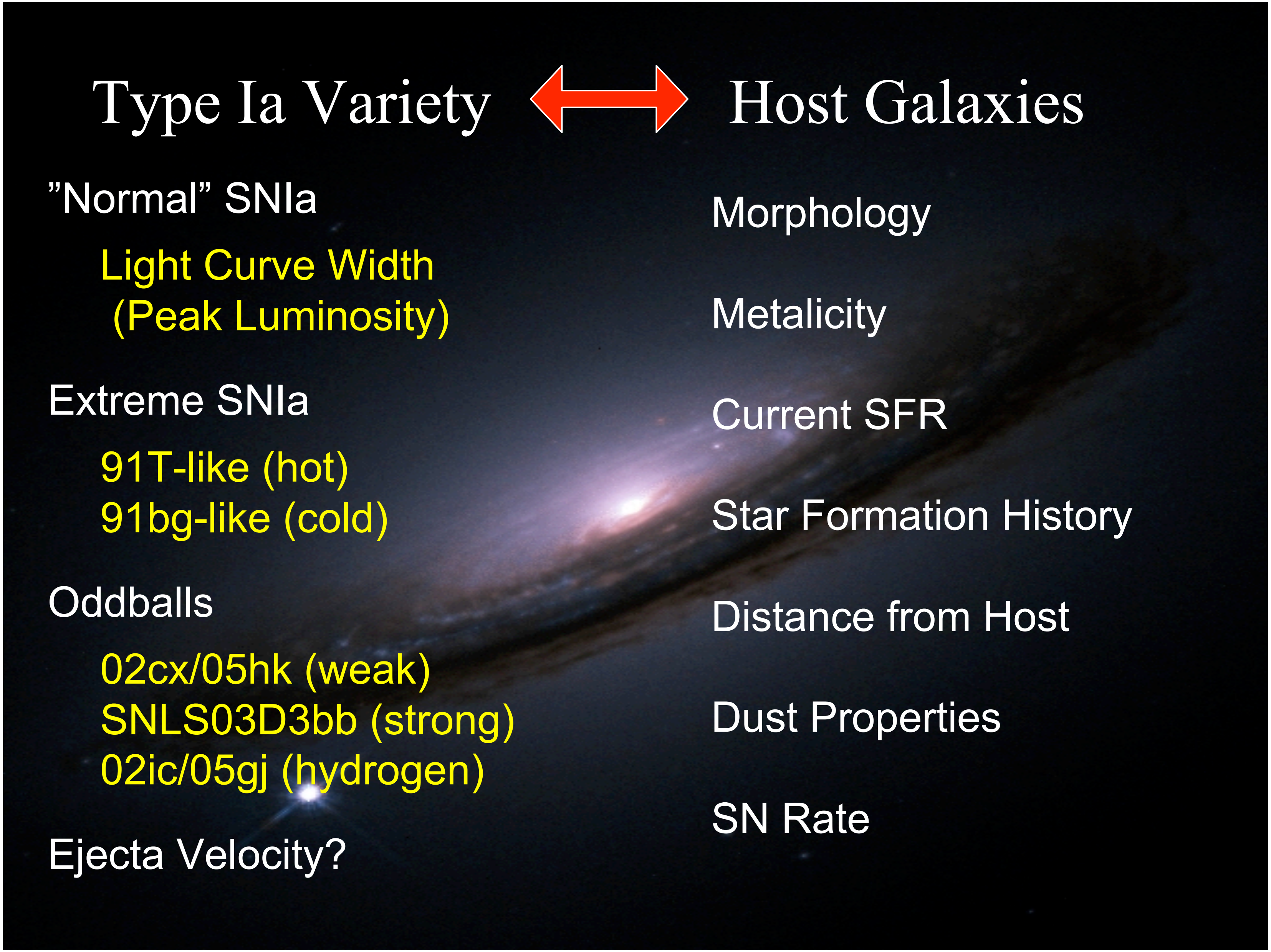
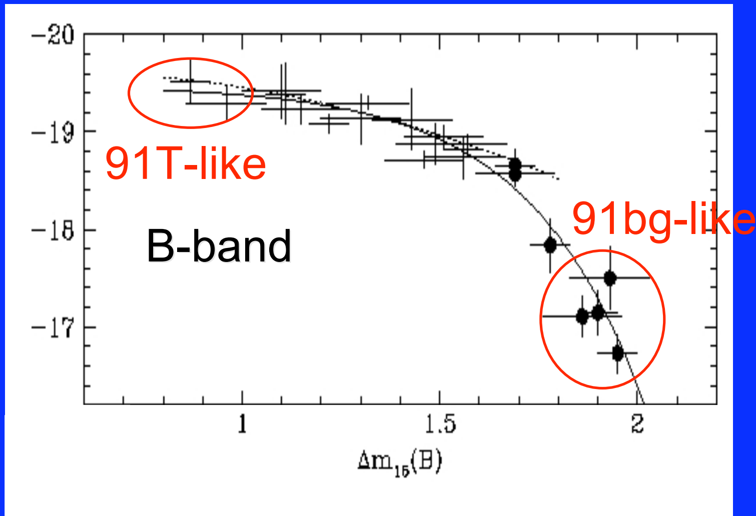
ROCK STAR SUPERNOVA

What Can Host Galaxies Tell Us About Type Ia Supernovae?


Type Ia Variety
Host Galaxies
"Normal" SNIa
Light Curve Width
(Peak Luminosity)
Extreme SNIa
91T-like (hot)
91bg-like (cold)
Oddballs
02cx/05hk (weak)
SNLS03D3bb (strong)
02ic/05gj (hydrogen)
Ejecta Velocity?
Morphology
Metalicity
Current SFR
Star Formation History
Distance from Host
Dust Properties
SN Rate

Light Curve Shape

"Phillips Relation": correlation between decline rate and peak luminosity



Phillips et al. (1999); Garnavich et al. (2004)

Parameterized by: Δm15(B)
or "stretch"
or Δ

Dust Extinction Corrected:
Colors of low extinction events
Measure or assume extinction law

^{56}Ni Yield <=> Peak Luminosity
Peak Luminosity <=> LC Shape

So LC shape can be an easy observable for Nickel output

- What causes the ^{56}Ni yield to vary?
- Is there another parameter that influences peak luminosity?

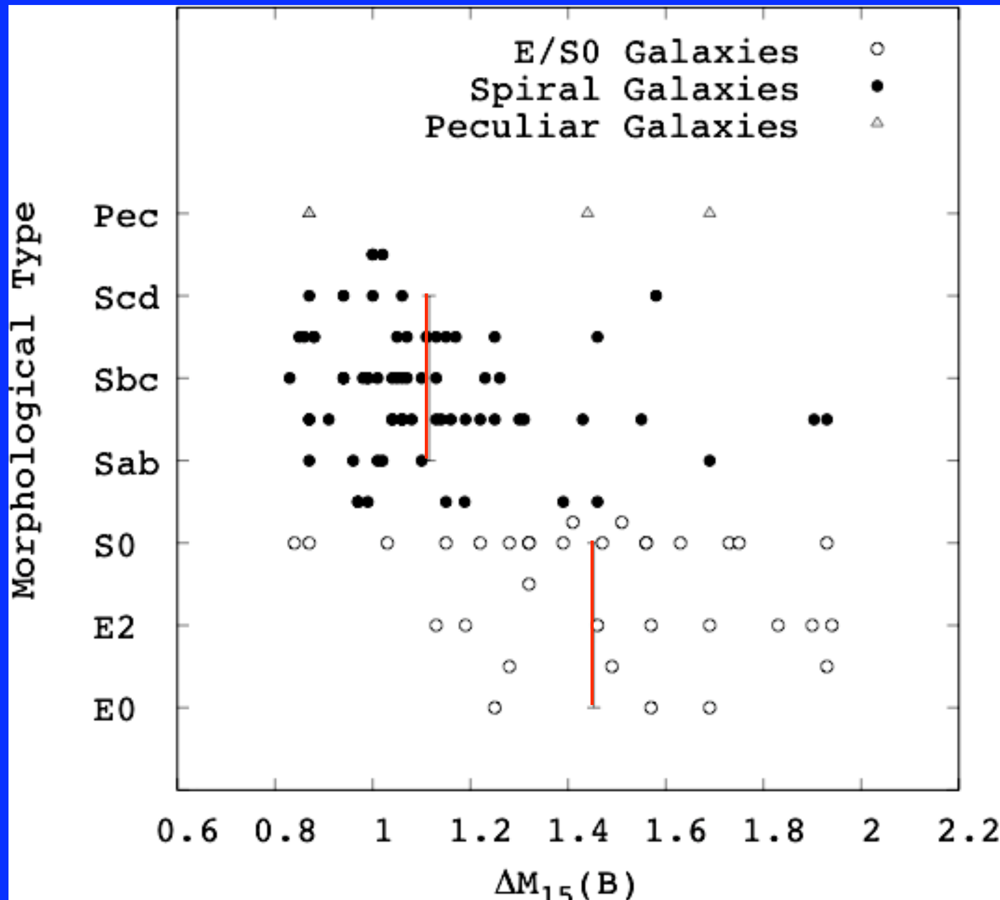
Clue to the SN Ia Diversity

Hamuy et al. (1996)
noted a trend
between host
morphology and
SNIa decline rate
in Calan/Tololo set

Adding all SNIa
available now:
See even stronger
division between
morphological types.

