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Space Debris Tracking in Changchun Observatory of China

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Aim

- The Space Debris Laser Ranging (DLR)

In Changchun , China

Introduction

- Changchun began SLR in 1982 ,
- The equipment upgraded in 2009,

  first realized kHz repetition

  and daylight observations,

- According to ILRS, Changchun is

  one of four "Strongest Performers".

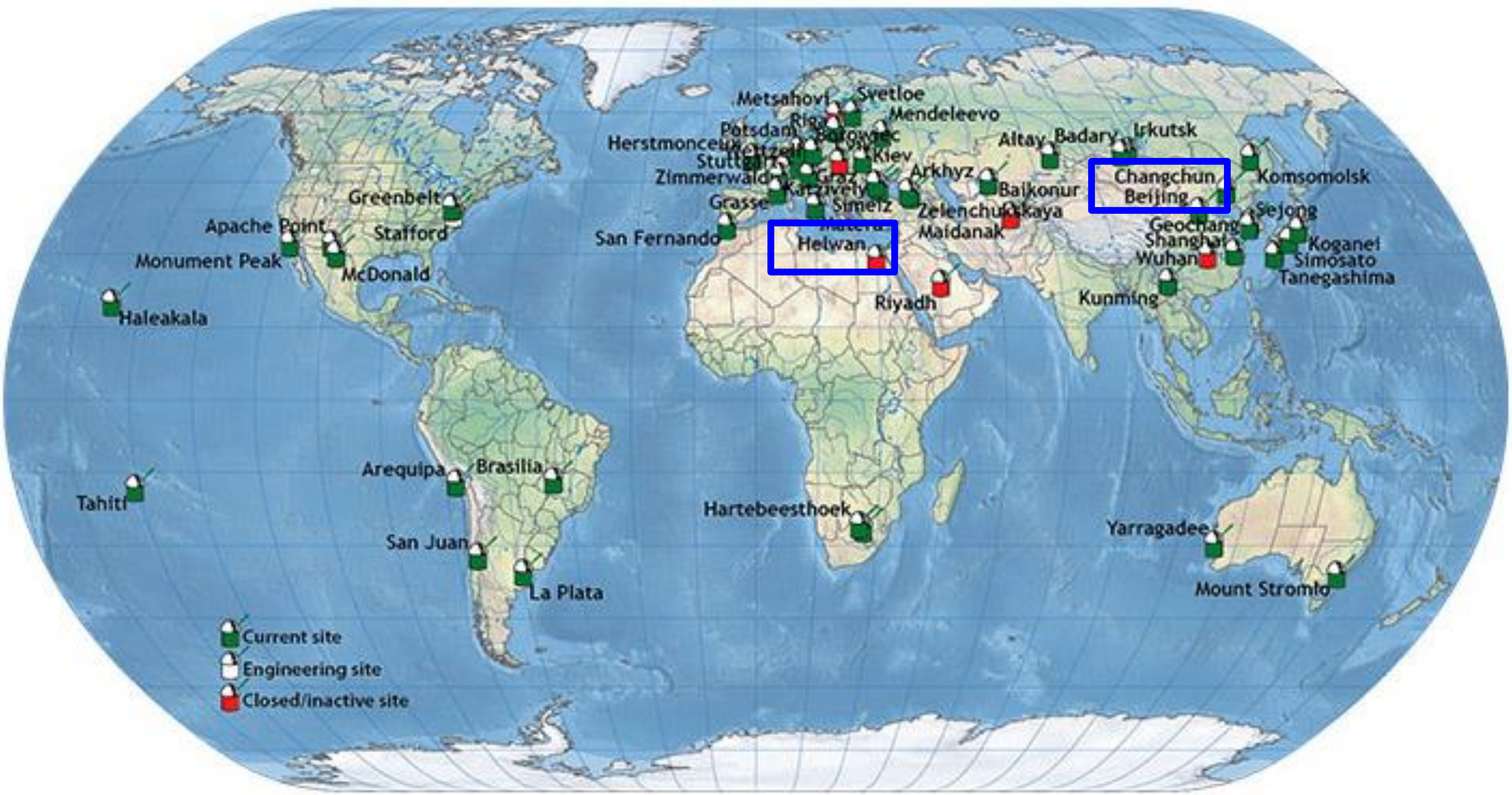
- The space debris laser ranging (DLR) started at

  the end of 2013,

Network Home » Network » List of Stations

Map of Stations

Mouse over a station name to view more information (view larger clickable map | download larger image).



