The US Extremely Large Telescope Program

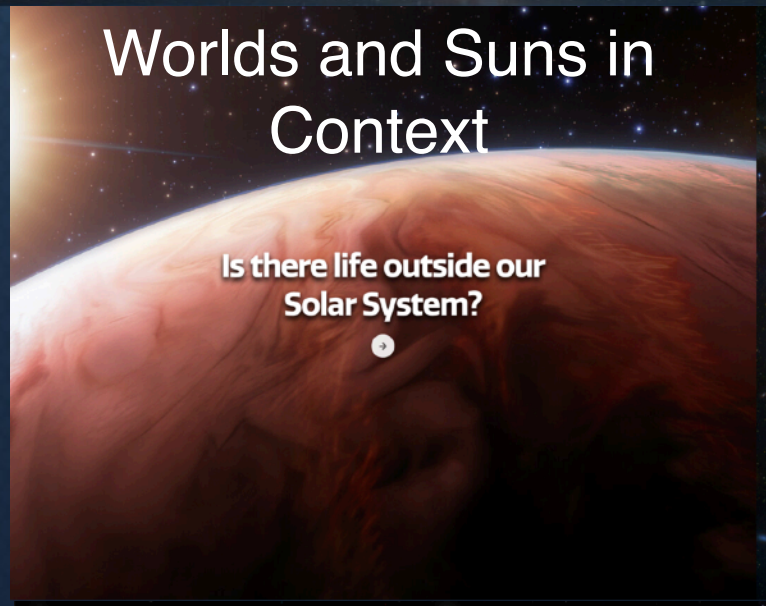
Eric Peng (NOIRLab)
On behalf of the NOIRLab US-ELTP Team

