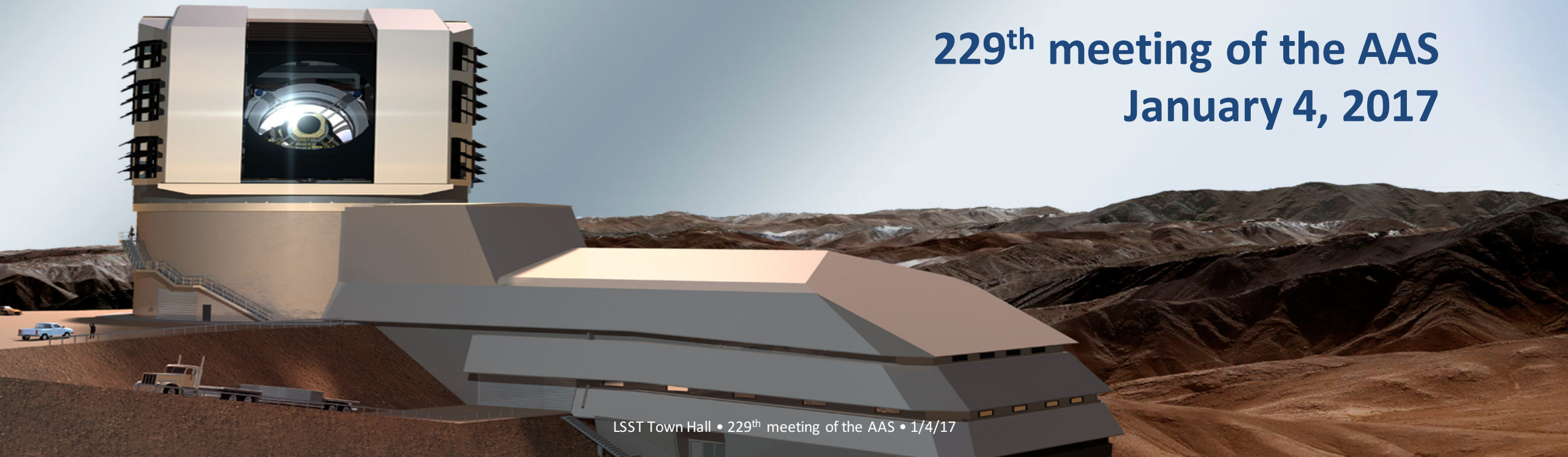


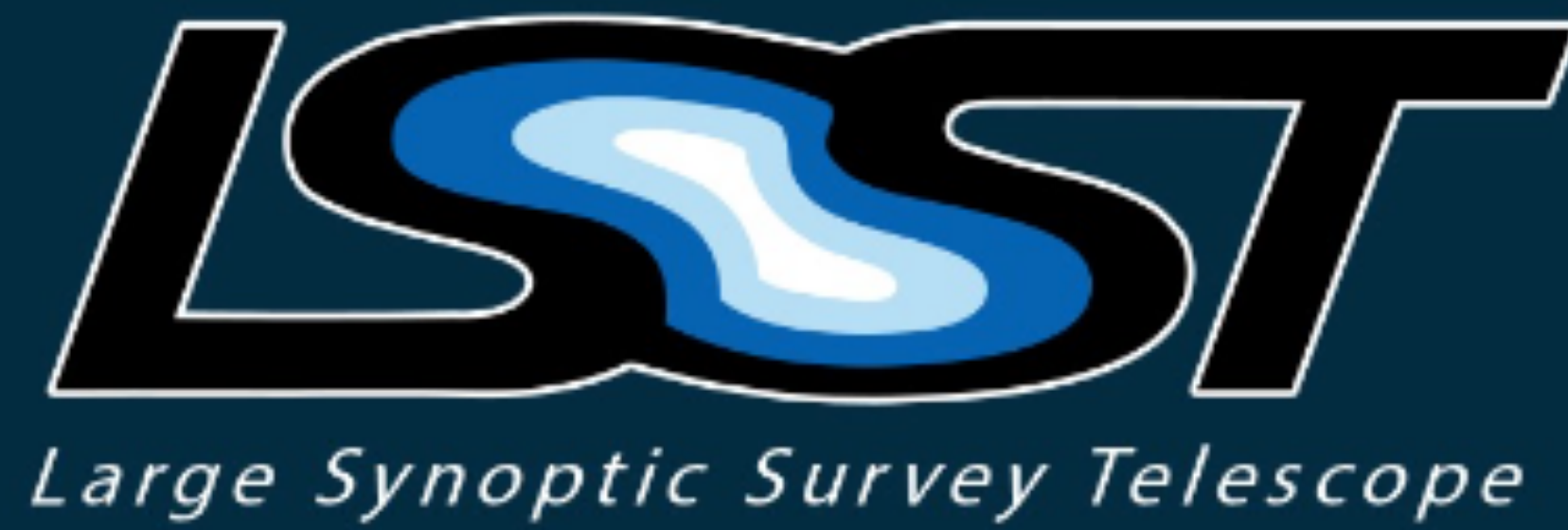


Large Synoptic Survey Telescope Town Hall

Beth Willman
LSST Deputy Director

229th meeting of the AAS
January 4, 2017





LSST PROJECT

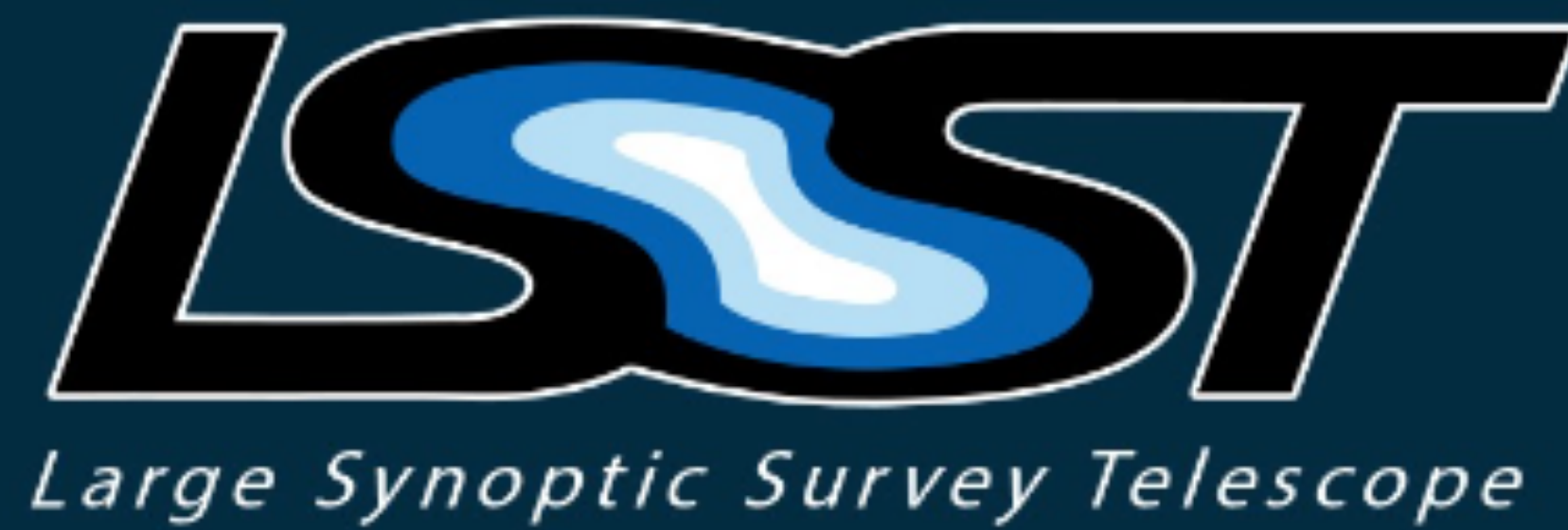
B. Willman

LSST CORPORATION

P. Eliason

LSST SCIENCE COLLABORATIONS

L. Walkowicz



LSST PROJECT

B. Willman

LSST CORPORATION

P. Eliason

LSST SCIENCE COLLABORATIONS

L. Walkowicz

Four LSST Science Drivers



Time domain science

- Nova, supernova, GRBs
- Source characterization
- Instantaneous discovery

Census of the Solar System

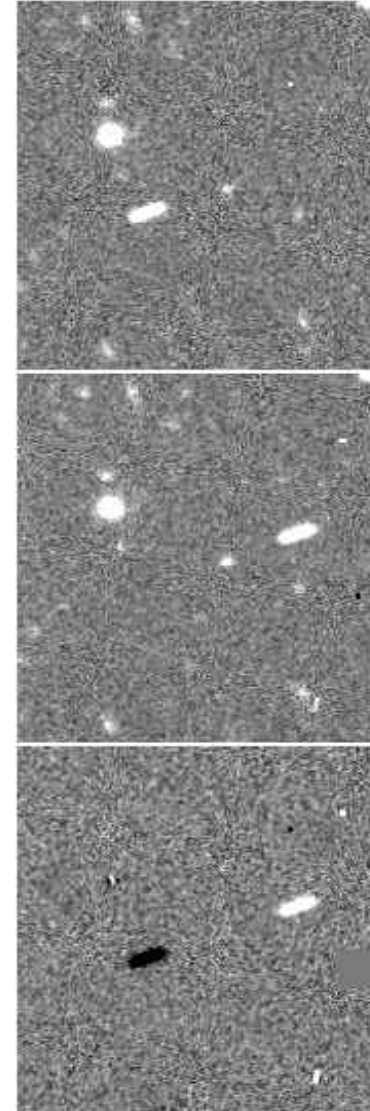
- MBAs, NEOs, Comets
- KBOs, Oort Cloud

Mapping the Milky Way

- Tidal streams
- Galactic structure

Dark energy and dark matter

- Strong Lensing
- Weak Lensing
- Constraining the nature of dark energy



Exposure 1

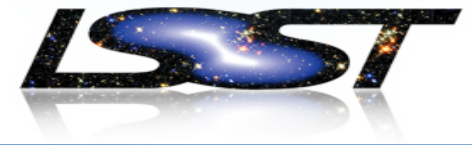
Exposure 2

Exposure 2

-

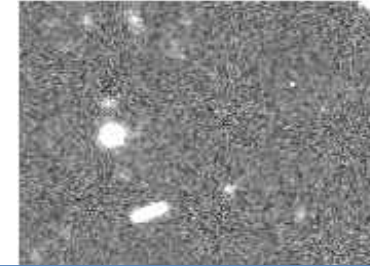
Exposure 1

Four LSST Science Drivers



Time domain science

- Nova, supernova, GRBs
- Source characterization
- Instantaneous discovery



Exposure 1

Census of the Solar System

- MBAs, NEOs, CBOs
- KBOs, Oort Cloud

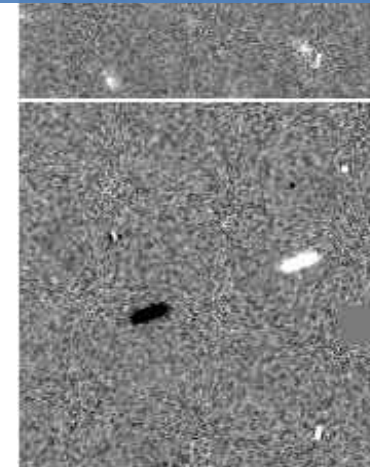
See the LSST Science Book and
Ivezic et al 2008 (arXiv:0805.2366)

Mapping the Milky Way

- Tidal streams
- Galactic structure

Dark energy and dark matter

- Strong Lensing
- Weak Lensing
- Constraining the nature of dark energy



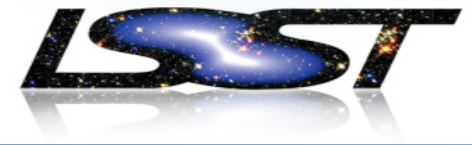
Exposure 2

Exposure 2

Exposure 1

“LSST: From Science Drivers to
Reference Design and Anticipated Data Products”

What is LSST?

