

# Preliminary assessment of the MLRO observational capabilities

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**Abstract - The Matera Laser Ranging Observatory (MLRO) is a state-of-the-art laser ranging system designed to perform distance measurements to targets orbiting the earth up to lunar distances. The system has a built-in two-color capability to perform measurements of the tropospheric optical delay, and it's now operational at the Italian Space Agency's Space Geodesy Center, located in Matera, Italy, where the final acceptance tests are underway. This paper describes the most significant observational results obtained so far.**



Fig. 1. The Matera Laser Ranging Observatory

## 1 INTRODUCTION

The Matera Laser Ranging Observatory (MLRO) is a no-compromise, multi-mission system designed to perform high-accuracy satellite and lunar laser ranging while supporting advanced (experimental) developments as well as astronomical applications. For a complete description of the system, see Bianco & Selden (1998, 1999).

The system has been installed in a new building, located at the Italian Space Agency's (ASI) Space Geodesy Center (CGS), in January, 2000, and saw its first light in the spring of the same year. Final debugging and refinements took about one year to be accomplished, and the system is now fully operational and ready to undergo the formal, final acceptance tests.

## 2 SATELLITE OBSERVATIONS

One of the most important features of the MLRO system is its very high precision (of the order of a few mm single-shot RMS), together with a very high observational efficiency, close to 100% for LAGEOS-class satellites in good observing conditions. Those features, other than being specified in the design, were first tested during the collocation experiment carried out at the NASA Goddard Geophysical and Astronomical Observatory in the fall of 1998, as described in [2].

After the system has been installed in Italy, several observational sessions have been performed, which confirmed the MLRO as the currently most precise such instrument in the world for civilian applications.

The figures in the following pages (Figure 2 to 7) illustrate the results of typical SLR observational sessions on several commonly laser-ranged satellites. For each satellite, the figure contains:

- A scatter plot of the orbital residuals as a function of the observing time
- A 2-dimensional periodogram of the orbital residuals
- A 3-dimensional wavelet spectrum of the orbital residuals, where the color indicates the spectral power from blue (low) to red (high).

The results of the spectral analyses confirm the existence of millimetric signatures, of geometric origin, in the orbital residuals. Moreover, the wavelet analysis shows that spectral features "rise" and "set" while the satellites move

with respect to the observatory during the pass over it. This result is potentially very important and investigation is underway to fully exploit this unique capability, which may lead to the instantaneous determination of a satellite orientation.

In the case of the LAGEOS-2 spacecraft (a passive spherical satellite covered with 426 retroreflectors, 60 cm in diameter, mass of over 400 kg, in a circular orbit at an inclination of  $52^\circ$  and an altitude of about 6000 km), the MLRO data have led to the first determination ever of the spacecraft rotation rate as well as its decay in time by means of SLR observations, as announced in [2] and fully described in [3]. The migration of the spectral lines (rotational signals) towards lower frequencies is evident by comparing Figures 6 and 7. Figure 8 clearly depicts the exponential period increase.

