Welcome

LSST Project and Community Workshop – Tucson 2018
To build an observing facility, conduct 10-year survey, process, archive, and serve images and data products.
Construction Funding Partners and Managing Organizations

Private, Corporate, and Institutional Donors

- NSF: US$ 473 M
- U.S. Department of Energy: US$ 168 M
- Private, Corporate, and Institutional Donors: US$ 30 M
Project Executed by Global Team of Staff and Contractors

Univ. of Washington
(Project Scientist, SE Support, DM Scientist)
Seattle, WA

UC Davis
(Chief Scientist)
Davis, CA,

Univ. Of Illinois / NCSA
(Information Security Officer)
Urbana, IL

SLAC National Lab
(Director, Camera Mgmt)
Menlo Park, CA,

SLAC National Lab
DOE Lead
Menlo Park, CA

Longhorn Industries
(Project Controls)
Tucson, AZ

AURA
(Project Management Office, Systems Engineering T&S, DM & EPO Mgmt)
Tucson, AZ

AURA
(LSST Site Office)
La Serena Chile

AURA Corporate
NSF Recipient
Washington DC

Princeton Univ.
(SAC Chair)
Princeton, NJ

AURA
Central Administrative Services (CAS and HR)
Tucson, AZ

University of Arizona.
(Deputy Director)
Tucson, AZ

AURA
CAS and HR Chile
La Serena, Chile
Project Executed by Global Team of Staff and Contractors

UC Davis
(Project Management, Algorithms)
Davis, CA,

SLAC National Lab
(Data Base)
Menlo Park, CA,

Cal Tech / IPAC
(SUIT)
Pasadena, CA,

AURA
(Project Management, Systems Engineering, SQuARE)
Tucson, AZ,

Univ. of Washington
(System Science, Pipelines)
Seattle, WA,

Univ. of Illinois / NCSA
(Infrastructure / HPC)
Urbana, IL,

Princeton Univ.
(Algorithms)
Princeton, NJ,

Florida international Univ.
(International Networks)
Miami, FL,

AURA
(Network Support)
La Serena Chile,

REUNA / Telefonica
(Network Installation / Administration)
Santiago, Chile,

IN2P3
(Infrastructure / HPC)
Lyon, France,

Data Management
Project Executed by Global Team of Staff and Contractors

SLAC National Laboratory
(Mangement, Camera Body and Mechanism, DAQ, CCS, I&T)
Menlo Park, CA

Materion (Filter Coating)
Buffalo, NY

Corning (Optics Fused Silica)
Corning, NY

Harvard University (Corner Raft, Science Raft)
Cambridge, MA

LPNHE/IN2P3 (Electronics, Carousel)
Paris, France

APC/IN2P3 (Filter control system, CCS)
Paris, France

LPSC/IN2P3 (Filter Autochanger)
Marseille, France

CPPM/IN2P3 (Filter Test Bench)
Clermont, France

REOSC (BBAR coating)
Saint-Pierre-du-Perray, France

Thales SESO (L3 assembly and filters optics)
Aix-en-Provence, France

Brookhaven National Laboratory (Science Rafts)
Upton, NY

Upenn (Electronics)
Philadelphia, PA

Vanguard Space technologies/Alliance Space Systems (L1-L2 composite structure)
San Diego, CA

Imaging Technology Laboratory (CCD)
Tucson, AZ

Arizona Optical System (L1, L2 optics fabrication and test)
Tucson, AZ

UC Santa Cruz (Management)
Santa Cruz, CA

Lawrence Livermore National Laboratory (Management, Optics)
Livermore, CA

Ball Aerospace (L1-L2 design and Integration)
Boulder, CO

Engineered Ceramic Materials (Grid, Raft baseplates)
Moosinning, Germany

UC Santa Cruz
(Santa Cruz, CA)

SLAC National Laboratory
(Menlo Park, CA)

Materion
(Buffalo, NY)

Corning
(Corning, NY)

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(Cambridge, MA)

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Harvard University
(Cambridge, MA)

Engineered Ceramic Materials
(Moosinning, Germany)
Project Executed by Global Team of Staff and Contractors

