USING SUPERNOVAE AS TRACERS OF STELLAR POPULATIONS

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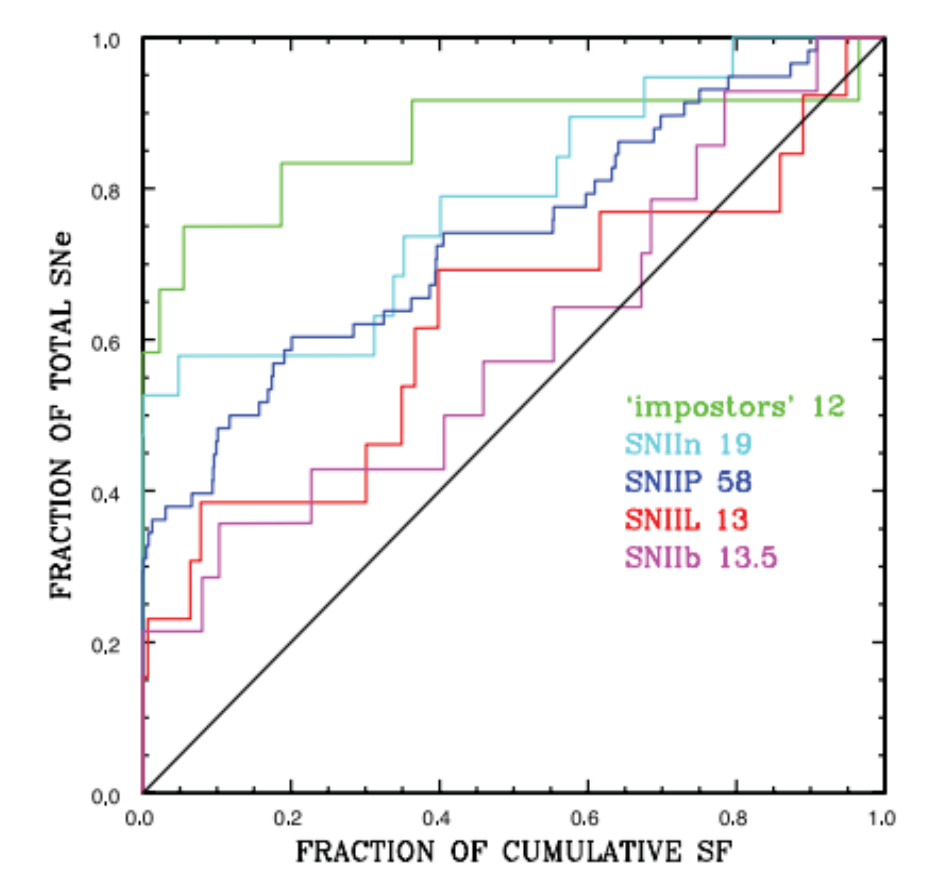
INTRODUCTION

- Brief Introduction
- Analysis of CCSN-distributions in Disturbed and Undisturbed galaxies
- Analysis of SNIIn environments
- Conclusions

CORE-COLLAPSE SUPERNOVAE



Anderson et al., 2012, MNRAS, 424, 1372

CORE-COLLAPSE SUPERNOVAE

Theory:

Envelope stripping sequence:

IIP → IIL → IIb → Ib → Ic

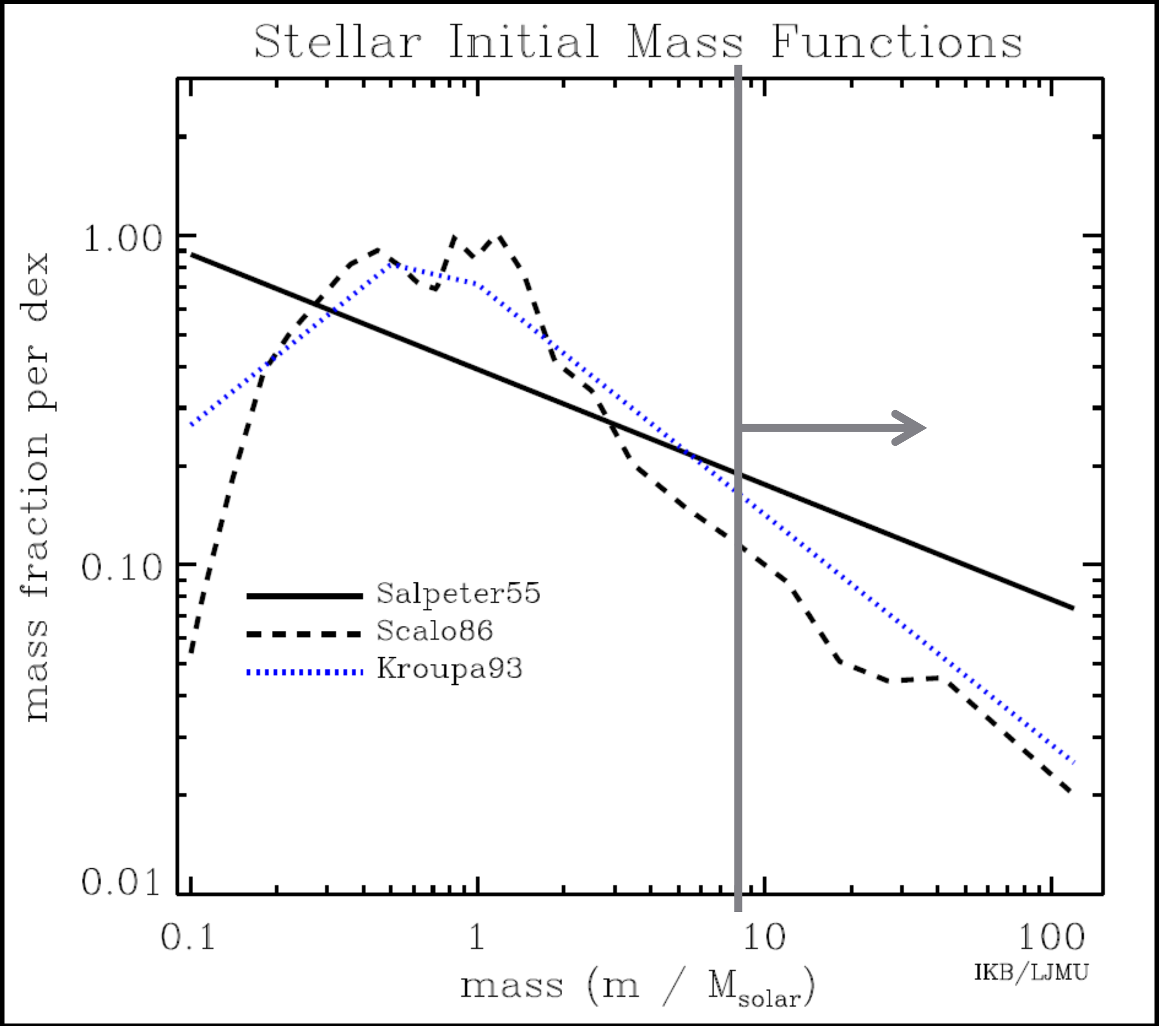
IIn???

Higher initial mass?

Binary companion?

Increased metallicity?

