



The Astronomical Event Observatory Network

Multi-messenger and
Time-domain Astronomy

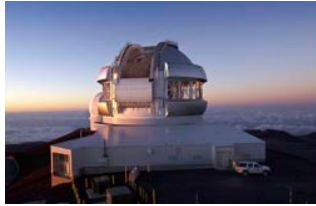
Las Cumbres
Observatory



Dr. Lisa Storrie-Lombardi
Observatory Director



Partnership to create an extended network of follow-up observing facilities



Community
Science & Data
Center



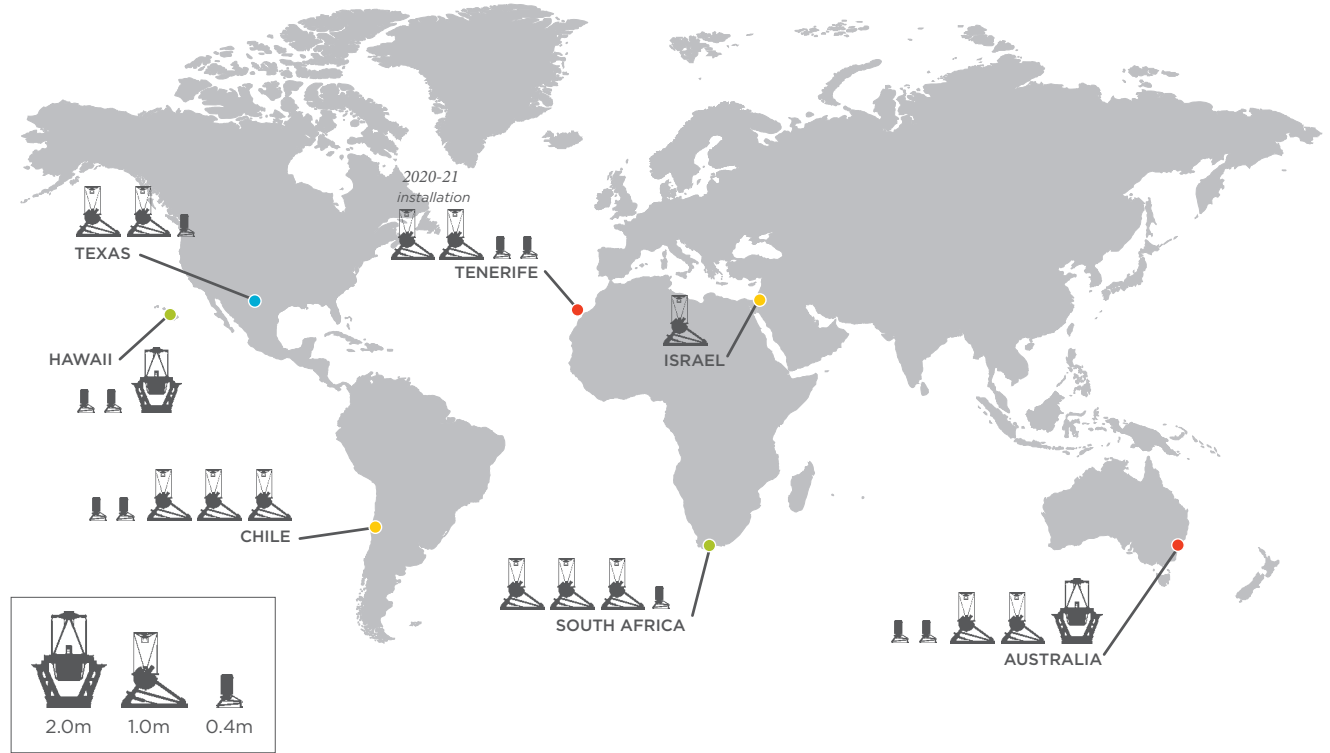
- A. Adamson, J.P. Blakeslee, B.W. Miller - Gemini Observatory/NSF's NOIRLab
- R.D. Blum, Vera C. Rubin Observatory/NSF's NOIRLab
- A.S. Bolton, C-H. Lee, S. Ridgway, Community Science and Data Center/NSF's NOIRLab
- T. Boroson, M. Bowman, E. Gomez, E. Heinrich-Josties, A. Hopkinson, J. Nation, R. Street, Las Cumbres Obs.
- C. Briceno, J. Elias, SOAR Telescope/NSF's NOIRLab
- S. Heathcote, Cerro Tololo Inter-American Observatory/NSF's NOIRLab
- D.R. Silva, The University of Texas at San Antonio

