US Extremely Large Telescope Program

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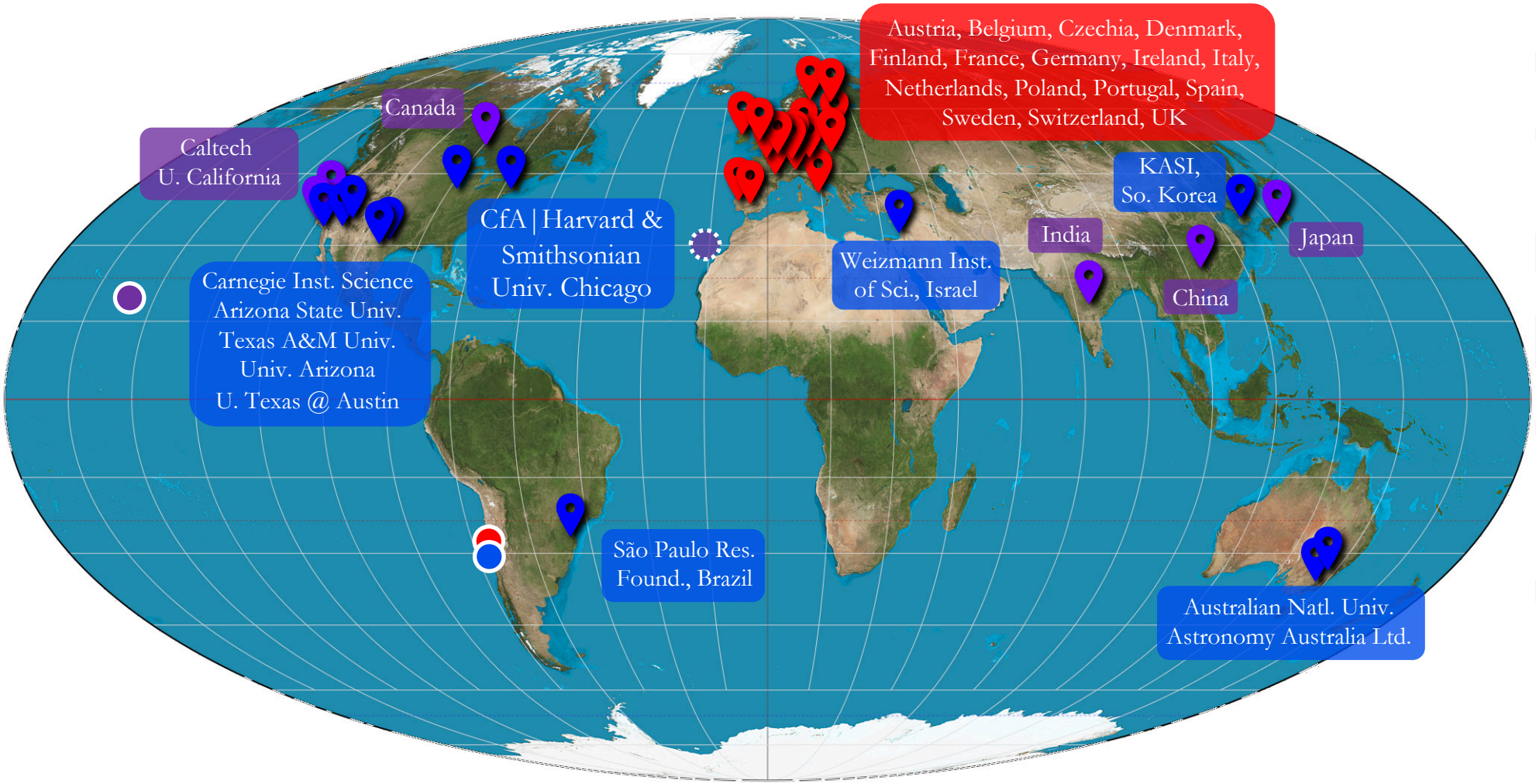
US-ELTP | NSF's NOIRLab

Emerging Global Consensus: ELTs are the future of ground-based optical/IR astronomy



