Rubin Observatory

Introduction

NSF/DOE Joint Status Review
Aug 31 - Sept 4, 2020

Steven Kahn

Director

Rubin Observatory's mission is to build a well-understood system that provides a vast astronomical dataset for unprecedented discovery of the deep and dynamic universe.

https://gallery.lsst.org — for a live webcam visit https://www.lsst.org/news/see-whats-happening-cerro-pachon

Renaming (as of January 2020)

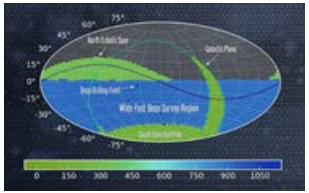
Rubin Observatory

Project, facilities in Chile and Tucson → Vera C. Rubin **Observatory**

Rubin Observatory

The astronomical Telescope → Simonyi Survey **Telescope**

10 year optical survey → Legacy **Survey** of Space and Time



LSST Legacy Survey of Space and Time

Original concept of slide by frossie@lsst.org

In a Nutshell

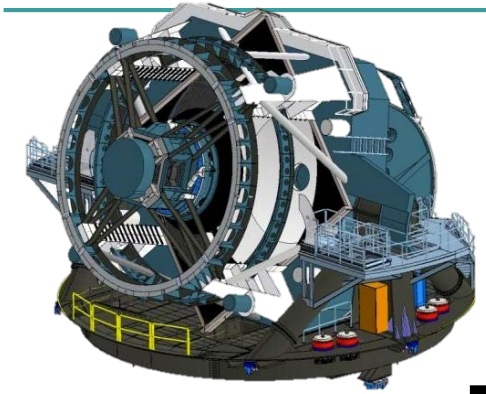
Rubin Observatory

Rubin Observatory is an integrated survey system designed to conduct a decade-long, deep, wide, fast time-domain survey of the optical sky. It consists of an 8-meter class wide-field ground based telescope, a 3.2 Gpix camera, an automated data processing system and a public engagement platform.

For the first ten years of operation, the Vera C. Rubin Observatory will perform the **Rubin Observatory Legacy Survey of Space and Time** (LSST), using the **Rubin Observatory LSST Camera** and the **Simonyi Survey Telescope**. During this time Rubin will acquire, process, and make available a collection of over 5 million images and catalogs with more than 37 billion objects and 7 trillion sources. Tens of billions of time-domain events will be detected and alerted on in real-time.

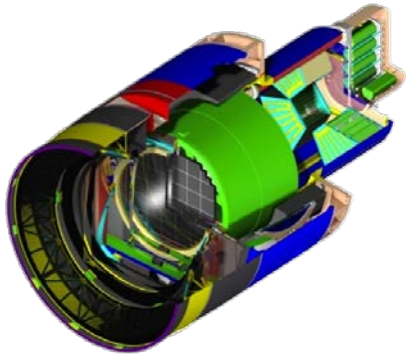
Rubin will enable a wide variety of complementary scientific investigations, utilizing a common database and alert stream. These range from searches for small bodies in the Solar System to precision astrometry of the outer regions of the Galaxy to systematic monitoring for transient phenomena in the optical sky. It will also provide crucial constraints on our understanding of the nature of dark energy and dark matter.

Rubin Observatory: An observing facility to conduct 10-year optical survey, process, archive, and serve images and data products



8.4m Telescope

+



3.2Gpix Camera

Raw Amp Images

Peta-scale Data Management

Reference Catalogs

SDQA

ISR

CCD Assembly

CR Split

Image Char.

Single Frame Meas.

Source Assn.

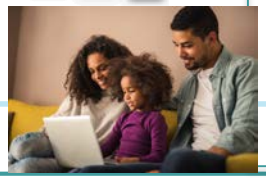
Calib Ref Images

Combined Image

Calibrated Visit Image

Source Catalog

Object Catalog



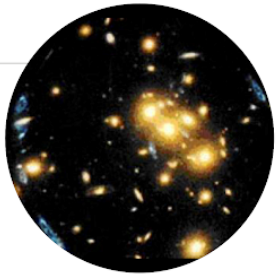
Science and Public user Interfaces

Four Science Goals

Rubin Observatory

Dark Matter, Dark Energy

- Weak Lensing
- Baryon acoustic oscillations
- Supernovae, Quasars

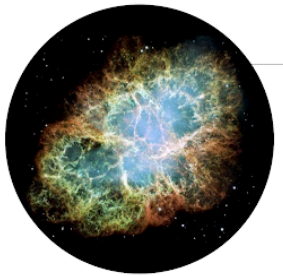


Cataloging the Solar System

- Potentially Hazardous Asteroids
- Near Earth Objects
- Object inventory of the Solar System

Milky Way Structure & Formation

- Structure and evolutionary history
- Spatial maps of stellar characteristics
- Reach well into the halo



Exploring the Transient sky

- Variable stars, Supernovae
- Fill in the variability phase-space
- Discovery of new classes of transients

"From Science Drivers to Reference Design", Ivezić et al. (2008), arXiv:0805.2366

Science requirement in SRD

Formally adopted in July, 2011, and unchanged since that time.

