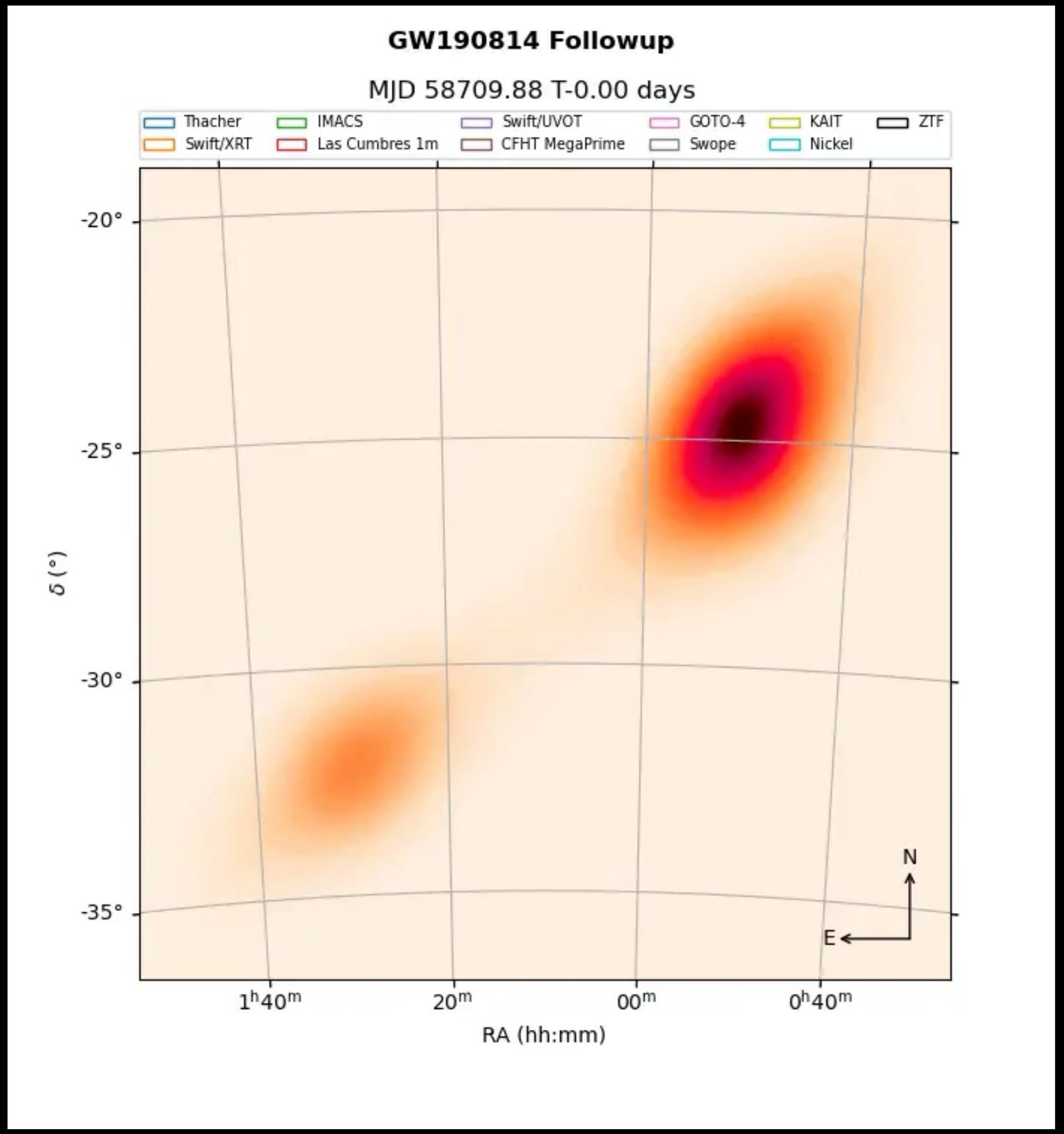
The Multi-Messenger Astronomy Followup Ecosystem

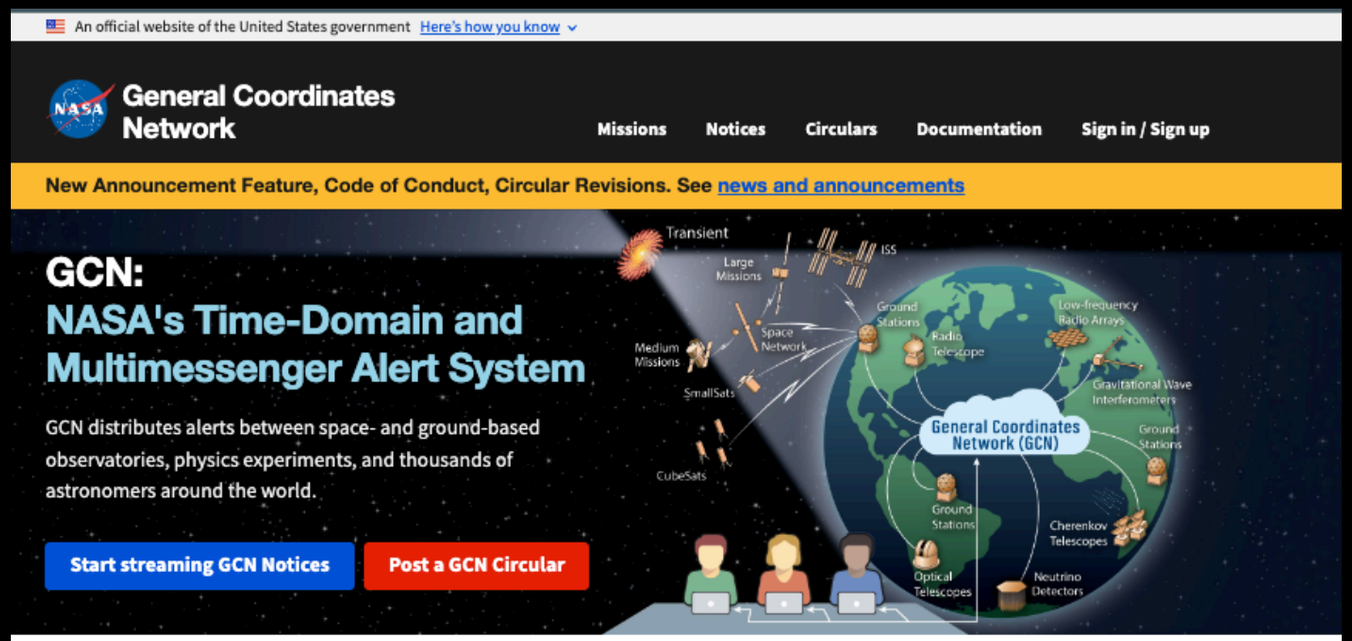
Curtis McCully

Las Cumbres **Observatory**

We Need Coordination!



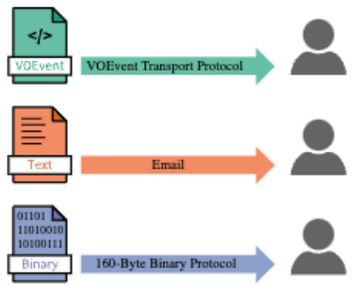
First, we need to know if a multi-messenger event occurred.



The General Coordinates Network (GCN) is a public collaboration platform run by NASA for the astronomy research community to share alerts and rapid communications about high-energy, multimessenger, and transient phenomena. For more information, see What is GCN? or check out our slide deck.

There are three ways to stream GCN Notices in real time:

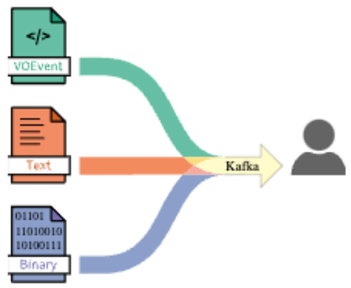
For legacy applications
GCN Classic



Three formats, three protocols.

Get Started (Old Web Site)

Recommended
GCN Classic over Kafka



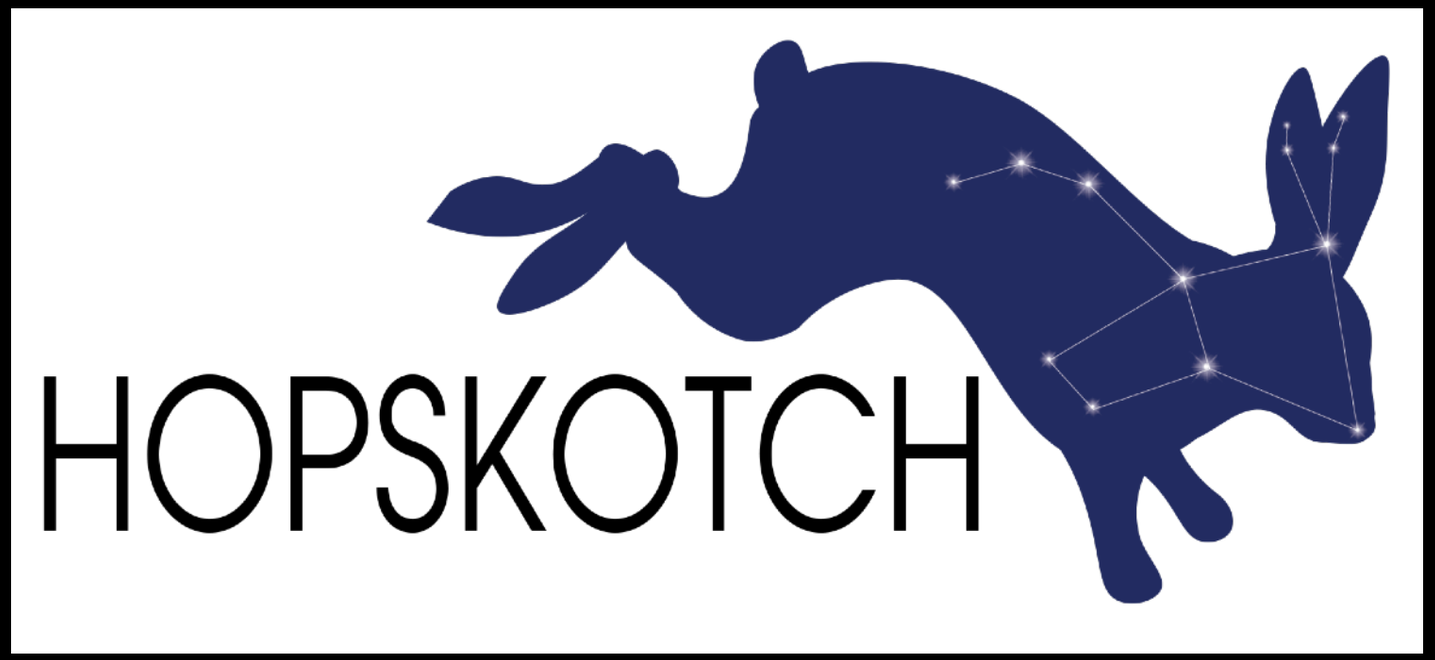
Three formats, one protocol.

