Big Software for Big Data: Scaling Up Photometry for LSST

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LSST Data Management

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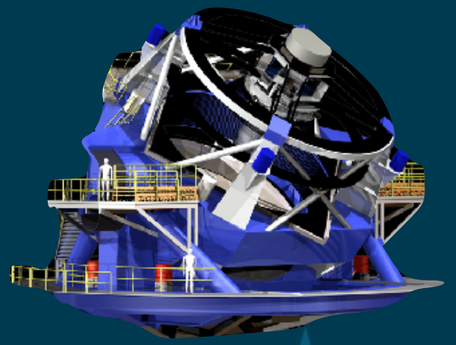
A Dedicated Survey Telescope



- In 2022, LSST will begin imaging the sky for 10 years
- The ultimate deliverable is fully reduced data for **YOU**
- Software is free and open source

field of view	3.5° radius
pixel count	3.2 Gigapixels
visit exposure	30 seconds
readout time	2 seconds

filters	*u*	*g*	*r*	*i*	*z*	*y*
visits per field	56	80	184	184	160	160
visit mag depth	23.9	25.0	24.7	24.0	23.3	22.1
survey mag depth	26.1	27.4	27.5	26.8	26.1	24.9

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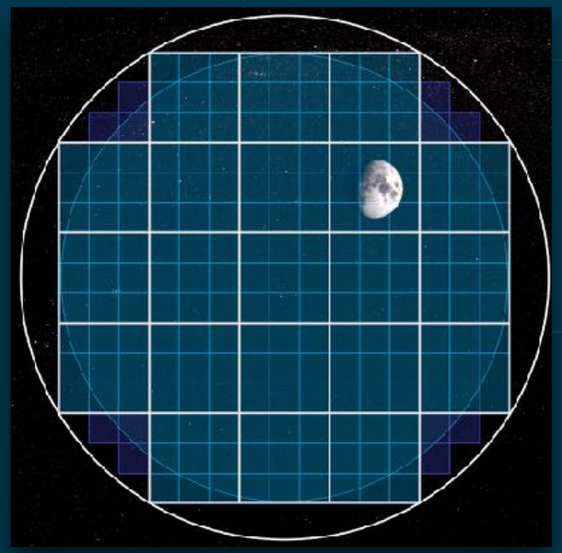
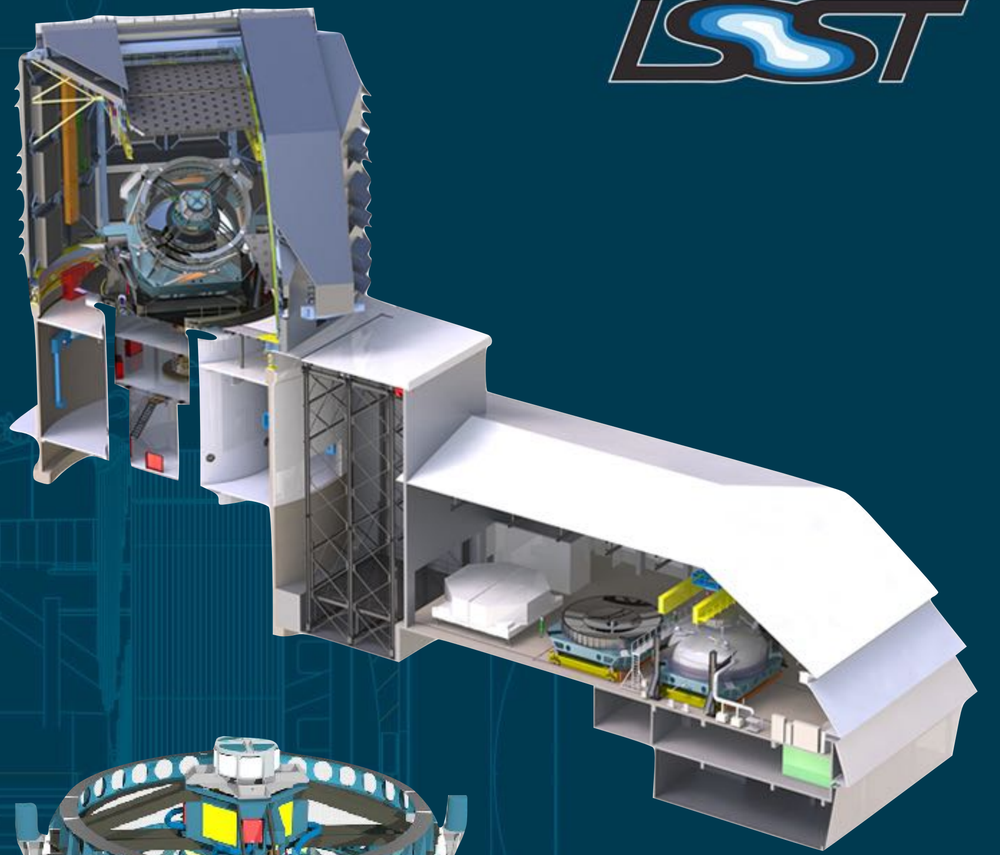
Facility and Hardware





