The Large Synoptic Survey Telescope (LSST) Construction Status
The System is becoming Real

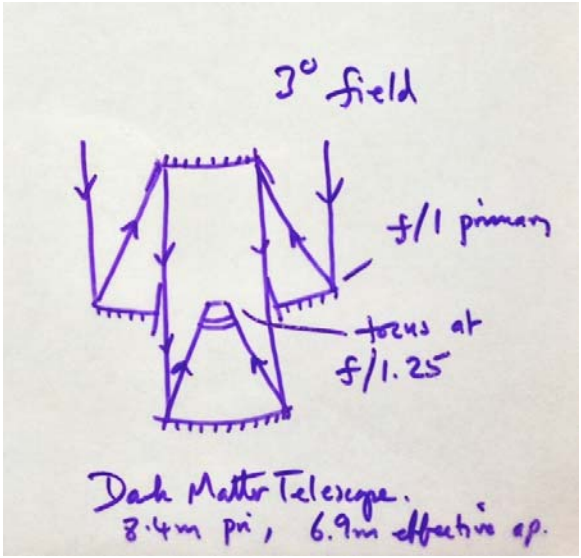
Victor L Krabbendam
LSST Project Manager

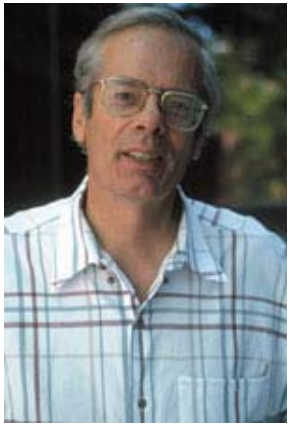
20 September 2018

The LSST dream started in mid 90's

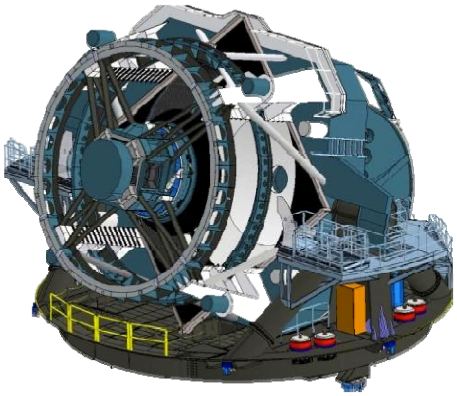
Tony Tyson – UC Davis: Dreamed of an all sky survey to explore Dark Matter and the time domain

Roger Angel – U Arizona: Dreamed of an optical design for large wide-field telescope



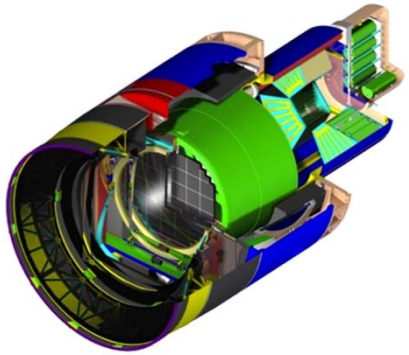


To build an observing facility, conduct 10-year survey, process, archive, and serve images and data products

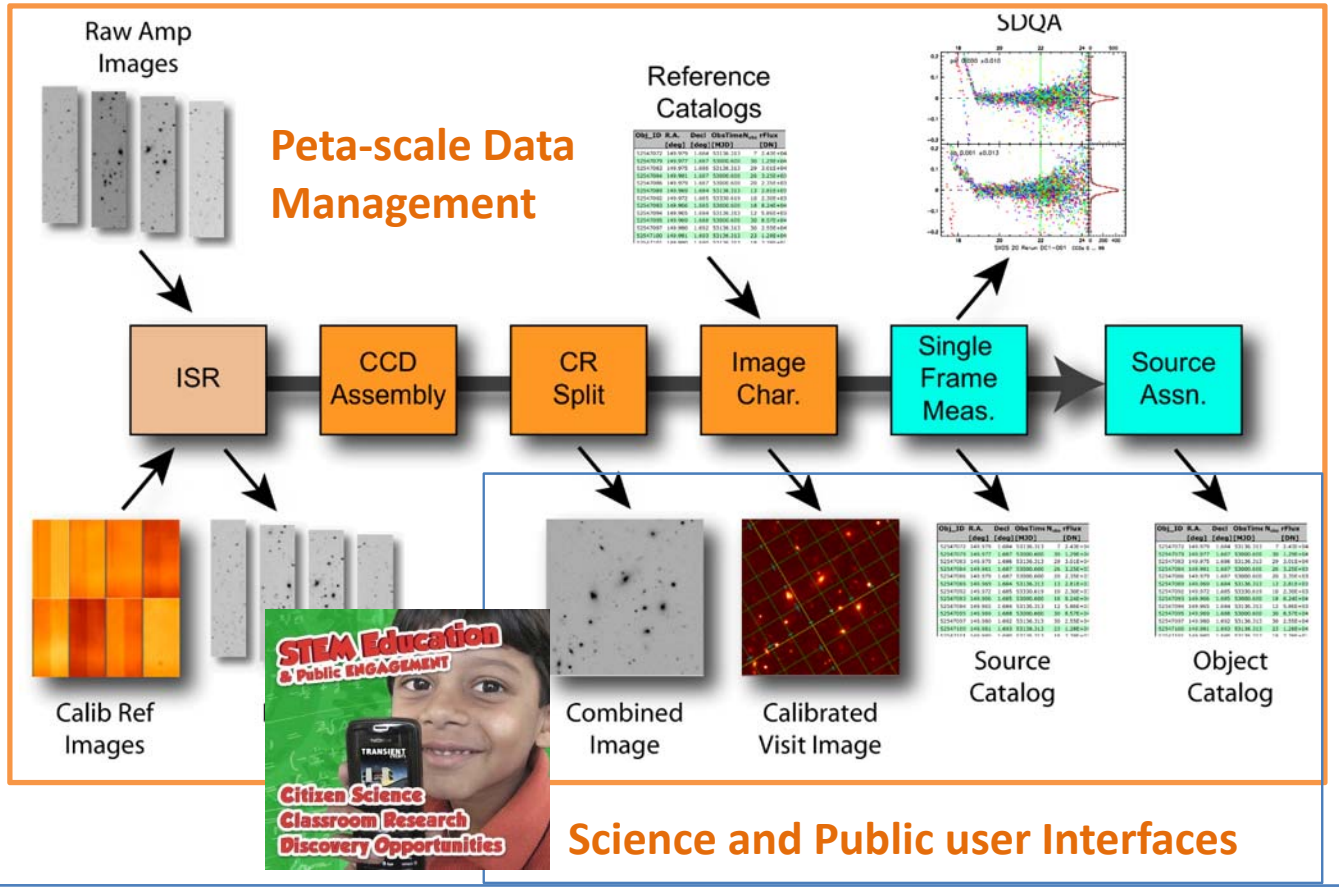


8.4m Telescope

+



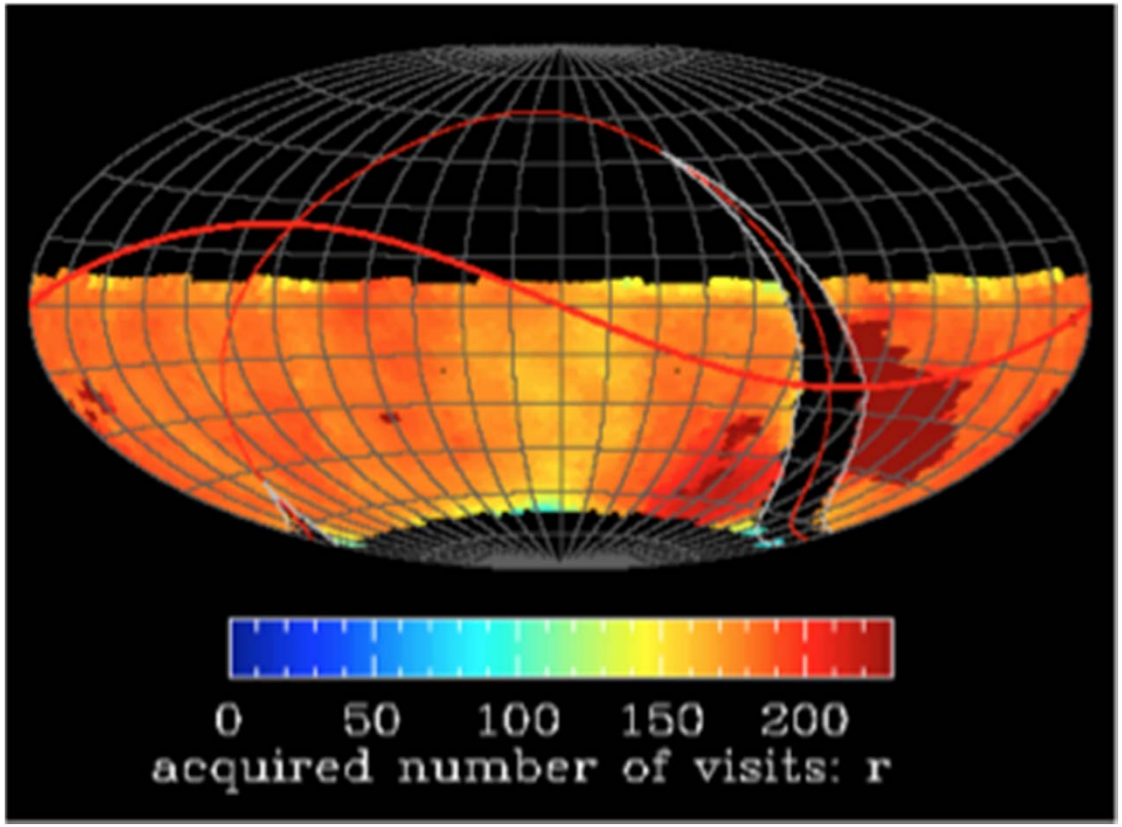
3.2Gpix Camera



LSST's survey will be a 10-year log of half the sky

LSST will image the entire Southern sky (18k sq deg) every few nights, taking an image every ~40 seconds, for 10 years.

The result: *an 825-frame movie in 6-filter technicolor of every object present*



Construction Funding Partners and Managing Organizations

US$ 473 M → AURA

US$ 168 M → SLAC NATIONAL ACCELERATOR LABORATORY

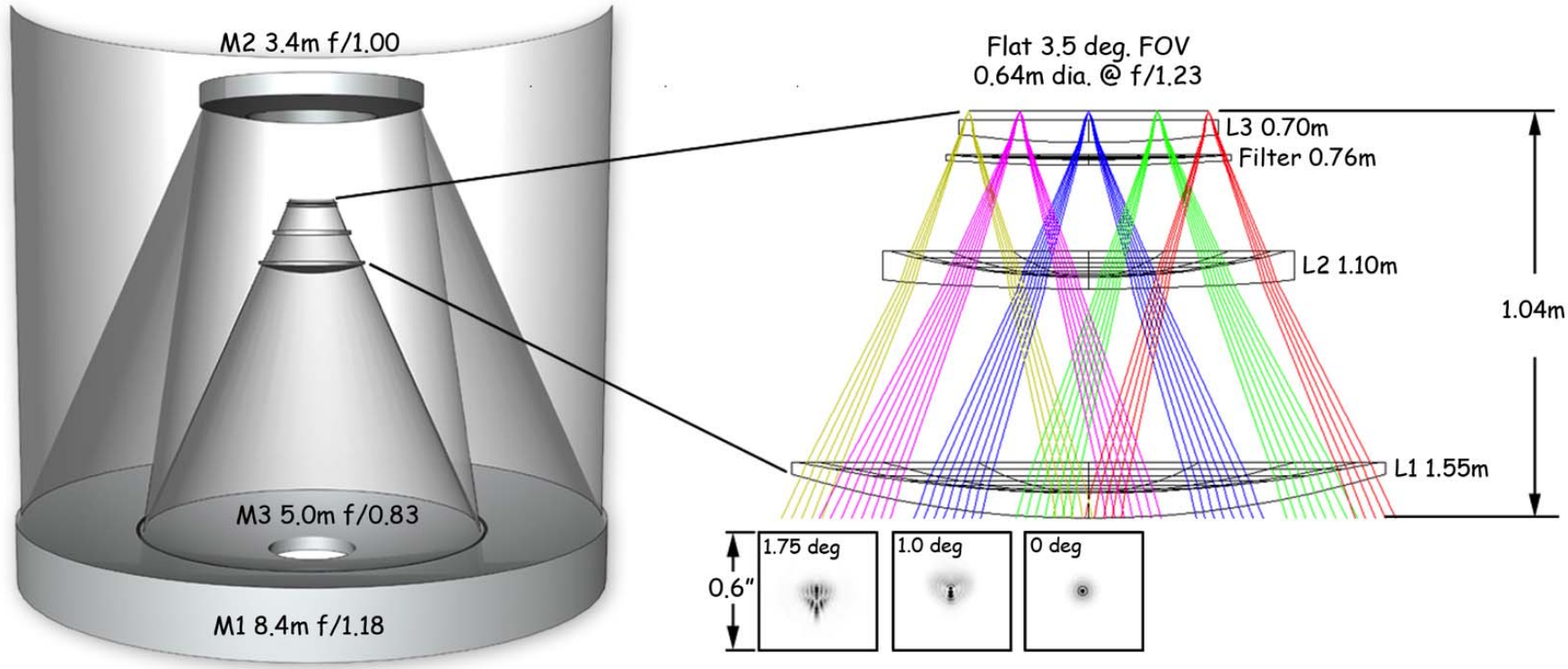
Private, Corporate, and Institutional Donors

