

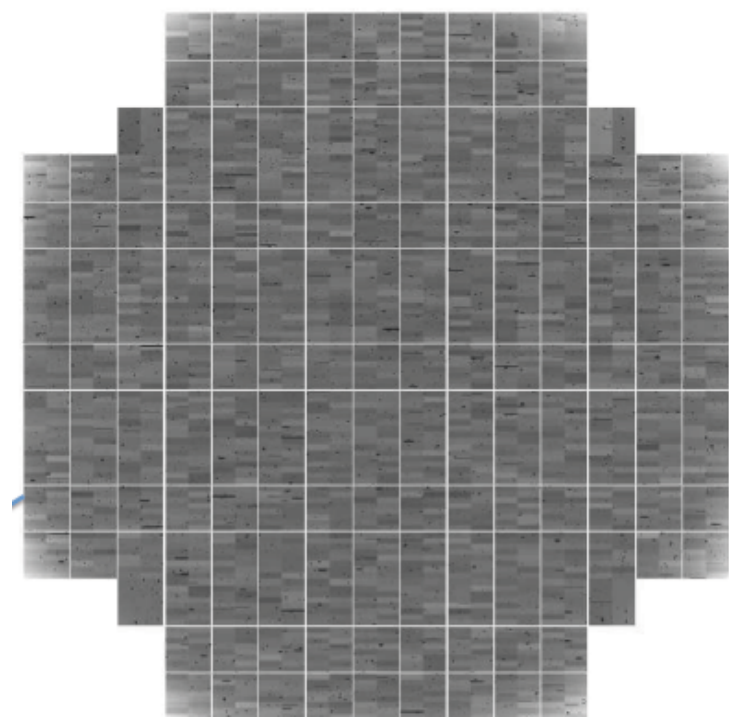
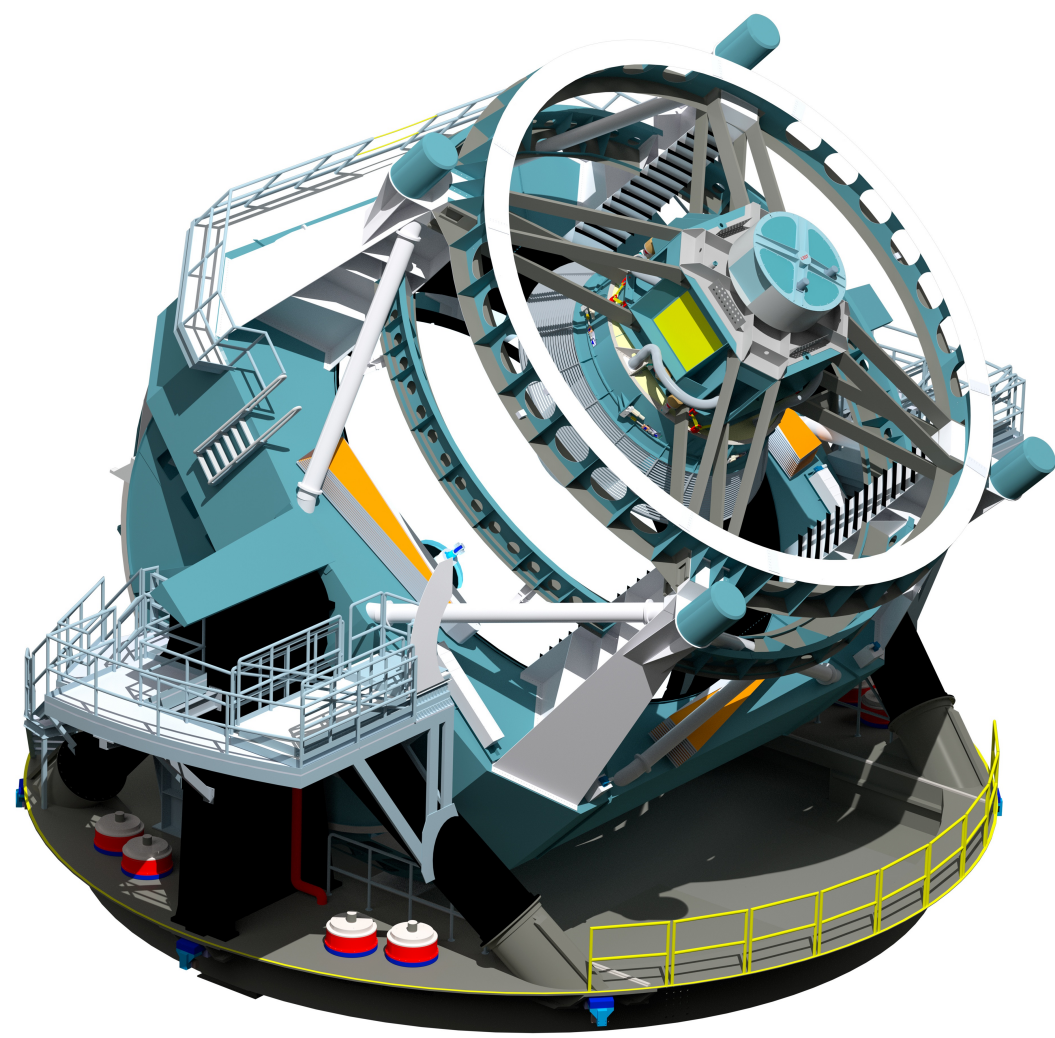
Storage for LSST image processing

