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The Vera C. Rubin Observatory Data Preview 2

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ABSTRACT

We present an early version of Rubin Data Preview 2 (DP2), the second data preview from the National Science Foundation–Department of Energy Vera C. Rubin Observatory. Early Data Preview 2 (EDP2) comprises coadds, detection catalogs, and ancillary data products; eventually, the full DP2 will also include single-epoch images and difference images. DP2 is derived from observations acquired by the LSST Science Camera (LSSTCam) on the Simonyi Survey Telescope at the Summit Facility on Cerro Pachón, Chile, primarily during the on-sky commissioning campaign between 2025-04-16 and 2025-09-21, supplemented by observations taken between 2025-10-25 and 2026-01-06 that overlap the commissioning footprint. The DP2 footprint comprises the Science Validation wide-area survey, five Deep Drilling Fields, and a number of targeted small-field regions, including Trifid and Lagoon, Prawn, M49, and New Horizons, all observed as part of the Rubin First Look campaign. Each field was imaged in up to six broad photometric bands, *ugrizy*, and coadded to produce deep imaging covering an estimated 3,000 deg^2. The addition of single-visit-only areas expands the total DP2 footprint to an estimated 15,000 deg^2, with coverage in at least one filter. The median per-visit PSF FWHM across the wide-area survey ranges from 1.17 arcsec in the z band to 1.26 arcsec in g and r bands, with the sharpest fields reaching $\sim 0\farcs0$. COSMOS, the deepest field, reaches estimated coadded 5σ

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depths of u=26 mag, g=26.8 mag, r=26.3 mag, i=26.1 mag, z=25.3 mag, y=23.9 mag. DP2 contains X distinct astrophysical objects, of which X are extended in at least one band in coadds, and X solar system objects, of which X are new discoveries. DP2 is approximately 59.15 TB in size and is available to Vera C. Rubin Observatory data rights holders via the Rubin Science Platform, a cloud-based environment for the analysis of petascale astronomical data. Based on a roughly five-month primary observing baseline and covering only part of the eventual LSST footprint, DP2's area, depth, and multiband coverage nonetheless support a broad range of early science investigations ahead of LSST Data Release 1.

Keywords: Rubin Observatory - LSST

1. INTRODUCTION

The National Science Foundation (NSF)–Department of Energy (DOE) Vera C. Rubin Observatory is a ground-based, wide-field optical-near-infrared facility on Cerro Pachón in northern Chile, built to carry out the Legacy Survey of Space and Time (LSST) (Ivezić et al. 2019). The observatory is named in honor of Vera C. Rubin, whose observations in the latter half of the 20th century established the first compelling empirical case for dark matter (Rubin & Ford 1970; Rubin et al. 1980). Its 10-yr survey will image the entire visible southern sky every 3–4 nights, reaching a coadded depth of ~ 27 mag in the r-band across an 18,000 $\deg^2$ footprint (Bianco et al. 2022).

At the heart of the facility is the 3.2 gigapixels-gigapixel LSST Science Camera (LSSTCam), mounted on the 8.4 m (6.5 m effective aperture) Simonyi Survey Telescope (Stalder et al. 2024). Together they deliver an instantaneous field of view of 9.6 $\deg^2$ in six broadband filters, *ugrizy* (320–1050 nm), with seeing-limited image quality. The system's étendue of 319 $\deg^2$ m^2 exceeds that of any previous optical facility by over an order of magnitude, enabling the rapid, deep, all-sky cadence that underpins Rubin's four core science themes: the nature of dark energy and dark matter; a census of the solar system; the transient and variable optical sky; and the structure of the Milky Way (Ivezić et al. 2019). An automated Data Management System processes tens of terabytes of images per night to produce science-ready data products within minutes of each observation for a global community of scientists.

This paper presents Rubin's third Data Preview, Data Preview 2 (DP2) (NSF-DOE Vera C. Rubin Observatory 2025), and the first to be based entirely on LSSTCam data. It marks the conclusion of the Rubin commissioning program and the transition to full survey operations. DP2 is a reprocessing of all science-grade exposures acquired with LSSTCam during on-sky commissioning and the initial phase of early operations, prior to the formal start of the LSST on 2026-06-29. As such, it represents a natural boundary and provides a comprehensive dataset that captures the on-sky performance of the as-built system at the end of the Rubin construction project.

