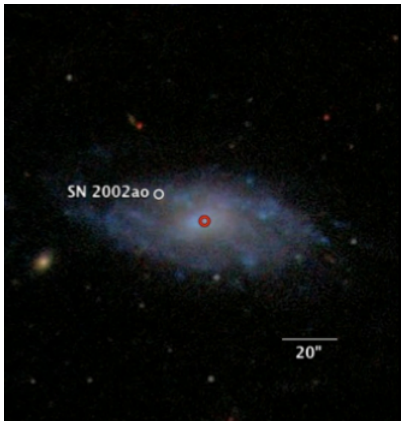
Metallicities at the Sites of Core-Collapse SN

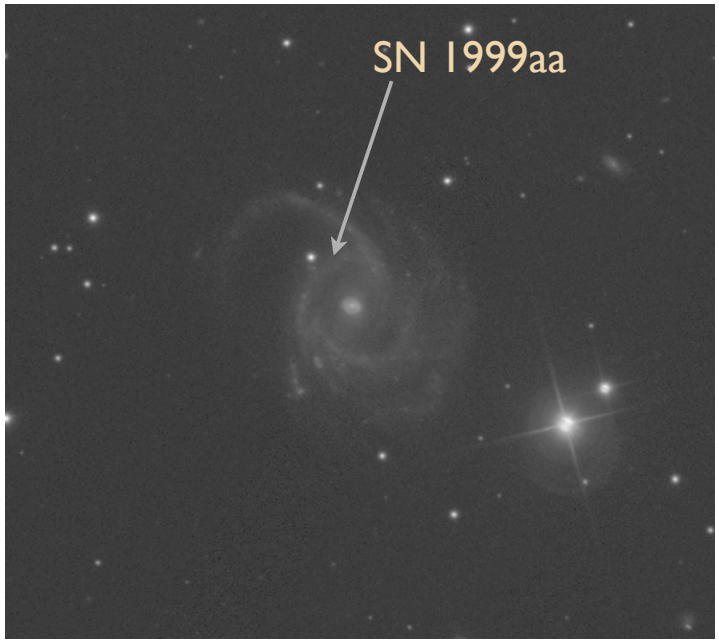


Patrick Kelly

Stanford University
advisers: David Burke and Steve Allen

Briefly:

SN Ia Calibration Dependence on Host Environments



SDSS g'-band

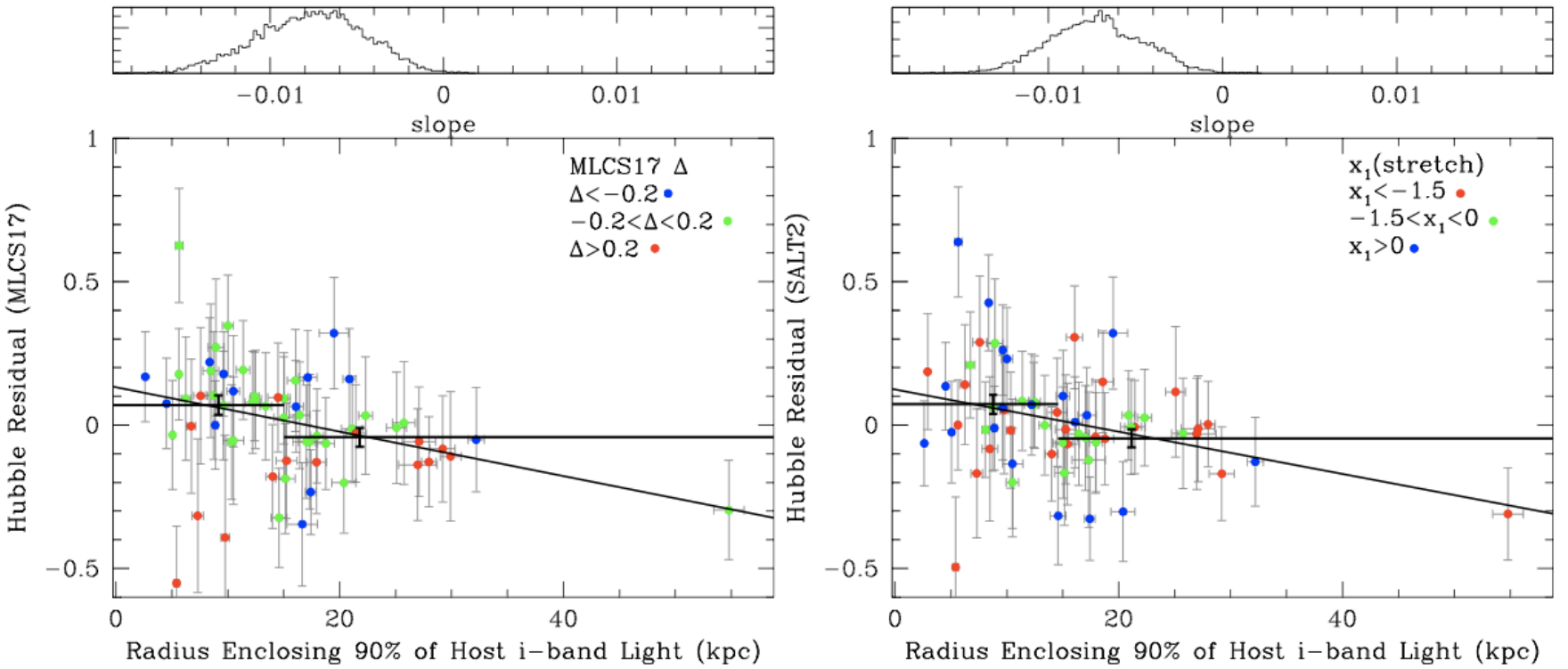
arXiv: 0912.0929
accepted by ApJ

Stanford/SLAC:
David Burke

Harvard:
Robert Kirshner
Kaisey Mandel
Malcolm Hicken

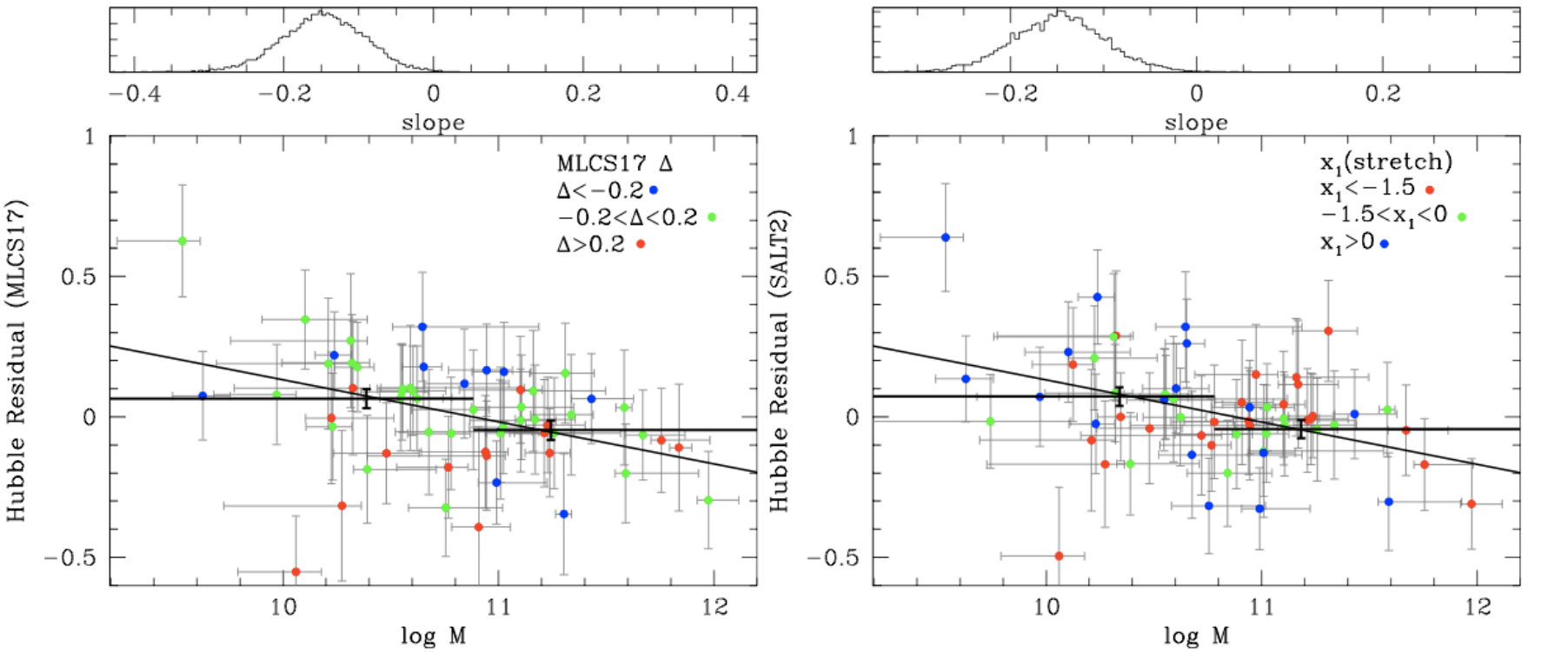
Correlation of Host Sizes w/ Hubble Residuals

