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The Large Synoptic Survey Telescope: Overview and Update

Invited talk

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Abstract. This talk provided an overview and update of the LSST Project and a review of the Data Management system, with a focus on the products most relevant to the researchers of transients and variables. The open opportunities for user-defined Special Programmes such as Deep Drilling Fields were also presented.

Keywords. Surveys, catalogues, methods: data analysis

1. Introduction

The primary driver for the design of LSST, as described by Ivezić *et al.* (2008), is the opportunity to make significant advances in four areas of astronomy – cosmology, the Milky Way, transient and variable phenomena, and small solar-system objects. Those science goals can be met by a deep, wide-area, multi-band survey of the full southern sky by employing an 8-metre telescope (or equivalent) that makes ∼800 exposures of ∼30 seconds each over an 10-year period.

This summary provides an overview of the LSST project, including hardware specifications (primary mirror size, field of view and filters) and survey qualities (single-visit image depth and saturation, number of visits per field and total area, etc.); details are available in Ivezić *et al.* (2008) and also at http://lsst.org. It also covers briefly various status updates regarding the construction on Cerro Pachón (see resource A in Table 1), camera integration (see resource B in Table 1), commissioning and science verification (see slide set entitled 'LSST Commissioning Overview', available at resource C in Table 1), survey strategy optimisation (LSST Science Collaboration 2017), and the possibility of a 'rolling cadence' (see slide set entitled 'LSST Observing Strategy', available at resource C in Table 1).

2. Data Products for Time-Domain Astronomy

Within the LSST Data Management (DM) team, the Subsystem Science Team has a strong responsibility to validate scientifically the DM pipelines and products and to ensure that they meet the needs of the science community. It should be emphasised that questions and feedback about DM data pipelines and products are welcome at any time. The DM's current plans for data processing are quite similar to those given in more depth in Workshop 7 (p. 245), so will not be repeated here. Jurić *et al.* (2017a) and Jurić *et al.* (2015) should be consulted for the most comprehensive explanations of the LSST DM team's data processing plans.

3. Special Programmes

In addition to the main survey, LSST is expected to spend ∼10% of the available observing time on Special Programmes, e.g., deep drilling fields (see resource D in Table 1), and mini-surveys. So far, four extragalactic deep fields have been pre-approved for Special Programmes because of an identified need to obtain legacy data from facilities with a limited lifespan (e.g. the *Spitzer* space telescope). Ivezić *et al.* (2008) describe a nominal strategy for a deep drilling field, and quote, as an example, a series of fifty ∼15-second exposures in each of the *griz* filters obtained every other night for four months; from that data set, nightly deep stacks could be differenced with a deep template in order to detect more distant supernovæ.

A series of initial white papers regarding the scientific potential of LSST Special Programmes was solicited in 2011 (see resource E in Table 1); Chapter 10 of the Observing Strategy white paper considers Special Programmes (LSST Science Collaboration 2017). Possible Special Programmes were also discussed during a dedicated session at the 2016 LSST Project and Community Workshop (see resource F in Table 1). The LSST DM technical note by Graham *et al.* (2017) contained a thorough review of a wide variety of aspects related to LSST Special Programmes, including summaries of science goals of previous proposals, potential telescope or camera constraints on observing strategy (see Section 3.2 on exposure times and filter changes), and how the processing pipelines for Special Programmes data will be built and run (see Section 3.3 on data processing).

The only aspects of future Special Programmes that are set in stone are the positions of the four pre-selected deep drilling fields; aspects that remain open for proposals include

- additional deep drilling fields
- refined observing strategies for deep drilling fields
- optimised survey areas for the North Ecliptic Spur, South Pole, and Galactic Plane
- refined observing strategies for the NES, South Pole, and Galactic Plane
- additional mini-surveys.

3.1. *Anticipated questions regarding LSST Special Programmes*

Several questions regarding upcoming calls for proposals were anticipated, and were answered as follows:

• *How do the upcoming calls for white paper proposals for Special Programmes fit in with the existing Observing Strategy white paper (LSST Science Collaboration 2017)?*
The next round of white papers will be separate from the existing Observing Strategy white paper, but could contribute analysis later.

• *What is the format and expected content of these white papers?*
In general, in addition to science goals and observing strategy, data processing needs should be discussed.

