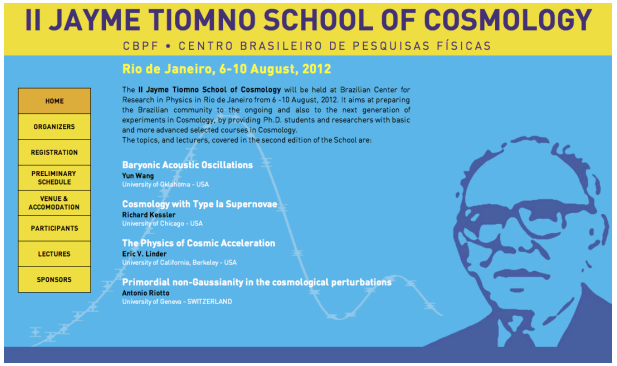

Lectures on Cosmology with Type Ia Supernovae: **Future Results and Surveys**

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II Jayme Tiomno School of Cosmology

Rio de Janeiro, Brazil

Aug 6-10, 2012

Overview

- Prelude : Photometric Identification

- Pan STARRS-1
- HST MCT (Candels)

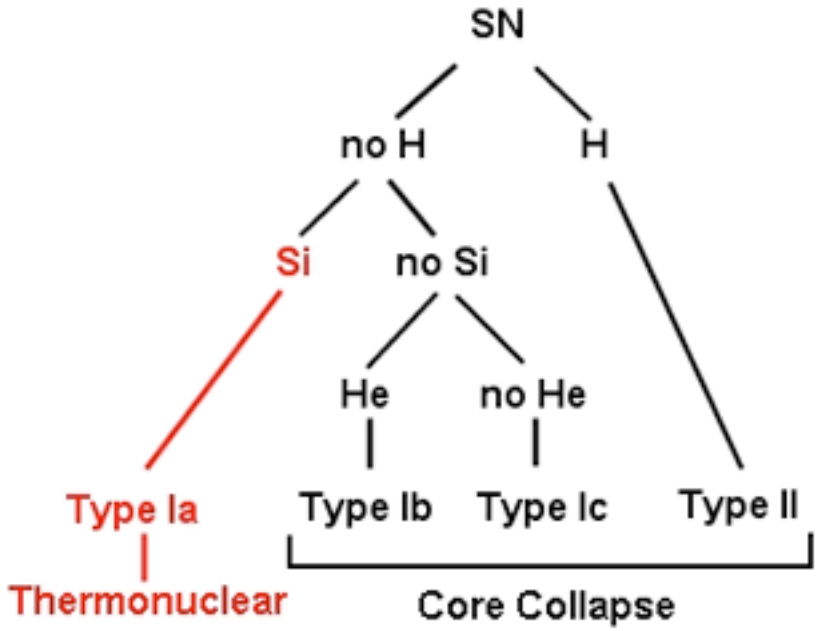
Ongoing analysis

- Dark Energy Survey (DES)
- Javalmabre Physics of Accelerating Universe Astrophysical Survey (JPAS)
- Large Synoptic Survey Telescope (LSST)

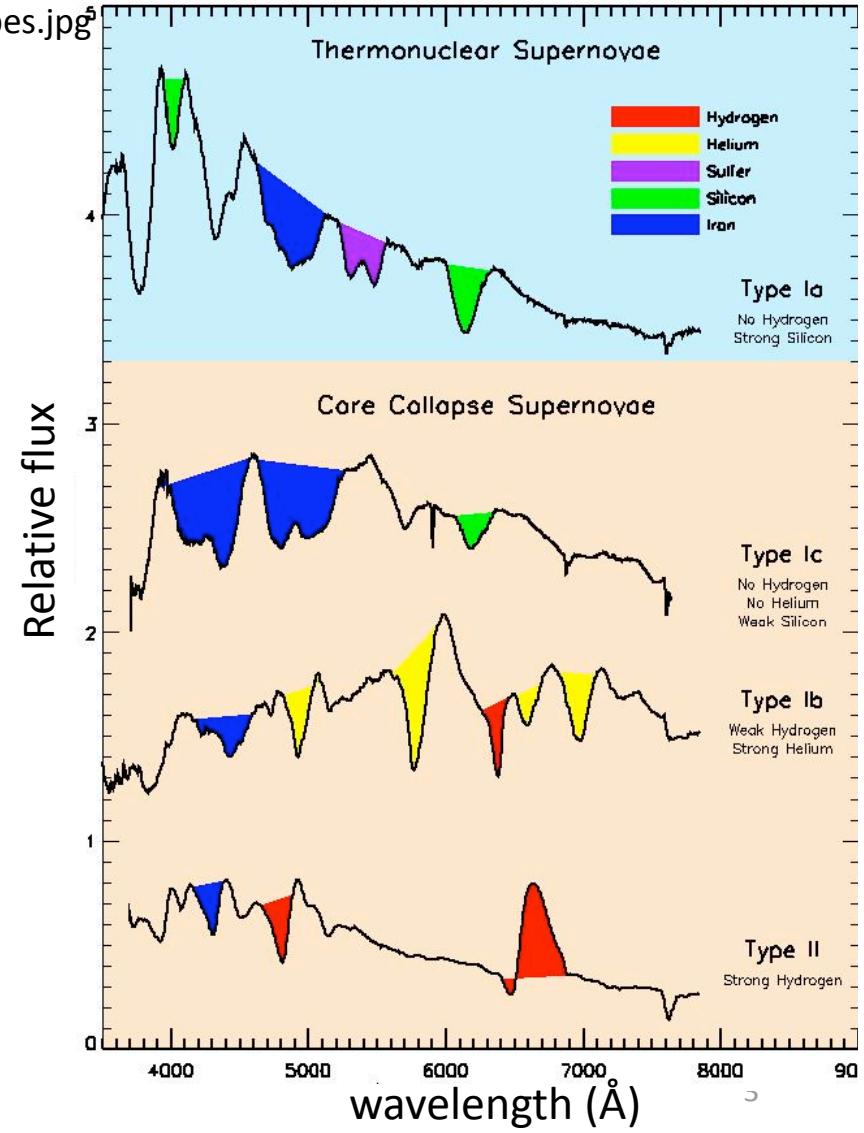
Future

Prelude: Photometric Identification

- Previous SNIa results are based on spectroscopically confirmed samples of a few hundred.



http://supernova.lbl.gov/~dnkasen/tutorial/graphics/sn_types.jpg

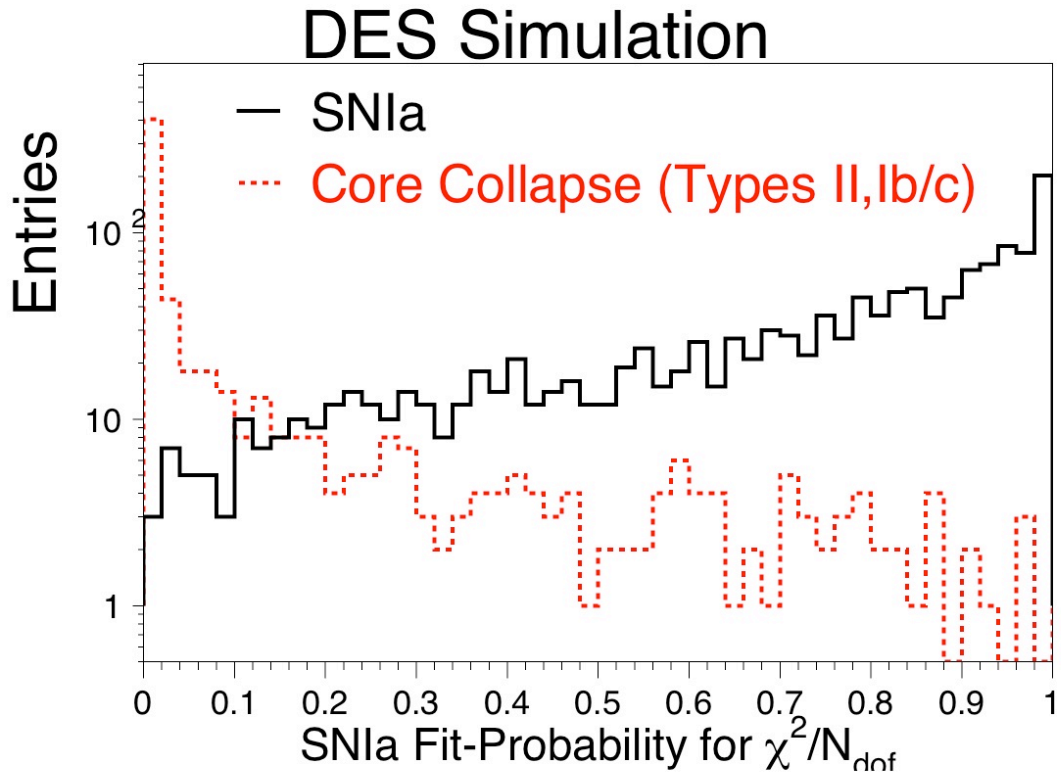


Prelude: Photometric Identification

- Previous SNIa results are based on spectroscopically confirmed samples of a few hundred.
- Future surveys with large field-of-view will collect thousands of SNIa, far beyond spectroscopic resources.
- Will need photometric identification to remove “Core Collapse” contamination.
- Hopefully can get host-galaxy redshifts using multi-fiber spectrographs; if not, will need SN+host “photo-z” as well.