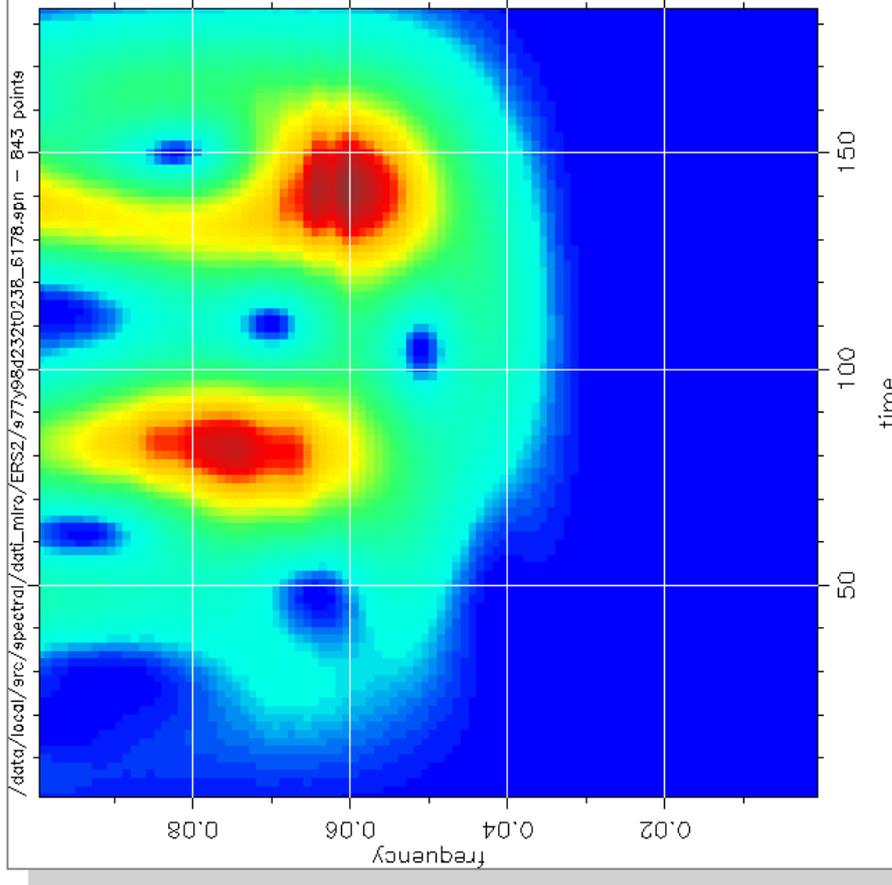
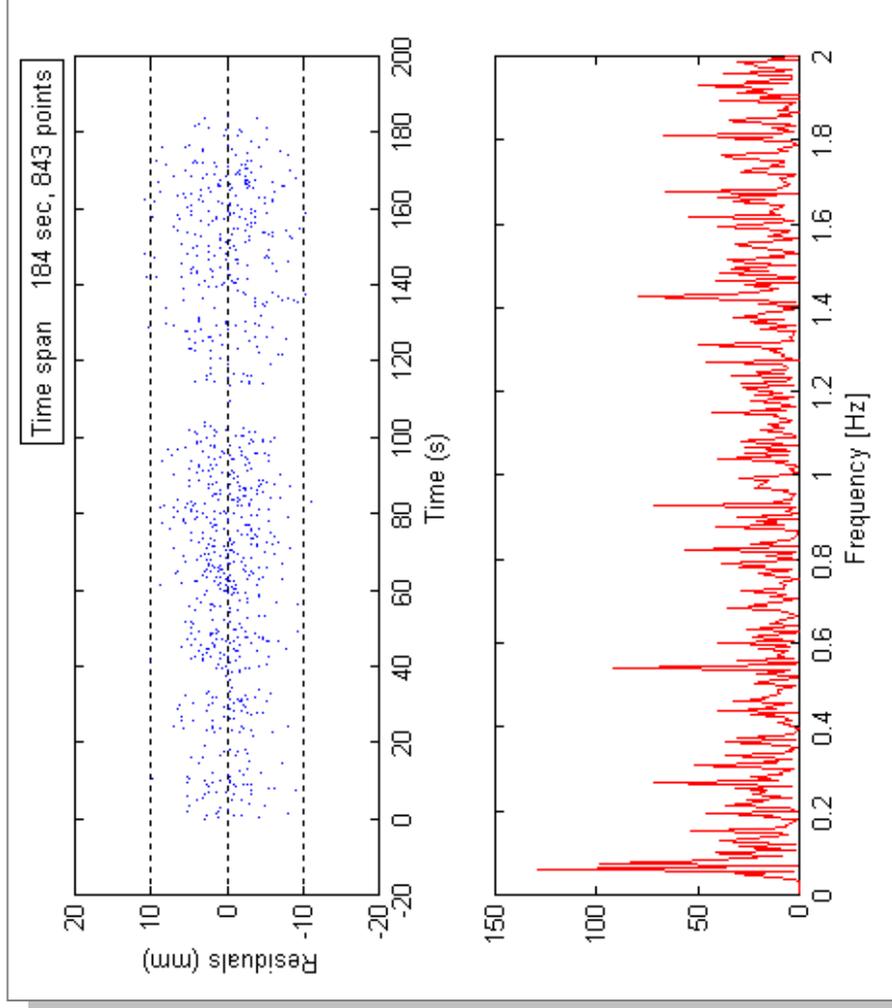


