Status of the SDSS-II Supernova Program

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Outline

- Supernova search
- SN rates
- Cosmology from Hubble Diagram: Calibration and Systematics

Supernova Search

- Search and follow-up with 2.5 meter SDSS telescope at Apache Point Observatory (APO)
- Repeat imaging of 300 sq. deg. (stripe 82) from Sep 1 - Nov 30, 2005-2007 (3 million galaxies)

2.5 x 120 deg^2

- On-mountain processing in < 24 hours
- Spectroscopic follow-up to identify SN type and measure redshift: HET, NTT, Subaru, WHT, ARC 3.5m, MDM, Keck, Kitt Peak, NOT, SALT

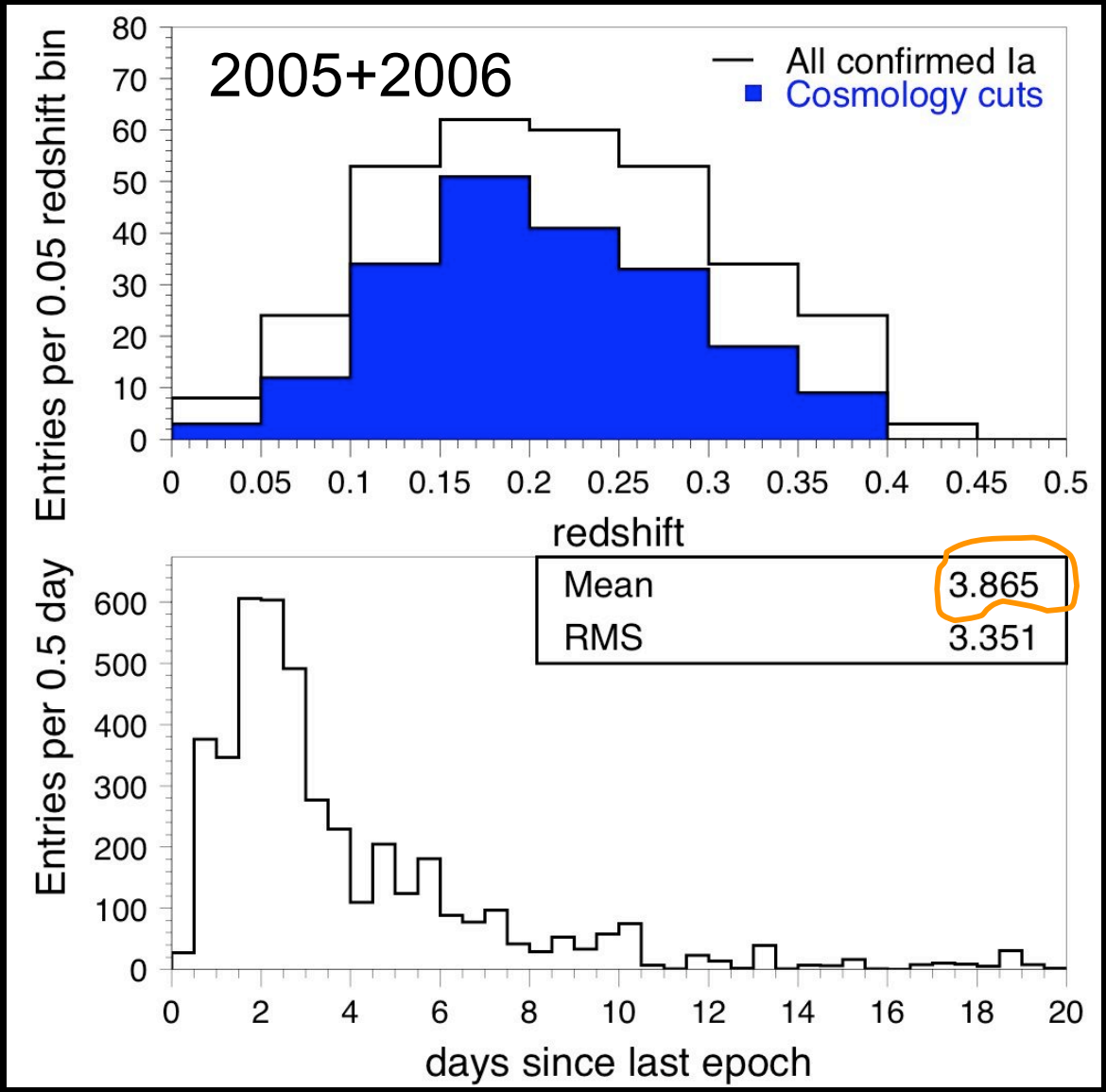
Two Seasons of SDSS-SN Search Yields:

- 325 spectro-confirmed type Ia ($0.05 < z < 0.4$)
- 31 spectro-probable type Ia
- 80 photometric type Ia with spectro host-z
- few hundred photometric type Ia, no spec info
- 14 spectro-confirmed type Ib/c
- 30 spectro-confirmed type II

