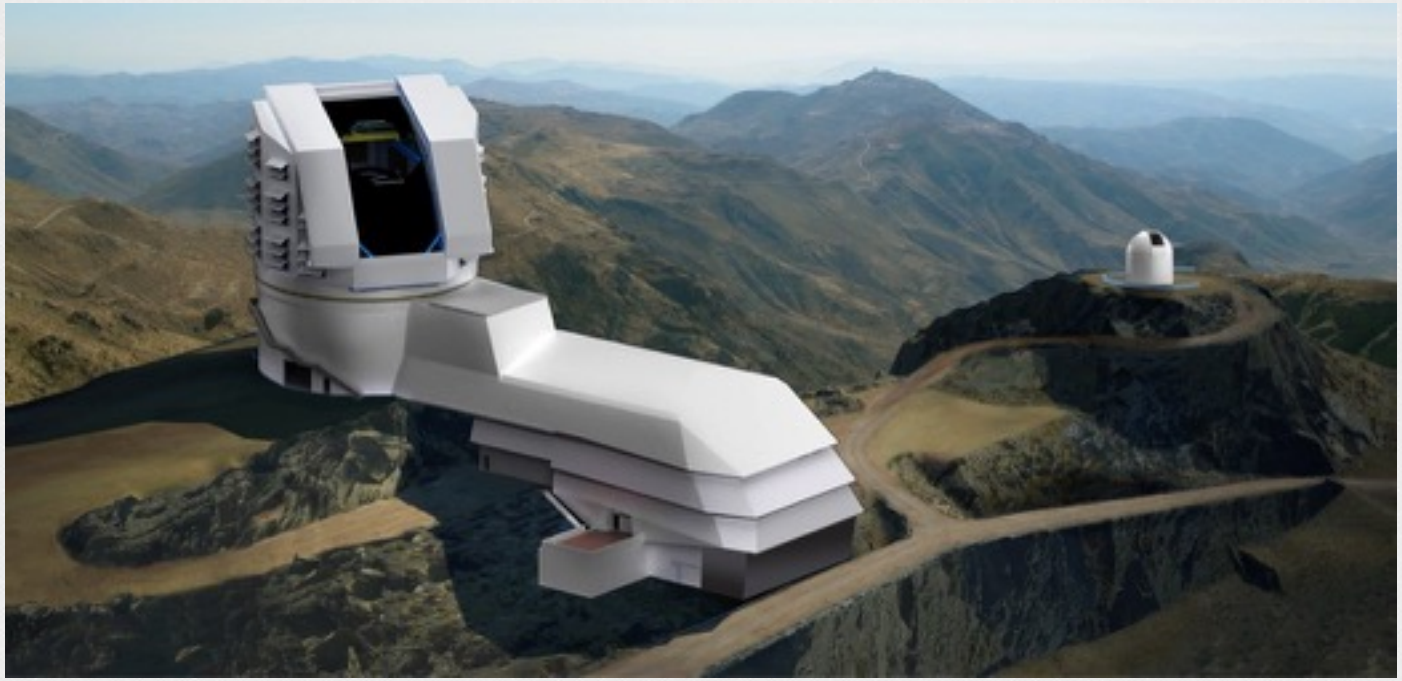
LSST Transient Alert Production Pipelines

David J Reiss
for the LSST Data Management team
LSST DM at University of Washington, Seattle, USA

