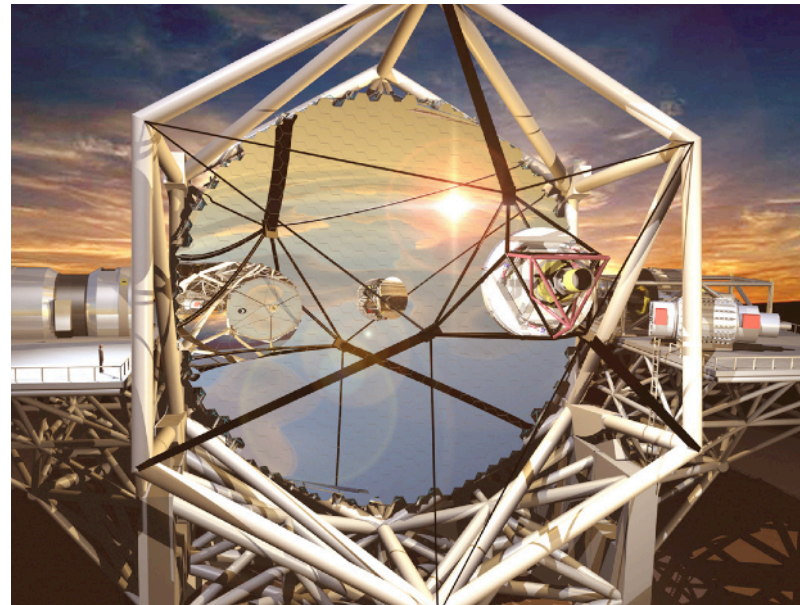


TMT-China

opportunities and challenges

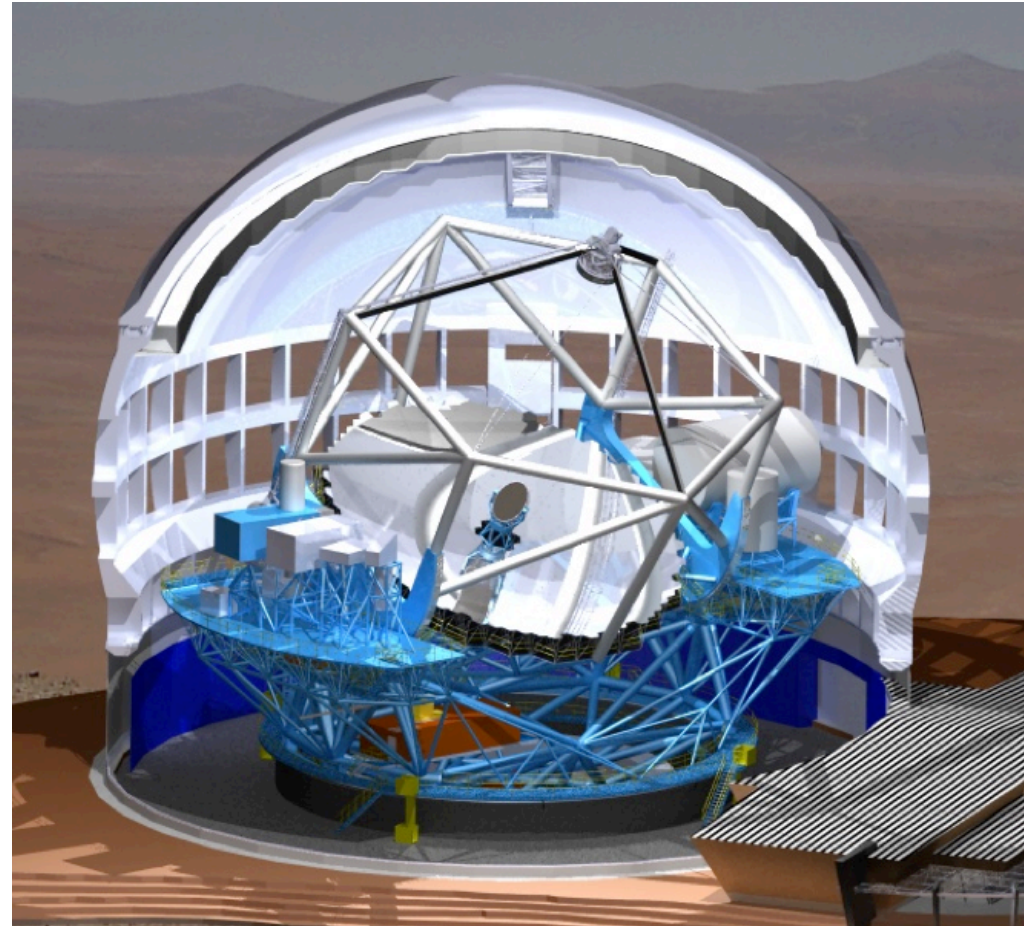
Shude Mao

(NAOC; TMT-China project scientist)



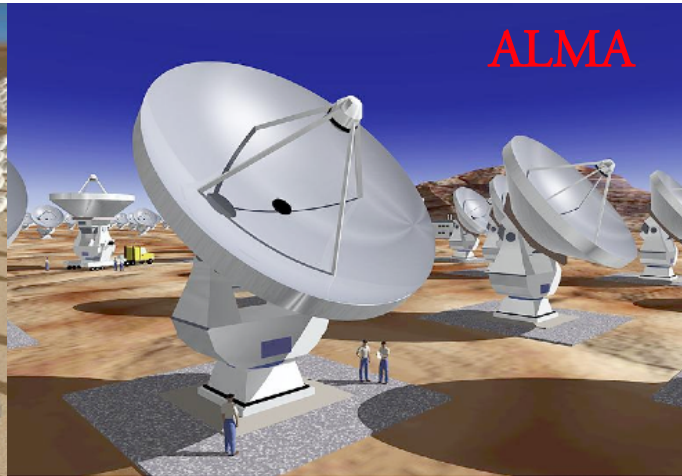
Outline

- Historical Background
- Telescope, instruments, science
- Current status
- Summary



