AI + Astronomy
Models, Data, Discovery

# Challenges and Observations in Developing Antarctic Optical Telescopes

## ——南极天文光学望远镜研制挑战与观测


**Li Zhengyang (Dr. Li 李正阳)**

[1]Nanjing Institute of Astronomical Optics & Technology, Chinese Academy of Science

[2]Polar Research Institute of China


Hello, I danced in a cold dream.

# Nanjing Institute of Astronomical Optics & Technology, CAS

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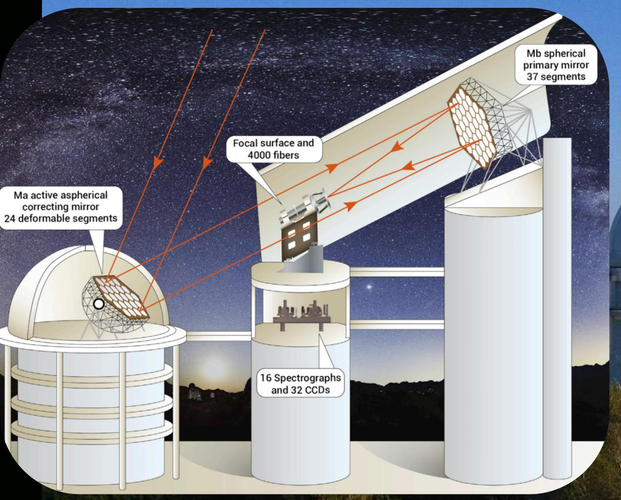
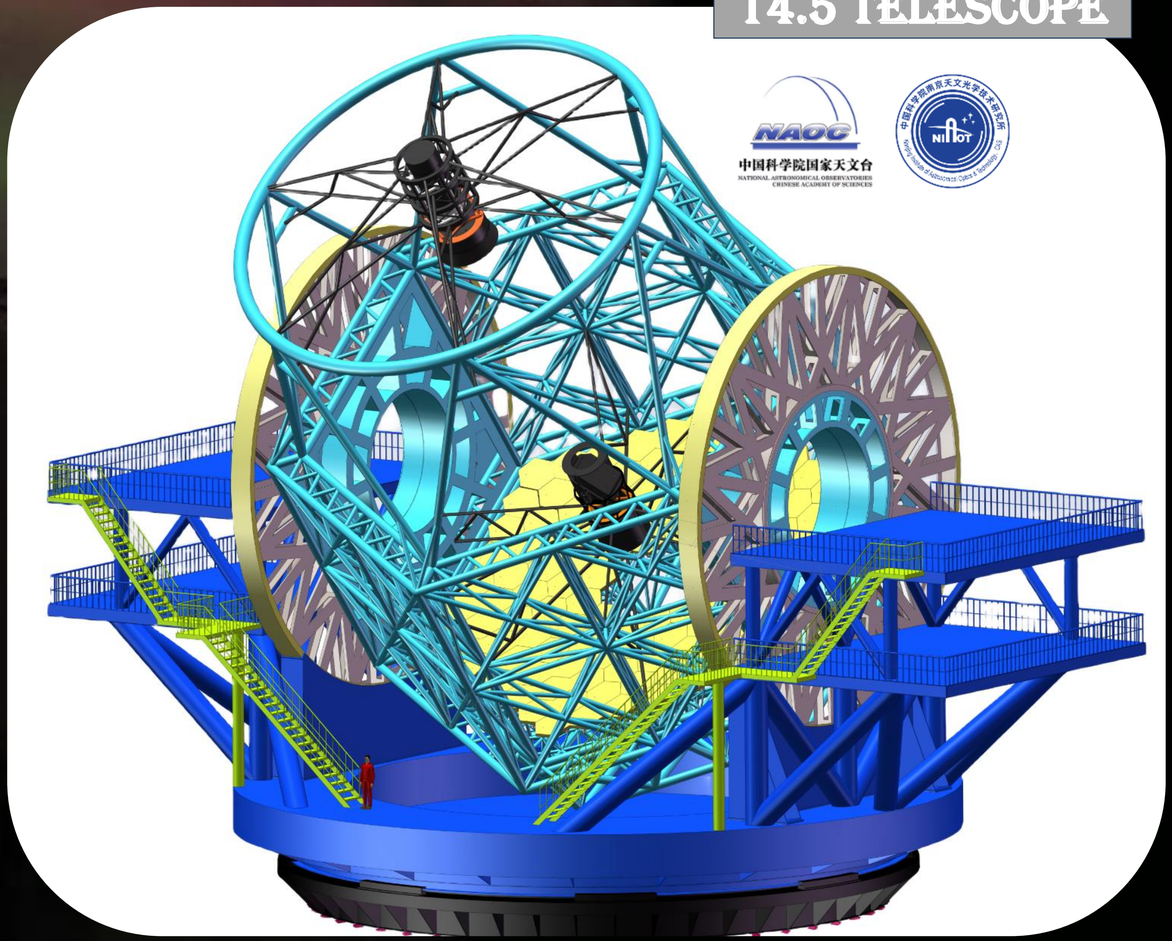
NIAOT established in 2001, evolved from R&D unit and Mirror Lab of Nanjing Astronomical Instrument Research Center, founded in 1958.

