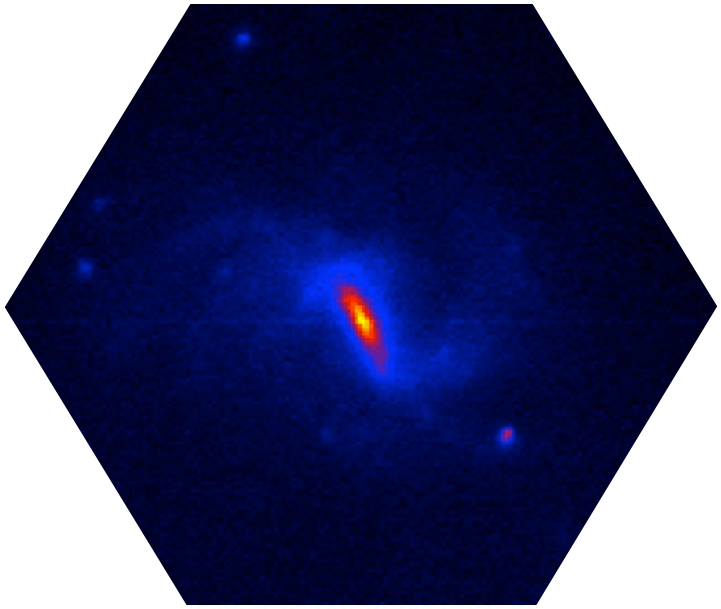
INTEGRAL FIELD SPECTROSCOPY OF SUPERNOVA HOST GALAXIES



CALIFA Survey

Lluís Galbany
(CENTRA, Portugal and MAS/DAS, Chile)

Vallery Stanishev (CENTRA, Portugal)

Ana Mourão (CENTRA, Portugal)

Myriam Rodrigues (ESO, Chile)

Hector Flores (GEPI, France)

and the *CALIFA* collaboration

TÉCNICO LISBOA

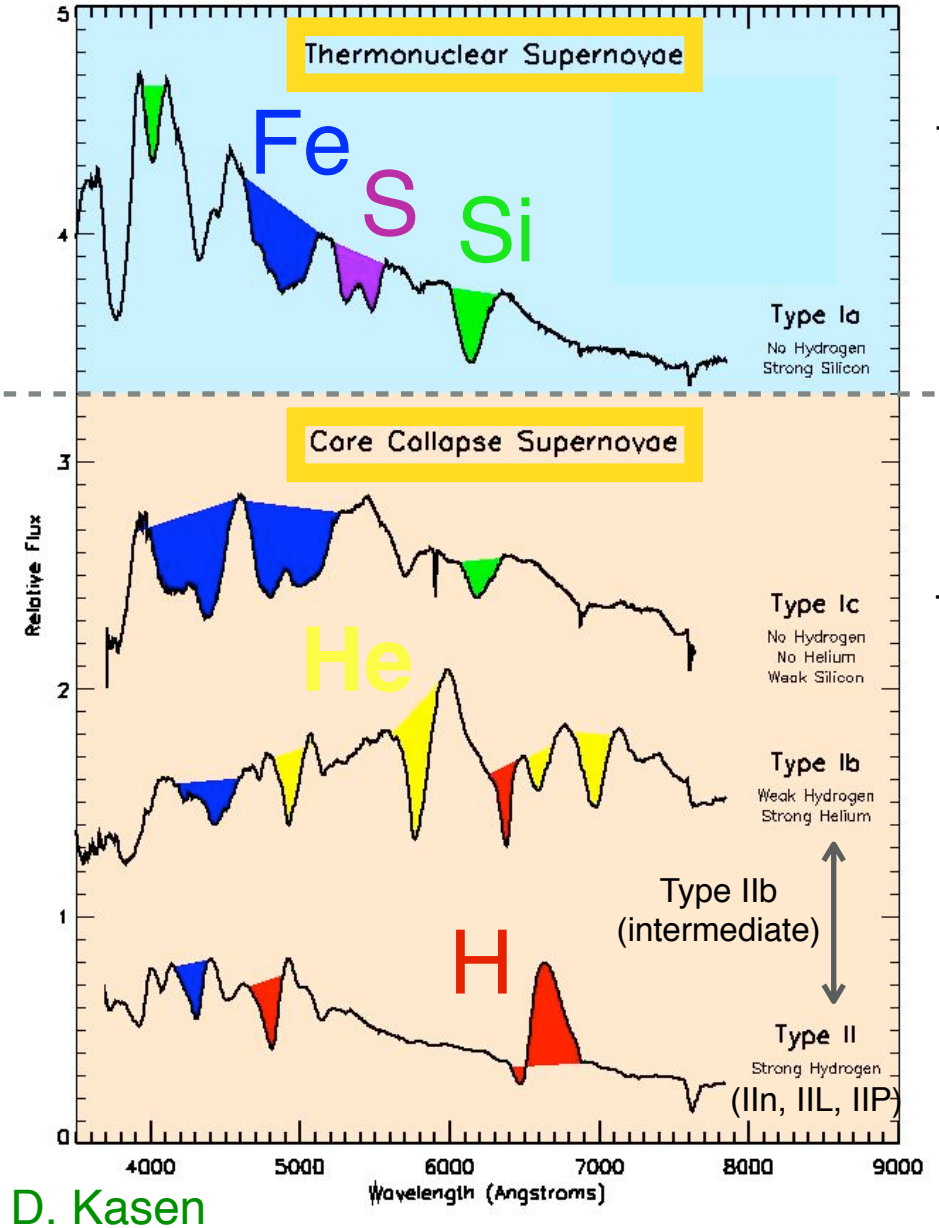
MULTIDISCIPLINARY CENTER FOR ASTROPHYSICS CENTRA

FACULTAD DE CIENCIAS FÍSICAS Y MATEMÁTICAS UNIVERSIDAD DE CHILE

MILLENNIUM INSTITUTE OF ASTROPHYSICS

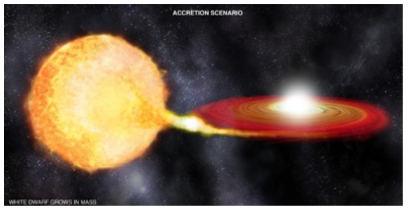
Institut d'Estudis Espacials de Catalunya (IEEC)
21 Maig 2014, Bellaterra

SN zoo



D. Kasen

CO white dwarfs in binary systems accreting mass from a companion

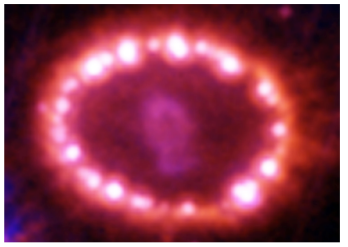


Two scenarios: - single degenerate (WD + massive star)

- double degenerate (2 WD)

Homogeneous brightness → Cosmology

Massive stars (8 to 30 Msun)



Two paths: - single massive stars + winds

- binary systems transferring mass

Differences depending on progenitor mass loss before explosion

Mass loss ↑

Ic lose both H and He envelopes

Ib lose H envelope

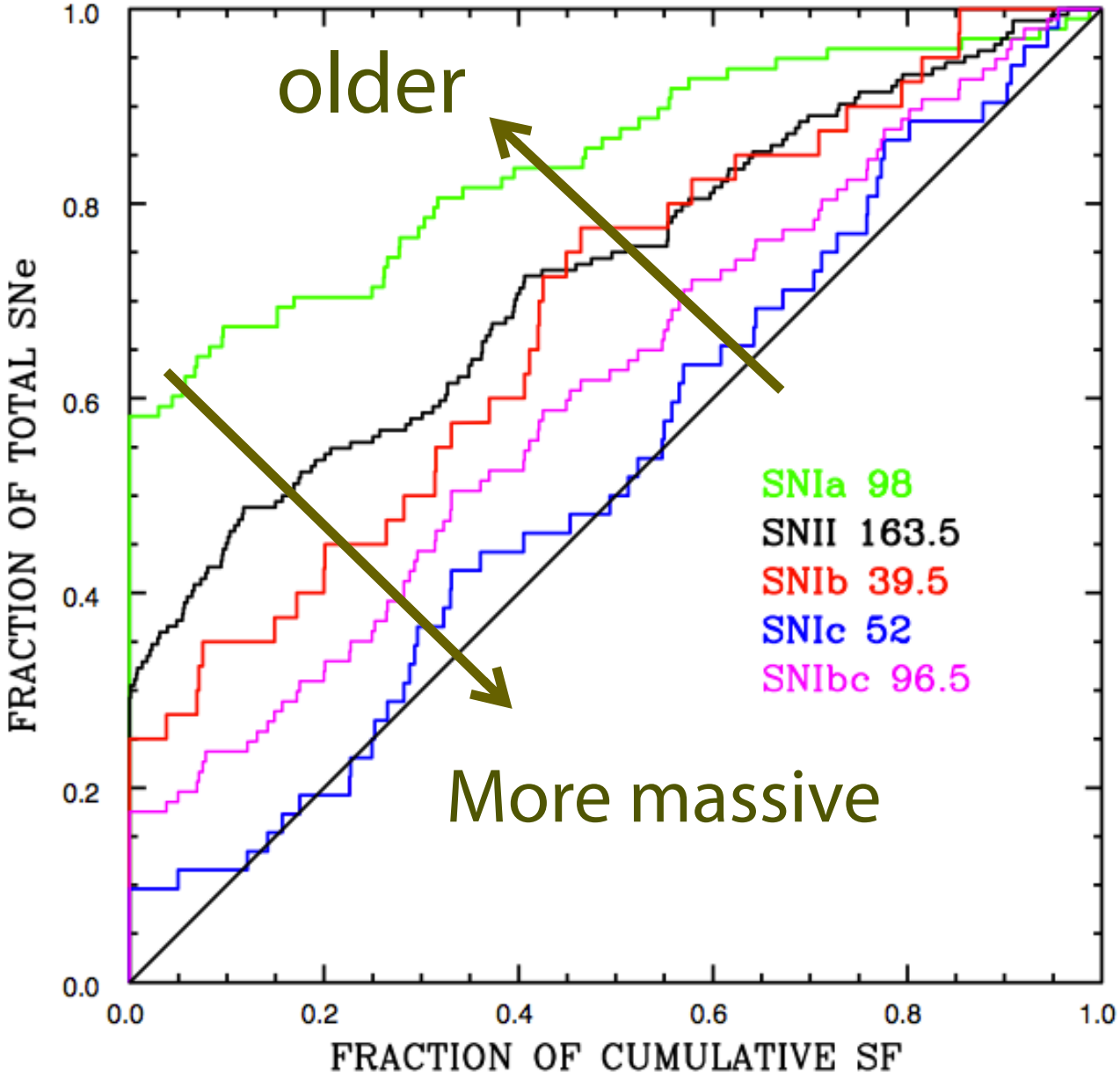
IIb intermediate between II and Ib

II retain external layers (H and He)

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

Alternative methods to constrain progenitor properties: ENVIRONMENT

Progenitor constraints



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

Anderson+12

Assuming that all the stars in a cluster have similar ages, more association to the star-forming region can be understood as young and more massive star

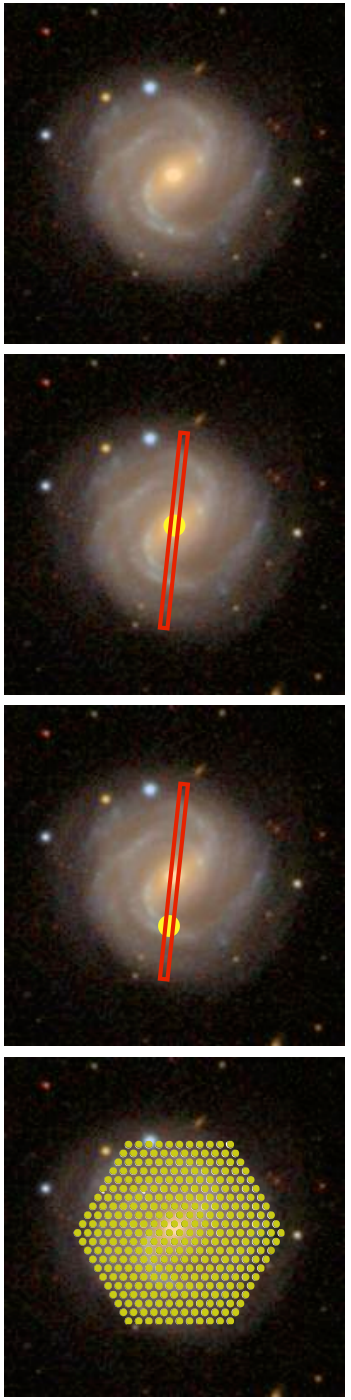
More massive stars have shorter lifetimes (age) and therefore have less time to move away from the star-forming regions

SN Environmental studies

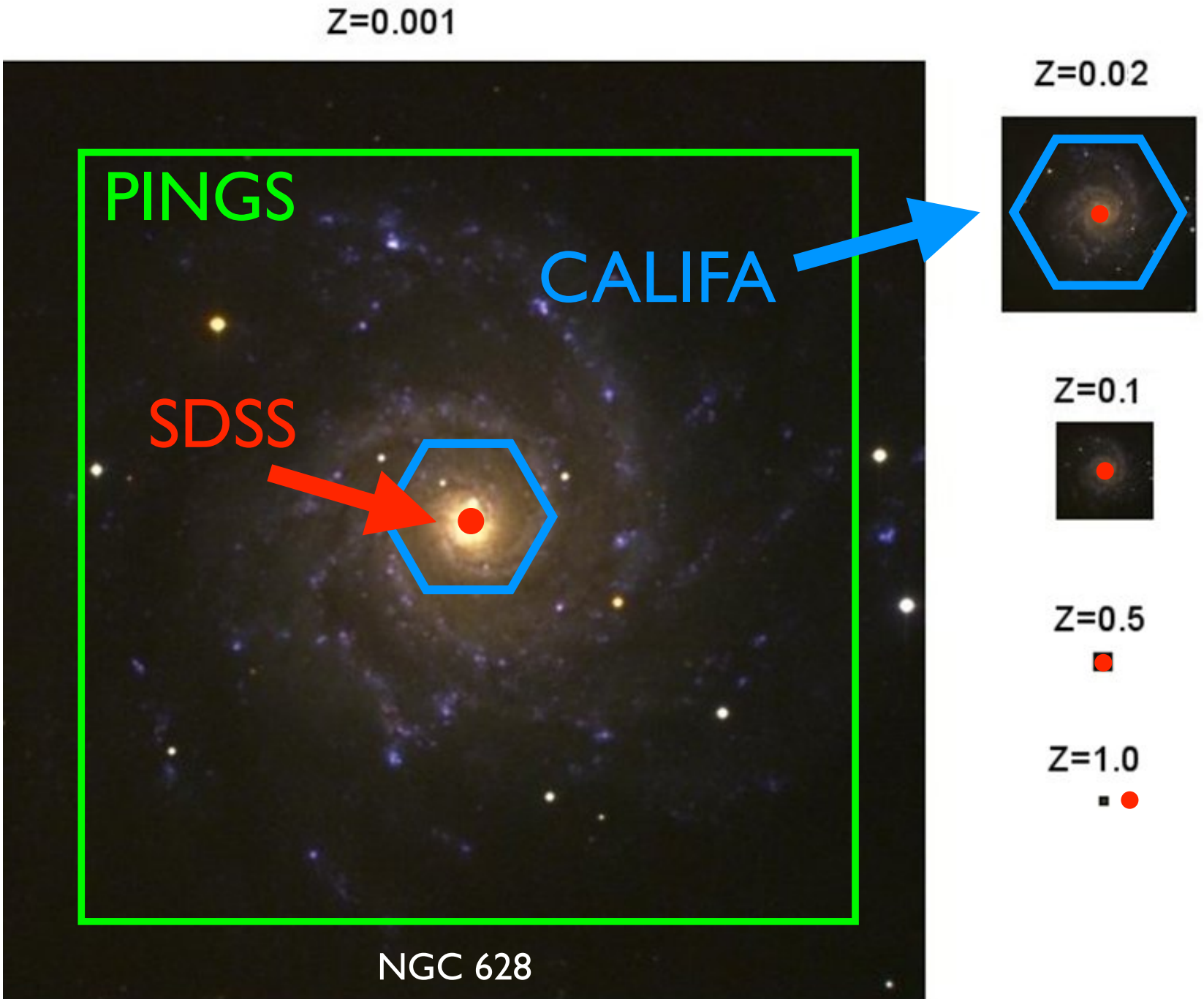
- Global properties
  - photometry / imaging
    (Sullivan+10, Lampeitl+10, Anderson+09…)
  - single-aperture /long-slit spectroscopy (@galaxy core)
    (Prieto+08, D'Andrea+12…)

- Local properties
  - central values + gradients
    (Boissier+09, Galbany+12…)
  - single-aperture / long-slit spectroscopy (@SN position)
    (Anderson+10&12, Modjaz+11…)

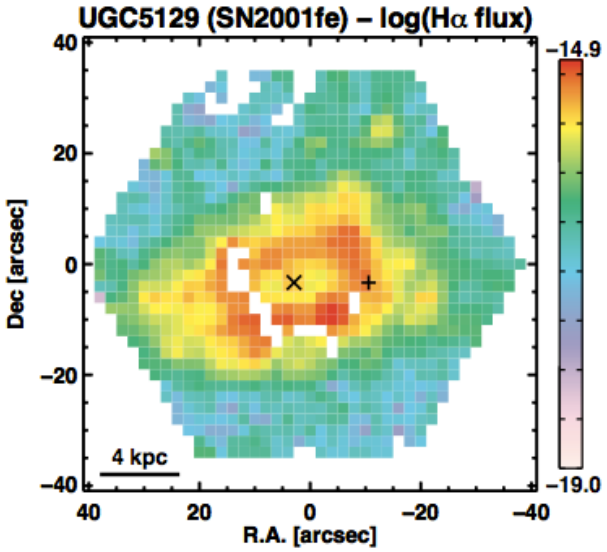
- Integral Field Spectroscopy
  (Stanishev+12, Kuncarayakti+13ab)

