



Vera C. Rubin Observatory
Data Management

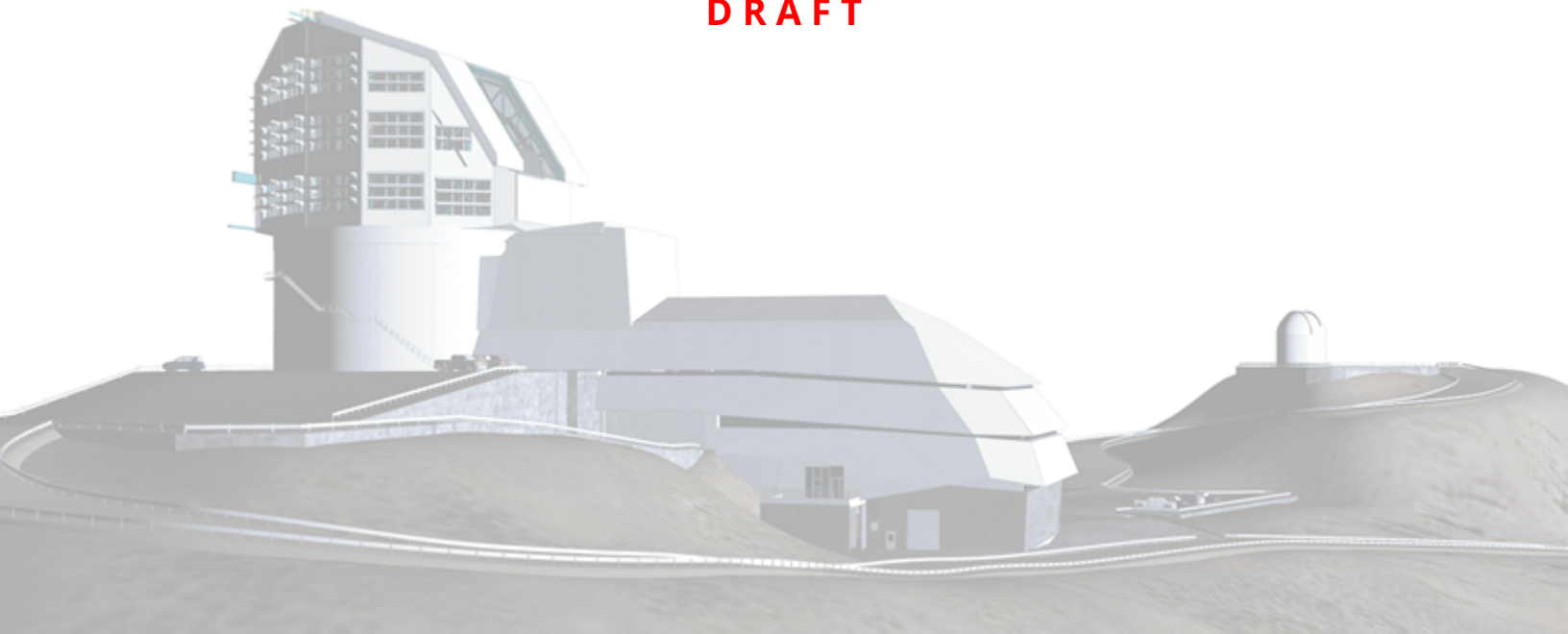
Characterization Metric Report: Science Pipelines Version 26.0.0

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DRAFT



Abstract

This brief report describes measurements of data quality metrics that were carried out for release v26.0.0 of the LSST Science Pipelines. The report for the previous version can be found in [DMTR-392].

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Characterization Metric Report: Science Pipelines Version 26.0.0

In this report, we characterize the performance of the Rubin Observatory Science Pipelines Version 26.0.0. We illustrate the performance via metrics that are measured on the HSC-RC2 dataset. RC2 consists of 3 tracts of data taken from the HSC-SSP survey, and selected to provide a means of testing various “pathological” cases (e.g., difficult astrometric solutions, extremely good seeing that does not provide a well-sampled PSF, difficult fields for deblending, and large galaxies, among others). These three tracts each contain between 112–149 visits split between the HSC-G, HSC-R, HSC-I, HSC-Z, and HSC-Y (*grizy*) filters.

