The local environments of core-collapse supernovae within host galaxies

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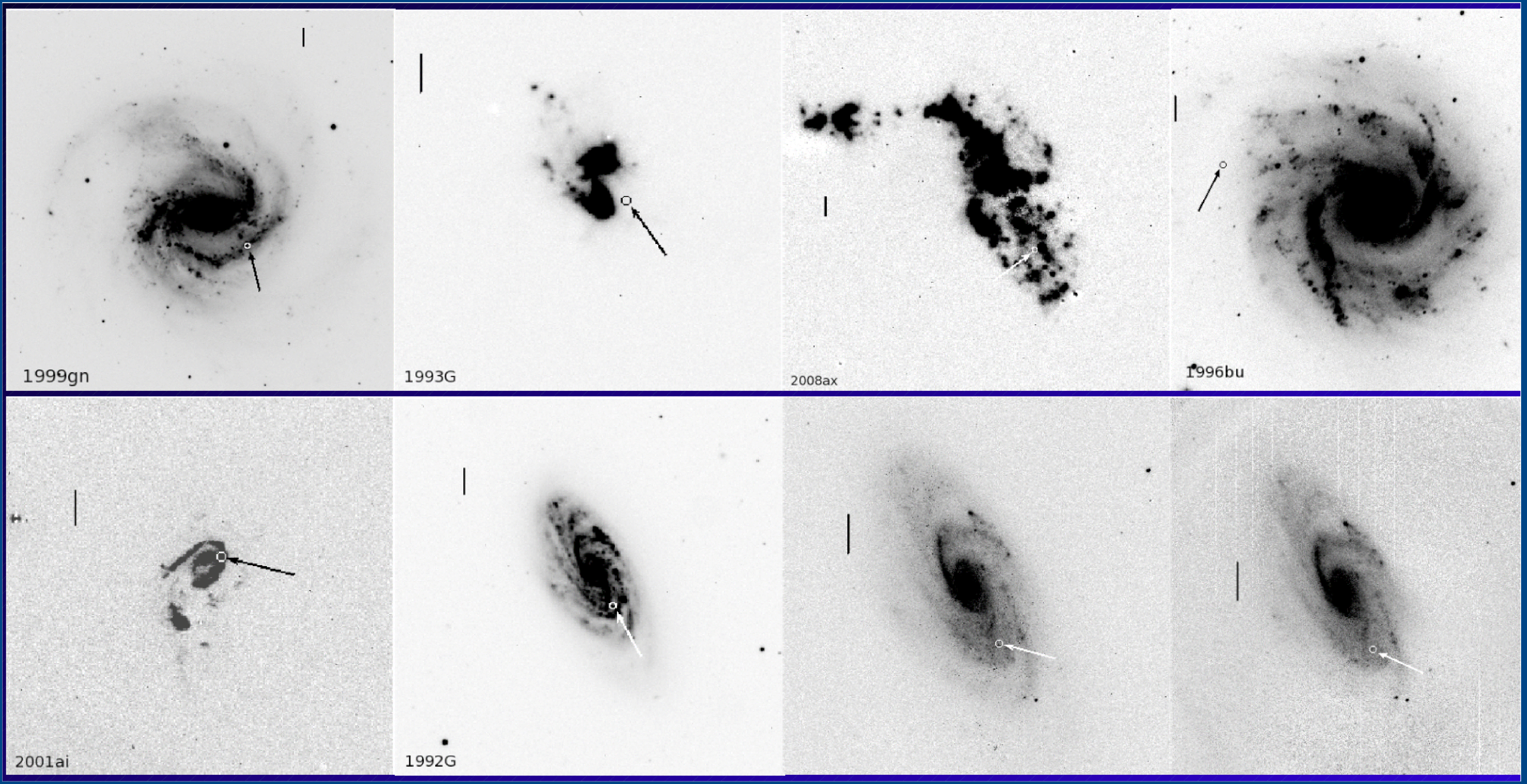


Diversity of CC SNe and their progenitors

- Stars above 8-10Msun explode as CC SNe
- What progenitor differences produce diversity of transient phenomena?

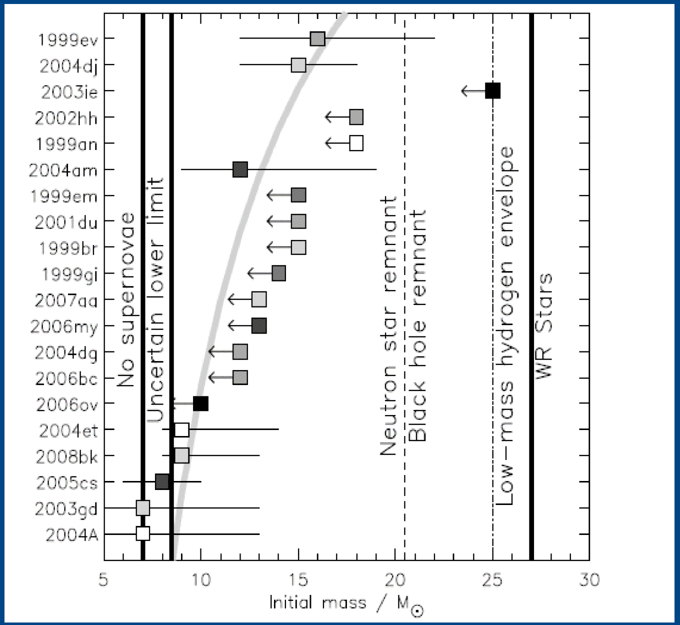
SNIIP → IIL → IIb → IIn → Ib → Ic

- Sequence of increasing pre-SN mass loss?

- How does progenitor mass, metallicity, rotation, binarity, produce these differences?
- Which progenitor stars produce SN 'impostors'?

