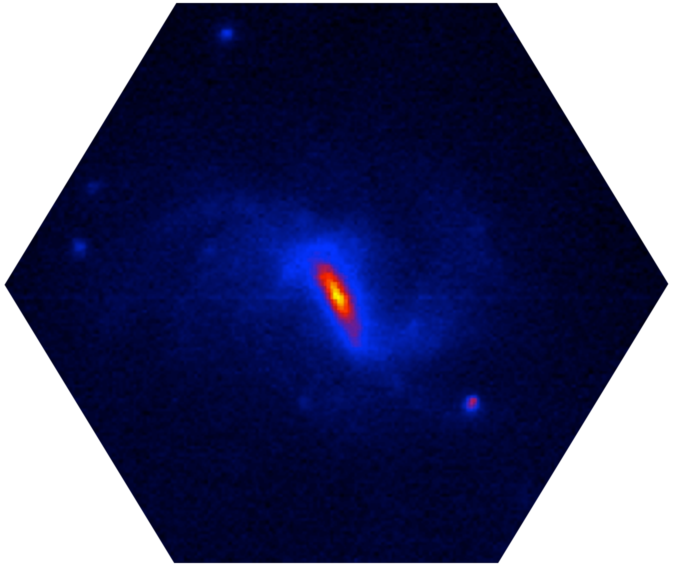
IFU observations of SN environments



Lluís Galbany, CENTRA-IST Lisboa
Vllery Stanishev, CENTRA-IST Lisboa
Ana Mourão, CENTRA-IST Lisboa
Myriam Rodrigues, ESO, Chile
Hector Flores, Obs. Paris, France

CALIFA Survey

AIP, 16 April 2013

~~Conclusions~~ Summary

- We found some indications on differences between type II, Ibc and Ia SNe
    - GCD
    - Star formation
    - Metallicity
- We found differences between global and local measurements
- work in progress... (gradients, any other idea?)

Astronomy & Astrophysics manuscript no. ccsne
April 10, 2013

Integral Field Unit spectroscopy of supernova host galaxies

Lluís Galbany[1], Vallery Stanishev[1], Ana M. Mourão[1], Myriam Rodrigues[2], Hector Flores[3], Luke Skywalker[4], Bilbo Baggins[5], Robb Stark[6], and other heroes.

[1] CENTRA - Centro Multidisciplinar de Astrofísica, Instituto Superior Técnico, Av. Rovisco Pais 1, 1049-001 Lisbon, Portugal.
[2] European Southern Observatory, Alonso de Cordova 3107 Casilla 19001 - Vitacura -Santiago, Chile
[3] GEPI, Observatoire de Paris, UMR 8111, CNRS, Universit Paris Diderot, 5 place Jules Janssen, 92190 Meudon, France
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Received ———- / Accepted ———-

Abstract

We aim to study the properties of the environment where supernovae (SNe) exploded, using Integral Field Unit (IFU) spectroscopic information of nearby galaxies ($0.005 < z < 0.03$) provided by the Calar Alto Legacy Integral Field Area (CALIFA) Survey and previous observations. With this approach we are going further than using simply an aperture spectrum centered at the galaxy core, or a spectrum from a slit positioned at a SN explosion, since we have 2-dimensional spectroscopic information of the whole filed of each host galaxy. We find differences in the location distributions among different SN types, being type Ibc more centered and occurring closer to H-II regions than type Ia, being type II in the middle of those. We also found differences although in the local elemental abundances of type Ibc compared to type II SNe. ...

Key words. supernovae: general – supernovae: host galaxies – techniques: spectroscopic

1. Introduction

tbw... Integral Field Unit (IFU)

IMPORTANCE OF SUPERNOVAE: Supernovae... ANDERSON: A key goal in current SN search is to provide links between progenitor systems and observed transients.

CCSNE: Core-collapsed supernovae are the final stage in the evolution of stars with large initial masses ($> 8\ M_\odot$). They are thought to arise from massive stars that collapse once they have spent their nuclear fuel. The exact understanding of their progenitor systems, and explosion mechanism remains elusive. HAKOBYAN08: Type II SNe bursts because of the collapse of the cores of young massive stars - the reds supergiants, whose envelopes contain a large amount of hydrogen. type Ibc SNe also bursts during the collapse of the cores of massive stars, probably Wolf-Rayet stars, but a large portion of the hydrogen envelopes of these stars are lost during the evolution of a close binary system or by some other means, which is probably why their progenitors have higher metallicity. TURKU: Core-collapse supernovae (CCSNe) mark the end-point of the evolution of massive stars, producing neutron stars and black holes, and in exceptional cases, long-duration gamma-ray bursts (GRBs). These phenomena play a vital role in our understanding of stellar evolution, the synthesis of heavy elements, and through feedback processes also in galaxy evolution. Furthermore, as CCSNe come from massive short-lived stars, their explosion rate directly reflects the on-going rate of star formation in their host galaxies, and thus CCSNe are beginning to be used as probes of the cosmic star formation history.

DIFFERNECES IBC/II: VANDERBERG97 showed that Ibc appeared to be more concentrated than II within host galaxies. EXPLANATION OF THE DIFFERENCES: Higher metallicity stars have higher line driven winds (Puls et al 1996, Hudritzi and Puls 2000, Mokiem et al. 2007), thus the progenitors lose more mass through these winds prior to SN, hence removing their H and He envelopes.

SNEIA: Type-Ia Sne...

...as Anderson et al 2009, Prieto et al. 2008 conclude, metallicity should be directly derived at the SN locations... ..lack of CCSNe and presence of thermonuclear SNIa in early type elliptical galaxies...

GLOBAL VS LOCAL PARAMETERS: GLOBAL PARAMETERS IA: Usually global parameters of the host galaxies have been used to try to correlate host and SN properties... Hamuy et al. (2000), bright Type Ia SNe occur preferentially in young stellar environments (AGE). Hamuy et al. (2000), bright SNe occur in low luminosity hosts. Gallagher et al. (2005), faint SNe occur in metal-rich hosts (METALLICITY). Sullivan et al. (2010); Kelly et al. (2010); Lampeitl et al. (2010), bright SNe in massive hosts (MASS) and in hosts with low SFR per stellar mass (specific SFR), after LC correction.

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Send offprint requests to: L. Galbany, e-mail: `lluis.galbany@ist.utl.pt`

Motivation

CCSNe

SNeIa

Cosmology

Stellar evolution
(progenitors)

Improve standardization
adding host/environment properties

Reduce systematic errors

Anderson, Modjaz, Prieto, Leloudas,
Smartt, Sorderberg, Follatelli, Pignata...

Sullivan, Kelly, Howell, Lampeitl,
Hamuy, D'Andrea, Gallagher...

most based on global
characteristics (or gradients)

overall galaxy properties
slits o imaging - local properties

previous study (IFS)
Stanishev+12 (7 SNe)
+

CALIFA - IFS

CALIFA - IFS

properties of one single pixel

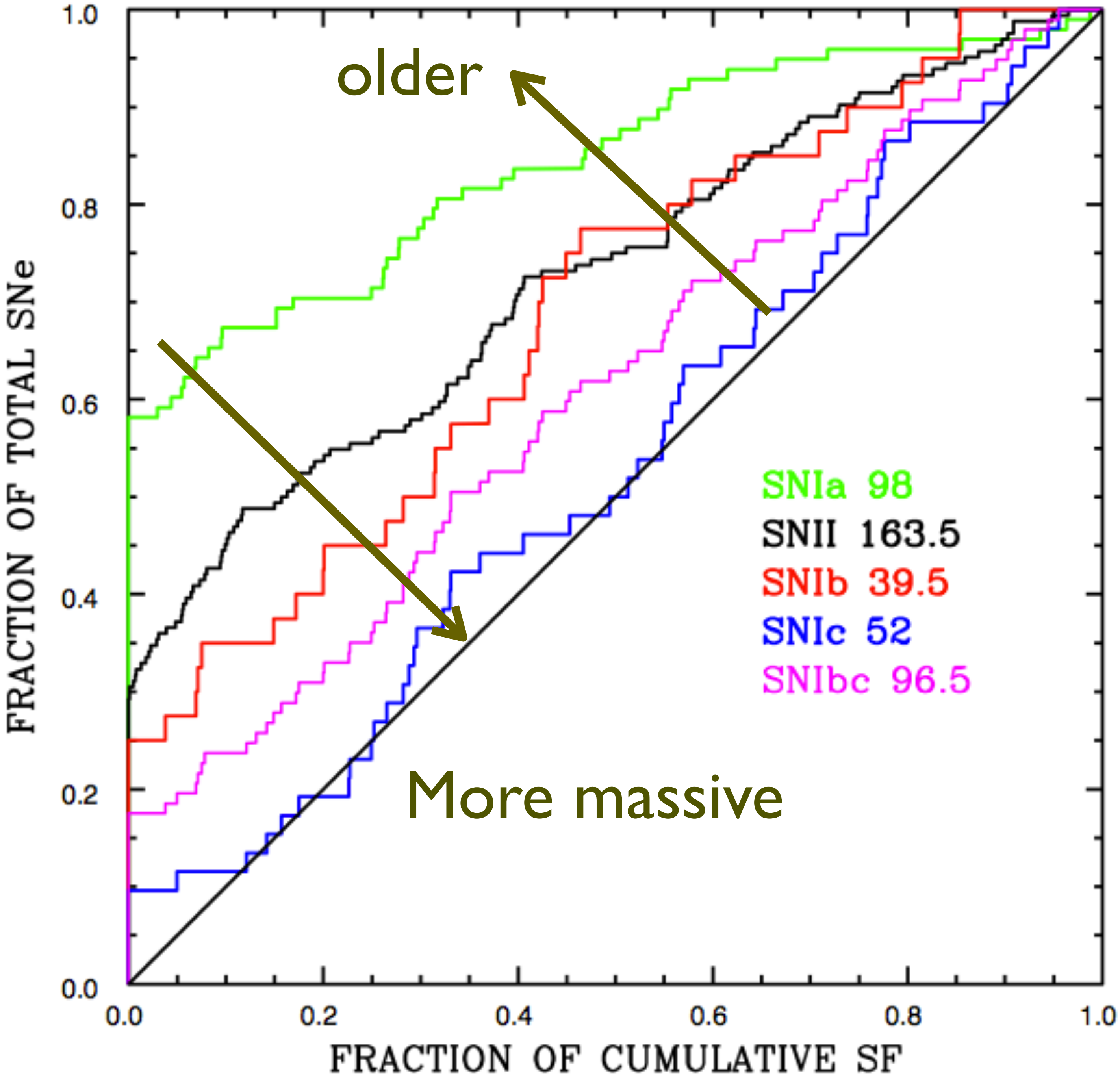
Second order corrections: Environment

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

...