Modification requires the approval of the LSST Corporation Board.

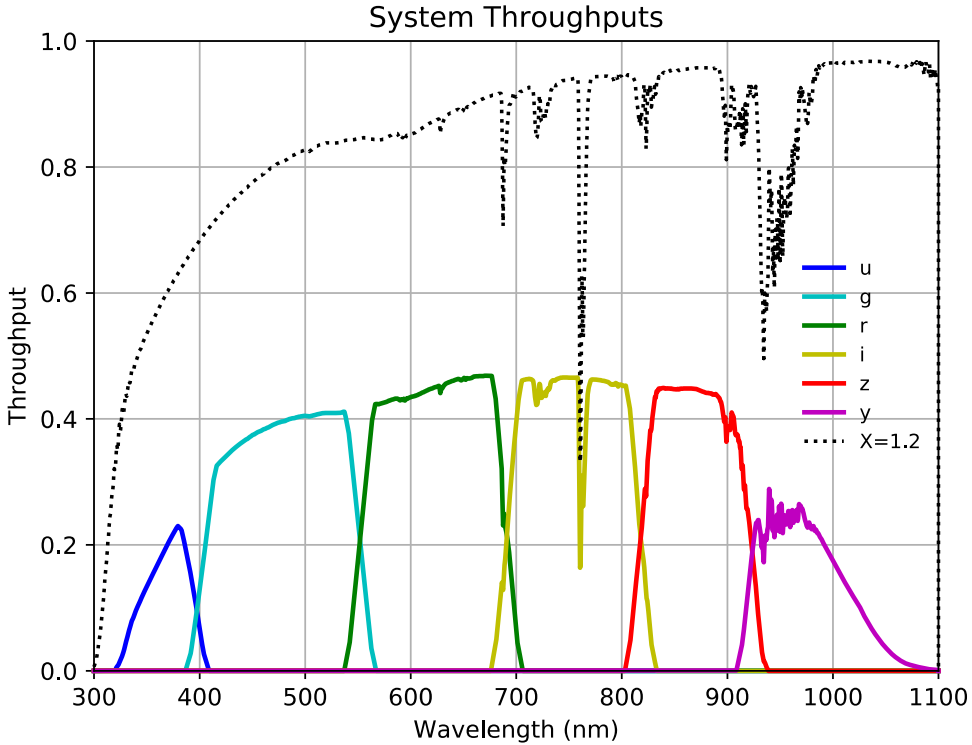
Includes a minimum specification, design specification, and stretch goals for all key parameters of the survey.

High level requirements summary

Rubin Observatory

Survey Property	Performance
Main Survey Area	18000 sq. deg.
Total visits per sky patch	825
Filter set	6 filters (ugrizy) from 320 to 1050nm
Single visit	2 x 15 second exposures
Single Visit Limiting Magnitude	u = 23.5; g = 24.8; r = 24.4; I = 23.9; z = 23.3; y = 22.1
Photometric calibration	2% absolute, 0.5% repeatability & colors
Median delivered image quality	~ 0.7 arcsec. FWHM
Transient processing latency	60 sec after last visit exposure
Data release	Full reprocessing of survey data annually

Filter Complement and System Throughput



Data Product Categories

Rubin Observatory

Prompt Data Products

Real Time Difference Image Analysis (DIA)

- Stream of ~10 million time-domain events per night (Alerts), transmitted to event distribution networks within 60s of camera readout.
- Images, Object and Source catalogs derived from DIA, and an orbit catalog for ~6 million Solar System bodies within 24h.
- Enables discovery and rapid follow-up of time domain events.

Data Release Data Products

Reduced single-epoch & deep co-added images, catalogs, reprocessed DIA products

- Catalogs of ~37 billion objects (20 billion galaxies, 17 billion stars), ~7 trillion sources and ~30 trillion forced source measurements.
- 11 Data Releases, produced ~annually over 10 years of operation.
- Accessible via the Rubin Science Platform (RSP) & Rubin Data Access Centers (DACs).

