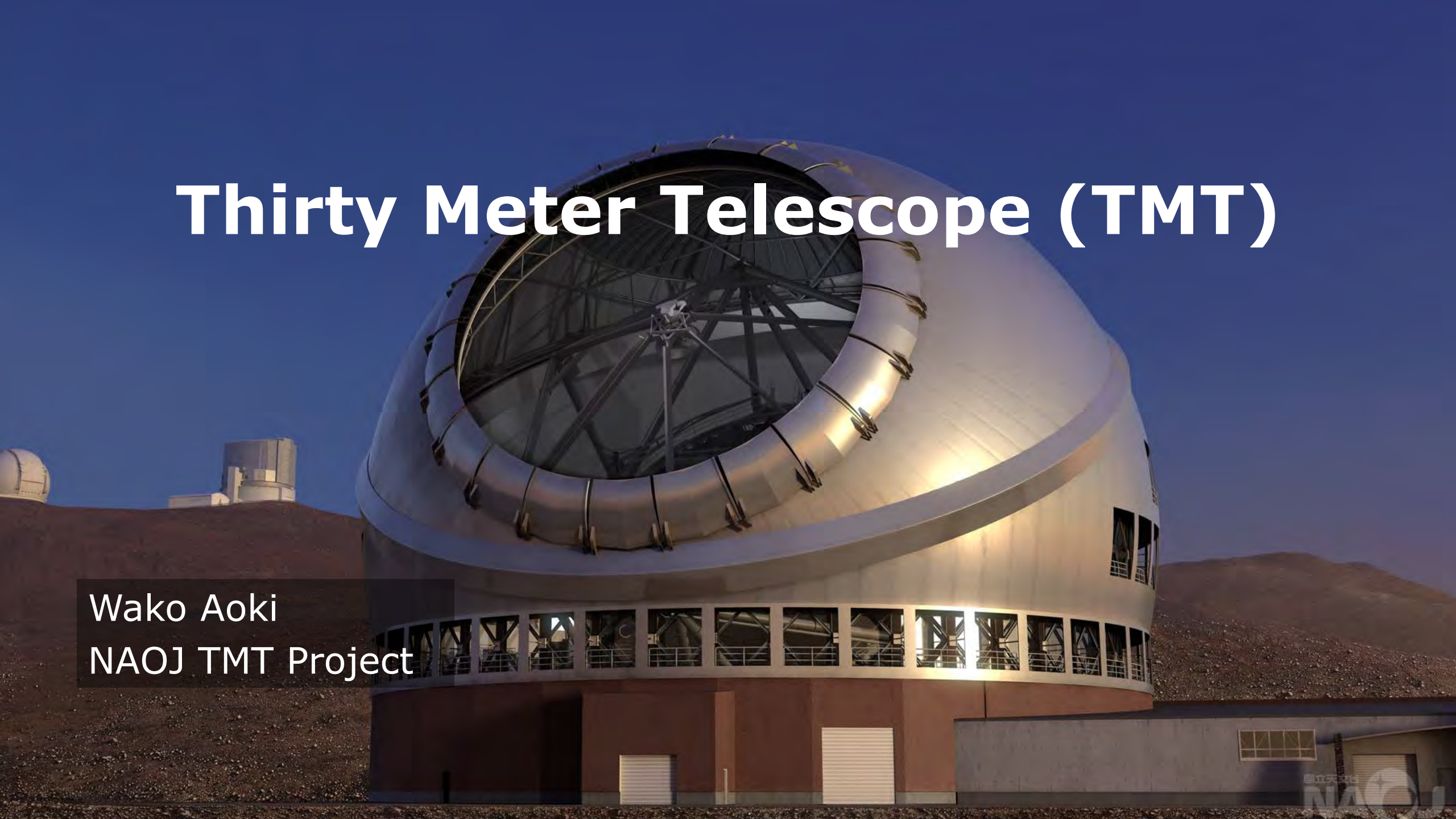
Thirty Meter Telescope (TMT)



