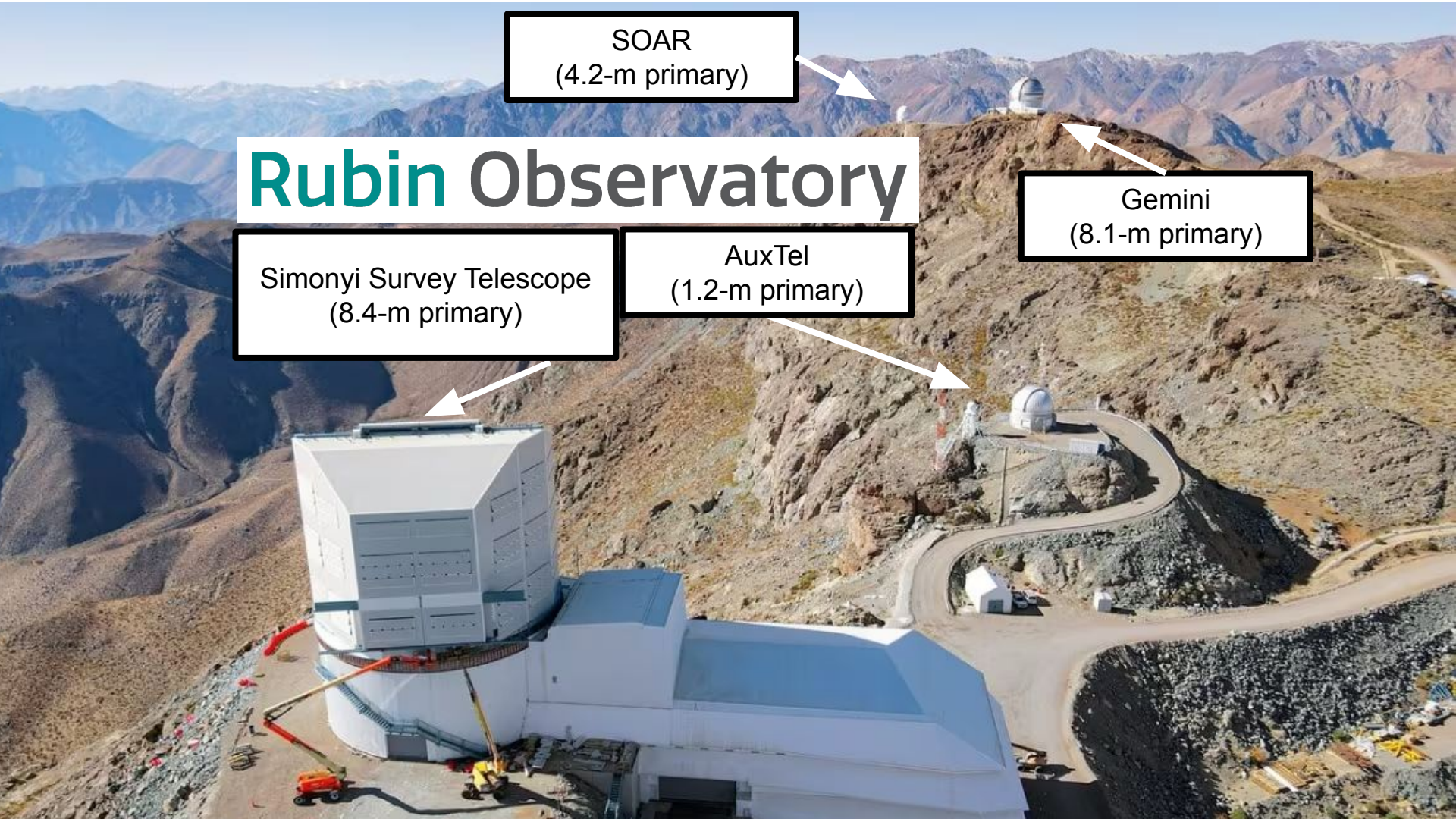
Rubin Observatory LSST and LSST DESC @Fermilab

