



SDSS Measurement of the SN Ia Rate for $z < 0.12$

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for the SDSS-II SN-Survey and
Spectroscopic Follow-up Teams

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Motivation

- ✓ Repeat imaging of 300 sq deg, combined with an efficient SN-search pipeline, provides an ideal data set for SN rate measurement.
- ✓ SN Ia Rate vs. redshift probes delay times of explosion relative to star formation, which can be related to the nature of SN progenitors.
- ✓ Nearby ($z \sim .1$) rate is limited by small samples and biases from targeting known galaxies.

Fall-2005 Data Sample (confirmed, $z < 0.12$)

- ✓ Begin analysis with 26 spectroscopically confirmed SN Ia ($z < 0.12$)
- ✓ To have well-understood efficiency, we require
 - * pre-max epoch
 - * epoch past 10 days in rest frame
 - * at least 5 epochs
 - * max SNR > 5 in g,r,i
 - * MLC2k2 lightcurve fit-prob > 0.01



15 SN Ia in final sample for rate.

Fall-2005 Data Sample (unconfirmed, $z < 0.12$)

- ✓ Post-survey analysis of ~ 1000 candidates lightcurves with improved photometry and improved (MLCS2k2) lightcurve model:

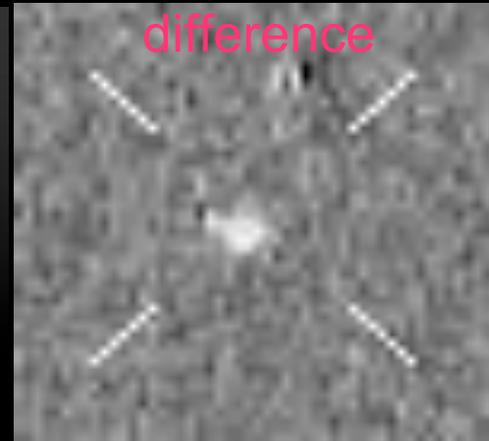
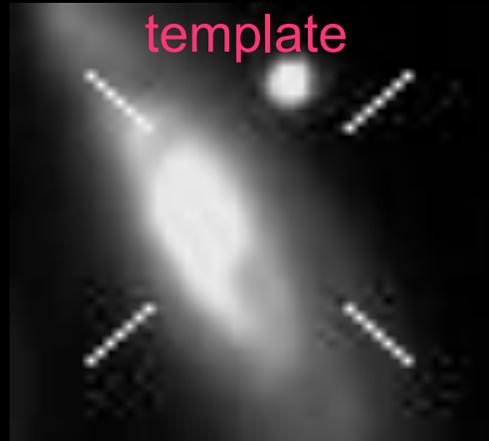


Fall-2005 Data Sample (unconfirmed, $z < 0.12$)

- ✓ Post-survey analysis of ~ 1000 candidate lightcurves with improved photometry and improved (MLCS2k2) lightcurve model:



recovered one highly extinguished SN 1a at $z=0.036$, $A_V \sim 4$!



Still have ~ 1000 more candidate lightcurves to process.
Systematic error for unconfirmed SN Ia sample: 2.

Fall-2005 Data Sample (excluded, $z < 0.12$)

- ✓ Note that two peculiar SN were rejected because MLC fit-prob $\ll 0.01$
(and therefore the selection efficiency has large uncertainty):
 - * 2005gj (Ia/II hybrid)
 - * 2005hk (underluminous 2002cx-like)

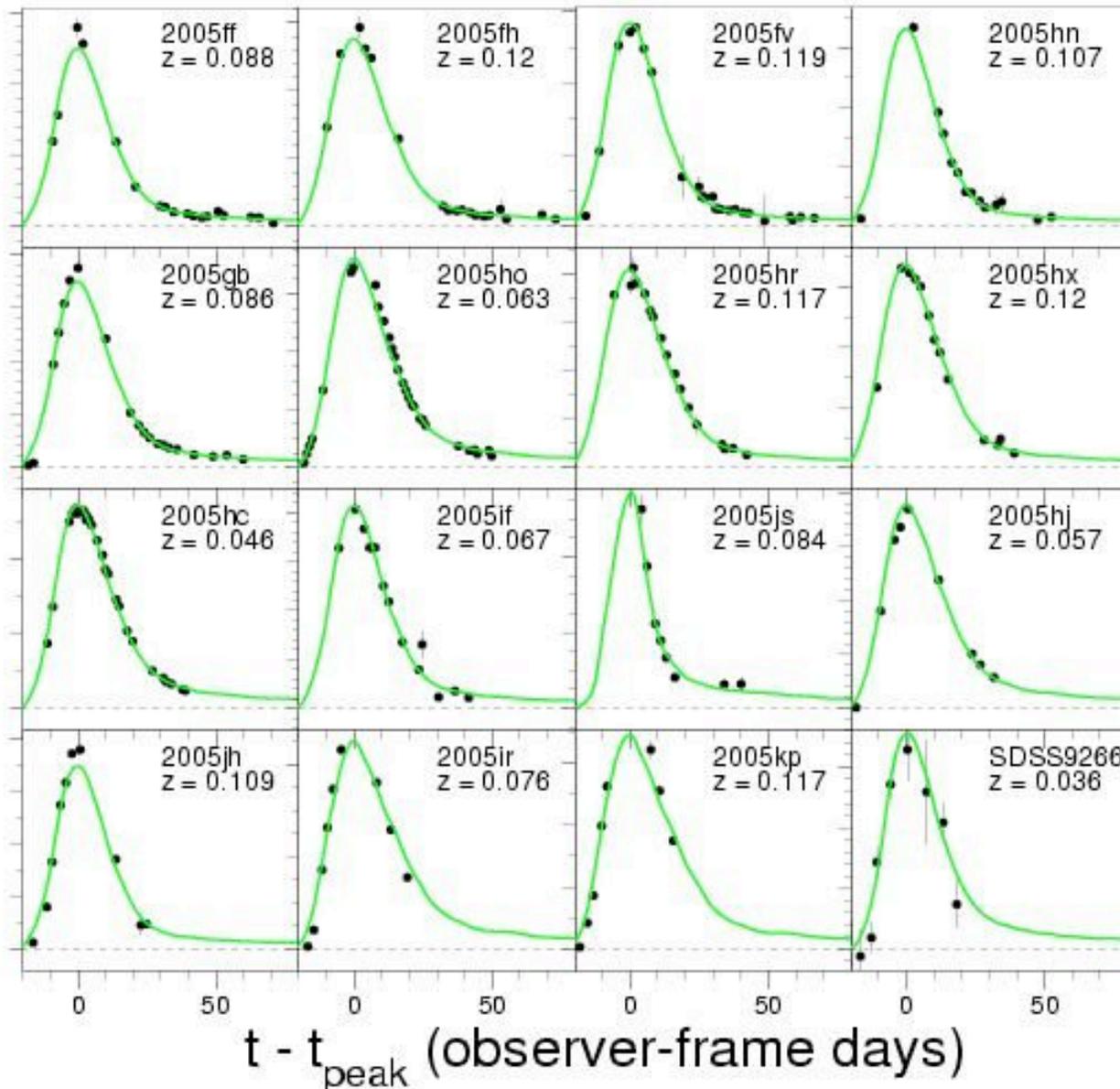
[See talk by J.Prieto for more details]

g-band Gallery of Low-Z Lightcurves

• Data

— Best fit MLCS model

SN Flux (arbitrary units)

