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Current DES Supernova Survey Strategy

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DES Survey Strategy
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Fermilab

Outline

- DES supernova (SN) strategy paper
- SNANA: SN analysis package
- DES SN survey strategy
- Summary & conclusions

DES-SN Survey Strategy Simulations Paper

DARK ENERGY SURVEY

Supernovae Simulations and Strategies: Application to the Dark Energy Survey (Draft: April 15, 2010)

J. P. Bernstein[1], R. Kessler[2,3], S. Kuhlmann[1], R. Reis[4],
I. Crane[1,5], D. A. Finley[4], J. A. Frieman[2,3,4], T. Hufford[1], A. G. Kim[6], J. Marriner[4],
P. Mukherjee[7], R. C. Nichol[8], P. Nugent[6], D. R. Parkinson[7], M. Sako[9], H. Spinka[1]. . .

ABSTRACT

We present an analysis of Type Ia supernova light curves simulated for the upcoming Dark Energy Survey (DES) supernova search. Employed is a code suite that generates and fits realistic supernova light curves in order to obtain distance modulus/redshift pairs which are passed to a cosmology fitter. We harnessed the fit results to investigate several different survey strategies including field selection, supernovae selection biases, and photometric redshift measurements. We forecast that the DES supernova search will discover on the order of 6000 Type Ia supernovae, with ~3000 passing selection cuts, with planned full spectroscopic host galaxy follow-up out to a redshift of 1. Thus, the DES will provide by far the largest self-contained, high-redshift Type Ia sample to date, and will significantly improve z-band coverage relative to SNLS due to the heightened red sensitivity of the DES camera. Prior to obtaining host spectra, our analysis during survey operations will rely on photometric redshifts. Our simulations predict that for the DES, the distribution of photometric minus true supernova redshift will have a width of less than 3 percent and minimal non-Gaussian tails when the host galaxy photometric redshift is used as a prior. We further present estimates of 1) systematic effects on DES supernova observations and 2) the Dark Energy Task Force figure of merit.

Subject headings: supernovae – cosmology: simulations

http://des-docdb.fnal.gov:8080/cgi-bin/ShowDocument?docid=2685

SNANA: SuperNova ANAlysis package for DES

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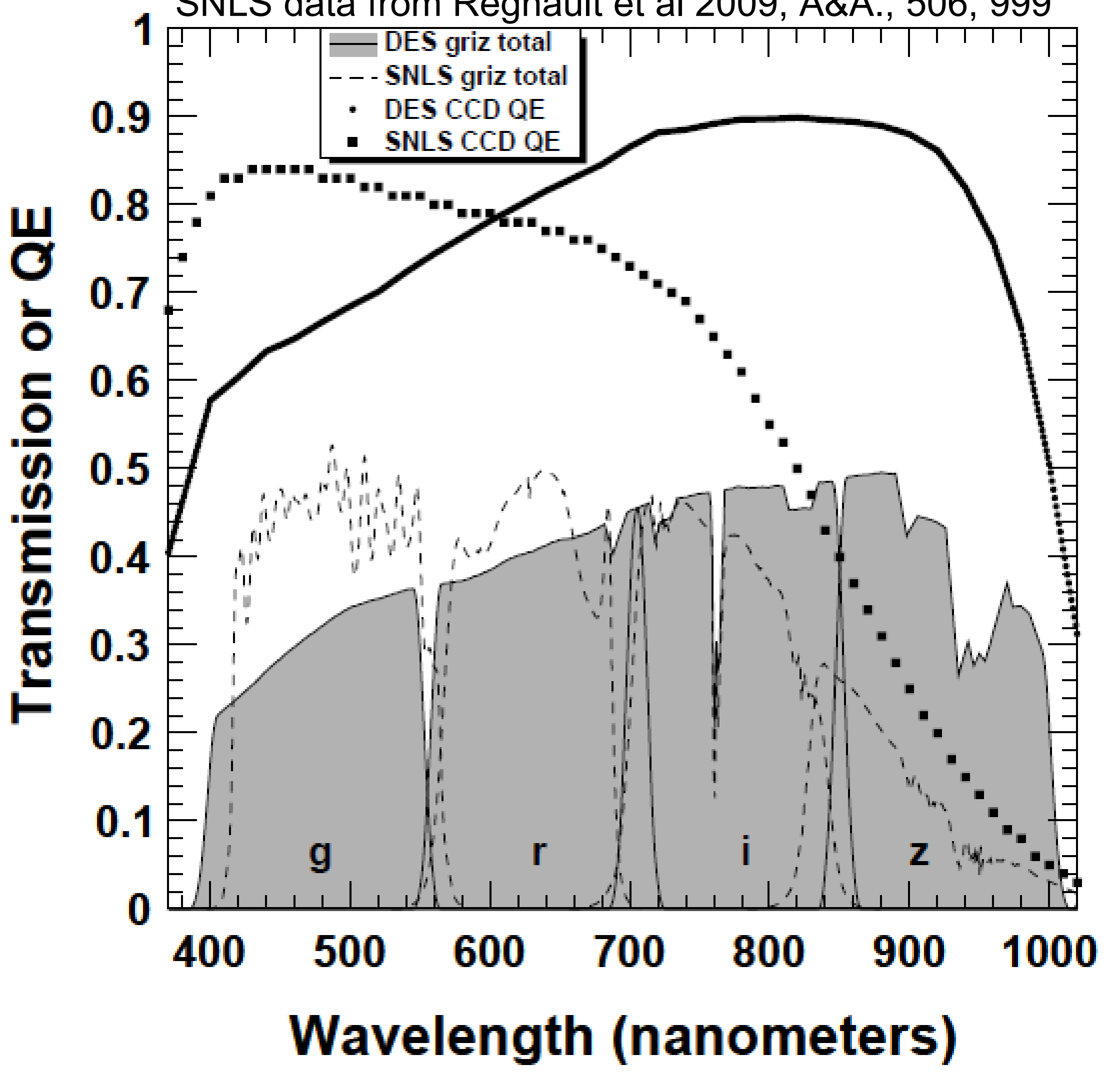
R. Kessler (U. Chicago), J. P. Bernstein, S. Kuhlmann, & H. Spinka (ANL)