ILRS

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Network

Home » Network » List of Stations » Active Stations

List of Stations

- Active Stations
- Engineering Stations
- Closed/Inactive Stations
- Future Stations

Site Information

Site Procedures

System Performance

Networks and Engineering Standing Committee

Quality Control Board

Quick Links

- Network Map
- List of Stations
- Monthly Report Card
- Quarterly Report Card
- Network Status Page
- Procedure for estimating laser beam divergence
- Recent Station Upgrades

General | Site Log | Meteorological Data | LAGEOS Performance | Satellite Data Info

Helwan

Jump to: Photo, Contact, Coordinates, News, Links

Back to Top

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Back to Top

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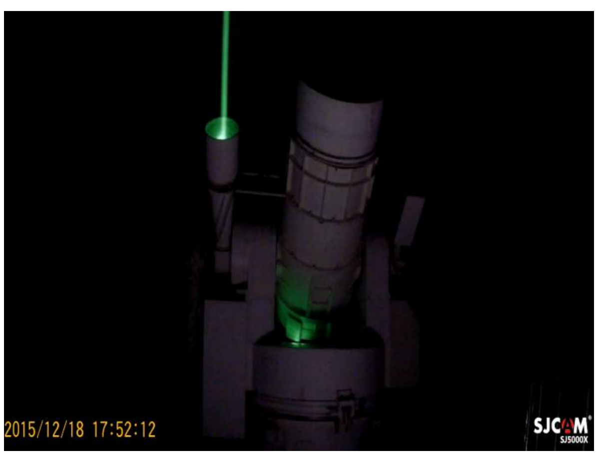
Telephone (secondary)	

The (SLR) In China (Changchun)

60-cm SLR Telescope



- **Now - the daylight ranging ability of SLR can reach 40,000 km**

- **The yearly data reach to 20,000 passes.**

- **According to the report of ILRS in 2016, Changchun ranked No.2 in over 40 stations worldwide.**

- **As for the (HEO), it is ranked No.1.**

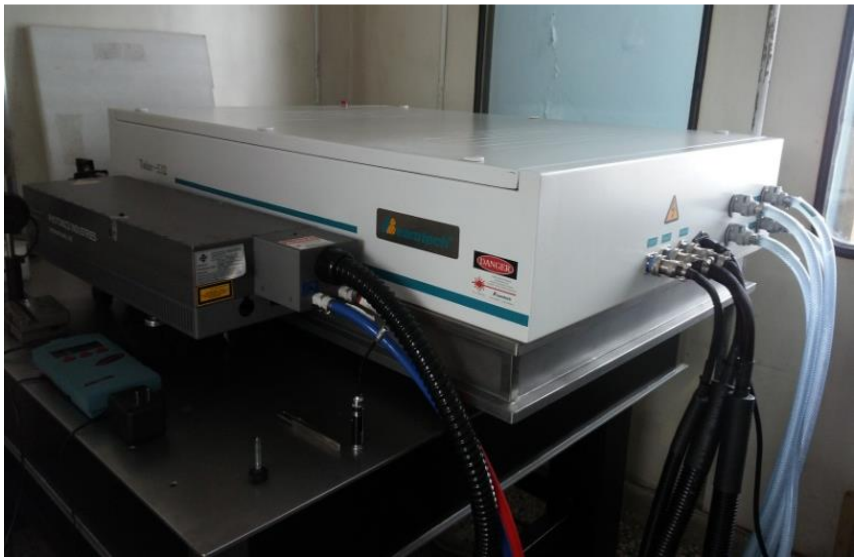
Changchun (DLR) System)

- The mount consists of two-step motors Azimuth & Altitude

- For operation, the computed predictions of satellite azimuth and altitude are fed to the step motor control unit by the computer.

- The receiver consists of a spherical lens of diameter 60.

Changchun (DLR) System)



Performances	Ns-laser
Working Mode	Laser diode pump
Wavelength	532nm
Repetition Rate	1-500Hz adjustable
Pulse Energy	60mJ
Pulse Width	9-10ns
Beam Divergence	0.4mrad

Nd:YAG Laser Generator produces laser pulses with Energy 60 mj per pulse of width 10 ns and with rep. rate of 500 Hz

Changchun (DLR) System)

- The detector type : Single Photon Avalanche Diode (C-SPAD) made by Czech Technical University.
- The quantum efficiency of this C-SPAD is 20%
- An Event timer A-033 is used for laser roundtrip time measurement.

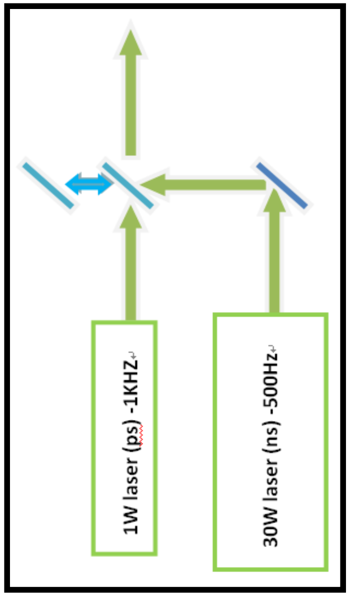
Its resolution is better than 10 ps

Changchun (DLR) System)

Real-time control & data-processing system

DLR System in Changchun

60cm telescope



Optical path

- **The biggest difference for the two laser ranging systems are the lasers.**
- **The two different lasers are set in a horizontal line**
- **A movable mirror 45° is applied into the laser ranging systems to switch the laser source.**

Tracking Technologies used in Changchun

New tracking technologies used in DLR system, such as

- **Tracking control program upgrade ,**
- **Space debris data base establishment,**
- **Closed-loop Tracking with CCD image**
- **Data identification in tracking**

  to select the effective signal against the huge noise.
- **Range bias improvement**

Rebound Index Calculation

I rebound shows the strength of reference echo

It is used to estimate the probability of a space debris target to rebound any laser pulse.

