

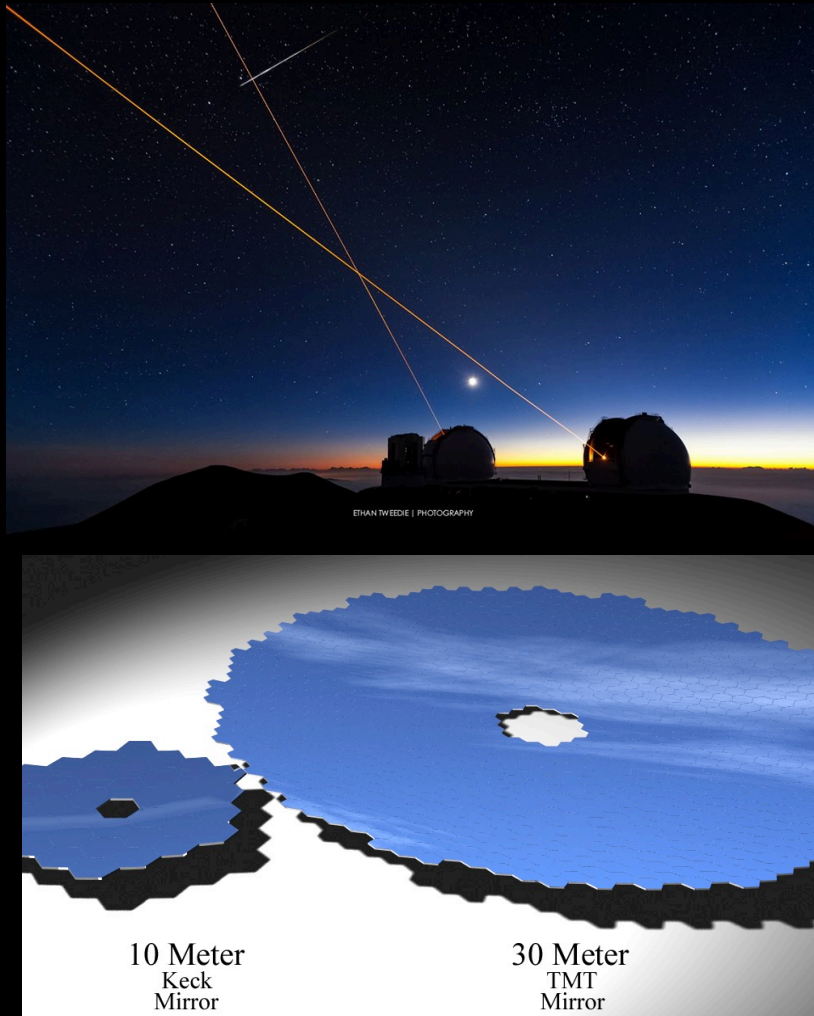
# Thirty-Meter Telescope: TMT

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Photo from Hawaii's Big Island Visitor Bureau

# Thirty-Meter Telescope: history



- In 2000 planning started for the next generation of ground-based astronomy facility
- Builds directly on technology and expertise that led to the development of the W.M. Keck Observatory
- Initial design development project had UC, Caltech, AURA and ACURA as equal partners
- Top priority of 2000 Decadal Survey was “Giant Segmented Mirror Telescope” developed as public-private partnership

# TMT Science

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Hubble Space Telescope resolution

