

Study on Space Debris Laser Ranging in Kunming Station

Reporter: Xiaoyu Pi

email: pixiaoyu@ynao.ac.cn

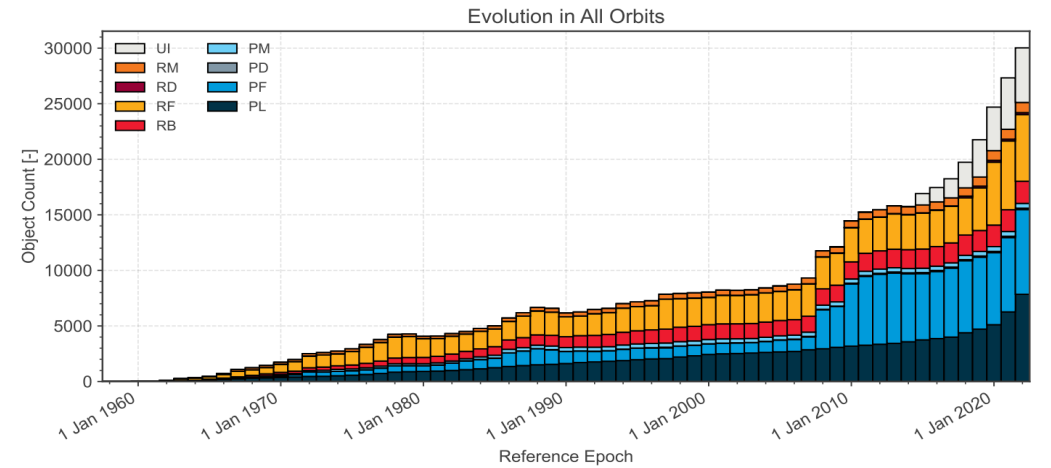
ILRS 2023 Virtual International Workshop on Laser Ranging (VIWLR)

Oct.20, 2023

Content

- Introduction
- Remote Tx and Rx DLR research
- Day-time DLR research

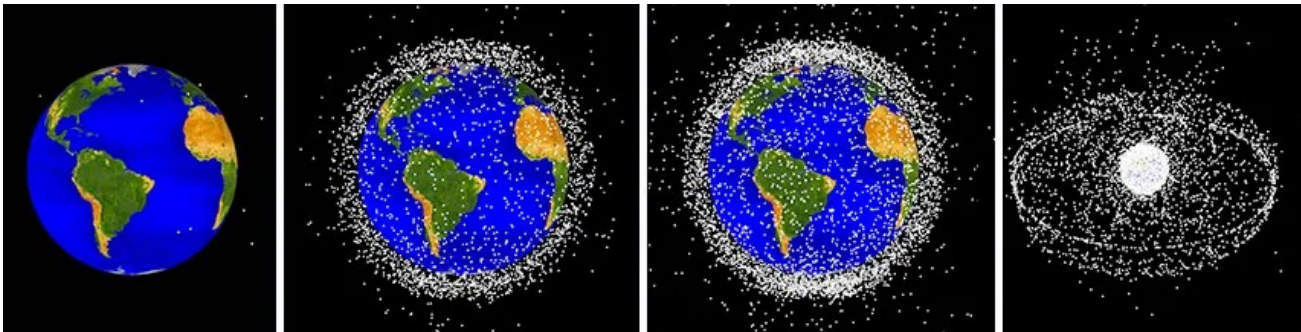
I. Intro: The Debris' Problem



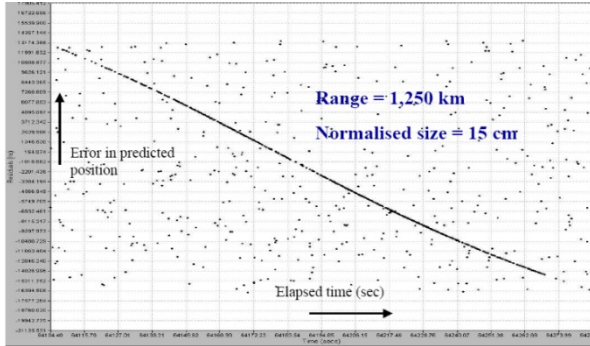
Source: ESA – Space Environment Report

The Debris are posing threats...

- Large amount
- Small size
- Orbit resource
- Collision with other space objects