It is a dimensionless number and is calculated as in equation:

$$I_{rebound} = \frac{S / S_0}{(R / R_0)^4}$$

Where

S is cross section area of the given space debris ,

S_0 is reference area, which is one square meter.

R is range to the space debris target,

R_0 is reference range, which is 1000 kilometer.

The rebound index $I_{rebound}$ shows the strength of reference echo .

Closed-loop tracking

Target Closed-loop with CCD image to ensure the target in the center of view.

On a given epoch, the CCD device snaps an image containing target and laser beam tip, and coincidentally passing stars.

The composite image is analyzed by software to extract target position offset.

The offset is then feedback to tracking computer, so that to keep the target in a reference point in FOV

Space Debris Database

Due to the difficulties facing the tracking of the space debris ,
(small cross section and short passing time)
So , the plan is to track the targets with the orbit height of about 1000km, RCS larger than 1m², and easier to track under Changchun estimation.

人卫数据小助手

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数据服务

说明

空间态势(SSR)
两行根数(TLE)

快捷预报
-已测目标
-今夜精选

空间碎片预报（>10）
空间碎片预报（>5）
微小碎片（.5-2㎡）
空间碎片预报（全部）

候测目标列表
回避目标列表

空间目标易测度排名
空间目标RCS排名

数据库状态

FK5

长春站空间碎片观测预报（小）

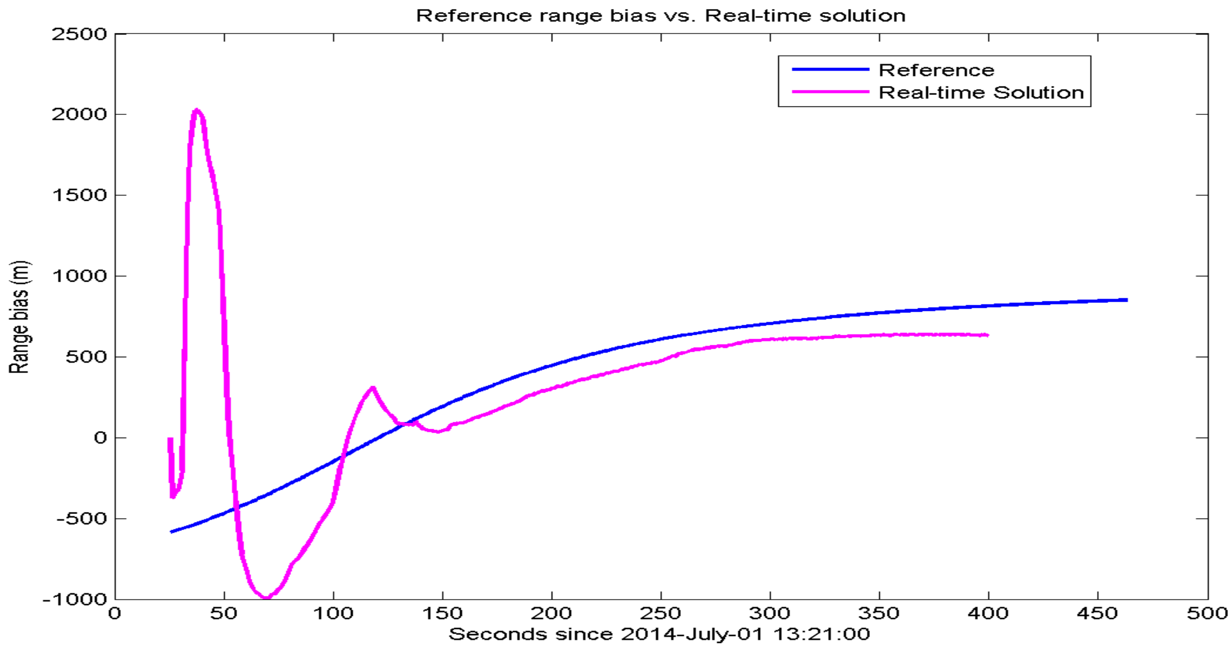
注：标亮表示回避

日期 Date	开始时刻 Begin	结束时刻 End	最大仰角 Max ELV	回波指数	NORAD ID	file	rcs	name	轨道高度
2014/05/13	00:00	00:07	86 deg	12.1	20855	file	7.3 m2	CZ-4 DEB	864 km
2014/05/13	00:00	00:11	63 deg	7.3	8520	file	6.5 m2	SL-3 R/B	863 km
2014/05/13	00:01	00:09	69 deg	5.7	8546	file	0.7 m2	SL-12 R/B(AUX MOTOR)	10463 km
2014/05/13	00:01	00:10	56 deg	13.1	19211	file	4.1 m2	SL-14 R/B	621 km
2014/05/13	00:02	00:12	57 deg	9.6	16953	file	6.5 m2	SL-8 R/B	768 km
2014/05/13	00:02	00:13	76 deg	21.0	19120	file	10.5 m2	SL-16 R/B	828 km
2014/05/13	00:02	00:11	67 deg	18.8	15370	file	4.2 m2	SL-14 R/B	620 km
2014/05/13	00:03	00:11	75 deg	86.6	28813	file	9.9 m2	SL-24 DEB	554 km
2014/05/13	00:07	00:13	28	11.6	11849	file	5.4	SL-3 R/B	434