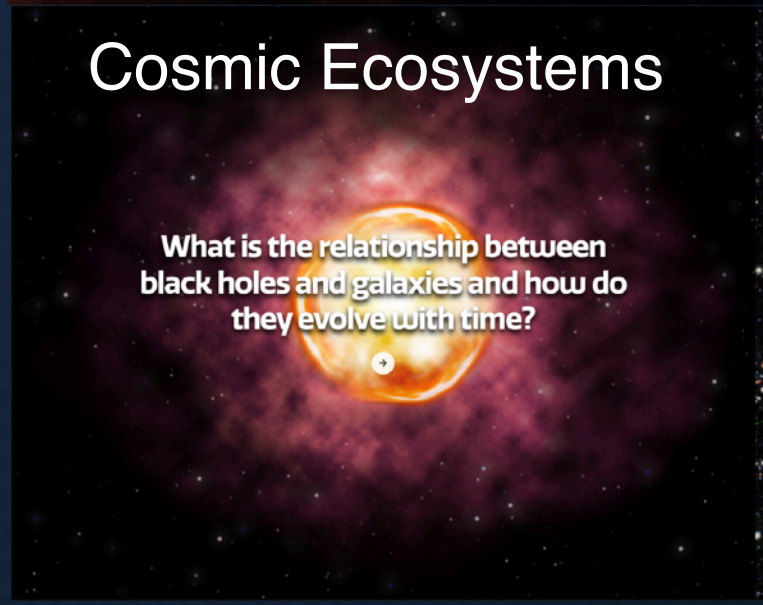
TMT
THIRTY METER TELESCOPE

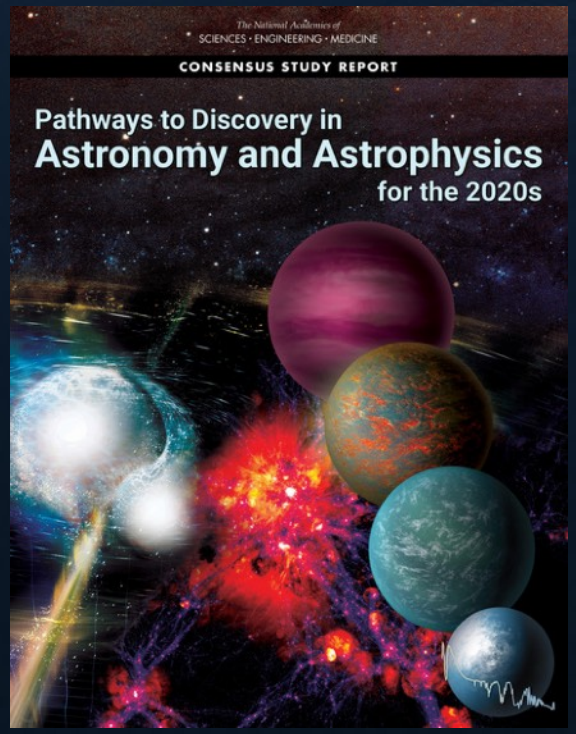
NOIR Lab

GIANT MAGELLAN TELESCOPE

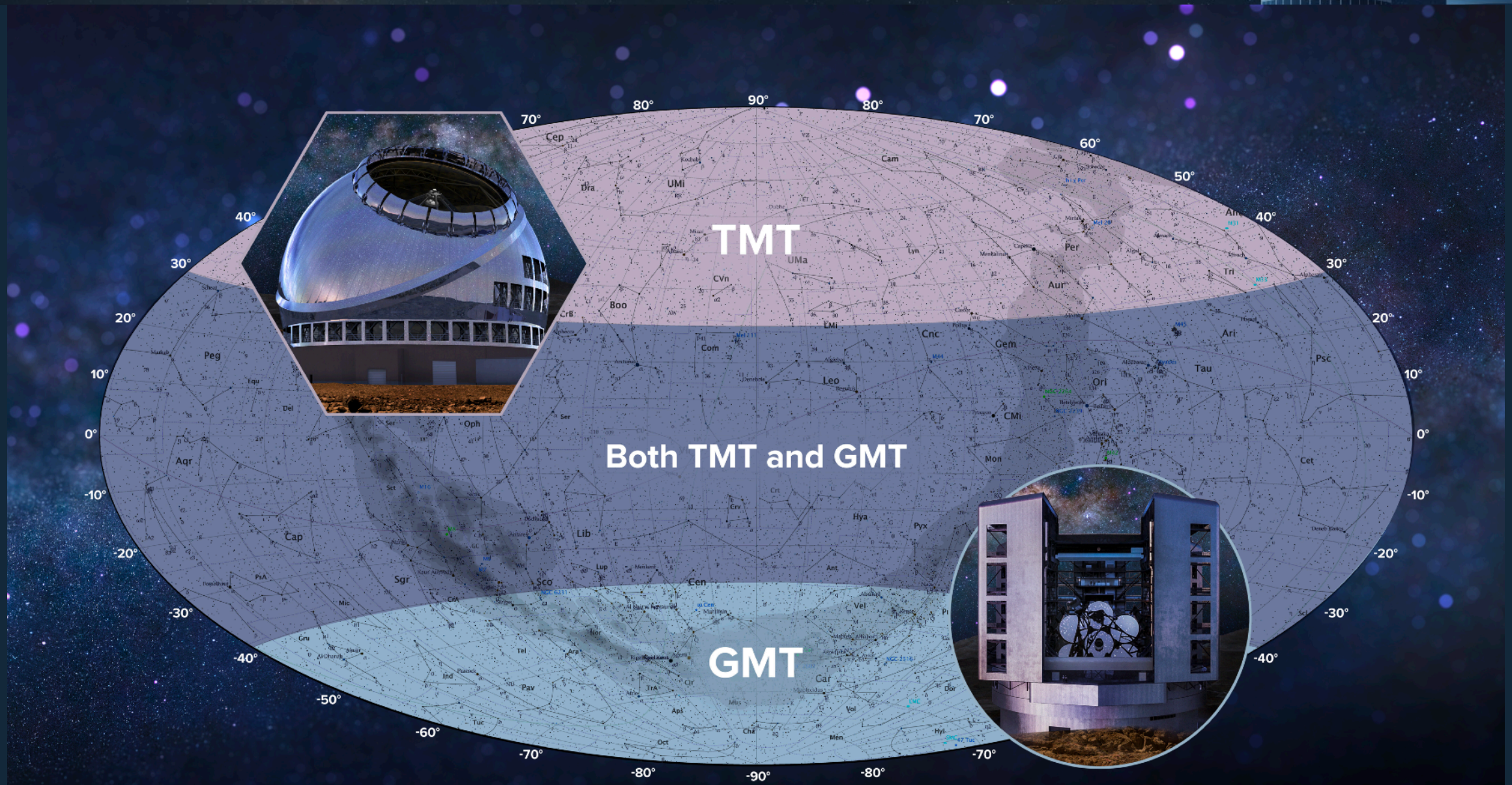
ELTs and the Big Science Questions







The Power of Two

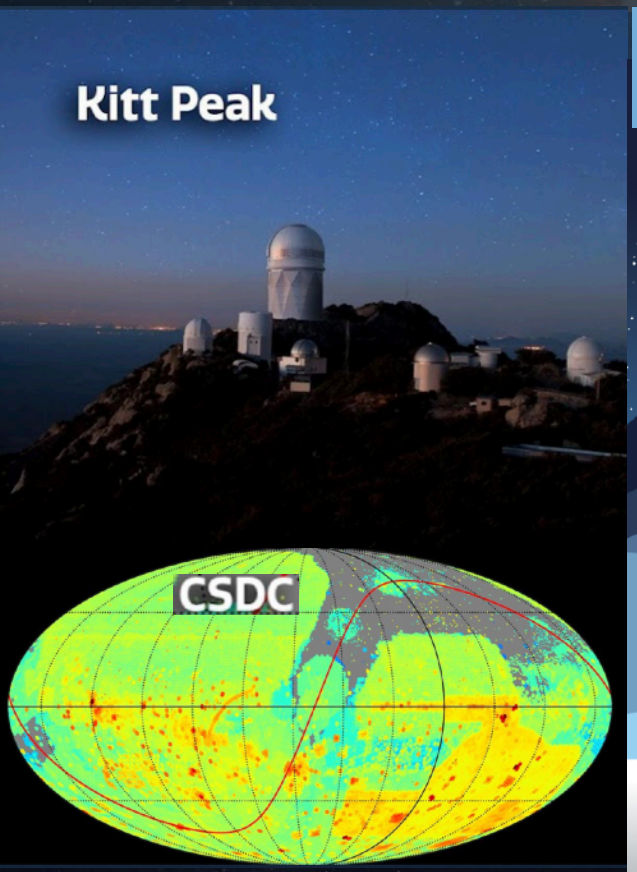


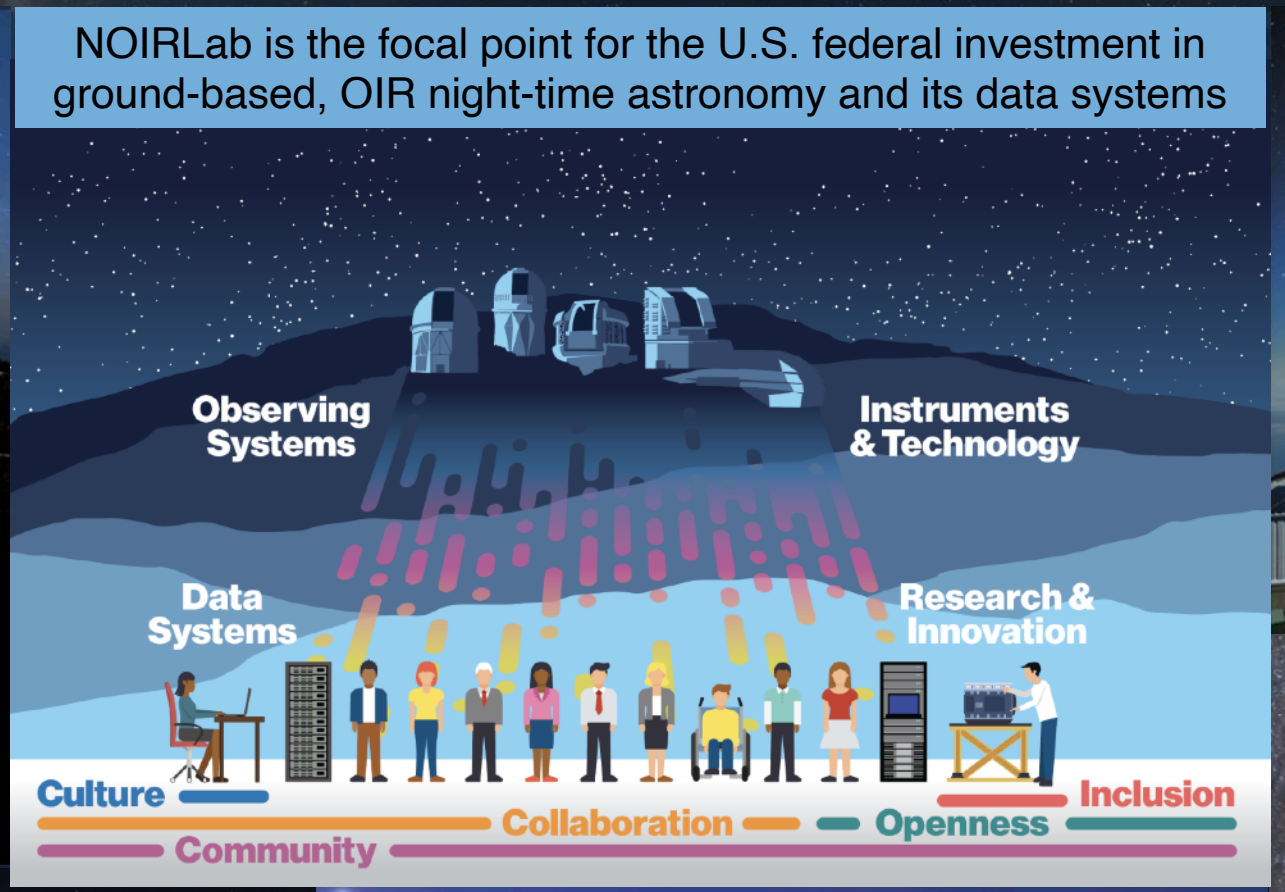
The Power of Two

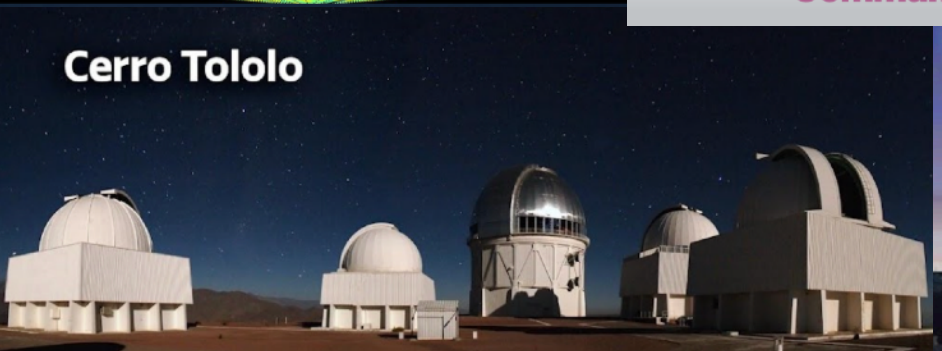
- US-ELT System has same collecting area as E-ELT
- Full coverage of rare events (e.g., best exoplanets for biosignatures)
- Longitudinal separation for time-domain astrophysics
- Two platforms for instrumentation
- Opportunities for international collaboration with many key partners

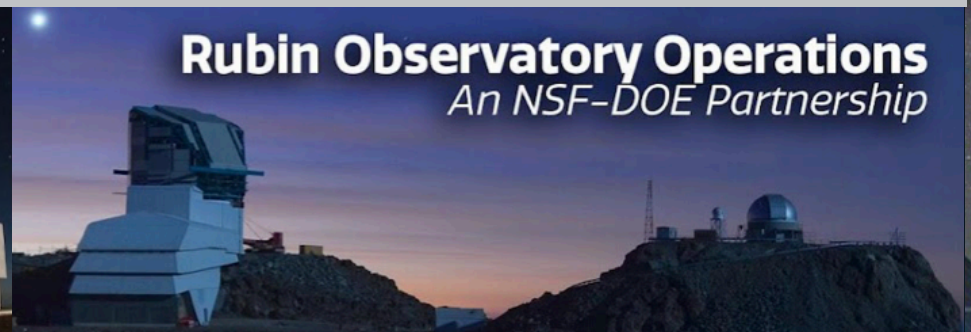
NOIRLab and the US-ELTP

NOIRLab is the focal point for the U.S. federal investment in ground-based, OIR night-time astronomy and its data systems









NOIRLab's Role in the US ELT Program

Enable the broad community to take full advantage of NSF's investments in the US ELTP

1. **Representation and Engagement.** We represent the interests of the NSF and the full US community in the design, construction and operation of the ELTs.
2. **Supporting Opportunity.** Ensure that all qualified scientists in the US have the tools and support needed to propose, conduct, and process observations to achieve science goals. Provide **outstanding user support** commensurate with the proposed US-ELTP investment.
3. **Creating a system.** Ensure that telescopes work as a system with an impact greater than the sum of its parts.
4. **Communication.** Communicate to the US public the results from the ELTs and the importance of fostering fundamental scientific research.
