Astronomy in China Today
- Large Astronomical Facilities in China

趙 剛 （Gang ZHAO）

National Astronomical Observatories
Chinese Academy of Sciences
2009-10-09 @ 北海道 (Hokkaido)
Outline

- Brief introduction of Chinese astronomy
- Ground-based facilities
- Space missions
- Future projects of Chinese astronomy
- Brief summary
Brief Introduction

- Glory of Chinese ancient astronomy

With over 4,000 years’ development, the Chinese ancient astronomy experienced a lengthy period of spectacular prosperity. This precious history not only established a profound foundation for the development of Chinese astronomy and bequeathed to us as a priceless legacy, but also serves as an otherwise unavailable source of records for modern astronomical research.

<The collection of Chinese historical astronomical records>
1100 pages with 10000 records
Brief Introduction
- Growing community

- The past 30 years since the adoption of 'open door policy' have witnessed great advance in astronomical studies in China, especially in the last decade

<table>
<thead>
<tr>
<th></th>
<th>1997</th>
<th>2007</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research funding</td>
<td>~3 Million $</td>
<td>~30 Million $</td>
</tr>
<tr>
<td>Faculty</td>
<td>~ 600</td>
<td>~ 900</td>
</tr>
<tr>
<td>Ph.D.</td>
<td>~ 12 per year</td>
<td>~ 80 per year</td>
</tr>
<tr>
<td>Journal papers</td>
<td>~150</td>
<td>~650</td>
</tr>
</tbody>
</table>
Brief Introduction

- Astronomical research institutions
  - Chinese Academy of Sciences (CAS)
    - National Astronomical Observatories
    - Purple Mountain Observatory
    - Shanghai Observatory
    - Univ. of S & T of China
  - Ministry of Education
    - Nanjing University
    - Peking University
    - Tsinghua University
    - Beijing Normal University
    - ……
Distribution of PMO, SHAO & Universities with Department of Astronomy or Research Group
Structure of NAOC (HQ)

Director General
1

Deputy Director
4

Academic Commission
31

Administration Department
37
Research Groups
93
Laboratories
111
Stations and Facilities
80
Ph.D.
256
Post-doc
17
Service Personnel
8
Brief Introduction
- Astronomical journals
  - Four professional journals
  - Including one English journal
    - *Chinese Journal of Astronomy and Astrophysics*, ChJAA
    - *Research in Astronomy and Astrophysics* from 2009
  - Two amateur astronomical magazines
Brief Introduction

- China has been playing a more and more important role in the international astronomical community
  - Wider international collaborations.
  - The 28th General Assembly of the International Astronomical Union (IAU GA) will be held in Beijing, China. This milestone event would promote China’s international status and enhance its presence in the astronomical community.
  - China also hosts more and more international symposiums, workshops, conferences.
CNCC Panorama

Undertaking some renovations in late 2009 after Beijing Olympics
The largest convention hall covers an area as large as 6,400 square meters, with 6,000 seats that can be removed or relocated to meet any special requirements.
The grand banquet hall can accommodate 3,500 people with more than 4860 square meters in size and 10 meters ceiling height. The pillar-free design offers a versatile range of possibilities in function plan for the grand banquet hall.
Ground Based Astronomical Facilities

Progress of LAMOST, FAST, 21CMA, and CSRH
Large Sky Area Multi-Object Fiber Spectroscopy Telescope (LAMOST) Completed in 2008

4-m meridian reflecting Schmidt telescope
Structure of LAMOST

- Fiber Positioning
- M_A mirror
- Fibers
- M_B mirror
- Spectrographs
- CCDs
Basic parameters of LAMOST

- Schmidt telescope: 4.8m/6.1m
- Declination of observable sky area: -10° ~ +90°.
- FOV: 20 square degree
- Fibers: 4000
- Spectrum resolution:
  - VPH (Volume Phase Holographic) Grating
  - R = 1000/2000; 5000/10000
- Ma: reflecting corrector (24 sub-mirrors) $\sim 4.8m$
- Mb: spherical mirror (37 sub-mirrors) $\sim 6.1m$
24 sub-mirrors of $M_A$
24 sub-mirrors of $M_A$ (Sept. 10, 2008)
37 sub-mirrors of $M_B$ (July 13, 2008)
Select the targets
Spectrographs room
\[ R_L = \frac{1000}{2000} \]
\[ R_M = \frac{5000}{10000} \]

