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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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
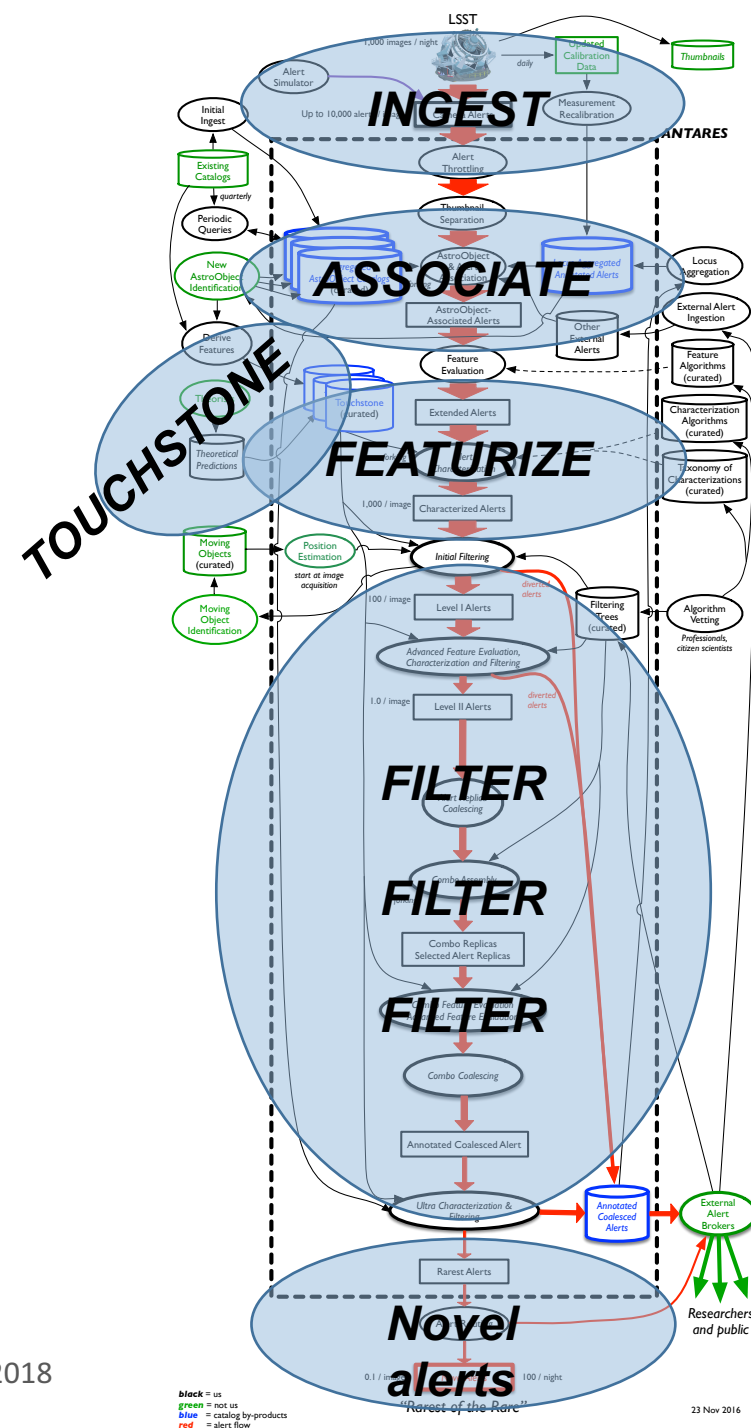 - ➤ (can) interface with TOMs to trigger rapid follow-up of transient alerts
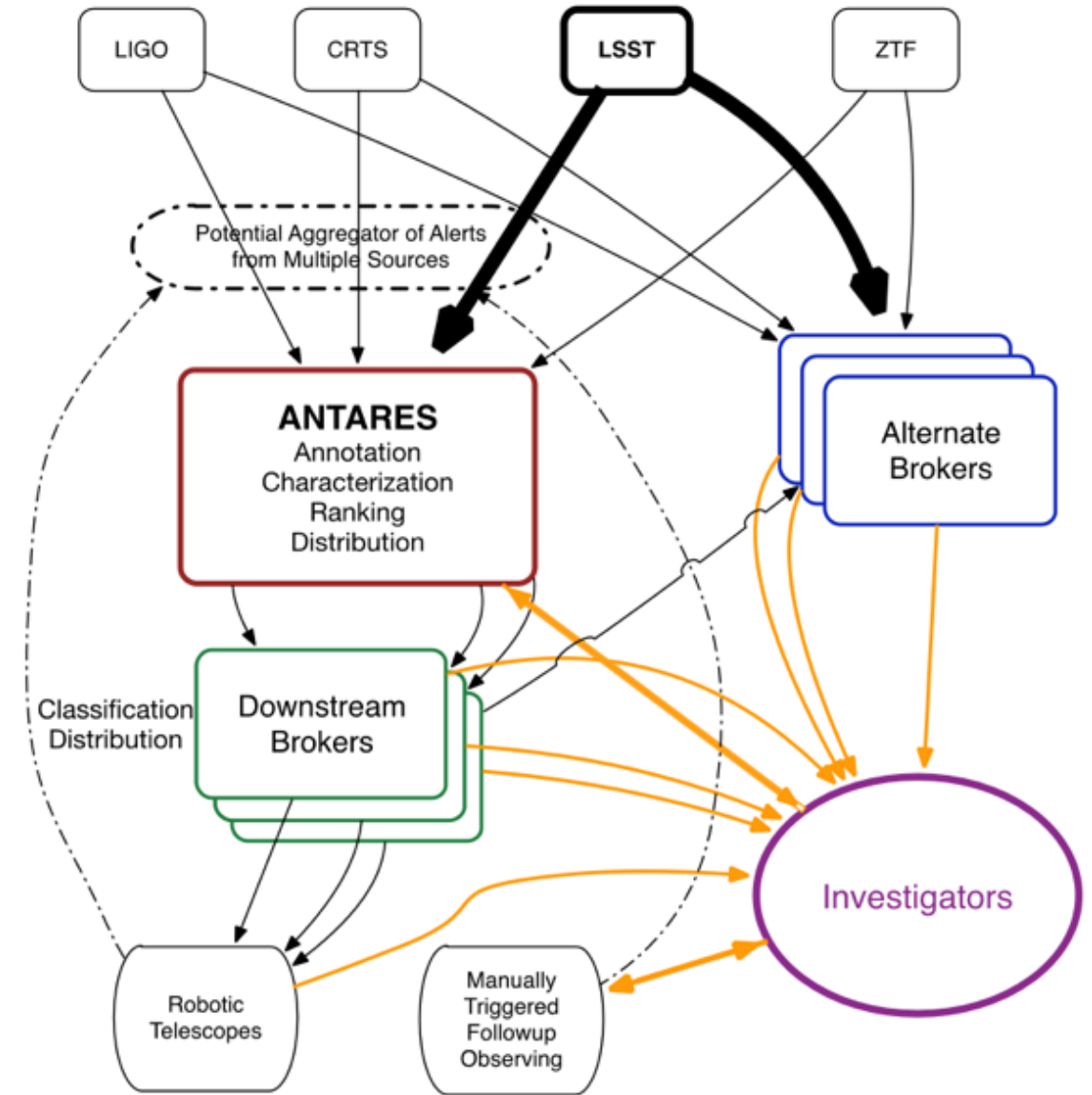
Backbone of ANTARES

