Laser Ranging on space debris with MéO

Dominique Albanese
Mourad Aimar
Clement Courde
Pierre Exertier
Dominique Feraudy
Myrtille Laas-Bourez
Hervé Mariey
Grégoire Martinot-Lagarde
Jocelyn Paris
Monique Pierron
Rémy Rigard-Cerison
Etienne Samain
Jean-Marie Torre
Hervé Viot
Hervé Haag
Guillaume Blanchet
Bruno Esmiller
Sophie Vial

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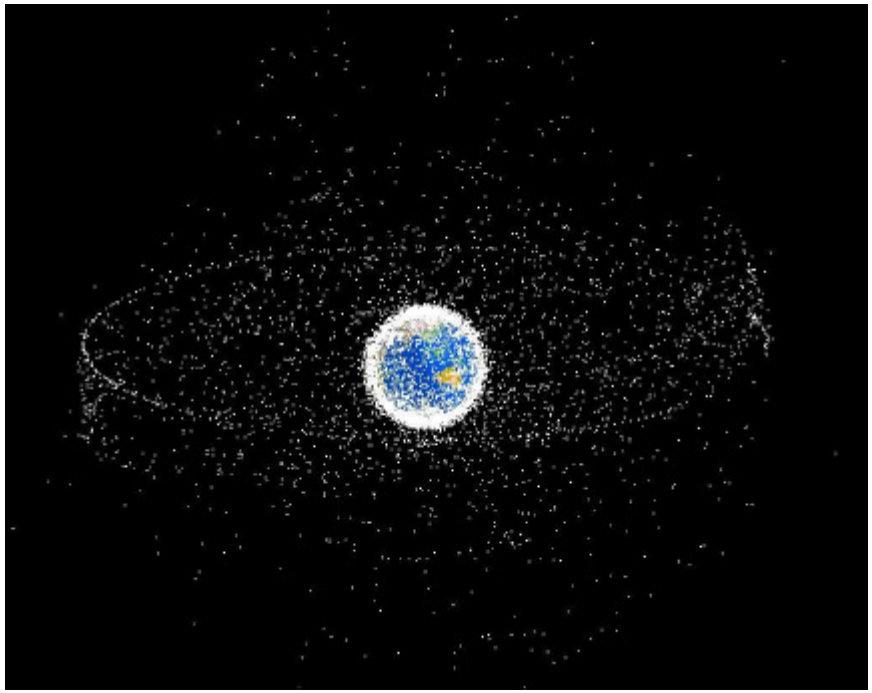
Overview

- Aim of the collaboration with ASTRIUM
- MéO description
- Technical developments
  - 2J laser
  - Low noise photodetection
  - Distance calibration
  - Observation constraints
- Results obtained

Aim of the collaboration with ASTRIUM

- Prove the ability to perform laser ranging on non-cooperative objects
- Validate the dimensioning studies concerning a laser ranging station dedicated to the active tracking on orbital debris



MéO description

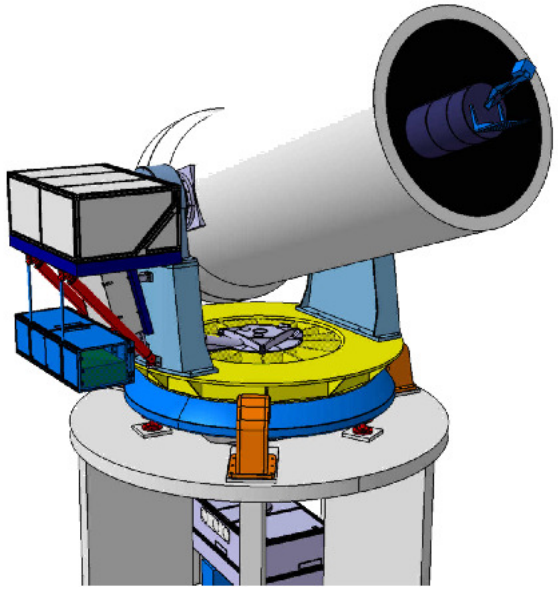
Laser station dedicated for Satellite and Lunar Laser Ranging

Fork mount Alt-Az with direct drive motors:

- Az axis speed : 5° /s
- Az axis acceleration: 1° /s^2
- Pointing accuracy: +/- 5 arcsec

Laser:

- Repetition rate: 10 Hz
- Energy max per pulse: 200 mJ at 532 nm
- Pulse width: 70 ps