Fig. 2. ERS-2 residual analysis

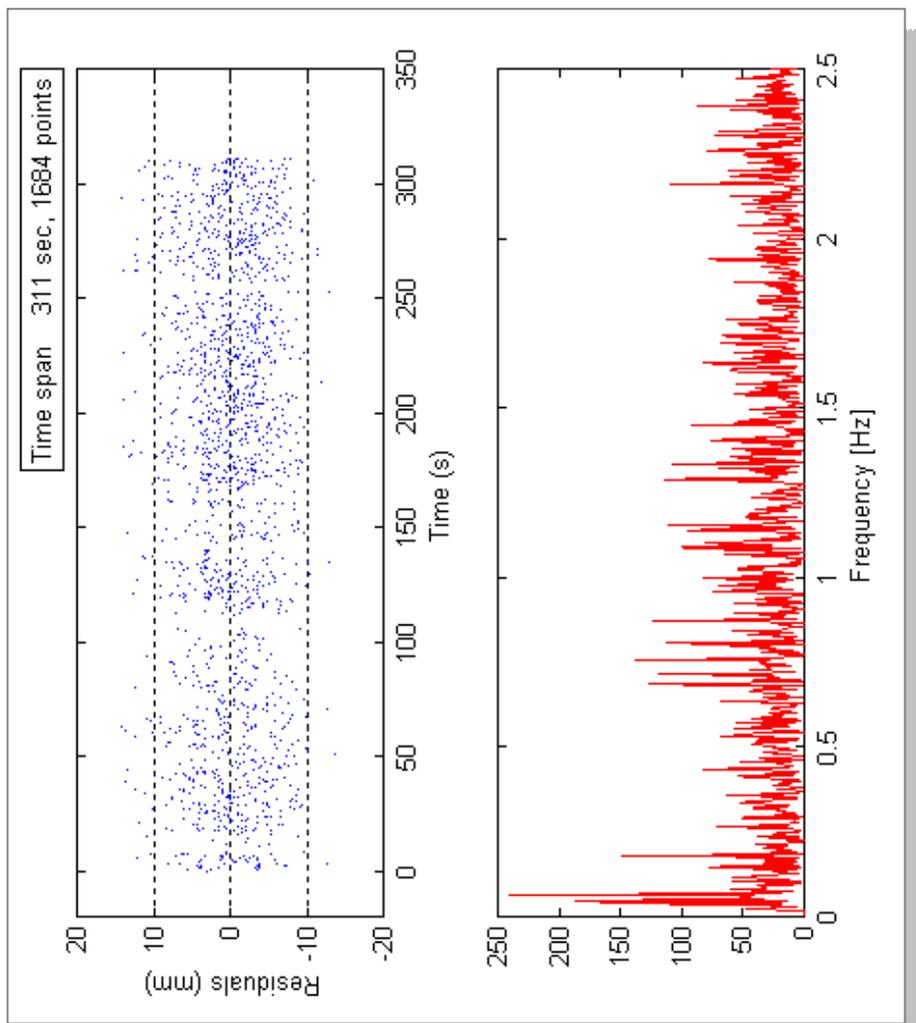
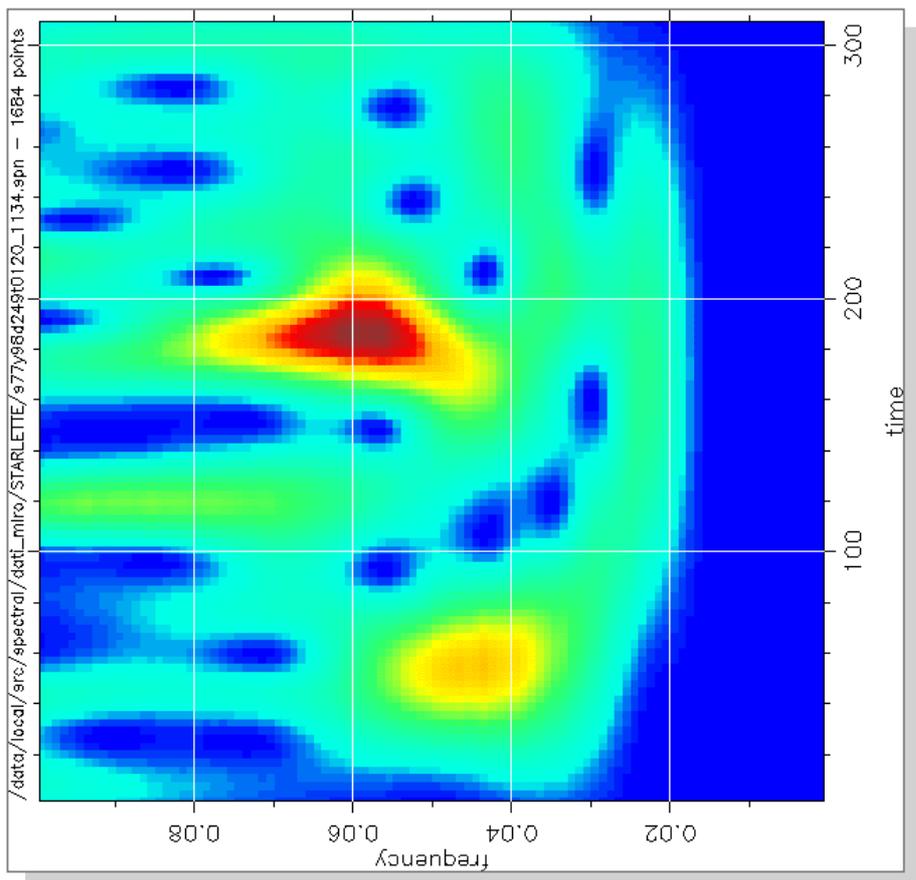