E-ELT

US-ELTP

TMT

GMT

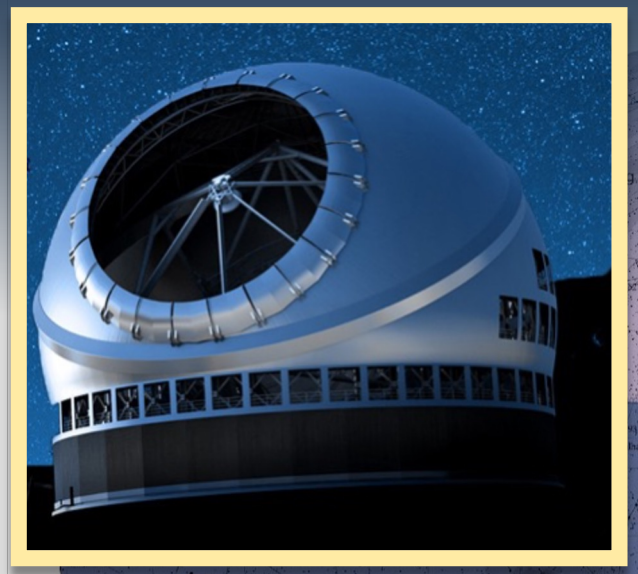
NOIRLab

Objectives of the US ELT Program

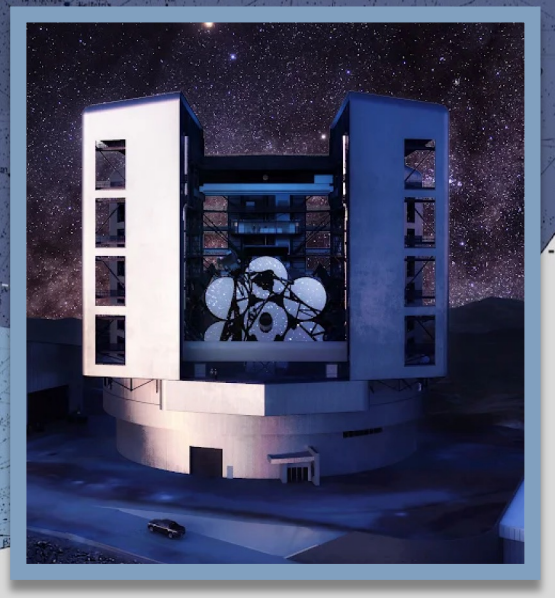
All US astronomers should benefit from national participation in a US ELT Program

- Enable **transformational science** through US access to a bi-hemispheric ELT system
- Enable and support large-scale, systematic, collaborative research (**Key Science Programs**)
- Provide **outstanding user support** commensurate with the proposed US-ELTP investment
- **Broaden participation in TMT+GMT science** and foster research inclusivity
- **Engage and represent the whole US community** in GMT+TMT governance, scientific planning, and instrumentation development

The Power of Two



TMT



both TMT and GMT

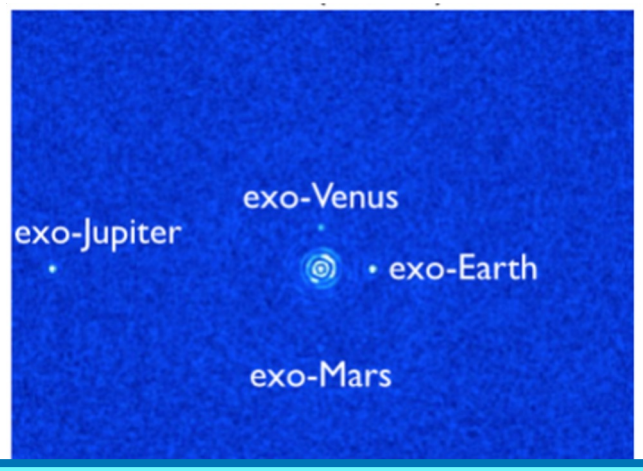
GMT

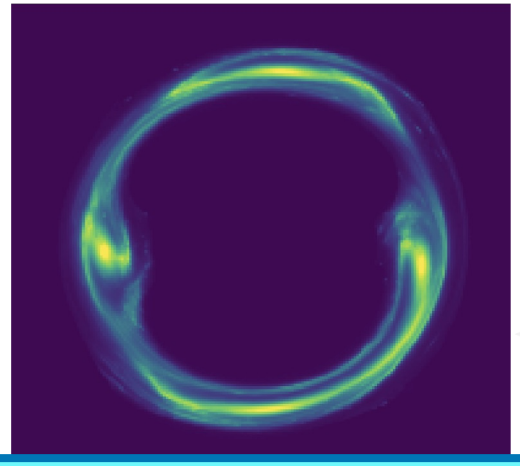
Modes of Investigation

- **Key Science Programs (KSPs)**
  - **Scientific legacy** through systematic investment in **large-scale, transformative research projects**
  - Projects on scales difficult to realize within time shares of current GMT+TMT partners
  - **Broad, inclusive scientist participation** in KSPs via open collaboration models
  - Data products with **high archival reuse value**
- **Discovery Science Programs (DSPs)**
  - Smaller PI-class proposals, allocated more frequently
  - Nimble, responsive to new discoveries, new opportunities, new ideas
- **Archival Research**
  - Community research using **all archived data** from TMT+GMT