I. Intro: The Debris' Problem

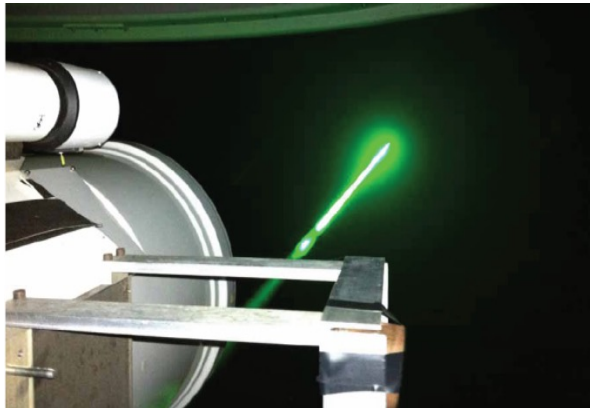


Stromlo, 2002

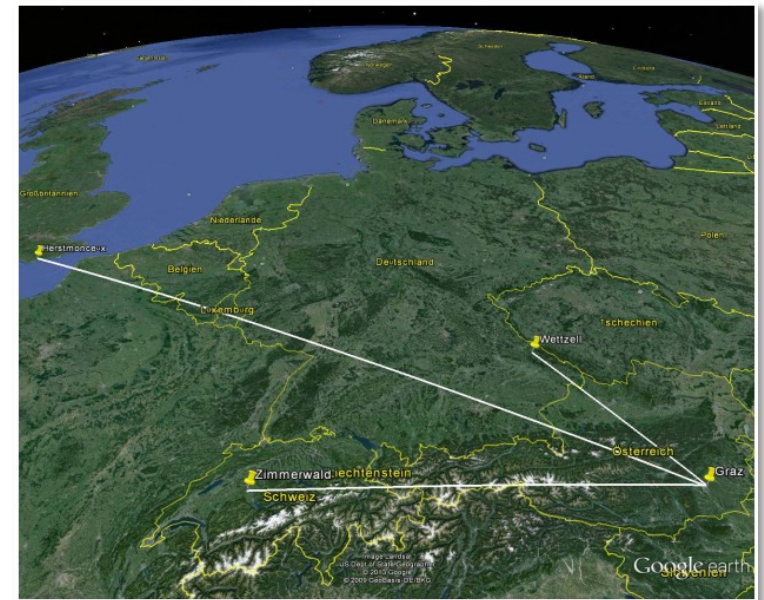
Multi-station DLR experiment

- Laser fired from Graz station
- Received by Graz, Wettzell (400km), Zimmerwald(600km) and Herstmonceux(1200km)

Grasse, 2011



Graz, 2011



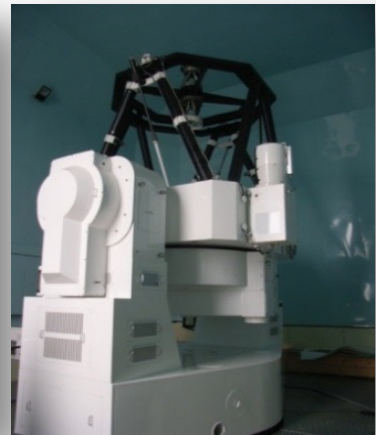
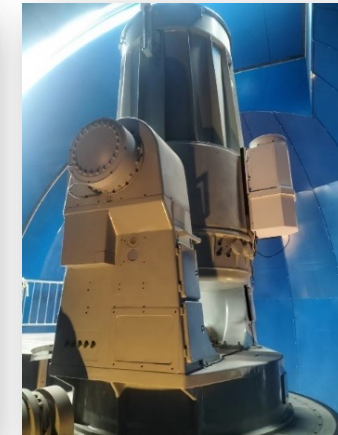
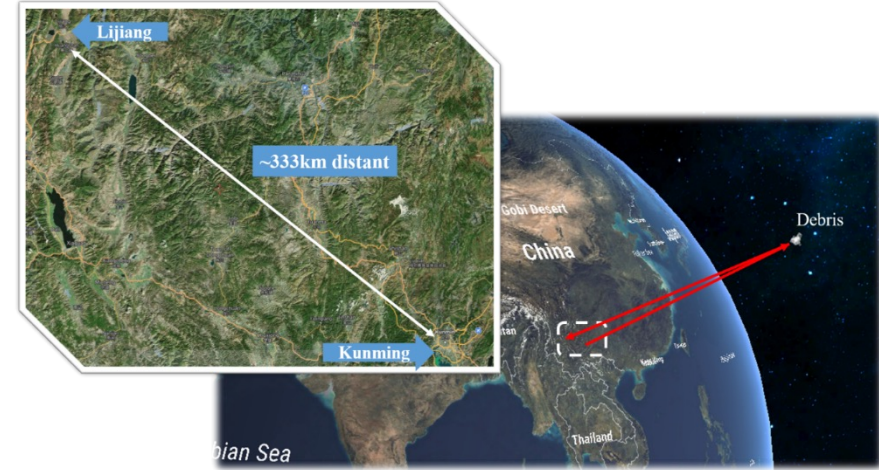
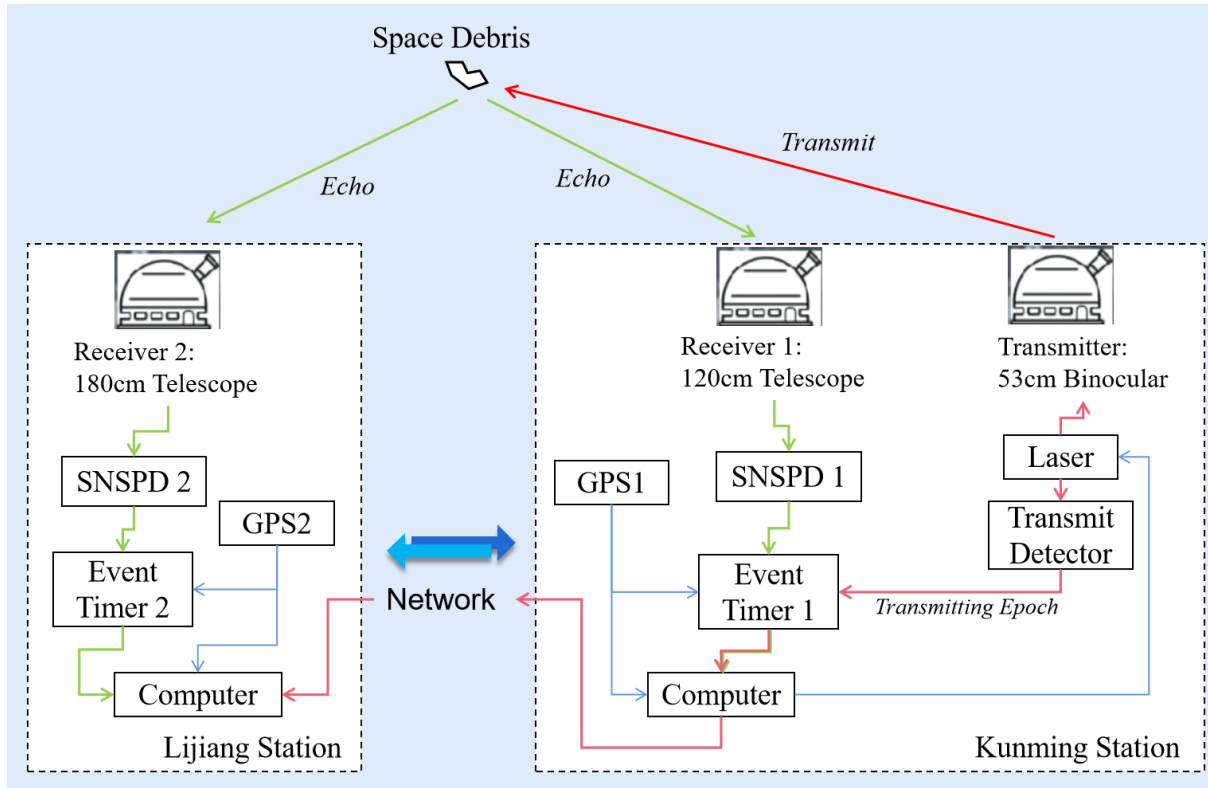
Source: Kirchner, G., Koidl, F. et al. Multistatic Laser Ranging to Space Debris. (2014).