Posterior Probablity Distribution



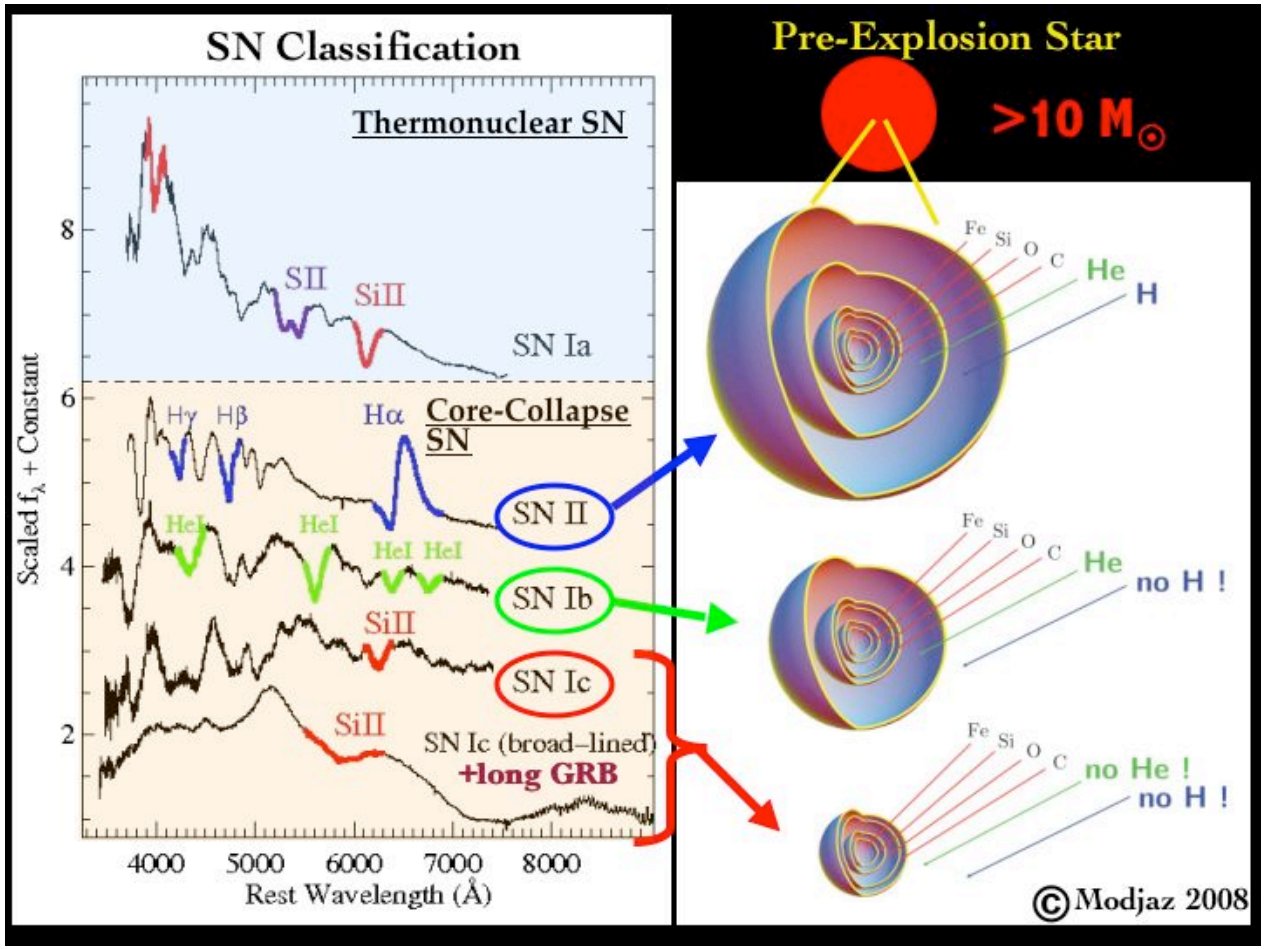
Correlation of Host Masses w/ Hubble Residuals

Posterior Probablity Distribution



Back to Metallicity Analysis:

Core-Collapse Spectra/Progenitors



Direct Detections of SN II + IIb progenitors

- ~10 SN II red giant progenitors
- SN 1993J Type IIb binary K-type supergiant and a B-type supergiant companion (Maund 2004)
- No SN Ib, Ib/c, or Ic progenitors yet

Progenitor Metal Content Important

- Metals increase opacity of the stellar envelope
  - accelerates mass loss => stripping of outer H, He shells
  - causes angular momentum loss, GRBs may need high angular momentum to form jets

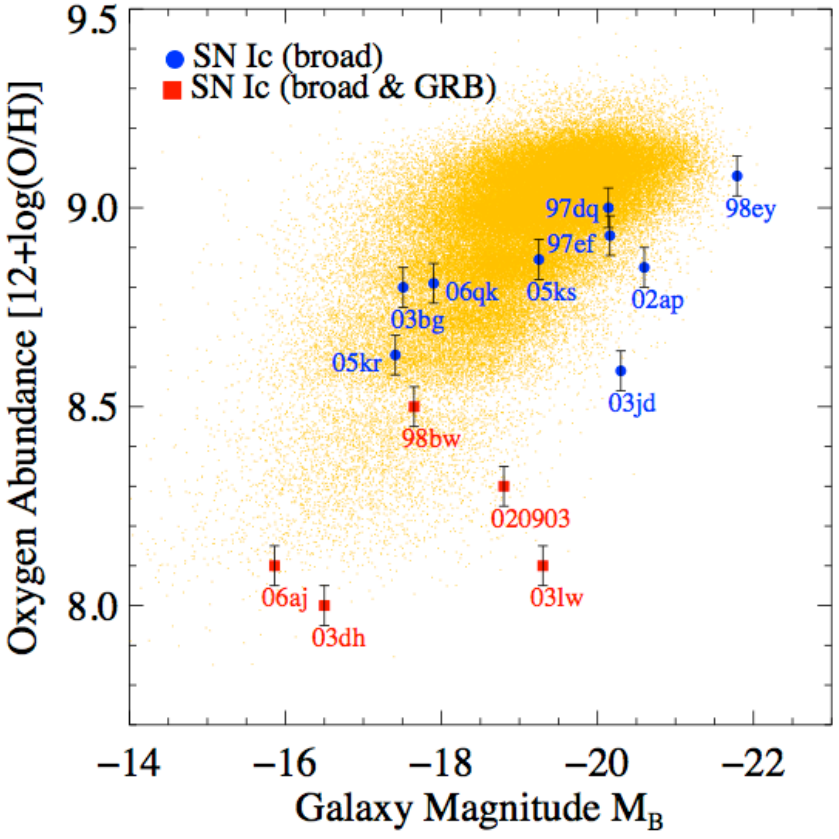
Broad-lined SN Ic

- High ejecta velocities on the order of 30,000 km/s
- Not all exceptionally luminous (i.e. SN 2002ap)
- Small fraction of observed SN Ic population

