



NSF's National Optical-Infrared  
Astronomy Research Laboratory

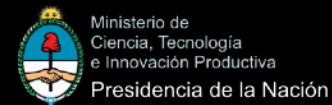


# Gemini in the Era of Multi-Messenger Astronomy

John Blakeslee  
Gemini Observatory  
NSF's Optical-Infrared Astronomy Research Lab

Kavli-IAU Transients Workshop

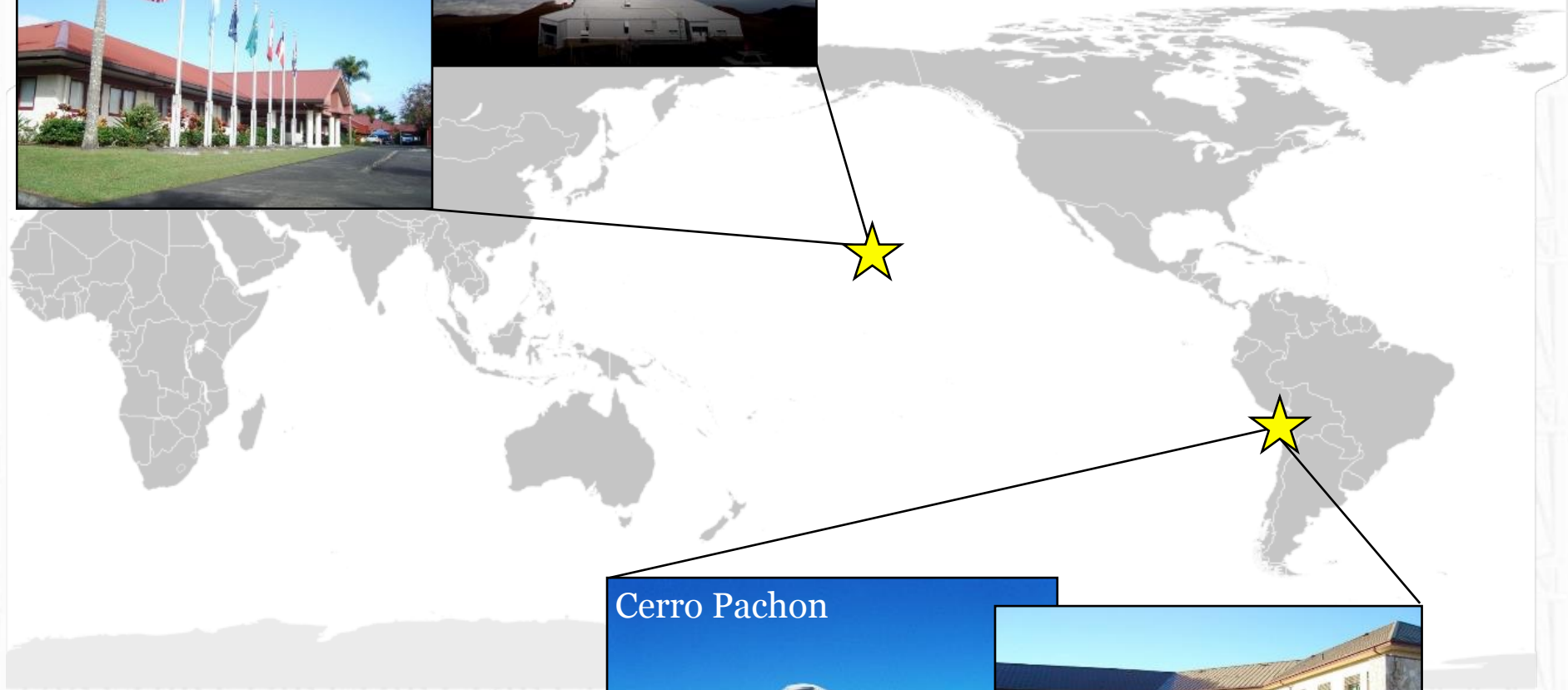
February 2020, Cape Town







**Gemini Observatory:**  
Operating twin 8.1 m telescopes  
on Mauna Kea and Cerro Pachón,  
**providing access to the entire sky**