Gaia Science Alerts Workshop
Liverpool, Nov. 2015

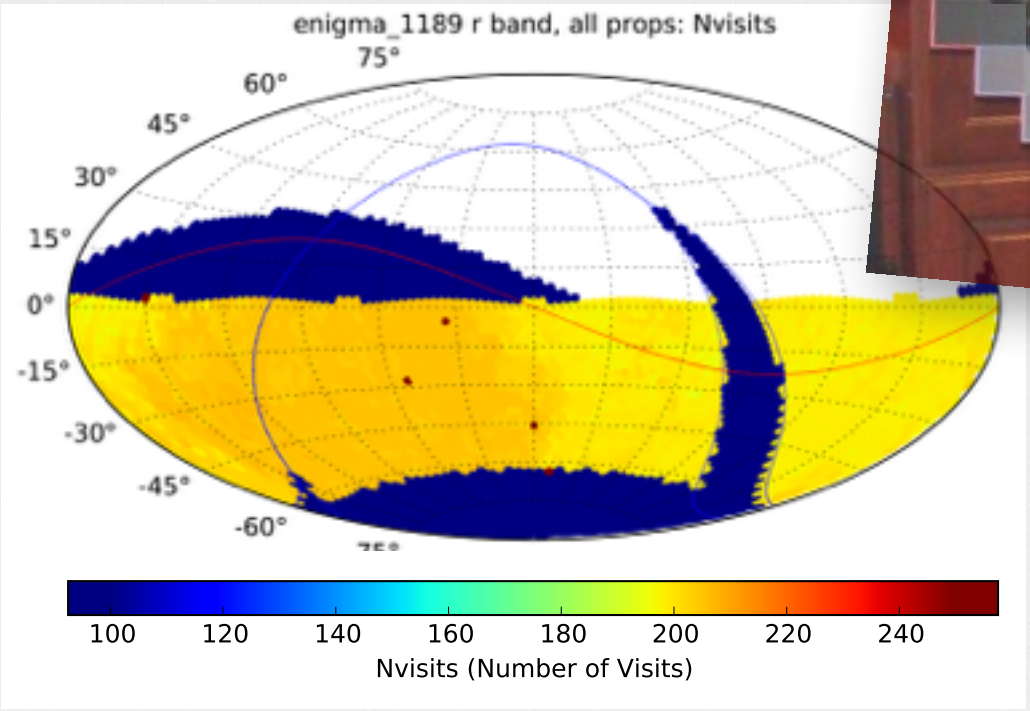
Deep, wide, fast: Pick any three

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



Deep, wide, fast: Pick any three

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

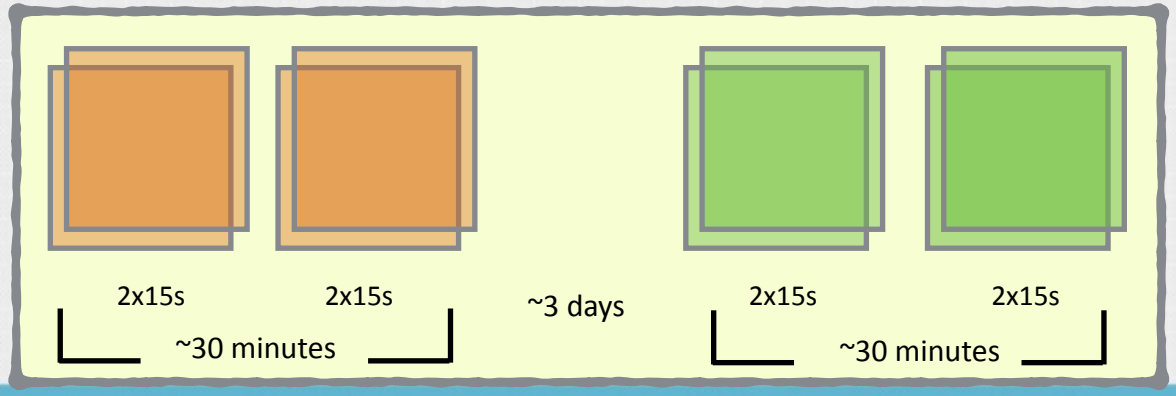


- (189 x 16Mpix CCDs)

Deep, wide, fast: Pick any three

- **Wide:**
  - 18,000+ deg^2
  - 6 bands (ugrizy)
  - ***3.2 gigapixel camera***
  - ~ 10 deg^2 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* ~ 24.5/visit; *r* ~ 27.5 total
  - ~ 0.67" seeing

