

# US Extremely Large Telescope Program

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US-ELTP | NSF NOIRLab

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



**ESO**

**US-ELT Program**

**TIO**

**GMTO**

**NOIRLab**

# What is the US-ELT Program?

- A joint endeavor of NSF NOIRLab and the organizations building the Giant Magellan Telescope and the Thirty Meter Telescope
- Provide the US astronomical community with nationally-funded access to an all-sky ELT system, to enable broad participation in transformational science

**All US astronomers should benefit from national participation in the US-ELT Program**

- Enable transformational science through open access to an *all-sky ELT system*
- Enable and support survey-class “Key Science Programs” for large-scale, systematic, collaborative and inclusive research with lasting archival reuse value
- Support PI-class “Discovery Science Programs” for nimble response to new opportunities and ideas
- Broaden participation in ELT science and foster research inclusivity
- Provide outstanding user support commensurate with the proposed investment
- Engage and represent the whole US community in GMT+TMT governance, scientific planning, and instrumentation development



# Transformational Science with US-ELTP



Worlds and Suns  
in Context



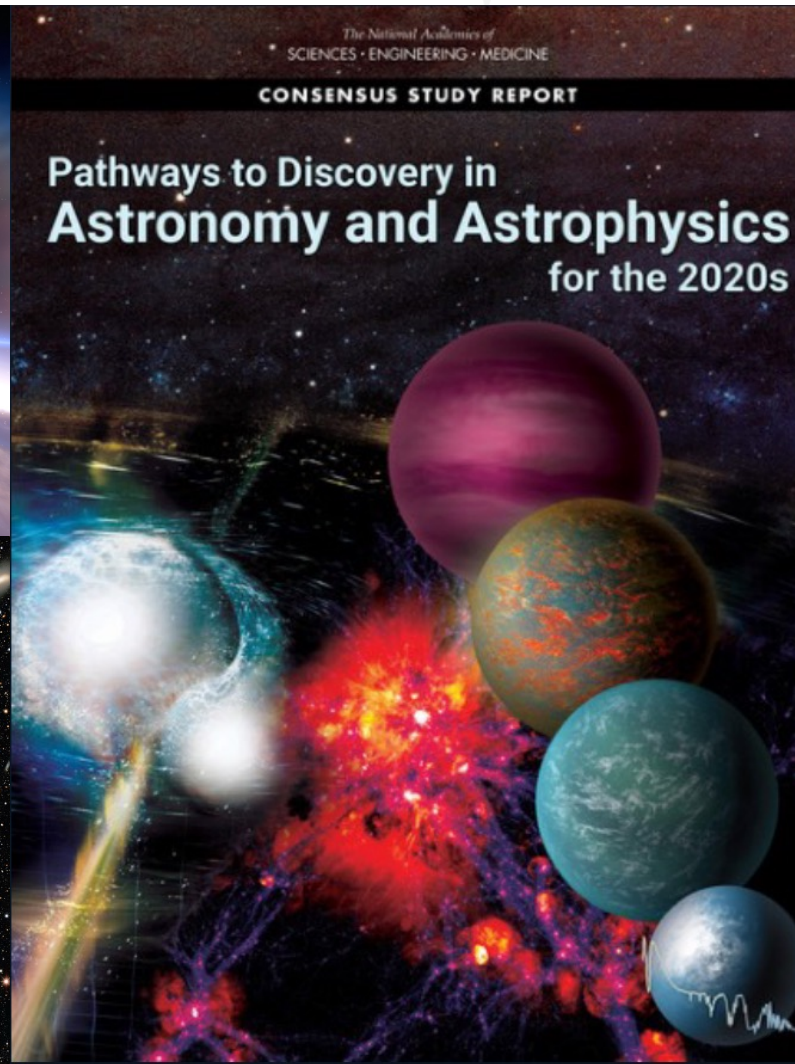
New Messengers  
New Physics



Cosmic  
Ecosystems



What else  
is out there?



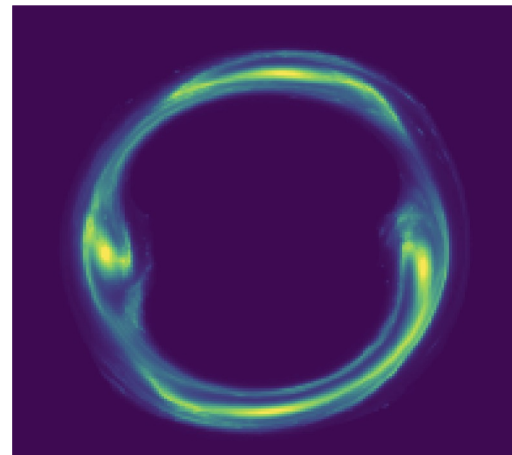
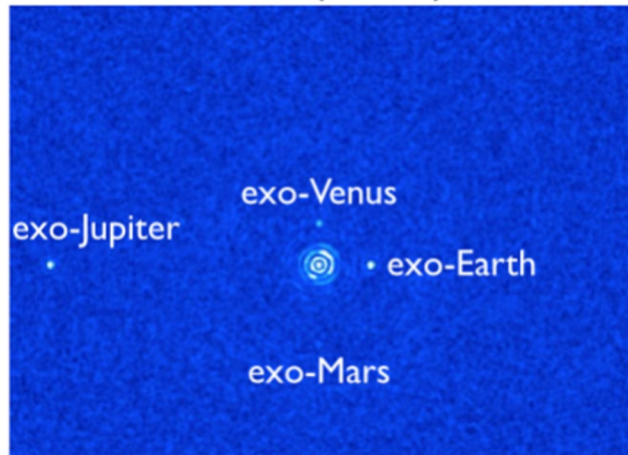
US EXTREMELY LARGE  
TELESCOPE PROGRAM