## LARGE SKY AREA MULTI OBJECT FIBER SPECTROSCOPIC TELESCOPE (6.5M PRIMARY)




## 14.5 TELESCOPE




Res. Astron. Astrophys. 2012; 12: 1197–1242

# Critical factors for Astro-Telescopes

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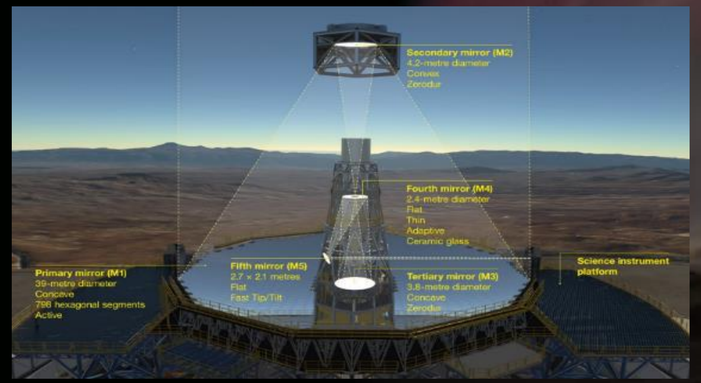
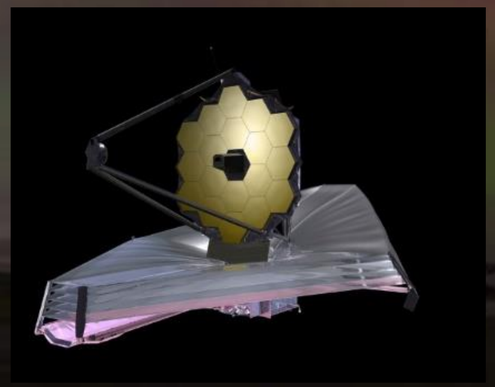
## Antarctic site could offer Earth’s clearest view of stars (Nature, 2020)

