



| NSF's National Optical-Infrared
Astronomy Research Laboratory



Time-Domain Discovery in the 2020s

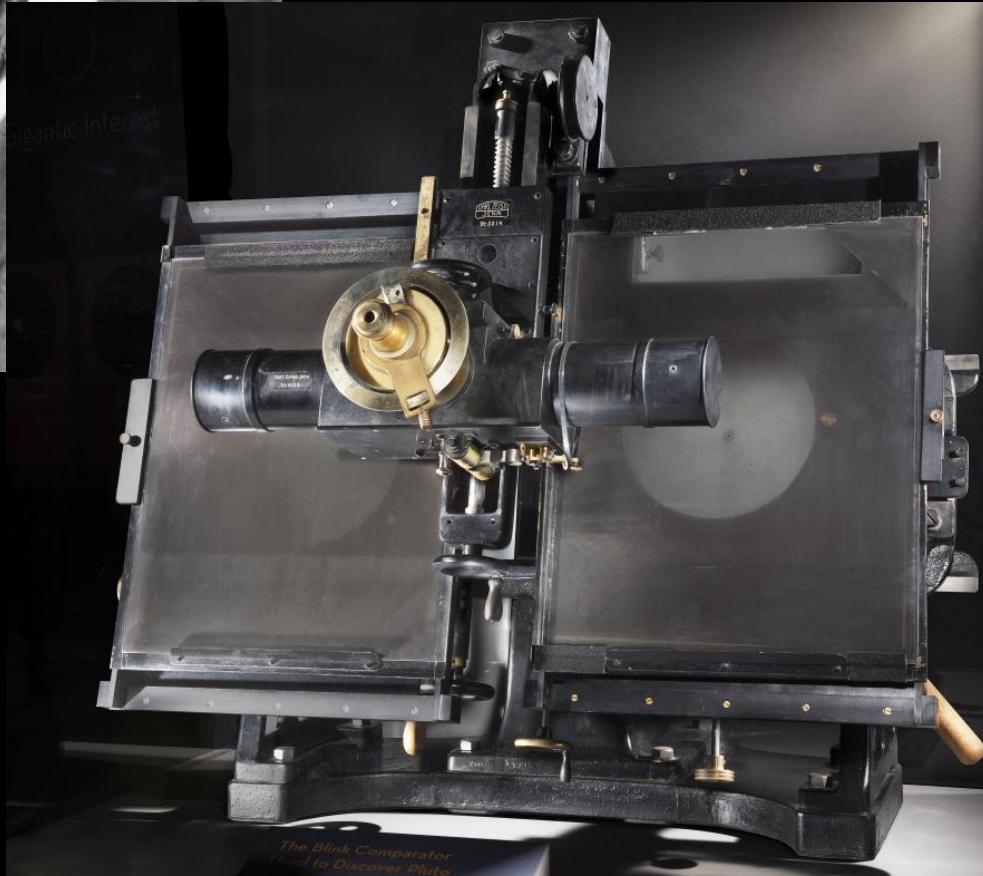
Tom Matheson

Abi Saha, Gautham Narayan, Monika Soraisam, Chien-Hsiu Lee, Carl Stubens, Nic Wolf, Pete Peterson, Adam Scott, Steve Ridgway, Rick Snodgrass, Carlos Scheidegger, John Kececioglu



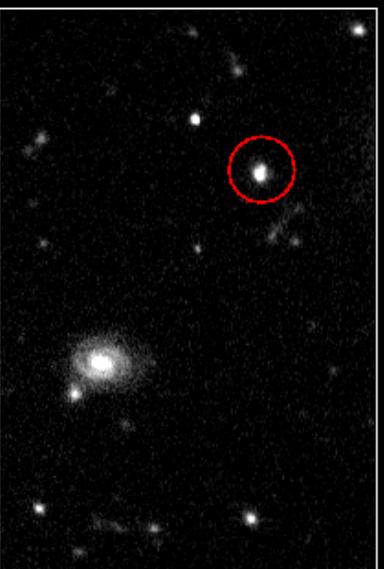
Clyde Tombaugh

Blink Comparator



Digital image subtraction
and large-format CCD
cameras have turned
detection of time-variable
astronomical objects into a
high-volume, automated
process

