LSST Overview & Science Data Products

Leanne Guy, LSST Data Management Project Scientist

Harvard Centre for Astrophysics, 2019-12-13

Large Synoptic Survey Telescope

Outline

- Science Drivers and Survey
- LSST Data Processing & Data Products
- LSST Science Platform
- LSST Science Collaborations – getting involved

Large Synoptic Survey Telescope

LSST in a Nutshell

The LSST is an integrated survey system designed to conduct a decade-long, 'wide-fast-deep' time-domain survey of the optical sky.

2022 - 2032

- 8.4 m primary mirror (6.5 m effective)
- Wide 9.6 deg^2 field-of-view
- High étendue (AΩ) of 319 m^2 deg^2
- 3.2 Gpix camera, 6 filters 'ugrizy'
- Fully automated peta-scale data processing system
- 20TB data and up to 10 million alerts every night
- Interactive data access and analysis environment
- Public user interfaces

LSST will enable a wide variety of complementary scientific investigations

LSST Science Drivers

Four science programs as the key drivers of the science requirements

Dark Matter, Dark Energy

- Weak Lensing
- Baryon acoustic oscillations
- Supernovae, Quasars

Cataloging the Solar System

- Potentially Hazardous Asteroids
- Near Earth Objects
- Object inventory of the Solar System

Milky Way Structure & Formation

- Structure and evolutionary history
- Spatial maps of stellar characteristics
- Reach well into the halo

Exploring the Transient sky

- Variable stars, Supernovae
- Fill in the variability phase-space
- Discovery of new classes of transients

Ivezić et al. (2008), V5(2018)

From Science Drivers to Science Requirements

Requirements determined by constraints from the four science drivers

Survey Property	Specification (Design Value)
Survey Area & Median Number of Visits/Pointing	18000 deg^2 with 825 visits
Filter set	6 filters (ugrizy) from 320 - 1050nm
Single (Alternate) visit	2x15s (1x30s) exposures
Single Visit Depth (SNR > 5)	u=23.5, g=24.8, r=24.4, i=23.3, y=22.1
Astrometry (single visit)	10 mas relative, 50 mas absolute
Photometry	2% absolute, 0.5% repeatability
Proper Motion	0.2 mas/yr @ r = 20.5, 1.0 mas/yr @ r = 24.0
Median delivered image quality (seeing)	~0.7 arcsec FWHM

…. also drive the design of the data processing system

Ivezić et. el (2008)

Ivezić et al. (2008), v5(2018)

LSST Science Drivers

LSST Science Drivers, Design and Data Products

Summarizes LSST hardware, software, and observing plans, science enabled by LSST, and educational and outreach opportunities 245 authors, 15 chapters, 600 pages

LSST Science Book: arXiv: 0912.0201

THE ASTROPHYSICAL JOURNAL

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

Željko Ivezić[1,85], Steven M. Kahn[2,3], J. Anthony Tyson[4], Bob Abel[5], Emily Acosta[2], Robyn Allsman[2], David Alonso[6], Yusra AlSayyad[7], Scott F. Anderson[1], John Andrew[2] +Show full author list

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Presents the LSST system design as derived from the LSST science drivers, the expected data products and their characteristics.

Ivezić et al. (2008), V5(2018)

The Wide -Fast -Deep (WFD) Survey

Number of Visits, 10 years, all filters

Median visits per filter (total) : 56,80,184,184,160,160 (824)

2 days in any filter

8 days in r band filter

~90% of LSST observing time will be devoted to the universal ‘WFD survey

Special Programs

Anything not WFD that extend the areal coverage, depth, and/or sampling cadence to obtain improved coverage of interesting regions and enable additional science

North Ecliptic Spur
(Solar System Science)

Galactic Plane, high density of stellar source (Stars & Planets)

Deep Drilling Fields (DDF)
(DDF nightly stacks to find high-z supernovae)

South Celestial Pole
(LMC, SMC)

~10% of LSST observing time will be devoted to special programs

Target of Opportunity (ToO)

Interrupt an ongoing sequence of planned observations to reposition LSST to observe sudden transient phenomena.

