



# The Rubin Alert Stream and the ANTARES Event Broker

Tom Matheson, Abi Saha, Monika Soraisam,  
Nicolás Esquivel, Sebastián Vicencio, Chadd  
Myers, Teal (NOIRLab), Gautham Narayan (Illinois)

May 20, 2026

*Discovering Our Universe Together*



# Rubin Generating Alerts



## Changes detected in ONE Rubin image

~ 200

### Supernovae

Rubin will discover more exploding stars in its first few months than we've found in all of history.



~ 7200

### Variable Stars

Rubin can spot stars that change in brightness over timescales ranging from seconds to years.



~ 70

### Active Galactic Nuclei

Most large galaxies have central, supermassive black holes, but these special ones are actively ingesting material and/or varying in brightness.



?

### Other activity in space

Stars ripped apart in tidal disruption events?  
Explosions of light from colliding neutron stars?  
Rubin will capture all kinds of surprises!

~ 400

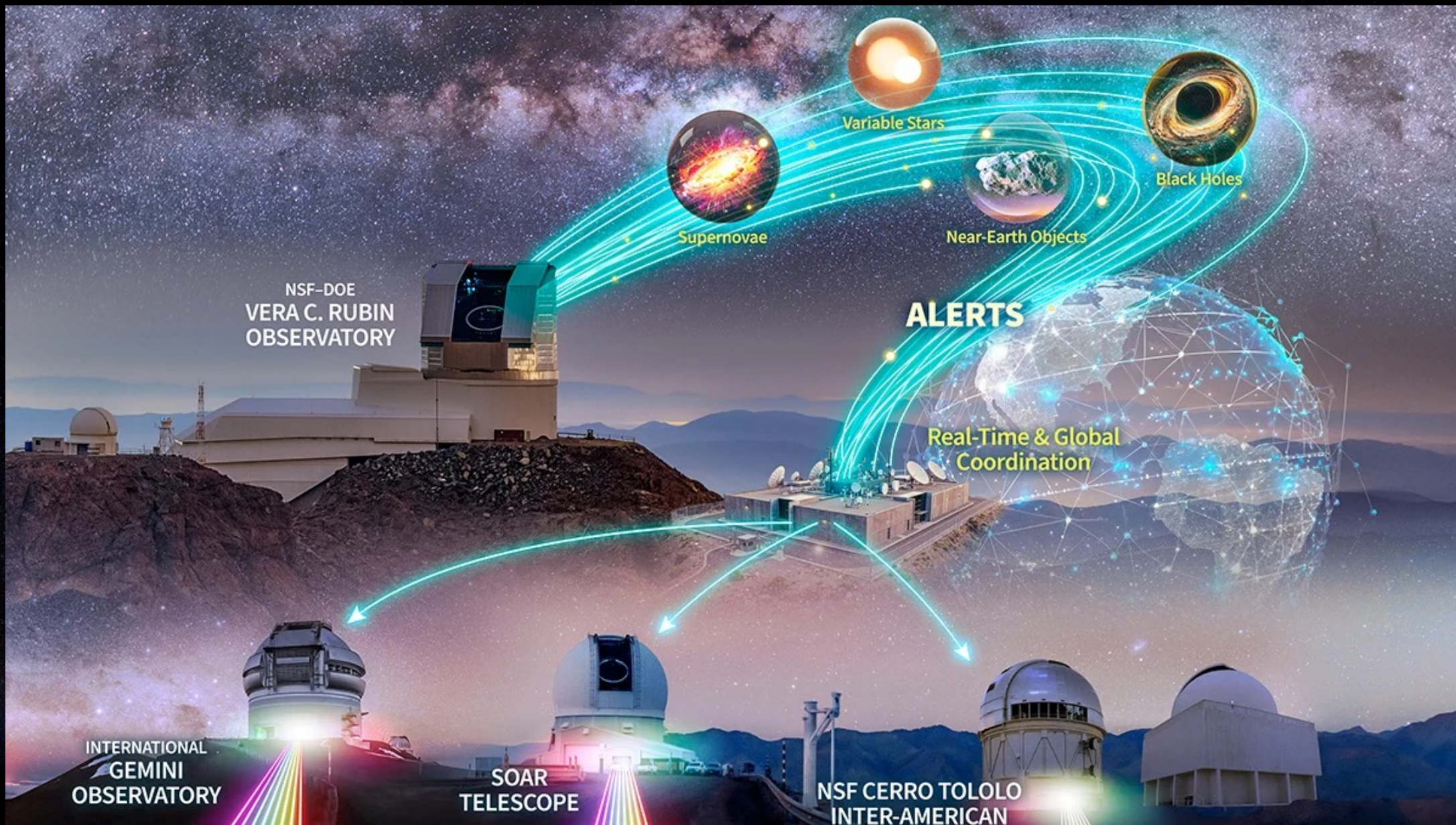
### Solar System Objects

... and some images could have 10<sup>x</sup> as many asteroids, comets, and more — depending on where we look.





# Rubin Generating Alerts





Goal is to  
generate alerts  
within 60  
seconds of  
shutter closing



Alerce



AMPEL



ANTARES



Babamul/  
BOOM



Fink



Lasair

Plus two  
downstream  
brokers:



SNAPS

POI/Variables





# NOIRLab's Comprehensive Time-Domain Ecosystem



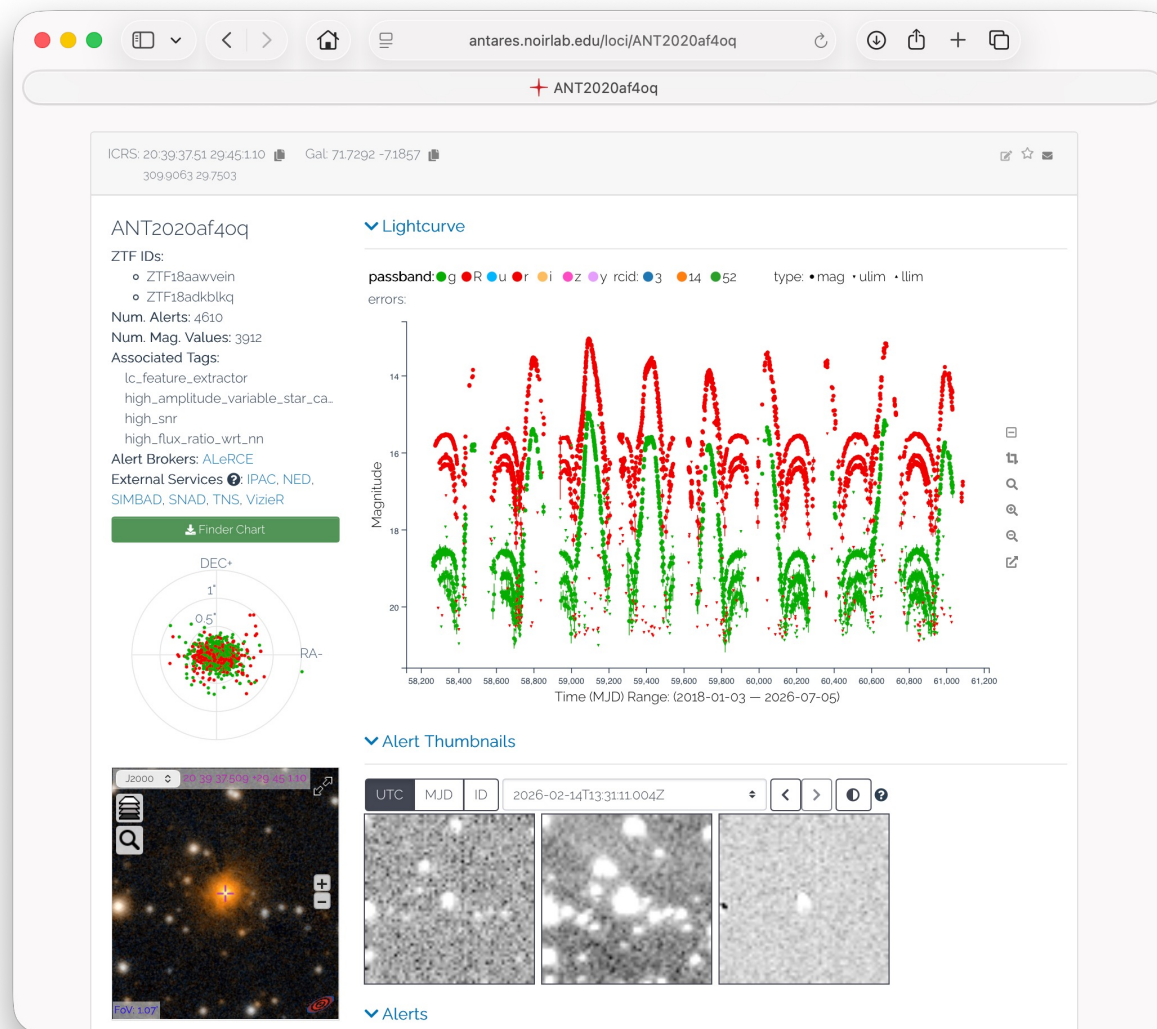
We're building an automated, end-to-end platform  
Users can focus on *science*, not process

