Vera C. Rubin Observatory
Data Management

Characterization Metric Report: Science Pipelines Version 25.0.0

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DMTR-392

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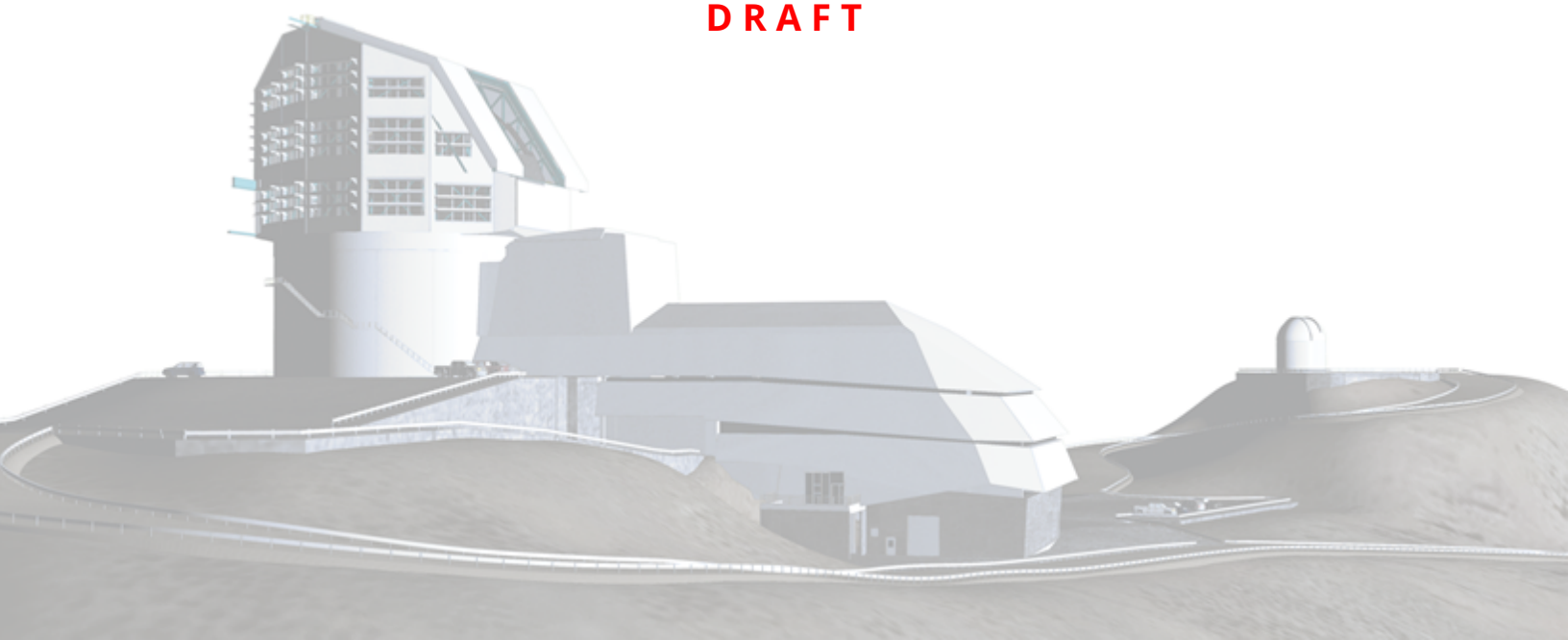
DRAFT



Abstract

This brief report describes measurements of data quality metrics that were carried out for release v25.0.0 of the LSST Science Pipelines. The report for the previous version can be found in [DMTR-391].