Community-Developed KSP Concepts

Extrasolar Planets and the Search for Extraterrestrial Life

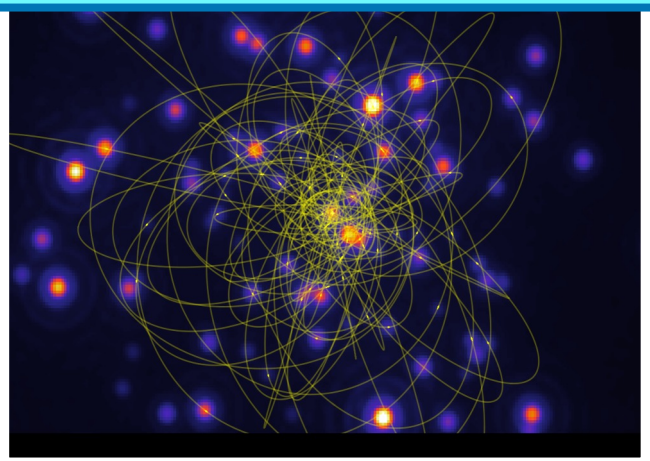




The Dark Universe and Physics Beyond the Standard Model

Actual, future KSPs would be selected by peer review

Extreme Gravity: from Gravitational Waves to Supermassive Black Holes



Resolving the Physics of Galaxy Evolution

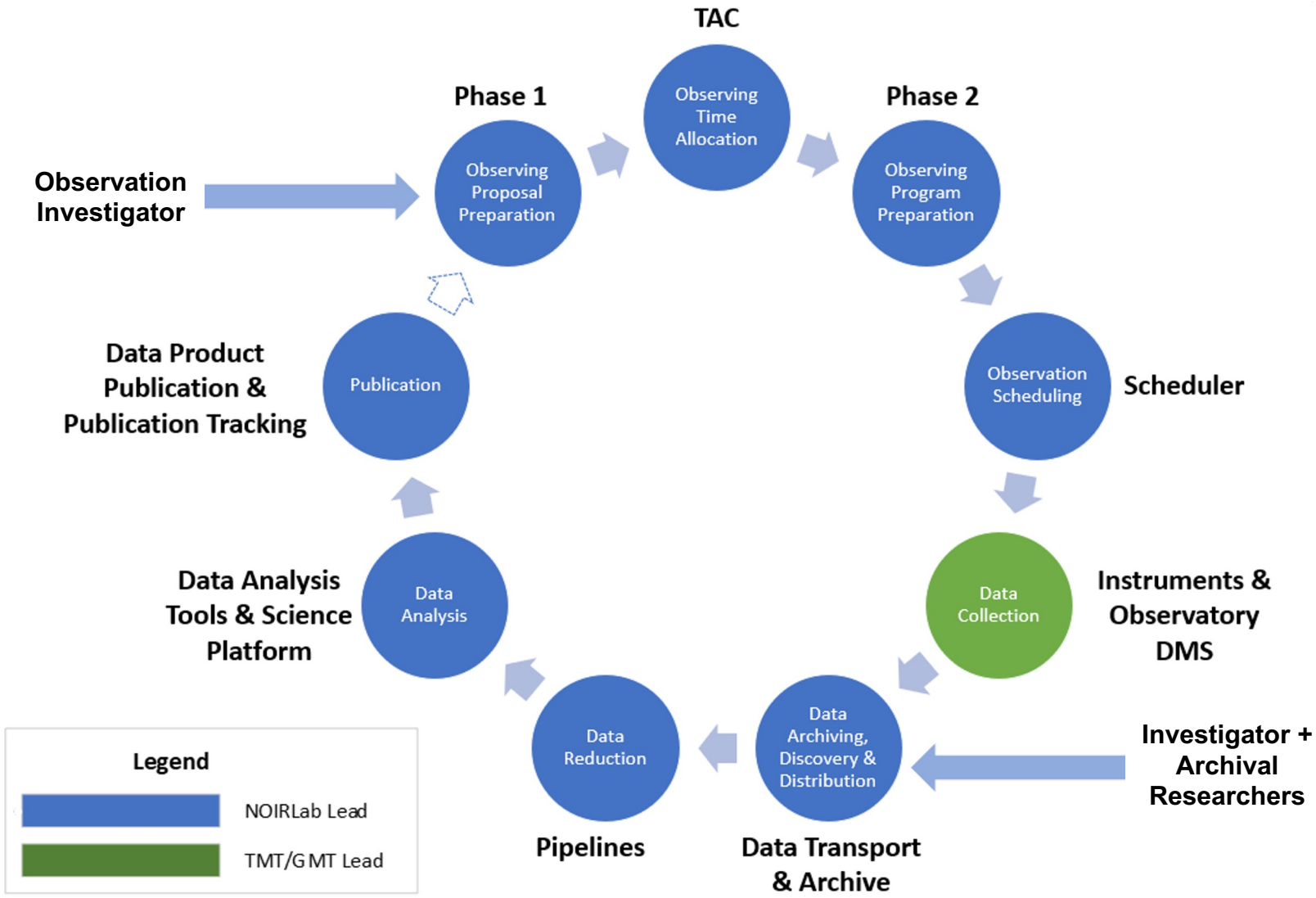
+ Solar System, Stars & Stellar Evolution, Explosive Transients, and more

Research Inclusion

Research Inclusion is central to NOIRLab's US-ELTP mission to enable participation by all astronomers in TMT and GMT science

- Particularly directed toward researchers at **smaller and/or under-resourced institutions (SUIs)**
- **Science-ready data products** will make GMT and TMT more accessible to all observers
- **Archival research creates science opportunities** that scale beyond the bounds of PI observing, and involves researchers from a broader range of institutions
- US-ELTP Data Science Suite will provide an **open platform for user training in data analysis**
- **Key Science Program teams** will be organized following **open collaboration models**
- Research inclusion will be an element of Key Science Program merit review

Science Data Life Cycle



- NOIRLab will provide user support systems and tools for researchers using GMT, TMT and their data throughout the **Science Data Life Cycle (SDLC)**
- Support will be provided by the **US-ELT Program Platform (UPP)**
- Provide researchers with uniform interfaces to TMT, GMT and their data
- NOIRLab's services and tools will be available to all GMT and TMT partners

