LSST Town Hall
AAS233 - 2019
Welcome & Introduction
Zeljko Ivezic – University of Washington

Large Synoptic Survey Telescope
Construction update & Commissioning Plan
Victor Krabbendam – AURA/LSST

Large Synoptic Survey Telescope
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
Developed and maintained objective to build an observing facility, conduct 10-year survey, process, archive, and serve images and data products.
Early Investments enabled specific development and valuable risk reduction.

8.4 m diameter lightweight borosilicate monolithic 2-surface mirror

3.5 m diameter ULE meniscus secondary mirror

Initial site preparation of Cerro Pachon, Chile
Construction Funding and Managing Organizations

- US$ 473 M
- US$ 168 M
- US$ 30 M

and Private, Corporate, and Institutional Donors
Construction Funding and Managing Organizations

US$ 473 M
US$ 168 M
US$ 30 M

and Private, Corporate, and Institutional Donors

December 2018: LSST Construction is now 70% complete
Critical path schedule on target for FY23 Survey

Data Management

Telescope & Site

Camera

- NSF MREFC
- DOE MIE
- Commissioning
- Operations

Construction Start

Critical Path

Pre Commissioning Preparations
Com Cam on Summit
Engineering First Light

Early Integration & Testing

Facility Support

Final DRP Release

System First Light
Operational Readiness Review

Critical Path Schedule Contingency

MIE to Ops

CD-4

Full Integration & Verification

+8.5

Pre- Full Operations

Now

Full System Integration “Start”

Science Operations Start

1 August 2018

AAS 233 – LSST TOWN HALL – 2018-01-09 – SEATTLE, WA
M1M3 glass and hardware now in Mirror Lab for full system testing

M1M3 system fully integrated and ready for interferometric testing – shipping to Chile set for March 2019
3.5m diameter secondary mirror system is completed and on site.

M2 system with polished glass mounted

M2 arrives in Chile

M2 substrate ready for support hardware integration
LSST Telescope structure completed factory testing

- Stiff 300 ton moving structure
- 10 deg/sec rotation
- 10 deg/sec² acceleration
- 3.5 deg slew-settle: 5 seconds

Valuable lessons learned – now being packed for shipment to Chile
Summit Facility is completed and focus is now on the dome and calibration hardware.

Extra equipment deployed to support Dome installation.

1.2m diameter calibration telescope serves as early commissioning activity.
Coating Chamber has arrived on site

Optical Coating Chamber in transit to the summit – Puclaro Tunnel

Optical Coating Chamber entering the summit facility
All required sensors delivered, 12 rafts completed – good performance but investing in some raft rework/cleaning.

189 4kx4k sensors packed in 21 rafts of 9 sensors
Camera Optics fabricated and coated and back to Ball / AOS for integration into housing.

1.6 M diameter Lens #1 for Camera

1.1 M diameter Lens #2 for Camera
Data Management software system maturing rapidly – Science Platform talk next

- Focus on a minimum viable system – many aspects of system functional
- Long Haul network tested to necessary capacity
- Infrastructure supporting workshops and boot camps focused on integration and commissioning

Network in place for data transfer

LSST Data Facility Kubernetes Cluster
The Education and Public Outreach mission is to 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.
Education and Public Outreach System

Development focus for 2019

Audiences: Citizen Science Principal Investigators, Formal Educators (middle & high school, college intro), Science Centers, Science-Interested General Public

Deliverables: Infrastructure to initiate CS projects through the LSST Science Platform, A suite of online investigations available through the Education Hub, Multimedia assets in universal (Data2Dome) format, Operations website in Spanish and English, Alert Stream highlights, Science news highlights via traditional and social media, Interactive visualization tools, Educator support materials, Professional development, PI support materials.
LSST commissioning efforts increasing now – leading to science verification

- LSST Commissioning is key part of Construction:
  - Integration of Subsystems
  - System Verification
  - Science Validation
- Efforts have started with early integration activities and tool development
- Commissioning Camera is nearly complete

Single raft camera for initial system verification
Commissioning team is focused on construction but will generate data.

