Design of LRA for Compass GEO and IGSO Satellites and Observations

Chen Wanzhen, Yang Fumin, Wang Yuanming ,
Zhang Zhongping, Li Pu

Shanghai Observatory, Chinese Academy of Sciences

Introduction

- The Chinese regional satellite navigation system (COMPASS) consists of 14 satellites with different orbital altitudes，including GEO, IGSO (Inclined Geosynchronous Satellite Orbit) and MEO.
- GEO and IGSO orbital satellites are the important part in the COMPASS system. All of those satellites will be equipped with LRA for precision orbital determination, all of which are designed and manufactured by Shanghai Astronomical Observatory.
- Last workshop it was reported the LRA on Compass MEO orbital satellite. This report presents the characteristics of LRA for Compass GEO and IGSO satellite and the observation of laser ranging by one of Compass SLR systems.

Characteristics of LRA for Compass GEO and IGSO satellite

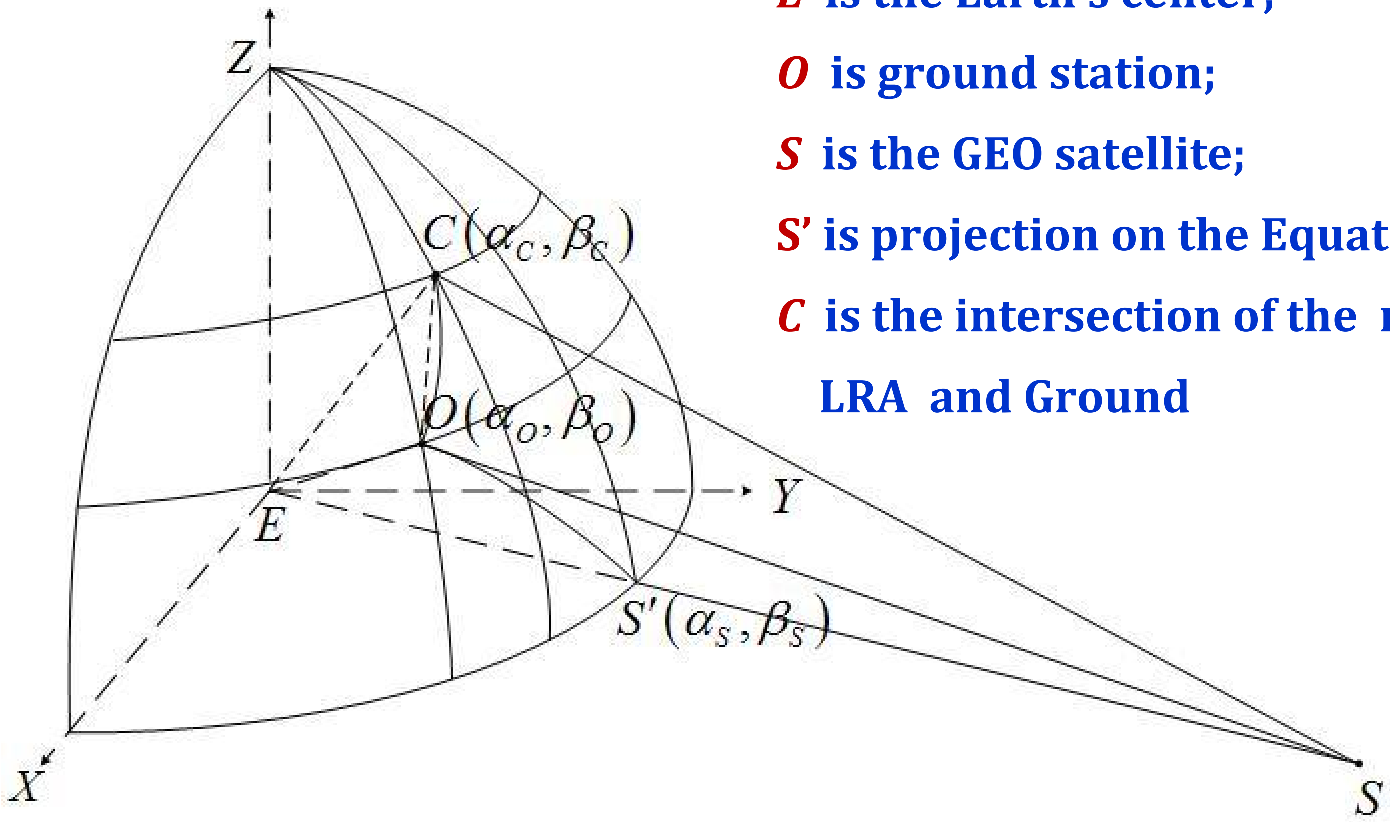
- Effective reflective area of LRA on GEO and IGSO : 770cm^2
- Diameter of the corner cubes :33 mm
- Compensation of the velocity aberration: 0.6 arc-seconds dihedral offsets with uncertainty of about 0.5 arc-seconds.
- All the surfaces of the corner cubes were without coating
- The optical reflectivity in 532nm of the corner cubes were about 92%
- Each corner cube was in an independent chamber, fixed into the planar base made of aluminum alloy material.

