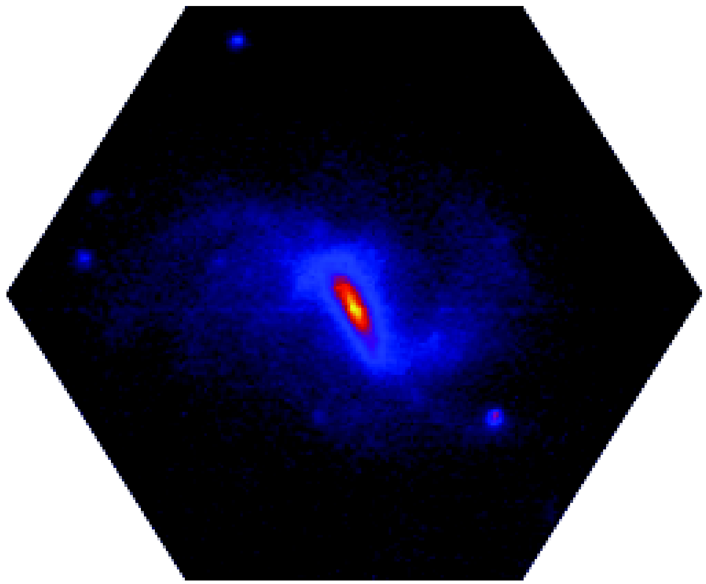
Integral Field Spectroscopy of nearby supernova host galaxies

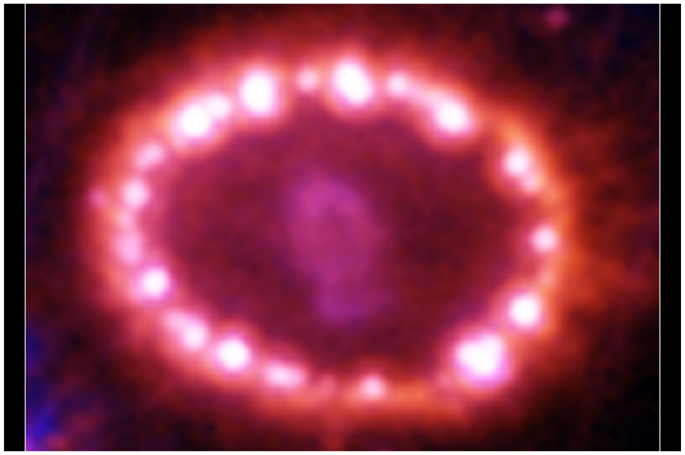


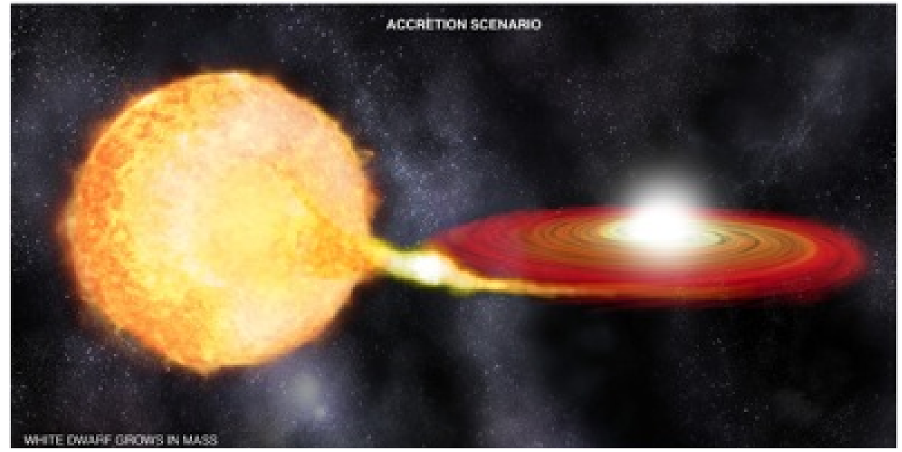
Lluís Galbany, CENTRA-IST
Vallery Stanishev, CENTRA-IST
Ana M. Mourão, CENTRA-IST
Myriam Rodrigues, ESO
Hector Flores, Obs. Paris

CALIFA Survey

XXIII ENAA, 18-19 July 2013, Lisbon, Portugal

Motivation





Core collapse SN

Type Ia SN

Massive stars (8 to 30 Msun)

Differences depending on progenitor mass loss before explosion

CO White dwarfs in binary systems accreting mass from a companion

Homogeneous brightness ---> Cosmology

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

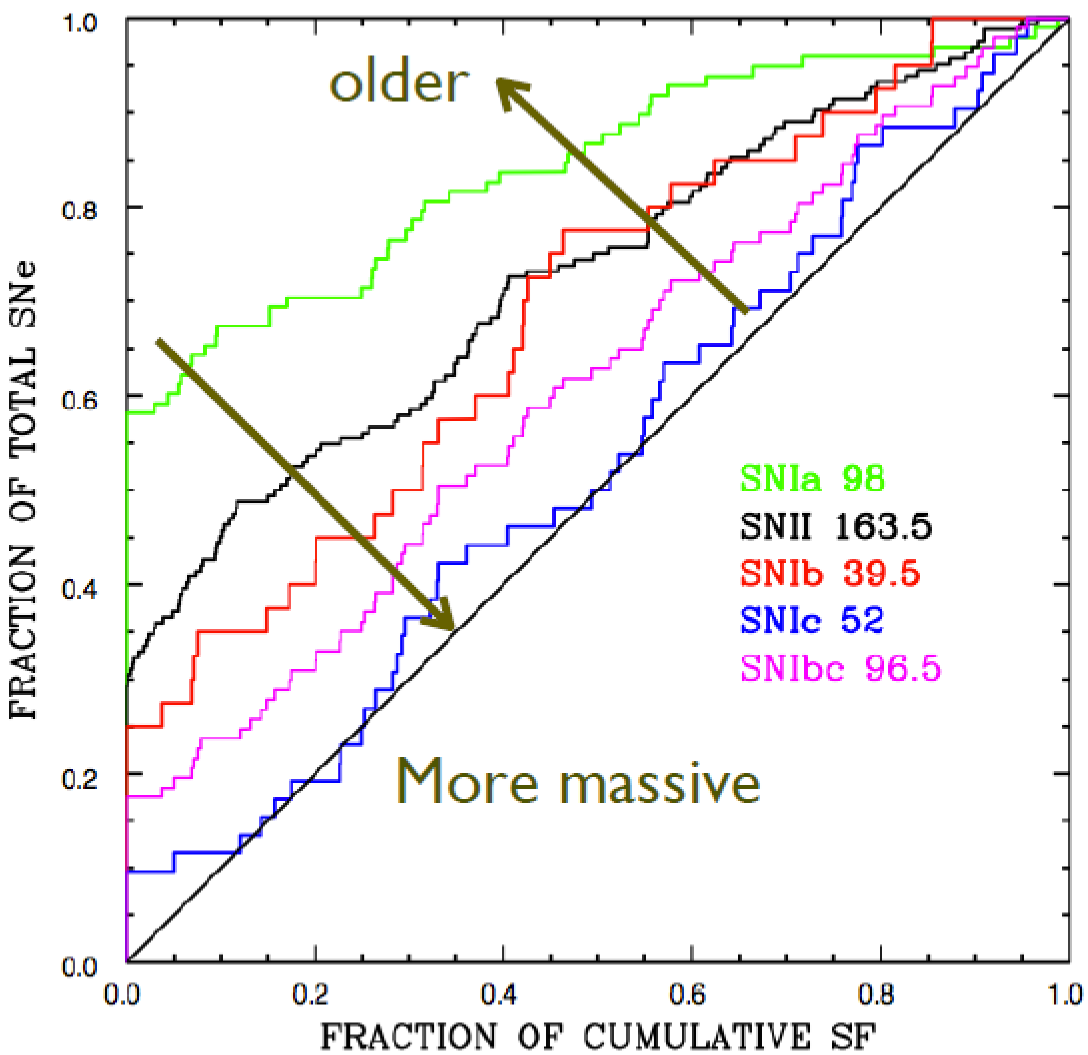
Alternative methods to constrain progenitor properties: ENVIRONMENT

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

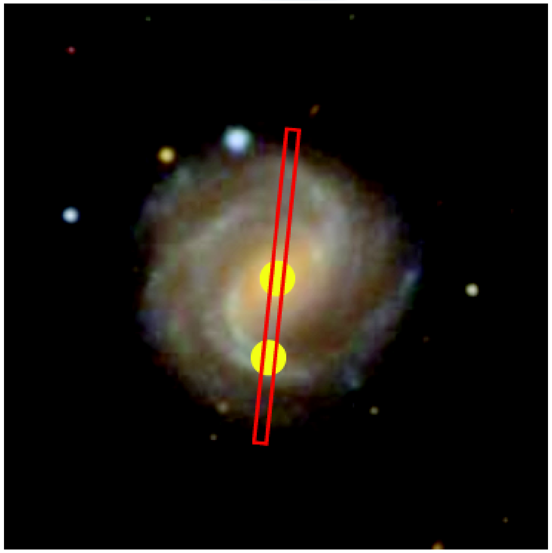


Cumulative distributions of local star-formation at SN position for several SN types

More correlation to the Star-formation, means less time to migrate from the formation region (age), and to lose enveloping layers (mass)

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, ...)

