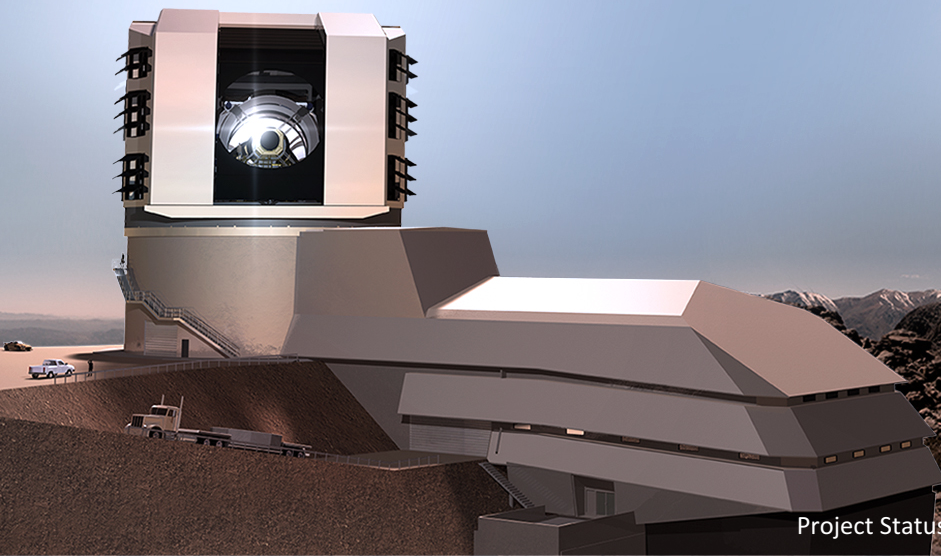


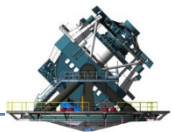


LSST Project Status - 2018

Victor L Krabbendam
LSST Project Manager

LSST@Europe
11 June 2018





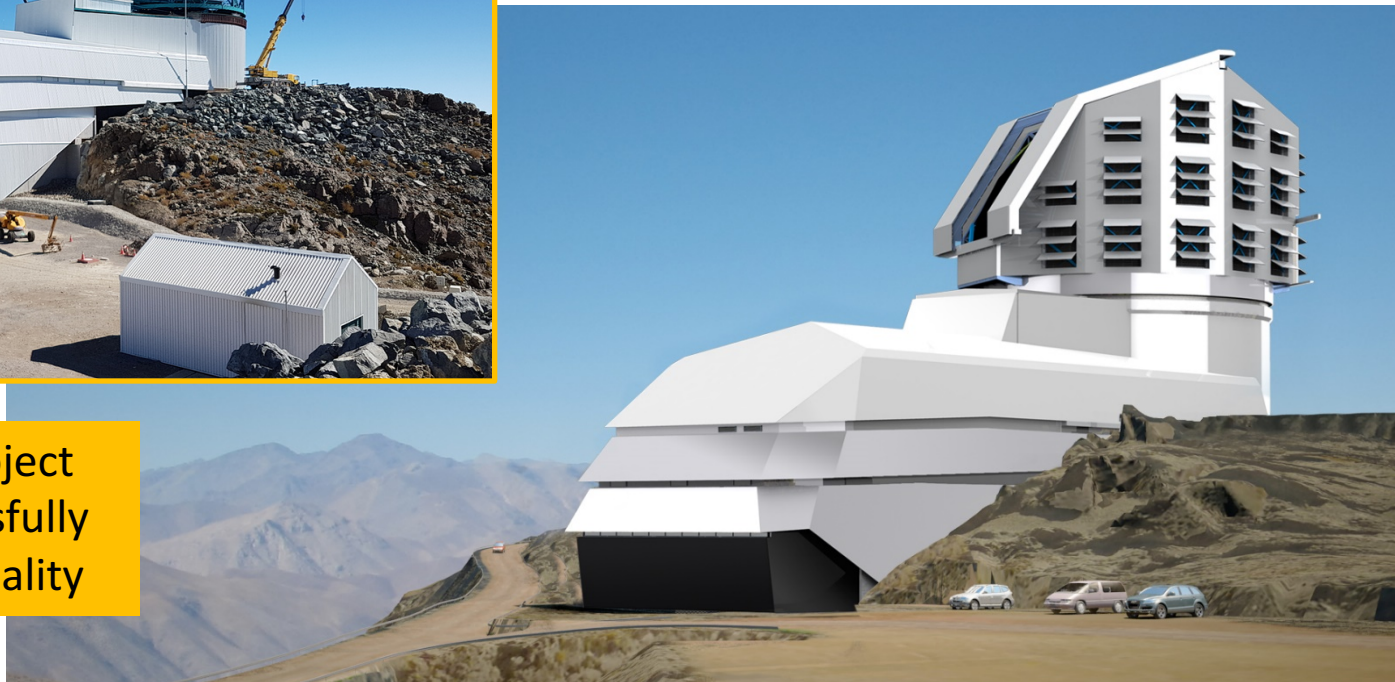
Large Synoptic Survey Telescope (LSST)

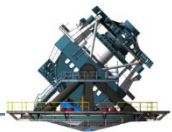


May 2018

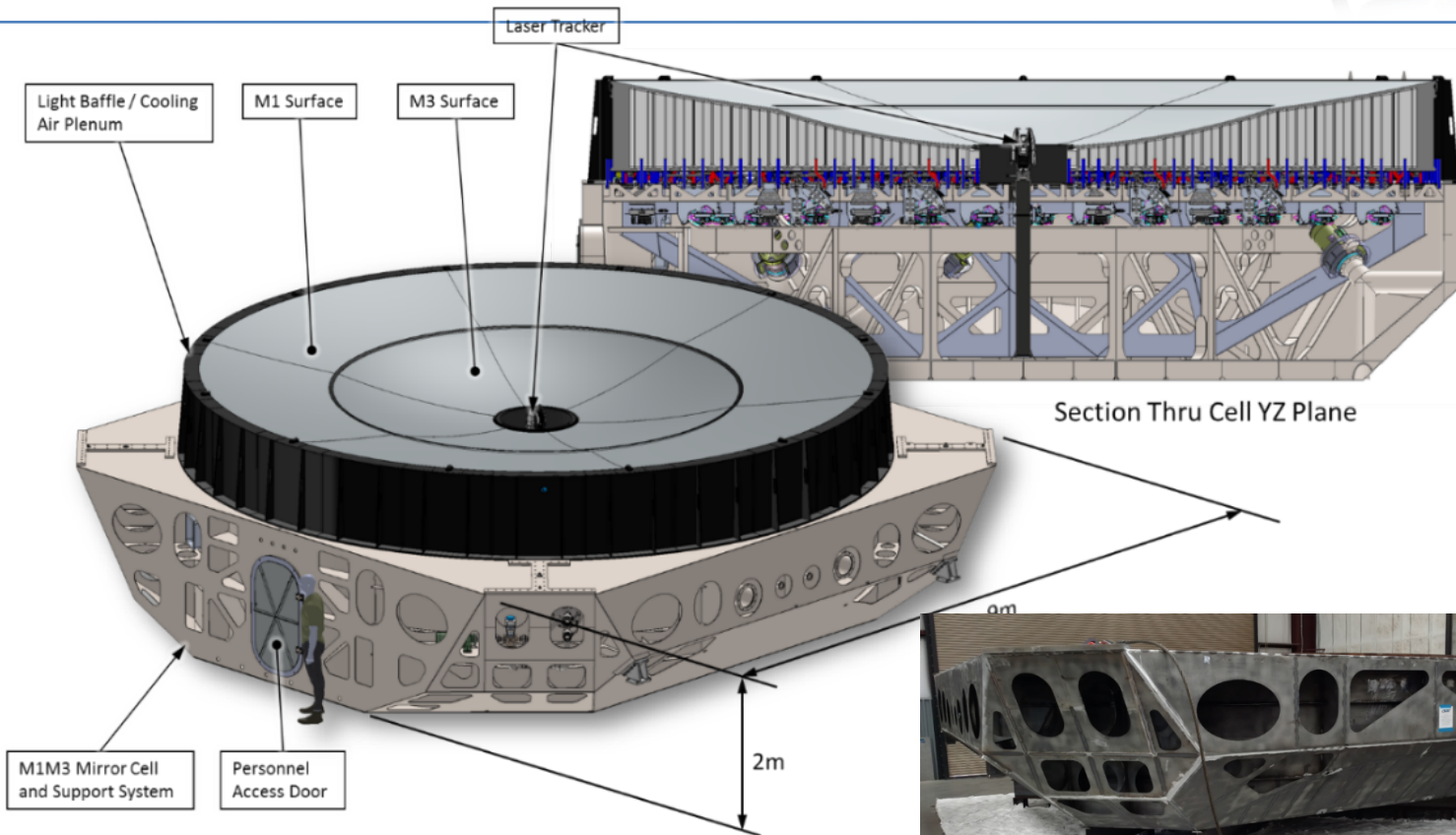


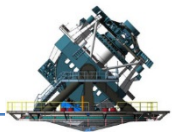
All Across the Project
efforts are successfully
transitioning to reality





A “Mirror” is Complex Assembly

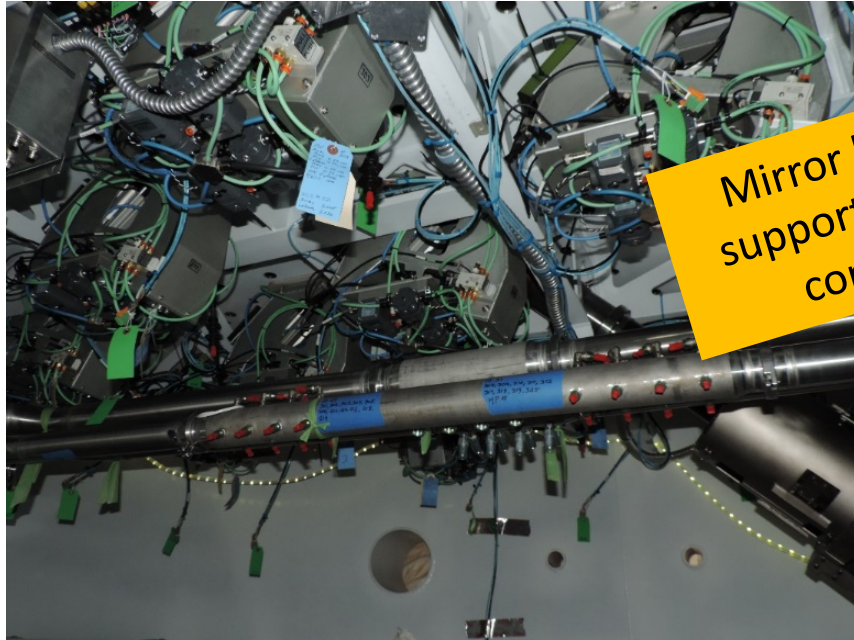




M1M3 Cell Completed – Surrogate Mirror Testing



Inside the Cell



Mirror lifted from static supports this week under computer control!

