# Overview & Status of LSST

John Swinbank • swinbank@lsst.org
Deputy Project Manager, LSST Data Management

LSST
Large Synoptic Survey Telescope

# 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**

# The Deep, Wide, Fast Survey

- Starting 2022

- Running for a 10 years

- 18000+ deg$^2$

- 30s exposure time per visit

- ~825 visits per point

  - ~50 to ~200 per filter

- $r_{AB}$~24.5/visit; $r_{AB}$~27.5 total

- Detailed survey strategy still being developed
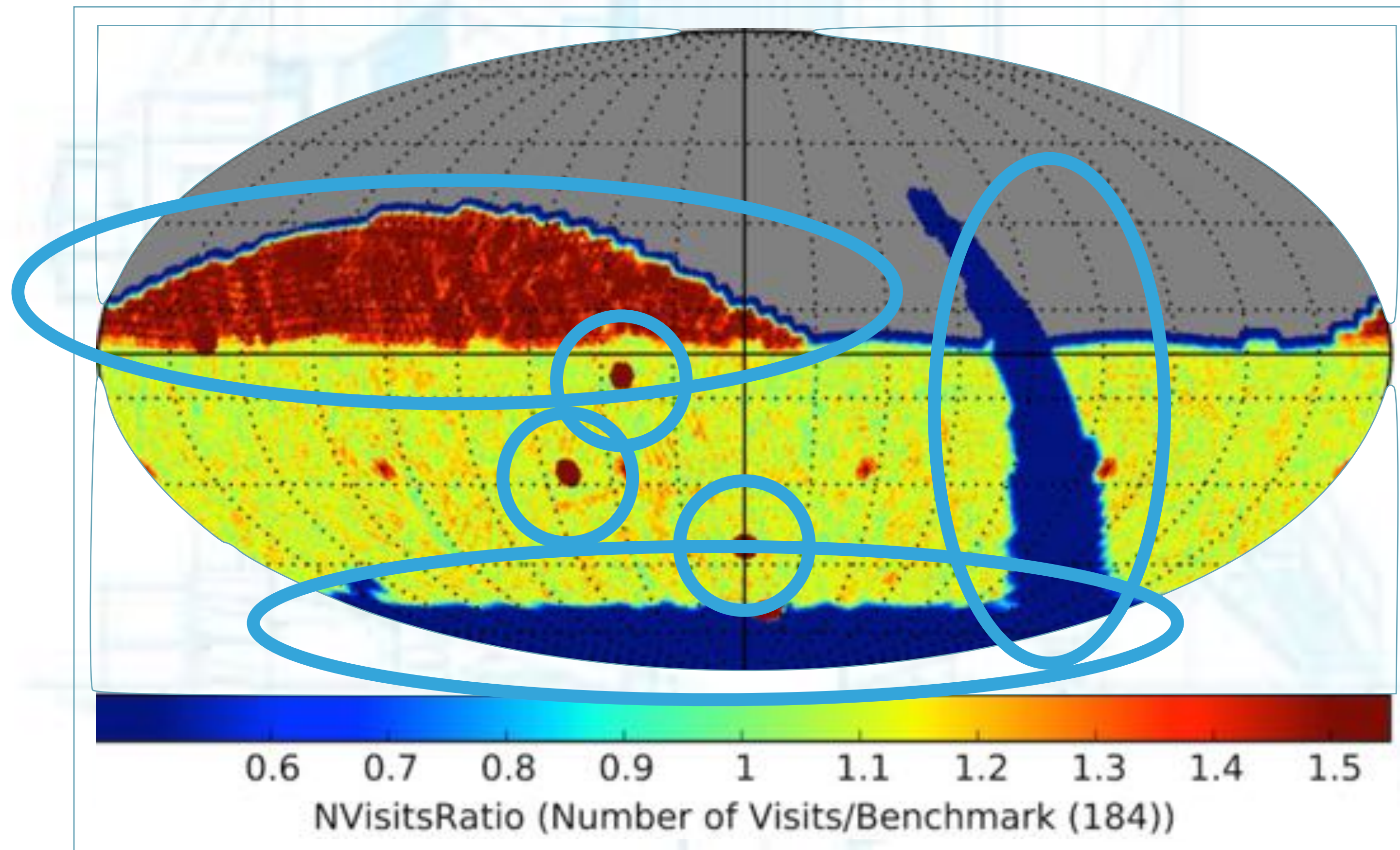


*Ivezic et al, arXiv:0805.2366*

# Progress on the summit



Rendering 2012

Photo May 2018

- Summit facility building completed March 2018

- Dome due late this year

# 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

# 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

M2

M1M3
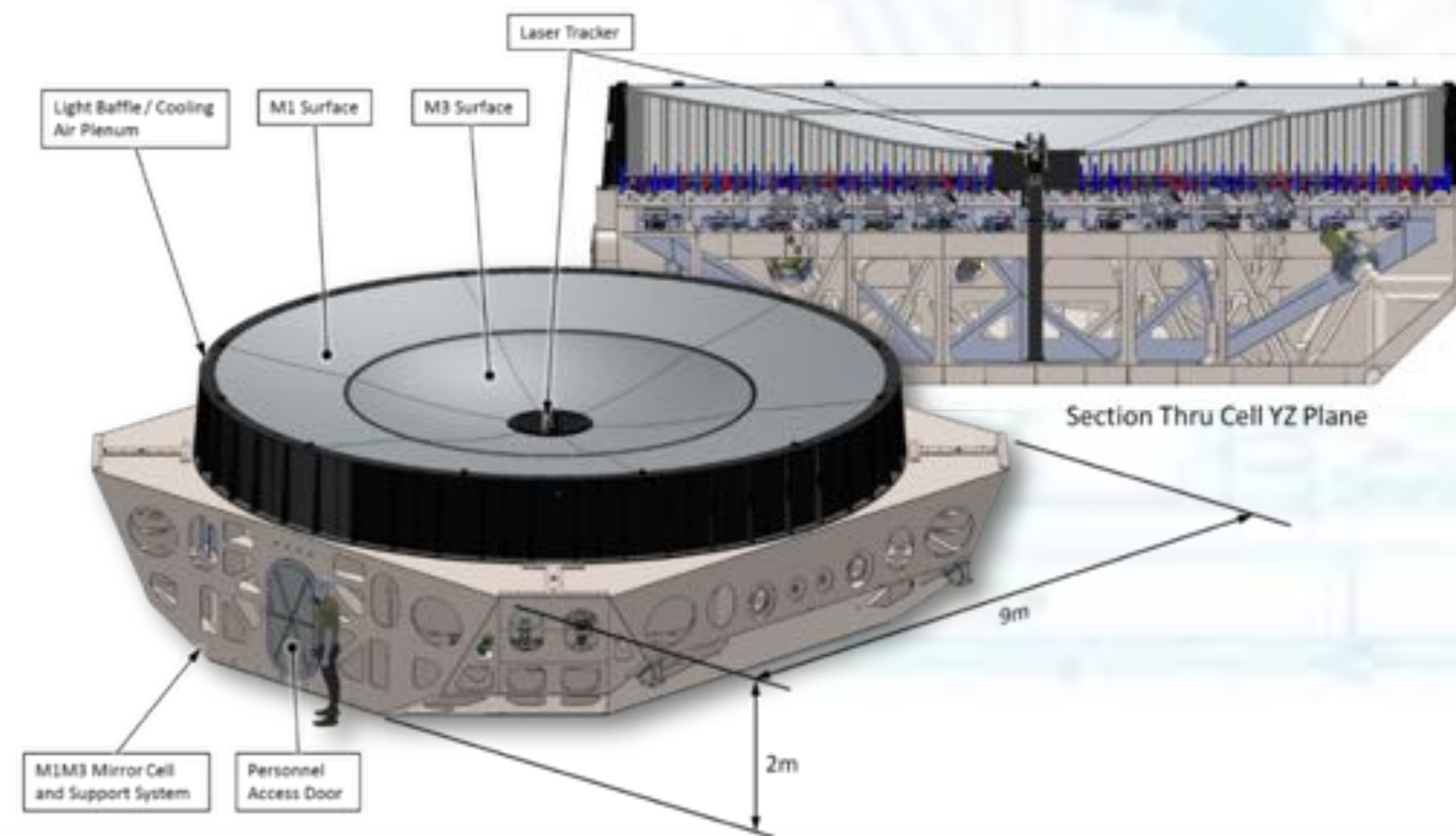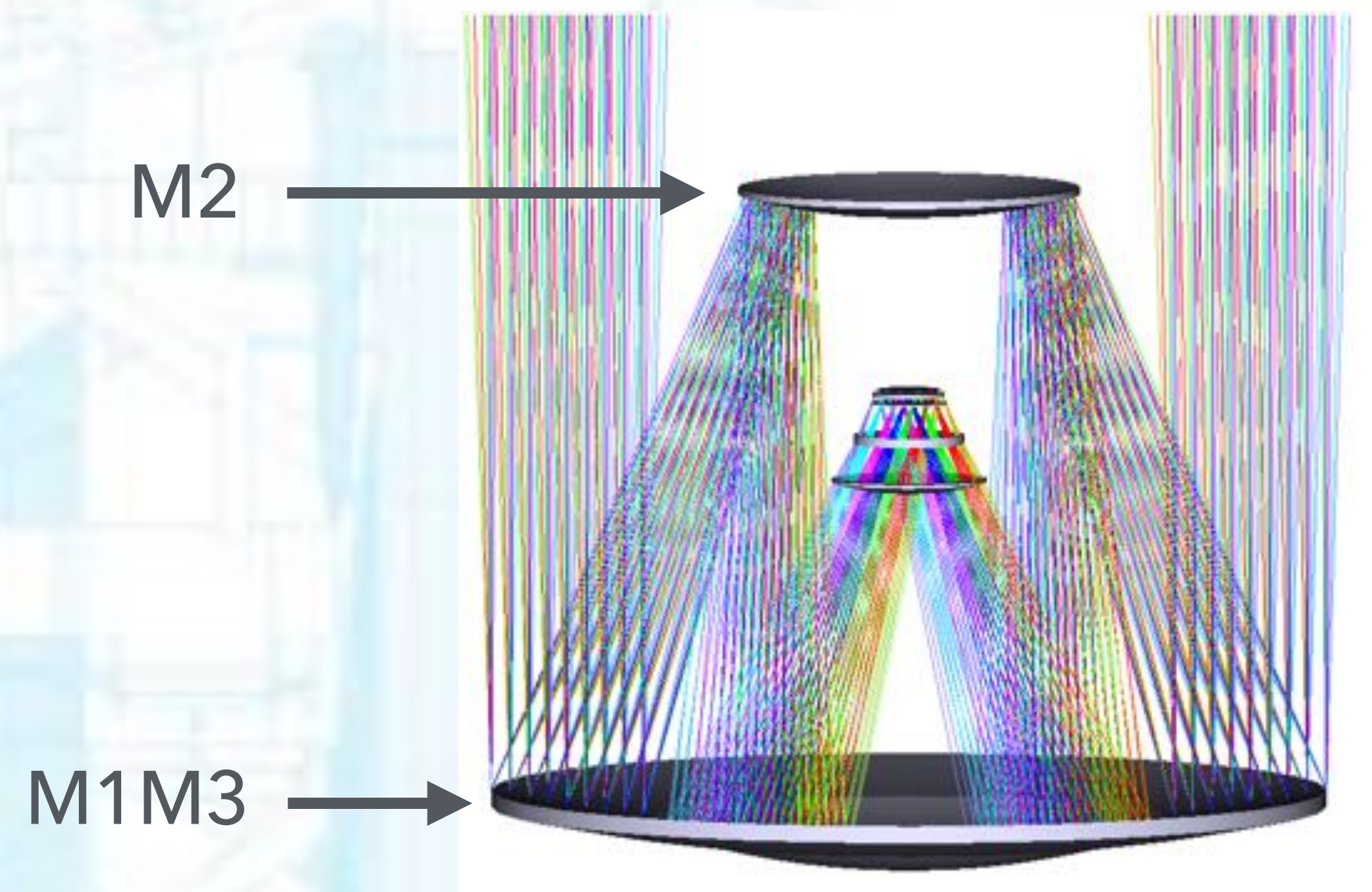
# Auxiliary Telescope

