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The preliminary Results of SLR with 10kHz Laser System at Shanghai Station

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Abstract: *Since September 2009 Shanghai Observatory have started routinely kHz repetition rate SLR and now the kHz SLR system can track to ILRS satellites (from 400km to 36000km) in daylight and at nighttime. Based on the kHz SLR system, the upgrading of Range Gate Generator, SLR data acquisition and controlling software and data post-processing software were performed successively at the past years to meet the requirement of 10 kHz repetition rate SLR. Through the cooperation with the Chinese institute, Shanghai Observatory installed a set of 10Hz repetition rate laser system with the power of about 3W, pulse-width 50ps, and divergence 0.5mrad. The RMS of calibration of ground targets is about 8-10mm for the 10 kHz laser. Through adopting the working mode of the two computers, Event Timer and CSPAD detector same as the kHz SLR, the SLR measurement to ILRS satellites with the 10 kHz repetition rate laser are successfully implemented. The measured satellites are from LEO to HEO with the single shot ranging precision of centimeters and less than 1cm for some satellites. The laser returns are several times more than kHz SLR.*

1. Introduction

Since September 2009 Shanghai SLR station started routinely kHz SLR and could track ILRS satellites with the orbit altitude from 400 to 36000km. For further extracting the advantages of high repetition rate SLR technique, such as increasing measuring data, improving Normal Point RMS, determining spin parameters of satellites and enhancing the stability of laser system, the 10kHz SLR technology was put forward and pushed in 17th ILRS workshop by Dr. Georg Kirchner. Shanghai SLR station has done experiment for promoting 10kHz SLR technology in China. The paper presents the preliminary results of 10kHz SLR at Shanghai SLR station.

2. Key technology

1) 10kHz repetition rate Laser

In our experiment, the 10kHz laser system is made by North China Research Institute of Electro-Optics (NCRIEO). The main performances are following:

- Power: ~3W;
- repetition rate:10kHz;
- pulse width:50ps;
- M2:<2

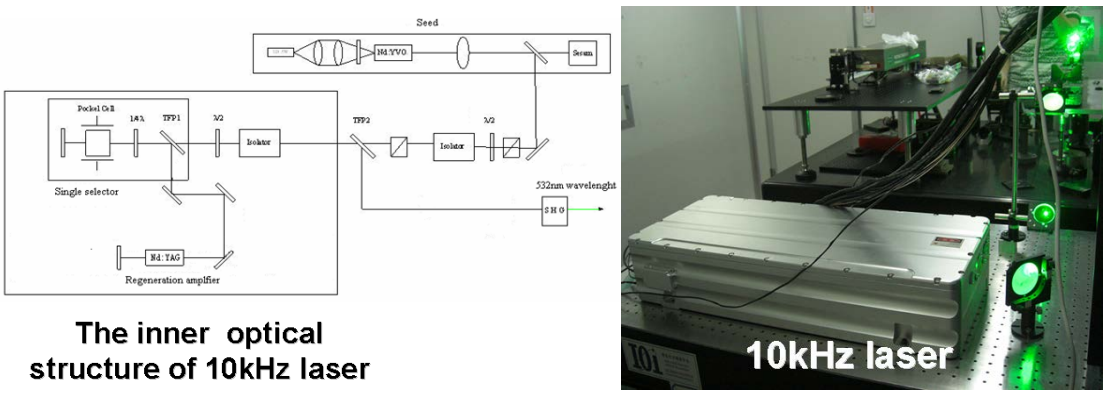


Figure 1 the optical structure of 10kHz repetition rate laser

2) Event Timer

A033-ET made by Latvia is common used as the time interval measurement in many SLR stations with precision of 3-5ps. As described in the manual, the maximum average measuring rate can be up to 12KSPS, but it actually can be increased based on the performance of computer and working mode. Through testing on industrial computer with E5300@2.6GHz CPU and 1G memory, the maximum rate of A033-ET could reach to 40KSPS and 33KSPS in EPP mode and Client/Server mode respectively, which can satisfy the requirement of 10kHz SLR data recording.