Wako Aoki
NAOJ TMT Project

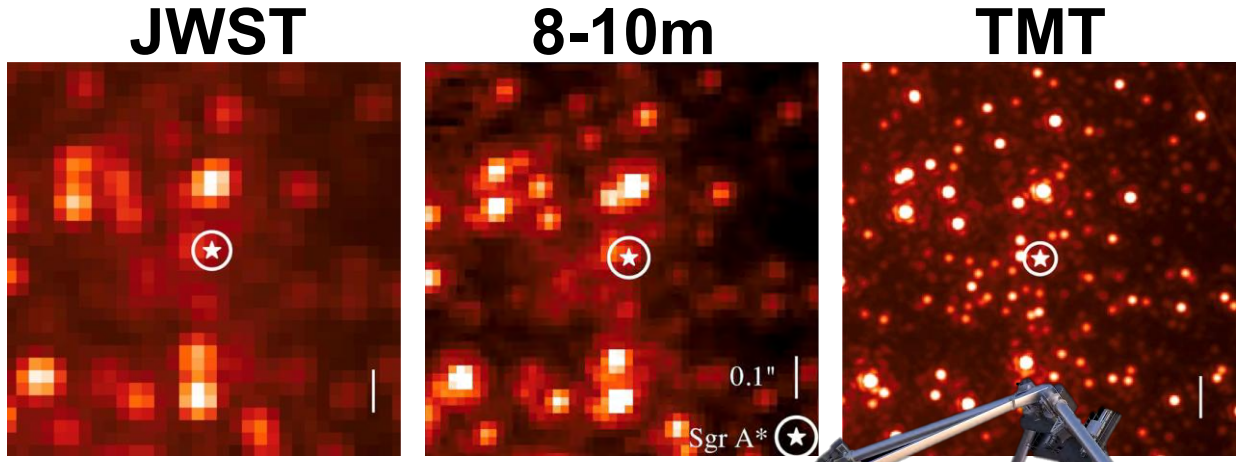
Unprecedented Capabilities of the TMT

Angular Resolution
Sensitivity

TMT offers exceptional clarity

TMT's images are

- ▶ 5x sharper than JWST
- ▶ 3x sharper than 8-10m class telescopes



TMT is extremely sensitive

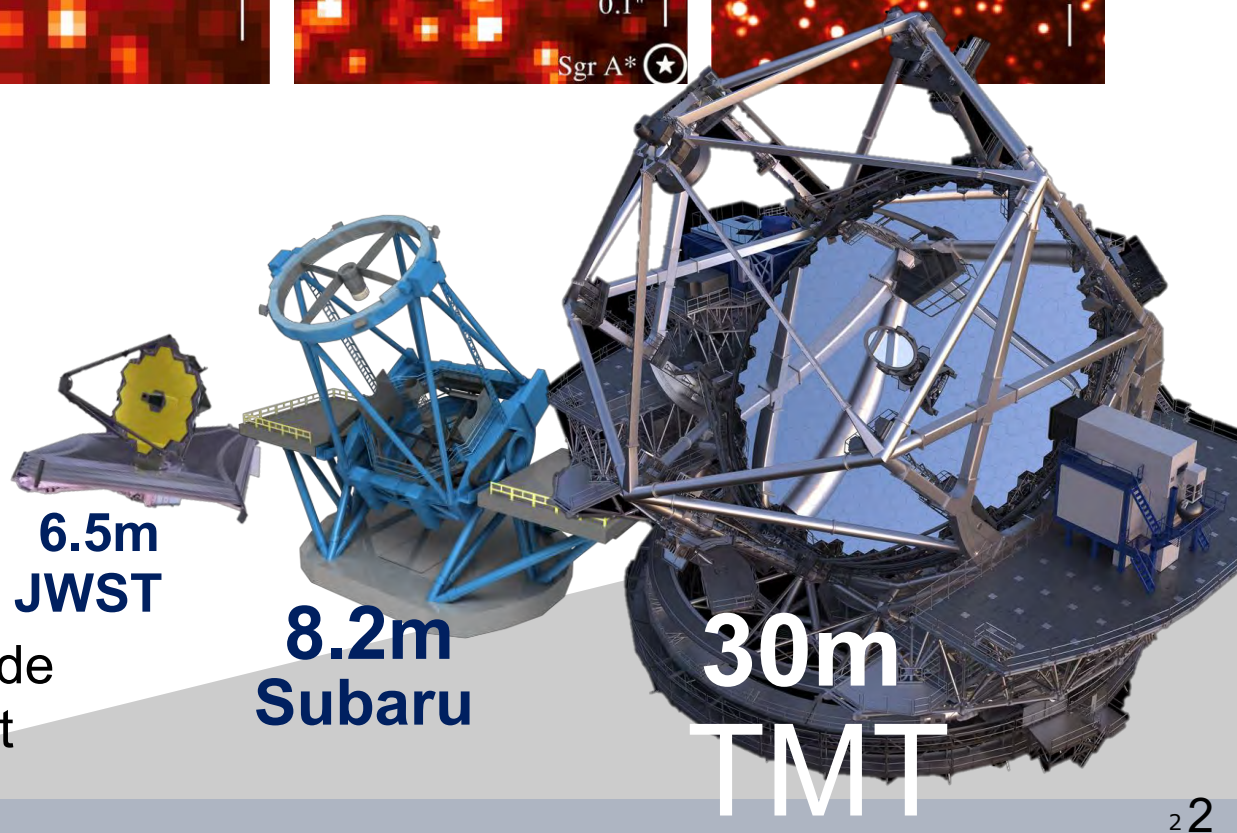
TMT is

- ▶ 20x more sensitive than JWST
- ▶ 100x more sensitive than 8-10m telescopes

TMT completes a 10-hour Subaru Telescope observation in just 3 minutes.

Japan's strategy

Subaru Telescope's wide-field observations will provide targets for TMT's observations, including most distant galaxies and rare explosive events like supernovae.



Synergies with JWST

Synergy and Strategy

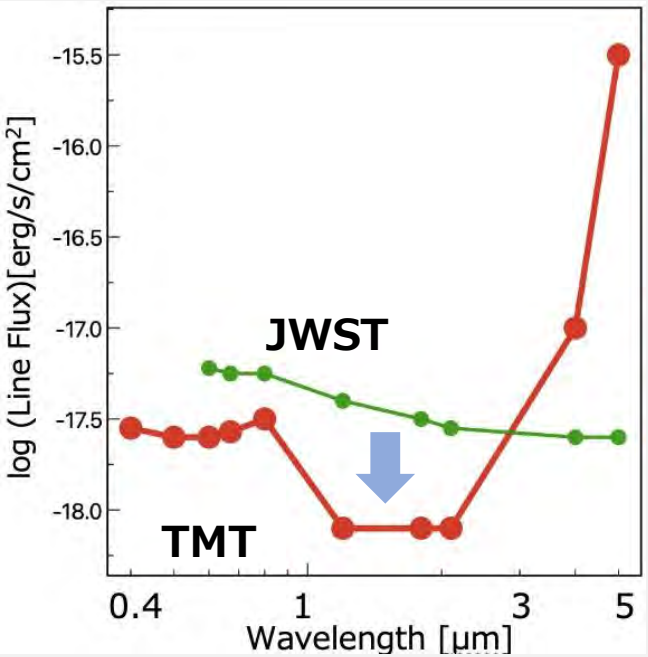
JWST

High-sensitivity in imaging and low-resolution spectroscopy, in particular mid IR with low thermal background

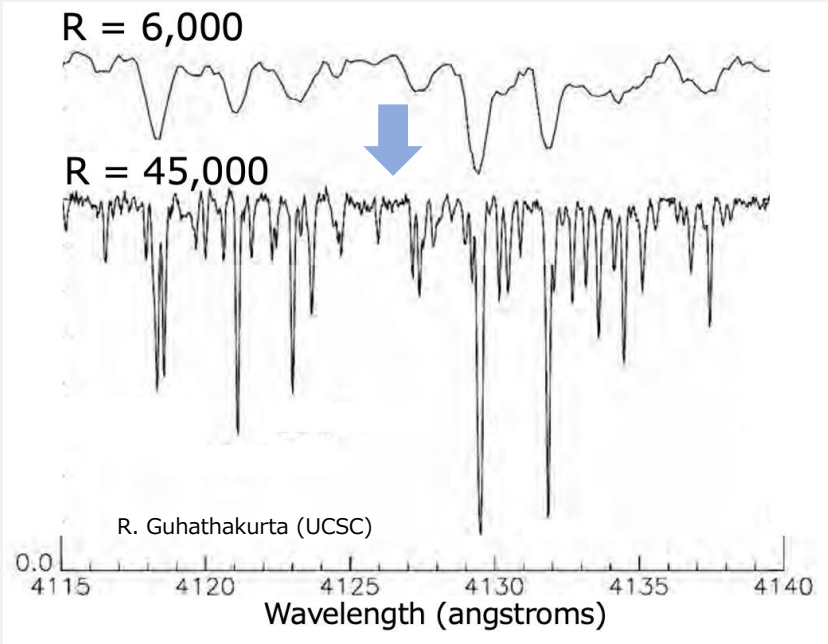
TMT

High-sensitivity in optical and near IR spectroscopy
High-resolution spectroscopy from UV to mid IR

