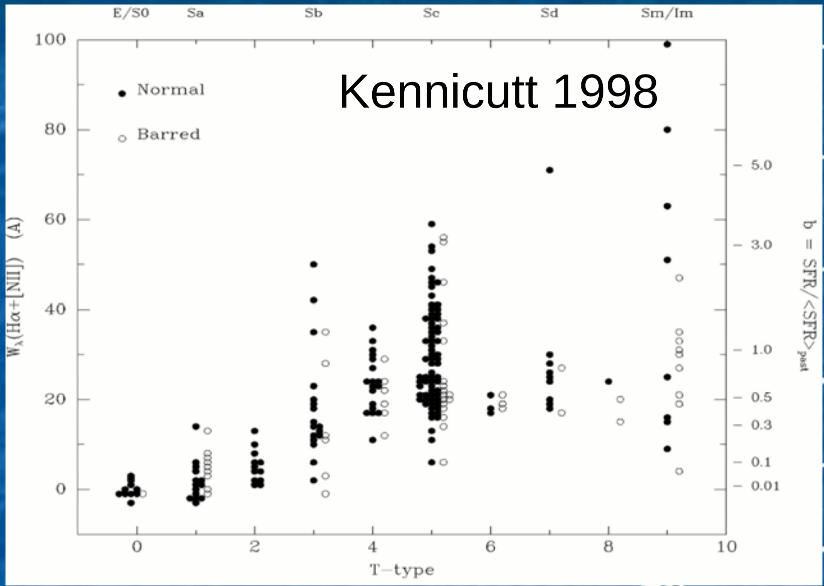
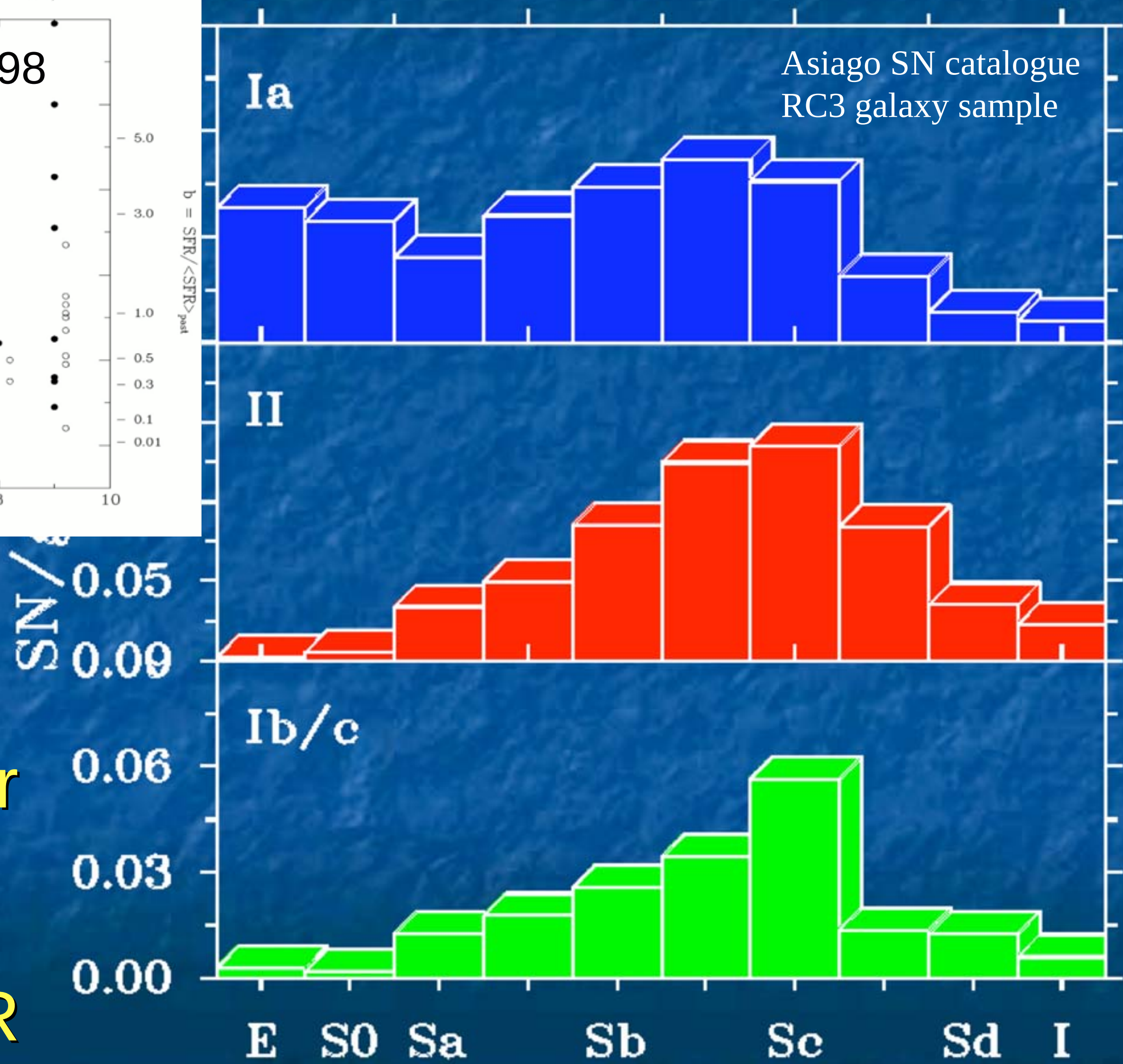
Some comments on supernova rates

Enrico Cappellaro

Osservatorio Astronomico di Padova
Istituto Nazionale di Astrofisica

Why to count for SNe





SFH

IMF & progenitor scenarios

SNR

Local SN rates

Cappellaro et al. 1999: 5 *historical* SN searches

Asiago (Italy)	Photograph	Cappellaro et al. 1993 A&A 268, 472
Crimea (Russia)	Photographic	Tsvetkov 1983 SA 27, 22
O.C.A. (France)	Photographic	Pollas 1994 in " Les Houches 1990, Bludman et al.
Calan/Tololo (Chile)	Photographic	Hamuy et al. 1993 AJ 106, 2392
Evans (Australia)	Visual	Evans 1997 PASA 14, 204

769

Coming soon: LOTOSS SN Search rates

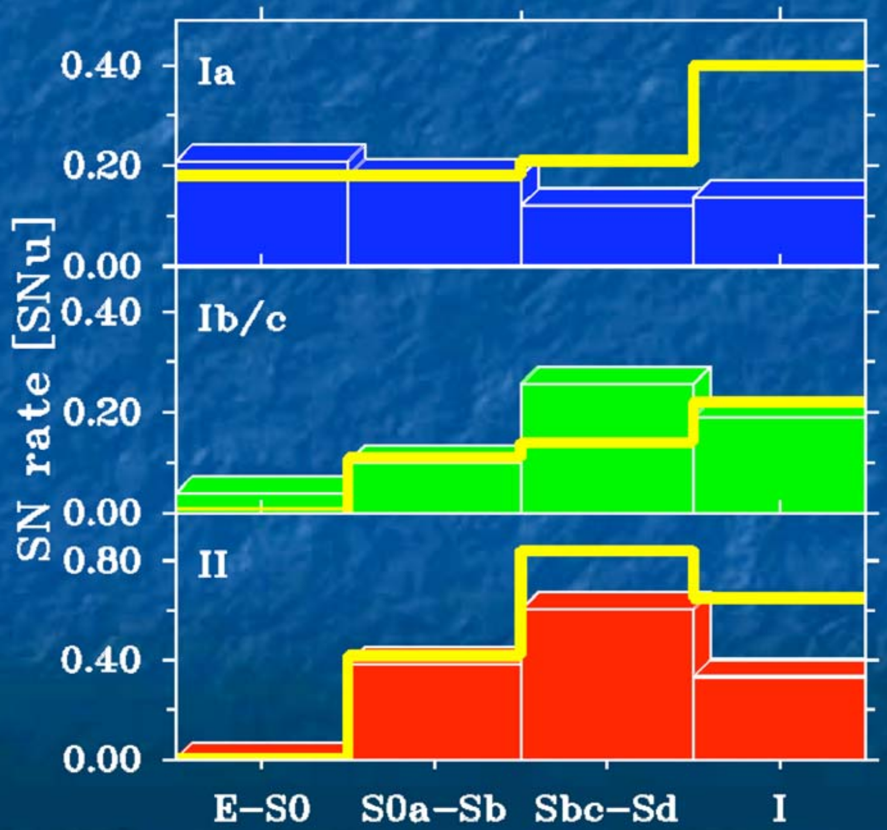
Jesse Leaman, Weidong Li, Alex Filippenko ......

