MEO - THE FUTURE OF THE FRENCH LUNAR LASER RANGING STATION

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Abstract

It has been decided to enlarge the capability of the French Lunar Laser Ranging (LLR) station and to initiate a new research and development program, in addition to the actual program on the Moon. The LLR station is renamed MeO, for **Me**trology and **O**ptics. Data acquisitions on low altitude satellites, that were performed until now by the French SLR station, will be done in the next future by MeO exclusively.
The new research and development activity on laser ranging will include: new kind of laser modulation, filtering, detection, multi-colors, Doppler, adaptive optics and also research on laser ranging in the solar system (ASTROD, TIPO). In order to achieve all these objectives, many developments are in preparation :

Telescope : high speed motorisation, high accuracy pointing,
Dome : new guiding device,
Building : focus laboratory, offices,
Optics : optical benches for experimental research, optical path,
Operational telemetry : lasers, high speed laser commutation, photo-detection,
Software.

Introduction

The French laser ranging capacity is based on 3 laser tracking stations :

Lunar Laser Ranging (LLR) for the Moon and high altitude satellites,
Satellite Laser Ranging (SLR) for low altitude satellites,
Transportable Laser Ranging System (FTLRS) for mobile campaigns.

Since the beginning of the year 2004, a new organization has been set up that will permit to initiate a new research and development activity, in addition to the actual program on the Moon and on satellites. The CERGA department was restructured and a new name was given : Gemini. It has been decided to centralize our work on both LLR and FTLRS stations and to stop, in the next future, SLR definitively. LLR station which was built at the end of the seventies, to track exclusively the Moon, will be transformed to be able to track targets from low altitude satellites up to future interplanetary spacecrafts. Because the station will become more versatile, it will loose its LLR denomination and will be renamed MeO : **Me**trology and **O**ptics.

Stations developments

- **Optics**

The station is based on a Ritchey Chretien telescope having a diameter of 1.5 m connected to a Nd:YAG laser at 10 Hz (figure 1).

Until now, the same telescope was used for the laser emission (laser located in a fix laboratory), and the detection and the video (units on a Nasmyth table in the dome of the telescope). The optical commutation was performed by a 2 rotating mirroirs at 10 Hz, one for the emission and the reception, and the other one for the commutation between the video and the reception. All the fold mirrors was treated for both 532 and 1064 nm and the telescope was treated with a classical metalization.

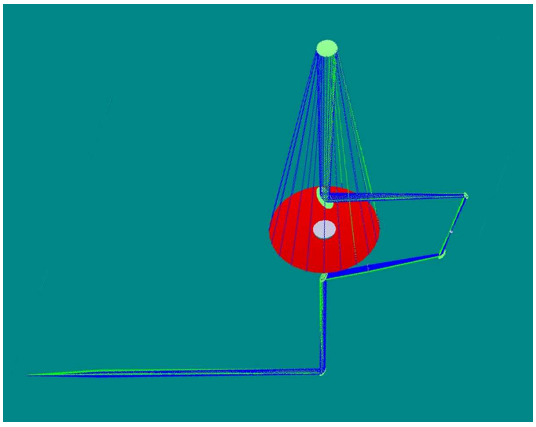

Figure 1 : Ritchey Chretien telescope and fold mirrors.

In the new design :

- Optical path for both emission and reception will be common in order to minimize the pointing differences between the beams. The detection module is put together with the laser on a common optical bench. The field of view allowed by the geometry is 300 arcsec. This imply large fold mirrors having a diameter of 200 mm.
- The optical flux coming from the telescope will be distributed through 5 different optical benches with the capability to dispatch the flux simultaneously on 2 different benches.
- The laser commutation will be well suited for low altitude satellites, that is to say capable of switching in less than 1 ms.
- The spectral bandwidth for both emission and reception will be in the range 400 - 1100 nm.

The principle of the new laser commutation is shown on figure 2. It uses an active retarder plate based on liquid crystal. This allow to switch beams having diameter as large as 100mm. The separation between the input and the output is performed by 2 polarizer beam splitters. A retarder plate (with a circle arrow on the figure) is inserted between these 2 polarizers. It is controlled by an active signal synchronized with the laser. This plate is not active during the laser shoot so that the laser beam (horizontaly polarized) went through the system without any modification. The return beam, which is depolarized by the target, is split into 2 distinct polarizations by the output polarizer. The vertical polarization is directly sent into the reception path while the horizontal one is actively transformed in vertical polarization by the retarder plate and mixed with the first direct vertical polarization by a third polarizer. At the end, both vertical and horizontal polarizations are recovered even if the target destroys the polarization figure. Some damage threshold tests have been done on a 10 mm retarder plate. The limit has been mesured at 30 mJ/cm² @ 200 ps. It is due to the temperature elevation of the liquid and should be solved in the next future with a suitable radiator.

