

中山大學 天琴中心

TIANQIN CENTER FOR GRAVITATIONAL PHYSICS, SYSU



TianQin Update

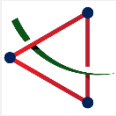
Jian-dong Zhang (张建东)

On behalf of the TianQin Collaboration

SPA & TQC @ SYSU

2026-07-17

NUS Singapore



I. TianQin Basic

II. Progress

III. Special Issues

IV. Summary



I. TianQin Basic

□ A Geocentric Gravitational Wave Detector in Space

➤ Orbit: geocentric, radius $\sim 10^5\text{km}$, armlength $\sim 1.7\times 10^5\text{km}$

➤ Constellation: normal triangle, facing J0806

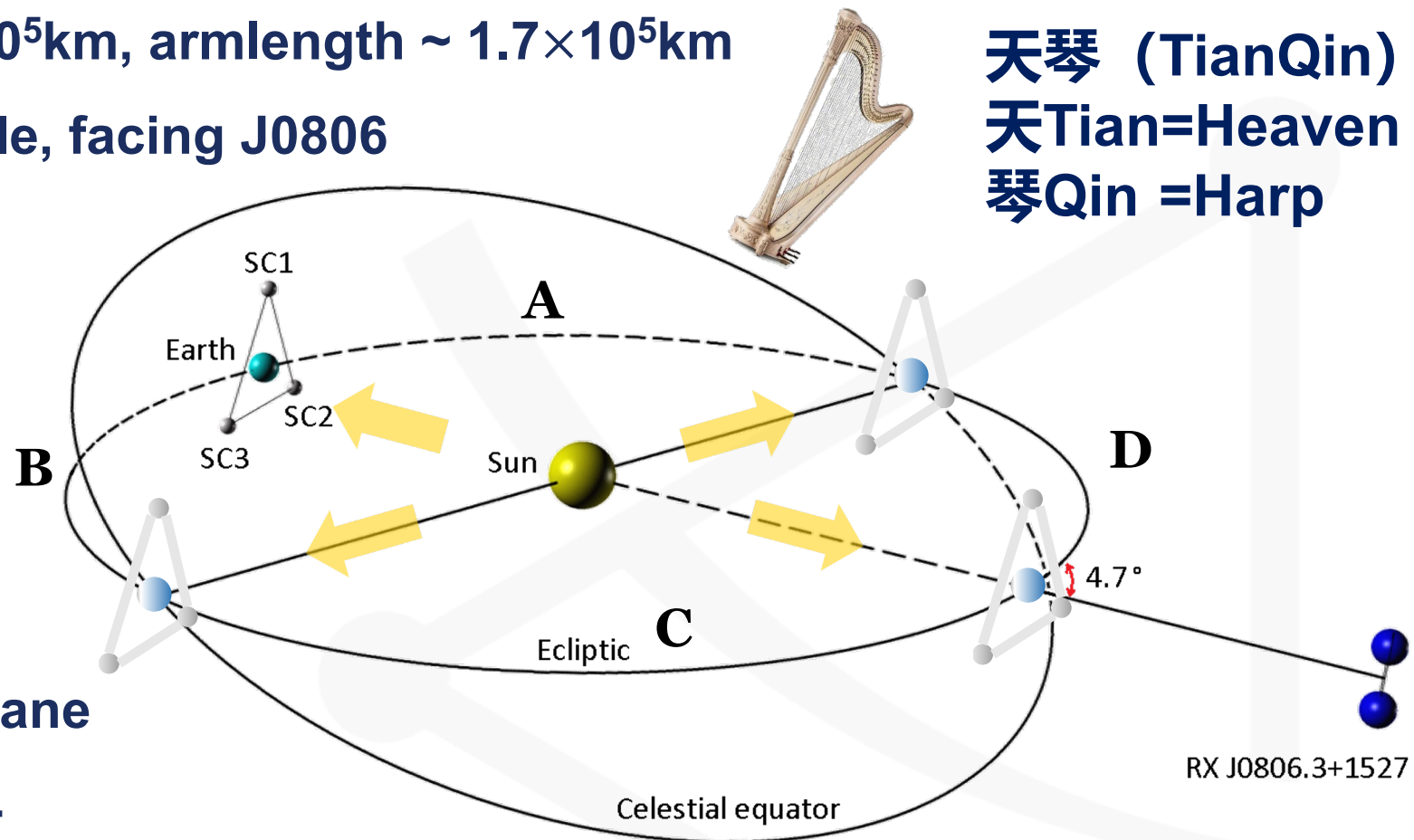
➤ Technical advantages:

- Deployment
- Orbital stability
- Communication
- Measurement & control

➤ Disadvantages: 3+3, fixed plane

➤ Proposed on March 24, 2014

➤ Expected launch: 2035

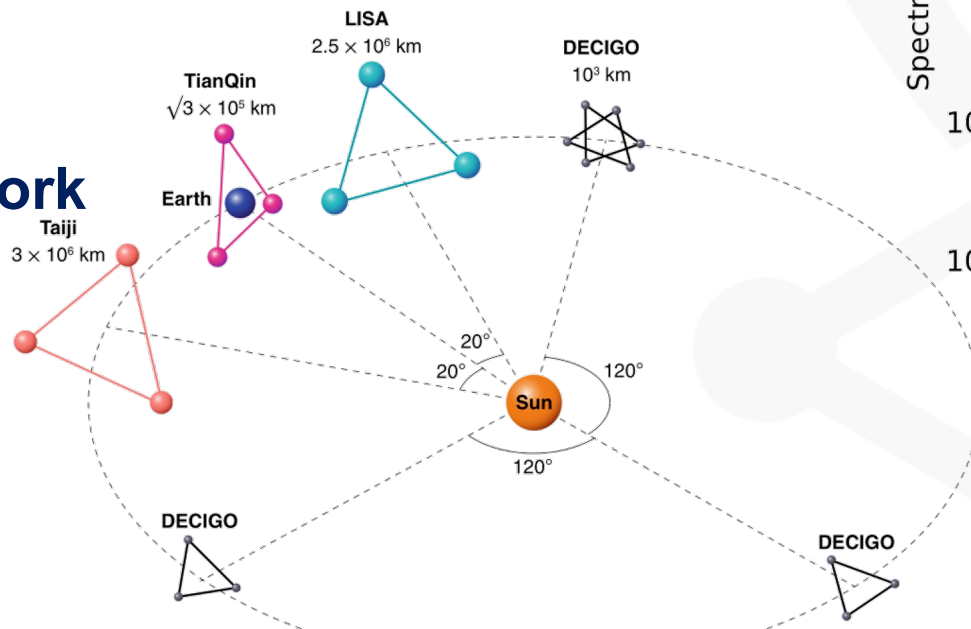




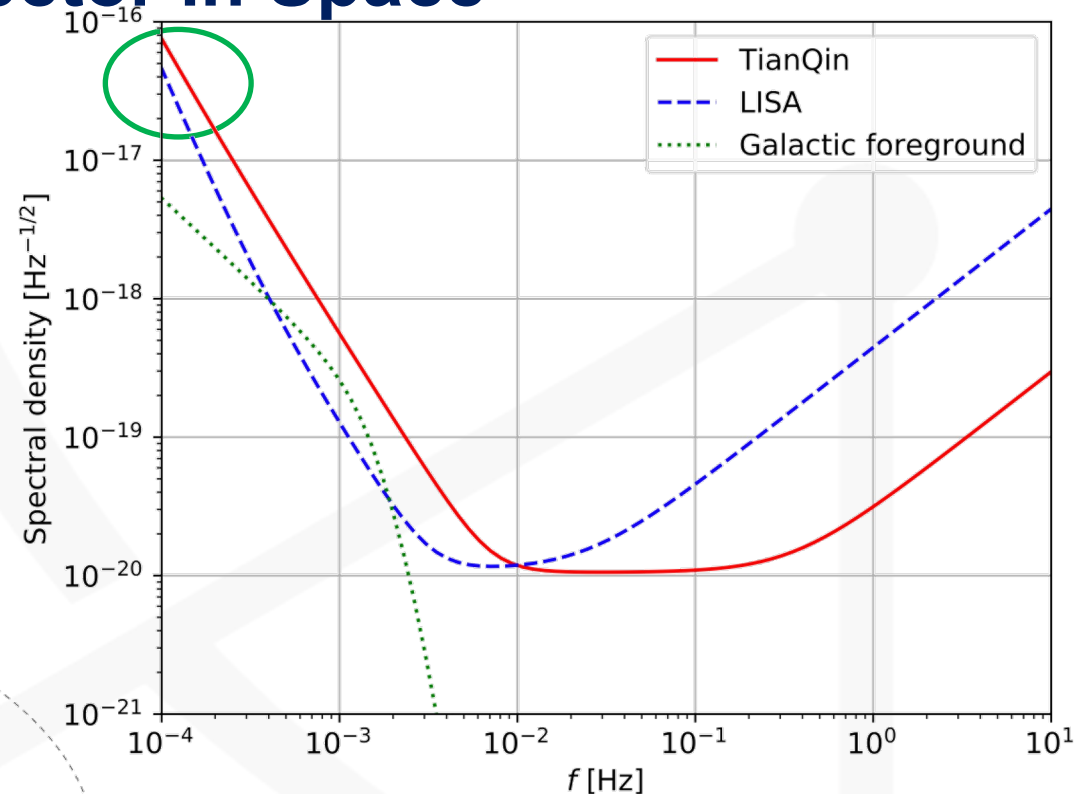
I. TianQin Basic

□ A Geocentric Gravitational Wave Detector in Space

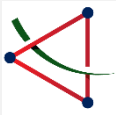
- $L = \sqrt{3} \times 10^8 m$
- $S_a = 10^{-30} m^2 s^{-4} Hz^{-1}$
- $S_x = 10^{-24} m^2 Hz^{-1}$
- Different response feature
- Different band
- Benefit for network



Gong et al., Nature Astron. 5 ,881-889 (2021)



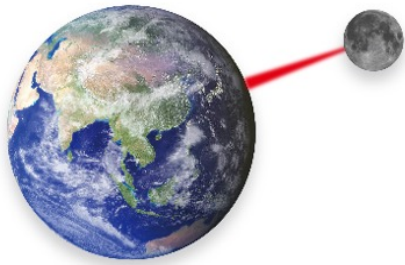
Torres-Orjuela et al., SCPMA. 67, 259511 (2024)



I. TianQin Basic

□ The “0123” Roadmap for Technology

0 Lunar Laser Ranging



2016~

1 Space Inertial Reference



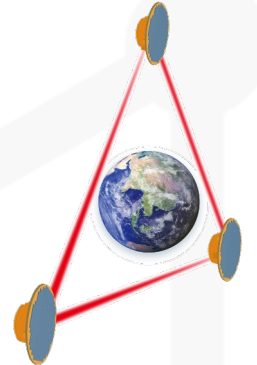
2018~2021

2 Inter-satellite Laser Interferometry



2027 (Expected)

3 Space-based GW Detection



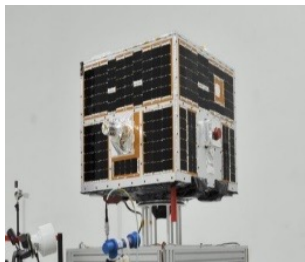
2035 (Expected)



LLR

2019.11.7:

- Range all five targets on Moon

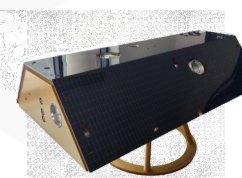


TQ-1

2019.12.20

~2021.1.29:

- Orders improve on core tech



TQ-2

2021.12:

- Mission approval
- 2027:
 - Expected launch

TQ-3

- Mission study
- Science analysis
- Data analysis technology



II. Progress

□ No Fundamental Obstacle for the Concept of TianQin

➤ Can the orbits be stable?

IJMPD 28, 1950121 (2019), PRD 103, 103026 (2021), PRD 109, 083033 (2024)

➤ Will the complex Earth gravity impair the GW detection?

PRD 103, 062001 (2021), PRD 107, 102004 (2023)

➤ Will moon eclipse disrupt GW detection by TianQin?

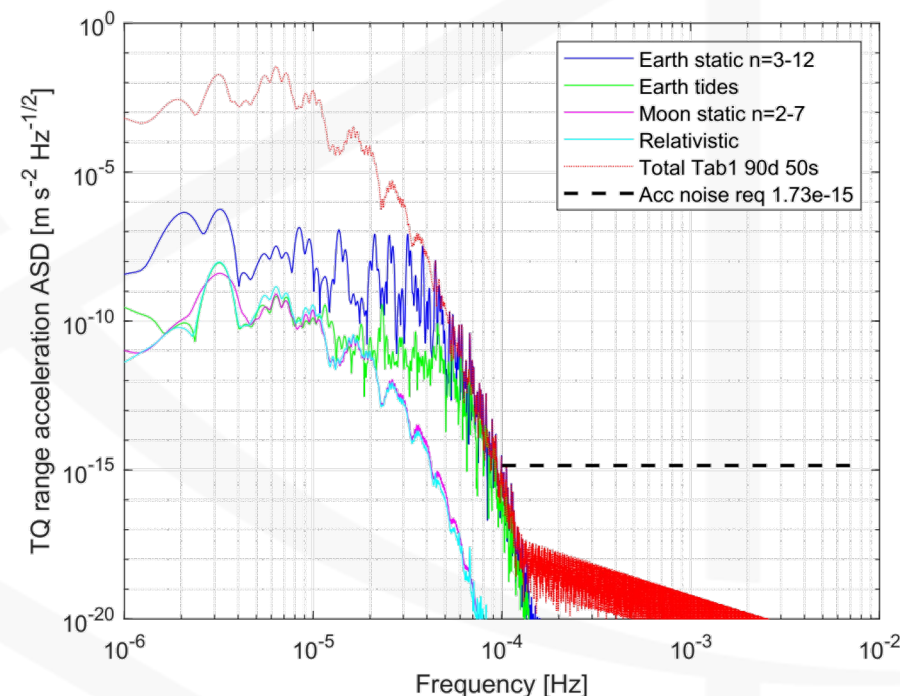
PRD 103, 042007 (2021)

➤ How to deal with large variation of the solar angle?

