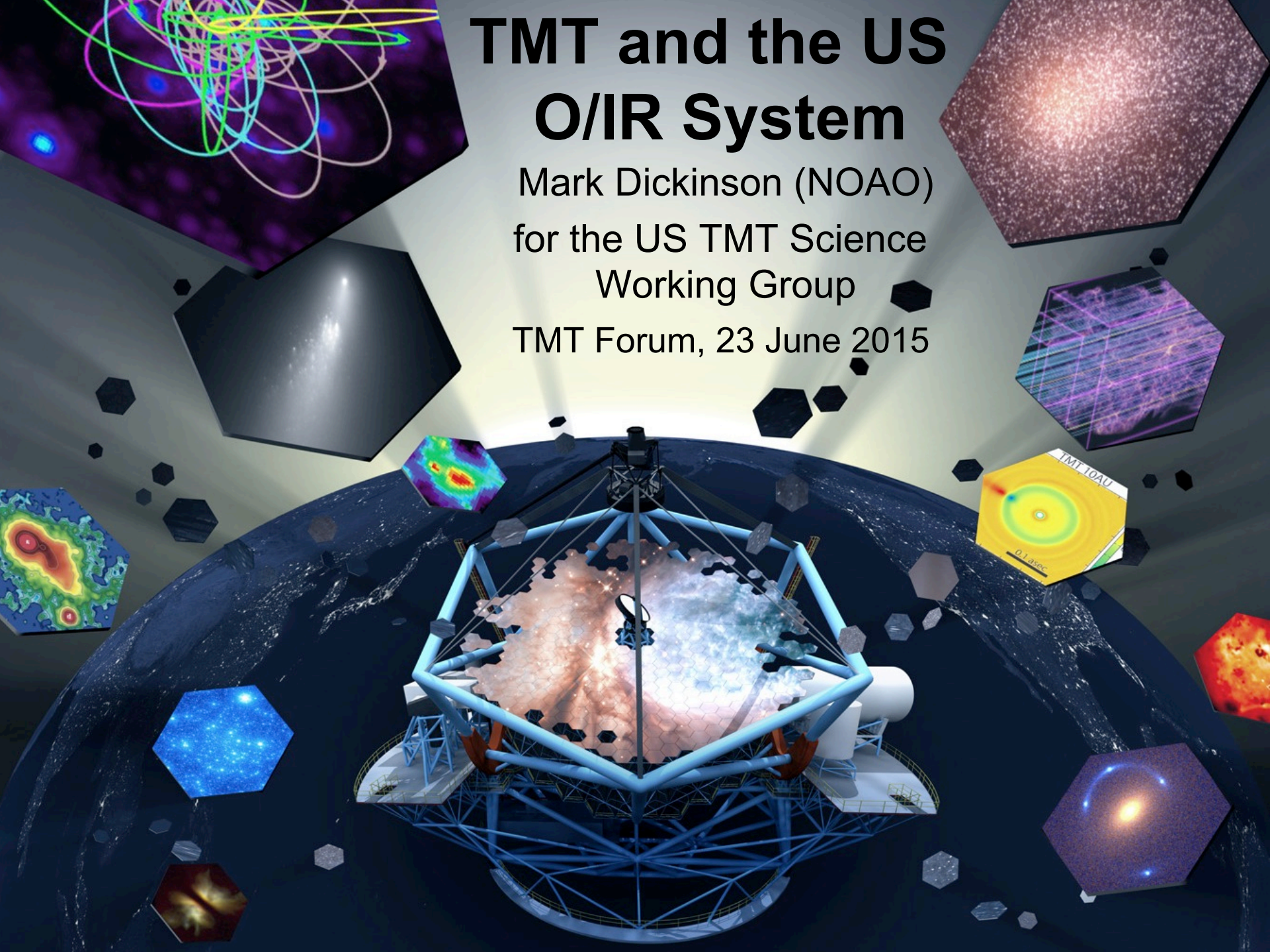


TMT and the US O/IR System

Mark Dickinson (NOAO)
for the US TMT Science
Working Group

TMT Forum, 23 June 2015



The 2000 & 2010 Decadal Surveys identified the need for US national participation in a Giant Segmented Mirror Telescope.

From *New Worlds, New Horizons* (Astro-2010):

“It is imperative that at least one of the U.S.-led telescope projects have U.S. federal investment. Such a federal role will leverage the very significant U.S. private investment, will maximize the potential for the project’s success, will help to optimize the U.S. scientific return on other federal investments (ALMA, JWST, and LSST), and will position the NSF for leadership in future large-telescope projects beyond GSMT.”

