TMT Thirty Meter Telescope

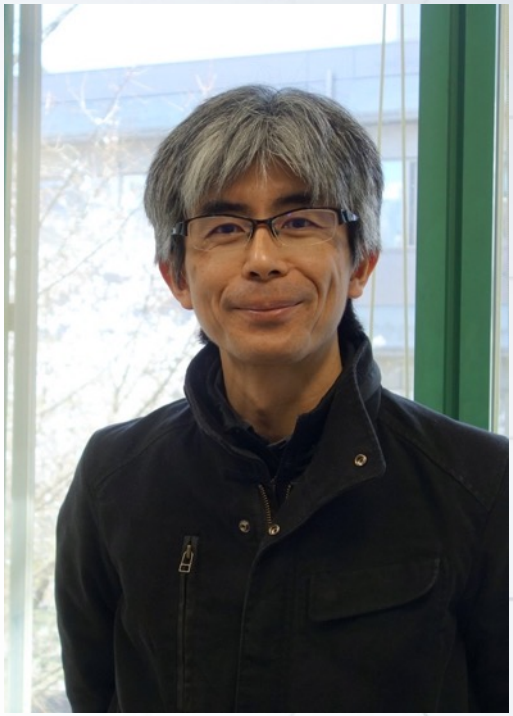
NAOJ National Astronomical Observatory of Japan

# Thirty Meter Telescope (TMT) Progress Report

**Tomo Usuda** (NAOJ TMT Project Manager)

# NAOJ TMT Project Deputy Project Manager

- Dr. Ikuru Iwata, Deputy Project Manager at NAOJ TMT Project will resign from NAOJ at the end of this January. He has been offered a manager position at IGES.
- We appreciate his outstanding contributions to TMT, Subaru Telescope, OAO, etc. at NAOJ and are looking forward to his future performances.
- This is a good result of the highly evaluated experience in international projects like TMT and Subaru Telescope. Moreover, it can be said that the experience of international projects at NAOJ can be utilized in wide fields.
- Two new positions (Professor and Associate Professor) will be open soon. We are waiting for your applications for the worthwhile project, TMT.



TMT Thirty Meter Telescope

# A New-year's Message from the Director General, NAOJ

NAOJ National Astronomical Observatory of Japan

- The actualization of TMT is extremely important, not only for astronomy, but for the overall academic development of Japan. I think that we can make TMT happen; or more correctly, I should say, allowing TMT to fizzle out uncompleted is not an option. But in order to create TMT, the most important thing is for not just everyone within NAOJ, but the entire Japanese astronomy community and the wider Japanese academic community to unite and declare with one voice that we won't give up on the construction of TMT.
- Thanks to the efforts of the MEXT, we have secured the JFY2022 budget for TMT as a Large-scale Academic Frontier Promotion Project. With the strong will of the community and such strength of Japan behind us, we are determined to build an extremely large telescope at the best site in the world.

TMT Thirty Meter Telescope

NAOJ National Astronomical Observatory of Japan

# NSF

# (National Science Foundation)

# Astro 2020

TMT Thirty Meter Telescope

# USELT Program

NAOJ National Astronomical Observatory of Japan

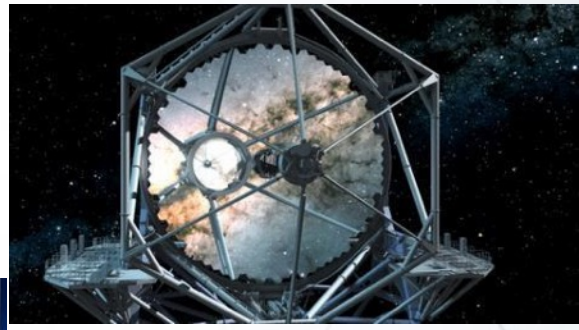
- The US-ELTP partners include: NSF's NOIRLab, managed by the AURA, GMTO, and TIO

→ **US ELT Program: ≥ 25% open access to both TMT & GMT**

to expand US scientific achievement,

to enable frontier research programs,

to deliver bi-hemisphere system.



NSF's National Optical-Infrared Astronomy Research Laboratory

GMT TMT

The US Extremely Large Telescope Program

# Community meeting December 15th (JST)

We held a community meeting via Zoom

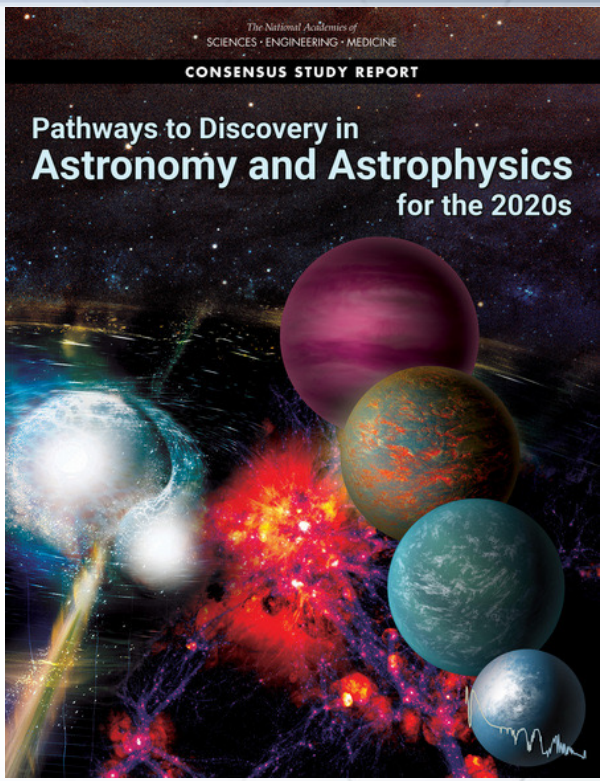
- The contents of the Astro2020 report

TMT Thirty Meter Telescope

# Astro 2020 Report (1/5) Summary

NAOJ National Astronomical Observatory of Japan

- **US-ELTP is the highest priority in the Ground-Based Frontier Category** because of the transformative potential that large (20~40 m) telescopes with diffraction-limited AO, and the readiness of the projects.
- TMT will either be sited on Maunakea in Hawaii, or on La Palma in the Canary Islands.
- **US-ELTP will create enormous opportunities for scientific progress**, and they will address nearly every important science question across all three priority science themes.
- NSF should achieve a federal investment in at least one and ideally both GMT & TMT, with a target level of at least 25% of the time on each. If only one proves to be viable, NSF should aim to achieve a larger fraction of the time, in proportion to its share of the costs and up to a maximum of 50%.




