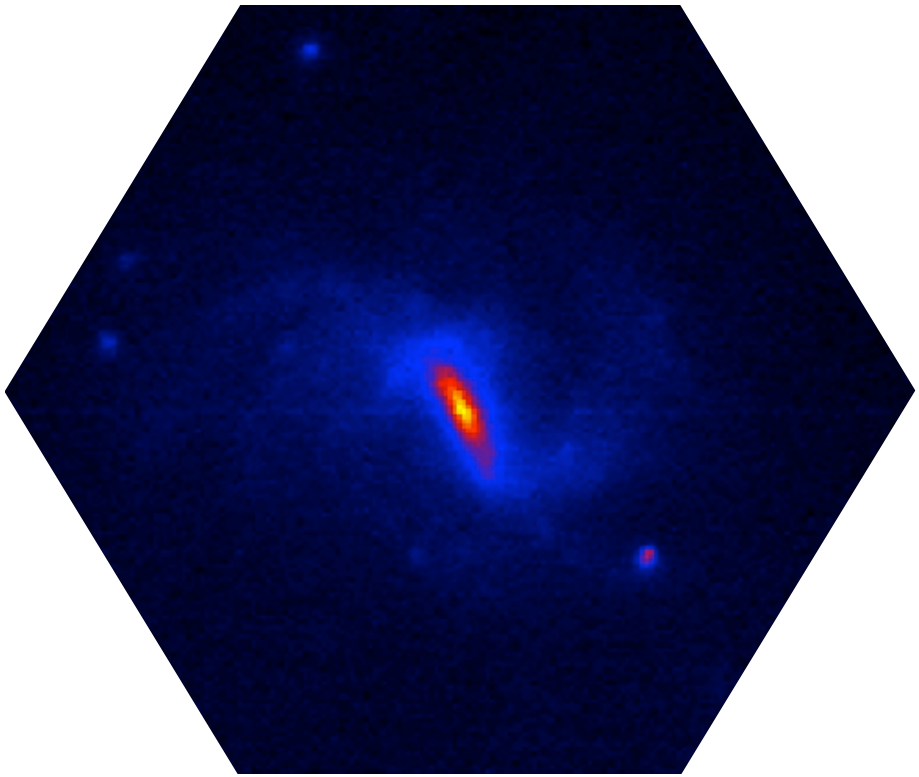
IFU observations of SN environments

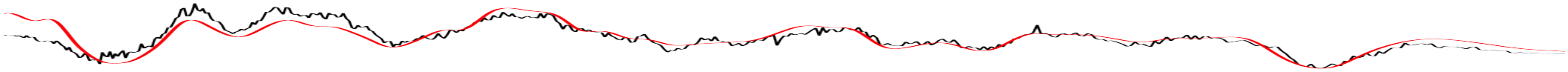


Lluís Galbany, CENTRA-IST Lisboa

CALIFA Survey

Calán, 2 April 2013

Second order corrections: Environment



Look for dependences of the SN properties on the host galaxy properties (focused on global characteristics of the host)

As they evolve with redshift, such dependences would impact the cosmological parameters

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

...

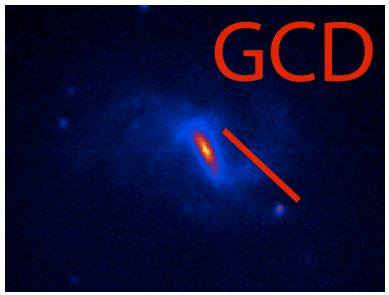
SNe Ia properties as a function of the GCD

The Astrophysical Journal, 755:1 (14pp), 2012 ???
doi:10.1088/0004-637X/755/1/1

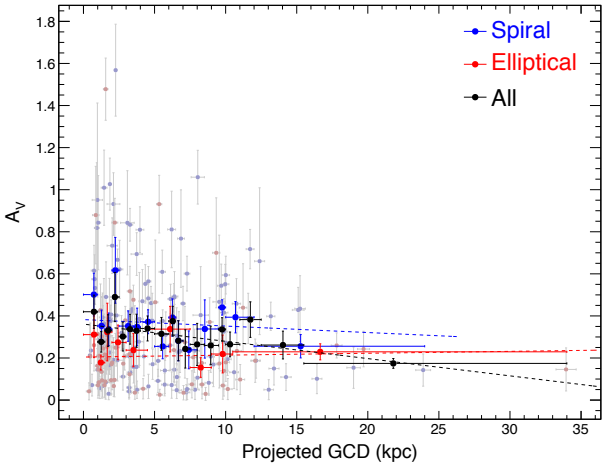
TYPE Ia SUPERNOVA PROPERTIES AS A FUNCTION OF THE DISTANCE TO THE HOST GALAXY IN THE SDSS-II SN SURVEY

Lluís Galbany[1,18], Ramon Miquel[1,2], Linda Östman[1], Peter J. Brown[3], David Cinabro[4], Chris B. D'Andrea[5], Joshua Frieman[6,7,8], Saurabh W. Jha[9], John Marriner[8], Robert C. Nichol[5], Jakob Nordin[10,11], Matthew D. Olmstead[3], Masao Sako[12], Donald P. Schneider[13,14], Mathew Smith[15], Jesper Sollerman[16], Kaike Pan[17], Stephanie Snedden[17], Dmitry Bizyaev[17], Howard Brewington[17], Elena Malanushenko[17], Viktor Malanushenko[17], Dan Oravetz[17], Audrey Simmons[17], and Alaina Shelden[17]

Galbany et al., 2012, ApJ, 755, 125



- Look for dependencies between SN Ia properties and its projected distance to the host galaxy center, using the distance as a proxy for **local** galaxy properties (star-formation rate, local metallicity, etc.).
- Use SDSS-II/SNe Survey 3-year sample
- Fit LCs using both MLCS2k2 and SALT2.
  - Color (A_V, c), Decline rate (Δ, x_1), and residuals in the fit to the Hubble diagram ($\delta\mu$).
- Correlate these parameters with several definitions of the distance of the SN to the center of the host galaxy



Δ increase with distance in ellipticals

A_V, c decrease with distance

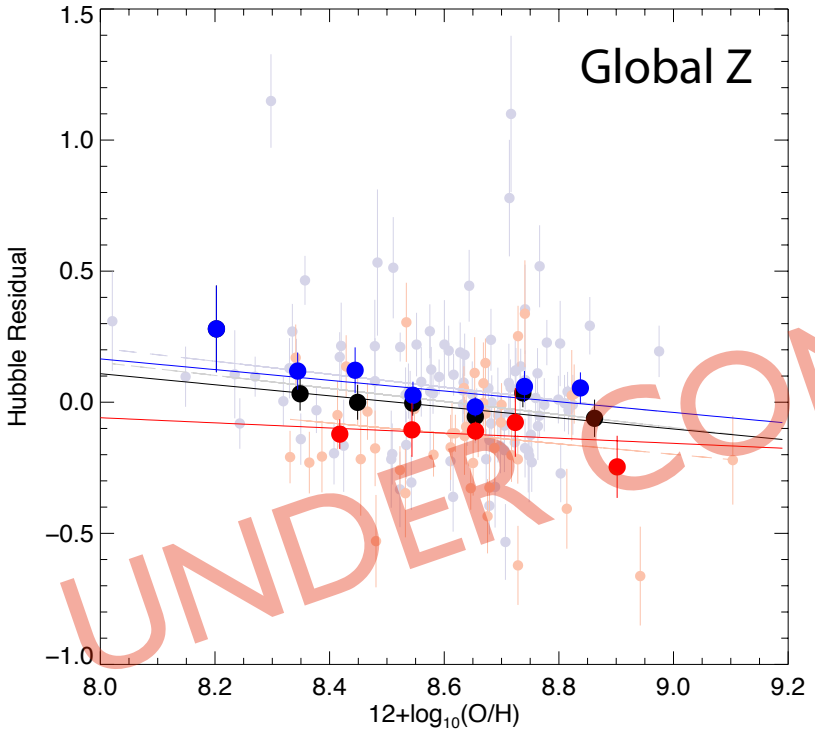
no correlations with HR

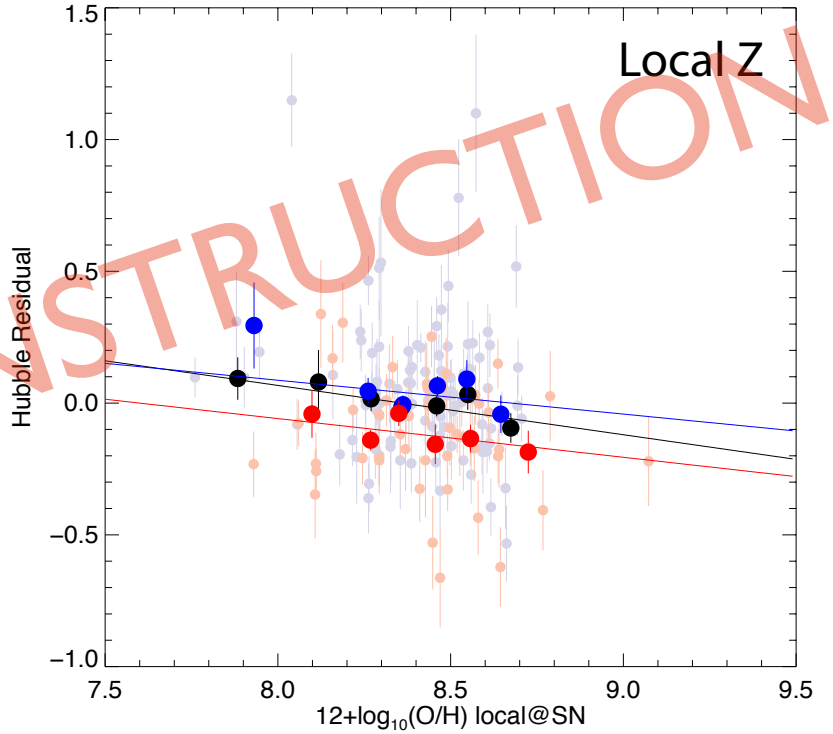
Metallicity gradients

We also considered the use of metallicity gradients as a better approximation to the local value at the SN position. We combine the expression in Boisser+09 with our own measurement of the NGCD.

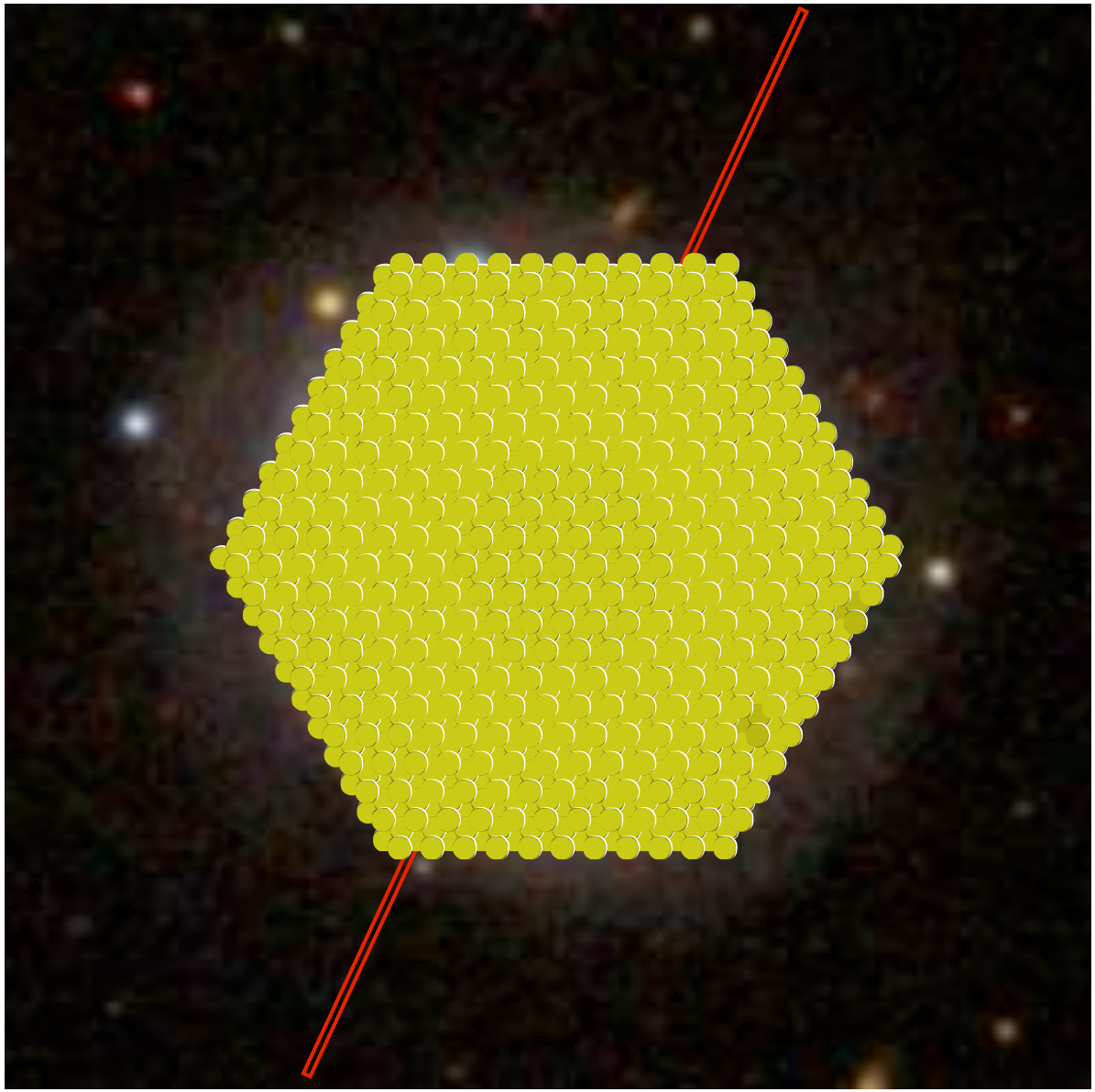
gradient in Boissier+09

$$[12 + \log(O/H)](\mathrm{NGCD}) = Z_{\mathrm{CORE}} + (0.204 + 0.04\ \mathrm{M_B})(\mathrm{NGCD})$$

