



Early Science with Rubin - What to Expect

Leanne Guy, AD System Performance
Bob Blum, Director of Operations

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U.S. DEPARTMENT OF
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Vera C. Rubin Observatory



A large-aperture, wide-field ground-based telescope located on Cerro Pachón, Chile.

- 6.7 m effective aperture (8.4m \varnothing M1)
- 9.6 deg² field-of-view (40 full moons)
- 3.2 Gpixel camera
- 6 optical-NIR filters, ugrizy (320-1050nm)
- High étendue ($A\Omega$) of 319 m² deg²
- Fully automated data processing system
- Science Operations, operated by NOIRLab and SLAC to start second half 2025

In the first 10 years of operation, the Vera C. Rubin Observatory will execute as its prime mission the Legacy Survey of Space and Time (LSST)

A “Wide-Fast-Deep” uniform optical/near-IR sky survey & color movie

- Entire visible sky, (18000 deg²) every 3 nights
- ~825 visits / pointing, ugrizy bands, $r \sim 27.5$ (36 nJy),
- 20 billion galaxies, 17 billion stars

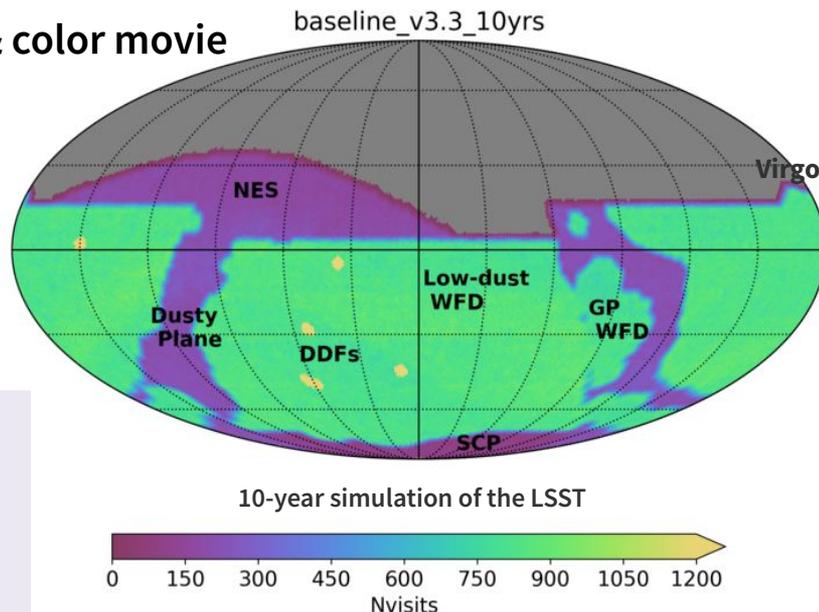
10 million alerts/night, 11 data releases over 10 yrs

Raw Data

6.4 GB/exposure
(compressed) | 20 TB/night |
~5 PB per year

Final 10-yr dataset

~6 million images | ~0.5 EB
data products | 15 PB final
catalog



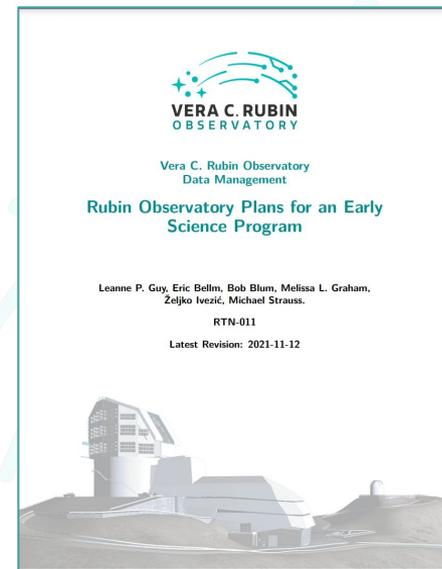
Early Science is defined as any science enabled by Rubin for its community through and including the first data release, Data Release 1 (DR1)

[RTN-011: Plans for Early Science \(V5.0\)](#) is the guiding document

- Plans for the Rubin Early Science Program;
- Early science data products & data access environment;
- Timeline for implementation;
- Science considerations and relationship with SCOC;
- Regularly updated to provide the most up to date information;
- Discussion on the [Rubin Community Forum](#),

Cite as follows:

Leanne P. Guy, et al. Rubin Observatory Plans for an Early Science Program. 5.0, Zenodo, 31 Oct. 2023, doi:10.5281/zenodo.5683848.



