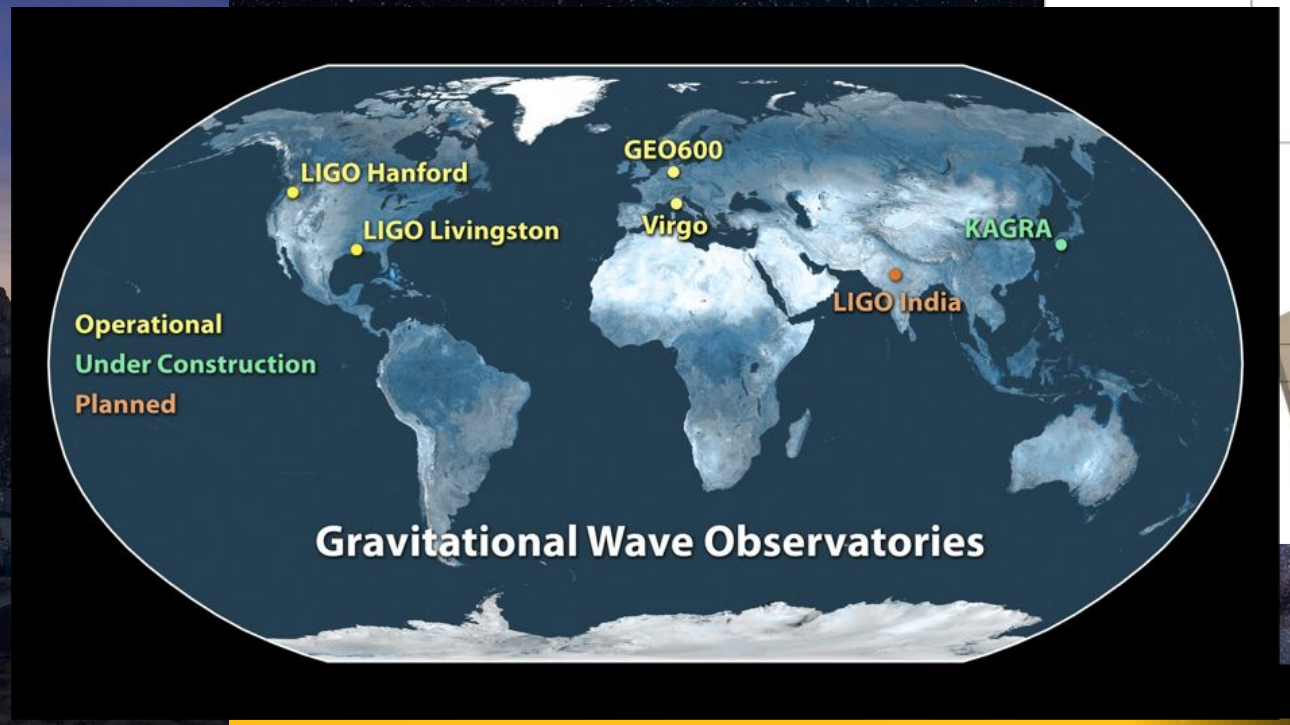
# Multi-Messenger & Time Domain Astronomy: the Role of Gemini Observatory