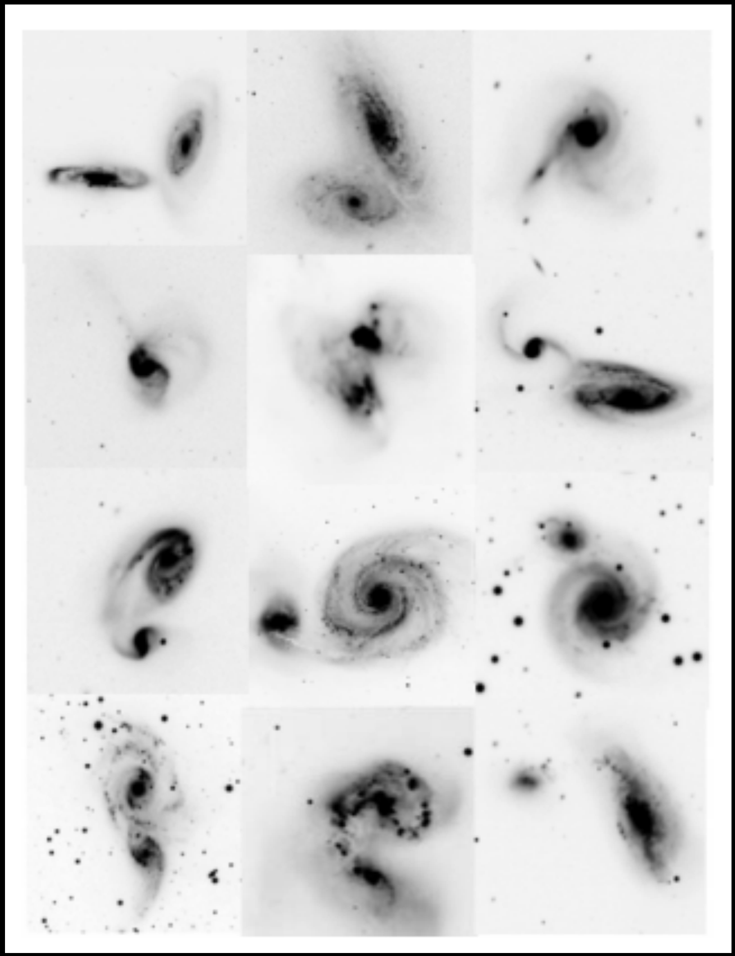
CORE-COLLAPSE SUPERNOVAE



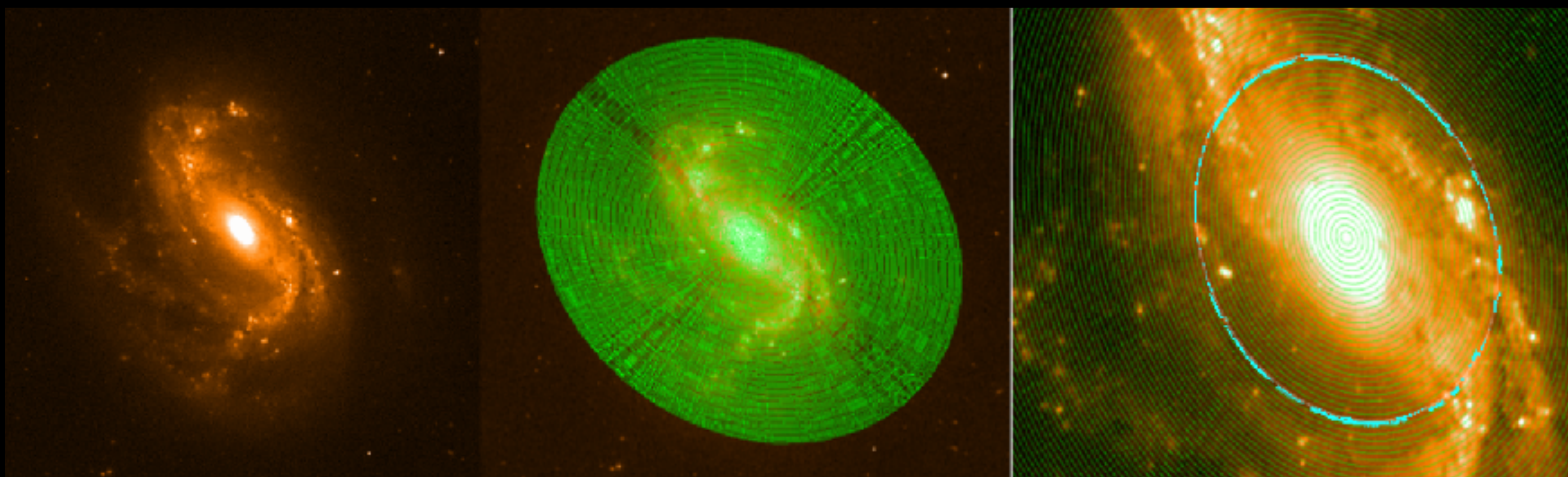
SAMPLE

- 258 CCSNe :
- 'Undisturbed' (136 SNe in 114 hosts)
- 'Disturbed' (123 SNe in 89 hosts)

- Breakdown:
  - SNII = 68
  - SNIIP = 66
  - SNIIL = 9
  - SNIIb = 18
  - SNIb = 40
  - SNIc = 51
  - SNIb/c = 6



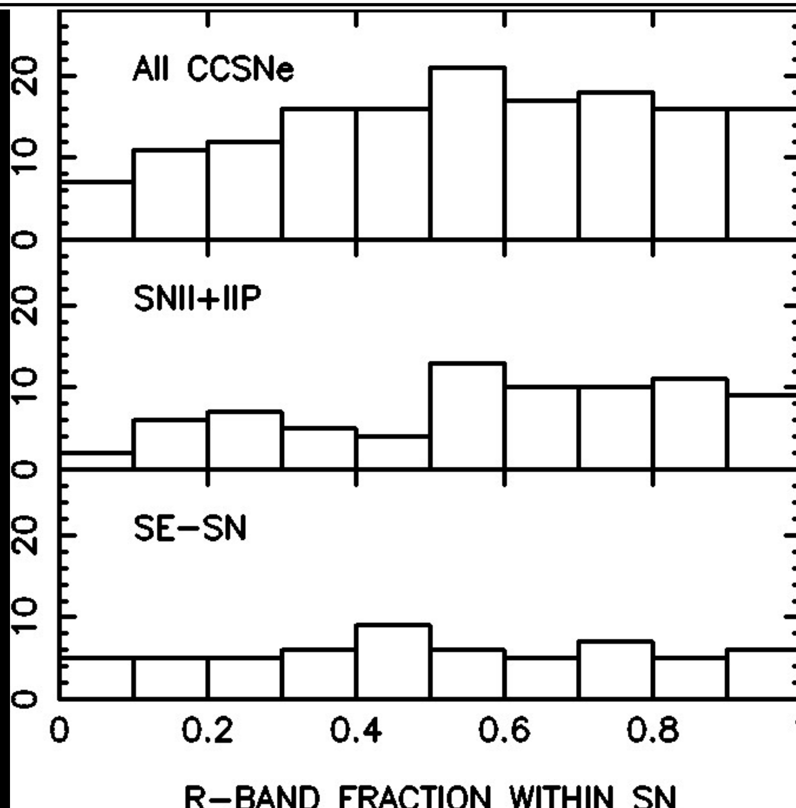
ANALYSIS



Fr(R) = 0.00 for a central SNe
(closer to the R-band peak than any Hα in case of Fr($H\alpha$))

Fr(R) = 1.00 for an extreme outlying SNe (or Fr($H\alpha$))

RESULTS – NORMAL GALAXIES



	SN II+IIP versus SE-SNe		SN IIP versus SN Ibc		SN II+IIP versus SN Ibc		SN Ib versus SN Ic	
	P	D	P	D	P	D	P	D
Undisturbed	0.106	0.2047	0.103	0.2566	0.086	0.2248	0.004	0.5052
Disturbed	0.060	0.2337	0.042	0.3171	0.014	0.2740	0.208	0.2963
Extreme	0.054	0.4231			0.035	0.4737		