Motivations for an Early Science Program

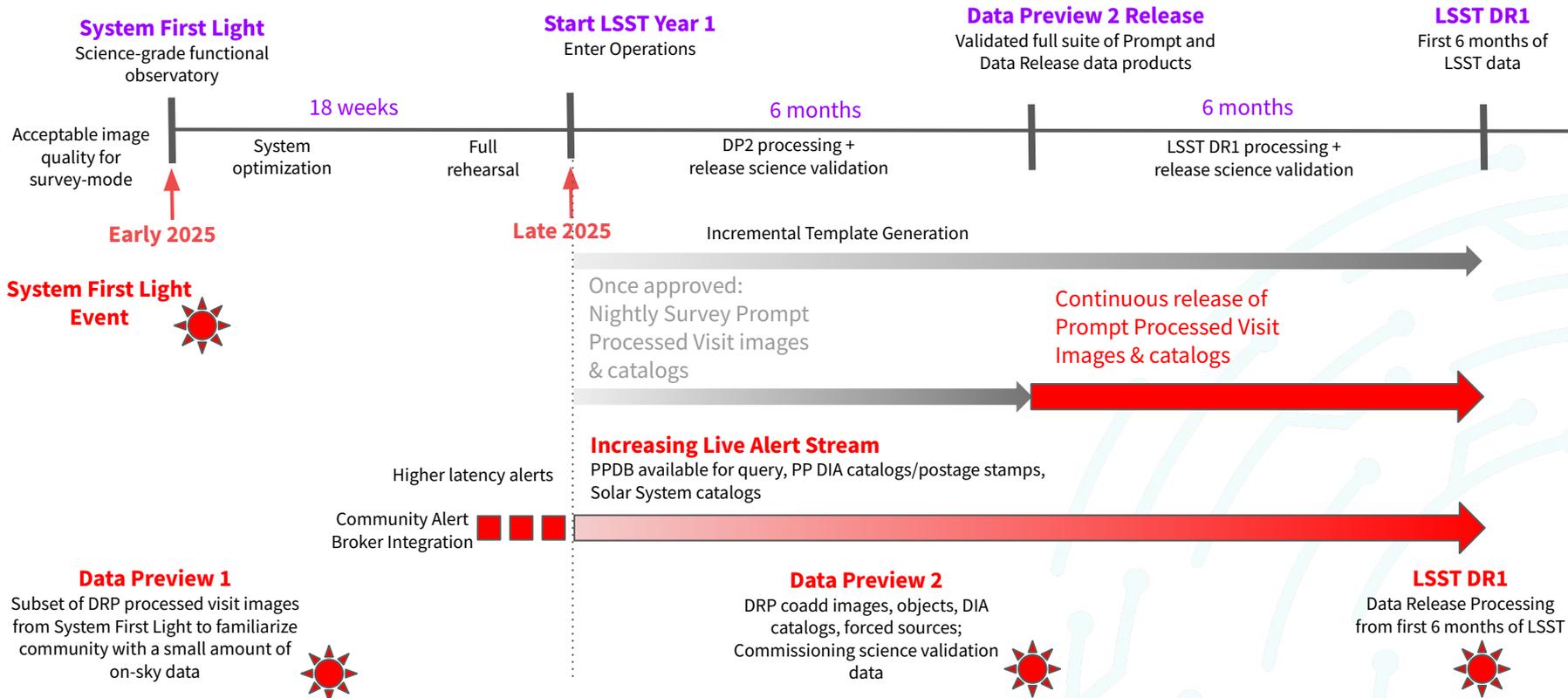
- To **enable high-impact science prior to the first data release, DR1**, both before and during the first year of regular survey operations.
- To provide **early access to both static-sky and time-domain science-ready data products** to support the community as they develop their LSST analyses in preparation for DR1,
- To **enable time-domain astronomy via Alert Production** during commissioning and in the first year of operations.

Elements of the Early Science Program

- Three **Data Previews (DP)**, **DP0**, **DP1** and **DP2**, based on either simulated LSST-like data (DP0) or data taken during the Rubin commissioning period with either the Commissioning Camera (ComCam) or LSST Science Camera (LSSTCam) (DP1 & 2).
- **A world-public stream of Alerts** from transient, variable, and moving sources that will be scaled up continuously during commissioning and year 1[‡].
- **Template generation**, both prior to the start of regular survey operations using LSSTCam commissioning data, and incrementally during the first year of regular survey operations to maximize the number of templates available for Alert Production during year 1[‡].
- **LSST Data Release 1 (DR1)**, which will be based on the Data Release Processing (DRP) of the first six months of LSST data

[‡] Due to the need for Data-Release-derived templates, Alert Production cannot run at full scale nor full fidelity during commissioning and year one.