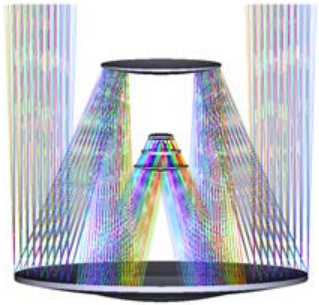
User Generated Data Products

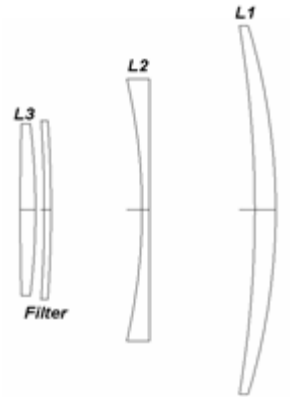
User-produced derived, added-value data products

- Deep KBO/NEO, variable star classifications, shear maps, etc …
- Enabled by services & computing resources at Rubin DACs and via the Rubin Science Platform (RSP).
- 10% of computing resources at the US Data Facility (USDF) will be allocated for User Generated data product storage & processing.

Unique Optical Design

- Rubin Observatory incorporates a unique and compact Modified Paul-Baker 3-mirror optical design, with the camera located just below the secondary.
- The surfaces of all three mirrors, and the six degrees of freedom orientation of the camera, are controlled by an active optics system.
- There are three refractive optics in the camera (L1, L2, L3), plus a filter with very modest optical power.
- The design has been optimized to reduce asphericity in the various elements, and to ease in testing.

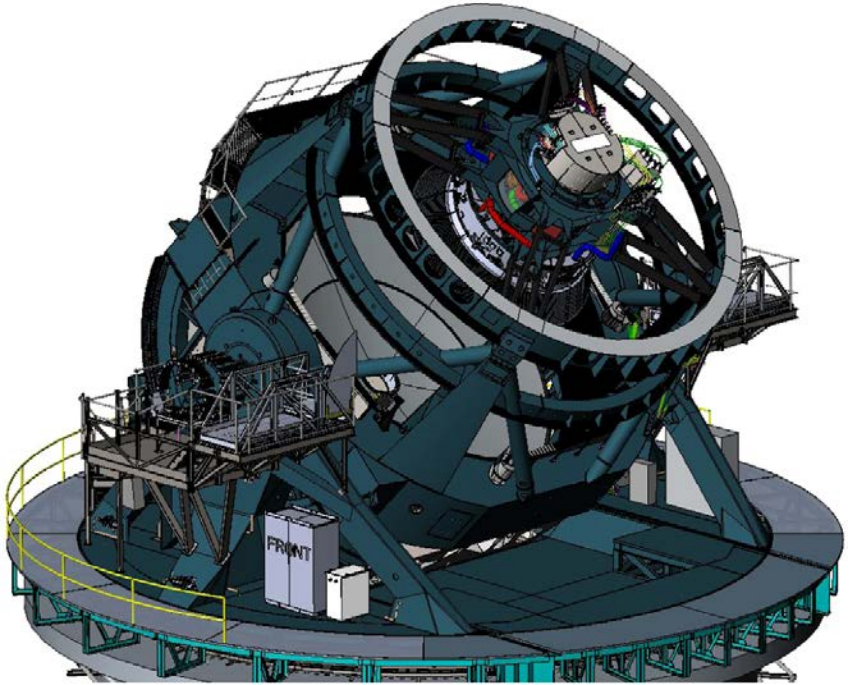




Telescope Mount Assembly

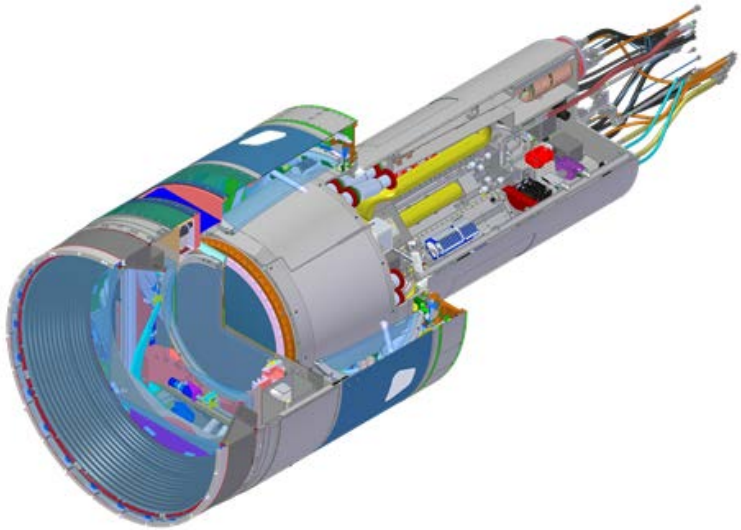
The telescope mount involves a compact stiff structure, necessary to achieve the short slew and settling time allocation of < 4 s for a 3.5 degree slew.

