

Session 8: Time Transfer Experiments

The T2L2 Flight Model Calibration and Performance Determination Campaign

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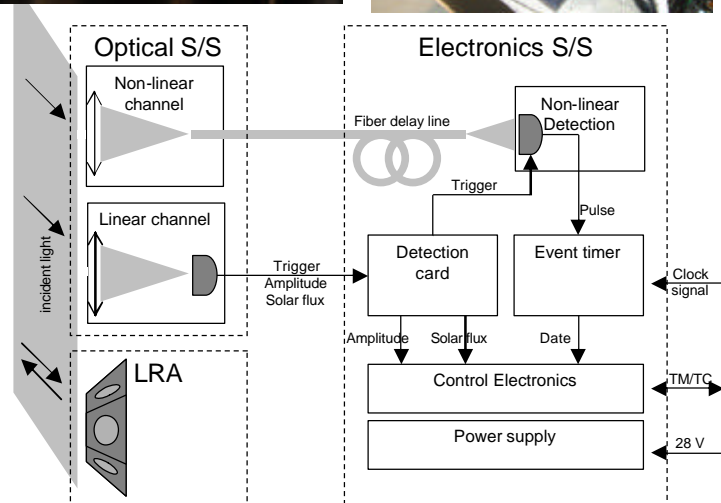
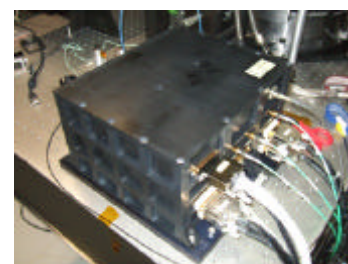
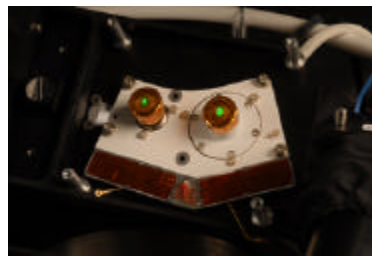
1. T2L2 Instrument Architecture
2. Experimental Conditions in Orbit
3. Test Campaigns
4. Test Bed
5. Calibration and Performance Determination

T2L2 Optics subsystem:

- Linear Channel: system trigger, laser pulse and cw measurement
- Non-linear Channel: precise timing (APD in Geiger mode)
- LRA (provided by Jason 2 mission)

T2L2 Electronics subsystem:

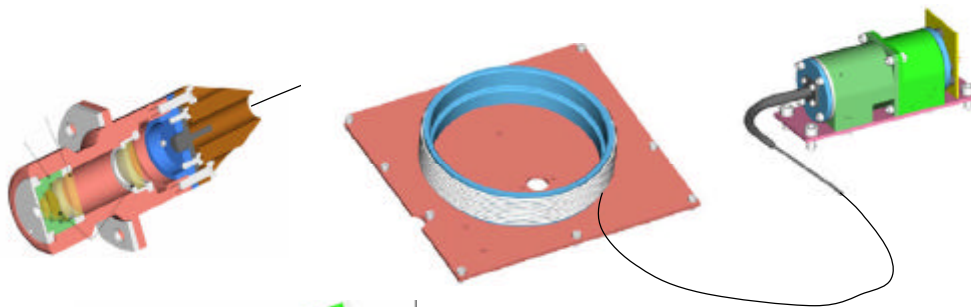
- Detection electronics: Signal processing, trigger
- Event timer: Timing of laser pulses in local temporal reference frame
- Clock: DORIS USO (provided by Jason 2 mission)
- Control Electronics: TM/TC
- Power supply



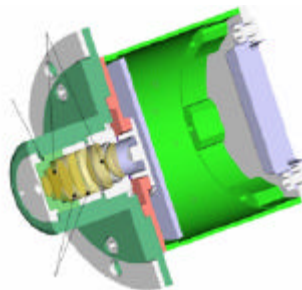
T2L2 Optics

- designed to cover a FOV of 110° (whole globe for Jason 2 orbit)
- collimation optics consisting of a set of lenses
- spectral filter for noise reduction
- neutral density filter with radial variation
in order to equalize the laser pulse energy levels for incidence angles between nadir (maximum flux) and $\pm 55^\circ$ (minimum)

non linear channel



linear channel



- Orbit characteristics:
 - 1336 km circular orbit, 66° inclination
 - six repeating ground tracks
 - pass: ~1000 s, dead time 120 min
- Implications on the instrument
 - w/ FOV=110° → integration of significant background noise from earth / atmosphere albedo
 - possible “leakage” of optics beyond FOV → even more noise
 - variation of incidence angles
 - “speckle” feature in satellite orbit: random variation of laser pulse energy
 - arbitrary polarization
 - equivalent point of detection ? point of reflection (depend on incidence)

