CCSN Rate in SDSS-II

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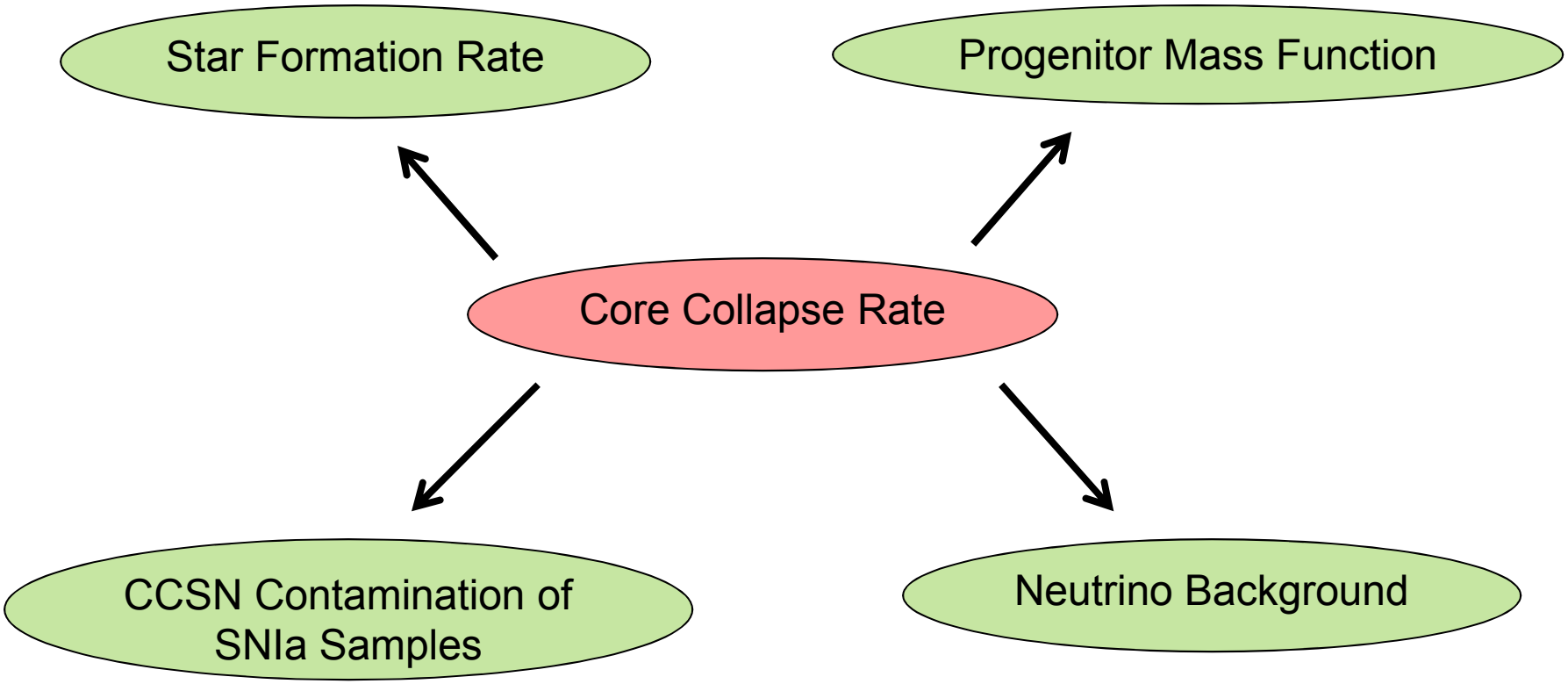
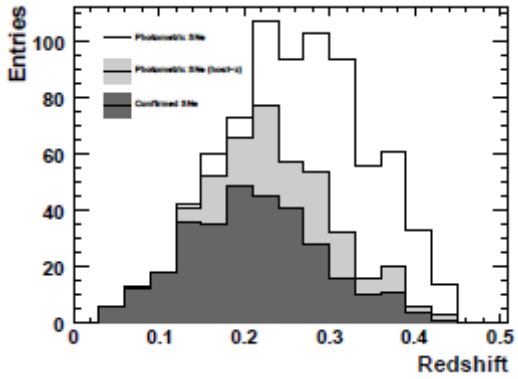
Why Measure CCSN Rate?



