Large Synoptic Survey Telescope

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Type Ia Supernova Cosmology with LSST

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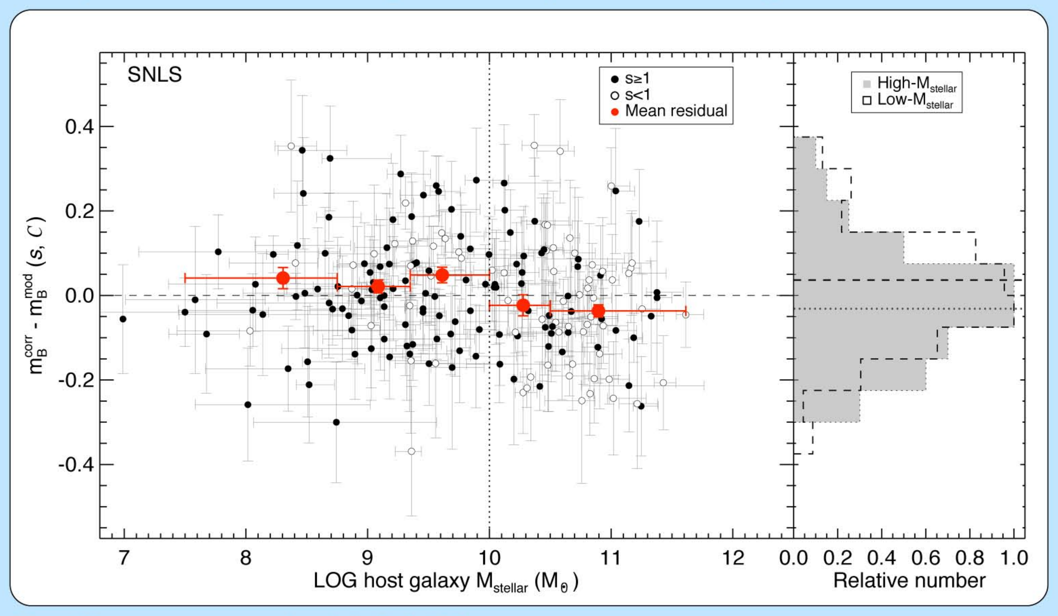
The LSST will discover over one million supernovae during its 10-year survey. This overwhelming compendium of stellar death throes will allow for novel techniques and insights in our study of the evolution of the Universe, large-scale structure, supernova explosion physics, and star formation and evolution. We here focus on the work that will be needed to fully exploit the cosmological potential of Type Ia supernovae from the LSST. We have developed tools to simulate supernova light curves in LSST with realistic sampling and then to test our ability to classify and estimate redshifts for the supernovae in those samples. We present our most detailed simulations to date of the light curves and properties of the supernovae that will be found by the LSST using the LSST operations and cadence simulation and the SNANA supernova survey modeling code. The largest uncertainty in our results is due to the lack of large samples of non-Type Ia supernovae and the uncertainty in the type-dependent supernovae rate as a function of redshift. To enable photometric classification and analysis of the supernovae to be found by LSST we will need to spend the first part of this decade obtaining increased observations of all types of supernovae in the nearby Universe and investigating what spectroscopic subsamples will be necessary to best exploit supernovae for precision cosmology in the era of LSST.

A Roadmap to Cosmology with LSST SNe Ia

Theory ➡ Evolution with z

Variations in SNIa luminosity need to be linked to SN and galaxy observables. Current studies are finding empirical correlations, but even unseen trends in current small samples will be magnified by LSST sample size. Theoretical guidance is needed to extrapolate expected systematics in large surveys and at higher redshifts.