- Phase B:
 - prototype testing

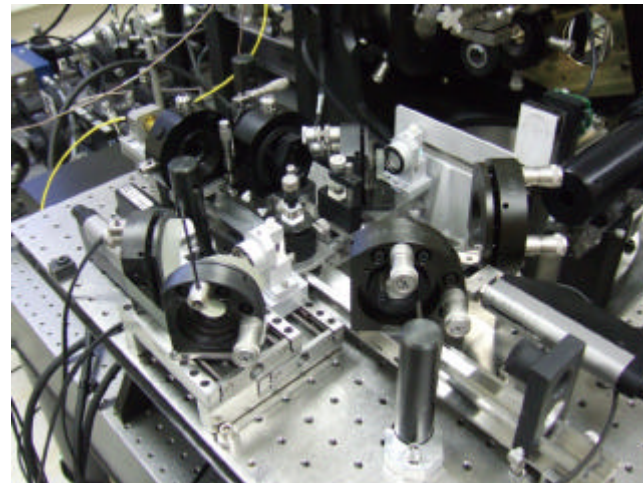
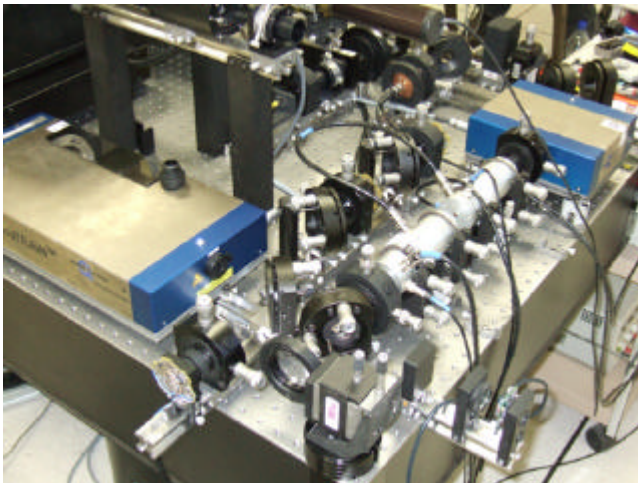
- Phase C:
 - Engineering Model verification
 - Instrument level tests (EMC, mechanical, thermal, etc.)
 - T2L2 stand-alone metrology examination at CNES
 - Calibration, correction tables for data reduction
 - Performance determination

- Phase D:
 - T2L2 integrated on Jason 2
 - Performance Verification
 - Satellite Level Tests (EMC, mechanical, thermal, etc)

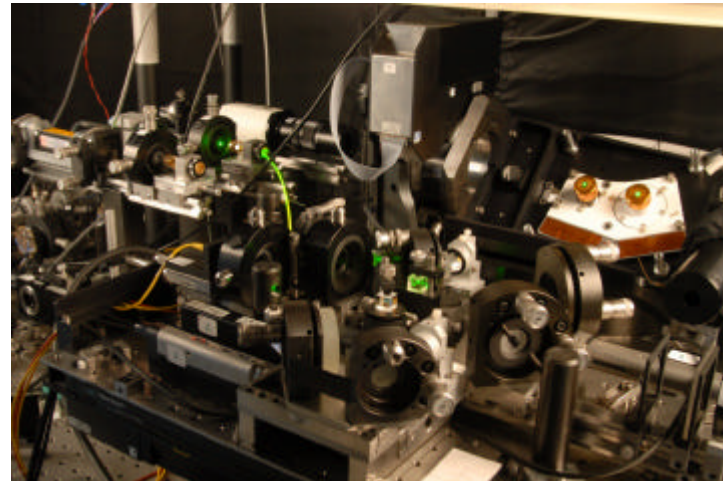
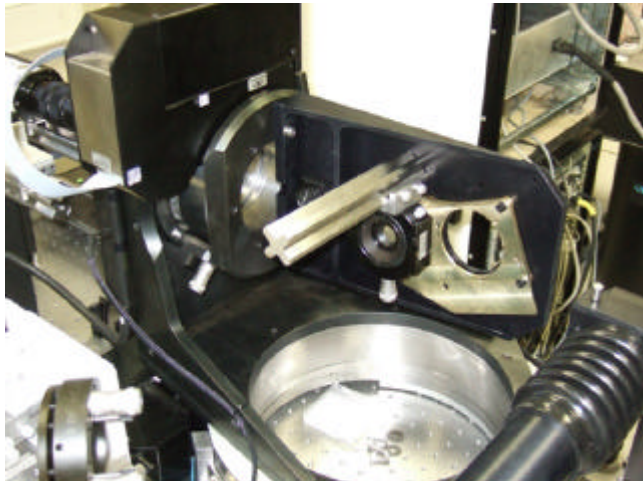
- Phase E:
 - In Orbit Verification