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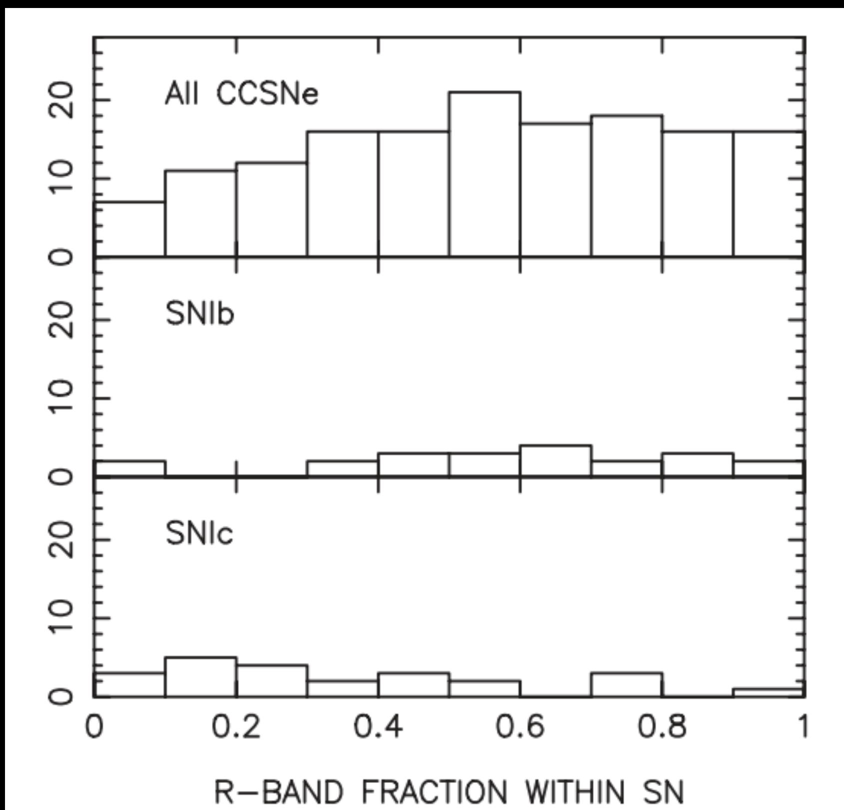


Local metallicity measurements of sample:

SNIb = 8.70 ± 0.18 (2)

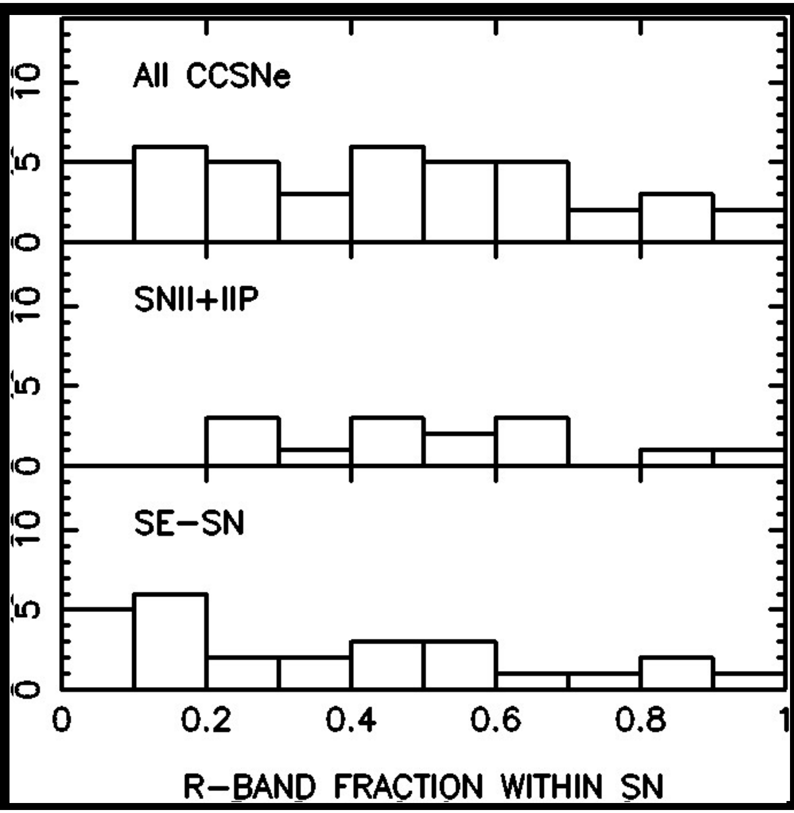
SNIc = 8.64 ± 0.15 (7)

V. low number statistics

Also see:

Anderson et al., 2010, MNRAS, 407, 2660
Modjaz et al., 2011, ApJL, 731, 4
Leloudas et al., 2011, A&A, 530, A95

RESULTS – DISTURBED GALAXIES



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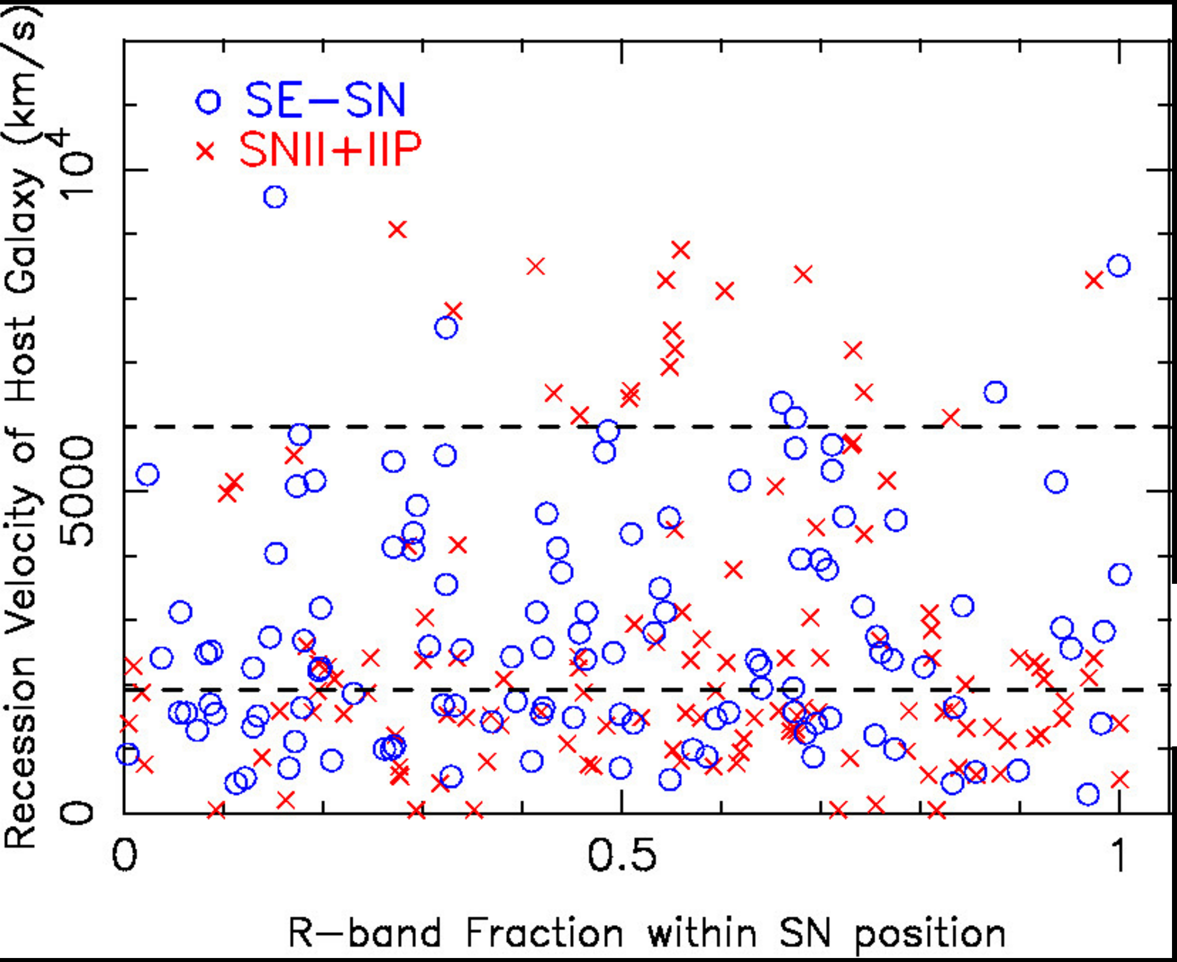
SELECTION EFFECTS