Get Started

Coming soon
GCN Kafka

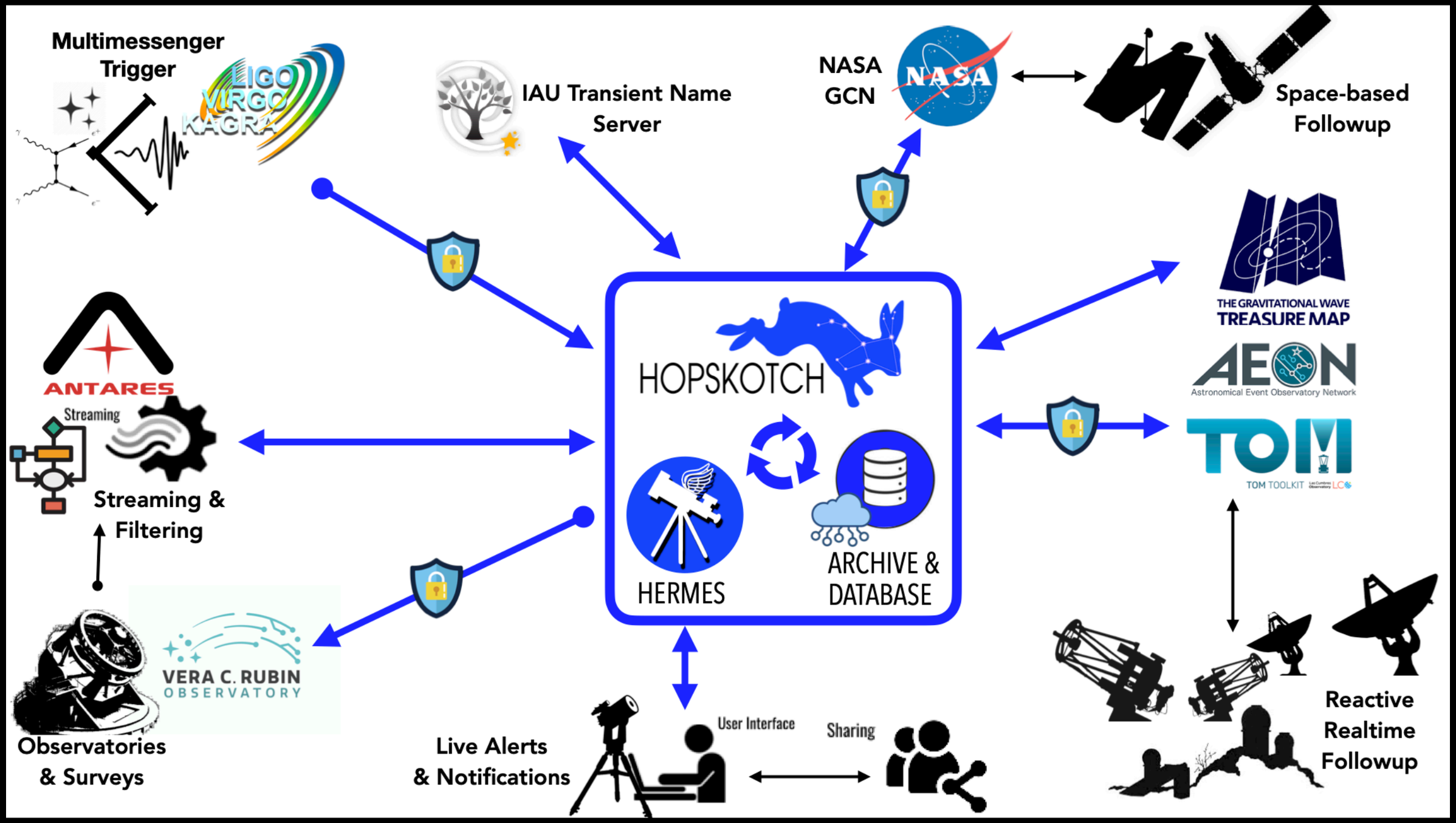
One format, one protocol.

First we need to know that a new transient has been detected.



- Messaging system built by SCIMMA (Scalable Cyberinfrastructure for Multimessenger Astrophysics) funded by the NSF - see scimma.org
- Pub-sub model - only subscribe to the information you want.
- Will carry existing existing astronomical messages, e.g. GCN Circulars and Notices, Transient Name Server messages, Astronomer’s Telegrams.
- Goal is to increase machine readable information.

Our goal is for HOPSKOTCH to be the messaging backbone for the MMA ecosystem



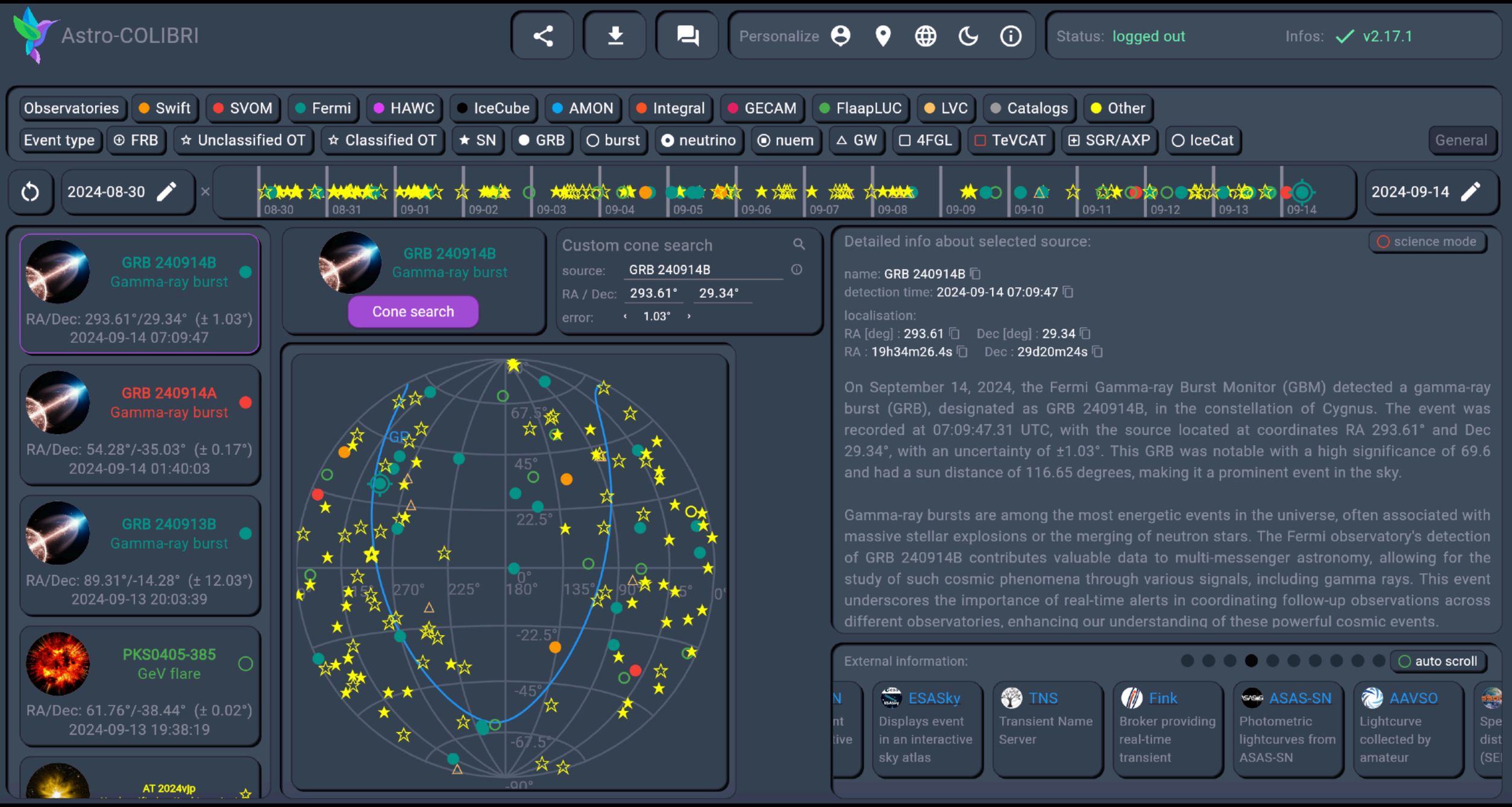
Then we need an interface to make follow-up decisions via human and/or AI

TOM Toolkit Home Targets Alerts Observations Data Non-Localized Events Users foo Logout

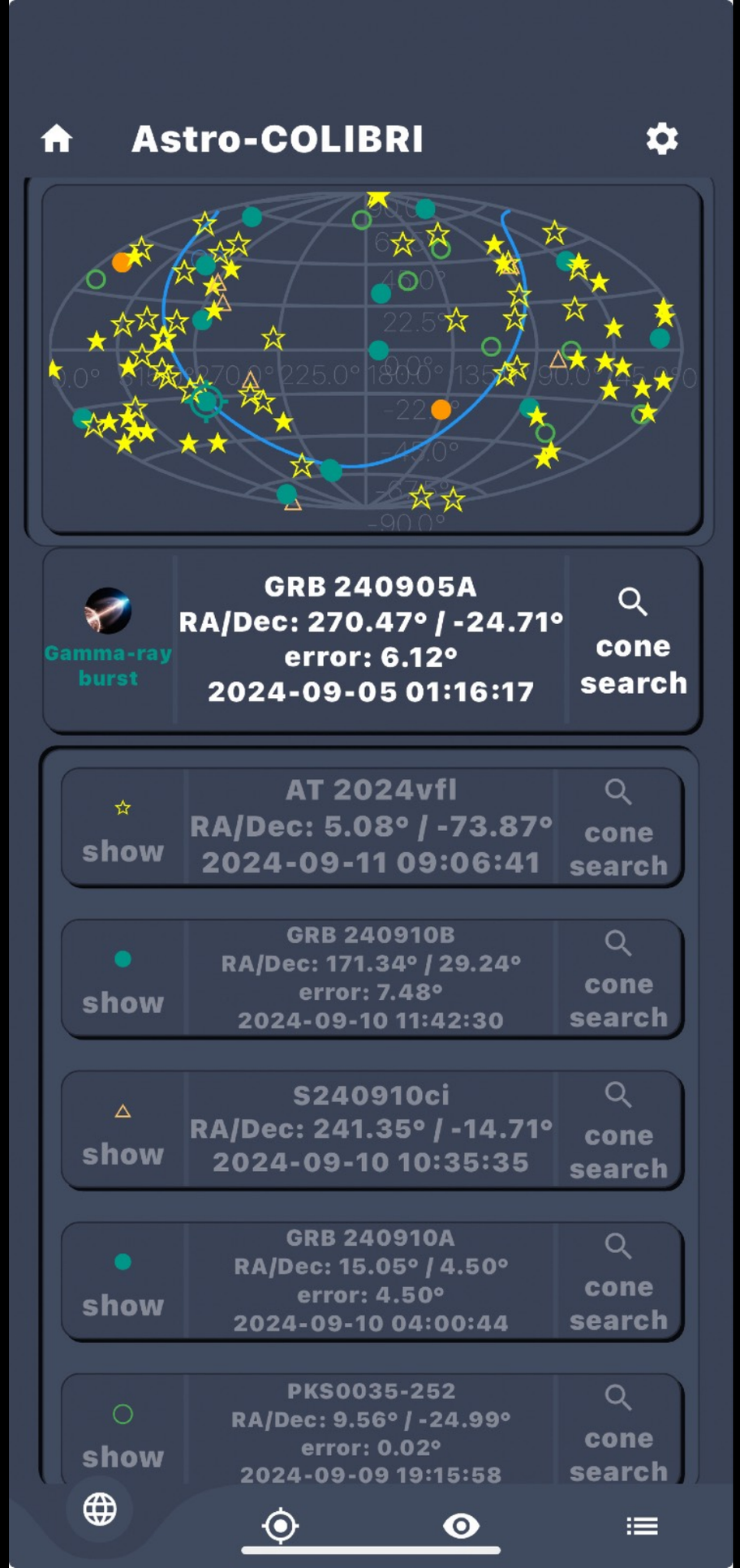
Non-Localized Event Index

Detail Page	GraceDB	Treasure Map	Event Type
1. **S190425z** Details	S190425z	S190425z	GW
2. **S190426c** Details	S190426c	S190426c	GW
3. **S190718y** Details	S190718y	S190718y	GW
4. **S200112r** Details	S200112r	S200112r	GW
5. **S200316bj** Details	S200316bj	S200316bj	GW
6. **S191110af** Details	S191110af	S191110af	GW
7. **S191216ap** Details	S191216ap	S191216ap	GW

Astro-COLIBRI



Thank you to our hosts!



It behooves us to take advantage of modern technology.