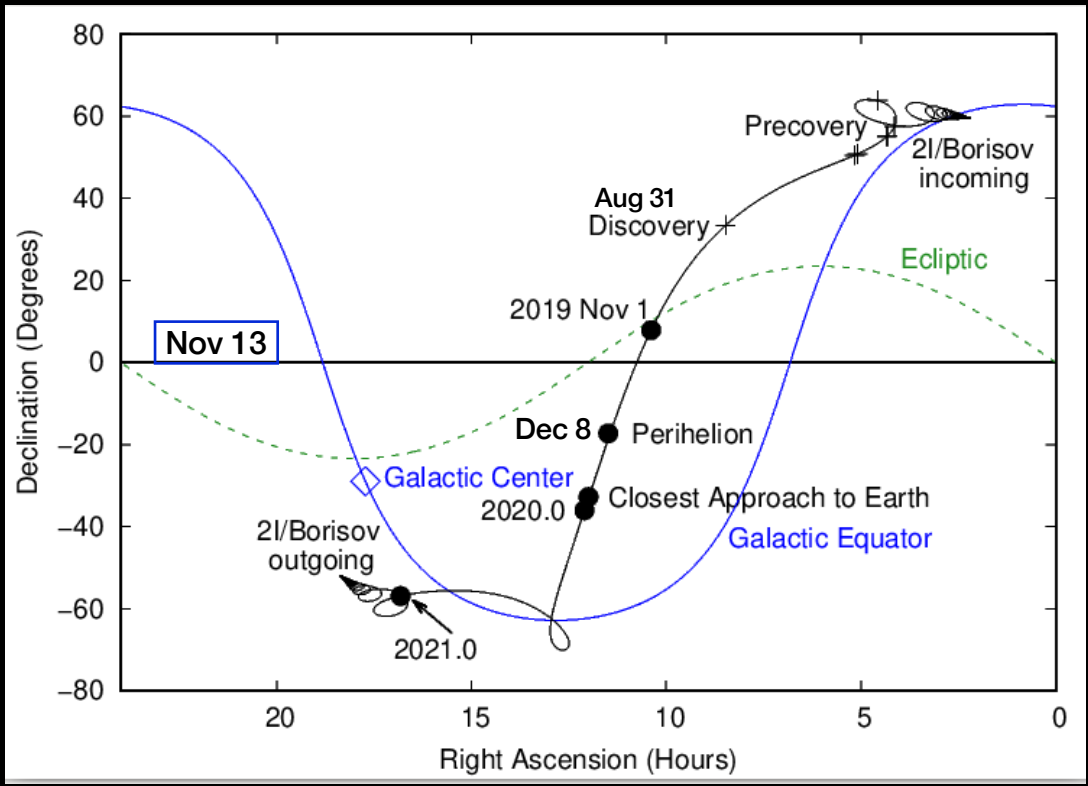
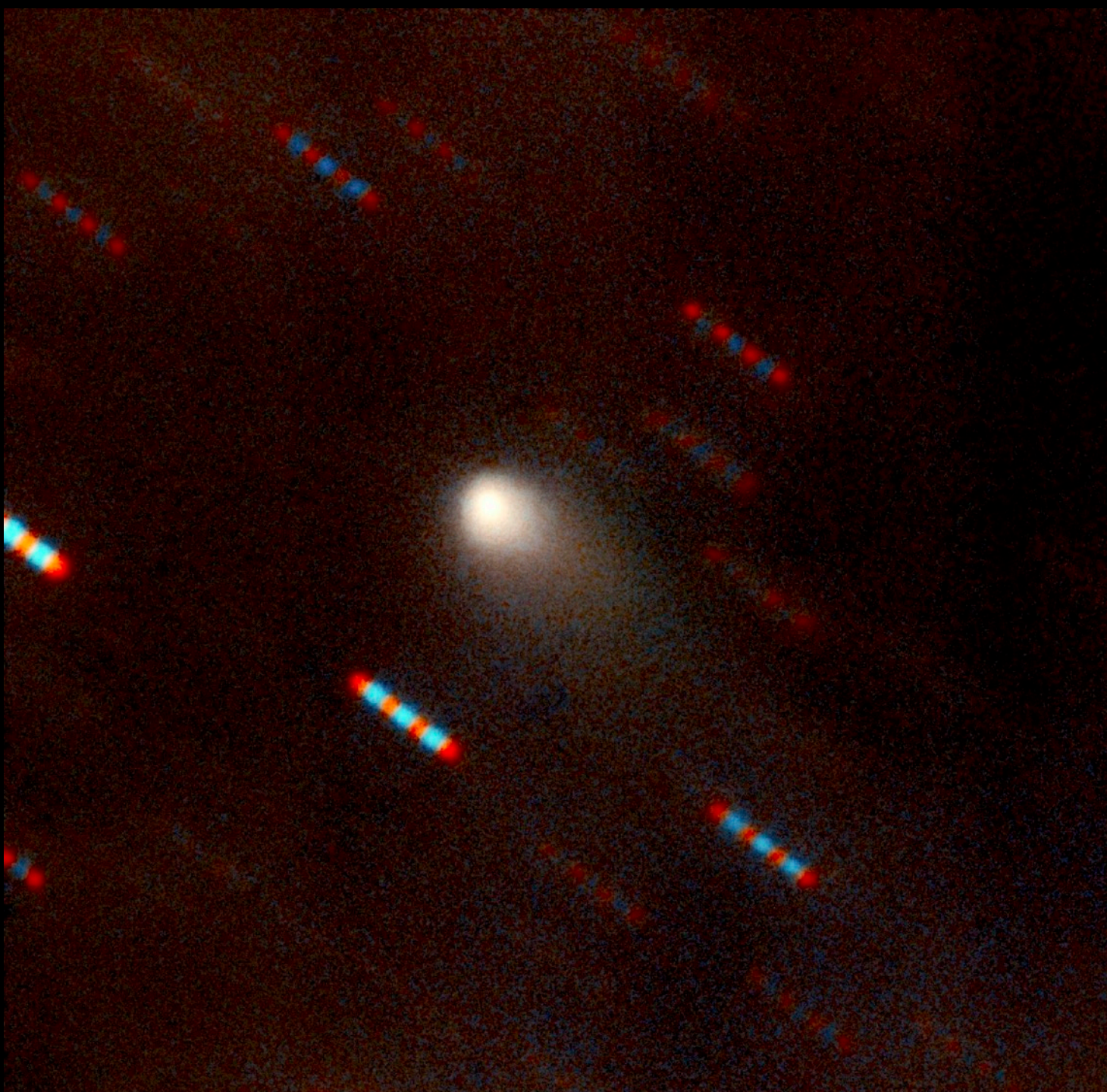
**WHAT IS  
GEMINI?**



*Guzik et al. 2019*  
*Nature Astronomy*  
(First peer-reviewed  
paper on 2I/Borisov)

Comet 2I/Borisov at  
3.4 AU, airmass 2.6,  
with GMOS-N in *g,r*  
on Sep 10, 2019.