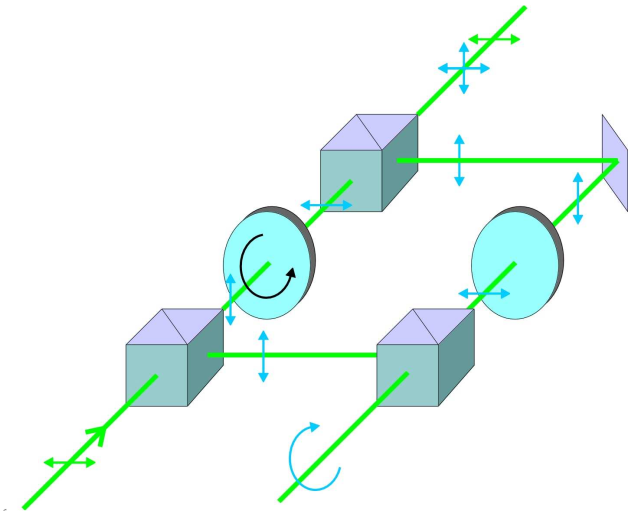

Figure 2 : Laser commutation based on liquid crystal retarder plate.

All the mirrors, expect the primary mirror, will be treated by some broadband dieletric coatings made by Sagem. The damage threshold is 10 J/cm² @ 10 ns and the mean value of the reflection factor is greater than 98 % (figure 3). This coating has been already used by the Bern University.

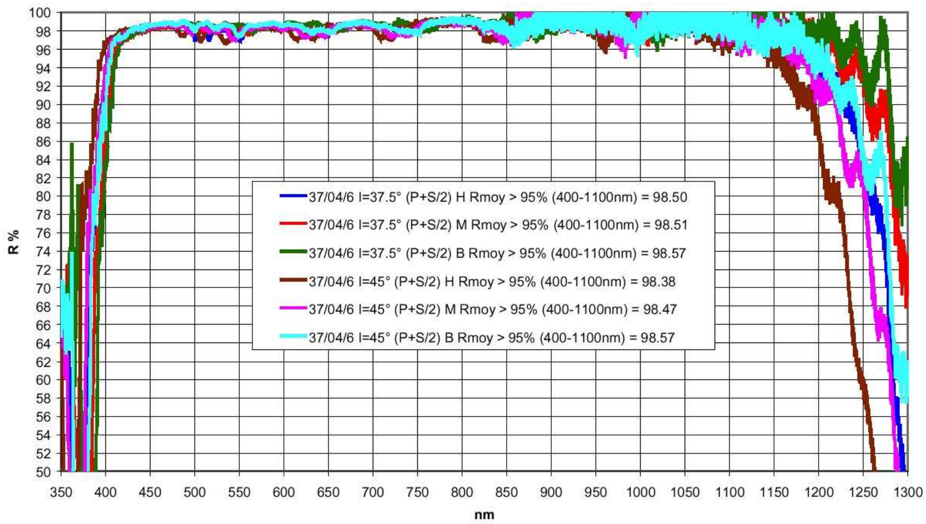

Figure 3 : Broadband dielectric coatings (Sagem, France).

- **Laser**

The laser will be implemented on a large optical bench together with the photo-detection system. It will include 3 ND:Yag cavities, one to produce laser pulses at 20 ps and 50 mJ, the second one for 200 ps and 300 mJ and third one for 2 ns and 1 J. The amplification system will be common for these 3 cavities. It will include a regenerative amplifier that will be able to produce coherent pulse trains.

- **Telescope**

The mechanical part of the telescope is presented in figure 4. Both the azimuthal and elevation rotations, performed until now with endless screws and tooghed wheels, will be replaced by a direct drive system. It will allow to improve the pointing accuracy of the telescope and to increase the speed limit. The cumulated pointing error of the actual system is better than 0.5 arcsec integrated over 1000s (figure 5).