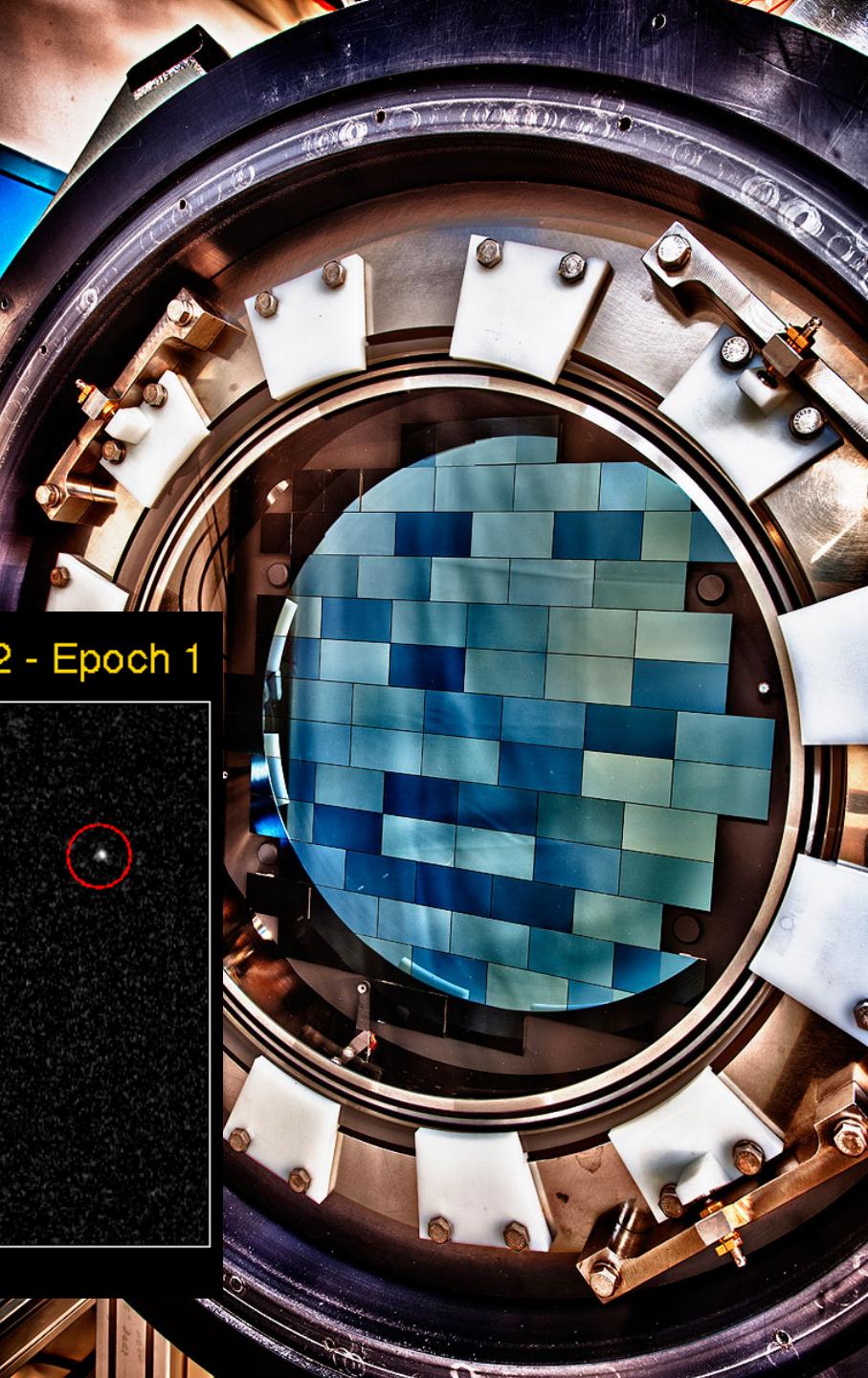
Epoch 1



Epoch 2



Epoch 2 - Epoch 1



LOSS



CSS/CRTS



PTF/iPTF/ZTF



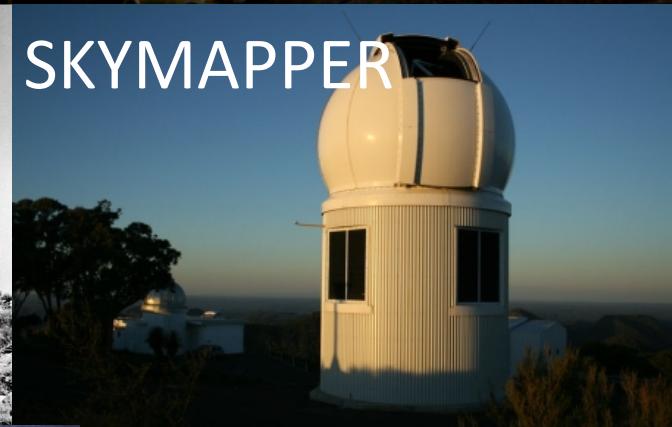
PAN STARRS



LA SILLA QUEST



