ANTARES and ZTF

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https://antares.noirlab.edu/

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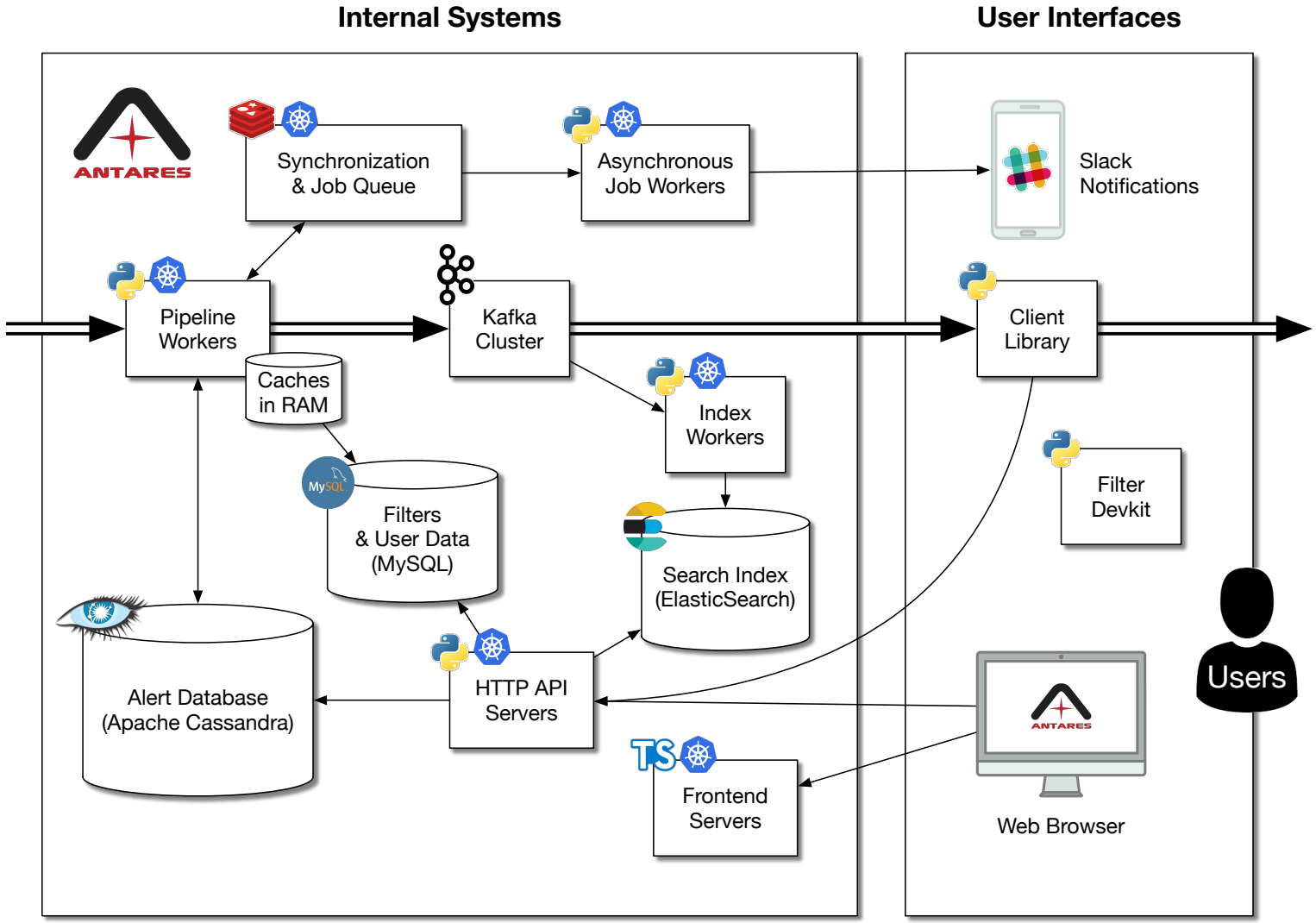
Discovering Our Universe Together