- 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
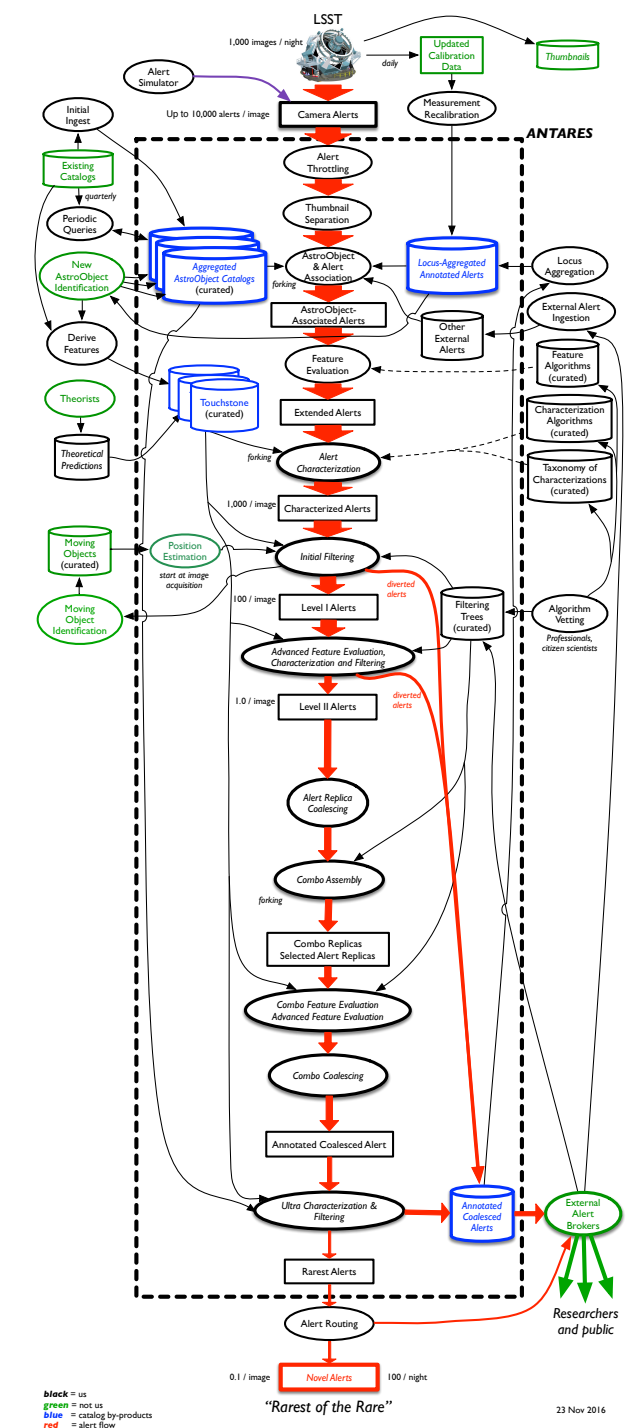
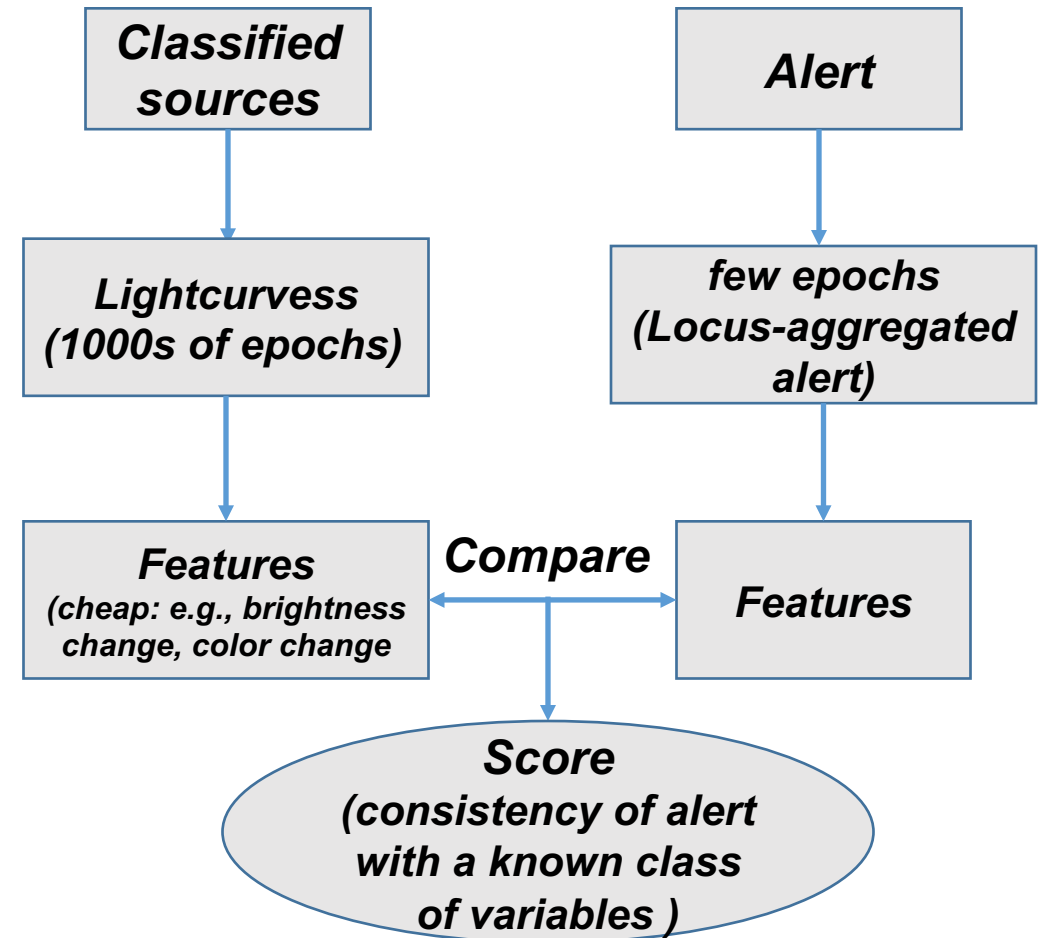- Novel alerts are distributed, while the rest are stored with their added values

