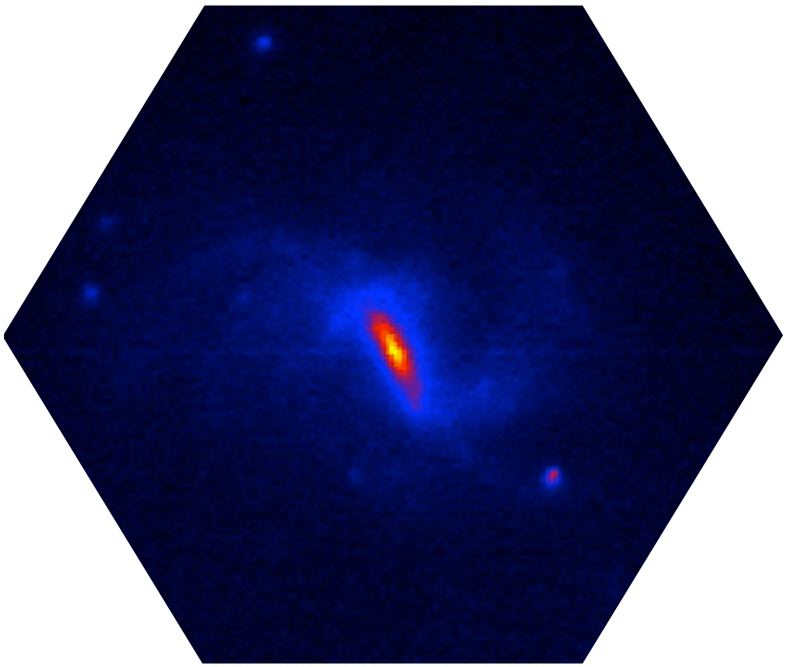
INTEGRAL FIELD SPECTROSCOPY OF SUPERNOVA HOST GALAXIES



CALIFA Survey

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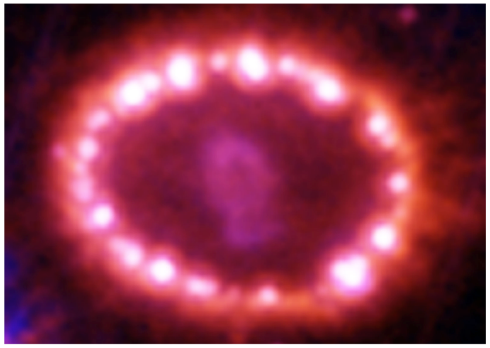
and the *CALIFA* collaboration

XIV LARIM 2013

29 Novembro, Florianópolis, SC, Brazil



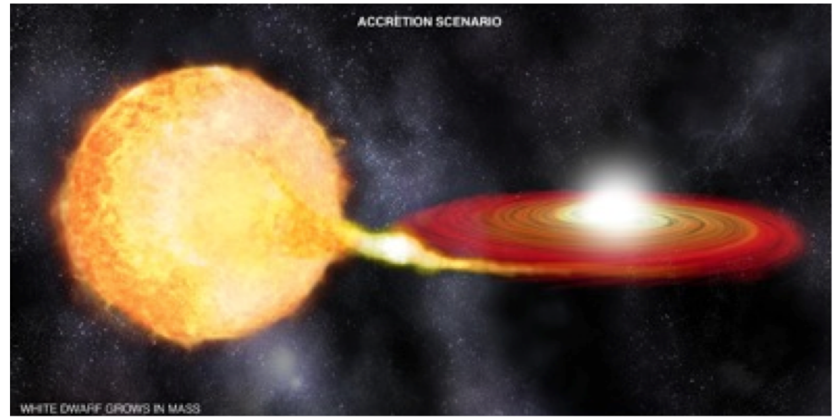
Core collapse SNe

Massive stars (8 to 30 Msun)

Differences depending on progenitor mass loss before explosion

- II retain external layers
- IIb intermediate between II and Ib
- Ib lose H envelope
- Ic lose both H and He envelopes

Two paths: single massive stars + winds, binary systems transferring mass



Type Ia SNe

CO White dwarfs in binary systems accreting mass from a companion

Homogeneous brightness → Cosmology

Two scenarios: single degenerate (WD + massive star), double degenerate (2 WD)

Few CCSNe and no SNe Ia direct progenitor detection (e.g. *Smartt+09*)

Alternative methods to constrain progenitor properties: ENVIRONMENT

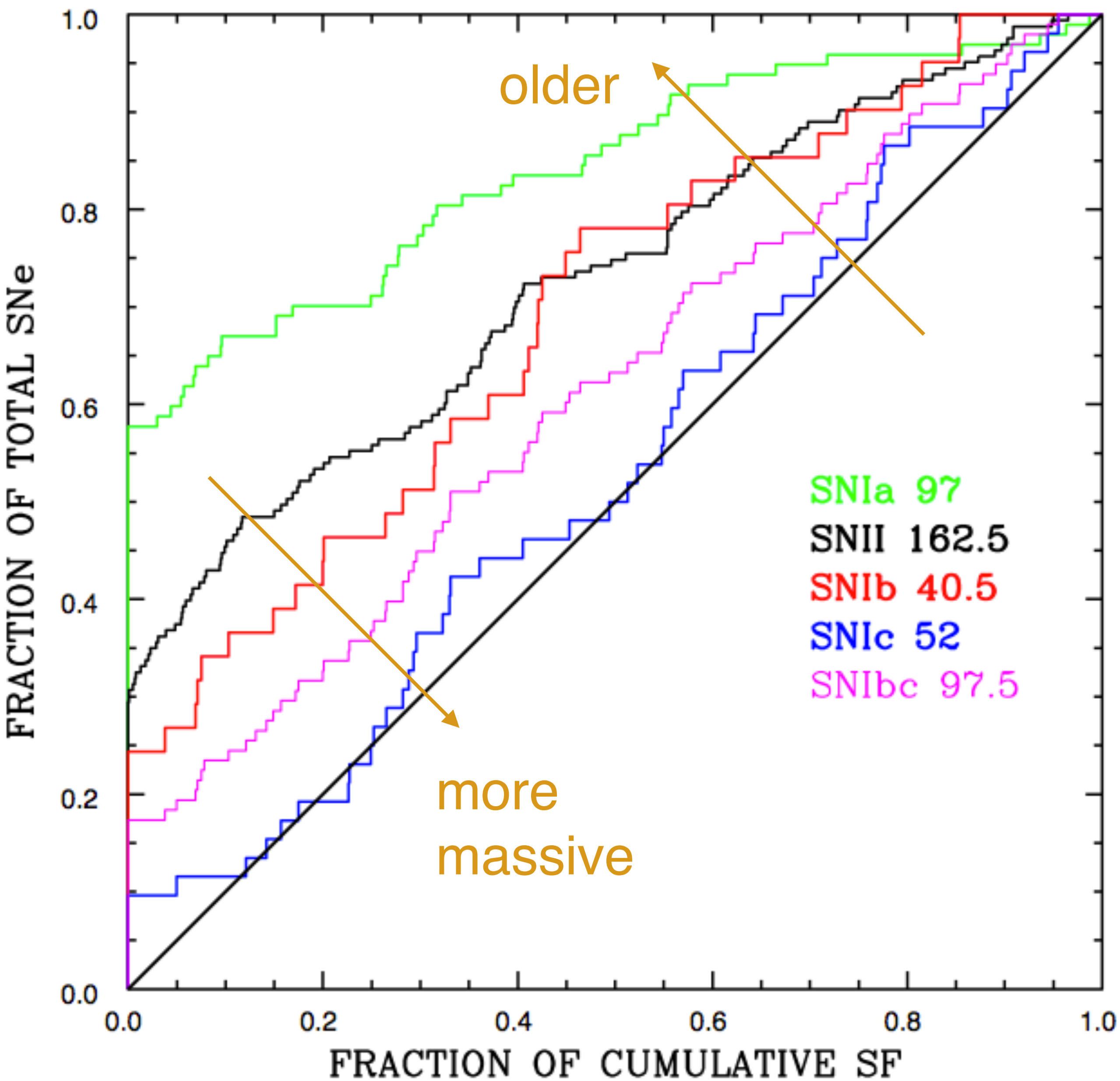
SNe Ia cosmology

Several works have been looking for correlations between the Hubble residuals (HR) and global properties of the host galaxy:

Hamuy et al. (1996)	Bright events occur preferentially in **young** stellar environments.
Hamuy et al. (2000)	Luminous SNe are produced in **metal-poor** neighborhoods
Gallagher et al. (2005)	**Age** is more likely to be the source of LC variability than **metallicity**
Sullivan et al. (2006)	Brighter events are found in systems with ongoing **star-formation**
Gallagher et al. (2008)	**Progenitor age** primarily determines the peak luminosity
Hicken et al. (2009)	SN Ia in **spiral** hosts are intrinsically fainter *(after LC-corr)*
Howell et al. (2009)	**more massive** progenitors give rise to less luminous explosions
Neil et al. (2009)	**Older** hosts produce less-extincted SNe Ia
Brandt et al. (2010)	Luminous SNe associated with recent **star-formation** and **young** prog.
Cooper et al. (2010)	SNIa are more luminous or more numerous in **metal-poor** galaxies
Sullivan et al. (2010)	SNIa are brighter in **massive** hosts (metal-rich) and with low **SFR** *(after LC-corr)*
Kelly et al. (2010)	SN Ia in physically **larger**, more **massive** hosts are ~10% brighter
Lampeitl et al. (2010)	introduce the stellar **mass** of the host in the parametrization
D'Andrea et al. (2011)	SNe are 0.1 mag brighter in **high-metallicity** hosts after corr.
Gupta et al. (2011)	**older** galaxies host SNe Ia that are brighter
Nordin et al (2011)	**passive** and **massive** galaxies host faint SNe
Konishi et al. (2011)	SNe in **metal-rich** hosts become brighter after corrections
Smith et al. (2012)	SNe rate is higher in **star-forming** galaxies

...

Progenitor constraints

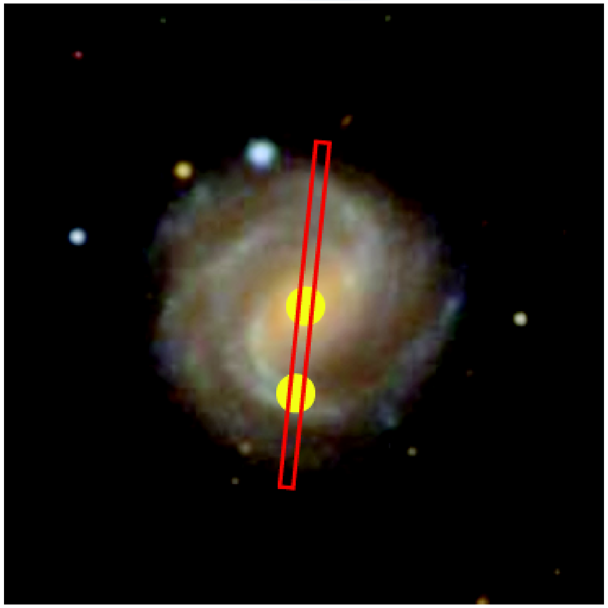


Cumulative distributions of local star-formation at SN position for several SN types

More massive stars have shorter lifetimes (age) and therefore have less time to move away from the star-forming regions

Anderson+12

Environmental studies



- Global properties

- Photometry/imaging
  (Sullivan+10, Lampeitl+10, Anderson+09, ...)