Early Science Timeline



Rubin Data Previews

Rubin Observatory Operations will prepare both the community and itself by providing early data for science through a series of shared-risk Data Previews (DPs)

Data Previews lead deliberately to Operations readiness through the systematic addition of data products and users at each stage.

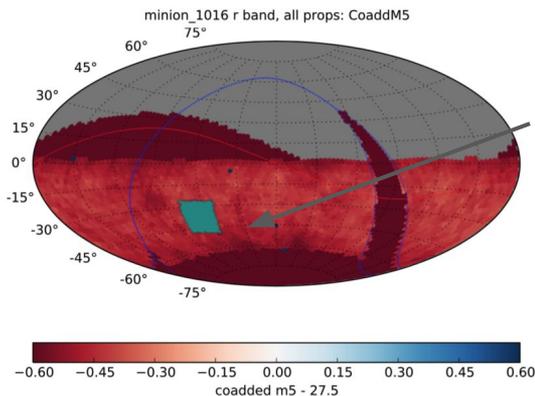
- 3 planned Data Previews,
 - ✓ DP0 - Based on Simulated datasets - **Complete July 2023**
 - DP1 - Early ComCam or LSSTCam data ~ **Early 2025**
 - DP2 - Science-grade LSSTCam Commissioning data ~ **Mid 2026**
 - DP0 split into DP0.1 (DESC-produced data products) and DP0.2(reprocessed DC2 data), DP0.3 (Solar System catalogs).
 - Current support for ~ 900 users working on DP0 on RSP – will ramp up to support all users by start of operations.

Data Preview/Release Schedule & Contents

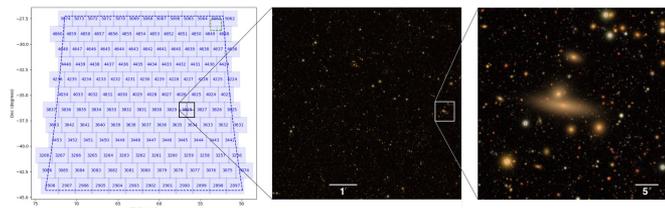
Rubin Early Science – Data Release Scenario

Data Product	Jun 2021	Jun 2022	Jun 2023	Oct 2024 – Jul 2025	Nov 2025 – May 2026	May 2026 – Jan 2027	May 2027 – Jan 2028	May 2028 – Nov 2028
	DP0.1	DP0.2	DP0.3	DP1	DP2	DR1	DR2	DR3
	DC2 Simulated Sky Survey	Reprocessed DC2 Survey	Solar System PPDB Simulation	ComCam or early LSSTCam Data	LSSTCam Science Validation Data	LSST First 6 Months Data	LSST Year 1 Data	LSST Year 2 Data
Raw Images	●	●	-	●	●	●	●	●
DRP Processed Visit Images and Visit Catalogs	●	●	-	●	●	●	●	●
DRP Coadded Images	●	●	-	-	●	●	●	●
DRP Object and ForcedSource Catalogs	●	●	-	-	●	●	●	●
DRP Difference Images and DIASources	-	●	-	-	●	●	●	●
DRP ForcedSource Catalogs including DIA output	-	●	-	-	●	●	●	●
DRP SSP Catalogs	-	-	-	-	-	●	●	●

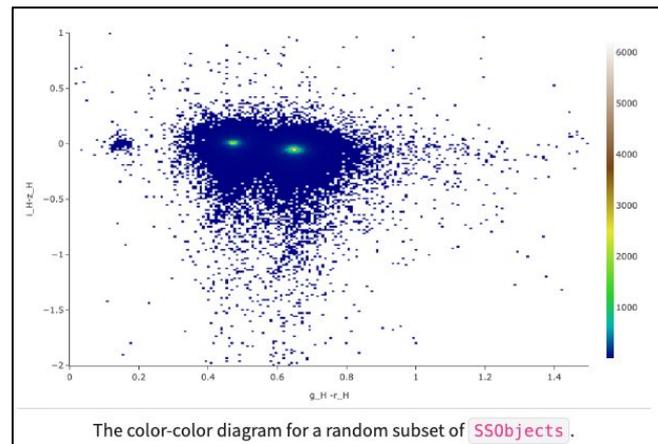
Source: [RTN-011](#)