US$ 30 M →

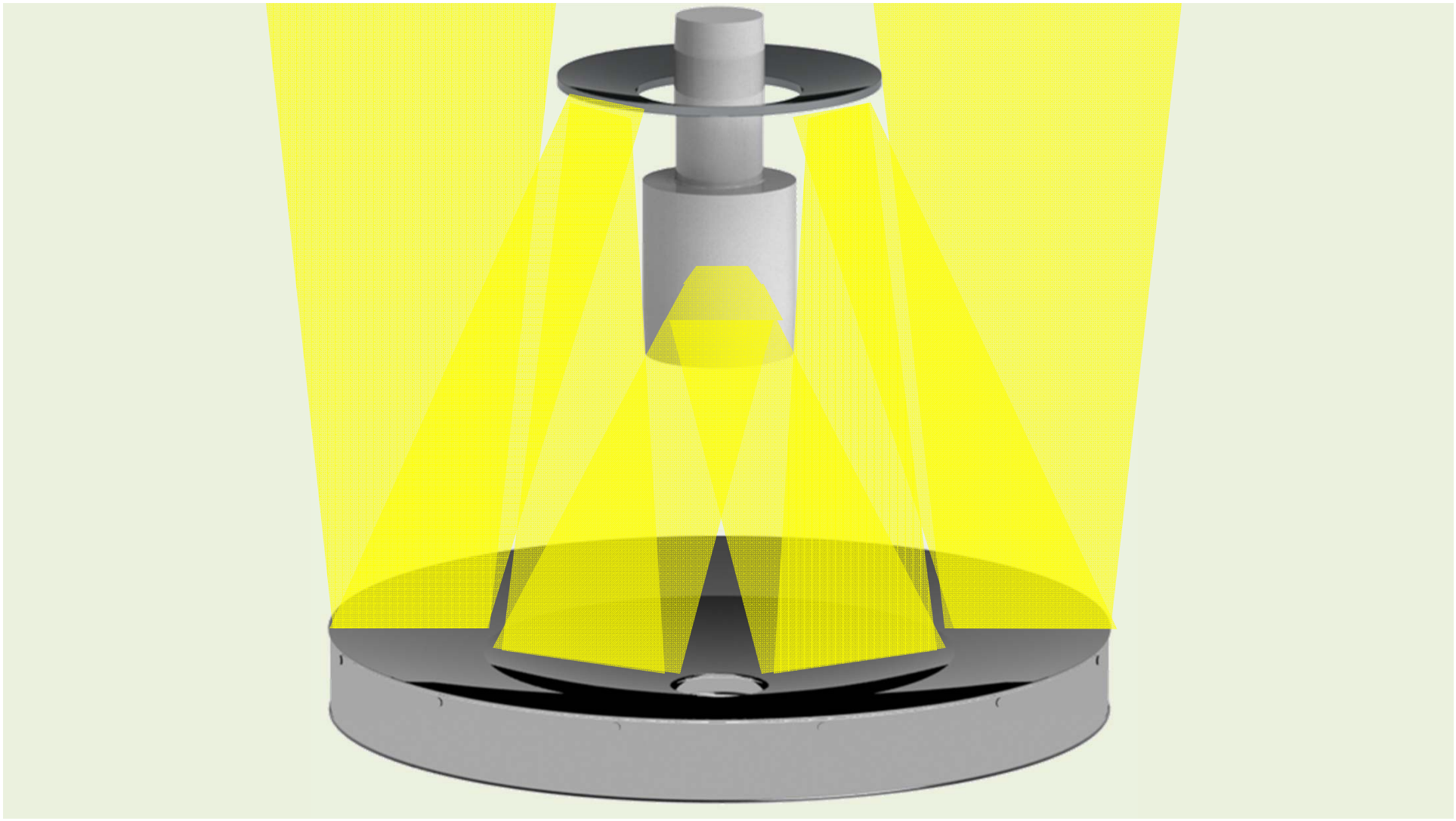
Large Synoptic Survey Telescope (LSST) Status