Broad-lined SN Ic Connected to Gamma-ray Bursts

- Broad-lined SN Ic superimposed on LGRB power-law
  - i.e. SN 1998bw, SN 2003dh, SN 2003lw, XRF 020903, SN2006aj
- ~80% of broad-lined SN Ic have no LGRB
  - Soderberg et al. 2006
- Low-luminosity LGRBs more common

LGRB prefer low-metallicity environments



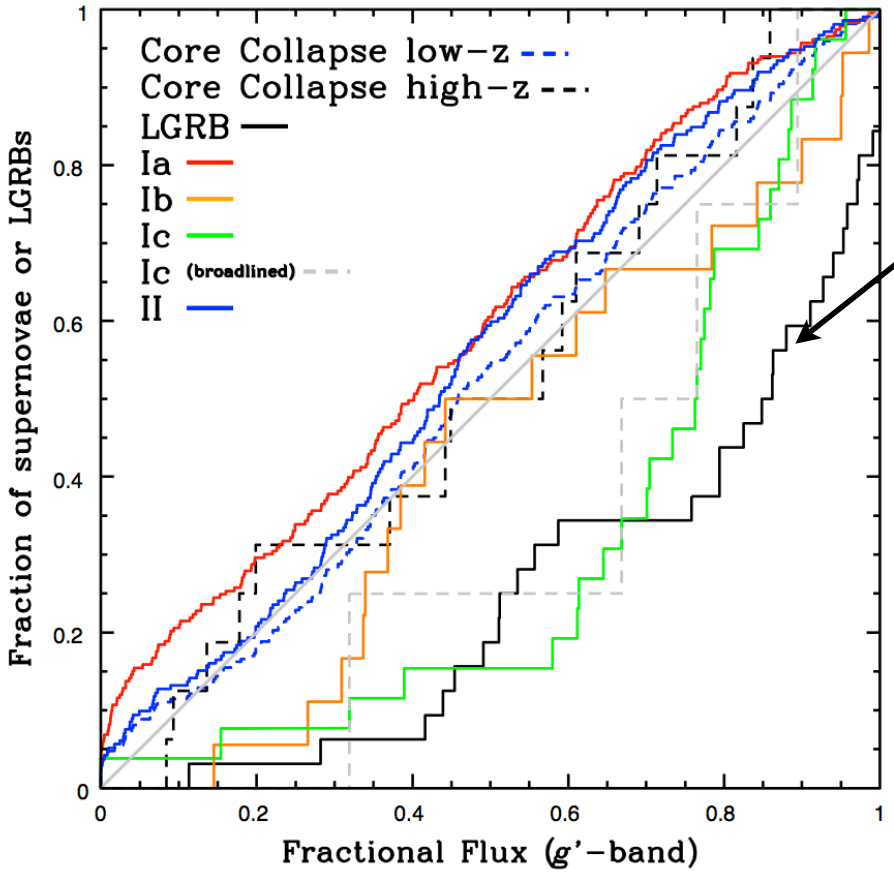
Modjaz et al. 2008

Low metallicity related to jet production?

SN (Ib+Ib/c+Ic) prefer more metal-rich environments than SN II

- 5% confidence Prieto 2008 from SDSS measurements (also Prantzos + Boissier 2009)
- How about Ib, Ib/c, Ic considered separately? Other spectroscopic types? May be surprises

SN Ic Occur in Bright Regions of Host Galaxies (similar to LGRB)