Telescope:

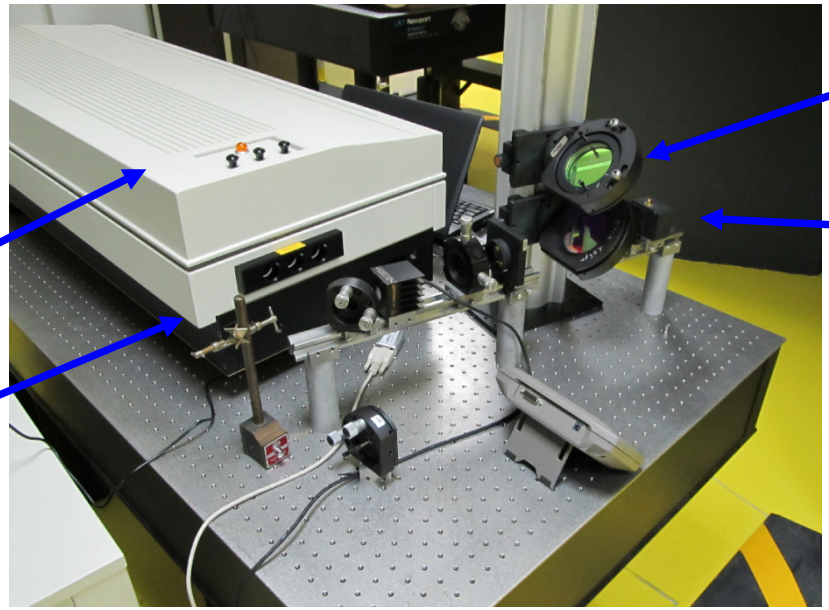
- 1.54 m diameter
- Photodetection FoV : 10 arcsec
- Camera FoV: 3 arcmin

Technical development for laser ranging on space debris

Laser **Continuum DLS 2J** integrated in 2011:

- Energy : 2.1 J/pulse
- Repetition rate : 10 Hz
- Pulse width : 5 ns
- Wavelength : 532 nm

The laser is **synchronized** by a **control module** developed specifically → Generates control signals of the Q-Switch flash from optical synchronization signal.



Single-phase autotransformer

Chilled water distribution

Coupling mirrors

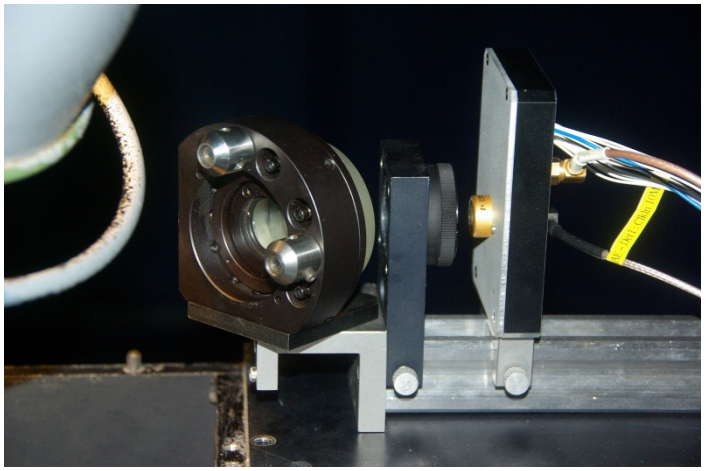
Photo detection that measures the starting tops laser pulses