Pneumatic actuators, hard points, glycol piping, air piping and electronics installed

Outside the Cell with Surrogate Mirror



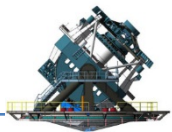
Surrogate mirror replicates shape, mass, and first order stiffness of glass

3.5m Diameter Secondary Mirror Nearing Completion

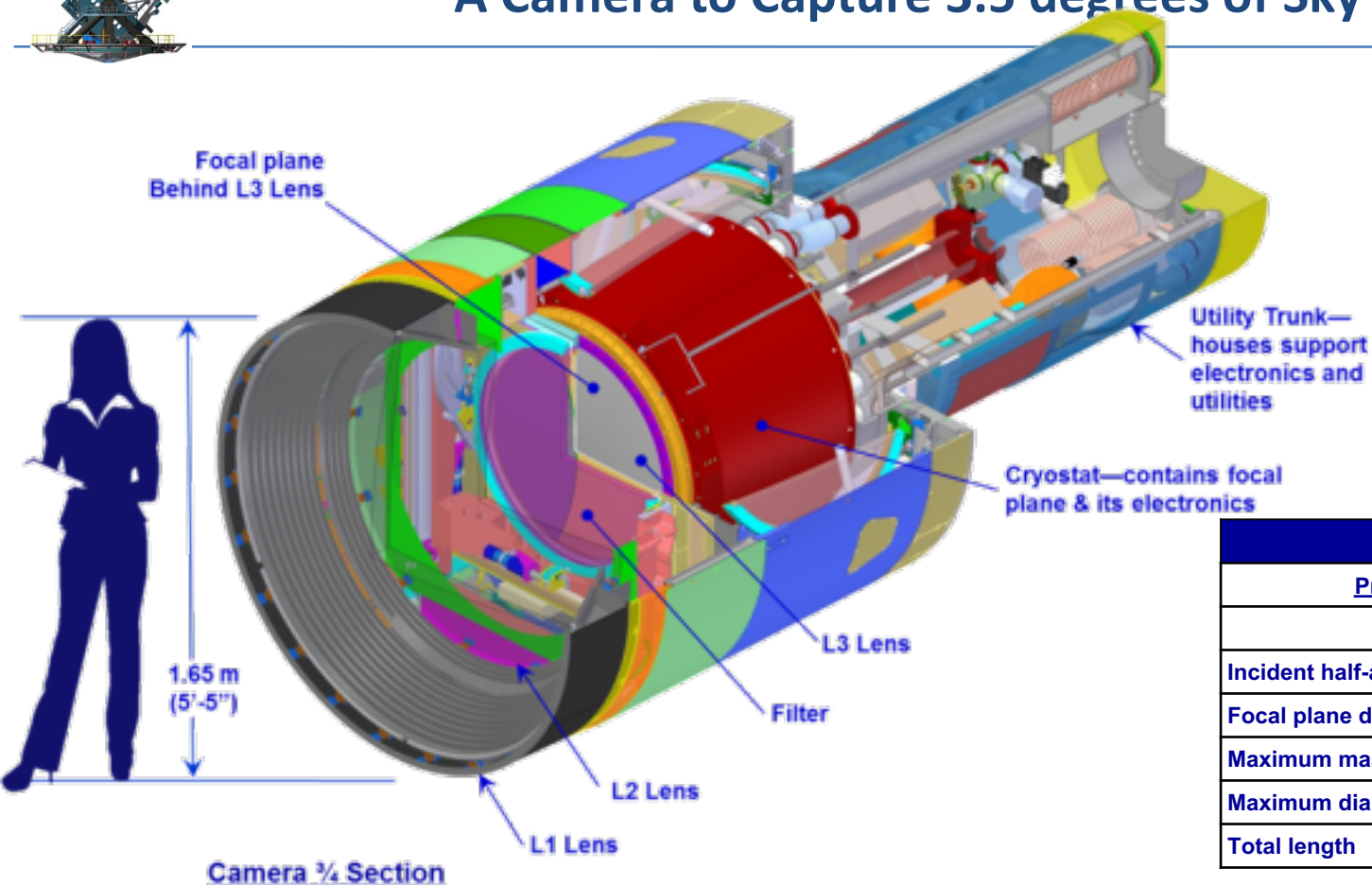


- Corning ULE blank procured early in Development phase
- Harris Corporation providing Optical Fabrication and Cell Assembly
 - Final delivery October 2018
 - With surrogate mirror for testing

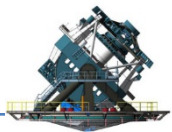




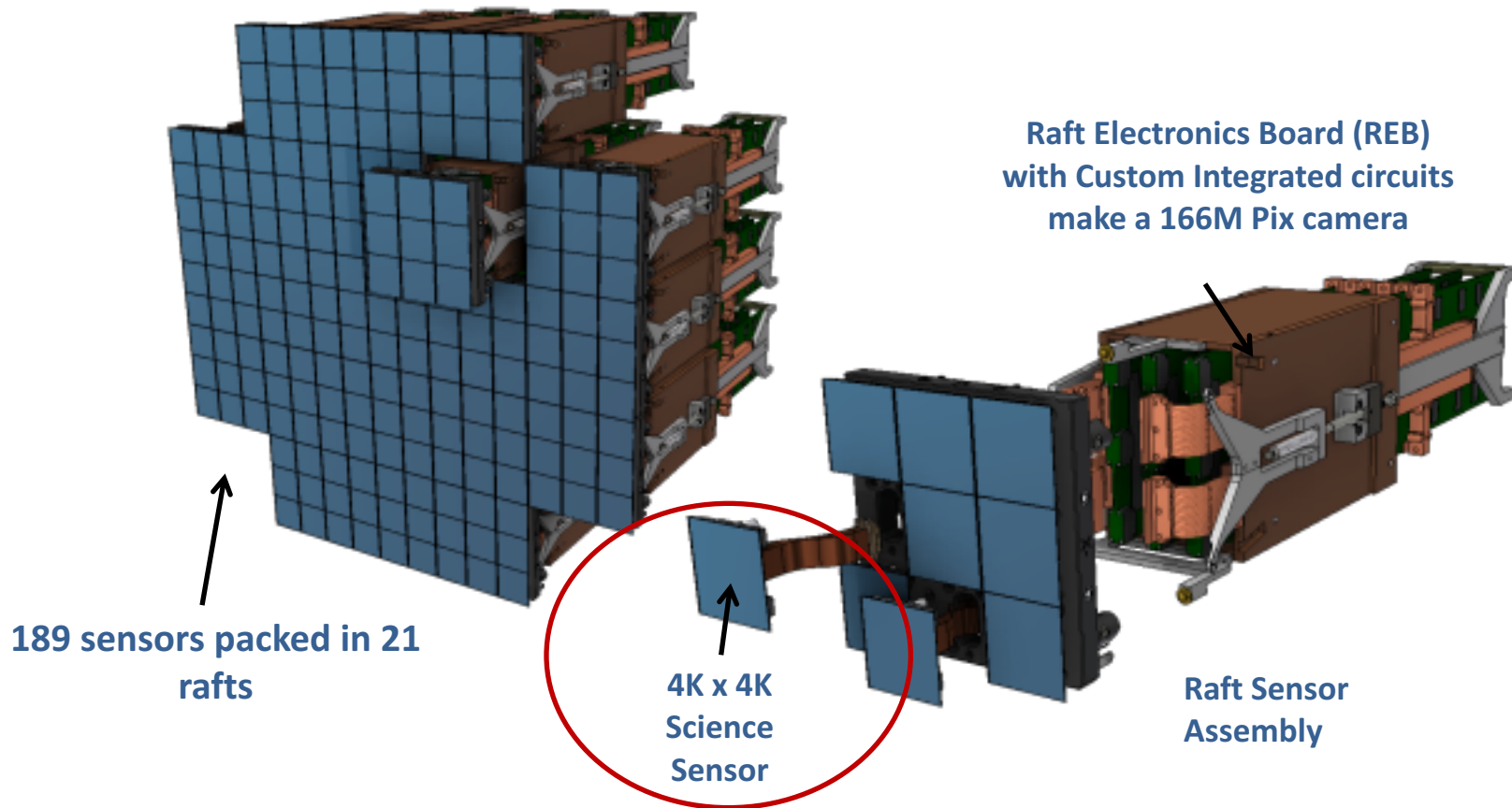
A Camera to Capture 3.5 degrees of Sky

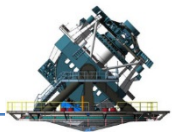


Camera Parameters	
Property	Value
	15 years
Incident half-angle in air	14.2°-23.6°
Focal plane diameter	634 mm
Maximum mass	3060 kg
Maximum diameter	1650 mm
Total length	3732 mm