- 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
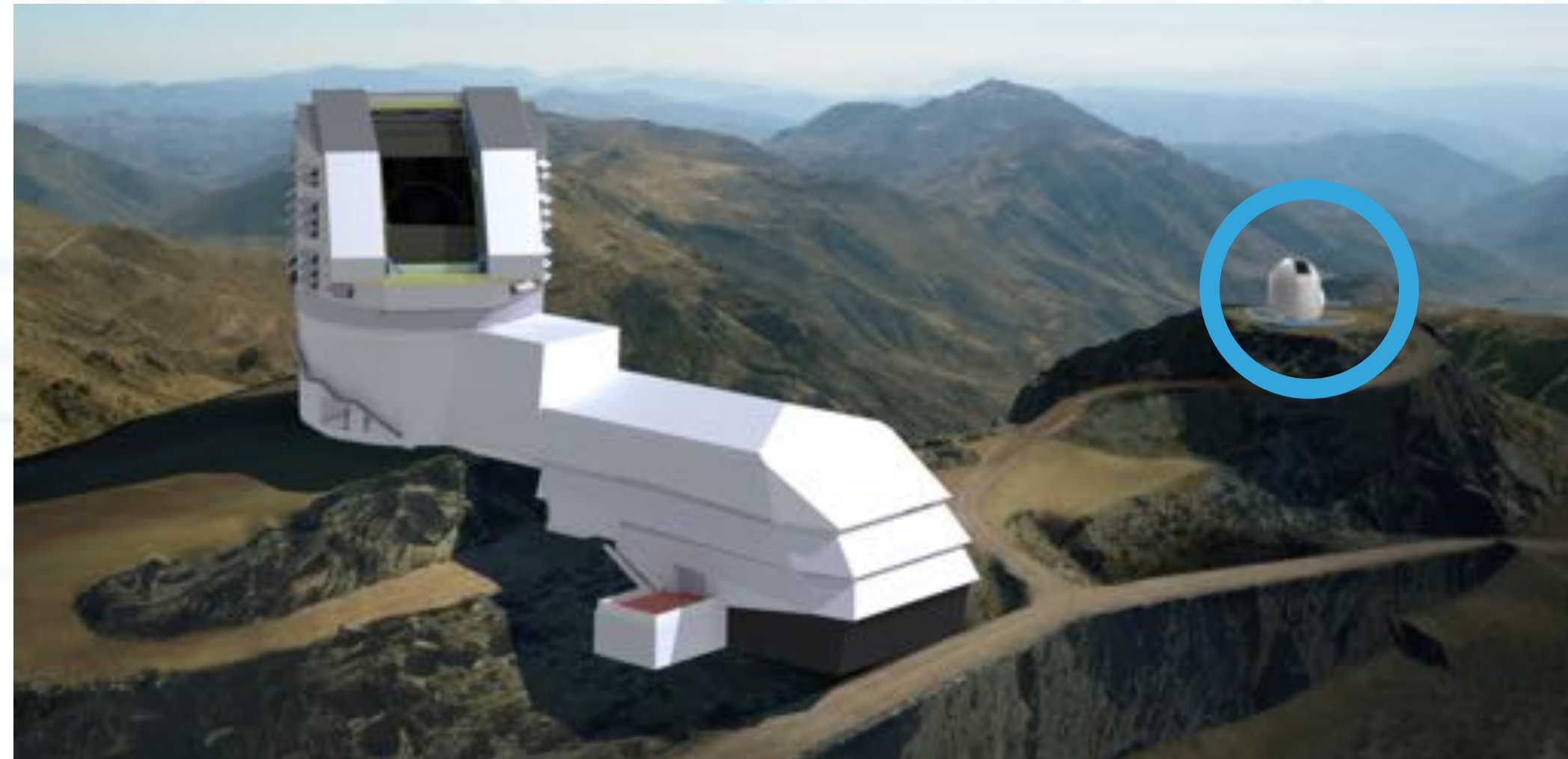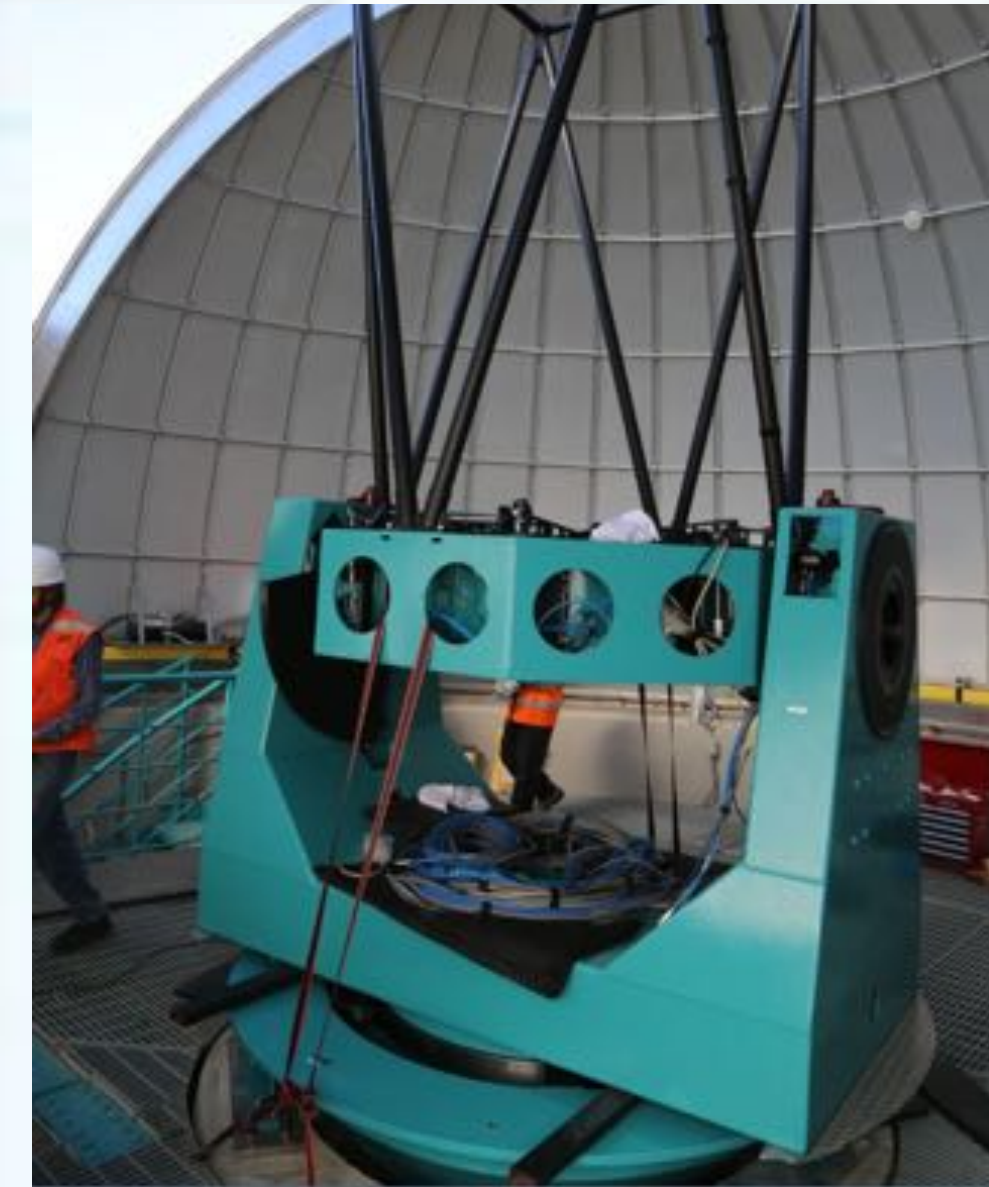
# Basic Parameters

