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Dark Energy Survey Activities (ANL HEP Astro Group Update Series)

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Leadership Computing Facility

Key Contributors

DES group members: Kyler **Kuehn**, Steve **Kuhlmann** (group leader), Hal **Spinka**, Rich **Talaga**

Mechanical group: Vic **Guarino**, Tom **Kasprzyk**, Frank **Skrzecz**, Allen **Zhao**

Additional: Eve **Kovacs**, John **Cunningham** (Loyola), **Ian Crane** (UIUC), Tara **Hufford** (Loyola)

HEP Lunch Seminar

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Argonne National Lab

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UChicago Argonne LLC

Office of Science
U.S. DEPARTMENT OF ENERGY

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Outline

- Dark Energy Survey (DES) Intro
- Dark Energy Camera (DECam)
- PreCam (e.g., “mini-DECam”)
- Studies of DECam charged coupled devices
- Studies of the DES Supernova Observing Strategy
- Summary & conclusions

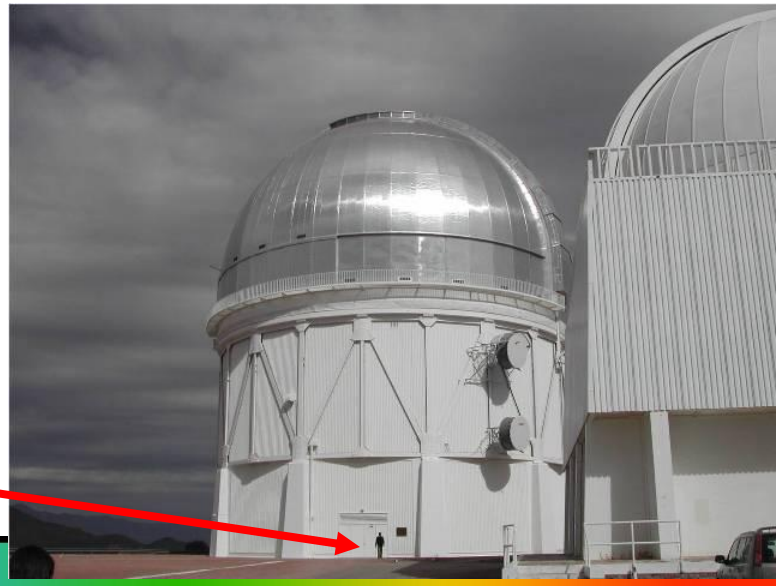
Dark Energy Survey (DES)

DES will survey 5000 square degree of sky and provide new 500Mpixel CCD camera (DECam) for Blanco 4m telescope at the Cerro Tololo Inter-American Observatory (CTIO), Chile, in exchange for 525 survey nights over 5 years starting in 2011.

DE investigation via 4 independent probes:

1) Galaxy angular clustering
2) Weak gravitational lensing
3) Baryon acoustic oscillations
4) SN Ia distances

DES is expected to observe ~10^8 galaxies & will obtain redshifts for the South Pole Telescope survey.



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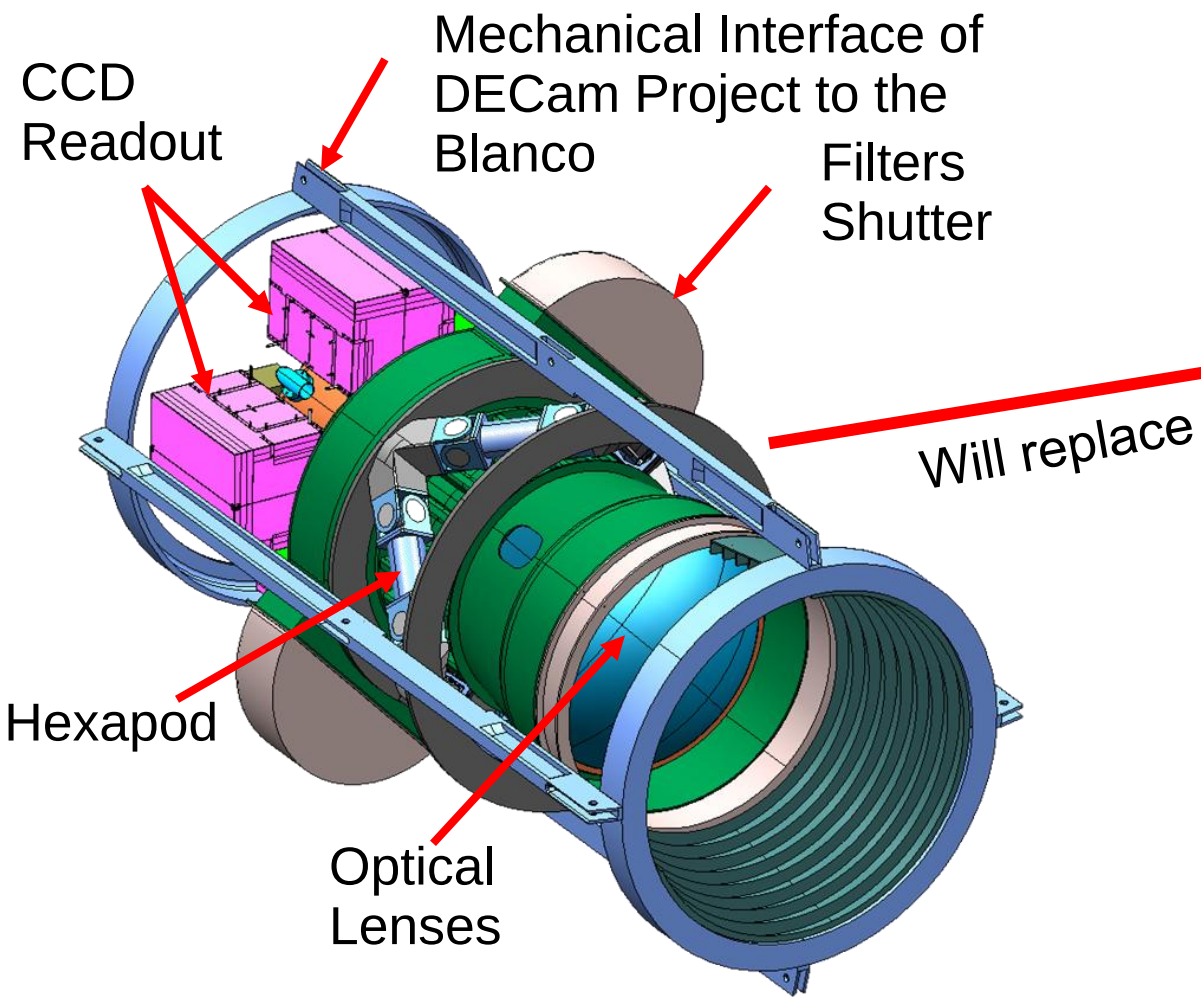
Dark Energy Camera (DECam)