Prelude: Photometric Identification

Simplest method: fit to SN Ia model and cut on fit-probability
(if it looks like a duck, and it quacks like a duck … then it's a duck)



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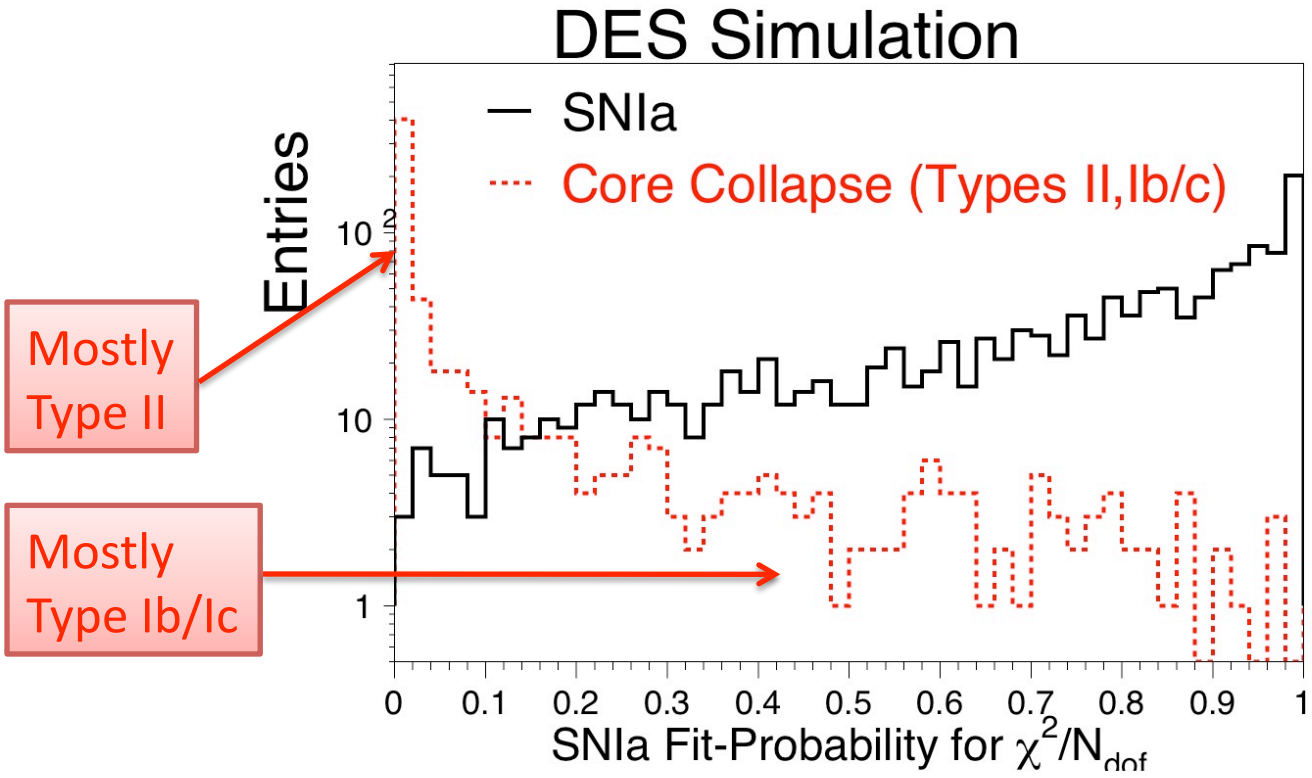
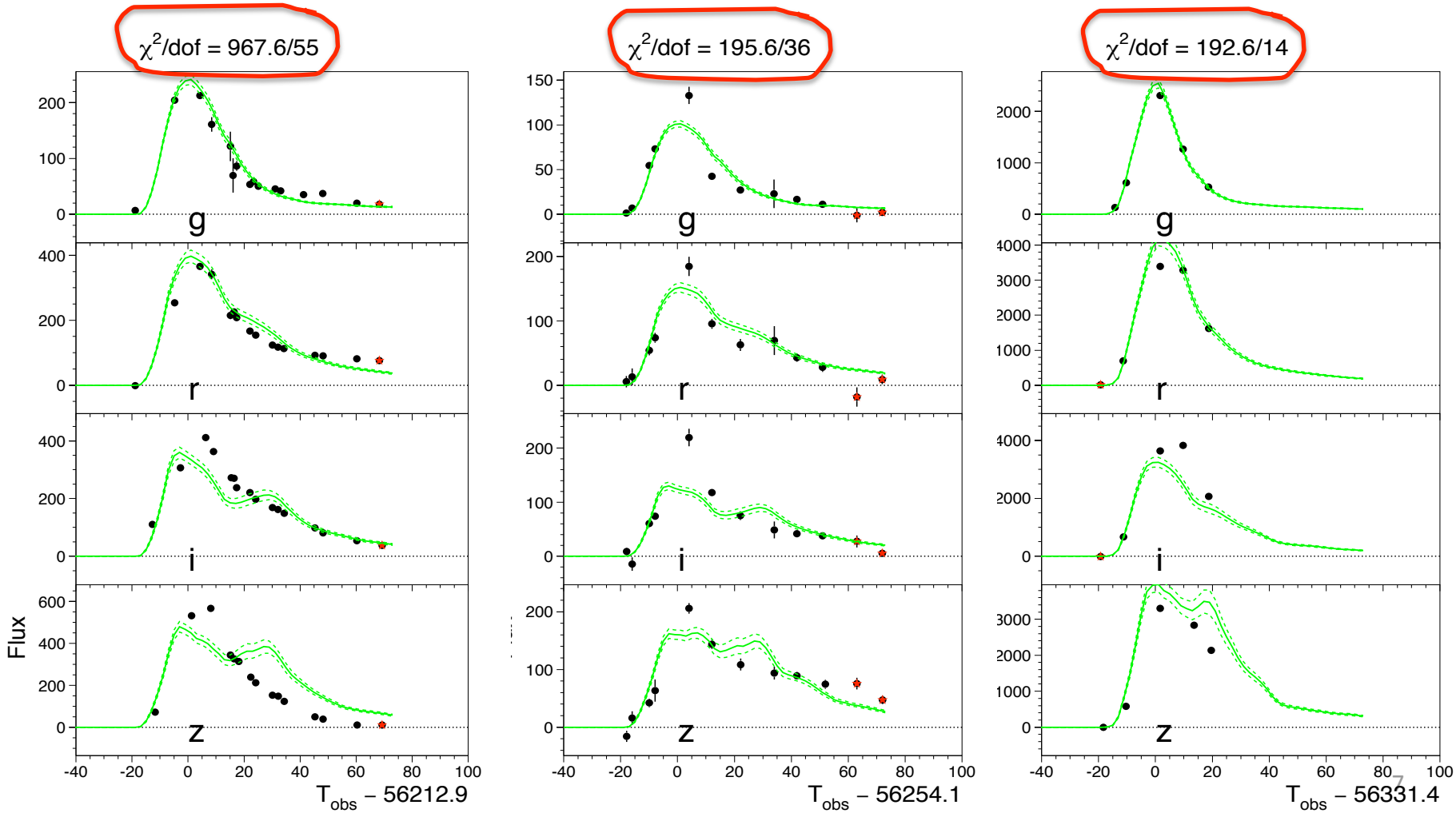


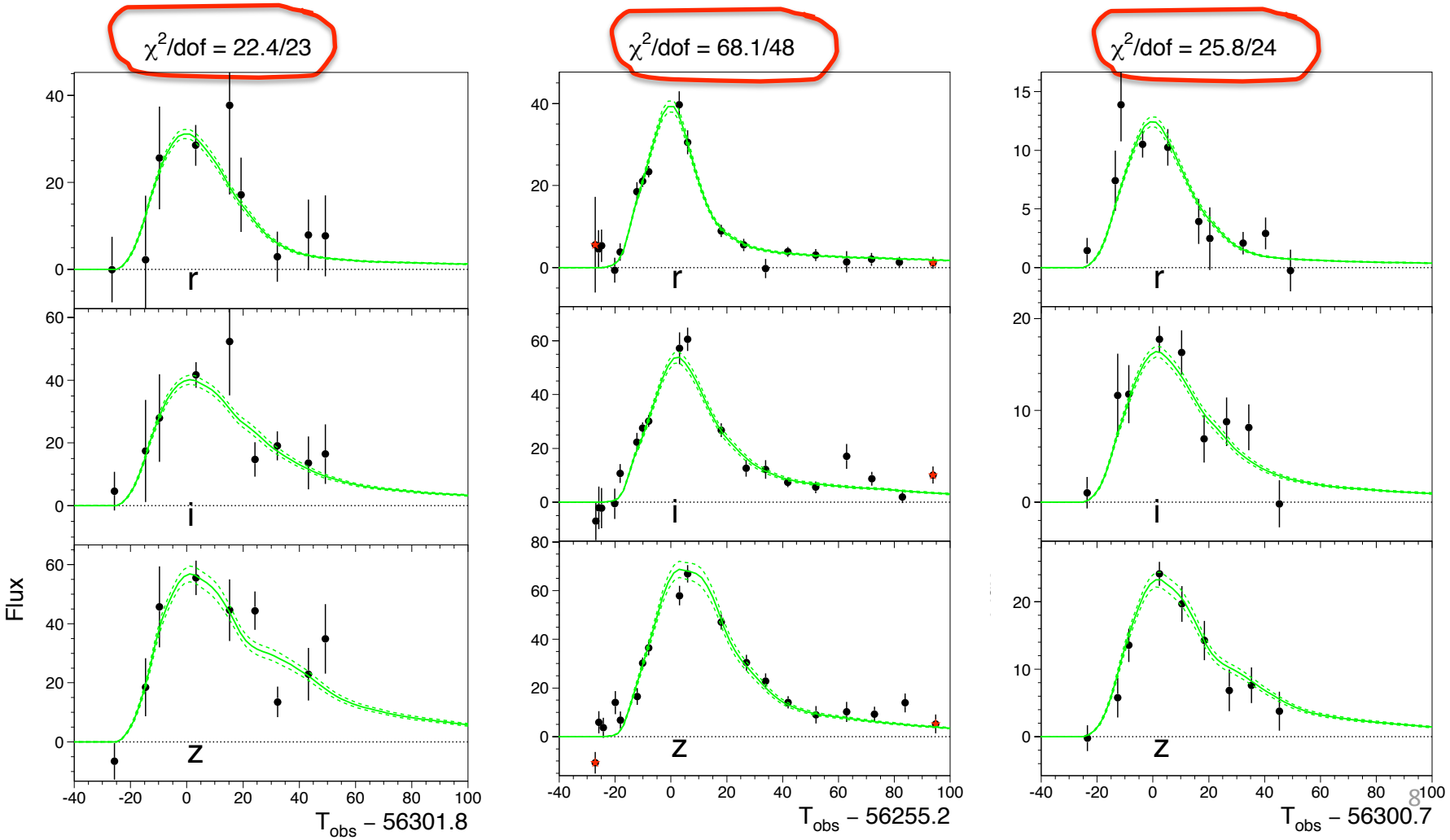
Prelude: Photometric Identification

- Simulated Type Ib/c SN for DES, **z = 0.05**
  - **Light curve fit to SN Ia model --> poor χ^2 at low redshift**



Prelude: Photometric Identification

- Simulated Type Ib/c SN for DES, **z = 0.50**
  - **Light curve fit to SN Ia model --> good χ^2 for small fraction**



Prelude: Photometric Identification

Other methods

- Compare to Ia and non-Ia templates:
  compute Bayesian evidence

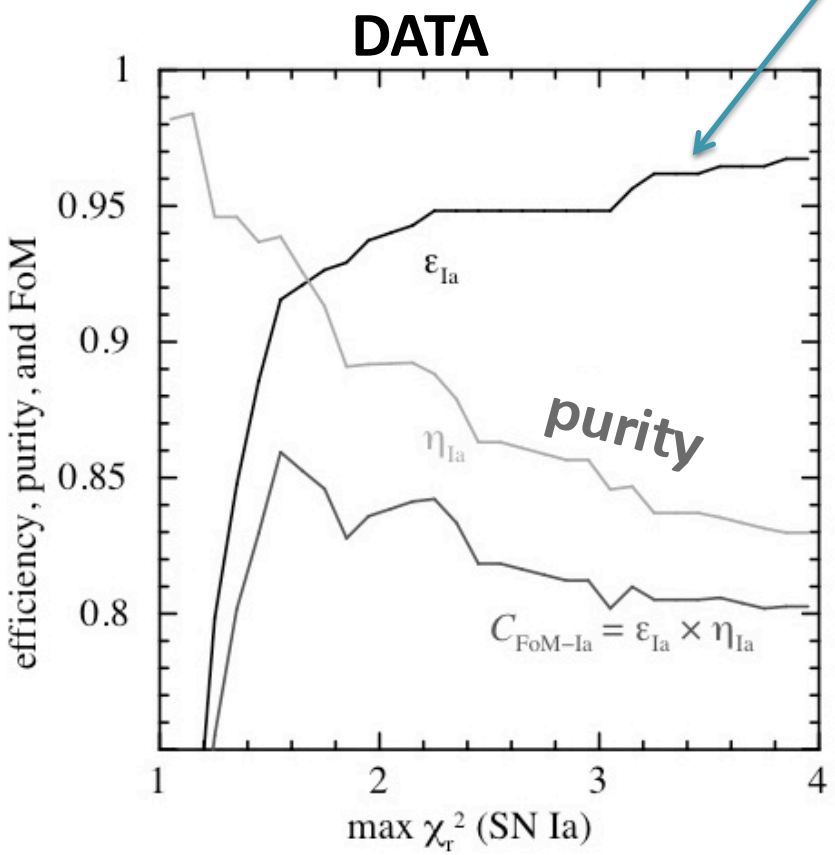
- Use spec-confirmed subset to define Hubble diagram;
  cut on SN-Hubble χ^2 for each unconfirmed SN.