5. **Developing the STEM workforce.** Ensuring participation of diverse professionals in all aspects of the US ELT Program.

NOIRLab US-ELTP team

- Project Director: **Lucas Macri**
- Project Manager: Steve Berukoff
- Systems Scientist: Marie Lemoine-Busserolle
- Research Inclusion Lead: Dara Norman
- Software Architect: François Pradeau
- Project Management Support: Brittany McClinton
- Document Manager: Sharon Hunt
- Senior Administrative Support: Sandra Ortiz

- Senior Advisor: Richard Green
- Project Scientist: **Eric Peng**

- Community Engagement Scientist: **André-Nicolas Chené**
- Principal Software Systems Engineer: Mike Fitzpatrick
- Project Management Consultant: Jeff Kantor
- GMTO Technical Monitor: Steve Ridgway
- Project Controls: Kevin Long

Using the ELTs

WHO WILL USE THE ELTS?

HOW WILL THEY USE THEM?

HOW WILL NOIRLAB HELP THEM BE SUCCESSFUL?

Who will use the ELTs?

Anyone and Everyone!

One of the main motivations for our involvement in the US ELTP to ensure that scientist at any institution can use the largest telescopes

JWST Cycle 2 Proposal Map is similar to NOIRLab Map – but even more diverse

20,300 investigators
9,600 US investigators
5,450 unique investigators

The US-ELTP Research Inclusion Initiative

Supports the **research participation of the broadest US astronomical community** by specifically addressing the concerns of researchers at small and under-resourced institutions that may be interested in participating in the US ELTP.

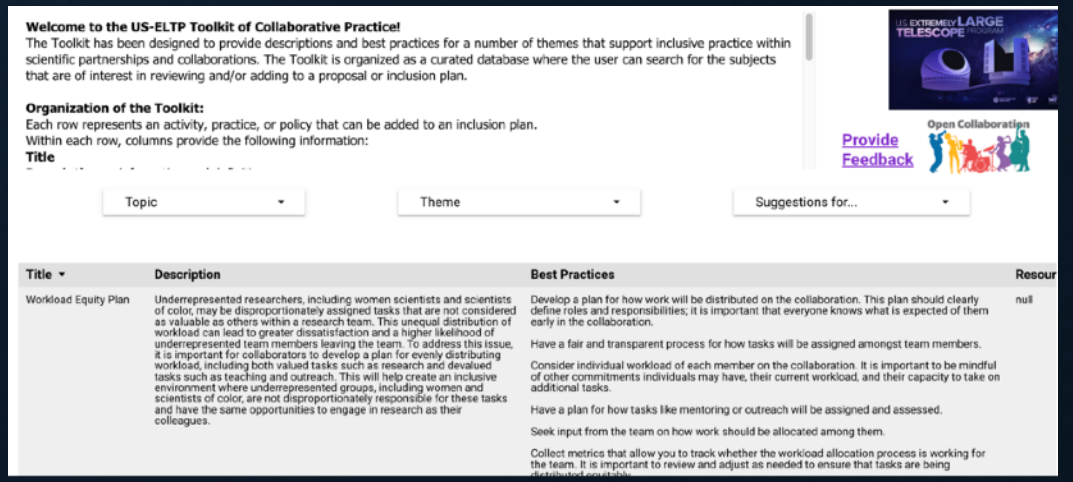
Focuses on 4 main areas of inclusion identified through conversations with researchers at small and under-resourced colleges and universities.