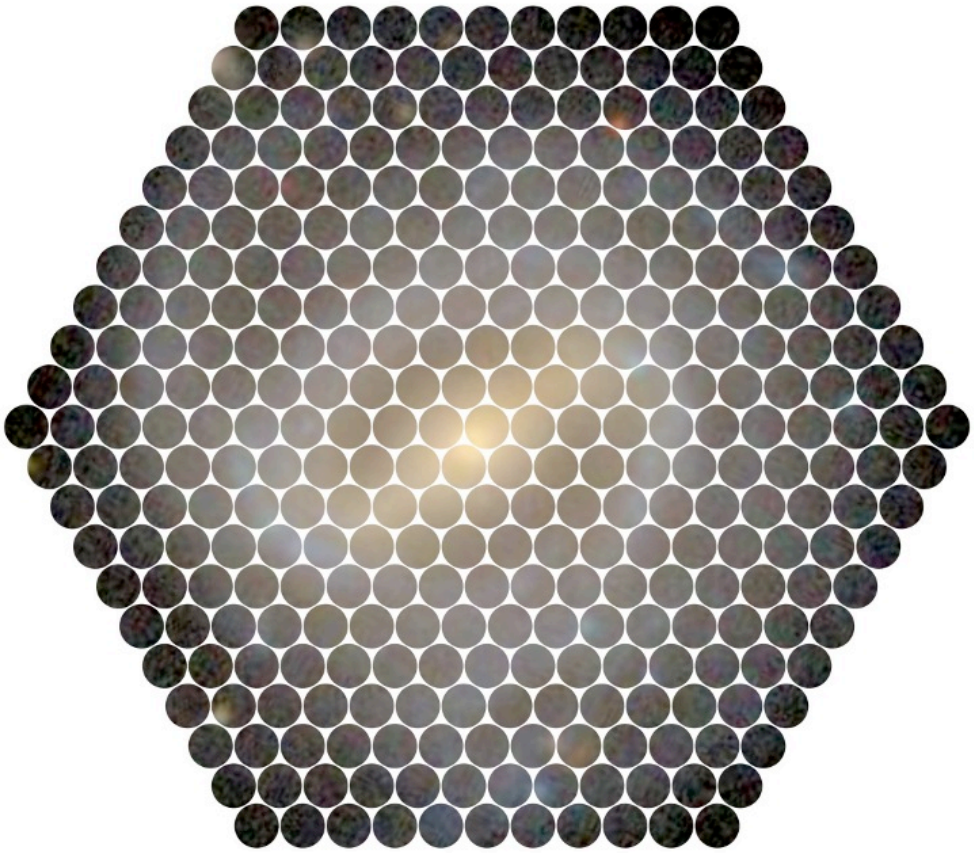




We **do not find any significant** (> 2 sigma) **slope** when using a metallicity gradient as an approximation to the local metallicity @SN position



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

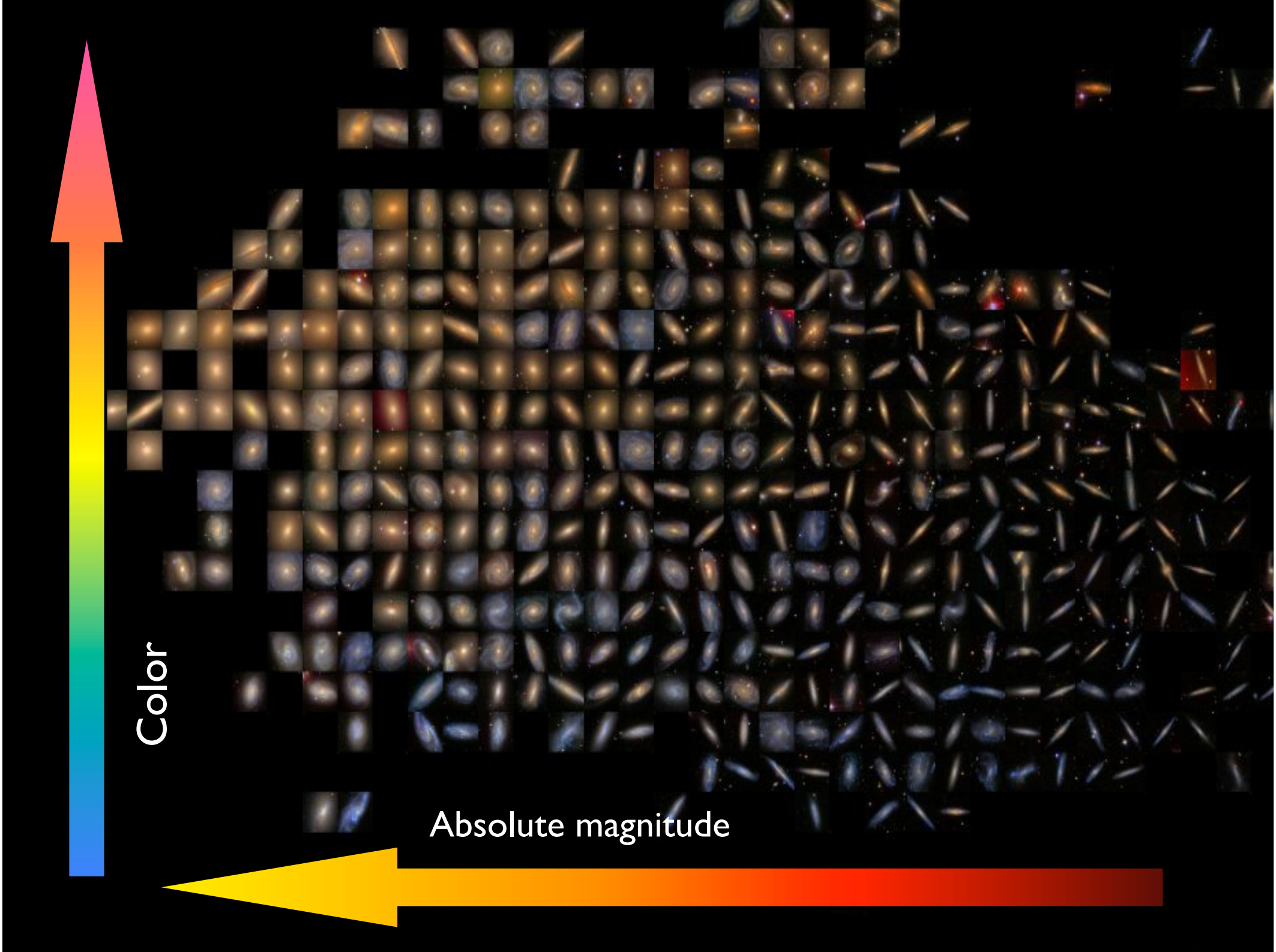
- IFS using PPAK @ 3.5m CAHA

  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


Color
Absolute magnitude

Sample selection

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

  ~300 galaxies observed (at least with one grating)

  55 hosted **65** SNe (8 with 2 SNe,1 with 3 SNe)

  47 in the field of view: **13** SNIa, **9** SNIbc, **19** SNII (2b, 2P, 5n), **6** untyped

  4 SNIa hosts with no emission lines:

37 SNe: 19 II, 9 Ibc, 9 Ia

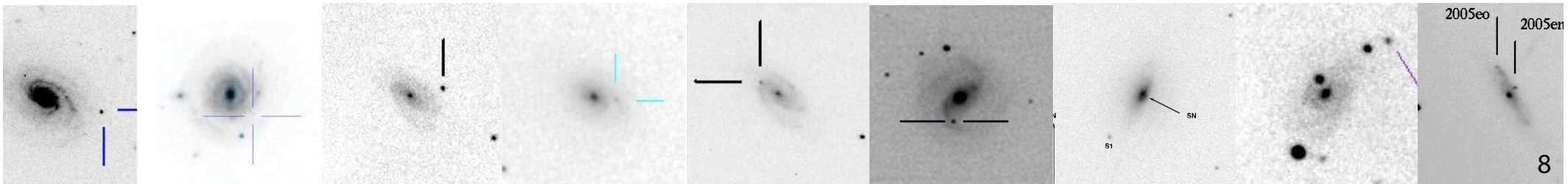
\+ 23 SNe: 8 II, 4 Ibc, 11 Ia

---

60 SNe: 27 II, 13 Ibc, 20 Ia

- Previous observations

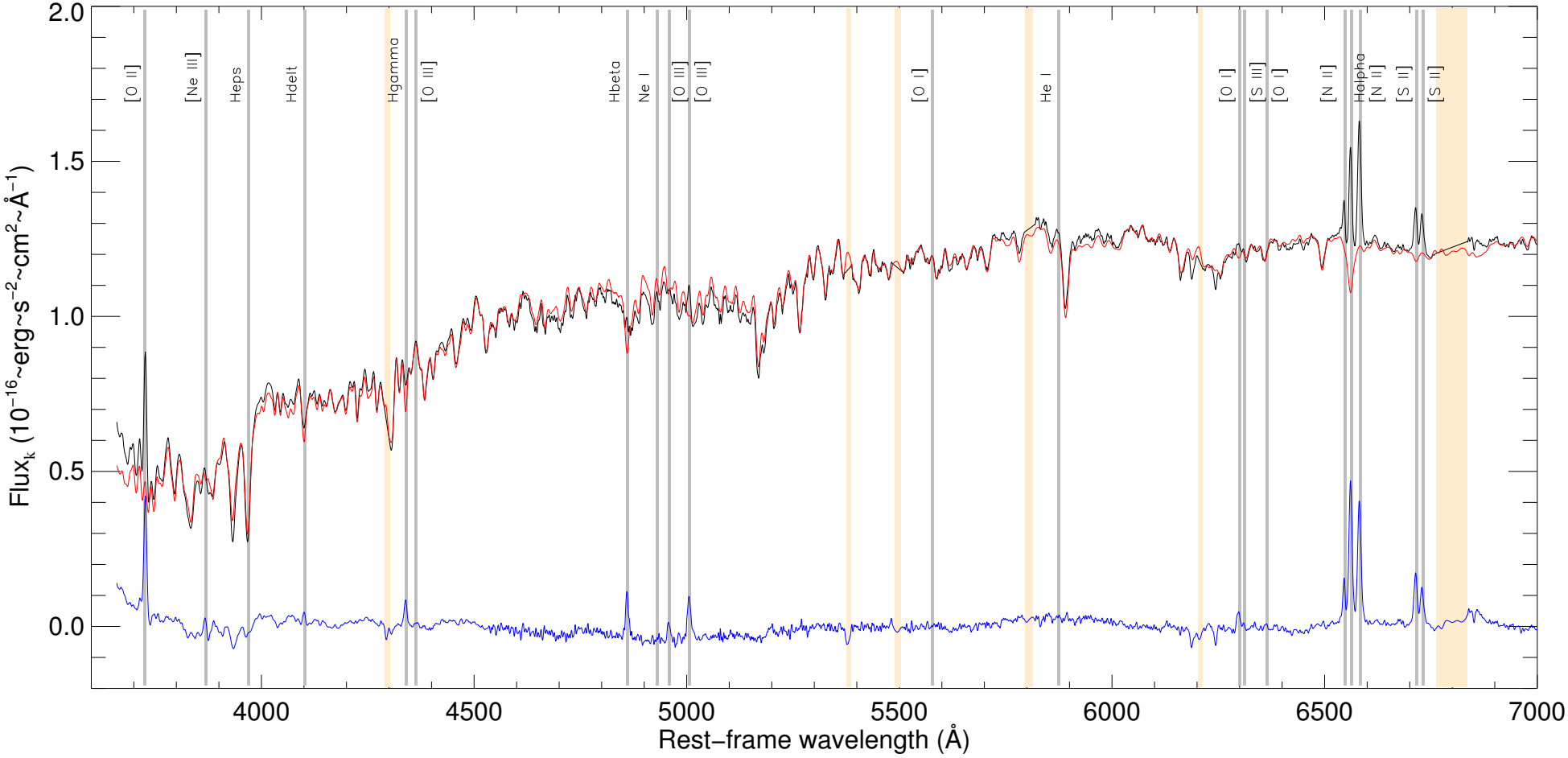
feasibility study for CALIFA, *Sánchez+12*
PINGS Survey, *Rosales-Ortega+10*
SNIa hosts, *Stanishev+12*
NGC5668, *Marino+12*