- Moog/CSA (Camera / M2 Hexapod) Mountain View, CA
- Pflow Industries (Summit Lift) Milwaukee, WI
- Harris Corp (M2 Subsystem) Rochester, NY
- Corning (Optics Fused Silica) Corning, NY
- Harvard University (Calibration Instrumentation) Cambridge, MA
- AURA (Telescope & Site Engineering Team) Tucson, AZ
- CAID Industries (M1M3 Cell, Cart, Integration) Tucson, AZ
- ARCADIS (Summit Facility A&E) Santiago, Chile
- Besalco (Summit Facility Construction) Santiago, Chile
- Rencore (Base Facility Construction) Santiago, Chile
- UofA Mirror Lab (M1M3 Fabrication & Testing) Tucson, AZ
- TORG (ComCam Optics) Tucson, AZ
- Rockterra (Summit Civil Work) La Serena, Chile
- Astronomical Consultants & Equip Inc. (Atmospheric Telescope) Tucson, AZ
- Pflow Industries (Summit Lift) Milwaukee, WI
- Harris Corp (M2 Subsystem) Rochester, NY
- Corning (Optics Fused Silica) Corning, NY
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- Rencore (Base Facility Construction) Santiago, Chile
- UofA Mirror Lab (M1M3 Fabrication & Testing) Tucson, AZ
- TORG (ComCam Optics) Tucson, AZ
- Rockterra (Summit Civil Work) La Serena, Chile
- AURA (Telescope and Site Summit Team) La Serena, Chile
- Von Ardenne (Reflective Coating System) Dresden, Germany
- European Industrial Engineering (Dome subsystem) Venice, Italy
- GHESA (Telescope Mount Assembly) Madrid, Spain
- Telescope and Site

La Serena, Chile
Milwaukee, WI
Rochester, NY
Corning, NY
Cambridge, MA
Tucson, AZ
Tucson, AZ
Santiago, Chile
Santiago, Chile
Tucson, AZ
Dresden, Germany
Venice, Italy
Madrid, Spain

Additional Companies:
- Moog/CSA
- Pflow Industries
- Harris Corp
- Corning
- Harvard University
- CAID Industries
- ARCADIS
- Besalco
- Rockterra
- UofA Mirror Lab
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- Besalco
- Rockterra
- UofA Mirror Lab
- TORG
- Astronomical Consultants & Equip Inc.
Project Executed by Global Team of Staff and Contractors

University of Arizona (education advisors)
Tucson, AZ

AURA
(Chile EPO Coordinator)
La Serena, Chile

Univ, of Alaska Anchorage (education advisors)
Anchorage, AK

Theresa Neil Strategy + Design (user experience and design)
Austin, TX

Inigo Films (historical media - construction & interviews)
Toronto, Canada

Science Office (3D modeling)
Lisbon, Portugal

Adler Planetarium (Planetarium and citizen science support)
Chicago, IL

NOIR (video production)
London / New York / Prague

Data2Dome / ESO (planetarium data integration)
Garching, Germany

University of Arizona
Tucson, AZ

AURA
(Chile EPO Coordinator)
La Serena, Chile

Inigo Films (historical media - construction & interviews)
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Education and Public Outreach
2017 Public Talk and much much more......

http://ls.st/b86

Building the Next Great Science Engine!

Constructing the Large Synoptic Survey Telescope

Victor L. Krabbendam, LSST Project Manager
Charles (Chuck) Claver, LSST System Scientist

Thursday, August 17, 2017

Available on LSST YouTube Channel
Search for “LSST2017”
All Across the Project efforts are successfully transitioning to reality
Primary Mirror Polishing Completed in 2014
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
A “Mirror” is a Complex Assembly
- Stiff 300 ton moving structure

- 10 deg/sec rotation
- 10 deg/sec² acceleration
63 CM Diameter Focal Plane with 3.2 GigaPixels

Raft Electronics Board (REB) with Custom Integrated circuits make a 166M Pix camera

Raft Sensor Assembly

189 sensors packed in 21 rafts of 9 sensors

4K x 4K Science Sensor
Camera Sensors Fabricated by Two Vendors

- 264 Science Sensors Delivered
- Need 208

Brookhaven National Labs does Raft integration
- 12 Rafts delivered
  Over half way!
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.
More Hardware Completion...