Discovering Our Universe Together



# ANTARES Overview

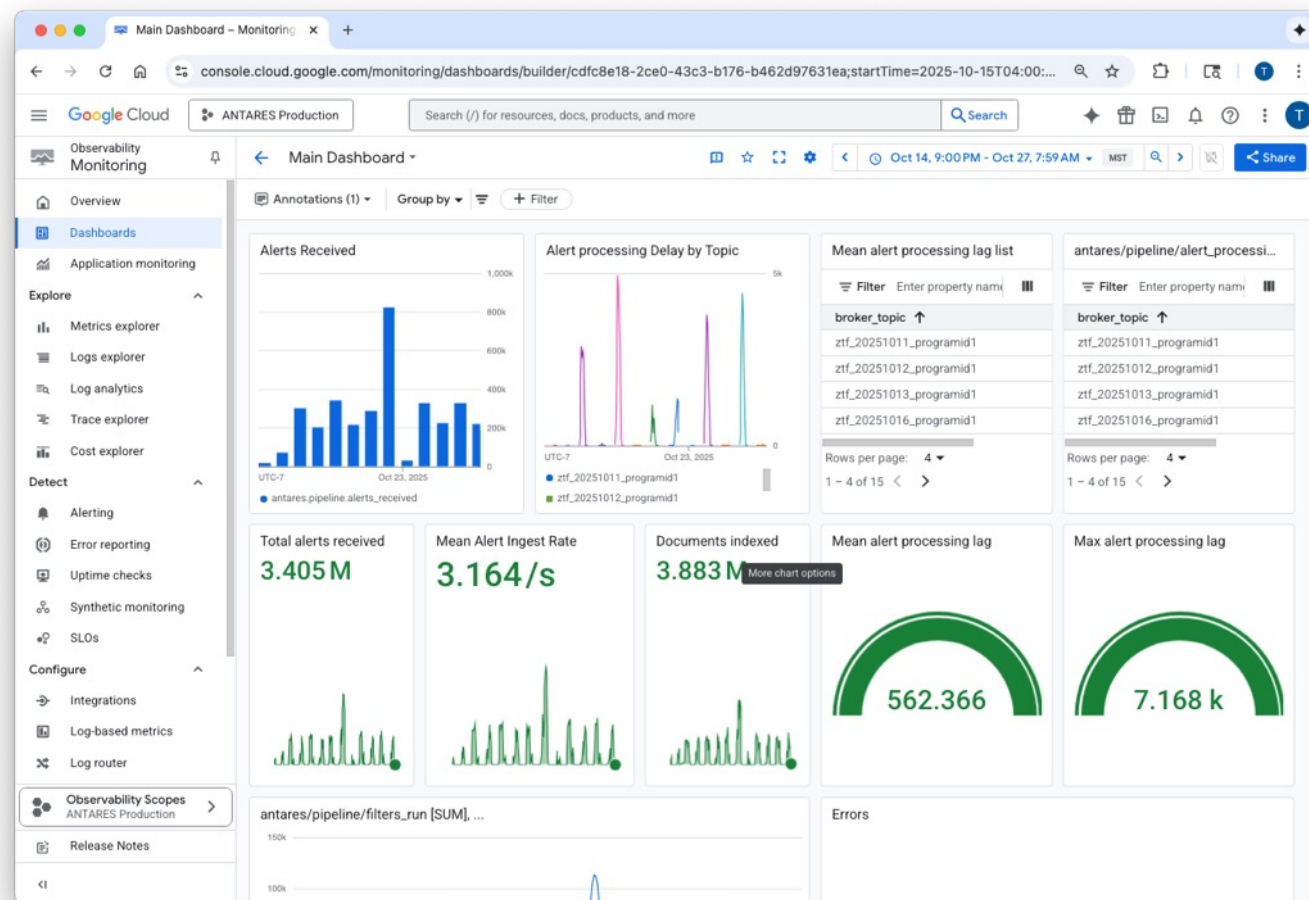
- Actively processing Rubin alert stream and Zwicky Transient Facility public stream
- Both streams together
- Fulfilling Rubin internal “alert filtering service” — Rubin Community Science Team developing filters
- Archive of alerts
- Web portal or programmatic (API) access
- ‘Instrument’ paper: Matheson et al. 2021 ([astroph/2011.12385](https://arxiv.org/abs/2011.12385))