Fig. 3. Starlette residual analysis

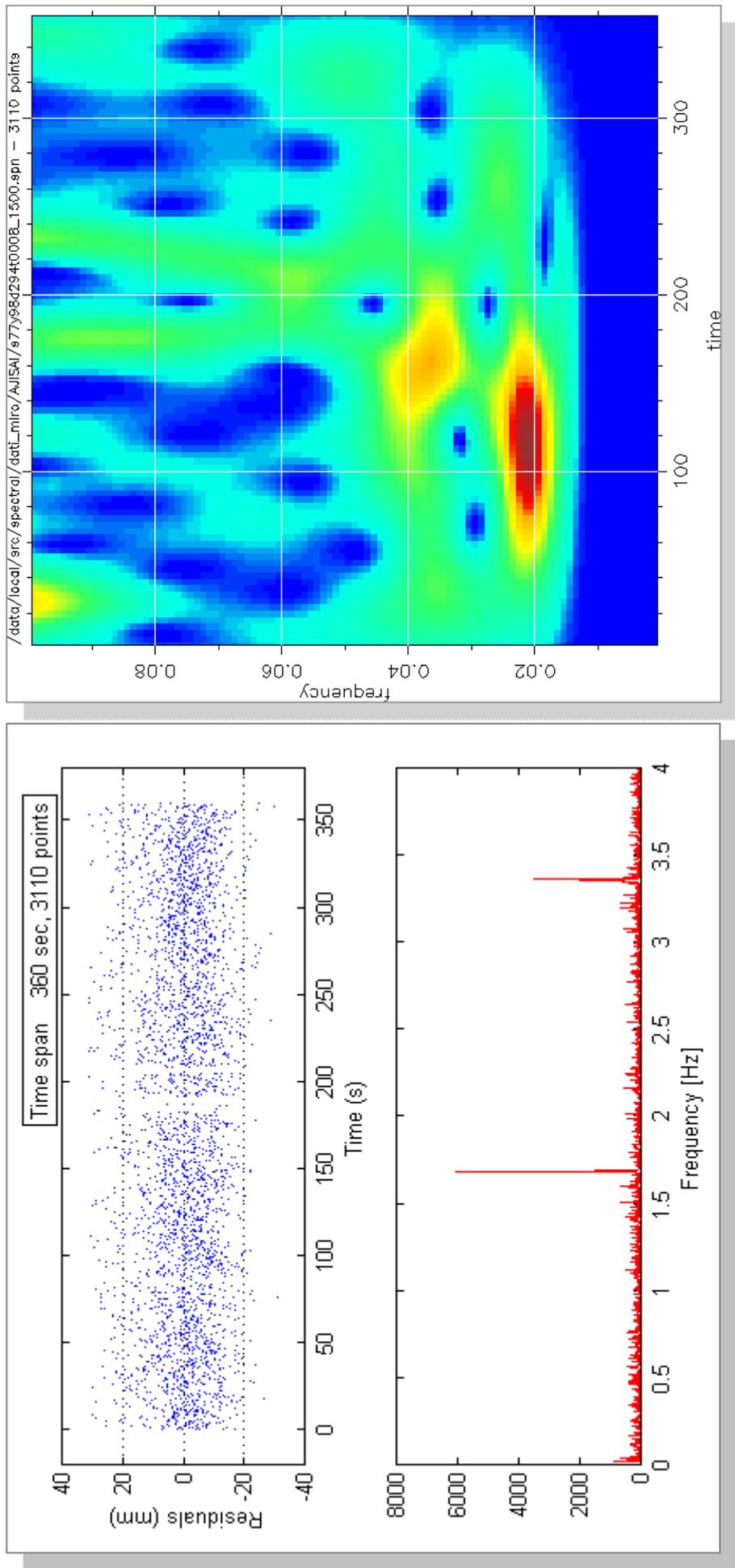


Fig. 4. AJISAI