63 CM Diameter Focal Plane with 3.2 GigaPixels

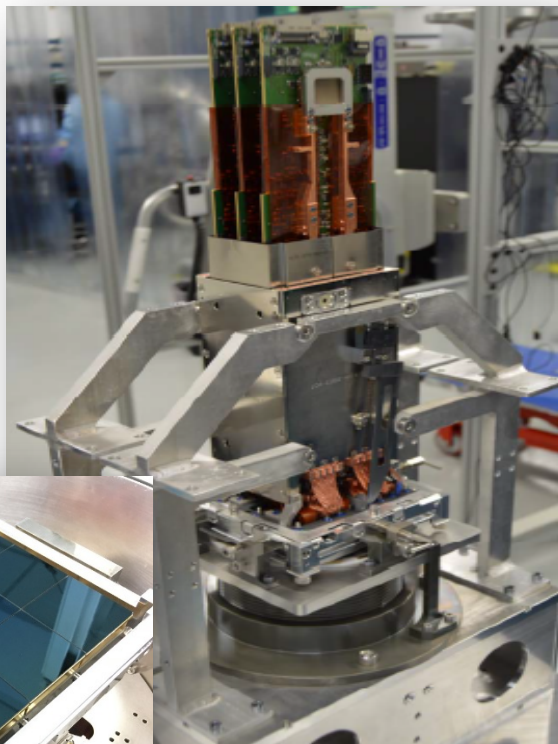
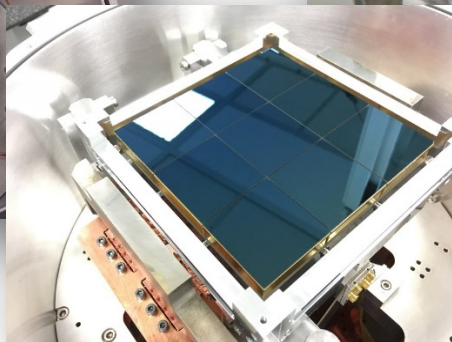
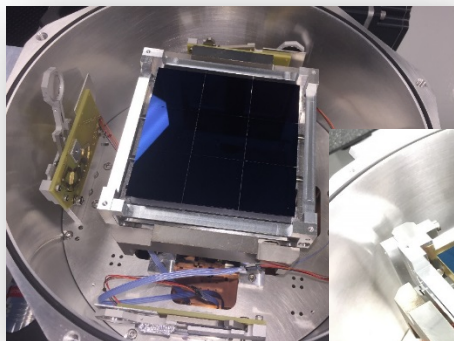




Camera Sensors Fabricated by Two Vendors

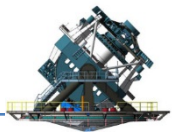


- 219 Science and Science Reserve Sensors delivered
- Need 198 for focal plane and 9 for spare raft.



- 8 Rafts delivered
- 5 more completed

Over half way

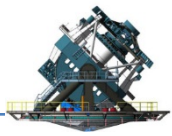


Camera Optics Progressing Well



- L1 and L2 lens polished and accepted for coating
- L2 first surface coated with broad band AR coating.
- L1-L2 composite structure completed
- L3 in Optical fabrication
- Filter substrates completed – coatings later this year
- Minor issues, some delays – Quality is high and within Baseline Schedule

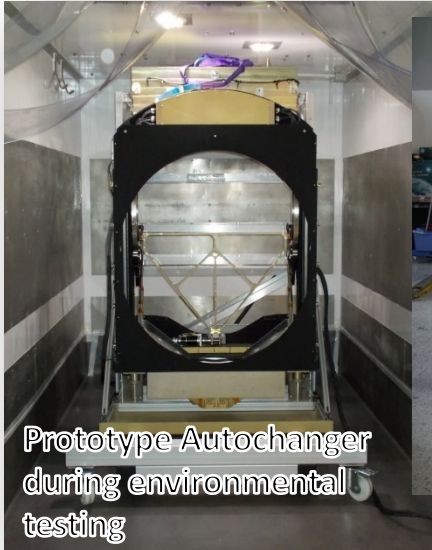




Filter Exchange Systems Complete and Tested



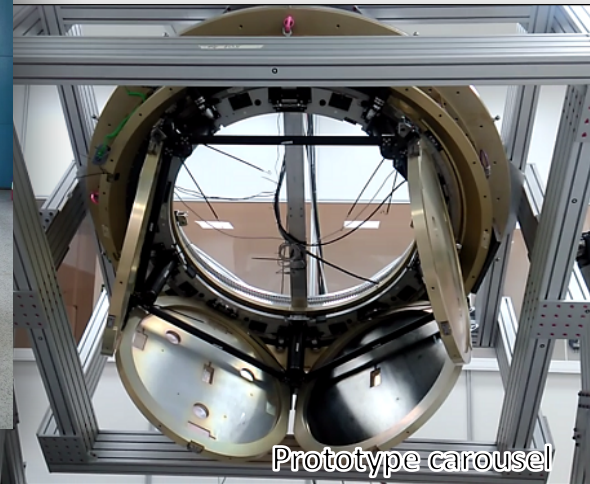
- Filter Autochanger full size prototype completed and tested
- Filter Manual loader prototype completed and tested
- Carousel full size prototype completed and tested – Only final assembly on camera back flange remains



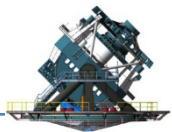
Prototype Autochanger
during environmental
testing



Prototype Filter
loader on transport
cart



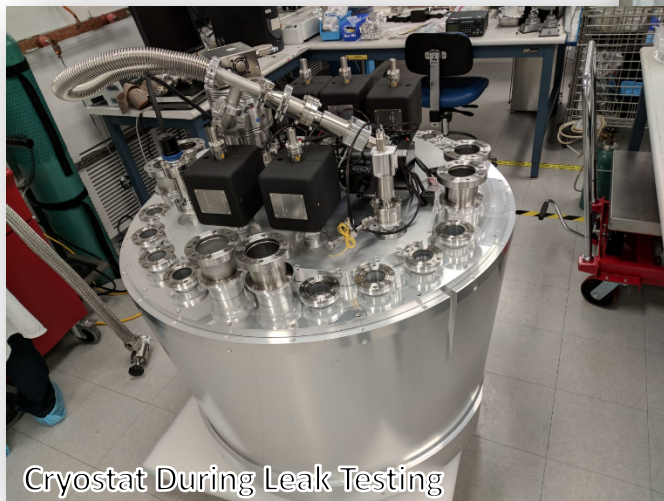
Prototype carousel



Cryostat progress (Critical Path)



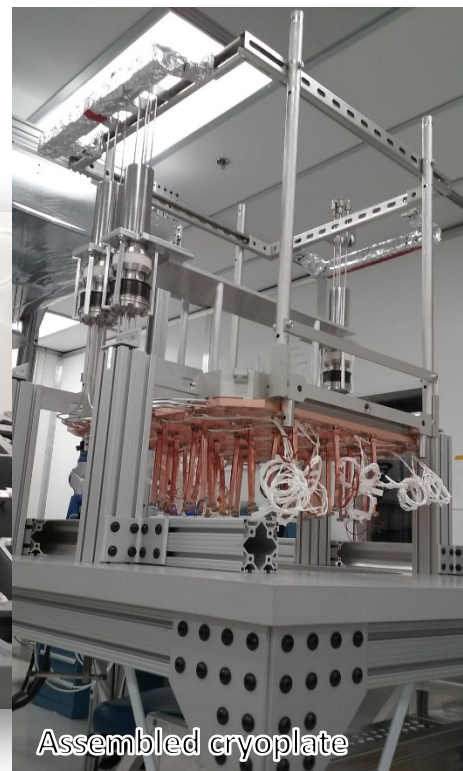
- Grid manufactured, cleaned and pre-assembled
- Cryo and cold plate manufactured and assembled
- Vacuum system completed and tested
- Cryostat assembly completed



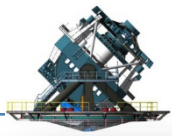
Cryostat During Leak Testing



Assembled grid



Assembled cryoplate

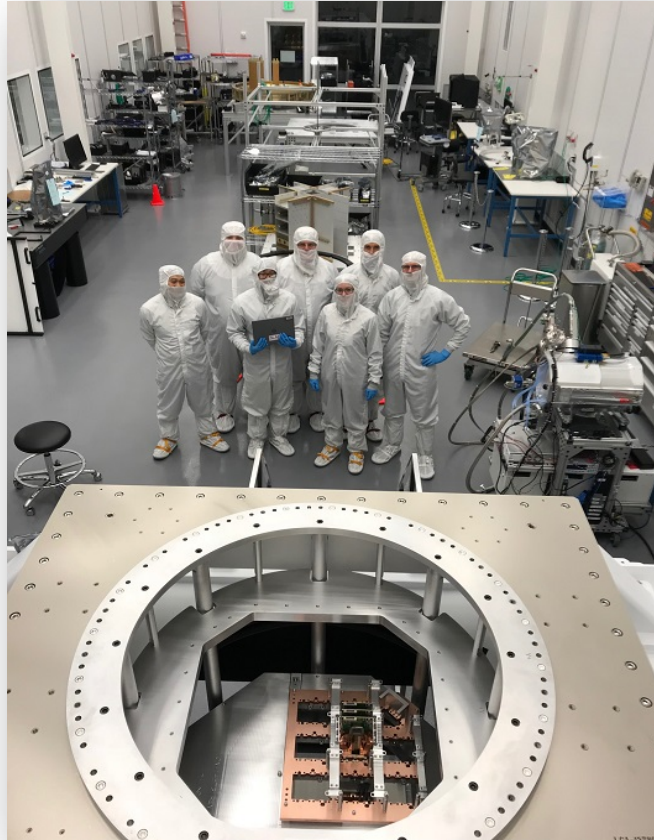


Integration and test activities progress

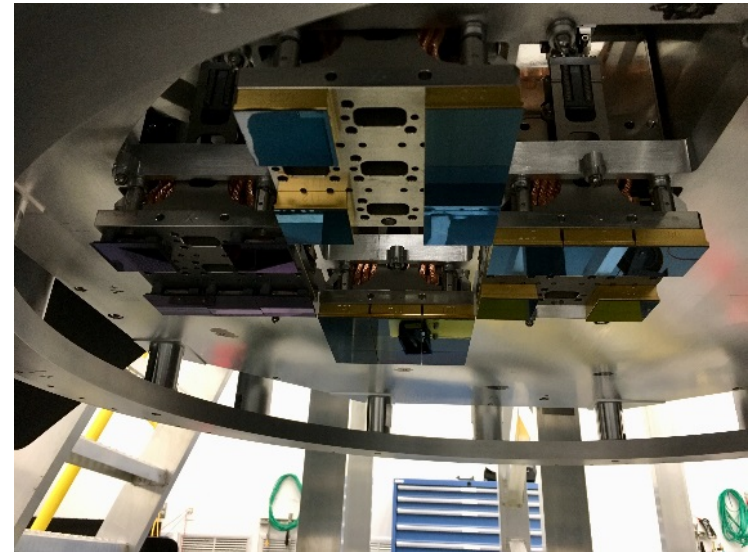


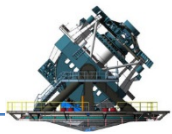
- Bench for Optical testing assembled and under test
- Raft integration fixture received and under test after performance issue with the 3-axis stage.
- Heat exchanger delays required re-shuffle of raft integration preparation activities to contain schedule
- Start of camera integration in the fall of 2018

