

Rubin Observatory Construction Status

Steven M. Kahn
Rubin Observatory Director

Committee on Astronomy and Astrophysics
April 1, 2020





An Interesting Time ...

- Will cover:
 - Construction team progress over the past six months.
 - Current programmatic status
 - COVID-19 implications
 - Operations planning and data rights issues

- Michael Strauss (SAC Chair) will follow with updates on activities of the Science Advisory Committee.



Tough first quarter in Chile (Pre-COVID)

Political unrest caused significant turmoil



- 1 day of no summit access
- 4 days of “emergency” staff only – No bus
- 6 days of late arrival / early return
- DOE personnel travel authorizations declined by Embassy
- Significant increase in staff tension (reduced over time)
- Individual disruptions
- Non-critical work was delayed



Dome continued to progress despite wind



Friction-drive
rotation system
Implemented



Provisional bridge
crane installed
and load tested

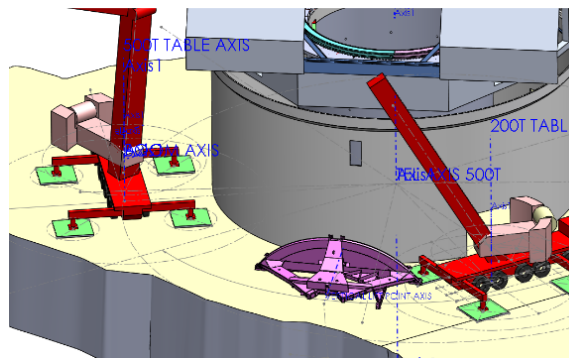




Telescope (TMA) install had excellent start

Azimuth Track (4 sectors)
installed, anchored, aligned,
leveled and grouted.

Done inside protective,
conditioned tent required
for metrology and grouting



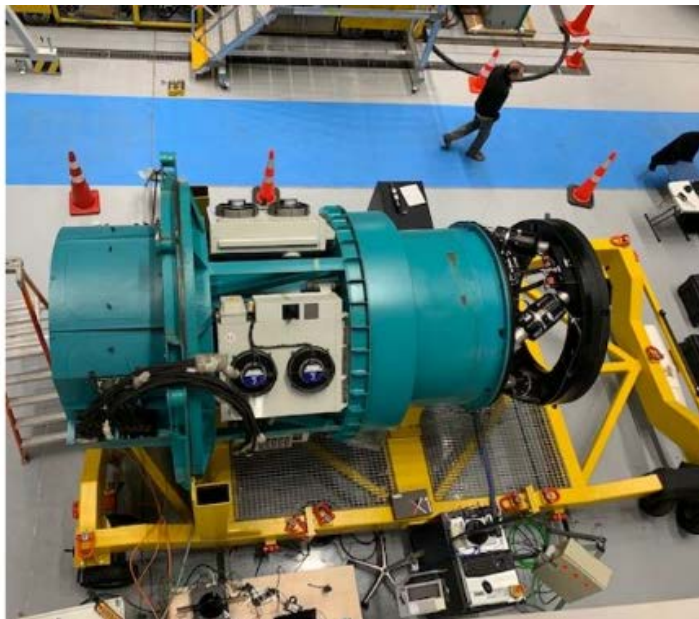
Two biggest lifts
completed in January





Off-telescope TMA work also met schedule

Hexapod-Rotator and Camera Cable Wrap integrated and tested under software control on the Maintenance Floor of the Summit Facility



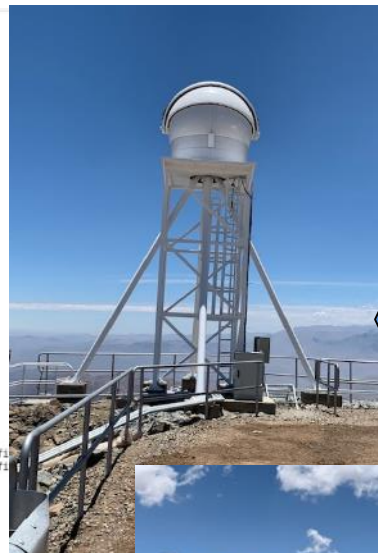
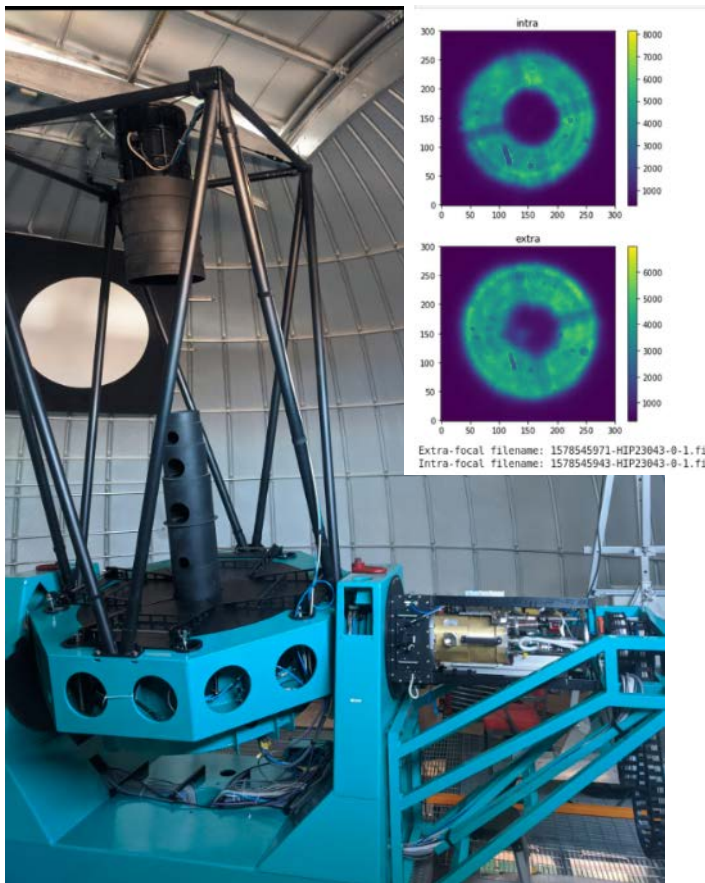
Hydrostatic Bearing Oil system installed in 1st floor of Facility.
Oil piping to TMA in procurement





Aux Tel and EAS integration

- Regular nighttime observing runs on Auxiliary Telescope about weekly throughout the quarter
- Optical alignment, mechanical fixes, and controls refinement carried out daily
- AT Spectrograph now installed and first light achieved in January

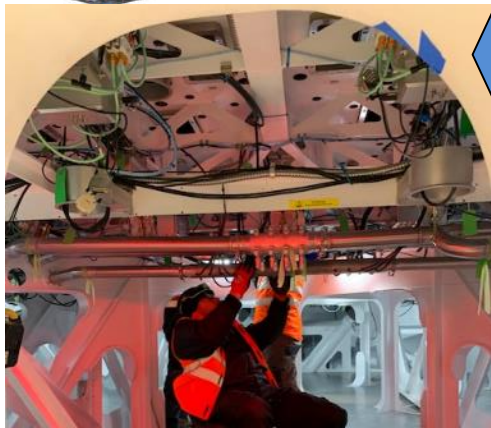


Environmental Awareness System has added full-time permanent seeing monitor and All-sky Camera