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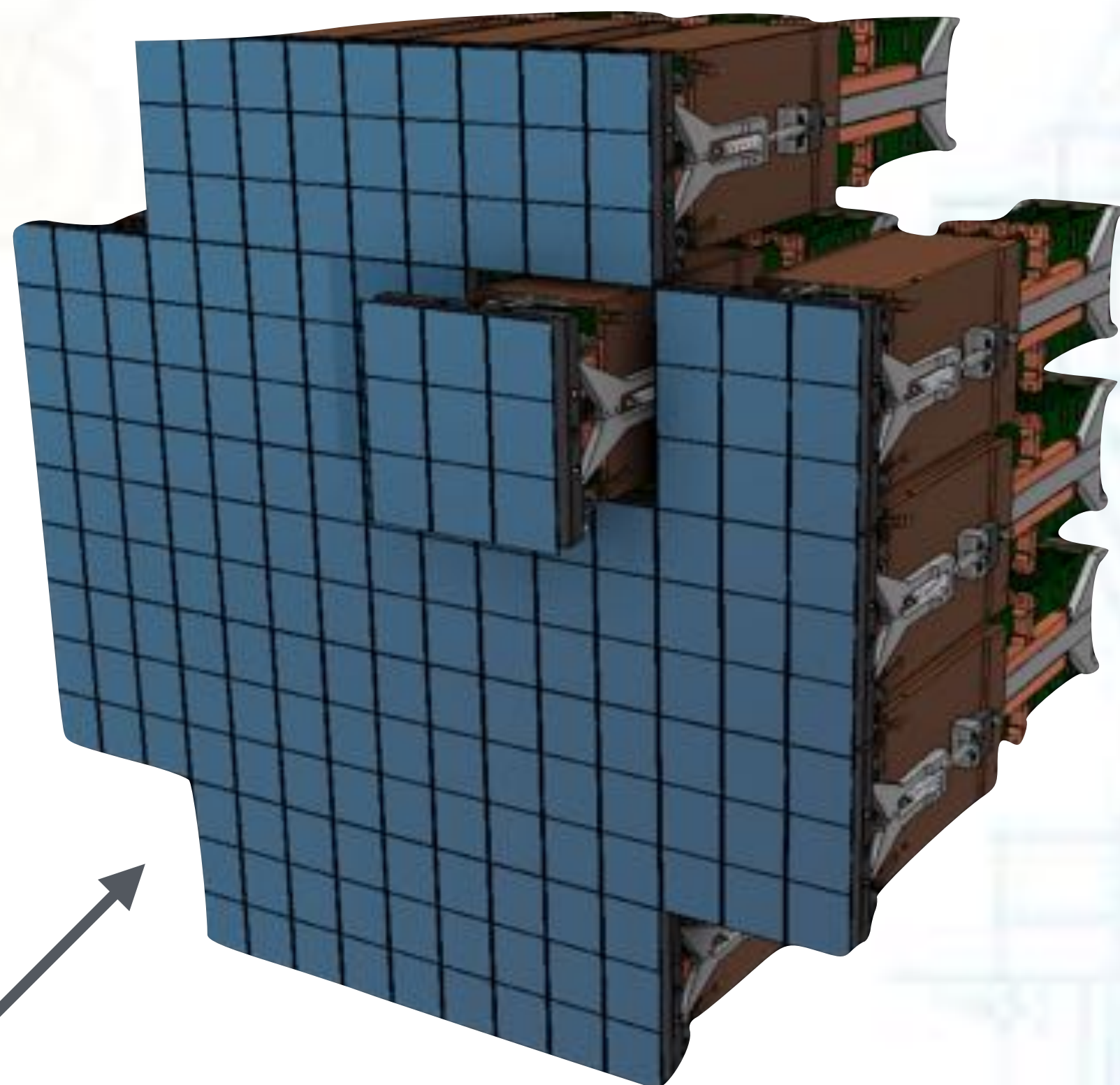- 1.65 by 3 metres; 2800kg
  - Size of a small car
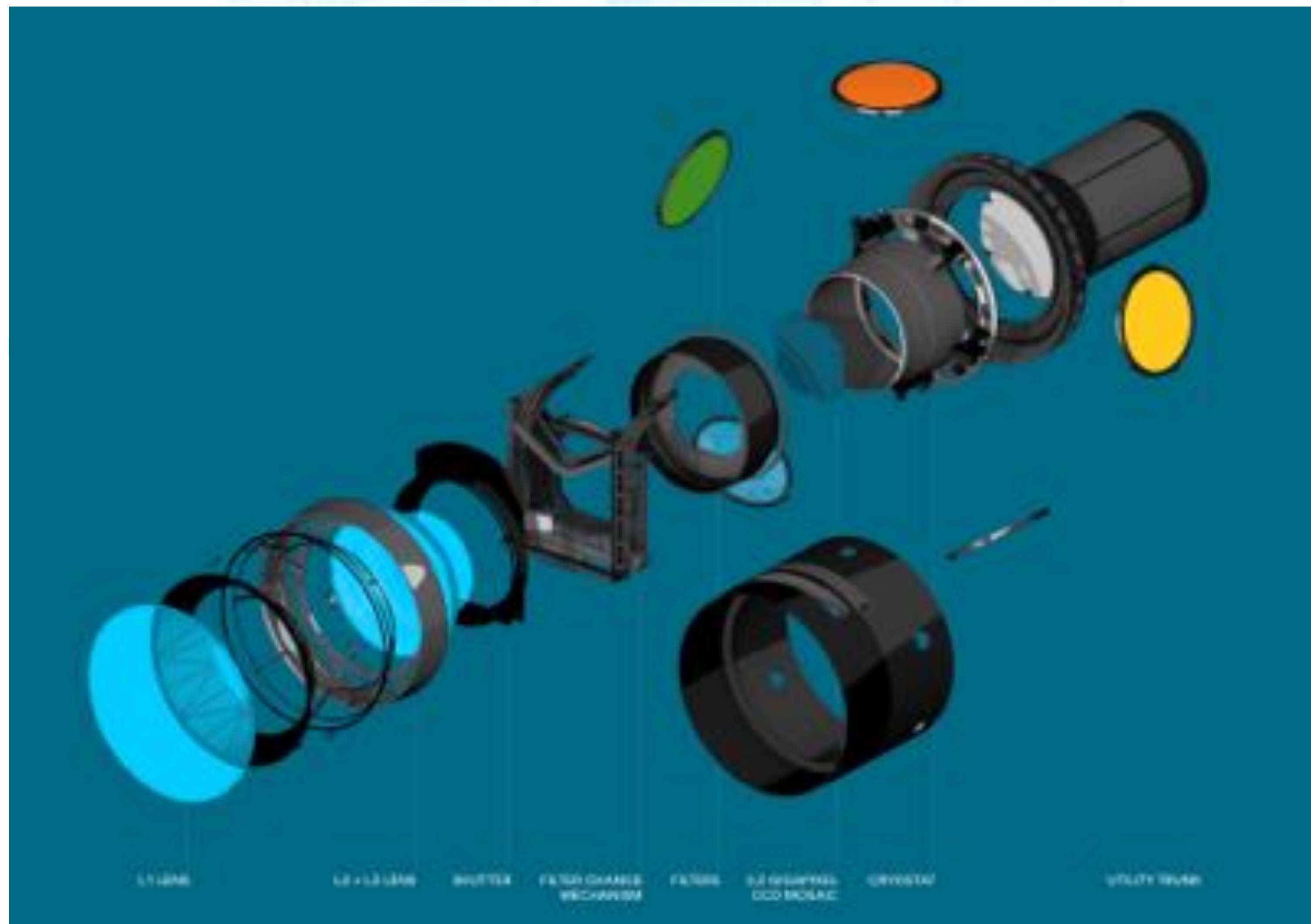


