



# Brokers: Making real-time astronomy with LSST possible

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NATIONAL OPTICAL ASTRONOMY OBSERVATORY

LSST TRANSIENT & VARIABLE SCIENCE WORKSHOP, JUNE 5, 2018

# ARIZONA-NOAO TEMPORAL ANALYSIS & RESPONSE to EVENTS SYSTEM

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INSPIRE Grant  
CISE AST-1344204,  
PI:Snodgrass.

# *Outline*

- I. Broker: what is it and why should we care?
- II. What does it take to assemble a broker?
- III. How does it work?
  - What's your role in that?

# Time Domain Astronomy (TDA) – then, now

- TDA has been historically driven by visual/human inspection to find a particular class of objects
- Current wide-field surveys rely on it as well
- Issues:
  - Not reproducible
  - Susceptible to error
  - Limited by data rate
  - etc.




Clyde Tombaugh at the Blink comparator.  
Photo: Lowell Observatory Archives



Animated gif showing what C. Tombaugh saw through the blink comparator in 1930.  
(<https://www.sightsize.com/articles/the-blink-comparator/>)

# Time Domain Astronomy (TDA) – near future

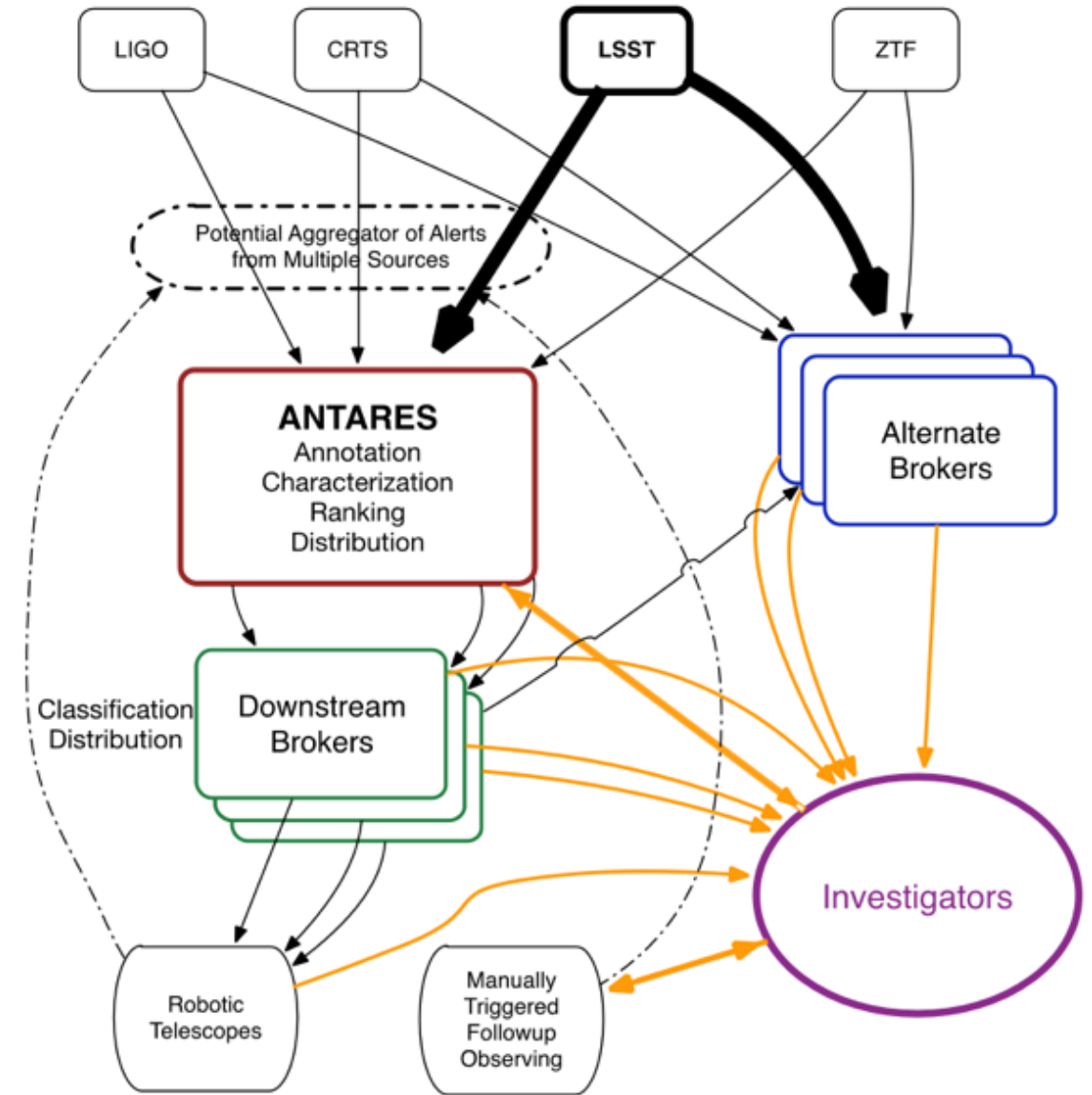
- *LSST*: inundation of data
  - colossal-bytes of images, catalogs, alerts
  - an astronomic alert rate  
( $\approx 10$  million/night, 1 image/40 secs)
  - an uncharted parameter space
- Community's diverse follow-up interests
  - Rare/novel things
  - Predicted but never-observed
  - Normal things behaving weird
- Rare short-lived alerts necessitate prompt follow-up