We may want to prioritize our targets using external services.

blast.scimma.org

Off-Campus Access | All Bookmarks

Blast Beta | Transients | Acknowledgements | Docs | Source Code | Login

Blast

A web service for the automatic, real-time characterization of transient host galaxies

Search the Blast database | Read the docs

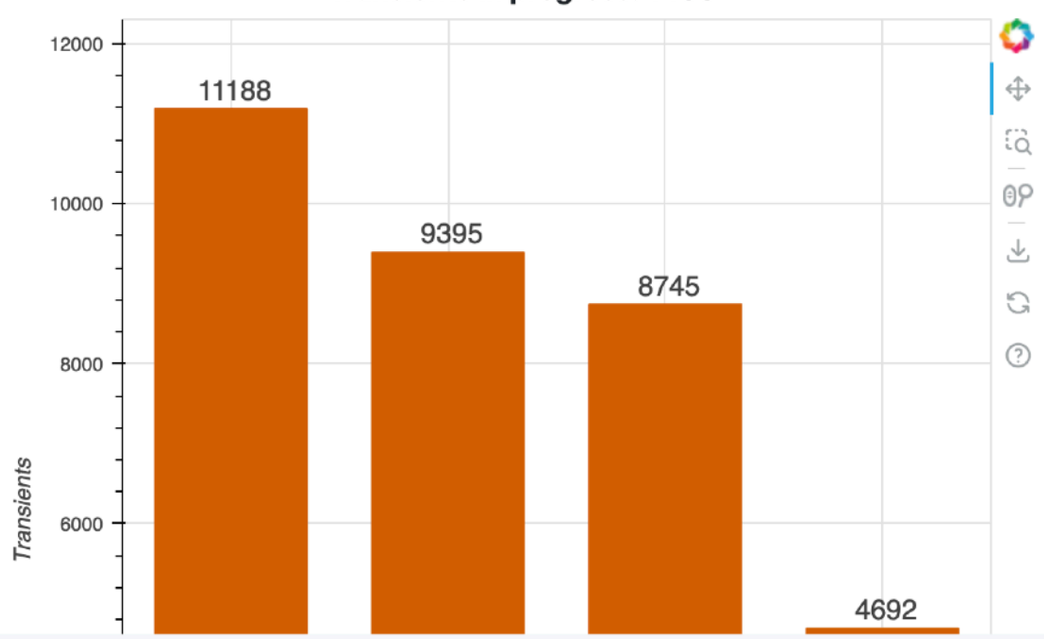
The host galaxies of astrophysical transients play a key role in our understanding of their progenitor systems and the use of Type Ia supernovae as standardizable candles for cosmology. However, fully characterizing host galaxy environments requires a high-statistics, unbiased, multi-wavelength dataset, preferably with 1-2 kpc resolution. Current analyses are limited by sample sizes of anywhere from ~10-200 SNe, predominantly optical host observations, and observational biases such as selecting from surveys that search for SNe within a pre-selected a set of galaxies.

Blast is a public web application built to provide information in real-time for every new transient reported to the International Astronomical Union (IAU):

- determine the transient's host galaxy,
- identify the available archival data,
- measure the resulting host galaxy star formation rates, masses, and stellar ages.

Database Snapshot

Transients processed: 10973
Transients in progress: 1438



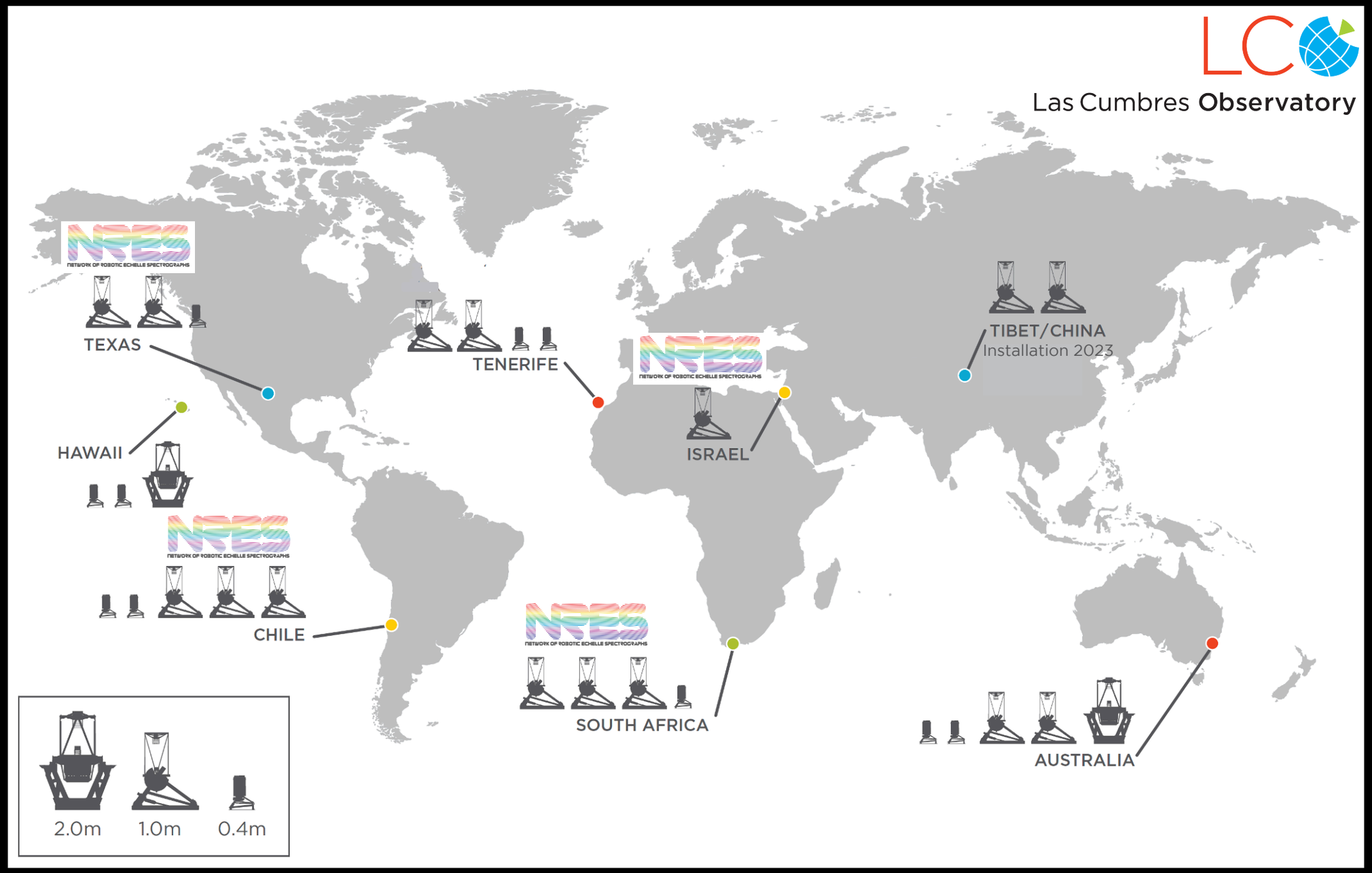
Report bugs and issues on Github here | UCSC Transient team web pages here

Once we have decided to followup an event, we need a rapid interface to trigger observations.

TOM Toolkit, SkyPortal

Las Cumbres Observatory

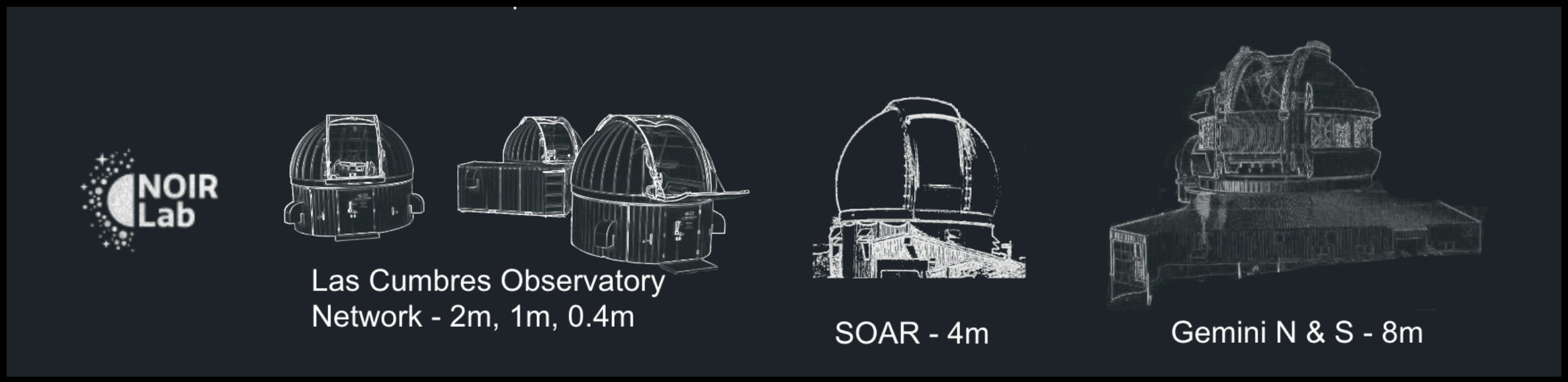
We operate a network of 25 robotic telescopes around the globe.



We need APIs trigger follow-up facilities

Collaboration of observatories for time-domain astrophysics

- Observations can be programmatically requested
- Queue-scheduled at least some of the time
- Manual and robotic operation