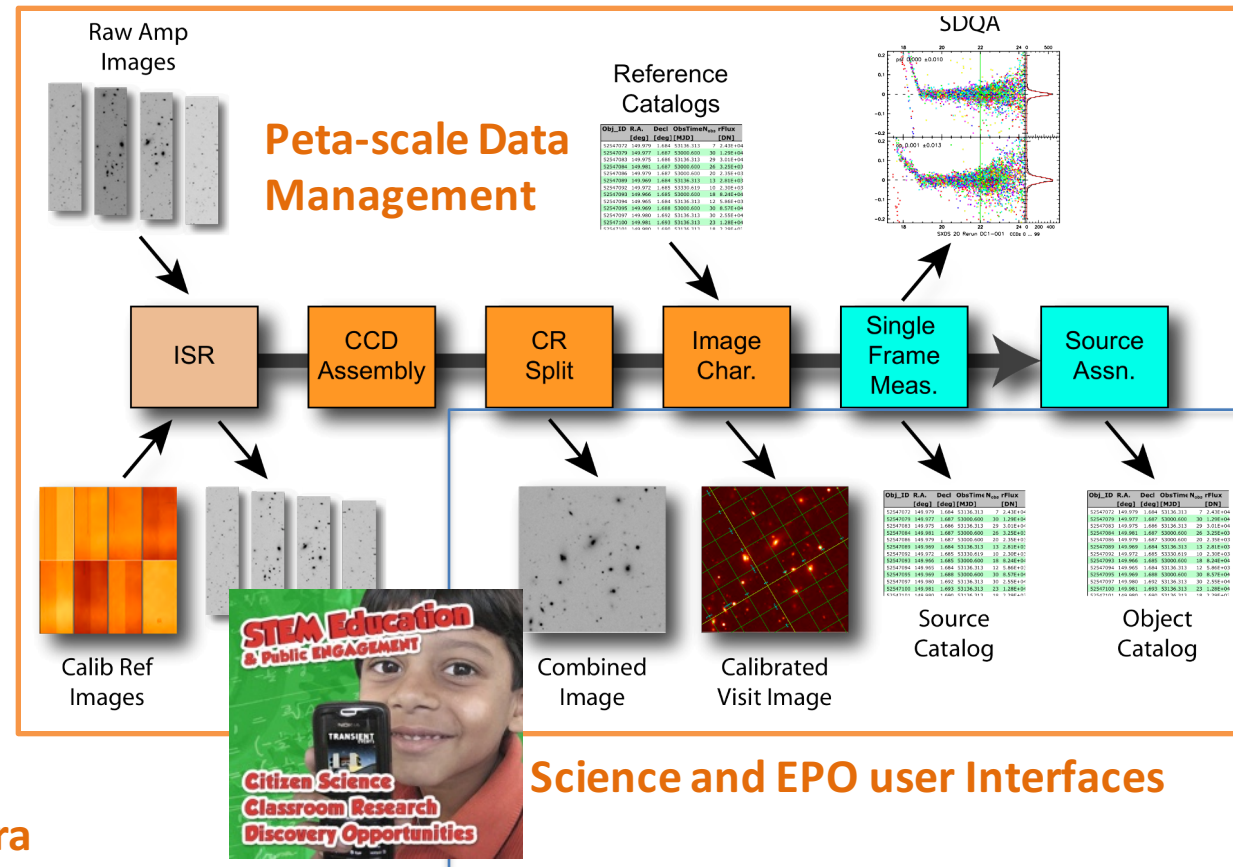


A comprehensive facility that will include: (i) an optical telescope, wide-field camera, 6 broad band optical filters, (ii) a data management system to process, archive, and serve images and data products, (iii) user interfaces.



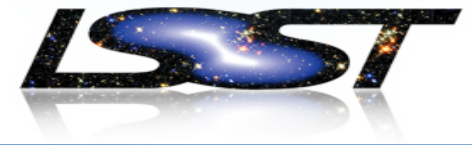
8.4m Telescope

3.2 Gpix Camera



Science and EPO user Interfaces

What is LSST?

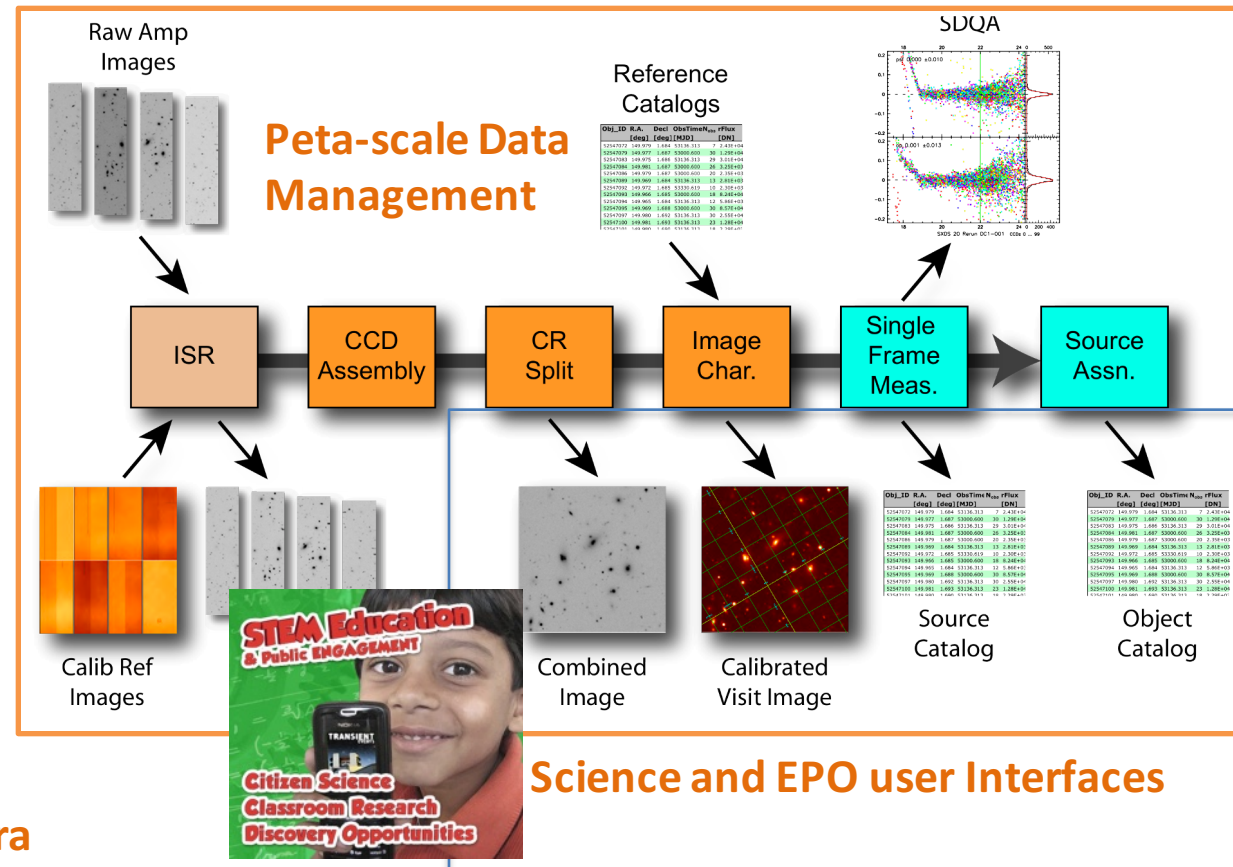


We will deploy this system for a 10 year, time domain survey in Chile covering $> 18,000 \text{ deg}^2$.
Survey will begin ~October 2022.



8.4m Telescope

3.2 Gpix Camera



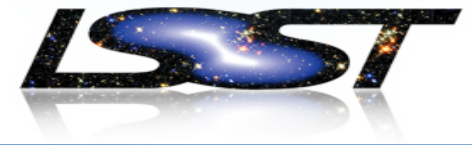
What is the LSST Project?



The LSST Project is the interagency (NSF MREFC and DOE MIE) LSST project that is building LSST, that will commission LSST, and that is developing the Operations Plan.