Cosmic Physics Center Meeting
October 30, 2023


SOAR
(4.2-m primary)
Rubin Observatory
Gemini
(8.1-m primary)
Simonyi Survey Telescope
(8.4-m primary)
AuxTel
(1.2-m primary)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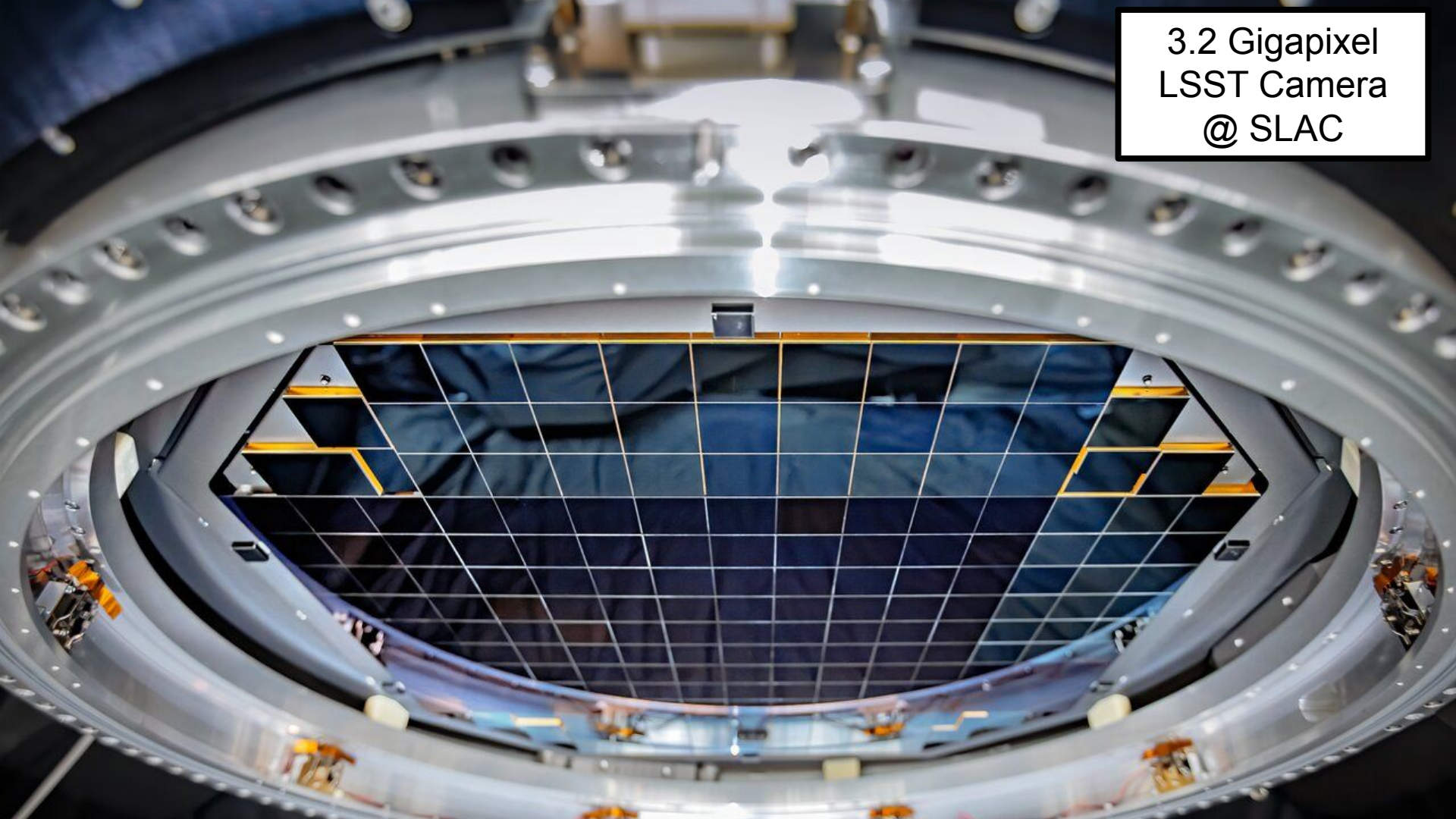

3.2 Gigapixel
LSST Camera
@ SLAC


CNET

Nomenclature

The Vera C. Rubin Observatory Project includes the construction and operation of the site, telescope, and camera.

The Legacy Survey of Space and Time (LSST) often referred to as Rubin LSST

The LSST Dark Energy Science Collaboration (DESC)

Using it in a sentence… “The Vera C. Rubin Observatory will perform the Legacy Survey of Space and Time, which the Dark Energy Science Collaboration will use to do fundamental physics.”

At Fermilab, we are involved in the (pre-)operations of Rubin Observatory and LSST DESC.

Science Goals

Rubin LSST has several science goals, one of them being:

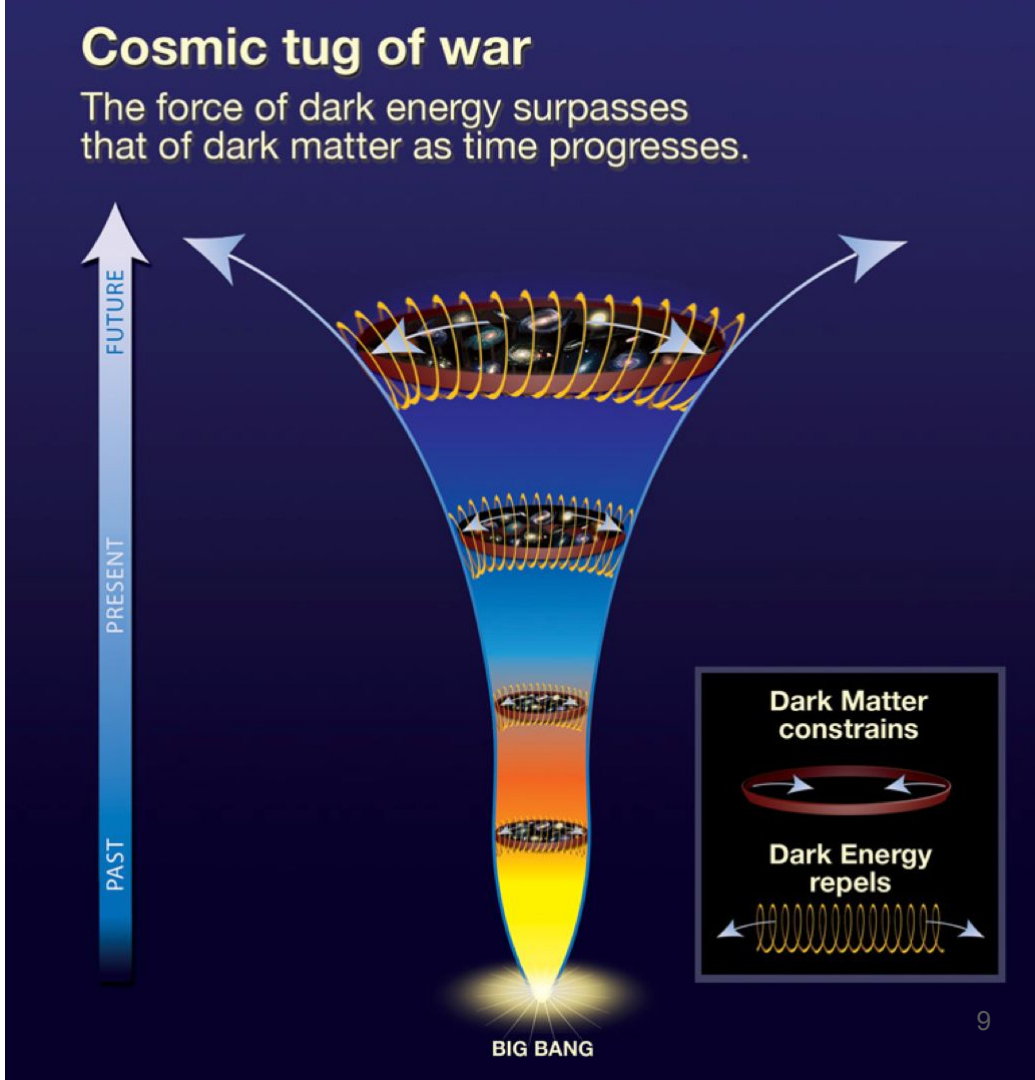
- “Probing dark energy and dark matter.”

The DOE-funded LSST DESC

- “is the international science collaboration that will make high accuracy measurements of fundamental cosmological parameters using data from the LSST.”
- “LSST DESC is planning to carry out full cosmology analyses (dark energy, dark matter, inflation, neutrinos, …)”

Fundamental Physics

- Dark energy
- Dark matter
- Neutrinos
- Modified gravity
- General relativity

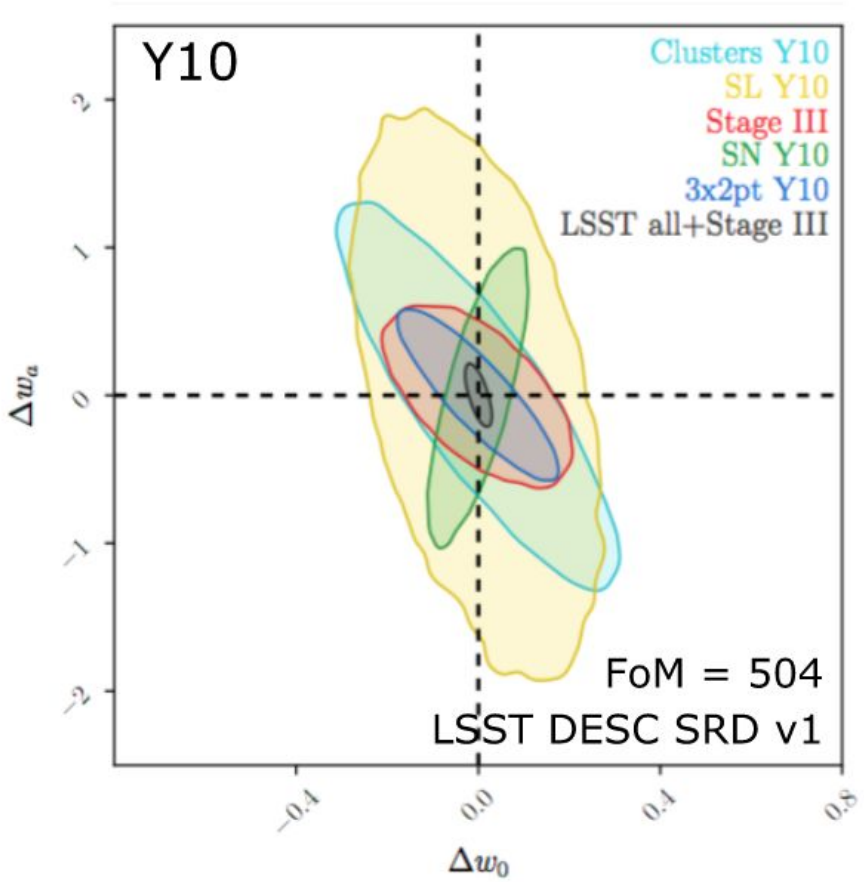


Fundamental Physics

- **Dark energy**
- Dark matter
- Neutrinos
- Modified gravity
- General relativity