16 spectrographs

250 fibers per spectrograph
LAMOST Spectrographs (I)

Low Resolution Spectrographs (LRS)

<table>
<thead>
<tr>
<th></th>
<th>Blue Arm</th>
<th></th>
<th>Red Arm</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R$</td>
<td>wave. (nm)</td>
<td>$R$</td>
<td>wave. (nm)</td>
</tr>
<tr>
<td>full slit</td>
<td>1000</td>
<td>370-590</td>
<td>1000</td>
<td>570-900</td>
</tr>
<tr>
<td>1/2 slit</td>
<td>2000</td>
<td>370-590</td>
<td>2000</td>
<td>570-900</td>
</tr>
</tbody>
</table>

16 LRSs with two 4K x 4K CCD each
LAMOST Spectrographs (II)

Medium Resolution Spectrographs (MRS)

<table>
<thead>
<tr>
<th></th>
<th>Blue Arm</th>
<th>Red Arm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R$</td>
<td>wave.(nm)</td>
</tr>
<tr>
<td>full slit</td>
<td>5000</td>
<td>510-550</td>
</tr>
<tr>
<td>1/2 slit</td>
<td>10000</td>
<td>510-550</td>
</tr>
</tbody>
</table>

* other wavelength ranges can be achieved by turning Volume Phase Holographic Grating
Technical Challenges

- Active optics
  - segmented thin mirror active optics in $M_A$
  - segmented mirror active optics in $M_B$

- Fiber positioning
  - LAMOST: 4000 fibers
  - SDSS: 640 fibers
  - 2dF: 400 fibers
<table>
<thead>
<tr>
<th>Milestone</th>
<th>Reviewed</th>
<th>Approved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary Design</td>
<td>Apr.-May 1999</td>
<td>Jun. 1999</td>
</tr>
<tr>
<td>Detailed Design</td>
<td>Sep. 2001</td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td>2001-2008</td>
<td></td>
</tr>
<tr>
<td>First Light</td>
<td>May 20, 2008</td>
<td></td>
</tr>
<tr>
<td>Completion</td>
<td>Oct. 2008</td>
<td></td>
</tr>
</tbody>
</table>
Inaugural of LAMOST completion
2008.10 @ Xinglong, China
Stellar Spectra in Commission (Sep. 28, 2008)
LAMOST Operation System

LAMOST Science Committee (LSC)

LAMOST Collaboration Council (CoCo)
LAMOST Executive Committee (Scientific Center)
LAMOST Arbitration Council (ArCo)

Observation Planning (Beijing)
Observation Operation (Xinglong)
Data Analysis (Beijing)
Data Center (Beijing)
User Supporting (Beijing)
Equipment Maintenance (Xinglong)
LAMOST Science Planning

  - LSC setup two working groups:
    - LEGAS - Extragalactic survey
    - LEGUE - Galactic survey
      ➔ Unique LAMOST spectroscopic survey
  - May 28-31, 2009
    - International evaluation for LAMOST survey project proposed by working groups
LEGUE Science Working Group:

- PI: DENG Licai    Co-PI: HOU Jinliang
  - CHEN Yuqin,
  - CHRISTLIEB Norbert,
  - HAN Zhanwen,
  - LEE Hsu-Tai,
  - LIU Xiaowei,
  - NEWBERG Heidi,
  - PAN Kaike,
  - WANG Hongchi,
  - ZHU Zi

LEGAS Science Working Group:

- PI: JING Yipeng    Co-PI: ZHOU Xu
  - CHEN Xuelei,
  - FAN Xiaohui,
  - LI Cheng,
  - SHEN Shiyin,
  - WANG Junxian,
  - WU Hong,
  - WU Xuebing,
  - ZHENG Xianzhong
Review Panel

- Respected experts from 7 countries and 10 world-known institutes or universities in astronomy and astrophysics

