Host Galaxy Environments on Type Ia Supernovae

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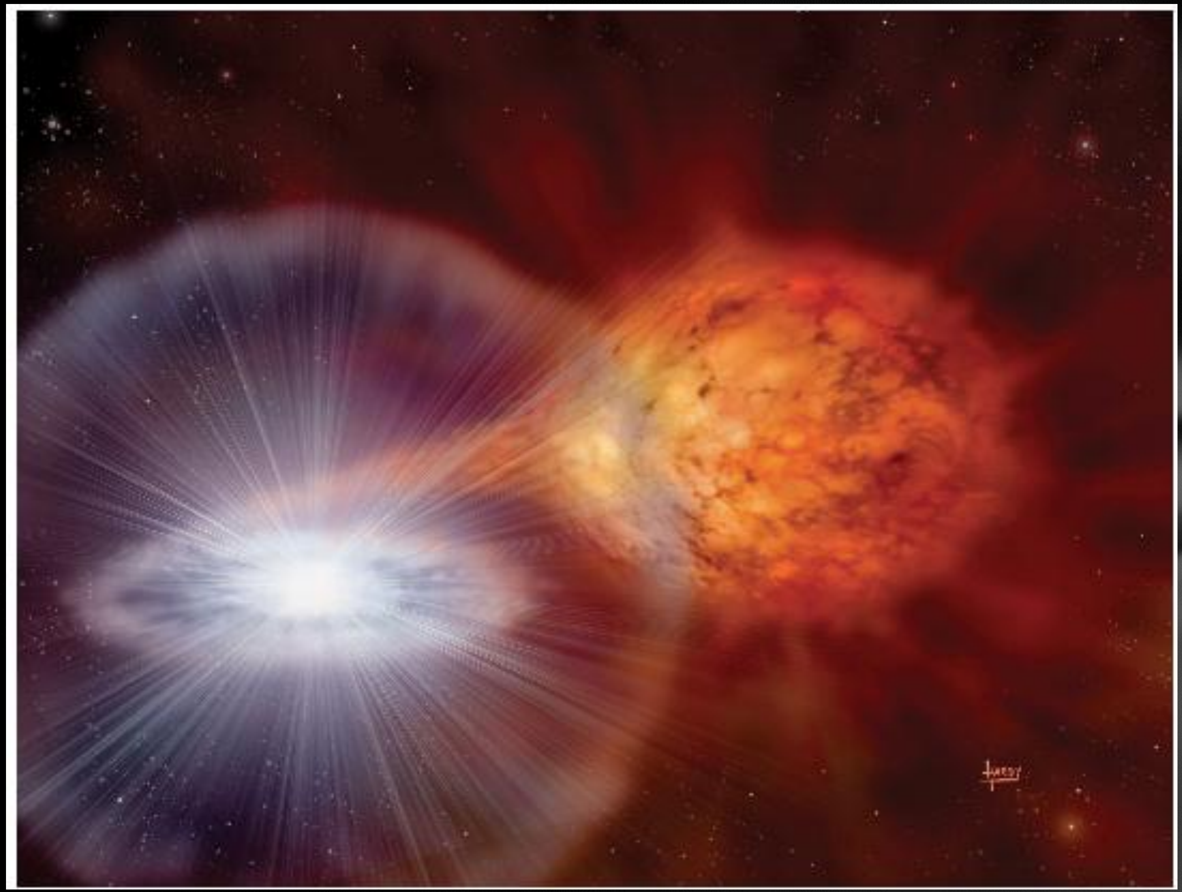
and SDSS-II Supernova Collaboration

IAP Colloquim 2010: Progenitors and environments of stellar explosions

Type Ia Supernovae



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Progenitor: Carbon/Oxygen white dwarf in binary

Luminosity source: decay of synthesized radioactive 56Ni

Usage: “Standard” candle for cosmology

Environmental dependence

<u>SN Ia brightness problem</u>

Stellar mass

- lower 56Ni mass is produced for high mass hosts
  (Neill+ 09, Kelly+ 10, Lampeitl+ 10, Howell+ 09)

Metallicity

- SN Ia luminosity decline rate not dependent on gas-phase metallicity
  for nearby star forming galaxies (Hamuy+ 00, Gallagher+ 05)

Non-agreement

- stellar mass is dependent on metallicity (e.g. Tremonti+ 04)