- Also used by SDSS & LSST
- Software suite for simulating and fitting SN light curves
- Motivation was a more accurate and complete study of DES-SN capabilities including DES CCD and filter characteristics, CTIO sky fluctuations using Essence data inputs, dust extinction effects, etc.
- Uses various models (e.g., MLCS2k2, SALT-II, stretch, etc.)
- Models and fits both Ia and non-Ia SNe
- Public URL: http://www.sdss.org/supernova/SNANA.html

(currently forwards to http://sdssdp47.fnal.gov/sdsssn/SNANA-PUBLIC)

Transmission Comparison to SNLS

SNLS data from Regnault et al 2009, A&A., 506, 999



DES Supernovae

- DES time allocation fixes total supernovae (SNe) exposure time
  - 1260 hr planned (73% non-photometric) over 5-year survey
  - maximal use of non-photometric time (~920 hr) planned
- Considered time per field & number of fields:
  - ultra-deep strategy (3 square degrees = 1 DES field)
  - deep strategy (9 square deg.)*
  - shallow but wide strategy (27 square deg.)
  - hybrid strategy, e.g., 2 deep + 3 wide (15 square deg.)
- Hybrid *griz* strategy is the current favorite (more later)

* Highlighted in DES DOE proposal

Currently Favored DES-SN Fields

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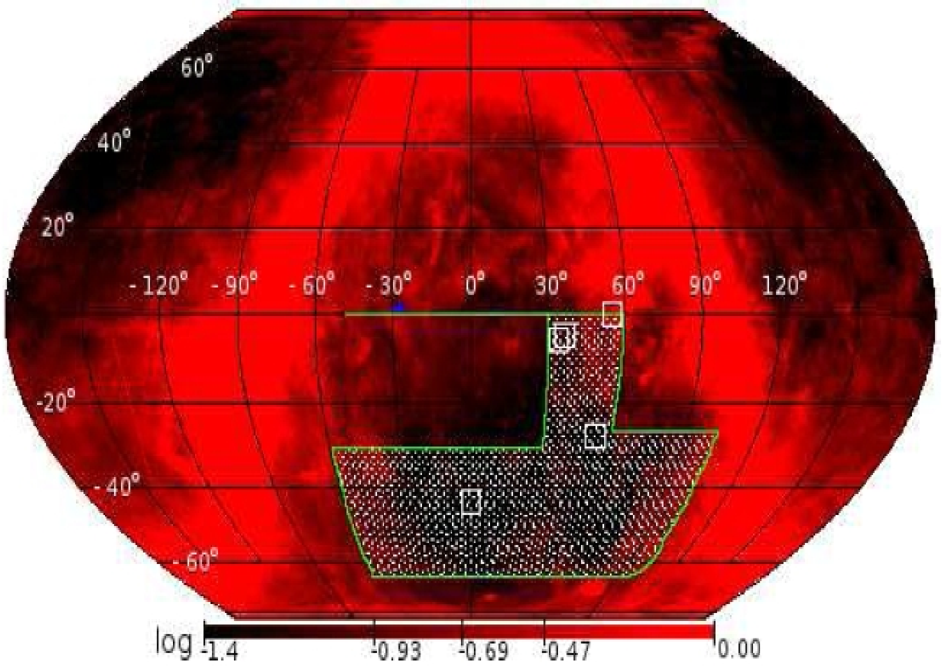
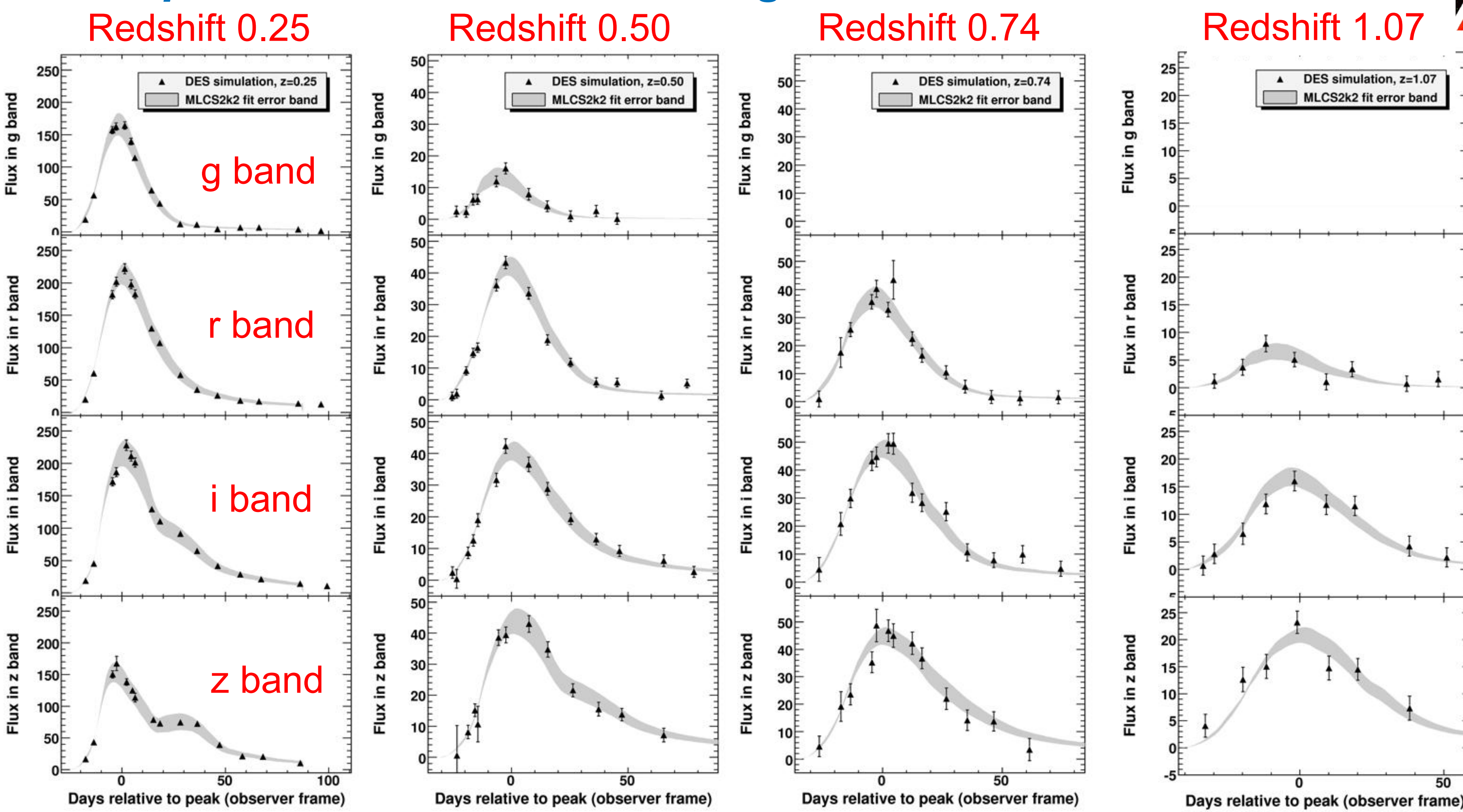
- Chosen to maximize:
  - visibility from DES site
  - past observation history
  - visibility from, e.g, Hawaii