GIANT MAGELLAN  
TELESCOPE

# Community-Developed KSP Concepts

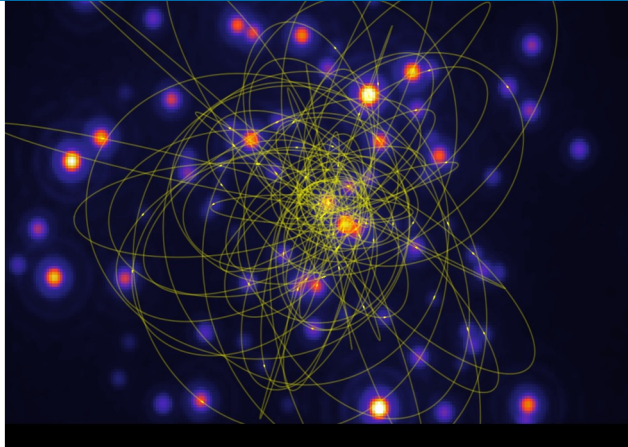
**Extrasolar Planets  
and the Search for  
Extraterrestrial Life**



**The Dark Universe  
and Physics Beyond  
the Standard Model**

**Actual, future KSPs would be selected by peer review**

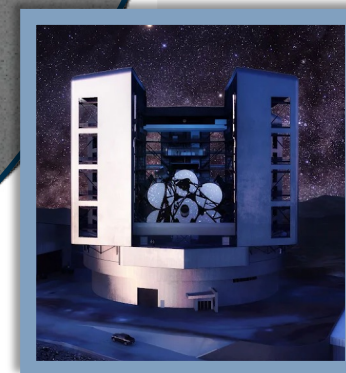
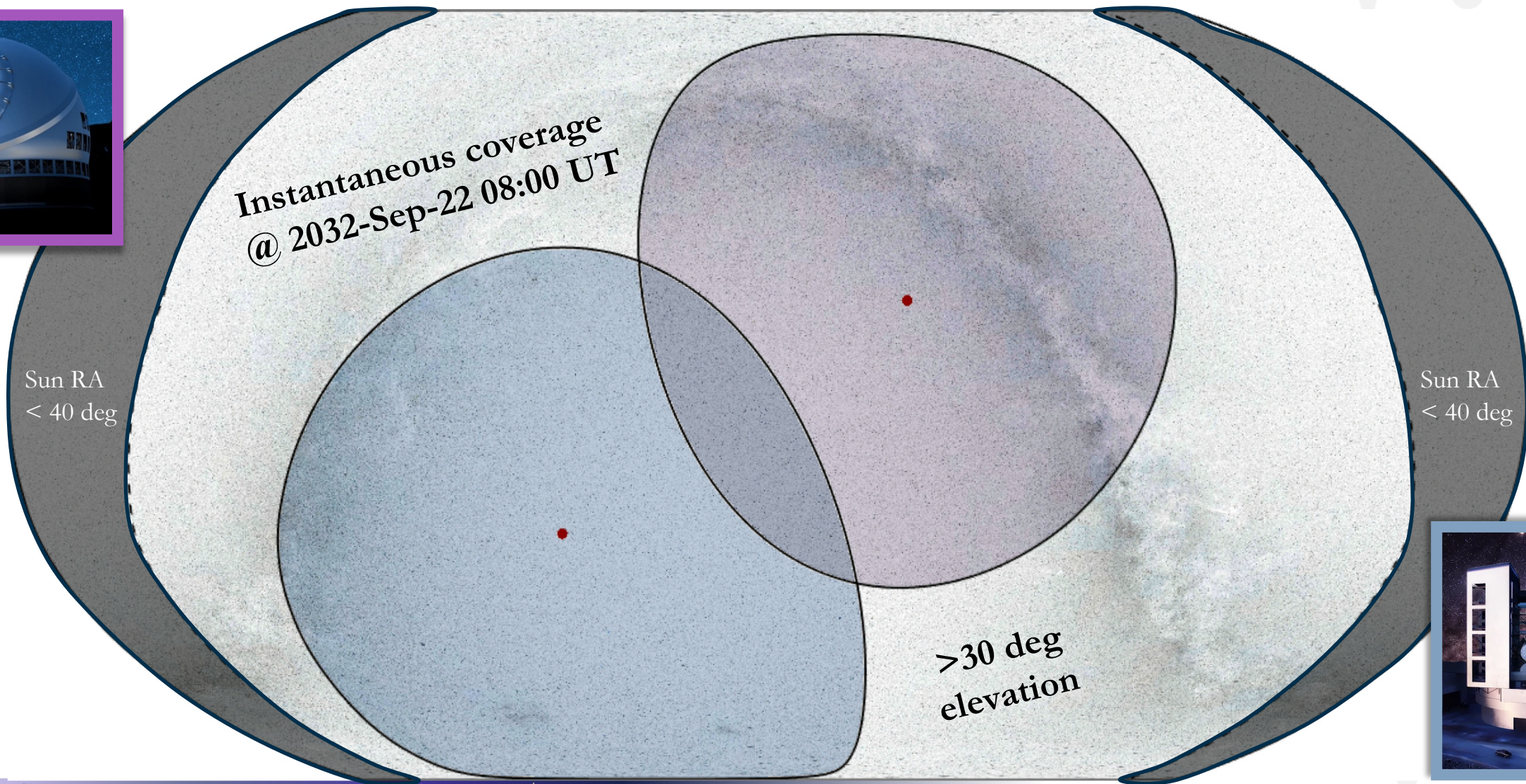
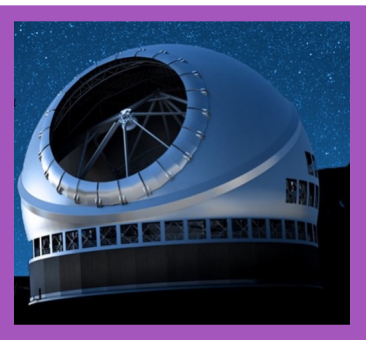
**Extreme Gravity: from  
Gravitational Waves  
to Supermassive  
Black Holes**