- Single-aperture / long-slit spectroscopy (at host galaxy core) **(Prieto+08, D'Andrea+12, ...)**

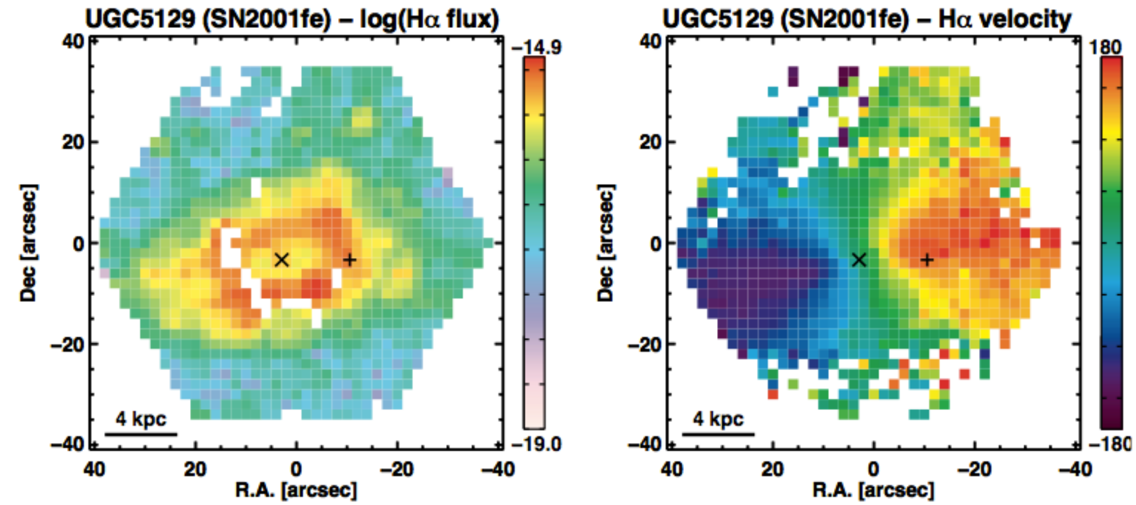
- Local properties

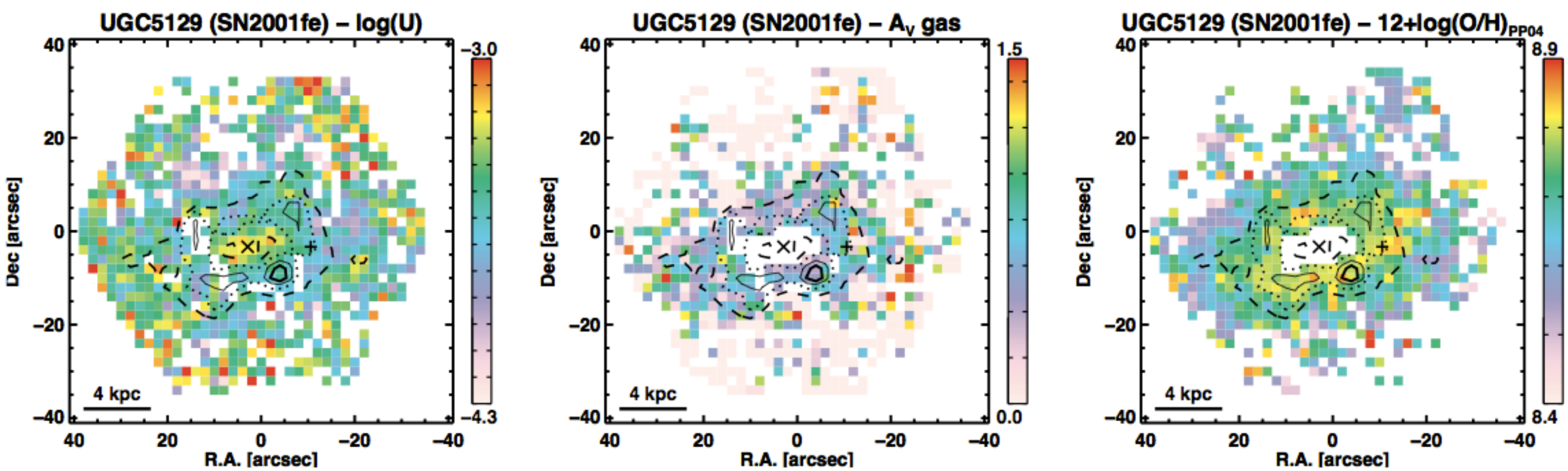
- Global values + gradients **(Boissier+09, Galbany+12, ...)**

- Single-aperture / long-slit spectroscopy (at SN position)
  (Anderson+10&12, Modjaz+11, ...)

- Integral field Spectroscopy **(Stanisjev+12, Kuncarayakti+13, ...)**

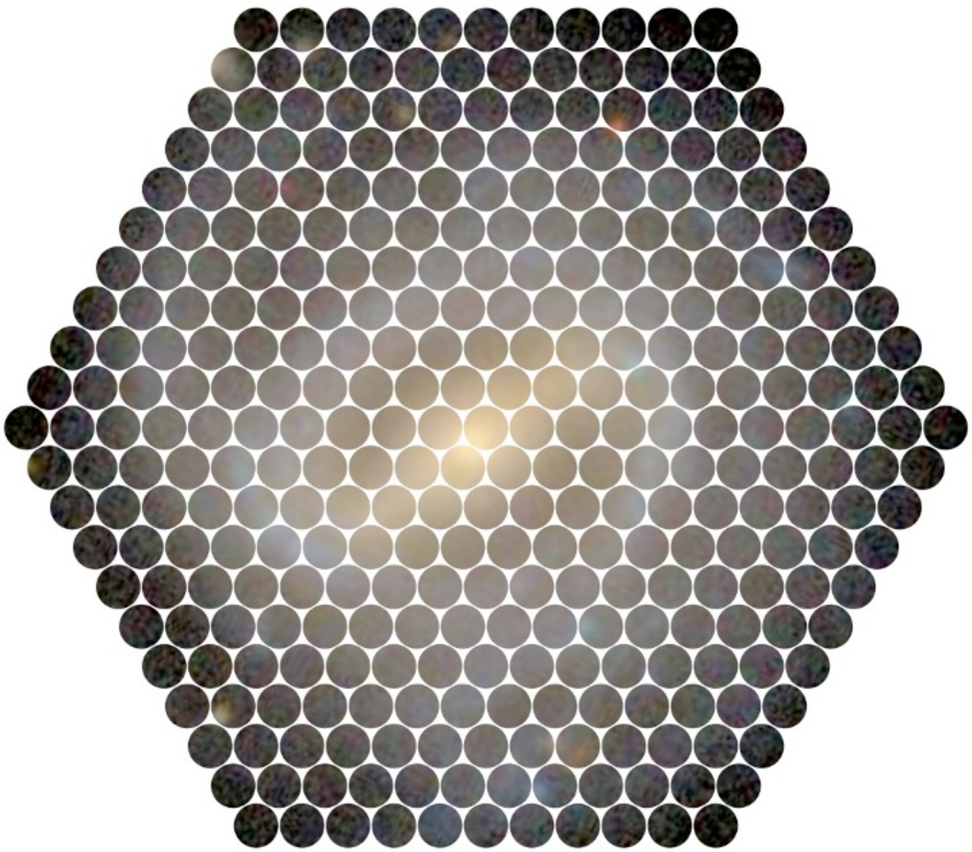
SNe Ia host galaxies with IFU





Stanishev+12

Calar Alto Legacy Integral Field Area



CALIFA Survey

Sánchez+12

- Survey of ~600 galaxies of all types at z=0.005 to 0.03
- diameter selected from SDSSDR7, 45 < D_{25} < 80, to fit in the IFU FOV

  CALIFA mother sample: 939 galaxies

- IFS using PPAK @ 3.5m CAHA

  2 setups: mid (V500) and high-res (V1200)

  Spectral coverage [3700-7000 A]

  Spatial resolution ~1 arcsec

- 250 dark nights over 3 years
- ~3000 spectra per galaxy
- Data will freely distributed to the community.

DR1 (100 galaxies), Huseman+13

Sample selection

- Cross-Check SNe IAU list with CALIFA galaxies (by coord.)

  ~400 galaxies observed so far (at least with one grating)

  65 hosted 73 SNe (6 with 2 SNe,1 with 3 SNe)

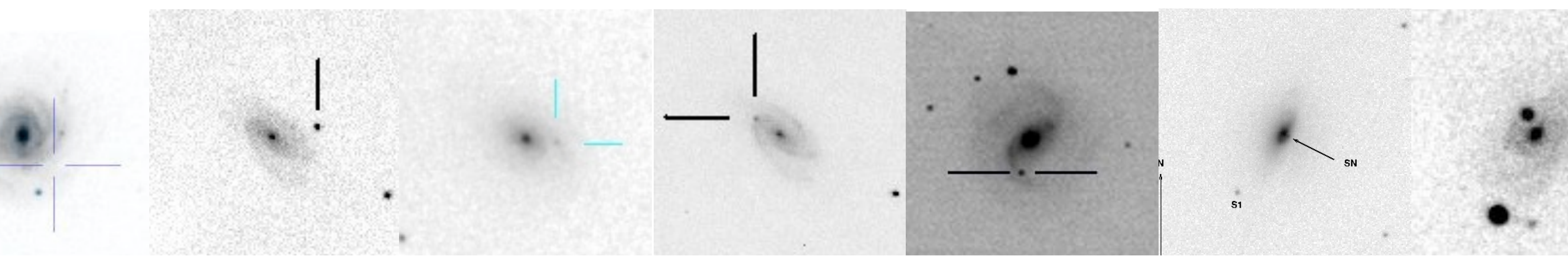
55 SNe in the field of view: 22 II, 13 Ibc/IIb, 20 Ia

Previous studies (SAME INSTRUMENT!!)

4 feasibility study for CALIFA, *Sánchez+12*
8 PINGS Survey, *Rosales-Ortega+10*
5 SNIa hosts, *Stanishev+12*
NGC5668, *Marino+12*
NGC3982, *Marino in prep.*
5 mergers, *Barrera-Ballesteros in prep.*