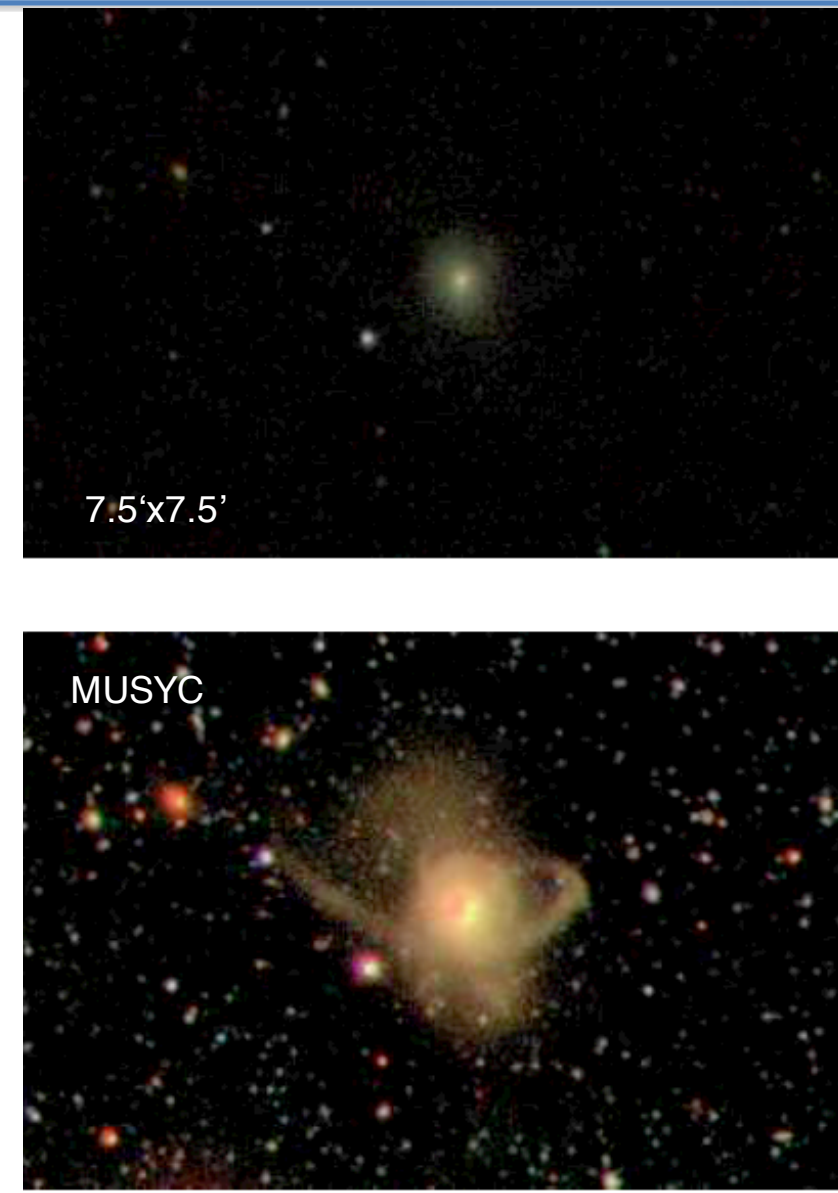
LSST-like Images



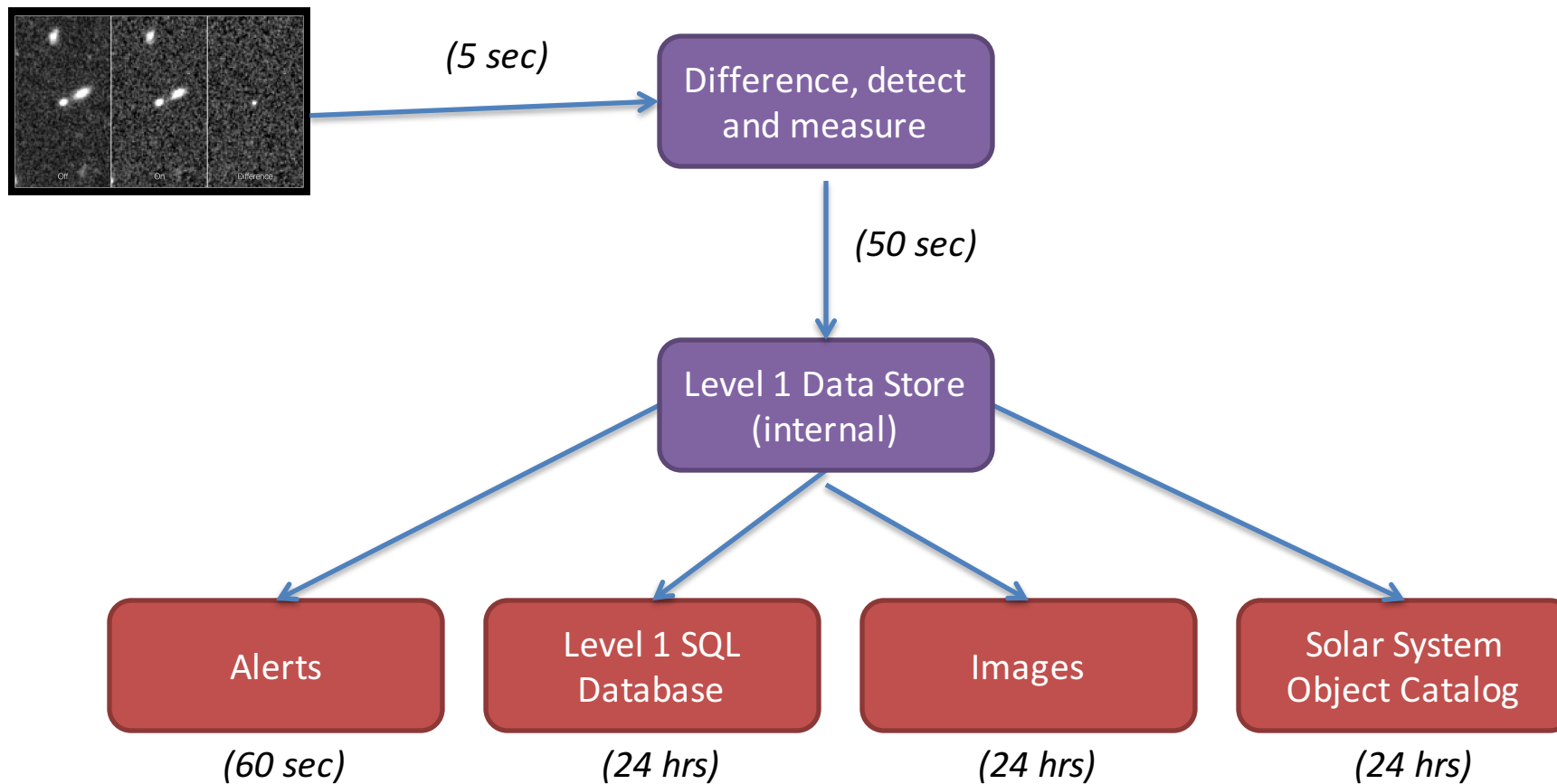
The Deep Lens Survey image is an analog in depth and image quality to a single LSST epoch

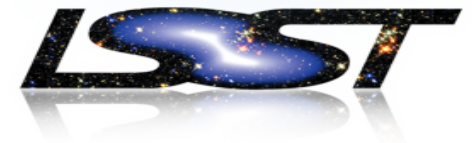


The MUSYC image is ~ 1 mag shallower than the co-added LSST; highlights possible LSB science



For every observation (“visit”):



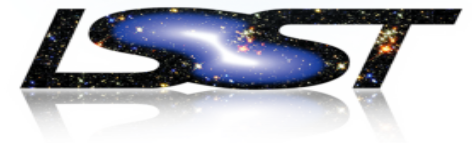


- A stream of ~10 million time-domain events per night, detected and transmitted to event distribution networks within 60 seconds of observation.
- A catalog of orbits for ~6 million bodies in the Solar System.

Nightly

- 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.

Annual



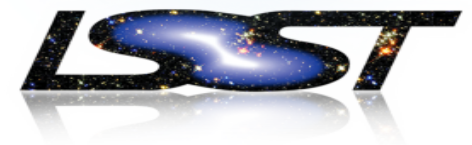
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Nightly

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- Deep co-added images.

Annual

Data products will be available as nightly and annual releases to the LSST community: all US and Chilean scientists, named international contributors.



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

Nightly

Annual

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

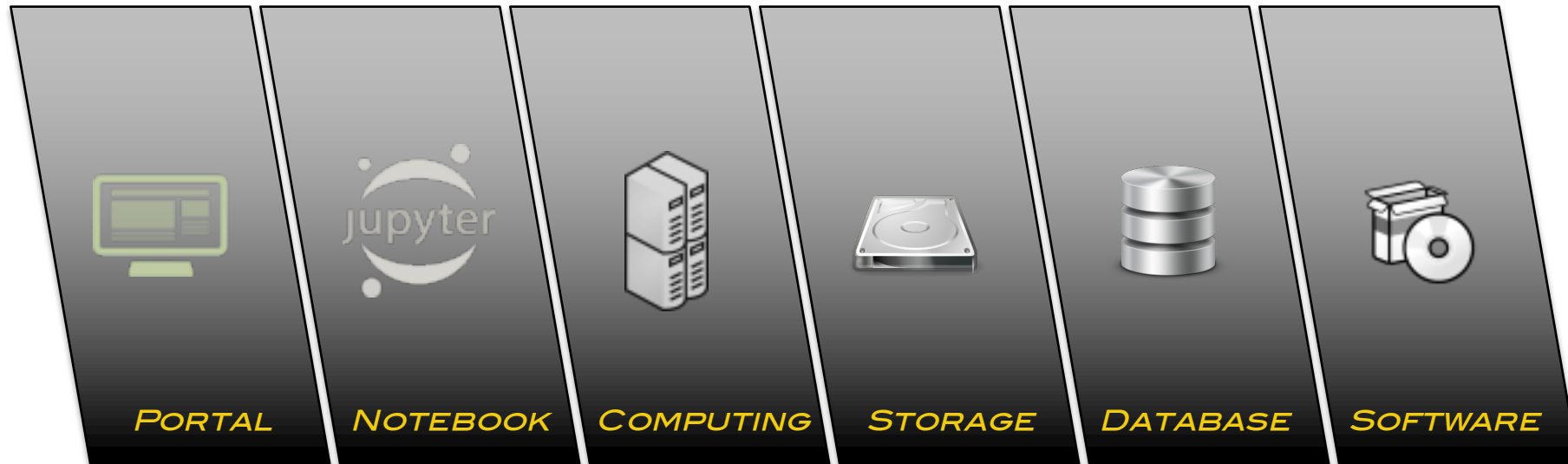
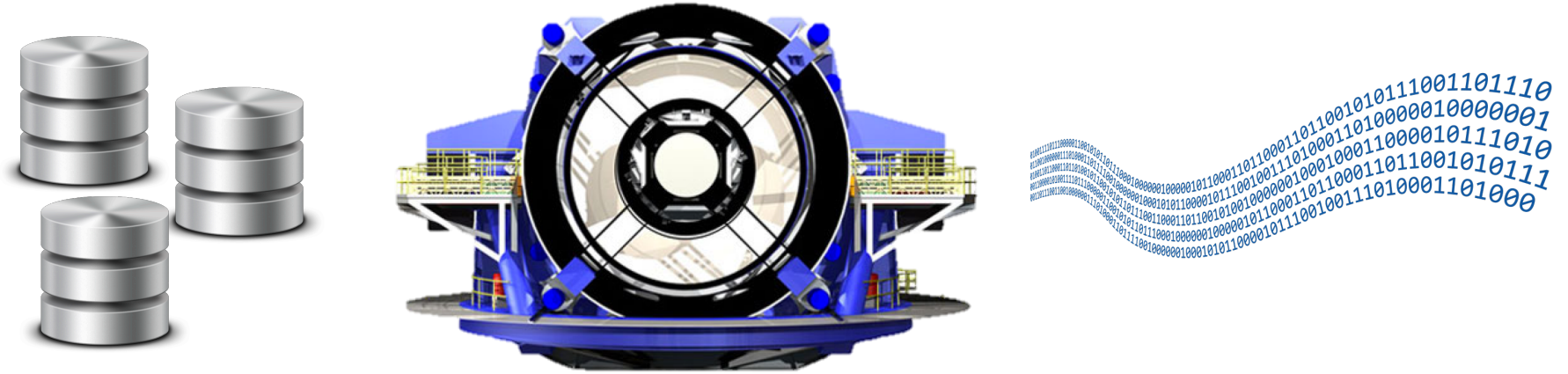
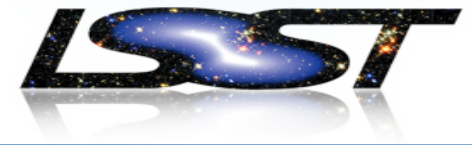


Come to Thursday Special Session 211 on the Value of Astronomical Data and its Long Term Preservation, 10- 11:30 am, Texas 3

I am giving a talk on Curating and Archiving LSST Data Products

The final database will be ~15 PB

Interacting with LSST Data





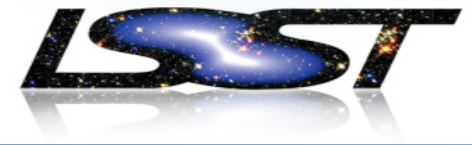
LSST's data products will enable a diverse set of science programs.

Community members will have additional specialized expertise and science cases.

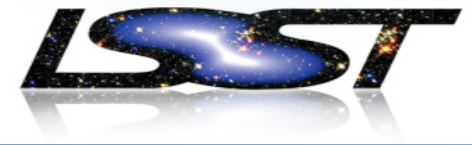
We will make it possible for the community to generate their own data products, directly from the images and/or from further analysis of the nightly and annual catalog data. We will provide:

- Limited end-user analysis and processing at the LSST data center
- User databases and workspaces (“mydb”)

<2 Years Until Summit Facility is Complete

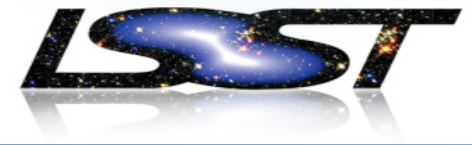


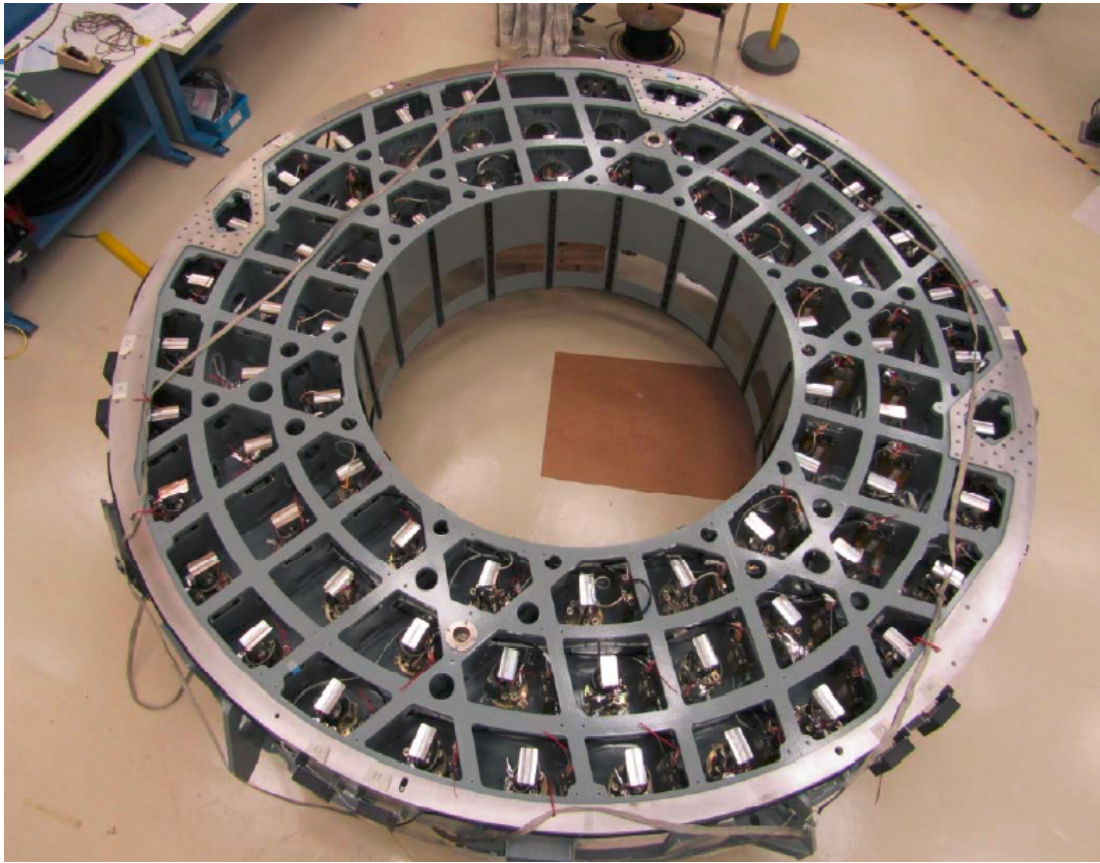
~3 Years Until Commissioning Data



Late 2018 – First calibration data from Auxiliary telescope
Early 2020 – First observations with a commissioning camera
Early 2021 – Scheduler-driven observing with full Camera, SV
October 1 2022 – Full Operations begins