- Spline fitting, dimensionality reduction, and
  semi-supervised learning.

Prelude: Photometric Identification

Template matching on SDSS data: Sako et al., ApJ 738, 162 (2011)

$$\frac{\text{eff (photometric ID cuts)}}{\text{eff (SNR cuts)}}$$

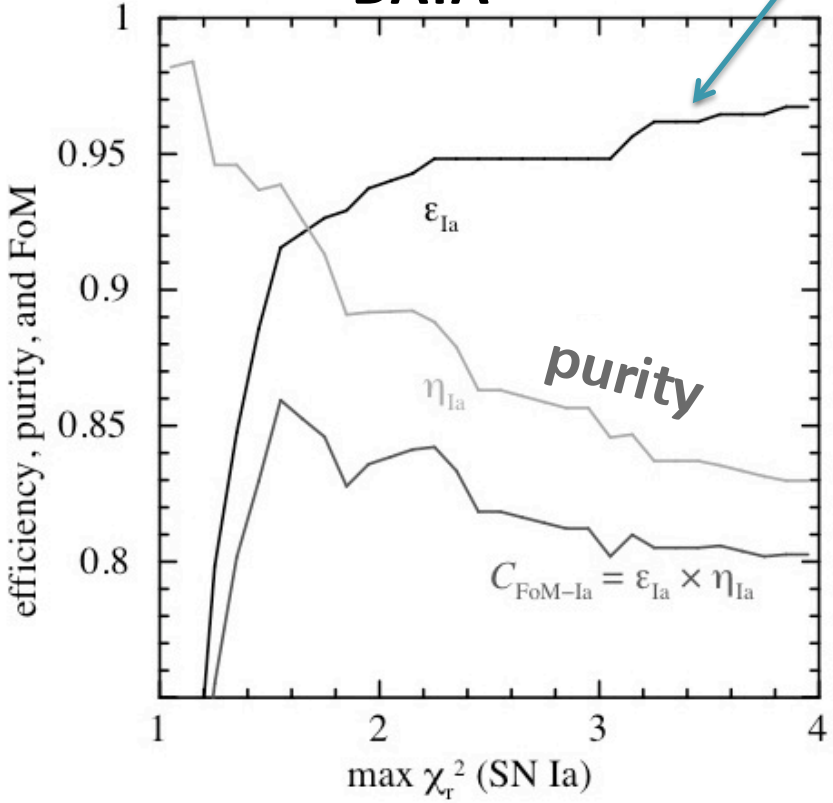


Prelude: Photometric Identification

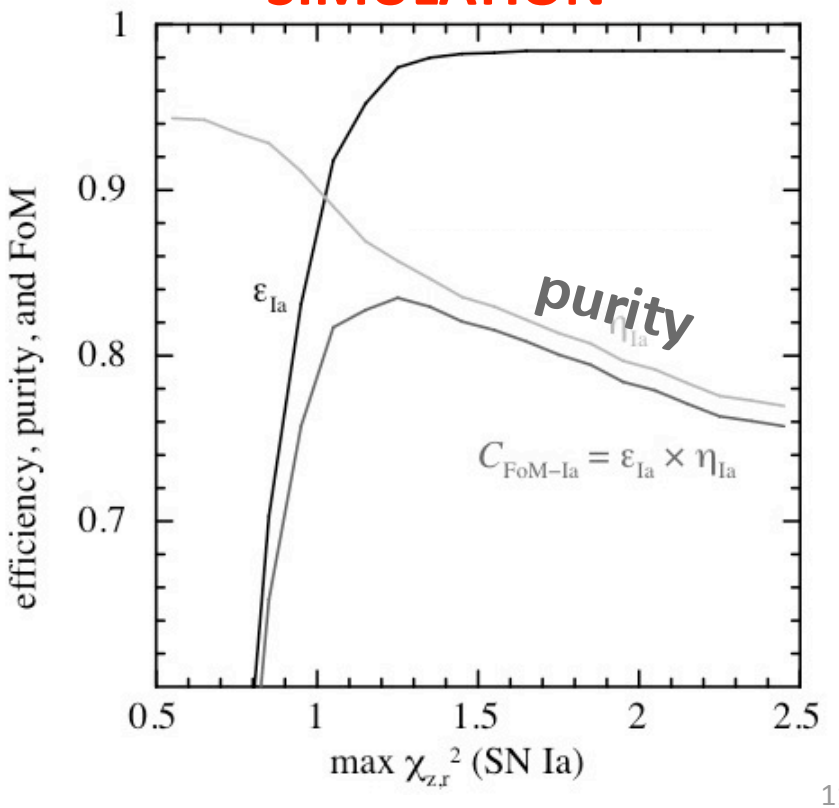
Template matching on SDSS data

$$\frac{\text{eff (photometric ID cuts)}}{\text{eff (SNR cuts)}}$$

DATA

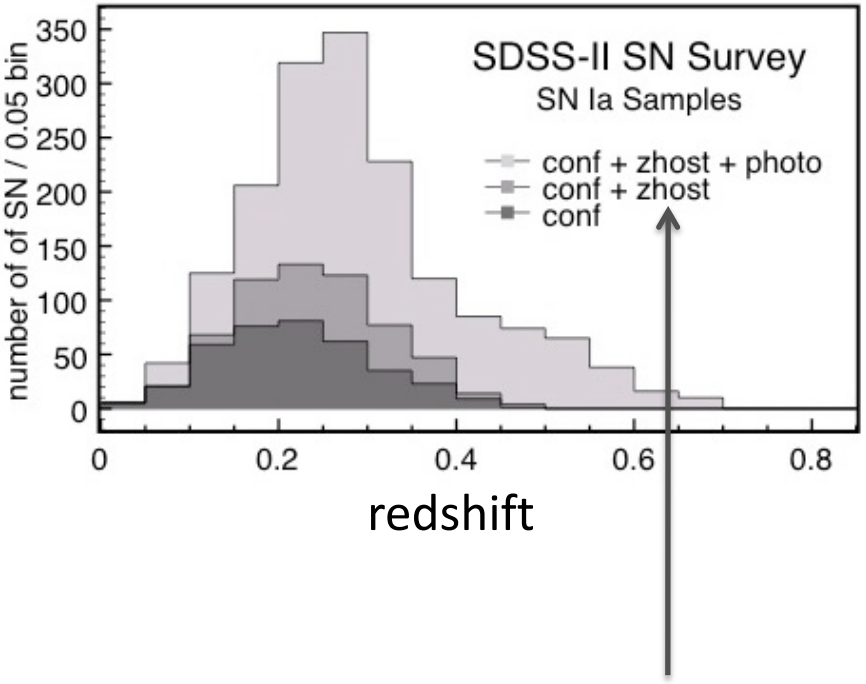


SIMULATION



Prelude: Photometric Identification

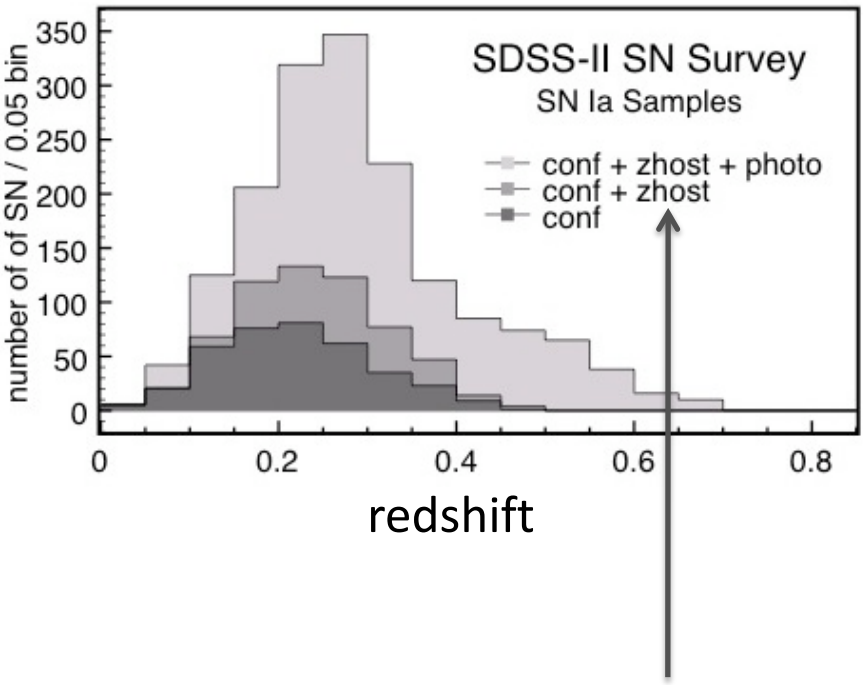
Template matching on SDSS data



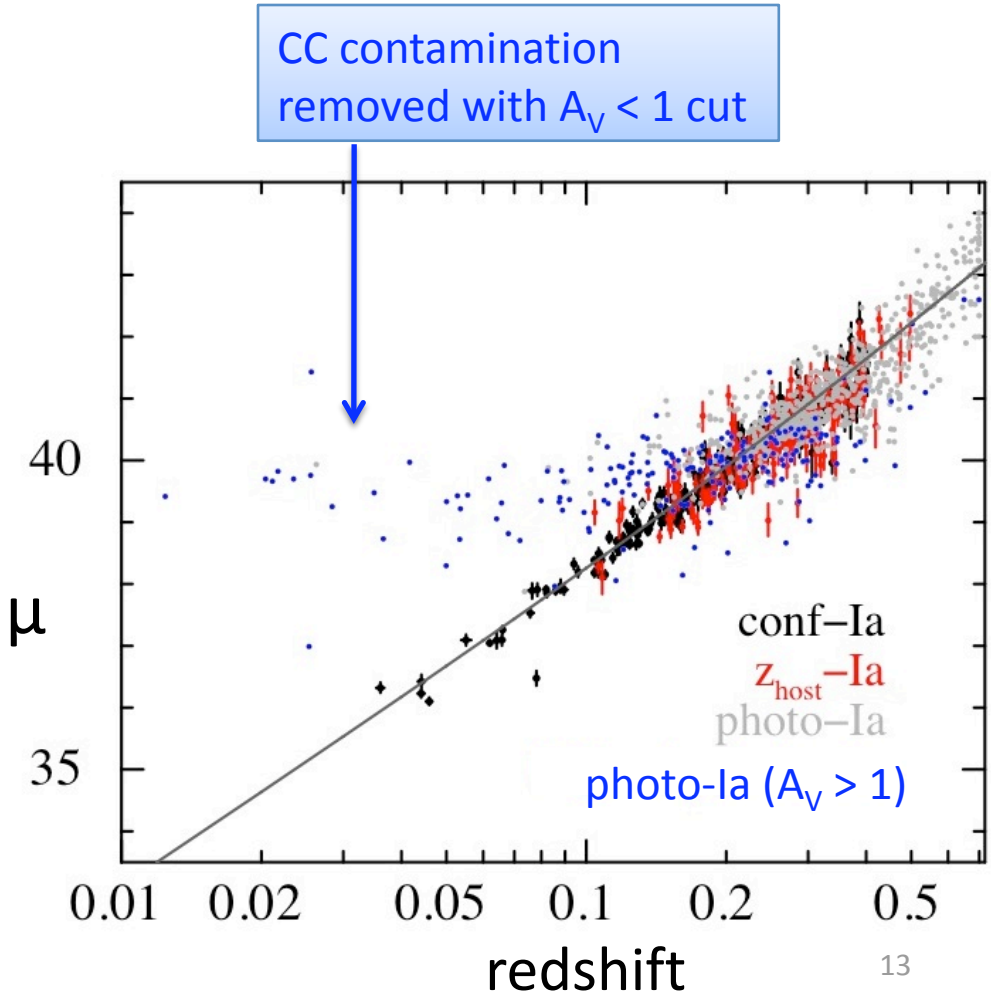
‘zhost’ -> host galaxy redshift

Prelude: Photometric Identification

Template matching on SDSS data



'zhost' -> host galaxy redshift



Prelude: Photometric Identification

SNIa Fit-Probability method on DES Simulations:
Bernstein et al., ApJ 753, 152 (2012)

Sample	f_p >0.0	f_p >0.1
Ib/c	571	57
IIP	110	2
IIn	225	2
IIL	62	2
Total SNcc	968	63
Ia	3482	3350
Ia+SNcc	4450	3413
Sample Ia Purity	78%	98.1%

Table 12:: Number of simulated SNe passing cuts and sample purity using the DES 10-field hybrid strategy.

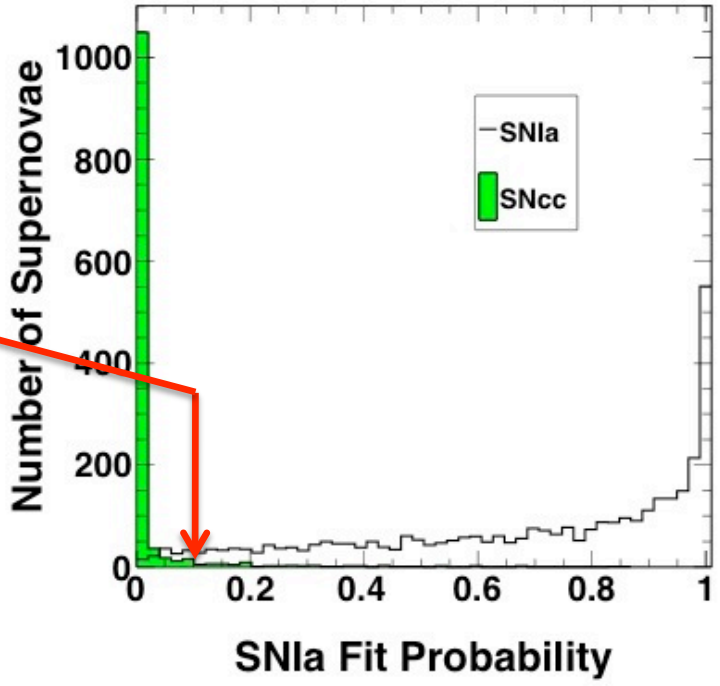
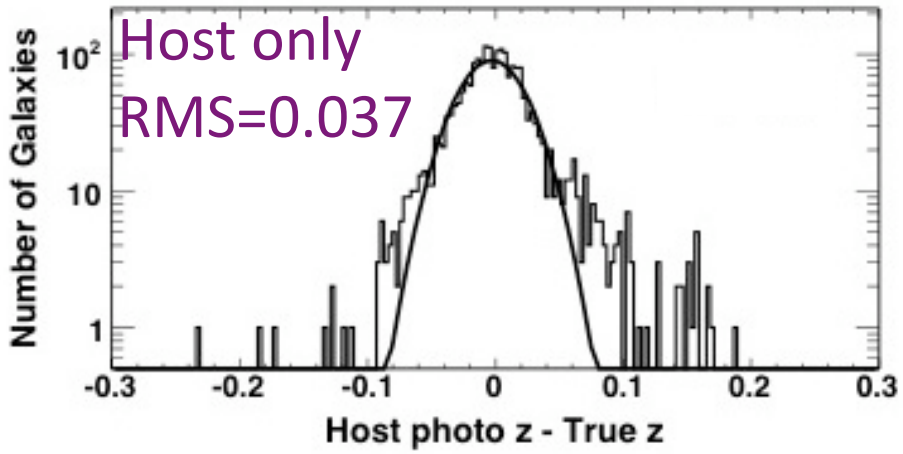
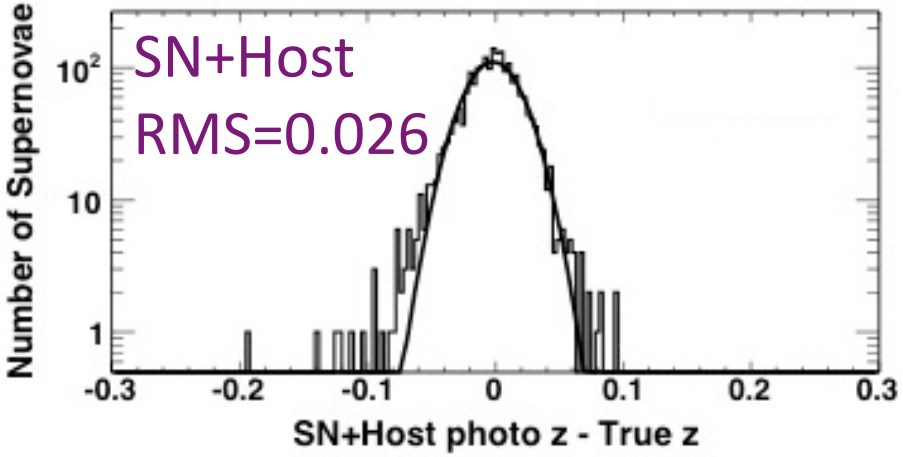


Fig. 18.—: Plotted are the SNIa fit probabilities for the SNIa and SNcc samples, after all other selection cuts are applied.

Prelude: Photometric *Redshifts*

DES Simulations (Bernstein et al., 2012)

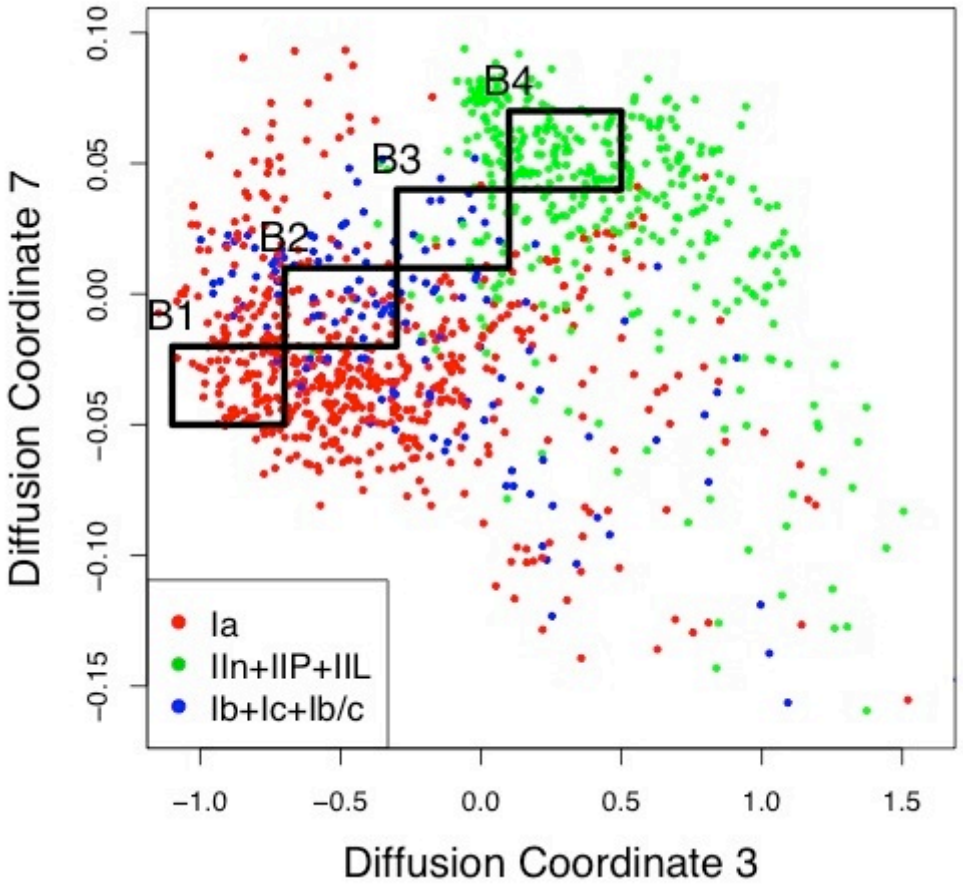




SN photo-z method:
float redshift as
5th parameter in
light curve fit
(Kessler et al., ApJ 717, 40, 2010)

Prelude: Photometric Identification

Semi-supervised Learning on DES simulations:
Richards et al., MNRAS 419,1121 (2012)



Most abstract method.