- Richard Ellis - Chair (CalTech)
- Jiansheng Chen (NAOC)
- Matthew Colless (AAO)
- Georges Comte (Obs. de Mars.)
- Carlos Frenk (Uni. Durham)
- Jingyao Hu (NAOC)
- Richard Kron (Uni. Chicago)
- Heather Morrison (Case Western Reserve Uni.)
- Timo Prusti (ESA)
- Hans-Walter Rix (MPIA)
- Nicholas Walton (Cambridge)
- Fred Watson (AAO)
- Don York (Uni. Chicago)
LAMOST Commission Period

- **Sep.-Dec., 2008**
  - Fiber positioning units
  - Spectroscopic calibration
  - Operation software
  - Pipelines for data processing

- **2009/2010:**
  - Stability (Active optics, Dome seeing)
  - Efficiency (Fibers, Spectrographs, CCDs)
  - Scientific test observations
    - Open clusters, nearby galaxies, selected area survey, …
LAMOST Regular Survey

- 2011 – 2015/2016
  - Extra-galactic spectroscopic survey —
    Galaxy and QSO red shift survey
    (6.3 millions)
  - Stellar spectroscopic survey —
    Structure of the Galaxy, and so on
    (7.5 millions)
Test Observations

- Sept. 2008: bright stars (V<16)
- Dec. 2008: M31 Field
- Mar. 2009: SDSS spectra
- Apr. 2009: stars (V<19)

- Several dark nights in each month
M31 Field

Dec. 27, 2008

- M31
  - Planetary nebula
  - Global clusters
- Others
  - Galaxies
  - Stars
- 1800s Exp.
3300 emission line objects:
1) 2729 PNe
2) 571 compact H II regions

Position: \( \sim 0.2'' - 0.3'' \)
Radial velocity: \( \sim 15 - 20 \) km/s
[O III] 5007 flux: \( \sim 0.1 \) mag

Complete to \( m_{5007} = 23.75 \)

Merrett et al., 2006, MN, 369, 120
White: emission line object; Pink: GCs; Green: 2MASS objects
Result from spectra of 15th spectrograph

- Targets include:
  - 186 emission line objects, 50 of them detected
  - 31 GCs
  - 22 2mass objects
  - 1 galaxy

Compare H\(_{\beta}\), [OIII] 5007 and H\(_{\alpha}\) velocities measured by LAMOST with previous results:
  ==> wavelength calibration

Compare [OIII] 5007 fluxes with previous results:
  ==> efficiency & pointing accuracy
LAMOST efficiency

- 17 of 24 MA mirrors employed
- 30 minute exposure
- Gains:
  - Blue: 0.89, 0.88 e-/ADU
  - Red: 1.19, 1.18 e-/ADU

Target: optical throughput ~10%

“$\leq$” upper limits for non-detected objects
“$+$” : detected objects
Test observation at the end Feb., 2009

- NGC 2244
- M67
- A1775
Apr. 1, 2009

Galaxies

$(g>19)$
Apr. 1, 2009

QSOs

$(g>19)$
Classify the type of stars
Determination of Stellar parameters $T_{\text{eff}}$, $\log g$, $[\text{Fe/H}]$
Apr. 26, 2009

- Stars (V<19)

- More than 3600 spectra got in one test observation (>90% of selected objects)
Preliminary Conclusion

- Whole system works well
- Get spectra of objects to $g=20$ now
- Further improvement
  - Accuracy of fiber positioning
  - Dome seeing
  - Optical throughput
  - Scattering light in dome and spectrographs
  - 2D & 1D pipeline
  - ......
Five-hundred-meter Aperture Spherical Telescope - FAST

- Unique Karst depression as the site
- Active main reflector
- Cable - parallel robot feed support
Optical Geometry and Specs

- Reflector: $R \sim 300m$, $D \sim 500m$, opening angle: $\theta \sim 110-120^\circ$
- Illuminated aperture: $D_{\text{eff}} = 300m$
- Sky coverage: maximum zenith angle: $40^\circ$
- Working frequencies: 70MHz-3GHz, up to C-, X-band
- Sensitivity 2000 $m^2/K$
- Resolution 2.9’
- Multibeam 19
- Pointing Accuracy: 8’’
Science Cases
- HI surveys
- Pulsar research
- Hosting VLBI network
- Molecular lines
- SETI