4 mechanical rafts
inserted to verify
integration system

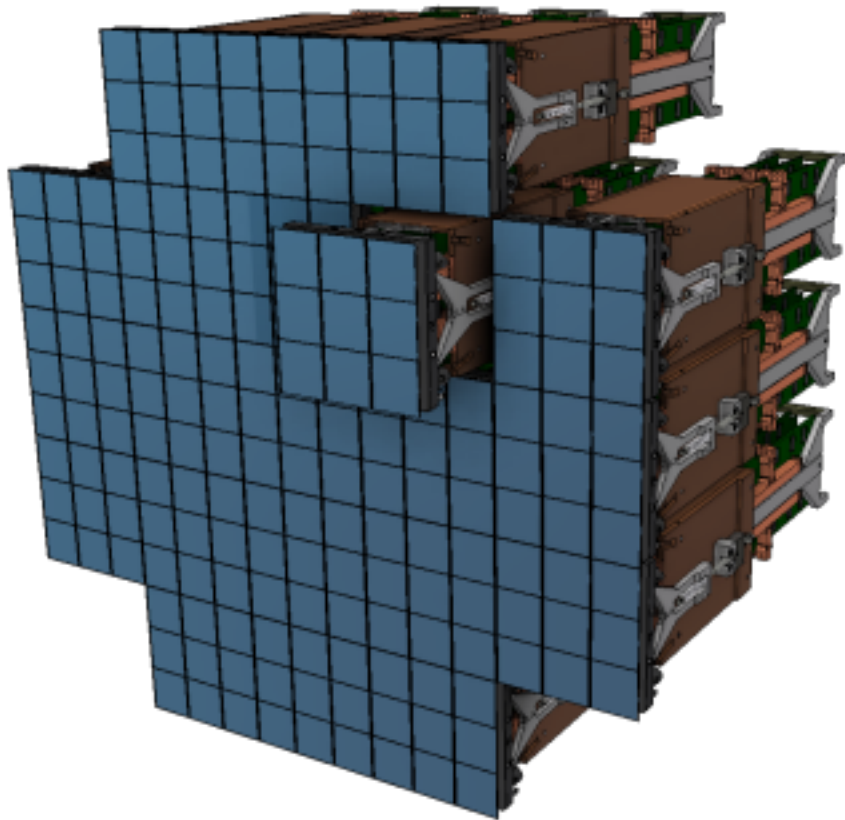


Bench for optical test
with mockup cryostat
and one mechanical raft





Sensor Gaps are Tight - Collecting Efficiency



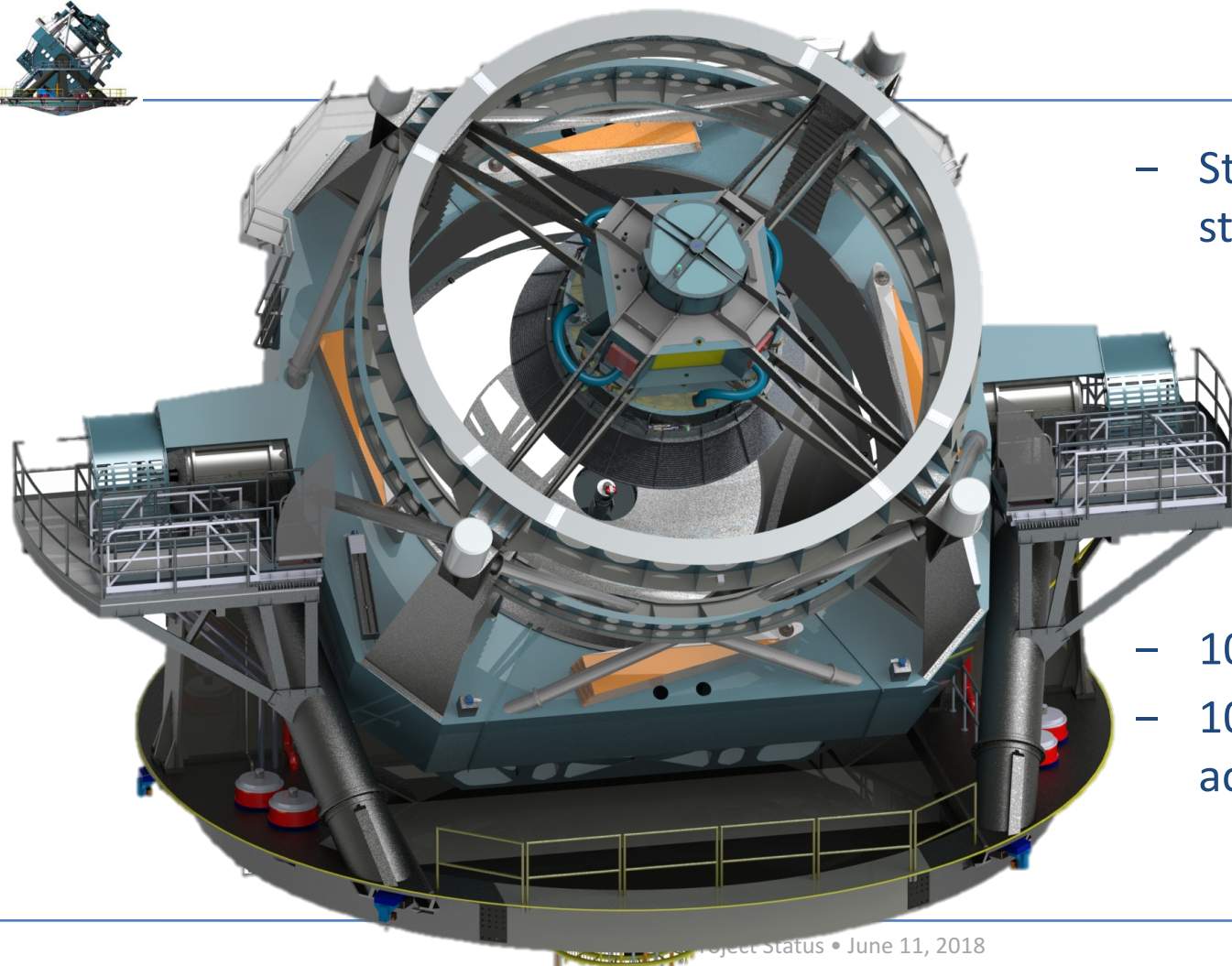
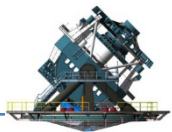
=

Each raft is slightly more delicate and valuable.....



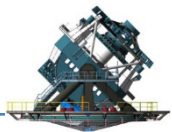
$\frac{1}{4}$ " spacing

$\frac{1}{4}$ " spacing



- Stiff 300 ton moving structure

- 10 deg /sec rotation
- 10 deg/sec² acceleration



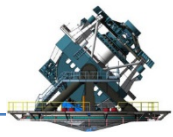
Telescope Mount Assembly (TMA) Factory

Testing Progressing in Spain



- All major subsystems integrated on Spanish pier
- Successful manual rotation on oil bearings
- Integration of CCW and all surrogates
- Verification of final safety Audit
- Now under computer motion control
- Sept/Nov 2018: FOB Aviles, Spain
- Oct 2018: Onsite assembly commences

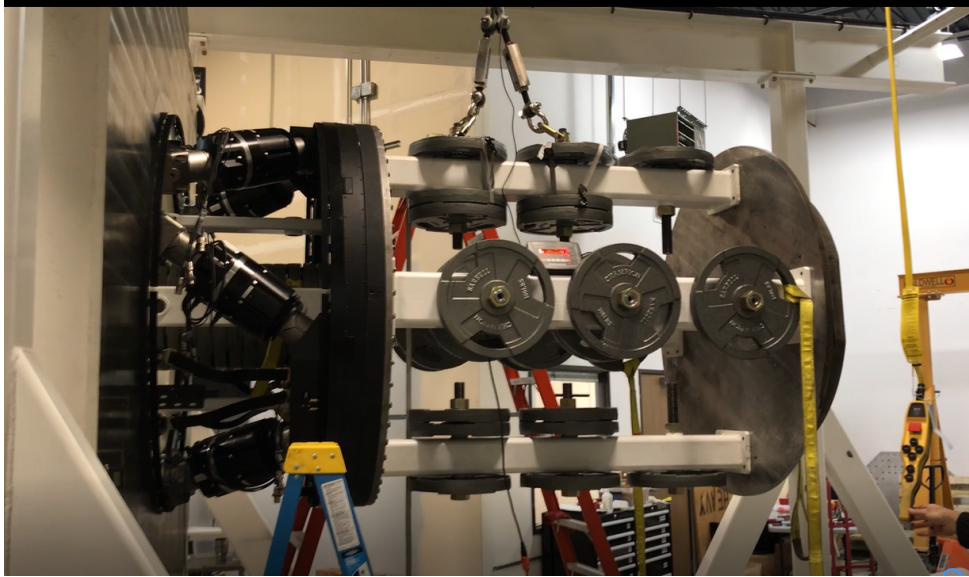




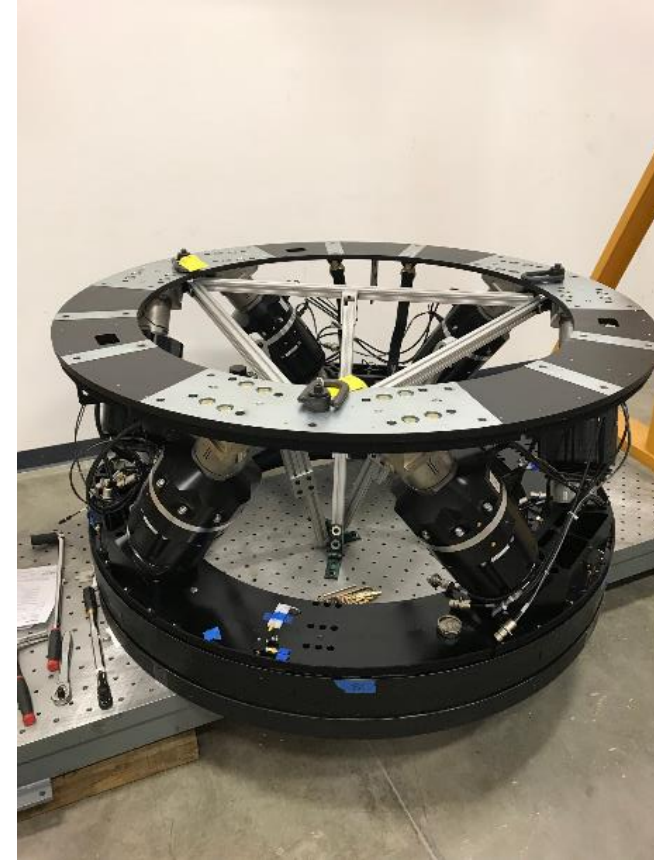
Optical alignment held with Camera and M2 motions