SKYMAPPER



ASSASN



GAIA



EVRYSCOPE



Large Synoptic Survey Telescope



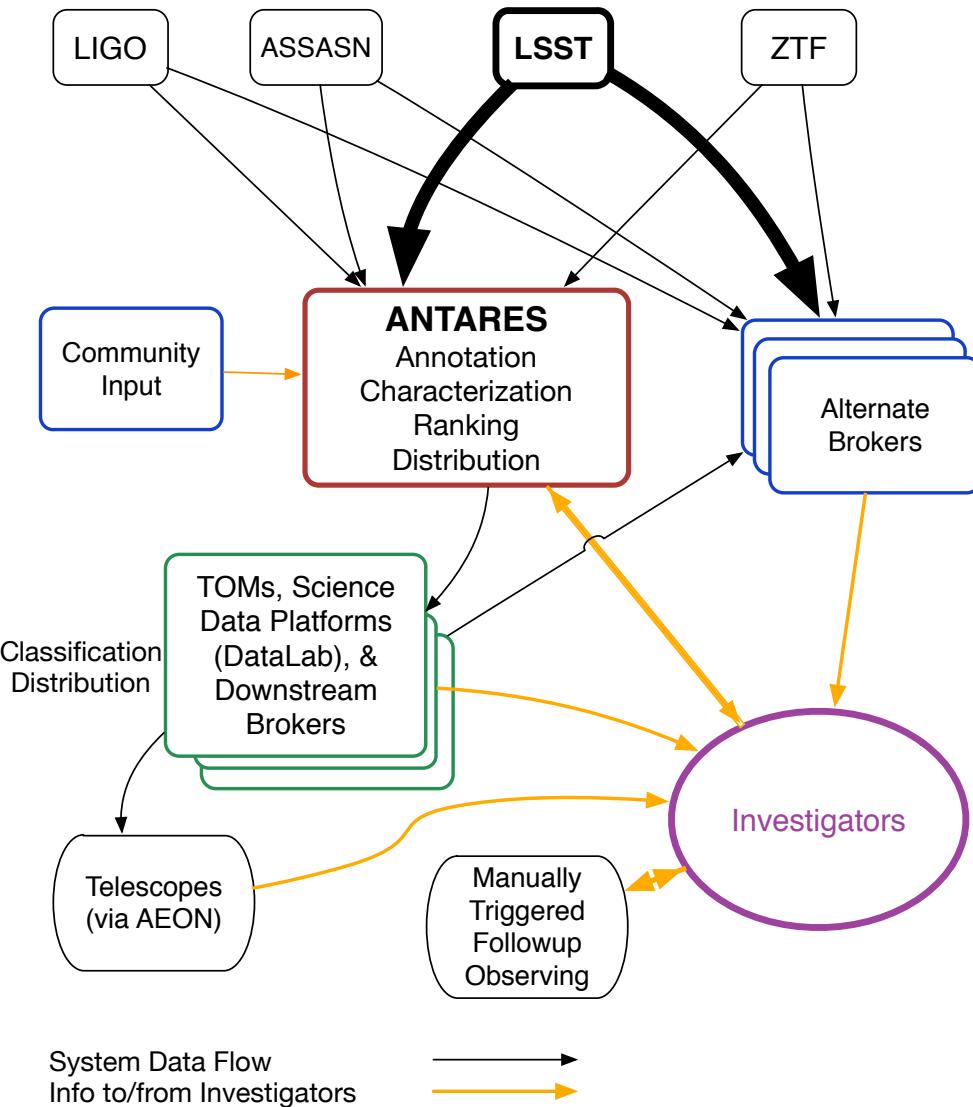
Wide, fast, deep survey yields ten million alerts per night