► **High-sensitivity in opt/near IR spectroscopy for point sources**



► **High-resolution spectroscopy**



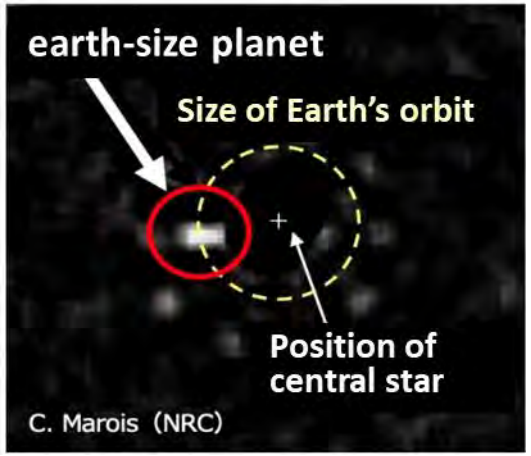
Top Level Science of TMT

PO-16P Yasui

Science Goals

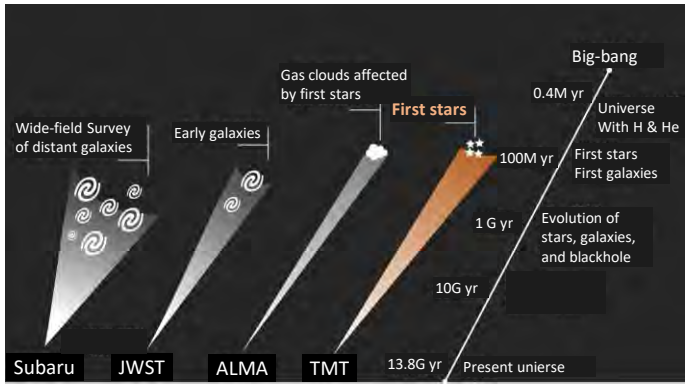
Optical/infrared telescope with 30m aperture to be constructed on Maunakea, Hawaii by international Collaboration

Searches for signature of life in exoplanets



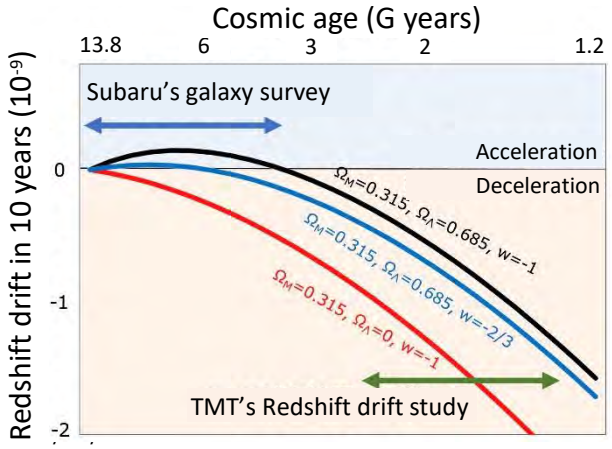
TMT will challenge detection of **molecules related to life (e.g., O_2, O_3, CH_4)** through **direct imaging of earth-like exoplanets** and spectroscopic study of their atmosphere.

Detection of light from first stars



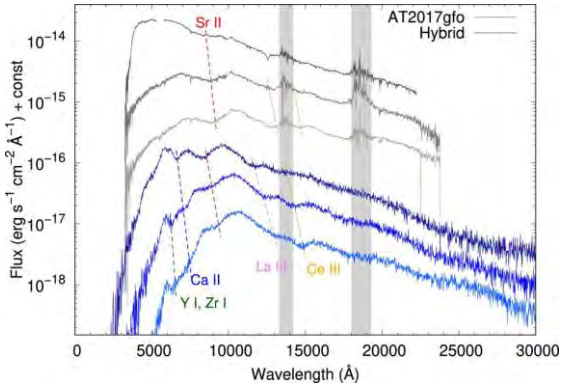
Detection of He emission line expected from first stars will constrain the timescale of first star formation as well as their nature and role in galaxy formation.

Constraining the nature of dark energy



Direct measurement of the universe expansion by the redshift drift of intergalactic matter will constrain the nature of dark energy.

Multi-messenger astronomy

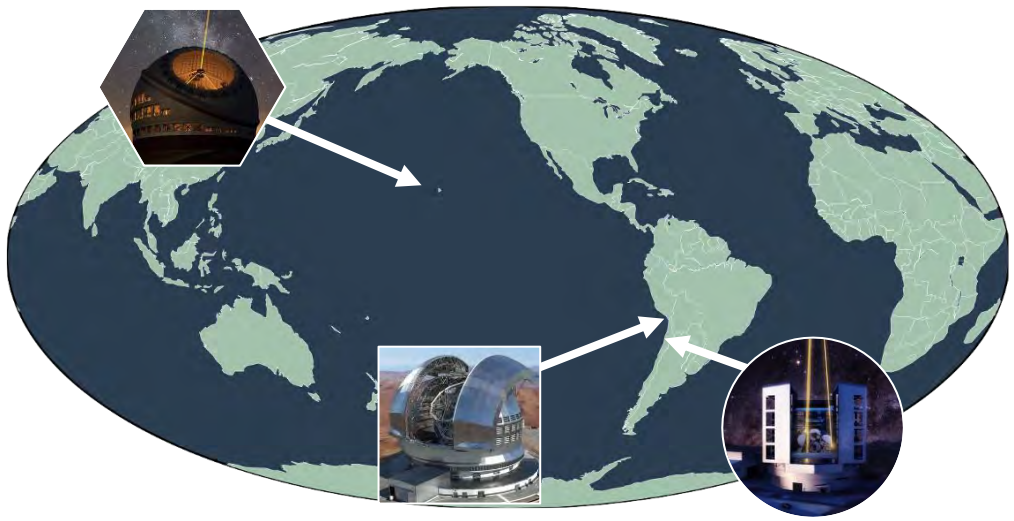


TMT will play crucial role in optical-infrared spectroscopy for events detected by gravitational wave or neutrino to explore physics in extreme environment and origins of heavy elements

