



U.S. EXTREMELY **LARGE**
TELESCOPE PROGRAM

The US Extremely Large Telescope Program

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



ELTs and the Big Science Questions



Worlds and Suns in Context

Is there life outside our Solar System?

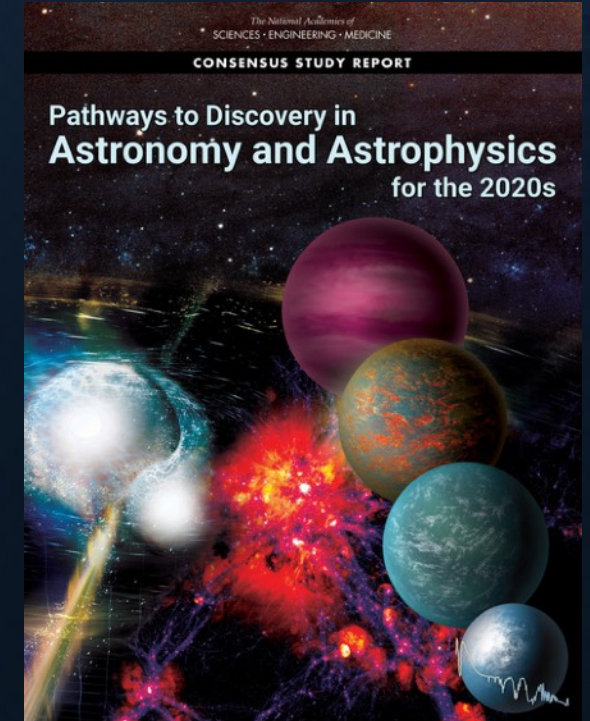
New Messengers New Physics

What is the nature of the Universe?

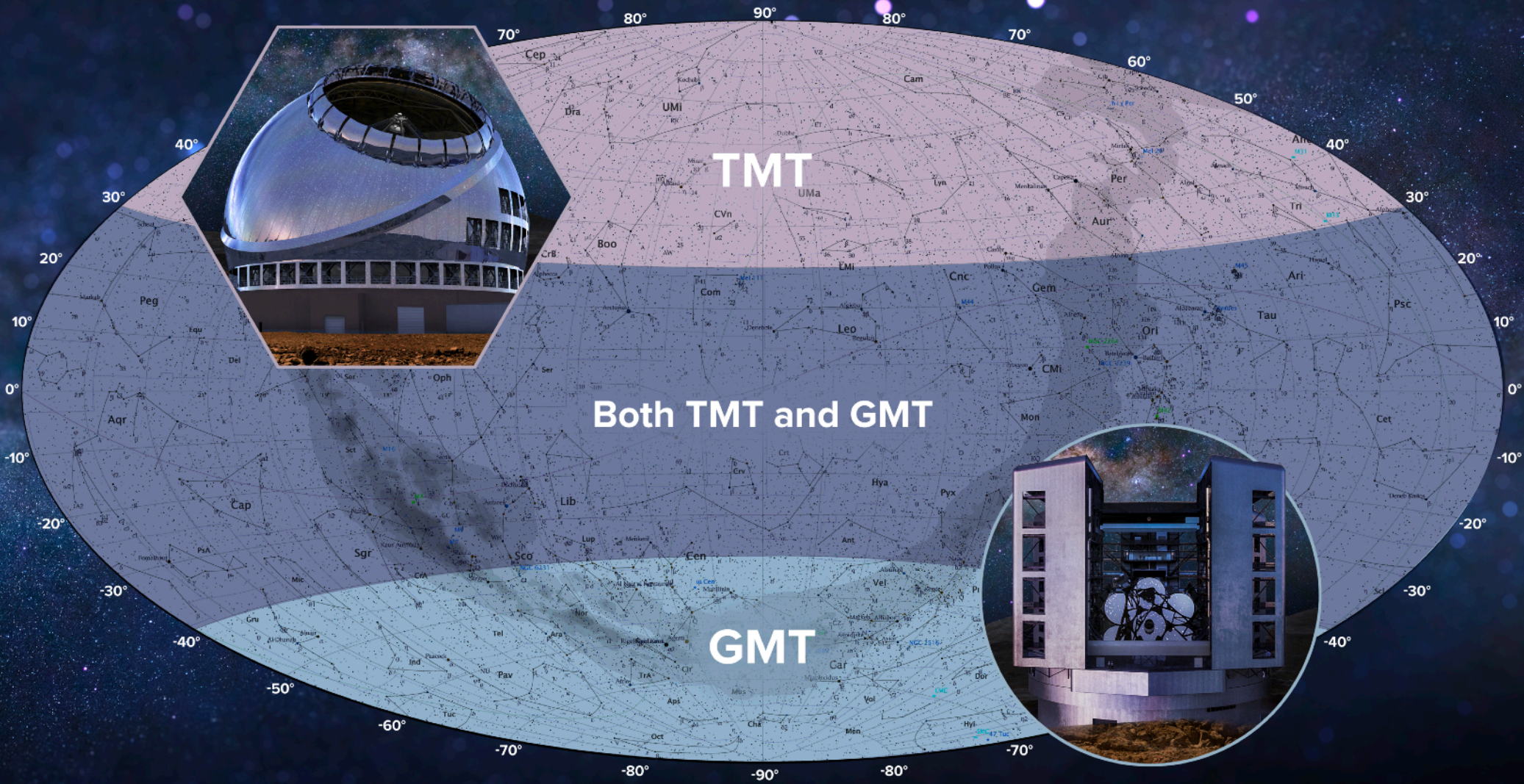
Cosmic Ecosystems

What is the relationship between black holes and galaxies and how do they evolve with time?

What else is out there?