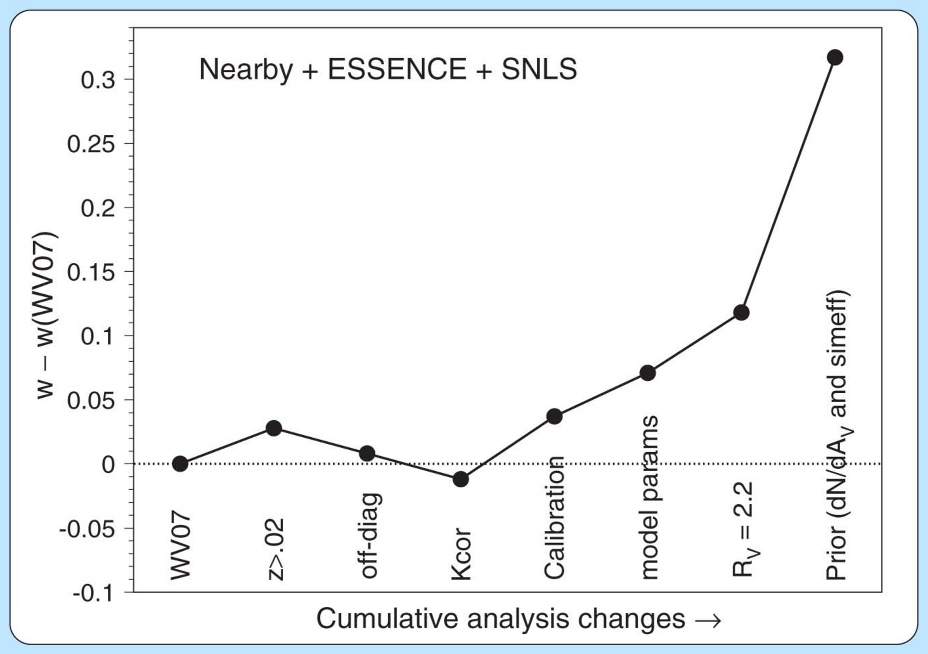


Sullivan et al. (2010) Also Kelly et al. (2009); Lampeitl et al. (2010)

SN brightness is correlated with host galaxy mass.

Analysis ➡ Systematics

End-to-end modeling of cosmological analysis methods with comparison with simulations is needed to ensure the analysis methods produce accurate results and to identify the largest sources of systematic uncertainty.



Kessler et al. (2009)

A detailed accounting of systematics in the first cosmological analysis of SDSS SNe.

Observations ➡ Populations

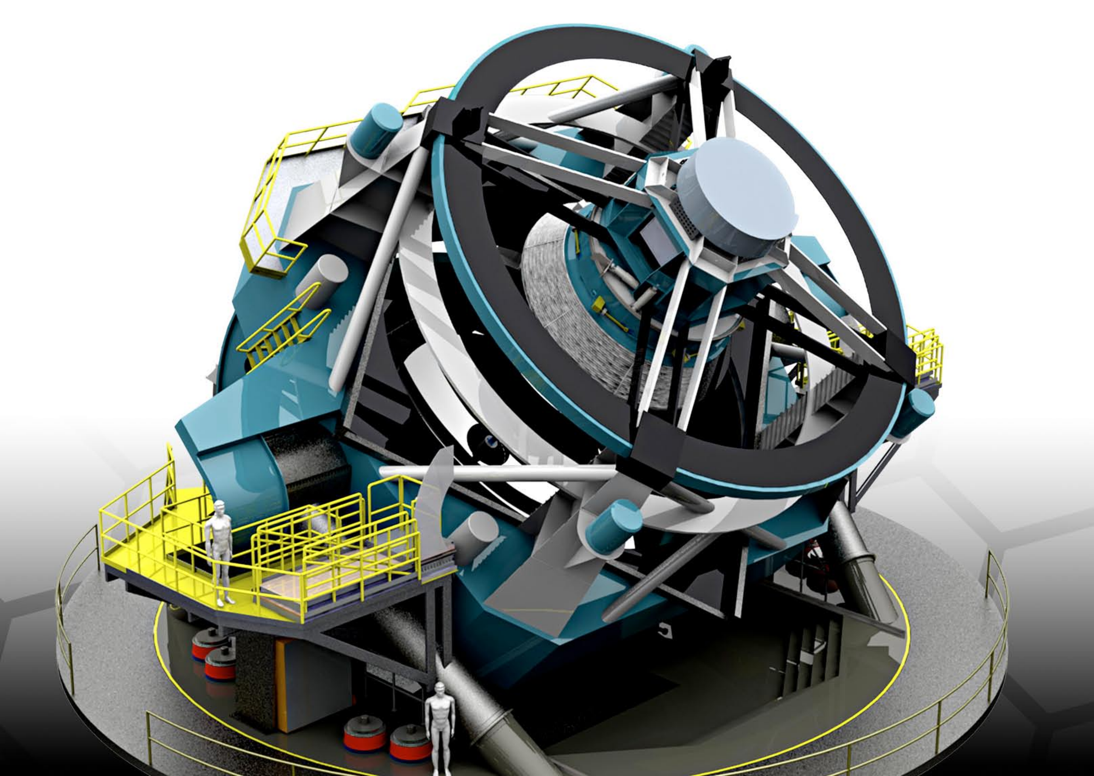
Complete samples of SNe, particularly non-SNe Ia are needed to feed classification and survey prediction and classification codes.