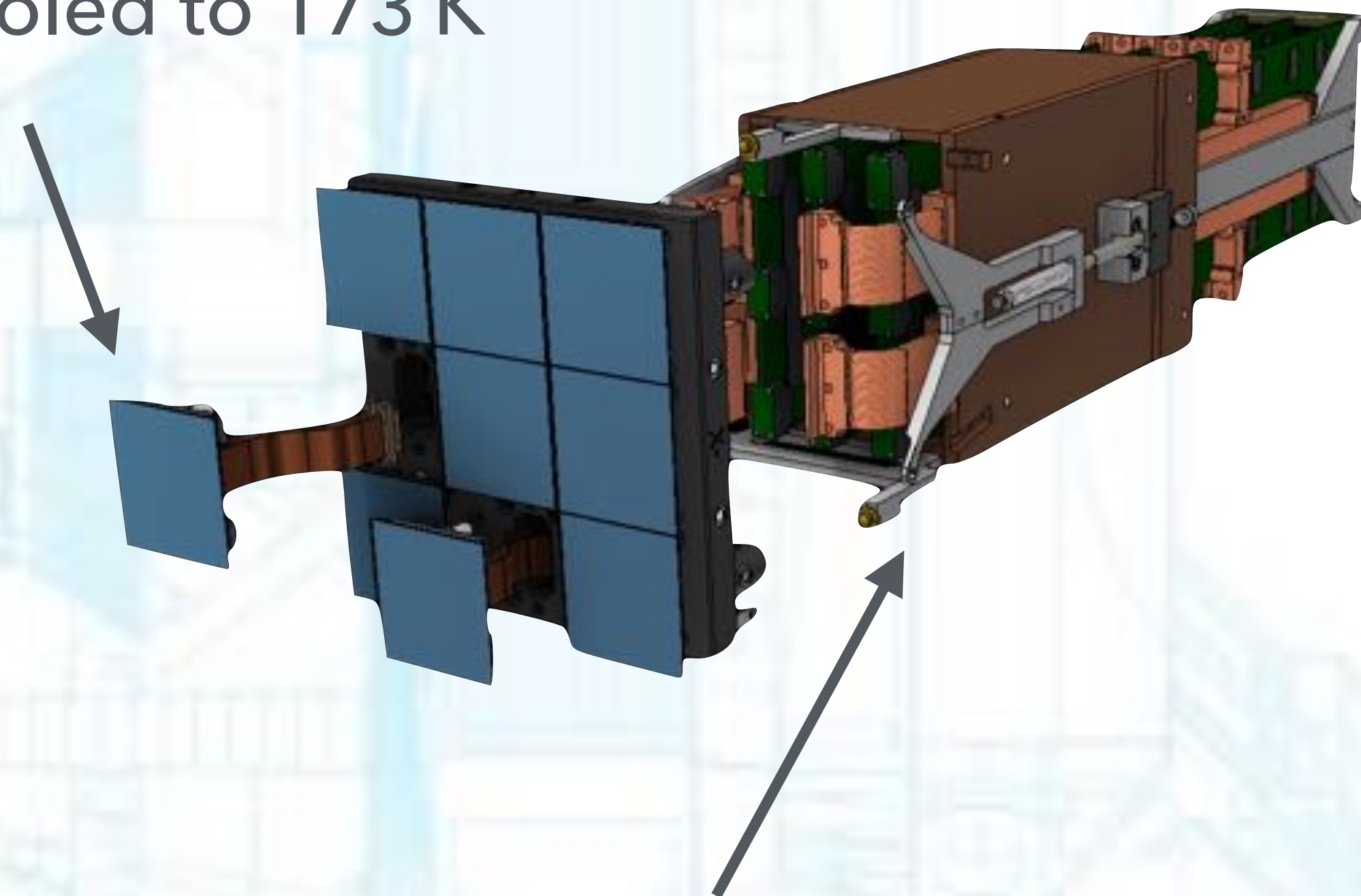*SLAC National Accelerator Laboratory*

# Focal Plane

- 63 cm diameter

- 4k by 4k pixel sensors

- 2 second readout time

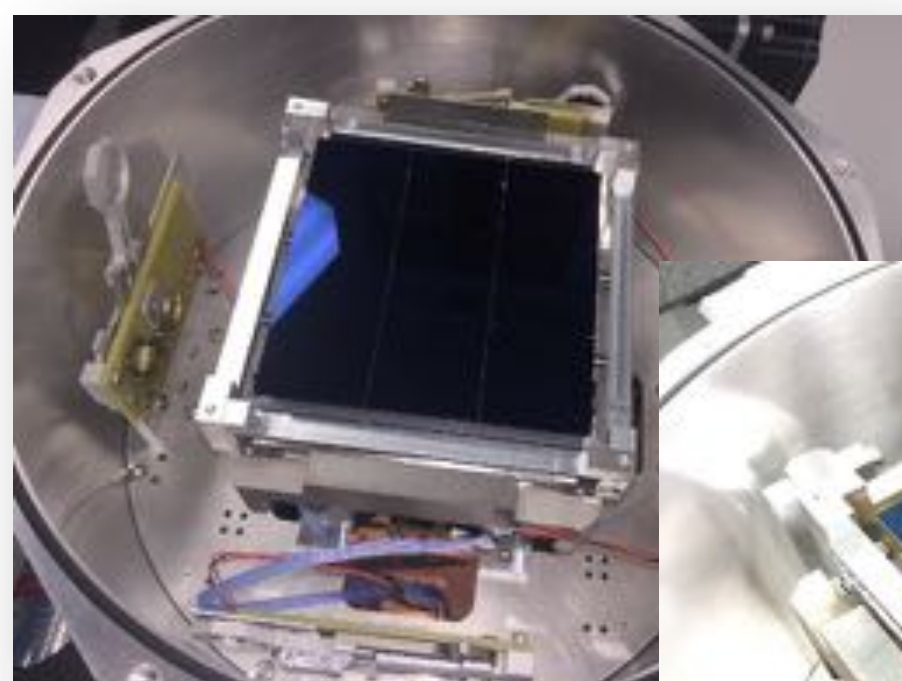- Cooled to 173 K



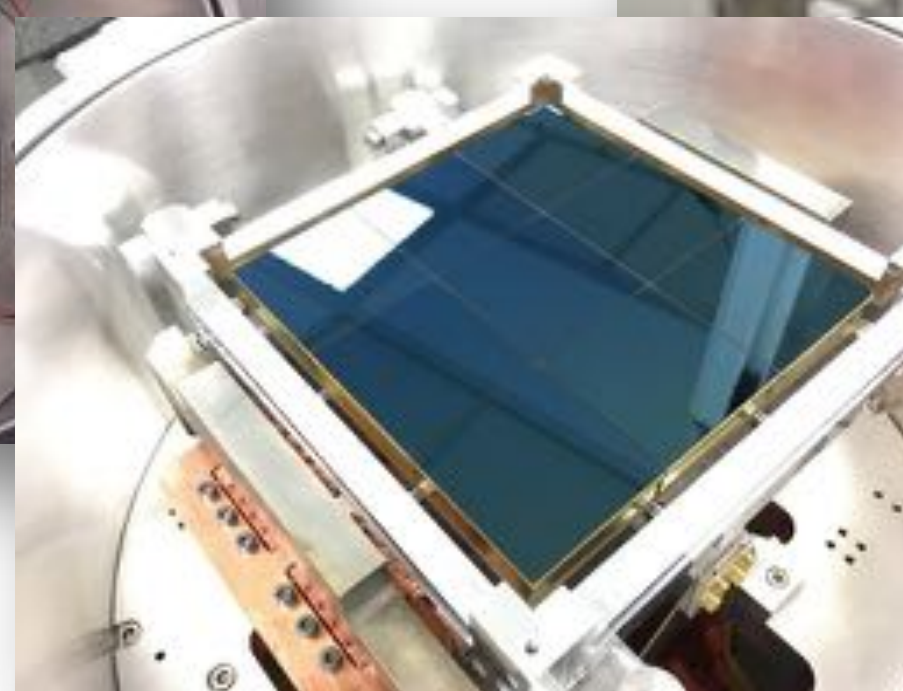- 189 sensors packed into 21 "rafts" of 9 sensors each

