The Vera C. Rubin Observatory and the LSSTCam: the largest digital camera in the world

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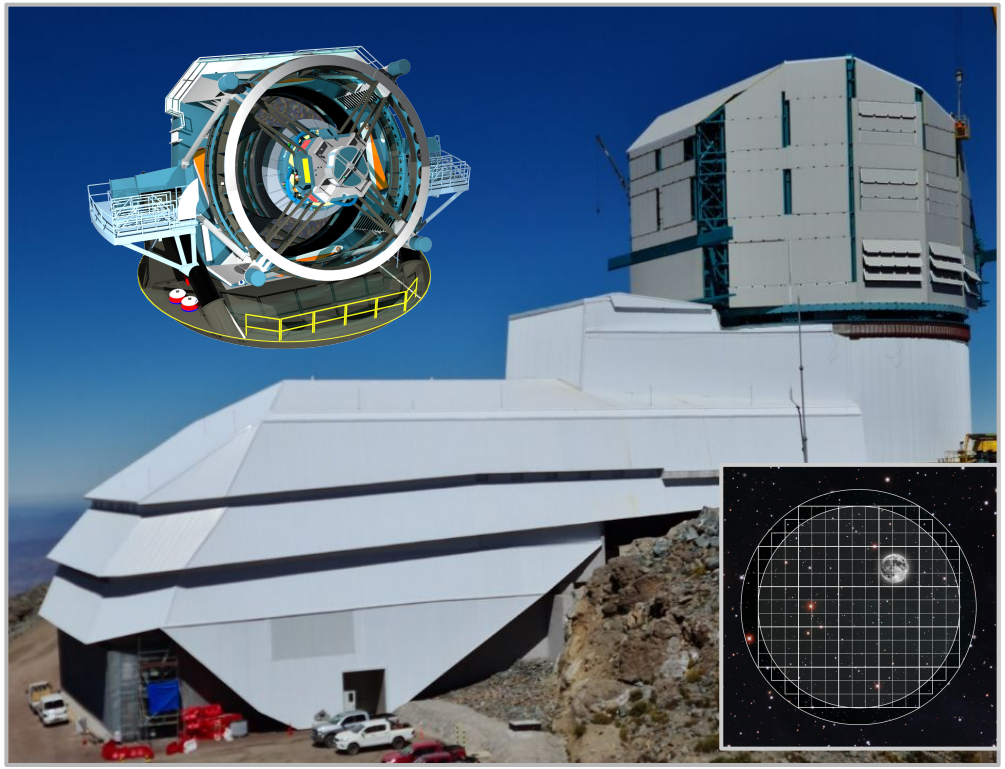
Rubin Operations Scientist (KIPAC/ SLAC)
Community Engagement and DM Calibrations Teams

Outline

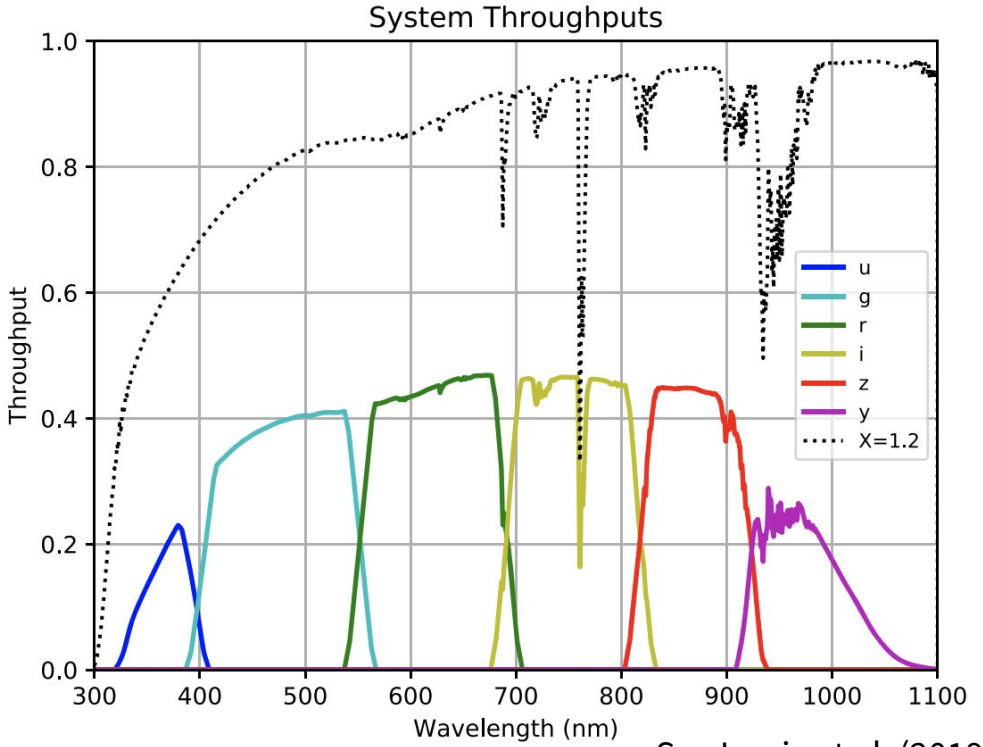
- The Vera C. Rubin Observatory
  - Legacy Survey of Space and Time
- The Camera and Telescope
  - Focal Plane: 189 Science CCDs (Charge-Coupled Devices)
- Rubin Status
  - Milestones
  - System Integration and Commissioning
    - AuxTel, LSSTComCam
- Getting Involved with Rubin and LSST
  - LSST Science Collaborations
    - DESC - Intrinsic Alignments
  - Data Rights and In-Kind Contributions: Japanese Participation Group

The Vera C. Rubin Observatory



- The Vera C. Rubin Observatory is located on **Cerro Pachón** in Chile.
- The **Simonyi Survey Telescope's** primary mirror has an 8.4 meter diameter
- Its camera has an **9.6 deg^2 field-of-view** and six **optical-NIR filters: *ugrizy*.**

LSST: Fast, Wide, Deep in Optical and NIR



See Ivezic et al. (2019).

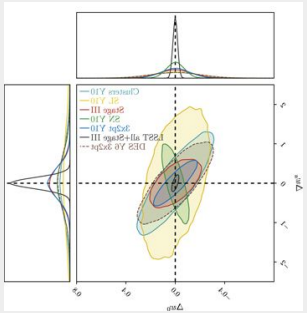
Once construction and commissioning are complete, Rubin Observatory will execute the **10-year Legacy Survey of Space and Time (LSST)**:

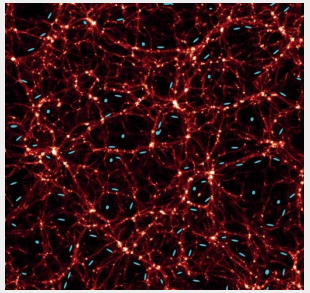
- 18000 square degrees of the southern sky
- ~825 30-second visits to all areas in 10 years
- single-image depths (point source; AB)
  - ***ugrizy*** = 23.9, 25.0, 24.7, 24.0, 23.3, 22.1 mag
- 10-year LSST depths (point source; AB)
  - ***ugrizy*** = 26.1, 27.4, 27.5, 26.8, 26.1, 24.9 mag

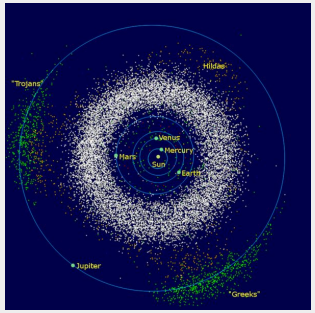
- **Fast - Wide - Deep:** A digital and color movie of the Universe!

Rubin Observatory/LSST Science Pillars

Probing dark energy and dark matter:
Weak lensing. Baryon acoustic oscillations. Supernovae and quasars. Large scale structure.



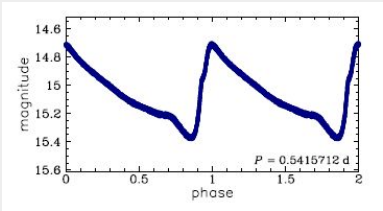


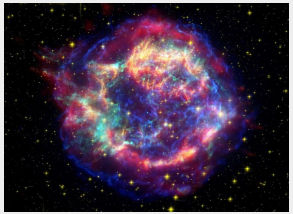


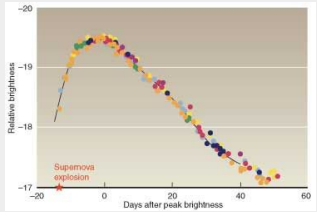
Taking an inventory of the solar system:
Near Earth objects. Potentially hazardous asteroids. Census of comets. Orbits of Trojan asteroids and Trans-Neptunian objects. Interstellar comets/asteroids.

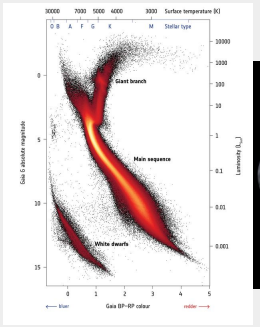
Rubin Observatory/LSST Science Pillars

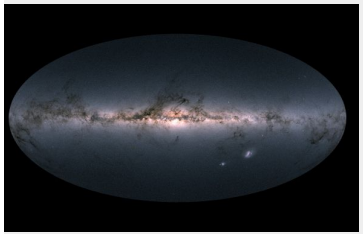
Exploring the transient optical sky:
Supernovae. Variable stars. Transiting exoplanets. Gravitational microlensing. AGNs. Tidal disruption events.

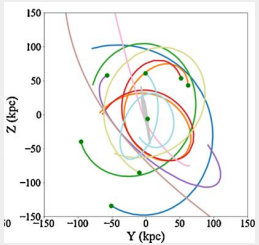






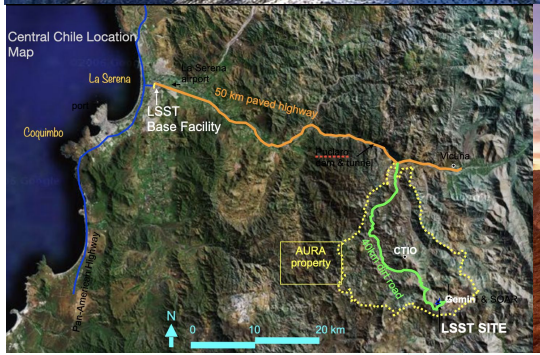






Mapping the Milky Way:
Structure and evolution of the bulge, disk, and halo. Census of dwarf galaxy satellites and tidal streams. Stellar evolution. Three-dimensional dust map. Hypervelocity stars.

Cerro Pachón, Chile, South America



Cerro Pachón

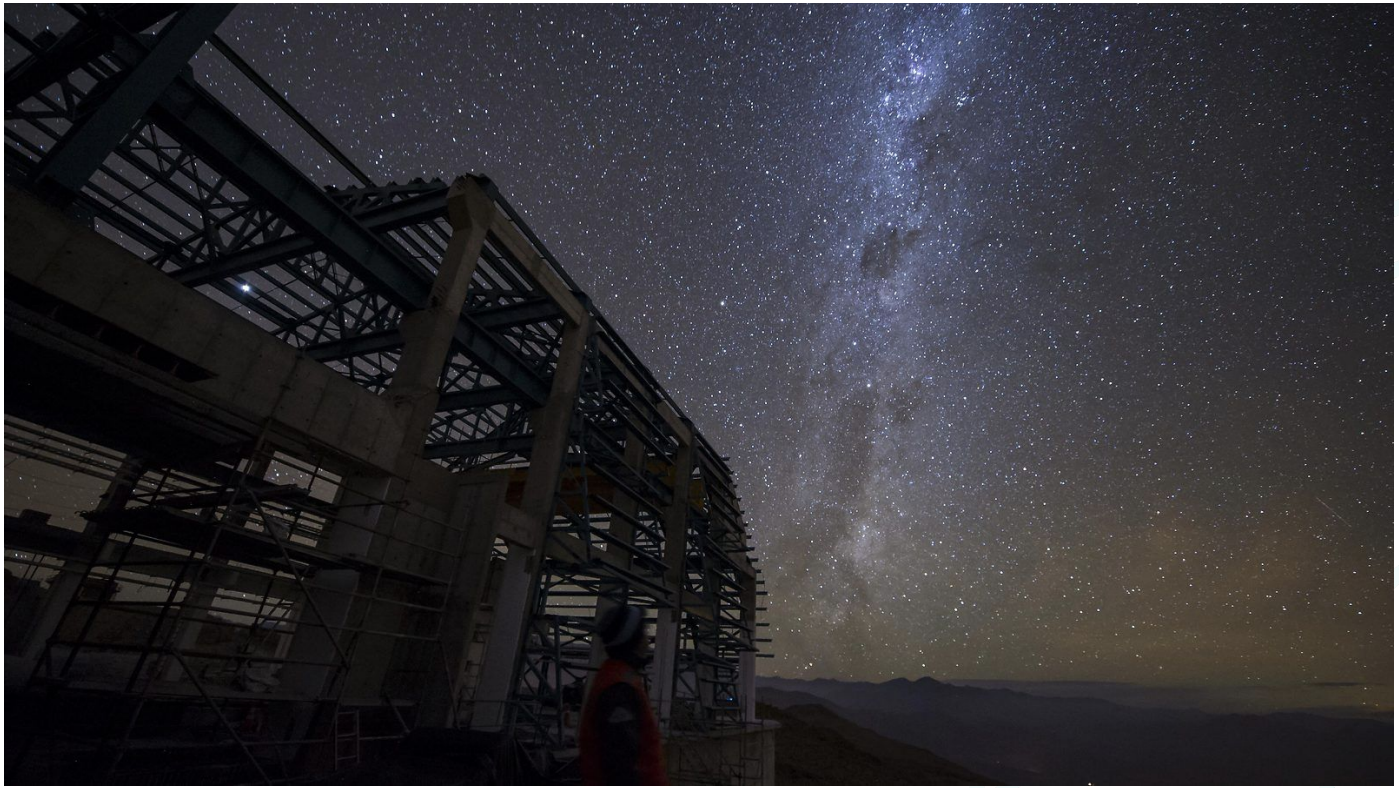
Credit: Johnny Steves

Credit: Aaron Roodman

Site Stats:

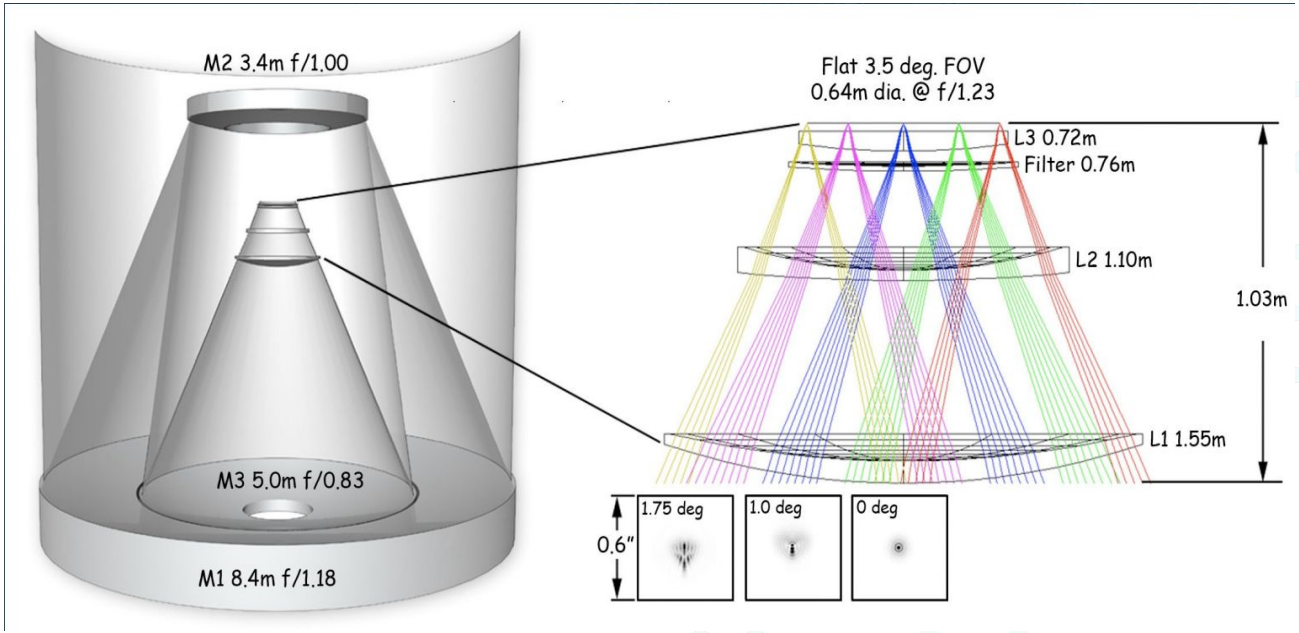
- Median Atmospheric PSF with outer scale of 30m: 0.67” (Tokovinin)
- Site: El Peñón, Cerro Pachón, Chile
- Site coordinates: latitude -30:14:40.68 longitude -70:44:57.90
- Altitude: 2647m
- Photometric time: 53% of night time (estimated)