ANTARES V1.0 Overview

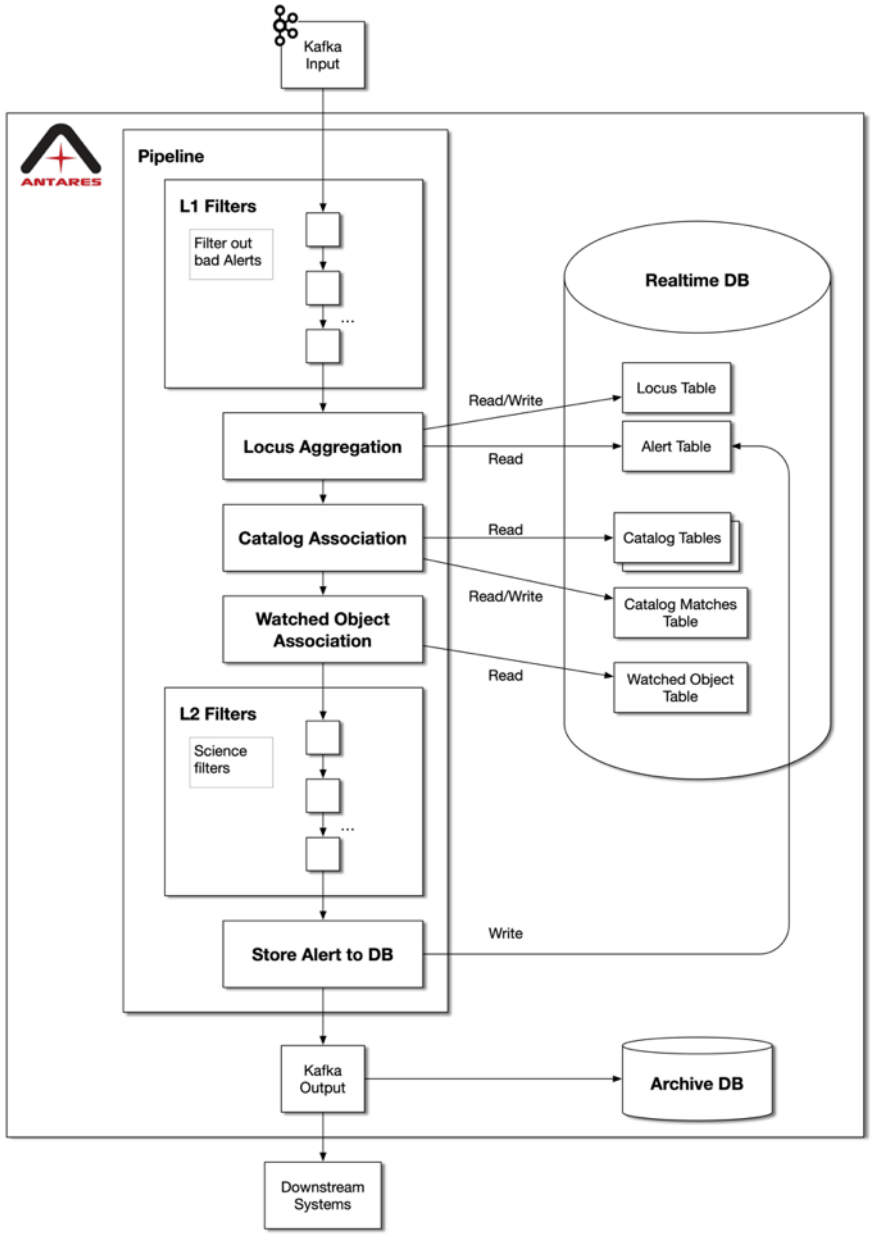
- Enabling broad scientific use of time-domain alerts
  - Process full LSST stream
  - Generic time-domain platform, community driven
  - If you can turn your algorithm into a filter, we'll implement it*
- Real-time alert processing (minutes)
- No user restrictions (SAC to determine resource conflicts, if any)
- Actively processing ZTF public alerts
  - https://antares.noirlab.edu/
  - Documentation/tutorials

ANTARES Features

- Kubernetes-based deployment
- Kafka streaming
- Cassandra and ElasticSearch database systems
- Provenance tracking