External triggered TOOs (1s)

- GRBs, Tidal disruption of stars
- Low-mass X-ray binaries
- Novae

- Internal triggered TOOs (2s)
  - Orphan GRBs not first seem with gamma rays
  - Targeted black hole transients surveys — search for stellar-mass black holes as transients in nearby Local Group galaxies

Survey Strategy Optimization

During 2018, LSST held a call for white papers on the survey strategy to better understand how to observe "main survey" (WFD) and how to spend 10-20% of time in mini-surveys

Goals: Optimize science – sky coverage, uniformity, timing/cadence, filter changes, science metrics

The Community Observing Strategy Evaluation Paper (COSEP) is actively updated and read

one possible new footprint

Timeline:

- Early 2020: Project delivers simulations to "Survey Cadence Optimization Committee" (SCOC)
- Early 2021: SCOC delivers recommendations to LSST Operations Director
- Mid 2021: Project delivers baseline simulation based on initial survey strategy

Submitted white papers are available to the public

Figure credit: Lynne Jones

Construction Update

Large Synoptic Survey Telescope

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LSST and Calibration Telescope

Telescope & Site Status

Telescope Mount Assembly (TMA)

- Stiff 300 ton moving structure
- Ensures fast slew and settle
- 10 deg/sec rotation
- 10 deg/sec2 acceleration
- Slews 3.5° to adjacent fields in ~ 4s

Telescope mount assembly completed by Empresarios Agrupados / Asturfeito

On the summit awaiting reconstruction since September 2019

6.3T.M.
JASP
JASP

LSST Optical Design

Modified Paul-Baker 3-mirror optical design

- 8.4m primary (M1) and 5.0m tertiary (M3) form a continuous surface
- M2 is the largest convex mirror ever made
- Enables a large FoV (3.5 degrees) and étendue
- Image quality limited by atmospheric seeing

LSST Mirrors M1/M3 — Status

M1M3 Mirror Polishing Completed in 2015

Mirror in Summit Storage May 11, 2019

LSST Mirrors M2 — Status

M2 Optic coated with Science-Grade final coating (Ag) 2019

Camera Focal Plane

- 189 4kx4k CCD sensors,
- Grouped into 3x3 CCD arrays mounted on rafts.
- 21 science rafts & 4 corner rafts for wavefront sensing & guiding
- 64cm diameter focal plane, 3.2 Gpix
- 3.5-degree field of view, greater that 40 times area of the full moon in each exposure
- Cooled to about -100 °C to minimize noise.
- Entire array read out in 2 s

LSSTCam — SLAC Lab — Integration & Testing

Figure credit: Aaron Roodman

Data Management & Science Data Products

Large Synoptic Survey Telescope

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LSST Data Management System

Raw Data: 20TB/night

Sequential 30s images covering the entire visible sky every few days

Prompt Data Products

Alerts: up to 10 million per night

Results of Difference Image Analysis (DIA): transient and variable sources

Solar System Objects: ~ 6 million

Data Release Data Products

Final 10yr Data Release:

- Images: 5.5 million x 3.2 Gpx
- Catalog: 15PB, 37 billion objects

60s via nightly alert streams

24h via Prompt Products Database

via Data Releases

Community Brokers

LSST Alert Filtering Service

LSST DACs (Chile & NCSA)

Independent DACs (iDACs)

Access to proprietary data and the Science Platform require LSST data rights

LSST Science Platform

Provides access to LSST Data Products and services for all science users and project staff

LSST Data Products

Prompt Data Products

Real Time Difference Image Analysis (DIA)

- Stream of ~10 million time-domain events per night (Alerts), transmitted to event distribution networks within 60s of camera readout.
- Images, Object and Source catalogs derived from DIA, and an orbit catalog for ~6 million Solar System bodies within 24h.
- Enables discovery and rapid follow-up of time domain events

Data Release Data Products

Reduced single-epoch & deep co-added images, catalogs, reprocessed DIA products

- Catalogs of ~37 billion objects (20 billion galaxies, 17 billion stars), ~7 trillion sources and ~30 trillion forced source measurements.
- 11 Data Releases, produced ~annually over 10 years of operation
- Accessible via the LSST Science Platform & LSST Data Access Centers.

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.