Telescope Mount Enables Fast Slew and Settle

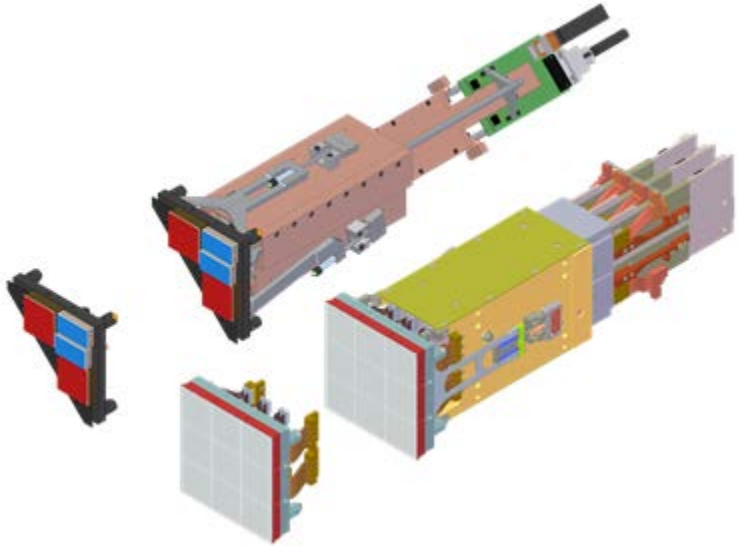


LSST Camera

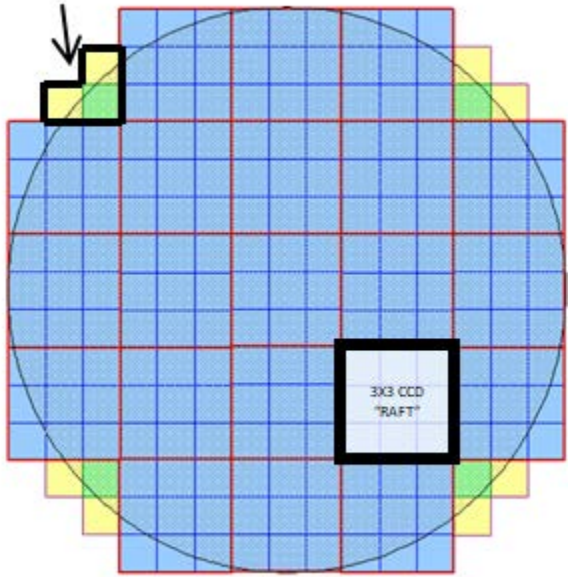
- The 3.2 Gigapixel LSST Camera will be the largest electronic camera ever built for ground-based astronomy.
- There are six optical filters, five of which are resident in the camera on any given night.