I. Intro: The Debris' Problem



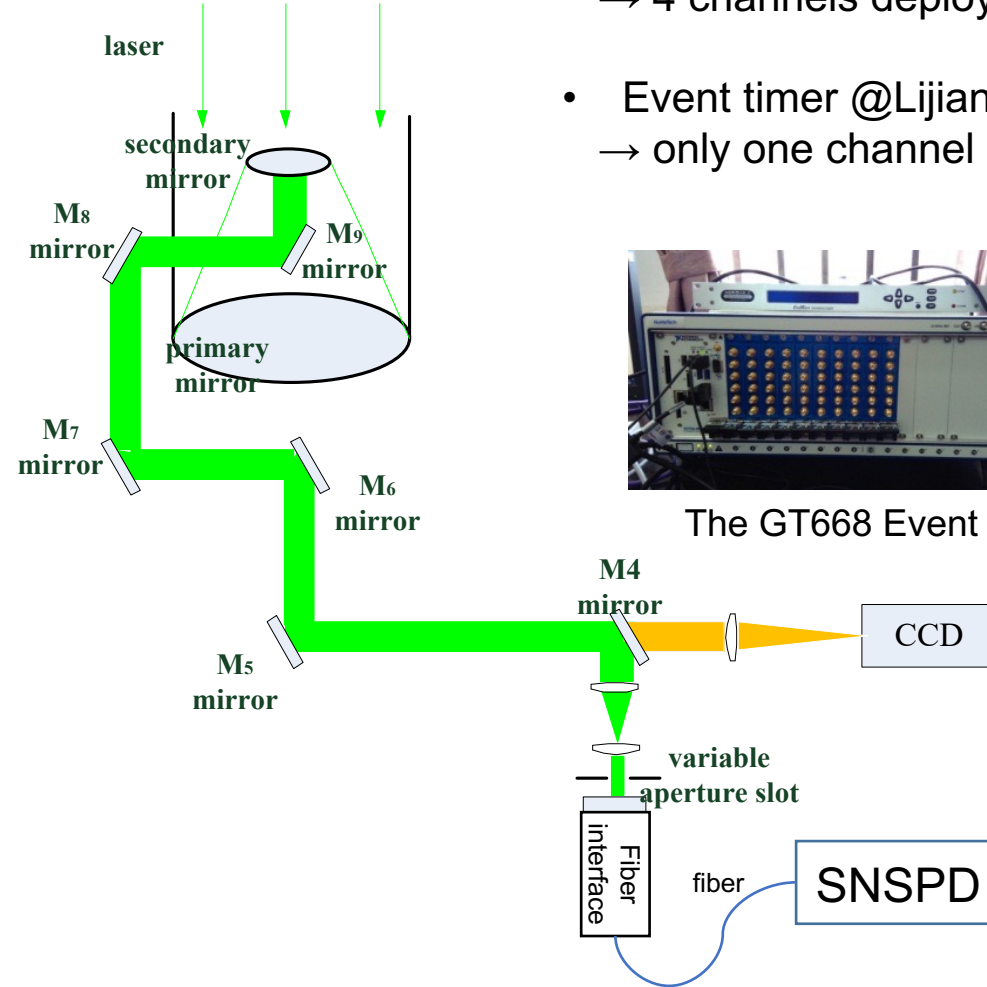
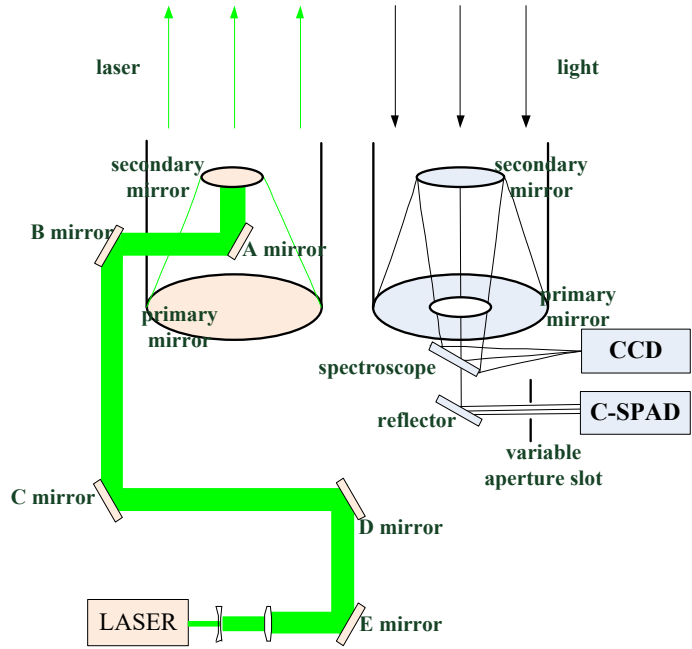
Station	Energy	Pulse Width	Wavelength	Frequency /Hz	Ranging Distance/km	Target size
Graz	25mJ	10ns	532nm	1000	600-2500	0.3-15m ²
Stromlo	2.5J	5ns	1064nm	100	1200	≤15cm
Grasse	2.1J	5ns	532nm	10	840-1800	
Shanghai	300mJ	≤8ns	532nm	200	500-2600	0.3-20m ²
Changchun	60mJ	10ns	532nm	500	400-1800	0.9-26.1m ²
Kunming (YNAO)	0.4J-3J	5.7ns	1064nm	100	500-2800 /6200	0.04-20 m ²