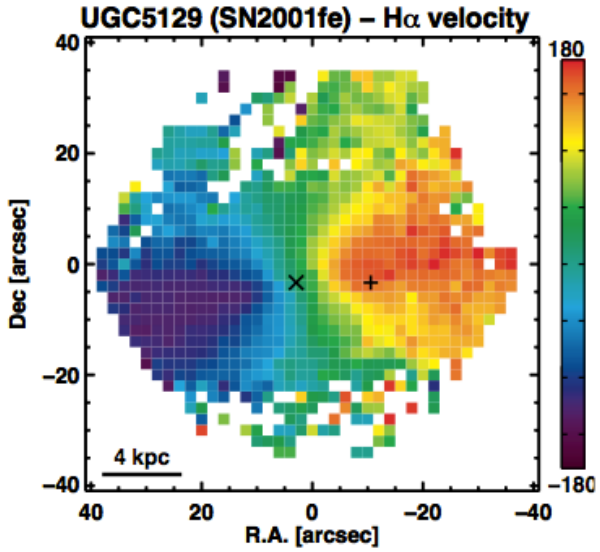


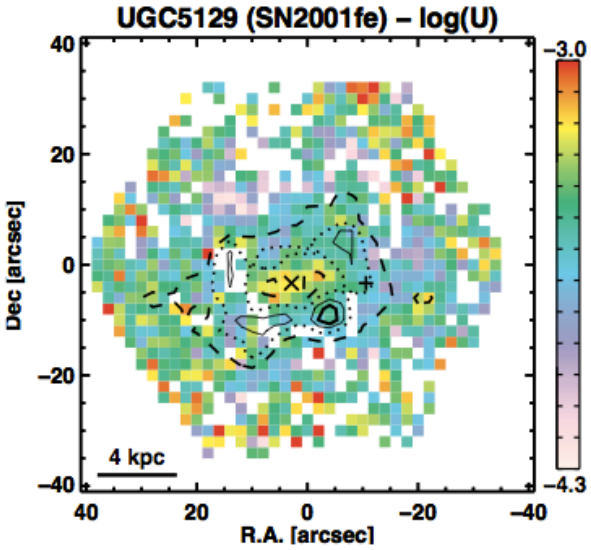
Why nearby? The FoV issue

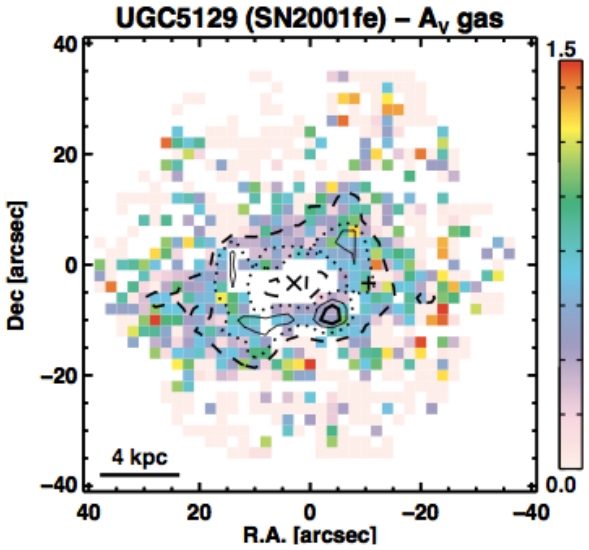


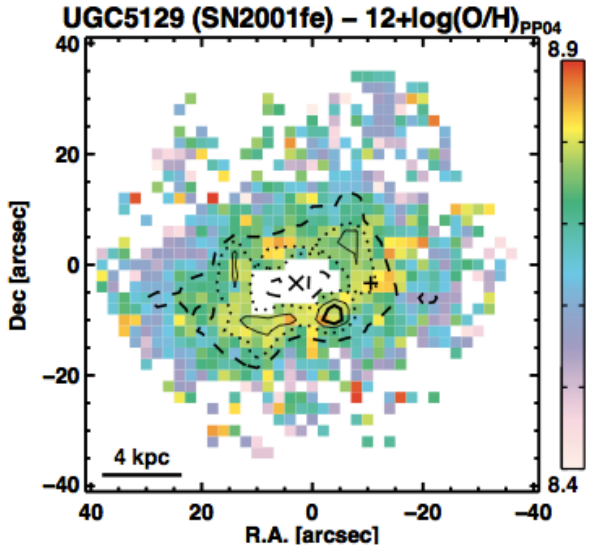
SNe Ia host galaxies with IFU







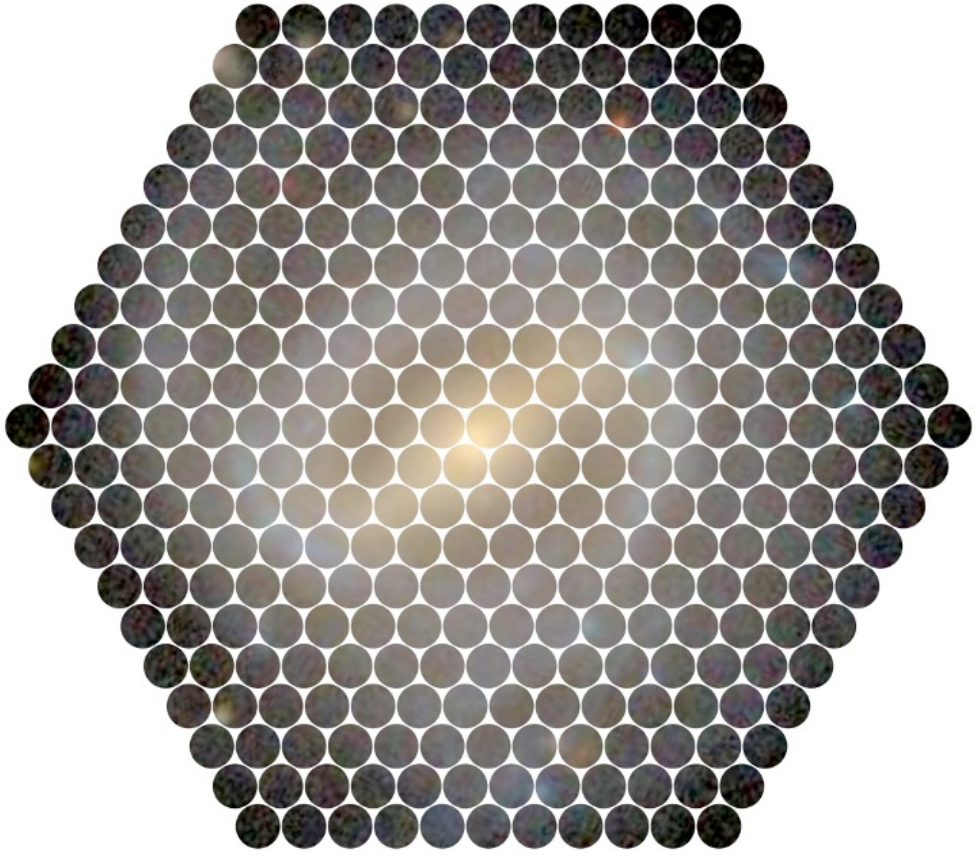




Stanishev+12

Calar Alto Legacy Integral Field Area

Sánchez+12



CALIFA Survey

- Survey of ~600 galaxies of all types at z=0.005 to 0.03
- diameter selected from SDSS DR7, $45 < D_{25} < 80$, 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]

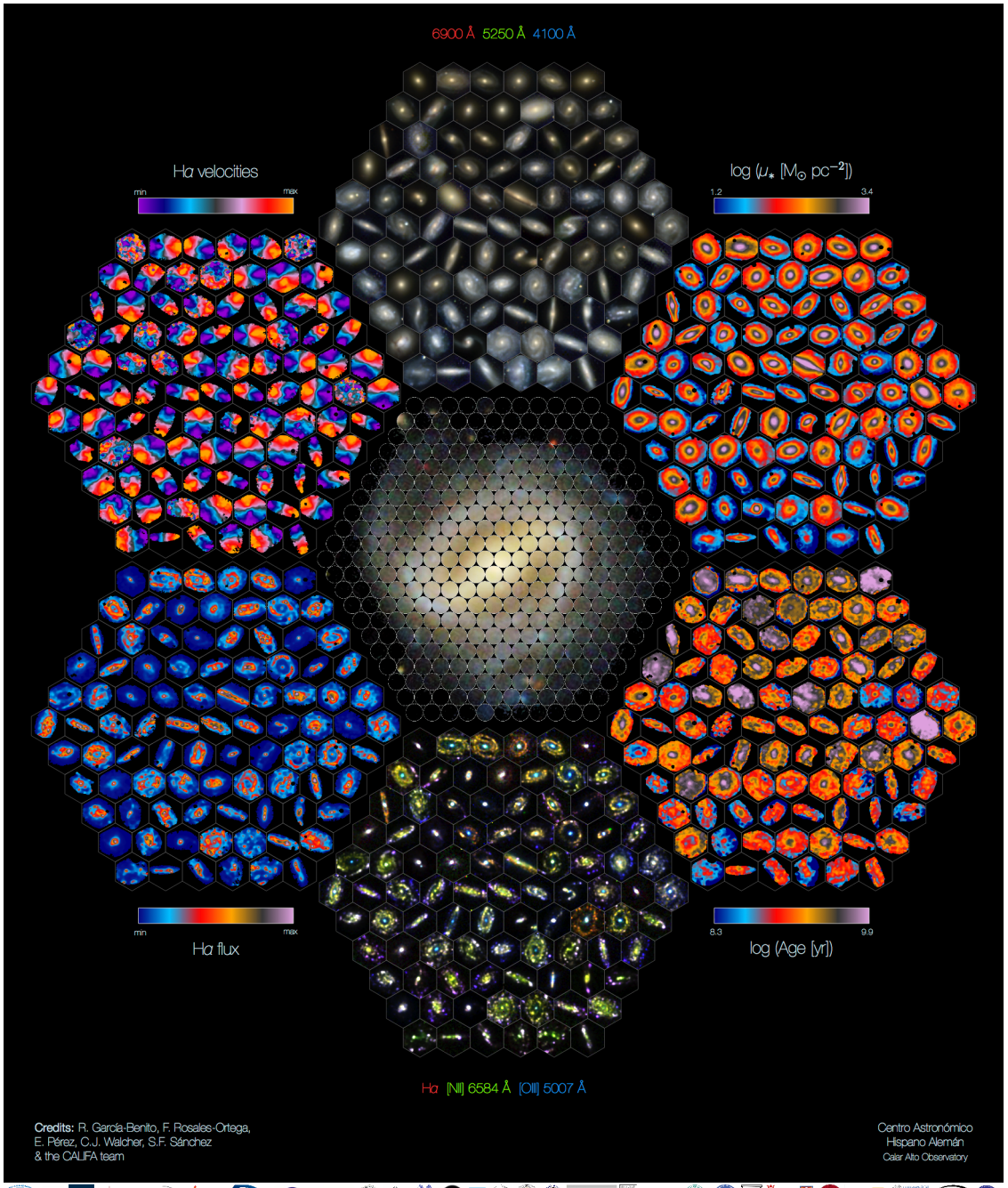
  Spatial resolution ~1 arcsec

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

DR1 (100 galaxies), Husemann+13
DR2 (300 galaxies), García-Benito in prep.

Calar Alto Legacy Integral Field Area

Sánchez+12



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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)

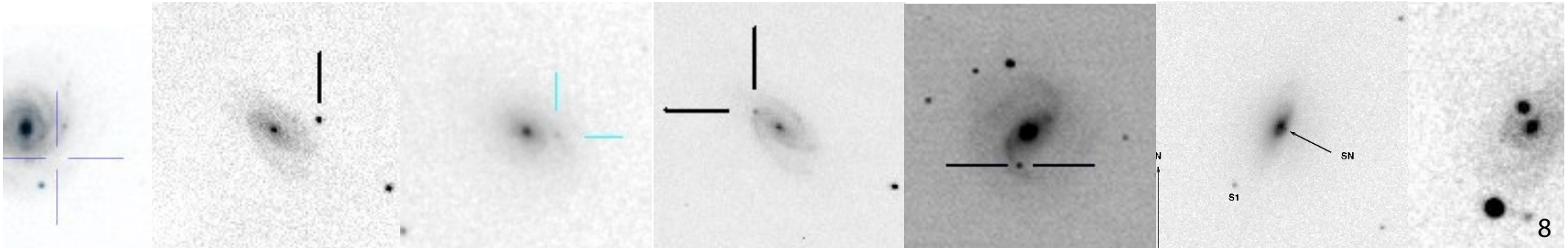
58 SNe in the field of view: 22 II, 13 Ibc/IIb, 23 Ia

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.
12 mergers, Barrera-Ballesteros in prep.