older
More massive
SNIa 98
SNII 163.5
SNIb 39.5
SNIc 52
SNIbc 96.5
FRACTION OF TOTAL SNe
FRACTION OF CUMULATIVE SF
0.0
0.2
0.4
0.6
0.8
1.0

Anderson+12

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

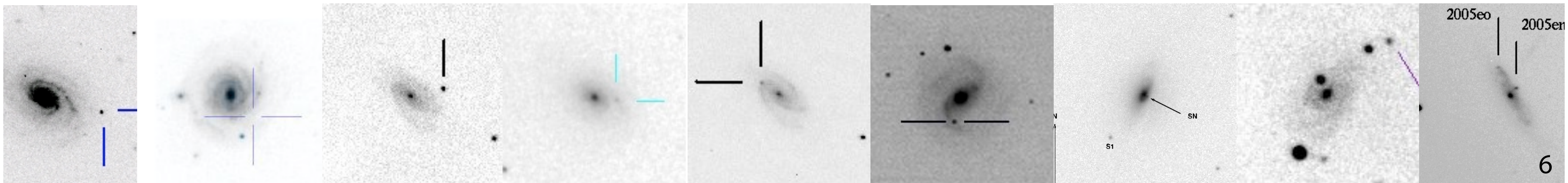
11 in DR1

feasibility study for CALIFA, *Sánchez+12*

PINGS Survey, *Rosales-Ortega+10*

SNIa hosts, *Stanishev+12*

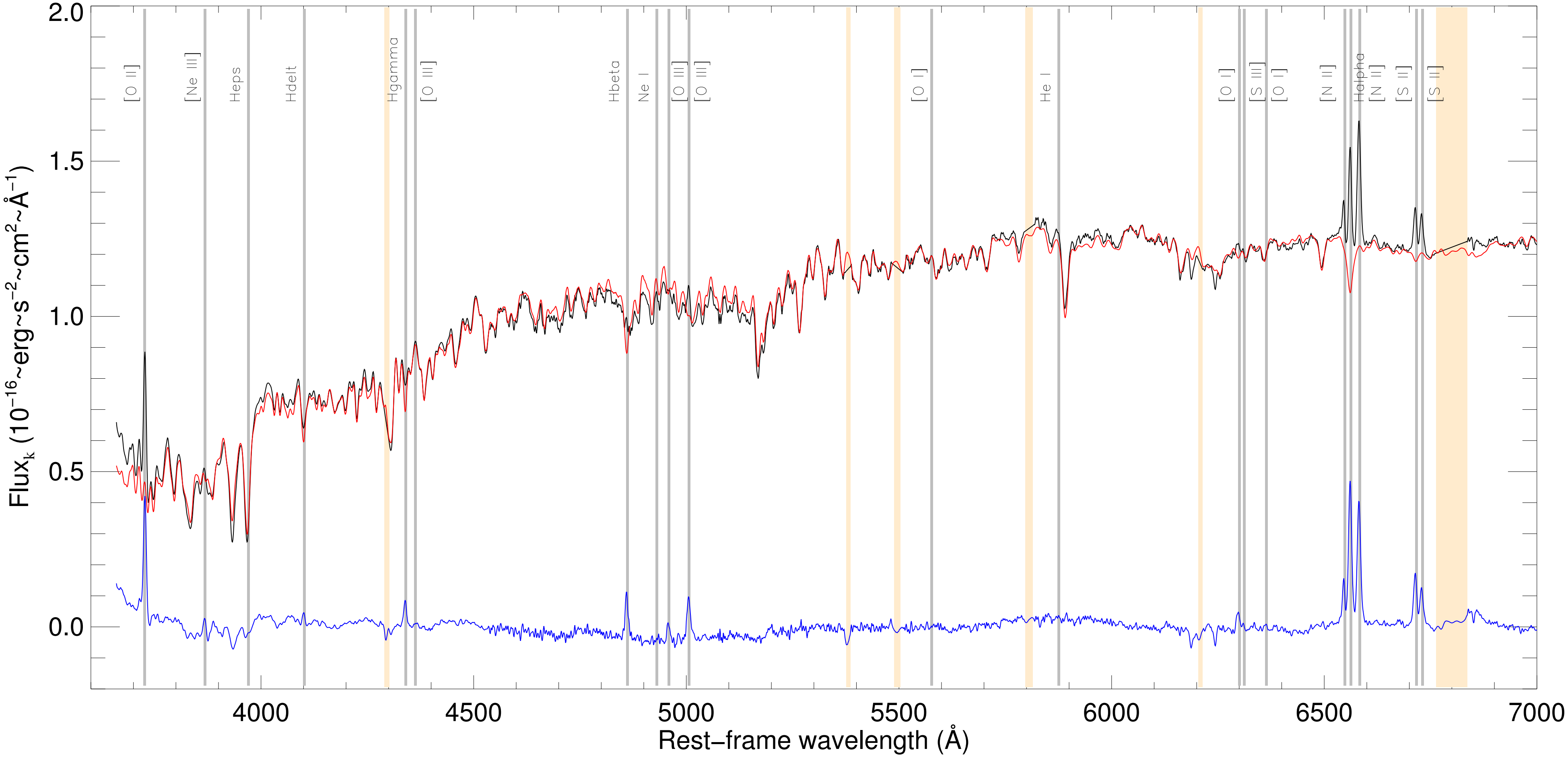
NGC5668, *Marino+12*

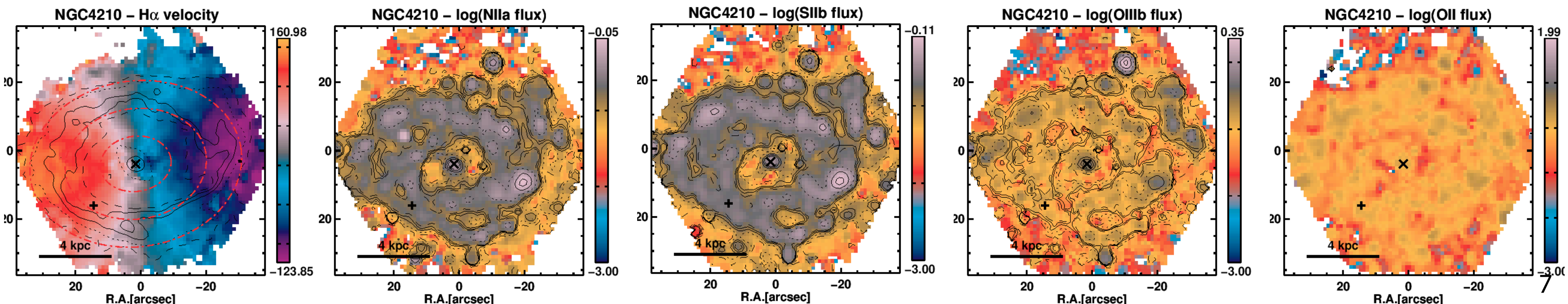


STARLIGHT *Cid Fernandes et al. 2005*

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