We will need spectroscopic subsets to train classification algorithms. Further studies are needed to determine precisely what samples of supernovae will most efficiently and sufficiently inform photometric surveys.

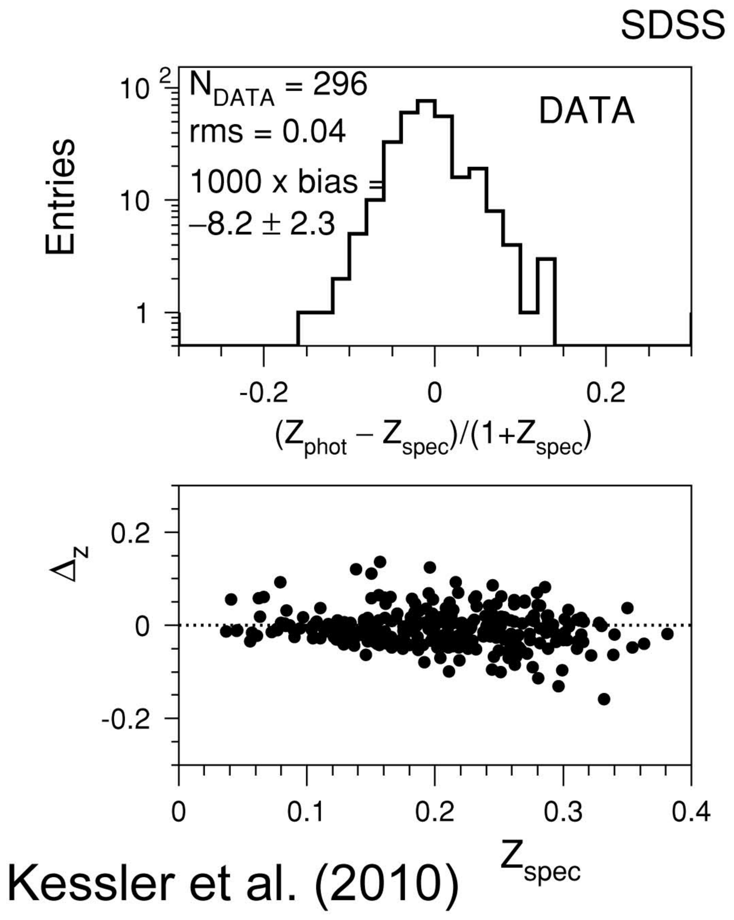
Simulations of all types of supernova light curves as they would be observed by LSST with proposed cadences and realistic conditions are publicly available at