CQG 38, 155015 (2021), PRD 109, 102007 (2024)

➤ How will the space plasma affect GW detection?

PRD 106, 082006 (2022)





II. Progress

▣ Science Capability

➤ Similar Sources:

GB, MBHB, SBHB, EMRI, SGWB, Burst

➤ Similar Targets:

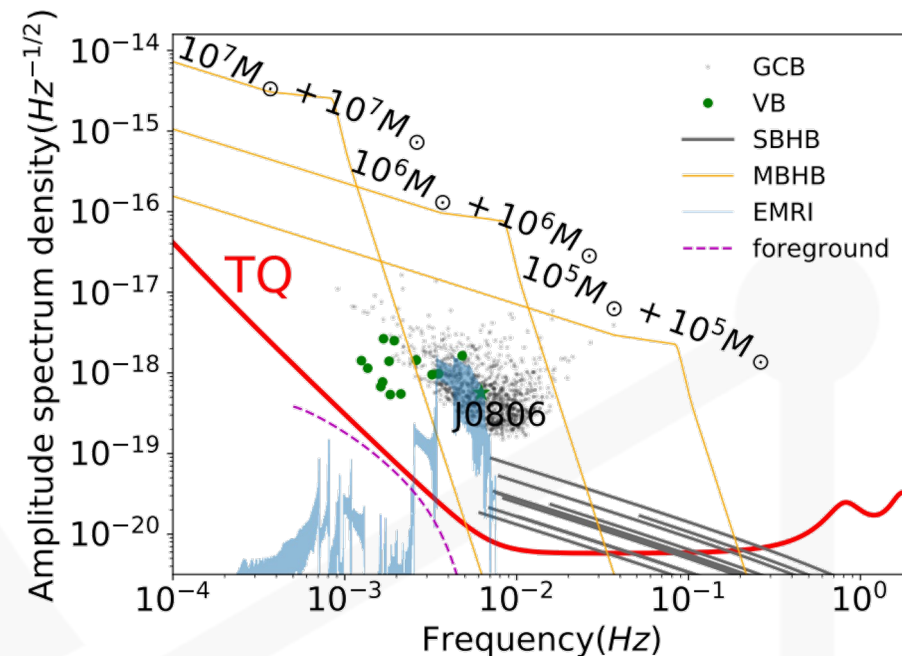
Astronomy, Testing GR, Cosmology

➤ Better for higher frequency sources

➤ Strongly influenced by the position:

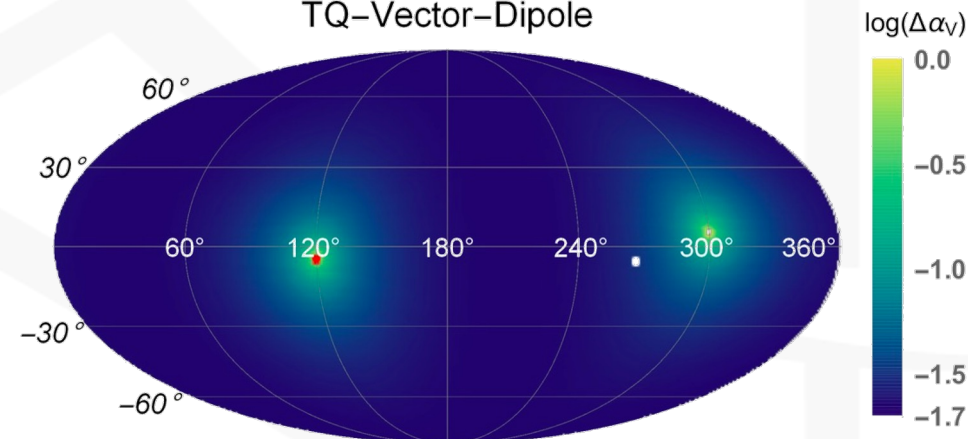
SNR, PE, Localization, Extra polarization

➤ Almost uninfluenced by foreground



Mei et al. PTEP, 2021, 059201

TQ-Vector-Dipole





➤ **The announcement of TianQin**

Progress at 2020

➤ **Joint detection of TianQin & LISA**

➤ **White paper for astronomy**

➤ **White paper for fundamental physics & cosmology**

➤ Progress at 2025

Living Reviews in Relativity (2024)29:1
https://doi.org/10.1007/s11047-024-10063-3

WHITE PAPER

Fundamental physics and cosmology with TianQin

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Abstract

The exploration of the surrounding world and the universe is an important theme in the legacy of humankind. The detection of gravitational waves is adding a new dimension to this grand effort. What are the fundamental physical laws governing the dynamics of the universe? What is the fundamental composition of the universe? How has the universe evolved in the past and how will it evolve in the future? These are the basic questions that press for answers. The space-based gravitational wave detector TianQin will tune in to gravitational waves in the millihertz frequency range (10^{-4} –1 Hz, to be specific), opening a new gravitational wave spectrum window to explore many of the previously hidden sectors of the universe. TianQin will discover many astrophysical systems, populating the universe at different redshifts: some will be of new types that have never been detected before, some will have very high signal-to-noise ratios, and some will have very high parameter estimation precision. The plethora of information collected will bring us to new frontiers on subjects that search for the breaking points of general relativity, the possible violation of established physical laws, the signature of possible new gravitational physics and new fundamental fields, and to improve our knowledge on the expansion history of the universe. In this white paper, we highlight the advances that TianQin can bring to fundamental physics and cosmology.

Keywords TianQin · Fundamental physics · Cosmology · Black hole · Dark matter · Dark energy

Extended author information available on the last page of the article.

