Antarctic Observatory at Chinese Kunlun Station
- Progress Updates

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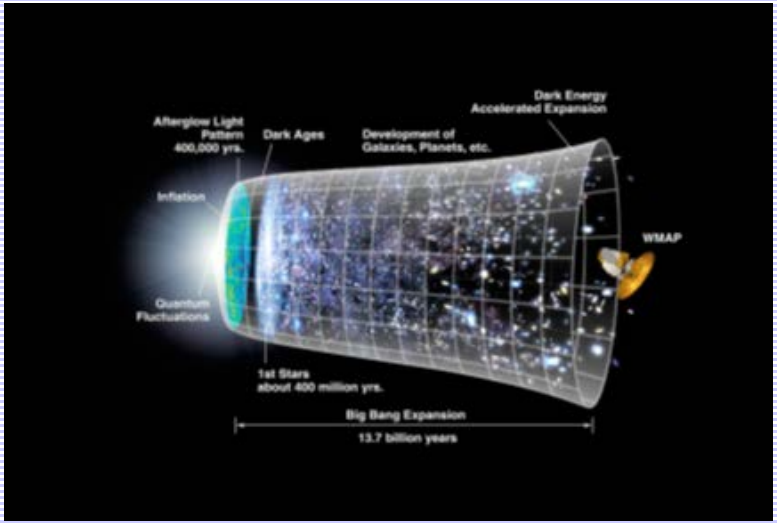
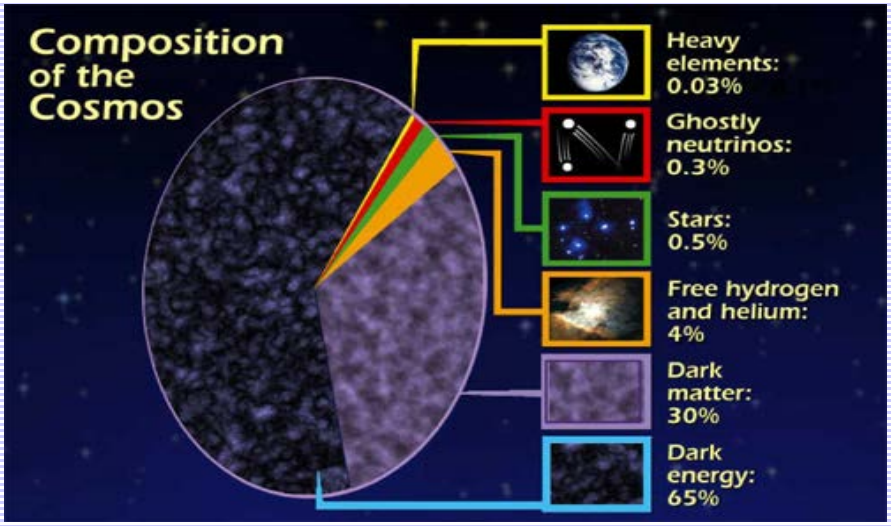
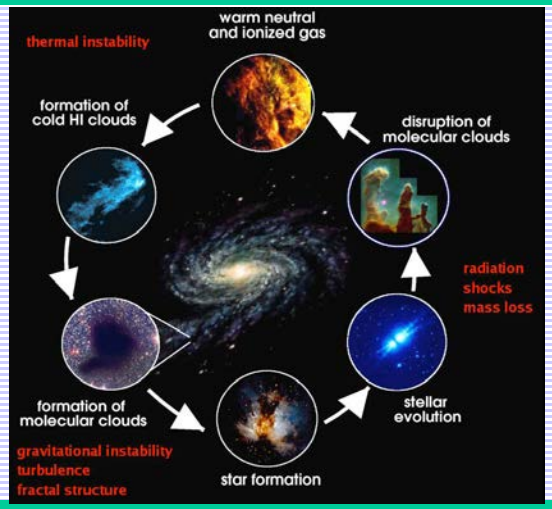
Major Challenges in Astronomy