Core multi-probe program

- Weak lensing
- Galaxy Clusters
- Large-scale structure
- Supernova
- Strong lensing

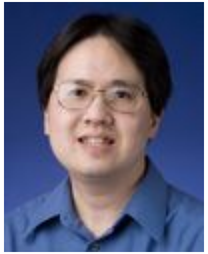


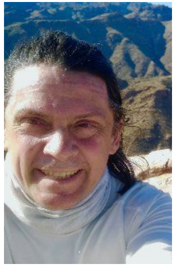
LSST DESC SRD Projections
1809.01669

Fermilab Rubin LSST + DESC Team

LSST DESC
Dark Energy Science Collaboration

Rubin Observatory













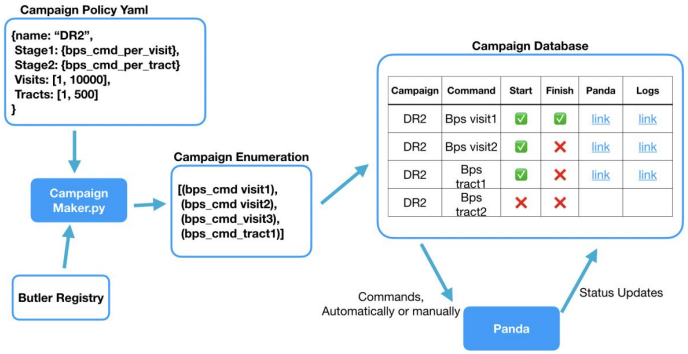


Rubin Observatory

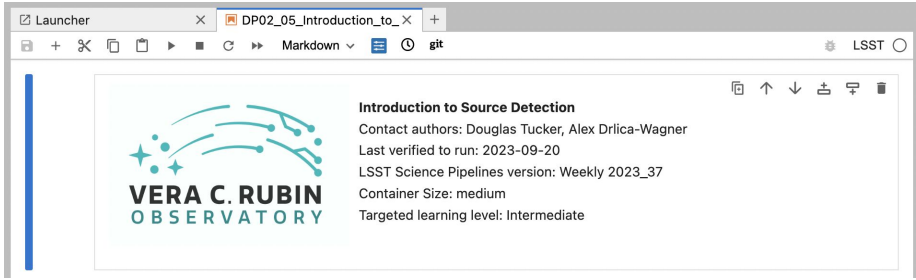
Fermilab's roles are in (pre-)Operations

- Data Management:
  - Data Processing Scientists
  - Data Movement Specialists
  - Infrastructure & Support

- System Performance:
  - Community Scientists
  - Verification & Validation Scientists
  - Survey Scheduling