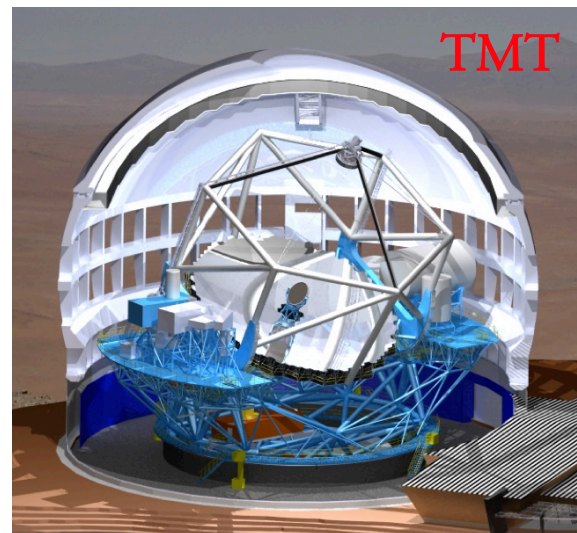
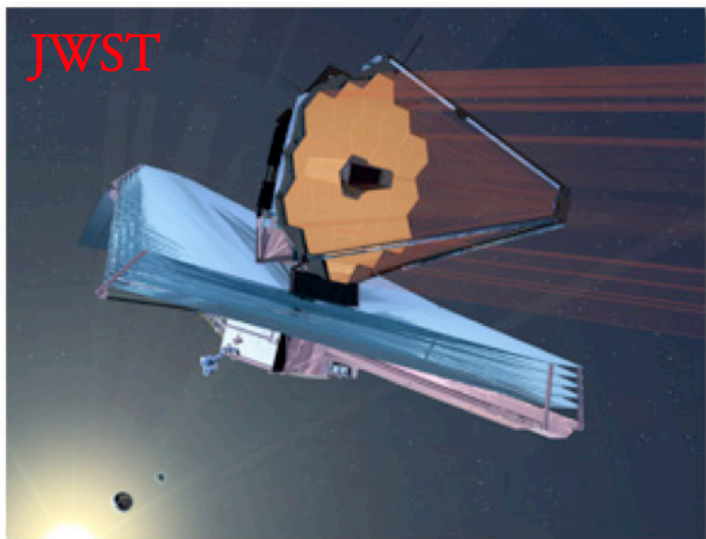
Thirty Meter Telescope (TMT)

Golden era of astronomy



LOFAR, LSST,
IXO, TMT/GMT
/ELT,...

LAMOST, FAST,
Dome-A, TMT, ...



- Multi-wavelength, all multi-billion dollar
- International collaborations

Why is China joining TMT?

- Big Questions often require big telescopes, surveys
- China lags severely behind in general-purpose telescope
 - 2.4m vs. 10m
 - No site as good as Hawaii/Chile so far (Dome-A/TMT)
- China made rapid progress in S&T (LAMOST)
- In Feb. 2009, The Astrophysics Strategy Committee recommended TMT & Dome-A
- TMT: low risk with in-kind contributions, and Hawaii site offers synergies with facilities in China