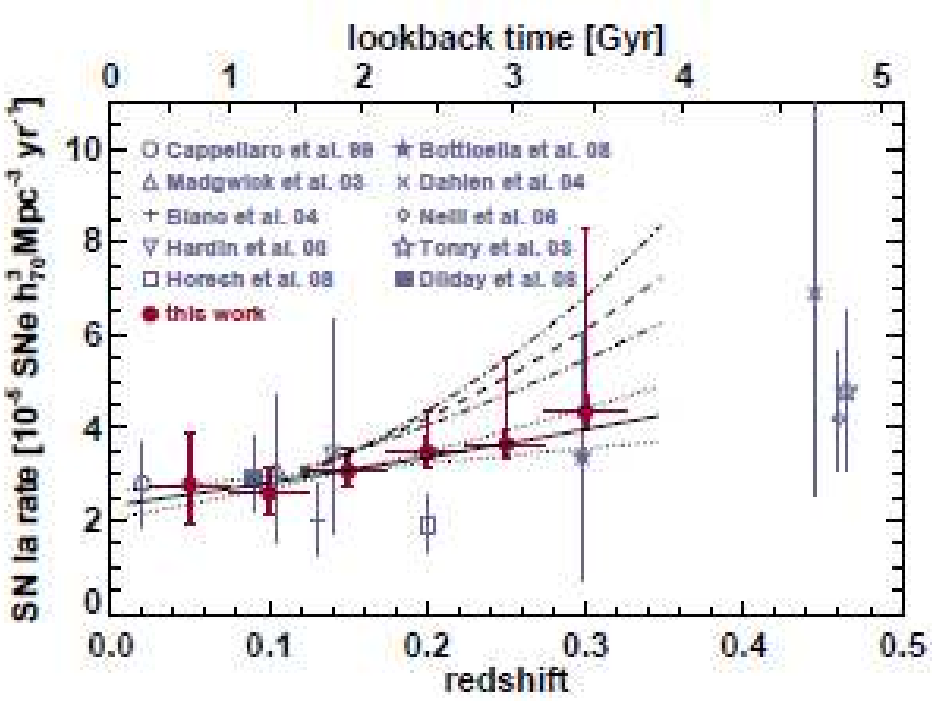
SNIa Rate from SDSS-II



774 SNIa passing all selection cuts

Table 5. SN Rate vs. Redshift

Redshift	SN Rate[a] $[10^{-5}$ SNe yr^{-1} Mpc^{-3} $h_{70}^3]$	$-\Delta N/N$[b]	$N_{\rm cc}/N_{\rm Ia}$
0.025 - 0.050	$2.78^{+1.12}_{-0.83}{}^{+0.15}_{-0.00}$	0.00 %	...
0.075 - 0.125	$2.59^{+0.22}_{-0.44}{}^{+0.18}_{-0.01}$	-0.06 %	$0.71^{+0.26}_{-0.13}$ %
0.125 - 0.175	$3.07^{+0.38}_{-0.34}{}^{+0.32}_{-0.05}$	-0.21 %	$2.99^{+2.37}_{-1.40}$ %
0.175 - 0.225	$3.48^{+0.32}_{-0.30}{}^{+0.02}_{-0.07}$	-0.21 %	$2.71^{+2.14}_{-1.37}$ %
0.225 - 0.275	$3.65^{+0.31}_{-0.28}{}^{+1.82}_{-0.15}$	+0.28 %	$2.06^{+1.63}_{-0.96}$ %
0.275 - 0.325	$4.34^{+0.37}_{-0.34}{}^{+3.06}_{-0.16}$	+1.86 %	$0.67^{+0.13}_{-0.11}$ %



Dilday et al., astro-ph/1001.4995 (2010, submitted to ApJ)

Our Approach

Low-z (0.025 – 0.075)