Field (3 deg^2 area)	Pointing RA&Dec (deg., J2000)
Chandra Deep Field S.	52.5°, –27.5°
Sloan Stripe 82	55.0°, 0.0°
SNLS D1/Virmos VLT	36.75°, –4.5°
XMM-LSS	34.5°, –5.5°
ELAIS S1	0.5°, –43.0°



From a study by Peter Nugent

Example DES Simulated SN Ia Light Curves



Selection cuts for DES supernovae
1. At least 5 total epochs above a very small, but non-zero, signal-to-noise threshold
2. At least one epoch before and at least one 10 days after the B-band peak
3. At least one filter measurement with a signal-to-noise above 10
4. At least two additional filter measurements with a signal-to-noise above 5

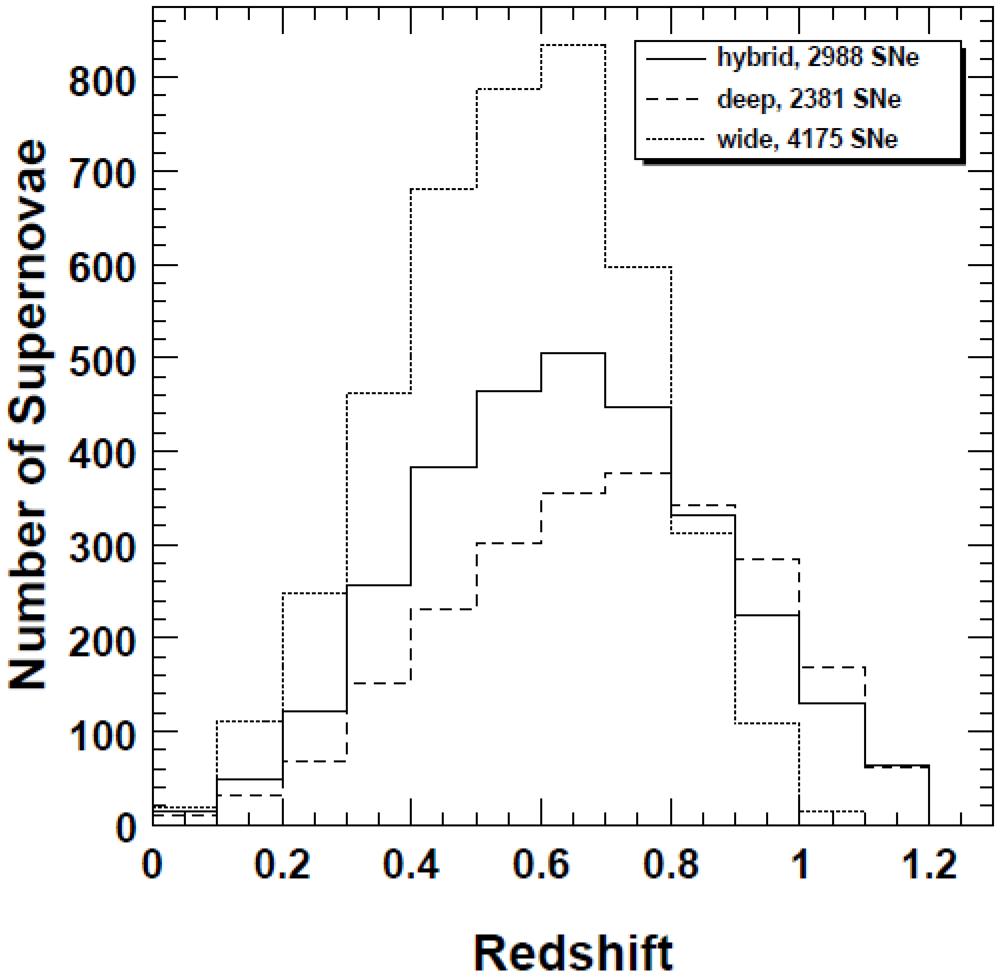
g band: 400 – 550 nm **i band: 700 – 850 nm**