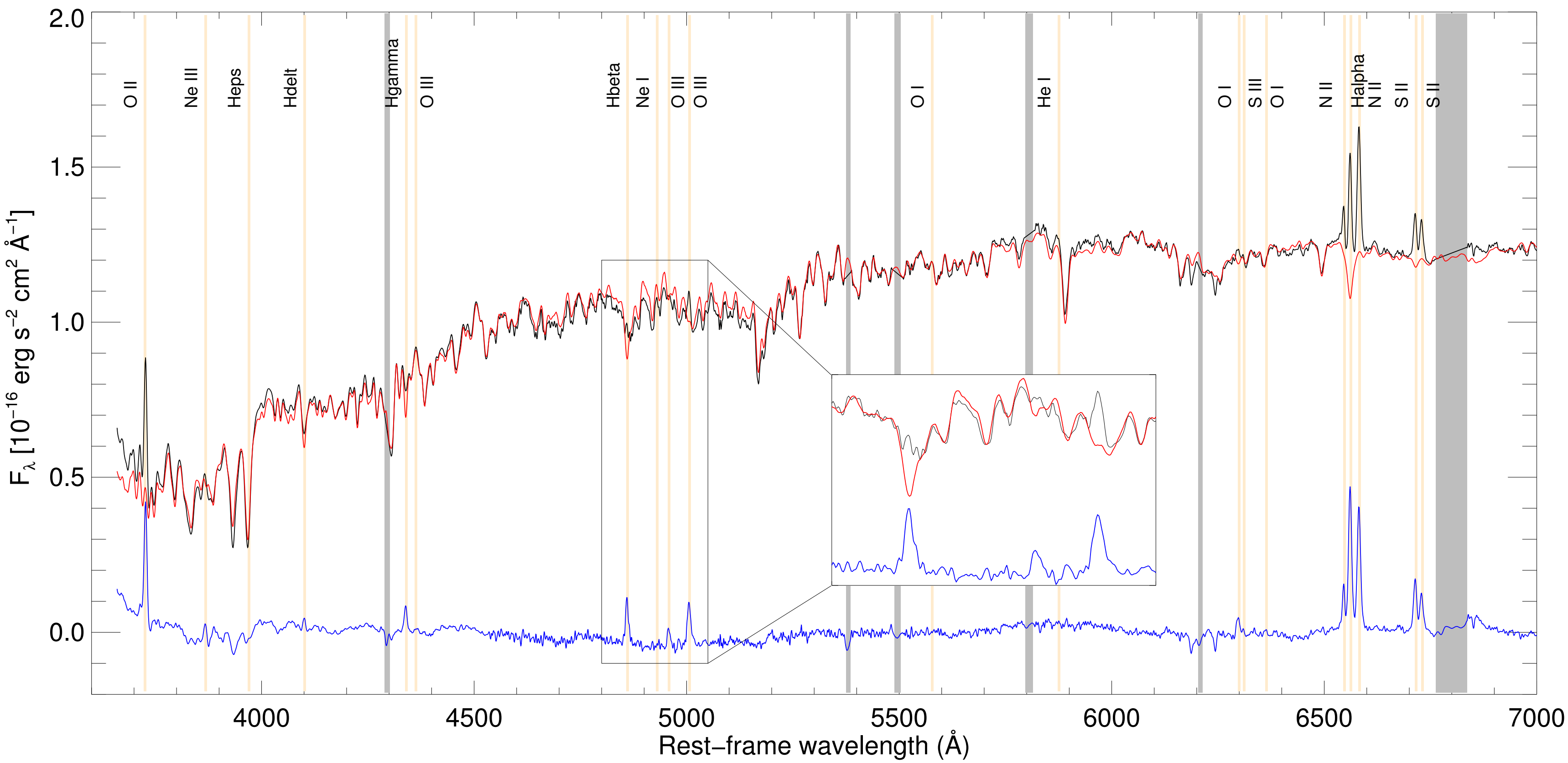
29 SNe: 10 II, 5 Ibc/IIb, 14 Ia

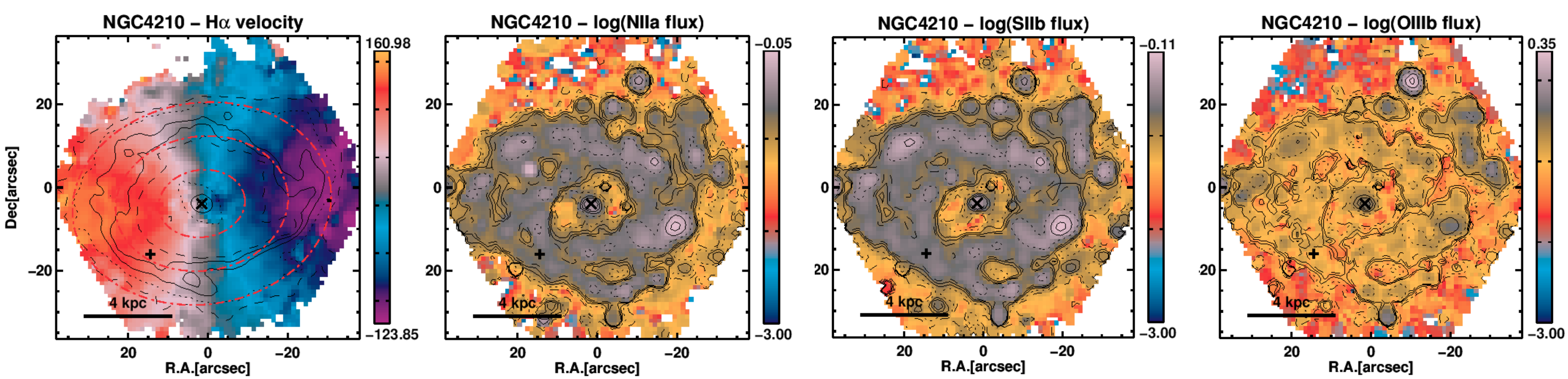
84 SNe: 32 II, 18 Ibc, 34 Ia

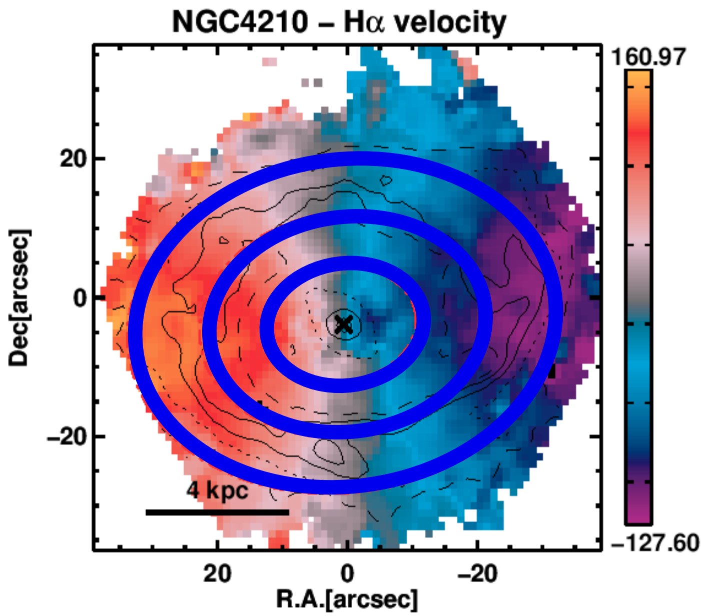


STARLIGHT *Cid Fernandes et al. 2005*

CB07: 17 Ages 10^6 to $1.8\ 10^{10}\ M_\odot$
4 metallicities 0.004, 0.05, 0.2, 2.5 $Z_\odot$





