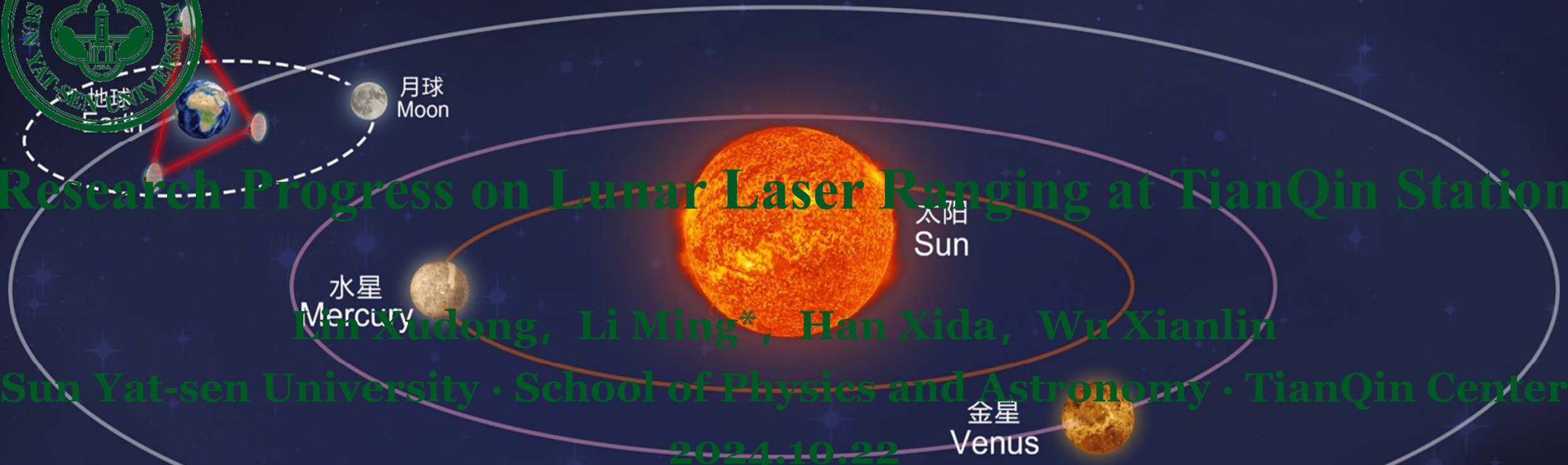
23rd International Workshop on Laser Ranging, Oct 20~26, 2024, Kunming, China



Research Progress on Lunar Laser Ranging at TianQin Station

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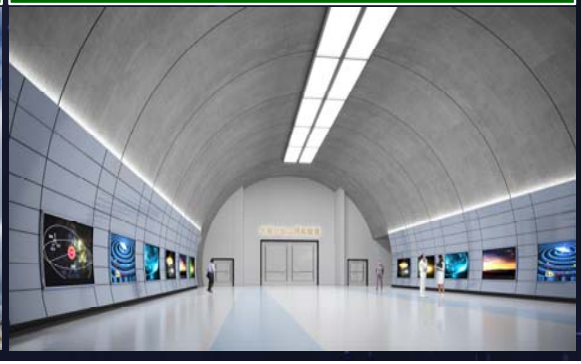
Sun Yat-sen University · School of Physics and Astronomy · TianQin Center