Cerro Pachón



LSSTCam Optical Design

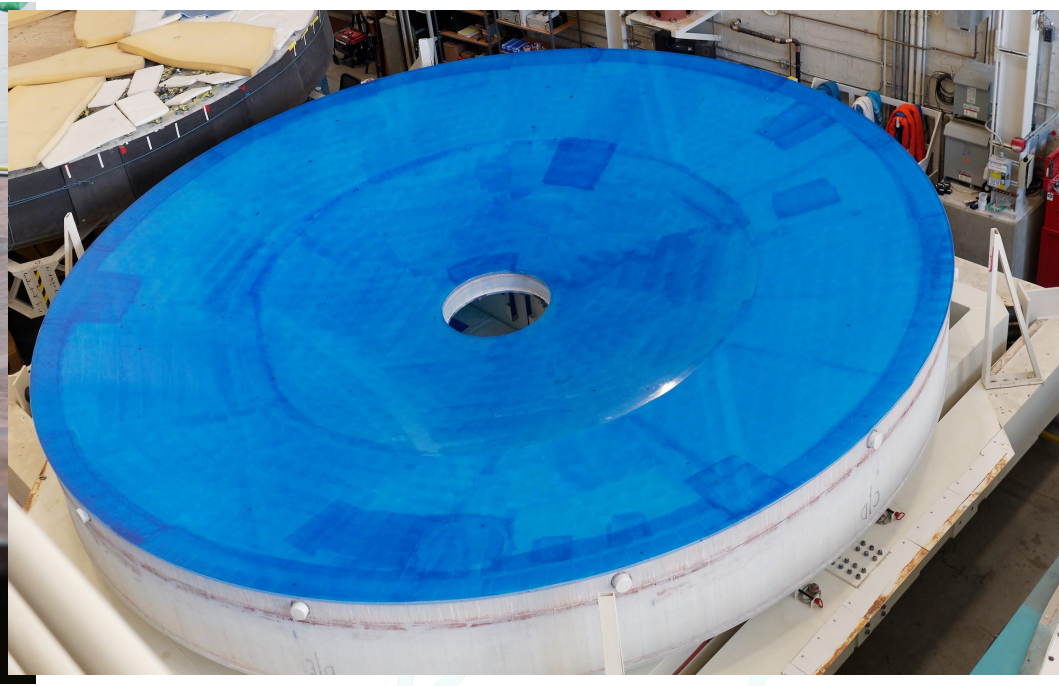
- Three Mirror Paul-Baker design
- Fast Optical Design with f/1.23
  - Combined M1-M3
  - Small optical aberrations
  - Squat structure for rapid slewing



Big FOV 3.5 degrees (9.6 square degrees)

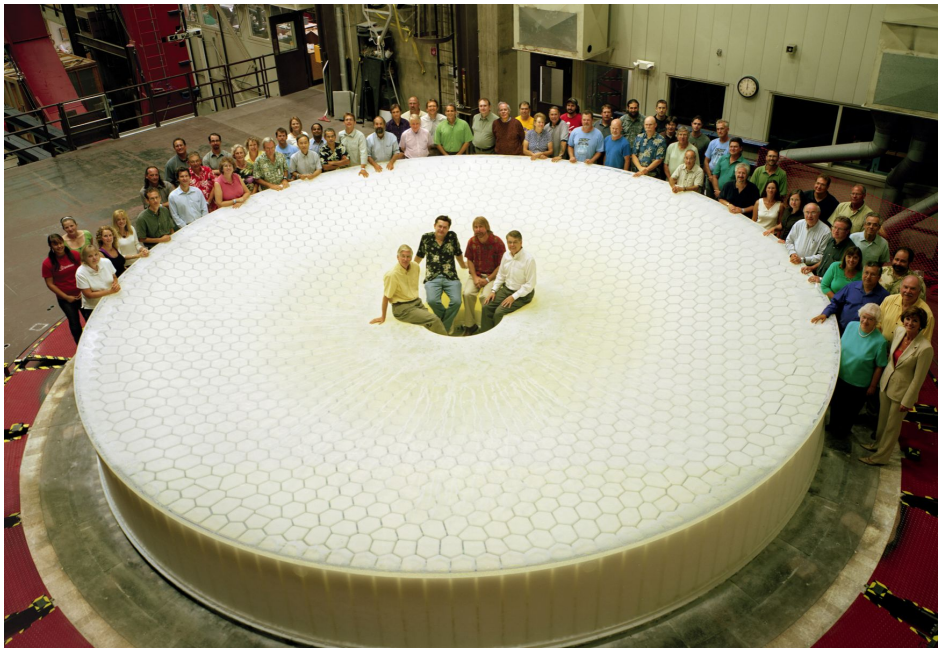
Surrogate for testing

M1+M3 8.4M 16,284 kg Glass

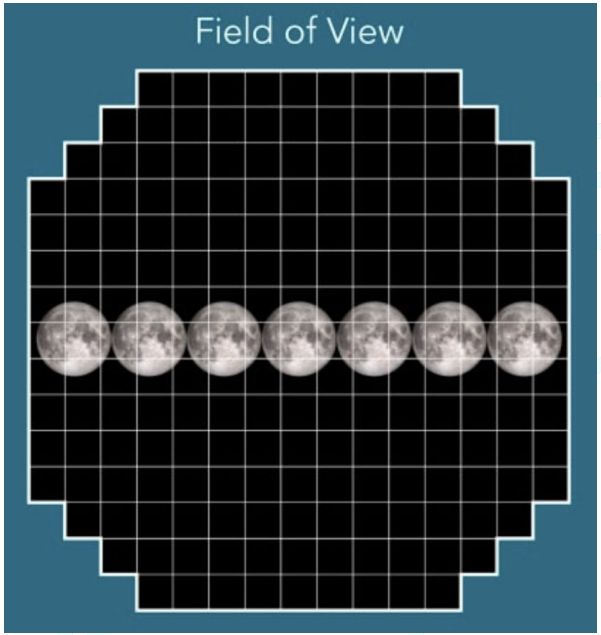


Rubin Observatory Design Rationale

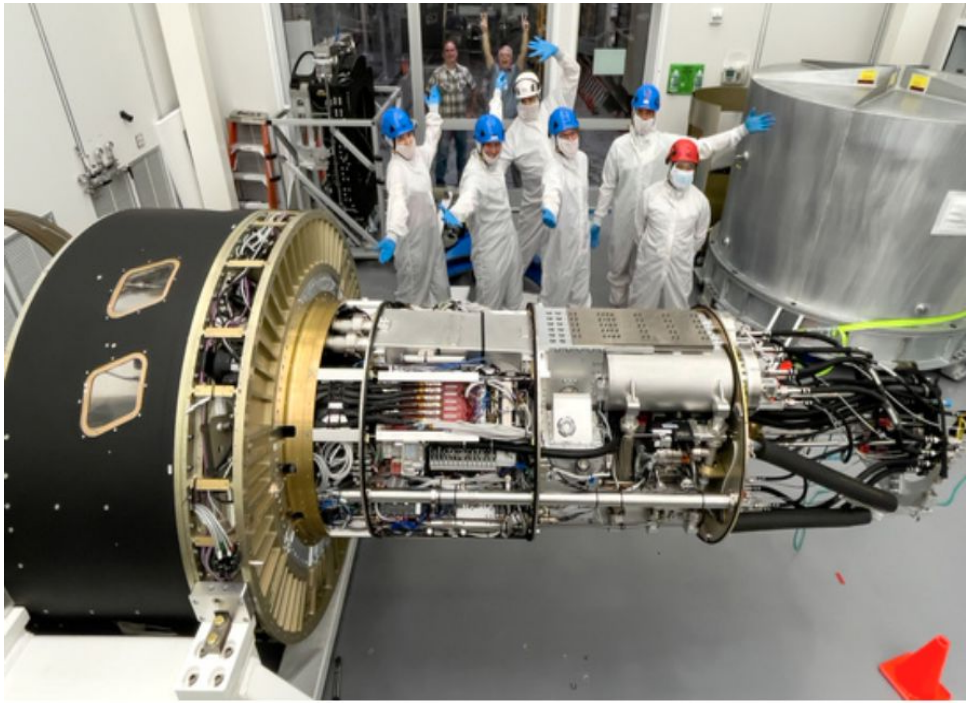
The survey speed is proportional to the **étendue**, in turn proportional to the product of the **mirror area** and the **field of view**. LSST étendue: **319 m^2 deg^2**



Credit: Aaron Roodman



Big camera to cover half the sky!



Camera complete and in verification

The largest astronomical camera:

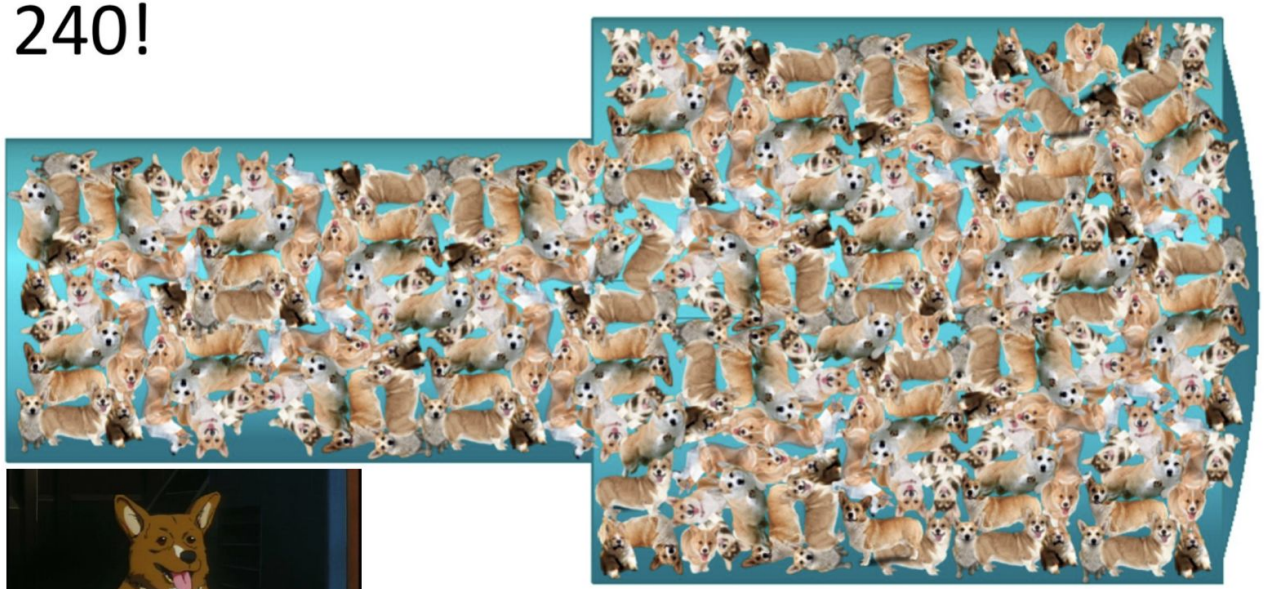
- 3,060 kg
- 3.2 Gpix
- 8.2 GB per exposure

To display every pixel you would need 378 4K monitors

Camera is a DOE contribution built at SLAC

Big Camera!

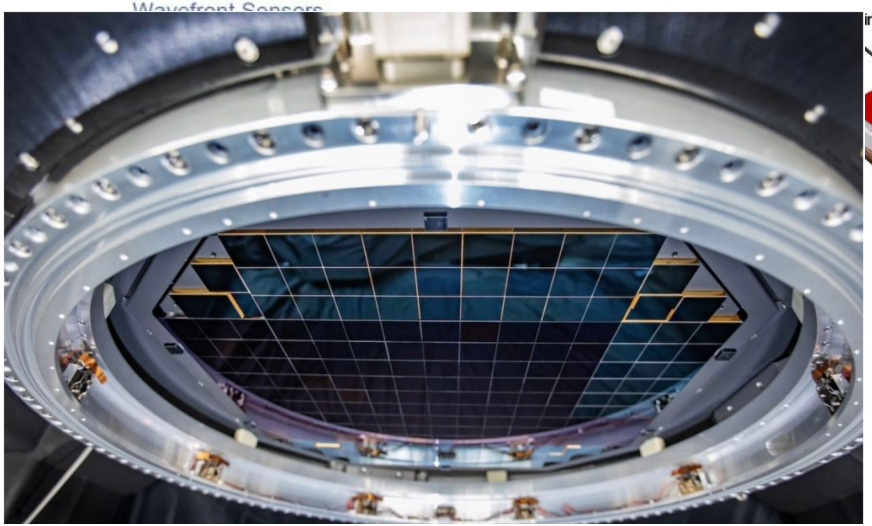
240!

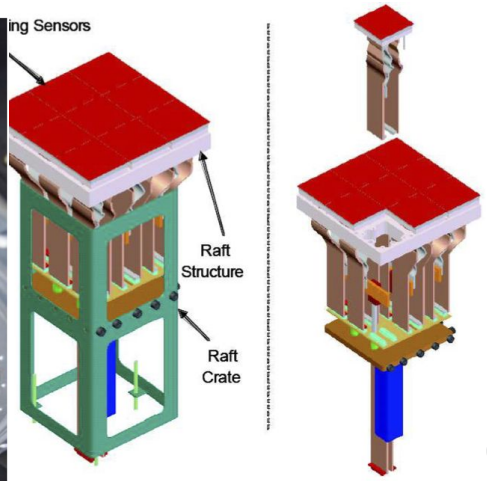


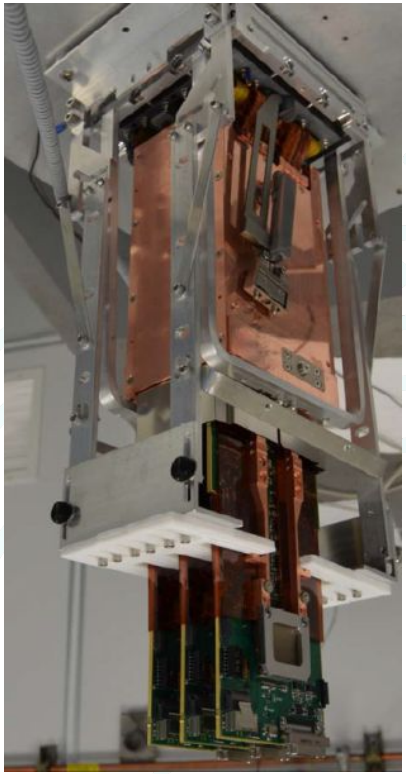
*no puppies were harmed in the making of this slide

