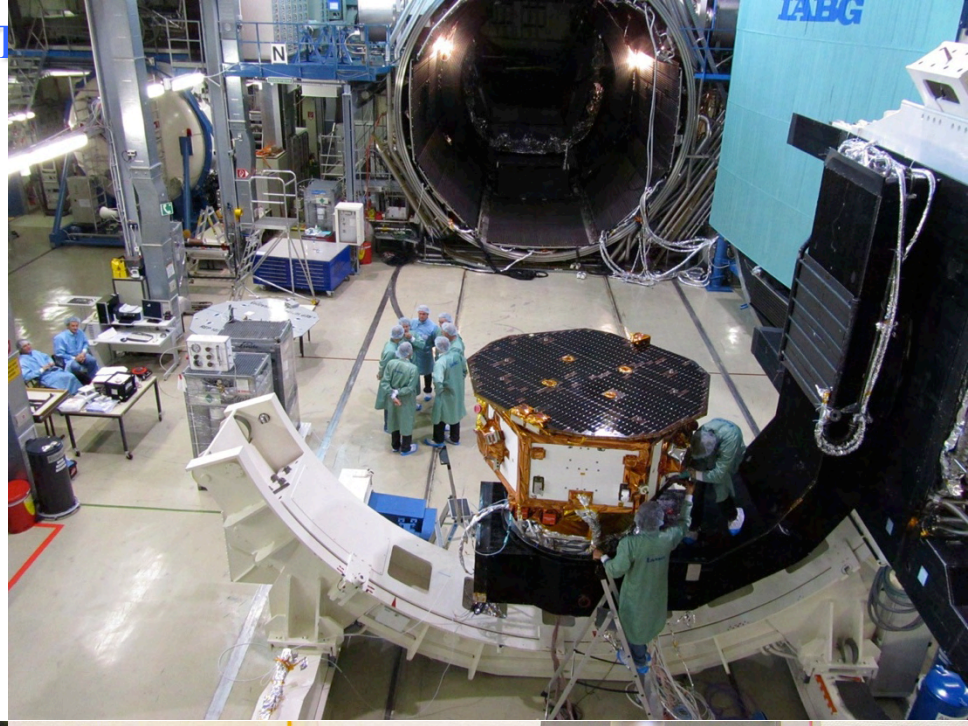
Leaks from the TT

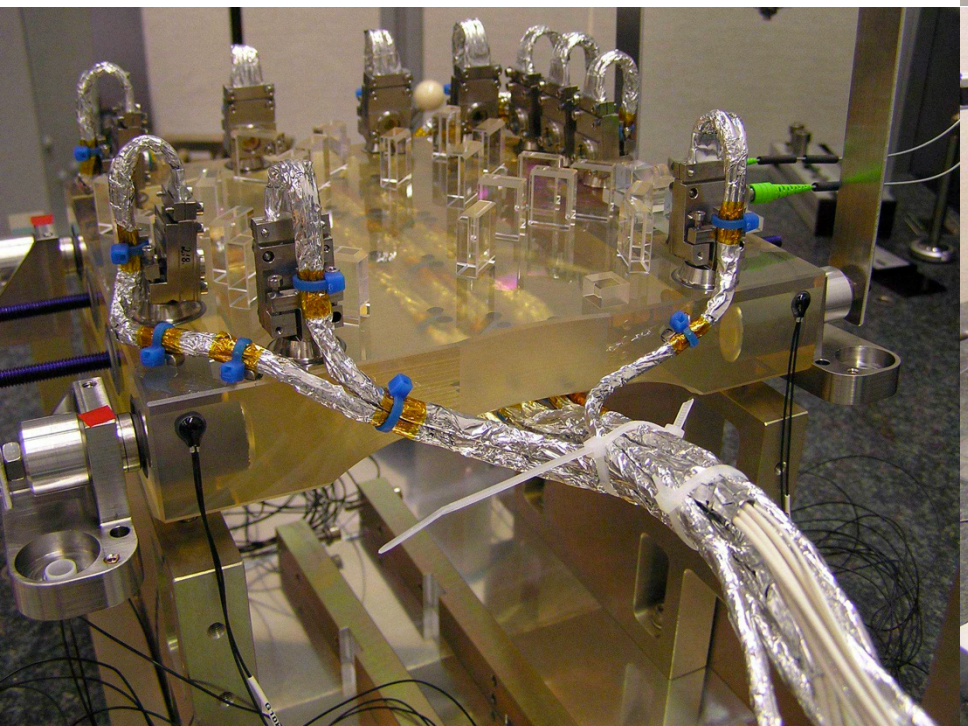
- A method of inspection of the joints may be available
- A possible process for refurbishing brazing joints without disassembling faces also identified but still to be assessed

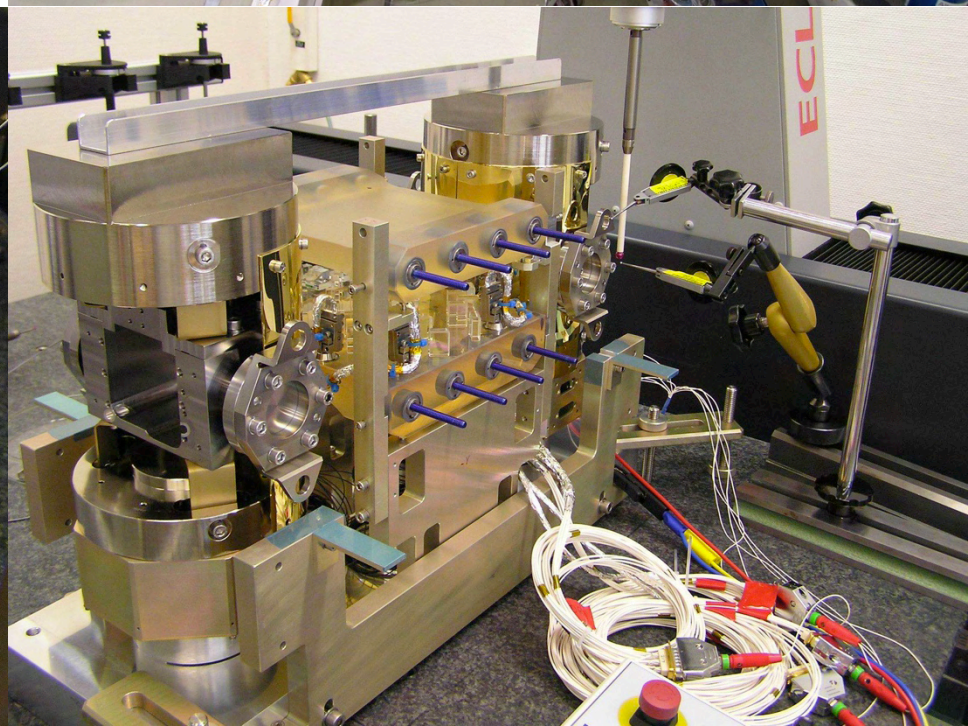


Optical Bench

- Optical bench n.3 used in thermal test now baseline for flight

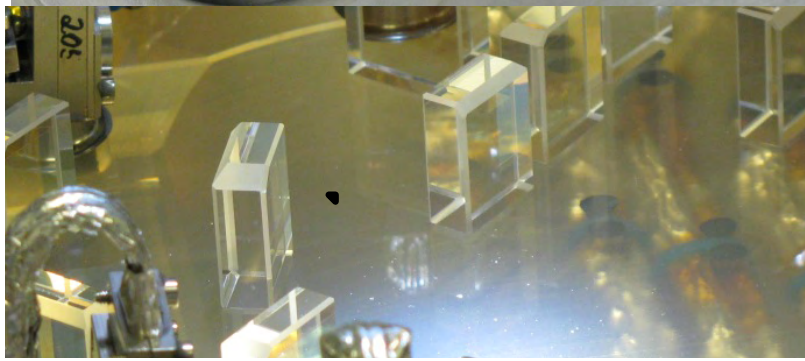


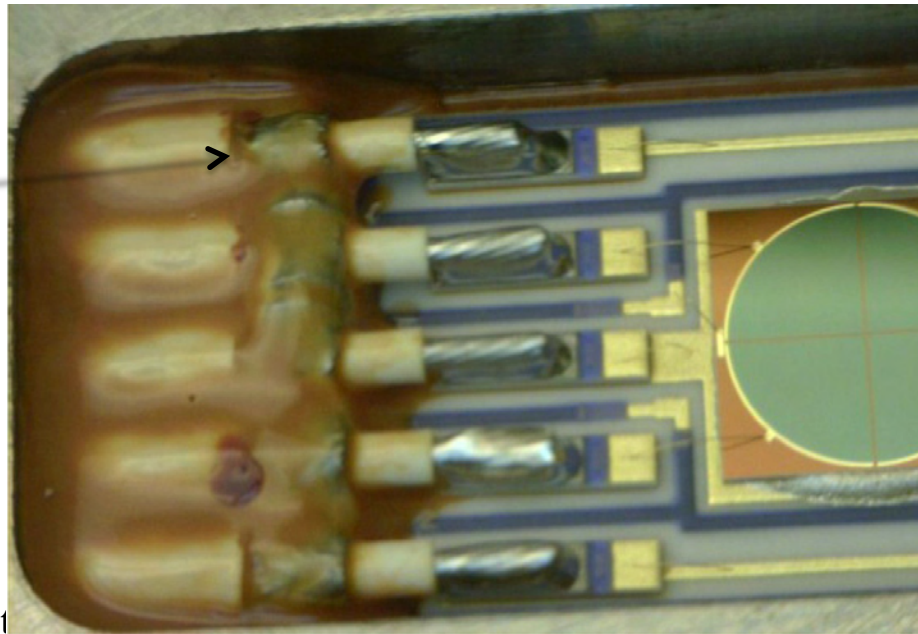




Optical Bench

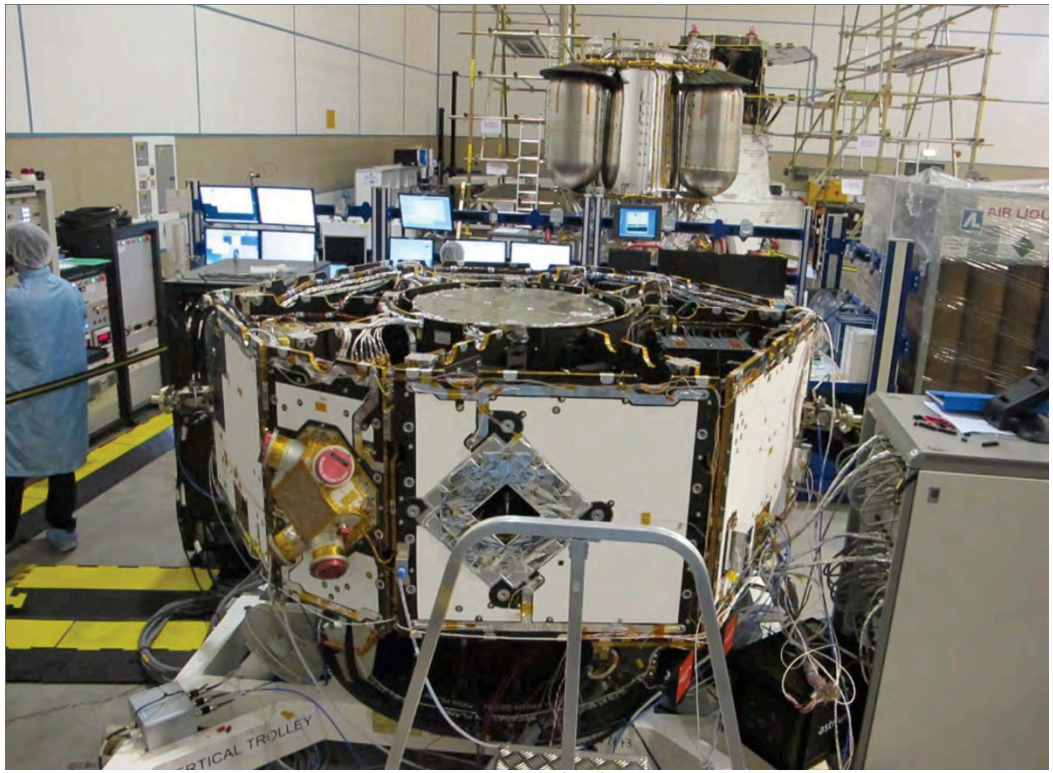
- Outstanding vibration qualification went well but:
  - Harness caused debris
  - While inspecting InGAs photodiodes for debris, damage was found in harness epoxy and debris inside harness
- Problems considered non critical