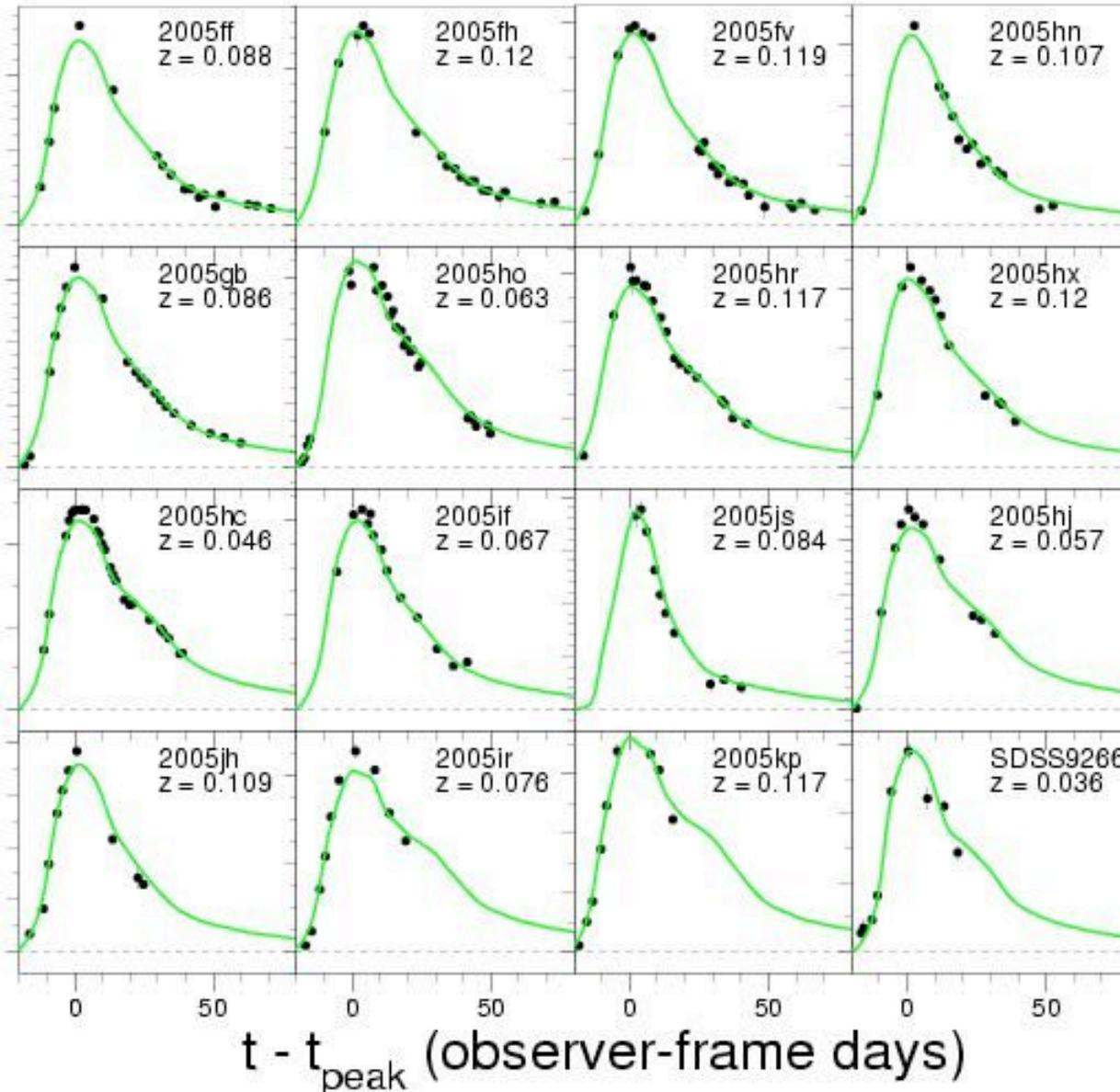


r-band Gallery of Low-Z Lightcurves

• Data

— Best fit MLCS model

SN Flux (arbitrary units)