Date	Beginning epoch	Ending epoch	Max elevation	Rebound Index	NORAD ID	RCS area / m2	Name	orbital altitude /km
8/29/2018	0:00	0:05	87 deg	30	3230	4.3 m2	SL-8 R/B	597
8/29/2018	0:00	0:06	79 deg	11.6	11427	4.8 m2	SL-8 R/B	767
8/29/2018	0:01	0:12	72 deg	11.9	6061	4.7 m2	SL-8 R/B	756
8/29/2018	0:04	0:15	59 deg	16.4	20625	13.8 m2	SL-16 R/B	843
8/29/2018	0:07	0:15	39 deg	11.1	23343	8.7 m2	SL-16 R/B	639
8/29/2018	0:08	0:21	88 deg	10.8	39016	10.1 m2	CZ-4C DEB	1092
8/29/2018	0:09	0:18	88 deg	54.6	19046	6.5 m2	SL-3 R/B	559
8/29/2018	0:10	0:17	87 deg	13.6	26034	1.2 m2	CELESTIS 03/TAURUS R/B	541
8/29/2018	0:14	0:23	67 deg	38.2	13154	5.9 m2	SL-3 R/B	571

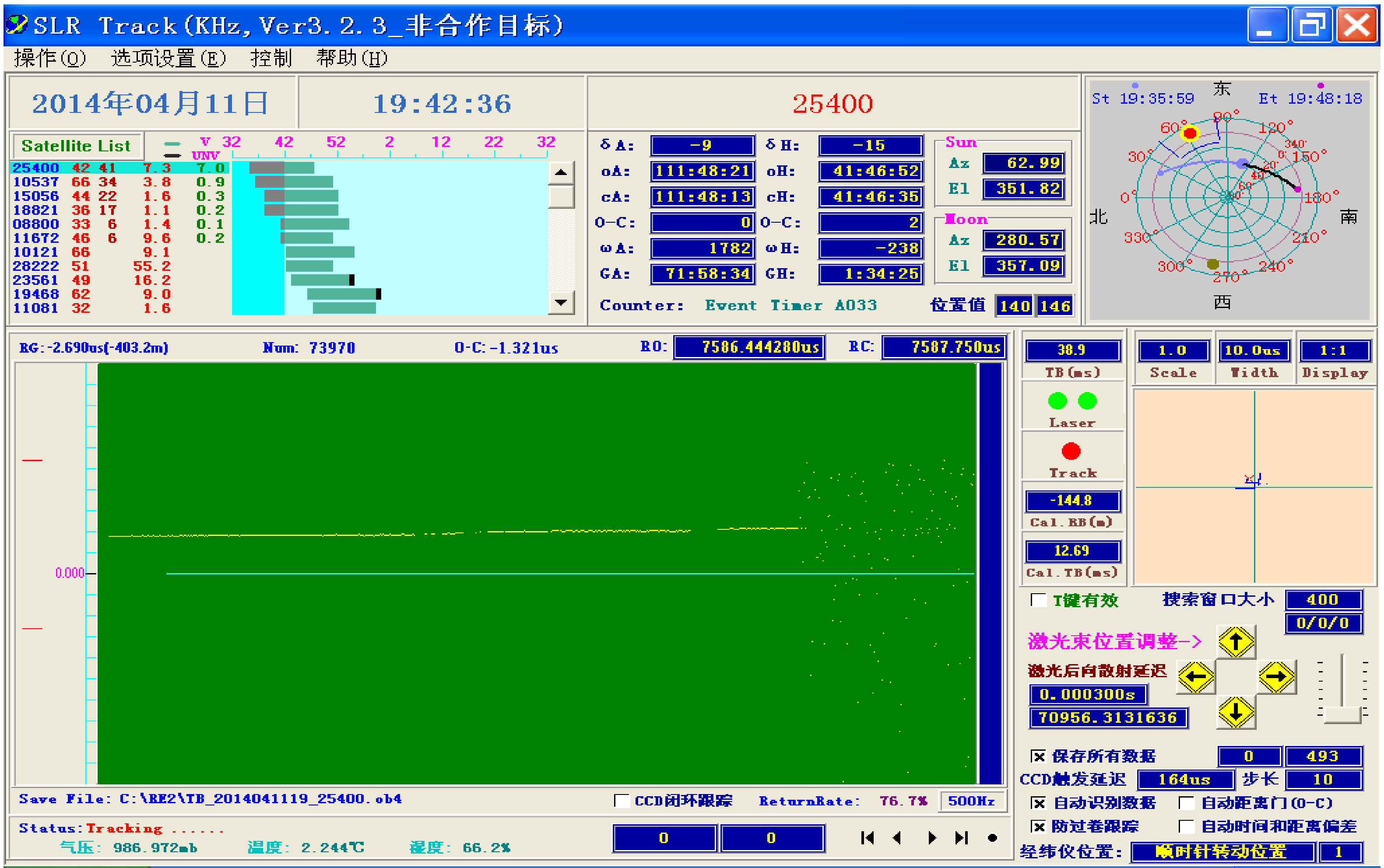
Range Bias Improvement

- As the range bias of TLE prediction could be up to a few hundred meters.
- it is necessary to improve the orbit prediction.
- A method is used to calculate the range bias according to real-time visual position bias,
- This improve the prediction accuracy to less than 100m **in a few minutes.**
- The results of range bias improvement is shown in Figure .