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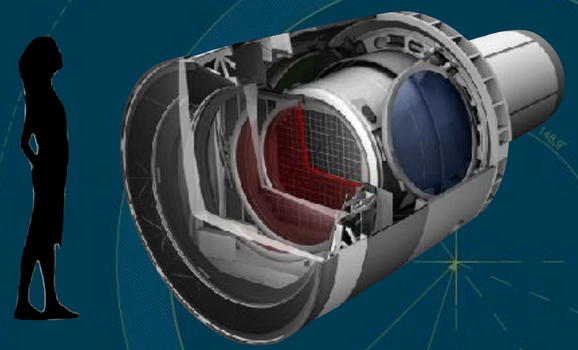
Camera



Utility trunk

Cryostat

CCDs

Filter changer

Shutter

L2 + L3 lens

L1 lens

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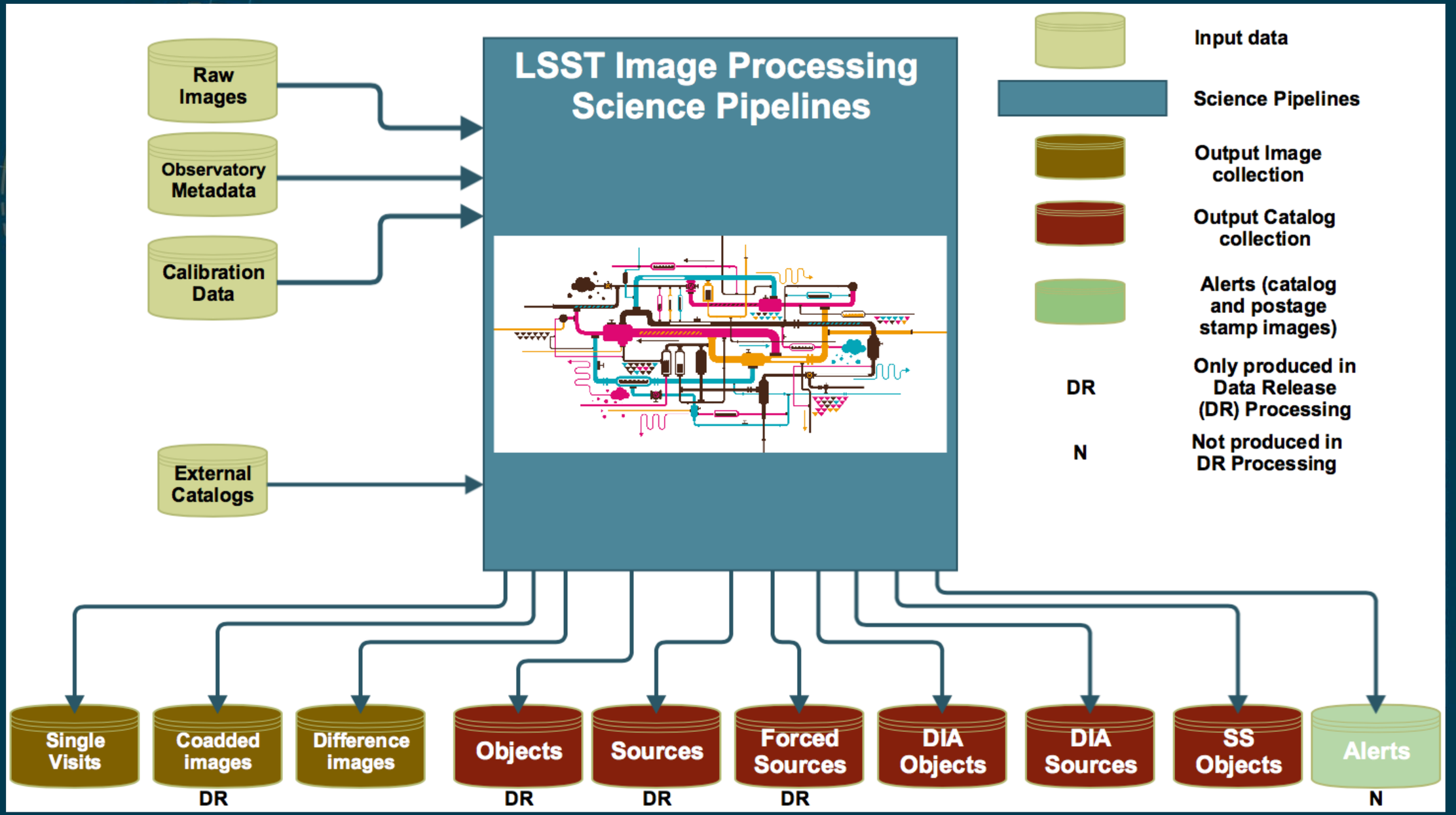
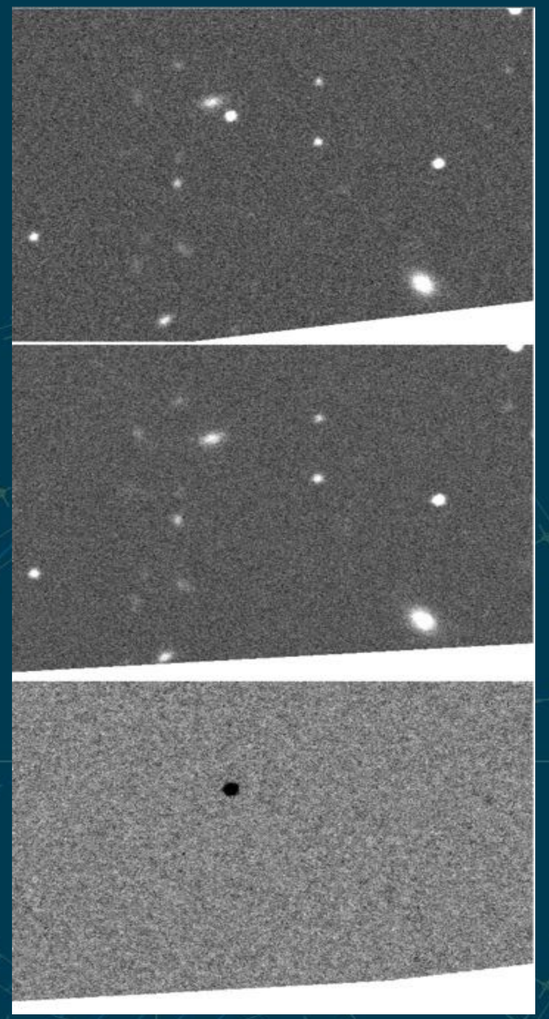
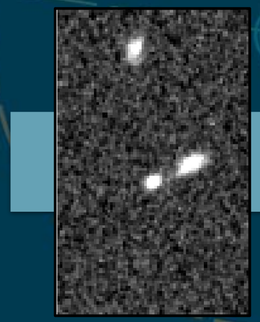