- Supernovae are well measured in this redshift range
- SN type is known with high confidence
- Directly exclude spectro- and photo-typed SNIa from CCSN sample

Mid-z (0.075 - 0.175)

- SN typing is not as secure
- Measure total SN rate, regardless of SN type
- Subtract SNIa rate, measured by Dilday et al., to find CCSN rate

High-z (0.175+)

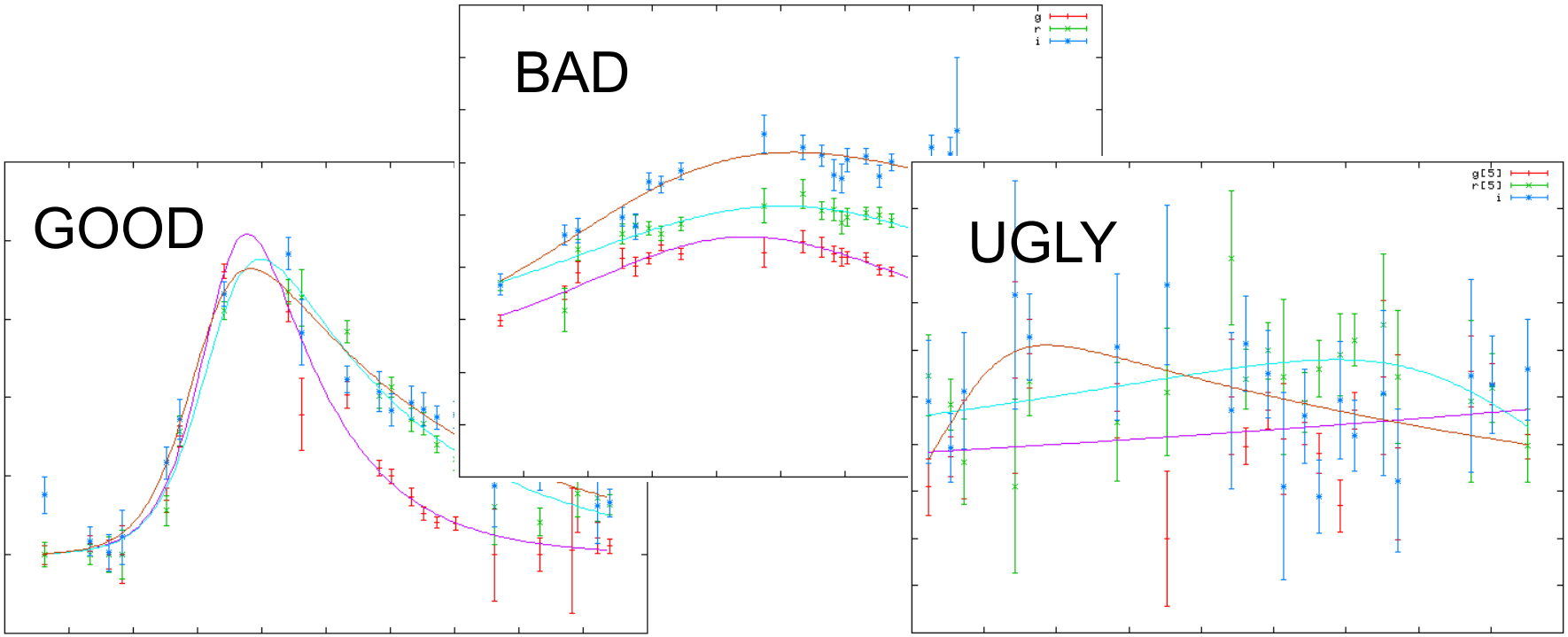
- Most CCSN are too dim to detect at this redshift with SDSS-II