Science Pipelines

LDM-151 describes the LSST Science Pipelines

LDM-163 provides details of what all these products are.

Conceptual design of LSST science pipelines for imaging processing.

Prompt Data Processing

Enables discovery and rapid follow-up of time domain events

1. Source detection run on difference images
2. DIASources with SNR > 5 are "detected"
3. DIASources associated by location into DIAObjects
4. Measurement & characterization for DIASources & DIAObjects

60s – Stream of Alert Packets, one per new DIASource

24h
– DIA Source & Object Catalogs
– Difference and Direct Images
– Solar System Catalogs

Prompt Data Products

Updated within 24 hours with objects and sources detected on difference images.

DIASource Catalog

- astrometry, photometry, shape (FWHM, tail, dipole, etc)
- Signal-to-noise ratio, spuriousness (real/bogus) threshold)
- Association DIAObject & SSOObject catalogs

DIAObject Catalog (associations of DIASources)

- proper motion, parallax, mean flux, orbital elements
- periodic & non-periodic variability features
- association with nearby Objects from the most recent Data Release

SSObject catalog

- Orbits, physical properties

Forced Photometry

- "Precovery" on last 30 days of data for new DIAObjects
- Forced fluxes for all DIAObjects seen in the last 12 months.

Prompt Products Database (PPDB)

Alert Distribution and Brokers

Alerts are delivered to the community brokers that filter and classify events to enable science

Community Brokers

- Third-party service to receive, characterize and/or redistribute Alerts.
- Added functionality such as, filtering, photometric classification & cross-matching
- GUIs for defining filters, making queries, etc

LSST Alert Filtering Service

- Limited capacity service provisioned via LSP; simple filters on alert packet contents only

Alert Packet Contents

Provide a rich update of what LSST knows about the changing sky

Alert Packets

- DIASource record that triggered the alert
- Associated DIAObject or SSObject record
  - Time series features
  - Crossmatches to nearby DRP Objects
- 2 months of DIASource history
- Science and template cut-outs

Alert packets and their contents are world-public and can be freely shared with anyone.

Alerts in Year 1 of Operations

The problem

- Alerts are a product of Difference Image Analysis (DIA).
- Difference Image Analysis requires that Templates exist.
- Templates are built during Data Release Production and made available in Data Releases.
- The LSST Data Release Scenario currently envisages Data Release 1 (DR1) for one year after the start of LSST operations, and to be based on the first six months of data

Consequently, prior to LSST DR1, Alert Production cannot run at full scale nor full fidelity.

The Project are engaging with the Science Collaborations to optimise pre-operations template building and science in year 1 :

Science-driven prioritization of sky templates during commissioning plans

Community Broker Workshop

In June the Project hosted a successful Community Broker Workshop.

Transient Alert Brokers in the LSST Era.

Leanne P. Guy,[1] Eric C. Bellm,[2] Melissa L. Graham,[2]
Federica B. Bianco,[3,4,5,6] Josh S. Bloom,[7] Robert Blum,[1] Željko Ivezić,[2]
and Rachel A. Street[8]

[1] *LSST Project Office, 950 N. Cherry Ave., Tucson, AZ 85719, USA*
[2] *University of Washington, Dept. of Astronomy, Box 351580, Seattle, WA 98195, USA*
[3] *Department of Physics and Astronomy, University of Delaware, Newark, DE, 19716, USA 2*
[4] *Joseph R. Biden, Jr. School of Public Policy and Administration, University of Delaware, Newark, DE, 19716, USA 2*
[5] *Data Science Institute, University of Delaware, Newark, DE, 19716, USA 2*
[6] *Center for Urban Science & Progress, New York University, Brooklyn, NY 11021, USA*
[7] *Astronomy Department, University of California, 601 Campbell Hall, Berkeley, CA 94720, USA*
[8] *Las Cumbres Observatory, 6740 Cortona Dr., Suite 102, Santa Barbara, CA 93117, USA*