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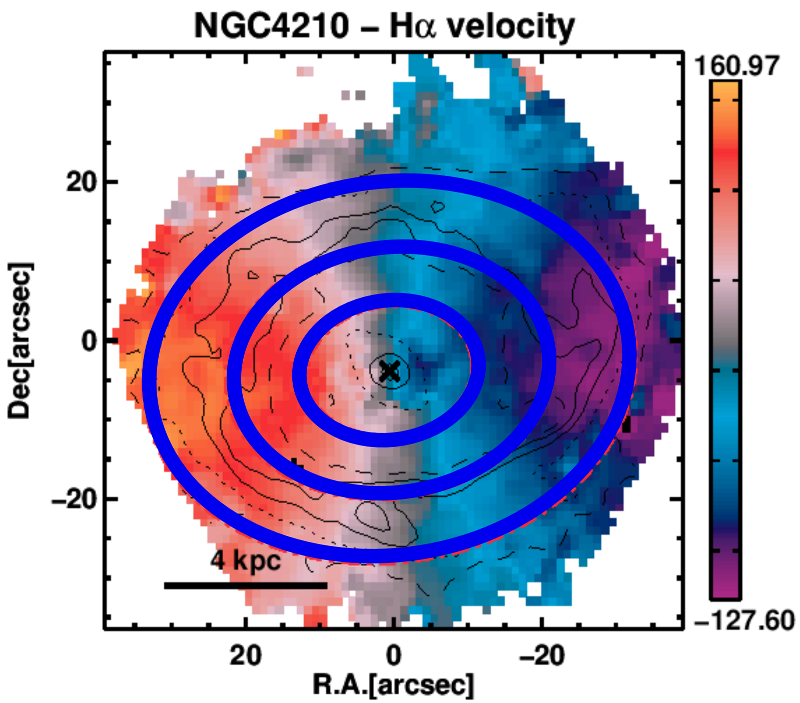
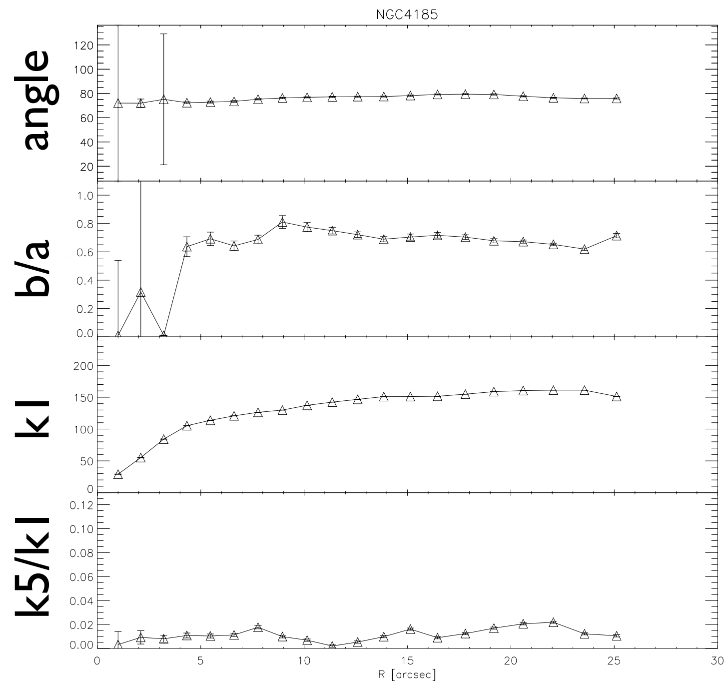




Kinemetry

Deprojection

Fit ellipses using *Krajnovic et al. 2006*

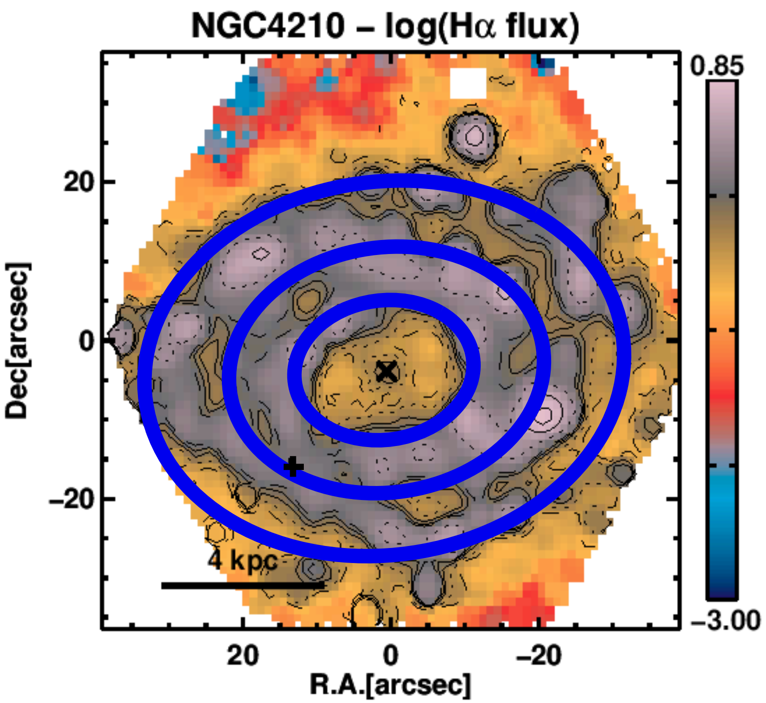
Measure distances in the galactic plane

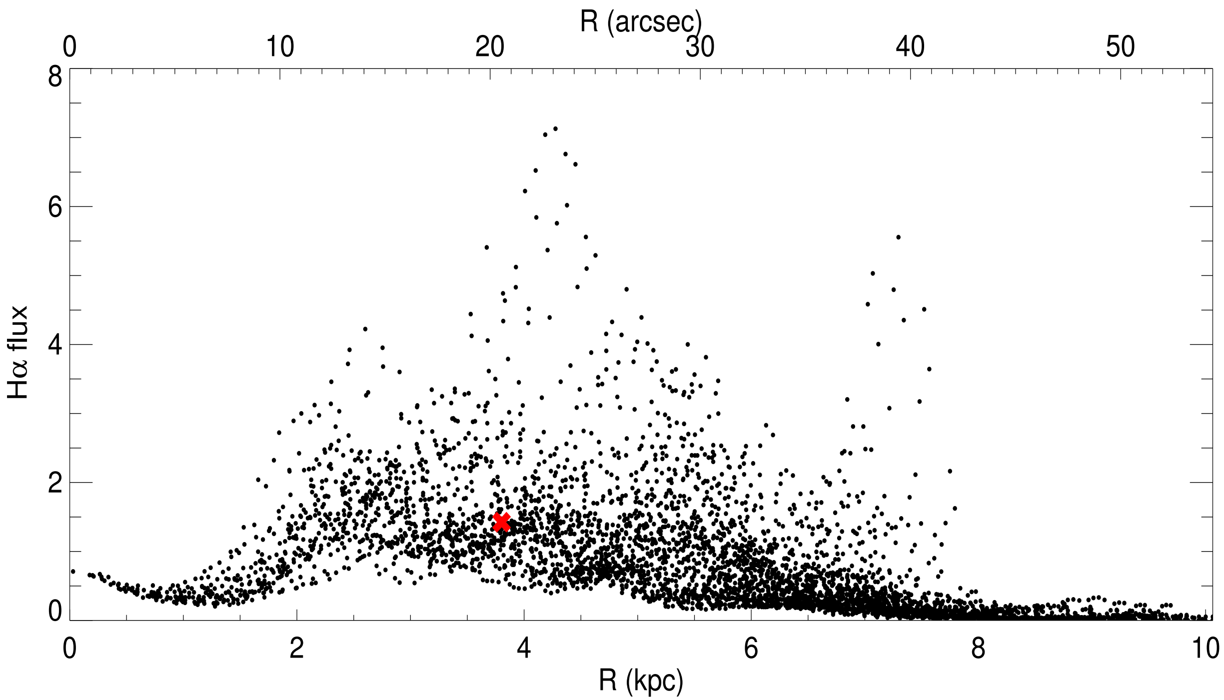
Azimutal average

Voronoi binning

Integrated spectrum

3" aperture spectrum





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

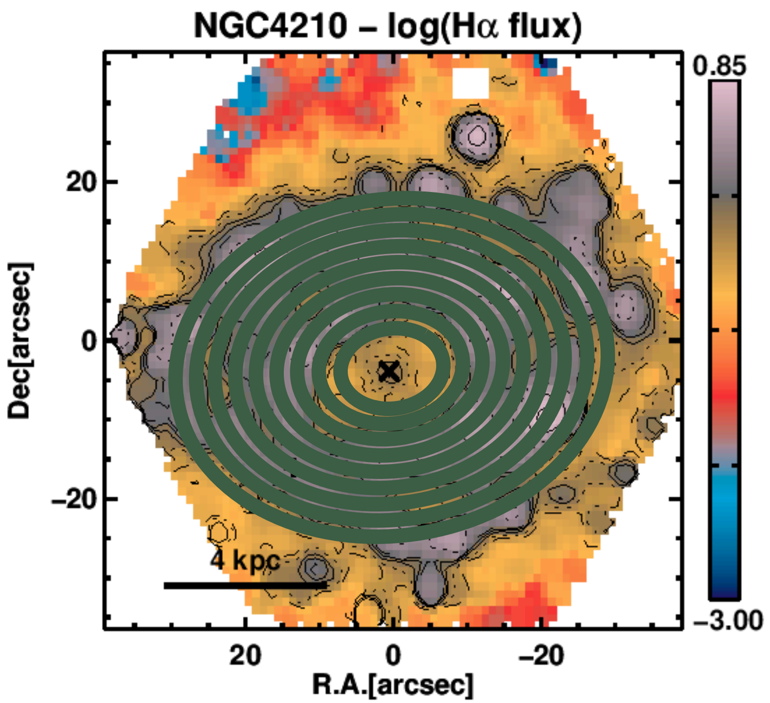
Deprojection — Measure distances in the galactic plane