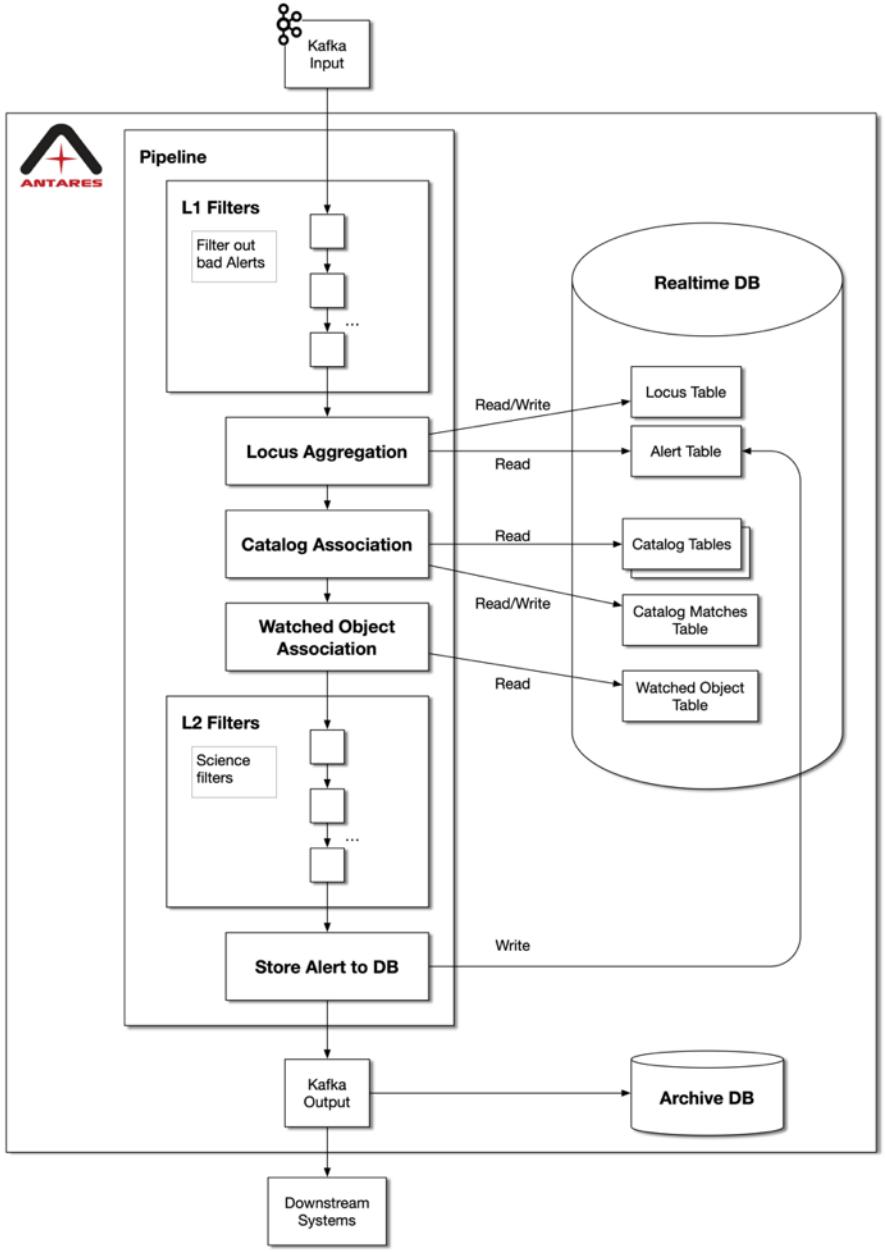


ANTARES Features



- Annotation from catalogs
- Filtering of alerts
- Searchable archive of alerts
- Watch lists
- Web portal displays streams, filters, light curve, thumbnails, pipeline, associations, finder charts

ANTARES Filters



- Near Known Extragalactic objects
- Bright or high significance
- In M31
- Nuclear transient
- Known Solar System objects
- Near potential tidal disruption hosts (contributed catalog)
- Gravitational wave counterparts
- AstroRAPID