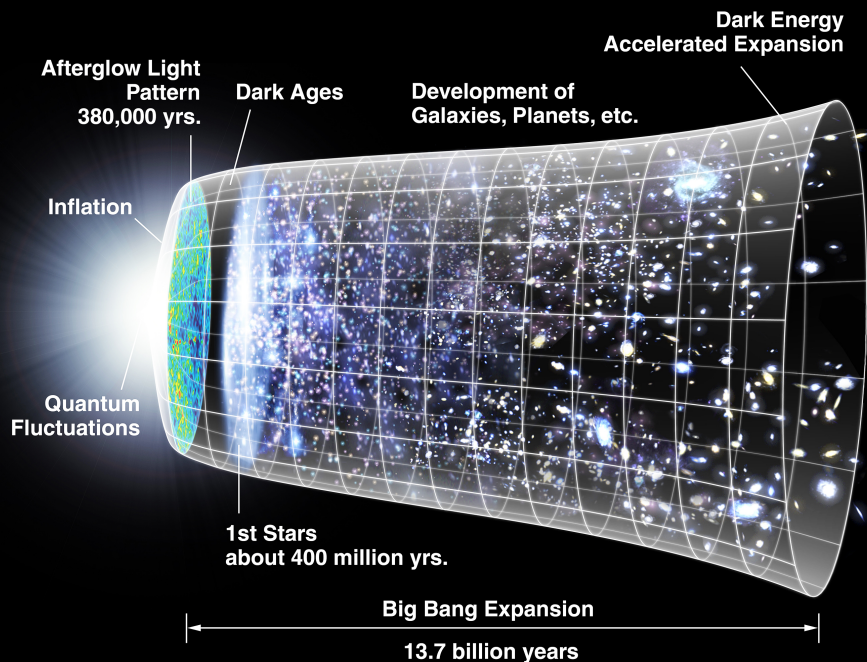


TMT + Adaptive Optics



- *Nine times* the light collecting power of a Keck Telescope
- *Twelve times* sharper images than the Hubble Space Telescope when used with adaptive optics
- *100 times* more sensitive than existing leading facilities for some types of observations. Gains scale from  $D$  to  $D^4$

# TMT Science

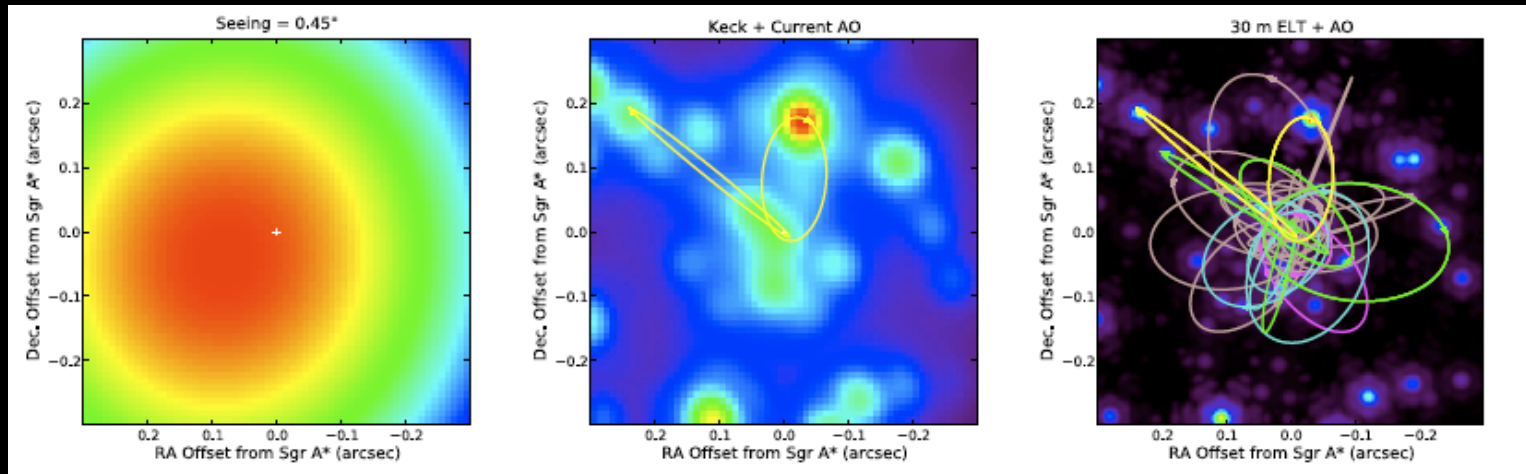


TMT light gathering power and very high spatial resolution will revolutionize studies in the areas of:

- the first epoch of star formation in the Universe
- the assembly and evolution of galaxies
- the discovery and characterization of extra solar planets
- New discovery space
- ...



# Science Example: Galactic Center



- The spatial resolution of the TMT will allow a dramatic advance in the work in the Galactic Center
- Will be able to probe the “strong regime” of General Relativity near the surface of the Black Hole