Between `w_2022_48` (2022-11-24; the source for pipelines version 25) and `w_2023_32` (v26 source), most major changes have been in the pipelines “middleware” and other pipelines infrastructure, with few changes that would be expected to affect the results of data processing. The major change that is expected to affect data products is the adoption of a modified form of `gbdes` for determining astrometric solutions in the pipelines. This was accompanied by a switch from using Gaia DR2 to DR3 as the astrometric reference catalog. However, as shown in this document, the adoption of `gbdes` did not lead to significant changes in the astrometry metrics as measured on RC2. As further adaptation and refinement of `gbdes` continues we expect to see improvements in these metrics.

All metrics reported here were calculated using the `faro` (DMTN-211) metric calculation package, which is part of the standard pipeline builds. All of the underlying algorithms to calculate metrics within `faro` are the same as they were in v25.0.0 of the Science Pipelines, so any differences between metrics from the v25 and v26 releases are due to changes in the underlying pipelines.

The metric calculation pipelines from `faro` were run on the RC2 tracts to derive the photometric, astrometric, and shape metrics that are reported here. We exclude the two astrometry metrics (AM3 and AF3) that concern residuals on 200-arcminute scales, since the individual tracts of RC2 do not span large enough spatial scales to enable these measurements.

For comparison, we provide the [SRD](#) required “design” value of each Key Performance Metric (KPM) as defined in the Science Requirements Document [LPM-17]. For the ellipticity correlation metrics, there are specifications only for *r* and *i* bands. The *ugzy*-band measurements are of interest primarily for historical tracking.

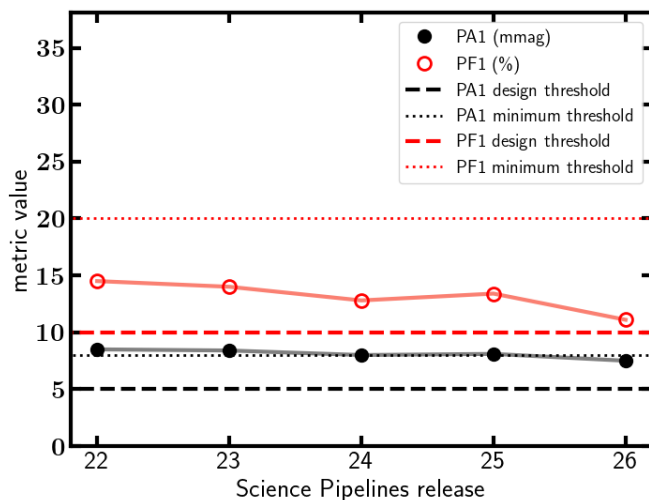


FIGURE 1: Photometry metrics PA1 (photometric repeatability) and PF1 (percentage of measurements exceeding the outlier threshold) measured in the r -band. The figure shows the values of these metrics as measured in versions 22-26 of the LSST Science Pipelines, compared against the SRD requirements (for both the “design” and “minimum” thresholds). The measured values of both metrics have improved slightly between the previous release (v25) and the current one (v26), likely due to improvements in the robustness of aperture correction measurements to outliers.

Some KPMs (e.g., PF1, AF1, AF2) involve thresholds that are different for “design”, “minimum”, and “stretch” specifications. Metrics in this report are all compared to the “design” thresholds. The assessment of these KPMs would be different if evaluated against different thresholds.

1 Summary of performance metrics

As noted in the previous section, most of the major changes between versions 25 and 26 of the pipelines are related to improvements in efficiency and other “under the hood” modifications. Other than the astrometric solver, the data processing algorithms in the Science Pipelines are virtually unchanged between versions 25 and 26, so the data quality metrics should also be similar. In spite of the switch to a new astrometric code, the astrometry metrics (Section 3) show only minor changes between the previous (v25) and current (v26) Science Pipelines releases. The ellipticity correlation metrics (Section 4) show only small differences between Release 25 and 26.

The photometry metrics (Section 2) improved significantly between v25 and v26, with the pho-

tometric repeatability (PA1) improving by 6-8% in all bands, and the percentage of stars exceeding the outlier limit (PF1) improving by 15-20% in all bands. We believe the improvement came about from the bug fixes on Jira ticket DM-37955. This ticket addressed the fact that the fitting of aperture correction maps was not robust, and so outliers (due to blends, unmasked cosmic rays, etc.) would bias the map and thus increase the scatter in the aperture corrections, on a per-image basis. By using a fitting algorithm that was more robust to outliers we have reduced the scatter between the calibration flux (measured in 12-pixel apertures) and the PSF flux, and thus decreased the scatter in the photometric repeatability measured using PSF fluxes.