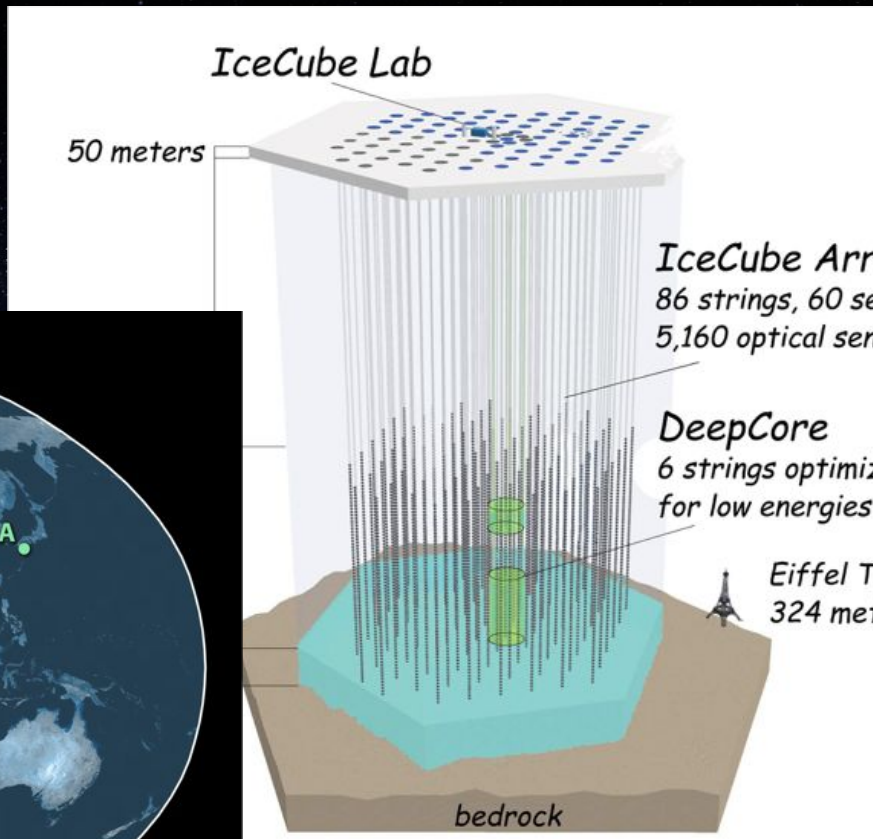
*Jennifer Lotz*

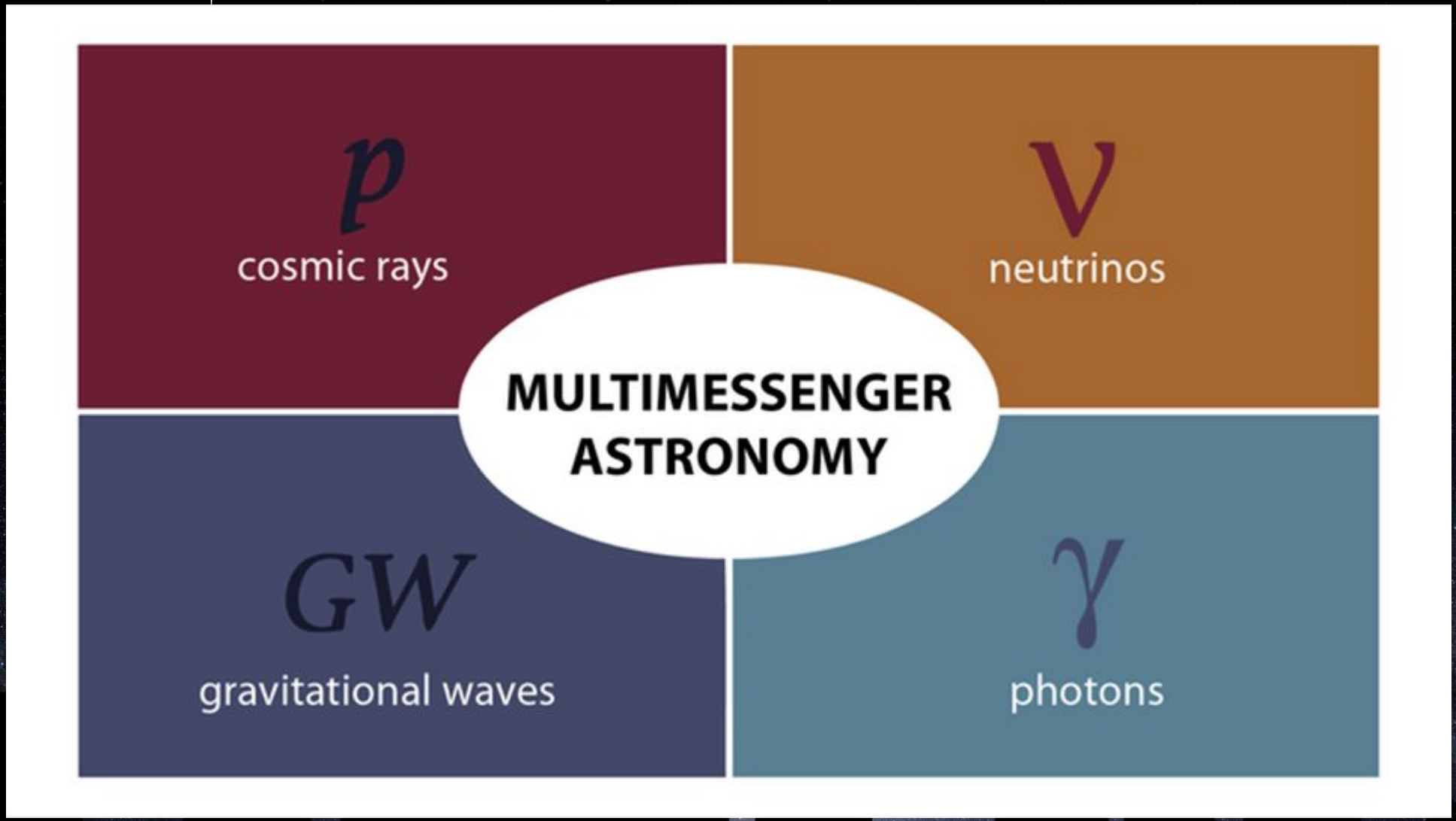
Gemini Observatory/NSF's NOIRLab

# 2020's -- MMA/TDA discovery engines

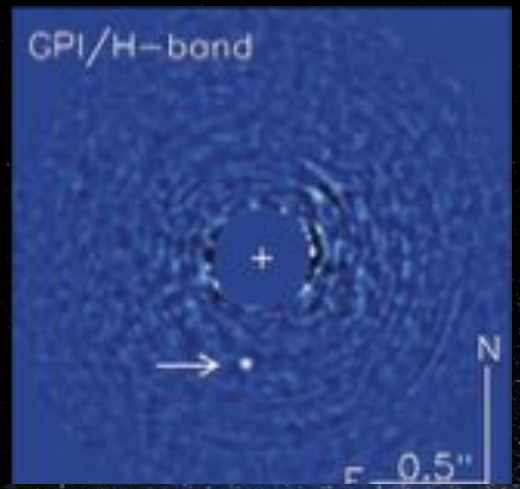
- LIGO, IceCube,
- Rubin Observatory
- Roman Space Telescope & EUCLID



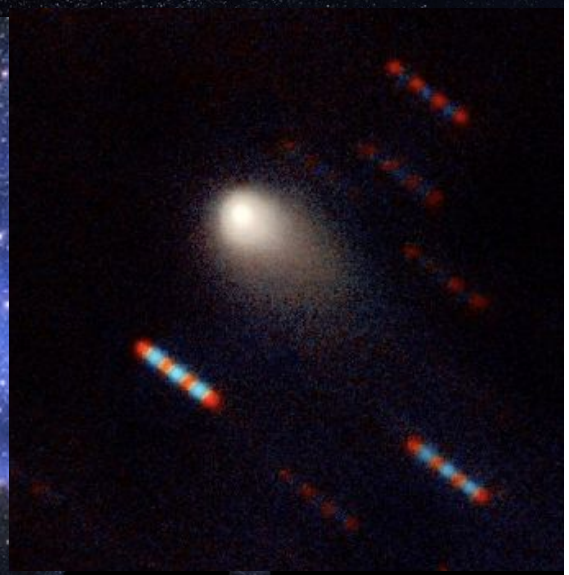


p
cosmic rays
ν
neutrinos
MULTIMESSENGER
ASTRONOMY
GW
gravitational waves
γ
photons