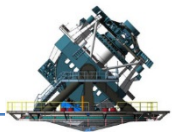


- Camera Hexapod / Rotator and M2 Hexapod being built by Moog - Final delivery August 2018



Successful 200% load test of cantilevered Camera





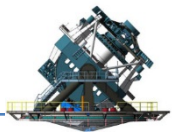
Summit Facility on Cerro Pachón



- Summit Facility Substantial Completion achieved by Besalco on Feb 28 – now finishing Punch List
- Computer room in use and IT infrastructure initiated
- 80-ton Pflow Lift tower completed; lift carriage/mechanism assembly in progress
- Dome erection is priority activity – Early 2019 completion expected



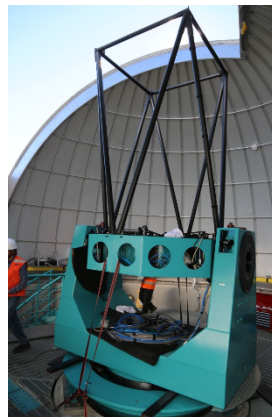


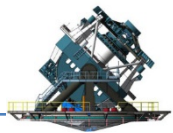


Hardware Completion

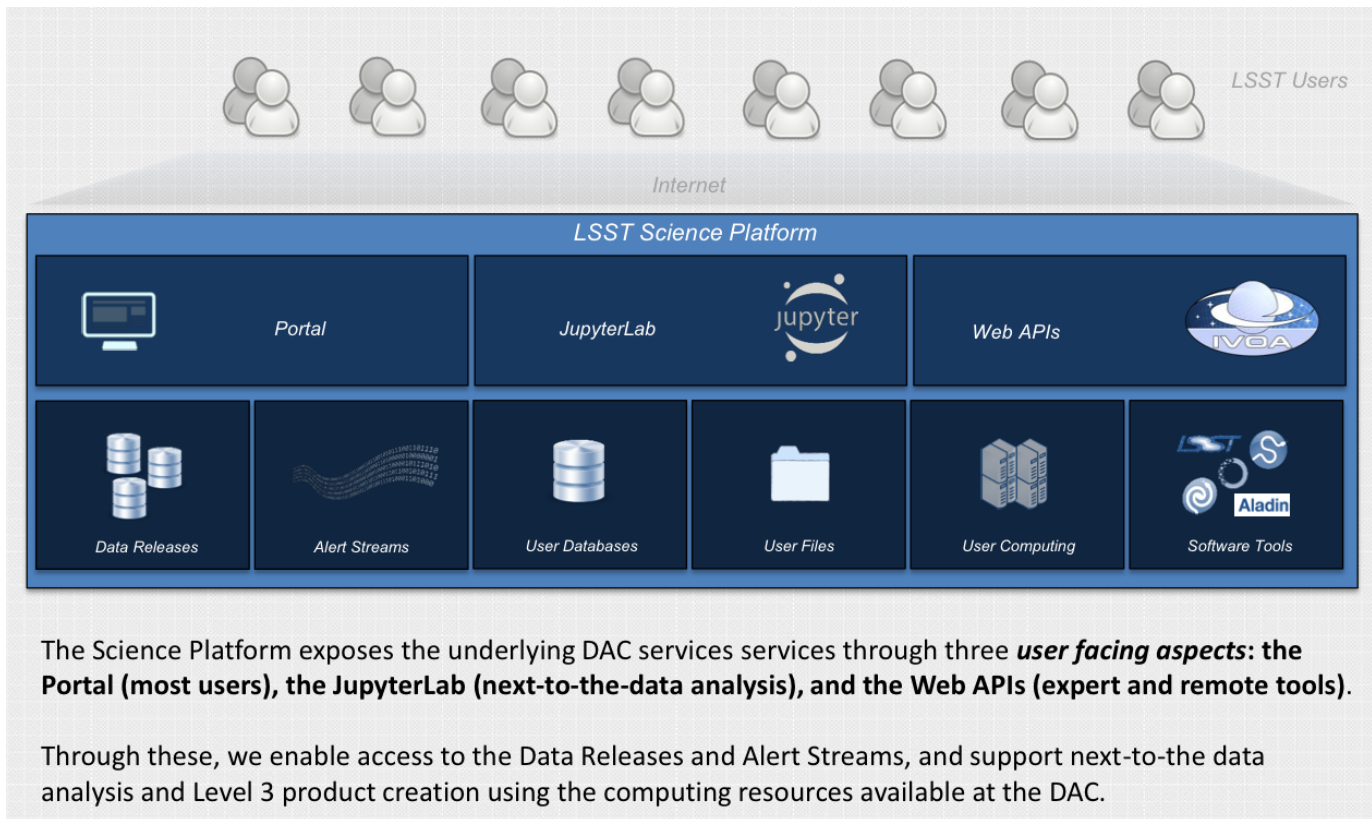


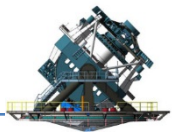
- Atmospheric Telescope re-assembled in Chile
- Spectrograph (lab) integration started in Tucson
- Goal for first light in early 2019 to begin characterizing the atmosphere and exercising the end-to-end system
- Coating Chamber Factory Acceptance in Progress at Van Ardenne
- Mirror Washing station already tested





The LSST Science Platform: Portal, JupyterLab, WebAPIs





LSST Data Products – Same Output, Different Name



- A stream of ~10 million time-domain events per night, detected and transmitted to event distribution networks within 60 seconds of observation.

- A catalog of orbits for ~6 million bodies in the Solar System.

Level 1

“Prompt Products”

- A catalog of ~37 billion objects (20B galaxies, 17B stars), ~7 trillion observations (“sources”), and ~30 trillion measurements (“forced sources”), produced annually, accessible through online databases.

Level 2

- Reduced single-epoch, deep co-added images.

“Data Release Products”

- User-produced added-value data products (deep KBO/NEO catalogs, variable star classifications, shear maps, ...)

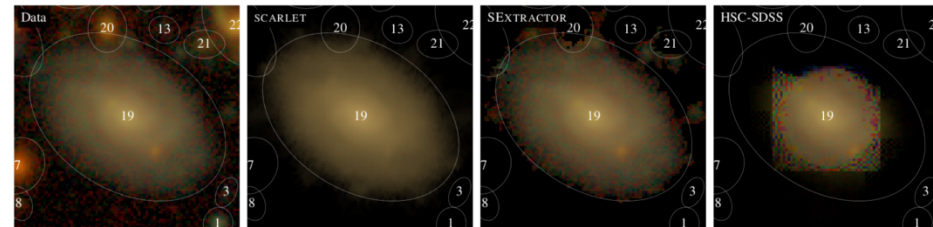
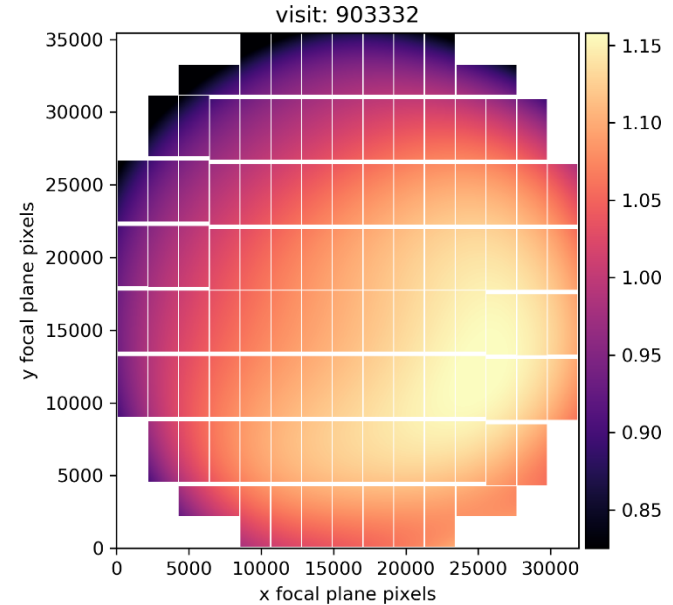
Level 3

“User Generated Products”

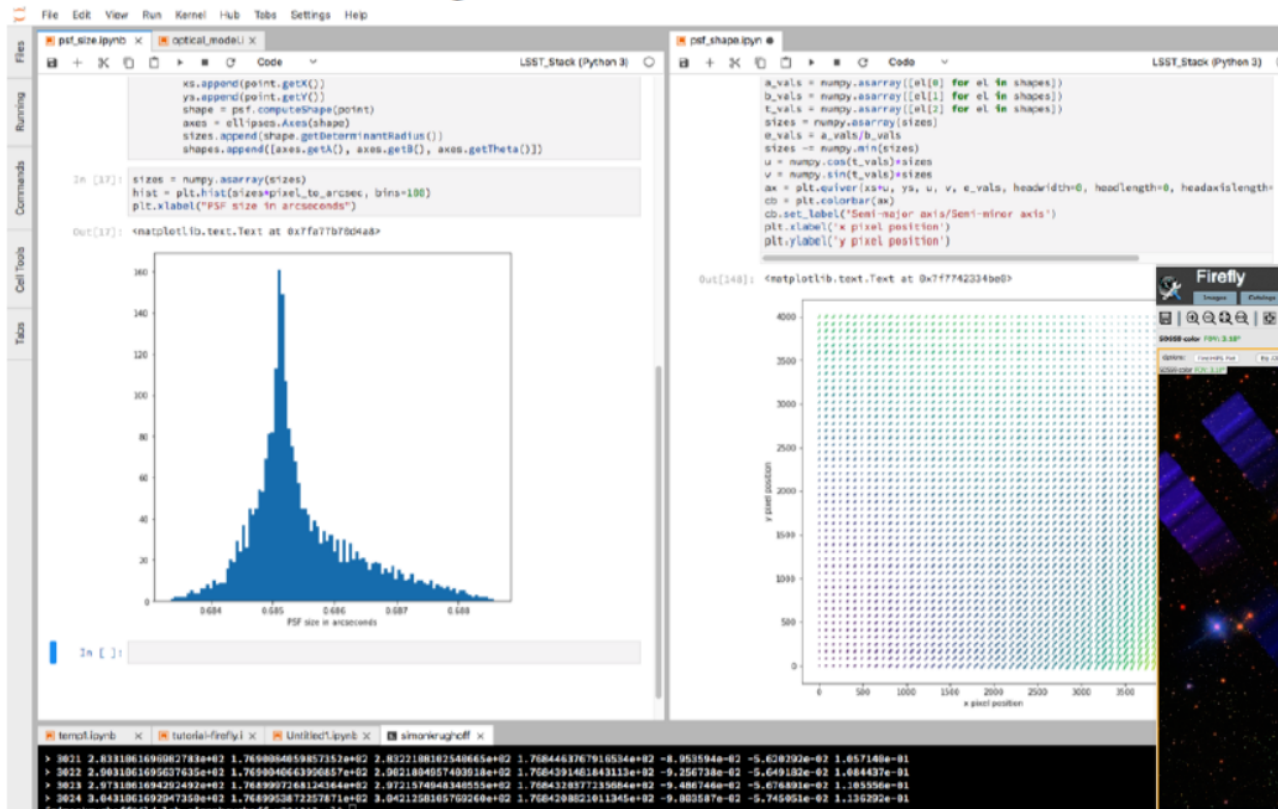
- lsst.io landing page and Pipelines getting-started tutorial
- JointCal - Simultaneous astro- and photometric fitting to source lists derived from multiple images
- Scarlet – new deblender separates overlapping astrophysical objects into their constituent components for measurement