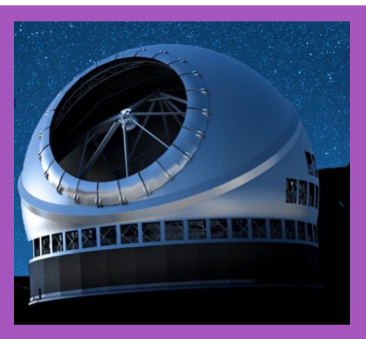
**Resolving the  
Physics of Galaxy  
Evolution**

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

# The Power of Two

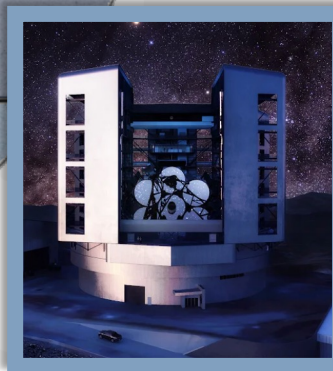
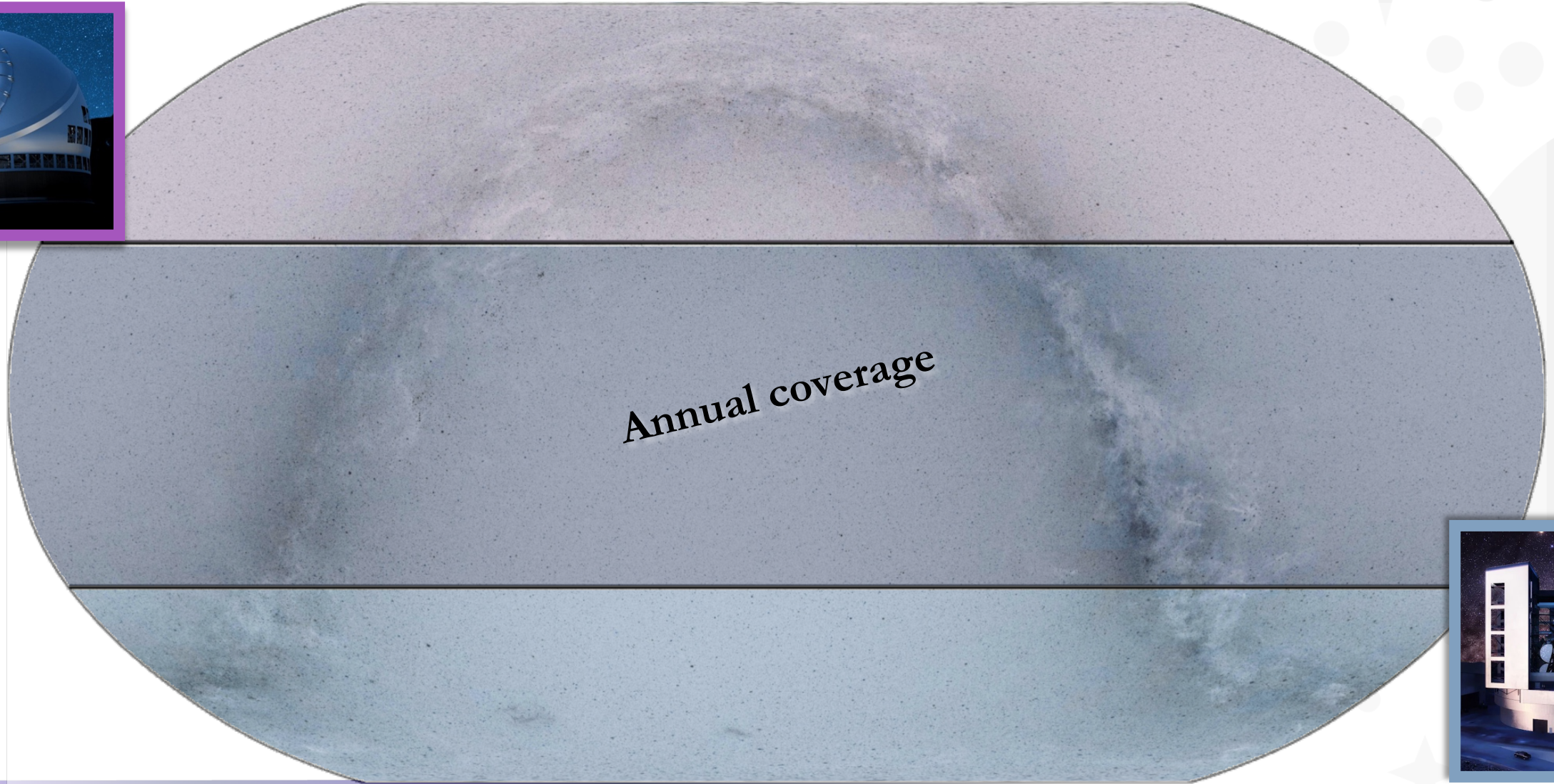
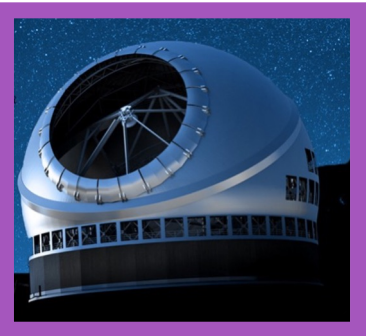