2024.10.22

微信公众号	天琴中心大楼	激光测距台站	山洞实验室
			

Outline

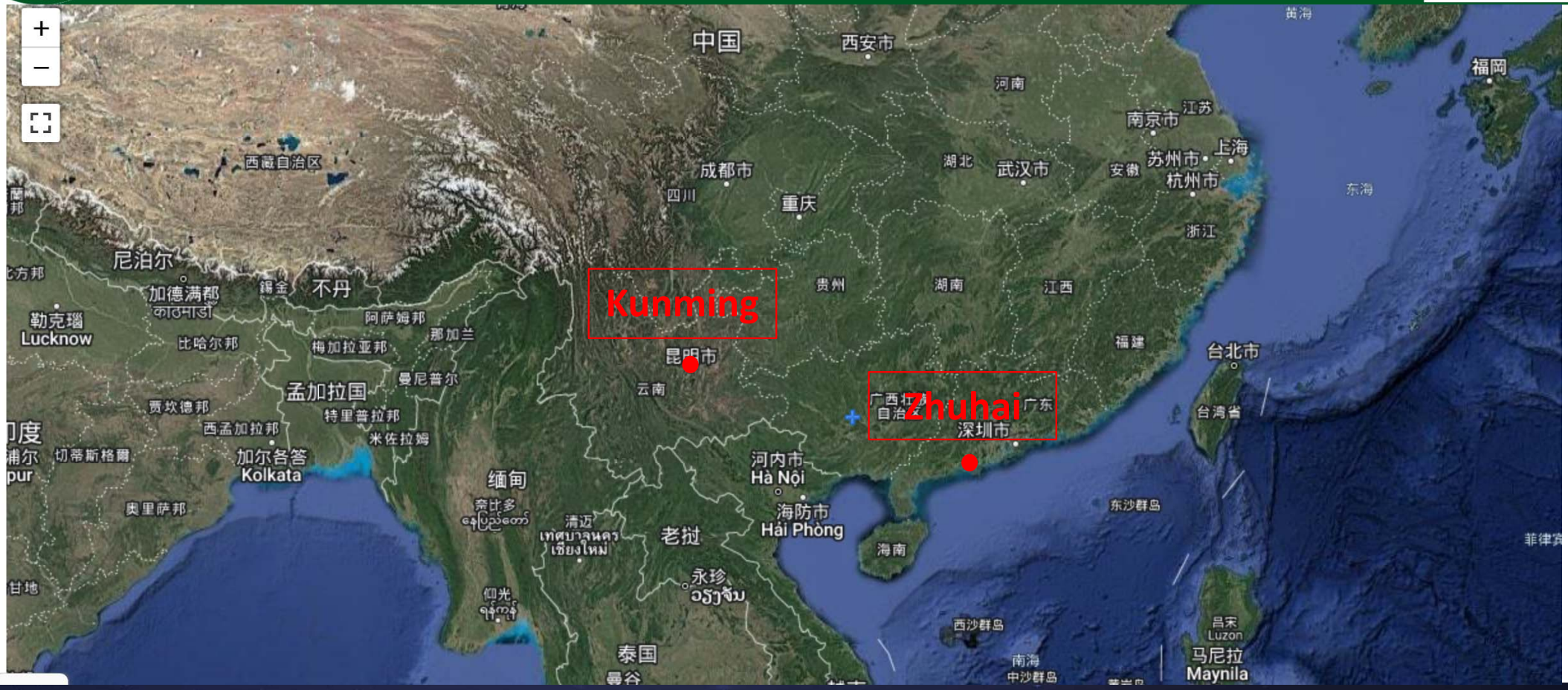
一、Introduction

二、TianQin Ranging System

三、Lunar Laser Ranging Results

四、Future Plans

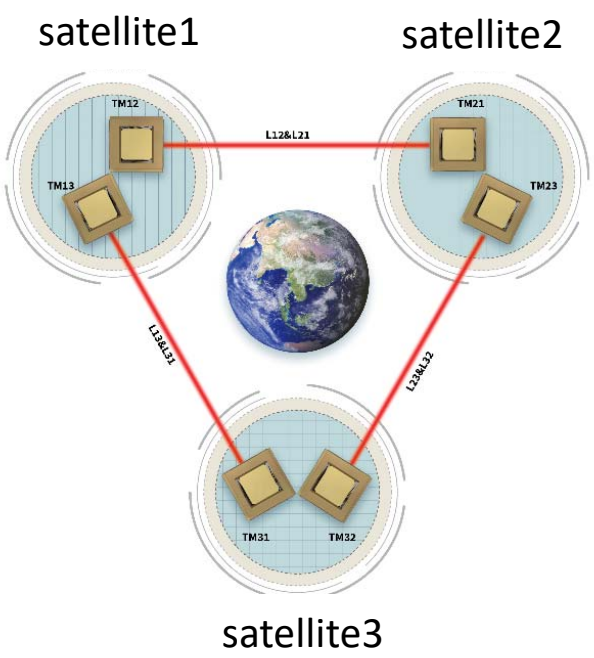
Introduction

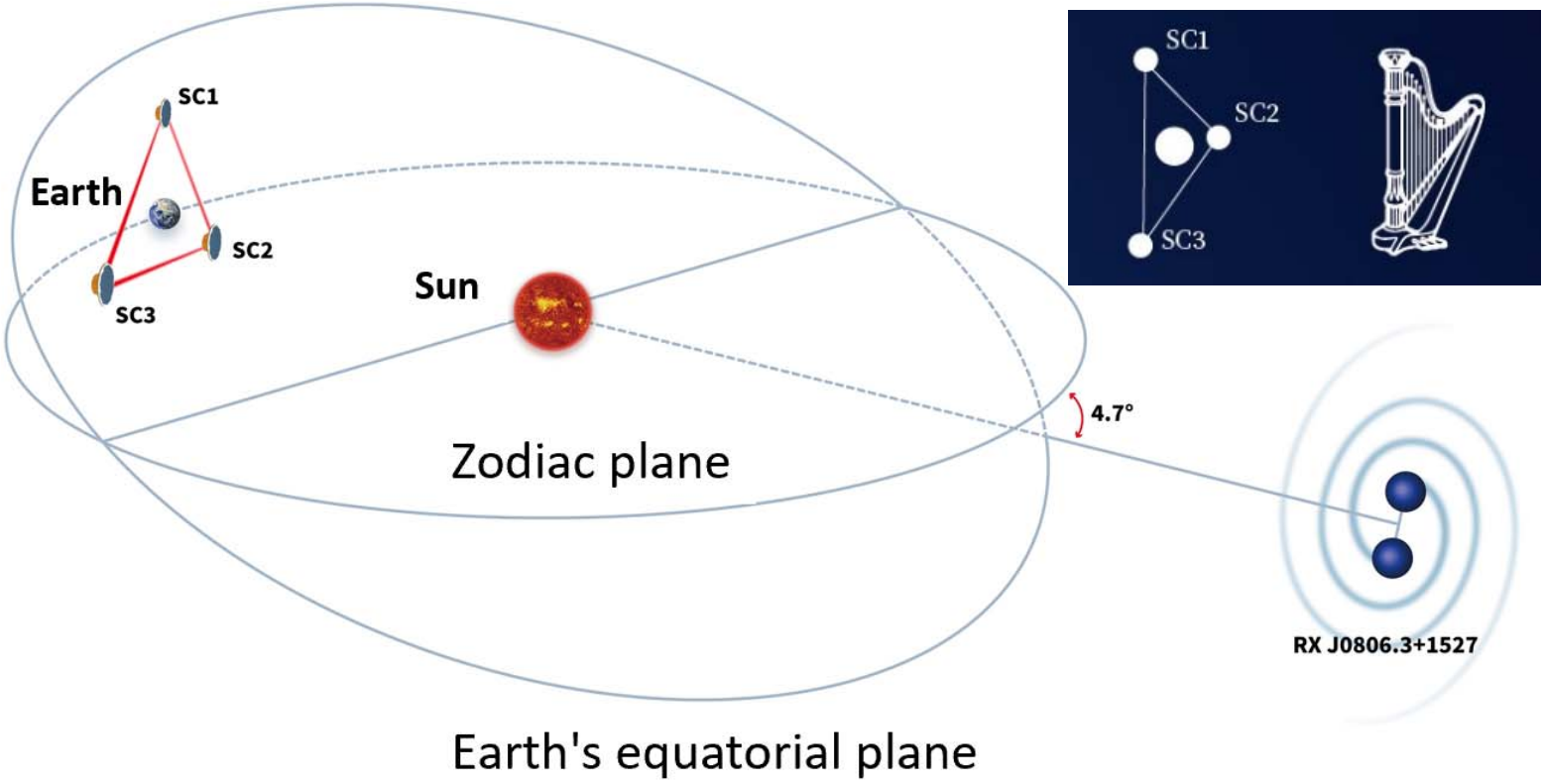


Introduction

Introduction

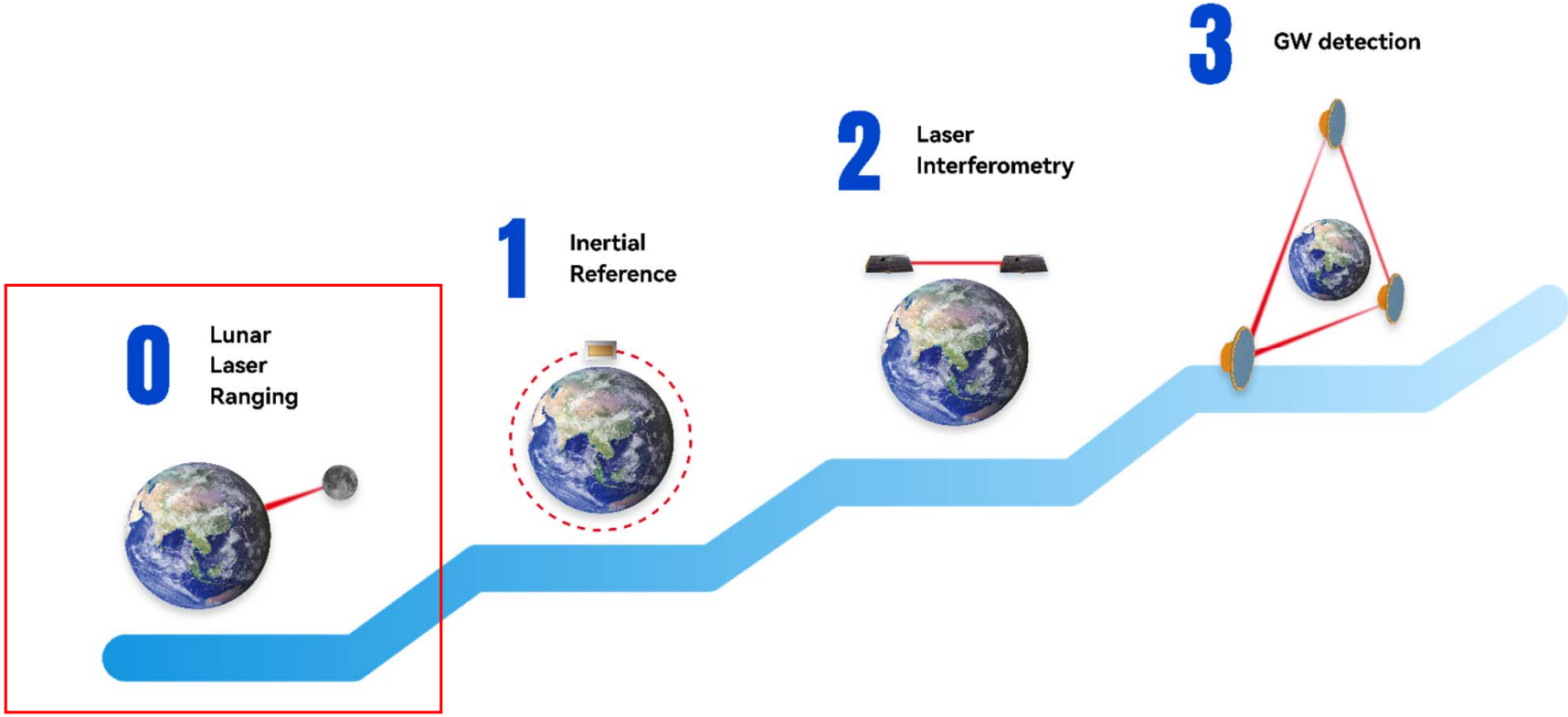
The TianQin Project: TianQin space gravitational wave observatory