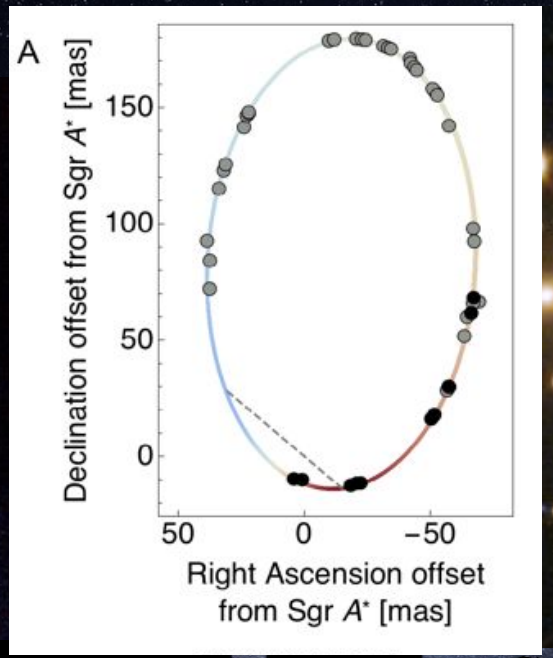
# Time-Domain Astronomy

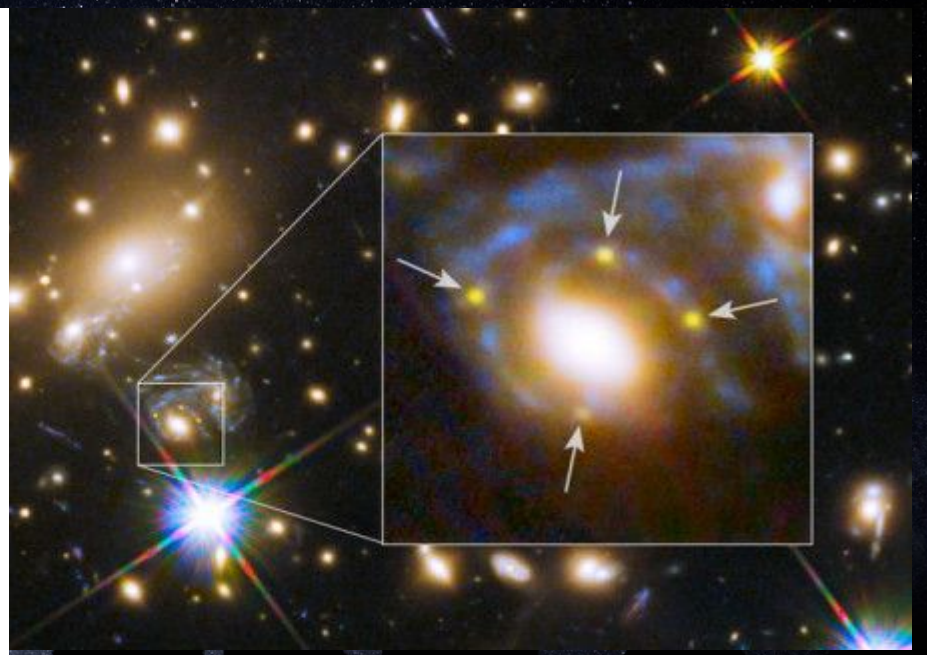



time-varying phenomena: asteroids, comets, exoplanets, variable stars, Galactic center, supernovae, accreting black holes, merging compact objects…

timescales of hours, days, months, years..





# Gemini Observatory

Twin 8.1 meter visible-near infrared telescopes in Hawaii and Chile open to entire U.S community, and international partners

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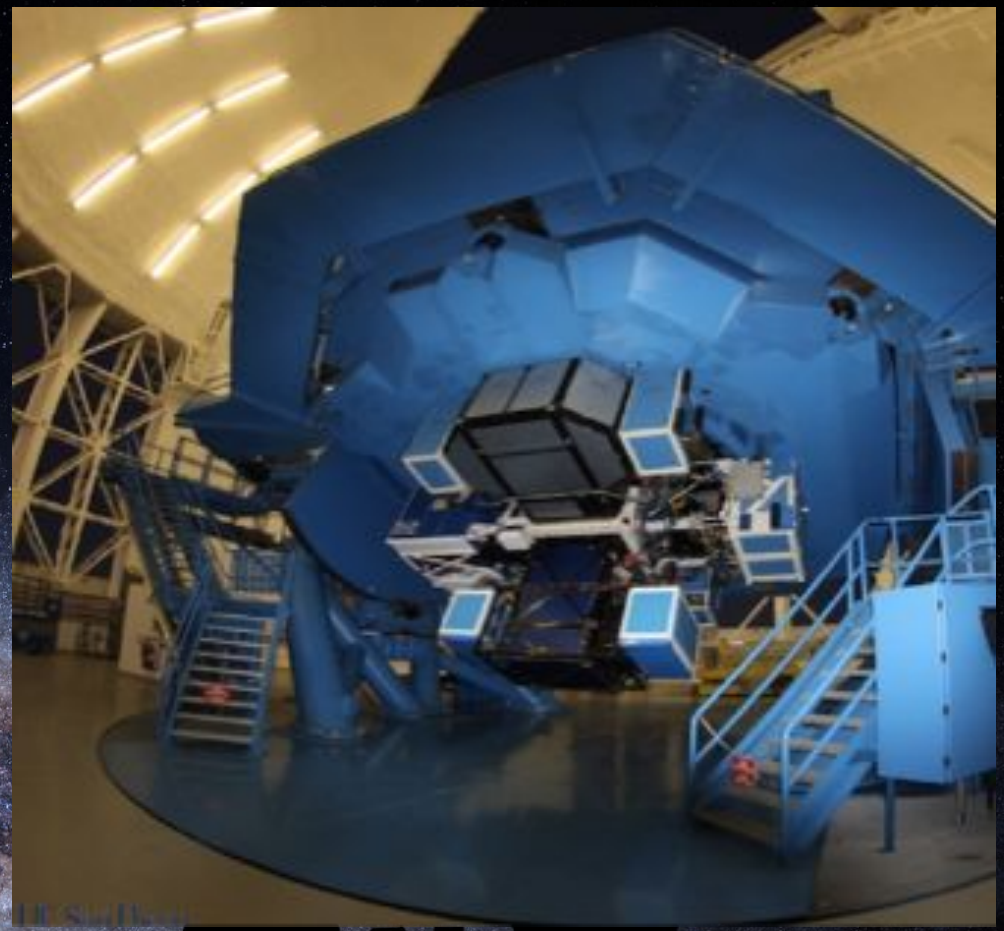
Exploring the Universe, Sharing its Wonders