Will replace

Mosaic Image Using Prototype DECam Imager
(currently using poor-grade CCDs)

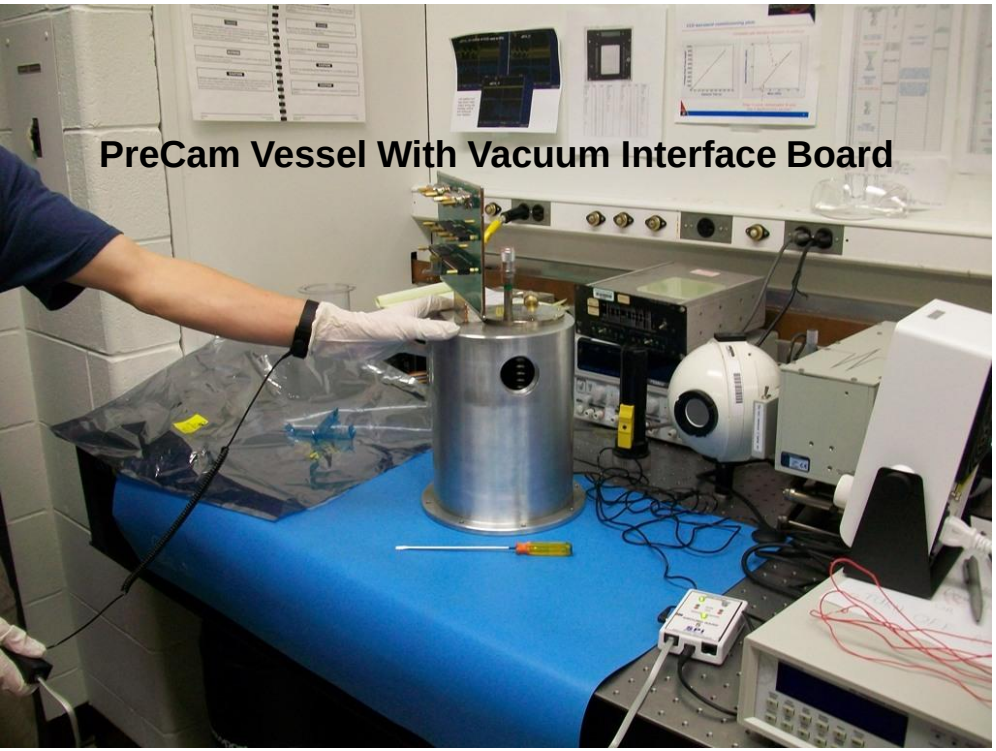
f/8 Handling System

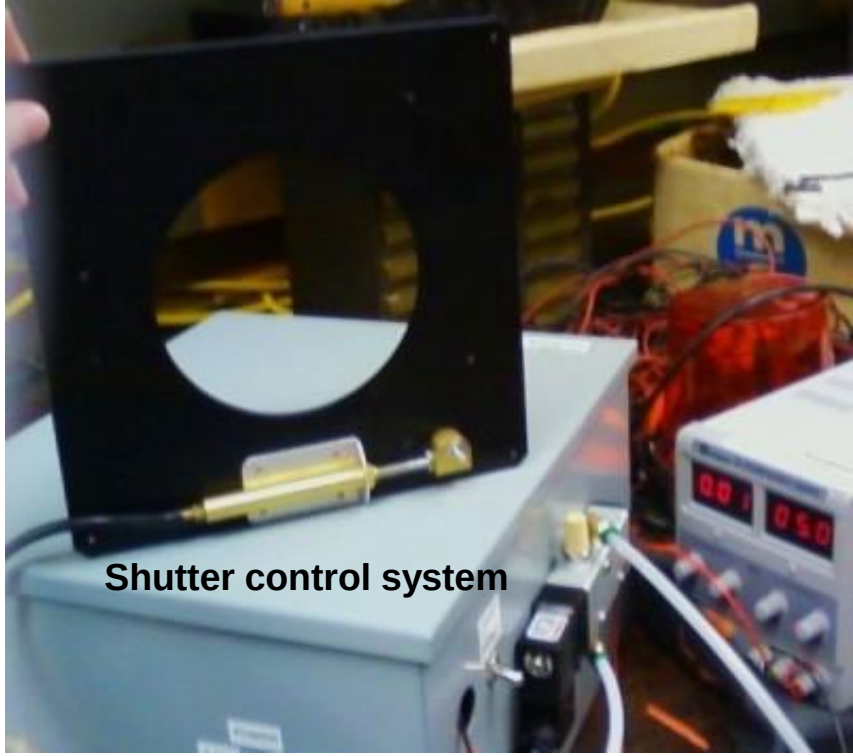
- Used to install and remove the f/8 secondary mirror from the front of DECam
- Assembled and tested in 366
- Shipment to FNAL started 5/28
- First piece of DECam to go through acceptance testing
- Will go through official hand-off and shipping process to CTIO this summer (winter)

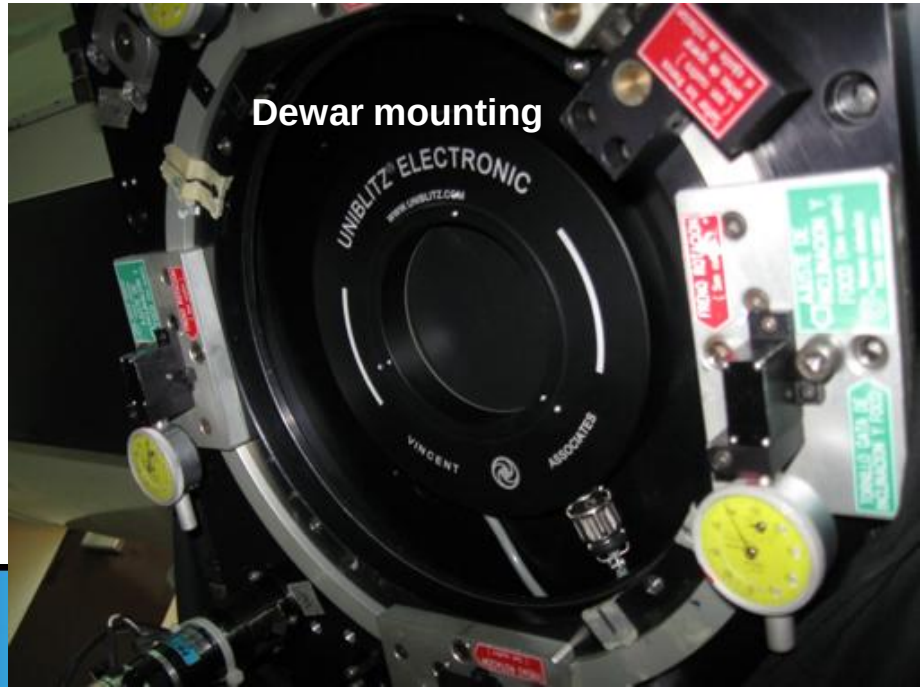
PreCam: a "mini-DECam," pre-DES Survey

- Science motivation for pre-survey observations with DECam hardware
  - 0.01 calibrated stars/image: ~1000 with SNR>50
  - reach 2% photometry requirement faster (1 yr vs 2yr?)
  - better chance to reach 1% photometry goal
  - dark energy EOS parameter uncertainty due to photometry is 0.06 with 2% photometry (0.03 with 1%)
- Test-bed for DECam hardware, software, and observing strategies
- PreCam components being tested in HEP
  - pressure vessel & turbo pump: can obtain pressures $<10^{-5}$ mbar
  - shutter control system: controls image exposure time
  - temperature control system: can regulate the CCD & vessel to 0.25K
  - dewer mounting plate
  - electronic readout crate
  - DAQ software
  - extremely red-sensitive (DECam) CCDs