Raw Images
Observatory Metadata
Calibration Data
External Catalogs
LSST Image Processing Science Pipelines
Input data
Science Pipelines
Output Image collection
Output Catalog collection
Alerts (catalog and postage stamp images)
DR
Only produced in Data Release (DR) Processing
N
Not produced in DR Processing
Single Visits
Coadded images
Difference images
Objects
Sources
Forced Sources
DIA Objects
DIA Sources
SS Objects
Alerts
DR
DR
DR
DR
N

A Next-Generation Data Processing System

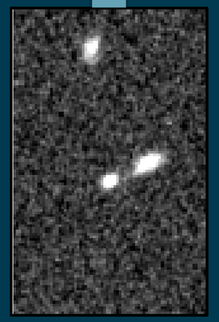
- Nightly Difference Imaging - **Level 1**
  - Testing with Dark Energy Survey Camera (DECam) and Hyper Suprime-Cam (HSC)
  - Alerts will enable rapid follow-up of events
- Annual Data Releases - **Level 2**
  - Deep co-added images and source catalogs



Level 1 Pipeline

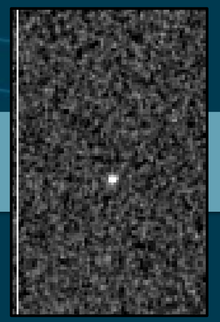


Visit

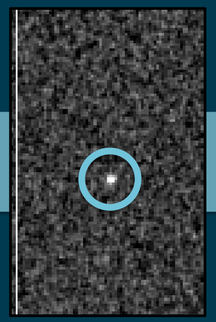


Template

Difference



Detect



Known Solar System Objects

Known Extrasolar Objects

Associate

Object Record

Transmit

Alert Brokers

- Position
- Flux, size, and shape
- History
- Variability characterization
- “Postage stamps”

0 seconds

60 seconds

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Shields up, red alert!

Nightly LSST alert stream

↓

Alert brokers

↓

Find follow-up objects

All of twitter

↓

Filtered search by hashtag

↓

Find interesting content

~60 kB/alert
~60 GB/night

- Alerts will include metadata, historical observations, and an image "postage stamp"
- Hierarchy of access systems via brokers
- Broadcast in a stream; archived in a database

The LSST Software Stack

- Python modules with some C++ to process, generate, and serve images, catalogs, and alerts
- Upgrade to Python 3 nearly complete
- The basis for "Level 3" community processing
- Active, open development at github.com/lsst
- Latest release version at pipelines.lsst.io

"The Stack" (to scale)