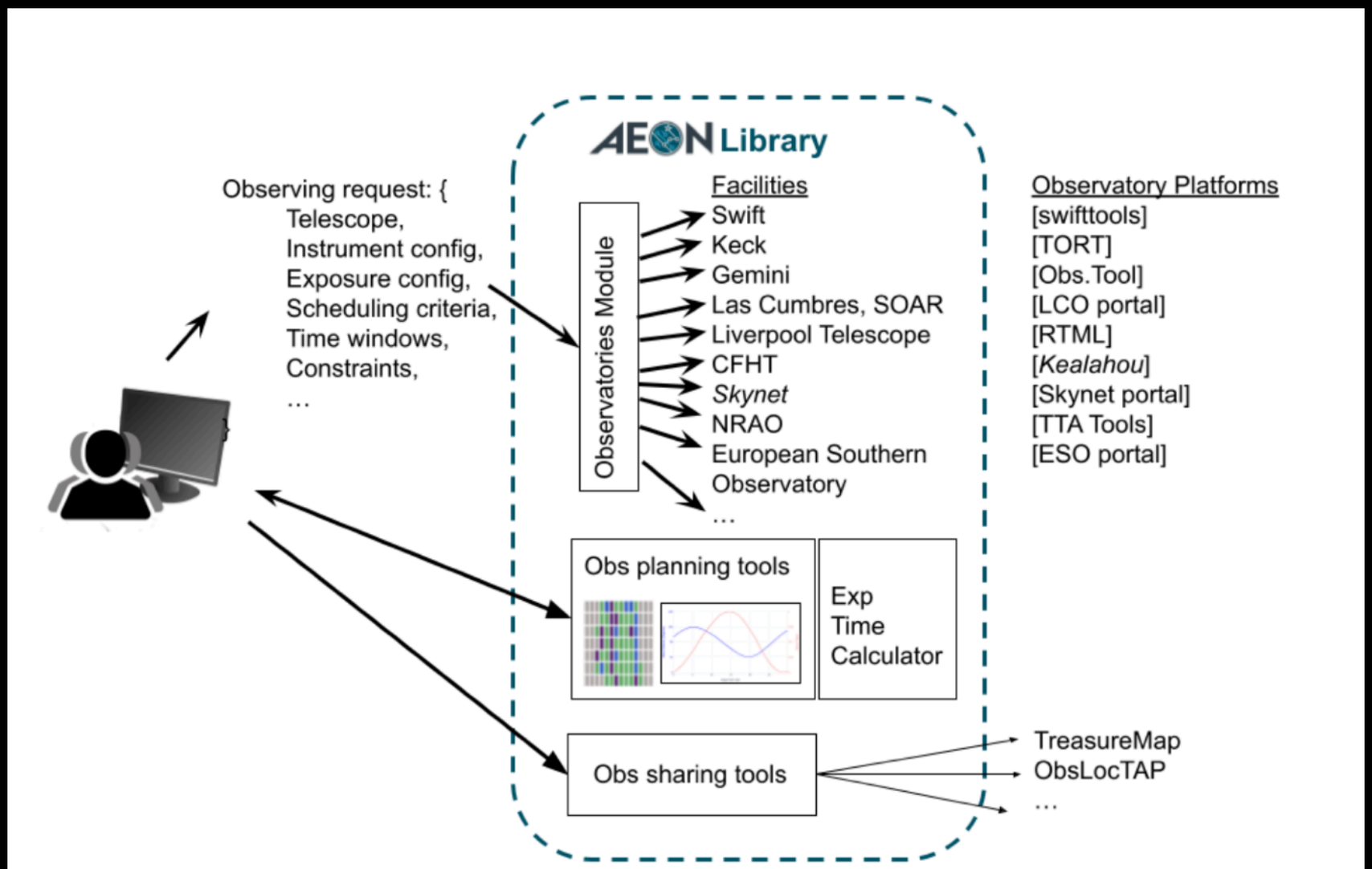


Street et al., 2020, SPIE, 11449, 25

AEON
Astronomical Event Observatory Network

AEON+

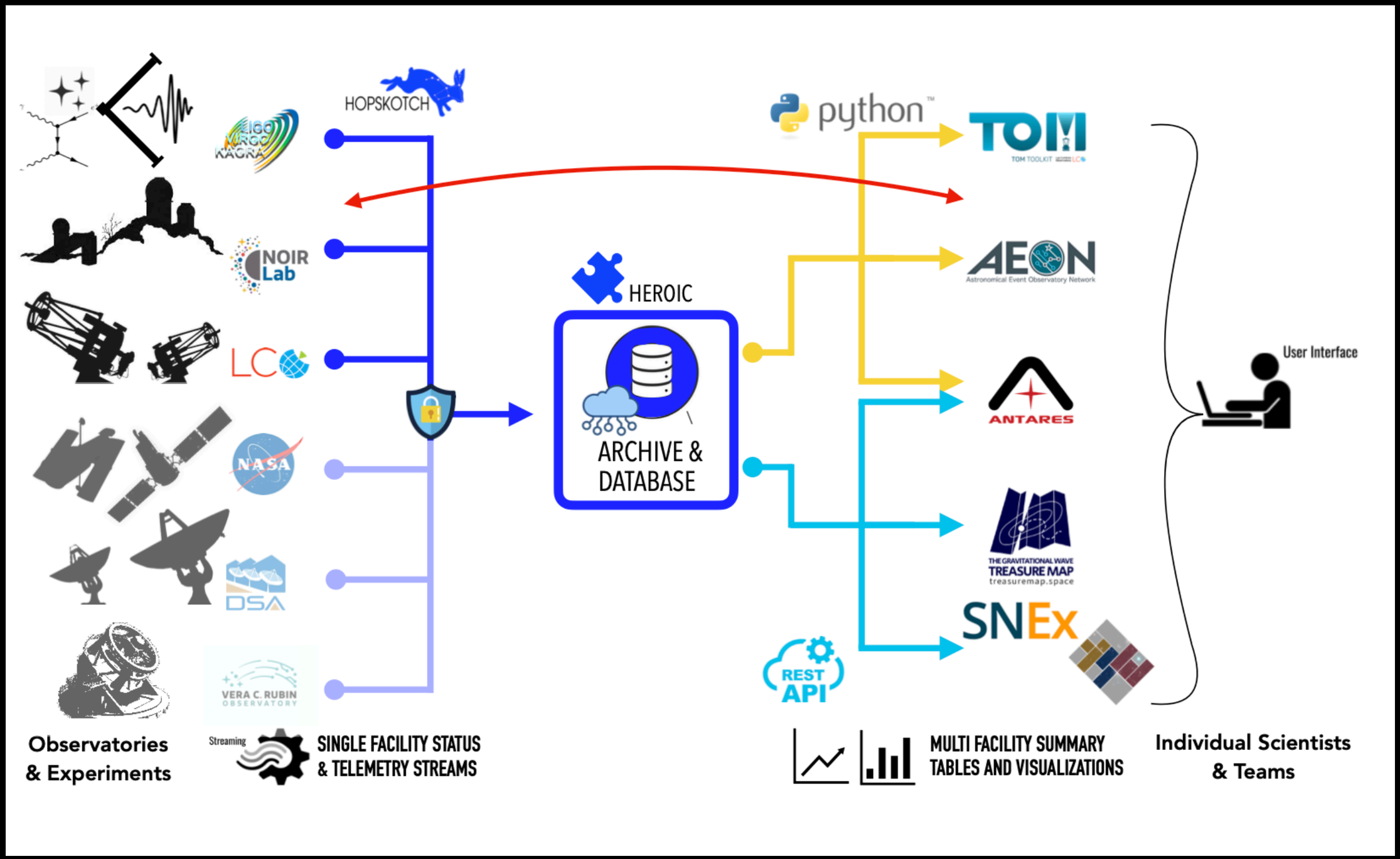
We have recently been funded to extend AEON to more facilities including CFHT, NOIRLab telescopes, and radio observatories.



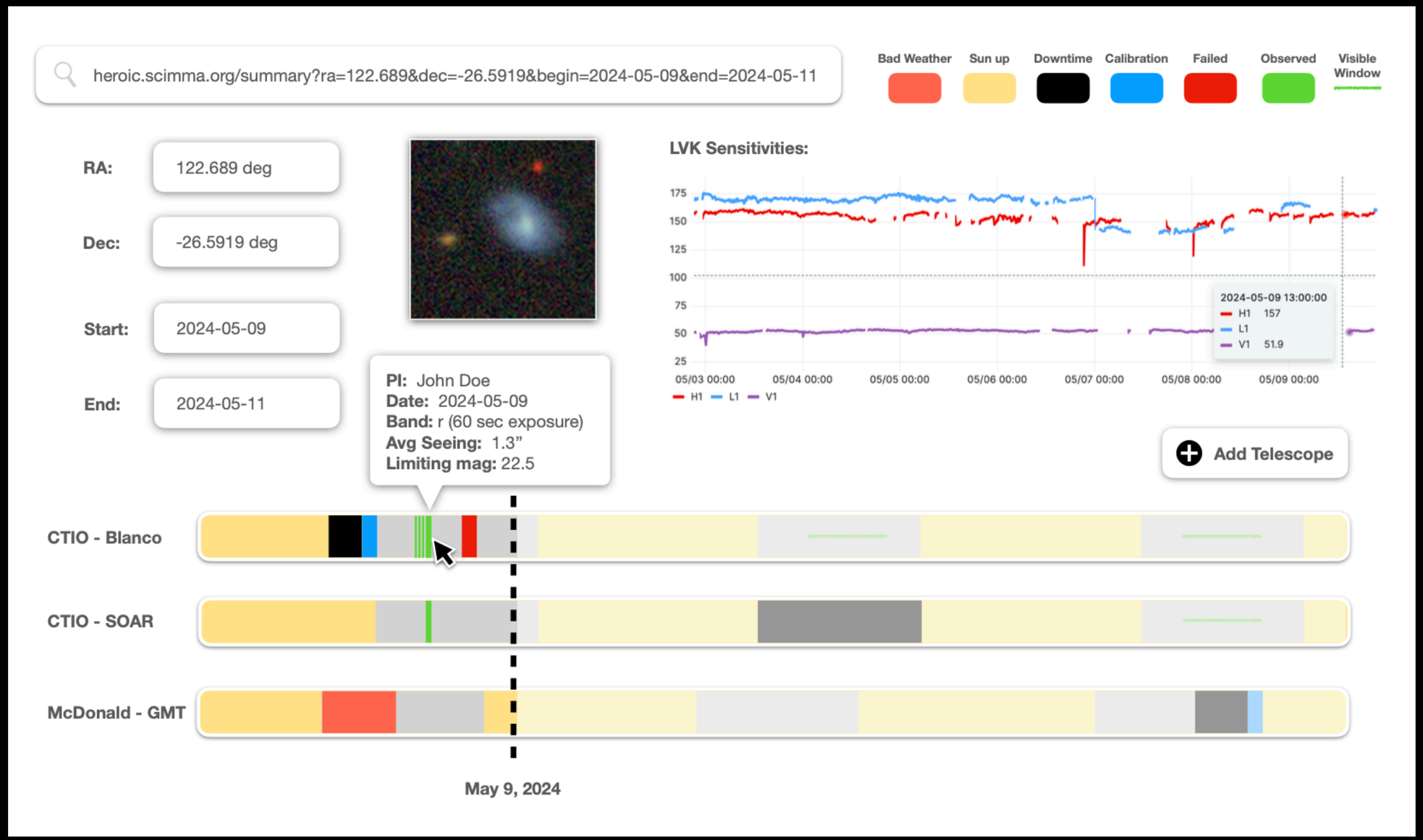
AEON
Astronomical Event Observatory Network

HEROIC

Hop Enabled Realtime Observatory Information and Coordination



HEROIC will provide realtime status for a variety of telescopes including AEON and NOIRLab telescopes



New observations need to be reported back to the community so they can used that to make future decisions.

Treasure Map

Treasure Map | Home | GW Events | Query Pages | Submit Pages | Observatory Statuses | Documentation | Login | Register

Welcome to the Gravitational Wave Treasure Map

The Treasure Map is designed to help coordinate electromagnetic followup of gravitational-wave (GW) events. It allows observers to easily report their planned and executed observations in search of counterparts to GW events, and to query the reports of other observers, in a programatic way. The goal is to enable coordination between observatories in order to minimize unnecessary overlap in these searches and find the counterpart as quickly and as efficiently as possible.

Please **register** for an account, so that you can programatically query the Treasure Map.

For more details on how to use the Treasure Map see our **User Guide**.

The Treasure Map is being designed and developed by:
Samuel Wyatt, University of Arizona
Aaron Tohuvavohu, University of Toronto
Iair Arcavi, Tel Aviv University
Dave Sand, University of Arizona
D. Andrew Howell, Las Cumbres Observatory
Michael Lundquist, University of Arizona
Curtis McCully, Las Cumbres Observatory
Austin Riba, Las Cumbres Observatory

Please direct any general inqueries to Iair Arcavi.

If you use the Treasure Map in your research, please cite the Treasure Map paper in addition to the circulars and/or papers of the teams whose pointing information you use.

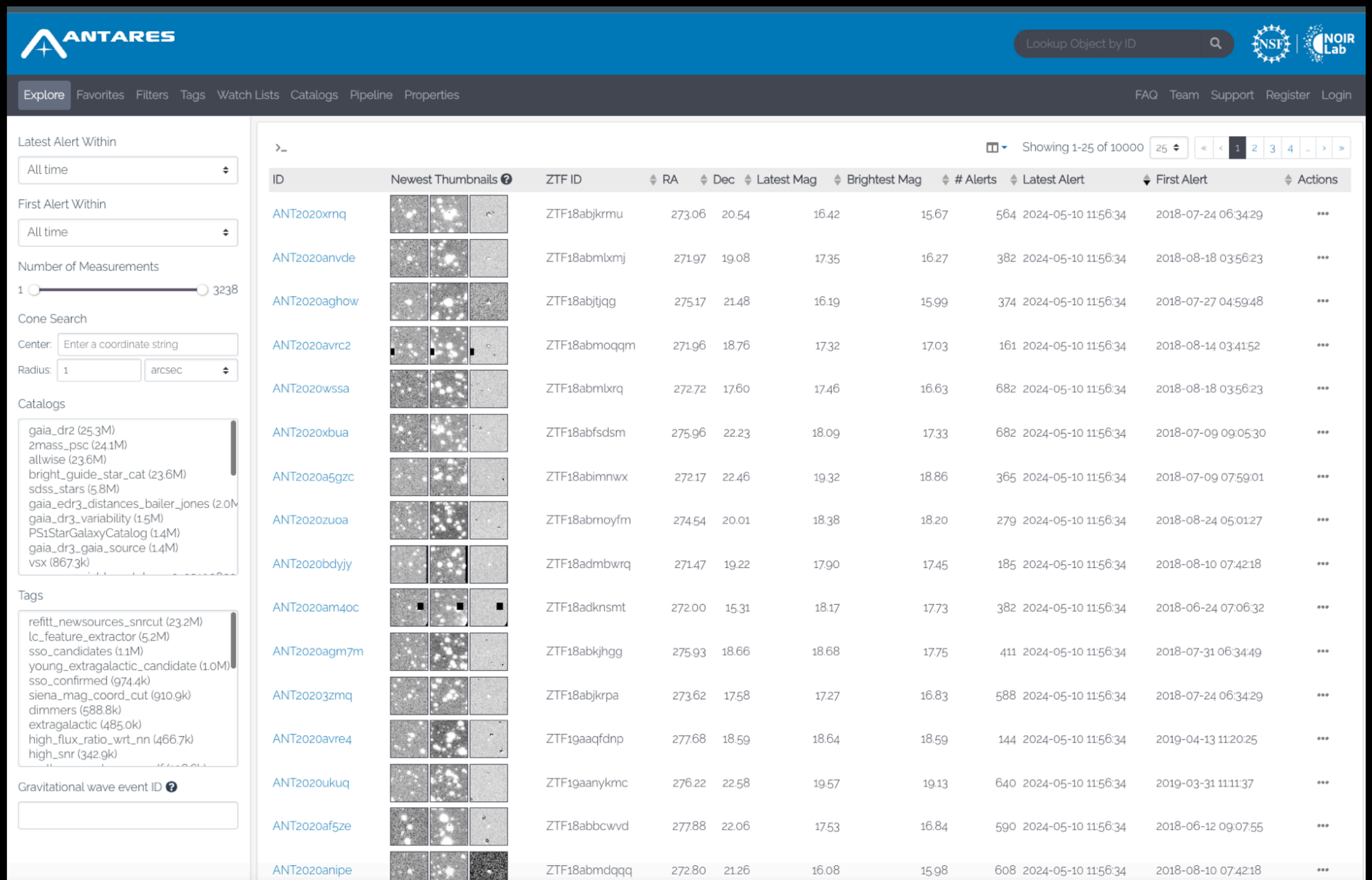
Instruments Reporting

Name	Pointings reported
Swift X-ray Telescope	7803
Swift Ultraviolet/Optical Telescope	6625
Gravitational-wave Optical Transient Observer (GOTO-4 prototype)	2714
ZTF	2586
Swope	1011
MLS10KCCD-CSS	980
Sinistro	728
Thacher ACP Camera	337
Nickel Direct Camera	315
J-GEM/Subaru/Hyper Suprime-Cam	240
Katzman Automatic Imaging Telescope	213
MMTCam	119
IMACS_f2_square	99
J-GEM/Kanata-HONIR	79
Canada France Hawaii Telescope MegaPrime	65
Wise observatory C28 Jay Baum Rich telescope	32
Swift Burst Alert Telescope	31
Wise observatory C18 telescope	24