# Agile, flexible operations

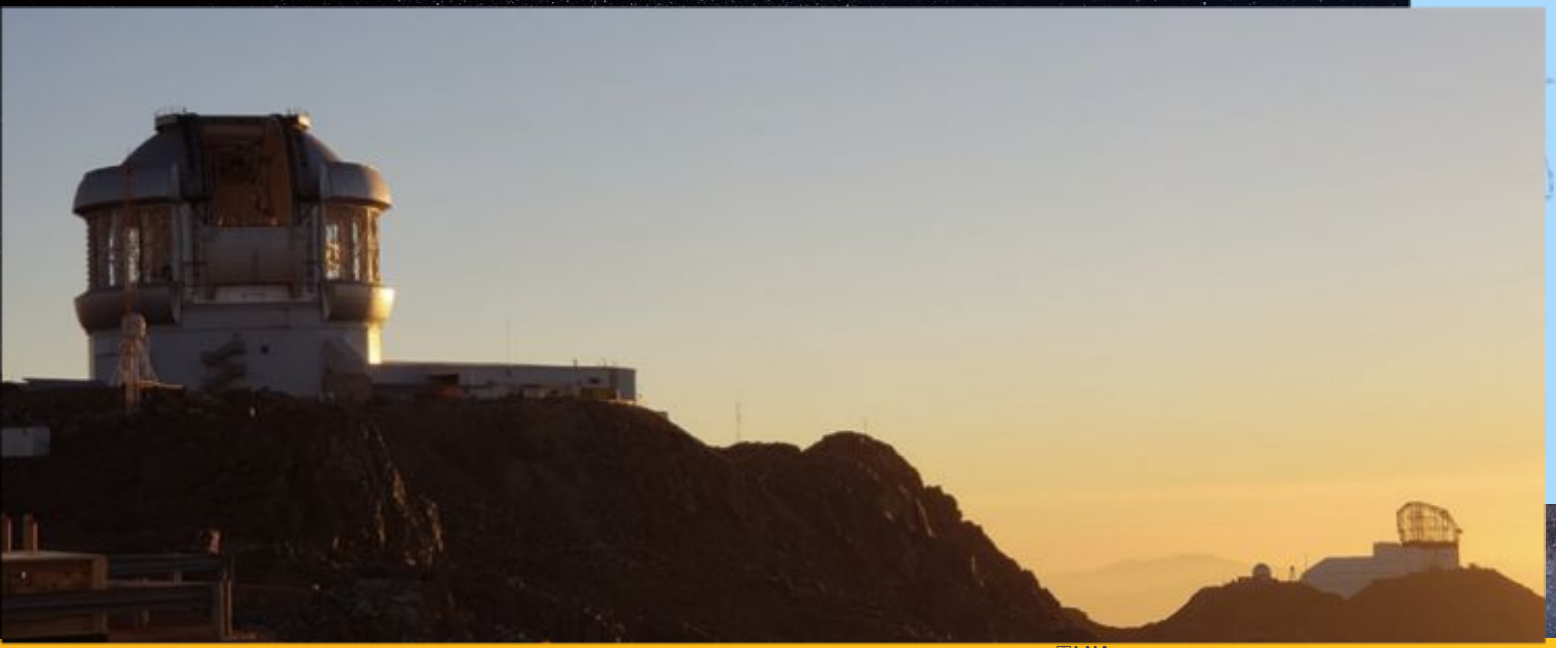


flexible queue scheduling, base-facility operations, & rapid instrument changes

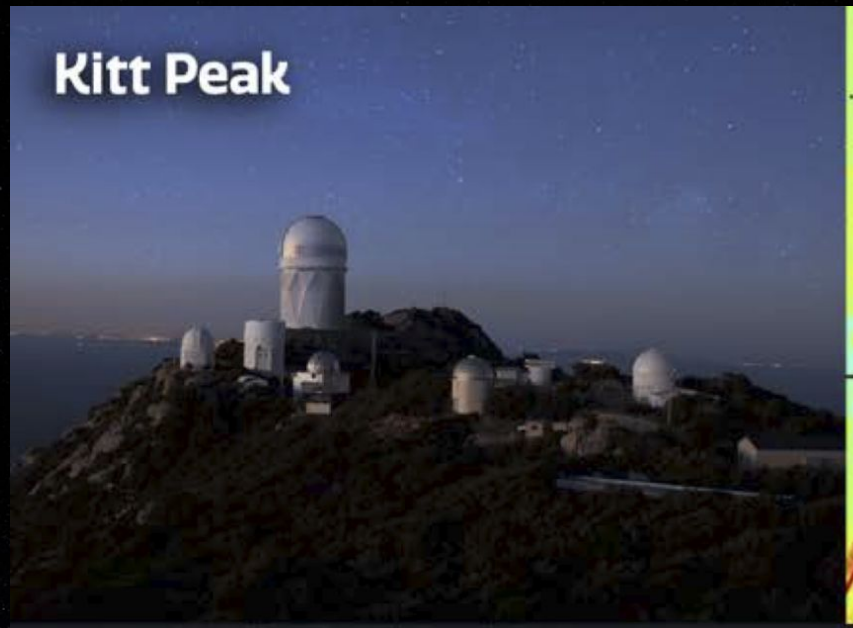
enables agile, rapid-response operations

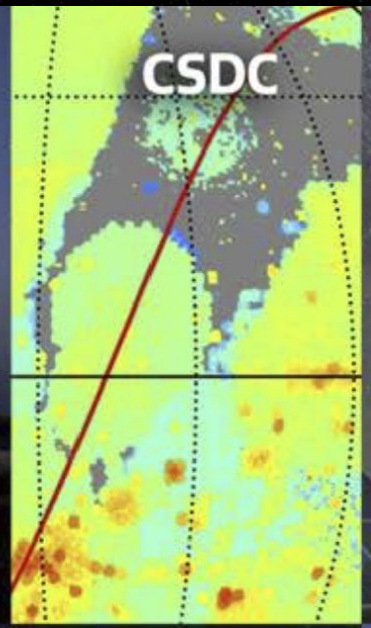
# Bi-hemisphere access

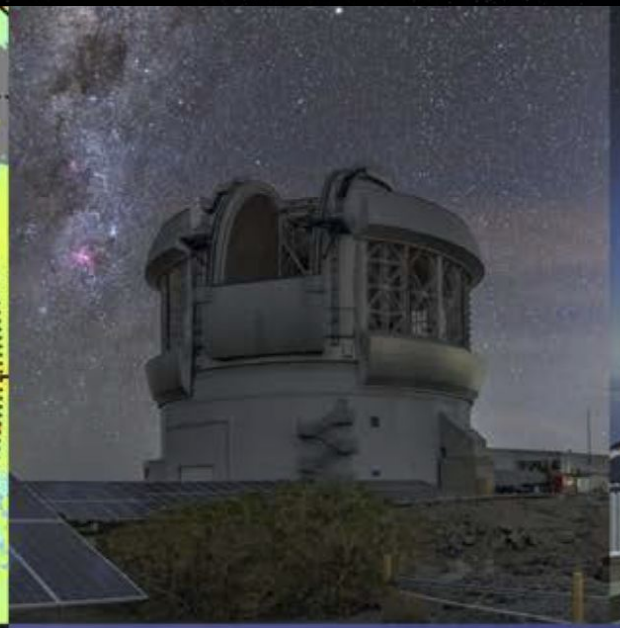
ideal observatory for follow-up of gravitational wave electromagnetic counterparts,  LSST transients, and other multi-messenger events.