https://www.nationalacademies.org/our-work/decadal-survey-on-astronomy-and-astrophysics-2020-astro2020

# Astro 2020 Report (2/5) Recommended Funding Criteria

- It will be necessary for NSF to commence with an external review with a target completion in 2023 in order to evaluate the financial and programmatic viability of US-ELTP, with the level of federal investment in at least one of the projects determined at the end of the review.

1. Demonstration of **financial viability** with agreed-upon commitments from partners for all of the necessary capital and operations money, pending only NSF investment.
2. **Final site selection** in the case of the TMT.
3. **A public share of telescope time** (run through NOIRLab) roughly equivalent to the total federal investment of construction and operations expenses.
4. **Full public archiving of all data** taken by the US-ELTP, after reasonable proprietary period.
5. Development of a **management plan and governance structure** for the joint project, agreed by all parties including the relevant observatory corporations and NSF.

TMT Thirty Meter Telescope

# Astro 2020 Report (3/5)

NAOJ National Astronomical Observatory of Japan

Depending on the outcome, the decision rules for NSF are the following:

- If NSF investment can only fund partnership in one telescope, but both are viable, NSF's investment should factor
  - in complementarity to the E-ELT, the ability to address the science questions of the Astro2020 survey, (cf. E-ELT & GMT in South / TMT in North)
  - the relative advantages of a larger diameter (D), which increases the sensitivity ~$D^2$ to $D^4$ (depending on the science application), versus a larger field of view, which increases survey speed and the number of targets per observation.

← Essential for TMT to demonstrate the viability including the site.

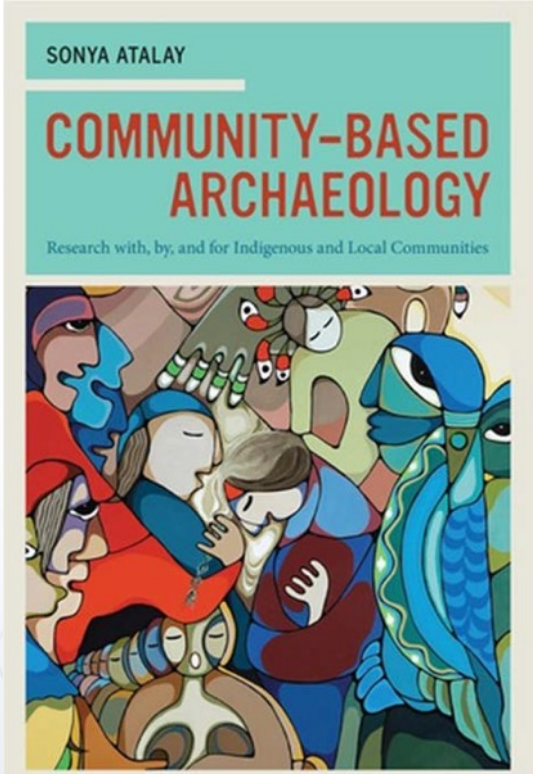
| | TMT | GMT | E-ELT |
|---|---|---|---|
| Diameter (m) | 30 | 24.5 | 39 |
| FOV (arcmin) | 20 | 20 | 10 |
| FOV (no vignetting) | 15 | | 5 |

TMT Thirty Meter Telescope

# Astro 2020 Report (4/5) Community Astronomy

NAOJ National Astronomical Observatory of Japan

- Laid out a set of principles for engaging with Indigenous communities
  - A few activities from the last 5 years that were presented as positives: Akamai Program, UH new Master Plan, Governor Ige 10-point Plan
- Introduced concept of “Community Astronomy model” based on specific examples of successful collaborations between local Indigenous people and science programs in other fields.



TMT Thirty Meter Telescope

# Astro 2020 Report (5/5) Community Astronomy

NAOJ National Astronomical Observatory of Japan

- Recommendation: **The astronomy community should**, through the American Astronomical Society in partnership with other major professional societies (e.g., American Physical Society, American Geophysical Union, International Astronomical Union), **work with experts from other experienced disciplines (such as archaeology and social sciences) and representatives from local communities to define a Community Astronomy model of engagement** that advances scientific research while respecting, empowering and benefiting local communities.
- NSF, NASA, DOE, facility managing organizations, project consortia, individual institutions, and other stakeholders can **work to build partnerships with Indigenous and local communities that are more functional and sustained through a Community Astronomy approach**, and by increasing the modes of engagement and funding for: (i) meaningful, mutually beneficial partnerships with Indigenous and local communities, (ii) culturally supported pathways for the inclusion of Indigenous members within the profession, and (iii) true sustainability, preservation, and restoration of sites.

TMT Thirty Meter Telescope

NAOJ National Astronomical Observatory of Japan

# Operation Plan

# Two Community workshops on instrument development and operation

Enhancing communication with user community about the latest status of the project and key issues on science operation & instrumentation.