Generalized Light Curve Fitting

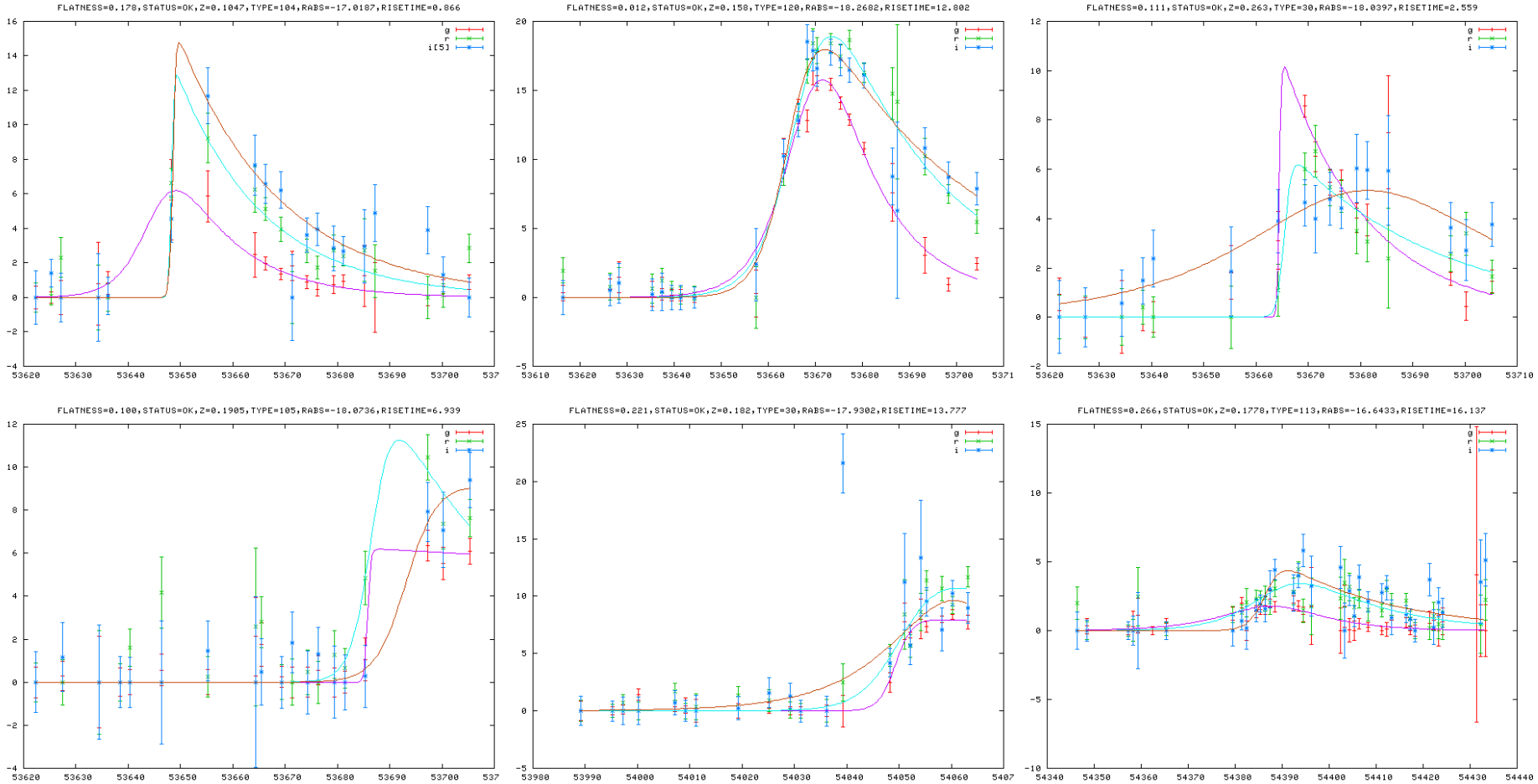
Method adapted from SNLS CC rate paper by Bazin et al.(2009)

$$f(t) = Ae^{-(\frac{t-t_0}{\tau_F})}(1+e^{-(\frac{t-t_0}{\tau_R})})^{-1}$$

Attempts to fit any light curve to a “peak”