- Atmospheric Telescope refurbished by Astronomical Consultants and Equipment re-assembled in Chile
- Coating Chamber Factory Acceptance completed at Van Ardenne - Germany
- Journey to Chile has started.
On schedule for First Light in 2021 and start of 10-year Survey in 2022
Exploring the Final Frontier with the Large Synoptic Survey Telescope

Phil Marshall & Ardis Herrold

Thursday, August 16th, 2018, 7pm
Space: The Final Frontier

“The frontier is everywhere.”
Carl Sagan
Where did we come from?
How does the Universe work?
What else is out there?
Magellan proposed a westward voyage to the spice islands in 1517. 273 crew in 5 ships departed in 1519. Only 18 men returned, 3 years later, on one ship: the “Victoria.”
Explorers make maps, for others to follow

The Straits of Magellan opened a route to the Pacific and beyond; Ribeiro’s map shows an ocean of possibility:

Overlay: Diogo Ribeiro’s “Padron Real”, 1527 (Heawood 1921)
Maps show us the way

Maps are simplified representations of the data, that help us understand what’s out there. *They reveal paths forward that we may not have realized were there.*
Discovery machine “LSST”

The biggest digital camera in the world (3Gpx), suspended above an 8.4-m diameter mirror, feeding a Data Facility that will process 500 Pb* of data

Observatory: Chile  
Data Facility: Illinois  
Headquarters: Tucson  
National Lab: SLAC
LSST’s unique mirror and huge camera make it super-fast
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.
Wide field imaging at high resolution: big data

LSST’s field of view is 60,000 pixels across

To print out an LSST image at 72dpi you need a 70x70 foot piece of paper
Wide field imaging at high resolution: big data

LSST’s field of view is 60,000 pixels across

To print out an LSST image at 72dpi you need a 70x70 foot piece of paper

and 3 tennis courts to lay it out on
The LSST Data Facility will automatically process the images, and measure every object’s position, brightness, size and shape in each one.

Thousands of astronomers will analyze these measurements, comparing them to predictions from physical models.

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LSST will take a census of the Solar System

- 5 million Main Belt asteroids,
- 300,000 Trojans,
- 100,000 NEOs,
- 40,000 KBOs.

All detected as moving objects, in multiple successive frames
The spins, orientations and wobbles of the planets and KBOs are not as simple as you might expect. Physical, computer models of solar systems forming make predictions about these properties, and also the thousands of Kuiper Belt Objects that LSST will see. The models predict an extra, long lost, detectable planet "Planet Nine."
Mapping the Milky Way

The details of the distribution of stars in the Milky Way contain a fossil record of our galaxy’s history.

Future simulations of the Milky Way’s formation and development will need to match the LSST star map.
Stellar streams could help identify the dark matter

Erkal et al 2017
LSST will map out the positions, brightnesses, colors and shapes of several billion galaxies.
With gravitational lensing we can trace the underlying dark matter “halos” and filaments.
Mapping the Universe as it expanded

With weak lensing we can map the dark matter structures in the Universe at different eras in its history - and see how structures grew
The expansion of the Universe is accelerating, and no-one knows why
Measuring cosmic acceleration to 1% precision

How to estimate the grade?

1. From the dynamics of falling objects:

1. By comparing apparent elevation with horizontal distance

Galaxies and DM halos, “clustering”

“Standard candles”
Cosmic distances from 100,000 LSST supernovae

Type Ia supernovae all look (roughly) the same: they are “standard candles” that we can use to measure distance.

With several thousand new supernovae detected every night, we can probe the expansion of the Universe in detail - including in different directions.
One possible “Dark Energy equation of state” has two fundamental parameters

LSST provides (at least) 5 ways to probe this new law of physics

Combining them together, we can get to about 1% precision - and also check that we haven’t made any mistakes
An Ocean of Possibility

What happens when Black Holes collide?