fabio hernandez

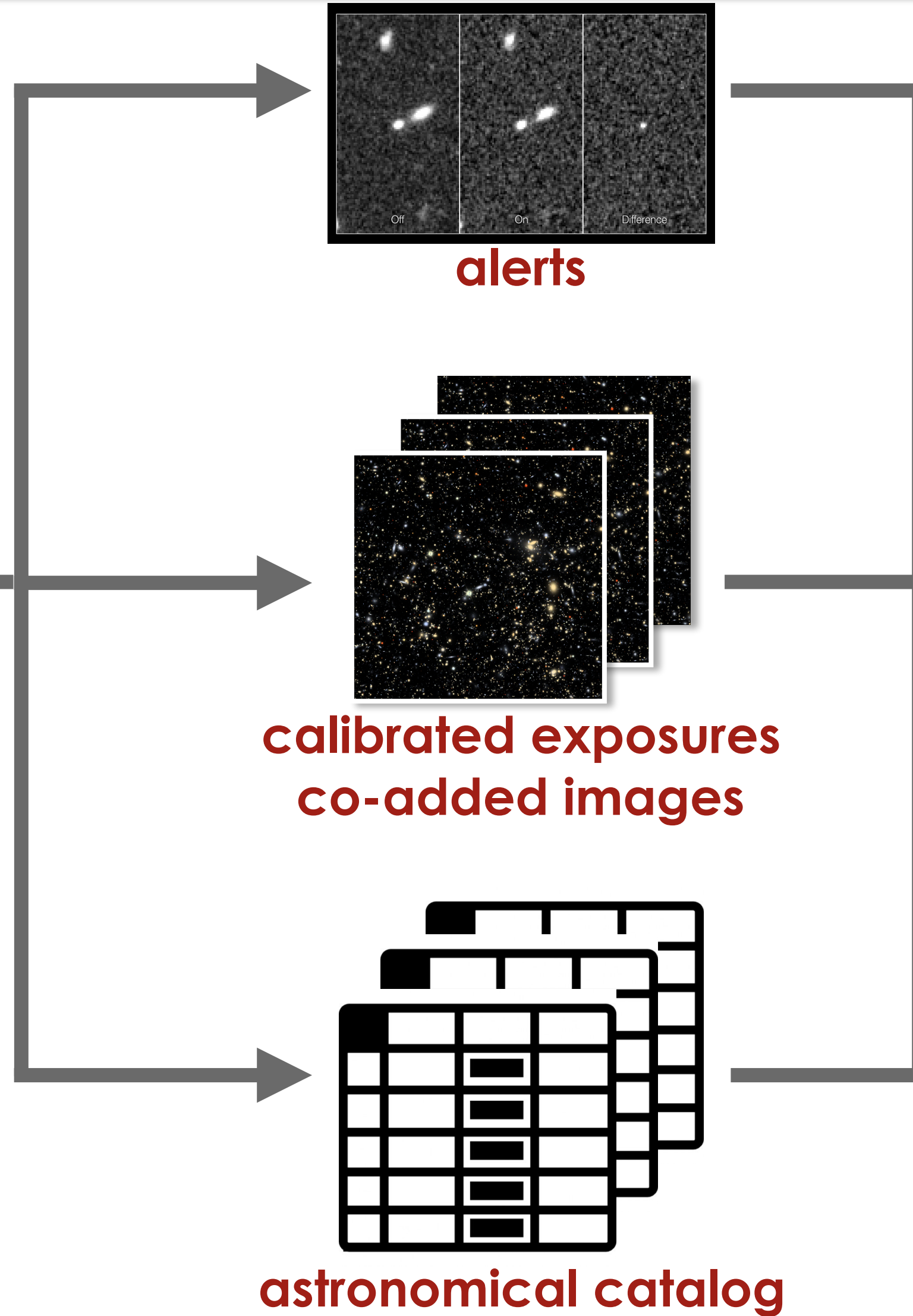
CONTENTS

- LSST overview
- Data processing
- Summary

LEGACY SURVEY OF SPACE AND TIME



raw images



alerts

calibrated exposures
co-added images

astronomical catalog

science
collaborations

LSST aims to deliver a catalog of 20 billion galaxies and 17 billion stars with their associated physical properties

LSST OVERVIEW (CONT.)

- Principle of operations

*90% of the observing time of the telescope devoted to a **deep-wide-fast survey***

one complete visit of the southern hemisphere sky every 3-4 nights, from 2022 for 10 years

43% of the celestial sphere will be covered by this survey

each patch of the sky to be visited about 1000 times

- Science themes

*determining the nature of **dark energy** and **dark matter***

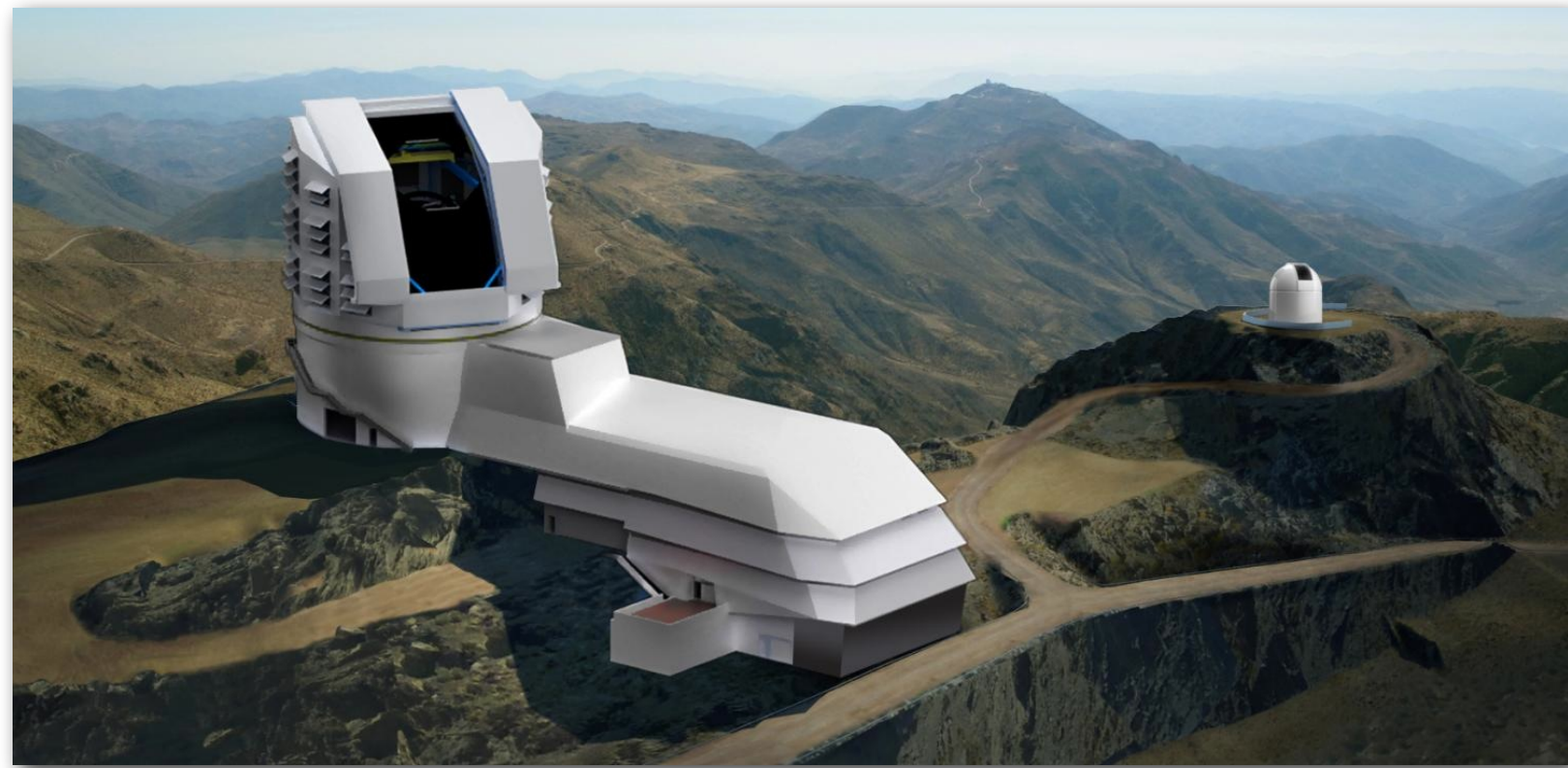
*taking an inventory of the **solar system***