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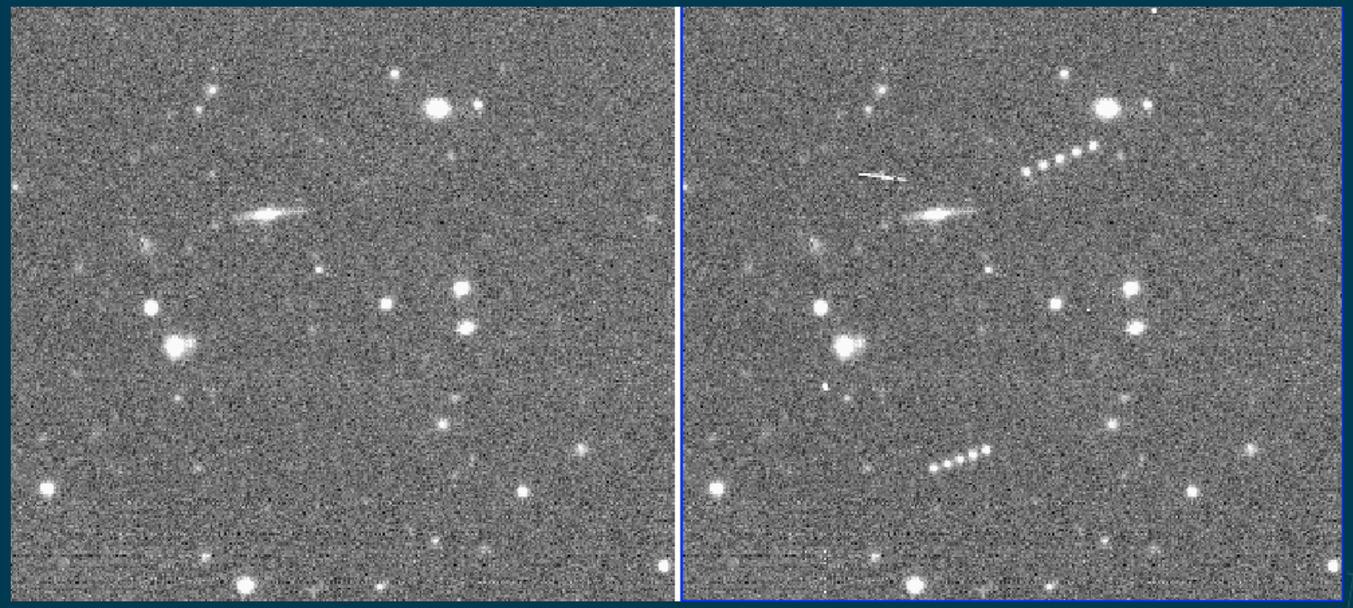
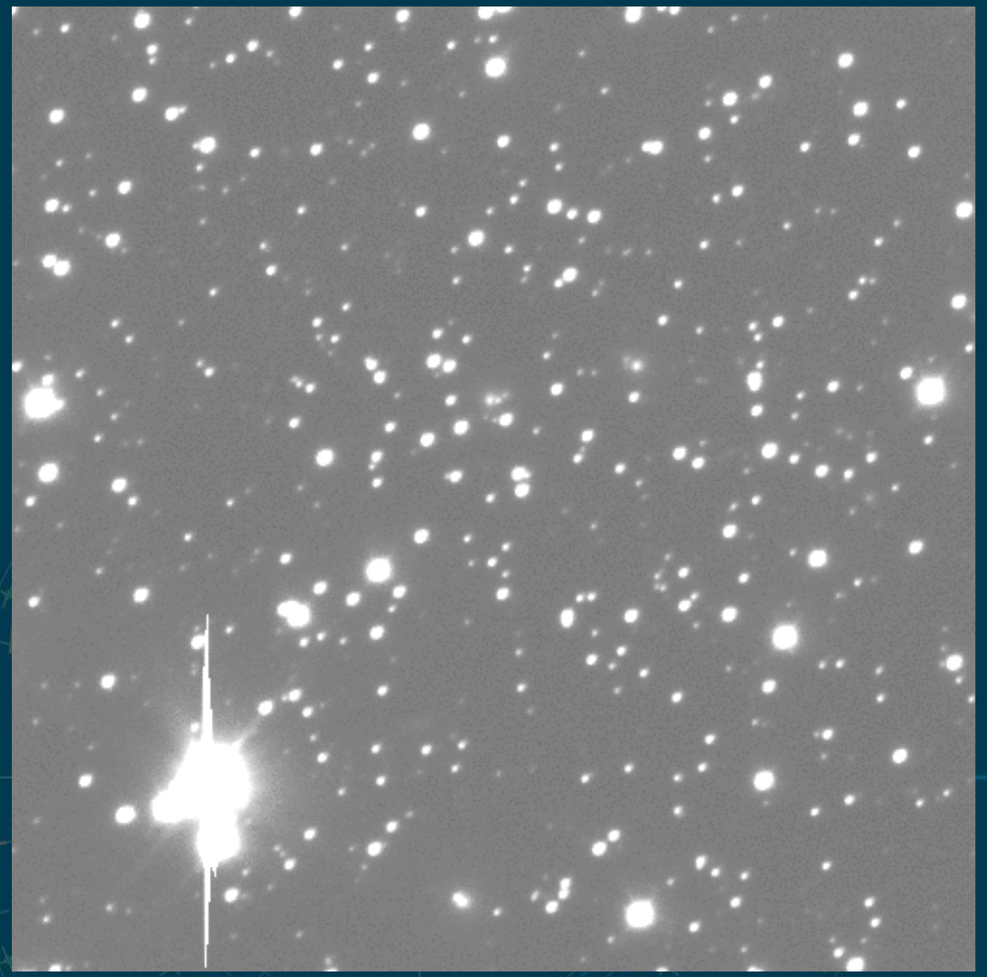
Stacked images and movies

