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

Zhang Zhongping, Chen Juping, Wu Zhibo, Zhang Haifeng, Li Pu, Meng Wendong
Shanghai Astronomical Observatory, Chinese Academy of Sciences (CAS)

Email: zzp@ shao.ac.cn, shcjp@shao.ac.cn

Track No:13-Po52

Introduction

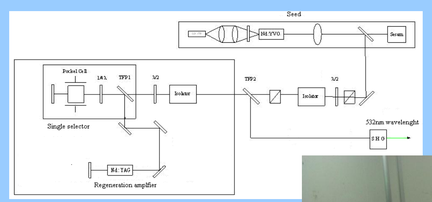
Since September 2009 Shanghai SLR station started routinely kHz SLR and could track ILRS satellites with orbit altitude from 400 to 36000km. For further extracting the advantages of high repetition rate SLR technique, such as increasing measuring data, improving Normal Point RMS, determining spin parameters of satellites, enhancing the stability of laser system and the ability to track space debris by high power laser, 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.

Key technology

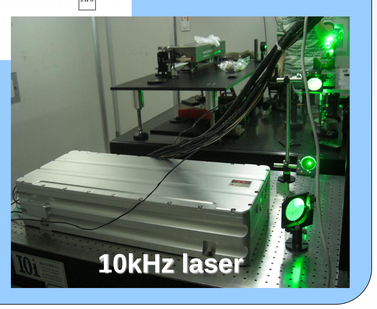
- **Laser**: power of ~4W, 10kHz repetition rate, pulse width:~40ps, M^2:<2
- **Event Timer**: measurement rate ~20kHz;
- **Range gate generator (RGG):** repetition rate ~10kHz, backscatter avoidance.
- **Controlling software**: real time and fast data processing (100us for one cycle).
- **Data post-processing software**: capability of processing massive laser data with size of up to several G Byte.

1. Laser

The 10kHz laser system is made by North China Research Institute of Electro-Optics (NCRIEO).

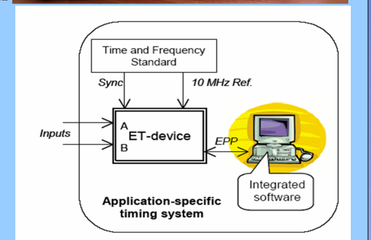


The inner optical structure of 10kHz laser



2. Event Timer

A033-ET made by Latvia are 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.

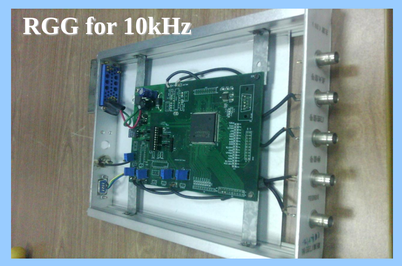


A033-Event Timer EPP mode

3. RGG

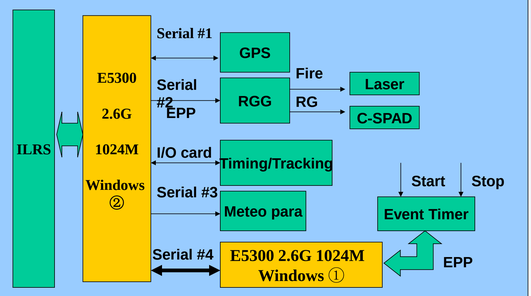
To make SLR control software run enough fast, RGG should take less PC time. In our measurement system RGG is developed based on FPGA by Shanghai SLR group, recording epoch of start pulse with 5ns resolution, real-time calculating range gate according to time of start pulse. The orbit prediction data 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 pulse and rang gate pulse.

The main parameters:
Resolution: 5ns;
Working frequency: >10kHz
Backscatter avoidance : 45us



4. 10kHz SLR control 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.



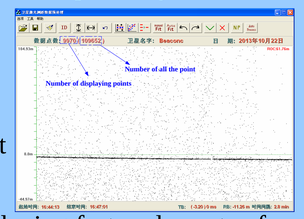
To ensure the data processing fast enough, the control software is developed by the VC++ programming tool.

Another computer ② used for servo system control to track satellites at the precision of 1″, RGG generates 10kHz 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.

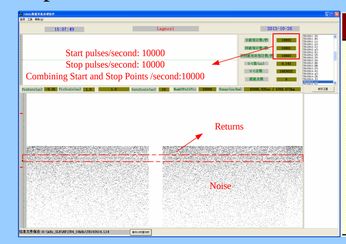


For range residual screen displaying fast, only parts of points are shown on the interface of software, but all laser data are processed.

Experiment results

Based on Shanghai 60cm telescope, laser ranging experiment with 10khz repetition rate is carried out from 25th to 27th of October, 2013.

The laser returns from LEO, Lageos and Glonass satellites are successfully obtained. For Beaconc returns per second is 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	14690	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

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) and instability of laser beam pointing which results in measurement precision of ~2cm and limitation of detecting ability, so development of low dark noise detector with high precision and upgrading 10kHz laser will be major works for routine 10kHz SLR measurement in the next step.