*exploring the **transient** optical sky*

*mapping the structure and evolution of the **Milky Way***

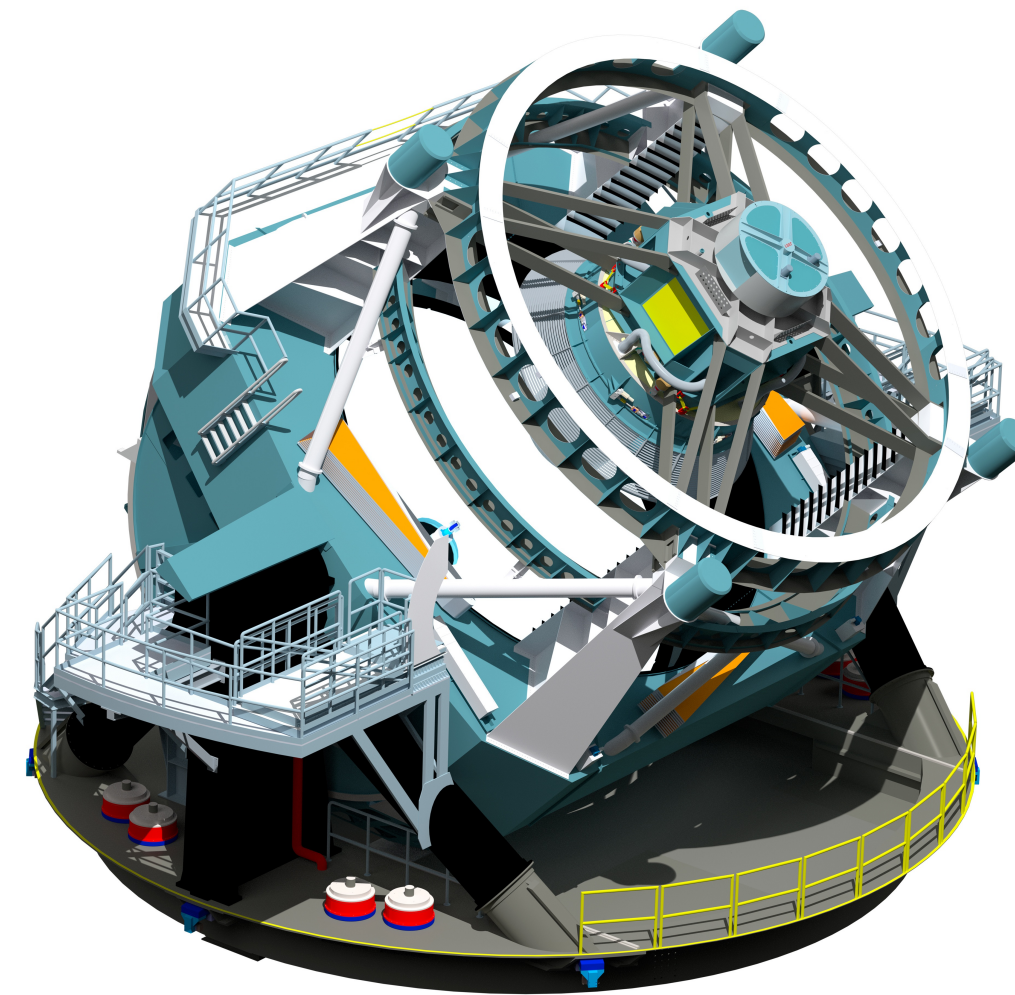
LSST OVERVIEW

RUBIN OBSERVATORY



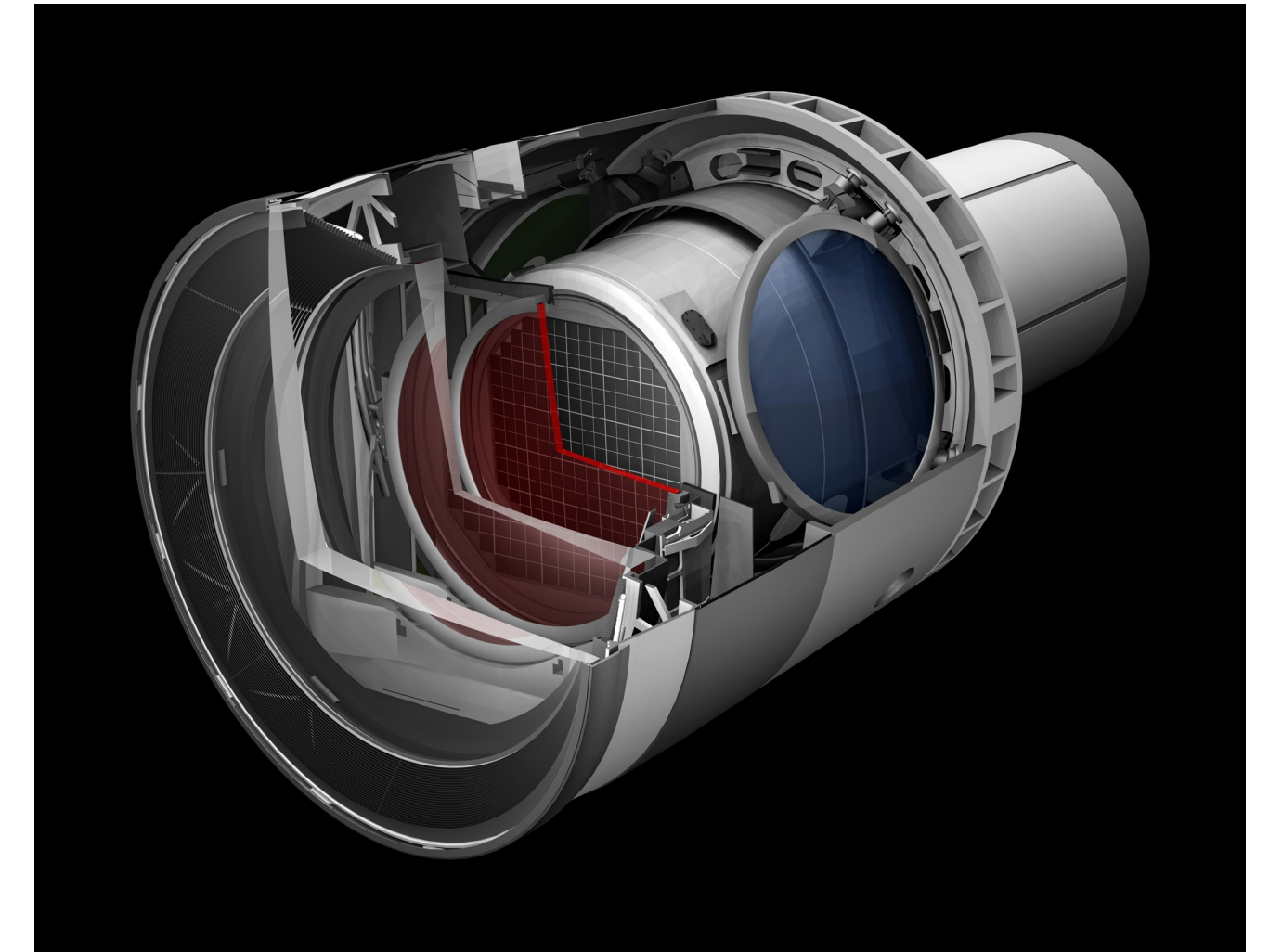
southern hemisphere | 2647m
a.s.l. | stable air | clear sky |
dark nights | good infrastructure