LRA on COMPASS GEO/IGSO

Size	49×43×3.0cm
Diameter of corner cube	33mm
Number of corner cube	90
Reflective area	770cm^2
Dihedral offset	0.6″
Weight	5.0 kg

- **Considering Compass GEO satellites mainly serving for Chinese region, a method of inclined installing LRA is adopted for increasing LRA reflective area, with the normal direction of LRA pointing to the Chinese continent rather than the earth's center. The theoretical calculation shows that the method is very effective.**

Design of the inclined installation



E **is the Earth's center;**

O **is ground station;**

S **is the GEO satellite;**

S' **is projection on the Equator of GEO**

C **is the intersection of the normal direction of LRA and Ground**

Calculation of Incidence angle

For the satellite oriented to the Earth's center

the satellite.

For Compass GEO

If the coordinates of the point C are (α_C, β_C), the incidence angle can be calculated by:

$$i_C = \arccos\left(\left(R_{SC}^2 + R_{SO}^2 - l_{CO}^2\right) / 2R_{SC}R_{SO}\right)$$

$$R_{SC} = \sqrt{R_E^2 + \left(R_E + h_S\right)^2 - 2R_E\left(R_E + h_S\right)\cos\beta_C \cos\left(\alpha_S - \alpha_C\right)}$$

$$R_{SO} = \sqrt{R_E^2 + \left(R_E + h_S\right)^2 - 2R_E\left(R_E + h_S\right)\cos\left(\angle OES\right)}, \quad l_{CO} = 2R_E \sin\left(\square OC/2\right)$$

Where i_C is the incidence angle between ground station (O) and the satellite (S), R_{SC} is the slant distance from the center of station network to the satellite, R_{CO} is the slant distance from the station to the satellite, l_{CO} is the curve distance from station to the center.

- **Considering several dedicated Compass SLR network on ground, the center of the ground station network is chose as the normal of LRA directing to point (C).**
- **The inclined angles for GEO satellite are less than 7 degree.**

- **The effective areas are increased up to 20.56% at the maximum. Although the increasing rate is not very much for every satellite , it is considerable significant for ground stations.**

The increasing rate of effective areas for different GEO satellites and ground stations

	GEO Satellite A	GEO Satellite B	GEO Satellite C
Ground Station 1	20.56%	15.73%	10.36%
Ground Station 2	13.37%	7.07%	1.50%
Ground Station 3	8.66%	7.08%	12.34%