Actual PreCam Hardware







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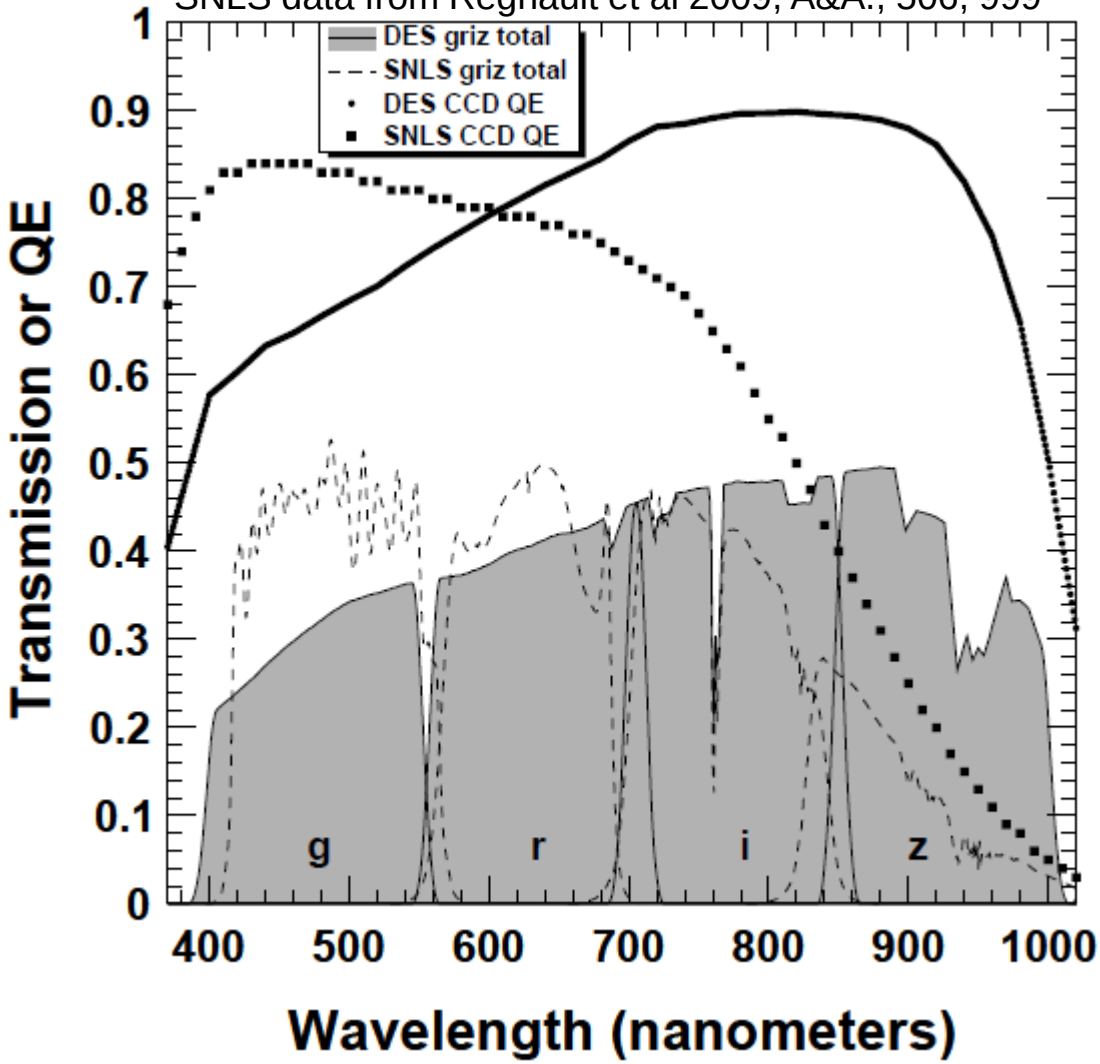
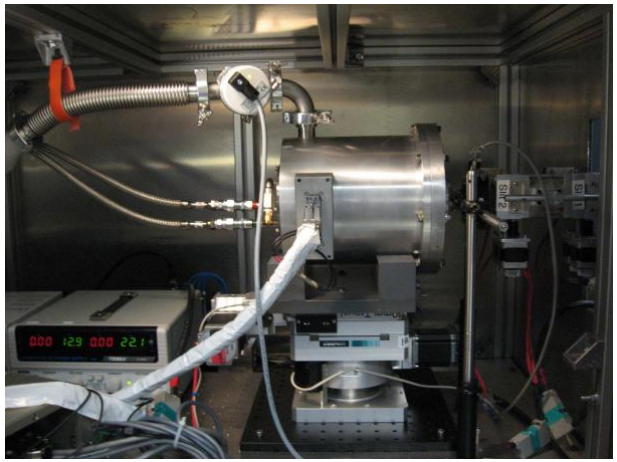
DES Transmission Compared to Supernova Legacy Survey

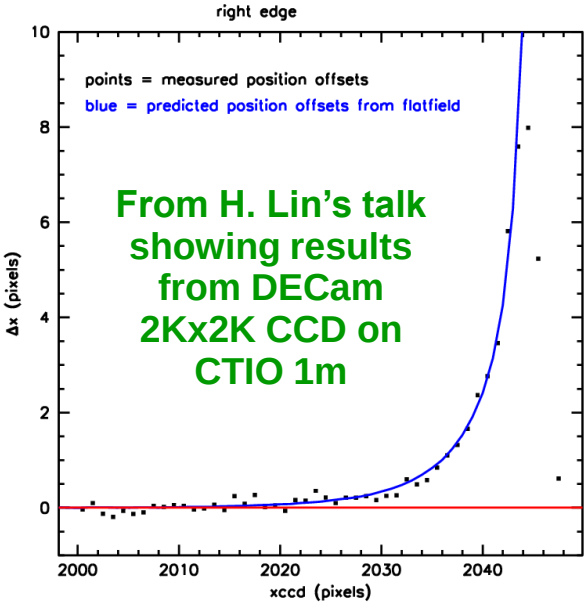
SNLS data from Regnault et al 2009, A&A., 506, 999



