Evaluating the LSST Observing Strategy: Metrics

Lynne Jones & Peter Yoachim
LSST 2019 PCW
Aug 14, 2019
Current Status

- WP Nov 2018 / SAC guidelines May 2019 / Simulations..
  - See July2019 update on community with more information on FBS 1.2 set of runs
- Not complete, but getting better understanding of what metrics are telling us and what will need to go into report to the SCOC
- Will be releasing more runs and also writeups describing interpretation and comparisons of various runs
- So let’s talk about metrics!
Key Metrics

- Galaxy counts
- Transient recovery
- Astrometry (parallax, proper motion)
- Solar system metrics
- What are we missing?
Galaxy Counts

- Galaxy Count Metric (credit Humna Awan)
- Calculate number of galaxies available for LSS studies

Baseline WFD: 10.8 billion galaxies
newB footprint WFD: 10.6 billion galaxies
Astrometry (Parallax and Proper Motion)

Uncertainty in the proper motion of an r=20 star

Baseline WFD median: 0.14 mas

simple_roll_mod10_sdf0.20 WFD: 0.30 mas

If there is no covariance, the proper motion uncertainty only depends on when observations happen and the centroiding errors. If we do a very aggressive rolling cadence, proper motion error blows up.
Transient Metrics

- Transient metrics: generate population of transients using (PLAsTiCC) light curves, distribute over sky & time, use MAF to test recovery rate

“Pre-peak” criteria: Measure a color before peak, and a rise slope in at least 1 filter

“Well sampled”: Divide LC into 10 bins, demand 5 have observations (any filters). I would love a better criteria!
Intra-night visits FBS 1.2 runs

4k Type Ia SNe

Pairs mixed 62% detected

Pairs same 62% detected

15% measured pre-peak

3% measured pre-peak

17% “well-sampled”

16% “well-sampled”
Solar system metrics

- To calculate metrics, first need to generate simulated observations of the objects
  - NEO (Granvik), MBA (S3M), Trojan (S3M), TNO (CFEPS L7)
  - + sims_movingObjects
  - [https://github.com/lsst-sssc/SSSC_test_populations_gitolfs](https://github.com/lsst-sssc/SSSC_test_populations_gitolfs)
Solar system metrics

- Discovery metrics (as previously)
  - 3 pairs in 15 nights
  - 3 pairs in 30 nights **
  - .. 3 pairs in 12 nights, 20 nights
  - .. 4 pairs in 20 nights, 3 triplets in 30
  - .. Single detection, single pair
  - .. 3x15 & 3x30 @ SNR=3,4,5.
  - HighVelocity (trailing) pair
Solar system metrics

- Characterization metrics (as previously)
  - “Chance of detecting activity”
    - Bin time (or mean anomaly) over survey (or orbit) and build histogram of visits - what fraction of bins received a visit?
- Inner solar system
  - Lightcurve inversion (updated metric)
  - Color determination (10+ SNR-weighted observations)
    - g + ([r or i] OR [z or y]) (2 colors)
    - 4 of grizy
    - 5 of grizy **
    - 6 of ugrizy
- Outer solar system
  - Lightcurve/Color in 1, 2, 3, 4, 5 ** or 6 filters (30+ obs in first filter, 20+ in secondary)
Solar system metrics

.. will also find a link for downloading full outputs if interest
Analysis

- u band filter swap
- baseline - pairs of visits
- WFD footprint
- rolling cadence
u band filter switch FBS 1.2 runs

- Limit u band to within +/-2 nights of new moon

Bugfix (in 1.3): +0.2 to u band mag
Visits

<table>
<thead>
<tr>
<th></th>
<th>Illum 15</th>
<th>Illum 30</th>
<th>Illum 60</th>
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<td>1.000000</td>
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CoaddM5

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<th></th>
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<th>Illum 30</th>
<th>Illum 60</th>
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Bugfix (in 1.3): +0.2 to u band mag
u band filter switch FBS 1.2 runs
- u band switch
- Motivation for limiting the time u band available comes from DESC/get best u band depth
- Limiting u band availability restricts potential WFD u band depth
- We get u band under good circumstances almost all of the time (even if it’s not “new moon”)