Yanny et al. 2023



Tucker et al. 2022

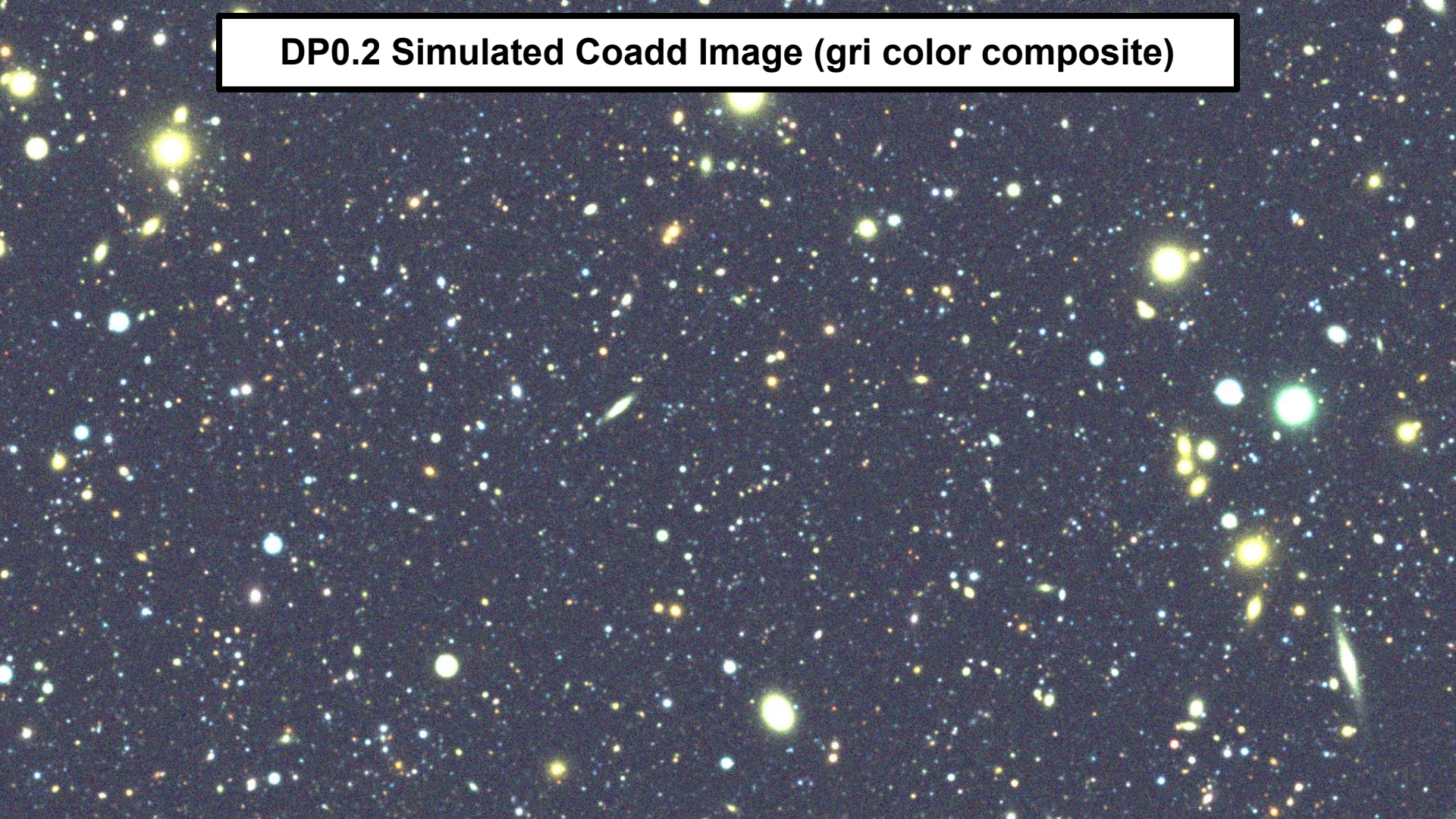
Data Processing Campaigns – DP0.2

Rubin Observatory

- **Data Preview 0.2 (DP0.2) processed 300 deg^2 of simulated images to typically 5-year LSST depth coming from the LSST DESC Data Challenge 2 (DC2)**
  - **DP0.2 served as a rehearsal for the LSST annual data releases**
  - **Processing used the LSST science pipelines and software stack**

- **Strong Fermilab effort in DP0.2 production (Data Management): Huan Lin (pilot), Jen Adelman-McCarthy, Brian Yanny, Nikolay Kuropatkin**
- **And validation/community support (System Performance): Douglas Tucker, Jim Annis, Alex Drlica-Wagner**

- **About 20,000 exposures, corresponding to 10-20 nights of LSST imaging**
- **Took 150 calendar days (12/21-05/22): 60 days of running, remainder for debugging and development**
- **Used 2.5 million core-hours, on Google Cloud cluster with ~4000 cores**
- **Data volume: 75TB images (input) → 3.4 PB output (2.5PB afer cleanout)**


DP0.2 Simulated Coadd Image (gri color composite)

Data Processing Campaigns – HSC PDR2

Rubin Observatory

Following the DP0.2 simulated data milestone, a followup processing campaign was run on real Hyper Suprime-Cam data (shared by NAOJ team).

1. 1000 square degree (re)processing of ‘real’ (not simulated) data from HSC (8m telescope and camera on Mauna Kea – depth similar to LSST 2-year depth

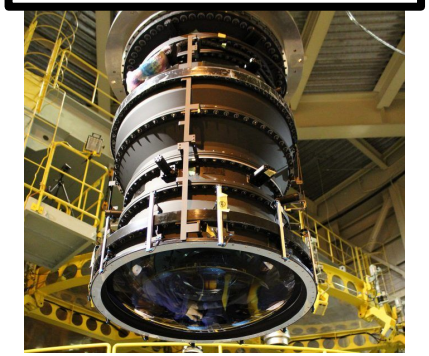
2. Using latest Rubin software stack and processing cluster

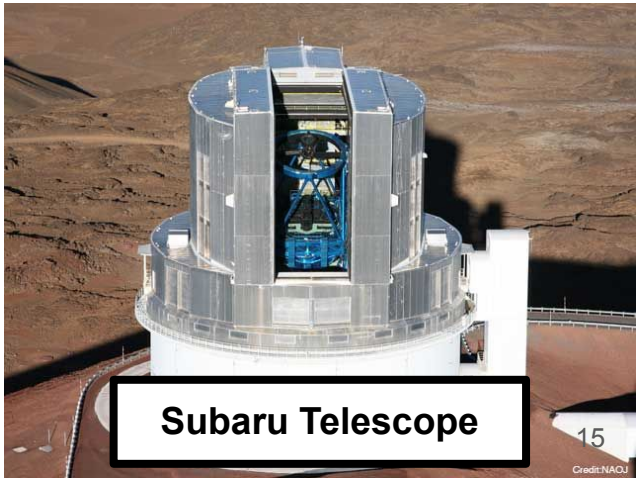
Lead processors: Jen Adelman-McCarthy (FNAL)