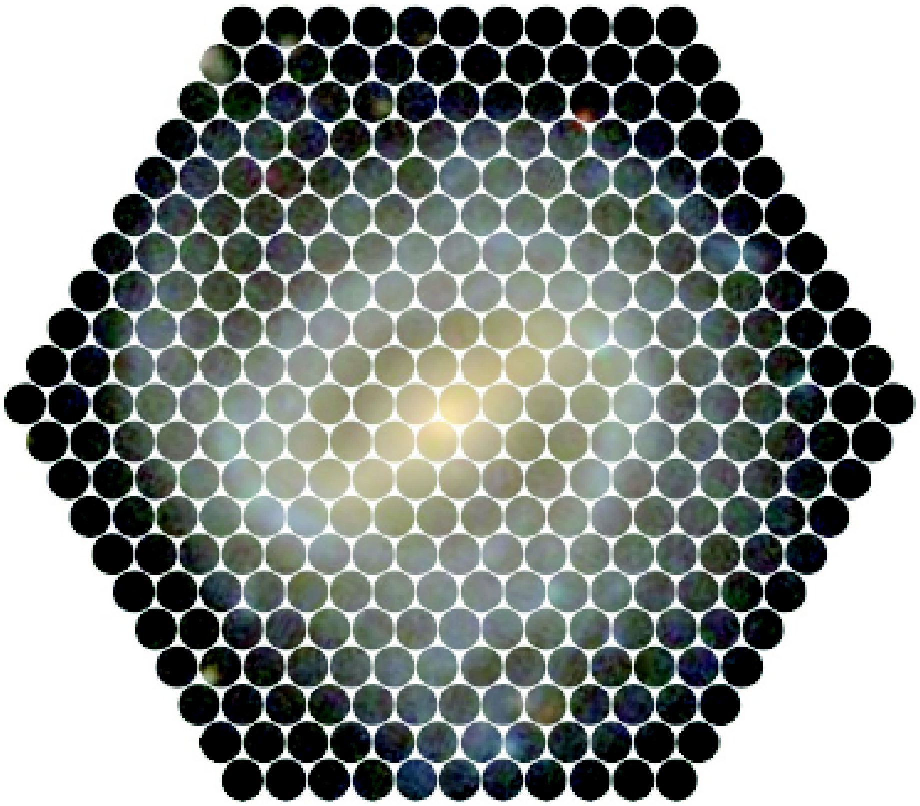
- Local properties

  - 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, ...)

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

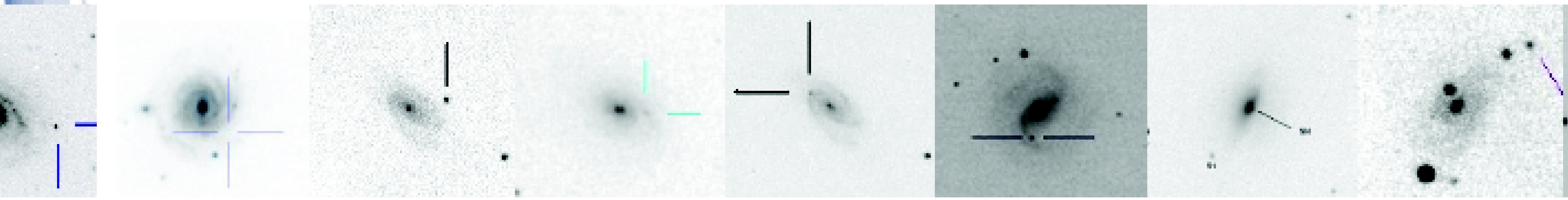
- Cross-check Sne IAU list with CALIFA galaxies (by coord.)

  ~350 galaxies observed so far

  42 hosted 50 SNe (after careful inspection)

- + previous observations (SAME instrument!):
  - Feasibility Study for CALIFA, Sanchez+12
  - PINGS Survey, Rosales-Ortega+10
  - Sne Ia hosts, Stanishev+12
  - NGC5668, Marino+12
  - Interacting galaxies project, Barrera-Ballesteros in prep.

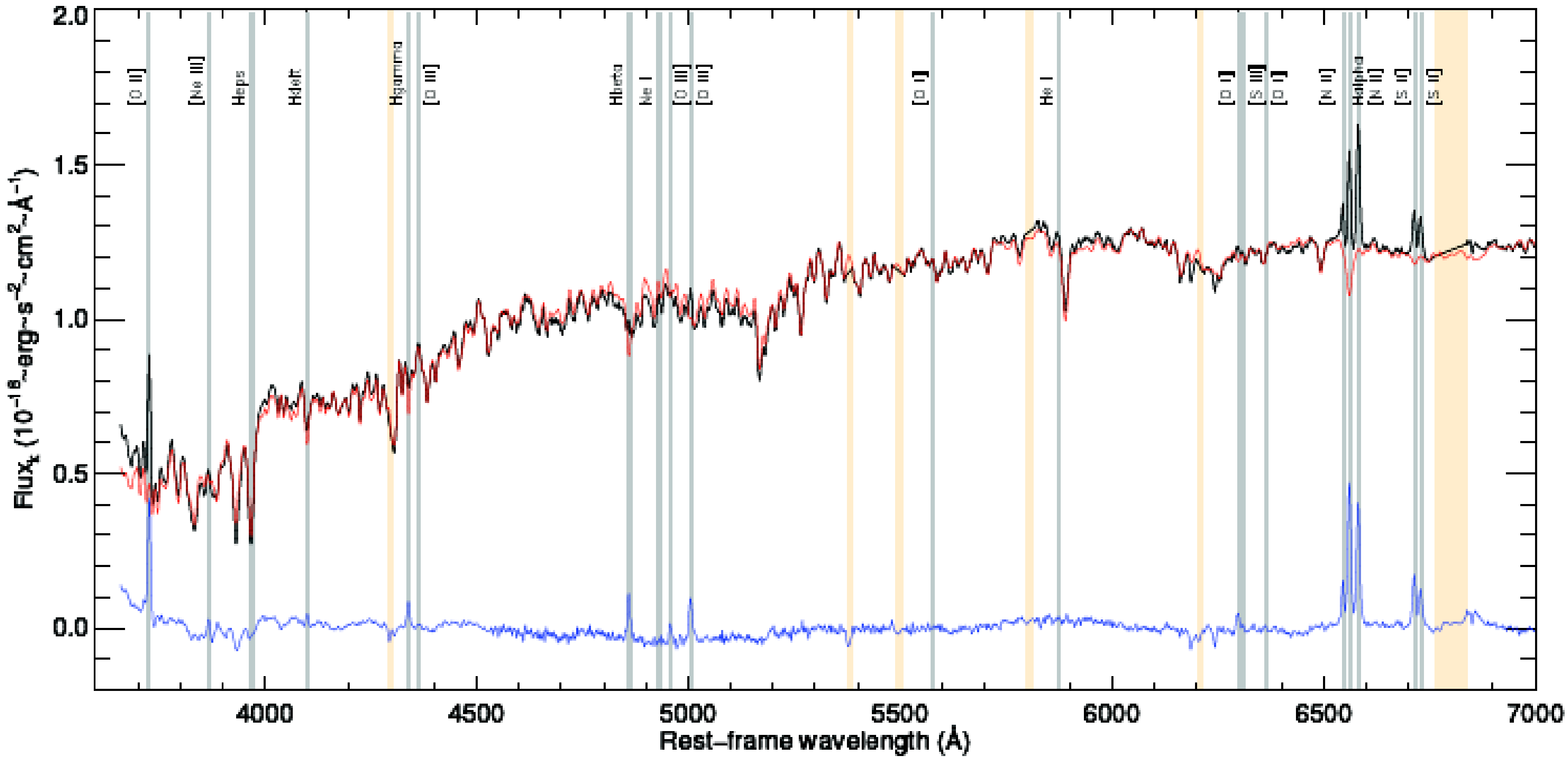
75 Sne: 32 type II, 13 type Ibc, 30 type Ia