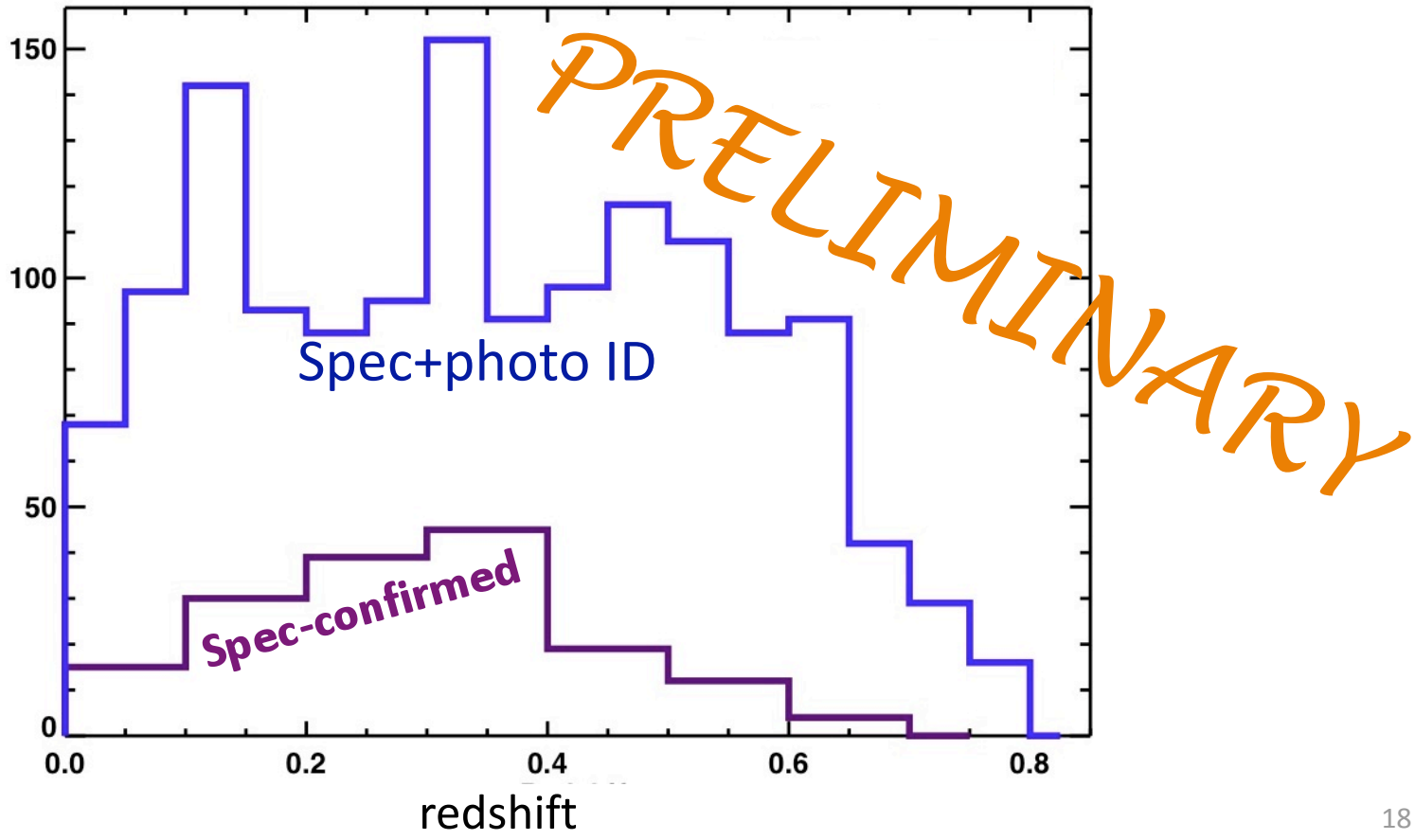
Major benefit:
always improves
with more data

Drawback:
diffusion coordinates
have no physical
meaning.

Major Goal: discover and characterize Earth-approaching objects, both asteroids & comets, that might pose a danger to our planet.

SN Program:

Ten 7 square-degree fields scanned repeatedly in griz

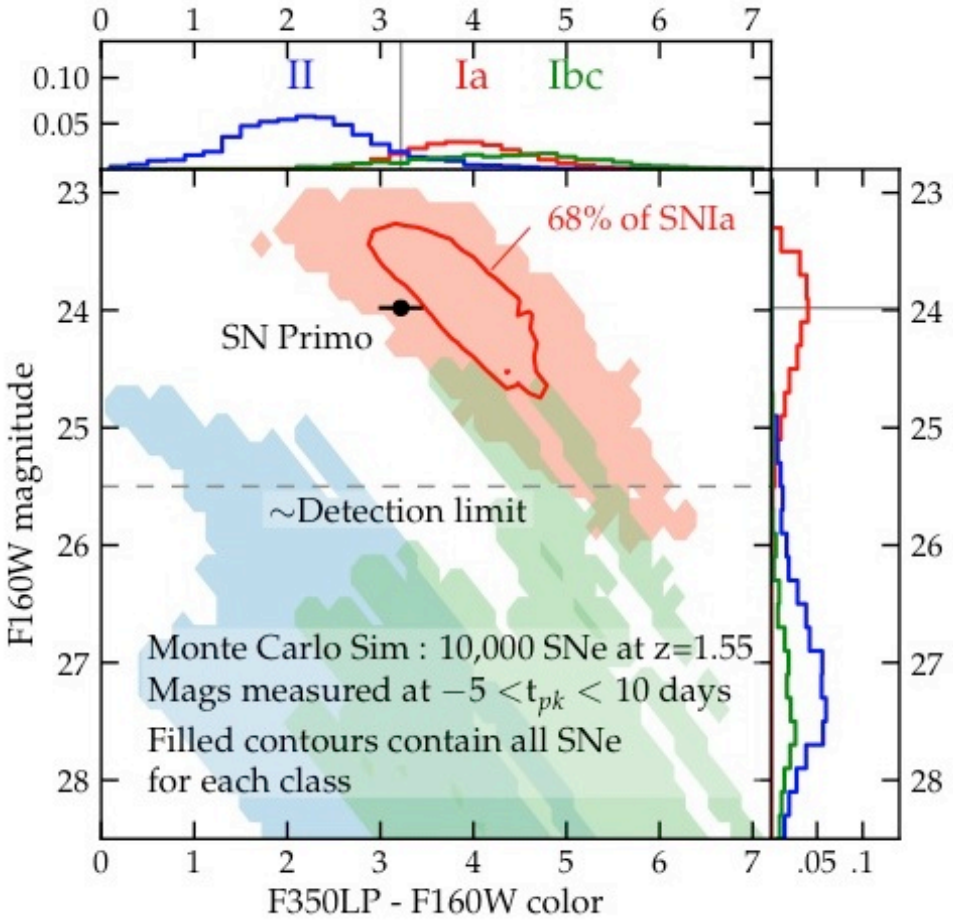


Part of largest HST project in history (900 orbits)

SN Ia Program:
Collect SN at z > 1.5 where Dark Energy (DE) is expected to contributed < 15% of the total energy density, compared with 70% today.

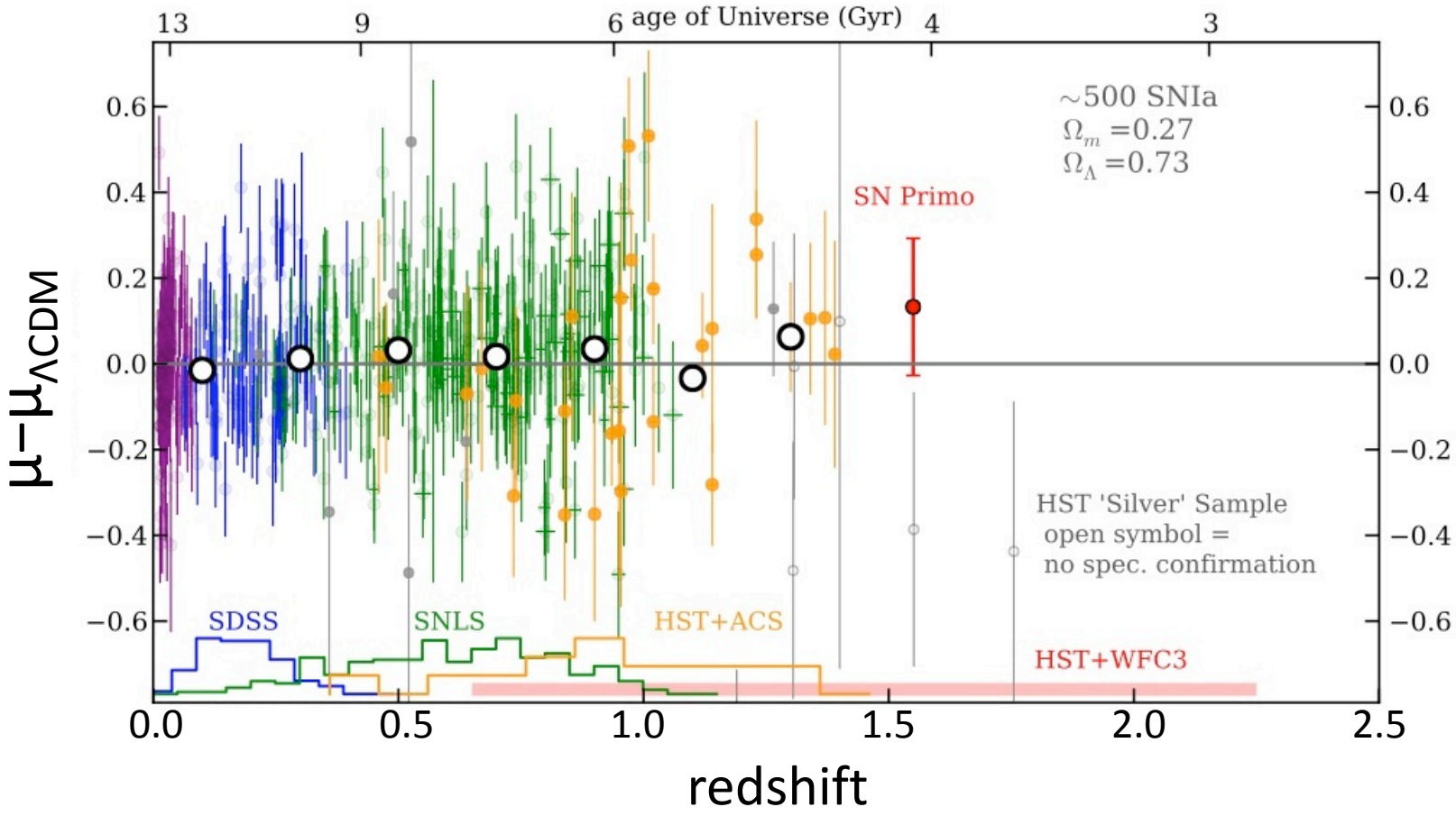
Test if DE contribution matches expectations.