◆39meter EELT （Ground base）

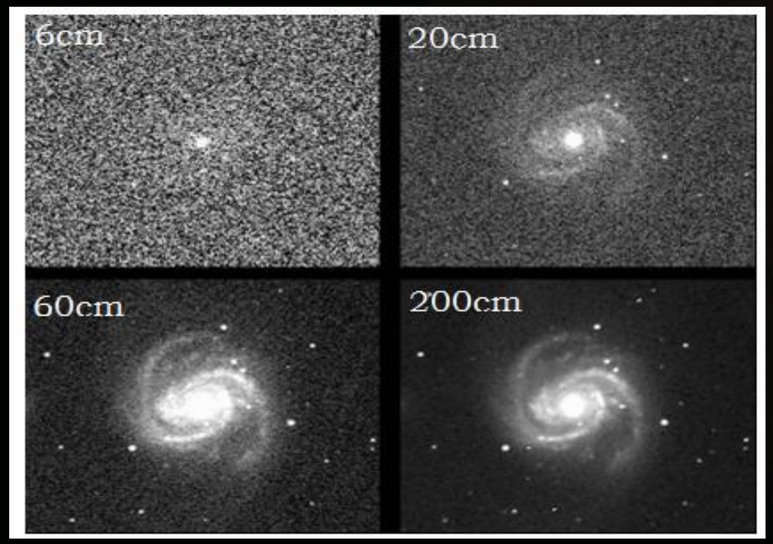



◆6.5meterJWST （Space）

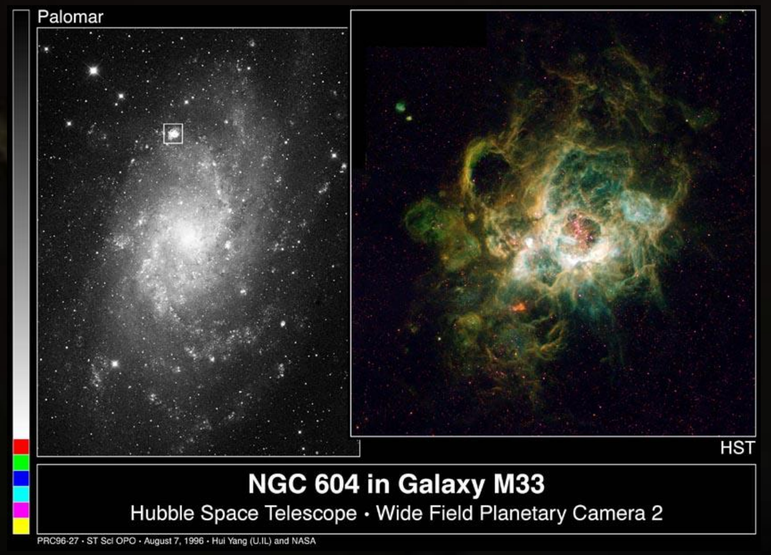


◆Clean & Thin air （Qusi-Space）

◆Aperture vs resolution：$\theta = \lambda/D$




◆Ground base 5m vs Space HST 2.4m



# Human-Inaccessible site: Dome A



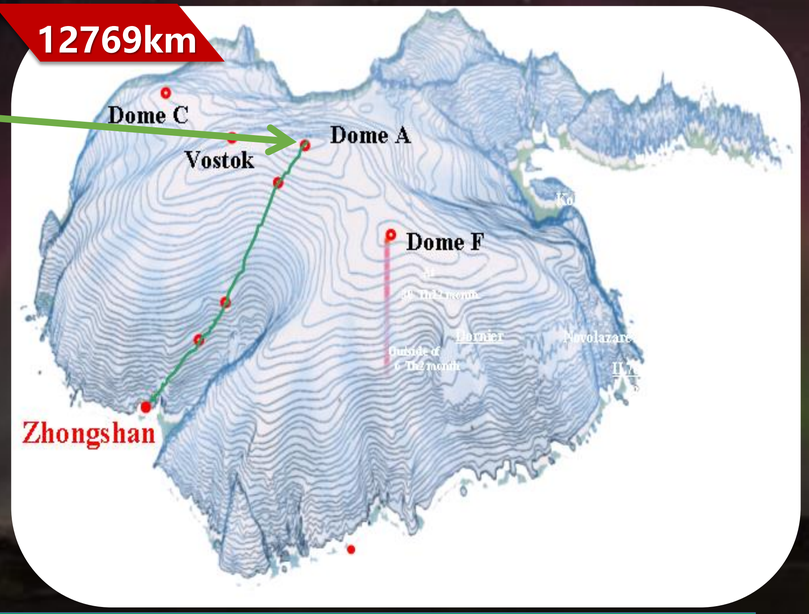
## Dome-Kunlun station

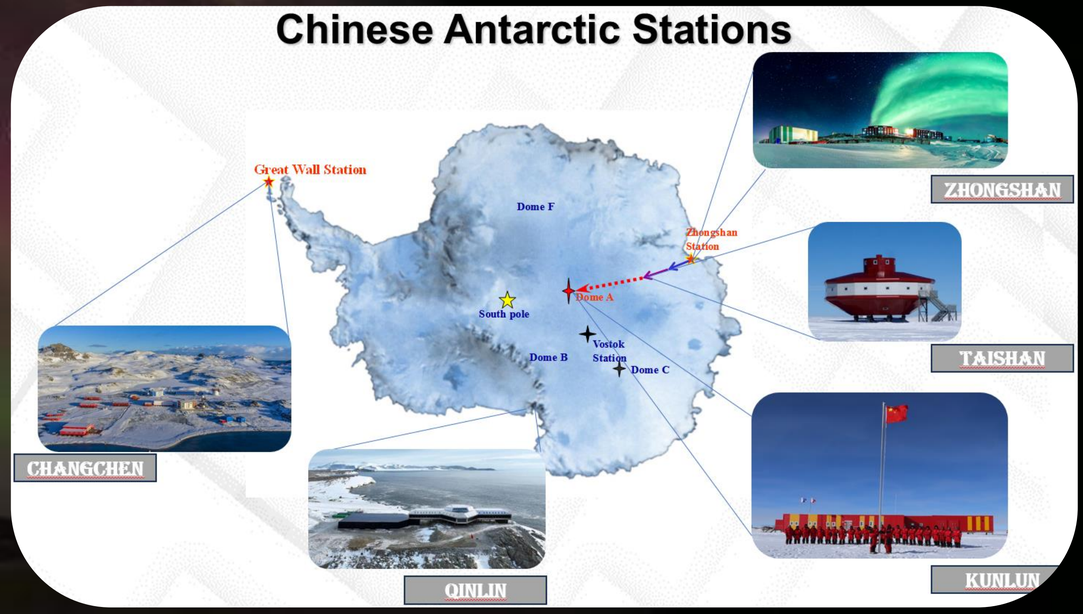
**Human-Inaccessible site**

The clearest view of stars

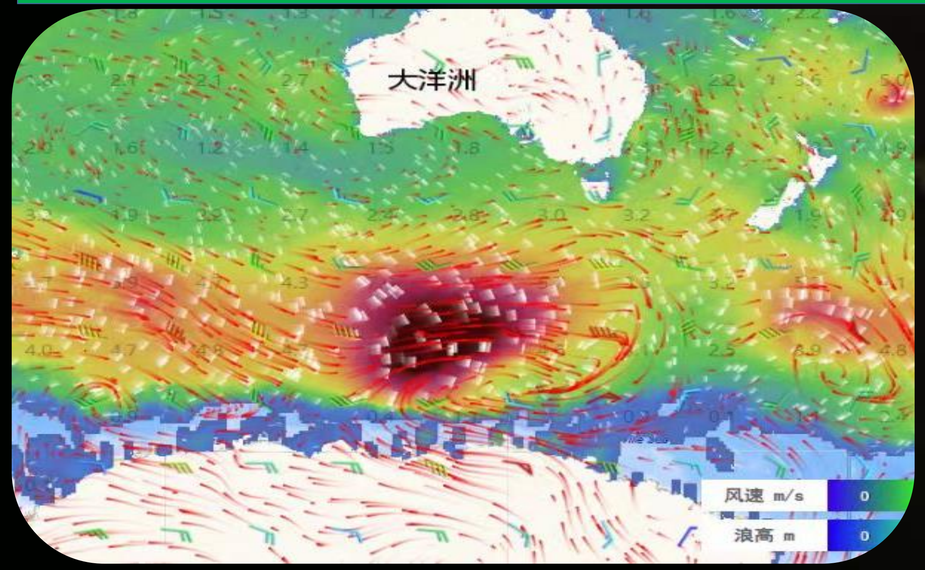
The longest polar night

The most extreme weather




Sounds like an amazing trip, spending 1 month on the XUELONG ship




# The warmest season for work there

## "Tourist Snapshots at -40°C"

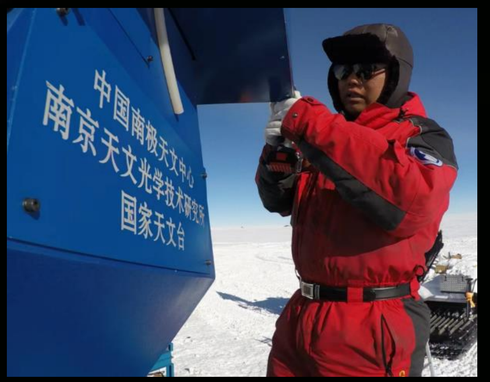
One of the four major scientific highlands—the coldest point, the magnetic pole, the South Pole, and the highest point—is Dome A.