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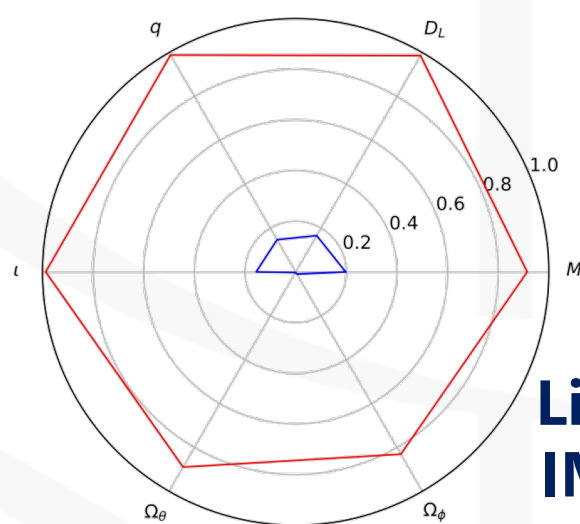
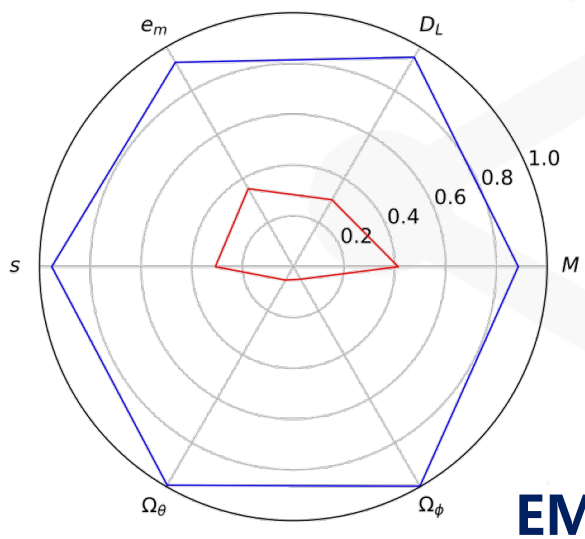
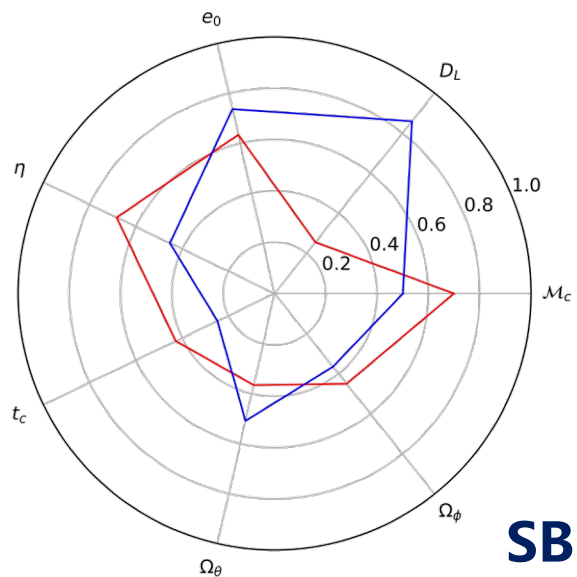
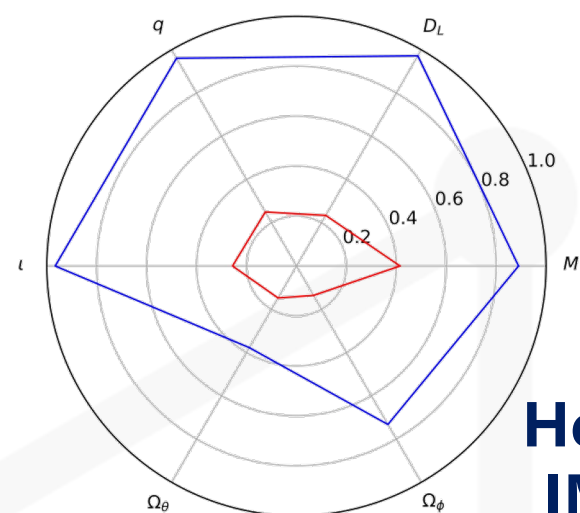
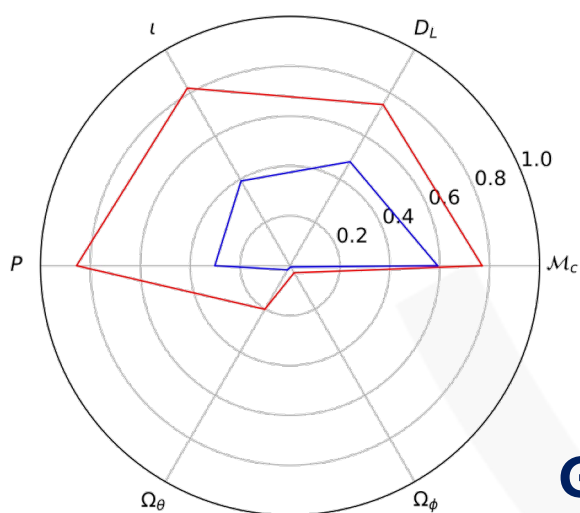
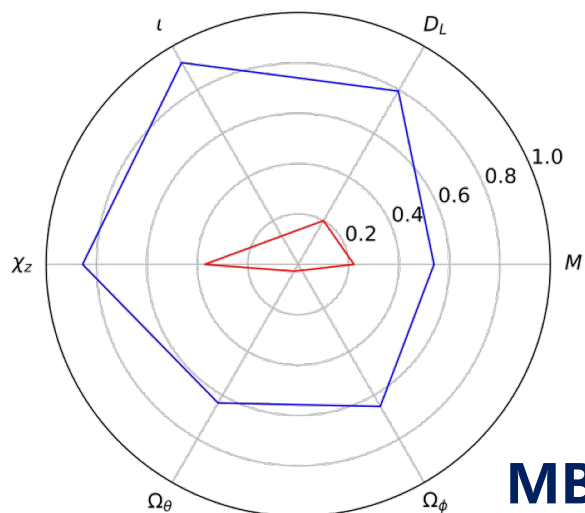
 Springer