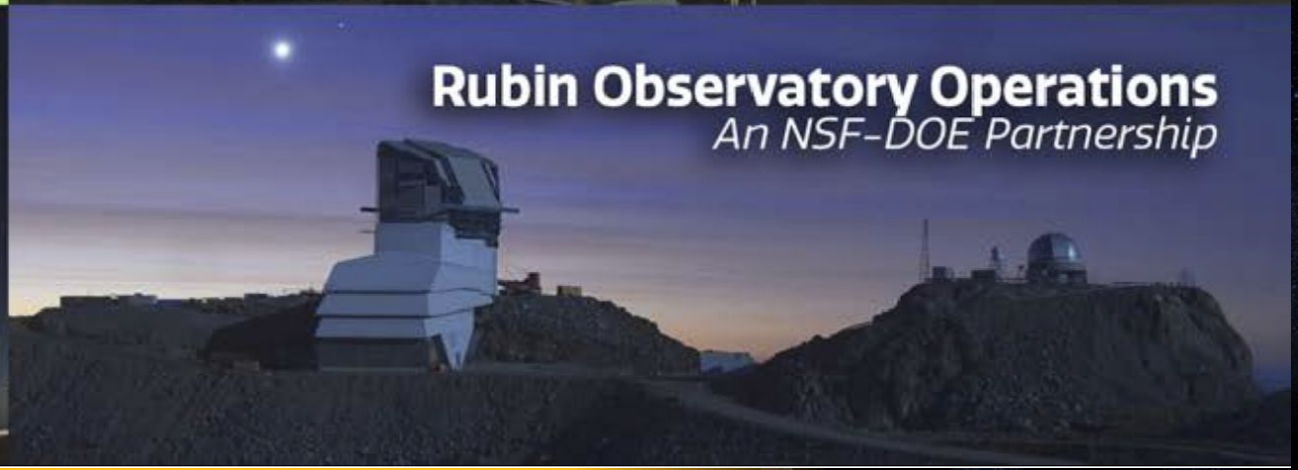

# NOIRLab facilities





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NRC·CNRC

Agencia Nacional de Investigación y Desarrollo

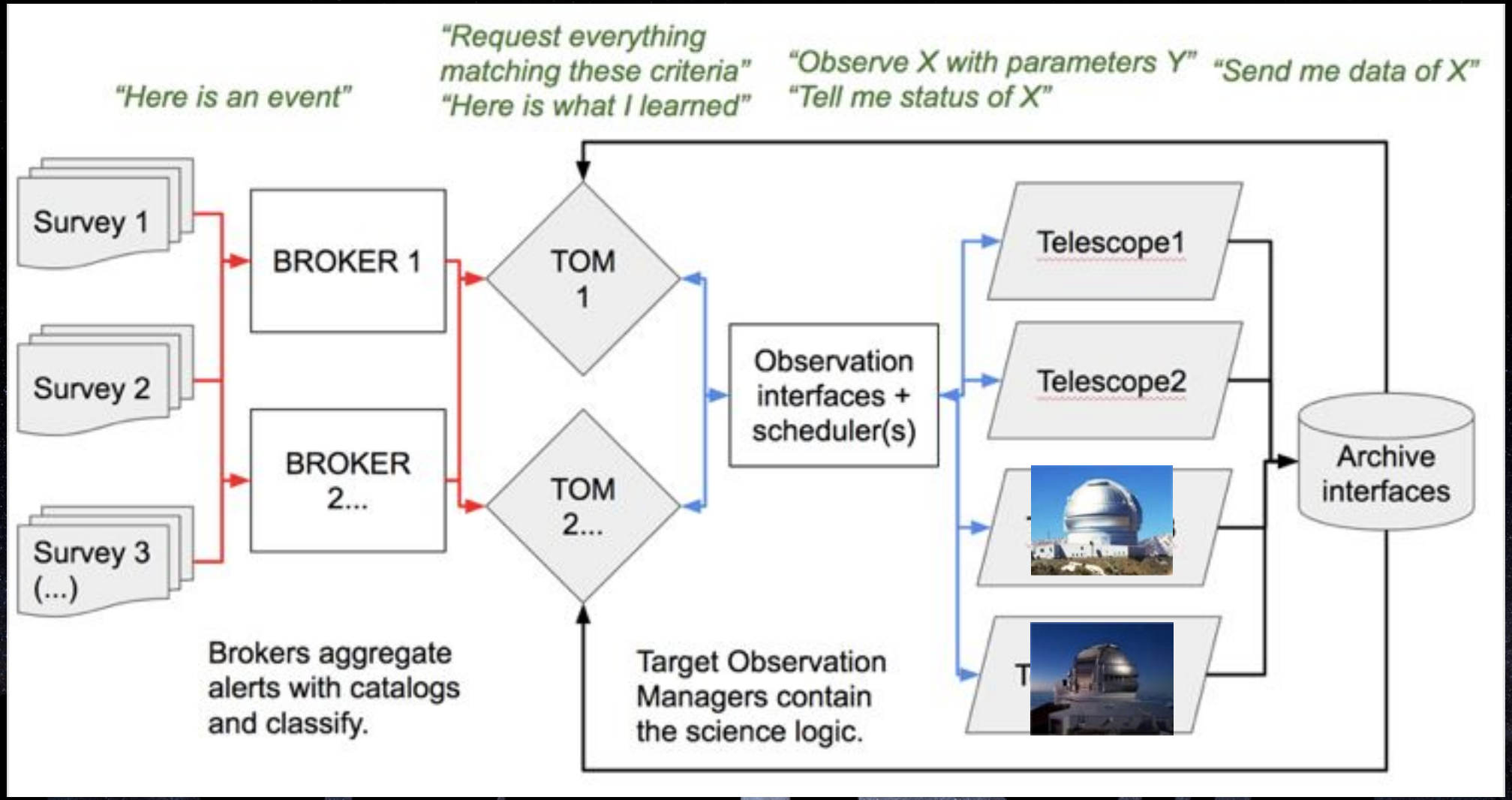
LNA Laboratório Nacional de Astrofísica
Ministério da Ciência, Tecnologia e Inovações
Pátria Amada Brasil

Ministerio de Ciencia, Tecnología e Innovación
Argentina

KASI 한국천문연구원
Korea Astronomy & Space Science Institute

# Network for TDA & MMA

# Gemini in AEON

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# Gemini in the Era of Multi-Messenger Astronomy

