

THE OCA LLR STATION - AN UPDATE

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ABSTRACT

The OCA station located in southern France shares its activities between the Moon and high-altitude satellites. Since the last laser WS several technical improvements have been studied or implemented, like an optical device for the correction of the velocity aberration for the satellites. For the Moon we are ready to use the redundant path on the last amplifier of the laser to double the output energy at 800 mJ in 300 ps. A major maintenance on the steering of the dome has been carried out in 2002 to replace the worn-out main rail.

A quality assessment has been performed on three years of range measurements on Apollo 15. The internal consistency per night is excellent, varying between 1 to 15 mm, with no obvious correlation with the number of returns, the number of normal points over each night, the pressure or the lunar libration. Smaller numbers, but with as much scatter, (0.3 to 3 mm) are obtained on the GPS satellites, but with a pulse of only 20 ps. A major effort is underway to automate the observations of the satellites to overcome the chronically under staffing of the station and at the same time increase its efficiency.

In 2001, the station netted 350 normal points on the Moon and more 9500 on the high-altitude satellites. Despite the funding uncertainties and the limited staff we plan to continue the operations on the Moon in the coming years with the main objective of improving the testing of gravitation theories and the comparison of reference frames.

I. MAIN TARGETS AND SCIENTIFIC OBJECTIVES

The main targets are the four reflectors on the Moon and the distant satellites like Lageos, Etalon, Glonass, GPS and LRE. This NASDA satellite has been launched on Aug. 29, 2001 with a very special orbit, between 250 km to 36198 km. The long awaited success came in on the night of Dec. 17 with the first ranging at Grasse LLR, since that time about 2689 normal points have been harvested.

The scientific objectives are:

- For the Moon: geophysics, selenophysics, celestial mechanics, rotation of the Earth and Moon, precession and nutation, terrestrial and celestial reference frames, test of gravitation theories.
- For the distant satellites: orbitography, geodynamics, positioning, comparison of tracking techniques and terrestrial reference frames.

II. RAW DATA PRODUCTION ON THE MOON

The raw data production on the Moon is shown in Fig. 1. The number of returns has decreased because since 2000 we have only one pulse for security reason. On the other hand, the number of normal points has also progresses, except in 1998 and 2001, primarily because of persistent spell of bad weather.

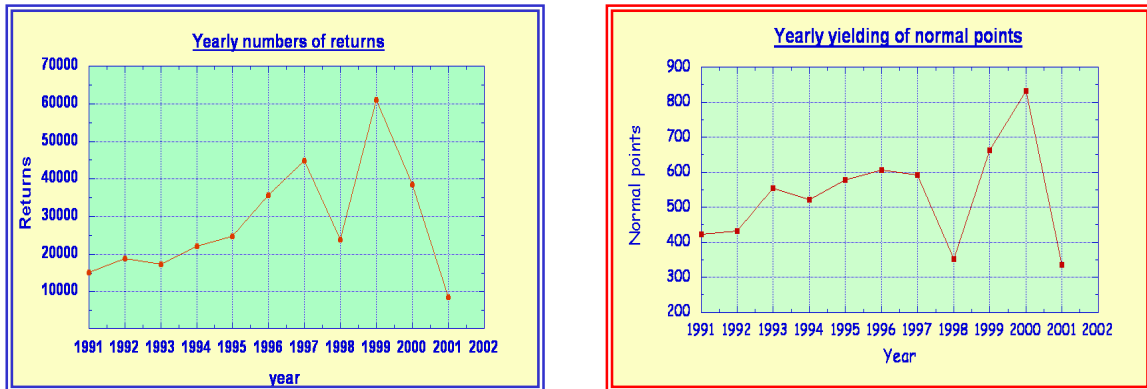


Fig. 1. Yearly number of returns(left) and of normal points (right) at the OCA Lunar Laser ranging station.

III. TECHNICAL EVOLUTION IN THE LASER OUTPUT

Developments are under way to increase the energy of the Moon laser by using an additional amplifier and a double frequency. This will permit to improve the number of returns from the Moon without increasing the noise. The diagram in Fig. 2 shows the three amplification steps and the light path in infrared and visible.

IV. TECHNICAL IMPROVEMENTS FOR DISTANT SATELLITES

- We use another laser with a semi-train and a 20 ps pulse width. It permits to increase the precision on high-altitude satellites. No more than 30 s are needed to switch between the two lasers.
- We have implemented, on the return path from satellites, a wedge plate to correct the angle, between the emission and reception axis, due to the velocity aberration. It should permit to decrease the noise and reduce the scattering of the transit time between the center and the edge of the detection diode.
- We have just started, for the high-altitude satellites, the automation of the observations.