NWNH recommended that the NSF select one of the two US-based GSMT projects for federal participation at a level of about 25%.

From the 2015 NRC report, “Optimizing the US Ground-based OIR System”:

"GSMTs will contribute critically to addressing the majority of the next decade's principle science questions and are required for five key science programs in *NWNH*."

GSMTs are "critical complements to major new facilities, including LSST, ALMA, JWST, Gaia, WFIRST and Euclid."

NSF “should plan for an investment in one or both GSMTs in order to capitalize on these observatories’ exceptional scientific capabilities for the broader astronomical community in the LSST era.”



TMT

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E-ELT, GMT, TMT

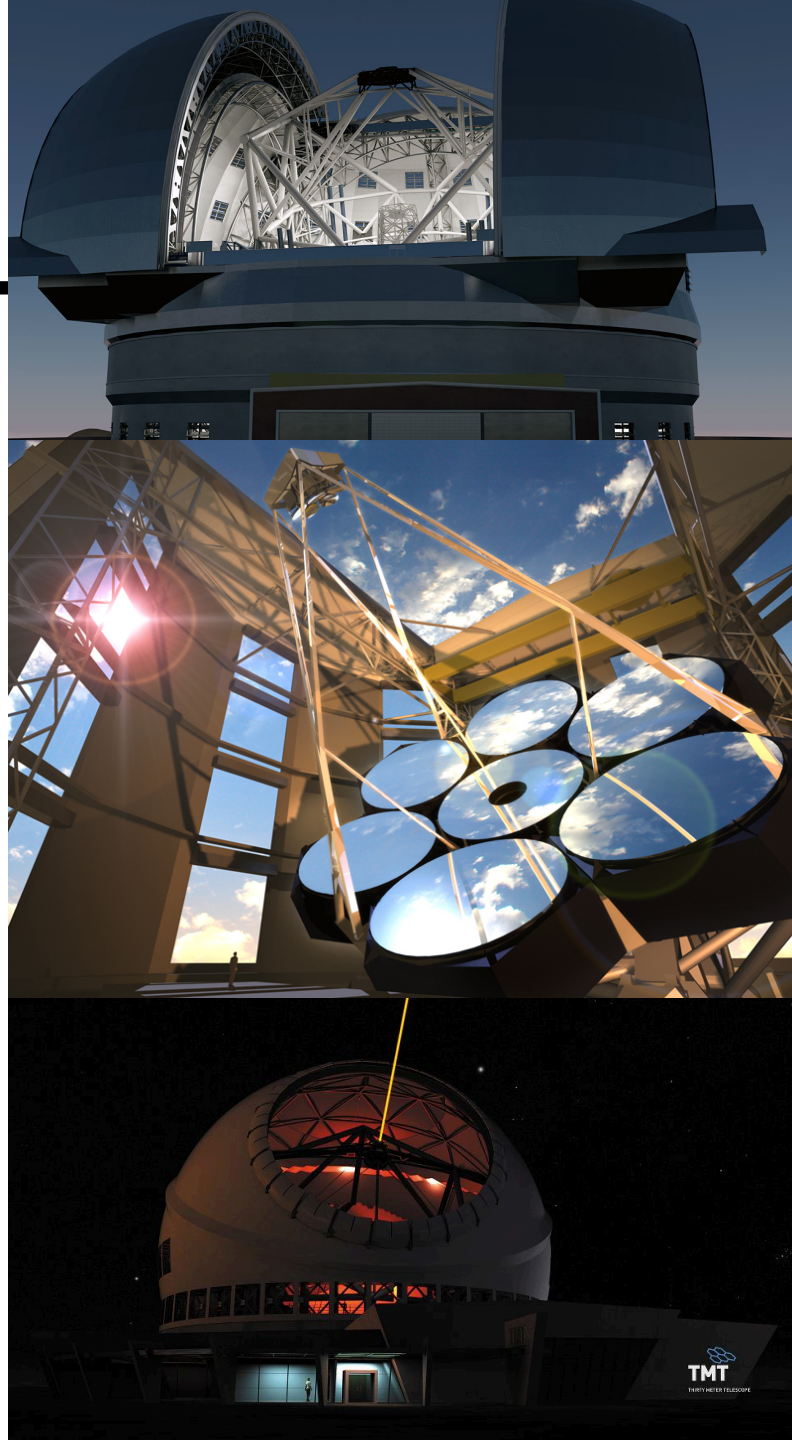
Countries with national access to these telescopes:

Australia, Austria, Belgium, Brazil, Canada, Chile, China, Czech Republic, Denmark, Finland, France, Germany, India, Italy, Japan, Korea, Netherlands, Poland, Portugal, Spain, Sweden, Switzerland, United Kingdom

US universities & institutions:

Caltech, Carnegie, Harvard, SAO, University of Arizona, University of California, University of Chicago, University of Texas at Austin, Texas A&M

What's missing from this picture?