DECam Charged Coupled Device Studies: X-ray irradiation studies in APS X-ray Lab



Paper Submitted



From H. Lin's talk showing results from DECam 2Kx2K CCD on CTIO 1m

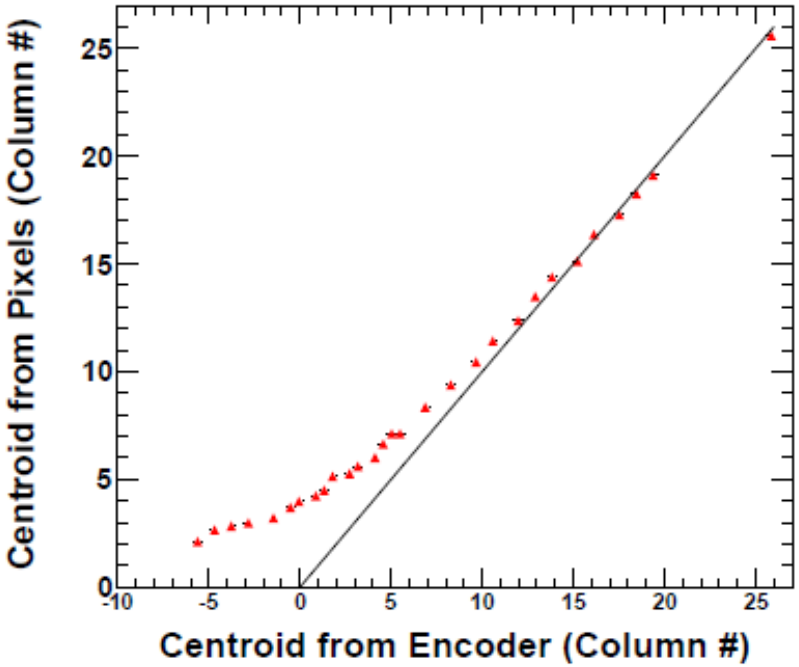
Experimental Astronomy manuscript No.
(will be inserted by the editor)

Narrow-Beam X-Ray Tests of CCD Edge Response

S. Kuhlmann · H. Spinka · J. P. Bernstein · K. A. Beyer · L. M. Gades · T. E. Kasprzyk · A. Miceli · R. A. Spence · R. Talaga

Received: date / Accepted: date

Abstract The physical boundaries of a fully-depleted CCD can lead to distorted field lines and non-uniform response. We study this response with a beam of x-rays constrained to a width of less than one pixel (15 μm), and a system to map the CCD response as a function of transverse position.



ANL SN Papers

2008 Cosmology, Proceedings of the 43rd Rencontres de Moriond", Eds. J. Dumarchez, Y. Giraud-Heraud, J. Tran Thanh Van, pp. 71-74, 2009, The Gioi Publishers, Vietnam

Dark Energy Survey Supernovae: Simulations and Survey Strategy

http://arxiv.org/abs/0906.2955

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For the Dark Energy Survey Collaboration

SNANA: A PUBLIC SOFTWARE PACKAGE FOR SUPERNOVA ANALYSIS

Richard Kessler,[1,2] Joseph P. Bernstein,[3] David Cinabro,[5] Benjamin Dilday,[4] Joshua A. Frieman,[2,1,6] Saurabh Jha,[4] Stephen Kuhlmann,[3] Gajus Miknaitis,[7,6] Masao Sako,[8] Matt Taylor,[5] Jake Vanderplas[9]

Publications of the Astronomical Society of the Pacific, Volume 121, issue 883, pp.1028-1035 DOI: 10.1086/605984

PHOTOMETRIC ESTIMATES OF REDSHIFTS AND DISTANCE MODULI FOR TYPE IA SUPERNOVAE

Richard Kessler,[1,2] David Cinabro,[3] Bruce Bassett,[11,12] Benjamin Dilday,[4] Joshua A. Frieman,[1,2,5] Peter M. Garnavich,[6] Saurabh Jha,[4] John Marriner,[5] Robert C. Nichol,[7] Masao Sako,[9] Mathew Smith,[11] Joseph P. Bernstein,[8] Dmitry Bizyaev,[13] Ariel Goobar,[14,15] Stephen Kuhlmann,[8] Donald P. Schneider,[10] Maximilian Stritzinger[16,17]

Accepted by ApJ

http://arxiv.org/abs/1001.0738

SUPERNOVA PHOTOMETRIC CLASSIFICATION CHALLENGE

Richard Kessler,[1,2] Alex Conley,[3] Saurabh Jha,[4] Stephen Kuhlmann[5]

Challenge Released on Jan 29, 2010. Last update: April 29, 2010

http://arxiv.org/abs/1001.5210

Supernovae Simulations and Strategies: Application to the Dark Energy Survey (Draft: April 19, 2010)

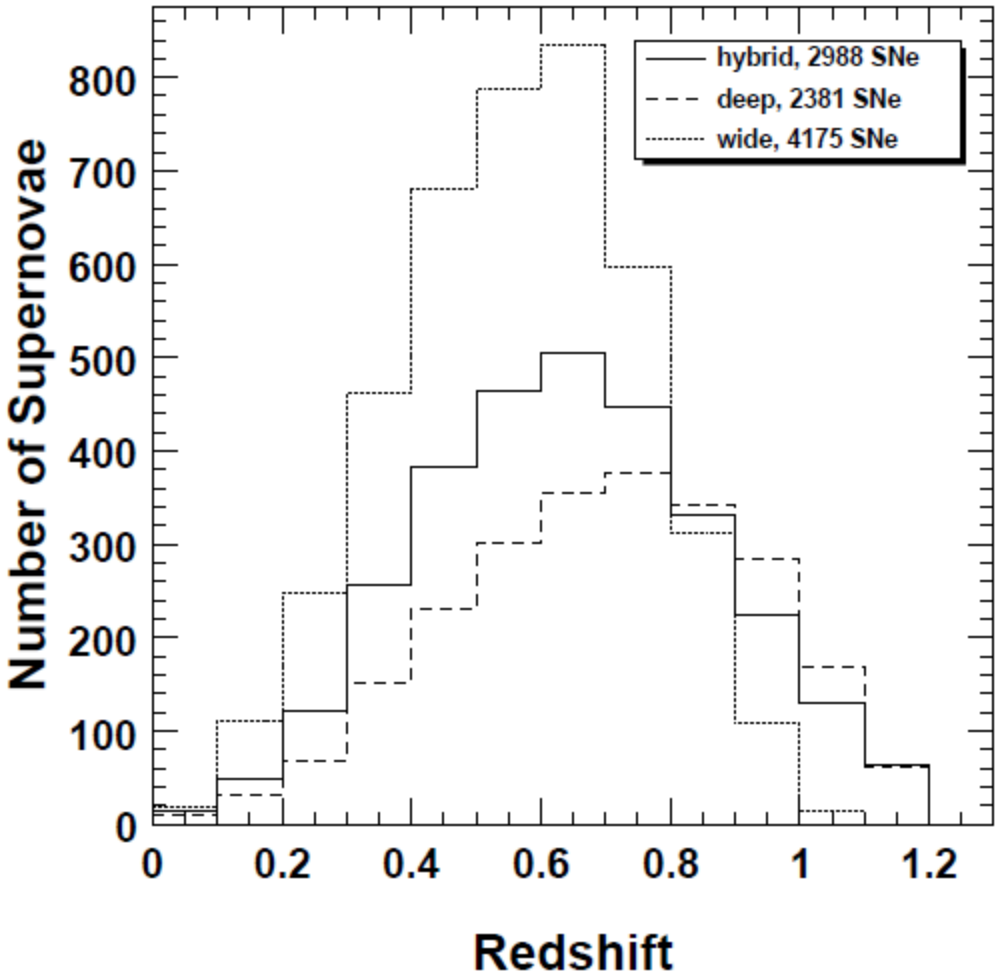
J. P. Bernstein[1], R. Kessler[2,3], S. Kuhlmann[1], R. Reis[4], I. Crane[1,5], D. A. Finley[4], J. A. Frieman[2,3,4], T. Hufford[1], A. G. Kim[6], J. Marriner[4], P. Mukherjee[7], R. C. Nichol[8], P. Nugent[6], D. R. Parkinson[7], M. Sako[9], H. Spinka[1]. . .