1. Policies and procedures that support mutually beneficial partnerships
2. Opportunities for scientific networking and collaboration building
3. Technical infrastructure that enables participation
4. Science platform and tools instruction

Dara Norman / NOIRLab

US ELTP Research Inclusion Initiative

- NSF Development funding to prepare the community for research inclusion proposal requirements (PIs and Reviewers); Led by D. Norman & T. Sacco
- A Toolkit of Collaborative Practice: prototype of a filterable database with identified inclusion themes (BAAS, 54, 1); v2 in Fall '23 will include metrics
  - Team Management, Mentorship, Communication, Cross-Institutional Partnerships, Authorship and Publishing, Evaluation, Mentoring Environment, Recruitment, Assessment, Resource Allocation, Conflict Management
- Invited use by those proposing to NASA, who have inclusion plan requirements now
- tinyurl.com/ToolkitCollaborativePractice

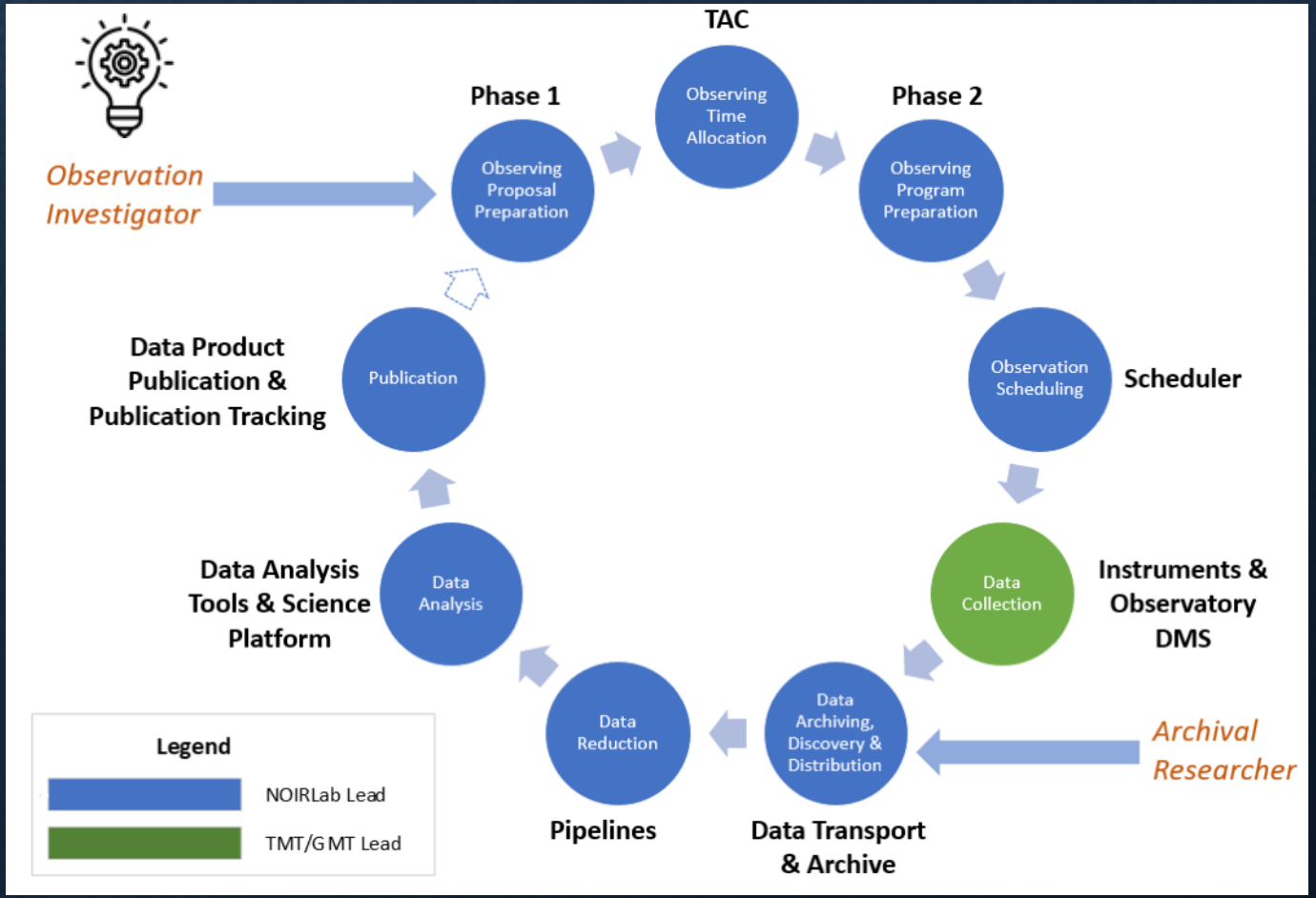


Research Inclusion is central to NOIRLab's US-ELTP mission to enable participation by all astronomers in GMT and TMT science

Modes of Investigation

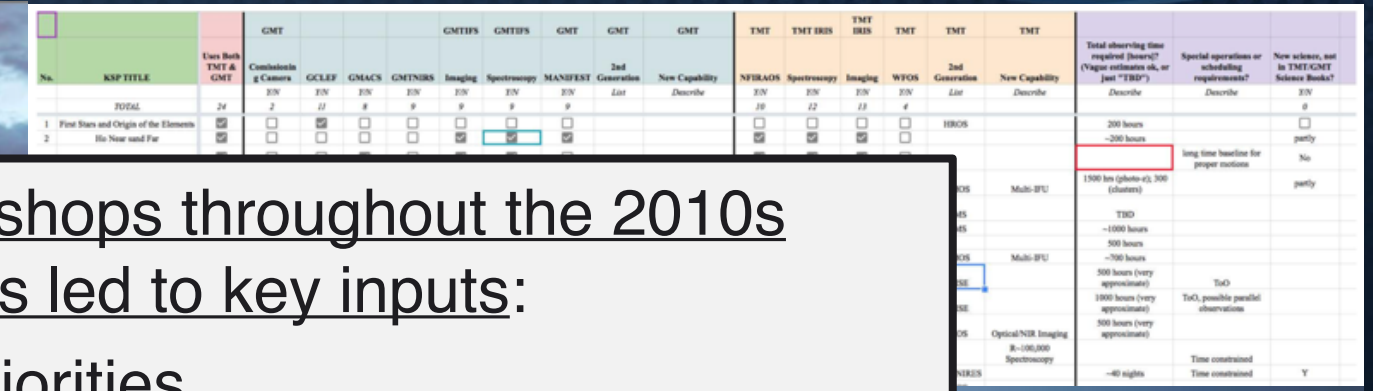
- Key Science Programs (KSPs)
  - Scientific legacy through systematic investment in large-scale, transformative research projects
  - Projects on scales difficult to realize within time shares of current GMT+TMT partners
  - Broad, inclusive scientist participation in KSPs via open collaboration models
  - 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 GMT+TMT