Sensor Raft Assemblies

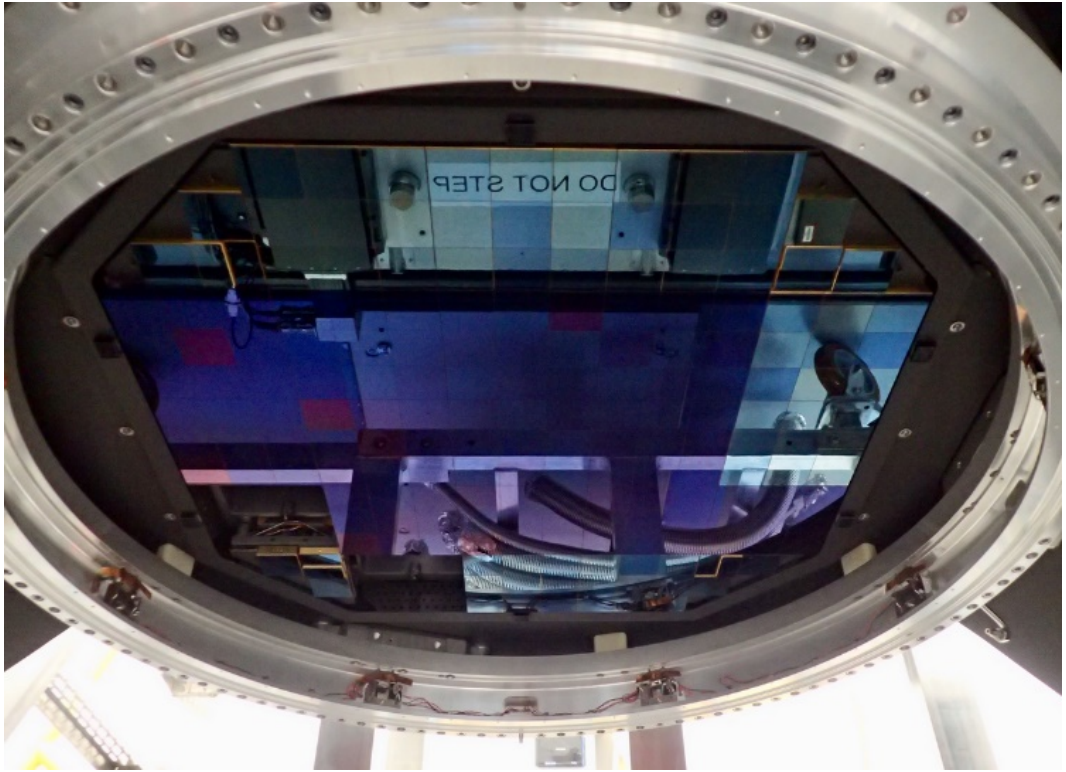


4 Corner areas for wavefront sensing (green) and guiding (yellow).

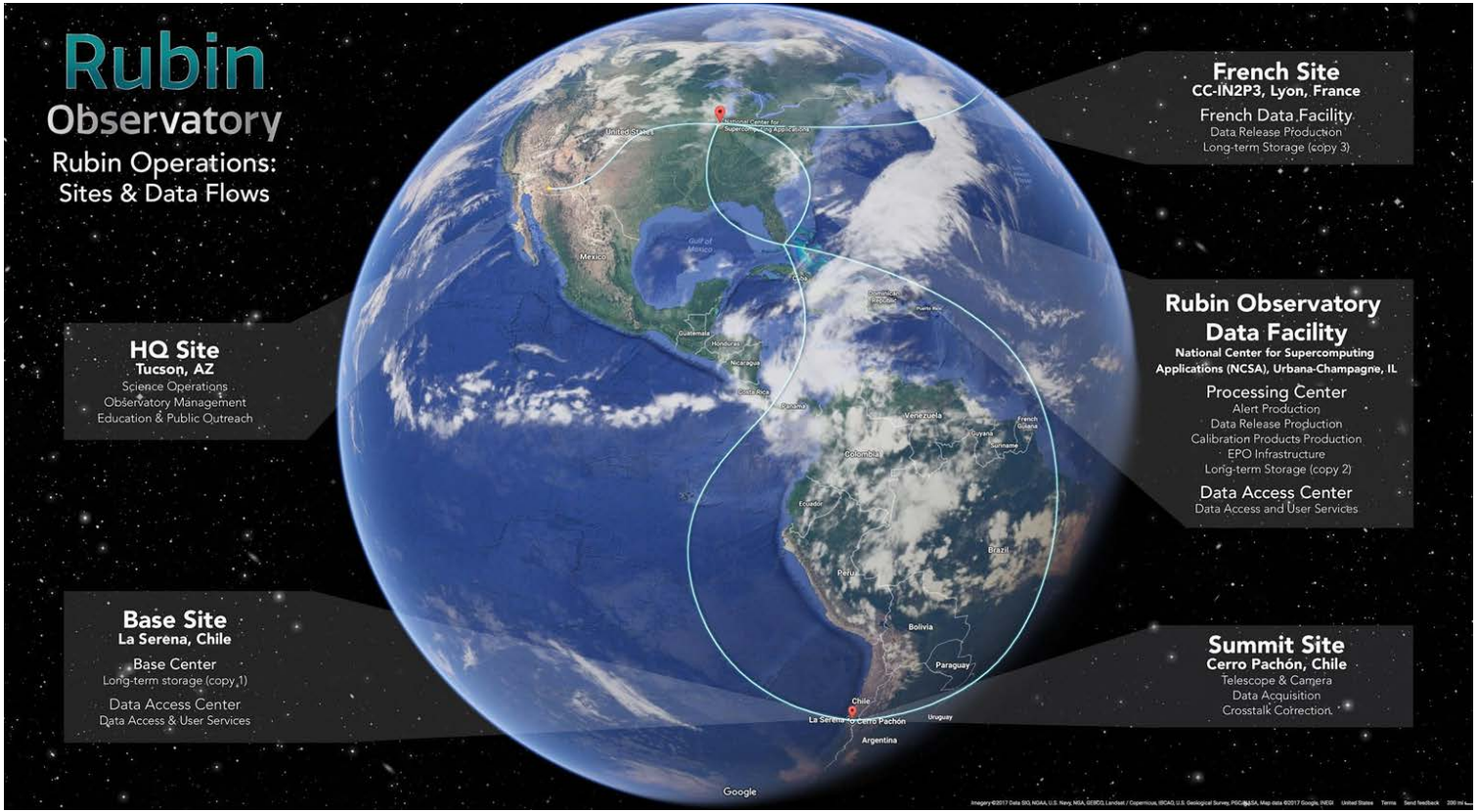


21 rafts make up the science array

Rafts Installed in Cryostat

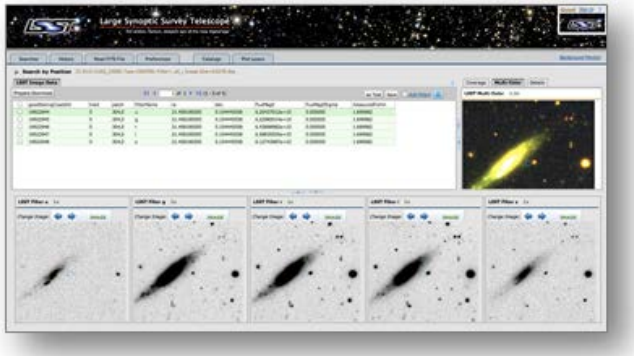


Rubin Data Sites and Data Transfer



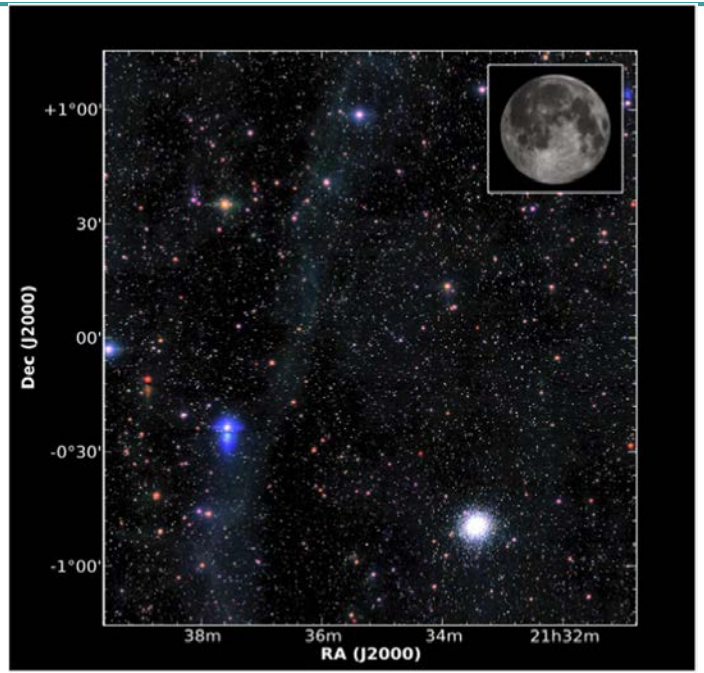
Data Processing and Data Access

*A petascale supercomputing system at the data **Archive** (at TBD) will process the raw data, generating reduced image products, time-domain alerts, and catalogs*