TMT's Uniqueness over E-ELT/GMT

Synergy and Strategy

- **The only ELT in the northern hemisphere**
- **Widest FOV** (9x than E-ELT) and **highest efficiency** (~1.2x than E-ELT), wide-field MCAO system, and wide-field visible MOS.
- **Quick instrument switching time (<10 min),** which is **a significant advantage** for rapidly decaying **ToO sources such as neutron star mergers, initial phases of supernovae explosion**
- AO-assisted at 1st light, providing diffraction limited resolution from early science



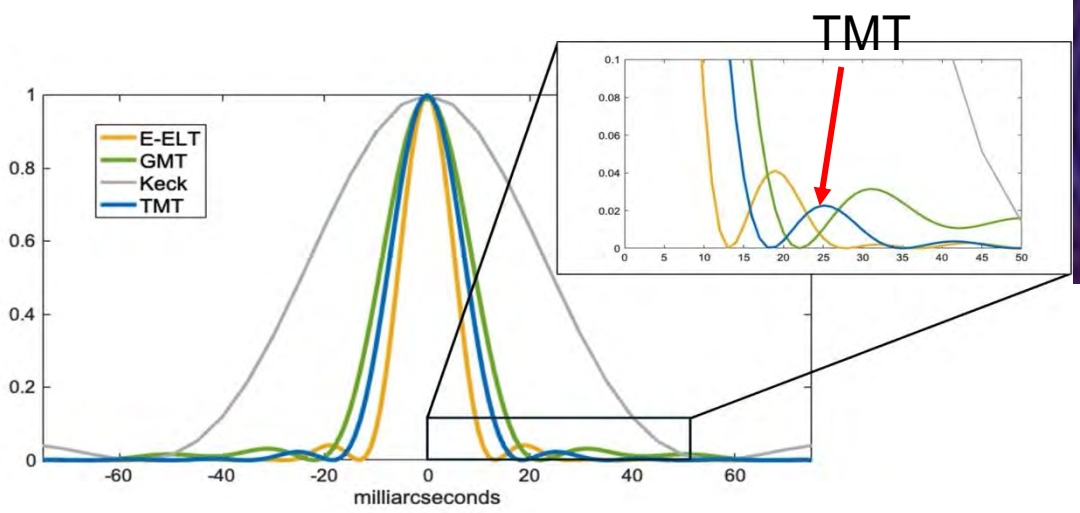
	TMT	GMT	E-ELT
M1	30m f/1	24.5m	39m f/0.87
M2	3.1m	1.1m x 7	4.1m
# of mirrors	3	2-3	5
Efficiency	0.92	0.92-0.95	0.79
FOV	20' (15' unvignetted)	20'	10' (5' unvignetted)

GMT : Giant Magellan Telescope, E-ELT : European Extremely Large Telescope

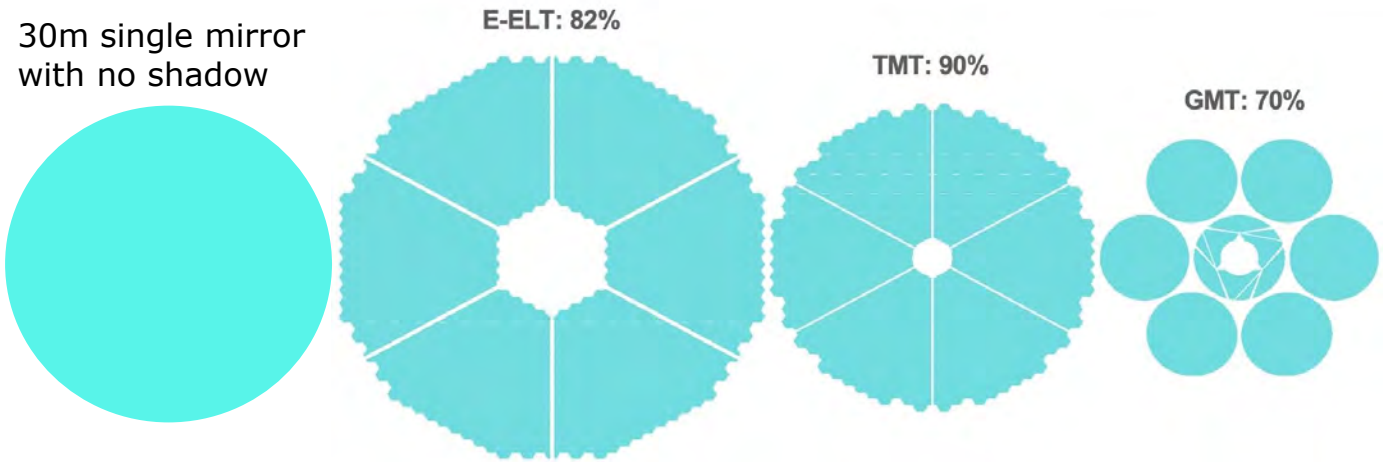
The best Point Spread Function

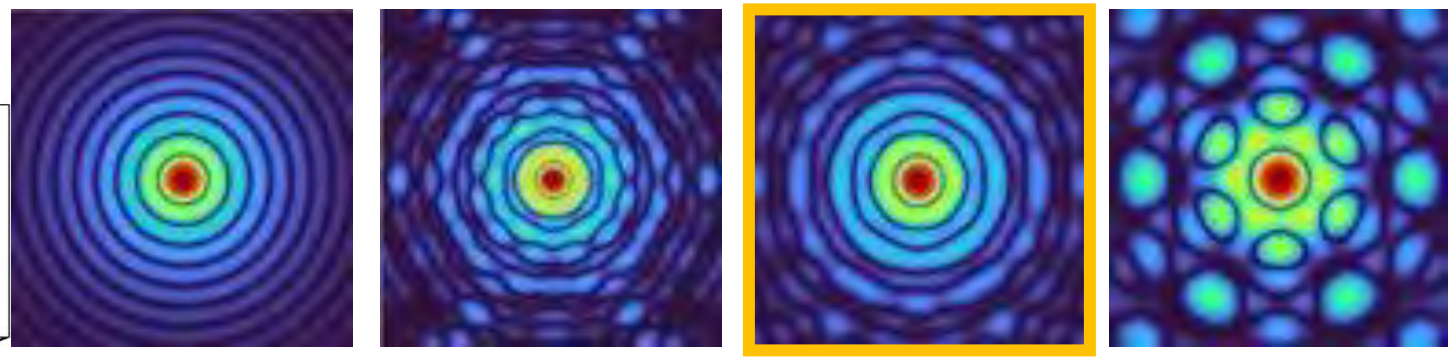
Site Comparison

- TMT has a simple optical layout with 90% of diameter filled with mirrors.
- TMT has the cleanest PSF with lowest side-lobes.
- Extremely important for high-contrast exoplanet observations.