Science Data Life Cycle



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

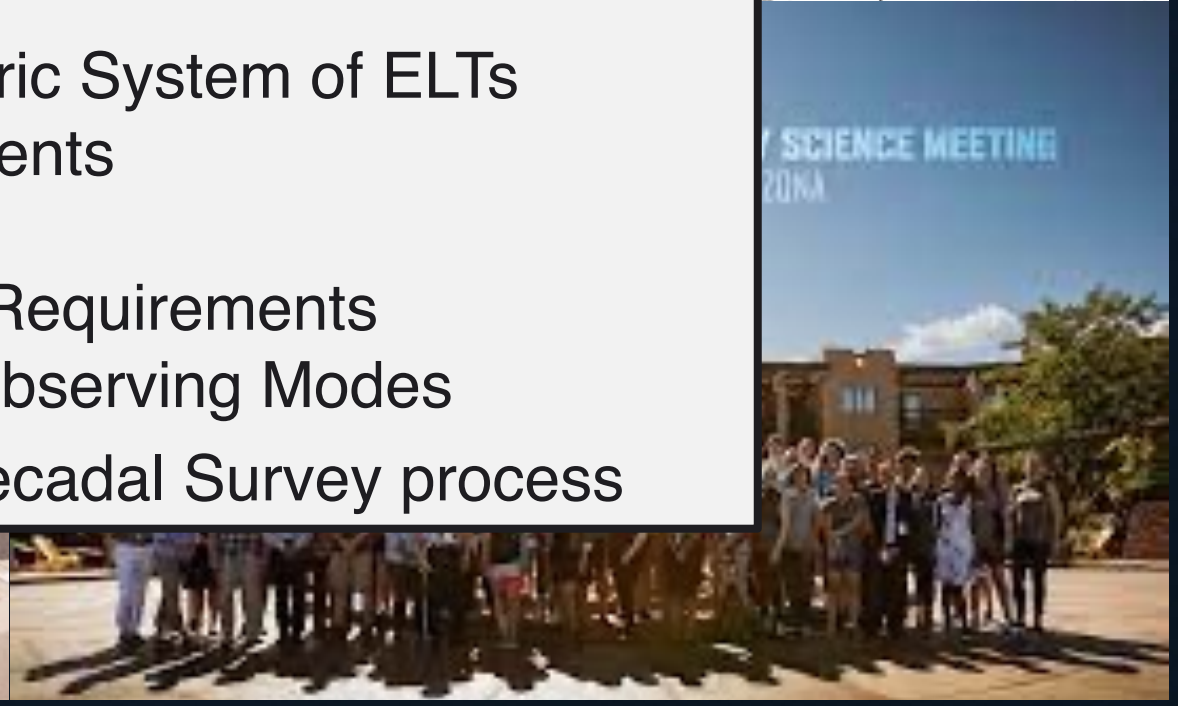
How will People Use the ELTs?



<u>Community Workshops throughout the 2010s and into the 2020s led to key inputs</u>:

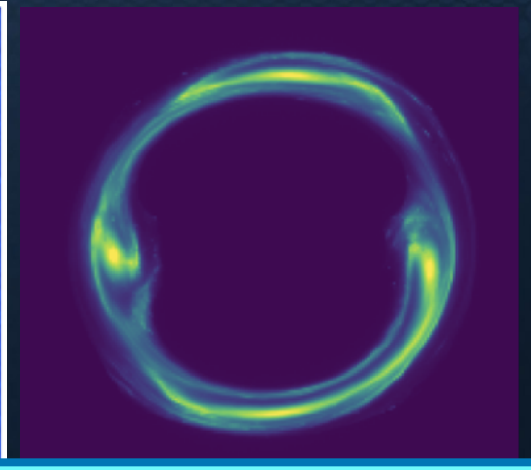
- Key Science Priorities
- Case for Bi-Hemispheric System of ELTs
- Operational Requirements
- User Support Needs
- End-to-End Software Requirements
- Instrumentation and Observing Modes

Fed into the US 2020 Decadal Survey process



Community-Developed KSP Concepts

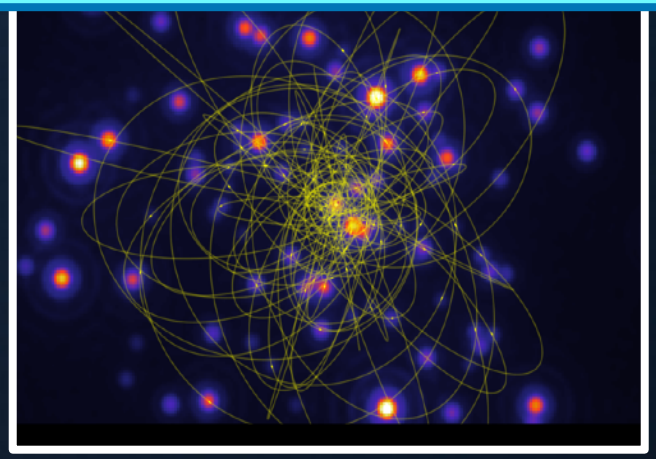
Extrasolar Planets and the Search for Extraterrestrial Life

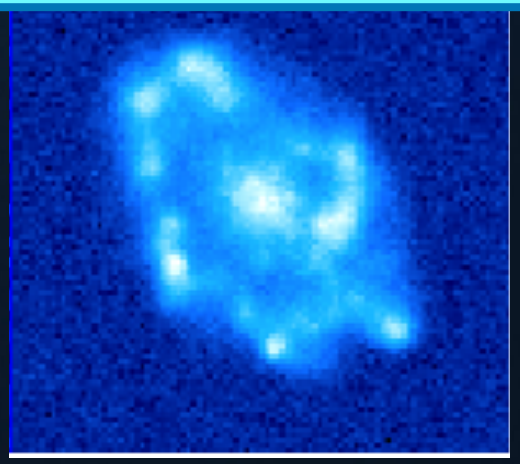


The Dark Universe and Physics Beyond the Standard Model

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

Proposal and Observation Preparation (Phase I&II): US ELT Program Platform (UPP)