FAST milestones:
- Concept born together with SKA, back to 1993
- Funding Proposal approved on July 10, 2007
- Feasibility Study approved on Oct. 31, 2008
- Preliminary Design evaluated on Dec. 15, 2008
- Opening Foundation held on Dec. 26, 2008
500米口径球面射电望远镜工程
Five-hundred-meter Aperture Spherical radio Telescope
奠 基 典 礼
2008.12.26

FAST Opening Foundation
21 Centimeter Array (21CMA)

Goal: Search for the Lights of First Stars at Epoch of Reionization

Physical Area: 50544m²  Working Frequency: 70-200MHz
10287 antennas  @  4x6 km arms

Chief Scientist: Prof. Xiangping WU  wxp@bao.ac.cn
21CMA Layout

81 pods along two perpendicular arms (6km+4km)

Baselines: 3240  Freq channels: 4096
Total data size: 4 terabytes / day
Characteristics of 21CMA

Frequency coverage:

70 - 200 MHz

Redshifted 21cm Line:

\[ \lambda = 21\text{cm} \ (1 + z) \]

<table>
<thead>
<tr>
<th>( z )</th>
<th>( \lambda ) (cm)</th>
<th>( \nu ) (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>147</td>
<td>200</td>
</tr>
<tr>
<td>10</td>
<td>246</td>
<td>130</td>
</tr>
<tr>
<td>20</td>
<td>441</td>
<td>68</td>
</tr>
</tbody>
</table>
Radio Sky Seen with 21CMA
100 sqr deg around NCP region

baseline=4555.566m, res=2.76arcmin
Strategy:
Remove foreground sources to “see” structures of reionization

VHF Sky@21CMA  Residual Background
Chinese Radioheliograph Project (CSRH)

Imaging spectroscopy in dm-cm range, with high temporal, spatial, and spectral resolutions, is important for addressing fundamental problems of energy release, particle acceleration and particle transport.

Array Configuration
Site: Inner Mongolia, China

Chief Scientist: Prof. Yihua YAN  yyh@bao.ac.cn

Low frequency array: CSRH-I  during 2008-2010
High frequency array: CSRH-II during 2011-2013
**CSRH Specifications**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freq. Range</td>
<td>~0.4–15 GHz ((\lambda): ~75 –2 cm)</td>
</tr>
<tr>
<td>Frequency Res.</td>
<td>64 or 128 chan (I: 0.4-2 GHz)</td>
</tr>
<tr>
<td></td>
<td>32 or 64 chan (II: 2-15 GHz)</td>
</tr>
<tr>
<td>Spatial Res.</td>
<td>1.3”– 50”</td>
</tr>
<tr>
<td>Temporal Res.</td>
<td>~&lt;100 ms (0.4-15 GHz)</td>
</tr>
<tr>
<td>Dynamic Range</td>
<td>25 dB (snapshot)</td>
</tr>
<tr>
<td>Polarizations</td>
<td>Dual circular L, R</td>
</tr>
<tr>
<td>Array</td>
<td>I: 40×(\varnothing)4.5m parabolic antennas</td>
</tr>
<tr>
<td></td>
<td>II: 60× (\varnothing)2m parabolic antennas</td>
</tr>
<tr>
<td>Max baseline</td>
<td>3 km</td>
</tr>
<tr>
<td>Field of view</td>
<td>0.6°– 7°</td>
</tr>
</tbody>
</table>

2-element prototype experiment in 2005 with Fringes of Solar Radio Signal at 1.6GHz for short baseline of 8 m
Space Missions

HXMT, SVOM, POLAR, WSO, SST, and SMESE
HXMT: planned for launch around 2011

Hard X-ray Modulation Telescope

Payload Cabin

Service Cabin
Detectors onboard

High Energy X-ray Telescope (HE) (20-250 keV, 18 modules, 5000 cm²)

Low Energy X-ray Telescope (LE) (1-15 keV) SCD, 384 cm²)

Medium Energy X-ray Telescope (ME) (5-30 keV) (SiPIN, 952 cm²)
Main science of HXMT

- Hard X-ray full sky survey with high sensitivity
  - Hard X-ray full sky map:
    - diffuse background and cosmic variance
  - Discover highly obscured supermassive BHs:
    - Galaxy formation and evolution
  - Discover new types of high energy objects:
    - usual surprises of new surveys
Main science of HXMT (cont.)

