Large Synoptic Survey Telescope

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Simulated LSST Mini-surveys

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The LSST operations simulator has been used to explore a range of possible mini-surveys which could be carried out within a 30 day window. Such opportunities may exist during LSST commissioning, as companion or constituent elements of the 10-year main survey, or as potential follow-on programs after the completion of the main program. Mini-surveys could achieve increased depth or more intensive cadences by covering a reduced sky area. The predicted performance, with respect to stacked depth and cadences realized, will be described for two distinctly different possible strategies.

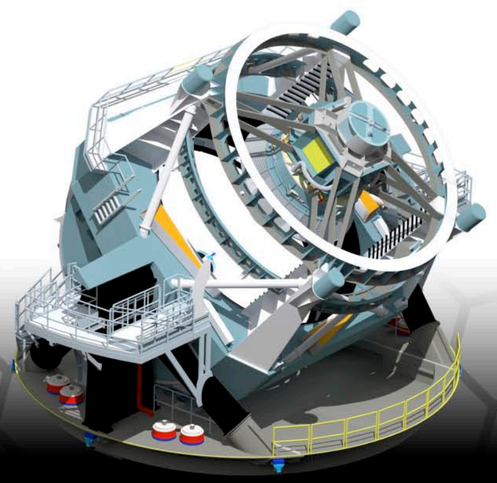
The LSST Universal Cadence

During operation, LSST will visit a new field every ~30 seconds. Owing to the large number of visits and the changing astronomical conditions and operational constraints, the scheduling must be fully automated. The LSST concept is for a universal cadence[1], which may be understood here as an observing sequence produced by a scheduler which works from a single set of rules, established in prior experience to provide an acceptable and sufficiently optimized observing program. The sequence of target fields will be selected to support the science of the key science drivers as described in the LSST Science Requirements Document (SRD).

Mini-surveys

The LSST observing strategy allows for up to 10% of the survey time to be used for "improved coverage of parameter space". This time might be used for regions of the sky outside the main survey (galactic plane, Magellanic Clouds), or for cadences (eg. optimized for supernova or solar system body detection and study) which are not adequately covered with the Universal Cadence. Mini-surveys (~1% of survey time each) are another option mentioned in the LSST Science Requirements Document. Also, a mini-survey is explicitly called-out for the LSST commissioning phase.

For this poster, we have used the LSST Operations Simulator[2] to evaluate the expected performance of mini-surveys for several assumptions about the objectives and execution. This allows us to conclude that a 30-day mini-survey of a small number of fields (~1% of the full survey) can reach both stacked depth and some cadence performance measures predicted for the full 10-year survey.



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Two possible Mini-survey Strategies

One approach (perhaps interesting during commissioning time) would be to carry out a one-month segment of the main survey, demonstrating as nearly as possible the LSST performance in the nominal program. For this experiment we adopted the region of the main survey accessible for one month around the equinoxes, 840 or 862 fields by the LSST tiling of the sky (differing due to the galactic plane exclusion zone).

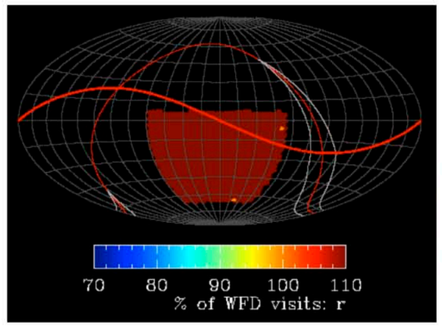

Figure 1. Aitoff plot of the number of visits per field in a 30-day mini-survey at the vernal equinox of an 862 field subset of the main survey (Sim pro.8)

For a second experiment, we adopted a constant-declination strip, accessible at the Vernal equinox. The strip consists of 40 fields, somewhat staggered due to adopting the standard LSST hexagonal gridding.

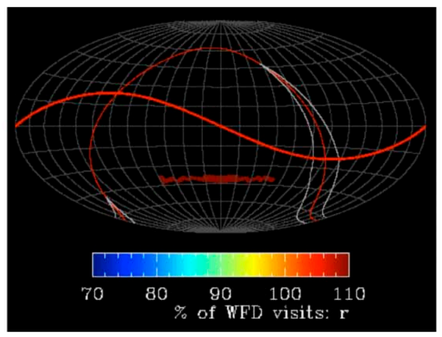

Figure 2. Aitoff plot of the number of visits per field in a 30-day mini-survey at the Vernal equinox of a 40 field subset of the main survey (Sim pro.18).