TELESCOPE



main mirror \varnothing 8.4 m (effective
aperture 6.5 m) | large
aperture: f/1.234 | wide field
of view | 350 ton | compact |
to be repositioned about 3M
times over 10 years of
operations

CAMERA



3.2 G pixels | \varnothing 1.65 m |
3.7 m long | 3 ton | 3
lenses | 3.5° field of view |
9.6 deg² | 6 filters ugrizy |
320–1050 nm | focal plane
and electronics in cryostat
at 173K

LSST OVERVIEW: DELIVERABLES

- Deliverable

*the science-enabling, **ultimate deliverable** of the project will be the **fully reduced data***

the scientific exploitation of the processed data will be performed by the scientific community

- Open data

*complete **cumulative data set** (images and catalogs), open to the scientific community of the participating countries, once per year, with no proprietary period*

***alerts** of detected variable sources (transients) made available for world-wide distribution **within 60 seconds of observation**, published via standard protocols*

- Open source software: github.com/lstst

LSST DATA PRODUCTS

PROMPT: REAL-TIME DIFFERENCE IMAGE ANALYSIS (DIA)

NIGHTLY

Stream of 10M time-domain **events** per night, detected and transmitted to event distribution networks within 60 seconds of shutter close

Catalog of **orbits** for 6M bodies in the Solar System

DATA RELEASE: REDUCED SINGLE-EPOCH & DEEP CO-ADDED IMAGES, REPROCESSED DIA PRODUCTS

ANNUAL

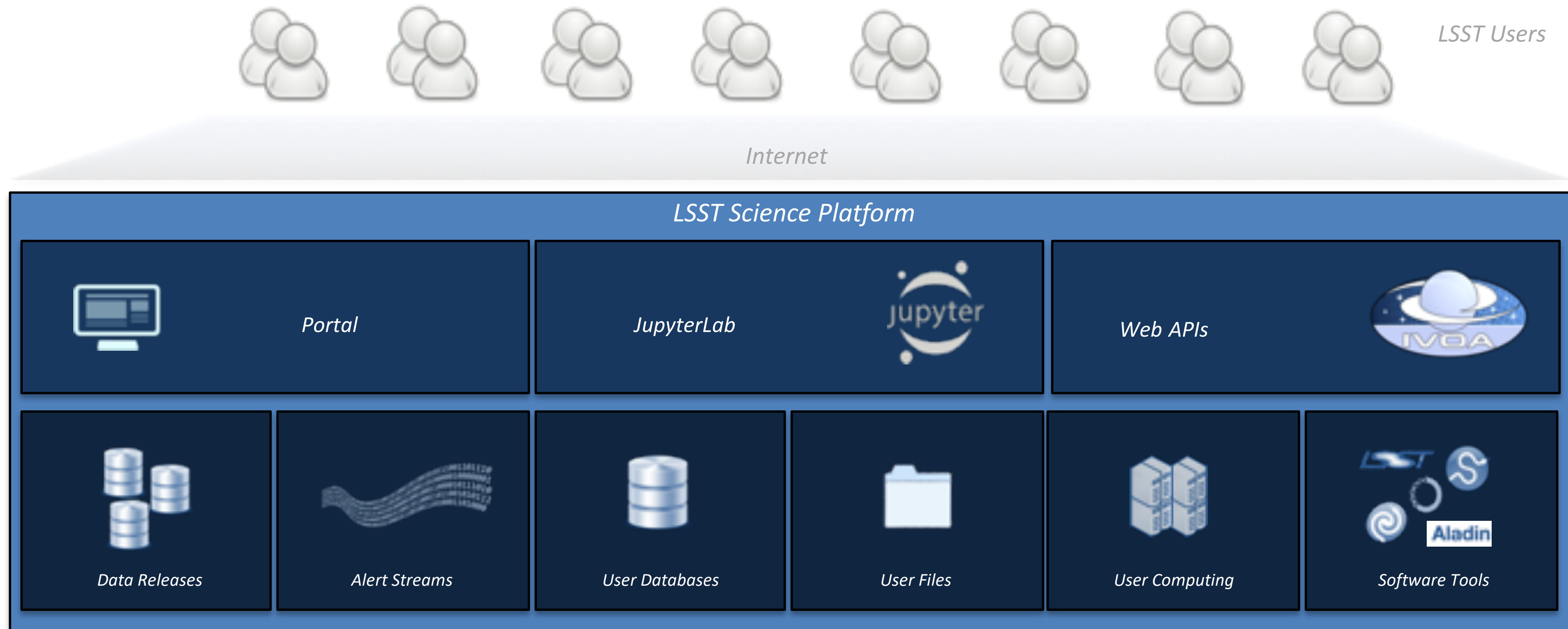
Catalog of 37B objects (20B galaxies, 17B stars), 7T observations, 30T measurements, produced annually, accessible through online databases

Deep co-added **images**

Source: LSST

User-generated data products not shown

LSST SCIENCE PLATFORM



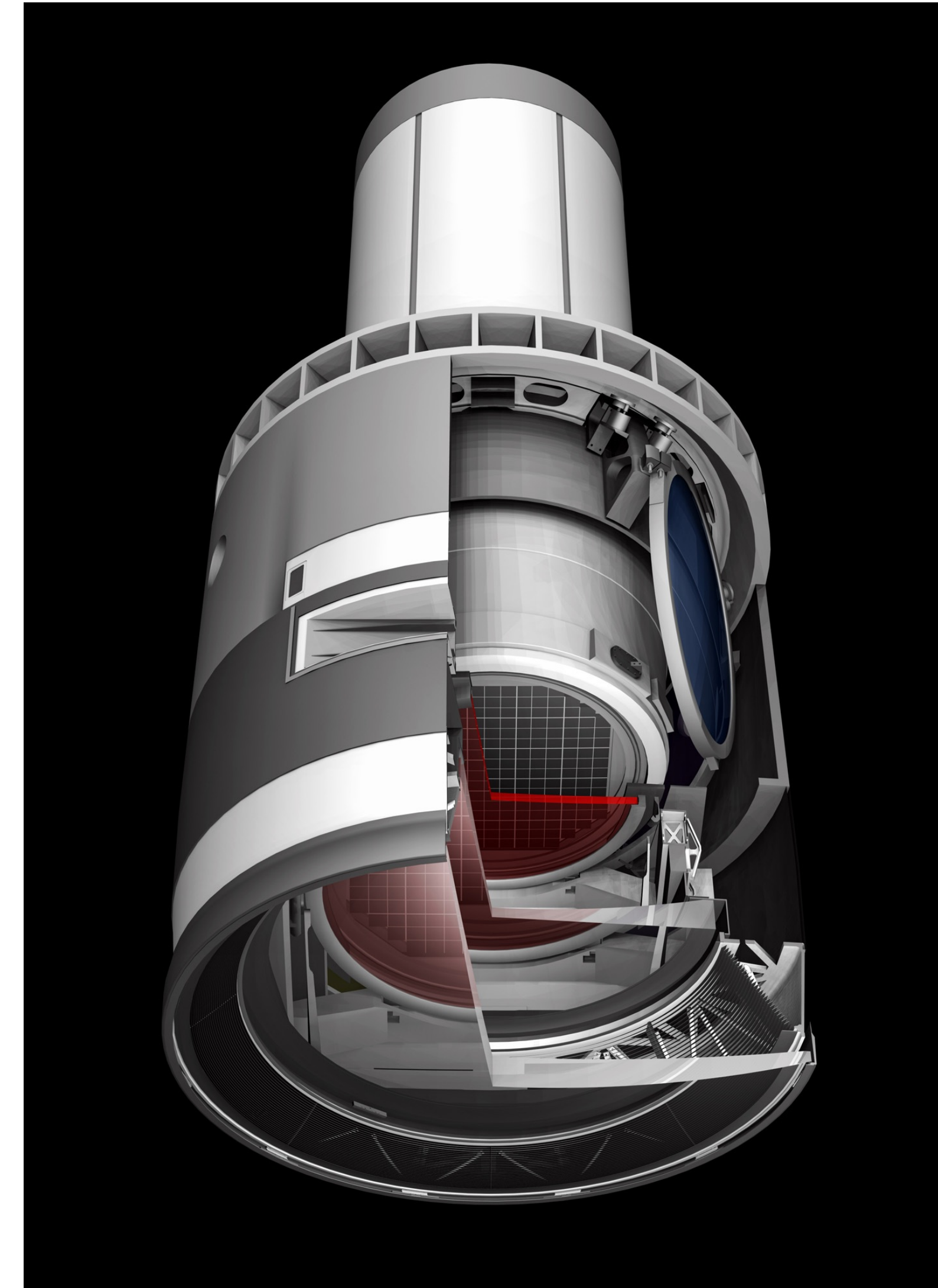
Set of integrated web applications and services, through which the scientific community will access, **visualize**, subset and perform **next-to-the-data analysis** of the data