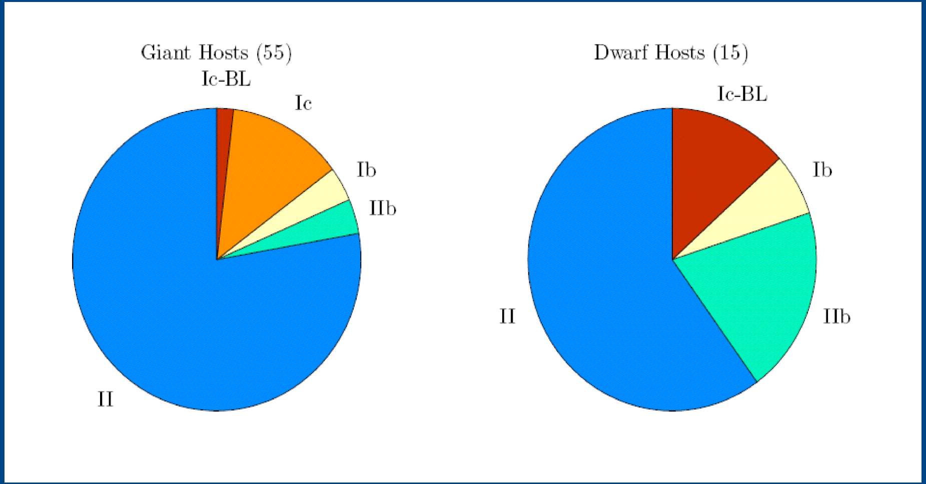
Constraining progenitor properties

- **Direct detections provide detailed info for individual nearby SNe**
  - low statistics, long-term answers
  - see van Dyk talk
- **Host galaxy studies allow statistical samples to be studied**
  - multiple stellar populations



Smartt et al. (2009)

- **Constraining progenitor properties using environments *within* host galaxies**
  - allows statistical studies
  - differentiate between stellar populations



Arcavi et al. (2010)

Environments of SNe within host galaxies

1) Spatial correlations of SNe with host galaxy star formation

- **Search for differences in the association of explosion sites with SF regions by SN type**
  - use of Hα and near-UV host galaxy imaging
  - investigate differences in progenitor mass

2) Host HII region metallicity derivations

- **Evaluate differences between SNII and SNIbc environment metallicities**
  - host HII region spectroscopy
  - investigate differences in progenitor metallicity

Spatial correlations with host galaxy SF

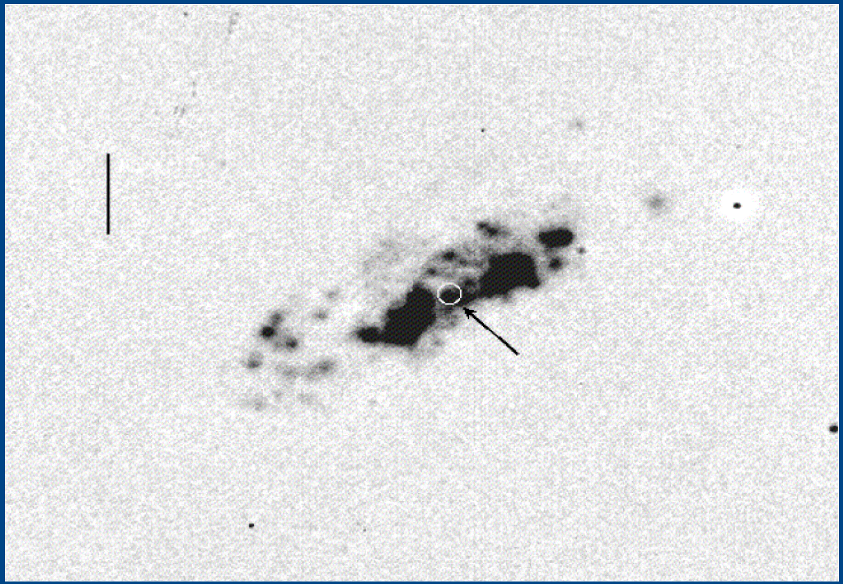
- **Host galaxy Hα imaging of large sample of CC SN**
  - 162.5 SNII (58 IIP, 13 IIL, 12.5 IIb, 19 IIn, 12 'impostors')
  - 97.5 SNIbc (40.5 Ib, 52 Ic)

- ***GALEX* near-UV imaging also used**
- **Hα emission = 'on-going' SF: <10-15 Myr**
- **Near-UV emission = 'recent' SF: 16-100 Myr**

CAVEAT: see Crowther talk!

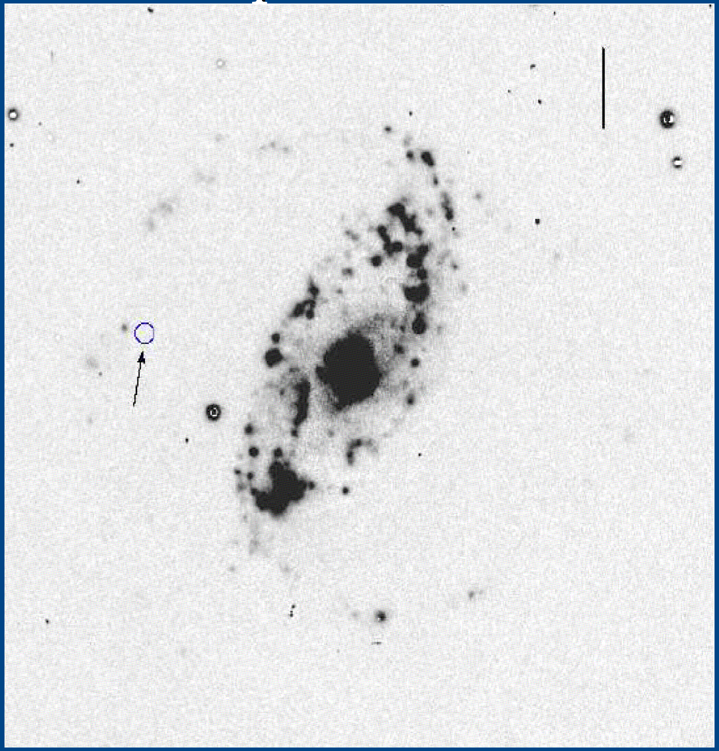
Host galaxy pixel statistics

- **'NCR' statistic to give the degree of association of an individual SN to the emission of its host galaxy**
  - James & Anderson (2006) (also Fruchter et al. 2006)
- **Statistic gives for each object a value between 0 and 1**
  - NCR value of 0 means zero flux or sky values
  - value of 1 means SN falls on highest count pixel