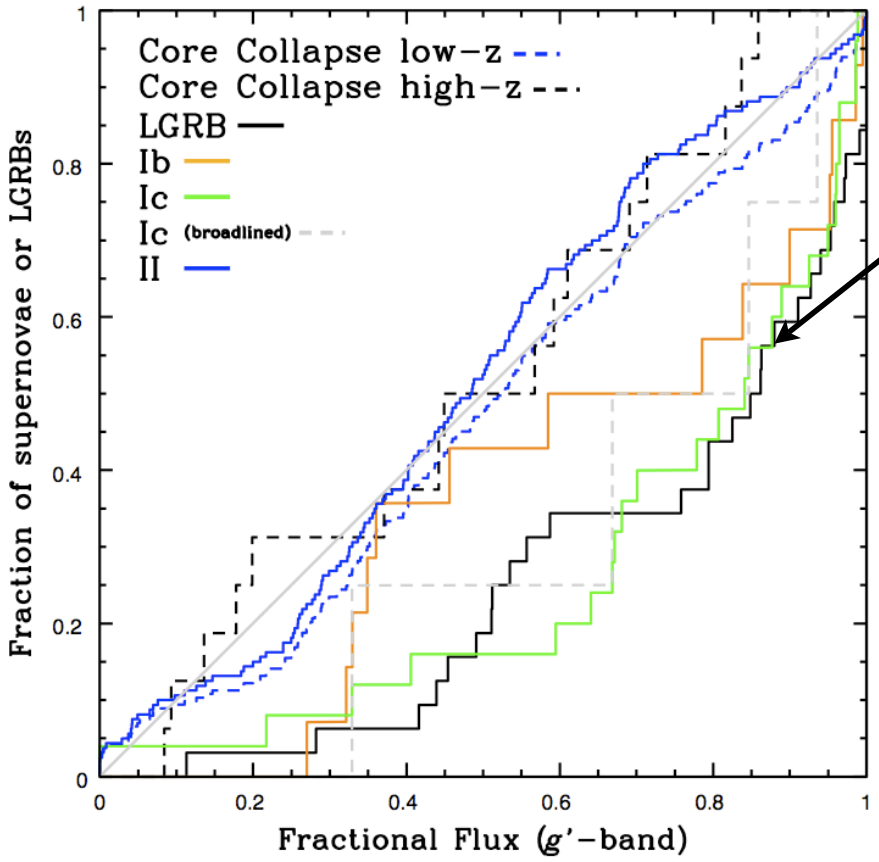


Fruchter et al. 2006

Kelly et al. 2008

SN Ic in brighter regions than SN Ib

Similarity Improves after Host Bulge Subtraction

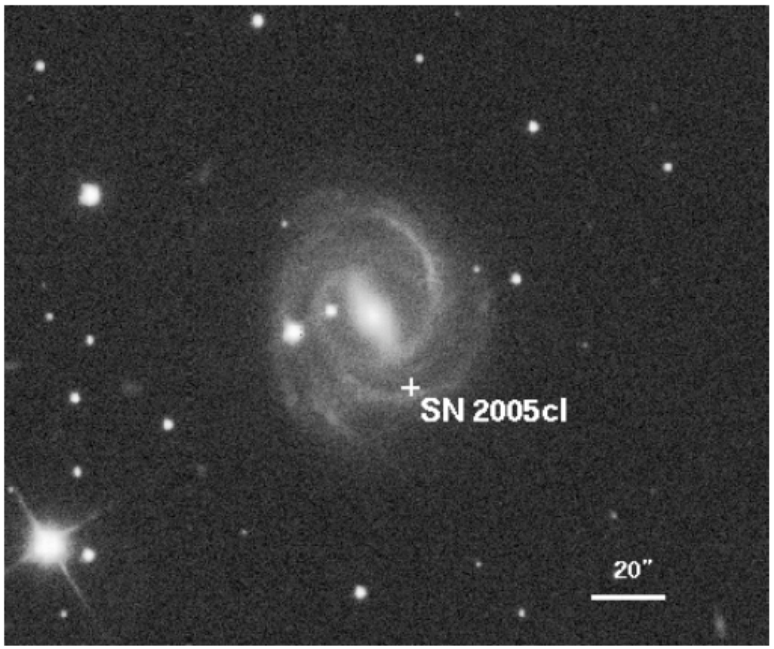


Fruchter et al. 2006

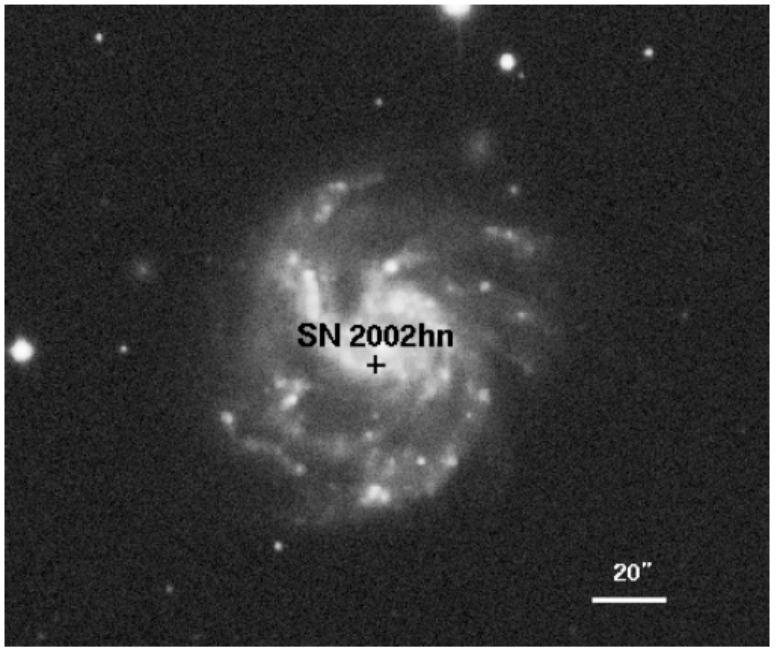
Kelly et al. 2008

More fair comparison to irregular LGRB hosts

SN Ic progenitors are more massive/metal rich?



SN IIn

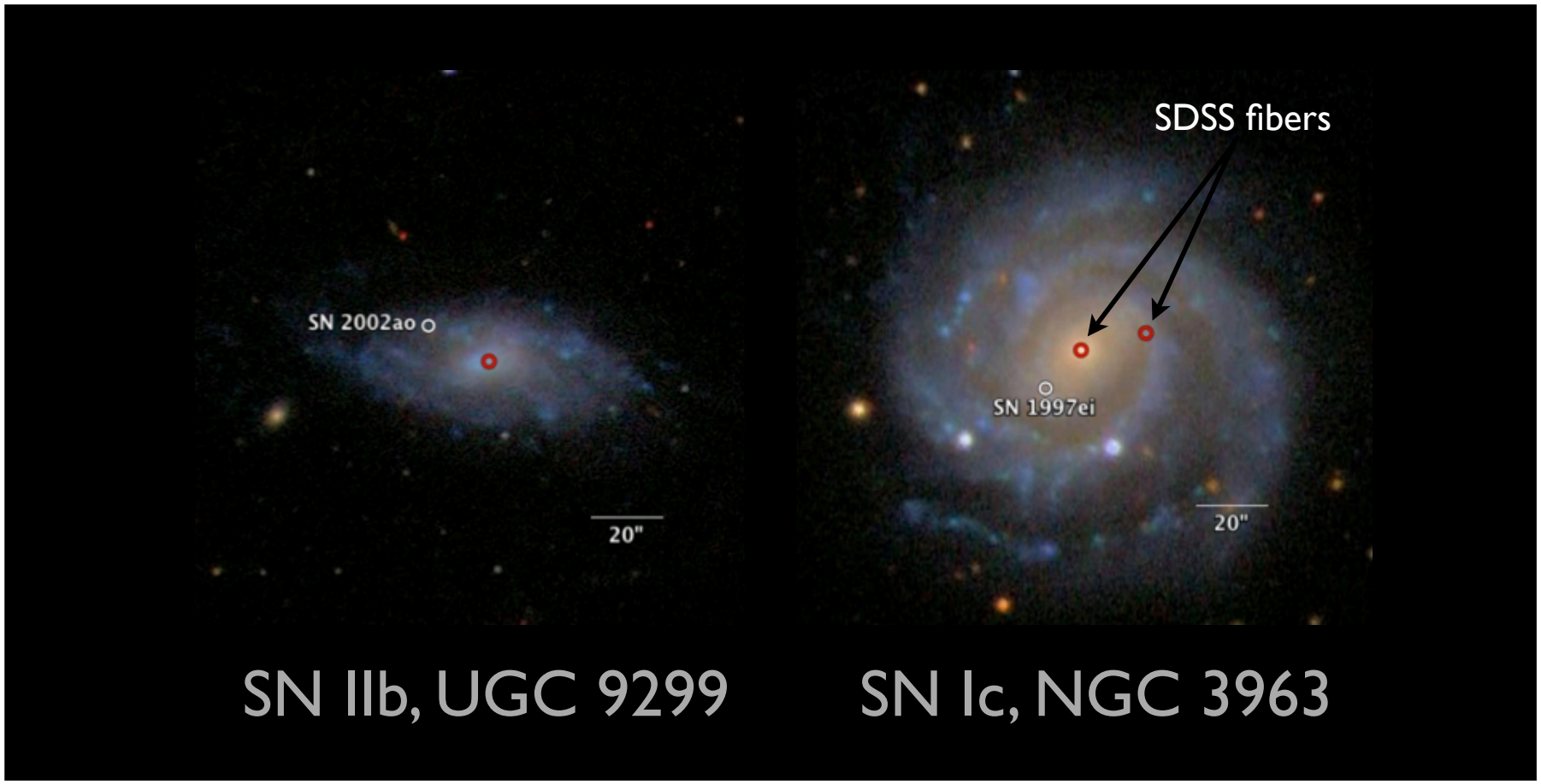


SN Ic

Open Questions

- Single vs. Binary Progenitors: Binaries produce stripped-envelope SN at lower metallicities
- Progenitor masses, metallicities
- Importance of angular momentum