In Preparation
All workshop participants will be invited to be co-authors

ABSTRACT

Beginning late 2022, the Large Synoptic Survey Telescope (LSST) will produce a nightly stream of ten million public alerts that will disseminate new information about transient, variable, and moving objects within 60 seconds. A number of *Community Brokers* will be selected to receive the full LSST alert stream, adding additional scientific value, and providing science users the ability to identify targets of interest and trigger follow-up observations. In June 2019, the LSST project hosted a workshop on *Community Brokers* in Seattle, WA, USA. The overarching goal of the workshop was to bring together LSST Project personnel, representatives of the LSST Science Collaborations, processers of community brokers and follow-up facilities to develop a vision of an integrated global ecosystem for transient science with the LSST alert stream. Topics of discussion included, scientific use cases and expectations for the LSST Prompt data products, LSST-broker interfaces, architecture and technology choices, the broker selection process, policy issues, and development progress and lessons learnt from precursor surveys. This paper provides a summary of that workshop and a road-map towards a building a global integrated ecosystem for time-domain science in the LSST era.

Keywords: LSST, Astronomy, Astrophysics, Algorithms, Brokers, Community Brokers, Data Management, Alerts, Computing, HTC, Networking, Machine Learning, Cloud

15 Letters of Intent

3 LONI

Community Brokers — Next Steps

- Plans and Policies for Alert Distribution, LDM-612, will continue to guide the selection process.
- The LSST Science Advisory Committee (SAC) has decided to invite all teams to submit full proposals.
- Call for LOI in review, will be issued by end 2019.
- Full proposals due ~Q2 2020
- LSST SAC responsible for generating the selection committee
- Provisional selection in ~Q3 2020

LARGE SYNOPTIC SURVEY TELESCOPE

Large Synoptic Survey Telescope (LSST)
Data Management

Plans and Policies for LSST Alert Distribution

Eric Bellm, Robert Blum, Melissa Graham, Leanne Guy, Željko Ivezić, William O'Mullane, Maria Patterson, John Swinbank, and Beth Willman *for the LSST Project*

LDM-612

Latest Revision: 2019-05-13

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http://ls.st/LDM-612

Solar System Processing

A daily catalog of SSO orbits and physical properties.

Daily Solar System Products (>= 5.5M objects)	
Orbits	Computed by the MPC
Light-curve characterization	Period, light curve shape, other features
Absolute magnitude estimates	Estimates of (H, G12) in u,g,r,i,z,y bands
MOID	Minimum Orbit Intersection Distance to Earth
Extendedness indicators	Is/was the object comet-like in its appearance.

A catalog of orbits and physical properties, refreshed daily.

The orbit solutions and designations will be obtained from the MPC.

The physical properties (absolute magnitudes, light curves, extendedness characterization) will be computed from LSST data.

SSObject and SSSource tables in http://ls.st/oug

Data Products Definition Document • Data Management Science Pipelines Design

Data Release Processing

Enable static sky science and time-domain science that is not time sensitive

Well calibrated, consistently processed, catalogs and images based on complete reprocessing of all data, for each data release

Images	**Single-Visit**	fully processed 2 x 15s exposures processed visit images (PVIs)
	Co-add	short-period (yearly & full survey) best seeing & deepest (unless the same) one per filter (ugrizy), and 'multi-color' transient-free template images
Catalogs	**Source** **(single-epoch)**	*Detections in single-visit images:* positions, aperture fluxes, point source fluxes, de-blending results
	Forced Source **(single-epoch)**	*In all single-visit images for all sources:* point-source fluxes, forced photometry
	Object **(associations of sources representing astrophysical phenomena)**	*All sources as well as detections in co-added images:* positions, aperture & point-source fluxes, de-blending results, model fits seeing-independent *galaxy* colours

.... and reprocessed DIA Catalogs and Images

Data Release Processing Pipeline

Running on HSC Strategic Survey Program Data

SDSS Cosmos

HSC HSC (COSMOS) g, r (1.5 hrs), and i (3 hrs) bands; PSF matched co-add (≈ 27.5).

Image credit: Robert Lupton / HSC Collaboration

Current Status

- LSST Science Pipelines are proven science-grade: the Hyper Suprime-Cam Subaru Strategic Survey Program already uses pipelines derived from the LSST Science Pipelines for data releases.
- Regularly processing of HSC and other precursor data

Running on HSC Strategic Survey Program Data

HSC HSC (COSMOS) g, r (1.5 hrs), and i (3 hrs) bands; PSF matched co-add (≈ 27.5).