LCO global telescope network

twenty-three
telescopes

seven sites
around the
world

working
together as
a single
instrument



Las Cumbres Observatory is unique

global telescope
network

robotic operations

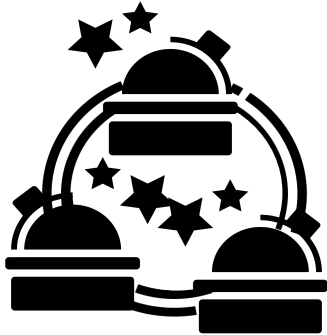
dynamic queue
observation
scheduling

rapid delivery of
processed data

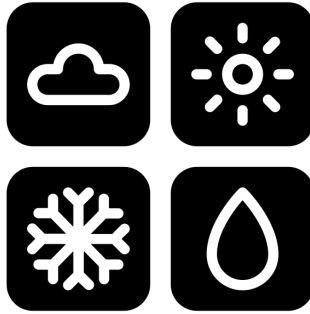
US Community access to LCO facilities provided through support from the National Science Foundation

Robotic Operations

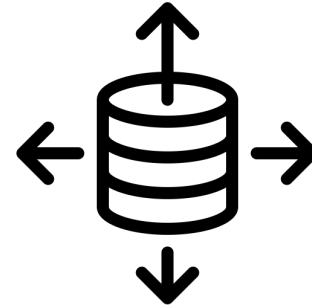
internet