Primary mirror with shadows of the secondary mirror and spiders





Point Spread Function (PSF): TMT has a clean PSF close to the 30m single mirror

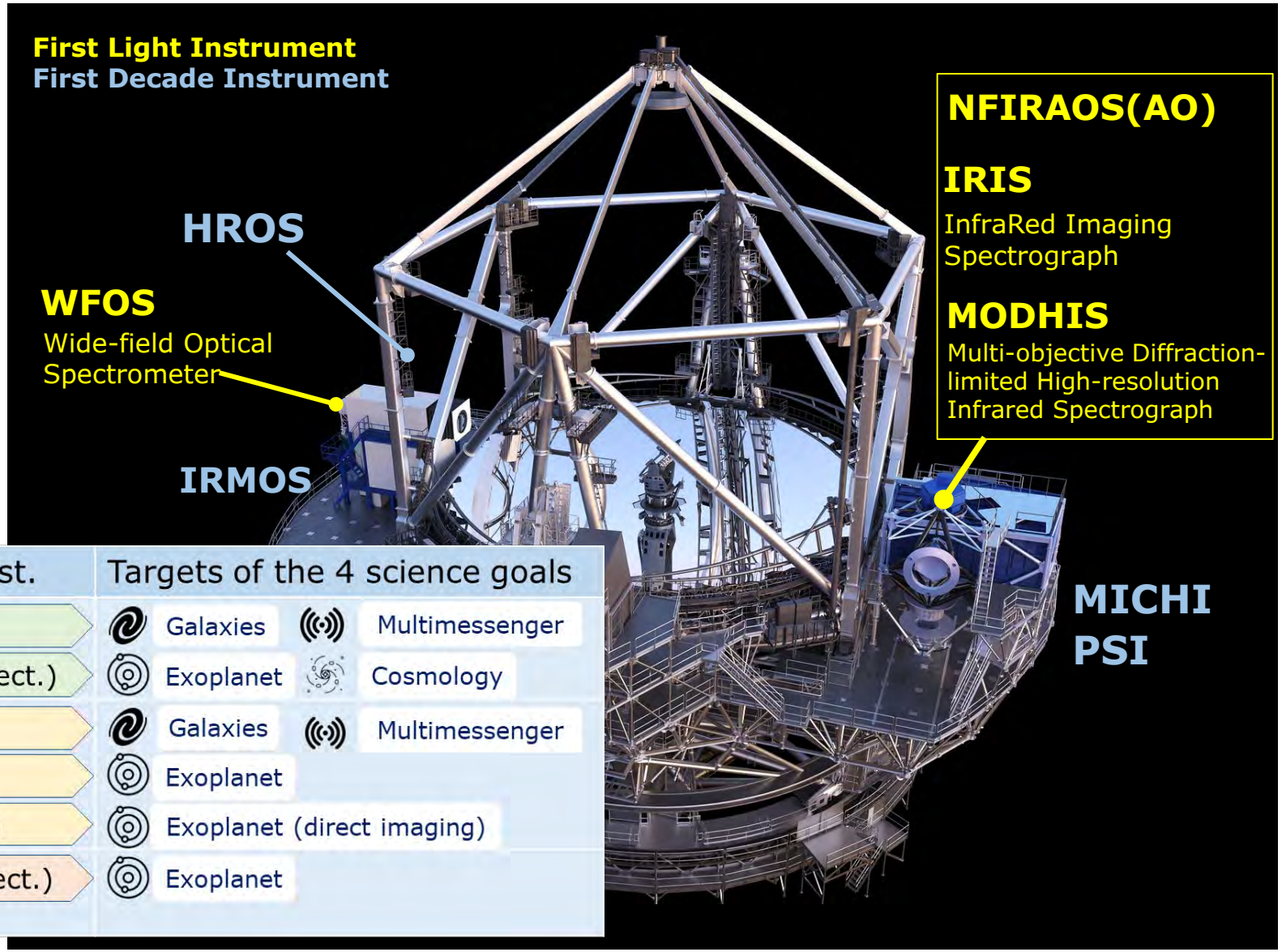
GMT：Giant Magellan Telescope, E-ELT：European Extremely Large Telescope

Science Instruments: First Light and Beyond

Instrument plan

- IRIS with AO provides diffraction-limit images
- MODHIS provides NIR high-resolution spectroscopy for exoplanet science
- Wide-field Optical Spectrometer WFOS

PO-17P Ozaki



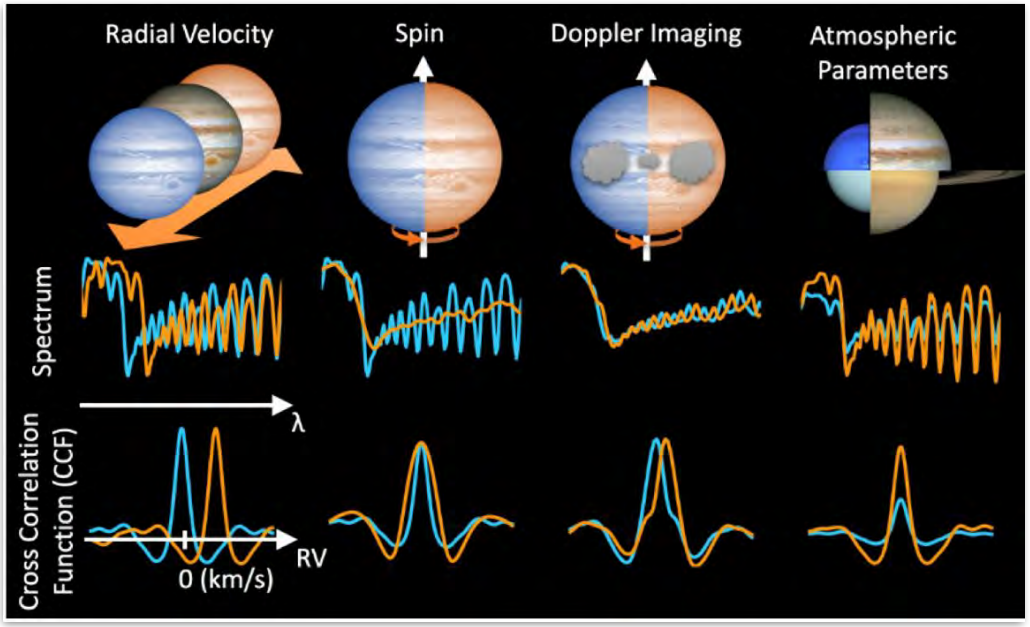
	First light inst.	2nd generation inst.	Targets of the 4 science goals
Optical	WFOS (Wide Field Spect.)		Galaxies, Multimessenger
		HROS (High-res spect.)	Exoplanet, Cosmology
Near Infrared	IRIS (Imager/Spect.)		Galaxies, Multimessenger
	MODHIS (High-res spect.)		Exoplanet
		PSI (High contrast)	Exoplanet (direct imaging)
Mid Infrared		MICHI (Imager/Spect.)	Exoplanet