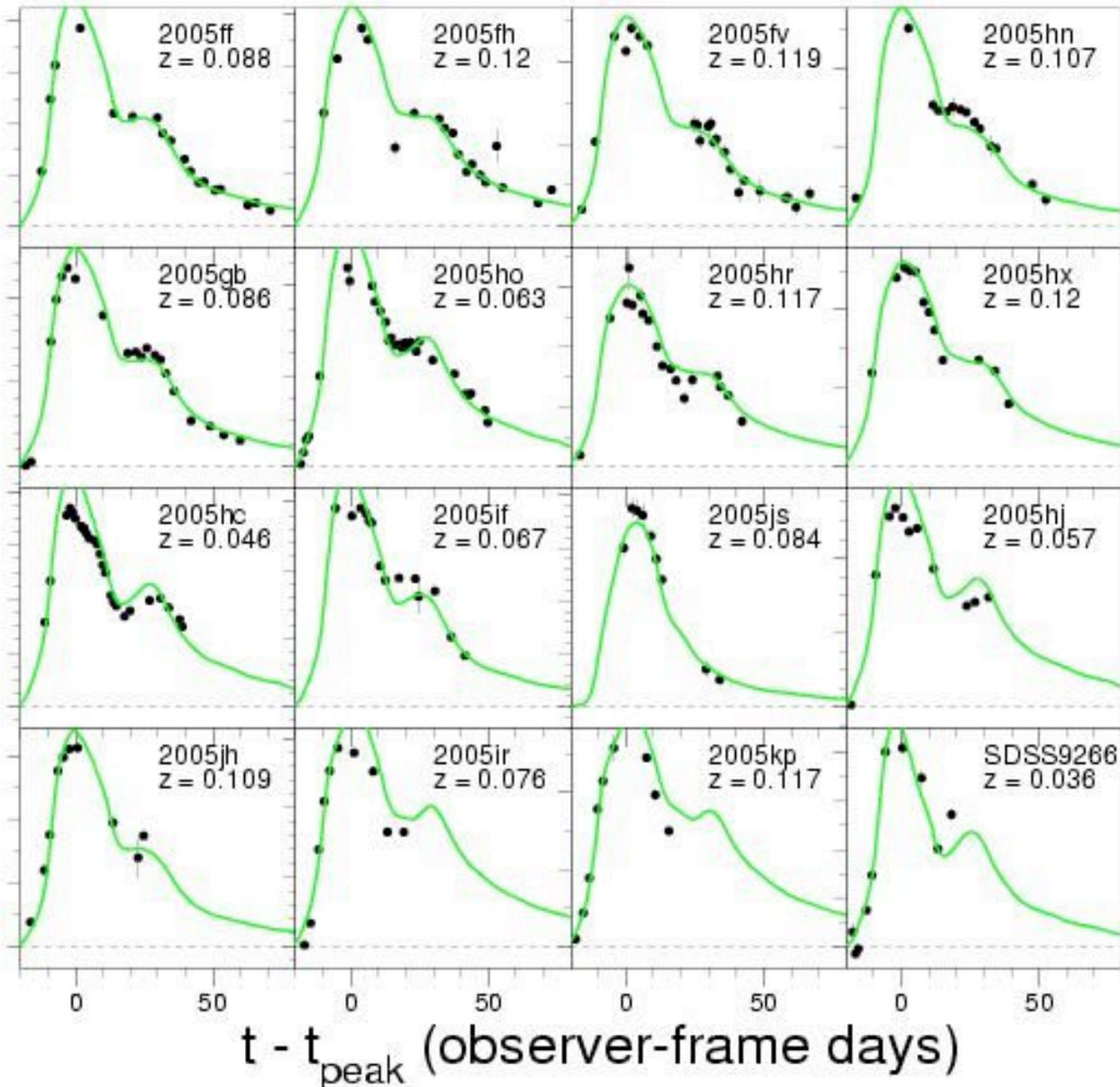


i-band Gallery of Low-Z Lightcurves

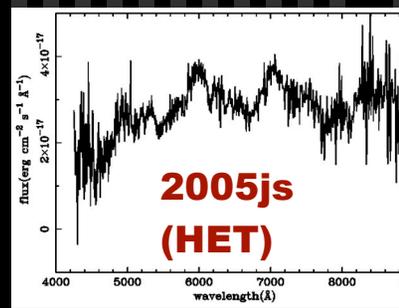
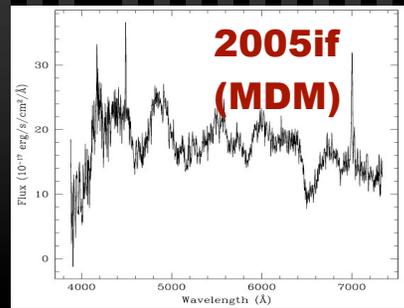
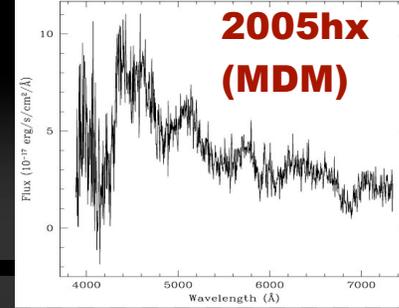
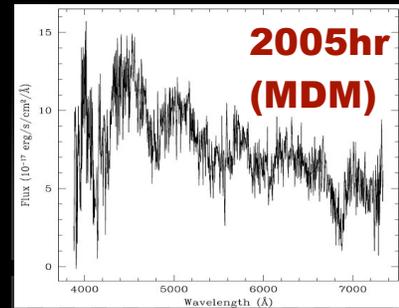
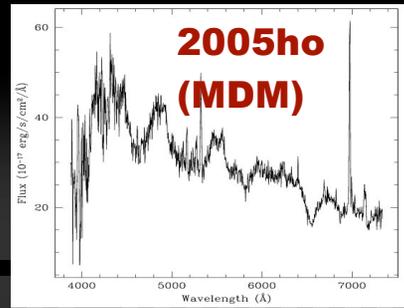
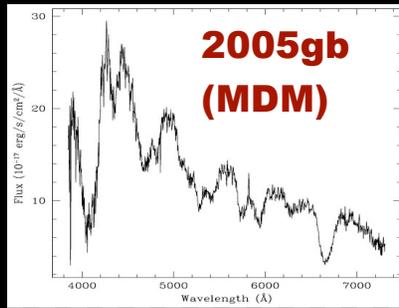
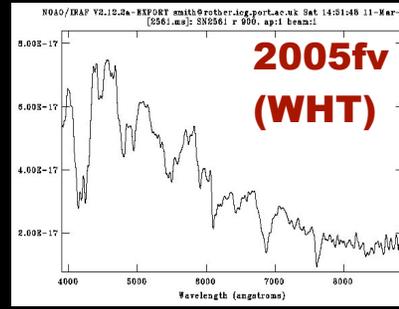
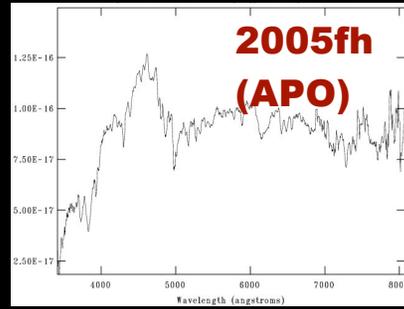
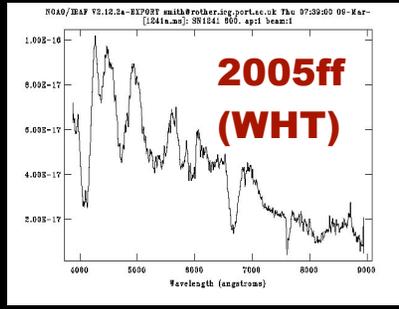
• Data