Often referred to as "the pole inaccessible to humanity," Dome A was first reached in 2005. Astronomical observations in this region commenced in 2008, and a research station was established there in 2009.



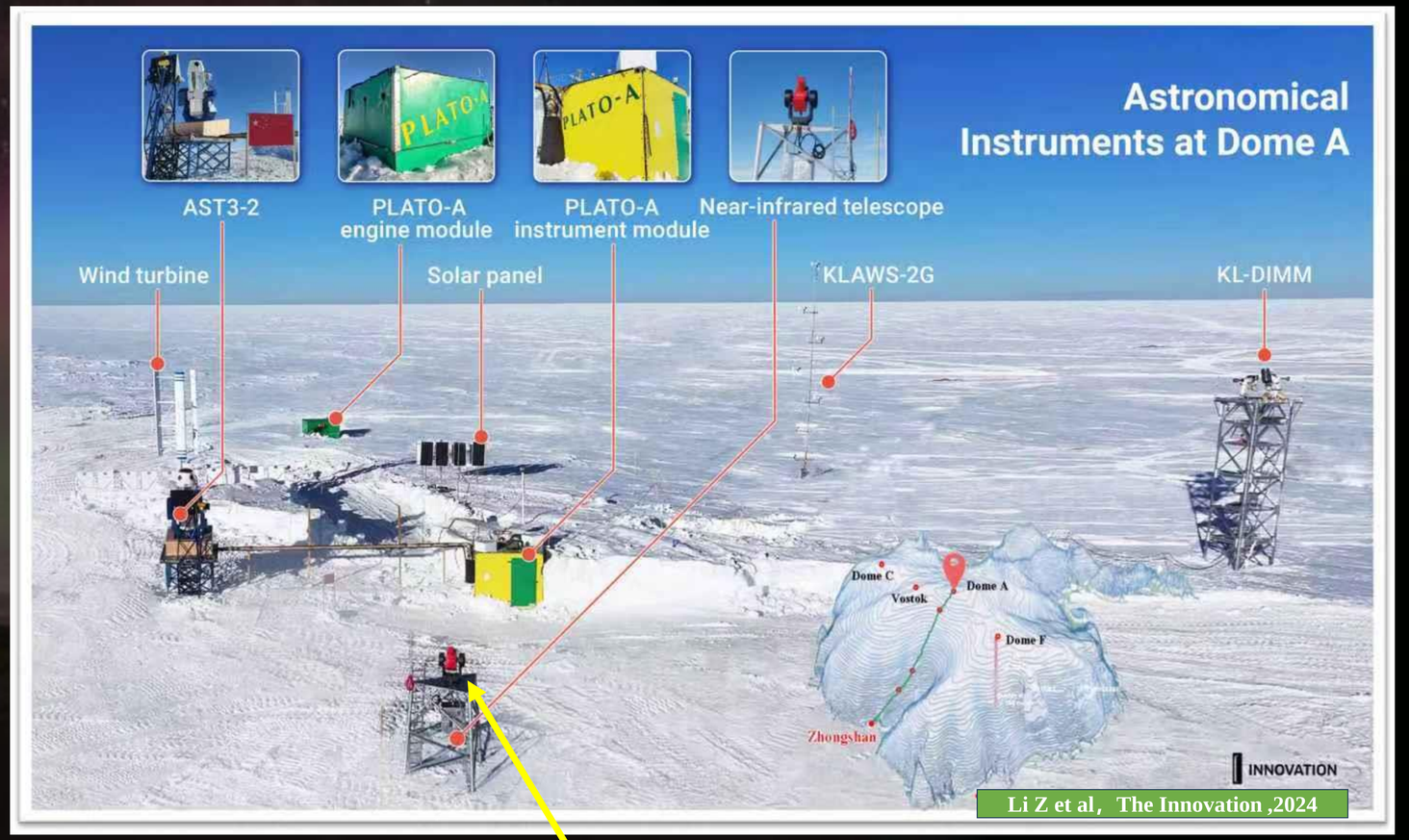

- In January 2012, I am China's 28th Antarctic scientific expedition member;
- In January 2015, I am China's 31th Antarctic scientific expedition member;
- In January 2024, I am China's 40th Antarctic scientific expedition member;

## A snowmobile driver who can't cook, will not be a good astronomer.

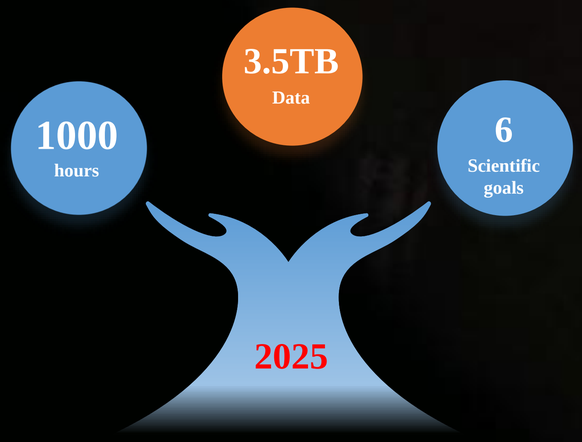


# ~ 300 days remotely control

Operating Temperature: -60 to -80°C, and under Frost, and Snow Conditions (Low wind speed); High Single-Point Failure Probability (with Redundancy Mechanism) with limited Energy Supply (1.2 kW during Polar Night, without solar panel and wind turbine)