Follow-up resources  
available to the entire  
astronomical community  
no match for the LSST  
alert rate

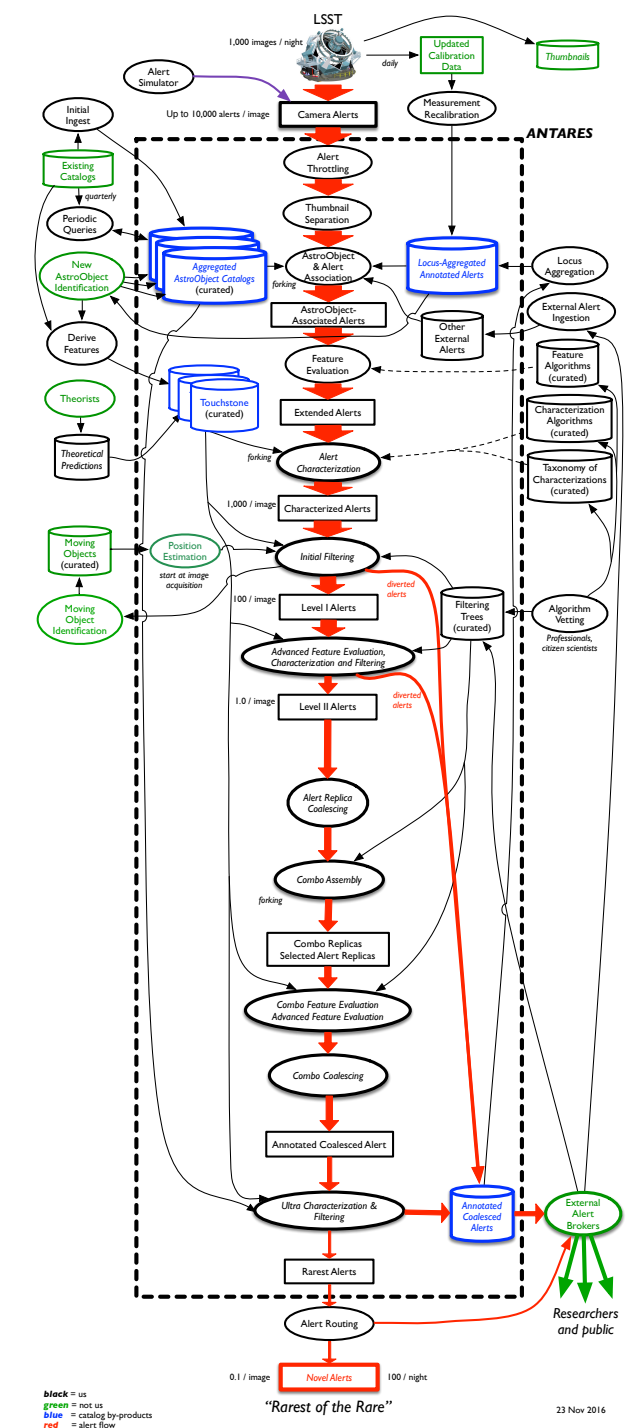
# Time Domain Ecosystem

- Alert generators: difference imaging, real/bogus classification, moving object assessment
- Brokers: manage the alert flow, winnowing down to the most interesting lot
  - characterize alerts automatically
  - distribute to interested parties