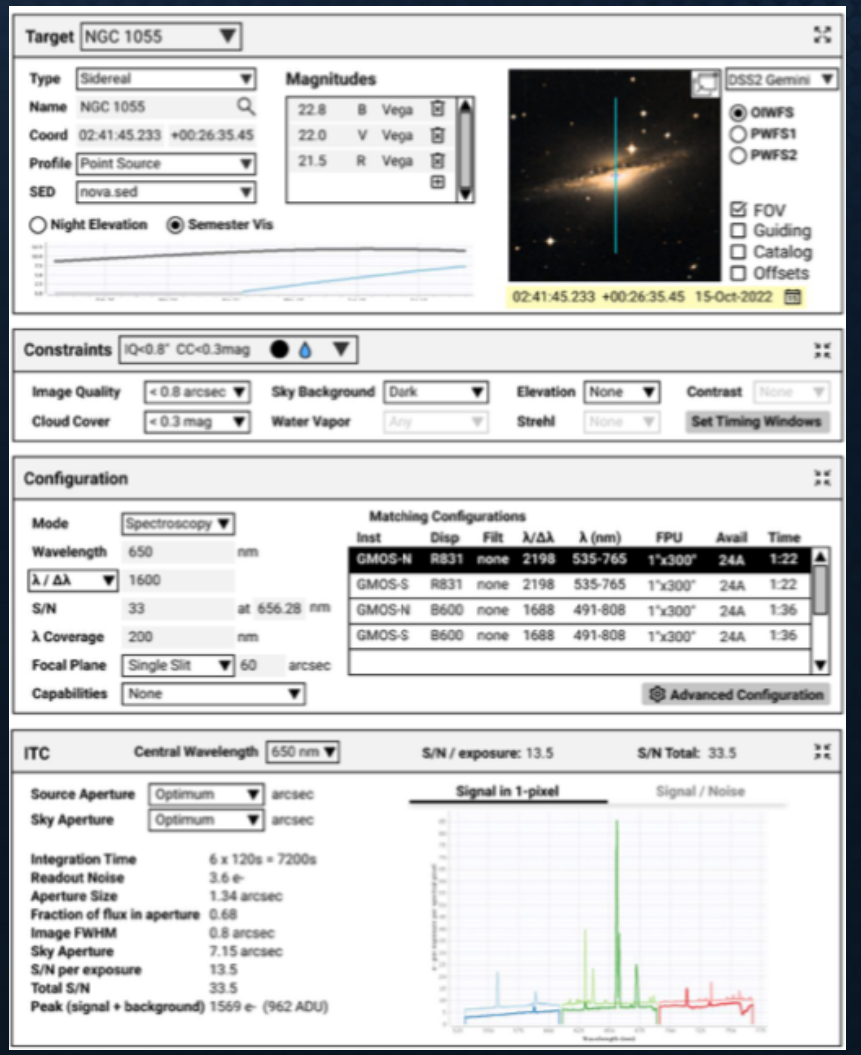
Uniform community interfaces for GMT and TMT

- Single Tool to combine and simplify processes for preparation of Phase 1 (proposal) and Phase 2 (observing program)

Phase I – prepare your proposal

- Define your targets
- Choose telescope(s), instrument(s), configuration(s)
- Determine feasibility, observability
- Run Exposure Time Calculator
- Produce SNR calculations and plots
- Prepare and upload your proposal
- Internal software checks proposal for feasibility

Mockup of Gemini Program Platform (GPP)



Proposal and Observation Preparation (Phase I&II): US ELT Program Platform (UPP)

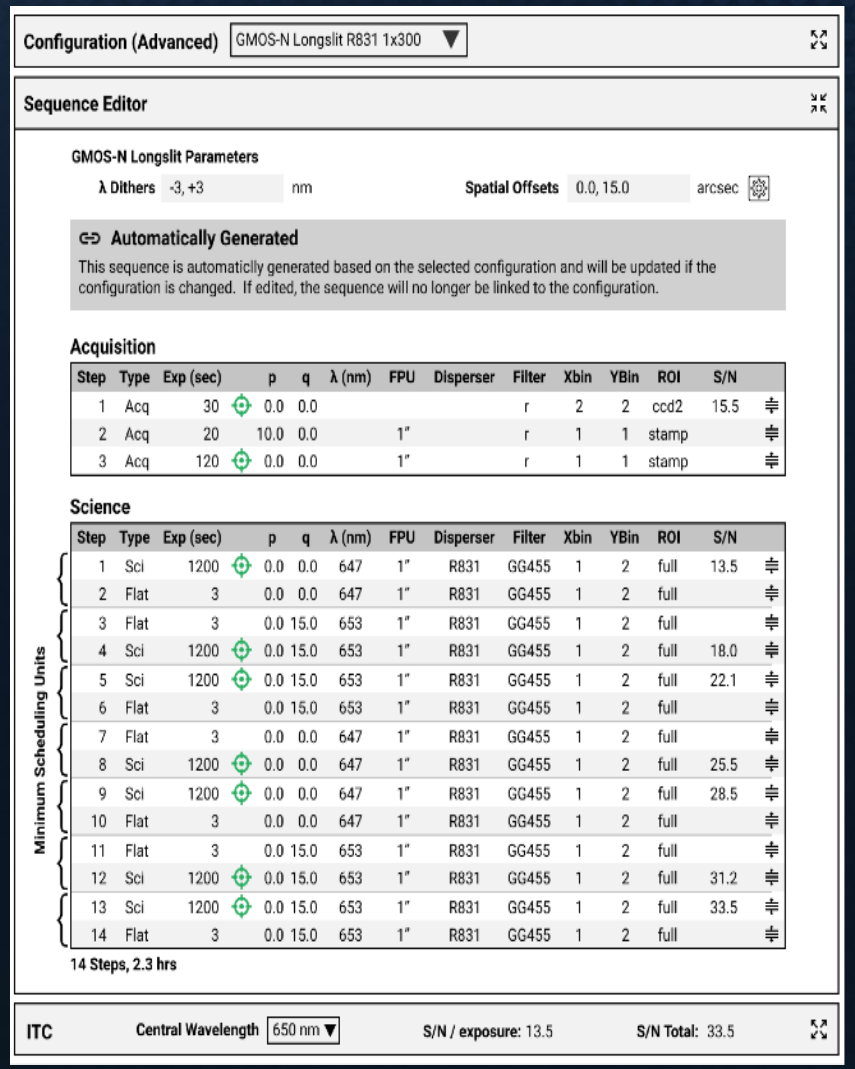
Uniform community interfaces for GMT and TMT

- Single Tool to combine and simplify processes for preparation of Phase 1 (proposal) and Phase 2 (observing program)

Phase II – prepare your observations

- Position your targets
- Select/accept guide stars, WF sensing+TT stars
- Set instrument parameters
- Generate observing scripts
- Instrument configuration motions
- WFS probe motions
- Submit Phase II
- Internal software checks Phase II for errors

Mockup of Gemini Program Platform (GPP)