Two earlier Data Previews preceded DP2 as part of the Rubin Early Science Program (Guy et al. 2026), established to provide the community with early access to data products and services needed to produce high-impact science during the period spanning commissioning through the first Data Release. Data Preview 0 (DP0) was based on simulated LSST-like data (LSST Dark Energy Science Collaboration (LSST DESC) et al. 2021) and served primarily to stand up early versions of the Rubin Science Platform (RSP) and prepare the community for data access at scale. Data Preview 1 (DP1) (NSF-DOE Vera C. Rubin Observatory 2025) delivered the first data products derived from on-sky observations using science-grade exposures acquired with Rubin Commissioning Camera (LSSTComCam) (Stalder et al. 2022, 2020; Howard et al. 2018; SLAC National Accelerator Laboratory & NSF-DOE Vera C. Rubin Observatory 2024); a 144-megapixel, single-raft instrument used during early commissioning prior to the installation of LSSTCam on the Simonyi Survey Telescope. DP2 supersedes both in scope, fidelity, and scientific depth.

DP2 contains X science-grade exposures acquired over 158 nights between 2025-04-16 and 2025-09-21, covering a total sky area of $\sim$15 $\deg^2$ across X fields. The data products include raw and calibrated single-epoch images, coadded images, difference images, source detection catalogs, and a range of derived data products. The release totals approximately 59.15 TB and contains around X distinct astronomical objects. Full release documentation is available at https://dp2.lsst.io.

Because DP2 is drawn from a commissioning and early-operations data rather than from the more uniform and systematic LSST, its images and derived products reflect a system that was still being commissioned and tuned. LSSTCam's greater scale and complexity relative to LSSTComCam introduced systematics with no direct counterpart in DP1. For much of the campaign the Active Optics System (AOS) closed loop converged on a slightly mis-calibrated focus target, imprinting a spatially varying defocus across the focal plane that was only corrected on sky in December 2025 and that remains visible in the point-spread function (PSF) of a large fraction of DP2 exposures. Delivered image quality and PSF ellipticity did not consistently meet LSST design requirements in wide-area survey-mode observations by the close of commissioning; and stray- and scattered-light artifacts, sky-background systematics in crowded fields, and a chromatic PSF dependence[20] were identified and only partially mitigated in DP2 processing. These effects, their diagnosis, and the mitigations applied are described in §2 and §5.

Unlike the systematic, rolling revisit pattern that will characterize the LSST, DP2's observing cadence is opportunistic: fields and filters were prioritized to serve AOS and Science Pipelines commissioning rather than to build a representative time series. The Science Validation survey footprint was repeatedly re-scoped over the course of the science validation campaign due to the competing demands of engineering tests and filter availability, which was constrained by hardware issues for part of the campaign. Visit counts and time sampling therefore vary substantially and idiosyncratically from field to field, and DP2 should not be read as a preview of LSST's eventual survey cadence, revisit statistics, or depth-accumulation pattern.

DP2 is being delivered in two phases across the Jul–Dec 2026 window. The first phase, Early DP2 (EDP2), comprises the deep coadd images and all associated catalogs, including new cell-based coadds and the first releases of the An object with measurements using the metadetection algorithm, or the catalog thereof. (ShearObject) (§4.3.4) shape-measurement catalog and the Isolated Star Stellar Motions catalog (§**??**). EDP2 is targeted for 2026-07-27. The second phase, DP2, adds the visit-level single-epoch and difference images, completing the full release, and is expected in the Oct–Dec 2026 range. Data products delivered as EDP2 will be incorporated into DP2 unchanged, without additional reprocessing (Guy et al. 2026). This phased delivery follows directly from Rubin's hybrid cloud architecture (O'Mullane et al. 2024), in which science data products are stored at the United States Data Facility (USDF) and served to users via the US Data Access Center (DAC) in Google Cloud. Deep coadd images and catalogs are hosted directly in Google Cloud and are therefore unaffected by hybrid-cloud readiness, allowing them to ship as EDP2. Visit-level images, however, must be streamed from the USDF, and the necessary capacity is not yet fully in place, introducing timing uncertainty for the second phase. Delivery of the Prompt Data Products follows the same logic. The Prompt Products DataBase (PPDB), Rubin's real-time catalog of transient, variable, and moving-object detections, does not depend on USDF–Google Cloud bandwidth and is therefore prioritized as the second Early-Operations delivery milestone, following EDP2 and preceding the full DP2 release, expected in the Sep–Oct 2026 range. Prompt images (raw images, Processed Visit Images, and difference images), which do require that bandwidth, have been deprioritized relative to EDP2 and the PPDB and are expected to become available only in the Oct–Dec 2026 range, following both.

DP2, like all Rubin Data Previews and Data Releases, is subject to a 2 yr proprietary period; during this time access is restricted to LSST data rights holders (Blum & the Rubin Operations Team 2020) via the RSP (Jurić et al. 2019), Rubin's cloud-based data science platform (Jurić et al. 2019). After the proprietary period, DP2 will be made public, though access through Rubin DACs in the US and Chile will remain limited to data rights holders (Blum & the Rubin Operations Team 2020). Alternative public access mechanisms have not yet been finalized.