M1M3 cell welded and heat treated





M2 Mirror Cell view from above with all 72 actuators installed

M2 Mirror Cell view from below showing actuator attachments to mirror pads





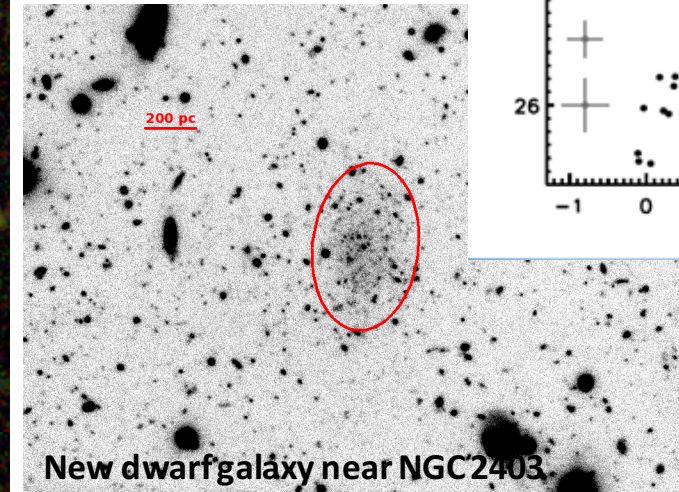
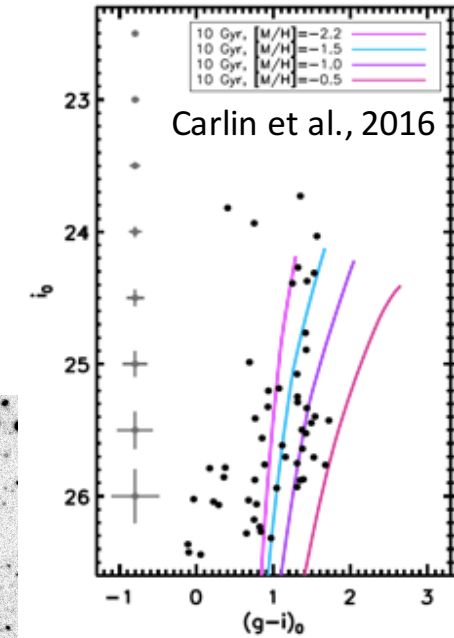
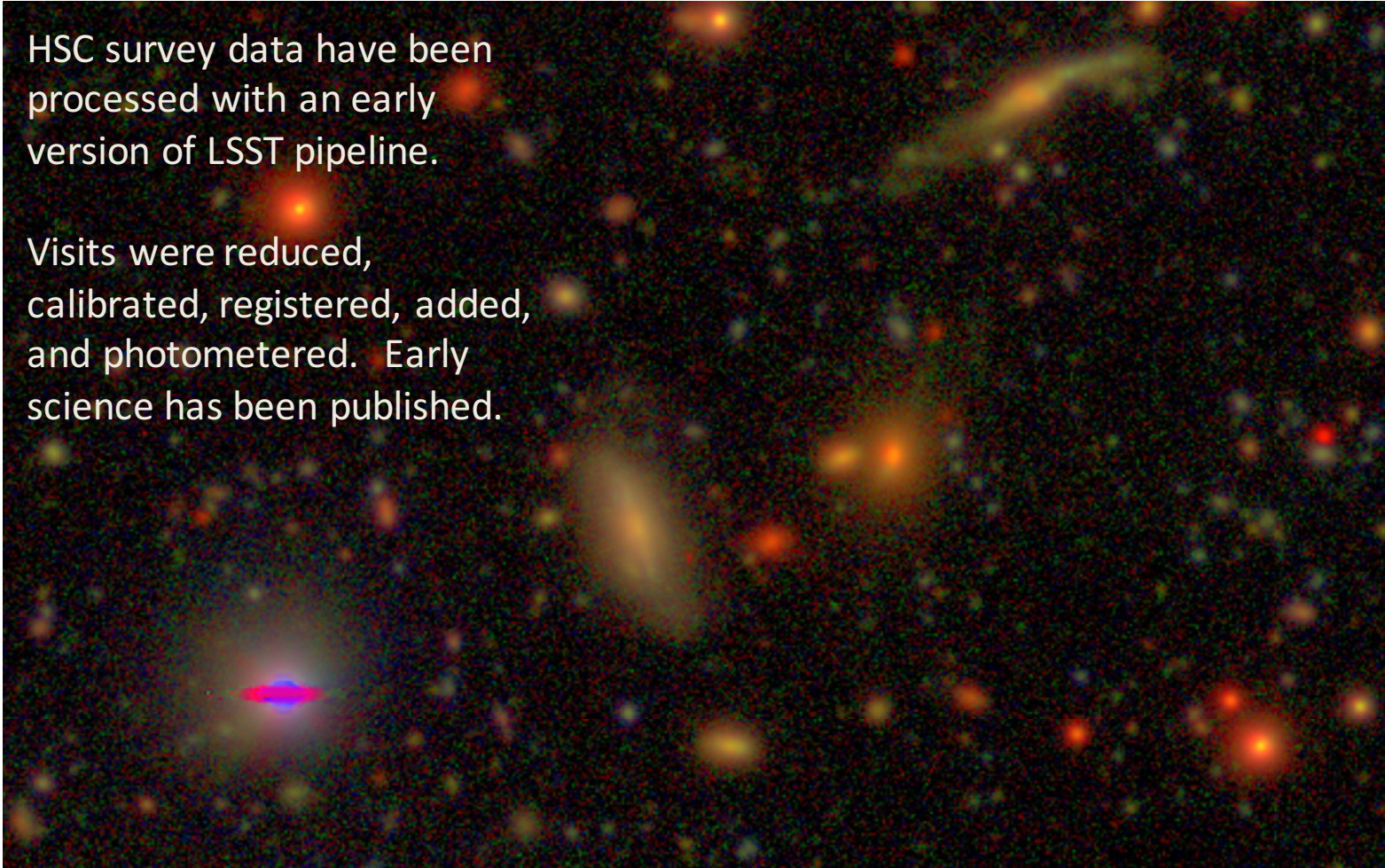
First camera engineering raft has been built

The first science raft that will go into the actual camera will be finished in March 2017

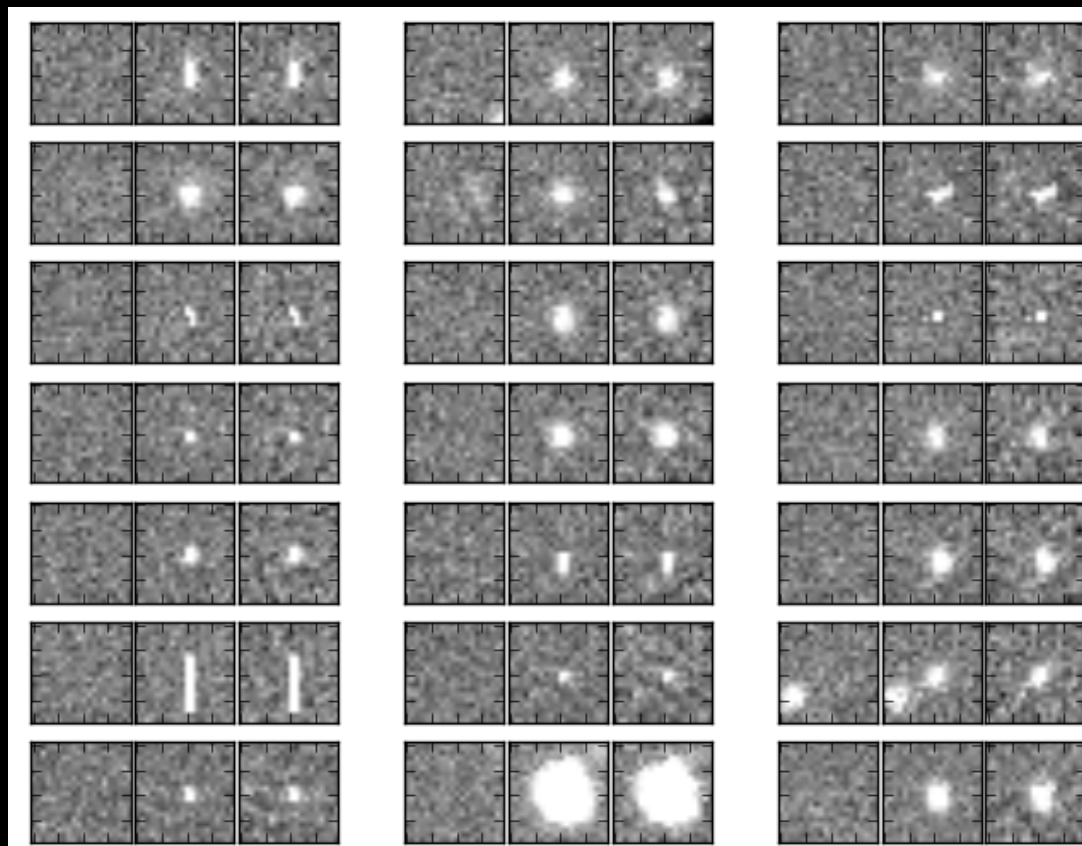
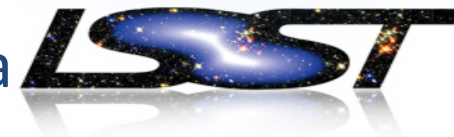
Left: ETU under test in Brookhaven cleanroom

HSC survey data have been processed with an early version of LSST pipeline.

Visits were reduced, calibrated, registered, added, and photometered. Early science has been published.



Early versions of LSST software have also been run on PI observations of Local Volume galaxies.



Exposure 1
Exposure 2
Difference

*Credit: Colin Slater and LSST DM @ U. of Washington
Data courtesy of L. Allen, NOAO*



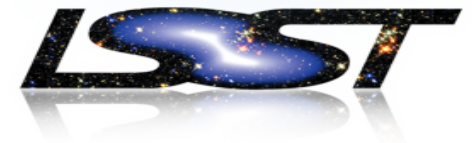
Develop and maintain an inclusive, positive workforce culture

Increase Diversity within the distributed LSST workforce

Improve Project Communication, both inward and outward

- Code of Conduct for LSST communication tools
- Communication and workplace culture surveys in August 2015 + 2016
- Development of manual for handling reports of Bullying and Harassment
- Workplace culture retreat for managers in February 2016
- Plenaries at LSST 2016: Rules of Engagement in Workplace Culture - How to improve trust and communication, How to run effective meetings

Information Resources For the Community



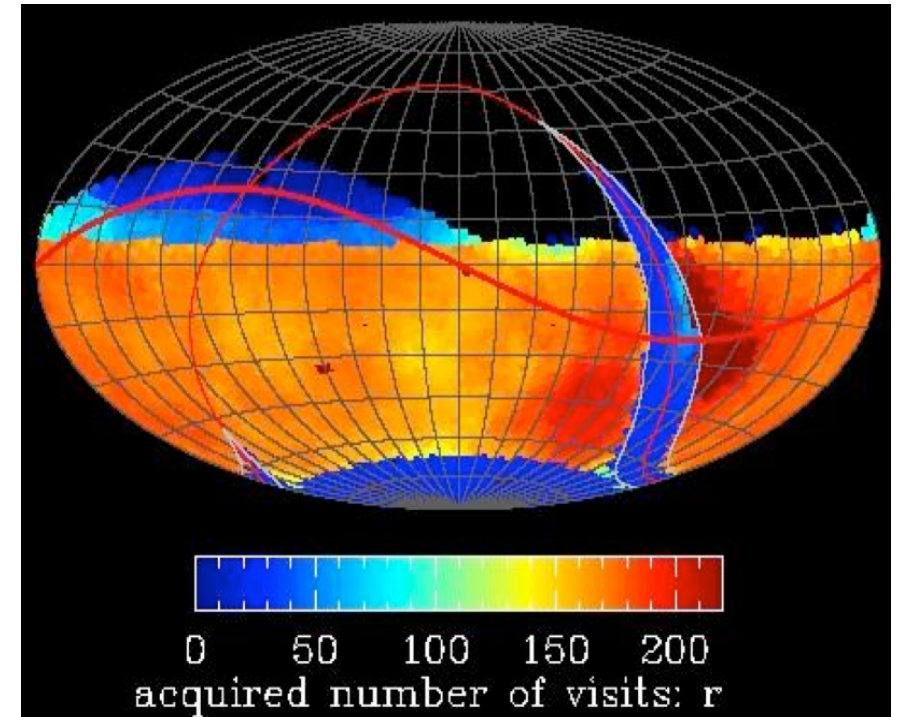
Resource	Description
www.lsst.org	Diverse materials available include: images, key numbers, key project documents, links to simulated data – including simulated observing strategies.
Weekly Digest	A weekly email update with LSST Project and LSST Corporation information sent from the Project out to staff and interested stakeholders in the scientific community. Anyone can sign up at www.lsst.org .
Zenodo.org	An open-access information repository that contains an informal (and incomplete) collection of LSST Data Management technical notes, LSST talks (including this talk and last year's Town Hall talk), and other documents.
Community.lsst.org	A Stack Overflow-like forum with public discussions about a wide-range of LSST-related issues. Both Project and community members participate in discussions and ask questions. This tool is available to everyone. Heavy usage from Data Mgmt and EPO.
lsstc.slack.com	Limited to Instant Messaging application for quick conversations. This tool is limited to project and science collaboration members, plus International PIs and a login is required. Both private and public discussion rooms. Numerous Project and Science users.