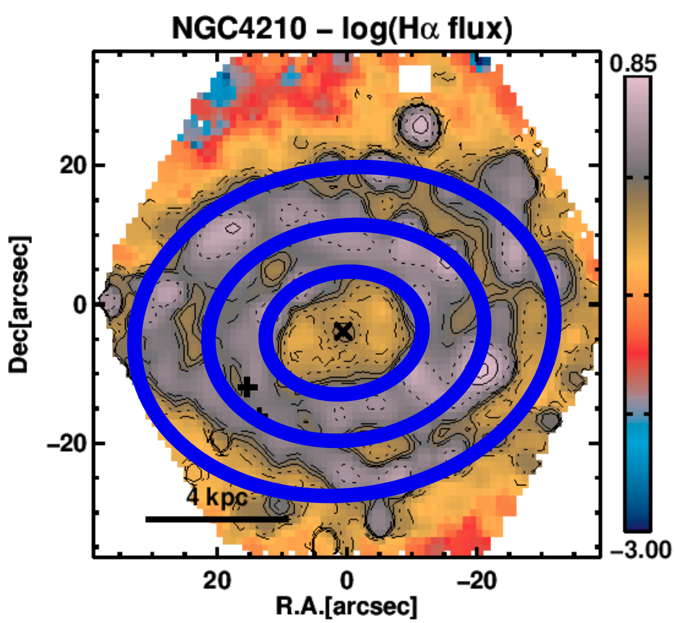


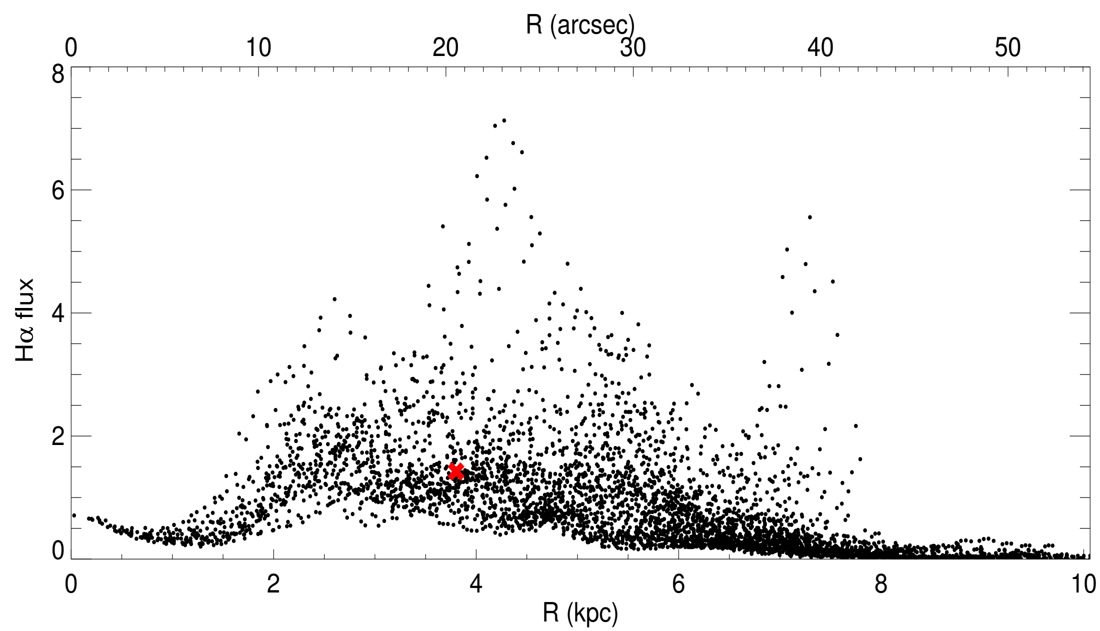
Kinemetry

Fit ellipses using *Krajnovic et al. 2006*

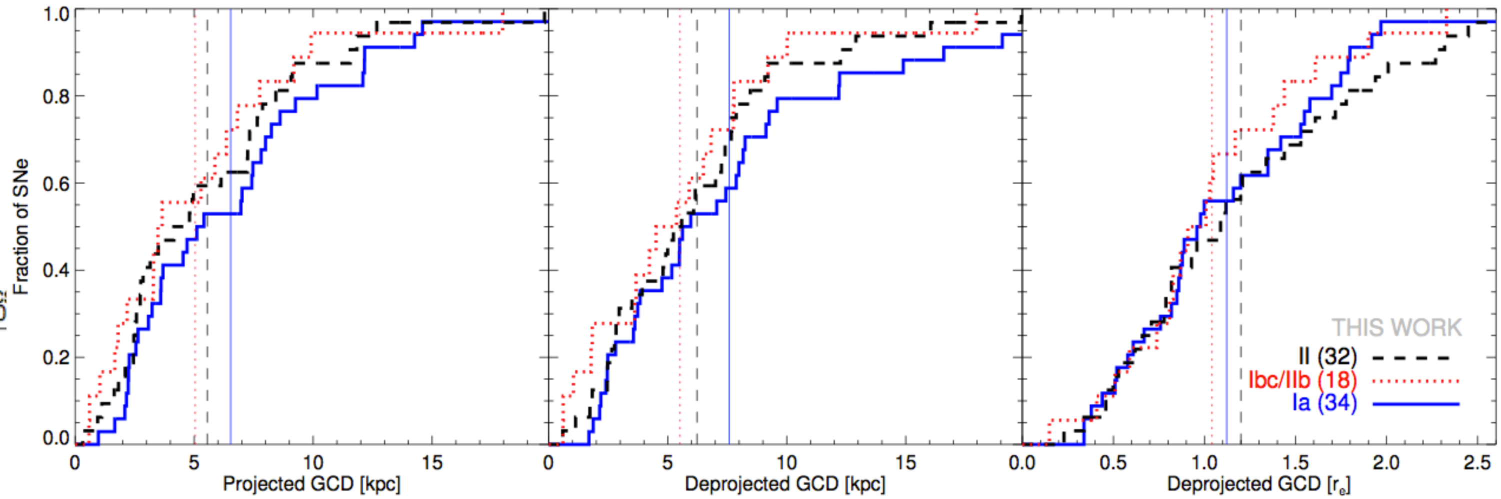
Deprojection

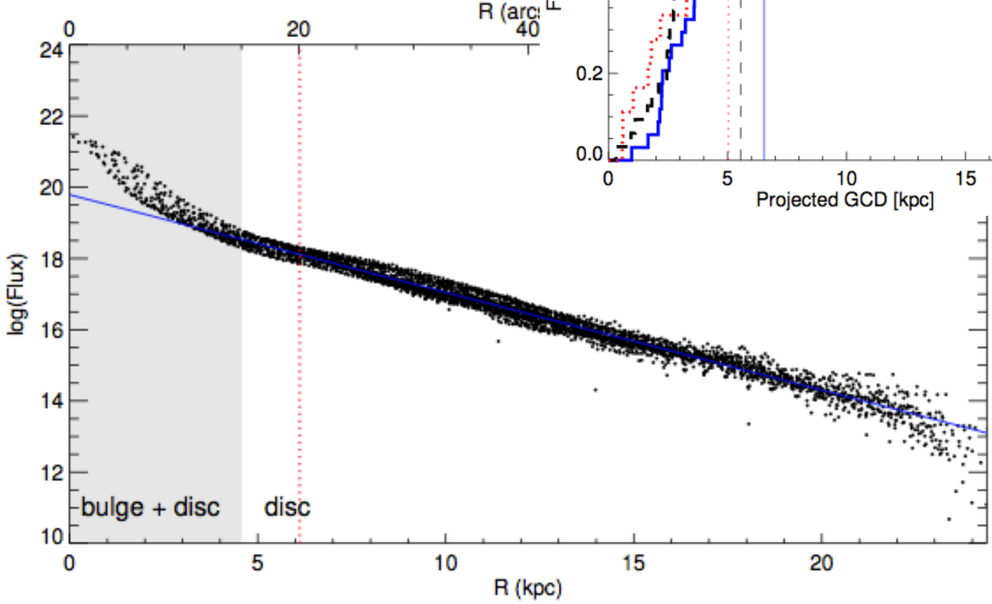
Measure distances in the galactic plane

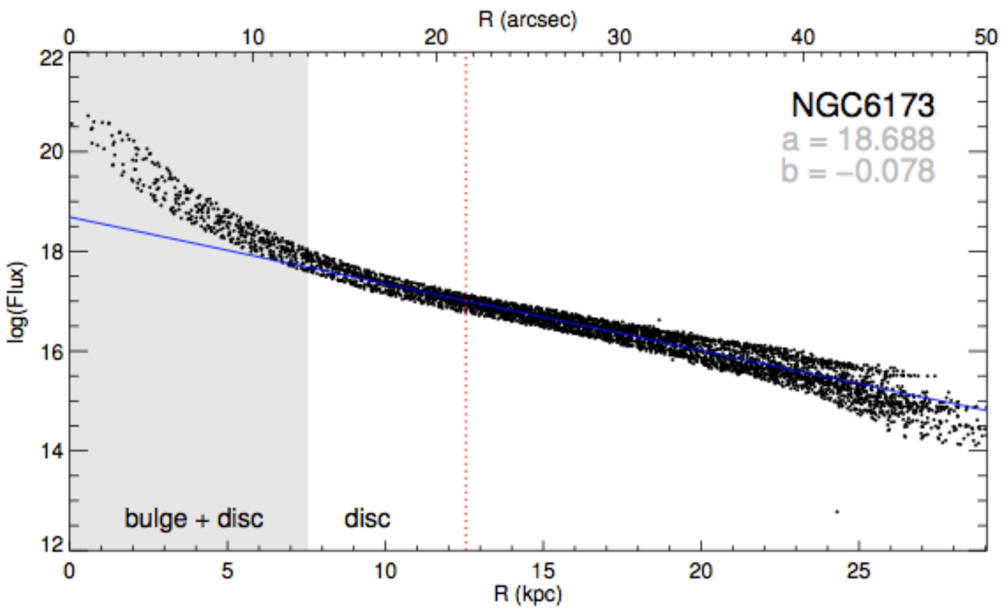




GCDs

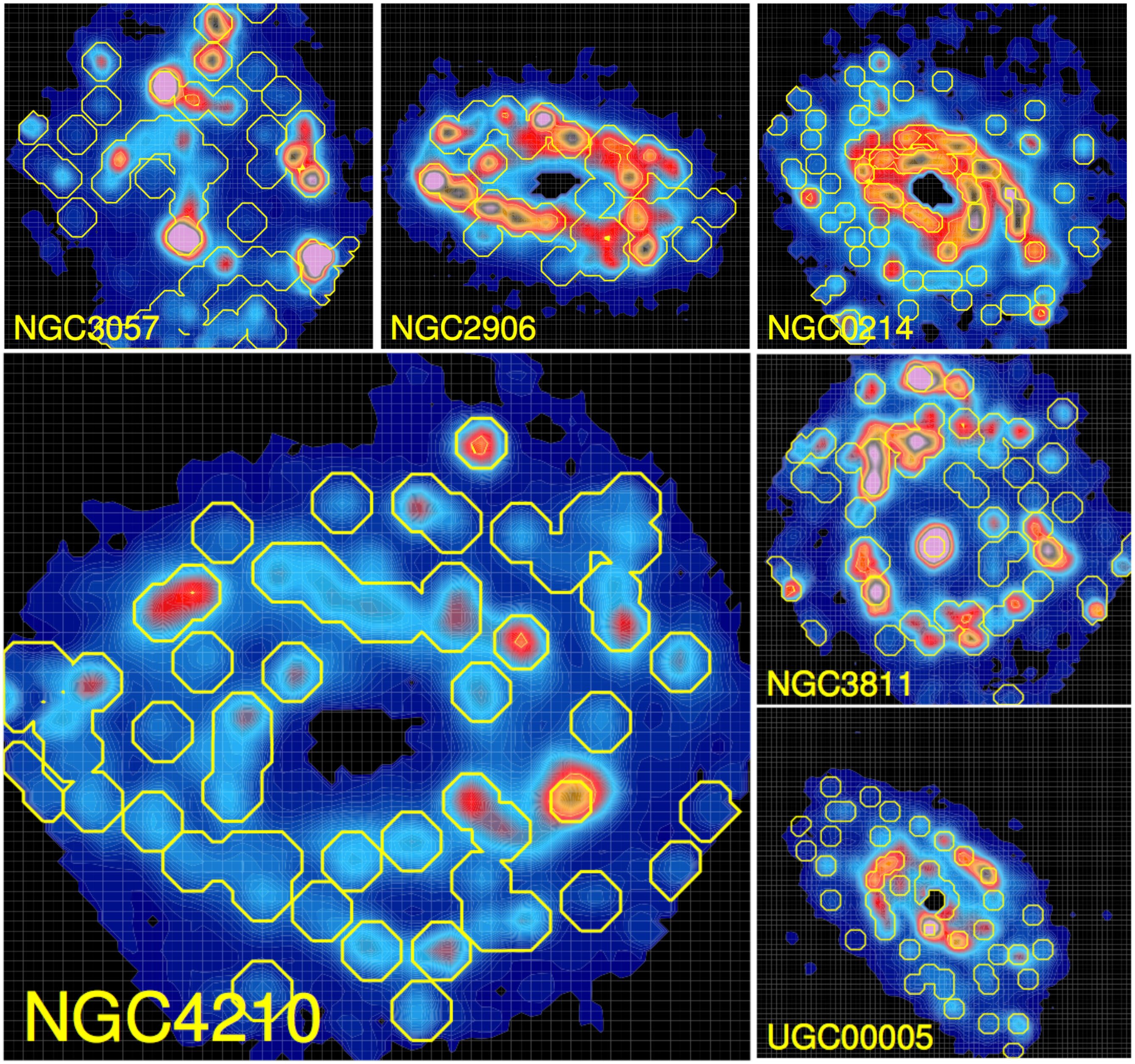






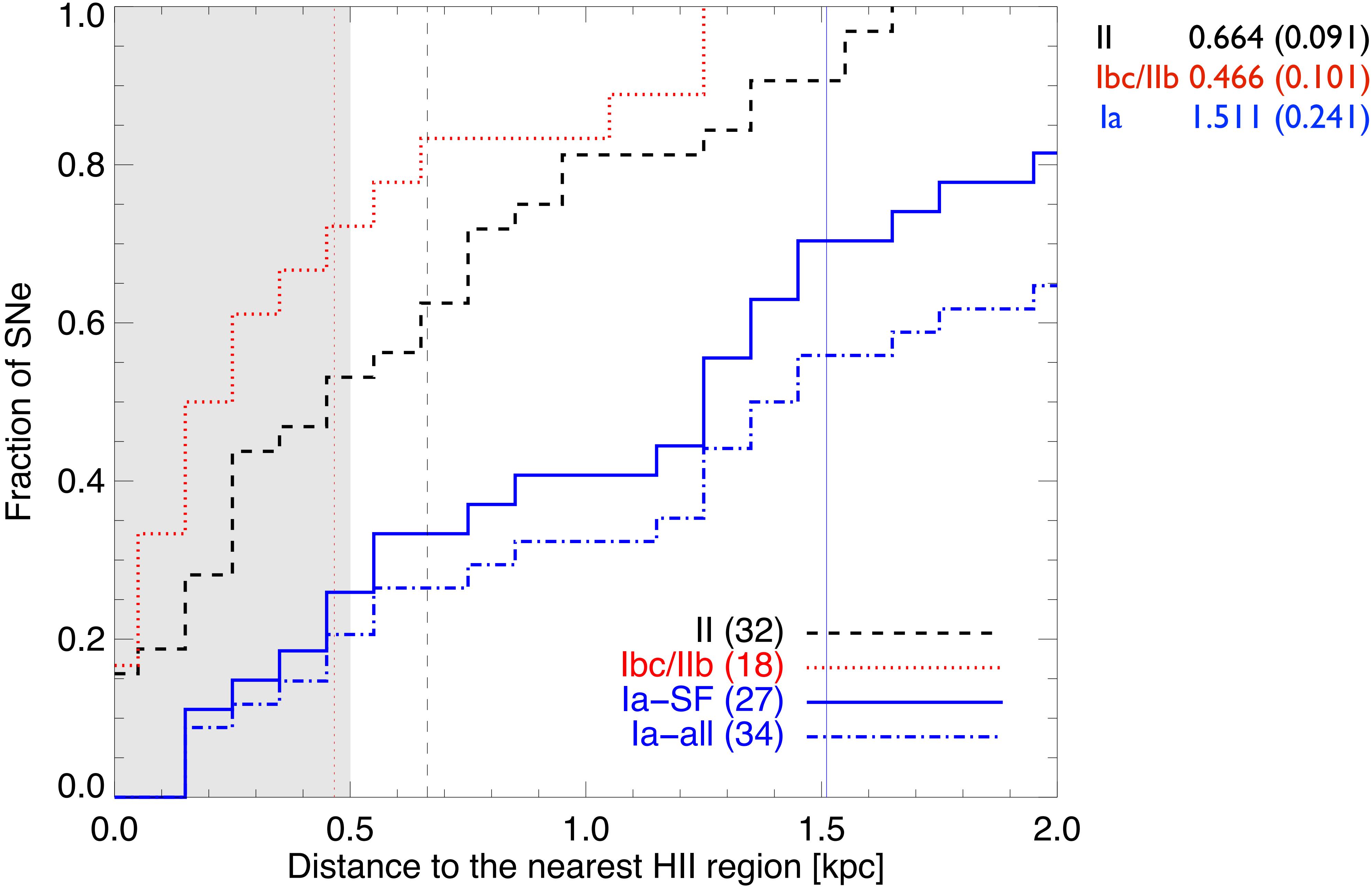
- Determination of the disk effective radius by fitting the light profile contribution from the disk
- Distance as a proxy of local metallicity, assuming the presence of gradients
- SNe Ibc/IIb found closer to the galaxy core - SNe Ia found further
- SNe Ibc/IIb would explode in metal-richer environments since they explode closer to the center of the galaxy