37 SNe: 11 II, 7 Ibc/IIb, 19 Ia

95 SNe: 33 II, 20 Ibc, 42 Ia

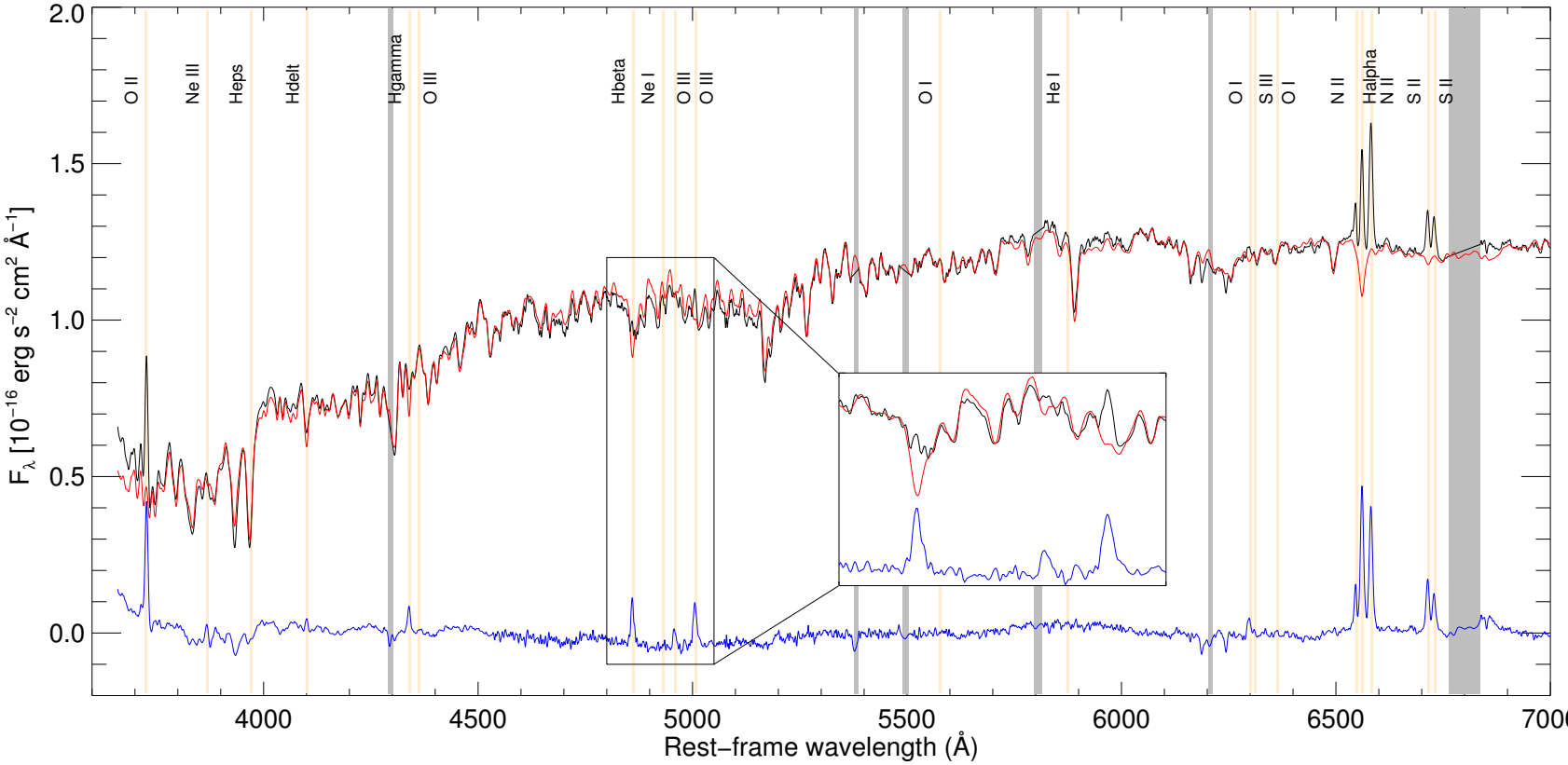


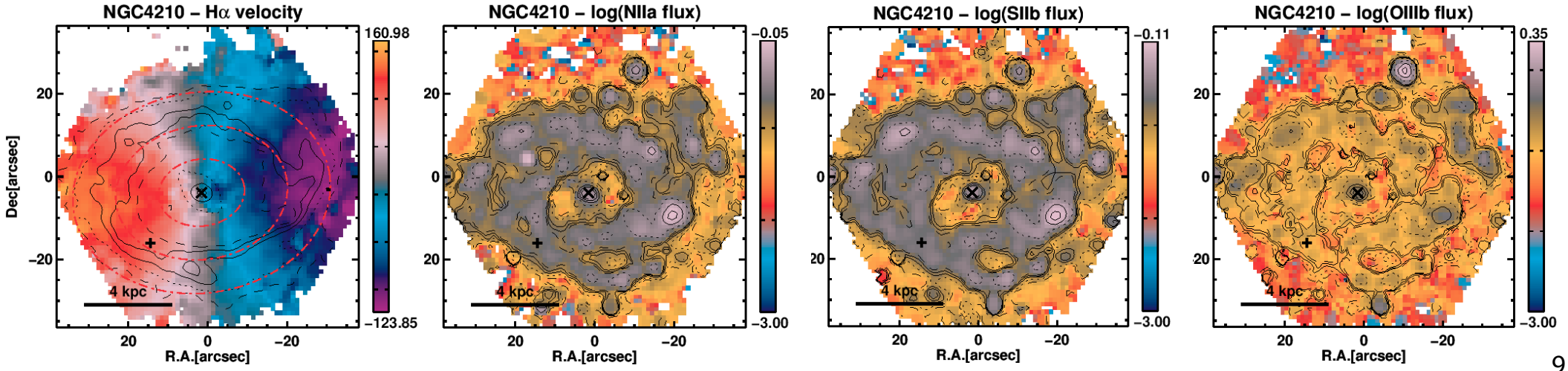
STARLIGHT

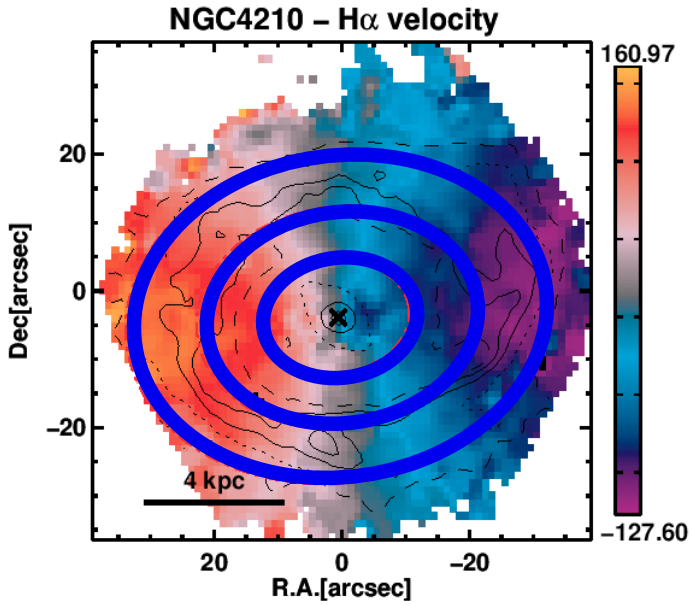
Cid Fernandes et al. 2005

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

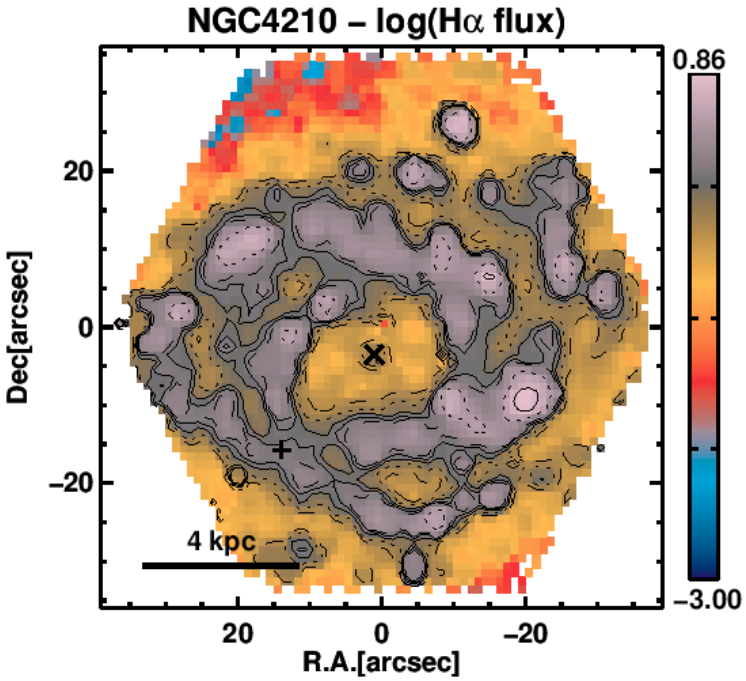
Fit ellipses using Krajnovic et al. 2006

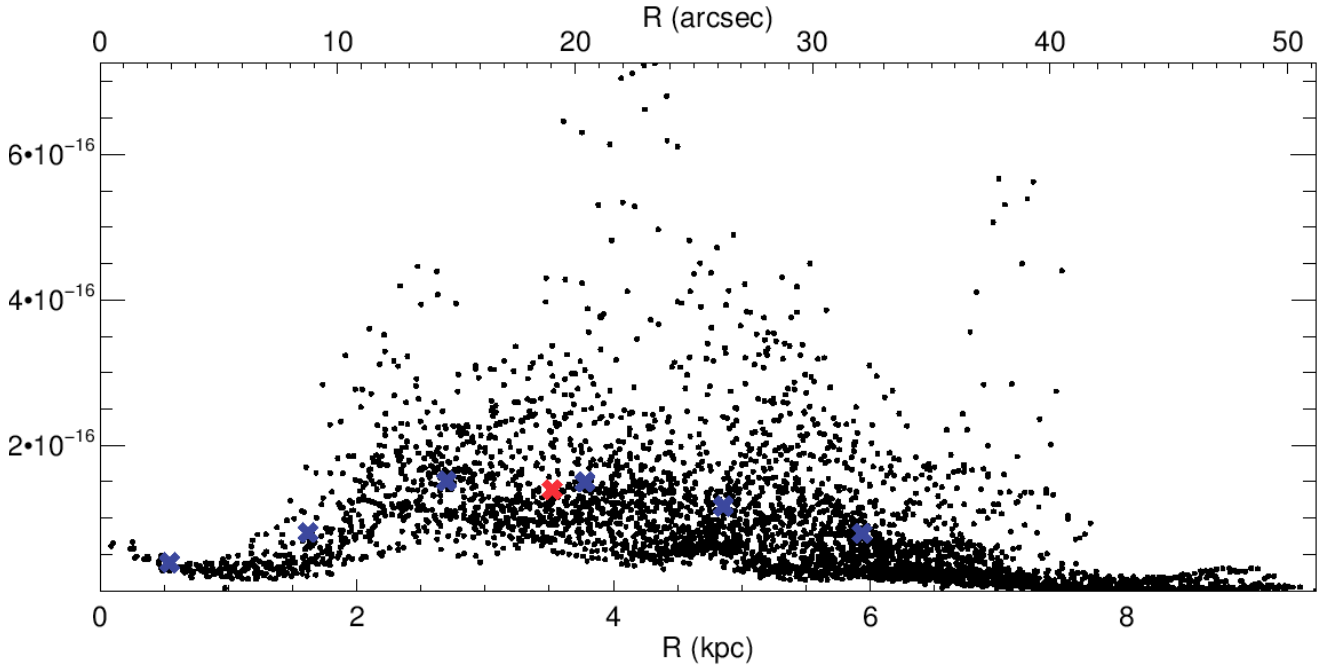
Deprojection

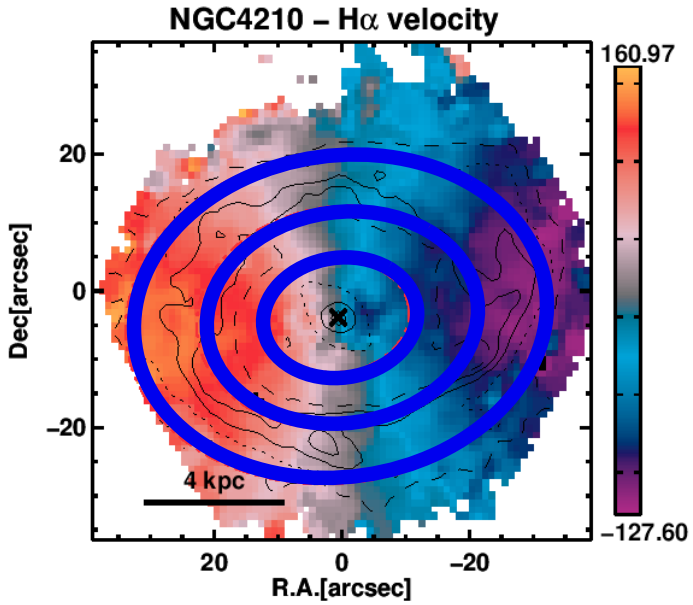
Measure distances in the galactic plane

Voronoi (spatial) binning

Increase S/N in the outskirts







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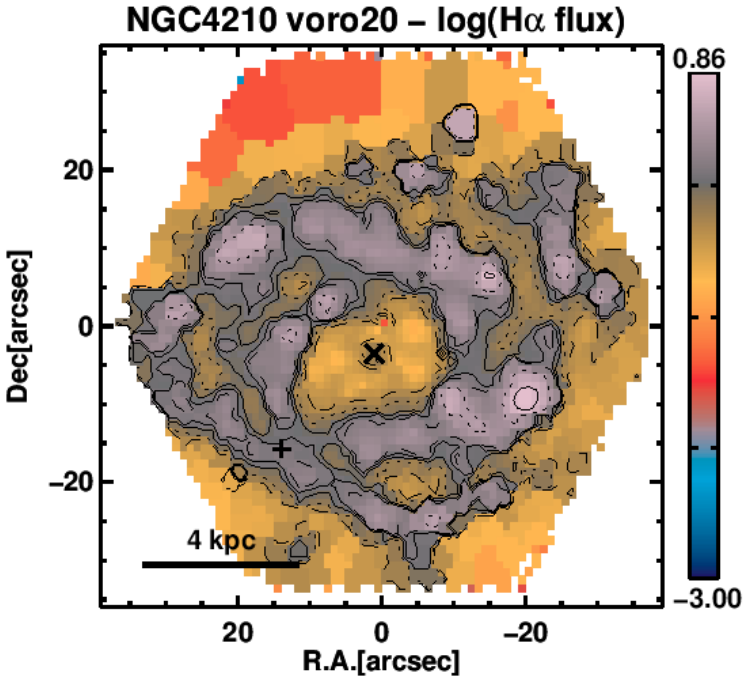
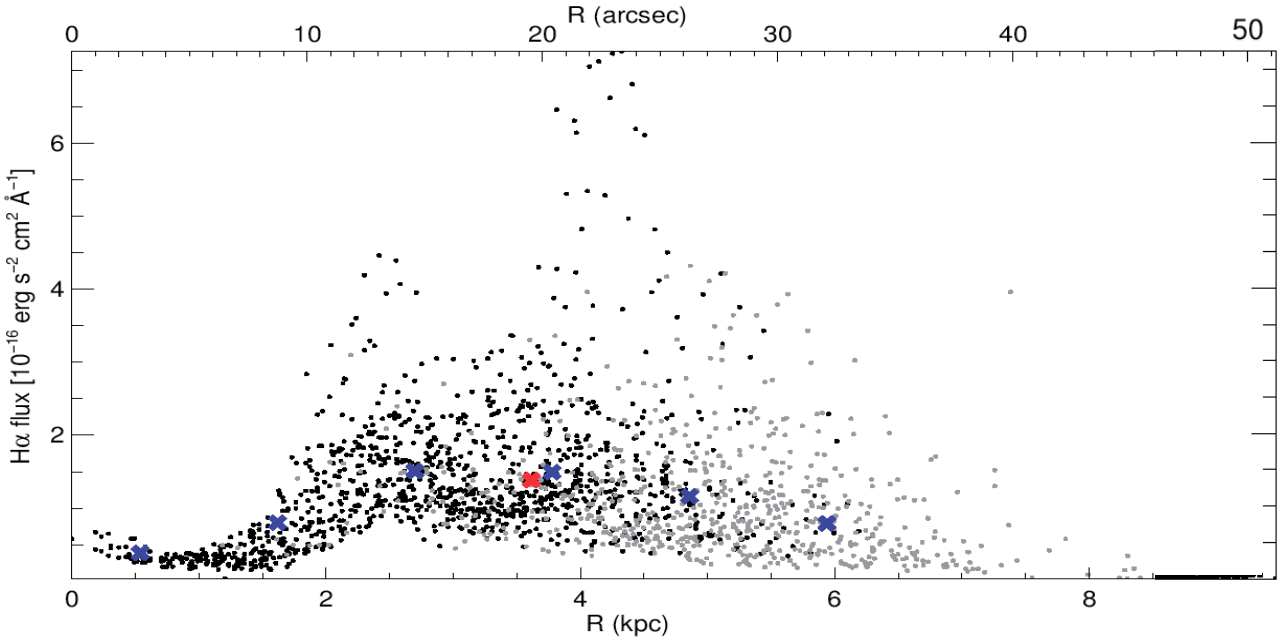




GCDs

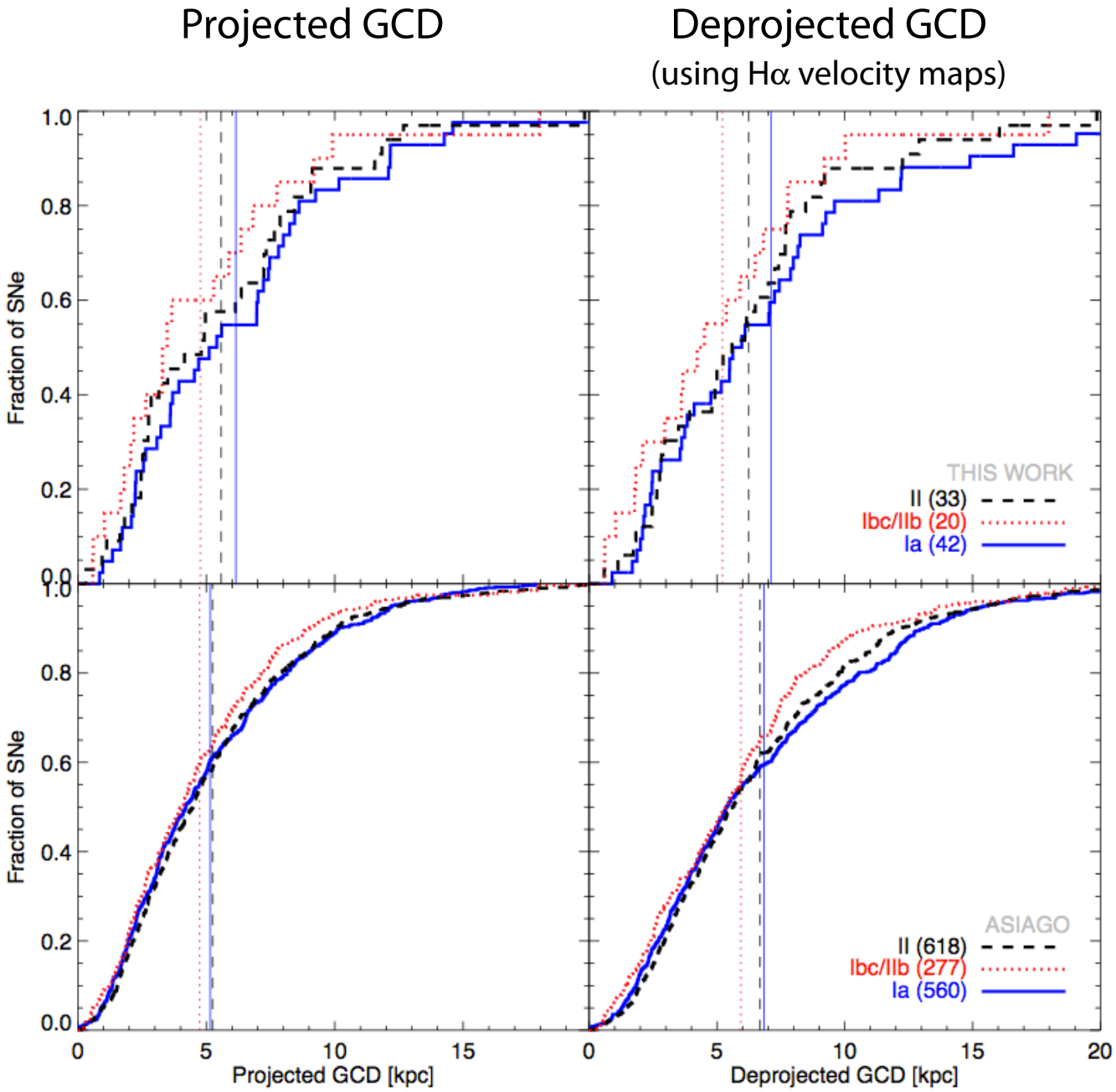
Distance as a proxy of local metallicity, assuming the presence of gradients (Galbany+12)