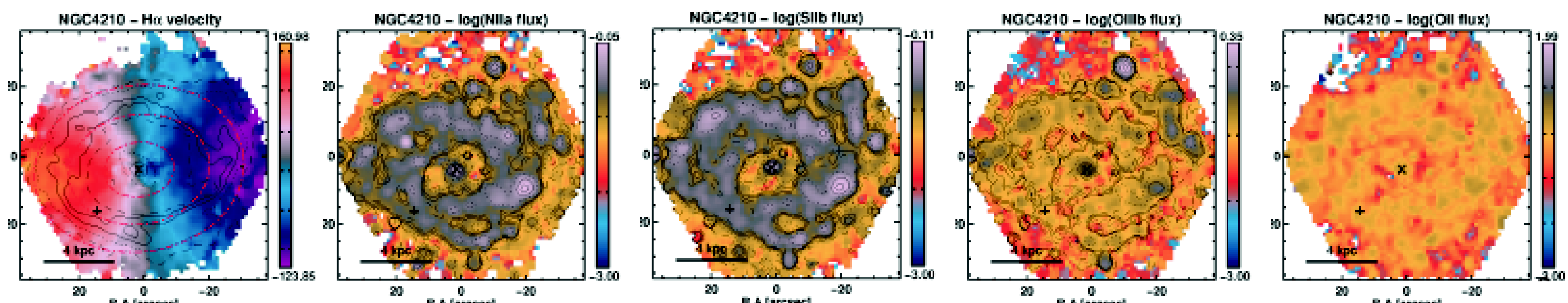


STARLIGHT *Cid Fernandes et al. 2005*

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*

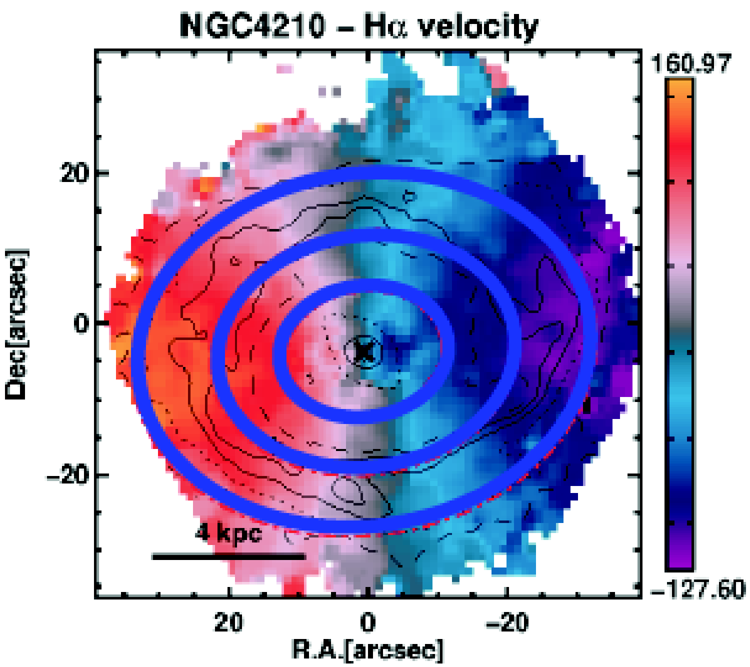
Deprojection

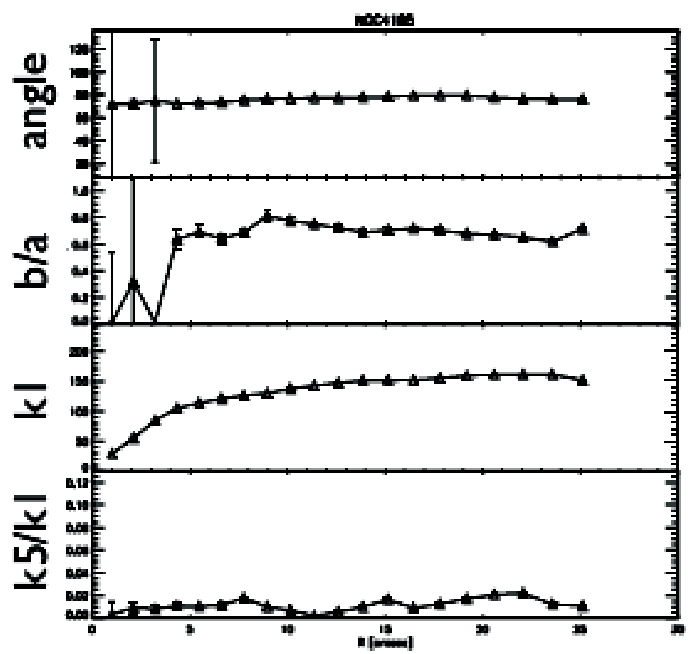
Azimutal average

Voronoi binning

Integrated spectrum

3″ aperture spectrum





Kinemetry

Deprojection

Azimutal average

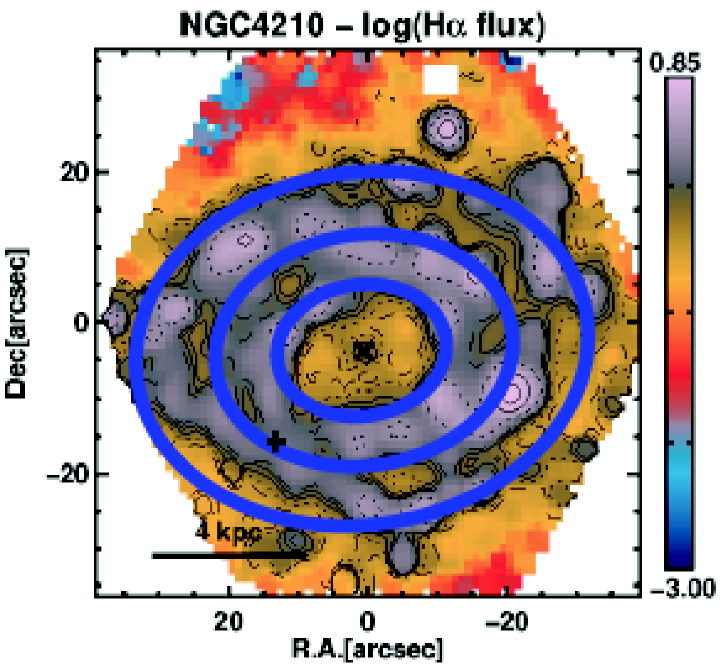
Voronoi binning

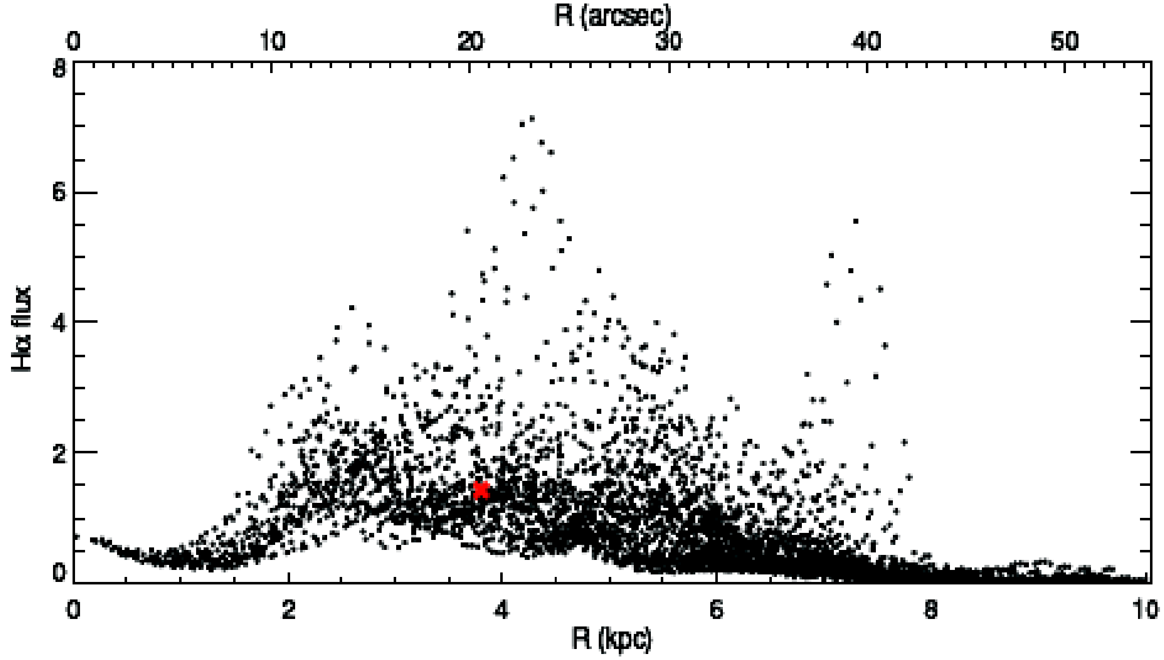
Integrated spectrum

3″ aperture spectrum

Fit ellipses using *Krajnovic et al. 2006*

↳ Measure distances in the galactic plane





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

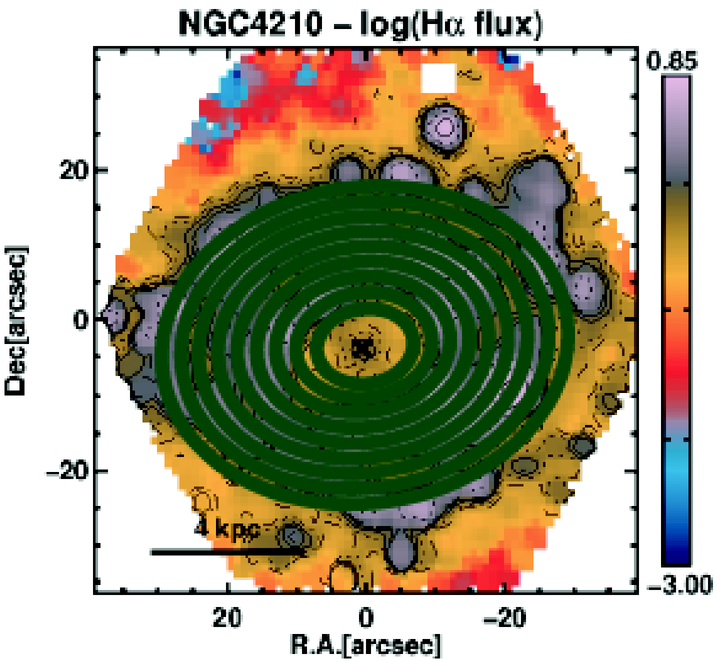
Deprojection — Measure distances in the galactic plane