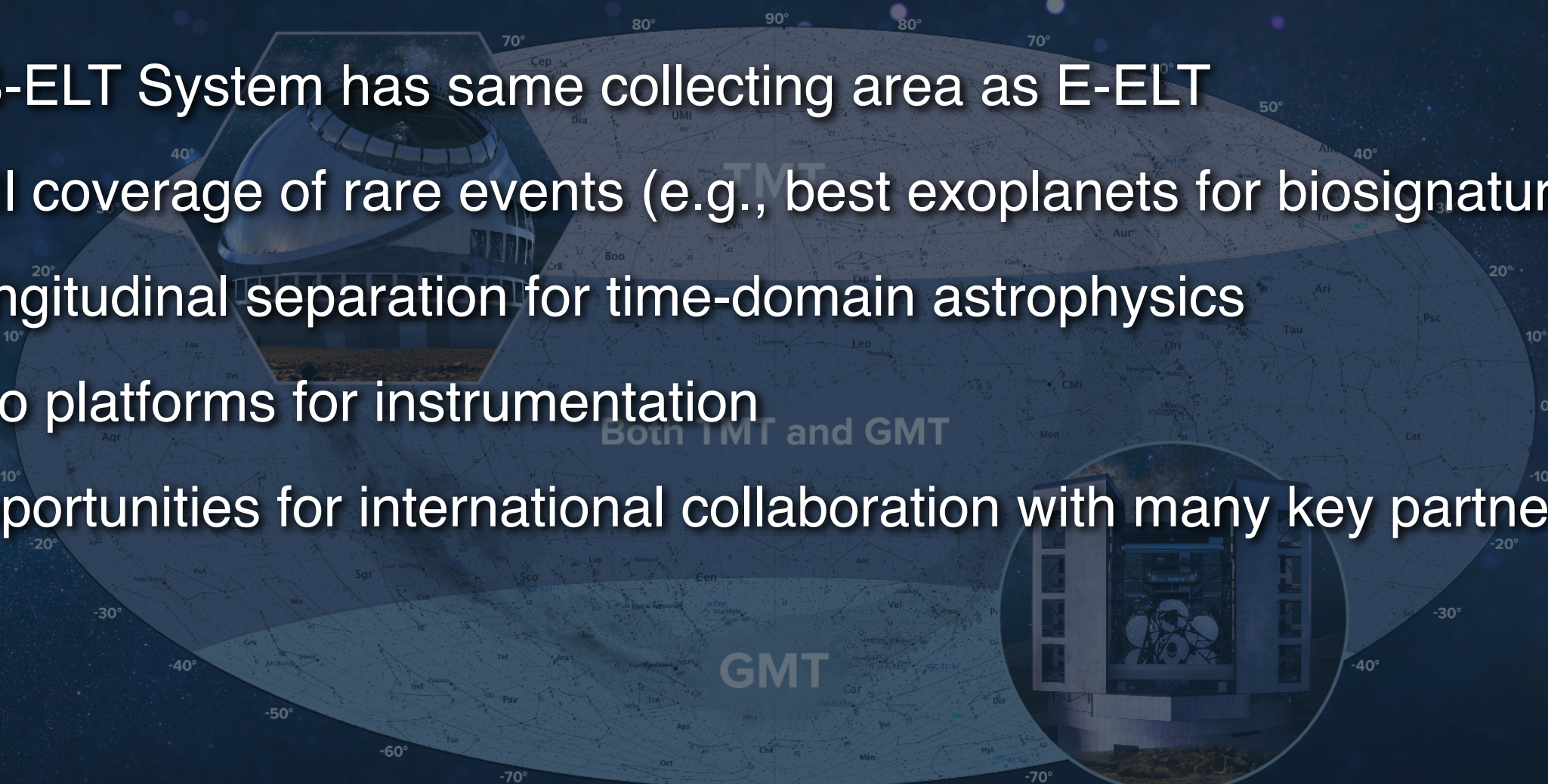


The Power of Two



The Power of Two

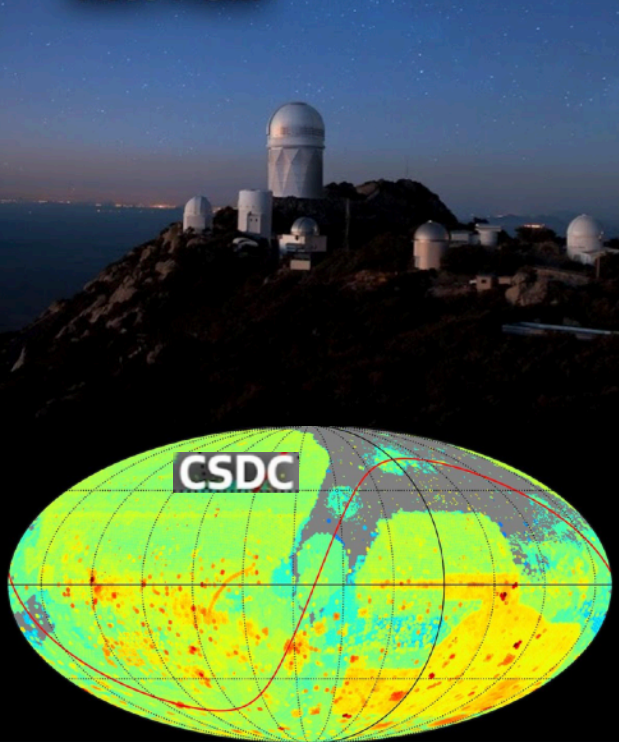
- US-ELT System has same collecting area as E-ELT
- Full coverage of rare events (e.g., best exoplanets for biosignatures)
- Longitudinal separation for time-domain astrophysics
- Two platforms for instrumentation
- Opportunities for international collaboration with many key partners