M1M3 and Coating integration going well

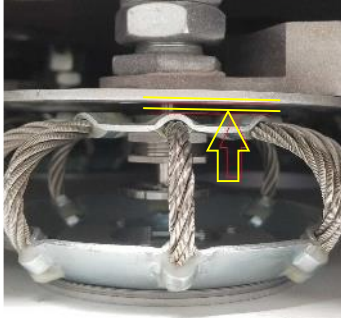


Pneumatic actuators installed
in M1M3 Cell

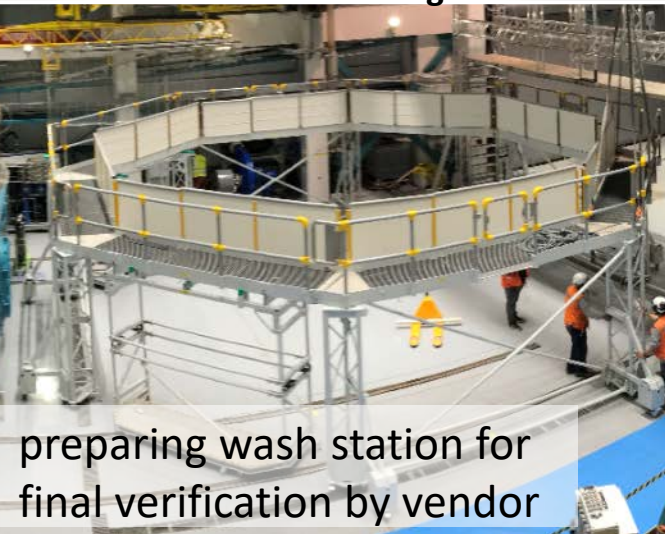
Cell and surrogate integrated
and fit under coating chamber



Surrogate lifted off
static supports by
Actuators in October



preparing wash station for
final verification by vendor





Chile Base Facility nearly complete



Moved fully into the new offices during the quarter.

LSST delivered new buildings to COS OIR Lab for operation, officially became a tenant



LSST Lab Space included in final remodeling phase started Oct. 1





Significant Tel. & Site work continued in Tucson



Shack
Hartmann
Wavefront
Sensor
Training



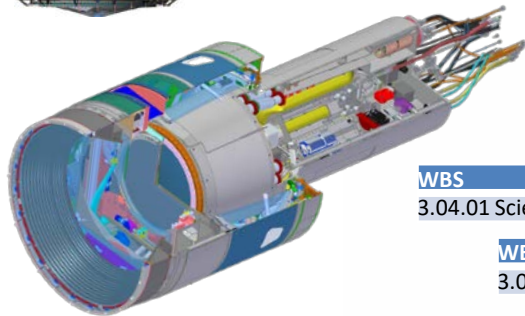
Shop work for ComCam Support Structure



Assembly
& testing
of M1M3
fan-coil
units



Major Camera Elements (November 2019 data)



WBS	Baseline (\$K)	% complete
3.04.02 Corner Raft Tower	\$7,064	100%

WBS	Baseline (\$K)	% complete
3.04.01 Science Raft Tower	\$17,507	100%

WBS	Baseline (\$K)	% complete
3.03 Sensors	\$34,011	100%

WBS	Baseline (\$K)	% complete
3.06.01 Camera Body	\$2,395	99%

WBS	Baseline (\$K)	% complete
3.06.02 Shutter	\$3,030	98%

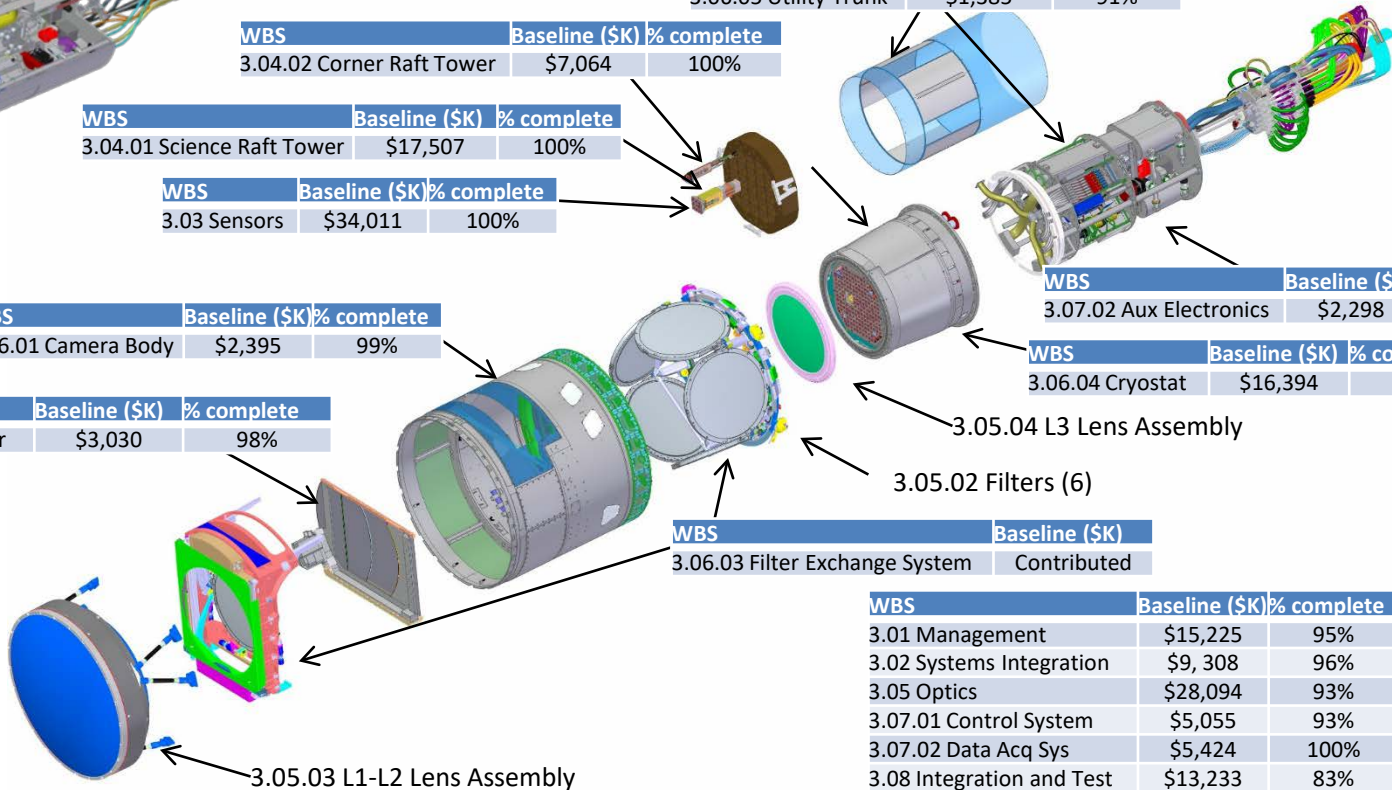
WBS	Baseline (\$K)	% complete
3.06.05 Utility Trunk	\$1,385	91%

WBS	Baseline (\$K)	% complete
3.07.02 Aux Electronics	\$2,298	100%

WBS	Baseline (\$K)	% complete
3.06.04 Cryostat	\$16,394	99%

WBS	Baseline (\$K)
3.06.03 Filter Exchange System	Contributed

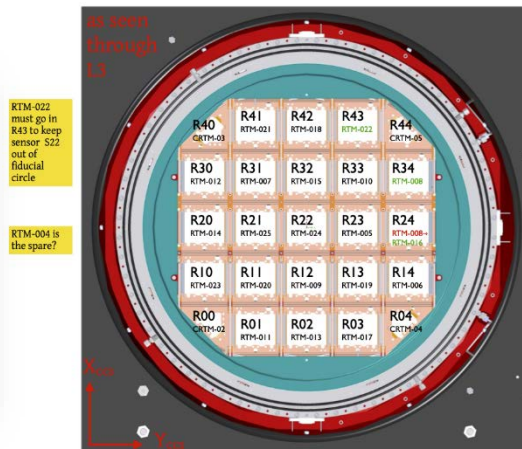
WBS	Baseline (\$K)	% complete
3.01 Management	\$15,225	95%
3.02 Systems Integration	\$9,308	96%
3.05 Optics	\$28,094	93%
3.07.01 Control System	\$5,055	93%
3.07.02 Data Acq Sys	\$5,424	100%
3.08 Integration and Test	\$13,233	83%
TOTAL	\$160,423	96.3%