  - (can) interface with TOMs to trigger rapid follow-up of transient alerts



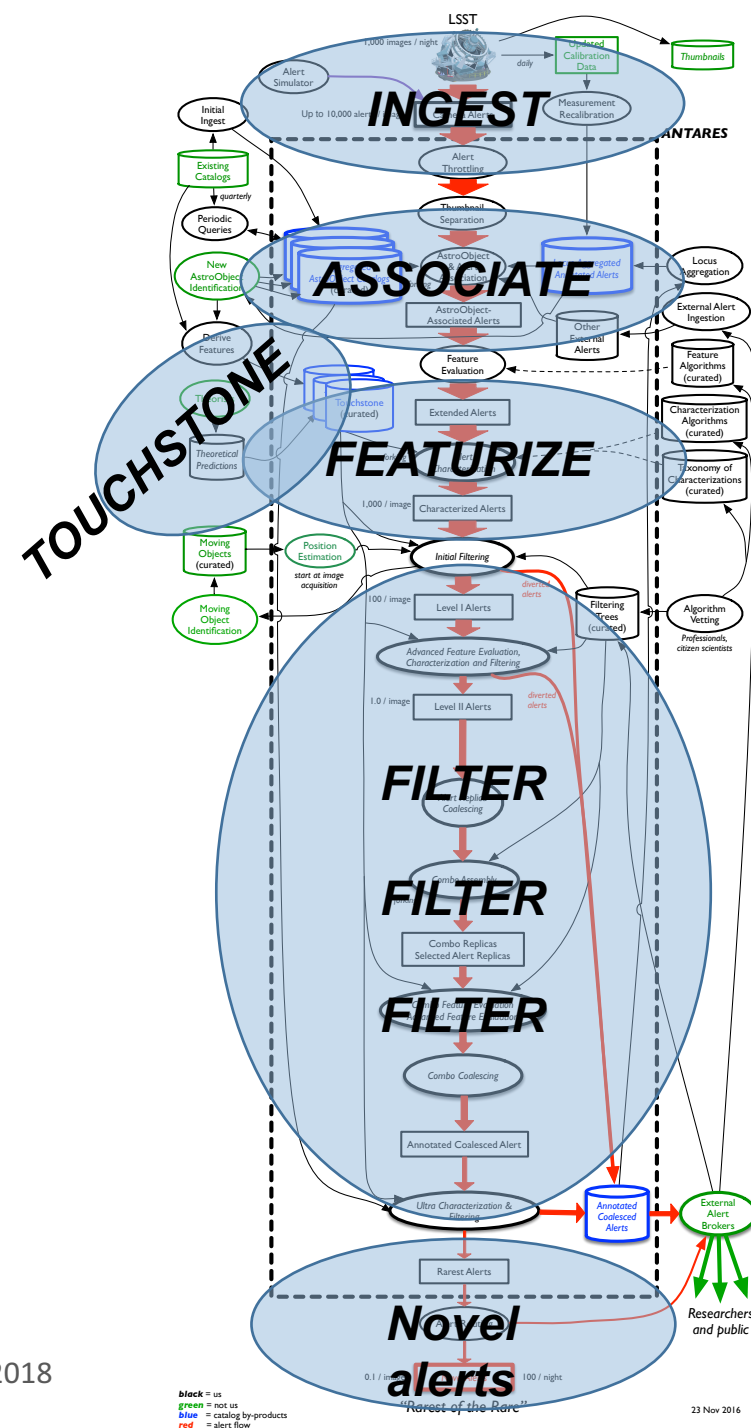
# Backbone of ANTARES

- Alerts are generated outside ANTARES, and then ingested
- Annotated with their 'immediate' history and external contextual data from associated astro-object
- Features are derived & compared against the 'Touchstone'
- Filtered/ranked
- Novel alerts are distributed, while the rest are stored with their added values