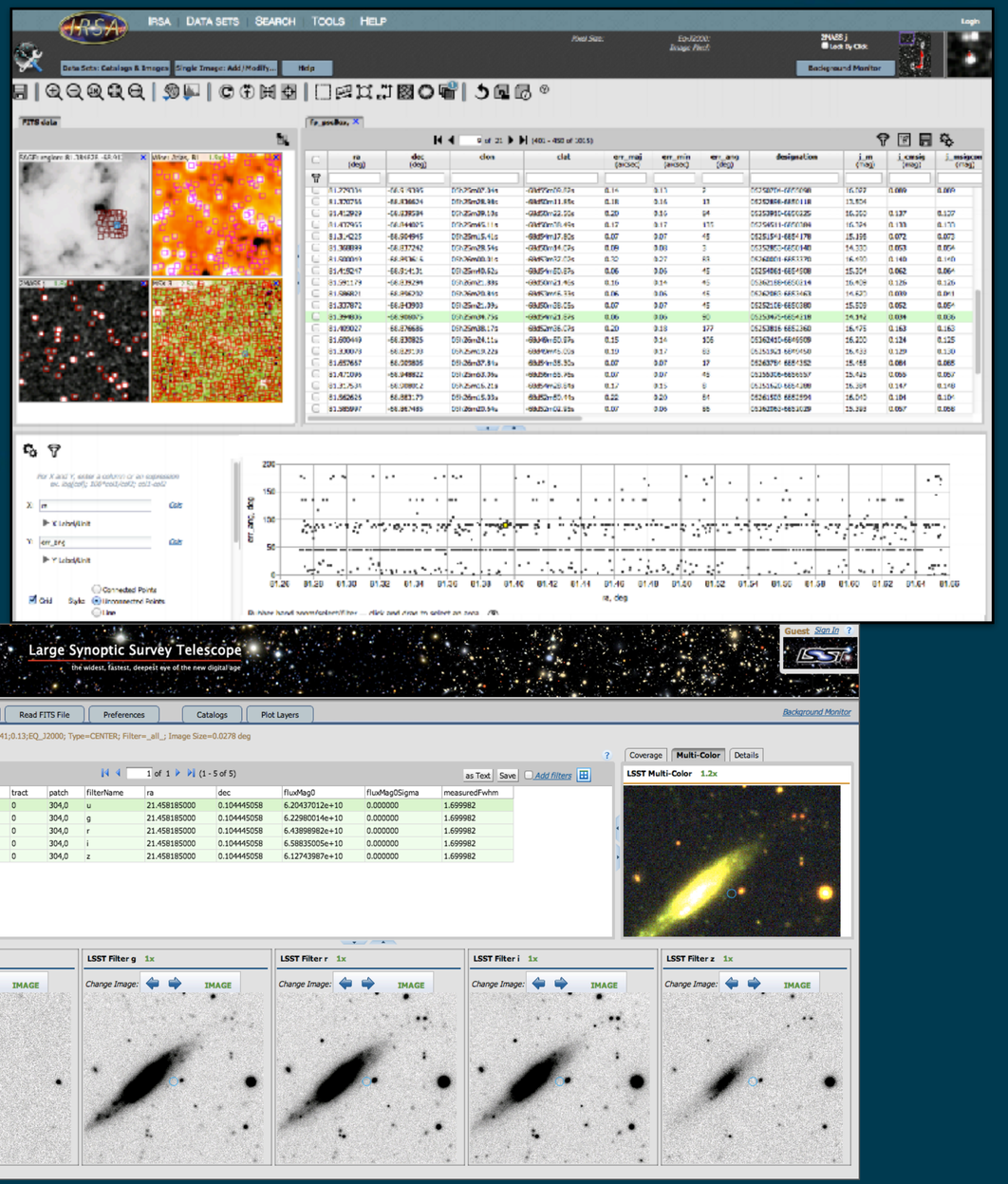




Asteroids: one person's nuisance
is another one's science!

Future data portal - SUIT

- **S**cience **U**ser **I**nterface and **T**ools
- Web and machine interfaces to database
- Toolkit, workspace, portal to processed data (no downloads)
- Search catalogs, manipulate images, create plots



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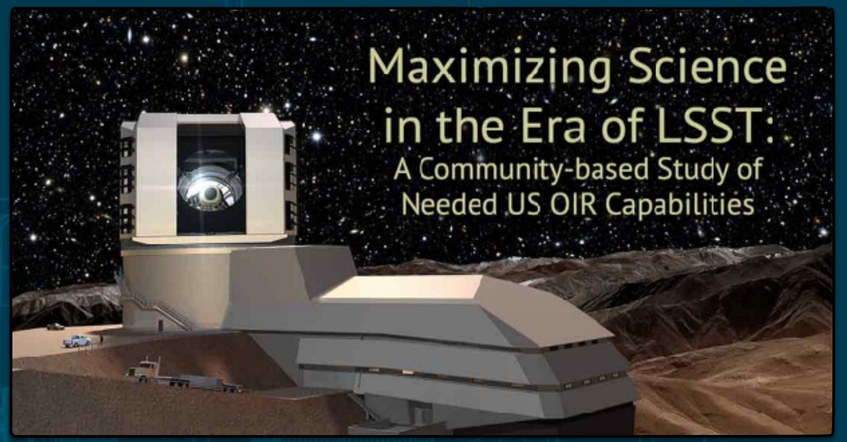
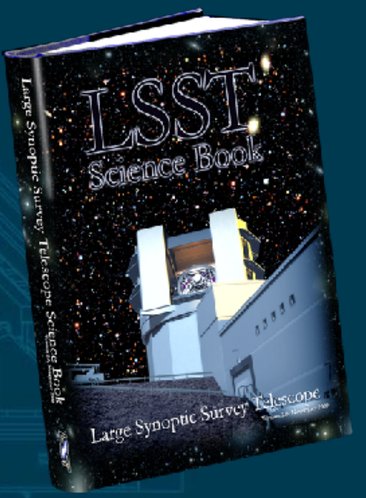
Tools for the community