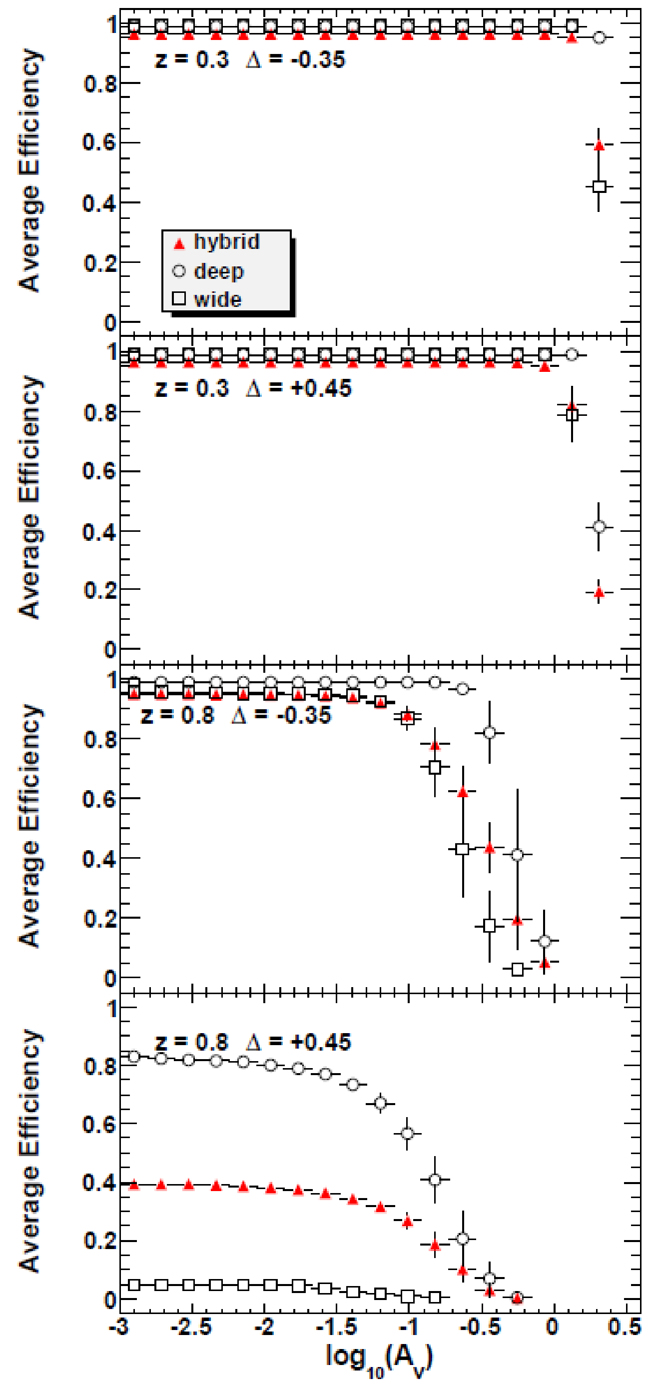
r band: 560 – 710 nm **z band: 860 – 1000 nm**

Filter	Range (nm)	Exposure time (s)
g	400–550	300
r	560–710	1200
i	700–850	1800
z	850–1000	4000
Z_1	850–970	n/a
Z_2	850–920	n/a
Y	970–1020	n/a

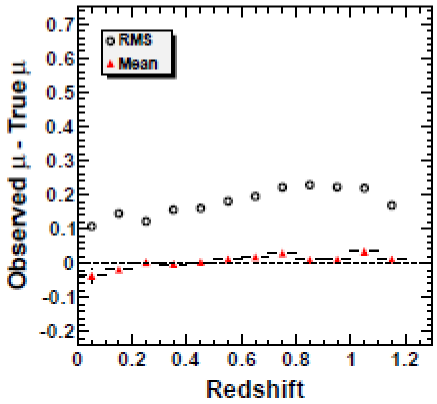
Deep; Wide = Deep/3

Number of SNe and Selection Efficiency

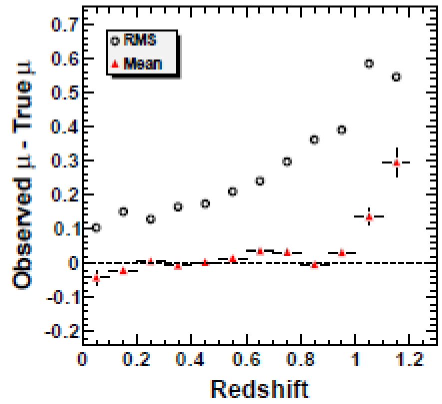




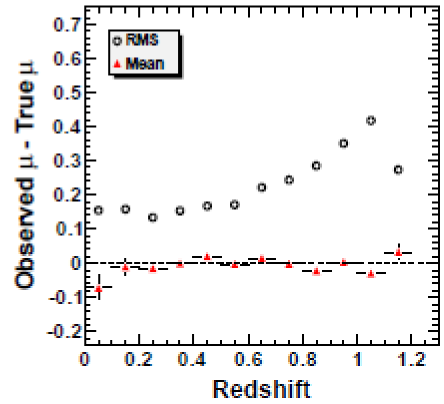
True Distance Recovery



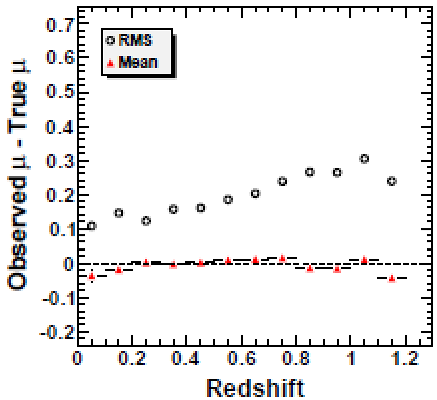
(a) MLCS2k2 fit for hybrid strategy with full priors.



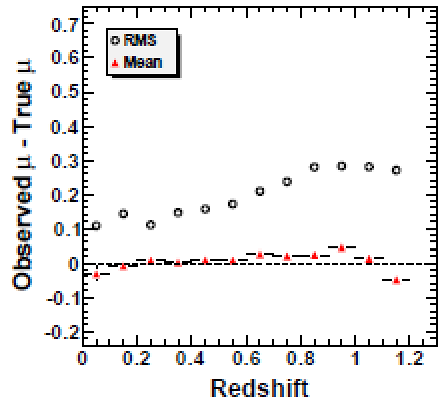
(b) MLCS2k2 fit for hybrid strategy with flat priors.



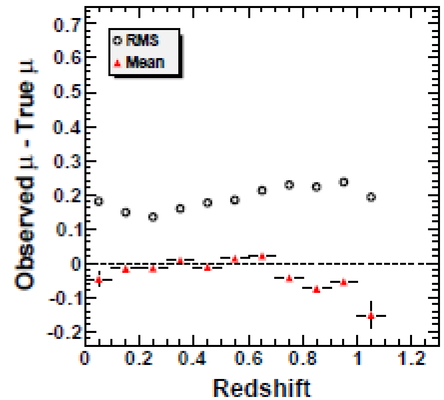
(c) SALT2 fit for hybrid strategy.



(d) MLCS2k2 fit for hybrid strategy with partial prior without efficiencies applied.

