Laser measurement to space targets by using dual-receiving telescopes and one transmitted system

Zhongping Zhang, Zhien Cheng, Zhibo Wu, Hurong Deng, Zhenghong Tang, Lurun Shen

Shanghai Astronomical Observatory (SHAO),
Chinese Academy of Sciences (CAS)

Outline

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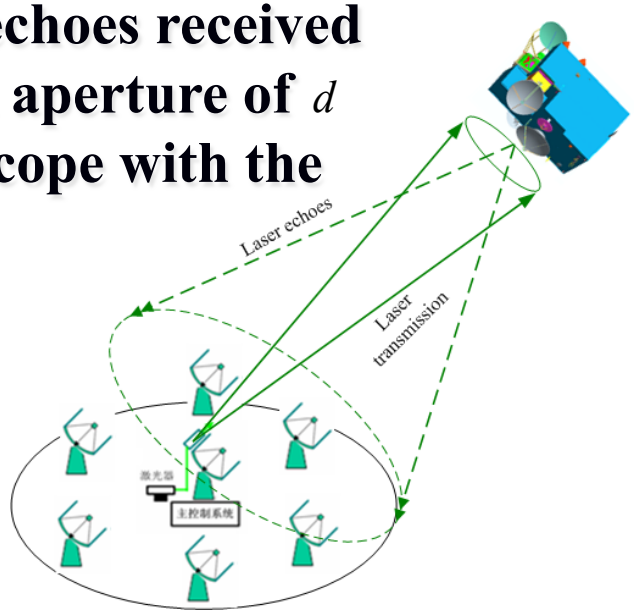
1. Introduction

- **According to laser measurement link equation, the number of laser echoes is proportional to receiving area of telescope.**

$$n_0 = \frac{\eta_q}{h\nu} \times \frac{E_t A_r \sigma}{4\pi\theta_t^2 R^4} \times T^2 \times T_t \times T_r \times \alpha$$

- **Theoretically speaking, the number of laser echoes received by the number of N receiving telescopes with aperture of d can be equivalently achieved by the one telescope with the aperture of $\sqrt{N} \times d$**

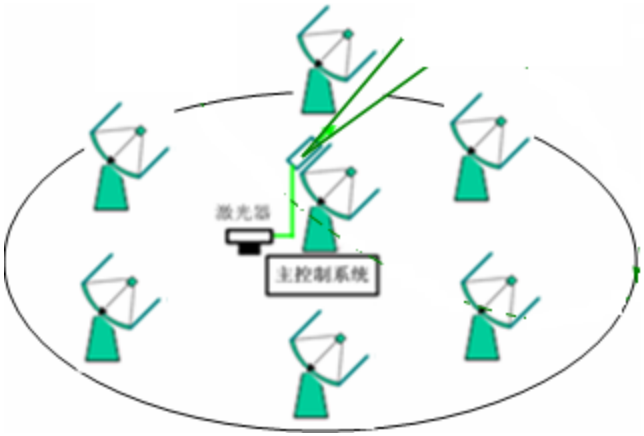
- **The equivalent receiving ability produced by one aperture telescope can be realized by way of multi-receiving telescopes.**



1. Introduction

- **Multi-telescopes independently track the same space target drived by respective servo systems.**

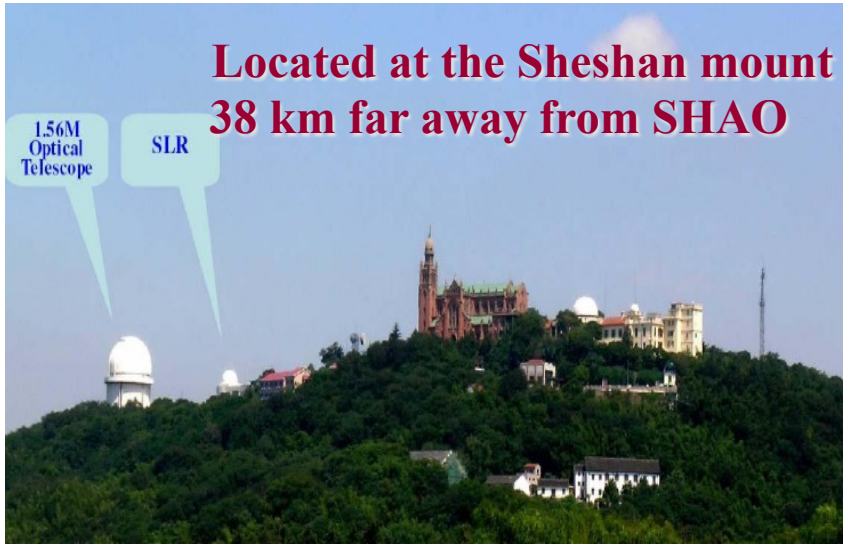
  - **Better agility of system and number of receiving telescopes can be controlled (adding or cutting);**
  - **Robustness of system at the aspect of running and maintenance;**
  - **Distribution of receiving telescopes according to the measuring requirements.**