2 Photometric Performance

These photometric performance metrics are defined in LSS-REQ-0093 (LSE-29) and Table 14 of LPM-17. Values in this table represent the mean of the results reported by *faro* for the three tracts in RC2.

Any entries left blank are those for which we do not have data in the given filter for that dataset.

Metric	Unit	SRD Requirement - Design	Release 25 Value (RC2)	Release 26 Value (RC2)	Comments
PA1: <i>u</i>	mmag	≤ 7.5	—	—	No data
PA1: <i>g</i>	mmag	≤ 5.0	6.7	6.3	
PA1: <i>r</i>	mmag	≤ 5.0	8.1	7.5	
PA1: <i>i</i>	mmag	≤ 5.0	8.7	8.2	
PA1: <i>z</i>	mmag	≤ 7.5	6.6	6.1	
PA1: <i>y</i>	mmag	≤ 7.5	7.2	6.7	
PF1: <i>u</i>	%	≤ 20	—	—	No data
PF1: <i>g</i>	%	≤ 20	9.2	7.7	
PF1: <i>r</i>	%	≤ 10	13.4	11.1	
PF1: <i>i</i>	%	≤ 10	14.1	12.0	
PF1: <i>z</i>	%	≤ 20	7.1	5.7	
PF1: <i>y</i>	%	≤ 10	8.9	7.2	

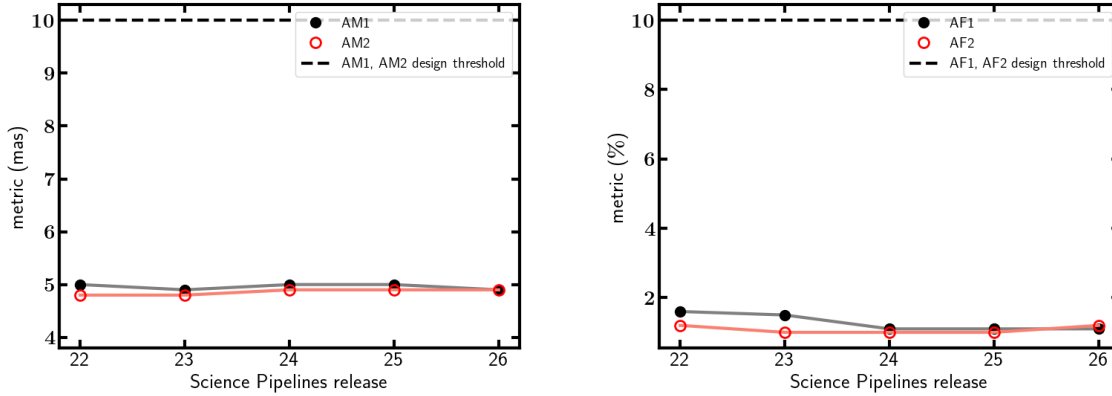


FIGURE 2: Astrometry metrics measured on r -band images compared over the past few major pipelines releases. *Left:* Median astrometric measurement error on 5-arcminute scales (AM1) and 20-arcminute scales (AM2), compared against the SRD requirements (for the “design” thresholds; note that the thresholds for AM1 and AM2 are the same, and thus indistinguishable on the figure). *Right:* Fraction of astrometric measurements exceeding the outlier threshold on 5-arcminute (AF1) and 20-arcminute (AF2) scales, compared against the SRD requirements (for the “design” thresholds; note that the thresholds for AF1 and AF2 are the same, and thus indistinguishable on the figure). The measured values of these metrics were virtually unchanged between pipelines version 25 and v26, which is surprising given the adoption of a new astrometric solver in the pipelines. We expect that further refinements of the `gbdes` astrometry algorithms will improve the astrometry metrics in the future.

3 Astrometric Performance

The following metrics are defined following LSR-REQ-0094 [LSE-29] and Table 18 of LPM-17. Values in this table represent the mean of the results reported by `faro` for the three tracts in RC2.

Any entries left blank are those for which we do not have data in the given filter for that dataset.