- Scientific engagement is valued element to validation
- Emerging Operation Operations team will serve data
- LSST and Agencies working together to define distribution

<table>
<thead>
<tr>
<th>Early Science Validation with ComCam</th>
<th>Early Science Validation with LSSTCam</th>
<th>Science Validation Surveys</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Installation and Initial Testing</strong></td>
<td><strong>Installation and Initial Testing</strong></td>
<td><strong>Survey 1: Wide Area</strong></td>
</tr>
<tr>
<td>Engineering focus, algorithm testing, instrument signature removal</td>
<td>Engineering focus, algorithm testing, instrument signature removal</td>
<td>Template generation</td>
</tr>
<tr>
<td>3-4 months</td>
<td>3-4 months</td>
<td>3 weeks</td>
</tr>
</tbody>
</table>

- Key Performance Metrics
  - Image quality, depth, astrometry, photometry

- **20-year Depth Test**
  - Exploring range of conditions

- **Scheduler Tests**
  - Nominal cadence, ToCs, environmental conditions

- **Survey 2: Full Depth**
  - 10-year survey depth in reference fields overlapping with deep external imaging and spectroscopy datasets

- **Survey 1: Wide Area**
  - Real-time alien production

https://www.lsst.org/content/lsst-information-scientists
### Data Product Categories

The LSST data products are organized into three main categories.

<table>
<thead>
<tr>
<th><strong>Prompt Data Products</strong></th>
<th><strong>Data Release Data Products</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Real Time Difference Image Analysis (DIA)</strong></td>
<td><strong>Reduced single-epoch &amp; deep co-added images, catalogs, reprocessed DIA products</strong></td>
</tr>
<tr>
<td>• A stream of ~10 million time-domain events per night (Alerts), transmitted to event distribution networks within 60s of camera readout.</td>
<td>• Catalogs of ~37 billion objects (20 billion galaxies, 17 billion stars), ~7 trillion sources and ~30 trillion forced source measurements.</td>
</tr>
<tr>
<td>• Images, Object and Source catalogs derived from DIA, and an orbit catalog for ~6 million Solar System bodies within 24h.</td>
<td>• 11 Data Releases, produced annually over 10 years of operation</td>
</tr>
<tr>
<td>• Enables discovery and rapid follow-up of time domain events</td>
<td>• Accessible via the LSST Science Platform &amp; LSST Data Access Centers.</td>
</tr>
</tbody>
</table>

### User Generated Data Products

User-produced derived, added-value data products

• Deep KBO/NEO, variable star classifications, shear maps, etc …

• Enabled by services & computing resources at the LSST DACs and via the LSST Science Platform (LSP).

• 10% of LSST computing resources will be allocated for User Generated data product storage & processing.
The LSST Science Platform

accessing LSST data and services, and enabling LSST Science

A set of integrated web applications and services deployed at LSST Data Access Centers (DACs) through which the scientific community will access, visualize, subset and perform next-to-the-data analysis of the LSST Data products.
LSP Portal Aspect: A Window into the LSST Archive

interactive exploratory analysis and visualization of the LSST archive

Exploratory analysis through browsing and visualization of available datasets guided by science cases.

Visualization of LSST Images.

Subsetting via forms, ADQL.

Plotting basic scientific graphics with linked data selection across plots and images.

The Firefly Web Science User Interface (Wu et al, 2016; ADASS)
delving deeper into the LSST Archive, the JupyterLab Aspect enables sophisticated data selection, analysis and creation of value-added User-Generated data products in Jupyter notebooks.

**Enables science discovery** by ‘bringing the analysis to the data’, avoiding the download of large volumes of data.

**User environments** with pre-installed libraries:
- AstroPy, LSST science pipelines, Anaconda, etc.
- Users can install additional tools.