LSST's Observing Strategy has not been finalized!

A basic implementation of LSST's 10-year survey can deliver on a wide range of science. The implementation of this strategy can be optimized for science output. We will continue optimizing the Observing Strategy through operations.

Community input on metrics to measure science output of different strategies will be valuable!

We are still developing the process and timeline for decisions about the observing strategy, in collaboration with our Project Science Team and Science Advisory Committee. See community study underway at <http://ls.st/o5k>



Example LSST Observing Strategy.

Study Organizing Committee (SOC):

Joan Najita (Co-chair, NOAO)

Beth Willman (Co-chair,
LSST/University of Arizona)

Douglas Finkbeiner (Harvard)

Ryan Foley (University of Illinois)

Suzanne Hawley (University of
Washington)

Jeff Newman (University of
Pittsburgh)

Greg Rudnick (University of
Kansas)

Josh Simon (Carnegie
Observatories)

David Trilling (Northern Arizona
University)



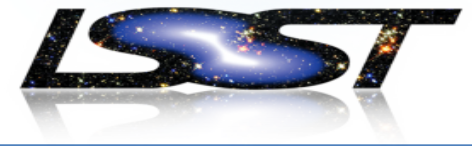
Report posted at
<http://www.noao.edu/meetings/lstt-oir-study/>



Our high priority findings overlap strongly w/ Elmegreen report findings

Diverse facilities with workhorse instruments will enable LSST science. Top recommendations:

- Highly multiplexed, wide-field optical multi-object spectroscopic capability on an 8-m or larger class telescope
- Broad wavelength coverage, moderate resolution ($R = 2000$ or larger) OIR spectrograph [Gemini-S]
- Some high-priority OIR capabilities are currently available, e.g. CTIO/DECam and NIFS on Gemini, among others
- Ensure development and early deployment of time-domain infrastructure
- Study the needs for software science tools and computing resources



Announcement of NSF/MSIP-funded open-access to Las Cumbres Observatory global telescope network

Starting in 2017, U.S. community open-access time will be available on the LCO global telescope network through an NOAO time allocation process. Specific goals for the use of this open-access time are (a) to effectively follow up on current time domain surveys, especially those with public distribution of data and alerts, and (b) to help the community prepare for time domain research in the LSST era by developing relevant programs, methods, and technologies.

There will be a splinter meeting at the Winter 2017 AAS to discuss preparing for LSST with the community time available through this award. Friday January 6, 6:30 pm – 8:00 pm.

See <https://lcogt.net/astronomers/msip/> for more details

Open Positions

Technical

Education Specialist | AURA/LSST | Tucson AZ | Education & Public Outreach

Science Writer | AURA/LSST | Tucson AZ | Education & Public Outreach

Research Associate Physics | Brookhaven National Lab | Upton NY | Camera

Research Programmer | NCSA | Urbana IL | Systems Engineering

OCS Software Developer III | AURA/LSST | Tucson AZ | Telescope & Site

Science

Survey Scientist | AURA/LSST | Tucson AZ | Telescope & Site

Scientific Programmer/Science Data Analyst/DevOps Engineer | AURA/LSST | Tucson AZ | Data Management

Postdoctoral Positions in Software | Princeton University | Princeton NJ | Data Management

Management

Integration and Test Engineering Manager | SLAC | Menlo Park CA | Camera

Camera Project Manager | SLAC | Menlo Park CA | Camera

Data Management Project Manager | AURA/LSST | Tucson AZ | Data Management

Engineering

Telescope Systems Engineer | AURA/LSST | Tucson AZ | Telescope & Site

Senior Software Engineer | SLAC | Menlo Park CA | Data Management



We're Hiring!

We regularly add more positions to our hiring page.

<https://www.lsst.org/hiring/>

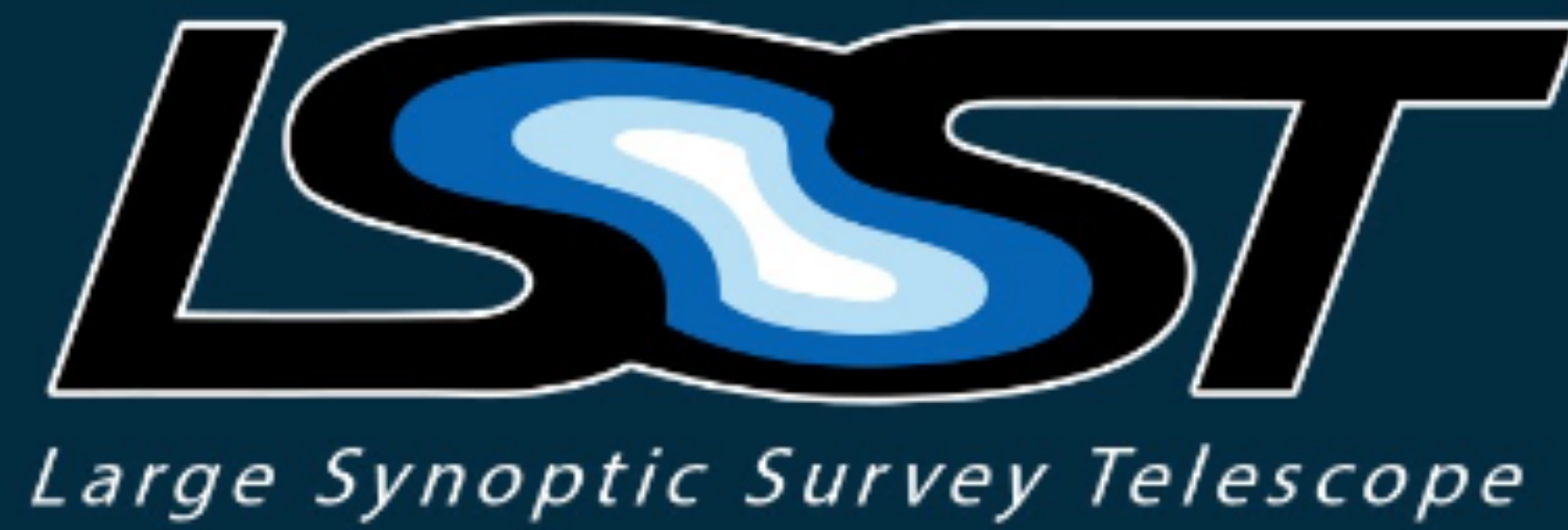
LSST CORPORATION (LSSTC)

Patricia Eliason, LSST Corporation Executive Officer



Large Synoptic Survey Telescope

CORPORATION



LSST PROJECT

B. Willman

LSST CORPORATION

P. Eliason

LSST SCIENCE COLLABORATIONS

L. Walkowicz

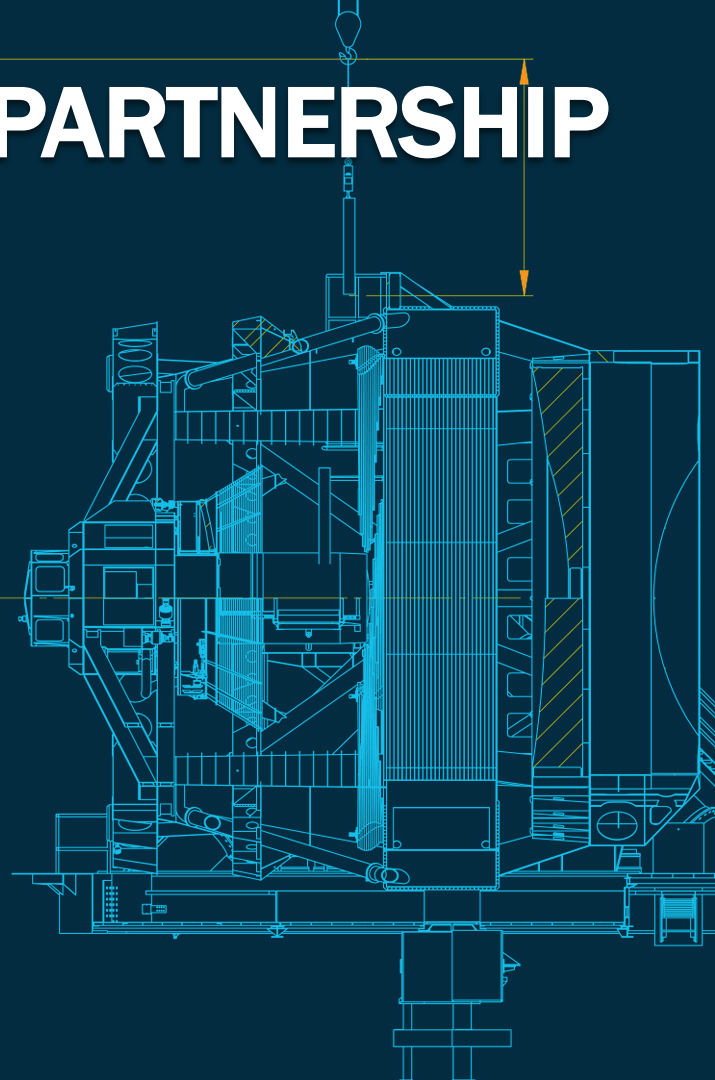
LSST: A PUBLIC/PRIVATE PARTNERSHIP

- LSST Corporation (LSSTC)
- Current Status
- LSSTC Roles & Responsibilities
- Enabling Science



Large Synoptic Survey Telescope

CORPORATION



WHAT IS THE LSST CORPORATION (LSSTC)?