Gemini has tracked  
Comet Borisov from  
Dec = +35° to -55°

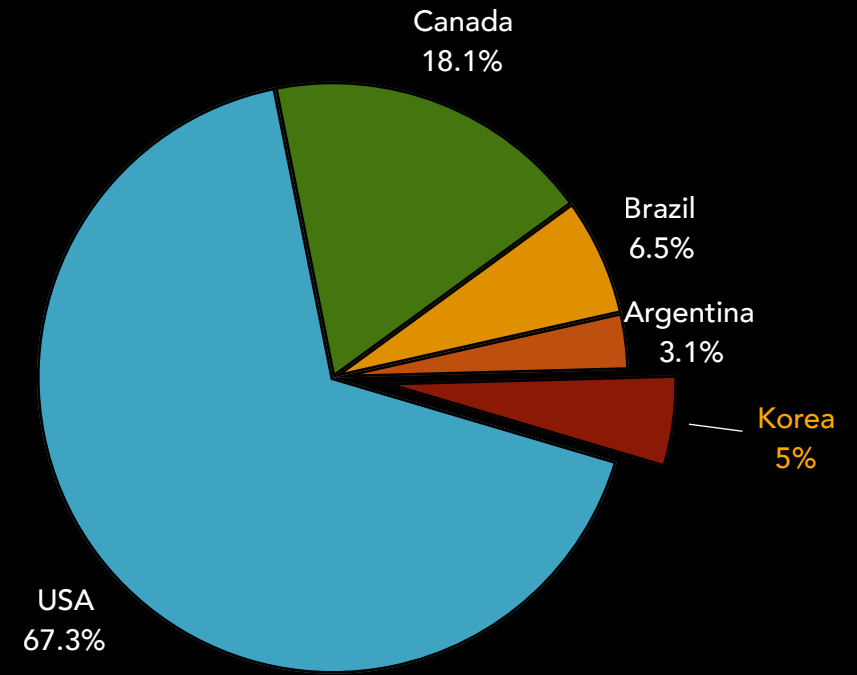




# GEMINI PARTNERSHIP



## Current Partner Shares



O&M Budget: \$ 29.8M

IDF Contributions: \$ 3.0M

Limited Term Collaborators:

- Weizmann Institute (\$100K/year)
- Ben Gurion University (\$100K/year)



# Gemini in the Era of Multi- Messenger Astronomy

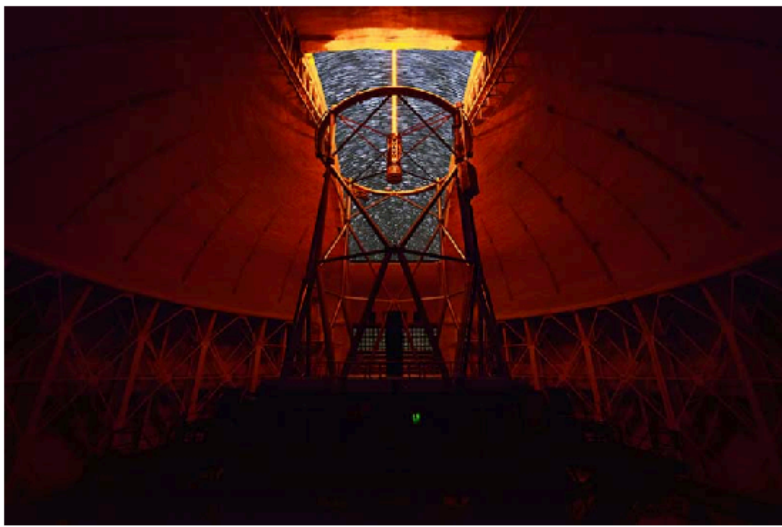
*Developing an  
advanced multi-  
conjugate adaptive  
optics system for  
high-resolution  
astronomy & a rapid  
response system for  
time domain science.*

# GEMMA

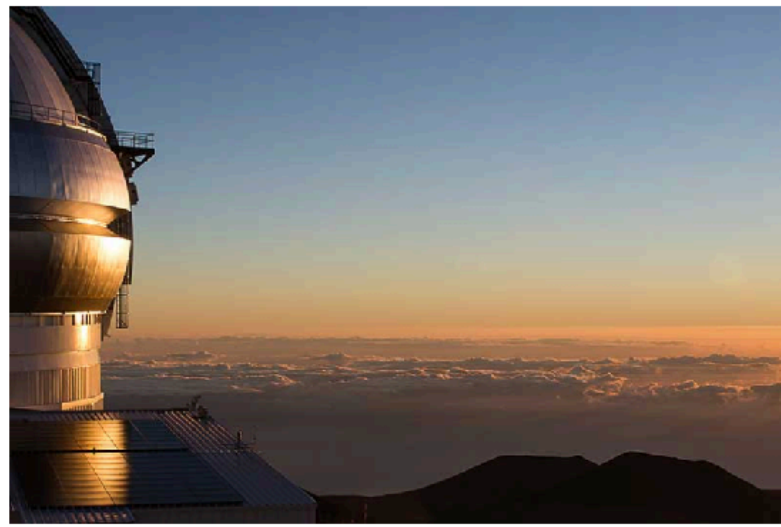




# Gemini in the Era



Adaptive Optics



Time Domain



Outreach

**Gemini-N multi-conjugate AO system + path to ASM**  
**AEON, dynamic scheduling, & quick-look data reduction**  
**Communicating the concepts of MM/TDA via outreach**



# Gemini's Scientific Plan for the 2020's



Orion Bullets,  
GeMS/GSAOI

"What's past is prologue,  
what to come, in yours  
and my discharge."



## Strategic Scientific Plan for Gemini Observatory

July 2, 2019

Prepared by: Gemini Observatory

Approved by the Gemini Board of Directors at their May 2019 meeting.

A large photograph of the Gemini Observatory telescope dome, illuminated from below, set against a starry night sky. The dome is a large, cylindrical structure with a grid-like pattern on its upper section.

