



LASER RANGING ON SPACE DEBRIS WITH THE CHANGCHUN SLR STATION
LIU Chengzhi Email: lcz@cho.ac.cn

ABSTRACT

The Changchun SLR station has upgraded to track space debris in 2014. The system operates with a 60mJ/10ns/500Hz@532.0nm laser ($M^2 < 1.5$) and an optical camera for closed-loop tracking. With this configuration, 466 passes of 233 different space debris targets were obtained during 19 terminator sessions, each about 1.5h. Target distances are between 460 km and 1800 km, with RCS (radar cross sections) from $>15 \text{ m}^2$ down to $<1.0 \text{ m}^2$. Measured range had an average precision of about 1.0 m RMS. The system can be conveniently operated by one person. The presentation will introduce the technical developments and the observation results obtained.
Key Words: Space Debris Laser Ranging, Closed-loop Tracking

Introduction

Changchun Station planned to begin the space debris laser ranging at the end of 2013, which was based on Changchun 60cm aperture laser ranging system. Aiming at a series of problems such as space debris objects' angular rate, prediction accuracy and signal identification, we established space debris laser ranging (DLR) system with high repetition rate, high precision, high sensitivity and high automation, realized effective observation at last. Up to now, the DLR system has achieved nearly 466 passes of 233 different space debris targets during 19 terminator sessions each about 1.5h.

DLR System Description

Structure

Dual laser System : Arranged in parallel in Changchun SLR system
Moveable mirror : Allows ns-laser (debris) through or directs the kHz ps-laser (satellite) to the coude path.

- ps-Laser (to SLR)**
1kHz repetition rate with pulse energy of 0.9 mJ /35ps@532 nm
- ns-Laser (to Space Debris objects)**
0.5kHz repetition rate with pulse energy of 60mJ/10ns@ 532 nm