Improvements:

- deeper (3-5 mag)
- accurate detection efficiency (CCD vs photog.)
- detailed SN spectral typing (ie. Ib/c)
- better statistics (~ x 5)

SN rates vs. recent discovery record

- *lines: rates from Cappellaro et al. 1999*
- *box: SN list, z < 0.01, period 2000-2006, RC3 normalization (galaxy type, luminosity)*



rate	from search
0.24	0.22
0.12	0.15
0.48	0.33

SNIa progenitor population

SN Ia explode (also) in Elliptical galaxies

van den Bergh (1959) Ann.Ap. 22,123; Bertaud (1961) Ann.Ap. 24, 516

→ progenitors are long lived, low mass stars

High rate of SN Ia in spirals

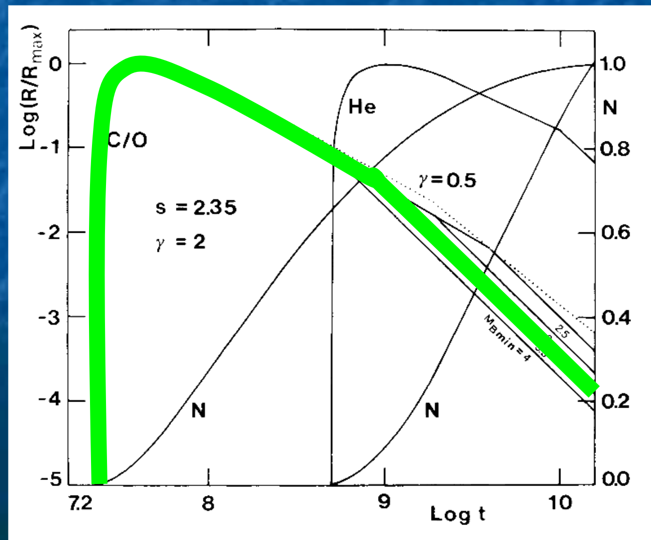
Oemler & Tinsley (1979)

→ most type Ia SNe come from short lived stars

↓

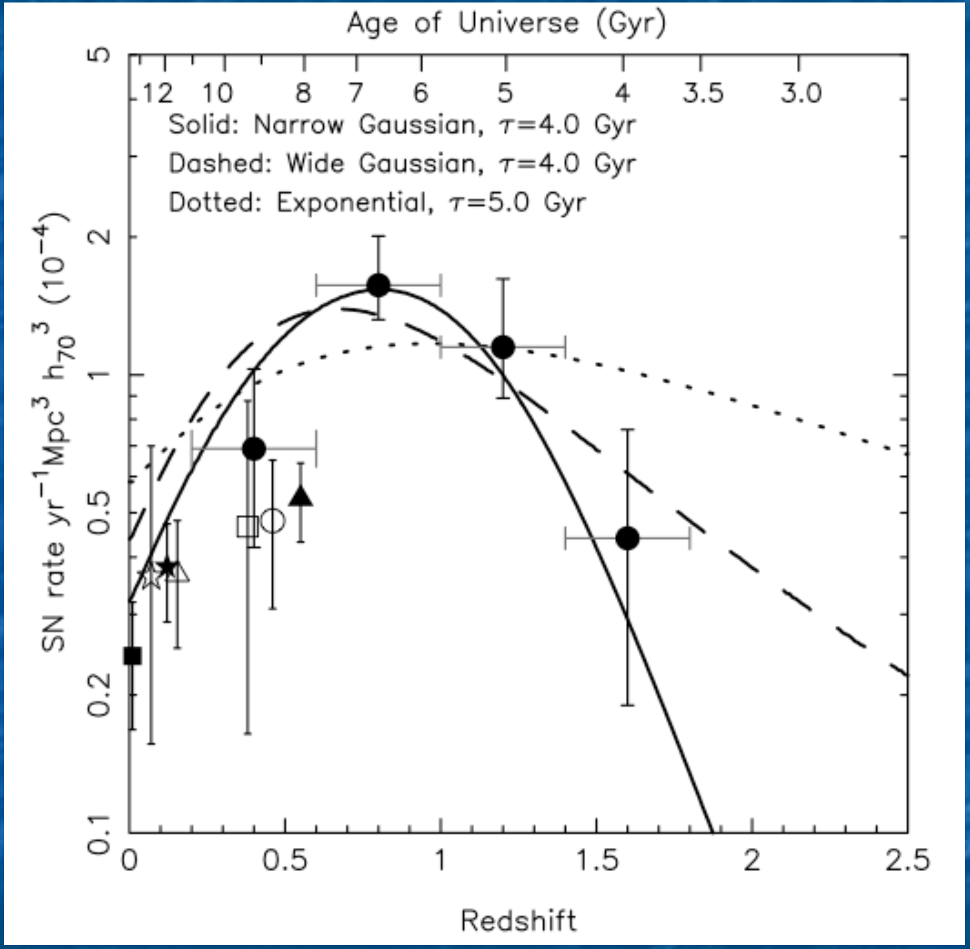
Wide distribution of delay times

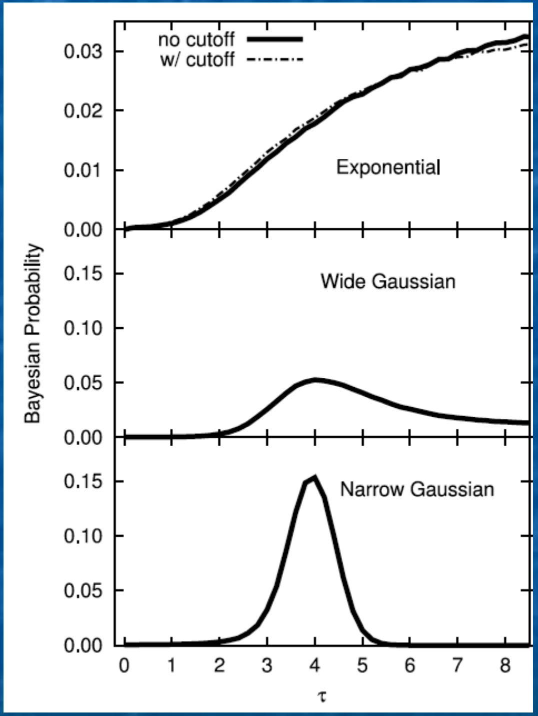
Greggio & Renzini (1983)



Cosmic evolution of SN Ia rate

Dahlen et al. 2004 ApJ 613,189
Strolger et al 2004 ApJ 613,200





SN Ia progenitors are 3-4 Gyr old

SN rate per unit mass

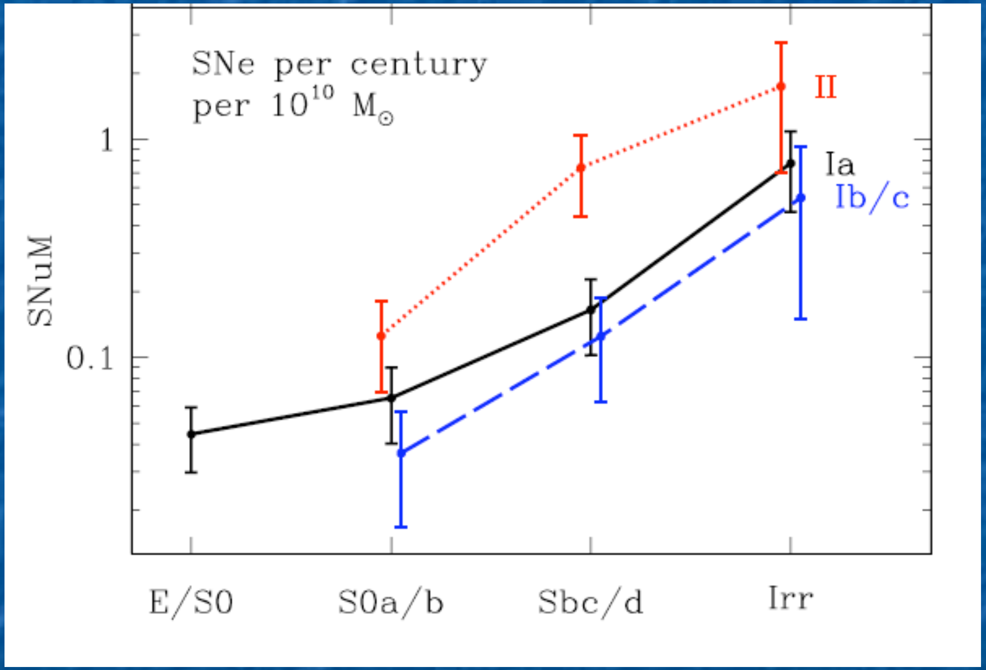
Mannucci et al. 2005 A&A 433,807

- SN rate in SNu from Cappellaro et al. 1999
- B ⟶ K galaxy magnitude normalization (from 2MASS)
- *log* (M/L_k) ∝ B-K