# ANTARES Overview

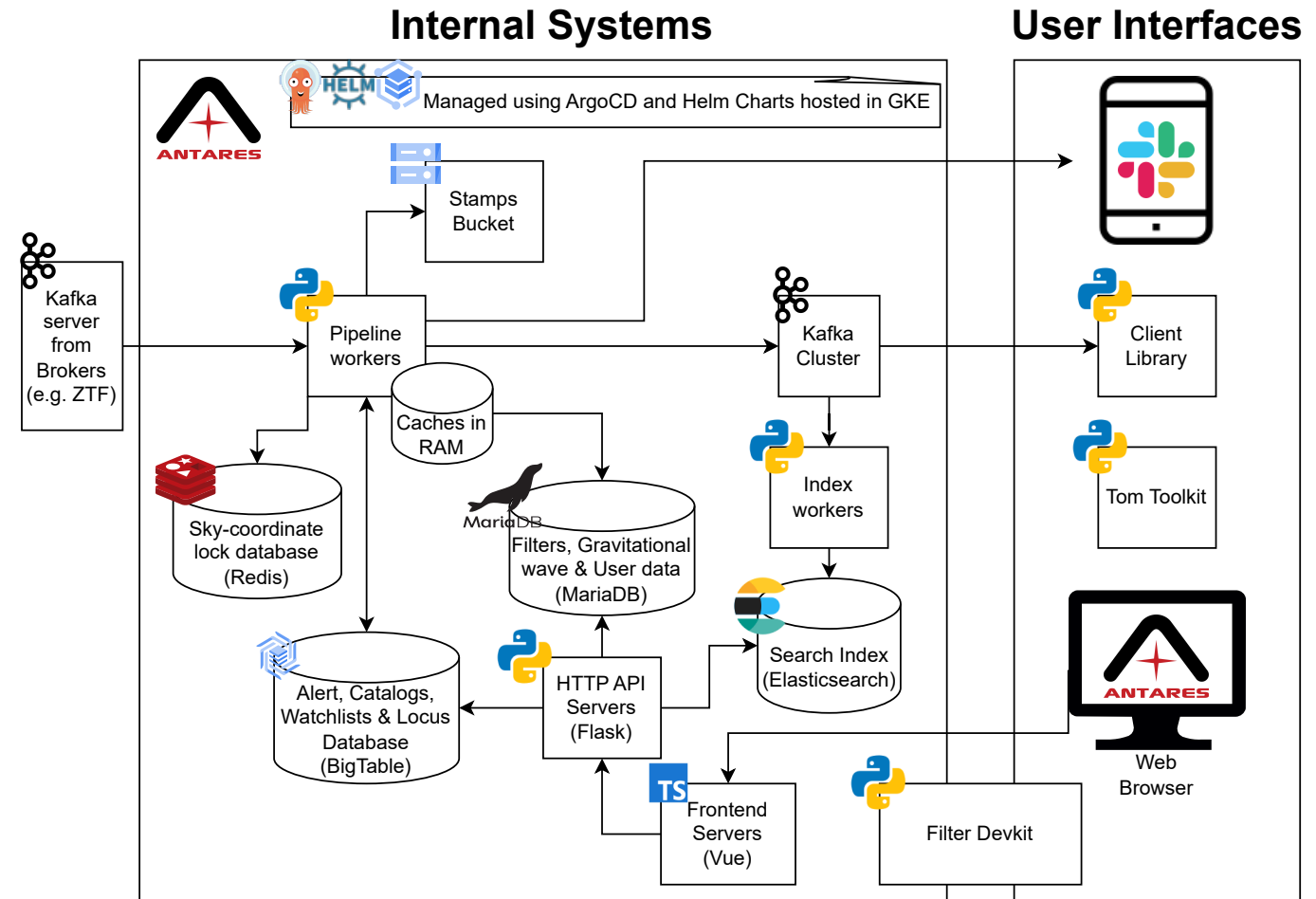
- Deployed on Google Cloud Platform (GCP)
- Flexibility of cloud hosting enabled testing at scale—confident technical solution can process LSST rate and volume