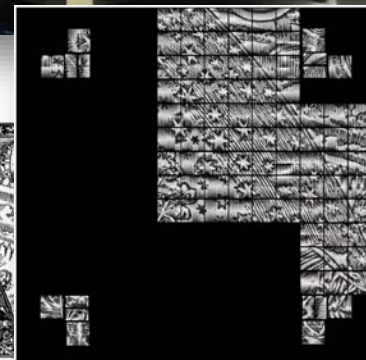
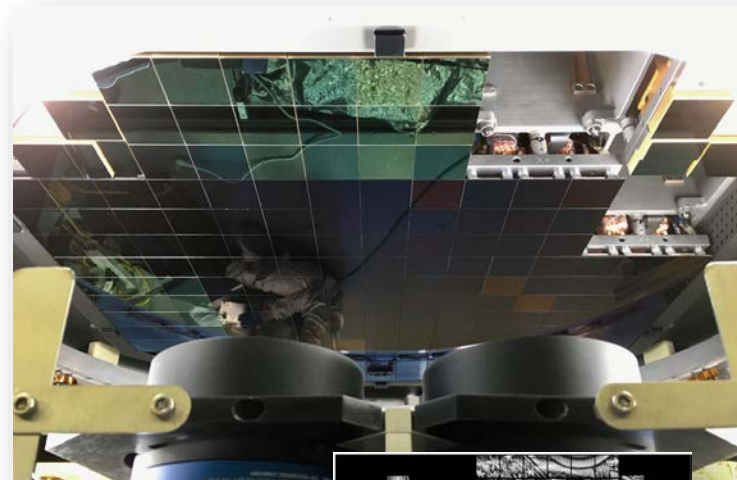


I&T progress status

- Camera
 - Camera Integration stand commissioning complete
 - Integration with camera Body and Filter Exchange started
- Cryostat
 - All rafts inserted (21 science+4 corner rafts)
 - 9 raft+4 corner raft metrology and Electro-optical testing complete
- Next steps
 - Full cryostat pump down, cooling and electro-optical testing

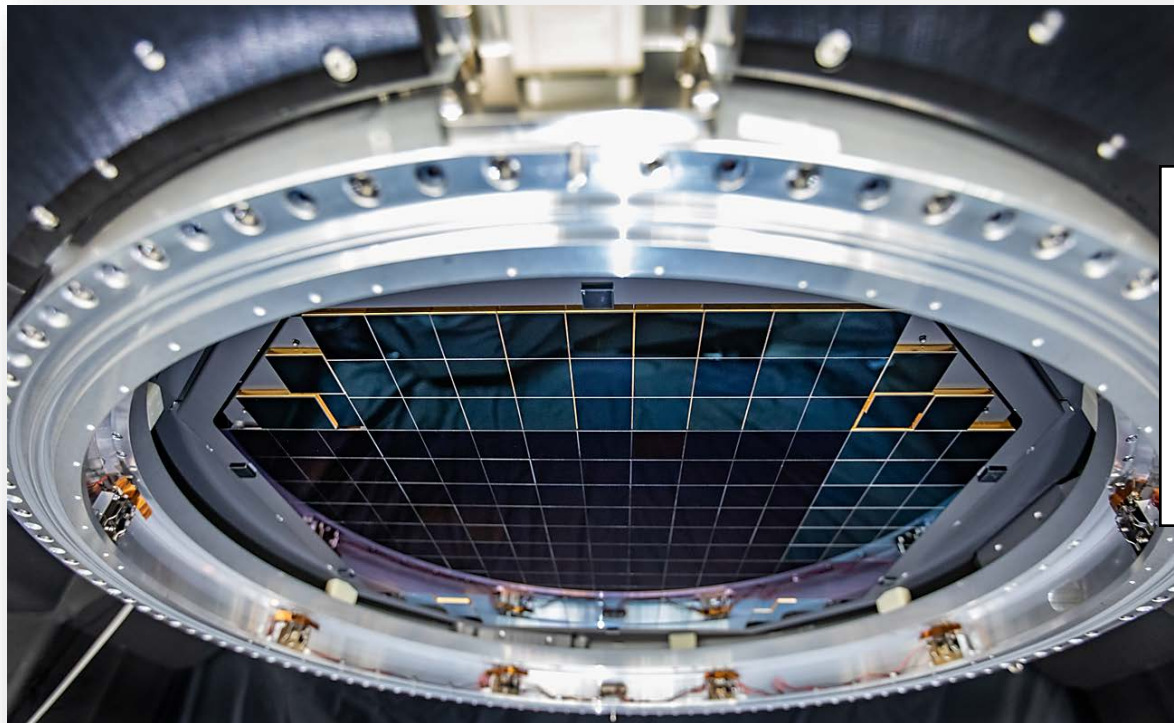


Next:
-R24
R43
R24
R34





Picture of the focal plane with all the rafts

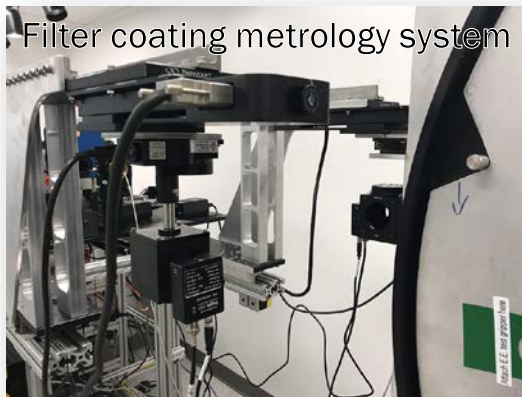


*Frame video of the full
integration of all 25 rafts (5min)*



Optics status

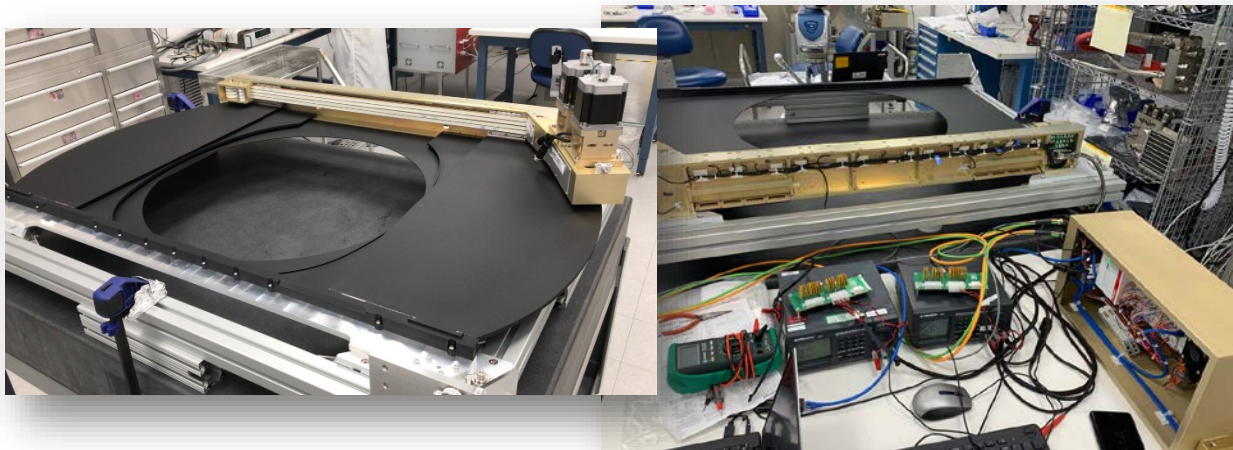
- Recent accomplishments
 - L1-L2 completed and delivered to SLAC 8/15/2019
 - L3 assembly completed and delivered to SLAC 10/08/2019
 - Coating R&D effort completed. R-band production filter coated
- Upcoming work
 - Complete assembly and coating of the filters
- Remaining Issues
 - Filter coating is still a risk until completed
 - Filter coating performance measurement on full size part is still a challenge
 - Chamber readiness took longer than expected do to equipment upgrades but is now ready as of 12/20 to start the i-band witness samples for actual i-band coating started 01/15/2020