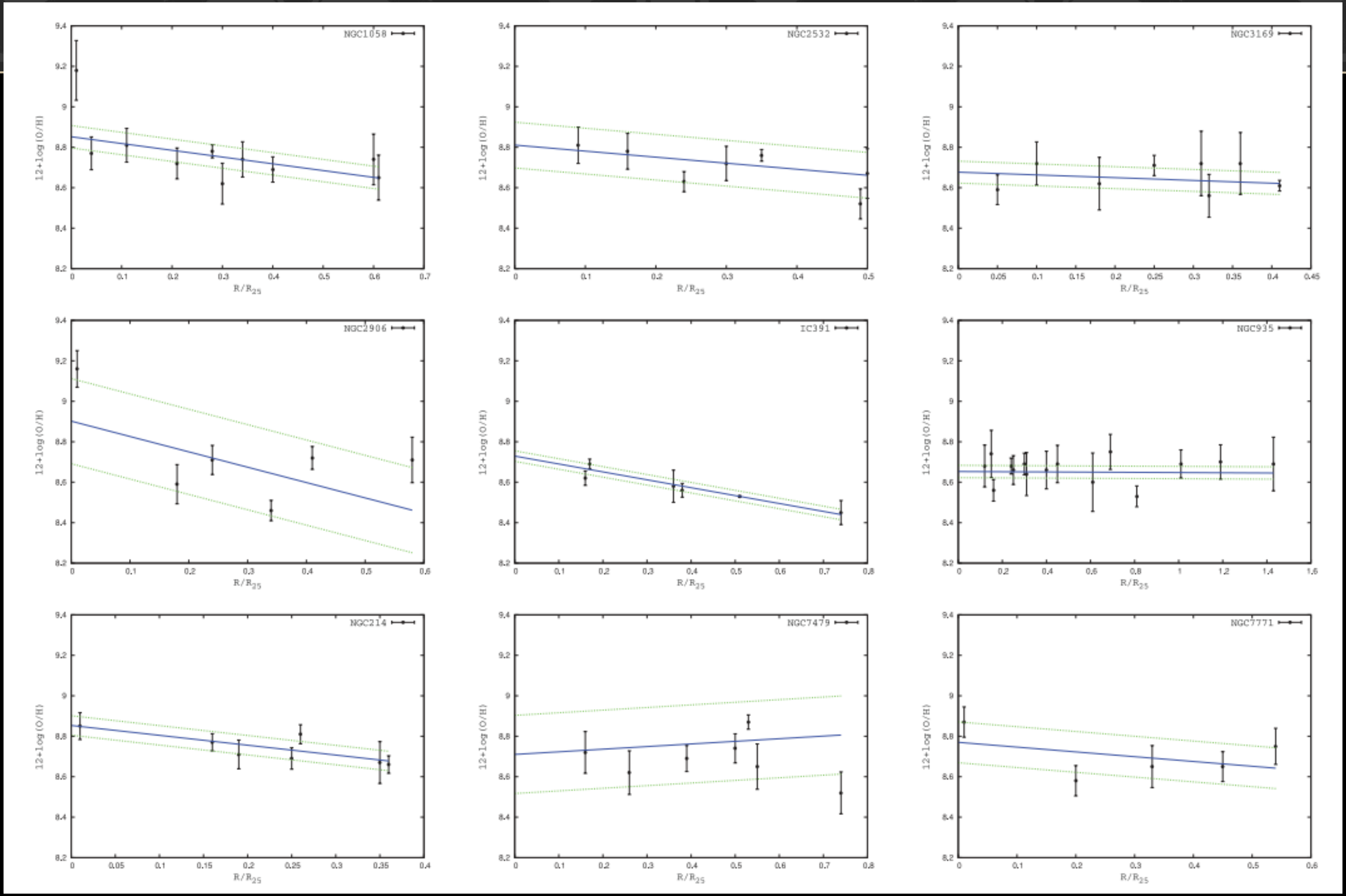


Radial distribution of SNII +IIP populations are consistent between redshift bins: P=0.990

KS test

(i) Low z bin versus middle z bin: $P = 0.947, D = 0.0647$.
(ii) Middle z bin versus high z bin: $P = 0.193, D = 0.2353$.

INTERPRETATIONS - METALLICITY



Also see the detailed studies of Kewley et al., 2010, ApJL, 721, 48

INTERPRETATIONS – BINARITY AND ROTATION

Single vs Binary channel:

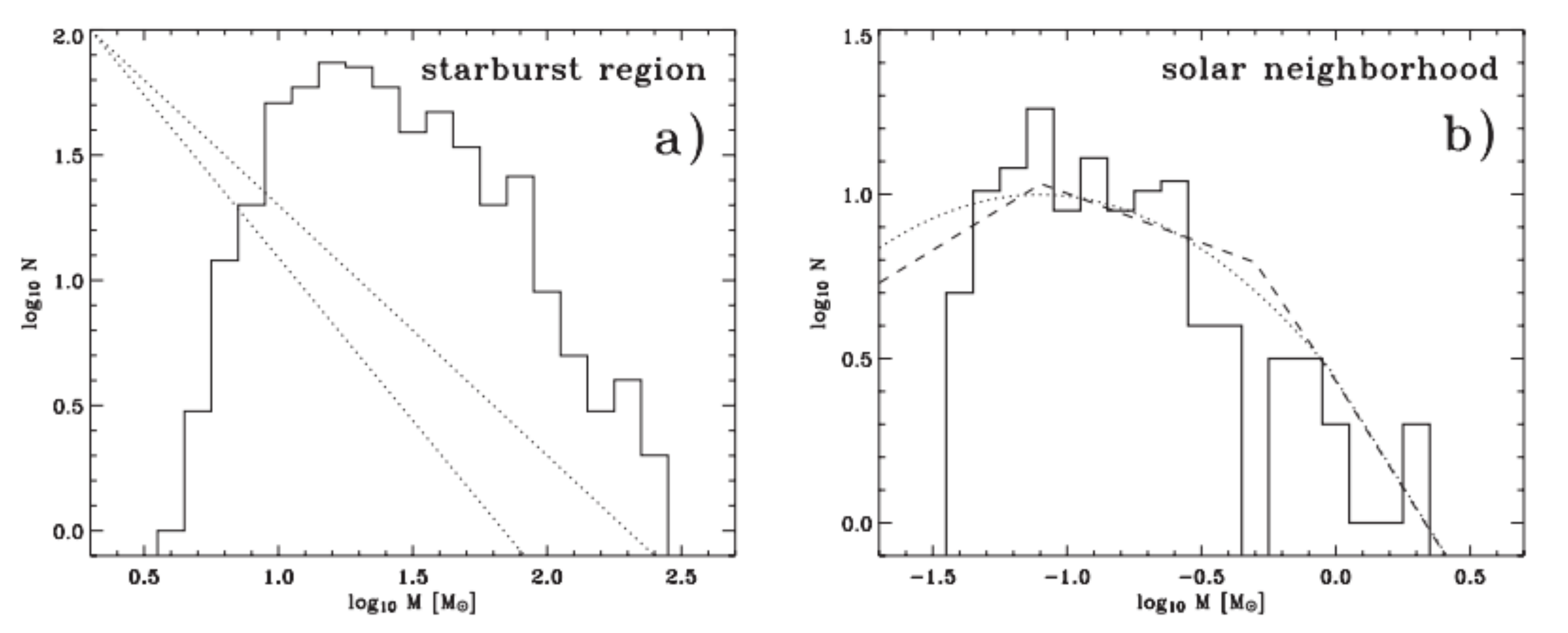
>50% SNIbc single stars (Georgy et al., 2012, A&A, 542, A29)