- Optical bench:

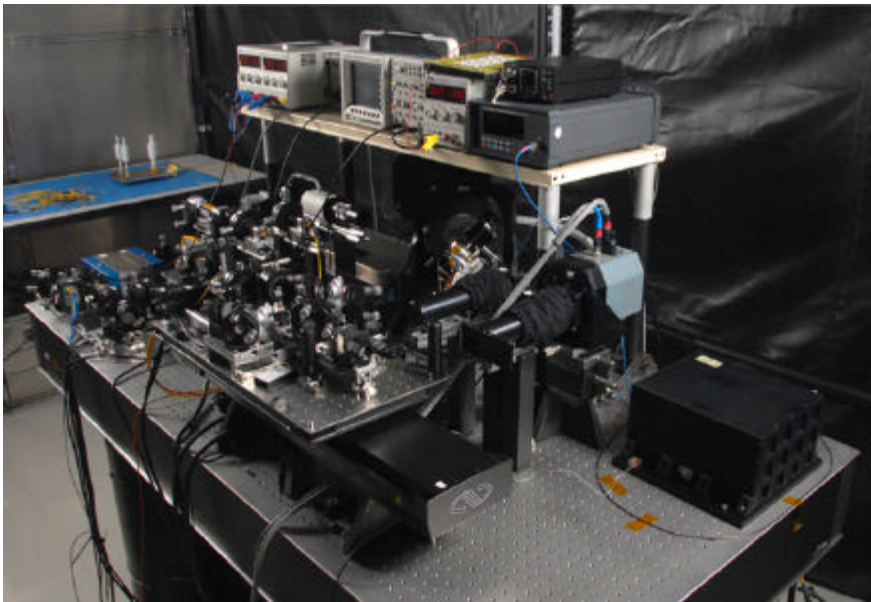
- Nd:YVO₄ mode locked laser: generation of green (532 nm) laser pulses (FWHM 20 ps), synchronization to clock signal
- Pulse picking system: selectable repetition rate (1 Hz to 5 MHz)
- Control of pulse energy and polarization
- CW green diode laser and white LED grid for background noise simulation
- Detectors for pulse energy and beam profile measurement
- Departure and return detectors: linear and Geiger mode APDs (reference timing)



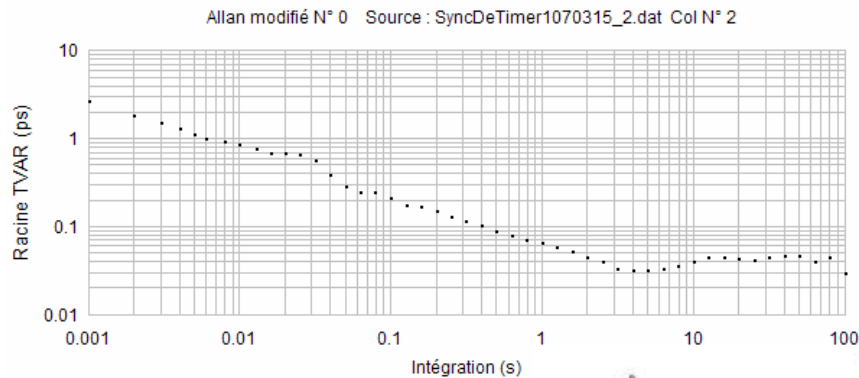
- Mechanics, Geometry:
 - Generation of two parallel, displaceable beams illuminating T2L2 optics
 - Two-axis motorized gimbal mount for attitude simulation: T2L2 optics and reference mirror
 - Furnace for heating of the T2L2 electronics subsystem