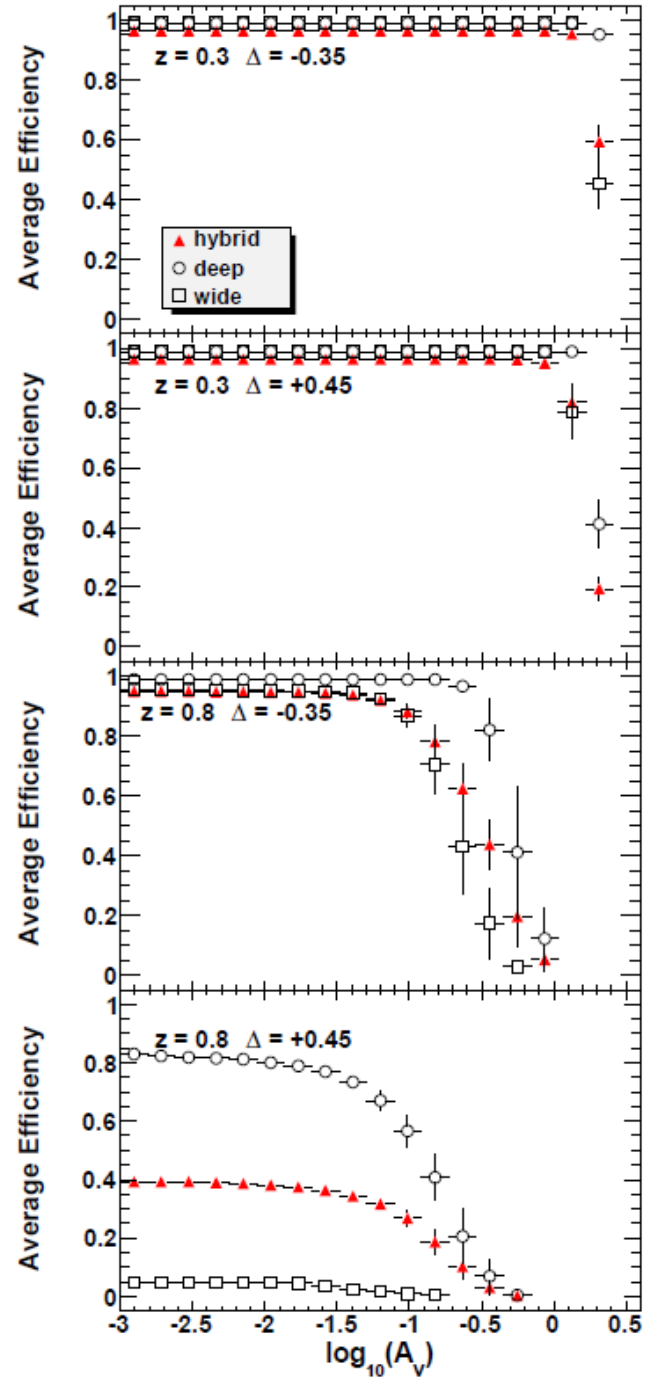
SNANA: SuperNova ANAlysis package for DES

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

Number of SNe and Selection Efficiency





Additional Simulation Results

- DES will rely on photometric SN identification and redshifts (z; initially)
  - photometric z – true z width ~ 4% using host galaxy colors only
  - when SN colors used with host as prior, improves to ~2.5%
- Detailed contamination study indicates level significant but manageable
- 3-year overlap with the VIDEO IR survey
  - allows for combined optical+IR sample of few hundred SNe
  - VERY useful for unraveling systematic effects
  - optical+IR SNANA simulation capabilities in place
- Filter zeropoint shift study: 0.01 leads to 0.03 shift in DE EOS parameter
- Other systematics still under evaluation
  - mostly “community-wide”, e.g., dust, with many working to reduce
  - can improve zeropoint systematic with PreCam

Summary & Conclusions

- DECam on track for delivery to mountain in late 2011
- f/8 platform designed, built, & tested at ANL (ship to FNAL started)
- PreCam on target to start survey operations in August
- ANL DES CCD study uncovered “features” stumped experts – journal paper recently submitted
- ANL leading DES-SN forecast – journal paper near submission