- Broad band and large collection area pointed observations of high energy objects
  - Space-time in strong gravitational field:
    - dynamics and radiation near BH horizons of stellar mass and supermassive BHs
  - High energy particle acceleration:
    - AGN, SNR, shock and relativistic jets
  - Large scale structure:
    - through hard X-ray detection of galaxy clusters

Project Scientists: Prof. Tipei LI  
litp@mail.ihep.ac.cn
Prof. Shuangnan ZHANG  
zhangsn@tsinghua.edu.cn
A multi-\( \lambda \) GRB project: SVOM

China: 30keV-5MeV
France: 4 - 150keV

ECLAIRs

Launch time: 2012 - 2013

China: 45cm diameter
France: 0.5 - 10keV

Space Variable Object Monitor
Chinese-French collaborated space project
Gamma-ray burst polarization experiment onboard China’s Spacelab: POLAR

- Instrument concept proposed by N. Produit, et al., NIM (2005)
- Onboard China’s spacelab TG-2: launch time 2011-12
- A China-led international collaboration
- FOV of POLAR: ~½ sky
- Requires directionality and energy spectrum known after the fact
World Space Observatory - Ultraviolet

- Wavelength range: Ultraviolet 1100—3500Å
- Primary mirror diameter: 1.7m
- Pointing accuracy: 0.05~0.1"

- Led by Russia, participated by China, Germany, Italy, Spain, etc.
- Launch: 2010 - 2012
- Operational Life: 5 years (10 goals)
- Cost 300 M Euro
- Operation mode: international space observatory
WSO-UV’s Three Science Instruments

Field Camera Unit (Spain)

High Resolution Double Echelle Spectrograph (Germany)

Long Slit Spectrograph (China)

Evgeny Skripunov
Lavochkin Association
skrip@laspase.ru
# China’s Long Slit Spectrograph

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength coverage</td>
<td>102~320 nm two-channel design</td>
</tr>
<tr>
<td>Width of slit</td>
<td>1” ≈ 82 μm</td>
</tr>
<tr>
<td>Length of slit</td>
<td>75” ≈ 6.2 mm</td>
</tr>
<tr>
<td>Spectral resolution</td>
<td>1500~2500</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>0.5”~1”</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>Optimized to observe faint sources</td>
</tr>
</tbody>
</table>

Diagram showing MCP detectors, Entrant Slits, Holographic Gratings, NUV Channel, and FUV Channel.
Space Solar Telescope (SST)

- EUSXT
- MOT
- HXI
- WIC
- HWT
- SIR
Payloads of SST

- **MOT**: Main Optic Telescope (1 Meter)
  - 0.1 ″, 2.8′ × 1.5′, 8 channels, two lines
  - polarization measurement accuracy ~ $2 \times 10^{-4}$
- **EUSXT**: Extreme Ultraviolet and Soft X-ray Telescope
  - 0.8 ″, 7′ × 7′, 2 EUV channels (19.5, 160 nm) + SXR
- **WIC**: White-light Inner-corona Coronagraph
- **HXI**: Hard X-ray Imager
- **HWT**: Hα and White Light Telescope
  - 1 ″, 0.7° × 0.7°, Full disk
- **SIR**: Solar & Interplanetary Radio Spectrometer
  - 2-50 MHz, 0.1s resolution
Scientific Objectives of SST

- Through coordinated, wide spectral coverage, high resolution and continuous observations
  - Study the evolution of multi-scale transients and various phenomena in the solar atmosphere
  - Investigate the heating mechanism of the chromosphere and the corona
  - Study the mechanism of the energy build-up and release in solar flares and CMEs

Project Scientist: Prof. Hongqi ZHANG
hzhang@bao.ac.cn
SMESE (SMall Explorer for Solar Eruptions)
Chinese-French Collaborated Space Project