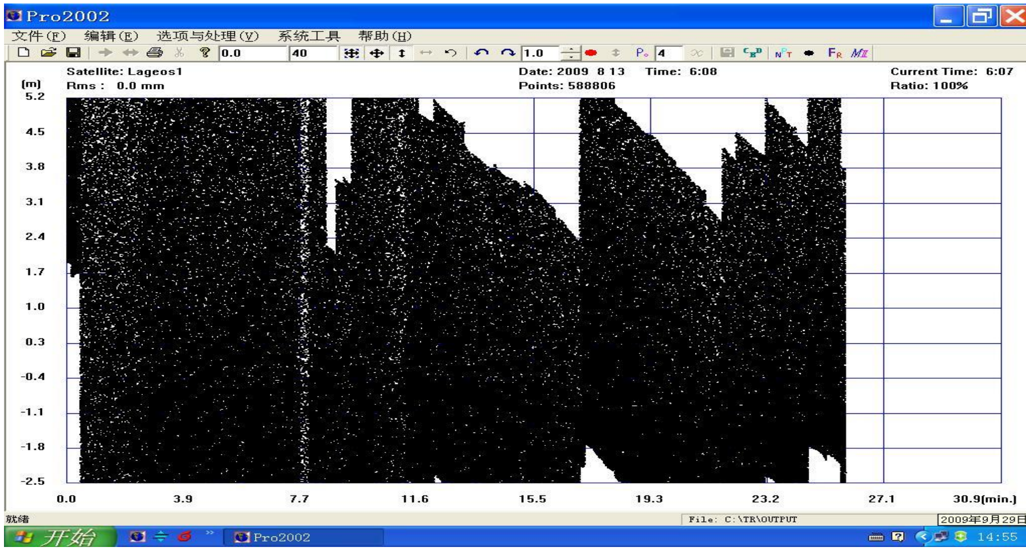


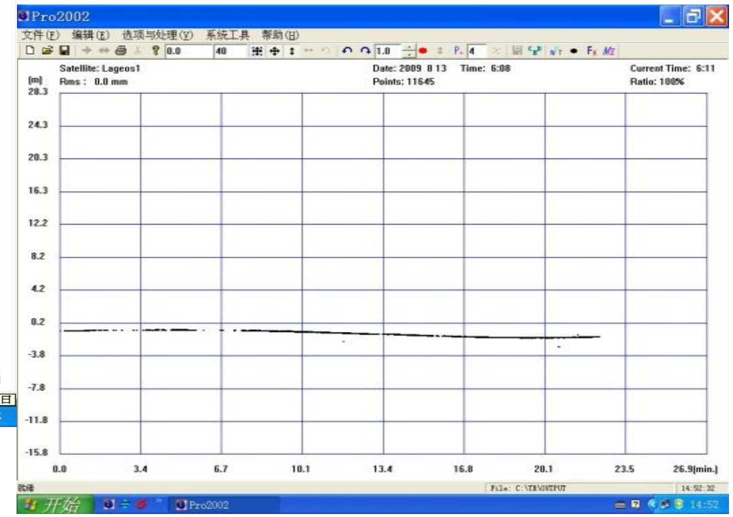
Sample of debris tracking

Space debris target running too fast, prediction accuracy is poor. Ranging control software specially added a time and ranging gate bias correction Auto-adjustment function