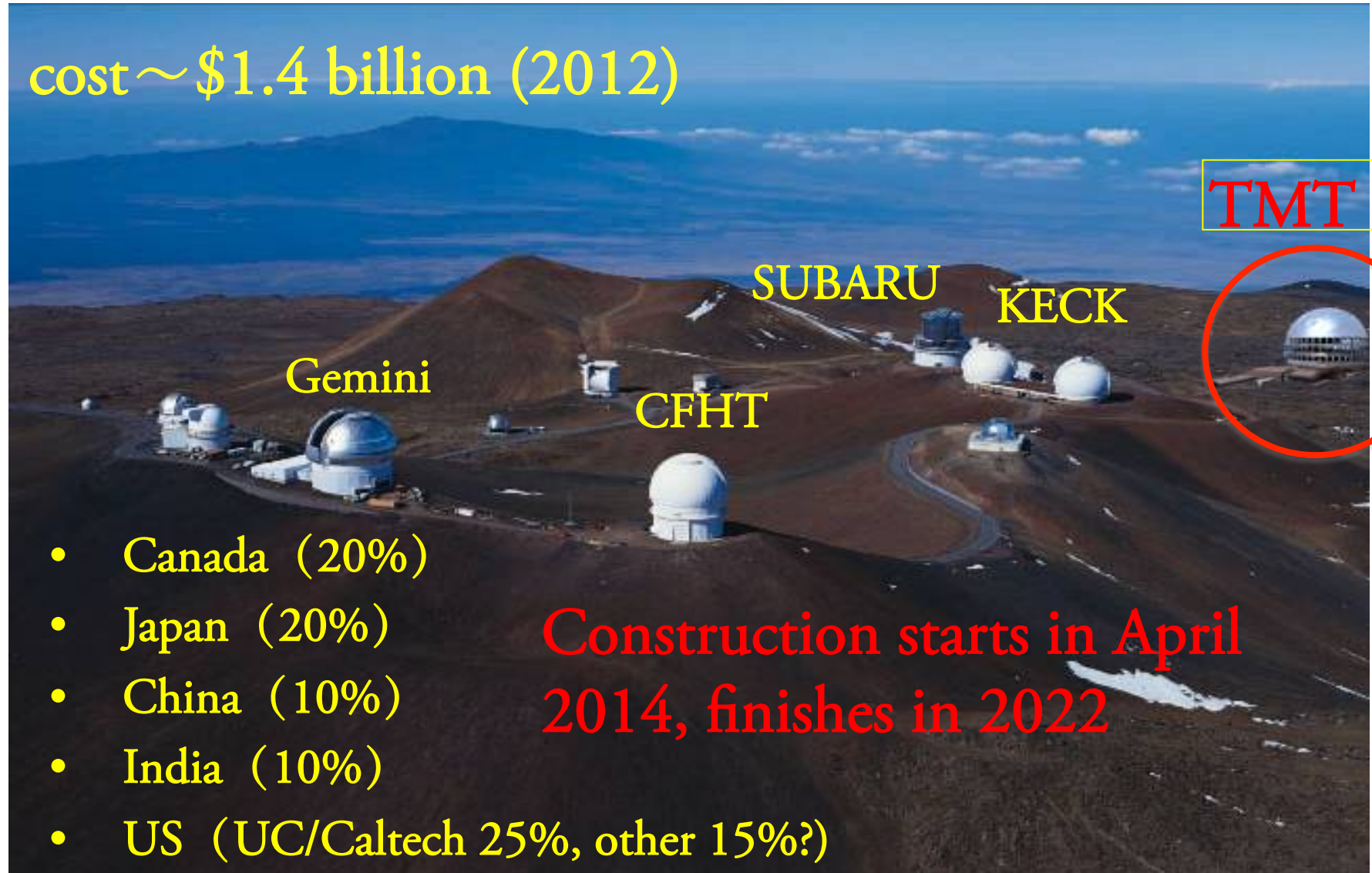
TMT international partnership

- US: UC/Caltech, other
- Canada: ACURA
- Japan: NAOC
- India: DST



Hawaii Mauna Kea

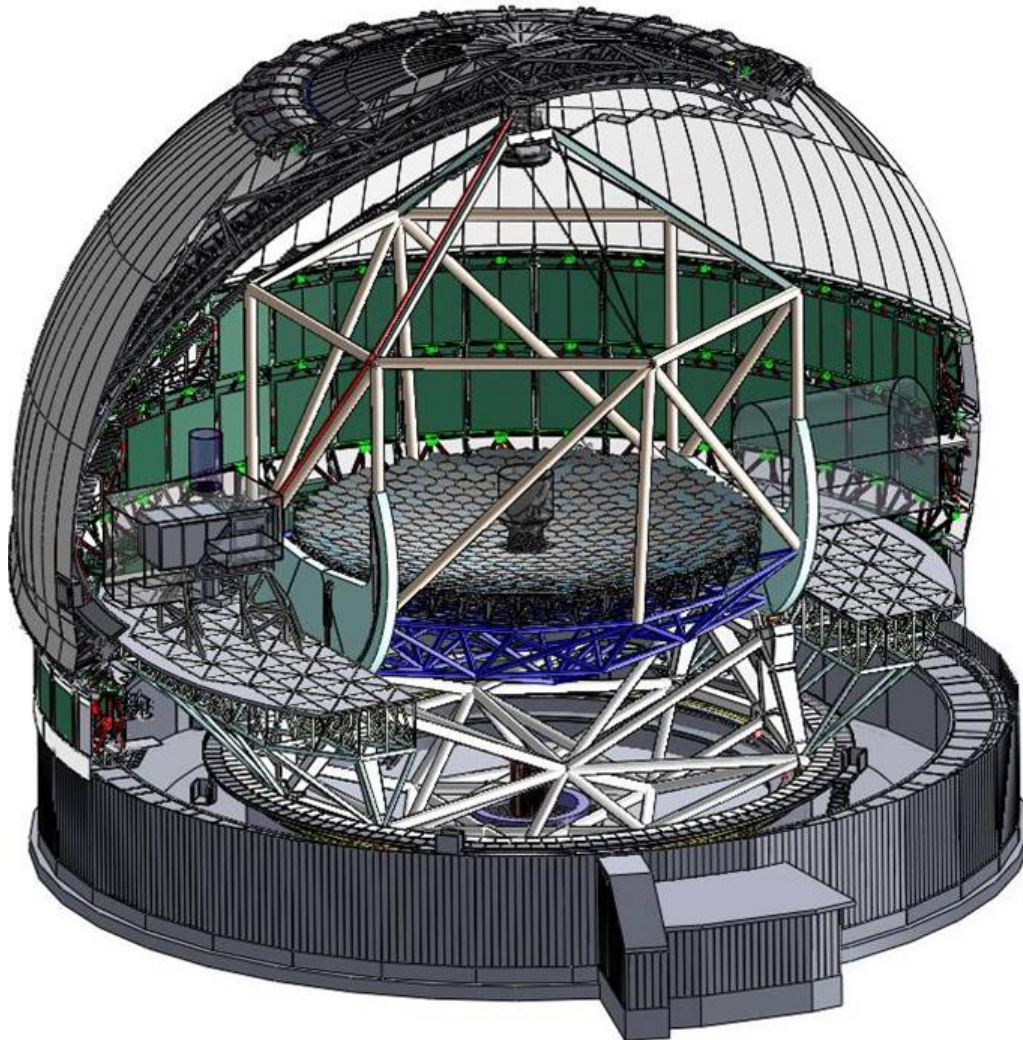
cost \sim \$1.4 billion (2012)



- Canada (20%)
- Japan (20%)
- China (10%)
- India (10%)
- US (UC/Caltech 25%, other 15%?)

Construction starts in April
2014, finishes in 2022

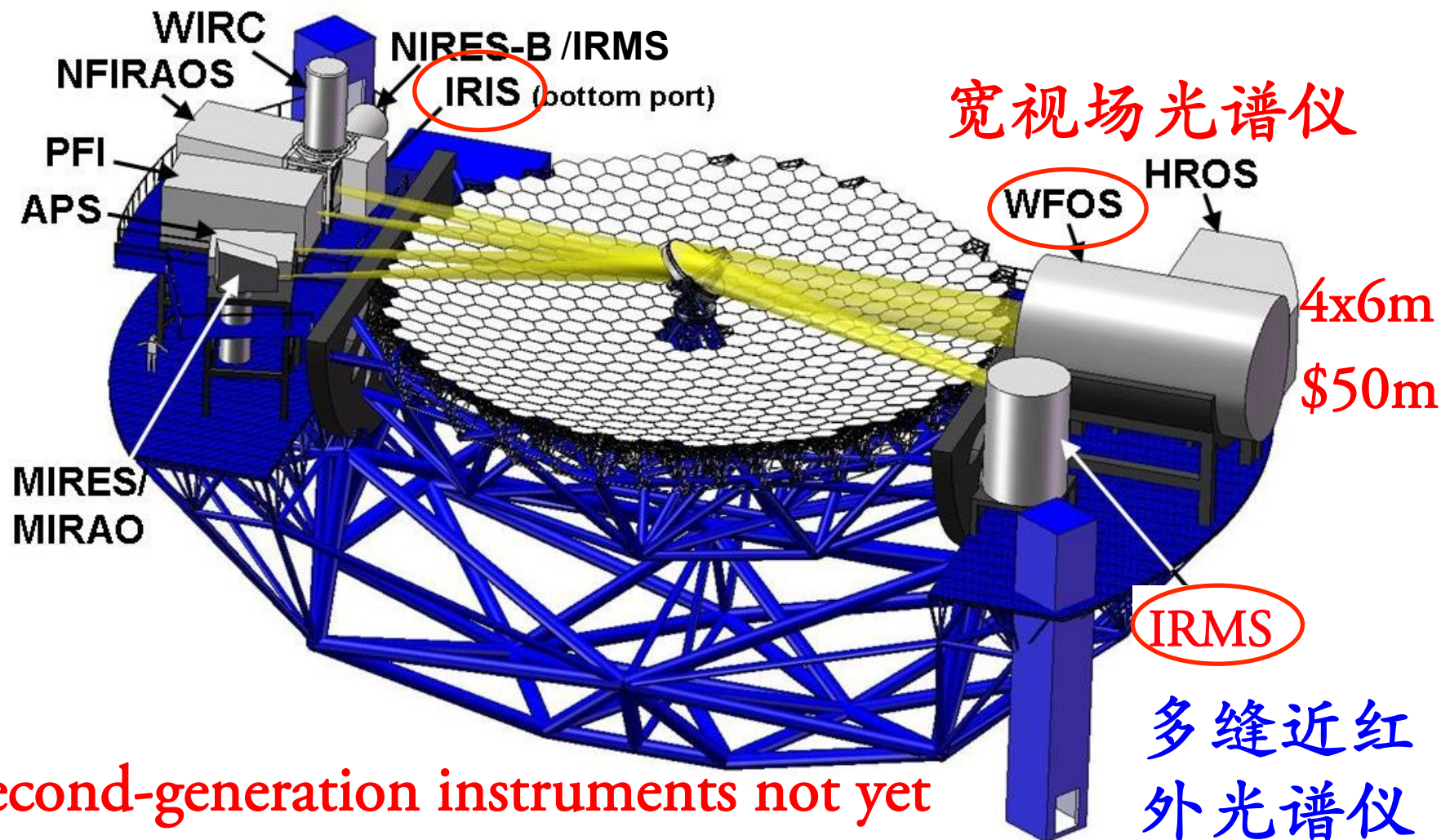
TMT Design



- D=30m, 492 segments
 - 3-mirror RC system
 - Primary mirror f/1
 - FOV: 20 minutes
- λ : 0.31- 28 μm
- Day-time observing!