Metric	Unit	SRD Requirement – Design	Release 25 Value (RC2)	Release 26 Value (RC2)	Comments
AM1: u	mas	≤ 10	—	—	No data
AM1: g	mas	≤ 10	5.4	5.5	
AM1: r	mas	≤ 10	5.0	4.9	
AM1: i	mas	≤ 10	5.0	4.4	
AM1: z	mas	≤ 10	5.8	5.6	

Metric	Unit	SRD Re- quirement - Design	Release 25 Value (RC2)	Release 26 Value (RC2)	Comments
AM1: <i>y</i>	mas	≤ 10	8.5	8.3	
AF1: <i>u</i>	%	≤ 10	—	—	No data
AF1: <i>g</i>	%	≤ 10	0.9	1.0	
AF1: <i>r</i>	%	≤ 10	1.1	1.1	
AF1: <i>i</i>	%	≤ 10	0.8	0.8	
AF1: <i>z</i>	%	≤ 10	0.8	0.8	
AF1: <i>y</i>	%	≤ 10	3.7	3.7	
AD1: <i>u</i>	mas	≤ 20	—	—	No data
AD1: <i>g</i>	mas	≤ 20	7.7	7.9	
AD1: <i>r</i>	mas	≤ 20	7.4	7.3	
AD1: <i>i</i>	mas	≤ 20	6.6	6.2	
AD1: <i>z</i>	mas	≤ 20	7.7	7.6	
AD1: <i>y</i>	mas	≤ 20	11.5	11.4	
AM2: <i>u</i>	mas	≤ 10	—	—	No data
AM2: <i>g</i>	mas	≤ 10	5.3	5.6	
AM2: <i>r</i>	mas	≤ 10	4.9	4.9	
AM2: <i>i</i>	mas	≤ 10	4.7	4.4	
AM2: <i>z</i>	mas	≤ 10	5.7	5.7	
AM2: <i>y</i>	mas	≤ 10	8.3	8.5	
AF2: <i>u</i>	%	≤ 10	—	—	No data
AF2: <i>g</i>	%	≤ 10	0.8	1.2	
AF2: <i>r</i>	%	≤ 10	1.0	1.2	
AF2: <i>i</i>	%	≤ 10	0.7	0.7	
AF2: <i>z</i>	%	≤ 10	0.8	0.8	
AF2: <i>y</i>	%	≤ 10	3.8	3.9	
AD2: <i>u</i>	mas	≤ 20	—	—	No data
AD2: <i>g</i>	mas	≤ 20	7.7	8.3	
AD2: <i>r</i>	mas	≤ 20	7.5	7.6	
AD2: <i>i</i>	mas	≤ 20	6.5	6.2	
AD2: <i>z</i>	mas	≤ 20	7.7	7.8	
AD2: <i>y</i>	mas	≤ 20	11.6	11.8	
AB1: <i>u</i>	mas	≤ 10	—	—	No data

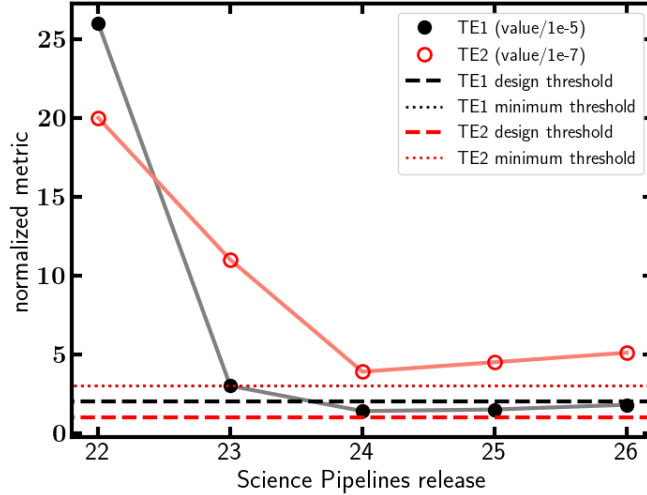


FIGURE 3: Median ellipticity residual correlations at 1-arcminute (TE1; normalized by a factor of 1×10^{-5}) and 5-arcminute (TE2; normalized by 1×10^{-7}) scales, as measured on r -band images, compared over the past few major pipelines releases. Measurements are compared against the SRD requirements (for both the “design” and “minimum” thresholds; note that the normalized minimum thresholds for TE1 and TE2 are the same, and thus indistinguishable on the figure). The measured values of these metrics show little change between v25 and v26, as expected since the shape measurement and PSF estimation algorithms were unchanged between v25 and v26.