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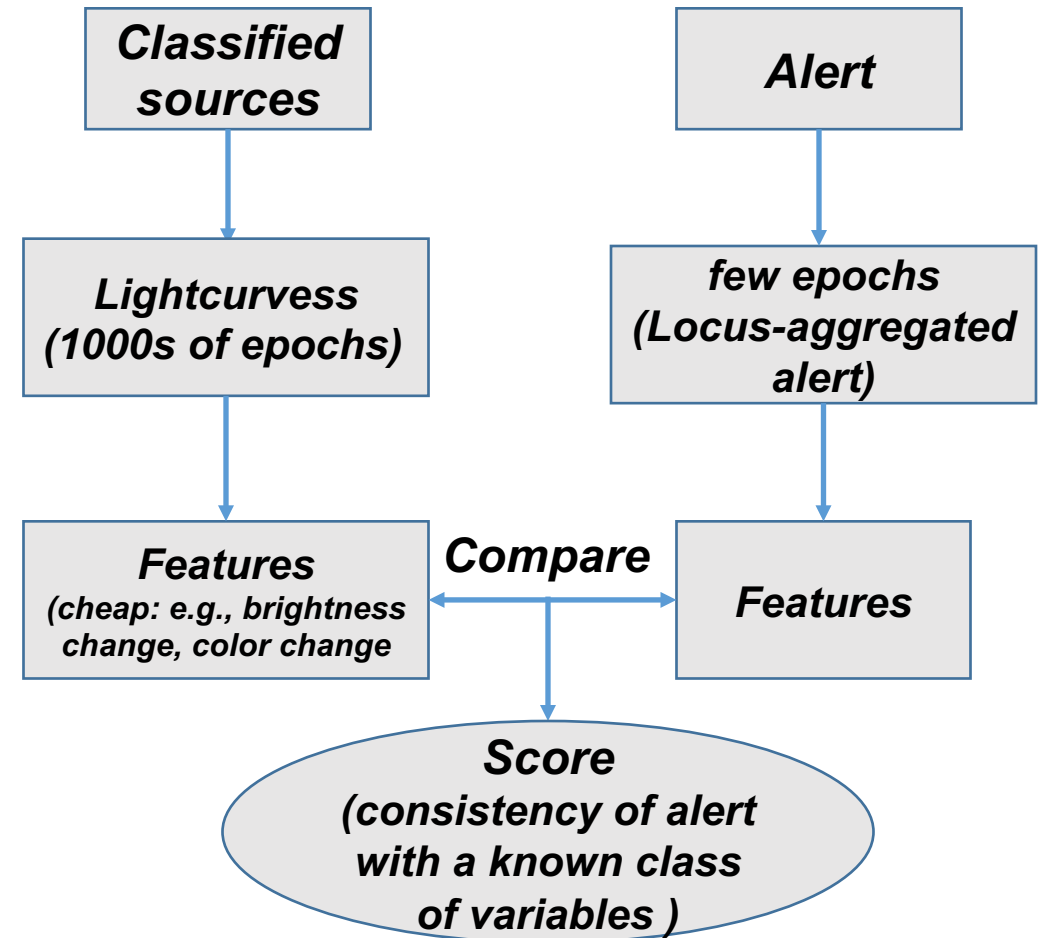
## ANTARES DOES NOT

- perform difference imaging and identification of sources on images
- real-bogus assessment of the source
- moving object identification
- follow-up coordination

# A novelty classification algorithm for time-domain surveys

(Work in progress)

- Motivation: use the available (most basic) properties of alerts, avoid expensive features
  - ✓ magnitude change per time
  - ✓ color change per time
- Compute score for each variable star, based on features, measuring the consistency of the features with lightcurves of *known, classified* variables (and transients) [e.g., Mahabal+2011,2017]