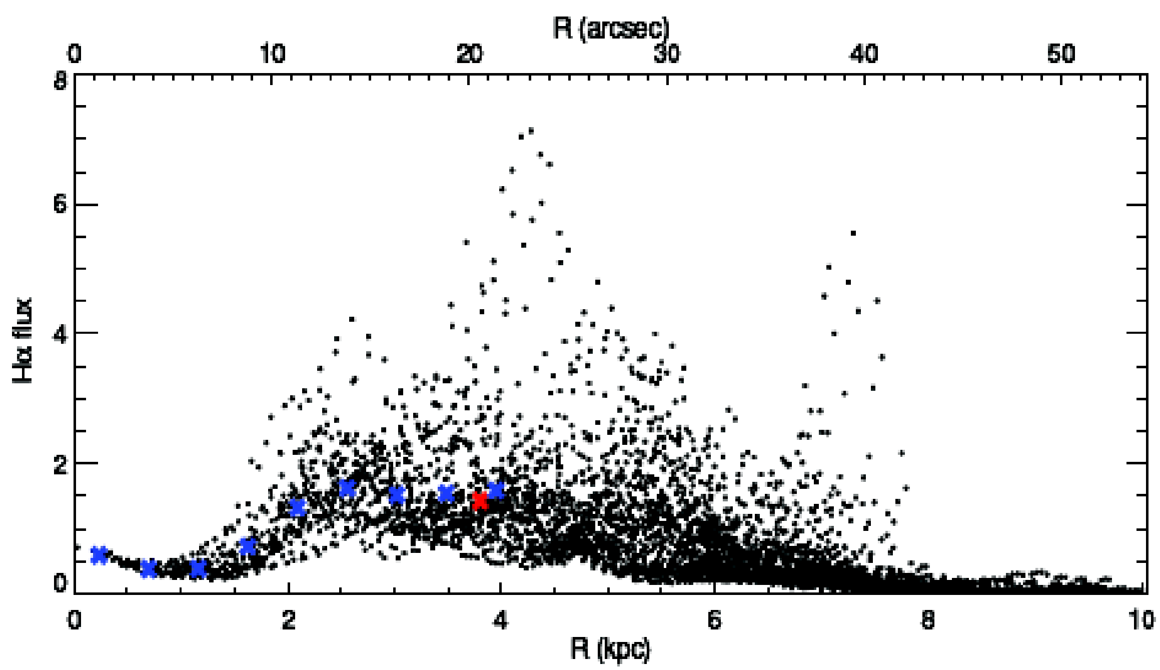
Azimutal average — Co-add ell. rings centered in the core