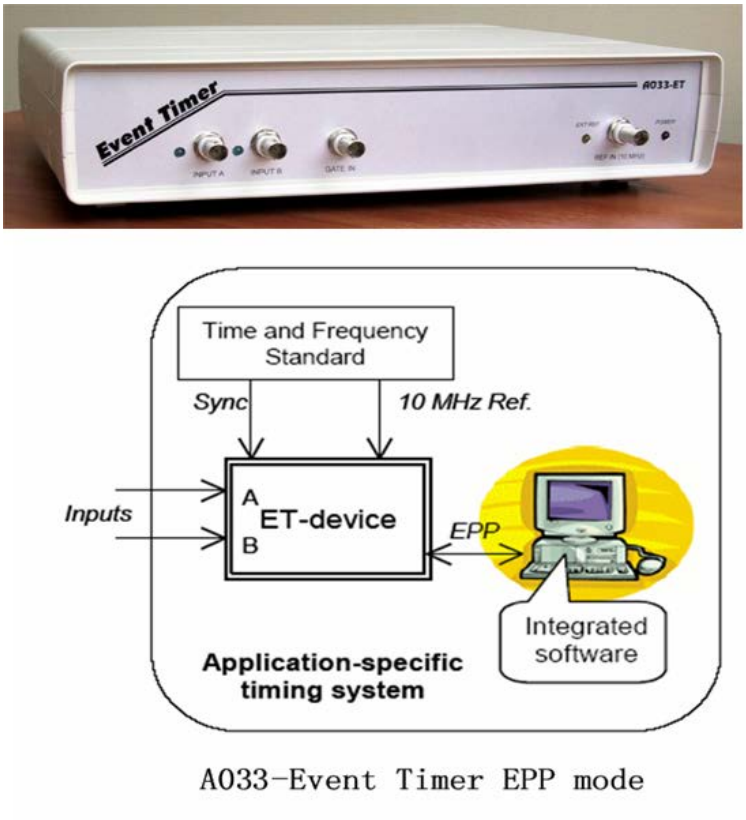


Figure 2 The A033-ET for 10kHz SLR time recording

3) Range gate generator (RGG)

To make SLR control software run enough fast, RGG should take less PC time. In our measurement system RGG is developed based on FPGA by Shanghai SLR group with 5ns resolution, real-time calculating range gate according to time of start pulse. The orbit prediction data for range gate are sent to RGG per second via RS232. The real-time processing module is in charge of generating gate

signal. RGG has been considered to avoid the backscatter according to the time difference between fire pulses and rang gate pulse.

Figure 3 Range gate generator for 10kHz SLR measurement

4) SLR Controlling system

Two computers are applied for setting up the 10kHz SLR control system under the Windows XP system. One computer ① is used for data communication with Event Timer to get the epoch time of start pulse and stop pulse for real time data processing and displaying range residual, storing laser data, etc. The control software is developed by the VC++ programming tool.

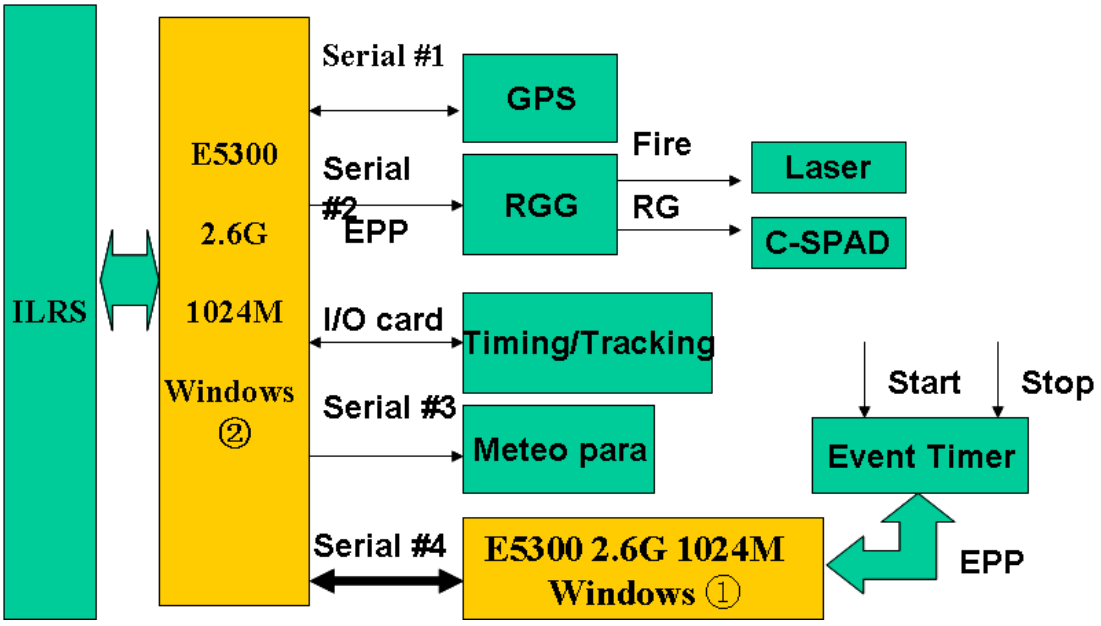


Figure 3 Structure of controlling system for 10kHz SLR measurement

Another computer ②used for servo system control to track satellites at the precision of 1″, RGG generates 10 kHz laser fire and range gate signal.

5) Data post-processing software

The size of laser data recorded per shot is about 50 bytes, so the total size of measurement data for 10kHz repetition rate will be over 150 MByte and 900 MByte for five minutes pass and half an hour pass respectively. Data post-processing software is developed by Fortran and VC++ while Fortran for data process and VC++ for data plot and manual operation.