# ~ 100 days polar nights (2025)

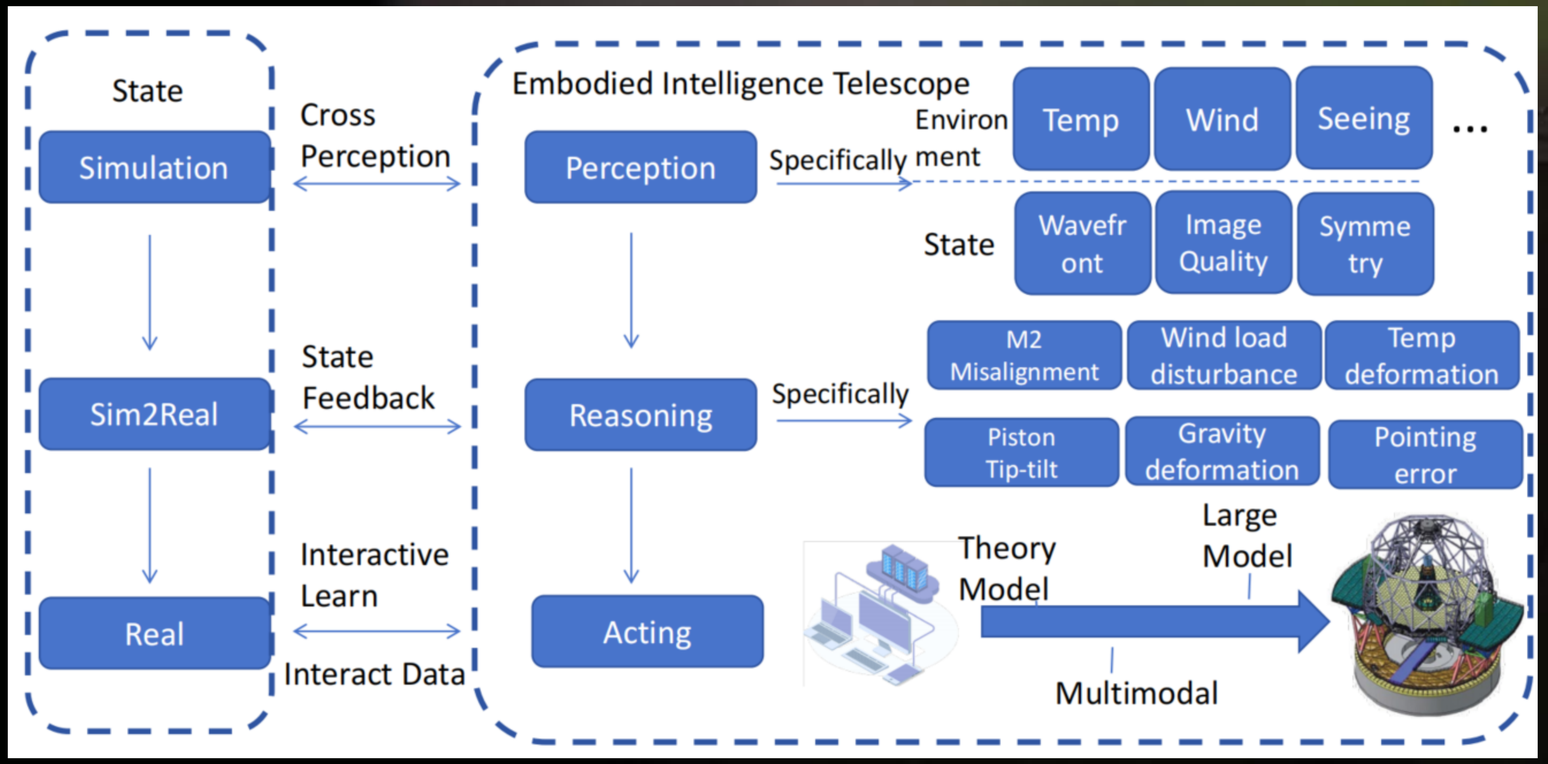


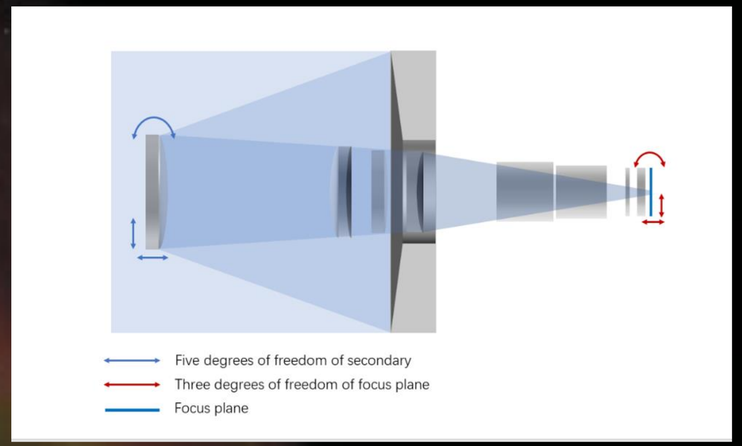

It is expected to last until the end of the 2026 observation season.