2013: NSF and TMT entered into a cooperative agreement to engage the US community in TMT planning and development.

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

- AURA is an Associate Member of the TMT International Observatory
TIO Board: David Silva (NOAO), Caty Pilachowski (Indiana)
TMT Science Advisory Committee: Mark Dickinson, Jen Lotz, Ian Dell’Antonio
- NOAO executes the responsibilities and participation activities of AURA, representing the US-at-large community
 - NOAO TMT liaison office: <http://ast.noao.edu/system/us-tmt-liaison>
 - NOAO TMT FAQ: <http://ast.noao.edu/system/us-tmt-liaison/survey-faq>
 - Questions? tmt@noao.edu

- Engages with the US community to understand its interests and aspirations for TMT
- Represents those interests to the TMT project, SAC, and Board
- Works with TMT to develop a *US TMT Participation Plan* for the NSF

Ian Dell'Antonio (Brown)

Mark Dickinson (NOAO, chair)

Anthony Gonzalez (Florida)

Stephen Kane (SFSU)

Jamie Lloyd (Cornell)

Jennifer Lotz (STScI)

Lucas Macri (TAMU)

Karen Meech (Hawaii/IfA)

Susan Neff (GSFC)

Deborah Padgett (GSFC)

Caty Pilachowski (Indiana)

Kartik Sheth (NRAO)

Lisa Storrie-Lombardi (IPAC)

**** TMT Science Advisory Committee or Board member***

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

US TMT Participation Plan

- Describes the scientific, technological, educational, and programmatic benefits of US participation in TMT
- Details choices & decisions that would maximize those benefits for the US astronomical community
 - Instrumentation and AO capabilities and their evolution
 - Time allocation and scientific program balance
 - Operations, observing modes, scheduling
 - Data management, archiving, pipelines
 - Integrated science and education plan

-
- A seat at the table for observatory governance and scientific planning
 - Consistent, long-term access to observing time
 - Ensures that US community astronomers can create and lead TMT science programs
 - Opportunity to participate in international TMT science collaborations and key program science
 - Participate in, and lead, science programs that would be too large for any one partner's time share alone
 - Access to archived data
 - Enhanced opportunities to participate in TMT instrumentation development



ASTRONOMY'S
NEXT-GENERATION
OBSERVATORY

Thirty Meter Telescope Science Forum

Save the Date: The Thirty-Meter Telescope observatory will host the inaugural "TMT Science Forum" on

July 22 and 23, 2013

at the

**Waikoloa
Resort on the island of Hawaii.**



The TMT is an international project to build and operate a 30-m telescope located on Mauna Kea, HI. The program will consist of talks and workshop discussions exploring science, first-light and future instruments, observatory operations, archiving and data products, key projects and cross-partnership collaborations, astronomy education and science, technology, engineering, and math (STEM) opportunities.

More information and the Forum program can be found at
<http://conference.ipac.caltech.edu/tmts>

If you are interested in attending the Forum, register at the conference website. As part of the NSF-TMT agreement, some travel funding will be available for U.S. community members (who are not at TMT institutions) to attend the forum. To request consideration for travel funding, send an email to TMT@noao.edu with your name, institutional affiliation, and areas of interest relevant to TMT.