## Workshop on TMT instrument development (June 4, online)

- 89 participants
- Reporting the status of the TMT project and development of first light instruments
- Discussion items:
  - NAOJ's support for instrument development in universities
  - Key technology to be developed for next generation instruments

## Workshop on TMT science operation (June 23, online)

- 83 participants
- Reporting the recent progress in TIO and US-ELTP on operation plan, and operations/data archive of Gemini, ALMA and Subaru
- Discussion items:
  - TIO operation plan in some details
  - TAC system: single TAC, multi-TACs, international TAC
  - User support and data archive in Japan, including those of Subaru

# TMT operation plan

- TMT operation plan in the US-ELT Program has been discussed to make NSF PDR proposal. International partners have been contributing to the discussion and documentation of the plan.

Current plan:

- Telescope operation (scheduling and observations) is conducted by TIO. User support is covered by partners.
- US-ELTP provides platform and tools for proposal preparation, scheduling, observation preparations, data archive, and user support. The tools are available for international partners.

Activities in 2021:

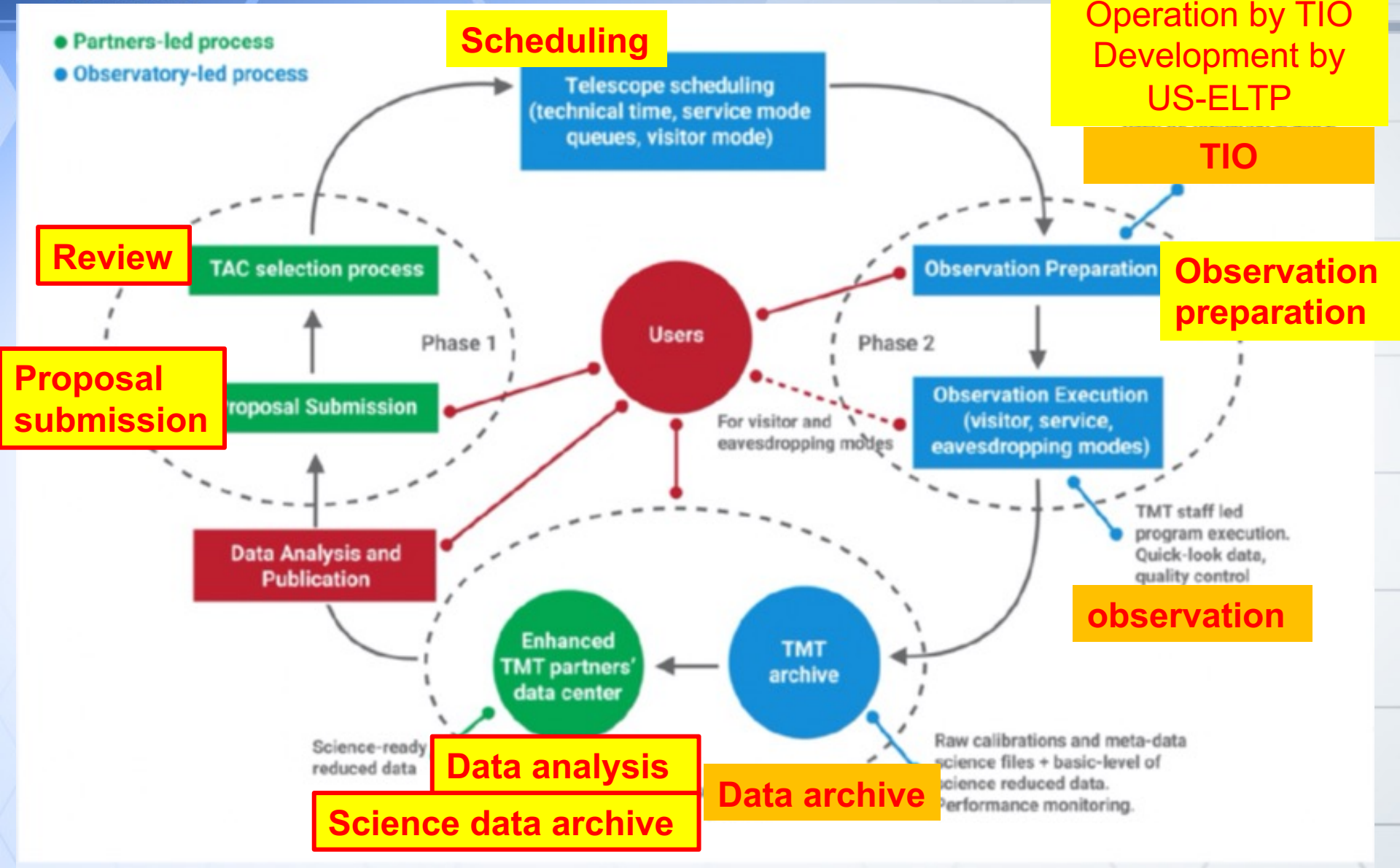
- Contributions to proposals of TIO operation plan and US-ELTP plan for NSF PDR by project and SAC members.
- Discussions in Japan (TMT-J SAC, community meetings, etc.)