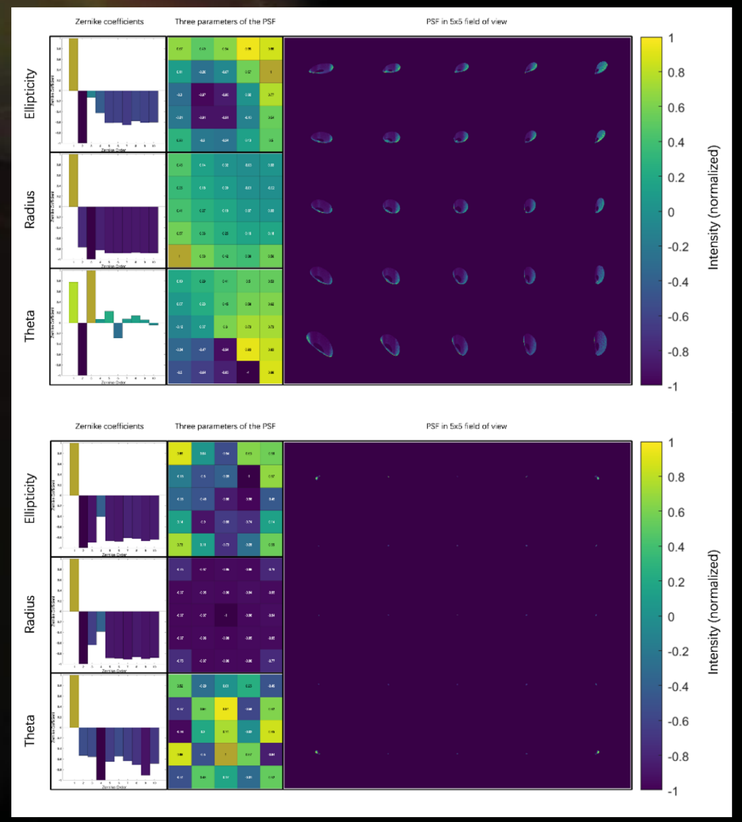

Example1: PSF machine learning active alignment

# Embodied Intelligence Telescope In Antarctica

- Perception layer: environmental sensors and Image quality sensors
- Reasoning layer: AI models to output correction commands
- Execution layer: keep the telescope in optimal condition