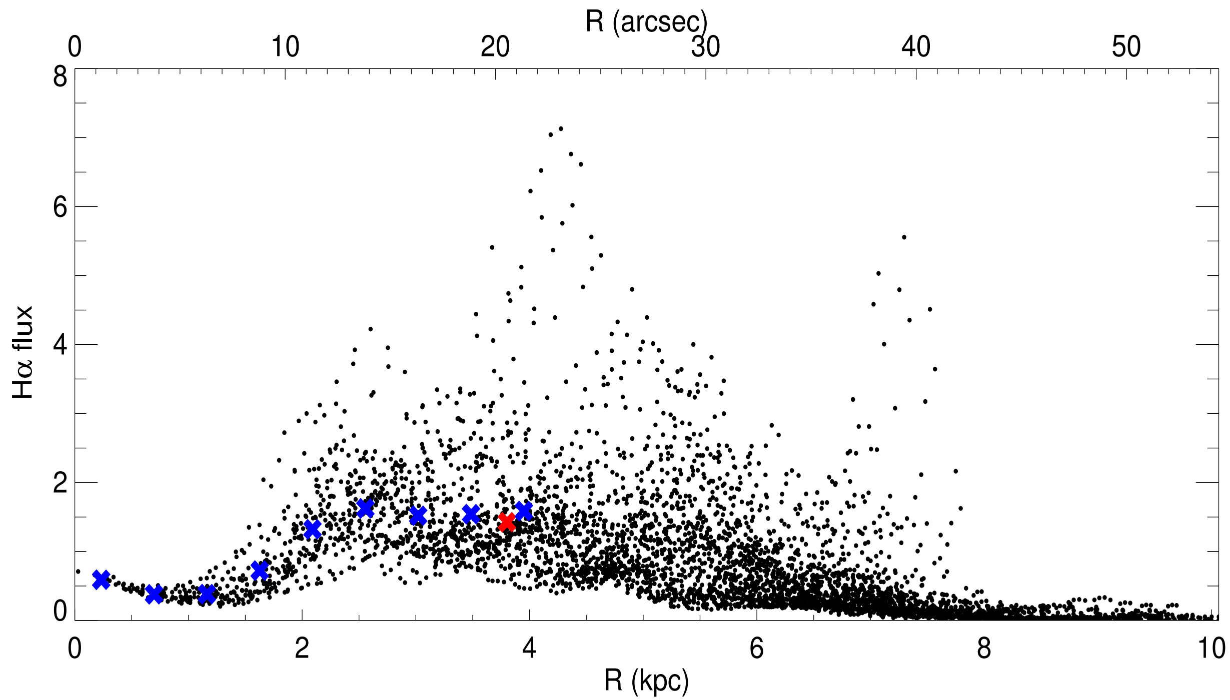
Azimutal average — Co-add ell. rings centered in the core

Voronoi binning

Integrated spectrum

3″ aperture spectrum





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

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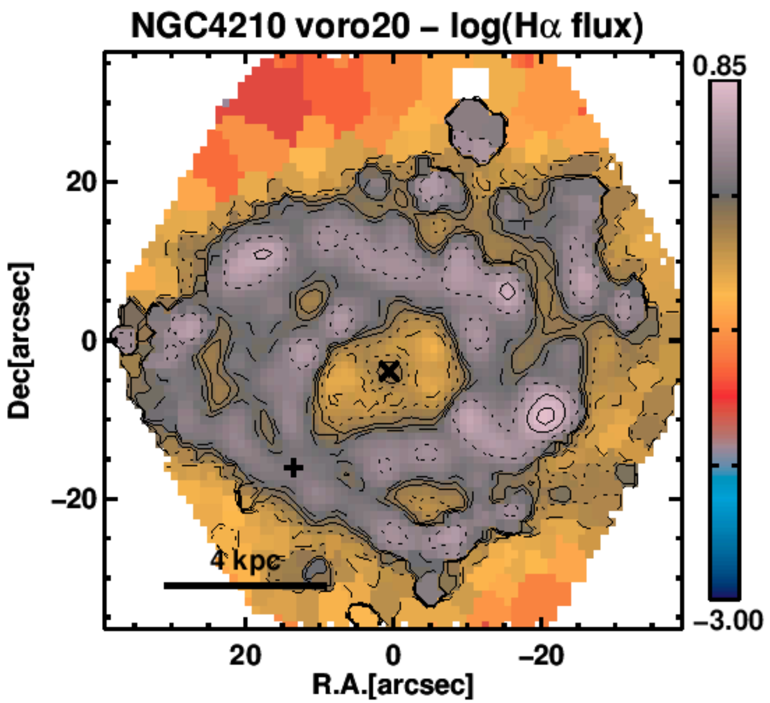
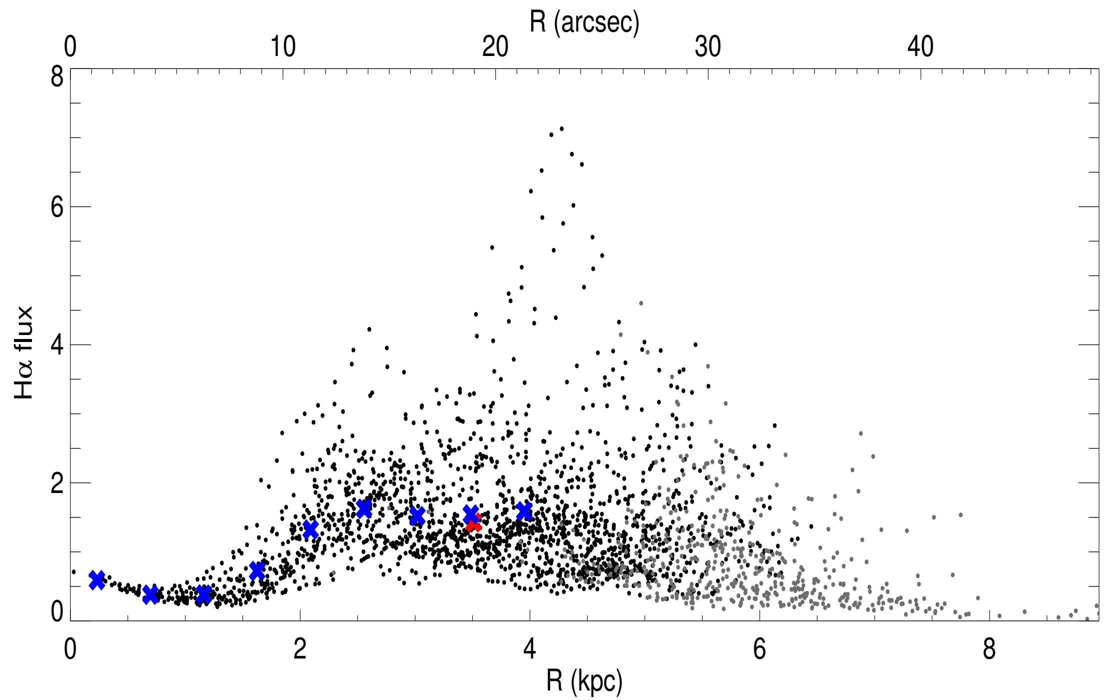
Voronoi binning — Requiring S/N > 20

Integrated spectrum

3" aperture spectrum





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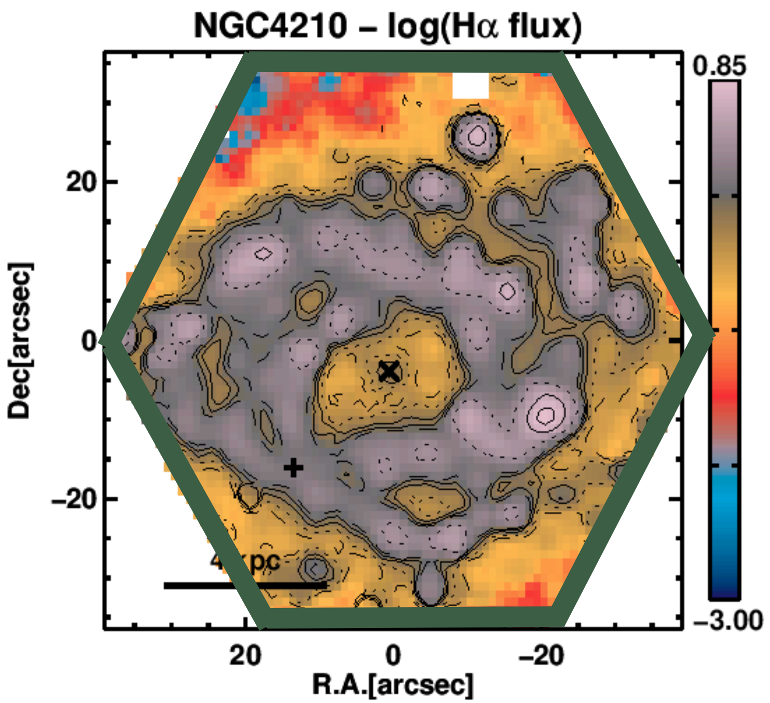
Integrated spectrum — For high-z (aperture effects)

3″ aperture spectrum



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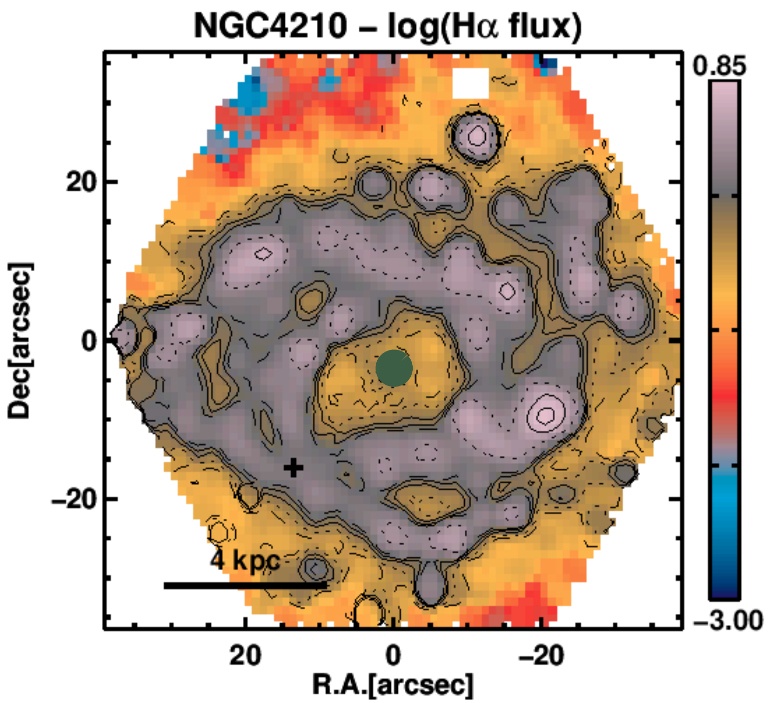
Azimutal average — Co-add ell. rings centered in the core