# TMT Operation Cycle w/ US-ELTP

partners (development by US-ELTP)

Operation by TIO
Development by US-ELTP

TIO




Observation preparation

Proposal submission

observation

# Japan's plan for TMT Operation

- **Directions for TMT operation in Japan (user support for proposal and observation preparations, data analysis, data archive etc.) based on discussion in Japan in 2021:**

| TMT operation in Japan | Impact on Subaru operation |
|---|---|
| Widely and effectively use the platform and tools developed by US-ELTP | Interface is required for common system for Subaru and TMT-J |
| Organizing TAC to select programs for the TMT-J observing time | Common TAC for Subaru and TMT-J, or separate TAC? |
| Arranging observing modes (visitor-mode and service mode) as ToO programs are efficiently conducted | |
| Making platform that supports international collaborations | |
| Making support systems and/or programs for users in Japanese community | Common support systems & programs for Subaru and TMT-J? |

TMT
Thirty Meter Telescope

NAOJ
National Astronomical Observatory of Japan

# Status of Hawai‘i

TMT Thirty Meter Telescope

# Community meeting December 15th (JST)

NAOJ National Astronomical Observatory of Japan

We held a community meeting via Zoom

- The contents of the Astro2020 report
- Activities in Hawai‘i were reported by Fengchuan Liu (TIO Project Manager) and Yuko Kakazu.
- Up to 234 people participated
- Many participants commented that it was good to know that they had never known about the efforts in Hawai‘i and the problems of Native Hawai‘ians behind the opposition movement.
- On the other hand, there were request further information on the on the situation of other partners, the detail schedule, and future plans. We will continue to share information with the community.

TMT Thirty Meter Telescope

# Status of Hawai‘i

NAOJ National Astronomical Observatory of Japan

- The TIO Project Manager (Fengchuan Liu) and the Director of the NAOJ TMT Project (Tomo Usuda) have relocated to Hilo. Together with NAOJ employees there, the Project Manager has met in small groups with more than 200 stakeholders in the local community.
  - Listen and Learn
  - Respect the people and community, build trust and relationship
  - Promote community services
    - proactive reach out to and help keikis from low-income communities/schools;
    - weekly presence at Hilo Intermediate school’s after-school tutoring program;
    - Anything related to protection and restoration of MK
- TIO’s outreach activities are consistent with Astro2020 report’s recommendation of community-based astronomy, and partnership with indigenous community. These are essential not only for TMT but also for MKOs including Subaru Telescope.

TMT Thirty Meter Telescope

# Status of Hawai‘i

NAOJ National Astronomical Observatory of Japan

Contributing 100 sets of hand-made pillows and blankets

Maunakea invasive plants removal (organized by CMS)

Helping keikis in After-school Homework Program @ Hilo Intermediate School


Donating to families impacted by Pu’ukapu fire

Visit by Royal Order of Kamehameha I

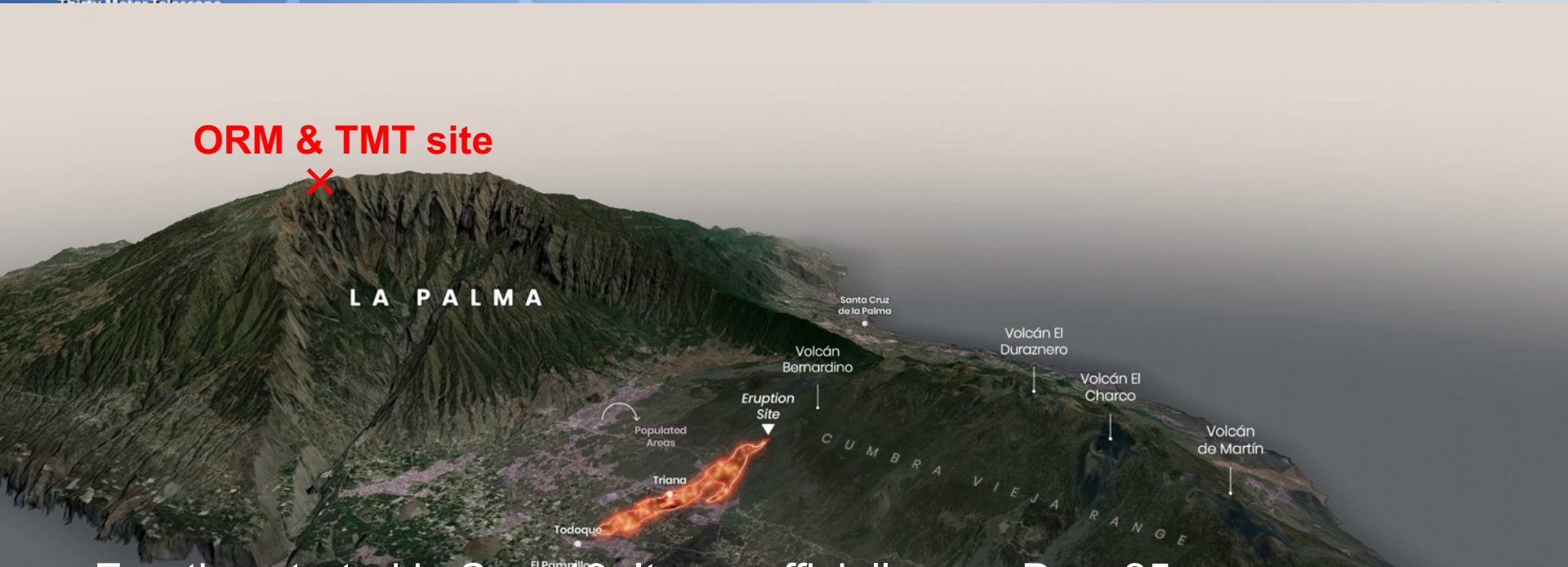
TMT
Thirty Meter Telescope

NAOJ
National Astronomical Observatory of Japan

# Status of La Palma

# Status of La Palma






- Eruption started in Sep. 19. It was officially over Dec. 25.
- ~7,000 persons have been evacuated
- ~3,000 houses and structures have been covered by lava
- Lava flow has covered more than 1,200 hectares
- ORM continue operations the first days after eruption started
  - About 15km away from caldera & 2,000m difference altitude
  - Dominant winds from the North pushed smoke away
- ORM sometimes closed due to more explosive, more ash

# Status of La Palma

- There is strong support for TMT by the Government of Spain and Canary Islands, and the municipalities of La Palma. Many opinion polls also support TMT.
- Decision received July 30th in the appeal filed by Ben Magec (Ecologistas NGO in Canary Islands) against the land concession. Judge ruled:
  i. the **Hosting Agreement is not in force**
  ii. since the Hosting Agreement is not in force, the concession should not have been directly granted to IAC but granted to TIO along with a public tendering.
- **Cabildo, IAC and TIO filed their respective appeals in September**
- No plans to change the position of La Palma as an alternative site
- It is important for TIO to maintain La Palma as an alternative site until the on-site construction work in Maunakea is carried out
- We will continue to pay attention to the activities of environmental protection groups and respond in cooperation with local governments and IAC.