First light instruments

红外成象光谱仪



Second-generation instruments not yet finalized, opportunities for all partners!

Key features of TMT

- Large aperture
 - Observe more distant, fainter objects
- Multi-conjugate adaptive optics
 - Resolution higher than HST by a factor of ~ 10
 - $t \sim 1/D^4$ for same S/N ratio for point sources
- IR optimized:
 - High-redshift universe
 - Extrasolar planets, bio-markers
- These features enable TMT to perform unprecedented science when constructed

Science case for TMT

Science Case for the Chinese TMT Project

(<http://tmt.bao.ac.cn/>)



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Completed in Dec. 2009, involved 54 scientists in 8 science areas

- 系外行星系统
- 基础宇宙学
- 黑洞的形成与增长
- 近距和高红移宇宙中的恒星形成
- 星系形成与演化
- 近场宇宙学与恒星物理
- 第一代天体与宇宙再电离
- 致密天体

Black Hole Physics

10米望远镜

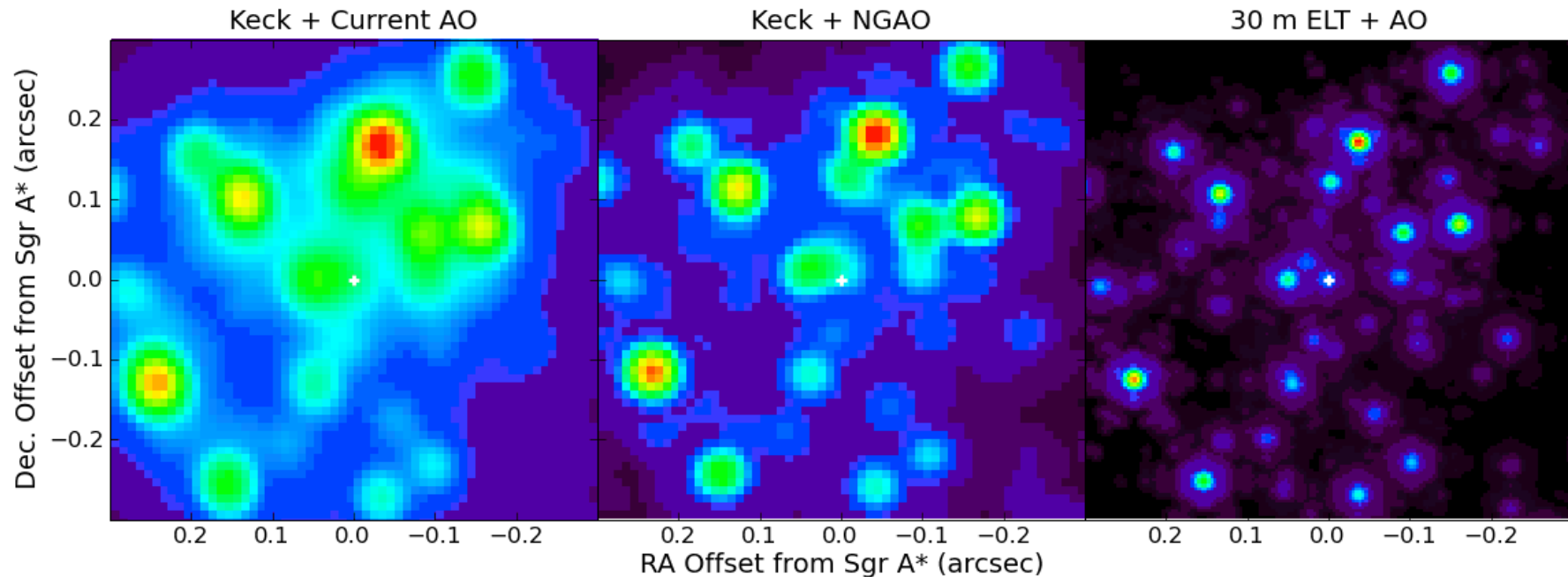
+ 现在主动光学

10米望远镜

+ 下一代主动光

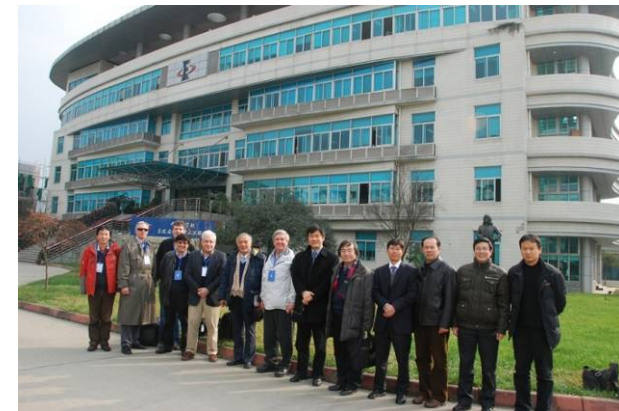
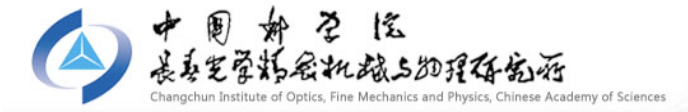
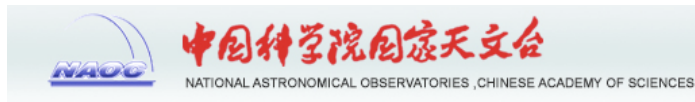
30米望远镜