SNIc 2004bm, NGC 3437; NCR = 0.704

- **Build up distributions of all SN types**

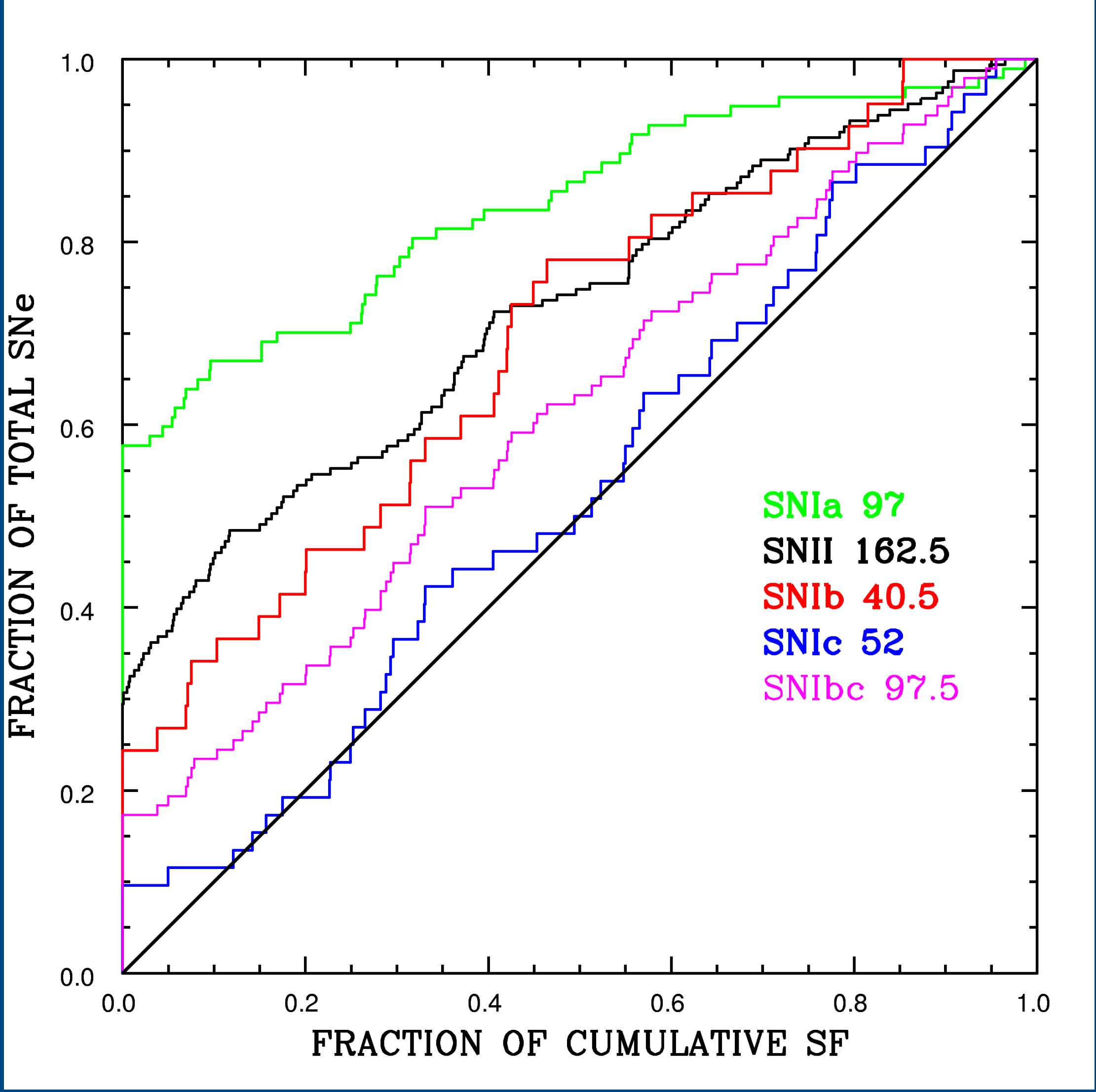


SN 'impostor' 2001ac, NGC 3504; NCR=0.000

Cumulative distributions

- Increasing association to emission means shorter lived, higher mass progenitors

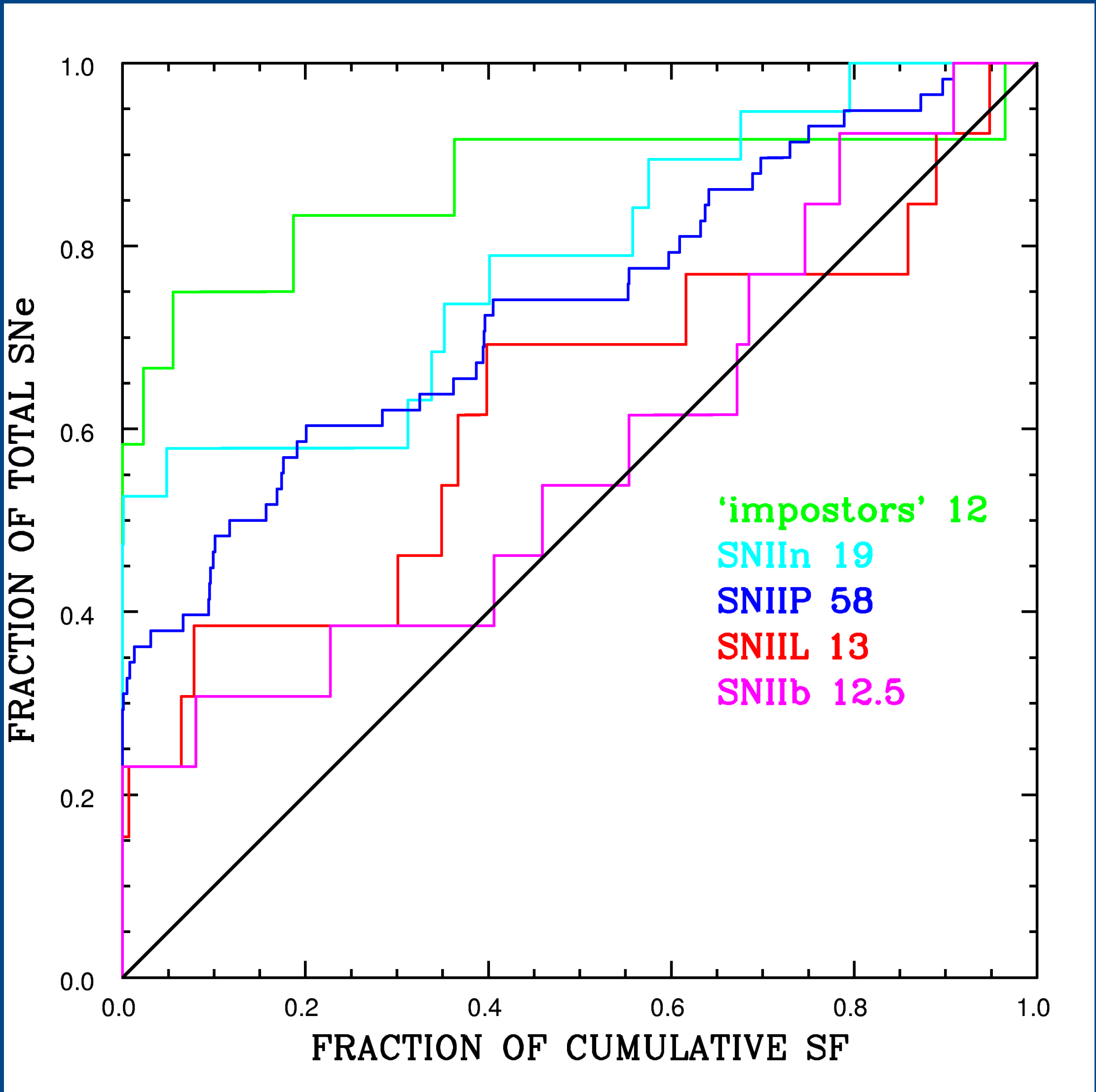
- Progenitor mass sequence observed: **Ia-II-Ib-Ic**
- SNIbc show higher correlation to Hα than SNII -> more massive
- SNIb do not trace 'on-going' SF: binaries?