~70% O stars transfer mass with companion (Sana et al., 2012, Science, 337, 444)

↓

Unclear that either of these channels increases sufficiently/at all in high density starburst environments

INTERPRETATIONS – IMF



Klessen et al, 2007, MNRAS, 374, 29

SUMMARY

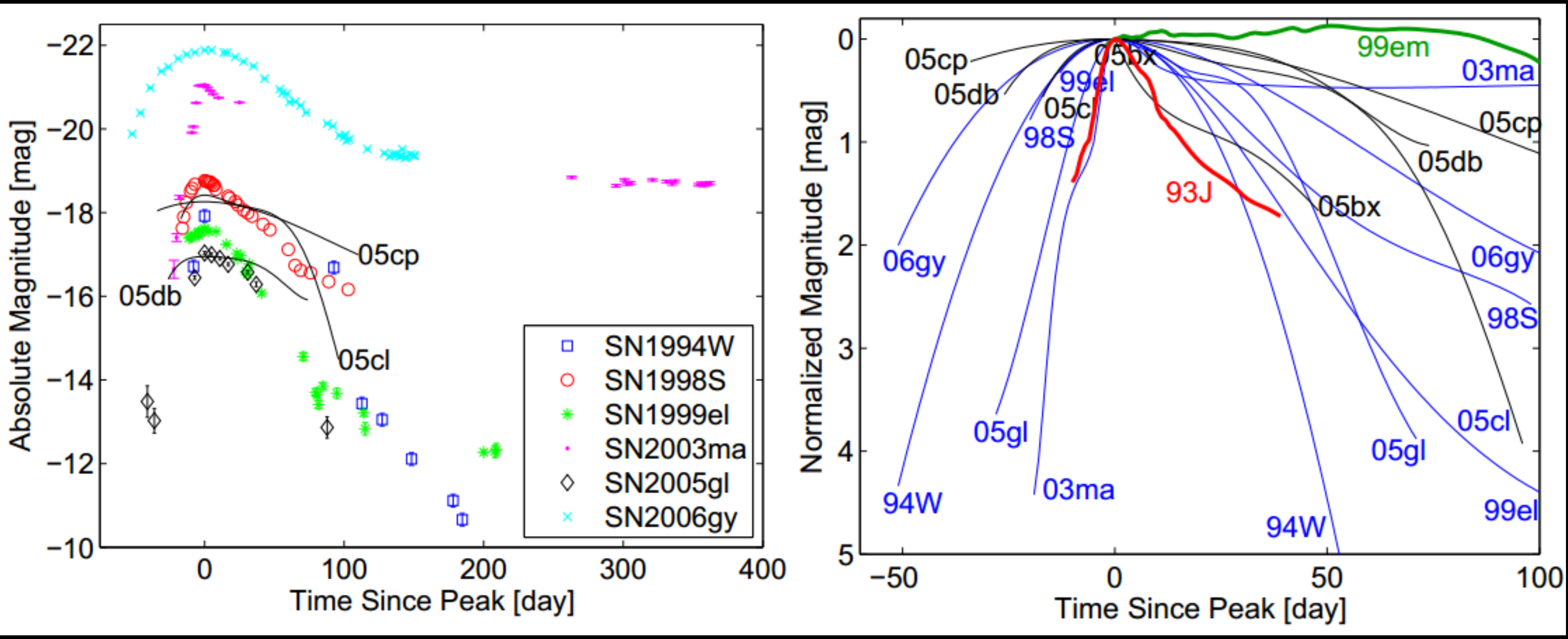
- In **disturbed** galaxies there is a real and statistically significant **excess** of **SE-SNe** in the central regions

- Our interpretation of this is that **within the central core of merging galaxies the IMF is biased towards the most massive stars**

- Within **normal** spiral galaxies there is a statistically significant difference in the **distribution of SNIb and SNIc** – is **metallicity** enough to cause this?

- Habergham, Anderson & James, ApJ, 2010, 717, 342
- Habergham, James & Anderson, MNRAS, 2012, 424, 2841

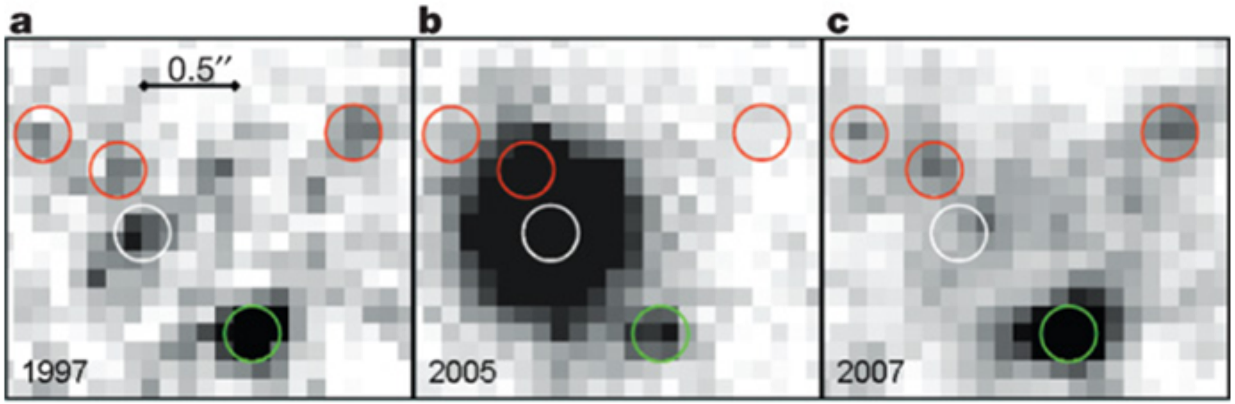
TYPE IIN SUPERNOVAE



Kiewe et al., 2012, ApJ, 744, 10

TYPE IIN SUPERNOVAE

The progenitor star of SN 2005gl
vanished after the supernova event.