Gemini South is well situated for rapid LSST follow up



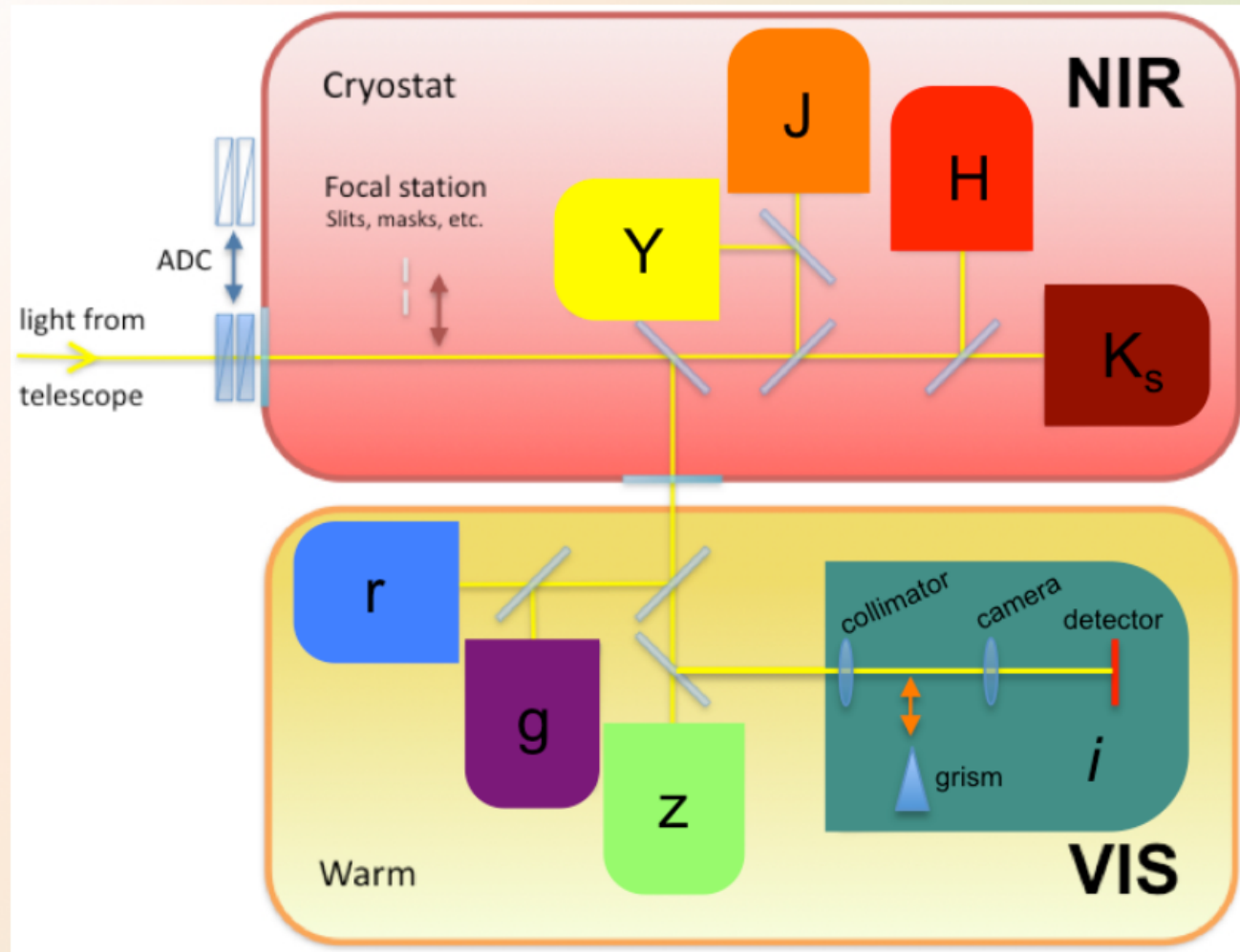
Cerro Pachón at sunset





## Spectrograph & Camera for Observations of Rapid Phenomena in the Infrared & Optical.

To be commissioned at Gemini South mid-2022.



- Simultaneous 8-band photometry or spectroscopy over 3' field
- Rapid identification and characterization of transient objects
- High-time resolution follow-up, from minutes to years
- Also a panchromatic workhorse instrument for static sources

Schematic view  
of light path

PI: M. Roberto, STScI



# **NSF Director's Question, October 2019, at the Gemini South observing room...**

*Why don't we just turn this whole observatory over to  
LSST spectroscopic follow-up?*

## **Tony Tyson's answer:**

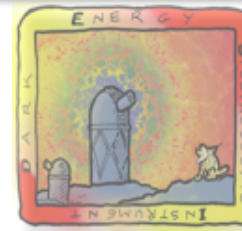
*Well, even if we had ten of them, it wouldn't be enough.*



**AEON** = NOAO/SOAR/Las Cumbres/Gemini collaboration to enable dynamic scheduling of targets from TOMs on SOAR, Gemini,...

**others welcome!**

Gemini has convened a community group of ToO users to advise us on strategies and policies for rapid follow-up in the Time-Domain Era.