ACURA

Association of
California Universities
for Research in
Astronomy

CALTECH

California Institute of
Technology

DSTI

Department of
Space and
Technology of India

NAOC

National Astronomical
Observatory of the
Chinese Academy of
Sciences

NAOJ

National Astronomical
Observatory of Japan

UC

University of
California

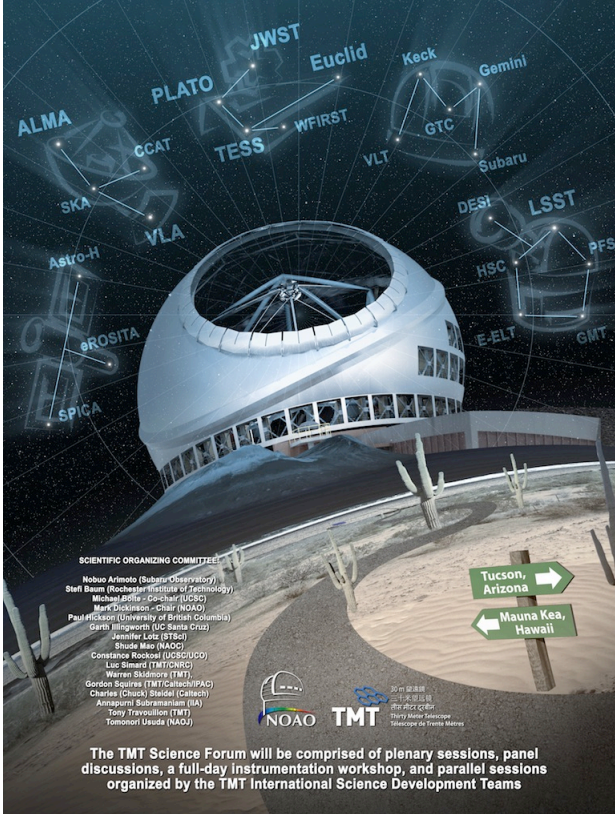
NSF

National Science
Foundation

TMT in the Astronomical Landscape of the 2020s

Exploring scientific and operational synergies between TMT and other
forefront astronomical facilities and capabilities in the next decade

17 - 19 July 2014, Ventana Canyon Resort, Tucson, Arizona, USA



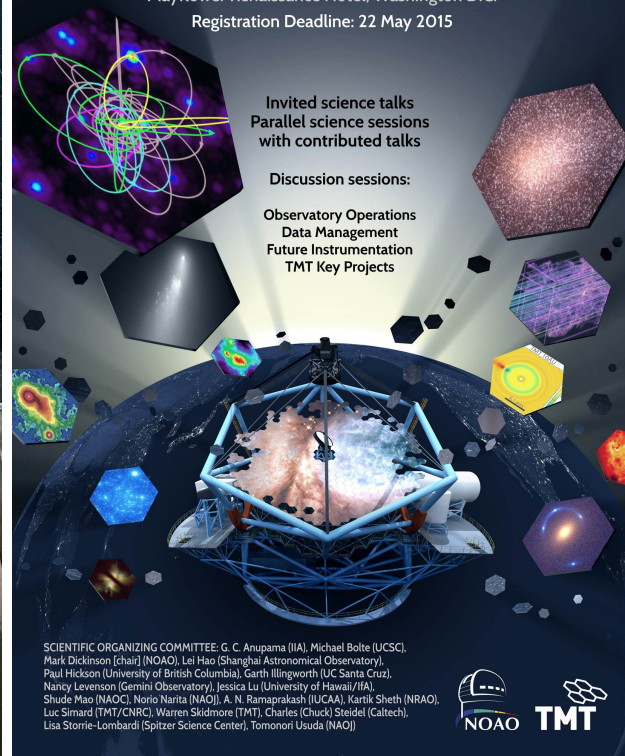
Maximizing Transformative Science with TMT

Exploring forefront science with the Thirty Meter Telescope, and ways to maximize its productivity through innovative collaborations, operations, and instrumentation

23 - 25 June 2015

American Association for the Advancement of Science (AAAS)
Mayflower Renaissance Hotel, Washington D.C.

Registration Deadline: 22 May 2015



TMT open house and town hall meetings at AAS meetings:

- January 2013: Long Beach
- January 2014: Washington, D.C.
- January 2015: Seattle





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NOAO NEWSLETTER

Issue 111, March 2015



Recent Developments with the Thirty Meter Telescope

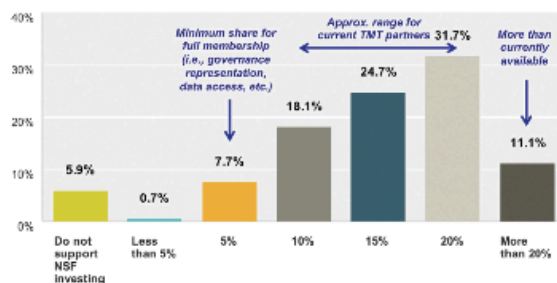
Mark Dickinson

The Thirty Meter Telescope (TMT) continues to move forward in its construction phase. Final legal permission to proceed with construction on Mauna Kea was secured in July 2014. The telescope and its many subsystems are approaching the "build stage," with a series of final design reviews planned in 2015. Production of blanks for the 492 1.44-m hexagonal mirror segments is well underway in Japan, and institutes in the US, Japan, China, and India are preparing to carry out segment polishing. Development of the first-generation instruments and adaptive optics system is progressing on many fronts. In December, the government of India signed financial agreements, and that country is now a full member in the TMT International Observatory (TIO), joining China, Japan, Caltech, and the University of California, which have also committed funding. Canada is a TIO Associate, awaiting funding decisions at the government level, and AURA is also a TIO Associate, with NOAO carrying out AURA's responsibilities and participation activities.