**LSST DACs** provide computation & analysis resources.

**Integrated platform** — queries are shared across the Portal and the JupyterLab aspects, e.g a user can submit a query in the Notebook then browse and visualize the results in the Portal.

*Analysis of SLAC Camera test stand data* using the LSST Science Pipelines on the LSST Science Platform
LSP WebAPIs: Integration with External Tools

remote access to LSST datasets and DAC services via APIs using community-accepted formats and protocols

**Backend Platform services** — databases, images and files will be exposed through machine-accessible web APIs.

**‘VO First’ Strategy** — we prefer to use IVOA protocols wherever possible, e.g. TAP (for catalogs) and SIAv2 (for images)

**Integrated platform** — build a query using the Portal query builder and access the final results from a JupyterLab notebook or remotely with tools such as TOPCAT

Remote access to catalogs using VO protocols with TOPCAT - tools such as these will enable direct access to the data sets served by the LSST DACs.

Figure credit: Mark Taylor, http://www.star.bris.ac.uk/~mbt/topcat/sun253/sun253.html.
Supporting Collaborative Work

the LSST Science Platform will provide support for collaborative work

Shared workspaces
Creation and sharing of data sets

- Dynamic creation of user-defined groups (e.g. a research group at a university, or a large science collaboration) would have access to a shared virtual “workspace” within the LSST DAC.
- Workspaces would include shared data sets – catalogs, images, queries, and other user-generated data products.
- Shared workspaces will be accessible from all three aspects of the platform and via VOSpace and WebDAV.
user-facing aspects of the LSST Science Platform will be built on top of a number of back-end services

### Database Services
- LSST Prompt and Data Release catalog Data Products as well as User databases will be stored in relational databases.
- Accessible via Astronomical Data Query Language (ADQL).

### File Services
- Per-user file space allocation will be provided.
- Upload code, store selected or transformed subsets of the LSST dataset, keep supporting files.

### Computing Services
- Analysis performed through all three Aspects will be served by a shared computing cluster.
- Launch jobs utilizing the APIs exposed through the JupyterLab and Web API aspects of the LSST Science Platform.

**Size of each of these resources is determined by the SRD requirement to provide 10% of total LSST computing and storage resources to LSST users.**
The LSST Science Platform as an LSST Commissioning Tool

Commissioning science verification activities will both use and test the LSST Science Platform from early AuxTel activities (2019) though Science Verification mini-surveys (2022) and the Operations Readiness Review (2023).

Comparison Serial CTE using LSST Science Pipelines and Camera eTraveler software. Differences are probably due to algorithmic differences.

Figure credit: Craig Lage, David Thomas
The LSST Science Platform in Action: LSSTC Stack-Club

LSST Science Collaboration members can learn how to use the LSST Science Platform & pipelines at ‘Stack-Club’

Tutorial Notebooks

Getting Started

Wondering how you can get started learning about the LSST software stack, by writing tutorial notebooks and contributing them to the Stack Club’s growing library? Need help getting going on the LSST Science Platform (LSP) JupiterLab? See the index table below for links to various resources, including: notes on the LSP notebooks to walk you through the Stack Club workflow, and some help on how to explore the Stack code. Click on the “rendered” links to see the notebooks with their outputs.

<table>
<thead>
<tr>
<th>Notebook</th>
<th>Short description</th>
<th>Links</th>
<th>Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Getting Started</td>
<td>Some brief notes on the LSP Science Platform JupiterLab set-up.</td>
<td>markdown</td>
<td>Phil Marshall</td>
</tr>
<tr>
<td>Hello World</td>
<td>Read about the Stack Club git/GitHub workflow, and make your first contribution to a notebook.</td>
<td>ipynb, rendered</td>
<td>Phil Marshall</td>
</tr>
<tr>
<td>Templates</td>
<td>A folder containing a template notebook, and a template folder README. No, to help you get your project started.</td>
<td>link</td>
<td>Phil Marshall</td>
</tr>
<tr>
<td>Finding Docs</td>
<td>Locate the documentation for Stack code objects, including using the stackcore library</td>
<td>ipynb, rendered</td>
<td>Phil Marshall</td>
</tr>
</tbody>
</table>

Analysis of Beam Simulator Images and Brighter-fatter Correction

This notebook demonstrates the ‘rexplored’ technique of converting images of stars and galaxies illuminated on an FITS image to the LSST beam simulator. The analysis of such images is crucial in evaluating the performance of the LSST beam simulator. Using a series of images and associated metadata, we demonstrate the broadening of images profile on the sky on a subject of images for various spatial frequencies, and a variable position angle, which allows for analysis of a broad range of images from various positions.