All Across the Project efforts are successfully transitioning to reality

LSST Optical Design



3 mirrors – 3 Refractive lenses – 6 possible filters

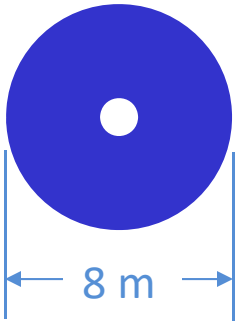


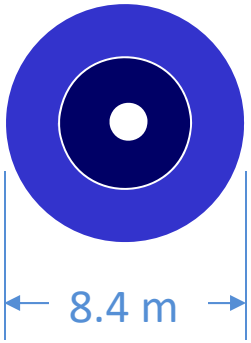
To go wide LSST needs field-of-view

Gemini South Telescope

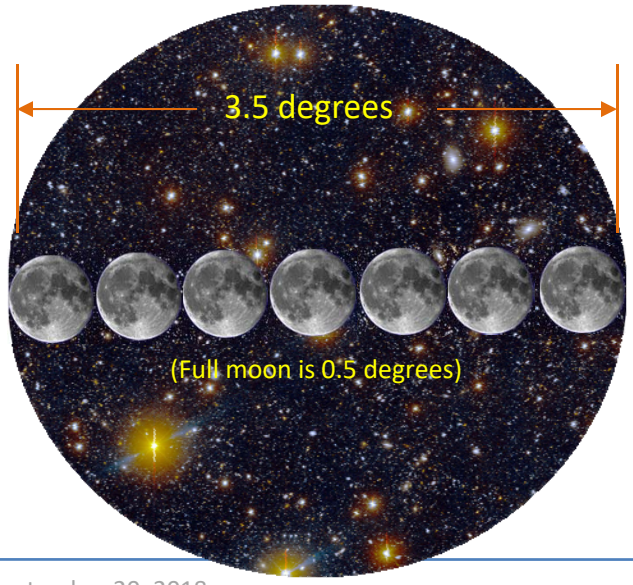
LSST

Primary Mirror Diameter

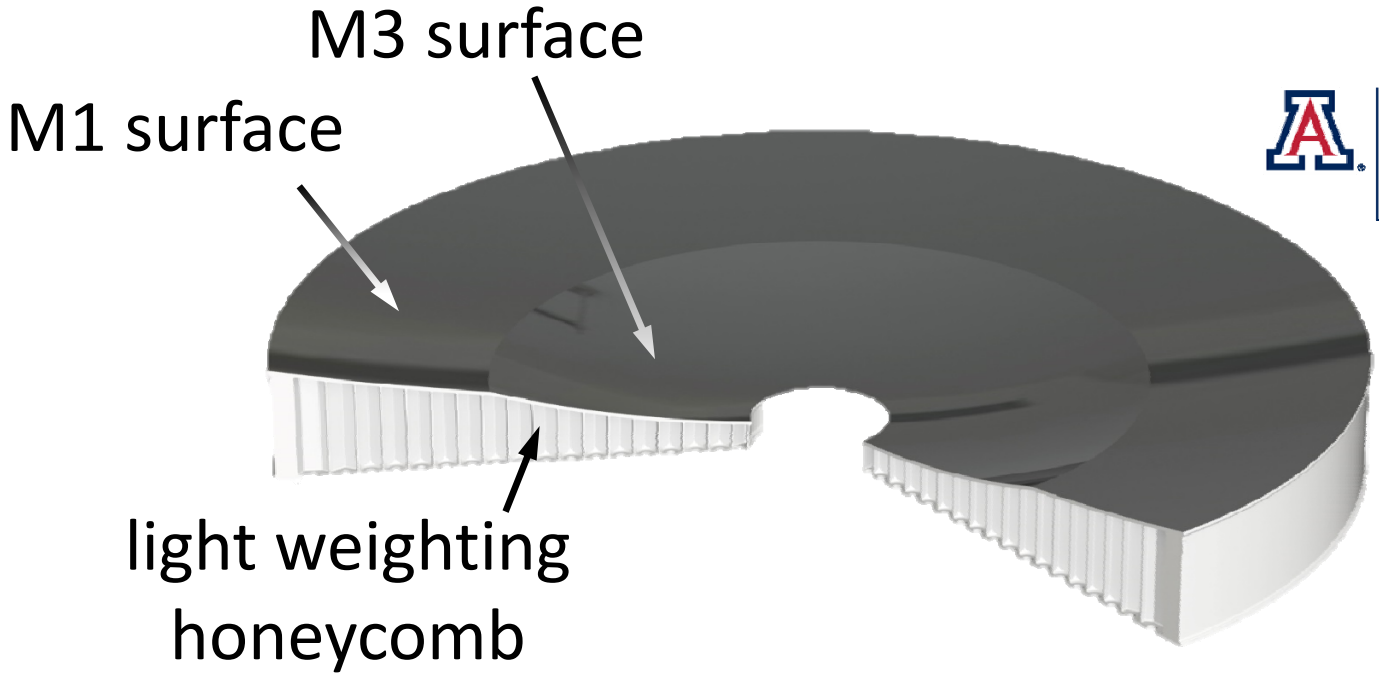




Field of View



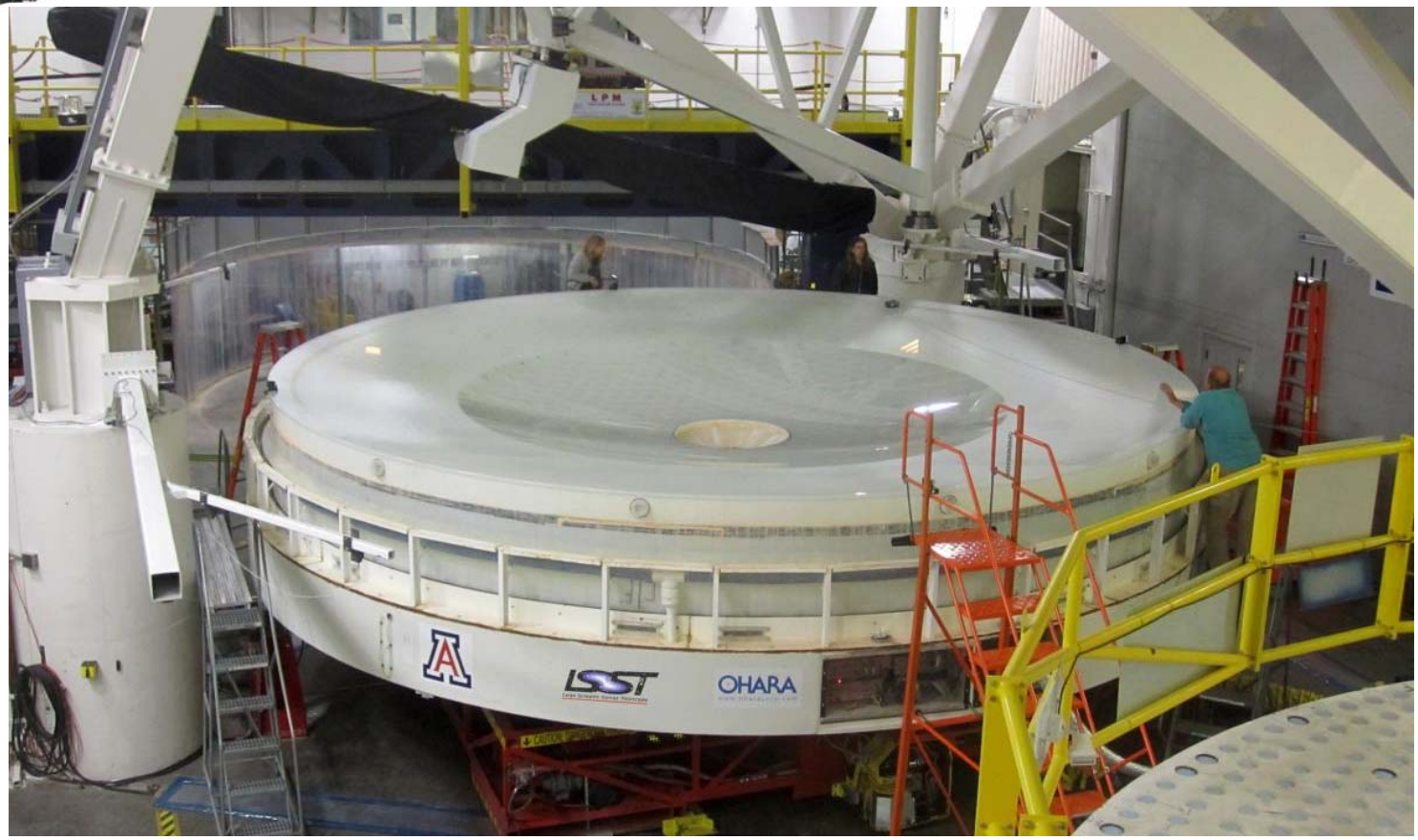
UofA Mirror Lab Technology



UA SCIENCE
RICHARD F. CARIS
MIRROR LAB
Steward Observatory

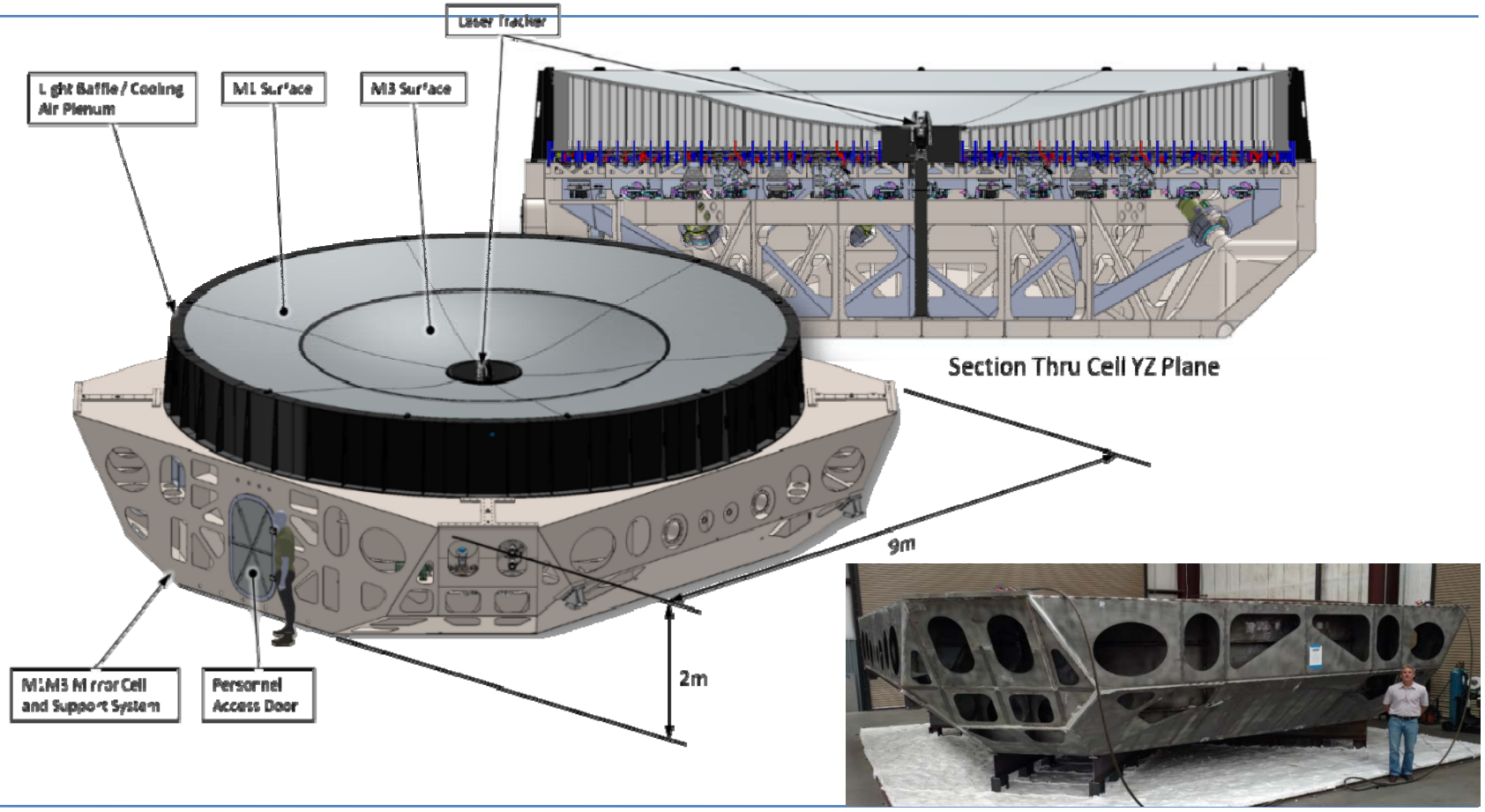
8.4 m (27.6 ft) diameter mirror

Mirror Polishing Completed in 2014



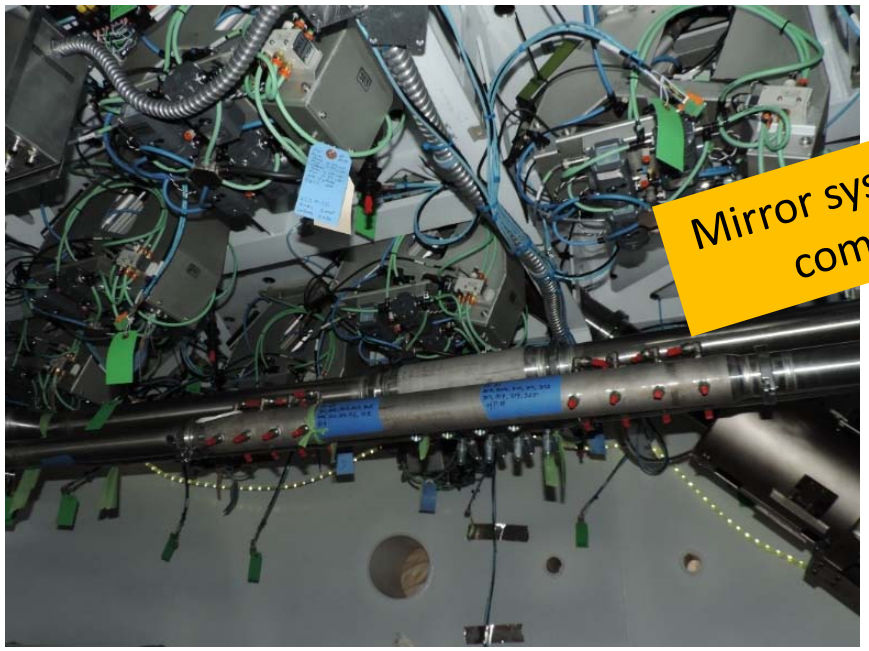
Mirror Moved to
Storage 2015 May 15

A “Mirror” is Complex Assembly



M1M3 Cell Completed – Surrogate Mirror Testing

Inside the Cell



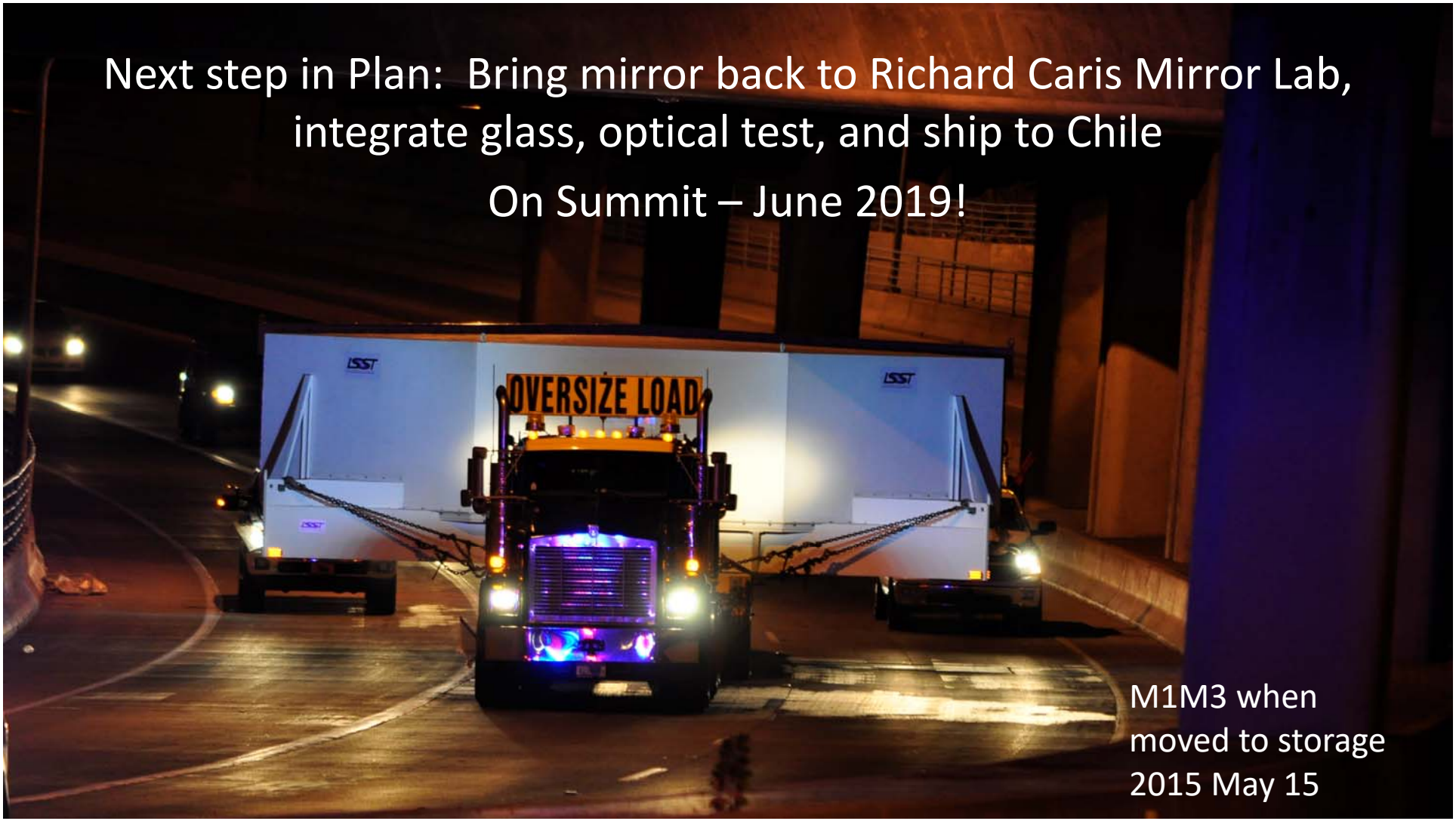
Pneumatic actuators, hard points, glycol piping, air piping and electronics installed

Outside the Cell with Surrogate Mirror

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

Next step in Plan: Bring mirror back to Richard Caris Mirror Lab, integrate glass, optical test, and ship to Chile

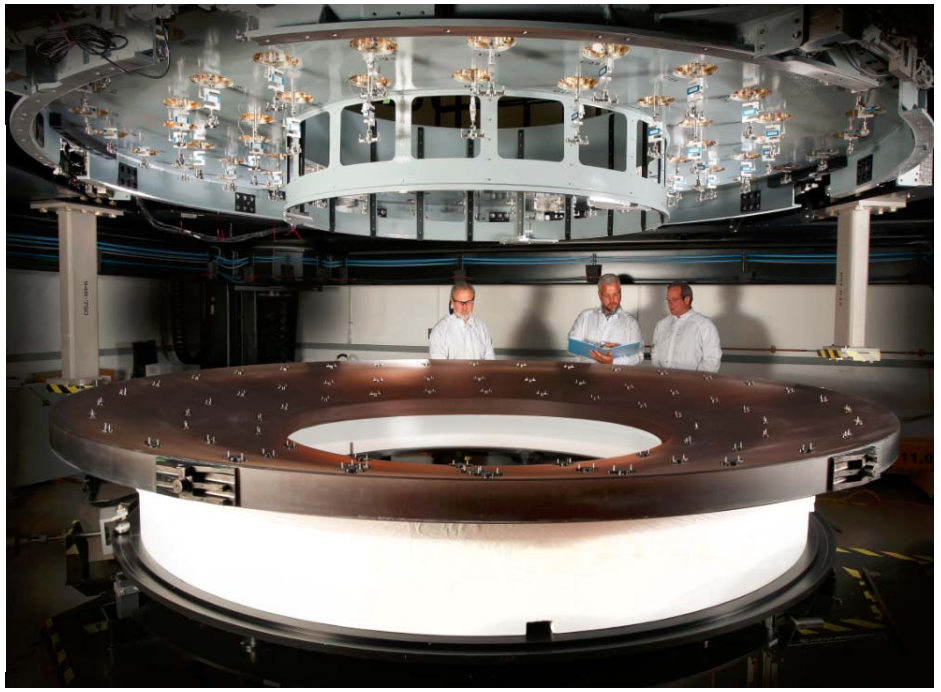
On Summit – June 2019!



M1M3 when moved to storage 2015 May 15

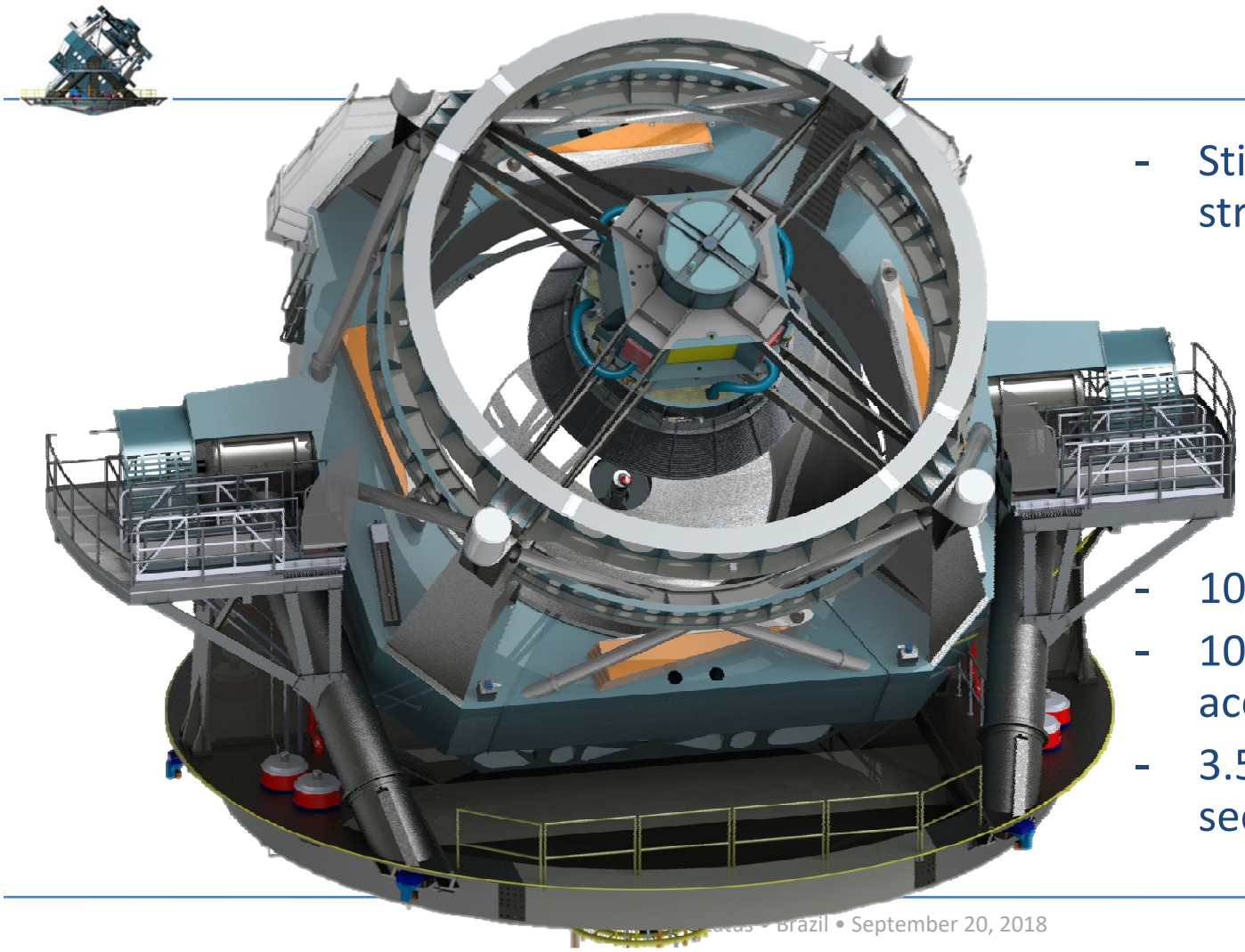
3.5m Diameter Secondary Mirror is Completed

- Corning ULE blank procured early in development phase
- Harris Corporation providing optical fabrication and full cell assembly
  - Final delivery plan: October 2018
  - Shipping to Site for first coating



Magnetron Sputtering Chamber Completed

- Coating Chamber Factory Acceptance completed at Van Ardenne - Germany
- Journey to Chile has started.