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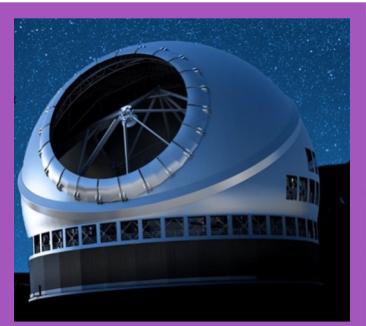




# The Power of Two



# The Power of Two



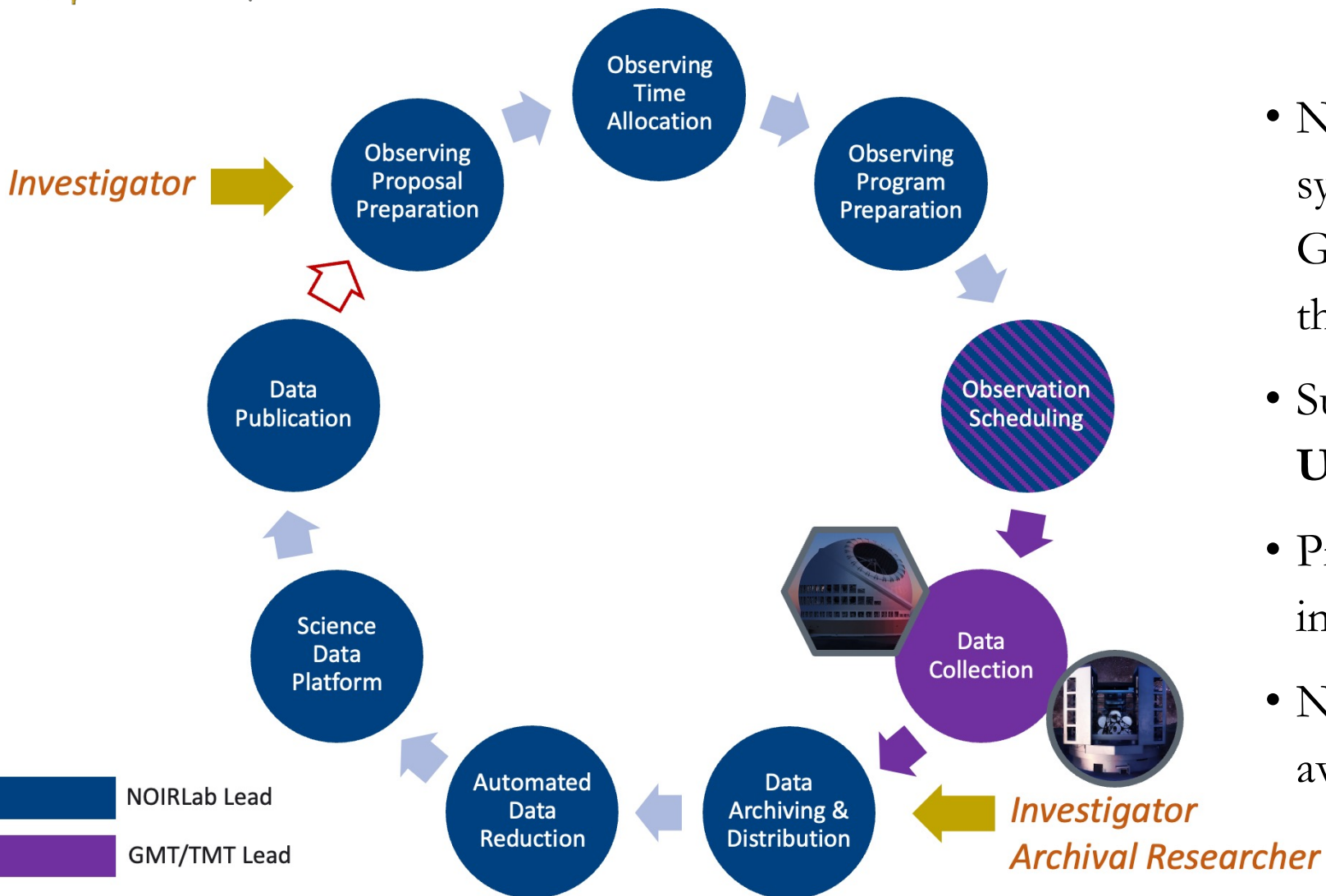
- US-ELT System has collecting area comparable to E-ELT
- Full-sky coverage for rare events (e.g., best exoplanets for biosignatures)
- Longitudinal separation for time-domain astrophysics
- Two platforms for state-of-the-art instrumentation
- Opportunities for international collaborations with many key partners