Founded in 2003 as a not-for-profit 501(c)3 U.S. corporation with the purpose to initiate LSST

- More than 35 organizations and individuals started designing and building the LSST as a public-private partnership
- LSSTC was instrumental in getting the project started, stewarding over \$60M of mostly private funds during the early design and development phases
- LSSTC's effort leveraged \$640M in federal funding

LSSTC's MISSION STATEMENT

Advance understanding of the dynamic universe by enabling LSST science through research, education, and outreach

The principal ways the LSSTC will carry out this mission are through:

- Partnering with the federal agencies during LSST construction and operations
- Engaging and representing international contributors in LSST operations
- Enabling the full science exploitation of the unique LSST data set

LSST OPERATIONS

LSST Partnership

- NSF/AURA, DOE/SLAC, LSSTC
- Governance, management, and oversight
- Funding

LSST OPERATIONS

Engage international participation and represent
International Contributors

- Financial agreements between LSSTC and international institutions provide data rights and data access equivalent to those provided to U.S. and Chilean scientists
- Currently 21 countries and over 320 Principal Scientists are participating



LSSTC'S ENABLING SCIENCE PROGRAM

Support people, workshops, training, and scientific research

- Support activities directed at current LSST community needs, such as meetings, workshops, and hack days
- Advocate and fund undergraduate, graduate, postdocs, and early career scientists
- Support LSST science and research

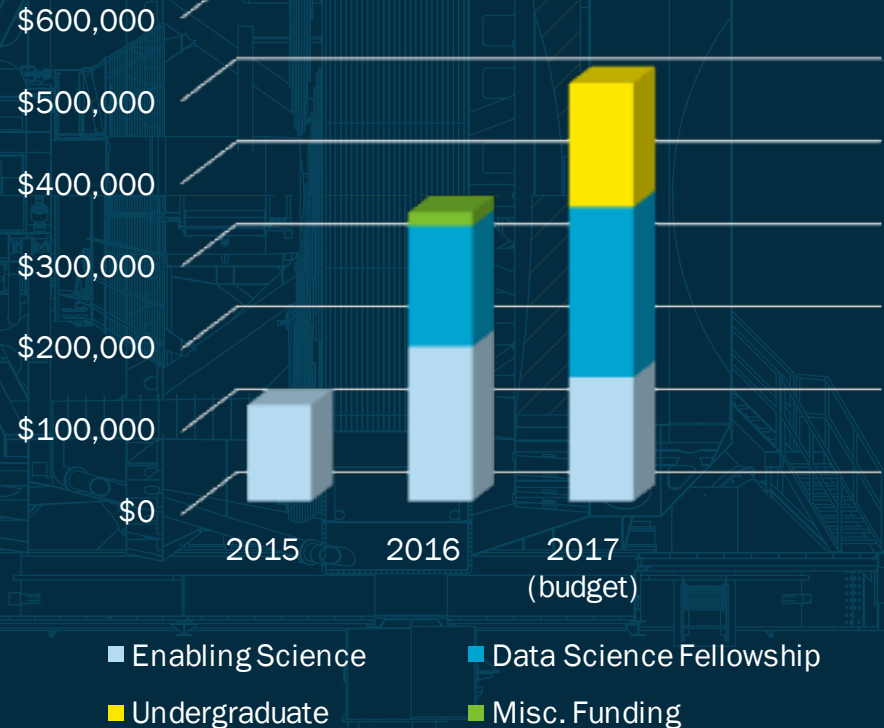


Photo credit: Jocelyn Duffy - Hack Week 2016 at Carnegie Mellon University

ENABLING SCIENCE FUNDING

Corporation's
Funding Support for
Enabling Science
Initiative Continues
to Grow

Enabling Science Expenditures/Budget



DEVELOPMENT, TRAINING, AND EDUCATION

Data Science Fellowship Program

- Two-year program to supplement graduate education in astronomy with data science skills

Undergraduate Internship Program

- Open to undergrads or post-baccalaureate students of any citizenship and not restricted to summer

LSSTC'S ENABLING SCIENCE INITIATIVE



- Annual *Call for Proposals*

www.lsstcorporation.org/activities


- LSSTC Data Science Fellowship Program

www.lsstcorporation.org/fellowship_program

- Developing a Case for Support to fund preparatory science that will target preparatory and impactful LSST science

LSST: A PUBLIC/PRIVATE PARTNERSHIP

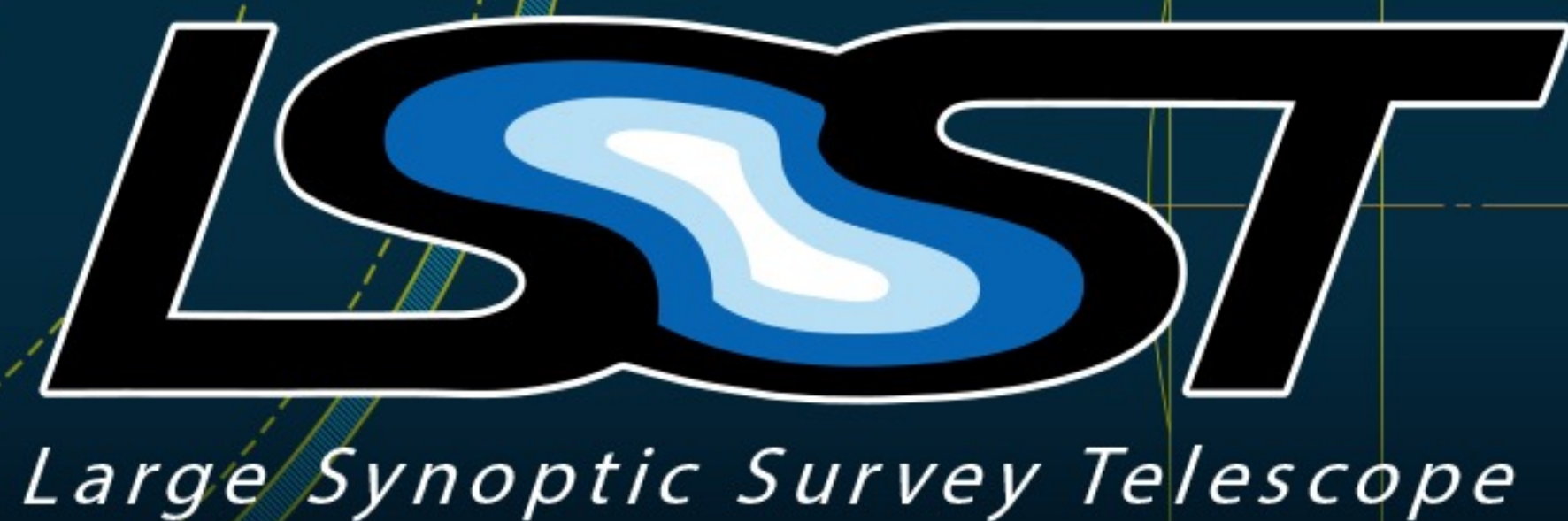
LSST is recognized as a leader in the new astronomical research paradigm of data intensive astronomy and is leading the way to do a new kind of science

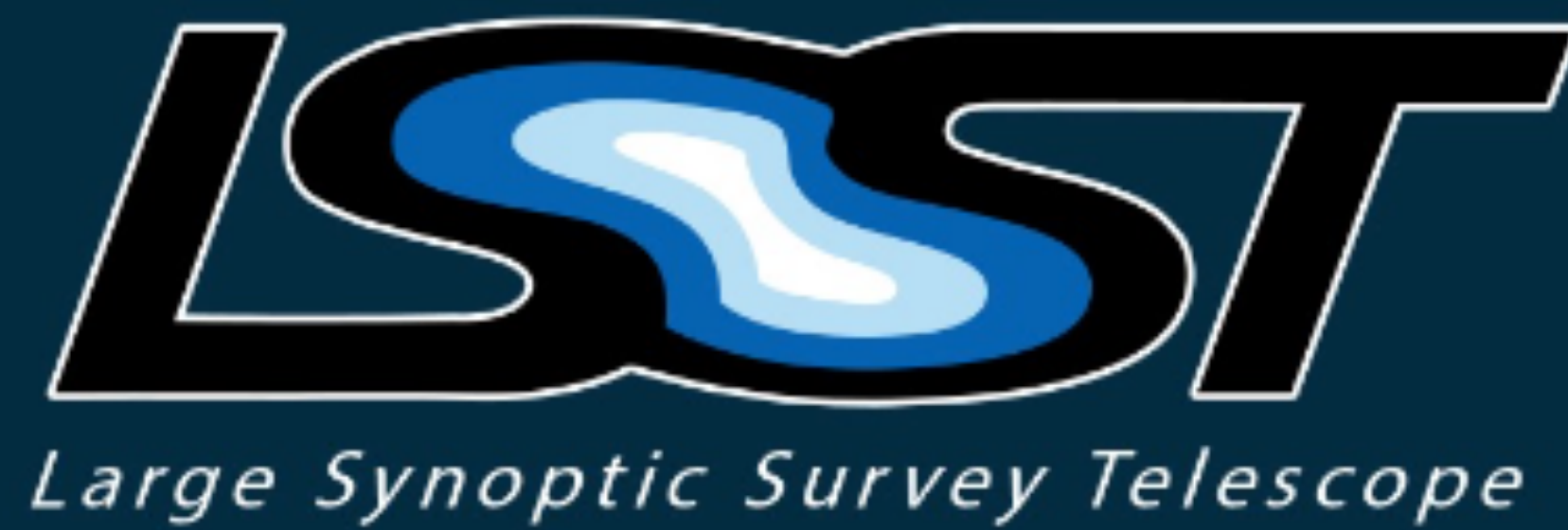
A decorative horizontal bar with a blue and white gradient, resembling a stylized telescope or a light beam, positioned below the first paragraph.

LSSTC's vision is to be a unifying force for LSST science advocacy, development, and support