+ 主动光学



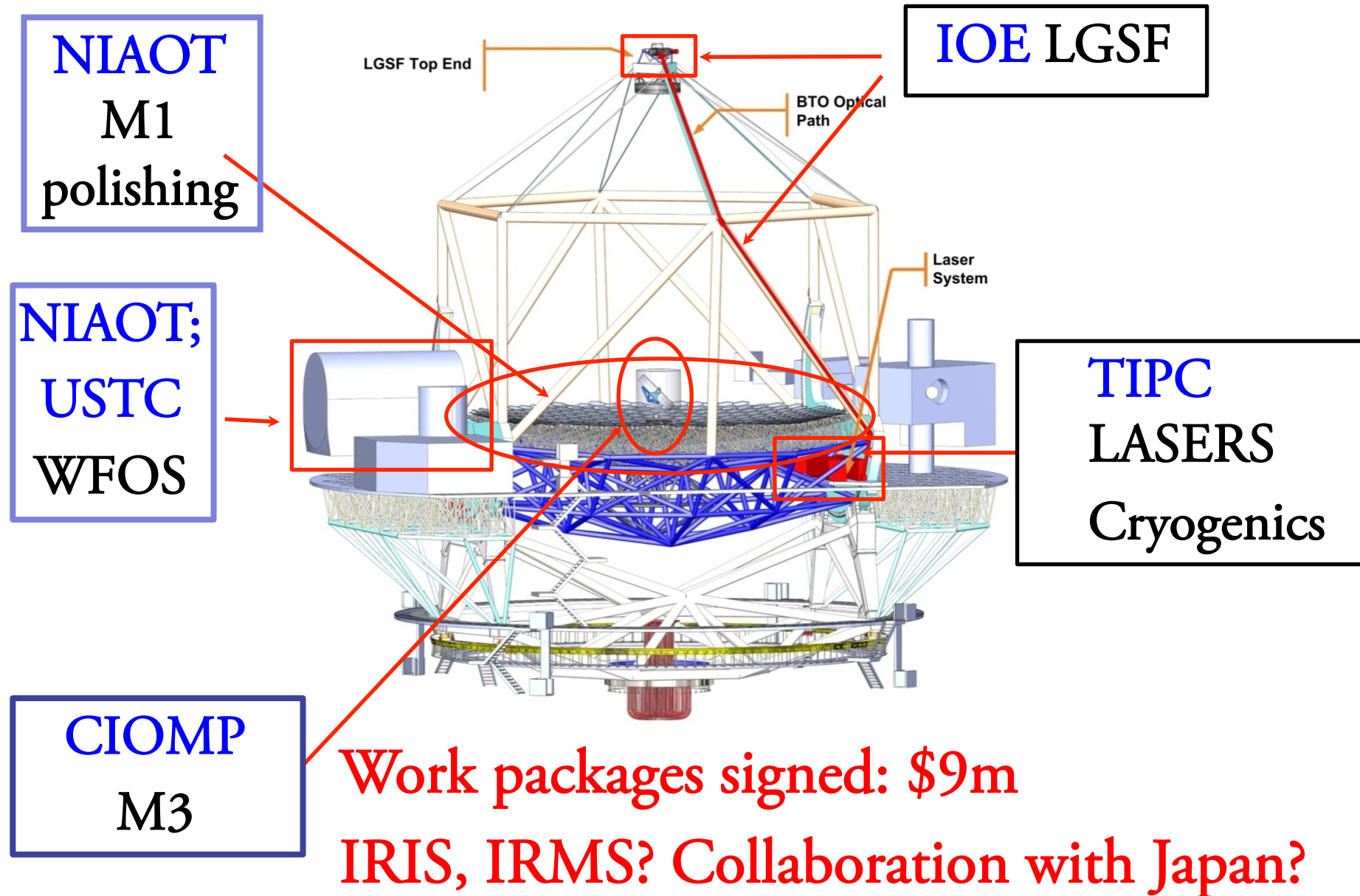
- Can observe more faint stars, potentially test GR more accurately
- Determine BH mass dynamically to $z \sim 0.4$, and study their evolution

Team TMT-China



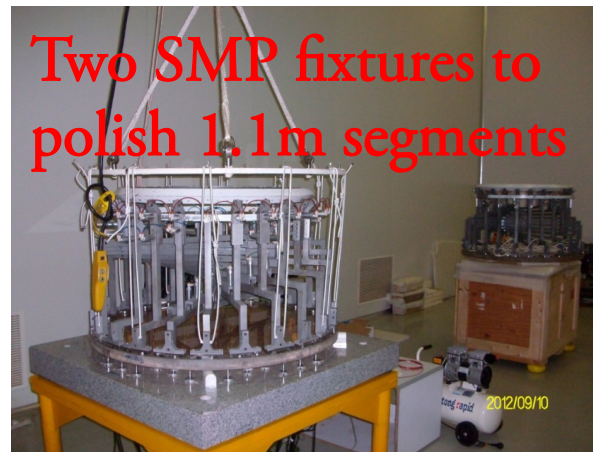
5 CAS institutes + many universities
(PKU, USTC, Tsinghua, Nanjing
University, etc.)

Chinese in-kind contributions



M1 mirror segments

- Polishing 82-types of a total of 574 segments is a major challenge for China; reviewed on 23/04/13
- Multi-national effort
 - China (NIAOT) 、 Japan (Canon)、 India
 - US (ITT) and quality control
 - **Scaling up, validation remain challenges!**

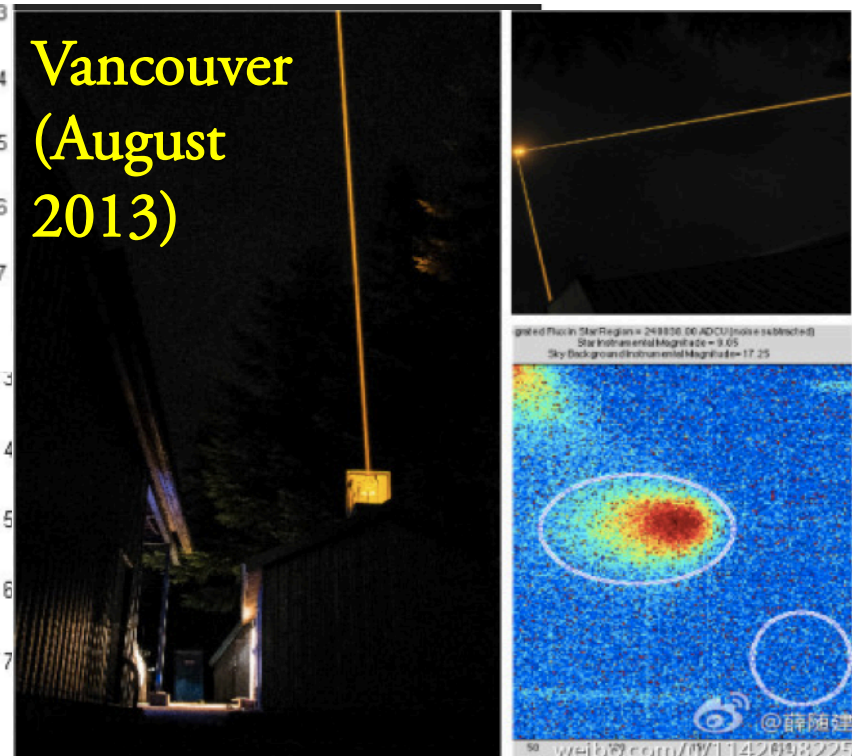
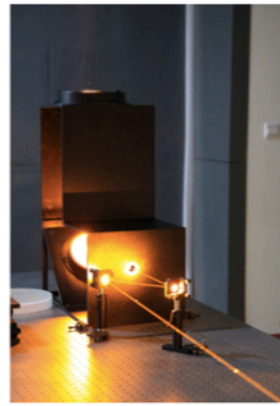
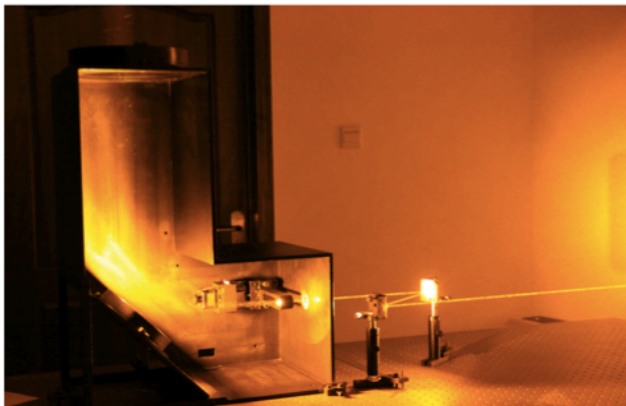
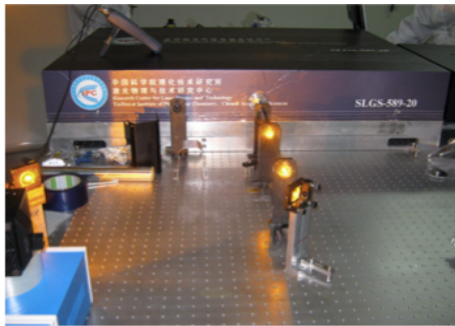