The structure of this paper is as follows. Section 2 describes the observatory system and its status at the close of commissioning, the fields included in DP2, and the observing strategy employed. Section 3 summarizes the data products in the release. The processing pipelines are described in Section 4, followed by data validation and performance characterization in Section 5. Section 6 describes the RSP. Section 7 outlines Rubin's community support model. A summary and outlook toward the start of formal LSST Data Releases is given in Section 8.

All magnitudes are quoted in the AB system (Oke & Gunn 1983) unless otherwise specified.

2. COMMISSIONING WITH LSSTCAM

3. OVERVIEW OF THE CONTENTS OF RUBIN DP2

4. DATA RELEASE PROCESSING

Data Release Processing (DRP) is the data pipeline that produces the calibrated images, detection catalogs, and derived data products defined in section §TBD, using the LSST Science Pipelines (citation). DP2 was processed at the United States Data Facility (USDF) at SLAC, with pilot runs at the National Institute of Nuclear and Particle Physics (IN2P3) computing center.

[20] LSSTCam has no atmospheric dispersion corrector

The processing campaign consists of four major stages: (1) single-frame processing, (2) calibration, (3) multi-visit processing, (4) variable and transient source processing. Data quality and key metrics for verification and validation are actively monitored during each stage, and comprehensive verification and validation assessments are completed before processing the next stage.

This section describes the high-level algorithms, configurations, and verification metrics for each stage, including changes and improvements from DP1 (citation).

4.1. *Single-Visit Processing*

4.1.1. *Calibration & Instrument Signature Removal (ISR)*

The first task in data processing begins with a raw image. This image is in integerized analog-to-digital units (ADU, or counts) and contains detector artifacts imprinted by the physics of the detector and readout hardware. This step aims to remove any artifacts that are not of astrophysical origin and produce science-ready, single-visit exposures in floating-point electron units with complete pixel masks.

The ISR pipeline is built on a physical model of the detectors and readout electronics, in which each artifact is tied to a specific point in the photon-transfer chain and is corrected using calibrations from dedicated campaigns conducted during the day or on cloudy nights. Figure 1 shows this model of the detector and readout components and the effects each imparts on the measured image. ISR works backward through the chain, undoing these effects in the reverse of the order in which they were imprinted.

Detector response and performance vary across the focal plane, and more so for LSSTCam than for ComCam during DP1 processing. The full LSSTCam focal plane comprises 189 science charge-coupled devices (CCDs) from two vendors (Imaging Technology Laboratories, ITL, and Teledyne e2v, E2V), each of which must be processed separately.

A detailed description of the DP2 ISR procedures and the calibration products they consume can be found in (Cite RTN-117 here when DOI becomes available).

The ISR processing pipeline for DP2 performs the following steps, in order: (1) conversion of the raw integers to floating point, (2) ADU dithering to mitigate quantization effects, (3) serial overscan subtraction, (4) saturated- and suspect-pixel masking, (5) gain (electrons/ADU) correction, (6) crosstalk correction, (7) parallel overscan subtraction, (8) non-linearity correction, (9) deferred-charge correction, (10) vendor-specific masking (E2V edge bleed; the ITL "dip," saturation sag, and edge bleed), (11) bias subtraction, (12) dark subtraction, (13) defect masking, (14) saturated pixel

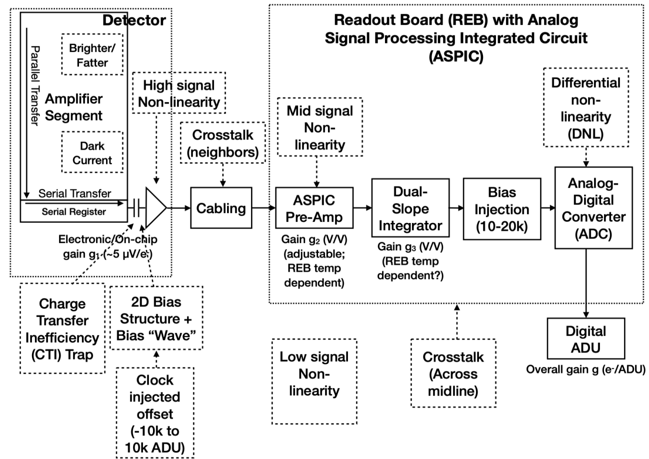

Figure 1. The model of the detector and REB components, labeled with the effects that they impart on signal.

footprint widening, (15) brighter-fatter correction, (16) variance plane estimation, (17) flat fielding, (18) interpolation over masked pixels, (19) amplifier-offset corrections.