End of Dark Age and Formation of First Generation Stars

Precision Cosmology dominated by Dark Energy & Dark Matter

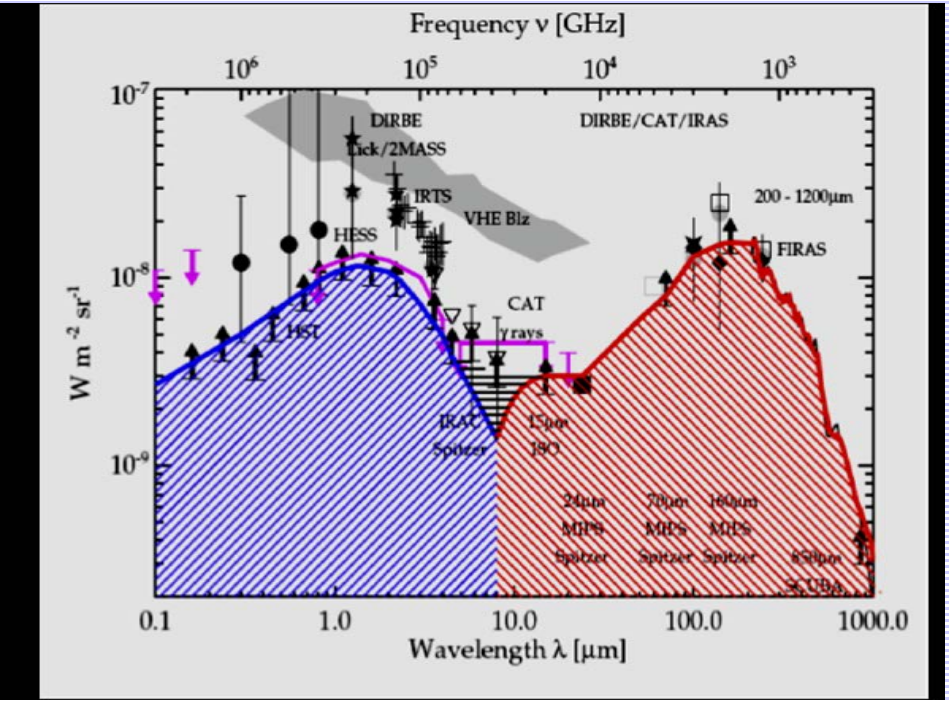


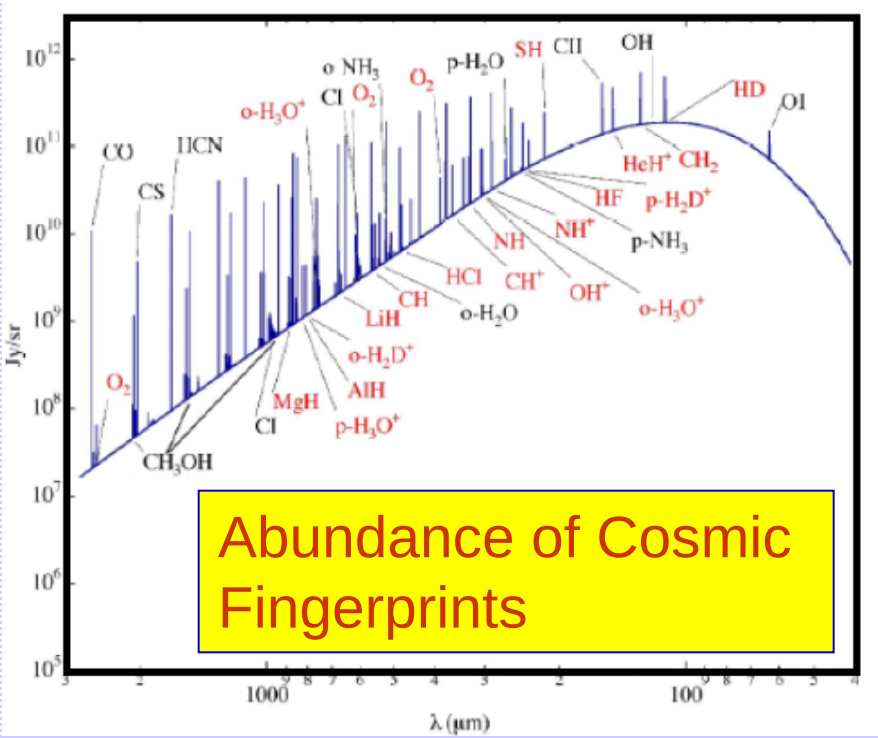
Ecology in the Universe: ISM, Stars, Galaxies

Origin of Planetary Systems & Life

THz Wavelengths: New Windows for Observing the Universe

- Cosmic SED peak at FIR/THz： THz as an important tracers to the distribution, structure, and motion at different levels.
- Intensive lines carrying important information on the origin of the universe, celestial bodies, and life.