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Monika Soraisam, LSST TVS Workshop, June 5, 2018

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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]

Classified sources → **Lightcurvess (1000s of epochs)** → **Features (cheap: e.g., brightness change, color change**

Alert → **few epochs (Locus-aggregated alert)** → **Features**

Compare

Score (consistency of alert with a known class of variables)

Distribution in Score space

(Work in progress)

(<=10 measurements in test lightcurves)   (<=100 measurements in test lightcurves)
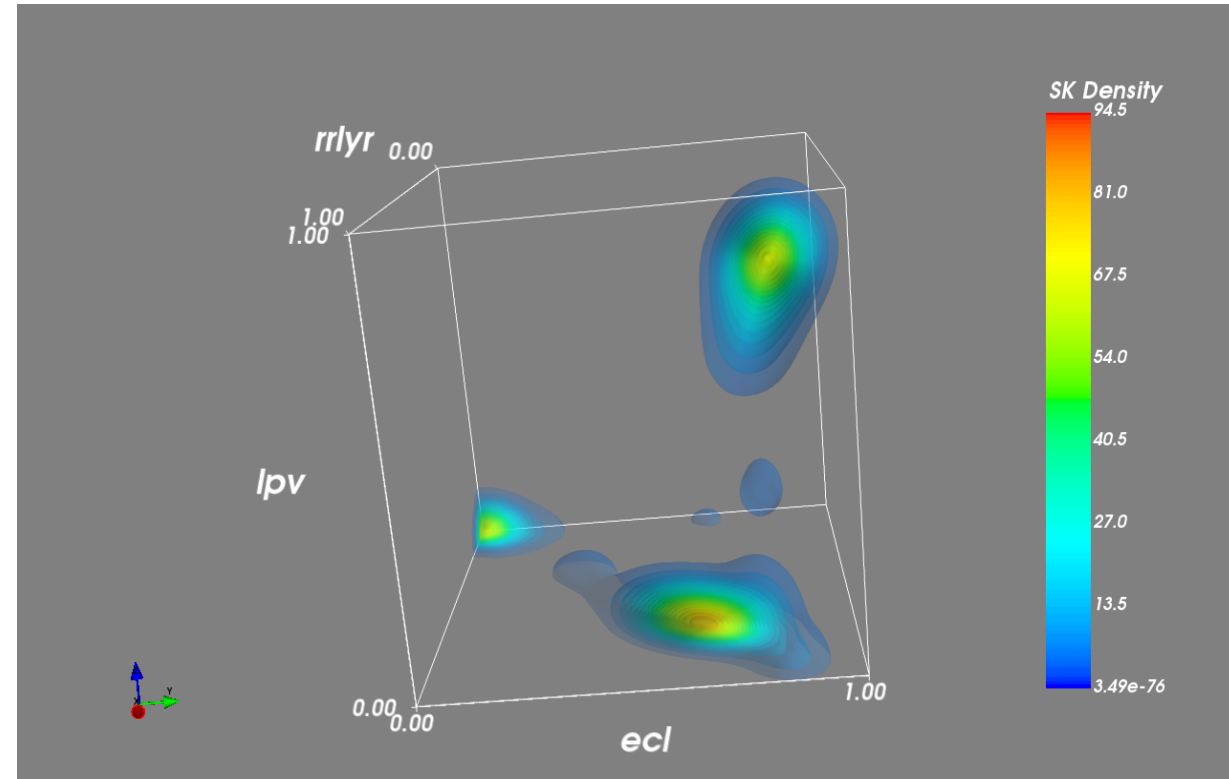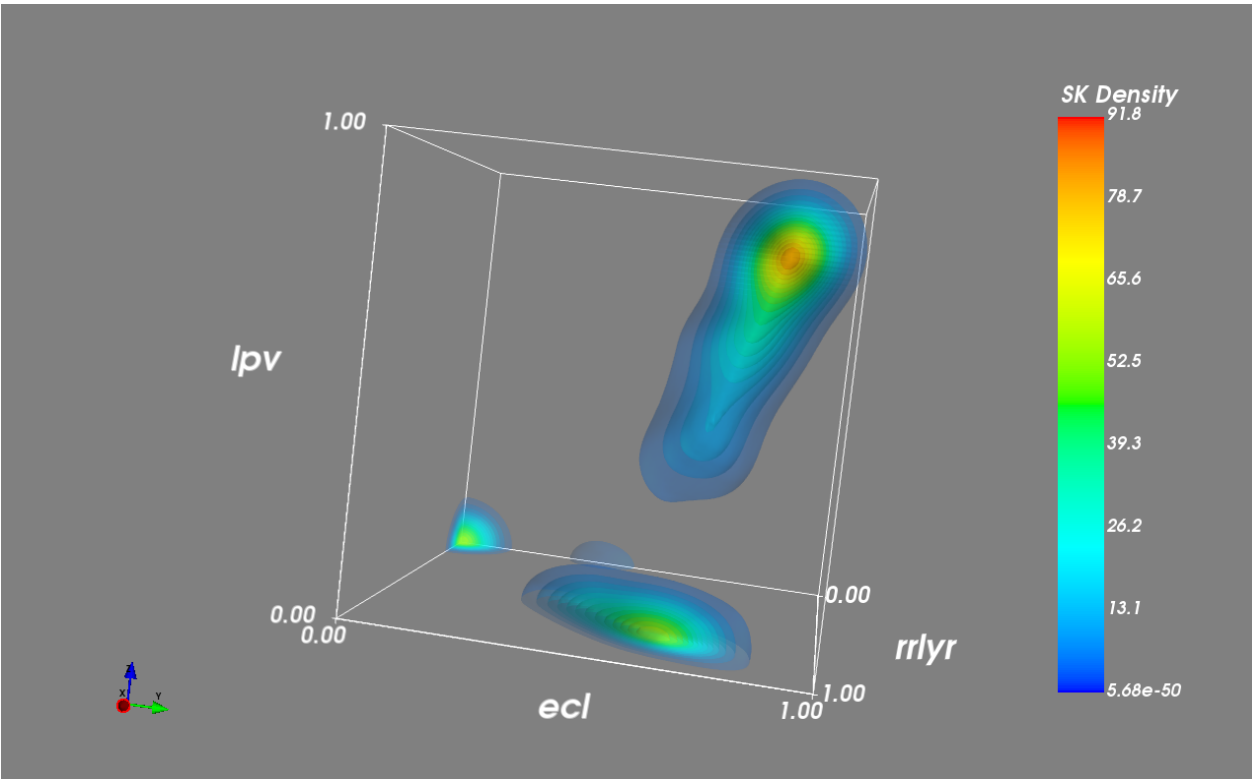
ANTARES STATUS