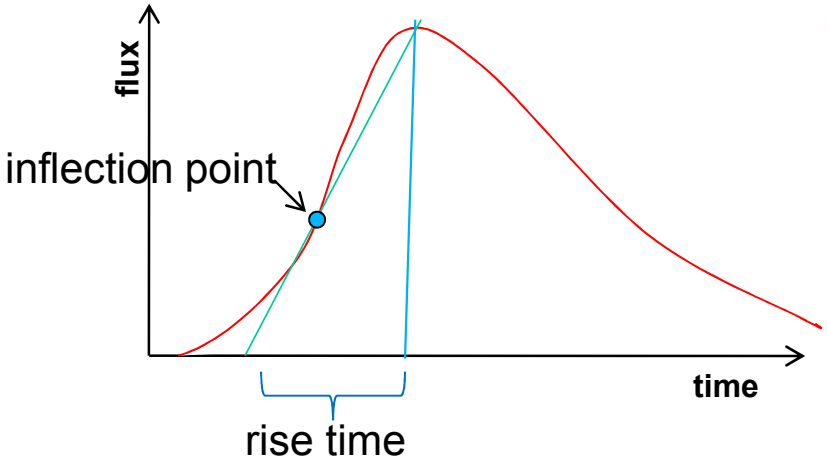


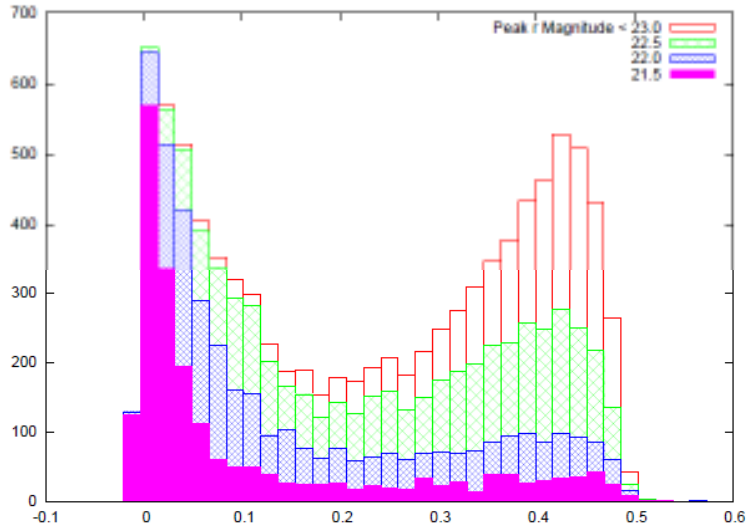
Sample Light Curve Fits



SN Selection Cuts

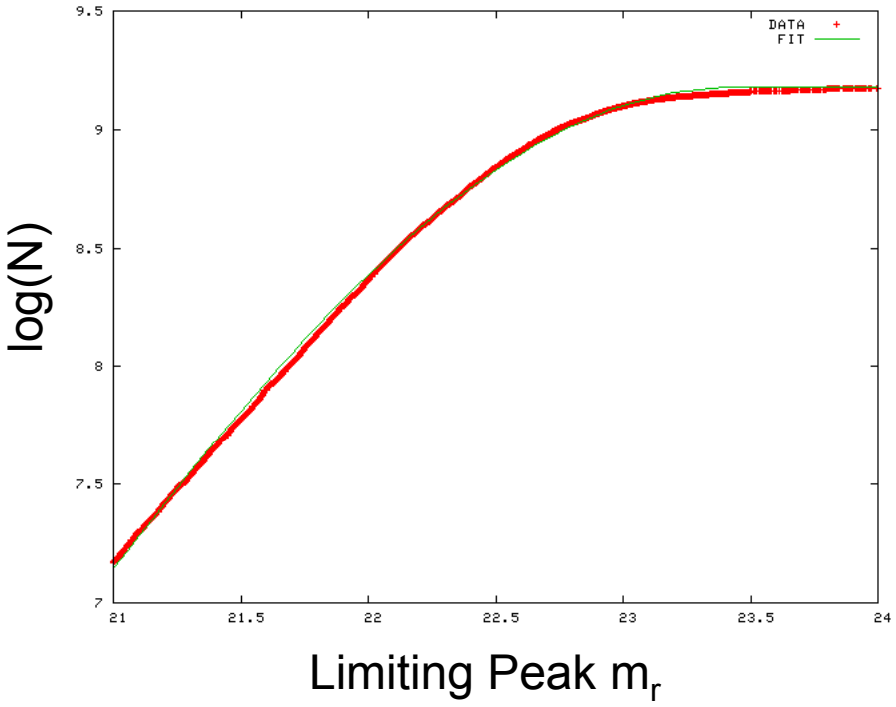
- Light curve fit must converge
- Peak M_r brighter than -15.4
- Observed 10 days before and after peak
- “Flatness” score less than 0.3
- Rise time less than 30 days