Voronoi binning

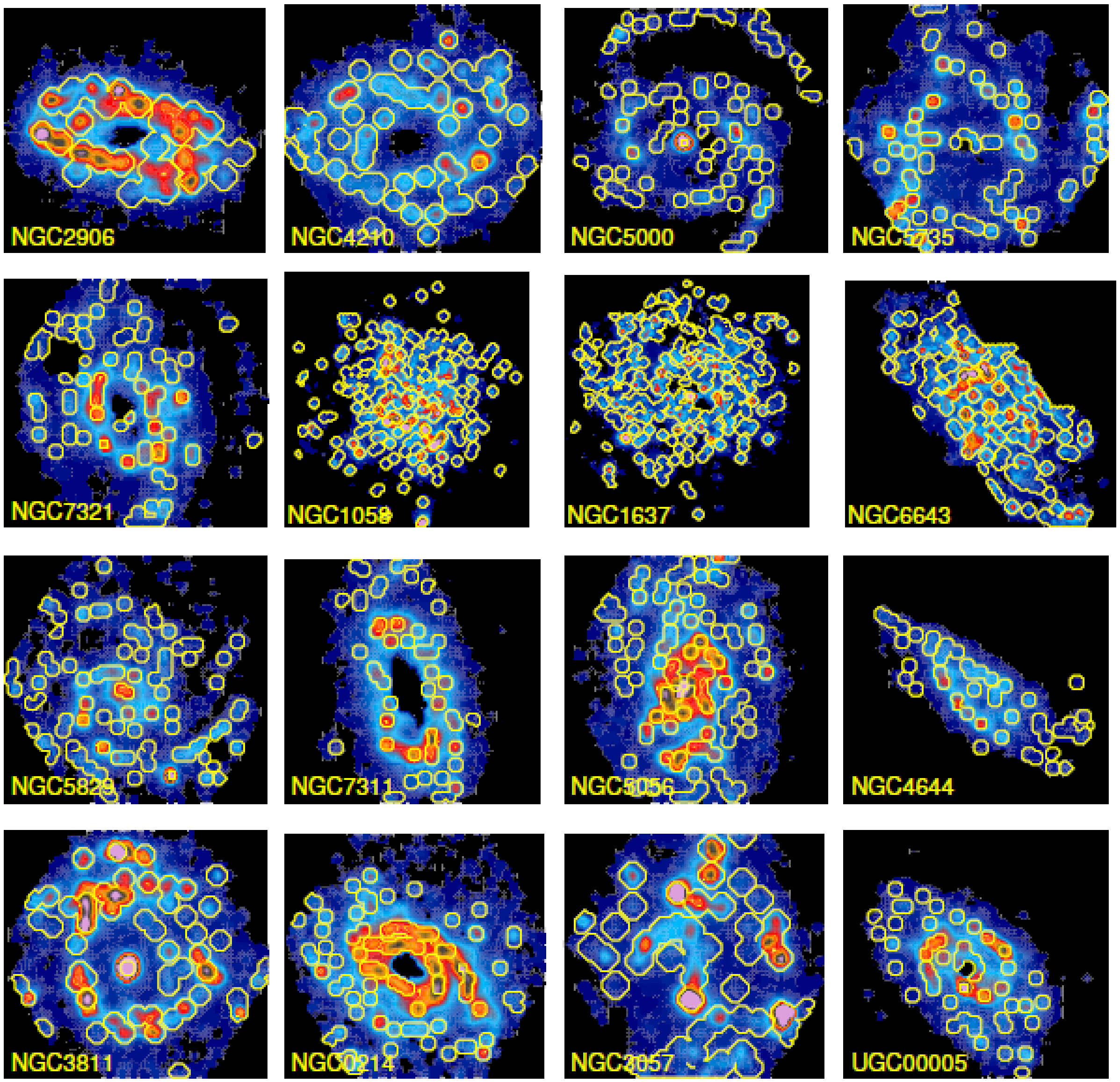
Integrated spectrum

3″ aperture spectrum



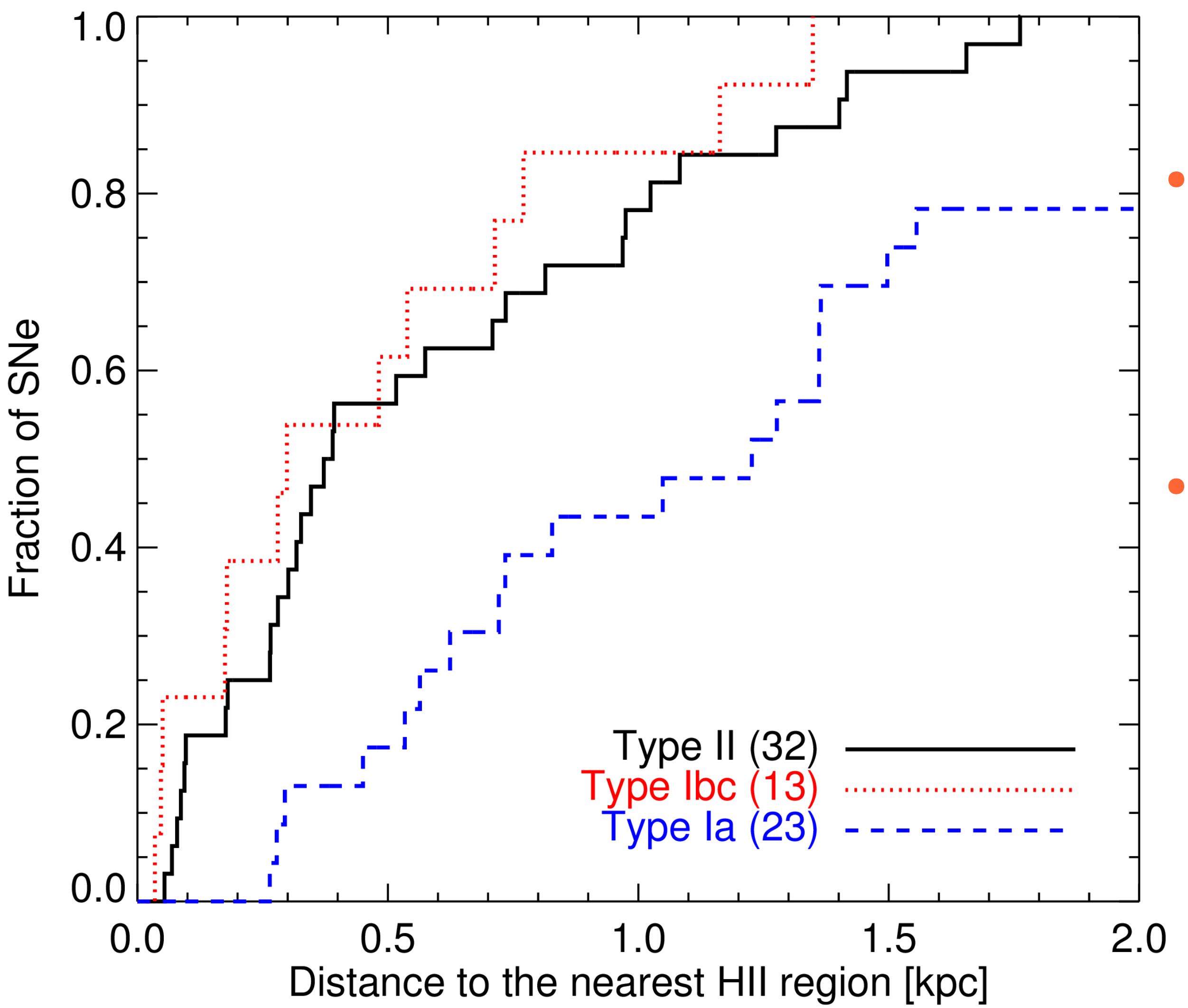


Star-forming regions



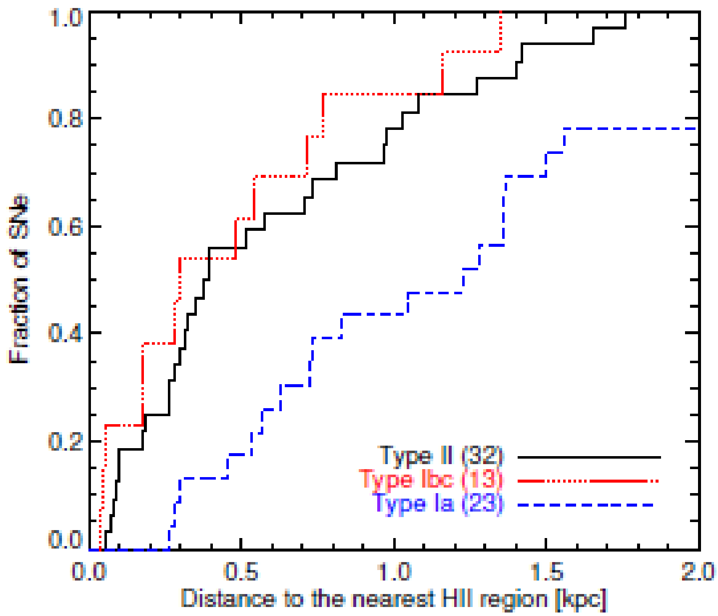
- HIIexplorer (Sanchez+12) to select HII clumps from Ha emission maps
- Measure distances from the SN explosion site to the center of the nearest HII clump

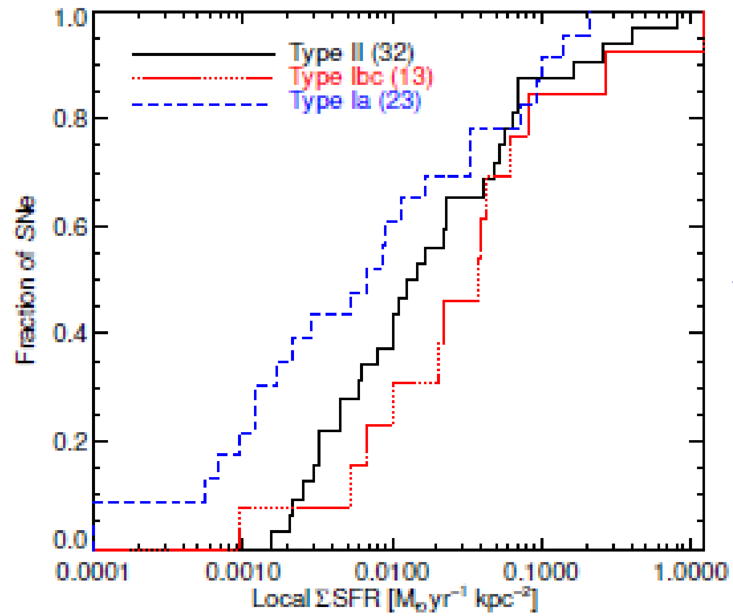
Star-forming regions



- HIIexplorer (Sanchez+12) to select HII clumps from Ha emission maps
- Measure distances from the SN explosion site to the center of the nearest HII clump