MéO Event Timer

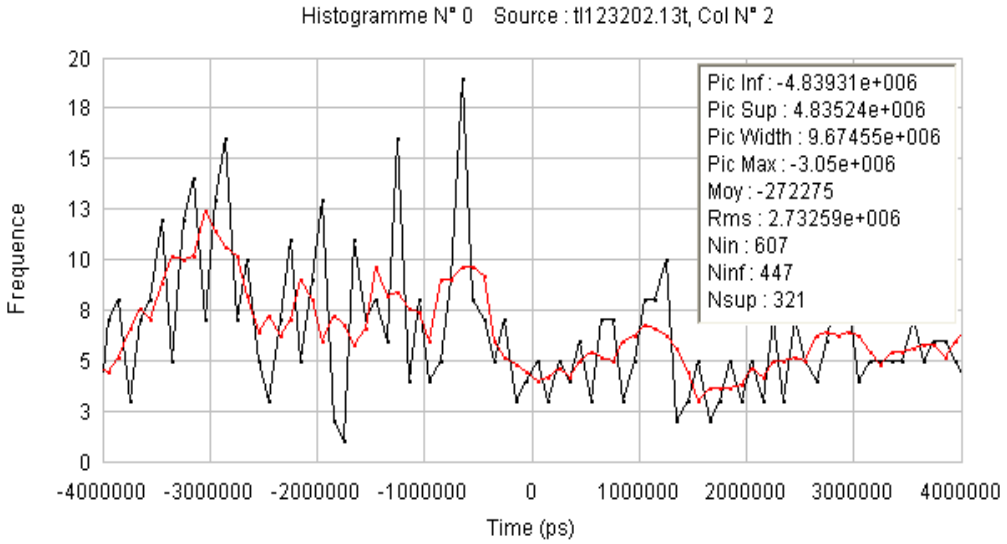
Technical development for laser ranging on space debris

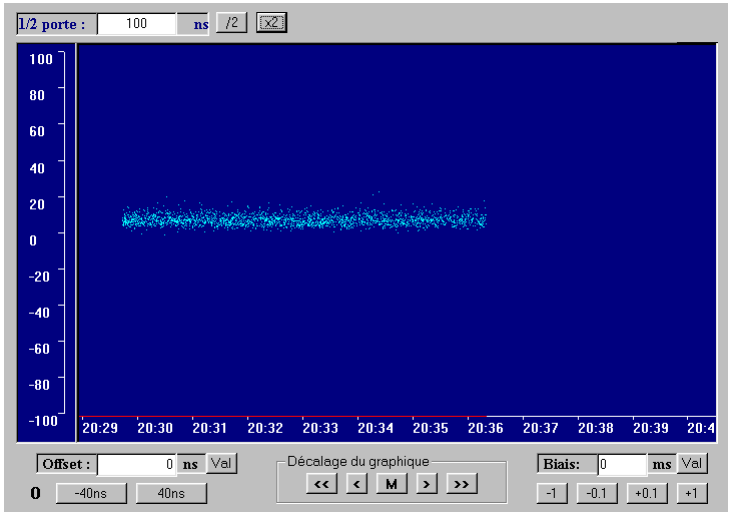
The low noise photo-detection:

- Global field of view : 28 arc sec (~ 280 m @ 2000 km)
- Spectral filter : 0.12 nm
- Photo detector: SAP500 in Geiger Mode
  - *Active diameter: 500 µm*
  - *Quantum efficiency measured: 40 %*
  - *Noise measured (real pass) : 55 event / µs @ 20° C*



