LSST Transient Alert Production Pipelines

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Deep, wide, fast: Pick any three

- **Deep:**
  - 8.4m (~ 6.5m effective)
  - 10 years
  - ~ 825 visits total
  - \( r \approx 24.5 \) /visit; \( r \approx 27.5 \) total
  - ~ 0.67” seeing
Deep, wide, fast: Pick any three

- **Wide:**
  - 18,000+ deg²
  - 6 bands (ugrizy)
  - 3.2 gigapixel camera
  - ~10 deg² field of view

- (189 x 16Mpix CCDs)
Deep, wide, fast: Pick any three

- **Wide:**
  - 18,000+ deg²
  - 6 bands (ugrizy)
  - 3.2 gigapixel camera
  - ~ 10 deg² field of view

- **Fast:**
  - 2s readout, 5s slew
  - 2 x 15s exposures per visit
  - entire sky imaged 2x, ~ every 3 nights
  - ~ 2.5 million visits total

- **Deep:**
  - 8.4m (~ 6.5m effective)
  - 10 years
  - ~ 825 visits total
  - $r \sim 24.5$/visit; $r \sim 27.5$ total
  - ~ 0.67” seeing

![Diagram showing 2x15s exposures and ~30 minutes intervals for Wide and Deep modes, with ~3 days between visits.]
Deep, wide, fast: Pick any three

- **Wide:**
  - 18,000+ deg$^2$
  - 6 bands (ugrizy)
  - *3.2 gigapixel camera*
  - $\sim$ 10 deg$^2$ field of view

- **Fast:**
  - 2s readout, 5s slew
  - 2 x 15s exposures per visit
  - entire sky imaged 2x, $\sim$ every 3 nights
  - $\sim$ 2.5 million visits total

- **Deep:**
  - 8.4m ($\sim$ 6.5m effective)
  - 10 years
  - $\sim$ 825 visits total
  - $r \sim 24.5$/visit; $r \sim 27.5$ total
  - $\sim$ 0.67” seeing
  - $\sim$ 10 million transient alerts per night
  - Alerts distributed within 60s of visit

- **Diagram:**
  - 2x15s exposures, total time $\sim$ 30 minutes
  - 2x15s exposures, total time $\sim$ 30 minutes
  - 2x15s exposures, total time $\sim$ 3 days
  - 2x15s exposures, total time $\sim$ 30 minutes
Petascale Computing, Gbps Networks

Data products:
- ~ 20 TB/night
- ~ 37 billion objects
- ~ 30 trillion measurements
- ~ 100 PB total
- ~ 10 million transient alerts per night
- Alerts distributed within 60s

The computing cluster at the LSST Archive at NCSA will run the processing.

Redundant, Long Haul Networks to transport data from Chile to the U.S.
- 2x100 Gbps from Summit to La Serena (new fiber)
- 2x100 Gbps for La Serena to Champaign, IL (path diverse, existing fiber)
Three levels of LSST data products

- A stream of ~10 million time-domain events per night, detected and transmitted to event distribution networks within 60 seconds of observation.
- A catalog of orbits for ~6 million bodies in the Solar System.

- Annual data releases.
- Deep co-added images.
- A catalog of ~37 billion objects (20B galaxies, 17B stars), ~7 trillion observations (“sources”), and ~30 trillion measurements (“forced sources”), accessible through online databases.

- Services and computing resources at the Data Access Centers to enable user-specified custom processing and analysis.
- Software and APIs enabling development of analysis codes.
Level 1 Overview

- **Primary purpose:**
  - Satisfy science cases requiring rapid identification and follow-up (transients, fast-moving NEOs, etc.)

- **Transient science**
  - Nova, supernova, GRBs
  - Source characterization
  - Instantaneous discovery

- **Solar System Objects**
  - NEOs, PHAs

adapted from Kulkarni et al. (2007)
Alert Production: Pipeline overview

Raw visit (two snaps) → Template → Diffim → Detect → Measure → DIASource

(DIAObject record)

DIASource records → Association → DIAObject → SSOObject

Alert Packet → Transmit to event brokers → LSST Simple broker

Community Brokers
Level 1: Alerts

- State-of-the-art image differencing pipeline
- Alerts issued within 60 seconds of observation
- 10M/night (average), 10k/visit (average), 40k/visit (peak)
- Each alert includes:
  - Position
  - Flux, size, and shape
  - Light curves in all bands (up to a ~year; stretch: all)
  - Variability characterization (e.g., low-order light-curve moments, probability that the object is variable)
  - Cut-outs centered on the object (template, image difference)

  - LSST Data Products Definition Document: [http://ls.st/dpdd](http://ls.st/dpdd)
Level 1 Processing: System Architecture
Level 1 Processing: System Architecture
Challenges and Progress

- Difference imaging algorithms
  - Error/noise propagation
- Template generation
  - Refraction
  - Flux dependent PSF
- Other sources of false-positives
  - Image simulations
- Many more…

Antilogus et al. 2014
Becker et al. Winter 2014 Report
In conclusion

LSST will:

- Commence survey operations in ~7 years
- Produce an unprecedented volume of transient alerts
  - Published to the worldwide community with low latency
- Generate annual data releases providing trillions of source measurements and petabytes of image data
  - Available to the US, Chile and international partners with no proprietary period
- Use and develop community standards for making data available wherever possible

How can you help us?
How can we help you?
Thanks from the entire LSST team.