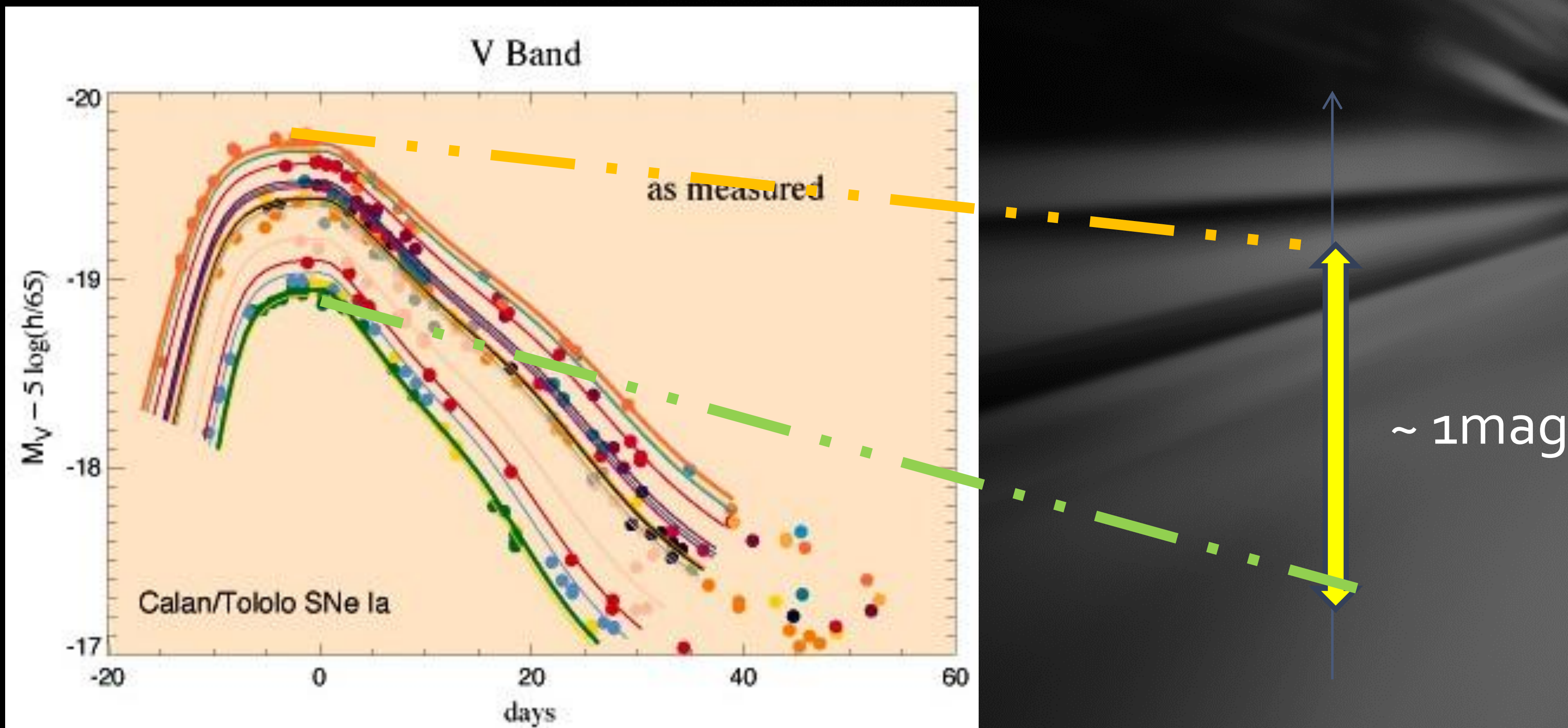
Environmental dependence

Another galaxy properties

- Color: brighter SNe Ia for bluer hosts (Hamuy+ 00)
- Line: brighter SNe Ia for hosts with prominent Hα emission lines (Gallagher+ 05)
- sSFR: brighter SNe Ia for high sSFR hosts (Howell+09, Neill+ 09, Tucker's talk)
- Age: dimmer SNe Ia for old (>1 Gyr) hosts (Neill+ 09)

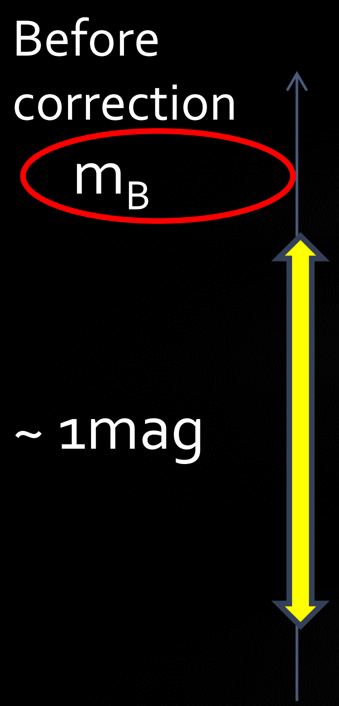
no gas properties studied for SN Ia hosts at cosmological distances (emission lines)