Observations

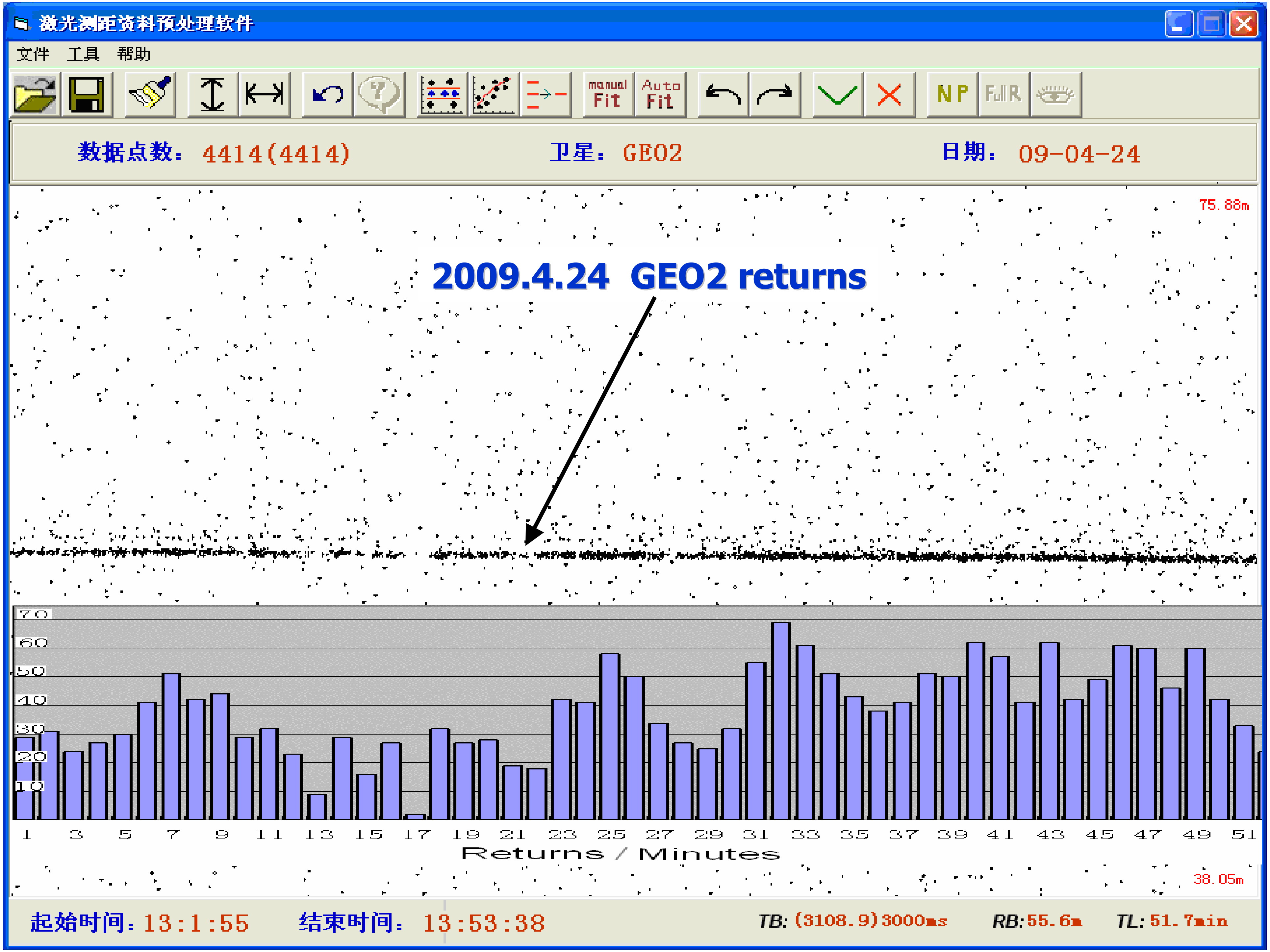
- The COMPASS-G2 ,G1, G3 and G4 were launched into different positions over the equator. The COMPASS-I1 (IGSO1), I2, I3 were launched last year and this year.

- The laser ranging experiments for these satellites have been done at a new dedicated COMPASS SLR station located in the north suburbs of Beijing City since April 2009.

- The parameters of this new SLR system can be seen from another report in this workshop.