Comparison with ASIAGO SN catalogue

Ibc/IIb closer to the galaxy core

Ia found further

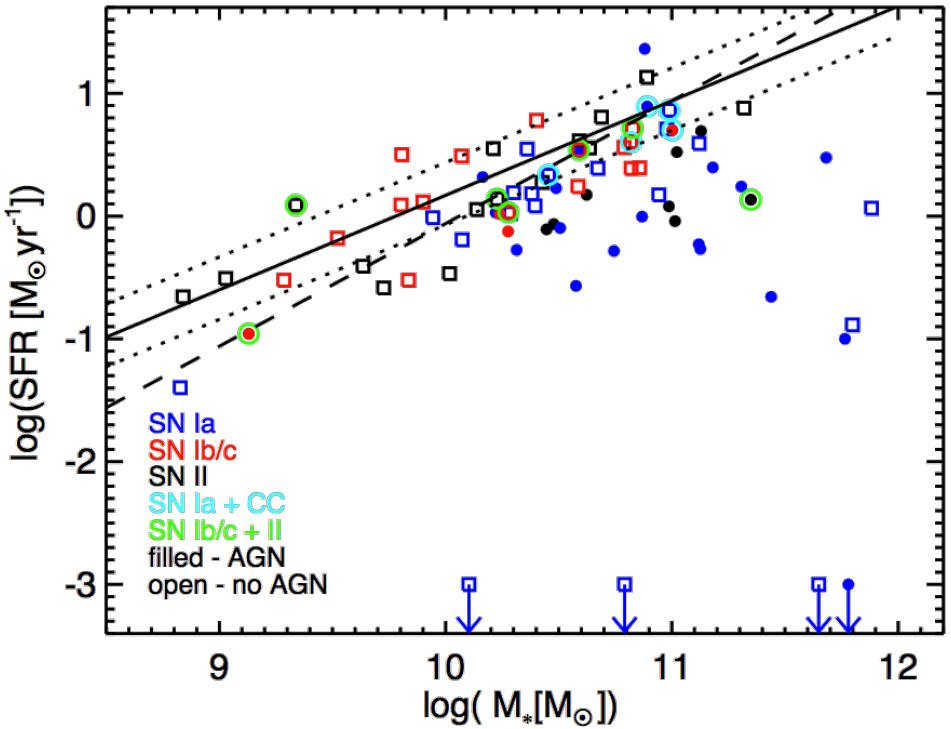
Ibc/IIb would explode in metal-richer environments since they explode closer to the center of the galaxy

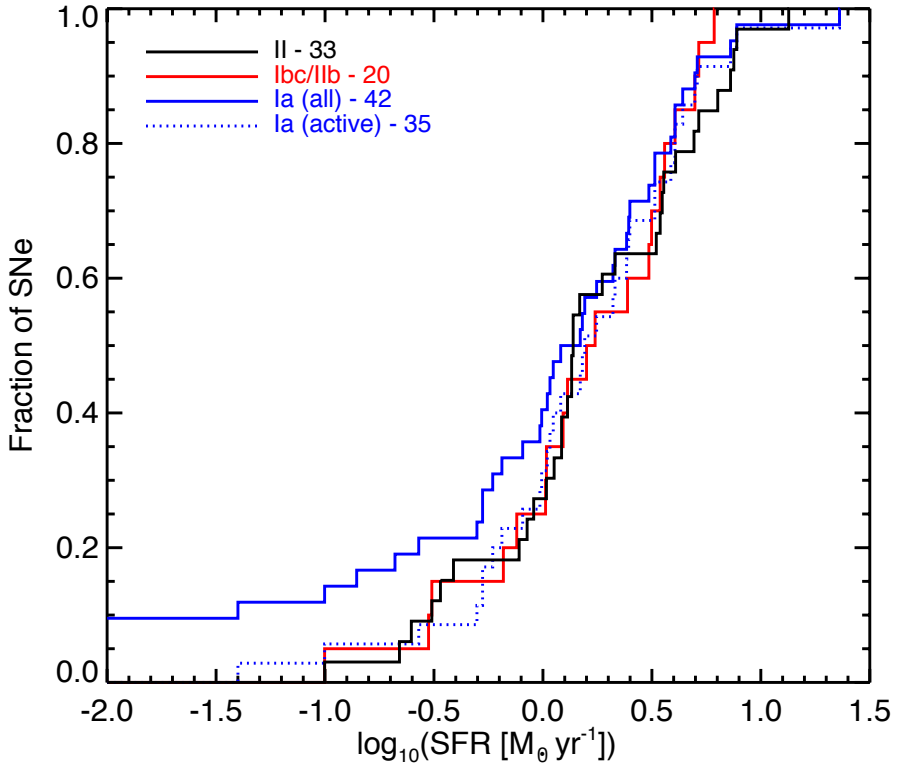


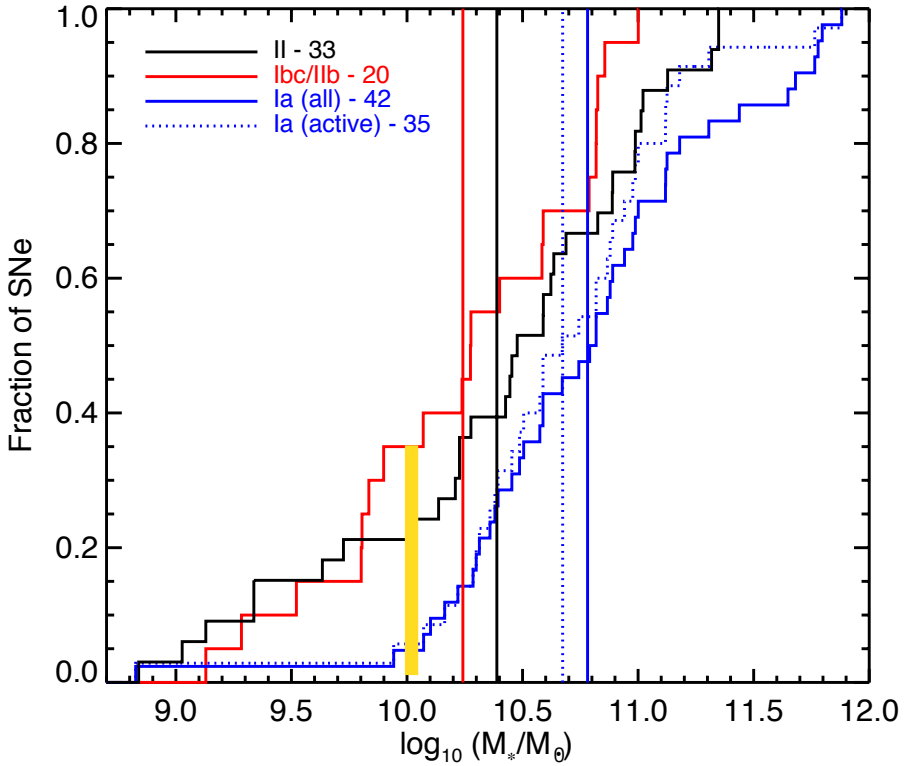
Global host galaxy properties

Construction of Integrated spectra

- on-going SFR from extinction-corrected Ha emission line maps
- galaxy total mass
- specific SFR (sSFR=SFR/mass)







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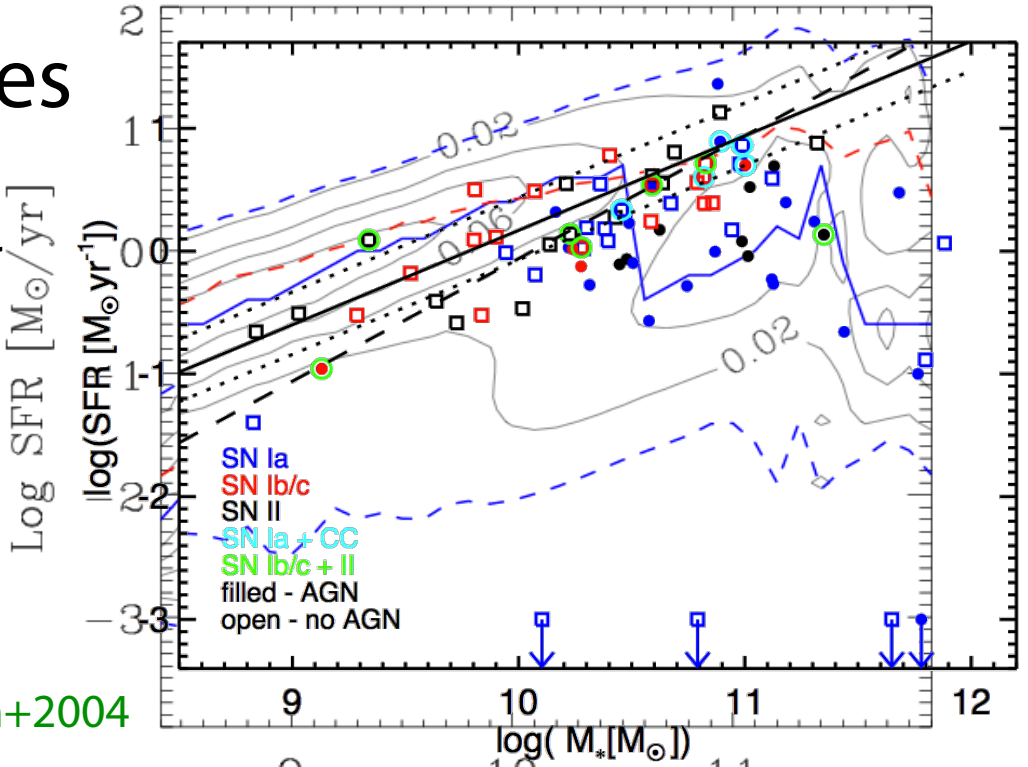
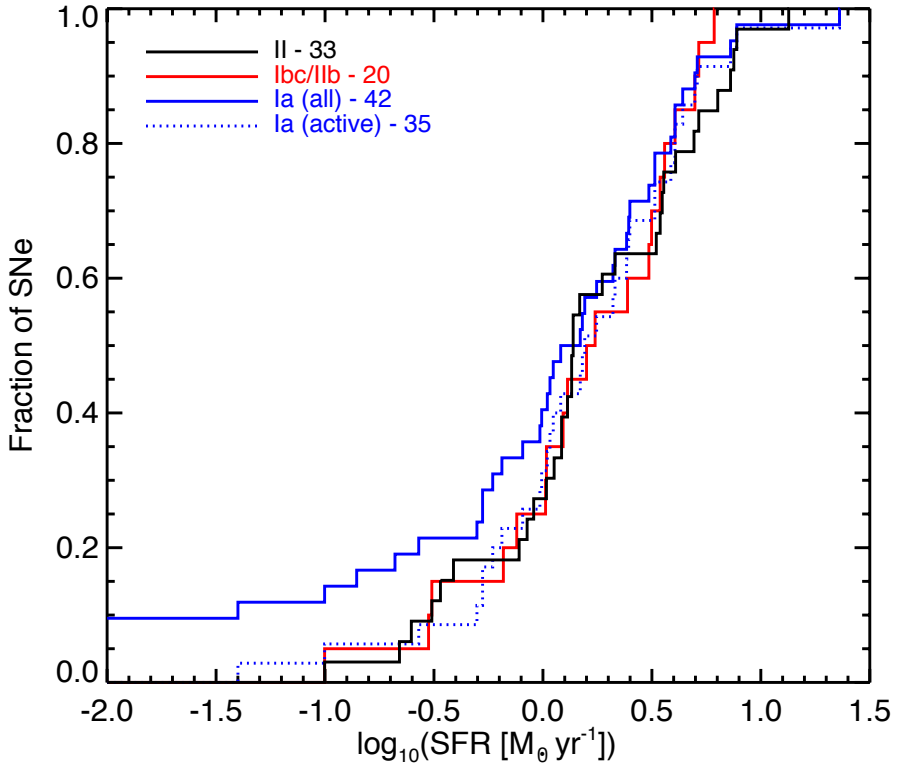
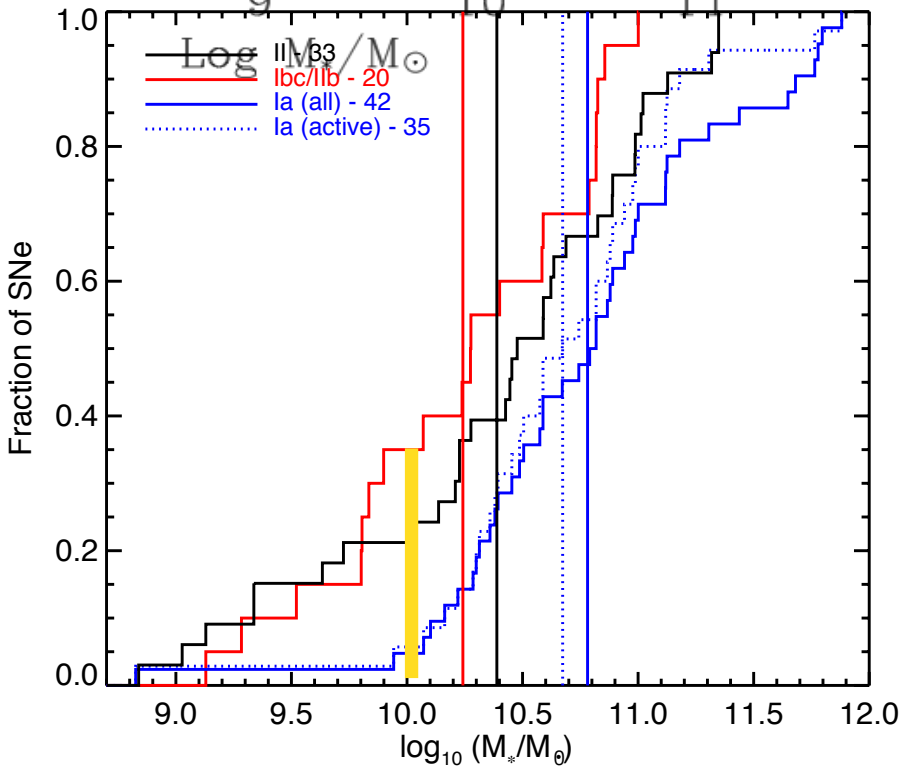


Brinchmann+2004





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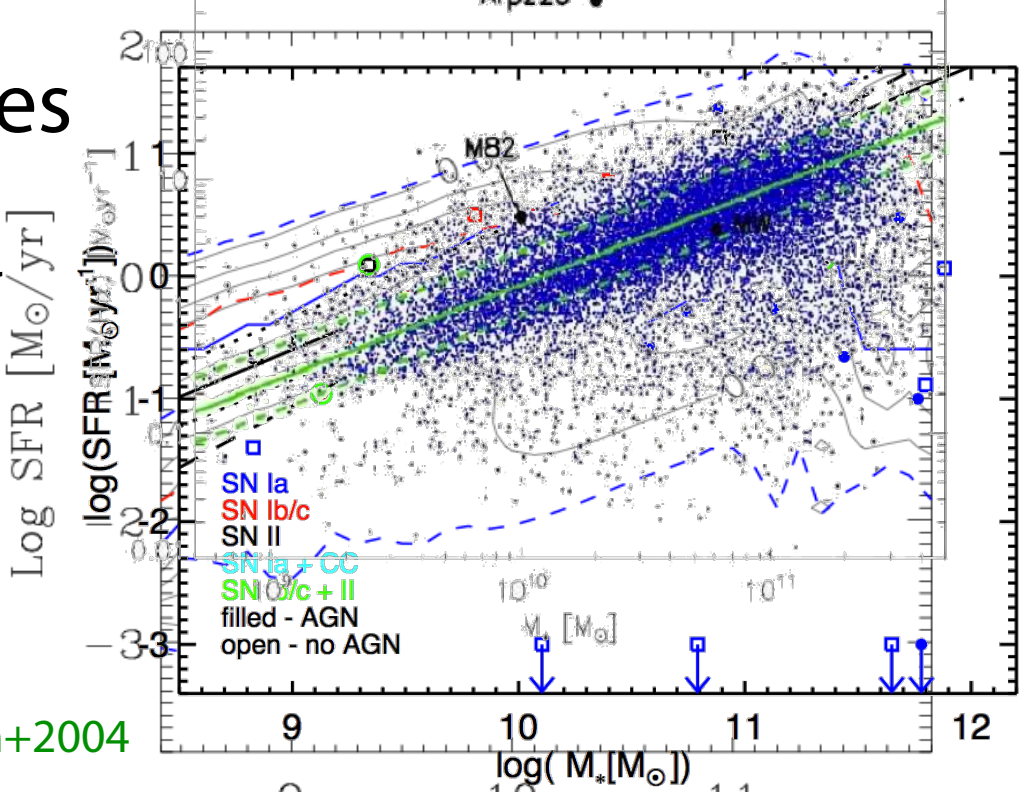
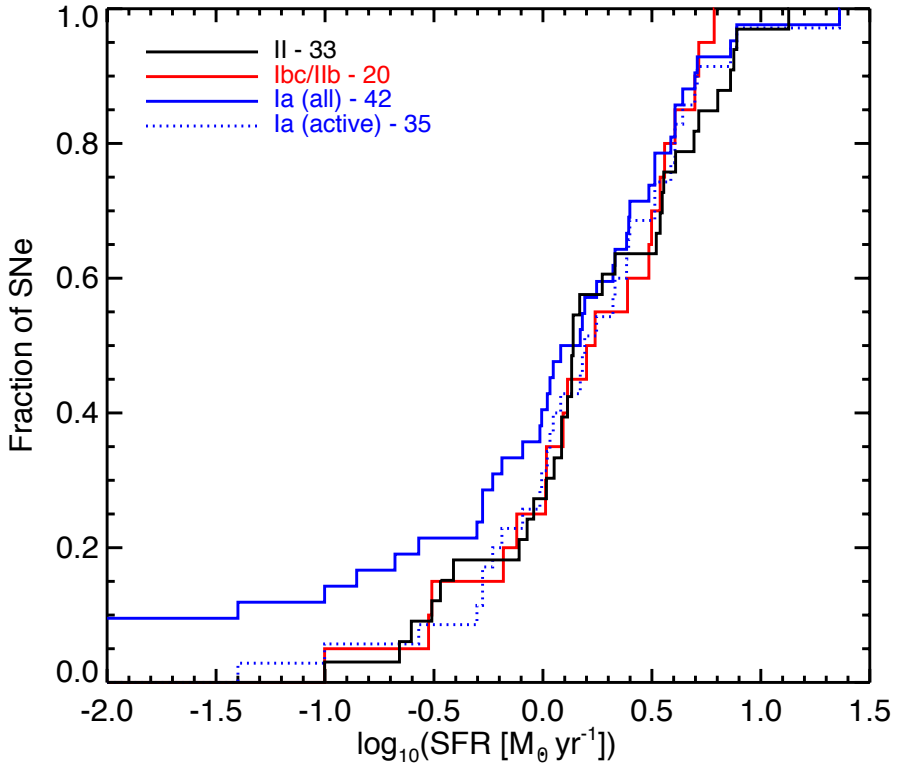
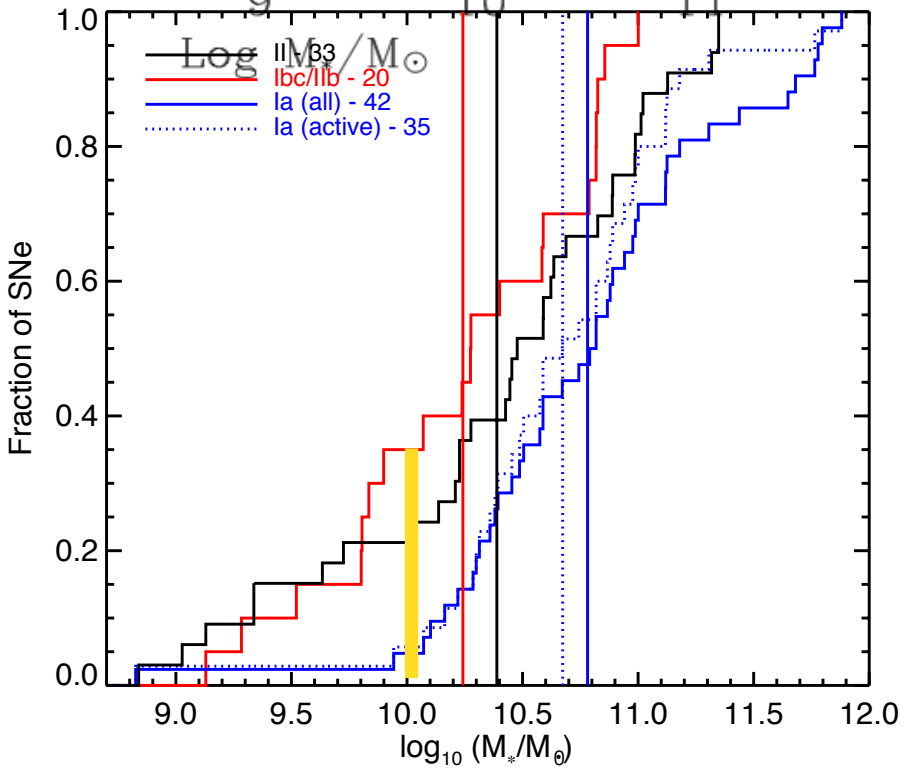
Elbaz+2007