SN Ia usage for cosmology

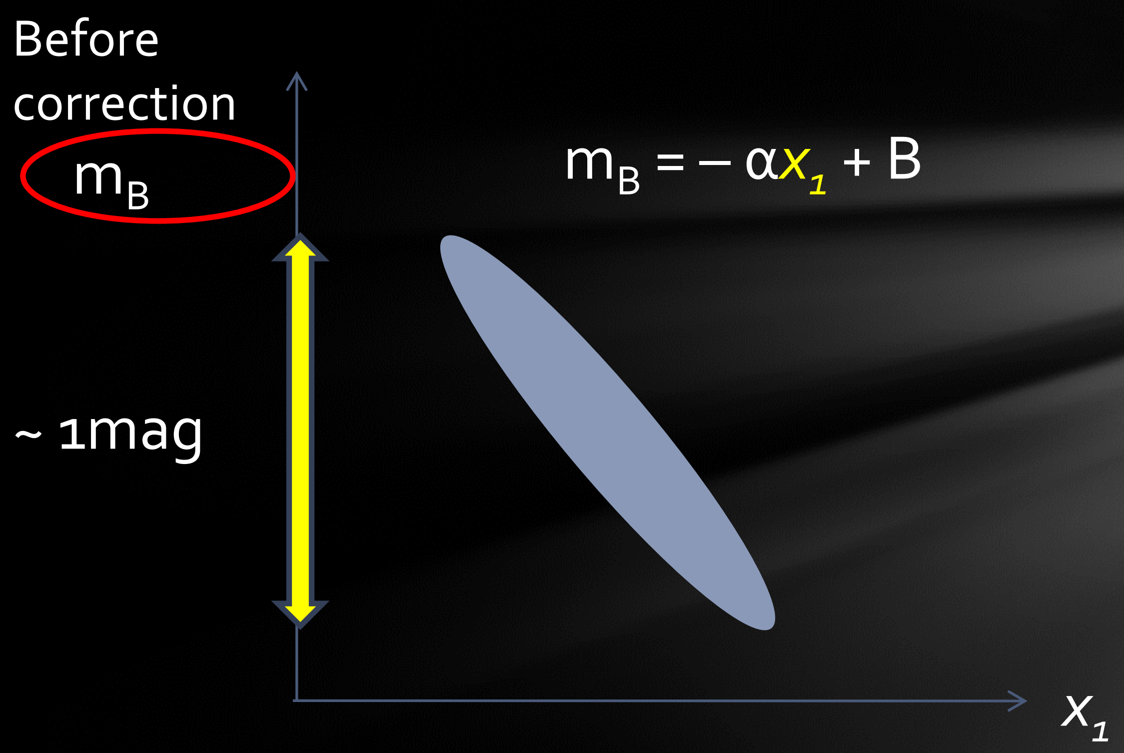


Days from maximum date [day]