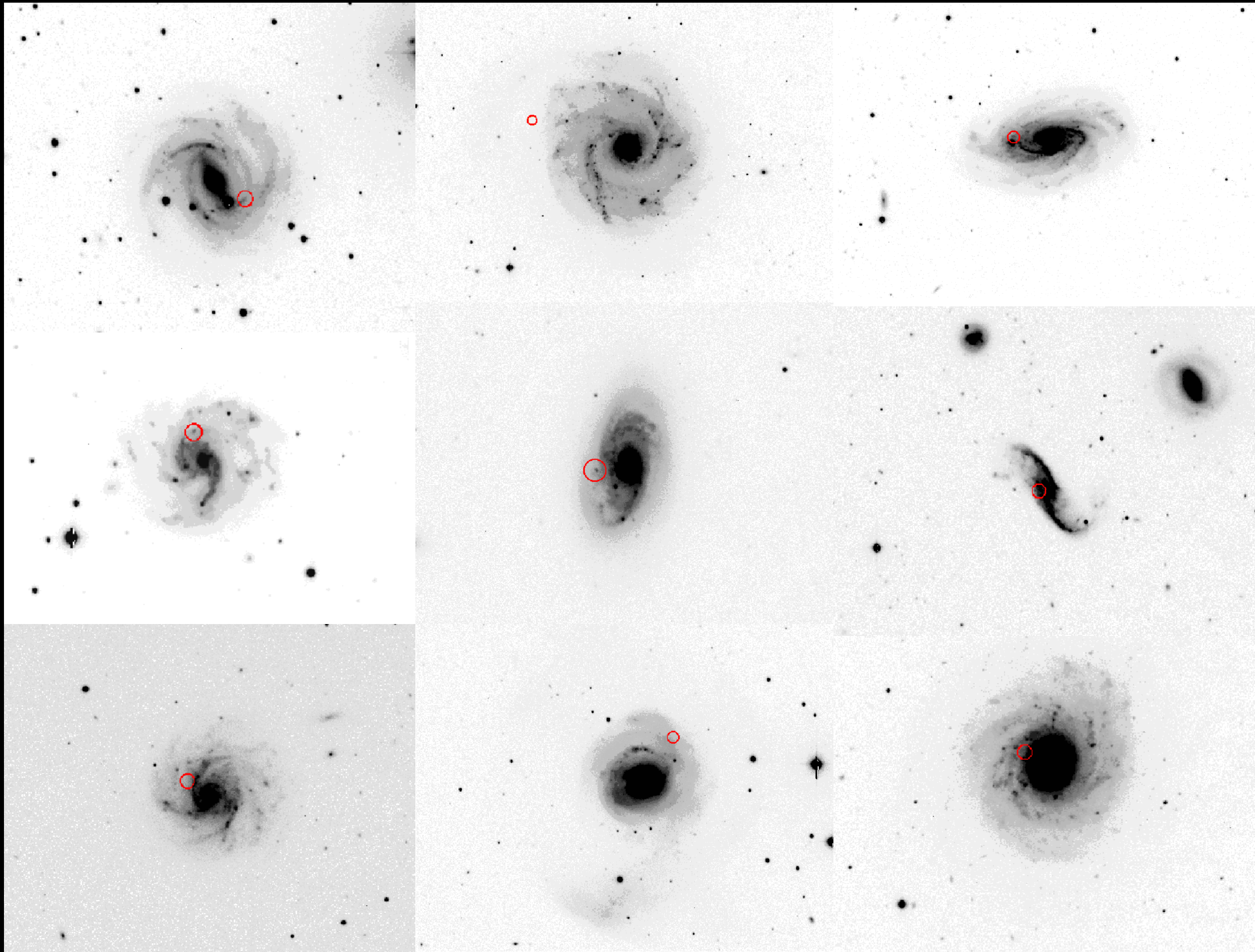


A Gal-Yam & DC Leonard *Nature* **000**, 1-3 (2009) doi:10.1038/nature07934

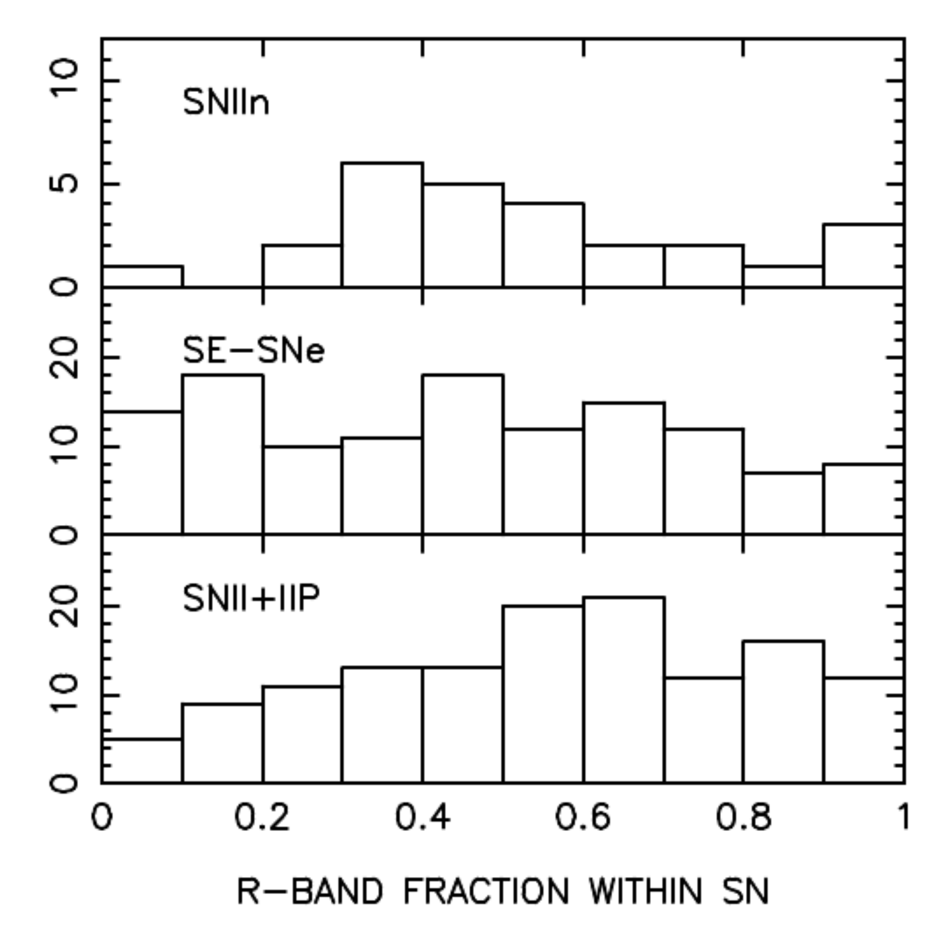
nature

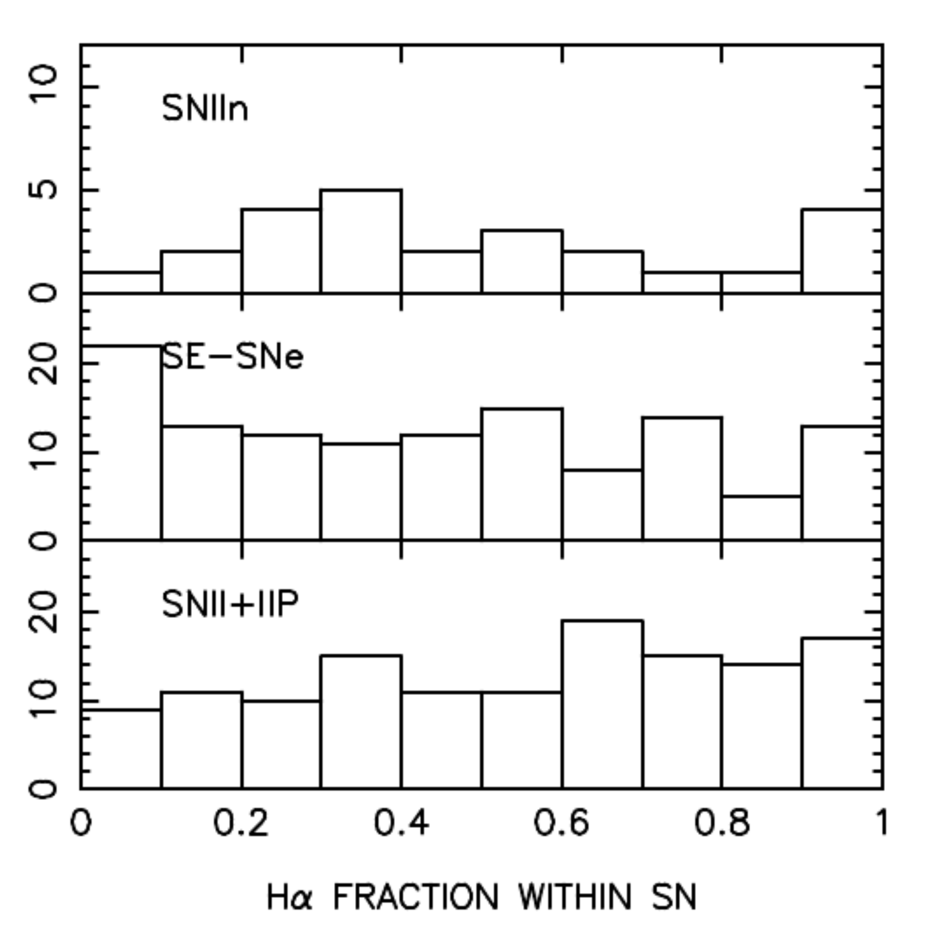
SAMPLE

- 26 SNIIn
- SF spiral or irregular hosts
- Average Vr = ~2600km/s

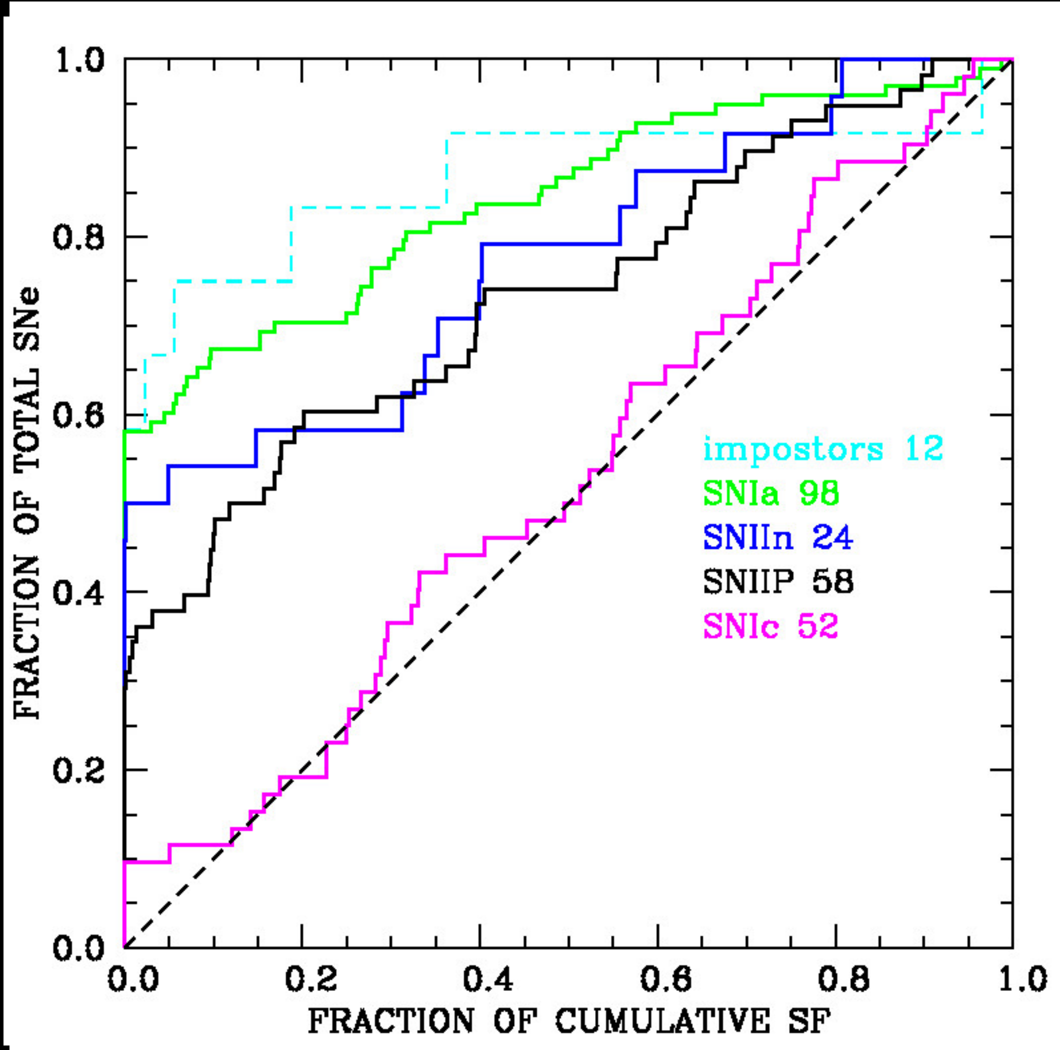


RESULTS


SNIIn
SE−SNe
SNII+IIP
R−BAND FRACTION WITHIN SN

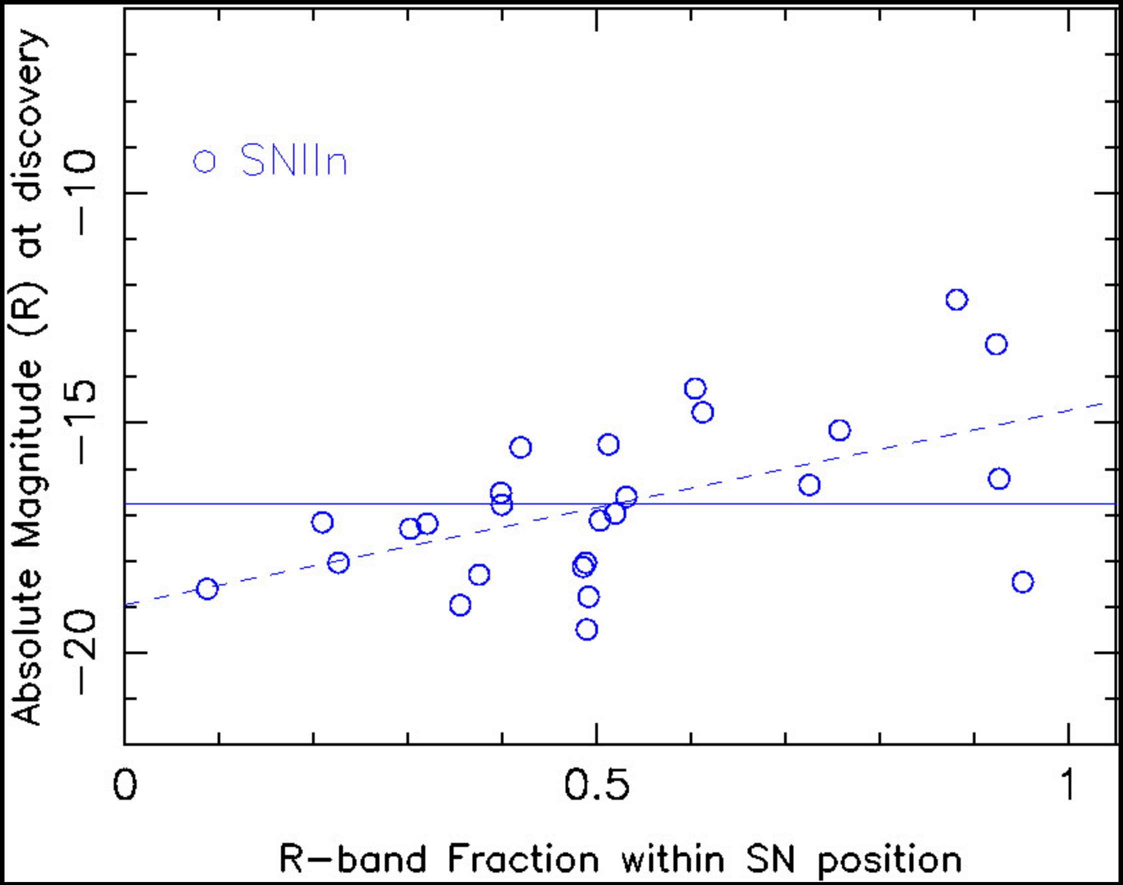

SNIIn
SE−SNe
SNII+IIP
Hα FRACTION WITHIN SN

RESULTS



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
impostors 12
SNIa 98
SNIIn 24
SNIIP 58
SNIc 52

SELECTION EFFECTS



Pearson Correlation Test:
R = 0.5419 P = 0.0021

SUMMARY

- The **radial distributions, and association with on-going SF, of SNIIn and SNIc** are statistically very different