Star forming regions

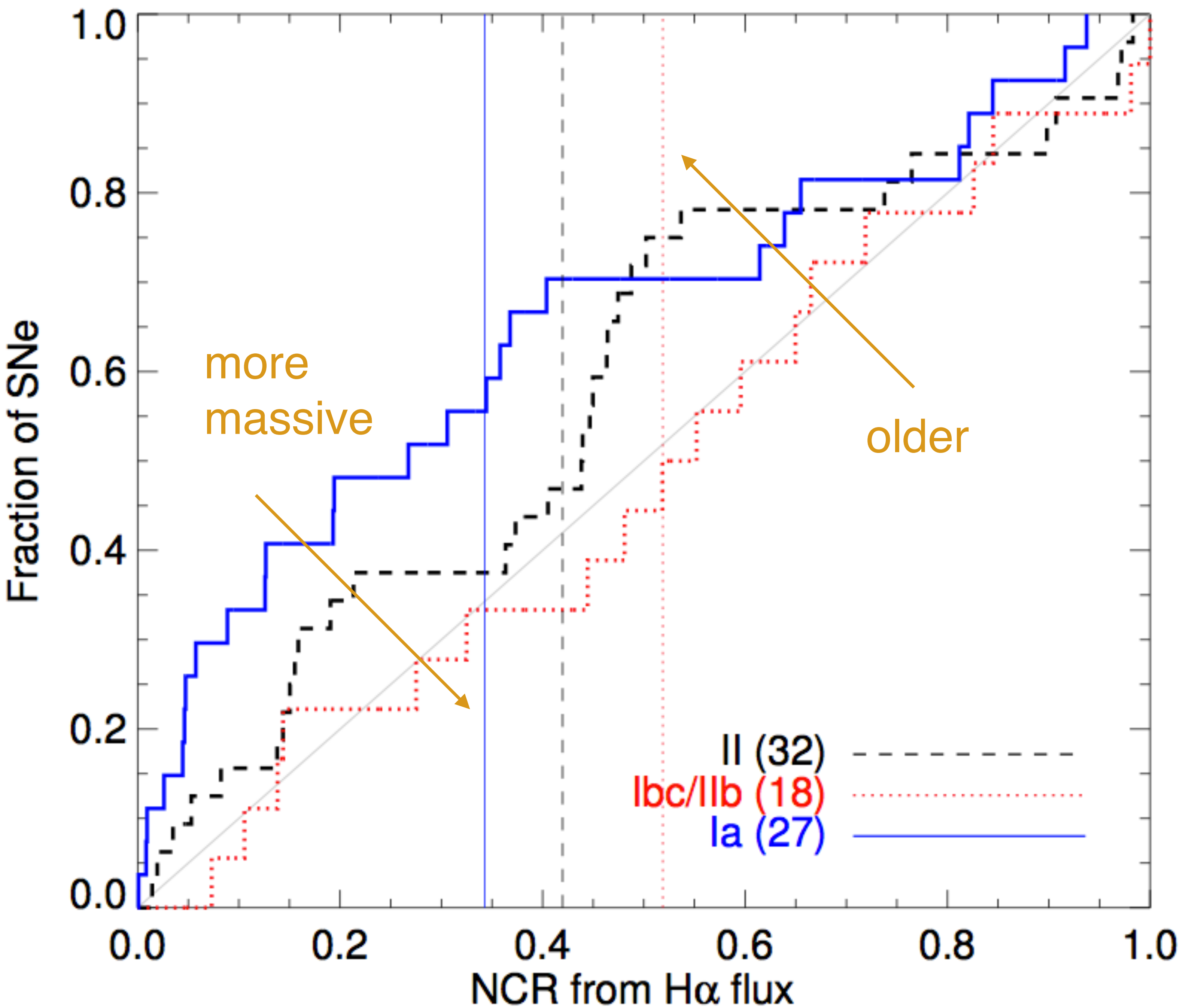


- HII clupms selected from Hα maps using HIIexplorer (Sanchez+12)
- Measure distances from the SN explosion site to the nearest HII clump

Star forming regions

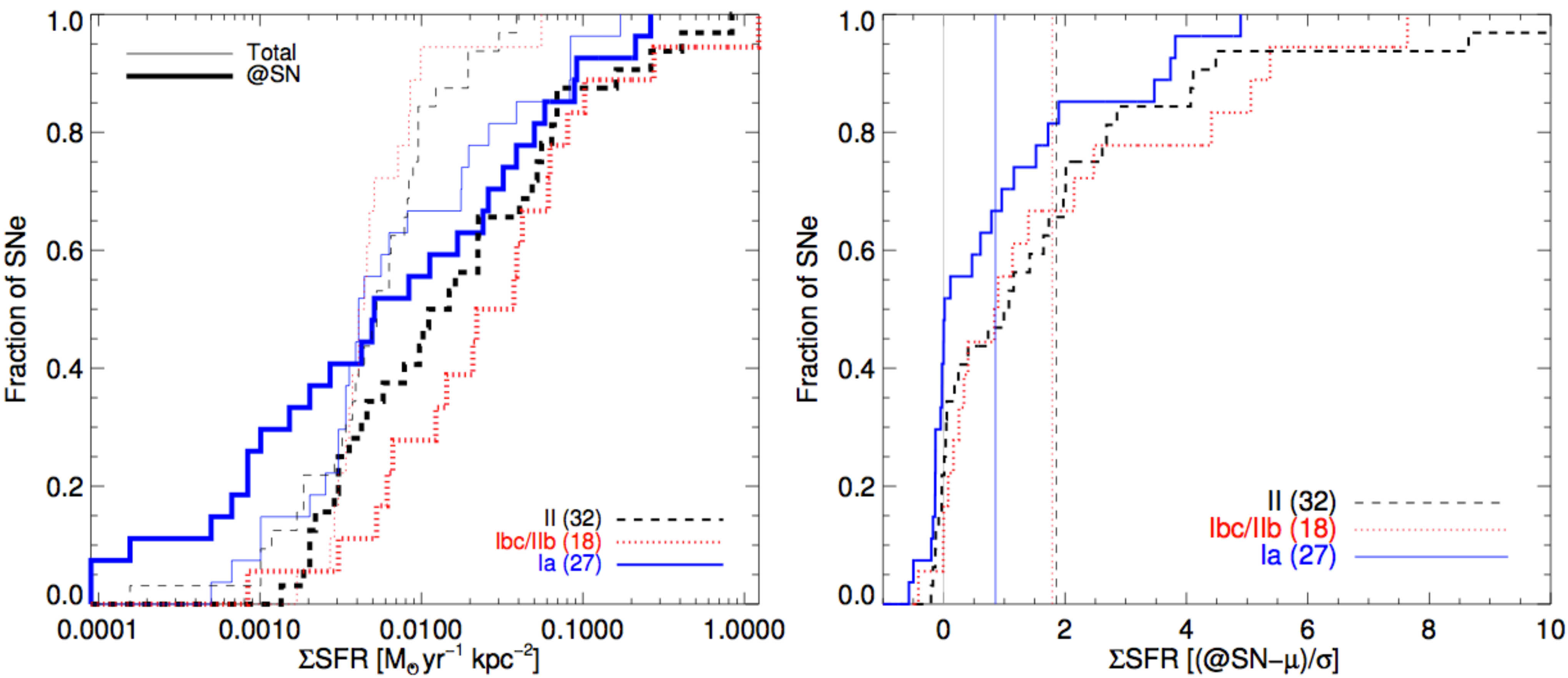


NCR



II	0.420	(0.053)
Ibc/IIb	0.519	(0.070)
Ia	0.343	(0.061)

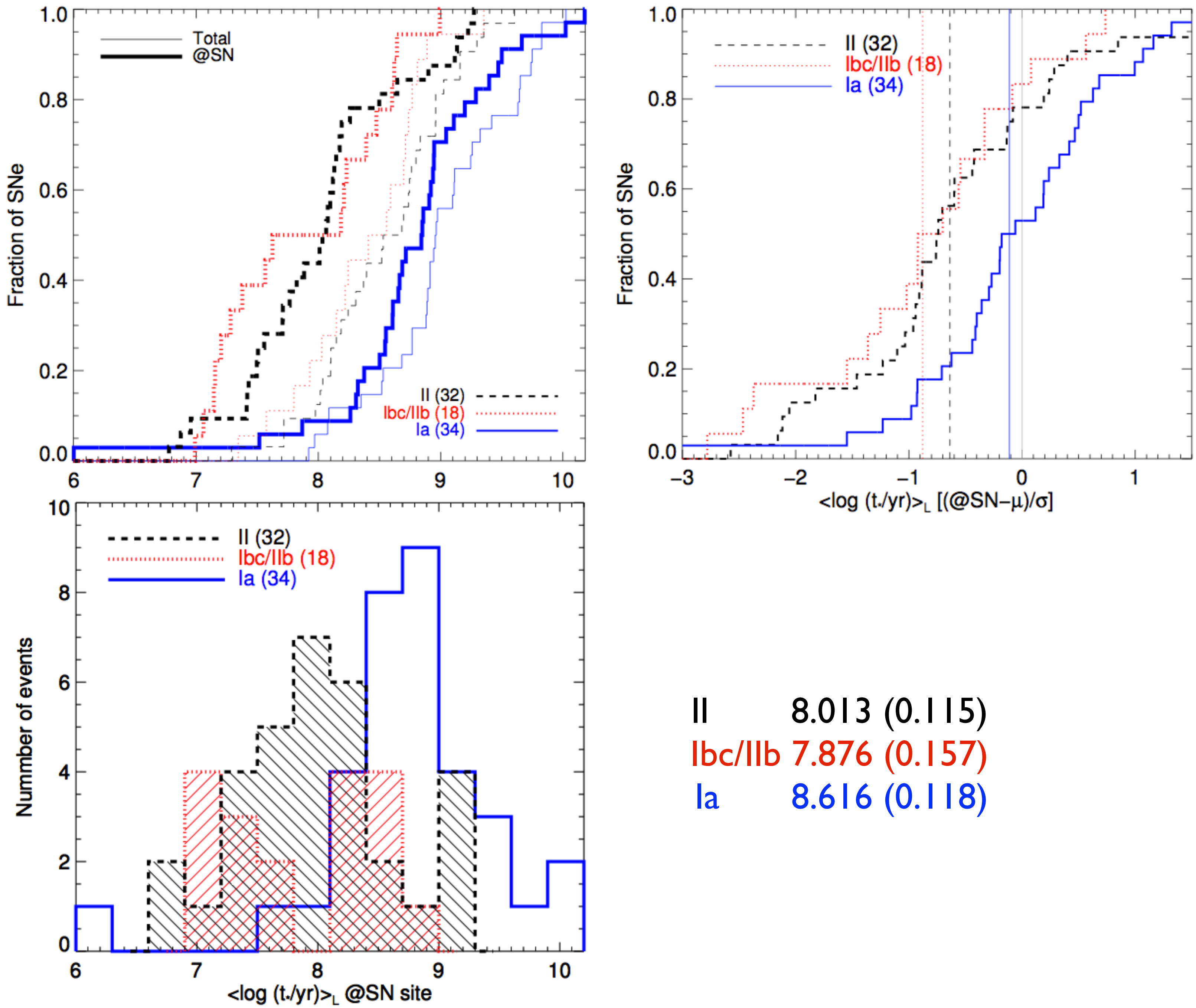
Star Formation Rate density (Σ_{SFR})