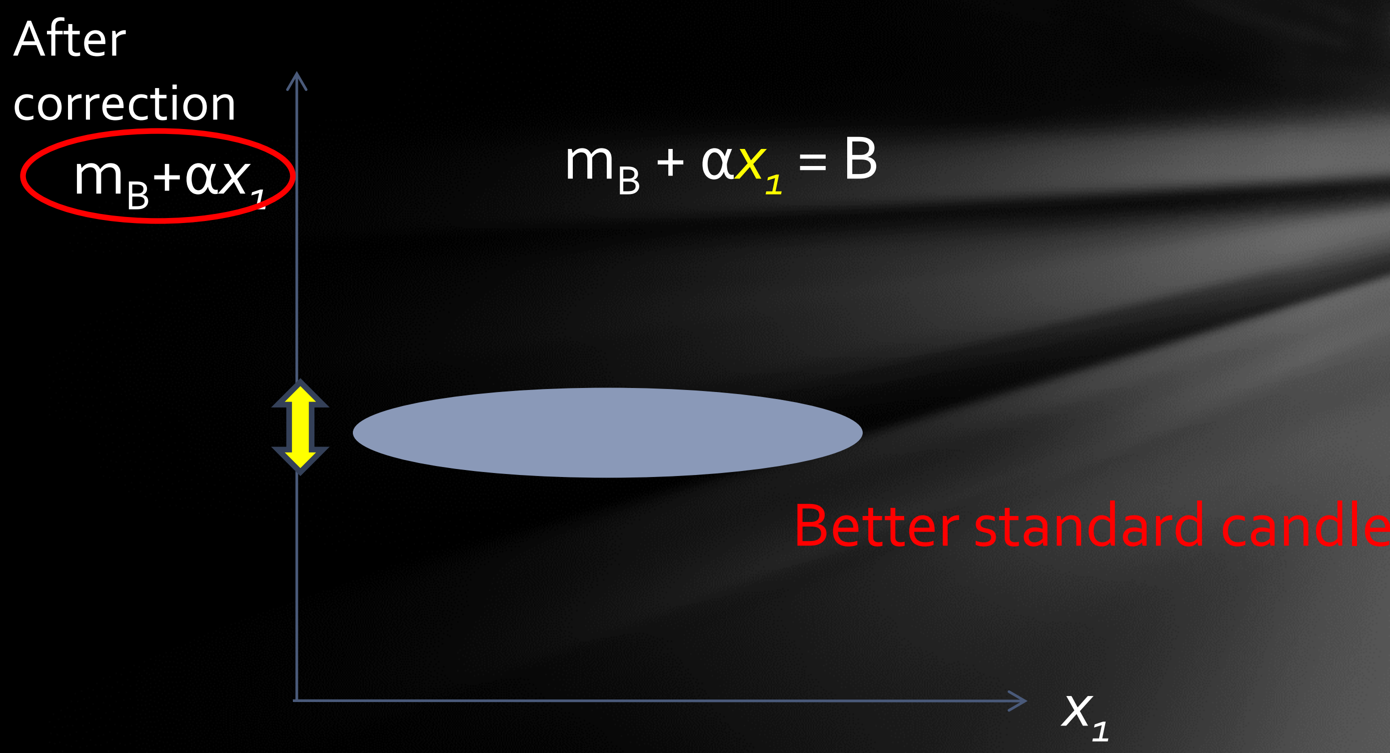
Luminosity correction



Luminosity correction



Luminosity correction

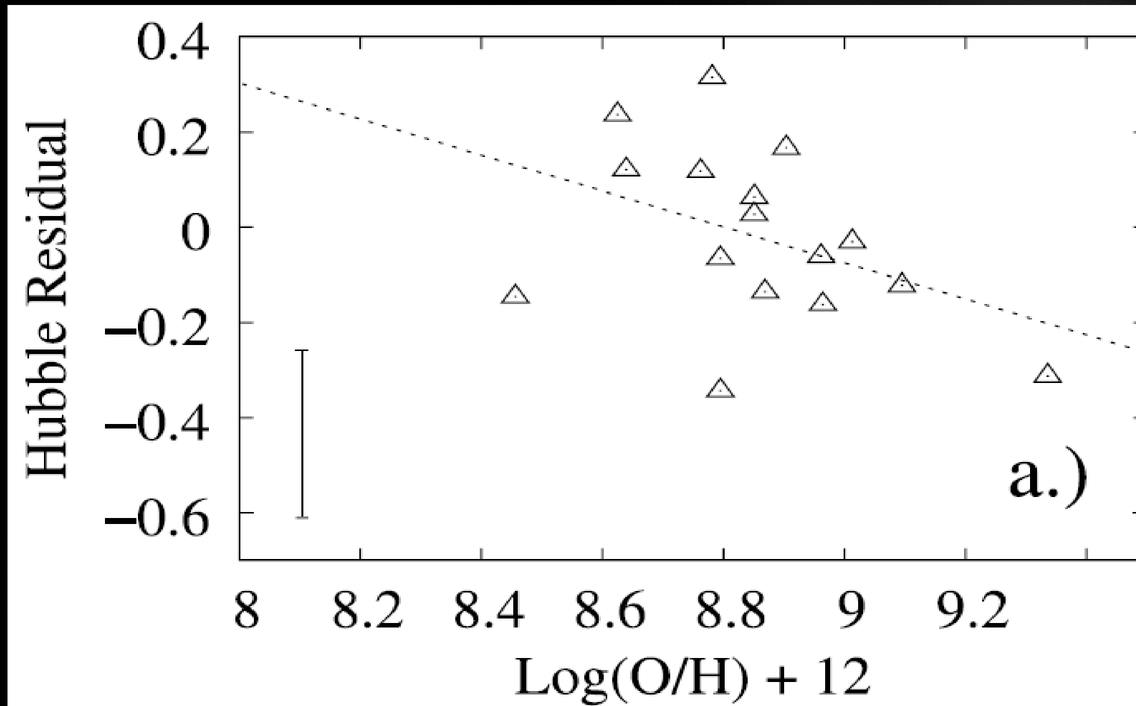


2 parameters:

- "lightcurve width" x_1 (Phillips 93), "color" c (Riess 98)

3rd parameter?

width and color corrected



Gallagher+ 05
Sullivan's talk

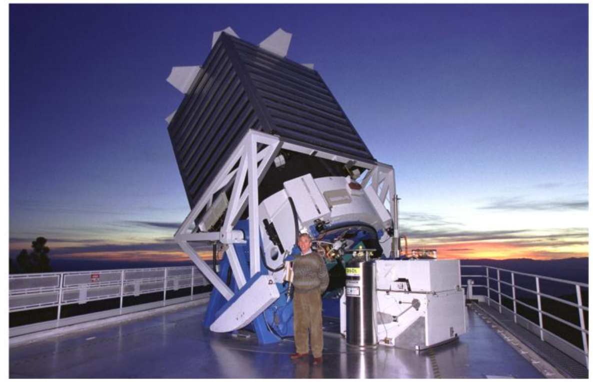
Host metallicity

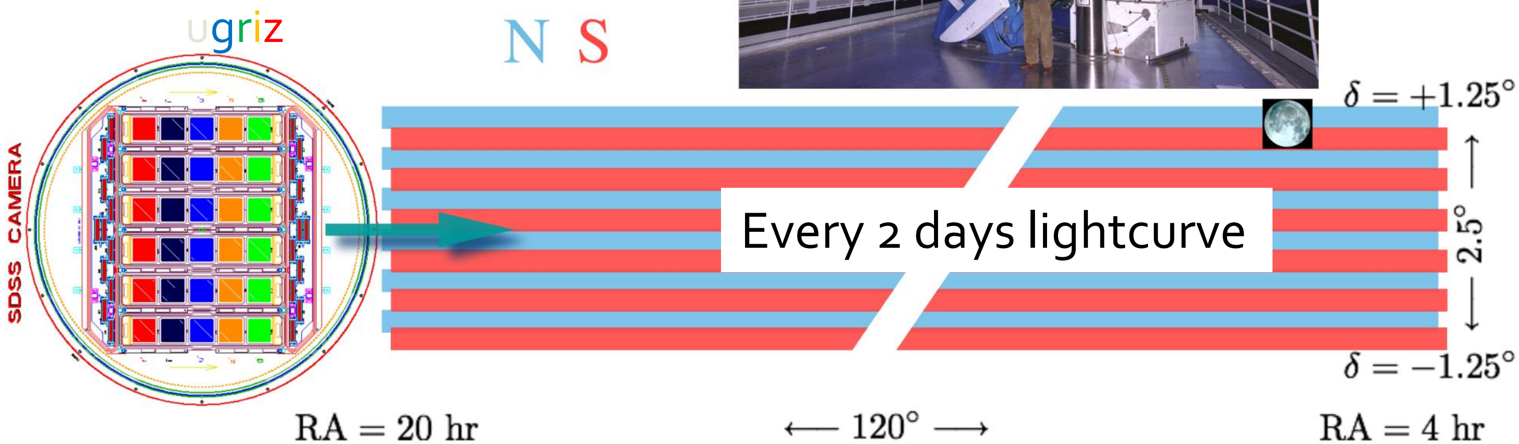
- better Hubble residual = $\{(m_B + \alpha x_1 - \beta c) - M + \gamma X - 5\log_{10}\{d_L(z, \Omega_M, \Omega_\Lambda)/10\mathrm{pc}\}$
- THEN, HR is dependent on host gas properties also for emission line galaxies at cosmological distances?