Camera Body and Shutter progress

- Recent accomplishments
 - Camera Backflange mounted to Camera Body
 - Two production shutter assembly complete
 - Testing of the two shutters complete
- Remaining work
 - Complete LED spurious light emission mitigation
 - Complete assembly of the insertion fixture



Production Shutters during assembly

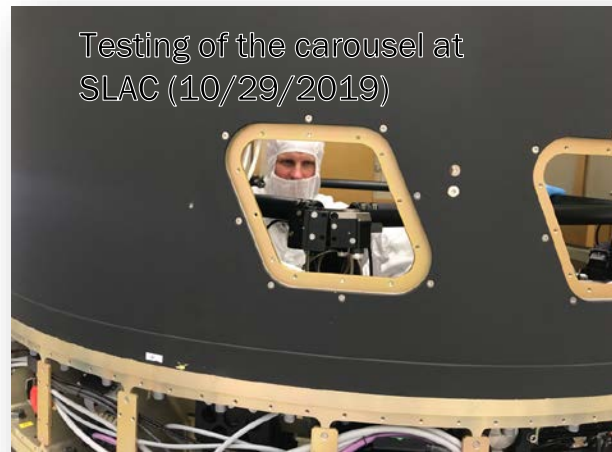


Camera Body, Backflange and Carousel



Filter Exchange System Progress (IN2P3)

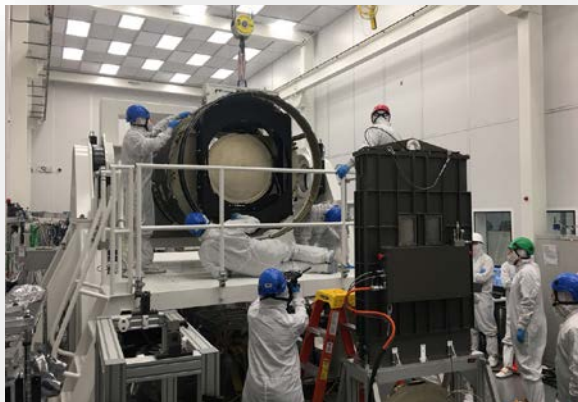
- Recent accomplishments
 - Carousel was received at SLAC on 10/18/2019
 - Autochanger, loader and auxiliary equipment were received at SLAC on 11/25/2019
 - Autochanger+Carousel+Camera Body+Backflange all together on 12/11/2019
- Upcoming work
 - Test all hardware using CCS in progressively more integrated states prior to final assembly with the cryostat in Spring 2020



Testing of the carousel at
SLAC (10/29/2019)



Filter Exchange
Engineering control
box



Arrival of the autochanger
and loader at SLAC on
11/25/2019



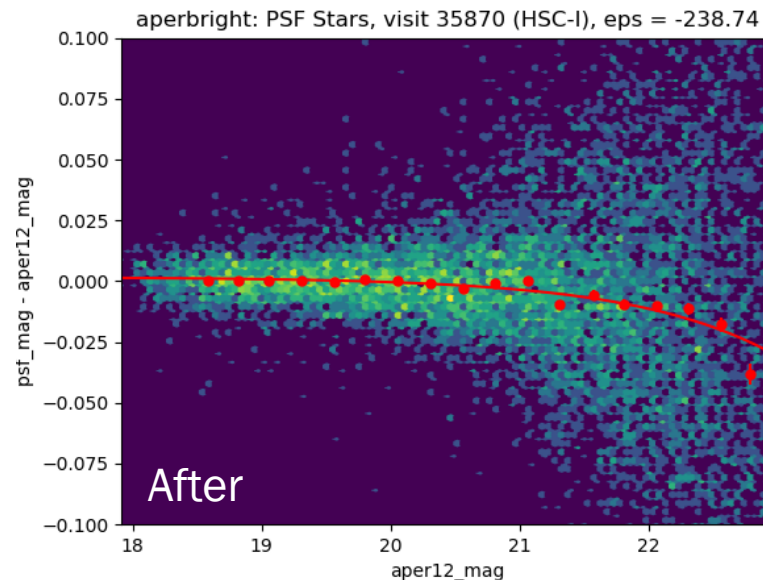
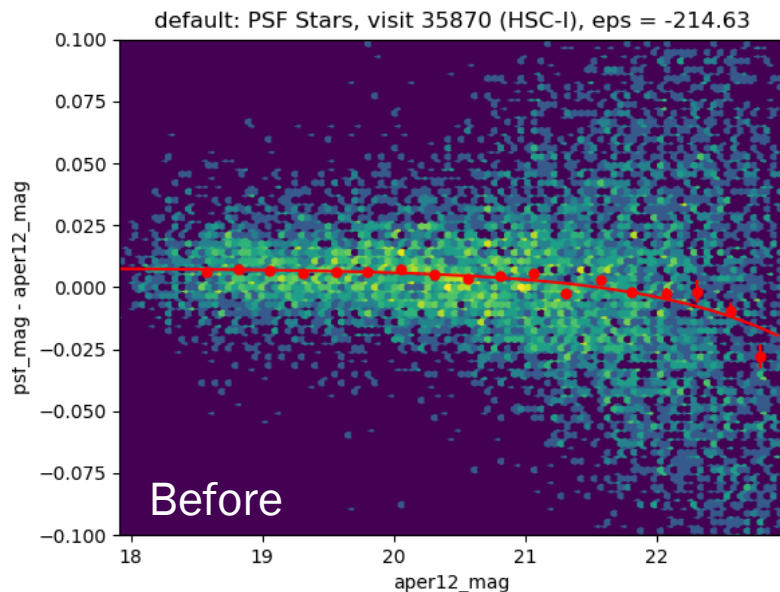
Data Management — diverse achievements

- Porting to the new “Generation 3” data access framework & processing middleware underway.
 - [DMTN-137](#) describes Amazon Web Services processing of precursor data using Gen 3.
- Activated 100 Gbit/s spectrum link between São Paulo and Boca Raton.
- [Release 19](#) of Science Pipelines out, with a range of key enhancements.
 - New calibration and deblending capabilities, calculation of DIAObject properties, much more.
- RFC-620, describing new solar system processing plan, published.
- More storage and compute nodes deployed at the US Data Facility in support of commissioning through the LSST Science Platform and other activities.
- DM-provided solution in use as Engineering & Facility database (next slide).



Improved scientific algorithms

We continue to test and improve our scientific processing on precursor and simulated data. Here we show recent improvements made to the photometric calibration system using Hyper Suprime-Cam data.