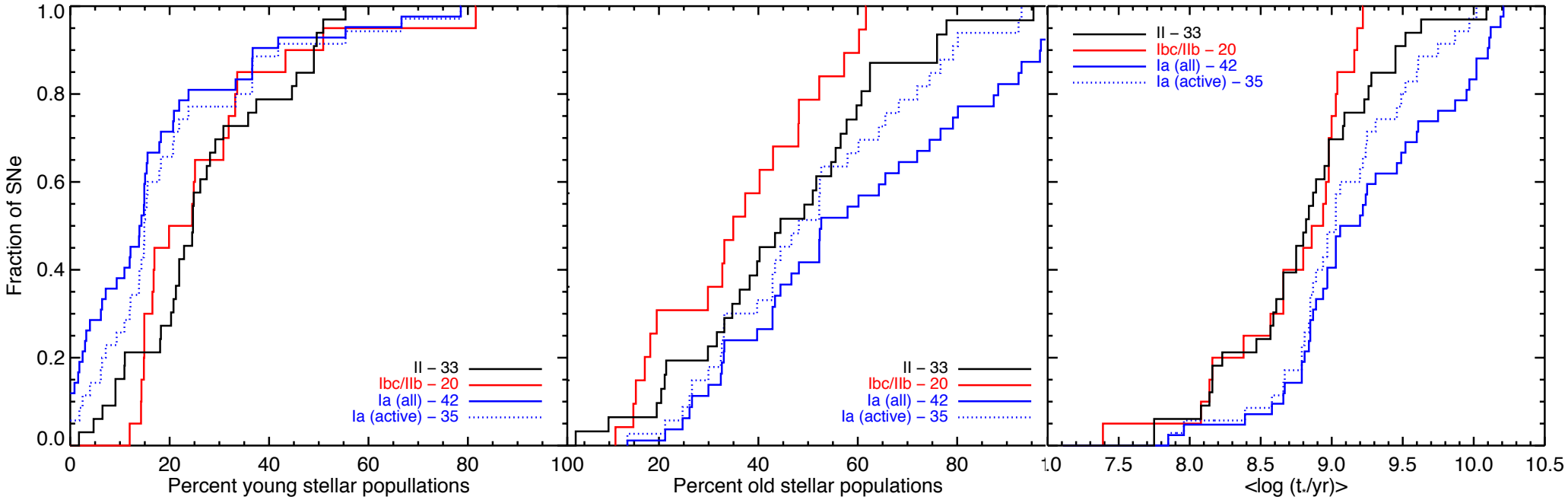
Brinchmann+2004







Global host galaxy properties

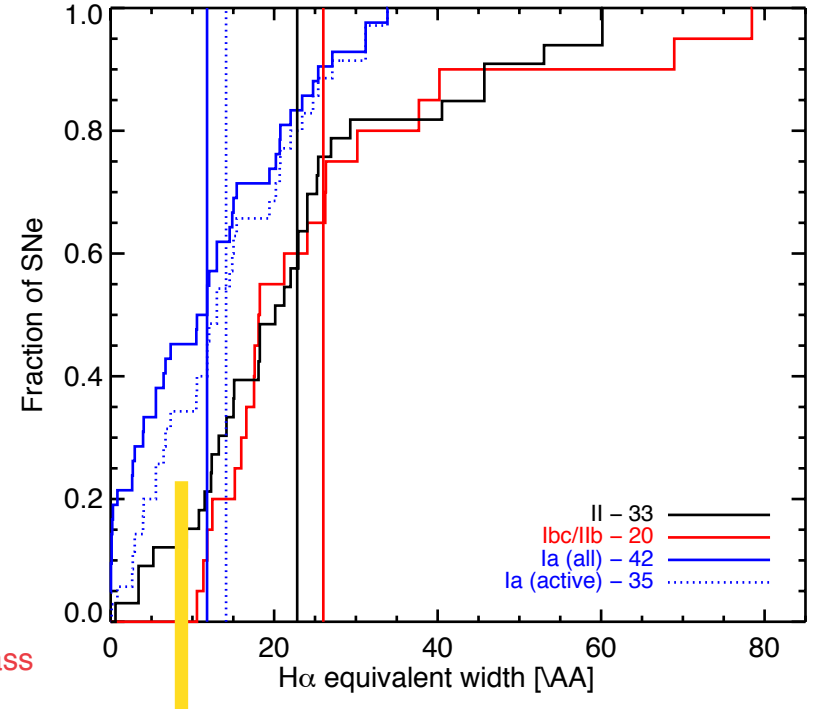


Most of the stellar mass is locked in old stellar populations

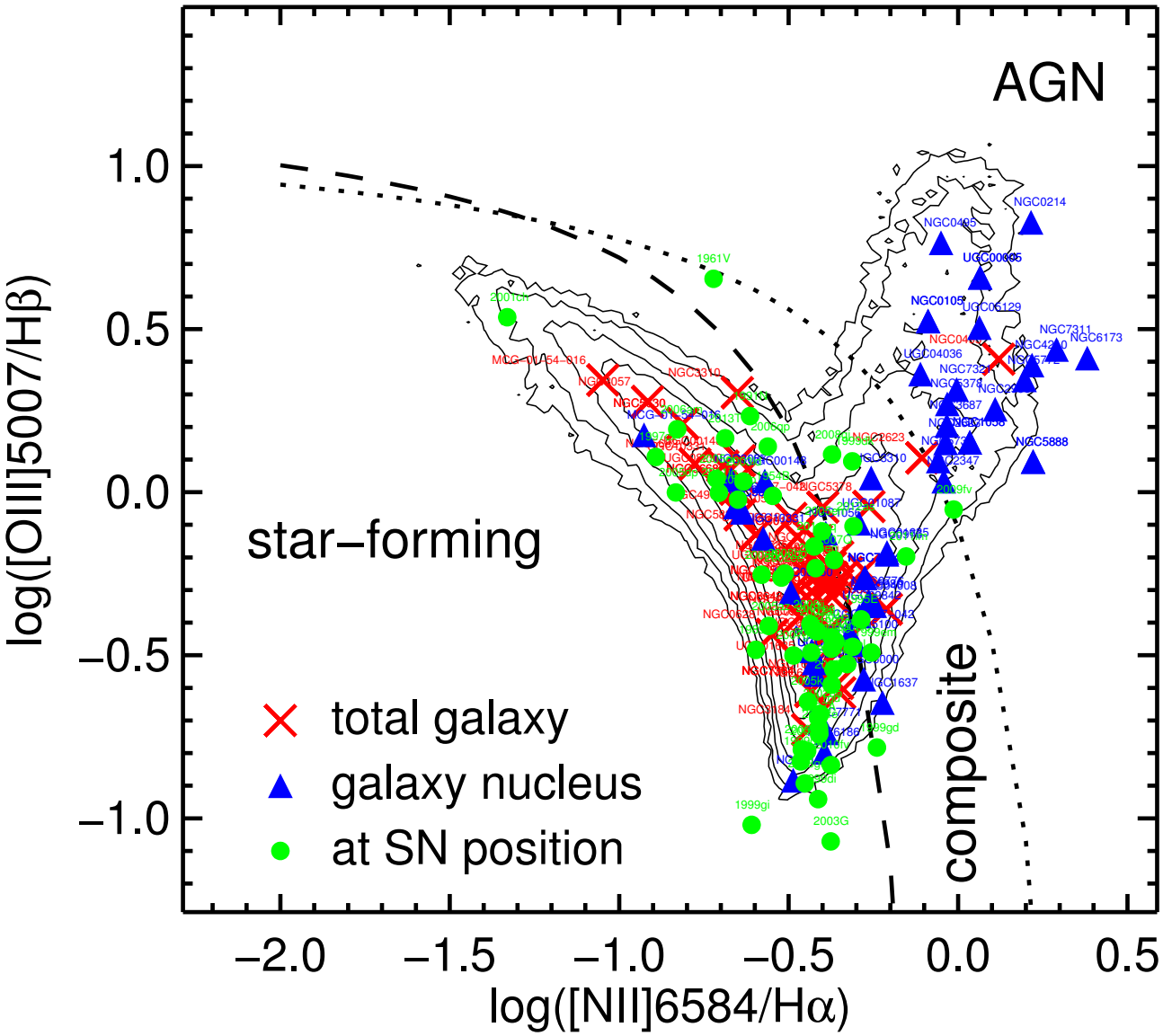
- SFH: percent of stellar populations
- galaxy mean age
- Ha equivalent width as a tracer of young stellar population

$$\sim \frac{\text{line}^{\text{gas}}}{\text{cont.}}$$

stars ~> mass



Global host galaxy properties - BPT diagram



Galaxy cores

50% Ia

30% II

20% Ibc/IIb

AGNs are diluted in integrated spectra

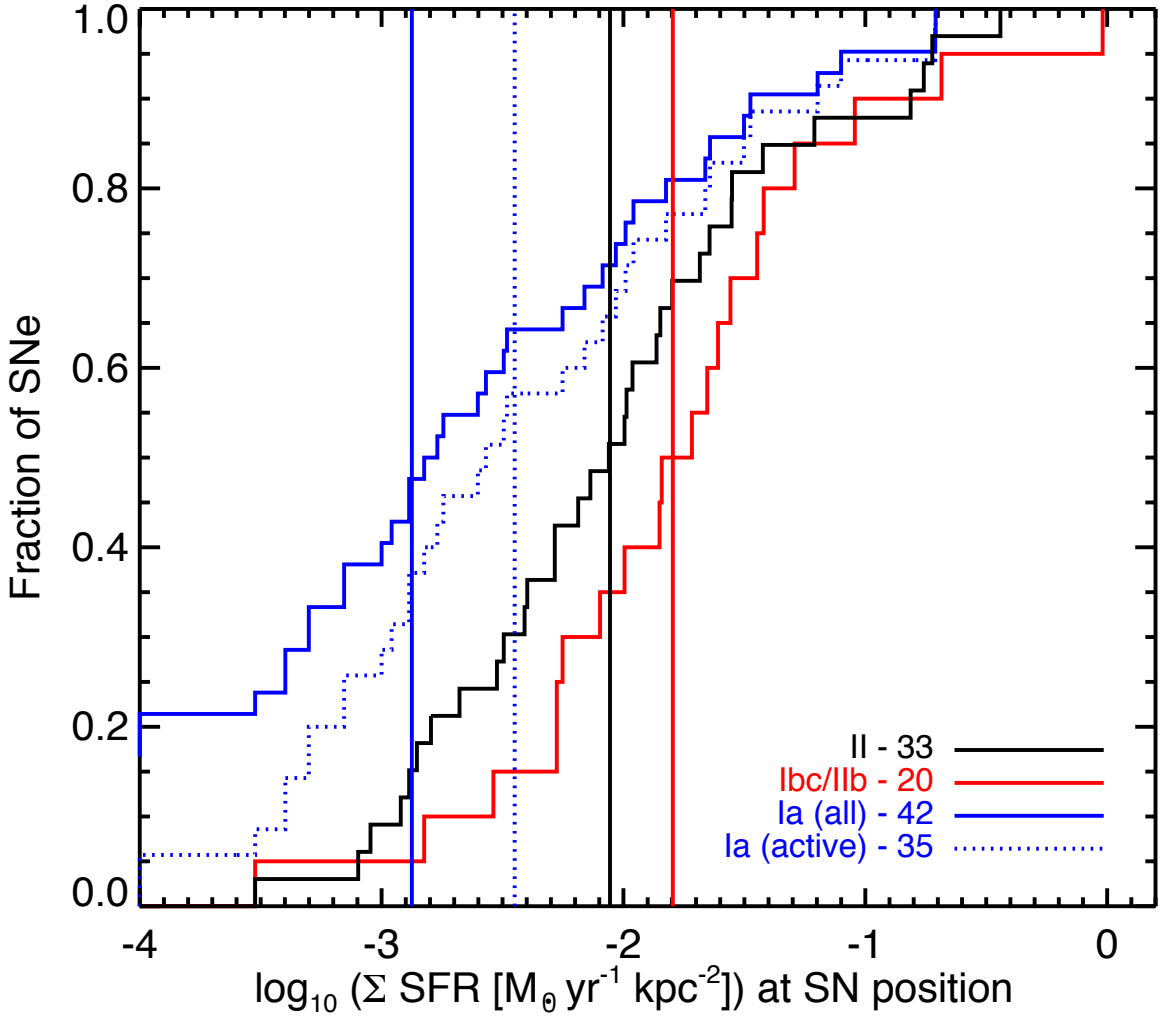
-> high-z

Local host galaxy properties

Star-formation rate density (ΣSRF=SFR/kpc^2)

SFR in the same neighboring region

Accounting for inclination

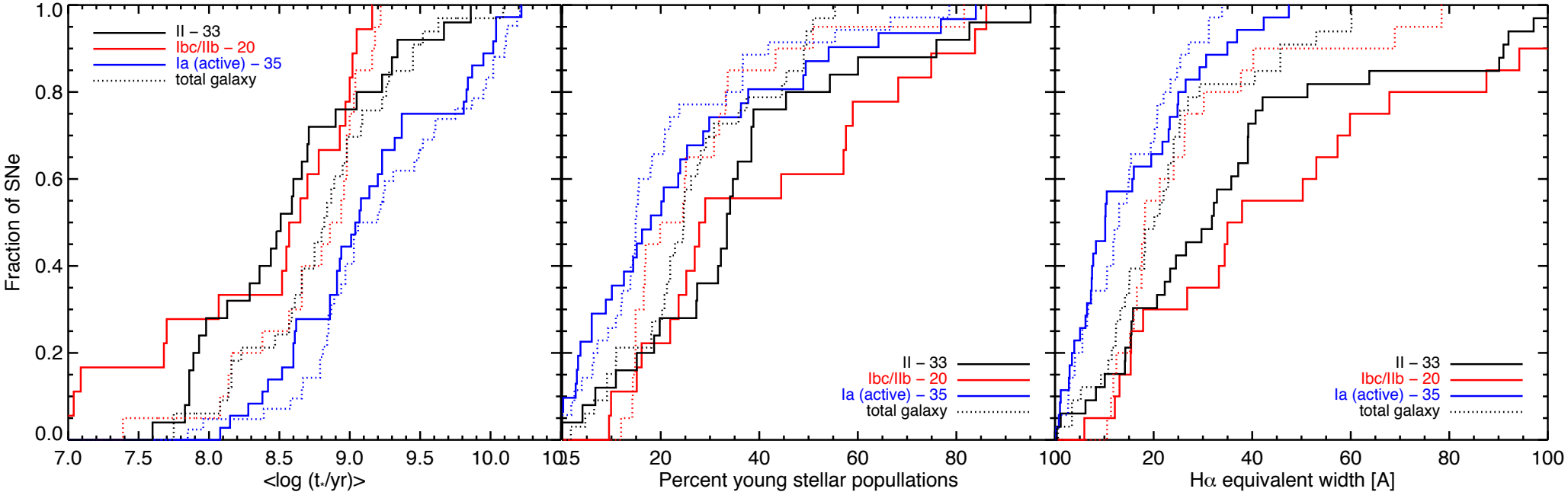


II	-2.05
Ibc/IIb	-1.80
Ia -SF	-2.44
Ia -all	-2.89

Even in galaxies with similar SFR, Ibc/IIb tend to explode in higher ΣSRF regions than II and Ia