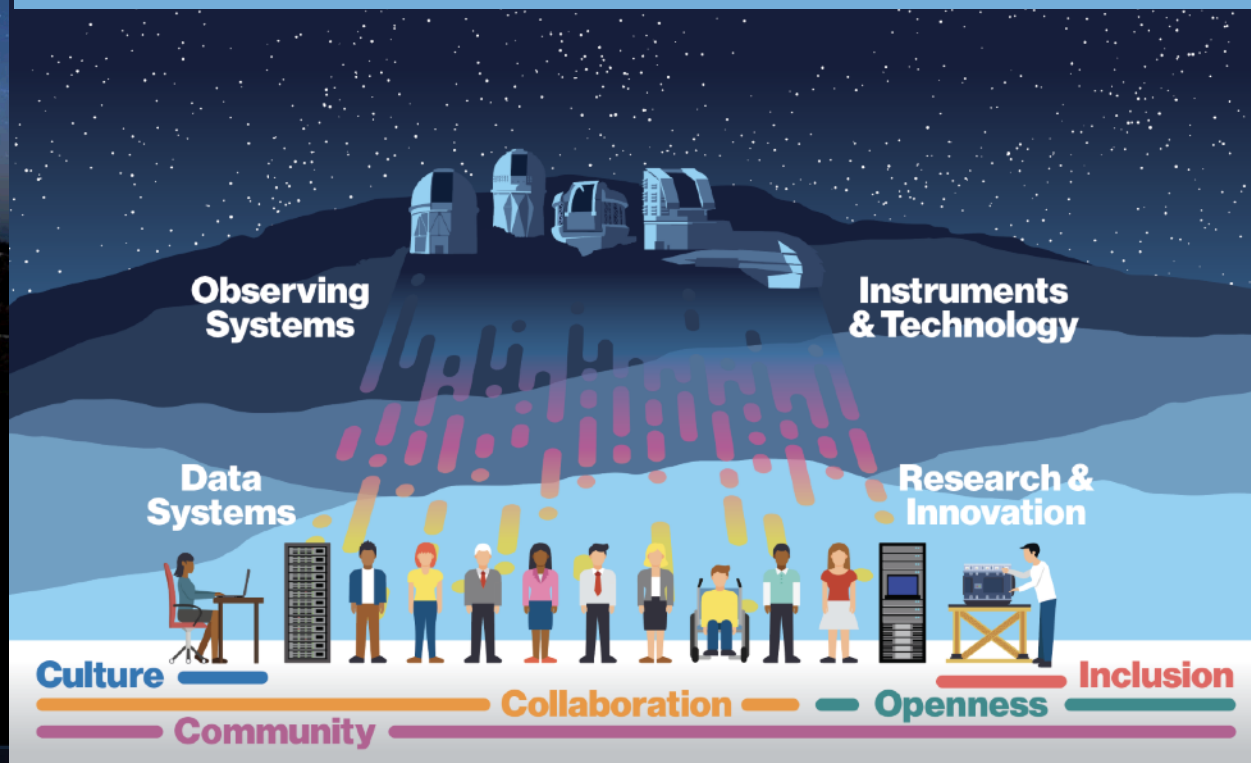
NOIRLab and the US-ELTP



Kitt Peak



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



Gemini

With our international partners



Cerro Tololo



Rubin Observatory Operations
An NSF-DOE Partnership



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

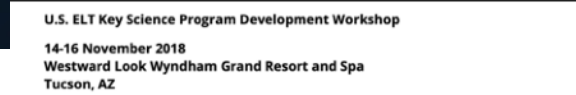
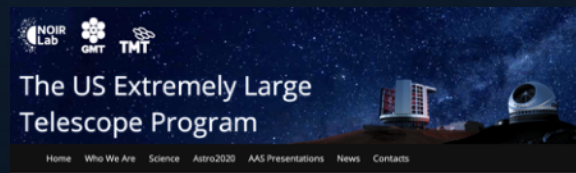
Supports the **research participation of the broadest US astronomical community** by specifically addressing the concerns of researchers at small and under-resourced institutions that may be interested in participating in the US ELTP.



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

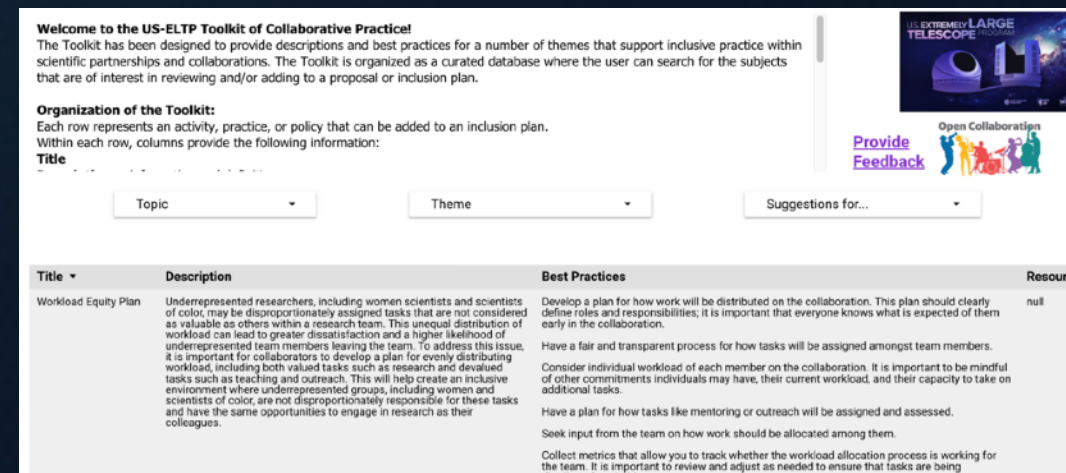


1. Policies and procedures that support mutually beneficial partnerships
2. Opportunities for scientific networking and collaboration building
3. Technical infrastructure that enables participation
4. Science platform and tools instruction



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



Welcome to the US-ELTP Toolkit of Collaborative Practice!
The Toolkit has been designed to provide descriptions and best practices for a number of themes that support inclusive practice within scientific partnerships and collaborations. The Toolkit is organized as a curated database where the user can search for the subjects that are of interest in reviewing and/or adding to a proposal or inclusion plan.

Organization of the Toolkit:
Each row represents an activity, practice, or policy that can be added to an inclusion plan. Within each row, columns provide the following information:

Title

Topic Theme Suggestions for...