Credit: Margaux Lopez, SLAC National Lab

Modular design - 21 rafts of 9x4K CCDs







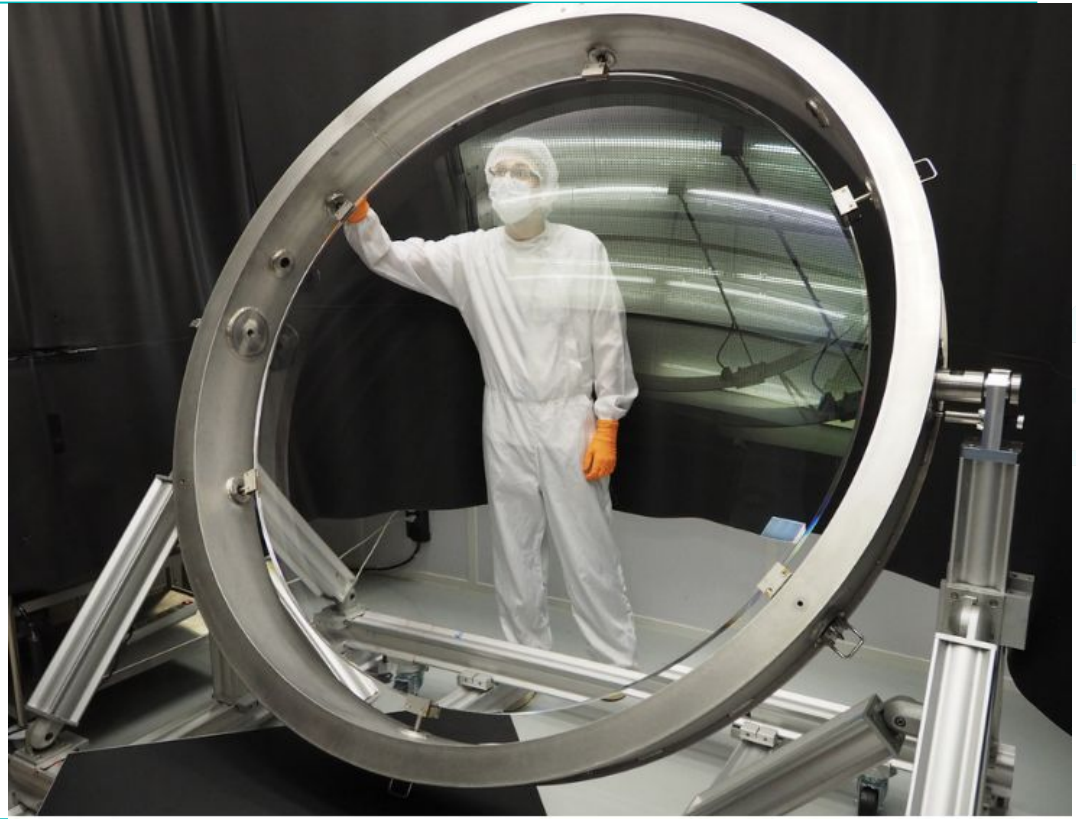
- Modular design: 3200 Megapix = 189 x16 Megapix CCDs
- 9 CCDs share electronics: raft (=camera 144 Megapix)

First of 21 rafts (2017) →

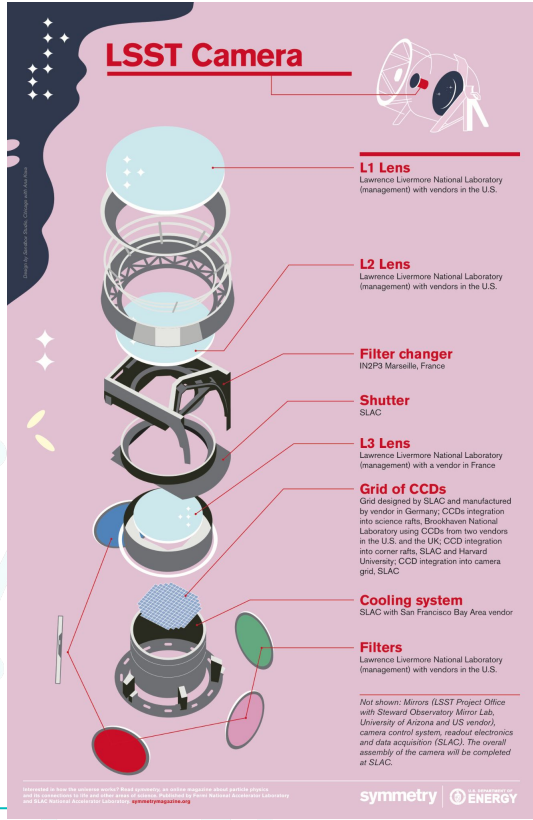
Biggest camera needs largest lens(l1) ever built

SLAC have two records in the Guinness book of records recognizing:

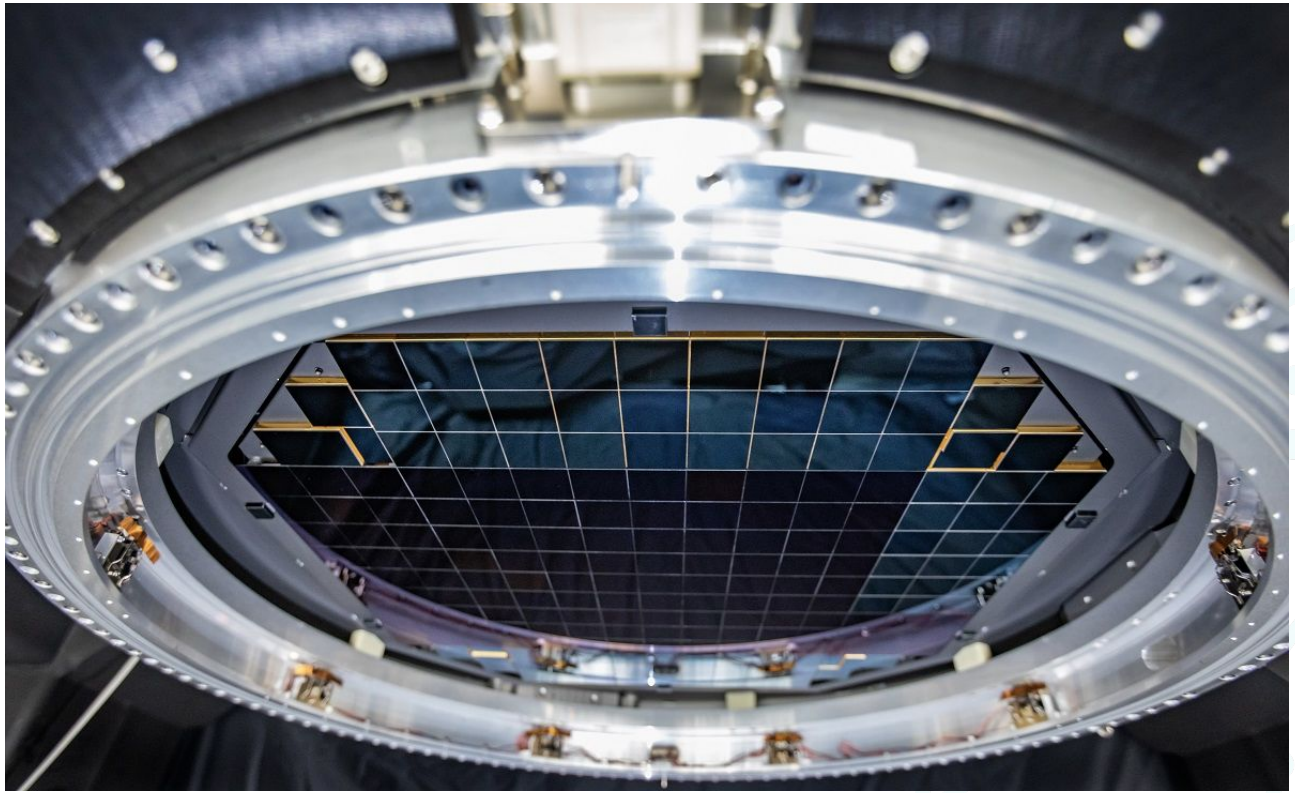
- The digital camera for having the highest resolution in the world (3.2Gpix),
- The biggest of the camera's three optical lenses as being the largest in the world. (1.57 meters)



Secondary Mirror & Camera Lenses



Completion of the Focal Plane



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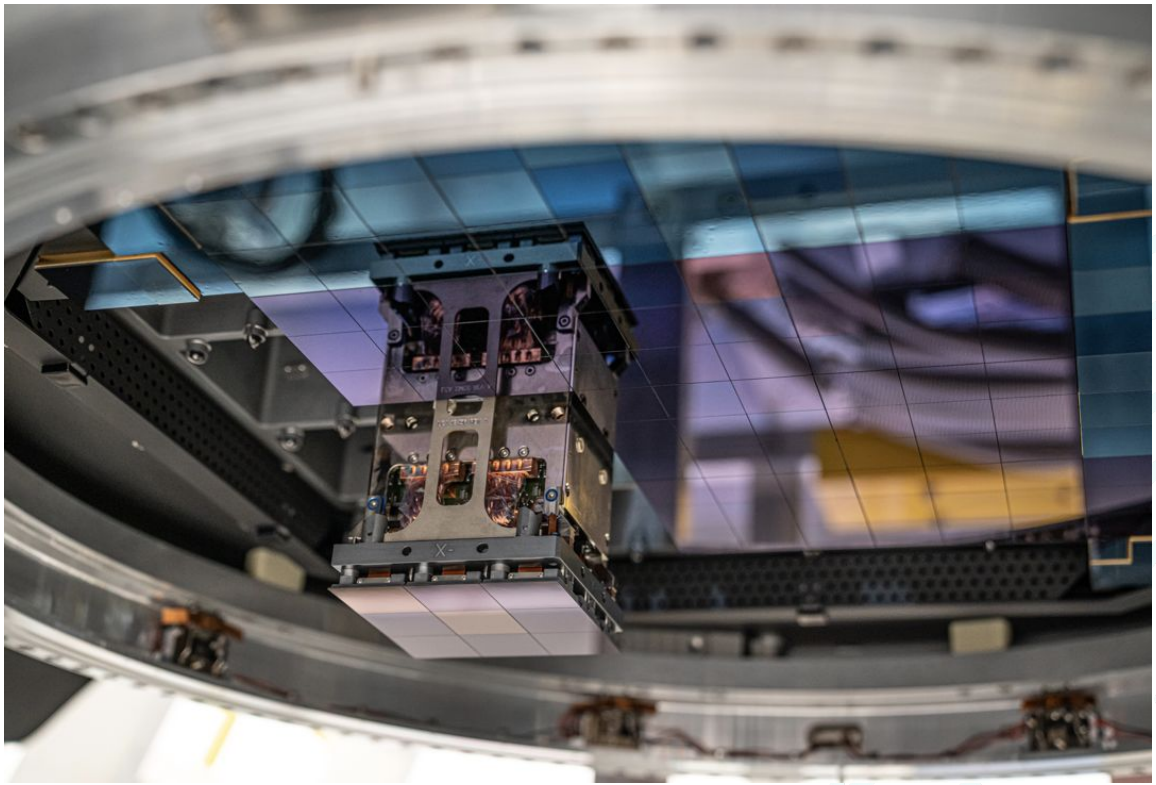

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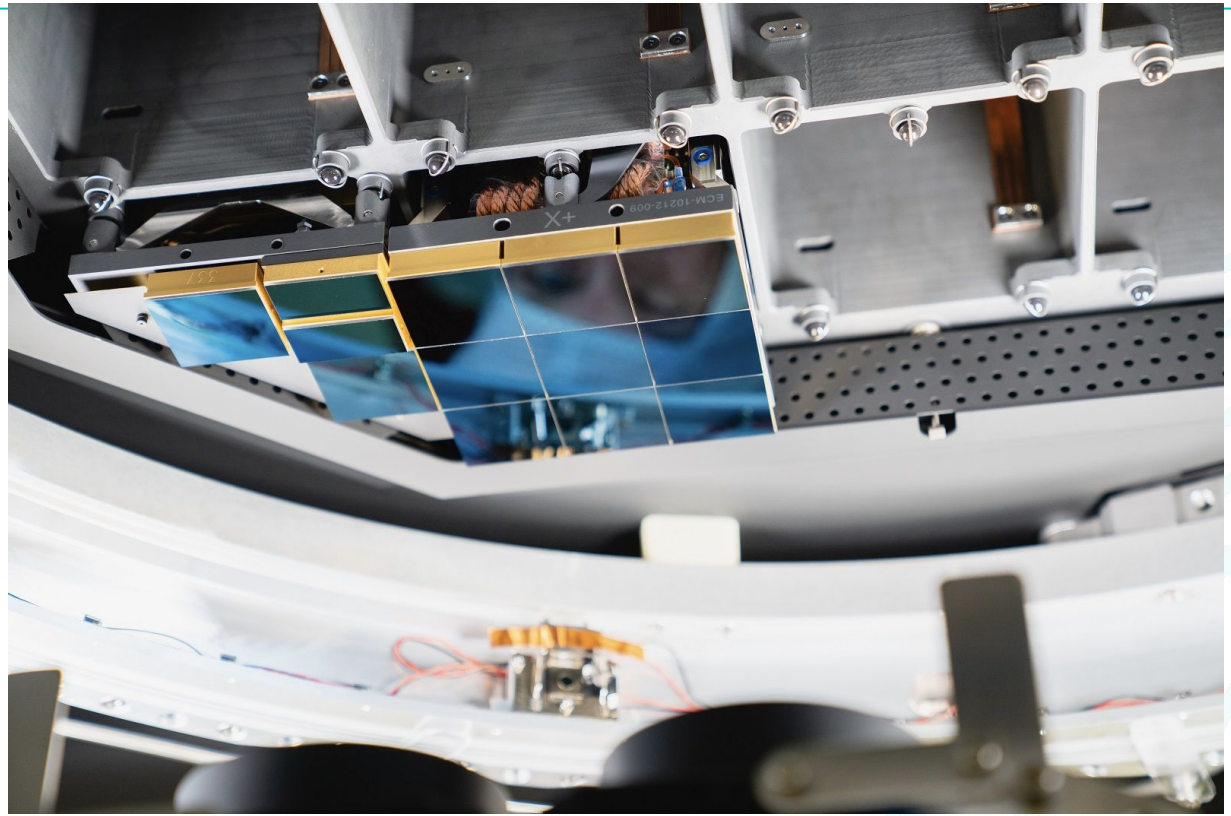

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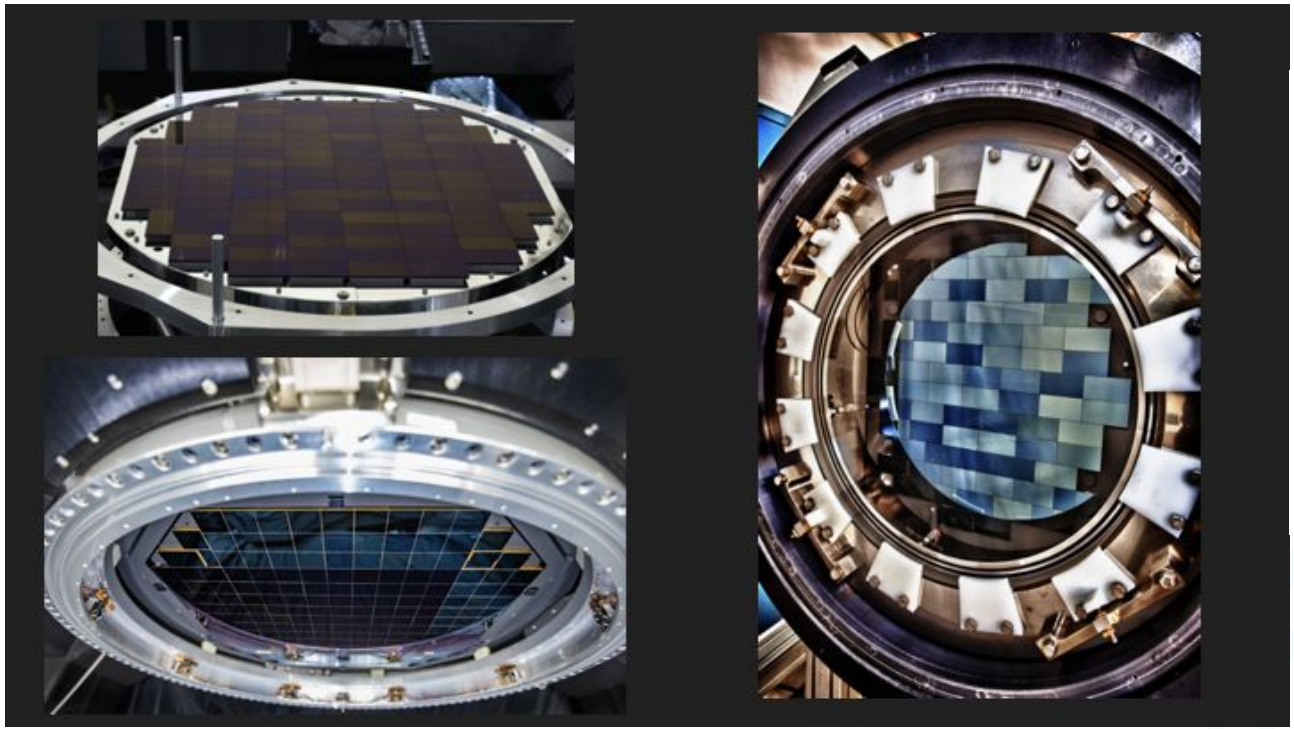
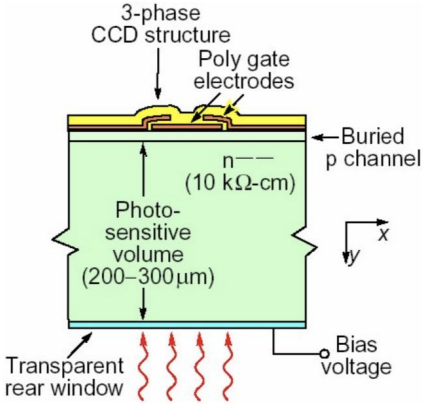
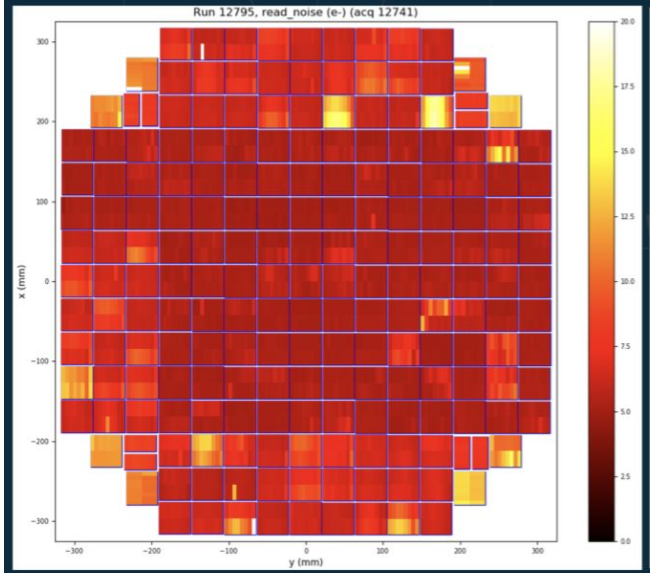