weather stations



status database



software brain to run it

Dynamic Scheduling • Rapid Data Delivery

entire network
reschedule every 5
minutes

support multiple
timing constraints

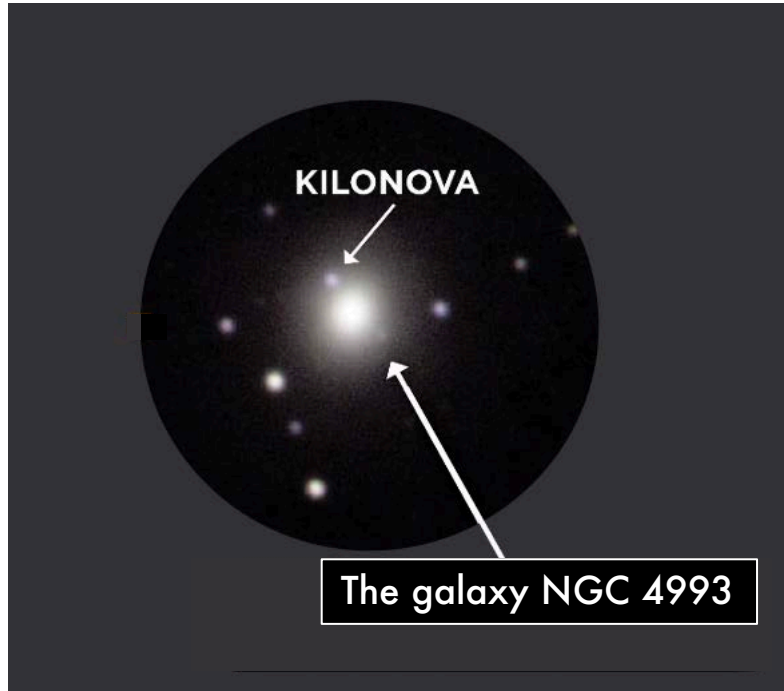
submit observations
programmatically

data available
within minutes of
shutter close

Example: kilonova AT 2017gfo

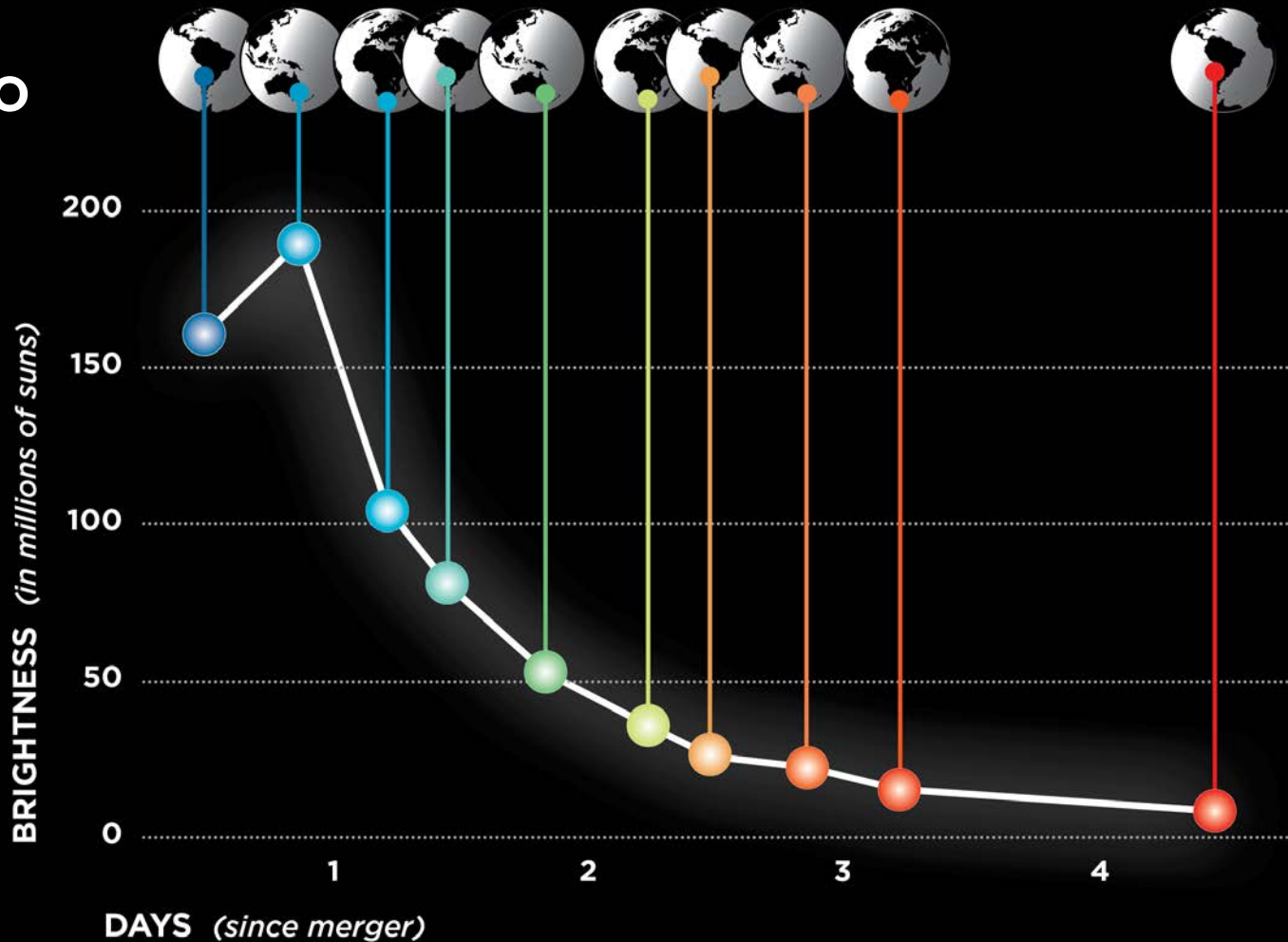
Only one gravitational wave event, GW170817, has had a detected electromagnetic counterpart, resulting in the discovery of the first kilonova, AT 2017gfo.