MODHIS – Searching for life

Extrasolar Planets

Multi-Objective Diffraction-limited High-resolution Infrared Spectrograph

- MODHIS uses high resolution spectroscopy (R=100,000) to characterize exoplanets. JWST has no instrument of this type.
- TMT's clean and sharp AO images maximize MODHIS's sensitivity.



MODHIS could be the first instrument to detect the effects of life on another world.

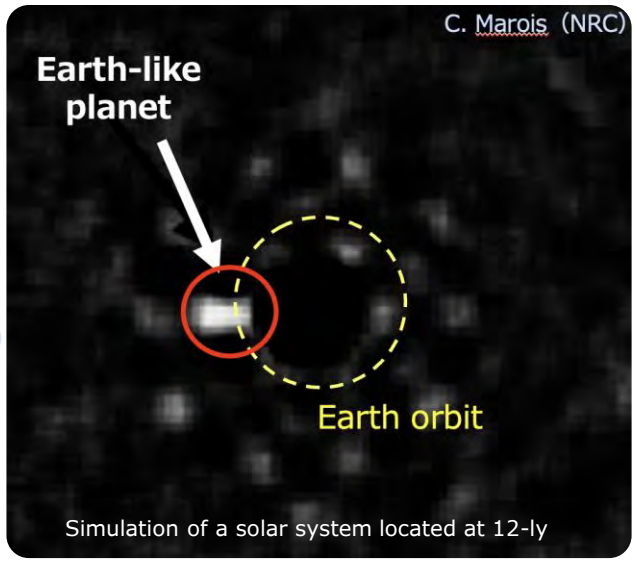


Direct imaging of rocky exoplanets

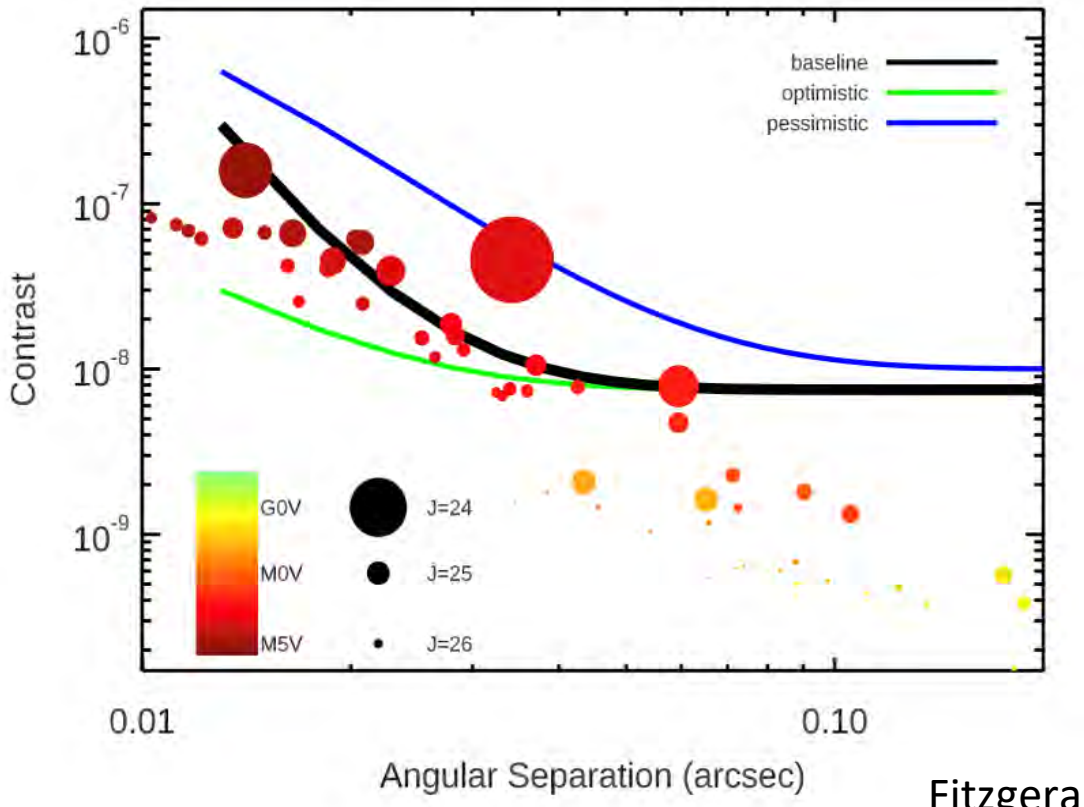
Extrasolar Planets

Discovery potential for habitable zone rocky planets.

- With PSI-Blue's high contrast observations (contrast 10^{-8}), it is possible to detect 1 to 20 Earth-sized habitable zone planets around nearby low-mass stars (M-type stars).