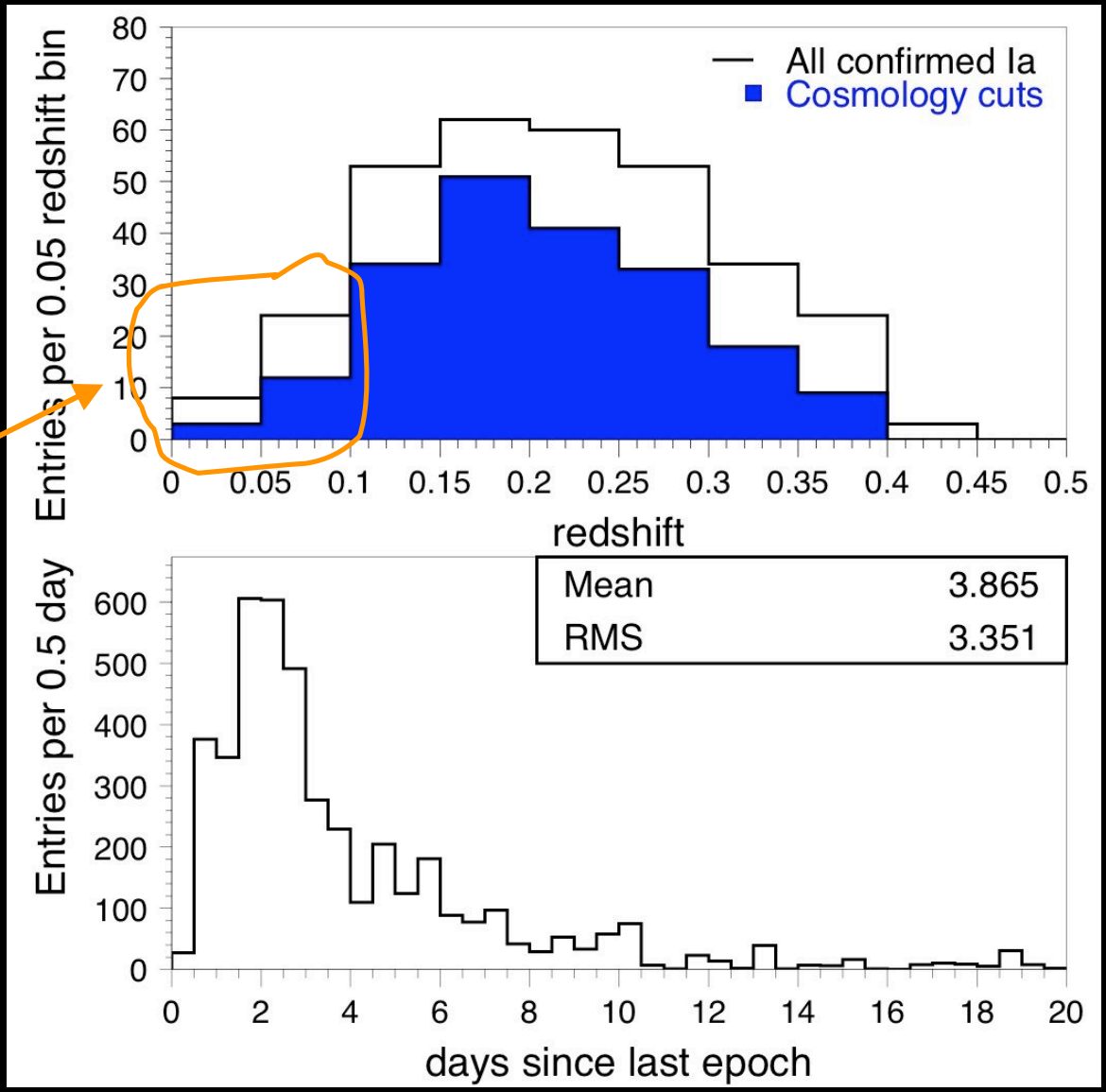
SDSS-SN Redshift & Cadence

redshift distribution for confirmed Type Ia SN

interval between observations of the same object

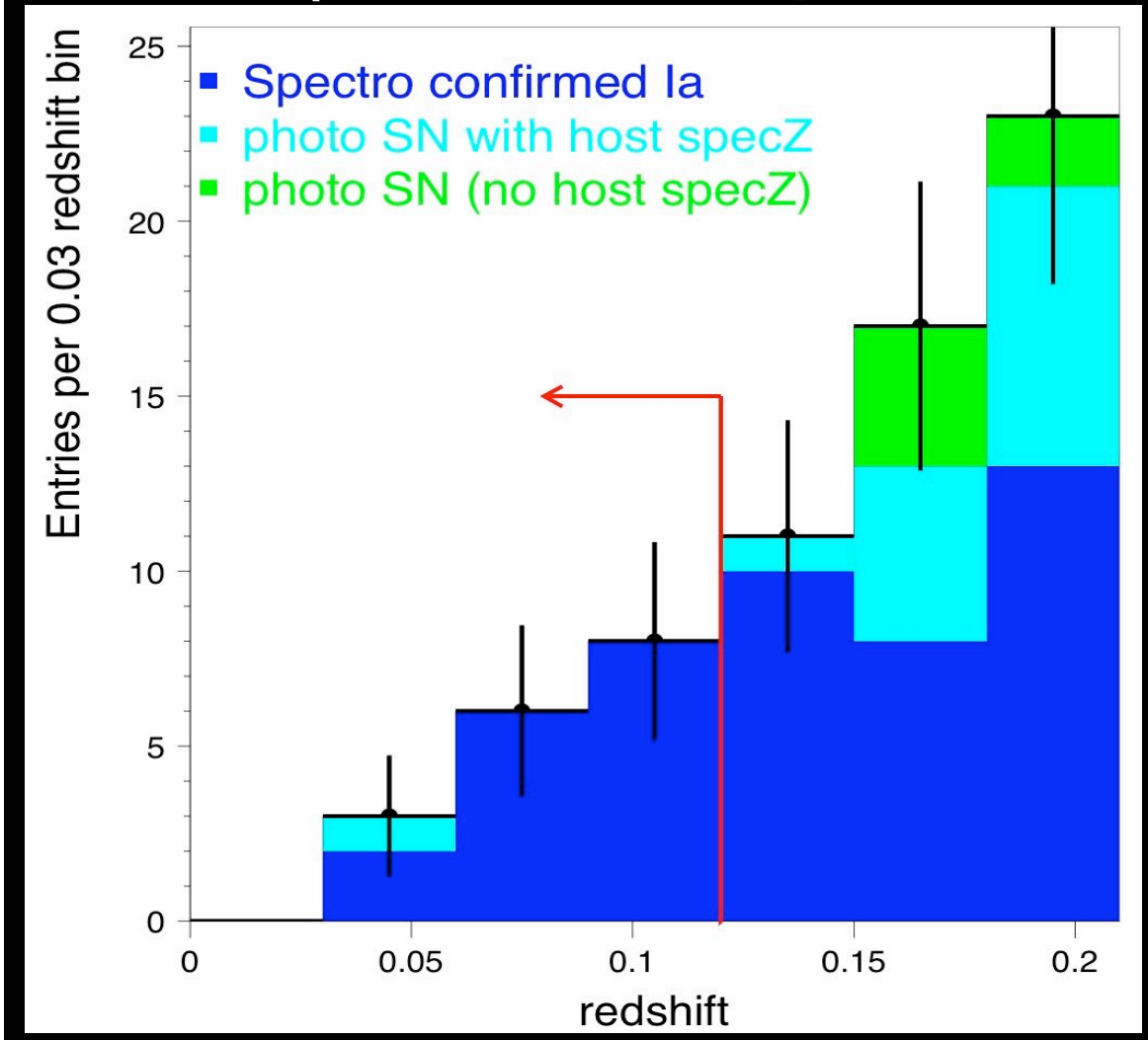


SDSS-SN Redshift & Cadence



Temporal edge effects: SN peak too early or too late. May relax cuts later.