**Learning Objectives:**
1. Characterize and measure objects (stars/galaxies) in LSST beam simulator images
2. Test the Brighter-Fatter beam correction method on those images
3. Build your own tools of such algorithms

**Logistics:**
This notebook is intended to be run on the test suite and the documentation library from a local pc clone of https://github.com/LSST-Science/beam_simulation

```
import numpy as np
import matplotlib.pyplot as plt

# Test some data

data = np.random.normal(size=100)
plt.plot(data)
plt.show()
```
The LSST Science Platform in Action: Conference Tutorials

we run tutorials at conferences including this AAS meeting and recently at LSST@Europe3. Come along, meet the team and discover the power of the LSST Science Platform today.

LSST Science Pipelines tutorial using the LSST Science Platform at AAS233 (2019)
Cadence Optimization White Papers
Lynne Jones - University of Washington
Survey Strategy Optimization White Papers

- During 2018, LSST held a call for white papers on the survey strategy
- Call - to better understand how to observe “main survey” (WFD) and how to spend 10-20% of time in mini-surveys
- Less than FOUR YEARS from the start of operations
- https://www.lsst.org/submitted-whitepaper-2018

Survey strategy goals

- **Maximize efficiency** - slew time AND best image conditions (seeing, sky brightness, filter) - and don’t do anything ‘obviously wrong’
- **Optimize science** - sky coverage, uniformity, timing/cadence .. science metrics
47 white papers from a wide section of the community

<table>
<thead>
<tr>
<th>Survey Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>WFD/All Sky</td>
<td>20</td>
</tr>
<tr>
<td>(10 cadence)</td>
<td></td>
</tr>
<tr>
<td>Deep Drilling Fields</td>
<td>4</td>
</tr>
<tr>
<td>Mini-Surveys</td>
<td>26</td>
</tr>
<tr>
<td>ToO</td>
<td>3</td>
</tr>
</tbody>
</table>
Very approximately, the total amount of time required to support all of the white paper proposals would be 115-250% of predicted available LSST time.*
Survey Strategy - next steps

- July 2018: Call issued
- Nov 2018: White papers received
- April 2019: LSST Science Advisory Council review with list of recommendations for next-step Operations Simulations runs
- Early 2020: Project delivers simulations to the “Survey Cadence Optimization Committee” (SCOC)
- Early 2021: SCOC delivers recommendations to LSST Operations Director
- Mid 2021: Project delivers baseline simulation of initial survey strategy
- Late 2022: LSST Operations start

The Community Observing Strategy Evaluation Paper (COSEP) is always open! [http://ls.st/o5k]
LSST Science Collaborations and the LSST Corporation’s Enabling Science activities

Federica B. Bianco - University of Delaware, LSSTC
LSST Science Collaborations Coordinator
LSST Science Collaborations

Formed by the LSST Project in 2006 with the intent to provide a forum to engage the community in interacting with the project team and played an essential part in producing the LSST Science Book in 2009.

At this stage, the LSST Project no longer oversees the LSST Science Collaborations: they set their own policies for admission, governance, publication, etc.