# ANTARES Technology

- Kubernetes-based deployment (containerized)
- Kafka streaming (ANTARES client provides a simple way to interact with Kafka streams to bring data to you)
- Google Bigtable and ElasticSearch database systems
- Provenance tracking
- Open source software



<https://gitlab.com/nsf-noirlab/csdc/antares/antares>



# ANTARES Overview

ANTARES adds value with contextual information from astronomical catalogs and past history

asasn\_variable\_catalog\_v2\_20190802

Allwise Id	Amplitude	Apass Bmag	Apass Drgid	Apass Gpmag	Apass Ipmag	Apass Rpmag	Apass Vmag
J220715.43+220318.4	0.4099999964237213		9797109	16.375999450683594		15.618000030517578	
J231450.37+022756.2	0.5199999809265137	17.042999267578125	17225150	16.63800048828125	15.906999588012695	15.967000007629395	16.2730007
J022302.72-694319.2	1.0700000524520874						
J121129.32-310229.8	0.8100000023841858	14.640000343322754	25992945	14.411999702453613	14.11299991607666	14.20199966430664	14.25199981
J140646.97-783022.9	0.36000001430511475	13.456999778747559	47402426	12.644000053405762		10.996999740600586	11.80700011

french\_post\_starburst\_gals

Dec	Htm20	Id	Original Id	Ra	Redshift
33.125999450683594	17205656294854	1	PSQ147750000043731808	0.004378799814730883	
31.721799850463867	17206062083406	10	PSQ146060000400316736	0.04000059887766838	
0.7523109912872314	17042607095303	100	SDSSspec123765719197090176	0.3763990104198456	0.10586299747228622
42.26169967651367	17183614090955	1000	PSP158710035622414624	3.5622599124908447	
30.48240089416504	17560168946606	10000	PSP144570308959599488	30.896099090576172	

galex

AVASPDEC	AVASPRA	BAND	CHKOBJ	TYPE	CORV	DECL	DIFFFUV	DIFFFUVDIST	DIFFNUV	DIFFNUVDIST	E BV	FEXPTIME	FOV
49.5928745438	189.9968427354	1	0	C		49.3693477801	0	0	0	0	0.0146059	245.1	0.54
33.0733646076	167.6477548096	1	0	C		33.2943029235	0	0	0	0	0.0326221	106.05	0.27
40.8010756766	170.472768146	1	0	C		40.5853719197	0	0	0	0	0.0137943	105	0.51
9.0793403162	178.9829363788	1	0	C		9.0454373897	0	0	0	0	0.0370091	119	0.14
42.7030416368	212.1535449264	1	0	C		42.7795495568	0	0	0	0	0.0129361	216	0.36