Data auto-Identification



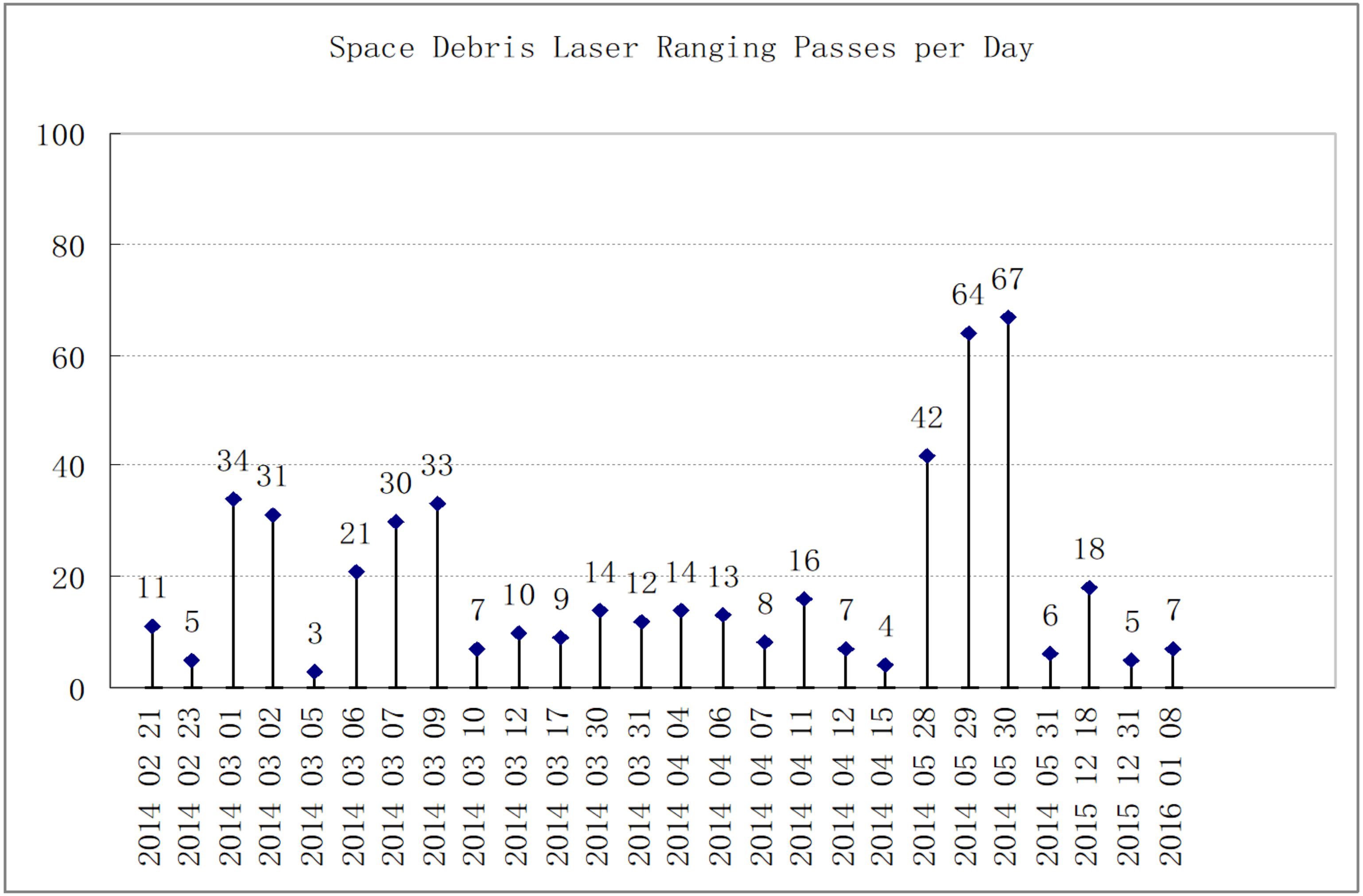


The data auto-identification was used to identify the real return signals from the huge signals.

Using this, we could find out the return signals easily.

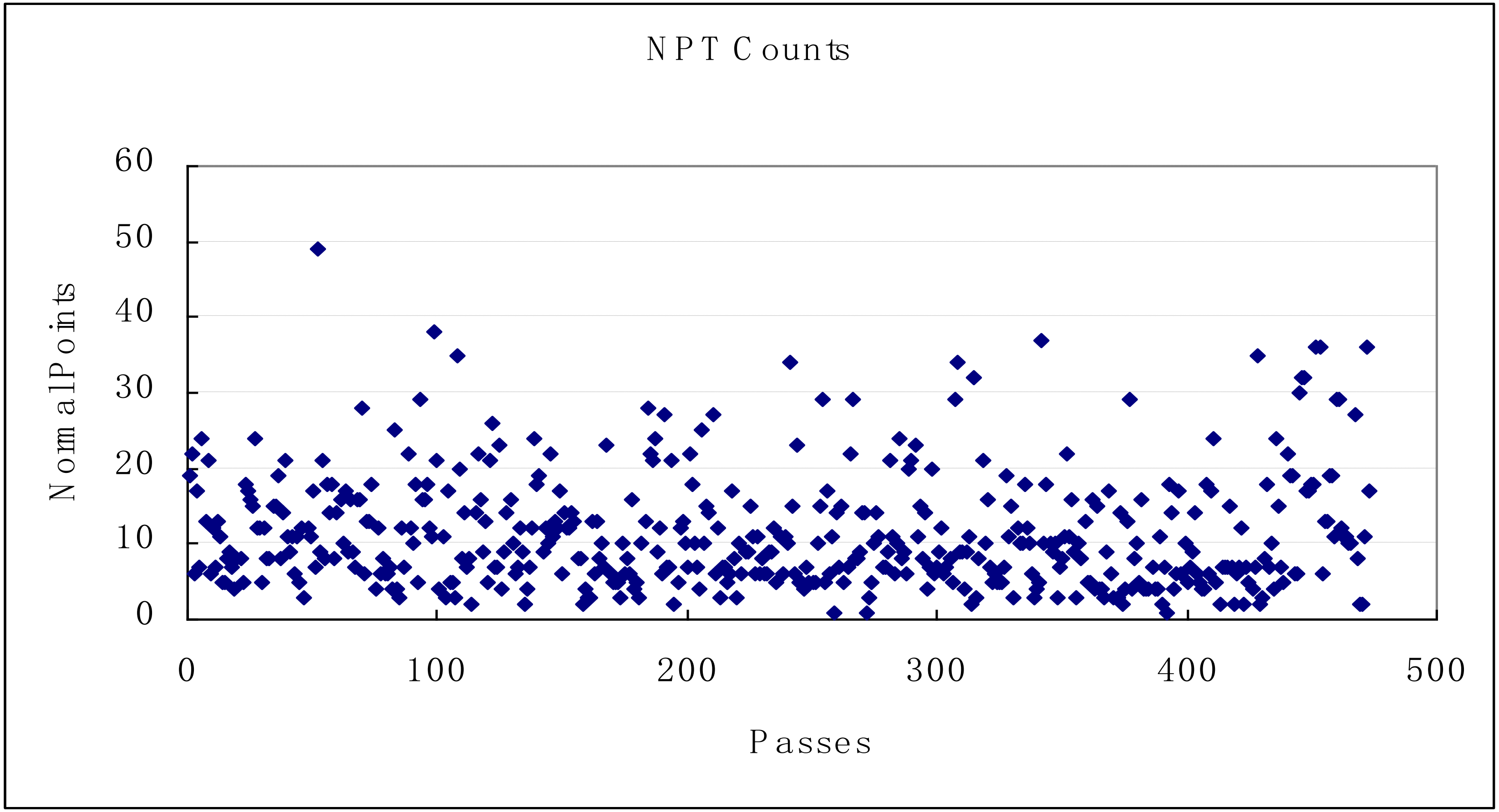
[G.Kirchner, F. Koidl, Graz KHz SLR system:design, experiences and results, 2004]