- Stiff 300 ton moving structure

- 10 deg /sec rotation
- 10 deg/sec^2 acceleration
- 3.5 deg slew-settle: 5 seconds

Telescope mount assembly development by Empresarios Agrupados / Asturfeito

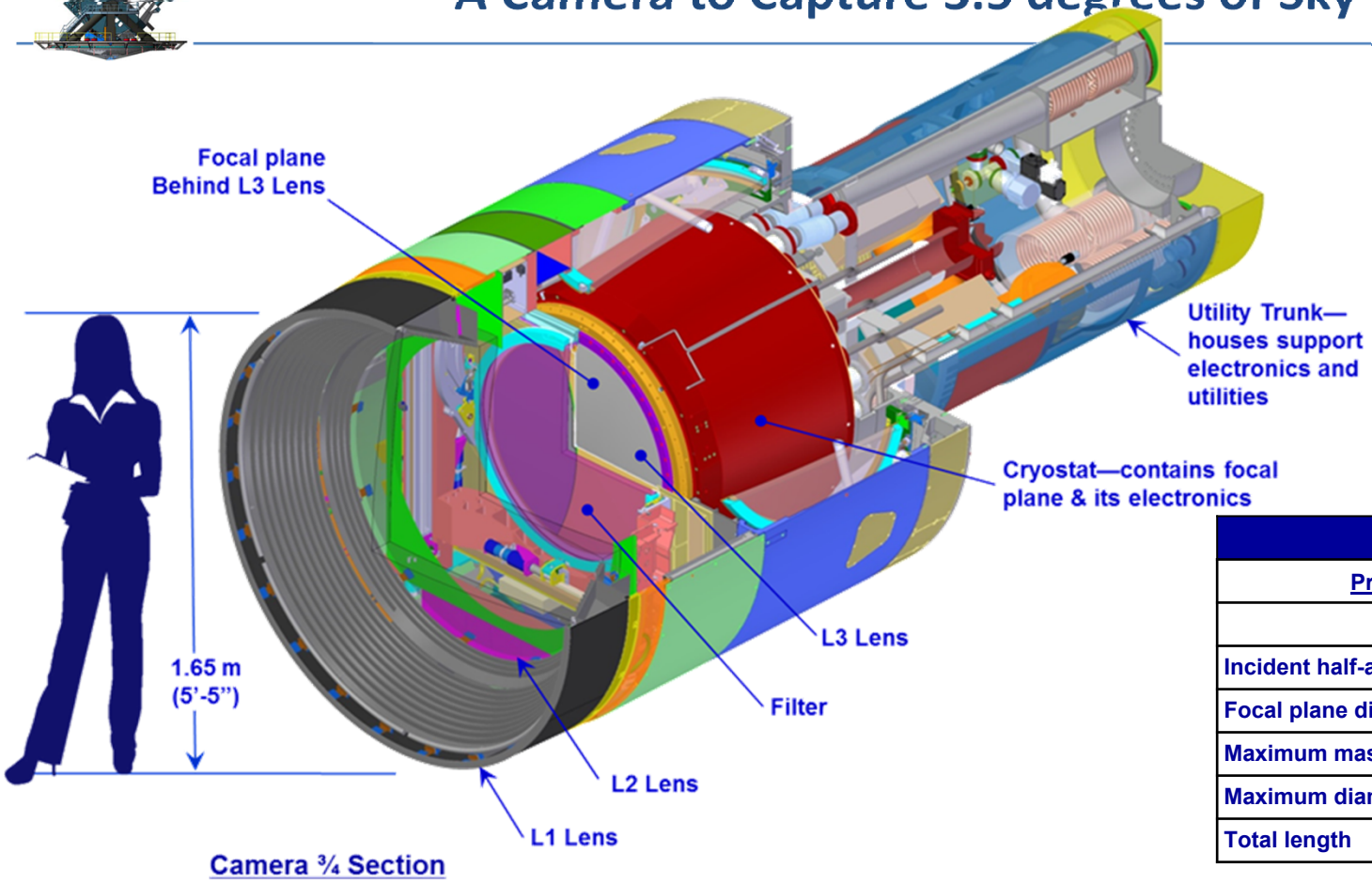
- All major subsystems integrated on factory pier
- All surrogates installed
- Verification of final safety audit
- Now under computer motion control
- Sept/Nov 2018: FOB Aviles, Spain

Optical alignment held with Camera and M2 motions

- Camera Hexapod / Rotator and M2 Hexapod being built by Moog – System Delivered August 2018

Successful 200% load test of cantilevered Camera and Integration with LSST software

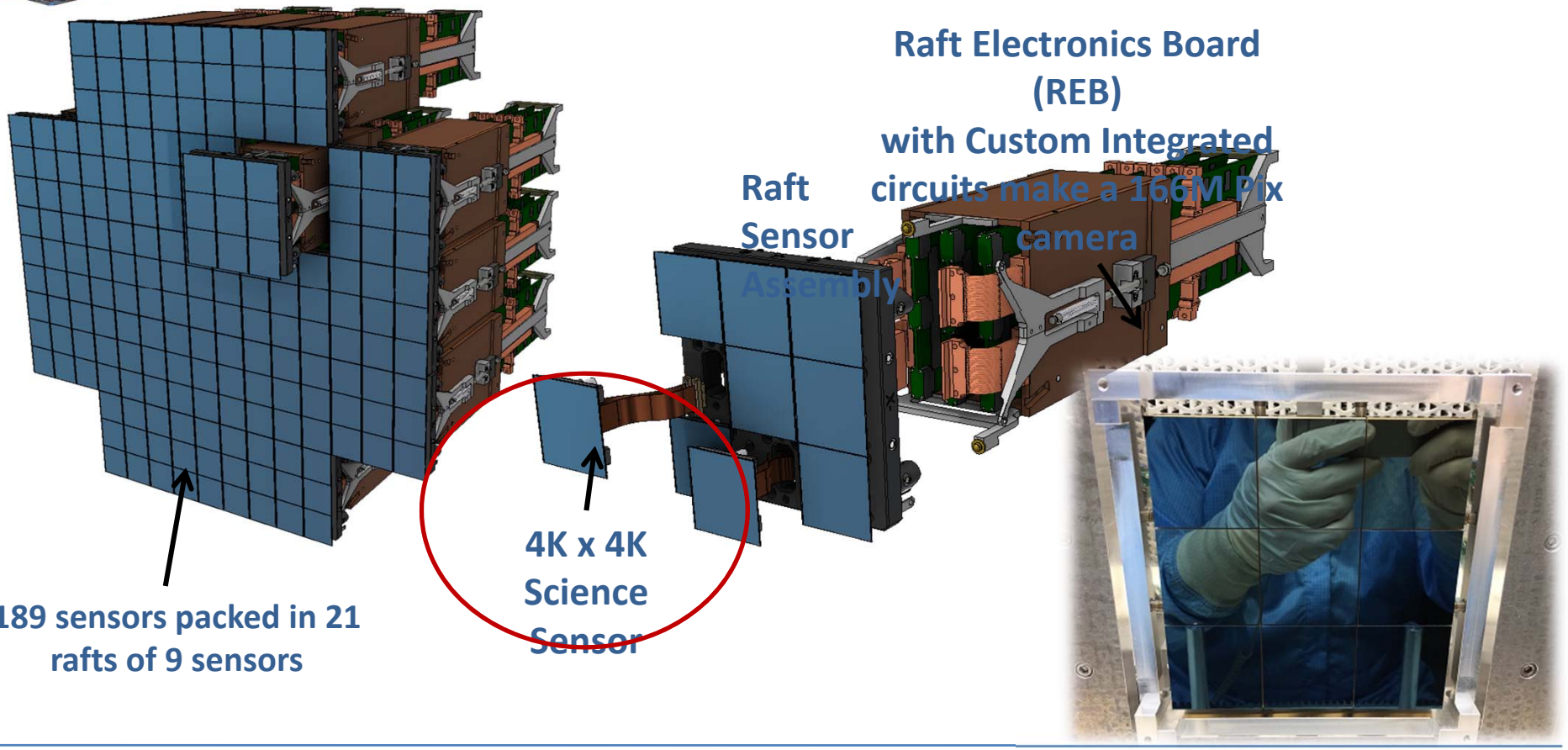
A Camera to Capture 3.5 degrees of Sky



Camera ¾ Section

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

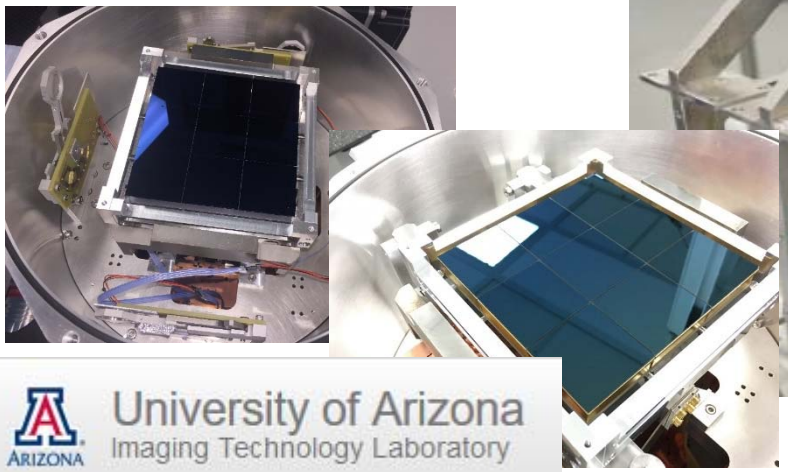
63 CM Diameter Focal Plane with 3.2 GigaPixels



Camera Sensors Fabricated by Two Vendors

- 274 Science Sensors Delivered
- Need 208

TELEDYNE e2v
Everywhereyoulook™



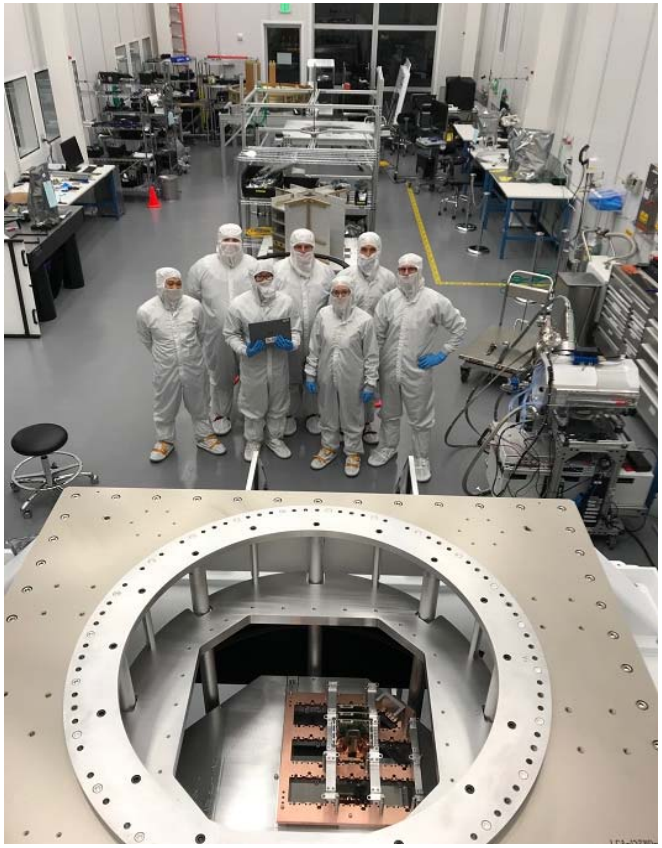
University of Arizona
Imaging Technology Laboratory

Brookhaven National Labs does Raft integration

- 12 Rafts delivered
- 1.6 Gpixels Ready!
- Need: 21 Science Rafts and 4 corner Rafts

Over half way!

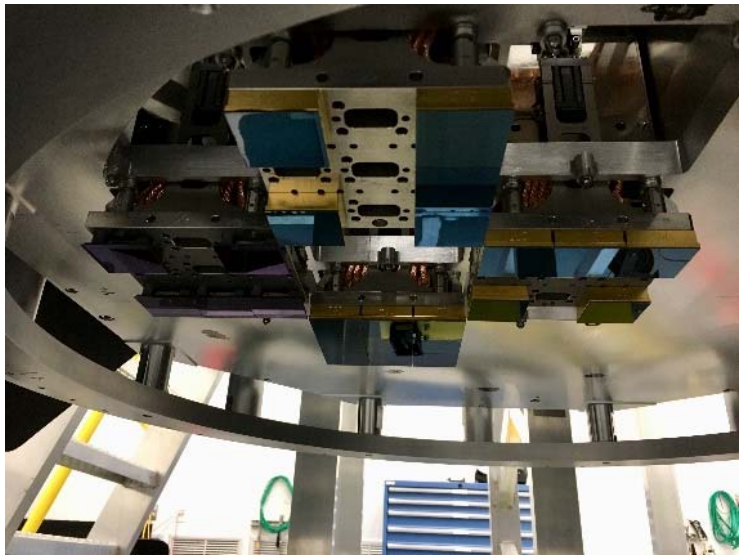
Integration and test activities progress



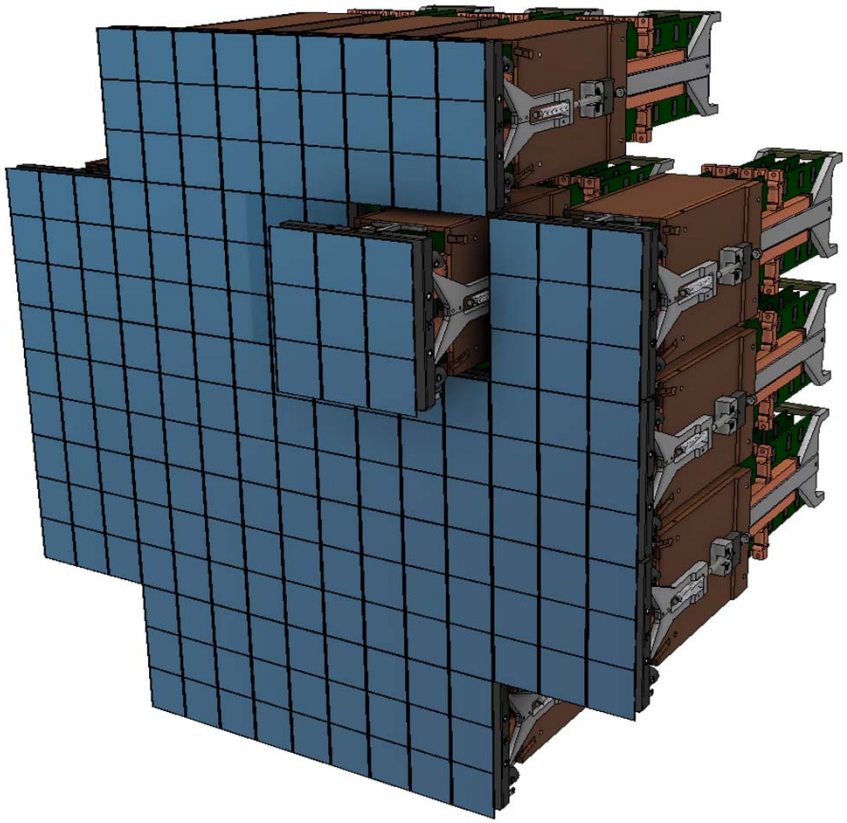
Bench for optical test with mockup cryostat and one mechanical raft

- Bench for Optical testing assembled and under test
- Raft integration fixture received and under test after performance issue with the 3-axis stage.
- Start of camera integration in the fall of 2018

4 mechanical rafts inserted to verify integration system



Sensor Gaps are Tight - Collecting Efficiency



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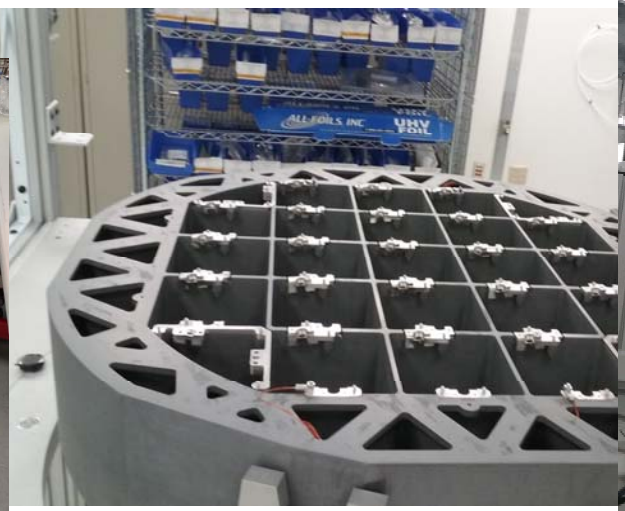
Each raft is slightly more delicate and valuable…..