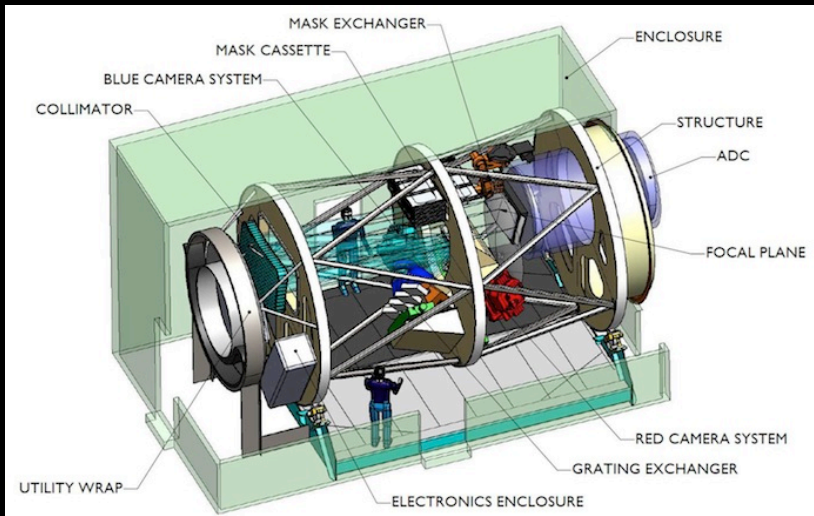
# NFIRAOS: AO system

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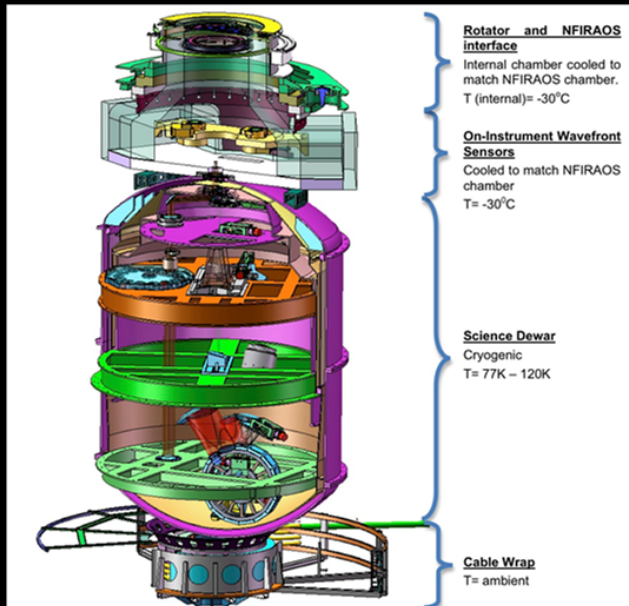
NFIRAOS is a dual-conjugate AO system being built largely by HIA in Canada

- 2' field correction
- 30'' DL field
- 50% coverage at NGP
- 187nm wavefront error at first light (K-band Strehl  $\sim 0.75$ )
- Multi-beacon laser system under design and testing in China



## First Generation Instrument designs underway

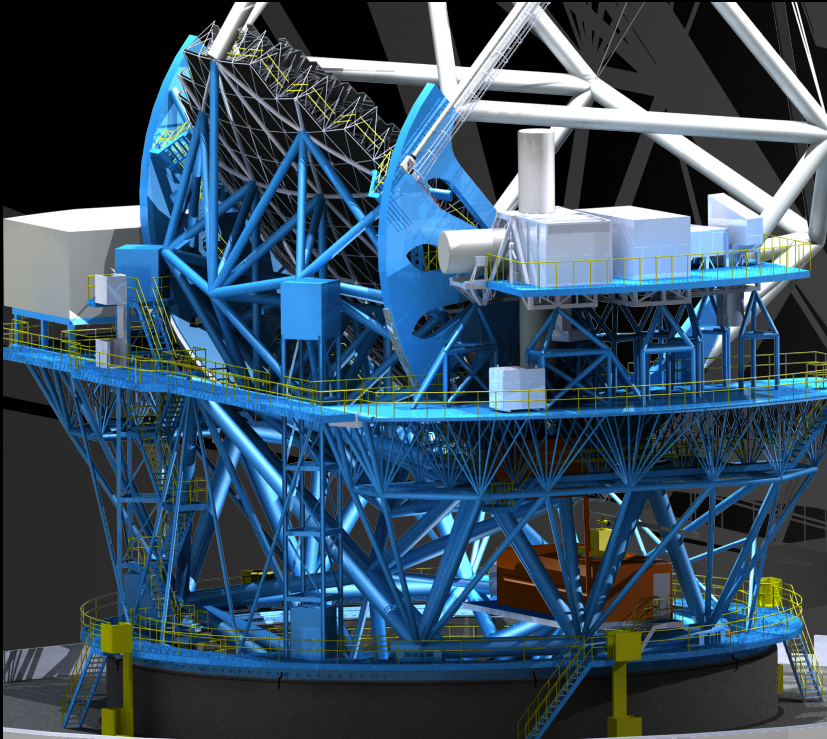
- **MOBIE** (Wide-field optical spectrometer) PI:
- **IRIS** (AO-fed spectrometer and imager) PI: J. Larkin
- **IRMS** (Keck MOSFIRE clone: PI: N. Konidakis)
- **NFIRAOS** 180nm WE AO system (HIA)