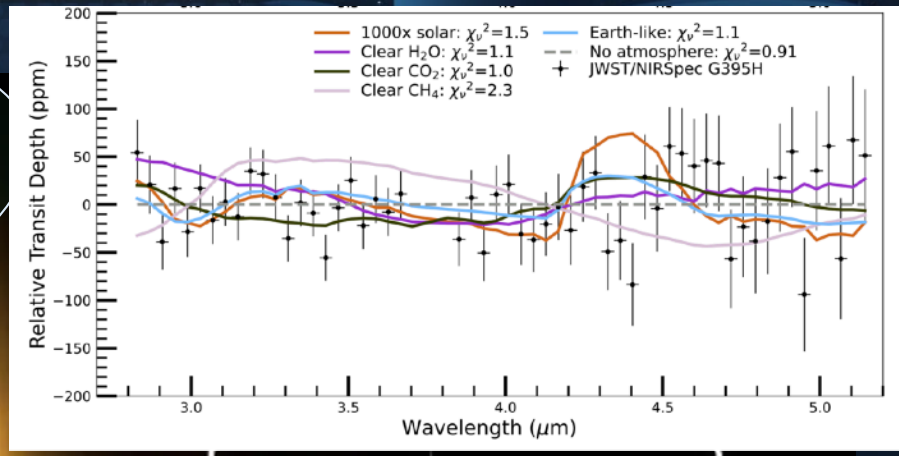


How will People Use the ELTs?

We expect many modes of use

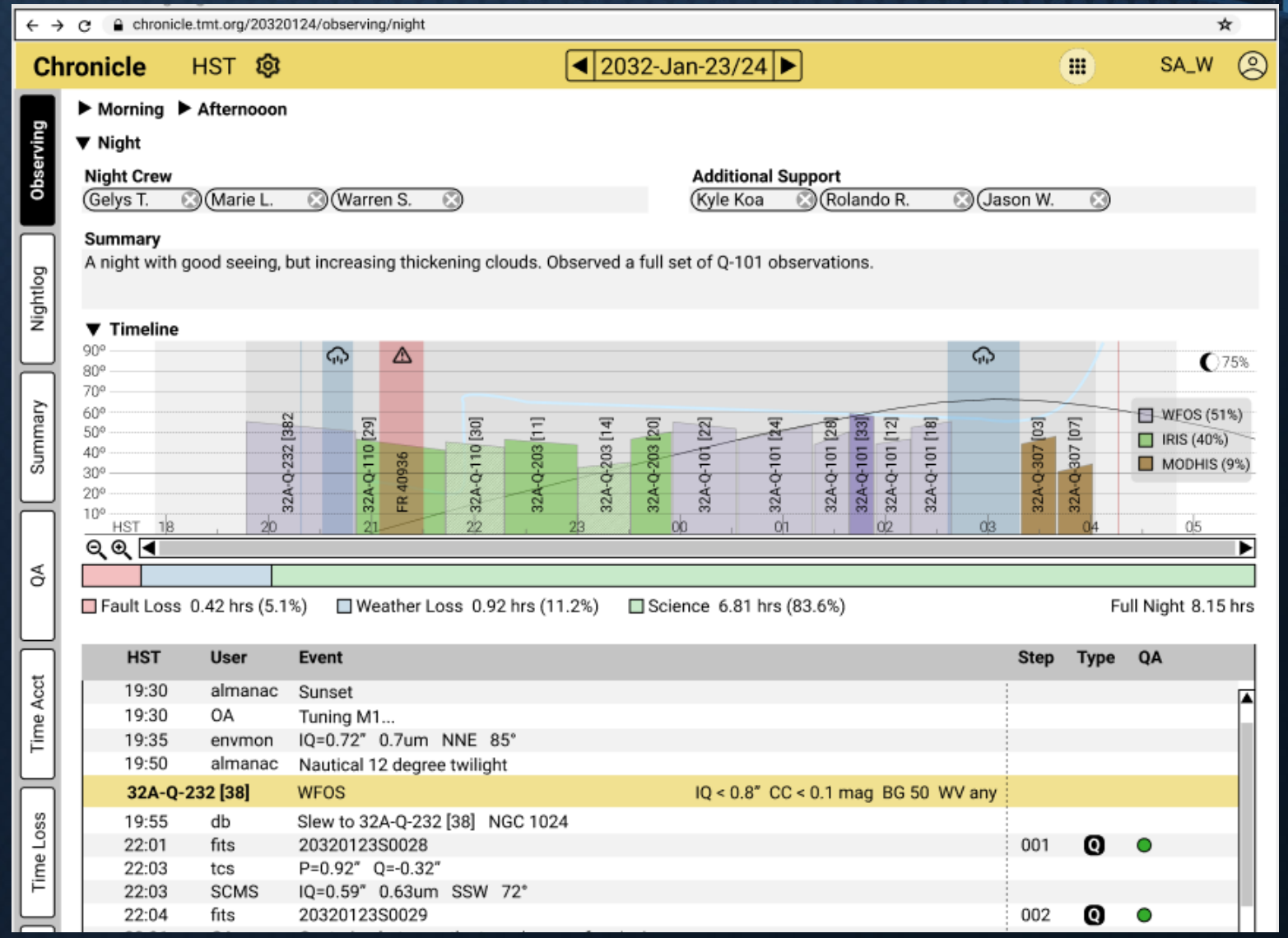
- Time-Critical Observing
  - Exoplanet Transits
  - Multi-Messenger Sources
  - Transient Events
  - Targeted EPRV measurements
- Adaptive Optics & Coronagraphy
  - Exoplanet imaging
  - Crowded fields
  - Black hole environments

These will be short, "high precision, high impact" observations



The "easy" exoplanet atmospheres will have been done with *JWST*, Keck, Gemini – the ELTs will be needed for the hard ones. Multiple transits will be needed