A survey at the Vernal equinox favors the galactic polar region. Other times of year could favor the galactic plane or a mix. The following simulations are experiments which could be further optimized for desired characteristics.

A Fragment of the Full Survey

Observing 862 accessible fields for one month in 6 filters delivers ~1-2 visits per field per filter. This suffices to verify the single visit depth, but little more, provides a likely heterogeneous data set due to limited sampling over weather and sky conditions, and gives virtually no cadence information. The immediate scientific return could be an early search for very rare targets. The ultimate scientific return depends largely on the value of the ~1% additional time devoted to the main survey.

The Strip Survey

By selecting a strip with a number of fields ~1% of the main survey, and observing ~1% as long, it is possible to deliver a stacked depth for those fields similar to the stacked depth for the main survey.

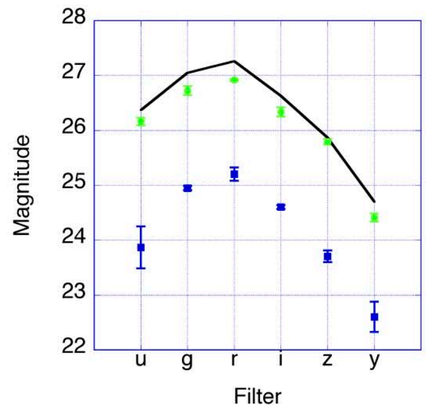

Figure 3. Stacked depth. Black line: 10 year simulation opsim3.61. Green circles: 3 versions of 40-field strip mini-survey. Blue squares: Autumnal (Vernal) 840 (862) –field mini-surveys. The 40-field experiment reaches near the 10-year survey stacked depth.

Intense observation of a small target set can achieve some cadences in numbers that will not otherwise be available until well into the full survey.

One simple measure of capability to detect transients is the number of visit pairs in a filter vs the time between the visits. In the very interesting time range of a 1-day interval between visit pairs, a small survey can perform similarly in total visit pairs to the full survey. This is true because the universal cadence places emphasis on visit pairs within the same night and on revisiting in a different filter on subsequent nights.

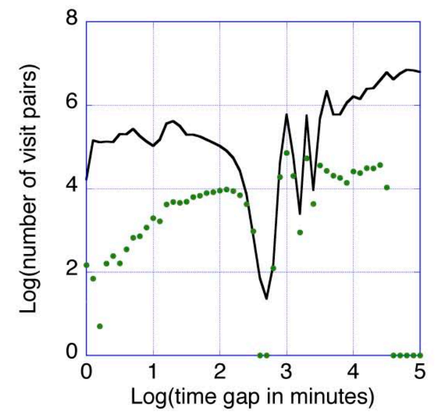

Figure 4. The number of visit pairs as a function of interval. Black line: 10 year simulation opsim3.61, dots 30-day strip mini-survey Sim pro.18. The mini-survey approaches full-survey numbers for intervals 1-3 day.

A related but more elaborate cadence measure is the number of sequences which provide, in the same filter, a series of visits with "uniform" sampling, such as would be desired to characterize a transient light curve. A 30-day mini-survey can provide as many such series as the full survey, over the interesting time scale of daily visits, and with ~8 hr sampling, can outperform the main survey.

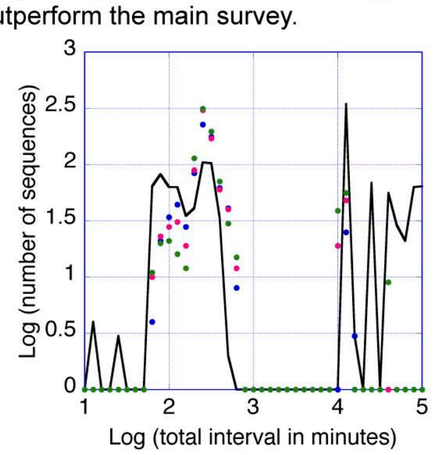

Figure 5. The number of well-sampled intervals at least 6 samples long, as a function of total interval length. Black line: 10 year simulation opsim3.61, dots 30-day strip mini-survey (Sim pro.18).

References

1. Ivezić et al., arXiv:0805.2366 (2008)
2. Ridgway et al., SPIE 7737, 22R (2010)

Fine Print

The telescope, weather, sky brightness and down-time models are constantly improving, as is the Operations Simulator. The observing strategy is evolving. The simulated results are best understood as showing relative performance – eventual absolute performance numbers may differ.

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