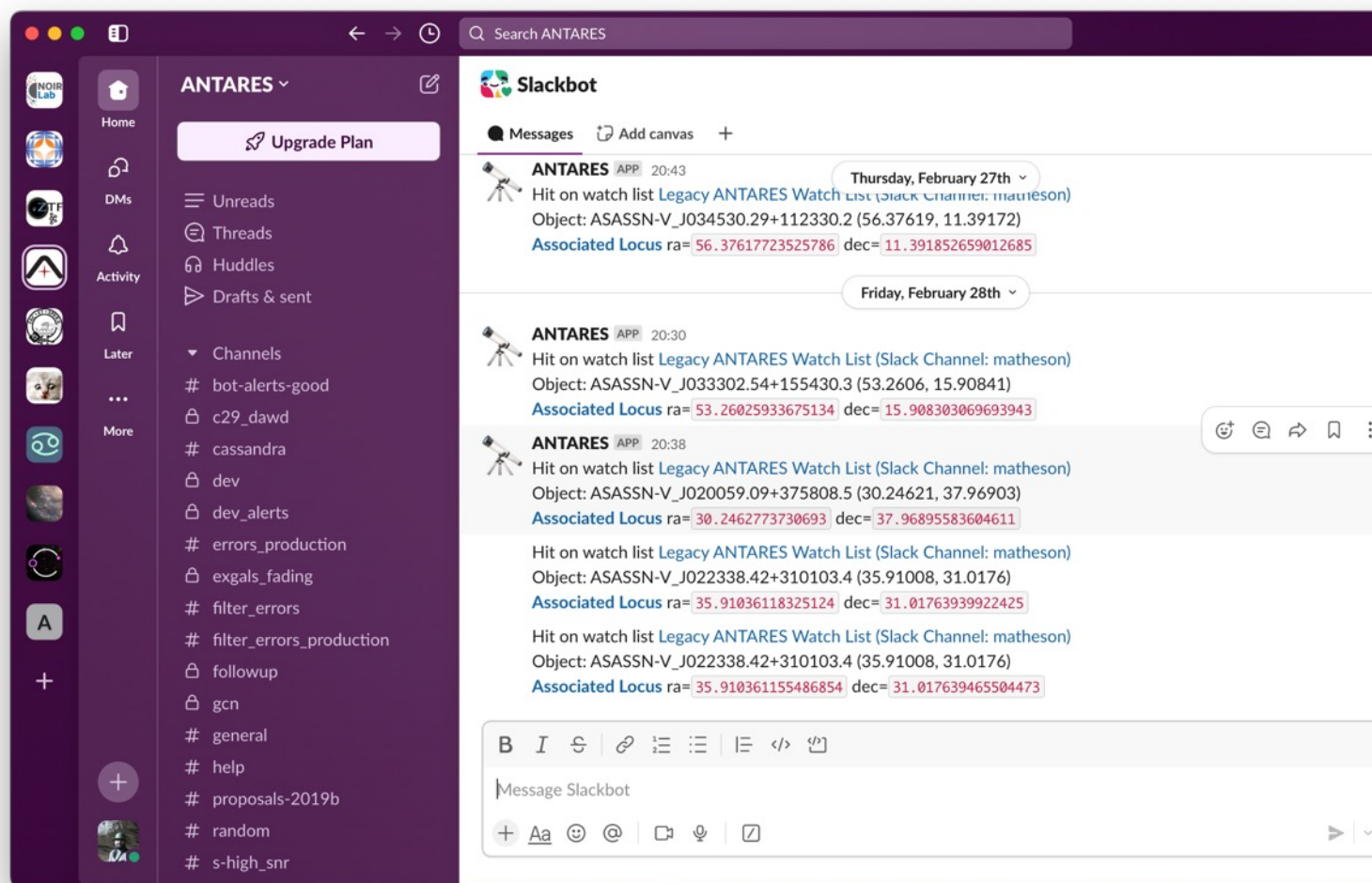
PS1StarGalaxyCatalog



# ANTARES Overview

Users can upload watch lists with direct notification via Slack of activity

For lists greater than ~1000, a catalog is a more efficient choice





# ANTARES Science



- Key science capability is filtering of alerts
- Filters are Python code that use features of alerts, from the survey or from our annotation
- Users can contribute filters; tagged alerts streamed directly to them
- Can be simple (brighter than 15th mag) to complex (machine-learning light-curve shape classifiers-e.g., LAISS, Superphot)
- Operated several classifiers for the ELASTICC challenge
- Multi-messenger alerts automatically generate tags for subsequent alerts

```
pythonProject -- m31.py
pythonProject -- m31.py
1 from astropy.coordinates import SkyCoord
2 import astropy.units as u
3
4
5 class InM31(dk.Filter):
6     NAME = 'in_m31' # for this default filter, name is same as its tag
7     ERROR_SLACK_CHANNEL = None
8
9     INPUT_LOCUS_PROPERTIES = [
10        'ztf_object_id',
11    ]
12
13    # bare absolute minimum alert properties proving it's good to go
14    INPUT_ALERT_PROPERTIES = [
15        'ztf_fid',
16        'ztf_magpsf',
17        'ztf_sigmapsf',
18        'ant_mjd',
19        'ant_survey'
20    ]
21
22    OUTPUT_TAGS = [
23        {
24            'name': 'in_m31',
25            'description': 'Locus is along the line of sight to M31',
26        }
27    ]
28
29    def run(self, locus):
30        if locus.alert.properties['ant_survey'] != 1: # be sure we don't work with upper limits
31            return
32
33        ra = locus.alert.properties['ant_ra']
34        dec = locus.alert.properties['ant_dec']
35
36        m31 = SkyCoord(18.6847083 * u.deg, 41.26875 * u.deg, frame='icrs')
37
38        c = SkyCoord(ra * u.deg, dec * u.deg, frame='icrs')
39
40        sep = c.separation(m31)
41
42        alert_id = locus.alert.alert_id # current alert_id
43        ztf_object_id = locus.properties['ztf_object_id'] # ZTF Object ID
44
45        if sep.deg < 2.0:
46            # print(alert_id, ztf_object_id)
47            locus.tag('in_m31')
```