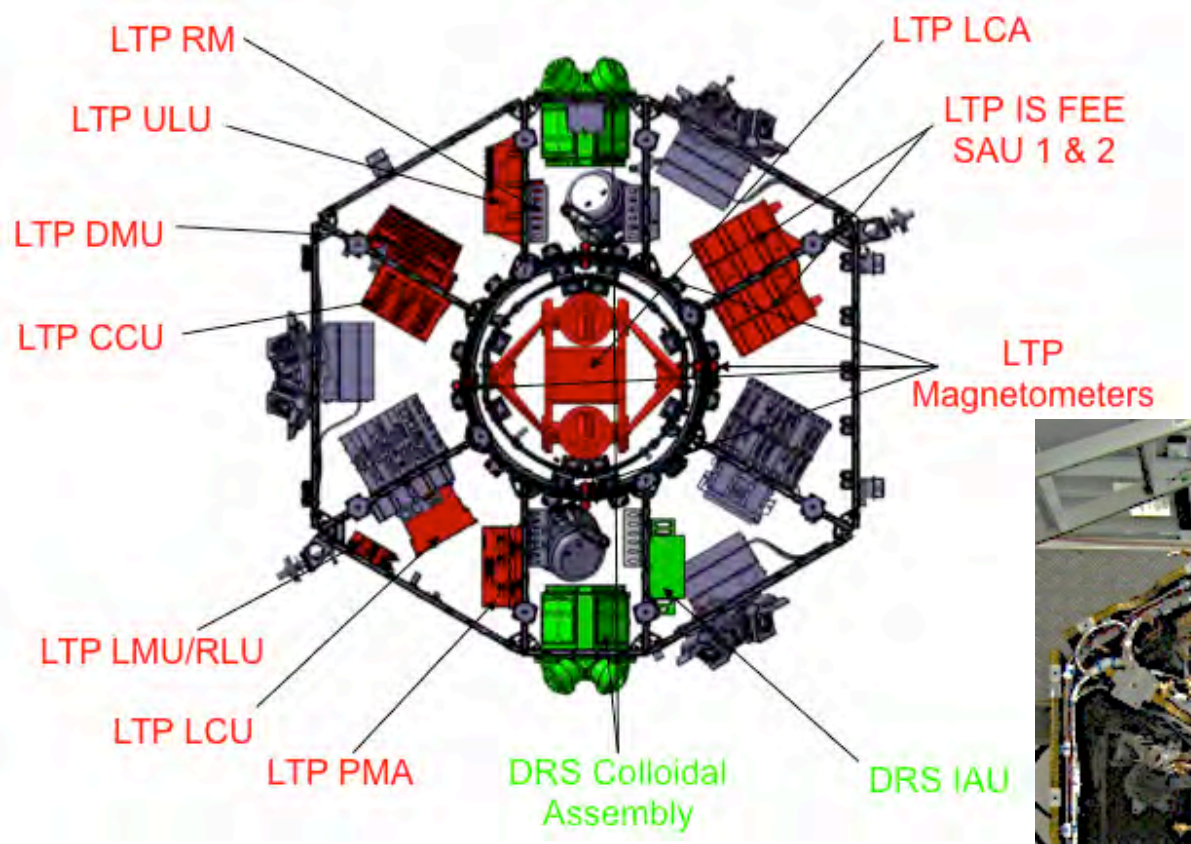




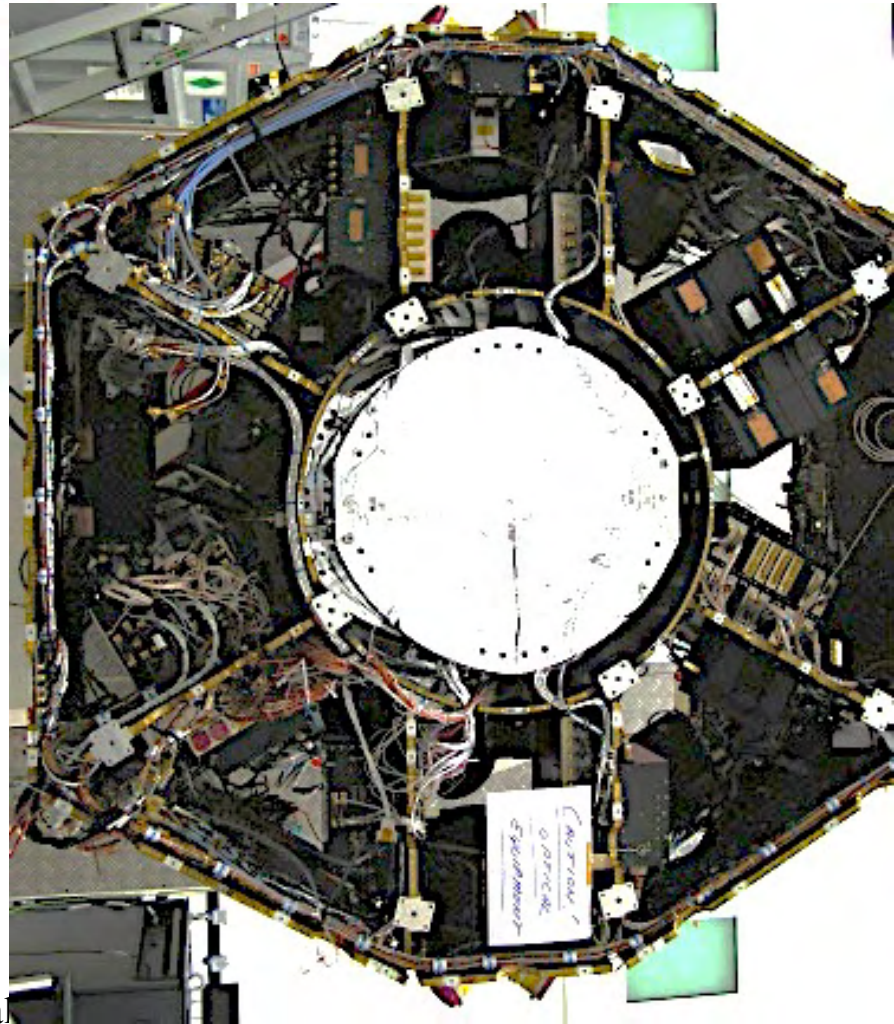
end-to-end tests

- Two relevant tests have been performed:
  - An end to end test of interferometry performance (already mentioned)
  - A closed-loop test of the satellite