Voronoi binning — Requiring S/N > 20

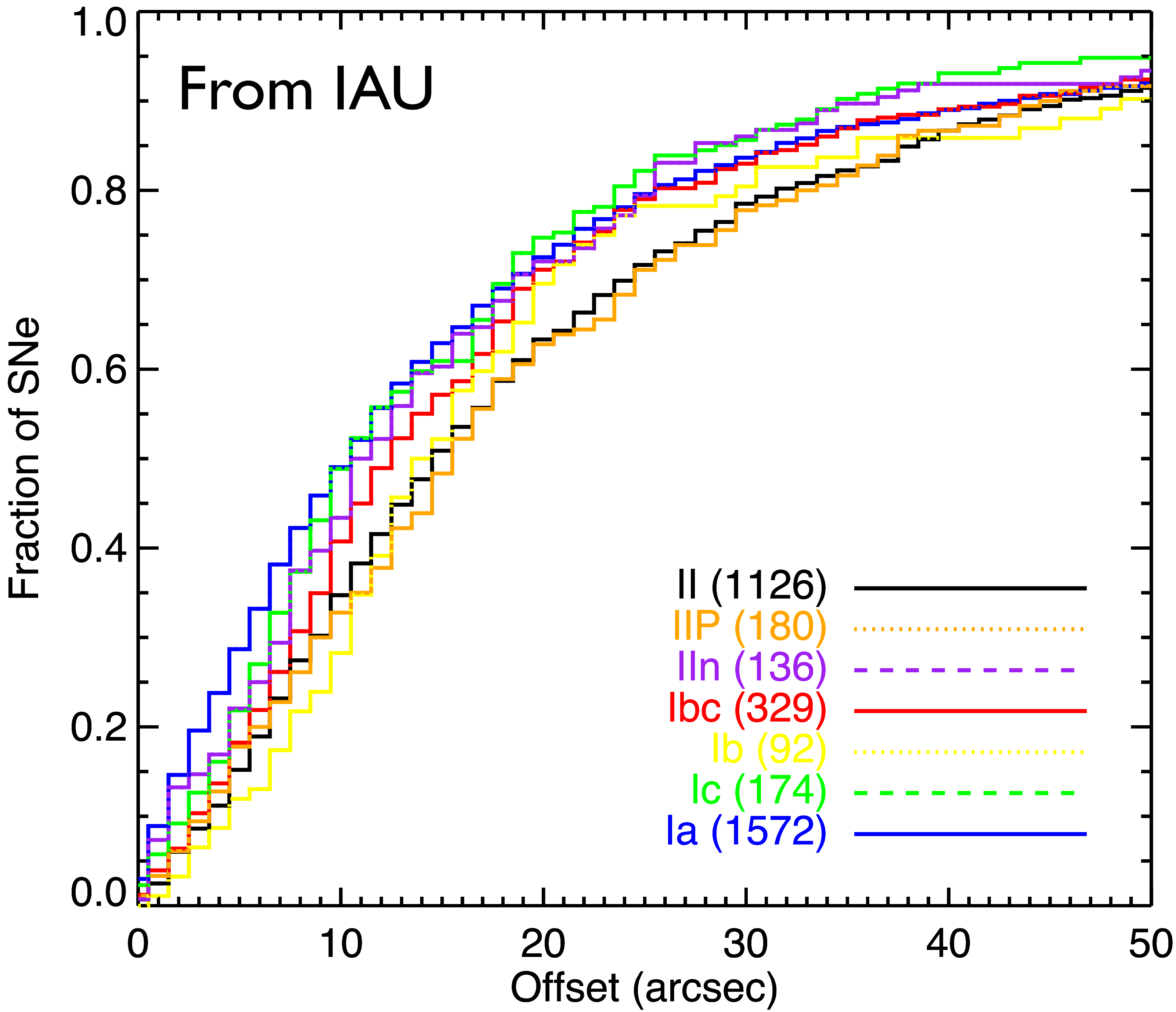
Integrated spectrum — For high-z (aperture effects)

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



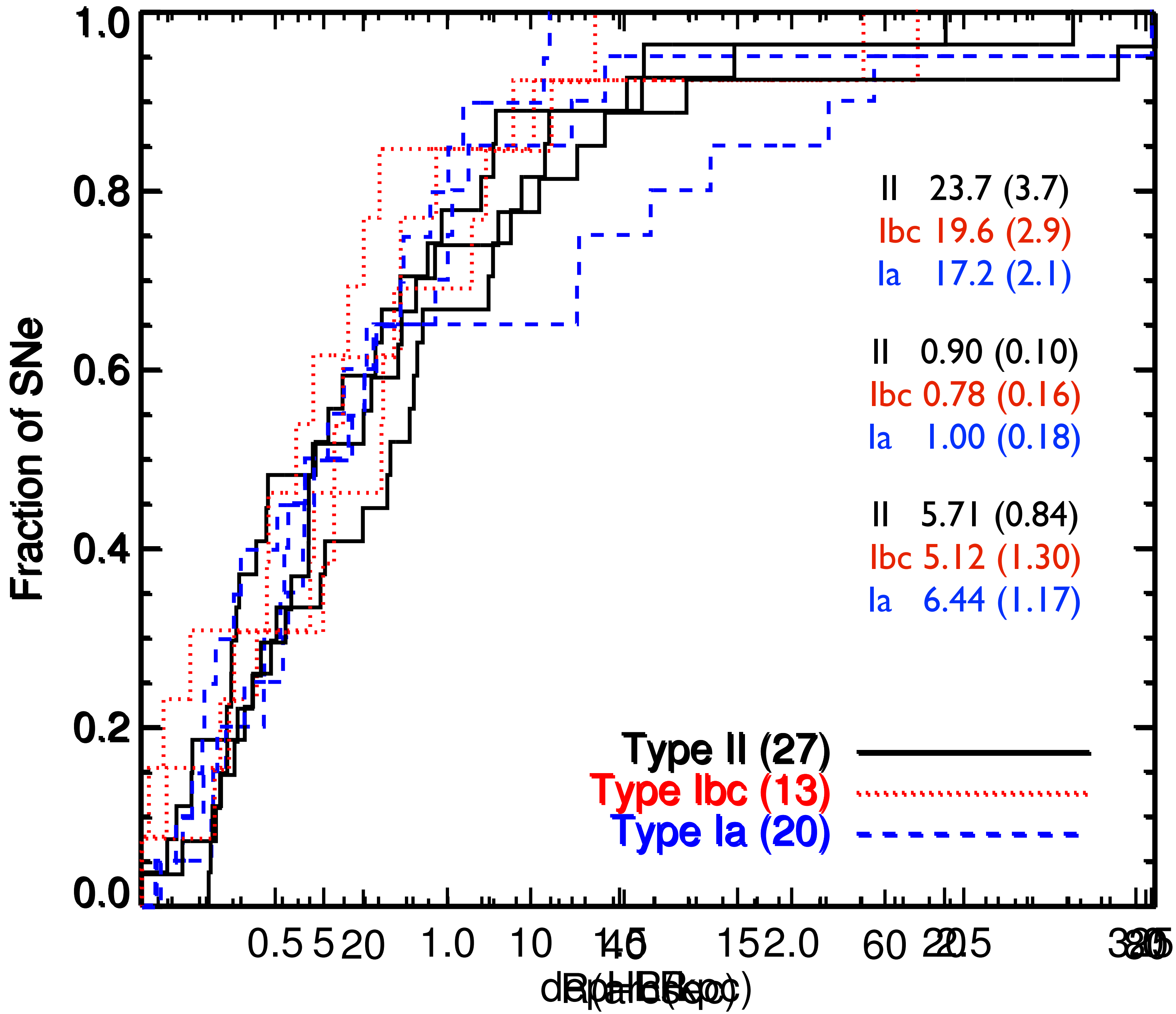
Results...