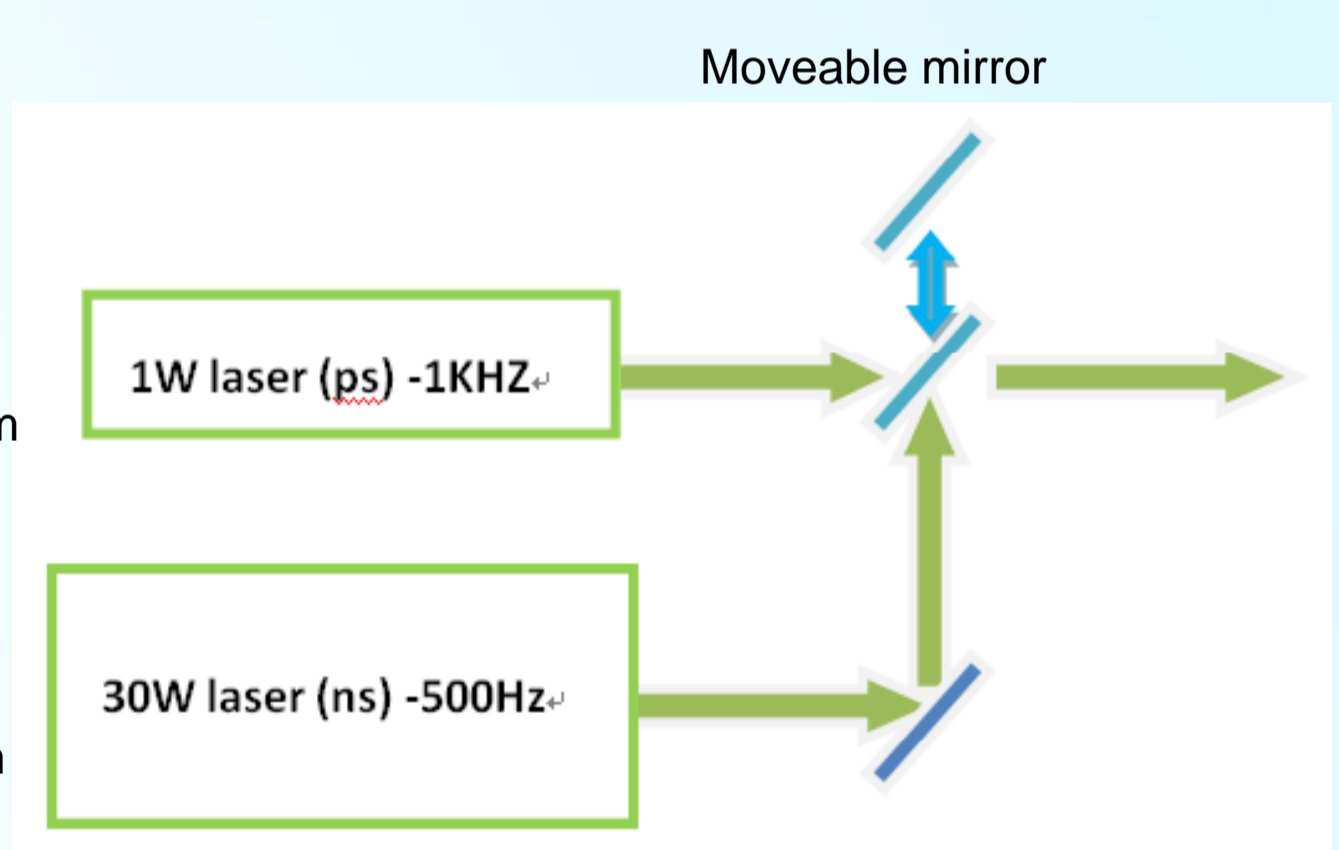


Fig.1 Structure of DLR System

Software

- Tracking control** : Upgraded Tracking control program
- Data base** : Established a database as the target select assistant
- Data identification** : Added the data identification in tracking to select the effective signal against the huge noise

Target Select Assistant

Target assistant software include:

- TLE automatic updates
- Target selection by:
 - Target Type
 - RCS
 - Pass max. Elevation
 - Rebound index

TLE=>CPF=>SLR=>tracking



Fig.3 Target Select Assistant Software

Upgrade Tracking Control

Tracking control software upgrade:

- Real-time rebound index calculation
- Target Closed-loop with CCD image
- Laser beam recognition
- Laser beam automatic adjustment
- Automatic TB and RB correction

Range bias Improved:

First to Obtain the object predicted position bias, which were used to produce ranges bias for laser ranging.