As part of a cooperative agreement with the National Science Foundation, TMT and NOAO have been engaging with the US astronomical community to understand its aspirations and priorities and to develop a model for potential US federal partnership in TMT. The US TMT Science Working Group (SWG), formed by NOAO, is helping to develop this participation plan, which will be submitted to NSF in 2015. The SWG consists of 13 astronomers from US institutions outside the current TMT partnership (see ast.noao.edu/system/us-tmt-liaison#SWG).

During September–October 2014, the SWG surveyed the astronomical community to gather information for the SWG's report to NSF. The online survey asked about priorities for TMT instrumentation, operations issues such as classical vs. flexible/queue scheduling, data management and archiving, and how to maximize the scientific return from a US national share of TMT observing time. Nearly 80% of the 467 people who responded to the survey were US astronomers outside the TMT partner institutions. Of those responding, 140 people contributed short "essays" with examples of TMT science programs that they might carry out, and there were hundreds of articulate comments related to the various survey topics.

One survey question asked: "In your opinion, what minimum partner share in TMT does the



Distribution of responses to the TMT US Community Survey question: "In your opinion, what minimum partner share in TMT does the US community (outside the current partners) need in order to conduct globally competitive science programs?"

US community (outside the current partners) need in order to conduct globally competitive science programs?" This question was accompanied by links to information about the costs and benefits of TMT membership and about the partner shares of the other TIO members. The graph above shows the distribution of responses to this question. Although about 6% of respondents did not favor US national partnership in TMT, those who did generally supported investment at a level similar to that of the other TIO members (approximately 10 to 20%). Sixty-eight percent favored participation at a level of 15% or more, which is roughly the share of TMT that is unsubscribed by the current partners. There were 166 respondents who offered thoughtful comments on this question, in many cases, providing justification for their recommended level of participation. Some wrote that participation at a level comparable to other partners was essential for the US community as a whole to aspire to a role of leadership in the 2020s, when three giant telescopes (TMT, Giant Magellan Telescope, and the European Extremely Large Telescope) will come on line. Others worried about the value of a relatively modest share of TMT time (15% would correspond to about 45 observing nights per year) for a large US community, or about the impact of TMT investment on NSF funding for other open-access observatories in the current budgetary climate. The SWG will take these comments into account in its report to NSF.

At the January American Astronomical Society (AAS) meeting in Seattle, TMT held an early

evening open house with refreshments that was attended by about 350 people. Michael Bolte (University of California, Santa Cruz) gave a short update on the TMT project status, and Mark Dickinson (NOAO) discussed the community liaison activities of the US TMT SWG and NOAO, including results from the community survey. (The presentation is available at ast.noao.edu/system/us-tmt-liaison.) After an open microphone question and answer period, participants at the open house broke up into several discussion groups that were organized by SWG members and TMT staff astronomers to talk about instrumentation, operations, data management, the role of TMT in the US optical/infrared system, and other topics.

During the coming months, the US TMT SWG will continue its dialogue with the astronomical community and develop its report for the NSF. The third annual TMT Science Forum (see associated article "Upcoming 2015 TMT Science Forum" in this issue) is an important opportunity for astronomers to get involved with TMT.

Resources for additional information:

NOAO TMT liaison activities:
ast.noao.edu/system/us-tmt-liaison
TMT information and FAQs:
ast.noao.edu/system/us-tmt-liaison/survey-faq
US TMT SWG on Facebook:
www.facebook.com/USMTSWG

+ NOAO Currents e-newsletter



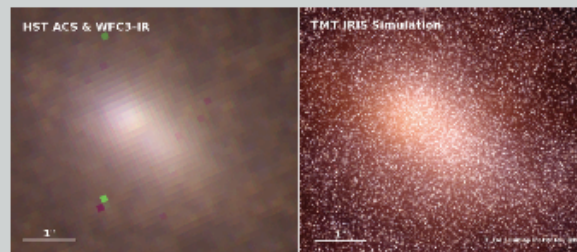
Upcoming 2015 TMT Science Forum

Mark Dickinson

The TMT Science Forum is an annual opportunity for astronomers from the international TMT community to meet, collaborate, and plan for future TMT science programs. Attending the Forum is the best way to become informed about the status of the observatory, its instrumentation and adaptive optics system, and to get involved in shaping the future of TMT.

The 2015 TMT Science Forum will be held on 23–25 June 2015 at the headquarters of the American Association for the Advancement of Science (AAAS) in Washington, D.C. The meeting theme is "Maximizing Transformative Science with TMT." The registration deadline is 15 May 2015.