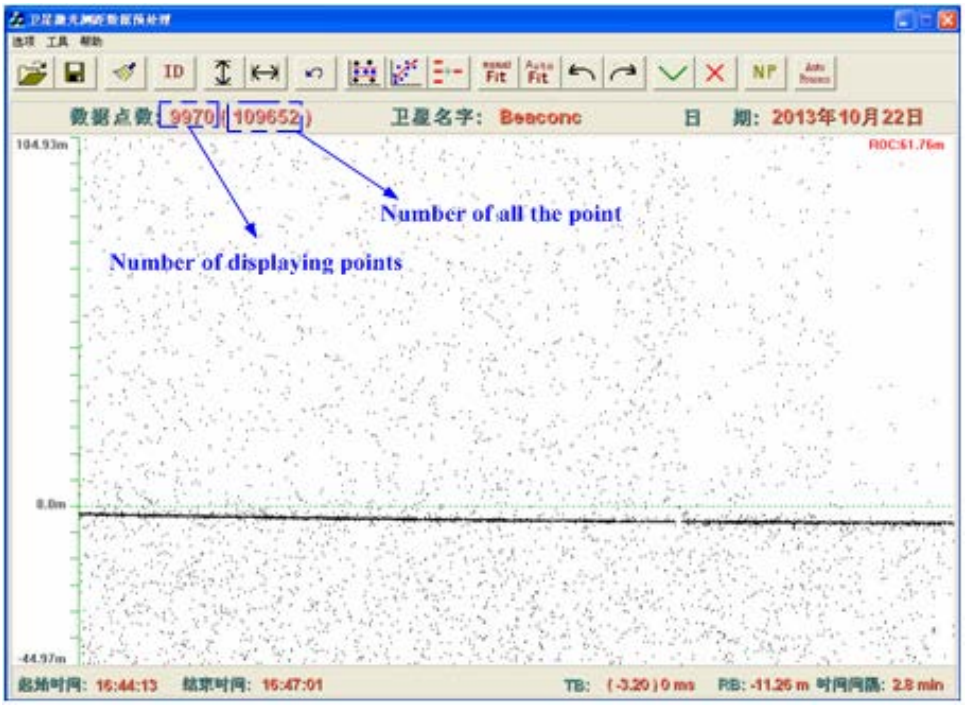
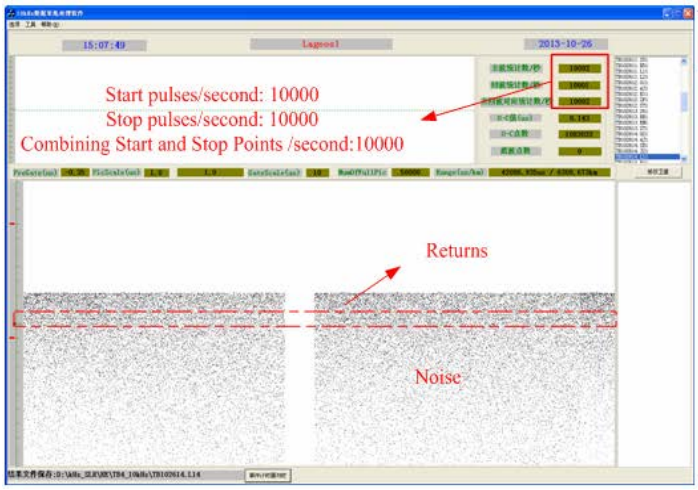


Figure 3 Laser observation data post processing for 10kHz SLR measurement

For range residual screen displaying fast, only parts of points are shown on the interface of software, but all laser data are processed.

3. Experiment results

Based on Shanghai 60cm telescope, laser ranging experiment with 10khz repetition rate is carried out from 25th to 27th October, 2013.The laser returns from LEO, Lageos and Glonass satellites are successfully obtained. For Beaconc satellite, returns per second are up to 2500, several times more than that from kHz SLR.



No.	Date	Satellite	Points	Time Length (seconds)
1	10-25	Jason2	2867	47
2	10-25	Beacon	49211	22
3	10-25	Lageos2	14699	435
4	10-26	Glonass107	6353	307
5	10-26	Glonass128	3850	299
6	10-26	Glonass101	1465	126
7	10-26	Ajisai	29790	78
8	10-26	Beacon	93312	71
9	10-26	Lageos1	16797	970
10	10-26	Lageos2	6231	680
11	10-27	Beacon	105882	24
12	10-27	Glonass126	3216	137
13	10-27	Ajisai	25997	193
14	10-27	Glonass102	4397	726
15	10-27	Lageos2	6322	626

Figure 3 the observing results of 10kHz SLR measurement

4. Summary

Adopting domestic 10kHz laser, developing of RGG, control software, date processing software by Shanghai SLR group, the experiment of 10kHz SLR measurement are successfully implemented and laser reruns are obtained from ILRS priority satellites (LEO, LAGEOS, HEO).

Dark noise of C-SPAD increasing rapidly with repetition rate (2MHz@10kHz), so development of one low dark noise detector with high precision will be major works for routine 10kHz SLR measurement in the next step.

References

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Georg Kirchner, Franz Koidl, Farhat Iqbal. Pushing Graz SLR from 2 kHz to 10 kHz repetition rate, Proceedings of the 17th International Laser Ranging Workshop, Bad Kötzting, Germany, May 16-20, 2011