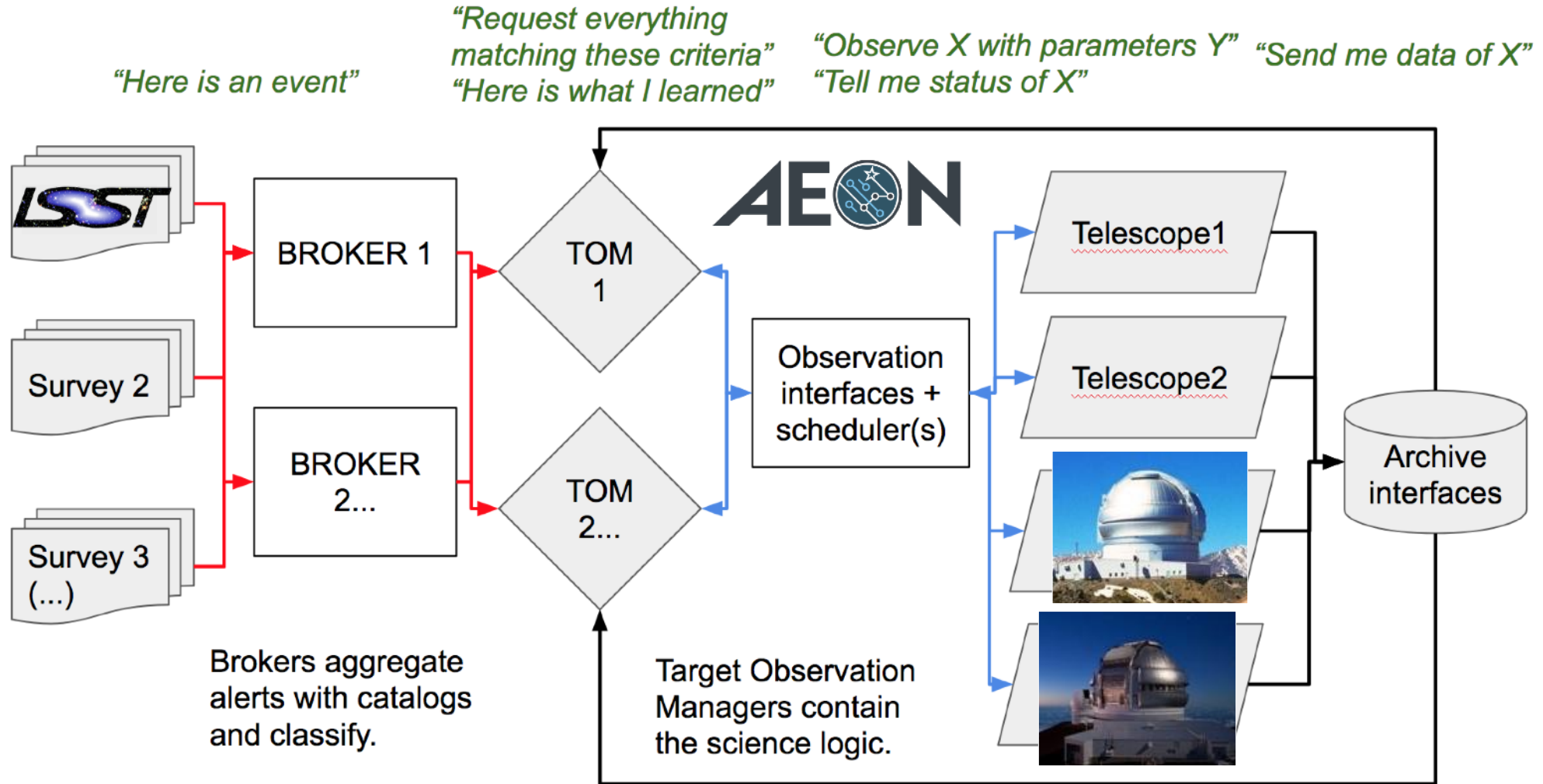


**Goal: Gemini/AEON ready for rapid response by 2022**





# The planned *AEON* network is a follow-up system that dynamically turns alerts into requested data



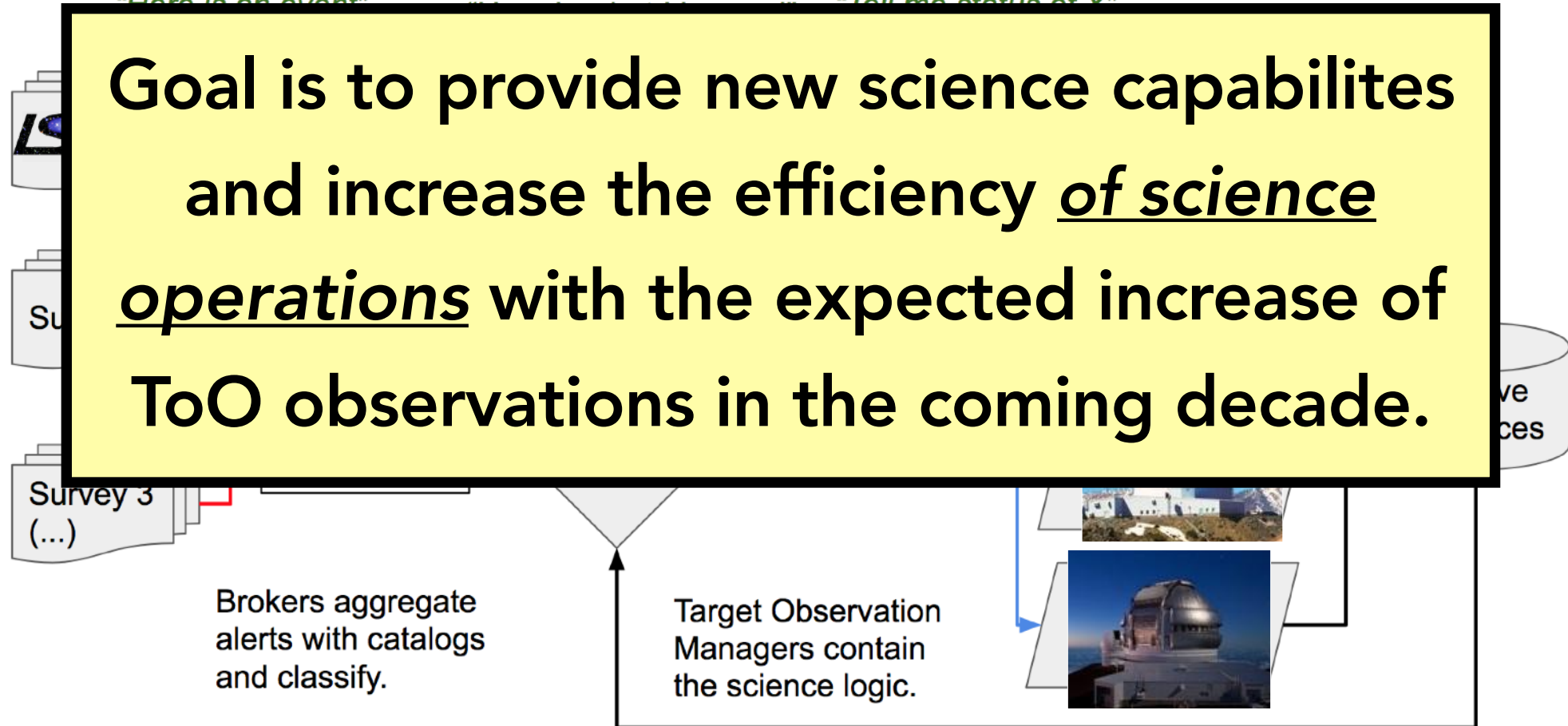
*Robust data pipelines also a key element of this.*

(See Strategic Scientific Plan)

The planned *AEON* network is a follow-up system that dynamically turns alerts into requested data

*“Here is an event”*  
*“Request everything matching these criteria”*  
*“Observe X with parameters Y”*  
*“Send me data of X”*  
*“Tell me status of Y”*

Goal is to provide new science capabilities and increase the efficiency of science operations with the expected increase of ToO observations in the coming decade.