II. Progress

Joint Observation with LISA

TianQin
LISA

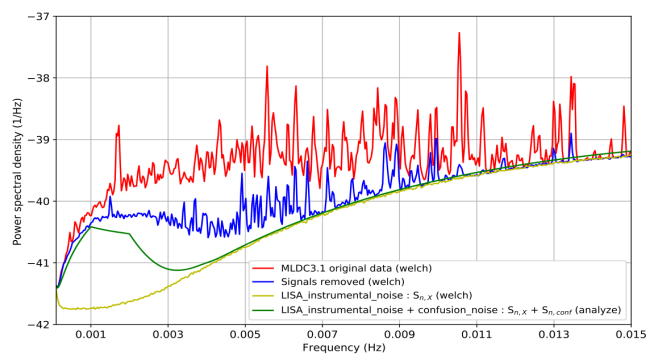




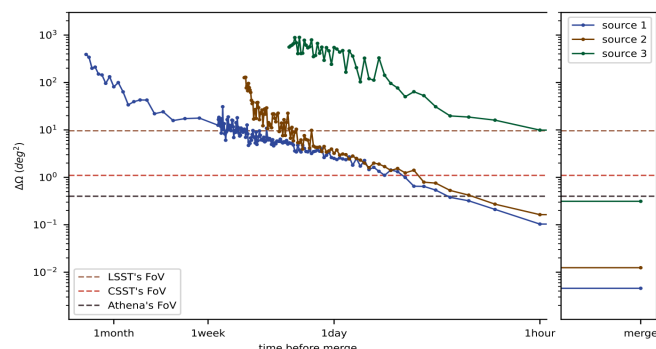
II. Progress

□ Data Analysis

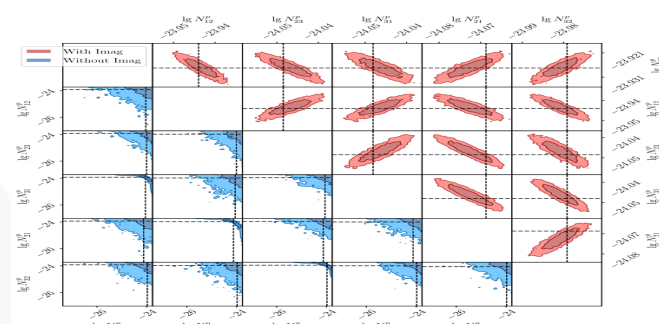
- Data analysis tools are being developed for all types of GW source
- Global fitting pipeline still in development