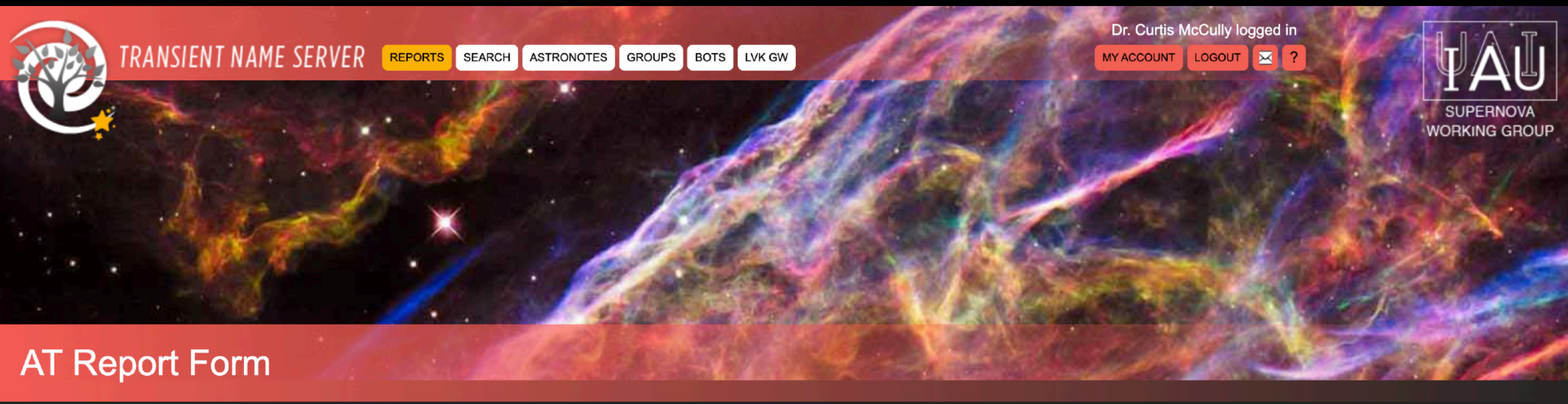
Open “treasuremap.space” in a new tab

New transients the need to be reported back to the community for further vetting.

Brokers: ANTARES, FINK, ALeRCE, LASAIR, et al., (TNS)



Once new counterpart candidates are discovered, they need to be reported to get an official IAU designation.



AT Report Form

AT Report Form | Classification Report Form | FRB Report Form

RA* Error Err units: arcsec

DEC* Error Err units: arcsec

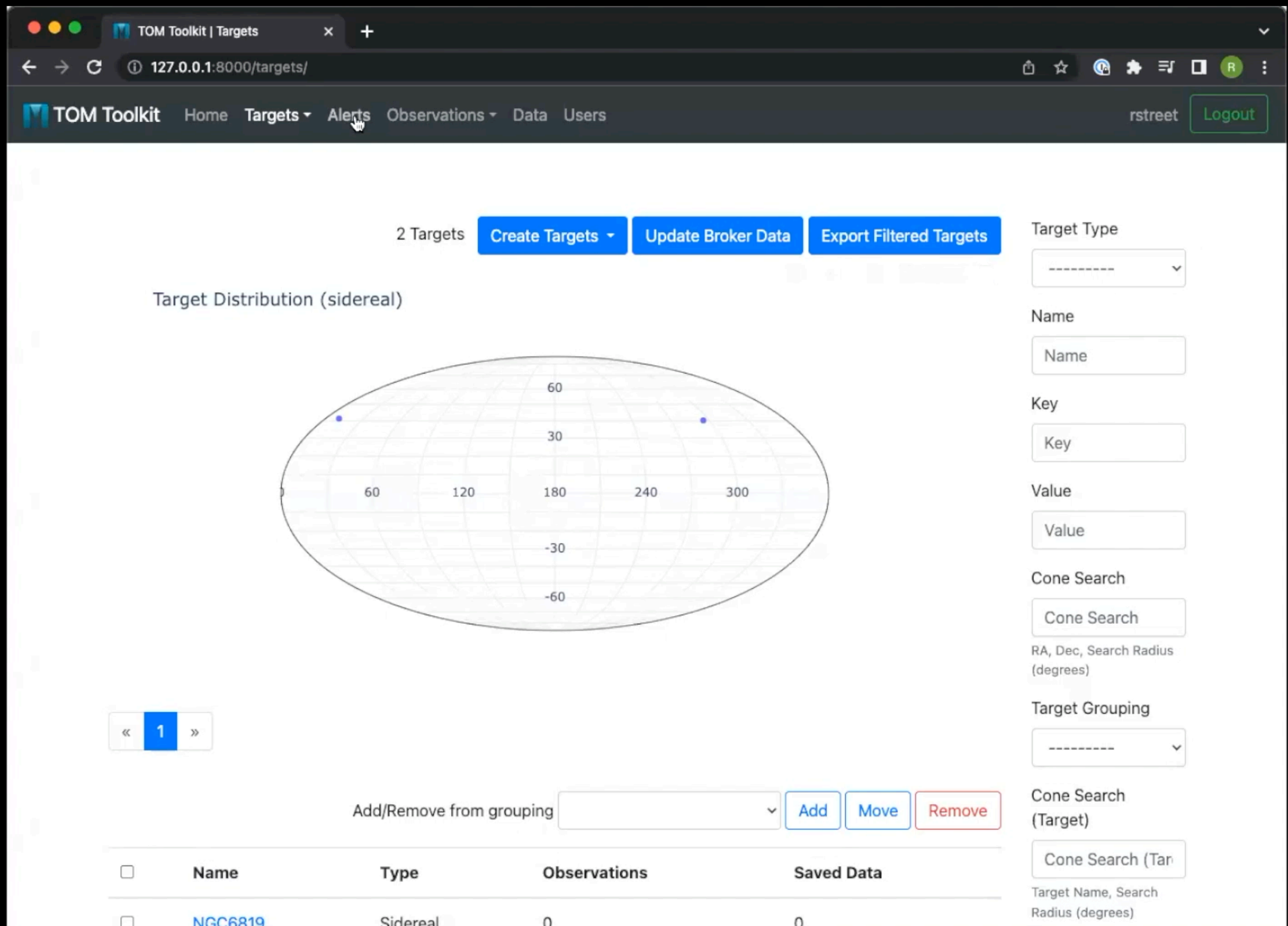
Reporting Group*: - Select -

Discovery Data Source*: - Select -

Reporter/s (Authors list)*: Curtis McCully

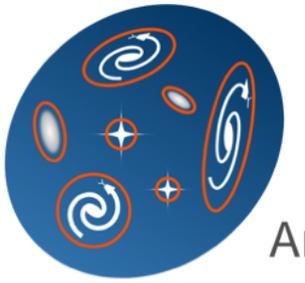
https://www.wis-tns.org/reports/frb

Let’s start by getting an interesting target from an alert stream



Once we have data, it needs to be procesed quickly

BANZAI, Pypeit, astropy photutils and specutils, DRAGONS



photutils

An Astropy Package for Photometry

specutils

An Astropy package for spectroscopy

The Astropy Project

DRAGONS

PypeIt

BANZAI

BANZAI is the pipeline framework designed specifically for Las Cumbres Observatory

BANZAI runs fully automatically, delivering data to users within minutes of shutter close.

