Progress in Changchun SLR

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Abstract

The paper presents the summary and progress of Changchun SLR during the past years. It includes some special satellites observation, such as ETS-8, GIOVE-A, B, and Compass (Beidou) ; the laser time transfer and comparison experiment cooperated with shanghai observatory; aintenance and improvement of the system; the design and development of any frequency fire rate control system; the basic process and application of SLR data.

1. System upgrading for LTT project

The LTT (Laser Time Transfer) experiment has been carried out at Changchun SLR station since August 2007. Changchun SLR was upgraded for the LTT project:

- New laser: (loan from the NCRIEO in Beijing)
  Active-active mode-locked Nd:YAG laser
  100-150mJ in 532nm, 250ps, 20Hz
- New Coude mirrors
- 210mm diameter transmitting telescope with 10 aresec laser beam divergency
- 2 sets of ET-A320 event timer (Riga Univ.)
- 1 set of hydrogen maser (Shanghai Obs.)
- LTT software: laser firing control, LTT data analysis

Figure 1. Active-active mode-locked Nd:YAG laser with 100-150mJ (532nm), 250ps,20Hz

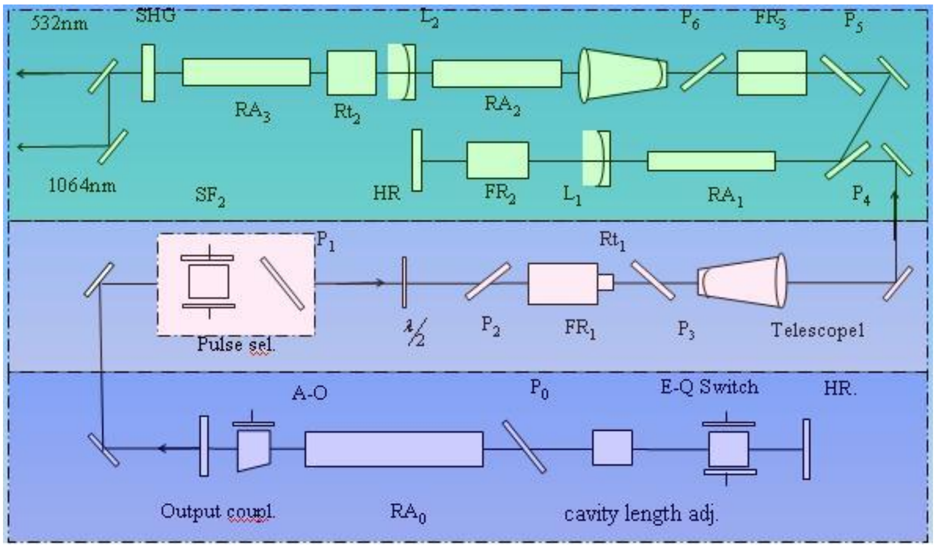

Figure 2. Diagram of Active-active mode-locked laser for LTT

Figure 3. Changchun SLR & LTT Control Room

Preliminary results of the LTT experiment has been obtained. The clock differences between the space rubidium clocks and ground hydrogen maser have been measured with a precision of 300ps (single measurement). The LTT experiment at Changchun SLR station was successful.

2. Special satellites observation in Changchun SLR station

Some special satellites observation, such as ETS-8, GIOVE-A, GIOVE-B, and Compass-M1 (Beidou) is fine (shown in Table. 1). Especially Changchun station is interested in ETS-VIII observation. For this one is a geosynchronous satellite. Changchun SLR station obtains 32 passes successfully. The elevation angle is 36°. When SLR station observes ETS-VIII, the range is more then 38000 km. A night time pass of Compass (BD-MEO) with 29k returns was also got (shown in figure 4).

Table 1. High Satellites SLR Data (Passes) tracked

Satellites	Pass		
	2007	2008	Total
Compass（BD -MEO）	34	47	81
GIOVE-A	72	33	105
ETS-8	28	4	32
GIOVE-B		24	24