Image credit: Robert Lupton / HSC Collaboration

Ongoing Challenges

- Deblending: in LSST, everything is blended.
- Weak-lensing grade shape measurements, including updating our baseline to match the latest community best practice.
- Computational throughput, especially for alert production.
- Minimizing the number of false positives in image differencing.

LSST Data Releases

Data Releases

- 11 Data Releases planned over 10 years of LSST operation
- Two for the first year of operations, one every subsequent year
- Full set of LSST data reprocessed with the latest code for every release
- Few PB (DR1) to ~70 PB for DR11

Table	Bytes/row	Rows (DR1 -> DR11)	DR1 (TB)	× Growth	DR10 (PB)
Object_Lite	1840	$2.26^{10} - > 4.74^{10}$	42	2.1	0.08
Object_Extra	20393	$2.26^{10} - > 4.74^{10}$	461	2.1	0.9
Source	453	$4.51^{11} - > 9.01^{12}$	204	20.0	4.0
ForcedSrc	41	$1.20^{12} - > 5.01^{13}$	49	42	2.0
DiaObject	1405	$7.94^{08} - > 1.54^{10}$	1.1	19.4	0.002
DiaSource	417	$2.26^{09} - > 4.52^{10}$	0.9	20	0.002
DiaForcedSource	49	$1.50^{10} - > 3.01^{11}$	0.7	20	0.001
Year 1 raw images:$3PB$, tables:~ $1PB$, half for Object_Extra,$0.2PB$ Sources					
Year 10 raw images:$30PB$, tables:~ $7PB$,$4PB$ Sources,$2.0PB$ Forced ,$1PB$ Object_Extra					

User Generated Data Products

Added-Value Data Products created by the community using LSST software & services.

- Enable science cases not fully covered by Prompt and Data Release processing, e.g:
  - Combined time series analysis of LSST and other survey time series, e.g Gaia
  - Custom processing of deep drilling fields
  - Application of custom measurement algorithms
  - Object classification using LSST catalogue parameters
  - Cross-matching with other survey catalogues

LSST sensitivity to 1-day alias (baseline2018a)
Credit: Joris De Ridder, ATS Workshop. Heidelberg 2019

Enabled by the LSST Science Platform and Services

Possibility to migrate user algorithms into the LSST processing.

Large Synoptic Survey Telescope

LSST Algorithms Workshop

17-19 March, 2020 | Princeton, NJ, USA

The LSST Project will host a workshop on the topic of image processing and algorithms for LSST. The aim of this workshop is to provide a forum for the presentation of the algorithmic challenges faced by LSST, and to solicit feedback and ideas as to how these algorithms can best meet the scientific needs of the community. Topics of discussion will include (but are not necessarily limited to): Calibration, Point Spread Function Estimation, Galaxy Photometry, Deblending & Crowded Fields, and Image Differencing.

LSST Science Platform

Large Synoptic Survey Telescope

LSST Science Platform

A set of integrated web applications & 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 LSST Data products.

Portal Aspect

exploratory analysis and visualization of the LSST archive

Notebook Aspect

in-depth 'next-to-data' analysis and creation of added-value data products

Web API Aspect

remote access to the LSST archive via industry-standard APIs

LSST Science Platform Vision

High-level vision for a collaborative environment for LSST Science

- Enable peta-scale analysis of LSST data
- Exploratory analysis through browsing and visualisation
- Enable discovery by ‘bringing the analysis to the data’
- Supports User-Generated product creation
- Integration with extant archives via IVOA protocols
- Collaborative working environment
- Provision of backend computation and analysis resources

LARGE SYNOPTIC SURVEY TELESCOPE

Large Synoptic Survey Telescope (LSST)
Systems Engineering

LSST Science Platform Vision Document

M. Jurić, D. Ciardi, G.P. Dubois-Felsmann, L.P. Guy

LSE-319

Latest Revision: 2019-07-24

https://ls.st/lsp

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LSST Science Platform -- Current Snapshot

Portal Aspect

exploratory analysis and visualization of the LSST archive

Notebook Aspect

in-depth ‘next-to-data’ analysis and creation of added-value data products

Web API Aspect

remote access to the LSST archive via industry-standard APIs

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

High-throughput Computing Use Cases

DMTN-086 details example use cases for high-throughput computations. E.g.:

- Making stellar density maps – GROUP BY-like aggregations (Qserv*)
- Light curve fitting for interesting objects – (Jupyter)
- Light curve feature computation for ~1% of objects – challenging.
- 2-point correlation functions – challenging
- Training machine learning models – challenging..