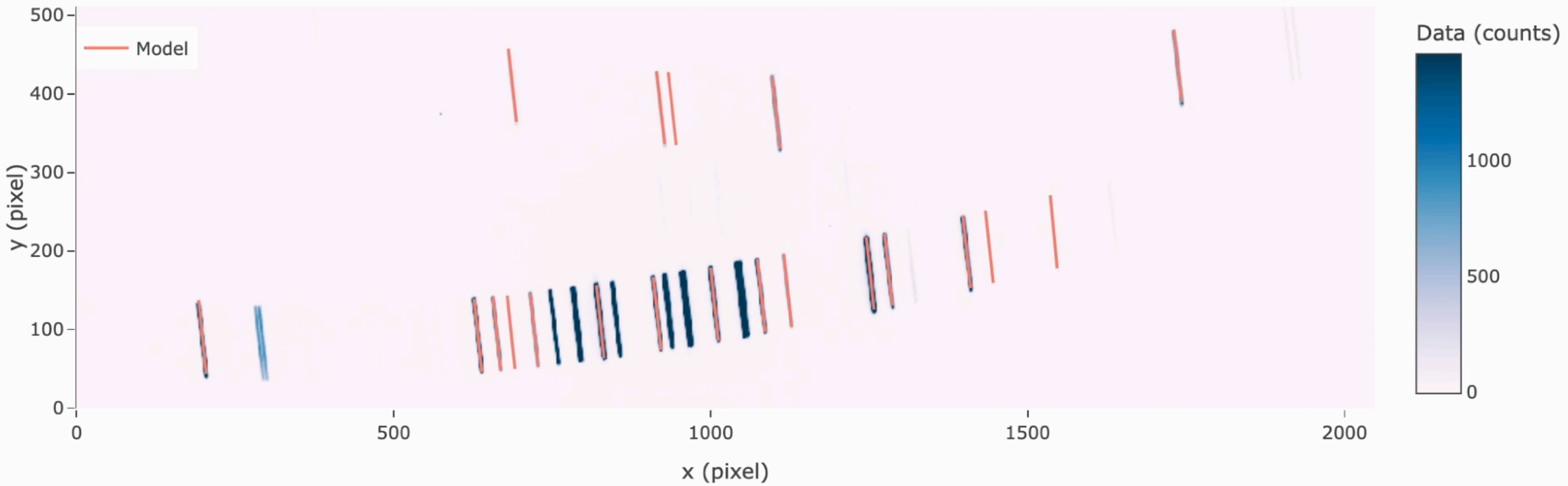
McCully+ 2018, SPIE, 107070K

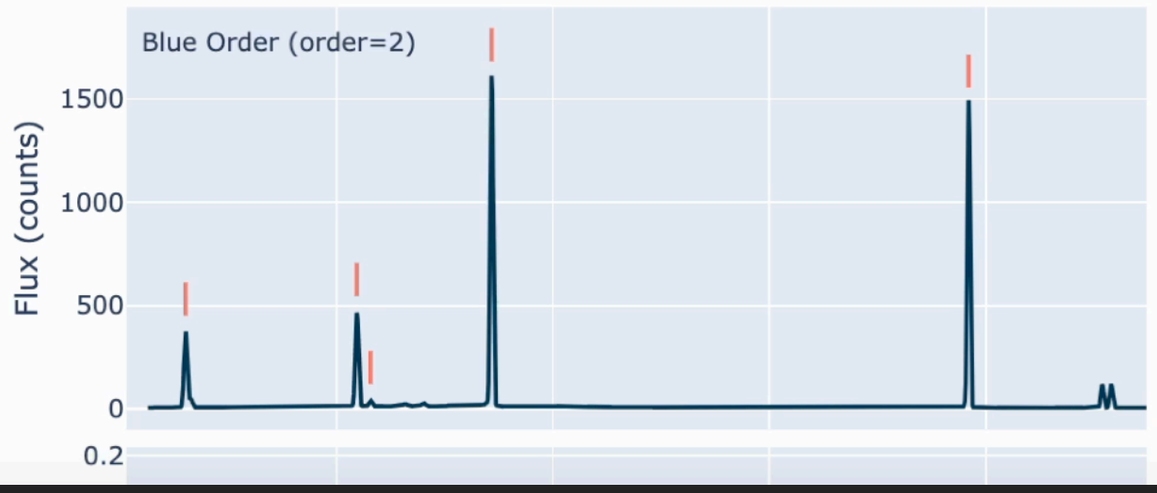
BANZAI-FLOYDS Reprocessing

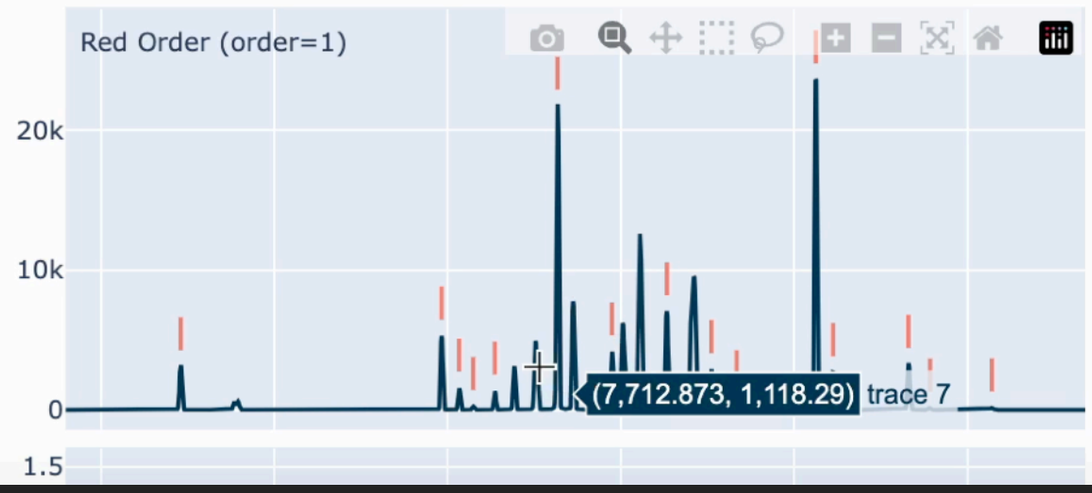
ogg × | 06/10/2024 → 06/17/2024

ogg2m001-en06-20240614-0017-e91-1d.fits.fz ×

Arc Frame Used in Reduction: ogg2m001-en06-20240614-0013-a91

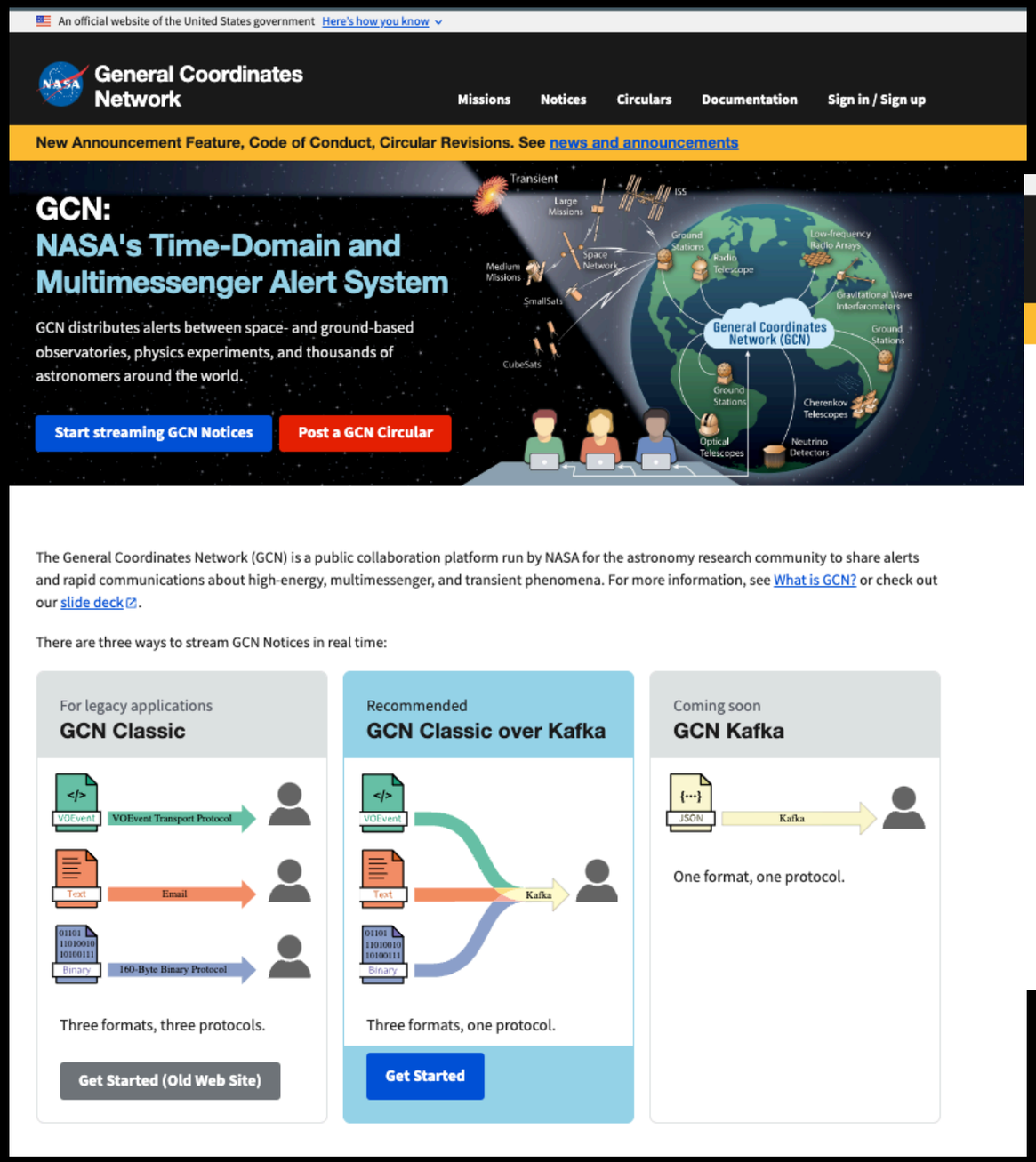


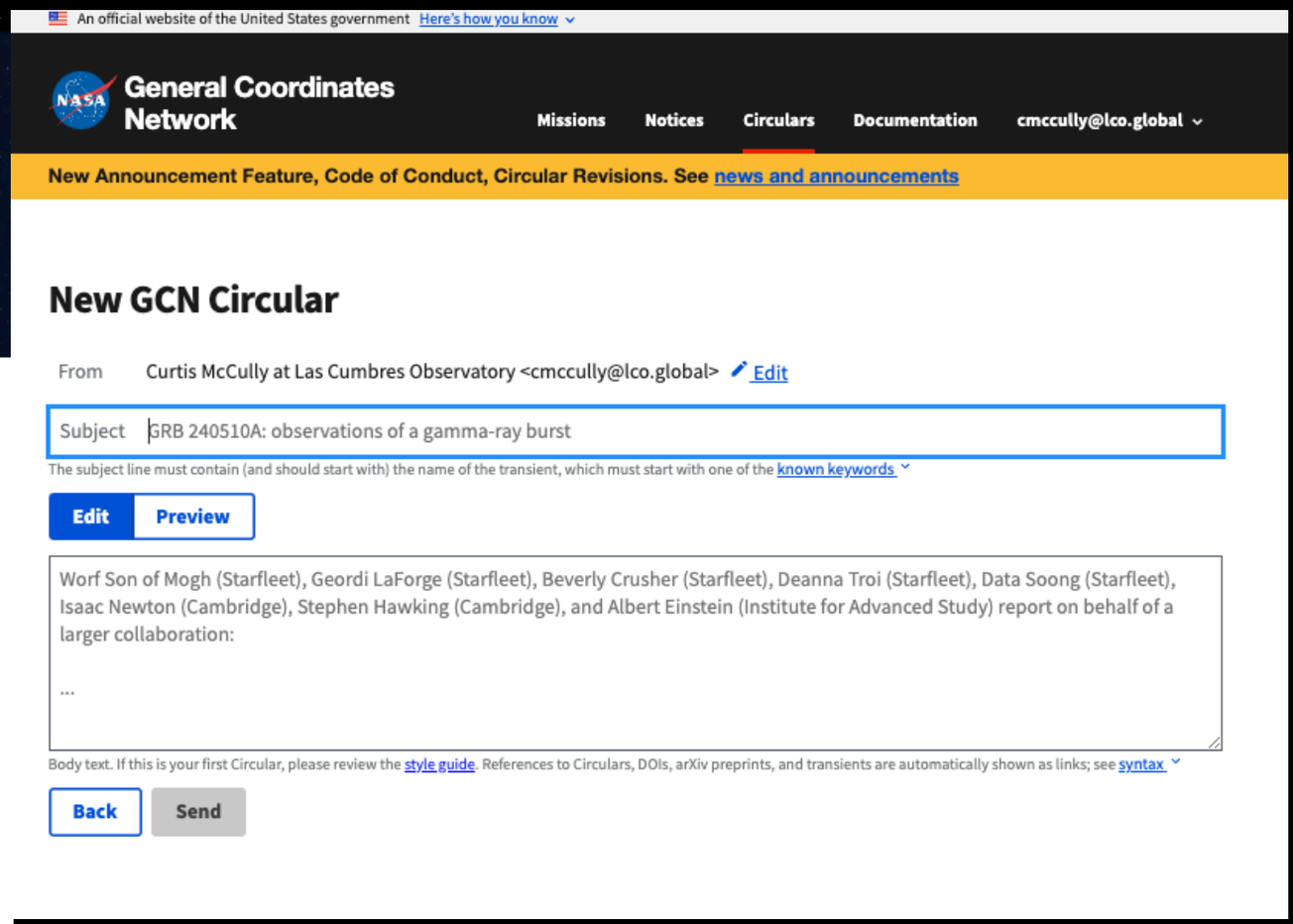




New observations need to be reported back to the community so they can use that to make future decisions.

GCN





New observations need to be reported back to the community so they can use that to make future decisions.

HERMES

HERMES Submit New Non-localized Event Submit Candidates Submit Non-Detections Submit Search Pointings Report Photometry Report Spectroscopy Report Observatory Availability User

‹ 1 2 ›

Topics hermes.test

	TIMESTAMP	TITLE	SUBMITTER
1	2022/07/26	Boom! Boom! Boom! So many Booms!	Hermes User.guest
2	2022/07/26	Title	Hermes User.guest
3	2022/07/26	Demo test for Boom!	Hermes User.guest
4	2022/07/26	A test submission -- Boom!	Hermes User.guest
5	2022/07/25	matt_test	Hermes User.guest
6	2022/07/25	matt_test	Hermes User.guest
7	2022/07/25	matt_test	Hermes User.guest
8	2022/07/25	Title	Hermes User.guest
9	2022/07/25	Foo	Hermes User.guest
10	2022/07/25	matt_test	Hermes User.guest

Fermi trigger No 680421061: Global MASTER-Net observations report

Vladimir Lipunov at Moscow State U/Krylov Obs <lipunov@xray.sai.msu.ru>

V. Lipunov, V.Kornilov, E.Gorbovskoy, K.Zhirkov, N.Tyurina, P.Balanutsa, A.Kuznetsov, D. Vlasenko, G.Antipov, D.Zimnukhov, V.Senik, E.Minkina, A.Chasovnikov, V.Topolev, D.Kuvshinov, D.Cheryasov, Ya.Kechin
(Lomonosov Moscow State University, SAI, Physics Department),

R. Podesta, C.Lopez, F. Podesta, C.Francile
(Observatorio Astronomico Felix Aguilar OAFA),

R. Rebolo, M. Serra
(The Instituto de Astrofisica de Canarias),

D. Buckley
(South African Astronomical Observatory),

O.A. Gres, N.M. Budnev
(Irkutsk State University, API),

L.Carrasco, J.R.Valdes, V.Chavushyan, V.M.Patino Alvarez, J.Martinez, A.R.Corella, L.H.Rodriguez
(INAOE, Guillermo Haro Astrophysics Observatory),

A. Tlatov, D. Dormidontov
(Kislovodsk Solar Station of the Pulkovo Observatory),

A. Gabovich, V.Yurkov
(Blagoveschensk Educational State University)

MASTER-OAFA robotic telescope (Global MASTER-Net: http://observ.pereplet.ru, Lipunov et al., 2010, Advances in Astronomy, vol. 2010, 30L) located in Argentina (OAFA observatory of San Juan National University) started inspect of the Fermi GBB220725.24 (trigger No 680421061 16h 46m 26.40s −42d 12m 12.0s, R 14) errorbox 445 sec after notice time and 486 sec

HERMES/TOMS can be used to share data automatically between groups.