II. Remote Tx and Rx DLR research



- 1064nm Laser @ 100Hz
- Laser fired from the 53cm Binocular of Kunming station
- Received by both the 120cm Telescope in Kunming and the 180cm Telescope in Lijiang

II. Remote Tx and Rx DLR research



- Event timer @Kunming: GT668
→ 4 channels deployed
- Event timer @Lijiang: A033
→ only one channel available



The GT668 Event Timer



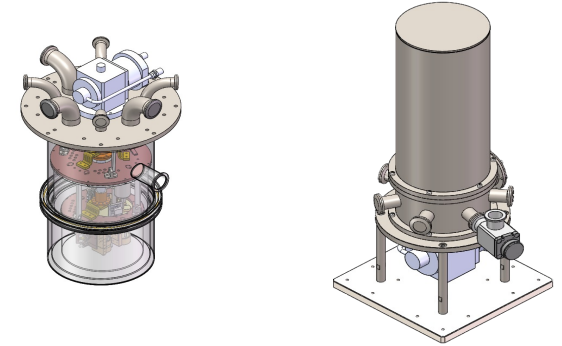
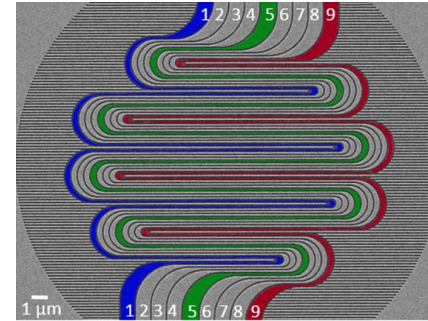
The A033 Event Timer

Transmitter Parameter	Value
Wavelength	1064 nm
Repetition rate	100Hz
Pulse Width	6.7ns
Pulse Energy	$\leq 3\text{J/pulse}$

II. Remote Tx and Rx DLR research

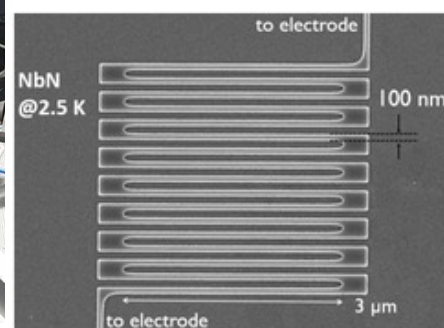


- Super-conducting Nano-wire Single Photon Detector
- SNSPD deployed at both stations
- Integrated signal in Lijiang due to limited ET input