¼ " spacing ¼ " spacing

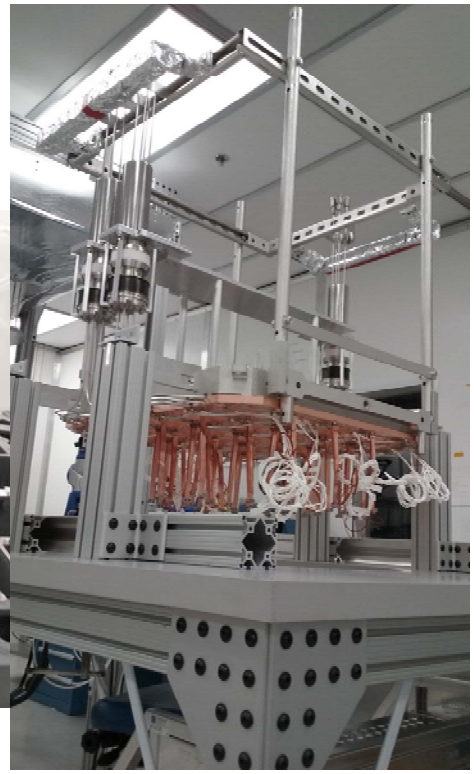
Cryostat progress (Critical Path)

- HB-Cesic 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

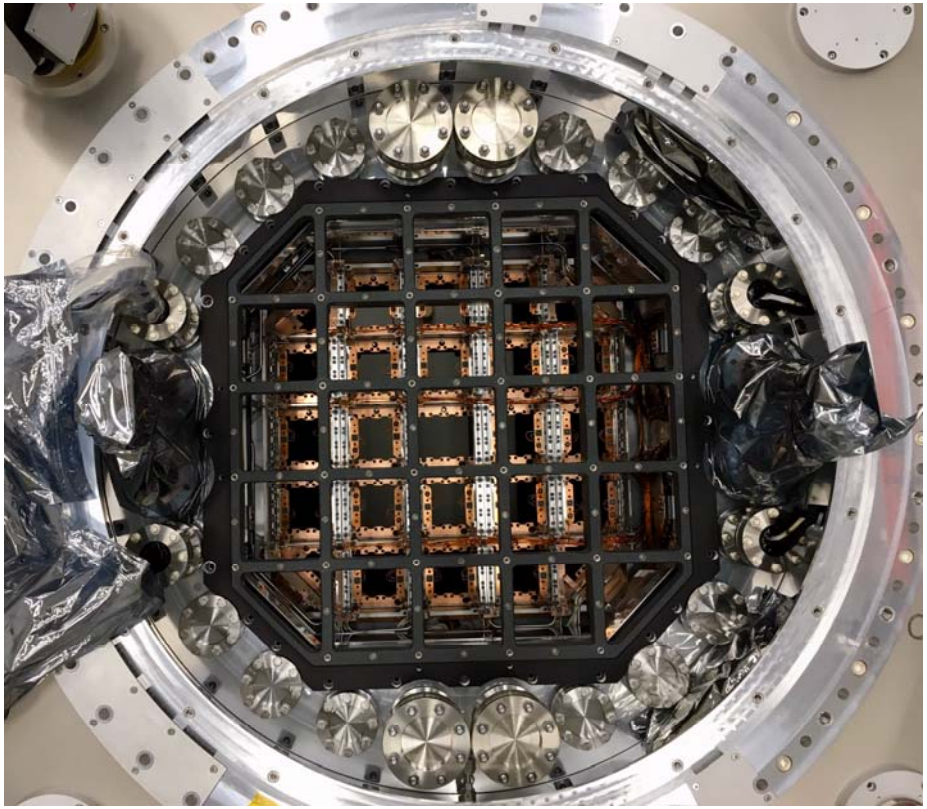


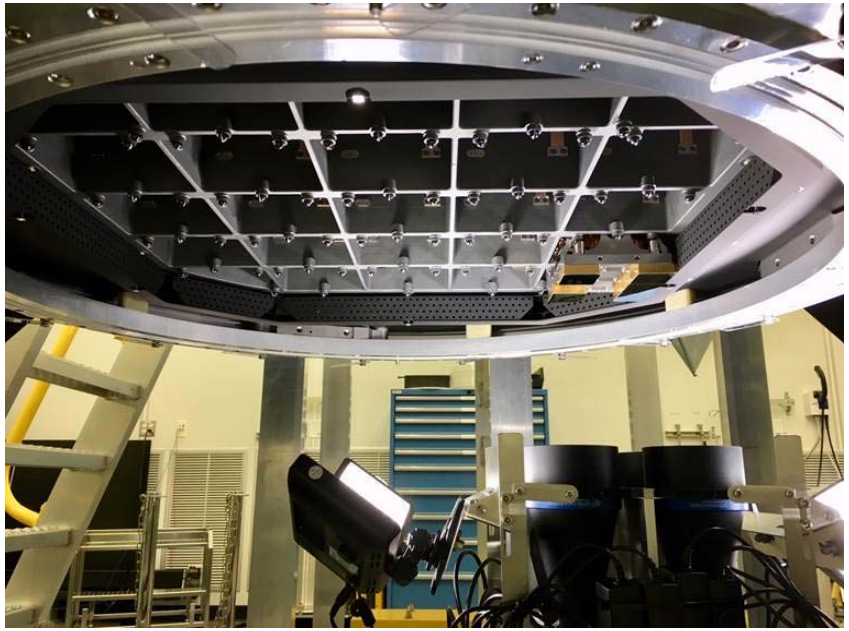
Assembled grid



Assembled cryoplate

Cryostat Ready for Rafts !



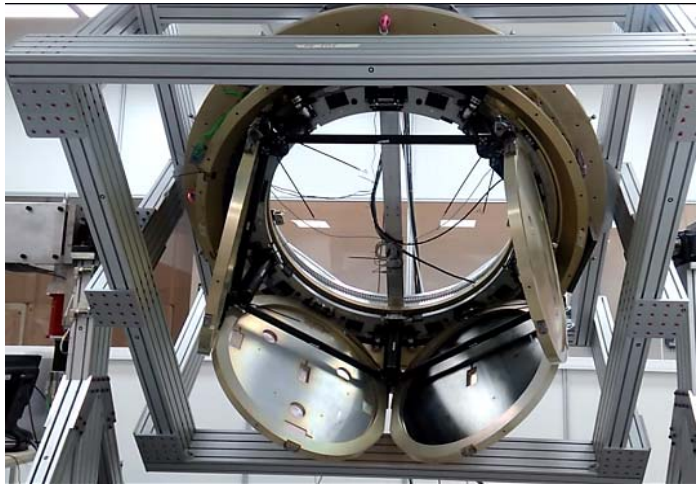


Filter Exchange Systems Complete and Tested

- Collaboration with IN2P3 labs in France for key Camera elements
- Filter Autochanger and Manual loader (6th filter) full size prototype completed and tested
- Carousel full size prototype completed and tested – Only final assembly on camera back flange remains

Filter Autochanger

Filter loader on transport cart



5 Filter capacity carousel

Camera Optics Progressing Well

- Ball Aerospace leading L1 and L2 Assembly fabrication
  - Lenses polished at Arizona Optical and accepted for coating
  - L1-L2 composite structure completed
- L2 first surface coated with broad band AR coating at REOSC.

L1 inspection

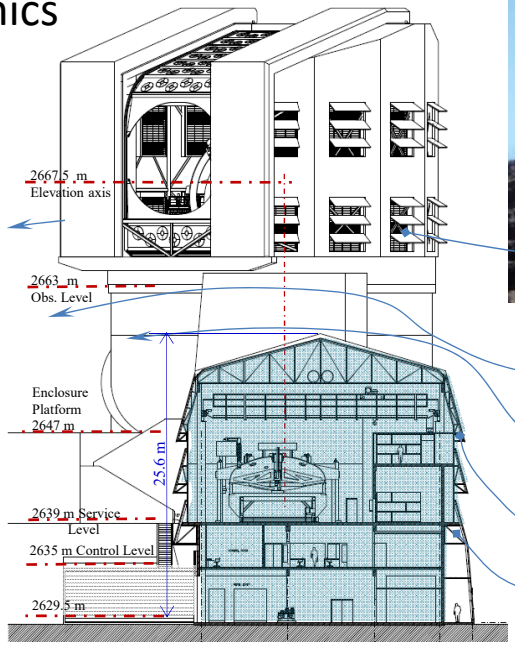
Leading the World in Precision Optics

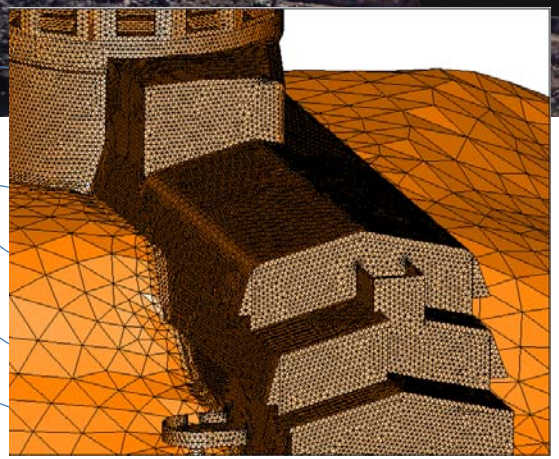
AOS
Arizona Optical Systems

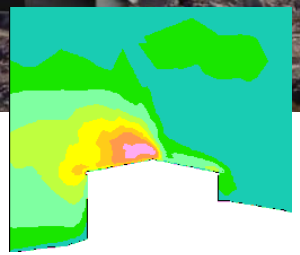
L2 at coating vendor

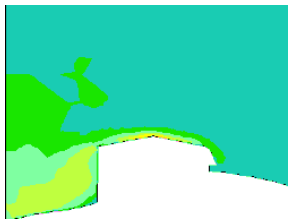
Summit Support Facility Design will Impact Observatory Performance

Exterior building composition shaped by topography & aerodynamics





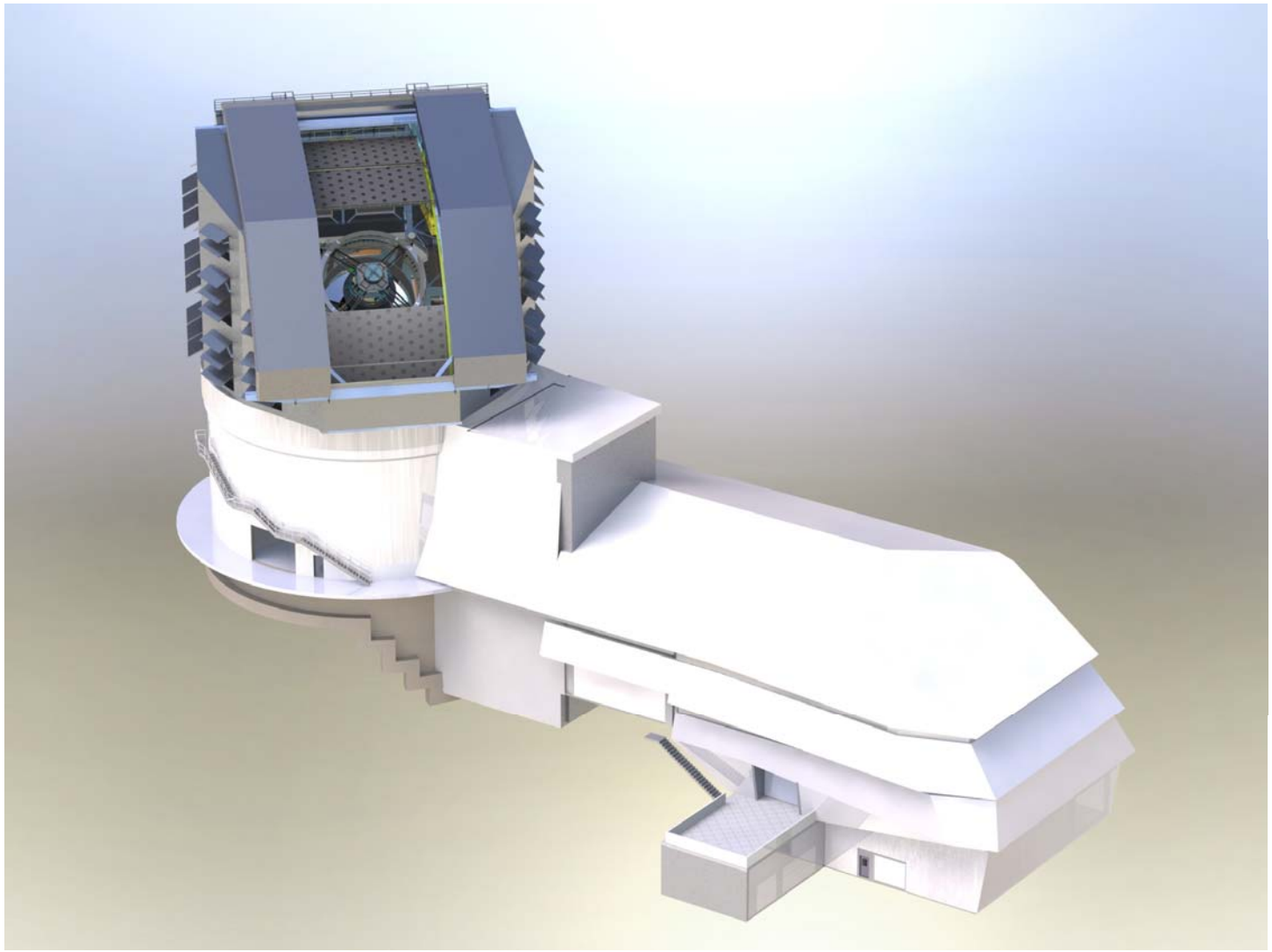




without panels

with deflector panels

Computational Fluid Dynamics (*CFD*) **Of Building Site and Dome**

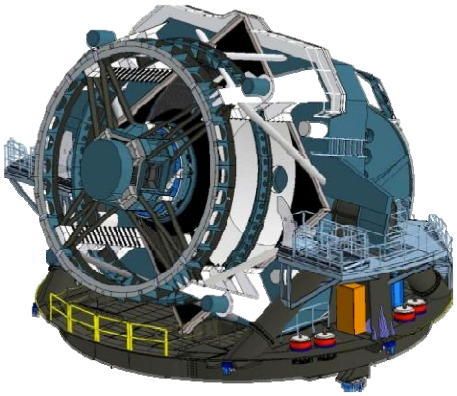


Summit Facility on Cerro Pachón

- Summit Facility Substantial Completion achieved by Besalco in February 2018
- Computer room in use and IT infrastructure initiated
- 80-ton Pflow Lift tower completed; lift carriage/mechanism assembly in progress
- European Industrial Engineering (EIE) Dome erection is priority activity – Early 2019 completion expected