Σ_{SFR} @SN position and from integrated spectra

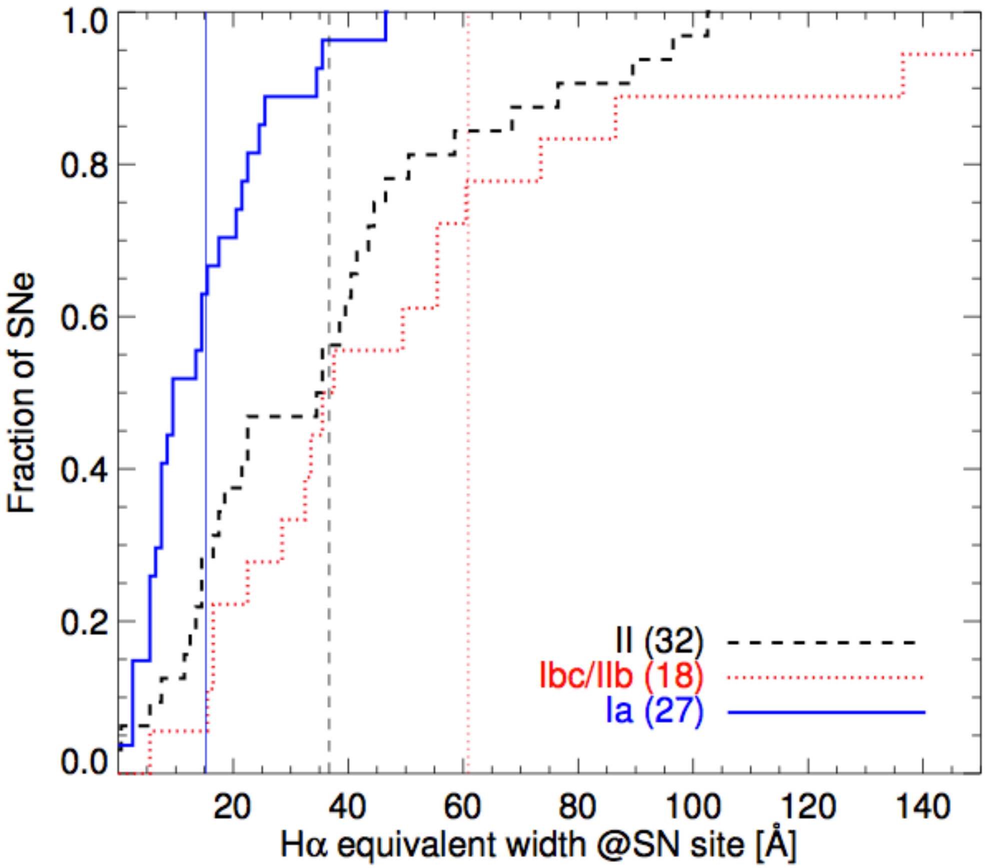
II	0.0704 (0.0290)
Ibc/IIb	0.1124 (0.0673)
Ia	0.0352 (0.0124)

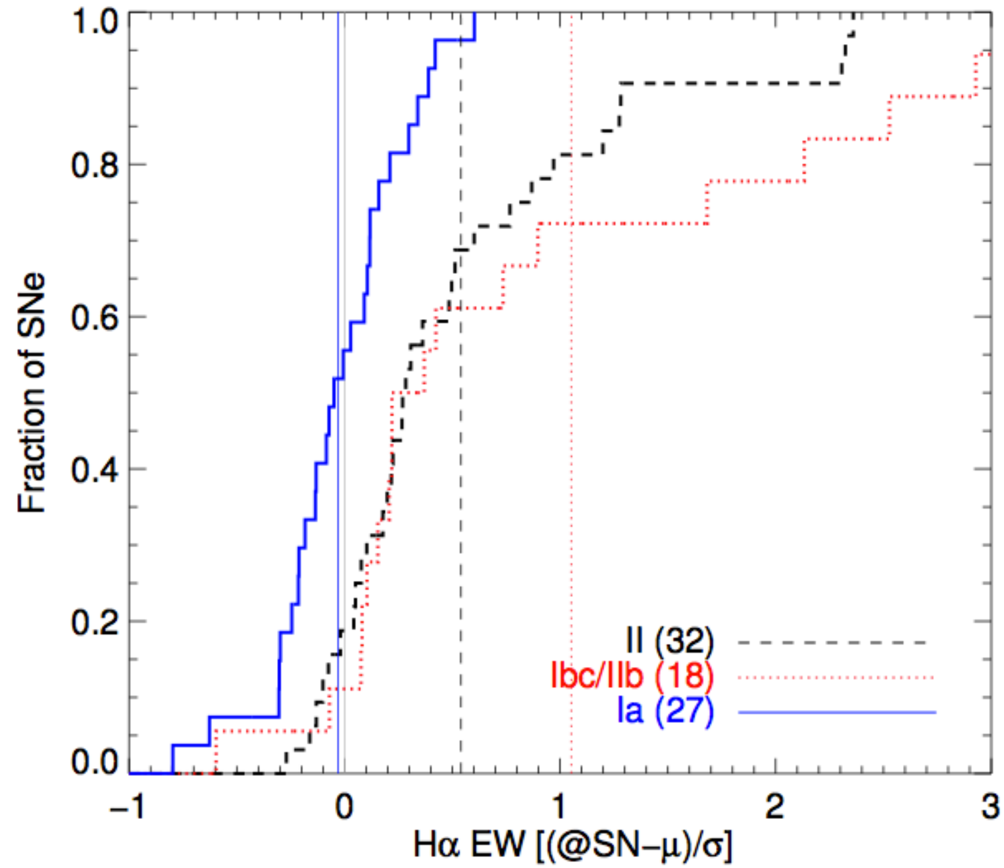
Stellar age



II	8.013 (0.115)
Ibc/IIb	7.876 (0.157)
Ia	8.616 (0.118)

Ha equivalent width

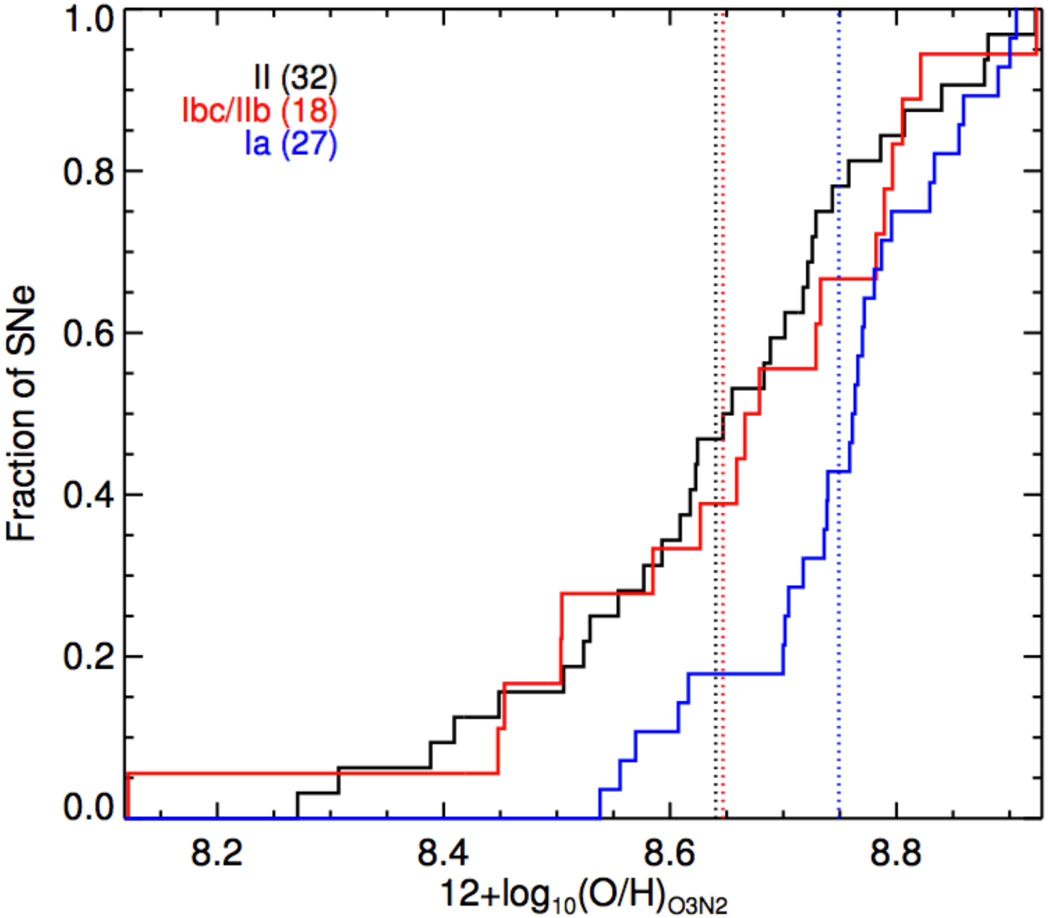




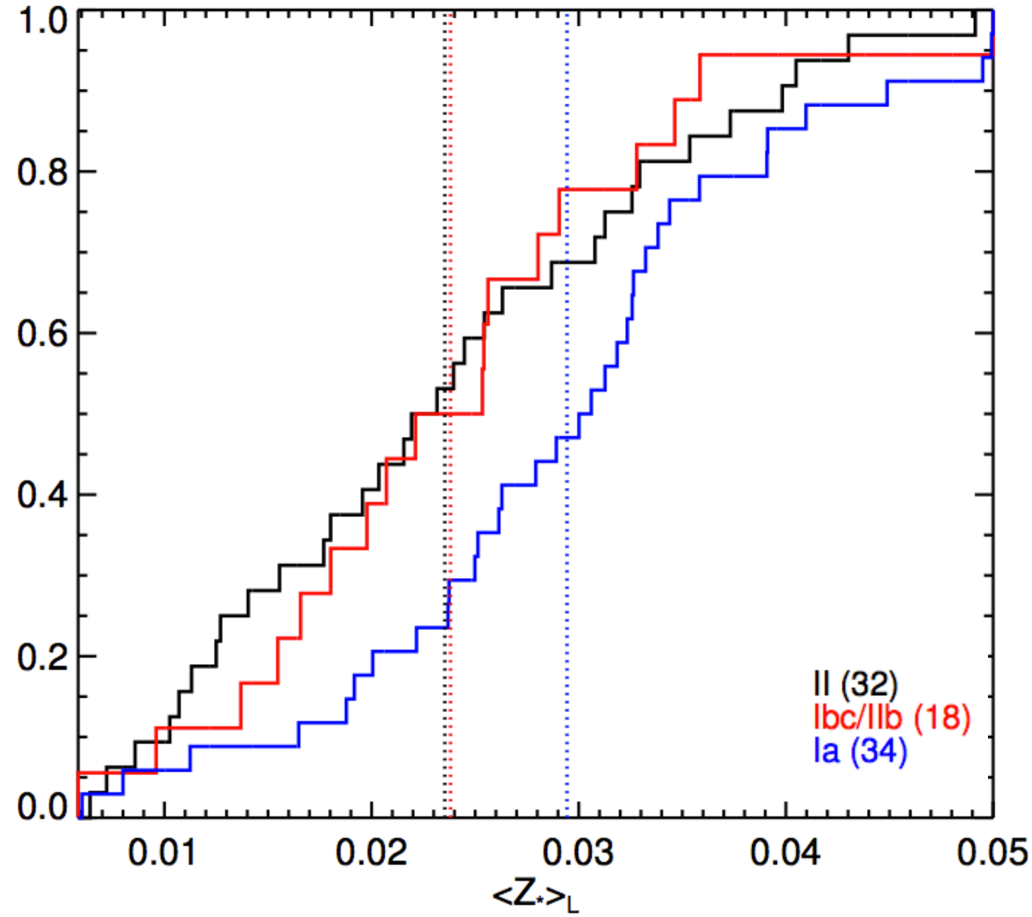
II	36.68 (4.85)
Ibc/IIb	60.88 (16.93)
Ia	-15.24 (2.21)

Ha EW can be used as a proxy of the age of the progenitor (Kuncarayakti+13)