Metric	Unit	SRD Requirement – Design	Release 25 Value (RC2)	Release 26 Value (RC2)	Comments
AB1: g	mas	≤ 10	4.9	5.1	
AB1: r	mas	≤ 10	4.7	4.8	
AB1: i	mas	≤ 10	5.7	6.0	
AB1: z	mas	≤ 10	4.9	4.8	
AB1: y	mas	≤ 10	7.0	7.2	

4 Ellipticity Correlations

The following metrics are defined following LSR-REQ-0097 [LSE-29] and Table 27 of LPM-17. Values in this table represent the mean of the results reported by `faro` for the three tracts in RC2.

Any entries left blank are those for which we do not have data in the given filter for that dataset.

Metric	Unit	SRD Requirement - Design	Release 25 Value (RC2)	Release 26 Value (RC2)	Comments
TE1: <i>u</i>	—	$\leq 2 \times 10^{-5}$	—	—	No data
TE1: <i>g</i>	—	$\leq 2 \times 10^{-5}$	1.6×10^{-5}	1.8×10^{-5}	
TE1: <i>r</i>	—	$\leq 2 \times 10^{-5}$	1.5×10^{-5}	1.8×10^{-5}	
TE1: <i>i</i>	—	$\leq 2 \times 10^{-5}$	1.5×10^{-5}	1.3×10^{-5}	
TE1: <i>z</i>	—	$\leq 2 \times 10^{-5}$	9.8×10^{-6}	1.1×10^{-5}	
TE1: <i>y</i>	—	$\leq 2 \times 10^{-5}$	2.8×10^{-5}	2.5×10^{-5}	
TE2: <i>u</i>	—	$\leq 1 \times 10^{-7}$	—	—	No data
TE2: <i>g</i>	—	$\leq 1 \times 10^{-7}$	6.1×10^{-7}	6.4×10^{-7}	
TE2: <i>r</i>	—	$\leq 1 \times 10^{-7}$	4.5×10^{-7}	5.1×10^{-7}	
TE2: <i>i</i>	—	$\leq 1 \times 10^{-7}$	6.3×10^{-7}	4.7×10^{-7}	
TE2: <i>z</i>	—	$\leq 1 \times 10^{-7}$	3.2×10^{-7}	3.2×10^{-7}	
TE2: <i>y</i>	—	$\leq 1 \times 10^{-7}$	6.3×10^{-7}	8.8×10^{-7}	

5 Computational Performance

Computational performance metrics were not measured for this release.

A References

- [1] **[DMTR-392]**, Carlin, J., 2023, *Characterization Metric Report: Science Pipelines Version 25.0.0*, DMTR-392, URL <https://dmtr-392.lsst.io/>, Vera C. Rubin Observatory Data Management Test Report
- [2] **[LSE-29]**, Claver, C.F., The LSST Systems Engineering Integrated Project Team, 2017, *LSST System Requirements (LSR)*, LSE-29, URL <https://lsst.org/LSE-29>

- [3] **[DMTN-211]**, Guy, L.P., 2022, *Faro: A framework for measuring the scientific performance of petascale Rubin Observatory data products*, DMTN-211, URL <https://dmtn-211.lsst.io/>, Vera C. Rubin Observatory Data Management Technical Note
- [4] **[LPM-17]**, Ivezić, Ž., The LSST Science Collaboration, 2018, *LSST Science Requirements Document*, LPM-17, URL <https://ls.st/LPM-17>

B Acronyms

Acronym	Description
DM	Data Management
DMTN	DM Technical Note
DMTR	DM Test Report
DR2	Data Release 2
DR3	Data Release 3
HSC	Hyper Suprime-Cam
KPM	Key Performance Metric
LPM	LSST Project Management (Document Handle)
LSE	LSST Systems Engineering (Document Handle)
LSR	LSST System Requirements; LSE-29
LSST	Legacy Survey of Space and Time (formerly Large Synoptic Survey Telescope)
PSF	Point Spread Function
SRD	LSST Science Requirements; LPM-17