Adaptive Optics

Time Domain

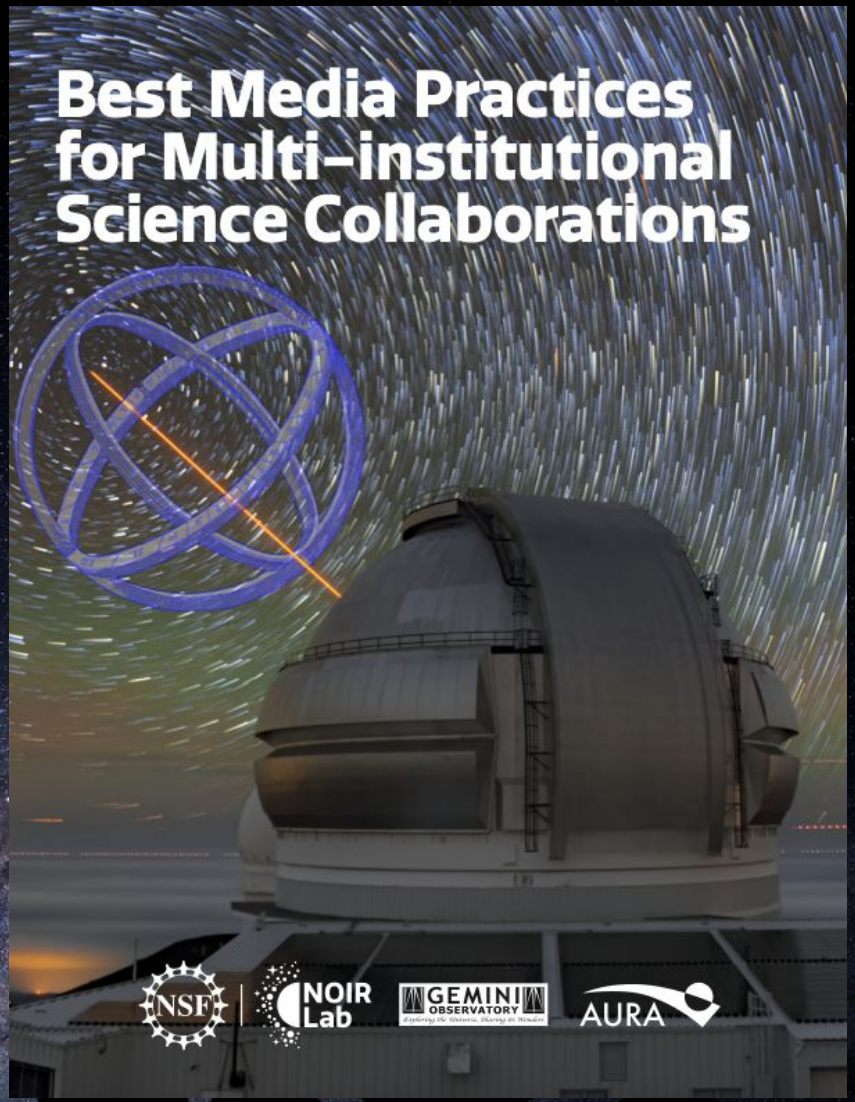
Outreach

$26M funded the National Science Foundation in October 2018
- new wide-field adaptive optics facility at Gemini North
- software infrastructure to support TDA/MMA astronomy
- communicating the message of MMA workshops & outreach

# MMA & TDA communications

MMA Communications Summit
November 2019
→ white paper

Fig. 1: Participants in the Multi-Messenger/Time-Domain Astronomy Summit. Credit: NOIRLab/NSF/AURA



# Software Infrastructure

Target Observation Manager -- software interface between astronomer and telescopes;  request follow-up observations

Dynamic scheduler -- automated scheduling software for telescope observations, to include time-critical and regular observations

DRAGONS (*Data Reduction for Astronomy from Gemini Observatory North & South*) -- “quick-look” data reduction for rapid turn-around of observations

# GNAO:nightly, wide-field high-resolution NIR imaging and spectroscopy

GeMS: wide-field infrared AO imaging at Gemini-S

GNAO: rapid-response, wide-field infrared AO imaging and spectroscopy at GN, available *nightly*

high-resolution: comparable to HST/JWST

sensitivity: spectroscopy comparable to JWST

# New Adaptive Optics

- utilize Maunakea, one of the world's best sites for AO
- support nightly queue operations for AO
- support GIRMOS, Canadian-built TMT-pathfinder instrument
- build upon the wide-field AO legacy of GeMS

→ ***support high-spatial resolution, wide-field NIR AO imaging and spectroscopy for MMA/time-domain astronomy, cosmology, stellar populations, + diverse science cases***