Each calibration must be valid for the conditions under which the science image was taken. Camera power cycles, large temperature shifts, and changes to the CCD operating mode (sequencer) can all invalidate earlier calibrations. Over the DP2 observing period, calibration products are therefore organized into three calibration epochs. Epoch 1 (April 24–July 2, 2025) covers the initial on-sky commissioning period with the `2s_v30` sequencer, using defect maps derived from in-lab calibration campaigns conducted before the camera was installed on the telescope. Epoch 2 (July 3–September 21, 2025) used an updated `3s_v1` sequencer, which lowered the saturation point but reduced read noise, crosstalk, and charge persistence relative to Epoch 1. Following an observatory maintenance shutdown in October, Epoch 3 (October 24, 2025–January 6, 2026) resumed under the same sequencer but used a new set of calibrations. A fourth epoch, not included in DP2, began January 23, 2026 with the `3s_v2` sequencer, bringing reduced correlated noise and improved linear readout response.

Compared to DP1 (Vera C. Rubin Observatory Team 2026), the ISR pipeline has been substantially upgraded, including improved sensor diagnostics and characterization, an entirely new brighter-fatter correction based on Astier & Regnault (2023) and Broughton et al. (2024), and an all-new flat-field production pipeline that corrects for gradients and mis-centering of the flat-field illumination using new calibration hardware. A new set of 10 LEDs spanning the full sensitivity range of the LSSTCam sensors (one in u, two each in $griz$, and a new 1050 nm LED shared between y and z). For the bands covered by two LEDs, we combine separate flats for each LED (for the blue and red side of the band) into a so-called “anaglyph” flat, with a weighting that approximates a flat spectral energy distribution across the band.

ogether, these upgrades allow ISR to deliver uniform, science-ready exposures across all 189 LSSTCam science sensors for DP2.

4.1.2. *Background Subtraction*

Background subtraction in `CalibrateImageTask` estimates and removes large-scale background signals from science imaging prior to source detection and measurement. Such signals include sky brightness from airglow, moonlight, scattered light, zodiacal light, and diffuse astrophysical emission. The background is estimated twice: an initial model (`psf_subtract_background`) is subtracted before PSF characterization, and a second model (`star_background`) is fit on the updated source-masked image before the final detection pass. Each post-ISR image is divided into 128×128 pixel superpixels, and the iterative 3σ-clipped mean of unmasked pixels in each bin is fit with a sixth-order two-dimensional Chebyshev polynomial, evaluated at native pixel resolution via Akima spline interpolation. Before fitting `star_background`, the `DETECTED` mask plane is dilated by up to 10 pixels to suppress source-wing flux from leaking into background bins. After `star_background` subtraction, a zeroth-order pedestal correction is estimated iteratively over bin sizes starting at 32×32 pixels, doubling each step until the cumulative pedestal level changes by less than 5% or 0.5 counts between steps. The `star_background` model and pedestal corrections together constitute the output background model (`preliminary_visit_image_background`; see Figure 2).

Compared to DP1 (NSF-DOE Vera C. Rubin Observatory 2025), several changes were made to background subtraction for DP2. The inline re-estimation performed after each detection pass in DP1 (`reEstimateBackground = True`) has been replaced by the dedicated `star_background` subtask. In addition to source mask dilation and a pedestal correction, other new features for DP2 include adaptive threshold determination and diffraction spike masking. The per-step illumination correction used in DP1 has been disabled for DP2. Following background subtraction, the median and standard deviation of all unmasked pixels and of *sky source* fluxes are recorded in the task metadata as diagnostics of background subtraction quality.

4.2. *Calibration*

4.2.1. *PSF Modeling*

PSF modeling in DP2 uses two distinct approaches, as described in the (Rubin Observatory Science Pipelines Developers 2025) and it is similar to what was originally described in DP1 The first model—faster but less precise—is fit with PSFEx (Bertin 2011), while the final model—slower yet more accurate—is fit with Piff (Jarvis et al. 2021). Broadly speaking, PSFEx and Piff both represent the PSF on a pixel basis and interpolate its parameters across a single CCD using two-dimensional polynomials. However, their technical implementations differ (see Bertin et al. and Jarvis et al. 2021 for more details). Previous comparisons have shown that Piff outperforms PSFEx by delivering an unbiased reconstruction of the PSF size (see Zuntz et al. 2018 and Jarvis et al. 2021), can work in sky coordinates like in Schutt et al. 2025, can include a color dependency like in Schutt et al. 2025, and is supporting alternative models and interpolation schemes (see Schutt et al. 2025 for more details).

In the initial PSF modeling pass, PSFEx is run with a pixel basis and a second-order polynomial interpolation on each CCD. For the final modeling, Piff uses its PixelGrid with a fourth-order polynomial interpolation per CCD—except in the u-band, where star counts are too low to constrain a fourth-order fit, so a second-order polynomial is used instead. Both are working in pixel coordinates. Choices of polynomial order, overall PSF-modeling performance, and known issues are discussed in Section “Performance and Known Issues for PSF.”

4.2.2. *Astrometric Calibration*

The final astrometric calibration of the data follows the method in DP1, but with some key additions. As described in DP1, a joint calibration is performed on all visits in a given band overlapping a given area. By associating all the isolated point sources shared among the overlapping visits, we can refine the astrometric solution beyond the level achieved in single-frame processing using only a reference catalog.