1. SN Ia rate x unit luminosity constant from E to late S
2. M/L 10 times higher in E than in late S

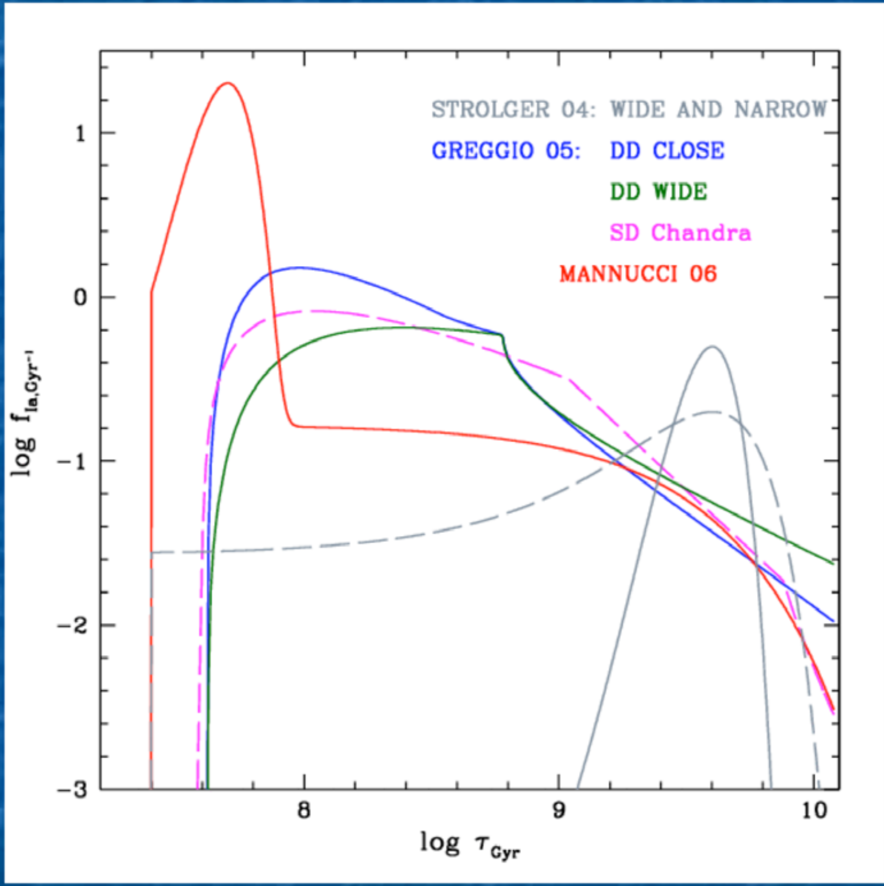
⇓

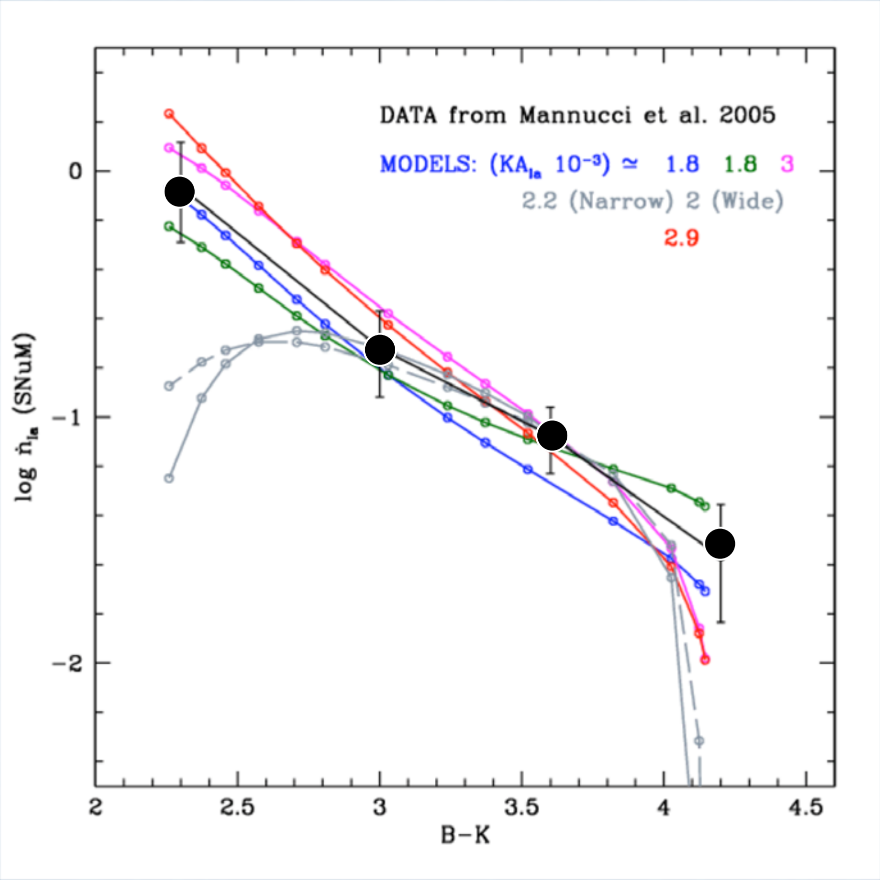
rate x unit mass 10 times lower in E than in late S



most SNIa in local spirals are from "young" progenitors

SN rate per unit mass





Laura Greggio

Why Are Radio Galaxies Prolific Producers of Type Ia Supernovae?

Della Valle et al. 2005, ApJ 629, 750

Radio	Galaxies	SNe	Rate SNu(B)
Quiet	1729	7.5	$0.11^{+0.06}_{-0.03}$
Faint	212	4	$0.23^{+0.18}_{-0.11}$
Loud	267	9.5	$0.43^{+0.19}_{-0.14}$

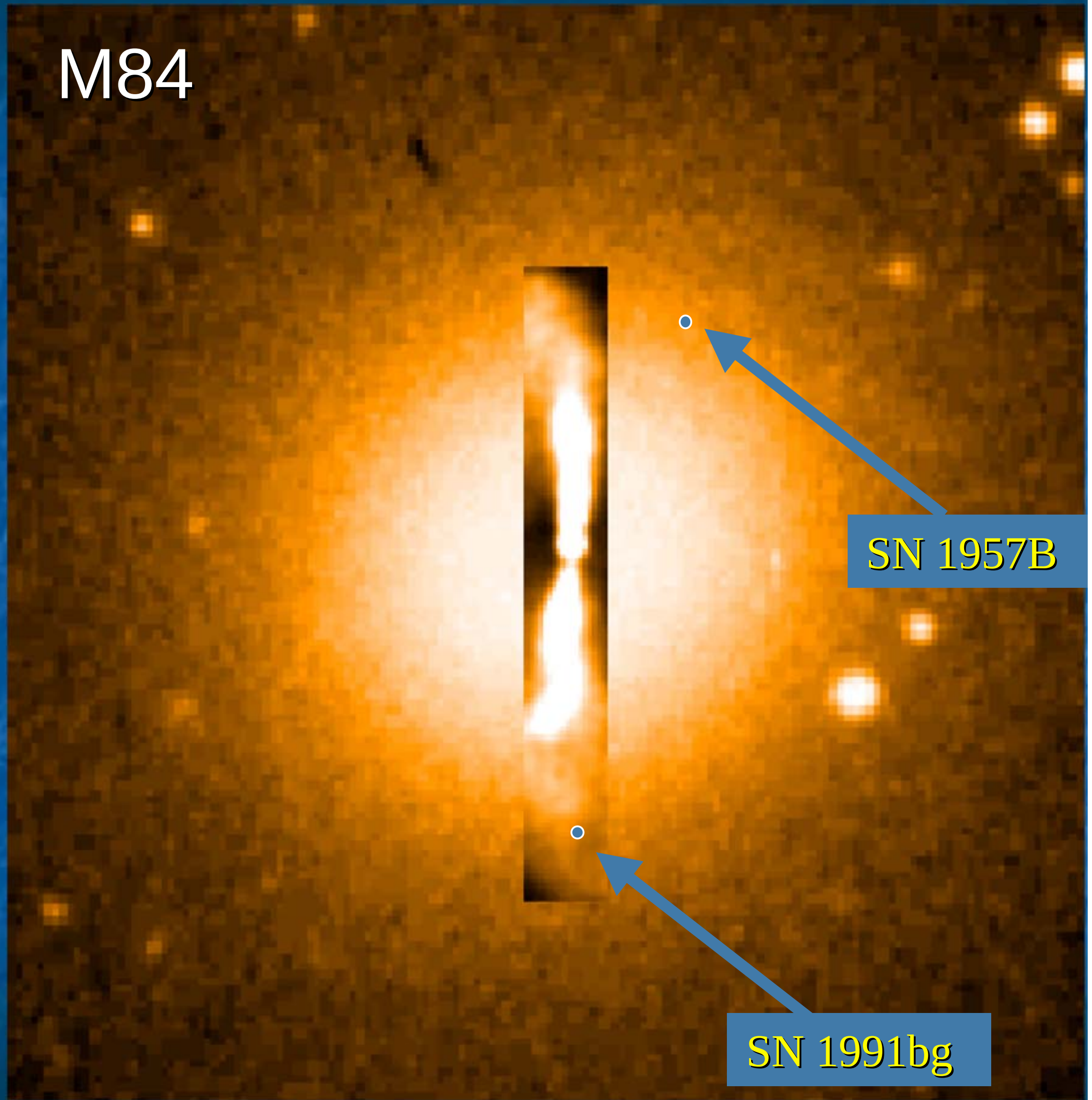
two proposed scenarios:

1. ‘jet-induced’ accretion
2. enhanced star formation after merging

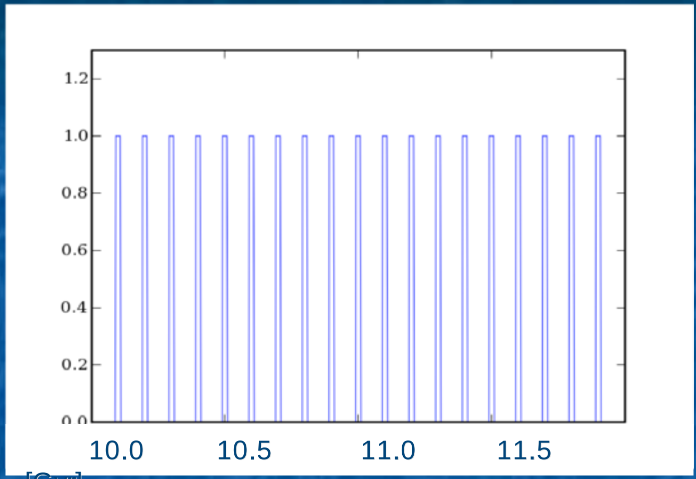
Jets may lead to an increase of the accretion onto the WDs from either ISM or the companion.
Capetti (2002), Livio et al. (2002)

⬇

SN Ia should be located close to the radio jet

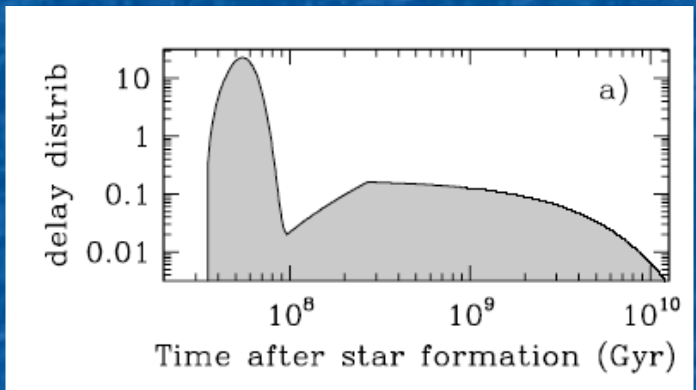


Mannucci, Della Valle & Panagia 2006, MNRAS 370, 773

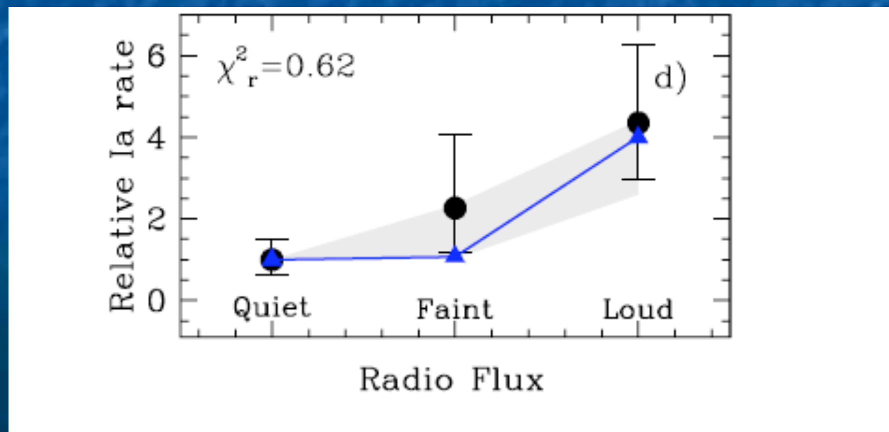


• 3% of stars in Es are produced in recurrent, short SF bursts after merging This also triggers radio.

•10% of Es are active at any given time



50% of SNIa come from very short delay (<10^8 yr)



Core collapse SNe in Ellipticals

	E	Sc
Ia	58	137
Ib/c		74
II		254
CC	5%	

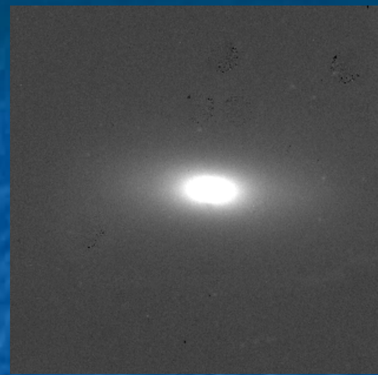
different IMF ?

>15 Ia fro

prompt channel

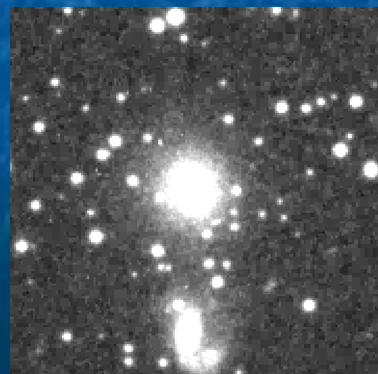
> 40 core collapse in Es are expected

SN2000ds in NGC2768
type Ib
E3/Sa



GC4589

SN2005md in NGC2274
type II
interacting pair



SN rate evolution with cosmic time

VST: a 2.5m telescope + 1sq deg optical camera

to be installed at Paranal in ~~2002~~ 2007

VST: M1 upon arrival at Paranal

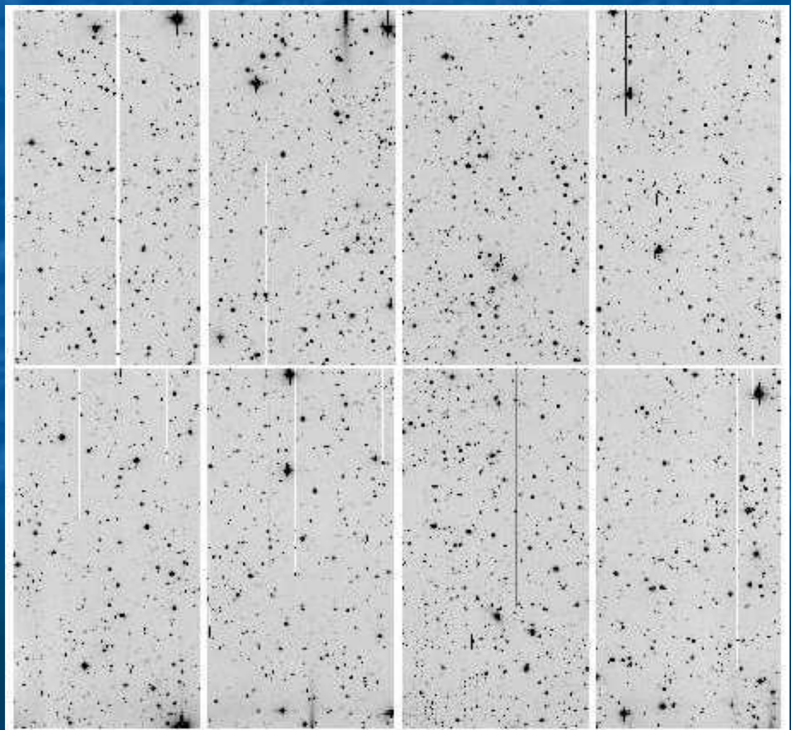
It became known on May 6, 2002

Southern Intermediate Redshift ESO SN Search

Cappellaro et al. 2005, Botticella et al. in preparation

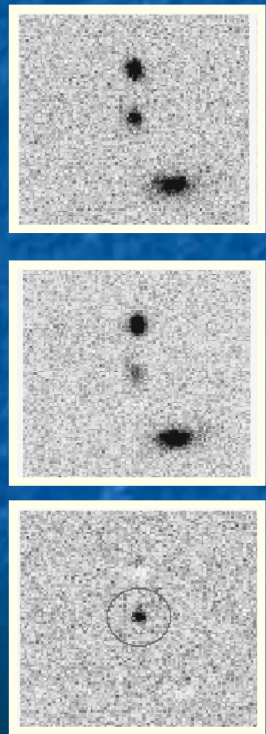
ESO WFI@2.2m

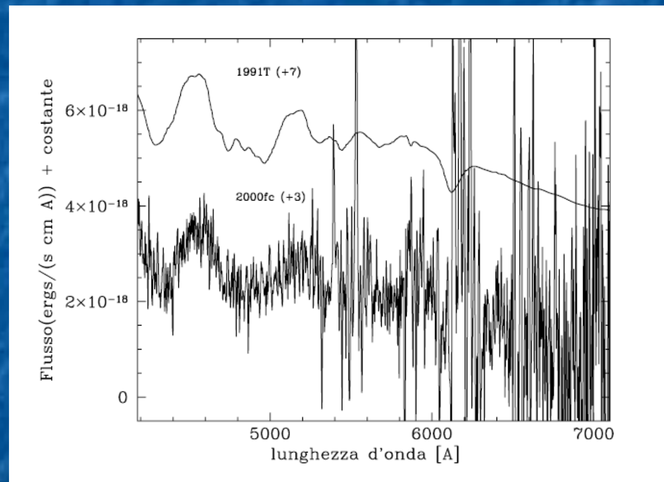
field of view: 34’x 33’
pixel scale: 0.238 arcsec/pix
effective search area ~5.1sq.deg
25(+13) nights