Figure: Melchior et al., 2018

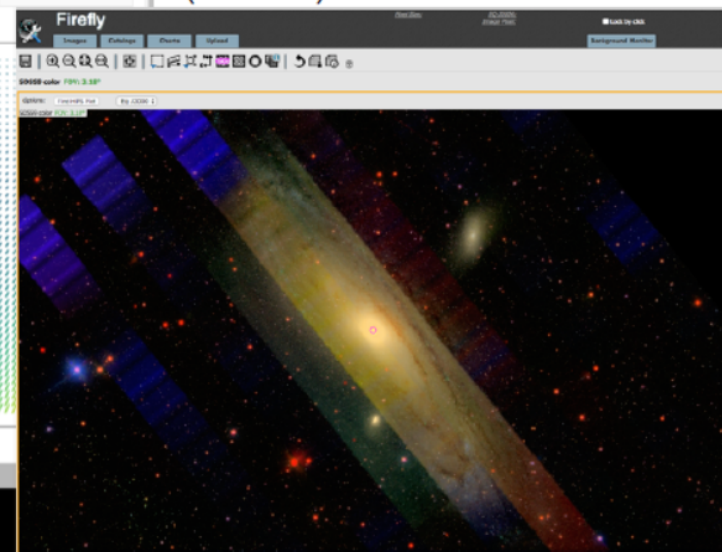
Figure: Parejko



Vision LSE-319 Design LDM-542 Test DMTR-51



Portal/Browser
Notebooks
Web API
(Batch)





New optical fiber to the summit completes path

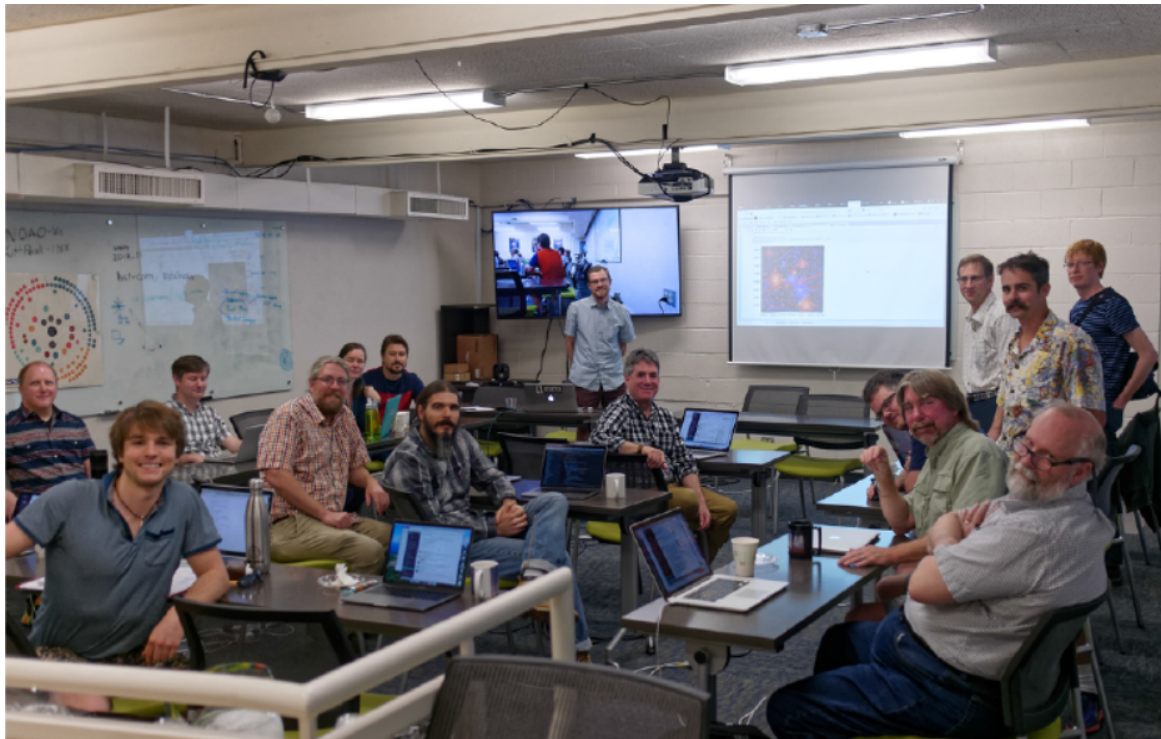


LSST SITE!



Successful transfer of digital data over LSST/AURA fiber optic networks from Cerro Pachón to La Serena and on NCSA.

- May 29-June 1
- Training on DM Stack
- Manipulate images and process them
- Quality assessments
- Jupyterlab hosted at NCSA





The LSST EPO team has grown quickly, and includes distributed advisors and contractors

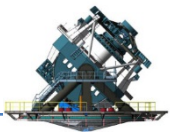


The mission of LSST EPO is to provide non-specialists access to a subset of LSST data through accessible and engaging online experiences so anyone can explore the Universe and be part of the discovery process.

Audiences:

1. Formal educators teaching astronomy content at the advanced middle school, high school, or college level
2. Citizen science principal investigators (scientists using LSST data)
3. Content developers at informal science centers / planetariums
4. Science-interested teens and adults



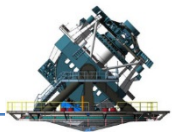


EVMS Executive Summary – April 2018 Data



	MREFC - NSF	LSSTCam – DOE
% Complete (April 2018)	55	81
SPI	0.98	0.97
CPI	0.98	0.97
Contingency (EAC)	\$39.1 M	\$8.1M
Contingency % Remaining Work (EAC)	19	28

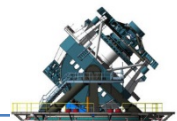
- Level 2 completion
- DM 40%
 - Camera 81%
 - T&S 72%
 - EPO 24%
 - SE / Commissioning 24%



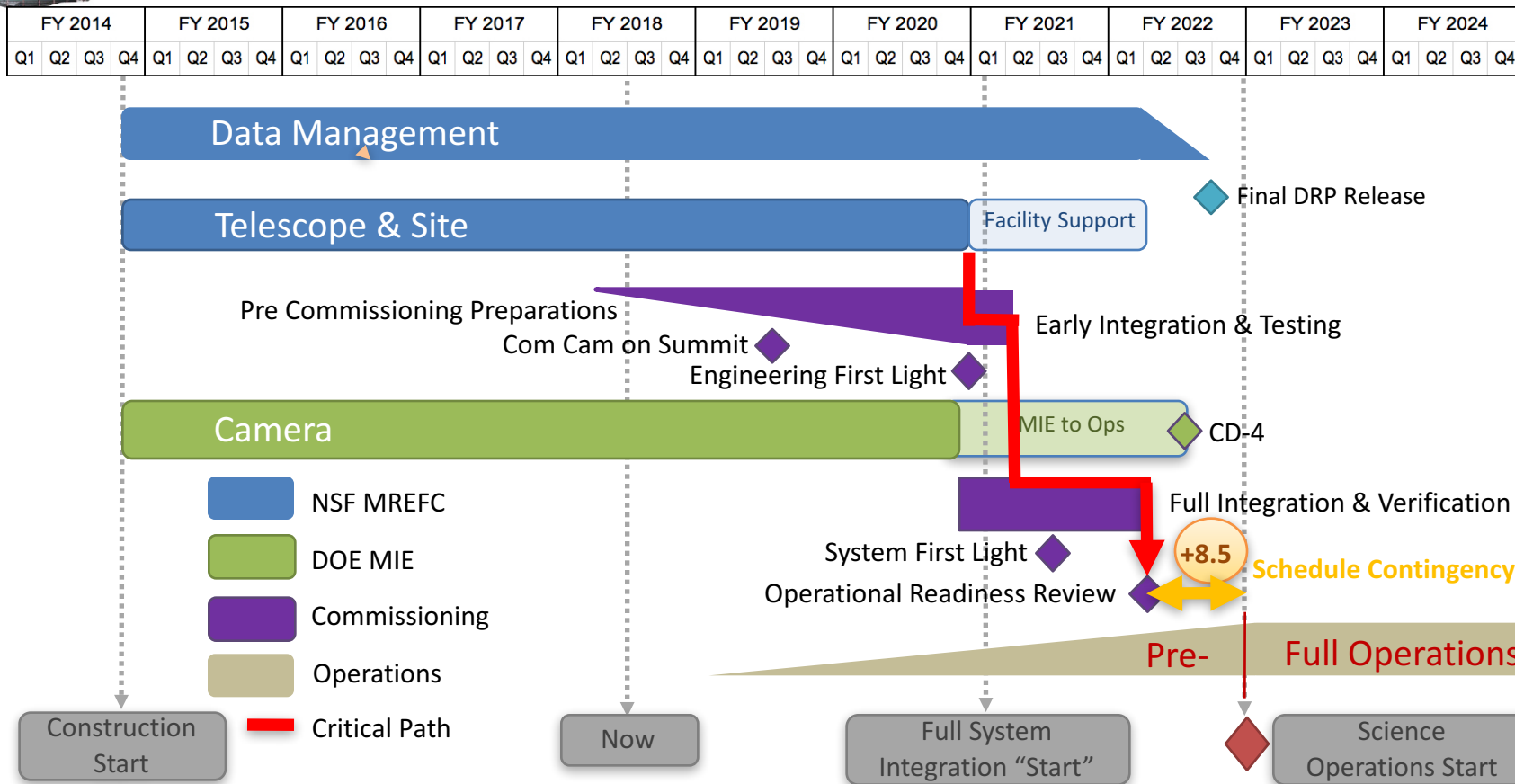
Project Schedule

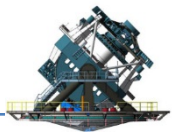


- Early completion Baseline still Nov 2021 (11 months contingency) **however:**
- M1M3 not able to mitigate forecasted delays in integration
- LCR now in progress for 10 week delay in Critical Path
 - M1M3 electrical installation delays telescope + 10 weeks
 - Project Schedule Contingency will be 8.5 months
- Other schedule changes in shadow of extended critical path
 - Heat exchanger fabrication delays camera delivery + 5 weeks
 - TMA factory integration delays but still off critical path