Change Record

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1	2023-01-04	First draft.	Jeff Carlin
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Document source location: `https://github.com/lsst-dm/DMTR-392`

Contents

Characterization Metric Report: Science Pipelines Version 25.0.0

In this report, we characterize the performance of the Rubin Observatory Science Pipelines Version 25.0.0. 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_28 (2022-07-07; the source for pipelines version 24) and w_2022_48 (v25 source), we have made the following major changes. The pipelines now have the capability to generate HIPS trees from high-resolution, healpix-projected coadds with native Rubin code. This task was used to produce the HIPS images that are viewable in the Portal for Data Preview 0.2. `ScarletDeblendTask` now outputs a single storage container that allows users to access both the `scarlet` models and flux re-distributed models. This change uses an order of magnitude less storage space. A new package called `analysis_tools` was added; `analysis_tools` provides efficient, scalable, consistent and reproducible calculation of metrics and plots for quality assurance analyses. This will be the main resource for data-quality monitoring tools in the future. Also added in version 25 of the pipelines is the package `gbdes`, which will be used for astrometry in future versions of the science pipelines. The `gbdes` task will be available in version 26. Finally, v25 introduces an image subtraction refactor, where the combination of `subtractImages` and `detectAndMeasureDiaSources` has been introduced to replace the `imageDifference` task.

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 v24.1.0 of the Science Pipelines, so any differences between metrics from the v24 and v25 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.

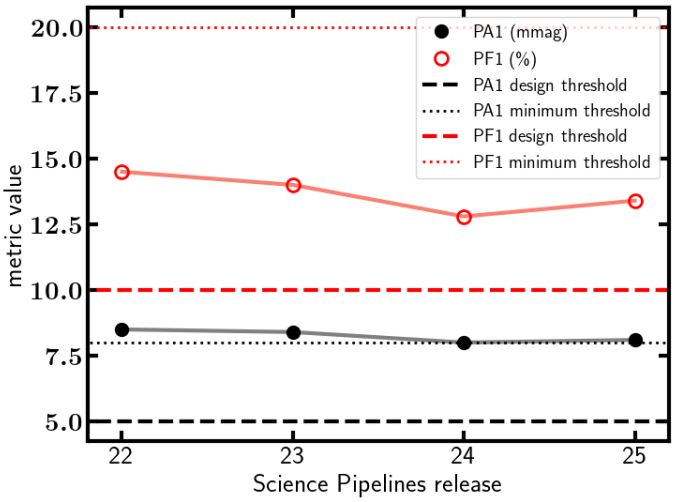

FIGURE 1: Photometry metrics PA1 (photometric repeatability) and PF1 (percentage of measurements exceeding the outlier threshold) measured in the *r*-band. The figure shows the values of these metrics as measured in versions 22-25 of the LSST Science Pipelines, compared against the SRD requirements (for both the "design" and "minimum" thresholds). The measured values of both metrics have not changed significantly between the previous release (v24) and the current one (v25), as expected since no major changes were made to the photometric measurement algorithms between v24 and v25.

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.

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

The major changes between versions 24 and 25 outlined in the previous section relate to ancillary data products, improvements in efficiency, new tasks that will not be fully in use until version 26, and difference imaging tasks. Thus the data processing algorithms in the Science Pipelines are virtually unchanged between versions 24 and 25, so the data quality metrics should also be similar. Indeed, the astrometry metrics (Section 3) are nearly identical (none

changed by more than 3%) between the previous (v24) and current (v25) Science Pipelines releases. The photometry metrics (Section 2) and ellipticity correlation metrics (Section 4) show small differences between Release 24 and 25, most of which represent minor improvements in the metric values.

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 24 Value (RC2)	Release 25 Value (RC2)	Comments
PA1: *u*	mmag	≤ 7.5	—	—	No data
PA1: *g*	mmag	≤ 5.0	6.8	6.7	
PA1: *r*	mmag	≤ 5.0	8.0	8.1	
PA1: *i*	mmag	≤ 5.0	8.6	8.7	
PA1: *z*	mmag	≤ 7.5	6.4	6.6	
PA1: *y*	mmag	≤ 7.5	7.0	7.2	
PF1: *u*	%	≤ 20	—	—	No data
PF1: *g*	%	≤ 20	9.4	9.2	
PF1: *r*	%	≤ 10	12.8	13.4	
PF1: *i*	%	≤ 10	13.5	14.1	
PF1: *z*	%	≤ 20	6.6	7.1	
PF1: *y*	%	≤ 10	8.2	8.9	