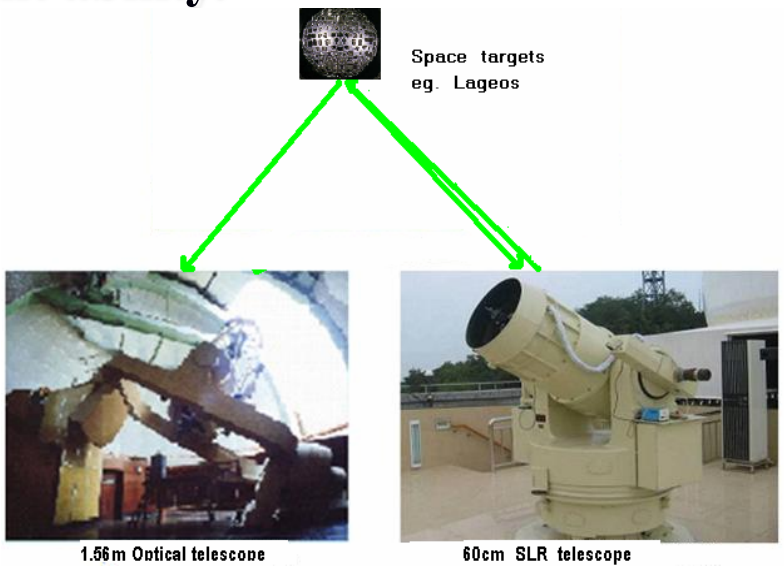


- **Favorable feasibility for future technical development and application in laser measurement to space targets.**

2. Demonstrating experimental system with two receiving telescopes

- The demonstrating experimental system based on 60cm SLR system and 1.56m astronomical telescope at the distance of ~ 50m was established in 2013 as the simplest form of multi-receiving telescopes
- Verifying technical feasibility of multi-receiving telescopes in laser ranging for increasing the measurement ability.





Two receiving telescopes

1.56m telescope:

- Optical system: R-C mode
- Equatorial mounted
- Focus length: 15 meter
- Receiving aperture and efficiency : 1.56m and 70% @ 532nm
- Tracking RMS: <3″

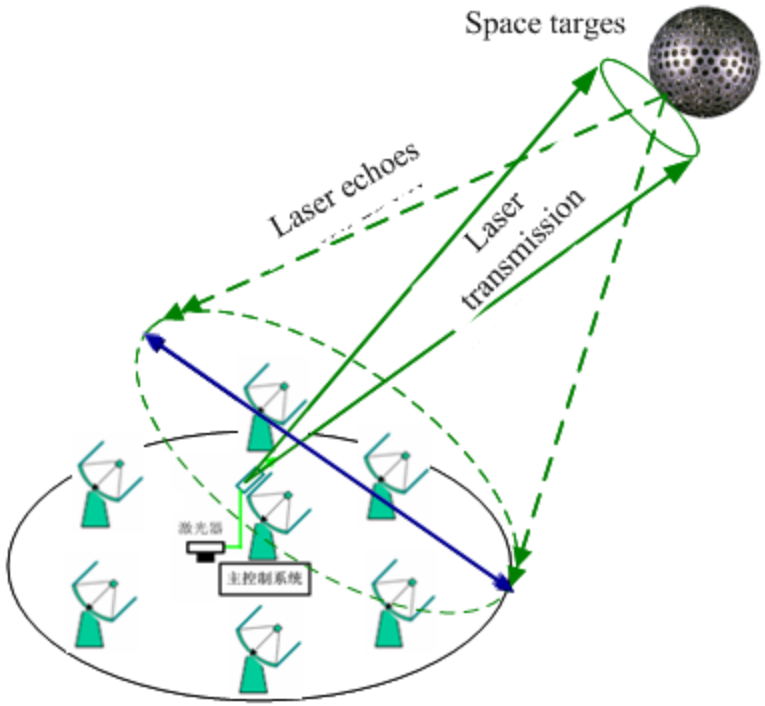
60cm SLR telescope:

- Optical system, R-C mode;
- AZ-EL mounted;
- Focus length: 4 meter
- Receiving aperture and efficiency : 60cm and 60% @ 532nm
- Tracking RMS: <1″
- Laser transmitting aperture: 21cm.