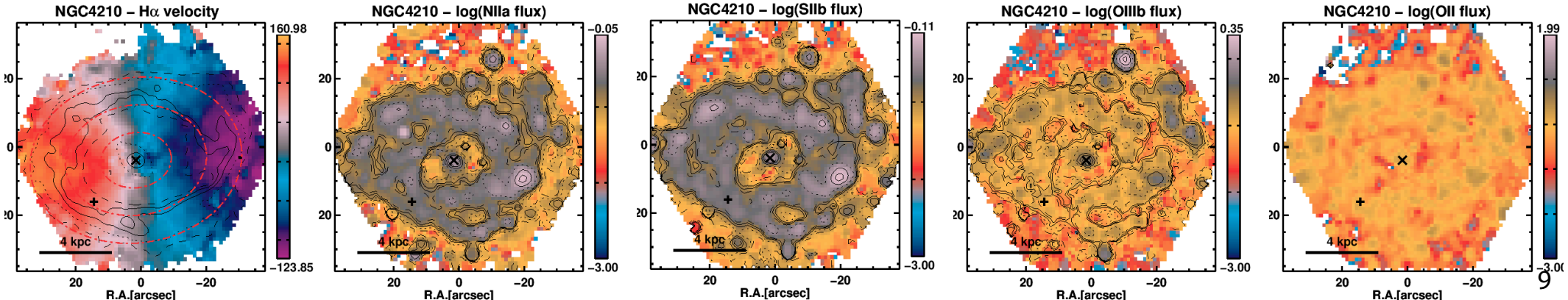


STARLIGHT *Cid Fernandes et al. 2005*

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

Deprojection

Azimutal average

Voronoi binning

Integrated spectrum

3” aperture spectrum

Kinemetry

Fit ellipses using *Krajnovic et al. 2006*

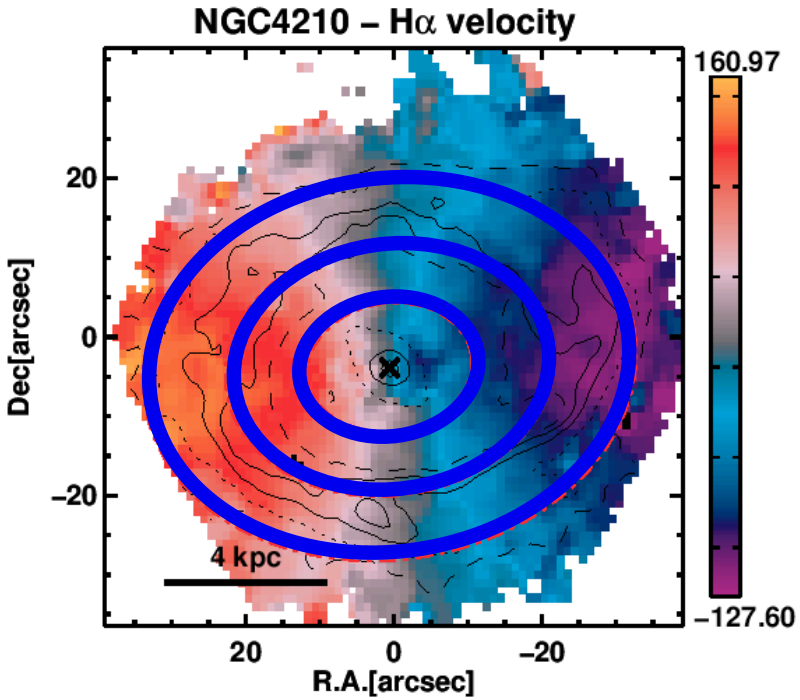
Deprojection

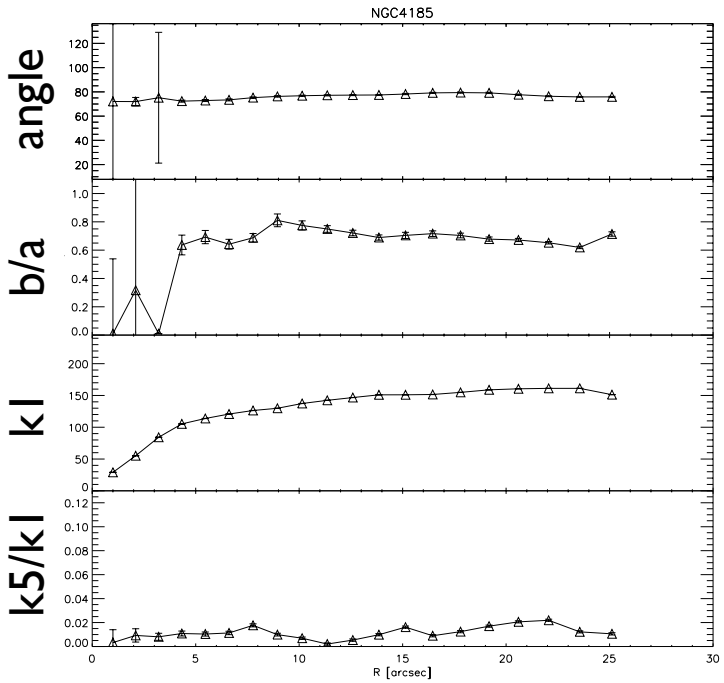
Azimutal average

Voronoi binning

Integrated spectrum

3” aperture spectrum





Kinemetry

Deprojection

Azimutal average

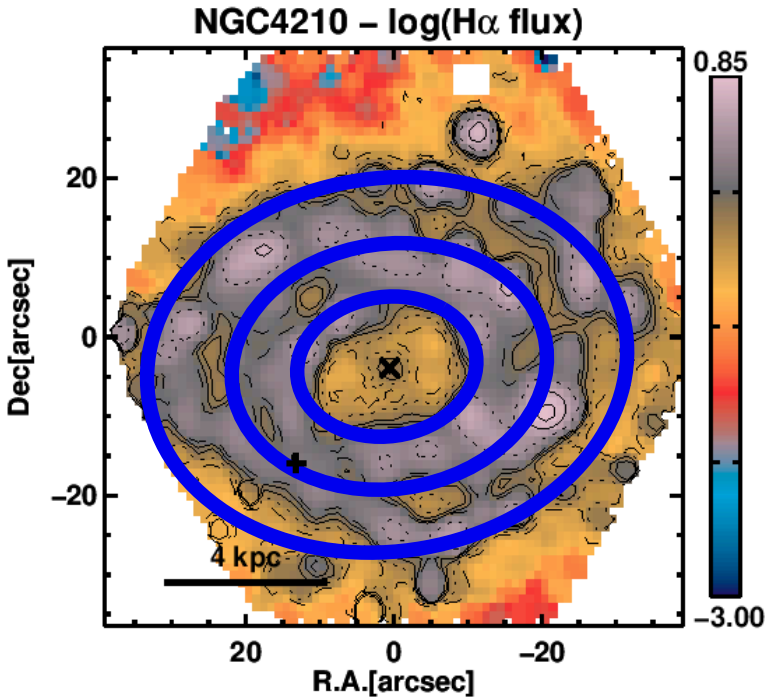
Voronoi binning

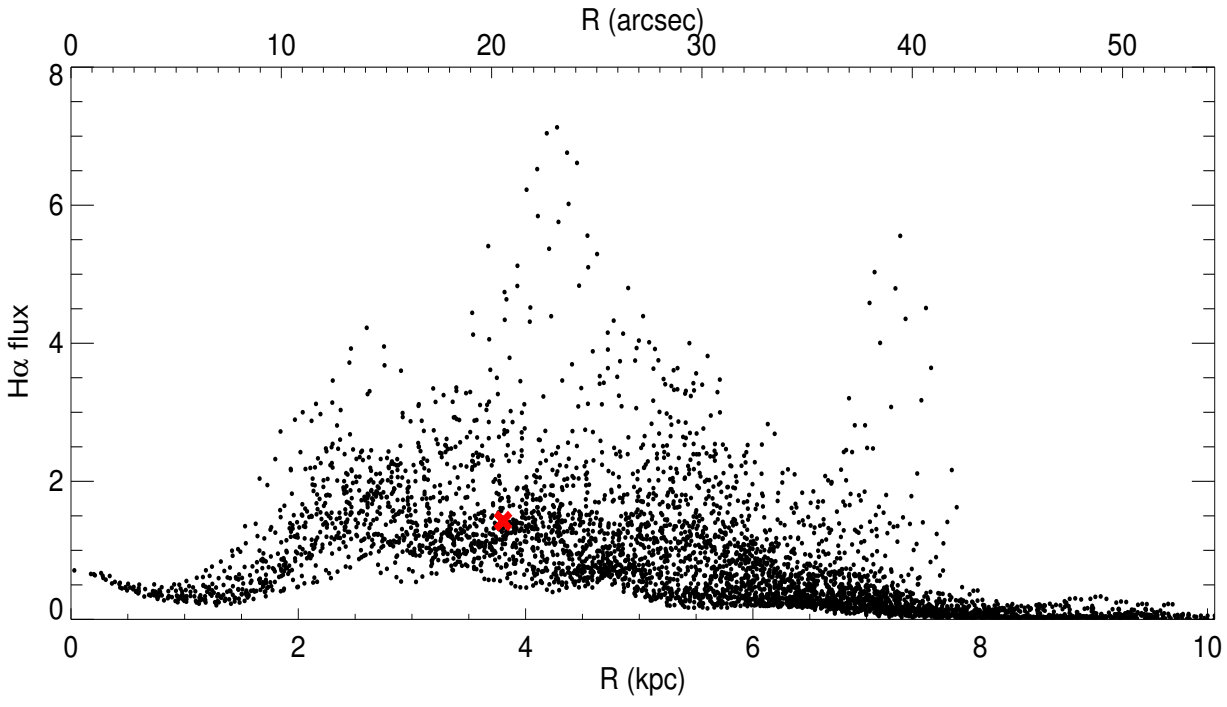
Integrated spectrum

3” aperture spectrum

Fit ellipses using *Krajnovic et al. 2006*

↳ Measure distances in the galactic plane





Kinemetry — Fit ellipses using *Krajnovic et al. 2006*

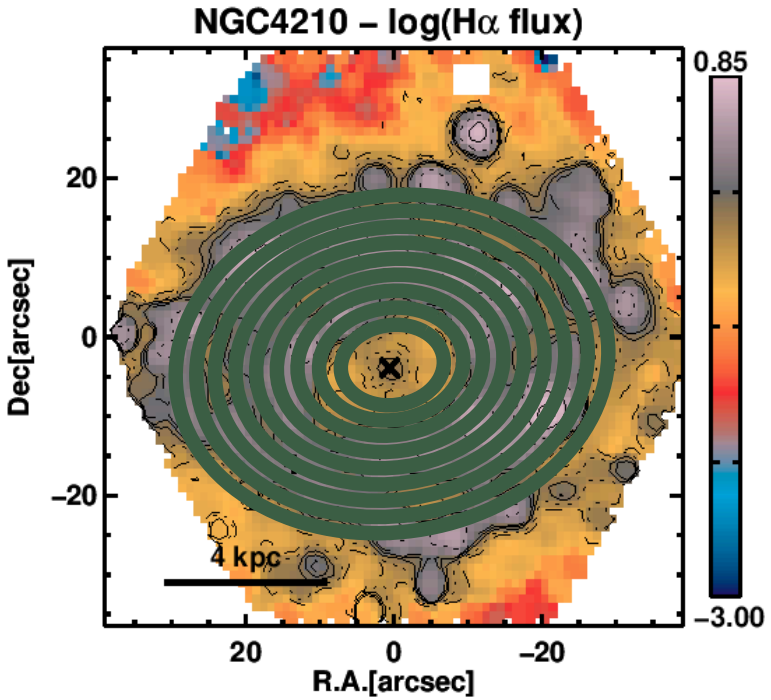
Deprojection — Measure distances in the galactic plane

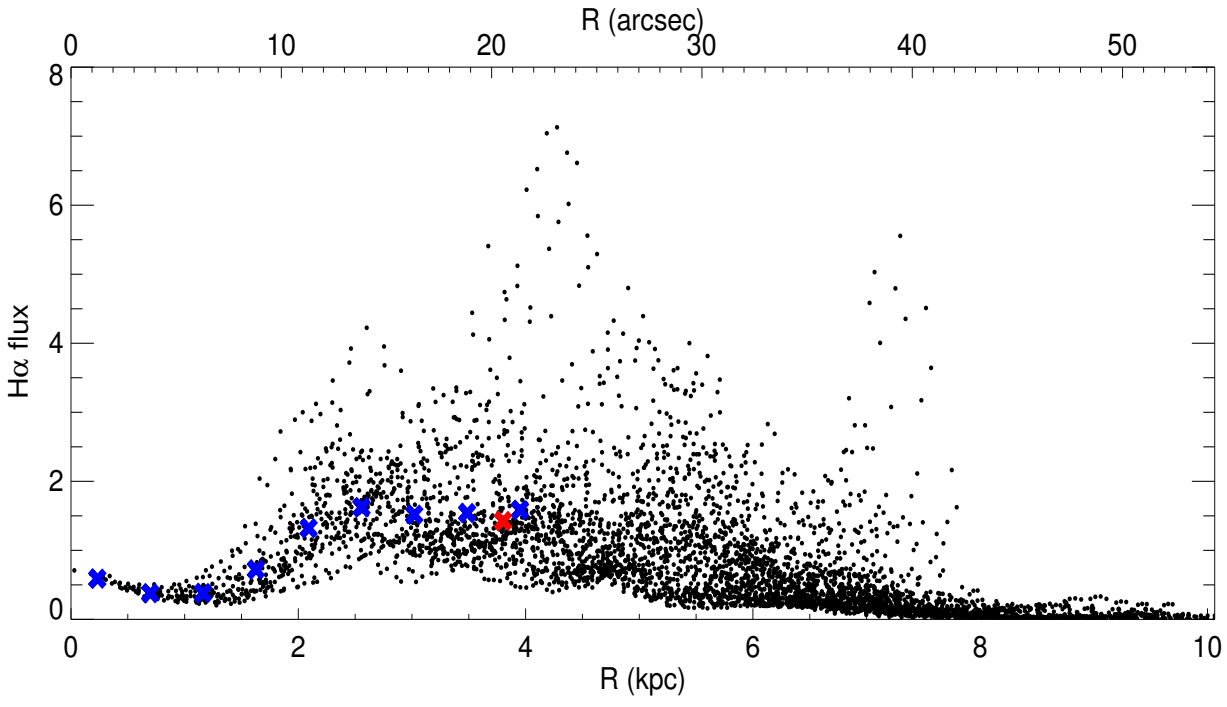
Azimutal average — Co-add ell. rings centered in the core

Voronoi binning

Integrated spectrum

3" aperture spectrum





Kinemetry — Fit ellipses using *Krajnovic et al. 2006*

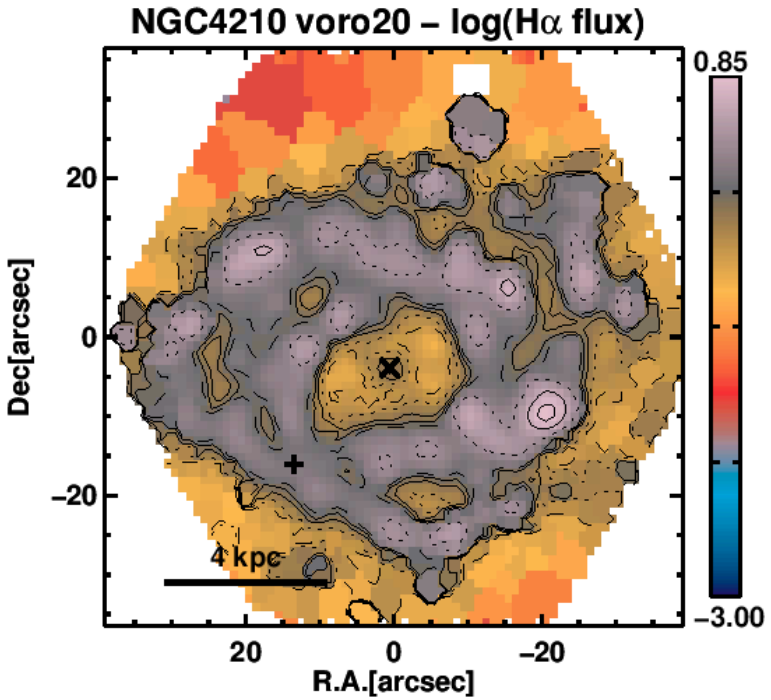
Deprojection — Measure distances in the galactic plane