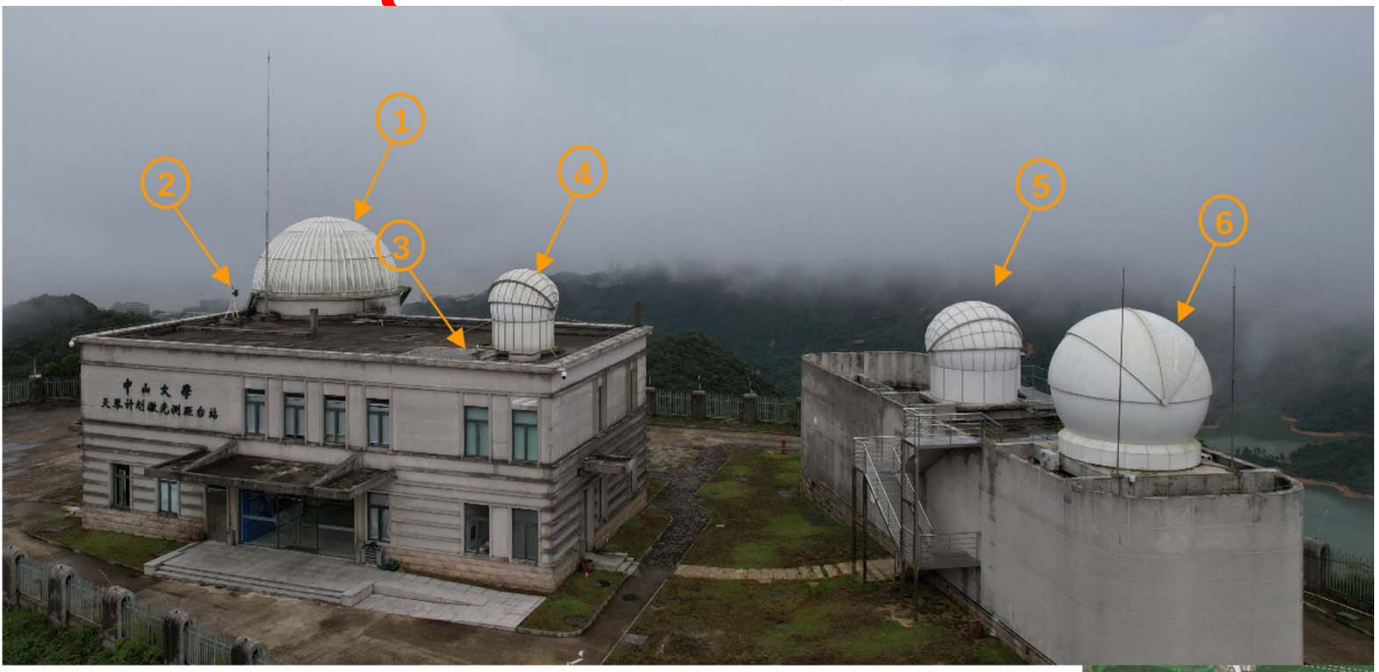
Introduction

The TianQin Project: “0123” technology roadmap



Introduction

The TianQin Station: orbit determination of TQ-3 satellites



① 13m Dome and 1.2m Laser Ranging Telescope
② Weather Station
③ Cloud Meter
④ Seeing Monitor
⑤ Optical Turbulence and Wind Profiler
⑥ Atmospheric Lidar

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TianQin Laser Ranging System

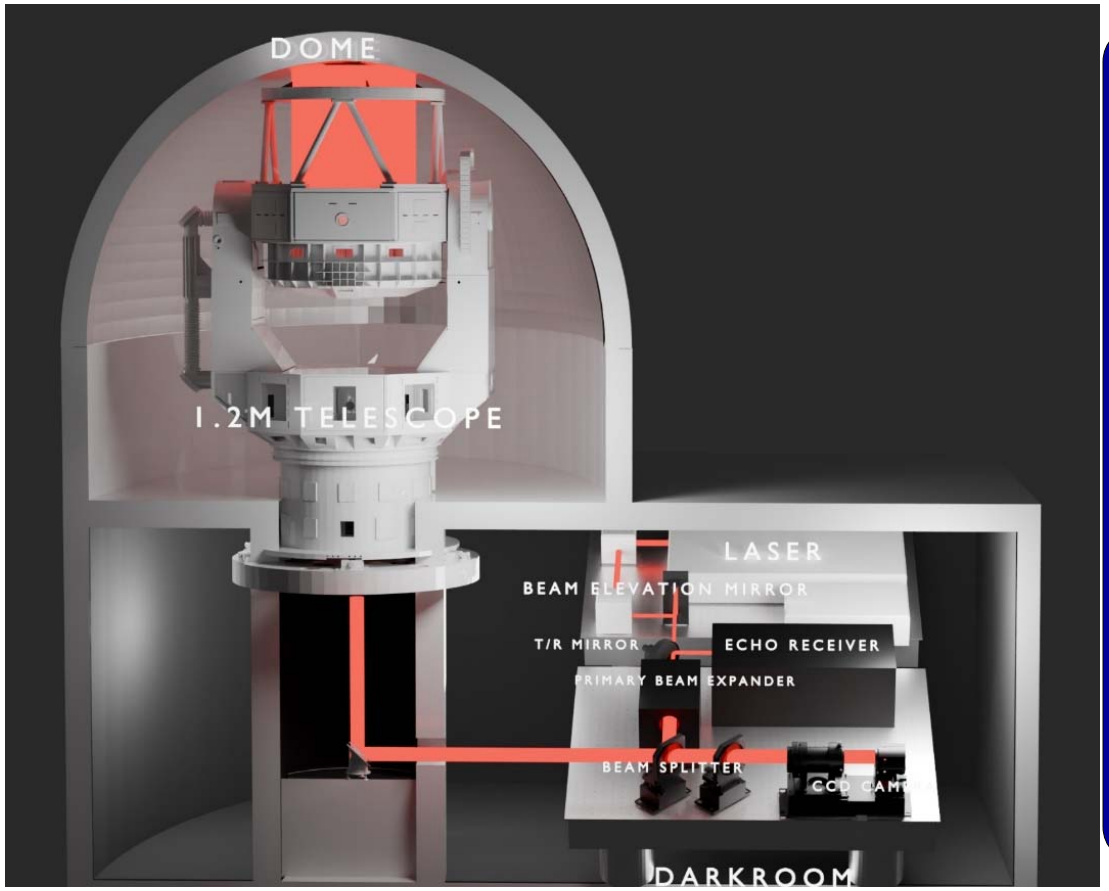
1） Use **1064nm wavelength**: **high** atmospheric transmittance, **low** background noise, and get **more** photons at the same laser energy

2） Use **1.2m-aperture telescope** technology: **high**-precision tracking, **small** laser divergence angle

3） Use **2×2 multi-channel** near-infrared band superconducting single-photon detector: **high** QE, **low** noise

4） Lunar laser ranging at **100 Hz frequency**: **improving** the echo rate and measurement accuracy

TianQin Laser Ranging System

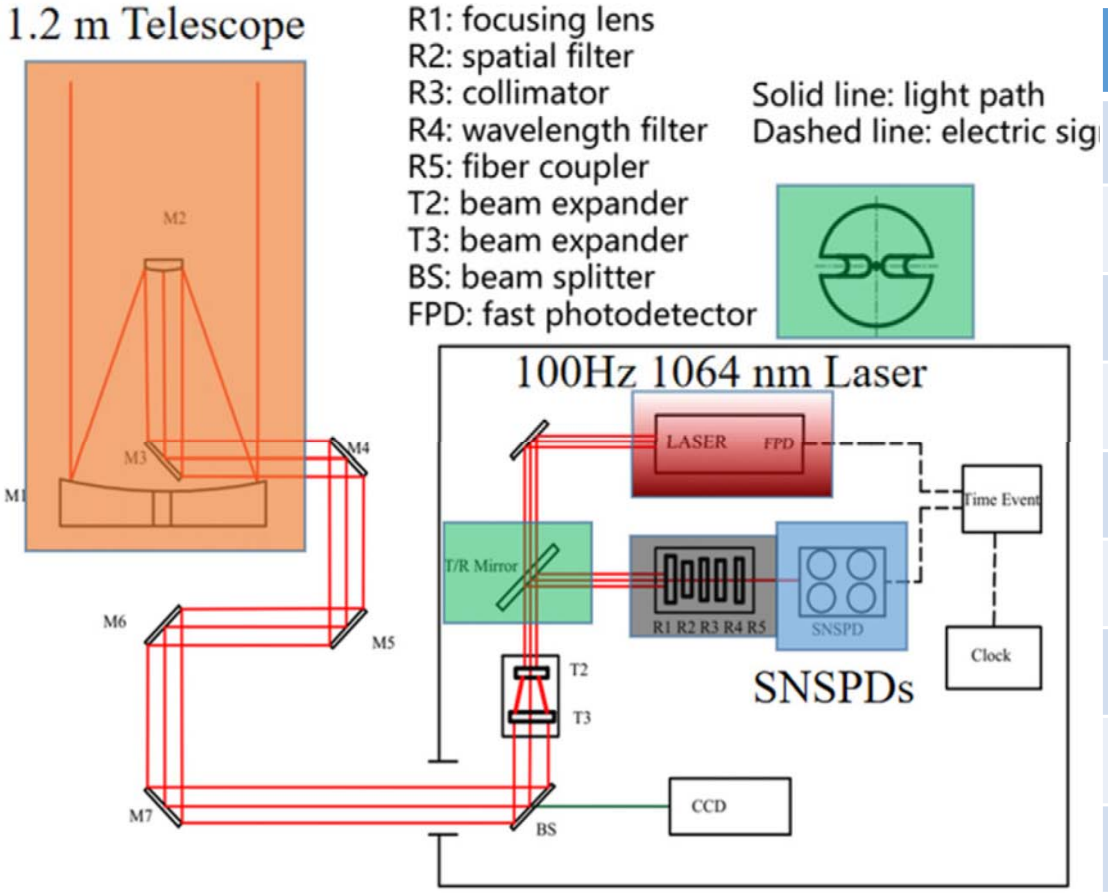


1.2m Laser Ranging System

- Telescope sub-system
- Laser sub-system
- Photon detection sub-system
- Ranging sub-system