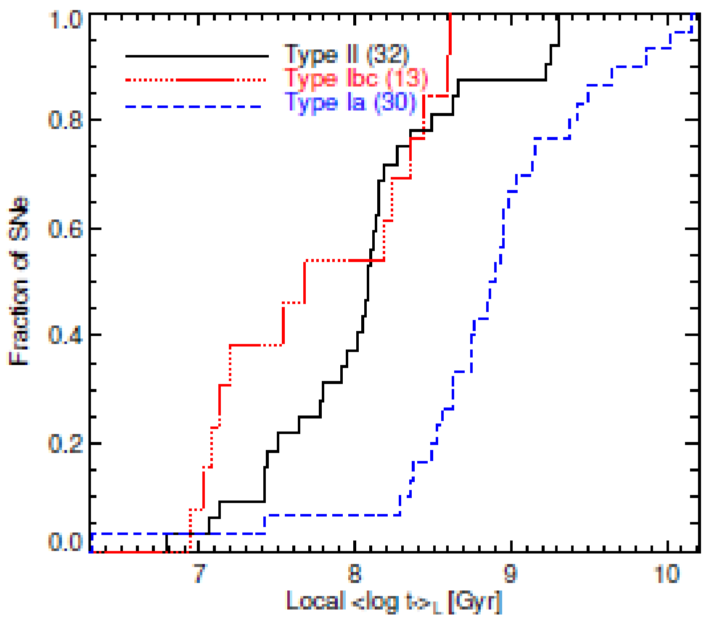
HII clump distamce

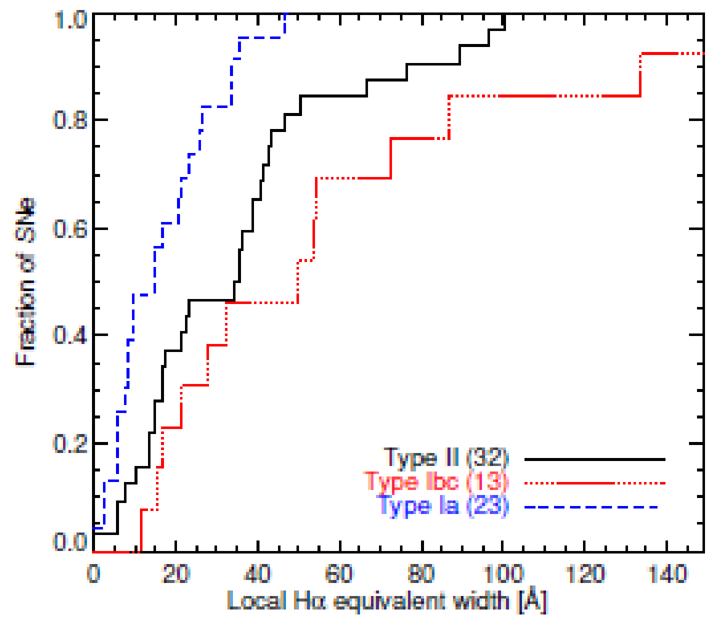




SF density

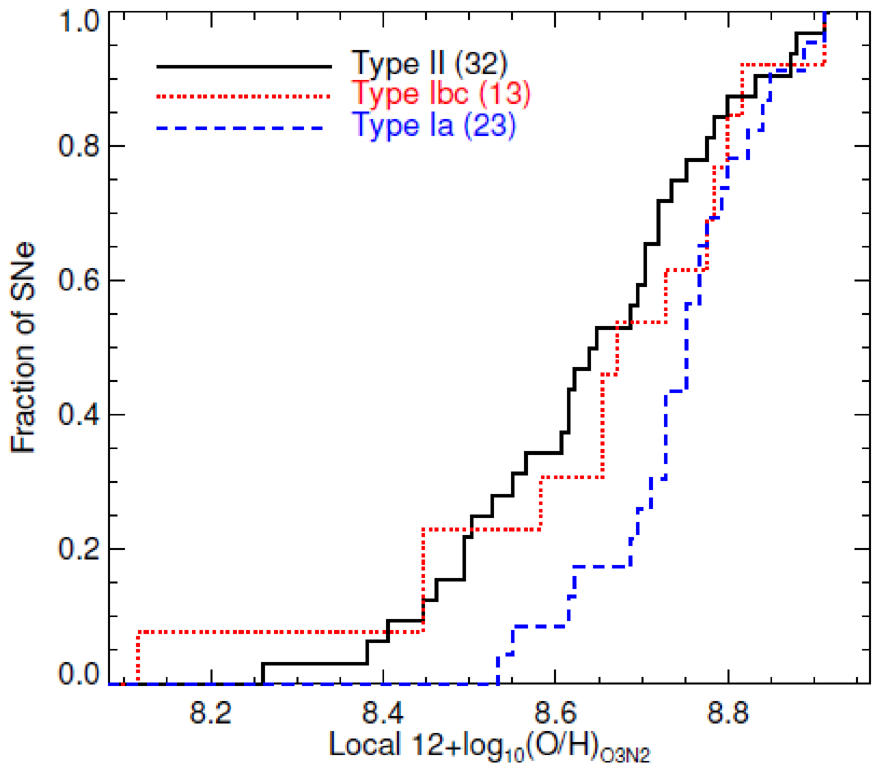
<log t*>



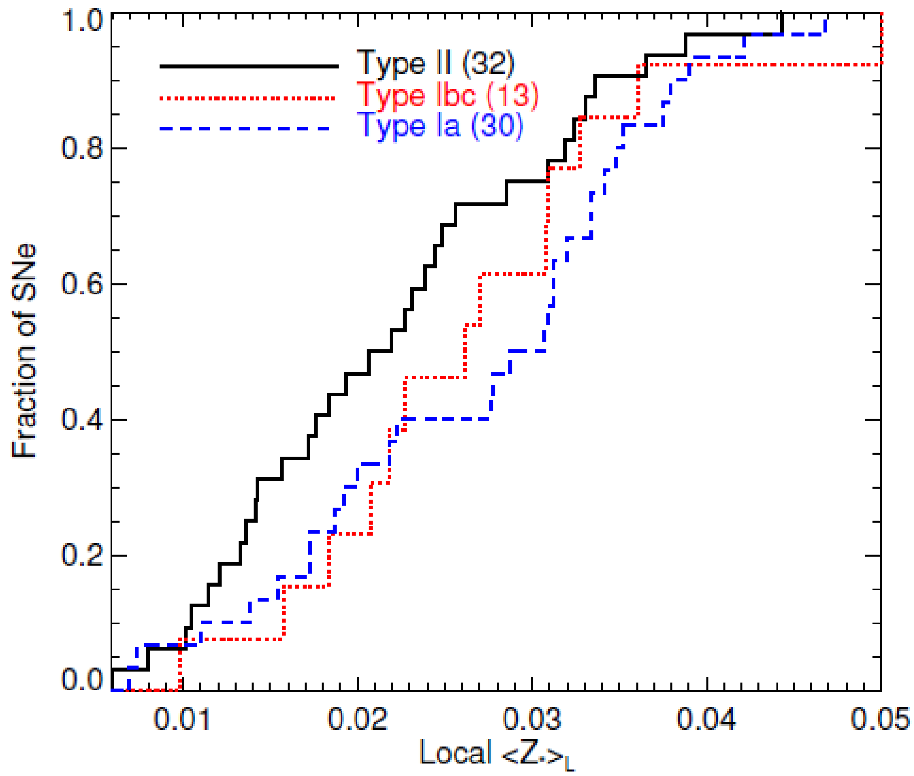


Ha EW

Metallicity

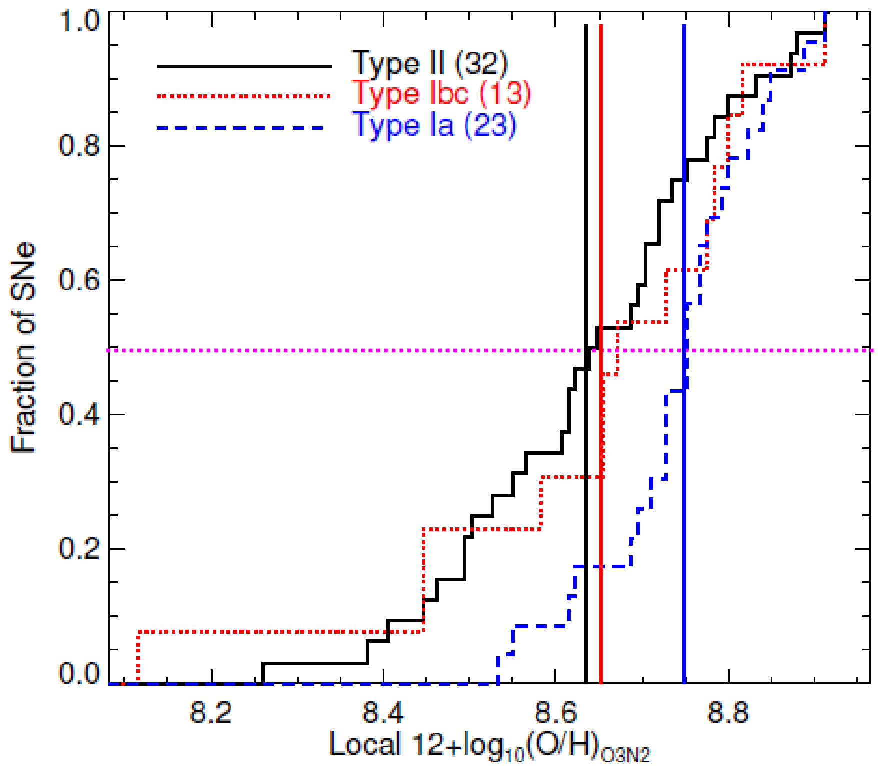


From gas emission line ratios

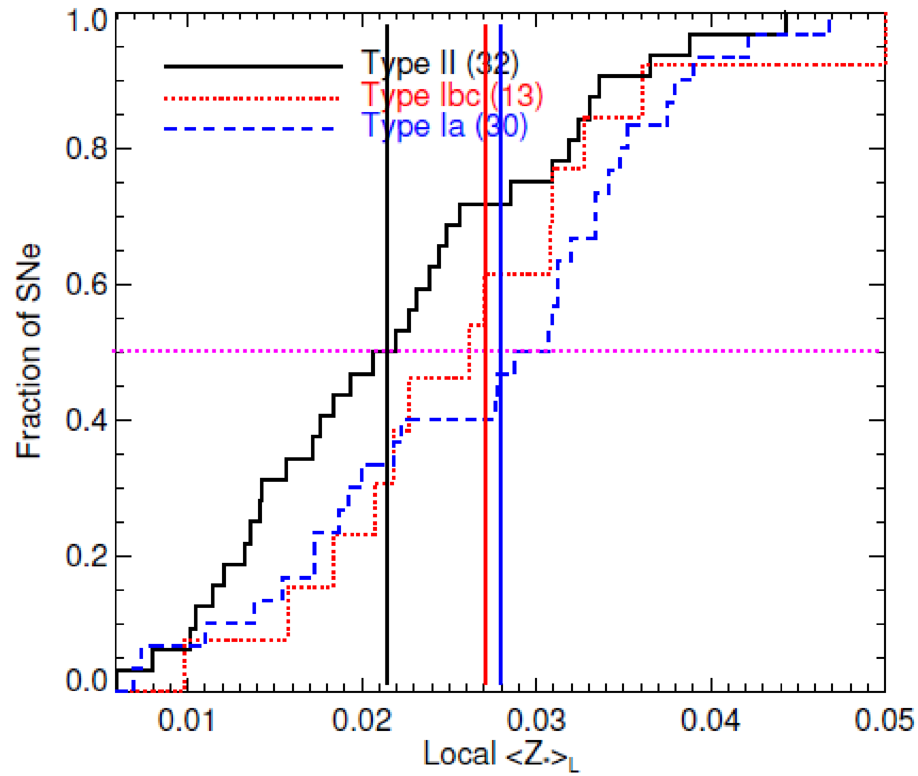


From stellar population

Metallicity



From gas emission line ratios