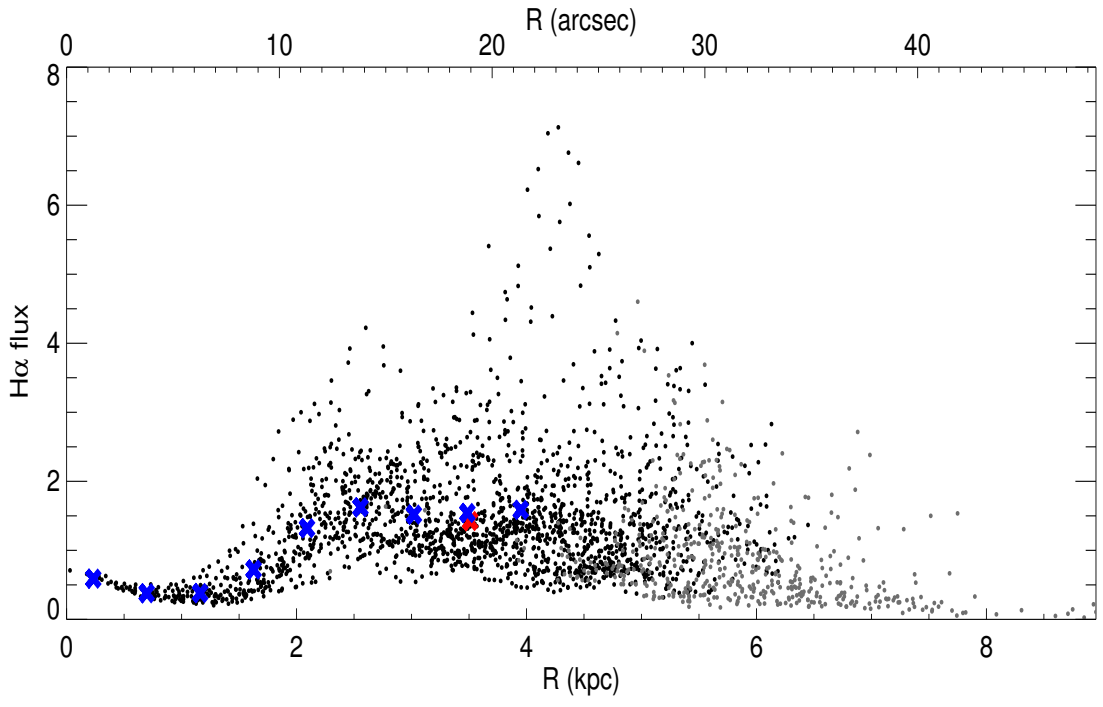
Azimutal average — Co-add ell. rings centered in the core

Voronoi binning — Requiring S/N > 20

Integrated spectrum

3" aperture spectrum





Kinemetry — Fit ellipses using *Krajnovic et al. 2006*

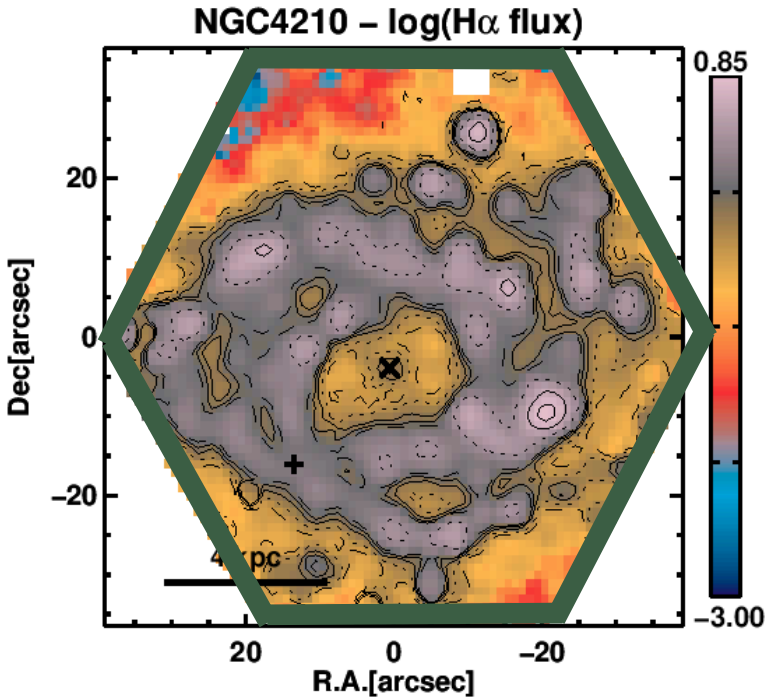
Deprojection — Measure distances in the galactic plane

Azimutal average — Co-add ell. rings centered in the core

Voronoi binning — Requiring S/N > 20

Integrated spectrum — For high-z (aperture effects)

3" aperture spectrum



Kinemetry — Fit ellipses using *Krajnovic et al. 2006*

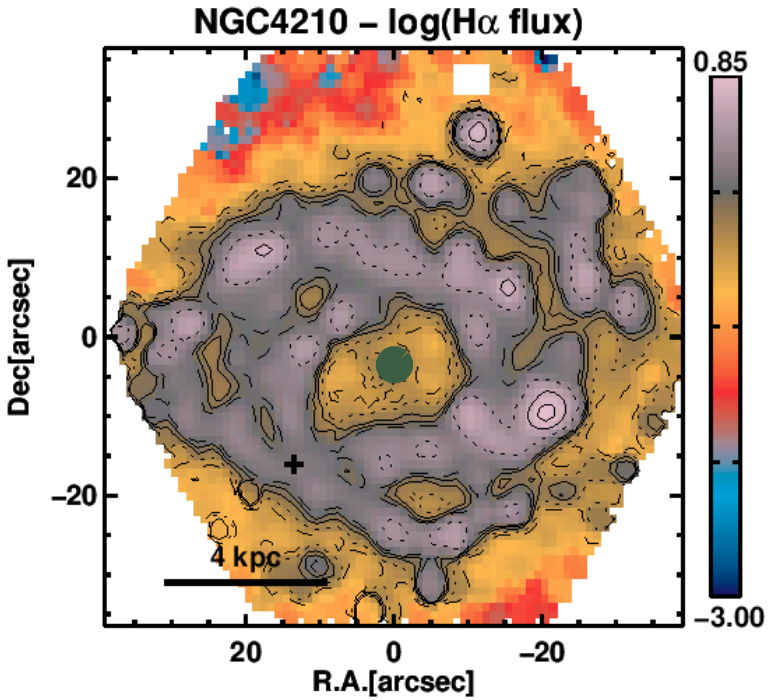
Deprojection — Measure distances in the galactic plane

Azimutal average — Co-add ell. rings centered in the core

Voronoi binning — Requiring S/N > 20

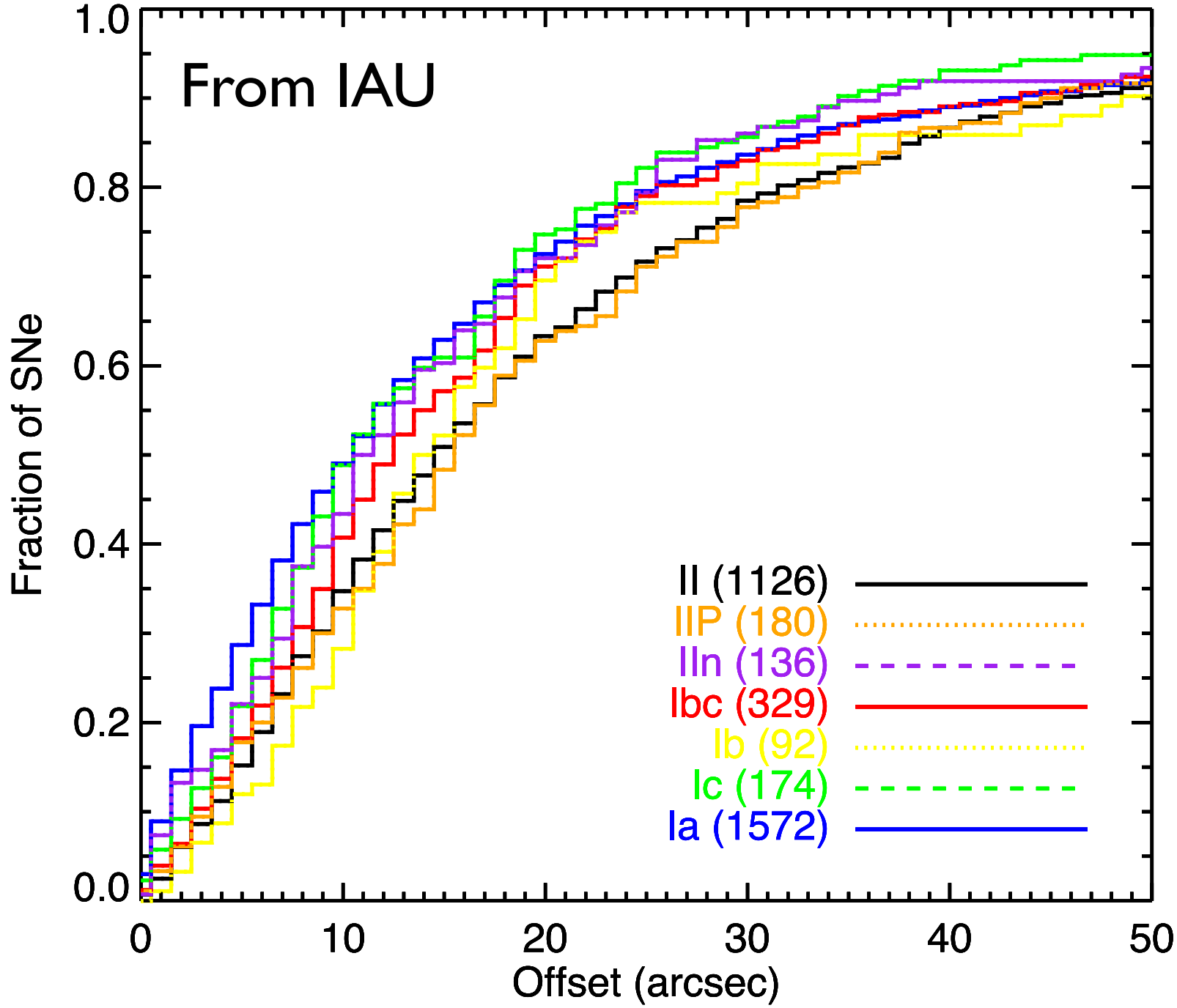
Integrated spectrum — For high-z (aperture effects)

3" aperture spectrum — Allow comparisons (SDSS + fiber)

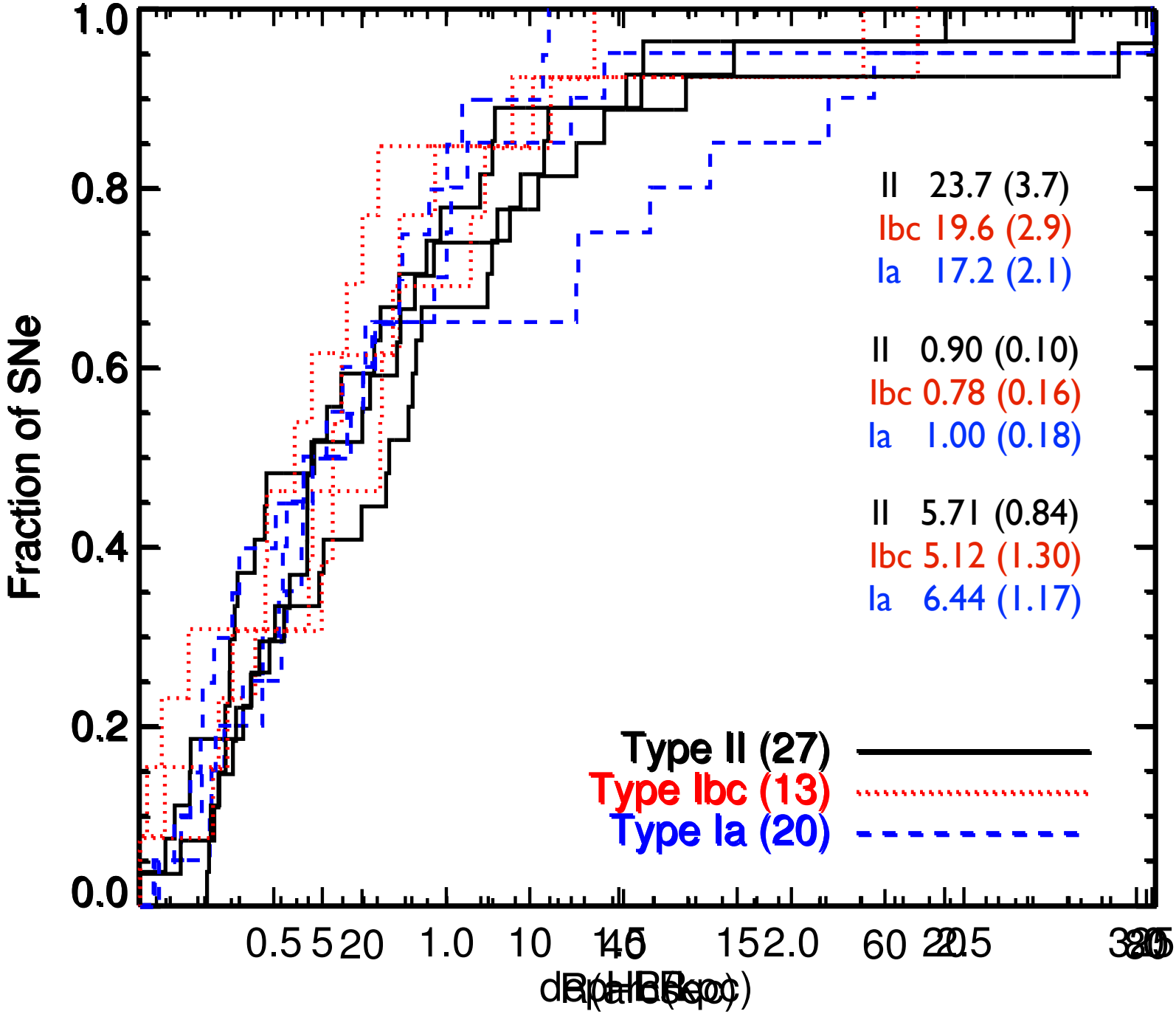


PRELIMINARY!!! Results...