SNSPD
@Kunming Station

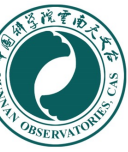
a 4-channel SNSPD
developed by Nanjing
University



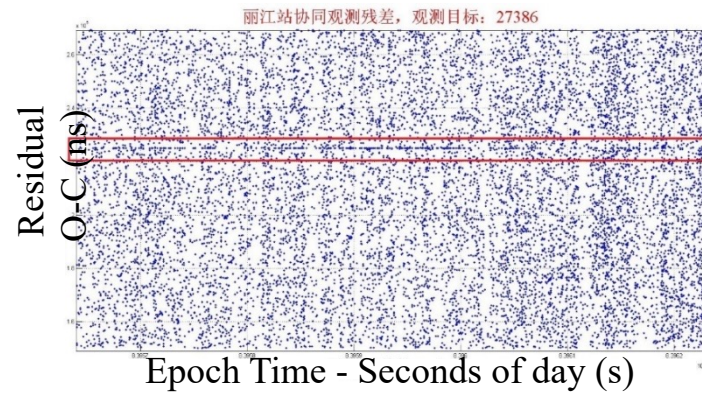
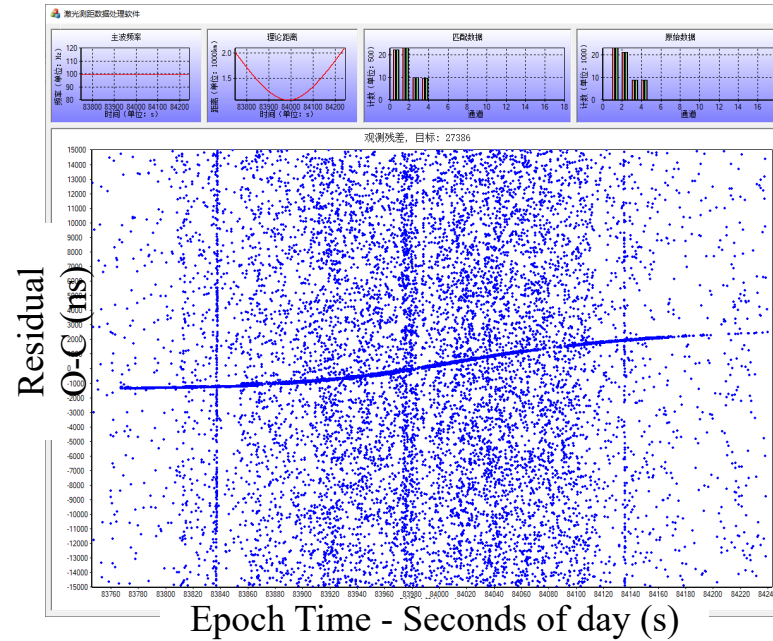
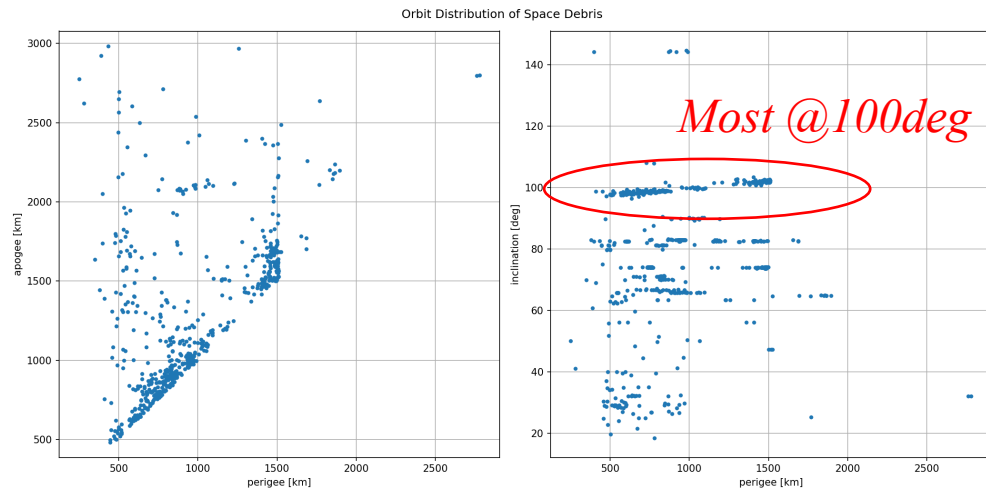
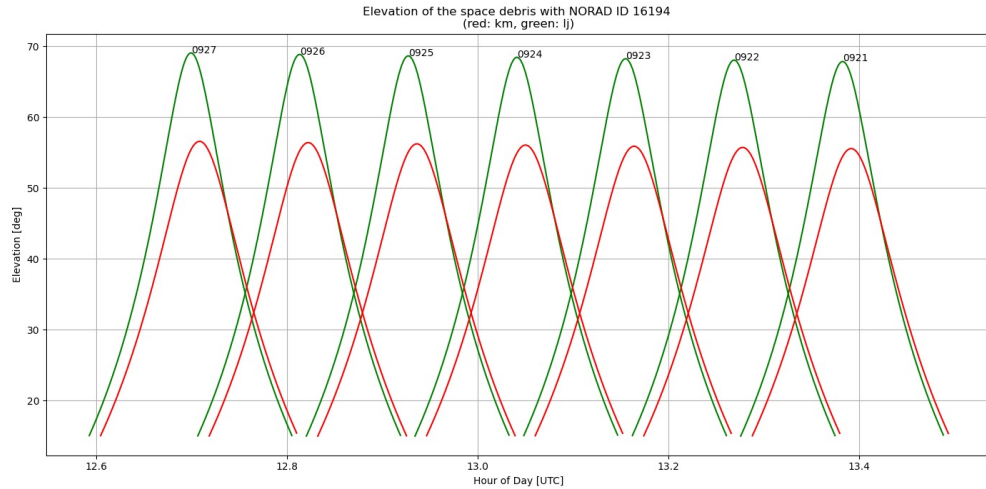
SNSPD @ Lijiang Station:
a Multi-channel-integrated
type developed by SIMIT
(Shanghai Institute of
Microsystem and
Information Technology)