LSST Project Schedule Forecast – 8.5 Months Contingency





Overview Conclusion

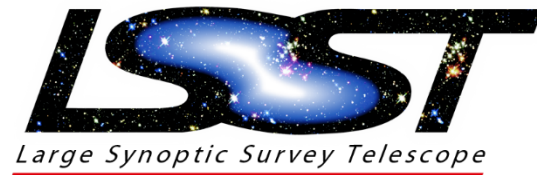


- Technical progress is excellent.
- Team is extremely busy finishing hardware, detail planning integration, coordinating Verification and Validation.
- Project status by the numbers is good.
- Second Schedule Contingency draw is reasonable at this stage
- Challenges and risks remain but LSST is currently on track for successful completion.

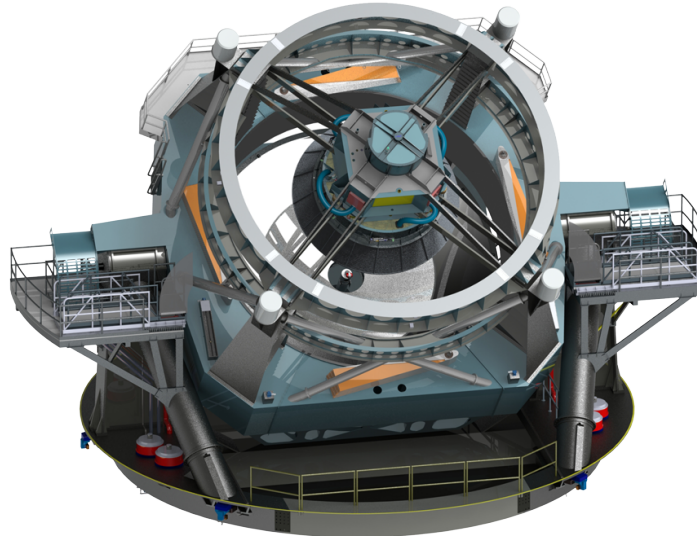
Contingency is tight but sufficient to complete Project
on time and within budget



Next Project and Community
Workshop : 13 August 2018,
Tucson AZ



Back-up Slides



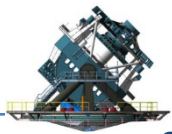
- 2018: Prototypes for various processes and databases - “Minimum Viable System”
 - Jan: Jointcal replace meas_mosaic (DONE)
 - Jun: At-scale test of Alert Distribution
 - Aug: Mountain base network up
 - Oct: Spectrograph data acquisition
 - Dec: Prototype QA/Commissioning Environment
- Dec 2019: ComCam L1, L2 Production
- Dec 2019: Base Center Integration Complete
- Jun 2020: Camera L1, L2 Production
- Jul 2021: US Data Access Center Integrated

Camera Milestone Chart – Level 2



Activity Name	Baseline	Forecast	Variance	Status
Level 2 Milestone				
COMP: Conceptual Design Complete (Ready for CD-1)	30-Nov-11	30-Nov-11 A	0	Completed
COMP: Prototype Science Sensors Received	3-Jan-12	03-Jan-12 A	0	Completed
COMP: Vertical Slice Test - Phase 1	16-May-13	16-May-13 A	0	Completed
COMP: Sensor Final Design Complete (Ready for CD-3a)	31-Mar-14	31-Mar-14 A	0	Completed
COMP: First Article Sensor Contract Placed	24-Apr-14	24-Apr-14 A	0	Completed
COMP: Performance Baseline Established (Ready for CD-2)	16-Oct-14	16-Oct-14 A	1	Completed
START: ASIC production (IN2P3)	31-Mar-16	25-May-15 A	213	Completed
COMP: Award L3 Assembly Phase 1 Contract	31-Jul-15	08-Jun-15 A	38	Completed
COMP: Camera Design Complete (Ready for CD-3)	30-Sep-15	12-Jun-15 A	77	Completed
COMP: L1-L2 Assembly Phase 2 FDR	29-Feb-16	30-Oct-15 A	80	Completed
COMP: First Sensor Tested	29-Feb-16	27-Jan-16 A	23	Completed
COMP: First article 2Kx4K Wavefront Sensor (Phase 1)	16-Dec-16	16-May-16 A	150	Completed
COMP: Award Sensor Lot 2	31-Aug-16	02-Aug-16 A	22	Completed
COMP: First RTM Ready for Integration	31-May-17	26-May-17 A	3	Completed
COMP: Sensor Production is 50% complete (end of lot 2)	28-Feb-18	29-Sep-17 A	102	Completed
COMP: L1 & L2 Pre-Coating Metrology (Phase 4b)	28-Feb-18	16-Feb-18	6	Completed
COMP: Cryostat Chamber & I&T Refrigeration System Ready for Integration	30-Aug-18	31-Oct-18	-43	To be updated when NSF releases camera need date
COMP: L3 Assembly Ready for Integration	30-Apr-19	22-Jan-19	69	30 days of float to I&T
COMP: Filter Exchange System Ready for Integration (IN2P3)	31-Jan-19	24-Jan-19	5	
COMP: Sensor Production Complete	29-Mar-19	30-Nov-18	73	
COMP: Commissioning Camera Ready to Ship for Testing	31-May-19	18-Apr-19	30	
COMP: 1st Filter Coated and Ready for Integration	30-Aug-19	1-Jul-19	43	
COMP: L1/L2 Assembly Ready for Integration	31-Oct-19	11-Jul-19	79	
COMP: Early Hardware & Software Ready for Summit	31-Oct-19	11-Feb-19	184	
COMP: Loaded Cryostat Ready for Integration	27-Nov-19	16-Jul-19	95	
COMP: Camera Fully Integrated & Ready for Verification Testing	30-Jun-20	15-Jan-20	116	
COMP: PSR/ORR - Camera Pre-Ship/Operations Readiness Review Complete	30-Nov-20	15-Jun-20	116	28 days lost
COMP: KPPs achieved (Camera Readiness Review, Ready for CD-4)	29-Oct-21	15-Jun-20	341	

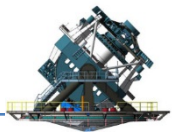
New Camera
Need Date:
27 July 2020



T&S Status and Upcoming 2018 Milestones



- Summit facility occupied; punch list completion expected by May 2018
 - Substantial completion achieved Feb 28, 2018; Computer room racks installed
 - Pflow tower erected; platform and drive motors installed; drive chains attached
 - Embedded rails fabricated and shipping to Chile early Apr 2018
- Base Facility & Data Center construction well underway with completion in Dec 2018
- Dome azimuth assembly installed/aligned/rotated; steel column erection continues
- AuxTel Tucson refurbishment complete; shipped to Chile with arrival mid-Apr 2018
- Camera rotator S/N 01 testing completed; hexapod/rotator testing completion Jul 2018
- Vendor factory testing campaigns planned (final acceptance on summit)
 - Telescope Mount Assembly Apr-Jul 2018 (Spain)
 - Coating Plant Apr-Jul 2018 (Germany)
- M1M3 team ready for surrogate testing mid-May; optical testing in Nov/Dec 2018; maintains aggressive work activity schedule (still critical path)
- M2 on track for completion in Aug 2018
- T&S SW review successfully completed Feb 26-27, 2018
- Completed successful T&S Joint Technical Meeting (JTM) in Tucson, Marc 1-3, 2018

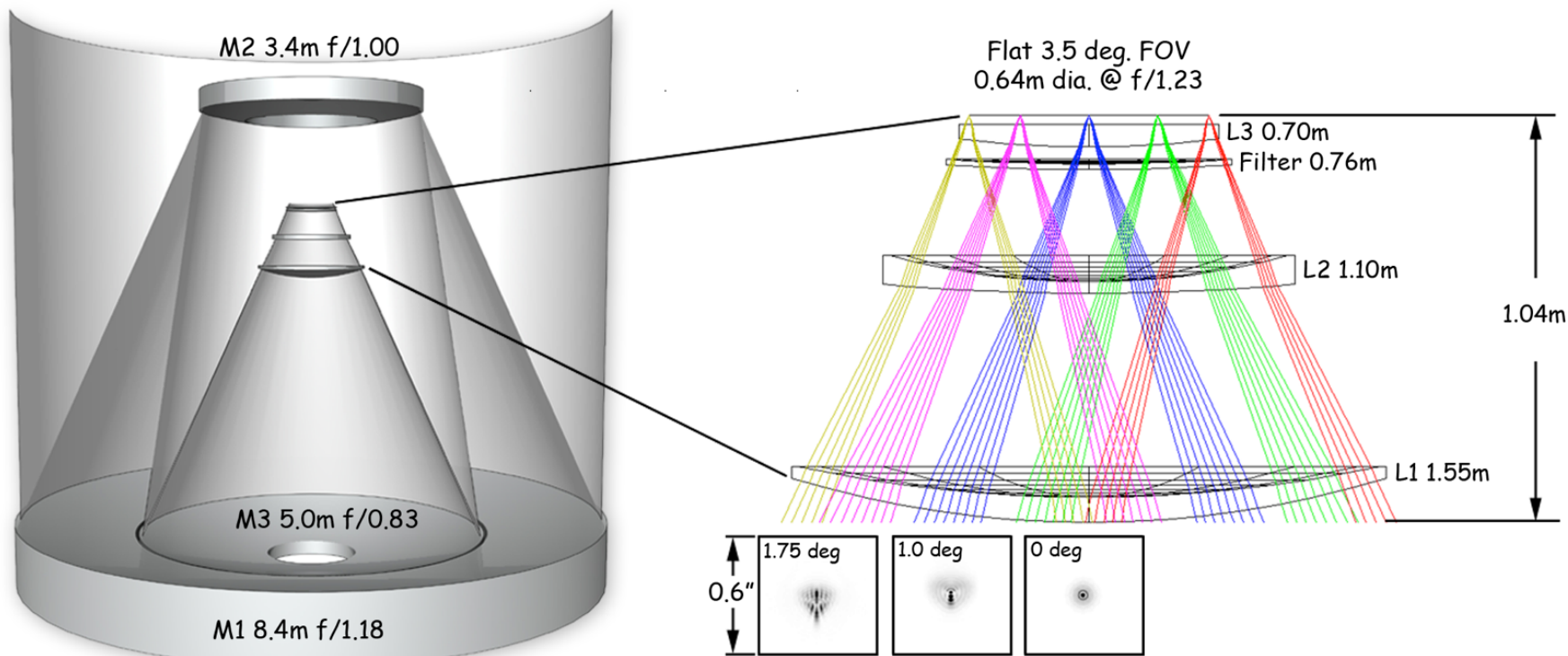
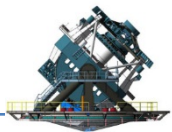