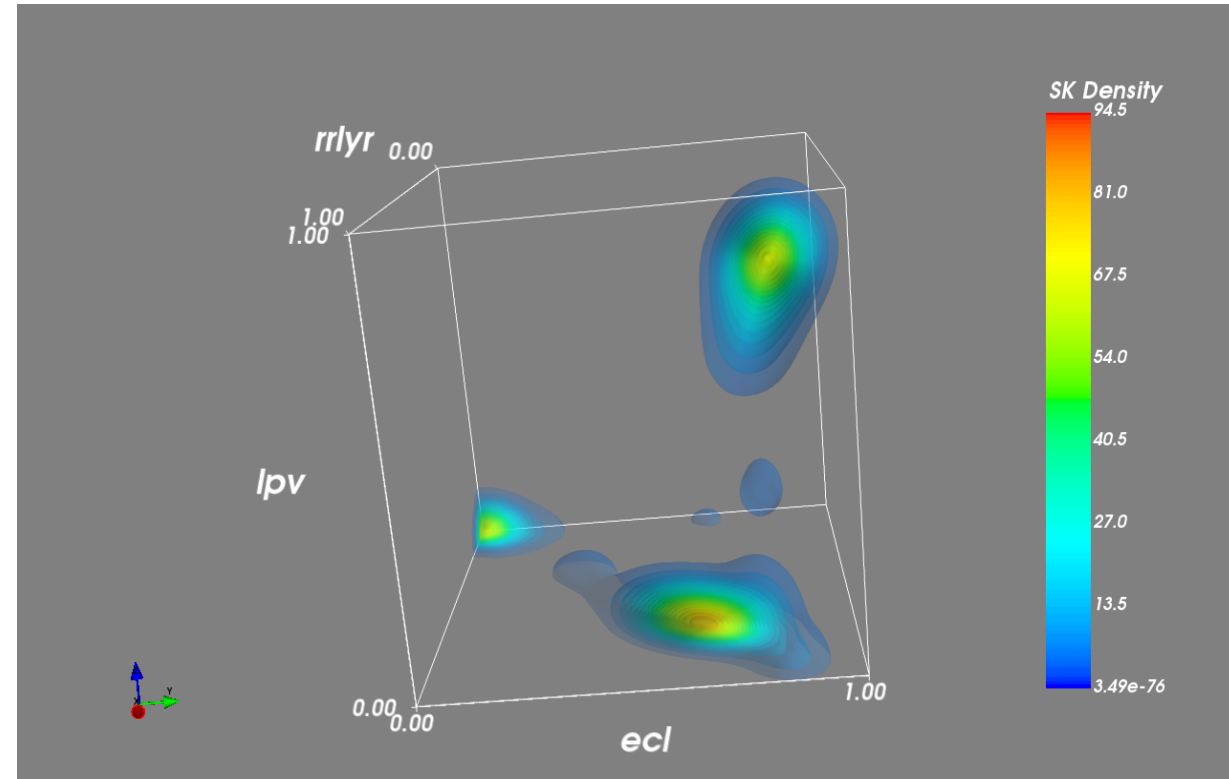
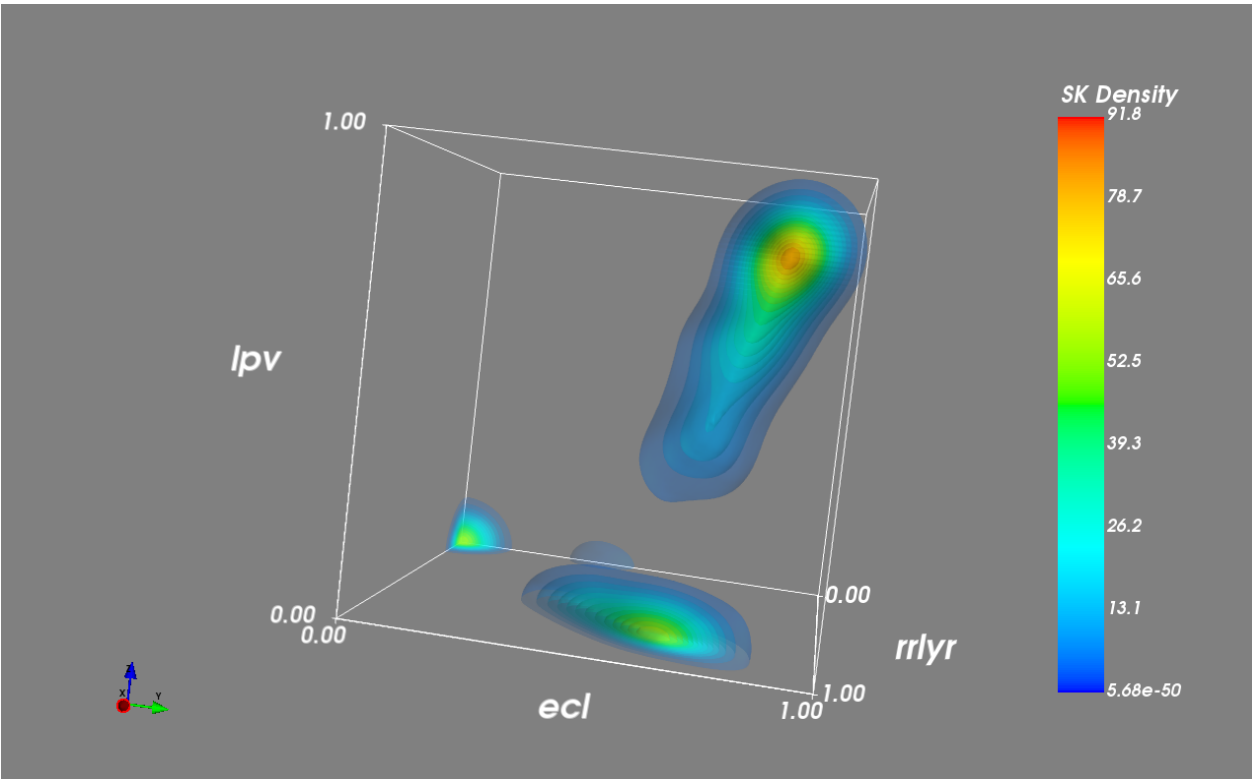