**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

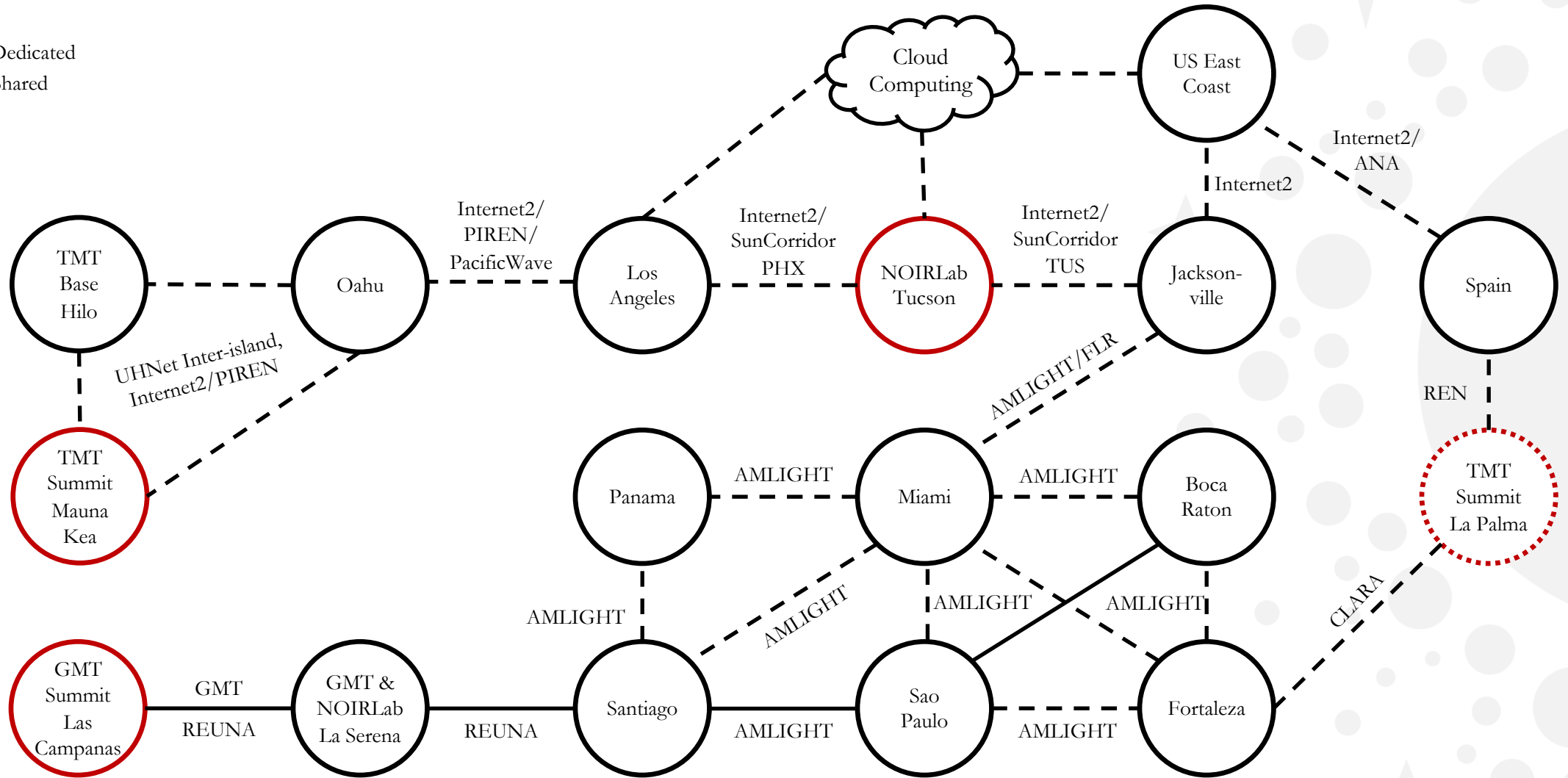
# Science Data Life Cycle



- 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

# Possible US-ELTP Network Circuits

— Dedicated  
 - - - Shared



# More details about TMT

- Next slides provided by TMT International Observatory
- See Sam Chan's talk (next) for details about GMT