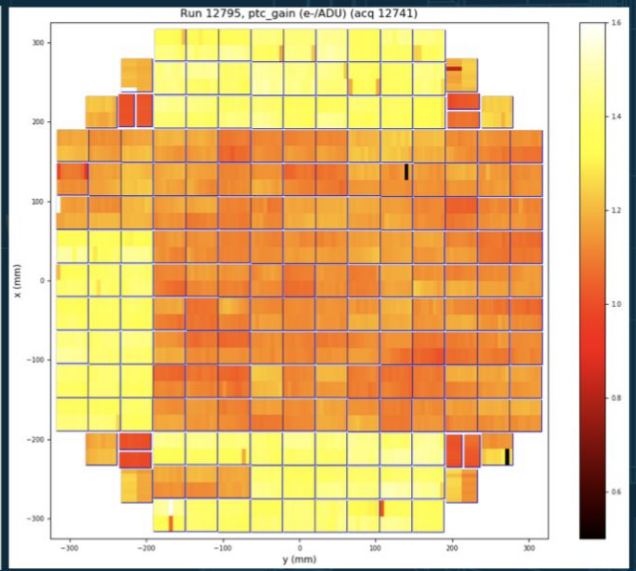
Focal Plane Characterization

VERA C. RUBIN OBSERVATORY

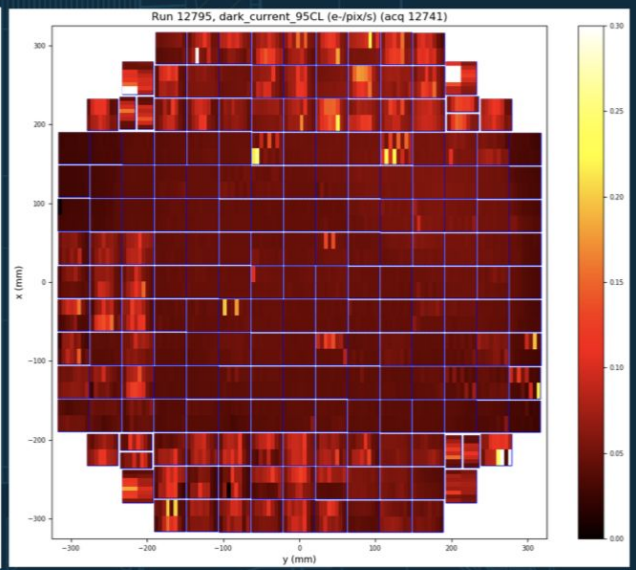
Read Noise



Gain (PTC)



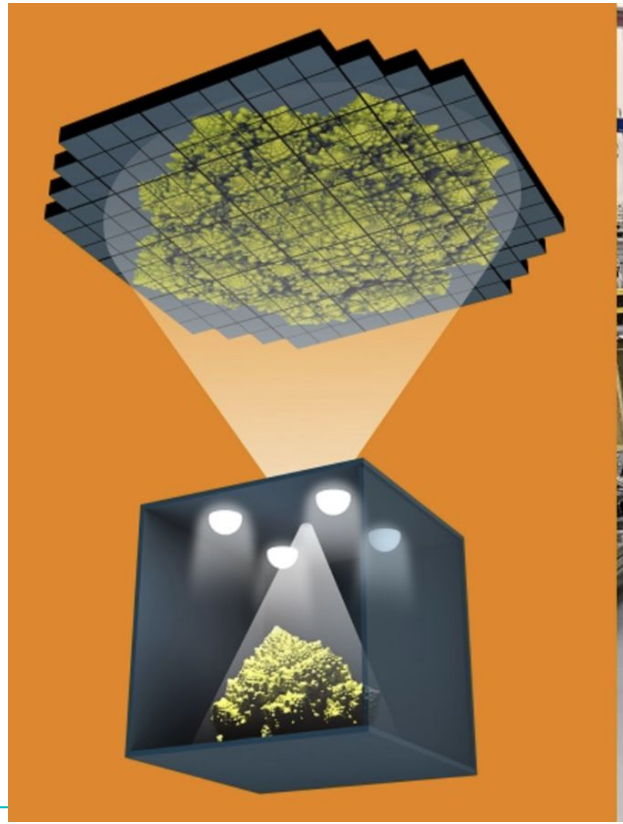
Dark Current

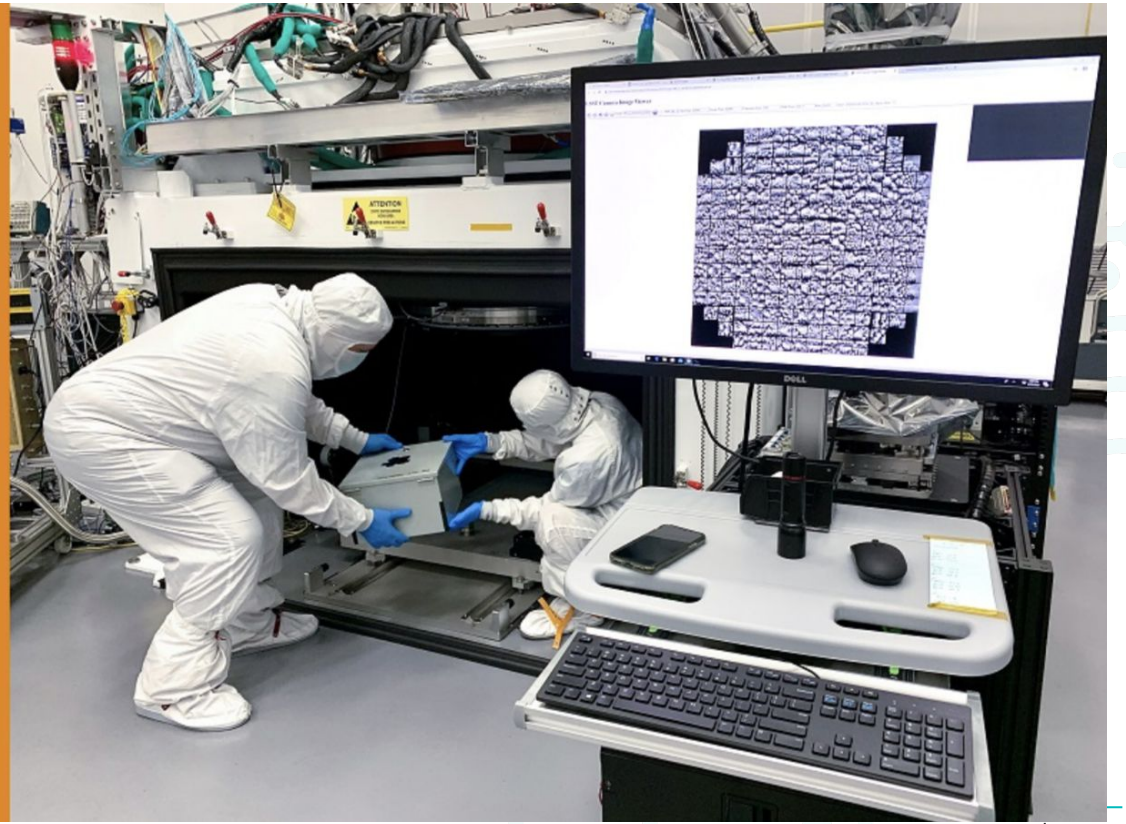


- Science Rafts: 3021/3024 Amplifiers functional
- Extensive automated analysis suite, producing detailed set of plots & data products

Credit: Aaron Roodman

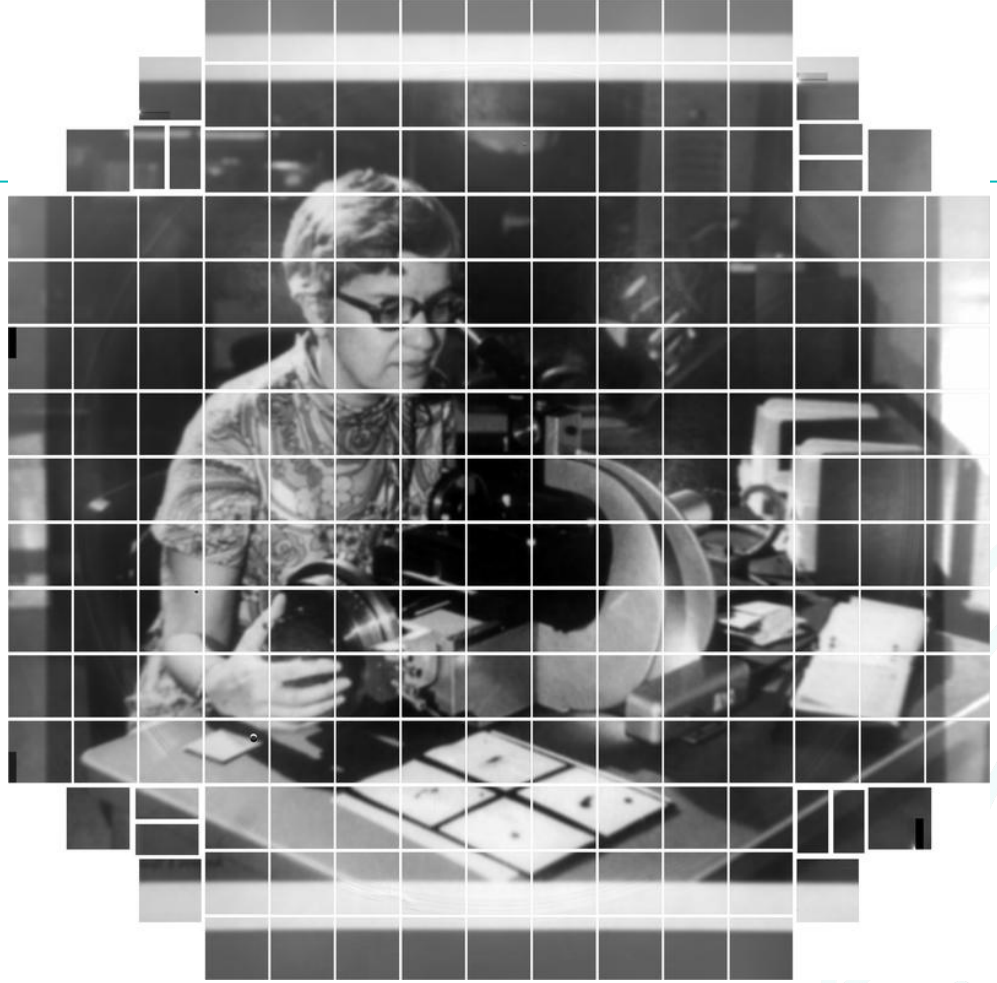
First-light images





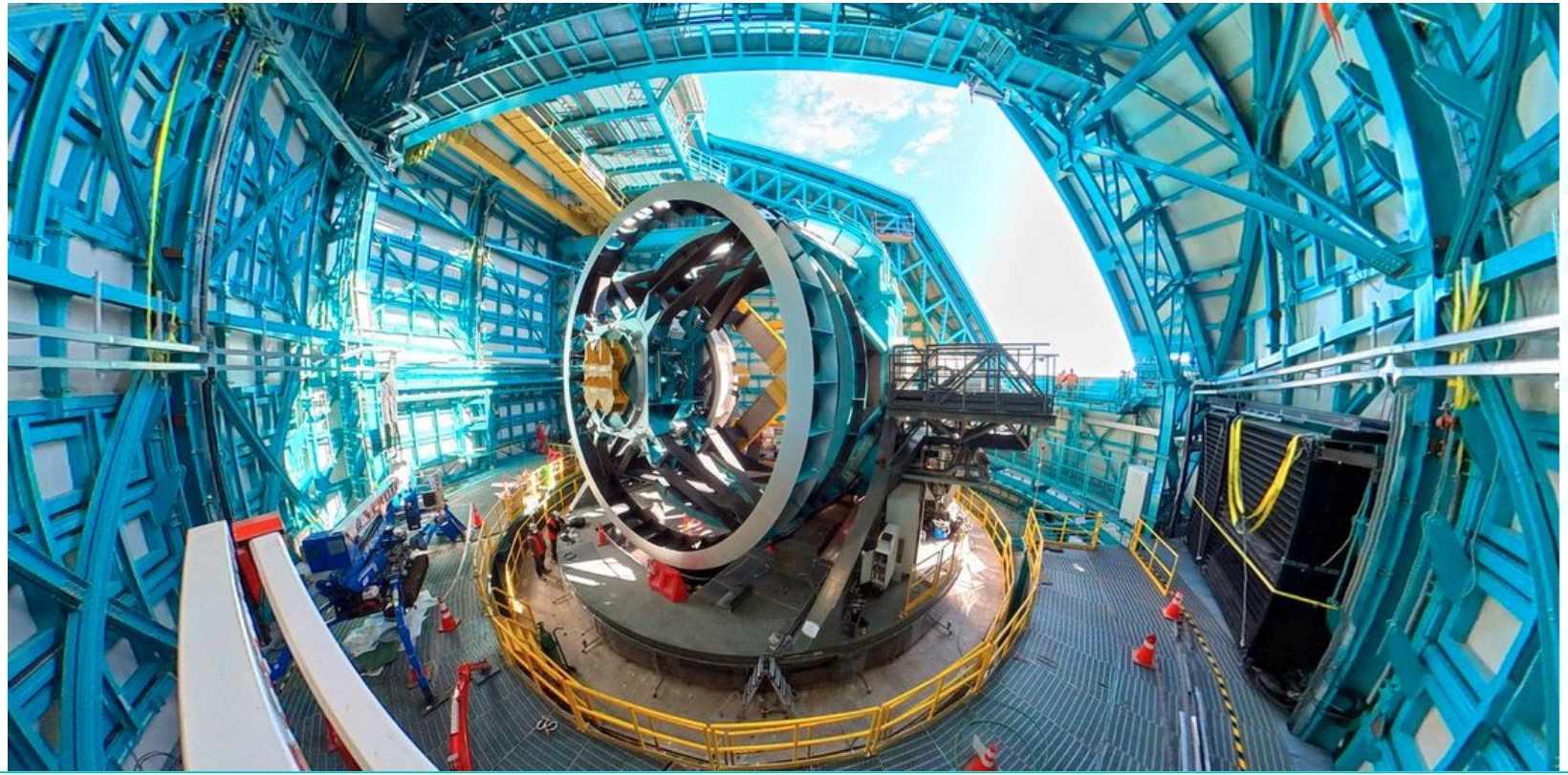
Pinhole camera 3.2Gpixel image of Vera C. Rubin

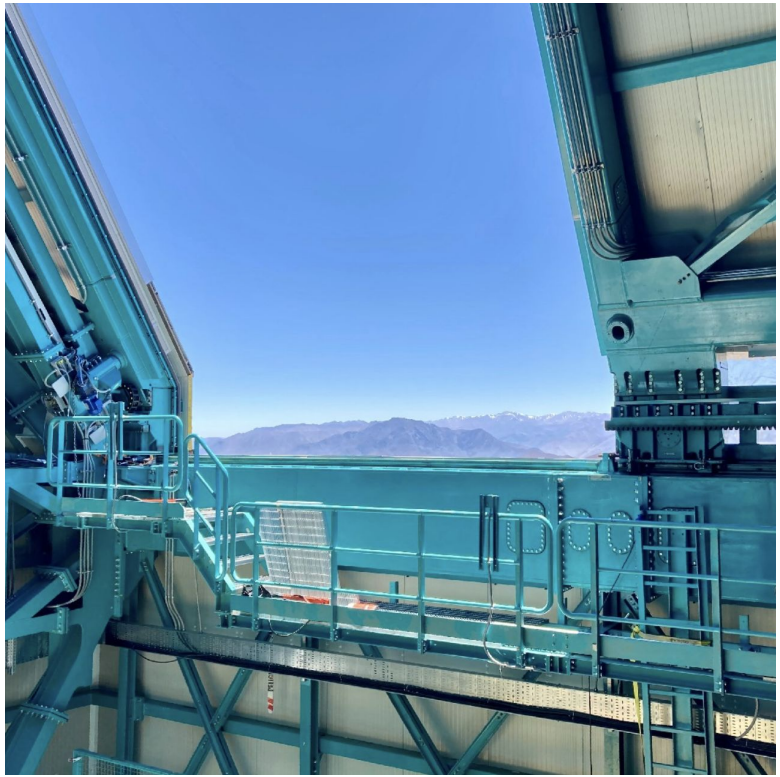
The camera is assembled and in verification



On December 20, 2019, the **Large Synoptic Survey Telescope** was renamed the **National Science Foundation Vera C. Rubin Observatory** in recognition of Rubin's contributions to the study of dark matter and her outspoken advocacy for the equal treatment and representation of women in science.