GCDs

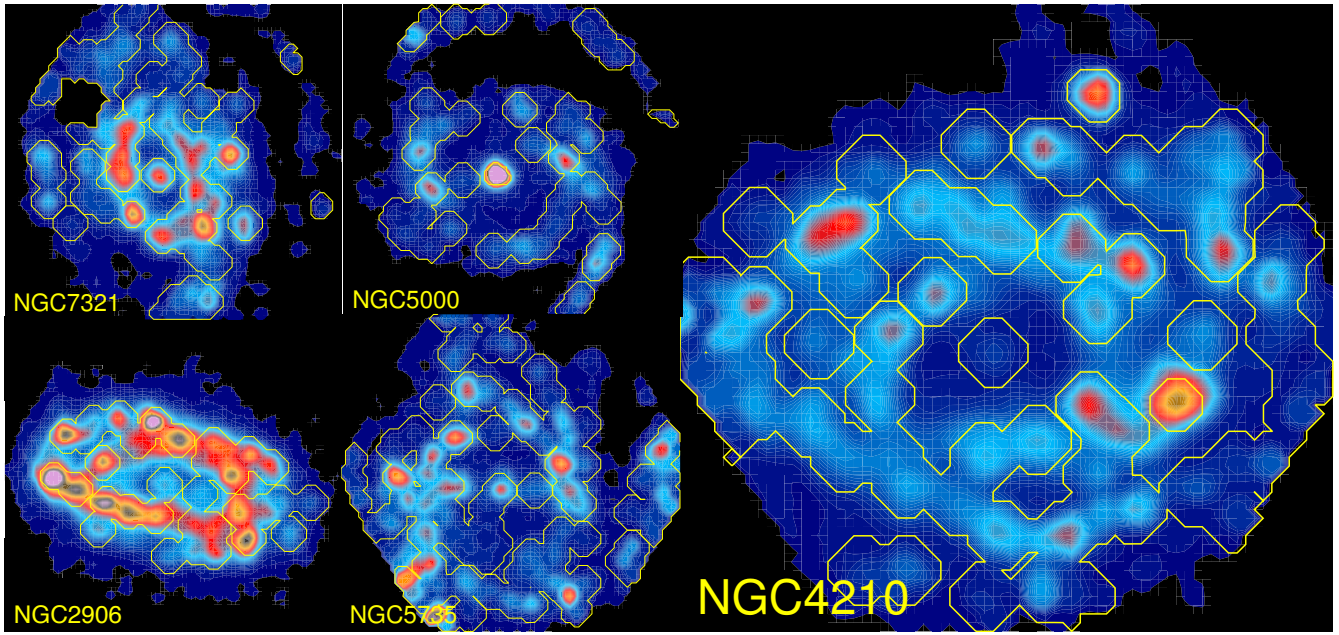

From IAU
Fraction of SNe
Offset (arcsec)
0.0
0.2
0.4
0.6
0.8
1.0
0
10
20
30
40
50
II (1126)
IIP (180)
IIn (136)
Ibc (329)
Ib (92)
Ic (174)
Ia (1572)

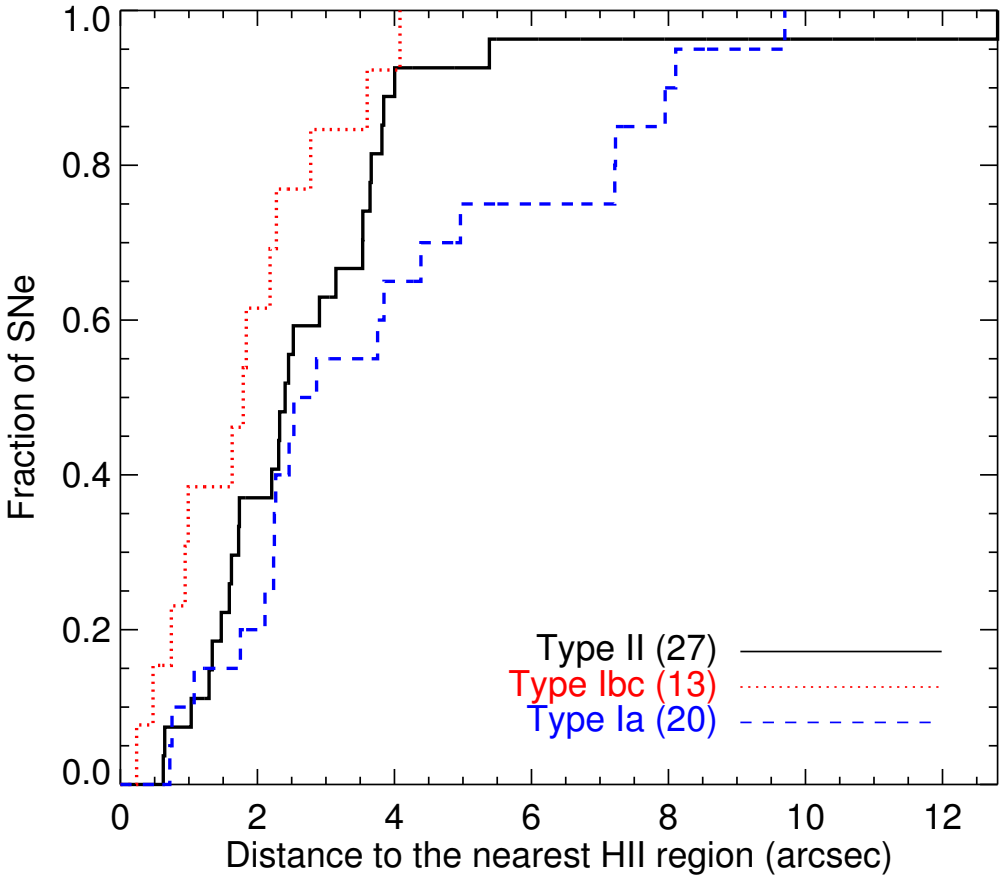
GCDs

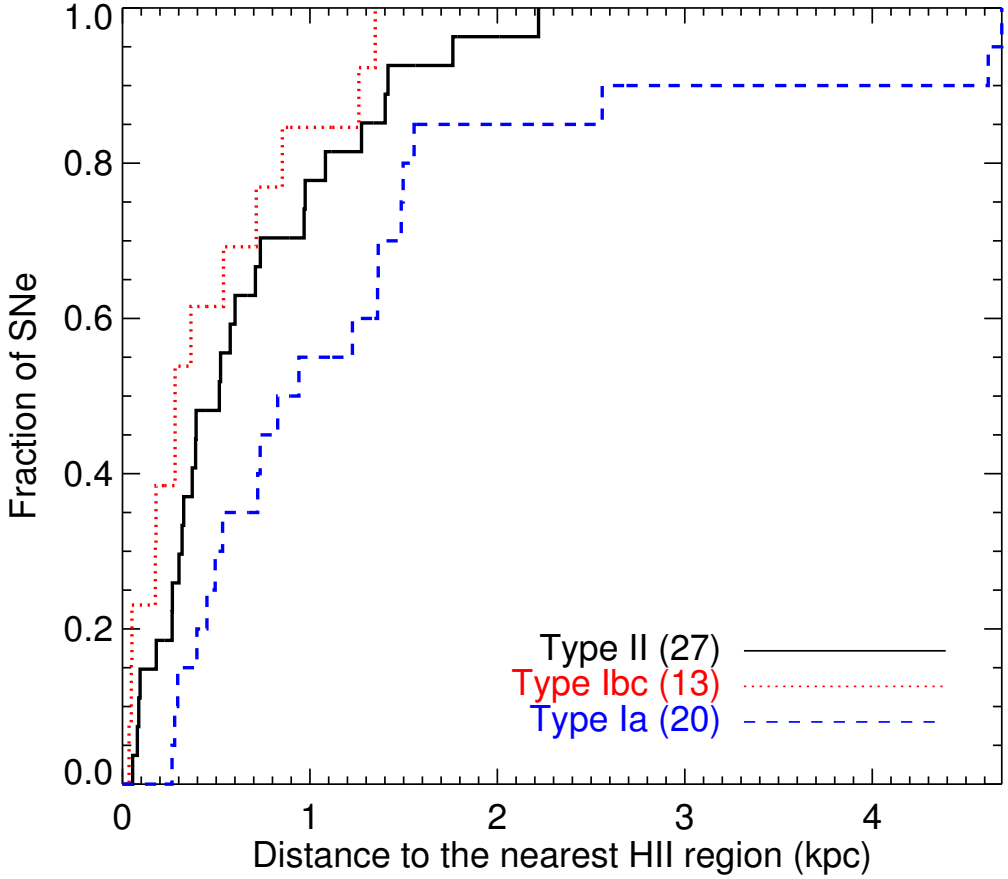

1.0
0.8
0.6
0.4
0.2
0.0
Fraction of SNe
II 23.7 (3.7)
Ibc 19.6 (2.9)
Ia 17.2 (2.1)
II 0.90 (0.10)
Ibc 0.78 (0.16)
Ia 1.00 (0.18)
II 5.71 (0.84)
Ibc 5.12 (1.30)
Ia 6.44 (1.17)
Type II (27)
Type Ibc (13)
Type Ia (20)
0.5 5 20 1.0 10 15 2.0 60
dR(HII) (kpc)