- 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)



e2v sensors

ITL sensors

- 10 rafts assembled and accepted

- All science rafts expected to be complete in January 2019

# 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.



L2
L3
L1
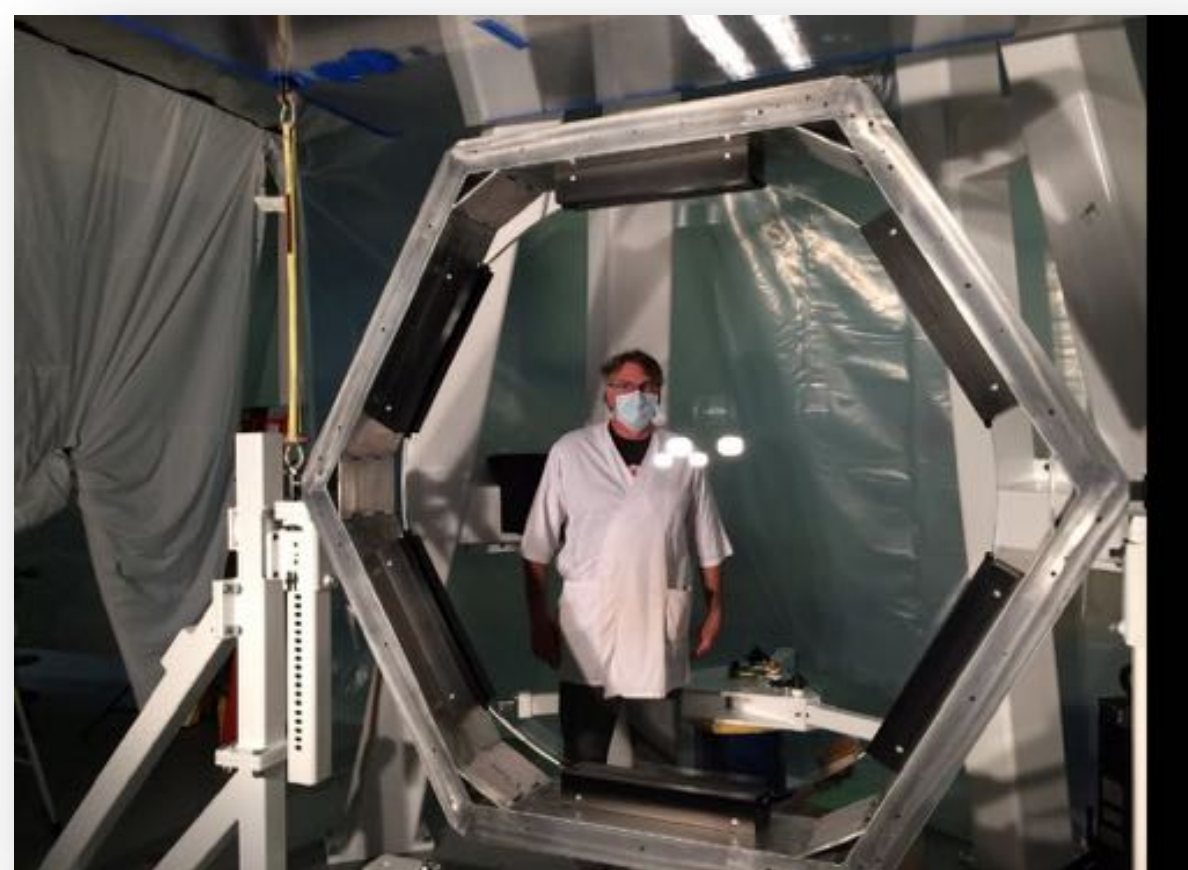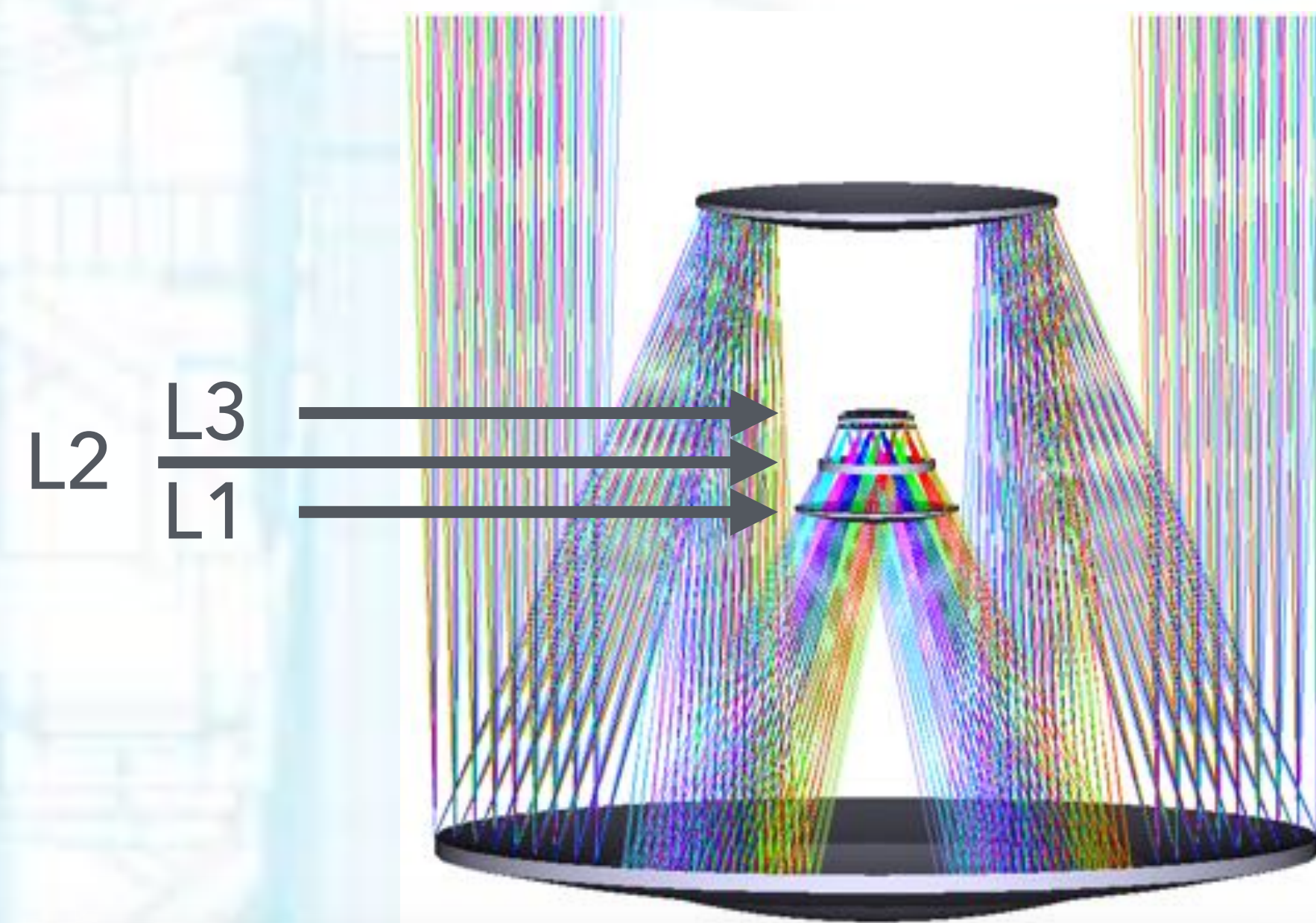