Diffraction-limited observations with lasers



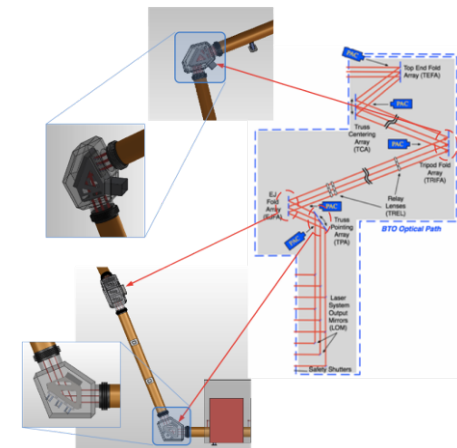
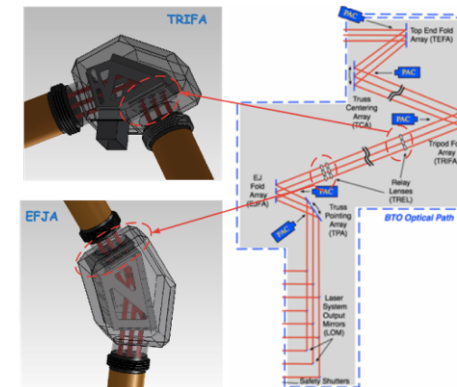
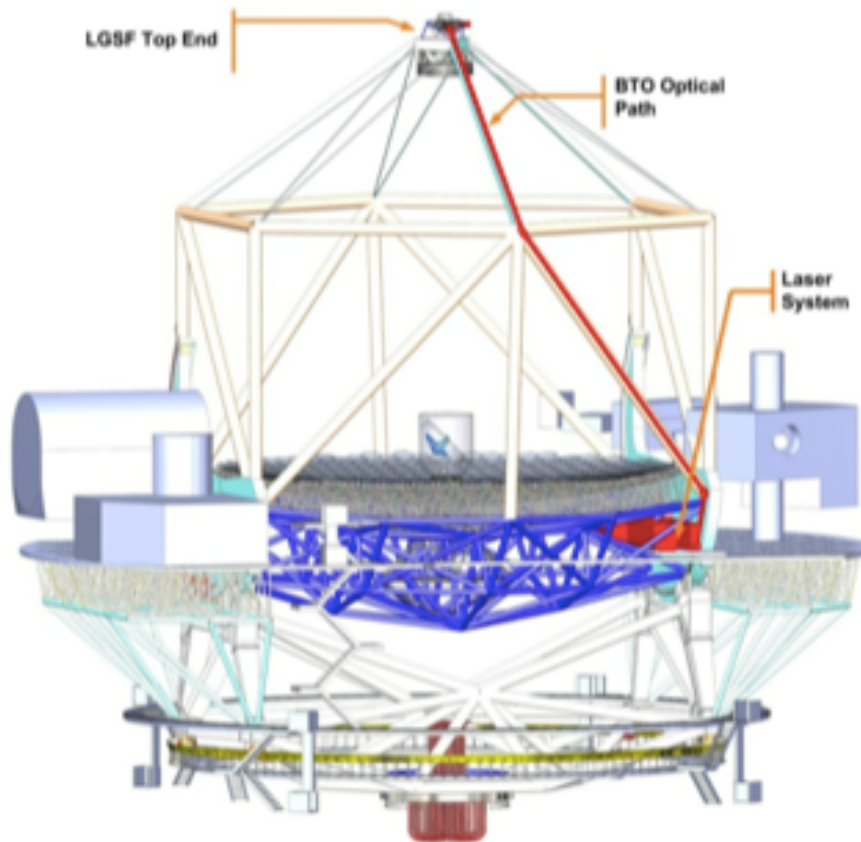
Lasers

- TIPC (理化所) leads in laser technology in some areas
- Laser power (20W) tested on the 1.8m telescope, producing an $m \sim 8$ star
- Photon return efficiency too low: needs D2b repumping