HII regions

HIIexplorer
Sánchez et al. 2012

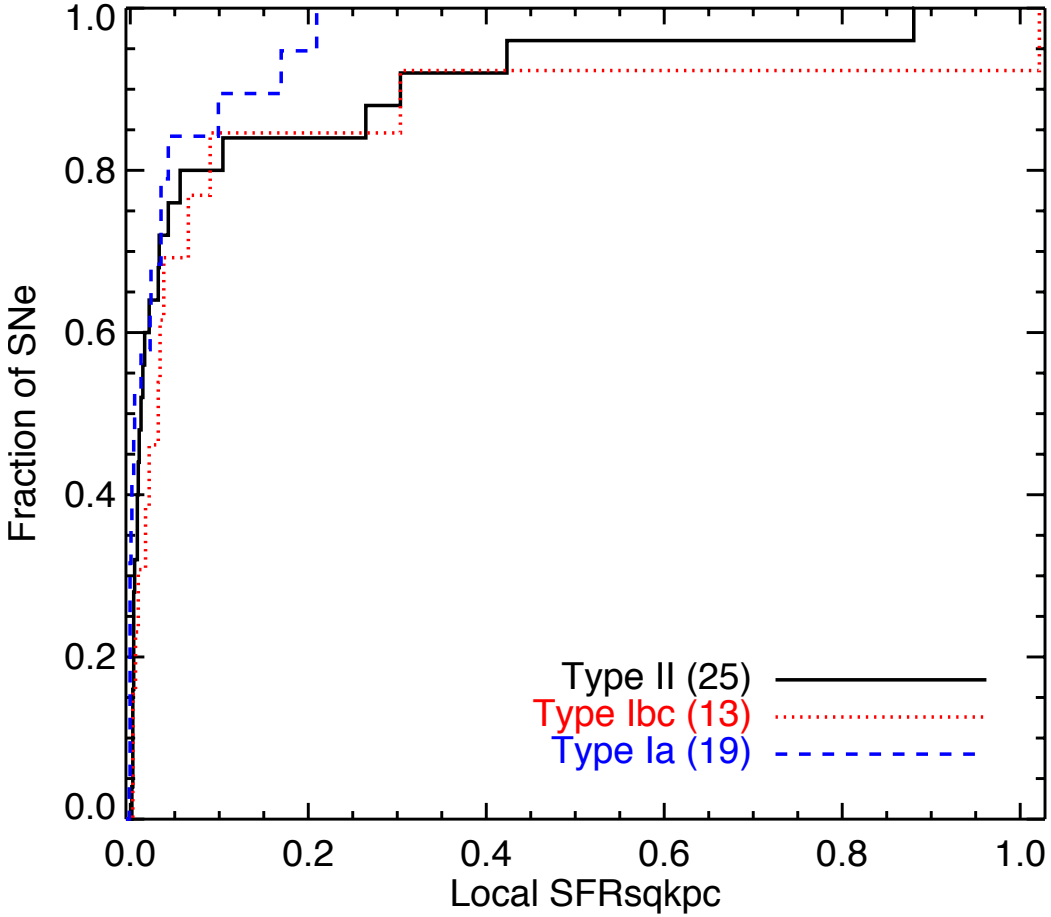


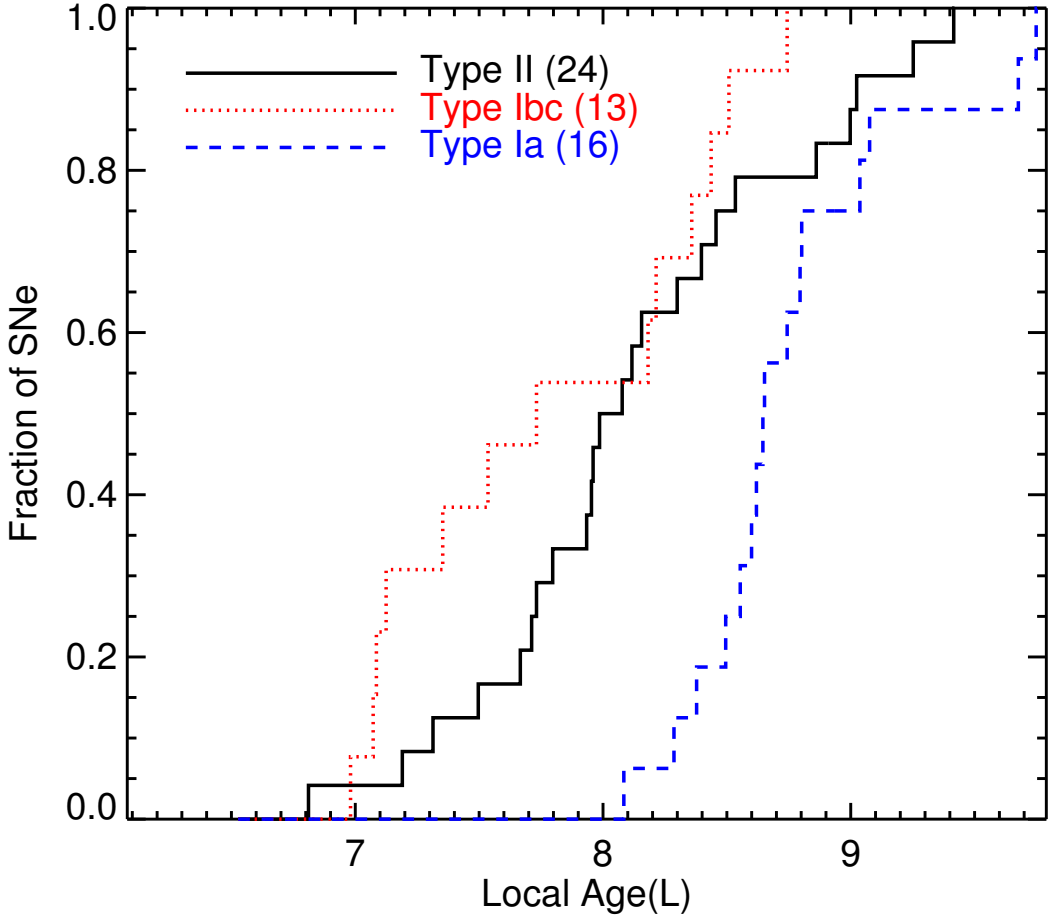




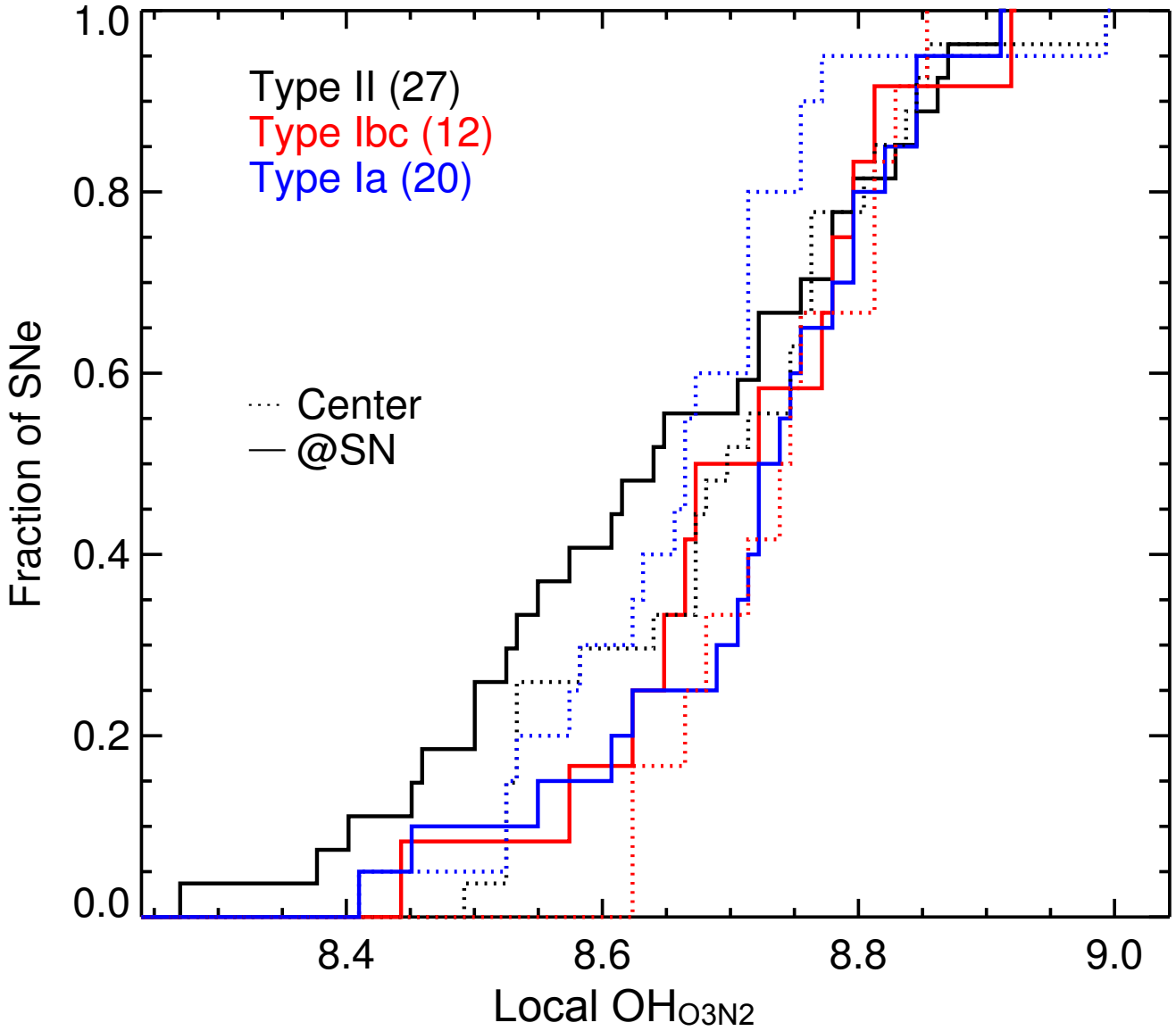
Σ_{SFR}

Stellar age





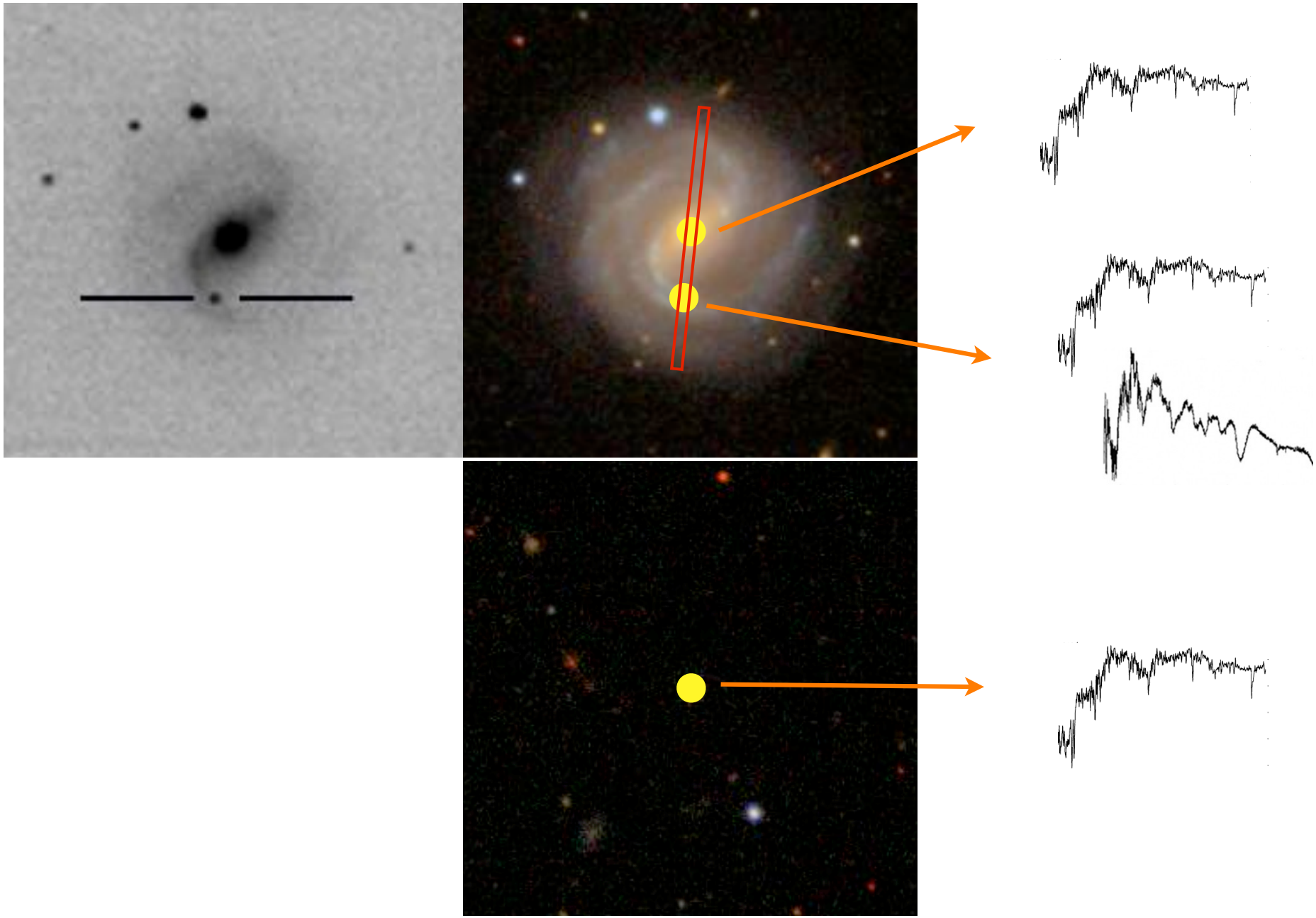
$Z_{Ia} \geq Z_{Ibc} > Z_{II}$



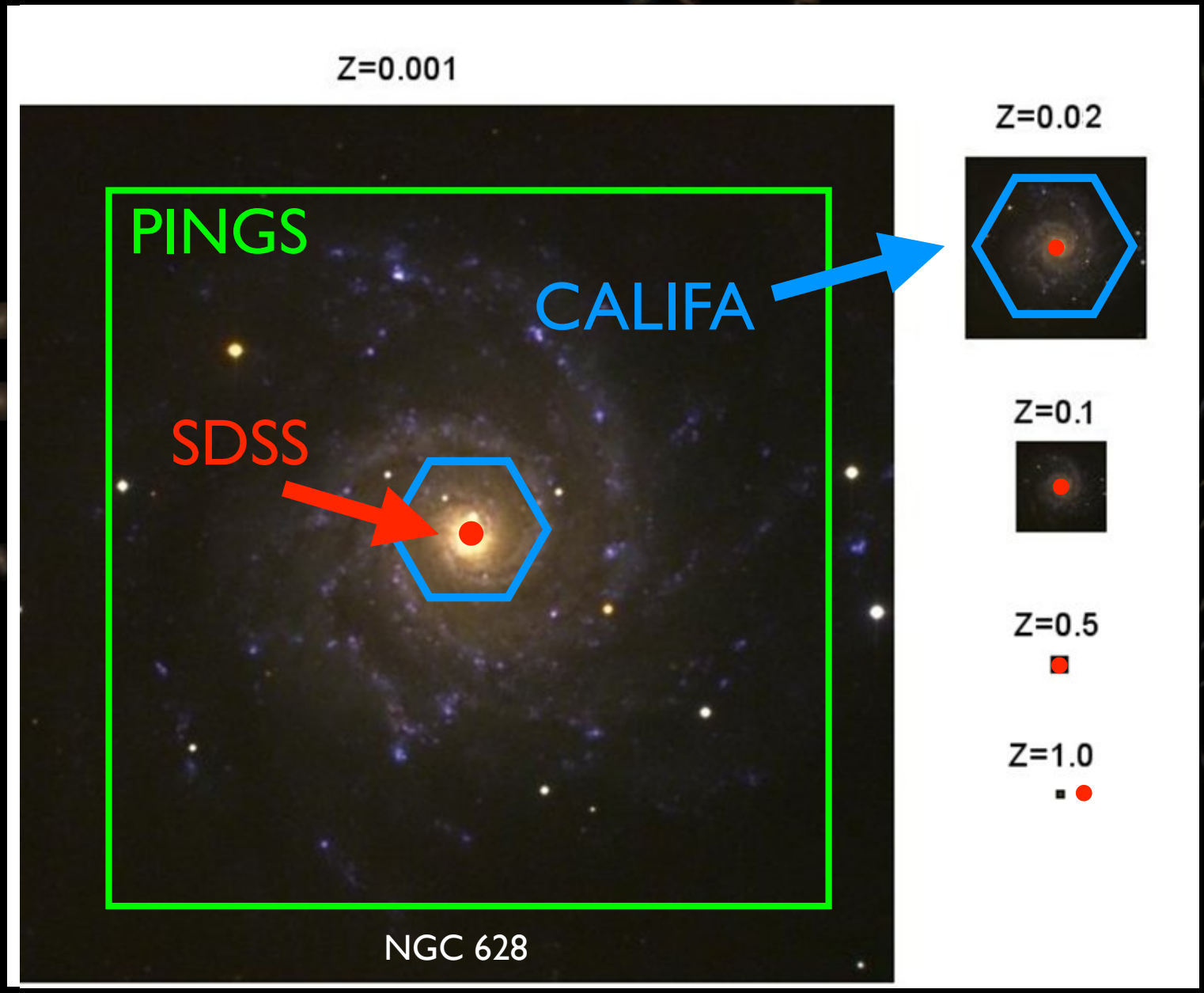
Broad-band photometry Fiber slit spectroscopy