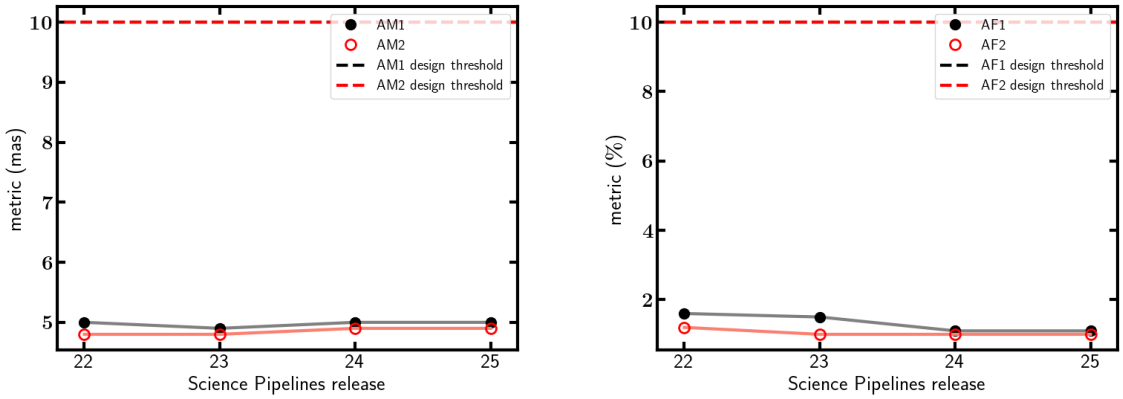

FIGURE 2: Astrometry metrics measured on *r*-band images compared over the past few major pipelines releases. *Left:* Median astrometric measurement error on 5-arcminute scales (AM1) and 20-arcminute scales (AM2), compared against the SRD requirements (for the "design" thresholds; note that the thresholds 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 24 and v25, as expected since no major changes have been made to astrometric measurement algorithms between v24 and v25.

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 24 Value (RC2)	Release 25 Value (RC2)	Comments
AM1: *u*	mas	≤ 10	—	—	No data
AM1: *g*	mas	≤ 10	5.4	5.4	
AM1: *r*	mas	≤ 10	5.0	5.0	
AM1: *i*	mas	≤ 10	4.9	5.0	
AM1: *z*	mas	≤ 10	5.8	5.8	

Metric	Unit	SRD Requirement – Design	Release 24 Value (RC2)	Release 25 Value (RC2)	Comments
AM1: *y*	mas	≤ 10	8.5	8.5	
AF1: *u*	%	≤ 10	—	—	No data
AF1: *g*	%	≤ 10	0.9	0.9	
AF1: *r*	%	≤ 10	1.1	1.1	
AF1: *i*	%	≤ 10	0.8	0.8	
AF1: *z*	%	≤ 10	0.8	0.8	
AF1: *y*	%	≤ 10	3.6	3.7	
AD1: *u*	mas	≤ 20	—	—	No data
AD1: *g*	mas	≤ 20	7.7	7.7	
AD1: *r*	mas	≤ 20	7.4	7.4	
AD1: *i*	mas	≤ 20	6.6	6.6	
AD1: *z*	mas	≤ 20	7.7	7.7	
AD1: *y*	mas	≤ 20	11.4	11.5	
AM2: *u*	mas	≤ 10	—	—	No data
AM2: *g*	mas	≤ 10	5.3	5.3	
AM2: *r*	mas	≤ 10	4.9	4.9	
AM2: *i*	mas	≤ 10	4.7	4.7	
AM2: *z*	mas	≤ 10	5.7	5.7	
AM2: *y*	mas	≤ 10	8.3	8.3	
AF2: *u*	%	≤ 10	—	—	No data
AF2: *g*	%	≤ 10	0.9	0.8	
AF2: *r*	%	≤ 10	1.0	1.0	
AF2: *i*	%	≤ 10	0.7	0.7	
AF2: *z*	%	≤ 10	0.8	0.8	
AF2: *y*	%	≤ 10	3.7	3.8	
AD2: *u*	mas	≤ 20	—	—	No data
AD2: *g*	mas	≤ 20	7.7	7.7	
AD2: *r*	mas	≤ 20	7.5	7.5	
AD2: *i*	mas	≤ 20	6.5	6.5	
AD2: *z*	mas	≤ 20	7.7	7.7	
AD2: *y*	mas	≤ 20	11.5	11.6	
AB1: *u*	mas	≤ 10	—	—	No data