Local host galaxy properties

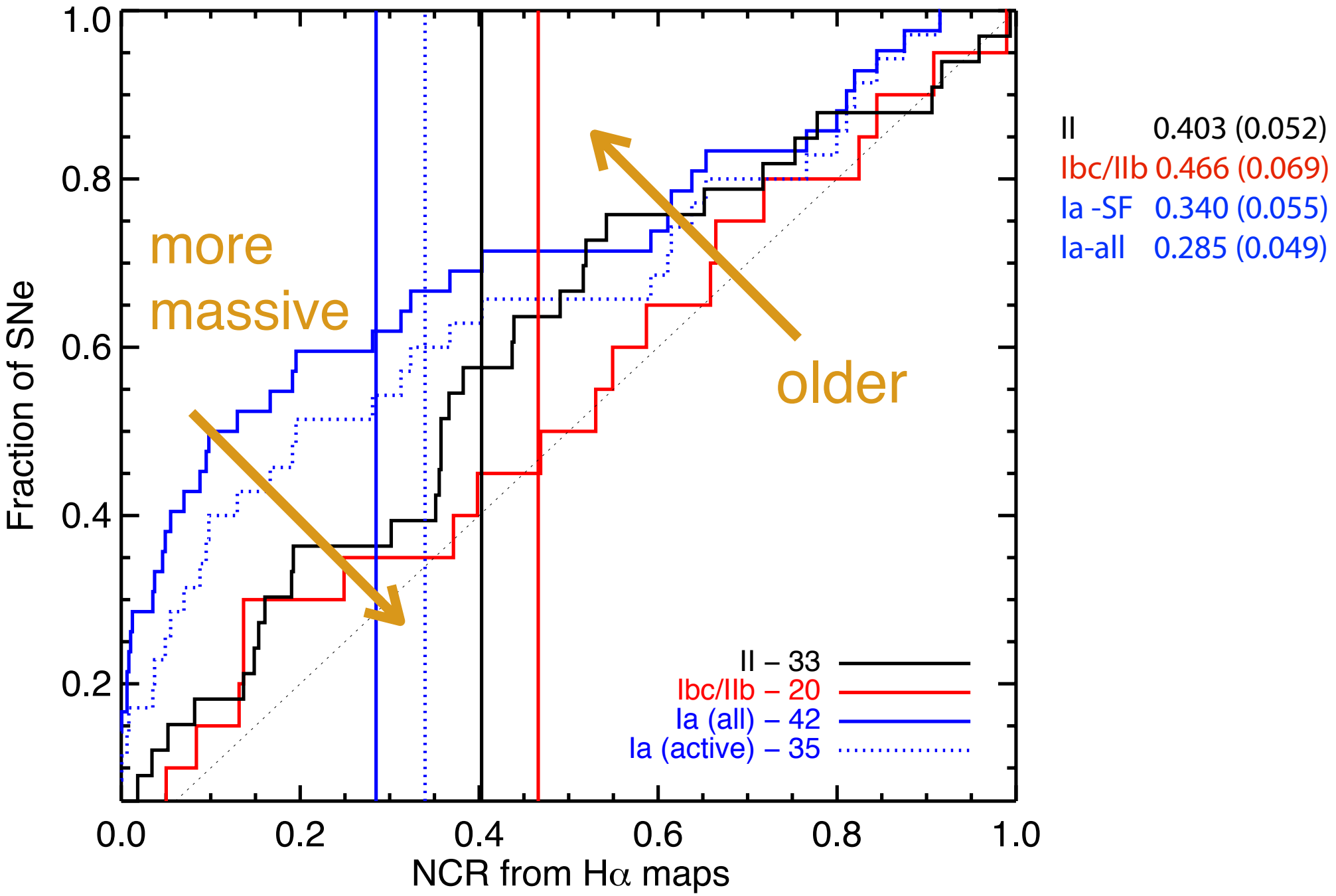
- Stellar age
- Percent of young stellar population
- Ha equivalent width



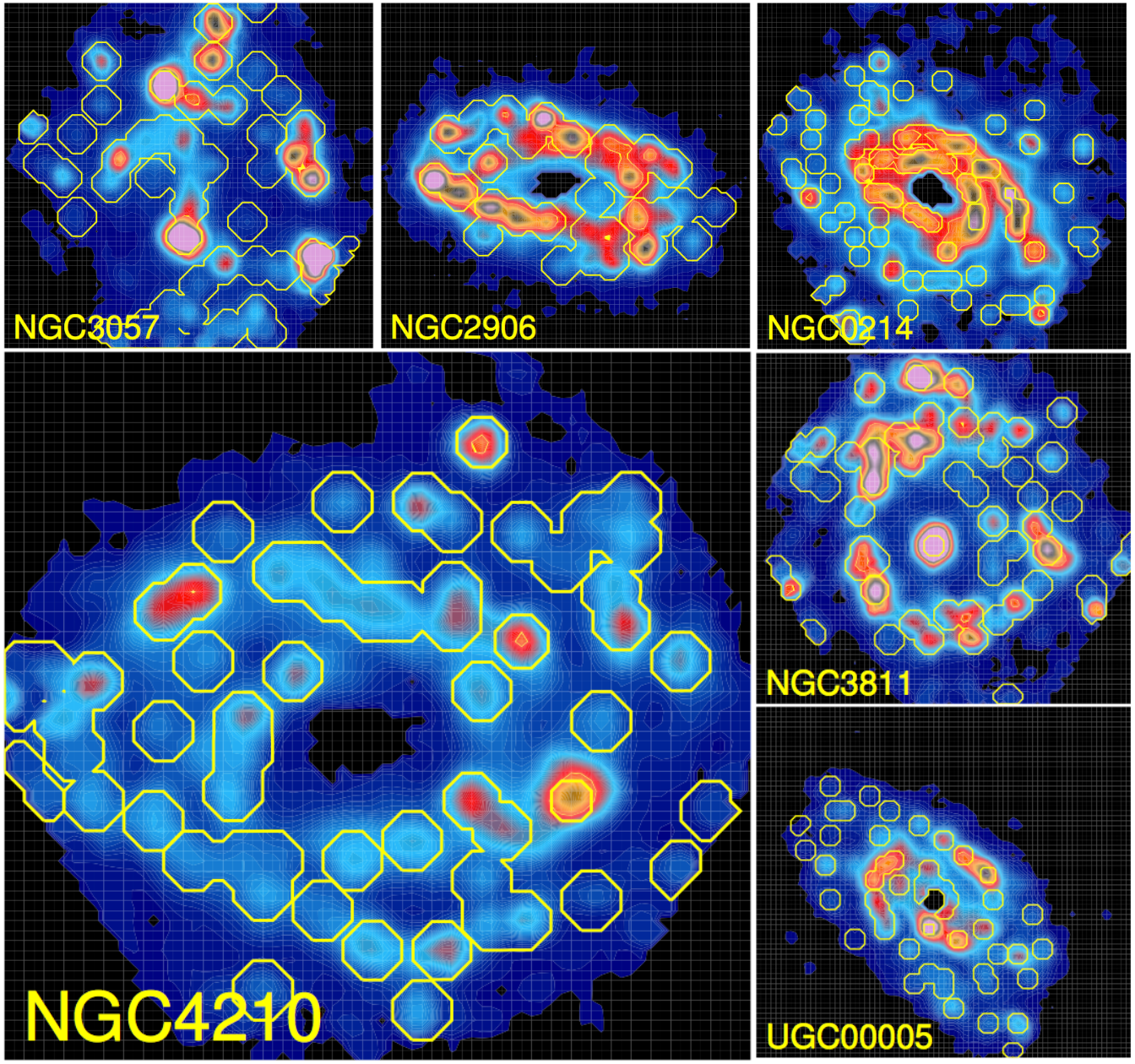
II	8.551 (0.106)	II	35,8 (4.1)
Ibc/IIb	8.356 (0.168)	Ibc/IIb	41.0 (5.8)
Ia -SF	8.978 (0.084)	Ia -SF	24.1 (3.8)
Ia-all	9.121 (0.091)	Ia-all	21.1 (3.5)

II	36.7 (5.0)
Ibc/IIb	57.3 (14.3)
Ia -SF	15.2 (2.2)

Local host galaxy properties - NCR



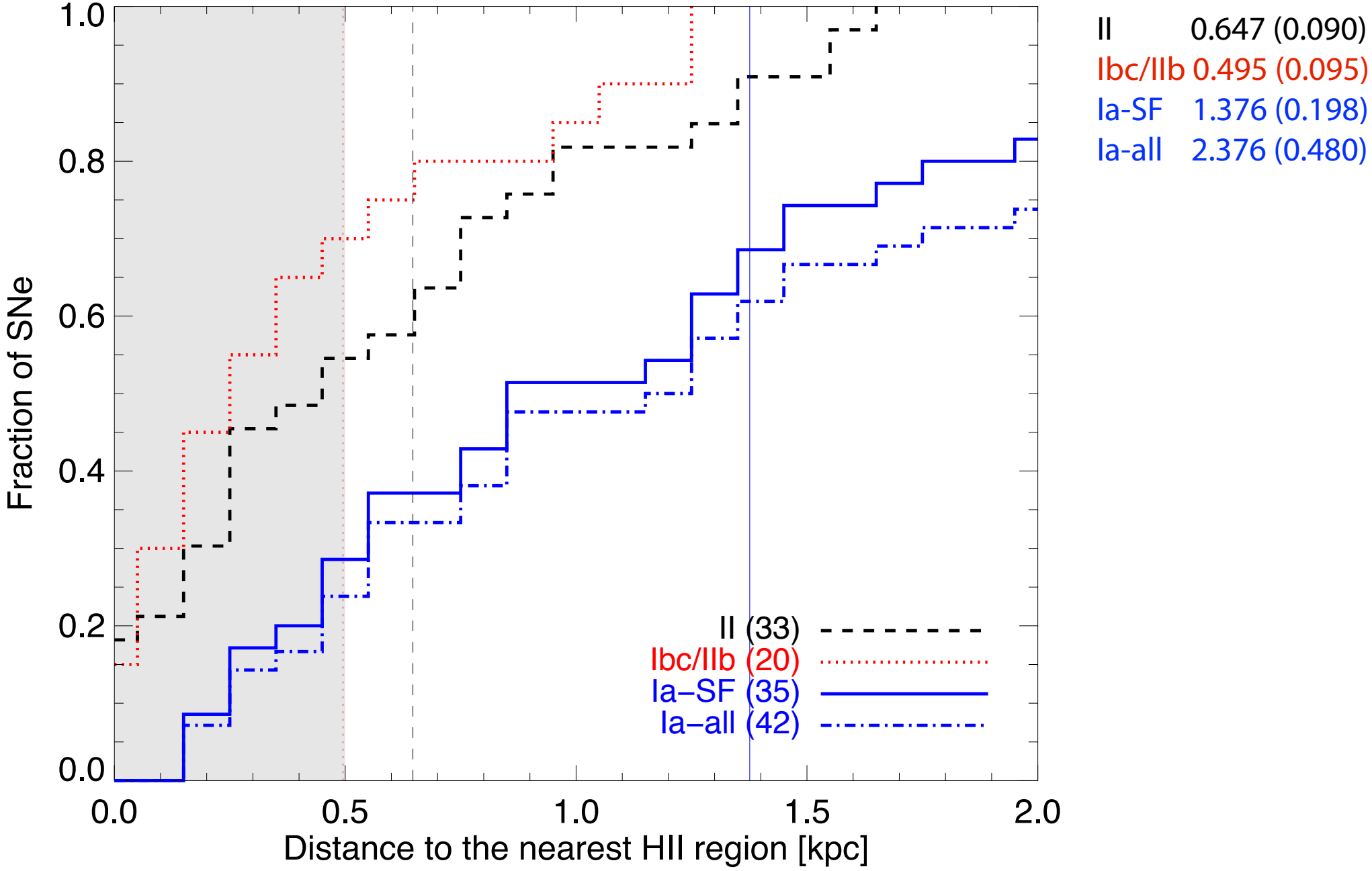
Local host galaxy properties - star forming regions



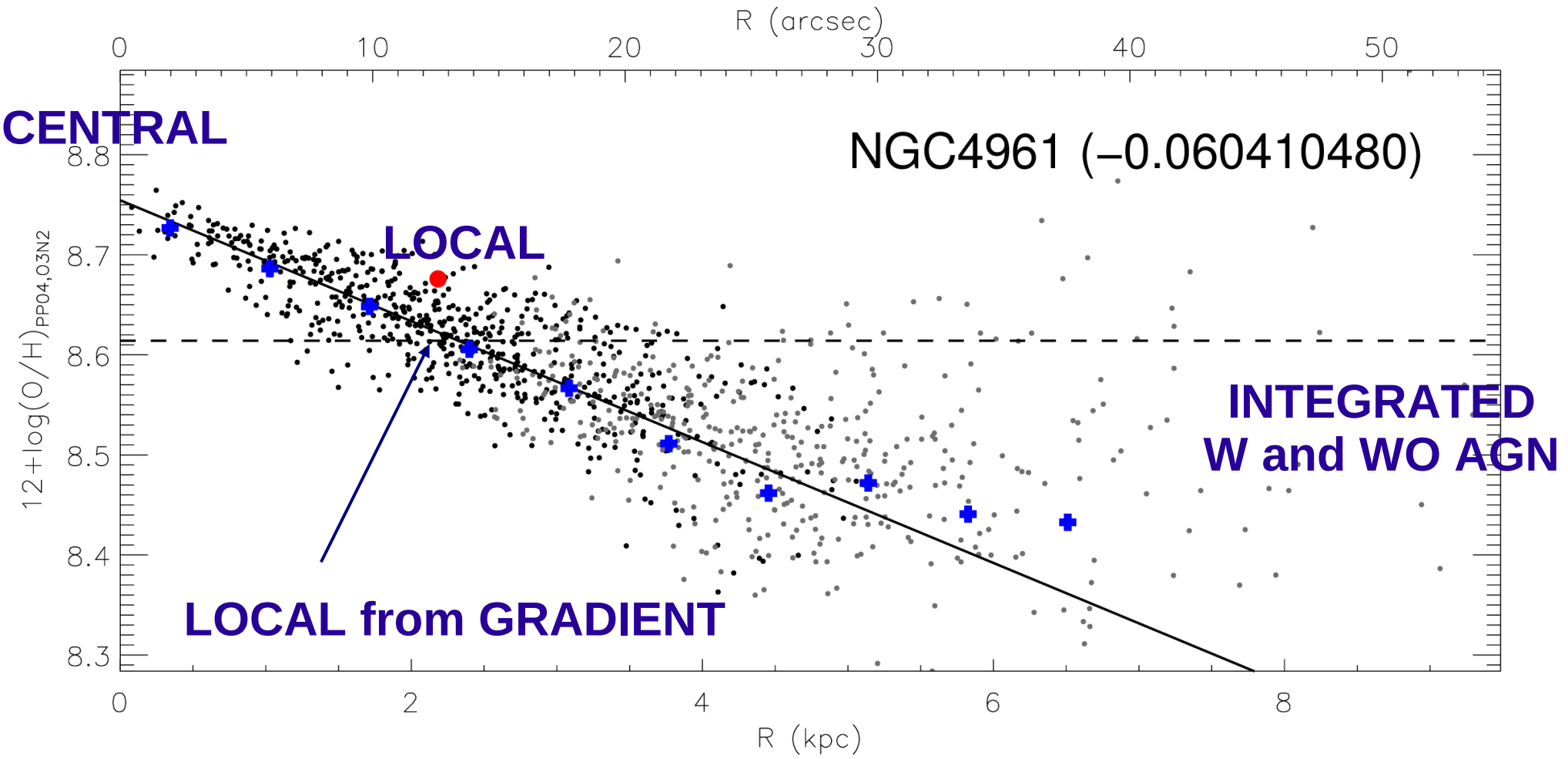
HII clupms selected from Hα maps using HIIexplorer (Sánchez+12)

Measure distances from the SN explosion site to the nearest HII clump

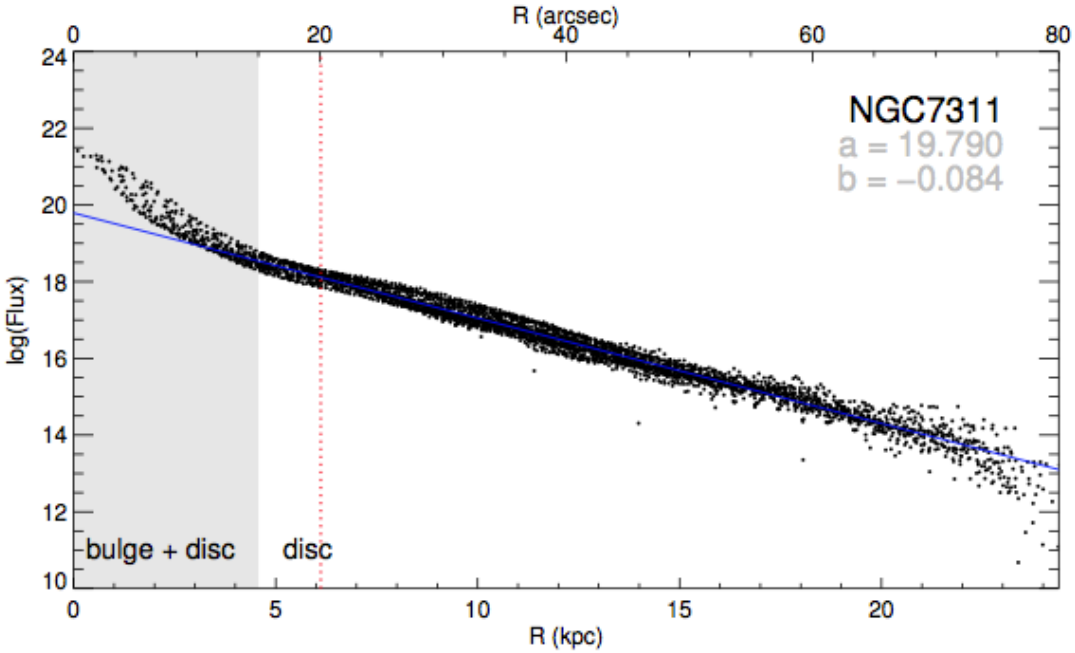
Local host galaxy properties - star forming regions