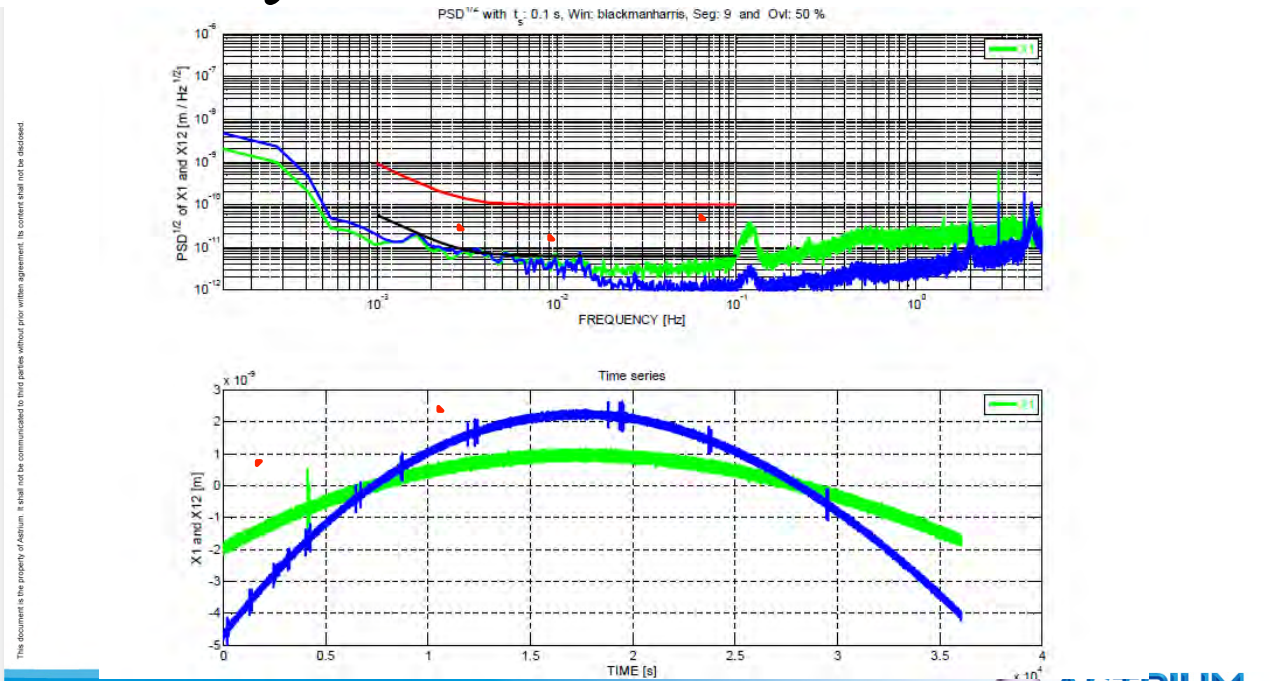


LTP electronic and optical units



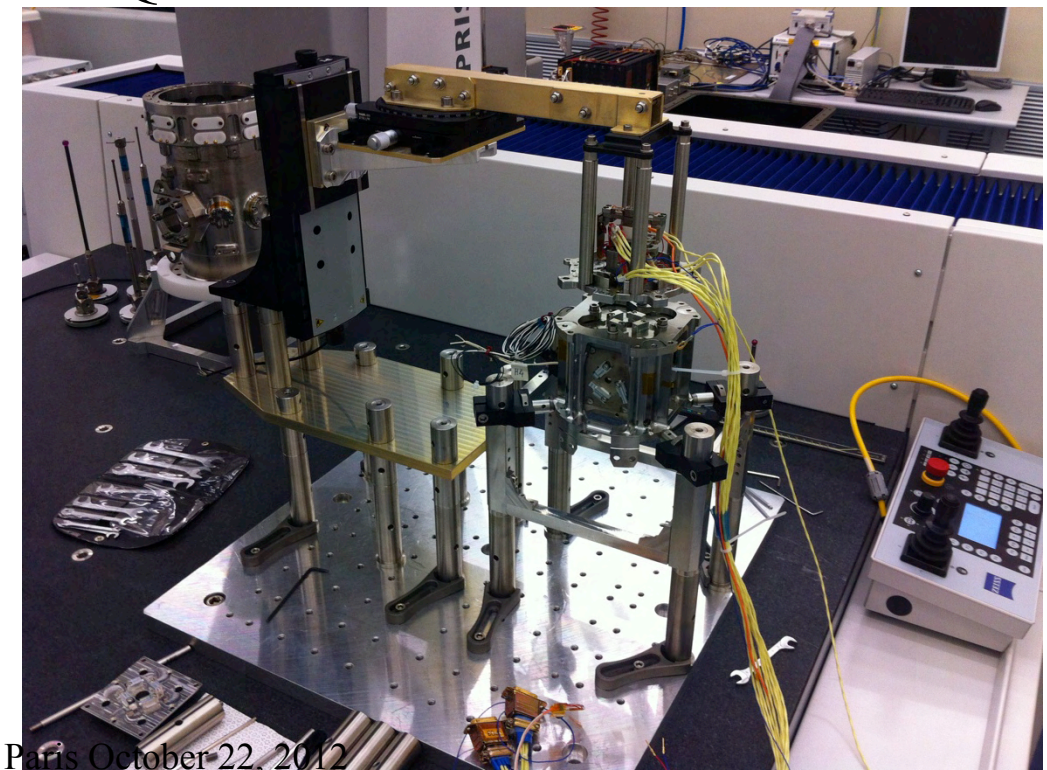
end-to-end tests

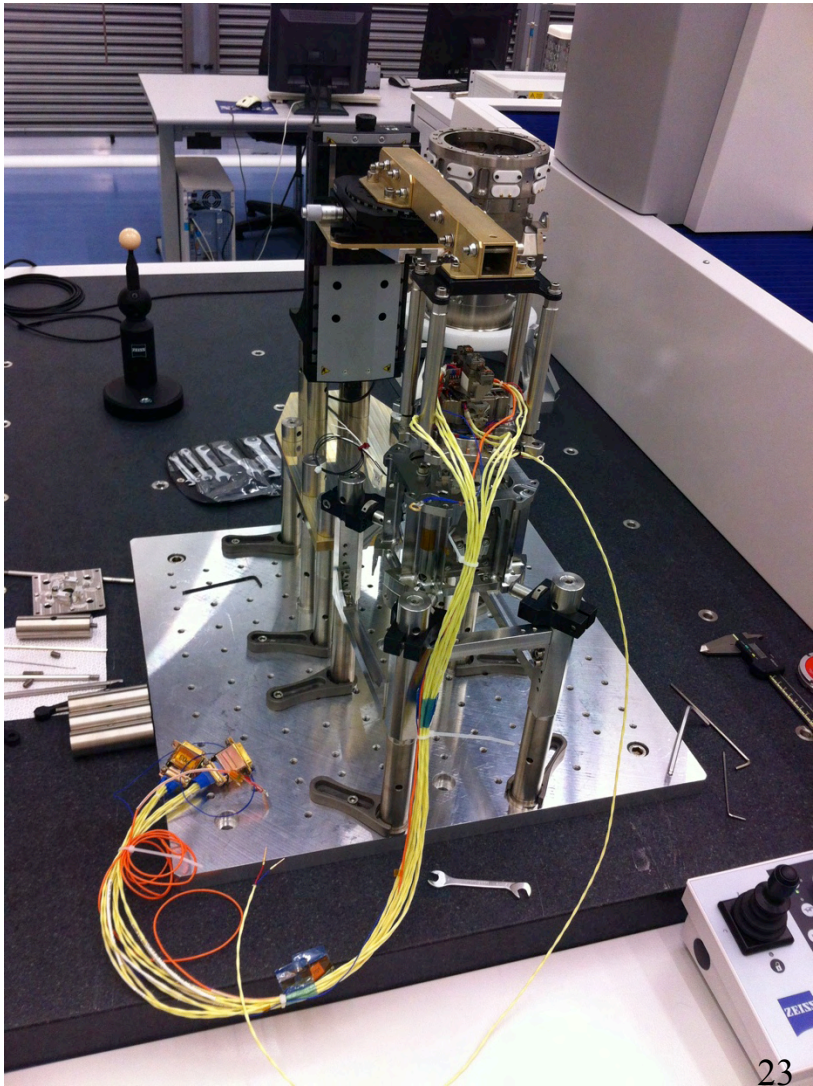
- During both tests, various “features” or non compliances were discovered.
- These are being assessed for impact on performance and possible fix. Quite a few have been already fixed



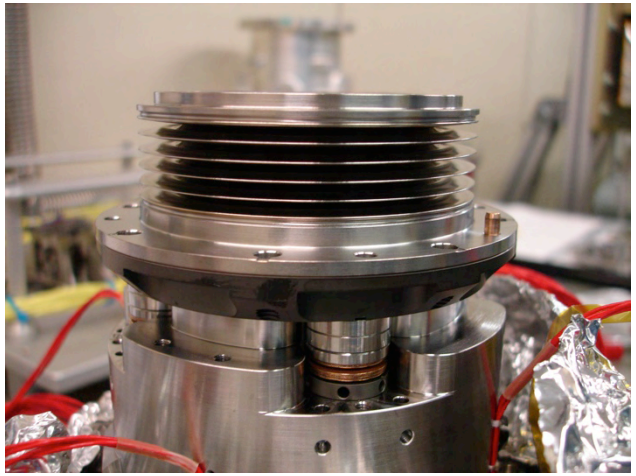
GRS EQM integration

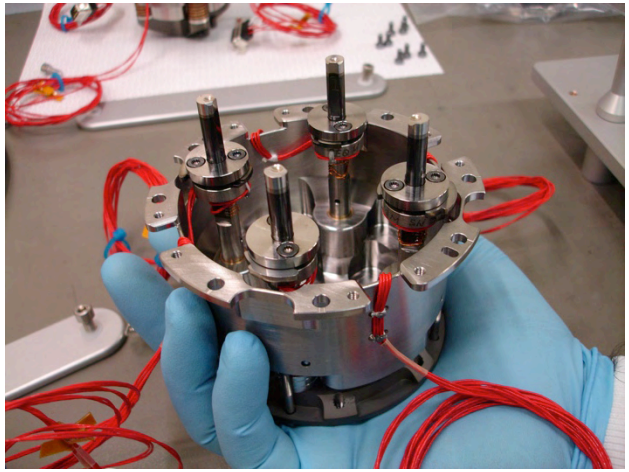
- A qualification test of the entire assembly including caging
- Qualification test in Feb 13