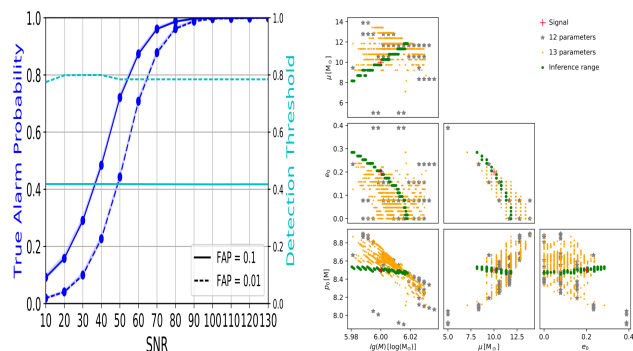
GCB



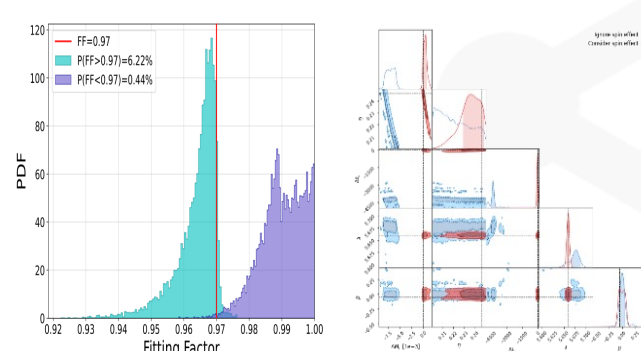
MBHB



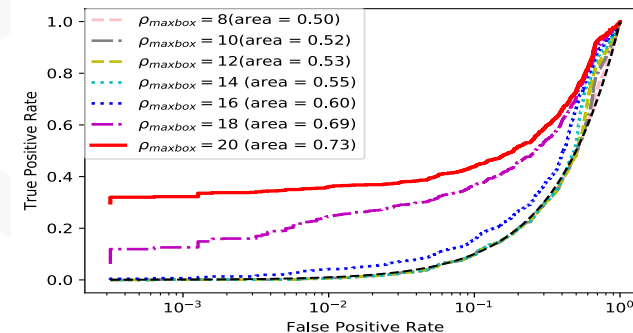
SGWB



EMRI



SBHB



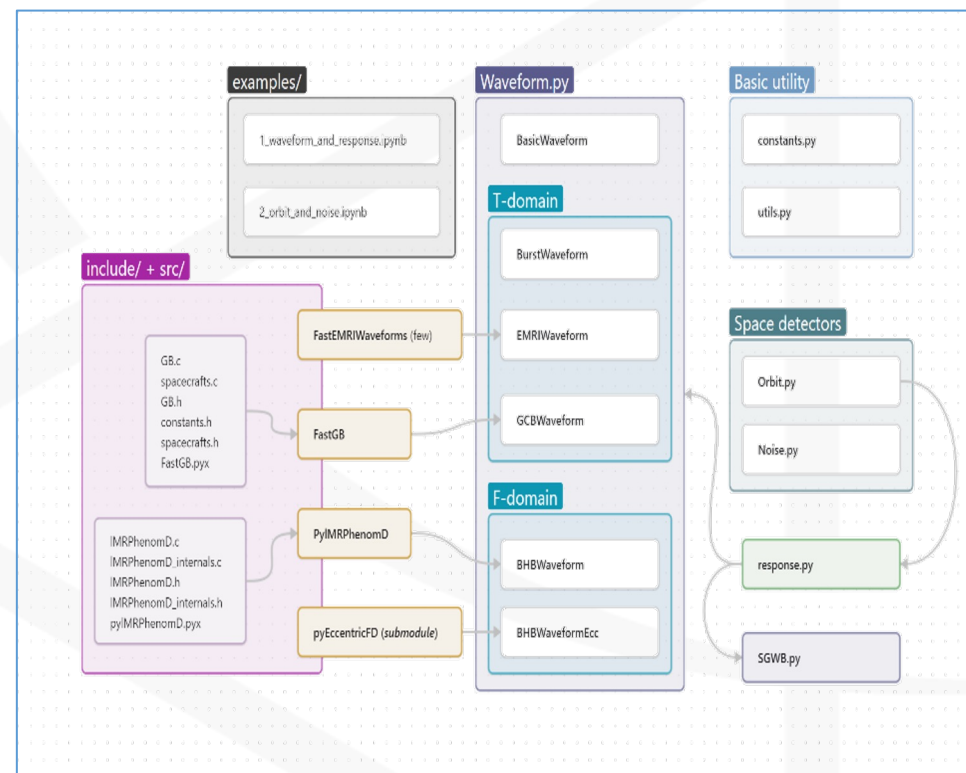
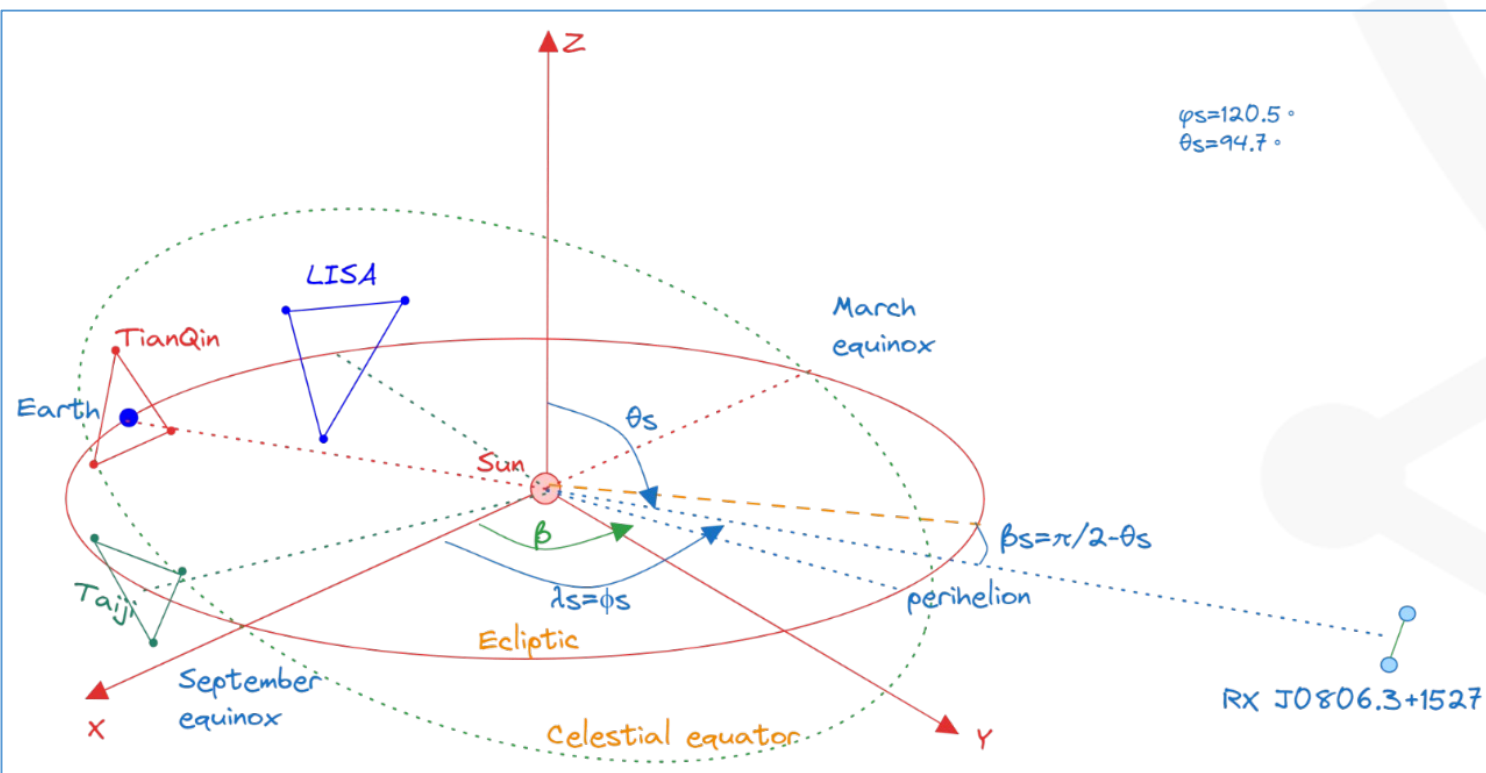
Burst, XMRI ...



II. Progress

□ Data Simulation & Data Challenge

- GWSpace: simulating coordinated response of TianQin, LISA and Taiji for all the sources
- Data challenge capability is being prepared to test the data analysis tools

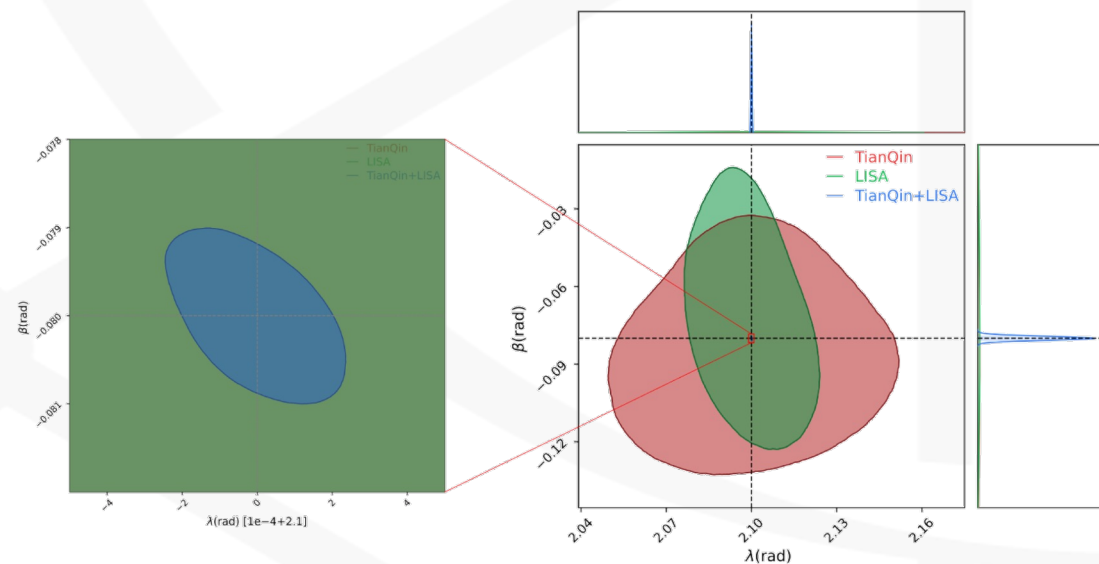
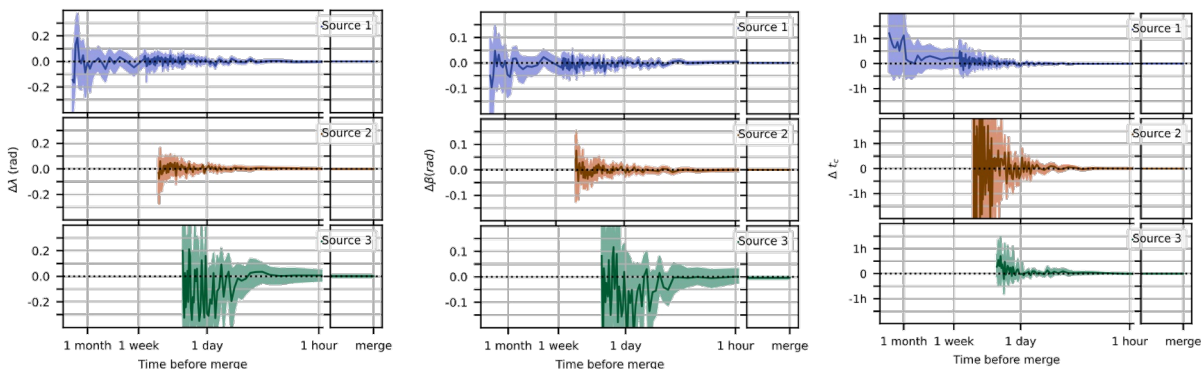
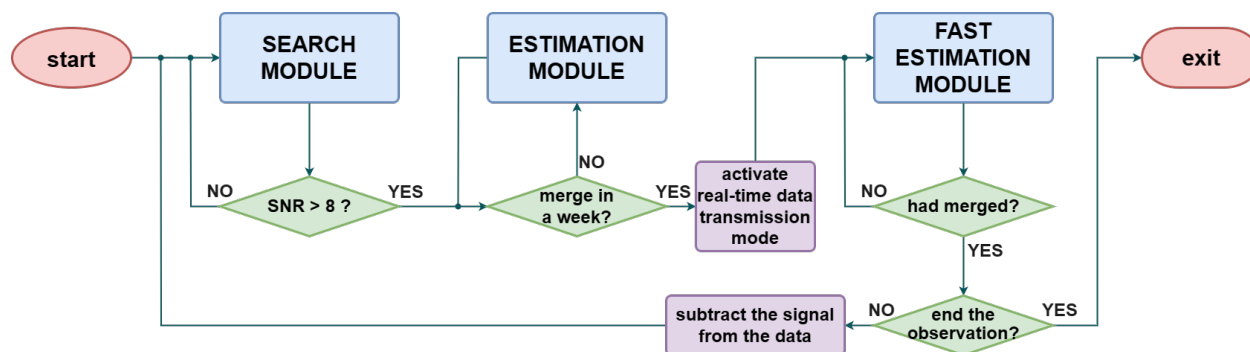