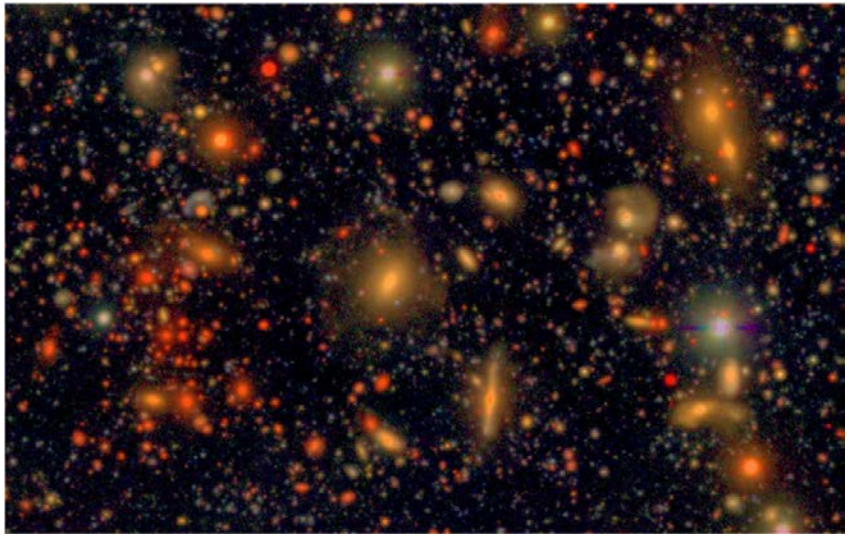


***Data Access Centers** in the U.S. and Chile will provide end-user analysis capabilities and serve the data products to Rubin users.*

Examples of Data Processed with the LSST Stack



SDSS Stripe 82



HSC *gri* image of the COSMOS field. Equivalent to 10 yr LSST depth.

Construction Funding

Rubin Observatory

Telescope and site facility construction, data management system, and education and public outreach.

US$ 473 M

AURA

Camera fabrication. Major Item of Equipment (MIE), through the Office of High Energy Physics in the Office of Science.