— Best fit MLCS model

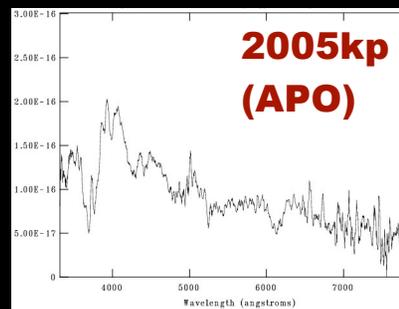
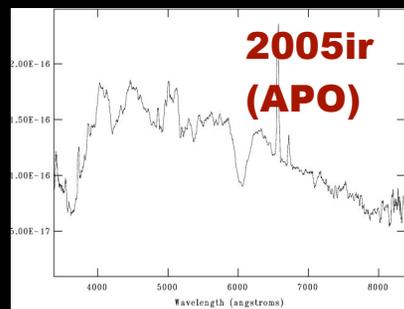
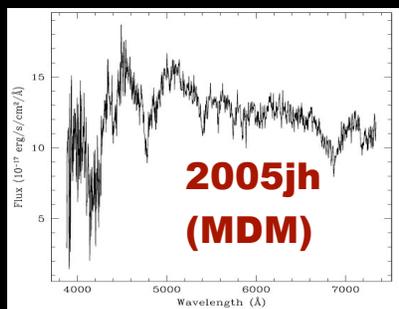
SN Flux (arbitrary units)



Gallery of SN Ia Spectra



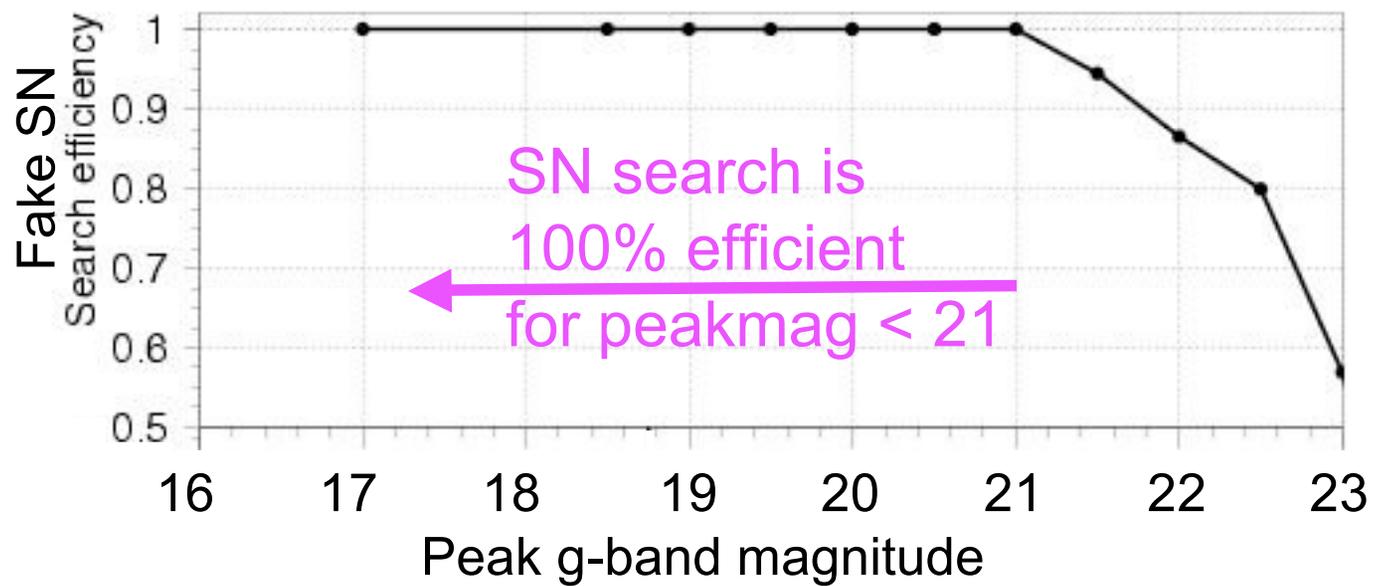
2005hj
(HET:
external
confirmation)