Cumulative distributions

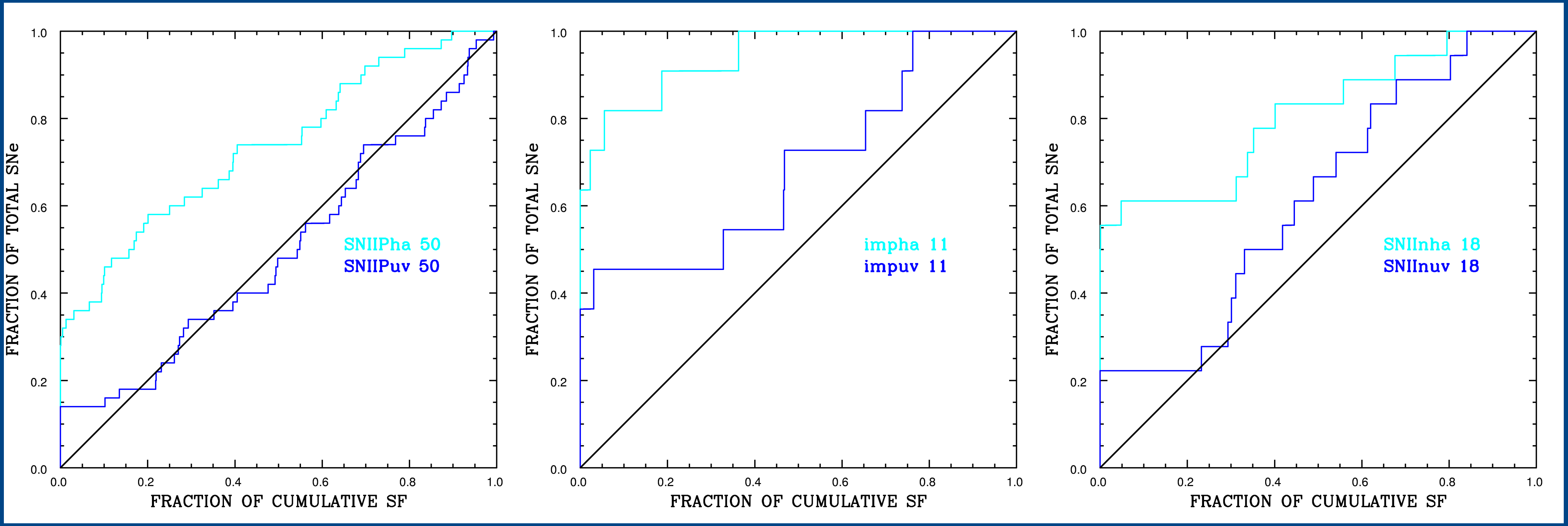
- SN 'impostors' – SNIIn – SNIIP – SNIIL – SNIIb

- SN 'impostors' and SNIIn show lowest correlation with emission; lower mass progenitors?
- SNIIL and SNIIb higher mass progenitors than IIP?



'On-going' and 'recent' SF

- SNIIP, IIn and 'impostors': correlation to 'recent' SF



- All show increased association to SF on longer timescales
- Additional evidence for low mass progenitors?