All sits on the Simonyi Telescope (Fast!)





Credit: C. Walters (Duke)

Education and Public Outreach

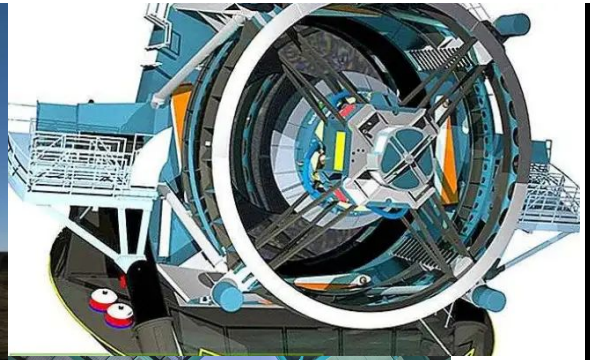
Rubin Observatory will open up a whole new era of astronomical discovery for scientists, and Rubin Observatory's Education and Public Outreach (EPO) program will provide opportunities for a wider public to interact with and explore Rubin Observatory data.

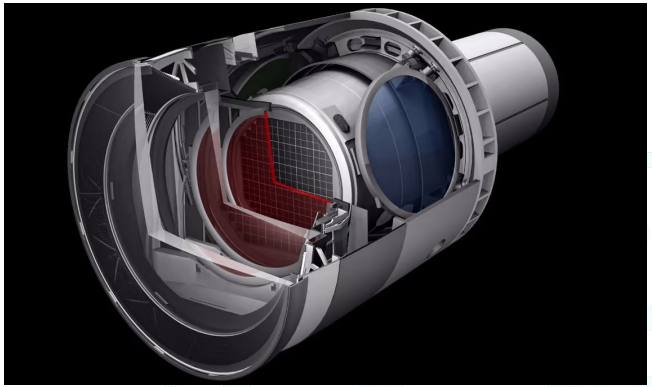
Rubin Observatory is unique among large telescope projects in that **its EPO program was built at the same time as the observatory itself**

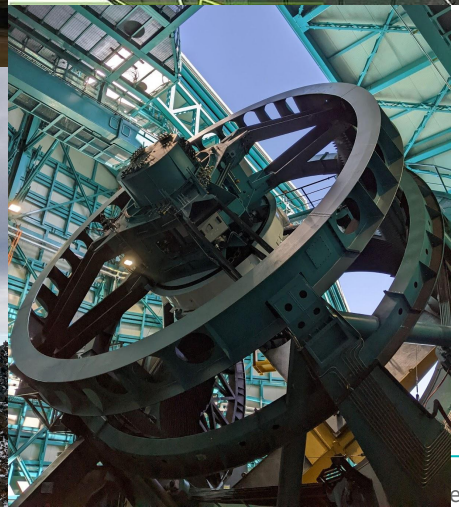
The Rubin Observatory EPO team has identified four primary audiences:

- General public
- Educators/teachers
- Planetariums and informal research centers
- Citizen/community scientists

Vera C. Rubin Observatory Is Becoming Real!







Credit Kevin Reil via Sandrine thomas

Status of Rubin Construction

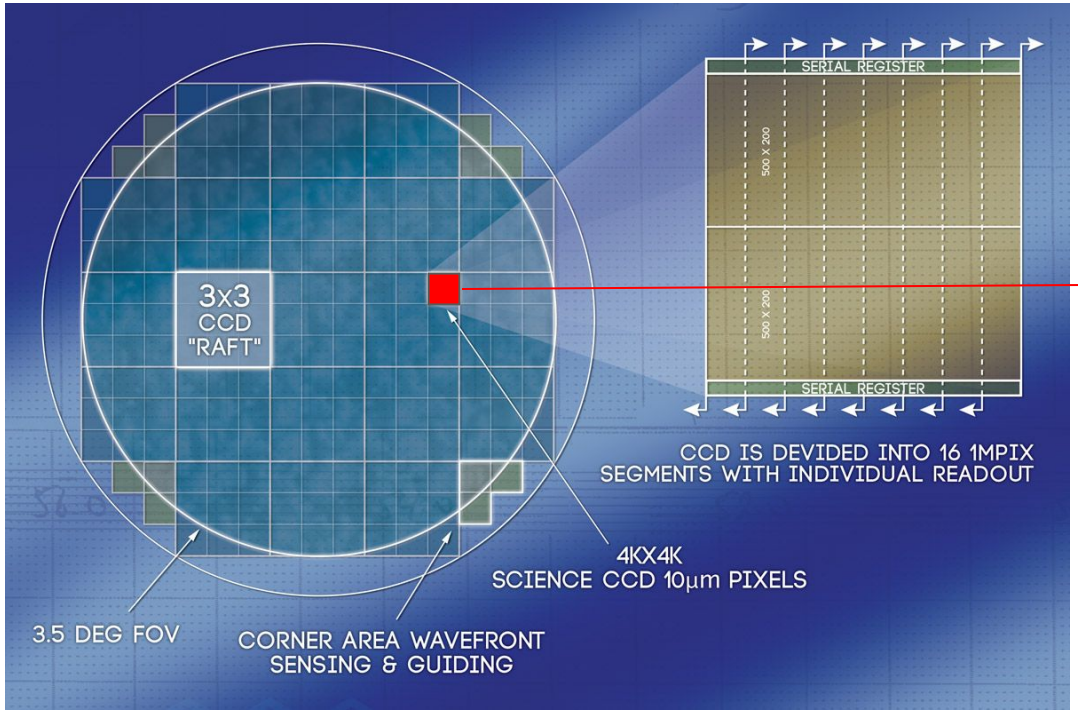
DMTN-232.lsst.io

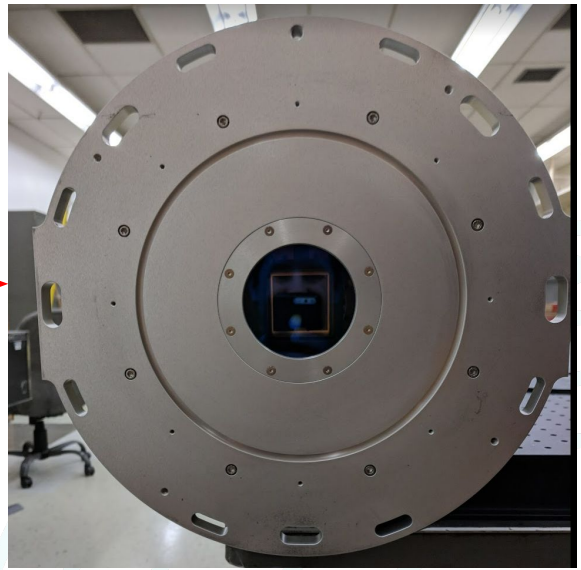
2022-09-30 : EPO Construction Finish
2022-10-18 : TMA Contract Complete
2023-03-28 : Dome Complete
2023-05-01 : COMP: Camera Pre-Ship Review at SLAC
2023-06-02 : 3-Mirror Optical System Ready for Testing
2023-07-19 : Engineering First Light w/ComCam**
2023-10-17 : Camera Ready for Full System AI&T
2024-03-13 : System First Light (LSST-1520)
2024-07-09 : Test report: Final Pipelines Delivery
2024-07-09 : Mini-Survey 2 Complete
2024-07-16 : Operation Readiness Review Complete

**LSSTComCam will no longer take on-sky data, instead, LSSTCam will be ready to be mounted

June 2022 on Cerro Pachón

Systems Integration: AuxTel (Auxiliary Telescope)





Credit: R. Lupton via S. Thomas

AuxTel, ComCam and LSSTCam all share same DAQ and CCS, both telescopes share code/algorithms

Auxiliary Telescope Status

Auxiliary telescope first light in **July 2019**

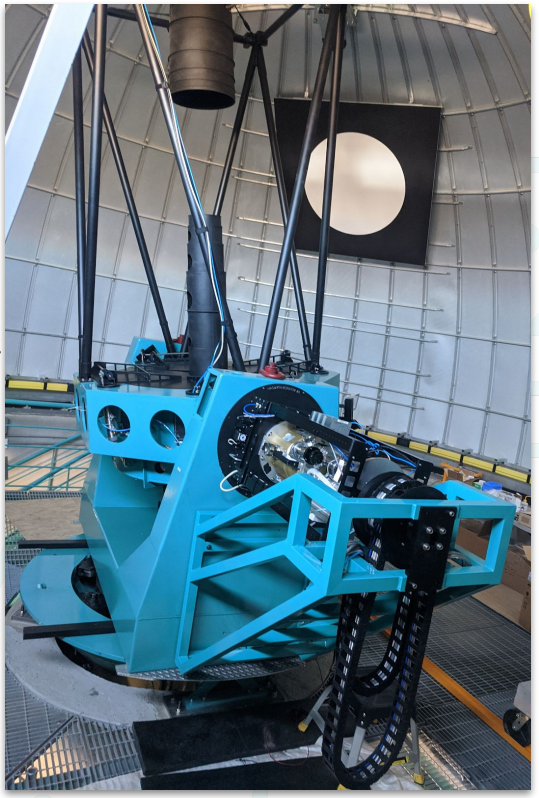
1) Same detector, same motors, same software as Simonyi Survey Telescope

=> Great pathfinder for the Simonyi Survey Telescope integration & commissioning!

- SIT: Already integrated but enhancements continue especially on the control software side, doing engineering runs without the spectrograph
- COM: Each run supports commission the system, exercising the pipeline
- SVV: Validating science level requirements conducting survey-like campaigns

2) Belongs to the same observatory, observing 2 times 3 nights a month

=> Great pathfinder for operation



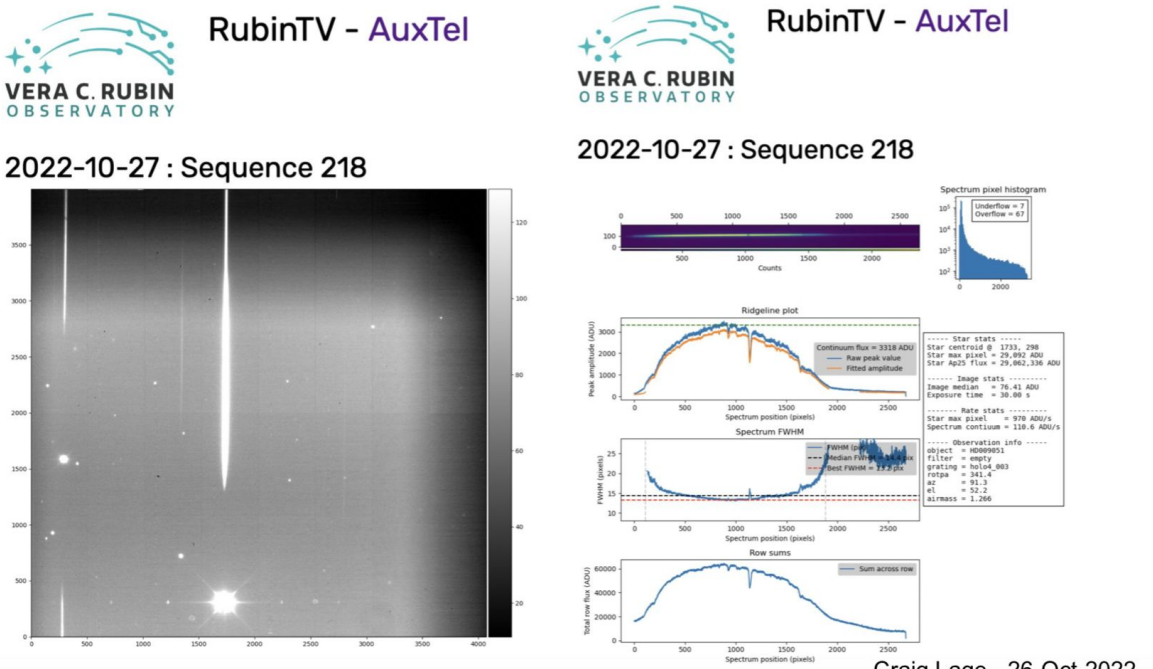
Credit: Robert Lupton via Sandrine Thomas

Auxiliary Telescope

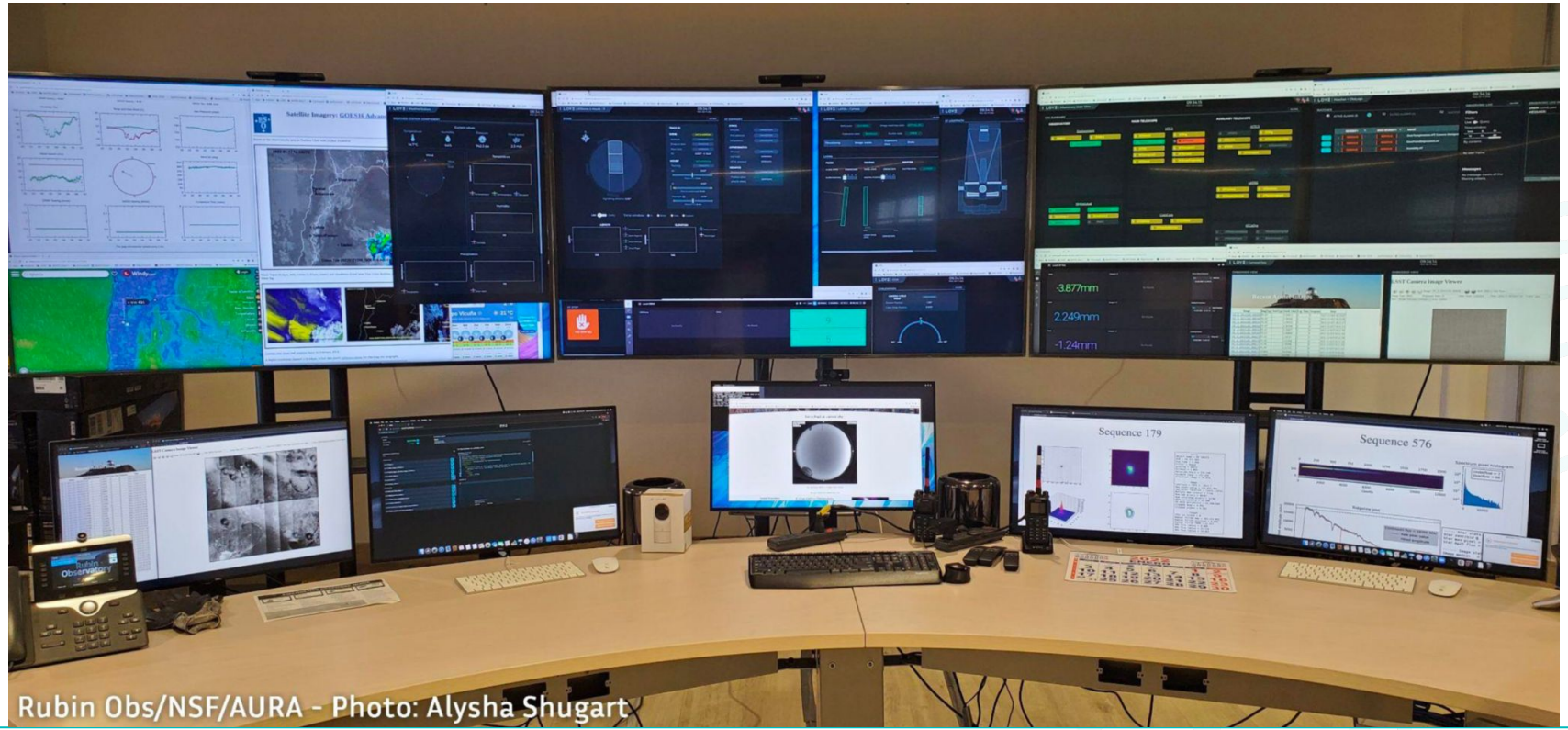
From Craig Lage (UC Davis):

The AuxTel has a slitless spectrograph (LATISS) which will be used to monitor the sky transparency while the main telescope is observing. We are also using the AuxTel to test and improve observatory control and image analysis software.