Maybe not the firehose we fear (Ridgway et al. 2014)

A Time-Domain Ecosystem

The Time-Domain Ecosystem

ALERT GENERATORS: Difference Imaging, Real/Bogus, & Moving Object Assessment



Alert Generators: Time-domain surveys, find and report, multi-messenger

Brokers: Software systems to annotate, filter, and categorize (or classify) alerts

Science platforms: Telescope scheduling, data processing, analysis, collaboration

Follow-up systems:
Photometric, spectroscopic,
multiwavelength—rethink
time allocation, scheduling,
data access

Many LSST Brokers Under Development

Lasair



ALeRCE
Automatic Learning for the
Rapid Classification of Events



POI Variables: Vanderbilt

INAF

Pittsburgh

New York University

Babamul: Caltech

SNAPS: Northern Arizona

LSST-ABCs: Geneva

South Africa

Arizona

GenESIS: Washington

Alert Management, Photometry and
Evaluation of Lightcurves (AMPEL)



MARS
Make Alerts Really Simple



NSF's National Optical-Infrared
Astronomy Research Laboratory



STScI | SPACE TELESCOPE
SCIENCE INSTITUTE



ANTARES Overview

- Enabling broad scientific use of time-domain alerts
- Efficient, effective, responsive, open, and flexible brokering system
 - Real-time alert processing
 - Scalable to LSST rate and volume
 - Community driven platform
 - No user restrictions
 - Containerized deployment
- Actively processing ZTF public alerts
 - <https://antares.noao.edu/>



HEISING-SIMONS
FOUNDATION



ANTARES
beta

About Streams Search Filters Pipeline Watchlist FAQ Staff Tools ▾

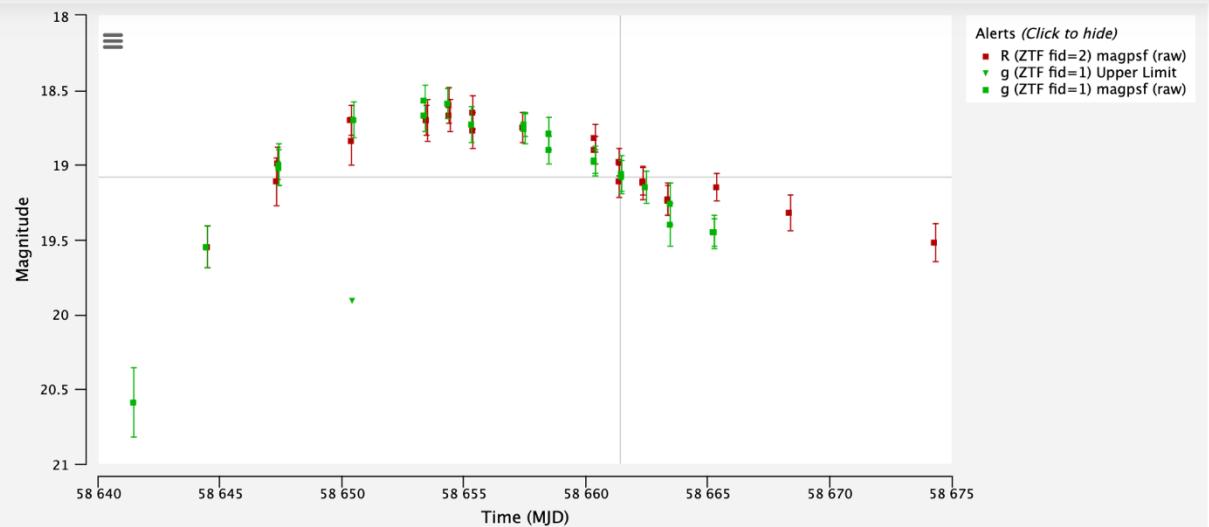
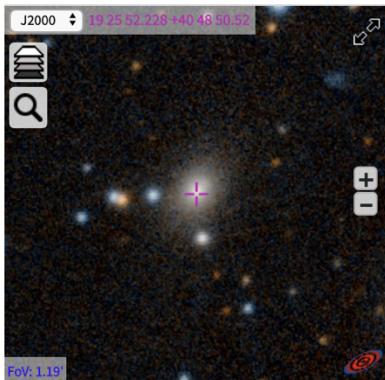
Logout (matheson)