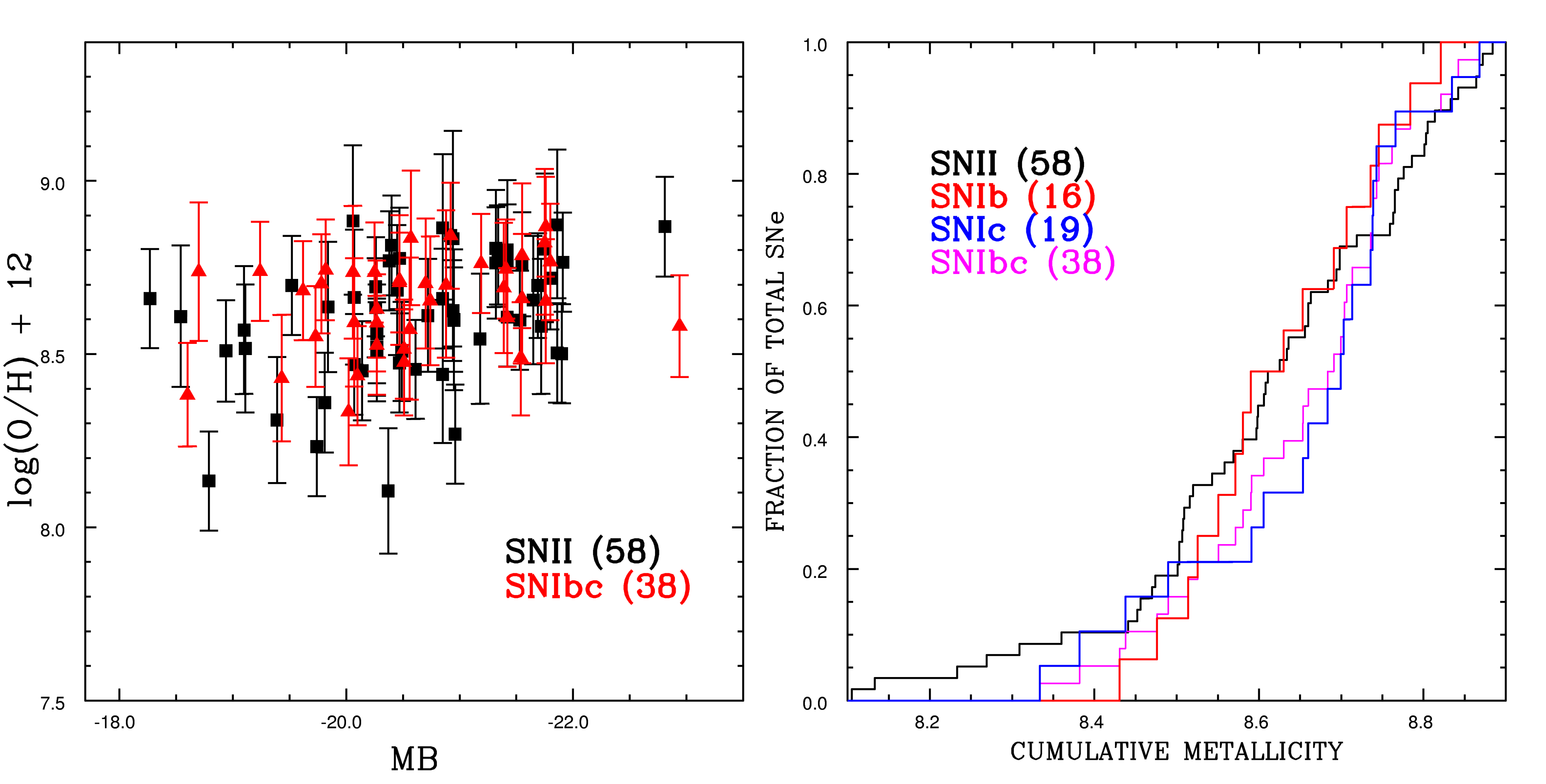
Progenitor mass constraints

- **SNIbc show higher association to 'on-going' SF than SNII**
  - higher mass progenitor stars
  - *NOTE*, this does not *necessarily* mean single stars
- **Progenitor mass seqeunce: Ia-II-Ib-Ic**
- **SNIc arise from the highest mass stars that explode in CC**
- **SNIIP trace SF on timescales 16-100Myr**
  - consistent with direct detection constraints
- **SNIIn *do not* trace SF on the shortest timescales**
  - majority of progenitors *do not arise from very massive progenitor stars*

Host HII region metallicities

- **Host HII region optical spectroscopy obtained for 96 CC SNe**
  - initial sample published in Anderson et al. (2010)
  - 58 SNII, 38 SNIbc
- **Main aim to evaluate differences in progenitor metallicties between hydrogen rich and hydrogen poor SNe**
  - other studies on SNIb-Ic-BLIc-GRBs; Modjaz et al. (2011), Leloudas et al. (2011)
- **Environment metallicities derived from ratio of strong emission lines**
  - Pettini & Pagel O3N2 or N2 used

Host HII region metallicities



- Only 0.04 dex difference between Ibc and II
- Tentative metallicity sequence: II-Ib-Ic

Progenitor metallicity constraints

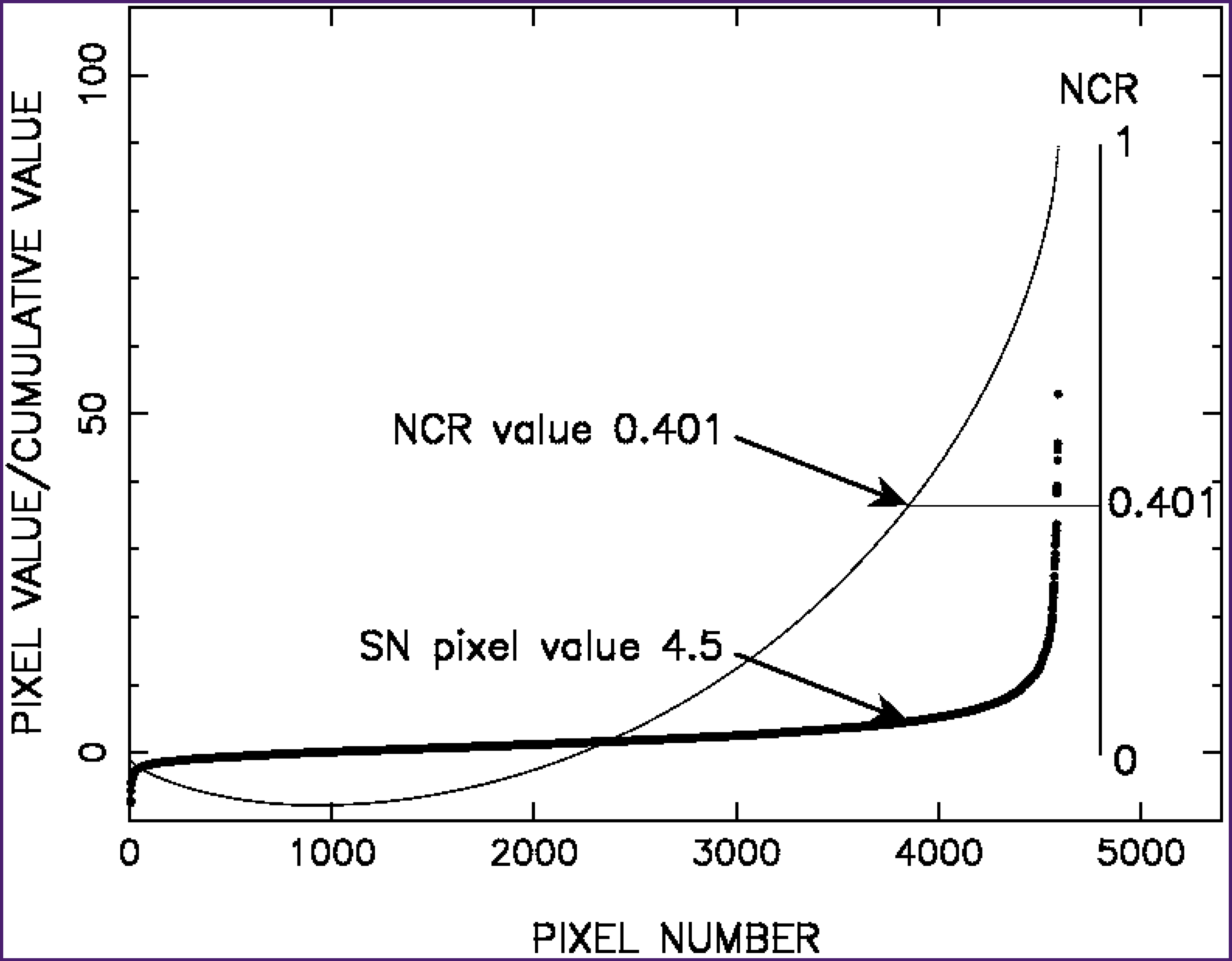
- **SNIbc have higher metallicity progenitors than SNII, *but* difference is not statistically significant**
  - metallicity does not significantly affect type produced?
- **SNII-Ib-Ic metallicity sequence is as expected, *but*, again not significant**
  - significant differences seen elsewhere (see Modjaz talk)
- **Caveat in this work is the lack of SNe in low luminosity host galaxies**
  - sample taken from Asiago and is hence dominated by massive galaxies
- ***Representative* sample needed from un-targeted survey**