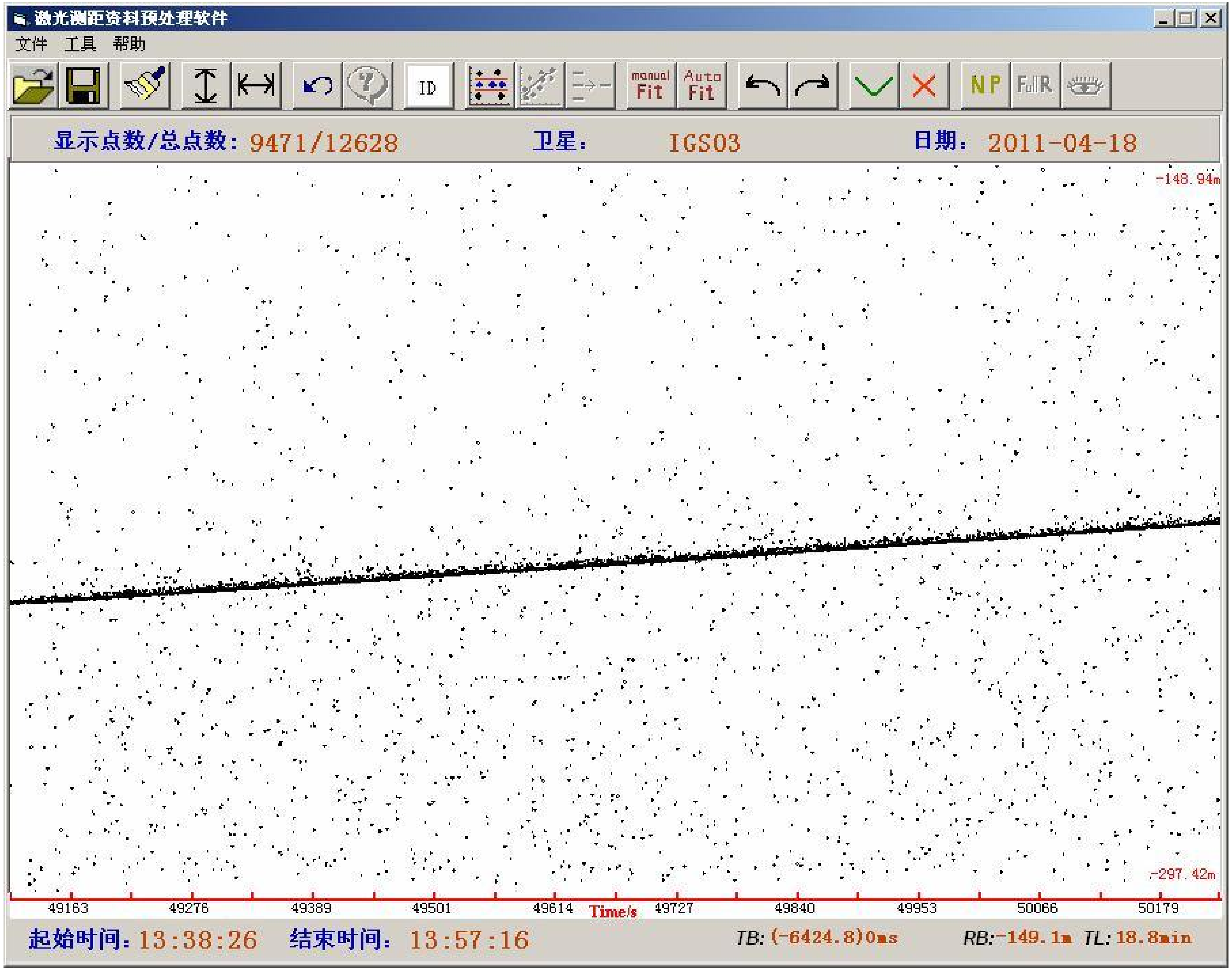
.

- Shanghai SLR station also tracked some of these satellites with the new kHz laser ranging system (1.5 mJ energy in 532nm, 15 ps pulse width, I kHz repetition)