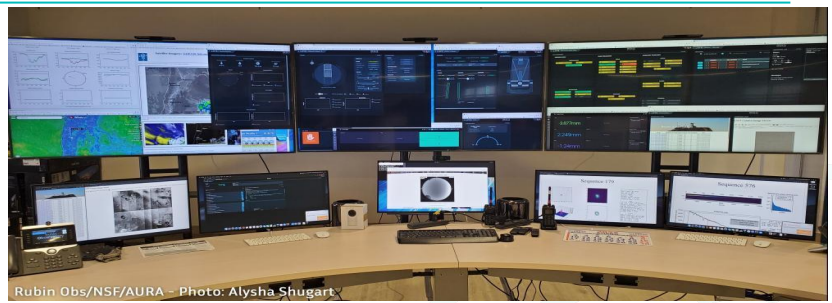
Sample AuxTel spectrum with Analysis.



AuxTel control room



Routine Calibrations on Cerro Pachón

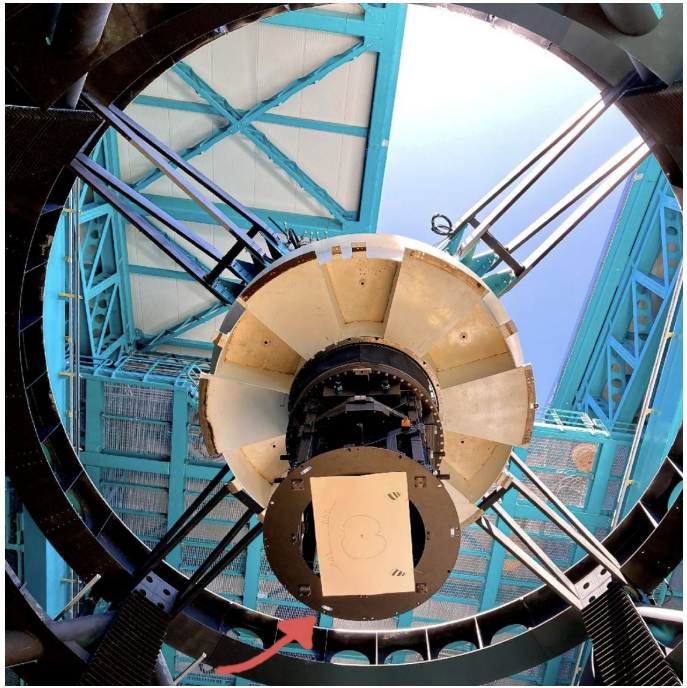


Our Observing Specialists use LOVE (LSST Operators Visualization Environment) to run a ScriptQueue command to take a standard set of “afternoon” calibrations

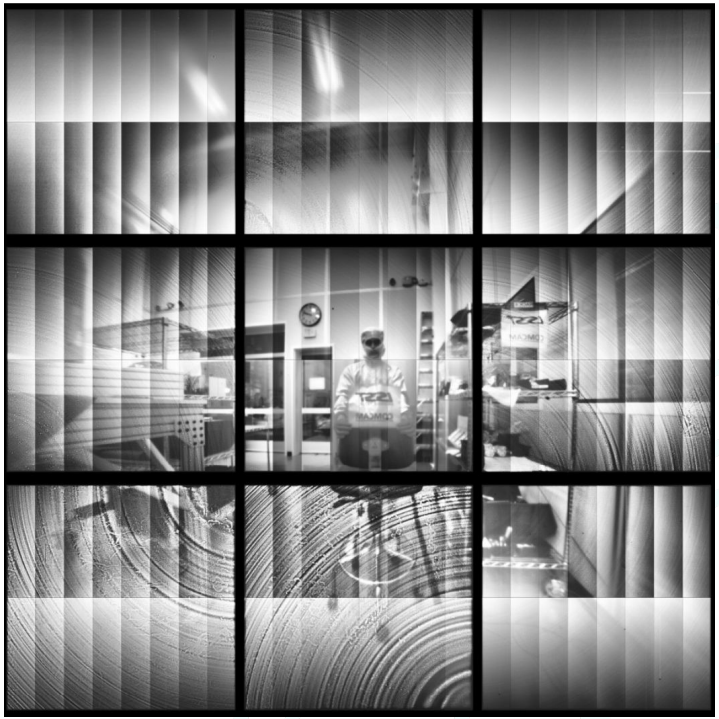
- Datasets
  - Biases
    - Combined bias frames
  - Darks
    - Combined dark frames
    - Defect maps
  - Flats (difficult but doable on AuxTel; requires moving the telescope by going to the dome)
    - Combined flat field frames
    - Defect maps
  - Photon-Transfer Curves (PTC)
    - Gain; potentially brighter-fatter kernels and linearity coefficients
- Calibration products are then checked by running cp_verify which automatically flags data problems.

Credit: Robert Lupton via Sandrine Thomas

Commissioning Camera: LSSTComCam



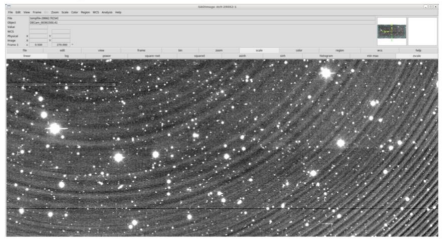
Credit: Eduardo Serrano

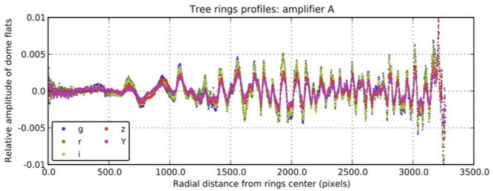


Static and Dynamic Electric Fields in CCDs

Tree Rings

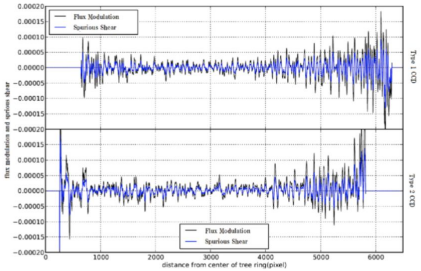
Raw DES image taken with DECam in the Blanco 4m telescope in Cerro Tololo, Chile.





Plazas Malagón et al. 2014b (1403.6127)

LSSTCam prototype CCDs



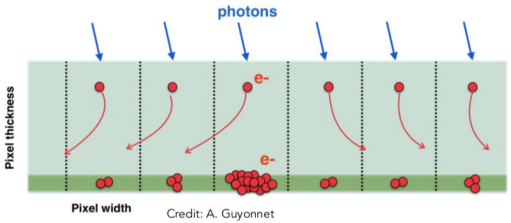
Okura, Petri, May, **Plazas Malagón,** Tamagawa 2016 (1604.07795)

Okura, **Plazas Malagón** et al. 2015 (1504.05614)

- Amplitude in LSST CCDs one order of magnitude less than in DECam

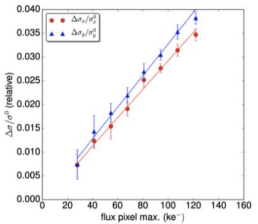
The Brighter Fatter Effect in CCDs

Charge self-interaction: as charge accumulates, a transverse electric field is generated, pushing incoming charge and distorting the effective pixel sizes → also generates correlations in flat-field images.



Credit: A. Guyonnet

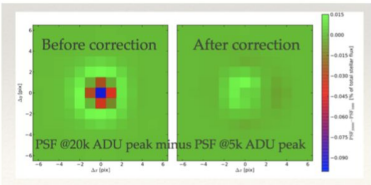
Credit: Guyonnet et al. 2015



(a) LSST - E2V 250 - Spots 550 nm

Breaks assumption of intensity-independent PSF

- **Solution:**
  - Move the charge back to where it should have landed
  - Model by Antilogus el at. 2014 (implemented for DECam by Gruen et al. 2015)
  - The Rubin Science Pipelines uses equivalent model by Coulton et al. 2017



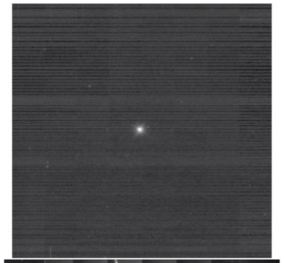
Gruen, …, **Plazas Malagón** …, et al 2015 (1501.02802)

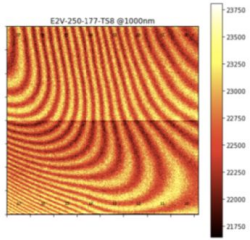
17

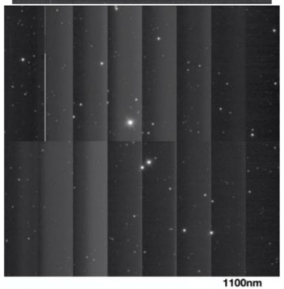
See "Weak lensing for precision cosmology" by R. Mandelbaum for a great overview of systematics in WL for cosmology, including detector effects and Intrinsic Alignments.

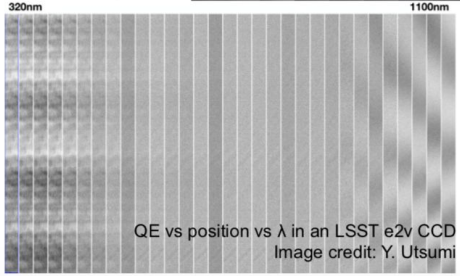
Instrument Signature Removal (ISR) and Calibration Products Production (CPP)

0. Integer-to-float conversion
1. saturation and suspect pixel masking
2. overscan subtraction
   - Optional: Apply crosstalk correction here before CCD assembly, and before trimming
3. CCD assembly of individual amplifiers
4. bias subtraction
   - Note: Calibration products construction (master bias, master dark, master flat).
5. variance image construction
6. linearization of nonlinear response
7. crosstalk correction
8. mask defects, edges, nan's, etc.
9. brighter-fatter correction
10. dark subtraction
11. fringe correction
12. stray light subtraction
13. flat correction
14. apply gains
    - Optional: Fringe Correction after flat
15. vignette calculation
16. attach transmission curve
17. illumination correction

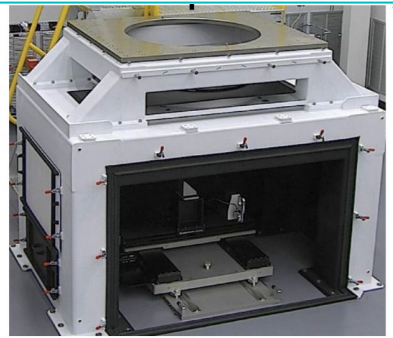


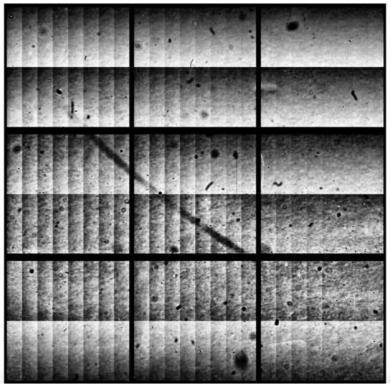






QE vs position vs λ in an LSST e2v CCD
Image credit: Y. Utsumi


Snyder et al 2021, Newbry et al 2018


http://ccs.lsst.org/FITSInfo/

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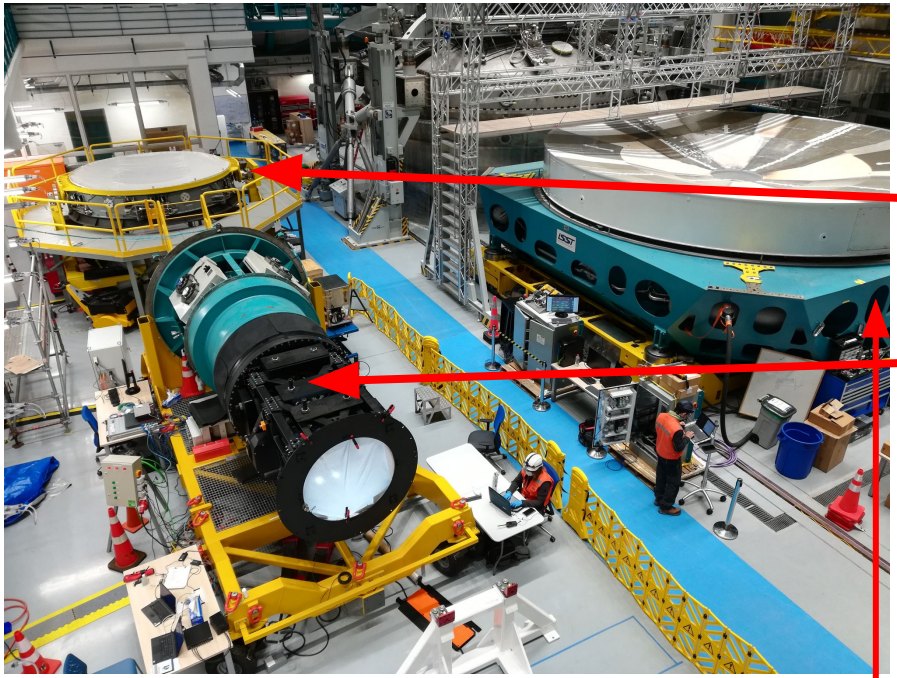
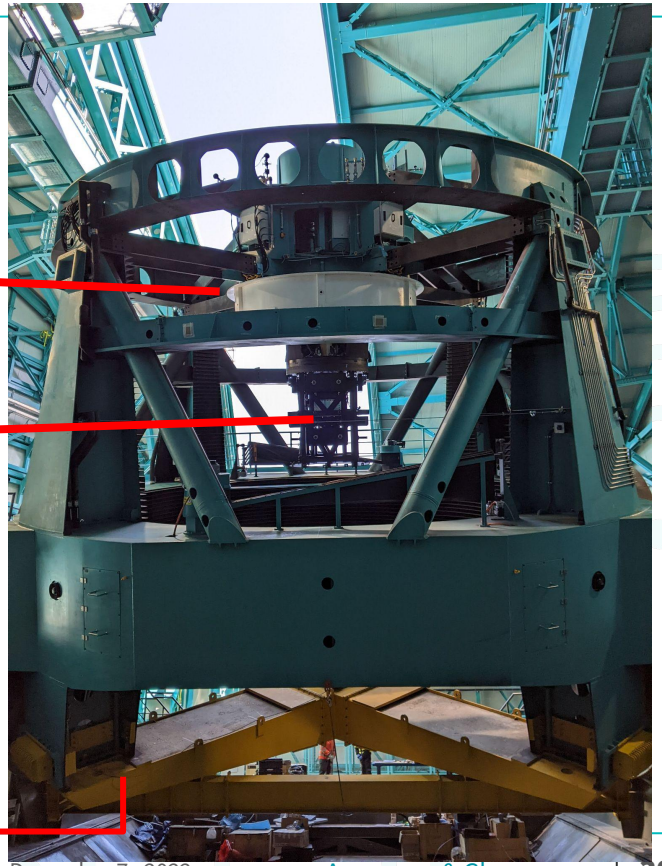
Integration with LSSTComCam



M2

Integrating structure:
ComCam, Cam Hex-rotator, CCW

M1M3



Data Product Categories (see LSE-163)

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.

Credit: Leanne Guy & Mario Juric

Data Access - no observing proposals

Data rights holders will have access to the catalogs and images via the **Rubin Science platform** (on Google OMullane 2022) see also Rubin Data Policy :RDO-013, and Science Platform Vision Document: LSE-319

- A subset of data will be public via Education and Public outreach
  - Including for citizen/community science projects
- Alert stream will be fully public immediately
- After a proprietary period of **two years**, **all the LSST data in a Data Release become public.**
  - However, access to the data will not be made available through Rubin Observatory Data Access Centers (DACs) in the US and Chile for non-data rights holders.