- The laser transmitted from 21cm aperture telescope at the 60cm SLR system with the power of 1W@ 1kHz repetition rate.
- And laser echoes received by 1.56m/60cm telescopes from space targets at the same time.

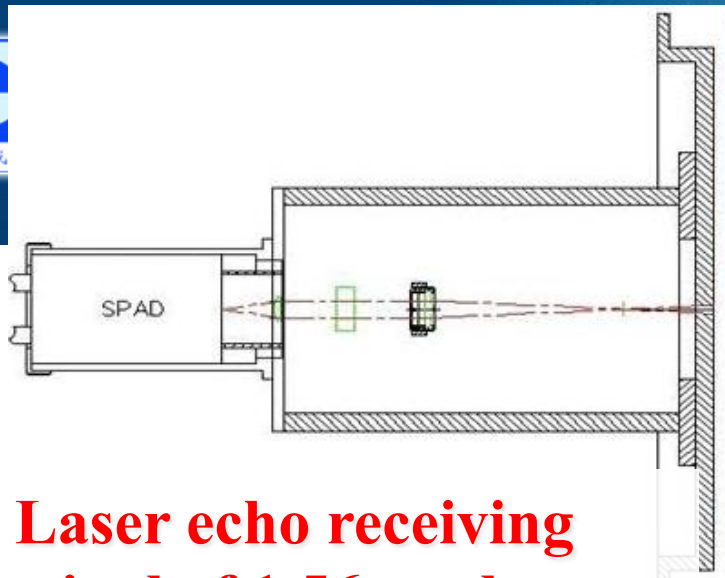
2. Demonstrating experimental system with two receiving telescopes

- **The footprint of laser echoes will cover the area with hundreds of meters for cooperative targets and diffuse reflection for uncooperative targets.**
- **For 1.56m/60cm telescopes with the distance of about 50m, laser echo from space targets could be received at the same time.**



2. Demonstrating experimental system with two receiving telescopes

- **The primary mission of 1.56m astronomical telescope is not dedicated to laser ranging.**
- **For establishing the experimental system of two receiving telescopes, some dedicated modifications for 1.56m telescope have been performed.**
  - **laser echoes receiving terminal;**
  - **laser measurement control system;**
  - **network link etc.**