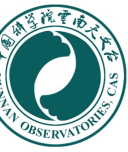
II. Remote Tx and Rx DLR research



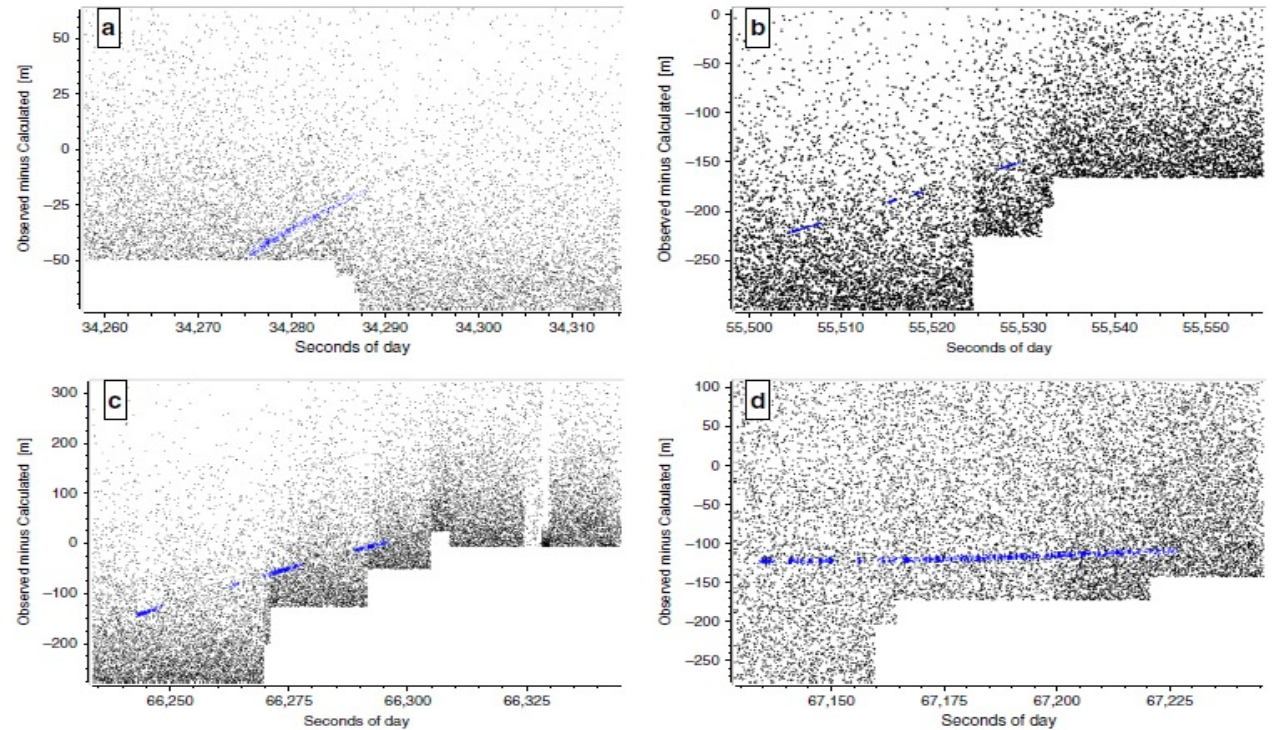
- Simultaneous visibility for both stations