Observational Results and Analysis



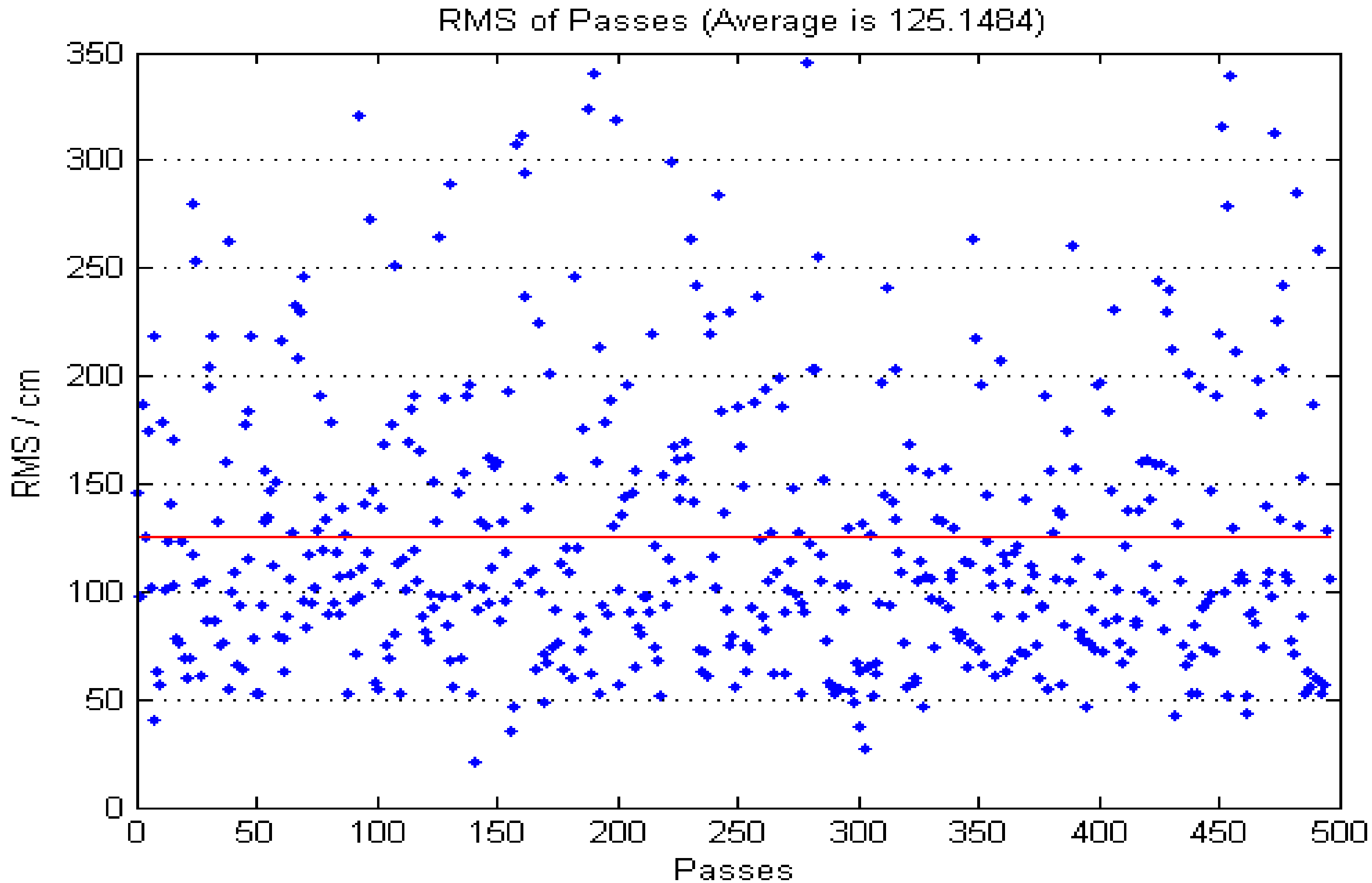
Passes per day during tracking period from year 2014 to year 2016