Credit: Eli Rykoff

Results from single-visit processing, *before* processing with the Forward Global Calibration Model

System Integration Test and Commissioning (SIT-Com) has begun



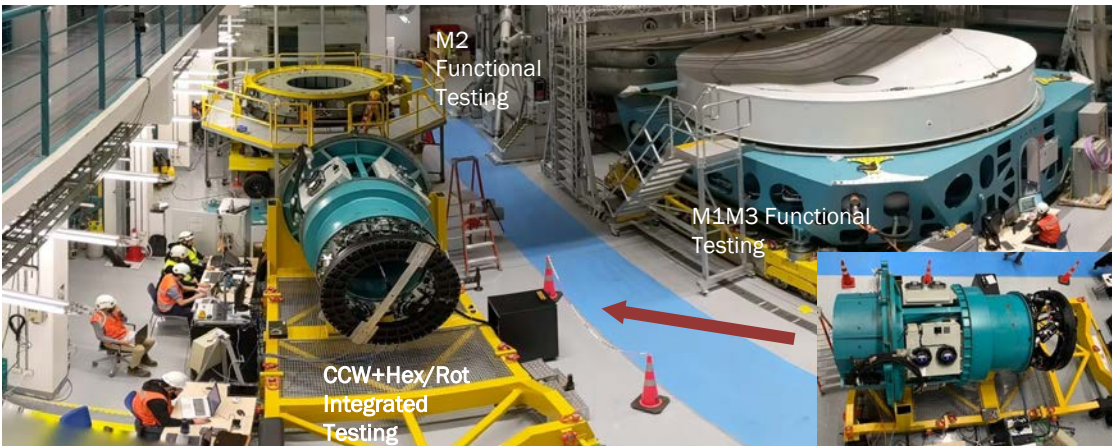
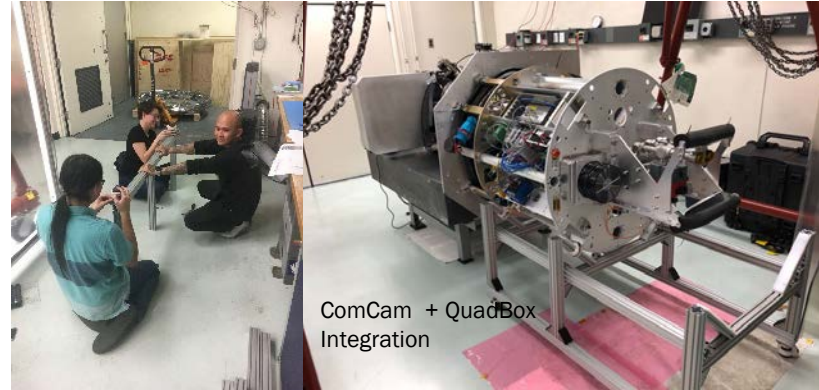
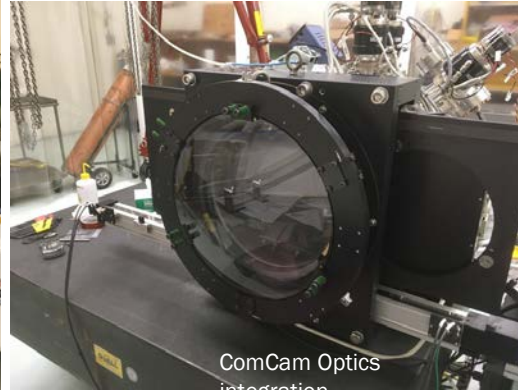
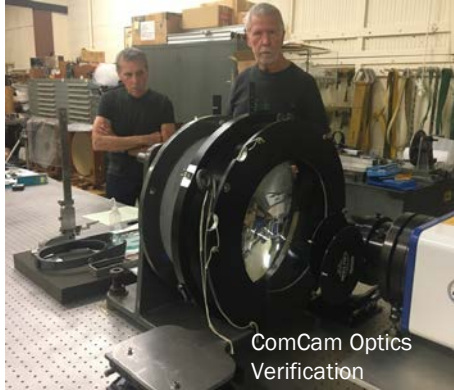
Integrating structure and Camera cable wrap delivered by Telescope vendor

Vendor delivered Camera Hexapod and Rotator

VRO team software and network infrastructure

VRO team engineering and facility database system

SIT-Com Progress Highlights



ComCam Integration ↑
← Camera Cable Wrap + Hex/Rot
Integration with M2 & M1M3 testing

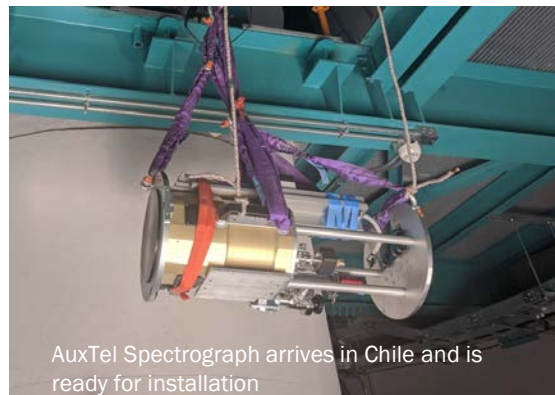




Other SIT-Com progress



DIMM
Installation for
site seeing
monitoring

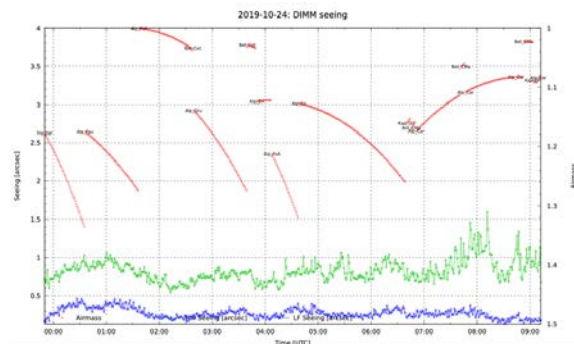


AuxTel Spectrograph arrives in Chile and is
ready for installation

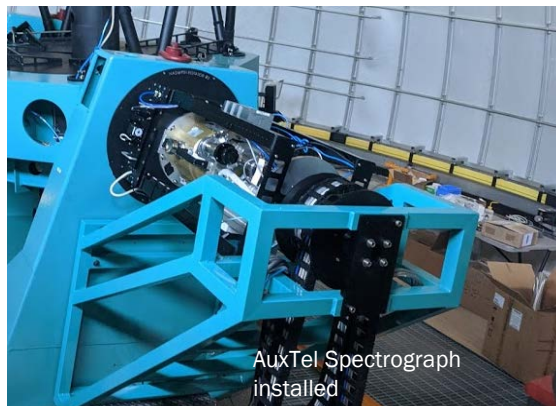


Dome seeing probe ready
for testing

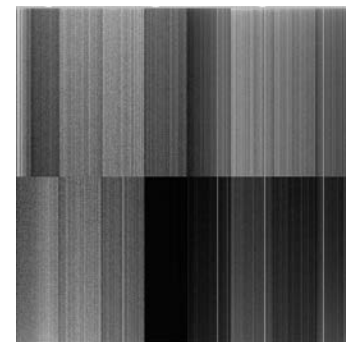
Dome seeing probe field testing Jan.
2020