Unlike in DP1, the area we use for individual fits of the astrometric solution is an order-3 healpix, instead of a tract. This is done to reduce repetitive calculations, since the small size of tracts compared to the LSSTCam field of view means that neighboring tracts often share identical overlapping visits, which would lead to doing many identical fits of the astrometric calibration.

As in DP1, the astrometric model consists of a static map from pixel space to an intermediate frame, which is followed by a per-visit map from the intermediate frame to the plane tangent to the telescope boresight, and fi-

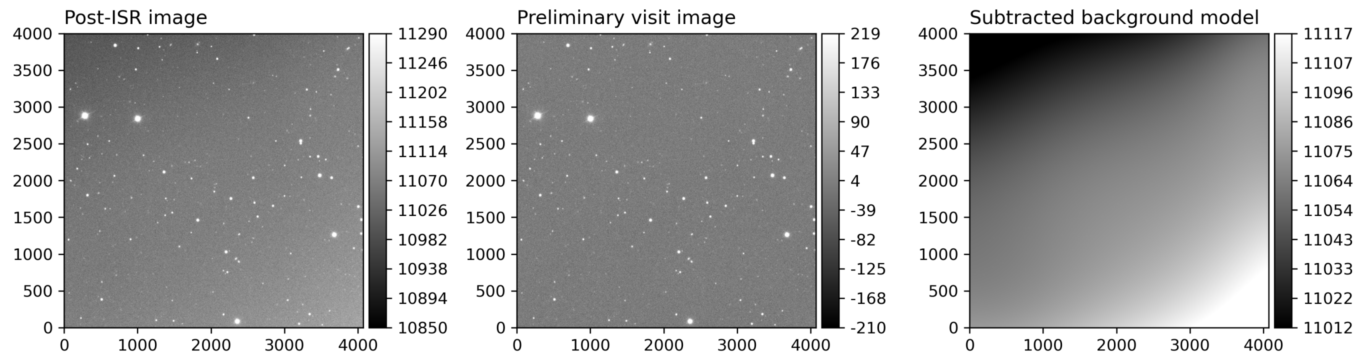

Figure 2. Background subtraction for LSSTCam visit 2025110500300, detector 25. *Left:* Post-ISR image (`post_isr_image`), before any background removal. *Center:* Preliminary visit image (`preliminary_visit_image`), after background subtraction by `CalibrateImageTask`. *Right:* The subtracted background model (`preliminary_visit_image_background`), illustrating the large-scale structure removed. All three panels use a linear stretch clipped to the central 95th percentile of pixel values.

nally a deterministic mapping from the tangent plane to the sky. This is done by the `gbdes` package (Bernstein et al. 2017), as described in Saunders (2024). The proper motion and parallax of the objects used in the calibration are fit as part of the solution, but we do not yet include differential chromatic refraction or lateral color. These will be included in future data releases during Rubin Operations.

The main difference from the DP1 astrometric calibration is an additional step that models the effect of atmospheric turbulence on the astrometry. The per-visit part of the astrometric model already described captures large-scale variation between visits, which includes some atmospheric effects. However, higher order oscillations are visible in the astrometric residuals, and these can be attributed to atmospheric turbulence (Saunders 2025). As described in Fortino et al. (2021) and Léget et al. (2021), the wave-like astrometric effects caused by turbulence can be modeled by a Gaussian process. In DP2, we do this by taking the astrometric residuals remaining after the `gbdes` fit, grouping them by visit, then modeling them with the Gaussian Process package `treegp`. We then use this Gaussian Processes model to predict the effects of turbulence on a grid. Finally, this grid is turned into a two-dimensional spline that can use the AST component `SplineMap` so that it can be concatenated with the `gbdes` model. By including this model for the higher-order atmospheric turbulence, we achieve a significant improvement in the astrometric calculation, as demonstrated in Section 5.

A corollary product of the `gbdes` astrometric calibration is the catalog of proper motions and parallaxes of the sources used in the calibration. Since the `gbdes` fit is done per-band, and then improved by the turbulence fit, we perform an additional final fit of the proper motion and parallax, using the final astrometric model and all available bands. The resulting catalogs are included in the DP2 data release. These catalogs only include isolated point sources, but future data releases will be extended to include proper motion and parallax for all objects.