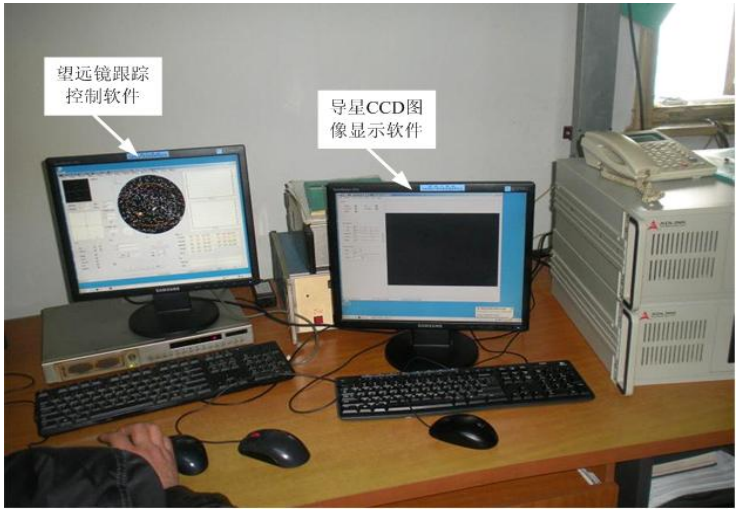


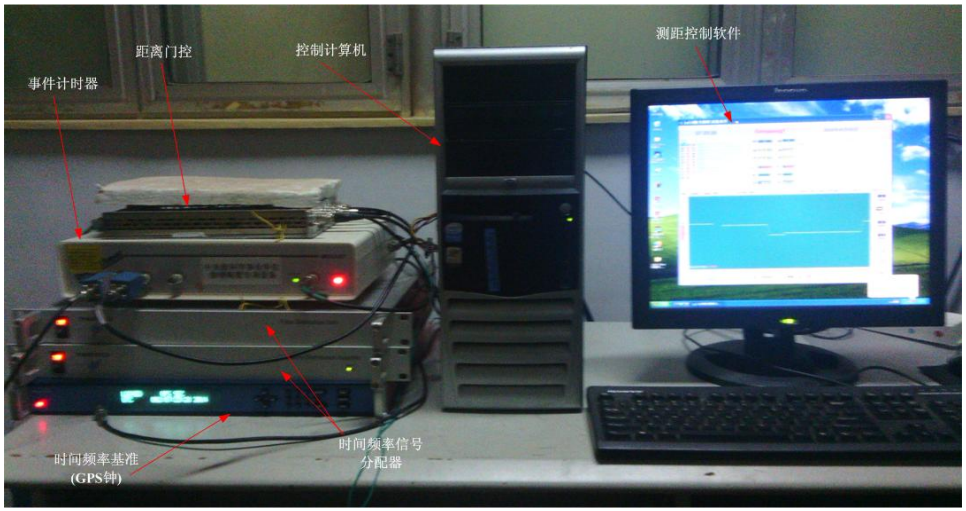
Structure of receiving terminal

Laser echo receiving terminal of 1.56m telescope

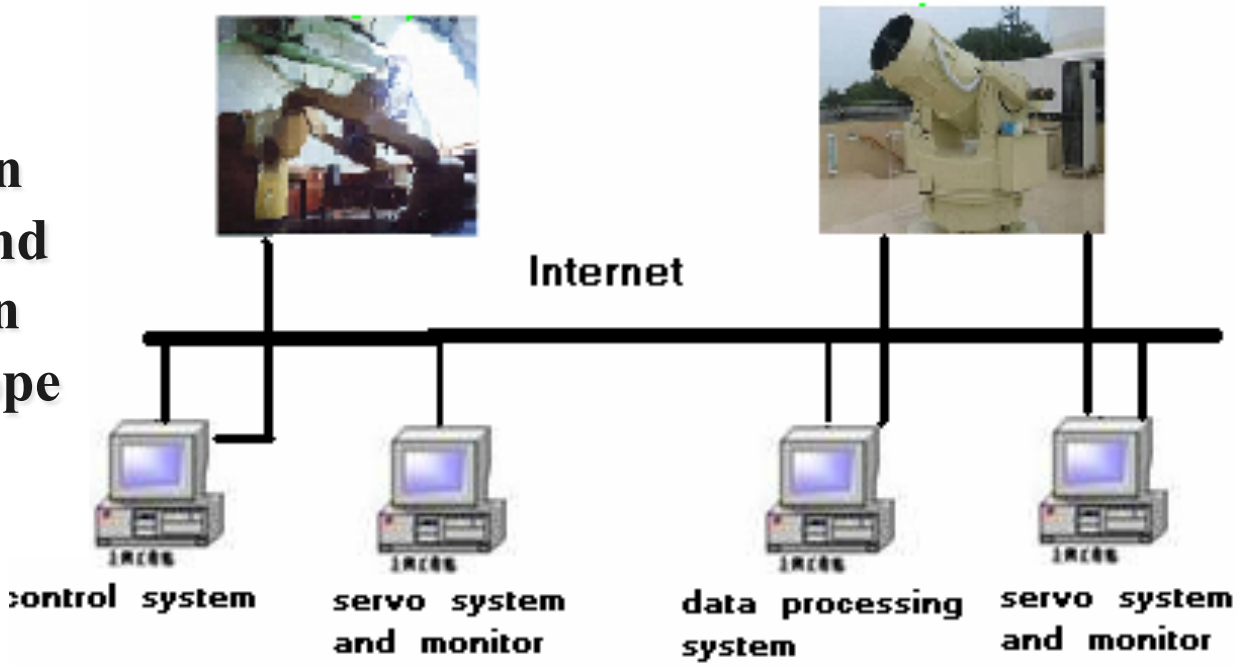
Entity of receiving terminal

Control system of 1.56m telescope

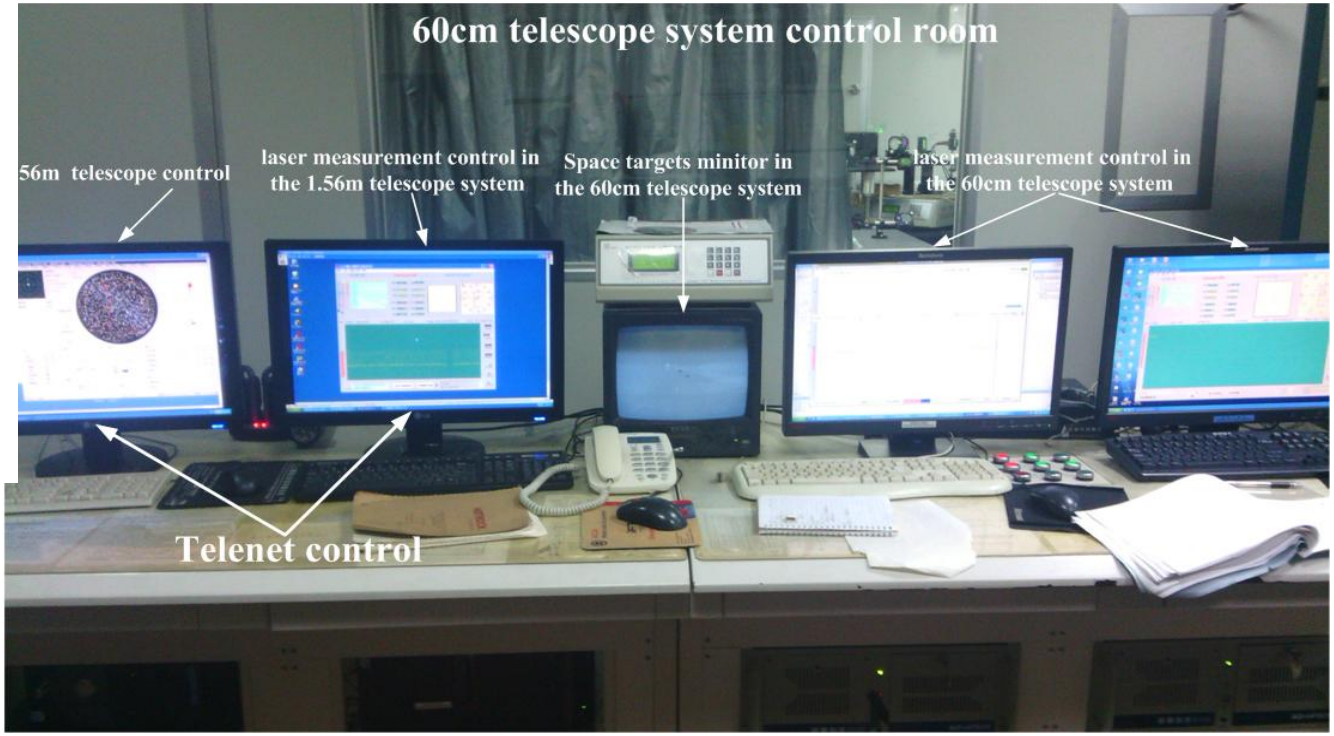




- **Establishment of network communication link for data transfer and data processing between 1.56m and 60cm telescope system.**



