MODERNIZATION OF THE BOROWIEC SLR SYSTEM

J. Bartoszak, S. Schillak
Space Research Centre of the Polish Academy of Sciences
Astrogeodynamic Observatory, Borowiec
sch@cbk.poznan.pl / Fax: +48-61-8170-219

Abstract

The poster presents the process of quality improvement of the satellite laser ranging system in Borowiec performed in the period 2002-2003. The following new devices were installed: time interval counter STANFORD SR620, fast start photodiode and Constant Fraction Discriminator TENNELEC TC-454 in start and stop channels. The realization consists several steps; installation and examination of a new counter, correction of the amplitude and shape of laser pulse by means of the fast photodiode, regulation of discriminator delay and levels for start and stop channels. All these works were finished in May 2003. The single shot precision and normal point precision was improved from 30 mm to 18 mm and from 7 mm to 4 mm respectively. Two centimeters systematic deviation of STANFORD time interval counter was eliminated. The better stability of the system delay vs amplitude of stop signal was observed. The accuracy of the Borowiec SLR data obtained from the results of the several orbital centers confirmed the improvement of the quality of the satellite laser ranging system in Borowiec.

Introduction

The paper presents the process of improvement the quality of the Borowiec SLR data performed in the period 2002-2003. The electronic system hitherto in used based on old Time Interval Counter PS-500 with accuracy 80 ps, Maximum Likelihood Timing Discriminator B6 and avalanche photodiode for start pulse introduced single shot precision on the level of 3 cm. Installation of the new devices allowed for near two times reduction of standard deviation of the satellite measurements.

The modernization of the Borowiec SLR system included in 2002 and 2003 the following tests and new devices:

- comparison tests of Borowiec Time Intervals Counters STANFORD SR620-A and SR620-B in Herstmonceux - 1-13 March 2002
- Time Interval Counter PS-500 replaced by STANFORD SR620-A - 7 May 2002 installation of neutral filters wheel - 25 October 2002
- Time Interval Counter STANFORD SR620-A replaced by STANFORD SR620-B - 15 November 2002
- installation a new fast photodiode in start channel - 19 November 2002
- discriminator TENNELEC TC-454 in start channel - 19 November 2002
- discriminator B6 replaced by discriminator TENNELEC TC-454 in stop channel - 29 March 2003
- installation of spatial filter - 18 May 2003

The system after modernization is presented in Figure 1.

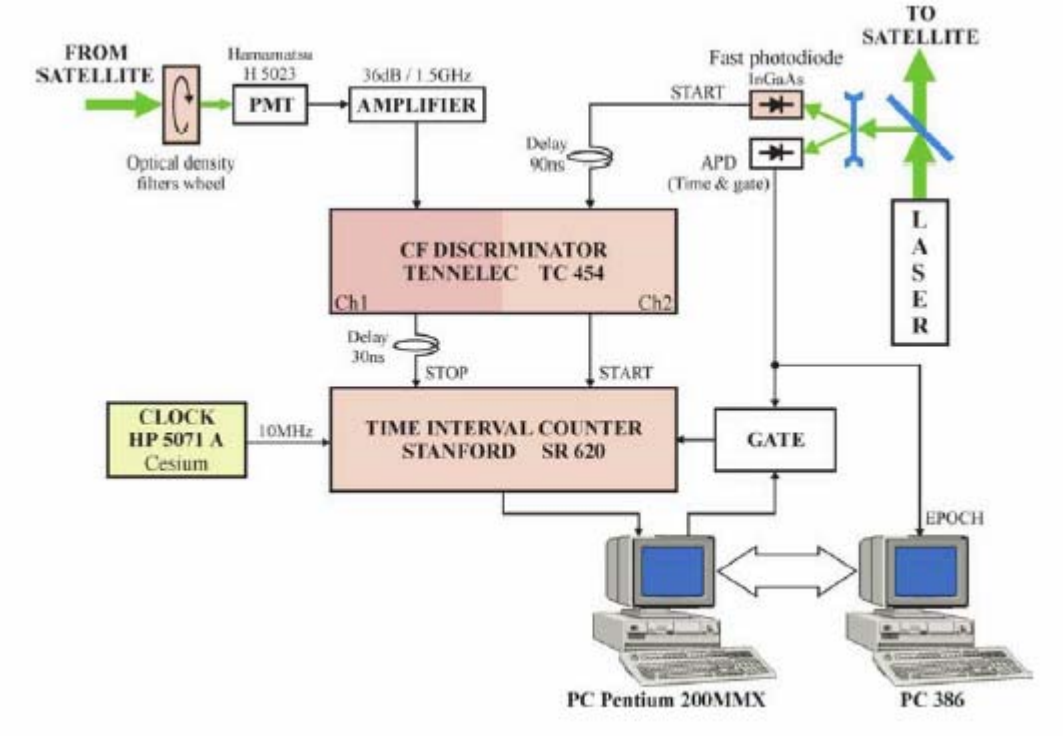

Figure 1. The scheme of the Borowiec SLR system.