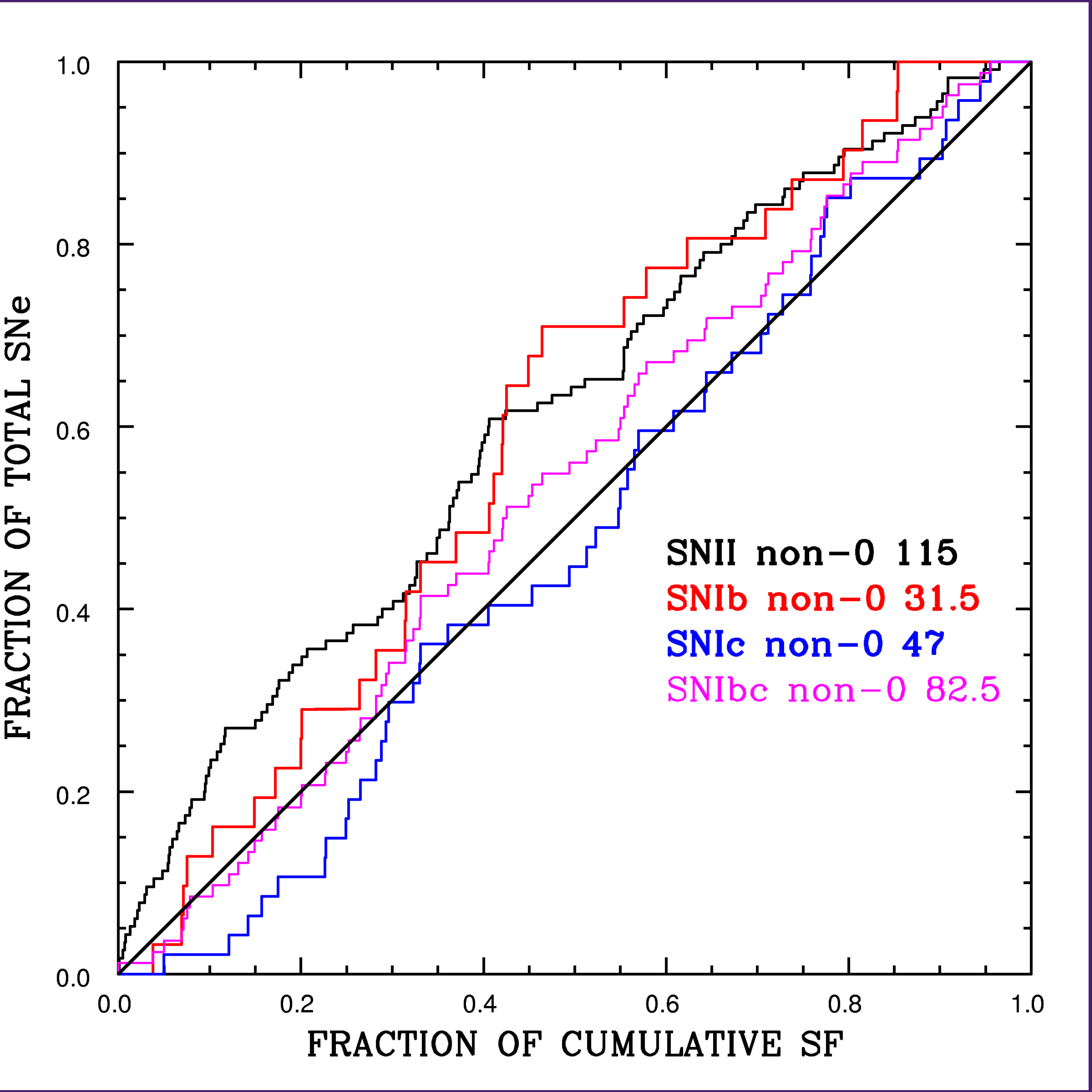
Summary/conclusions

- SNIbc arise from shorter lived and hence more massive stars than SNII
- Progenitor mass sequence observed: SNIa-II-Ib-Ic
- SNIb arise from less massive stars than SNIc
- SNIIP results consistent with direct detections
- SNIIn do not arise from very massive stars