Oxygen abundance



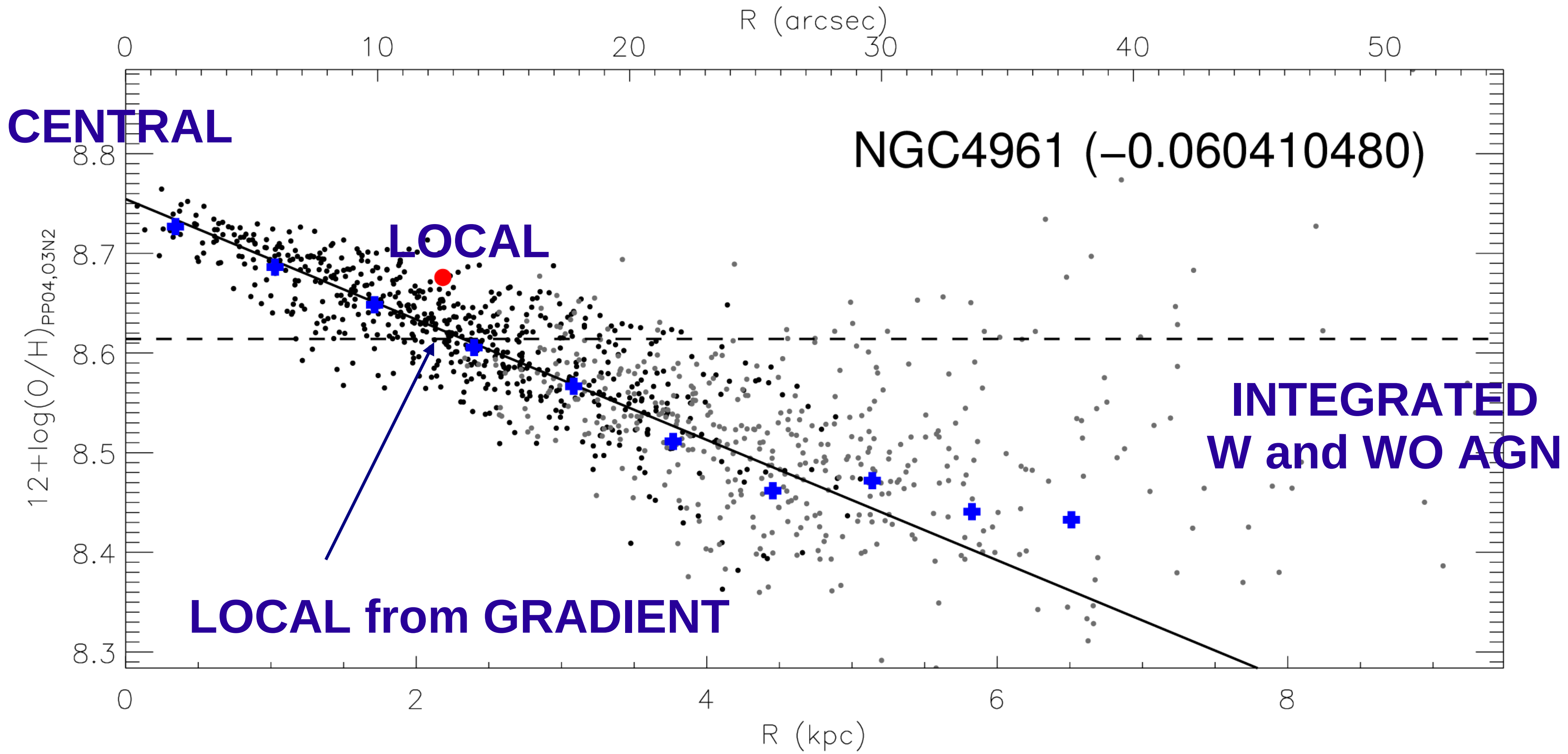
Oxygen abundance from the emission lines



Metallicity from the fit to the stellar continuum

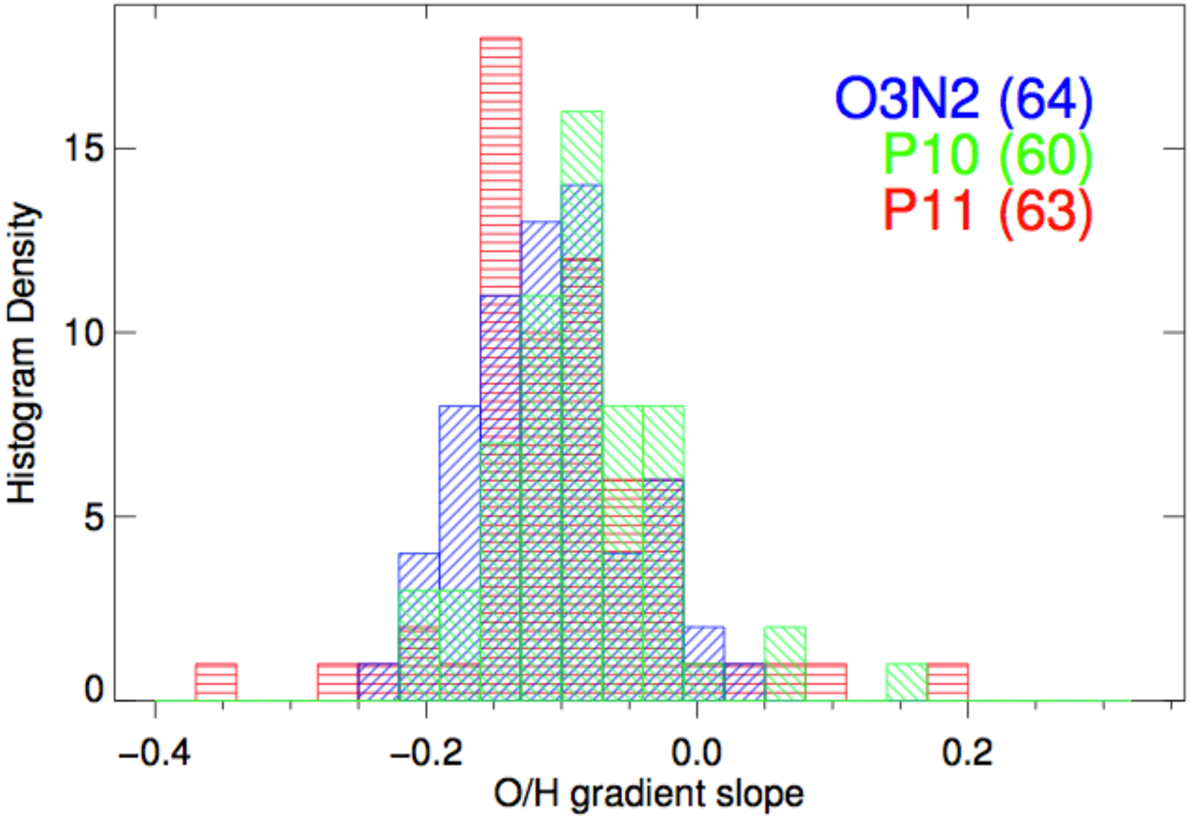
II	8.640 (0.028)	II	0.0235 (0.0020)
Ibc/IIb	8.647 (0.045)	Ibc/IIb	0.0238 (0.0025)
Ia	8.749 (0.019)	Ia	0.0294 (0.0019)

Z gradients

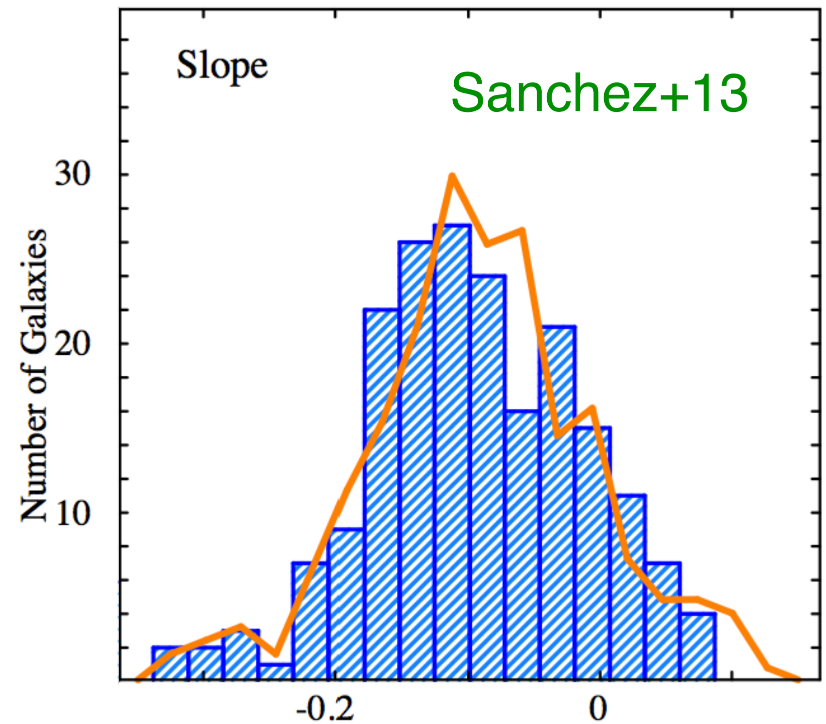


R (arcsec)
0
10
20
30
40
50
CENTRAL
NGC4961 (−0.060410480)
LOCAL
INTEGRATED
W and WO AGN
LOCAL from GRADIENT
12+log(O/H)PP04,O3N2
8.8
8.7
8.6
8.5
8.4
8.3
0
2
4
6
8
R (kpc)

Z gradients



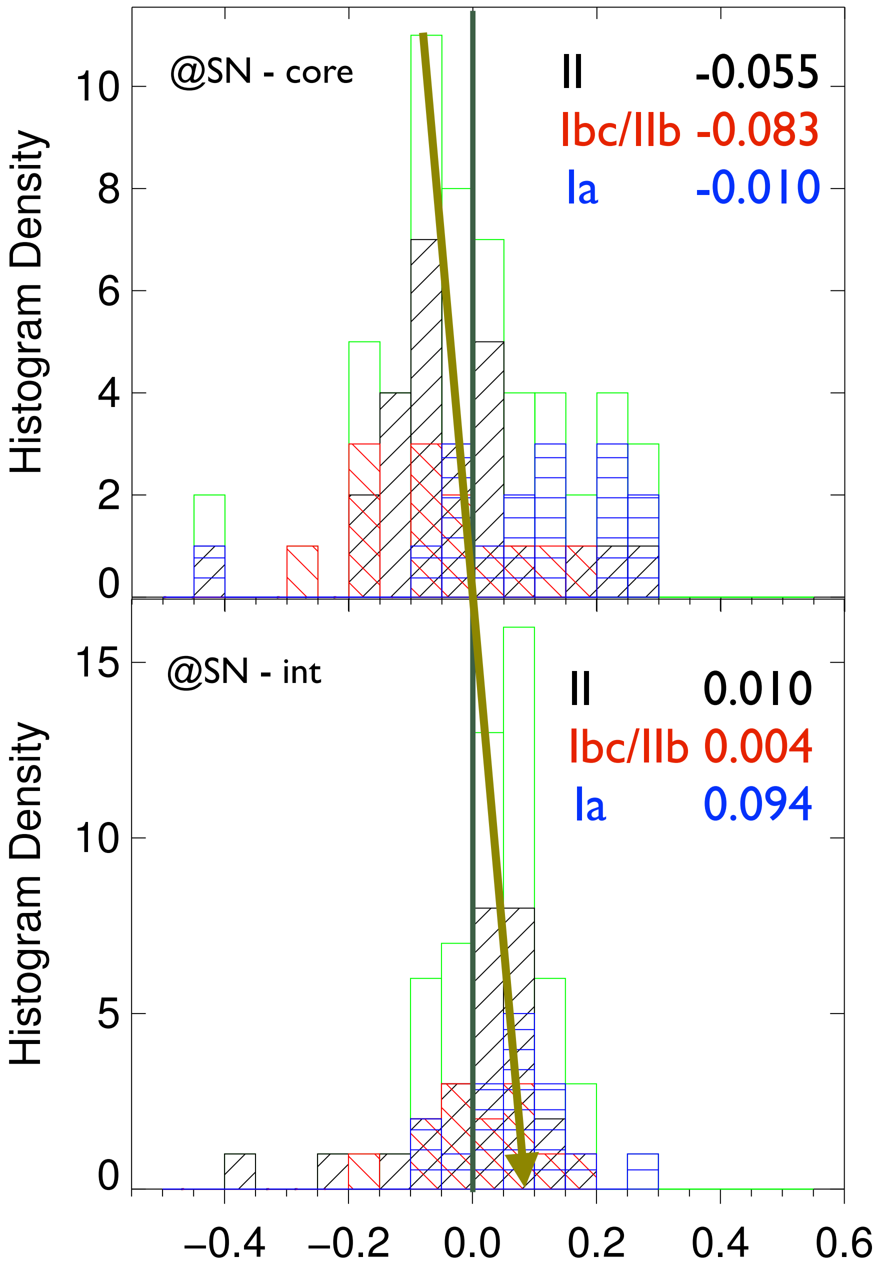
yesterday on astro-ph !!