# ANTARES Science



- If you can write your algorithm, we can implement it now
- Filters are stored on GitLab, you control access and versioning
- Filter development environment on NOIRLab's Data Lab or on your own machine with the ANTARES devkit, <https://gitlab.com/nsf-noirlab/csdc/antares/devkit>
- General instructions, <https://nsf-noirlab.gitlab.io/csdc/antares/devkit/learn/>

```
[1]: import antares.devkit as dk
dk.init()

Loading ANTARES from /data0/sw/antares-kernel-0.4/lib/python3.7/site-packages/ANTARES-1.9.0-py3.7.egg/antares/_init_.py

ANTARES v1.9.0

Connecting to MySQL server...
Connecting to Cassandra cluster...
Testing loading a random Locus with 'dk.get_locus()'...

ANTARES v1.9.0 DevKit is ready!
Website: http://antares.noirlab.edu
Documentation: http://noao.gitlab.io/antares/filter-documentation/

[5]: import numpy as np
[6]: ld.properties
[6]: PropertiesDict({'ztf_object_id': 'ZTF20aarbqwn', 'num_alerts': 14, 'num_mag_values': 1, 'newest_alert_id': 'ztf_candidate:1151122390515015008', 'brightest_alert_id': 'ztf_candidate:1151122390515015008', 'brightest_alert_magnitude': 19.775651931762695, 'brightest_alert_observation_time': 58905.12239579996, 'newest_alert_magnitude': 19.775651931762695, 'newest_alert_observation_time': 58905.12239579996, 'oldest_alert_id': 'ztf_candidate:1151122390515015008', 'oldest_alert_magnitude': 19.775651931762695, 'oldest_alert_observation_time': 58905.12239579996})

[7]: #np.ma.is_masked(ld.lightcurve["ant_mag_corrected"][-1])
t = ld.lightcurve["ant_mag_corrected"][-1]
np.ma.is_masked(t)

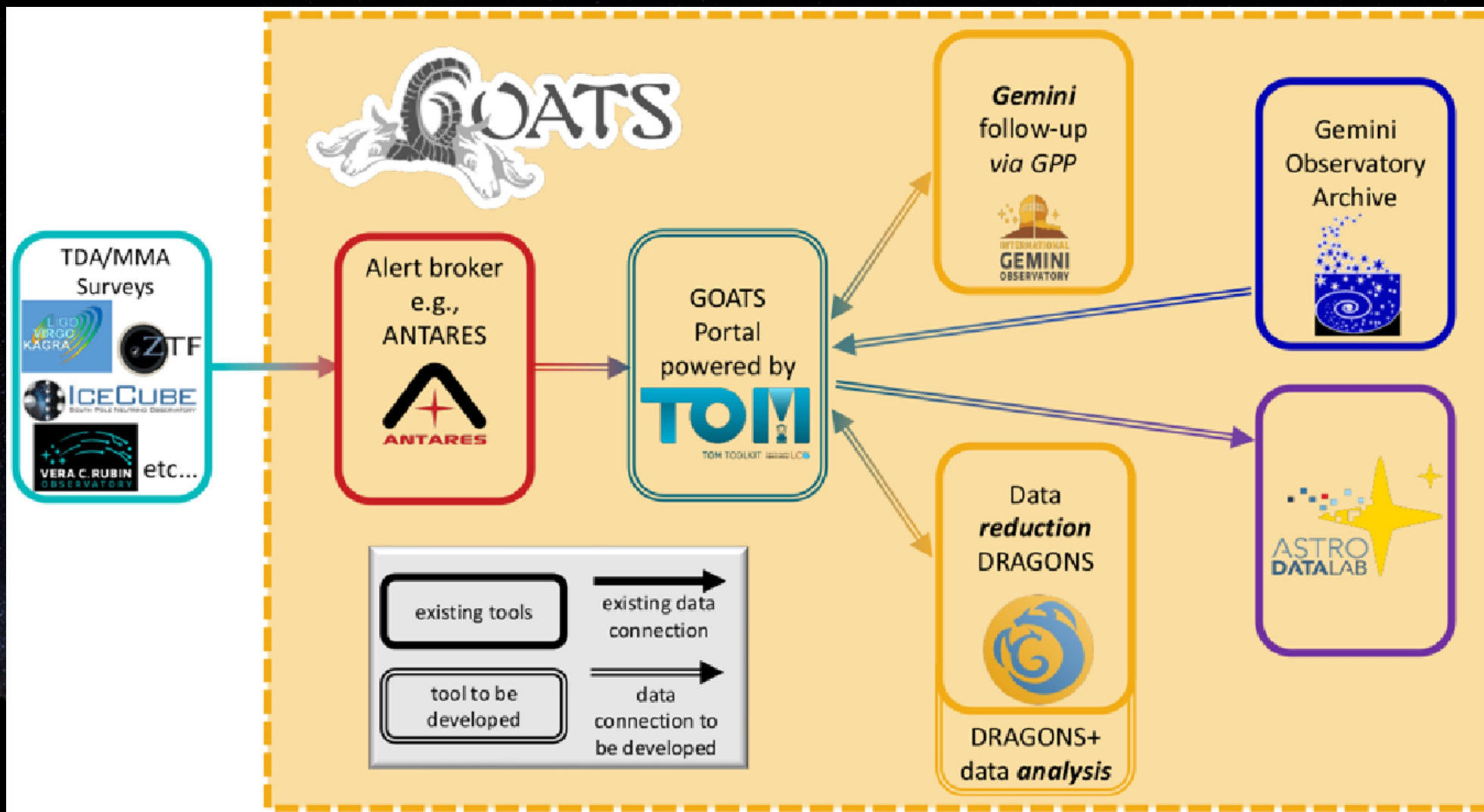
[7]: True
```