Title	Description	Best Practices	Resour
Workload Equity Plan	Underrepresented researchers, including women scientists and scientists of color, may be disproportionately assigned tasks that are not considered as valuable as others within a research team. This unequal distribution of workload can lead to greater dissatisfaction and a higher likelihood of underrepresented team members leaving the team. To address this issue, it is important for collaborators to develop a plan for evenly distributing workload, including both valued tasks such as research and devalued tasks such as teaching and outreach. This will help create an inclusive environment where underrepresented groups, including women and scientists of color, are not disproportionately responsible for these tasks and have the same opportunities to engage in research as their colleagues.	<p>Develop a plan for how work will be distributed on the collaboration. This plan should clearly define roles and responsibilities; it is important that everyone knows what is expected of them early in the collaboration.</p> <p>Have a fair and transparent process for how tasks will be assigned amongst team members.</p> <p>Consider individual workload of each member on the collaboration. It is important to be mindful of other commitments individuals may have, their current workload, and their capacity to take on additional tasks.</p> <p>Have a plan for how tasks like mentoring or outreach will be assigned and assessed.</p> <p>Seek input from the team on how work should be allocated among them.</p> <p>Collect metrics that allow you to track whether the workload allocation process is working for the team. It is important to review and adjust as needed to ensure that tasks are being distributed equitably.</p>	null

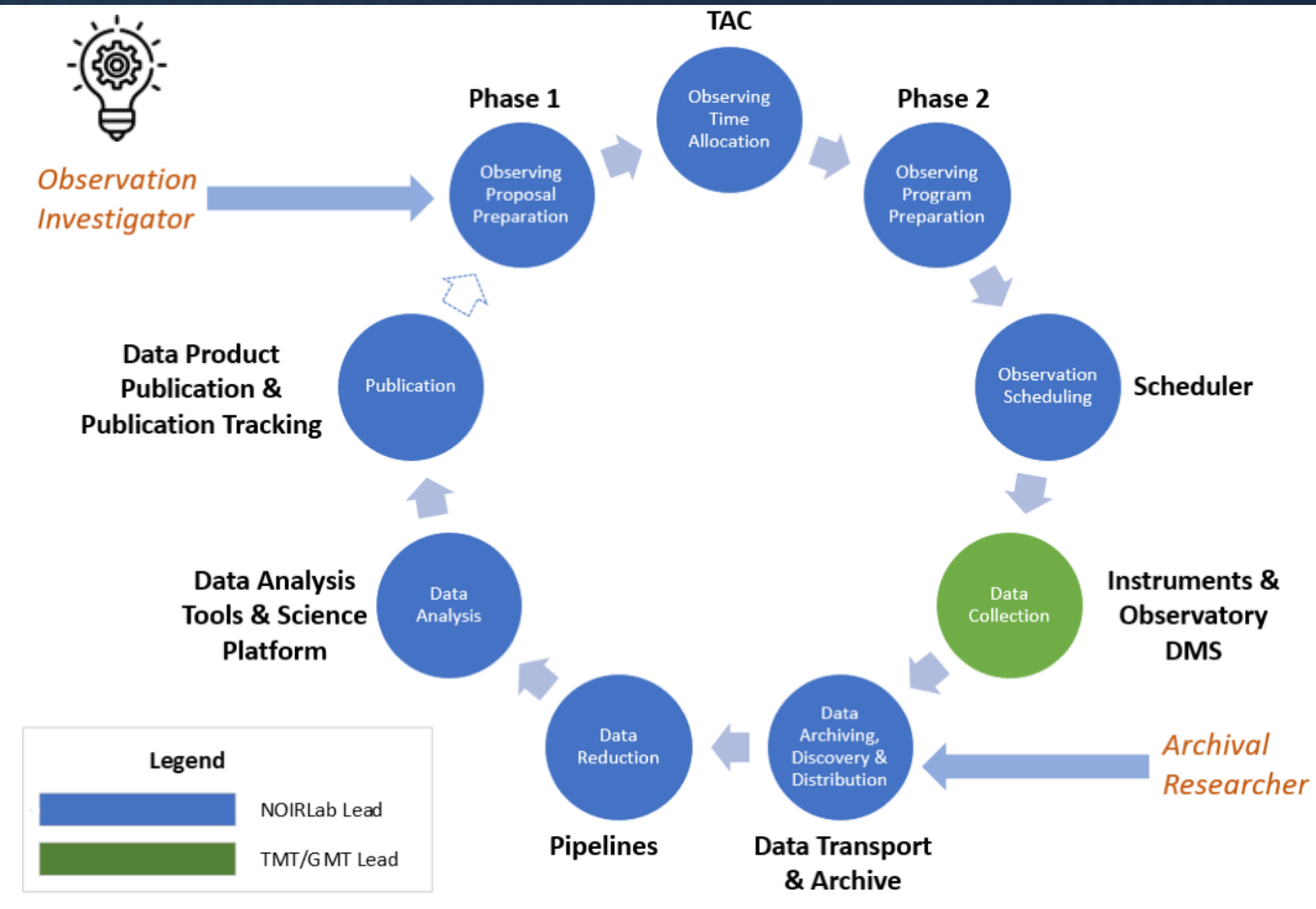
Research Inclusion is central to NOIRLab’s US-ELTP mission to enable participation by all astronomers in GMT and TMT science



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?