Data

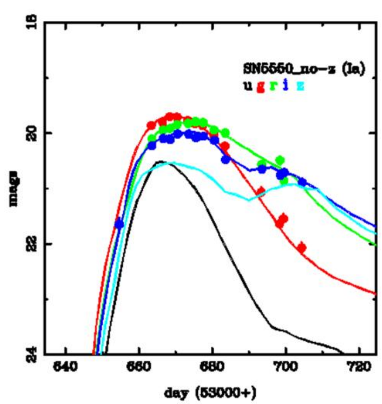
SDSS-II Supernova Survey

Friemann+ 08
Nichol's talk





Use the SDSS 2.5m telescope



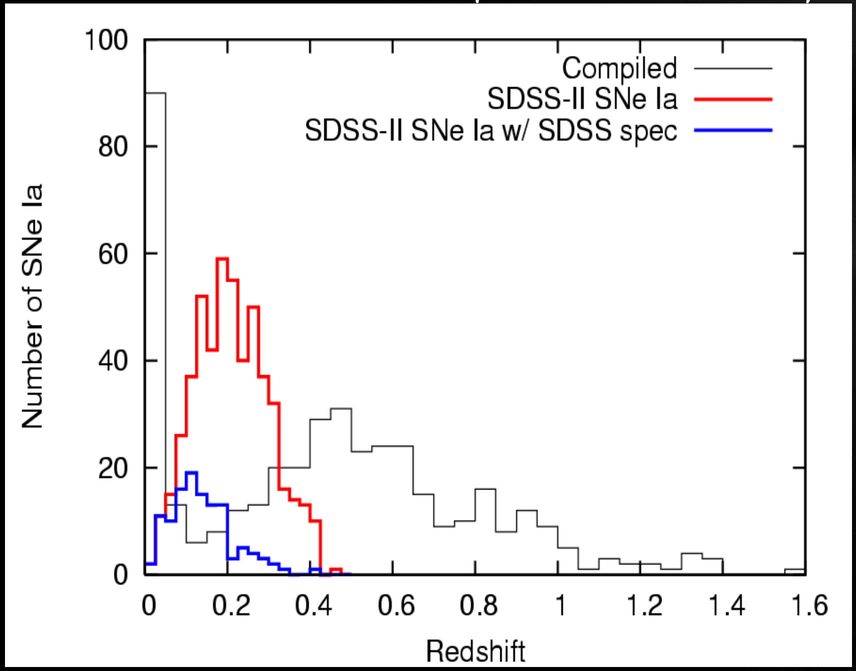
Many telescopes for followup spectroscopy

- **Redshifts, Type, Physical properties (Zheng+08, Ostman+10, Nordin+ 10, Konishi+ in prep)**

SDSS-II Supernova Survey

Largest homogeneous sample

- SN Ia gri lightcurves
  - >1 pt w/ p<-4, >1 pt w/ p>4, >5 pts w/ -20<p<+60, reasonable fit
  - spectral confirmed (> 500)
- w/ host spectra in SDSS Legacy survey (> 100)
- z>0.04 to avoid spectra of only galaxy core measurements



SNe Ia/Hosts	Metal	EW/Hα emission
Nearby (z<0.1) Gallagher+ 05	26	51
Mid-z (z~0.15) This study	**58**	**74**

Measurements

^{56}Ni mass

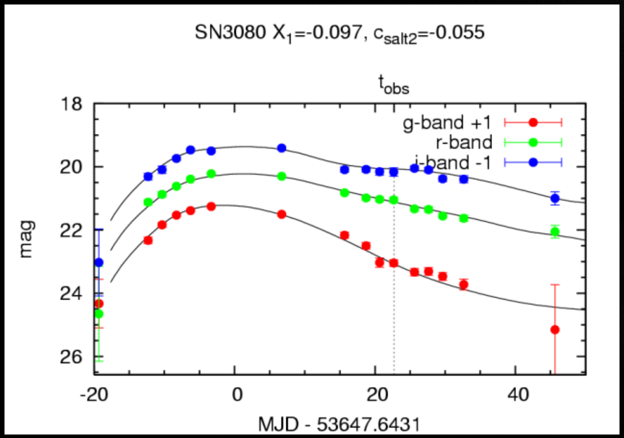
rise time

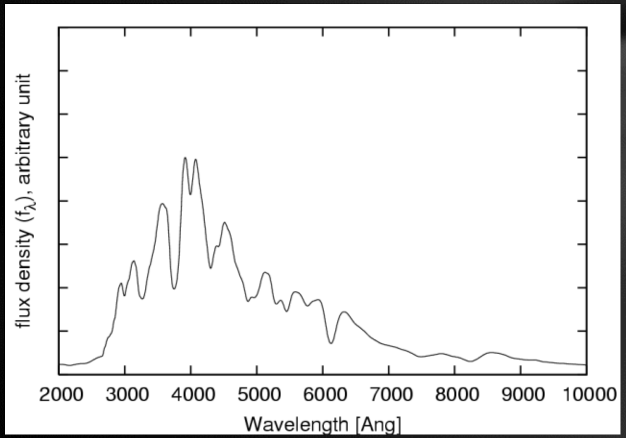
M(56Ni) ∝ Bolometric luminosity/Radioactive luminosity

gri-Lightcurve
For parameters

Synthetic spectrum
For bolometric flux

Bolometric
luminosity





SALT2 method (Guy+ 07)