US$ 168 M

SLAC NATIONAL ACCELERATOR LABORATORY

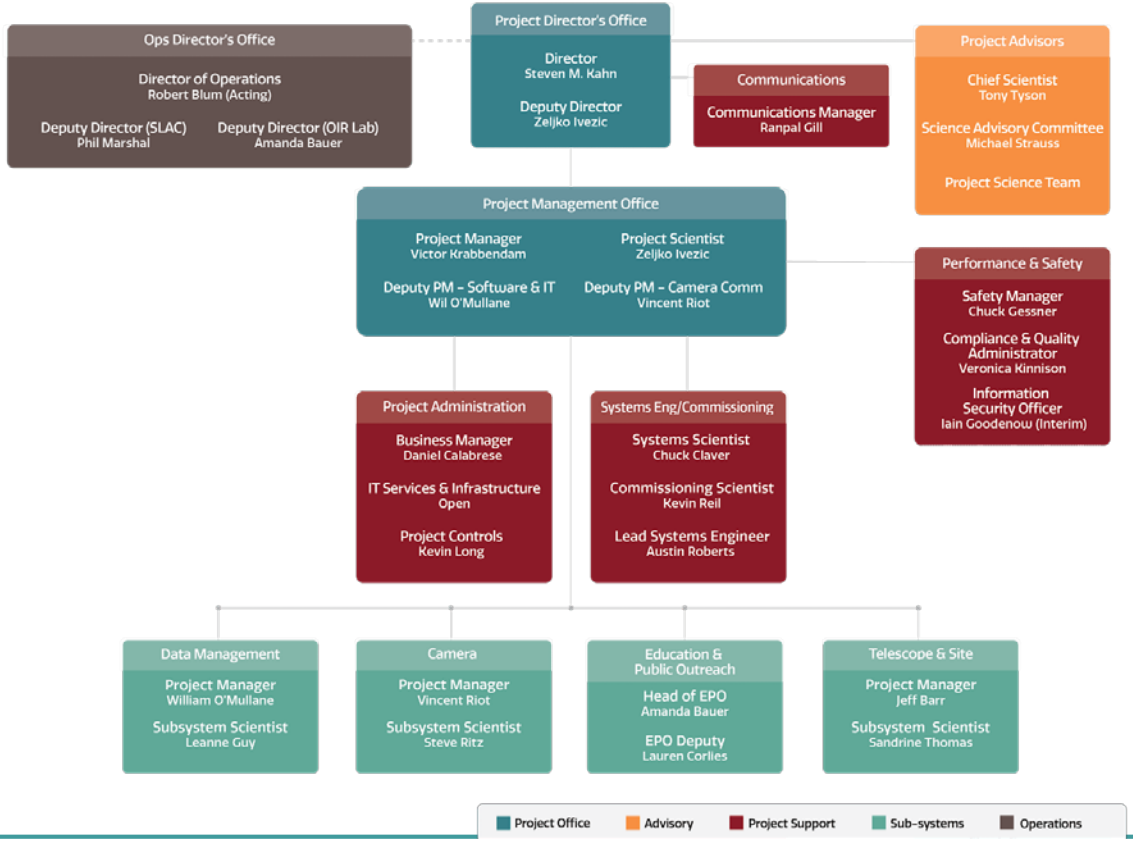
Primary/tertiary mirror, secondary mirror blank, preliminary site preparation, early sensor studies.