$$\text{Flatness} = \frac{X^2_{\text{model}}}{X^2_{\text{model}} + X^2_{\text{constant}}}$$

Efficiency Correction



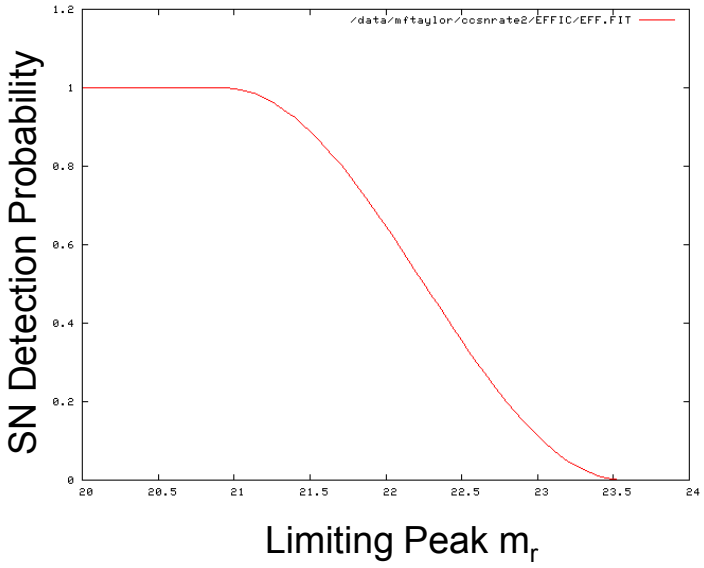
$$E(m) = \begin{cases} 1 & (m < m_1) \\ (1+\cos((m-m_1)/(\pi\Delta)) /2 & (m_1 < m < m_0) \\ 0 & (m > m_0) \end{cases}$$

Fit SN count vs. limiting magnitude to

$N = (c_3R^3 + c_4R^4 + c_5R^5 + c_6R^6) \times E(m)$

where

$R = 10^{mr/5}$



Corrected Rate Sample

	0.025 < z < 0.075	0.075 < z <0.175
Total Candidates	**655**	**2079**
Fit Non-Convergence	11	24
Flatness Cut	527	1420
Rise Time Cut	17	54
Subluminous Cut	19	4
Peak in Season Cut	21	53
Type Ia Cut	23	n/a
Base Sample	**37**	**524**
Efficiency Correction	0	129
Extinction Correction	2	8
Corrected Sample	**39**	**660**

Sources of Error

	0.025 < z < 0.075	0.075 < z <0.175
Corrected Sample Size	**39**	**660**
Statistical Error	**± 9**	**± 34**
Efficiency Correction	± 0	± 129
Extinction Correction	± 2	± 8
Photometric Redshift	± 15	± 106
Systematic Error	**± 16**	**± 167**

Rate Calculation

$$\text{SN Rate} = \frac{(\text{SN Count})}{(\text{Survey Volume}) \times (\text{Survey Time})}$$

$$\text{Survey Volume} = {}^{1}/_{3}\,\Omega\,(D_L(z_{max})^3 - D_L(z_{min})^3)$$

Low-z
(0.025 – 0.075)

$$\rho_{CCSN} = 0.72 \pm 0.16(\text{stat}) \pm 0.28(\text{sys}) \times 10^{-4}\ h^3 / (\text{Mpc}^3\ \text{yr})$$