GCDs



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

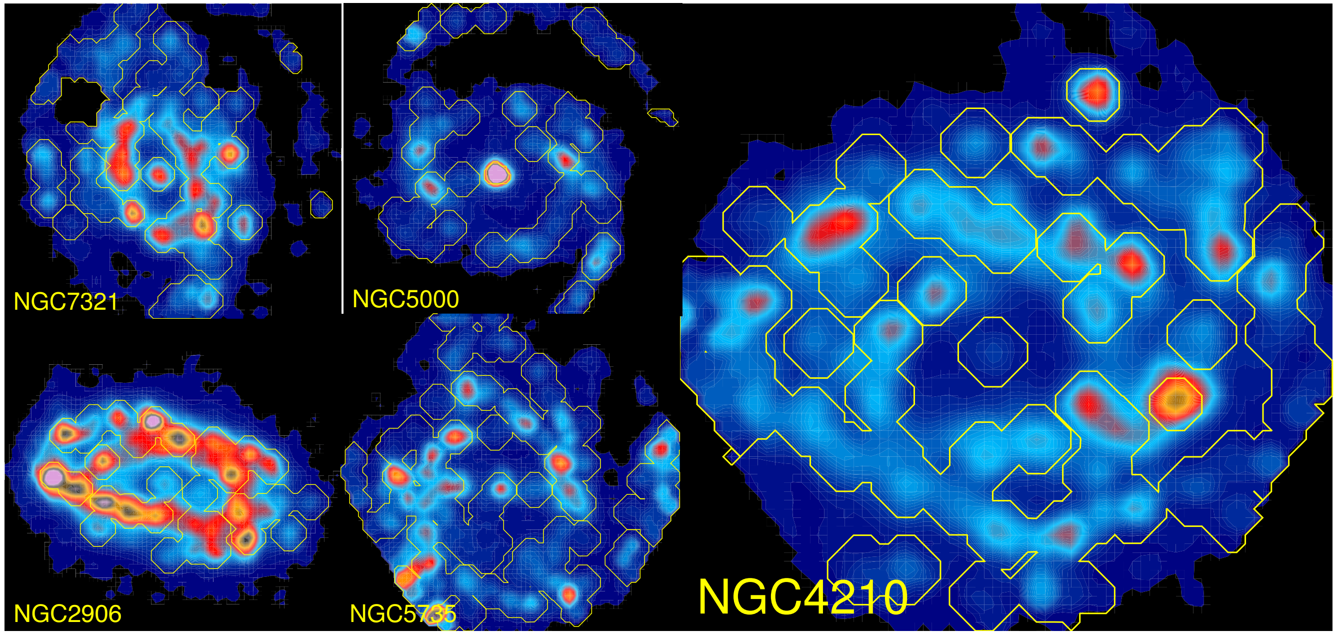
GCDs

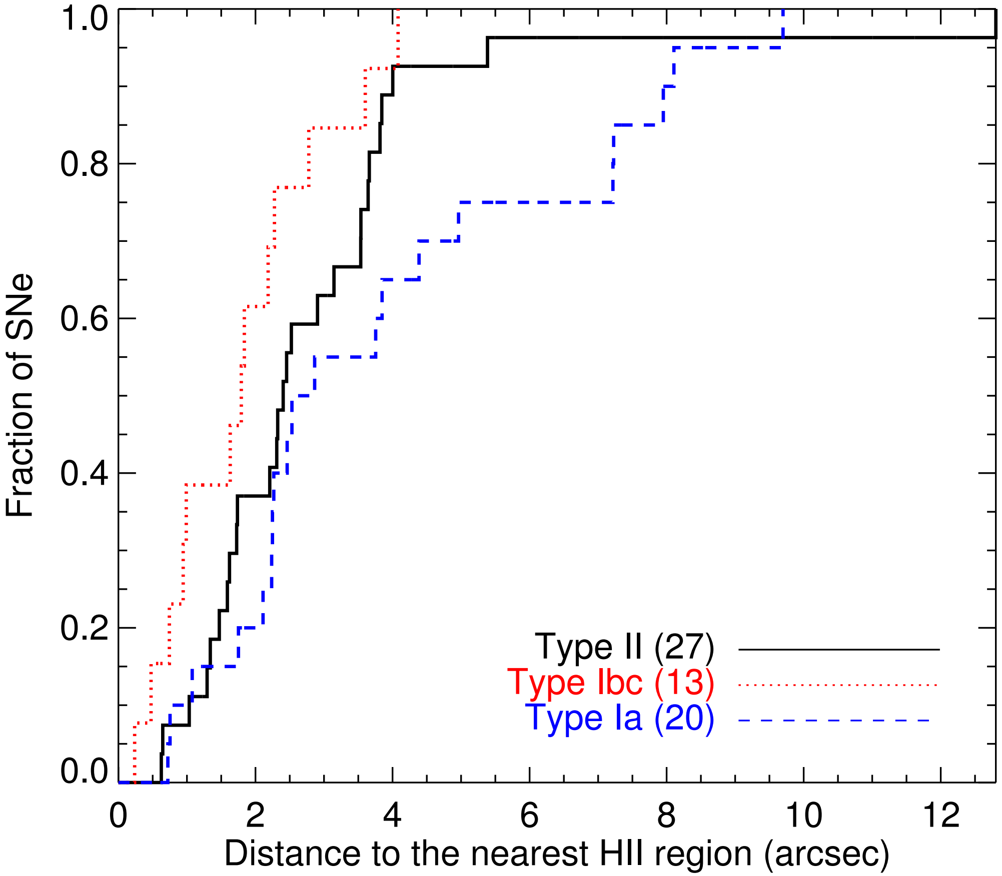


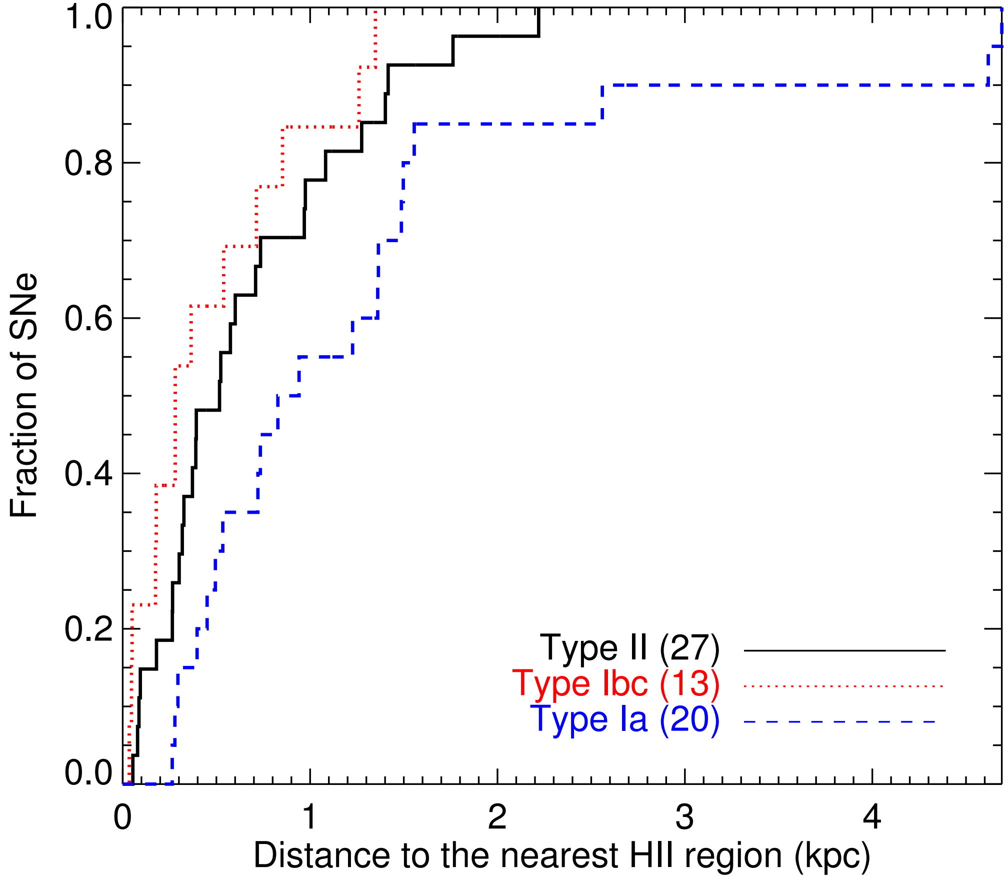
Fraction of SNe
1.0
0.8
0.6
0.4
0.2
0.0
II 23.7 (3.7)
Ibc 19.6 (2.9)
Ia 17.2 (2.1)
II 0.90 (0.10)
Ibc 0.78 (0.16)
Ia 1.00 (0.18)
II 5.71 (0.84)
Ibc 5.12 (1.30)
Ia 6.44 (1.17)
Type II (27)
Type Ibc (13)
Type Ia (20)