Guiding Principles for the UPP

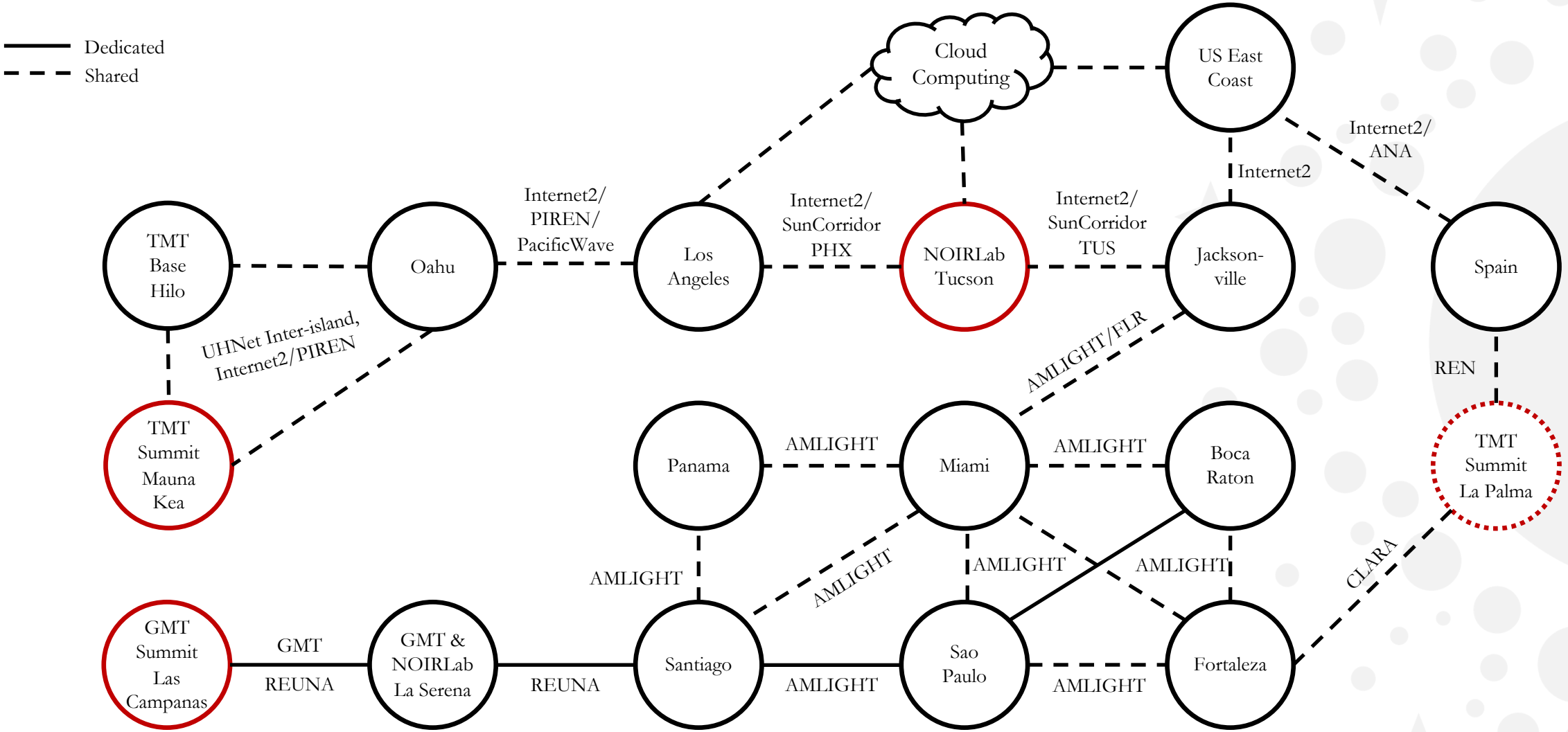
- Provide a level of support unprecedented for US ground-based OIR telescopes
- Provide researchers with uniform interfaces to TMT and GMT and their data
- Partner with TMT and GMT technical teams to develop requirements and define interfaces
- Minimize duplication of effort and define clear roles and responsibilities
- Inform design from existing NOIRLab systems where appropriate
- Upgrade based on lessons learned & specific US-ELTP requirements

Data Analysis and Publication

- Science platform for data analysis by science teams or archival researchers
  - Computing and data storage resources
  - Library of common astronomical analysis software installed and available
  - Notebook computing environment to script data processing and analysis
  - Documentation and tutorials to assist users
  - Shared workspace, activities logging, and notifications for team collaboration
- Teams can publish high-level contributed science products for long-term archiving and distribution by NOIRLab
- Science program data are tracked through publication and archival data products

➡ Archival researchers find new uses for the KSP data products, make new discoveries, write new papers, submit new observing proposals …

Possible US-ELT Network Circuits



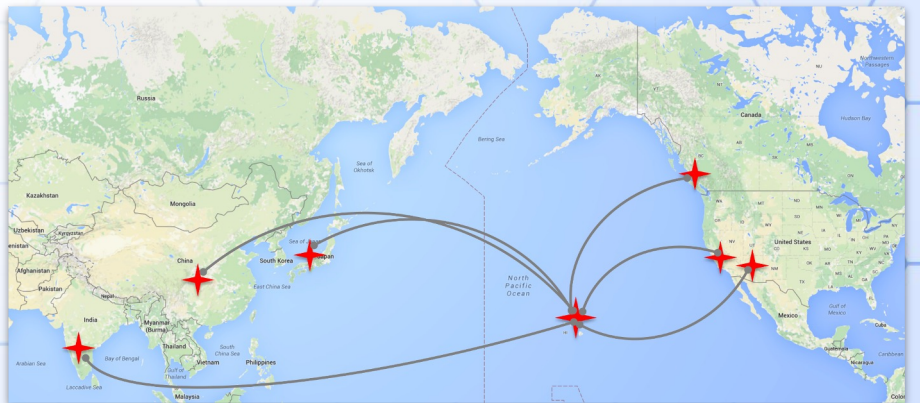
More details about TMT

- Slides courtesy of Christophe Dumas,
  Observatory Scientist & Head of Operations, TMT