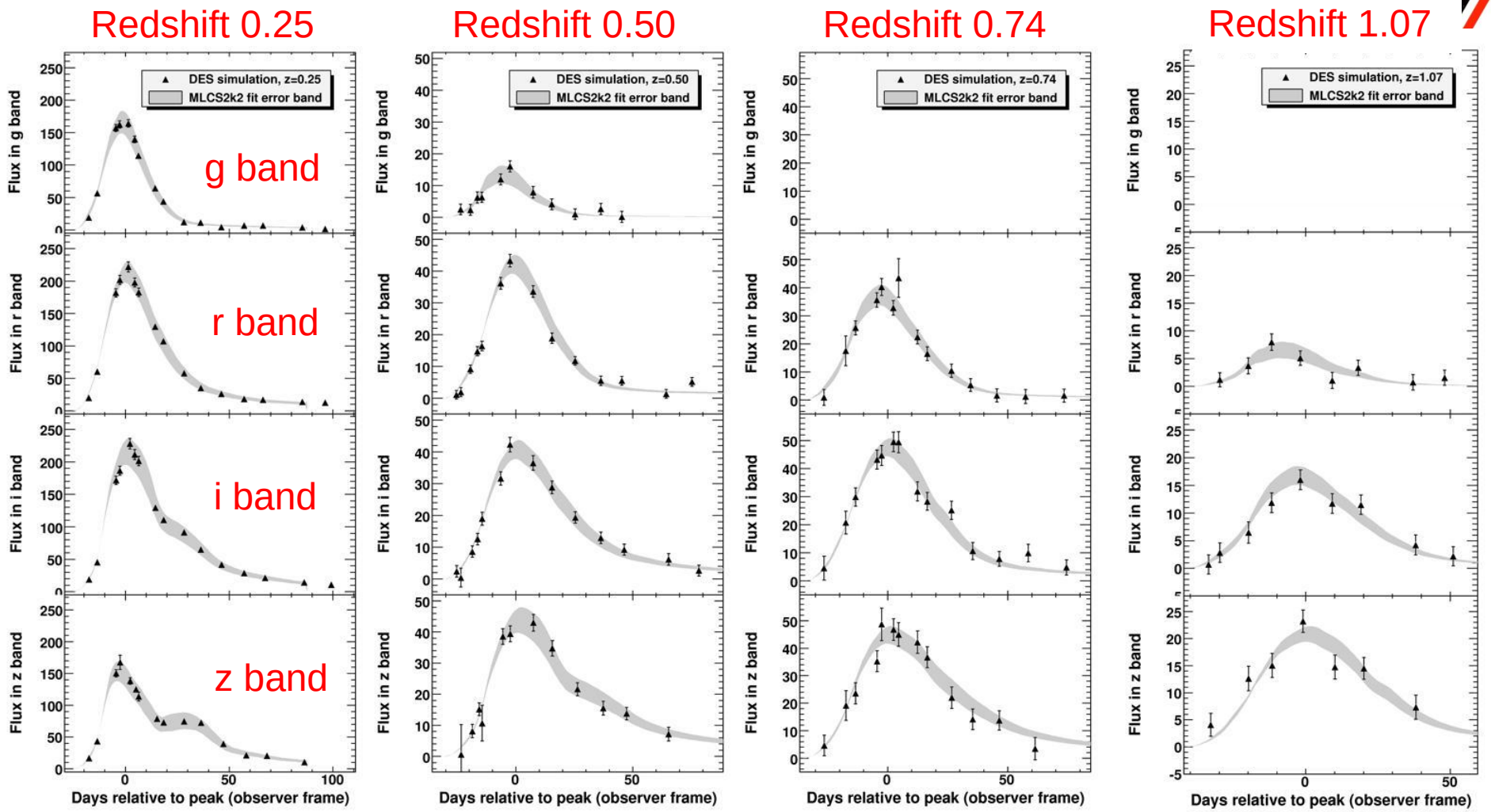
Backup

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

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

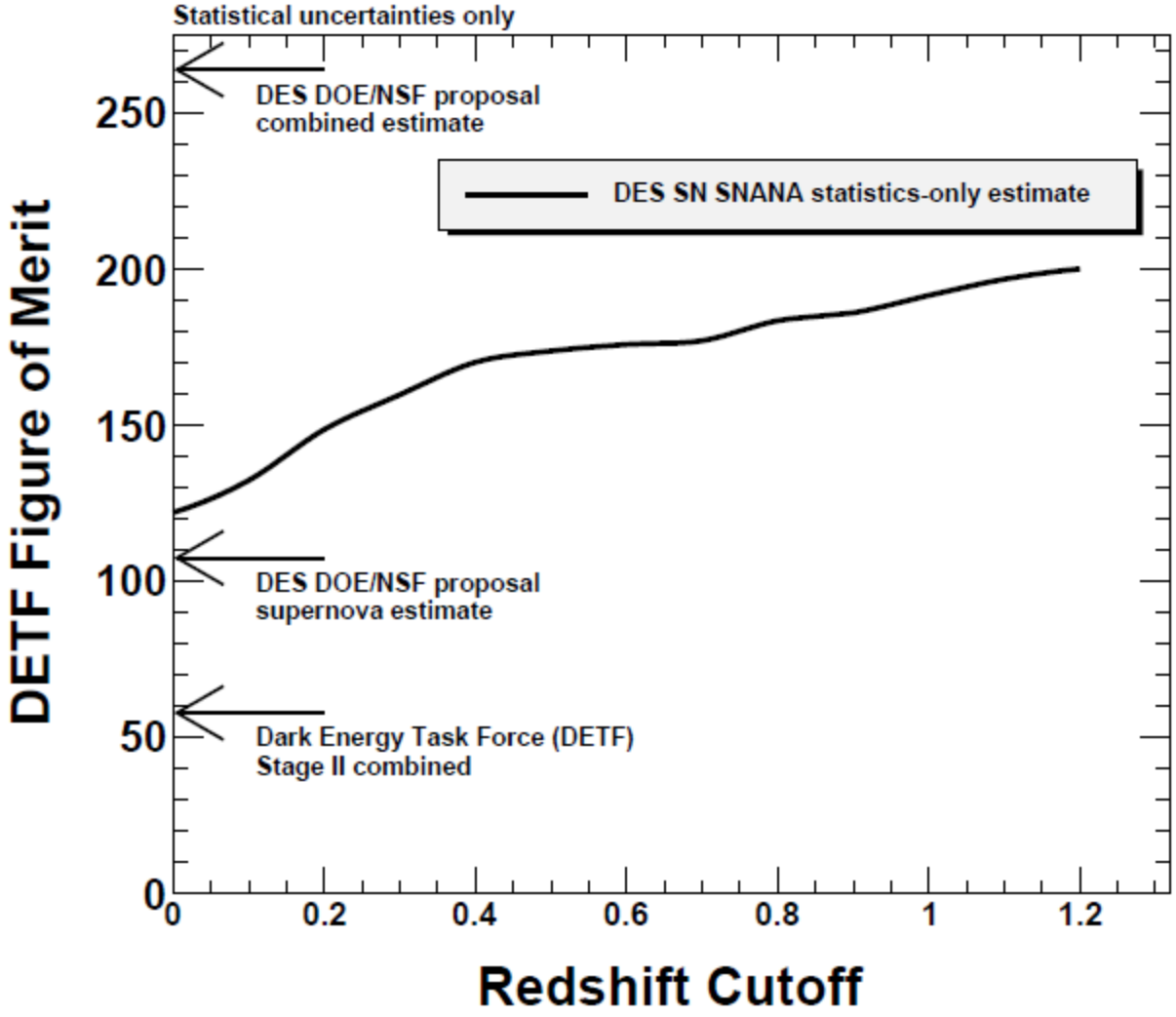
g band: 400 – 550 nm **i band: 700 – 850 nm**