Rubin Science Platform

It will not be possible to download the entire LSST data set, and scientists will need a venue for **“next-to-the-data analysis”**.

The **Rubin Science Platform (RSP)** is a set of integrated web-based applications and services running at the Rubin Observatory Data Access Centers (DACs).

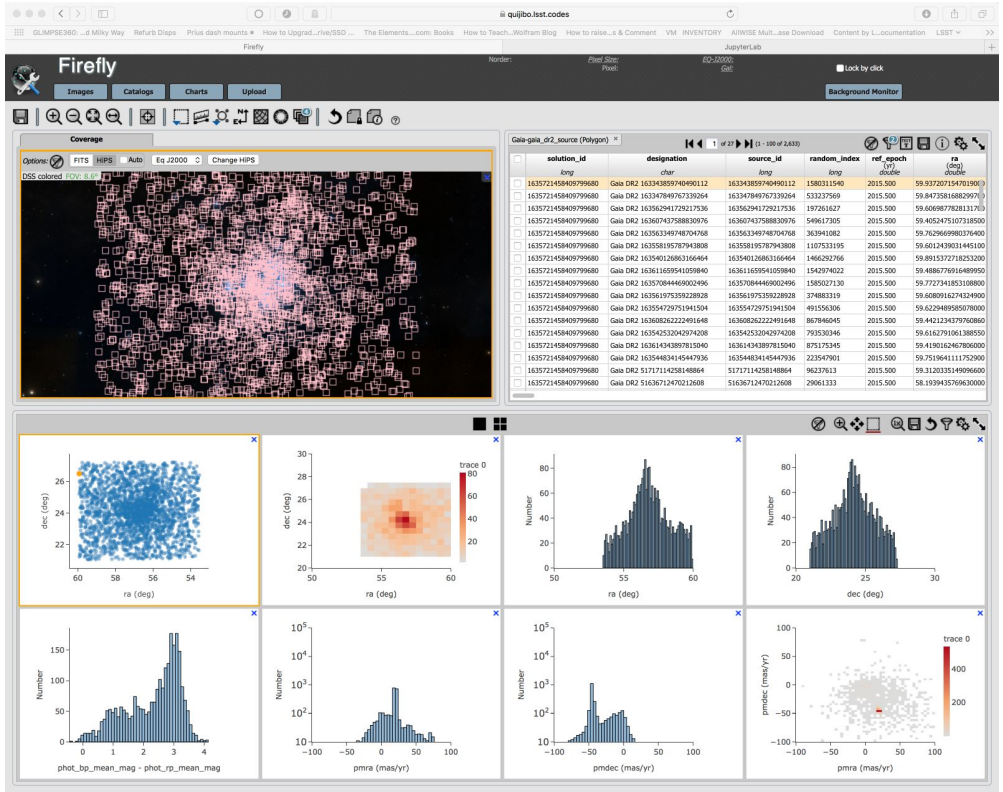
Portal Aspect
exploratory analysis and visualization of the Rubin archive

Notebook Aspect
in-depth ‘next-to-data’ analysis and creation of added-value data products

API Aspect
remote access to the Rubin archive via industry-standard APIs

The RSP will include tools to query, visualize, subset, and analyze the full LSST data archives in a stable software environment located “next-to-the-data”, along with storage space, compute resources, and remote access options.

Portal Aspect



Explore and analyze image and catalog datasets for your science.

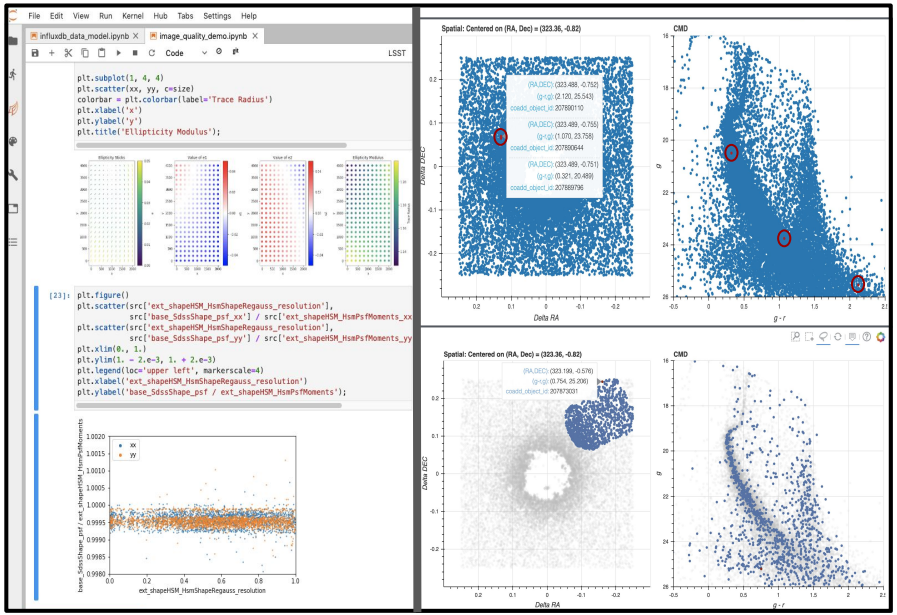
View and interact with LSST images.

Subset data catalogs via forms and query languages.

Plot scientific graphs with linked data selection across plots and images.

← The Firefly framework.
https://github.com/Caltech-IPAC/firefly

Notebook Aspect (Jupyter)



Subsetting and plotting in a Jupyter Notebook.

Use case example: data subsetting with Bokeh's lasso.

Enables science discovery via 'next-to-the-data' analysis.

Provides user environments with pre-installed libraries:

- LSST science pipelines, Anaconda, AstroPy, etc.
- Users can also install tools.
- Subsetting via forms, ADQL*.

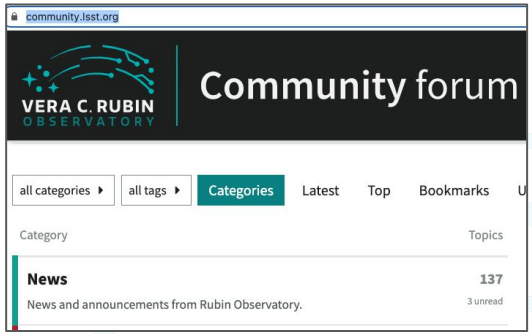
Provides compute resources of the Data Access Centres for science user analysis.

*ADQL = Astronomical Data Query Language
https://gea.esac.esa.int/archive-help/adql/index.html

More information - get involved

Join:

- One of the eight science collaborations lsstcorporation.org/science-collaborations
- Rubin Community Forum
  - Community.lsst.org
- Science Mailing list
  - Which you can find at lsst.org/scientists
- Attend Rubin PCW: July-August 2023 (in Tucson/virtual)



Make an in-Kind contribution to get **data rights**

- See [RDO-031](RDO-031): Handbook for in-Kind Contributions
- Dr. Satoshi Miyazaki: **Japanese Participation Group** Proposal lead by NAOJ and IPMU
- Apply to be a DP0 delegate, once you have data rights

Preparation and Collaboration for LSST

The **8 LSST Science Collaborations** learn and prepare together.

Active Galactic Nuclei SC

Transients and Variable Stars SC

Dark Energy SC

Stars, Milky Way, and Local Volume SC

Galaxies SC

Strong Lensing SC

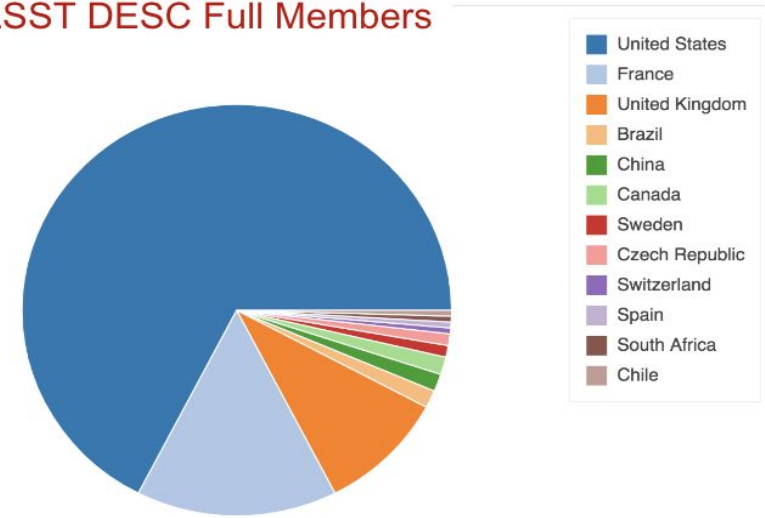
Informatics and Statistics SC

Solar System SC

We are a large community of scientists getting ready to do cosmology with the Rubin Observatory LSST

Slide from:
Intro to DESC

- The DESC has around 1100 Members, of which about 230 are “Full Members”
- Anyone with LSST data rights can become a Member via a web form (linked here). Those with a well-defined path to data rights can become Provisional Members.
- If you plan to spend a significant fraction (i.e., 30% or more) of your research time on DESC projects, and have demonstrated engagement with the collaboration (for ~1 year), you should apply to become a Full Member



Full Members can vote - and hence help steer the collaboration

Our objective is to perform a “standalone” Stage IV Dark Energy experiment

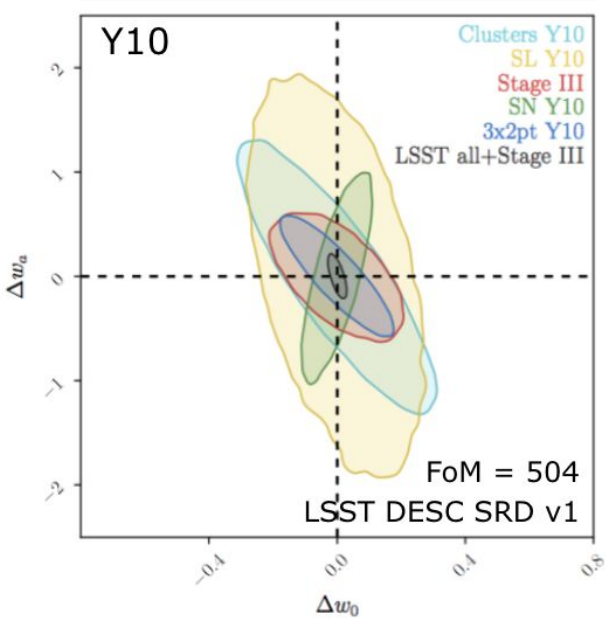
Slide from:
Intro to DESC

Reaching DETF FoM = 500 means:

- Carrying out a complex, high-dimensional, blinded joint inference, controlling systematic errors to extraordinary levels

To do this we will need to work together very well, to:

- Understand and mitigate all the systematics
- Make best use of our limited resources (e.g., human time, CPU time, disk space, money) by being efficient and well-organized

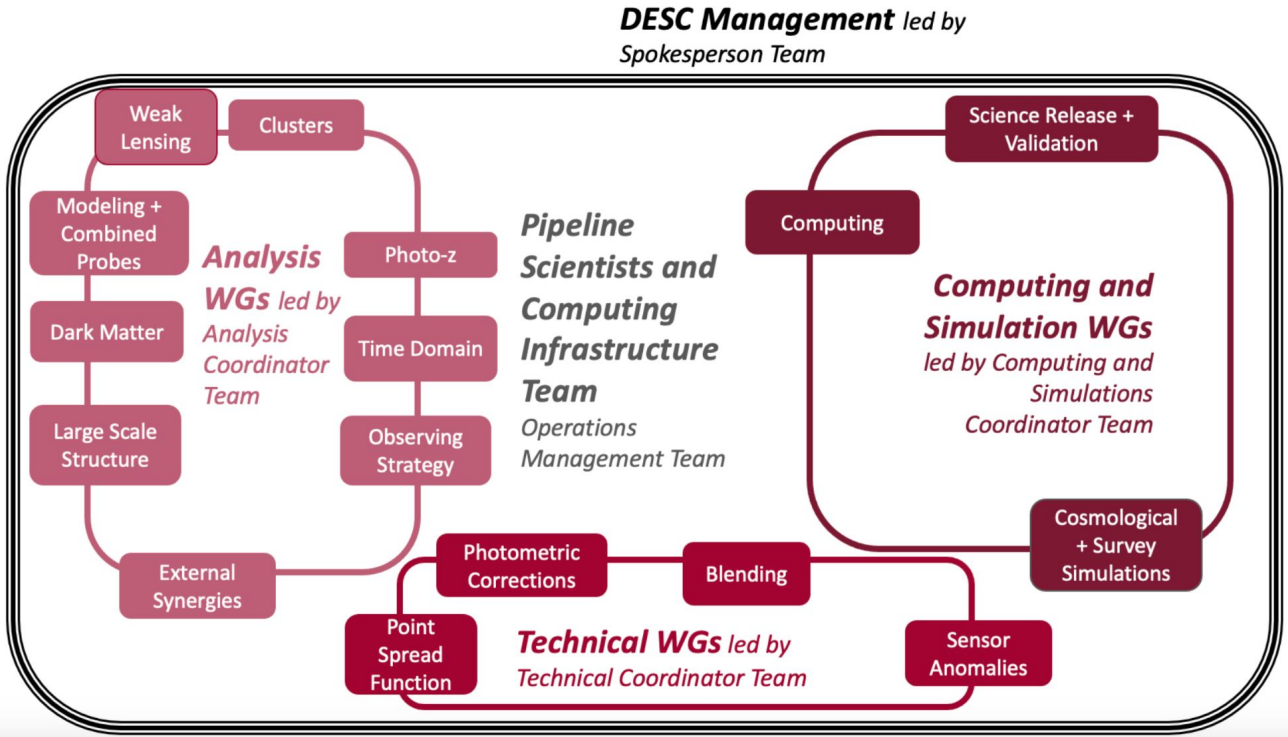


Big collaborations can do things that little ones cannot!

LSST DESC Structure

Rubin Observatory Mission: Serve high quality LSST data to the community

DESC Mission: Use the data to do Stage IV cosmology (from: Intro to DESC)



Intrinsic Alignments and LSST DESC

- Modeling and Combined Probes Working group (from DESC Science Roadmap):
  - Research priorities
    - 1 . Fast and accurate predictions for cosmological observables:
      - d) Modeling of systematic effects, especially astrophysical (e.g. **intrinsic alignments**, galaxy bias, and baryonic effects), and their consistent inclusion in observable predictions.
- Topical Teams in DESC
  - "Topical teams are informally-defined groups that capture focused activity beyond the scope of a single project, within or across DESC working groups." (from https://lsstdesc.org/pages/organization.html#topical-teams)
- DESC Science Roadmap:
  - Project 27: DC2 Project: Testing intrinsic alignment mitigation methods
  - Project 53: Intrinsic alignment self-calibration
- Several speakers and participants in this meeting are also DESC members!
- DESC members have applied for LSST Corporation funding to work on IA-related problems within DESC framework:
  - "We will adapt and use LSST-DESC tools such as TXPipe, Core Cosmology Library in order to extract intrinsic alignments of galaxies from precursory data sets such as DES and KIDS surveys. Removing this astrophysical systematic will provide more accurate measurements of cosmic shear from LSST." (from here)
  - "This project will produce simulated galaxy catalogs with realistic galaxy shapes and orientations. These catalogs, which will be available to the LSST community, will enable a range of studies to better understand the "intrinsic alignments" of galaxies and to validate mitigation strategies needed for robust cosmology with weak lensing and galaxy clustering." (from here)

LSST DESC References

- LSST DESC public website: https://lsstdesc.org/
- Introduction to DESC slides: http://ls.st/3hd
- Science Roadmap describes what we need to do to get ready for the LSST data: https://zenodo.org/record/5527255#.Y4_2i-xBx0s
- First public data release of Data Challenge 2 (DC2): https://arxiv.org/abs/2101.04855
- DC2 paper: https://ui.adsabs.harvard.edu/abs/2020arXiv201005926L/abstract

DESC Planning Documents

The following planning documents describe DESC's science goals and priorities (Science Overview), plans for research and infrastructure development in the next few years (Science Roadmap), the requirements on control of systematic uncertainties to achieve DESC science objectives (DESC Science Requirements Document), and plans for how DESC will store and serve data (Data Management Plan).