L1 inspection



L2 at coating vendor

# 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

ComCam Dewar





ComCam raft assembly at BNL

# Data Management
# The DM System

## 20TB raw data per night
(with calibration exposures)

## Prompt Data Products
via nightly alert streams
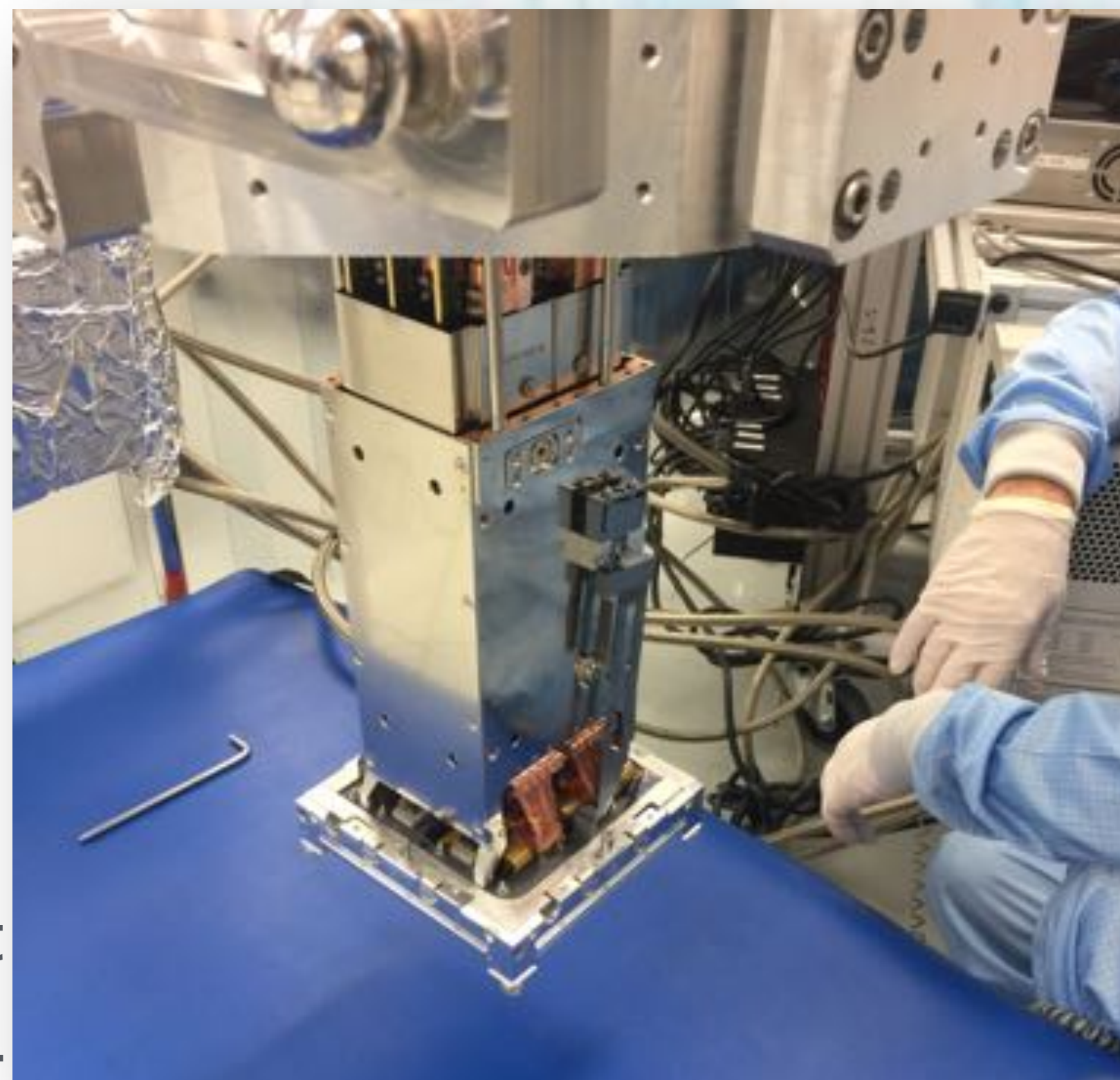
Average 10 million alerts per night
Issued within 60 s of shutter close

## Data Release Data Products
via annual data releases

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

**LSST Science Platform**

Alert database & "mini-broker"

Current & previous data releases
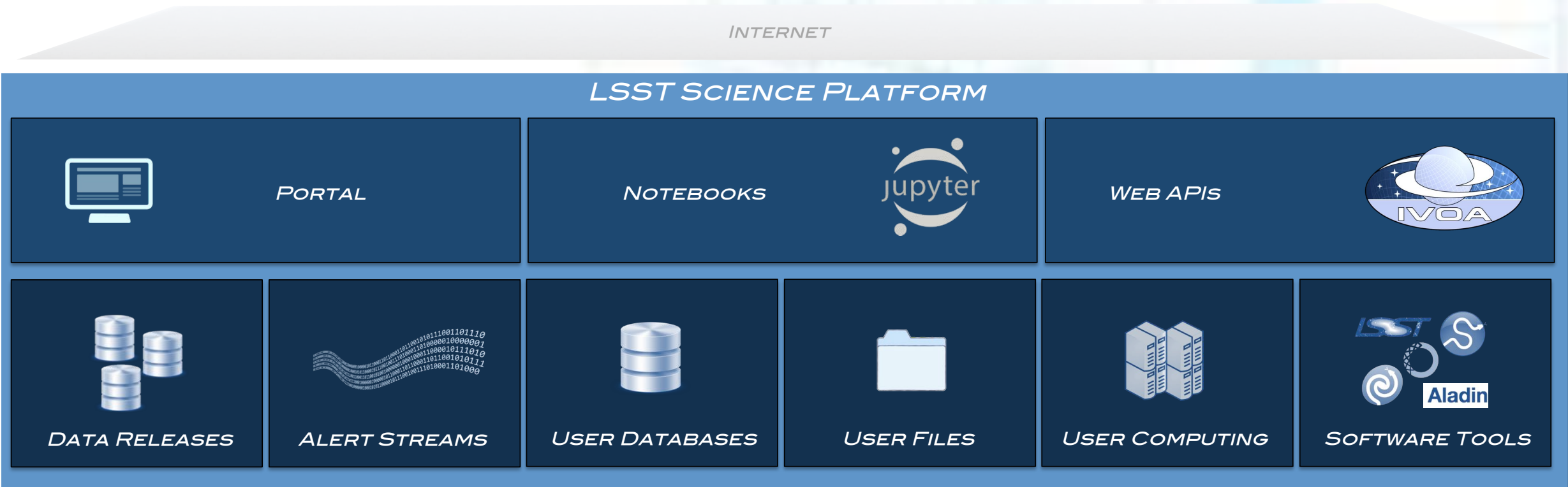
Data access & end-user computing

*INTERNET*

### LSST SCIENCE PLATFORM

| PORTAL | NOTEBOOKS | WEB APIs |
|---|---|---|
| | jupyter | IVOA |

| DATA RELEASES | ALERT STREAMS | USER DATABASES | USER FILES | USER COMPUTING | SOFTWARE TOOLS |
|---|---|---|---|---|---|
| | | | | | Aladin |

# 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.

**Prompt**

- 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.

**Data Release**

- Services and computing resources at the Data Access Centres to enable user-specified custom processing and analysis.

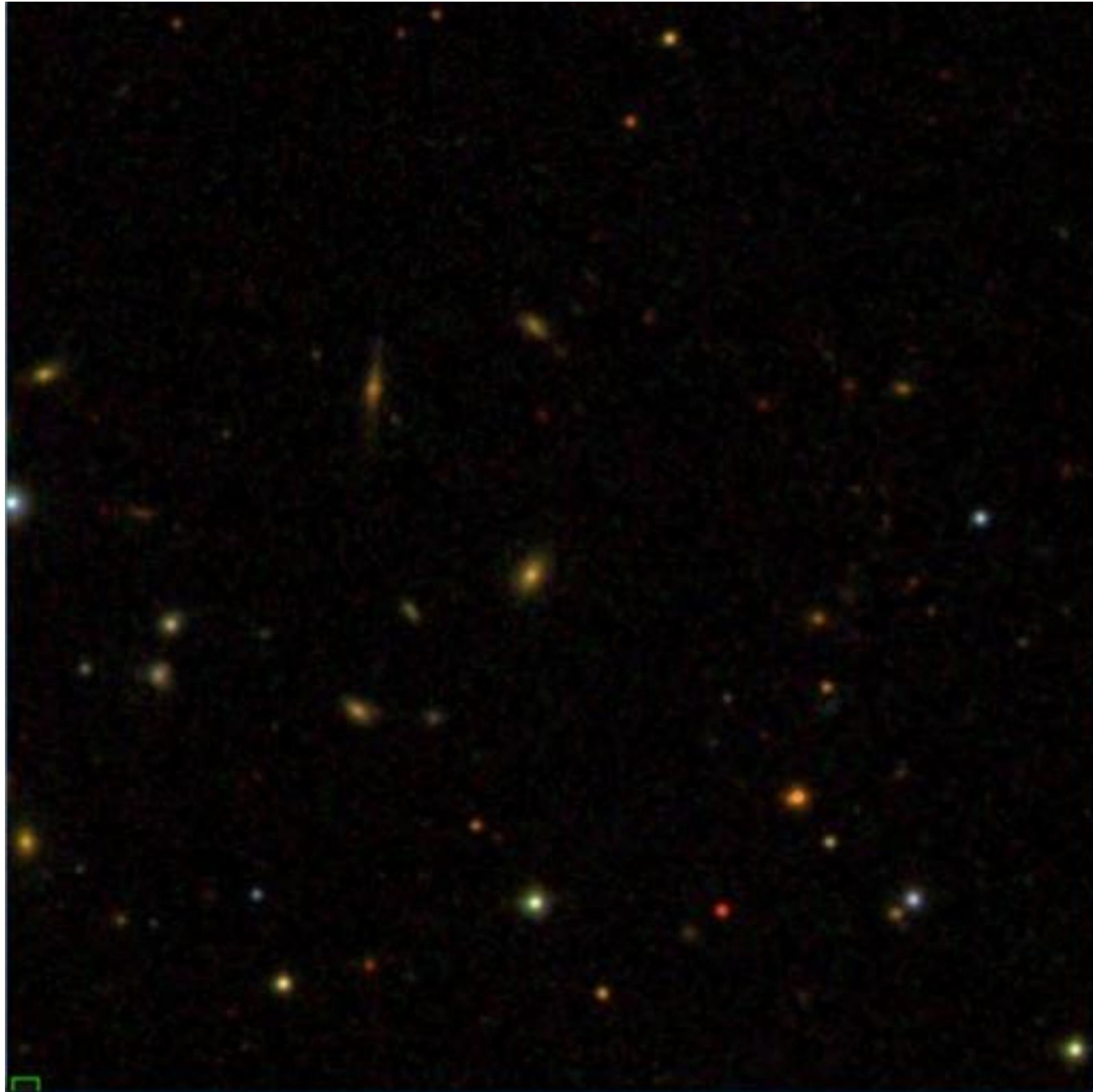- Software and APIs enabling development of analysis codes.