Metallicity

= gas-phase oxygen abundance

1. Gas temperature

- Ratio of auroral line ([OIII] 4363) & nebular line ([OIII] 5008)

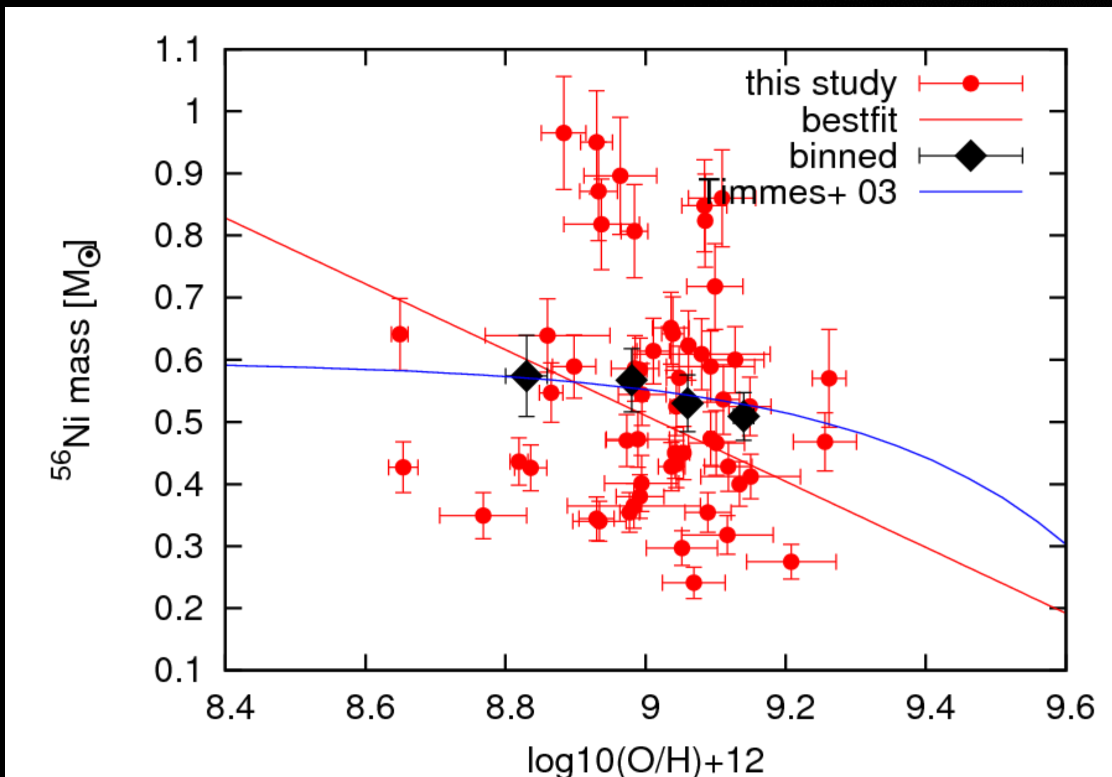
2. Flux ratio of “strong” emission lines:
   Kewley & Dopita 2002

- R = [N II] 6585/[O II] 3727
  - **Very sensitive for metal rich region**

[Problem] Affected by dust reddening
→ EBV Corrected from Balmer lines

Results

^{56}Ni mass and host metallicity



A hint for mass decrease

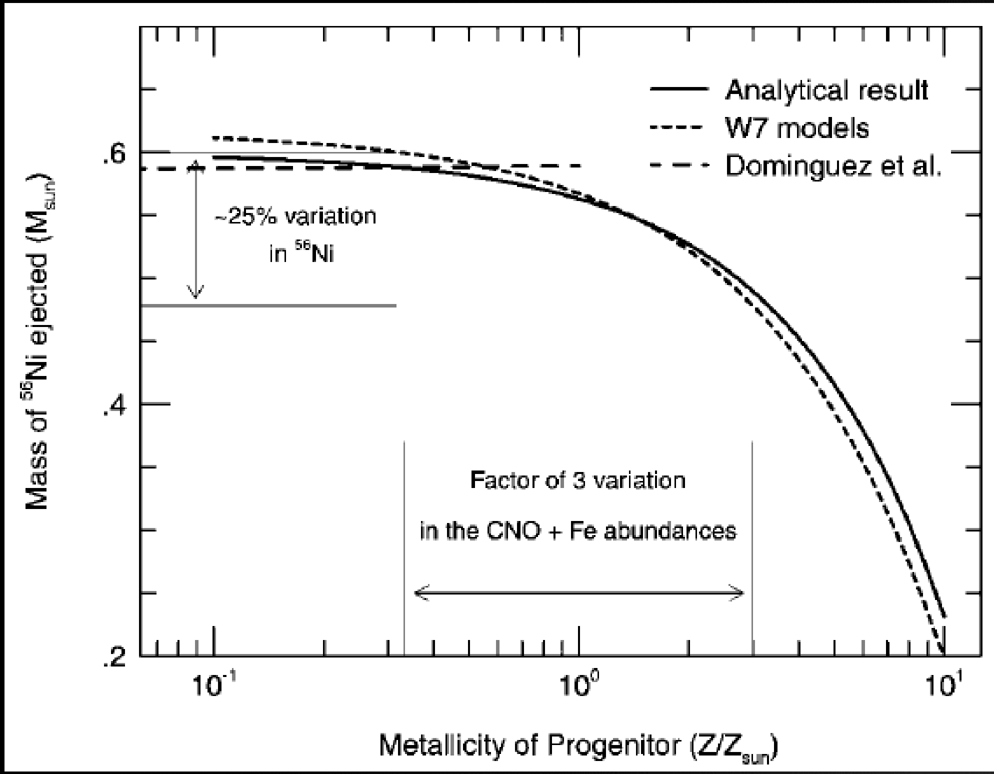
Consistent with theory (Timmes+ 03)