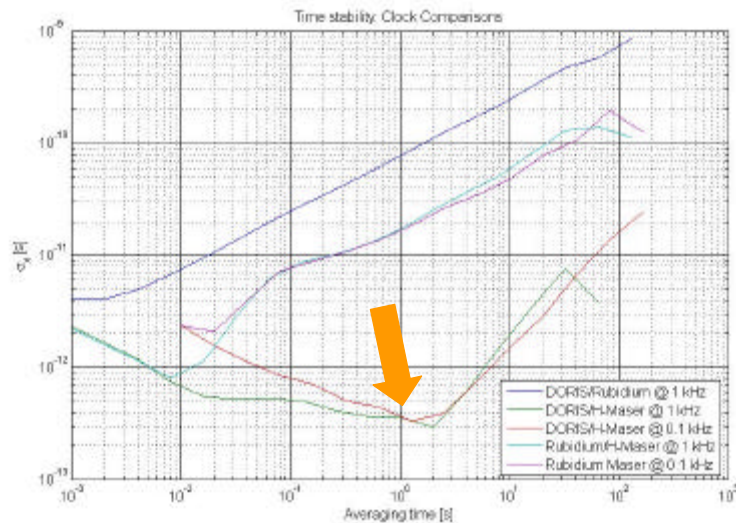
- Time Frequency and Control Electronics:
 - Different clocks furnishing a 10 MHz input: Cs-Std, H-Maser, Rubidium, DORIS engineering model
 - Picosecond event timer (Dassault): reference timing (precision 2 and 5 ps, respectively)
 - Generation of electrical pulses (ECL) synchronous or asynchronous to clock signal for simple electronic comparison
 - Control PC and electronics (TM/TCT2L2 & Test Bed)



- Calibration of vernier (fine scale timing): linearity and calibration signals
- Stability of internal reference signal generation (TVAR of phase to ref.)

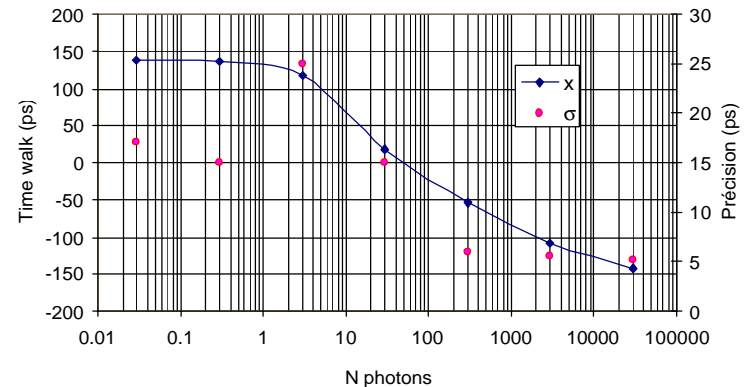


- Stability of event timer (soon) (Precision = 2 ps)
- Stability of DORIS clock:





- Linear APD:
 - Calibration of laser pulse energy measurement as a function of polarization voltage (gain)
- Geiger mode APD:
 - Calibration of Time Walk correction
 - Precision and stability
 - Single hv precision: 17 ps
 - @ 1000 hv: 2 ps



- Sensibility towards laser energy (verification of correction tables)

Continuous noise from atmosphere albedo (sun light):

- Linear APD:
 - Calibration of cw flux measurement as a function of polarization voltage (gain)
- Determination of Signal to Noise Ratio depending on sun noise level
- Determination of false event rate
- Detection threshold

Variable incidence angles:

- Differential **optical path** and **transmission** measurement for various angles of incidence (θ and ϕ) and polarization
- Determination of detection equivalent point
- Global measurement: simulation of all parameters varying

- The test bed permitted to fully characterize all instrumental parameters
 - in accordance with specification
 - construction of correction tables of T2L2 raw data
 - determination of final metrological performance
- Verification of operation and performance during a last test campaign when T2L2 was integrated on Jason 2 at Thales Alenia Space in Cannes
- But: data analysis still underway