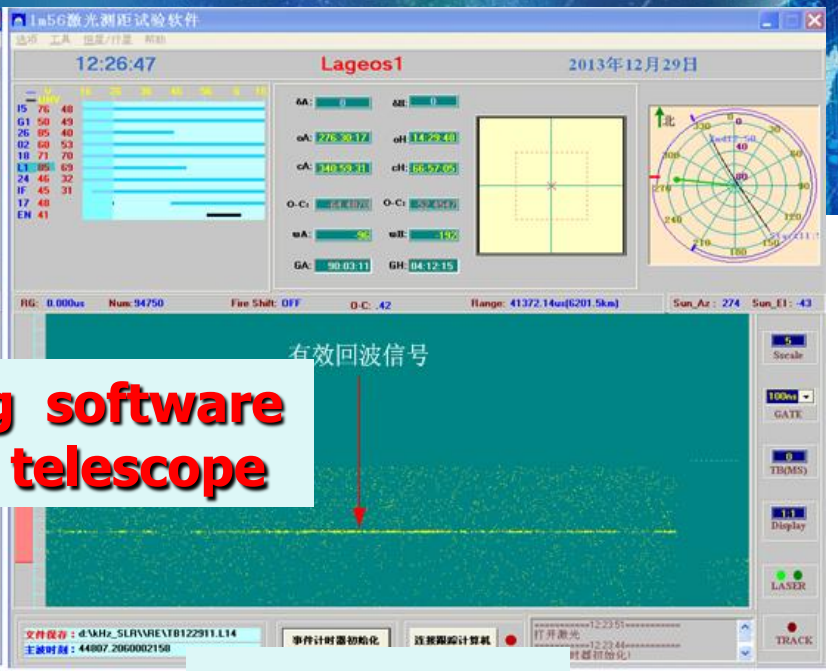
- **60cm SLR system, as the manipulator, control 1.56m telescope through telnet**



3. Laser measurement results from two receiving telescopes and data analyses

- Laser measurement to satellites with reflectors were carried out from Dec of 2013 to Jan of 2014 and passes of laser data from different satellites at the altitude of 6,000km to 36,000km were successfully measured.