HII regions

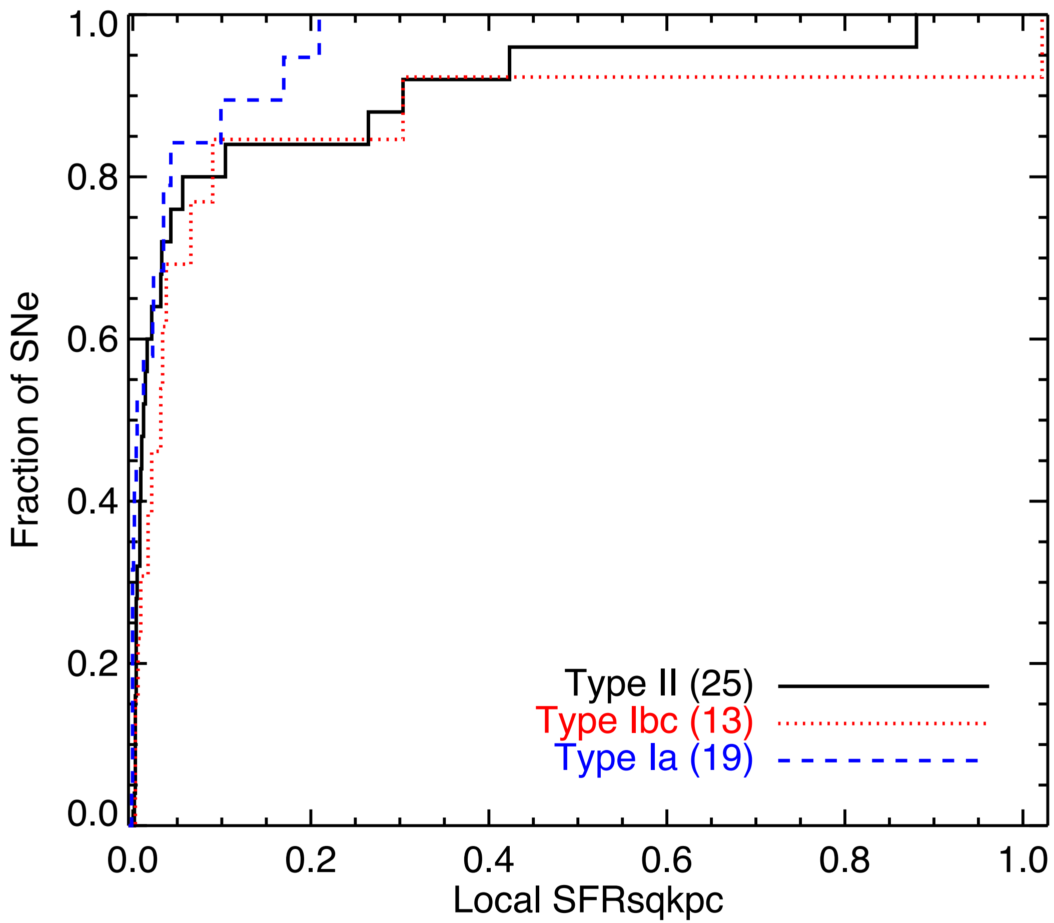
HIIexplorer
Sánchez et al. 2012

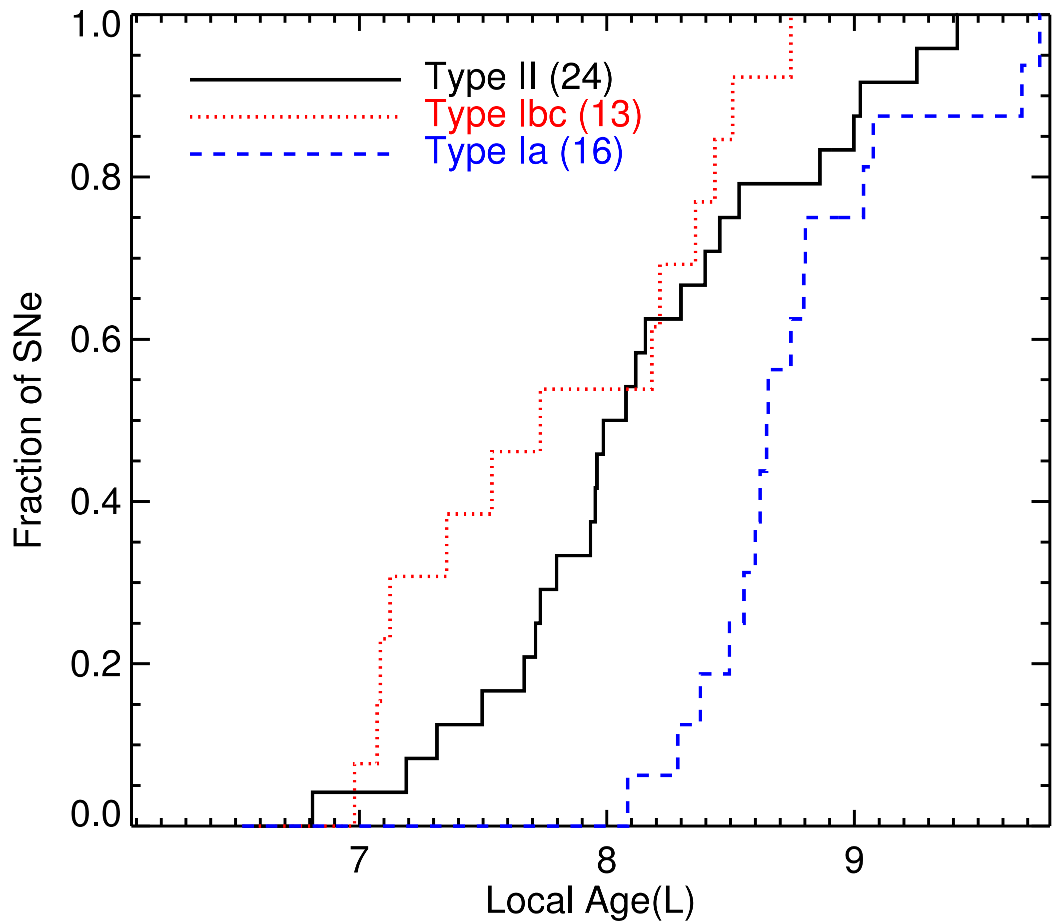




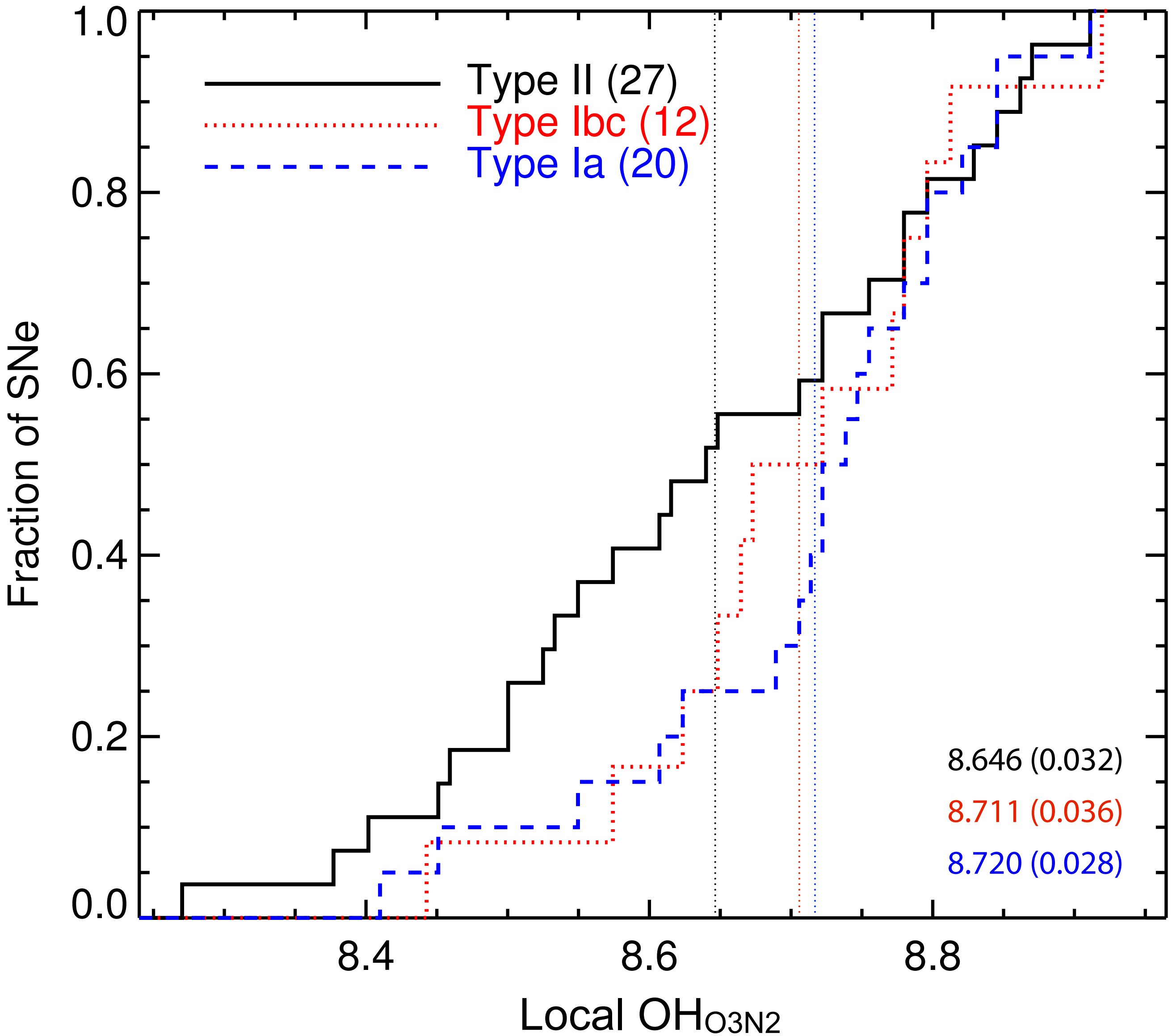


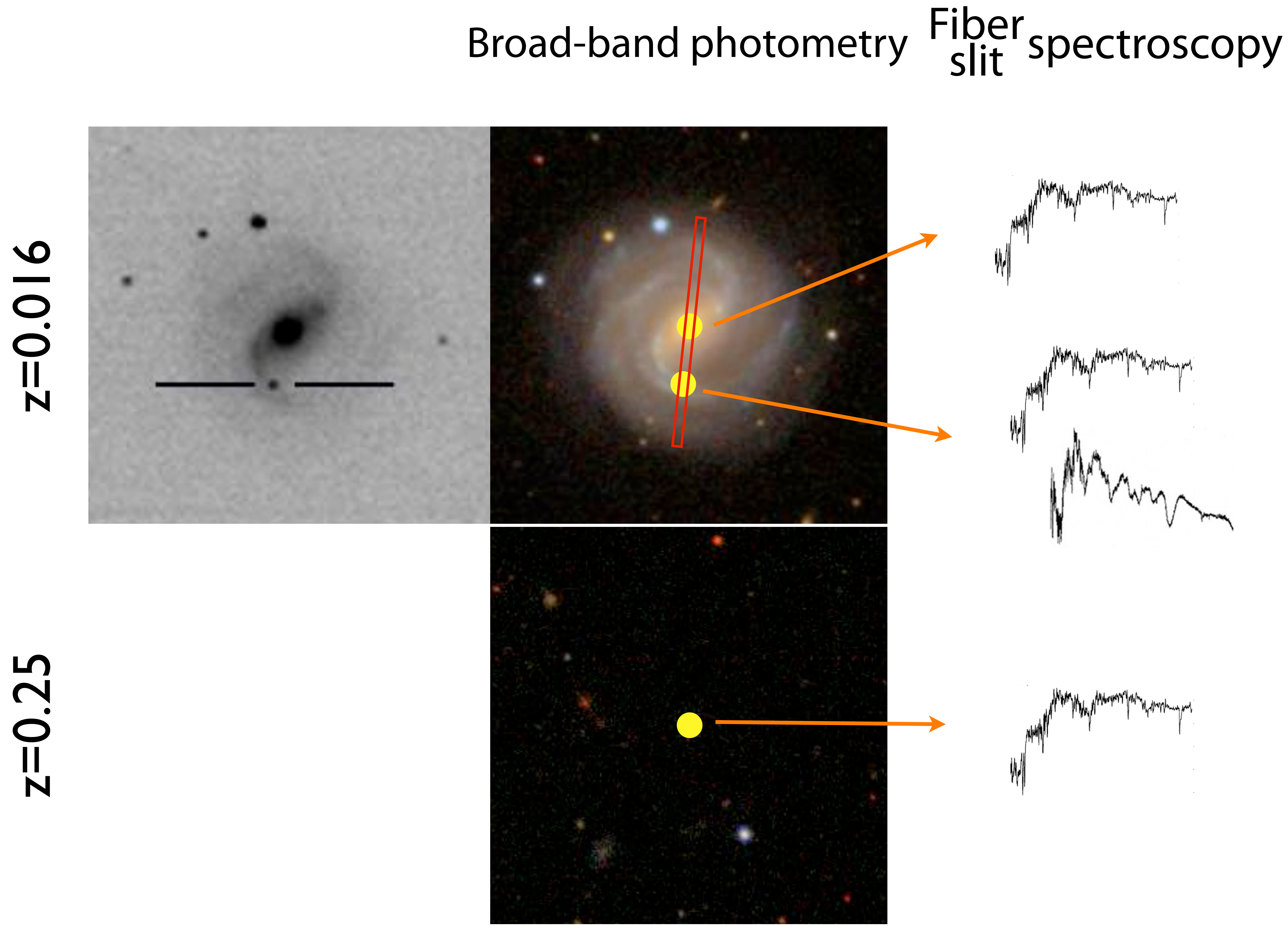
Σ_{SFR} Stellar age



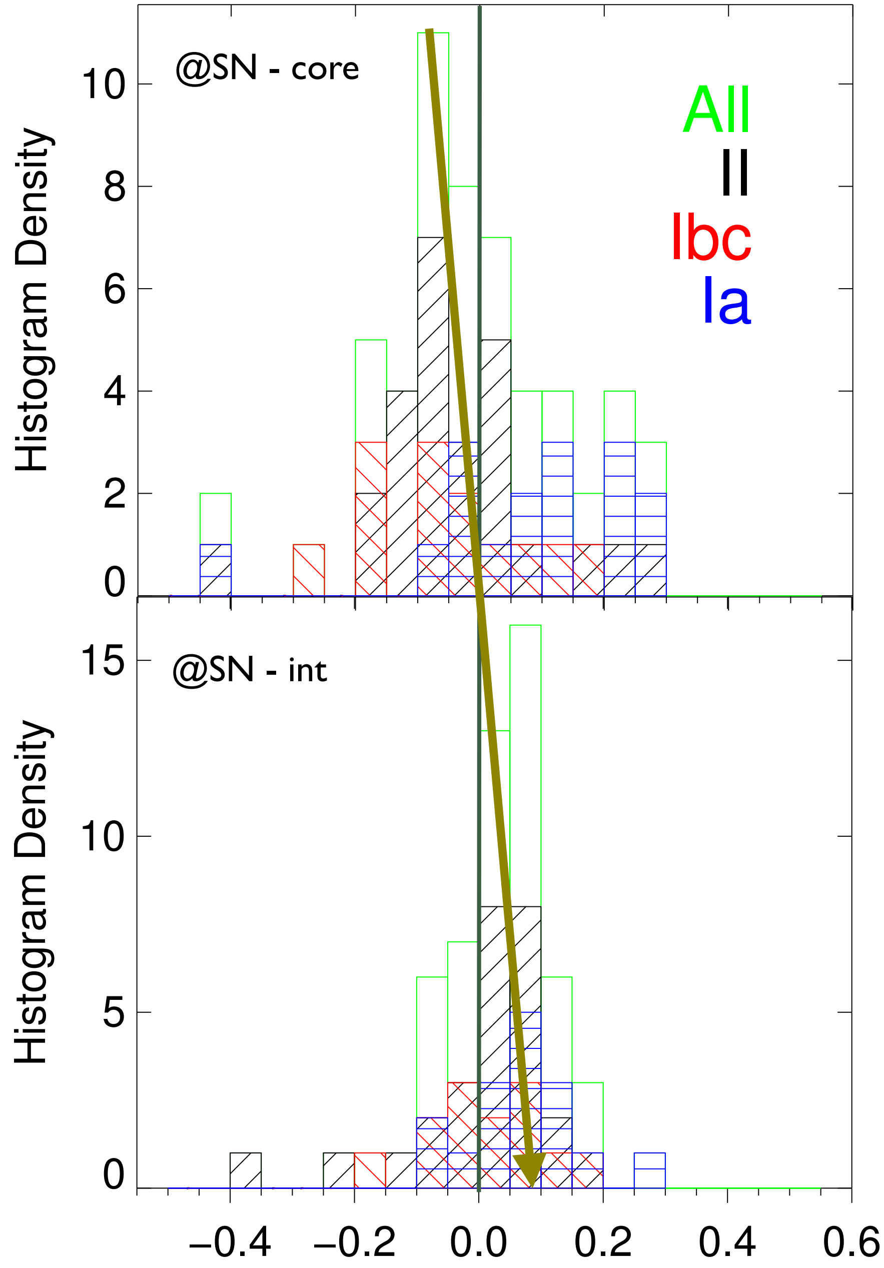