residual analysis

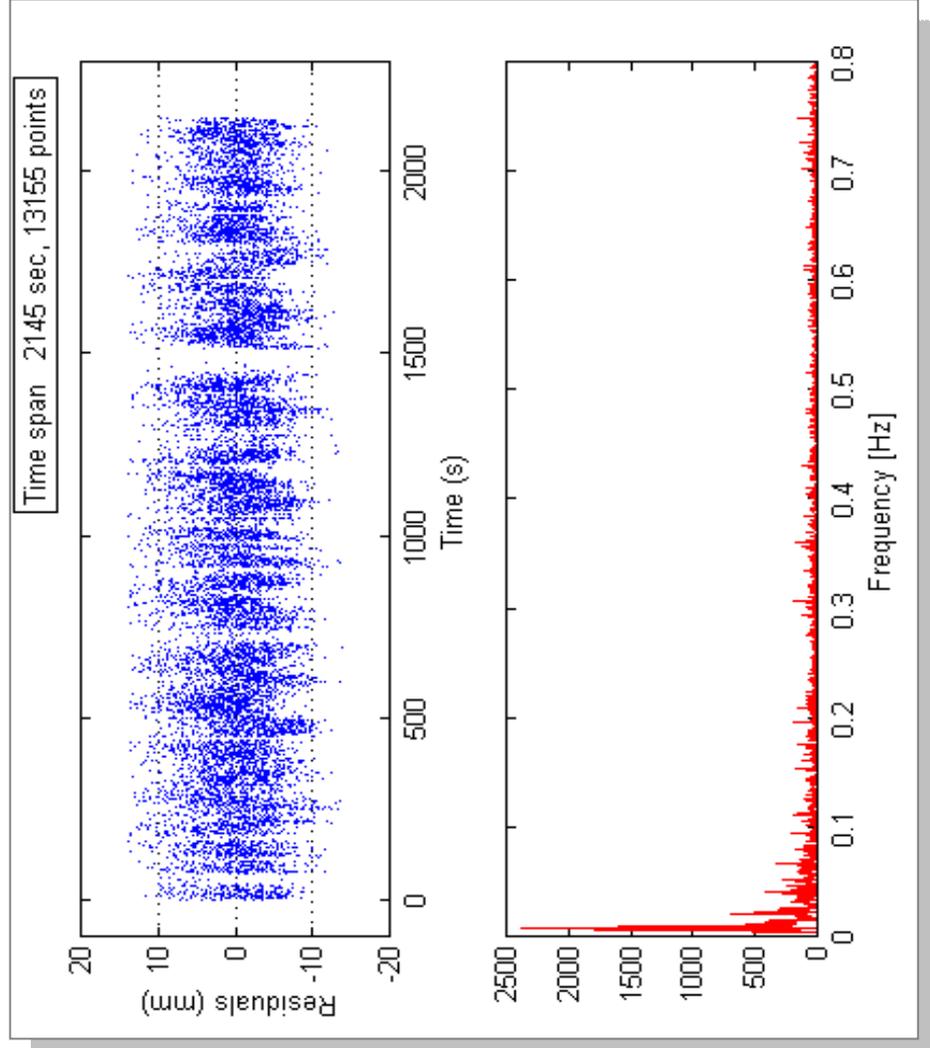
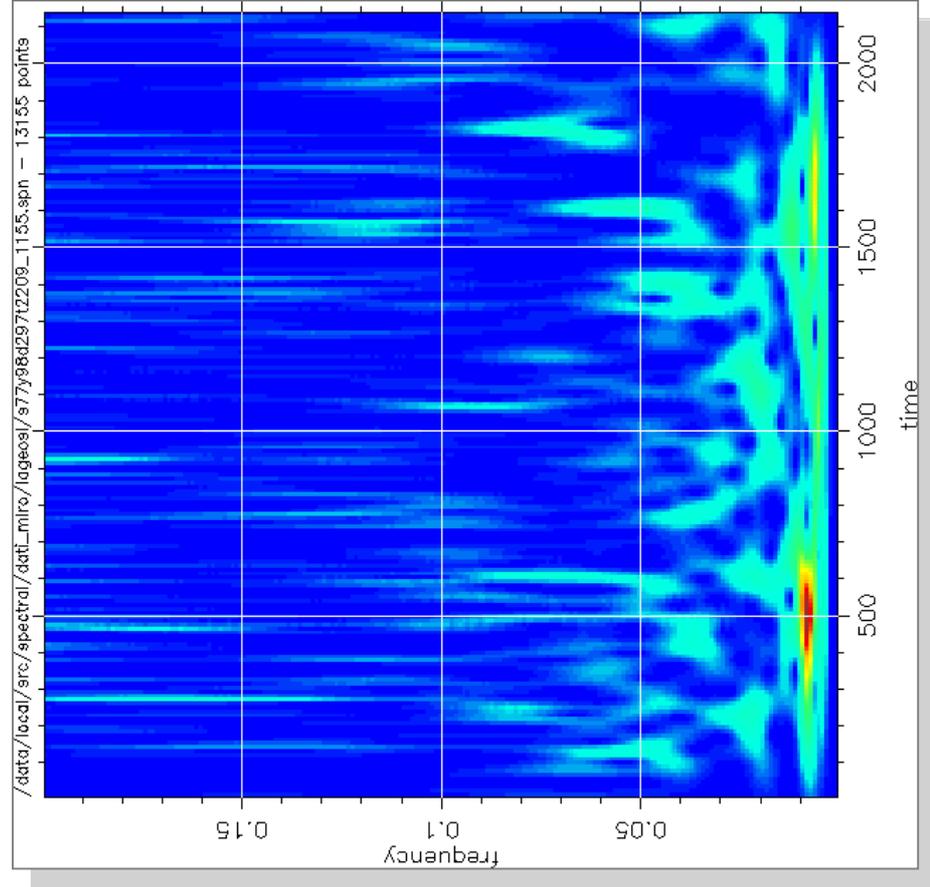