# TIO location (Hawaii)

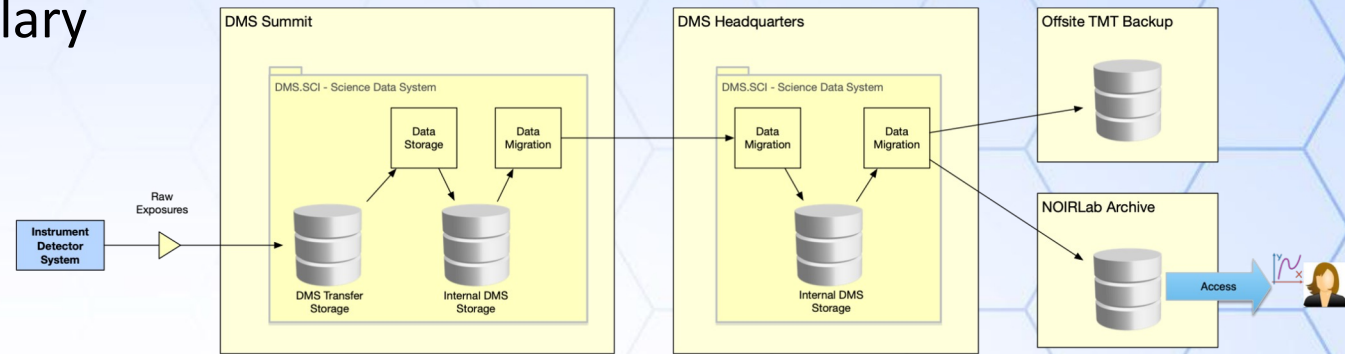
- **Sea-level HQ:**
  - Location of main “Science-operations” control room
  - Location of most staff, except for carrying out daily on-site maintenance activities, or during major interventions
- **Summit:**
  - Only Telescope operators will be present at summit during nighttime operations
    - With 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)



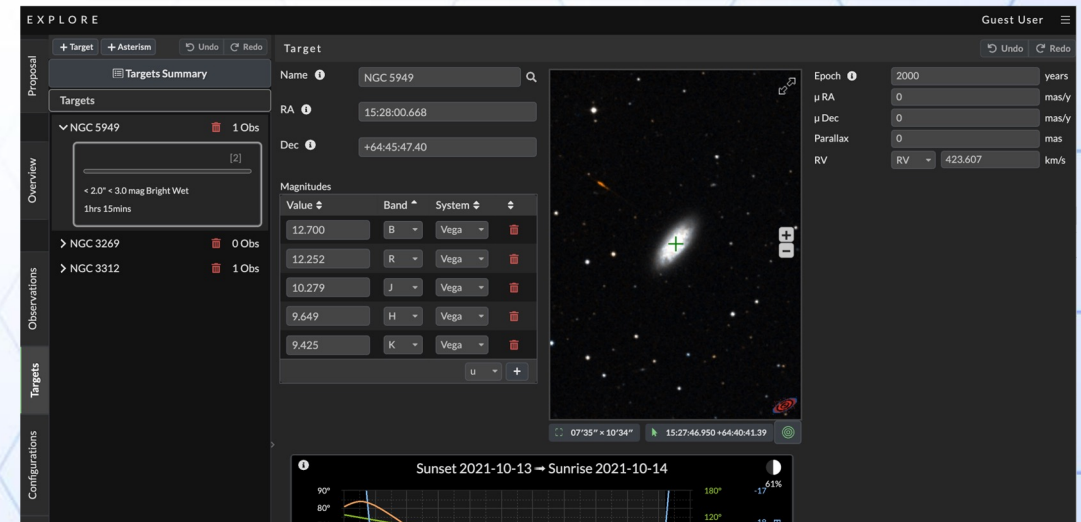
# TIO Data Management System (UPP's components)

- TIO Data Management System (DMS) reliably stores and tracks science exposures and ancillary files to support archive transfer.
- TIO DMS/UPP responsibilities and tasks:
  - Collaborating in design work with NOIRLab
  - Collaborating in development of data transfer / synchronization ICD and policies between TIO & UPP
  - Enabling the implementation of TIO's data transfer
  - Verifying and validating data transfer to US-ELTP Science Archive and integration with TIO DMS