Fast (faint) SNIa like
E/S0 galaxies while
Slow (bright) events
prefer Spirals

Gallagher et al. 2005

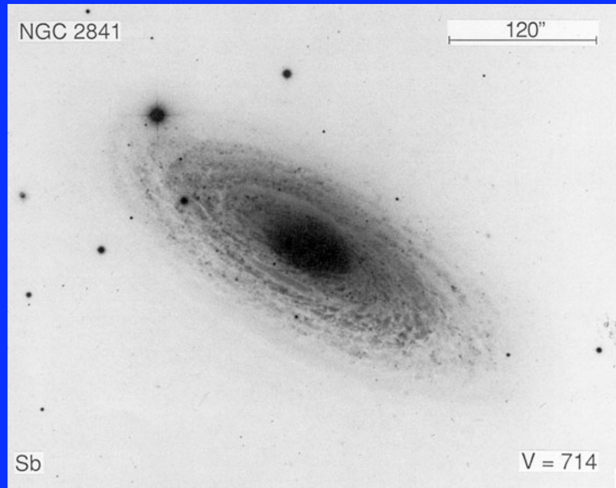


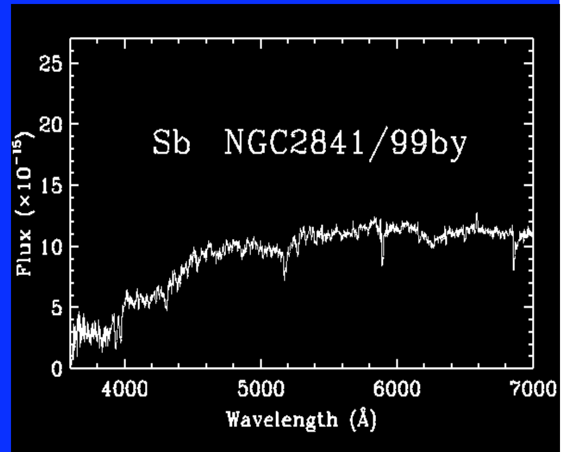
Diversity: Metallicity or population age?

Spectra of Hosts: Morphology is Not Enough

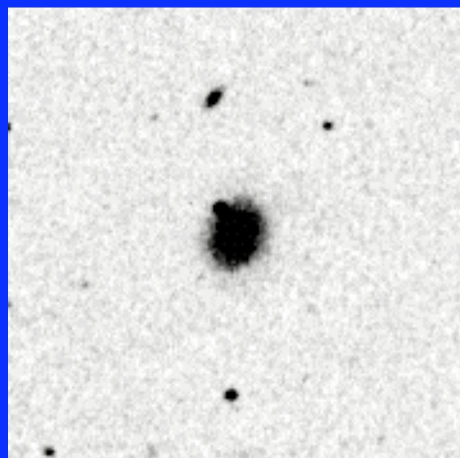
Exceptions:

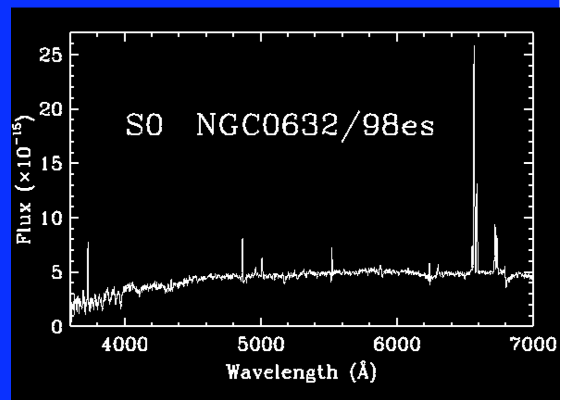
1999by in NGC2841
Sb galaxy with an extreme fast decliner => very little emission indicating a low star-formation rate .





1998es in NGC 632
an extreme slow decliner in an early type galaxy => very large emission indicating rapid star formation – a central star burst.





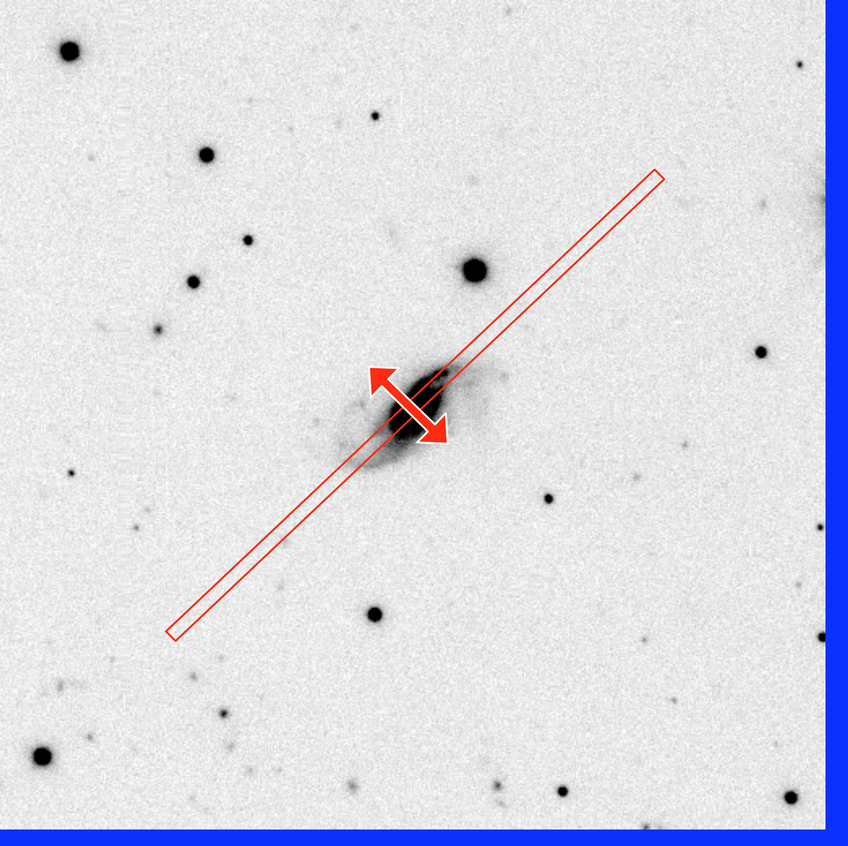
Integrated Spectroscopy

Spectra allow estimate of host metalicity and star formation rate.

If long delay between stellar formation and SN explosion then local population has nothing to do with the progenitor.

Integrated spectrum at least gives global averages. What we get when doing high redshift supernovae.