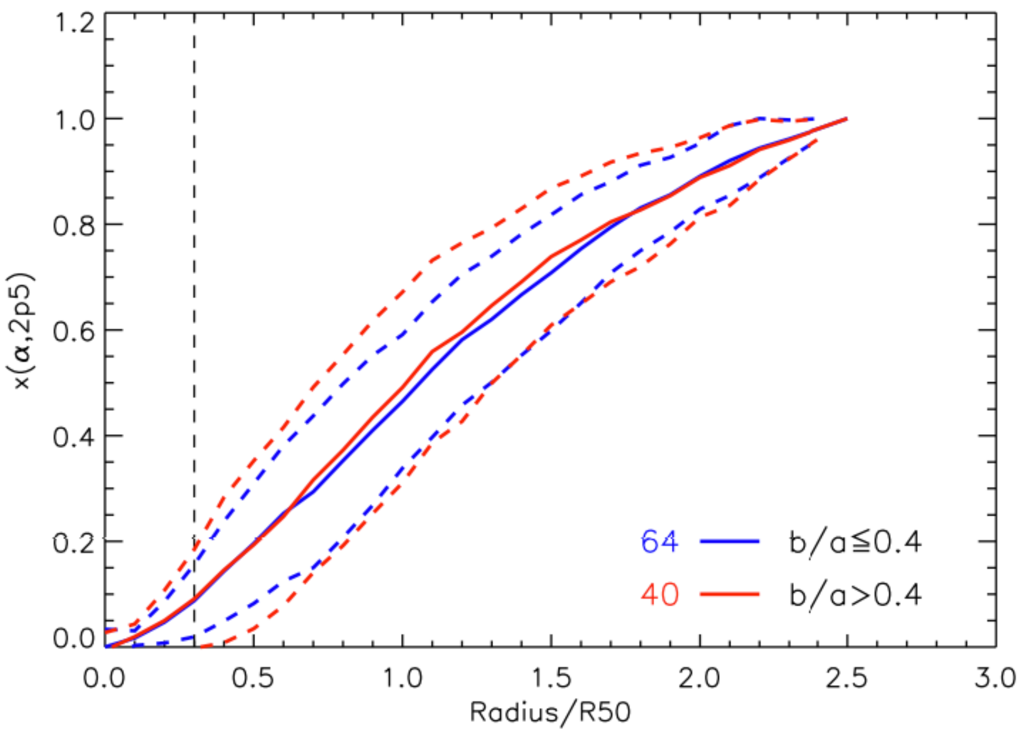


Show a characteristic gradient (~ -0.1 dex)

No dependence on O/H estimator or SN type

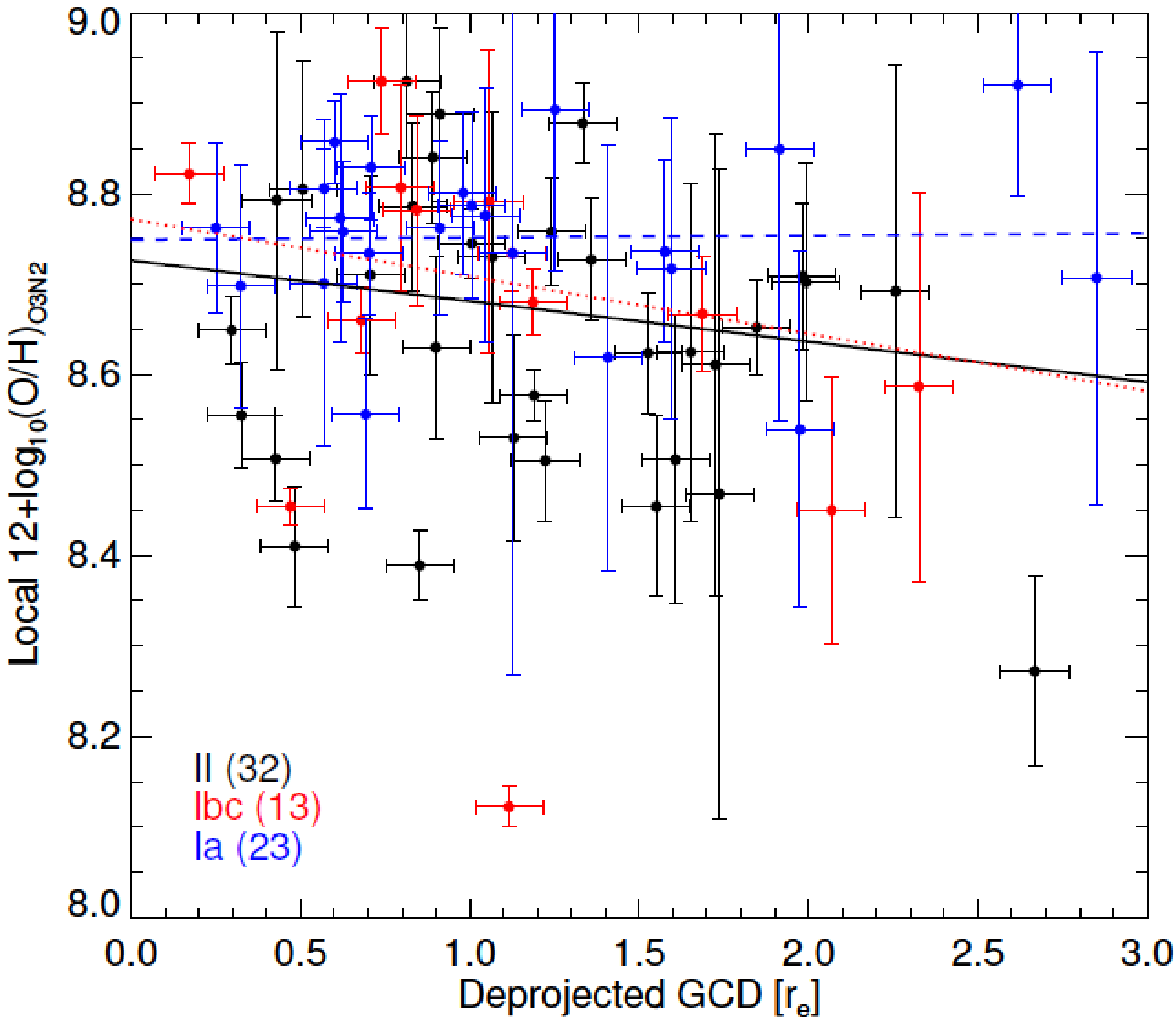
Aperture effects



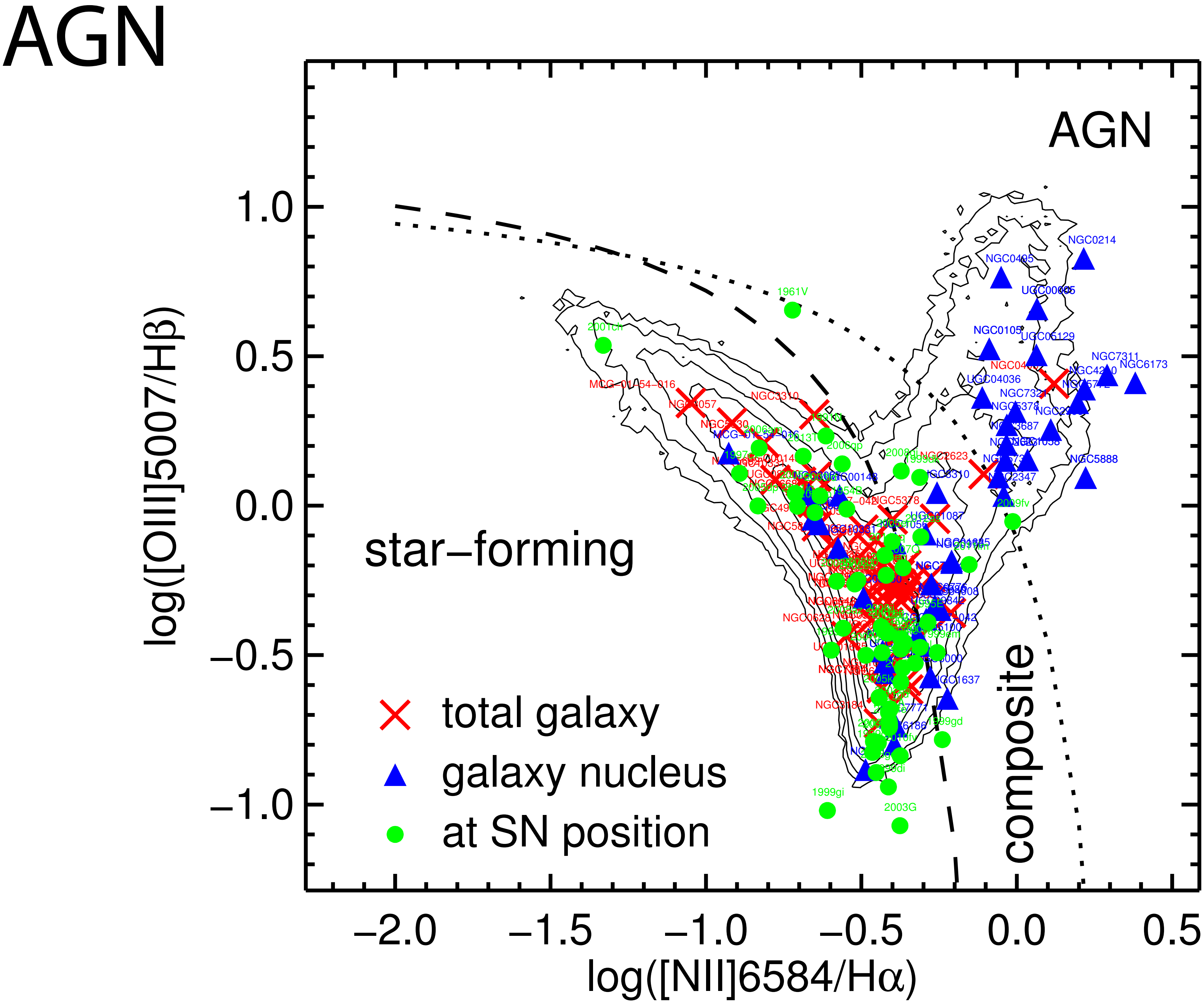


Iglesia-Paramo et al. 2013

Metallicity gradients



- Type Ia SNe do not show a decrease in metallicity at larger distances
- CC SNe local metallicity have lower values in the outskirts


AGN
AGN
star−forming
composite
total galaxy
galaxy nucleus
at SN position
log([OIII]5007/Hβ)
log([NII]6584/Hα)
1.0
0.5
0.0
−0.5
−1.0
−2.0
−1.5
−1.0
−0.5
0.0
0.5

Conclusions

- IFU is a powerful technique at low redshift
- Differences found in galactocentric distances. This can be understood as differences in the progenitor metallicity, in sequence from type Ibc/IIb, type II, and type Ia SNe.
- Differences found in association to star-forming regions. This can be understood as differences in the progenitor mass and age, in the same SN type sequence.
- No differences found in type Ibc/IIb and type II SNe environmental metallicities, giving support to the progenitor mass and age to determent the SN type. SNe Ia occur systematically in metal-richer environments.
- IFS allowed us to study aperture effects and the use of metallicity gradients as an indirect approximation to the local values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