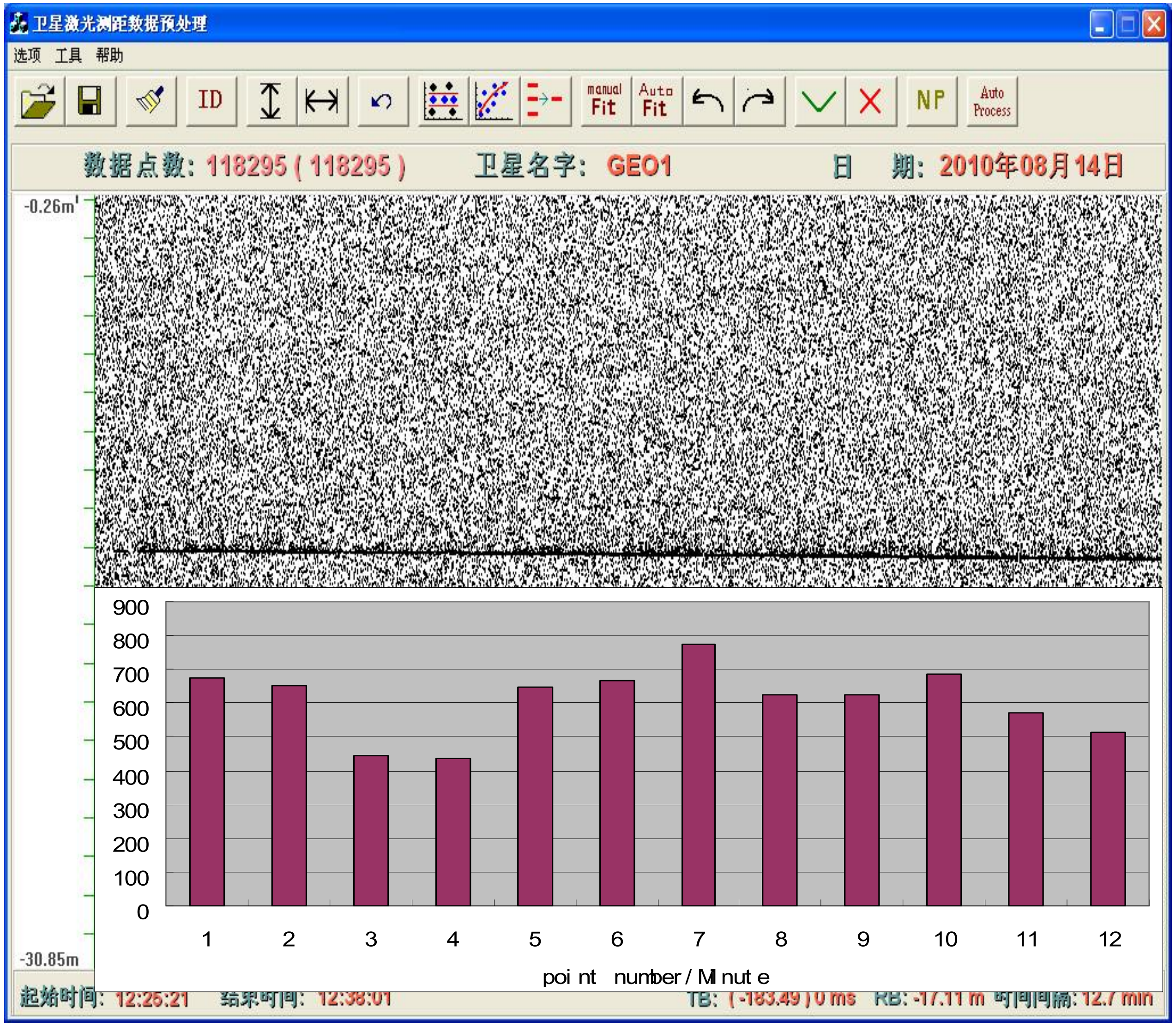


激光测距资料预处理软件
文件 工具 帮助
manual Fit
Auto Fit
NP
FullR
数据点数：4414(4414)
卫星：GEO2
日期：09-04-24
75.88m
2009.4.24 GEO2 returns
70
60
50
40
30
20
10
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51
Returns / Minutes
38.05m
起始时间：13:1:55
结束时间：13:53:38
TB: (3108.9)3000ms
RB: 55.6m
TL: 51.7min

Range residual from IGSO3 satellite at nighttime



Range residual of GEO1 at Shanghai kHz system



- Range: 38000km
- RMS: 1.17cm
- Power: 1.8w
- Returns: 7,126
- Return rate: 0.9%

Conclusion

- Up to now, Shanghai Observatory has accomplished sets of LRA for COMPASS satellite.
- For GEO satellites, the method of inclined installed LRA is adopted to make its normal direction point to the stations on ground, not to the Earth's center. This original way of installation makes the reflective area and returns increased effectively.
- Measuring results show that the performances of LRA on COMPASS satellites is well.
- The methods of design and manufacture of LRA on COMPASS satellites has successfully applied to other satellites.

Thank you!