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



Figures from DMS design docs and GPP prototype

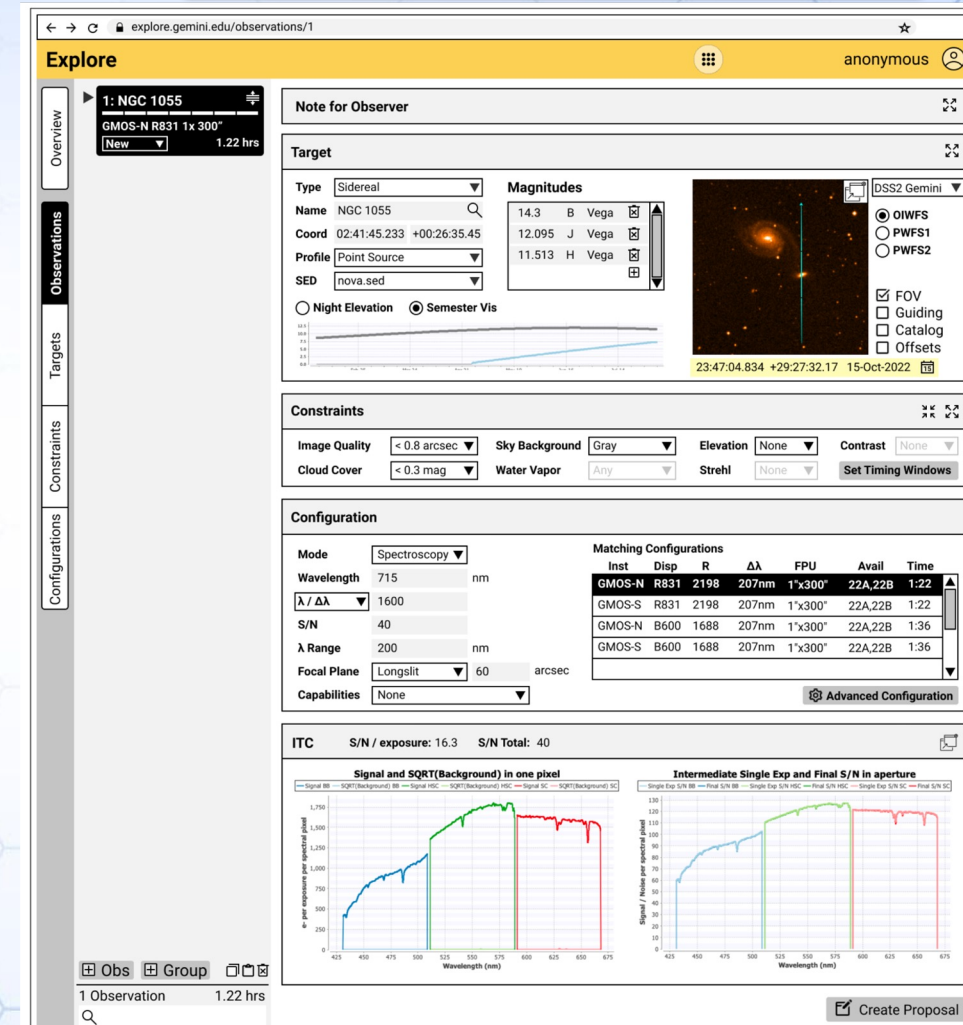




# TIO Data Management System (UPP's components)

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



The screenshot displays the Gemini Explore web interface for observation 1: NGC 1055. The interface is organized into several sections:

- Overview:** Shows the target name (1: NGC 1055), instrument (GMOS-N R831 1x 300), and duration (1.22 hrs).
- Note for Observer:** A text area for additional notes.
- Target:** Includes fields for Type (Sidereal), Name (NGC 1055), Coord (02:41:45.233 +00:26:35.45), Profile (Point Source), and SED (nova.sed). It also shows a table of Magnitudes for Vega stars and a small image of the target.
- Constraints:** Fields for Image Quality (< 0.8 arcsec), Sky Background (Gray), Elevation (None), Contrast (None), Cloud Cover (< 0.3 mag), Water Vapor (Any), and Strehl (None). A "Set Timing Windows" button is present.
- Configuration:** Shows Mode (Spectroscopy), Wavelength (715 nm),  $\lambda / \Delta\lambda$  (1600), S/N (40),  $\lambda$  Range (200 nm), Focal Plane (Longslit 60 arcsec), and Capabilities (None). A "Matching Configurations" table is also shown.
- ITC (Integration Time Calculator):** Displays S/N / exposure: 16.3 and S/N Total: 40. It includes two graphs: "Signal and SQRT(Background) in one pixel" and "Intermediate Single Exp and Final S/N in aperture".

At the bottom, there are buttons for "Obs", "Group", and "Create Proposal".

# TIO Archives



**Summit Storage**

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



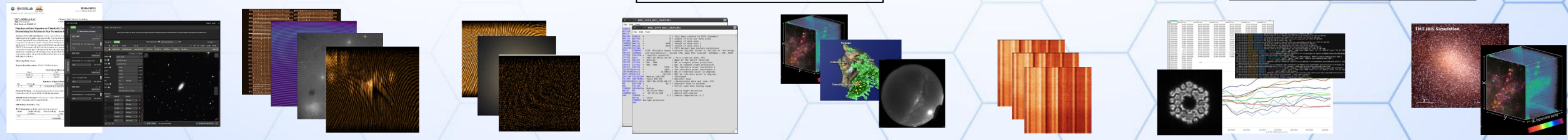
**TIO Archive**

- 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	
TIO 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**