Payloads:
- Ly $\alpha$ Imager (up to 1.15 R$_\odot$)
- EUV Imager (Fe XII 19.5 nm)
- Far IR Telescope (35 & 150 $\mu$m)
- Ly $\alpha$ Coronagraph (1.1-2.5 R$_\odot$)
- X-ray Spectrometer (10-300 keV)
- $\gamma$-ray spectrometer (0.2-600 MeV)

To detect solar flares and CMEs
Expected to launch in 2012-2013

Project Scientist: Prof. Cheng FANG
fangc@nju.edu.cn
Future Projects of Chinese Astronomy

- Chinese Antarctic Observatory
- Participation in 30m Class Telescope Projects
Chinese Expedition in Antarctica

About 1228km


Prince Charles Mountain

Grove Mountain

Zhongshan

Princess Elizabeth Land

DOME A 1993/1994

1996/1997

1997/1998

1998/1999

2004/2005

Chinese Expedition in Antarctica

Mawson

Princess Elizabeth Land

Prydz Bay

Davis

E60'

E70

E80

DOME A 1993/1994

1996/1997

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E60'

E70

E80
Chinese Center for Antarctic Astronomy

- On Jan. 18, 2005, led by Professor Yuansheng LI, Chinese group reached Dome A
- Dome A - the inland peak of the Antarctica
  - altitude of 4100m
  - 60km x 10km “drop” shape
- China’s aspiration to build the Antarctica station and carry out related scientific researches
Chinese astronomers look to Antarctic

A Chinese expedition returned last week from a 14-day crawl across the East Antarctic ice sheet in cargo containers, pulled by tractors, that doubled as living quarters. The trip, sponsored by the Polar Research Institute of China, completes only the second traverse to Dome A — the highest point on the eastern ice cap and the place where China intends to start building a research base next year.

The team also set up a suite of research instruments to study the atmosphere and sky above Dome A, most notably a remotely operated observatory called PLATO, which will assess how good the skies are for astronomical seeing. PLATO includes four 14.5-centimetre telescopes, built in China, that will take advantage of more than three straight months of darkness during the Antarctic winter. "We think Dome A is the best site on Earth for astronomy," says Xiangqun Cui of the Nanjing Institute of Astronomical Optics and Technology.

The hope is that the dust-free plateau, which sits 4,100 metres above sea level, will boast conditions rivalled elsewhere on the planet — even at the French/Italian base at Antarctica's Dome C, 1,200 kilometres away, which set up its own automated test observatory in 2000 and has since ramped up to larger projects.

Proposers of Antarctic astronomy have looked to Domes A and C as alternative sites to the South Pole, above which 300 metres of turbulent air cause observations of stars to jitter and blur. Dome C, by contrast, has only an additional 100 metres is very important because...
CSTAR: 4 x 14.5cm telescope array

- To construct 4 CCD photometric telescope, with 4 colors, radius of 14.5cm and FOV ~ 20 deg²
- Scientific goals:
  - Variance in luminosity and colors of ~8000 objects
  - To detect supernova, nova, etc.
  - To search for exo-planets
  - Light curves of variables
  - Statistical number of Antarctic variables
  - Site evaluation

The first star map of the southern sky observed by Chinese astronomers
PLATO (Plateau Observatory, collaboration with Australia and U.S.)

Facilities inside PLATO: MASS, Lunar SHABAR, SNODAR, Nigel, Gattini Dome A, Pre－HEAT, etc.
MASS, Lunar SHABAR and Nigel

- **MASS (Multi-Aperture Scintillation Sensor):** provided by UNSW and CTIO, to measure the 500 – 20000m atmosphere structure constant with star light

- **Lunar SHABAR (SHAdow Band And Ranging):** provided by UNSW and CTIO, to measure the 20 – 100m atmosphere structure constant with moon light

- **Nigel:** provided by UNSW, to take multi-fiber low dispersion spectra of polar lights to examine polar light background and its effect on astronomical observations, etc.
SNODAR
(Surface layer Non-Doppler Acoustic Radar)

provided by UNSW and CTIO, to measure the 5 – 100m atmosphere structure constant in high resolution (1m)
provided by Caltech, two sky-imaging modes (different FOV) to investigate the cloud coverage, sky light background, atmospheric transparency, etc.
Pre – HEAT
(the High Elevation Antarctic Terahertz Telescope)