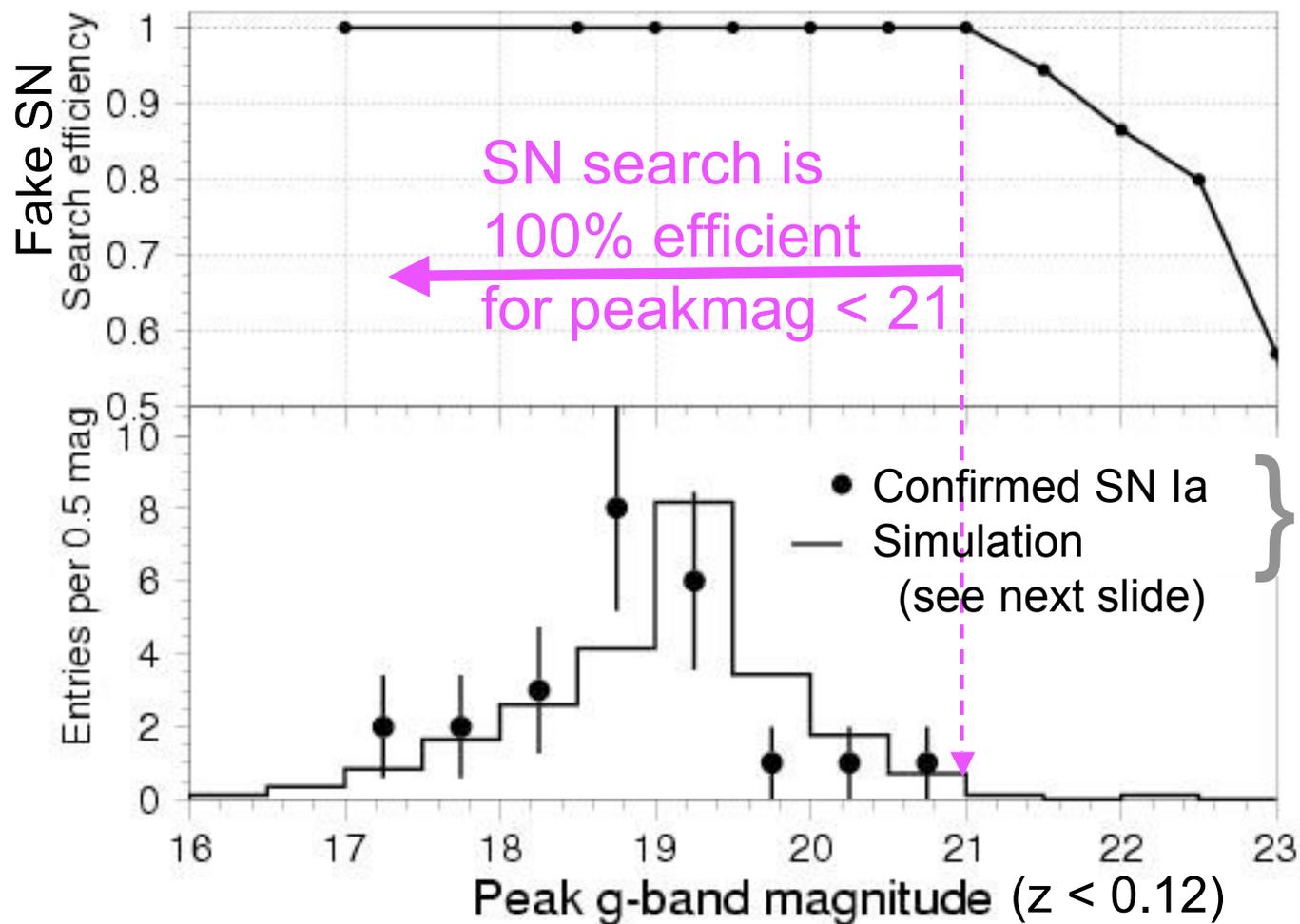
Efficiency Determination

- ✓ Fake SN lightcurves inserted into images DURING SURVEY to monitor search efficiency.
- ✓ Lightcurve simulation to determine selection efficiency after cuts (also used for cosmology systematics)

Search Efficiency During Fall-2005 Survey (from fake SN inserted into images)

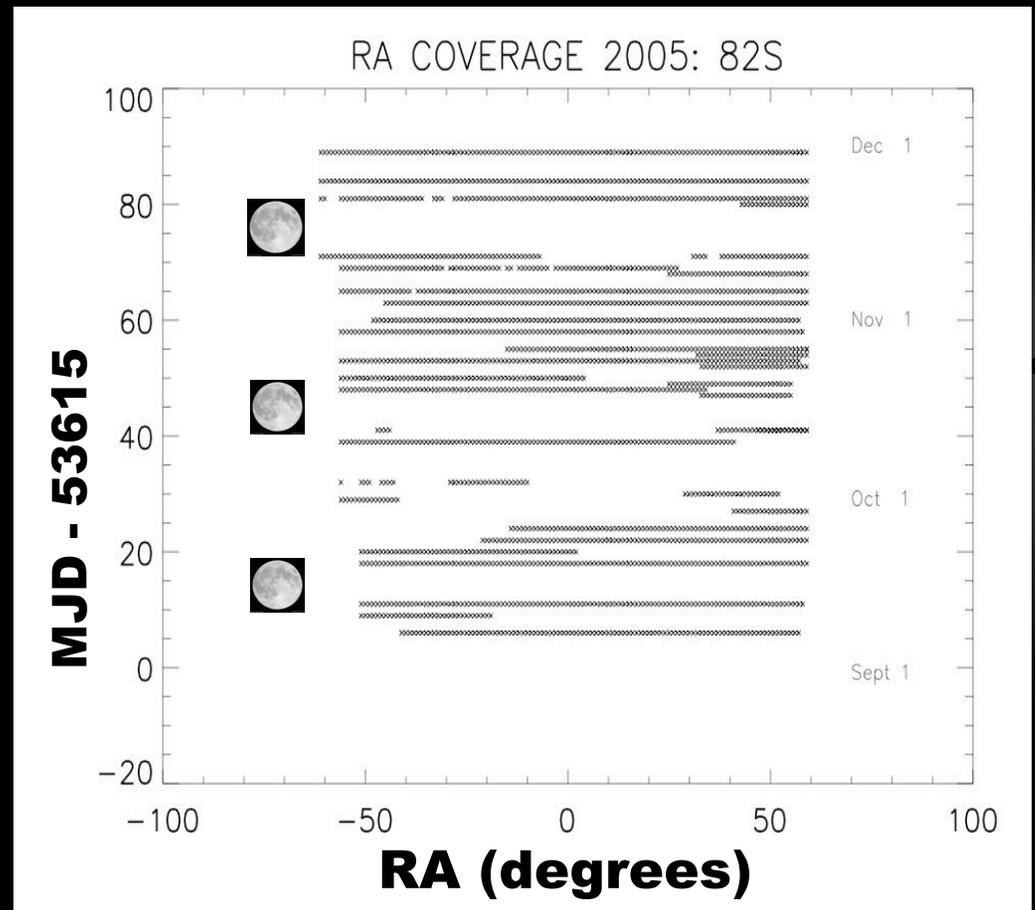


Search Efficiency During Fall-2005 Survey (from fake SN inserted into images)