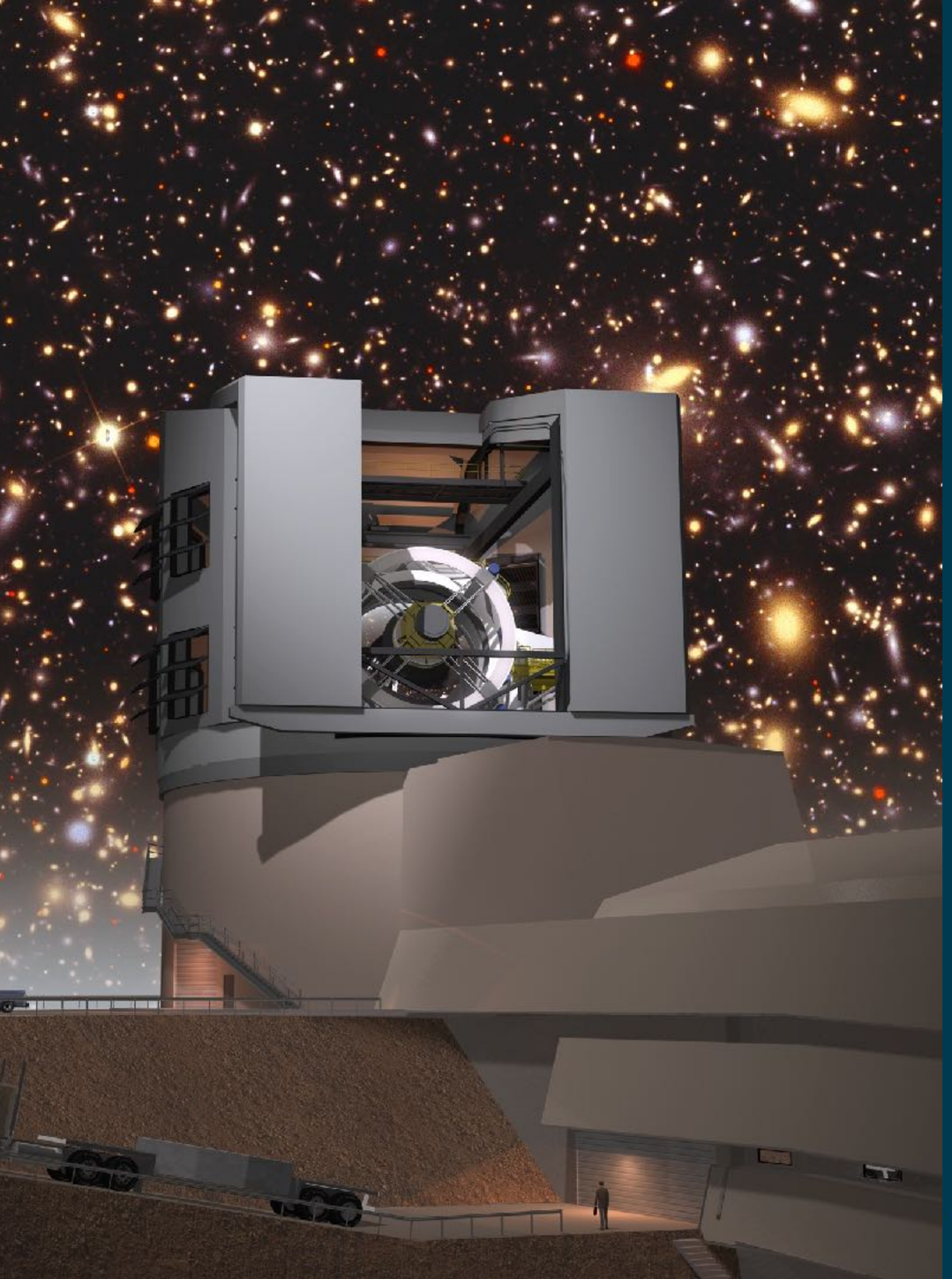
- Project project.lsst.org
- Conversation community.lsst.org
- Code github.com/lsst
- Documentation pipelines.lsst.io
- Development developer.lsst.io
- Science lsstcorporation.org/science-collaborations

noao.edu/meetings/lsst-oir-study



lsst.org/lsst/scibook





LSST begins in 2022

- Data products and software are for you
- Nightly alert stream, annual data releases, and community-driven pipelines
- Science collaborations and planning follow-up observations play a large role
- Please talk to me about what you would like to do with LSST!