Provided by University of Arizona and collaborated with the Purple Mountain Observatory, to measure atmosphere opacity of millimeter and sub-millimeter wave, and imaging of Galactic emission lines
Scientific Strategy

- Comprehensive site evaluation of Dome A
- Establish observation platforms in optical/infrared, sub-millimeter/THz astronomy led by Chinese astronomers and with international collaborations
- Build optical/infrared wide field survey and sub-millimeter/THz telescopes
- Study the frontier of observational astronomy, including searching for exo-planets and supernova, monitoring transient objects, dark matter and dark energy, stellar and galactic formation and evolution, etc.
Road Map of Chinese Antarctic Observatory

- **2006-2008:**
  - site survey
  - preliminary observation – CSTAR, PLATO(Pre-HEAT(THz), SNODAR, etc)

- **2008-2012:**
  - comprehensive site survey (accurate measurement of atmosphere turbulence, seeing, transparency, temperature, wind speed, etc.)
  - further observation – CSTAR, Pre-HEAT, HEAT, FTS, Antarctic Schmidt Telescope (AST3)
Road Map of Chinese Antarctic Observatory

- 2011-2014:
  - 3-5m millimeter/THz telescope

- 2011-2016:
  - 4m wide field optical/infrared telescope

- 2015-2020:
  - 10-15m large THz/FIR telescope
  - 8-10m infrared spectroscopic survey telescope (super LAMOST) or optical/infrared telescope with superb imaging capability
Participation in 30m Class Optical/Infrared Telescope Projects
GMT
Motivation and Strategy

- Promote Chinese astronomical scientific and technical research, comprehensively and effectively
- Achieve breakthrough in frontiers of modern astronomy
- Exploit the most advanced resources available
- Cultivation of the next generation of Chinese astronomers
- Complement with China’s key astronomical projects
  - Large spectroscopic survey facility: LAMOST
  - Large radio telescope: FAST
THIRTY METER TELESCOPE
Thirty Meter Telescope

- 30m filled aperture, highly segmented
- Three mirror telescope
- f/1 primary
- Field of view 20 arcmin
- Elevation axis in front of the primary
- Wavelength 0.31 – 28 µm
- Operational 1° thru 65°
- Seeing-limited mode
- Adaptive optics mode
Summary of Estimate for Construction Phase

- **Budgeted Cost for TMT = $759.7 million (2009US$)**
- **Contingency = $227.2 million at 29.9%**
- **Total = $986.8 million (2009US$)**

The cost estimate is continuously updated to reflect:
- Changes in the project schedule
- Updated supplier quotes
- Design changes/optimizations
- Other economic and external influences

This estimate is under development
- TMT Cost Review Fall 2009 following site selection
TMT Schedule by Program Phase

TMT Project Schedule by Programmatic Phase
(by calendar year)

- DDP
- ECP
- Construction
- EOPS/Operations
Progress and status of C-TMT

- Chinese delegation visited TMT in Jan. and June, 2009
  - Introduced the progress of researches
  - Discussed possible collaboration based on TMT
  - China will be involved in the TMT instrumental development
- In August 2009, NAOC Director General signed a letter of intention to TMT Board
- In September 2009, NAOC setup C-TMT structure: C-TMT Board, Science Advisory Committee, Project Office: Project Manager, Scientist, Engineer
During the last decade, astronomy in China has experienced enormous advances, among which the most significant progress is reflected by the construction and development of large astronomical facilities. Ground-based and space facilities have been or are planned to be built in recent years, e.g., LAMOST, FAST, 21CMA, HXMT, WSO, SST and so on. Future large astronomical projects in China will put even more emphasis on international collaborations, and we are expecting invaluable perspective, advice and input from our international colleagues.
Postface

- China is still a developing country; the Chinese astronomy is still under developing and has a long way to go
- With the rapid economic growth, China has the determination and is more capable to make significant contributions to astronomical development as we did in ancient history
- We look forward to wider and closer collaborations with astronomers worldwide
Thanks!
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