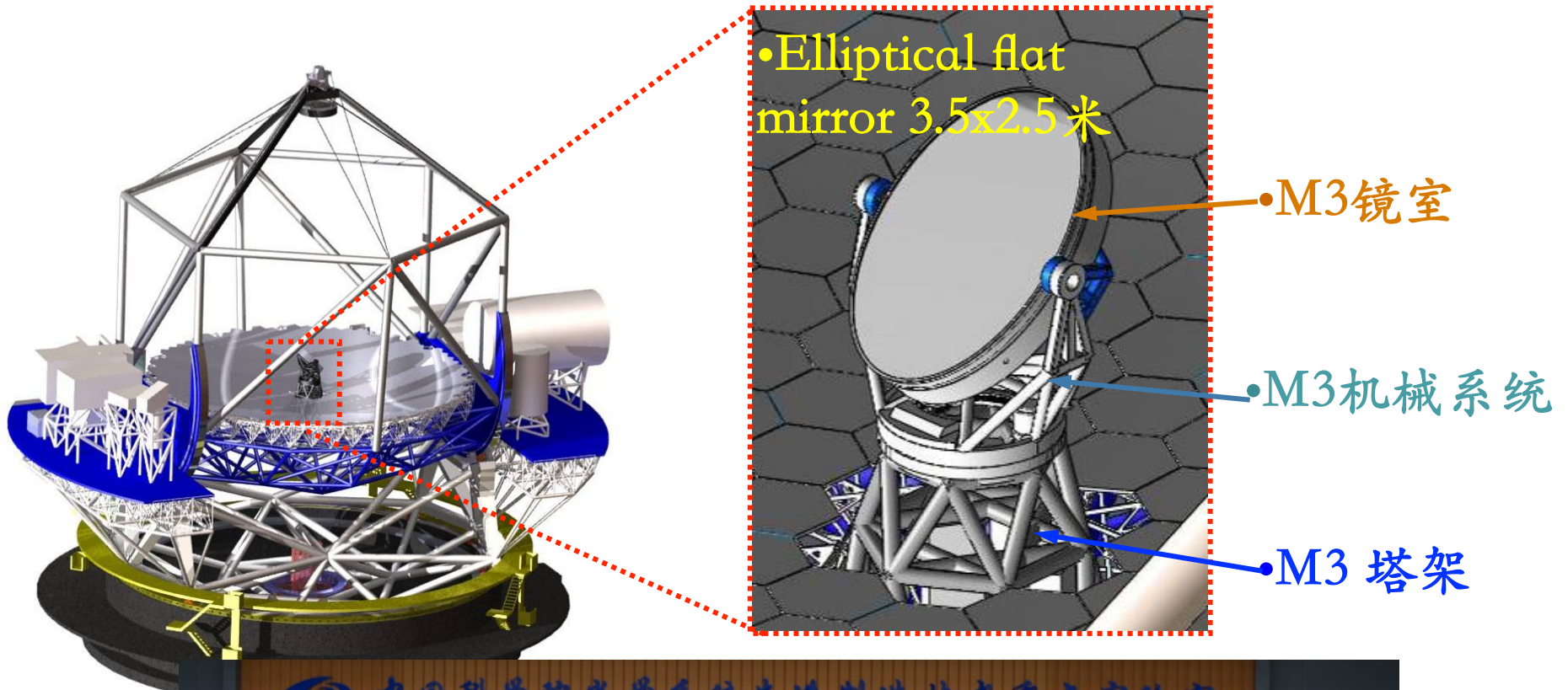


Laser guide star facility

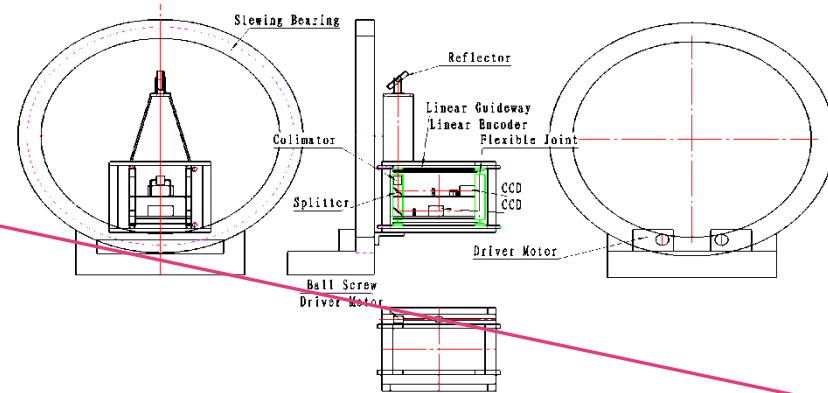
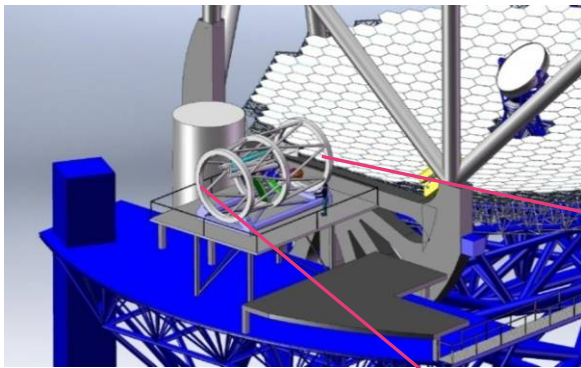
- IOE finished preliminary design of LGSF in 2010
- Personnel already working on KECK laser!
- Laser provider for other telescopes?



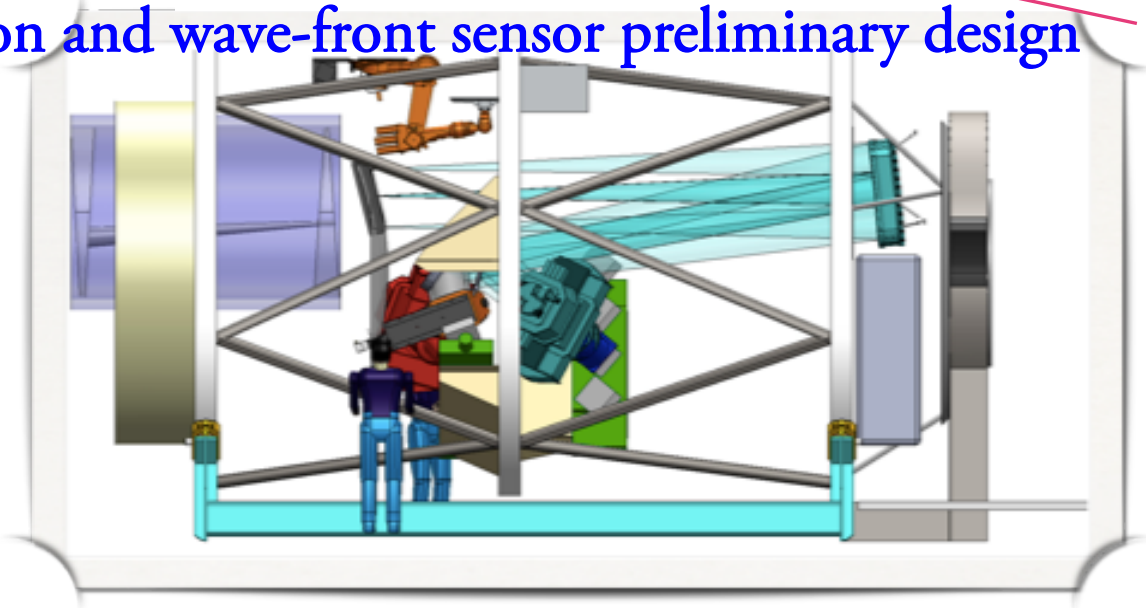
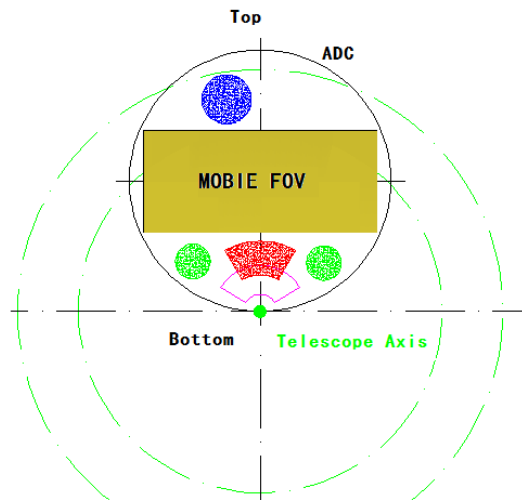
CIOMP (长光所): M3



WFOS (NIAOT, USTC)



WFOS target acquisition and wave-front sensor preliminary design



Meeting on June 5-6, 2013 between UCSC/China
Larger roles? Review on Oct. 29, 2013

Since 2008, more than 200 bilateral visits, identified key **high-tech** in-kind contributions!