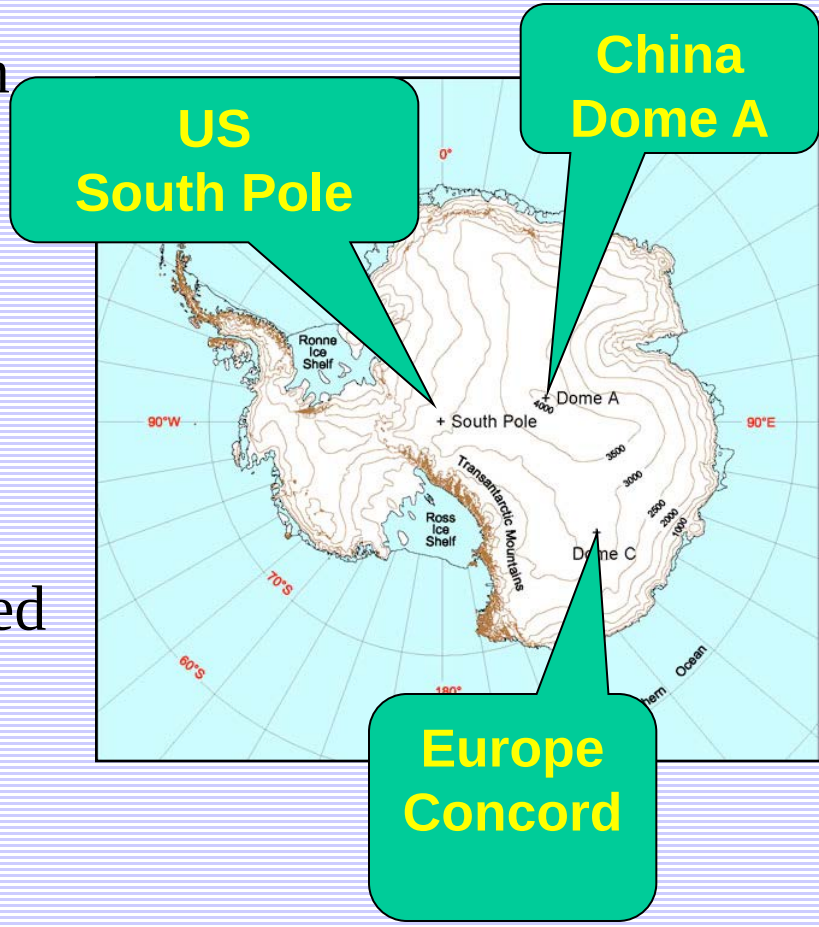


Dole, H. et al. 2006; Driver, et al. 2008

Credit: The Herschel Team

Place of Interests
——Dome A, Antarctica

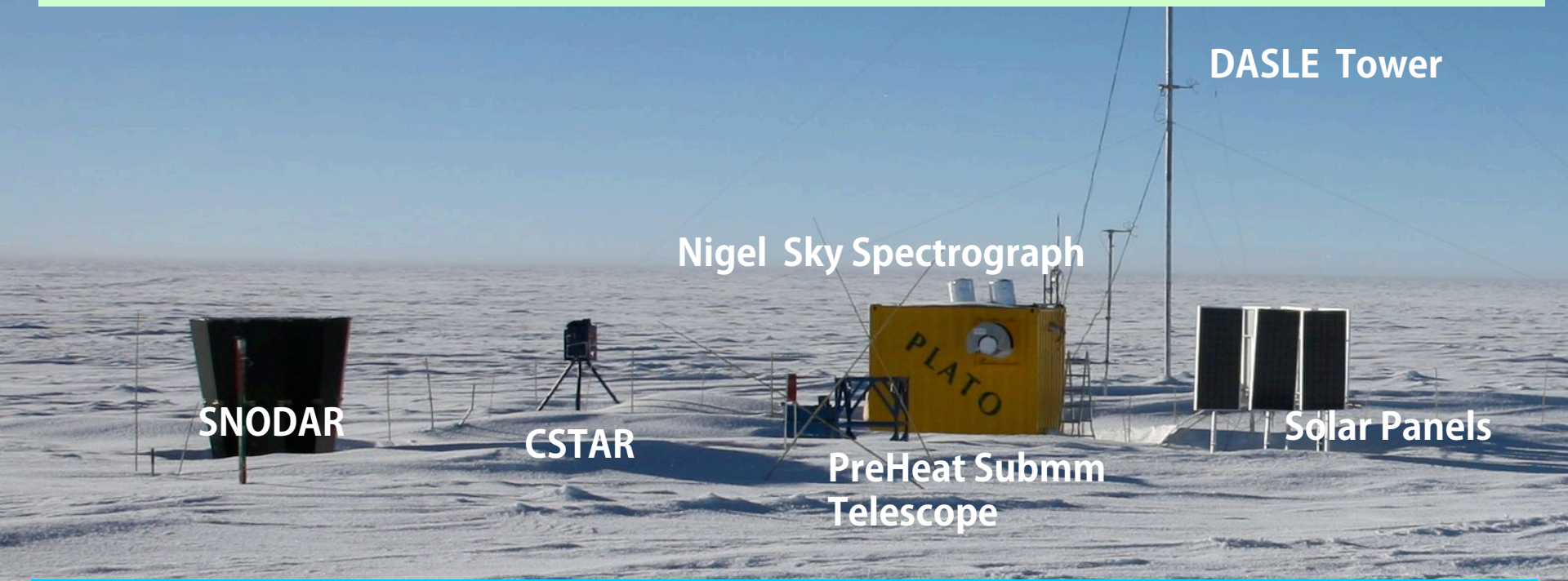
- Dome A (4093m, -83°C), Best Site on Earth
- Low thickness of ground layer
- Clear Sky & Low Wind Speed
- Very good transmission from 150 to 800 μm
- Much cheaper than space
- Accessible each year, permitting staged deployment of instrumentation
- Long lifetime



Establishment of Dome A Observatory

- Dome A (60km×10km) at an altitude of 4100m, a plateau of small fluctuation; cold, dark, clear, dry and low wind speed。

- **2005.1.18 Chinese inland expedition team reached Dome A.**
- **Astronomy follows on from 2007/2008 , by the 24th Chinese Antarctic Expedition), continued by 2009-2012, with international collaborations.**



- Site surveys under the IPY Panda Program suggest that Dome A is a promising site for astronomy, particularly in THz & IR.