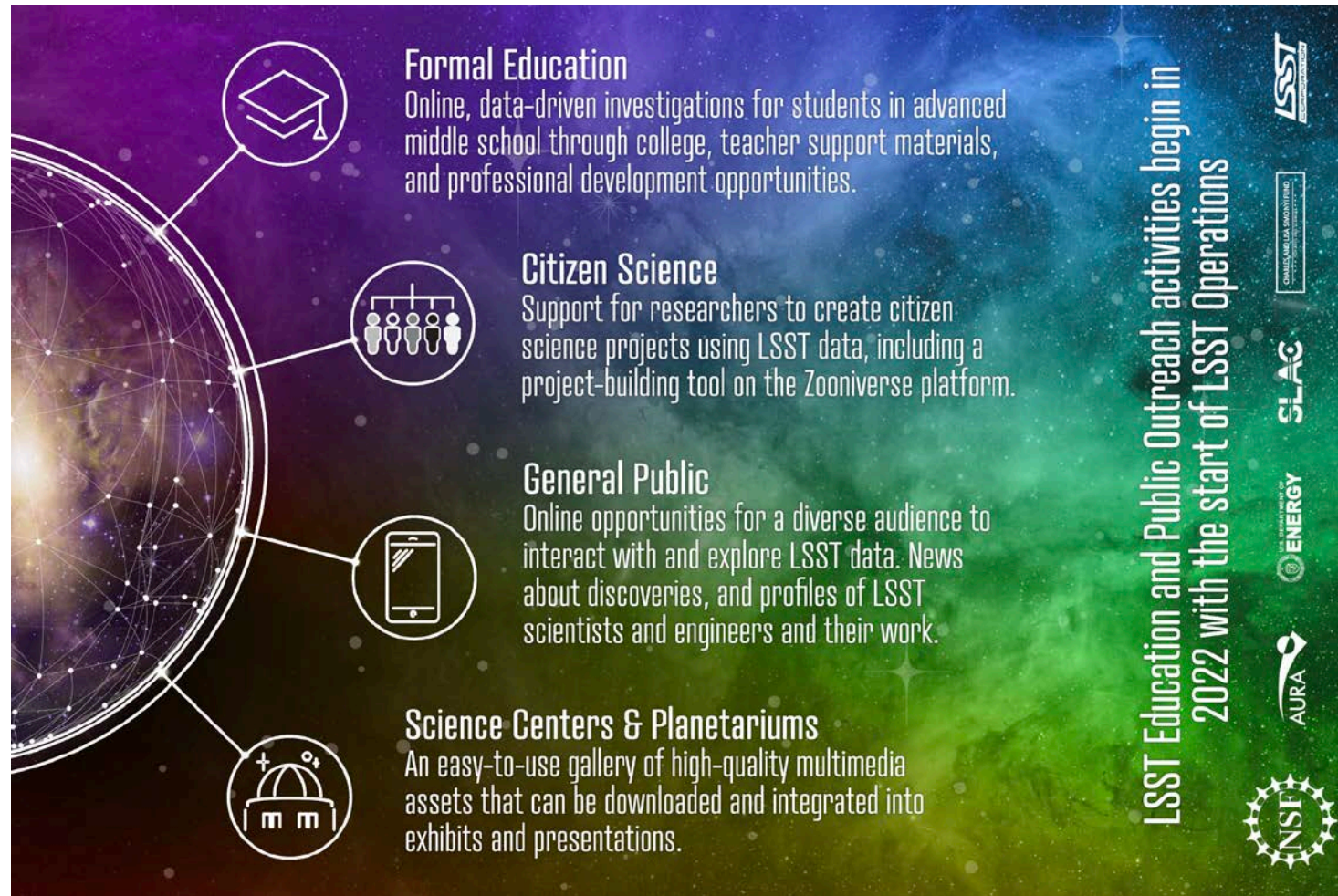
Automated DIMM operation and data
recording commissioned



AuxTel Spectrograph
installed



Successful liveness test of AuxTel
spectrograph at Summit - Jan. 17, 2020



Formal Education
Online, data-driven investigations for students in advanced middle school through college, teacher support materials, and professional development opportunities.

Citizen Science
Support for researchers to create citizen science projects using LSST data, including a project-building tool on the Zooniverse platform.

General Public
Online opportunities for a diverse audience to interact with and explore LSST data. News about discoveries, and profiles of LSST scientists and engineers and their work.

Science Centers & Planetariums
An easy-to-use gallery of high-quality multimedia assets that can be downloaded and integrated into exhibits and presentations.

LSST Education and Public Outreach activities begin in 2022 with the start of LSST Operations

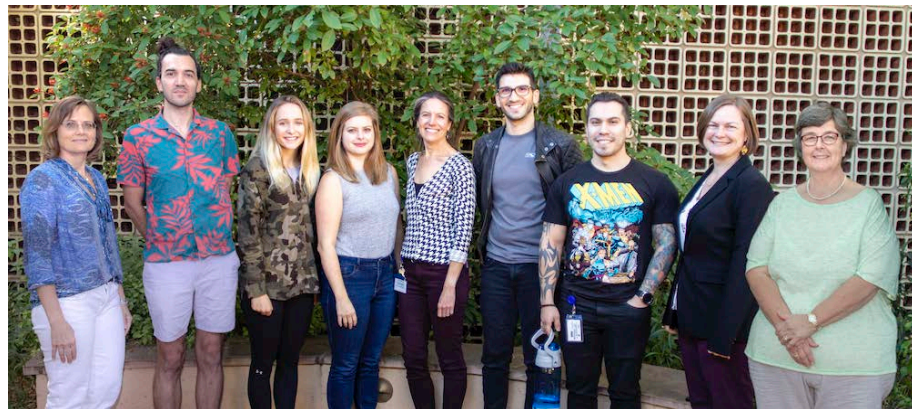
Logos: **NSF**, **AURA**, **U.S. DEPARTMENT OF ENERGY**, **SLAC**, **LSST**, **CONSEJO NACIONAL EN INVESTIGACIONES CIENTÍFICAS**



Recent focus on Time Domain Astrophysics



Screenshot from a Promo video released with naming announcement (with English and Spanish narrations and subtitles).



Staff growth over last 6 months:

- web developer (Oct 2019, 1 FTE)
- web designer (Dec 2019, 1 FTE)
- Developer intern (Oct 2019, 0.2 FTE)



EVMS Executive Summary – Feb 2020 Data

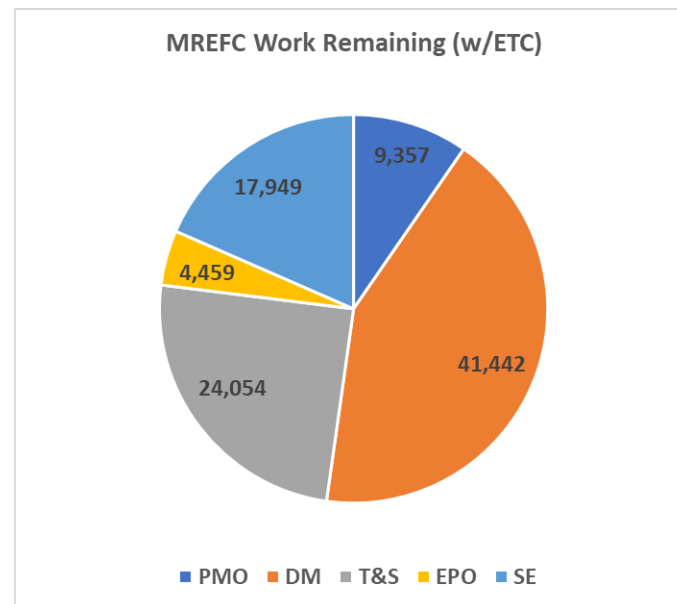
	MREFC - NSF	LSSTCam – DOE
% Complete (Feb 2020)*	81	97
SPI	0.99	0.99
CPI	0.98	0.96
Contingency (EAC)	\$26.0M	\$1.6M
Contingency % Remaining Work (EAC)	29	32