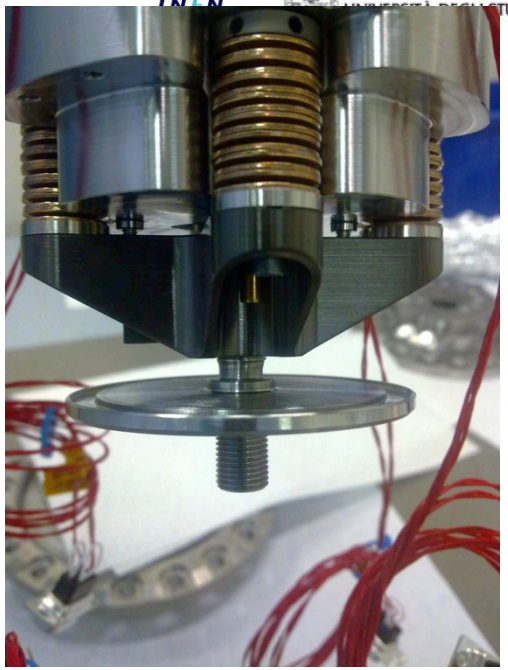


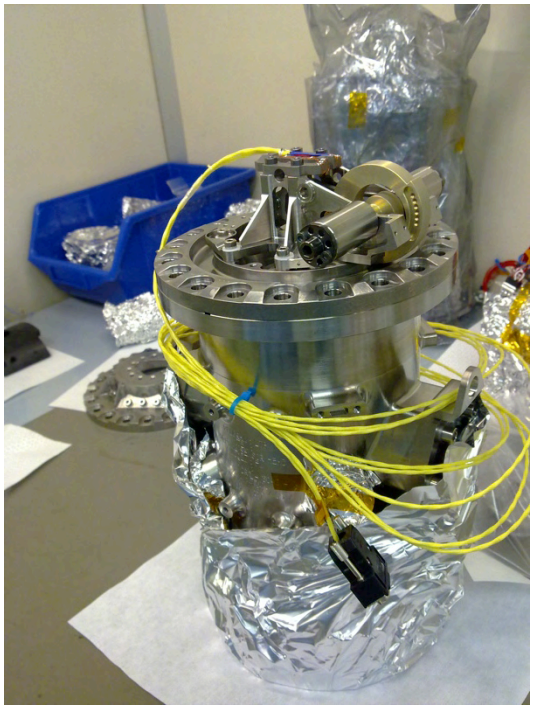


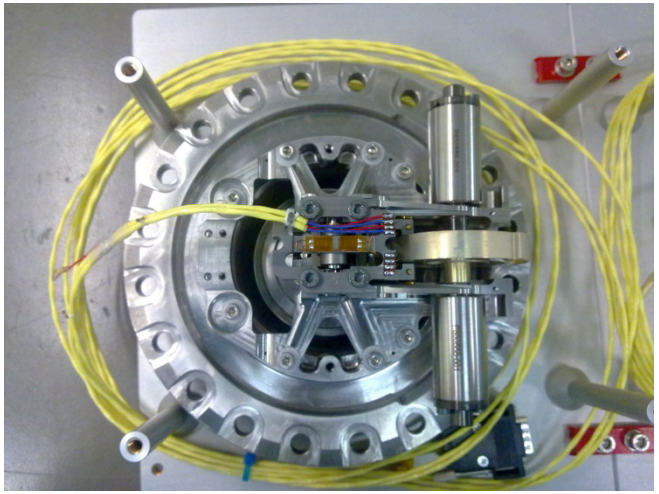
ISH EQM Integration

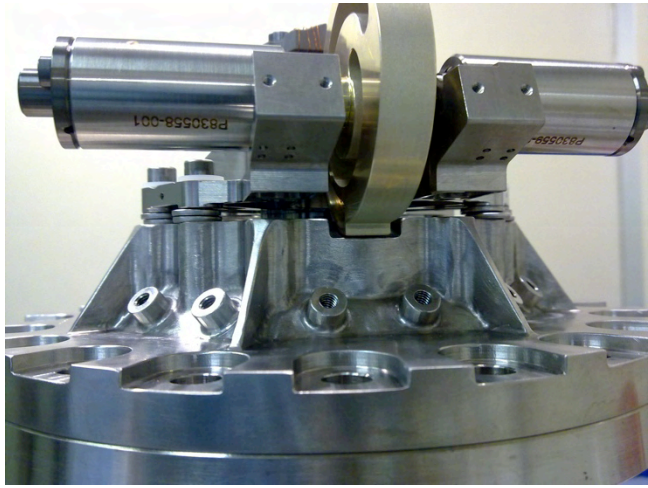








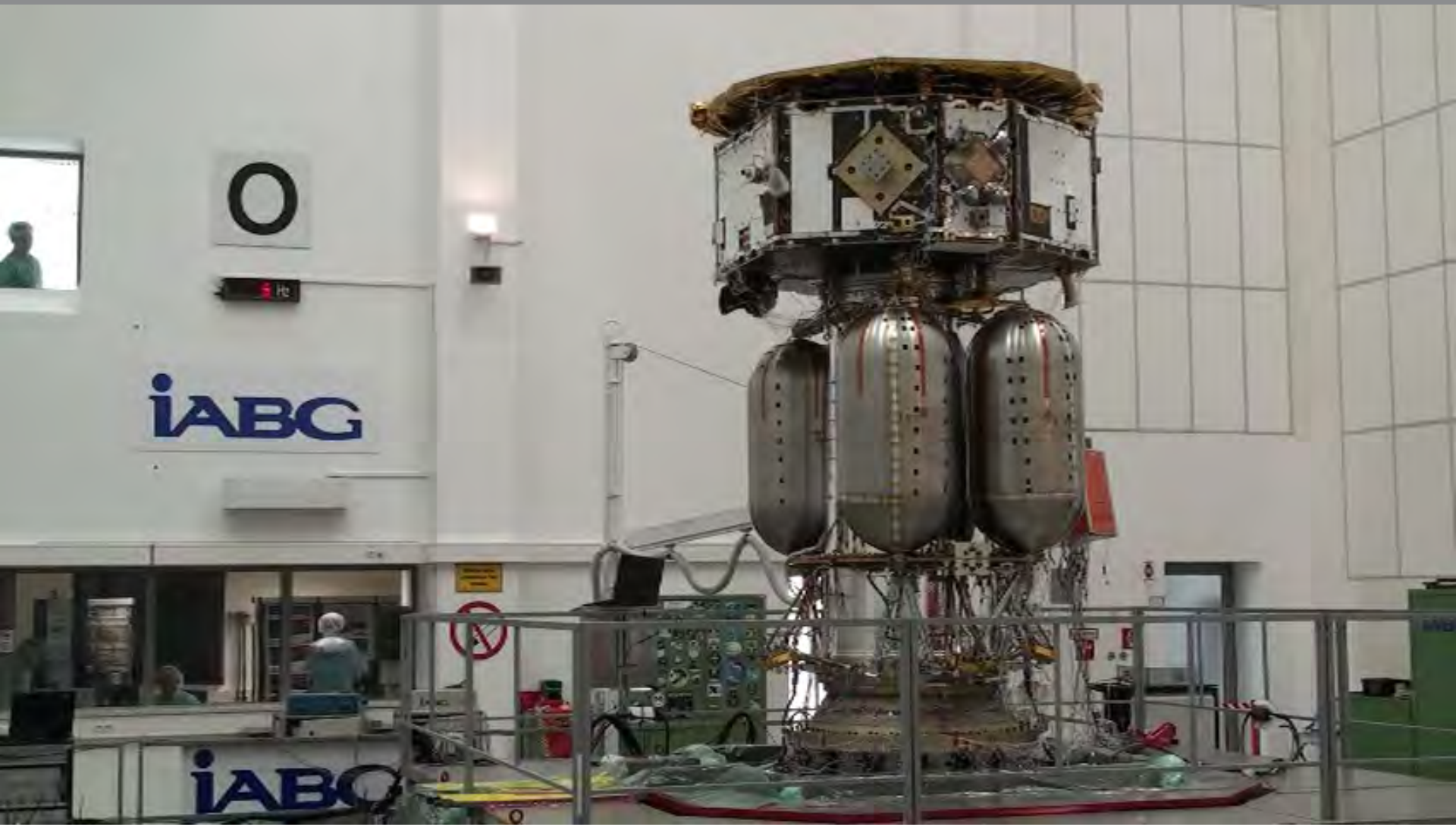




Integration schedule

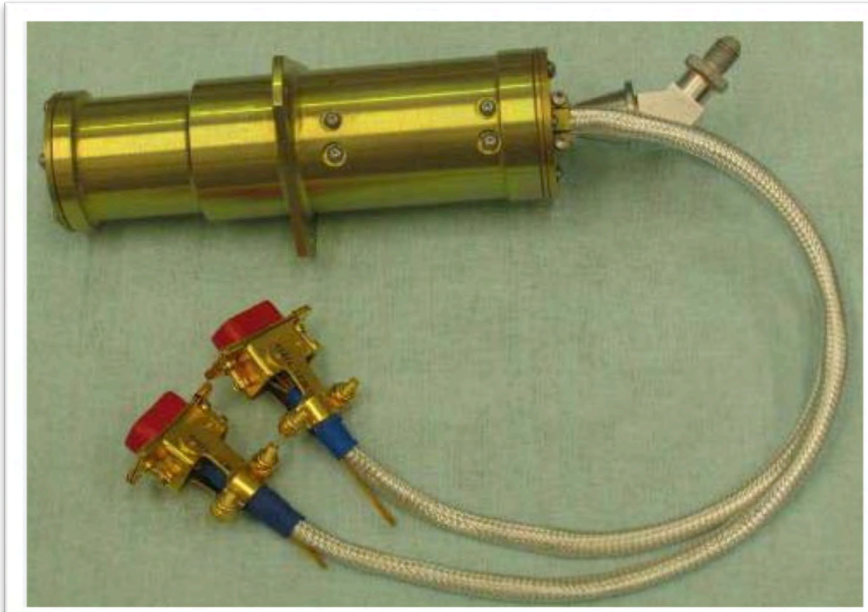
- Integration and testing is the schedule bottleneck
- GRS requires 15 month after repair of EH
- LCA 7 more months
- A group has been set-up to scrutinize requirement to check if test, alignment requirements, integration environment requirements.. can be relaxed to make up some time.

Spacecraft and launcher



The micro-Newton thrusters

- Cold gas developed for Gaia better than requirements
- Now selected as baseline in place of FEEPs



Date 14/09/2012 **Ref** SRE-PN/18234-12/CGM

From C. García Marirrodriga (SRE-PN) **Visa** T. Passvogel (SRE-P)

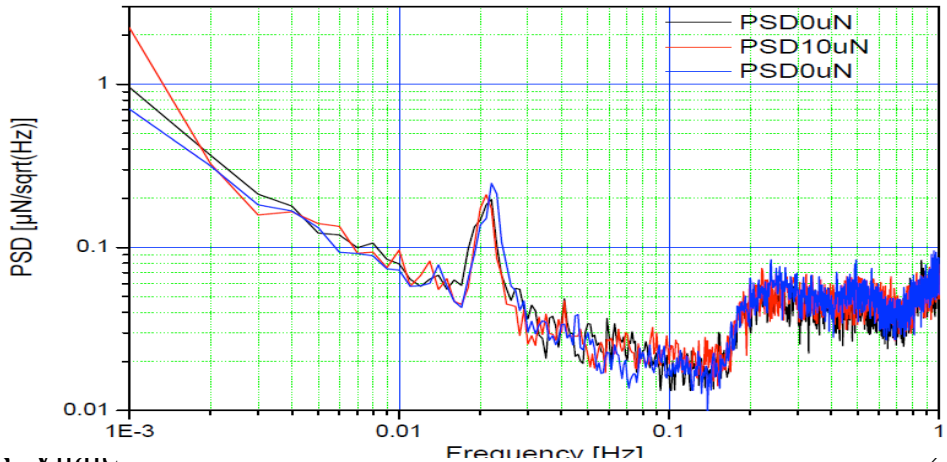
To LISA Pathfinder MPSR Board:
R. Schmidt (DG-I)
W. Veith (TEC-Q)
C. Stavrinidis (TEC-M)
A. Tobias (TEC-S)
M. McCaughrean (SRE-S)
G. Saccoccia (TEC-MP)

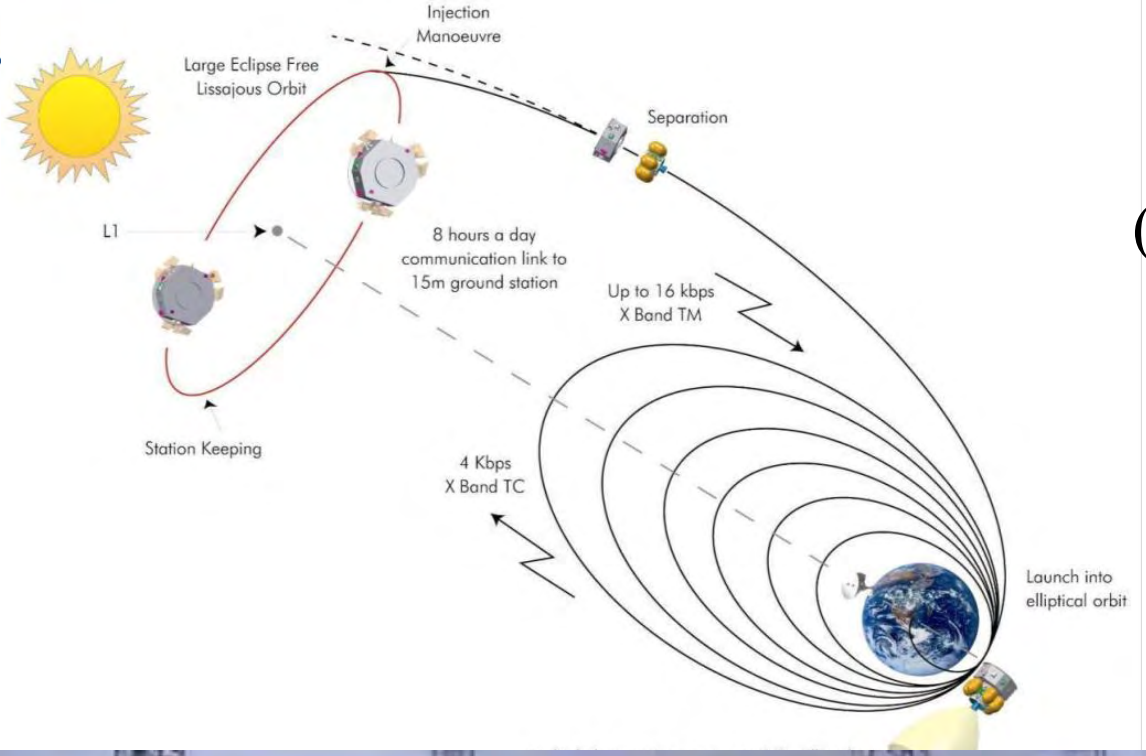
Copy A. Giménez Cañete (D/SRE)
P. McNamara (SRE-SA)
S. Vitale (University of Trento)
E. Bachem (DLR)
B. Sanders (TNO)
LPF Project Team & MPS support

Subject: Decision on the change of Micro-Propulsion System baseline for LISA Pathfinder

In November 2011 the LISA Pathfinder Micro-Propulsion System Review (MPSR) Board reviewed the status of the Caesium FEEP development tests and of the alternative Cold Gas system. The Board recommended (cf. Board Report DG-IR/2011/109/KL) continuing the testing of the FEEPs on unit and assembly level (TUVT and TAET respectively). In parallel, as a backup, the Board recommended to proceed with and complete the design work for the cold gas system, and to initiate the procurement of the long lead items. The overall status should be presented to the Board not later than April 2012. Such report was released in due time by the LPF Project (cf. SRE-PN/17498-12-GR), including the criteria to reach a decision on the MPS for LPF.

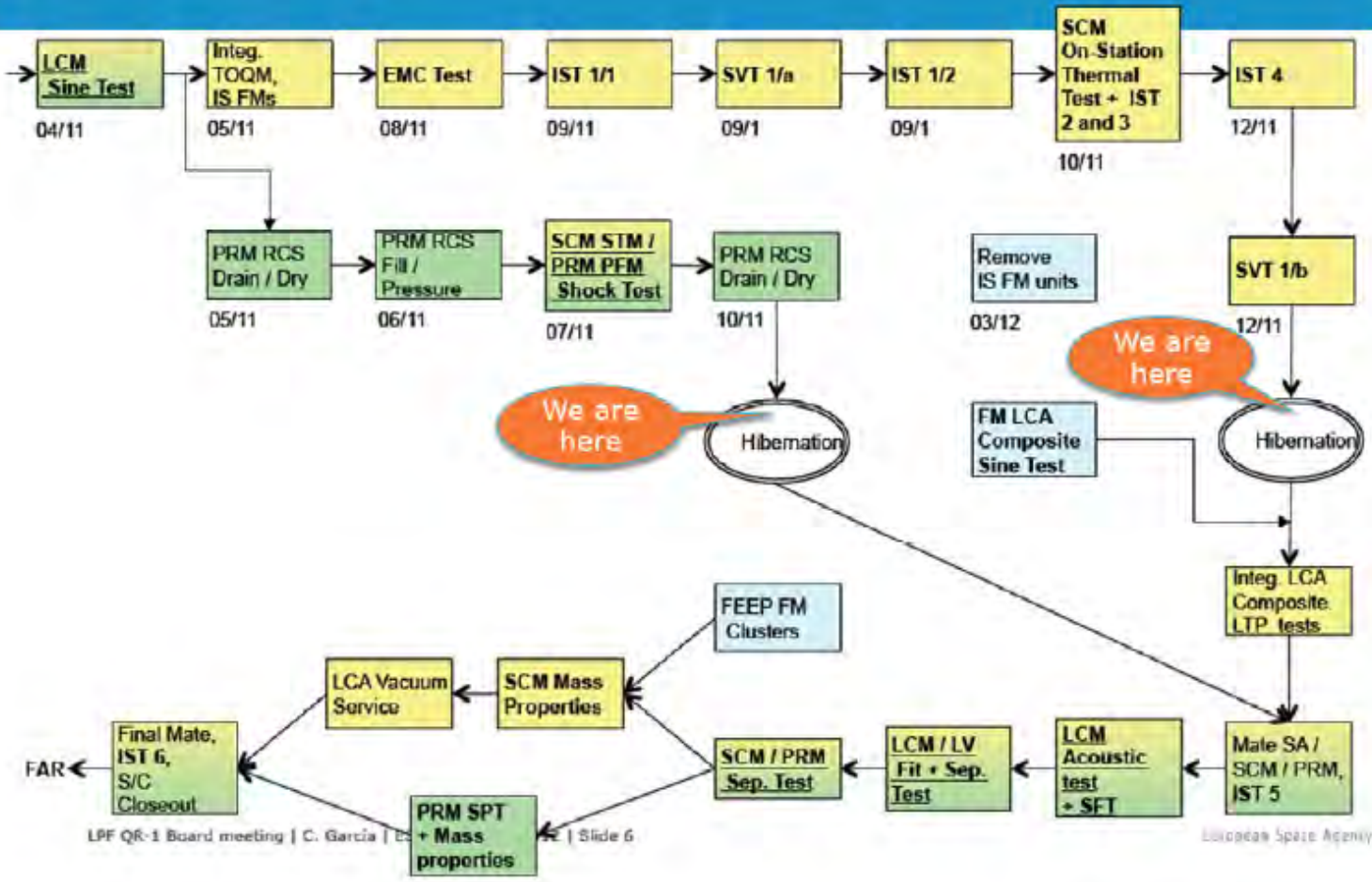
This memorandum summarizes the status reached at the present time, and introduces the LPF Project decision to select the cold gas micro-propulsion system as baseline and to discontinue further development work of the FEEP system within the context of the LISA Pathfinder project.