Establishment of Dome A Observatory

Systematic Measurements of Site Conditions over winters at Dome A

New Instruemtns for 2009-2010：

THz-FIR FTS、SHABAR

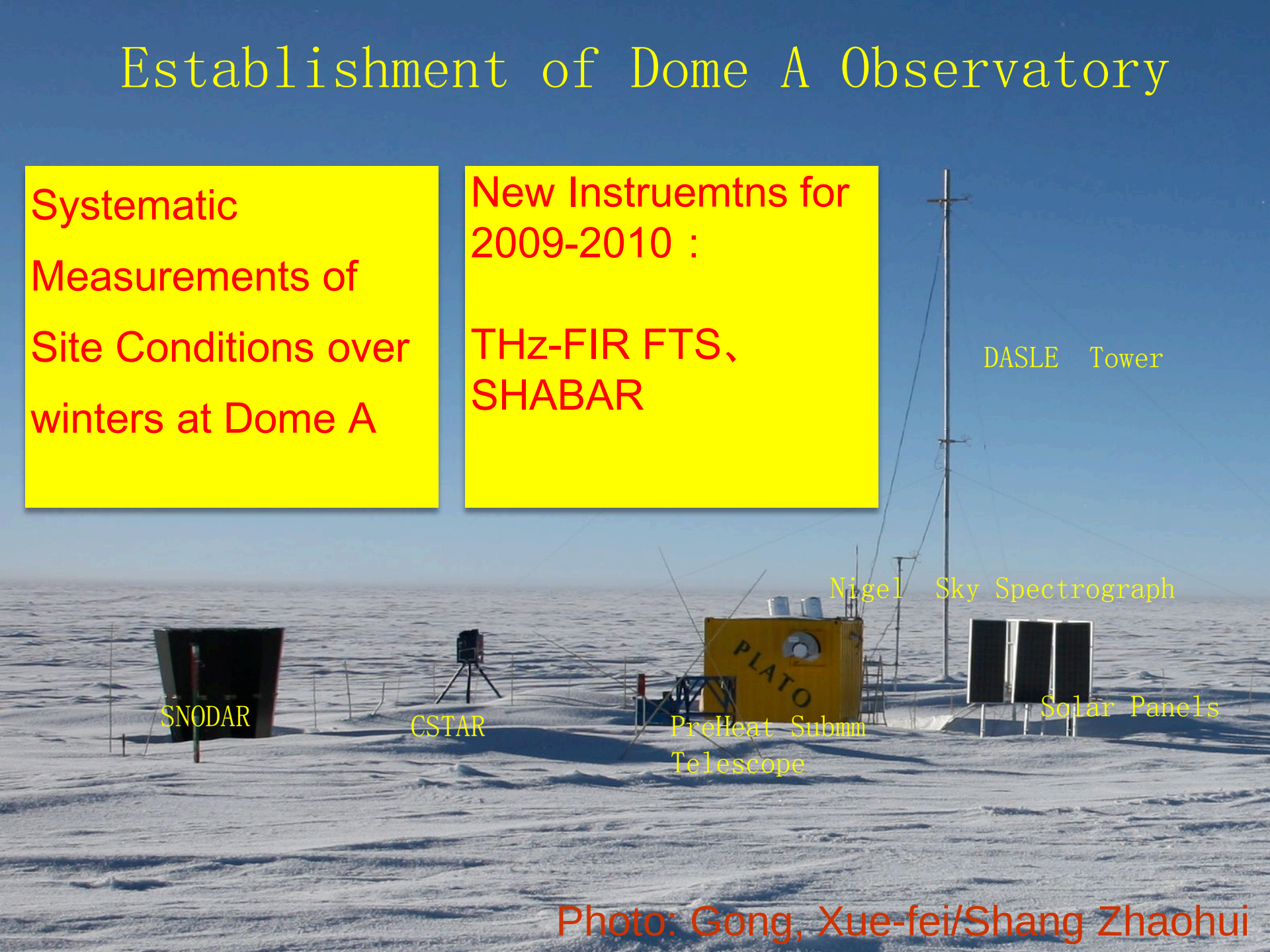
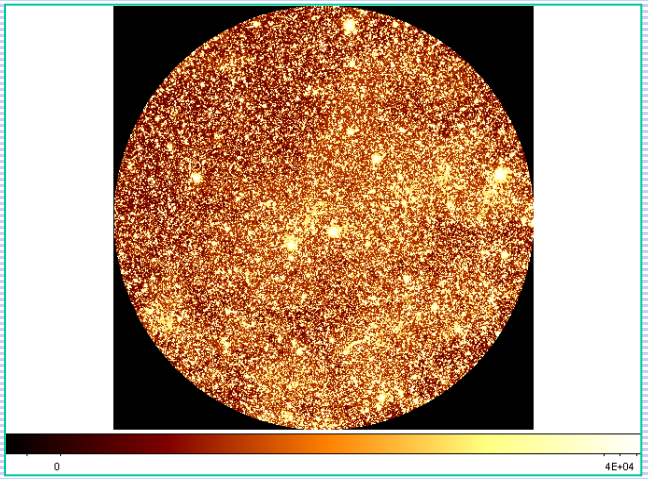


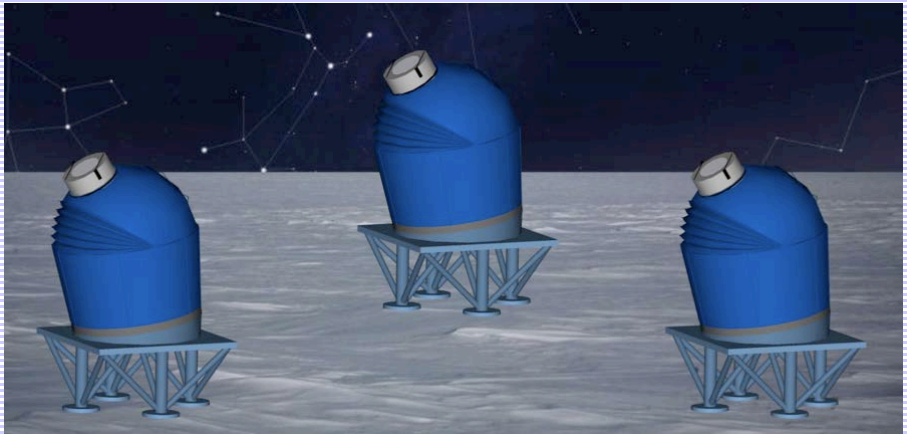
Photo: Gong, Xue-fei/Shang Zhaohui

CSTAR: 4×14.5cm Telescope
（Chinese Small Telescope Array）

- 4×4 14.5cm telescope array; field of view 20 square degrees, 4 colors, no tracking.
- Installed in 2007. PLATO supports power supply & communications, instrument control and data storage.
- Dome A sky brightness & transparency measurements (Zou, H. et al. 2010, AJ, 140, 602).
- New discovery of CV, Nova, variables, and even gamma-ray burst (Zhou, X. et al. 2010).
- Be further used for time-domain monitoring.