Table 1. Comparison of the time intervals counters PS-500 and STANFORD SR620

	PERIOD	ORBITAL RMS (mm)	RANGE BIAS (mm)	PRECISION (mm)
PS-500	1998.05.01-1998.05.18	30	-22	6
STANFORD	1998.05.19-1998.06.10	53	-48	10
PS-500	1998.06.11-1998.06.30	28	-27	5
PS-500	2002.01.01-2002.04.11	28	-5	9
STANFORD	2002.05.17-2002.11.30	48	-38	6
STANFORD	2002.12.01-2003.02.28	28	-18	4

Time Interval Counter

The experiments performed with time interval counter STANFORD SR-620 in 1998 show about 2 cm systematic shift in comparison to the counter PS-500 (Table 1). The tests performed for both Borowiec STANFORD counters in Herstmonceux in March 2002 didn't confirm of this shift (Fig. 2). The maximum systematic deviations for both counters for the distance to LAGEOS were on the same several picoseconds level (Gibbs et al., 2002). The STANFORD SR620 was used in the Borowiec SLR system from May 2002. The two centimeters systematic shift was confirmed again (Table 1). The testing experiments revealed that the reason was a mistake in counter gating. The mistake was eliminated in December 2002.

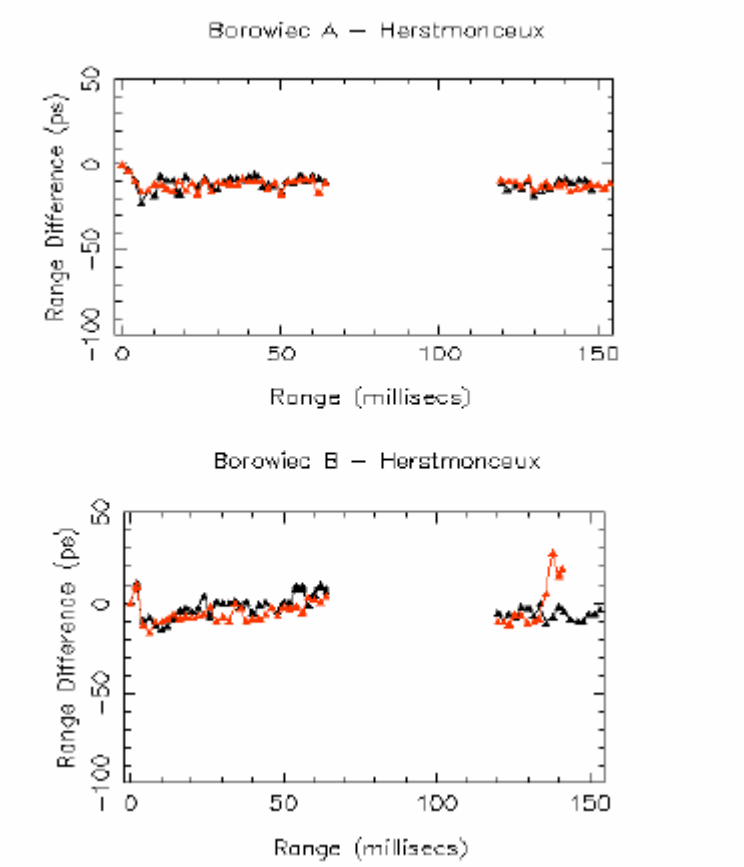

Figure 2. Comparison tests between Herstmonceux STANFORD SR620 timer and Borowiec SR620 timers (A and B) – two series of measurements (black and red), (Gibbs, Herstmonceux 11-13 March 2002)

Start photodiode and discriminator

The second step in upgrading of the Borowiec SLR electronics was installation of the fast start photodiode and Constant Fraction Discriminator TENNELEC TC-454. The start pulse from new photodiode is presented in figure 3, the old start signal from avalanche photodiode is used now as start pulse for epoch registration and gate generator (left pulse in down part of figure 3). The use of time interval counter STANFORD SR620 and fast photodiode open possibility for installation of CF discriminator TENNELEC TC-454, first in start channel and then in stop channel after regulations of the levels and delay for achievement the best parameters of discriminator. The photo of new electronic system is presented in figure 4.