**User Generated**

# Complex Image Processing



Image: Robert Lupton
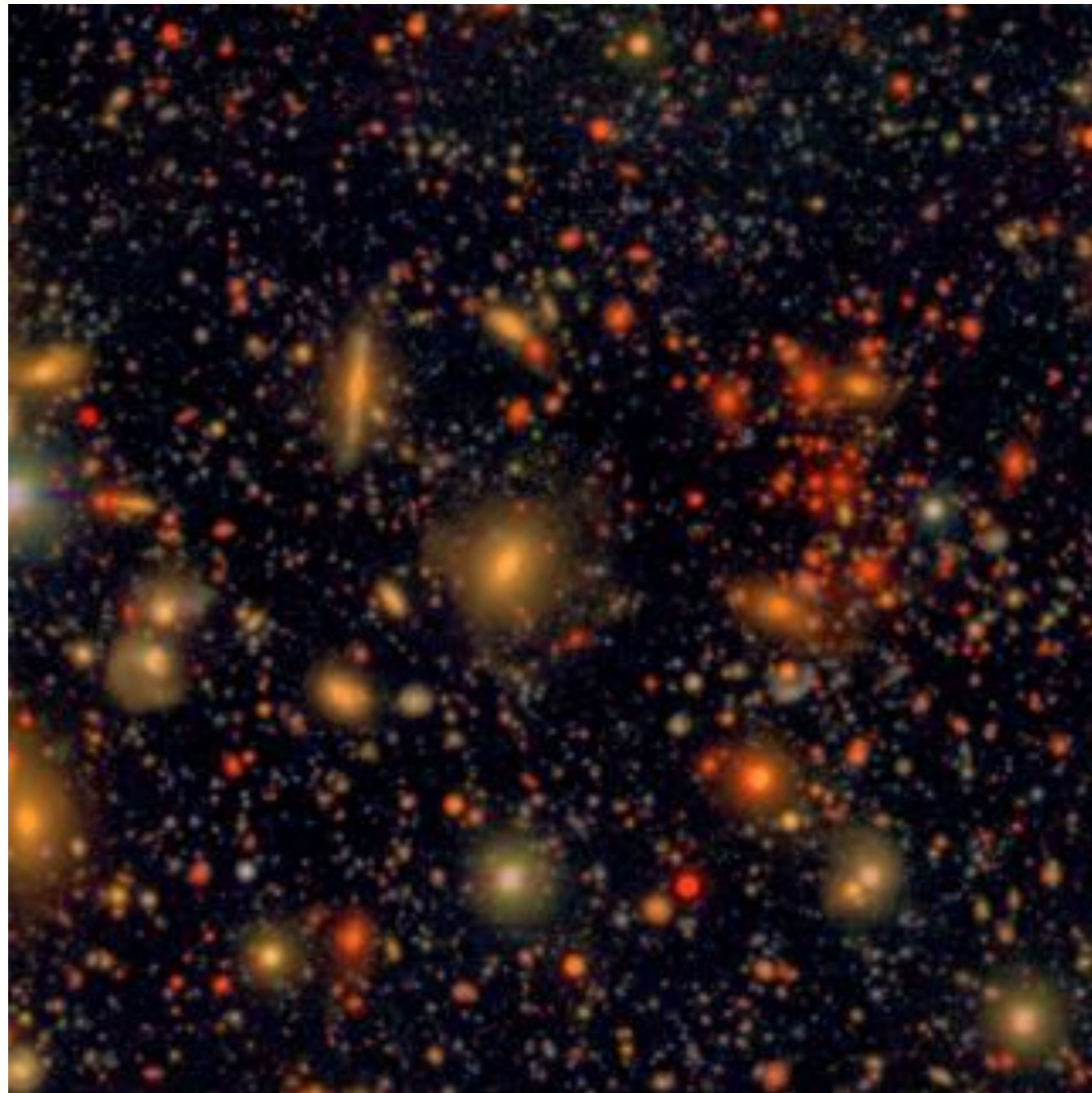
- SDSS image of the COSMOS field from Lupton et al (2004)
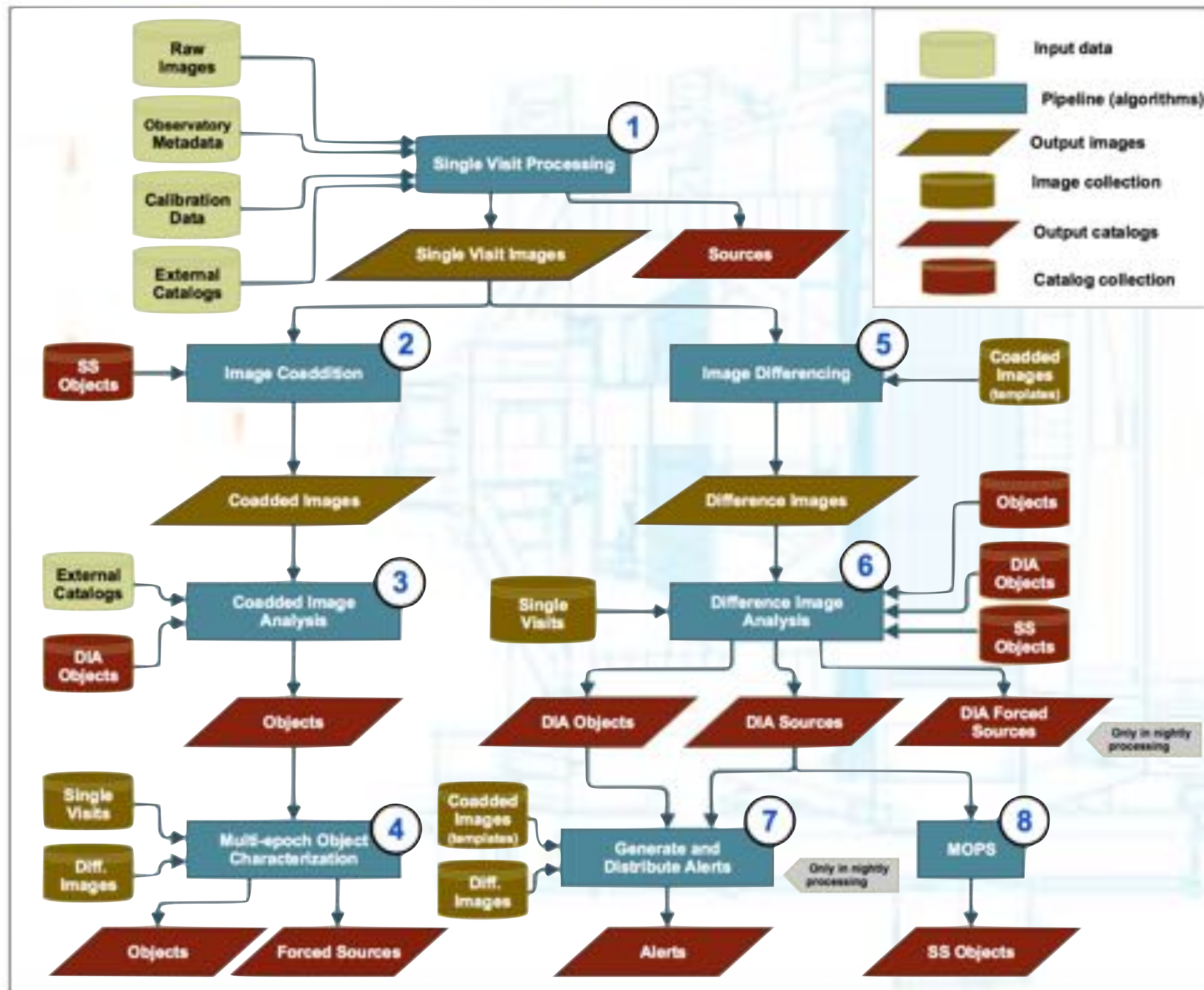
- ~ 3.5′

# Complex Image Processing



*Image: HSC Collaboration & Robert Lupton*

- 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

# Data Management
# Pipelines



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 PSF 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* incl. details of the associated SSObject) and further processing time.