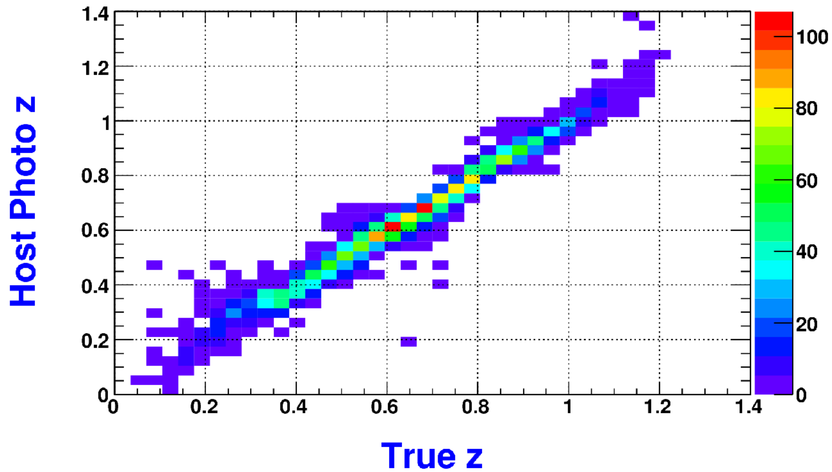


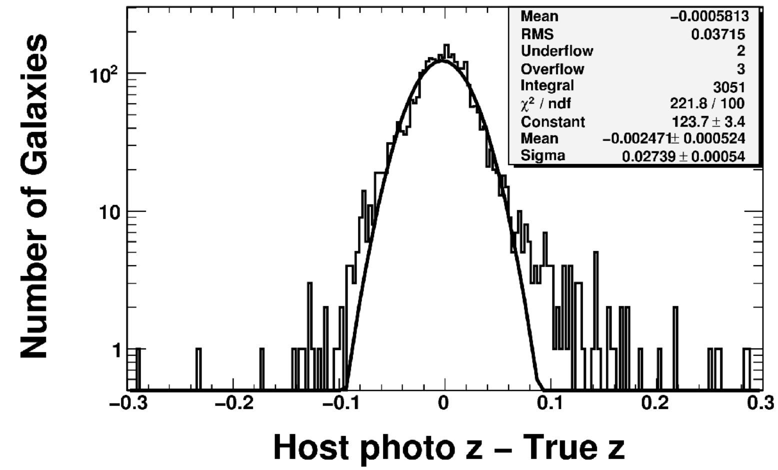
(e) MLCS2k2 fit for deep strategy with partial prior without efficiencies applied.

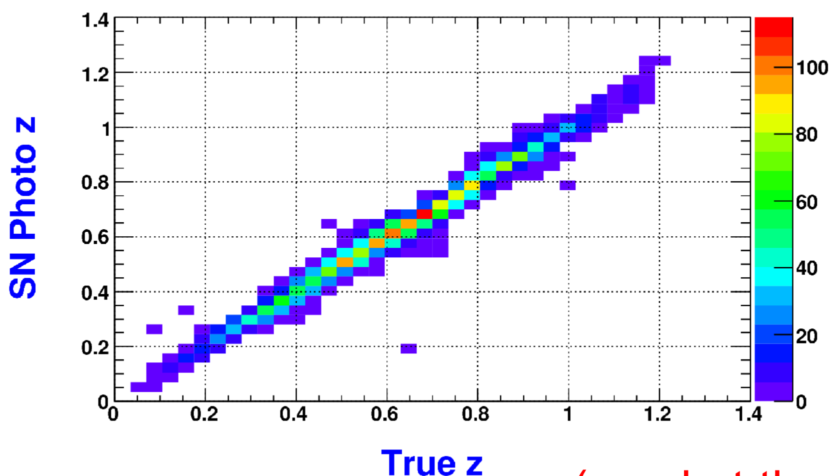


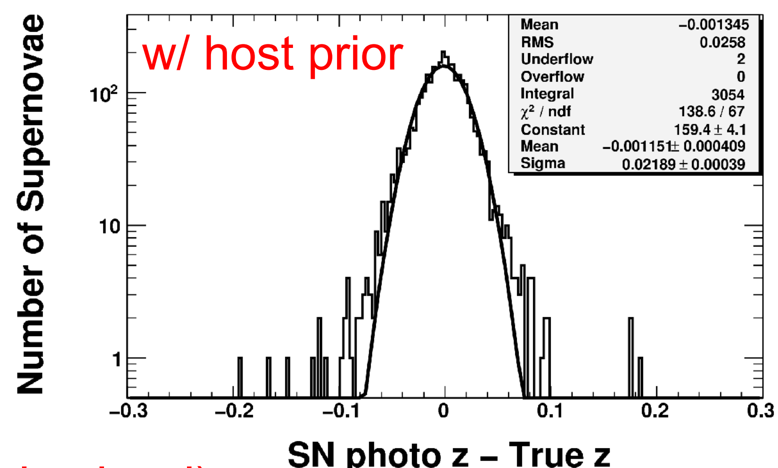
(f) MLCS2k2 fit for wide strategy with partial prior without efficiencies applied.