ANTARES Portal

Alert 47383239

ICRS: (*ra*) 19h25m52.23s (*dec*) 40d48m50.52s
Galactic: (*l*) 73.1759 (*b*) 11.3742
Ecliptic: (λ) 305.645 (β) 61.6241

ANTARES Locus ID: [3177809](#)
ANTARES Version: 0.2.14
External Catalogs: [SIMBAD](#), [TNS](#), [NED](#), [MARS](#)
Ingest Timestamp: 2019-06-27 14:59:22
ANTARES Message Timestamp: 2019-06-27
11:08:16
Provenance ID: 6342
ZTF Candidate ID: 907452983515015056
ZTF Object ID: ZTF19aaqait



Highcharts.com

Science (Download)

File Edit View Zoom Scale Color

Regions WCS Analysis Help

77.670 -0.605 43.042 (physical)

58.9 59.3 60.2 61.8 65.2 71.8 85.0 111.6 164.1

Template (Download)

File Edit View Zoom Scale Color

Regions WCS Analysis Help

69.7 70.0 70.5 71.6 73.8 78.1 86.7 104.1 138.3

Difference (Download)

File Edit View Zoom Scale Color

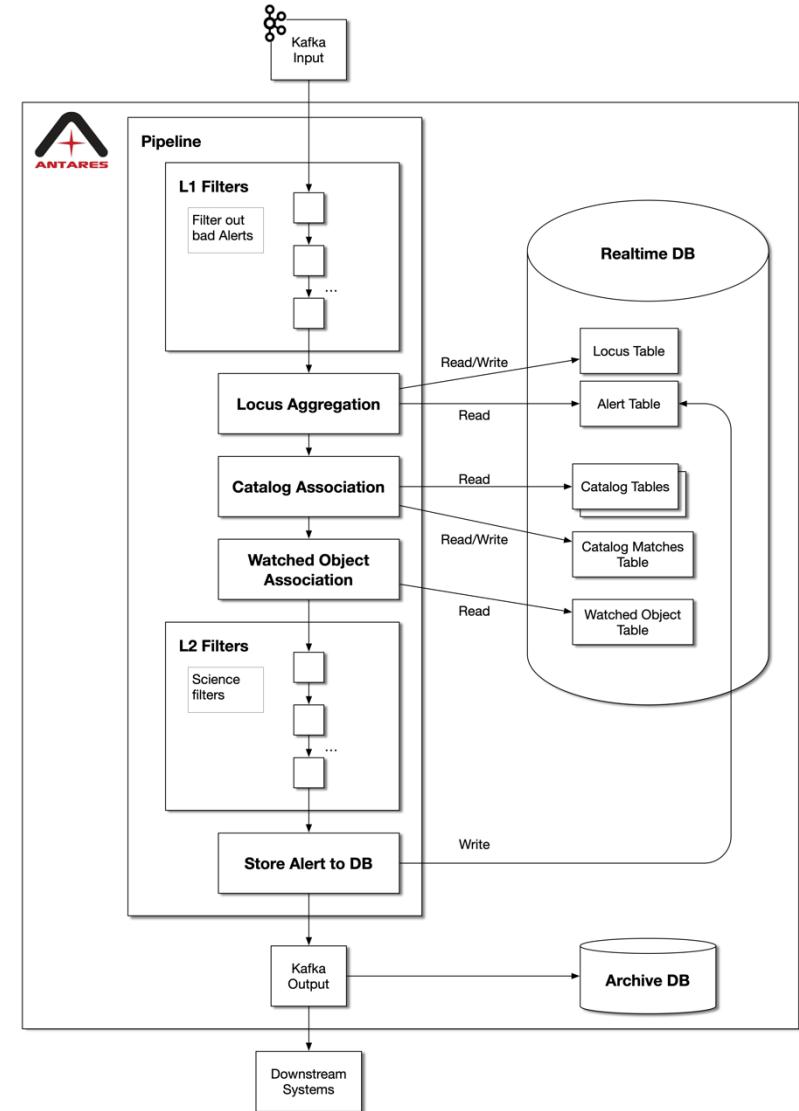
Regions WCS Analysis Help

