Dome A Astronomical Observatory
Plan: 2011-2015

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On Behalf of Chinese Center for Antarctic Astronomy (CCAA)
Major Challenges in Astronomy

End of Dark Age from the Big Bang 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
Answers to be Made by the Next Generation Telescopes

Diameters of 30m—exploring even fainter

Major Science Goals:
- Exoplanetary System
- Origin of Stars, galaxies, and Black Holes
- Dark Matter & Dark Energy
- Required Seeing condition ~ 0.6-0.7 arcsec photometric nights ~ 60-65%, observable nights 80% over a year

GMT by US
TMT (by US, JP, China?)
ELT by Europe (ESO)

A 10m telescope at Dome A may have sensitivity comparable to a 30m optical telescope, or equivalent power of 60-100m infrared telescope at Mauna Kea.
Next-generation Space Telescopes

JWST, a 6.5m telescope at IR and longer wavelengths

JDEM, a 2m-class survey telescope with large FoV for dark energy

Dome A site condition is of semi space specification
Telescopes for Large Field of View

LSST—8.4m telescope of large FoV

- Nature of Dark Energy
- Solar System Map
- Optical Transients
- Galactic Structure

A telescope of 3-4m at Dome A may gain a power comparable to LSST
World Trends and Challenges in Ground based Astronomy (Optical, NIR, THZ)

- World trends for **large fields of view**, **high sensitivities**, **high resolution** and **multi-wavelength coverage**;
- Finding best sites for large facilities to achieve the best performance;
- Or, to put telescopes into space, under the cost of money and technological risks!
- **Difficulty in finding world-class sites for optical/NIR/THz within China**. Dome A be an **potential opportunity for China** was widely recognized.
Place of Interests
——Dome A

• Dome A (4000m, -83°C), Best Site on Earth
• Very good transmission from 150 to 800 μm
• Much cheaper than space
• Accessible each year, permitting staged deployment of instrumentation
• Long lifetime
Dome A: Basic Facts

- Dome A, altitude 4100m (60km×10km), a plateau of small fluctuation. Lowest Temp -83°C.
- Site surveys under Panda Program suggest: Dome A is a promising site for astronomy, particularly in THz & IR.

- 2005.1.18 Chinese inland expedition team reached Dome A.
- Astronomy follows on from 2007/2008, by the 24th Chinese Antarctic Expedition.)
Establishment of Dome A Observatory

Systematic Measurements of Site Conditions over winters at Dome A

New Instruments 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.
- Telescope outside PLATO supporting platform; PLATO supports power supply & communications, instrument control and computers.
- New discovery of CV, Nova, variables, and even gamma-ray burst.
- Be further used for time-domain monitoring.
Pre-HEAT measured the transparency of the sky above Dome A at submillimeter wavelengths using a high frequency heterodyne receiver at 0.66 THz. Installed by Chinese 25th antarctic expedition team and data were collected from Jan 24, 2008.

University of Arizona, USA; Purple Mountain Observatory, China; University of Exeter, UK; University of New South Wales, Australia.
Phase 1 Site Survey in THz over 2007-2008 using tipping radiometer measurement of PWV at 660 GHz by Pre-HEAT (UoA /NSWU /PMO /Exter)

- Dome A (4000m, -83°C) THz Measurement (2007-2008, Pre-HEAT)
- The best site ever knew
- New THz windows over 150-800 μm

In 2009, a FIR/THz FTS was fabricated to measure the atmospheric transmission over 0.75-15 THz under the collaboration among PMO, CfA, and NAOJ, with remote operation support from 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 working at 200-350 mm windows can be planned.
AST3 Telescopes: 3 × 0.5m Telescopes
(See Yuan, X.-y.’s Talk for a finished system)

AST3 Progress
- 1st set fabrication finished;
- Field testing over winter in 2010-2011;
- 2011-2012 scheduled installation at Dome A.
Antarctic Support Platforms for Remote Operation: Joint Developments

Function: To supply power, communication, remote operation and data storage/manipulation capabilities.