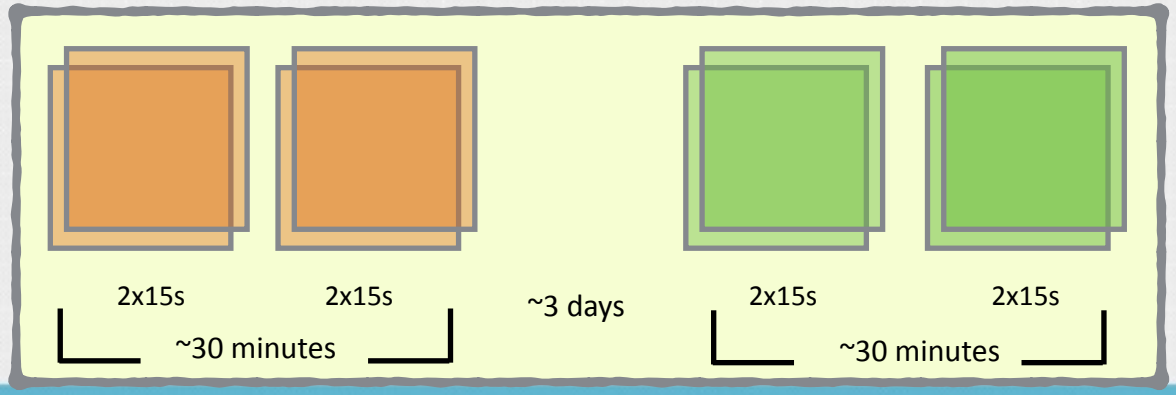


Deep, wide, fast: Pick any three

- **Wide:**
  - 18,000+ deg^2
  - 6 bands (ugrizy)
  - ***3.2 gigapixel camera***
  - ~ 10 deg^2 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* ~ 24.5/visit; *r* ~ 27.5 total
  - ~ 0.67" seeing

- **~ 10 million transient alerts per night**
- **Alerts distributed within 60s of visit**



Petascale Computing, Gbps Networks

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

Archive Site and U.S. Data Access Center
NCSA, Champaign, IL

Base Site and Chilean Data Access Center
La Serena, Chile

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)

Data products:

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

Three levels of LSST data products

Level 1

- 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.

Level 2

- 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.

Level 3

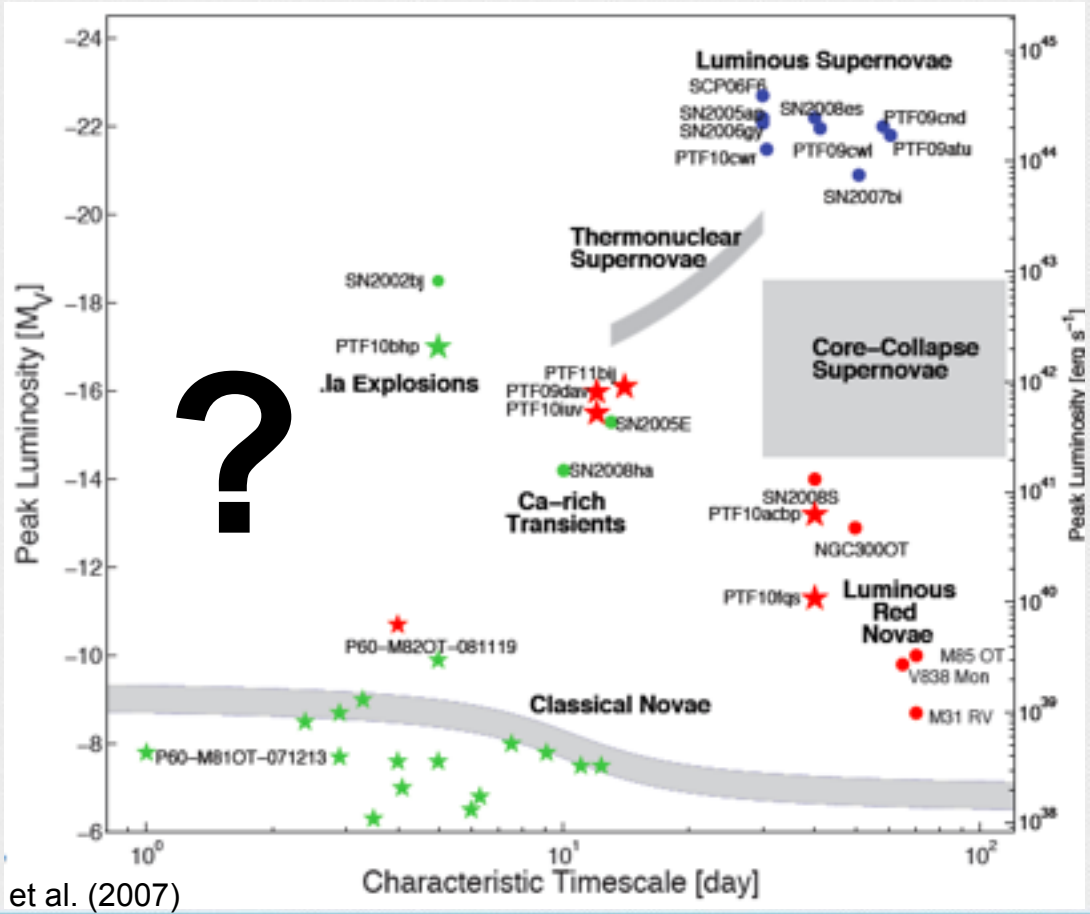
- Services and computing resources at the Data Access Centers to enable user-specified custom processing and analysis.
- Software and APIs enabling development of analysis codes.