4.2.3. *Photometric Calibration*

Photometric calibration of the DP2 dataset is based on the Forward Global Calibration Method (FGCM Burke et al. 2018) adapted for the LSST Science Pipelines (Aihara et al. 2022; Fagrelius & Rykoff 2025). We used the FGCM to calibrate the full DP2 dataset with a forward model that uses a parameterized model of the atmosphere as a function of airmass along with a model of the instrument throughput as a function of wavelength. The FGCM process typically begins with measurements of the instrumental throughput, including the mirrors, filters, and detectors. For the LSSTCam filter throughputs, we start with the filter scans provided by the manufacturer, Matereon. These were taken in a grid with 159 positions, at 5 incidence angles from 13.8 to 23 degrees, at a wavelength resolution of 1 nm. We performed an averaging procedure to get the approximate appropriate throughput for the LSSTCam beam as it intersects the filter at the central location of each detector. For the LSSTCam detector quantum efficiency (QE) curves, we start with per-raft measurements of the QE performed at Brookhaven National Laboratory (BNL) and SLAC National Accelerator Laboratory (SLAC) at 10 to 25 wavelength steps. These preliminary scans were then normalized relative to each other at 750 nm. However, there are still some per-raft systematic differences seen, particularly in the u and y bands. In the future we will use the in-dome tunable laser system and the Collimated Beam Projector (CBP) for improved filter and detector throughputs.

The FGCM atmosphere model, provided by MODTRAN (Berk et al. 1999), was used to generate a look-up table for atmospheric throughput as a function of zenith distance at Cerro Pachón. This model accounts for absorption and scattering by molecular constituents of the atmosphere, including O2 and O3; absorption by water vapor; and Mie scattering by airborne aerosol particulates. Nightly variations in the atmosphere are modeled by minimizing the variance in repeated observations of stars with an SNR greater than 10, measured using "compensated aperture fluxes." These fluxes include a local background subtraction to mitigate the impact of background offsets. The model fitting process incorporates all six bands (*ugrizy*) but does not include any gray (achromatic) terms, except for a linear assumption of mirror reflectance degradation and dust accumulation on lenses. Fortunately, there is no evidence of any significant loss of throughput over the 250 days of the DP2 dataset. As an additional constraint on the fit, we use a subset of stars from the Monster reference catalog (Ferguson et al. 2025), primarily to constrain the system's overall throughput and establish the "absolute" calibration.

4.3. *Multi-Visit Processing*

4.3.1. *Input Data Selection*

4.3.2. *Coaddition*

4.3.3. *Detection, Deblending, & Measurement*

Coadd detection and measurement proceeds with a similar order of steps as in DP1; however, numerous changes have been made to individual algorithms. The main change is that algorithms run on cell-based coadds, which have fewer PSF discontinuities within cells. For this release, though, none of the measurement algorithms take cell boundaries into account, and those that require a PSF model use the PSF model at the centroid of the object (and therefore of the cell that the centroid is within) for all cells.

First, peaks are detected in single-band patch images. These peaks are then merged across bands to produce a multiband peak catalog. This catalog is used as an input for deblending, which outputs deblended (but not deconvolved) images for each object. All object catalog measurements are performed on these deblended images.

The basic methodology for detection is largely unchanged from the description in Bosch et al. (2018), which we summarize here. To detect peaks, each image is convolved by a circular Gaussian approximation to the measured PSF to make a significance image. A footprint is a contiguous region of pixels above the detection threshold, which is set to detect isolated point sources above 5σ significance. Footprints can have multiple peaks, which are defined as pixels with values higher than all 8 neighbours (local maxima within a 3x3 box). Note that even for an isolated object, the significance of a detection is not precisely the same as the signal-to-noise from subsequent PSF model fluxes.

Pixels within footprints are marked with the DETECTED bit mask. The remaining pixels are used for background estimation and subtraction, excluding significantly negative-valued pixels which are likely to be residual artifacts. The algorithm also attempts to randomly place 100 "sky objects" within the noise-dominated pixels, reducing the number in crowded fields with low numbers of sky-dominated pixels if necessary. These objects do not appear in the final object catalog but are used to characterize the sky variance in intermediate steps.

As explained in Aihara et al. (2019), the process of convolving the image by an approximation of the PSF reduces the variance in the image, and therefore the pixel significance threshold must be adjusted to achieve the desired detection threshold. This factor is computed by measuring the standard deviation of the PSF model Signal to Noise Ratio (SNR) of the sky objects.

Once detection has run in each available band, footprints and their peaks are merged in a fixed priority order, *irzygu*, which is roughly in order of expected SNR for typical objects. New peaks are only added if they are at least $1.''0$ further than an existing peak, and existing peaks are marked as detected in multiple bands if a new peak is found within $0.''3$; peaks within this range are ignored. After merging, probable spurious peaks detected in only one band are removed.