*Only data right holders can join*
LSST Science Collaborations

8 LSST Science collaborations

ranging in size between ~40 and ~200

over 1000 members in total from 5 continents

multiple affiliations are possible

<table>
<thead>
<tr>
<th>Collaboration</th>
<th>Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGN</td>
<td>51</td>
</tr>
<tr>
<td>Dark Energy (DESC)</td>
<td>133</td>
</tr>
<tr>
<td>Galaxies</td>
<td>105</td>
</tr>
<tr>
<td>Stars, Milky Way, Local Volume</td>
<td>129</td>
</tr>
<tr>
<td>Solar System</td>
<td>88</td>
</tr>
<tr>
<td>Informatics and Statistics</td>
<td>72</td>
</tr>
<tr>
<td>Strong Lensing</td>
<td>44</td>
</tr>
<tr>
<td>Transients and Variable Stars</td>
<td>191</td>
</tr>
</tbody>
</table>
LSST Science Collaborations

8 LSST Science collaborations

ranging in size between ~40 and ~200

over 1000 members in total from 5 continents

multiple affiliations are possible

the SCs share interests and science goals multiple affiliations facilitate exchanges that will ultimately maximize LSST’s throughput
LSST Science Collaborations

8 LSST Science collaborations

ranging in size between ~40 and ~200

over 1000 members in total from 5 continents

multiple affiliations are possible

the SCs share interests and science goals multiple affiliations facilitate exchanges that will ultimately maximize LSST’s throughput
LSST Science Collaborations

An increasingly international community

Chile: 69
UK: 57
Italy: 60
France: 45

California: 144
Washington: 88
Arizona: 52
Pennsylvania: 40
LSST SCs current activities include:

- identifying gap in scientific preparation that would impair the LSST success in theoretical advancement (e.g. predictions on photometric observables, sparse time series analysis), software (e.g. sparse time series analysis tools, crowded field photometry, TOM), existing data (e.g. multiwavelength coverage of Deep Drilling Fields)
- learning and testing the LSST pipeline and science platform
- preparation of User-Generated data products
- designing and scoping LSST observing strategies for different science cases
LSST Science Collaborations

COSEP living document testing LSST observing strategies for different science cases

https://github.com/LSSTScienceCollaborations/ObservingStrategy

Science-Driven Optimization of the LSST Observing Strategy

Marshall et al. 2017

Prepared by the LSST Science Collaborations, with support from the LSST Project.

Version 1.0
Most recent commit: fe8342a
(Mon, 14 Aug 2017 02:08:33 -0700)
LSST Science Collaborations

LSST Cadence white papers: SC contributions

Cadence White Paper Submissions

- unknown/other: 15.6%
- Galaxies: 2.2%
- AGN: 6.7%
- DESC: 4.4%
- multiple: 2.2%
- SL: 2.2%
- SMWLV: 13.3%
- TVS: 40.0%
- SS: 13.3%
Why join an LSST Science Collaboration?

A community to better prepare for LSST.

All SCs have a direct line of communication with the LSST Project to ask questions and to make recommendations.
Why join an LSST Science Collaboration?

A community to better prepare for LSST.

Each SC has a DM liaison
Monthly meetings between LSST Project and SCs’ chairs

- Commissioning - Science Verification Status - C. Claver/L. Guy
- LSST Science Collaborations Status + current activities - LSST Science Collaboration Chairs
- The Scheduler development progress and new Feature-based algorithm - T. Ribeiro/L. Jones
- Blending in LSST - F. Moolekamp
- LSST Solar System Processing: Status and Plans - M. Juric
- LSST Alert Stream - E. Bellm
- LSST Astrometry - J. Bosch
- Photometric Products - R. Lupton
- LSST Pipelines and Data Products - J. Bosch
- LSST Project Status - V. Krabbendam
- Status of the LSST Image Simulations - C. Walter
- LSST Education and Public Outreach - A. Bauer
- What to Expect of the LSST Archive: The LSST Science Platform - M. Juric
- LSST Observing Strategy - Z. Ivezic
- DM Plans for Crowded Star Fields - J. Bosch
- OpSim Development - A. Connolly
- LSST Commissioning Overview & Data Plan - C. Claver/B. Willman

videos available at https://www.lsst.org/scientists
LSST Science Collaborations

recent SC activities

files available at
https://www.lsst.org/scientists
http://ls.st/58s
http://ls.st/btk

apply to join an SC!