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

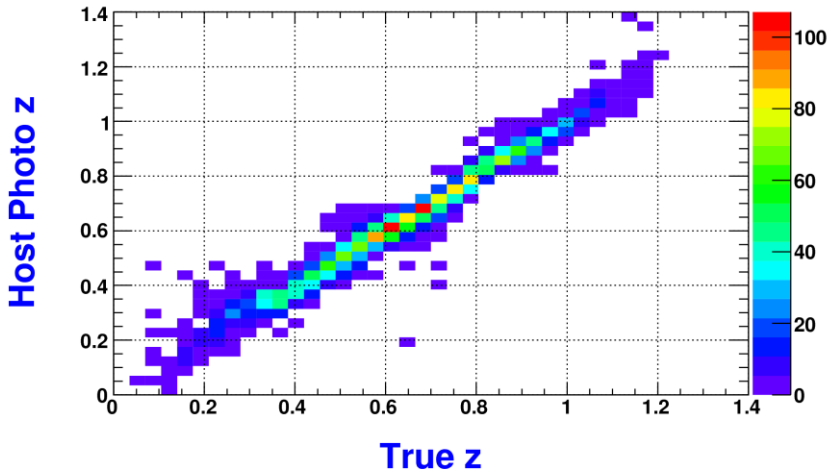
Filter	Range (nm)	Exposure time (s)
g	400–550	300
r	560–710	1200
i	700–850	1800
z	850–1000	4000
Z_1	850–970	n/a
Z_2	850–920	n/a
Y	970–1020	n/a

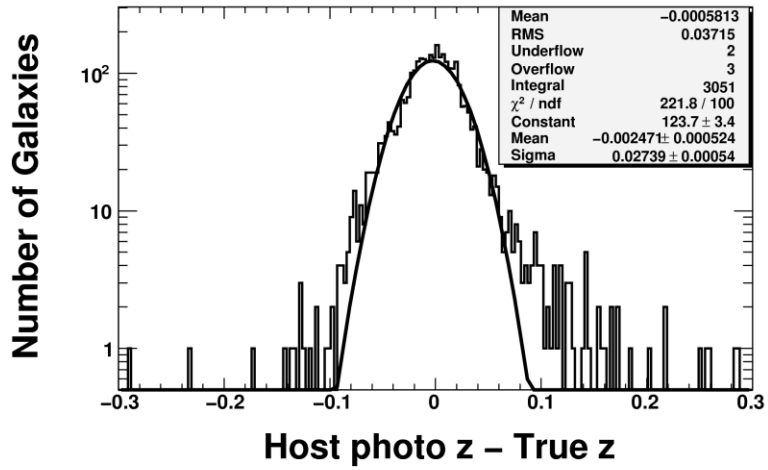
Deep; Wide = Deep/3

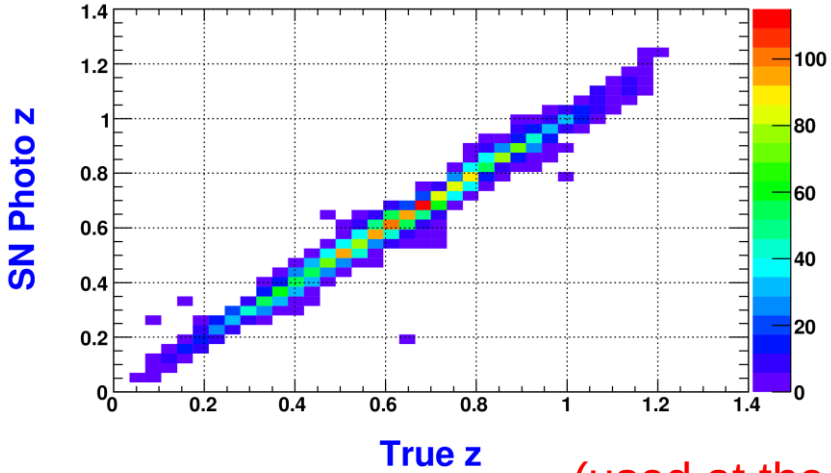
Effect of Spectroscopic Redshift Cutoff on Figure of Merit

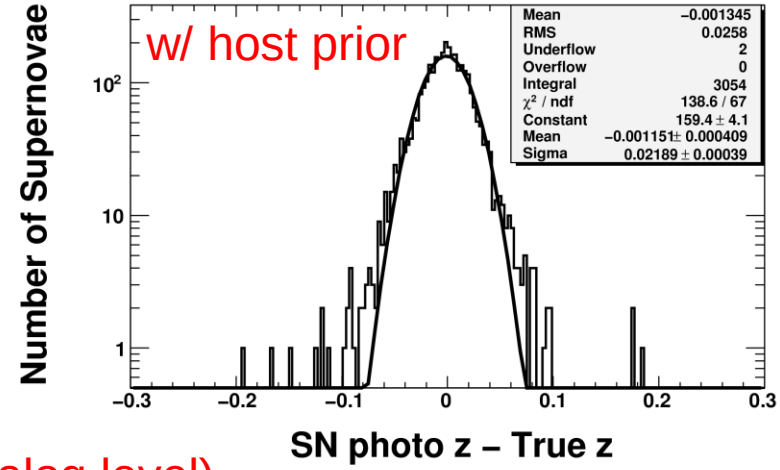


Photometric Redshifts







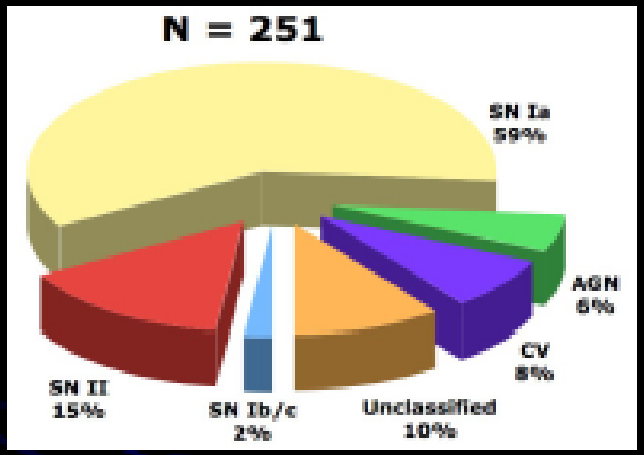


(used at the catalog level)