# Distribution in Score space

*(Work in progress)*

(<=10 measurements in test lightcurves)

(<=100 measurements in test lightcurves)

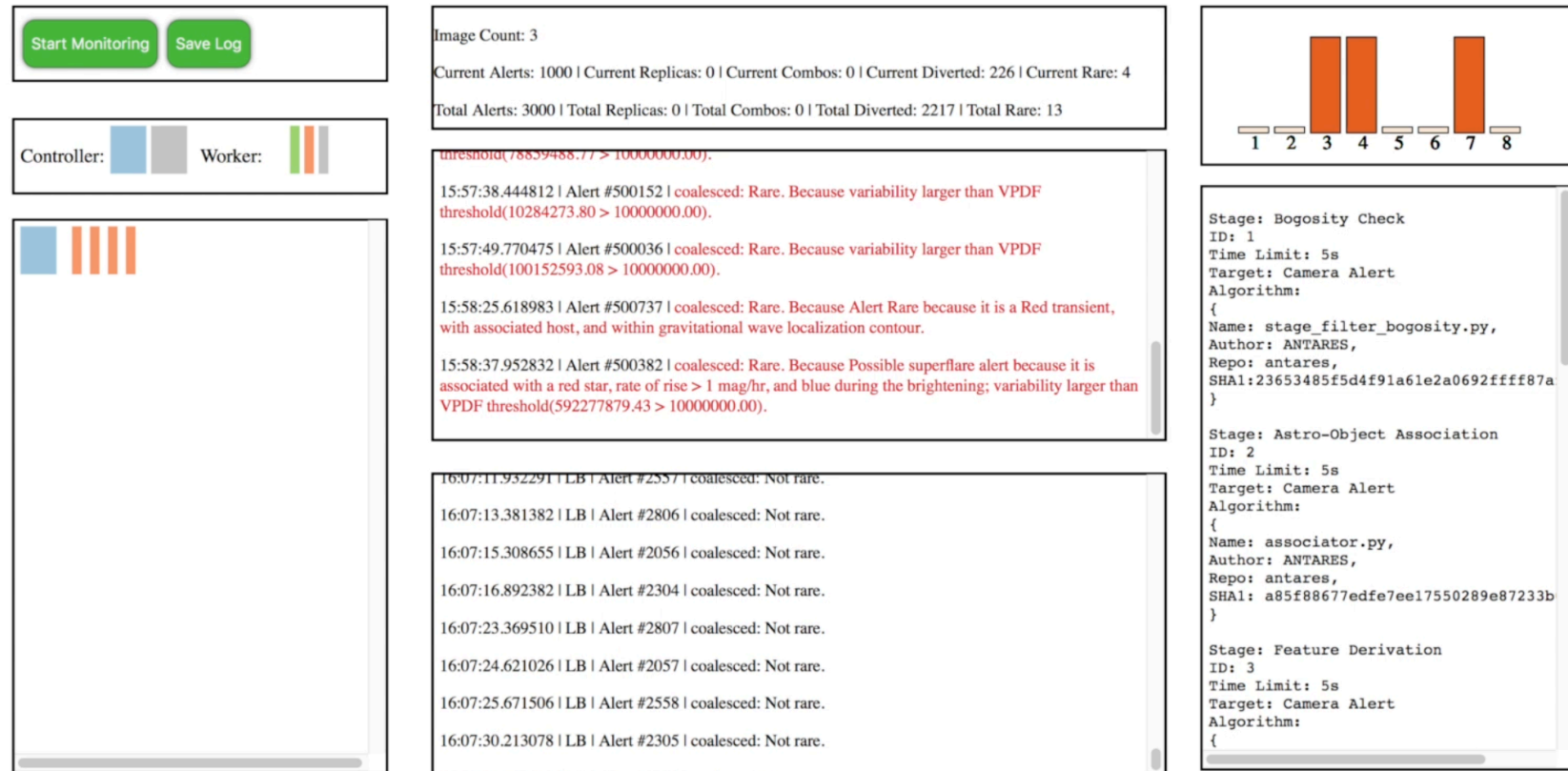


# ANTARES STATUS

- Functional prototype being hosted at the cluster at Arizona UITS
  - Basic architecture design implemented
  - Robust system API
  - Astro-object catalogs covering wide range of wavelengths (2MASS, ALLWISE, NED, Chandra, Gaia DR1, Galex, SDSS)

# ANTARES STATUS

- Function
  - Basic
  - Robust
  - Astro ALLV



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  - Basic architecture design implemented
  - Robust system API
  - Astro-object catalogs covering wide range of wavelengths (2MASS, ALLWISE, NED, Chandra, Gaia DR1, Galex, SDSS)