*Robust data pipelines also a key element of this.*

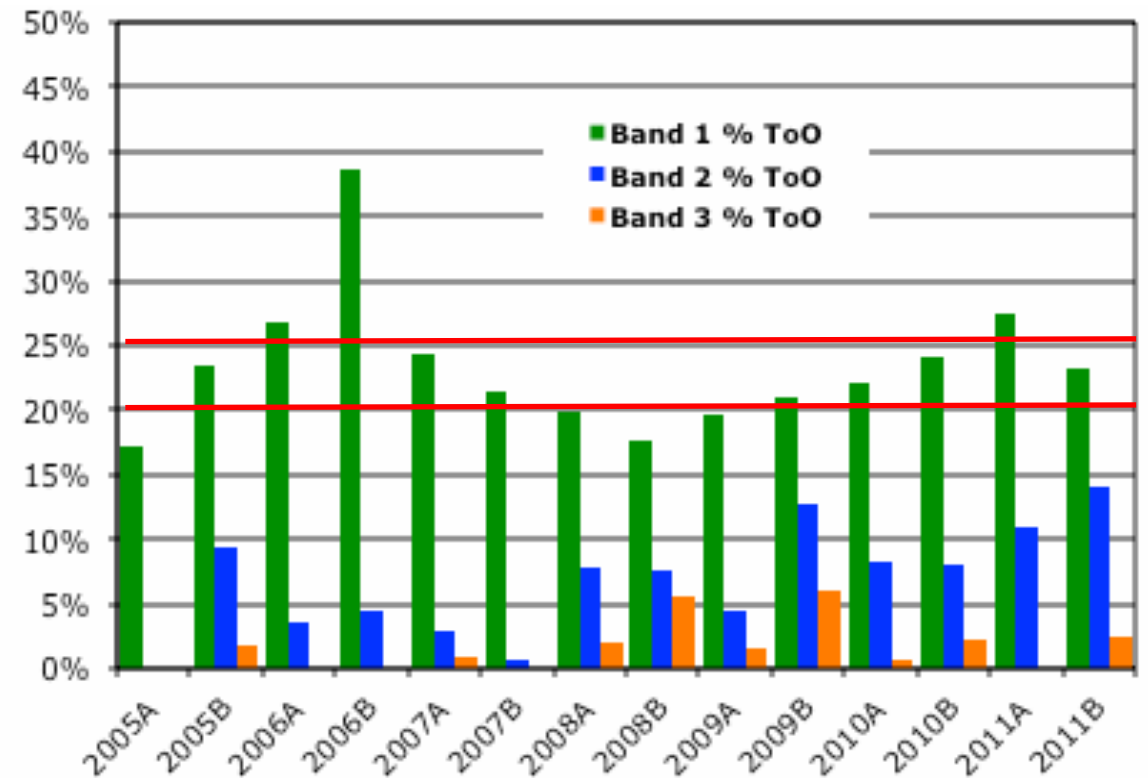
(See Strategic Scientific Plan)



# Gemini is undertaking operations improvements to handle a greater number of ToOs more efficiency

Currently at Gemini, ToOs make up ~25% of Band 1

- Scheduling process is manual, observing plans are static
- Current max ToO rates ~ few per night; many more would make observing very inefficient because of fixed nightly plans.

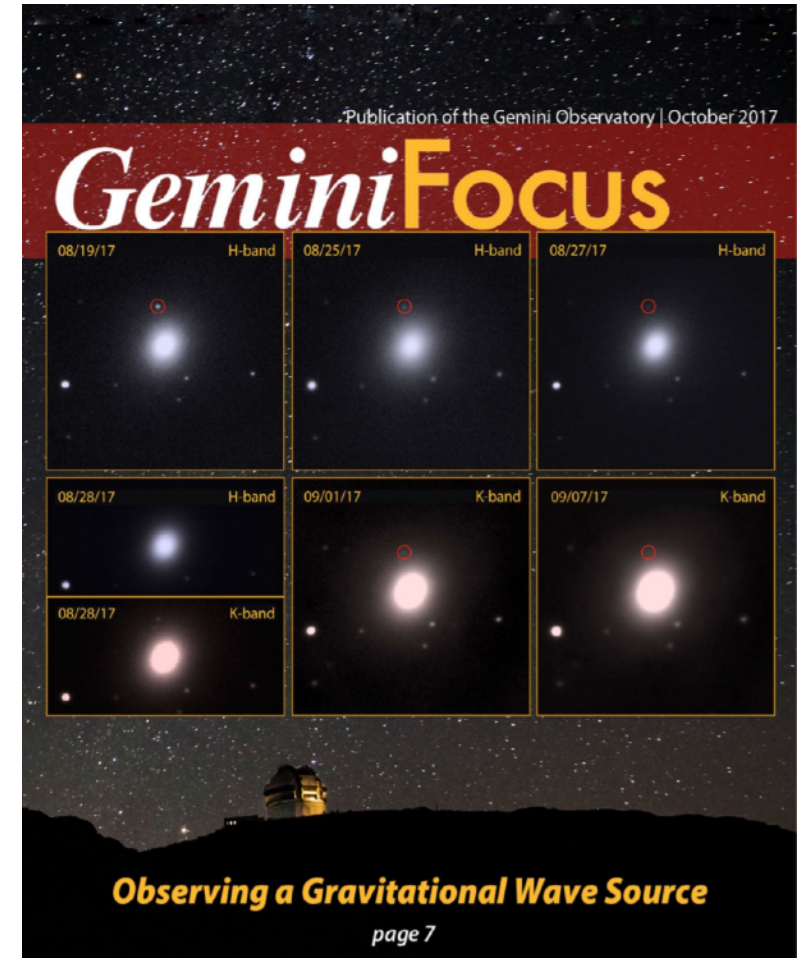


# Gemini will support AEON as part of ongoing OCS Upgrades and GEMMA Programs

## OCS Upgrades Goals:

- Improve usability, e.g. easier Phase 2s
- Improve efficiency of operations
- Enhance use of APIs for TDA, etc.
- Make code more maintainable & scalable
- Support new instruments, e.g. SCORPIO
- Avoid obsolescence

Progress, documentation, and a suggestion form can be found at: <https://www.gemini.edu/node/21272>



See Oct 2017 Gemini Focus, p.20



Gemini can now work as part of AEON via our TOM Toolkit plugin

<https://tomtoolkit.github.io>

Makes use of our existing, basic, API for triggering [github.com/bryanmiller/gsselect](https://github.com/bryanmiller/gsselect)

Now being used at Gemini for LIGO & ZTF follow-up.