Intrinsic Brightness

Duration of Explosion

1 day

3 months
We’ve come a long way since the first explorers reached Tucson

Vogelhard Cave mammoth carving, c. 35,000 BCE
Citizen science projects will give everyone a chance to explore

Help find gravitational lenses in LSST-like images at http://spacewarps.org
Any scientist can build a Zooniverse LSST project

LSST have teamed up with the Zooniverse to make it easy to set up citizen science projects to explore the LSST data - and contribute to the research.

The Final Frontier: citizen-led science projects

#lsst2018
LSST will provide many different maps for others to follow -

Including *you*. 
A Voyage of a Different Sort
Why Explore?

Inventiveness develops critical thinking

Learning builds context, expands our “world view”

Writing our story improves our communication skills
In the first *week* of Operations, LSST will collect more data than the sum of all data collected by the Hubble Space Telescope.

Hubble Space Telescope Ultra Deep Field. NASA, ESA, A. Riess (JHU and STScI), S. Rodney (JHU), and the Hubble Heritage Team (STScI/AURA)
EPO Mission
We provide worldwide access to, and context for, LSST data through accessible and engaging online experiences so anyone can explore the universe and be part of the discovery process.
Please take out your phone and go to:
Kahoot.it

Wifi password: LSST18
The Expanding Universe
90 Years Comparison

Left: 40 minute exposure of the Andromeda galaxy from the 100" Hooker telescope, 1923.
From the Pros to you - how to get into the game
From the Pros to you- how to get into the game
Rec Leagues

Science Centers, Planetariums, Amateur Astronomers
Image Credit: NASA/JPL-Caltech/CSS-Univ. of Arizona
Fans and Mascots

Science enthusiasts from teens through adults.
Skyviewer
Minor leagues

Teachers of students in advanced middle school, high school and non-science majors in college.
Investigations for students

Introduction and Background

Today you will be using a data visualization tool called the H-R Diagram, first developed more than a century ago by Einar Hertzsprung from Denmark, and Henry Norris Russell, an American. The H-R Diagram will enable you to create your own "window" to the stars and explore what it can reveal about star properties such as size, temperature, and energy output.

In order to accurately compare stars to each other and measure properties such as their energy outputs, it is important to account for the fact that two stars of the same brightness will look very different if one is farther away from Earth than the other. One way to address this issue is to collect data from a group of stars in a star cluster, in which all the stars are the same distance away. Today you will collect and analyze data for the stars in one cluster, which will allow you to determine the variation that exists in stellar properties.

In this investigation, the term luminosity refers to the total energy output from a star per unit of time. Luminosity is typically reported as a ratio of the star's energy output compared to the energy emitted by the Sun. For example, a star with a solar luminosity of "3" emits ten times more energy than the Sun.

Procedure and Data

First call up the information and data for your star cluster. Type in the name of your cluster and press Enter.

Type in the name of your cluster and press Enter. Return...
Science themes

Formal Education Themes

- Galaxies and the Milky Way
- Cosmology
- Properties of Stars
- Solar System
- Properties of Light
- Dynamic Sky
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
Six- filter mixing tool

Color The Universe
Learn how to make astronomy images.

- U
- G
- R
- I
- Z
- Y

Blue
Blue
Green
Orange
Red
Red

Raset  Print

https://lsst-epo.github.io/properties-of-light/
A discovery space for amateur research

Ana Humphrey
Alexandria, VA

2018 Intel ISEF Best of Category Award - Physics and Astronomy

Finding Exoplanets by Assessing the Dynamical Packing of Kepler Three- and Four-Candidate Systems
Then
Now

What do you want to CREATE today?

- Interactive Writing
- E-BOOK
- PODCAST
- 5 Photo Story
- Visual Notetaking
- Narrated Art
- Narrated Slideshow
- Puppet Video
- Quick Edit Video
- Geo Map
- Simulation Game
- Digital Story

Google search: (17.5 inches + 2.1 feet) / 4 mm = cm

(17.5 inches) x (2.1 feet) / 4 mm = 108,858,000 centimeters

#lsst2018
We are enamored with stars
Twinkle, twinkle little star
How I ______ what you are.
What will we discover?
What will we discover?
What will we discover?
What will we discover?