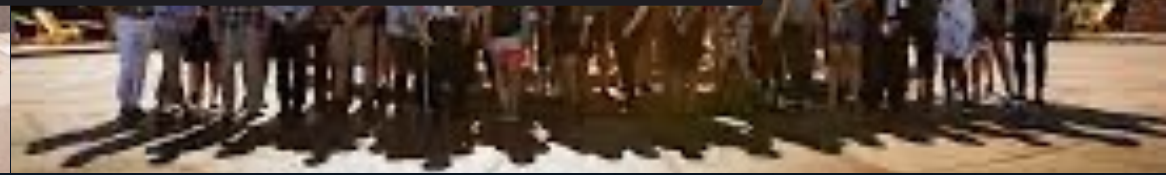
US ELT KSP Development Workshop
14 - 16 November 2018, Westward Look Resort, Tucson

No.	KSP TITLE	Uses Both TMT & GMT	GMT		GMTFS		GMTFS		GMT		GMT		TMT		TMT IRIS		TMT IRIS		TMT		TMT		Total observing time required (hours)? (Vague estimates ok, or just " TBD")	Special operations or scheduling requirements?	New science, not in TMT/GMT Science Books?
			Combination	g Camera	GCLFP	GMACS	GMTNRS	Imaging	Spectroscopy	MANIFEST	2nd Generation	New Capability	NIRAOs	Spectroscopy	Imaging	WFOS	2nd Generation	New Capability	Describe	Describe	Describe	Describe			
TOTAL		24	2	11	8	9	9	9	9	9	10	12	11	4									200 hours		
1	First Stars and Origin of the Elements	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	200 hours			
2	Life Near and Far	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	200 hours	long time baseline for proper motion	No	

Community Workshops throughout the 2010s and into the 2020s led to key inputs:

- 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

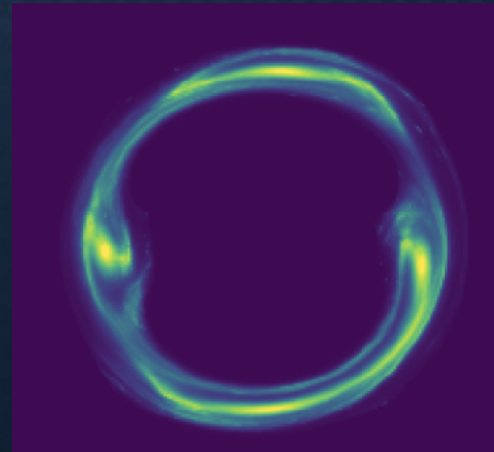


Community-Developed KSP Concepts

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

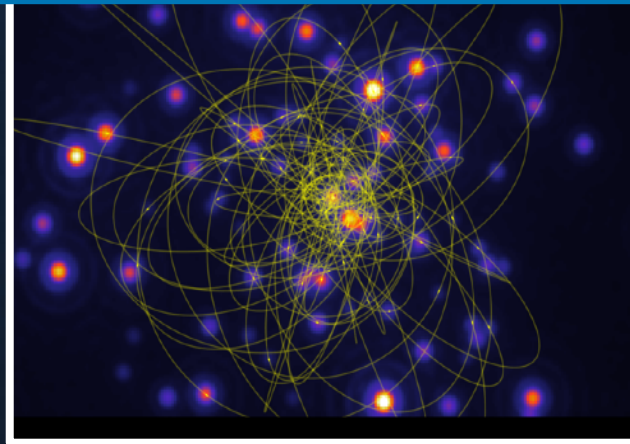


**The Dark Universe
and Physics
Beyond the
Standard Model**

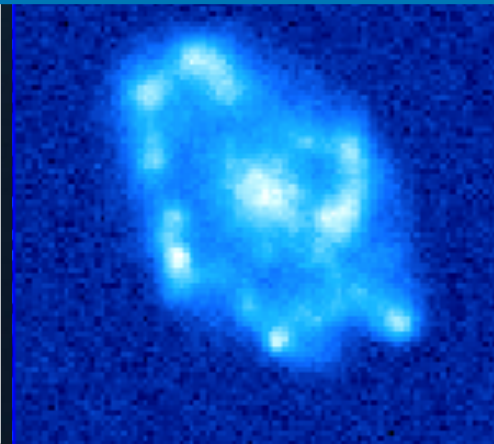


Actual, future KSPs would be selected by peer review

**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)

The screenshot displays the Gemini Program Platform (GPP) interface, which is used for target selection and proposal preparation. The interface is divided into several sections:

- Target Selection:** Shows the target name (NGC 1055), coordinates (02:41:45.233 +00:26:35.45), profile (Point Source), and SED (nova.sed). It also includes a magnitude selection tool and a preview image of the target.
- Constraints:** Allows users to set constraints for image quality, sky background, elevation, contrast, cloud cover, water vapor, and Strehl.
- Configuration:** Shows the mode (Spectroscopy), wavelength (650 nm), and other parameters. It also displays a table of matching configurations.
- ITC (Integration Time Calculator):** Shows the results of the ITC, including source aperture, sky aperture, integration time, readout noise, aperture size, fraction of flux in aperture, image FWHM, sky aperture, S/N per exposure, total S/N, and peak signal + background.

Inst	Disp	Filter	$\lambda/\Delta\lambda$	λ (nm)	FPU	Avail	Time
GMOS-N	R831	none	2198	535-765	1"x300"	24A	1:22
GMOS-S	R831	none	2198	535-765	1"x300"	24A	1:22
GMOS-N	B600	none	1688	491-808	1"x300"	24A	1:36
GMOS-S	B600	none	1688	491-808	1"x300"	24A	1:36

Parameter	Value
Source Aperture	Optimum arcsec
Sky Aperture	Optimum arcsec
Integration Time	6 x 120s = 7200s
Readout Noise	3.6 e-
Aperture Size	1.34 arcsec
Fraction of flux in aperture	0.68
Image FWHM	0.8 arcsec
Sky Aperture	7.15 arcsec
S/N per exposure	13.5
Total S/N	33.5
Peak (signal + background)	1569 e- (962 ADU)

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)

Configuration (Advanced) GMOS-N Longslit R831 1x300

Sequence Editor

GMOS-N Longslit Parameters

λ Dithers -3, +3 nm Spatial Offsets 0.0, 15.0 arcsec

Automatically Generated

This sequence is automatically generated based on the selected configuration and will be updated if the configuration is changed. If edited, the sequence will no longer be linked to the configuration.

