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# LSST Camera Instrumental Signature Characterization, Calibration and Removal

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## ABSTRACT

We describe the receipt of the LSST Camera on the summit of Cerro Pachon in Chile and the subsequent reverification of the camera. We then describe the installation and initial commissioning of the camera on the telescope. Finally, we describe initial instrument signature signal characterization, calibration and removal from early commisioning data.

## 1. INTRODUCTION

**Eventually, please replace all of the remaining text with your paper text.**

The LSST Construction Project team needs to document the as-built hardware and software (see LSE-79 and LSE-390 for details). Although this activity will likely continue well into the operations phase, the majority of anticipated documents will be necessary to enable efficient and robust early science with the LSST facility and thus must be available, at least in a draft form, by the first data release.

As a first step, we are now assembling teams that will be in charge of delivering these documents. An initial paper list collated by subsystem leaders includes about 40 papers that will be submitted to relevant professional journals. Therefore, this deliverable represents a major undertaking and we need to start early. In addition, the commissioning period will be shorter than anticipated due to various delays in construction and thus the time to complete these papers will be shorter, too. Although most of these papers cannot be finished before the end of construction because they will require analysis of LSST commissioning data, we can significantly mitigate the risk that they will never be finished by starting early. The early start will also help mitigate another source of stress for the team during the busy commissioning phase.

## 2. RECEIPT OF THE LSST CAMERA ON CERRO PACHON

We reference the shipping of the camera paper OR write up the shipping of the camera. We (or reference and summarize) the unpacking and installation of the camera on the camera integration stand.

## 3. REVERIFICATION OF THE LSST CAMERA ON CERRO PACHON

We reference the verification of the camera in Integration and Test paper (roodman). We then describe how we reverified the camera on the integration stand. We also summarize all of the instrument signatures from camera I&T.

## 4. INSTALLATION OF THE LSST CAMERA ON THE SYMONI TELESCOPE

We describe the intallation on the telescope.

## 5. INSTRUMENTAL SIGNATURE OF SKY

### 5.1. *Dead pixel-columns*

### 5.2. *Brigher Fatter*

### 5.3. *astrometry*

ala Bernstein Comparisons of determined star fields astrometry vs GAIA

### 5.4. *Photometry*

### 5.5. *Charge Transfer*

### 5.6. *Summary*

### 5.7. *Conclusion*

## 6. CLEAN UP

The subsystem leaders have assembled an initial list of papers, listed in Appendix. It is likely that this list will evolve with time. Each paper has an editor assigned to it. Each editor is meant to be a team leader who will be initially responsible for the completion of the assigned paper (or perhaps until somone else from the team assumes this leadership role). The editor is not necessarily the team member who will do most of the required work, or who will eventually become the first author. Both issues will be handled by on an individual team basis.

### 6.1. *The timeline*

We would like to have all the sections that do not depend on commissioning data written and reviewed by February 2021. If we accomplish this goal, we will both have easier time completing these papers, and the team will be less stressed during the commissioning phase.

Our initial timeline is as follows (the further into the future, the less certain it is):

1. Subsystem leads assemble the initial list of papers (DONE)
2. Setup latex templates and email exploders (lsst-constrpapers) (DONE)
3. Schedule the first telecon to discuss task, overall plan and timeline (Oct 2019).
4. Delivery of paper outlines and the second telecon (Jan 2020). Each paper outline should at least contain the list of all sections, their lead authors, and a

few sentences about the section scope. Overachievers can add a list of figures etc. for extra credit.

5. First rough draft of sections that can be written without having the LSST commissioning data and the third telecon (June 2020). These drafts should at least include subsection structure, lists of planned tables, figures, rough text, and identification of any impediments to make the Oct. deadline for drafts ready for review (so that we can replan if need be).
6. Sections that can be written without having the data ready for an internal project review and the fourth telecon (Nov 2020).
7. Reviews available and the fifth telecon (Feb 2021)
8. Implementation of the reviewers' comments (from Feb 2021 until first light)
9. Final drafts, including sections that depend on LSST data, available for review and the sixth telecon (Aug 2022)
10. Implementation of the reviewers' comments (from Aug 2021 until the start of operations, planned for Oct 3, 2022). Proceeding with submissions, details TBD...