SDSS Rate for SN Ia with z < 0.12 (2005 sample ➡ 1/3 of total)



Contributions:

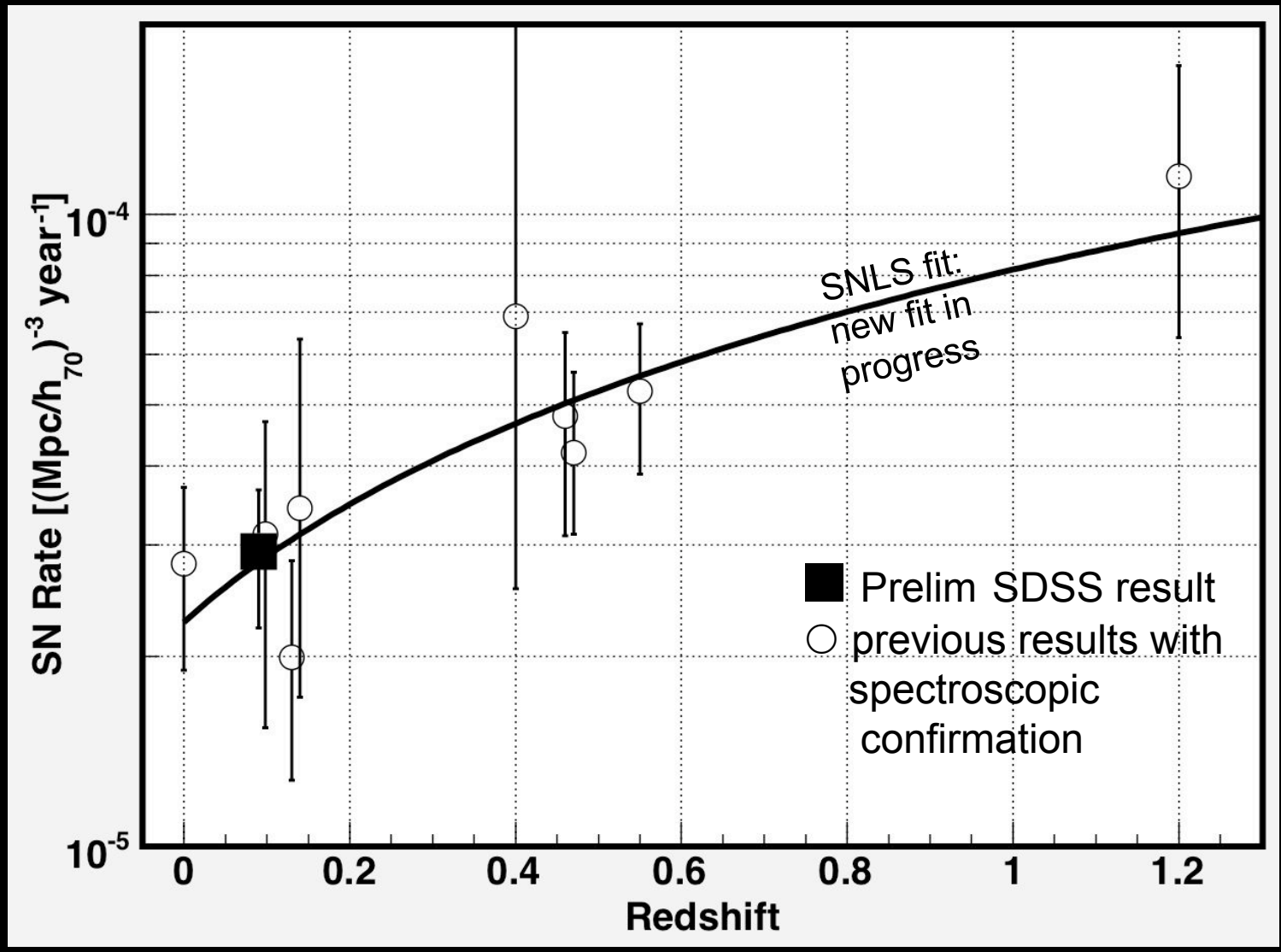
16 spectroscopically confirmed Ia (26 before cuts)

1 photometric-id with host spec-Z

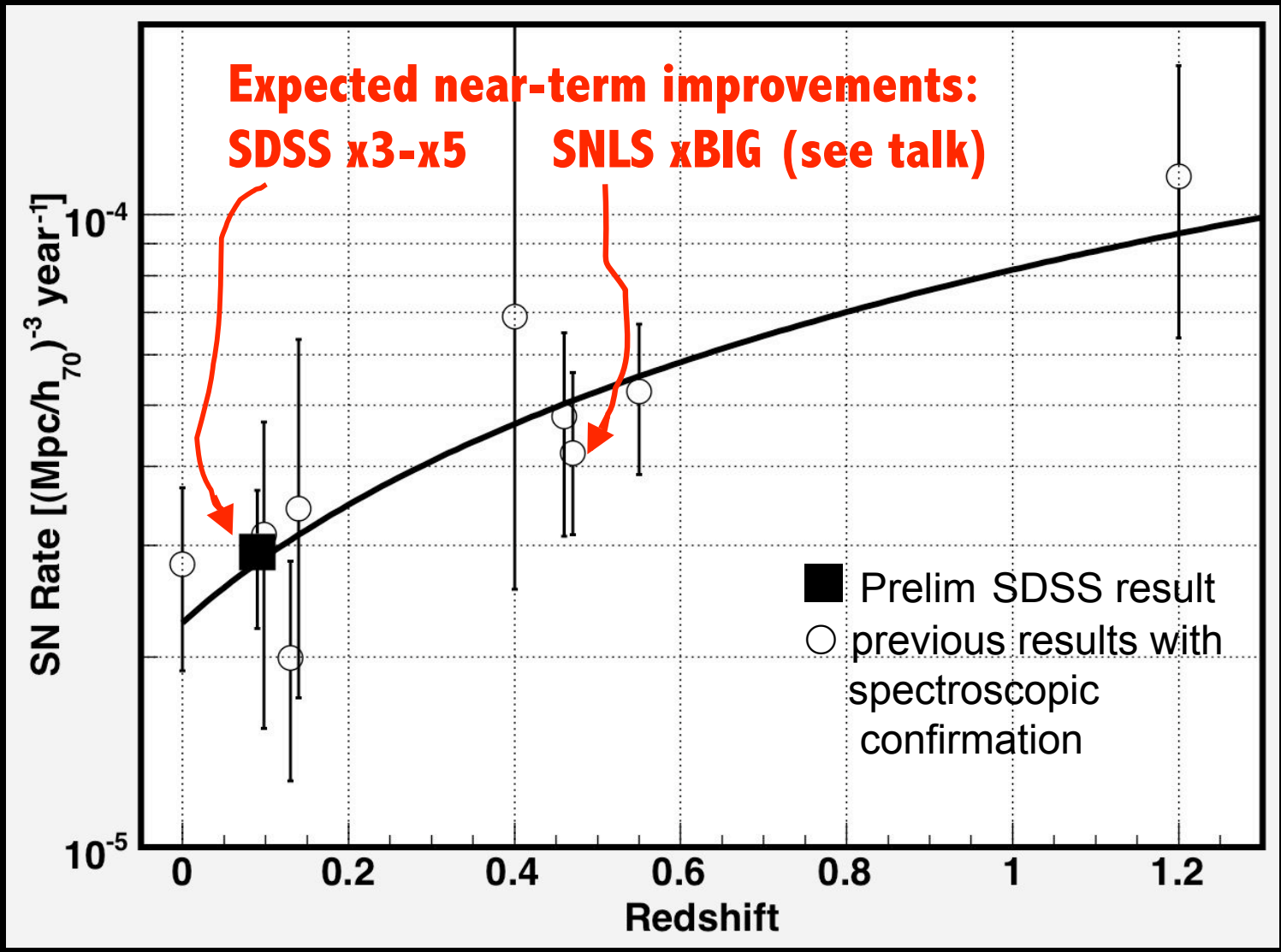
PRELIMINARY SDSS Rate: (2005 sample -- paper in preparation)