Abbott et al., 2017



kilonova AT 2017gfo

LCO observations were key for constraining the peak of the light curve to be a few hours after the merger.

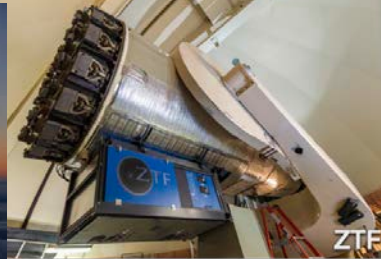
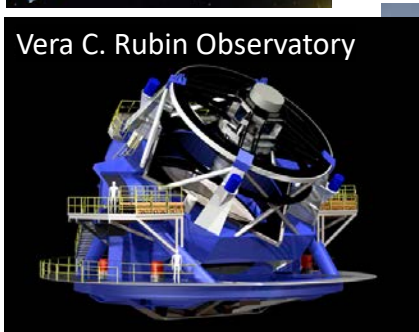
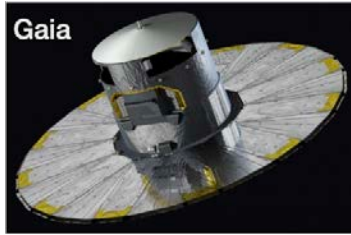


Arcavi et al., 2017



**Facilitate efficient access to the
follow-up resources that
astronomers need for their science.**

Astronomy Discovery Engines



...and many more

Astronomical surveys are producing greater data volumes and many issue alerts in near-real time

Telescope Allocations in Astronomy

Normally allocated in 6 month semesters by competitive proposal

Block scheduling of contiguous nights is common



Characterization observations are required to achieve the science with major surveys

- almost all scientific use-cases require follow-up with a range of facilities
- imaging and spectroscopy
- alert follow-up can be disruptive to telescope schedules

Observing Use Cases

single-shot

**repeated
monitoring**

**time
constrained**

**rapid
response**

Infrastructure Requirements

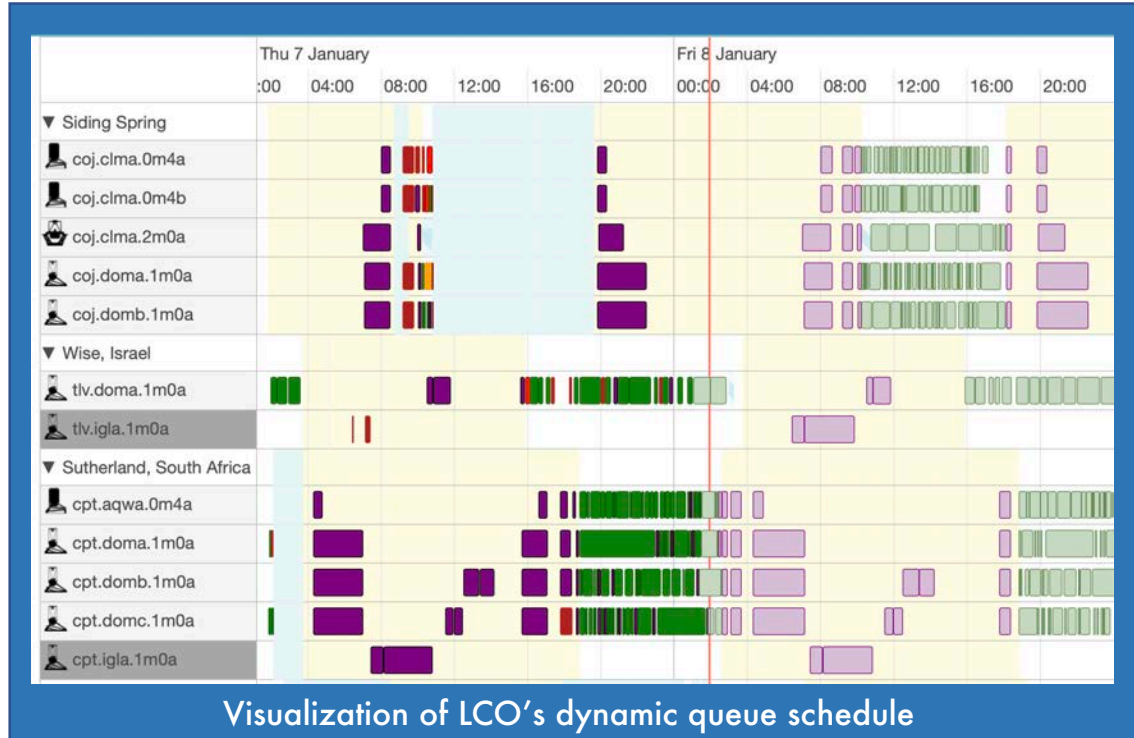
Software-enabled
dynamic queue
scheduling