www.lsstcorporation.org/
science-collaborations
LSST Corporation

Founded in 2003 as a not-for-profit 501(c)3 Arizona corporation to maximize the scientific impact of the LSST project

More than 35 universities, institutions, corporations, and individuals started designing and building LSST as a public-private partnership
LSSTCorp raised over $50 million in the Design Development phase of the LSST project

LSSTC is committed to raise funds that will enable a robust program of science and educational initiatives through LSST’s 10-year survey and beyond
Engaging industry and academic partners  

https://www.lsstcorporation.org/become-institutional-member

Engaging the international community through individual MOUs governing the purchase of data rights and inclusion in the LSST community (including the ability to participate in Science Collaborations)

23 international contributors (23 country, 42 institutes)
LSSTC advocates for LSST and advises LSST through the LSSTC Executive Board a number of Committees

New!! Science Collaboration Standing Committee funded in January 2019
LSST Corporation

LSSTC Director for Science - Jeno Sokoloski
LSSTC Senior Director of Development - Dan Petrocelli

Strategizing fund-raising:
- approaching foundations
- securing funds for scientific activities for SCs
- supporting Institutional Members of LSSTC
The LSST Corporation, the Heising-Simons Foundation, and the Simons Center for Computational Astrophysics are organizing and hosting a 3-day workshop for representatives from the Science Collaborations (SCs) and cadence-simulation experts from the LSST project to help and guide workshop participants.
2019 Enabling Science Call for Proposals

The 2019 Enabling Science Call for Proposals is available to provide funding for workshops and other programs, including limited funding for undergraduate students to engage in research in preparation for LSST.

This Call also solicits Notices of Intent to request support for undergraduate researchers to attend a two-day student-specific program at the LSST Project & Community Workshop in August 2019.

proposals due tonight!
LSSTCorp provides support for meetings and training since 2015: 

funded by a 2015 $500k Match Challenge from Charles+Lisa Simonyi and Bill Gates

The Enabling Science Proposal Call distributed $1,487,953.50

2019 Proposals Call makes $200,000 available

- Science and Science Collaboration Activities
  - SC and topical meetings/workshops/hackathons
  - Stack Club: a reading group to learn the LSST processing software and platform

- Broader Education and Outreach:
  - Undergraduate training
  - PLAsTiCC Kaggle challenge seed funding
  - Big Data Academy for High School Students
  - The LSST Data Science Fellowship Program
THE LSSTC DATA SCIENCE FELLOWSHIP PROGRAM

OUR VISION

Astronomers equipped for a data-rich future.

2017 LSSTC Data Science Fellows

2018 LSSTC Data Science Fellows

https://astrodatascience.org

Lucianne Walkowicz, Director
LWalkowicz@adlerplanetarium.org

Adam Miller, Program Director
amiller@northwestern.edu
LSSTC Enabling Science activities 2018 & 2019

2018 proposal submissions

16 meetings and collaborative activities

8 student internships
Topical meetings (Blending, GW counterparts)
Science Collaboration meetings (TVS, DESC, SS)
Joint activities among SCs (TVS+SMWLV)

meetings and collaborative activities

student internships

funded:
fully
partially
fully
partially

8/16
4/16
4/8
1/8
Topical meetings (Blending, GW counterparts)
Science Collaboration meetings (TVS, DESC, SS)
Joint activities among SCs (TVS+SMWLV)

19 undergraduate interns attended the LSST 2018 Project & Community Workshop

funded: fully partially fully partially
8/16 4/16 4/8 1/8
The requests for funds grow as we approach LSST’s first light. This is just the beginning!
LSST’s mission is to build a well-understood system that provides a vast astronomical dataset for unprecedented discovery of the deep and dynamic universe.

Thank you!

Questions

This presentation: http://ls.st/z5p
Our website: www.lsst.org