- Remaining NSF Contingency, % $(TPC - BAC - CV)/(EAC - ACWP)$



MREFC Work Remaining

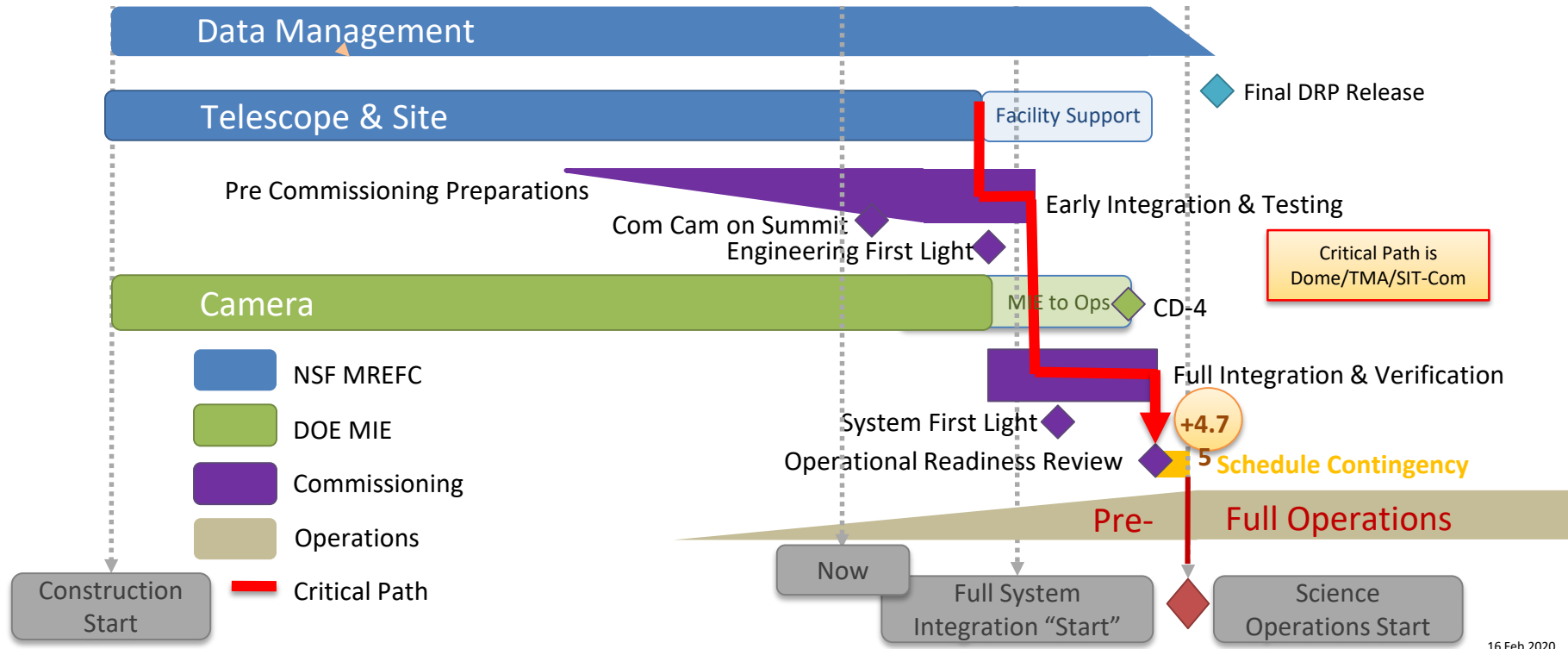
- Contingency has improved this Quarter
 - SIT-Com Replan
 - DM Hardware Descope
- DM and EPO are on track
 - Performing to Plan
 - Risk Exposure = Scope Options
- T&S + SE = \$42.0M (EAC)
- PMO + DM + EPO = \$55.3M (EAC)
- Total work to-go (EAC) = \$97.3 M





LSST Schedule – 4.75 Months Contingency

CY2014				CY2015				CY2016				CY2017				CY2018				CY2019				CY2020				CY2021				CY2022				CY2023				CY2024			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
FY2014				FY2015				FY2016				FY2017				FY2018				FY2019				FY2020				FY2021				FY2022				FY2023				FY2024			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4





Progress on the Summit Facility:

- As cases began to arise in Chile, shelter-in-place types of restrictions started to be adopted.
- AURA issued a “work at home” directive to all employees in the country. In addition, there was a threat that the road from La Serena to the summit might be closed to prevent infection in the Elqui Valley.
- Further, the contractor that was reassembling the telescope mount assembly on the summit recalled its employees to Spain on advice of their embassy.
- We therefore made the decision to shut down operations on the summit as of March 20th.
- Unfortunately, this action had to be taken before the dome was fully enclosed. With the approaching winter in Chile, we are facing the threat that adverse weather conditions may impact us more than a simple day for day slip.
- Due to full shutdown, summit work is in day for day slip plus several month mobilization back to 120 workers on site.



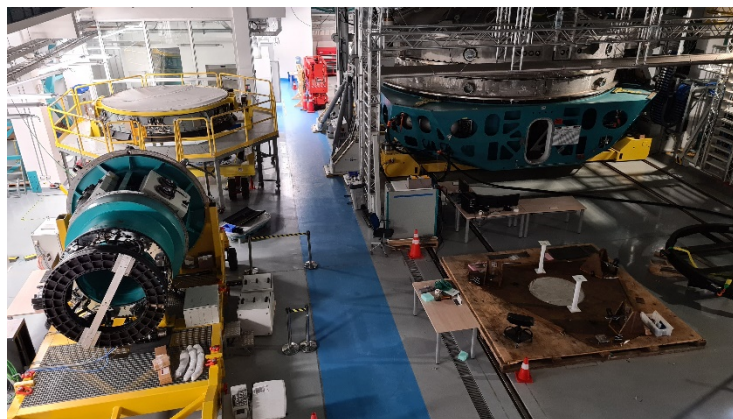
Current State of the Facility



Telescope
mount tarpped



Electrical boxes, equipment and materials
tarpped in dome



M1M3 Cell,
coating facility,
M2 system,
Hexapods, all
secured and
shutdown



COVID-19 Related Issues

Progress in the States:

- Similar actions were taken at the Rubin Observatory headquarters facility in Tucson and at SLAC National Laboratory in the Bay Area.
- Both organizations are now on a work from home basis.
- The assembly of the camera at SLAC is the most affected. We were in the midst of diagnosing a potential problem with the refrigeration system when the shutdown occurred.
- The slip against the critical path will at least be day for day. There could be further delays due to start up issues and decreased efficiency.

Agency Reactions:

- Both agencies have advised us to track COVID-related cost and schedule impacts. We are expecting to rebaseline both the NSF MREFC project, and the DOE MIE project once the crisis abates.



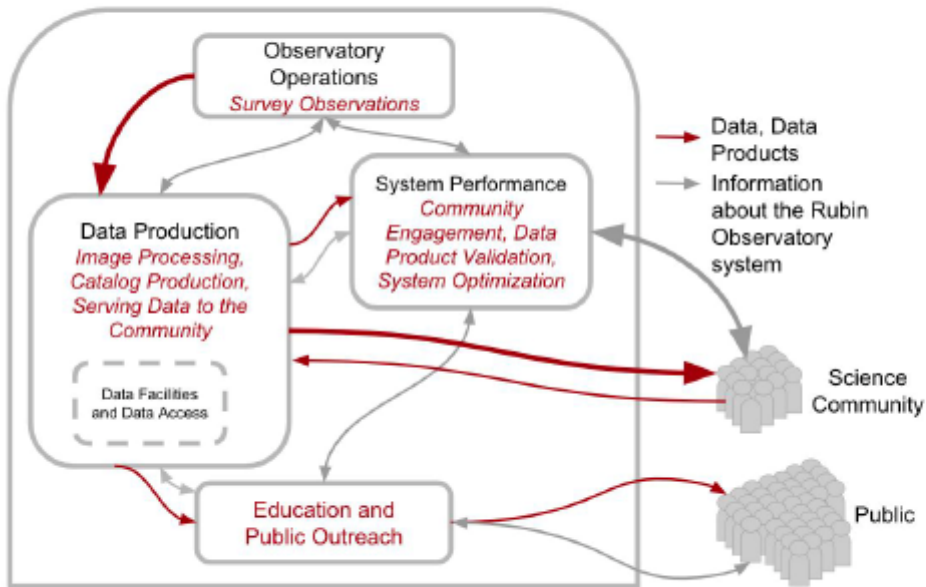
Rubin Observatory Operations

- Pre-operations is the phase of operations we are in right now
- FY19 - FY22
- Funded by NSF and DOE
 - NSF -> OIR Lab Program Operations Plan (POP); current CSA 3 years
 - DOE -> Annual Field Work Proposal (FWP) to SLAC
 - Rubin Observatory Ops jointly plans via a POP that informs both NSF and DOE process
- Pre-operations is the period to:
 - Define operations plan
 - Build staff transition plan and fill operations roles
 - Define and document needed operations processes and procedures
 - Start operations activities to ensure readiness
- The team is on track for Operations Planning!