- There is a **correlation** between the **distribution** of **SNIIn** events and the **absolute magnitude** at discovery

- How many different progenitors of SNIIn are there and how can we distinguish between them?

- Habergham et al.., in prep.

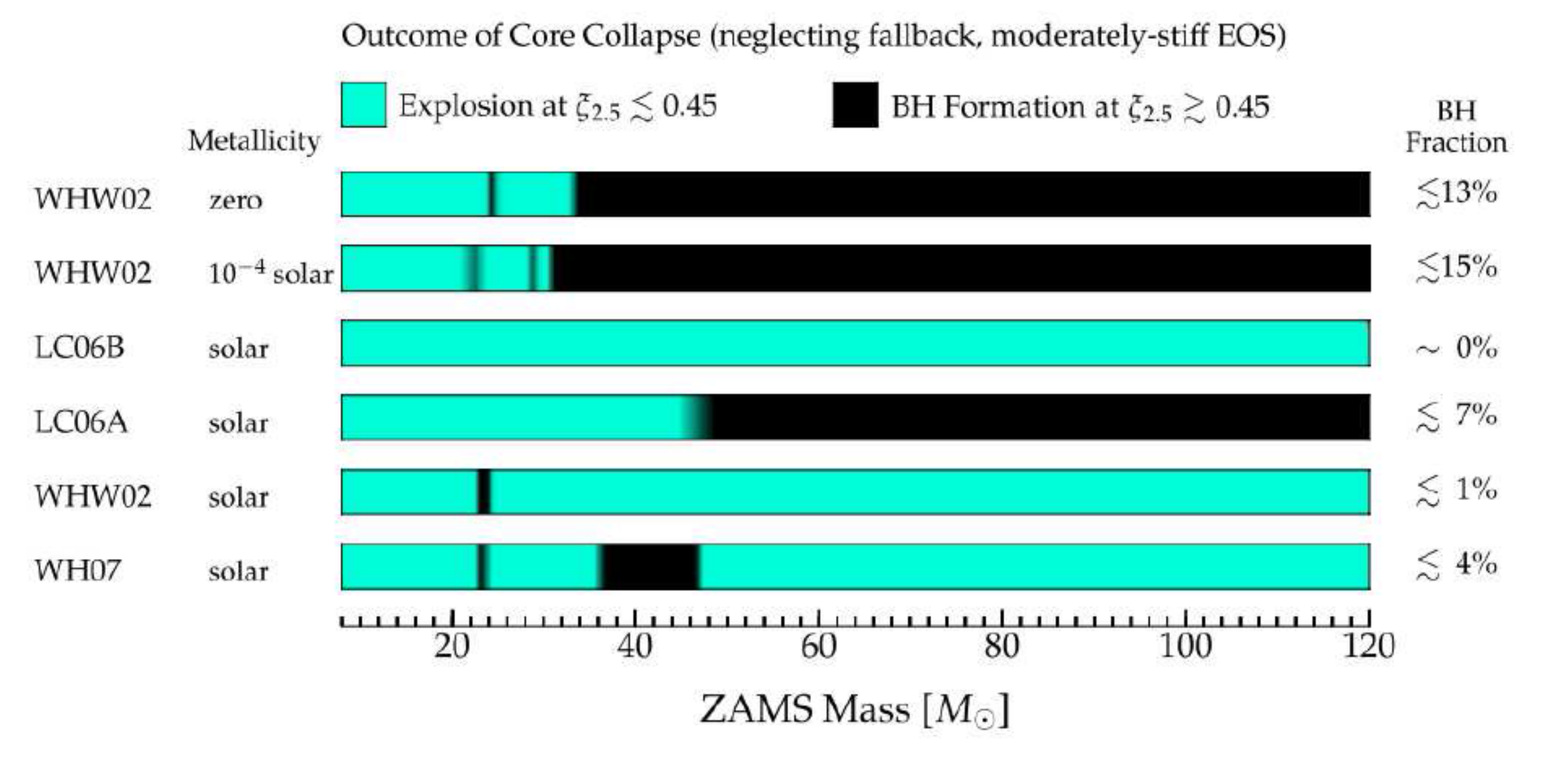
CONCLUSIONS

- Host galaxy environment studies are powerful **with statistically significant samples**

- The distributions of CCSNe subtypes differ in disturbed and undisturbed hosts
- **Central excess of SE-SNe** in **disturbed** systems most plausibly explained by a variation to a **top-heavy IMF** in these starburst nuclei
- **SNIc** are more centrally located than **SNIb** in undisturbed systems – **metallicity**?