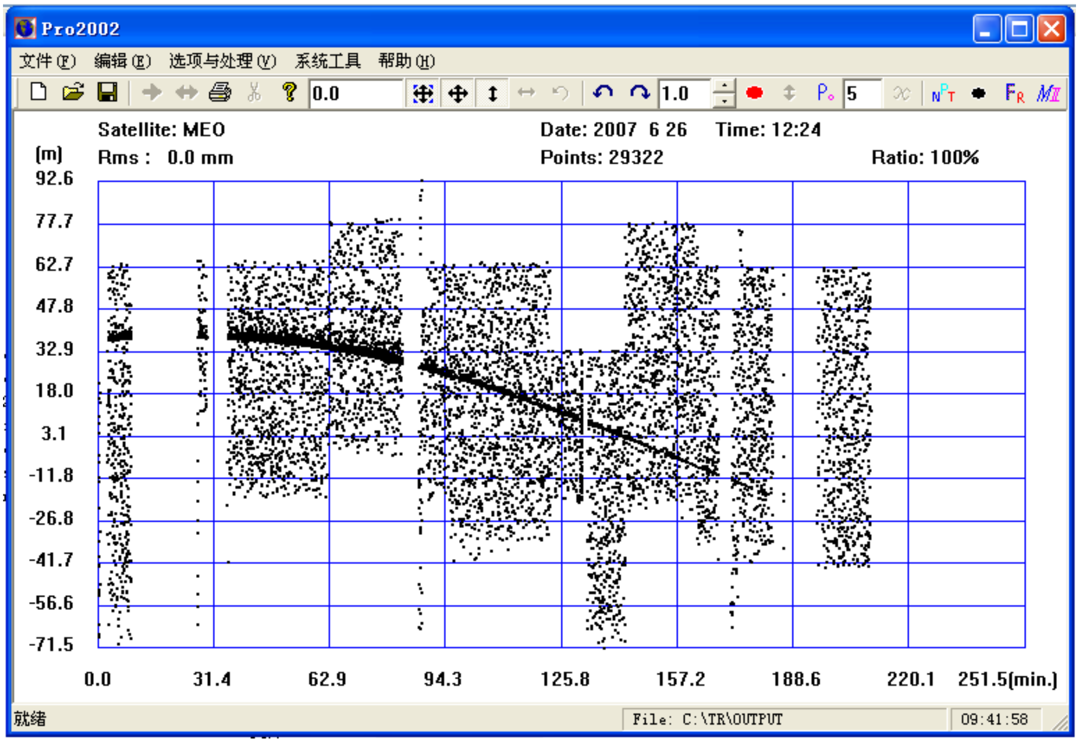

Figure 4. Plot of data from a night time pass of Compass with 29k returns

3. KHz SLR Experiments

The high repetition-rate control system has been developed and used in Changchun SLR station. The system can make the SLR system work at from 1 Hz to more than 2 KHz. The real-time control hardware and software run under Windows XP environment. The hardware control circuit includes three parts: accurate timing part, range gate control part and laser firing control part. A 2KHz laser which borrowed from Wuhan SLR Group was used to work together with the controlling system to test the performance. The experimental results show that the any frequency fire rate control system can work very well at or less than 2 KHz.

Figure 5. Real time control interface

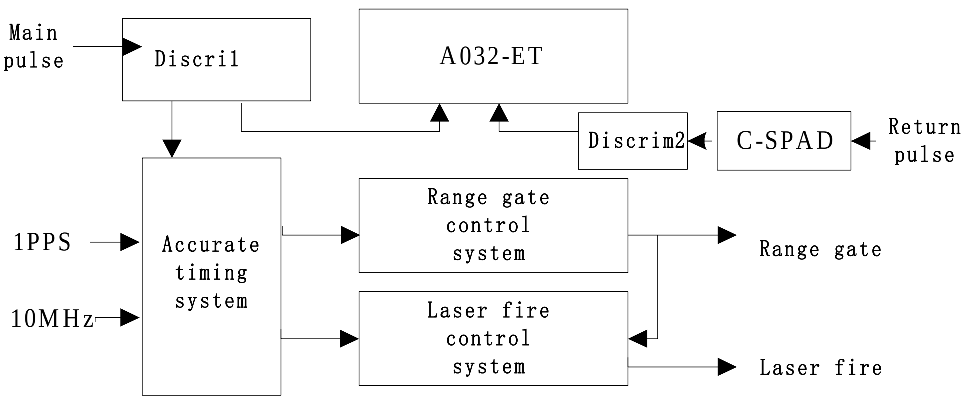

Figure 6. The block diagram of the hardware control system configuration

The hardware control system is mainly composed of three parts: accurate timing part, range gate control part and laser fire control part.

The detailed specifications of the ns kHz Laser system are summarized in the Table 2.