Antarctica Survey Telescopes (AST3)

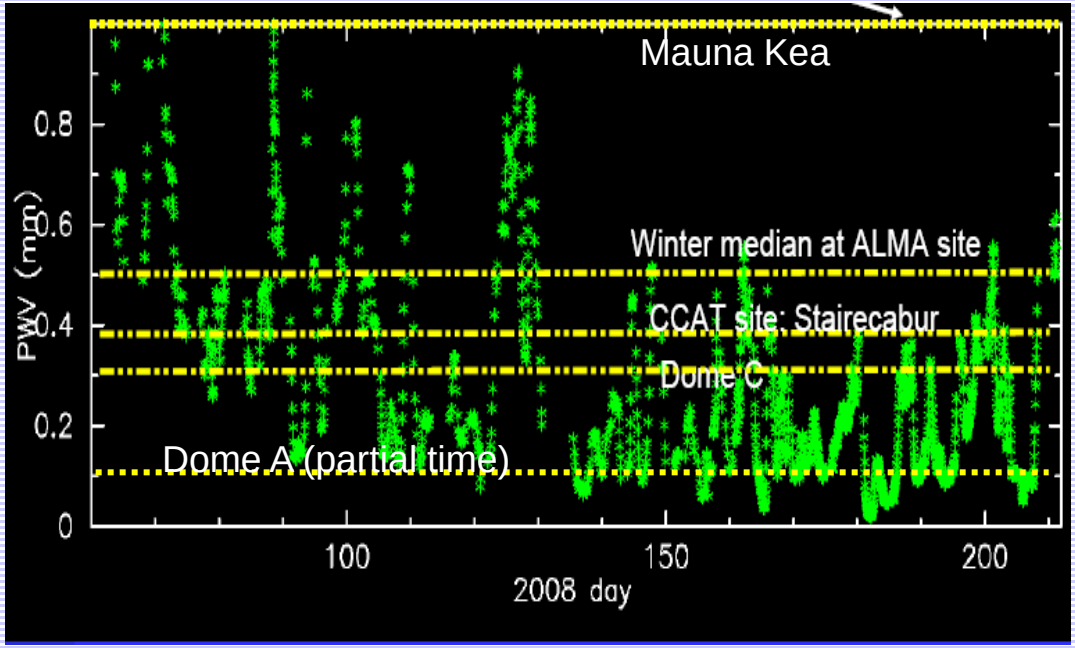


- Telescopes: ϕ50cm× 3 units
- FOV：4.2°；
- Wave band：400nm-900nm
  (g, r, i filters for 3 telescopes);
- Image quality：80％energy encircled in one pixel;
- Focal plane scale：1 arcsec/pixel;
- CCD: STA1600 9 micron/pixel, 10580×10560 (95.22 mm × 95.05 mm image area);
- Working mode: frame transfer;
- The first unit was installed at Dome A in 2012 and obtained some results

THz Observing Conditions at Dome A

Phase 1 Site Survey in THz was carried out over 2007-2008 using tipping radiometer measurement of PWV at Dome A by a 660 GHz at Pre-HEAT, which was installed by Chinese 25th Antarctic expedition team and data were collected from Jan 24, 2008. The results show the best site ever knew, which opens new THz windows over 150-800 μm .

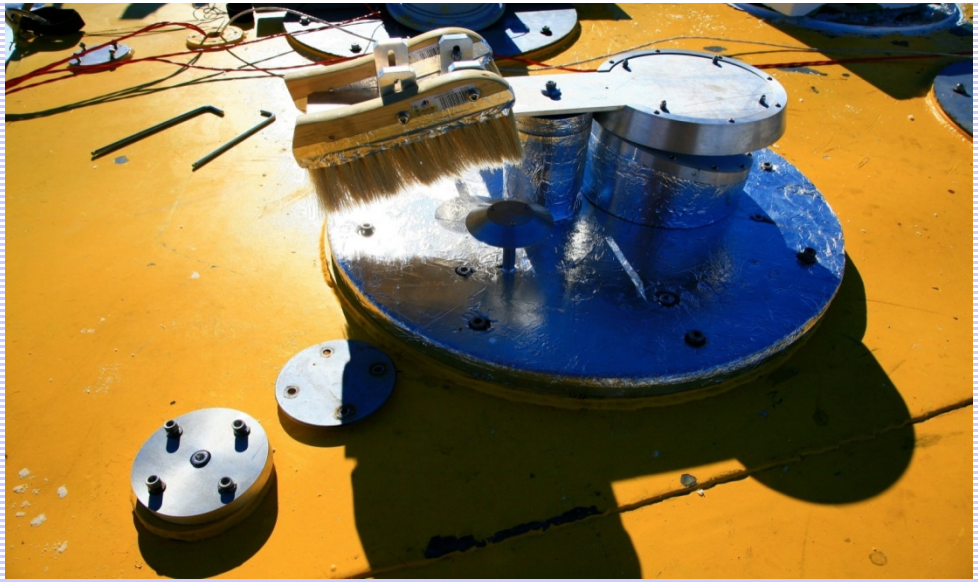
The THz site measurements at Dome A are resulted from a very successful collaboration among University of Arizona, Purple Mountain Observatory, Exeter University, & University of New South Wales.



Yang, H. et al. 2010, PASP, 122, 490; (also, Sims, G. et al. 2012, PASP, 124, 74)

Measurement of Broadband Atmospheric THz Transmission by FTS

- In 2009，a FIR/THz FTS was developed & installed to measure the atmospheric transmission over 0.75-15 THz, under the collaborations among PMO, CfA, and NAOJ, with remote operation support by NSWU.
- The results，combined with 660GHz radiometer measurement by Pre-HEAT，strongly suggest that Dome A is a unique site for ground-based THz observations.
- THz facilities for 200-350 micron windows should be planned.