Launch Q4 2014 (led by integration and micro-thruster procurement)

LPF – Test Programme



Preparation of Operations

The first end-to-end STOC simulation

esa

LPF STOC Simulation Campaign 1

J. Fauste
ESAC
12/06/2012

European Space Agency

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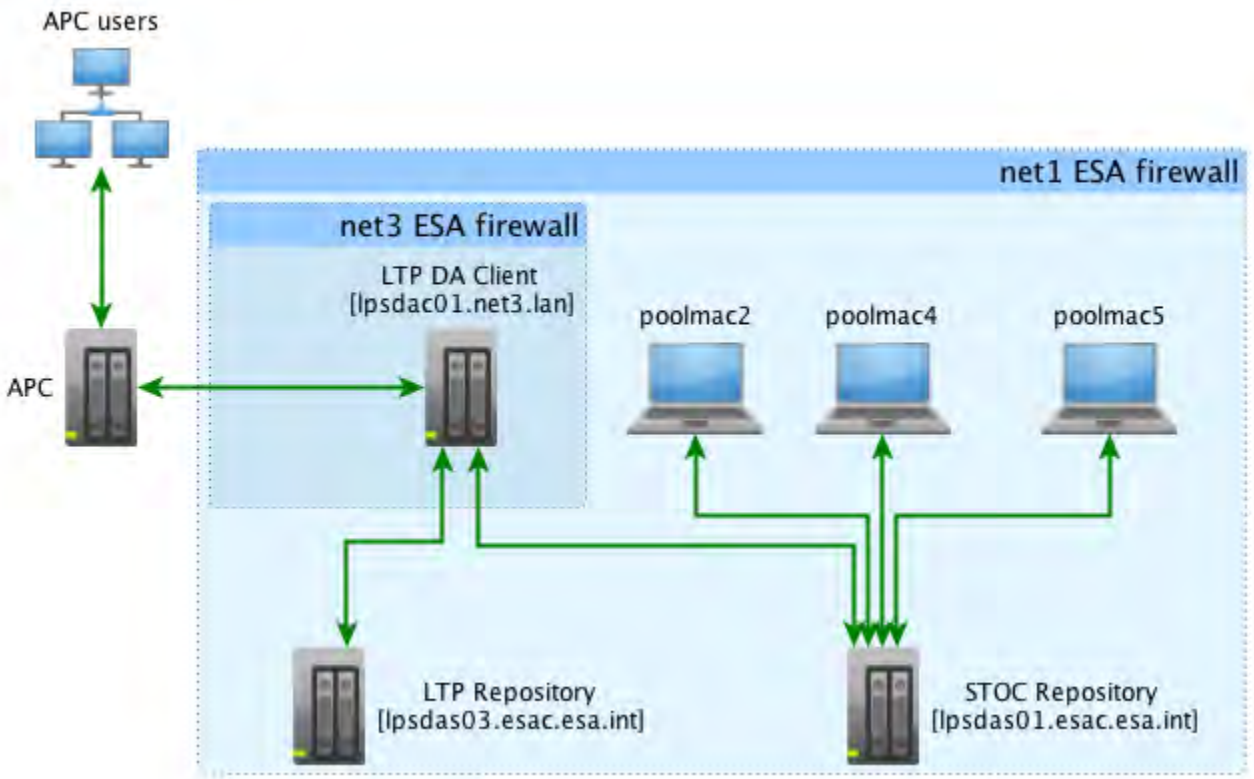
The organization of the exercise

- "Quick look" data processing at STOC (ESAC)
- Off-line processing center (APC)



The teams

- ESAC

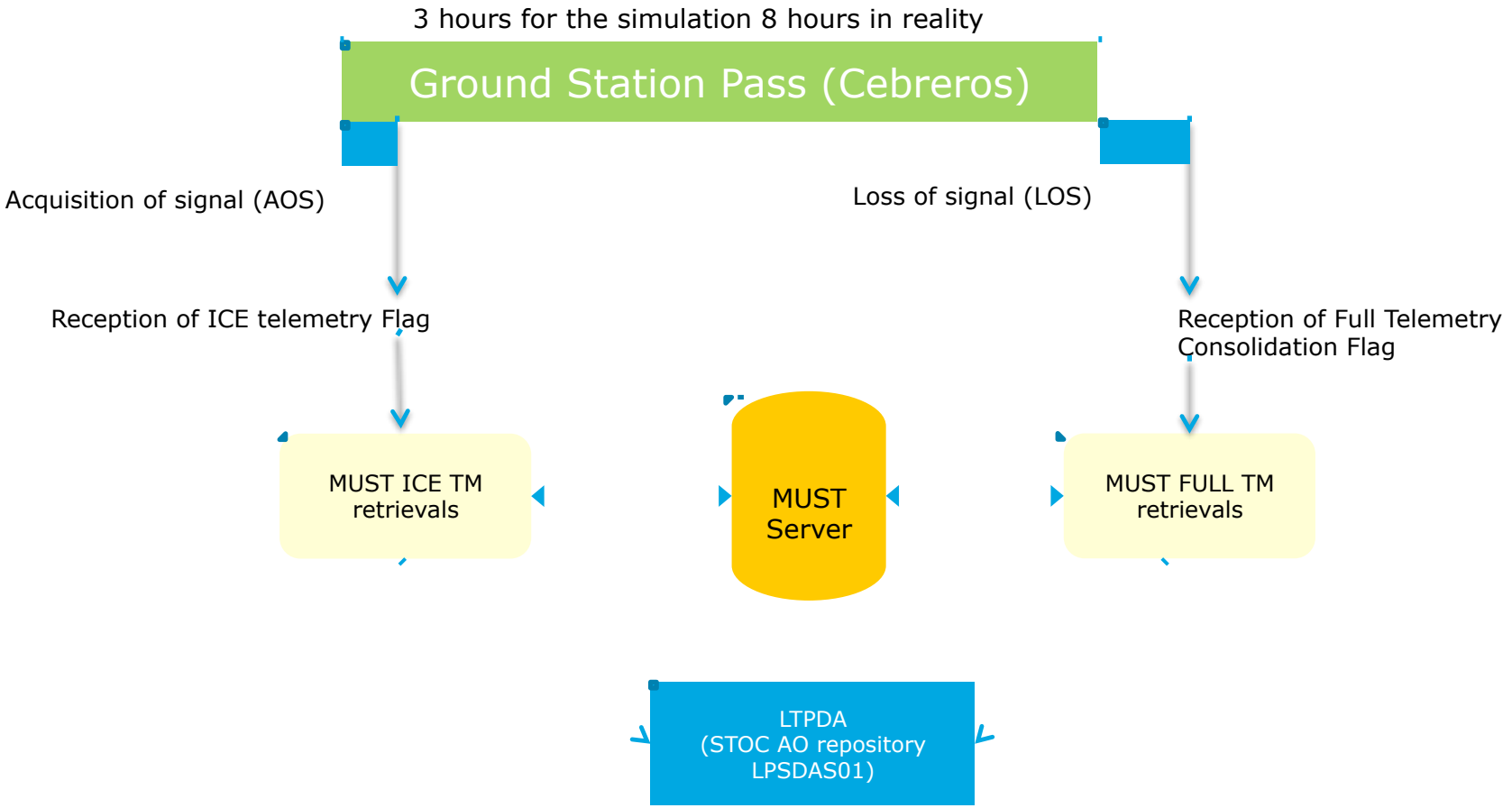
Name	Role
Miquel Nofrarias	QL DA
Peter Wass	QL DA
Mauro Hueller	Scribe
Paul McNamara	Operations Scientist “on duty”, spokesman
Stefano Vitale	Senior Scientist “on duty”

- +operation team
  - Michele Armano op-scientist
  - Jorge Fauste op-engineer
  - Marco Freschi op-engineer
  - Damien Texier boss

APC

- Eric Plagnol *Boss*
- Luigi Ferraioli
- Giuseppe Congedo
- Natalia Korsakova
- Ewan Fitzsimons
- Heather Audley
- Rita Dolesi
- Bill Weber
- Ferran Gilbert
- Nikos Karnesis
- Ed Porter
- Volker Beckmann
- Antoine Petiteau
- Davor Mance.