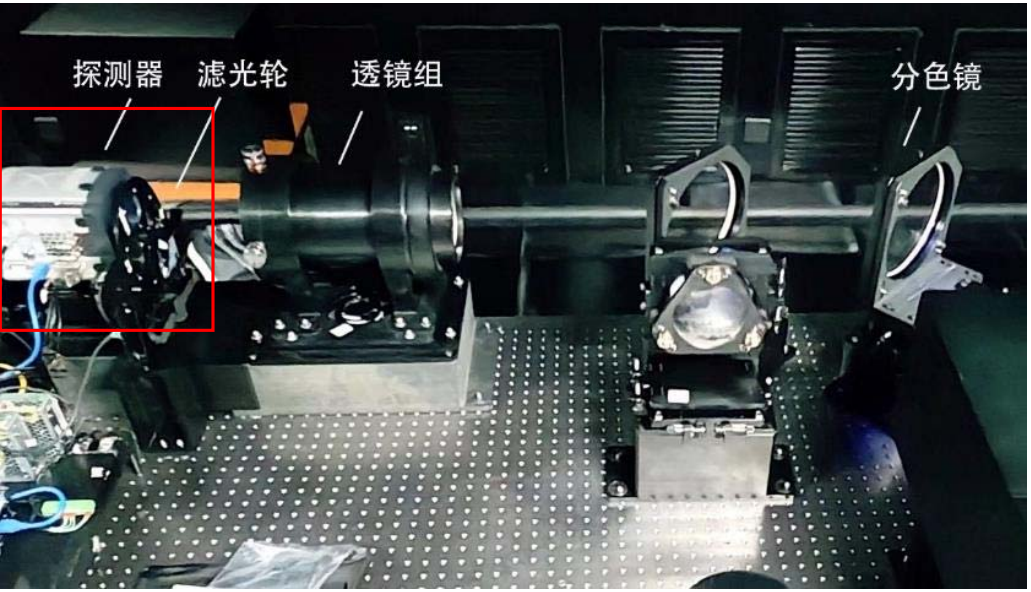

TianQin Laser Ranging System

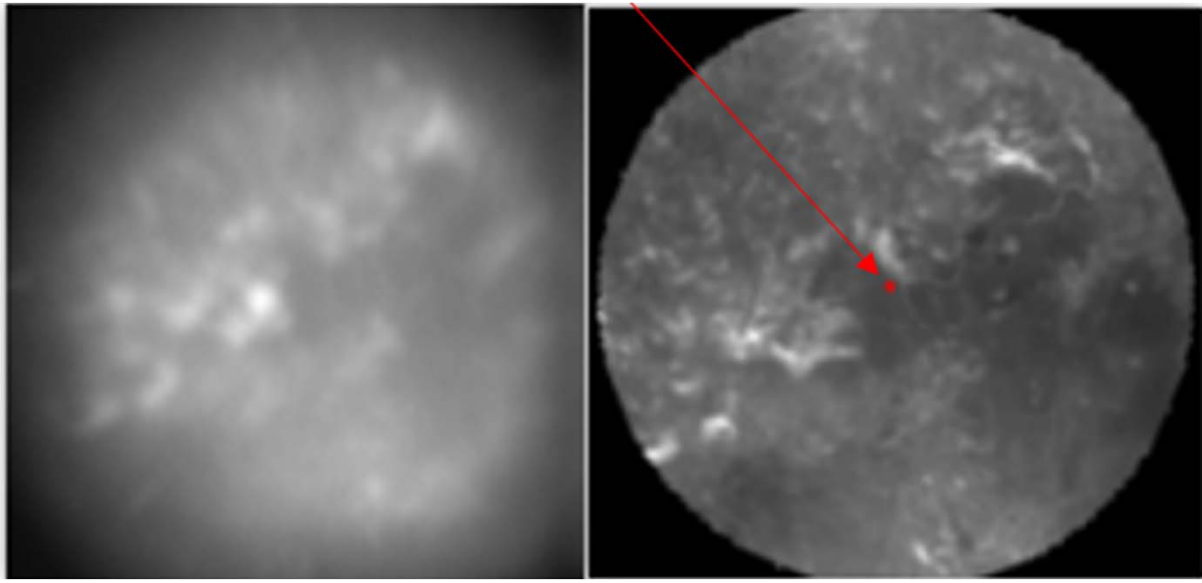


Main parameters of TianQin Station		
Parameter	**Value**	**Comment**
λ	1064nm	Laser wavelength
E_t	300mJ	Laser pulse energy
f_{pulse}	100Hz	Laser pulse repetition rate
D	1.2m	Aperture of the telescope
θ_{laser}	2”	Divergence angle of laser
θ_{track}	2”	Tracking error of telescope
η_t	0.6	Transmitting efficiency of optical sys
η_r	0.2	Receiving efficiency of optical sys

TianQin Laser Ranging System

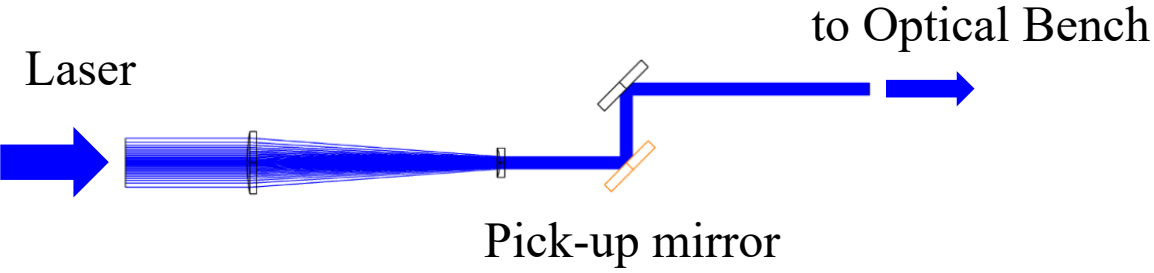
Pointing and Tracking: Common optical path