- Number of SN ($z < 0.12$) = 17
- Search eff ~ 100% from in-situ fake SN
- Analysis eff = 0.77 ± 0.02 from detailed sim (loss mainly from temporal edge effects)
- SN Ia Rate ($z < 0.12$) = $[2.9 \pm 0.7_{stat} \pm 0.3_{syst}\ ] \times 10^{-5}\ (\mathrm{Mpc}/h_{70})^{-3}\ \mathrm{yr}^{-1}$

SN Ia Rate vs. Redshift

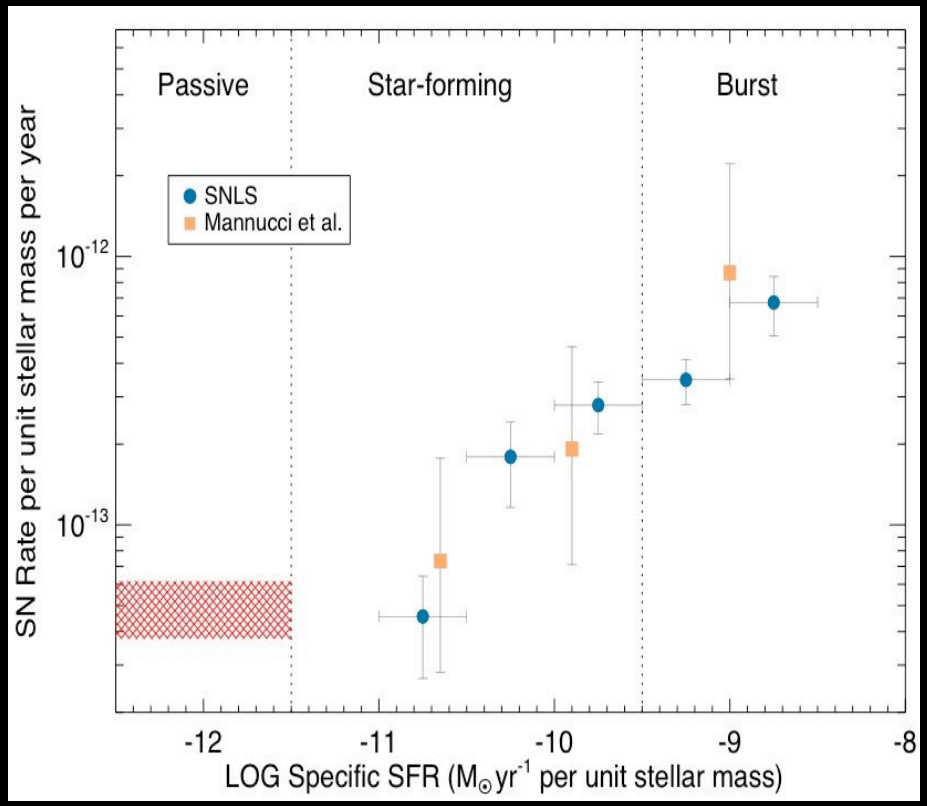


SN Ia Rate vs. Redshift

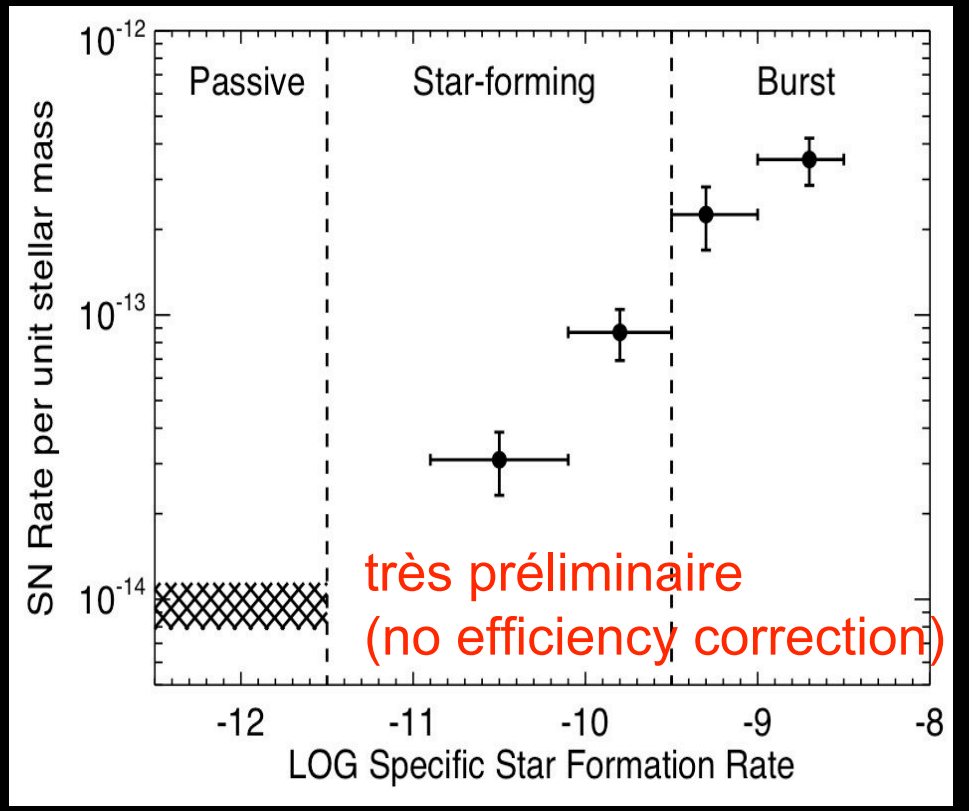


SN Ia Rate versus Star Formation Rate

SNLS (Sullivan 2006)