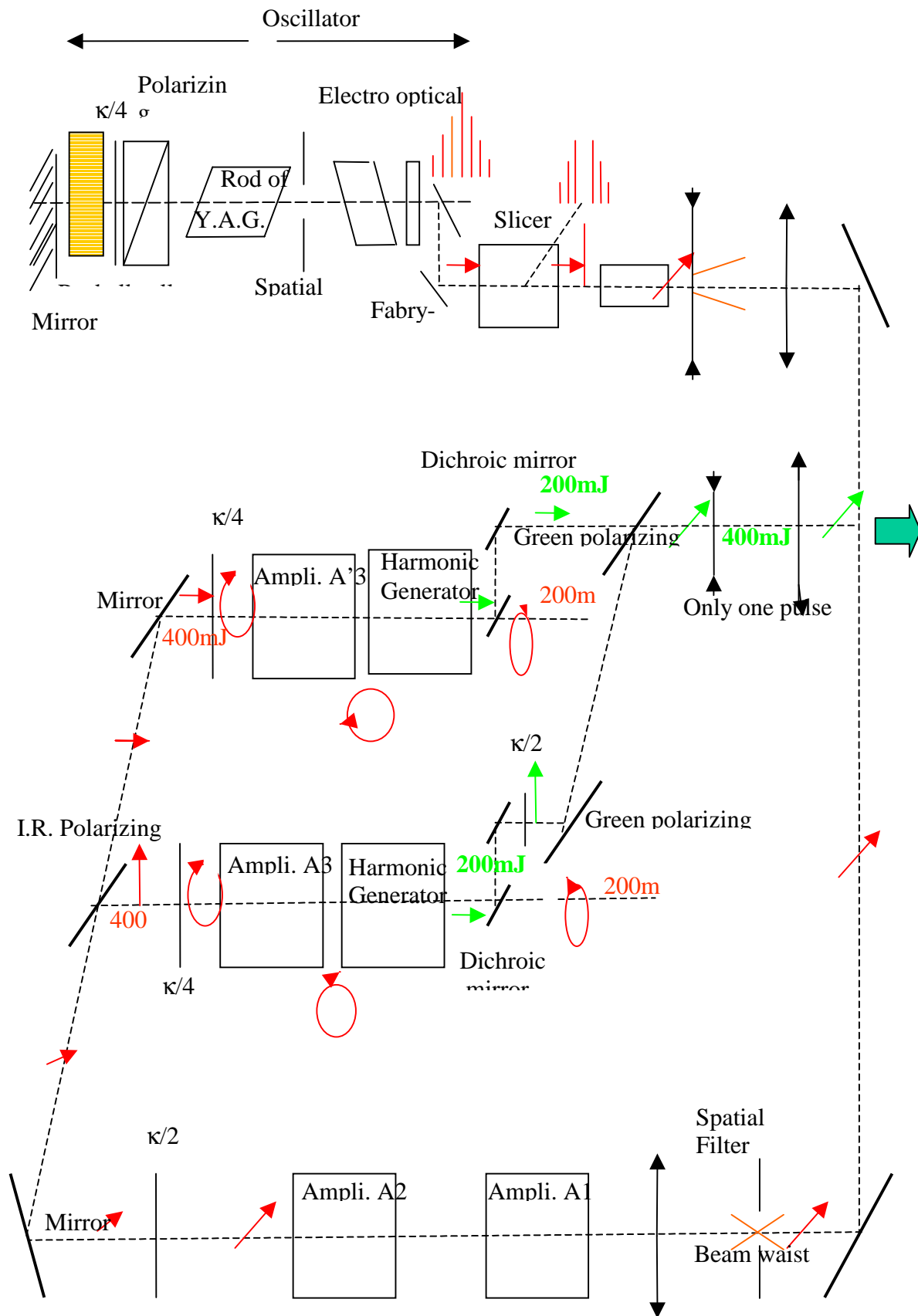


Fig. 2 I.R. YAG laser is in red color; Green laser is in green with arrows indicating the polarization.

- A major maintenance on the steering of the dome has been carried out in 2002 to replace the worn-out main rail.

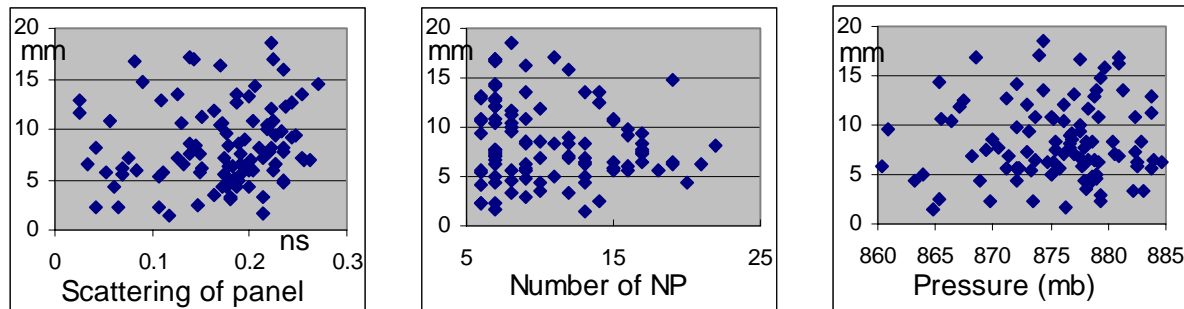


Fig.3. Analysis of the accuracy of the normal points as a function of the orientation of the panel of reflectors (varying with the lunar libration), the number of normal points during the night or the ground pressure. There is no visible trend in these plots.