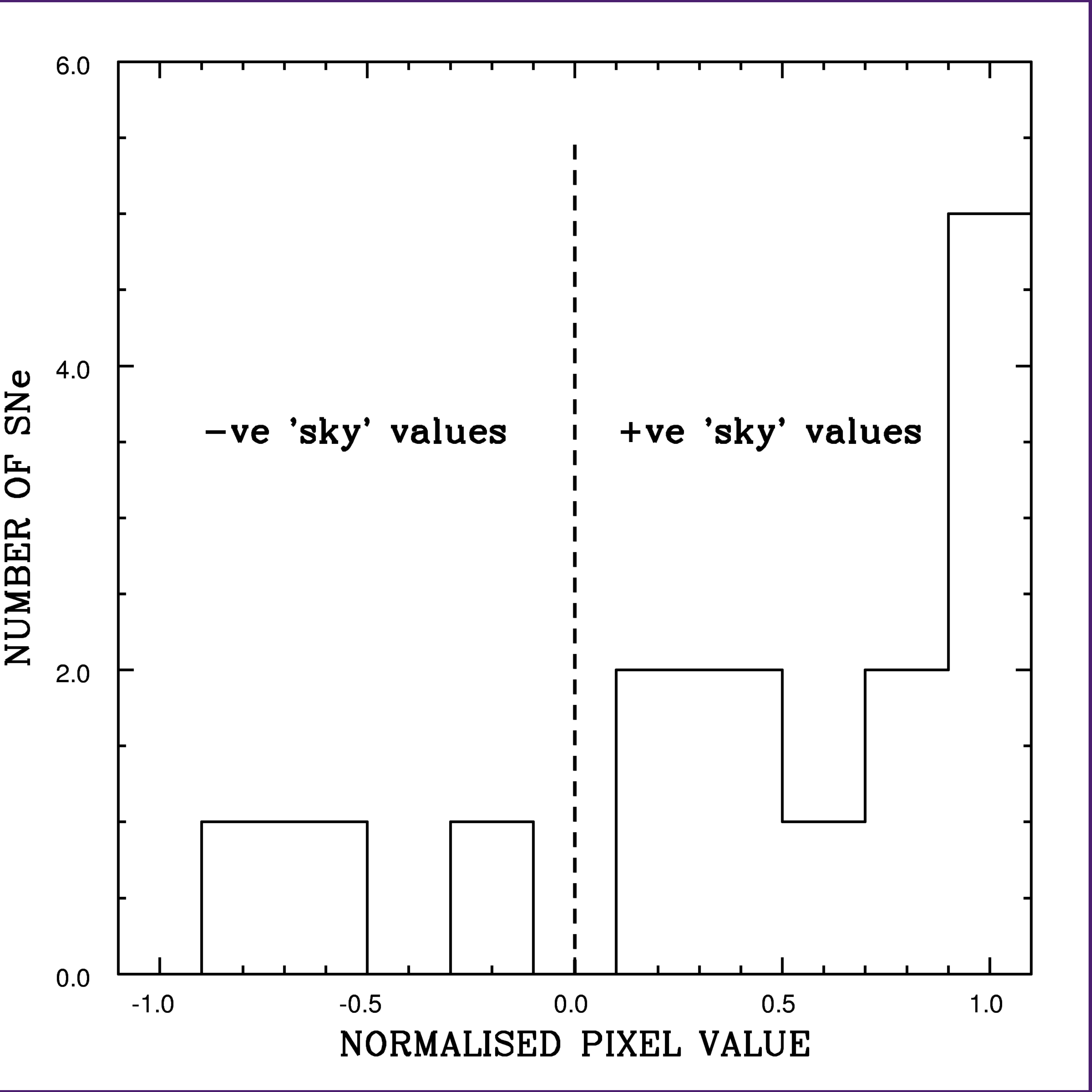
- No large metallicity difference between SNII and SNIbc
- Tentative metallicity sequence: SNII-Ib-Ic

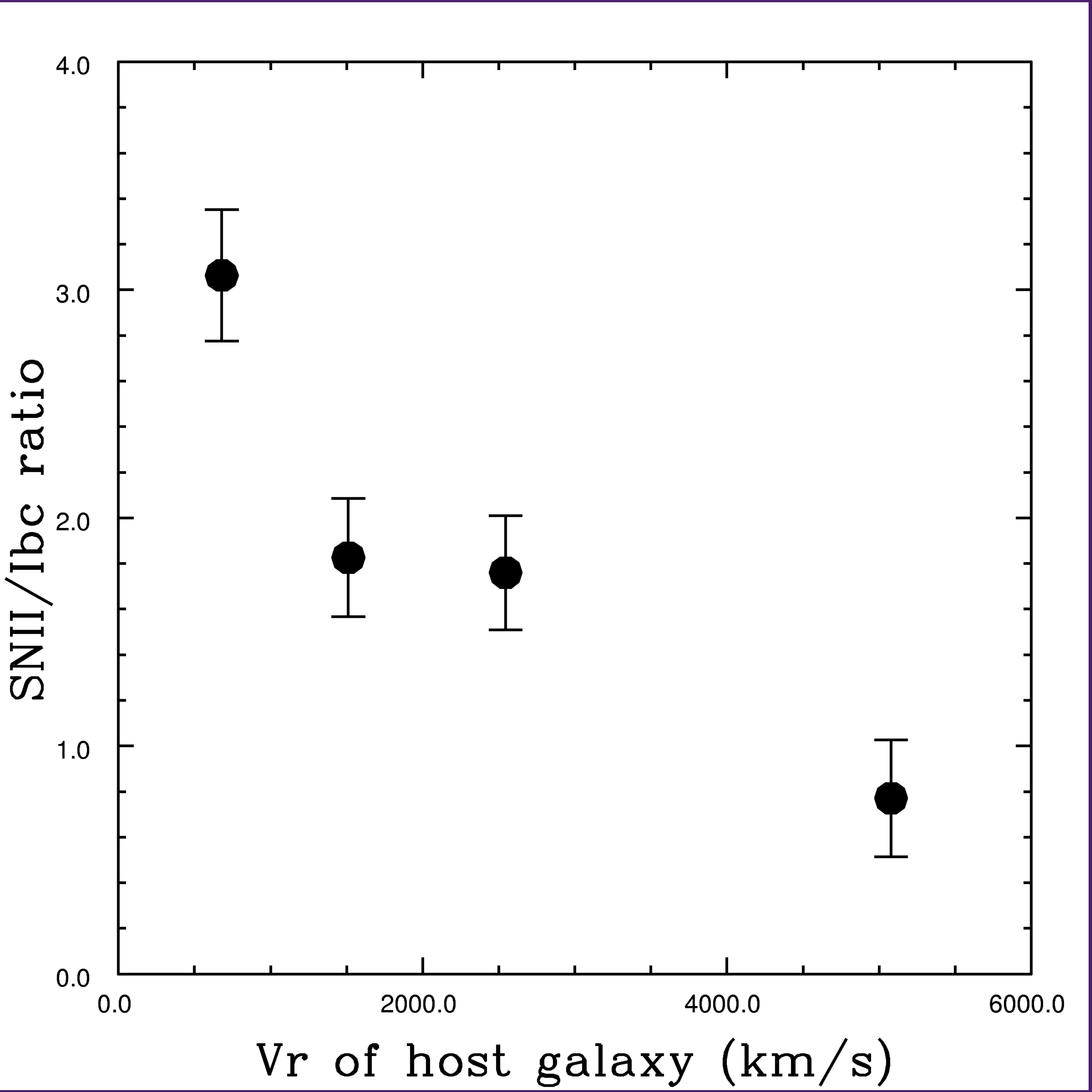
- Progenitor mass is dominant (over metallicity) feature that determines SN type