DC2 overlaid on the
coadded depth skymap
(minion_1016).
[arXiv:2101.04855](https://arxiv.org/abs/2101.04855)



DC2 image simulations. Left: tracts in the DC2 area,
Middle: upper quadrant of tract 3828 in gri,
Right: zooms in on a region [arXiv:2101.04855](https://arxiv.org/abs/2101.04855)



DP0.1: dp0-1.lsst.io

DP0.2: dp0-2.lsst.io (includes the
getting started checklist

DP0.3: dp0-3.lsst.io

Alert Generation in Commissioning and Year 1

We aim to release high-quality alerts as soon as is feasible, sometime following System First Light. Once Alert Production begins, it is expected to continue without interruption through the ten-year duration of the LSST survey

To enable alert production prior to DR1, templates will be generated incrementally using the best images available from commissioning and year 1 data:

- **Commissioning Data Templates:** Build templates, where possible, from all science-quality commissioning data before the start of year one, and use them to generate alerts during year one
- **Year One Data Templates:** Build templates progressively from data obtained during year one (e.g., on a weekly or monthly timescale), and use them to generate alerts during year one, either instead of, or in addition to using commissioning data to build templates.

Alert Production Ramp Up

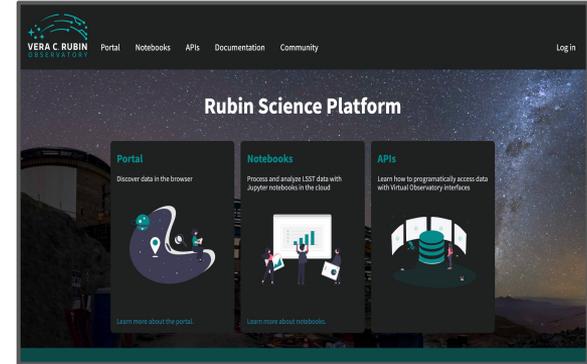
- Precursor Alerts based on DP02 reprocessed data products. Targeting Q3/Q4 CY 2023. *Dates still flexible – prompt processing is now live at the USDF and in testing.*
- LSSTCam alerts will be scaled up during commissioning with the aim of beginning routine Alert Production as soon as is feasible following System First light.
- Once begun, Alert Production will then proceed continuously without interruption into and throughout the full LSST. *Alerts generated during commissioning through DR1 may be produced with higher latency than planned during the full survey.*
- All alerts will be distributed to Brokers and will be world public.
- Prompt Products DB will be available before DP2 via the RSP
- Community Science Team will support the Community to work with early Alerts.

Rubin Science Platform

Enables peta-scale analysis of LSST data by providing services for scientists to access, visualize, subset and perform next-to-the-data analysis of Rubin Data products. Deployed in the Google cloud the RSP provides 1TB storage and 2 cores per user.

Community Alert Brokers

Software systems that ingest, process, and serve astronomical alerts from Rubin and other surveys to the scientific community. Typical broker functionality includes cross-match with archival catalogs, enabling follow-up observations, and photometric classification based on light-curve analysis.



References

- Science Drivers to Reference Design and Anticipated Data Products, [Ivezic et al. 2008, Version 5: May 2018](#)
- LSST Science Requirements : [LPM-17](#)
- LSST Data Products Definitions Document (DPDD): [LSE-163](#)
- LSST DM Science Pipeline Design: [LDM-151](#)
- Alerts Key Numbers: [DMTN-102](#)
- Options for Alert Packets: [DMTN-248](#)
- Plans and Policies for Alert Distribution: [LDM-612](#)
- Design of the Alert Distribution System: [DMTN-093](#)
- Pre-operations Alert Distribution Integration Exercises: [RTN-010](#)
- Planning for the First Public Release of LSSTCam Alerts: [RTN-061](#)
- LSST Science Platform Vision Document: [LSE-319](#)
- Rubin Documentation for Data Preview 0.2: [dp0-2.lsst.io](#)
- Rubin Observatory Data Security Standards Implementation: [DMTN-199](#)
- Rubin Observatory Community Forum: [community.lsst.org](#)

Rubin Observatory's mission is to build a *well-understood system* that will produce an *unprecedented astronomical data set* for studies of the deep and dynamic universe, make the data *widely accessible to a diverse community of scientists*, and *engage the public* to explore the Universe with us.