z=0.016

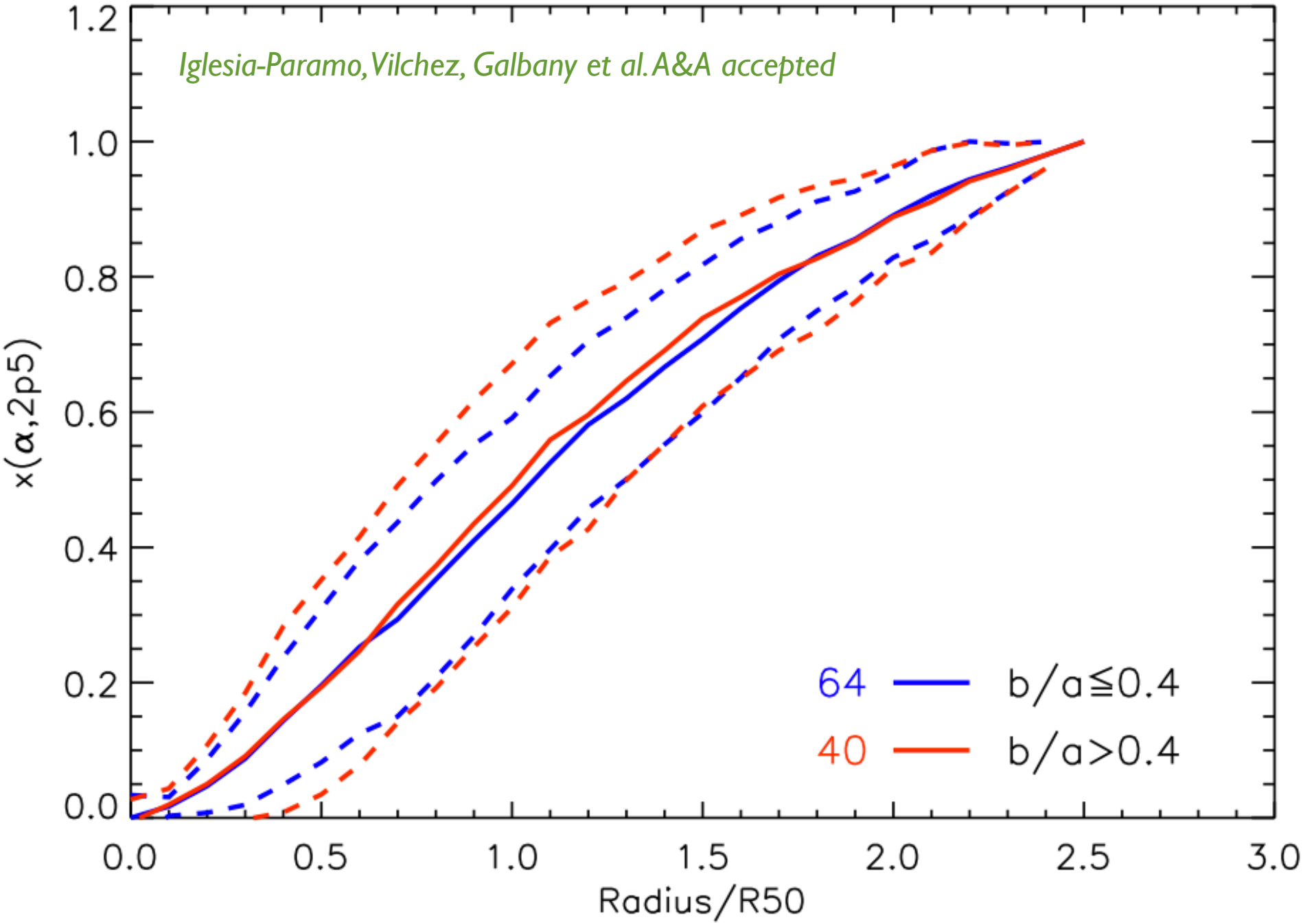
z=0.25



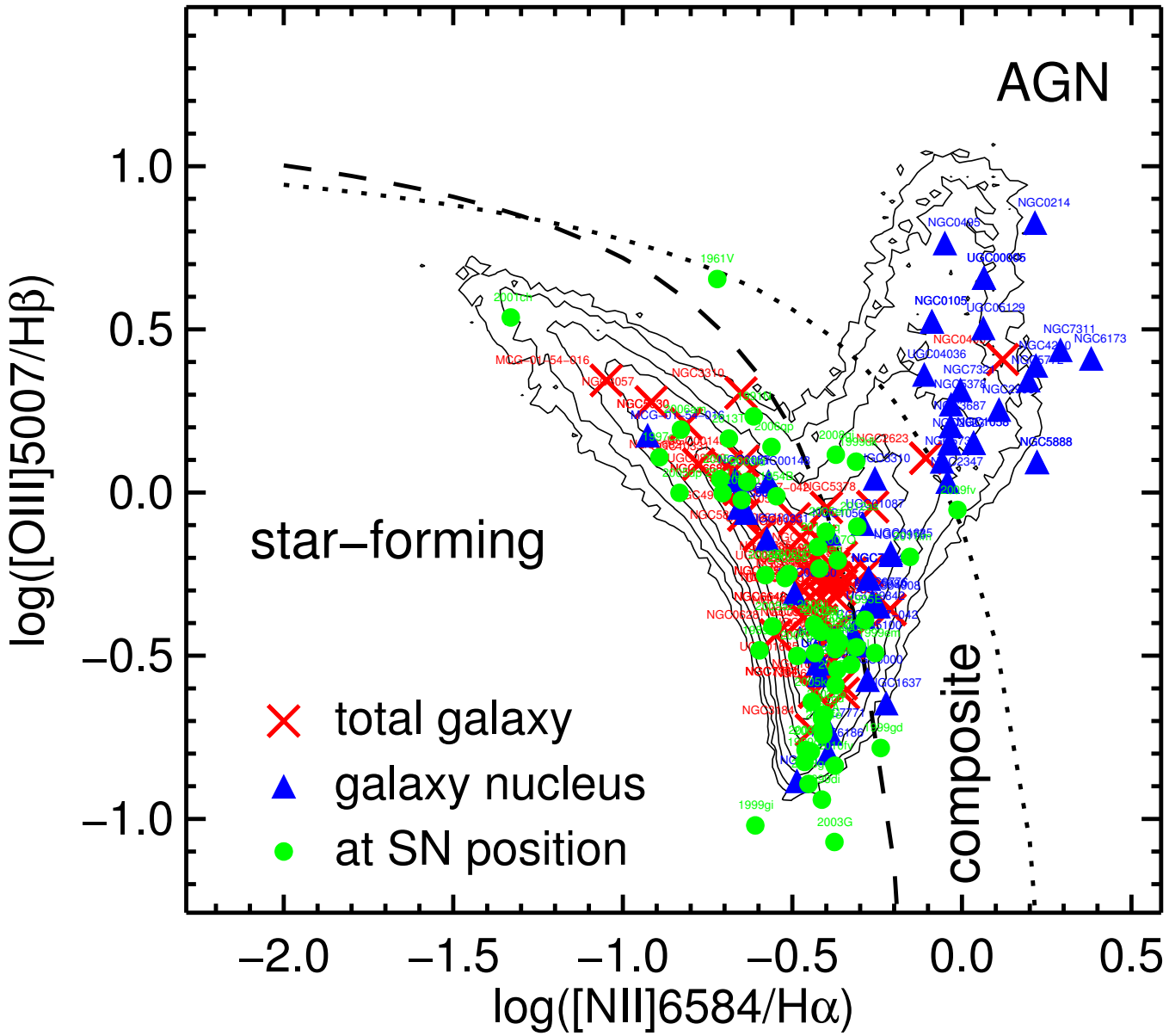
The FoV *issue*

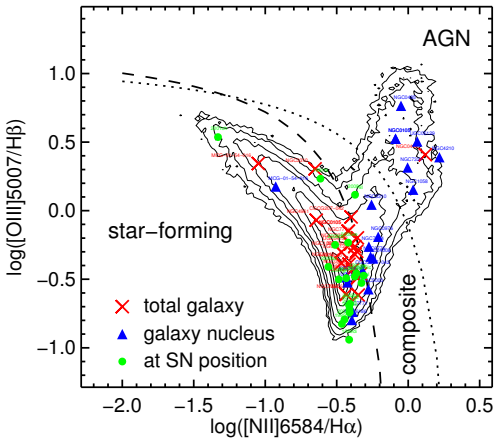


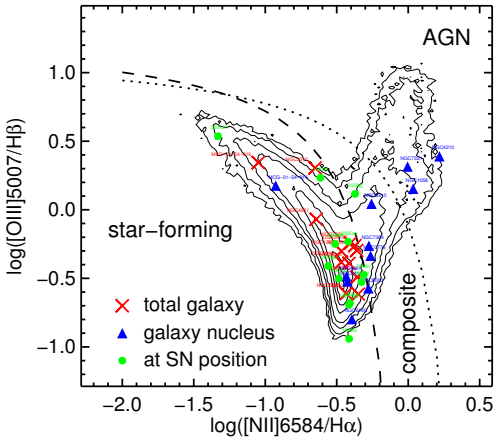
global Z Vs Local Z

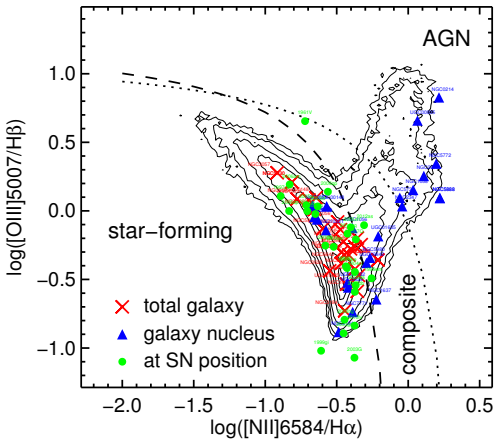


AGN

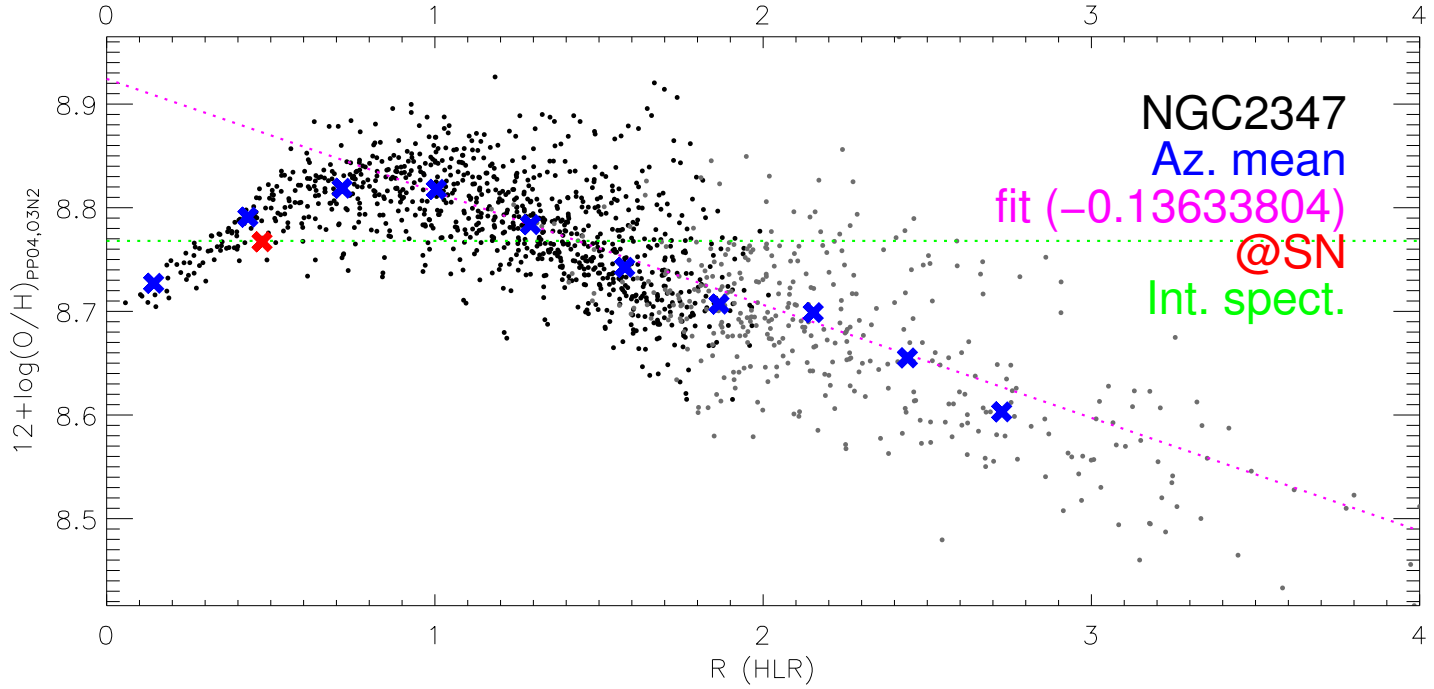

AGN
star–forming
composite
total galaxy
galaxy nucleus
at SN position
log([OIII]5007/Hβ)
log([NII]6584/Hα)
1.0
0.5
0.0
−0.5
−1.0
−2.0
−1.5
−1.0
−0.5
0.0
0.5

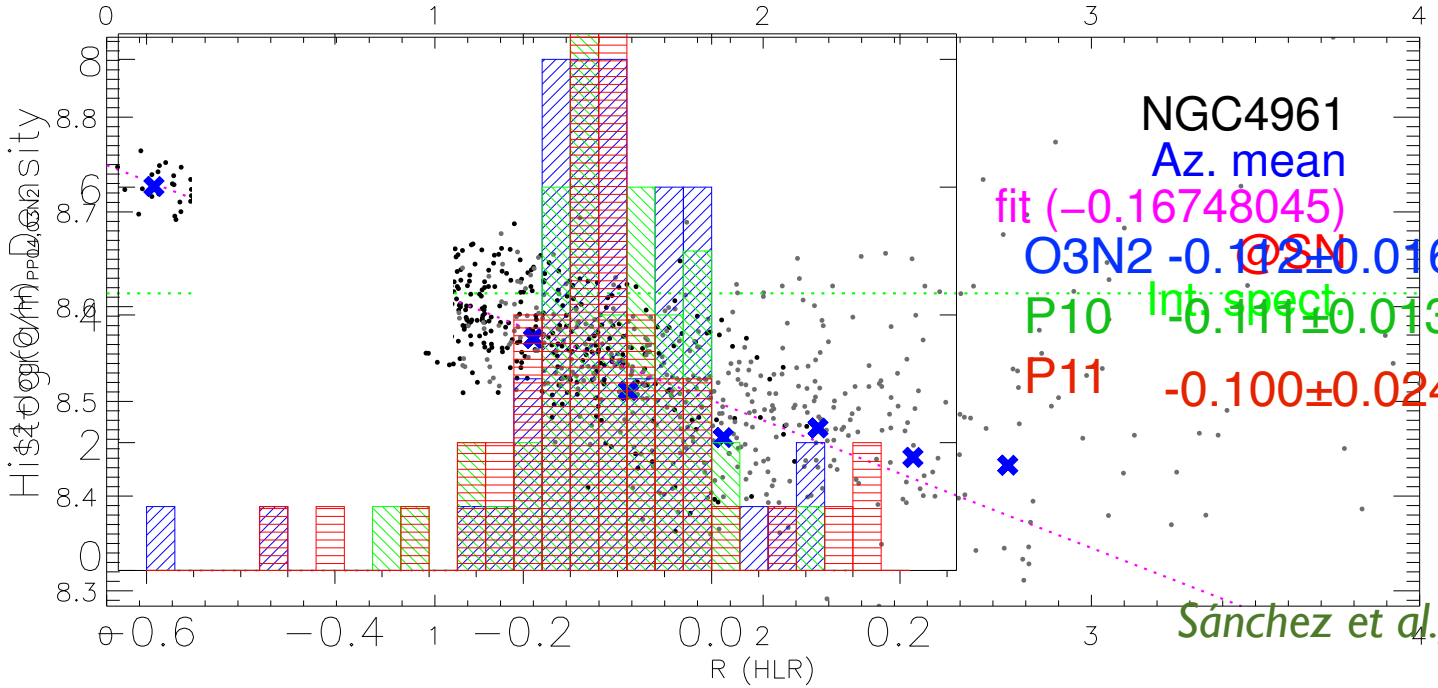

AGN
star–forming
composite
total galaxy
galaxy nucleus
at SN position
log([OIII]5007/Hβ)
log([NII]6584/Hα)