ESO VLT+FORS1/2

spectroscopic follow-up
13 nights





SN 2000fc Ia z=0.42

Pros

- unbiased candidate selection
- both Ia and CC rates
- well defined galaxy sample
- detailed error analysis
- improved treatment of extinction correction

Cons

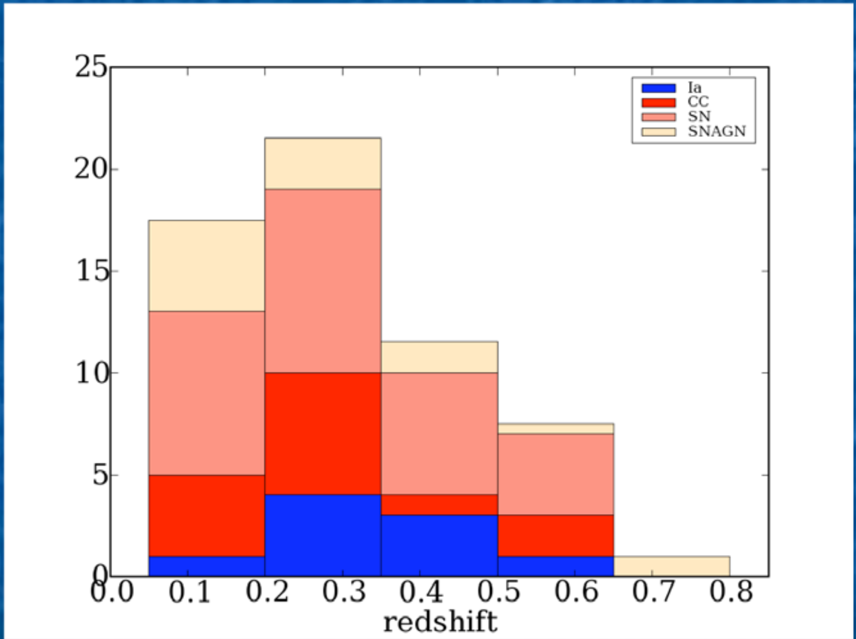
- only 40% SN spectroscopic classification
- U band not available
- limited redshift range

Southern Intermediate Redshift SN search

Botticella et al. 2007

~200 candidates

~60 long term variability AGN



41 direct spectroscopy

15 Ia 14 II 5 Ib/c

7 AGN

44 host galaxy spectra

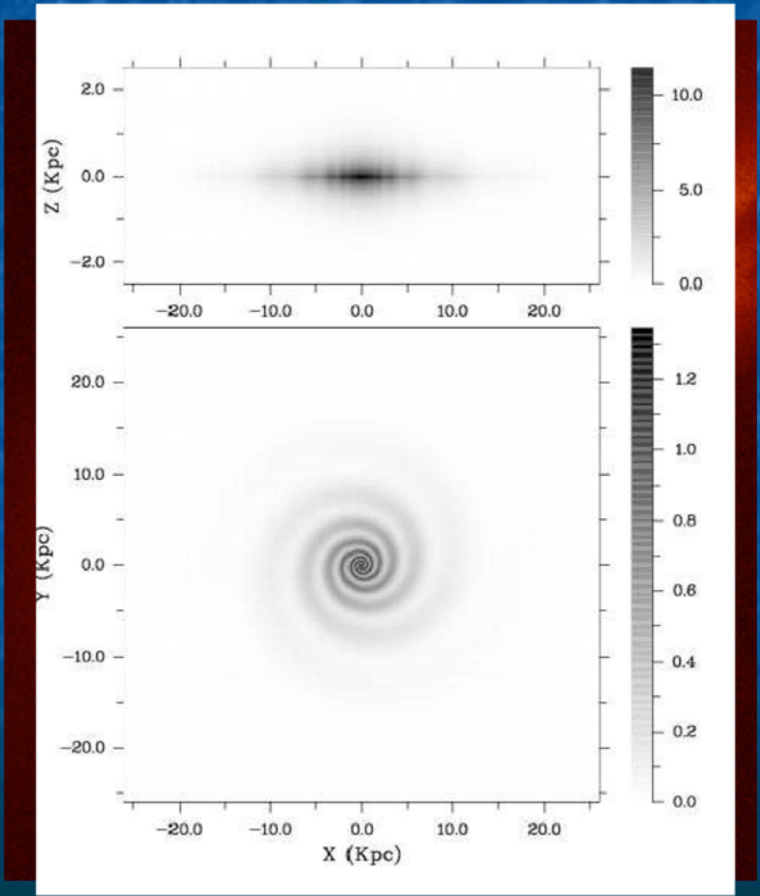
22 AGN

Photometric redshifts for ~40000 galaxies

Extinction correction

Riello & Patat 2005

Modeling of dust and SN distribution in spiral galaxies



Dust optical depth calibrated to reproduce the average extinction of observed SNe

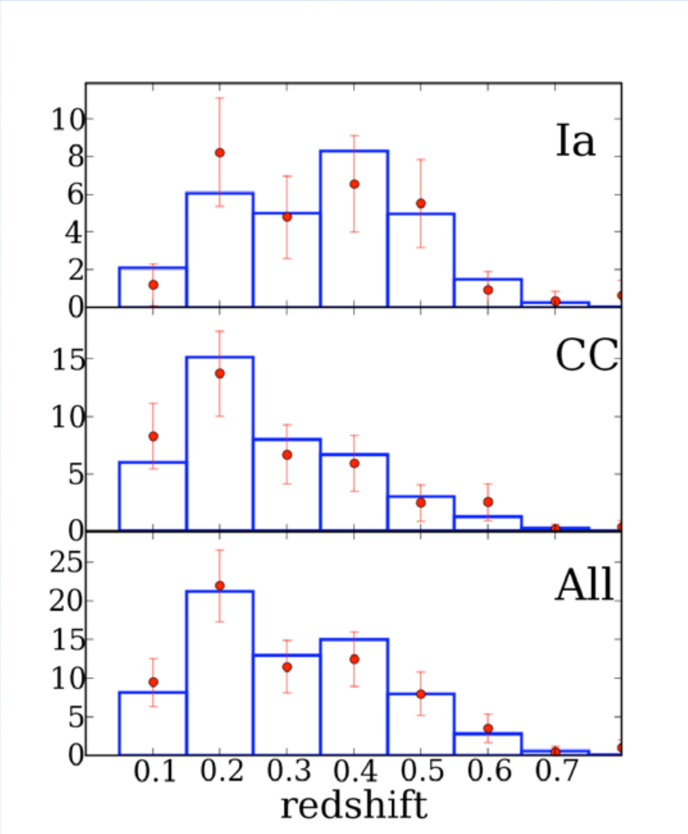
~0.3 mag SNIa, ~0.7 mag SN CC

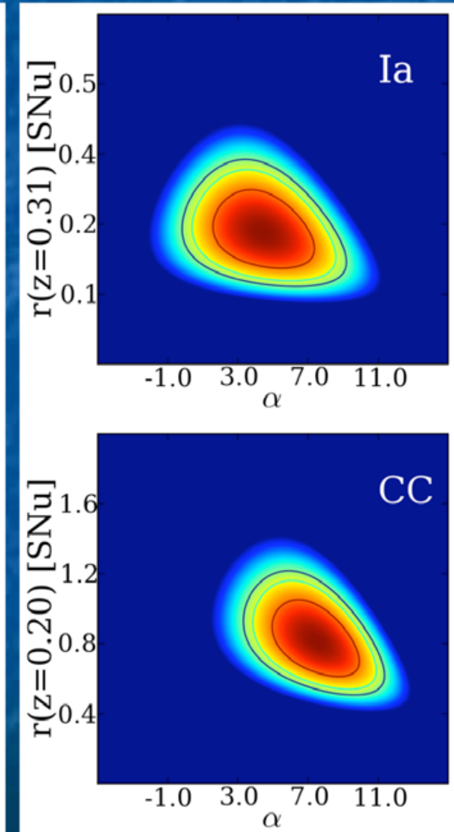
Output: extinction distributions for SN population of the different types, for selected observing band and redshift