With nine times more collecting area than a Keck telescope and 12 times better angular resolution than the Hubble Space Telescope (HST) in the near-infrared, TMT will enable amazing new science (see figure). The 2015 Forum is an opportunity to think about how to maximize the scientific return from TMT through innovative collaborations, telescope operations, data management, and instrumentation development. The meeting will feature presentations about truly transformative science that will be possible with TMT and focus on *how*



Diffraction-limited imaging and integral field spectroscopy from TMT's first-light instrument IRIS (Infrared Imaging Spectrograph) and the NFIRAOS (Narrow Field Infrared Adaptive Optics System) will resolve stars at the center of M31, measuring proper motions within the sphere of influence of the central, supermassive black hole as well as dynamics and stellar population properties. Left: A three-color image using the HST Advanced Camera for Surveys (F814W) and Wide Field Camera 3 (F110W, F160W). Right: A three-color image (J, H, and K bands) using TMT-IRIS. The diffraction limited point spread function has full width half-maximum equal to 0.017 arcseconds at a wavelength of 2 microns. (Image credit: Dr. Tuan Do and the IRIS Science Team.)

best to accomplish that science. There will be working sessions devoted to planning for possible TMT key programs that could span the international TMT partnership as a way to carry out projects that might exceed the capacity of individual scientists and teams within any single partner. The implications of such programs for TMT operations and the evolution of its instrumentation suite will all be discussed.

The NSF-TMT cooperative agreement provides generous funding for members of the US community to attend the TMT Science Forum. Write to tmt@noao.edu for more information, and watch the Forum website (conference.ipac.caltech.edu/tmtsf2015), the NOAO Currents electronic newsletter, and the US TMT SWG Facebook page for more information.

Community engagement: Visits and presentations

- Warren Skidmore (+ occasionally others)
- Detailed presentation about TMT project and science
- Extended visits to meet & talk with local scientists

Univ. of Cincinnati, Cornell, Penn State, Univ. of Florida, Florida International Univ., NOAO & Univ. of Arizona, Boston Univ., Brown Univ., MIT, IPAC, NASA Goddard, Univ. of Maryland, Univ. of Indiana, Caltech Astronomy, STSCI, John Hopkins Univ., UH Manoa/IfA, Gemini North, CFHT/Keck, Subaru, UH Hilo, Michigan State Univ., Univ. of Michigan Ann Arbor, Arizona State Univ., USNO, Lowell, Northern Arizona Univ., Univ. of Texas Austin, Univ. of Texas San Antonio, SWRI, NRAO & Univ. of Virginia, Georgia State Univ., Georgia Tech, Texas A&M, Sam Houston State, Rice Univ., Aerospace Corp, Ohio State, Louisiana State, AMNH, Stony Brook, Columbia, San Francisco State Univ., UC Davis, Univ. of Rochester & RIT, Rutgers, UC Davis, UC Riverside

- Contact Warren (was@tmt.org), Mark, or tmt@noao.edu if you would like to arrange a visit

TMT International Science Development Teams (ISDTs)

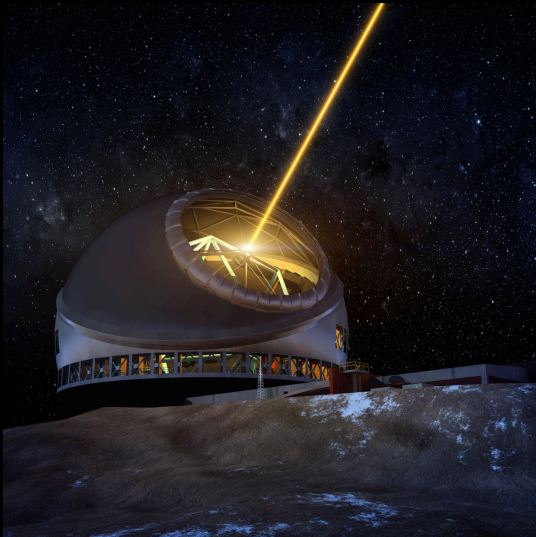
- **Open to all PhD astronomers**
 - 198 scientists worldwide, **56 from US-at-large community**
 - Annual call for new members
 - **The best way for astronomers anywhere to get involved in TMT**

Fundamental Physics & Cosmology Early Universe, Galaxy Evolution, and the IGM Milky Way and Nearby Galaxies Supermassive Black Holes	Formation of Stars & Planets Exoplanets Our Solar System Time Domain Science
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- Provide **scientific input & guidance** to TMT
- Help **define observatory capabilities & operations model**
- Plan for **future TMT science programs**
- **Foster collaboration & cooperation** between scientists in and beyond the international TMT partnership