Fig. 5. LAGEOS-I residual analysis

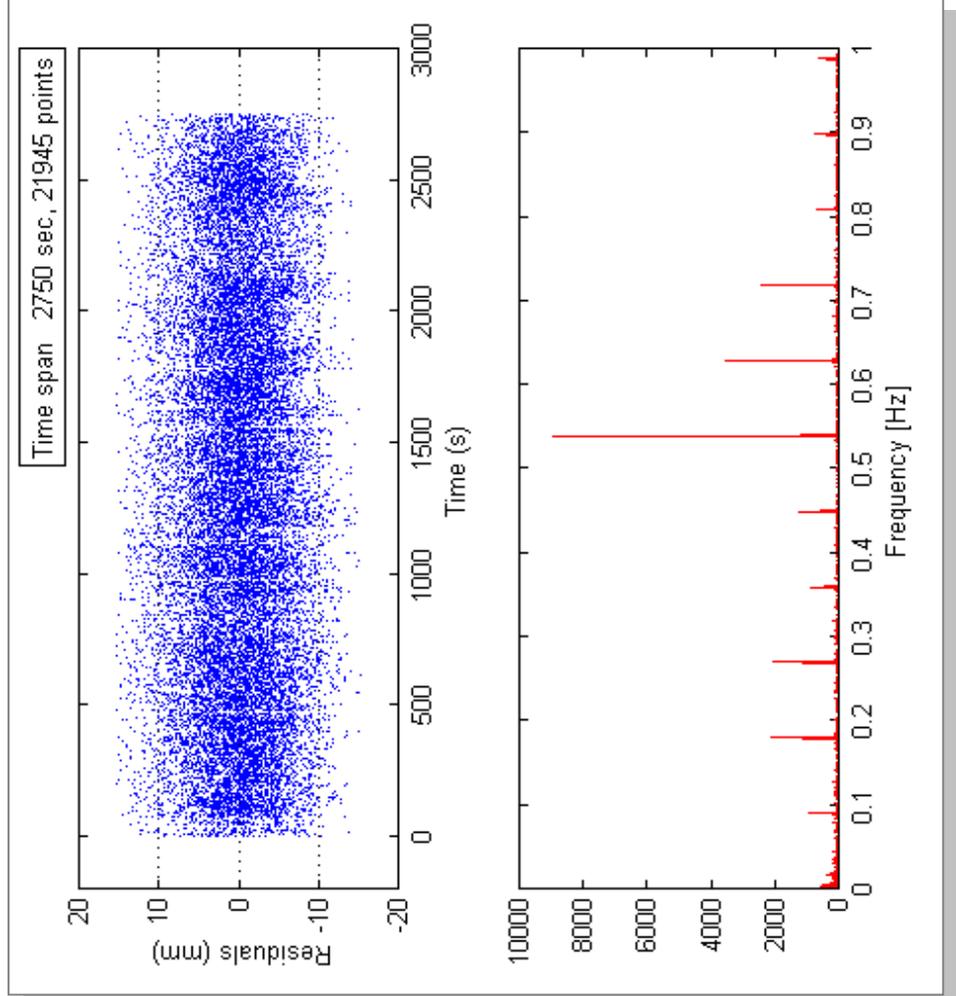
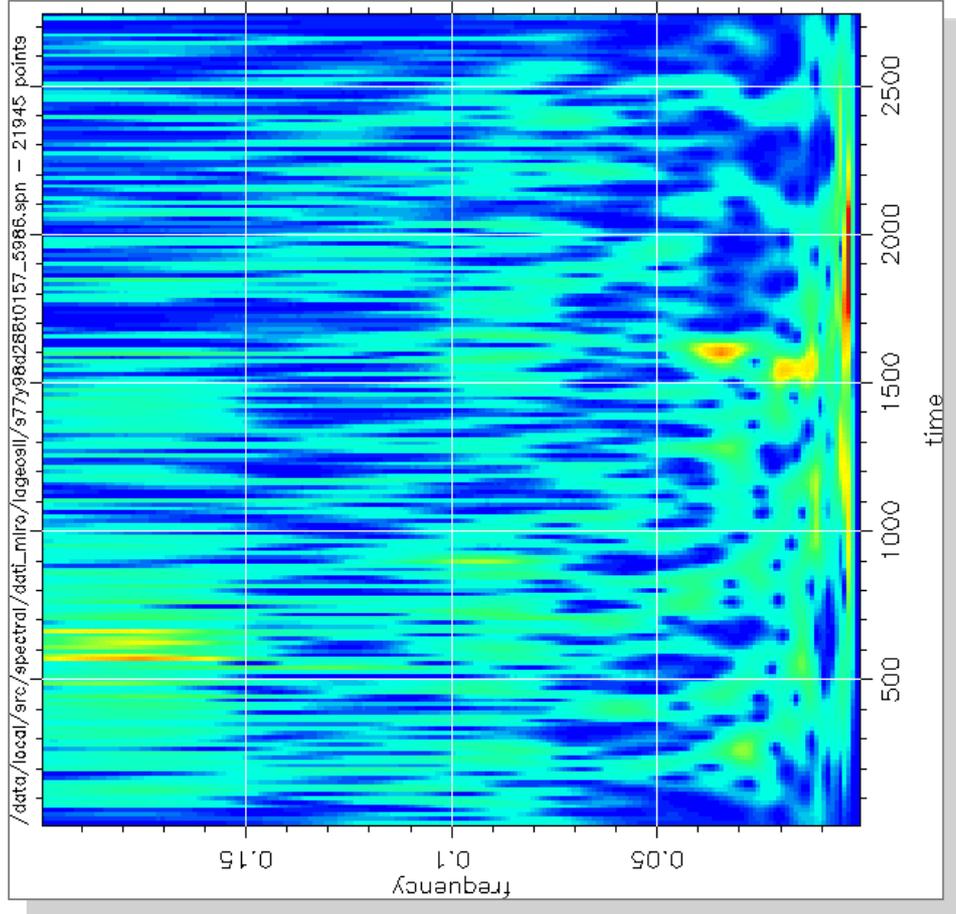


Fig. 6. LAGEOS-II residual analysis (October 15<sup>th</sup>, 1998)

