EVALUATING THE OPTIMAL STRATEGY FOR DARK ENERGY SURVEY SUPERNOVAE

Joseph P. Bernstein[1], Richard Kessler[2], Stephen E. Kuhlmann[1], and Harold Spinka[1]
for the Dark Energy Survey Collaboration
[1]Argonne National Laboratory, 9700 S Cass Ave, HEP Division, Argonne, IL 60439; [2] University of Chicago Kavli Inst. for Cosmological Physics, Chicago, IL 60637

INTRODUCTION

The deaths of low to moderate mass stars, e.g., the Sun, produce degenerate remnants called "white dwarfs". A dwarf in a binary system with a normal star can accrete mass resulting in the demise of the dwarf via a thermonuclear explosion that is thought to give rise to Type Ia supernovae (SNe). The intrinsic luminosity of such SNe is obtainable from their apparent brightness leading to the designation "standard candles". Along with accurate distances, this makes them excellent tools for probing the evolution of the Universe. Observations have shown that distant Type Ia SNe are dimmer than predicted by models of a matter-dominated Universe (1, 2). Dark energy is theorized to pervade the Universe and to have a negative pressure that has accelerated the expansion of the Universe thereby explaining this dimness. The Dark Energy Survey aims to elucidate the nature of dark energy including its putative time evolution.

Starting in 2011, DES will investigate dark energy via four independent methods (galaxy clusters, weak gravitational lensing, galaxy angular clustering, and SN distances). DES will be a deep optical and near-infrared survey of 5000 square degrees (sq. degs.) of the sky and is designing a new 3 sq. deg. camera to be mounted on the Blanco 4-meter telescope located at the Cerro Tololo Inter-American Observatory. The DES camera will have greater red sensitivity as compared to those previous and will be available for community use. In exchange, DES will receive 525 observing nights over 5 yrs with ~10% allocated to a 9–27 sq. deg. SN program.

In order to aid in the design of the optimal DES SN survey, we simulate DES SN observations using a new code suite (SNANA) that generates realistic SN light curves taking into account seeing conditions, dust extinction (3), and intrinsic SN luminosity variations using MLCS2k2 (4) or SALT2 (5) models. Simulated errors include noise from the signal, sky, and host galaxy. We employ an MLCS-based fitter to obtain the distance modulus (μ, distance parameterized by brightness) for each SN. We harness the light curves and the Dark Energy Task Force figure of merit (DETfom – a measure of the improvement in the understanding of dark energy) to optimize filters and exposure times and the number of fields, observing cadence, and control of systematics.

DISCUSSION

Fig. 1 shows an example result of SNANA simulated light curve fits. A μ bias is manifest in the difference between fitted and simulated μ beyond a redshift (a shift in the frequency of light toward lower values which, in this case, is due to the expansion of the Universe and implies distance) ~ 0.6. It arises from not accounting for selection efficiencies and illustrates the magnitude of the μ-correction that will be needed. Consistent with this picture is the fact that only less and less extincted SNe pass cuts (not shown) as redshift increases beyond ~ 0.6. Fig. 1 also indicates that a deep survey (9 sq. deg.) offers substantially improved statistics relative to an ultra-deep survey (3 sq. deg.) while avoiding much of the bias suffered by a wide survey (27 sq. deg. – note that the total observing time is fixed so that a larger survey area implies shorter exposures). Thus, we move forward by considering both a deep survey and a hybrid approach with a mixture of deep and wide fields.

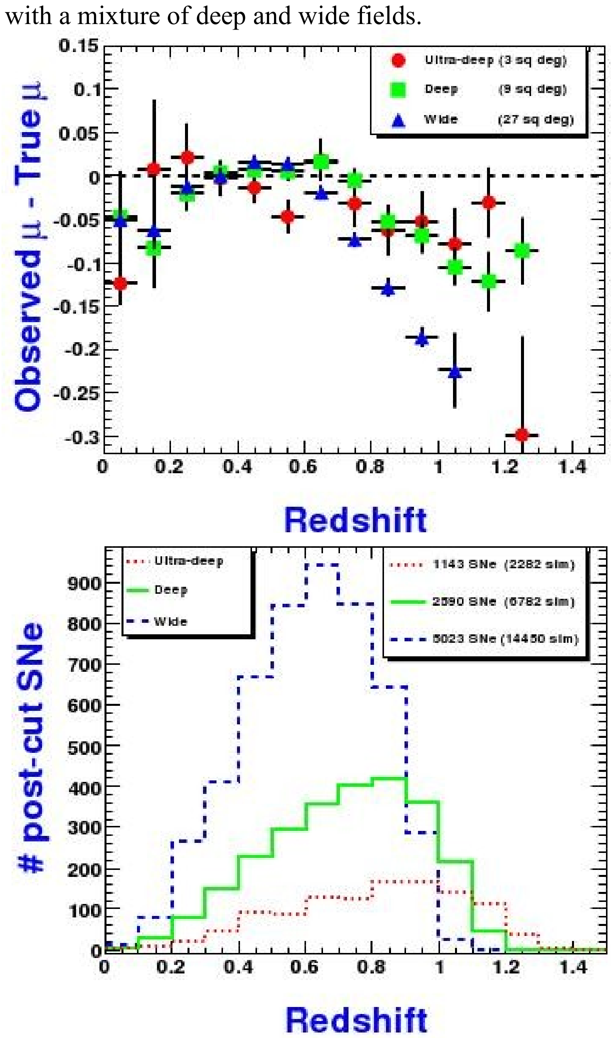

Fig. 1. *Top*: Difference in fitted ("observed") & simulated ("true") distance modulus (μ). *Bottom*: Number of SNe. Cuts ensured SNe had sufficient signal to noise.

The DES project proposal estimated that the survey would improve the DETfom by a factor of 4.6 relative to current surveys. In order to obtain a more robust calculation of the DES DETfom, we have implemented a cosmology fitter in our SNANA studies. We currently have statistics-only DETfom estimates and are working on furthering our analysis to account for estimates of systematic DES SN uncertainties. Once completed, we will use SNANA to obtain a realistic constraint on the optimal DES SN survey strategy and produce a detailed paper.

REFERENCES

1. S. Perlmutter *et al*., Nature, **391**, 51 (1998).
2. A. G. Reiss *et al*., Astronomical J., **116**, 1009 (1998).
3. J. A. Cardelli *et al*., Astrophysical J., **345**, 245 (1989).
4. S. Jha *et al*., Astrophysical J., **659**, 122 (2007).
5. J. Guy *et al*., Astronomy & Astrophys., **466**, 11 (2007).

ACKNOWLEDGEMENTS

DES is funded by the U.S. DOE and NSF.