Experimental setup



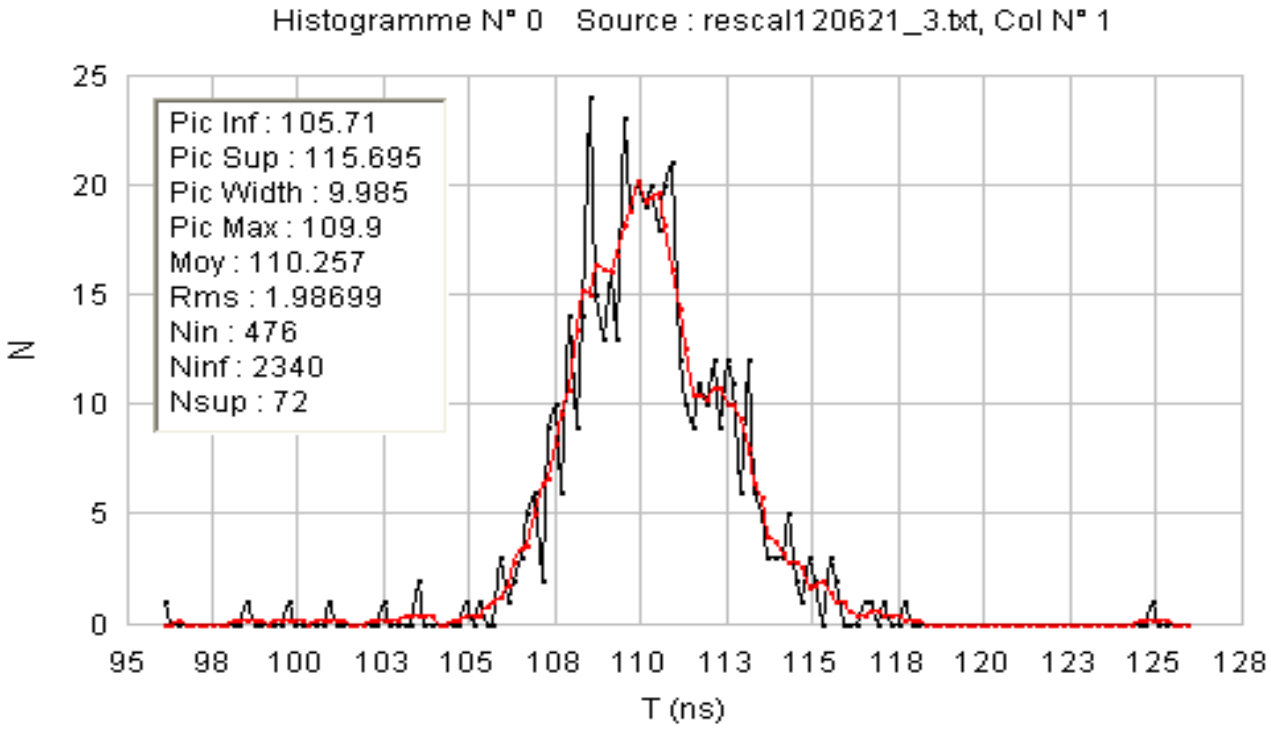


Noise and temporal resolution measurement

Distance Calibration

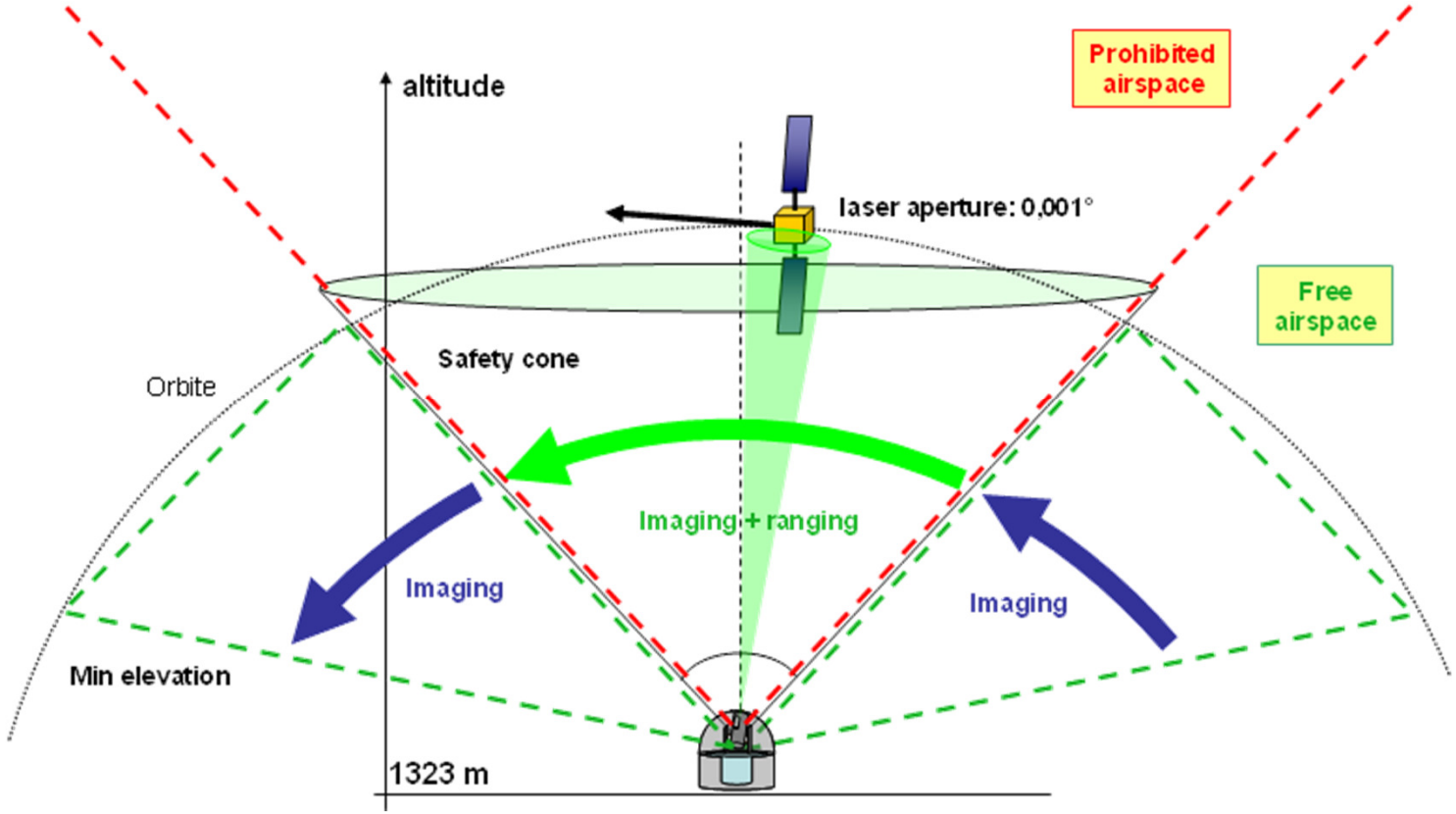
- ✓ **Calibration** is performed through a telemetry made on an internal corner cube - The final telemetry is deduced from the difference between the time of flight obtained on that corner cube and the target