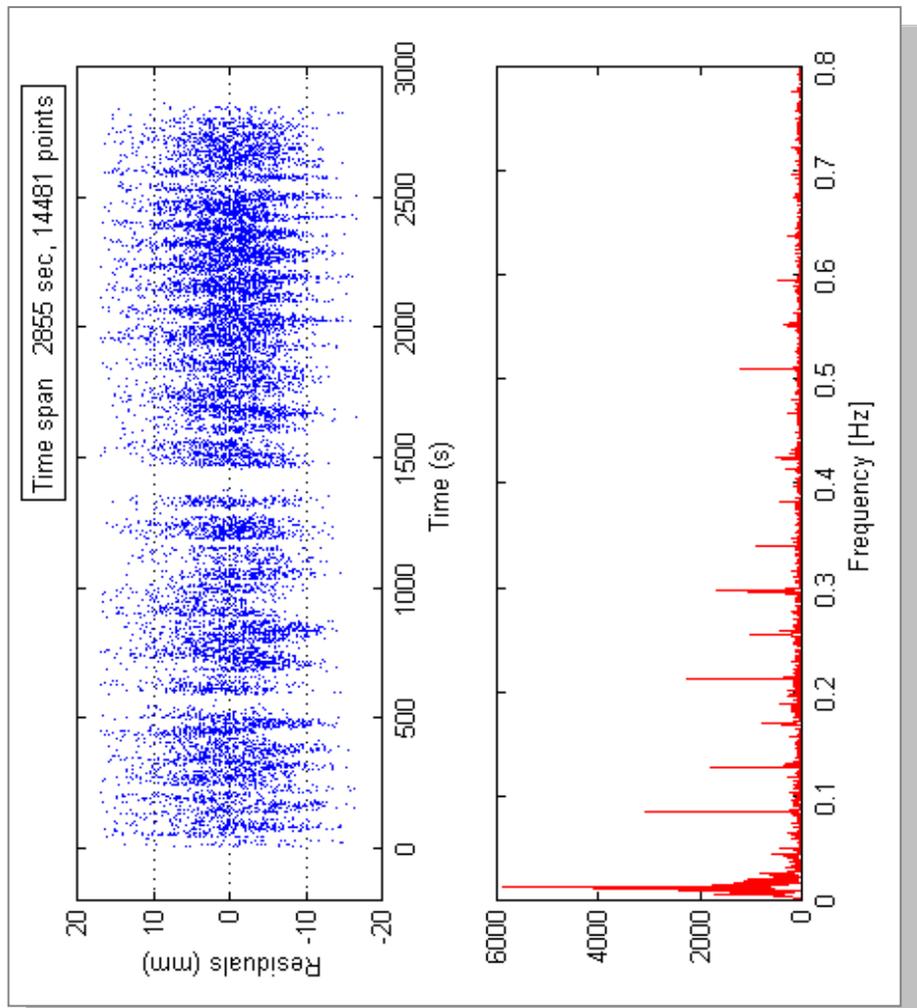
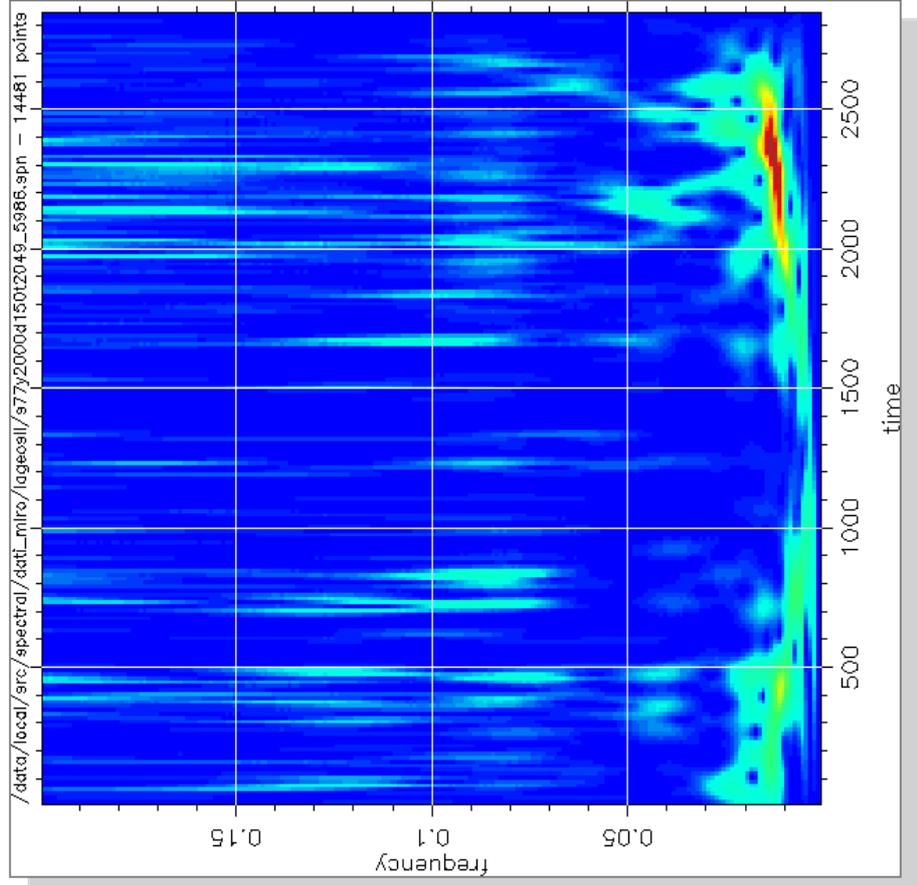


Fig. 7. LAGEOS-II residual analysis (May 29<sup>th</sup>, 2000)