Acquisition

Step	Type	Exp (sec)	p	q	λ (nm)	FPU	Disperser	Filter	Xbin	YBin	ROI	S/N
1	Acq	30	0.0	0.0				r	2	2	ccd2	15.5
2	Acq	20	10.0	0.0		1"		r	1	1	stamp	
3	Acq	120	0.0	0.0		1"		r	1	1	stamp	

Science

Step	Type	Exp (sec)	p	q	λ (nm)	FPU	Disperser	Filter	Xbin	YBin	ROI	S/N
1	Sci	1200	0.0	0.0	647	1"	R831	GG455	1	2	full	13.5
2	Flat	3	0.0	0.0	647	1"	R831	GG455	1	2	full	
3	Flat	3	0.0	15.0	653	1"	R831	GG455	1	2	full	
4	Sci	1200	0.0	15.0	653	1"	R831	GG455	1	2	full	18.0
5	Sci	1200	0.0	15.0	653	1"	R831	GG455	1	2	full	22.1
6	Flat	3	0.0	15.0	653	1"	R831	GG455	1	2	full	
7	Flat	3	0.0	0.0	647	1"	R831	GG455	1	2	full	
8	Sci	1200	0.0	0.0	647	1"	R831	GG455	1	2	full	25.5
9	Sci	1200	0.0	0.0	647	1"	R831	GG455	1	2	full	28.5
10	Flat	3	0.0	0.0	647	1"	R831	GG455	1	2	full	
11	Flat	3	0.0	15.0	653	1"	R831	GG455	1	2	full	
12	Sci	1200	0.0	15.0	653	1"	R831	GG455	1	2	full	31.2
13	Sci	1200	0.0	15.0	653	1"	R831	GG455	1	2	full	33.5
14	Flat	3	0.0	15.0	653	1"	R831	GG455	1	2	full	

14 Steps, 2.3 hrs

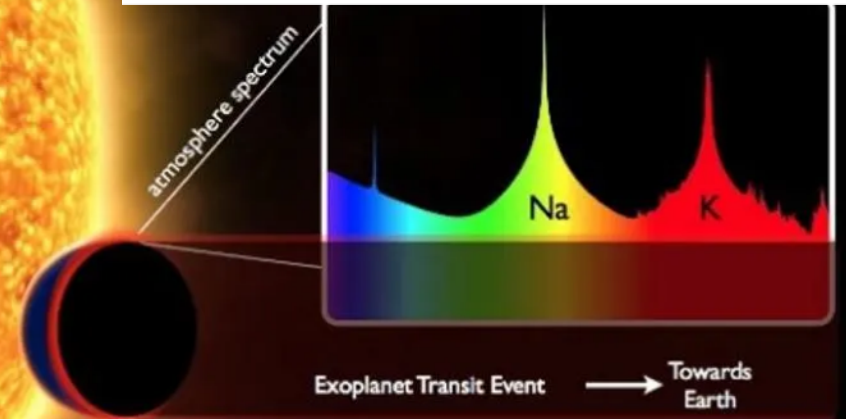
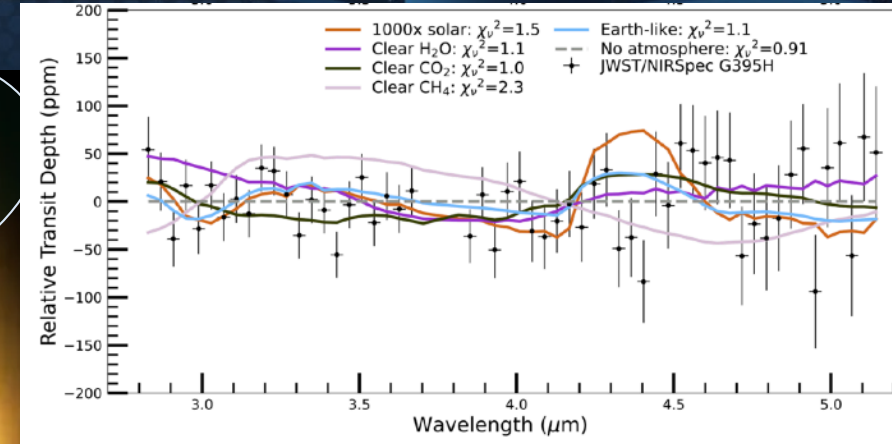
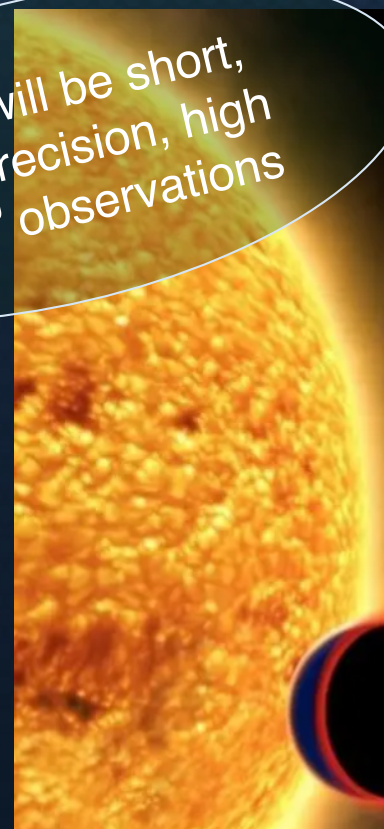
ITC Central Wavelength 650 nm S/N / exposure: 13.5 S/N Total: 33.5

How will People Use the ELTs?