Table2. Specifications of the ns kHz Laser

Model	DS20-532
Wavelength	532 nm
Average Power @ 10 kHz	18 Watts
Nominal Pulse Width @ 10 kHz	40 ns
Pulse Energy @ 10 kHz	1.8 mJ
Beam Mode	TEM00 - M2 < 1.1
Polarization	100:1 Vertical
Beam Diameter	1.0 mm
Beam Divergence	1.6 mrad
Pulse-to-Pulse Instability	<3% rms
Long-Term Instability	+/- 3%
Pointing Stability	< 25 μrad
Pulse Repetition Rate	500 to 10kHz

4. Preparation of daylight tracking

As you know, the system hardware and software were ready for daylight tracking since the end of 2005. But because of some special projects, we did not carry out the tracking. And the research of the daylight tracking was continued. At 11 am of May 16th, 2008, we tried once daylight tracking. The system got the return pulses of satellite ERS-2, and following is the data process result on the screen. It also means that the breakthrough of daylight tracking was achieved in Changchun station.

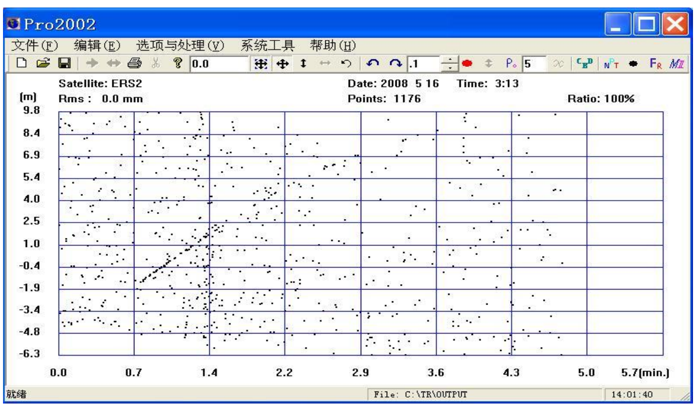

Figure 7. First result of Changchun station daylight tracking

From the experiment result, we find that we must solve the too much noise problems.
In the future we must improve our system:

- Using Variable receive iris with Φ0.5mm minimum aperture to get smaller Receiving field of view :30"
- Improve mount pointing performance and transmit/receive boresight

5. Data Analysis

From the beginning of 2008, Changchun Observatory has carried out routine short-arc (3-day) orbit determination and station residual analysis on LAGEOS SLR data. Meanwhile, we commence analysis in some aspects of related issues, such as the satellite precise orbit determination and its preliminary applications. The short-arc orbit determination accuracy is around 1.2cm with moderate difference. So now Changchun Observatory has the foundation in SLR POD work. Routine POD and residual analysis results on LAGEOS-1/2 have been put on the Changchun station website.

In the case of our study, the choice of gravity model has slight effect on precision of LAGEOS orbit determination. The influencing magnitude is on sub-mm level. The station coordinates can also be determined in POD process, and the proper value can do help to improve orbit determination precision. The cause of variability of station coordinates need to be further investigated. What we can do using POD results, how to apply them in relevant geodynamic and geophysical problems, how to combine them with our observational duty, need seriously consideration. We wish the POD work in Changchun will build a bridge to connect theoretical research and observational work.

References

1. Yang Fumin, Huang Peicheng, Ivan Prochazka, Zhang Zhongping, Chen Wanzhen, Zhang Haifeng, Wang Yuanming, Meng Wendong, Wang Jie, Liao Yin, Zou Guangnan, Wang Luyuan, Zhao You, Fan Cunbo, Han Xingwei. *The Preliminary Results of Laser Time Transfer (LTT) Experiment.* Proc. of 16th International Workshop on Laser Ranging, Poznan, Poland, 2008
2. ZHAO You, HAN Xingwei, FAN Cunbo, DAI Tongyu. *Fulfillment of SLR daylight tracking of Changchun station.* Proceedings of 15th International Laser Ranging Workshop, Canberra, Australia, Oct.15-21, 2006, pp587-592
3. FAN Cunbo, DONG Xue, ZHAO You, HAN Xingwei. *A032-ET Experimental Test on Changchun SLR*. Proceedings of 15th International Laser Ranging Workshop, Canberra, Australia, Oct.15-21, 2006, pp300-305
4. ZHAO You, FAN Cunbo, HAN Xingwei, LIU Chengzhi, SHI Jianyong, ZHANG Ziang. SHAO Baodong, ZHANG Haitong. etc. *System Improvement and GIOVE-A Observation of Changchun SLR.* Proceedings of 15th International Laser Ranging Workshop, Canberra, Australia, Oct.15-21, 2006, pp399-404