- LSST DESC Science Overview Document (SOD) on Zenodo
- LSST DESC Science Roadmap (SRM) on Zenodo
- LSST DESC Science Requirements Document (SRD) (data products on Zenodo)
- LSST DESC Data Management Plan for reference in US DOE HEP funding proposals

Relevant Rubin Observatory Project Documents

- LSST Summary of Data Management Principles (LPM-151) for reference in data management plan section of US DOE HEP funding proposals
- LSST Science Requirements Document (LPM-17)
- LSST Data Products Definition Document (LSE-163)
- List of Key Project Documents

From LSST DESC website

In-Kind Contribution: Japanese Participation Group

JPG: Contribution Leads can be found in:
https://lsst.org/in-kind-program/programs

- A list of prospective **Principal Investigators and Junior Associates** will be set up via a selection process to be executed in the next few months.

- **DP0 is a great opportunity to engage with Rubin**:
  - As soon as any JPG scientist knows (from JPG leadership) that they will have LSST data rights, they can apply for DP0 access.

Current DP0 call: https://forms.gle/ZeHmnSXiYHGdEu8E8
anyone with Rubin data rights to submit a request to become a "DP0 delegate".

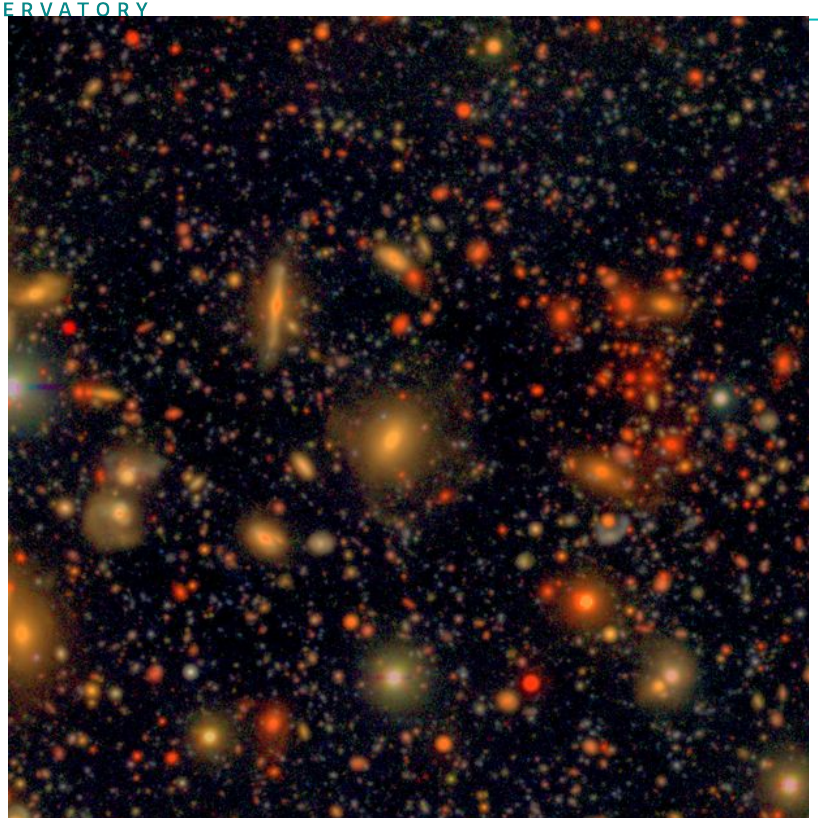
Japanese Participation Group in-Kind Programs

1. **Telescope time on Subaru** including spectroscopic follow-up
2. Subaru **PFS** spectroscopic follow-up survey of LSST **transients in deep drilling fields**
3. Subaru **PFS** filler survey for LSST **photo-z training dataset**
4. Contribution to the LSST photo-z calibration with PFS-SSP galaxy evolution dataset
5. Help with **Commissioning**
6. Serving **Rubin Science Platform** (Development and Support)
7. Serving LSST Catalogs from the **NAOJ Lite Independent Data Access Center (IDAC)**

8. Serving LSST Catalogs from the **Kavli IPMU Lite IDAC**
9. **Software** for calibrating the **covariance matrix** for large-scale structure probes
10. **ML deblending algorithm** with ground- and space-based images
11. Directable effort in the **SL working group**

https://lsst.org/in-kind-program/programs

Japan: HSC and Rubin LSST



The COSMOS field seen by Hyper Suprime-Cam, courtesy of the HSC Collaboration, R. Lupton, and N. Lust.

- Rubin's LSST is not the first wide-field imaging survey…
- HSC survey: like LSST depth (but tiny area)
- Hyper Suprime-Cam gri
  - 3.5'x3.5'
  - r~27
  - processed with Rubin code within the HSC collaboration. (Bosch et al 2019)
- LSST will deliver 5 million such images

Resources

Rubin Observatory maintains several resources about the international data rights model for the community:

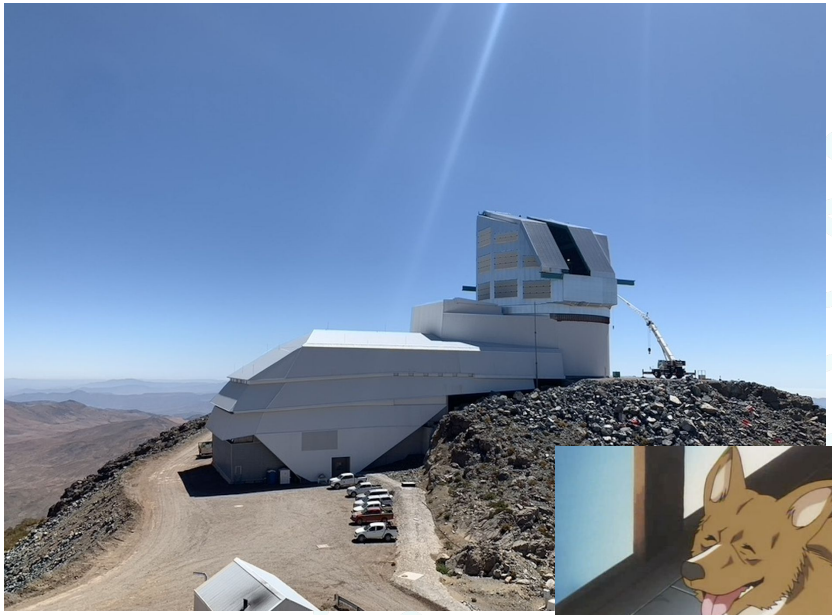
- The Rubin Data Policy: ls.st/rdo-013
- In-Kind Program website: https://www.lsst.org/scientists/in-kind-program
  - In particular, FAQ's: https://www.lsst.org/in-kind-program/faq
- The website of the in-kind Contribution Evaluation Committee (CEC)
- The In-Kind Contribution Program Handbook for Proposal Teams - which describes the proposal process and criteria for contributions to be accepted
- The Manual for In-Kind Contributions - which describes how in-kind contributions are managed, with information both for contributors and recipients
- **Current DP0 call: https://forms.gle/ZeHmnSXiYHGdEu8E8**

Questions for Rubin Observatory about **international data rights** can be sent directly to **Bob Blum** (rblum@lsst.org), Acting Director for Rubin Observatory Operations, and **Phil Marshall** (dr.phil.marshall@gmail.com), Deputy Director of Rubin Observatory Operations at SLAC.

Thank you!

Feel free to contact me at any time!

Andrés A. Plazas Malagón
plazas@slac.stanford.edu



ご清聴ありがとうございました!

Get Involved / Get Prepared

Join a Science Collaboration: https://www.lsstcorporation.org/science-collaborations

Use the Rubin Observatory Community Forum, Community.lsst.org

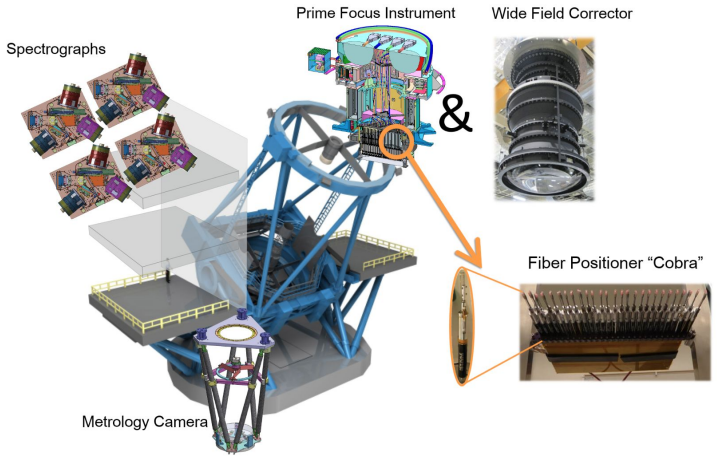
Attend the (free, virtual) Rubin Project and Community Workshop, July/Aug (TBD) 2023

2021: https://project.lsst.org/meetings/rubin2021

Resources and publications

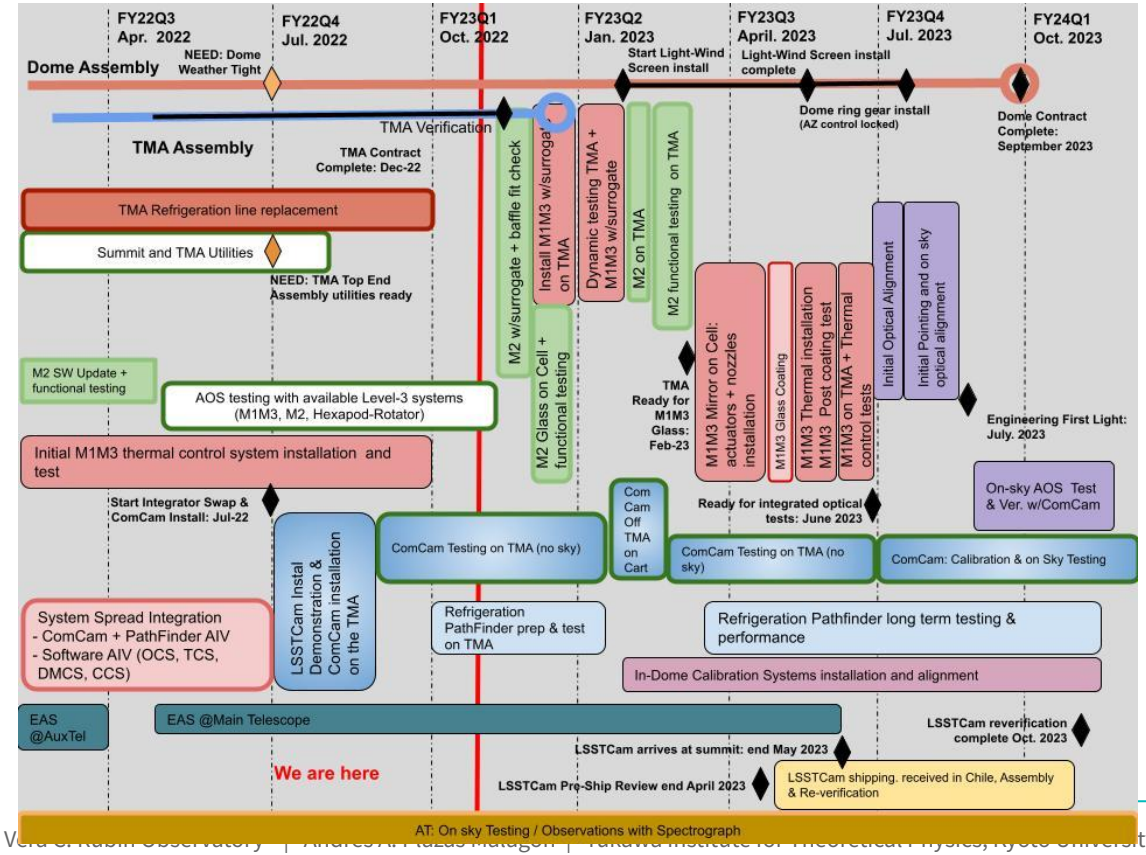
- Rubin Observatory “For Scientists” Webpage: lsst.org/scientists
- The Science Book: lsst.org/scientists/scibook
- LSST: From Science Drivers to Reference Design and Anticipated Data Products (Ivezić et al. 2019)
- Rubin Observatory technical documents, lsst.io

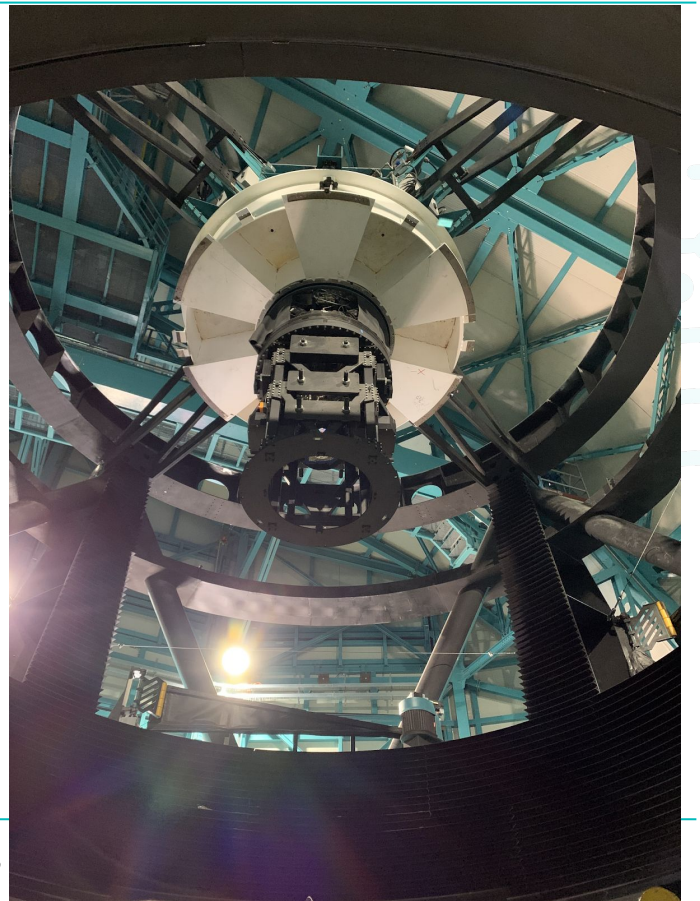
Japan: Prime Focus Spectrograph (PFS) and Rubin LSST



- PFS: multi fiber-fed spectrograph to be mounted on the prime focus of the Subaru telescope.
  - 2394 robotically actuated fibers over 1.25 deg2 sky area
  - R ~ of 2300 - 4300 over 380 - 1260 nm.
- LSST: photometry to r < 27.5 and time resolved measurements to r < 24.5
- Complementary:
  - spectroscopic survey of LSST transients within Deep Drilling Fields (DDFs)
  - Improvement of photo-z accuracy of LSST photometric redshifts

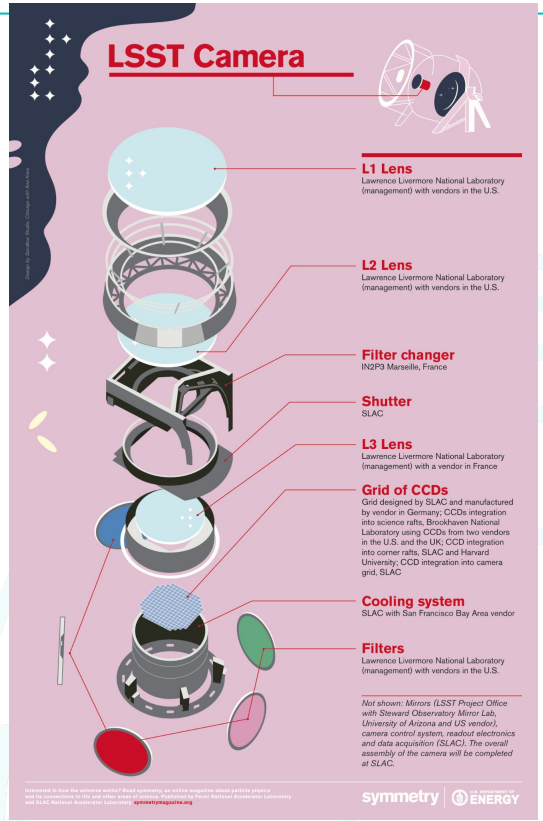
What is the next integration activity?





LSSTCam

- Focal Plane with 3.5 deg diameter Field of View
  - 0.2”/10μm pixel
  - 3.2 Giga-Pixels
- Image Entire Available Sky in 3-4 nights
  - Pairs of Short 15 sec Exposures = 1 visit
  - 2 second readout to minimize deadtime
  - 16 channel CCDs
- Light weight for fast slewing
- 189×16 Channels total
  - Electronics in the Cryostat
- Fast Optics F/1.23
  - Shallow Depth of Focus
  - very flat focal plane




Credit: Chris Walters