Host of SN 2000cf

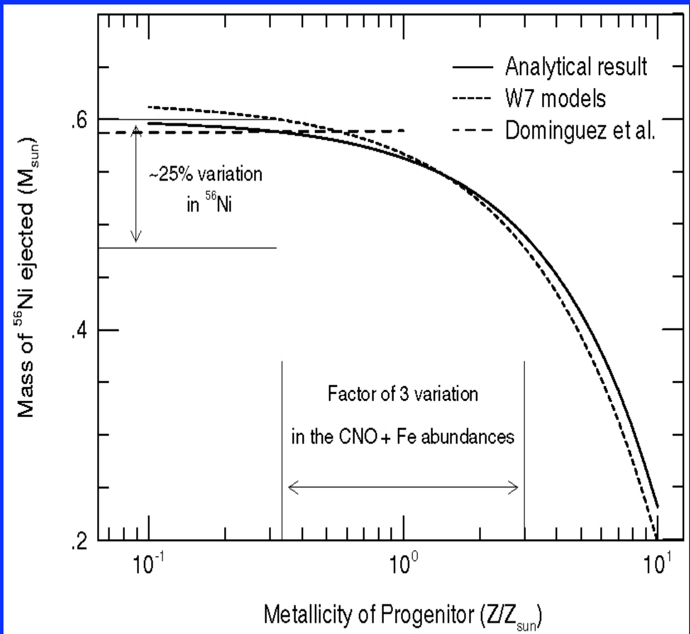


Gallagher et al. 2005

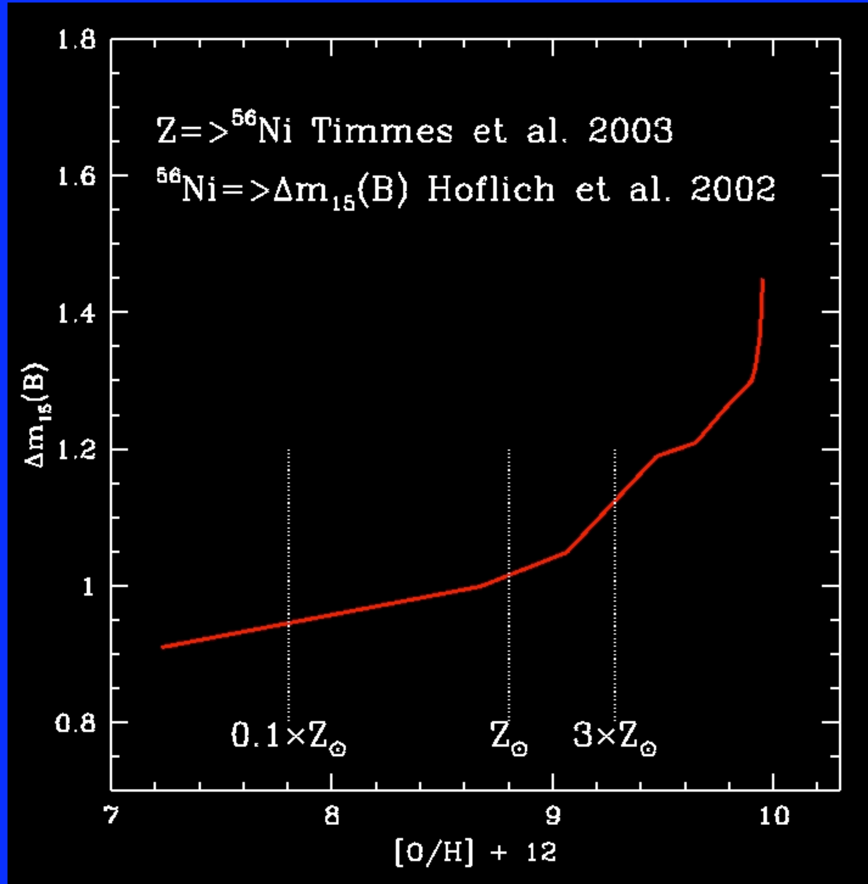
Model: Brightness – Metallicity Relation?

Progenitor metalicity influences the content of the resulting WD

Timmes Brown & Turan:
For fixed e⁻/nucleon ratio,
initial Z drives ^{56}Ni yield down

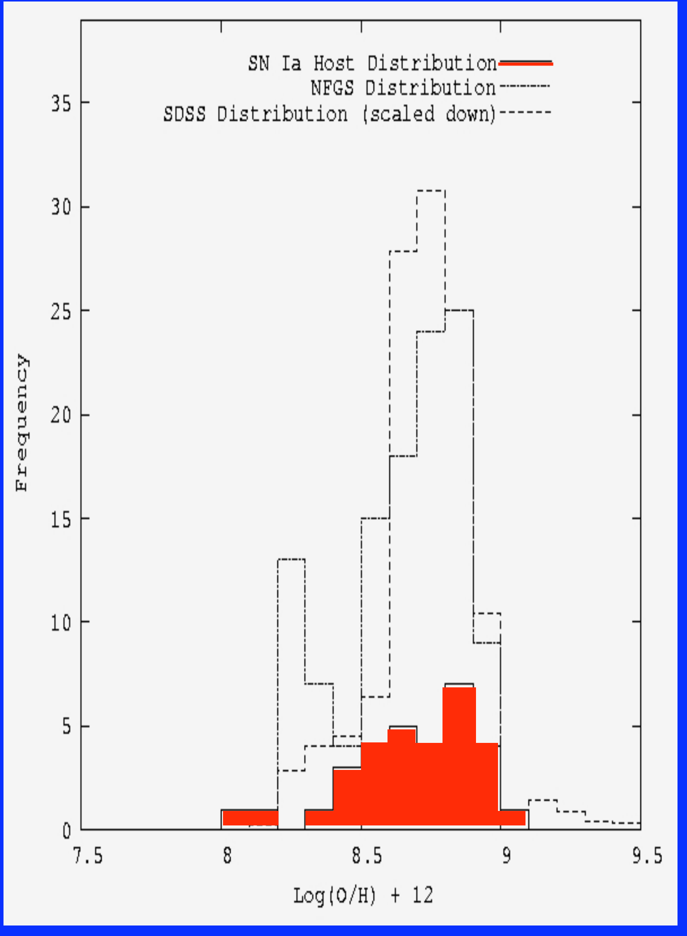


Timmes, Brown & Truran 2003



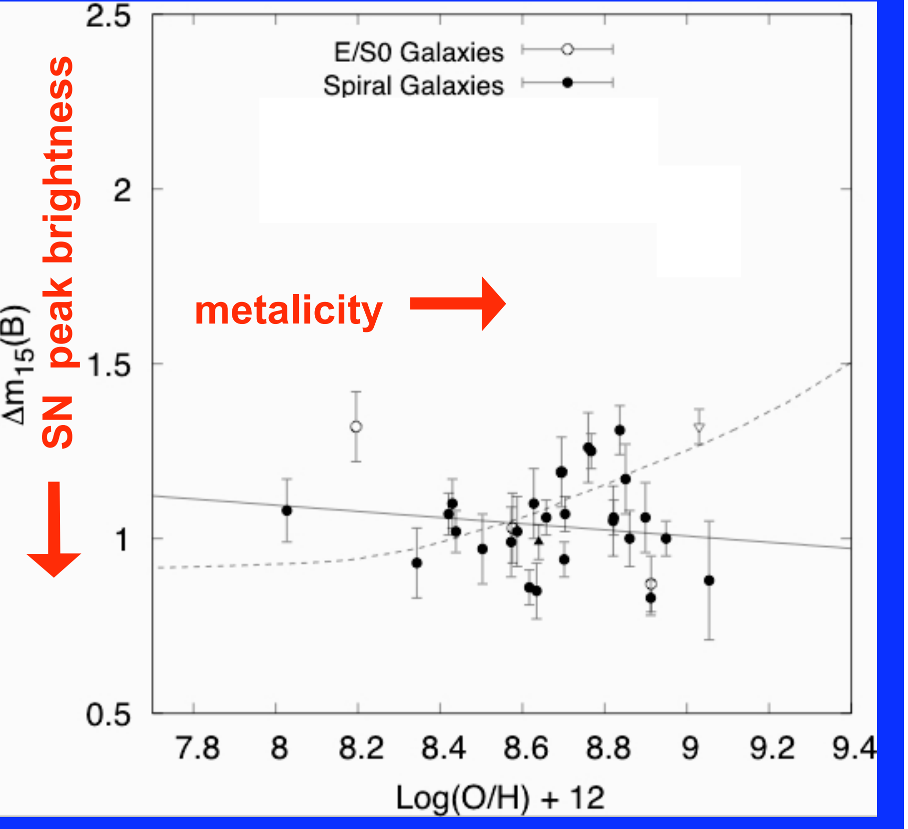
Host Metallicity

O/H ratio from emission line fluxes (Kewley & Dopita 2002)



No clear trend between host metalicity and decline rate.

Early-type galaxies (Hamuy et al) have the same metallicity as some spirals, but a wide range of decline rate.