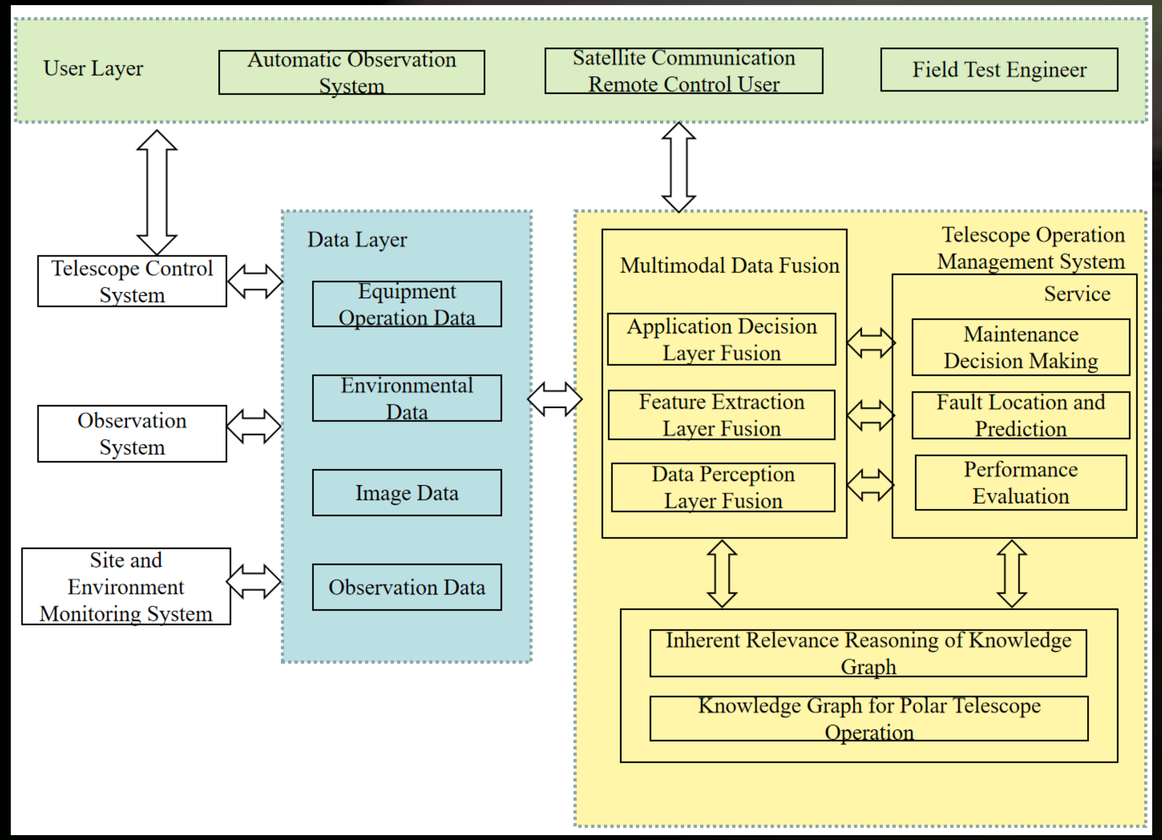


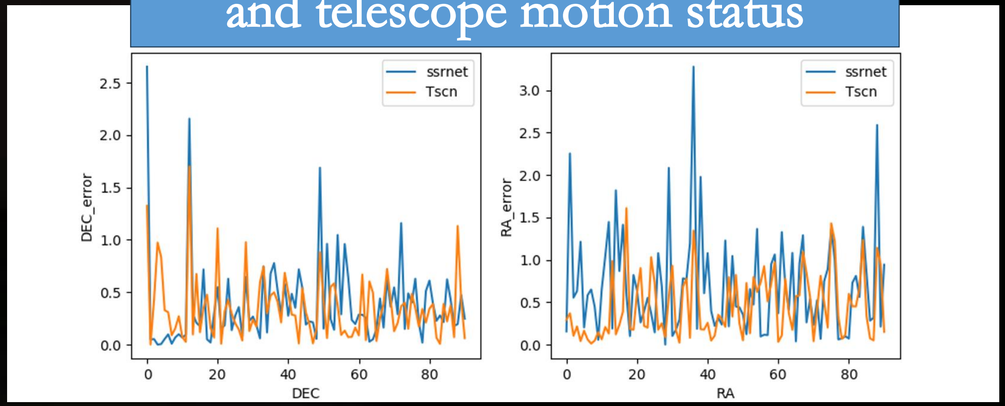



# Intelligent Operation Management System for Unmanned Polar Telescopes

- Multimodal data fusion technology
- Knowledge Graph
- Relational reasoning



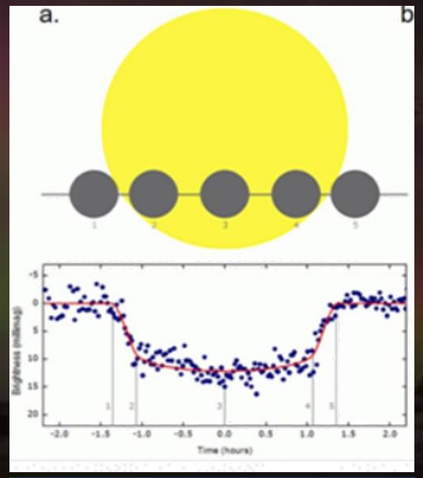

Data fusion of monitoring images and telescope motion status



# Exceptional achievements

- Gravitational wave optical counterpart observations,
- Supernova searches,
- Exo-planets searches,
- Daytime infrared background measurements,
- Space debris monitoring, and other scientific objectives (~510 + 117 variable stars, etc.)


Hu L .et al，Science Bulltin,2017

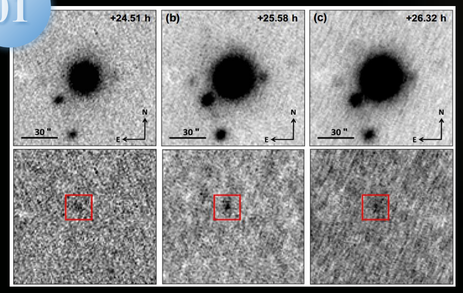


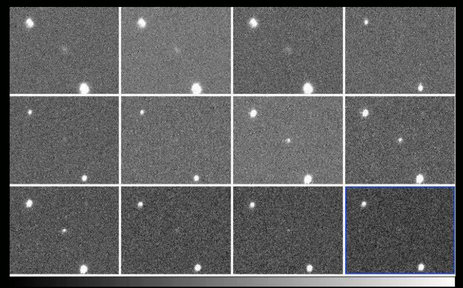

Zhang H et al，APJS,2018,2019,2020


Li Z et al，PASP ,2024

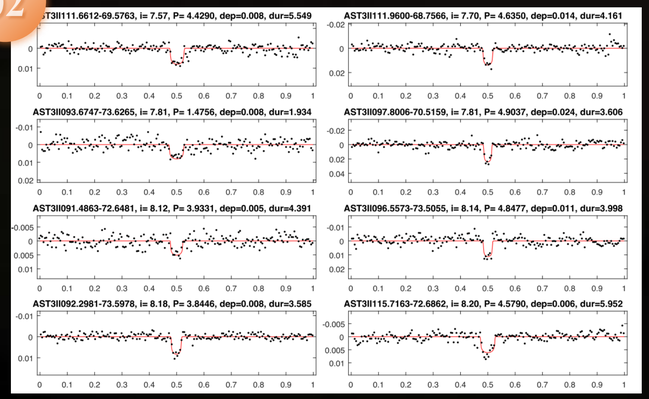
## Three Approaches to Data Management with AI