First SN Ia named "Primo" : Rodney et al., ApJ 746, 5 (2012)

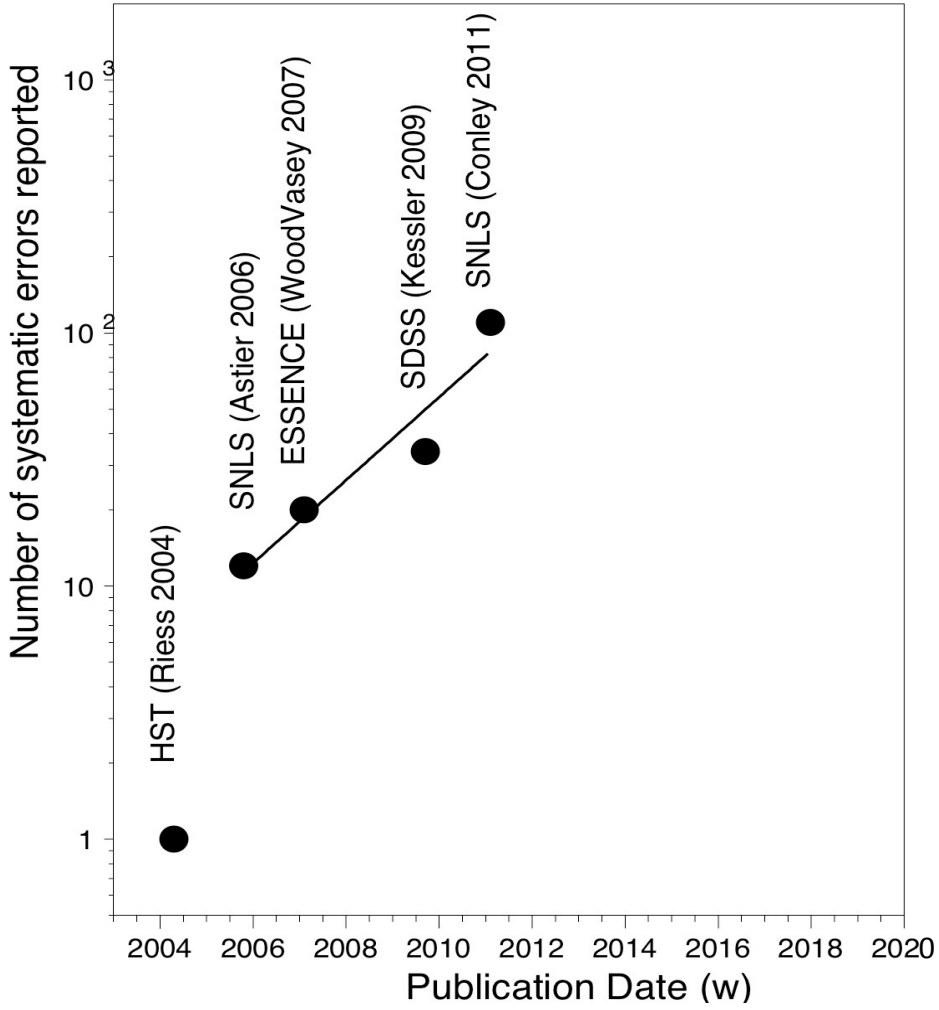


Photometric identification based in part on Monte Carlo simulations of SNIa and core collapse SNe.


CANDELS
Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey


13
9
6
age of Universe (Gyr)
4
3
~500 SNIa
Ω_m =0.27
Ω_Λ =0.73
SN Primo
HST 'Silver' Sample
open symbol =
no spec. confirmation
SDSS
SNLS
HST+ACS
HST+WFC3
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
0.0
0.5
1.0
1.5
2.0
2.5
redshift
μ−μΛCDM

Systematic Uncertainties: more in-depth with each publication



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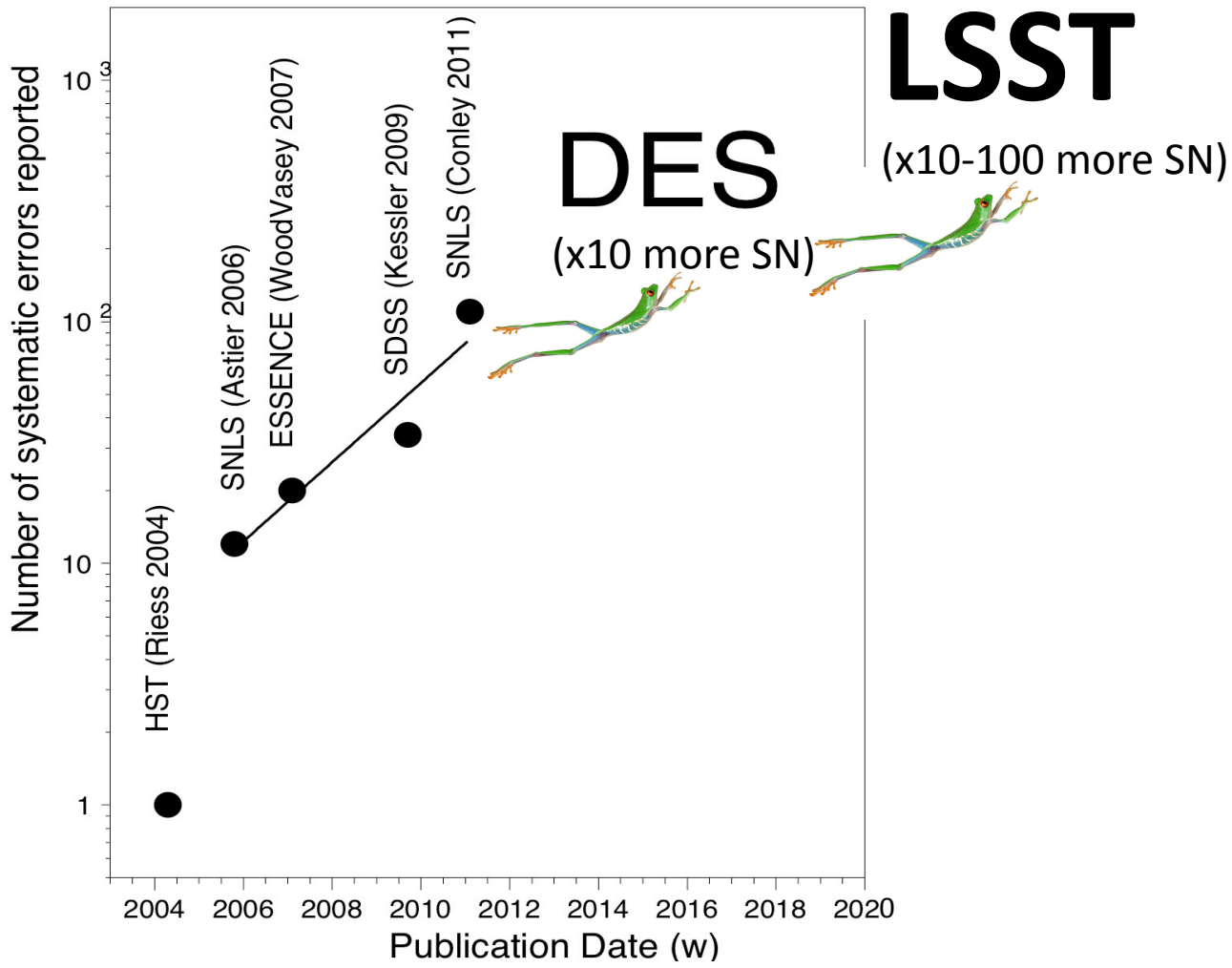


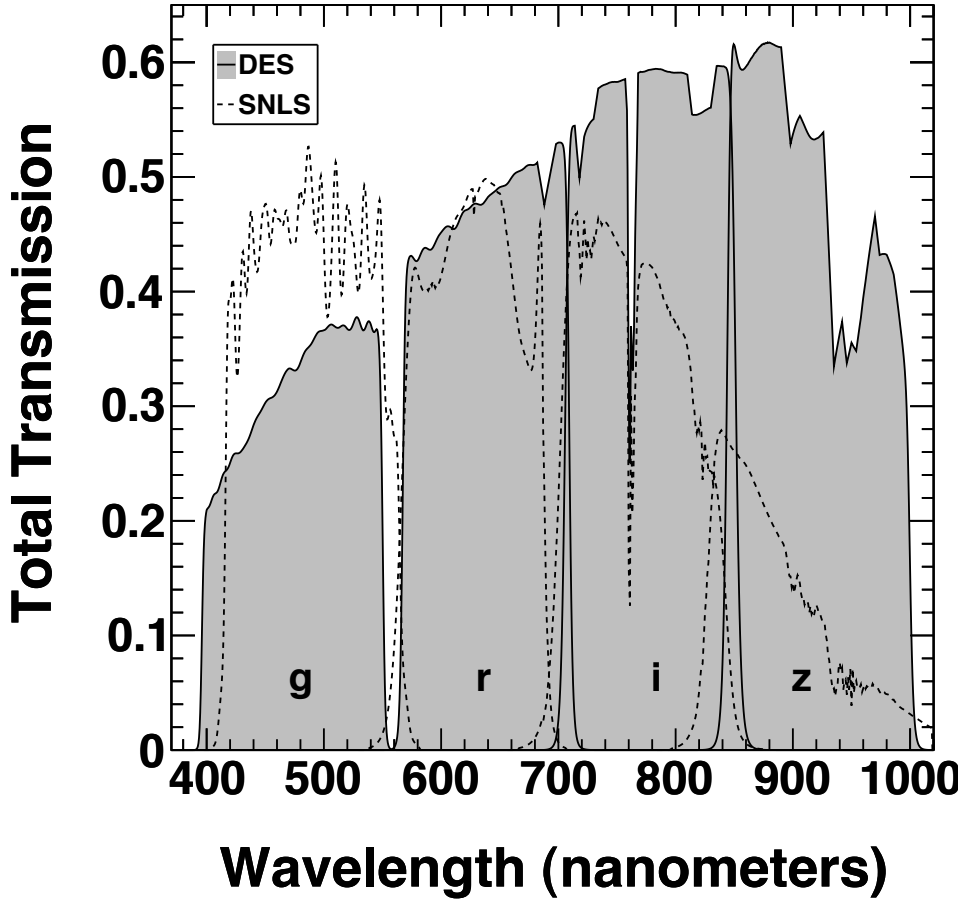
DES

THE DARK ENERGY SURVEY

(begins Fall 2012)