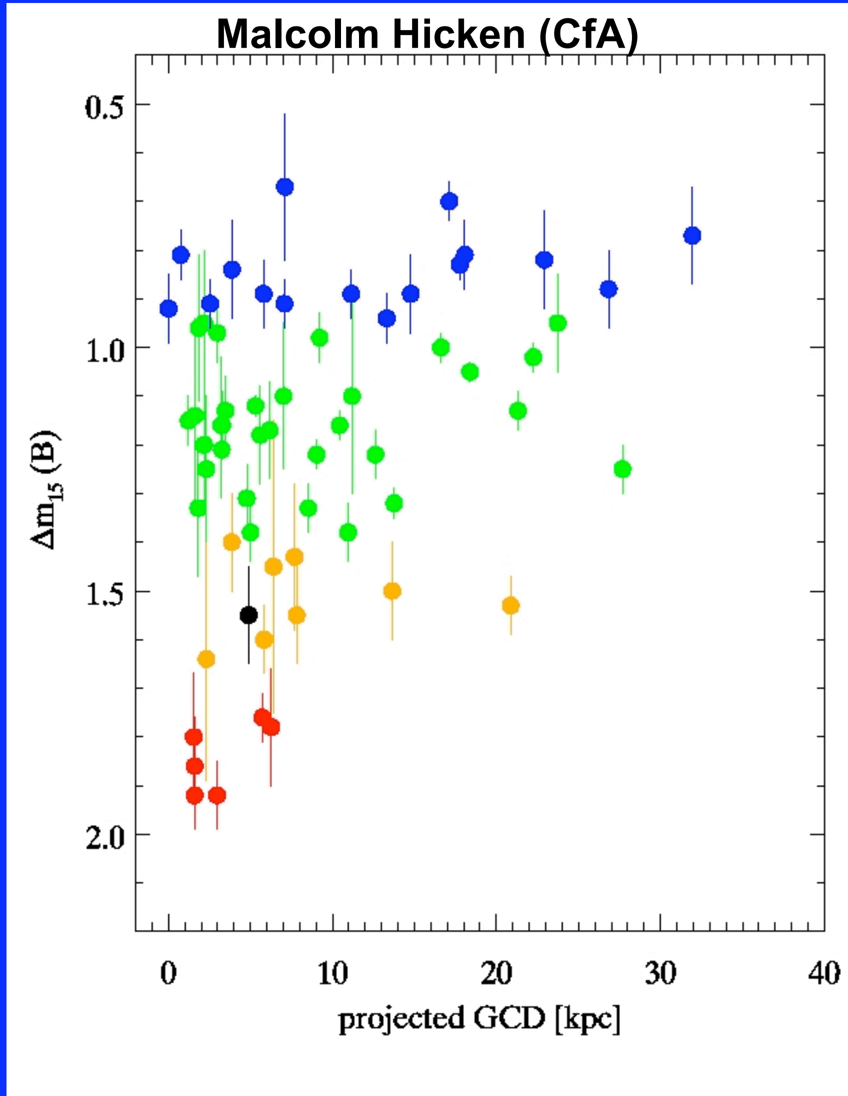
Distance from Galaxy Center

Trend: largest dispersion in light curve width near galaxy center.

In Milky Way, the variation in metalicity is a factor of 8 between 4 kpc and 16 kpc.

Metalicity increases closer to the center => if higher metals means less nickel production => should see increasing Δm15 with decreasing distance.

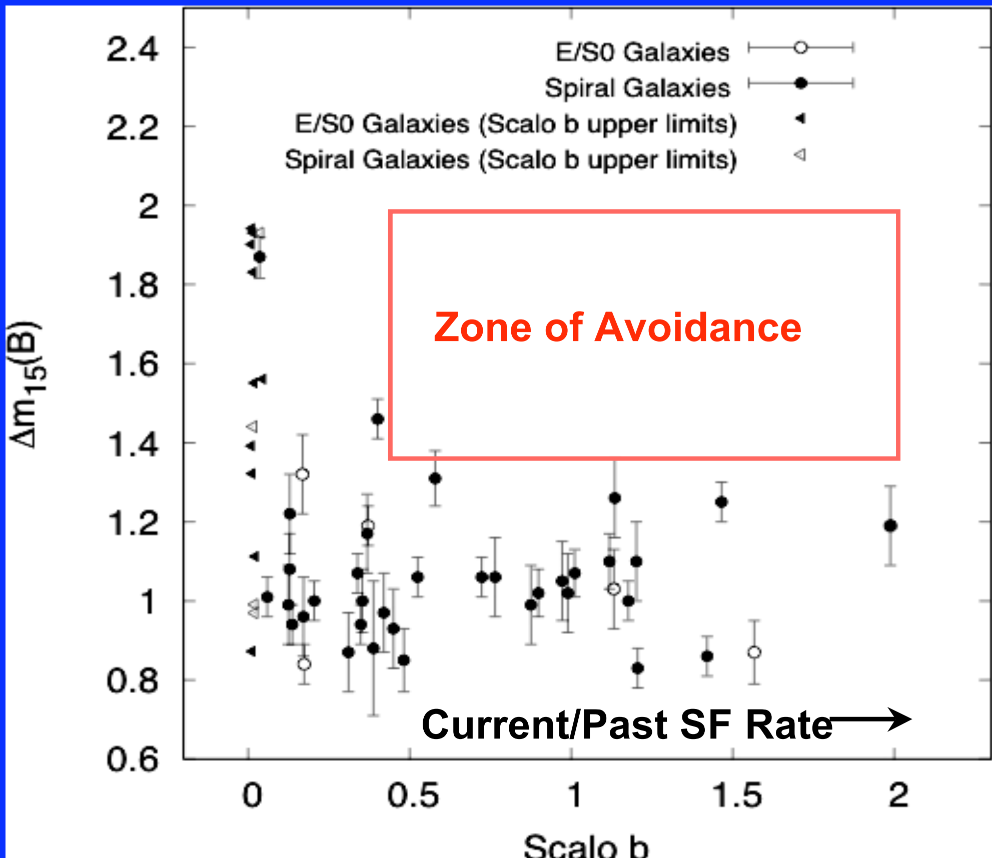
And we do!



Star Formation History

Hα equivalent width is a measure of the current star formation rate compared to the average in the past – Scalo "b" parameter.

Fast (faint) SNIa found only in hosts with very low SFR (b<<1)



Population age (SFR) is more important than metallicity in determining ^{56}Ni yield in SN Ia.

Metalicity of Low SFR Hosts

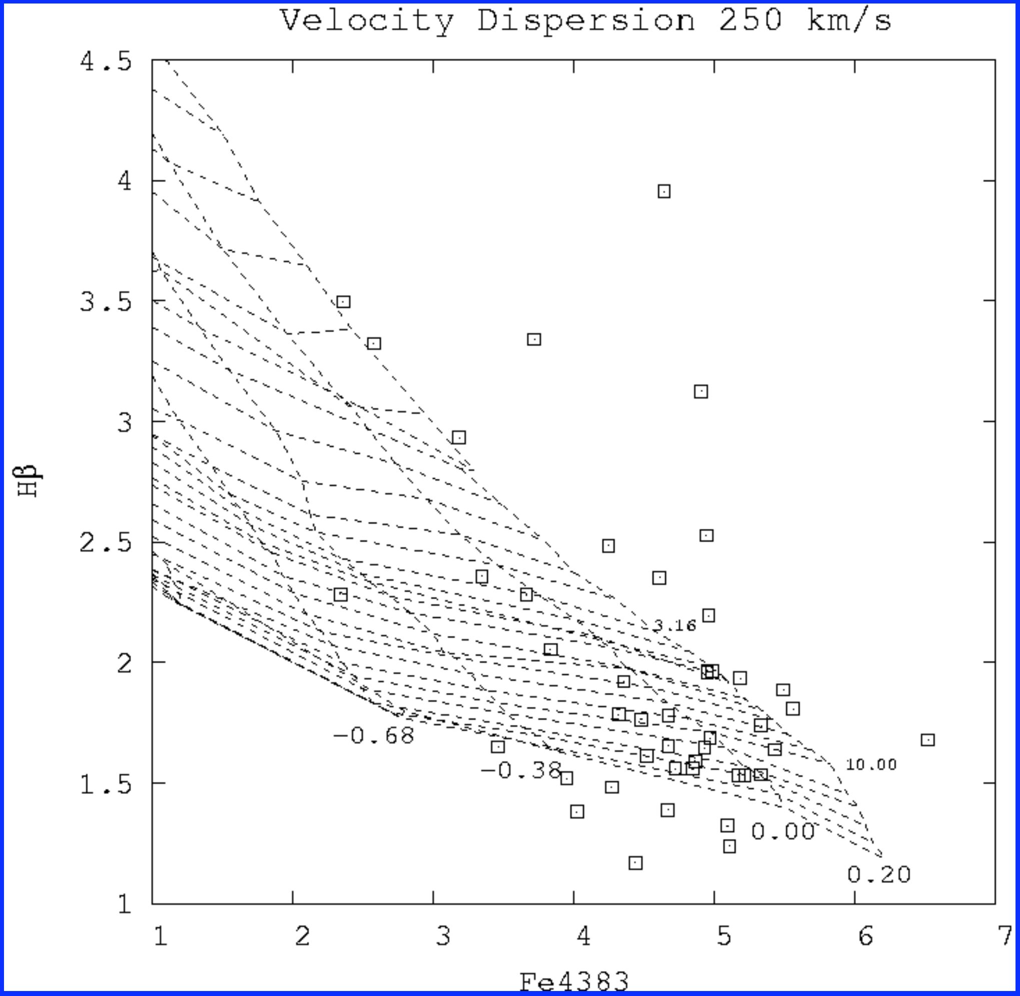
Measuring metalicity of emission line galaxies is “easy”