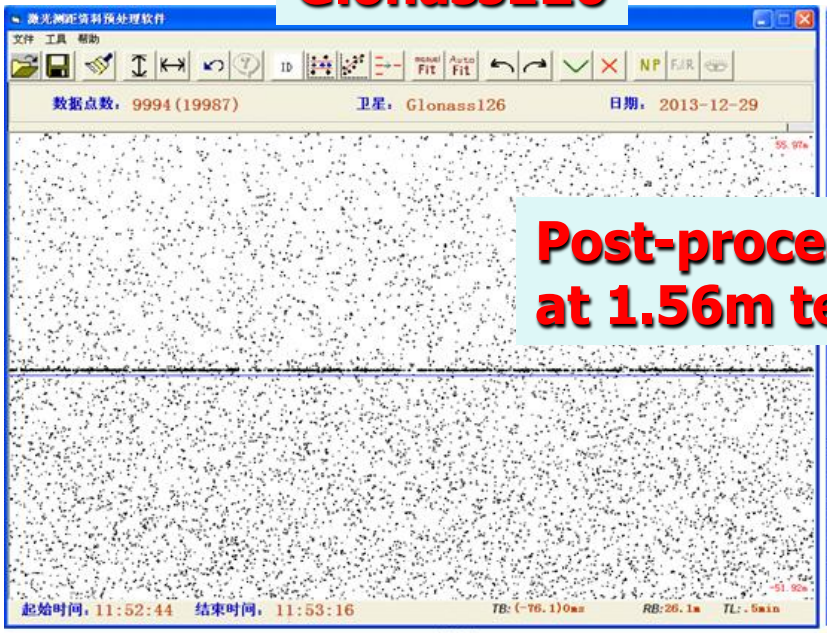
NO	Date	Start time (UTC)	Arc length /min	Returns	precision /mm	Satellite Name	Altitude/km
1	2013-12-29	12:25:39	2.9	48663	18.5	Lageos1	6000
2	2013-12-29	12:58:59	1.4	3516	16.7	Compassg1	36000
3	2013-12-29	12:39:49	4.9	18616	28.3	Glonass102	20000
4	2013-12-29	11:48:10	5.3	8957	23.7	Glonass126	20000
5	2013-12-31	12:18:37	3.3	8235	17.8	Glonass129	20000
6	2013-12-31	12:57:24	6.3	49197	18.6	Lageos1	6000
7	2013-12-31	12:05:11	4.7	49529	20.0	Lageos2	6000
8	2014-01-02	11:50:16	4.2	5942	21.4	Lageos2	6000
9	2014-01-06	13:55:44	27.2	21772	29.7	Glonass124	20000