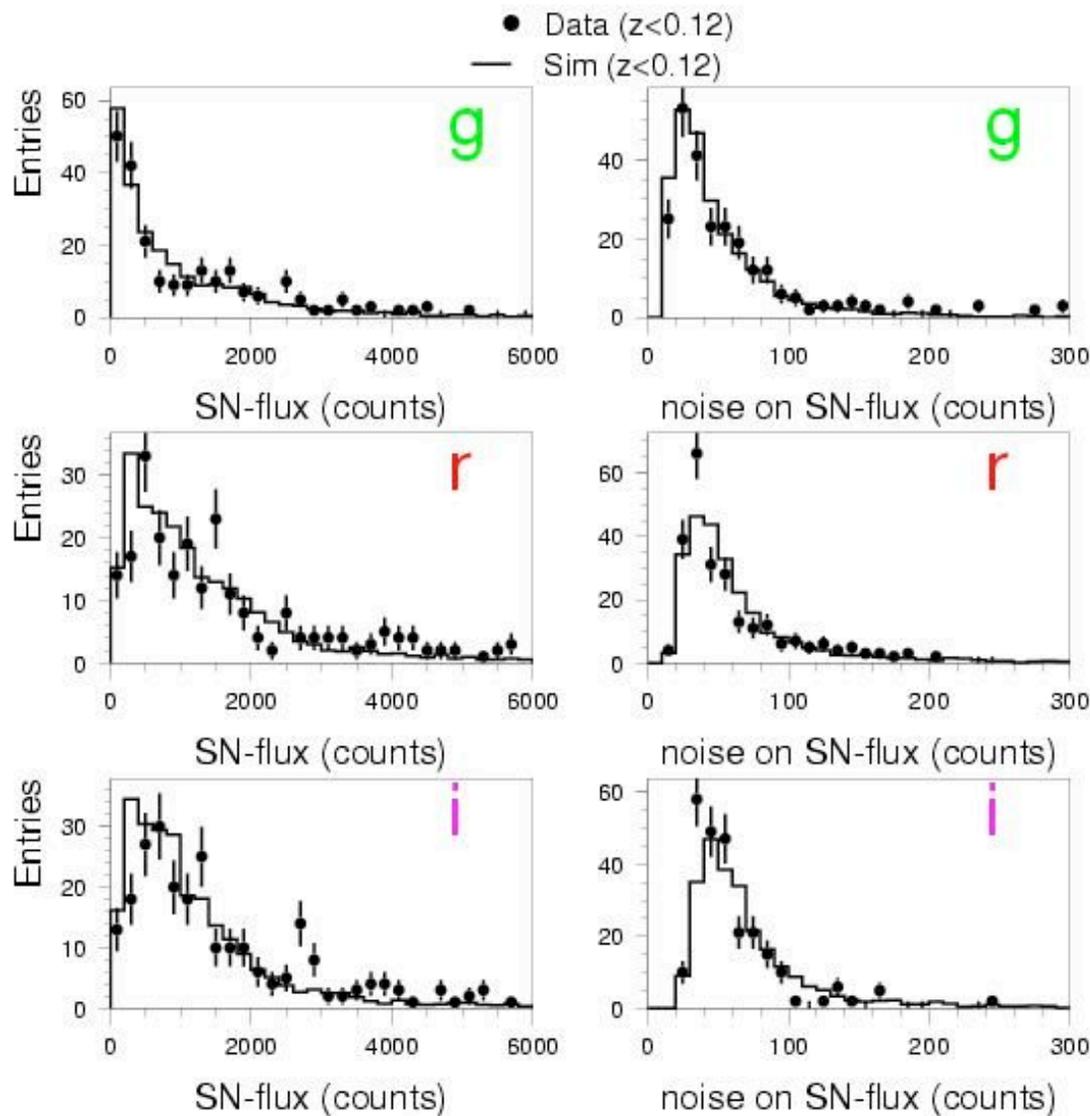


Selection efficiency from lightcurve simulation based on observed epochs: for each epoch use

- measured PSF
- measured sky noise
- host-galaxy noise from random galaxy
- host extinction from $\exp(-A_V/0.4)$
- SN flux from MLCS2k2 model with random color variations based on model errors.



Simulation Check on SN fluxes and errors for all 260 epochs with $z < 0.12$



Simulation has x10 data statistics, and sim distributions are re-scaled to have same stats as data.

Data and simulation have consistent distributions;
adds confidence in using simulation to predict efficiency

Selection Efficiency from Simulation

Efficiency ($z < 0.12$)

$$= 0.83 \pm 0.02_{\text{stat}} \pm 0.01_{\text{syst}}$$

$$= 0.88 \times 0.95$$

MJD edge effects
from pre-max
and +10 day
requirements

telescope
efficiency
(includes
weather)

vary host extinction
distribution between
 $\exp(-A_v/0.2)$ and
 $\exp(-A_v/0.6)$



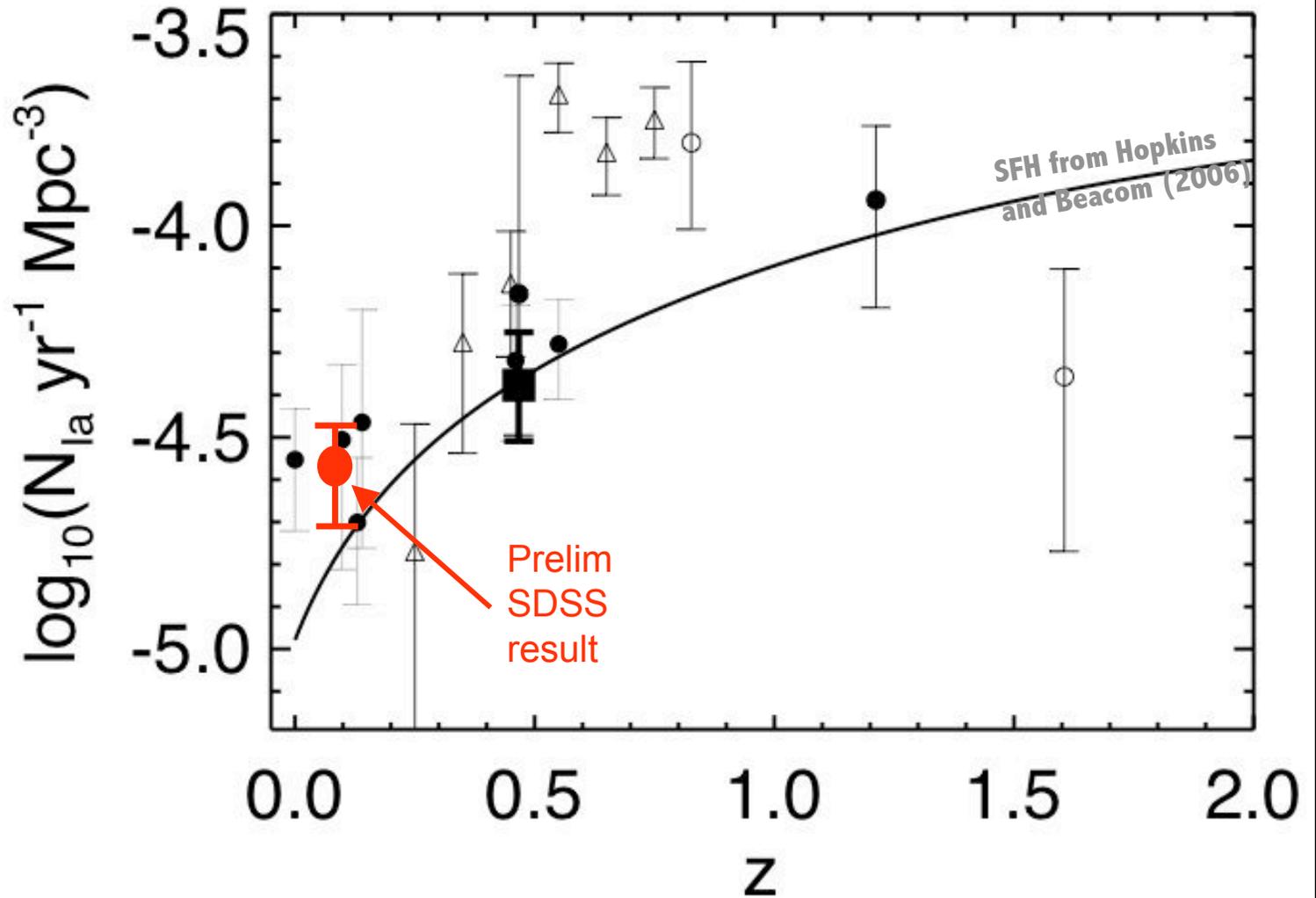
Preliminary SDSS Result

- ✓ Acceptance = 0.83 ± 0.03
- ✓ Comoving Volume x Time :
 $7.36 \times 10^5 \text{ (Mpc}/h_{70})^3 \text{ years}$
- ✓ No. of observed SN Ia (Fall-2005) : 16
- ✓ Systematic error: $2/16 = 13\%$
- ✓ Mean redshift: 0.09
- ✓ SN Ia rate ($z < 0.12$) =
 $(2.7 \pm 0.7_{\text{stat}} \pm 0.3_{\text{syst}}) \times 10^{-5} \text{ (Mpc}/h_{70})^{-3} \text{ yr}^{-1}$

!!! most precise low-redshift rate measurement !!!