Low SFR galaxies require absorption line analysis.

Use stellar model spectra to make populations of fixed age and metals. Measure spectral indices (Hbeta for age, Iron lines for metalicity).

See where real hosts fall in the model grid.

Gallagher et al. in prep



Secondary Parameter?: Metallicity

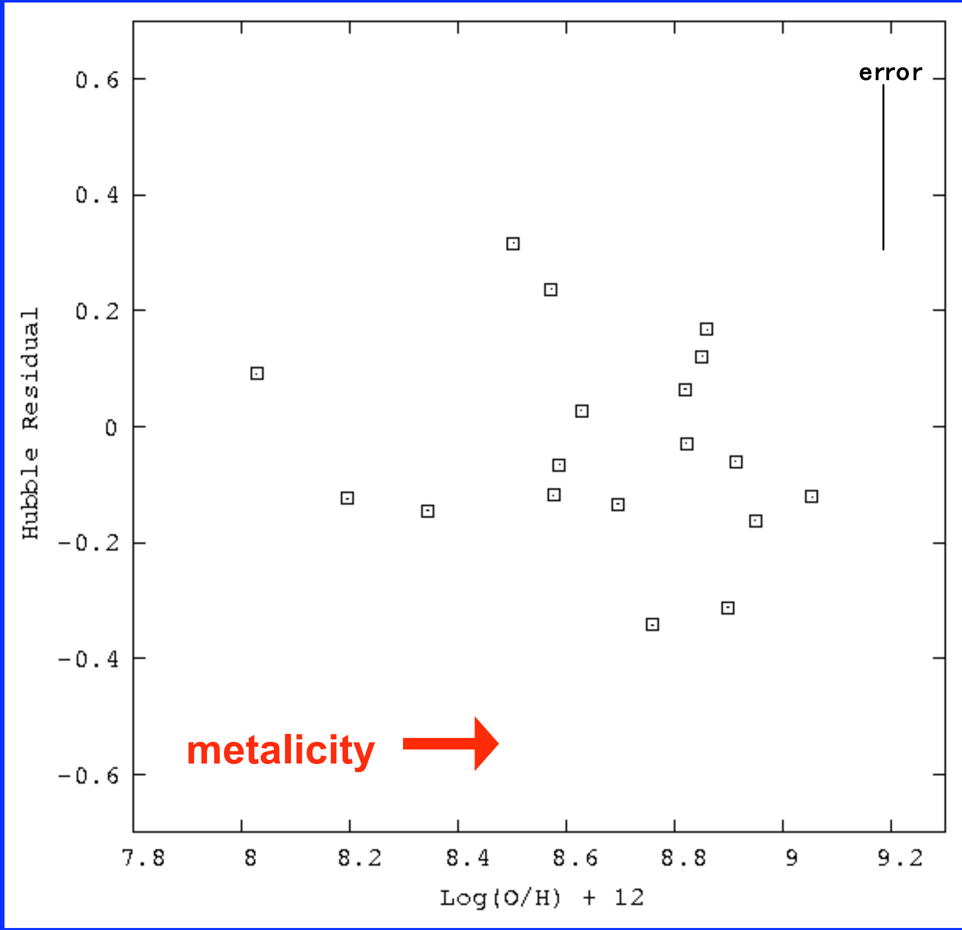
After light-curve shape correction, is there a metalicity dependence?

Hubble Flow RMS ~0.16 mag

Residuals to the Hubble diagram show no significant correlation with Oxygen abundance.

Galaxies span only one decade of metalicity

Need many more Hubble flow supernovae to really tell if there is a correlation.



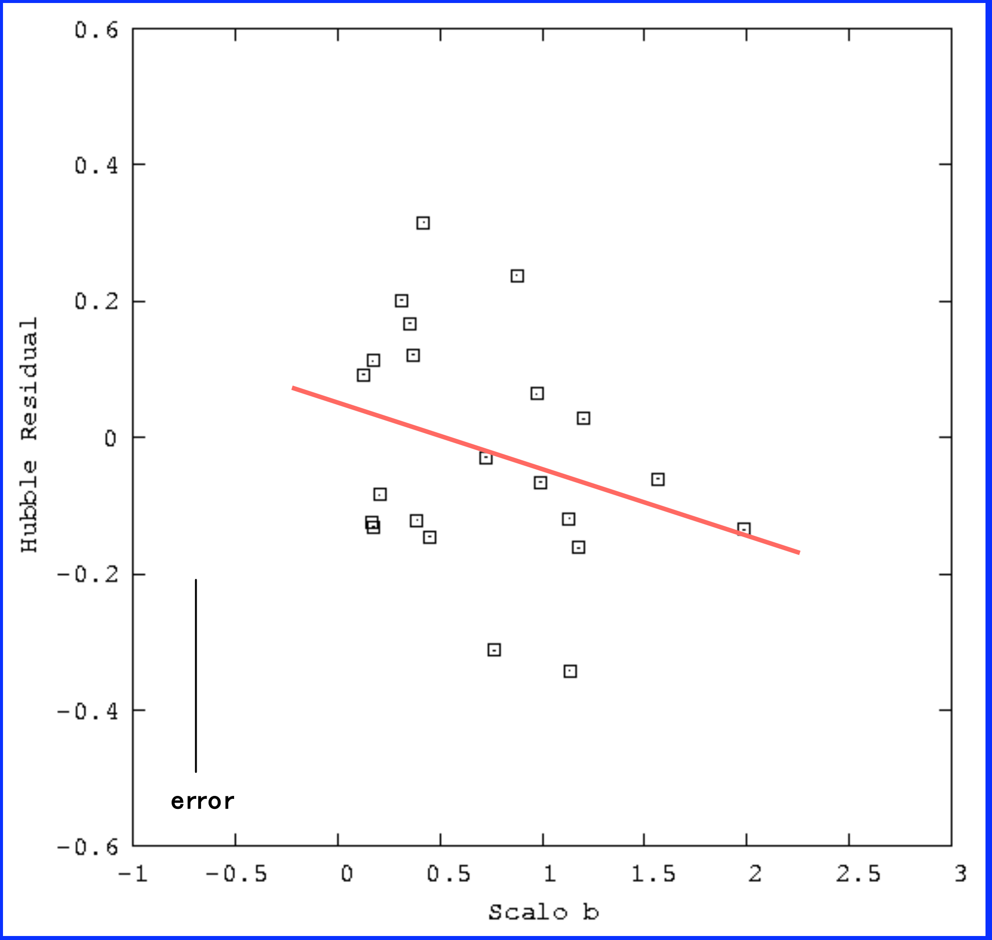
Second Parameter?: Star Formation Rate

Hubble residuals compared with Scalo b parameter show a hint of correlation.

Galaxies with higher than normal current star formation lack low luminosity supernovae.

Only a 2-sigma significance

May indicate some bias at high redshift where star formation rates were higher than now.