THE LSST SCIENCE COLLABORATIONS

LUCIANNE WALKOWICZ
LSST SCIENCE COLLABORATION COORDINATOR





LSST PROJECT

B. Willman

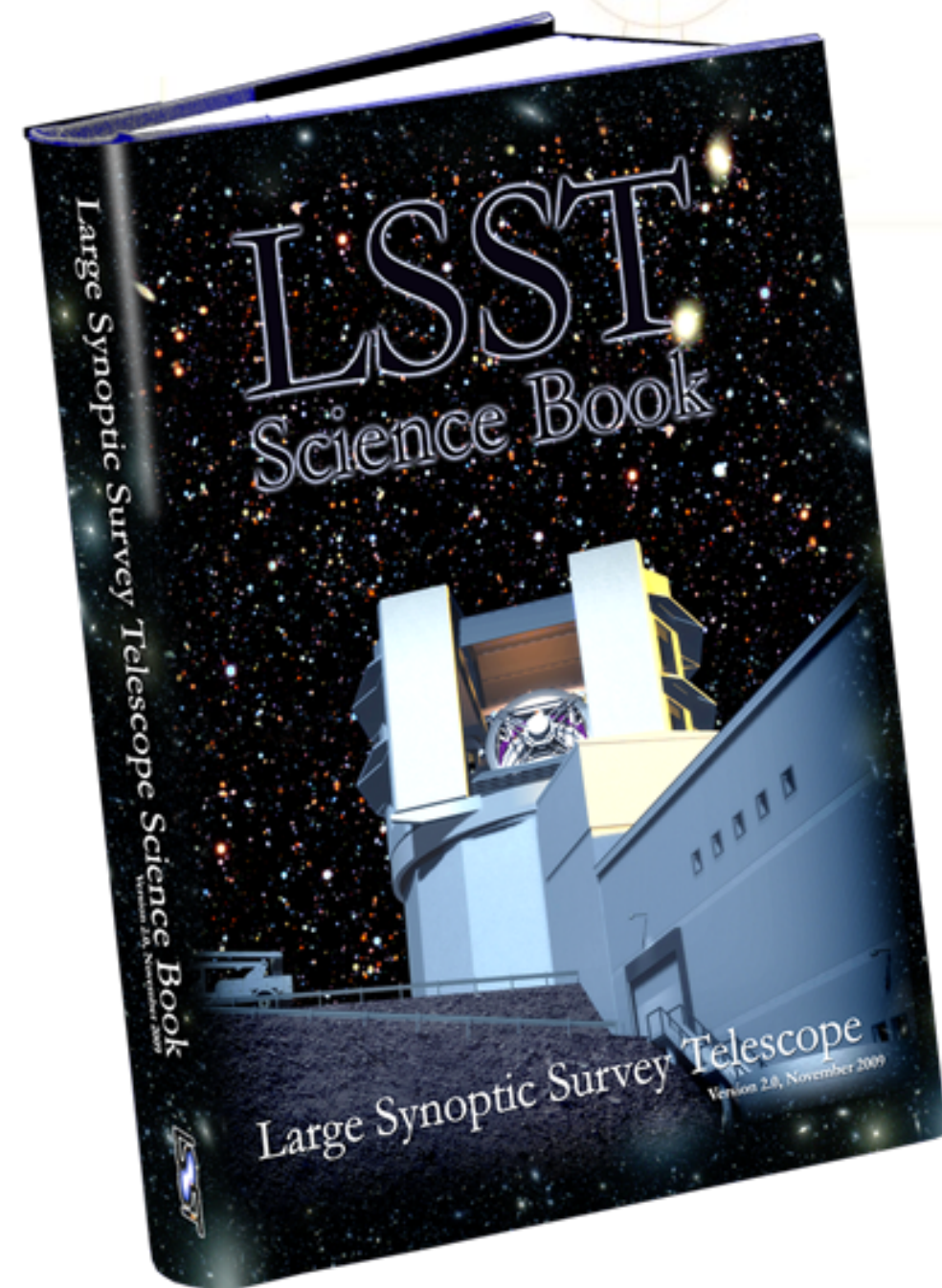
LSST CORPORATION

P. Eliason

LSST SCIENCE COLLABORATIONS

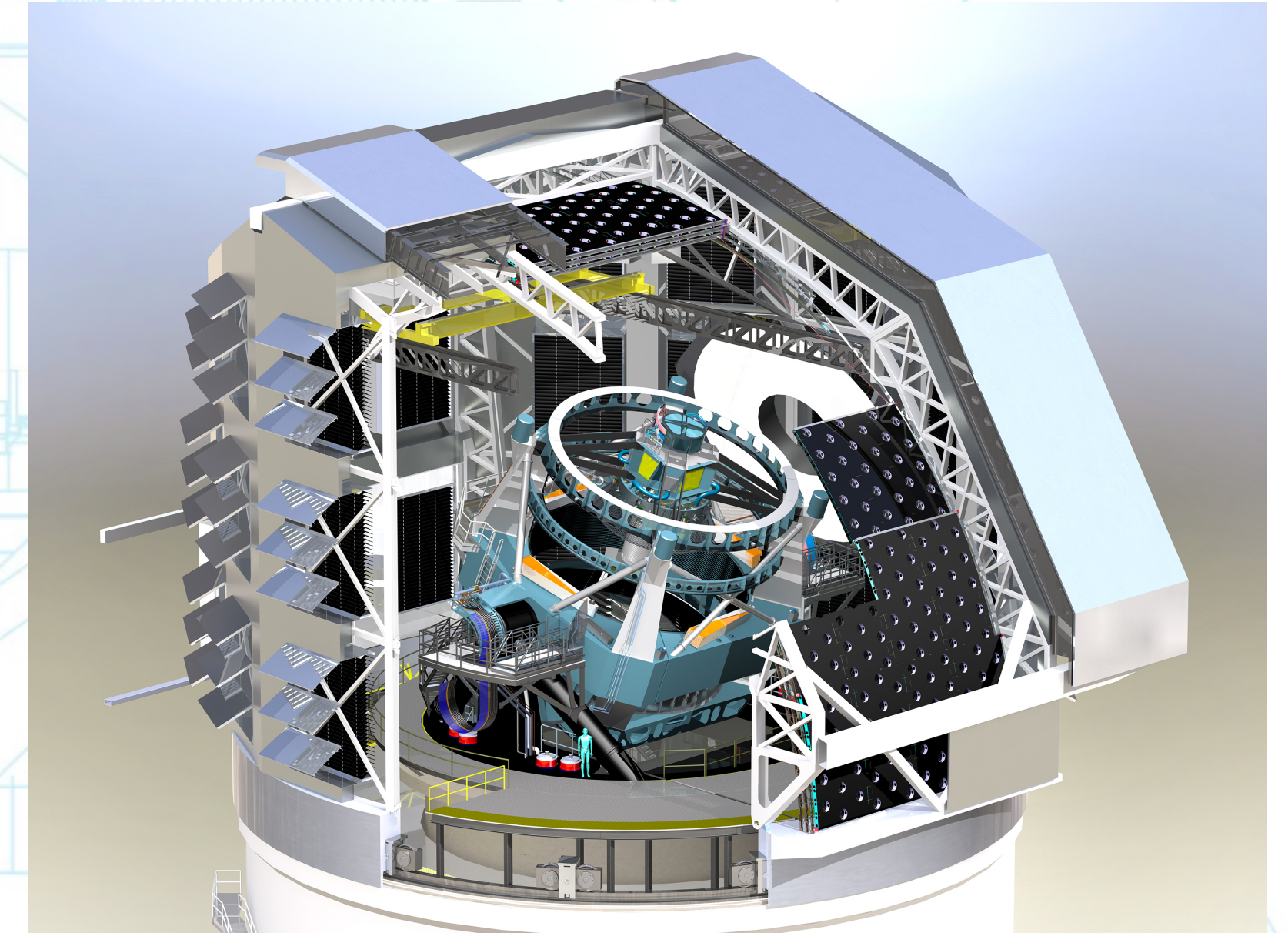
L. Walkowicz

WHAT ARE THE LSST SCIENCE COLLABORATIONS?



Collaborations played
big role in making the
science case for LSST

<https://www.lsst.org/scientists/scibook>



Now they are the user community:
helping prepare for & produce LSST science

WHO MAY BELONG TO A SCIENCE COLLABORATION?



Anyone with rights to LSST data may apply to be a member of the science collaboration of their choice

Science collaborations manage their own membership (and associated rules)

THERE ARE CURRENTLY 8 SCIENCE COLLABORATIONS



Galaxies

Michael Cooper (UC Irvine) & Brant Robertson (UCSC)

Stars, Milky Way & Local Volume

John Bochanski (Rider); John Gizis (U Delaware); Nitya Kallivayalil (U VA)

Solar System

Lynne Jones (UW); David Trilling (NAU)

Dark Energy

Rachel Bean (Cornell) & Jeff Newman (Pitt)

Transients & Variable Stars

Federica Bianco (NYU); Ashish Mahabal (Caltech)

AGN

Niel Brandt (Penn State)

Strong Lensing

Chuck Keeton (Rutgers); Aprajita Verma (Oxford)

Informatics & Statistics

Tom Loredó (Cornell); Chad Shafer (CMU)

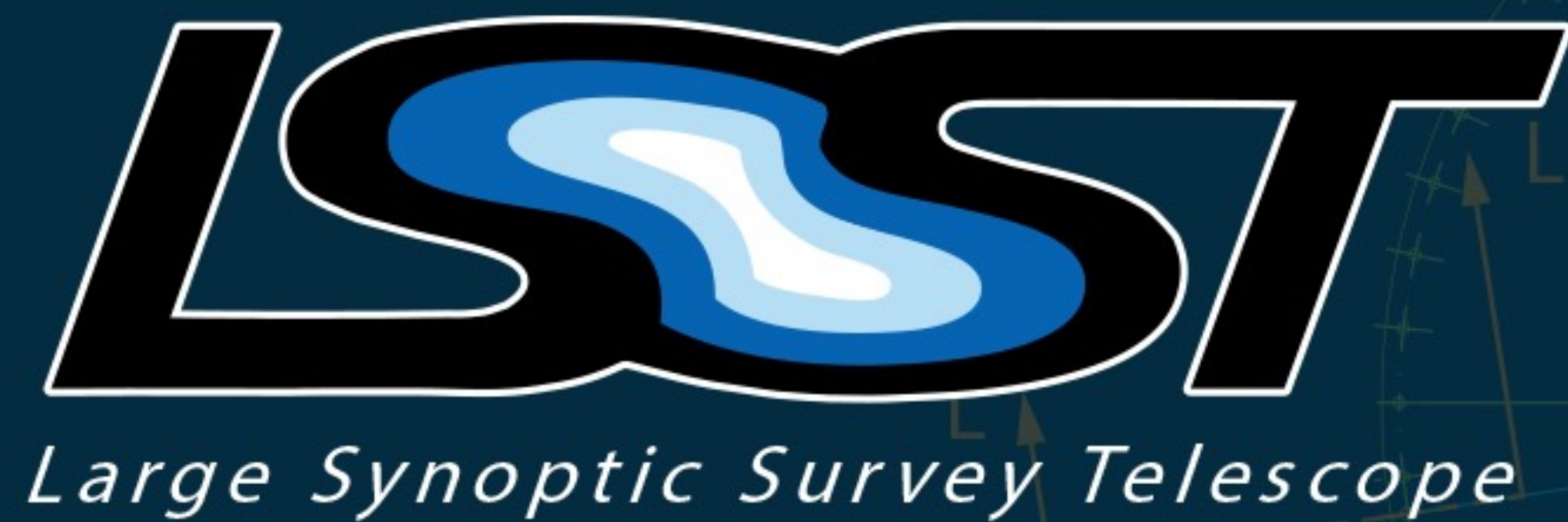
SCIENCE COLLABORATIONS ARE ELIGIBLE FOR ENABLING SCIENCE FUNDING



Science Collaborations may apply for seed funds from the LSST Corporation

LSSTC and the Enabling Science Committee have been instrumental in facilitating science collaboration activities

SO, WHAT ARE THE SCIENCE COLLABORATIONS UP TO?



CROSS-COLLABORATION ACTIVITIES

- Identifying research goals along the path to LSST science
- Developing quantitative metrics for evaluating the LSST Observing Strategy, using LSST simulated operations
- Meeting to foster working collaborations to maximize science with LSST
- Onboarding new membership

FUNDING FOR LSST PRECURSOR SCIENCE



Recent effort in the Science Collaborations to identify major projects prior to first light

Over 30 white papers:
coordinated, complementary efforts
across all collaborations

GALAXIES



Extragalactic Science Road Map



Brant Robertson
(UCSC)



Michael Cooper
(UC Irvine)

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Monthly telecons & an
annual in-person meeting

[https://github.com/brantr/
ExtragalacticScienceRoadmap](https://github.com/brantr/ExtragalacticScienceRoadmap)

AGN



AGN Road Map & contributions to Extragalactic Science Roadmap



Niel Brandt (PSU)

LSST AGN Science Collaboration Roadmap Development Meeting

An Open Splinter Meeting as part of the

229th AAS Meeting, Grapevine, TX

Tuesday, January 3, 2017, 9:00 AM - 6:00 PM; Appaloosa 2 (Gaylord Texan Resort & Convention Center)

The goals of the meeting are to: 1) start the development of a comprehensive Roadmap for the Active Galactic Nuclei (AGN) Science Collaboration of the Large Synoptic Survey Telescope (LSST), presenting a coherent vision for AGN research pre- and post-LSST commissioning, 2) form dedicated Working Groups within the Science Collaboration who will work on specific projects described by the Roadmap, 3) explore funding opportunities to support the highest-ranked projects described by the Roadmap, and 4) encourage eligible active extragalactic researchers to join the

Bootstrapping current &
near-term data:

Deep Fields & Stripe 82;
DES, PanSTARRS,
SUMIRE,
LSST

DARK ENERGY (DESC)

Particle physics-style collaboration focused on cosmology

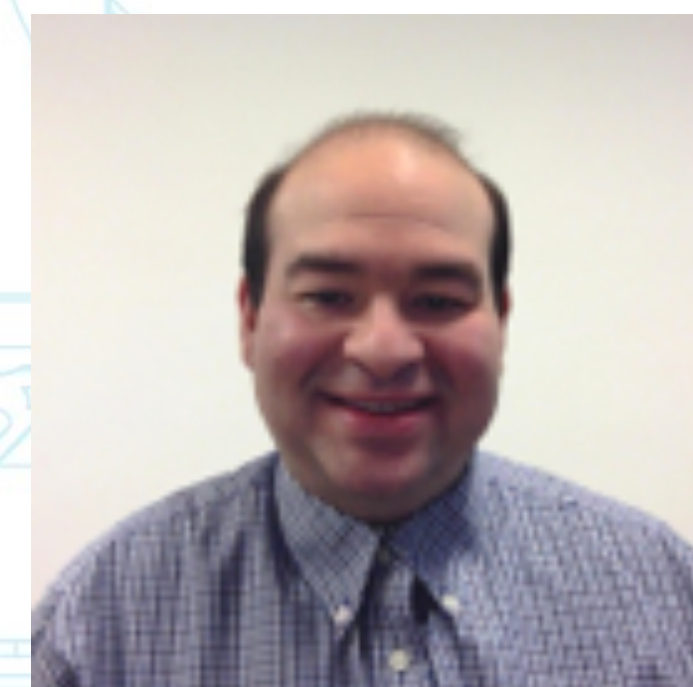
Current focus on **Data Challenges:**

using simulated data for working groups to build & test individual analysis pipelines

Activities structured around the
DESC Science Roadmap (available online)



Rachel Bean
(Cornell)



Jeff Newman
(Pitt)



Also:
DESC Hack Weeks,
DE School,
in-person meetings

INFORMATICS & STATISTICS



SAMSI ASTRO:

Year-long program on Statistical, Mathematical and Computational Methods for Astronomy (ASTRO)



Chad Schafer
(CMU)

Time Series Analysis for Synoptic Surveys and Gravitational Wave Astronomy
March 20-23 2017, ICTS, Bengaluru, India



Tom Lored
(Cornell)

Astrophysical Population Emulation and Uncertainty Quantification
April 3-7, 2017 at SAMSI, Research Triangle Park, NC

TRANSIENTS & VARIABLE STARS



Ashish Mahabal
(Caltech)

Heavy involvement in SAMSI:ASTRO WG2 on synoptic survey stats/ML topics, esp. focusing on transient classification (including upcoming data challenge)

LSSTC proposal topics ranging from SN science, software development for LSST follow up, visualization of LSST transient classes, hackathons, and transient challenge, &c.

