EXPLORING TVS SCIENCE REQUIREMENTS

BROKERS
ALERT-BASED SCIENCE OBJECTIVES

- Real-time transient triggers
  - Early photometric classification
  - Selection of objects for follow-up observations

- Triggers from quality threshold
  - E.g. periodic targets which have been observed for enough cycles to identify a sub-category

- Target-of-Opportunity observations
  - Targeted search for electromagnetic counterparts to GW events
2018 Task Force aimed to

- Stimulate scientists from all fields in astronomy to think through how they will extract targets of interest from LSST
- Understand what information and data products they will require at each stage,
- Understand their requirements for timescales of delivery and modes of interaction with brokers.
- Derive functional and performance requirements and provide feedback to broker developers
- Understand constraints on broker development teams

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## 2018 SURVEYS

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62 responses                                         6 [team] responses
ALERT CONTENT

LSST alert content sufficient for your science?

- Yes: 75.4%
- No: 24.6%

Requested features:

- Target flux not from LSST: 18 (36.7%)
- Lightcurve history: 11 (22.4%)
- Periodogram parameters: 14 (28.6%)
- Amplitude parameters: 4 (8.2%)
- Probability distribution shape: 8 (16.3%)
- Orbital or movement parameters: 5 (10.2%)
- Variability indices: 
- Rapid follow-up photometry: 
- Lightcurve history nice to have: 
- Lightcurve fit: 
- Real-bogus classifier: 
- Historically cataloged sources: 
- Spectroscopy: 
- Cross match with AGN, X-ray catalogs: 
- Host galaxy offset/colors/classification: 
- Orbital elements/photometric properties of Solar System objects: 
- Follow-up with other telescopes: 
- Spectra: 
- Other data products from L3 tools: 
- Simultaneous colors/NUV photometry: 
- Pixelated image cutouts: 

Color information
Lightcurve metrics
Source contextual information
Classifications
External catalog data
Respondents gave a number of written examples of the selection queries they would like to use.
INTERACTING WITH BROKERS

- Through an interactive website: 50 (82%)
- By writing software of my own which can...: 37 (60.7%)

**Pie Chart**
- Every few minutes or less: 27.9%
- Once or more an hour: 24.6%
- Once or a few times per day: 18%
- Once or a few times per week: 23%
- Once or a few times per month: 18%
84% of respondents felt it was important for brokers to provide alert classification.

But understanding how alerts are classifications is essential.

- Need to quantify selection biases.
- Want ability to run simulated alert streams through brokers.
- Want to run new filters on older data.
CLASSIFICATION

- Need to extract complex, customized features for a large fraction of events in real-time
  - E.g. to run a pre-trained neural network
- May need to use Bayesian techniques (e.g. MCMC) to evaluate some targets in real-time
  - Leads to high computing overhead
Preferred method of receiving information on alerts of interest

- Email: 17 (36.2%)
- SMS Message: 4 (8.5%)
- RSS Feed: 4 (8.5%)
- VOEvent stream: 17 (36.2%)
- Online page: 27 (57.4%)
- API subscriber: 21 (44.7%)
- Avro serialization/VOEvent lite: 1 (2.1%)
- Database archive: 1 (2.1%)
- Avro stream: 1 (2.1%)
- Email+online link: 1 (2.1%)
- Prefer to pull alerts: 1 (2.1%)
INTERFACING WITH TOM SYSTEMS

- Many users expect to make additional observations in response to LSST alerts
- Need to interface brokers with TOM systems
  - TVS members expect to continue to use essentially all ToO and queue-scheduled telescope facilities
- AEON-compatible facilities under development will have TOM interfaces
- Traditionally-scheduled facilities can also be supported through a TOM system
Subject of discussion at the 2019 LSST workshop for broker developers

Speed of ingest of new alerts to brokers depends on technologies used

- Within ~5-10min is achievable with current technologies
- <1-2min would require more advanced [expensive] technologies
HOW FAST DO YOU REALLY NEED ACCESS TO ALERTS?

http://ls.st/7vb/
OUTSTANDING QUESTIONS

- Need for high-accuracy classifier for galactic transients that depends on a few data-points.
  - Broker solution: classification algorithms + sophisticated alert filtering options
- Catching exotic and unknown transients
- Interfacing with TOMs for rapid follow-up
- Coordinating follow-up among multiple teams and limited telescope resources
- Please complete alerts survey: http://ls.st/7vb/