ANTARES Data Products

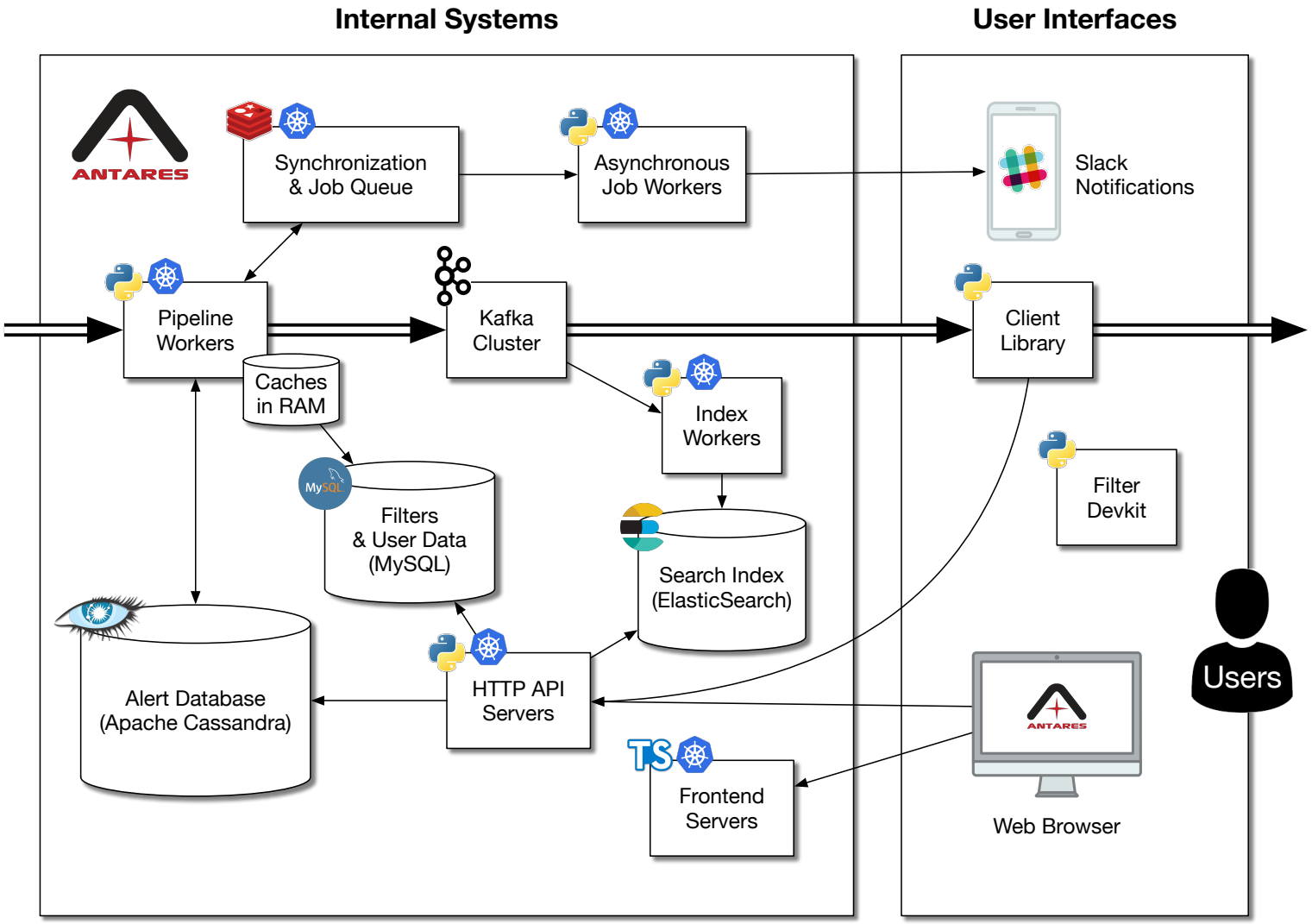
```python
class HighSNR(dk.Filter):
    NAME = "High SNR"
    ERROR_SLACK_CHANNEL = ""  # Put your Slack user ID here
    REQUIRED_LOCUS_PROPERTIES = [
        'ztf_object_id',
    ]
    REQUIRED_ALERT_PROPERTIES = [
        'passband',
        'ztf_sigmapsf',
    ]
    OUTPUT_LOCUS_PROPERTIES = []
    OUTPUT_ALERT_PROPERTIES = []
    OUTPUT_TAGS = [
        {
            'name': 'high_snr',
            'description': 'Locus has one or more Alerts with high SNR.',
        },
    ]

    def run(self, locus):
        """
        If this Alert has a high SNR, then tag the Locus "high_snr".
        """
        # The threshold is dependent on the band that is being imaged.
        # These thresholds should flag ~2-3% of alerts.
        snr_threshold = {
            'g': 50.0,
            'R': 55.0,
        }
        passband = locus.alert.properties['ant_passband']
        if passband not in snr_threshold:
            print(f'passband {passband} is not supported by this filter.')
            return  # Do nothing.
        threshold = snr_threshold[passband]
        sigmapsf = locus.alert.properties['ztf_sigmapsf']  # Get the ZTF Alert property
        alert_snr = 1.0 / sigmapsf
        alert_id = locus.alert.alert_id  # Get the ANTARES alert_id
        ztf_object_id = locus.properties['ztf_object_id']  # Get the ZTF Object ID
        print(f'Alert {alert_id}')
        print(f'Object {ztf_object_id}')
        print(f'snr = {alert_snr}')
        if alert_snr > threshold:
            print('High SNR detected')
            locus.tag('high_snr')
```