http://sdssdp62.fnal.gov/sdsssn/SIMGEN_PUBLIC/

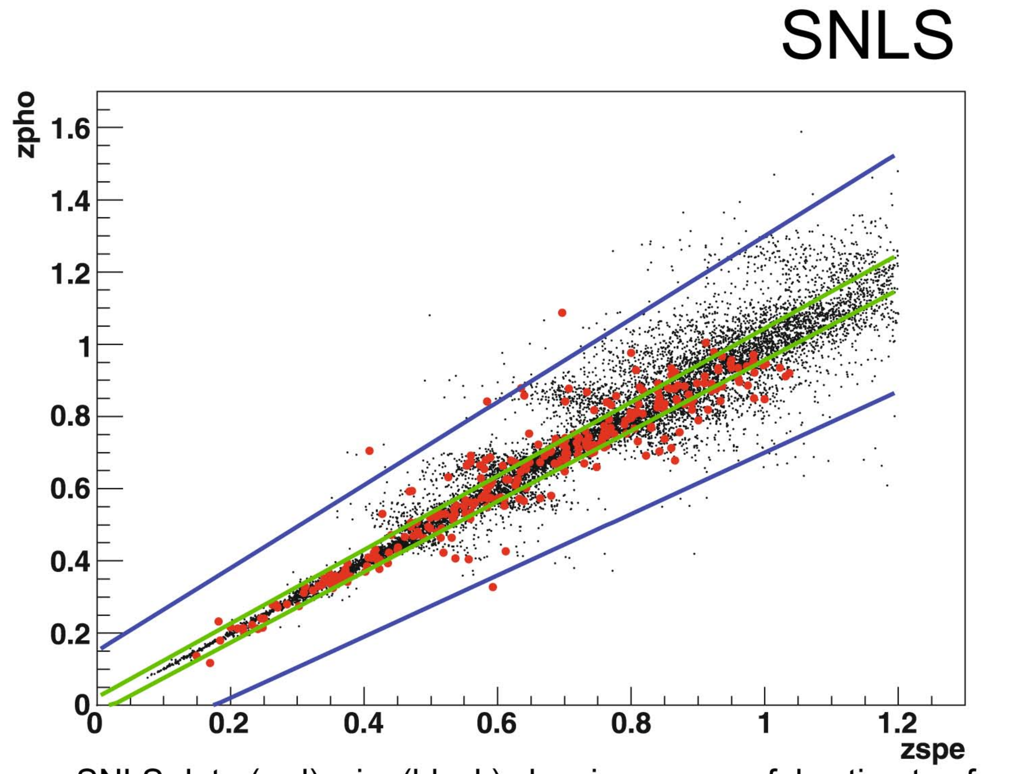
http://sdssdp62.fnal.gov/sdsssn/SNANA-PUBLIC/



Supernova Photo-z Are Promising



Kessler et al. (2010)