SDSS DR7 Imaging + Spectra

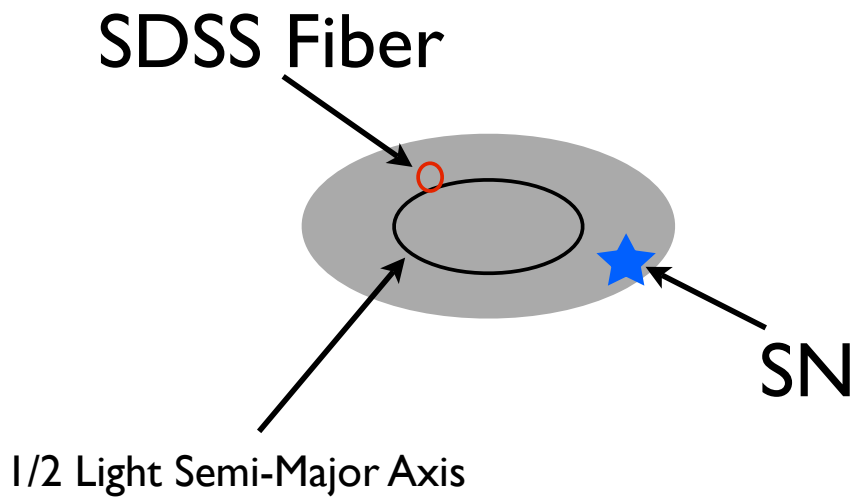


Metallicities from MPA-JHU collaboration + Modjaz et al. 2008

Metallicity as a Function of Offset + Host Mass

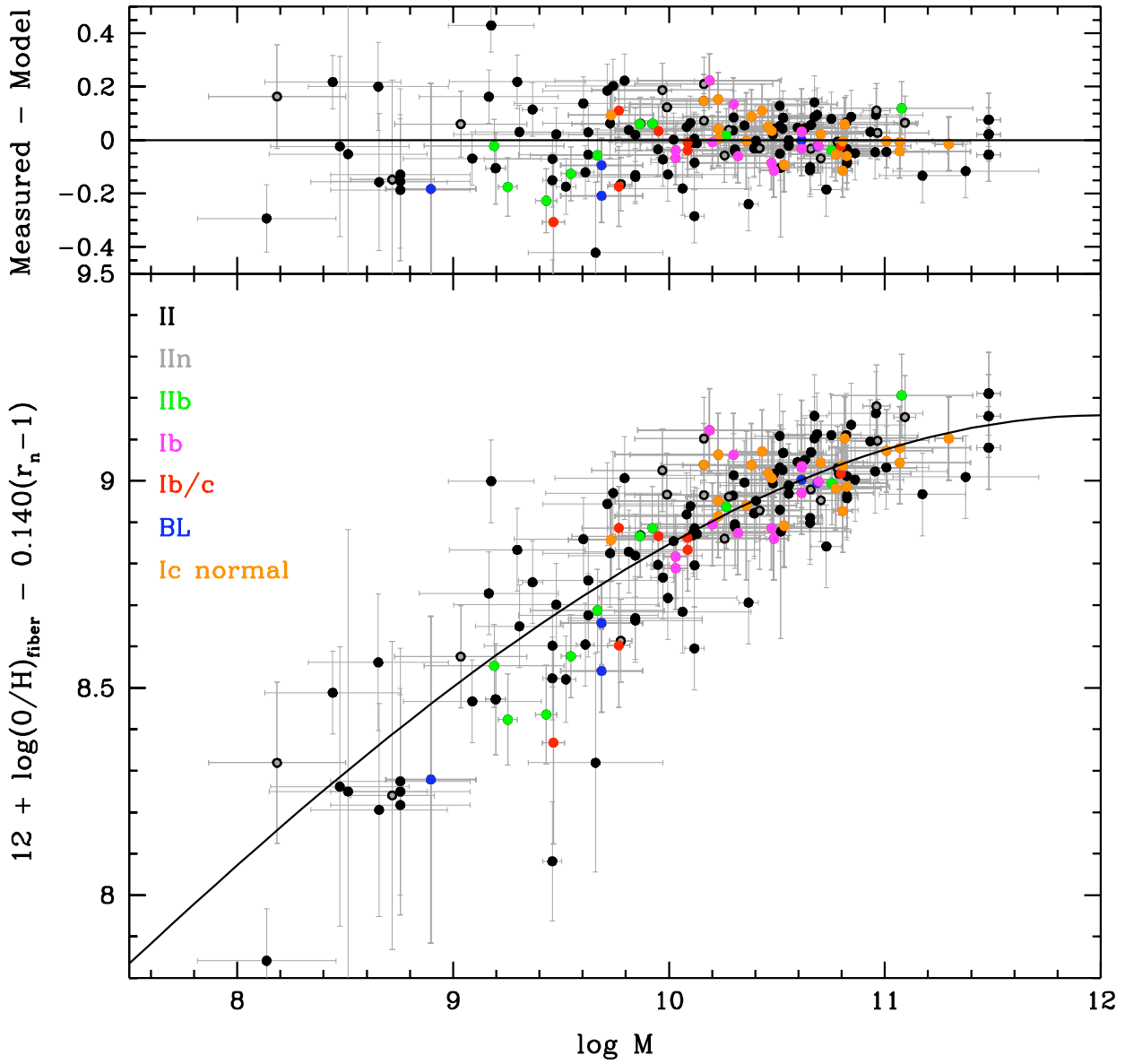
- Metallicity usually higher near galaxy center
- 3” SDSS fiber aperture + nearby galaxies
  => aperture bias problem
- Prieto 2008 used SDSS DR4 metallicities

Find deprojected normalized offsets of fibers + SN

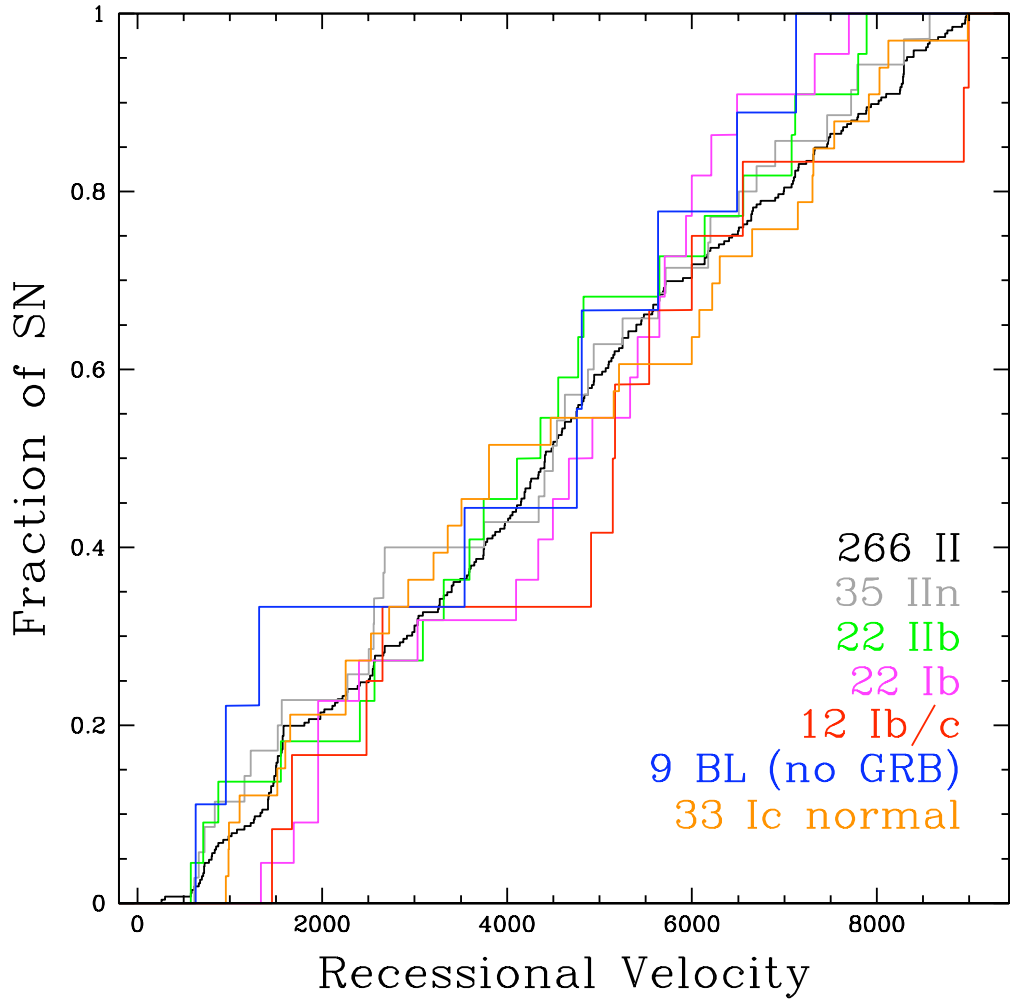


Tight relation between host stellar mass, fiber offset, and 12 + log(O/H)