Fitzgerald+2022

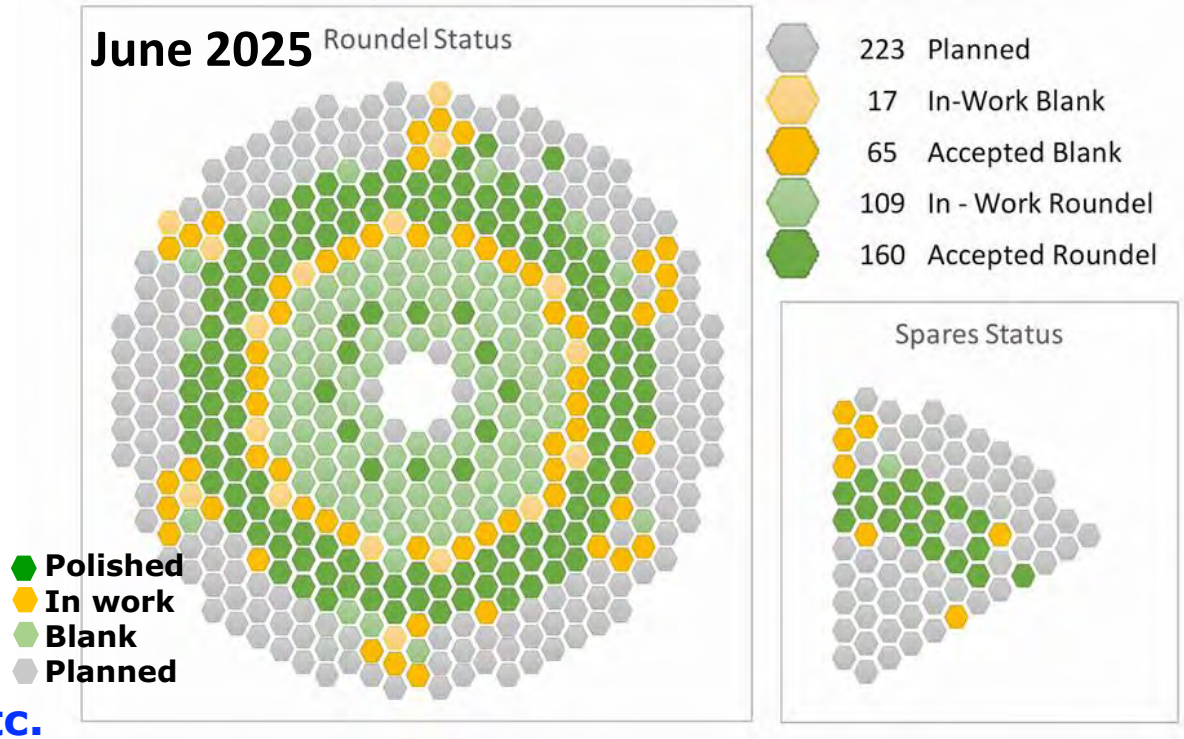
Technical Readiness: Primary mirror

Primary mirrors

PR-9P Noumaru

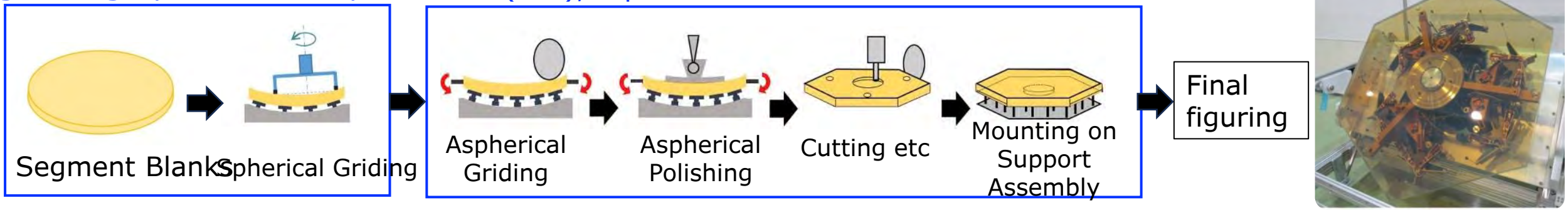
Mass production for blanks and aspherical polishing are ongoing

- **482(+82 for exchange) segments**
  356 blanks have been manufactured in Japan
- **Polishing in US(TIO), Japan and India**
  Polishing of more than 180 segments is completed.



Mirror blanks +spherical grinding: produced in Japan

Aspherical polishing etc. in US(TIO), Japan and India.



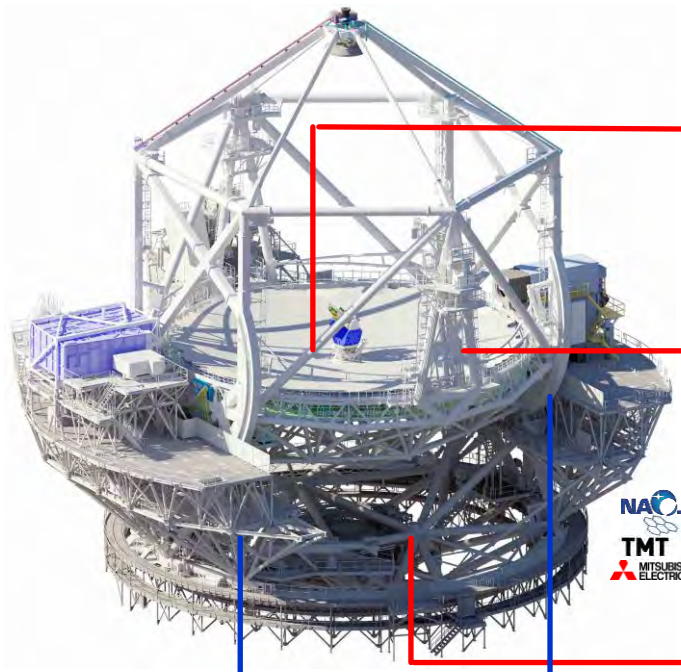
Technical Readiness: Telescope Structure

Telescope structure

PO-15P Terada

The final design of the telescope structure and its control system are completed.

- Eextensive analysis, modeling, and prototyping by Mitsubishi Electric (MELCO), Hitachi Zosen (Hitz, now Kanadevia) and NAOJ.
- Passed three production readiness reviews (PRRs) of the main components (Azimuth, Elevation and Nasmyth structures)





Prototype of the primary mirror cell

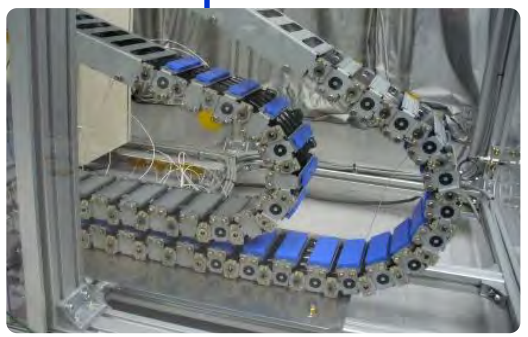


GOOD DESIGN

Segment-Handling Robot, equipped with an image recognition system and force sensors. Winner of the 2016 Good Design Award.



Prototype of welded joint of multiple branch pipe supporting telescope structure.



Cable winder for the Elevation axis. The cableveyor connection structure allows for a smooth operation.



A unique seismic isolation mechanism that combines seismic isolation damper and locking functions.

TMT's progress towards construction

Construction site

Building trust for Maunakea Astronomy and TMT

TIO reviewed problems of the activities in Hawai'i until 2019 and reshuffled the engagement team.