6. Otherwise, the new DIASource is used to update the correspon 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.

# Moving Object Processing

- During the day, we:

  - Recompute orbits of known SSObjects

  - Refine association of DIASources w

  - Search for new SSObjects based DIASources.

Mario's talk at 11:00 for details of MOPS.

# Status of Pipelines

- 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.

# 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
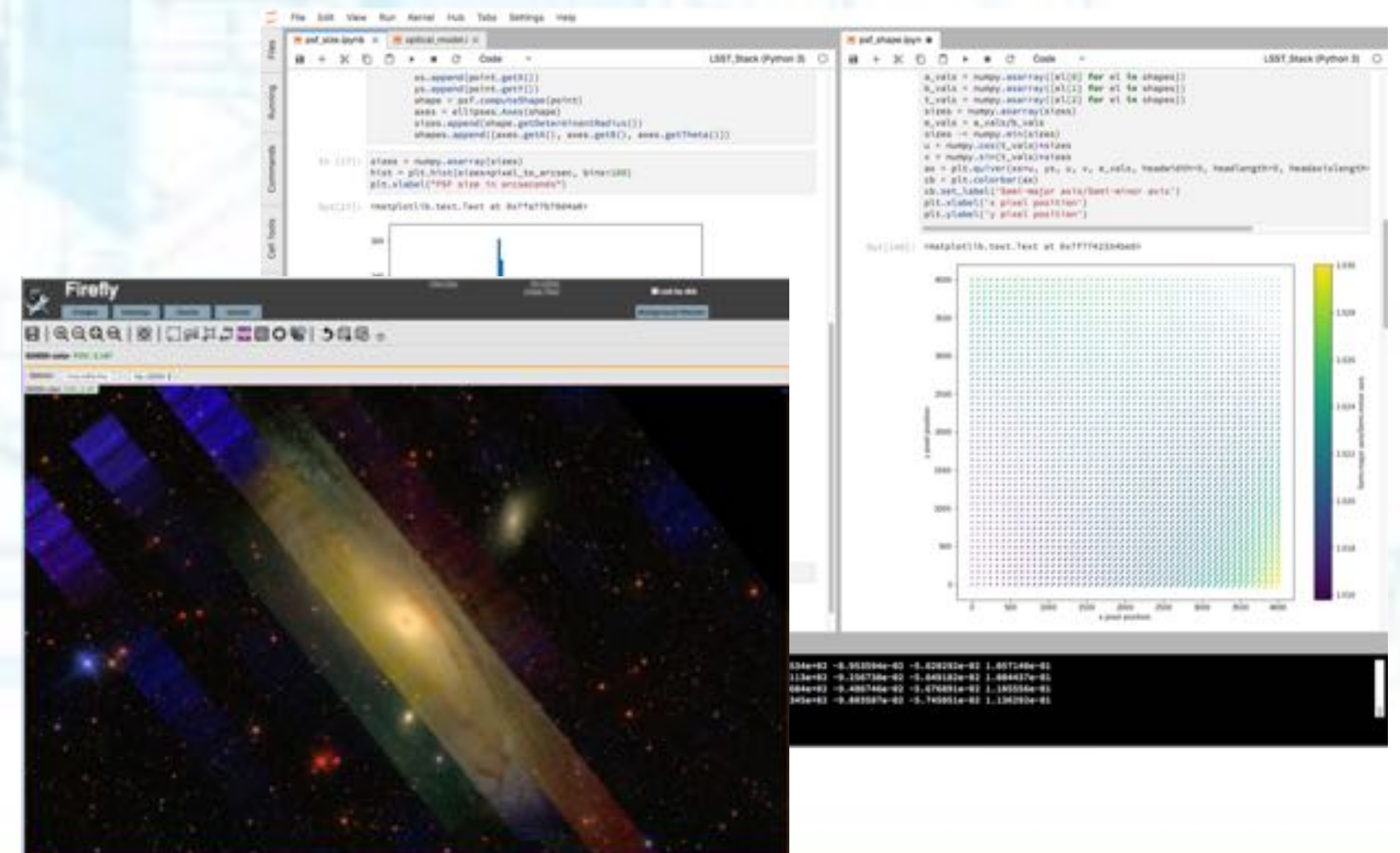
# The EPO System

- 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.

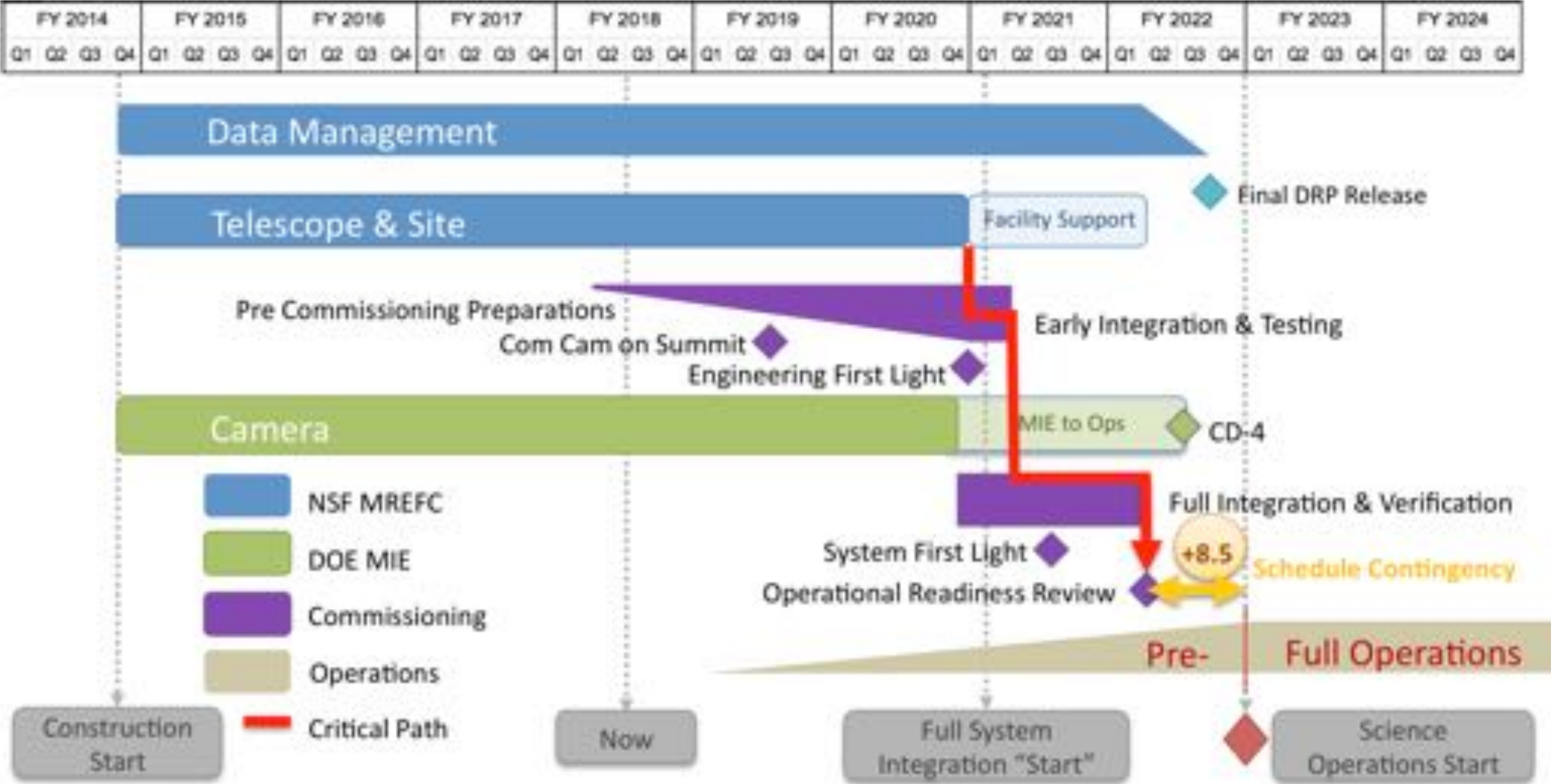  - Science-interested teens & adults.

# "Earned Value" summary

Fractional Completion      Telescope & Site    72%

Camera    81%

Data Management    40%

EPO    24%

Commissioning    24%

Based on April 2018 Data

# Timeline to full operations

# 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!