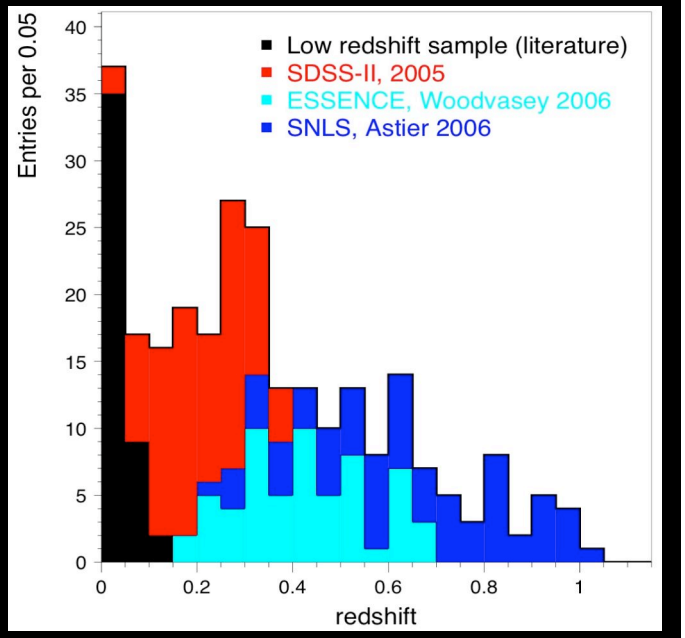


SDSS

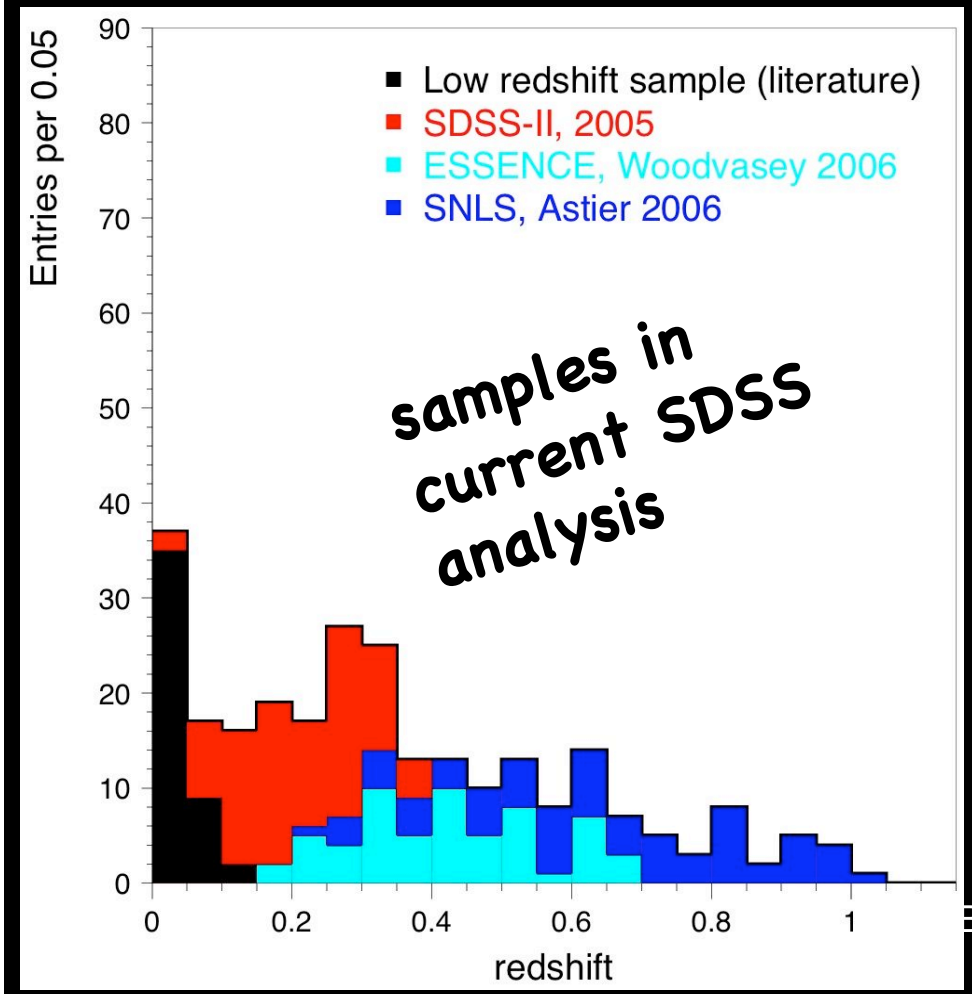


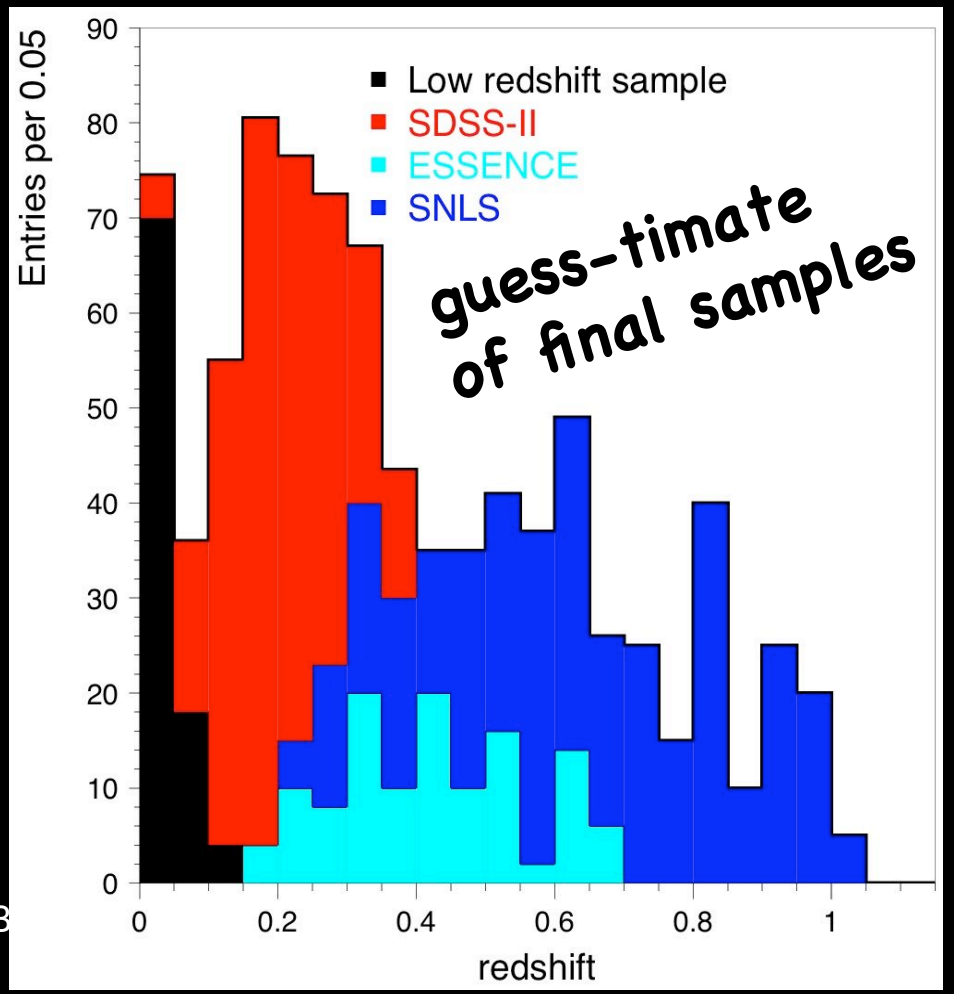
SDSS Hubble Diagram Analysis: Samples Include

