

# Calibration of System Delays in the European Laser Timing to 10 ps Accuracy

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Recently the European Laser Timing (ELT) experiment is under preparation. It is an optical link prepared in the frame of the European Space Agency (ESA) mission “Atomic Clock Ensemble in Space” (ACES)<sup>1</sup>. The objective of this laser time transfer is the synchronization of the ground based clocks and the clock on board the International Space Station with precision of the order of units of picoseconds and the accuracy of 50 ps. We are reporting on a progress in calibration of the system delays involved

The technique is relying on the existing ground based infrastructure used for satellite laser ranging (SLR). In order to reach the ultimate precision and accuracy the ground systems participating in time transfer have to be properly calibrated for this purpose. The new tool “ELT Calibration Device” is currently under construction. The device is a “twin” of the flight module of the ELT detector operating in space. It is planned to be operated successively on the participating SLR stations to characterize the ground segment timing performance prior to the mission launch. The calibration principle is plotted in Fig. 1.

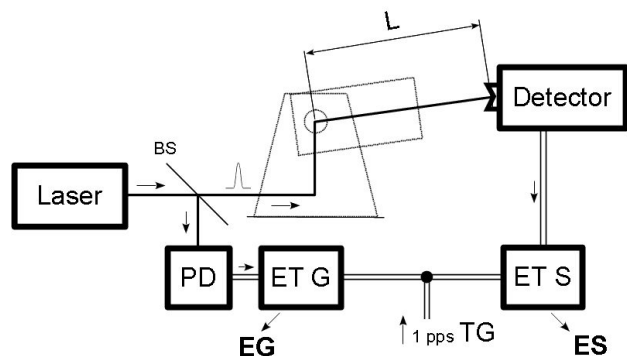


Fig. 1: Principle of the ELT system delays calibration. The “Detector” and ETS represent the Calibration Device, the rest corresponds to the SLR system.

Considering the experiment setup the calibration constant  $B$  for ELT related to the particular ground station can be evaluated as  $B = L / c - (ES - EG)$ , where  $L$  is a separation of reference points,  $c$  is a group speed of light,  $ES$  and  $EG$  are the epoch readings of Even Timers. The distance  $L$  is of the orders of meters, it can be determined with accuracy better than one millimeter (3 ps). The accuracies of the Event Timers are of the order of units of picoseconds. Hence the accuracy of determining the calibration constant  $B$  well below 5 ps is achievable. Considering the ELT principle and its systematic errors other contributors, one can conclude, that the resulting systematic errors of ELT below 10 ps is achievable.

The first field calibration results acquired at the SLR Station Wettzell, Germany, will be presented.

<sup>1</sup> U. Schreiber, I. Prochazka, P. Lauber, U. Hugentobler, W. Schafer, L. Cacciapuotti, R. Nasca: *The European Laser Timing (ELT) experiment on-board ACES*, Proceedings of the European Frequency and Time Forum, International Frequency Control Symposium, Besancon, France, April 20-24, 2009.