TMT
Thirty Meter Telescope

NAOJ
National Astronomical Observatory of Japan

# Project Progress

TMT Thirty Meter Telescope

# Members' contributions

NAOJ National Astronomical Observatory of Japan

Telescope

Enclosure

M2

M1 blank

M1 polish

30%

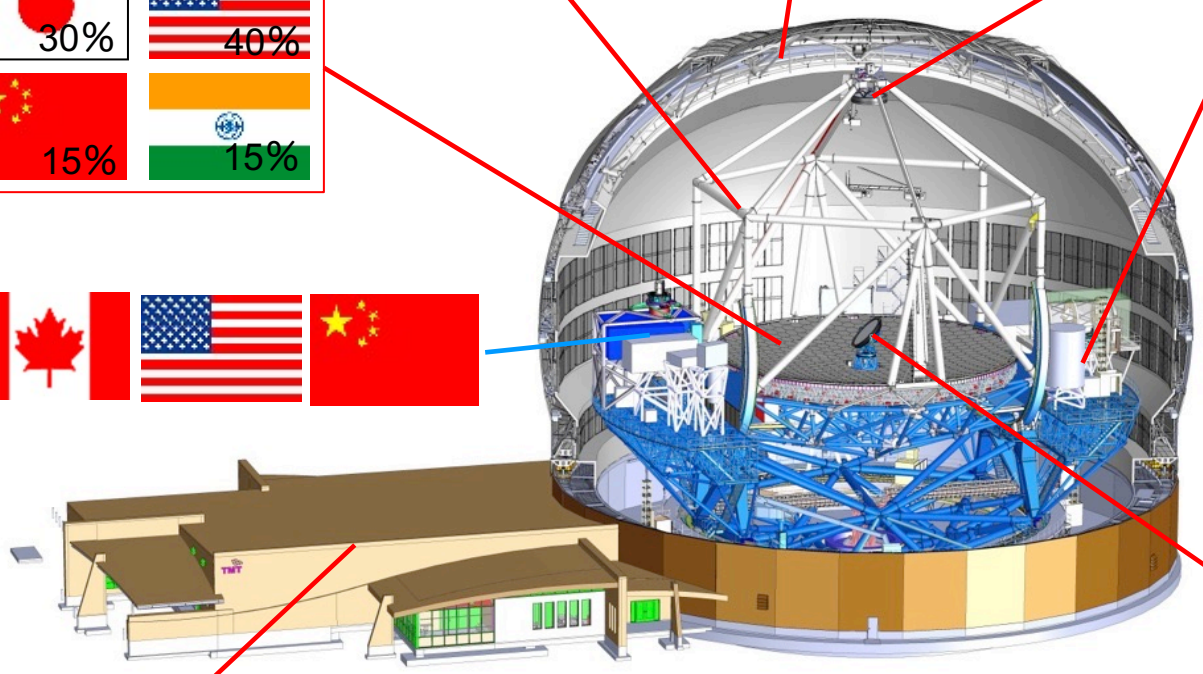
40%

15%

15%

Instruments

AO



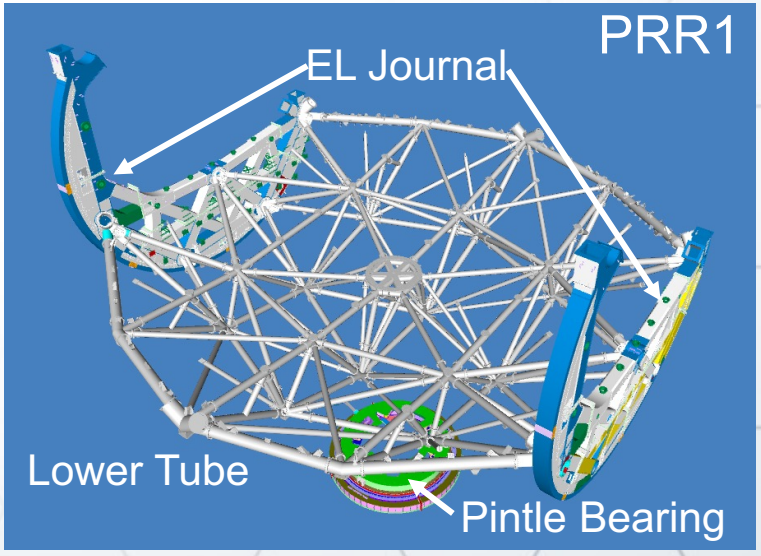
M3

Facility

Control Systems & Software

# Telescope Structure (STR) Status

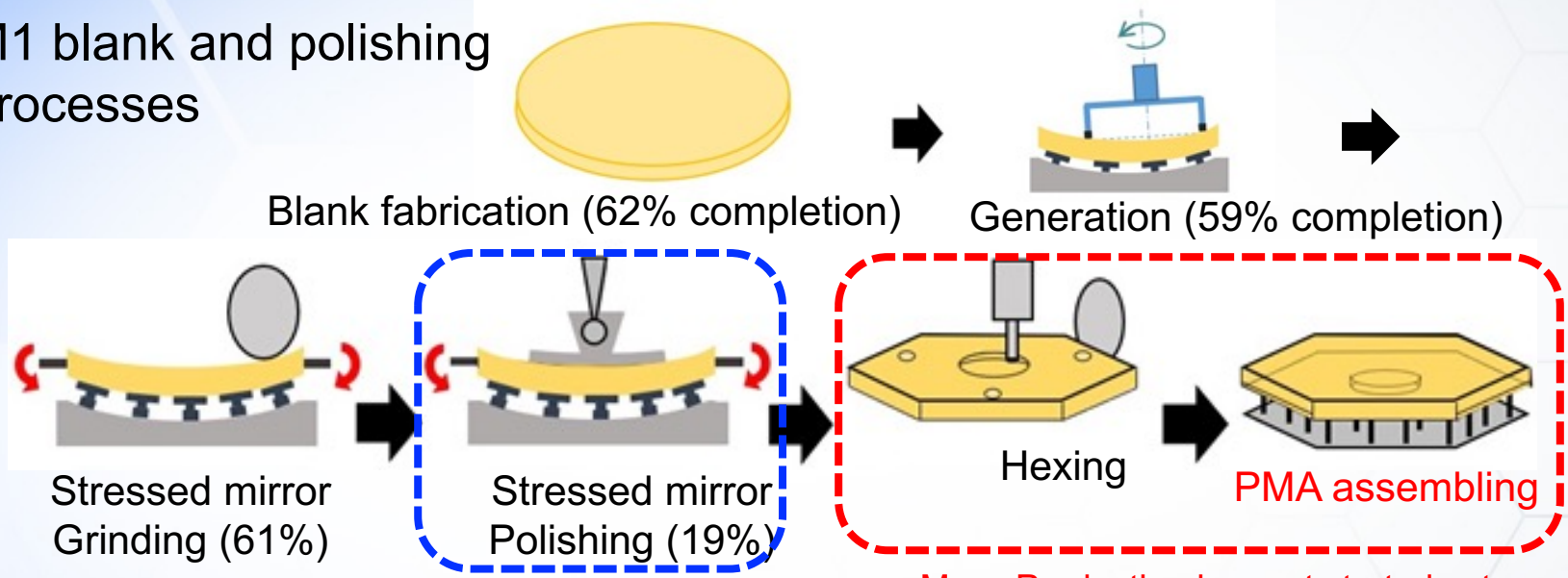
- STR is in the Fabrication phase. Making fabrication drawings of the STR main structure (Az/El structure and Nasmyth) and their revision work are on going by MELCO for the PRR2 & 3 in 2022.
- Final design for some sub-systems (SHS, Elevator, $CO_2$ Clean Arm) which will be Tier-B/C reviewed in 2022~2023.
- To start fabrication, MELCO is keeping its core members. Design updates and studies are on-going by MELCO/NAOJ to close or retire action items for the subsystems.
- Schedule: STR Production Readiness Review (PRR) Series:
  - 8-9 Oct 2015: Long-Lead Procurement Review ✓
  - 13-15 Nov 2019: FDRC ✓
  - 11-12 Mar 2020: PRR1 ✓
  - **Apr 2021: PRR1 close-out** ✓