III. Special Issues

□ Special Benefits

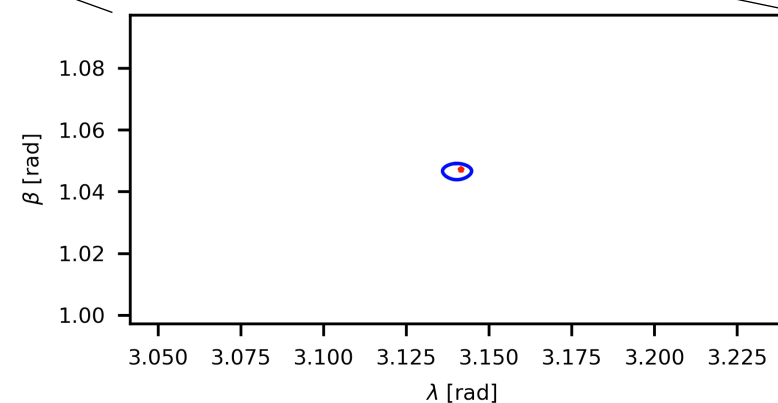
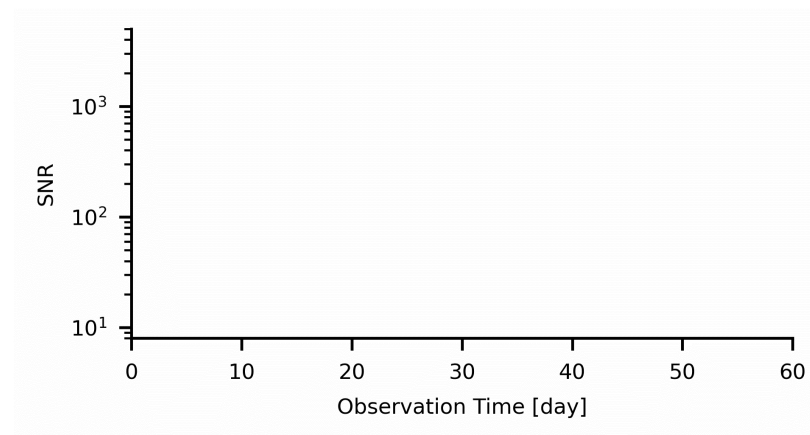
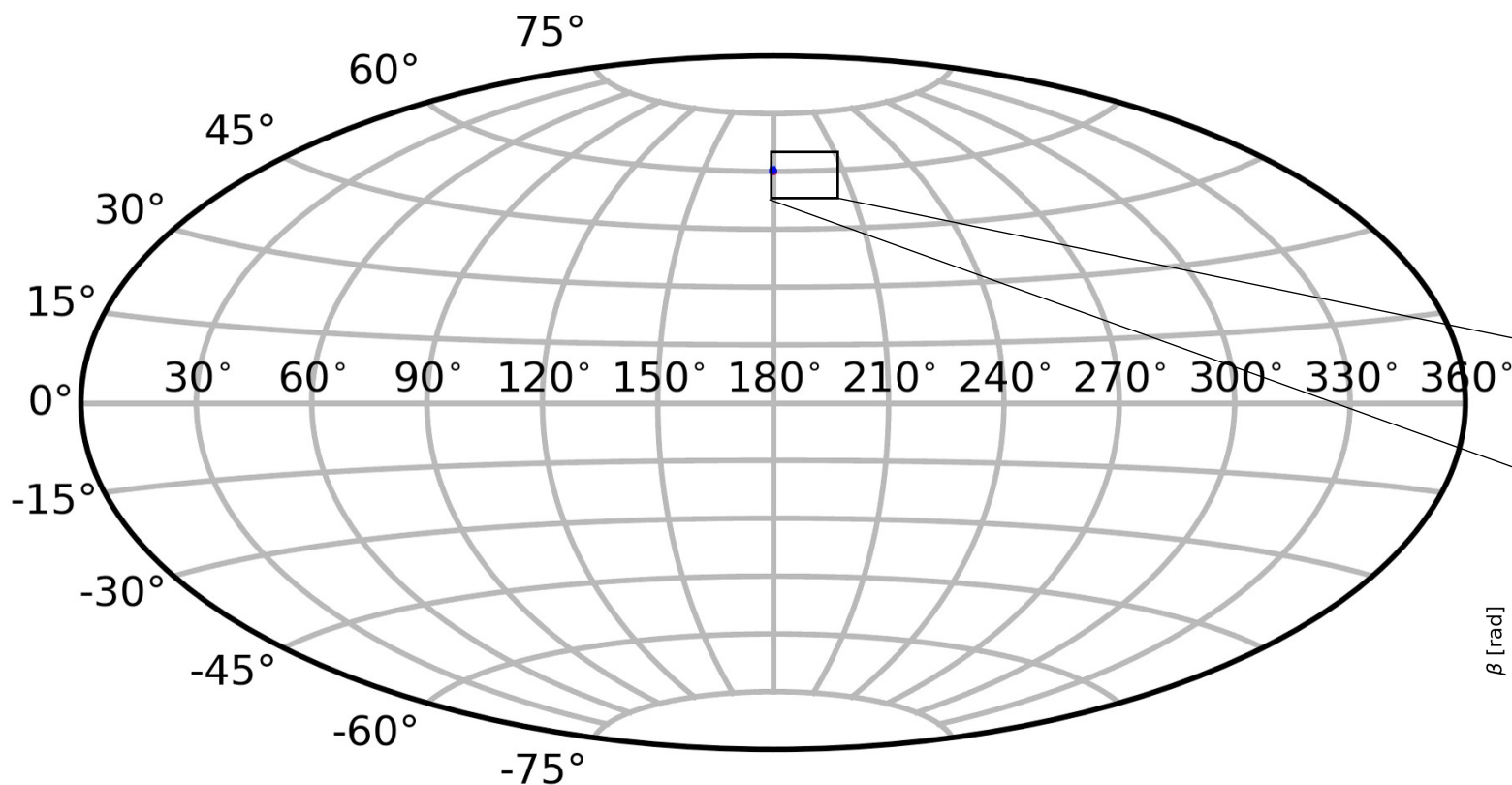
- Near real time data transmission (each hour) $\implies$ Near real time data analysis
1 day before merger, $\sim 1 \text{ deg}^2$, $\sim 10 \text{ mins}$
- Orders of magnitude improvement on localization for network