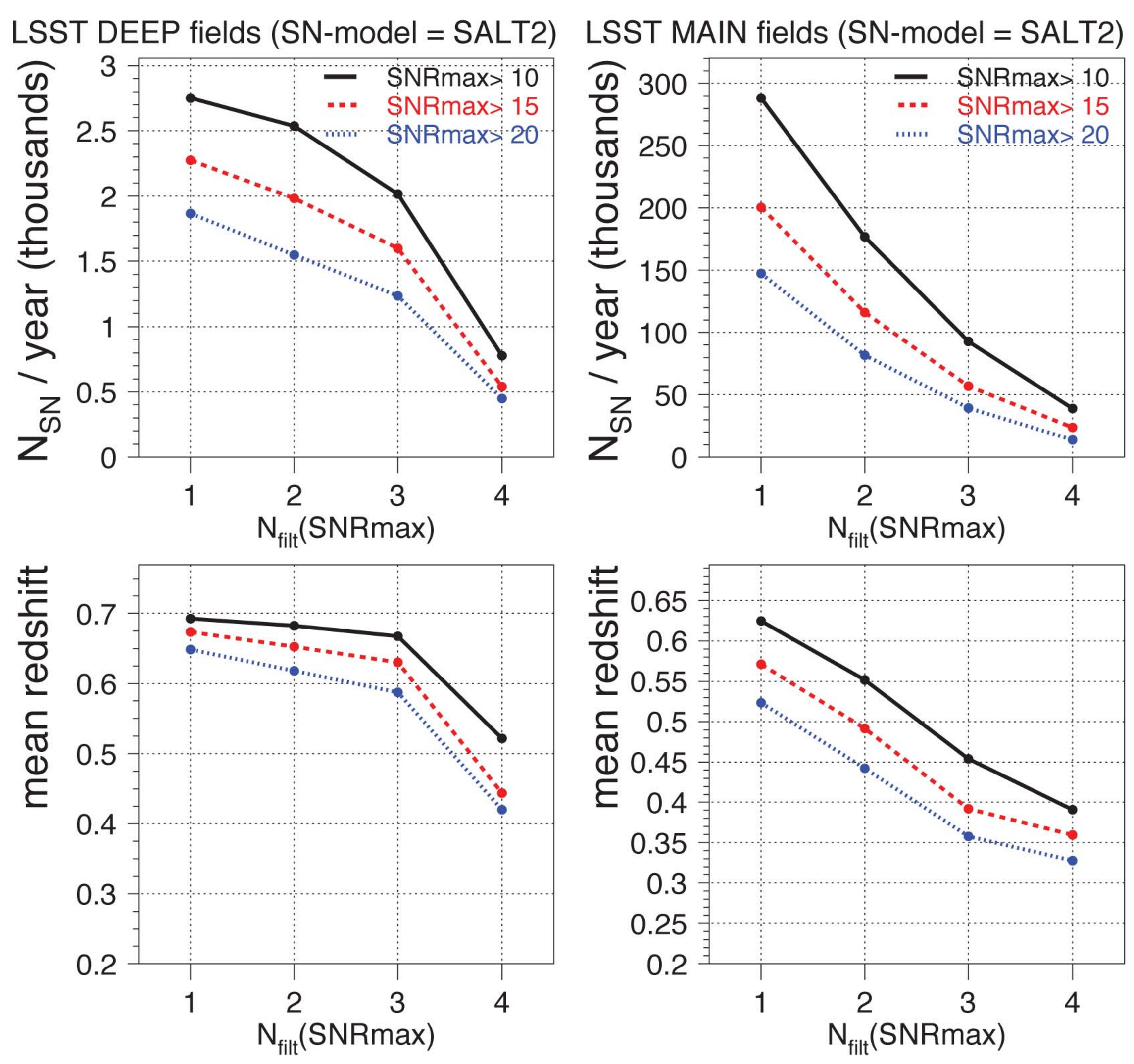


SNLS data (red), sim (black) showing successful estimates from photo-z. Green lines show the 0.03 rms and the blue lines the catastrophic error criterion.

Palanque-Delabrouille et al. (2010)

