LSST Observing Strategy: status and impact on cosmology with SNe Ia

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Vera C. Rubin Observatory project: 10-year Legacy Survey of Space and Time (LSST)





VRO

- Cerro Pachón in north-central Chile.
- ► 8.4-meter Simonyi Survey Telescope
- > 3-mirror design FoV ~ 9.6 deg²
- Camera: 3.2 gigapixels

Science areas

- **D**ark energy and dark matter
- **G** Solar system
- **Transient** optical sky
- Milky way



Current schedule

- May 2023 LSST cam on site
- April 2024 first photon
- July 2024 system first light (commissionning)
- Fall 2024 start 10-year LSST

LSST Observing Strategy: how the decision will be made

- Survey Cadence Optimization Committee (SCOC) (2018)
 - standing committee through the Vera Rubin Operations
 - make specific recommendations for the cadence for the full 10 years
 - help communicate these recommendations to the scientific community
 - make specific recommendations for "Early Science" observations
 - during operations: track survey progress and make recommendations for survey changes
- SCOC members
 - 13 members: 10 voting, 1 chair, 2 "ex-officio" (simulation team)
 - chair: Federica Bianco (since 2022) (Zeljko Ivezic)

https://www.lsst.org/content/charge-survey-cadence-optimization-committee-scoc



LSST Observing Strategy - decision timelines









Current OS contours

- ~ 2 millions of visits
- Exposure time

obs. time +7%

- \circ 1x30s in *u*-band
- grizy: currently 2x15s -> 1x30s (commissioning)
- North Ecliptic Spur only in griz
 - Mainly for solar system objects
- Bulge and Plane have redder filter distribution
- Fewer observations in high extinction areas and in South Celestial Pole (high airmass)
- Low Dust WFD
 - Includes LMC/SMC and Virgo cluster
- Rolling cadence = baseline strategy (WFD)
- 5 deep drilling fields (6 pointings)



Rolling Cadence

- Rolling cadence = cadence where a portion of the sky is emphasized in one rolling cycle, to then be de-emphasized in the following rolling cycles.
- Start after 1.5 years (first part of the sky with a complete season uniform cadence)
- baseline WFD strategy: half-sky 0.9-weight rolling cadence
- 3-band rolling also studied



Current DDF strategy

- Deep Drilling Fields: large number of visits per obs. night (45' to 2h)
- 5% budget of the overall not sufficient for SNe Ia science
- Increase fraction of time (up to 7%) and change the cadence (choice of new cadence still in progress)
- 10 year DDF depth in COSMOS in the first few years "highly desirable"
- Euclid DF South as the 5th DDF (2-pointings observed collectively to the depth of other DDFs)



DDF Science: cosmological measurements with Type Ia Supernovae

• SNe Ia collected by LSST

cosmological measurements : Hubble Diagram (HD)



WFD: impact of rolling strategy - cadence

Not rolling

Rolling



Footprint with observed SNe Ia

WFD: impact of rolling strategy - z_{complete}

Not rolling

Rolling



Footprint with observed SNe Ia

WFD: impact of rolling strategy - $N_{SN}^{z \leq zcomplete}$

Not rolling

Rolling



Footprint with observed SNe Ia

SNe Ia: optimized DD surveys

Deep Universal (DU)

- 5 fields observed for ten years
 same cadence, z_{complete} (N_{visits}/band/obs. night)
- large N_{SN}
- low z_{complete} (budget -> low N_{visits}/obs. night)
- difficult to have a regular and high cadence
- sub-optimal use of spectro. ressources





Deep Rolling (DR)

Fields observed \sim 2-3 years - high cadence



In practice: instrumental and observational effects

• Dithering (translational and rotational)

-> DD fields = set of pixels on the sky

-> translational dithering -> pixels with various cadence and obs. parameters

-> the cadence decreases from the center to the field periphery -> loss SNe Ia

• Moon

- lunar phase < 20% -> z or y bands replaced by u-band
- SNe Ia LC -> Signal-to-Noise Ratio -> z_{complete}
- Gaps (clouds, maintenance)
 - Intra-night gaps -> no observation -> cadence \
- Host-z spectro scenario
 - $\sigma_{r} \rightarrow SNe Ia parameters + HD$
 - Host-z spectro preferred
- Systematics
 - Minimized systematics:
 - Malmquist bias -> high z_{complete}







LSST OS: Next steps (2023)

- Early science recommendations (commissioning+first year)
- Tune remaining OS parameters
 - Microsurveys (northern stripe), nano surveys
 - ToO time likely 2-3% for followup
 - Filter balance (GP+SCP)
 - Footprint (GP)
 - Rolling cadence
- DDF
 - Strategy not defined yet
 - Crucial for SNe Ia cosmology
 - Develop accurate estimator to assess DDF strategies (SNe Ia)