Thirty Meter Telescope Detailed Science Case: 2015

International Science Development Teams
& TMT Science Advisory Committee



Detailed Science Case 2015

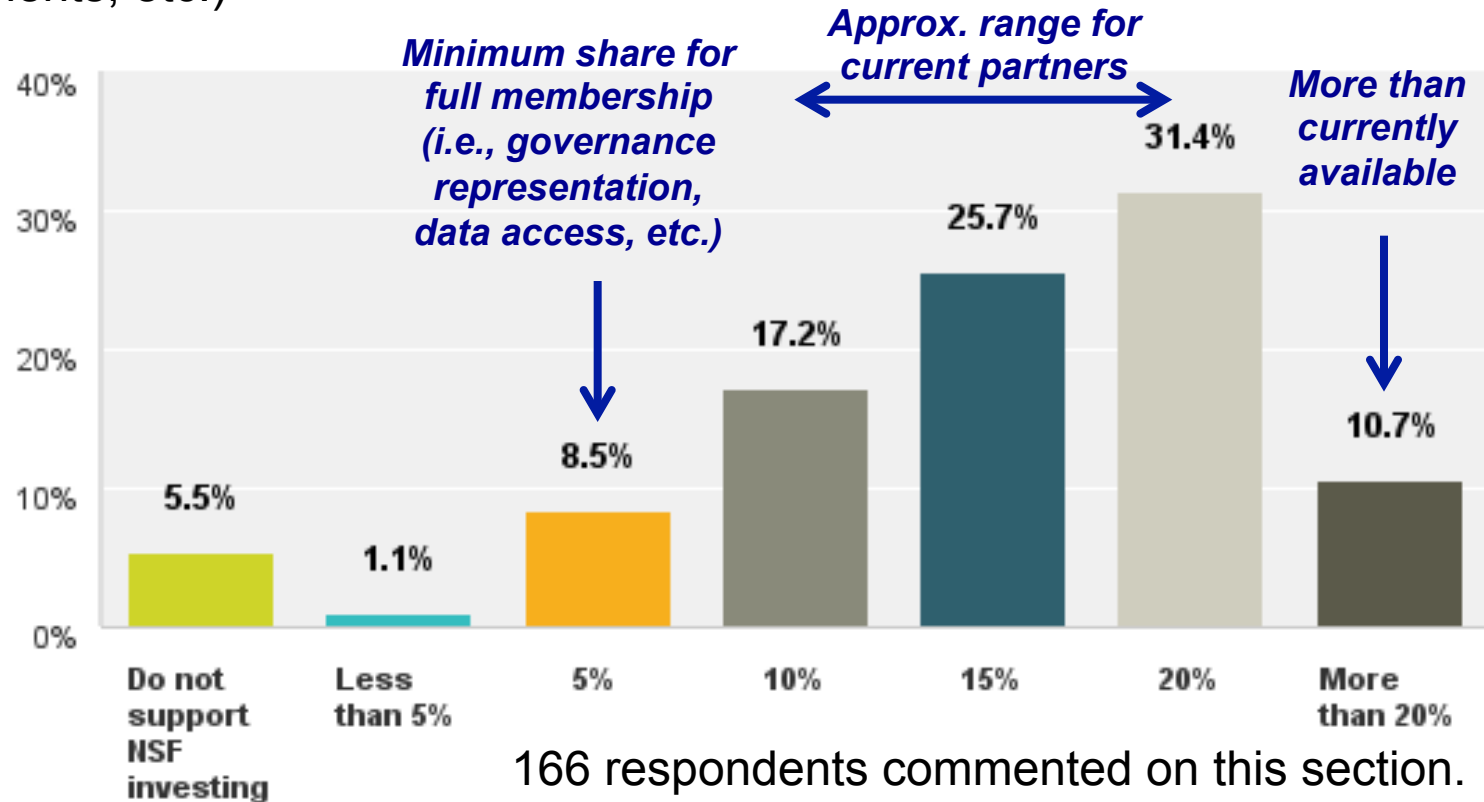
- **DSC is the highest-level description of the scientific motivation for a TMT**
- 2007 version was significantly outdated
- 2013: launched on update, enlisting the (then) new ISDTs
- **152 people contributed to DSC-2015 – a TMT-wide community effort!**

arXiv:1505.01195

Warren Skidmore: editor-in-chief

-
- Sept.-Oct. 2014: US TMT SWG carried out an on-line survey of the astronomical community's interests in, priorities for, and opinions about TMT
 - Aimed primarily at the US-at-large community
 - Results inform the SWG's report to the NSF
 - 467 responses, 364 (78%) from US scientists outside the TMT member institutions (UC+Caltech). *Thank you!*
 - 21 main questions, mostly multiple choice, with optional comment / essay sections
 - Many articulate comments regarding instrumentation, operations, time allocation, data management
 - 140 “essays” with example science programs
 - Solar system, exoplanets, star & planet formation, stellar physics, stellar populations, galaxies & AGN, high-z galaxy evolution, first-light & reionization, fundamental physics, cosmology, time domain

“In your opinion, what minimum partner share in TMT does the US community (outside the current partners) need in order to conduct globally competitive science programs?”
(Accompanied by information on costs & benefits, comparison to other NSF-AST investments, etc.)



