Overview & Status of LSST

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Overview of LSST

Not “just” a telescope

- An integrated survey system:
  - A wide field survey telescope
  - The “world’s biggest digital camera”
  - Automatic scheduling & operations
- A decade-long survey
- Fully reduced data products
- An interactive data access & analysis environment
Overview of LSST

The Deep, Wide, Fast Survey

- Starting 2022
- Running for a 10 years
- 18000+ deg²
- 30s exposure time per visit
- ~825 visits per point
  - ~50 to ~200 per filter
- \( r_{AB} \sim 24.5/\text{visit}; \quad r_{AB} \sim 27.5 \text{ total} \)
- Detailed survey strategy still being developed

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**Diagram**: Sky coverage for the LSST baseline cadence, showing regions of high and low visitation rates.

*Ivezic et al., arXiv:0805.2366*
Telescope & Site

Progress on the summit

- Summit facility building completed March 2018
- Dome due late this year
Telescope & Site

Telescope Mount Assembly

- 300 ton moving structure
- 10 deg / second rotation
- 10 deg / sec\(^2\) acceleration
- Under construction by Asturfeito, S.A., Spain
- Assembly on the mountain in late 2018
- Photo: April 2018
Telescope & Site

**Mirrors**

- M1M3 polished in 2014
- Integration activities ongoing in Tucson
- On summit mid-2019
- M2 mirror & assembly on track for shipping from vendor October 2018
Telescope & Site

Auxiliary Telescope

- 1.2 m telescope, in its own dome next to LSST
- Spectrophotometric measurements of stars to probe atmospheric absorption in support of LSST calibration
- Telescope now on site; spectrograph in the lab in Tucson
- First light expected early 2019
Camera

Basic Parameters

- 3.2 Gigapixels
- ~7.2 GB per exposure
- 2 second readout
- 0.2 arcsec pixels
- 1.65 by 3 metres; 2800kg
- Size of a small car
Camera

**Focal Plane**

- 63 cm diameter
- 189 sensors packed into 21 “rafts” of 9 sensors each
- 4k by 4k pixel sensors
- 2 second readout time
- Cooled to 173 K
- Raft Electronics Board (REB) make each raft a ~150 MPix camera
Sensors & Rafts

- Sensors fabricated by two vendors
- Procurement almost complete
- 242 sensors accepted (including reserves)

- 10 rafts assembled and accepted
- All science rafts expected to be complete in January 2019
Camera

Optics

• L1 & L2 lenses polished and accepted for coating
• L3 polishing in progress; coating expected mid-2018
• Filter fabrication and coating contracts in place; filters currently in production.
Commissioning Camera

- Equivalent to a single raft of the full LSST camera
- Used in system integration & early commissioning activities
- Delivery on track for Jan 2019; on summit mid-year
Data Management
The DM System

Prompt Data Products
via nightly alert streams

Average 10 million alerts per night
Issued within 60 s of shutter close

20TB raw data per night
(with calibration exposures)

Data Release Data Products
via annual data releases

11 Data Releases in 10 years
Final database catalog: 15 PB

Alert database & “mini-broker”

Current & previous data releases

LSST Science Platform

Data access & end-user computing
Data Management

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.
- A catalog of ~37 billion objects (20B galaxies, 17B stars), ~7 trillion observations ("sources"), and ~30 trillion measurements ("forced sources"), produced annually, accessible through online databases.
- Deep co-added images.
- Services and computing resources at the Data Access Centres to enable user-specified custom processing and analysis.
- Software and APIs enabling development of analysis codes.
Data Management

Complex Image Processing

- SDSS image of the COSMOS field from Lupton et al (2004)
- ~ 3.5’
Complex Image Processing

- Hyper Suprime-Cam data
- PSF matched coadd
  - 1.5 hours in g, r
  - 3 hours in i
- Reaching approx 10 year LSST depth
- Image processing performed with prototype of LSST codebase

Image: HSC Collaboration & Robert Lupton
Refer to LSE-163 for details of what all these products are. https://ls.st/lse-163
Prompt Data Processing

1. Incoming data is reduced to a *Processed Visit Image* (CR rejection, calibration, etc).
2. PVI is *differenced* against a deep template and *DIASources* are detected on the diffim.
3. Flux and shape of each DIASource are measured on the diffim, and PSE photometry on the PVI for total flux.
4. DIASource is matched against known *DIAObjects* and *SSObjects*.
5. If the DIASource corresponds to a known SSOBJECT, an alert is issued incl. details of the associated SSOBJECT and further processing proceeds in daytime.
6. Otherwise, the new DIASource is used to update the corresponding object record, or a new object record created, and an alert issued incl. details of the associated object.
7. *Forced photometry* is performed on the position of all new DIAObjects within 30 days.

Leanne's talk next, for details of the alert stream.
Data Management

Moving Object Processing

• During the day, we:
  • Recompute orbits of known SSObjects;
  • Refine association of DIASources with SSOObjects;
  • Search for new SSOObjects based on unassociated DIASources.

Mario's talk at 11:00 for details of MOPS.
None of the Science Pipelines are yet complete... but many parts of the system are quite usable.

- **Primitives and Algorithms**
  - A rich collection of high-performance tools for working with astronomical data you can pick up and use today.

- **Data Release Processing**
  - Pipelines regularly being used to reprocess Hyper Suprime-Cam data (and make their data releases).

- **Alert Production**
  - Currently running small-scale tests on DECam data; rapidly scaling over the rest of this year.

- **Moving Objects**
  - Solid basis of algorithmic research completed; development of code to be deployed for LSST gearing up this year.
Data Management

Processing and Data Access

- Petascale computing facility under construction at NCSA (Illinois) to host the bulk of LSST computing and data access
- Satellite system at CC-IN2p3 (France)

- Science Platform based on Firefly, JupyterLab, IVOA protocols now becoming a reality
- Now being used by Commissioning Team
The mission of LSST's EPO is to provide non-specialists with access to a subset of LSST data through accessible & engaging online experiences, so that anyone can explore the universe and be part of the discovery process.

Audiences:
- Formal educators teaching astronomy content at the advanced middle school, high school or college level.
- Citizen science principal investigators.
- Content developers at informal science centers & planetariums.
- Science-interested teens & adults.
Overall Status

“Earned Value” summary

Fractional Completion
Telescope & Site 72%
Camera 81%
Data Management 40%
EPO 24%
Commissioning 24%

Based on April 2018 Data
Overall Status

Timeline to full operations
Conclusions

LSST construction is on track

- All subsystems are making rapid progress
- The DM team already has software capable of doing great science
- This is a super exciting time to be involved with LSST!
- Best wishes for a productive & enjoyable week!