- First phase code refactoring summer 2017
  - Various fixes to non-functional units
  - Identifying bottlenecks in the software
  - Exposing possible vulnerabilities of system
- Improved front-ends including *data provenance* support

# ANTARES STATUS



Alert Viewer

[Home](#) [Runs](#) [Images](#) [Alerts](#) [Locii](#) [API](#)

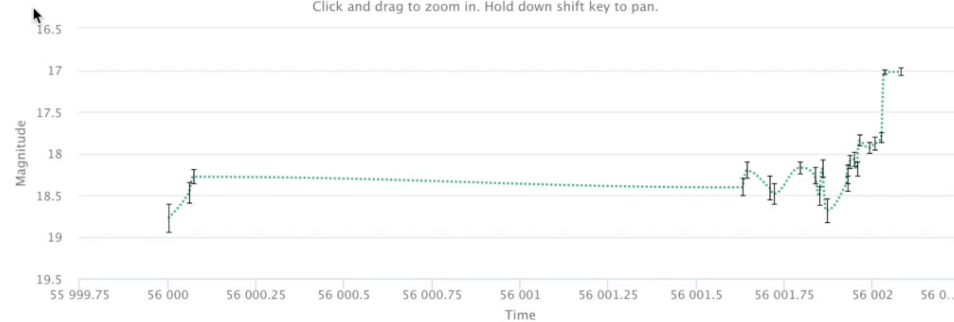
## Alert #500151

Alert ID	RA	Decl	Locus ID	Rarity	Annotation	Provenance
500151	0.00295	-14.8786	<a href="#">8823575788551</a>	R	variability larger than VPDF threshold(10284273.80 > 10000000.00)	<a href="#">View</a>

### Light Curves

Source: ANTARES Database

Click and drag to zoom in. Hold down shift key to pan.