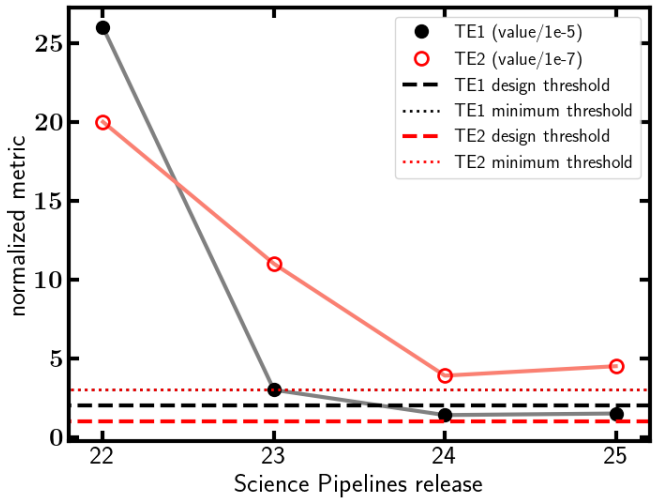

FIGURE 3: Median ellipticity residual correlations at 1-arcminute (TE1; normalized by a factor of 1×10^{-5}) and 5-arcminute (TE2; normalized by 1×10^{-7}) scales, as measured on *r*-band images, compared over the past few major pipelines releases. Measurements are compared against the SRD requirements (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 v24 and v25, as expected since the shape measurement and PSF estimation algorithms were unchanged between v24 and v25.

Metric	Unit	SRD Requirement – Design	Release 24 Value (RC2)	Release 25 Value (RC2)	Comments
AB1: *g*	mas	≤ 10	4.8	4.9	
AB1: *r*	mas	≤ 10	4.8	4.7	
AB1: *i*	mas	≤ 10	5.7	5.7	
AB1: *z*	mas	≤ 10	4.9	4.9	
AB1: *y*	mas	≤ 10	7.0	7.0	

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 24 Value (RC2)	Release 25 Value (RC2)	Comments
TE1: *u*	—	$\leq 2 \times 10^{-5}$	—	—	No data
TE1: *g*	—	$\leq 2 \times 10^{-5}$	1.4×10^{-5}	1.6×10^{-5}	
TE1: *r*	—	$\leq 2 \times 10^{-5}$	1.4×10^{-5}	1.5×10^{-5}	
TE1: *i*	—	$\leq 2 \times 10^{-5}$	1.5×10^{-5}	1.5×10^{-5}	
TE1: *z*	—	$\leq 2 \times 10^{-5}$	9.1×10^{-6}	9.8×10^{-6}	
TE1: *y*	—	$\leq 2 \times 10^{-5}$	2.4×10^{-5}	2.8×10^{-5}	
TE2: *u*	—	$\leq 1 \times 10^{-7}$	—	—	No data
TE2: *g*	—	$\leq 1 \times 10^{-7}$	7.6×10^{-7}	6.1×10^{-7}	
TE2: *r*	—	$\leq 1 \times 10^{-7}$	3.9×10^{-7}	4.5×10^{-7}	
TE2: *i*	—	$\leq 1 \times 10^{-7}$	4.2×10^{-6}	6.3×10^{-7}	
TE2: *z*	—	$\leq 1 \times 10^{-7}$	4.0×10^{-7}	3.2×10^{-7}	
TE2: *y*	—	$\leq 1 \times 10^{-7}$	7.5×10^{-7}	6.3×10^{-7}	

5 Computational Performance

Computational performance metrics were not measured for this release.

A References

[1] **[DMTR-391]**, Carlin, J., 2023, *Characterization Metric Report: Science Pipelines Version 24.1.0*, DMTR-391, URL `https://dmtr-391.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://ls.st/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
HIPS	Hierarchical Progressive Survey
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
LSS	Large Scale Structure
LSST	Legacy Survey of Space and Time (formerly Large Synoptic Survey Telescope)
PSF	Point Spread Function
SRD	LSST Science Requirements; LPM-17
SSP	Solar System Processing