DATA ACQUISITION

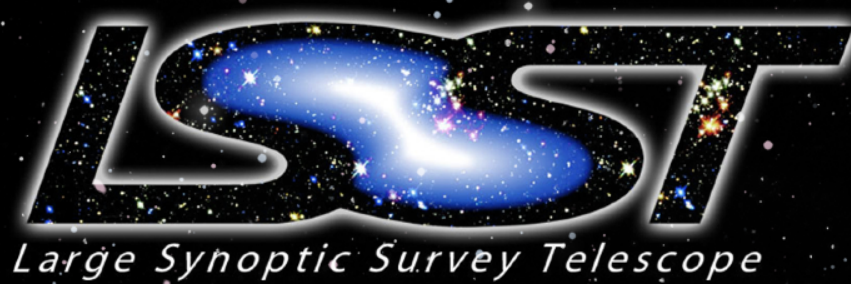
- **Raw data**
7.2 GB per image
2000 science images + 450 calibration images per night
300 nights per year, ~20 TB per night \Rightarrow ~6 PB per year
- **Aggregated data over 10 years of operations***, including derived data
image collection: ~6M exposures, 515 PB

final catalog database: 15 PB

* source: [LSST key numbers](#)



Source: LSST



LSST Operations: Sites & Data Flows



HQ Site
Science Operations
Observatory Management
Education & Public Outreach

Base Site
Base Center
Long-term storage (copy 1)
Data Access Center
Data Access & User Services

French Site
Satellite Processing Center
Data Release Production
Long-term Storage (copy 3)

Archive Site
Archive Center
Alert Production
Data Release Production
Calibration Products Production
EPO Infrastructure
Long-term Storage (copy 2)
Data Access Center
Data Access and User Services