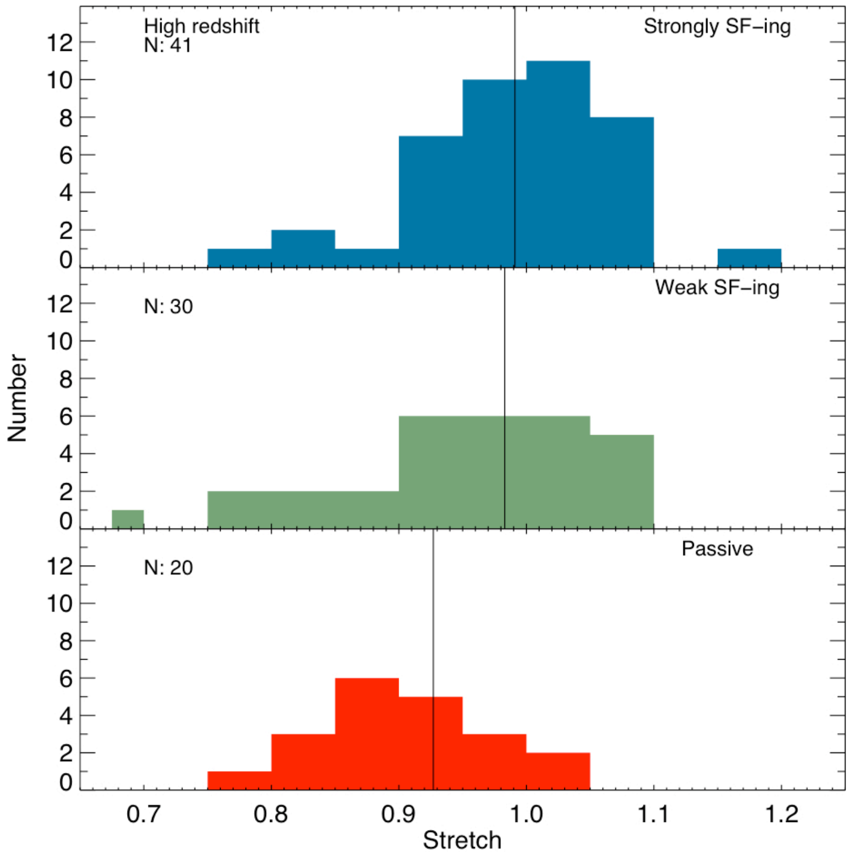
Hi-Z Too

SNLS (Sullivan et al. 2006) divide their high-z hosts sample into:
•Strong
•Weak
•Passive

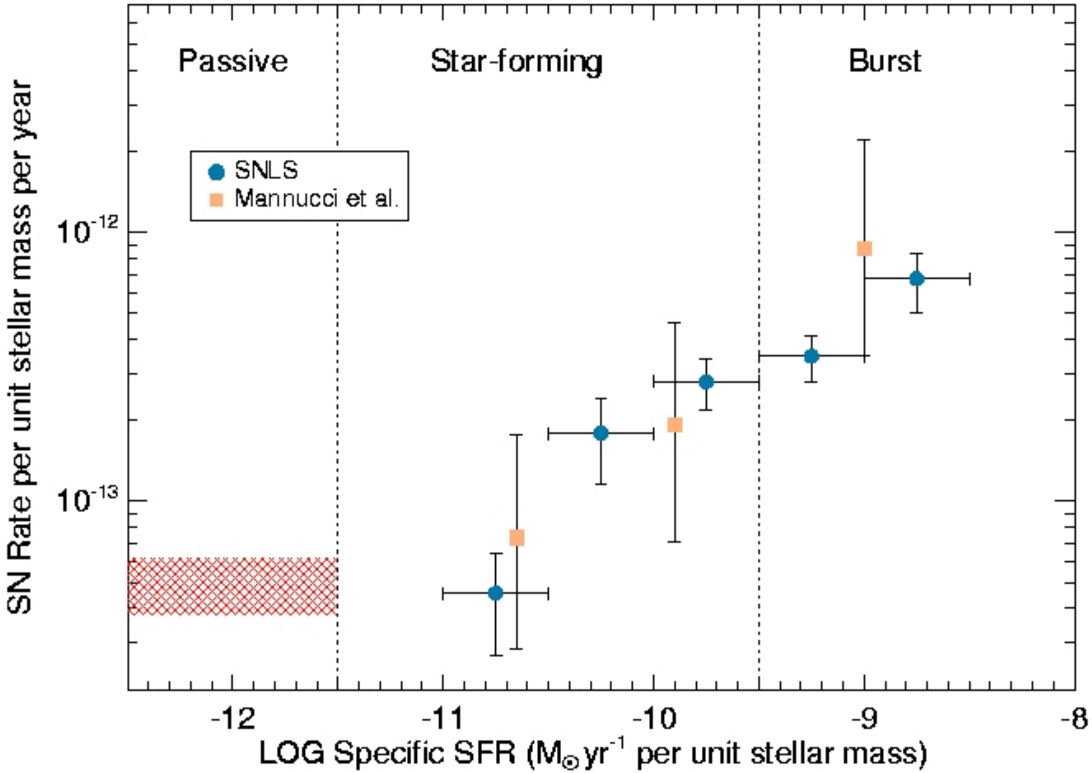
Strong and weak have the same stretch distribution.

Compare with low-z (Gallagher et al. 2005)
=> agree <=

Subluminous SNIa found in zero to very-low SFR hosts



SNIa Rate versus Host SFR

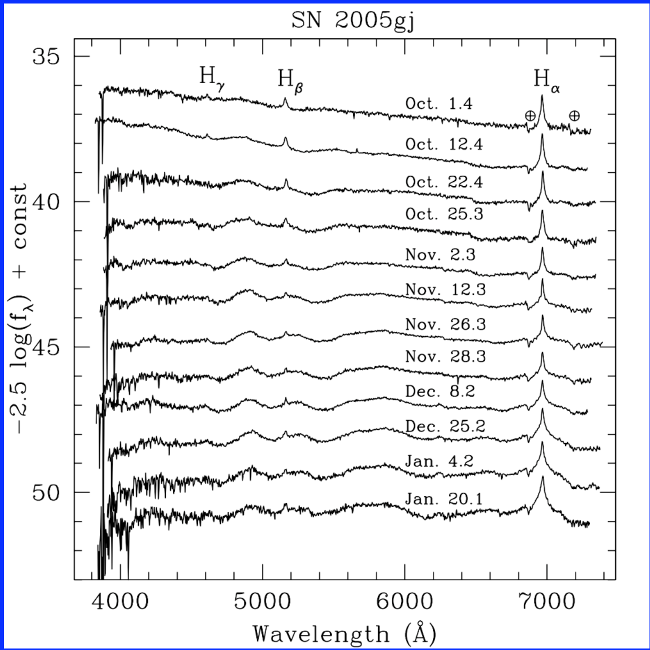


SNLS (Sullivan et al. 2006)   SN rate highest at high SF => prompt explosion
(Mannucci et al. 2005)