V. A QUALITY ASSESSMENT

Objective: Evaluate the performances of the Grasse LLR system and try to understand their variations. This seems possible from nights when the number of normal points is superior to 6, on Apollo XV.

Method : We use the same method showed in 12th WS Matera. We add a third degree polynomial fit on residues and compute the Normal Points rms. We analysed 101 nights between Oct.1998 and Dec.2000.

Results : The internal consistency per night is excellent, varying between 1 to 15 mm, with no obvious correlation with the lunar libration, the number of normal points over each night, the pressure, the signal/noise ratio or the number of returns.

If the signal/noise ratio is > 6 , the RMS of the Normal Points is less than 15 mm. If the mean number of returns by serials in the night is larger than 100, the RMS goes down below 10 mm

The sources of these variations are not properly identified: noise, insufficient number of echoes, etc... and variation of the atmospheric properties

VI. CONCLUSIONS

- For 20% of nights, the internal consistency is lower than 5 mm and for 50% falls between 5 and 10 mm.
- Interestingly the internal consistency on GPS 35 and 36 (with similar signatures due to the panel of reflectors) varies between 0.4 mm and 4mm, but with a laser 20ps. It seems that it is a link with the wind speed.

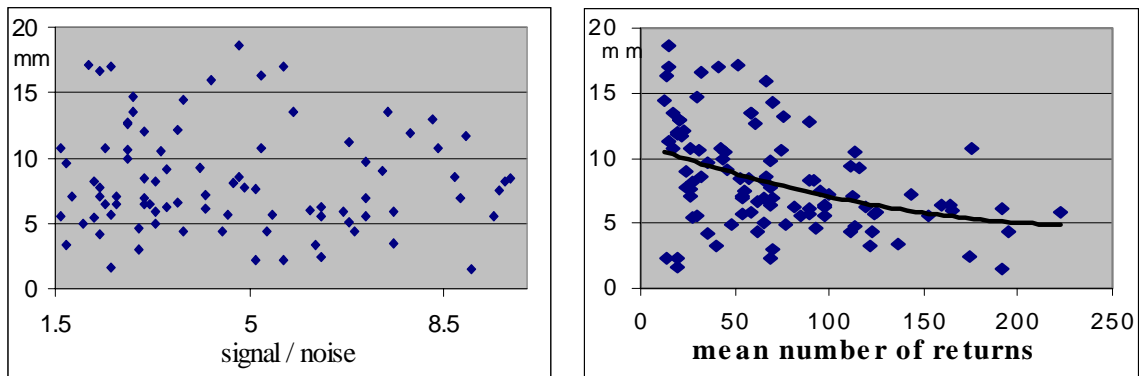


Fig. 4. Analysis of the normal point rms against the signal-to-noise ration and the mean number of returns in these points. In the former case no obvious relation can be established.

- We hope in a near future, thanks to the doubling of the laser energy, to increase the number of returns and the signal / noise ratio, therefore the precision.

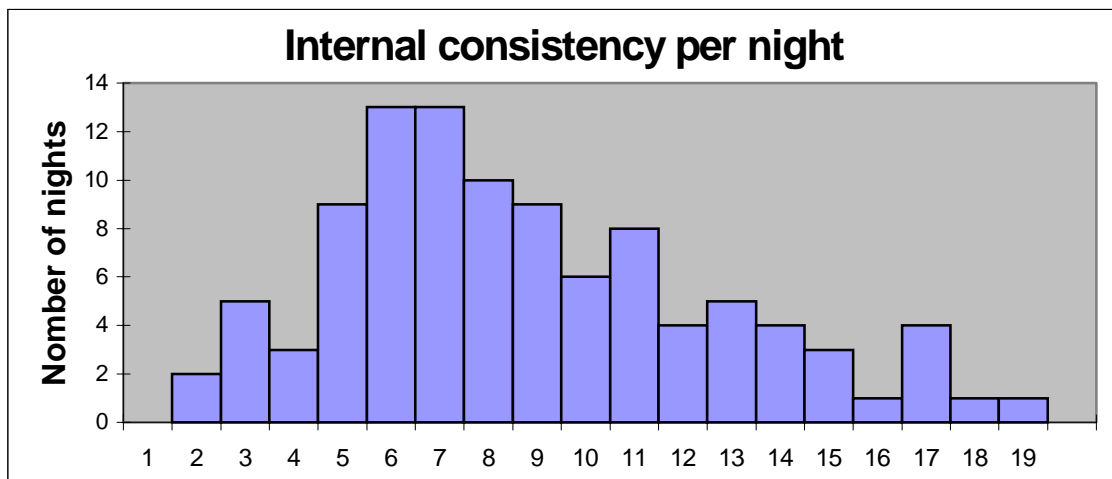


Fig. 5. The plot shows the scatter of the measurements per night expressed in mm in the abscissa.