New red-sensitive camera (DECAM) on CTIO 4m

525 night survey: SN fields get 10% + non-photometric time



DES

THE DARK ENERGY SURVEY

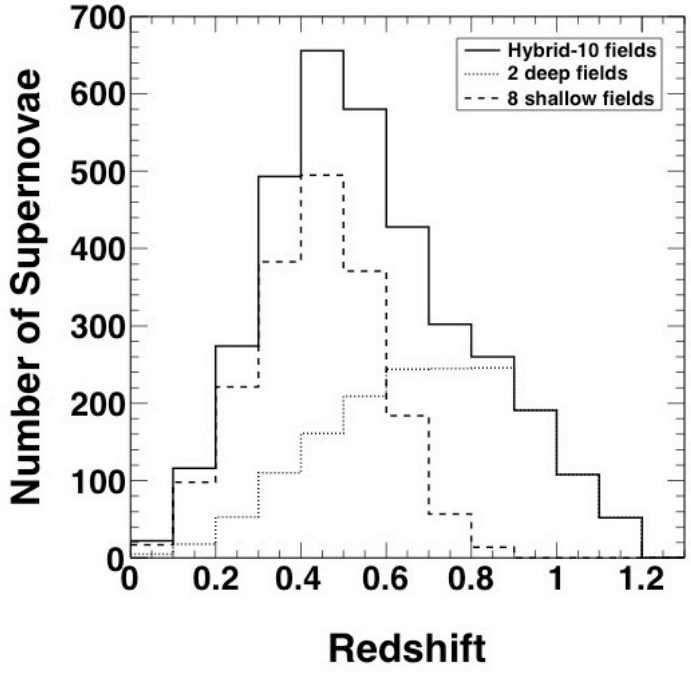
New red-sensitive camera (DECAM) on CTIO 4m

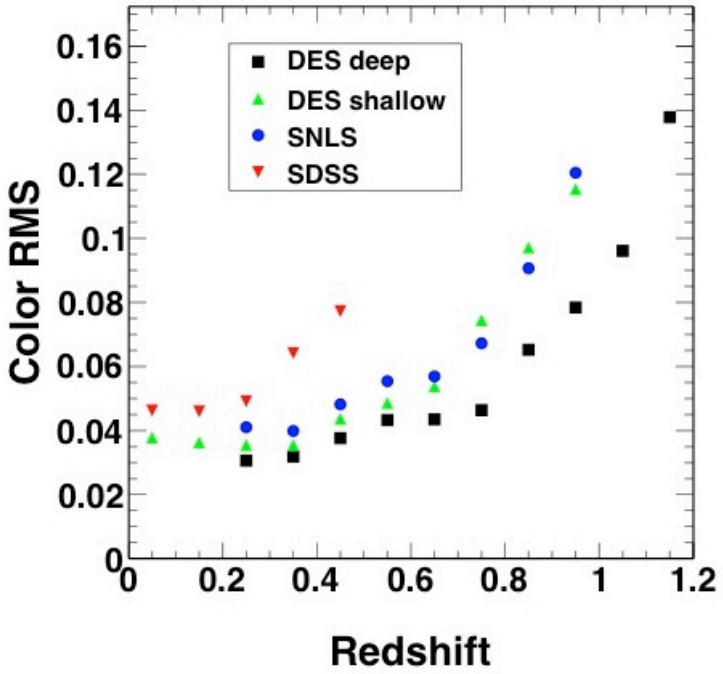
SN program:

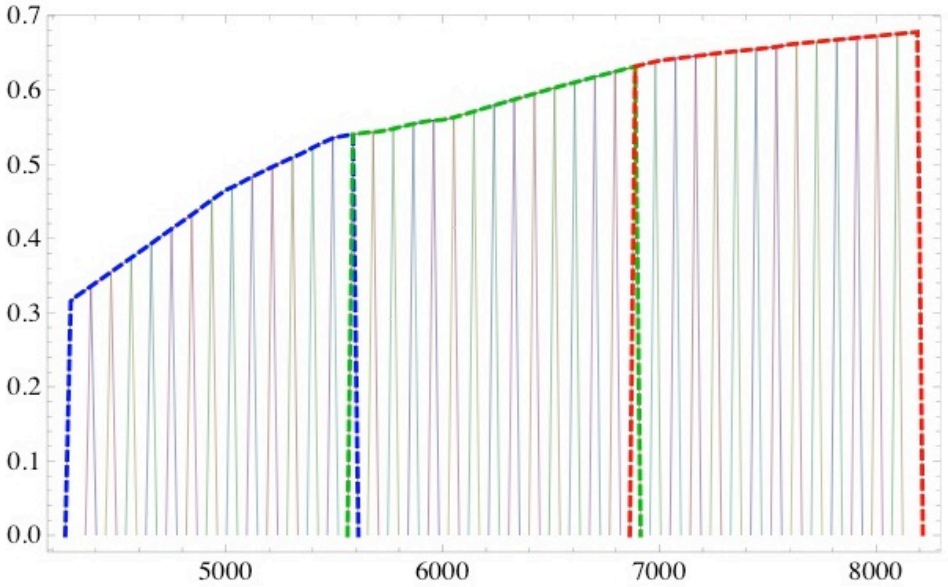
2 deep fields (6 sq-deg)

8 shallow fields (24 sq-deg)

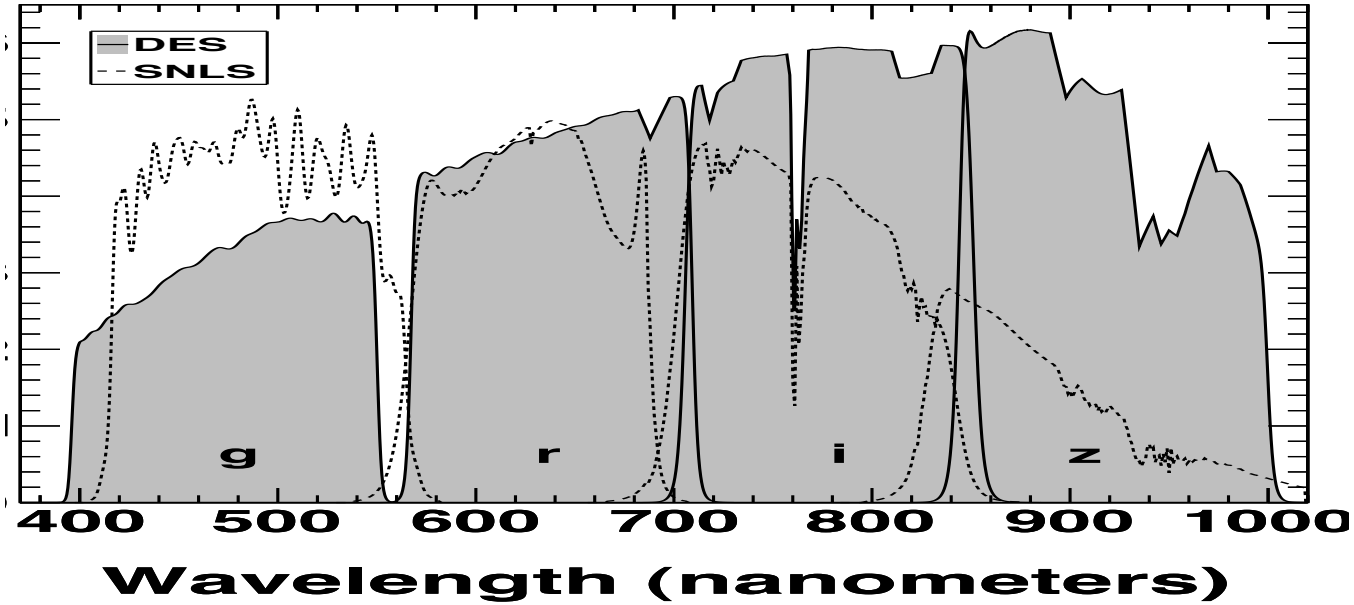
-> expect 4000 SNIa after strict cuts (SNRMAX > 10 …)