Overall Operations Organization

The information flow through the Rubin system drives the design of its mgmt structure



1. **Observe** sky, keep going
2. **Produce data**
 - Check results
 - Emit Alerts
 - Release catalogs
3. Support community and learn from them, **Optimize** survey and system
4. Involve and inform the **public**



Network of Operations Facilities





Change in Funding Guidance

The December 2017 operations plan was based on a funding model where:

- International contributions (ICs) totaling \$156M (25% of the total cost) were to be collected by LSST Corporation, in exchange for data rights.
- The IC funds were to be transferred to AURA, which was then to cover 75% of the operations scope.
- DOE was to cover the remaining 25% of the scope (including 50% of Chilean labor and observatory M&S, via a bulk service procurement to AURA). This 25% DOE scope amounted to around 30% of the total cost (due to the higher overhead at DOE labs).

In May 2019, NSF and DOE decided that:

- Only in-kind (and no monetary) contributions will be accepted in exchange for data rights governed by agreements held by the agencies.
- Subsequent verbal guidance was that **NSF and DOE will each cover 50% of the cost of Rubin Observatory operations**, with DOE's share increasing from 30% (~\$20M/yr in steady state) to 50% (~\$35M/yr)



Reconsideration of US Data Facility

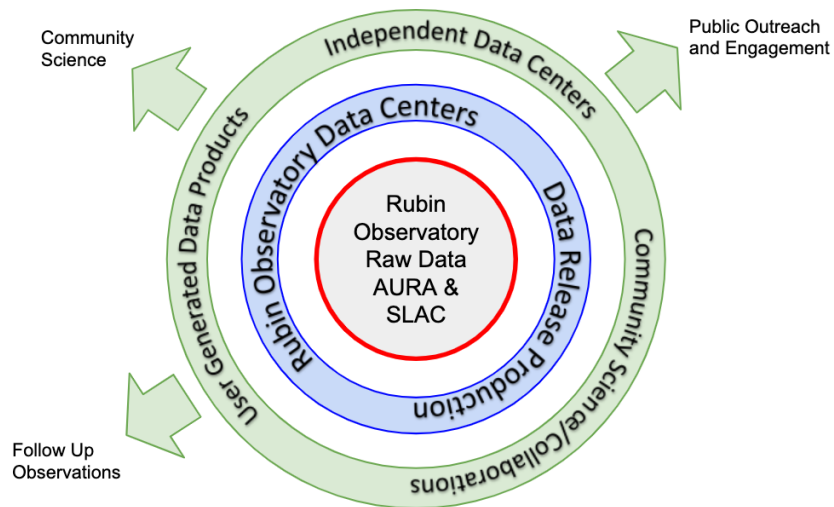
The Rubin Observatory system will have at least 2 data facilities, one in the US and one in France (CC-IN2P3). The US Data Facility (DF) is being prototyped at NCSA as part of Rubin Observatory construction and commissioning:

- DOE labs have long experience processing big data from HEP experiments. In order to more effectively use DOE resources for its 50% commitment to operations, OHEP asked: could a DOE Lab be the US DF?
- Fall 2019 investigation was carried out by the Rubin Ops team, at DOE's request. The Ops team determined there were good options for a USDF hosted by DOE.
- Ops team is currently awaiting joint agency decision on where the data facility will be sited.



International Contributions Now In-Kind

- Most in-kinds are beyond the critical, WBS based activity in the operations plan
- Support community in science enterprise
- A few agreements will likely be for true offsets of cost associated with activity in the WBS.





International In-Kind Contributions

41 international (non-US and Chile) groups are seeking data rights for 580 PIs in return for in-kind contributions to Rubin and LSST.

Potential contributions include: Follow-up time, complementary datasets, science infrastructure, observatory (and commissioning) enhancements, some operations cost offsets (UK)

- Community-centered Contribution Evaluation Committee established and evaluating proposed contributions through FY20
- International Program Coordinators within Director's Office to help track
- Agency-level Resource Board to oversee program, solve problems together





Summary

- Rubin Observatory construction was making excellent progress, despite a number of technical and logistical challenges.
- However the COVID-19 outbreak will impact us significantly, particularly given the onset of Chilean winter.
- We will have regular inspections of the site while we are down, but cannot resume construction progress until the contractor teams return from Europe.
- Operations planning is well underway.

Vera C. Rubin Observatory Science Advisory Committee

Michael Strauss, Princeton University
SAC chair

The Science Advisory Committee comprises 16 astronomers

- Franz Bauer (U. Catolica de Chile): AGN
- Rachel Bean (Cornell): Cosmology
- Federica Bianco (U. Delaware): Transients and variables
- Niel Brandt (PSU): AGN
- Márcio Catelan (U. Catolica de Chile): Stars and Stellar Populations
- Mansi Kasliwal (Caltech): Transients
- David Kirkby (UC Irvine): Cosmology
- Charles Liu (AMNH/Staten Island): Galaxies and AGN
- Amy Mainzer (JPL): Solar System
- Meg Schwamb (Gemini)/Queens: Solar System
- Joshua Simon (Carnegie): Milky Way structure
- Stephen Smartt (Queens Belfast): Supernovae
- Anže Slosar (Brookhaven): Cosmology, LSS
- Michael Strauss (Princeton) - Chair: Galaxies and LSS
- Lucianne Walkowicz (Adler Planetarium): Variables
- Risa Wechsler (Stanford): Cosmology

The SAC gives advice to the Project on matters of concern to the scientific community

- Developing and giving feedback on the Rubin Observatory data rights policy
- Getting community input on survey strategy decisions
- Developing policy for selection of community event brokers
- Developing policy and mechanism for assessment of proposals for in-kind contributions from international partners.
- We have developed the formal charge for the working of the Science Collaborations

Survey Strategy

- The so-called “universal cadence” of covering the sky, as described in the Rubin Observatory white paper, satisfies the scientific requirements. But it is not optimal, and the community has long wanted to refine the survey strategy to maximize the scientific return.
- For example: an approach of maximizing the sky coverage at any given time means that a given area of sky is revisited only every ~10 days in a given filter, too long for measurements of supernova light curves and fast transients.
- An alternative “rolling cadence”, in which in any given year most of the observations are limited to, say, 1/3 of the survey footprint, has the potential to improve the measurement of short timescale variability.

A community call for survey strategy white papers

- A call in late 2018 resulted in 46 white papers, exploring a wide variety of ideas.
- The SAC reviewed these papers, and made detailed recommendations to the Rubin Observatory Operations Simulations team, including metrics that quantify how well any given survey strategy realization meets specific science goals.
- These simulations have mostly been completed. The SAC is setting up a subcommittee, the Survey Cadence Optimization Committee, that will review the results of these simulations, and make recommendations to the Operations Director.

Communication with the Project, Community, and Science Collaborations

- Federica Bianco (convener of the Science Collaborations) is an ex officio member of the SAC.
- Michael Strauss (chair of the SAC) sits on the Rubin Observatory Project Science Team (chaired by Željko Ivezić).
- SAC meeting minutes are posted publicly, and are advertised in the Rubin Observatory Weekly Digest.