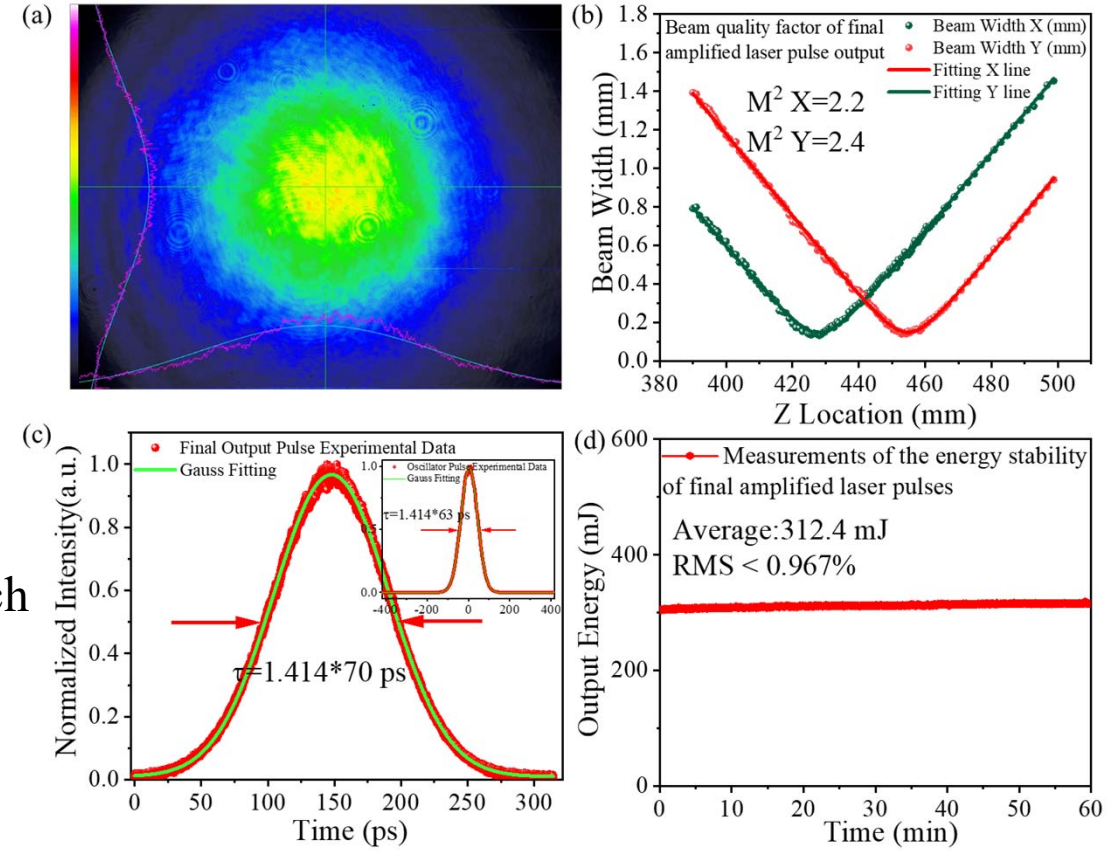




TianQin Laser Ranging System

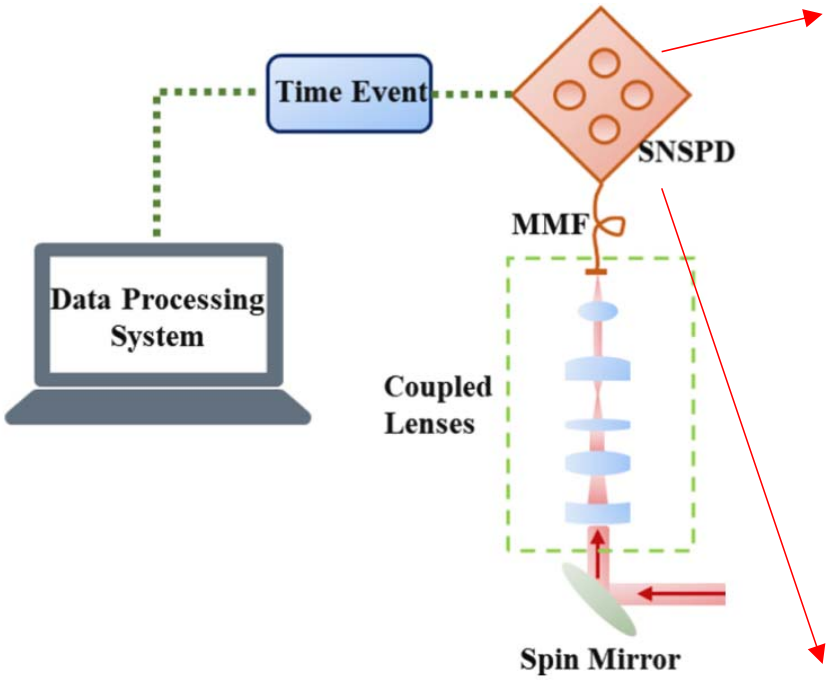
Laser:





TianQin Laser Ranging System

SNSPD: Superconducting Nanowire Single-Photon Detector



Parameter	Value
Array	2×2
Detection Efficiency	>30%@1064nm
Dead time	50ns
Jitter time	<70ps
Counting rate	20MHz max
Dark count rate	<1000 @T=2.3K
Photon-sensitive area	200μm

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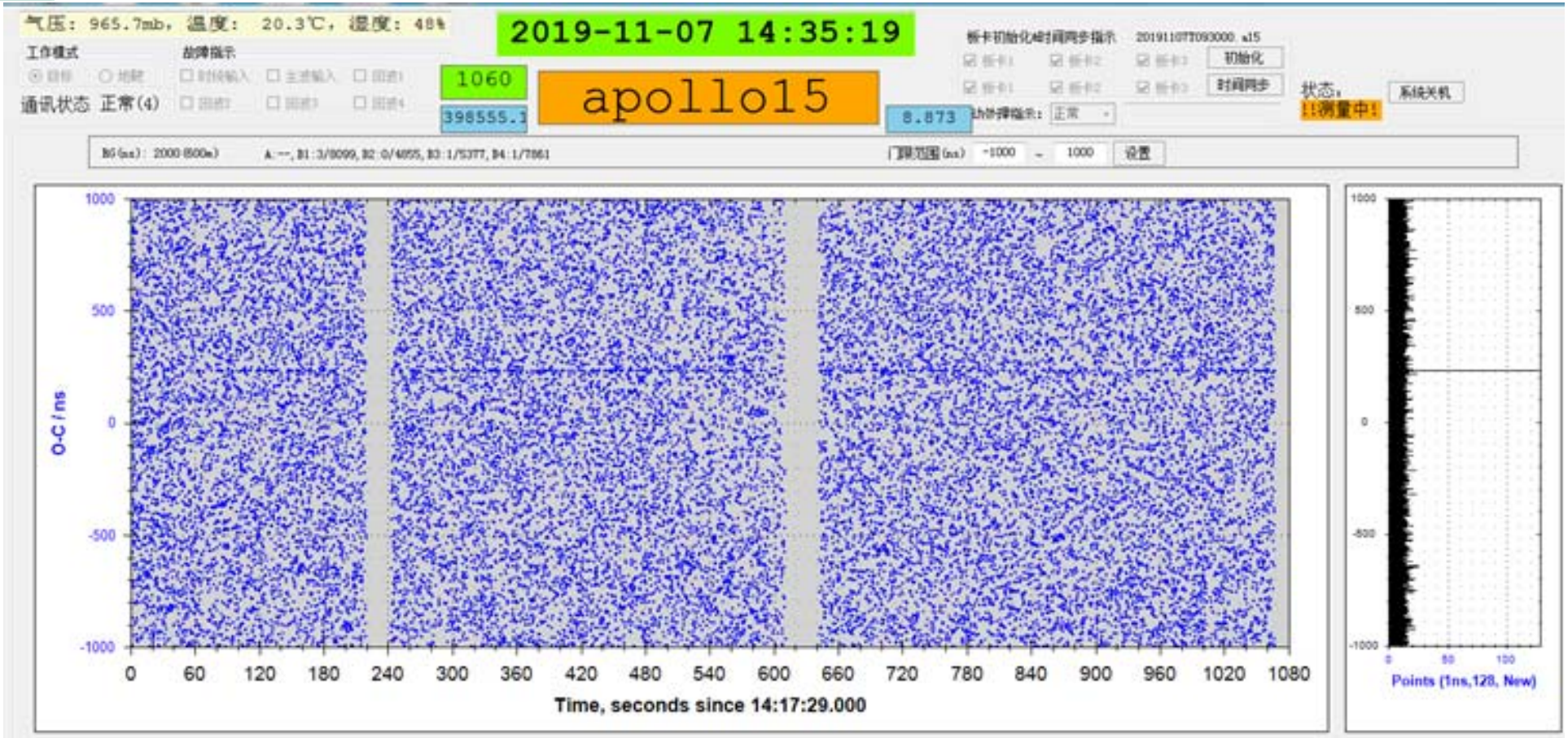
LLR Results

Some key milestones:

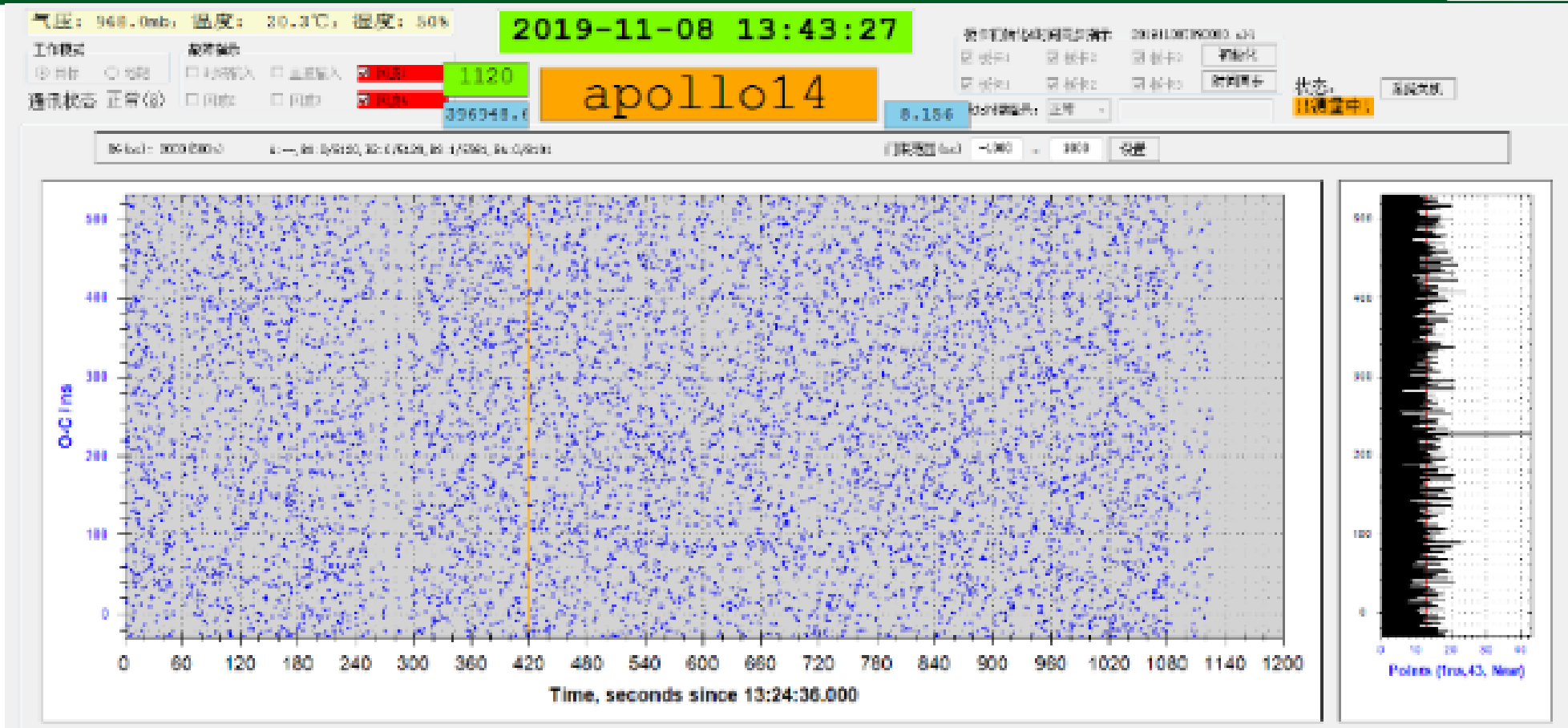
- 08-06-2019 First Laser Ranging of A15
- 07-11-2019 Laser Ranging of all 5 Retroreflector Arrays
- 29-09-2023 Laser Ranging of A15 @ Full Moon condition

LLR Results [1]



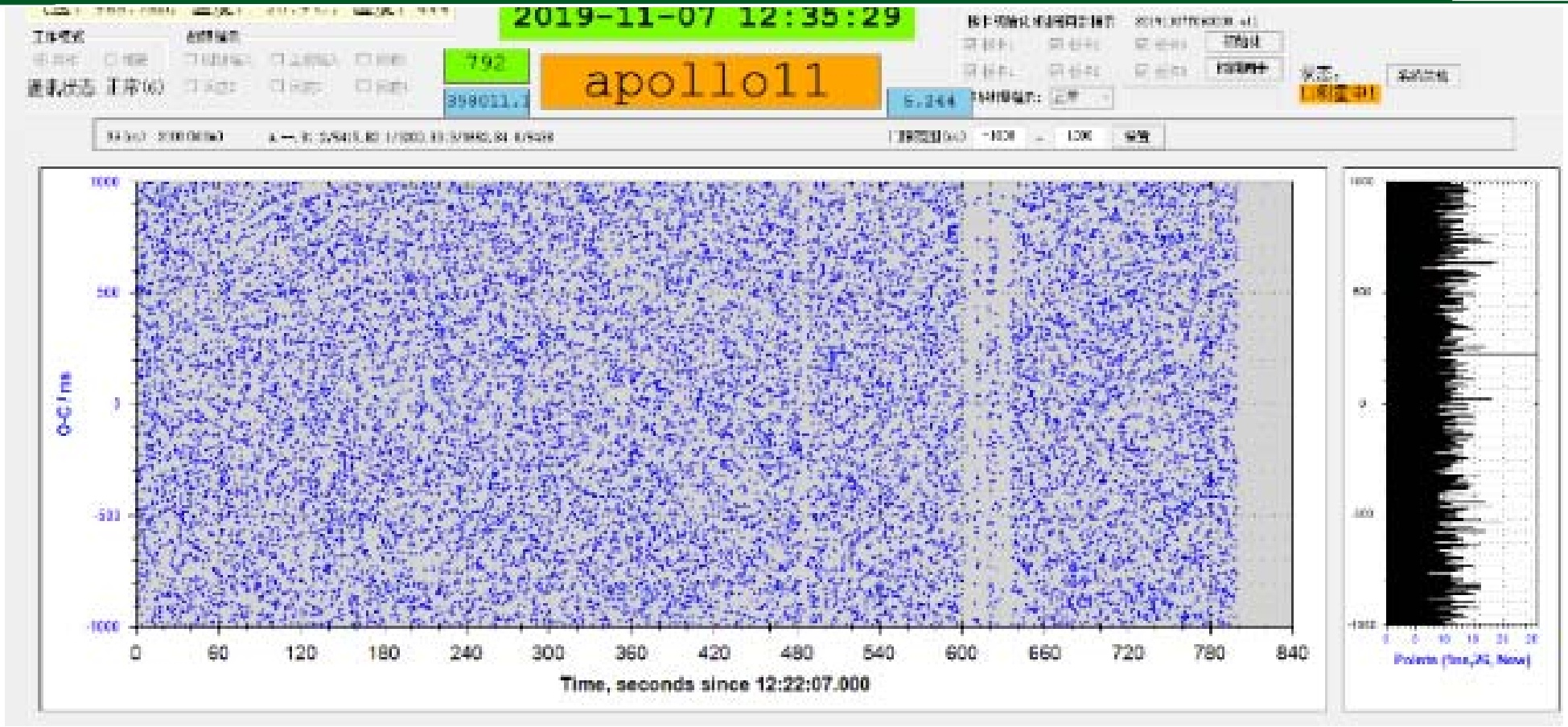
[1].Tianquan Gao *et al.* Optics and Laser Technology. *167* 2023 109741

LLR Results [1]



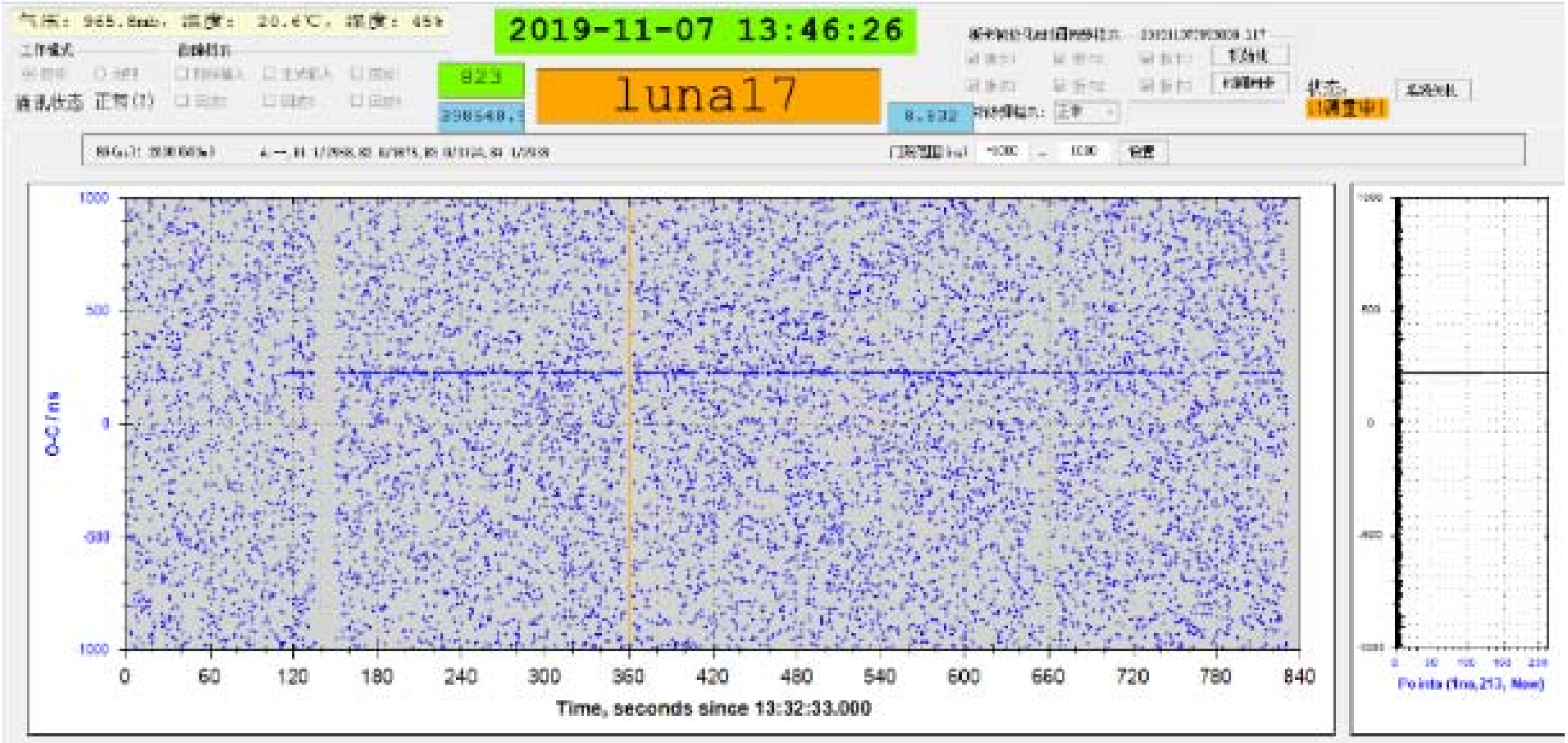
[1].Tianquan Gao *et al.* Optics and Laser Technology. *167* 2023 109741