  - *2022: PRR2/3 & Tier-B/C review for 3 subsystems*



# M1 Blank and Polishing

NAOJ/OHARA/Canon have made steady progress in M1 production.
Now focusing on R&D to mitigate future risks for planned mass production.

- M1 blank and polishing processes




Passed conformance review, but R&D studies required for better production rate.

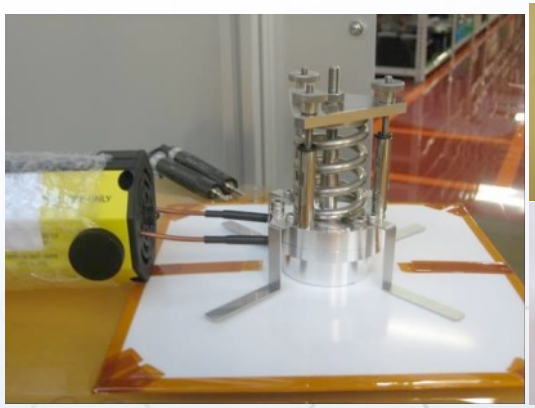
Mass Production has not started yet. Preparation activities are on-going in order to reduce cost & major risks.

- Remaining issues
  - For Hexing: Surface protection during Hexing → R&D Studies in JFY2021
  - For PMA (Primary Mirror Assembly): R&D on going (Next page)
  - For Stressed Mirror Polishing: Improve the mass production rate (now 24 per year) → R&D Studies in JFY2021

# M1 Blank and Polishing

- Eight roundels (SN024,SN025,SN027-SN031, and SN061) passed a conformance review on April 28th, 2021.
- Four roundels (SN019-022) passed a second conformance review on December 17th, 2021
  - Total number of the passed roundels is 13.
  - Two roundels (SN026,062) have good measured numbers but are waiting for visual inspections.