Highcharts.com


## Properties

Property ID	Name	Confidence	Value	Annotation
12072	IMAG	None	17.021	None
12073	IMAGERR	None	0.047	None
12074	MJD OBS	None	56002.077	None

a UITs

gths (2MASS,

# ANTARES STATUS


**Alert Viewer**

## Alert #500151

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### Light Curves

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### Properties

Property ID	Name	Confidence
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12073	IMAGERR	None
12074	MJDOBS	None

DAFCAA // Dynamic Alert Flow Computation Analyzer on ANTARES

File Settings

Version 002 (v0.4rc-289-gb84b580) | 29 Mar 2018 18:05:18 -> 31 Mar 2018 19:37:15 | 003 runs | **Select** Version 2

Stage Code | Version Comparison | Property Dependency Tree | Catalog Info | Alert Lightcurve

### Stages

- ☒ Include All Stages
- ☐ Limit to Stages with Property: amplitudeY

stagefilter\_bogosity.py

associator.py

stagefeatureDerivation.py

stagefilter\_VPDF.py

stagefilter\_kNN.py

stagefilter\_gu.py

### Properties

- ☒ Include All Properties
- ☐ Limit to Properties in Stage: stagefilter\_VPDF.py

acorr

skewnessz

amplituder

kurtosisY

rMAGERR

amplitudeY

hlratou

zRefmag

shapirowilkr

rFLUXERR

q31Y

uRefmag

iMAG

```
def filterVPDF( alert, rarityThreshold=1E7 ):
    ra = alert.ra
    decl = alert.decl
    thisid = alert.ID
    if thisid != alert.LA.getScalar('LastUpdatedAlertID'):
        aobj = api.MakeTouchstoneObject(alert)
        amps = aobj.get_amplitude(smoothed=False)
        for pb, amp in amps.items():
            if amp == [0.]:
                amp = 0.
            alert.LA.setScalar('%sAmplitude'%pb, amp)

    # alert.LA.LastUpdatedAlertID.value = alert.ID
    alert.LA.setScalar('LastUpdatedAlertID', alert.ID)
    alert.LA.DBCCommit()

filters = ['g','r','i','z','V','U','B','R','I']
ampwave = [[alert.LA.getScalar('%sAmplitude'%pb), general_funcs.get_wavelength(pb),pb] for pb in filters]
for i in range(len(ampwave)):
    if ampwave[i][0] is None:
        ampwave[i][0] = 0.
ampwave = np.rec.fromrecords(ampwave, names='amp,wave,pb')
mask = (ampwave.amp > 0)
ampwave = ampwave[mask]
```

### Notes

amplitude\_Y is set in stagefilter\_VPDF.py.  
We should investigate aobj.get\_amplitude() function|.

Alert ID  **Go**

### Alert Data

# 204017

**Rarity**  
R; Alert is far from any neighbor; value is above threshold

**Time Captured**  
2018-03-29 18:05:18.0  
Run ID: 21

**Locus**  
ID: 218787531  
RA: 247.35  
Decl: -26.4319

**Property Values**

amplitudeY: 78054.5

- kurtosisY: 0.9182

- skewnessY: 0.784

- varianceY: 0.485

### Alert Associations

**Replicas**

**In Combo**

**LA-Context**



## End Notes

- ANTARES, to serve as a community alert broker for large-scale optical time-domain surveys (LSST, ZTF), is being rigorously developed.
- Community involvement will be a big factor for success of brokering
  - *or brokering of success for LSST time-domain efforts.*
- Examples:
  - providing the probability model for the variable or transient class that one has studied;
  - supplying expected lightcurves for the unusual object one is interested in;
  - writing a stage that describes one's object of interest.