See the video at

[https://youtu.be/PC\\_5kmSdZBU](https://youtu.be/PC_5kmSdZBU)

### NGC4792

[Update Target](#) [Delete Target](#)

Identifier	NGC4792
Name	NGC4792
Name 2	
Name 3	
Target Type	SIDEREAL
Right Ascension	193.765 12:55:3.685
Declination	-12.497 -12:29:49.474
Epoch Of Elements	None
Proper Motion (Ra)	None
Proper Motion (Declination)	None
Galactic Longitude	None
Galactic Latitude	None
Distance	52.240
Distance Error	None

Observe Observations Data

### Observe

[LCO](#) [GEM](#)

### Plan

Start Time

2019-03-05 00:00:00

End Time

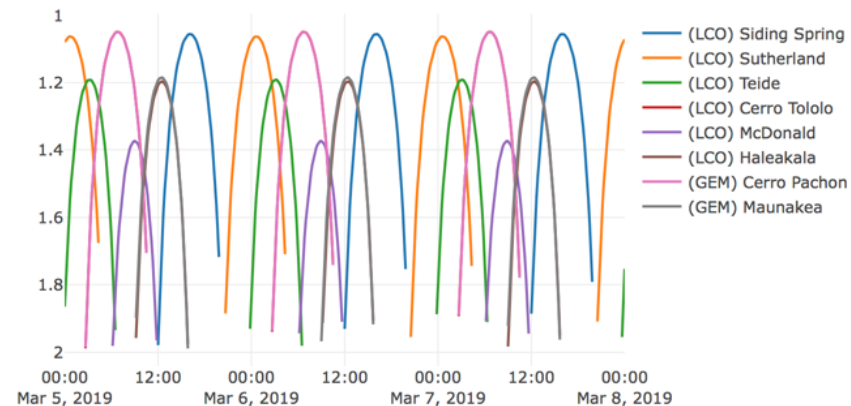
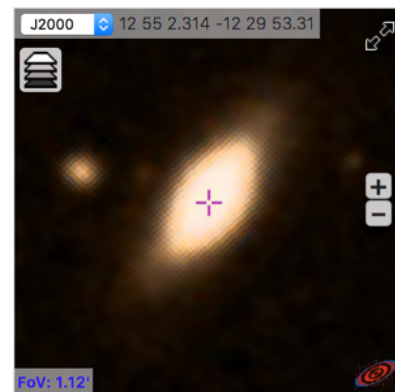
2019-03-08 00:00:00

Maximum Airmass

2.0

[Plan](#)

### Survey View



# TOM Toolkit Workshop



## **TOM** Managing Follow-up Observations in the Era of ZTF and LSST

**Carnegie Observatories, Pasadena, CA,  
Sept 30 - Oct 4, 2019**

The workshop will be an interactive introduction to key technologies and observing facilities that will drive time-domain astronomy in the LSST era and a chance for scientists to influence their development. Participants will have exclusive access to a unique proposal opportunity for development mini-grants and telescope time to kick-start their observing programs. The workshop is open to everyone from all areas of astronomy, and the agenda will be designed to interest both newcomers and those with substantial experience with alert-based science.

[Workshop homepage](#)

Goals and current status

[Agenda](#)

[Training Materials](#)

[Participant's List](#)

[TOM Team](#)

Meet the workshop organizers

[Proposal opportunity](#)

Exclusive to workshop  
participants

[Lodging](#)

[Restaurants &](#)



T

**TOM Toolkit Workshop: ~80 applicants, but limited to 50.  
Attendance was a prerequisite for submitting a proposal.  
Proposal deadline 9 days after meeting.**



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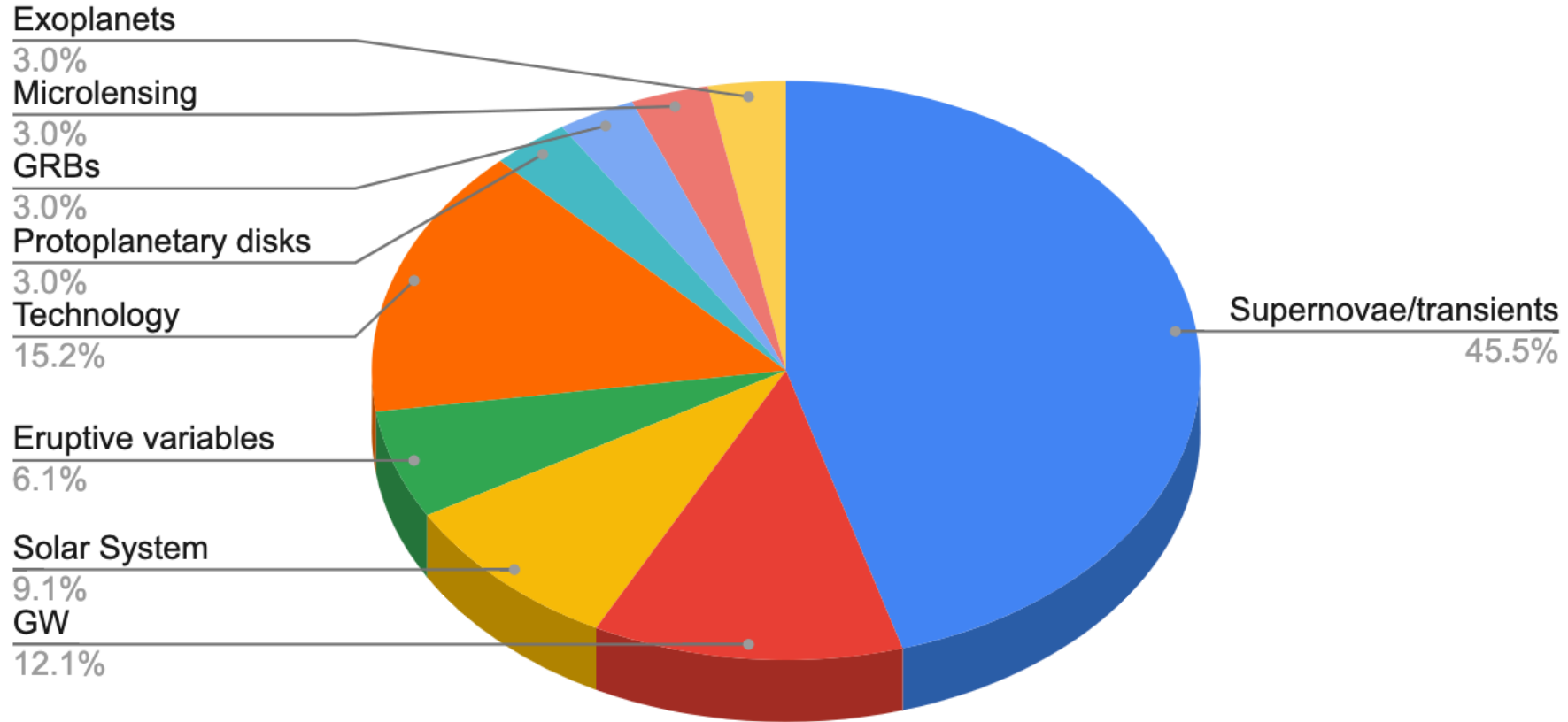
**TOM Toolkit observing program: 33 proposals received.**  
**Requests are for semesters 2020A & 2020B.**