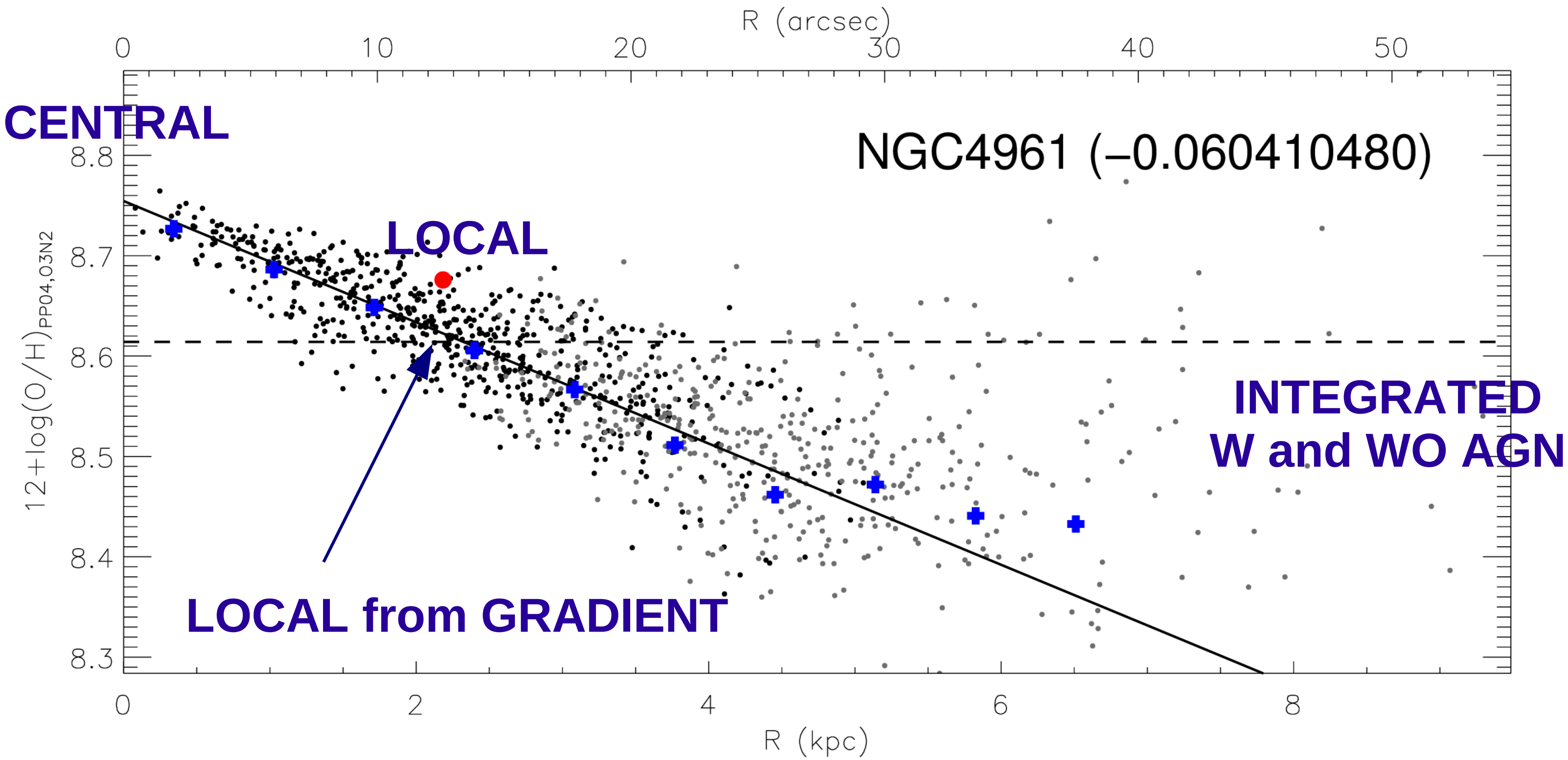
From stellar population

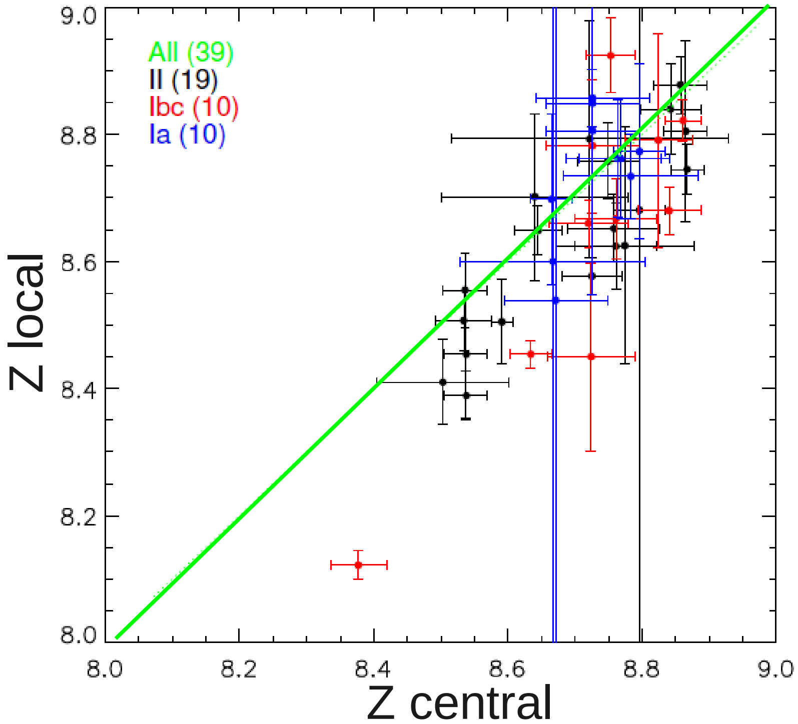
Sequence in metallicity at SN position from Sne Ia to Sne II

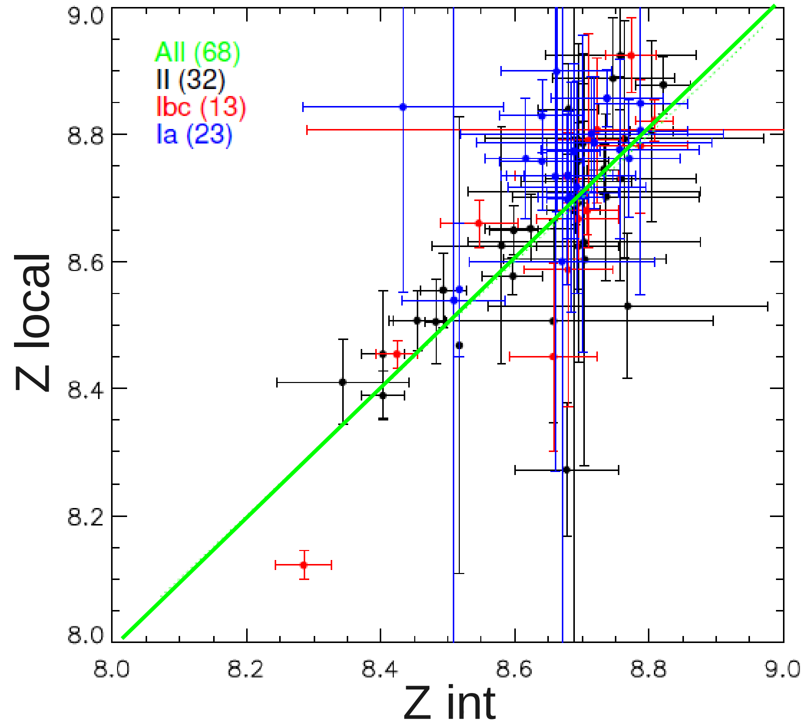
Slight difference between mean values of Ibc and II (~0.01 dex)
larger differences in the median (~0.04 dex)

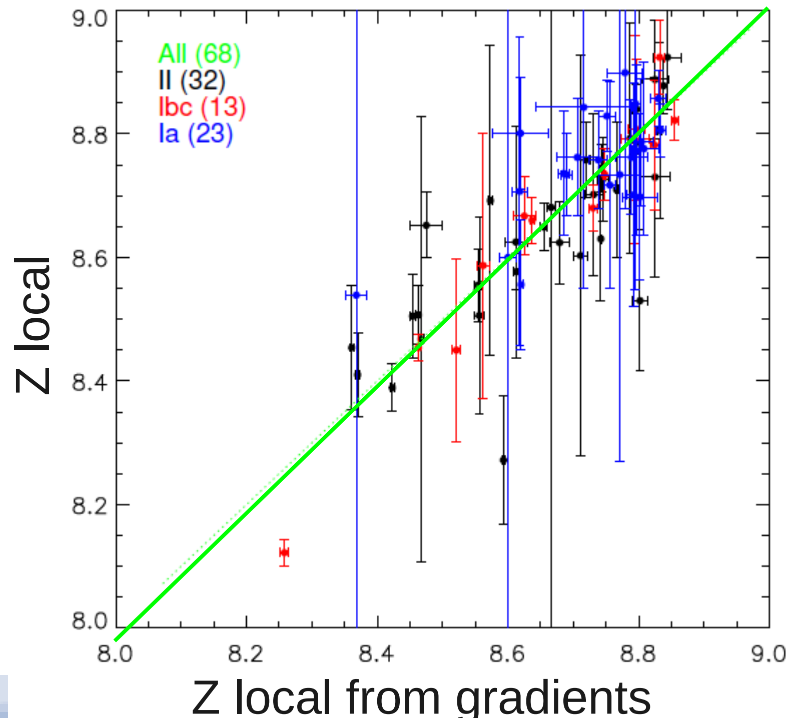
Aperture effects

4 different measurements:









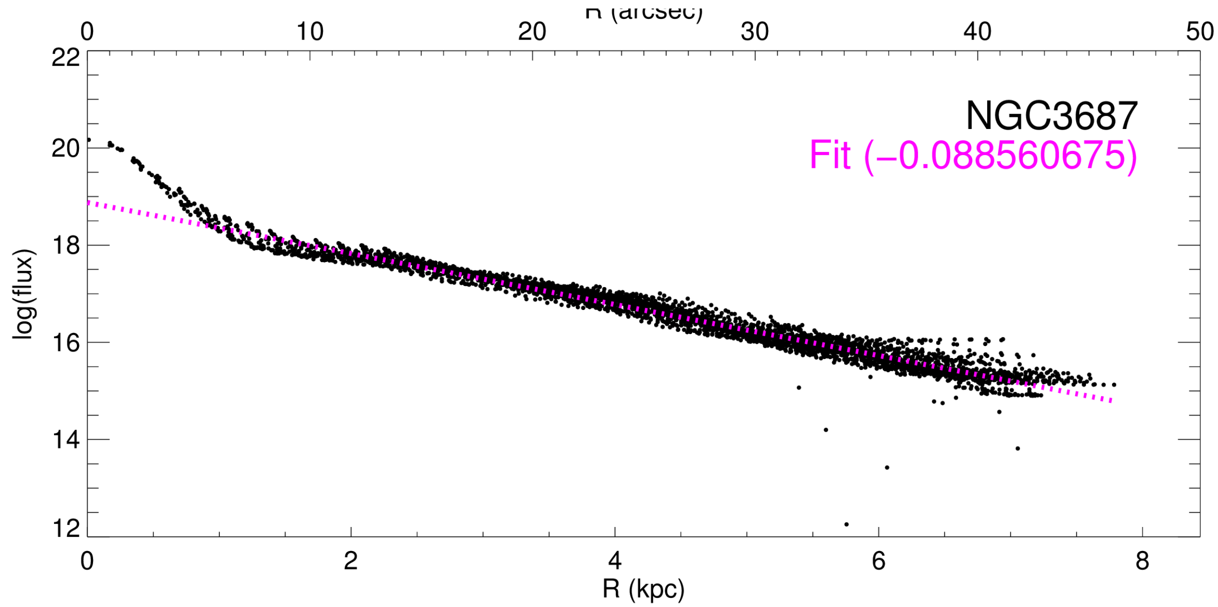
- CEN - LOC ~ 0.07 dex CC SNe
- INT - LOC ~ -0.08 dex SNe Ia
- INT(AGN) ~ INT(noAGN)
- GRAD – LOC ~ 0.01 dex CC Sne

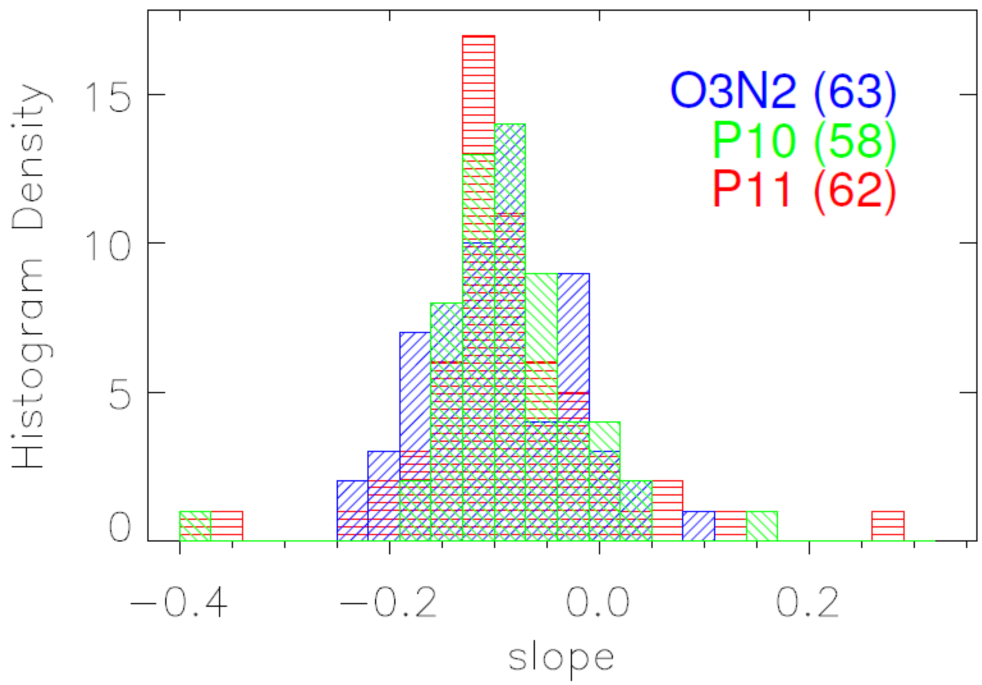
~ -0.03 dex Sne Ia

error when using gradients

Metallicity gradients

- Measure metallicity gradients normalizing distance to the disc effective radius (r_e)

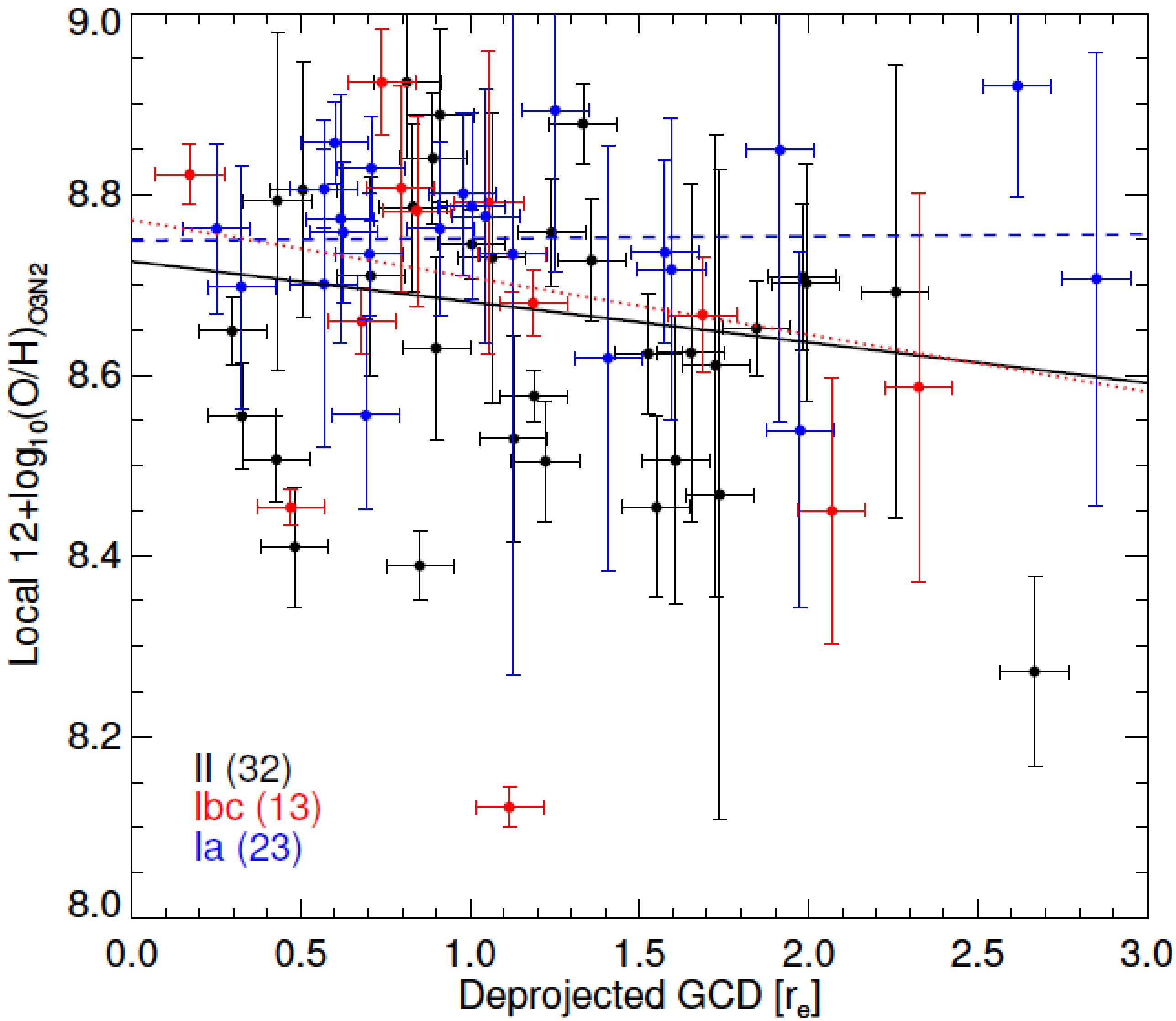




- Show a universal gradient (~ -0.1 dex)

  study in preparation using all CALIFA galaxies (Sanchez+ in prep.)

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

Conclusions

- Differences found in the environment of different SN types
  - Association to star-formation
  - Local metallicity

  that can help constrain the properties of each type of SN progenitor

- IFS allowed us to study aperture effects (spectroscopy at different redshift) and the use of metallicity gradients as an indirect approximation to the local values.
  - Central and integrated spectra
  - Integrated spectra including AGN

  differences found depending on SN type: usefulness in host galaxy studies in Type Ia cosmology