New Sub-Classes of Type Ia

SN Ia going off in a dense circumstellar environment

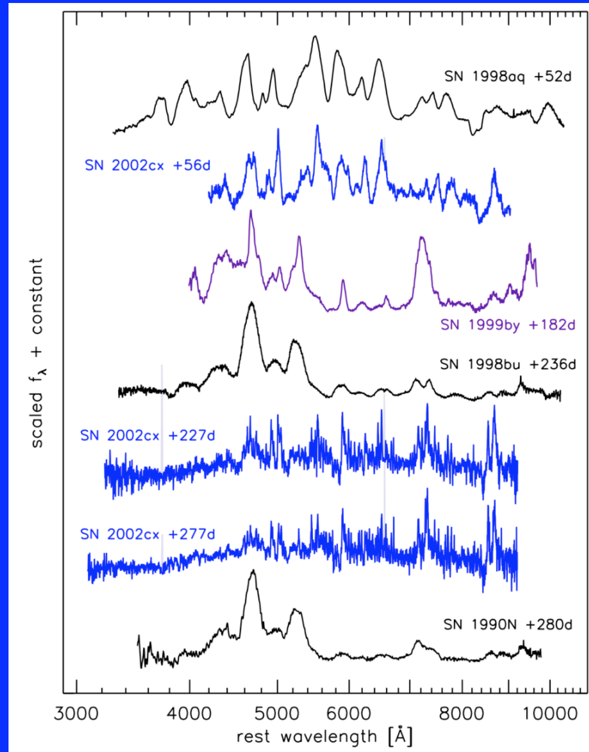
Prieto et al. 2007 - 2005gj



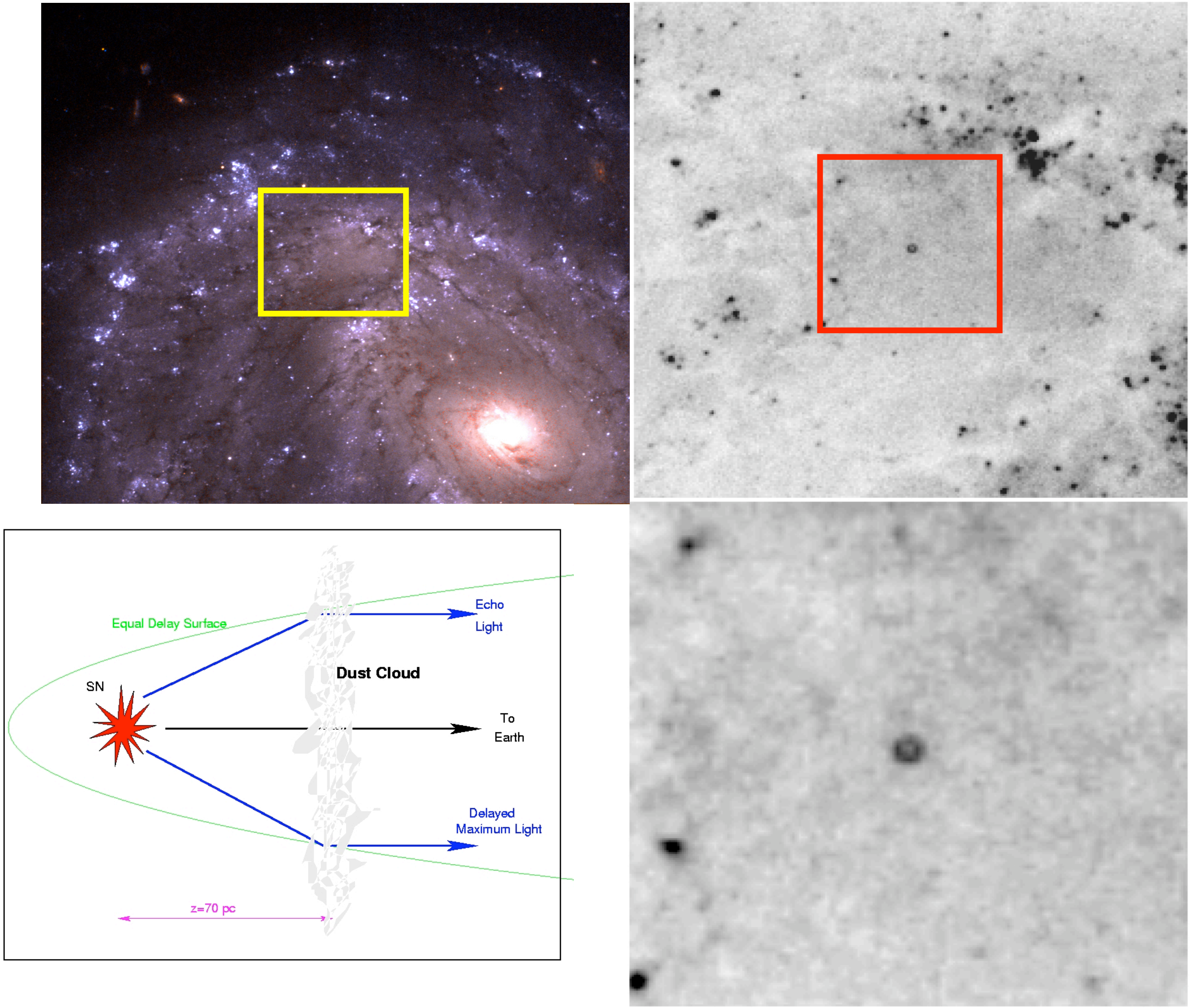
1997cy, 1999E, 2002ic, 2005gj
3 are strong star-forming hosts

Weak explosion: Deflagration?

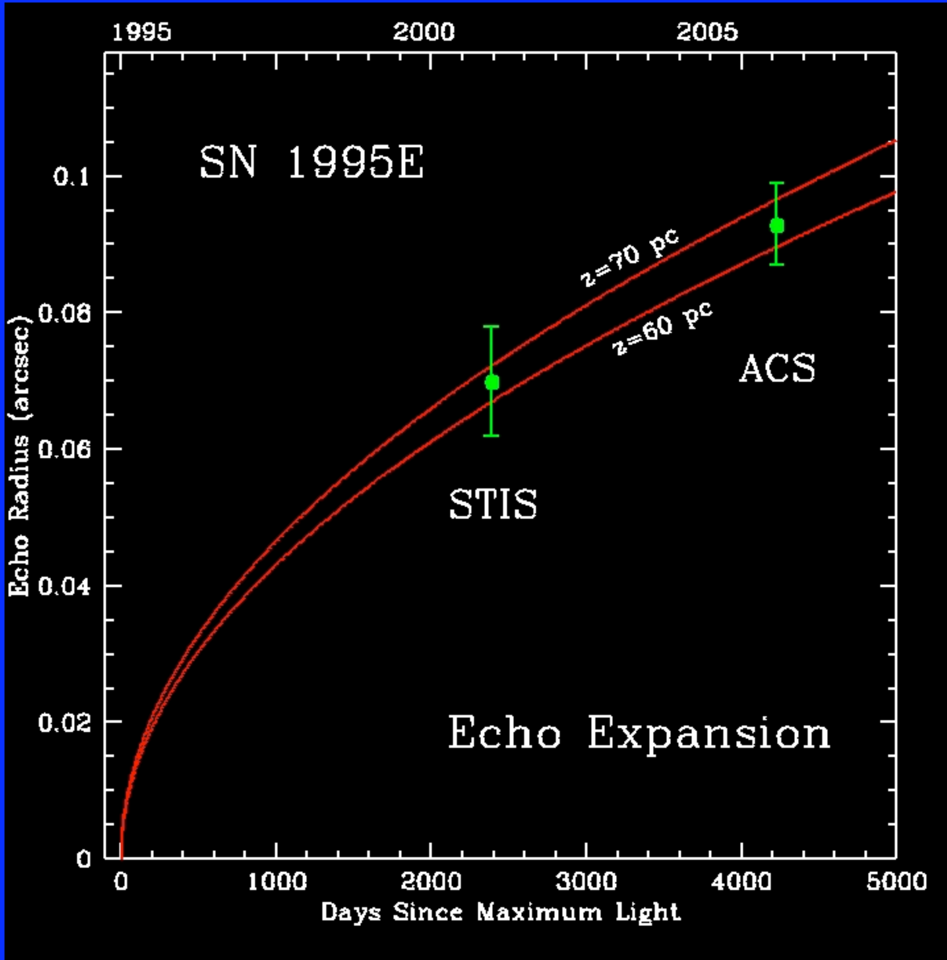
Jha et al. 2006 - 2002cx



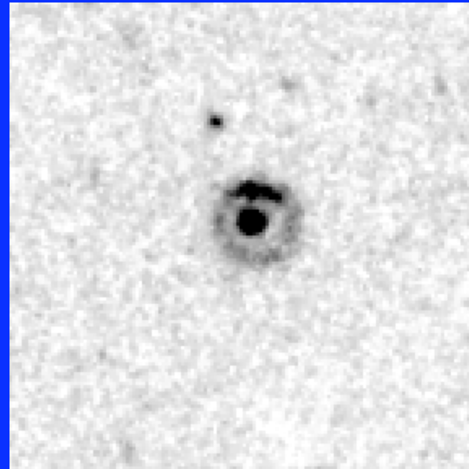
2002cx, 2005P, 2005cc, 2005hk -
all spirals, one star burst


Echo
Light
Equal Delay Surface
Dust Cloud
SN
To
Earth
Delayed
Maximum Light
z=70 pc