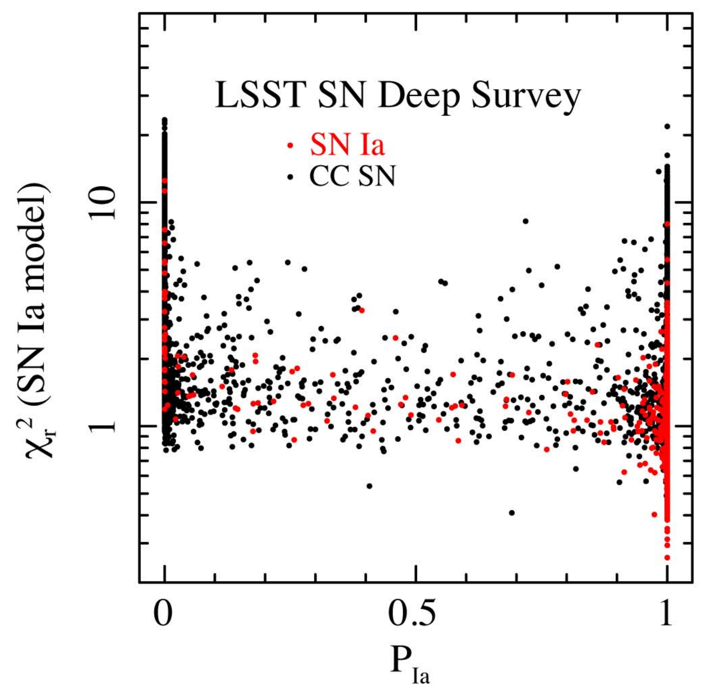
Fitting photometric redshifts for SNe Ia from the SDSS (left) and SNLS (right) surveys yields a redshift precision of 0.04 with a catastrophic error range of 1-2%. Adding host galaxy data to these efforts has the potential to yield robust SN+gal photometric redshifts free from catastrophic errors. These results are promising for determining photometric redshifts from LSST SNe.

SN Cadence Simulations

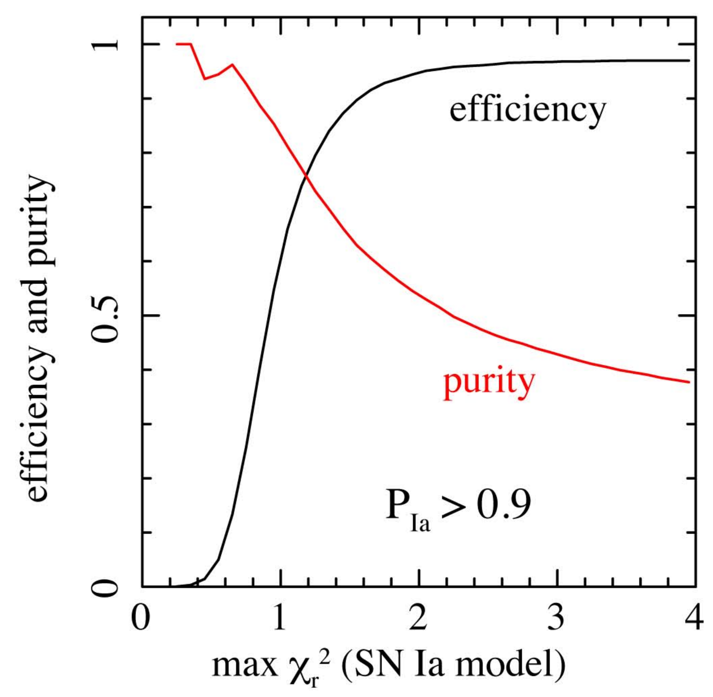


(LSST Science Book, 2009) LSST will find millions of SNe over its ten years, but the quality and coverage of the light curves depends on the observing cadence adopted. Above: the number/field and mean redshift of SNe Ia with light curves satisfying signal-to-noise ratio requirements of 10, 15, 20 in 1, 2, 3, or 4 filters. The DEEP (left) and MAIN (right) fields are for the deep-drilling and main survey cadence, respectively. A major focus of our work in 2011 will be determining suitable cadences to get high quality light curves for 100,000s of SNe Ia with LSST.

SN Photometric Classification Works: Efficiency versus Purity



Probabilistic classification of simulated supernova light curves based on realistic LSST cadences in the deep-drilling fields.



Balancing completeness against contamination will be a critical part of using LSST SNeIa for cosmology.

Sako et al. (2011, in prep)

A preliminary effort at classifying supernovae works reasonably well with sufficient light-curve points. Efforts continue to improve this photometric analysis. Early result clearly indicate a need to better understand the contamination fraction in the large samples such as those from LSST.

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