# Rapid-Response Near-Infrared Observations

8m rapid-response

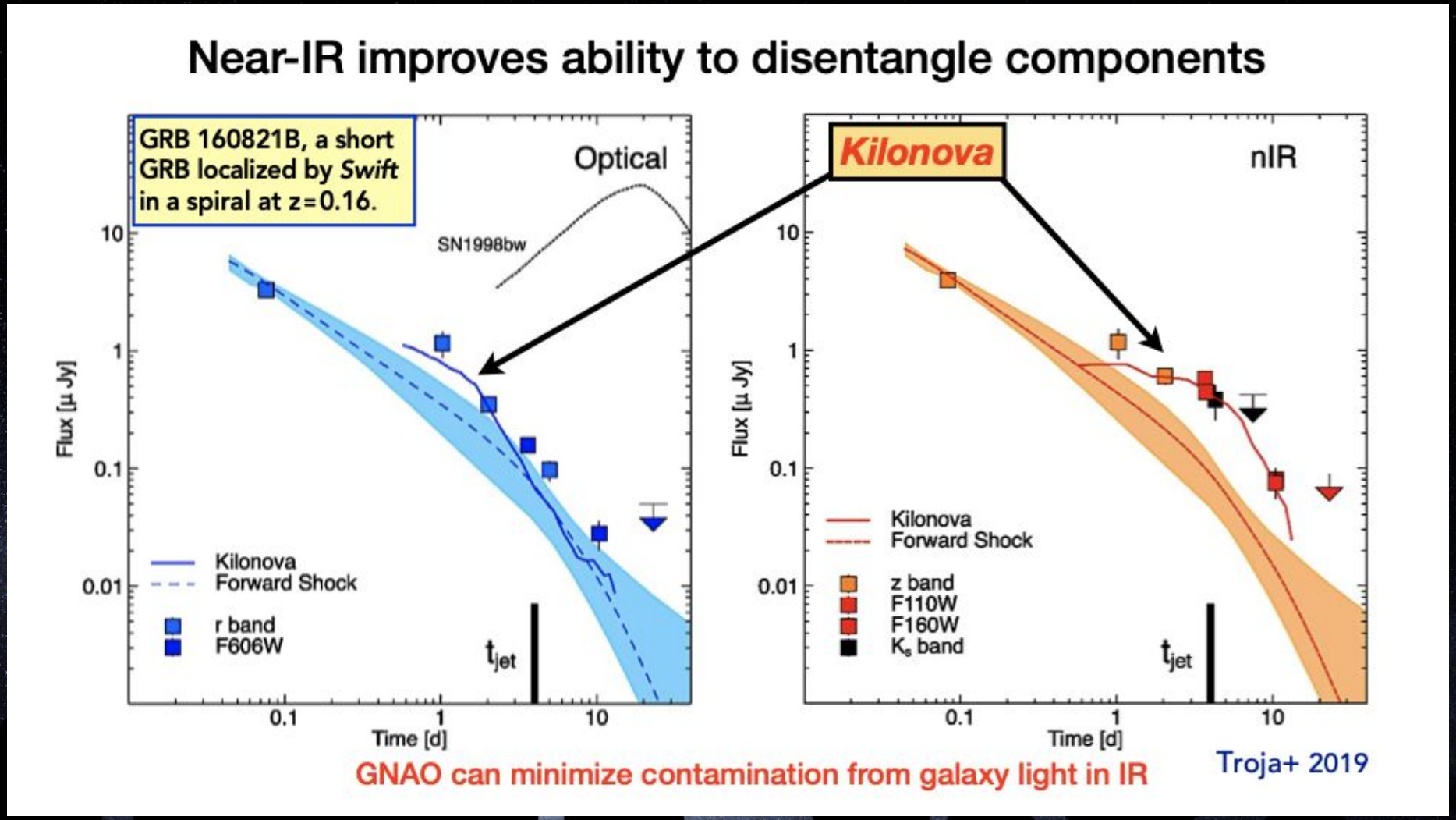
needed to characterize

early phases of MMA events

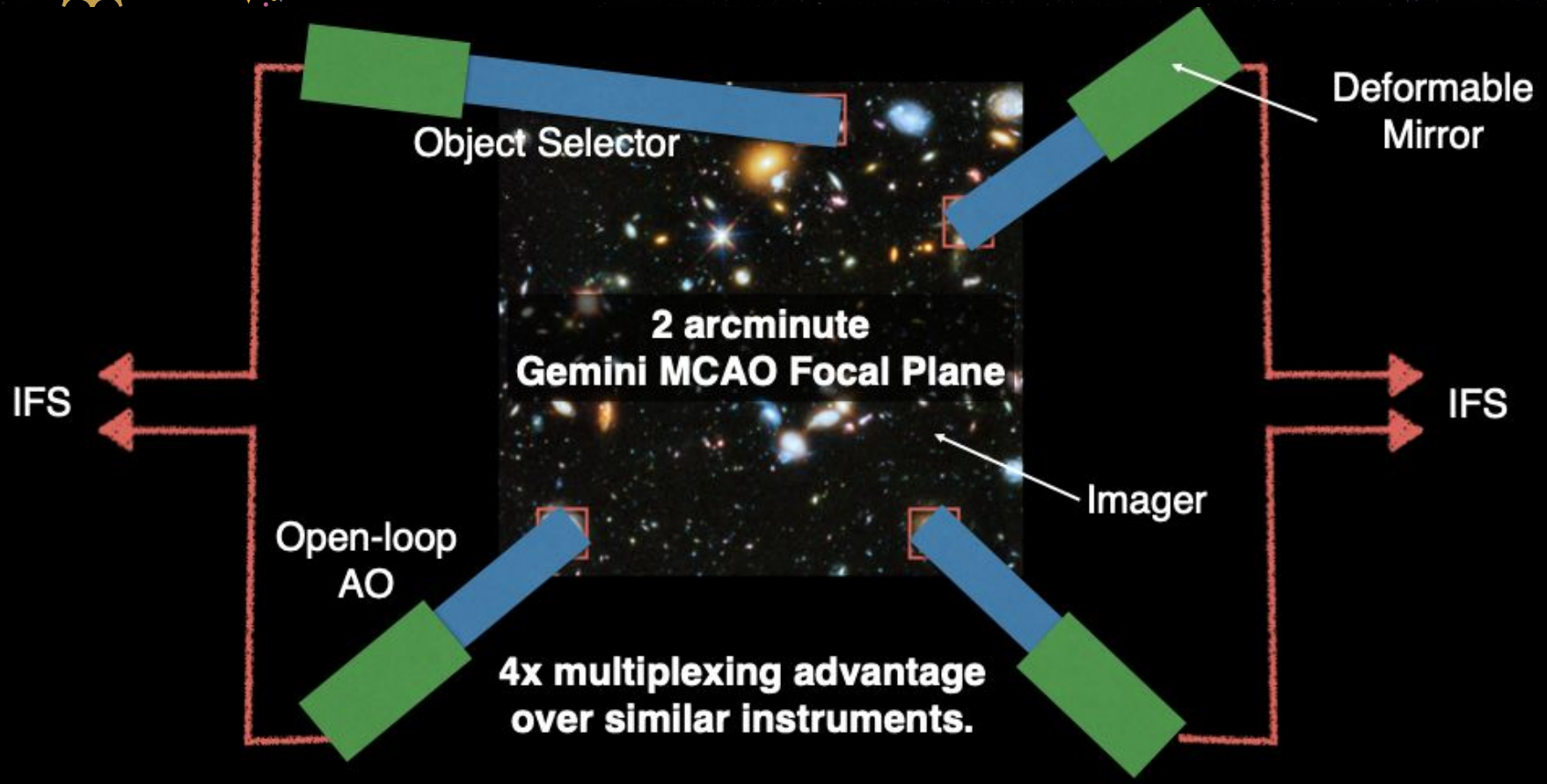
spatially resolved

spectroscopy - disentangle

host galaxy from kilonova



# GIRMOS

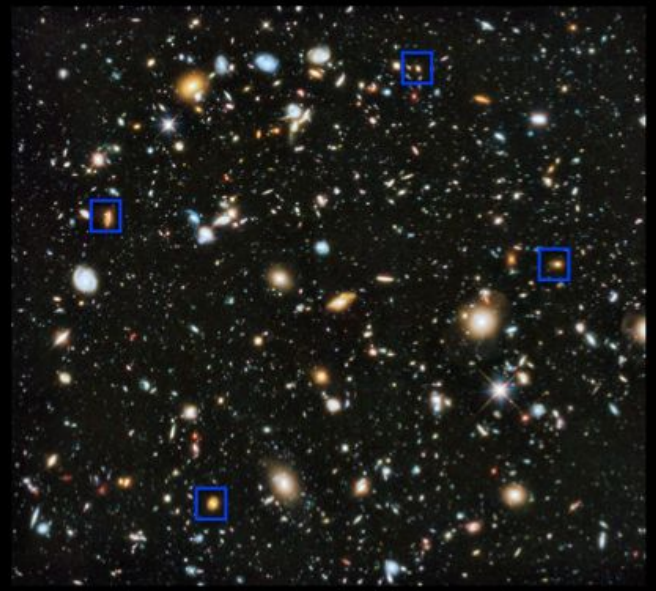



**GIRMOS is an AO-fed multi-object integral field spectrograph**

- Can simultaneously observe four objects

PI: S. Sivanandam; funded by Canadian Innovation Fund

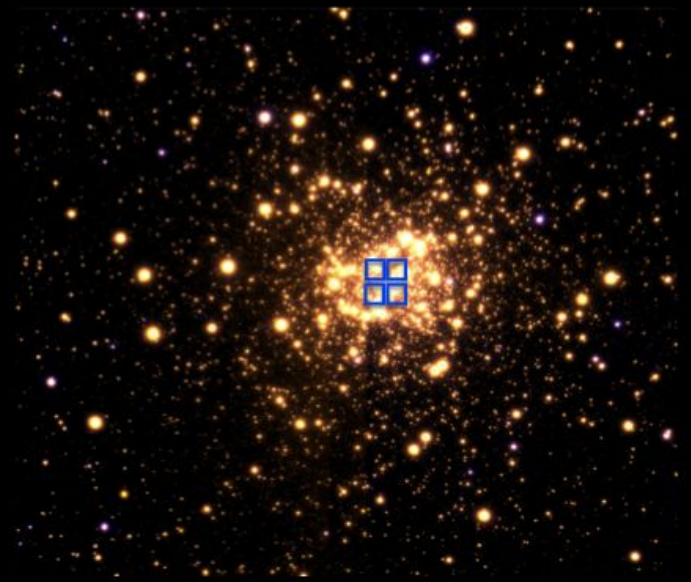
# GNAO + GIRMOS



Multiple Objects