International Colloquium on Thirty-Meter Telescope



Challenge: export license



UNITED STATES DEPARTMENT OF COMMERCE
BUREAU OF INDUSTRY AND SECURITY
WASHINGTON, D.C. 20230

COMMODITIES:			TOTAL
QTY	DESCRIPTION	ECCN	PRICE
1	MODEL: TMT PROJECT, TECHNOLOGY FOR THE DEVELOPMENT OF ION FIGURING AS WELL AS FOR MRF, REACTIVE ATOM PLASMAS, INFLATABLE MEMBRANE TOOL FINISHING AND FLUID JET FINISHING.	2E001	\$1
1	MODEL: TMT TECHNOLOGY, TECHNOLOGY FOR THE APPLICATION OF INORGANIC OVERLAY COATINGS OR INORGANIC SURFACE MODIFICATION COATINGS TO NON-ELECTRONIC SUBSTRATES.	2E003	\$1
D464486			
VALIDATED: DEC 15 2011			
EXPIRES: DEC 31 2013			

1	MODEL: TMT TECHNOLOGY, TECHNOLOGY FOR THE DEVELOPMENT AND PRODUCT OF OPTICAL CONTROL EQUIPMENT SPECIFICALLY DESIGNED TO MAINTAIN THE ALIGNMENT OF PHASED ARRAY OR PHASED SEGMENT MIRROR SYSTEMS CONSISTING OF MIRRORS WITH A SEGMENT DIAMETER OR MAJOR AXIS LENGTH OF 1M OR MORE.	6E001	\$1
1	MODEL: TMT TECHNOLOGY, TECHNOLOGY FOR THE DEVELOPMENT AND PRODUCT OF OPTICAL CONTROL EQUIPMENT SPECIFICALLY DESIGNED TO MAINTAIN THE ALIGNMENT OF PHASED ARRAY OR PHASED SEGMENT MIRROR SYSTEMS CONSISTING OF MIRRORS WITH A SEGMENT DIAMETER OR MAJOR AXIS LENGTH OF 1M OR MORE.	6E002	\$1
TOTAL:			\$4

- 4 person-months involving: high-powered Washington lawyers
- TMT high-tech: \$4 granted in Dec. 2011
- Participation in some IR research deemed as basic research, no restriction

Challenges

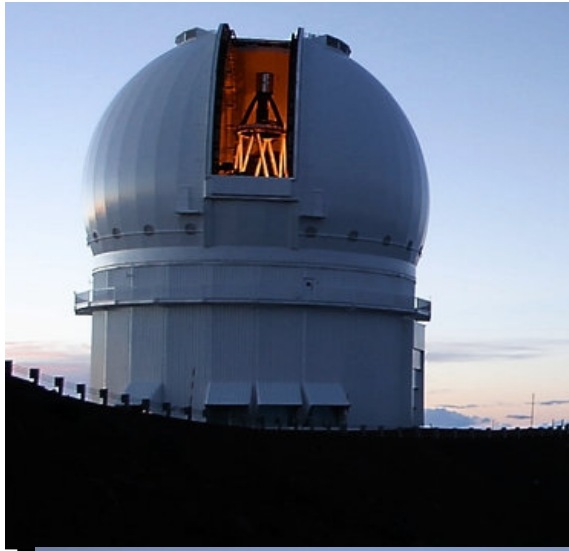
- Supported by many Chinese leaders (刘延东、路甬祥、徐匡迪)
- Still seeking full funding
 - lack of government involvement on the US side?
 - consensus from Chinese community?
- Needs to strengthen the scientific community
 - Domestic facilities (2.16m, 2.4m)
 - Telescope Access Program (4-6.5m telescopes)

Telescope Access Program (TAP)

CFHT

3.6m

15 nights



Palomar

5m

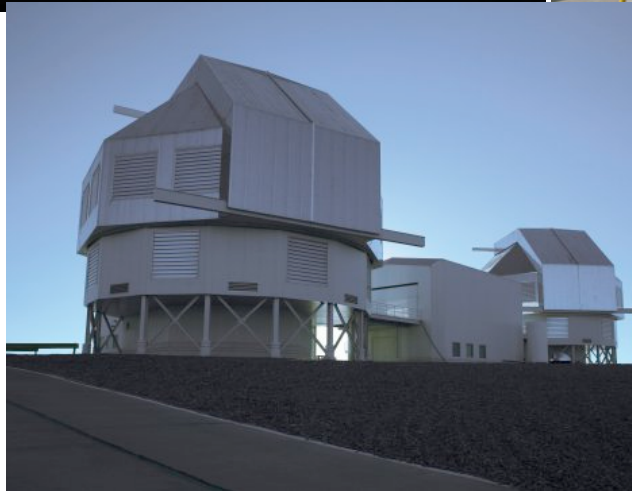
20 nights



Magellan

6.5m

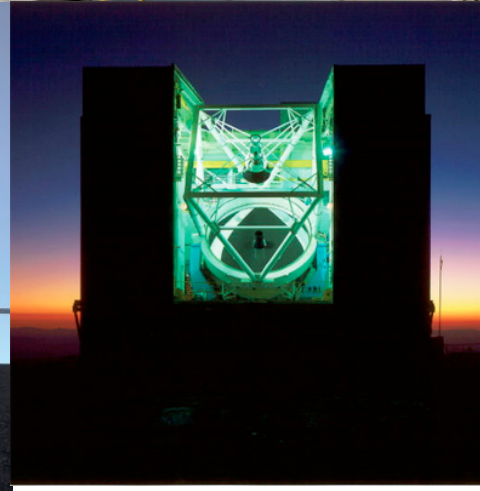
4 nights



MMT

6.5m

10 nights



- Total budget ~ \$1m/yr
- Over-subscription ~3, 100-200 people submit proposals each semester

Opportunities

- TMT offers a unique opportunity for China to
 - engage in the next generation extremely large telescope: science, state-of-the-art instruments, system integration and management
 - leverage other facilities
- East-Asia collaborations
 - Sharing of telescope times (north-south swap? Cost sharing of current telescopes?)
 - Next-generation instruments?

Summary

- TMT offers a unique opportunity to make a quantum leap in the optical/IR for the Chinese community
- China is making solid progress in in-kind contributions towards TMT
 - Already stimulating progress in domestic projects!
- TMT is for the young generation!
 - foundation for future hyper-large telescope?
 - Opportunities to collaborate across east Asia

TMT is NOW!

Blessing ceremony



August 25, 2013

First dirt!



August 27, 2013

TMT is fully ready for construction
in 2014, exciting decade ahead!