Interior Spaces within Summit Facility

To build an observing facility, conduct 10-year survey, process, archive, and serve images and data products



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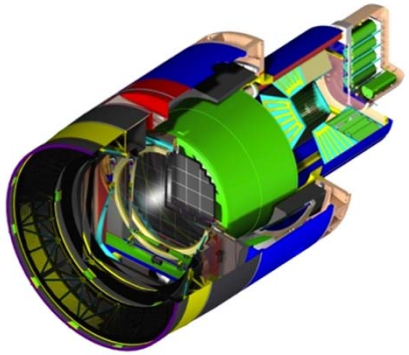
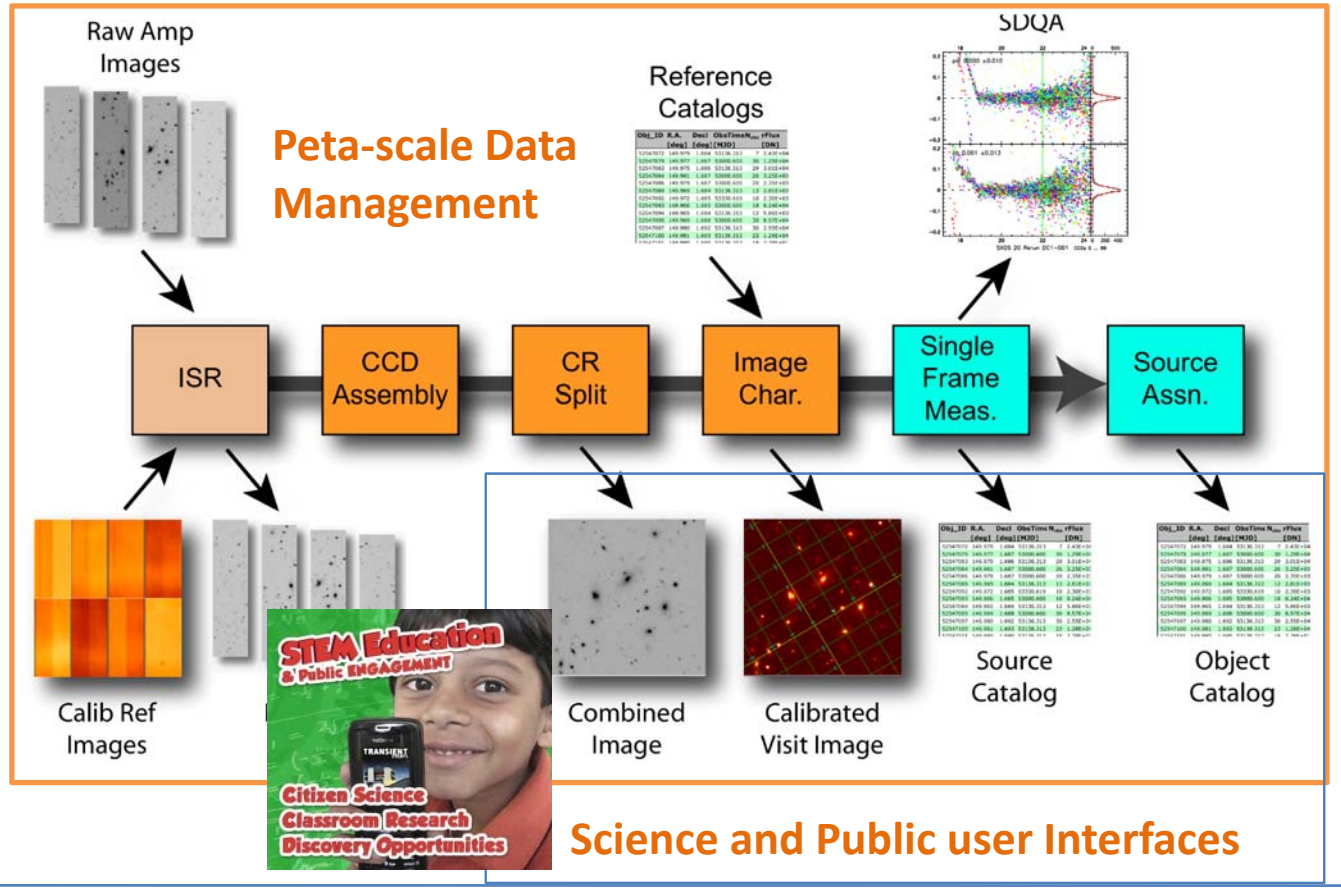
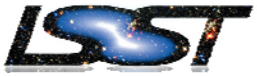


3.2Gpix Camera



Data Products



- 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.

Prompt

- 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.
- Deep co-added images.

Data Releases

The production of data products will be transparent: All software is developed open-source and will be available to the community.

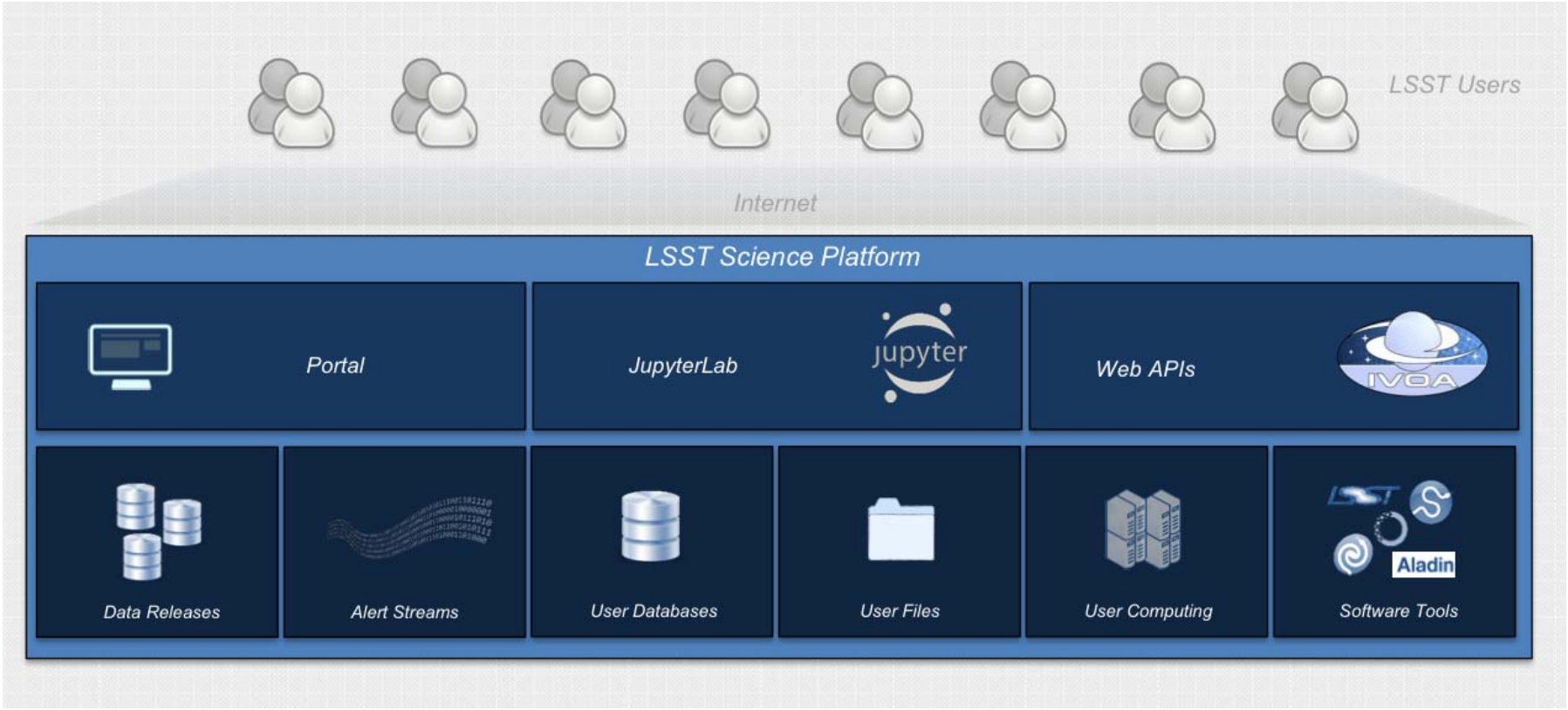
*For more details, see the **"Data Products Definition Document"**, http://ls.st/lse-163*

LSST Algorithm and Pipelines Progressing

Simulated image based on three filters
From just one of 189 CCDs

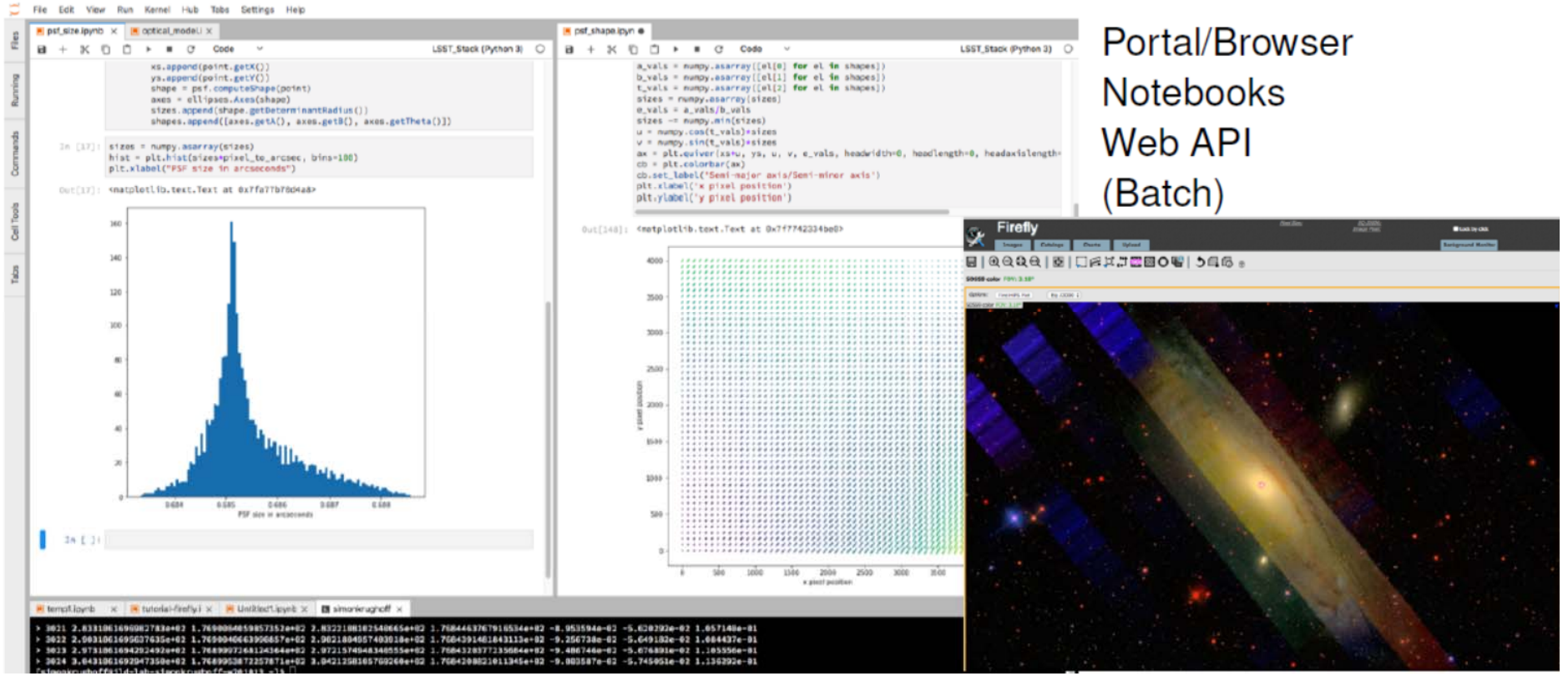
Processed through the
LSST Science Pipelines
`https://pipelines.lsst.io/`
The Pipelines are already in use with other facilities, e.g. Hyper Suprime-Cam.