**01** ❑In-situ data ROI ( 20 KB )

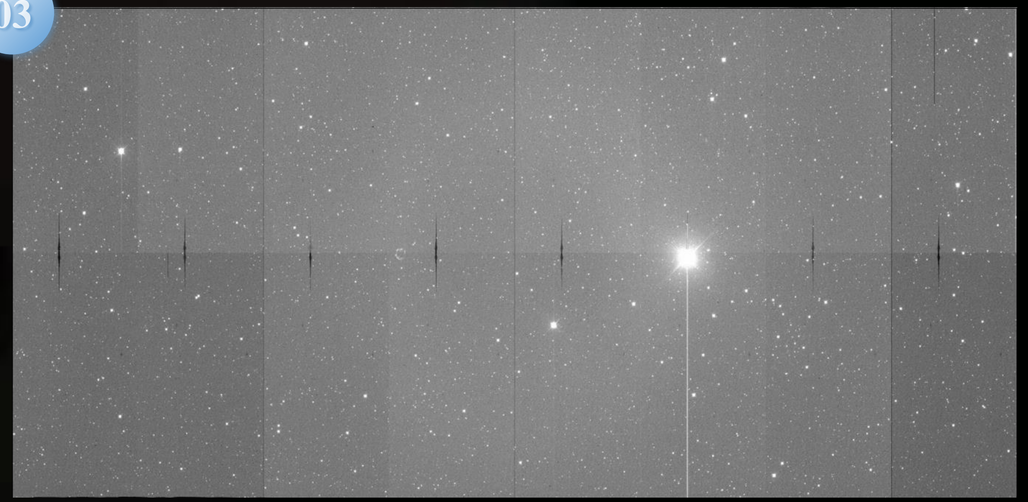


**02** ❑In-situ data analysis & catalog transfer via satellites




**03** ❑Carrying back the HDD annually

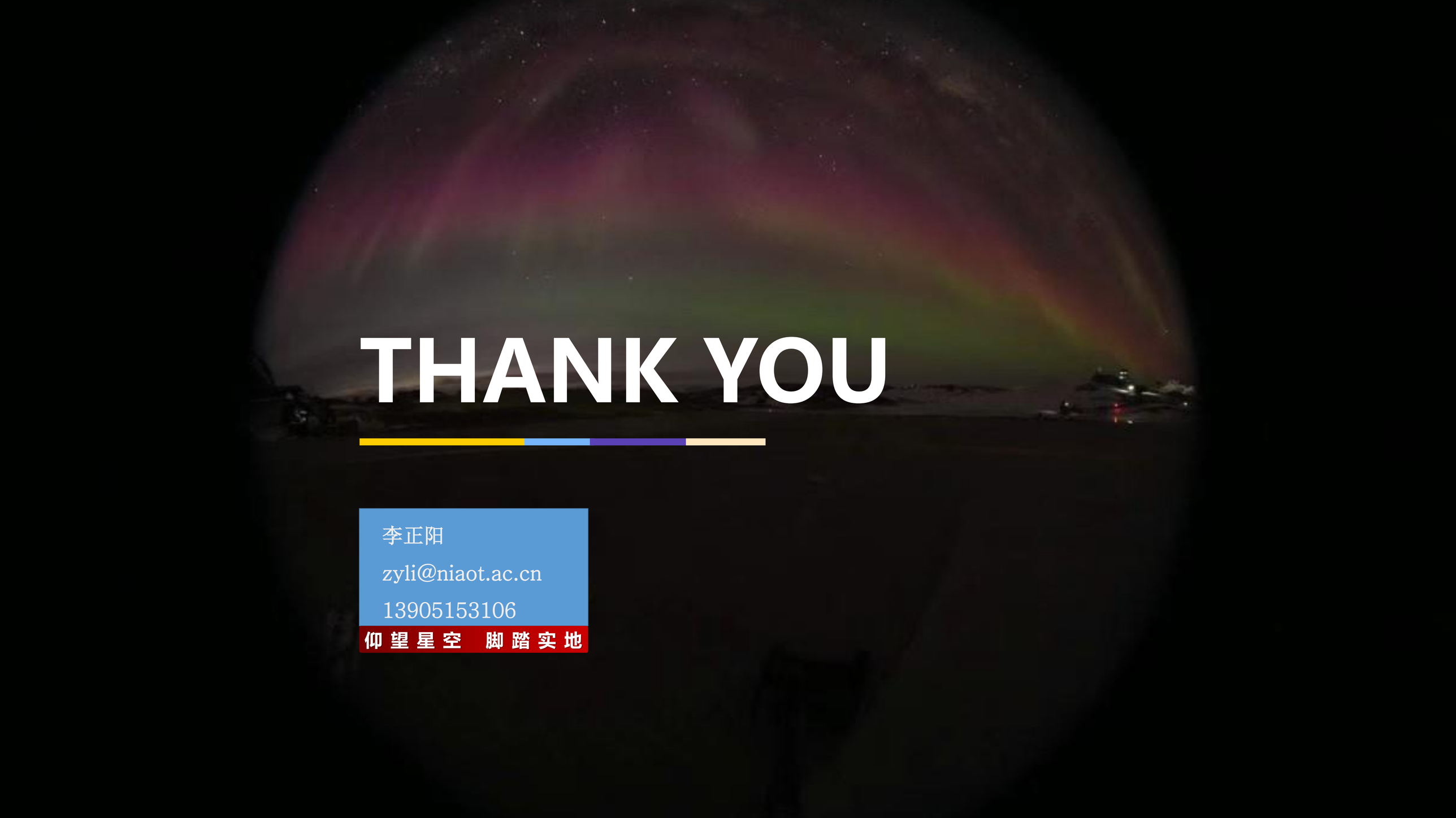


# Rewards:  Astronomers' happiness



Standing on the white wasteland, the sky is gradually turning dusk gray. The egg-yolk-like moon is hanging there, huge in size. I'm so worried that it might fall down. In a daze, I feel as if I'm on another planet. There isn't a single sound around.

A great many penguins




李正阳
zyli@niaot.ac.cn
13905153106

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