Private, Corporate, and Institutional Donors

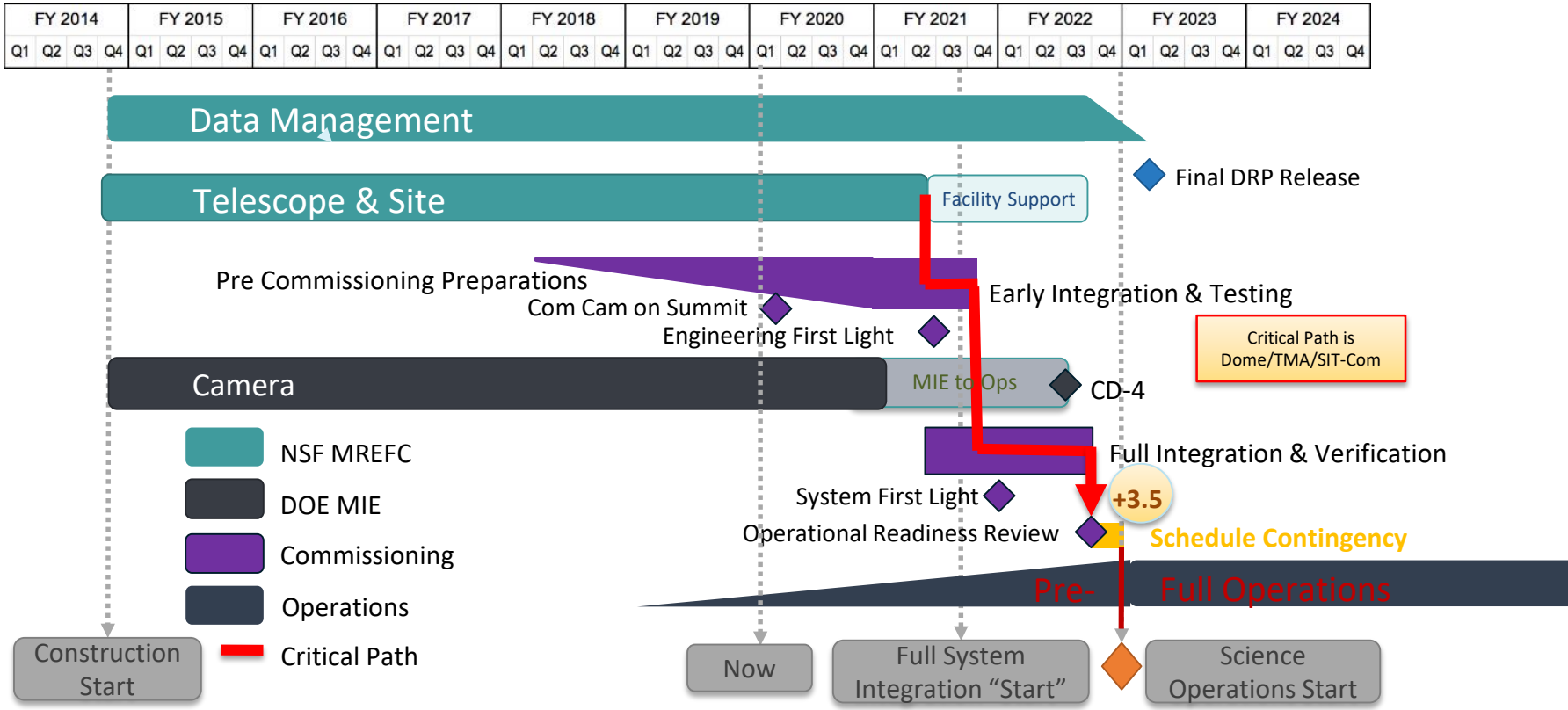
US$ 30 M

LSST CORPORATION

Project Organization Structure



Construction Schedule – Pre-Covid



It has been an eventful year …

- Civil unrest in Chile
- Covid crisis
- Killing of George Floyd and the resulting attention to anti-Black racism in all facets of life in America.

All three have had a significant effect on the Project!

Diversity, Equity & Inclusion

Rubin Observatory

The **Multimessenger Diversity Network** is a community of representatives from multimessenger astronomy research collaborations focused on increasing equity, diversity, inclusion, and accessibility in the field.

https://astromdn.github.io/

Two project members, Lauren Corlies and Keith Bechtol, participate in monthly meetings. The group produced a decadal survey white paper centered on increasing DEI in large collaborations.

AURA

AURA Chief Diversity Officer - Ameerah McBride (December 2019)

Priorities in conjunction with NOILab:

1. Add broadening participation element in performance assessment
2. Annual DEI report
3. Recruitment - unconscious bias & applicant diversity

Workplace Culture Advocates

https://project.lsst.org/workplace-culture-advocate

Sandrine Thomas
Telescope and Site
Project Scientist
Telescope and Site
Tucson, AZ

Richard Dubois
Senior Staff Scientist
Camera
SLAC National
Accelerator Laboratory,
Menlo Park, CA

Chuck Gessner
Head of Safety
Project Office
Tucson, AZ

Andy Connolly
Simulations Scientist,
Systems Engineering
University of
Washington, Seattle, WA

Carol Chirino
Administrative Manager/
Jefe de Administración
Project Office
La Serena, Chile

Felipe Daruich
Senior Electronics
Engineer
Telescope & Site
La Serena, Chile

Working with management as well as Communication and Training to roll out a workplace improvement plan focusing on:

Increased diversity
Retention
Satisfaction

Document-35933

Concluding Remarks

Rubin Observatory

- The Rubin Observatory construction was nearing completion when Covid hit. We were not without issues, but the technical and programmatic progress was strong.

- We are now facing significant and uncertain delays. Nevertheless, we are maintaining our focus and devising new strategies to minimize the impacts.

- Our team is strongly committed to getting back to full capability. The Rubin Observatory will be a paradigm-changing facility, and we are all proud to be part of the effort to make it a reality.