Programmably
accessible
telescopes

Dynamic Queue Scheduling

Queue: Interleave observations from different programs

Dynamic: schedule regenerated at regular intervals to allow for changes in conditions and/or observing requests



Programmably accessible telescopes

Online interface or client that allows users to specify their own observation requests

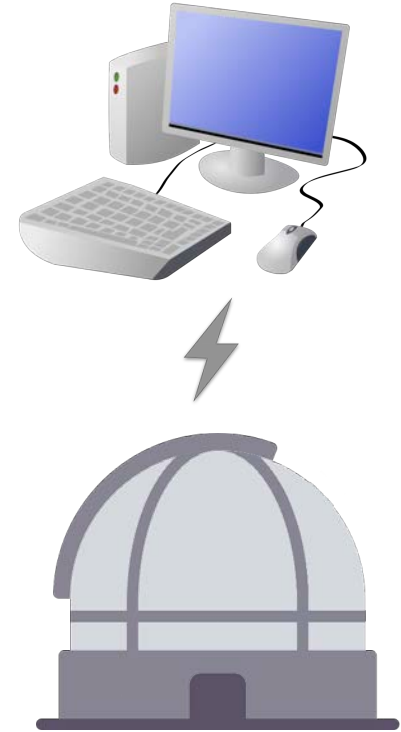
Provides traceability

Enables monitoring by user/observatory staff

APIs* enable requests submitted by software, such as Target and Observation Manager systems

Public TOM Toolkit package available:
<https://tom-toolkit.readthedocs.io/en/stable/>

*API = application programmable interface - software intermediary allowing two packages to communicate with each other



SOAR 4m Telescope

Interface via existing programmatic
portal when they choose

Available as a queue-scheduled node on LCO
network when in AEON-mode

- Traditionally scheduled the rest of the time - SOAR controls the schedule

Human operators on-site



Programmatic submission of observations provided by LCO portal

- Automatic TOM compatibility provided through LCO portal

Operating in AEON mode since August 2019

Elias et al. 2018, SPIE: Observatory Operations, 107040B



Gemini 8-meter Telescopes

Facility's own scheduling system with compatible interface

- Queue-scheduled observations
- Programmatic submission of observations with an existing API
- Gemini observing TOM Toolkit available module plugin (built by Bryan Miller, Gemini)
- Ongoing re-design of operations software designed with AEON and new automated scheduling system





Full-featured observatory control system

Provide a community-ready OCS that can be adapted for new and existing observatories around the world.

- Fully open source
- Well-documented
- Provide community support

Future Development

AEON's request language is designed to extend to new instruments

A diverse network, spanning all longitudes, latitudes, and wavelength regimes will enable science

New AEON partners are welcome



Lisa Storrie-Lombardi
lisa@lco.global

thank you