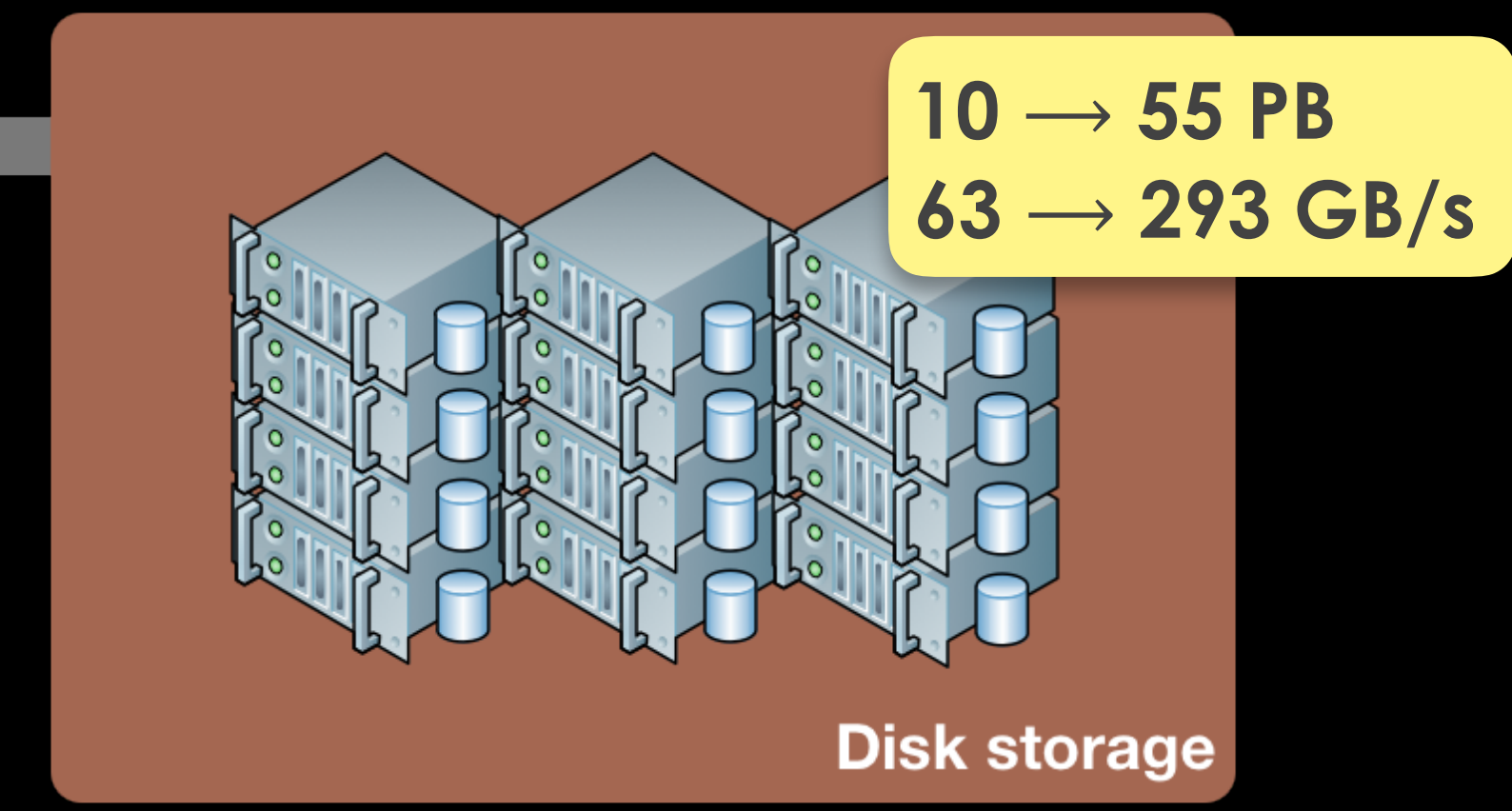
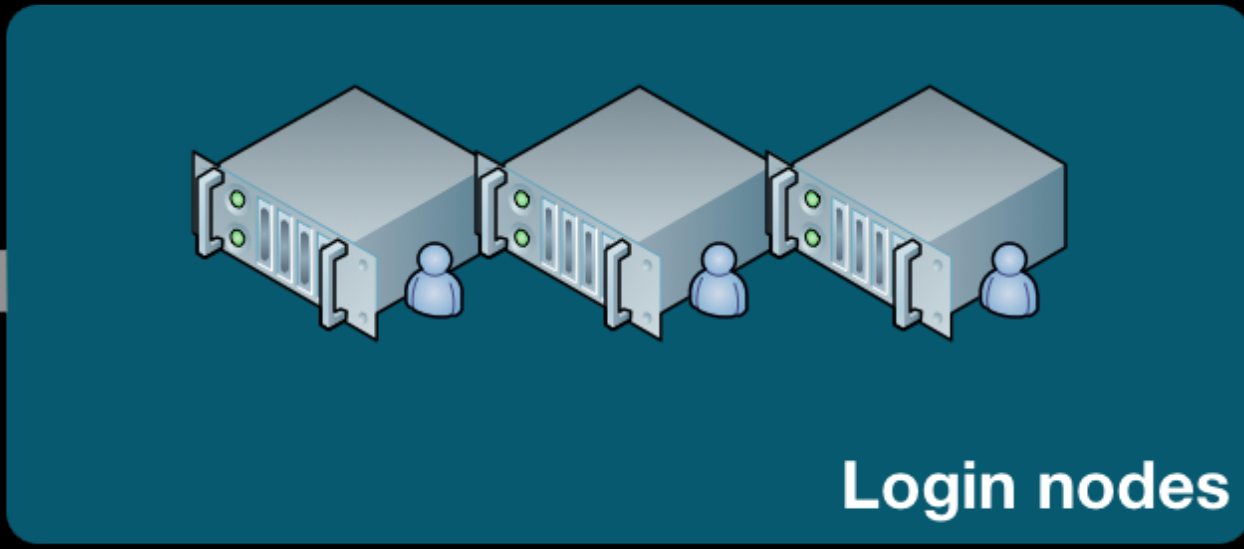
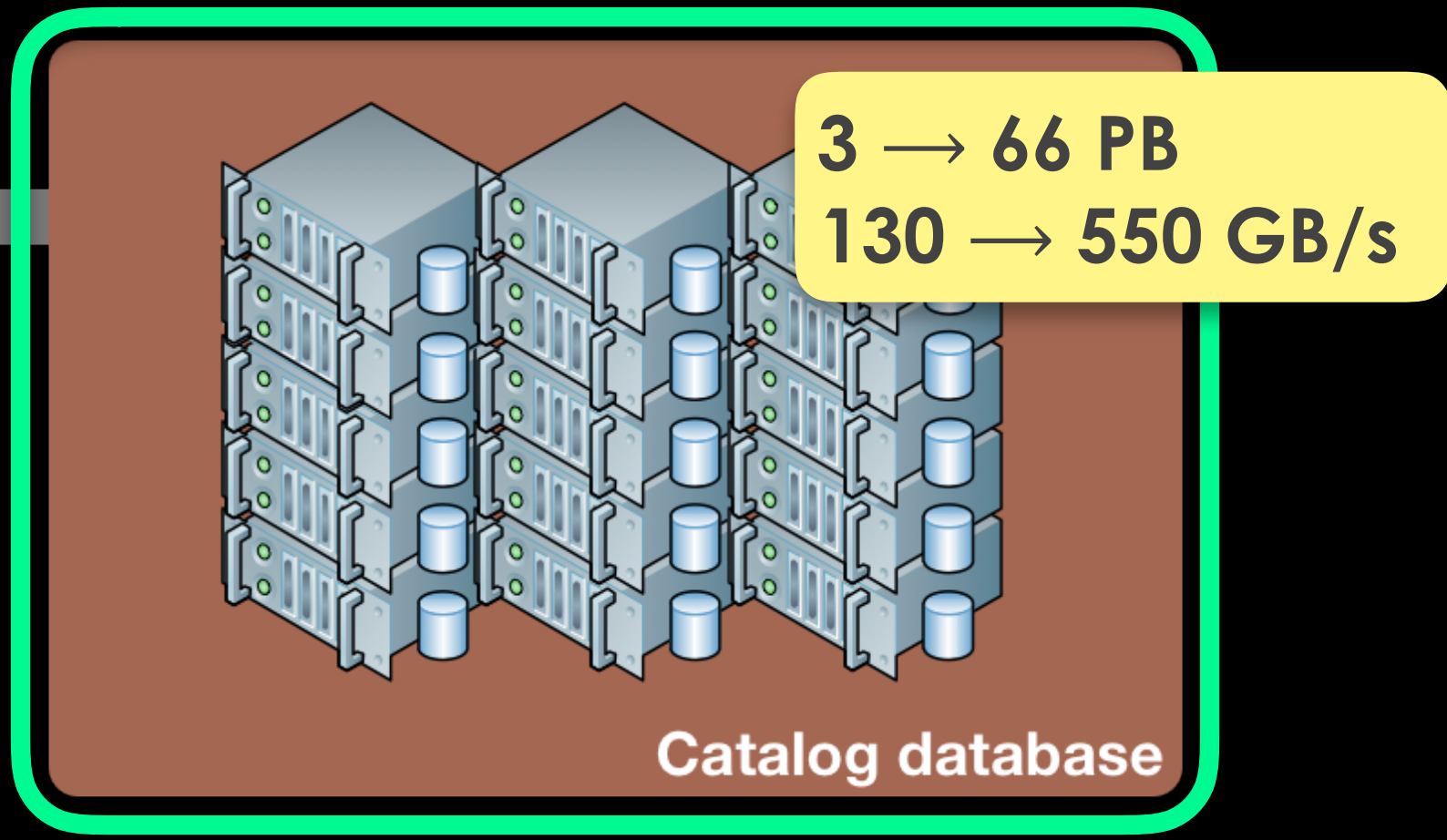