Deblending is performed by the The "lite" version of the scarlet algorithm, optimized for multiband deblending on pixel-aligned grids. Includes the scarlet_lite and meas_extensions_scarlet Python packages. (scarlet lite) python package. scarlet lite is an optimized implementation of the scarlet (Melchior et al. 2018) deblending algorithm with the assumption that the input images are aligned to the same pixel grid at a fixed resolution, as is the case in coadds. Prior to deblending, a new addition in DP2 is a per-band partial deconvolution of the input coadds to a common $\sigma = 0.8 pixel$ integrated circular Gaussian PSF. This allows us to sub-divide large parent blends (footprints) into multiple smaller blends that are only connected by the wings of the PSF. These smaller sub-blends and the initialization of galaxy morphologies from the partially deconvolved images improves numerical convergence and performance, both in the goodness-of-fit of the final models and in memory usage and runtime. Users will notice that this has improved our coverage in crowded fields from DP1; however, in the densest fields, an entire patch can still be a single blend and must be skipped due to excessive memory requirements.

Object measurements are conducted in three modes: independent per-band measurements, forced measurements in each band, and multiband measurements. As detailed in Bosch et al. (2018), measurement first replaces all pixels in footprints with noise, so that algorithms that require pixel values beyond footprint boundaries can perform measurements without contamination from neighbors (whether they are part of the same blend or not). During measurement, isolated objects have their original pixel values inserted back into the image, while blended objects use the scarlet lite models as templates to re-distribute the original image values. This preserves the flux from the original image where objects have no overlap and dampens the noise elsewhere, since the flux is reapportioned to multiple objects.

The single-band measurement plugin system remains unchanged from DP1 and largely follows the description in Bosch et al. (2018). Measurements are made in every available band, and a reference band is defined from the same priority order as detection merging (*irzygu*) for a second round of forced measurements. These use the shape and position from the reference for consistency. Most algorithms have their free measurements reported in the final object table, but forced values are generally recommended.

A variety of flux measurements are provided, including aperture fluxes, Kron (1980), and Gaussian-Aperture-and-PSF (Gaussian Aperture and PSF (GAaP) Kuijken 2008; Kannawadi 2025) fluxes for consistent galaxy colors. Forward Point Spread Function (PSF) model and Composite model (CModel) magnitudes (Abazajian et al. 2004; Bosch et al. 2018) are provided for each band.

The MultiProFit astronomical source modelling code, including the multiprofit Python package and its dependencies, and the meas_extensions_multiprofit package for pipeline tasks. (MultiProFit) (Taranu 2025) performs multiband forward modelling. Beginning in DP2, an exponential profile is fit first and used to initialize a subsequent Sérsic model (Sérsic 1963; Sersic 1968) fit, which improves convergence and reduces the prevalence of Sérsic fits with unrealistically large effective radii. Both exponential and Sérsic model fits have free centroids, which serve as alternative, multiband astrometry for objects. The Object table now includes uncertainties on the fitted ellipse parameters for both models (the x- and y-axis effective radii and correlation parameter ρ). These will be converted to uncertainties on more commonly used parameters (major/minor effective radii and axis ratios) for DR1.

Some additional derived parameters are included in the object catalog, mainly for object classification. “extendedness“ is a binary classifier, set to 1 if the PSF to CModel flux ratio is below 0.985. “sizeExtendedness“ is a quasi-probabilistic morphological classifier reported as $1 - exp(-0.5 * ((T_{HSM} - T_{PSF})/T_{PSF}^{0.5})^2)$, where T_{HSM} and T_{PSF} are the sum of the squares of the x- and y-axis moments for the object from the HSM algorithm and for the PSF model, respectively. As an alternative, DP2 adds model_extendedness, which is a continuous, heuristic classifier that uses both the exponential model effective radius and the ratio of the Sérsic model to PSF model flux. It is available for each band and separately for the sum of the *griz*-band fluxes.

As for DP1, photometric redshifts are not computed or included in the object table but are planned as a supplementary user-generated product.

Further details on the performance of these algorithms are found in TODO: add relevant section references.

4.3.4. *Metadetection and ShearObject*

The ShearObject catalog using the multiband metadetection algorithm (Sheldon et al. 2020) is new to DP2. It creates an entirely separate catalog with detections that do not correspond to the Object catalog. Each 150x150 cell in ‘griz‘ bands is extracted with a 50 pixel border to make 250x250 pixel images, that are then passed to metadetect. Internally, metadetect makes counterfactual images by deconvolving by the original PSF, shearing the image and reconvolving to a new PSF using the `fitgauss` reconvolution algorithm. Metadetect coadds ‘riz’ bands to form a coadd for detection, and measures shear using the `gauss` algorithm by fitting a 2D elliptical Gaussian to r, i, z coadds. Additionally, for these detections, it also reports force-photometered fluxes in g, r, i and z bands for these detections measured using the `pgauss` algorithm. There is no deblending performed prior to these measurements.