- Annotated alerts
  - Feature calculation
  - External catalogs (e.g., catsHTM)
- Filtered alerts
  - All features including annotations
  - Can be user designed, Jupyter-based dev kit on Astro Data Lab

ANTARES Outputs

- Output three ways
  - Web portal (API as well)
  - Slack Channel (antares-noao.slack.com)
  - Kafka streams (Python API)
- Archive
  - Longer timescale analysis



ANTARES Science

147 ANTARES-flagged SN candidates confirmed in TNS (40% early) from Aug 2019 to Mar 2020

Many dwarf novae and novae

First R Cor Bor star from public ZTF survey, Lee et al. 2020

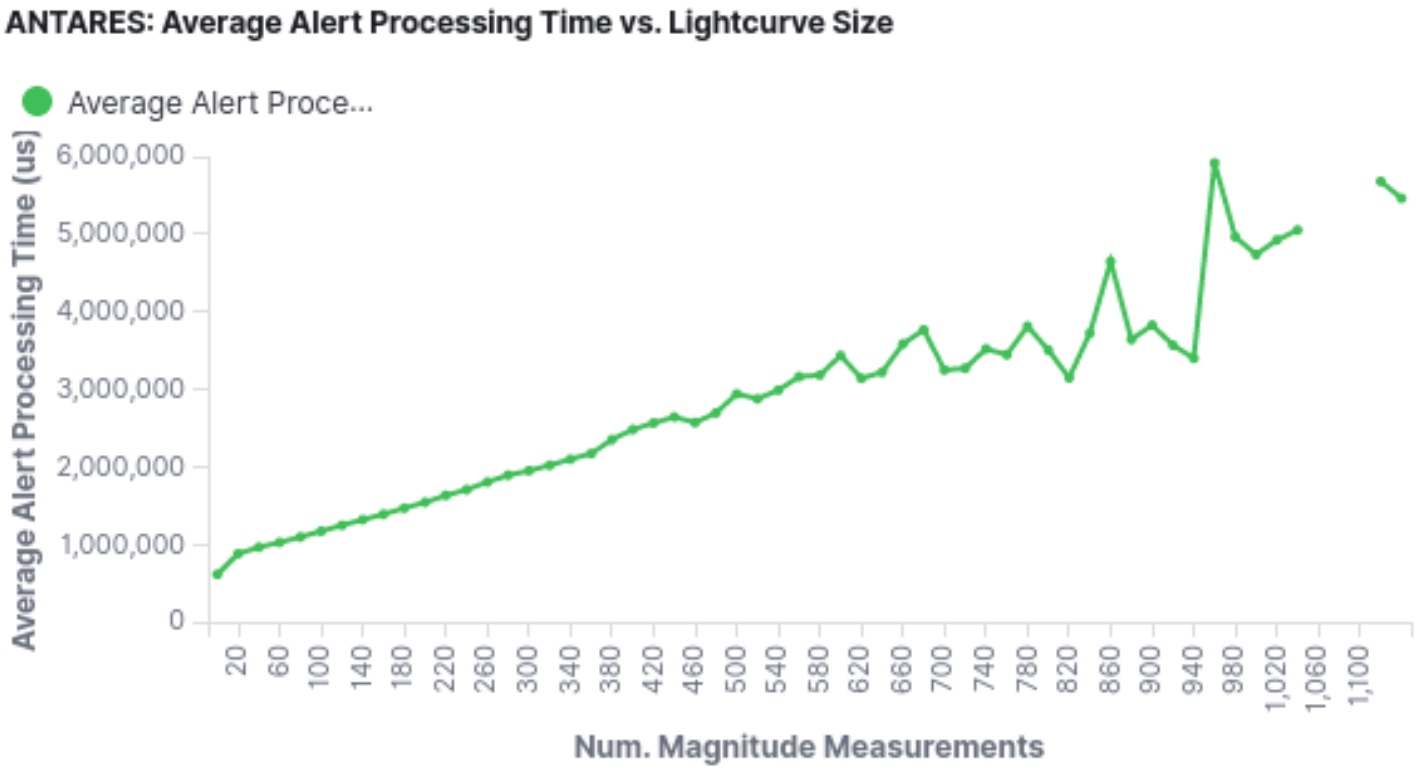
Anomaly detection in Galactic Bulge, Soraisam et al. 2020