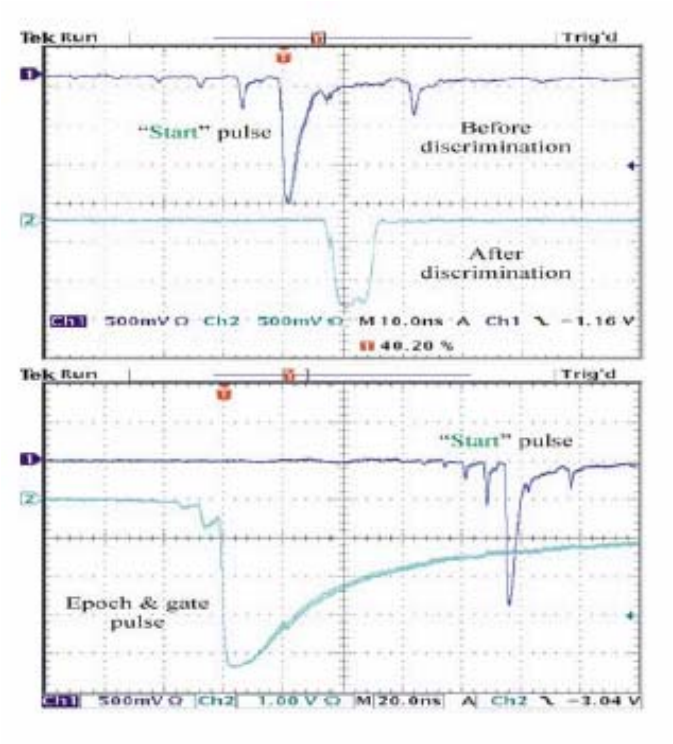

Figure 3. Start and epoch-gate pulses

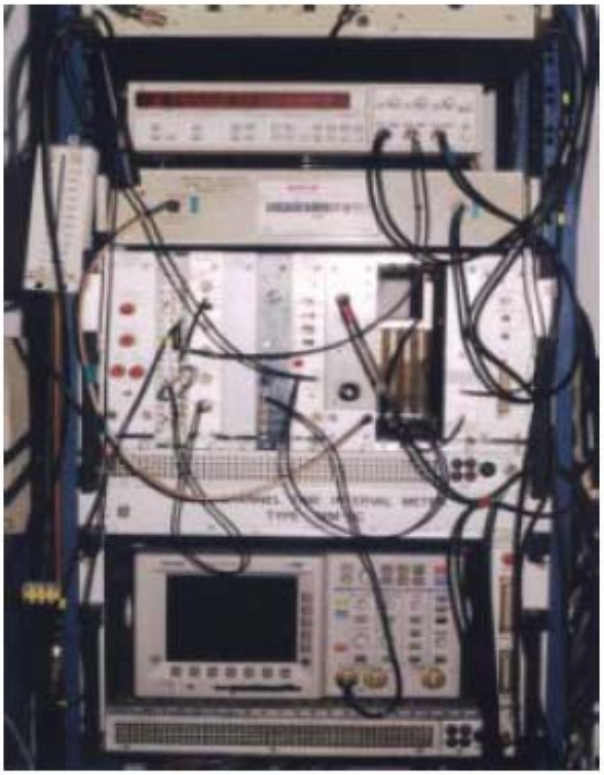

Figure 4. Measuring system: Time Interval Counter **STANFORD SR620**
Amplifier **HAMAMATSU C5594**
CF Discriminator **TENNELEC TC454**
Oscilloscope **TEKTRONIX 3052B**

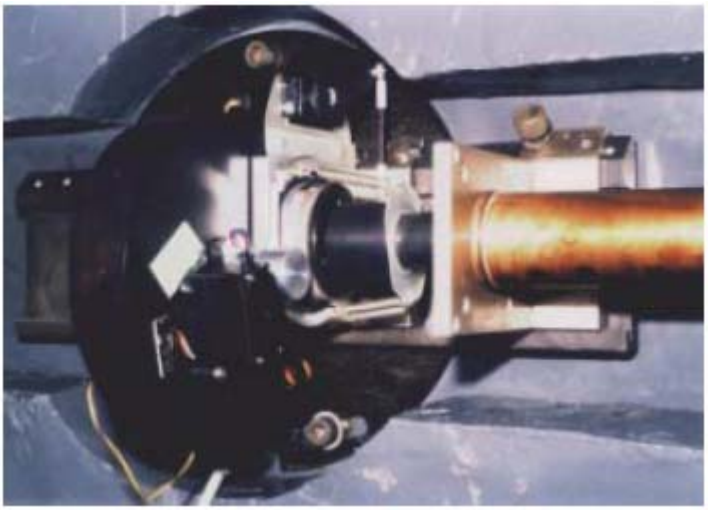

Figure 5. Photomultiplier HAMAMATSU H5023 with filters wheel, diaphragm and green filter