Highly adaptive queue observing



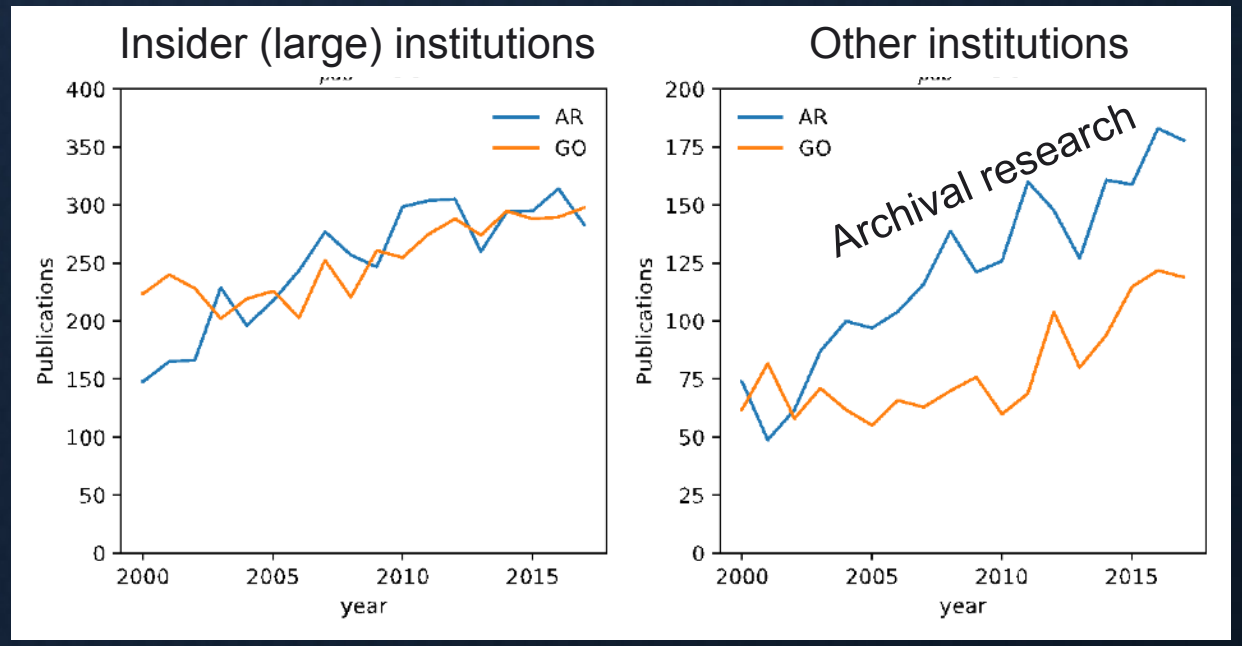
Post Observing

In Practice

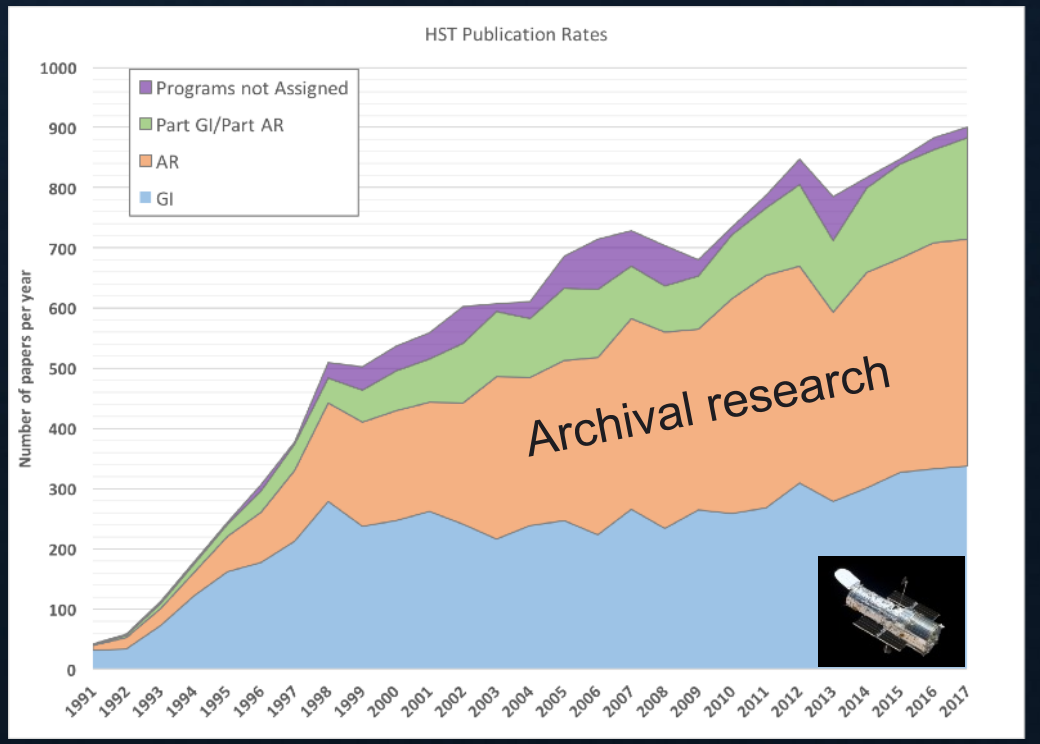
- Instrument teams define/develop algorithms for instrument-specific processing tasks
- Common framework for languages, standards, protocols, keywords,…
  - Developed across the US ELT partnership
- Pipelines turn raw data into science-ready data products in the archive
- Virtual machines allow users to run pipelines as part of the science platform
- NOIRLab will provide long-term continuity
  - Instrument teams move on to the next project
  - Need corporate memory to maintain pipelines

US ELT Archive will broaden participation

- Access to “science ready” data from a full-fledged *HST* archive had a very significant impact on publication rates for scientists who are not in “insider” institutions
- And it doubled publication rates overall!



Josh Peek, et al. (2019)



User Experience in the US ELT *System*

NOIRLab Scope

GMT/TMT Scope

Scientist with an Idea!

- Science Goals
- Target List

US ELT Proposal Interface

- Planning Tools
- Telescope and Instrument Data
- Ancillary Data

OIR Data Archive

Other

Gem N

TMT Instrument sAO

GMT Instrument s AO

GemS

Rubin

Phase I Proposal

Dual Anonymous Peer Review

Scheduling

Phase II

Program Execution

QC

Quick Look

Data!

Meta Data

Pipelines

Level 1 and 2 data products

Level 0 Data

OIR Data Archive

Tools & Ancillary Data

System Capabilities

Selection

Implementation

Post Observing

Proposal Preparation

Execution and Analysis

An Integrated System of Extremely Large Telescopes will maximize the return on investment

NOIRLab Project Status

- Continuing work on System Definition and Requirements for Science Data Life Cycle Services
- Research Inclusion Toolkit completed, v2 coming soon
  - Already in use by some NASA programs
- Working to identify joint collaboration activities (Gemini, Rubin, CSDC) re:DMS
- Started trilateral working group on USELT Concept of Operations
- US-ELT website redesign in progress (coming soon)
- AAS joint booth (visit the poster room!)

- Original award from NSF for $5.5M
  - Some milestones completed/exceeded, others at ~85%
  - NSF review of outcomes from original award tentatively scheduled for Feb ‘24
- Supplemental funding request awarded on 9/15/23
  - $2.3M to support efforts through 12/31/24
  - Targeting NOIRLab CoDR in ~Dec ‘24 (cf Observatory FDRs NET ~ 2025)

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, and realize our investment
- US-ELTP user services will broaden participation in science with GMT+TMT 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 US-ELTP to ensure we build the system that researchers need

How will you use the ELTs and what will you need?
Please tell us!