Many of the topics to be discussed at this Forum are subjects of active consideration by the SWG:

- How to maximize the scientific return of TMT for all astronomers
 - And specifically for the US community as a potential TMT partner
- Time allocation and the balance of small and large science programs
- “Key Programs”
 - Enabling bigger TMT science
 - Opening more opportunities for participation in TMT science
 - Producing large, coherent data sets with high archival re-use value
- Data management, pipelines and archives
- TMT operations and observing / scheduling modes
- Future generation TMT instrumentation
- Workforce, Education, Outreach, Communications

For more information or questions: tmt@noao.edu

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

US TMT SWG: <https://www.facebook.com/USTMTSWG>

Thank you!



TMT

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Wide interest in all 3 first-light instruments:

55%	IRIS – Near-IR diffraction-limited IFU
44%	WFOS – Wide-field optical multi-object spectrograph
37%	IRMS – Near-IR multi-object spectrograph
18%	<i>TMT first-light instruments are not suitable for my science</i>

Diverse priorities for future-generation instrumentation

- Strong interest in high-resolution spectroscopy (not part of current TMT 1st-light instrument suite)

Respondents put high priority on support for data reduction & analysis:

- High quality data reduction software & pipelines viewed as very important (70-80%)
- 39% feel that TMT should routinely process & archive most science data

86 detailed, articulate comments from users:

- Many remark that high quality data support is essential to realize the scientific return from TMT for the US community
- Frequent comparisons of data management support to that for space observatories (e.g., HST, Chandra, Spitzer)
- But, recognition of the challenges (& costs) of doing this for ground-based O/IR

Current TMT operations model plans for mainly classical observing (initially)

- Allows partners to run their own queues within their time allocations if desired

“How important is it for the US community to use queue scheduling for part or all its time?”

6%	Not important
23%	Somewhat important
38%	Very important
33%	Essential

- 66% of respondents felt that TMT should have an observatory-run, partnership-wide queue for some (39%) or all (28%) of its observing time.

52 comments, often quite detailed, ranging from strong advocates for queue/flexible scheduling to strong reservations.

Optimizing a US share of TMT (time allocation & other issues)

- Current TMT operations model has independent time allocation for all partners (like Keck).
- Survey asked how US time should be used to maximize the scientific return from TMT for the US community.

“If the US were a TMT partner, how should it allocate its time?”

44%	Mainly PI-led regular observing programs
53%	20-50% for large or survey programs
2%	50-100% for large or survey programs

TMT may implement large/survey programs (“key projects”), involving shared/ coordinated time allocation from multiple partners.

“Would US participation in multi-partner TMT large/survey programs be important?”

10%	Not important
35%	Somewhat important
41%	Very important
14%	Essential

Survey comments about US national participation in TMT

Enthusiasm:

“Crucial to remain competitive.”

“What I MOST see as a continued need is access to QUALITY facilities for students and faculty not associated with the large institutions!”

“Large aperture absolutely needed to go beyond what JWST can do in terms of raw sensitivity and resolution.”

“The United States should aspire to a role of leadership. Therefore it is important that its share be approximately equal to that of the largest partners.”

“This is roughly the size of the US (NASA) access (18%) to Keck, and it's working out.”

“Community access to the data archive is key.”

Concerns:

“Mostly, I worry that time on it would just be too difficult to get!”

“Depends on capabilities and amount of time available. 1 hour per year is not useful.”

“Only if available in large enough amounts of time to compete with the large share holders.”

“Only if it also includes a high dispersion spectrograph.”

“The best thing for most of the community would be significant access to medium and large class telescopes, not a very large telescope with minimal time available.”

“I would prefer the US community did not get involved in this, when we can't even afford to keep Kitt Peak operating.”

Acknowledgments

We thank the Gordon and Betty Moore Foundation for its generous support of the TMT Project, and the National Science Foundation who support the US TMT liaison activities under a cooperative agreement with TMT.

We recognize and acknowledge the very significant cultural role and reverence that the summit of Mauna Kea has always had within the indigenous Hawaiian community. We are most fortunate to have the opportunity to conduct observations from this mountain.