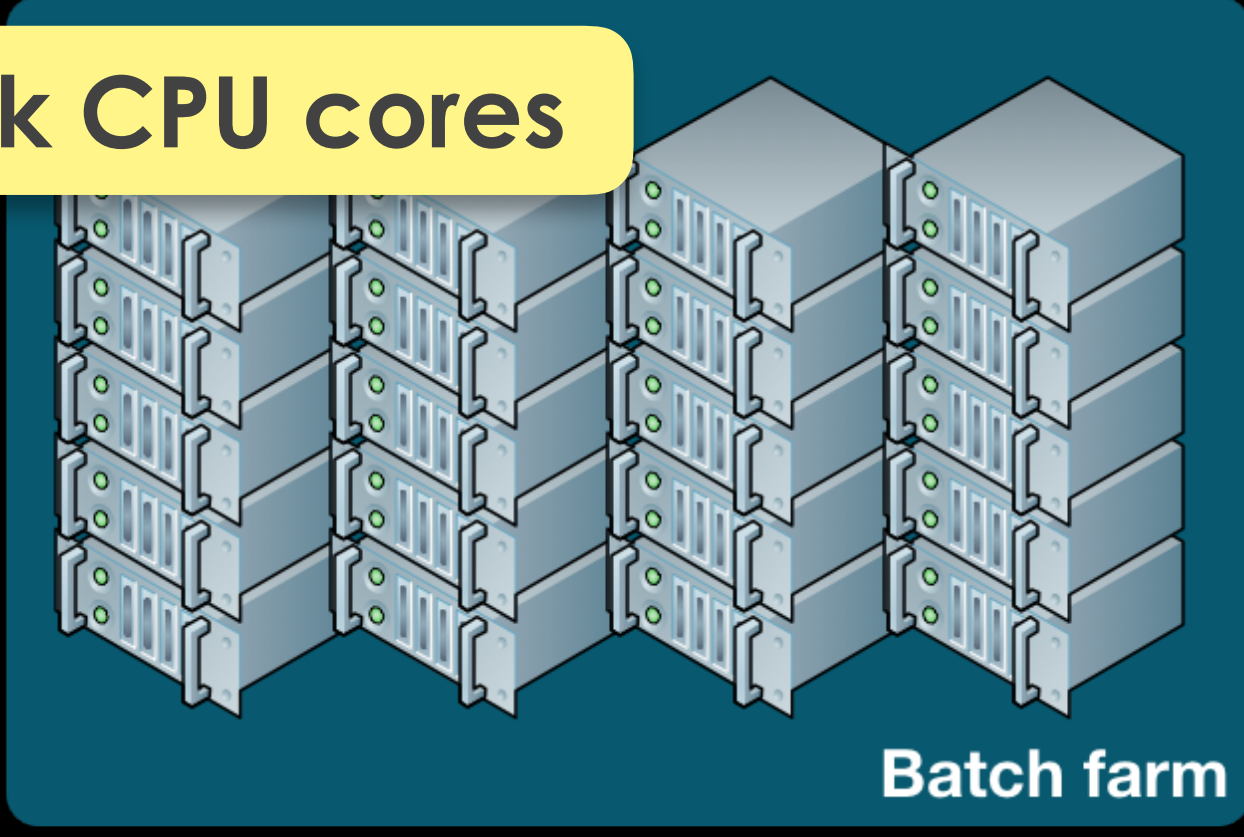
Summit Site
Telescope & Camera
Data Acquisition
Crosstalk Correction