- See Sam Chan's talk (next) for details about GMT

TMT location (Hawaii)

- **Sea-level HQs:**
  - Location of main “Science-operations” control room
  - Location of most staff, except for carrying out daily on-site maintenance activities, or during major interventions
- **Summit:**
  - Only Telescope operators will be present at summit during nighttime operations
    - With a higher level of automation and safety measures in place, all nighttime staff could be located at sea-level. This might be considered in a future stage of operations
- TIO partners might develop their own **Remote Operations Centers**, to support their own community (science programs preparation & optimization, data-reduction, including remote observations)

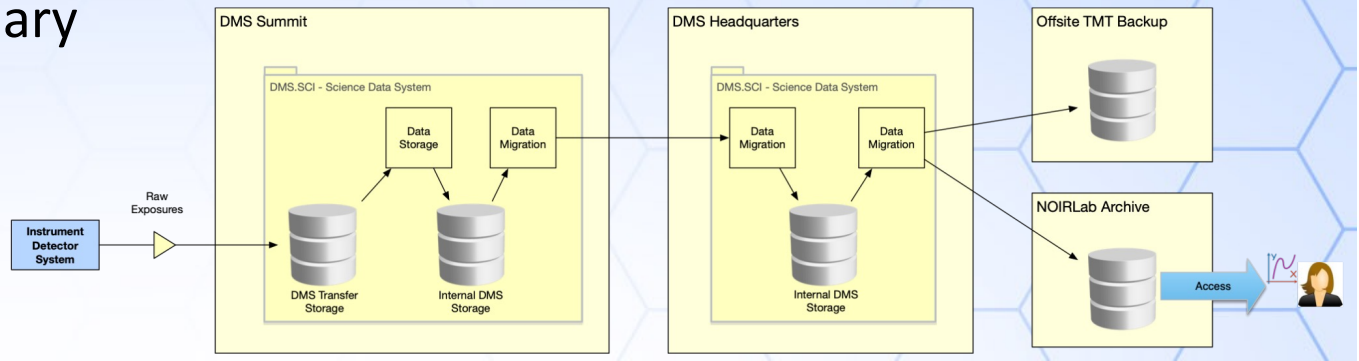


TMT Data Management System (UPP's components)

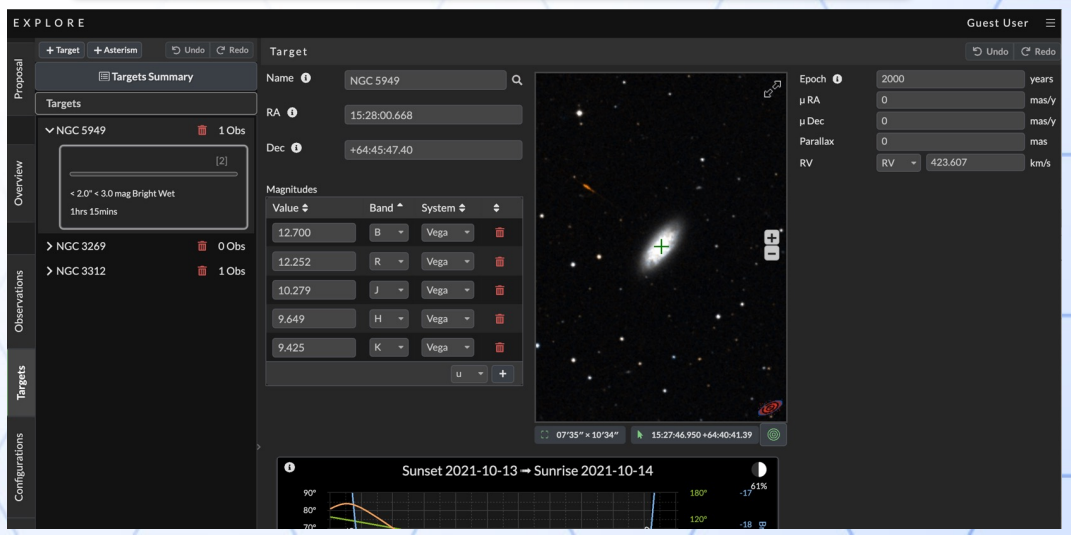
- TMT Data Management System (DMS) reliably stores and tracks science exposures and ancillary files to support archive transfer.