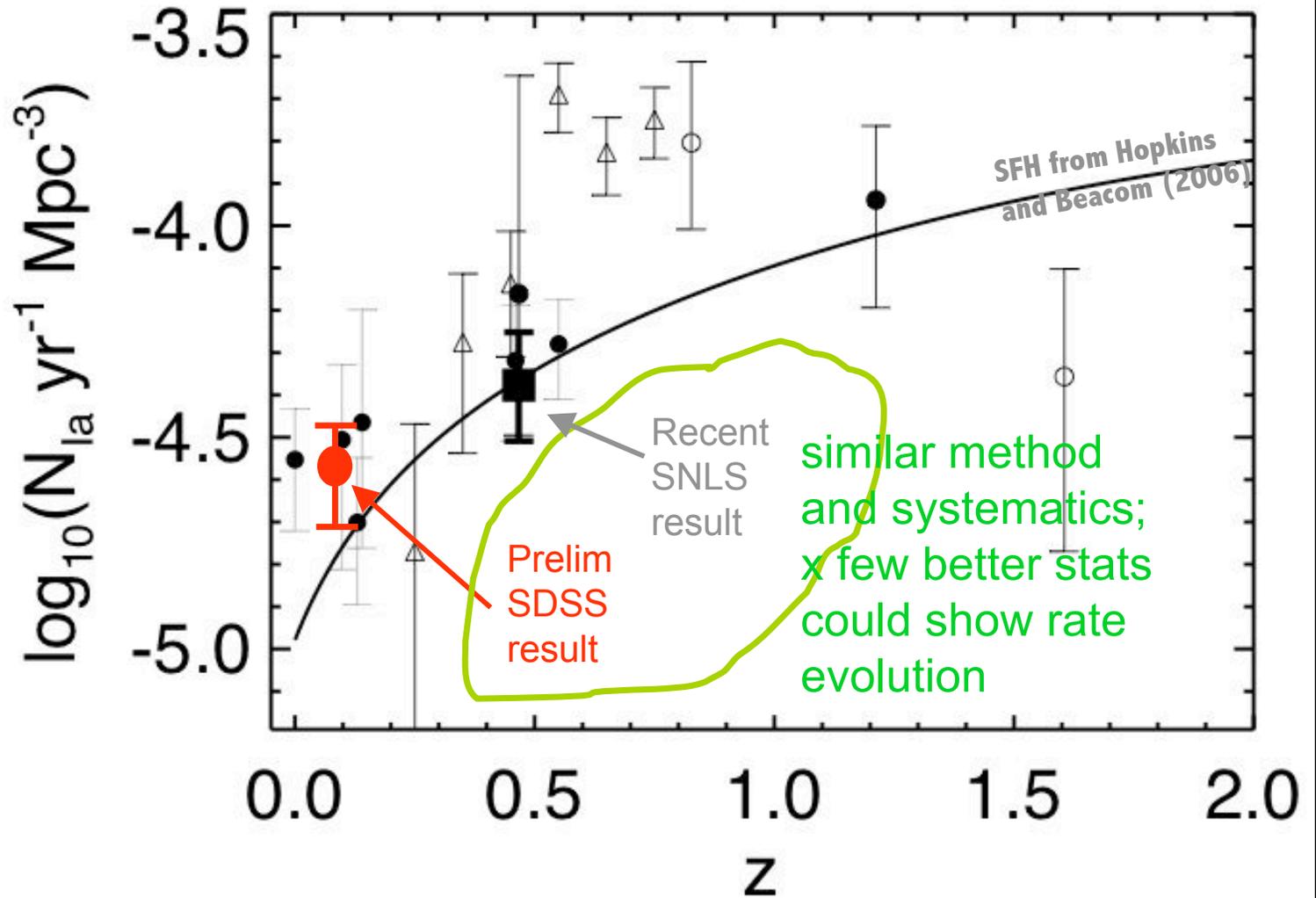
SN Ia Rate Comparisons

Figure from SNLS: astro-ph/0605148
(see Fig 1 caption for list of measurements)



SN Ia Rate Comparisons

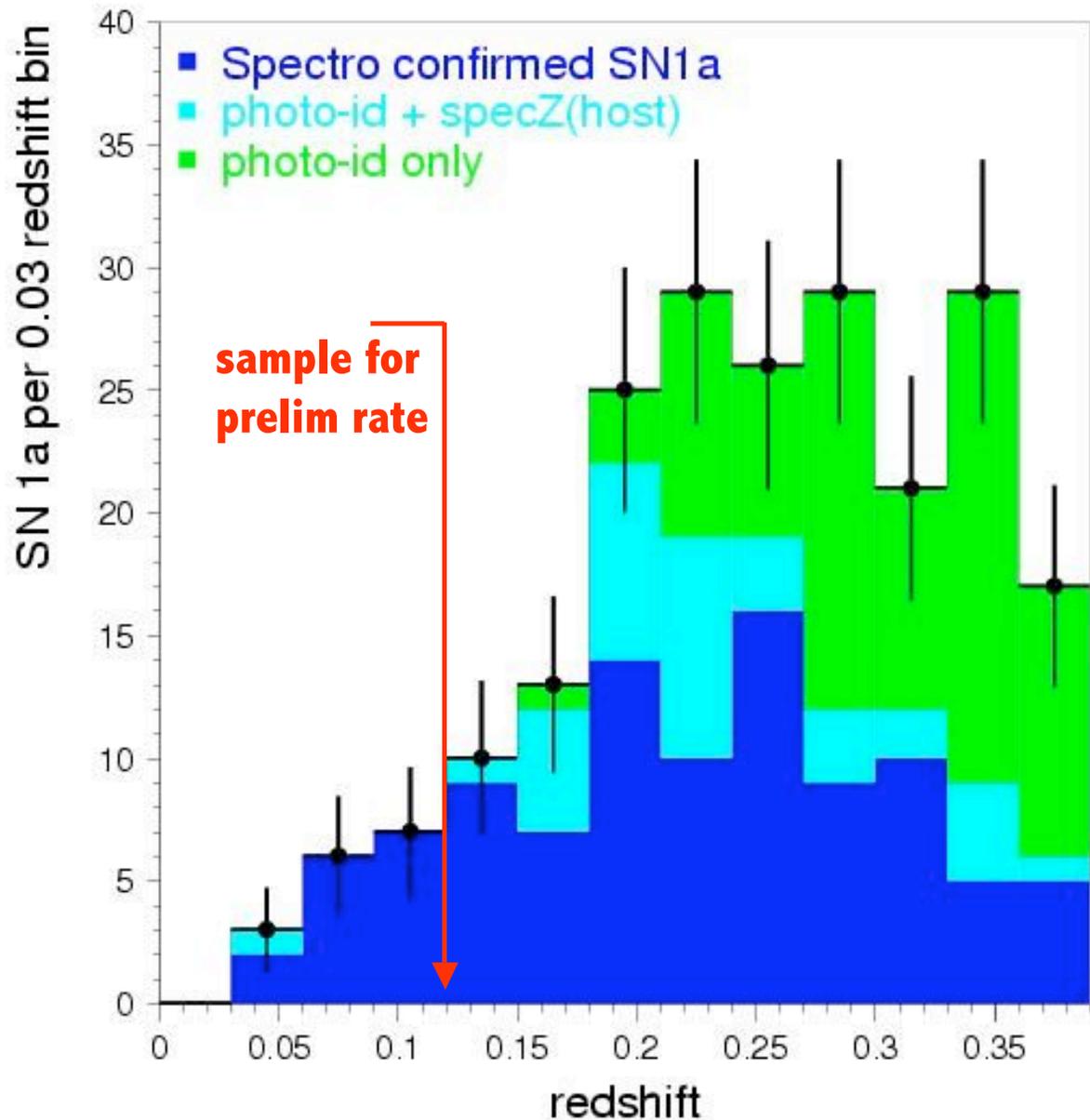
Figure from SNLS: astro-ph/0605148
(see Fig 1 caption for list of measurements)