- The distributions of **SNIIn and SNIc are statistically very different** – is this an indication that the population of SNIIn are not all from LBV progenitors? How many could be?

DIRECT BH FORMATION



O'Connor & Ott, 2011, ApJ, 730, 70

GALAXY DISTURBANCE

Galaxy	Isolated	Group–no interaction	Group–minor interaction	Group–major interaction	Asymmetry–minor	Asymmetry–major	Shells	Tails	Irregular structure	Peculiar dust lanes	Clumpy morphology	Double	Starburst
IC 391	X	–	–	–	–	X	–	–	–	–	–	–	–
MCG-02-14-03	–	–	X	–	X	–	–	X	–	–	–	–	–
NGC 1821	X	–	–	–	–	X	–	–	–	–	X	–	–
NGC 1832	–	X	–	–	–	X	–	–	–	–	–	–	–
NGC 1961	–	–	X	–	–	X	–	–	X	–	–	–	X
IC 438	–	X	–	–	X	–	–	–	–	–	–	–	–
IC 2152	–	X	–	–	–	–	–	–	–	–	–	–	–
NGC 2207	–	–	–	X	–	–	–	–	–	–	–	X	–
NGC 2146	–	–	X	–	X	–	–	X	–	X	–	–	X
ESO 121-G26	X	–	–	–	–	–	–	–	–	–	–	–	–