<b>Observatory</b>	<b>Las Cumbres</b>	<b>SOAR</b>	<b>Gemini South</b>	<b>Gemini North</b>
<b>Hours offered</b>	1000	50	25	25
<b>Hours requested</b>	3210	199.3	110.3	225.3
<b>Over-subscription</b>	3.2	4.0	6.7 (GN+GS)	



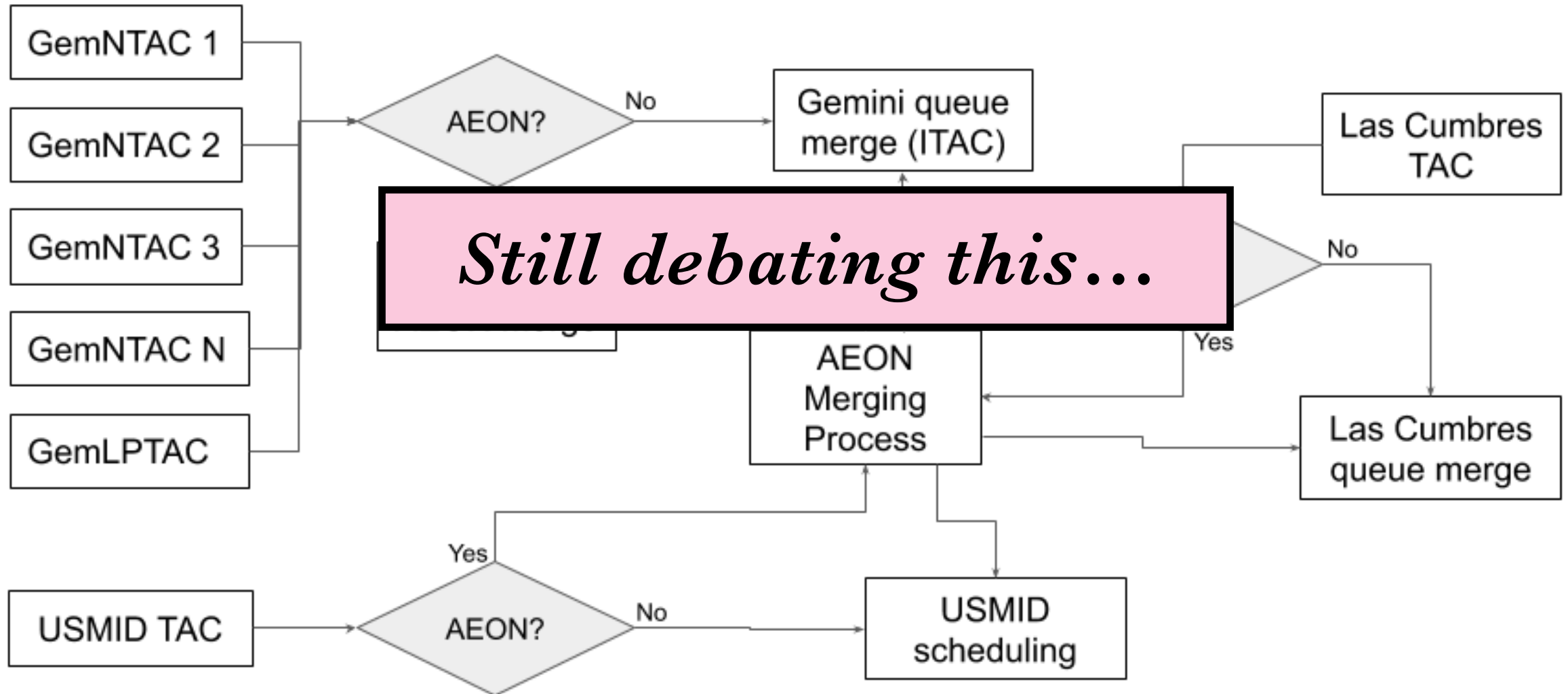
# TOM Toolkit observing program: 33 proposals received.

## Proposals by Science Domain



orth

# Allocating time on AEON? Possible "time exchange" model (no unified TAC)



An AEON proposal is one that requests time on multiple AEON facilities (e.g. Gemini/Las Cumbres, Gemini/SOAR/Las Cumbres).



# We close the loop by serving data via science archives and tools for science quality reduction



- Automated processing is required for the LSST era
- Gemini IRAF to pure **DRAGONS** transition:
  - Pure python; imaging package released Oct 2019
  - Working on spectroscopy package **in consultation with SOAR**
- New instruments (*e.g.*, SCORPIO) come with reduction pipelines based on DRAGONS environment.
- Tutorials and Documentation:  
<https://dragons.readthedocs.io/en/stable/>
- Open source:  
<https://github.com/GeminiDRSoftware/DRAGONS>





# Summary



Las Cumbres/SOAR/Gemini/OIRLab are developing a follow-up network that will involve:

- Brokers (alert filters)
- TOMs (target/resource matching) and APIs
- Dynamic scheduling and execution
- New instrumentation (SCORPIO)
- Data reduction pipelines (BONZAI, DRAGONS)

Much of this works already, but have to sort out things like Time Allocation; community involvement is key.



*Discovering our Universe Together*