Five additional instruments were defined by the SAC for the “first decade” suite, but these will be revisited

# TMT: Technical Status

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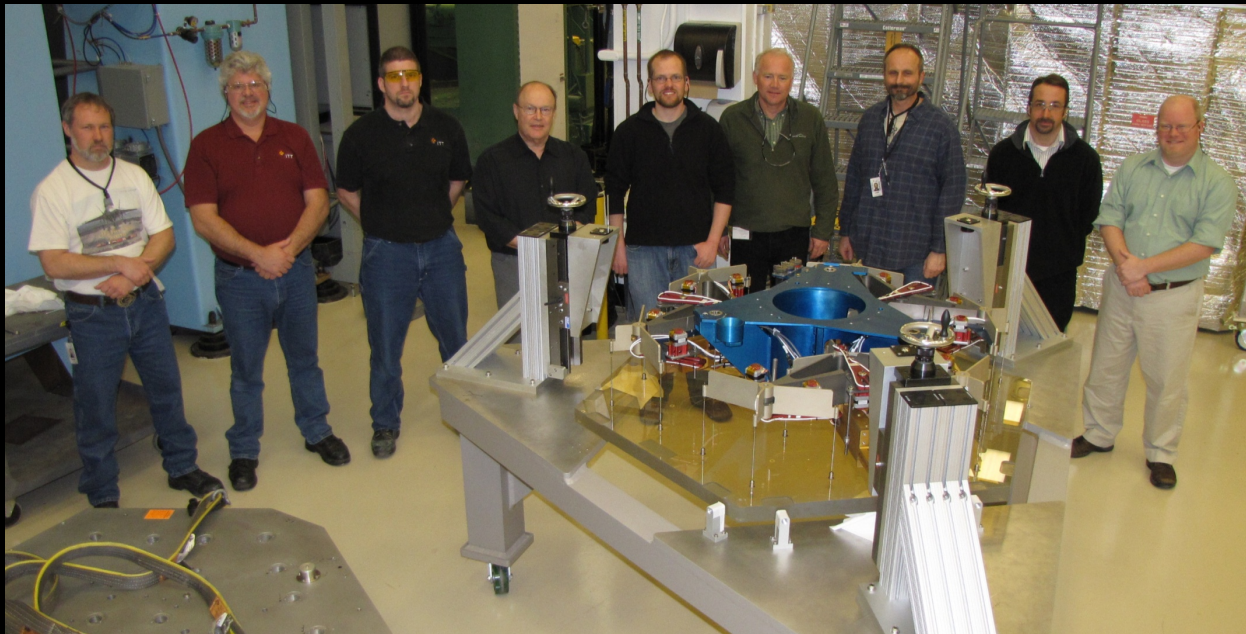
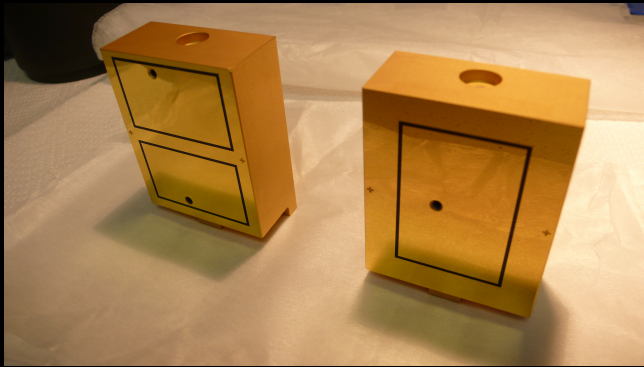


- Design is at build stage for telescope, mirrors and control systems, enclosure and summit facilities
- Very rigorous project management procedures and tools in place
- Project has undergone multiple, extensive external reviews for technical readiness, and cost and contingency fidelity



# At “P2” and final design for key components

- Actuators
- Sensors
- Segment support
- Segments





Site



Prevailing Wind

Disturbed area to be graded similar to the existing site contours to create a more natural surface

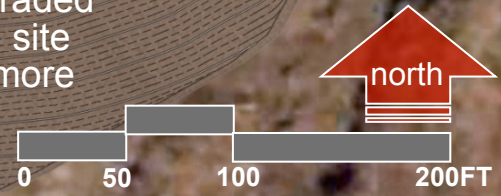
Crushed basalt surface, typical at vehicular drive