Dust Echo - Third Dimension

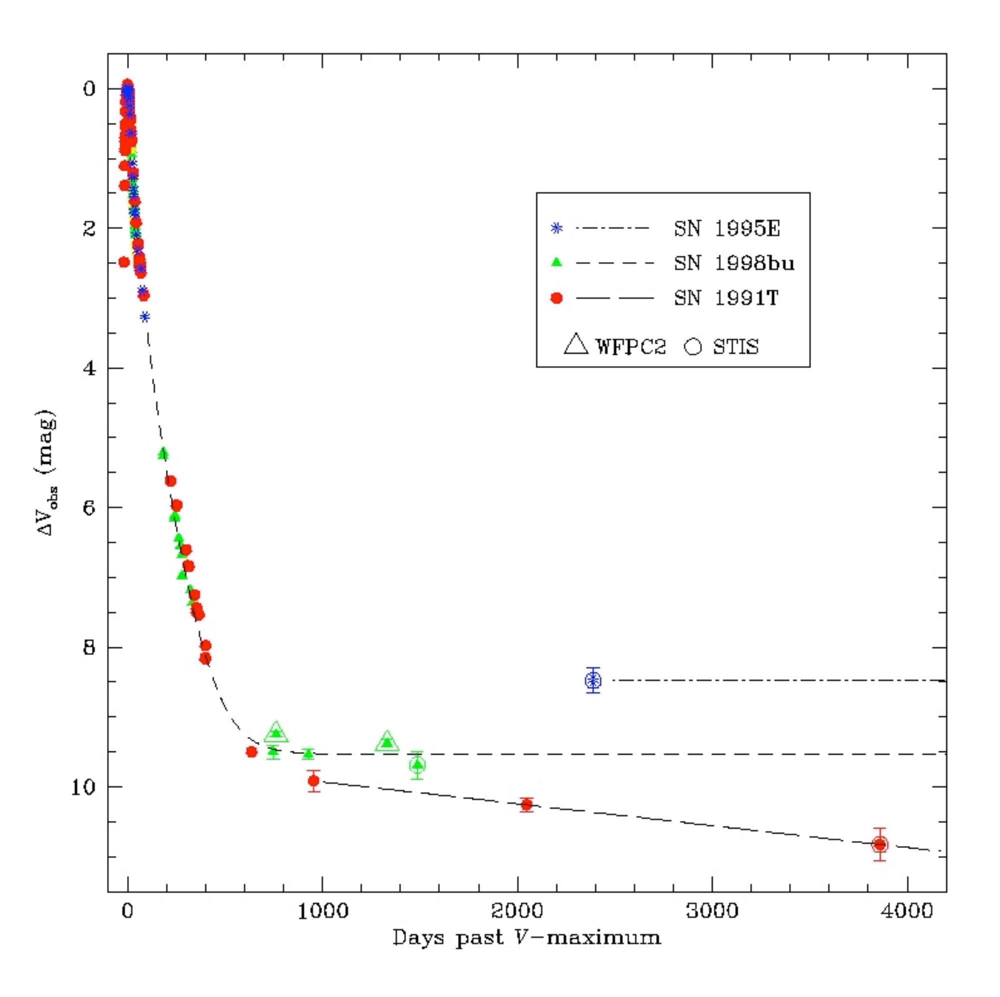


SN 1998bu - two echos 120pc and <20pc

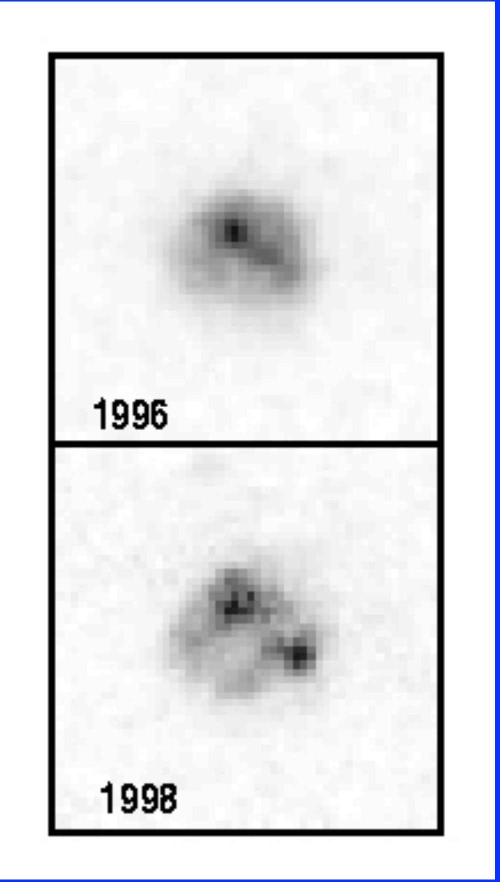


SN 1995E - 70pc from disk

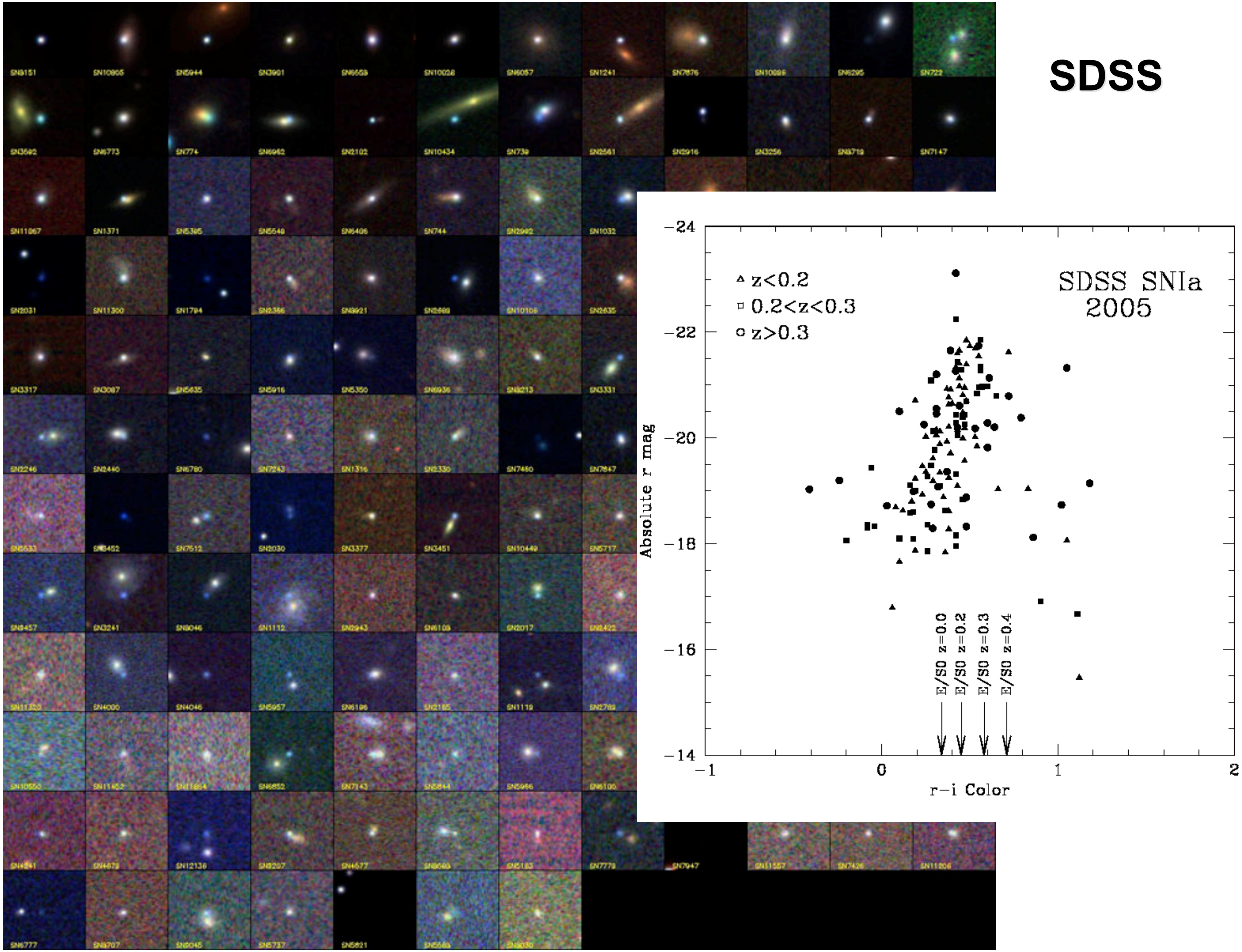
Dust Associated with SNIa



SN 1991T dust is within 10pc and surrounds the SN



SDSS



SDSS SNIa
2005
z<0.2
0.2<z<0.3
z>0.3
Absolute r mag
r−i Color
−24
−22
−20
−18
−16
−14
−1
0
1
2
E/S0 z=0.0
E/S0 z=0.2
E/S0 z=0.3
E/S0 z=0.4