$Z_{Ia} \geq Z_{Ibc} > Z_{II}$




Broad-band photometry
Fiber
slit
spectroscopy
z=0.016
z=0.25

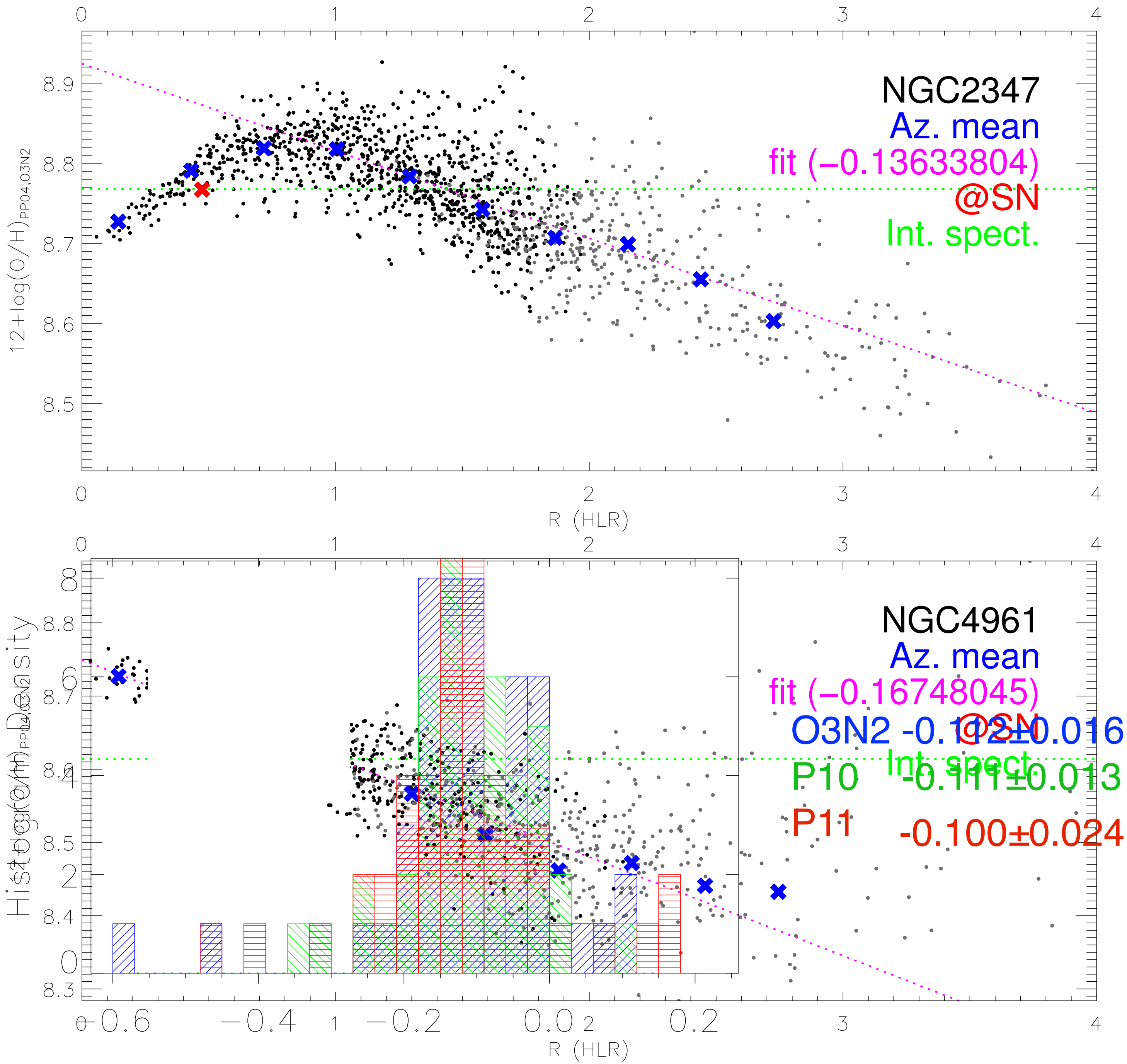
global Z Vs Local Z



II -0.060
Ibc -0.052
Ia -0.076

II 0.006
Ibc 0.011
Ia 0.066

metallicity gradients



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