SNEx 2.0 Home Targets Alerts Scheduling Data Users TNS Targets Search by name or coor Curtis McCully Logout

SN 2022wpy

SN Ia z= 0.0152 04:46:28.004 -04:47:23.68 71.6167 -4.7899

Overview Details Observations Manage Data Observing Runs Images Photometry Spectroscopy

Known as:

AT 2022wpy
SN 2022wpy
ATLAS22bhuw

Add a new name

Science Interests:

Classification
Ia
Nearby SNe
Young SNe

Select Science Tags

Interested Persons:

J. Craig Wheeler
Or Graur

I'm Interested

Add to Interesting Targets

Data Used In:

First name of first author

Last name of first author

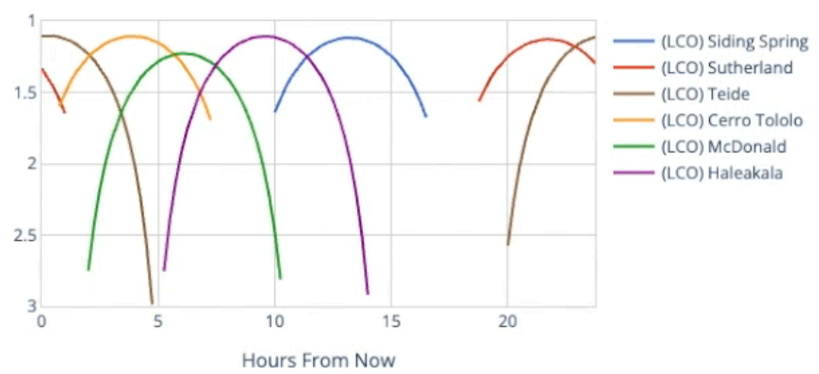
Brief description of contents of this paper, i.e. "All photometry and

Latest Comments

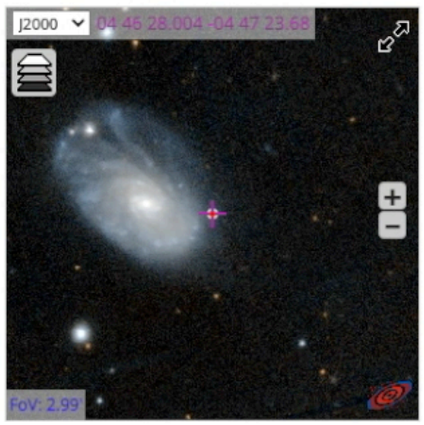
Craig Pellegrino on 2022-10-03
In NGC 1659 (64.3 Mpc, dm=34.04), discovered at 19.0 with a 1 day nondetection at 19.6