Mass spread at a fixed metallicity is larger

Physical parameters other than metallicity

^{56}Ni mass and progenitor metallicity

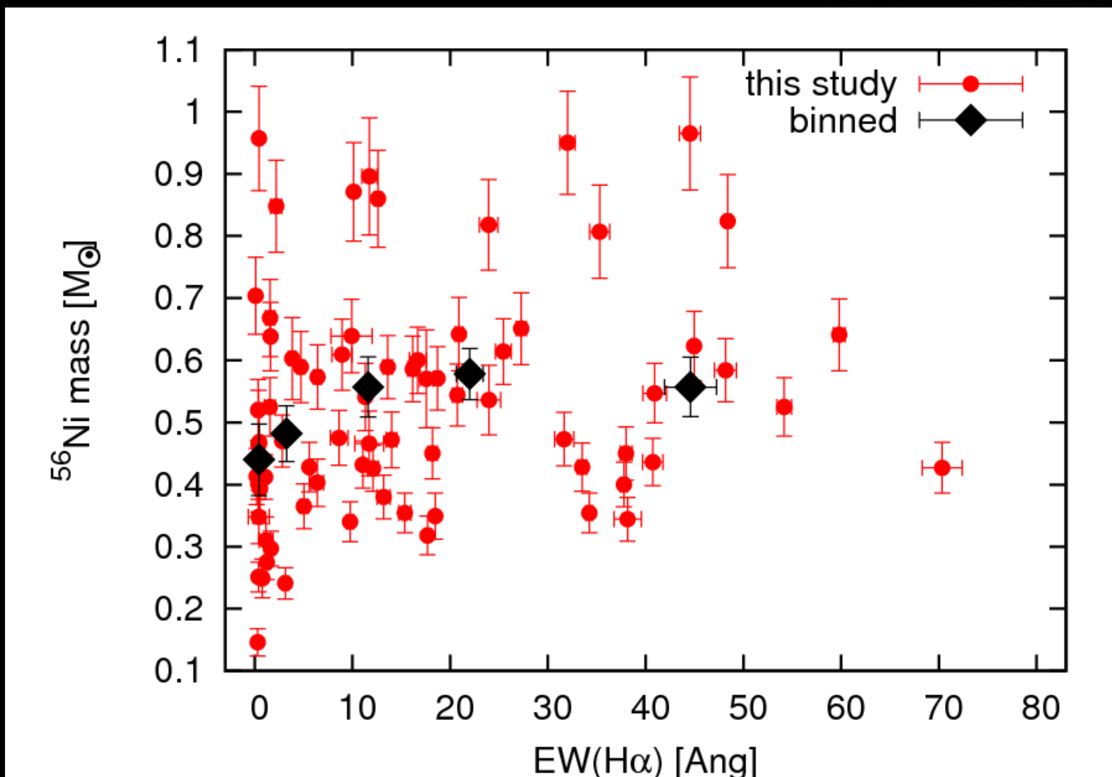
Theory



Timmes et al. 2003
Roepke et al. 2006

Higher metal → Larger fraction of Ne (p=10,n=12)
→ Larger fraction of n>p nuclei
→ Smaller fraction of ^{56}Ni, p=n nuclei