Production Scientist: Brian Yanny (FNAL)

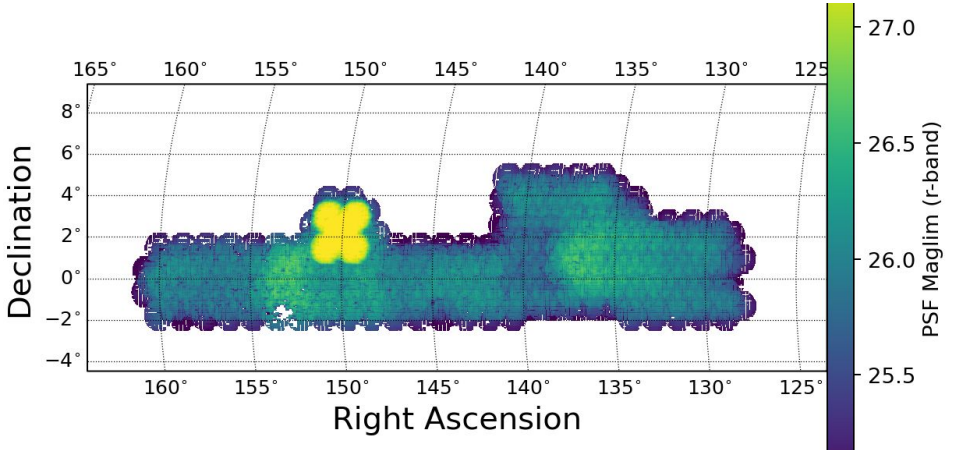
Completed on Aug. 23!

Hyper Suprime-Cam





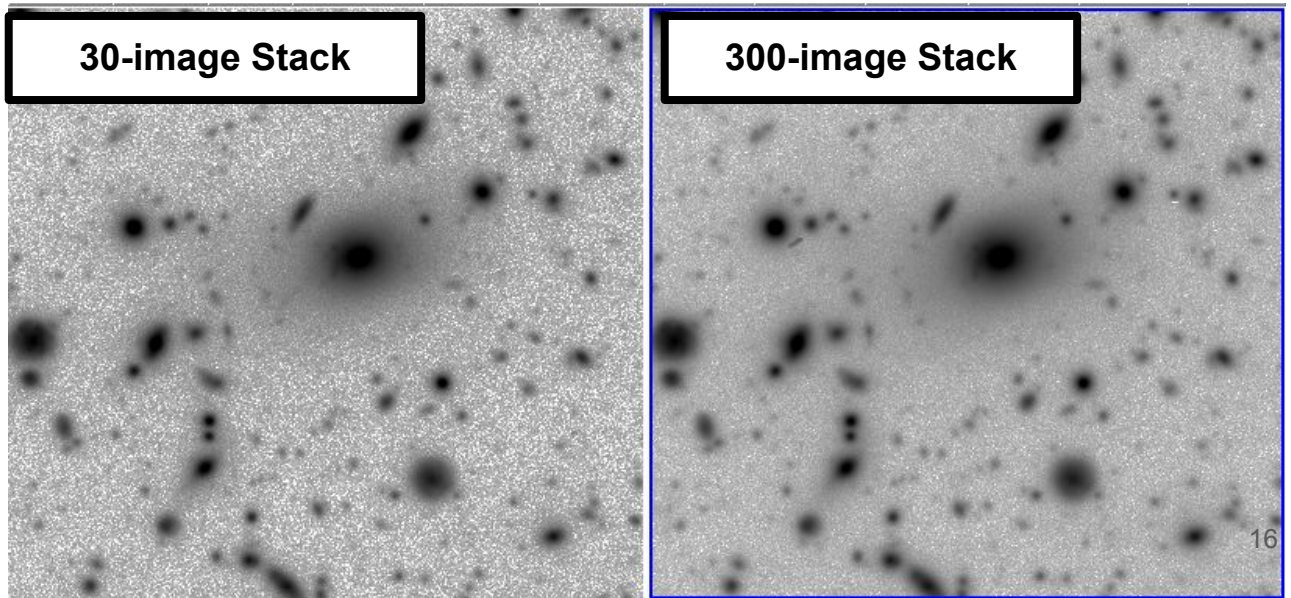
HSC PDR2 Reprocessing Campaign



Rubin Observatory

Depth and excellent image quality make HSC a good trial for LSST.

Point source detection in the Cosmos field (RA, DEC) = (150, 2) deg reaches r=27.5.