- SDSS 2005 (~ 90)
- Low redshift from literature (~ 44)
- SNLS published (~ 70)
- ESSENCE published (~ 60)

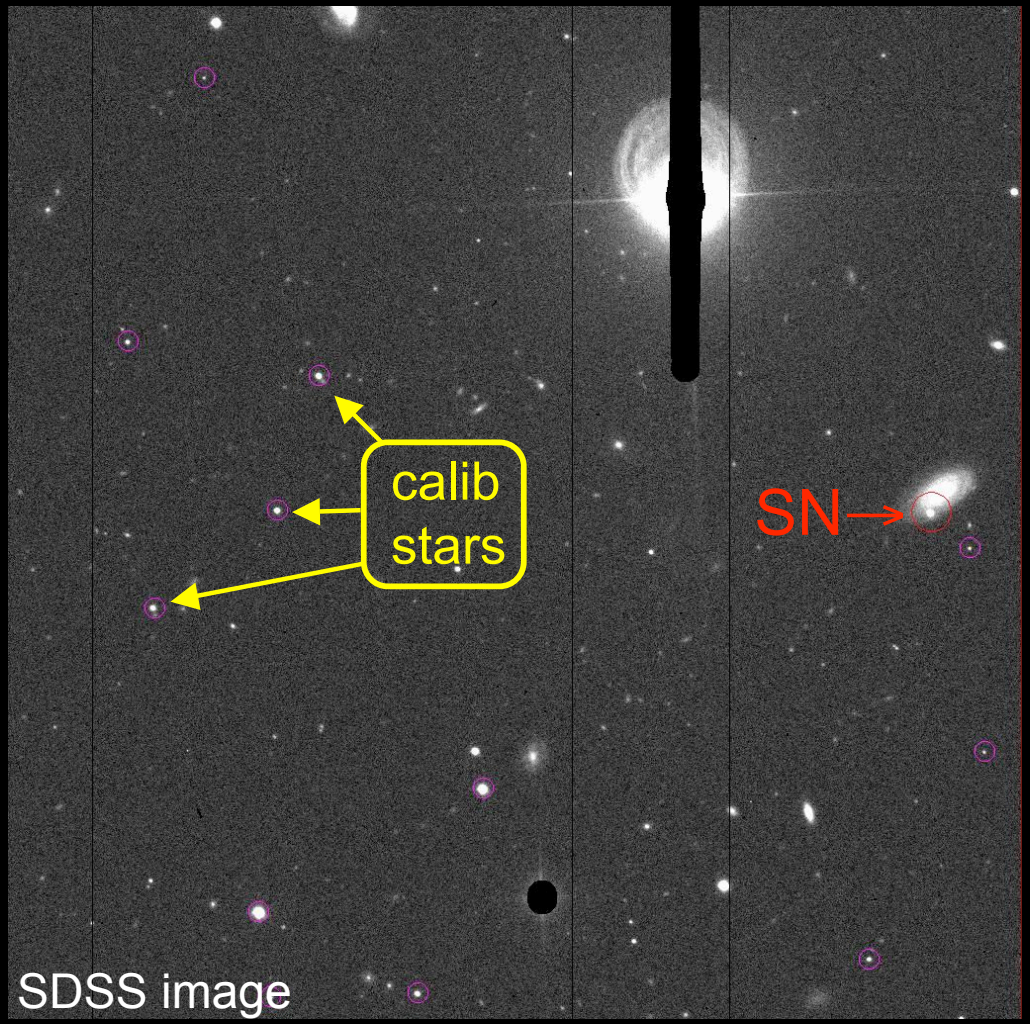


Global Redshift Distribution





Supernova Photometry from Fit



FIT-DATA:
all images (few dozen × ugriz)

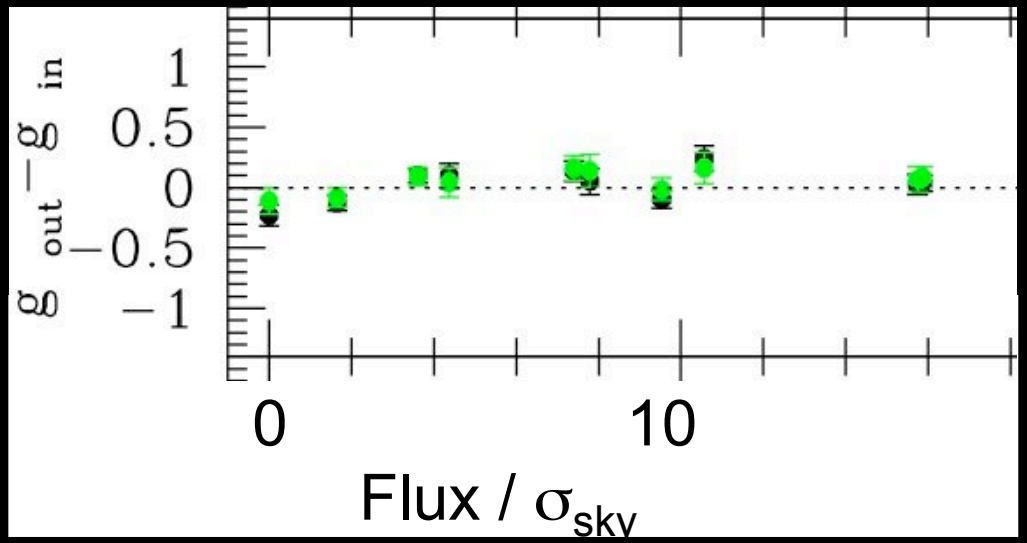
FIT-MODEL:
galaxy + stars + SN + sky

FIT PROPERTIES:
gal + stars: same in every image
SN: variable in every image
gal + stars + SN: PSF-smeared

NO PIXEL RE-SAMPLING !
➪ no pixel correlations
➪ proper stat. errors
(paper in preparation)

Photometry Tests Include:

- Recover zero flux pre-explosion
- Recover star mags
- Fake SN



MLCS2k2‡ Lightcurve Fitter: modifications include

- fit flux instead of mag.
- improved K-correction algorithm.
- extinction prior includes detection efficiency determined from simulation: function of redshift, host extinction and intrinsic luminosity.