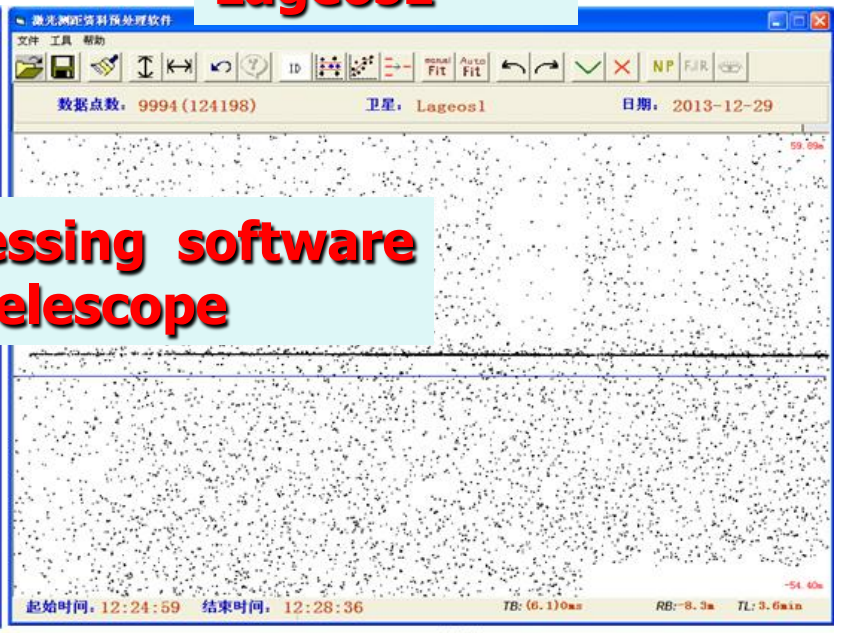


controlling software at 1.56m telescope

Glonass126

Lageos1





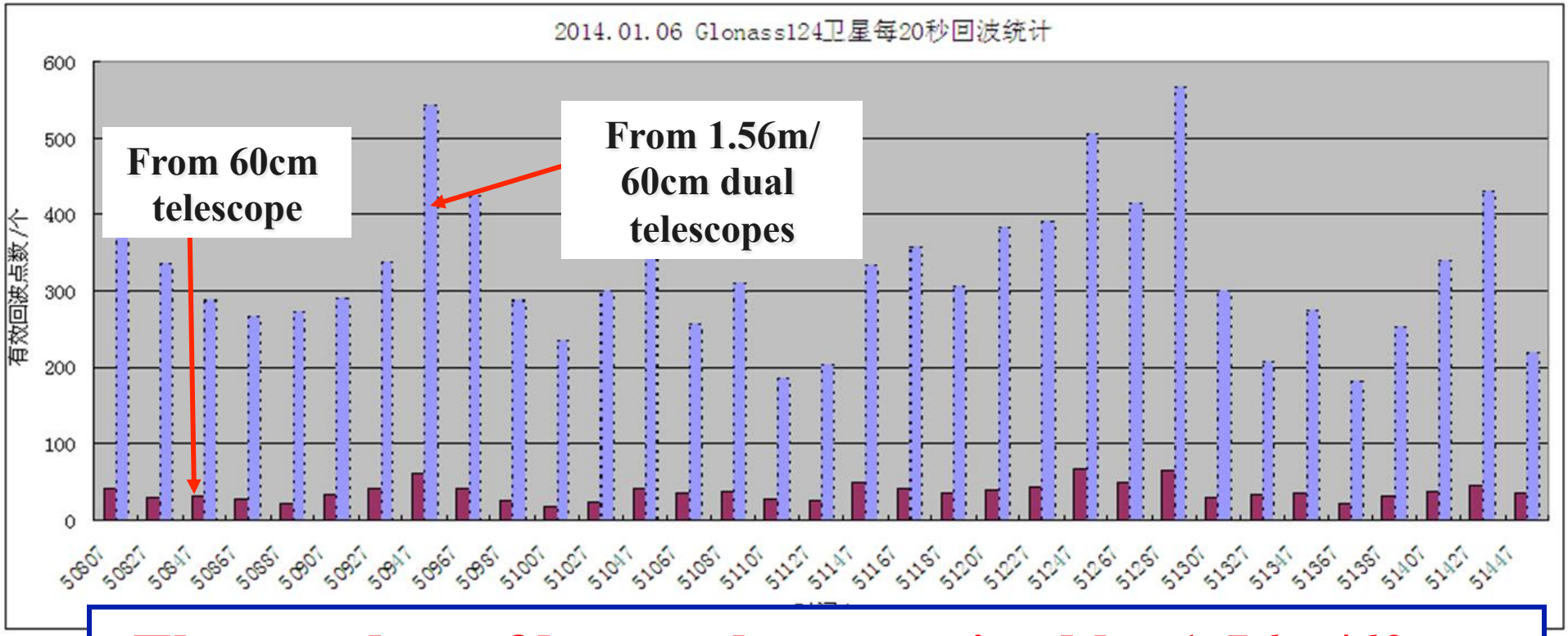
Post-processing software at 1.56m telescope

Glonass126卫星

Lageos1卫星

According to results of Glonass124, laser echoes per 20 seconds of 1.56m/60cm is about 6~7 times as that of the 60cm telescope