III. Special Issues

□ Example for Early Warning with Near Real-time Analysis





IV. Summary

□ Statues & Benefits & Challenges

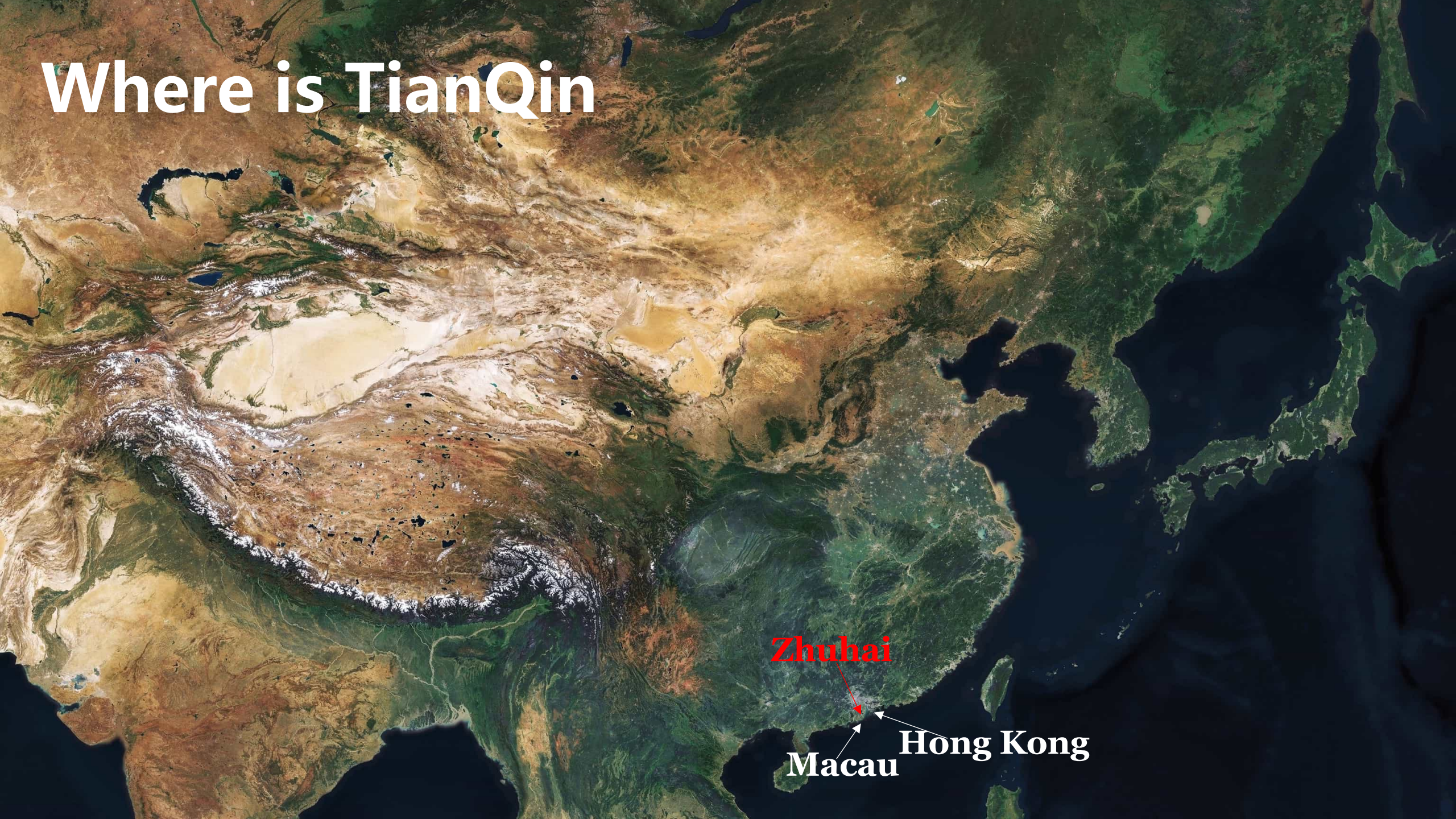
- The mission concept of TianQin has been studied and is feasible;
- Key technologies of TianQin are being developed: Hardware & Software
Some have reached the requirement, and many are less than an order away;
- The scientific output of TianQin is promising
- The gain from the joint observation with other detectors is huge
- Some new challenges: 3+3, global fitting for joint observation
- Any collaboration and anyone want to join us are welcome!

Where is TianQin

Zhuhai

Macau

Hong Kong



Where is TianQin

Laser Ranging facility

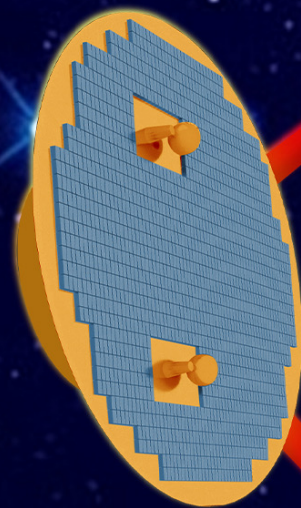


Cave Lab

Ground simulation
facility

TianQin Building





Thanks!