Observational Results and Analysis



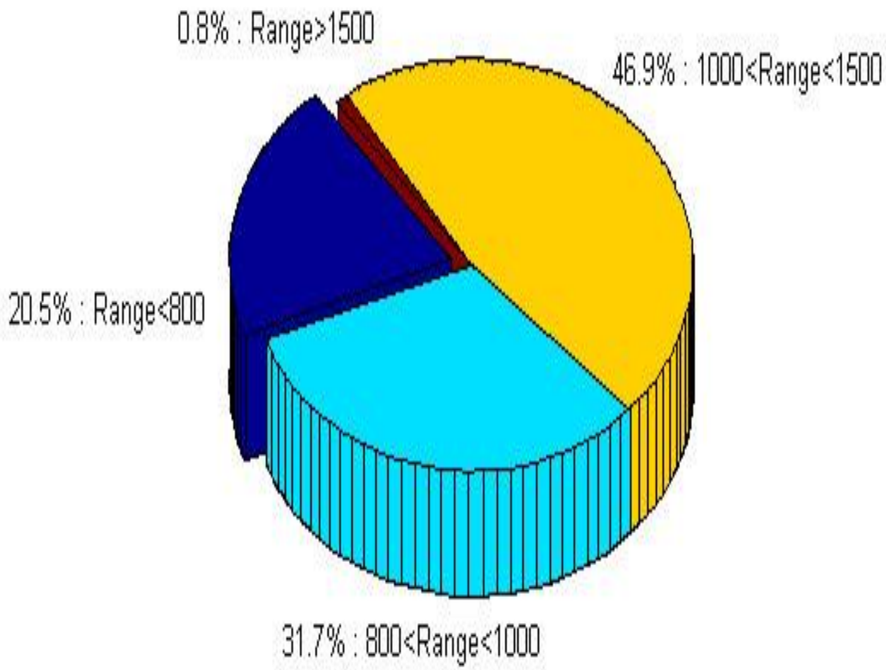
Normal points per pass during tracking period from year 2014 to year 2016

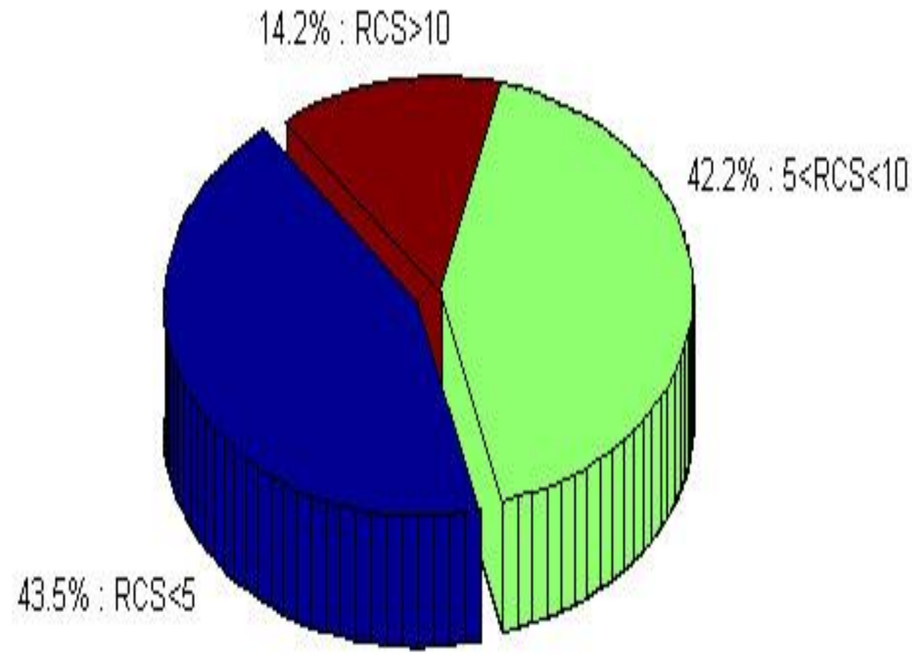
Observational Results and Analysis



Precision (RMS) of Passes distribution

Observational Results and Analysis





The distribution of the observed space debris

Conclusions

- Changchun Observatory tracked Space Debris since Feb. 2014.

- From 2014 to 2016, 491 passes of 232 space targets were acquired, elevation is from 19° to 87°.

- The space debris target distances are ranging between 460 km to 1800 km, with (RCS) vary from 26 m^2 to 0.75 m^2.

- The best record are up to 67 passes acquired in a single day.
  and 36 passes was obtained in one twilight.
  once obtained 60,000 points in 4 minutes.

THANKS

谢谢　　　　　شكرا