Add a comment

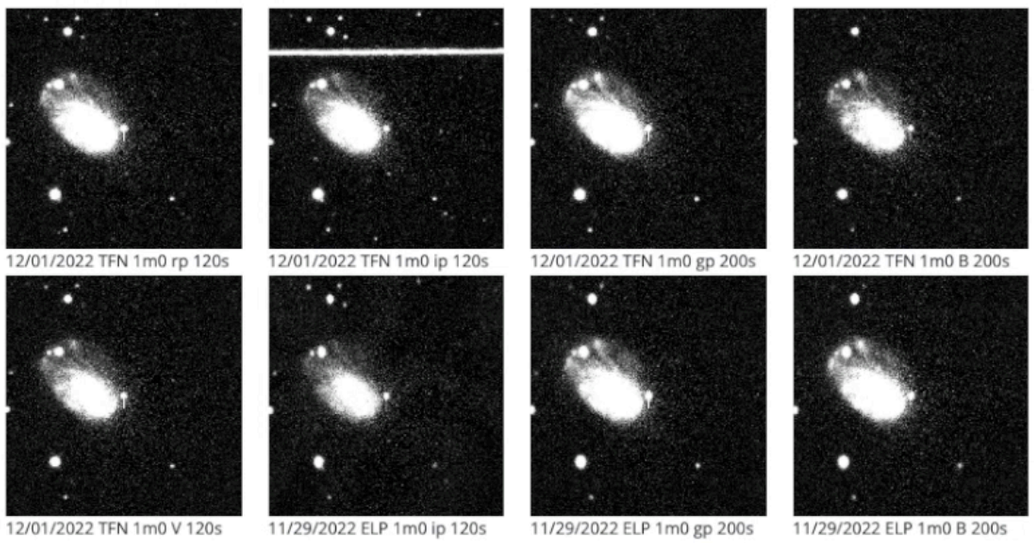
Latest Visibility at LCO



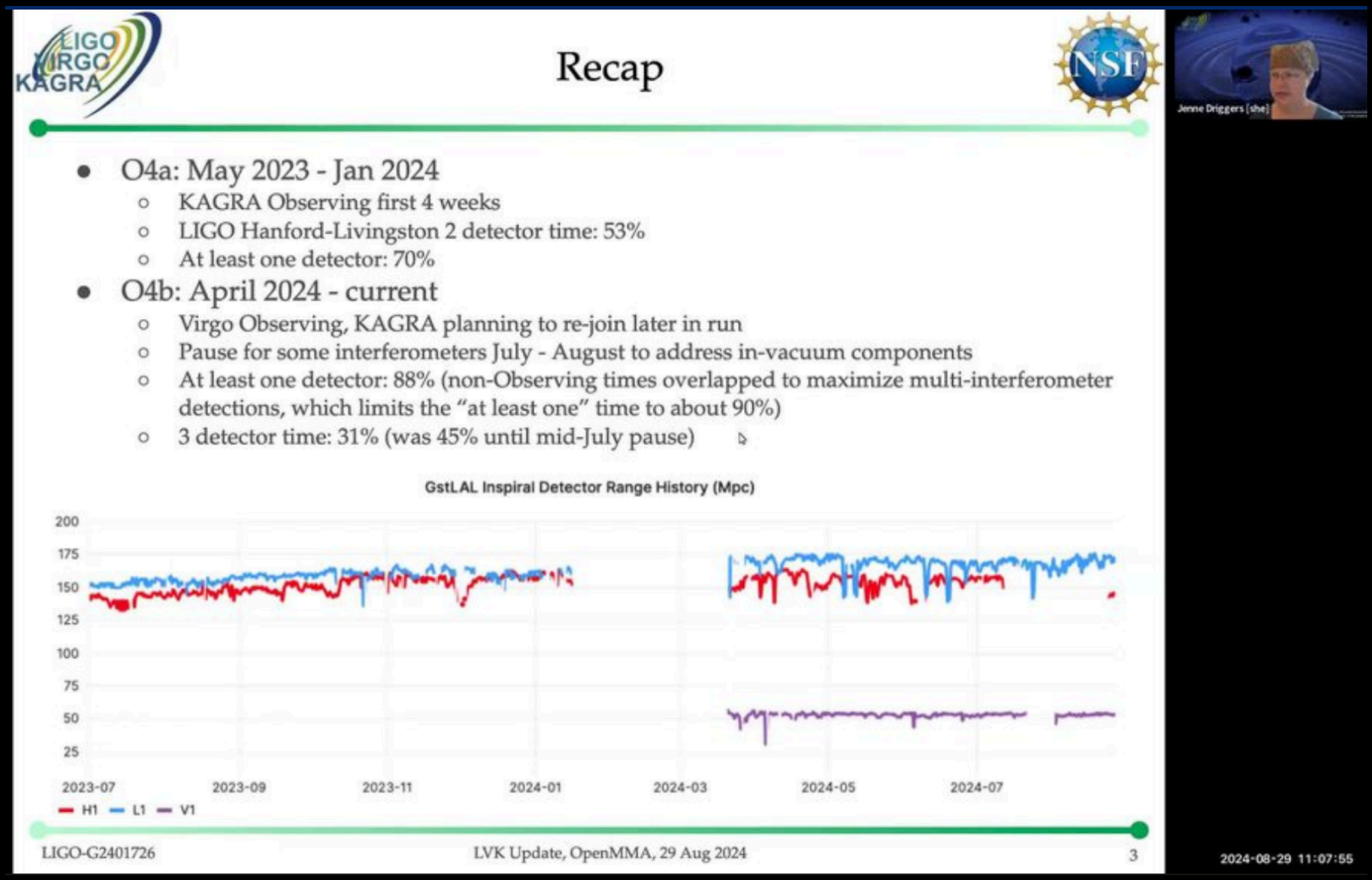
Aladin Viewer



Recent LCO Images

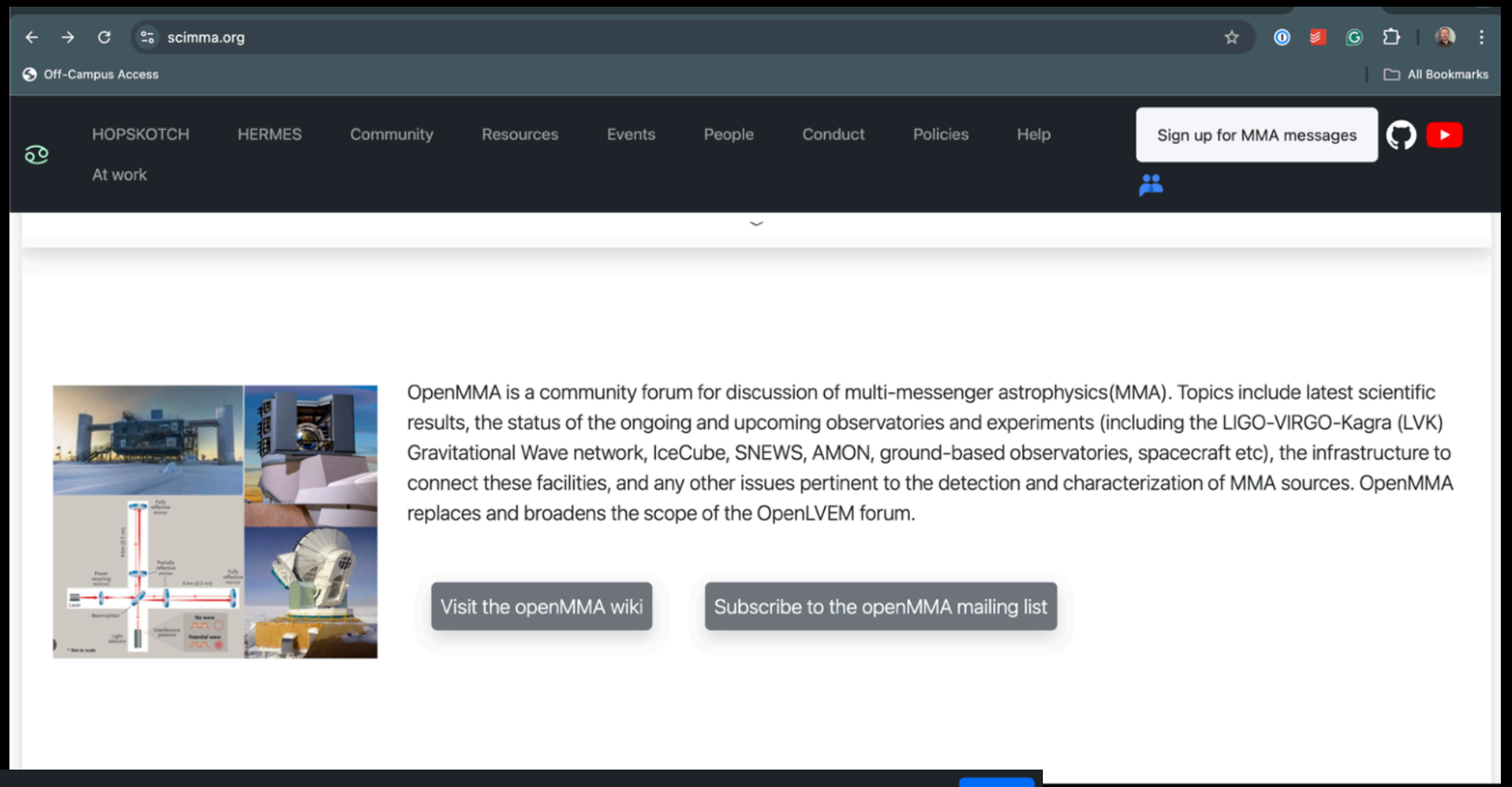


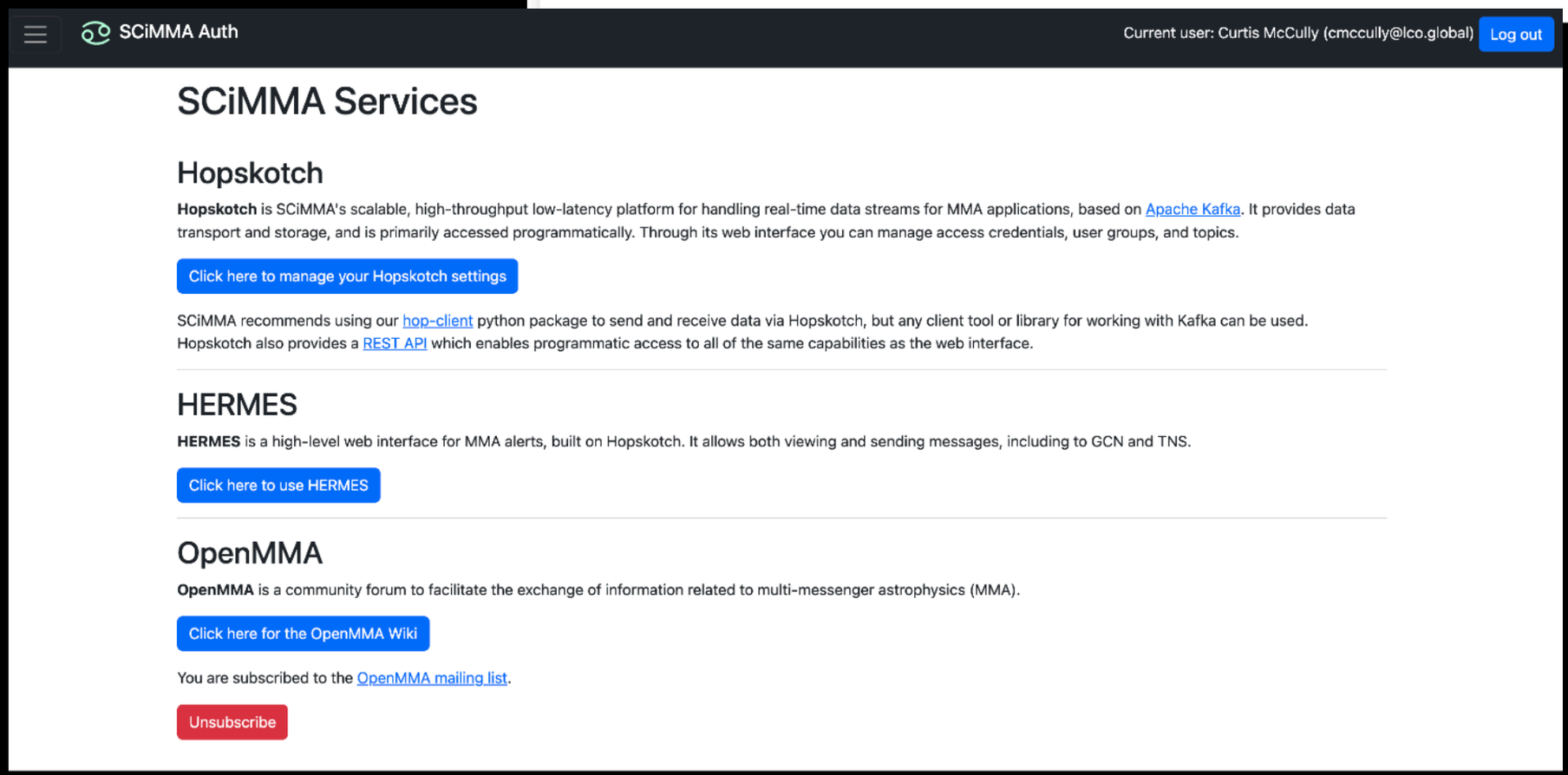
Human coordination is even more important than techonology.



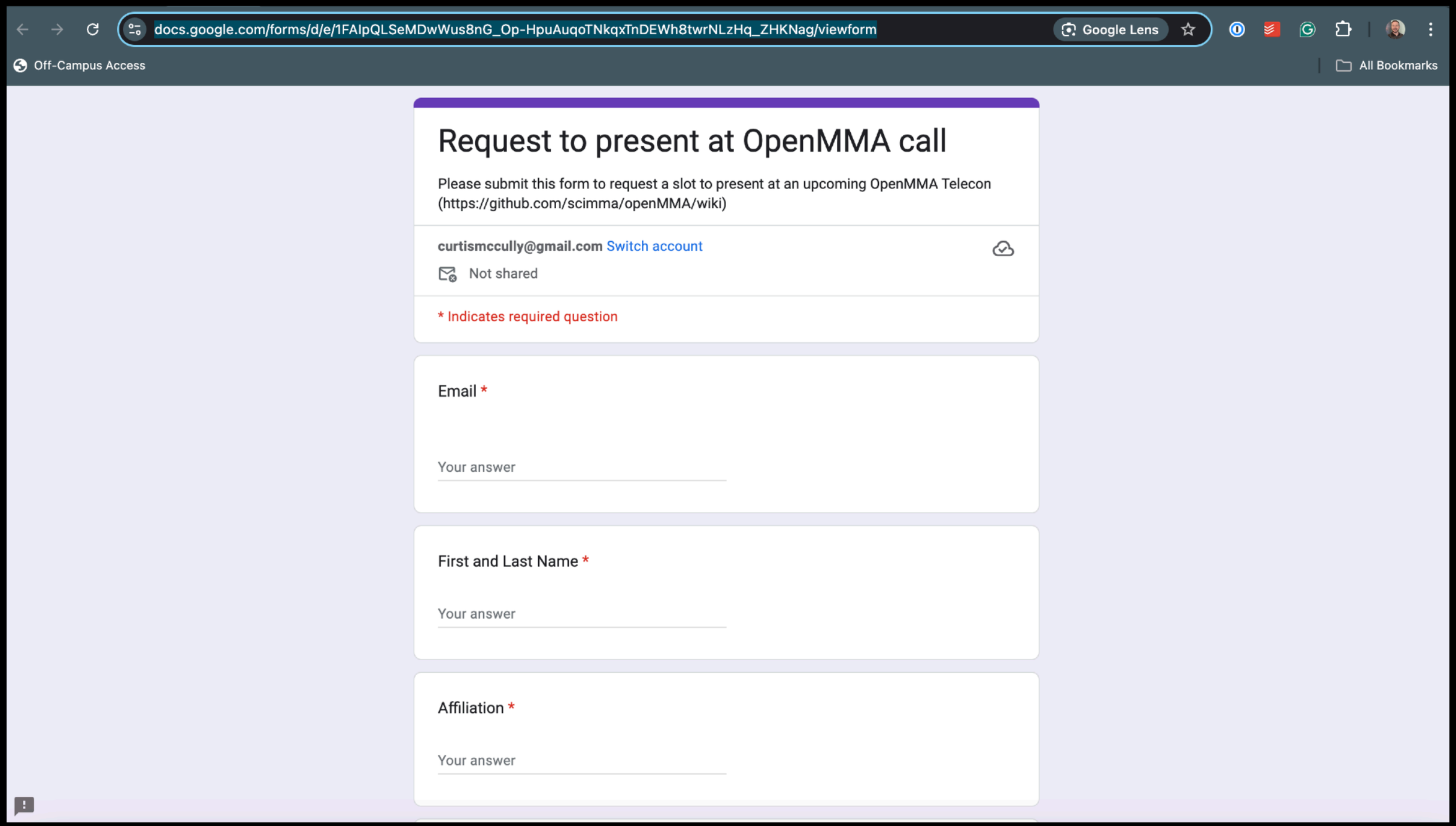
We have recently restarted the OpenMMA telecons.

Signup!

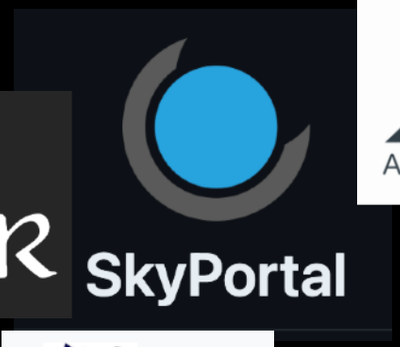

scimma.org
Off-Campus Access
All Bookmarks
HOPSKOTCH
HERMES
Community
Resources
Events
People
Conduct
Policies
Help
At work
Sign up for MMA messages
OpenMMA is a community forum for discussion of multi-messenger astrophysics(MMA). Topics include latest scientific results, the status of the ongoing and upcoming observatories and experiments (including the LIGO-VIRGO-Kagra (LVK) Gravitational Wave network, IceCube, SNEWS, AMON, ground-based observatories, spacecraft etc), the infrastructure to connect these facilities, and any other issues pertinent to the detection and characterization of MMA sources. OpenMMA replaces and broadens the scope of the OpenLVEM forum.
Visit the openMMA wiki
Subscribe to the openMMA mailing list

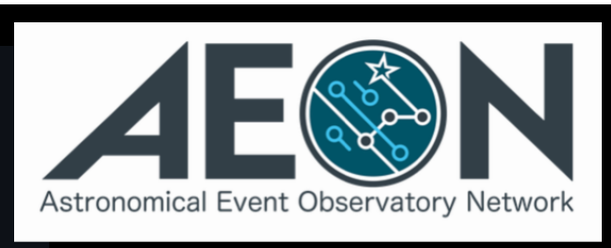

SCiMMA Auth
Current user: Curtis McCully (cmccully@lco.global)
Log out
SCiMMA Services
Hopskotch
Hopskotch is SCiMMA's scalable, high-throughput low-latency platform for handling real-time data streams for MMA applications, based on Apache Kafka. It provides data transport and storage, and is primarily accessed programmatically. Through its web interface you can manage access credentials, user groups, and topics.
Click here to manage your Hopskotch settings
SCiMMA recommends using our hop-client python package to send and receive data via Hopskotch, but any client tool or library for working with Kafka can be used. Hopskotch also provides a REST API which enables programmatic access to all of the same capabilities as the web interface.
HERMES
HERMES is a high-level web interface for MMA alerts, built on Hopskotch. It allows both viewing and sending messages, including to GCN and TNS.
Click here to use HERMES
OpenMMA
OpenMMA is a community forum to facilitate the exchange of information related to multi-messenger astrophysics (MMA).
Click here for the OpenMMA Wiki
You are subscribed to the OpenMMA mailing list.
Unsubscribe

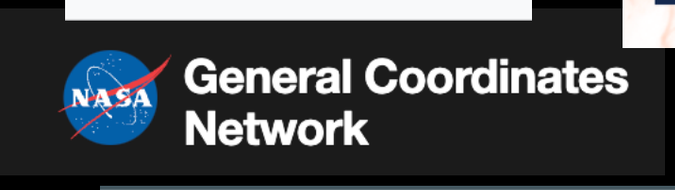
If you want to present at an OpenMMA telecon, fill out this web form



Conclusions







How do we lower the barrier to entry on these tools?

How do we increase adoption?

How do we integrate these tools seamlessly?