Photometric Redshifts



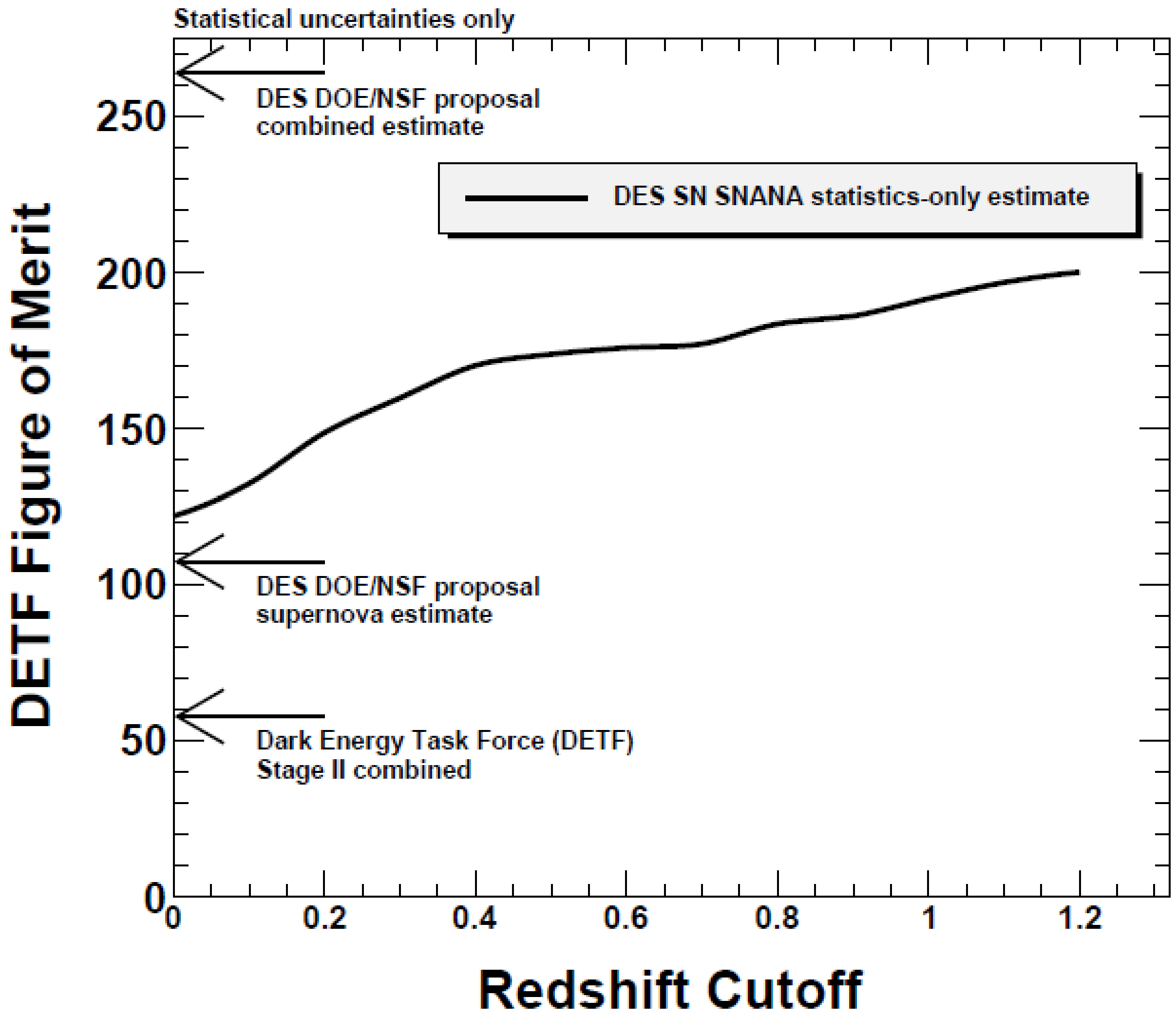






(used at the catalog level)

Updated Spectroscopic z Cutoff Plot



Input Core Collapse SN Rate & Relative Fractions

- Use $\alpha(1+z)^{\beta}$, with $\beta=3.6$ (same as SFR)

- Determining α
  - Use SNLS CC/Ia ratio of 4.5 for z<0.4
  - Gives $\alpha=6.8\times 10^{-5}$

Reference	Ib/c fraction
Li et al. (2007)	26.5 ± 5.4%
van den Bergh et al. (2005)	24.7 ± 2.6%
Smartt et al. (2009)	29.3 ± 4.7%
Prieto et al. (2008)	24.7 ± 4.9%
Leaman et al. (2009)	33.3 ± 4.3%
Cappellaro et al. (1999)	15-22%

Table 3: Various references for the relative fraction of type Ib/c supernovae.

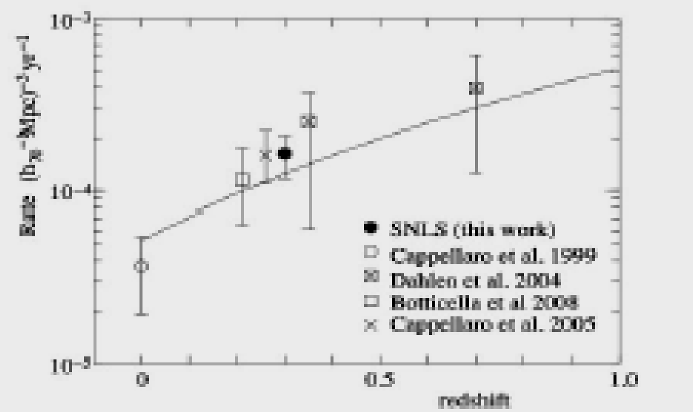


Fig. 13. The measured rate of SNcc as a function of redshift. The SNLS point includes a 15% correction for host absorption as described in the text. The error bars correspond to statistical and systematic uncertainties added in quadrature. The line is the best fit for rate ∝ $(1+z)^{3.6}$, i.e. proportional to the SFR.

Forecasted Contamination

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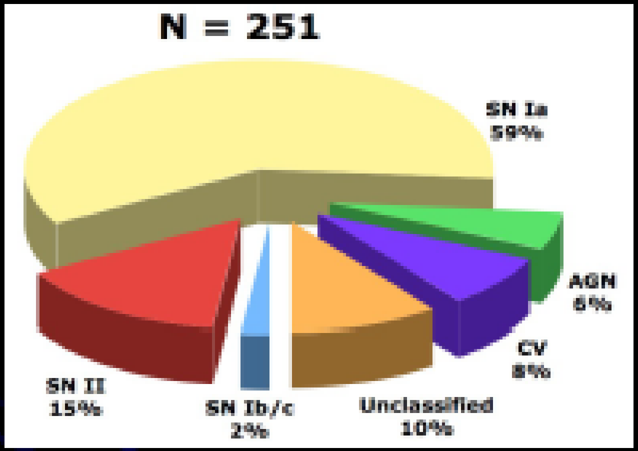
PTF magnitude limited (Nugent) (12% Ib/c)



Snippet from Masao's RIO presentation

- Total of **1409** SNe (726 SN Ia + 683 non-Ia) with spectroscopic redshifts and good light curves.
- 704 pass photo SN Ia cuts with flat z-prior (P_Ia > P_Ibc & P_Ia > P_II & $\chi^2 \leq 2.0$).
  - 670 SN Ia → 670/726 = **92.3% completeness**
  - 34 non-Ia → 34/704 = **4.8% contamination**

Sample	f_p >0.0	f_p >0.1	f_p >0.5
Ia	2876	2777	2104
Ib/c	821 (20%)	302	60
IIn	2465	20	0
IIP	698	21	0
IIL	175	21	2
Contamination		11.5%	2.9%

Table 5: Number of simulated supernovae passing cuts and using a single gaussian for all of the core collapse types.