Natural Landscaping

Natural Landscaping

Disturbed area to be graded similar to the existing site contours to create a more natural surface

Site Access Road



# TMT site: status

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- Permit secured for Mauna Kea construction, initial site preparation initiated Aug 2013
- Detailed dome, support facilities and telescope construction plans have been developed: no small challenge to choreograph these activities at the summit







# TMT Partnership

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- Four countries selected TMT after considering the other ELT projects
- Japan, China, India, Canada
- Construction proposals submitted in 2012/13
- Partnership agreement has been developed over past 18 months



“Scientific Authorities” from Caltech, Canada, China, India, Japan and UC signed Master Partnership Agreement in July 2013. Financial authority signatures targeted for Feb 2014

# Timeline

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## TMT Timeline

- Construction start: April 2014
- First science operations 2022

# TMT, the NSF, and the US community

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## **“Planning a Partnership Model for a Giant Segmented Mirror Telescope (GSMT)”**

Cooperative Agreement established as a result of TMT response to NSF-AST solicitation

**“The primary deliverable of this award is to be a partnership model that might allow NSF to join the TMT Project on behalf of the US astronomical community.”**

**Current TMT partner shares: 10 to 20% each**

**Potential NSF share of TMT is comparable to that of the other partners.**



# US participation in GSMTs

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- **Astro2000 decadal survey:** GSMT ranked top-priority ground-based large project; recommended \$350M NSF investment (50%)
- **TMT formed from merger of several GSMT designs:**
  - CELT (UC+Caltech) + VLOT (Canada/ACURA) + GSMT (AURA/NOAO)
- **2002-2008: AURA community GSMT Science Working Group** (chair: Kudritzki)
- **2005-2012: NSF awards \$18M development funds to TMT and GMT**
  - NOAO designated program manager for GSMT technology development
- **Astro2010:** GSMT ranked top-priority large project by ground-based OIR panel, but 3<sup>rd</sup> in the main Astro2010 report (after LSST and MSIP)
- **2012:** NSF solicitation for GSMT community engagement
- **2013-2017:** NSF-TMT cooperative agreement; **new US TMT SWG**, etc.

# Cooperative Agreement Activities

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- **US TMT Liaison** office established at NOAO
- **US TMT Science Working Group** represents community interests and develops US TMT Participation Plan
- US community representation on the **TMT Science Advisory Committee** and **TMT Collaborative Board**  
Board: **Caty Pilachowski** (Indiana), **David Silva** (NOAO), **Vern Pankonin** (NSF)  
SAC: **Ian Dell'Antonio** (Brown), **Mark Dickinson** (NOAO), **Jennifer Lotz** (STScI)
- **Workforce, Education & Public Outreach Advisory Group**  
(chair: **Steven Pompea**, NOAO)
- Annual **Town Hall meetings**; **TMT Science Forum**

**Gives the US community a voice in defining the TMT Observatory and the potential NSF role in construction and operation.**

# US TMT Science Working Group

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Todd Boroson (LCOGT)

Ian Dell'Antonio (Brown)

Mark Dickinson (NOAO, chair)

Anthony Gonzalez (U.Florida)

Stephen Kane (SF State)

Jennifer Lotz (STScI)

Lucas Macri (Texas A&M)

Paul Martini (Ohio State)

Susan Neff (GSFC)

Deborah Padgett (GSFC)

Lisa Storrie-Lombardi (IPAC)

Charles Telesco (U.Florida)

- **Represent the US community's interests and priorities**
- **Develop a US TMT Participation Plan**

***The US community is shaping TMT development now.***

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*\* US representatives to TMT Science Advisory Committee (SAC)*

- Represent the US community's interests and priorities
- Develop a US TMT Participation Plan

*The US community is shaping TMT development now.*



# US TMT Participation Plan

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To be developed by the US TMT SWG and US Board members on behalf of the community, for the NSF

First draft planned by end of 2014; final report end 2015

- Describes the scientific, technological, educational & programmatic benefits of US participation in TMT
- Details choices & decisions that would maximize those benefits
  - Telescope, instrumentation & AO capabilities
  - Evolution of instrumentation (e.g., 2<sup>nd</sup>-generation instrument priorities)
  - Operations modes (e.g., queue vs. classical, large programs, time allocation)
  - Data management issues (pipelines, archives, etc.)
- Integrated science & education plan