SN rates are derived from maximum likelihood fit of the observed SN redshift distribution

$$N_{SN}(z) = r_{SN}(\bar{z})\left(\frac{1+z}{1+\bar{z}}\right)^{\alpha SN} \cdot CT(z)$$

$$\bar{z} = \frac{\sum z \cdot CT(z)}{\sum z}$$





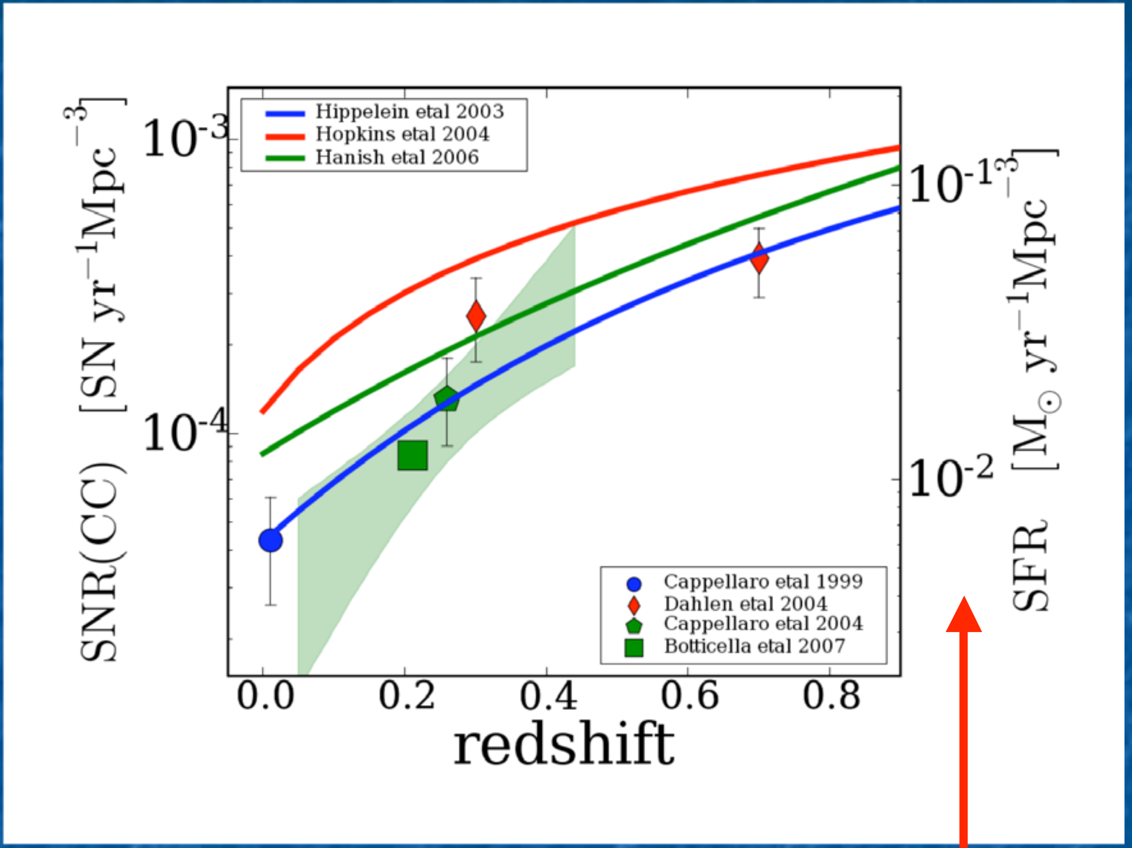
$$rIa(z=0.31) = 0.22^{+.10}_{-.08}\ \text{SNu}$$

$$\alpha Ia = 4.4^{+3.6}_{-4.0}$$

$$rCC(z=0.21) = 0.81^{+.32}_{-.25}\ \text{SNu}$$

$$\alpha CC = 7.5^{+2.8}_{-3.4}$$

Core collapse rate evolution

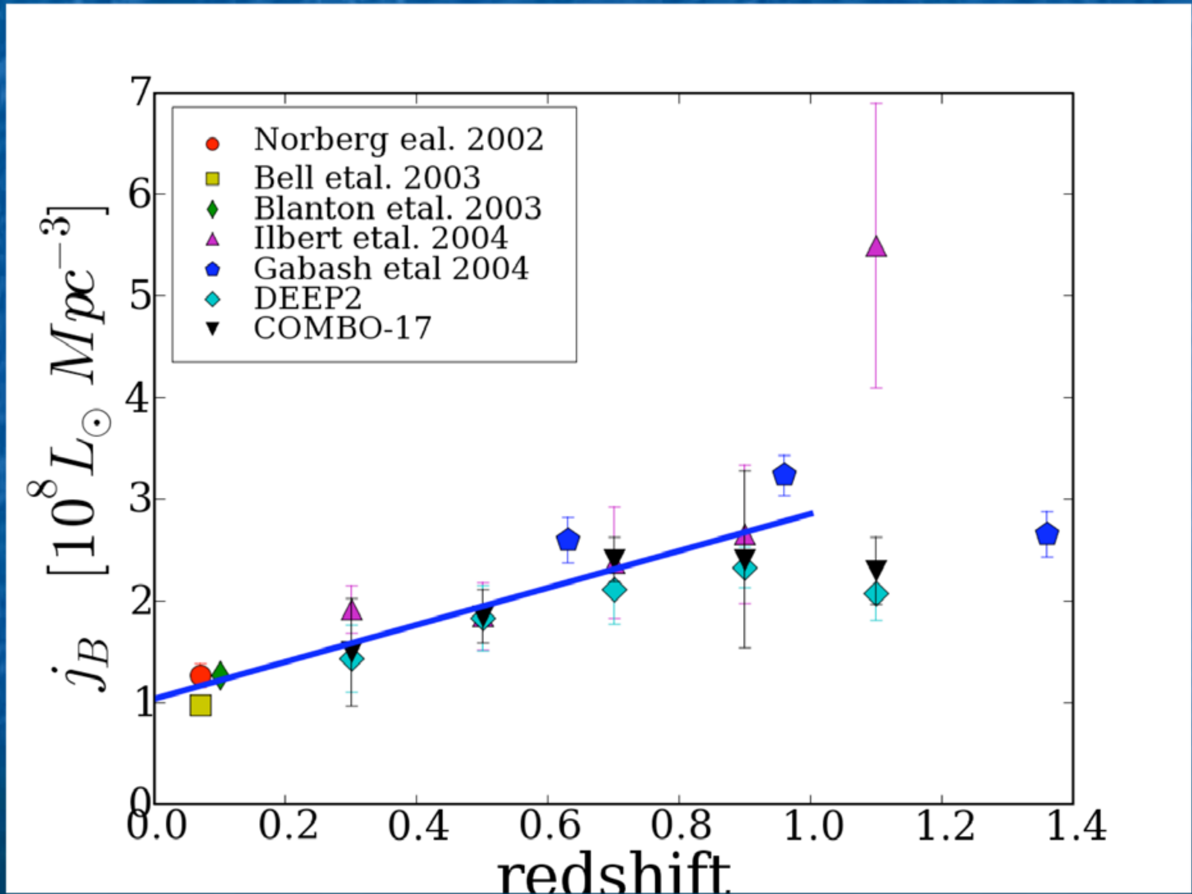


$$\dot{\rho}_{SNCC} = \dot{\rho}\frac{\int_{M_L}^{M_U}\psi(M)dM}{\int_{0.1}^{100}M\psi(M)dM}$$