-15.2 -15.0 -14.7 -14.0 -12.6 -9.9 -4.5 6.4 28.0



ANTARES Features

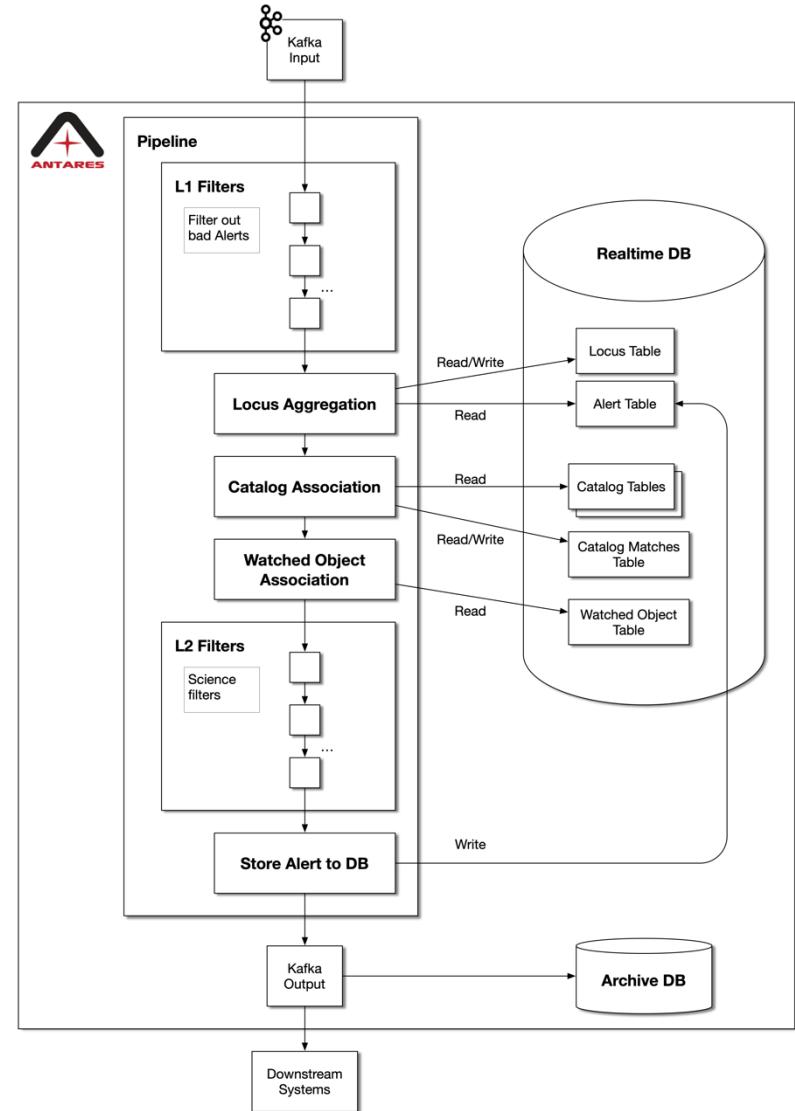
- Kubernetes-based deployment
- Kafka streaming
- Annotation from catalogs
- Filtering of alerts
- Searchable archive of alerts
- Watch lists
- Web portal displays streams, filters, light curve, thumbnails, pipeline, associations
- Provenance associated with each alert





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

- Annotated alerts
 - Feature calculation
 - External catalogs (e.g., catsHTML)
- Filtered alerts
 - Access to all alert features including annotations
 - Can be user designed, dev kit on NOAO Data Lab
- Output three ways
 - Web portal
 - Slack Channel (antares-noao.slack.com)
 - Kafka streams (Python API; could be full stream)
- Archive
 - Longer timescale analysis



ANTARES Summary

- Functional at ZTF scale
- Roadmap for LSST scale
- <https://antares.noao.edu>