- ✓ The **repeatability error** of the whole system is **5 ns**: In accordance with the FWHM of the laser pulse and the photo detection noise

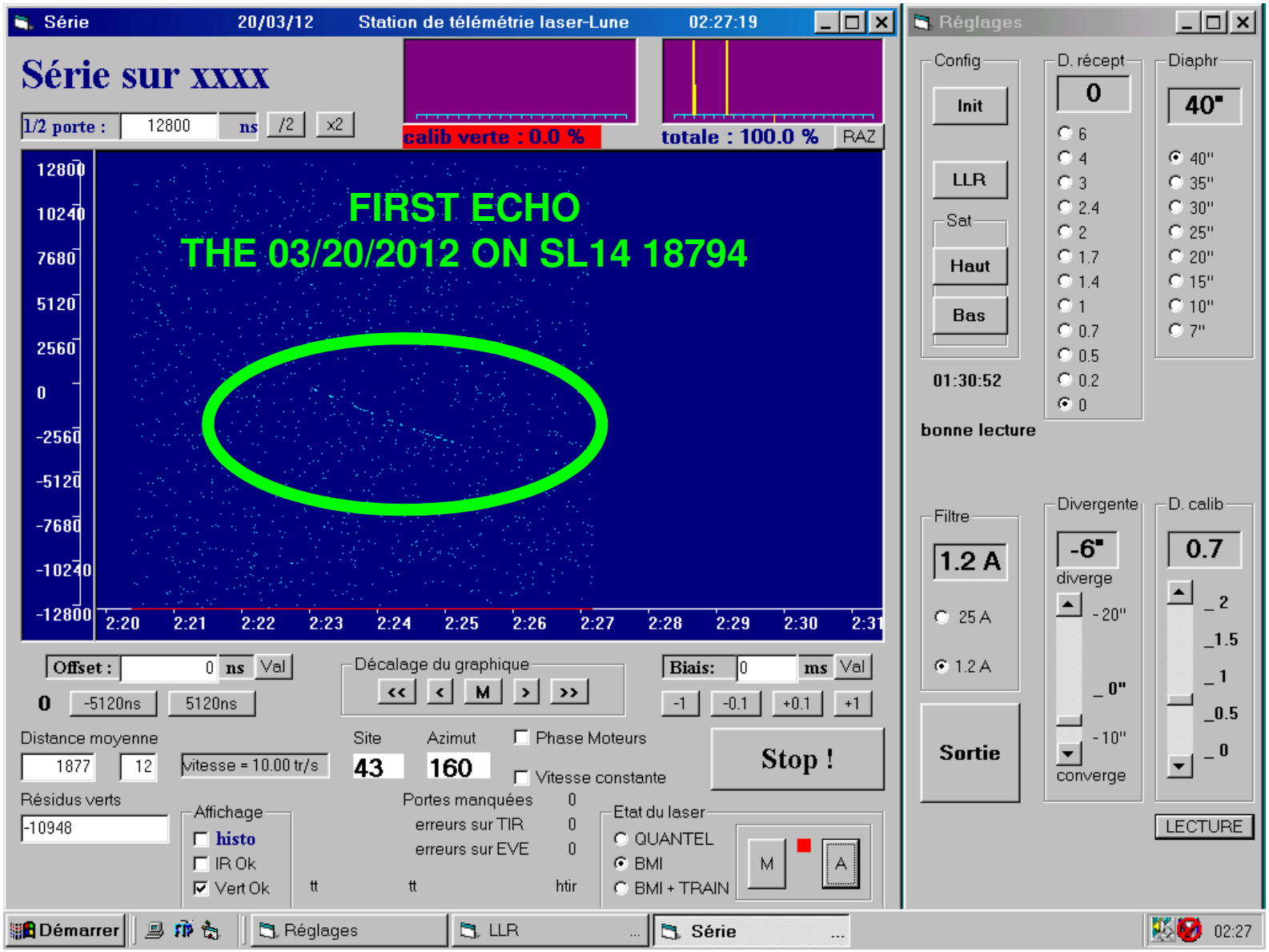


Constraints

- **Precision of the TLE predictions** : ± 10 km → angular error = ± 0.5° => camera
- **Airspace safety** (collaboration with French Civil aviation)
  => laser ranging only above 45° elevation



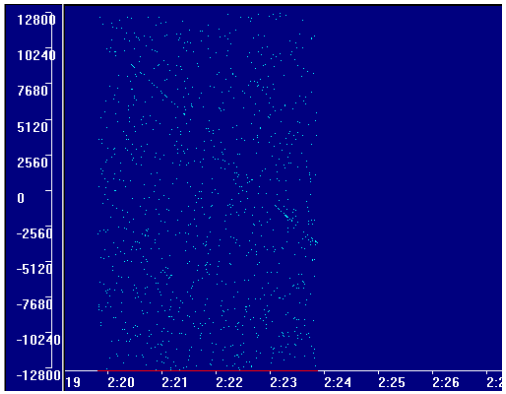
Laser echoes on space debris

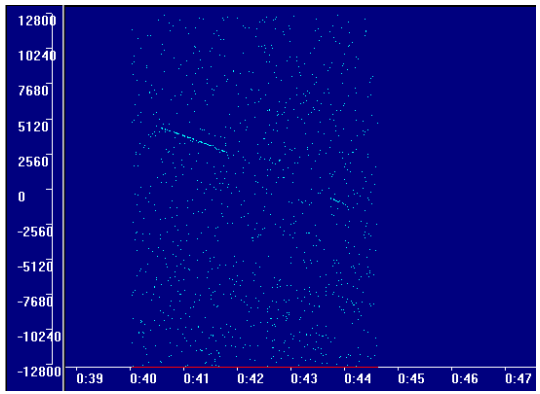


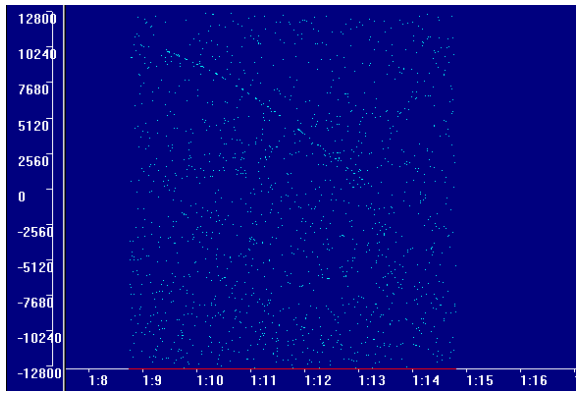
Laser echoes on space debris

→ 10 non cooperative objects detected

Date	Name	# NORAD	Tracking start	Tracking stop	Distance min (km)
28 march	SL14	20197	2h22'12	2h35'52	1500
	SL14	20238	0h20'05	0h27'48	1475
	SL14	16594	0h32'05	0h43'02	1800
	SL19	37155	1h15'07	1h24'25	1480
	SL8	14085	2h18'03	2h25'32	1170
29 march	Ariane 40	22830	2h26'51	2h32'21	847
	SL14	19196	2h40'33	2h53'32	1520
	SL14	14522	1h05'07	1h18'20	1580
30 march	SL8	07443	2h02'36	2h16'13	1670
	SL14	16144	2h15'49	2h27'45	1700







Conclusions for laser ranging on space debris

- First observations on non cooperative objects with MéO
- Issues overcomed: energy densities manipulated, low noise photodetection, airspace safety in collobaration with civil aviation, target choice
- System can be quickly operational and perennial => alternative/complementary for collision avoidance

Thanks for your attention

Rocket breeze upper stage

Ariane 40