Metallicity at half-light radius



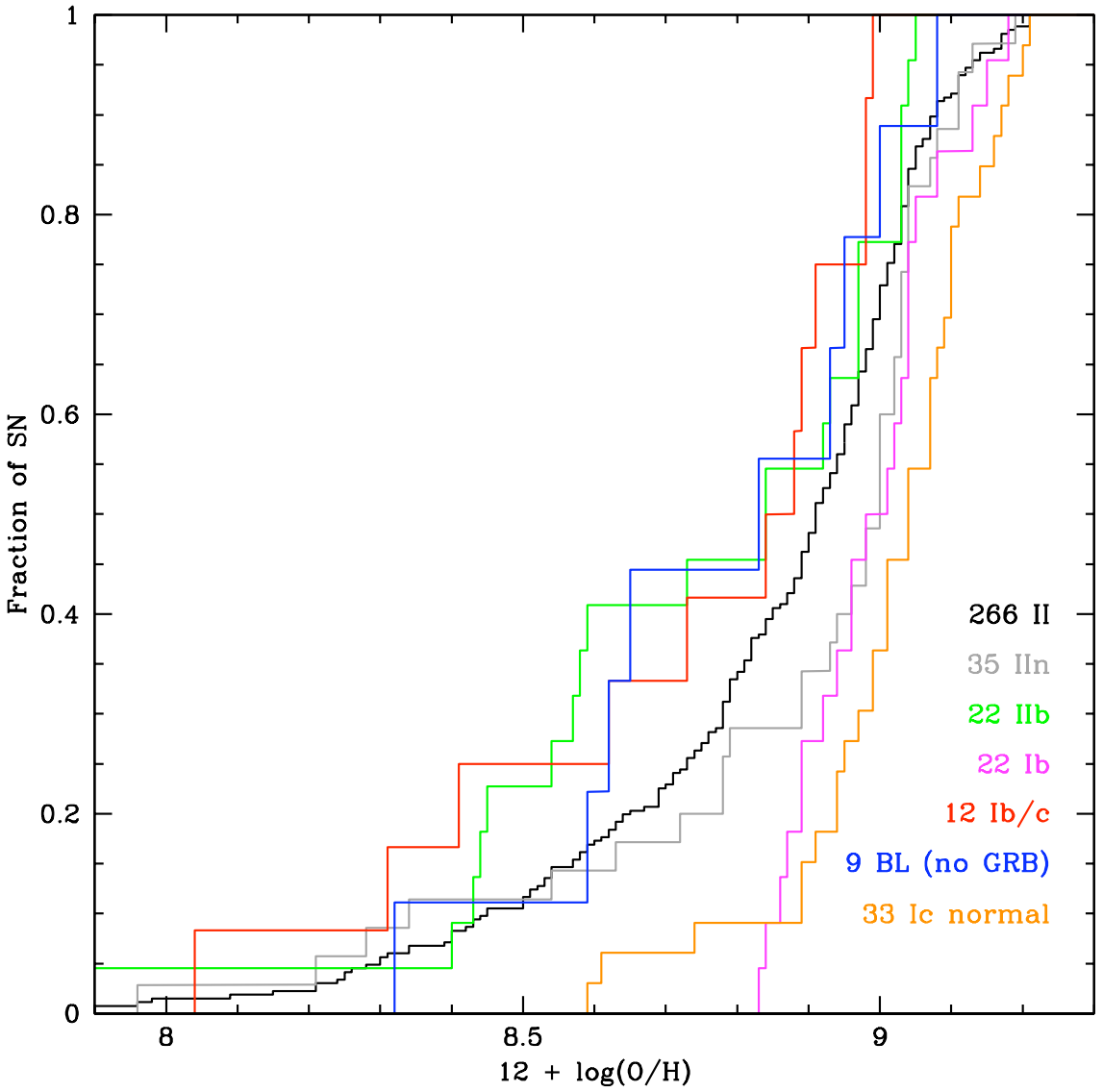
Redshift Distributions (z<0.03) of SN Types are Very Similar