- Gemini Observation and Analysis of Targets System
- A Target and Observation Manager (TOM) specifically for interaction with NOIRLab tools and services
- Based on Las Cumbres TOM Toolkit
- TOM functionality (collaboration, observation triggering) as well as incorporation of data reduction tools



# Time-Domain Ecosystem





- Astronomical Event Observation Network
- Telescopes joined by a common set of standards for accessibility in triggering time-domain observations
- Programmable interfaces
- Includes Gemini, SOAR, Blanco (NEWFIRM now, DECam soon), Las Cumbres
- Rubin in-kind contributions
- time

# End to End Test with Rubin Alerts



Full test of the the entire NOIRLab time-domain system from alert generation through reduced data. All elements worked without any issues. Software systems can scale.

**ANT2026qtlk3I54sfqa**

Details

Names	ANT2026qtlk3I54sfqa
	314051320305156133
Target Type	SIDEREAL
Permissions	PRIVATE
Right Ascension	60.377671715
	04:01:30.641
Declination	-48.82199404
	-48:49:19.18
Broker	<a href="#">ANTARES</a>

Recent Photometry

Timestamp	Magnitude
No recent photometry.	

Survey View

J2000

Observe Observations Manage Data Manage Groups Photometry Spectroscopy

Select and Plot Data Products

Use the table below to select data products. Note that FITS and CSV files are supported. See [Manage Data](#) for an example of the format. Click the **Plot** button to add the selected data product to the plot.

Click to enter Plot title

Click to enter Plot subtitle

Flux (adu)

Wavelength (Angstrom)

Click on labels to edit text, and click directly on the end values of the x and y axes to adjust their ranges.

Type to filter file names...

Spectra from Gemini and SOAR are reduced using NOIRLab pipelines

18 objects across multiple observatories and instruments

# NOIRLab's Comprehensive Time-Domain Ecosystem

Working now, try it for yourself