Simulation execution and operational timeline



European Space Agency

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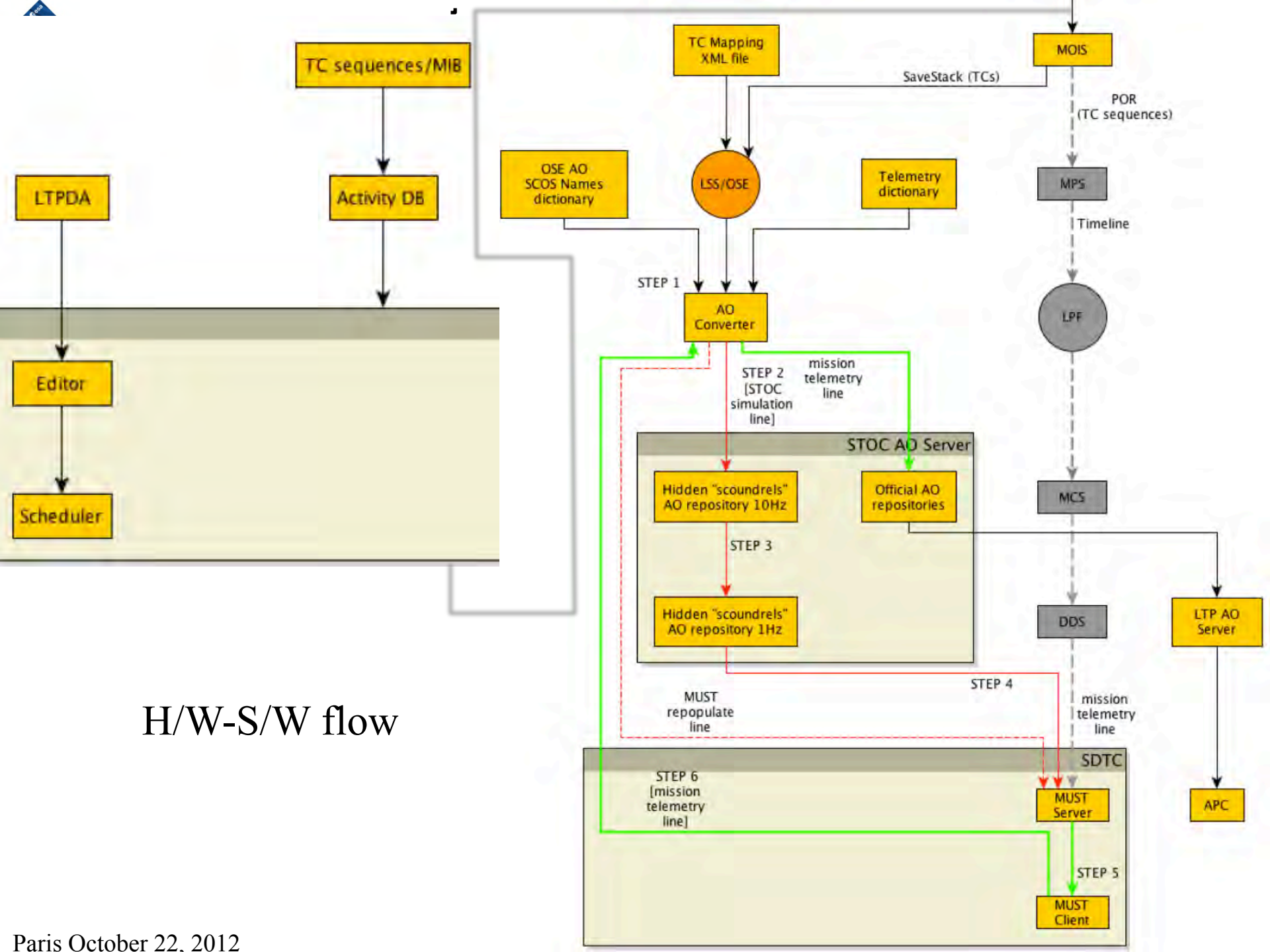
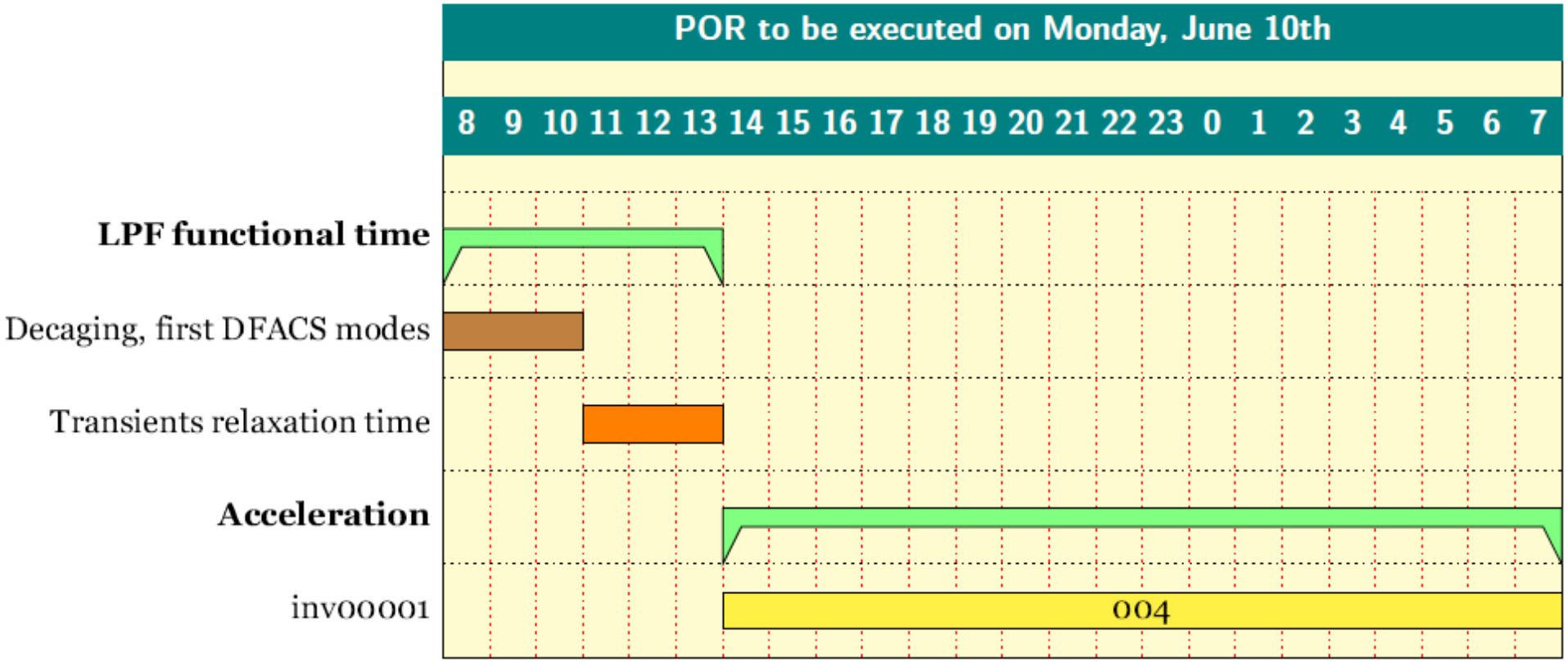
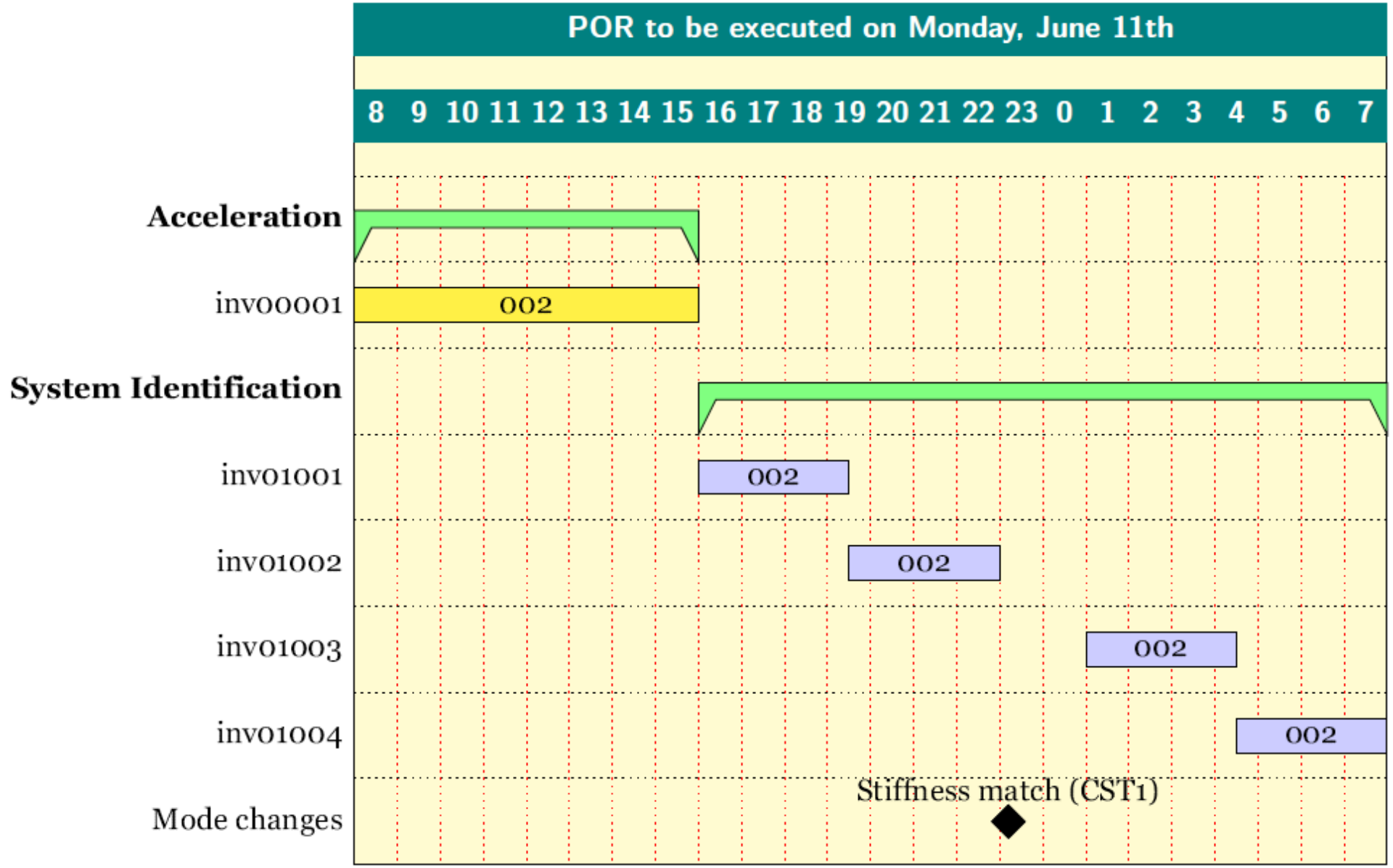

TC sequences/MIB
TC Mapping XML file
MOIS
SaveStack (TCs)
POR (TC sequences)
LTPDA
Activity DB
OSE AO SCOS Names dictionary
LSS/OSE
Telemetry dictionary
MPS
Timeline
Editor
Scheduler
STEP 1
AO Converter
LPF
STEP 2 [STOC simulation line]
mission telemetry line
STOC AO Server
Hidden "scoundrels" AO repository 10Hz
Official AO repositories
MCS
STEP 3
Hidden "scoundrels" AO repository 1Hz
DDS
LTP AO Server
STEP 4
MUST repopulate line
mission telemetry line
SDTC
STEP 6 [mission telemetry line]
MUST Server
APC
STEP 5
MUST Client