We expect many modes of use

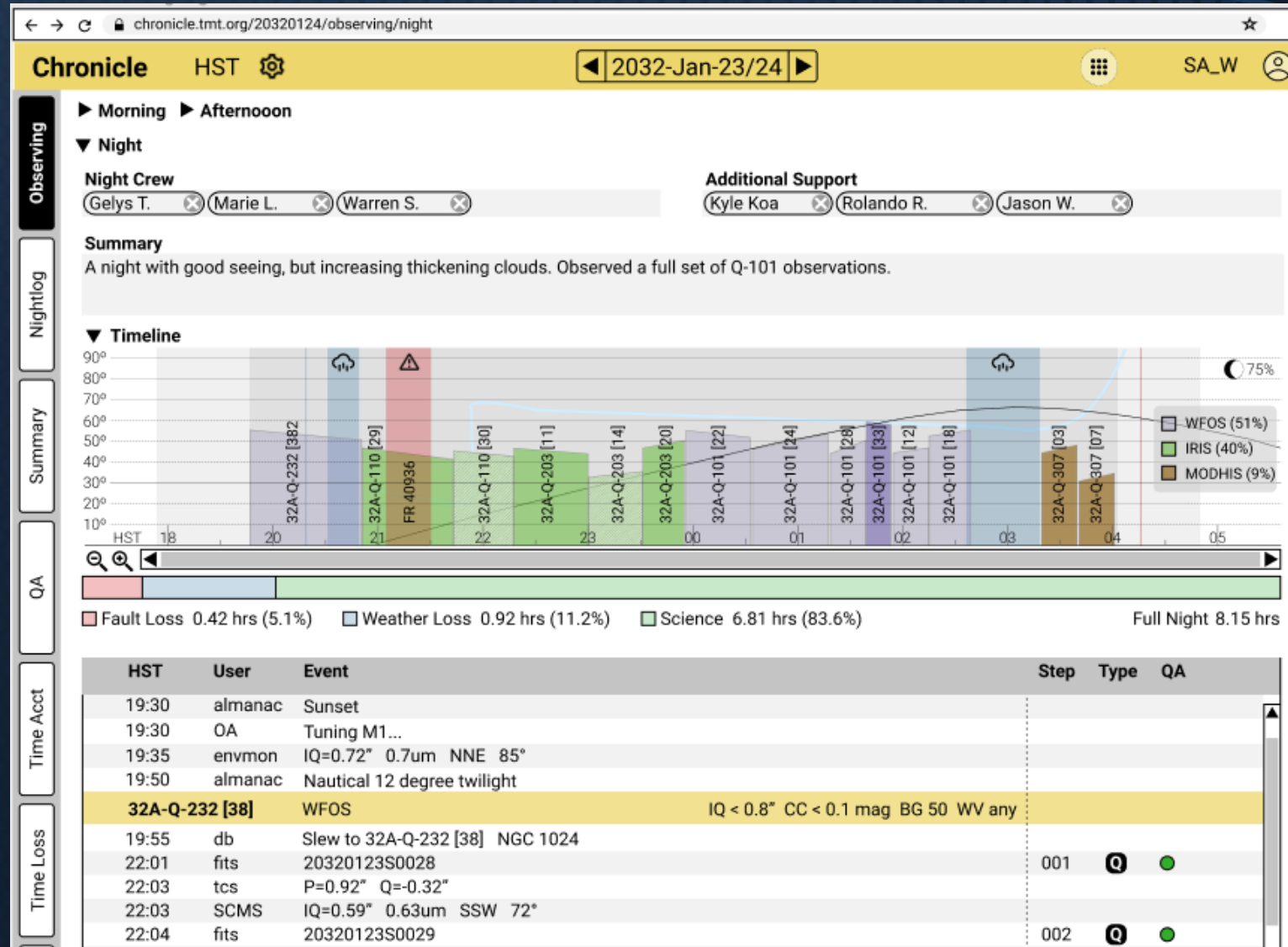
- Time-Critical Observing
 - Exoplanet Transits
 - Multi-Messenger Sources
 - Transient Events
 - Targeted EPRV measurements
- Adaptive Optics & Coronagraphy
 - Exoplanet imaging
 - Crowded fields
 - Black hole environments