- Development work for PMA assembling
  - Debonding methods for packs (and central diaphragms) were established by
    - Induction Heating
    - Debonding chemicals



TMT Thirty Meter Telescope

IRIS Infrared Imaging Spectrograph

# IRIS Imager & IFS Tier-C FDR

NAOJ National Astronomical Observatory of Japan

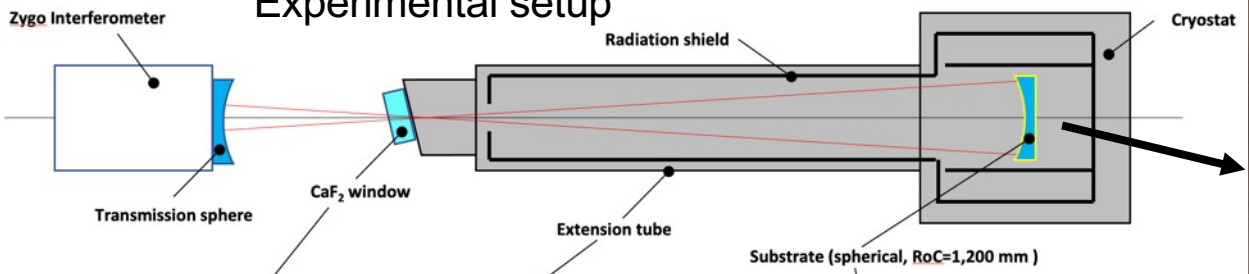
- June 21-23, 2021 (PDT)
- Review items:  Imager operational modes, requirements, interfaces, design (optics, opto-mechanics), performance analysis (thermal, structural), prototyping, AIT (assembly, integration and test) plan, compliance, risks, and next step.
- Not including: Software, reliability, quality assurance, verification procedures and plans, electronics/cable rack and management/cost/schedule.

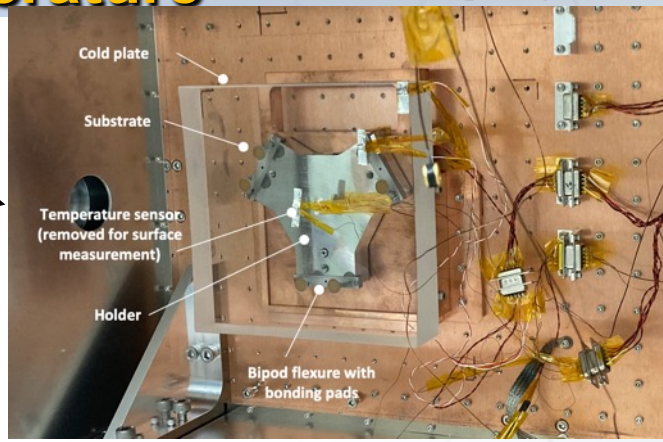
# Prototyping
# Mirror deformation measurement and modeling at cryogenic temperature

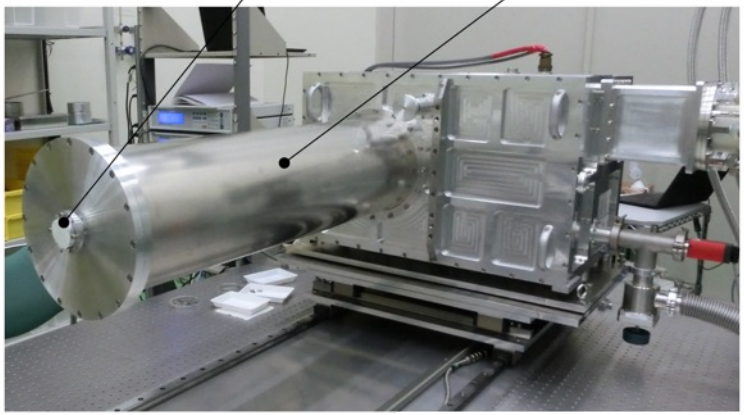
TMT Thirty Meter Telescope

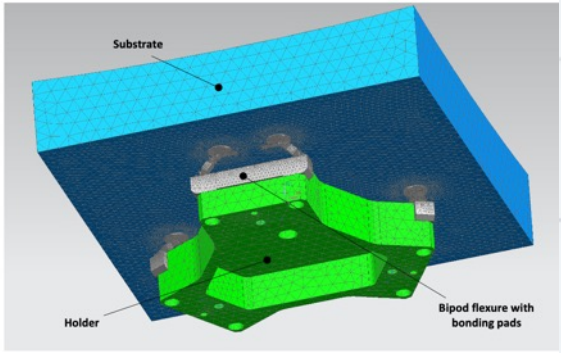
NAOJ National Astronomical Observatory of Japan