The LSST Science Platform: Portal, JupyterLab, WebAPIs

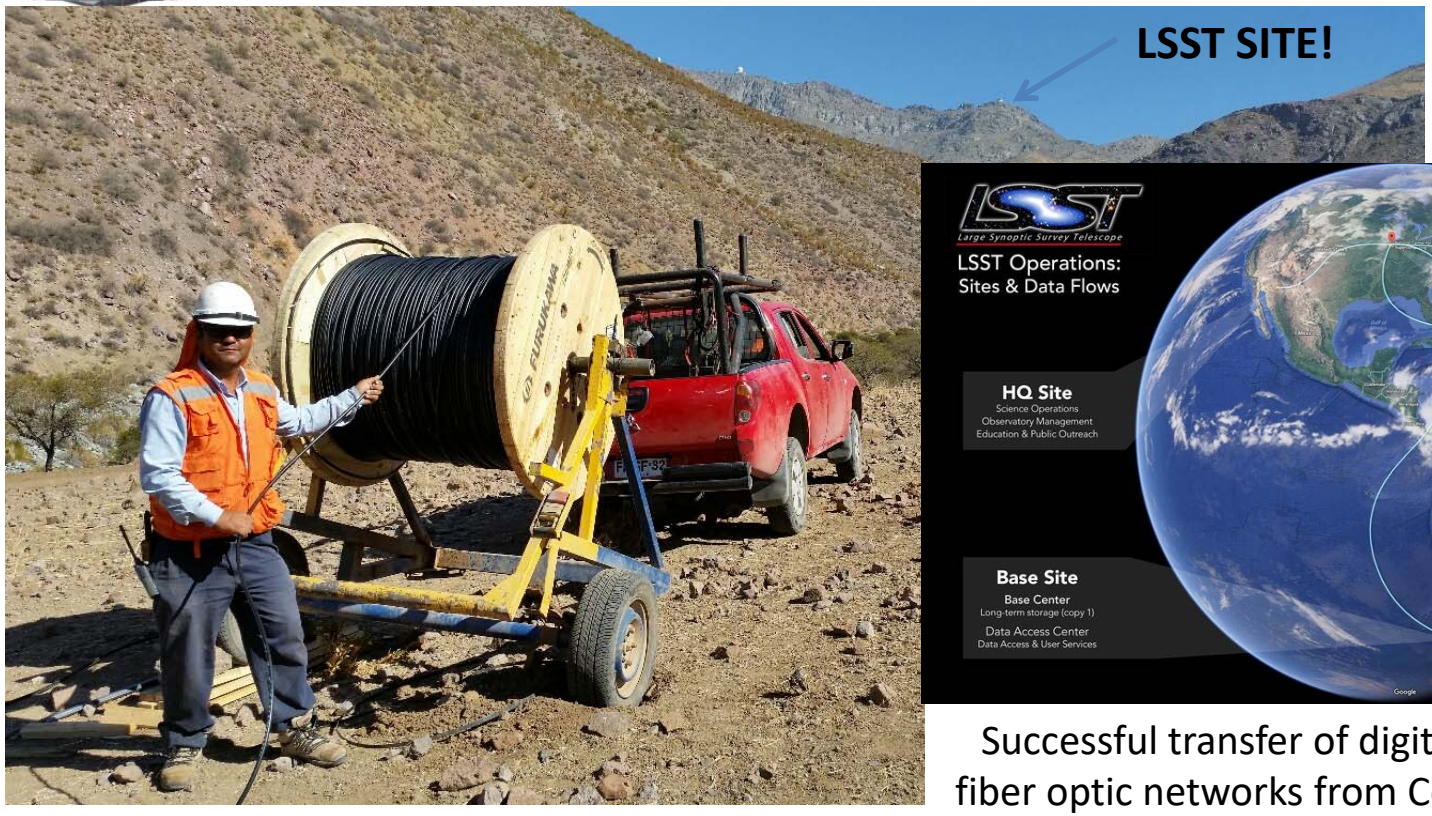


Science Platform Vision to Early Reality

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



New optical fiber to the summit completes path



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

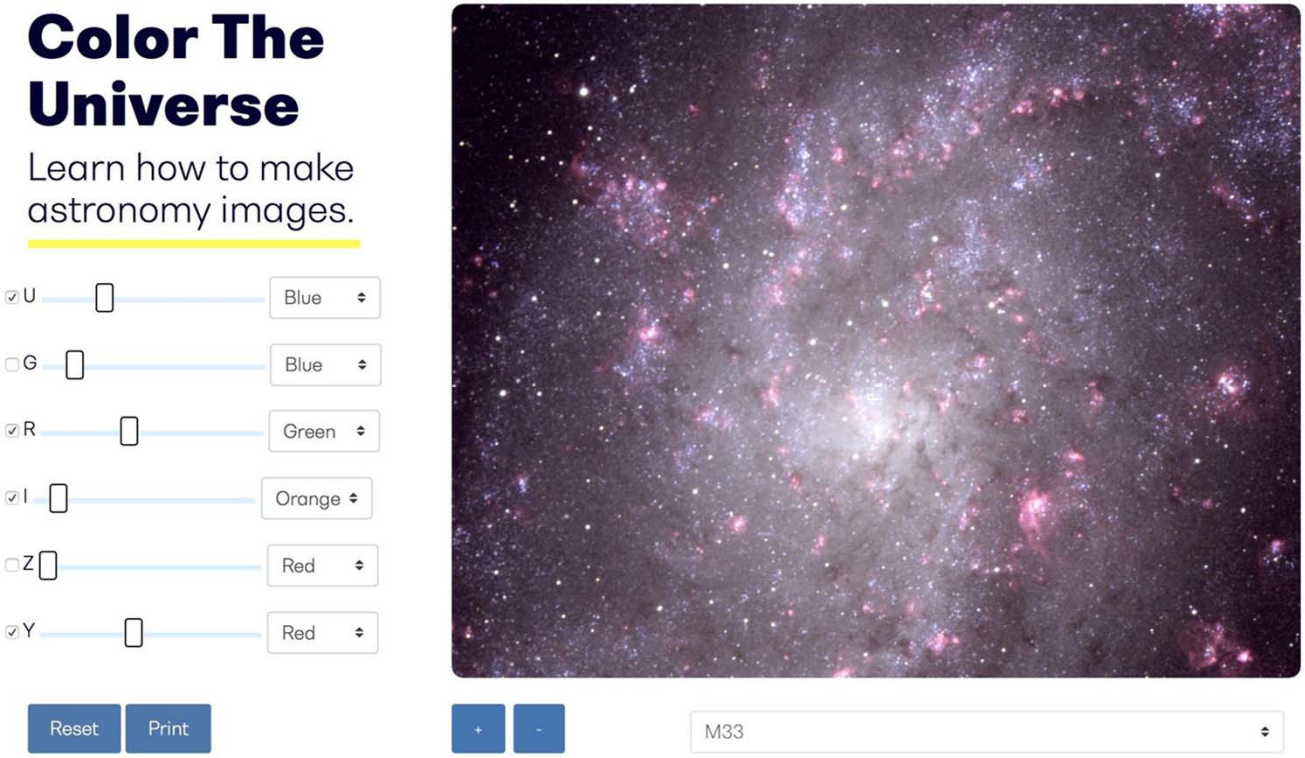
The LSST Education and Public Outreach System

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:

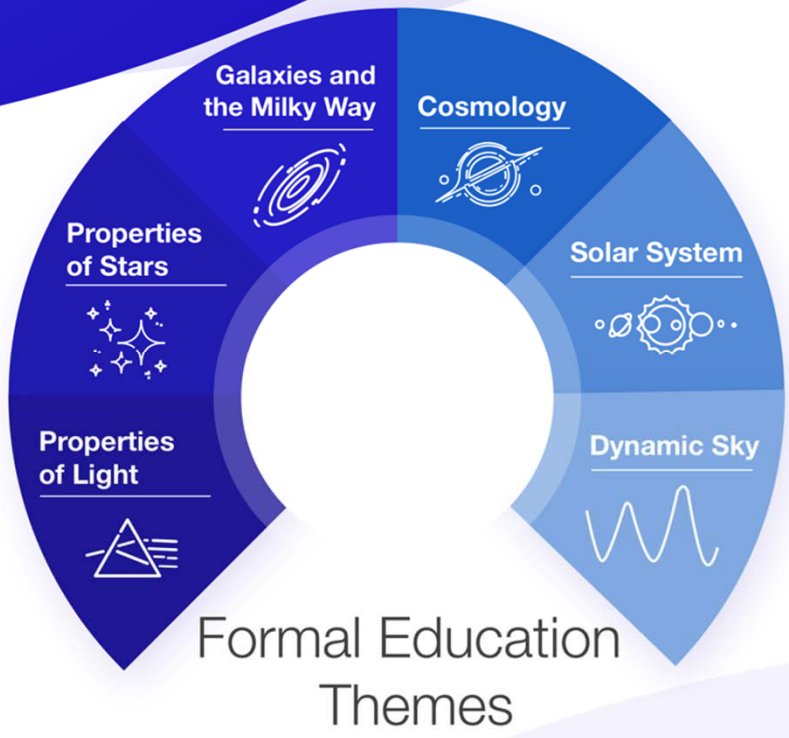
1. Formal educators teaching astronomy content at the advanced middle school, high school, or college level
2. Citizen science principal investigators (scientists using LSST data)
3. Content developers at informal science centers / planetariums
4. Science-interested teens and adults

Six- filter mixing tool



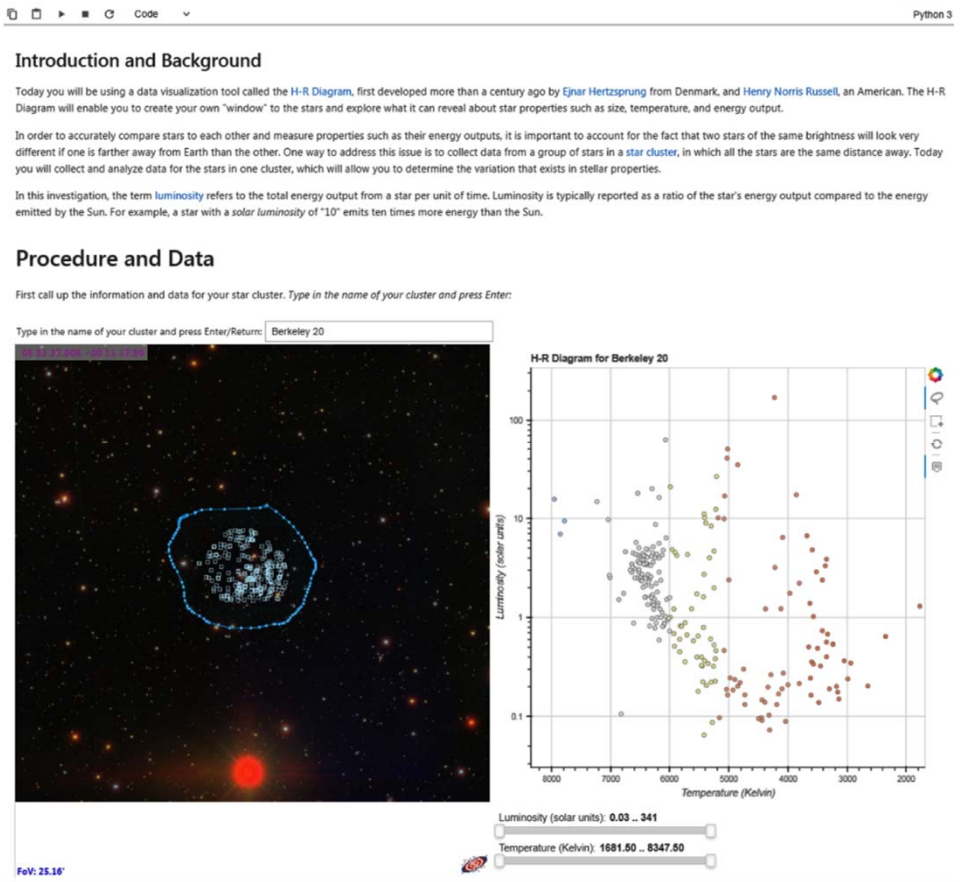
https://lsst-epo.github.io/properties-of-light/

Science themes

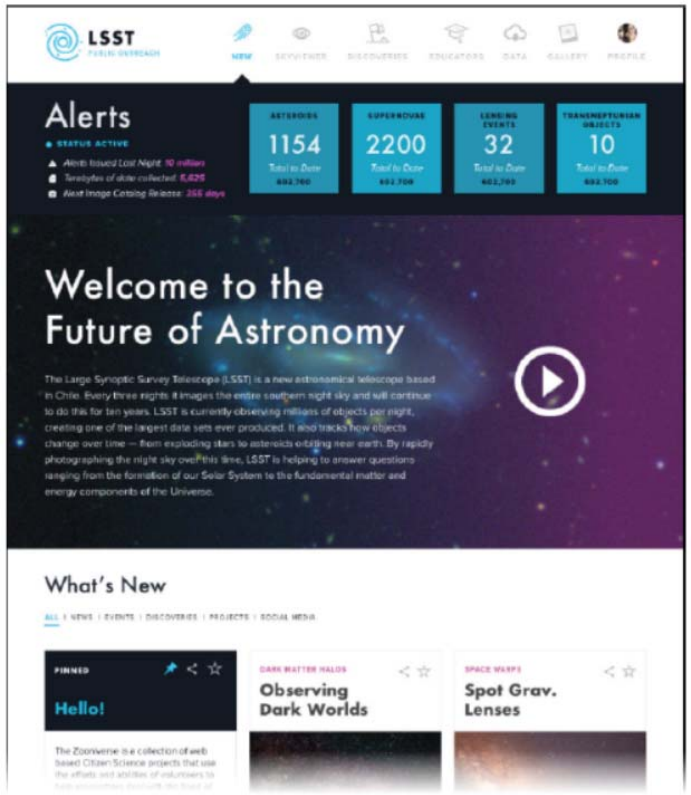


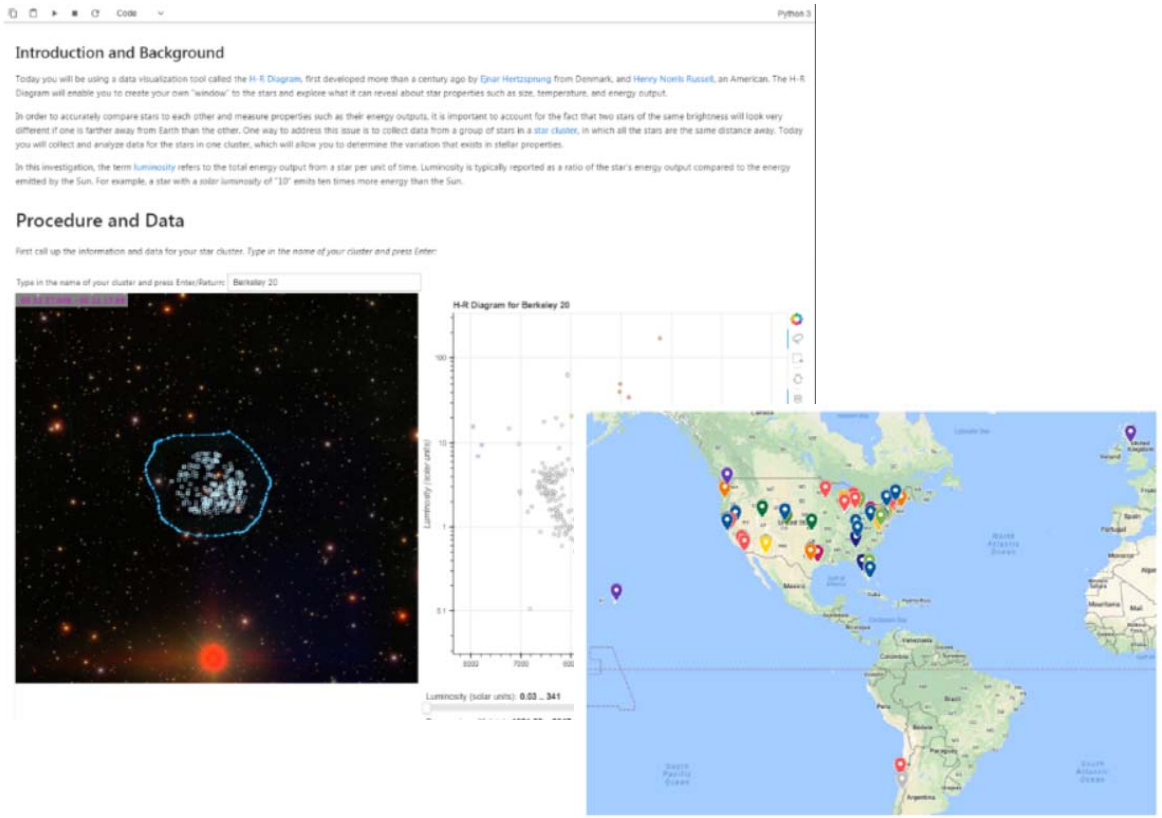
Online Notebooks

- Accessible through a website
- No special software required
- No need to download data
- Embedded tools for data interaction & analysis
- Customizable
- Class management tools, teacher guide and assessment materials available for educators