(need efficiency/bias for ESSENCE and SNLS samples ⇨ general problem combining data)

‡Jha, Riess, Kirshner
ApJ 659, 122 (2006)

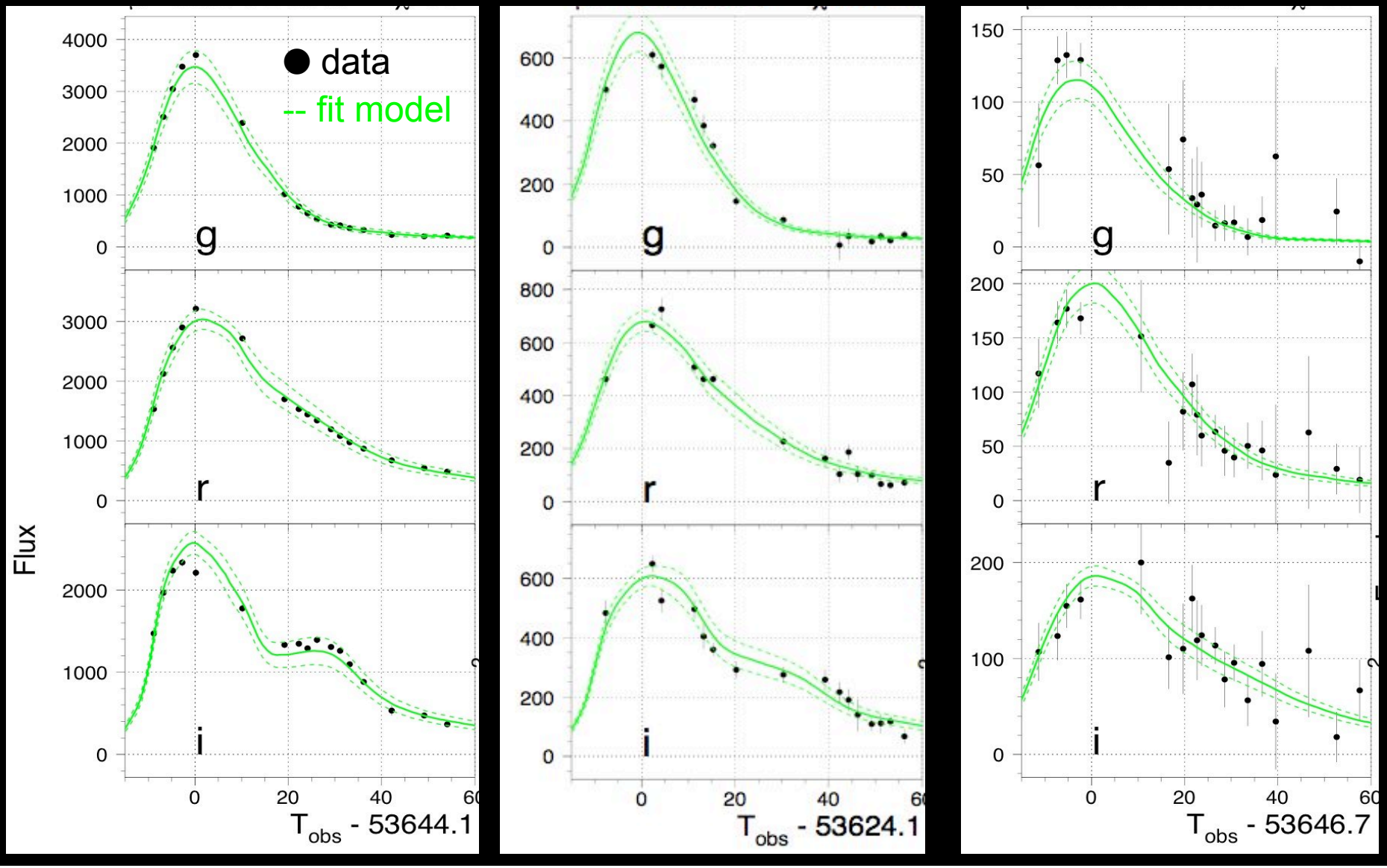
Also Comparing MLCS2k2 fits with:

- SALT II ‡
- Salted MLCS2k2:
  no A_V prior and $R_V \sim 1.5$ (instead of 3.1)

‡ J. Guy et al., astro-ph/0701828

SDSS SN Ia Lightcurves @

z = 0.09 z = 0.19 z = 0.36



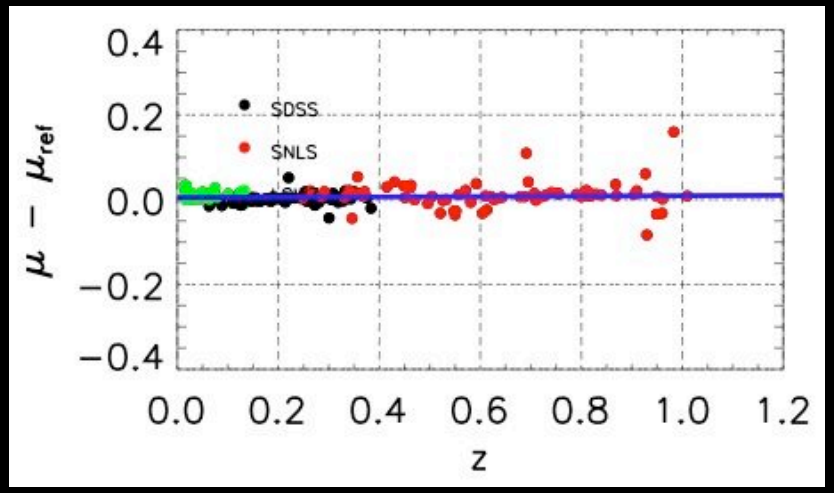
Cosmology Fits

- Flat universe ($\Omega_{TOT} = 1$)
- Baryon Acoustic Oscillation (BAO) prior from Eisenstein et. al., 2005.
- Blind analysis: only differences w.r.t standard analysis are examined.
- Fit for w and Ω_{MAT}