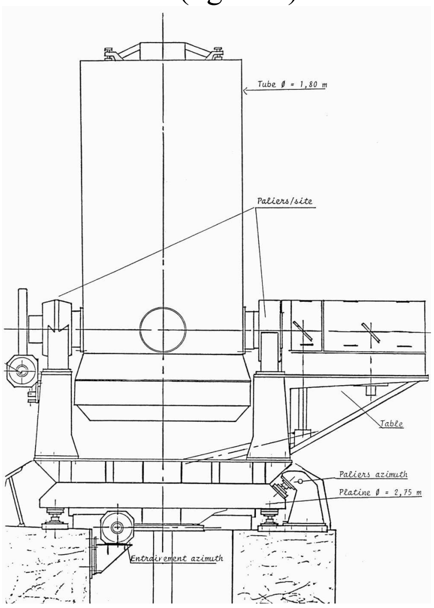

Figure 4 : Telescope.

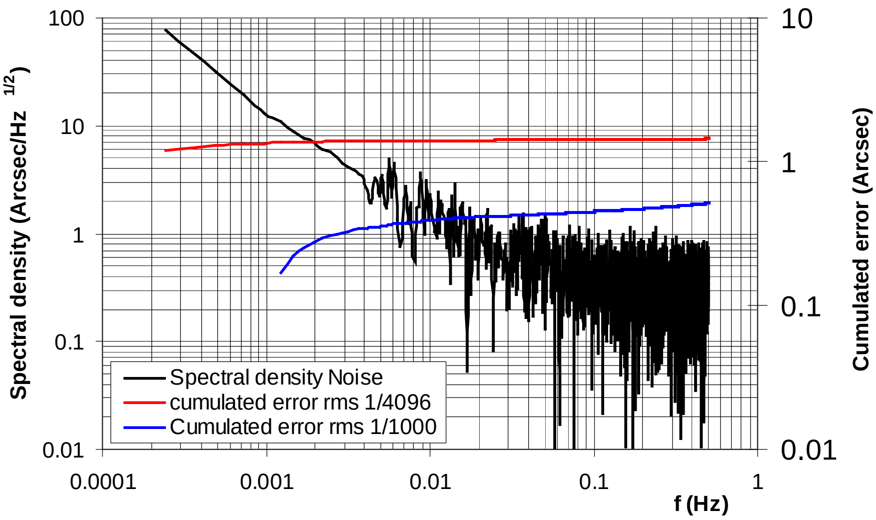

Figure 5 : Spectral density of pointing and cumulated error in arcsec rms.

- **Software**

The software synoptic is shown on figure 6. It will be based on a Win32 client/server architecture. The station will be piloted by a central machine linked through ethernet connections to instrumental machines.

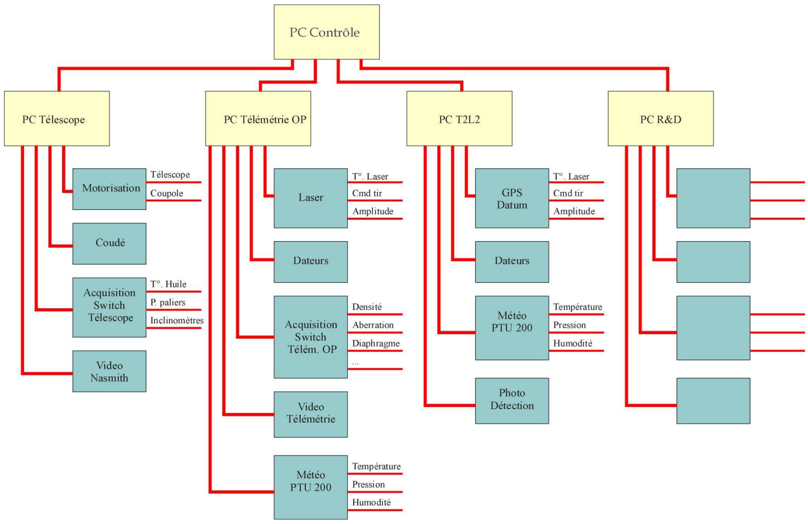

Figure 6 : Synoptic of the MeO station software.

Conclusion and prospective

All these developments are crucial for the future to be able to track both low and high altitude satellites and also to have the capability to integrate new research and development projects on the station. In the medium term, laser ranging in France will be done by the FTLRS station for low altitude satellites and mobile campaigns, and by the MeO station for all targets and specially the moon.

Our future research and development program will include :

- Coherent modulation,
- Femtosecond lasers - Streak camera - multicolor laser ranging,
- Multi-photons detection,
- Cw laser and low noise video for target research,
- Time transfer by Laser Link (T2L2).

Even if this program represents a large amount of work, tracking satellites and tracking the moon will remain the most important task for our station.