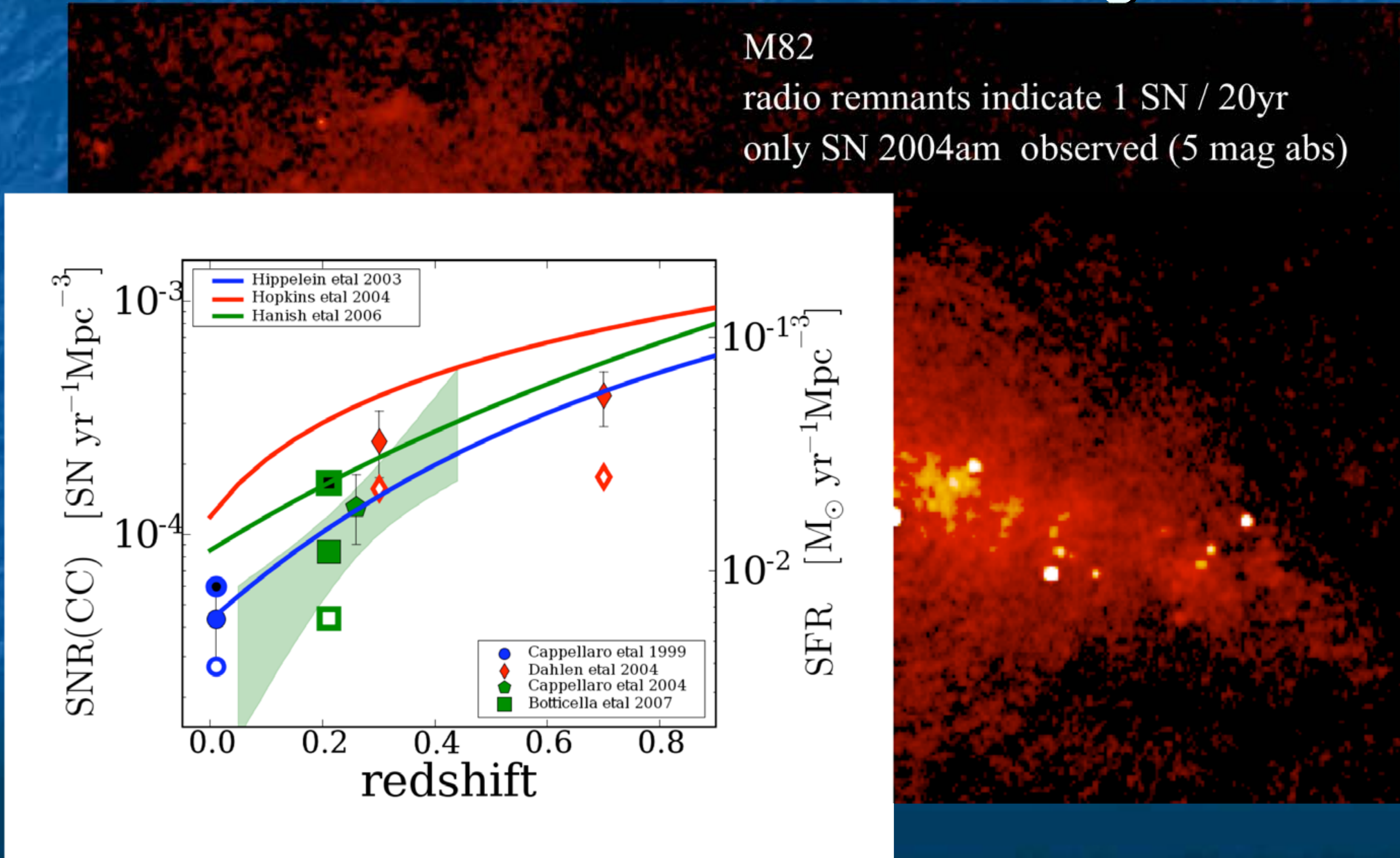
Salpeter A IMF

M_L=9 - M_U=40

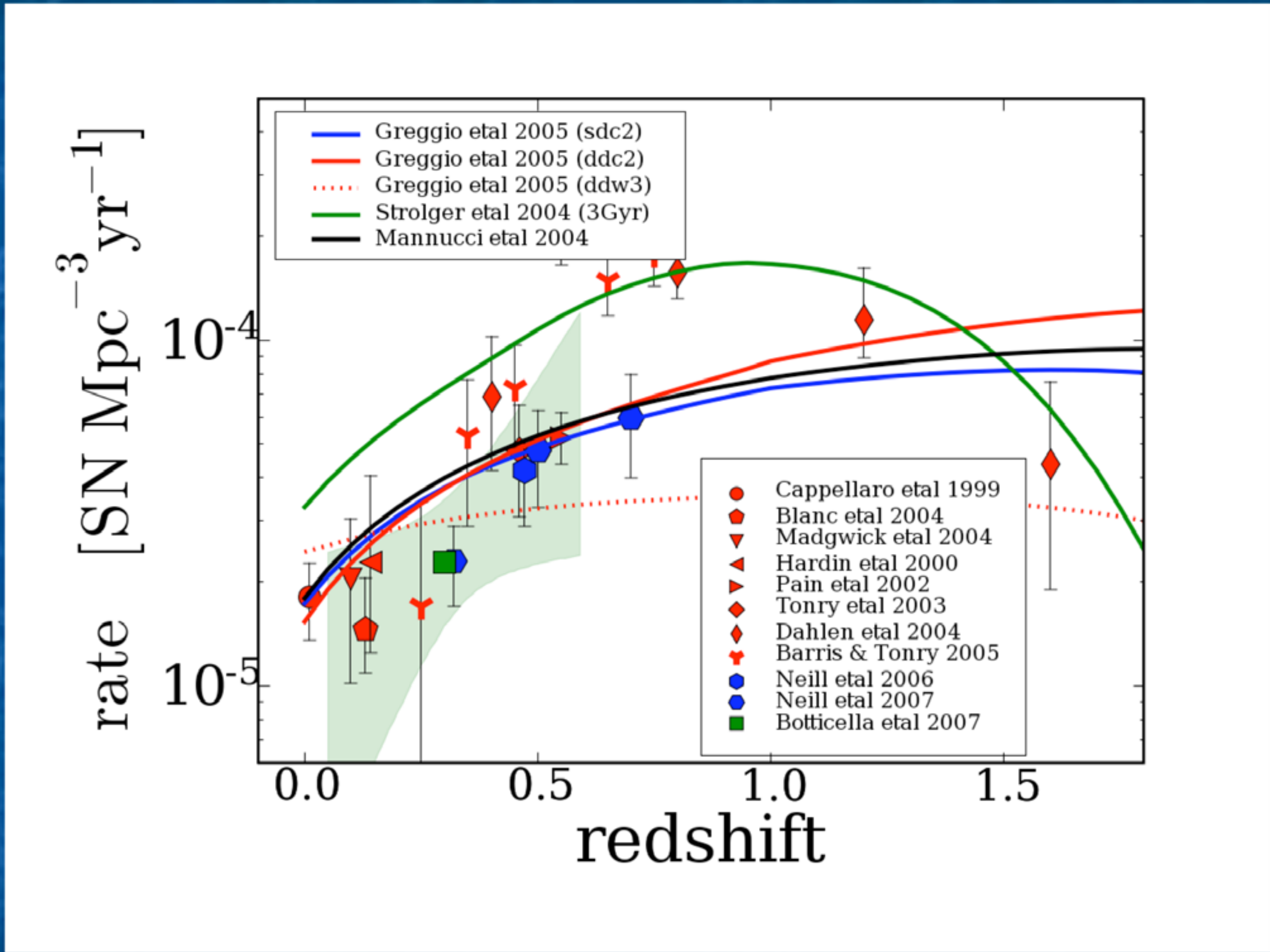
Local rates are per unit luminosity. High-z rate are (usually) per unit volume. Conversion requires to adopt an evolution of the luminosity density



what is not accounted for:
SN in the nucleus of starburst galaxies

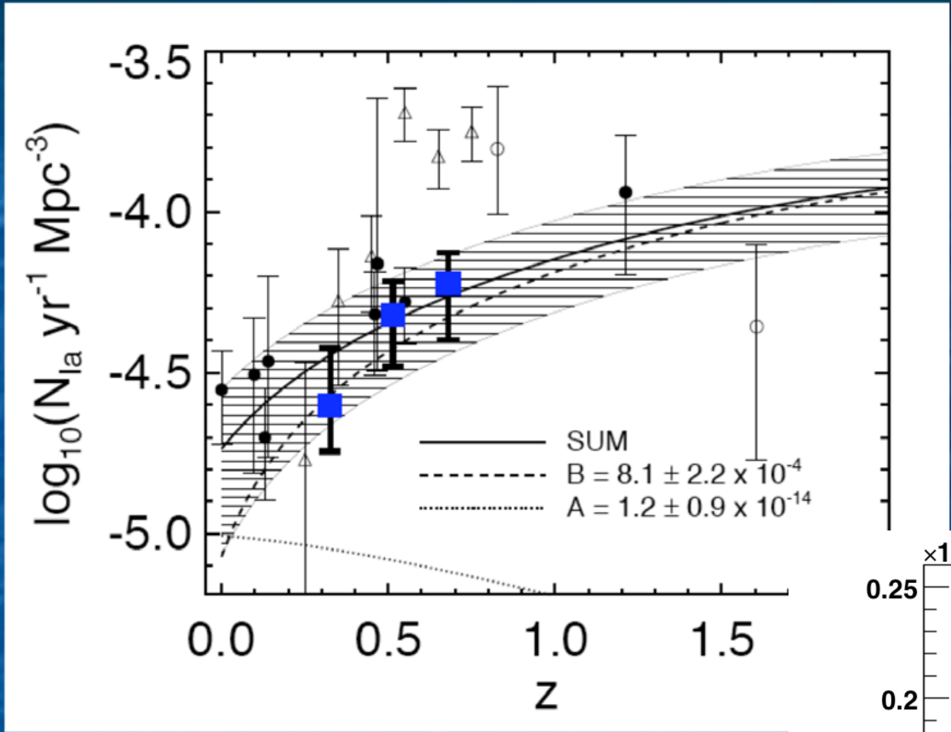


SN Ia rate evolution

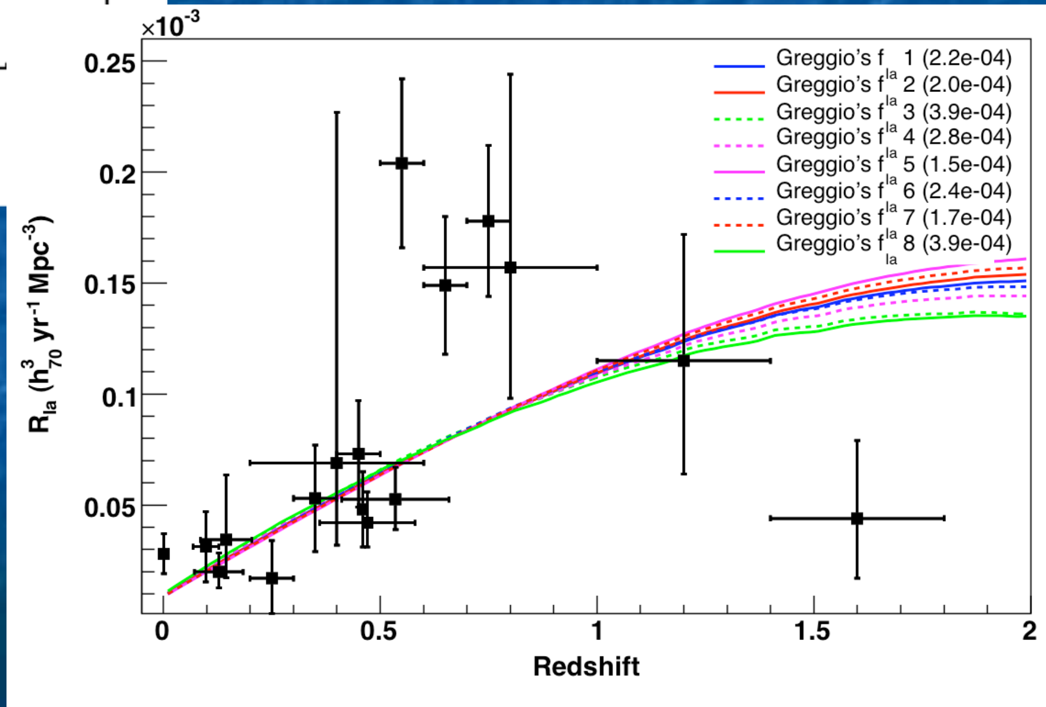


Assuming SFR as in Hopkins & Beacon 2006

Neill et al. 2007 (astro-ph/0701161)