## 7. SOME TECHNICALITIES: AUTHOR LIST AND STANDARD LSST REFERENCES

Thank you Tim Jenness and Wil O'Mullane for helping with templates!

### 7.1. *The LSST LaTeX Classes*

Please see the installation instructions[1] for lsst-texmf. Once you have it installed, you should be able to compile your paper using make.

### 7.2. *How to handle author list?*

Authors come from the authors.yaml file – find the author ids in the lsst-texmf/etc/authordb.yaml - use db2authors to get the authors and institutes from the db.

**XXX Wil, the above is unclear: need more detail about how to use db2authors, what is its output and what to do with it...**

### 7.3. *How to handle LSST standard references?*

The papers should cite standard LSST references[2], where appropriate. For the usage, please see below. These examples all use the ADS handle, unless they are project docs then the use the project handle like LSE-17.

All are on the lsst-texmf which you can get from http://lsst-texmf.lsst.io

[1] https://lsst-texmf.lsst.io/install.html
[2] See https://github.com/lsst-pst/LSSTreferences

#### 7.3.1. *LSST System and Science*

The LSST system (brief overview of telescope, camera and data management subsystems), science drivers and science forecasts are described in:

- LSST Science Requirements Document: Ivezić & The LSST Science Collaboration (2018).
- LSST overview paper: Ivezić et al. (2019).
- LSST Science Book: Abell et al. (2009).

#### 7.3.2. *Simulations*

The LSST simulations are described in a series of papers. Use of the LSST simulations should cite the LSST simulations overview paper Connolly et al. (2014) and the specific simulation tools used:

- LSST Catalogs (CatSim): Connolly et al. (2014)
- Feature-Based Scheduler: Naghib et al. (2018)
- Operations Simulator (OpSim): Scheduler Delgado & Reuter (2016), SOCS Reuter et al. (2016)
- Metrics Analysis Framework (MAF): Jones et al. (2014)
- Image simulations (Phosim): Peterson et al. (2015)
- Sky brightness model: Yoachim et al. (2016)
- LSST Performance for NEO (or moving object) discovery: Jones et al. (2018)

#### 7.3.3. *Data Management*

LSST data management system and the data products are described in:

- The LSST Data Management System: Jurić et al. (2017)
- Data Products Definition Document: Jurić et al. (2017)

#### 7.3.4. *Camera*

- Design and development of the LSST camera: Kahn et al. (2010)

#### 7.3.5. *Telescope and Site*

- Telescope and site overview and status in 2014: Gressler et al. (2014)

### 7.3.6. *System Engineering*

- LSST systems engineering: Claver et al. (2014)
- System verification and validation: Selvy et al. (2014)