Level 1 Overview

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

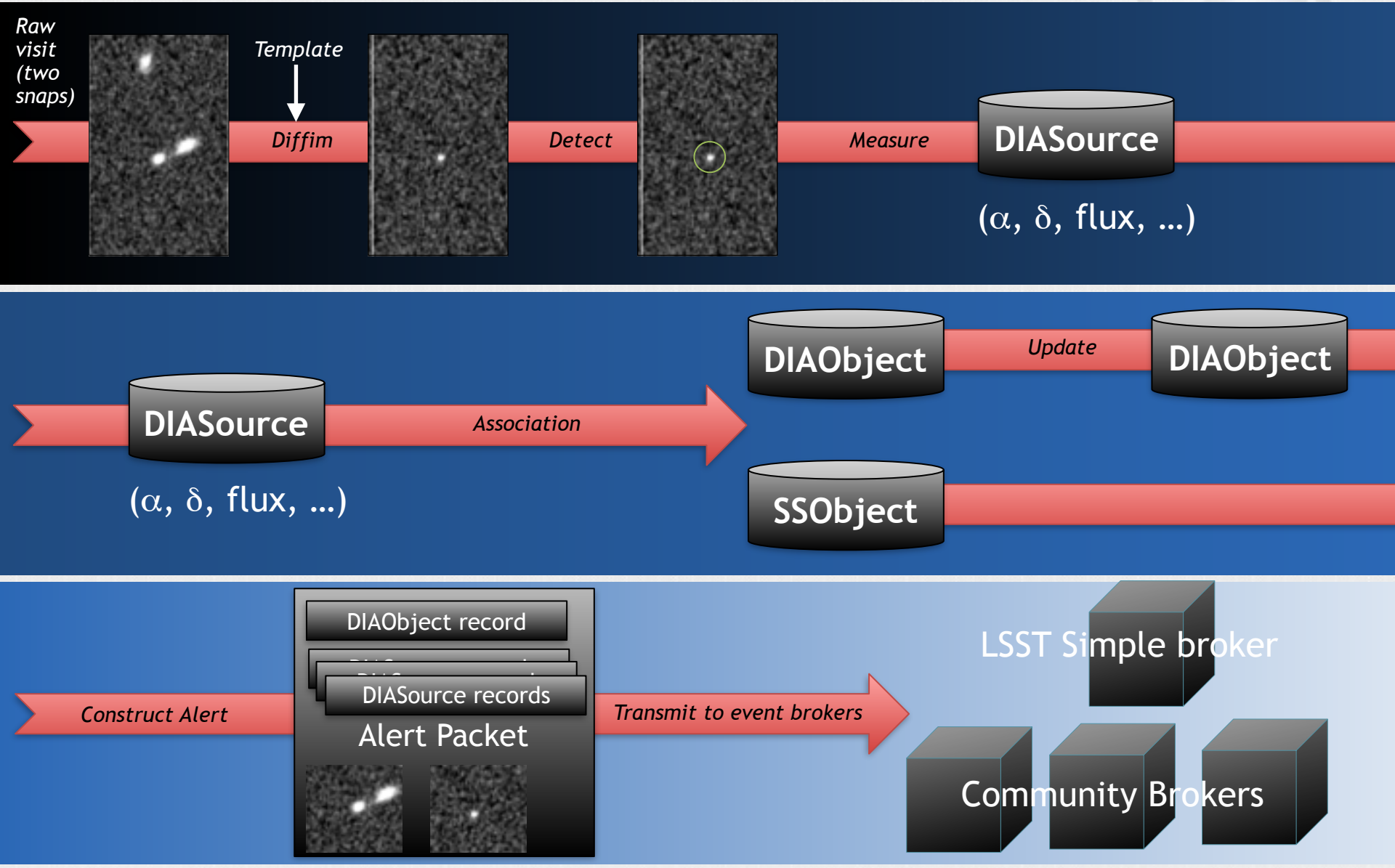
- **Transient science**
  - Nova, supernova, GRBs
  - Source characterization
  - Instantaneous discovery