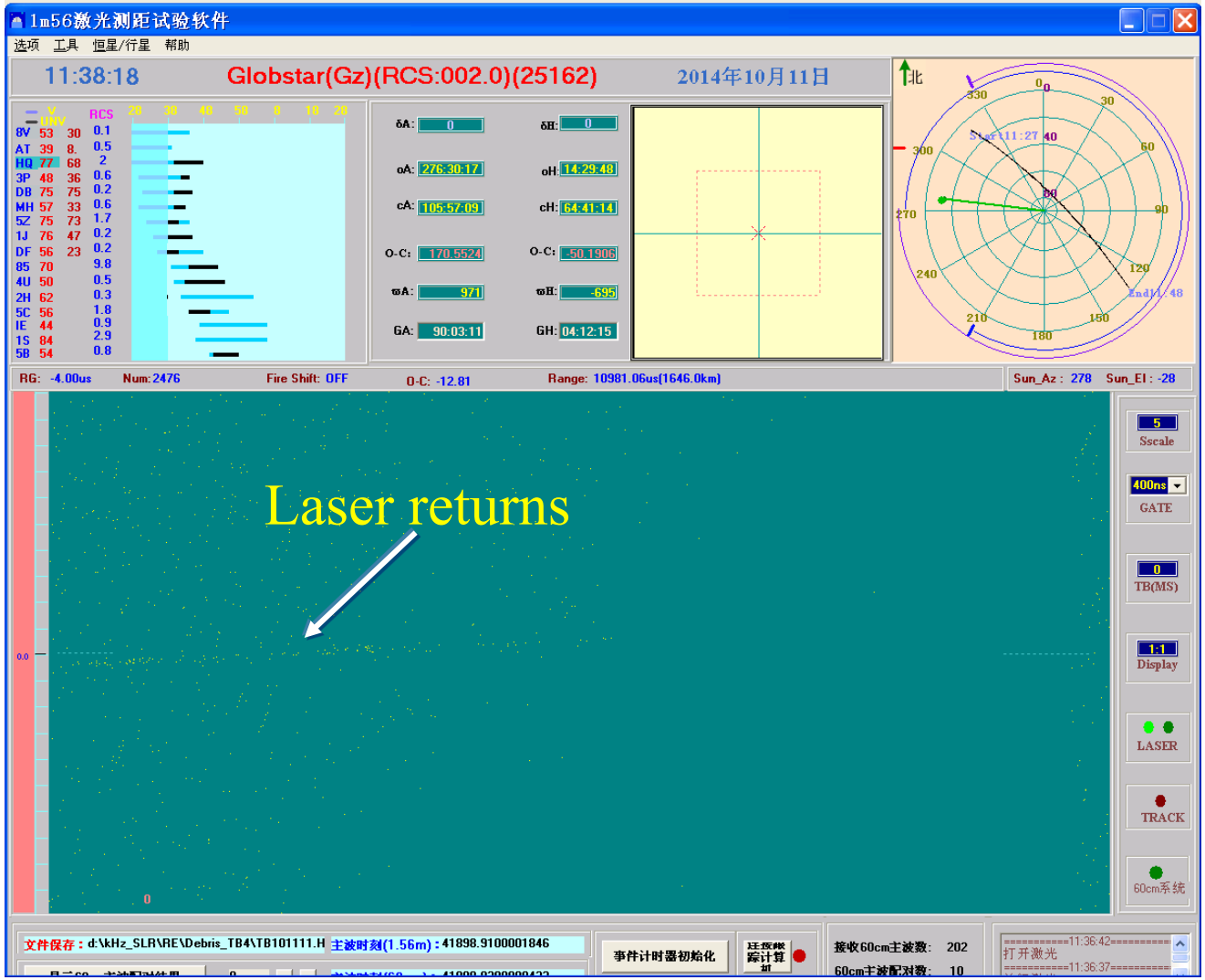
Statistics of laser echoes per 20s for Glonass satellite



The number of laser echoes received by 1.56m/60cm dual-telescopes can be equivalent to one telescope with the aperture of about 1.67m.

1.56m telescope receiving laser returns from space debris

- Preliminary realization of receiving laser echoes from space debris by the 1.56m telescope
- Further laser ranging to space debris by 1.56m telescope has been performing.



4. Summary

- Multi-receiving telescopes technology is put forward to improve detection capability of laser ranging to space targets produced by one large aperture of telescope.
- Demonstrating experimental system with dual-receiving telescopes is established by Shanghai Observatory to assess the technical feasibility.
- The measurement results validate the effects of measuring system to increase the ability of laser echo detection.
- Expected to be the effective way to improve the ability of laser ranging to space targets with weak laser echoes.
- Laser ranging to space debris by using the dual-receiving telescopes and data processing for orbit determination will be performed in future.

Thanks for your attention!