## APPENDIX

**Initial paper list added here for reference.**

"Editor" is a responsible team leader but not necessarily the person who will do most of the required work, or who will eventually become the first author. Both issues will be handled by individual teams.

```
domain: Telescope & Site
editor: Jeff Barr
title: Overview of the LSST Telescope

domain: Telescope & Site
editor: Sandrine Thomas
title: Performance of the LSST Telescope

domain: Telescope & Site
editor: Lynne Jones
title: The LSST Scheduler Overview and Performance

domain: Telescope & Site
editor: Bo Xin
title: Performance of the LSST Active Optics System

domain: Telescope & Site
editor: Tiago Ribeiro
title: LSST Observing System Software Architecture

domain: Camera
editor: Justin Wolfe
title: LSST Camera Optics

domain: Camera
editor: Chris Stubbs
title: LSST Camera Rafts

domain: Camera
editor: Steve Ritz
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title: LSST Camera Cryostat

domain: Camera
editor: Ralph Schindler
title: LSST Camera Refrigeration

domain: Camera
editor: Steve Ritz
title: LSST Camera Body and Mechanisms

domain: Camera
editor: Mark Huffer and Tony Johnson
title: LSST Camera Control System and DAQ

domain: Camera
editor: Tim Bond and Aaron Rodman
title: LSST Camera Integration and Tests

domain: Data Management
editor: Leanne Guy
title: Overview of LSST Data Management

domain: Data Management
editor: Michelle Butler
title: LSST Data Facility

domain: Data Management
editor: Tim Jenness
title: LSST Data Management Software System

domain: Data Management
editor: Jim Bosch
title: LSST Data Release Processing

domain: Data Management
editor: Eric Bellm
title: LSST Prompt Data Products

domain: Data Management
editor: Gregory Dubois-Felsmann
title: LSST Science Platform
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domain: Data Management
editor: Simon Krughoff
title: LSST Data Management Quality Assurance and Reliability Engineering

domain: Data Management
editor: Leanne Guy (with likely delegation to new DM V&V Scientist)
title: LSST Data Management System Verification and Validation

domain: Data Management
editor: Mario Juric
title: LSST Moving Object Processing

domain: Data Management
editor: Robert Lupton
title: LSST Calibration Strategy and Pipelines

domain: Calibration
editor: Patrick Ingraham
title:  Performance of the LSST Calibration Systems

domain: Calibration
editor: Patrick Ingraham
title: Atmospheric Properties with the LSST Auxiliary Telescope

domain: EPO
editor: Amanda Bauer
title: Overview of LSST Education and Public Outreach

domain: EPO
editor: Ardis Herrold
title: LSST Formal Education Program

domain: EPO
editor: Amanda Bauer
title: LSST EPO: The User Feedback

domain: Commissioning
editor: Chuck Claver
title: LSST Observatory System Operations Readiness Report

domain: Commissioning
editor: Bo Xin
title: Performance of Delivered LSST System

domain: Commissioning
editor: Chuck Claver
title: Active Optics Performance with LSST Commissiong Camera

domain: Commissioning
editor: Chuck Claver
title: LSST Active Optics Performance with the LSST Science Camera

domain: Commissioning
editor: Brian Stalder
title: Integration, Test and Commissioning Results from LSST Commissiong Camera

domain: Commissioning
editor: Kevin Reil
title: LSST Camera Instrumental Signature Characterization, Calibration and Removal

domain: Commissioning
editor: Patrick Hascal
title: Installation and Performance of the LSST Camera Refrigeration System

domain: Commissioning
editor: Andy Connolly
title: Science Validation of LSST Alert Processing

domain: Commissioning
editor: Keith Bechtol
title: Science Validation of LSST Data Release Processing

domain: Commissioning
editor: Michael Reuter
title: Tracking of LSST System Performance with Continuous Integration Methods

domain: Commissioning
editor: Chuck Claver
title: The LSST Science Platform as a Commissioning Tool

domain: Commissioning

editor: Chuck Claver
title: Commissioning Science Data Quality Analysis Tools, Methods and Procedures

domain: Commissioning
editor: Lynne Jones
title: Performance Verification of the LSST Survey Scheduler

## A. REFERENCES

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Peterson, J. R., Jernigan, J. G., Kahn, S. M., et al. 2015, ApJS, 218, 14

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Yoachim, P., Coughlin, M., Angeli, G. Z., et al. 2016, in Proc. SPIE, Vol. 9910, Observatory Operations: Strategies, Processes, and Systems VI, 99101A

## B. ACRONYMS

| **Acronym** | **Description** |
|---|---|
| ADS | Astrophysics Data System |
| DAQ | Data Acquisition System |
| DM | Data Management |
| EPO | Education and Public Outreach |
| I&T | Integration and Test |
| LPM | LSST Project Management (Document Handle) |
| LSE | LSST Systems Engineering (Document Handle) |
| LSST | Legacy Survey of Space and Time (formerly Large Synoptic Survey Telescope) |
| LaTeX | (Leslie) Lamport TeX (document markup language and document preparation system) |
| NEO | Near-Earth Object |
| OpSim | Operations Simulation |
| SLAC | SLAC National Accelerator Laboratory (formerly Stanford Linear Accelerator Center; SLAC is now no longer an acronym) |
| TBD | To Be Defined (Determined) |