WZ Sge dwarf nova, Soraisam et al. in press

Table 1. Summary of ATels by ANTARES team and collaborations

ATel#	Name	Classification	Report date	Facilities
12935	ZTF19aazcxwk	SN Ia	07/12/2019	LCO 2m telescope
12943	ZTF19abfqlzi	M31 recurrent nova	07/15/2019	Gemini telescope
12946	ZTF19abdooly	dwarf nova	07/18/2019	LCO 2m telescope
12980	ZTF19abgsssu	dwarf nova	08/02/2019	Shane 3m Telescope, Lick Observatory
13053	ZTF19abpmetl	SN Ia	08/30/2019	Shane 3m Telescope, Lick Observatory
13055	ZTF19abraqpf	dwarf nova	08/30/2019	Shane 3m Telescope, Lick Observatory
	ZTF19abqstxq	dwarf nova	08/30/2019	Shane 3m Telescope, Lick Observatory
13115	ZTF19abtuflm	SN II	09/18/2019	Shane 3m Telescope, Lick Observatory
13119	ZTF19abpvysx	SN Ia	09/21/2019	Shane 3m Telescope, Lick Observatory
	ZTF19abrelog	SN Ia-91T	09/21/2019	Shane 3m Telescope, Lick Observatory
	ZTF19abulrfa	SN IIP	09/21/2019	Shane 3m Telescope, Lick Observatory
13141	M31N2019-09b	M31 nova	09/28/2019	Gemini telescope
13149	ZTF19abyukuy	Galactic nova	10/01/2019	Shane 3m Telescope, Lick Observatory
13153	ZTF19abxnerq	M31 nova	10/01/2019	Gemini telescope
13178	ZTF19abzpkss	dwarf nova	10/09/2019	Shane 3m Telescope, Lick Observatory
13183	ZTF19abydbvw	dwarf nova	10/11/2019	Shane 3m Telescope, Lick Observatory
13200	ZTF19acbwmqd	SN IIP	10/18/2019	Shane 3m Telescope, Lick Observatory
13210	ZTF19acbzgog	M31 nova	10/21/2019	Gemini telescope
13231	ZTF19acfsteg	M31 nova	10/28/2019	Gemini telescope
13261	AT2019tsc	M31 nova	11/04/2019	Gemini telescope
13286	ZTF19acmdpyr	SN Ia	11/12/2019	Shane 3m telescope, Lick Observatory
	ZTF19acklbjr	SN Ia	11/12/2019	Shane 3m telescope, Lick Observatory
13317	ZTF19acnfsij	M31 nova	11/28/2019	Shane 3m telescope, Lick Observatory
13358	ZTF19acxrihd	M31 nova	12/19/2019	Gemini telescope
13362	ZTF19acqprad	M31 nova	12/21/2019	Shane 3m telescope, Lick Observatory
13399	ZTF20aabbimu	dwarf nova	01/11/2020	Shane 3m telescope, Lick Observatory
13406	ZTF19acoqctv	SN IIP	01/15/2020	Shane 3m telescope, Lick Observatory
13430	ZTF20aakdppm	M31 nova	01/30/2020	Gemini telescope
13527	ZTF20aahpagw	SN IIn	02/27/2020	Shane 3m telescope, Lick Observatory
13570	ZTF19actabny	SN IIn	03/20/2020	Shane 3m telescope, Lick Observatory
13706	ZTF20aawbodq	Anomalous	05/03/2020	Anomaly filter by Soraisam et al. (2020)

ANTARES Path to LSST



Load tested the system on Google Cloud Platform using ZTF alerts

Plenty of database and pipeline optimization to be done

Current, on-premise system can process 5.5 million alerts in 24 hours

The ANTARES technical solution can scale to LSST rate and volume

Collaborating with other brokers and science teams

https://antares.noirlab.edu