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



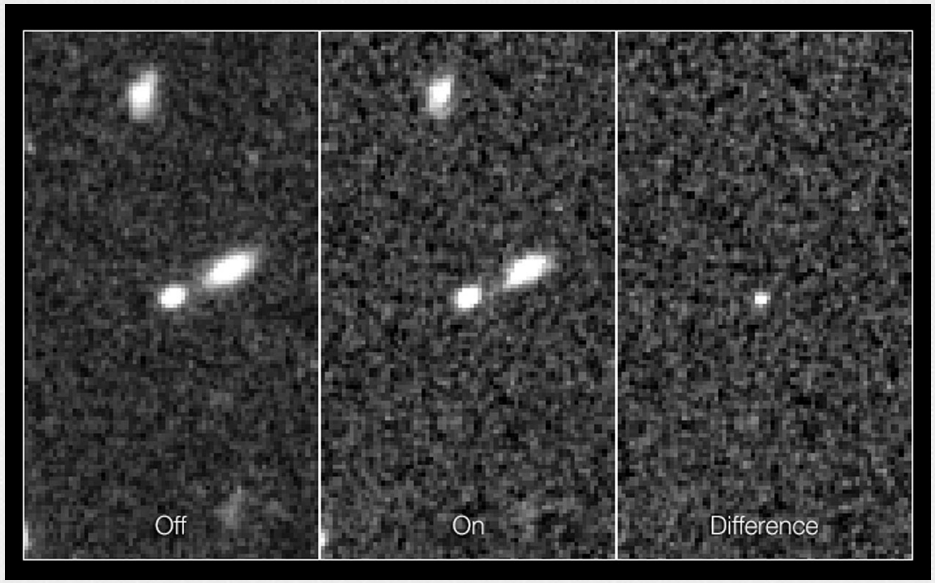
adapted from Kulkarni et al. (2007)