Uniqueness of Dome A Astronomy

- Science：Prospective
- Site：Unique
- Technology：Feasible

Targeted Science Drivers

- **Time Domain- The Legacy of a Dynamic Universe**
- **Large FOV+High Resolution- Revealing the Dark Universe**
- **New THz/IR Window- Star & Planet Formation, and the Origin of the Universe**

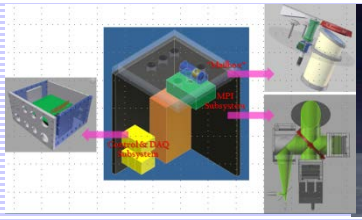
Dome A Observatory Development: A Roadmap

2006-2008

Site Survey & Small Telescope

2009-2015

+Site Testing & Middle-size Telescope



2013-2020

Dome A Observatory Phase I

2.5m Opt/NIR
KDUST

5m THz
DATE5

Long-term

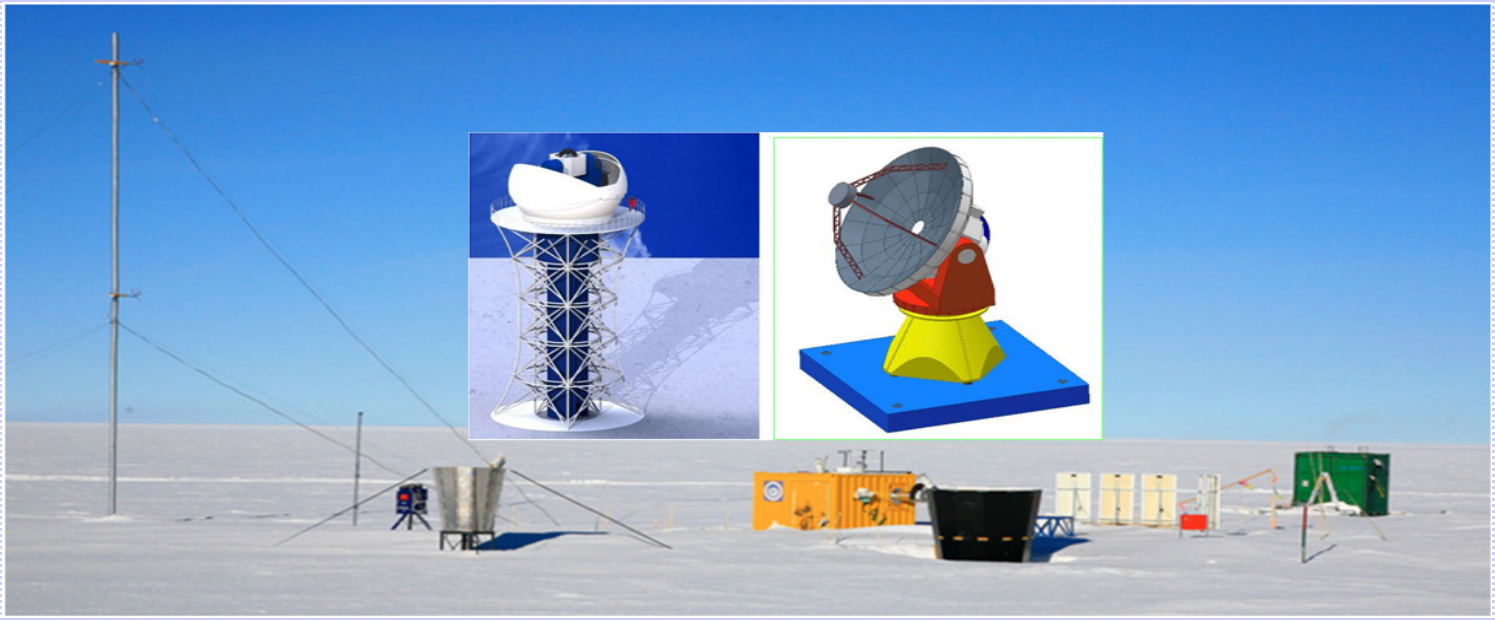
Dome A Observatory Phase II

Concepts for Dome A Observatory (Phase I)

- Taking the advantage of Dome A superior site conditions to build next-generation optical/IR, THz observing facilities, and to build efficient international collaborations;
- Major science goals are focused on dark energy and dark matter, exo-planets, time-domain subjects, formation & evolution of stars and galaxies;
- **The facility should be in self-supported observing mode over winter under remote control;**
- **Bulk data are stored on-site and partially send back for timely analysis and follow-up purposes ;**
- **Instrument maintenance/upgrade and data retrieval are made by summer traverse.**
- ***The proposal was made to the Government for the National Mega-Science Facility Plan.***

National Plan for Mega-Science Facility Formally Issued in 2013

Major Construction for Antarctic Observatory Prepared for National Mega-Science Facilities



- 2.5m Opt/NIR & 5m THz telescopes as the major observing facilities;
- The 2.5m Opt/NIR telescope will be a wide-field survey telescope combined with high spatial resolution;
- The 5m THz telescope will explore new observing windows over the THz regime.