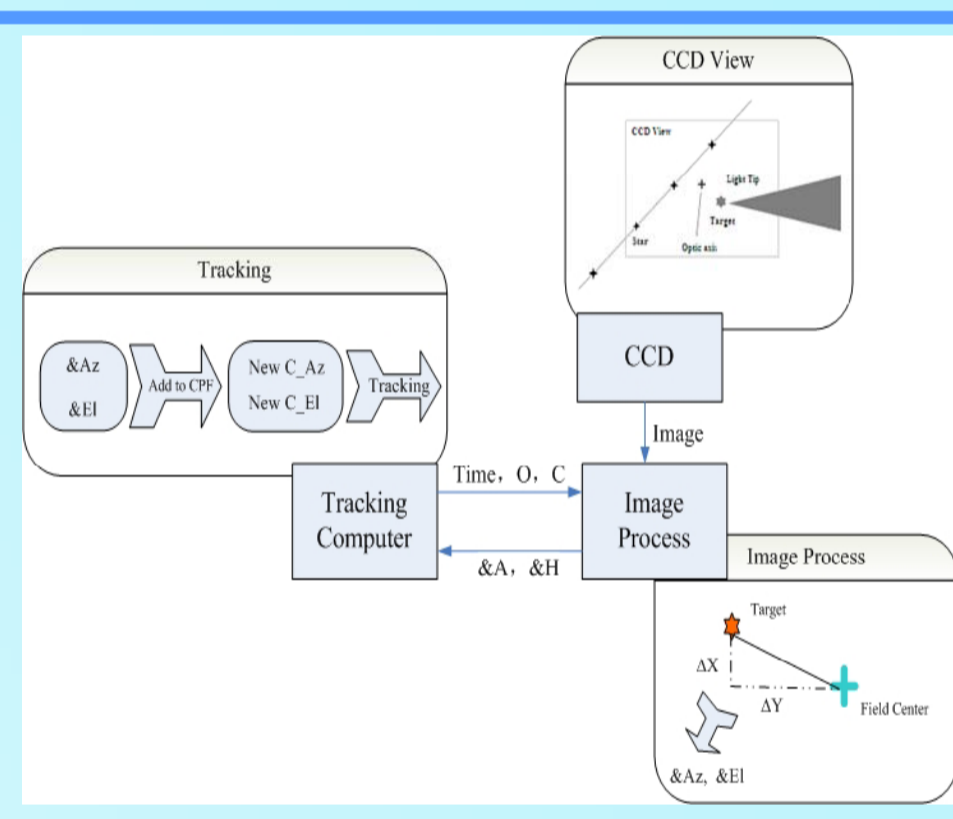


Fig.4 Closed-loop with CCD image

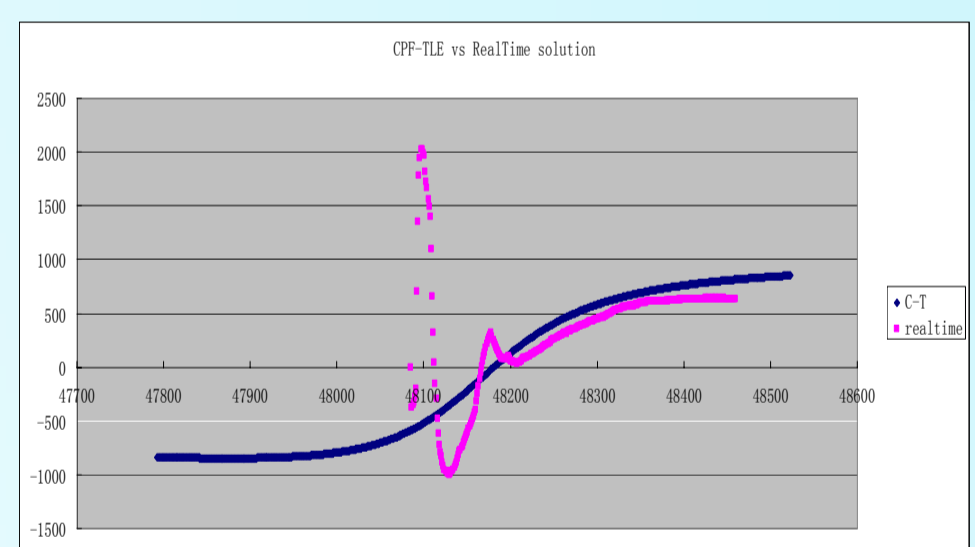


Fig.6 Range bias improved by position bias



Fig.5 Data Identification in tracking control

Observation Results

Observation Results:

- 26 passes data obtained in Twilight time
- Elevation from 19° to 87°
- Acquired 72 passes in a day
- Revisited passes obtained for multiple targets
- Obtained about 60000 points in 4 minutes

Tab.2 Debris Ranging Data Examples

NORAD	PASSES	DATA POINT	MIN RANGE (km)	MAX RANGE (km)	RCS M^2
28222	8	17500	658.056	1197.68	11.9
37363	7	8628	556.117	1065.762	5.1
28738	6	14586	646.069	1140.722	12.7
25723	6	5896	524.638	1050.787	4.9
25400	6	5691	830.435	1603.899	11.6
25732	6	2910	815.441	1137.727	6.7
38341	5	3180	722.51	1627.874	18.5
24797	5	3971	632.563	1388.042	10.1
5118	5	2910	593.595	990.821	6.8
24298	5	4332	852.915	1732.805	8.8

Summary

In short, Changchun high rate DLR system runs well since 2014-02-18, and the data is also obtained in twilight, with the elevation lasted from 19° to 87° , distances between 460 km and 1800 km, RCS (radar cross sections) from $>15 \text{ m}^2$ down to $<1.0 \text{ m}^2$. Now, we are planning the space debris laser ranging on 1m telescope at Changchun station.

ns-Laser

A ns-laser was used in DLR system made by Beamtech Optronics Company, Limited.

Tab.1 Table of ns-laser performances

Performances	ns-laser
Working Mode	LD pump
Wavelength	532nm
Repetition Rate	1-500Hz
Pulse Energy	60mJ/500Hz
M ² Factor	≤1.5
Pulse Width	9-10 ns
Beam Divergence	0.4 mrad



Fig.2 Appearance of ns-laser (left to right: Power, Laser, Water cooling)