Alert Production: Pipeline overview



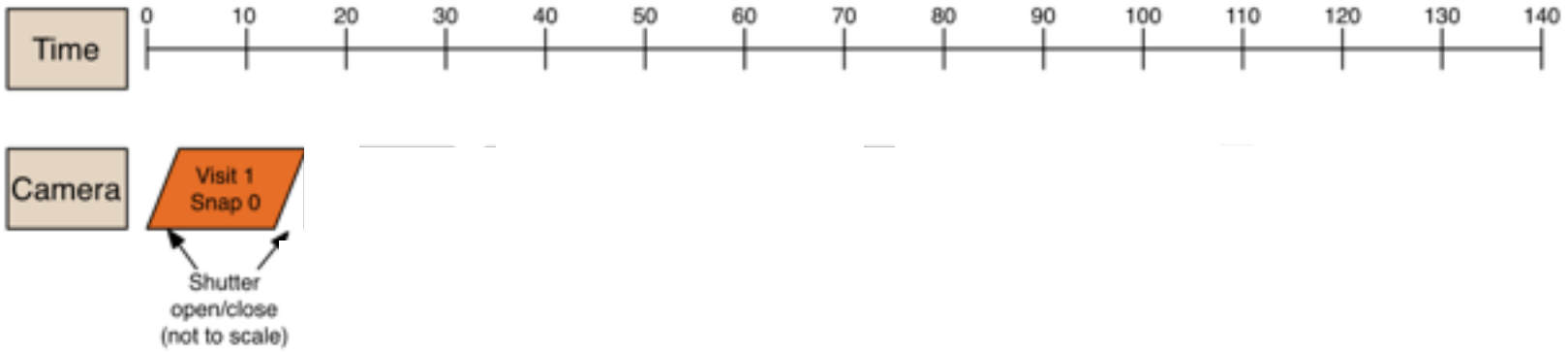
Level 1: Alerts

- 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)