SDSS Prospects for Increased Statistics

- ✓ x 2 volume if $z_{\max} \rightarrow 0.15$
- ✓ x 3 using all 3 seasons (2005,6,7)
- ✓ x 1.? relax selection requirements
- ✓ Potential 6-fold increase in statistics would give ~ 100 SN Ia for low-z rate.

Preliminary SDSS Redshift Distribution



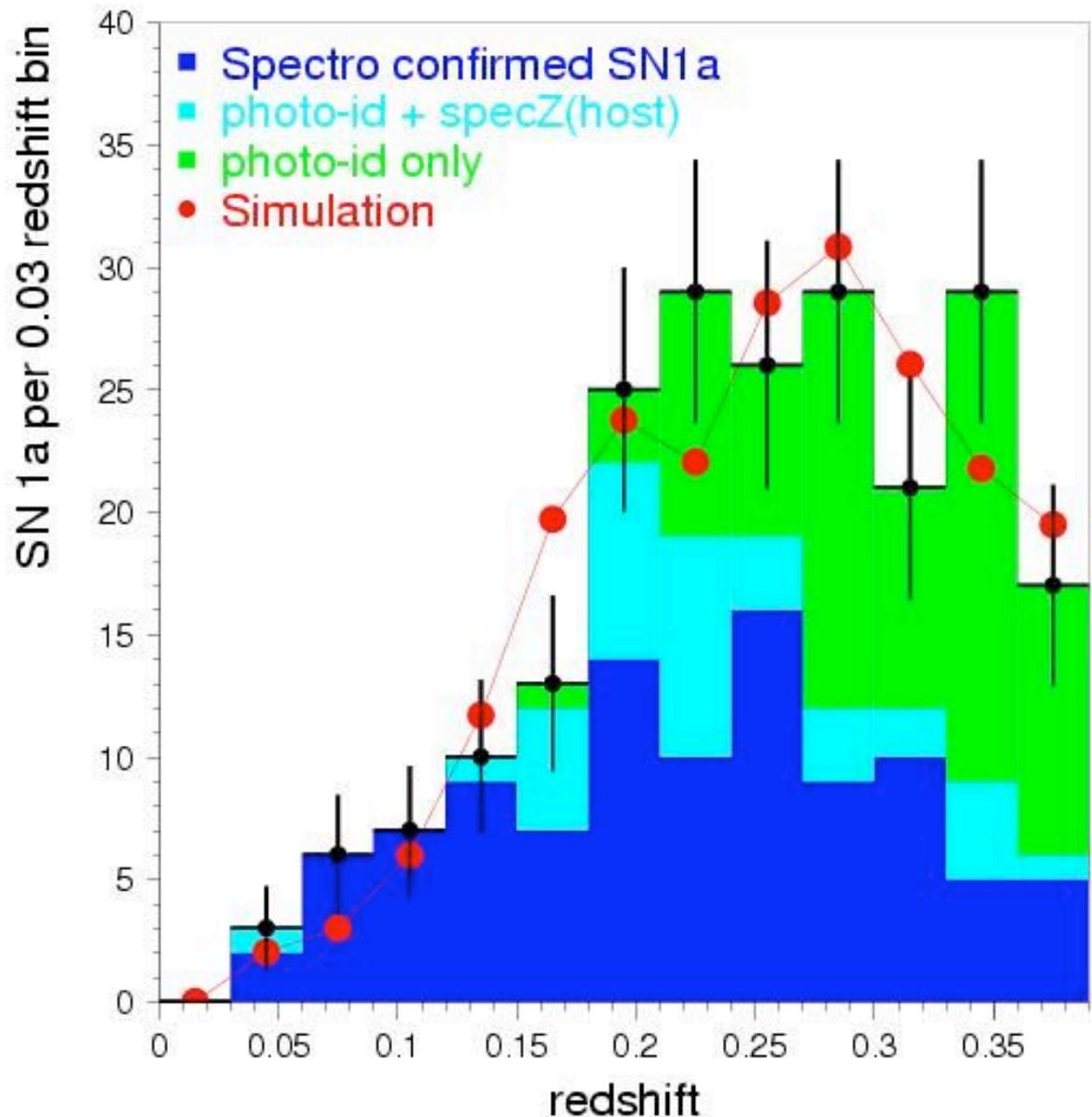
Photometric Selection of SN Ia:

- pre-max epoch
- rest-frame epoch past 18 days
- 5 or more epochs
- max SNR > 5 (g,r,i)
- MLCS fit-prob > 0.01
- sane luminosity parameter ($\Delta > -0.6$)



Rejects all 13 confirmed non1a-type SN
(2006 sample has 30 more non1a to test cuts)

Preliminary SDSS Redshift Distribution



Simulation looks promising: photometric SN Ia might be useful for rates and for cosmology systematics.

More host redshifts available soon.