H/W-S/W flow

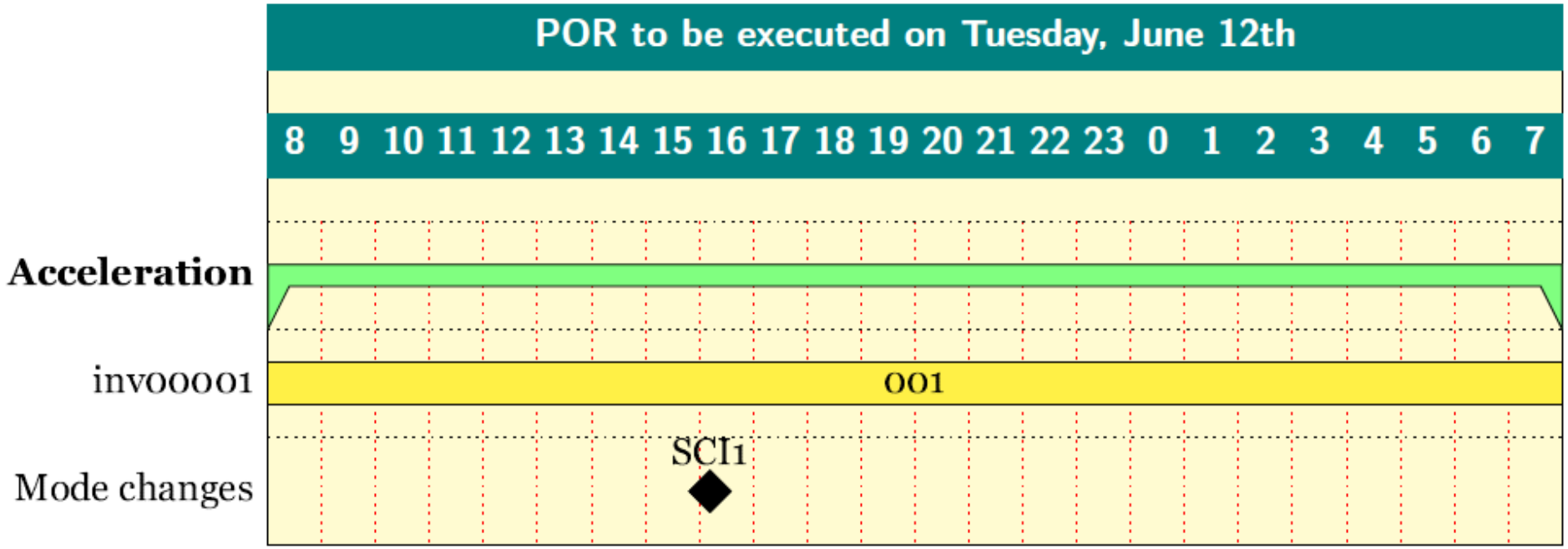
The time-line



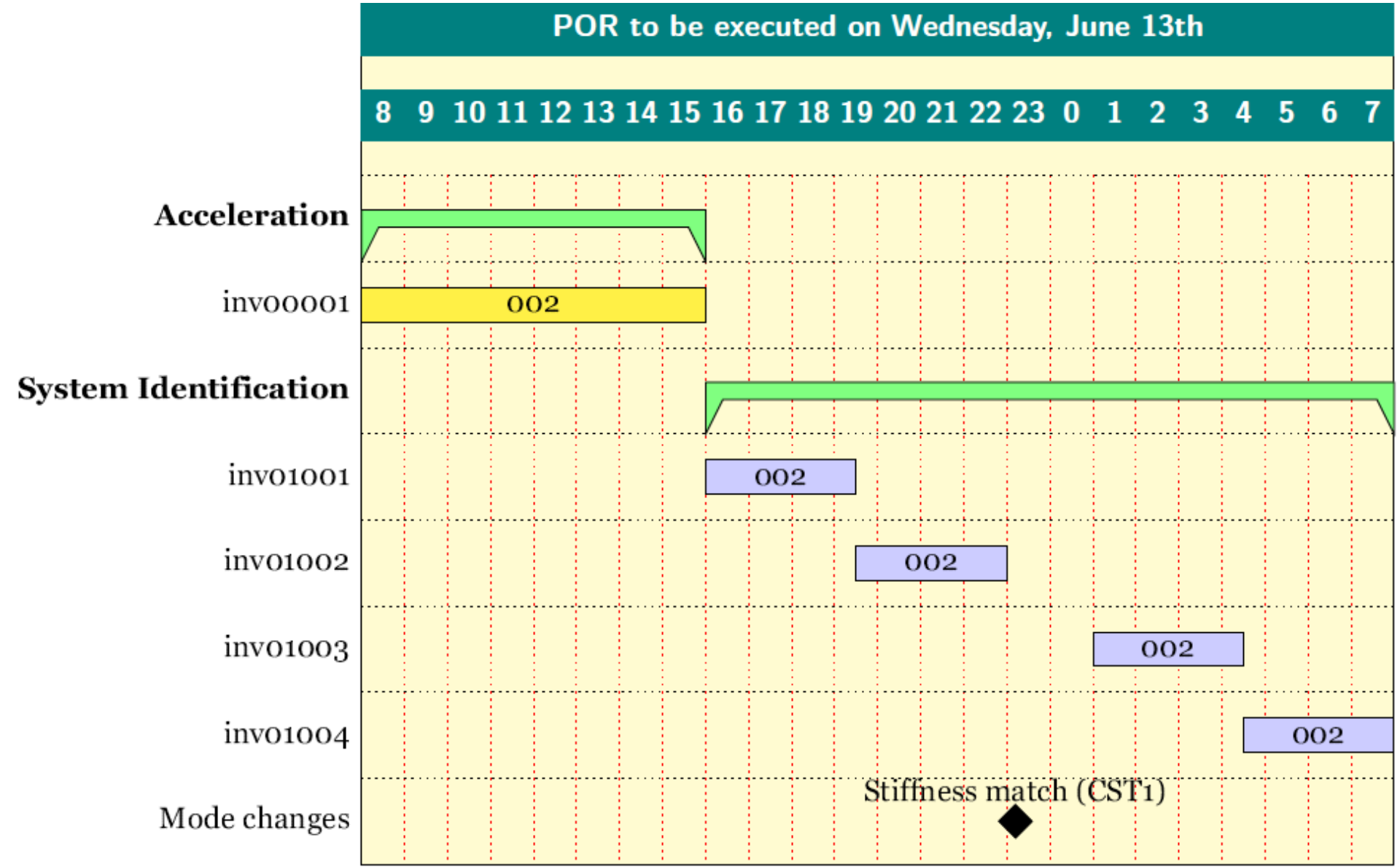
The time-line

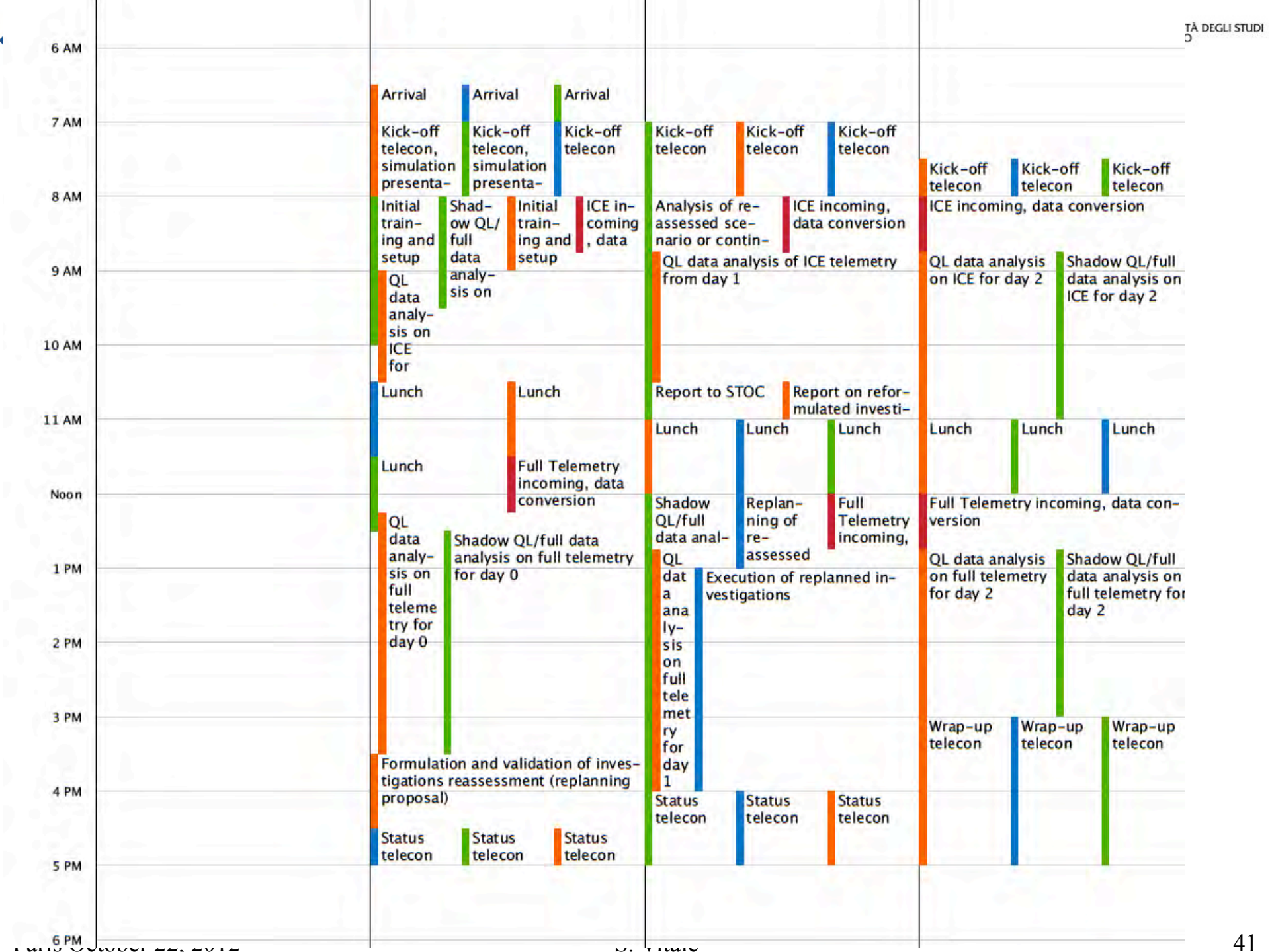


The time-line



The time-line




6 AM
7 AM
8 AM
9 AM
10 AM
11 AM
Noon
1 PM
2 PM
3 PM
4 PM
5 PM
6 PM
Arrival
Arrival
Arrival
Kick-off telecon, simulation presenta-
Kick-off telecon, simulation presenta-
Kick-off telecon
Initial train-ing and setup
Shad-ow QL/ full data analy-sis on
Initial train-ing and setup
ICE in-coming , data
QL data analy-sis on ICE for
Lunch
Lunch
Lunch
Full Telemetry incoming, data conversion
QL data analy-sis on full teleme try for day 0
Shadow QL/full data analysis on full telemetry for day 0
Formulation and validation of inves-tigations reassessment (replanning proposal)
Status telecon
Status telecon
Status telecon
Kick-off telecon
Kick-off telecon
Kick-off telecon
Analysis of re-assessed sce-nario or contin-
ICE incoming, data conversion
QL data analysis of ICE telemetry from day 1
Report to STOC
Report on refor-mulated investi-
Lunch
Lunch
Lunch
Shadow QL/full data anal-
Replan-ning of re-assessed
Full Telemetry incoming,
QL dat a ana ly-sis on full tele met ry for day 1
Execution of replanned in-vestigations
Status telecon
Status telecon
Status telecon
Kick-off telecon
Kick-off telecon
Kick-off telecon
ICE incoming, data conversion
QL data analysis on ICE for day 2
Shadow QL/full data analysis on ICE for day 2
Lunch
Lunch
Lunch
Full Telemetry incoming, data con-version
QL data analysis on full telemetry for day 2
Shadow QL/full data analysis on full telemetry for day 2
Wrap-up telecon
Wrap-up telecon
Wrap-up telecon

A functional test on the entire chain

Viewing Issue Advanced Details

ID:	Category:	Severity:	Reproducibility:	Date Submitted:	Last Update:
208	[Observation Reports]	minor	N/A	12-06-13 10:11	12-06-26 15:16

Reporter:	pmcnamar	**Platform:**	
Assigned To:		**OS:**	
Priority:	normal	**OS Version:**	
Status:	closed	**Product Version:**	
Product Build:		**Resolution:**	fixed
Projection:	none		
ETA:	none		

Summary: Investigation summary and POR file on Livelink does not represent the operations performed on the OSE for Day 0 (11th June 2012)

Description: The Investigation summary (and corresponding POR file) doe snot match the operations which were run on Day 0 of the simulation.
Traceability from operations to POR files was lost.

Steps To Reproduce:

Additional Information:

Attached Files: POR__STOMPS_D12163AA_stocsim1_day1____00031.LPF.txt (107 KB) *12-06-13 10:12*
Investigation_summary copy.pdf (135 KB) *12-06-13 10:13*

Notes

(0000208) jgallego 12-06-15 11:42	June15 (MA, JF, JG): Propose to close with SPR on IPT; describing the traceability data to be written by IPT on the file headers. In general, all systems generating files should include information for traceability to be used by other systems. MOIS TBD.
(0000262) jgallego 12-06-26 15:16	closed with SPR 126 on IPT

A functional test on the entire chain

Unexpected features observed in the response ADT20033 to S/C guidance signals. The 3rd injection is using a fade-in and fade-out feature that was not requested. The 5th injection of the Inv01001 (matched stiffness section) has wrong frequency.