Forecasted Contamination

DARK ENERGY SURVEY

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**

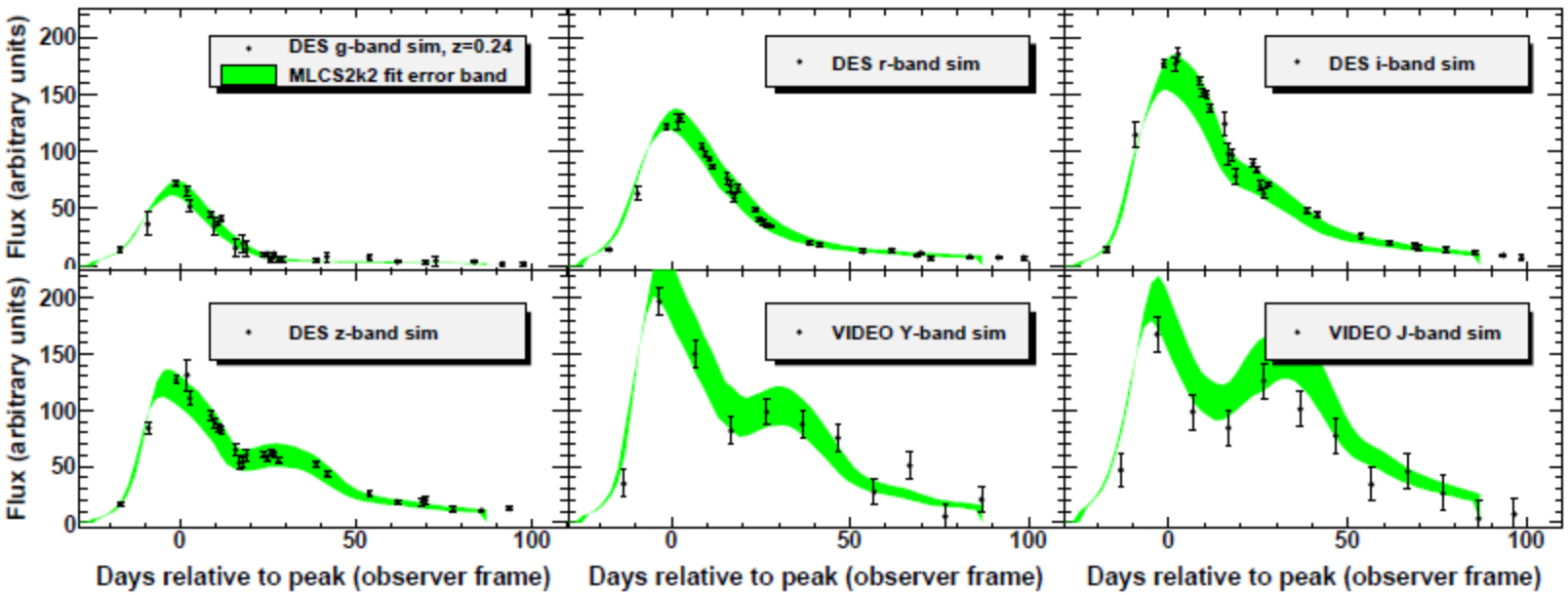
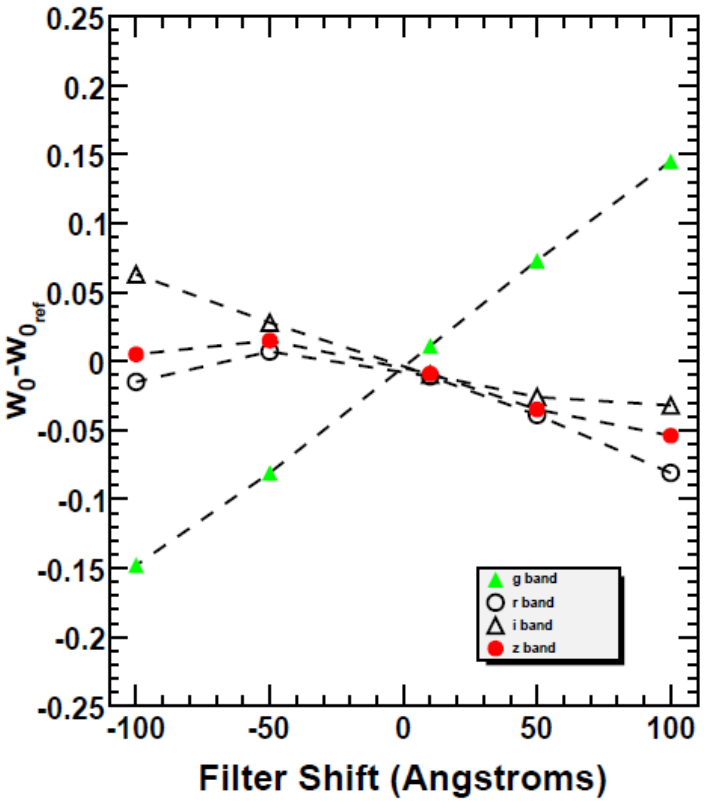
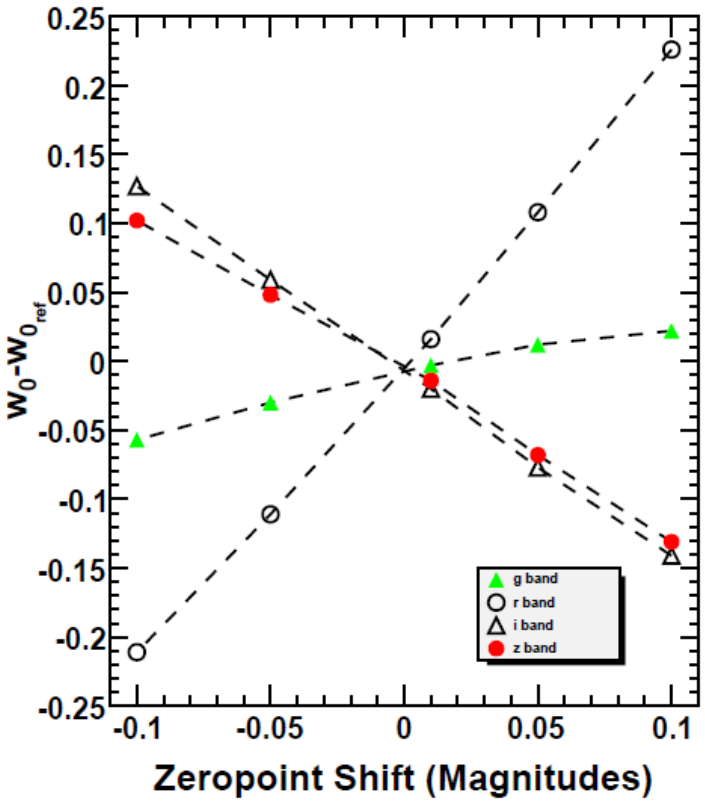
Sample	f_p >0.0	f_p >0.1	f_p >0.5
Ia	2876	2777	2104
Ib/c	821 (20%)	302	60
IIn	2465	20	0
IIP	698	21	0
IIL	175	21	2
Contamination		11.5%	2.9%

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.

Example DES+ VIDEO SN Ia Light Curves



Systematic Studies