EPO is Prototyping and Evaluating





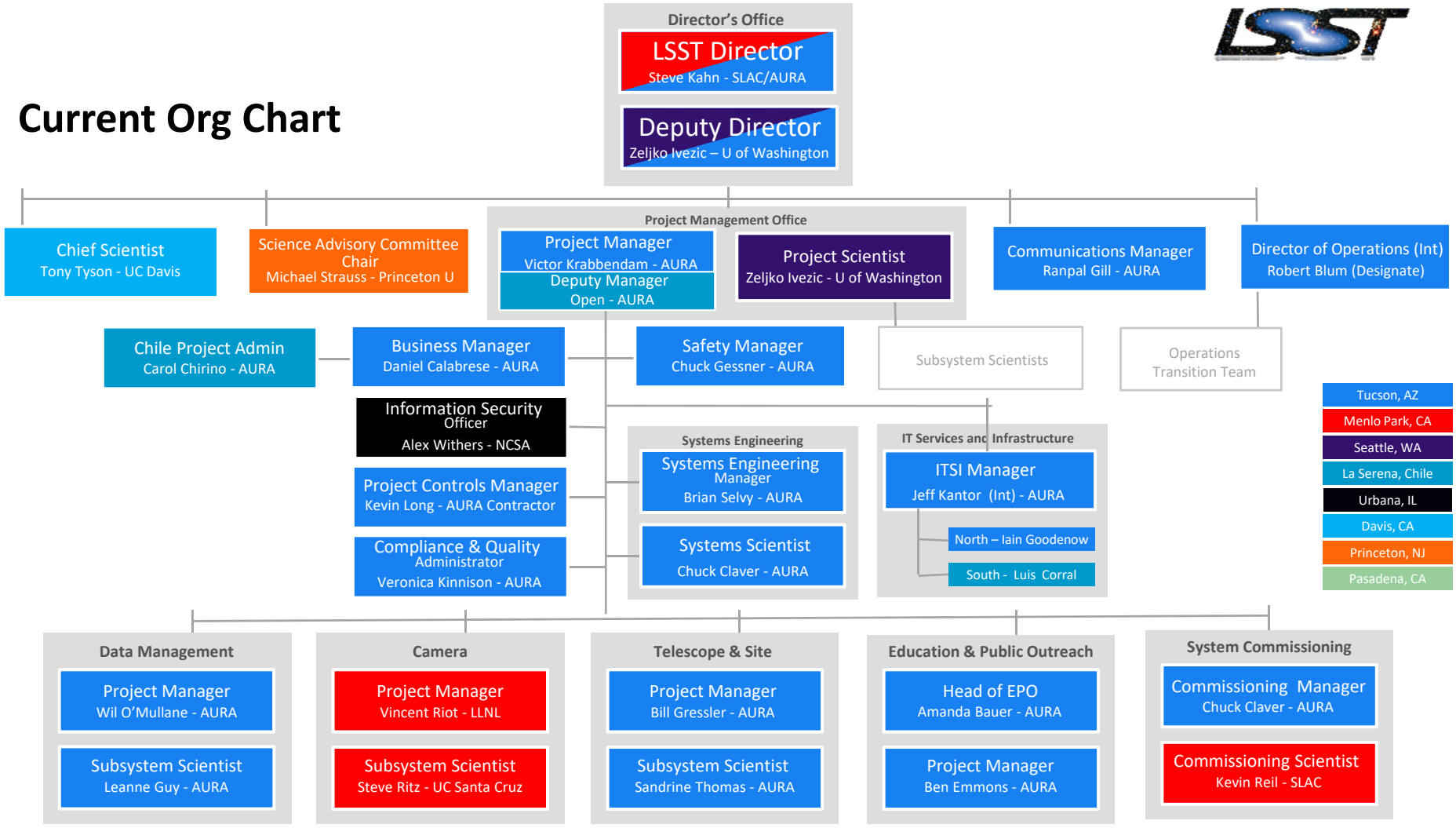
LSST Continues Focus on Safety

- Detailed tracking continues:
  - 0.37 injury rate (2016 US avg =2.9)
  - Rate = Incidents / 100FTE
  - Based on estimated 2.7 million hours
- Supporting 2 (3) construction sites
- Integrations activity assessments
  - SLAC, M1M3, TMA

- Culture - Attitude - Cooperation

SLAC - Camera Team	0
AURA - T&S, DM, and PO	.41
Summit Contractors	.46
Base Facility Contractors	.41
Total of these groups	.37

Current Org Chart



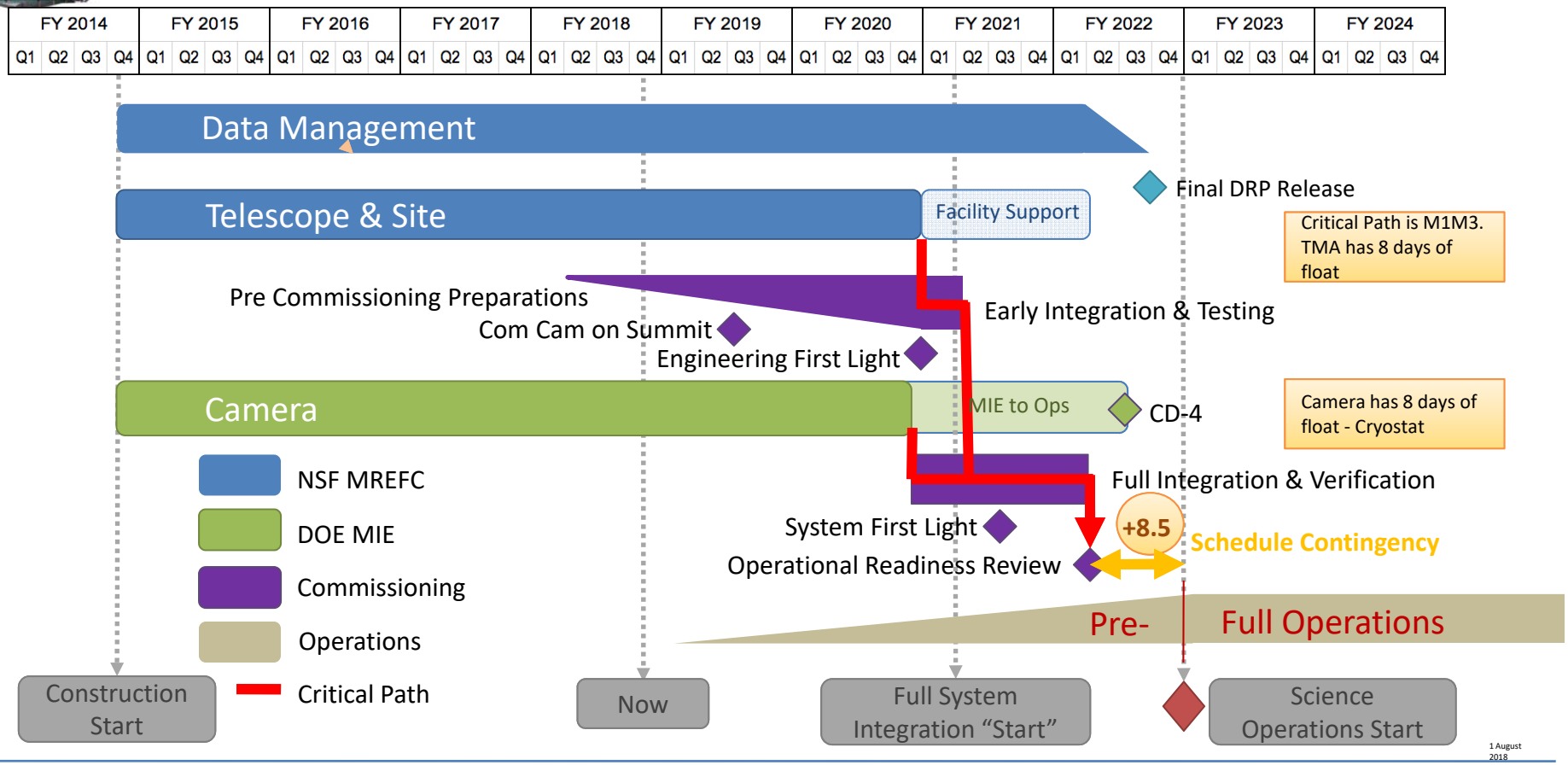
EVMS Executive Summary – July 2018 Data

	MREFC - NSF	LSSTCam – DOE
% Complete (July 2018)	59	85
SPI	0.97	0.97
CPI	0.98	0.97
Contingency	$37.4 M	$6.6M
Contingency % Remaining Work	20	28

Level 2 completion

- DM 44%
- Camera 81%
- T&S 76%
- EPO 29%
- SE / Commissioning 24%

LSST Project Schedule – 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 – Contingencies remain but are tight.
- Challenges and risks remain but LSST is currently on track for successful completion.

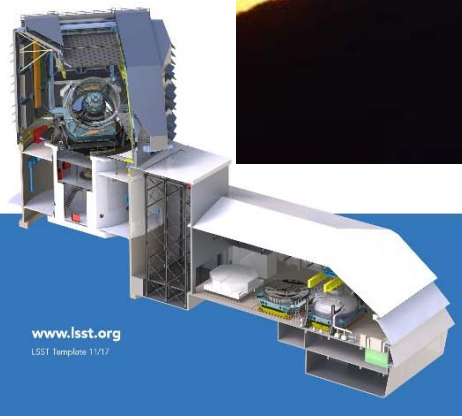
Made possible by an incredible team!


On schedule for First Light in 2021 and start of 10-year Survey in 2022
Photo: Gianluca

Thank You.

LSST Week in Brazil: 24 – 28 September

Wil O'Mullane – Data Management Manager
Tuesday – 25 September 1:30 PM
Ranpal Gil – Senior Manager / Communications
Wednesday - 27 September 1:00 PM
Amanda Bauer – Head of Education and Public Outreach
Wednesday – 27 September 1:45 PM



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LSST Template 11/17

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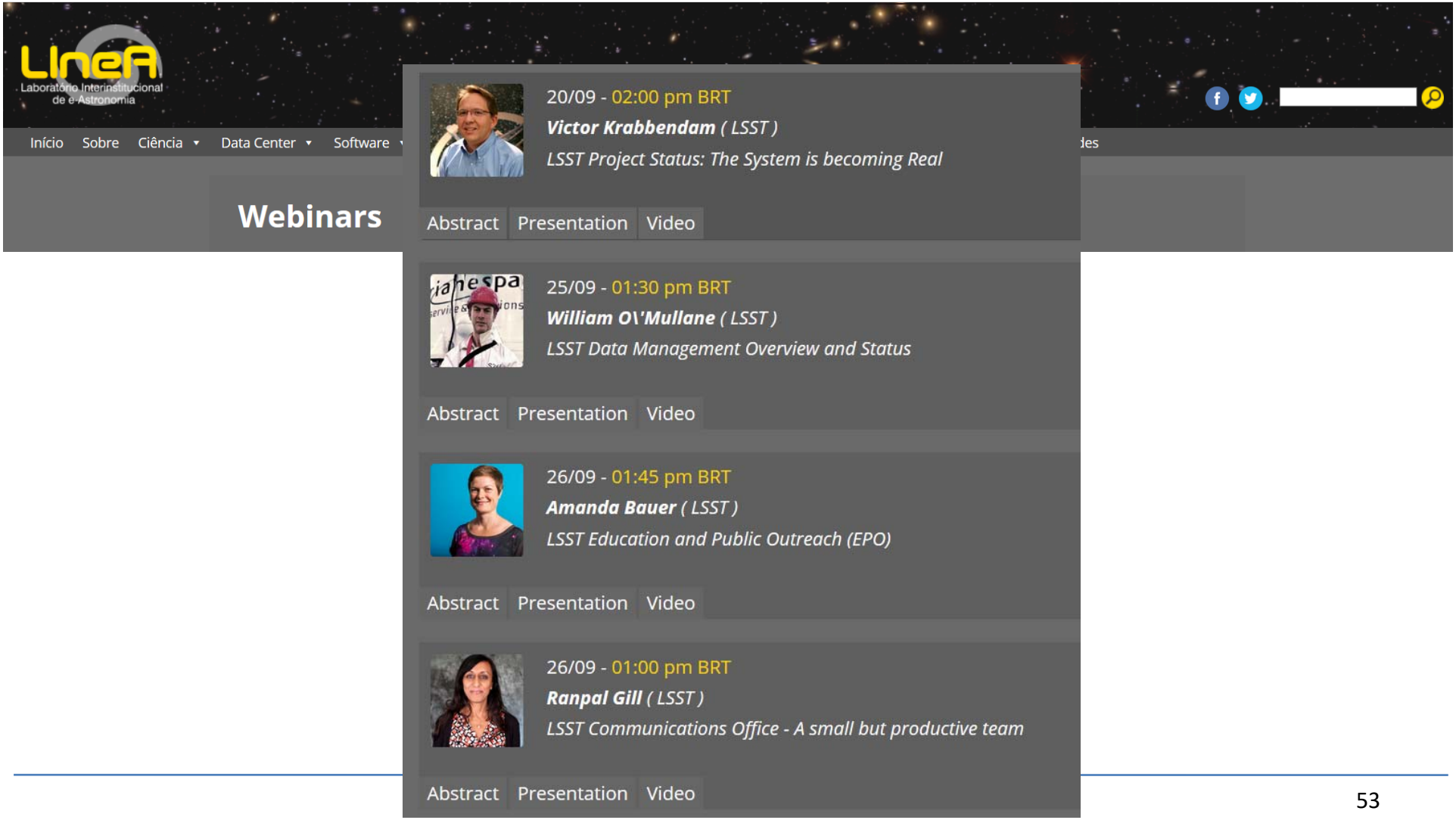
LIneA
Laboratório Interinstitucional de e-Astronomia
Início
Sobre
Ciência
Data Center
Software
Webinars
20/09 - 02:00 pm BRT
Victor Krabbendam (LSST)
LSST Project Status: The System is becoming Real
Abstract
Presentation
Video
25/09 - 01:30 pm BRT
William O\'Mullane (LSST)
LSST Data Management Overview and Status
Abstract
Presentation
Video
26/09 - 01:45 pm BRT
Amanda Bauer (LSST)
LSST Education and Public Outreach (EPO)
Abstract
Presentation
Video
26/09 - 01:00 pm BRT
Ranpal Gill (LSST)
LSST Communications Office - A small but productive team
Abstract
Presentation
Video