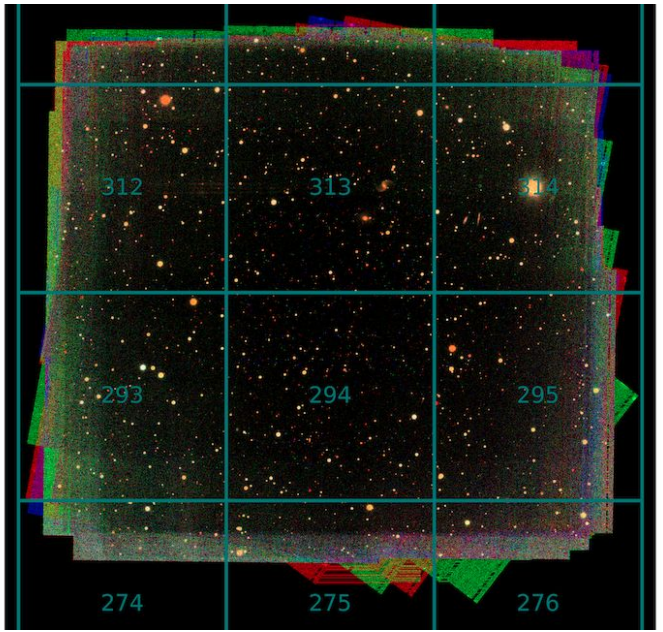


Auxiliary Telescope (AuxTel)

AuxTel/LATISS

- **1.2-m AuxTel hosts the “LSST Atmospheric Transmission and Slitless Spectrograph (LATISS)”**
  - **Uses a *single* LSST 4k x 4k CCD**
- **Will provide spectroscopic atmospheric calibration data during LSST operations**
- **Currently being used to prepare for main telescope commissioning**
- **Observing runs every 2 weeks, including imaging data that serves to test LSST processing pipelines, as well as “verification and validation (V&V)” activities, on real data.**
- **Data processing led by Fermilab (H. Lin)**

AuxTel mosaic coadd image (gri composite)



Study the behavior of an LSST CCD on sky

LSST DESC Science and Operations

Pipeline Scientists

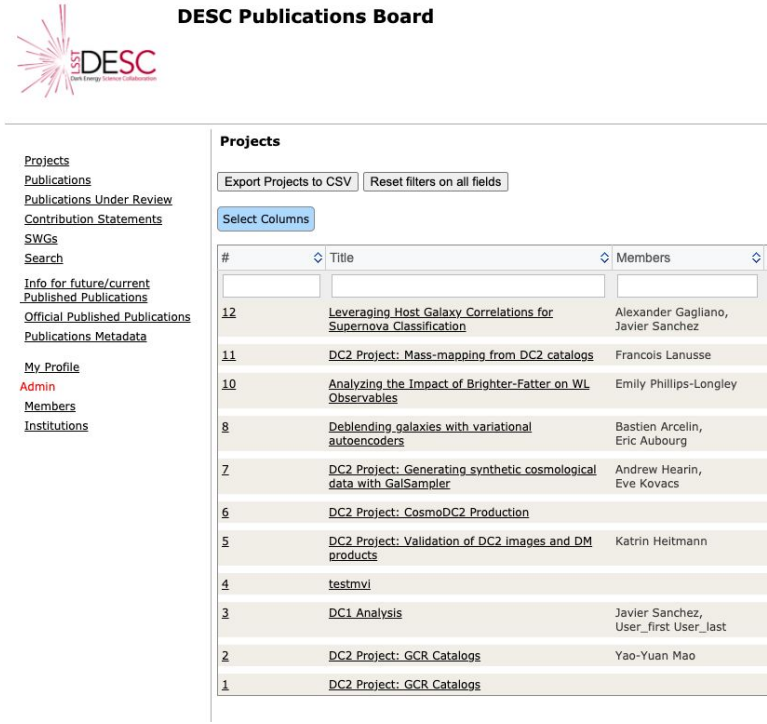
- Likelihood frameworks, MCMC samplers, Photometric Redshifts, Fast Access to Survey Transients Database

Collaboration Management

- Publication Board, Operations Committee, Collaboration Council, etc.

Science Working Groups

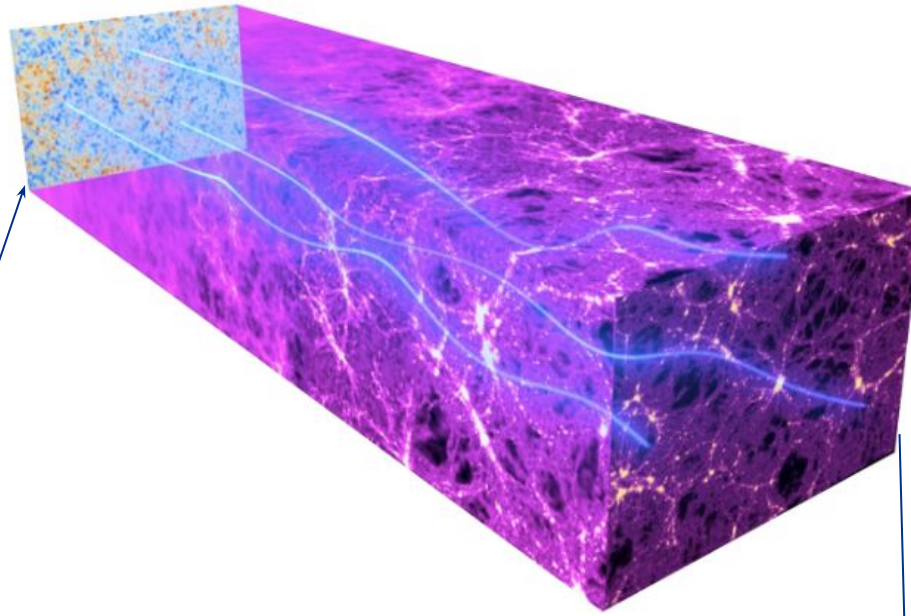
- Modeling and Combined Probes, Weak Lensing, Photo-z, Dark Matter, Time Domain/Strong Lensing etc.