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

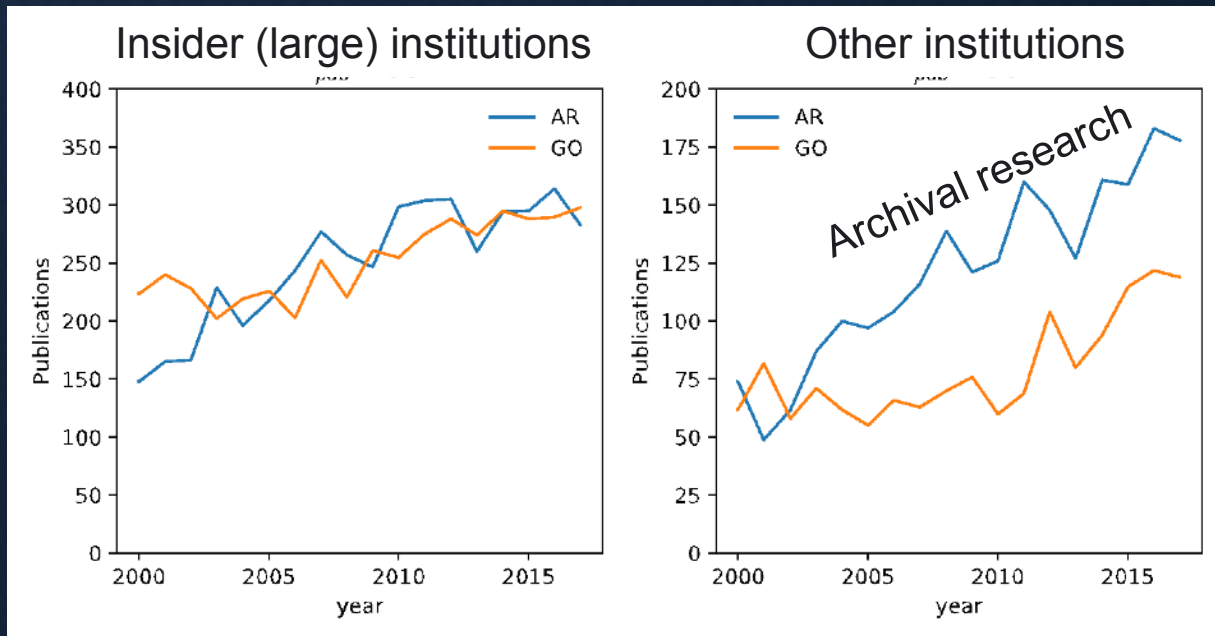


In Practice

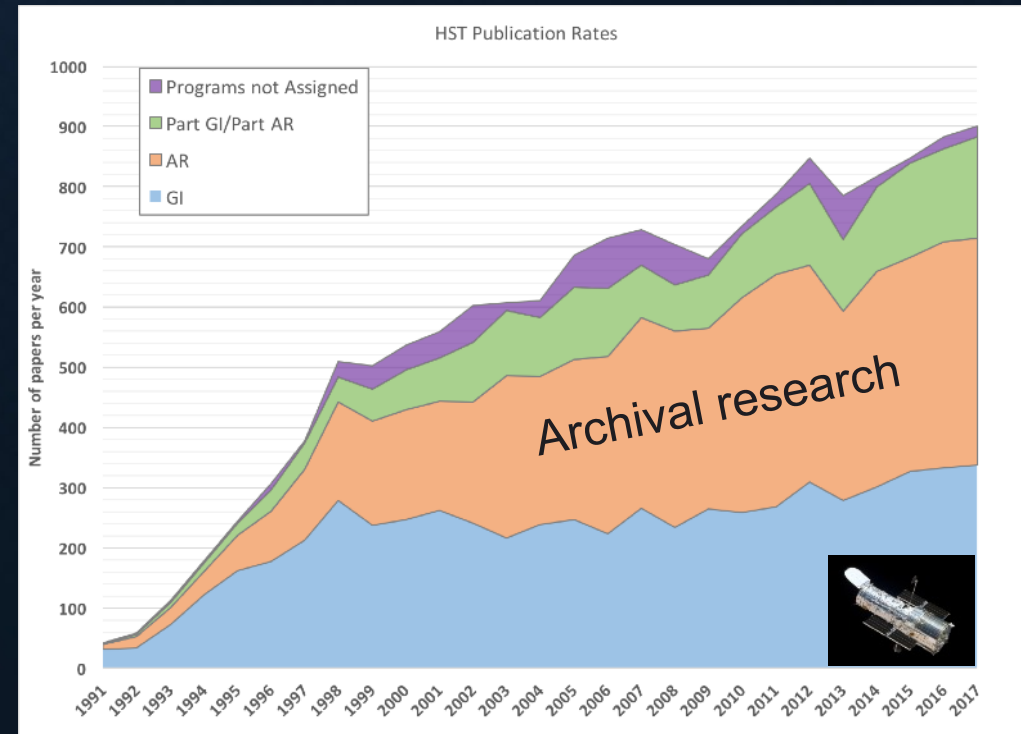
- Instrument teams define/develop algorithms for instrument-specific processing tasks
- Common framework for languages, standards, protocols, keywords, ...
 - Developed across the US ELT partnership
- Pipelines turn raw data into science-ready data products in the archive
- Virtual machines allow users 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!

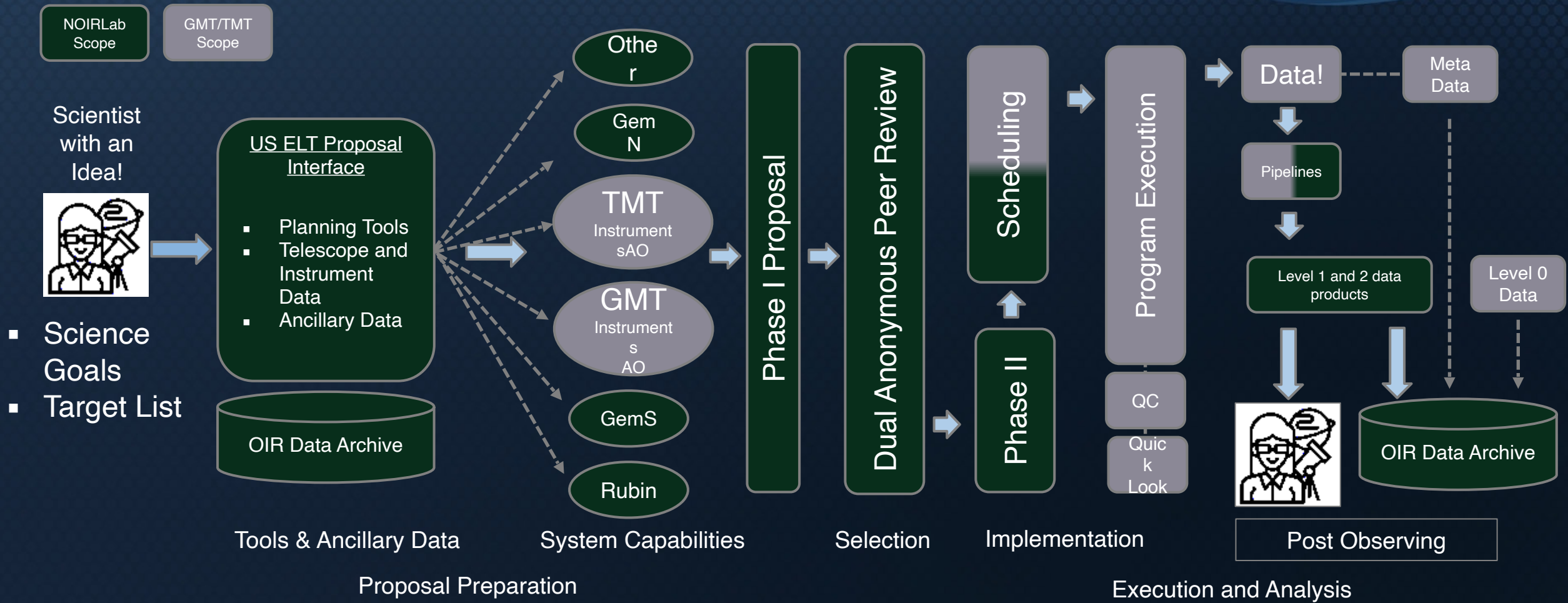


Josh Peek, et al. (2019)





User Experience in the US ELT System



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!**