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

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

# Data Processing

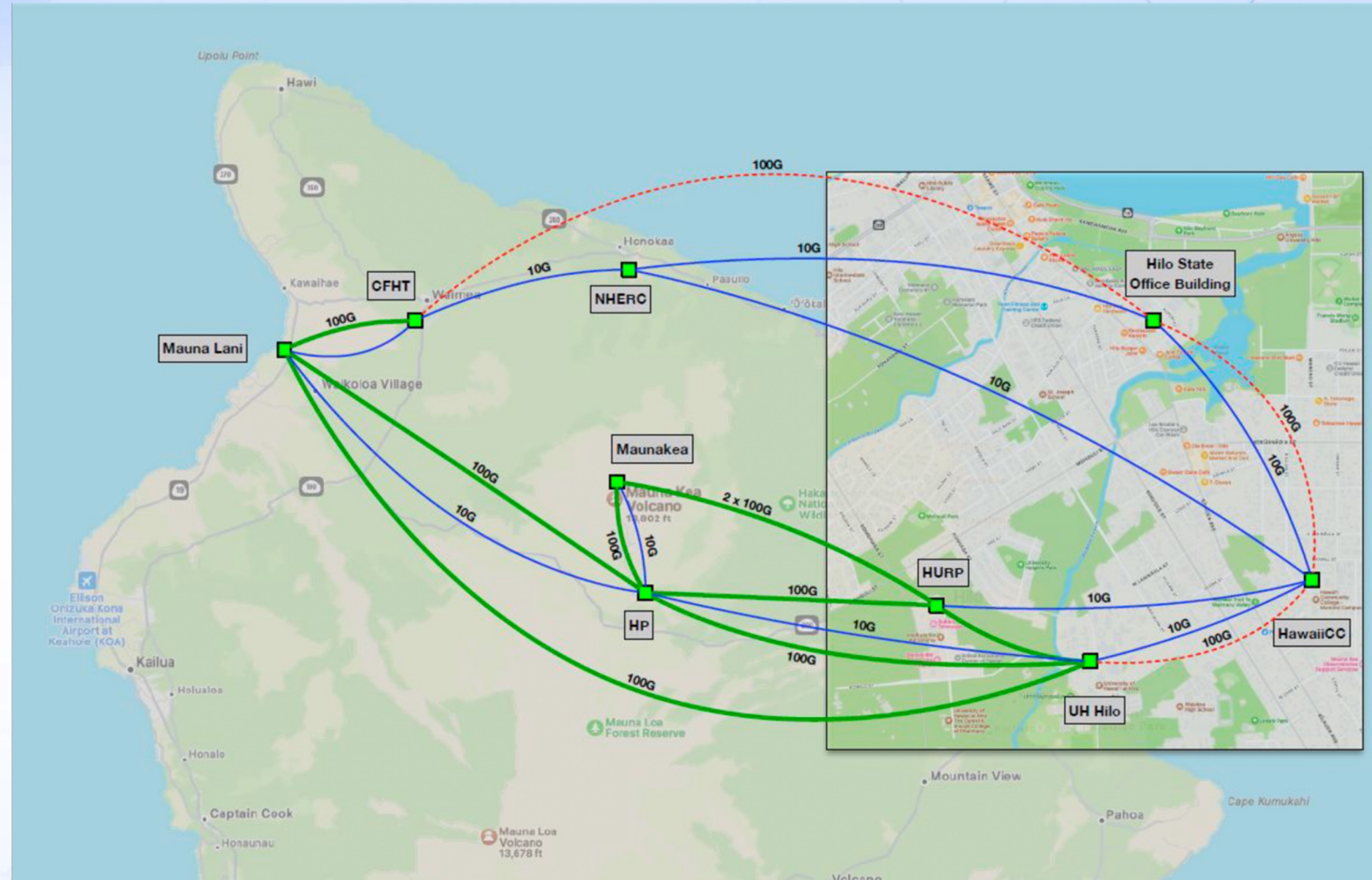
## Data Processing Pipelines are required deliverables to enable scientific application of TIO data

- Basic Data Reduction Pipelines (DRPs) for acquisition and real-time quality assessment required as part of instrument deliverables
- Customizable DRPs with additional processing algorithms will be integrated with US-ELTP archive to provide Level-2 and Level-3 data products to users
- Pipeline source code available for download via GitHub for custom reductions
- Pipelines maintained collaboratively by community with oversight from committee composed of TIO Staff, instrument builders, TIO Partner institutions

Level Value	Usage Description
0	Raw instrumental data, in a proprietary or internal data-provider defined format, that needs instrument specific tools to be handled.
1	Instrumental data in a standard format (FITS, VOTable, SDFITS, ASDM, etc.) which could be manipulated with standard astronomical packages.
2	Calibrated, science ready data with the instrument signature removed.
3	Enhanced data products like mosaics, resampled or drizzled images, or heavily processed survey fields. Level 3 data products may represent the combination of data from multiple primary observations.
4	Analysis data products generated after some scientific data manipulation or interpretation

# TIO 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
<b>Total</b>	<b>4211</b>
<b>Total without Engineering Data</b>	<b>3839</b>



- Open access to GMT+TMT will enable transformational research by US astronomers
- Outstanding user support will help researchers more fully achieve their scientific goals
- 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