AGN
star–forming
composite
total galaxy
galaxy nucleus
at SN position
log([OIII]5007/Hβ)
log([NII]6584/Hα)


AGN
star–forming
composite
total galaxy
galaxy nucleus
at SN position
log([OIII]5007/Hβ)
log([NII]6584/Hα)

metallicity gradients



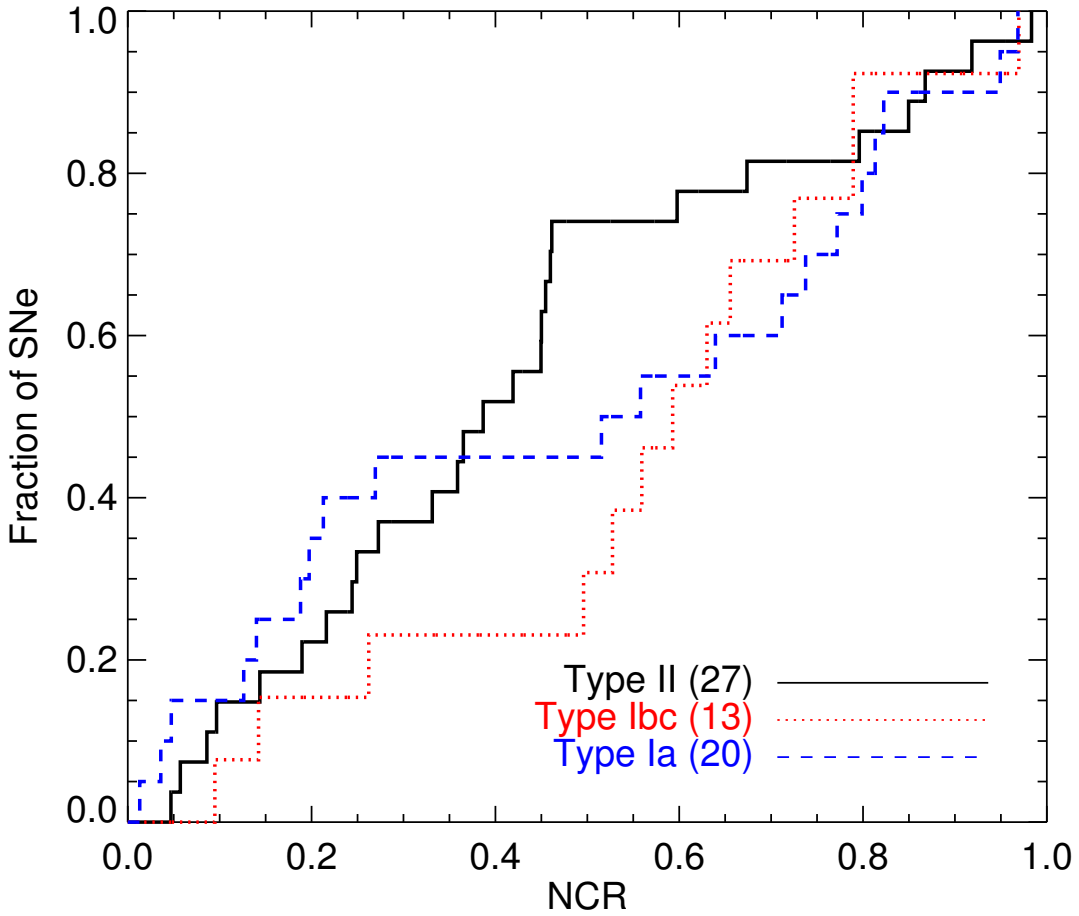


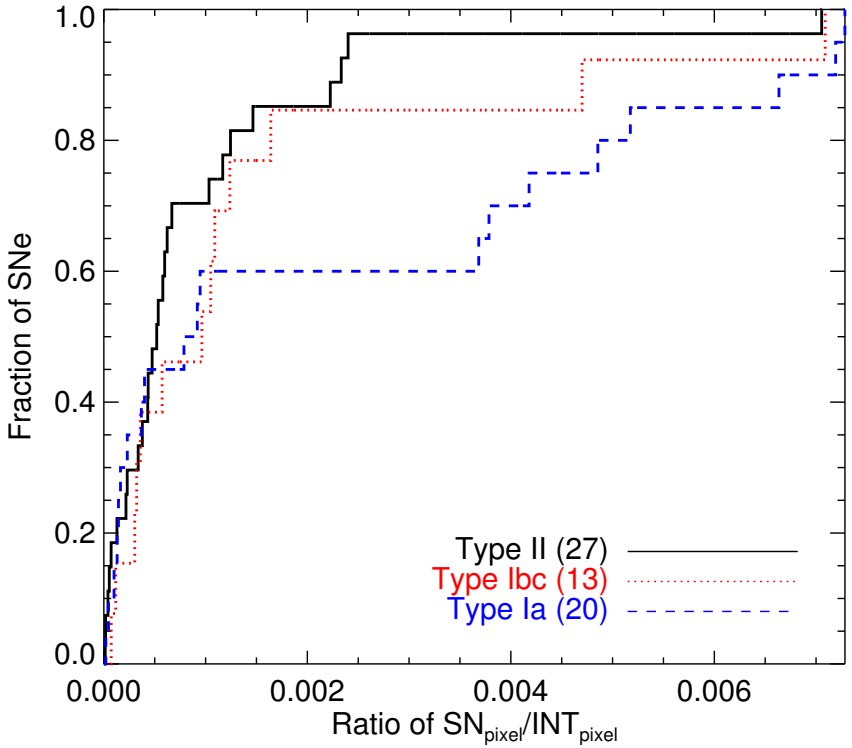
Sánchez et al., A&A submitted

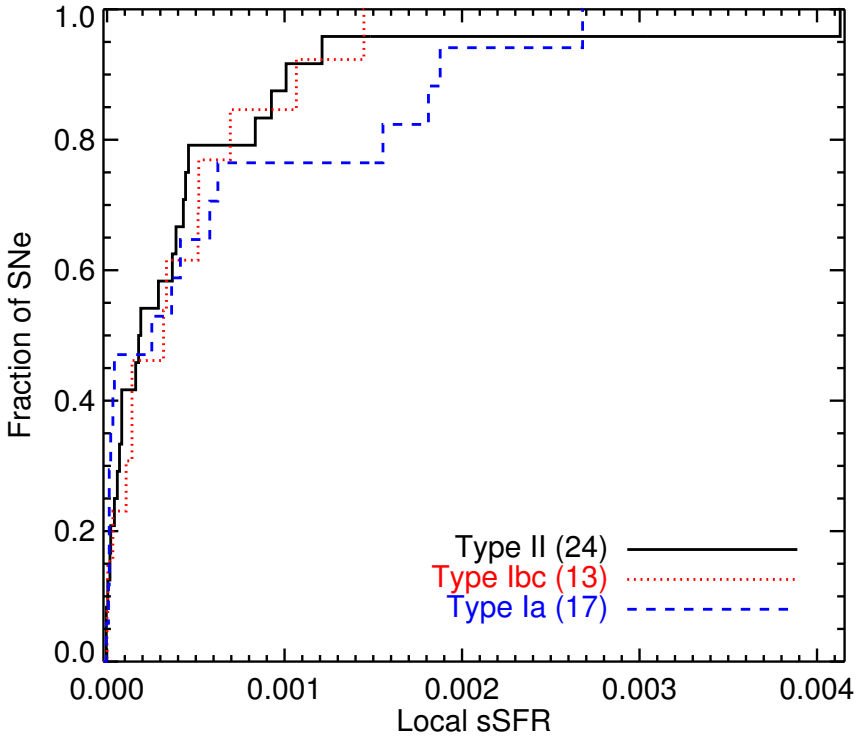
~~Conclusions~~ Summary

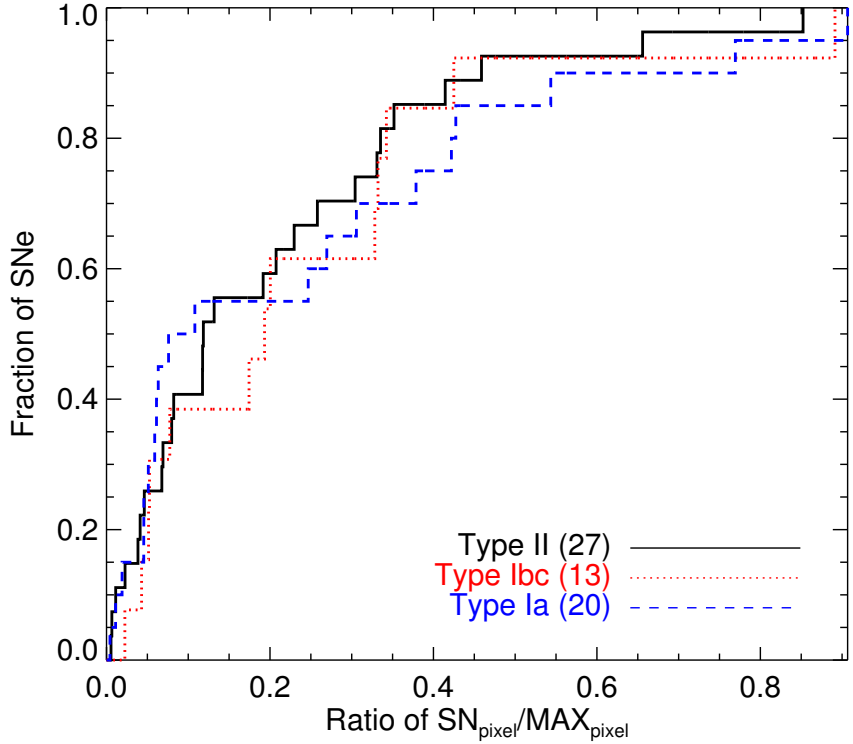
- IFU is a powerful technique at low redshift
- We found some indications on differences between type II, Ibc and Ia SNe
- We found differences between global and local measurements
- work in progress...

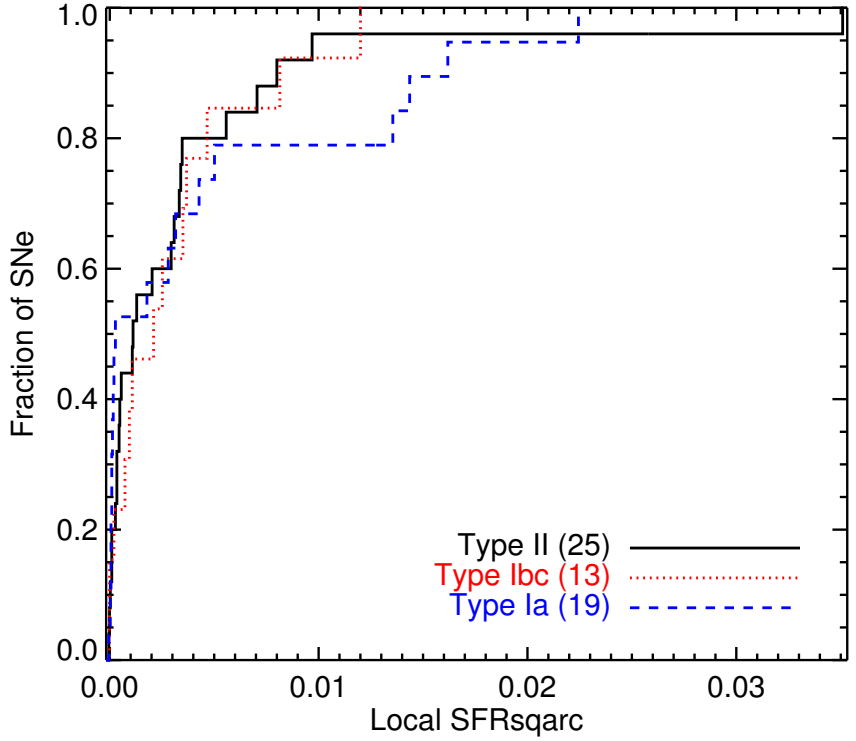
NCR


1.0
0.8
0.6
0.4
0.2
0.0
Fraction of SNe
0.0
0.2
0.4
0.6
0.8
1.0
NCR
Type II (27)
Type Ibc (13)
Type Ia (20)


Fraction of SNe
Ratio of SN$_{pixel}$/INT$_{pixel}$
Type II (27)
Type Ibc (13)
Type Ia (20)


Fraction of SNe
Local sSFR
Type II (24)
Type Ibc (13)
Type Ia (17)


Fraction of SNe
Ratio of SN$_{pixel}$/MAX$_{pixel}$
Type II (27)
Type Ibc (13)
Type Ia (20)


Fraction of SNe
Local SFRsqarc
Type II (25)
Type Ibc (13)
Type Ia (19)