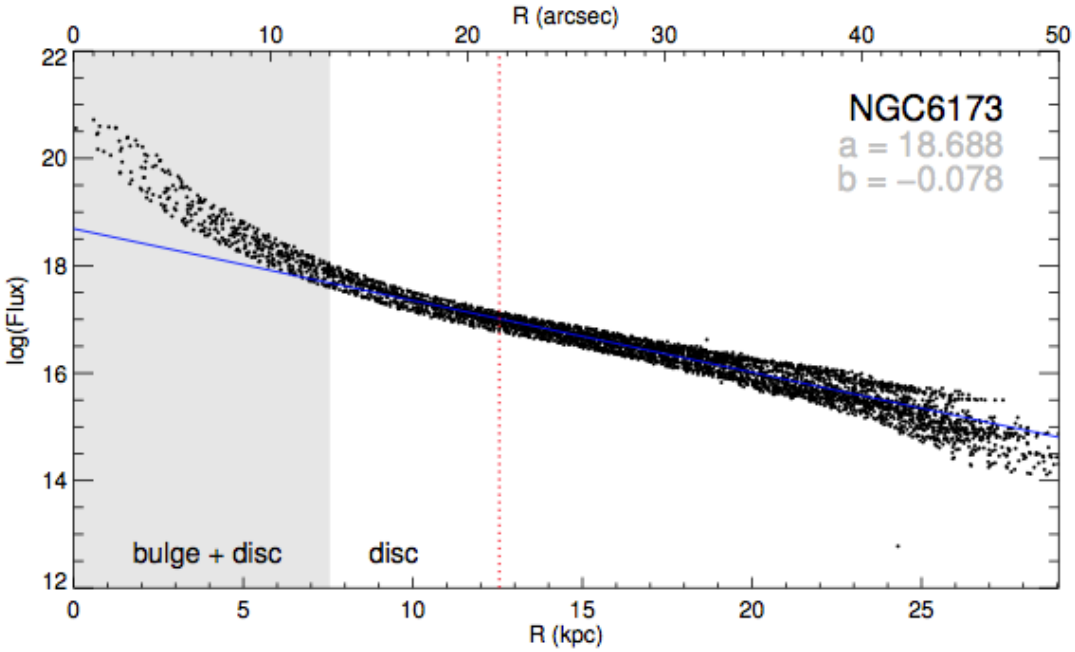


Local host galaxy properties - oxygen abundance



Disk effective radius (r_e)

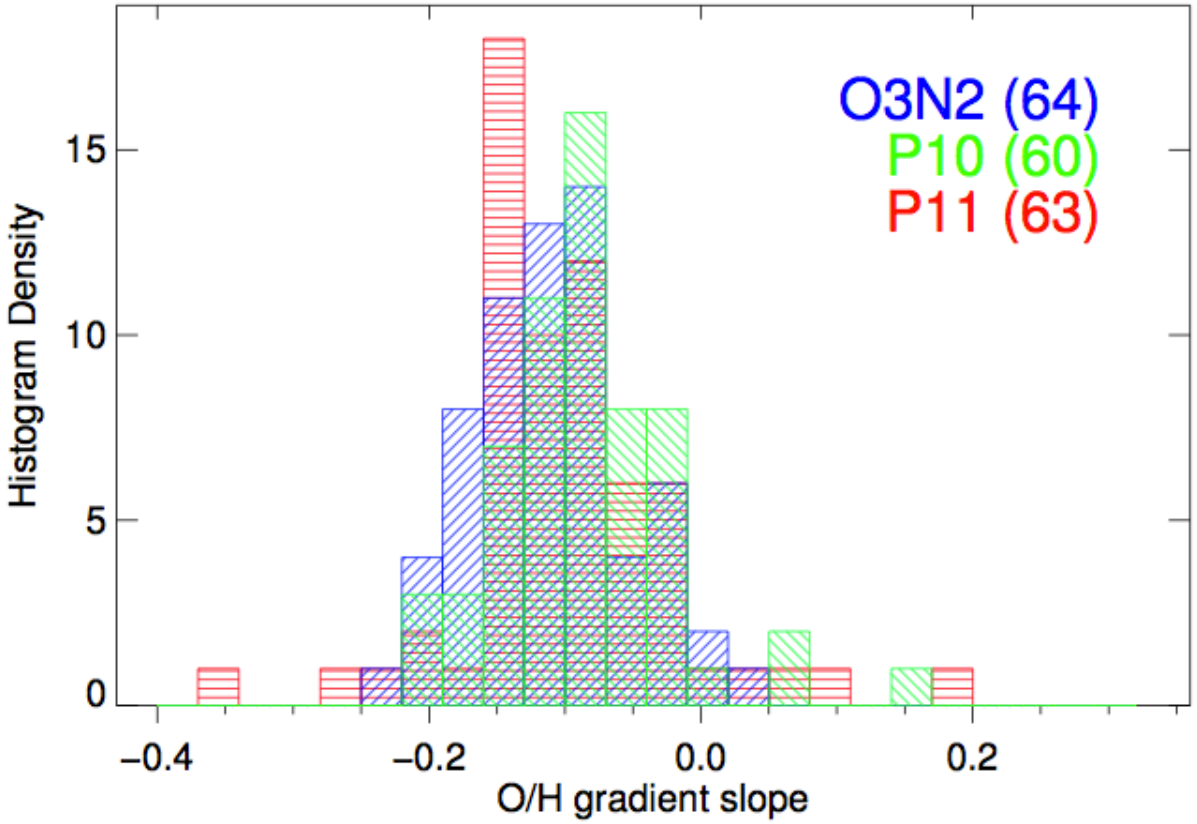


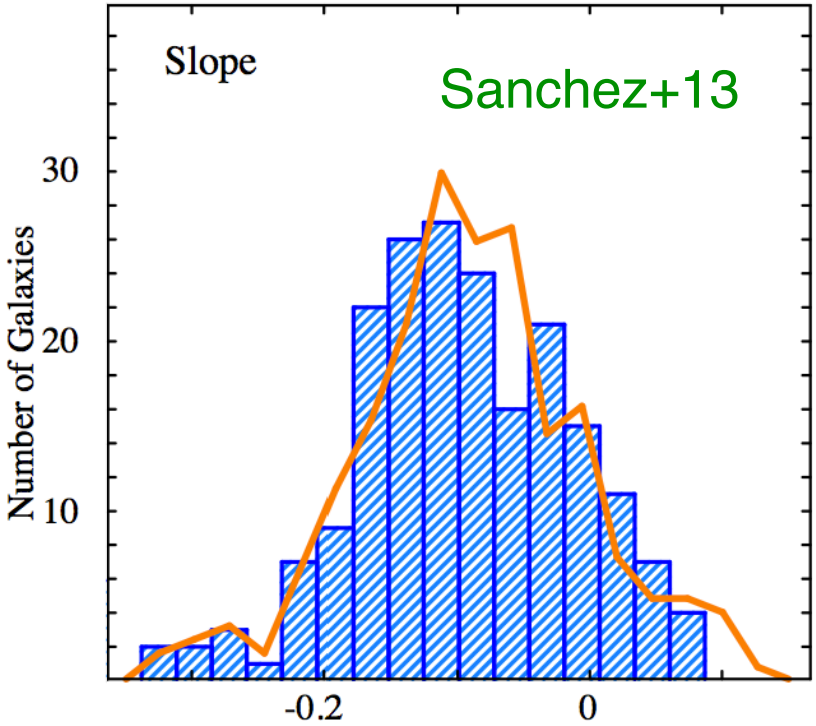


Determination of the disk effective radius by fitting the light profile contribution from the disk

Decoupling bulge and disk using the projection of the r-band brightness

Local host galaxy properties - metallicity gradients



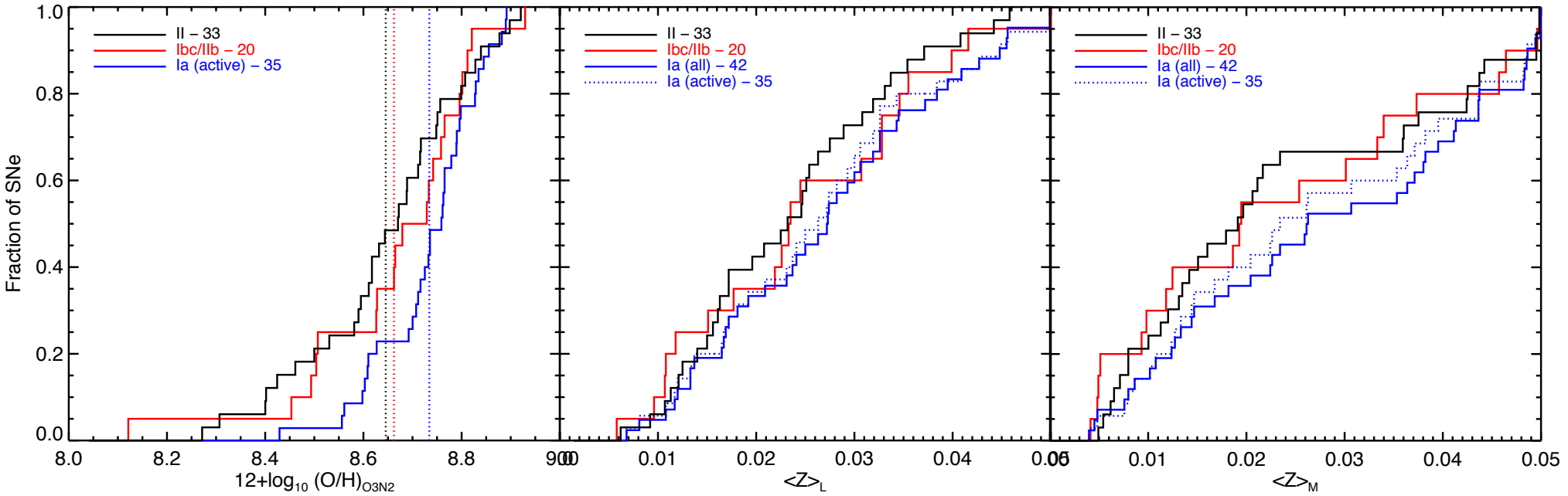


Show a characteristic gradient (~ -0.1 dex)

No dependence on O/H estimator or SN type

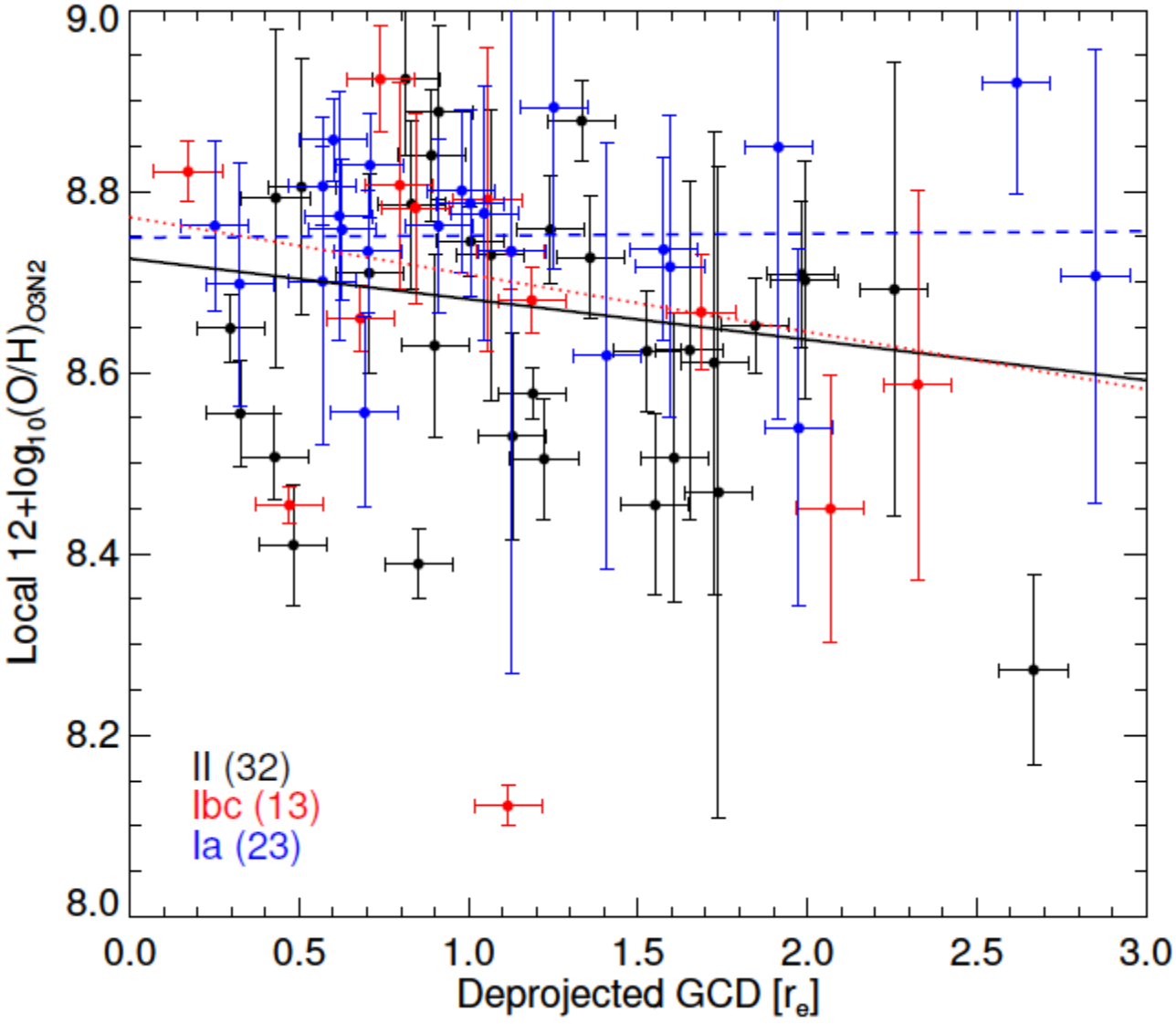
Local host galaxy properties - local metallicity

- Oxygen abundance from the emission lines (with several indicators)
- Stellar metallicity from the fit to the continuum fit (Z_L, Z_M)



II	8.645 (0.029)	0.023 (0.002)	0.024 (0.003)
Ibc/IIb	8.662 (0.040)	0.025 (0.003)	0.024 (0.004)
Ia -SF	8.734 (0.018)	0.026 (0.002)	0.027 (0.003)
Ia-all		0.027 (0.002)	0.028 (0.002)

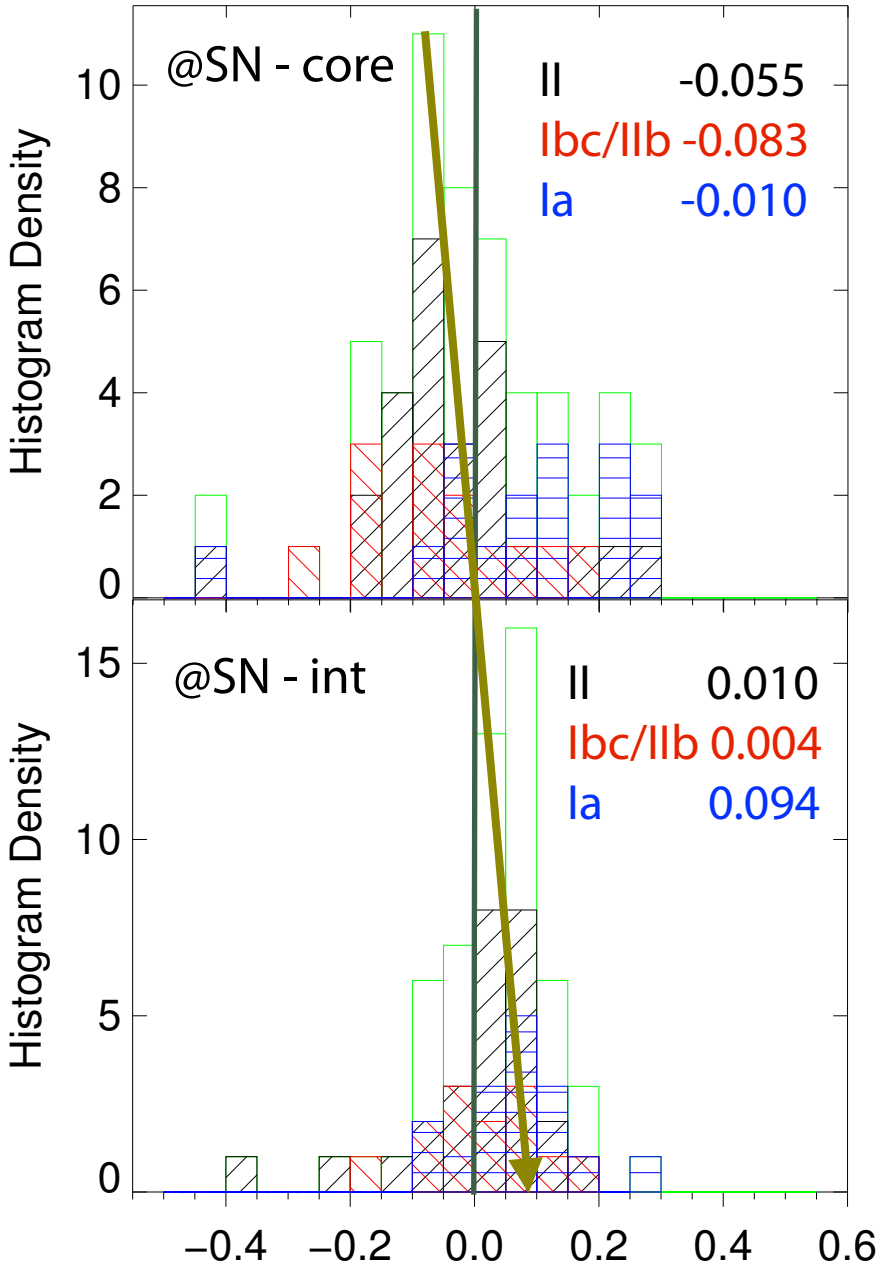
Local host galaxy properties - metallicity gradients