LSST AT CC-IN2P3

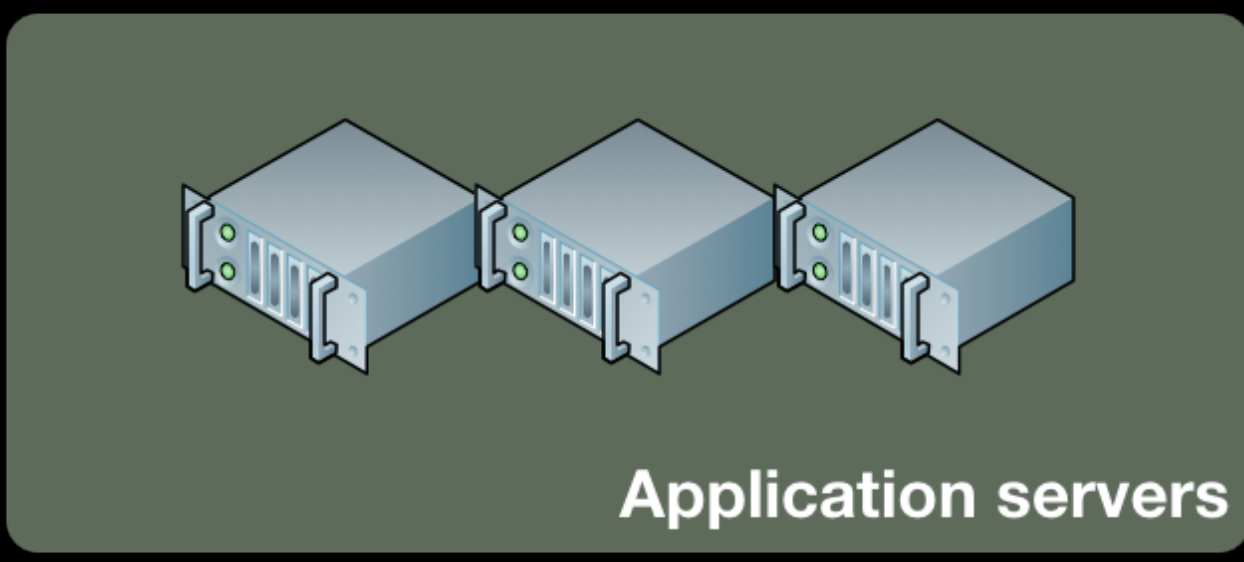
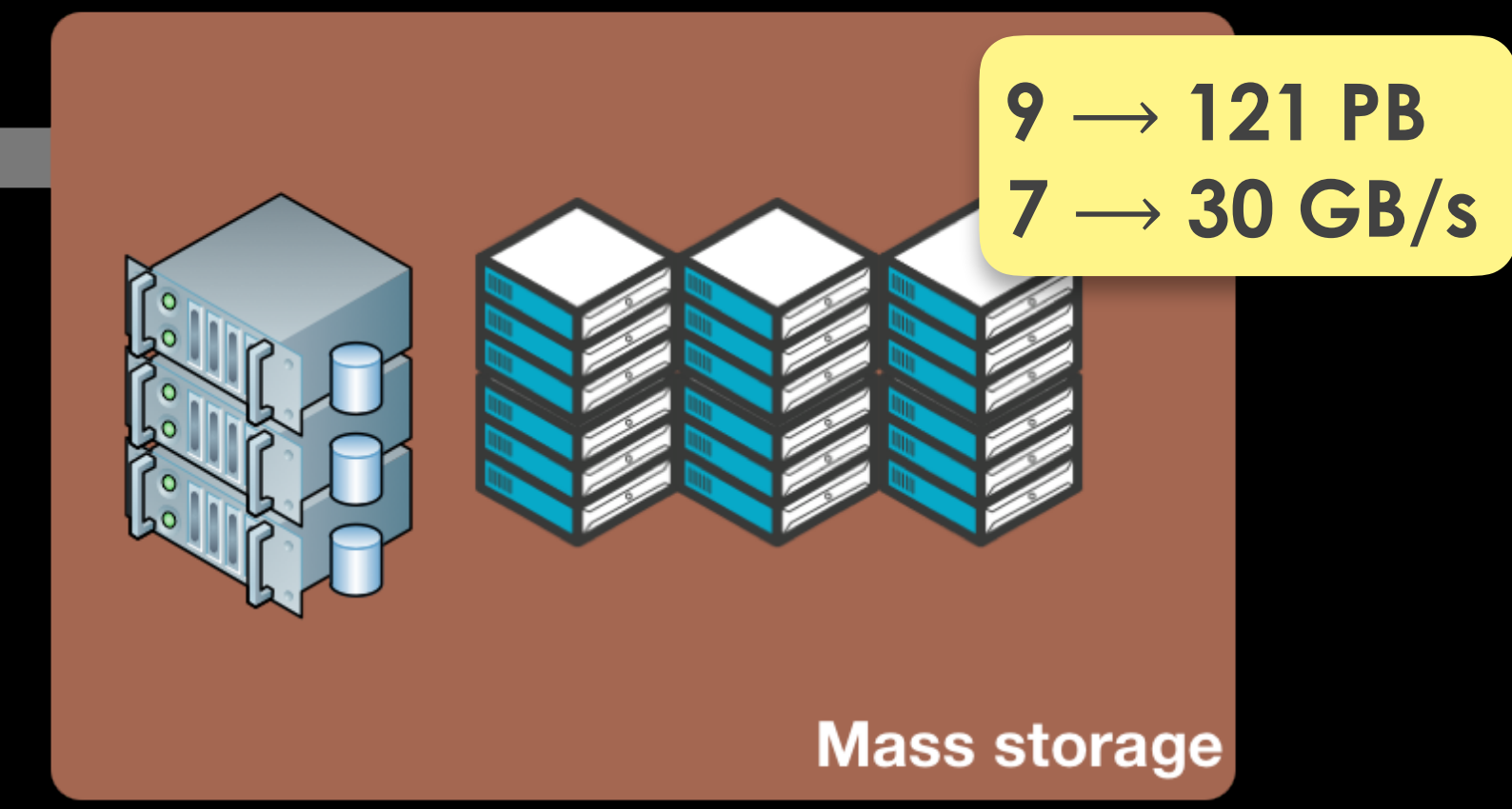
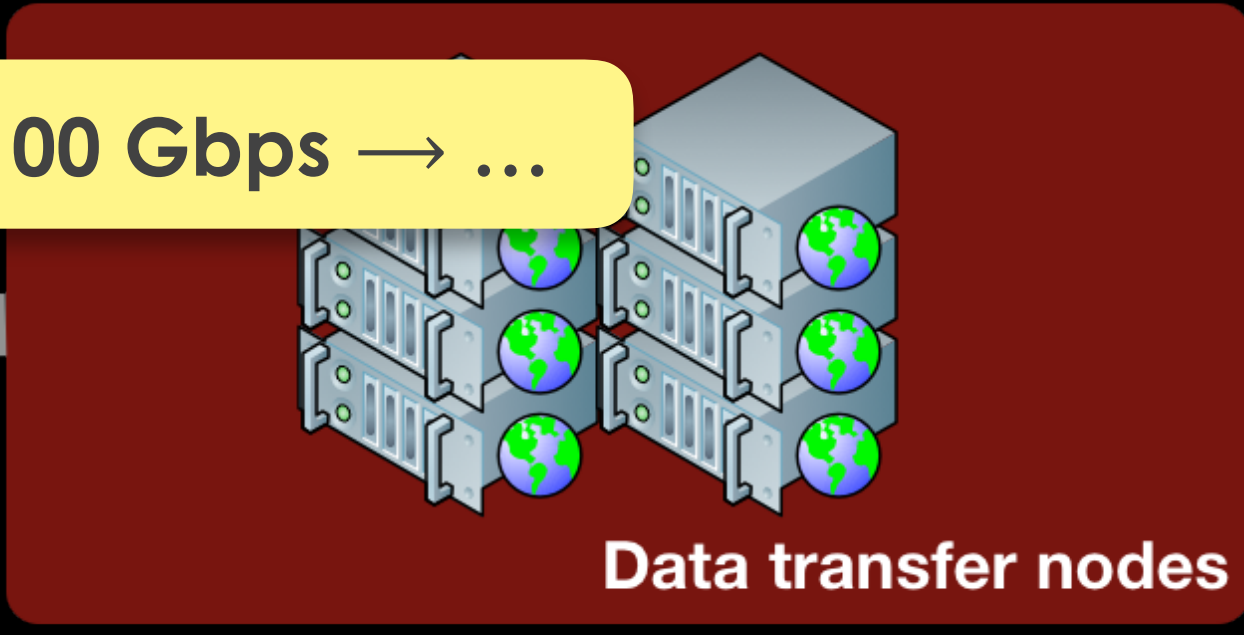
- **Satellite data release production**, under NCSA leadership
*CC-IN2P3 and NCSA each to **process 50% of the raw data***
- Both NCSA and CC-IN2P3 will exchange and validate the data produced by the other party
- Each site to **host an entire copy of both raw and reduced data**
i.e. the products of the annual data release processing (images and catalog)

FORESEEN ARCHITECTURE

22k → 123k CPU cores



100 Gbps → ...



LAN

2022 → 2032

LSST IMAGE STORAGE

- **File sizes in the range 50 - 100 MB**
 - 1 file per CCD, 189 CCDs in the focal plane*
 - FITS format (currently) for processing, archival and publication*
 - ~10B files, aggregated over the 10 years of operations (raw + derived data)*
- **High-level I/O abstraction layer**
 - designed to make life easier for scientists*
 - currently requires storage systems exposing either POSIX or S3 APIs, but extensible architecture*
- **Data file sizes**
 - raw: exposures of 3.7 GB, composed of 189 files, ~20 MB each after compression*
 - derived: calibrated exposures composed of 189 files of 110 MB each*
 - other kind of image products: ~100 MB per file*

LSST IMAGE STORAGE (CONT.)

- **Image data already compressed**
baseline: 3 integral copies around the world (US, France, Chile)
- **Raw image data as well as released data products to be archived**
likely on tape for budgetary reasons
- **Annual data processing**
to process all the data collected since the beginning of the survey
new release of the data products delivered (both images and astronomical catalog)
fixed time budget of about 5 months per year for bulk processing

LSST IMAGE STORAGE (CONT.)

- **Image data caching**

probably not for bulk processing local to a site: the cache mechanisms of the worker nodes and the storage backends should suffice

caching may be of interest for exposing image data products to remote sites or even to end users' laptops, for instance to hide latency

authentication required to ensure access to data is only allowed to authorised parties, in particular during the 2 years of embargo after data acquisition

- **Data access patterns**

image processing often requires reading the whole image, but this does not necessarily mean sequential file access, depending on the file format used for the processing phase

SUMMARY

SUMMARY

- We are exploring mechanisms for providing LSST data processing tasks with the data they need
this are not yet stabilised even if we are
- More work needed to understand the specifics of data access patterns for all the stages of the processing pipeline
I would like we use as much as possible standard tools and protocols

QUESTIONS & COMMENTS