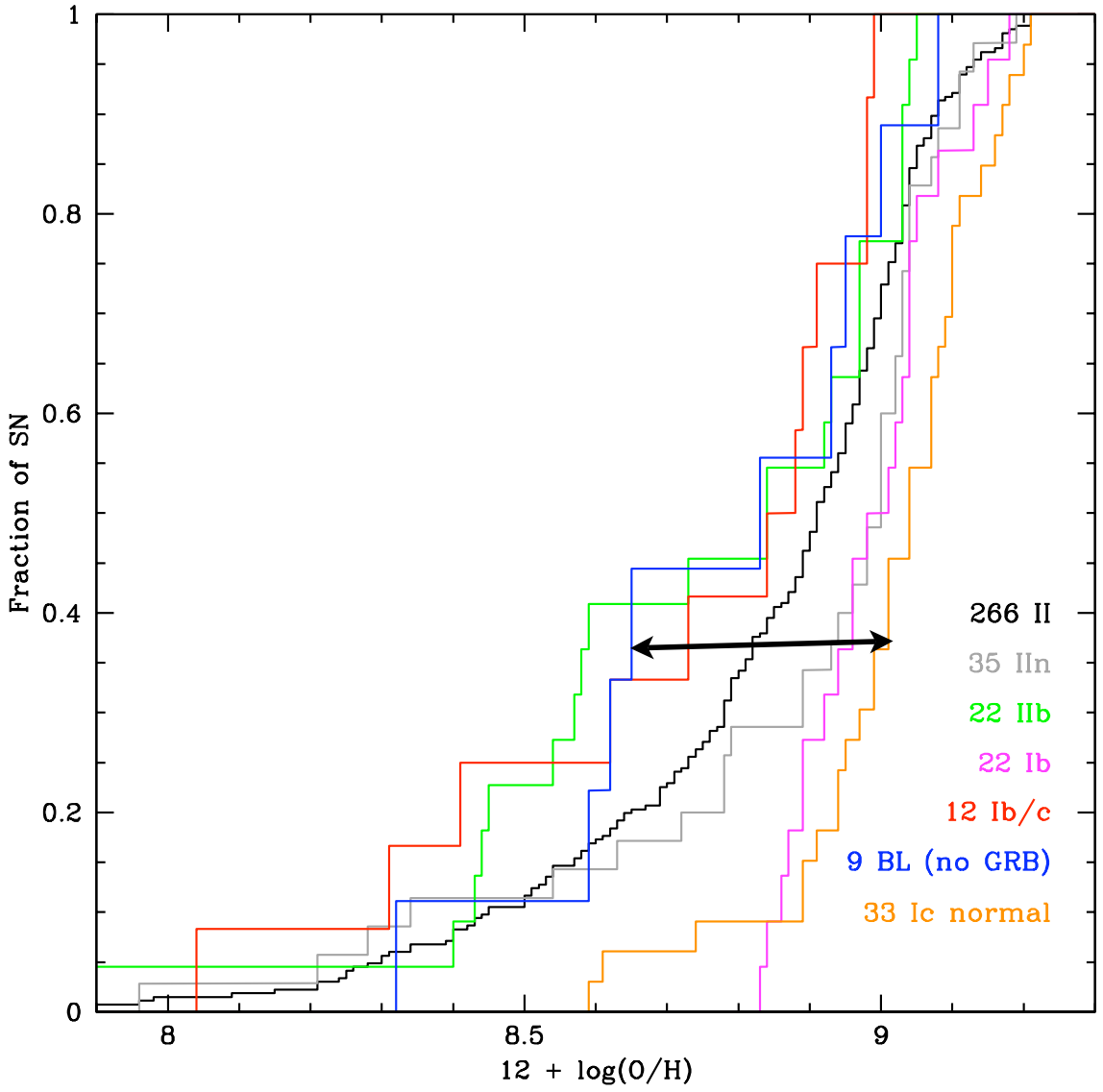
SN Ib and Ic are relatively similar

SN Ib, Ic each distinct from SN II p<1%

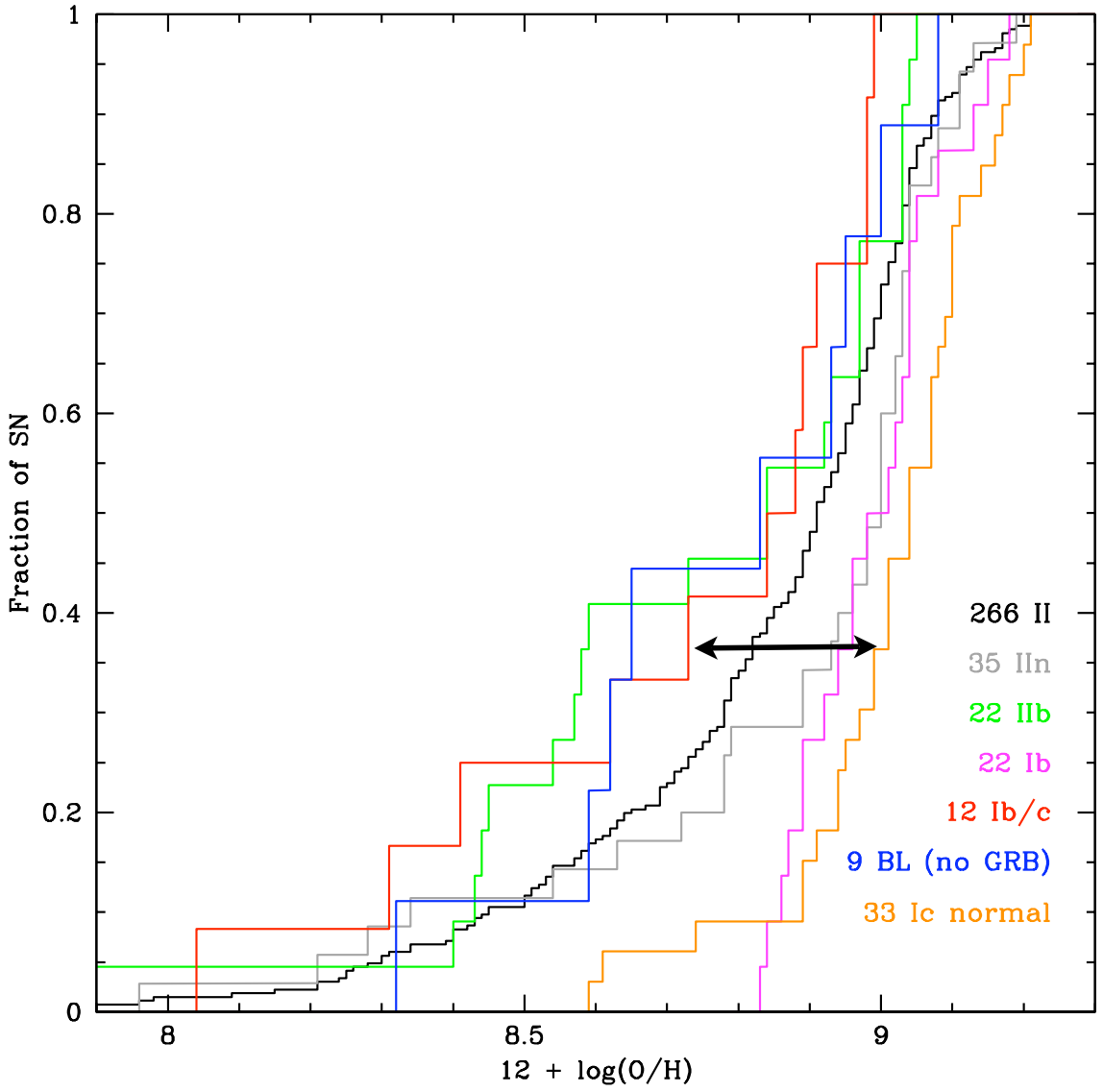
There are SN Ib at low Z (SN 2005hm + PTF)



Broad-lined SN Ic (without a GRB) in lower metallicity environments than "normal" SN Ic



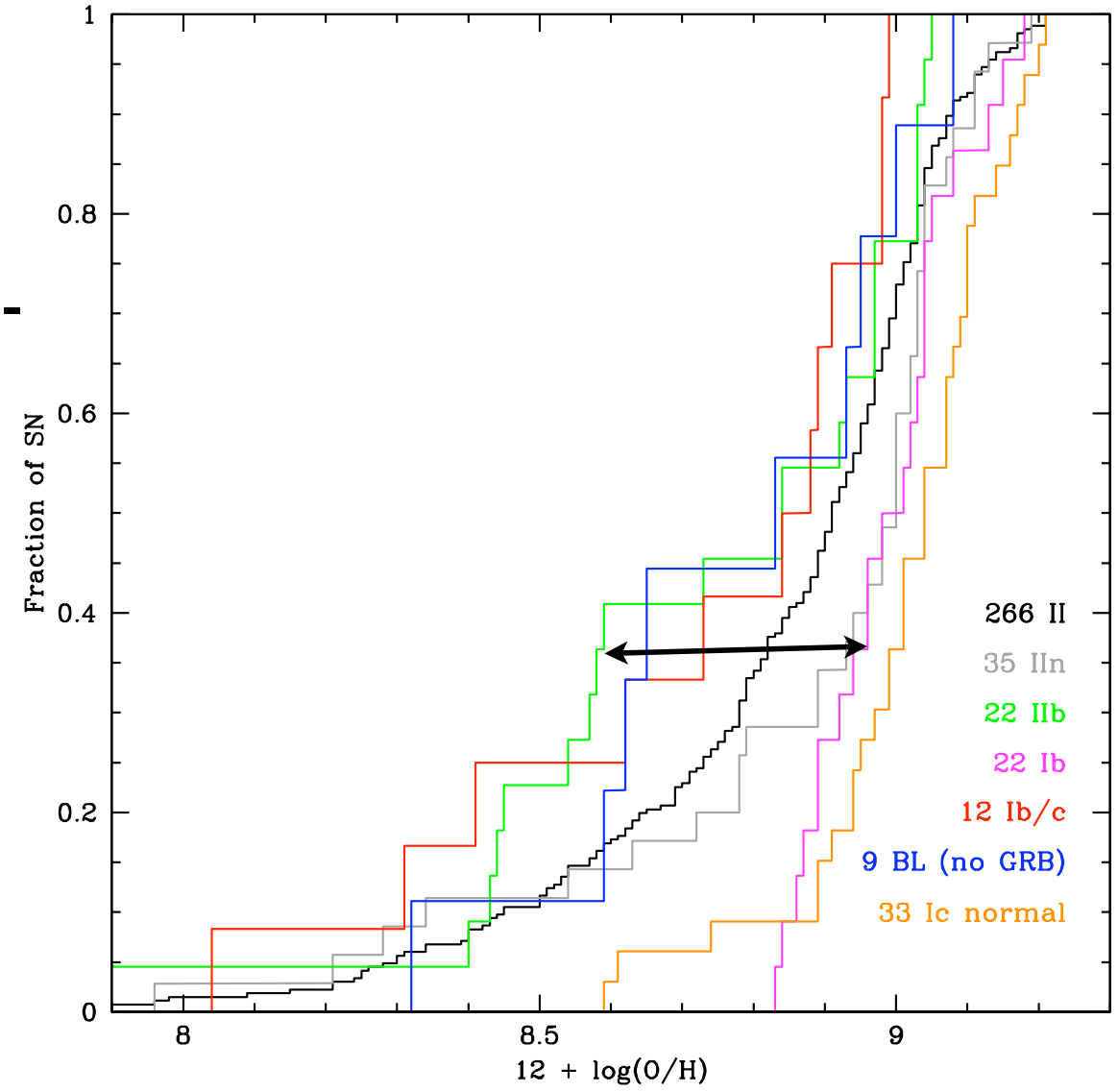
Type Ib/c in more metal-poor environments than Ib +Ic?