NCR
1
0.401
0
NCR value 0.401
SN pixel value 4.5
PIXEL VALUE/CUMULATIVE VALUE
100
50
0
0
1000
2000
3000
4000
5000
PIXEL NUMBER

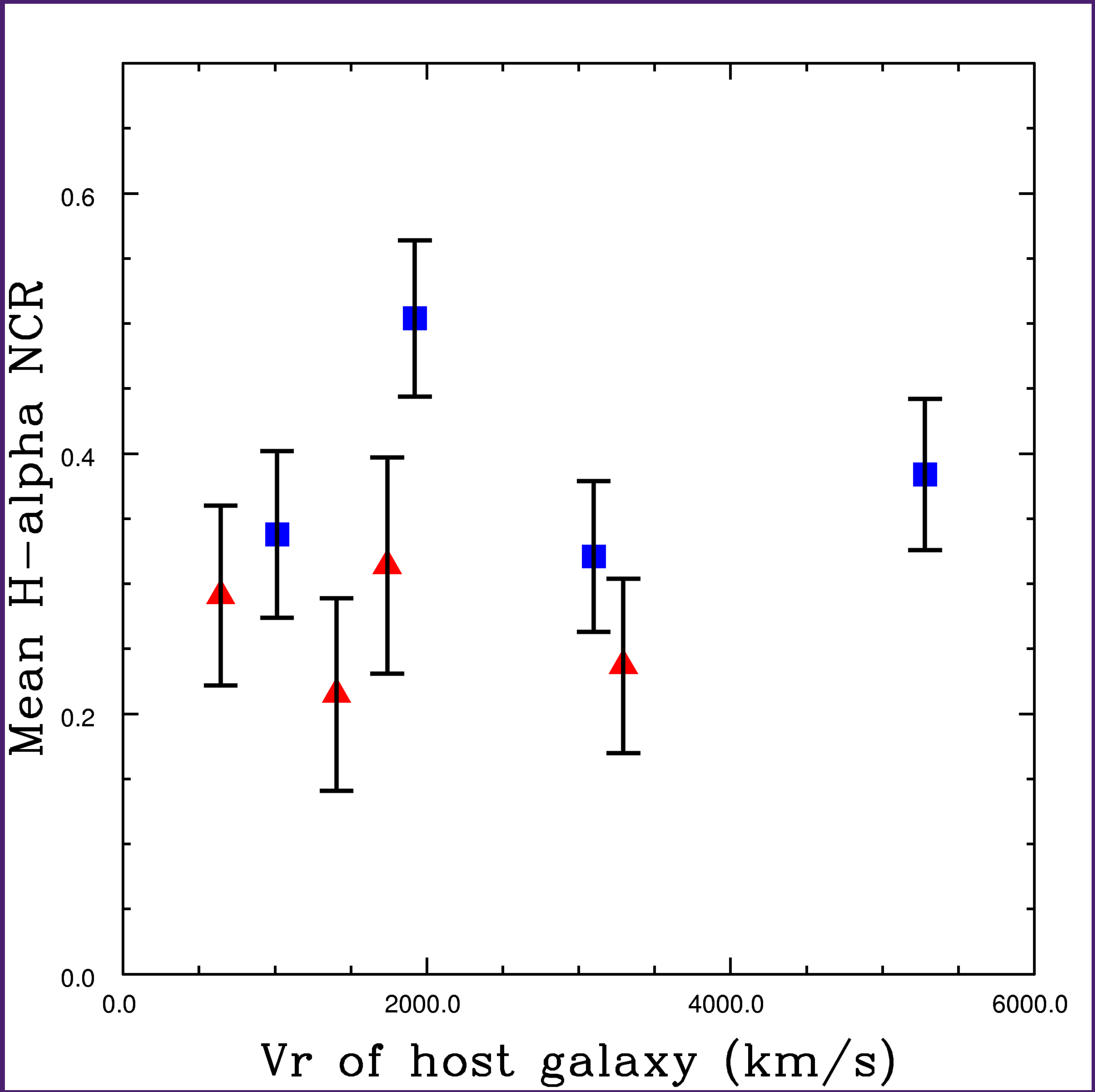


1.0
0.8
0.6
0.4
0.2
0.0
FRACTION OF TOTAL SNe
0.0
0.2
0.4
0.6
0.8
1.0
FRACTION OF CUMULATIVE SF
SNII non-0 115
SNIb non-0 31.5
SNIc non-0 47
SNIbc non-0 82.5


6.0
4.0
2.0
0.0
NUMBER OF SNe
−ve 'sky' values
+ve 'sky' values
-1.0
-0.5
0.0
0.5
1.0
NORMALISED PIXEL VALUE



4.0
3.0
2.0
1.0
0.0
SNII/Ibc ratio
0.0
2000.0
4000.0
6000.0
Vr of host galaxy (km/s)


Mean H−alpha NCR
0.0
0.2
0.4
0.6
0.0
2000.0
4000.0
6000.0
Vr of host galaxy (km/s)