- Re-run with even more emphasis on u during dark time?
  - Look at longer exposures in u band? (& there will be improvement with bugfix in FBS 1.3 too)
Intra-night visits FBS 1.2 runs

- Filters for pairs (same, mix, presto)

- Transient metrics: generate population of transients using (PLAsTiCC) light curves, distribute over sky & time, use MAF to test recovery rate

  “Pre-peak” criteria: Measure a color before peak, and a rise slope in at least 1 filter

  "Well sampled": Divide LC into 10 bins, demand 5 have observations (any filters). I would love a better criteria!
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Intra-night visits FBS 1.2 runs

Mixing filters for pairs does have a cost to SSOs.

Set up some small % of visits to be same filters?

<table>
<thead>
<tr>
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<th>NEO H=22</th>
<th>MBA H=21.25</th>
<th>Trojan H=18</th>
<th>TNO H=7.5</th>
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<tbody>
<tr>
<td>baseline_1exp_pairsame_10yrs</td>
<td>67.3</td>
<td>59.2</td>
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<tr>
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<td>baseline_2exp_pairsame_10yrs</td>
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<td>52.7</td>
<td>48.4</td>
<td>54.3</td>
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~1% mixing pairs

~2% mix pairs + 2x15s

~5-6% presto_third
Analysis

- Motivation for pairs in different filters comes from characterizing (slowly) changing transients
- Increases pre-peak sampling of SNIa (3% - 15%)
- Pushback comes from worry that SSOs will be harder to discover - there is some impact on SSO discovery, particularly with presto_third in its current form.
- Additional pushback that changing filters is less efficient - ~2% penalty
- Add some small % of visits in same-filter, try to rework presto_third

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WFD footprint FBS 1.2 runs

- ‘WFD footprint’

- Galaxy Count Metric (credit Humna Awan)
- Calculate number of galaxies available for LSS studies

Baseline WFD: 10.8 billion galaxies

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‘WFD footprint’

More coverage in the north improves discovery of TNOs.

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WFD footprint FBS 1.2 runs

- ‘WFD footprint’

More coverage in the north improves characterization of TNOs AND NEOs.

Need to add MBC & resonant TNO

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<td>100.0</td>
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Analysis

- Footprint
- Motivated first by DESC desire for more galaxies
- Galaxy counts don’t show clear improvement
- Some motivation from mini-surveys (NES, Euclid, DESI)
- Some improvement for SSOs (discovery and characterization) if WFD footprint extended north

- Return to DESC for clarification on metrics
- Redo footprint with E(B-V) cut exactly (done)
- Redo footprint with 90% WFD and with 825 visits .. look at options to increase visits in N/S (counter poor seeing)
Rolling cadence FBS 1.2 runs

- ‘rolling cadence variations’

SNe group has been running more intensive analysis and giving feedback on sims

From Nicolas Regnault
Rolling cadence FBS 1.2 runs

- ‘rolling cadence variations’

Rolling cadence has some impact on discovery of NEO and MBAs. Have not tested MBCs yet or looked into potential orbital element distribution changes.

~2-3% losses for NEOs and MBAs, slightly better with higher background visits.

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~4-7% fewer NEOs obtaining measurement of grizy colors
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If there is no covariance, the proper motion uncertainty only depends on when observations happen and the centroiding errors. If we do a very aggressive rolling cadence, proper motion error blows up. Need full sky coverage in year 1 and 10 to keep proper motion errors low.
Analysis

- Rolling cadence
- Motivated by desire to increase cadence for WFD observations (better discovery for transients)
  - Rolling cadence does better for SN discovery, but doing pairs in mixed filters is largest improvement
- Has some negative impact on discovery and characterization of inner solar system (NEO, MBA) objects
  - Check wider range of rolling cadence runs
  - Run simulations with higher background rate?
- Likely to need full-sky coverage each year for difference imaging templates & calibration
- Likely we’re missing some metrics sensitive to rolling cadence variations