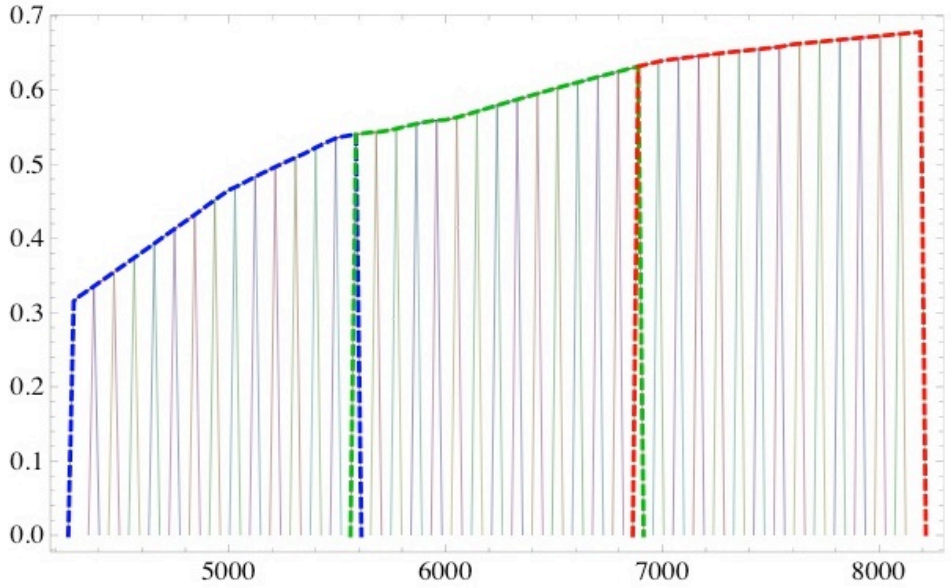




JPAS filters:
100 Å width



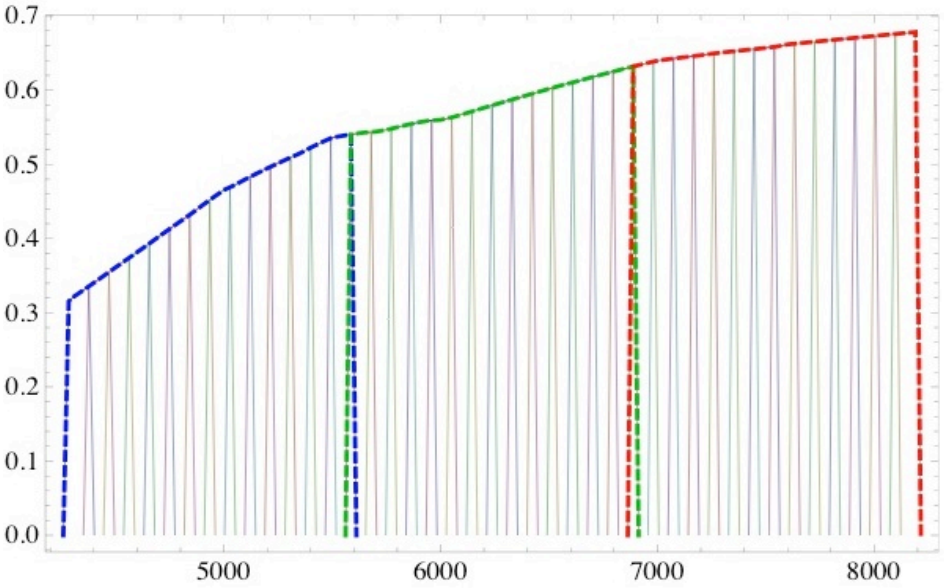
DES filters:
1000 Å width



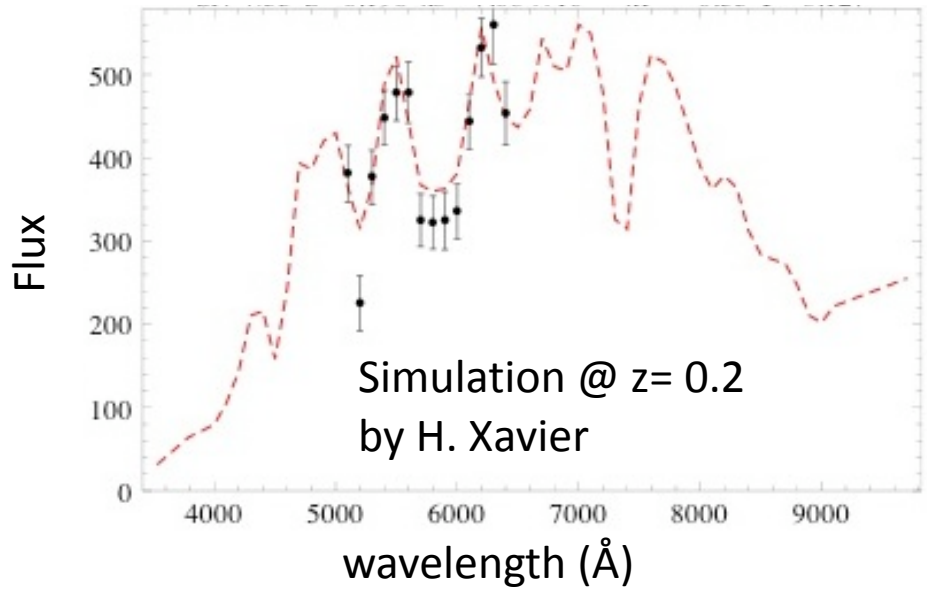
JPAS filters:
100 Å width

Main goal:
BAO with precise photo-z

Also investigating JPAS Supernova Survey (JPASSS)
with precise “host+SN” photo-z



JPAS filters:
100 Å width



---- true flux vs. λ

predicted photometry
from 1 filter “tray”

SN Science from “Deep Drilling Fields” (10% of survey), about 50-100 square degrees with deep observations in each ugrizY filter every few days.

Tens of thousands of SNIa !

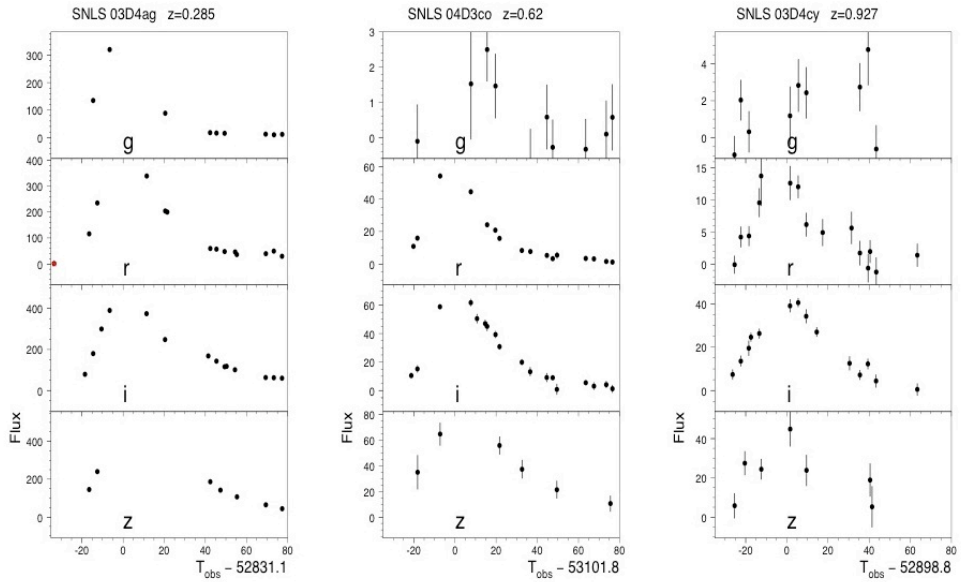


Figure 3: Typical light curves (flux vs. day) observed by the SNLS (Astier et al. 2006) at redshifts $z = 0.29$, $z = 0.62$ and $z = 0.93$. The passband ($griz$) is indicated in each panel.

SNLS SuperNova Legacy Survey

Real light curves

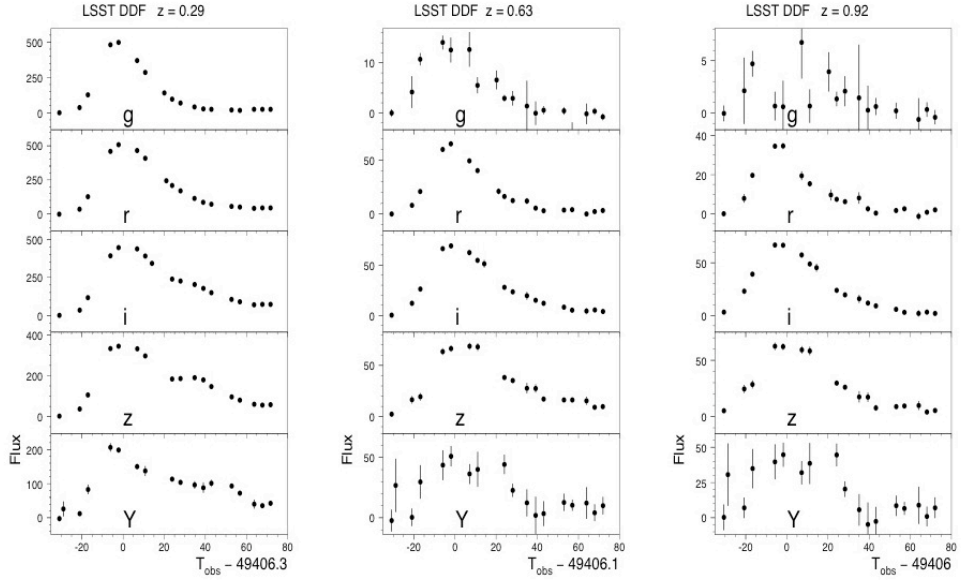
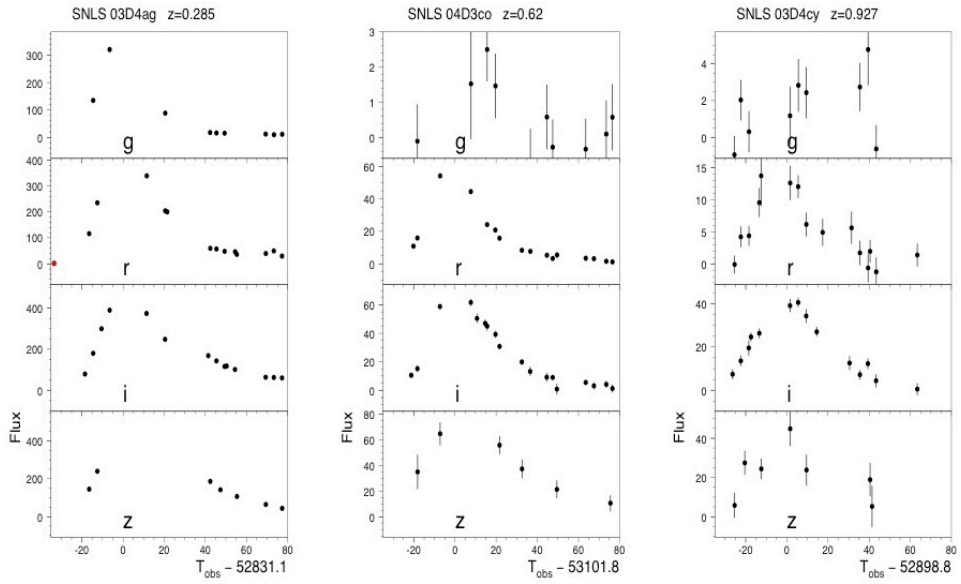


Figure 4: Simulated DDF light curves at the same redshift, color and stretch as the SNLS light curves shown in Fig. 3.

SNLS light curves (above) simulated for LSST Deep Drilling Fields.



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SNLS SuperNova Legacy Survey

Real light curves

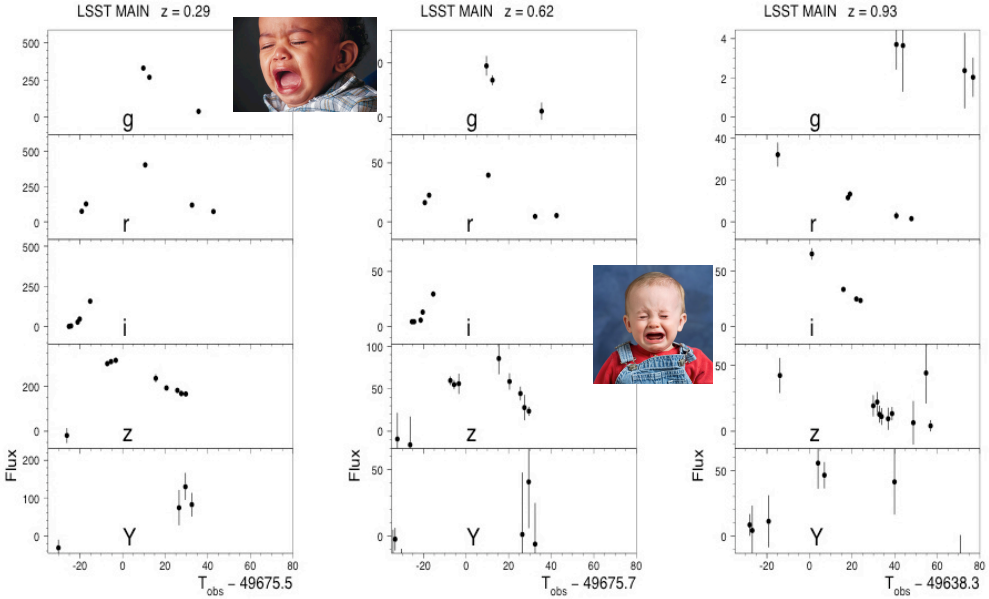

Figure 5: Simulated light curves for the main LSST survey at the same redshift, color and stretch as the SNLS light curves shown in Fig. 3.

Large Synoptic Survey Telescope
the widest, fastest, deepest eye of the new digital age

SNLS light curves (above) simulated for LSST **Main** survey (90% of time)