***Pick-off System***

MOAO

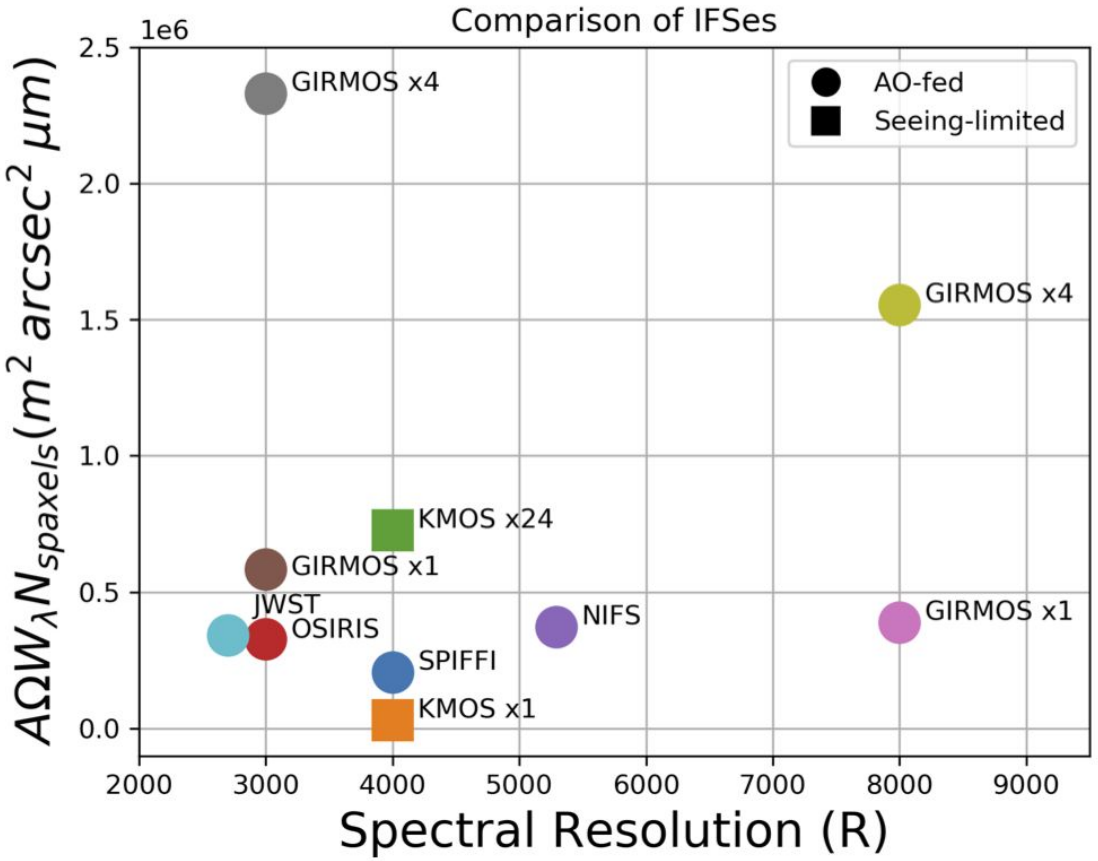


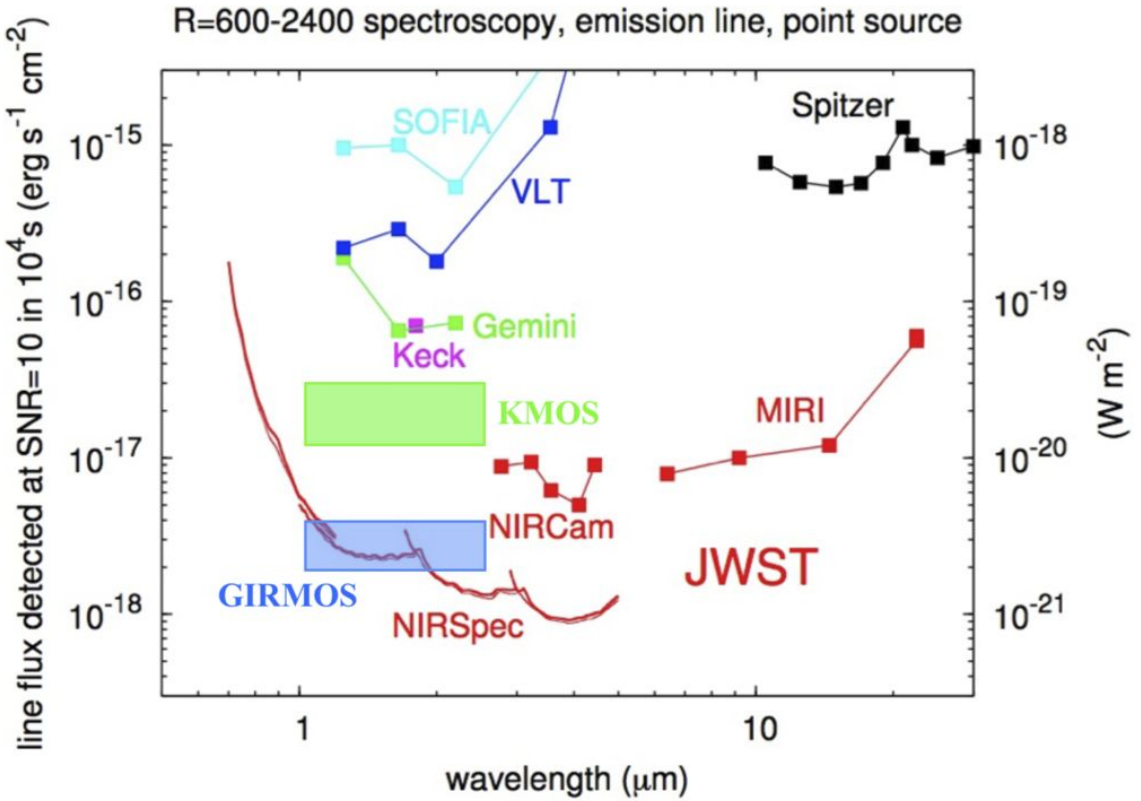
Single Object

***Tiled Super-IFU***

LTAO/MCAO

# GIRMOS - 4 deployable IFSs, R~3000, 8000 modes




Sivanandam, SPIE 2018, arXiv:1807.03797

# Summary

Thank you NSF!

New & improved facilities will drive discovery engines for multi-messenger and time-domain astronomy.

Coordinated, rapid follow-up across the globe is needed to understand these phenomena.

Gemini Observatory is developing infrastructure and instrumentation to be ready for the next decade of discovery.