Results: PLATO operated over 204 days in 2008, and full winter over 2009-2010. New design of ASP by CCAA-SEU: higher power output & larger data storage, testing in Tibet in 2010 summer.
The undergoing projects and plans:

- **SPT**, a 10m millimeter-wave telescope operated by US;
- **TRSS**, a 3m optical telescope proposed by France;
- **IRAIT**, a 80cm NIR telescope project proposed by Italy & France;
- **KEOPS**, an optical interferometer project by planned France & Italy;
- **Pilot**, 2.5mopt/IR telescope project proposed by Australia, France & Italy.
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 Formation, and the Edge of the Universe
Concepts for Dome A Observatory Phase I

- Taking the advantage of Dome A superior site conditions to build optical/IR, THz observing facilities, and to build efficient international collaborations;
- Two telescopes with competitive observing capability, proposed as National Mega-Science Facilities;
- Major science goals on dark energy and dark matter, exoplanets, time-domain subjects, formation & evolution of stars and galaxies;
- Self-supported observing mode over winter under remote control;
- On-site bulk data storage and partially send back for timely analysis and follow-up purposes;
- Instrument maintenance/upgrade and data retrieval by summer traverse.
Major Construction for Dome A Observatory
Proposed for 2011-2015 Construction

- 2.5m Optical/NIR Telescope
- 5m THz Telescope
- Antarctic Support Platform
- On-Site Assembly
- Transportation System
- Remote Operation
2.5m KDUST (Cui’X-.q. et al)

Optics: R-C or SNAP type
Operation Mode: Large FoV Survey
Science: Dark Universe, Exoplanetes
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
5m THz Telescope (Shi, S.-c et al)

Working wavelengths: 350 \( \mu \text{m} \), 200 \( \mu \text{m} \), fully tracking

Precedent to Space Program

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<thead>
<tr>
<th></th>
<th>5m</th>
<th>Herschel</th>
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<tbody>
<tr>
<td>Resolution</td>
<td>Higher</td>
<td>Lower</td>
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<tr>
<td>Duration</td>
<td>Long</td>
<td>Limited</td>
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<tr>
<td>Upgrade</td>
<td>YES</td>
<td>No</td>
</tr>
<tr>
<td>Cost</td>
<td>Lower</td>
<td>Higher</td>
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Complement to ALMA/CCAT

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<tr>
<th></th>
<th>Dome A 5m</th>
<th>ALMA/CCAT</th>
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<tbody>
<tr>
<td>Frequency ((&lt;350 \mu \text{m}))</td>
<td>YES</td>
<td>NO</td>
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<tr>
<td>FoV</td>
<td>Wide</td>
<td>Narrow/Wide</td>
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Technological Supports: NIAOT, NAOC

LAMOST segmented mirror & thin mirror active optics

Mirror Fabrication Facility

Large-telescope Technology

Experience derived from LAMOST

2.5m

13.7m
Technological Support: PMO

Development in mm, submm, THz receivers. Construction and Operation of millimeter telescope, joint development of SMA & ALMA

Superconducting Array Receiver

Series SIS mixers from 100GHz to 860 GHz

Joint R&D of HEB Mixers

460 GHz Telescope

THz FTS for Dome A
Infrastructure at Dome A

Fully Supported by Polar Research Institute, China

Xuelong Ice breaker

Dome A Expedition Team

Finishing Kunlun Station

Enhanced Infrastructure in Future

Polar Research Planning: New Ice Breaker & Airplane
<table>
<thead>
<tr>
<th>Year Range</th>
<th>Stage</th>
<th>Telescope Specifications</th>
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<tbody>
<tr>
<td>2006-2008</td>
<td>Site Survey &amp; Small Telescope</td>
<td>2.5m Opt/NIR KDUST</td>
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<tr>
<td>2009-2011</td>
<td>+Site Testing &amp; Middle-size Telescope</td>
<td>5m THz DATE5</td>
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<tr>
<td>2011-2015</td>
<td>Dome A Observatory Phase I</td>
<td>6-8m Opt/NIR</td>
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<td>2016-2025</td>
<td>Dome A Observatory Phase II</td>
<td>15m THz</td>
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CCAA Partner Institutes

- Purple Mountain Observatory (Host Institute)
- National Astronomical Observatories, Chinese Academy of Sciences (NAOC)
- Polar Research Institute
- Nanjing Astronomical Optics and Technology Institute, NAOC
- Tianjing Normal University
- Institute of High-Energy Physics (IHEP)
- Chinese University of Sciences and Technology
- Tsinghua University
- Nanjing University
- Shanghai Astronomical Observatory
- Yunnan Astronomical Observatory, NAOC
Summary

• Stimulated by Polar Research activities, the site surveys at Dome A demonstrate its excellent observing conditions for ground-based astronomy;

• Small-scale instruments have been used at Dome A for continuing site survey and astronomical observations;

• Dome A has been selected as one of the major goals of development for Chinese astronomy for the next decade; Major Instruments are proposed;

• Dedicated teams in China has been well organized; and international collaborations have been very successful;

• Dome A astronomy has achieved rapid development through the solid supports from polar society, and infrastructure for future development is promising;

• International collaboration has been successful and will be encouraged in future.