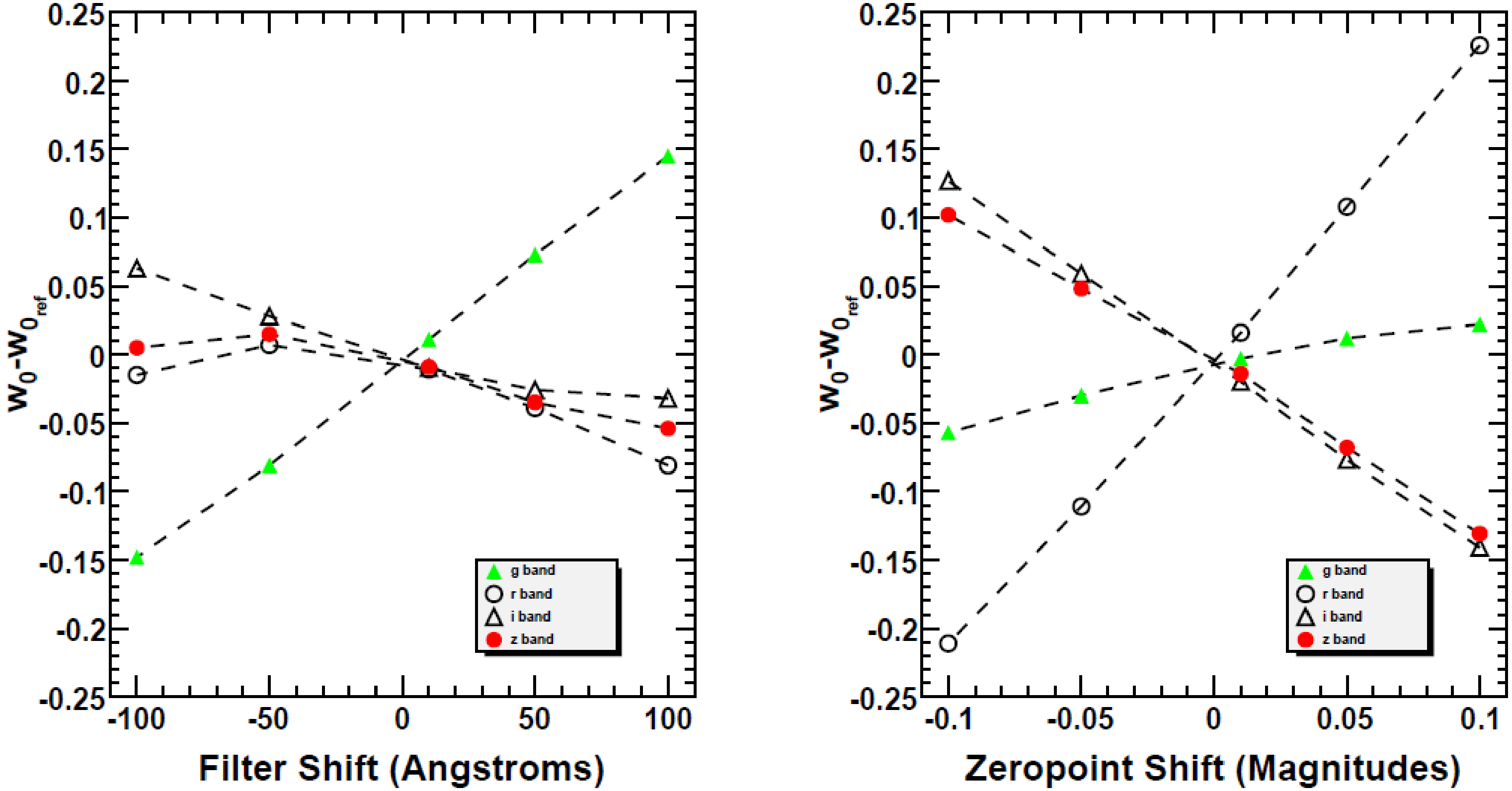
Sample	f_p >0.0	f_p >0.1	f_p >0.5
Ia	2876	2777	2104
Ib/c	3301	824	137
IIn	2946	20	0
IIP	729	21	0
IIL	506	44	3
Contamination		23.8%	6.2%

Table 6: Number of simulated supernovae passing cuts and using a double gaussian for Ib/c and IIL.

SNANA IR Simulations

- New IR model for SNANA: mlcs2k2.IR paper
  - UBVRIYJHK filters
  - uses UBVRI data from mlcs2k2.v006b
  - vectors by J. Marriner, currently -10 to +71 days only
  - uses new 9-filter genmag_mlcs.c routine
  - UBVRI works as mlcs2k2.v006b if YJHK templates do not exist
- NB: A_V-prior dominates YJHK fits b/c sim has no lever arm on color
- IR sims & DES-SN sim paper
  - introduce VIDEO connection & show SNANA IR capability
  - branch full IR study off in separate paper
  - IR meaty subject (e.g., Alex Kim's preliminary IR SNR results)
  - allows for our VIDEO external collaborators to be co-authors

Systematic Studies



- Zeropoint shifts
  - 0.01 (DES spec) leads to 0.03 change in w
  - linear: 0.02 (too large) leads to 0.06 change in w
- Other systematics still under evaluation
  - mostly “community-wide”, e.g., dust, with many working to reduce
  - we can improve zeropoint systematic with PreCam