## Experimental setup

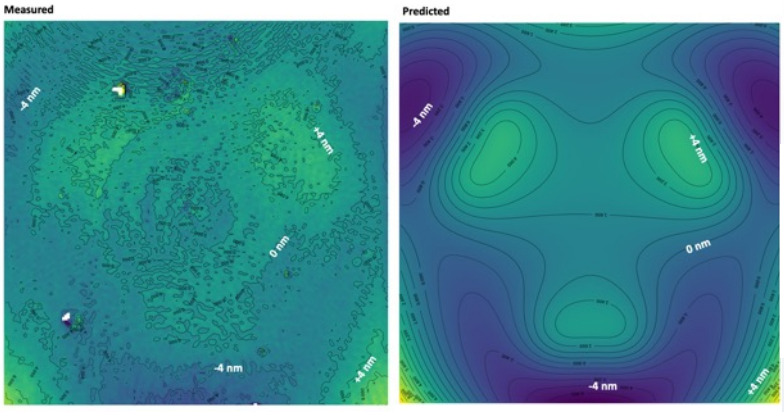





FE model of spherical substrate

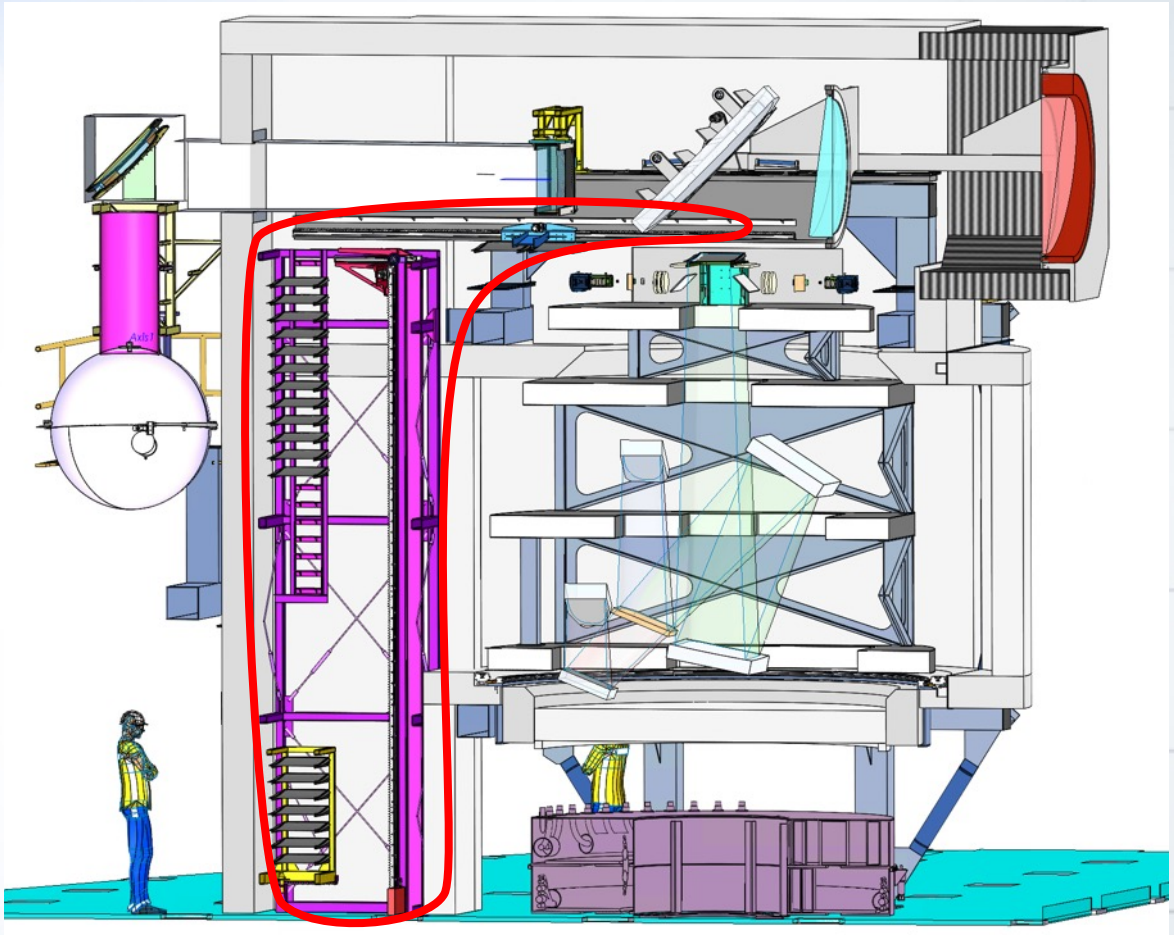



Measured (left) and predicted (right) surface figure of the large substrate at 110 K. Piston, tip/tilt, and power are subtracted.

IRIS Infrared Imaging Spectrograph

# WFOS
## in-kind Contribution to CoDR Phase3

- NAOJ is making **in-kind contribution** to CoDR phase3 for many essential parts of WFOS.
- Trade study on the exchange concept of the slit mask exchange system (SMX) has been completed.
- A conceptual operation plan of the mask fabrication system (SMF) has been developed.
- Costs of SMX and SMF have been estimated.



SMX (red solid line) in the WFOS

TMT Thirty Meter Telescope

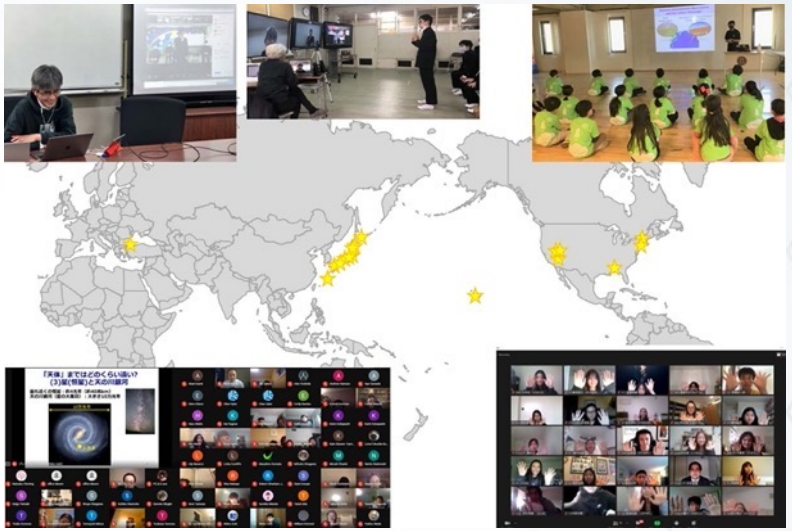
# Outreach activities

NAOJ National Astronomical Observatory of Japan

**We are adjusting and developing outreach activities under the COVID-19 situation.**

43 Lectures and talks for public in FY2020

90% by virtual, including lectures for Japanese schools in US and Turkey



Continuing virtual exhibition, and restarting real exhibition

NAOJ booth for the Optics and photonics International Exhibition (OPIE; Jun 30 ~July 2): number of visitors is smaller than usual, but we could have useful dialogue on the project status and technology

# Summary

- TMT will play an essential role in the 2030s to deepen the human perception of the Universe.
- In Astro2020, US-ELTP was named as the highest priority in the Ground-Based Frontier Category.
- As Japan's in-kind contribution, some preparation activities (front loading) are on going in order to reduce cost & major risks.
- TIO Project Manager and Director of the NAOJ TMT Project have relocated to Hilo to meet in small groups with more than 200 stakeholders in the local community. These efforts are vital for building trust and mutual-respect with the local community.


Mahalo !
国立天文台
NAOJ