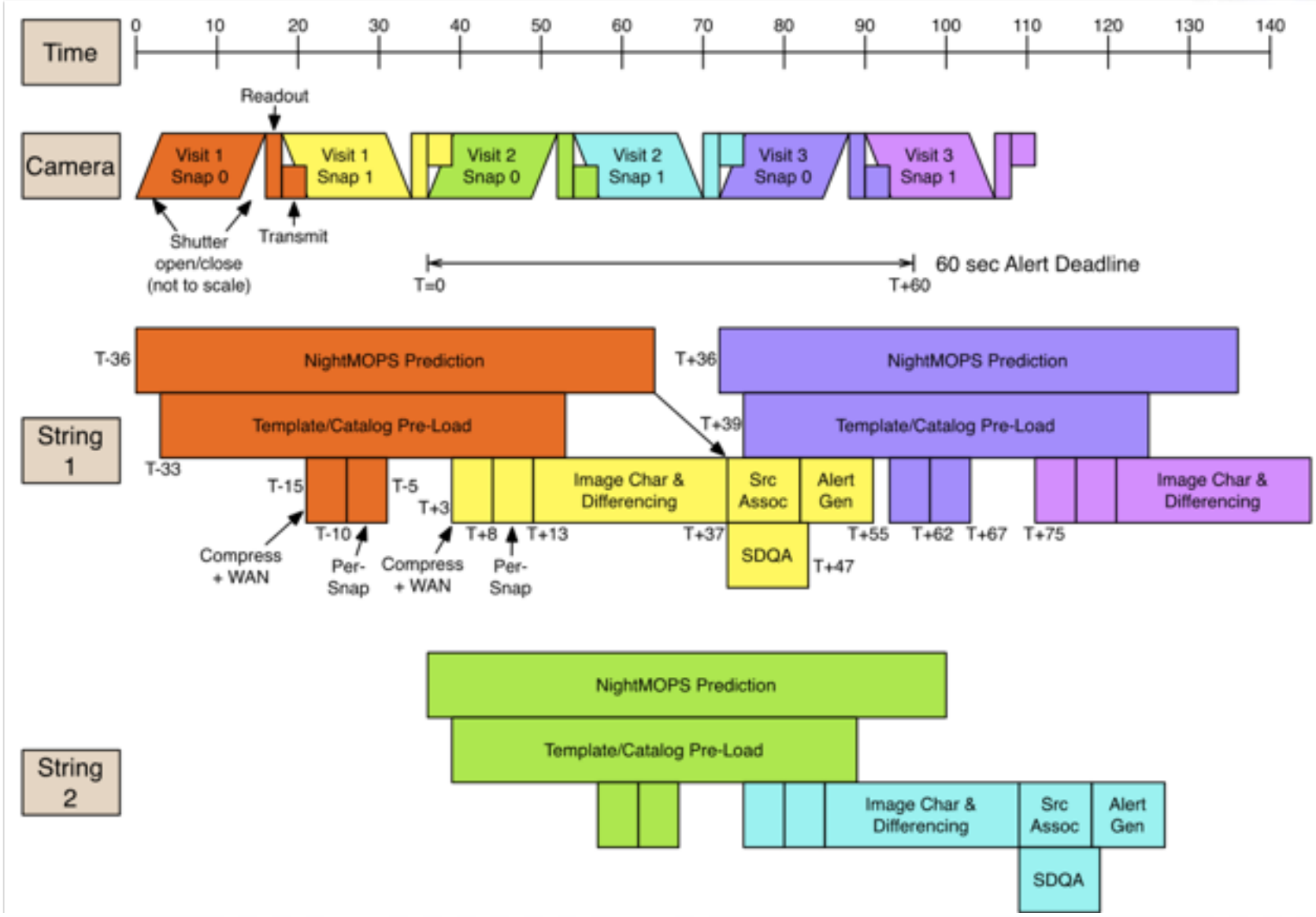


– *LSST Data Products Definiton Document*: ***http://ls.st/dpdd***

Level 1 Processing: System Architecture

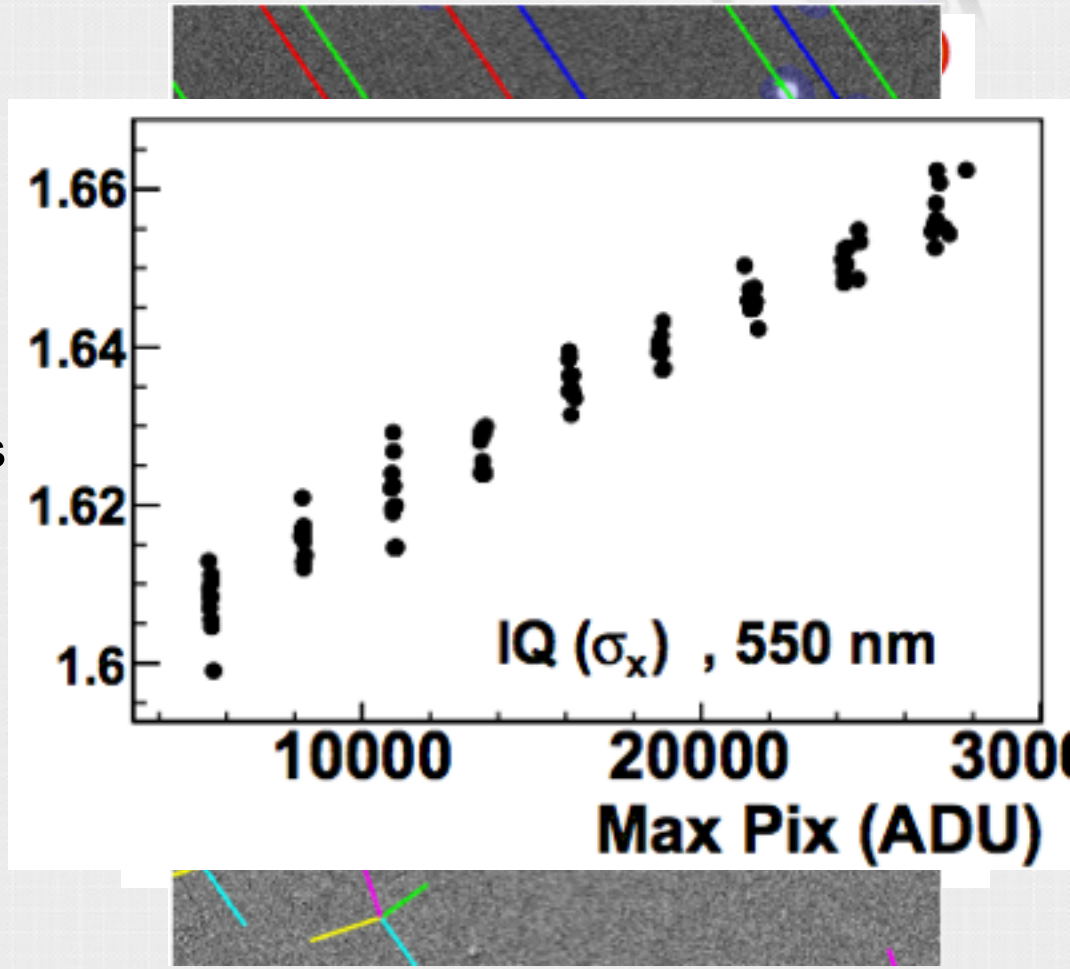


Level 1 Processing: System Architecture



Challenges and Progress

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



Becker et al. 2014

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.