LLR Results [1]



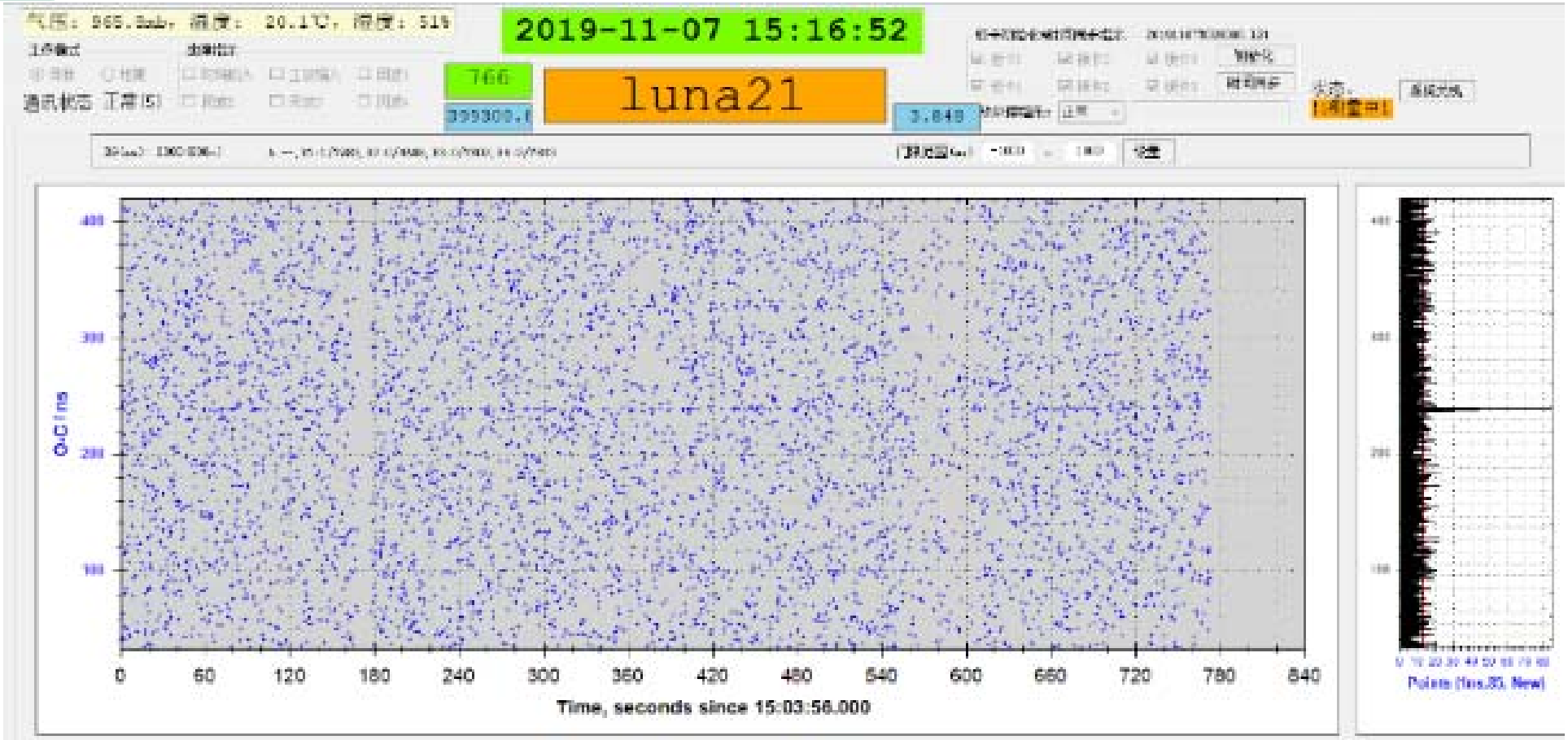
[1].Tianquan Gao *et al.* Optics and Laser Technology. *167* 2023 109741

LLR Results [1]



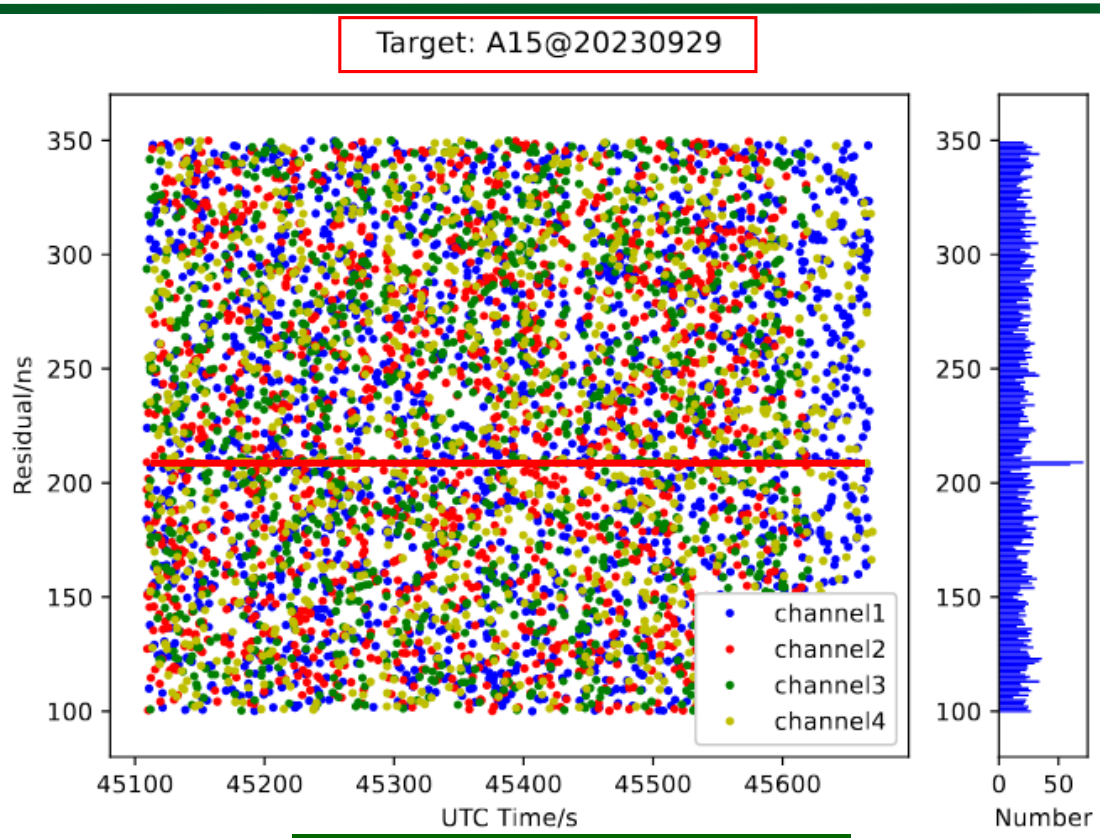
[1].Tianquan Gao *et al.* Optics and Laser Technology. *167* 2023 109741

LLR Results[1]