II. Day-time DLR research



- More ranging data
- Precise cataloging
- Monitoring and warning

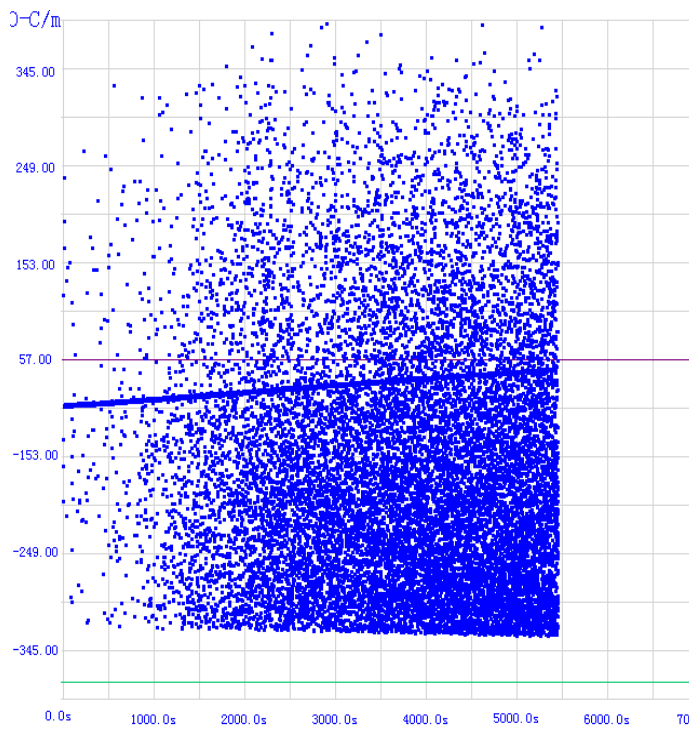


Source: Steindorfer M A , Kirchner G , Koidl F , et al. Daylight space debris laser ranging[J]. Nature Communications, 2020.”

II. Day-time DLR research

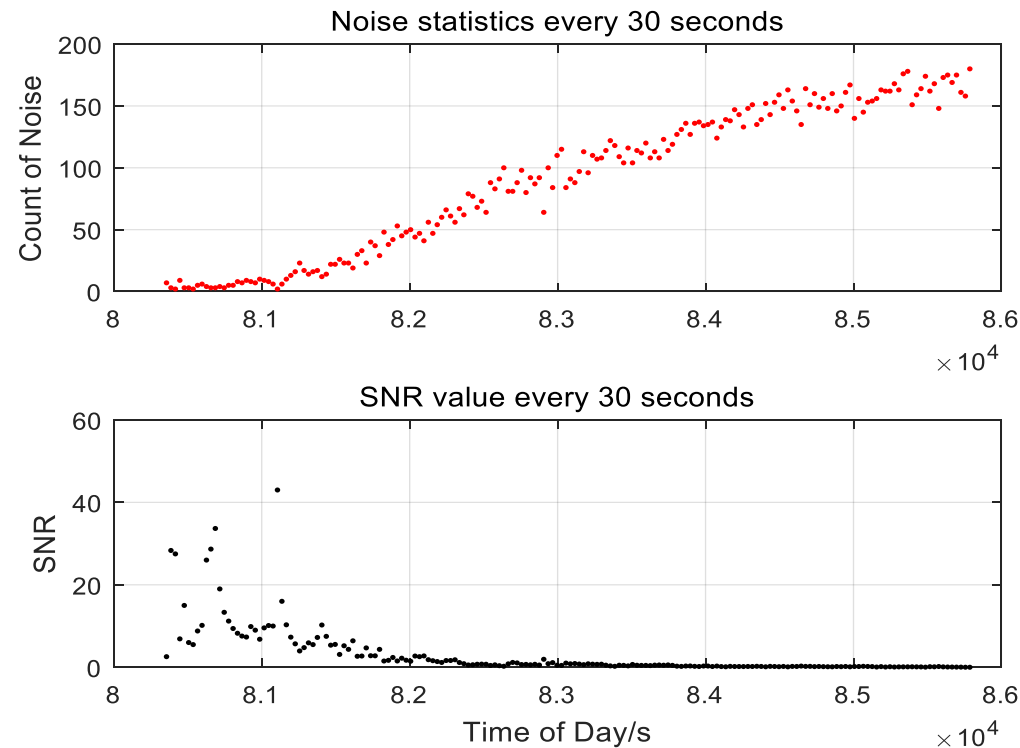


Day-time SLR



Distance residual plot of day-time laser ranging of Galileo 204 (~20 000km)

Day-time Noise Analysis



During ranging, with the increasement of the solar elevation from -5.67° to 14.42° , the noise kept rising continuously while the SNR was decreasing

II. Day-time DLR research

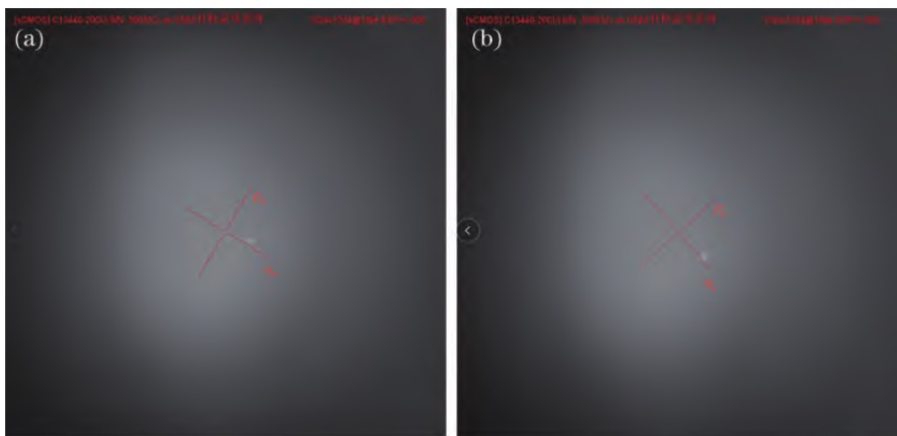


Key Issue:

- High precise pointing
- Strong-noise filtering and signal identification

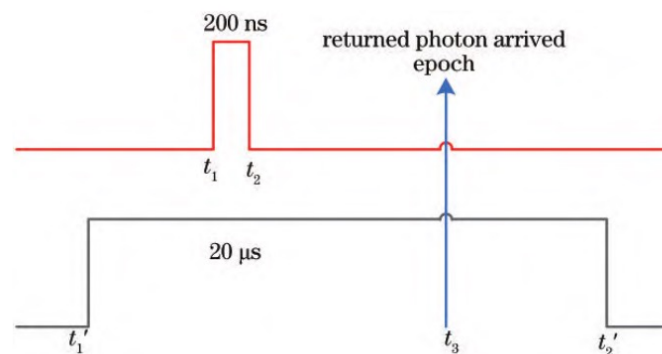
Precise Pointing

- Optical calibration during twilight
- Central position mark



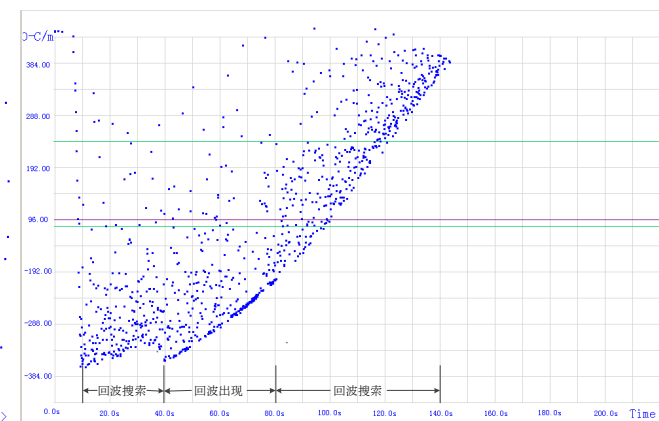
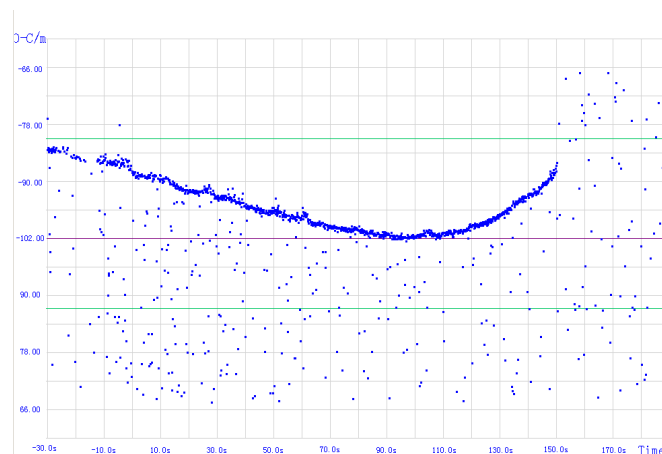
Increase SNR

- Improve range gate accuracy
- Reduce gate-open duration
- Low BW filter



III. DLR at the Yunnan Observatories – Day-time DLR

Date/local time	Type/Code	sunrise/ local time	sunset/ local time	phase angle	Perigee/km	Apogee/km	RCS/m ²
2020.11.13 (10:38:04)	ROCKET BODY/26474	07:23:55	-	168.15°	540	618	15.67
2020.11.23 (07:31:17)	ROCKET BODY/28932	07:30:57	-	67.09°	528	653	16.13
2020.11.24 (08:33:40)	ROCKET BODY/28480	07:31:40	-	105.80°	703	909	10.77
2020.11.27 (07:42:07)	ENVISAT/27386	07:33:49	-	67.80°	764	766	17.61
2021.04.21 (17:20:39)	TOPEX/22076	-	19:33:49	86.95°	1331	1343	8.59
2021.04.22 (07:14:14)	ENVISAT/27386	06:40:02	-	41.06°	764	766	17.61
2021.04.22 (07:46:33)	ROCKET BODY/6155	06:40:02	-	139.99°	629	683	13.16
2021.04.22 (18:55:02)	ROCKET BODY/25861	-	19:34:17	94.33°	622	645	13.61
2021.04.22 (19:16:07)	ROCKET BODY/38341	-	19:34:17	104.17°	577	655	18.50
2021.04.22 (19:26:12)	ROCKET BODY/28738	-	19:34:17	102.79°	520	538	12.75
2021.04.22 (19:32:00)	ROCKET BODY/28480	-	19:34:17	98.01°	703	909	10.77
2021.05.04 (06:51:13)	ROCKET BODY/20453	06:30:47	-	123.03°	415	803	9.86



- Solar elevation 11.82°
- Rocket body - 28480
- RCS: 10.77m²
- Perigee 704km
- Apogee 908km

- Solar elevation 35.87°
- Rocket body -26474
- RCS: 15.67m²
- Perigee: 539km
- Apogee: 619km

From April to May 2021, experiments were conducted again, the observational and the experimental results were published in the “Laser & Optoelectronics Progress”.

Thank you