High-throughput Computing in the LSP

- LSST data ≫ bandwidth
- Object table ~ 50TB after one year, 300 TB at full-width;
- ForcedSource grows 65 TB per year (1 Gbps is ~ 0.5 TB/hour)

The logical solution is to adopt a "Bring your code to the data" model; circumventing the bandwidth bottleneck.

Visualizing Large Datasets in the LSP

Gaia DR2 data with Parquet, Dask, HoloViews and Datashader

Gaia DR2 Density Map

1.7 billion objects in the Gaia source catalog

Data in parquet files

Dask: 15 workers, 4 cores, 12GB RAM,

~20 sec to aggregate & bin

Notebook Credit : ***rv_gaia.ipynb. Simon Krughoff***

Pre-Operations Data Release Scenarios

Large Synoptic Survey Telescope

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Releasing pre-survey LSST data

Operations team's primary activity prior to start of operations

- The Project will produce images and catalogs from the commissioning (ComCam and LSSTCam Science Validation [SV] survey) raw images
- The Commissioning Team will perform verification studies with these data, to check that the LSST system and science requirements are met
- The Operations Team will use them to develop and demonstrate their readiness to process and serve the LSST survey data
  - Successful data service involves providing documentation and user support
  - Community feedback will be vital both during the survey (to enable optimization of the system) and during commissioning (to help us make sure the system is set up well in the first place)

Data Previews

LSST Operations is planning a sequence of three pre-survey data releases, of increasing scope, to develop the facility's data release capability

- The idea is to process, serve, and support, three datasets that will drive the development of our data release processes (including the collection and processing of community feedback)

- To distinguish these pre-survey releases from the survey data releases (DR1, DR2 etc), we refer to them as "data previews" (DP0, DP1, and DP2)

The LSST Data Previews are in their design phase: we will need input from the science community as to their content and delivery, to be balanced against the capabilities of the as-built system and operations team

LSST Pre-Operations

Data Preview 0: Precursor, Sep 2021

- 120 accounts / simultaneous logins
- Minimal web API
- No batch compute

Data Preview 1: ComCam, Apr 2022

- Best-effort Portal
- Scaled-up logins/processes
- Iterated web API
- Best-effort batch compute

Data Preview 2: LSSTCam, Nov 2022

- Full-flight Portal
- Full-scale sessions/accounts/compute
- Full-scale web API

LSST Science Collaborations

Large Synoptic Survey Telescope

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LSST Science Collaborations

Figure credit: Federica Bianco

- Formed by the LSST Project in 2006 with the intent to provide a forum to engage the community in interacting with the project team.
- 8 quasi-independent, self governing science collaborations, each with a charter, publication policy, code of conduct
- Instrumental in developing the science case for LSST – LSST Science Book 2019
- ….. and the LSST Observing Strategy

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

LSST Science Collaborations

Figure credit: Federica Bianco

LSST is a Global Community

Figure credit: Federica Bianco

1000 Members: US~450 Chile: 69 UK: 57 Italy: 60 France:45

LSST Corporation Sponsored Stack-Club

LSST Science Collaboration members (individuals with data rights) can learn how to use the LSST Science Platform & pipelines at 'Stack-Club'

Tutorial Notebooks — StackClu

https://stackclub.readthedocs.io/en/latest/not...

StackClub
latest

Search docs

⊟ Tutorial Notebooks

- Getting Started
- Basics
- Visualization
- Image Processing
- Source Detection
- Deblending
- Validation

The `stackclub` Package

twilio
SMS API for web & mobile applications
Make and receive SMS messages in your applications with just a few lines of code.
Sponsored · Ads served ethically

Read the Docs v: latest

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) JupyterLab? 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.