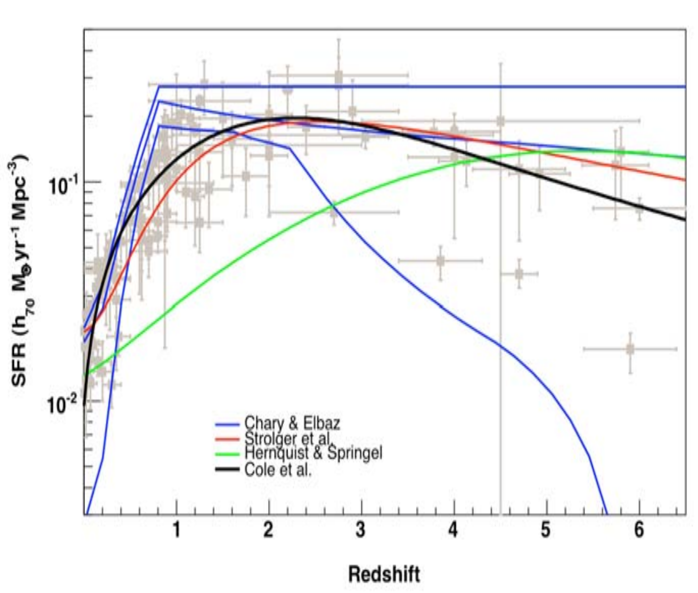
Blanc & Greggio in prep.



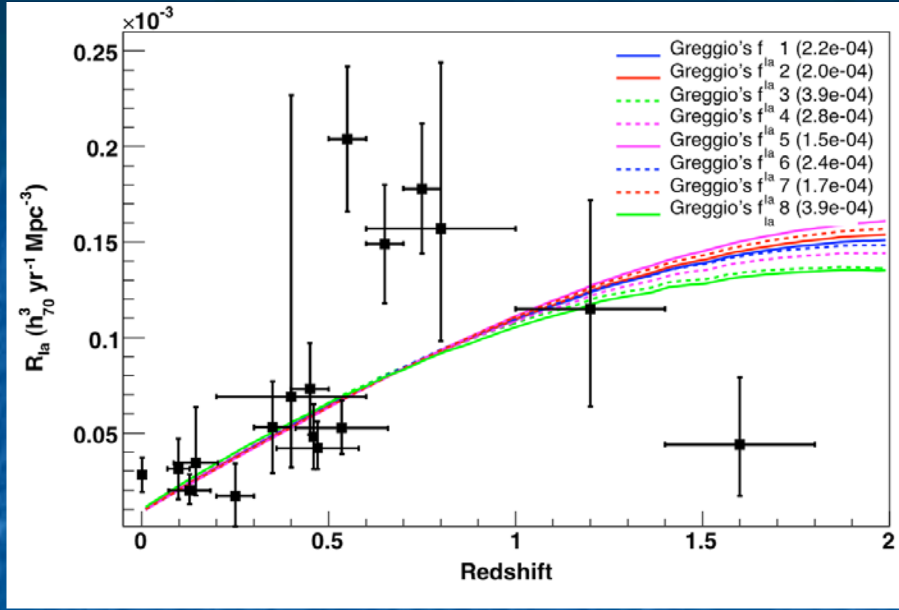
SFR from
Cole et al. 2001
Hopkins & Beacom 2006

Blanc & Greggio preprint

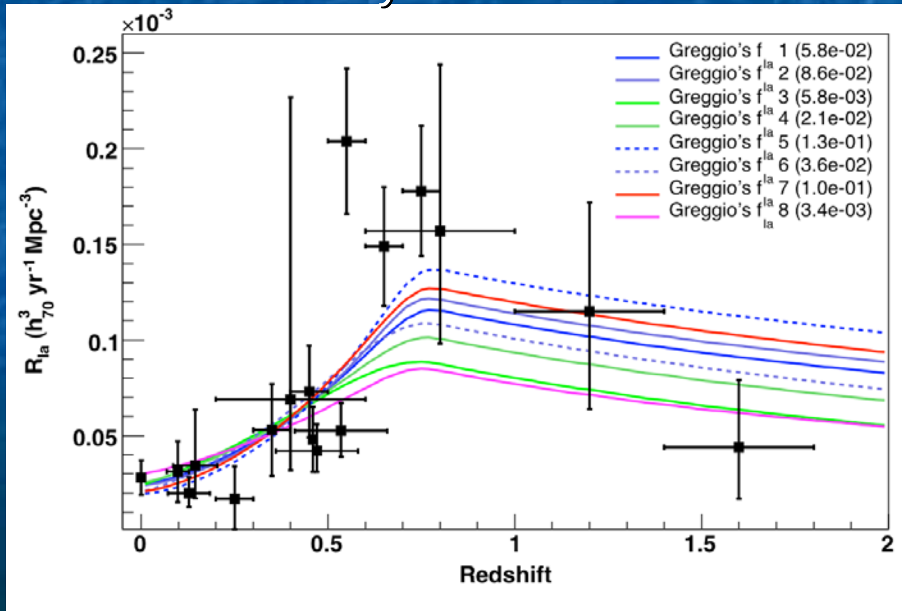
Star formation rate evolution



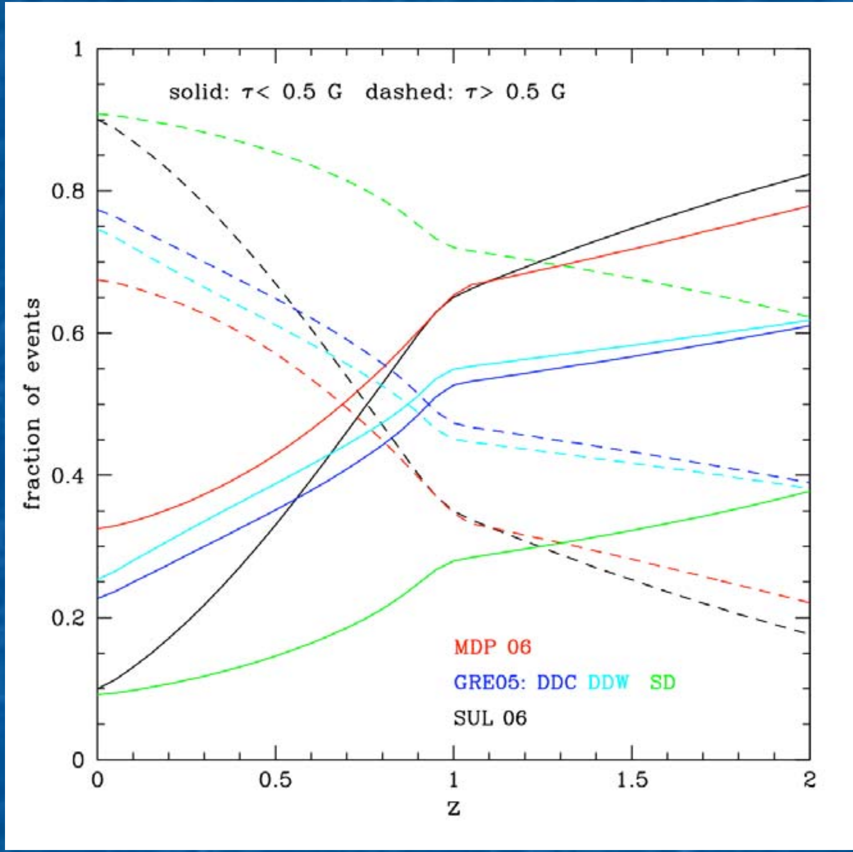
SFR from Cole et al. 2001



SFR from Chary & Elbaz 2001



SN progenitor age with redshift



Convolved with SFH

Gyr	sd2	dd2	Mannucci
<0.1	2%	6%	25%
<0.5	14%	48%	29%
<1.5	35%	61%	37%
<2.5	47%	67%	46%
<5	66%	77%	66%

Most local SN Ia are from old progenitors
High-z SN Ia are from young progenitors

Conclusions

Possible inconsistency in the calibration of SFR and CC SN rates. From SN side problem may be extinction correction.

For rate determination systematics is now more important than statistics

Star formation history causes uncertainties in the SNIa rate prediction as large as the delay time function

Most of SN Ia in the local and low-z Universe are from middle age progenitors.

All current scenarios predict that at high-z SN Ia progenitor are young (~0.5 Gy at z~1.5)