SN Ib/c in Metal-Poor Regions

- Calcium-rich spectra: SN 2001co, SN 2003dg, SN 2005E (Perets 2009)
- SN 2007eb + SN 2002ji had high ejecta velocities

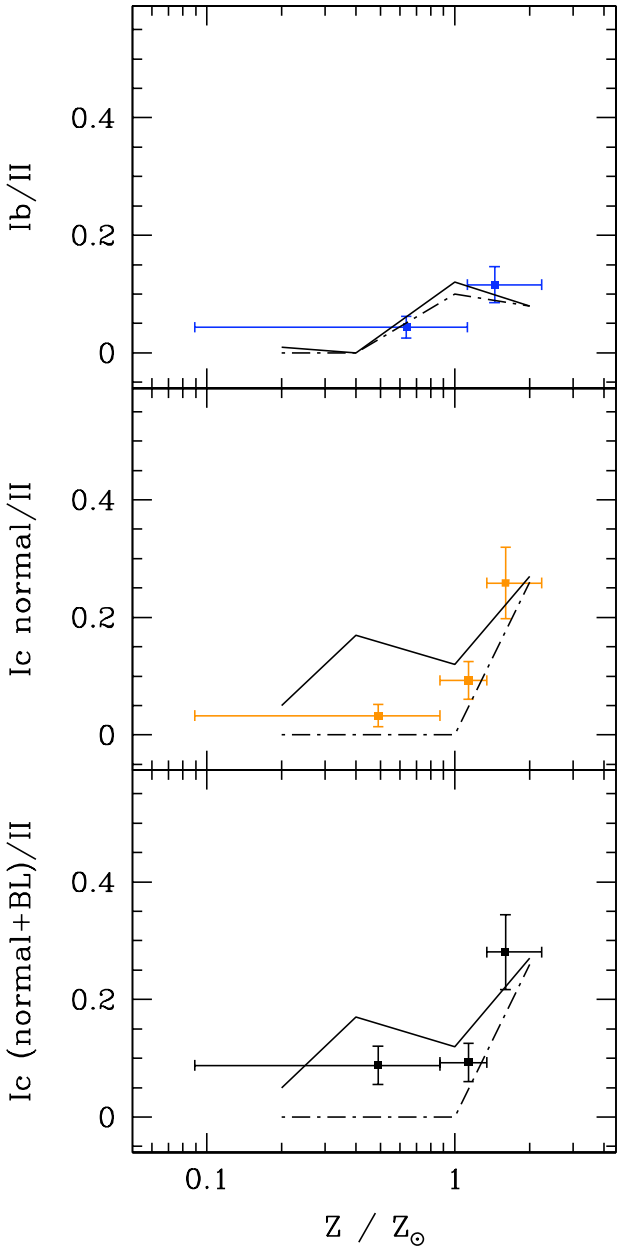
SN IIb in more metal-poor regions than SN Ib



Extended + Compact SN IIb?

- Chevalier + Soderberg 2010
- Extended:
  - SN 2001gd ~9.04 dex
- Compact less metal-rich than SN Ib
  - SN 1996cd ~8.4 dex
  - SN 2008ax ~8.45 dex

Comparison of SN Relative Rates to Predictions



Single Progenitors:

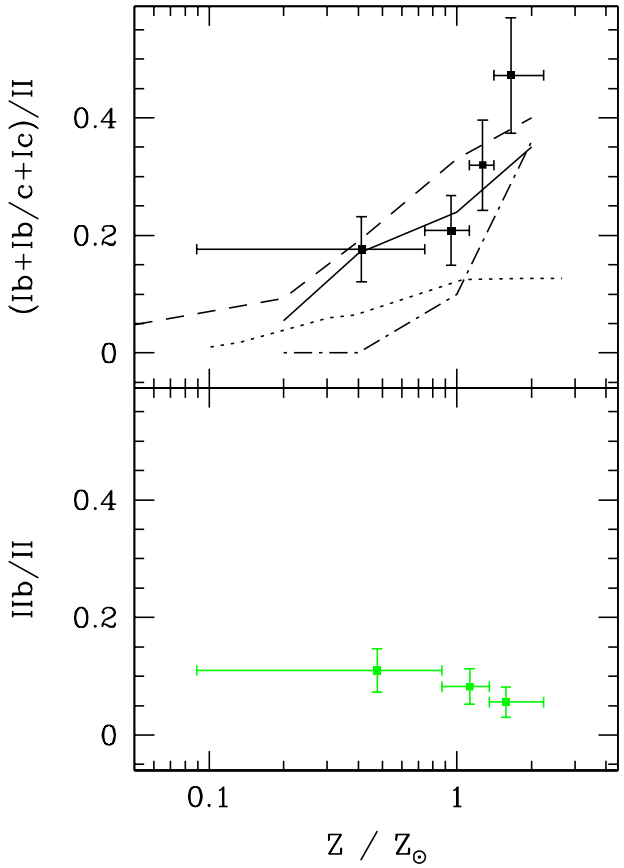
Georgy 09 Black Hole SN

Georgy 09 Black Hole No SN

Eldridge 08

Binary Progenitors:

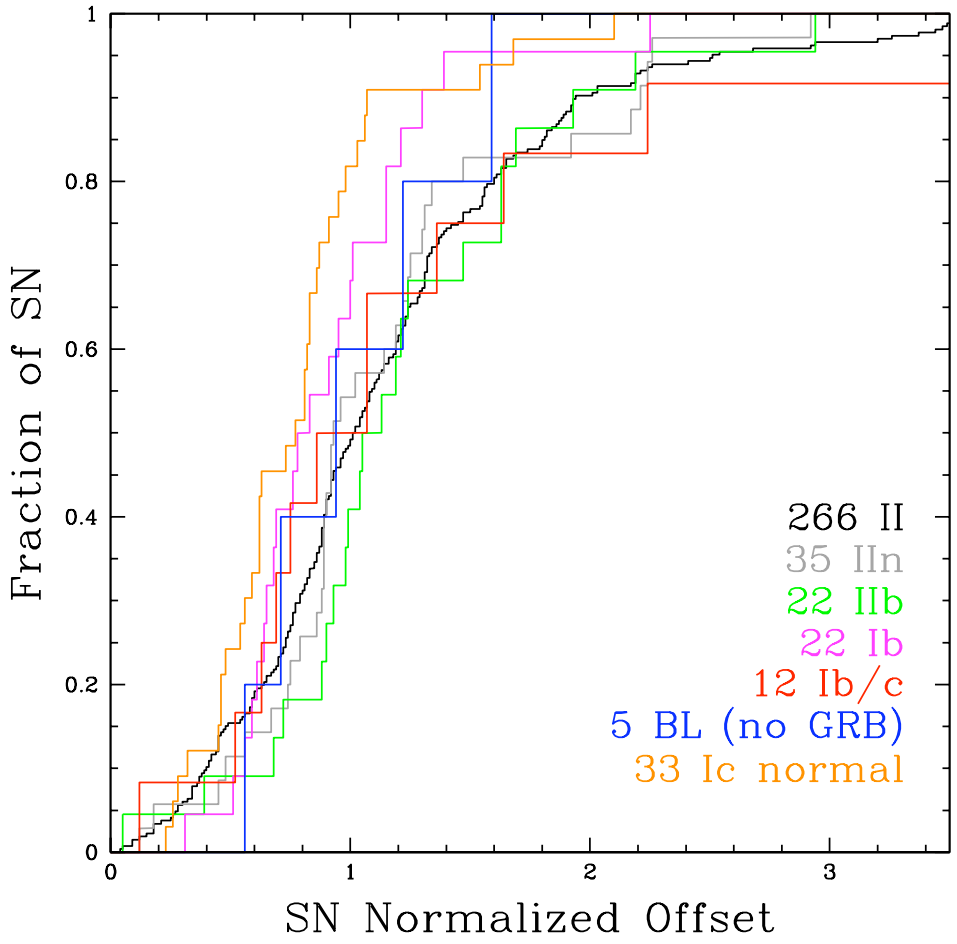
Eldridge 08



Conclusions

- SN Ib/II + Ic/II rates can be largely accounted for by single, rotating progenitors -> neutron stars
- Metals linked to width of SN Ic lines
- SN Ib/c differ from SN Ib and SN Ic
- SN IIb in less metal rich environments than SN Ib

SN Deprojected Offsets



Consistent with high SN Ib and Ic metallicities