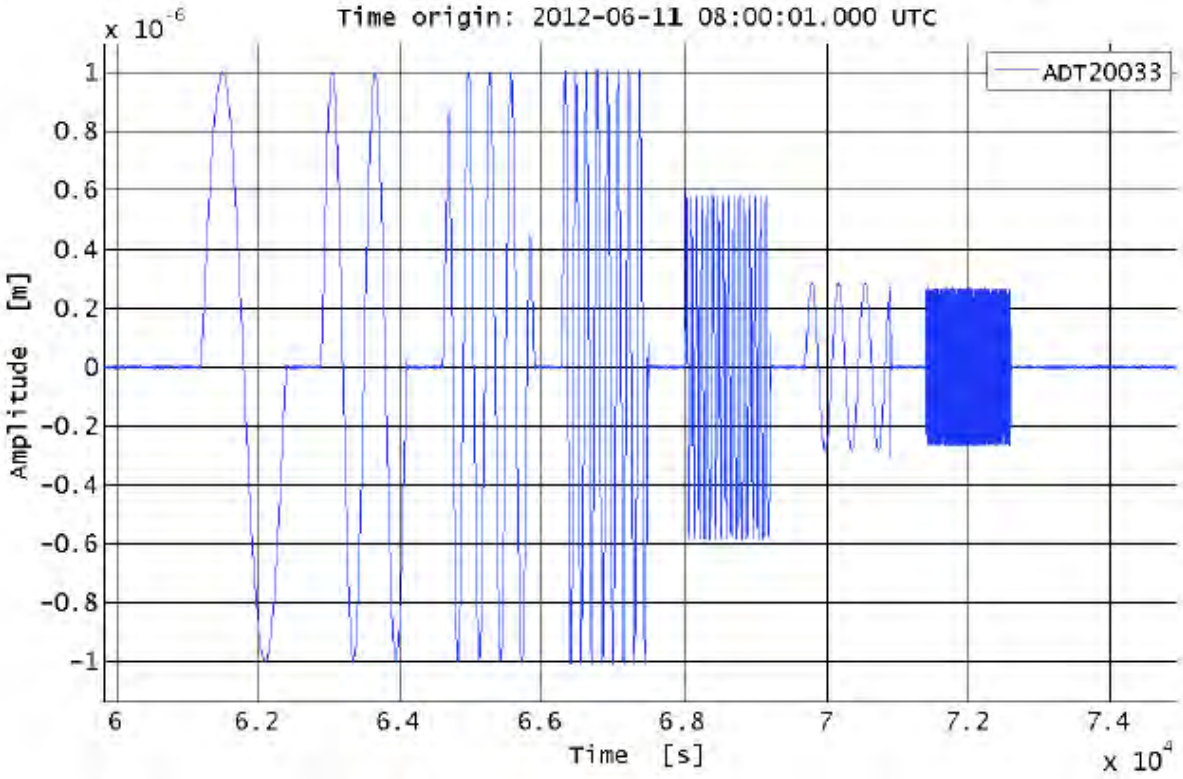


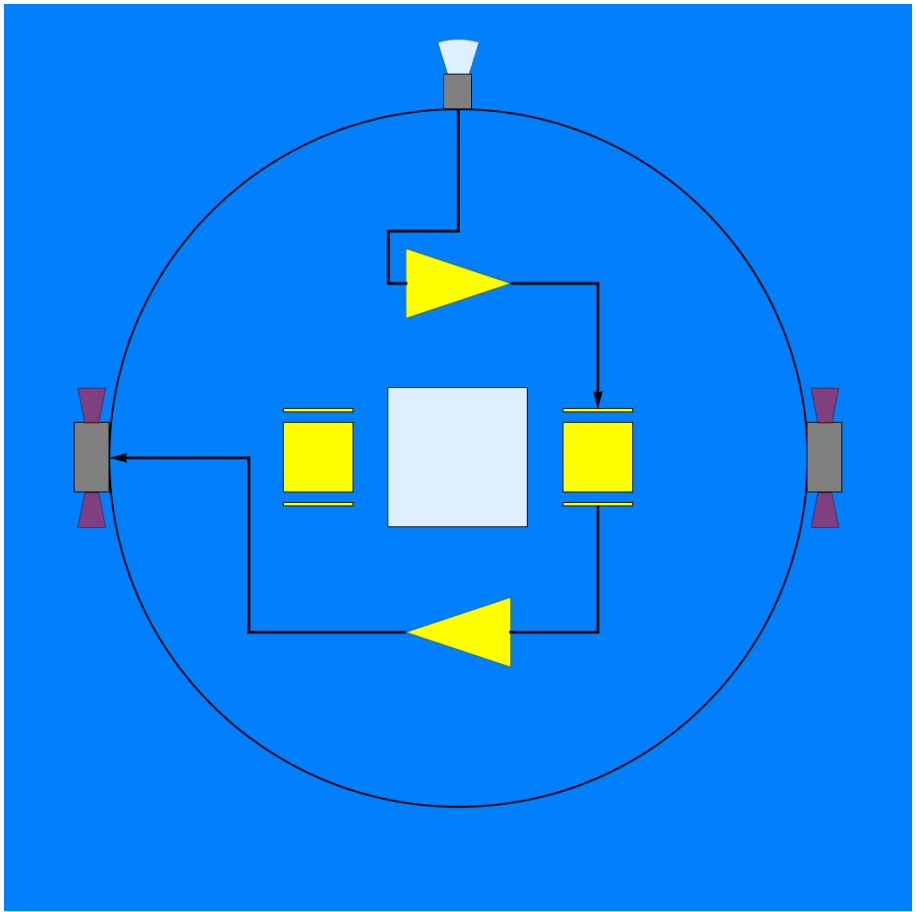
Figure 10 ADT20033 for the Inv01001 investigation, matched stiffness. The 3rd and 5th injections show unexpected features.

A true experiment

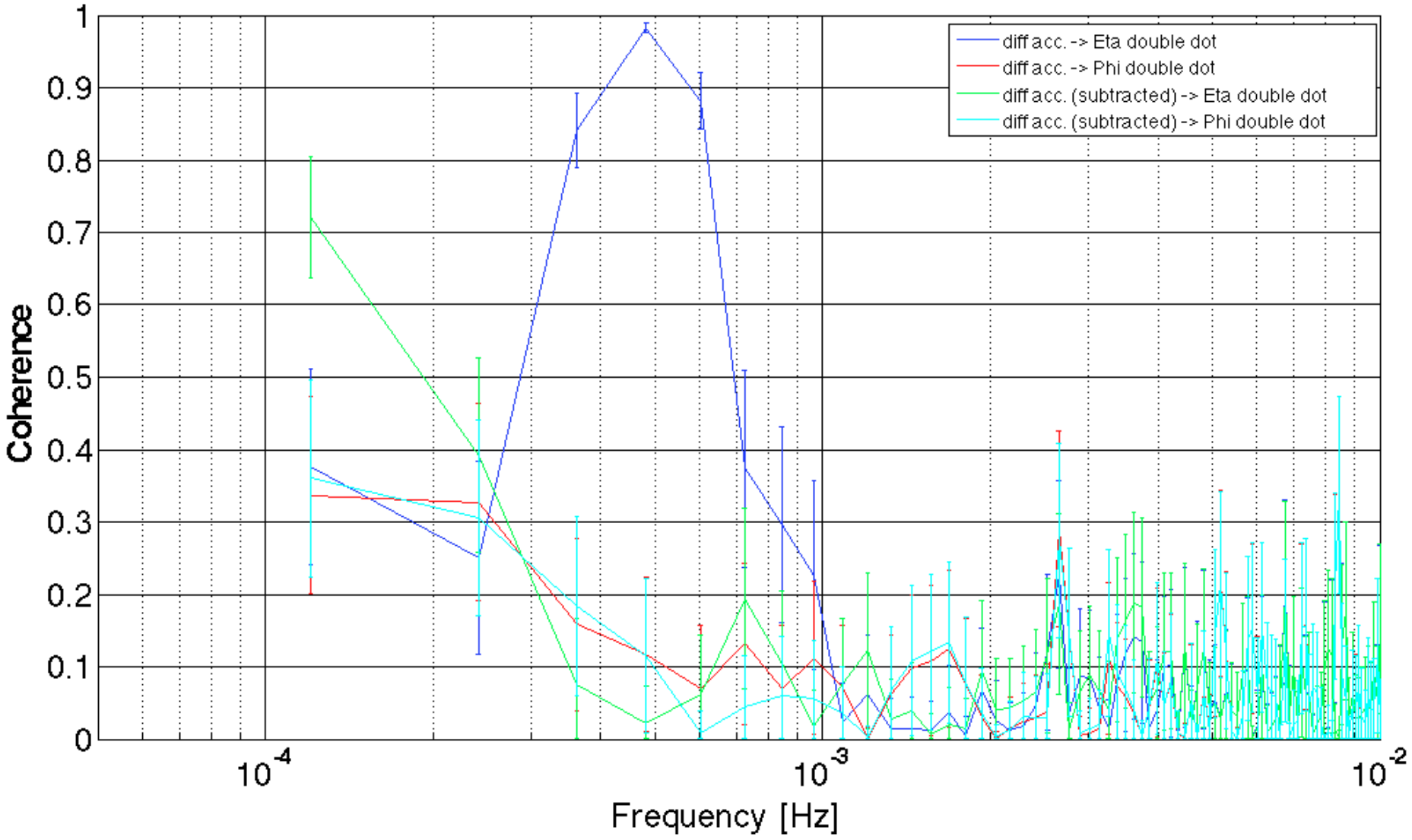
- Strong correlation found between main channel Δx, and force commanded on test-masses along y
- These forces are used to control the attitude of S/C

Limitation of LPF method

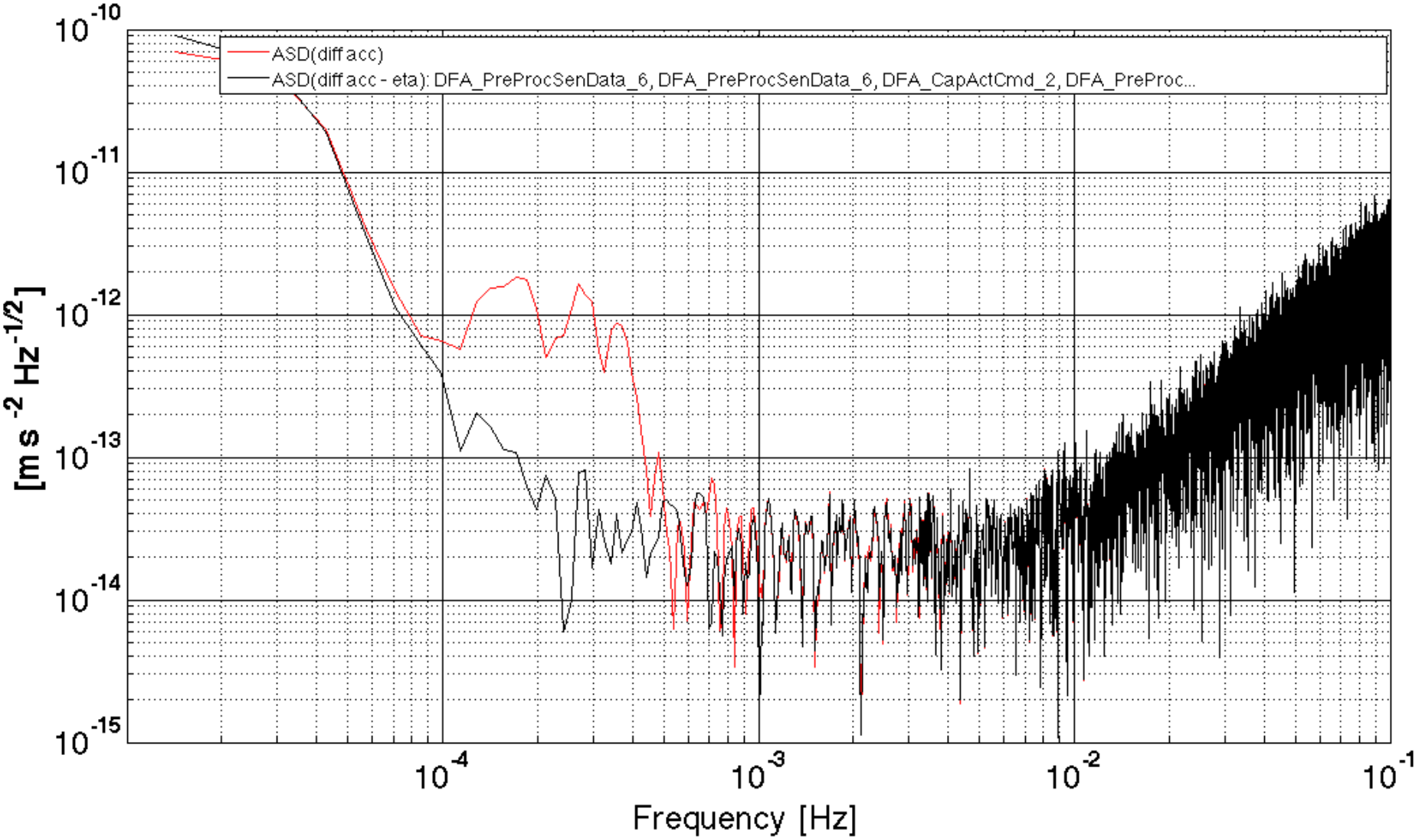
- Star Trackers are used to stabilize rotation
  - Star Tracker pushes test-masses with differential force $\Delta f_y = f_{y1} - f_{y2}$ to restore orientation.
  - Spacecraft/optical bench follows using thrusters.
- *Star Tracker are very noisy: up to 100 μrad/√Hz @ 0.1 mHz*



Cross-coherence between Δx and f_{y1}-f_{y2}.



De-correlation by subtraction in the time domain $\Delta x' = \Delta x - \alpha(f_{v1} - f_{v2})$



Summary

- A few item with low criticalities
- Micro-thrusters nominally on critical path just for procurement reasons.
- *EH on critical path because quick fix is still outstanding. October 30 we'll know more*
- All remaining sectors are doing well.