^{56}Ni mass and host Hα EW

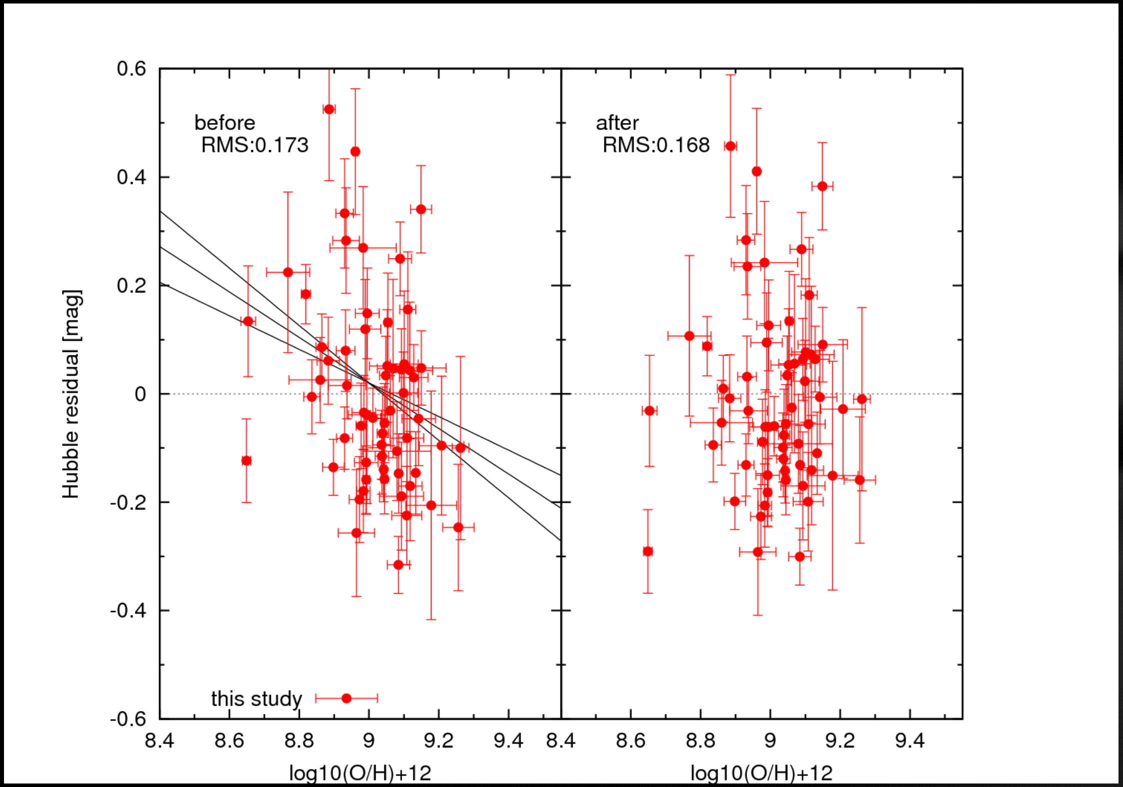


Fewer ⇐ Young stars ⇒ Larger

Averagely smaller ^{56}Ni mass for older galaxies

Hubble residual and metallicity

Corrected for lightcurves

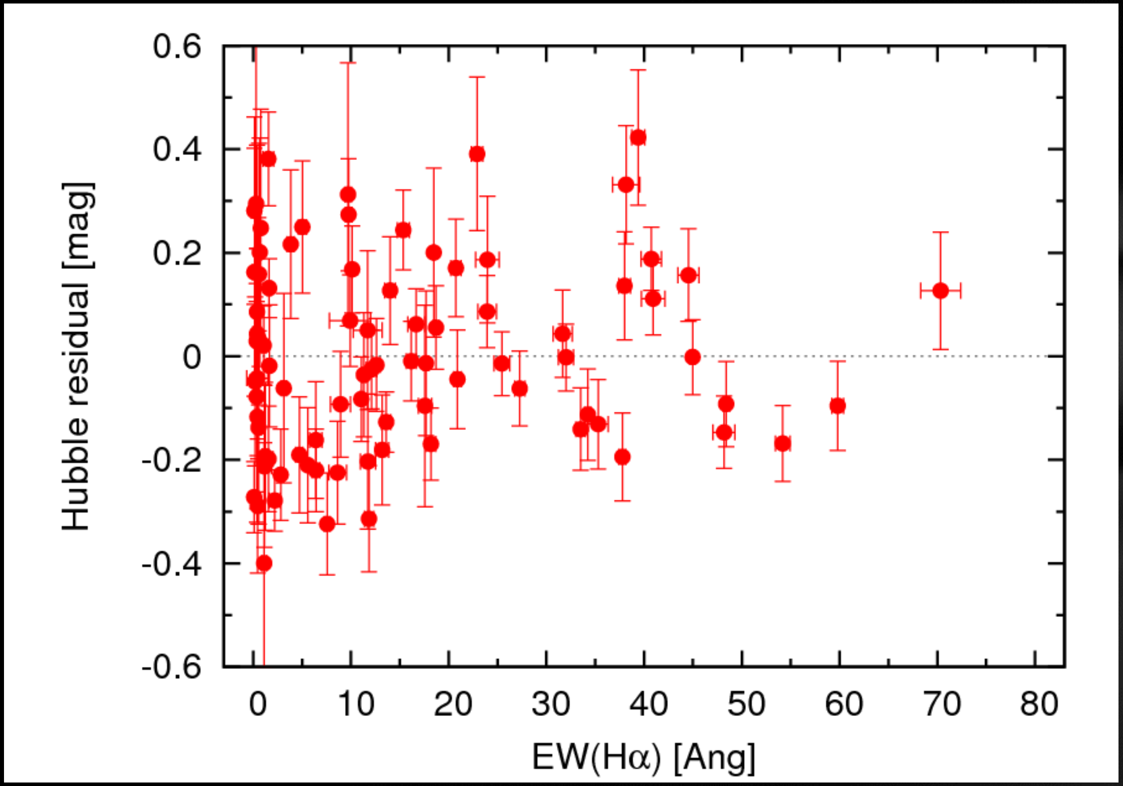


Negative slope > 3σ between residuals and metallicity

Slight improvement of HR RMS after metallicity correction

Hubble residual and Hα emission

Corrected for lightcurves



Zero slope < 2σ between residuals and EWHα

Summary

We used spectroscopically confirmed SNe Ia and their host spectra from the SDSS-II Supernova and Legacy survey to examine host gas environments.

A hint for ^{56}Ni mass decrease for metal rich hosts

- trend consistent with theory
- mass scatter is larger

^{56}Ni mass decrease for low EWHα hosts

- consistent with nearby SNe Ia

Hubble residual

- still correlates with metallicity after lightcurve corrections
  - slightly smaller after metallicity correction
- not correlates with EWHα

Thank you for your listening