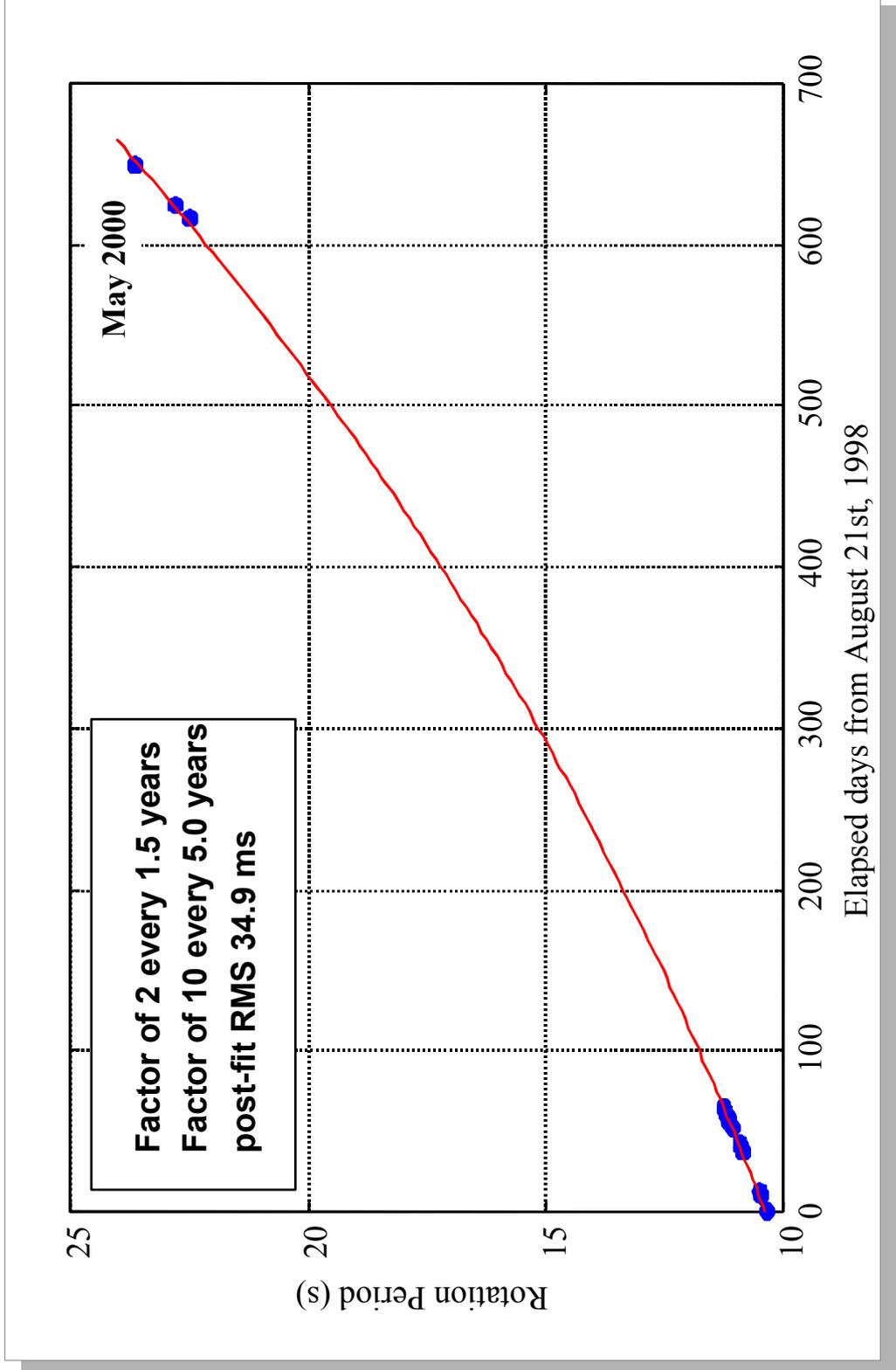


Fig. 8. LAGEOS-II down-spinning rate determination

### **3 CONCLUSIONS**

During its first year of operations, the MLRO system data yield extremely good results, the most important one being the first ever direct determination of a laser-ranged satellite rotation period.

The observing site has proven to be very good, featuring 1-2 arcseconds (occasionally, sub-arcsecond) seeing conditions.

Two color observations at 532 nm and 355 nm wavenghts are currently being performed using either a two-channel micro-channel plate photomultiplier set up or a 700 fs resolution streak camera. This capability will allow a direct determination of the differential tropospheric delay. Routine lunar laser ranging observations will start soon as well.

### **4 REFERENCES**

- [1] G. Bianco, M. Selden, "Matera Laser Ranging Observatory System", in M. De Sario e A. D'Orazio (eds.), Atti del 5° Convegno Nazionale "Strumentazione e Metodi di Misura Elettrootici", Matera, 12-14 maggio 1998
- [2] G. Bianco, M. Selden, "The Matera Laser Ranging Observatory", Proceedings of the ODIMAP II, University of Pavia, Italy, May 20-22, 1999, 253
- [3] G. Bianco, M. Chersich, R. Devoti, V. Luceri, M. Selden, "Measurement of LAGEOS-2 Rotation by Satellite Laser Ranging Observations", Geophysical Research Letters, Vol.28, No.10, 2001, 2113-2117