2.5m Optical/NIR Telescope (KDUST)

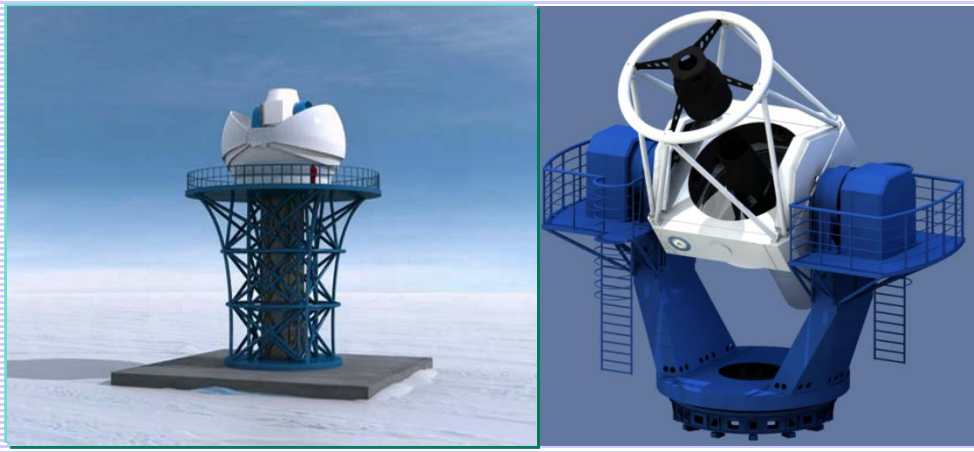
Optics: R-C or SNAP type

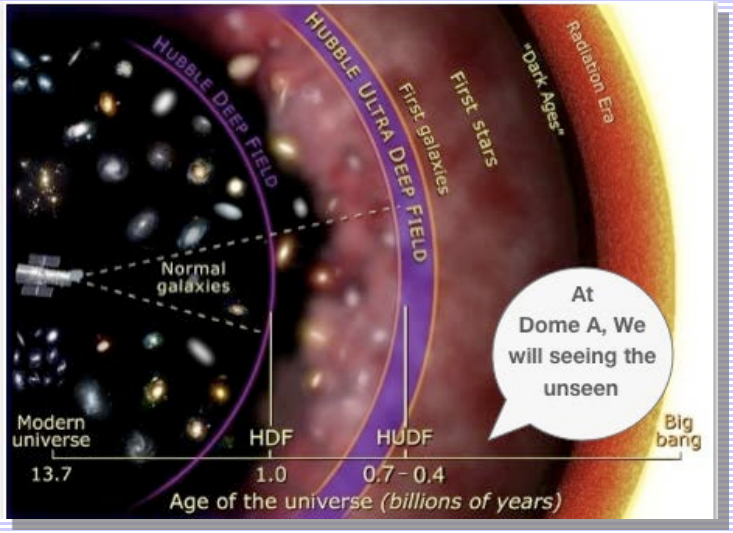
Operation Mode: Large FoV Survey

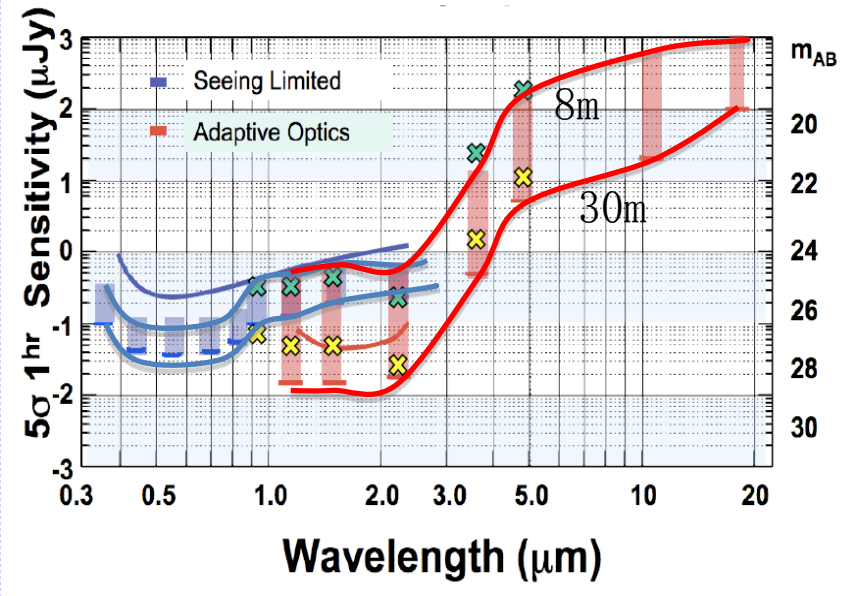
Science: Dark Universe、Exoplantes

Methods: SNIa, Lensing

Construction: 5 Years







Goals:

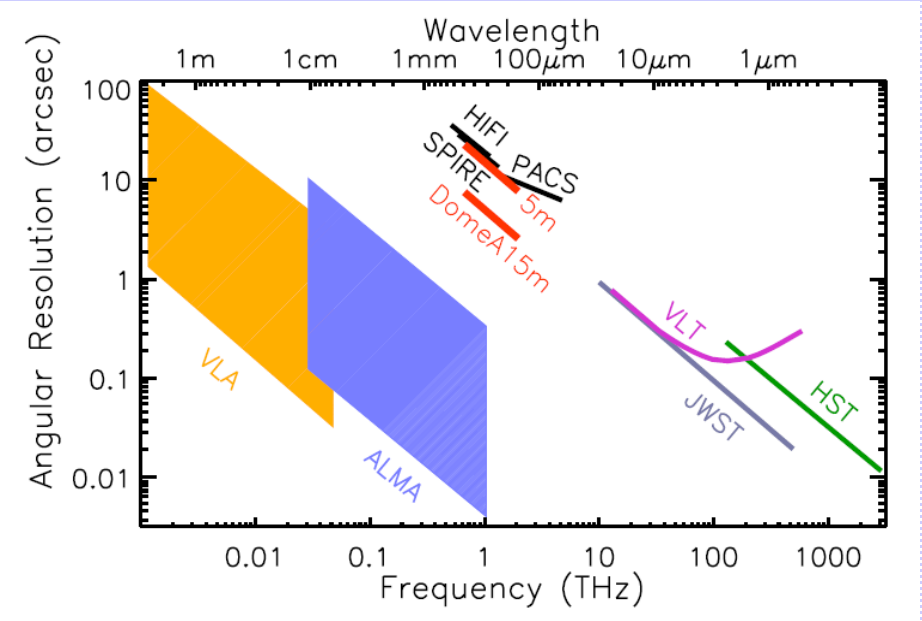
➔To reach seeing limited image quality of 0.3” in optical