- TMT DMS/UPP responsibilities and tasks:
  - Collaborating in design work with NOIRLab
  - Collaborating in development of data transfer / synchronization ICD and policies between TMT & UPP
  - Enabling the implementation of TMT's data transfer
  - Verifying and validating data transfer to US-ELTP Science Archive and integration with TMT DMS

Assets flow from TMT DMS at Headquarters/TMT Archive to USELTP Archive



Figures from DMS design docs and GPP prototype

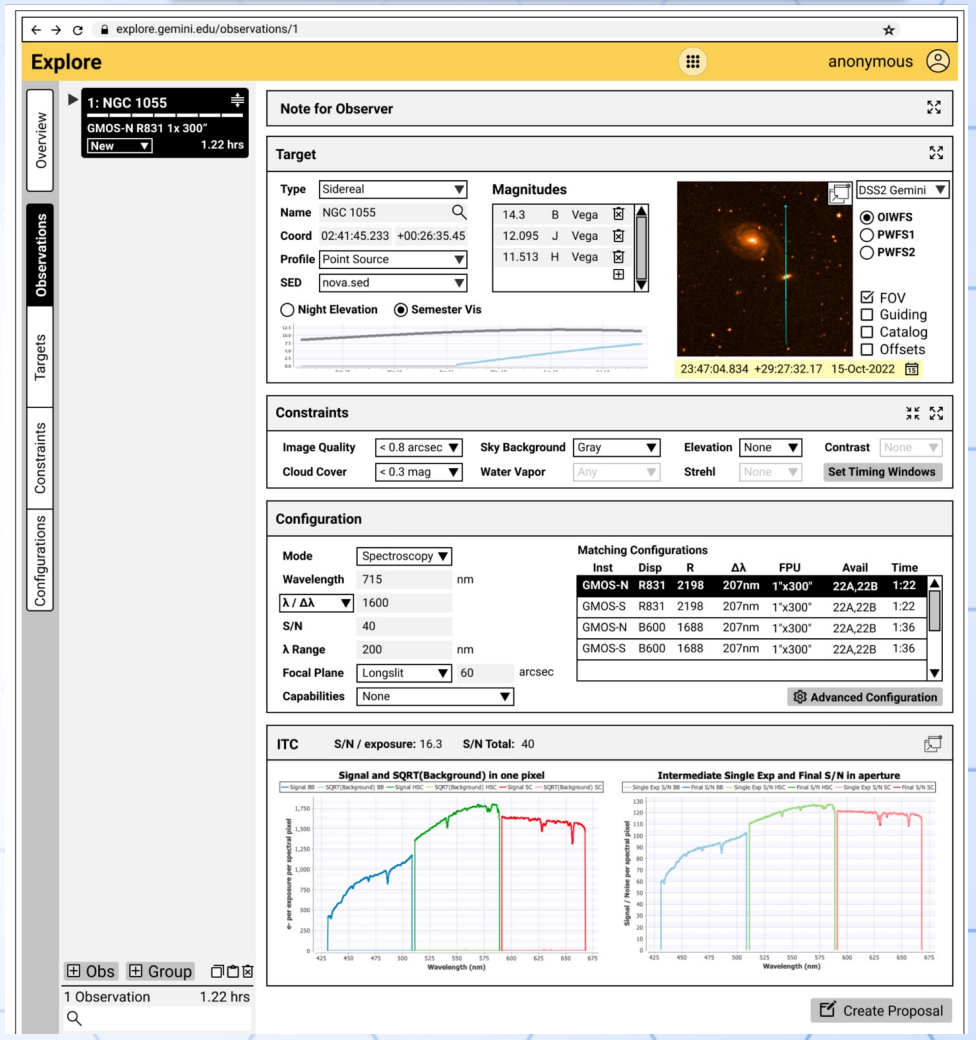


TMT Data Management System (UPP's components)

- TMT Data Processing System (DPS) ensures commonality and standards for processing of all science instrument data

- TMT DPS/UPP scope and tasks:
  - Collaborating with NOIRLab to design the UPP's Explore Integration Time Calculators (Explore-ITC) tools and verifying/validating interfaces to instrument specifications
  - Collaborating and supporting the integration of TMT's data processing tools into the UPP environment
  - Testing, validating UPP tools for data processing

Figure is from Gemini GPP review documentation



TMT Archives

Summit Storage

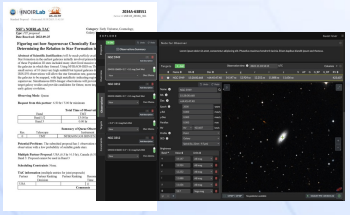
- Raw Science Files
- Calibration Files
- Science Metadata
- Ancillary Data
- Readouts
- Engineering Data
- Software Logs

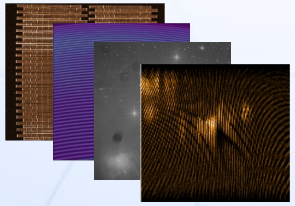
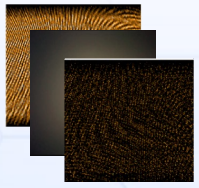
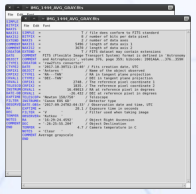
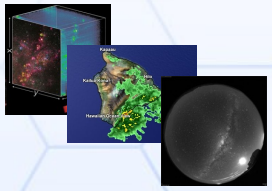
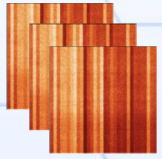
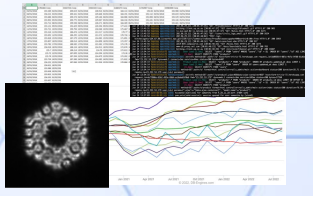
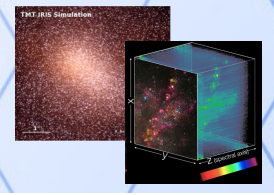
TMT Archive