4.3.5. *First Look*

4.4. *Variable & Transient Source Processing*

4.4.1. *Difference Image Analysis (DIA)*

DP2 difference imaging analysis did not change significantly relative to DP1. DP2 Difference Image Analysis (DIA) uses the decorrelated Alard and Lupton image differencing algorithm (Alard & Lupton 1998; Reiss & Lupton 2016). Both positive and negative `DIASource`s are detected in the difference image at 5σ. We fit a dipole model to sources containing both positive and negative peaks, and infer trail parameters from the second moments of the PSF. After rejecting likely artifacts

(§4.4.2), we associate DIASources into DIAObjects with a 1″ matching radius.

4.4.2. *Artifact Rejection*

DIA analysis is prone to false positives. We employ several layers of artifact rejection, although we err on the side of completeness rather than purity in Data Release Processing.

As in DP1, prior to writing the DIASource catalog, we remove sources with pixel flags artifacts, non-astrophysical trail lengths, and unphysically negative direct fluxes. In DP2 we also reject sources that land on the modeled positions of diffraction spikes and apply morphological cosmic ray rejection on both the direct and difference images. Further, we flag but do not remove multiple DIASources that occur in a straight line with glint_trail, indicating that they may be due to rotating orbital debris (Karpov & Peloton 2022).

We developed a machine-learned reliability score to assess whether DIASources were astrophysical. (Acero-Cuellar et al. 2026) provides an overview of the model architecture, training, and performance of the real-bogus model. The v0.1 model used in DP1 was again used during DP2 processing. No cuts were applied on reliability for the DP2 DIASource catalogs, so users interested in higher purity should apply a minimum reliability threshold.

4.4.3. *Light Curves*

4.4.4. *Solar System Processing*

5. PERFORMANCE CHARACTERIZATION AND KNOWN ISSUES

6. RUBIN SCIENCE PLATFORM

7. SUPPORT FOR COMMUNITY SCIENCE

8. SUMMARY AND FUTURE RELEASES

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Software: Rubin Data Butler (Jenness et al. 2022), LSST Science Pipelines (Rubin Observatory Science Pipelines Developers 2025), LSST Feature Based Scheduler v3.0 (Jones 2026; Yoachim et al. 2024; Naghib et al. 2019), Astropy (Astropy Collaboration et al. 2013, 2018, 2022), PIFF (Jarvis et al. 2021), GBDES (Bernstein 2022), MultiProFit (Taranu 2025), Qserv (Wang et al. 2011; Mueller et al. 2025), Slurm, HTCondor, CVMFS, FTS3, ESNet

APPENDIX

Glossary

AOS: Active Optics System.

AURA: Association of Universities for Research in Astronomy.

DAC: Data Access Center.

Data Management System: The computing infrastructure, middleware, and applications that process, store, and enable information extraction from the LSST dataset; the DMS will process peta-scale data volume, convert raw images into a faithful representation of the universe, and archive the results in a useful form. The infrastructure layer consists of the computing, storage, networking hardware, and system software. The middleware layer handles distributed processing, data access, user interface, and system operations services. The applications layer includes the data pipelines and the science data archives' products and services.

DIA: Difference Image Analysis.

DOE: Department of Energy.

DP0: Data Preview 0.

DP1: Data Preview 1.

DP2: Data Preview 2.

EDP2: Early Data Preview 2.

exponential profile: The radial distribution of flux of an astronomical source that is characterized: I(r)=I0exp(.68(r/re)) The normalization 1.68 is chosen so that the model radius is a half-light radius. An 2-dimensional elliptical version of this profile is fit to every detected source.

flux: Shorthand for radiative flux, it is a measure of the transport of radiant energy per unit area per unit time. In astronomy this is usually expressed in cgs units: erg/cm2/s.

footprint: See 'source footprint', 'instrumental footprint', or 'survey footprint', 'Footprint' is a Python class representing a source footprint.

GAaP: Gaussian Aperture and PSF.

HSM: Shape measurement algorithm from Hirata & Seljak (2003) and Mandelbaum et al. (2005).

LSST: Legacy Survey of Space and Time.

LSSTCam: LSST Science Camera.

LSSTComCam: Rubin Commissioning Camera.

MultiProFit: The MultiProFit astronomical source modelling code, including the multiprofit Python package and its dependencies, and the meas_extensions_multiprofit package for pipeline tasks..

NSF: National Science Foundation.

Object: In LSST nomenclature this refers to an astronomical object, such as a star, galaxy, or other physical entity. E.g., comets, asteroids are also Objects but typically called a Moving Object or a Solar System Object (SSObject). One of the DRP data products is a table of Objects detected by LSST which can be static, or change brightness or position with time.

PPDB: Prompt Products DataBase.

PSF: Point Spread Function.

RSP: Rubin Science Platform.

scarlet lite: The "lite" version of the scarlet algorithm, optimized for multiband deblending on pixel-aligned grids. Includes the scarlet_lite and meas_extensions_scarlet Python packages..

ShearObject: An object with measurements using the metadetection algorithm, or the catalog thereof..

SNR: Signal to Noise Ratio.

USDF: United States Data Facility.

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