Example DES+ VIDEO SN Ia Light Curves

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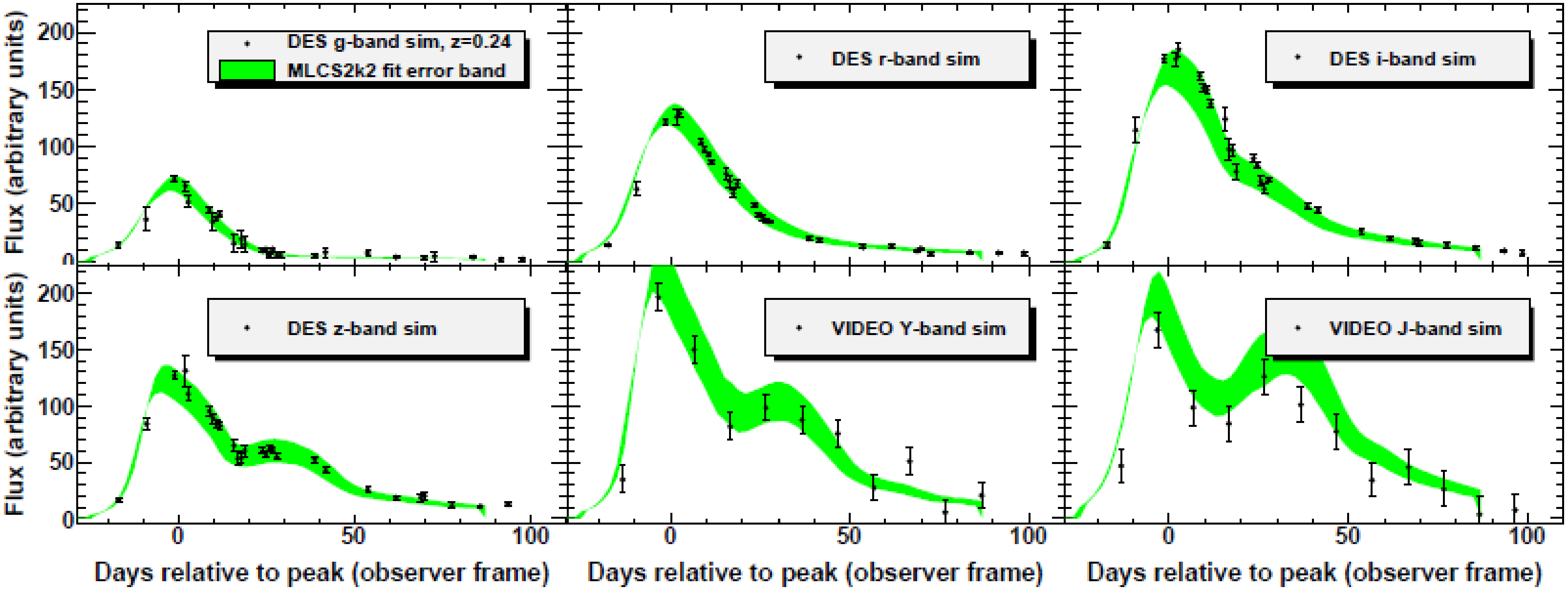

Example DES+VIDEO SN Ia Peak Mags & SNR

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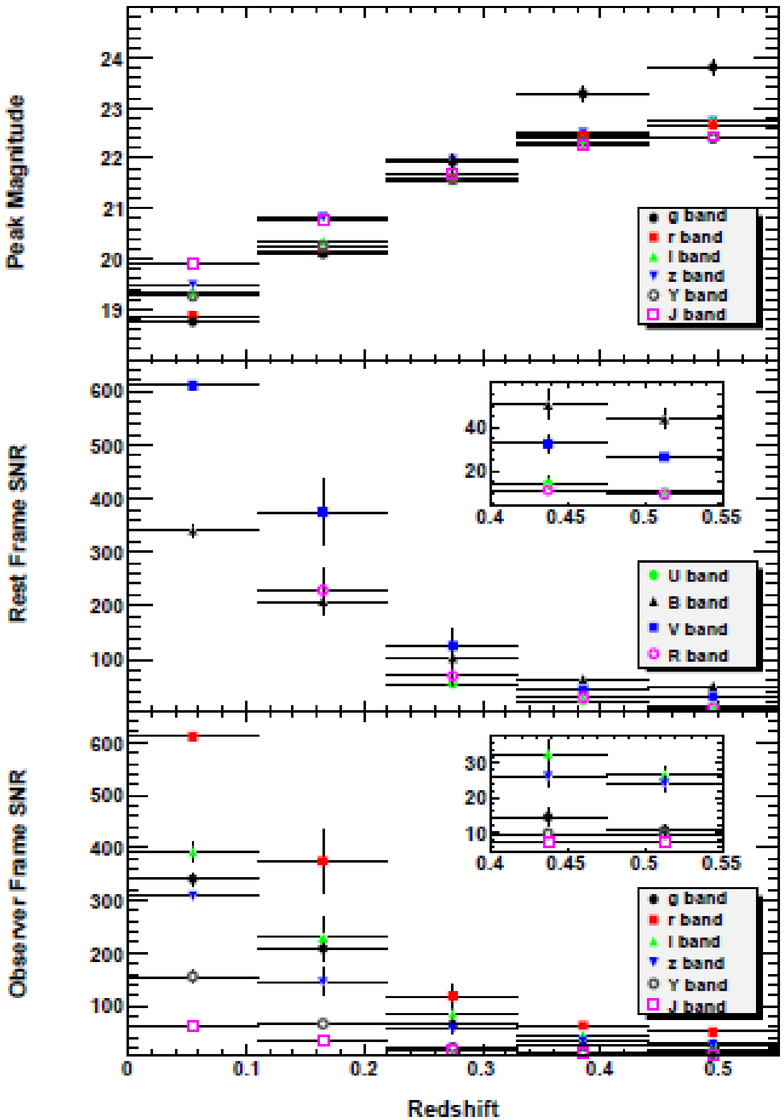

Summary & Conclusions

- DES will compile a sample of ~3000 well-measured SNe to z~1
- Hybrid strategy of “deep” and “wide” fields currently favored
- Simulated DES photoz performance encouraging
- Contamination significant but manageable
- DES-SN Strategy simulation paper nearing submission
- Ongoing/Future work
  - further systematics studies
  - optimization of *griz* exposure time split
  - model spectroscopic follow-up strategy
  - follow-on DES+VIDEO IR SN paper