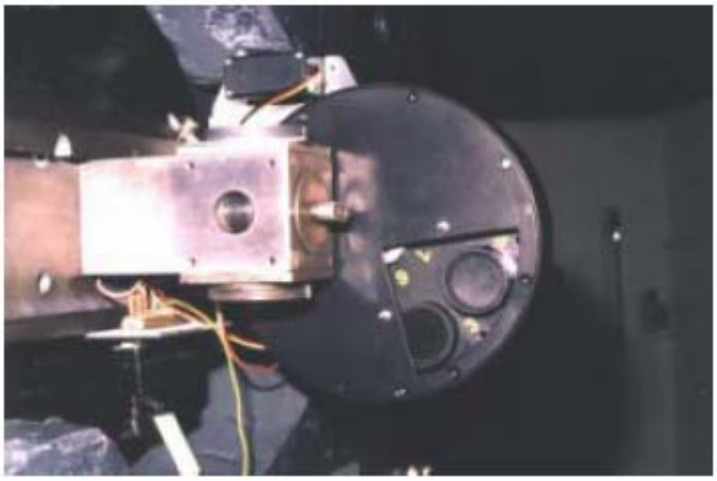

Figure 6. Filters wheel

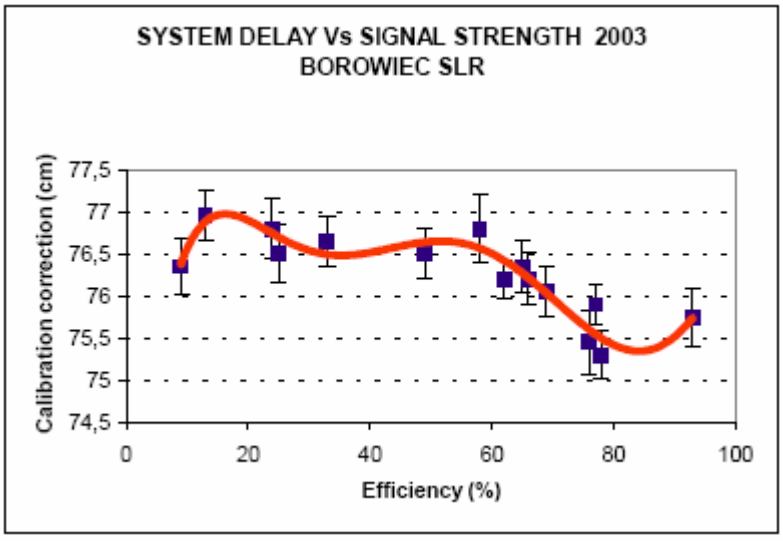

Figure 7. System delay vs signal strength

Table 2. Effect of the Borowiec SLR system modernization

	Before (mm)	**After (mm)**
Single shot standard deviation	30	18
Normal points standard deviation	7	4
Overall system accuracy	18	10

Conclusions

As the effect of modernization of the Borowiec SLR system is near two times better precision and accuracy of measurements (Table 2). The precision is presented on the ILRS web page http://ilrs.gsfc.nasa.gov/stations/sitelist/charts/BORL_LAGEOS_RMS.gif .

The jump of RMS in March 2003 is visible. The accuracy of the Borowiec SLR data obtained from results of the four orbital centers in the form of short term stability on the level of 10 mm confirmed the improvement of the quality of the satellite laser ranging system in Borowiec http://ilrs.gsfc.nasa.gov/docs/2003q2_short.gif .

The next step needed to enhance the accuracy of the Borowiec SLR to a level below 1cm is the implementation of a microchannel photomultiplier (MCP) and an event timer ensuring a precision below 10 ps. Improvement of the pointing accuracy of the telescope is important for an increase in the tracking efficiency to more than 100 points per a normal point, high satellites tracking, in future Galileo, and daylight observations. This improvement would demand a substantial modernization of the telescope, which is planned in the next few years.

Acknowledgements

The authors wish to thank Philip Gibbs and staff of Herstmonceux SLR station for tests of the Borowiec time interval counters. This work has been supported by the Polish Committee for Scientific Research within grant no. 9T12E02419 (July 2000 to June 2003).

References

Gibbs P., Koidl F., Kirchner G. (2002). *Range Comparison Results for Various EUROLAS SLR Timers*, Proc. 13th International Workshop on Laser Ranging, Washington, 7-11.10.2002.