- Proposals
- Observation Plans
- Raw Science Files
- Calibration Files
- Science Metadata
- Ancillary Data
- Engineering Data
- Software Logs

US-ELTP Archive

- Proposals
- Observation Plans
- Raw Science Files
- Calibration Files
- Science Metadata
- Ancillary Data
- Readouts
- L2 Reduced Data



Data Storage Facilities

Storage Location	Types of Data	Purpose	Lifetime	Access
Summit Storage	Observation Data, Metadata, Ancillary Data, Calibration Files, Logs	Immediate save of data, real-time access, short term backup	At least 3 months	Observatory Staff, pipelines and other software
	Engineering Data, Logs	Immediate save of data	At least 7 days	
TMT Archives (Engineering and Science Data)	All data except readouts	Local and/or cloud permanent store	At least 50 years	Observatory Staff, visitor and eavesdropping astronomers
US-ELTP Archive (hosted by NOIRLab)	Observation Data, Metadata, Ancillary Data, Calibration Files, Readouts	Archive, redundant permanent store	At least 50 years	Observatory Staff, Investigators/teams, public after proprietary period

- Multiple storage locations provide data durability
- Proprietary periods initially restrict access to data to PI and Partners
  - Policies still be being developed and finalized. DMS designed to be flexible.

Instrument Usage Rates

- Early Operations:
  - First light instruments
  - First 5 years
  - Weighted toward IRIS for “safer” estimate
- Steady-State
  - First Light + First Decade instruments
  - Rest of lifetime of observatory
  - Approximates future instruments

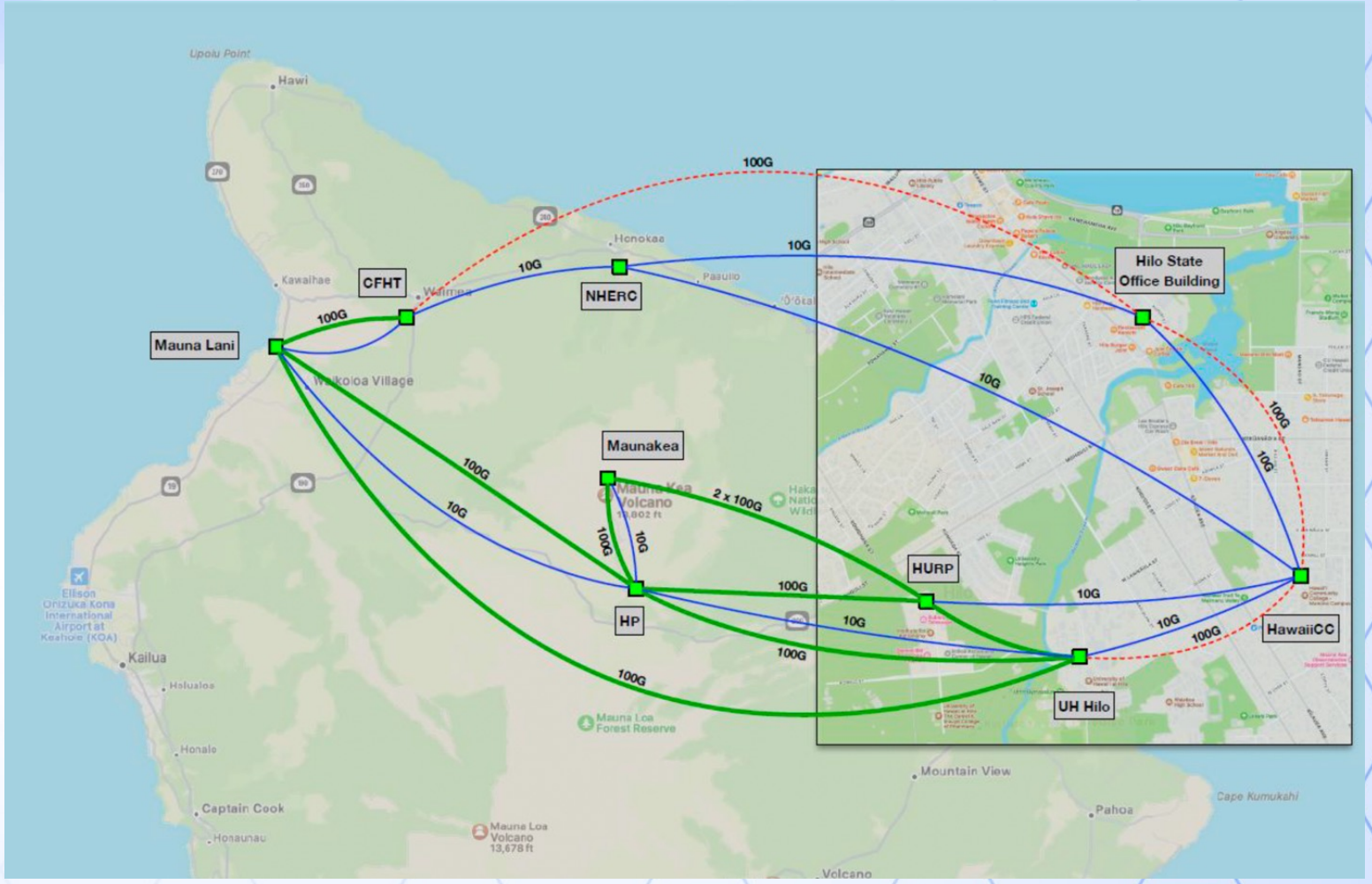
Distribution of Instrument Usage

	Early Operations	Steady-State
IRIS	75%	25%
MODHIS	10%	10%
WFOS	15%	25%
PSI	–	5%
IRMOS	–	5%
HROS	–	25%
MICHI	–	5%