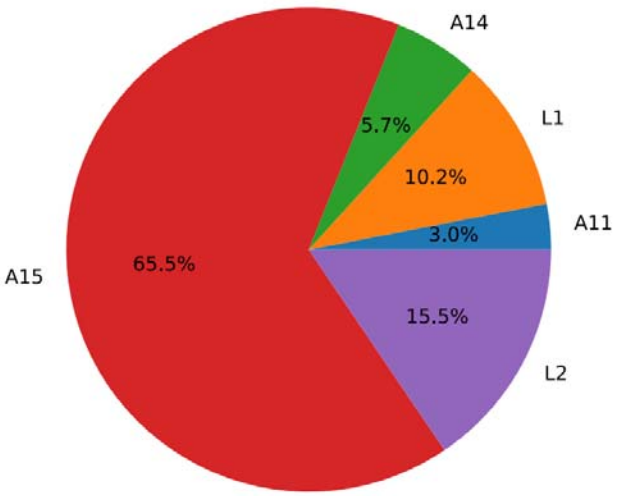
[1].Tianquan Gao *et al.* Optics and Laser Technology. *167* 2023 109741

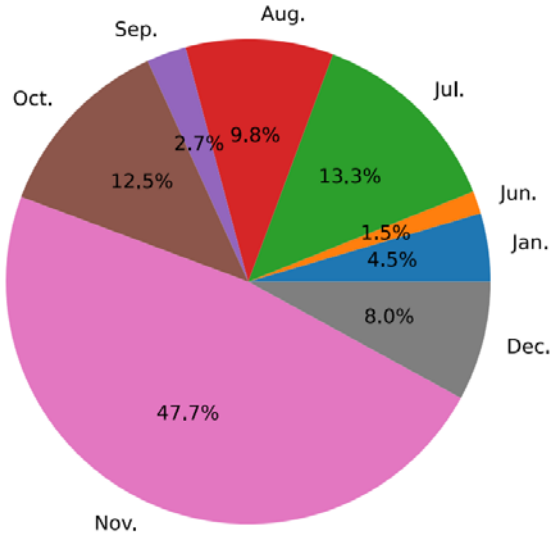
LLR Results

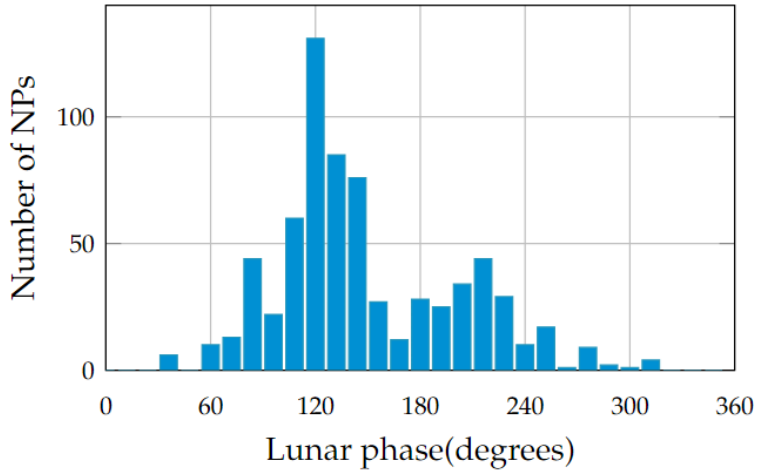


LLR@Full Moon

LLR Results





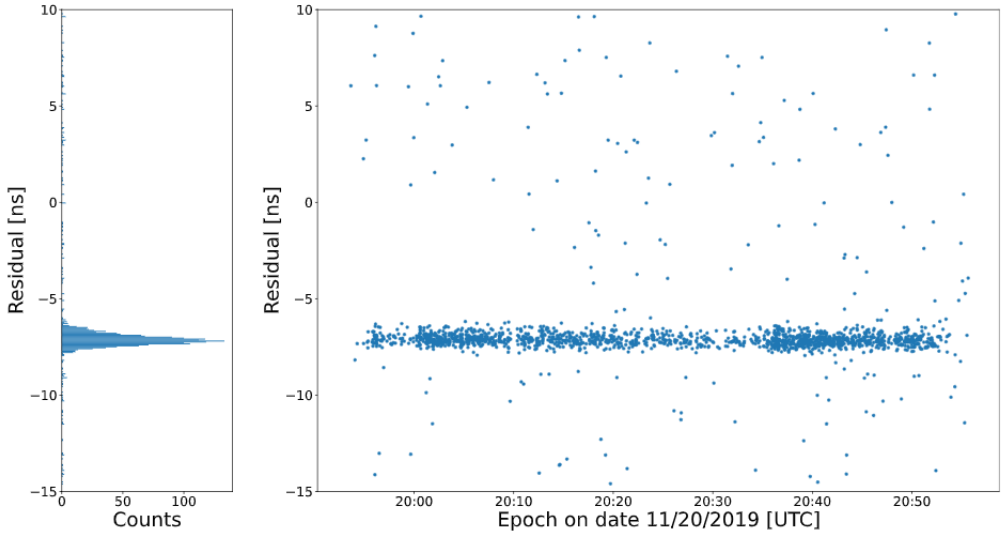


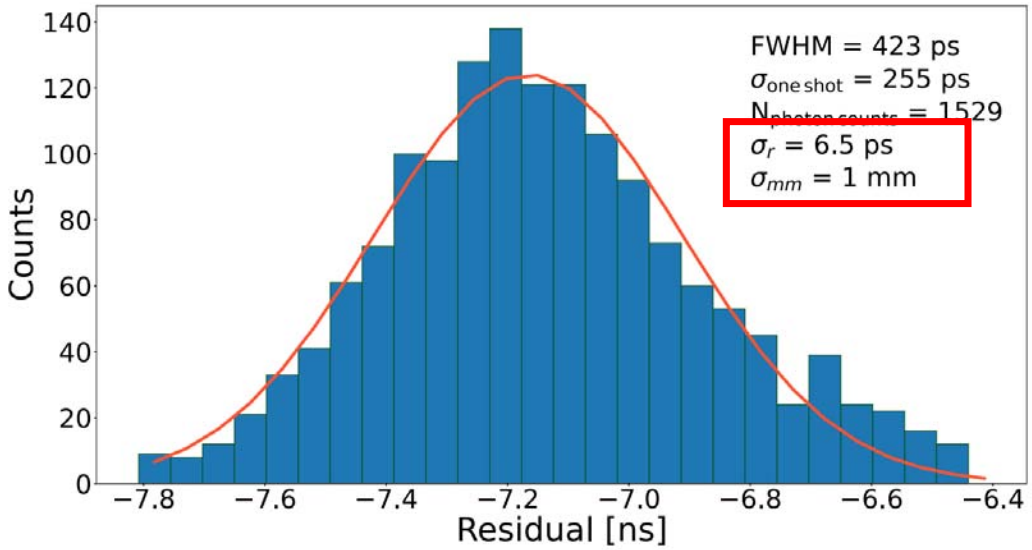
Target statistics

Monthly statistics

Moon phase statistics

LLR Results





One hour LLR and statistics of A15 array[2]

[2].Caishi Zhang *et al* 2022 *Class. Quantum Grav.* **39** 125005

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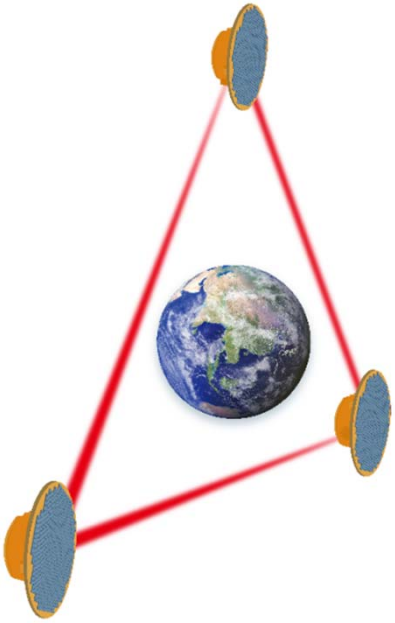
Outlook

- Daylight laser ranging
- Dual-wavelength laser ranging



Goal:

High-precision orbit determination of TianQin-3 satellites

Thanks

- Yunnan Observatories, Chinese Academy of Science
- Academy of Opto-Electronics, Chinese Academy of Sciences
- School of Electronic Science and Engineering， Nanjing University
- Changchun Institute of Optics， Fine Mechanics and Physics， Chinese Academy of Science

Thanks

Thank you !

月球
Moon

Earth

Mercury

金星
Venus

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