**Forms the basis for an NSF partnership model with TMT**

# International Science Development Teams

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- Provide **scientific input & guidance** to TMT
- Help **define observatory capabilities & operations model**
- Stimulate **planning for future TMT science programs**
- **Foster collaboration & cooperation** between scientists in and beyond the international TMT partnership

## **8 topical groups established:**

Fundamental physics & cosmology

Early universe, galaxy formation, IGM

Supermassive black holes

Milky Way & nearby galaxies

Formation of stars & planets

Exoplanets

Our solar system

Time-domain science

# International Science Development Teams

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## Call for new membership (annual):

- ISDTs are open to all Ph.D. astronomers
- Applications due 17 January 2014
- <http://www.tmt.org/about-tmt/international-science-development-teams>  
(Google “TMT ISDT”)

## ISDT tasks and benefits:

- Update and expand the TMT *Detailed Science Case*
- Develop possible Key Programs
- Work with instrument teams, exercise observatory & instrument software
- Become involved & informed
- Meet potential collaborators
- Possible membership in large project consortia
- Registration fee waived at Forum

**ISDT membership requires a commitment of time & effort**

# TMT Science Forum

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- Annual gathering to discuss TMT science, instrumentation, operations, education & outreach
- NSF funding available to support attendance by US community members

## **2013: First TMT Forum (22-23 July, Waikoloa, HI)**

- 140 attendees, 34 from mainland US-at-large community + 20 from Hawaiian institutions



# 2013 TMT Science Forum

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Waikoloa, Hawaii, 22-23 July 2013



# Intense ISDT discussion

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# TMT Science Forum

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## **2013: First TMT Forum (22-23 July, Waikoloa, HI)**

- 140 attendees, 34 from mainland US-at-large community + 20 from Hawaiian institutions

## **2014 TMT Forum: week of 14 July 2014, Tucson AZ**

Theme: Synergy with post-2020 astronomical system

- Plenary talks & events
- Instrumentation Workshop
- ISDT working meetings

**E-mail [tmt@noao.edu](mailto:tmt@noao.edu) for more information**

# TMT community presentations

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- TMT scientists and staff travel to give **presentations at your department or regional meeting**
- **7 presentations in 2013:**
  - San Diego State, Caltech, UCSB/LCOGT, Penn State, UC Riverside, UCLA, Univ. of Cincinnati
- **Many more planned for 2014:**
  - UA/NOAO, STScI/JHU, UT Austin, GSFC, Univ. Florida, Univ. Michigan, Michigan State, Gemini-N, Univ. of Hawaii, MIT, Indiana Univ., Univ. of Maryland, Brown, etc.

Contact **Warren Skidmore** ([was@tmt.org](mailto:was@tmt.org)) or write to the **TMT Liaison Office** ([tmt@noao.edu](mailto:tmt@noao.edu)) to schedule a visit



# Getting involved with TMT

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- Visit the **TMT booth (#243)** here at the AAS
- **Respond to community surveys & solicitations**
- Attend the annual **TMT Forum** as a US community member
- **Request a visit to your department/regional meeting** to present and discuss the TMT project and US community involvement
- Indicate your interest (via future announcements of opportunity) in **participating in the development of TMT instrumentation**
- Join the **TMT community e-mail group** (sign up at [tmt@noao.edu](mailto:tmt@noao.edu))
- Follow the **US TMT SWG on Facebook**

<https://www.facebook.com/USTMTSWG>

**Write to SWG and US TMT Liaison Office ([tmt@noao.edu](mailto:tmt@noao.edu))**



# What the US TMT SWG wants to know from **you**:

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- **How would you use TMT?**
  - Your science programs
  - Required capabilities
  - Instrumentation priorities
- For your science, **how does TMT complement other post-2020 astronomical facilities** (ground- and space-based)?
- Should US TMT time be **classically or queue scheduled**, or both?
- Should TMT devote time **to large programs** (what fraction)?
  - If other TMT partners were not interested in collaborative large programs, should the US consider carrying out large programs anyway?
- How important is a **TMT archive with processed, calibrated data**?
  - What resources should be invested to achieve that?
- **What partner share does the US community need** to carry out globally competitive science programs?

**Write to the SWG: [tmt@noao.edu](mailto:tmt@noao.edu)**

**Facebook: <https://www.facebook.com/USTMTSWG>**



<http://www.tmt.org/>

<http://ast.noao.edu/system/us-tmt-liaison>