➔To reach diffraction limited image quality in NIR

PI of Image

5m Dome A Terahertz Explorer (DATE5)

- Objectives：New windows at THz
- Diameter：5m
- Wavelengths：350 micron & 200 micron (0.9THz & 1.5THz)
- Resolution：18″ & 10″
- Major science Objectives: Formation of star & planetary systems, local Universe, ISM



Comparison with space observations

	DATE5	Herschel
Resolution	Higher	Lower
Duration	Long	Limited
Upgrade	YES	No
Cost	Lower	Higher

Complementary to ALMA/CCAT

	Dome A 5m	ALMA/CCAT
Frequency （<350 μm）	YES	NO
FoV	Wide	Narrow/Wide

The Major Challenges to Antarctic Observatory : The Extreme Site Conditions

- High altitude: 4093 m;
- Low pressure: 570 hPa;
- Extremely low temperature & large temp difference:
  -58.4 ℃ , (-10 ℃ ~ -83 ℃);
- Harsh weather conditions： snow, ice, radiation;
- Transportation: complicated & limited support;
- Installation/testing： limited working time/facilities;
- Operation: low-bandwidth communication link;
- Logistics: limited summer support, no winter-over.

Construction Concept: 4 Major Engineering Systems

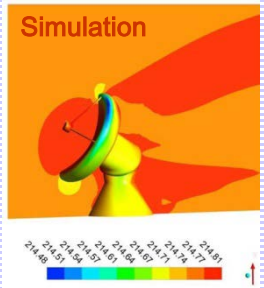
Joint Preparatory Working Group: PMO, NIAOT, PRIC
Project Office: PMO

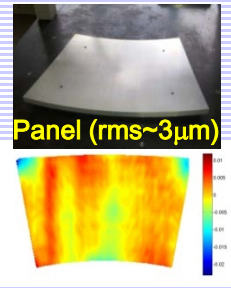
Construction System	PI Institute for Conceptual Studies
5m THz Telescope	Purple Mt. Observatory (PMO)
2.5m Opt/NIR telescope	Nanjing Institute of Astronomical Optics and Technology (NIAOT)
Site Preparation and on-Site Infrastructure	Polar Research Institute (PRIC)
Control and Operation	Purple Mt. Observatory

R&Ds for DATE5

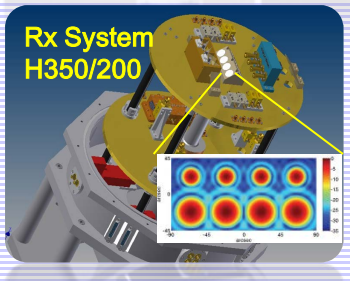
- Conceptual studies on THz antenna
- Laboratory developments of high performance THz receivers
- Development of broadband digital FFTS prototype back-end

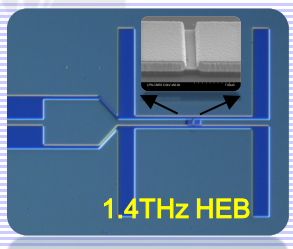
Antenna



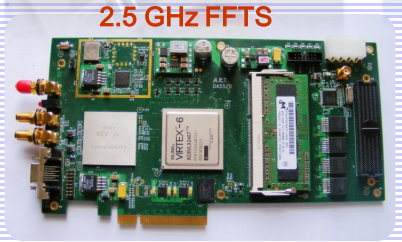


Mixers & Detectors





Back-ends & Others



On-going R&D Activities for DATE5 Antenna and Measurements

- ✓ **Fabrication of a prototype aluminum panel**
- **High-precision mold fabrication for the CFRP panels & Fabrication of a prototype CFRP panel**
- **Environmental tests of the prototype aluminum panel & prototype CFRP panel**
- **Prototyping and environmental tests of critical moving components (actuators, motors, encoders, etc.)**
- **Methods for micron-level surface figure adjustment & measurement under extreme environment**
- **Surface measurement by mm-wave holography**

Summary

- **Site surveys** at Dome A demonstrate its excellent observing conditions for ground-based astronomy from optical to THz;
- **Small-scale to mid-size instruments** have been used at Dome A for continuing site survey and astronomical observations through the solid supports from Polar Research Institute;
- Dome A has been selected as one of the goals of development for Chinese astronomy for the next decade; **Major Instruments**, including a 2.5m opt/NIR telescope and a 5m THz telescope, are proposed as National Mega-Science Facility,;
- **Conceptual designs** have been carried out during the past three years. Significant progress has been achieved in R&D for the two telescopes, and some of the key technological issues against the extreme site conditions are under studies;
- **International collaborations**, especially with Australian institutes, have been successful and should be promoted in future course.