The new TIO engagement team and education programs（2021～）

- ► The TIO Project Manager and the NAOJ TMT Project Manager have been communicating with many local residents through long hours of direct dialogue based on listening and respect.
- ► TIO has implemented a program to support the education of local children based on the needs found through the above dialogues.
- ► The change of TIO has been being recognized in local community. TMT has strong support by the state Governor, legislature, and the county Mayor

Maunakea management（2023～）

- ► The new Maunakea management organization MKSOA involving native Hawai'ians formally started the transition period
- ► At the September 2025 board meeting of the MKSOA, the TIO Project Manager gave a report, and the project was discussed in depth.
- ► Decommission of two aged telescopes completed in 2024.


Dialogue with native Hawai'ians



Article featuring TMT's change

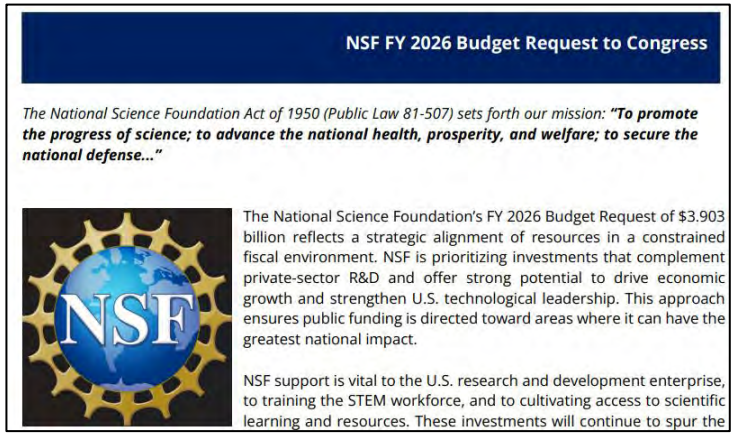

CSO Decommission 2024

Status toward NSF's participation

Construction plan

Review process of National Science Foundation (NSF) of USA

- Review of the project for construction funding (Preliminary Design Phase and Final Design Phase)
- NSF's Environmental impact assessment and the National Historic Preservation Act in Hawai'i



Status of NSF process

- The **FY2026 NSF budget request** (May 30) stated that while GMT would advance to the Final Design Phase, TMT would not.
- In July **the Senate Appropriations Committee** issued a report accompanying its appropriations bill, which contained strong language directing that "**NSF shall immediately advance both US ELTs into final design review**". Discussion at the Congress on the federal budget for FY2026 is critical.
- TIO and NAOJ are actively engaging with U.S. congressional stakeholders and other relevant parties.

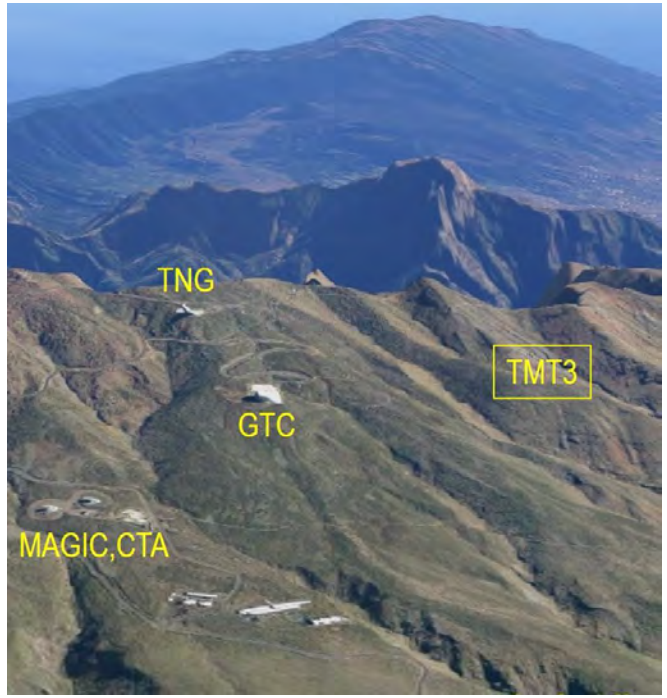


Spanish Proposal Regarding TMT La Palma

Construction plan

Background

- La Palma Island as alternative site selected in 2017
- Construction permits have been obtained and are valid



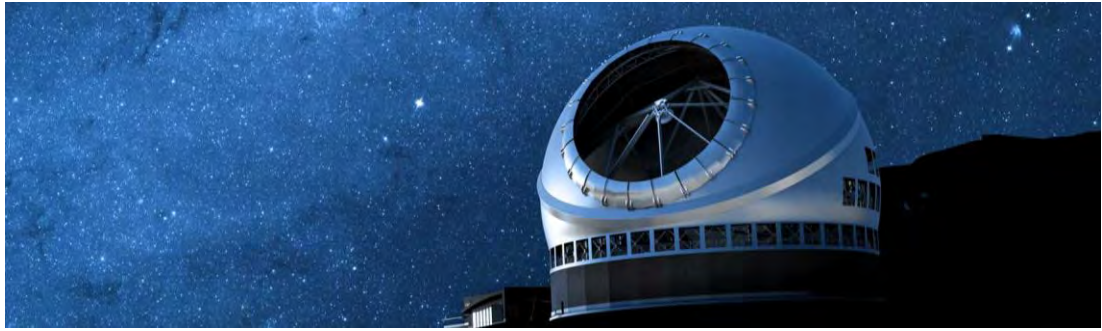
Proposal by Spain

- In July, TIO received a proposal from CDTI (Centre for Technological Development and Innovation). Spain's Minister of Science, Innovation, and Universities announced that, in order to host TMT on La Palma, the Spanish government proposes to contribute up to €400 million through CDTI.
- TIO has been communicating with CDTI/IAC for fact finding and discussions.

NAOJ's position

- NAOJ expresses its support for relocation to La Palma in the case that construction in Hawai'i becomes infeasible, provided that the project is expected to receive sufficient funding for construction and operation in La Palma.

Thirty Meter Telescope



summary

- ►TMT has unprecedented capability in the extremely high spatial resolution and sensitivity. Good synergies with JWST and Subaru.
- ►TMT is the only ELT in the northern hemisphere.
- ►The activities of TIO engagement team and education programs in Hawai‘i since 2021 have been being recognized in local community. For participation of NSF, discussion at the Congress on the federal budget for FY2026 is critical.
- ►TIO has been communicating with Spain following their proposal for construction in La Palma.

The astronomy community in Japan expresses strong support for the TMT project at Maunakea and at La Palma as the alternate site.