• *How will these white papers be evaluated and decisions made?*
Proposals are to be reviewed by the Science Advisory Council, based on criteria set by the Project Science Team; recommendations would then be made to the LSST Director. The criteria will be clarified in the call for white papers.

3.2. *Observational constraints on LSST Special Programmes*

Certain observational constraints on (1) filter changes and (2) exposure times will apply to proposals for Special Programmes, as described below.

Filter Changes: The maximum time for filter change is 120 seconds; that includes 30 seconds for the telescope to reorient the camera to its nominal zero-angle position on the rotator, and 90 seconds for the camera subsystem to execute the change (see item OSS-REQ-0293 in Claver *et al.* 2017). The minimum time between filter changes has no

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Table 1. List of selected online LSST resources indicated above

Ref.	Description	URL
(A)	Construction Site Webcam	https://www.lsst.org/news/see-whats-happening-cerro-pachon
(B)	Camera Information	https://www.lsst.org/about/camera
(C)	'For Scientists' Webpage	https://www.lsst.org/scientists
(D)	Deep Drilling Fields	https://www.lsst.org/scientists/survey-design/ddf
(E)	2011 DDF White Papers	https://project.lsst.org/content/whitepapers32012
(F)	2016 DDF Workshop	https://project.lsst.org/meetings/lsst2016/agenda/deep-drilling-fields-and-other-lsst-mini-surveys
(G)	DDF Community Forum	https://community.lsst.org/t/deep-drilling-fields-and-data-management

restrictions from (say) thermal tolerances. However, from experience based on overheads and efficiency, it is recommended to keep the rate of changes of filter to lower than once every 10 minutes. The maximum total number of filter changes is 100,000 over 15 years, or an average of 18 changes per night. The maximum number of filter swaps in/out of the carousel is 3000 in 15 years, or once every 2 nights.

LSST: Overview and Update: The minimum exposure time is 1 second, with a stretch goal of 0.1 seconds (see item OSS-REQ-0291 in Claver *et al.* 2017). However, the minimum exposure time needed to create an image with a PSF that is well enough formed for difference imaging is a separate question. Furthermore, assuming that a 1-second exposure can be reduced and calibrated, its detected point sources will span $13 < r < 21$ magnitudes, whereas a 15-second exposure saturates at $r \sim 15.8$ mag. How that affects the required photometric or astrometric solutions should be considered carefully for short-exposure Special Programmes. The maximum exposure time is not restricted (but the saturation limit quoted above should be taken into account).

3.3. *Processing data from Special Programmes*

LSST will not write unique algorithms for processing Special Programmes data or reprocessing Main Survey data, *but* LSST will make the Software Stack source code available and extendable to the community, *and* LSST will reconfigure its own pipelines to generate imaging and catalogue products for Special Programmes data, whenever possible. Furthermore, an additional ~10% of the LSST computing resources are allocated for the creation of user-driven analyses and data products. It is expected that the call for white-paper proposals will request that the data processing needs be discussed. Several preliminary examples of such a discussion can be found in Graham *et al.* (2017).

Questions about LSST Special Programmes and Data Management can be posted to a dedicated `Community` forum (see resource G in Table 1).

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References

Claver, C. F., *et al.* 2017, *Observatory System Specification* (LSE-30), https://ls.st/LSE-30

Graham, M. L., *et al.* 2017, *LSST Data Management and Special Programs* (DMTN-065), https://ls.st/dmtn-065

Ivezić, Ž., Tyson, J.A., Abel, B., *et al.* 2008, arXiv:0805.2366

Ivezić, Ž., The LSST Science Collaboration. 2011, *LSST Science Requirements Document* (LPM-17), https://ls.st/LPM-17

Jurić, M., *et al.* 2015, arXiv:1512.07914

Jurić, M., *et al.* 2017a, *LSST Data Products Definition Document* (LSE-163), https://ls.st/LSE-163

Jurić, M., *et al.* 2017b, *LSST Science Platform Vision Document* (LSE-319), https://ls.st/LSE-319

LSST Science Collaboration, Marshall, P., Anguita, T., *et al.* 2017, arXiv:1708.04058

https://doi.org/10.1017/S1743921318002545 Published online by Cambridge University Press