- 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
  - Robu
  - Astro
    ALLW
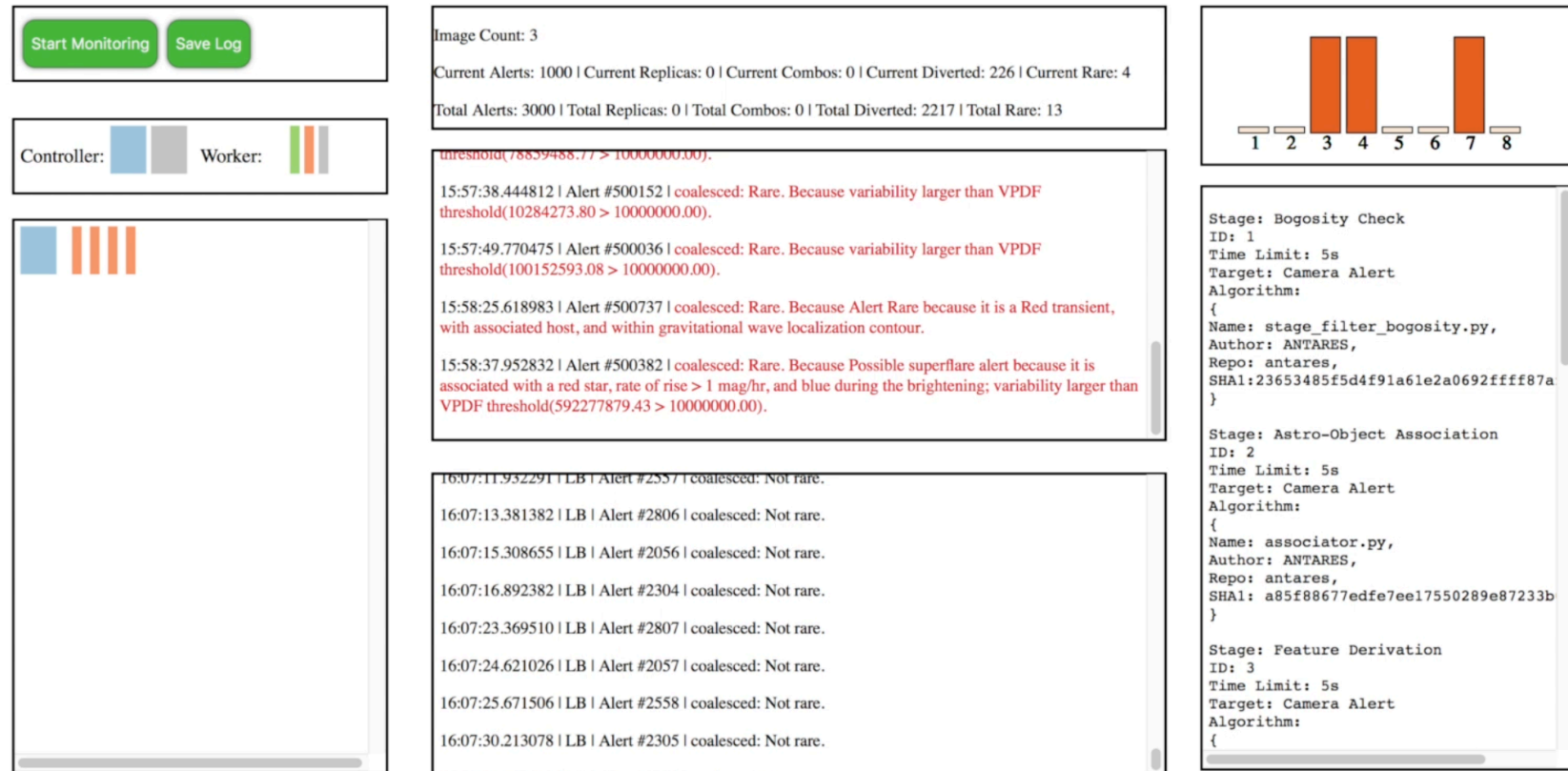
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- First phase code refactoring summer 2017
  - Various fixes to non-functional units
  - Identifying bottlenecks in the software
  - Exposing possible vulnerabilities of system

- Improved front-ends including *data provenance* support

ANTARES STATUS

a UITS

gths (2MASS,

ANTARES STATUS

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.