Percentages are models for the purposes of data rate and storage estimates and are not requirements for instrument usage

TMT Data Transfer (Hawaii)

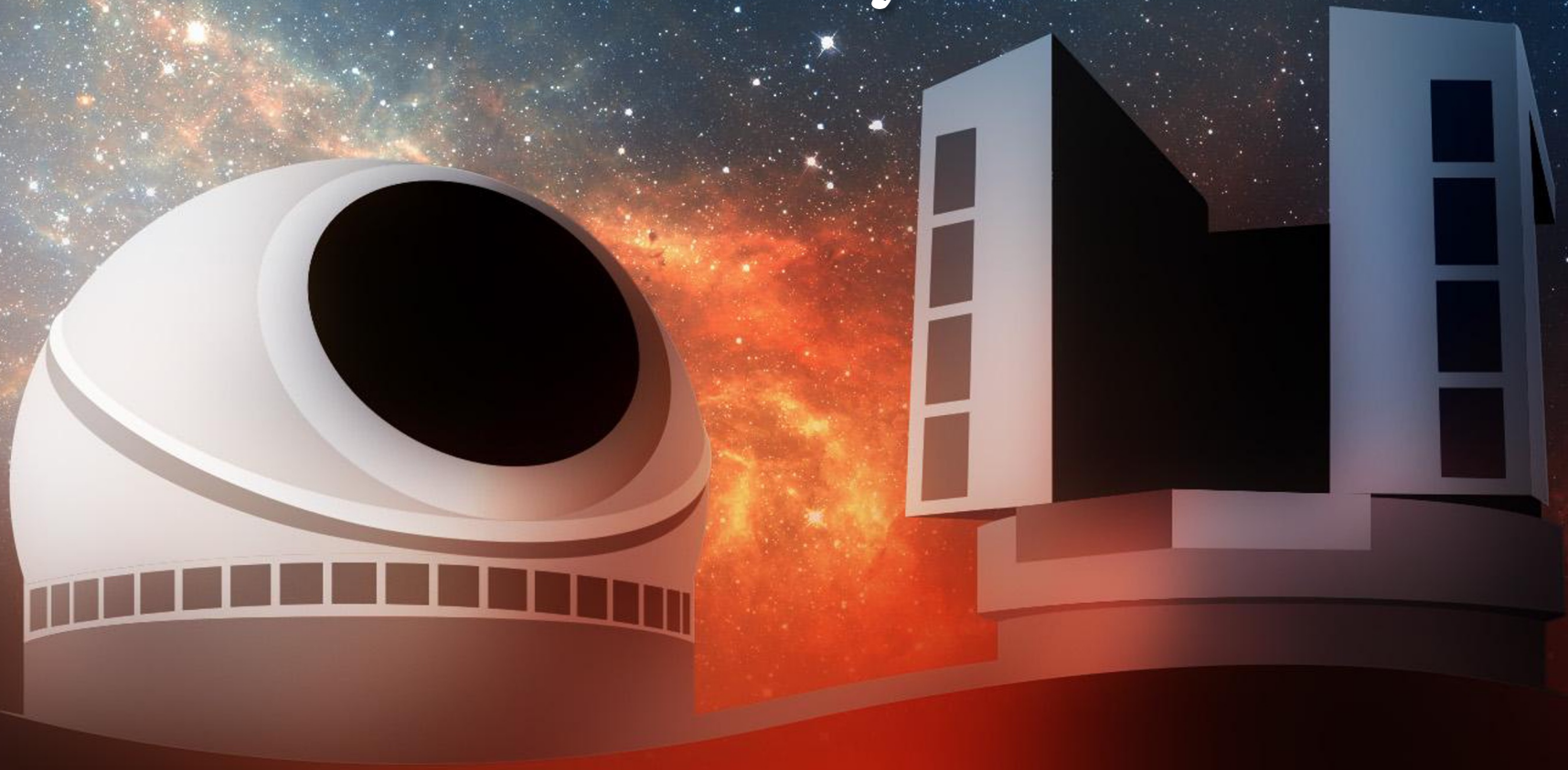
Type of Data	Daily Rate (GB/day)
Science Exposures and Calibrations	598
Ancillary Data (without Readouts)	303
Saving individual readouts	2938
Engineering Data	372
Total	4211
Total without Engineering Data	3839



Summary

- Open access to GMT+TMT will enable transformational research by US astronomers
- Outstanding user support will enable researchers to more fully achieve their scientific ambitions
- US-ELTP user services will broaden participation in science with TMT+GMT and their data, growing the research community and enhancing the scientific outcomes
- NOIRLab will work closely with the scientific community throughout the development and construction phases of the US-ELTP to ensure we build the systems that researchers need

Thank you



noirlab.edu/public/projects/useltp/

TMT
THIRTY METER TELESCOPE

NOIR Lab

GIANT MAGELLAN TELESCOPE