Notebook	Short description	Links	Owner
Notes on Getting Started	Some brief notes on the LSST Science Platform JupyterLab set-up.	markdown	Phil Marshall
Hello World	Read about the Stack Club git/GitHub workflow, and make your first contribution to a notebook.	ipynb, rendered build passing	Phil Marshall
Templates	A folder containing a template notebook, and a template folder README file, to help you get your project started.	link	Phil Marshall
Finding Docs	Locate the documentation for Stack code objects, including using the `stackclub` library	ipynb, rendered	Phil Marshall

Analysis of Beam Simulator Images and Brighter-fatter Correction

Owner(s): **Andrew Bradshaw** (@andrewkbradshaw)
Last Verified to Run: **2018-09-14**
Verified Stack Release: **16.0 and 16.0+22 (w_2018_31)**

This notebook demonstrates the brighter-fatter systematic error on images of stars and galaxies illuminated on an ITL-3800C-002 CCD at the UC Davis LSST beam simulator laboratory. Using a series of images at increasing exposure times, we demonstrate the broadening of image profiles on DM stack shape measurements, and a possible correction method which iteratively applies a kernel to restore electrons to the pixels from which they were deflected. To keep things simple, for now we skip most DM stack instrument signature removal (ISR) and work on a subset of images which are already processed arrays (500x500) of electrons.

Learning Objectives:

After working through this tutorial you should be able to:

1. Characterize and measure objects (stars/galaxies) in LSST beam simulator images
2. Test the Brighter-Fatter kernel correction method on those images
3. Build your own tests of stack ISR algorithms

Logistics

This notebook is intended to be runnable on `lsst-lspdev.ncsa.illinois.edu` from a local git clone of https://github.com/LSSTScienceCollaborations/StackClub.

```
plt.plot(bf_dat['corrflux'][:,index],bf_dat['corrshapey'][:,index],'g.',label='Corrected')
plt.xlabel(flux_param),plt.ylabel(bf_param2)
plt.xscale('log')
plt.savefig(cat_dir+str(index).zfill(5)+'bfcorr.png')
```

How to get involved with LSST

1. Join a Science Collaboration :

- https://www.lsstcorporation.org/science-collaborations
- Only Data Rights holders can join a Science Collaboration
- Everyone at an institute in the US and Chile has Data Rights

2. Join stack club

- Stack Club Membership Application Form
- This will give you access to the LSST Science Platform
- Learn how to use the LSST Science Pipelines and Platform, make cool Jupyter notebooks with fun LSST people !

LSST is Coming Soon

We are here

First light with ComCam

DOE CD-3 review

SLAC I&T facility ready

Focal Plane Grid Received

50% Sensor Production Complete

Light up LSST network

Summit substantial completion

Auxiliary Telescope data processing system available

Camera L1-L2 assembly complete

Telescope & Site substantial completion, System integration & test start

Data Access Services available at US DAC

System first Light

Full science operations Survey Begins

2016 2017 2018 2019 2020 2021 2022 2023

Lower enclosure ready for dome

First Prototype Science Platform

First production science raft complete

Base facility complete

Commissioning Camera ready for testing

Camera ready at SLAC

Engineering first light

Science verification complete

First light with LSSTCam

First light ~12 months away

Operations starts in ~3 years

Keep in Touch

communications-team@lists.lsst.org

@myLSST

@lsst

lsst_astronomy

http://ls.st/z6u

large-synoptic-survey-telescope-lsst-

www.lsst.org

community.lsst.org

Subscribe to the LSST "Newsletter"
Send blank email to:
lsst-digest-join@lists.lsst.org

Useful Resources

- Science Drivers to Reference Design (Ivezic et al. 2008)
- LSST Science Requirements Document: LPM-17
- LSST Data Management Subsystem Requirements: LSE-61
- LSST Data Management System Design: LDM-148
- LSST Data Products Categories: LPM-231
- LSST Data Products Definition Document: LSE-163
- LSST Data Management Science Pipelines Design Document: LDM-151
- LSST Science Platform Vision Document: LSE-319
- LSST Science Platform Requirements: LDM-554
- LSST Science Platform Design Document: LDM-552

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.

Questions

Photo Credit: W. O'Mullane -- LSST Project/NSF/AURA