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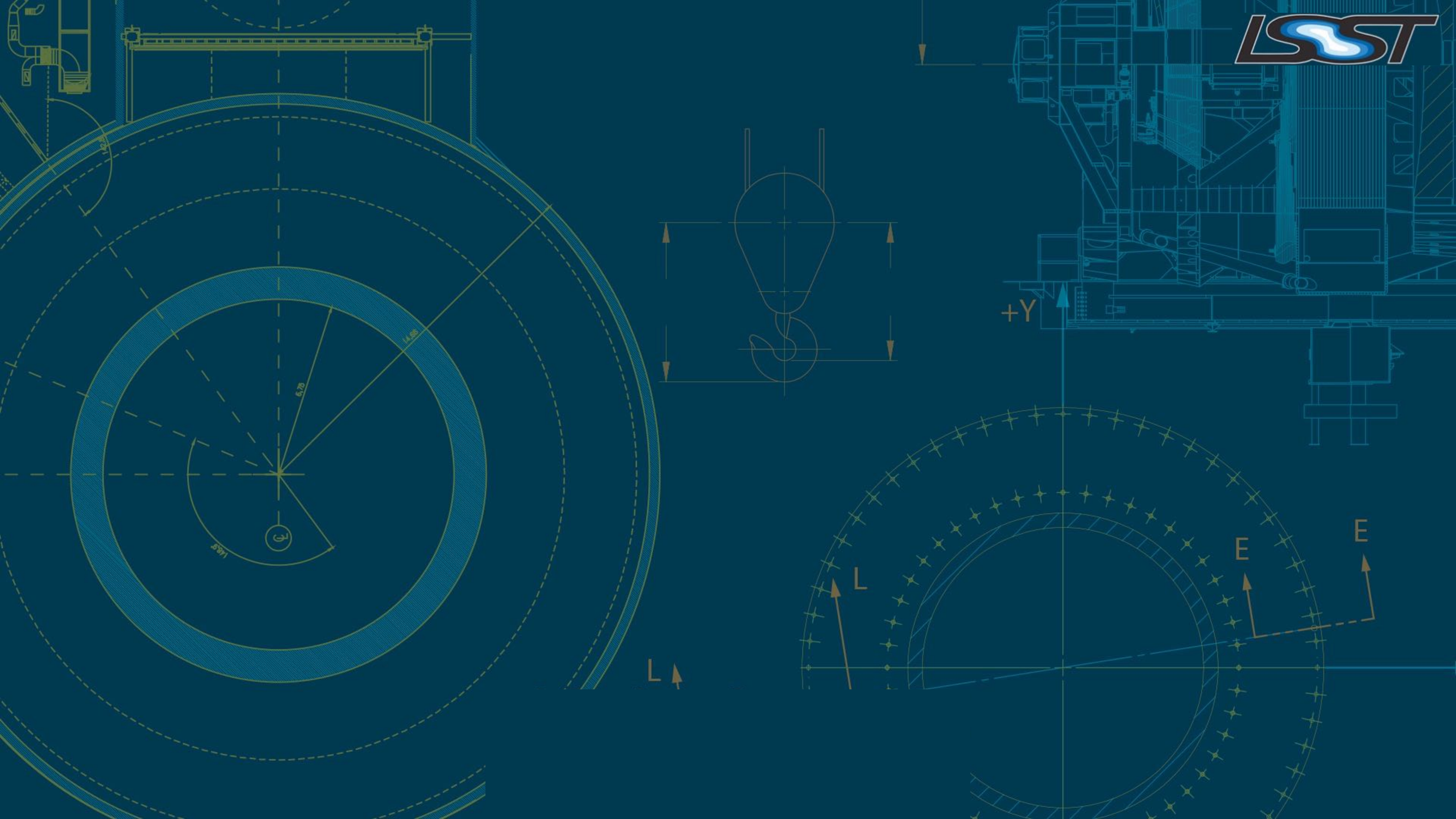
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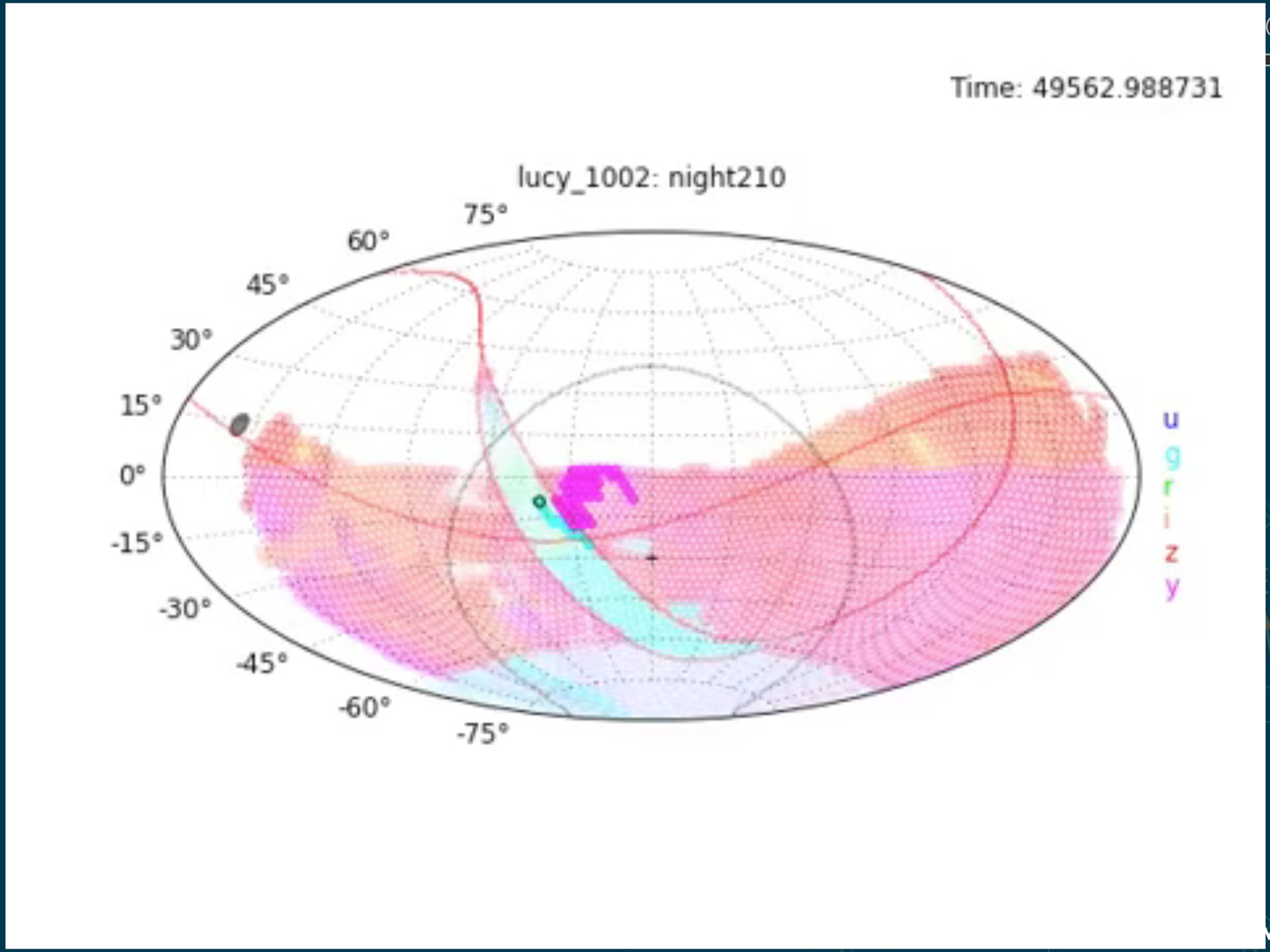
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60°
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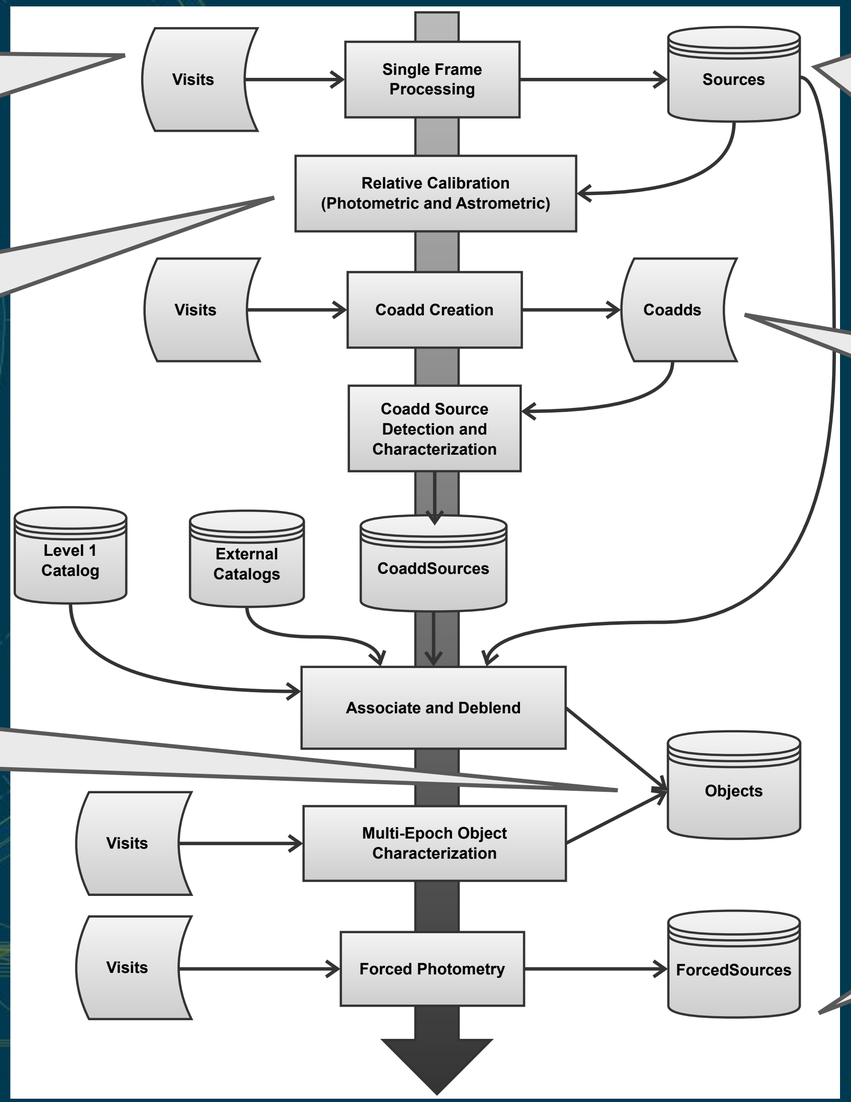
Release Processing

Single visit images
Raw exposures and processed frames

Calibration products
Darks, flats, biases, fringe, etc.

Object catalogue
Detailed, multi-epoch characterization; model fits, colors, centroids, fluxes, surface brightness, etc.



Source catalogue
Independent measurements on each exposure; high-SNR

Coadded images
Deep, short-period, best seeing, PSF-matched; those not stored generated on request

Forced photometry
Measure flux of every source on every visit and characterize the light curve for every object