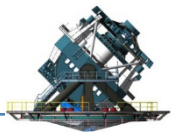
Upcoming 2018 Milestones

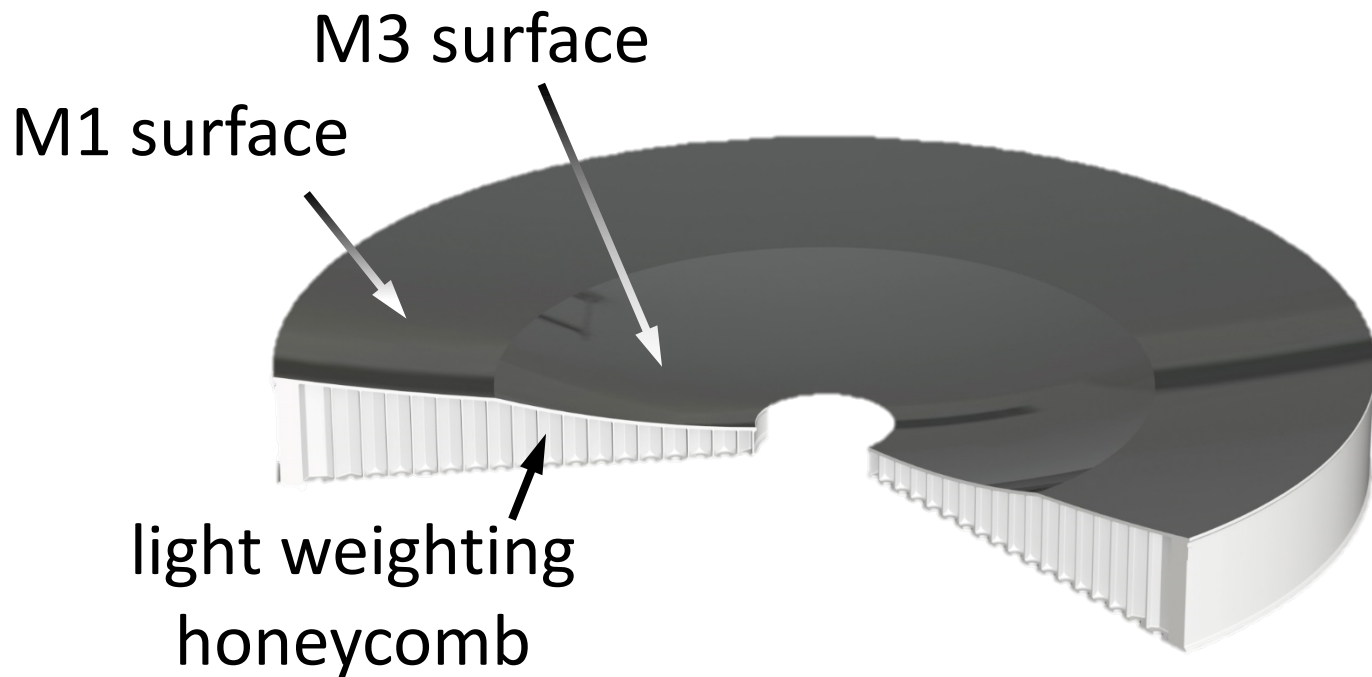
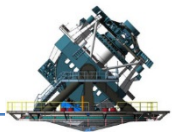


Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
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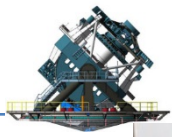
Summit Facility	<i>Final Acceptance</i>													
Pflow Lift	<i>Welding/Assembly</i>		<i>Final Acceptance</i>											
Summit Hotel	<i>---- Award Bid -----</i>				<i>Construction -----</i>				<i>Final Acceptance</i>					
Base Facility	<i>----- Construction -----</i>				<i>Remodeling Complete</i>				<i>Construction -----</i>				<i>Final Acceptance</i>	
Hex/Rotator	<i>--- Cam Hex/Rot Testing</i>			<i>Rot#2 to SLAC</i>				<i>Final Acceptance</i>						
M2 Assembly	<i>-- Opt Test #3 --</i>		<i>-- Ion #4 --</i>		<i>-- Opt Test #4 --</i>		<i>-- Ion #5 --</i>		<i>-- Opt Test #5 --</i>		<i>Final Acceptance</i>			
M1M3 Assembly	<i>----- Surrogate Testing @CAID -----</i>										<i>Ship to UofA</i>		<i>----- Optical Testing @UofA -----</i>	
TMA	<i>----- Factory Testing Campaign -----</i>								<i>Pack/Shipping to Chile -----</i>				<i>Arrival in Chile/Summit Assy</i>	
Coating Plant	<i>----- Factory Testing Campaign -----</i>								<i>Pack/Shipping to Chile ----</i>				<i>Arrival in Chile/Summit Assy</i>	
Aux Tel	<i>-- Test in AZ --</i>			<i>-- Pack/Ship to Chile --</i>					<i>---- Summit Debug ----- Initial Operation</i>					



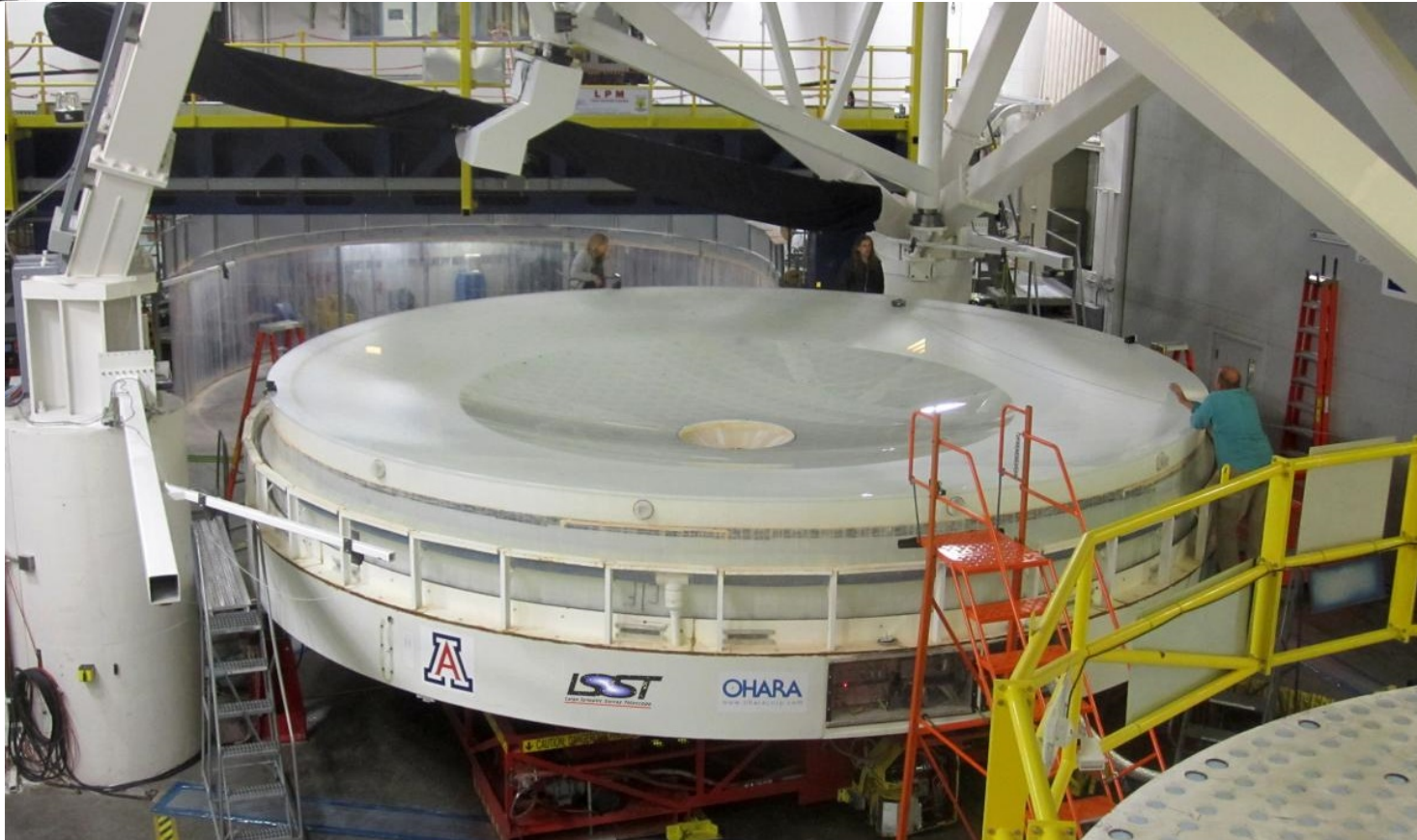




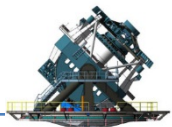
8.4 m (27.6 ft) diameter mirror



Mirror Polishing Completed in 2014







Low Deflection Needed - Mirror and Vacuum