+ regularly-held virtual meetings



Federica Bianco
(NYU)

SOLAR SYSTEM

Evaluating LSST User Interface performance on comet studies

Studying how cadence choices affect NEO recovery performance

ls.st/o5k



Lynne Jones
(UW)



David Trilling
(NAU)

Science-Driven Optimization of the LSST Observing Strategy

A community white paper about LSST survey strategy ("cadence"), with quantifications via the Metric Analysis Framework. We are drafting some individual science cases, that are either very important, and somehow stress the observing strategy, and describing how we expect them to be sensitive to LSST observing strategy. MAF metric calculations are then being designed and implemented - we started this during the 2015 LSST Observing Strategy Workshop (in Bremerton, WA, August

STARS / MILKY WAY / LOCAL VOLUME



Developing pipeline for crowded fields

Nitya Kalivayalil
(U Virginia)



Working on star-galaxy separation at LSST depths

John Bochanski
(Rider)



Testing and verifying astrometry

John Gizis
(U Delaware)



STRONG LENSING



New leadership!

Contributing to Extragalactic Science Roadmap

Joint collaboration meetings with DESC-SLWG

Work on Lens finding (citizen science, machine learning) & modeling (methods, candidate lens screening) ongoing



Aprajita Verma
(Oxford)



Chuck Keeton
(Rutgers)

UPCOMING MEETINGS



Enabling Dark Energy Science with the LSST Through Interactive Dark Energy Schools and Hack Days - 13 February 2017; SLAC

Discovering the Unexpected, 27 Feb - 2 Mar, 2017; STScI

Blind Analysis in High-Stakes Survey Science: When, Why, How? - 13-15 Mar 2017, SLAC

Brokering Workshop, 22-26 May 2017, NOAO

SNe Workshop, 31 May - Jun 2, 2017; Northwestern University

Workshop on LSST Detection of Optical Counterparts of Gravitational Waves 2017;
Columbia University

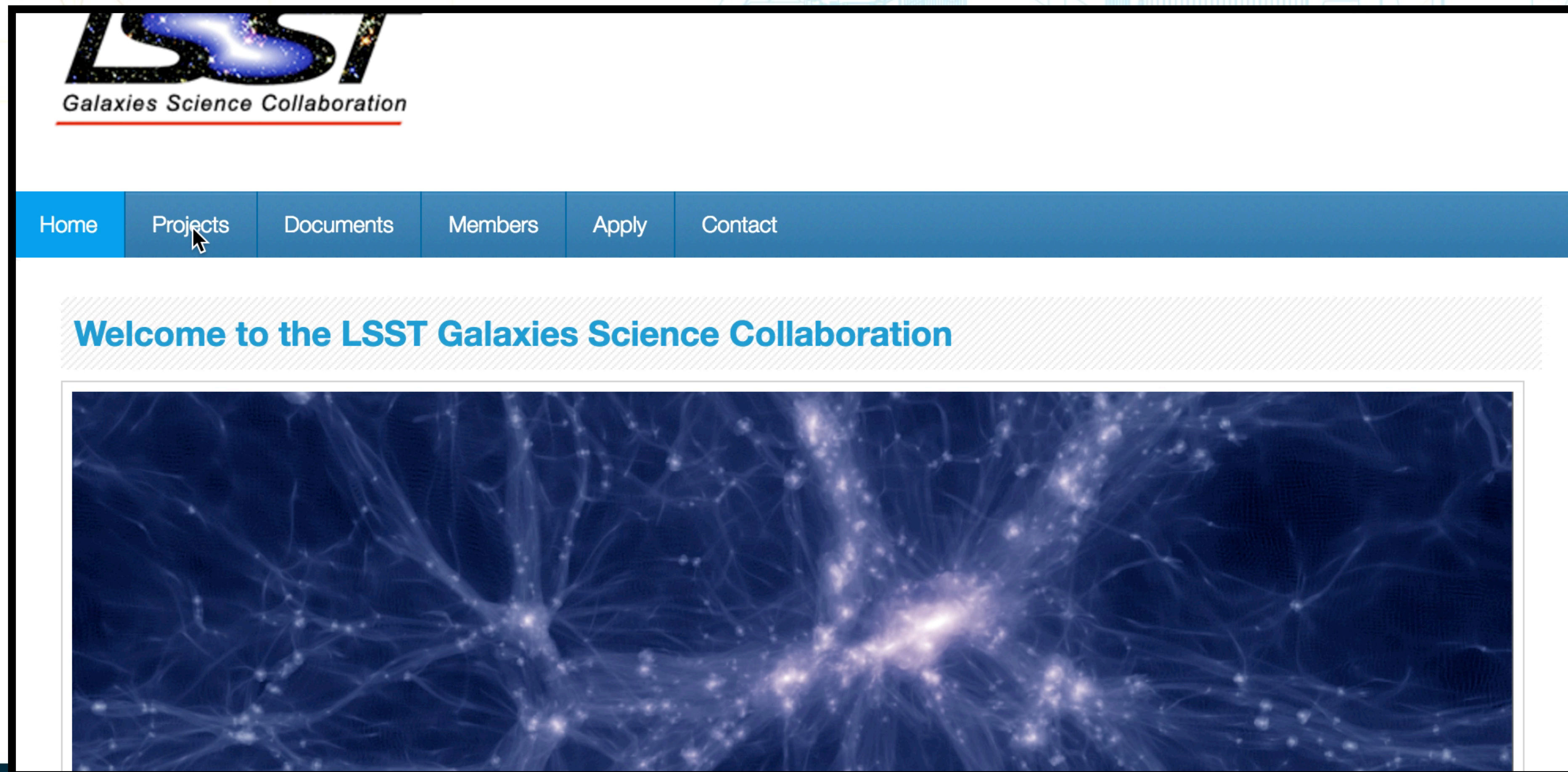
WHERE DO I LEARN MORE?



Large Synoptic Survey Telescope

https://www.lsstcorporation.org/science-collaborations

Example: LSST Galaxies Collaboration Webpage



community.lsst.org

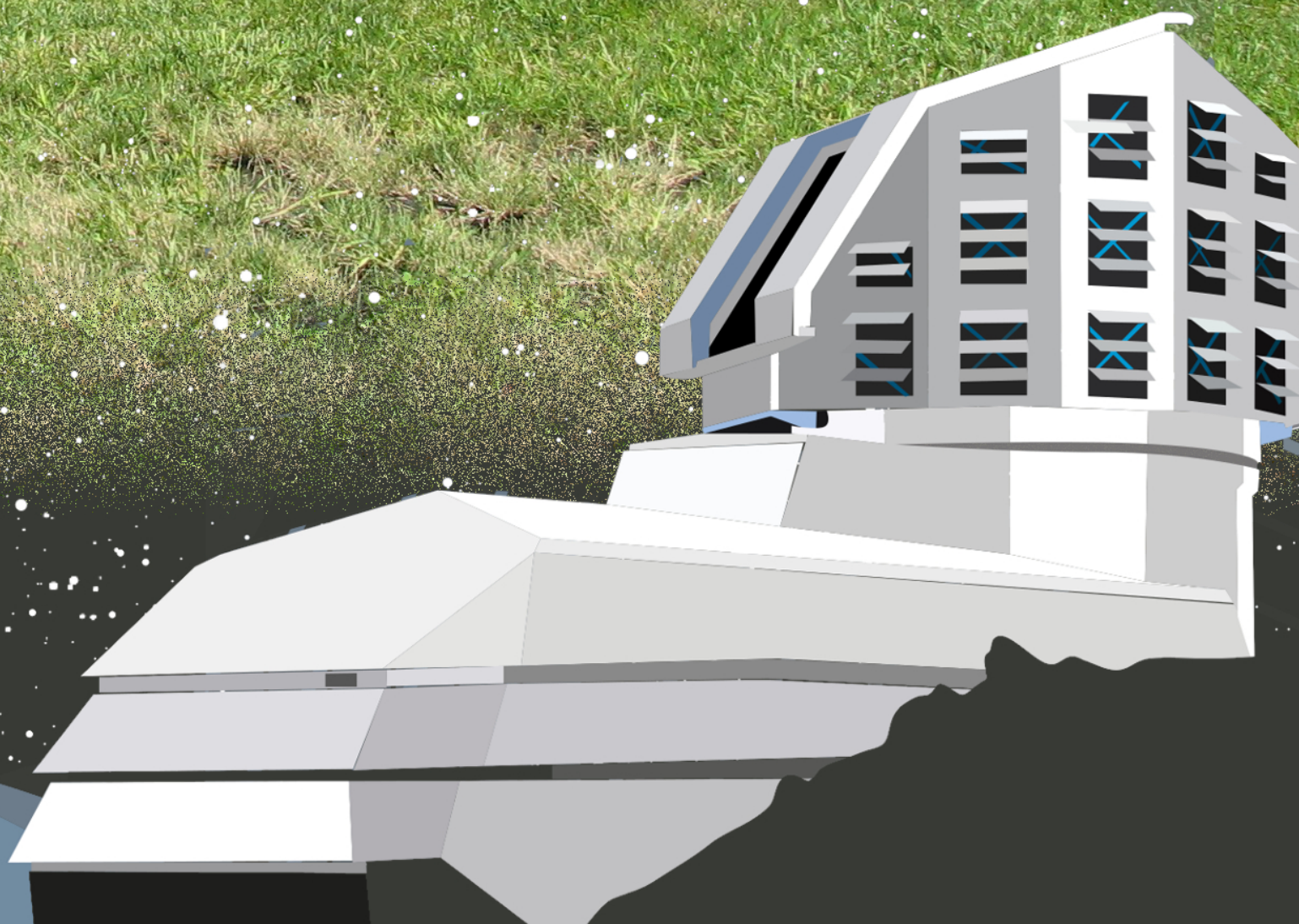


LSST Community						Sign Up	Log In	Q	≡
Topic	Category	Users	Replies	Views	Activity				
Welcome to community.lsst.org community.lsst.org is a place for the astronomy community to discuss the Large Synoptic Survey Telescope's ongoing development and get help with using LSST's software today. What's here Community members can read, pos... read more	Meta		2	784	Aug '15				
DM Monthly Status Report for May	DM Notifications		0	19	1d				
Building obs_decam	Support		27	110	1d				
How to subsection a butler data repository butler	Data Management		13	68	2d				
DM Highlights 2016-06-08 to 2016-06-14 dm-highlights	DM Notifications		0	19	2d				
Winter / Extra 2016 Release - Status and Discussion square, stack-releases	Data Management		10	242	2d				
Installing Science Pipeline for LSST@Europe conf. tutorials, issue with conda	Support		4	33	2d				
17 June Visualization meeting	Camera-DM Visualization		0	22	2d				
Testing obs_decam and obs_cfht	Data Management		8	170	2d				

LSSTC DATA SCIENCE FELLOWSHIP

2 year program to
supplement graduate
education in astronomy
with data science skills

Admissions for next
student cohort open in
Feb 2017



THE LSST COMMUNITY IS ACTIVE & THRIVING!



WHO MAY BELONG TO A SCIENCE COLLABORATION?



Australia

The University of Sydney - ARC CAASTRO
The University of Western Australia (UWA)

Brazil

Laboratorio Interinstitucional de e-Astronomia (LIneA)
Laboratorio Nacional de Astrofisica (LNA)
Rede Nacional de Ensino e Pesquisa (RNP)
Academic Network at Sao Paulo (ANSP)
Americas Pathways (AMPATH)

Canada

University of Toronto (UofT)

Canary Islands

Instituto de Astrofisica de Canarias (IAC)

China

LSST-China Consortium

Chile

Croatia

Ruder Bošković Institute (RBI)

France

IN2P3

The United States

Germany

Ludwig-Maximilians-Universität (LMU)
Max Planck Institute for Astrophysics (MPA)
Max Planck Institute for Astronomy (MPIA)

Hungary

Eotvos Lorand University (ELTE)
Konkoly Observatory

India

Inter-University Centre for Astronomy and Astrophysics (IUCAA)

Korea

Korea Astronomy and Space Science Institute (KASI)

New Zealand

University of Auckland (UOA)

Serbia

Nano Center

South Africa

The National Research Foundation (NRF)

Switzerland

Eidgenoessische Technische Hochschule Zuerich (Eth Zuerich)

Taiwan

Academia Sinica Institute of Astronomy & Astrophysics (ASIAA)

United Kingdom

Science and Technology Facilities Council (STFC) - UK
LSST Consortium