LSST Cross Correlations

Extend DESC pipelines (TxPipe and Firecrown) to support cross-correlation between cosmic shear and CMB lensing

- Validation and cosmological constraints purely from shear and CMB lensing data public available: HSC, KiDs, DES, ACT, Planck and SPT data



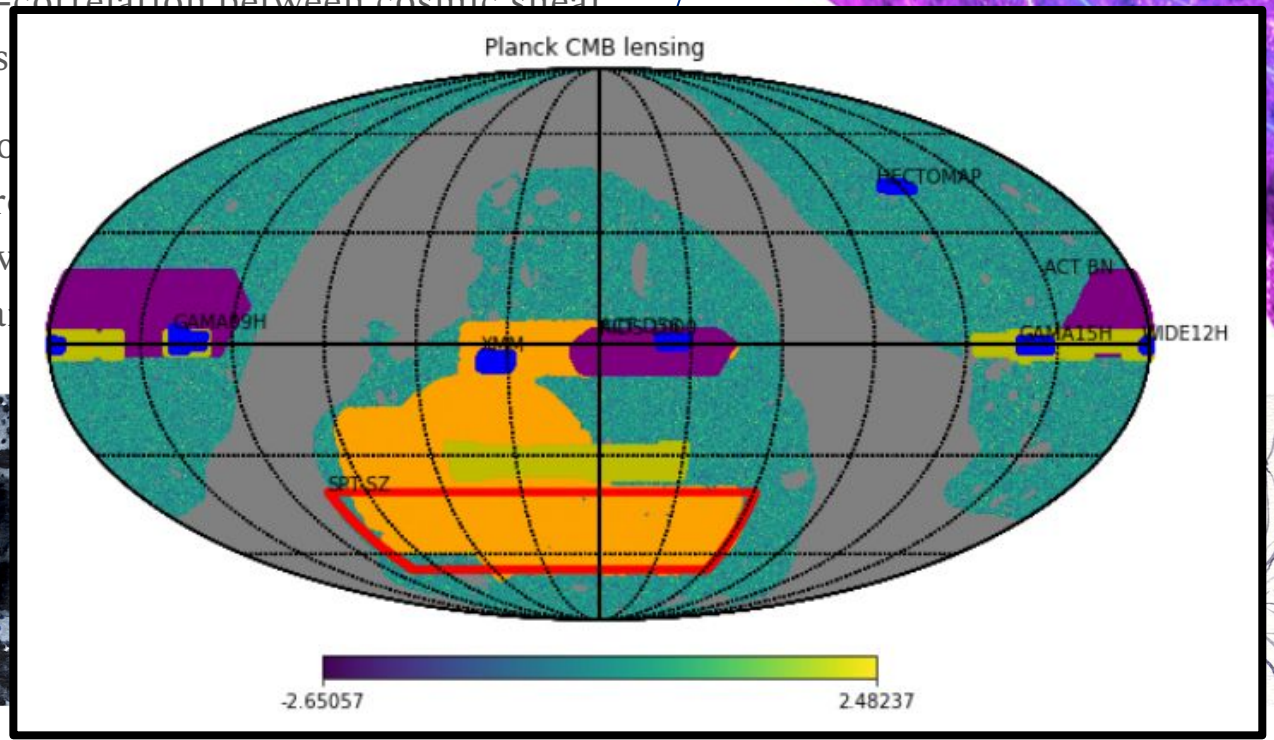
Credit: ESA/Planck team

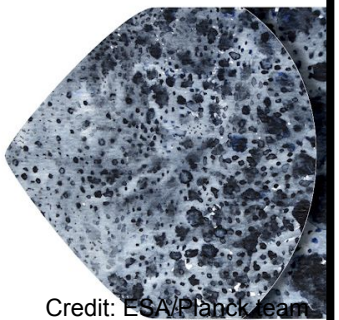
LSST Cross Correlations

Extend DESC pipelin
support cross-correlation between cosmic shear
and CMB lens

- Validatic
  purely fr
  public av
  Planck a

Apply LSST pipelines to Public Stage-3 Data





Credit: ESA/Planck team

Schedule

Rubin Observatory

Lots of milestones scheduled for this spring…

Camera currently planning to ship to Chile in ~March 2024

On-sky data with ComCam July-August 2024 (2 months)

System First Light with LSSTCam is projected for January 2025

Construction completion in May 2025

Start of LSST data taking in 2025 and first LSST data release (DR1) in 2026

http://ls.st/dates