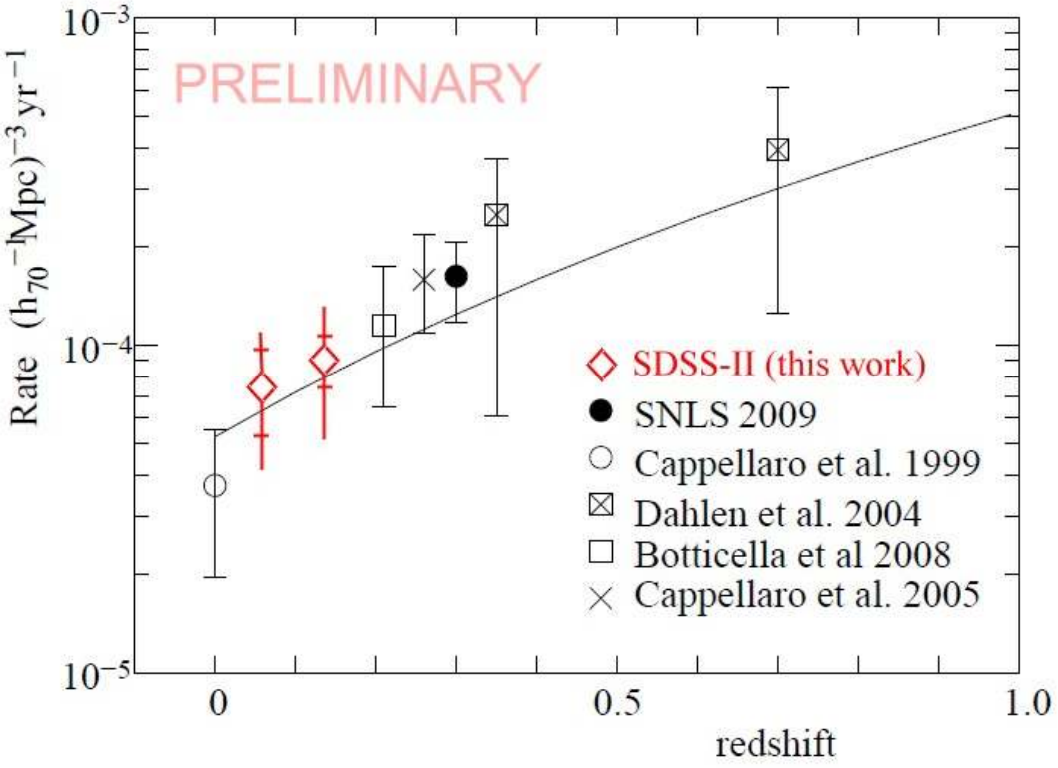
Mid-z
(0.075 – 0.175)

$$\rho_{SN} = 1.17 \pm 0.06(\text{stat}) \pm 0.30(\text{sys}) \times 10^{-4}\ h^3 / (\text{Mpc}^3\ \text{yr})$$

$$\rho_{SNIa} = 0.30 \pm 0.04(\text{stat}) \pm 0.04(\text{sys}) \times 10^{-4}\ h^3 / (\text{Mpc}^3\ \text{yr})$$

$$\rho_{CCSN} = 0.87 \pm 0.07(\text{stat}) \pm 0.30(\text{sys}) \times 10^{-4}\ h^3 / (\text{Mpc}^3\ \text{yr})$$

Comparison with Prior Work



Total SN Sample Sizes

Cappellaro 1999	54
Blanc 2004	34
Dahlén 2004	42
Cappellaro 2007	140
Bazin (SNLS) 2009	117
SDSS-II (0.025 < z < 0.075)	37
SDSS-II (0.075 < z < 0.175)	524

Figure adapted from SNLS CC rate paper by Bazin et al.(2009)

Future Work

- Human evaluation of light curves to measure error in cuts
- More host galaxy redshifts from SDSS-III are on the way
- Total SN Rate (Ia+CC) as a measure of star formation
- SN Luminosity Function