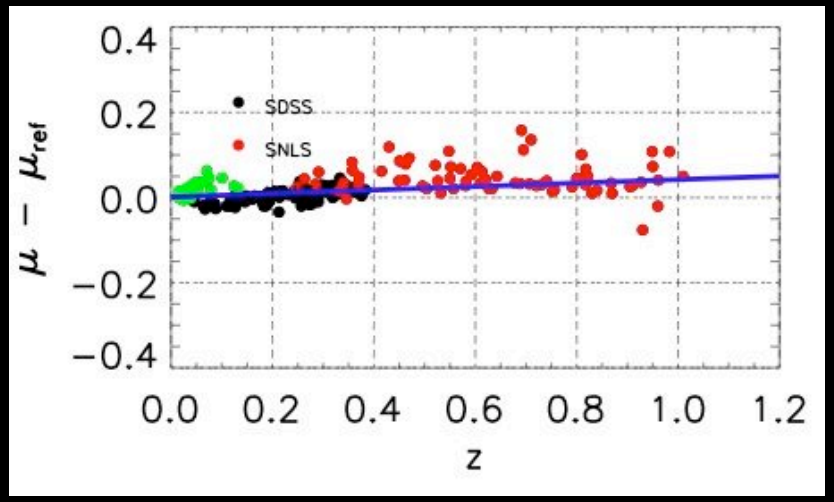
Calibration Issues for Low-Z Sample:

	SNLS & ESSENCE (published)	SDSS (work in progress)
Primary ref	Vega	BD+17
Primary spectra	ground-based	HST stis
UBVRI primary Landolt mags	measured with Johnson-Cousins	measured by Landolt
UBVRI Bessell filters	shifted for zero color terms	No shifts; straight from Bessell90
color transf.	none (by defn)	Landolt ➡ Bessell

Hubble Diagram Differences w.r.t standard SDSS analysis



Replace BD+17 with VEGA, re-evaluate color terms:
➪ $|\delta w|$ ~ 0.02



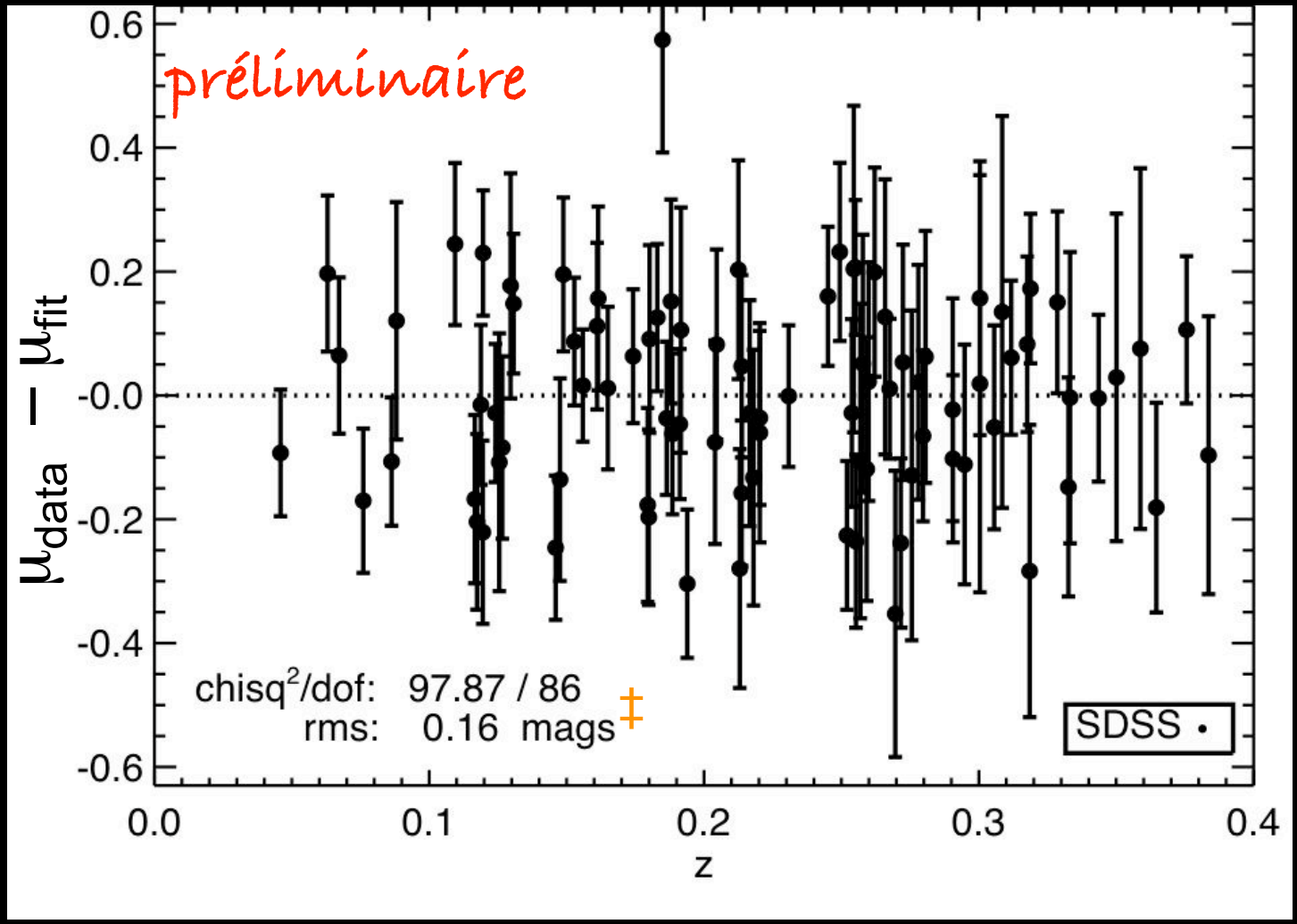
Calibrate with Astier05 (SNLS) method:
➪ $|\delta w|$ ~ 0.08

Calibration Uncertainties on w

(many other uncertainties still under evaluation)

Source of uncertainty	δw
δmags(UBVRI) = 0.01 for BD17	0.023
Landolt ↔ Bessell color terms	0.007
AB offsets for SDSS mags	0.006
gri central filter wavelength ($\delta\lambda_{gri}$ = 7, 16, 25 Å)	0.009
TOTAL CALIBRATION	0.026

SDSS Hubble Diagram Residuals



‡ 0.08 mag added in quadrature to fitted μ as prescribed by MLCS2k2

Why no result yet ? Systematic issues for

- excluding SDSS i-band
- alternate MLCS2k2 training vectors (used in recent ESSENCE result)
- efficiency/bias for ESSENCE & SNLS samples ?