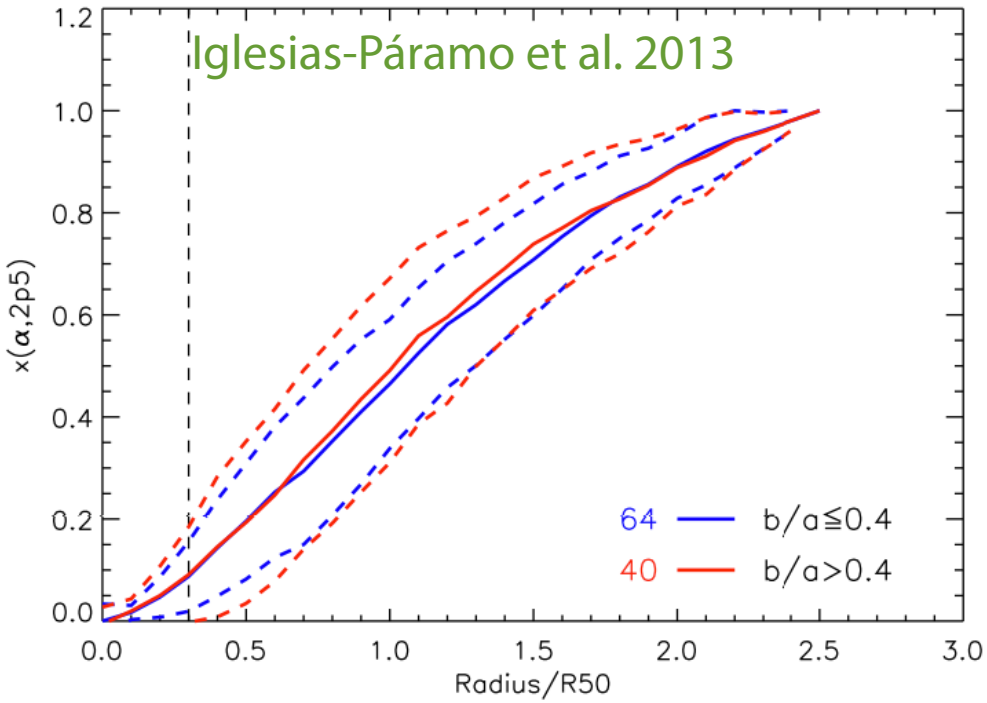


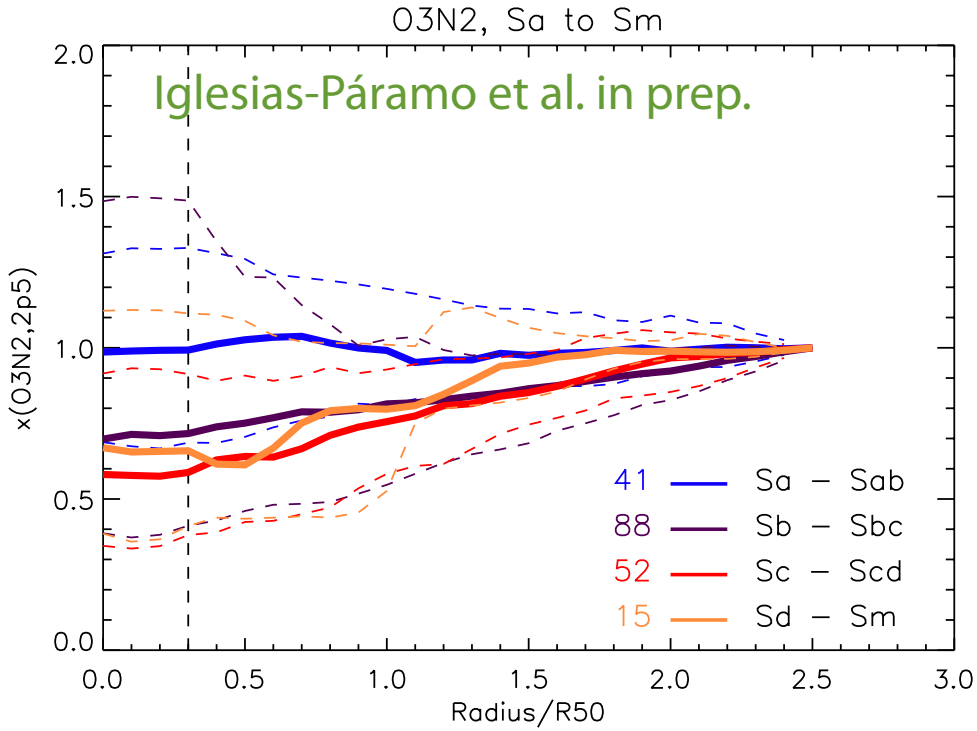
CC SNe local metalicity have lower values in the outskirts

SNe Ia do not show a decrease in metallicity at larger distances

Aperture effects





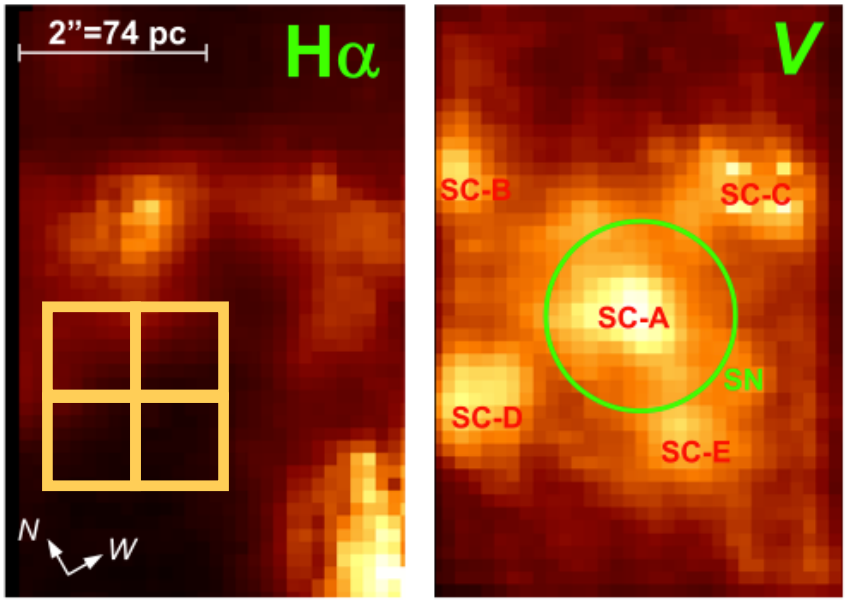


Conclusions

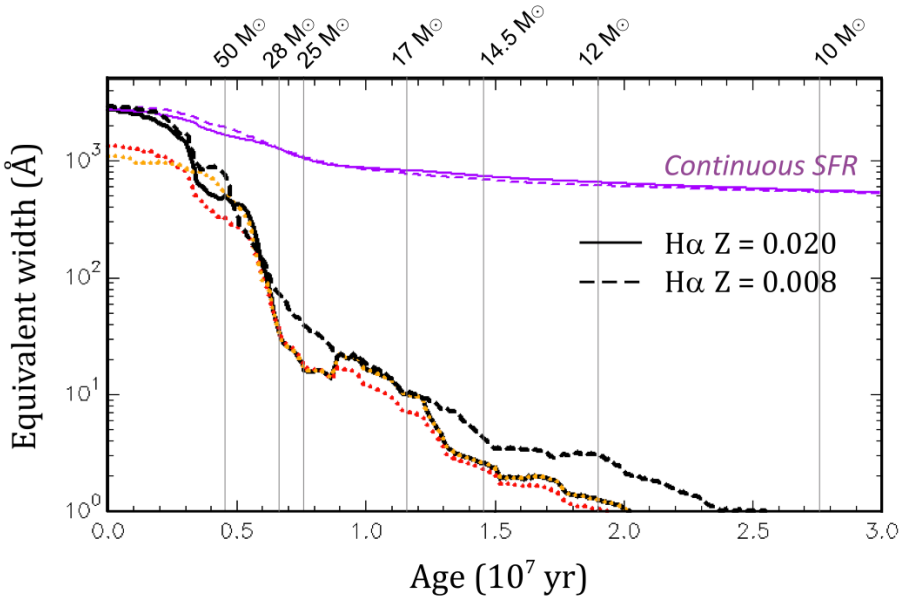
- IFU is a powerful technique at low redshift
- Differences found in galactocentric distances. This can be understood as differences in the progenitor metallicity, in sequence from type Ibc/IIb, type II, and type Ia SNe.
- Differences found in association to star-forming regions. This can be understood 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 determine the SN type. SNe Ia occur systematically in metal-richer environments.
- Differences between local and integrated values can be understood as uncertainties on the estimations of these parameters at high redshift. Although not so important for SNe Ia.

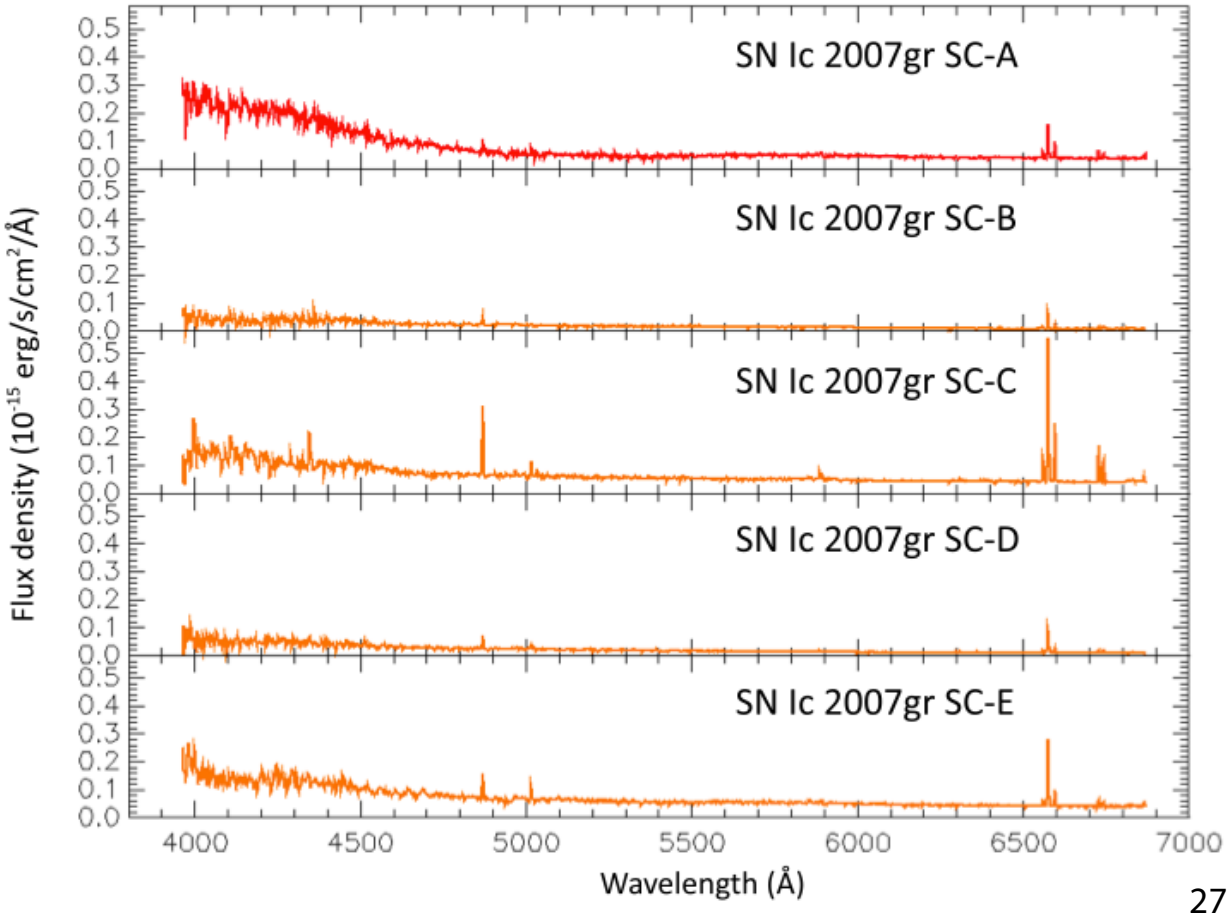
Present

SINFONI
IMACS
SNIFS
GMOS
…



Kuncarayakti+ 2013ab
Kuncarayakti+ in prep.





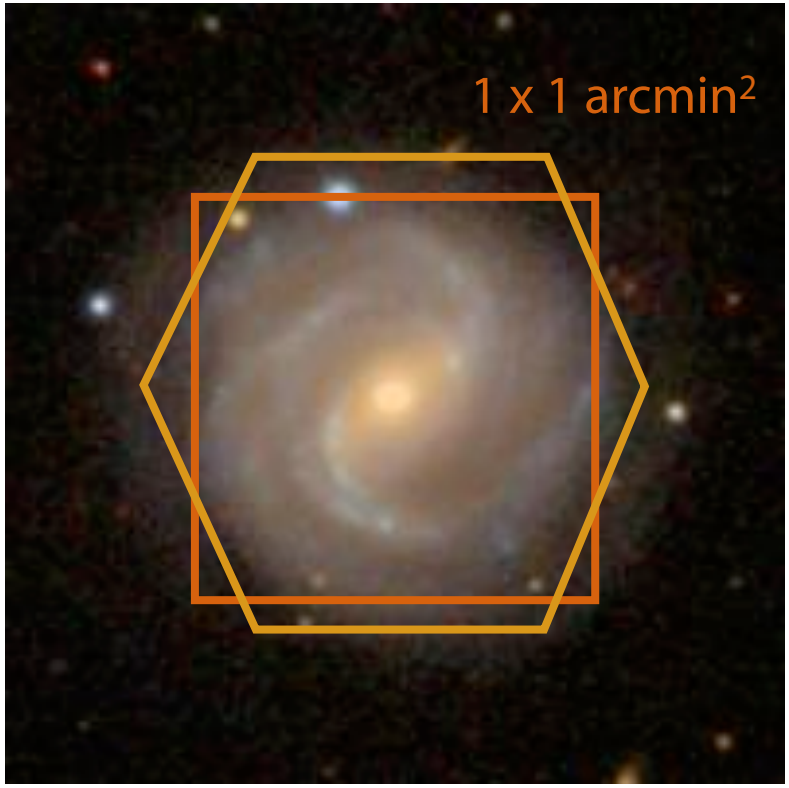
Future

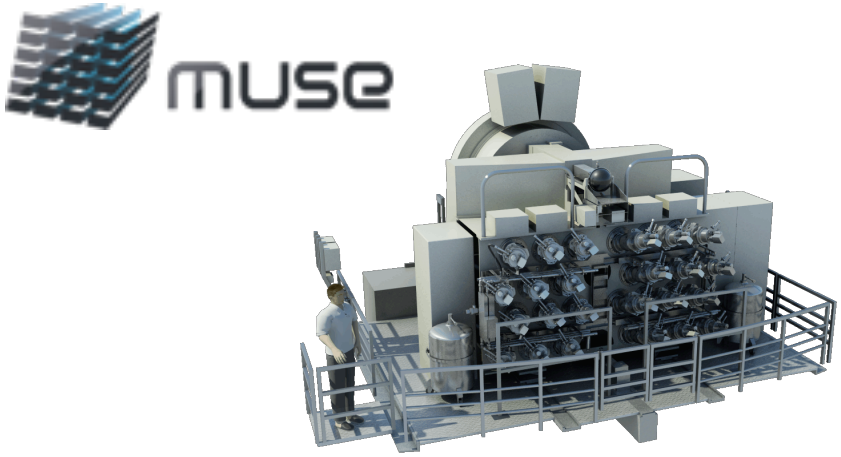
New IFUs almost prepared or under construction

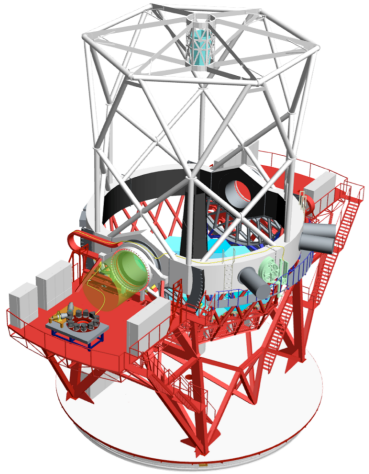
-Larger FoV

-Better spatial resolution

3.5 x 3.5 arcmin^2








Gràcies