Stellar populations in Type 2 galaxies;

Differences between SP in HII galaxies and in AGNs

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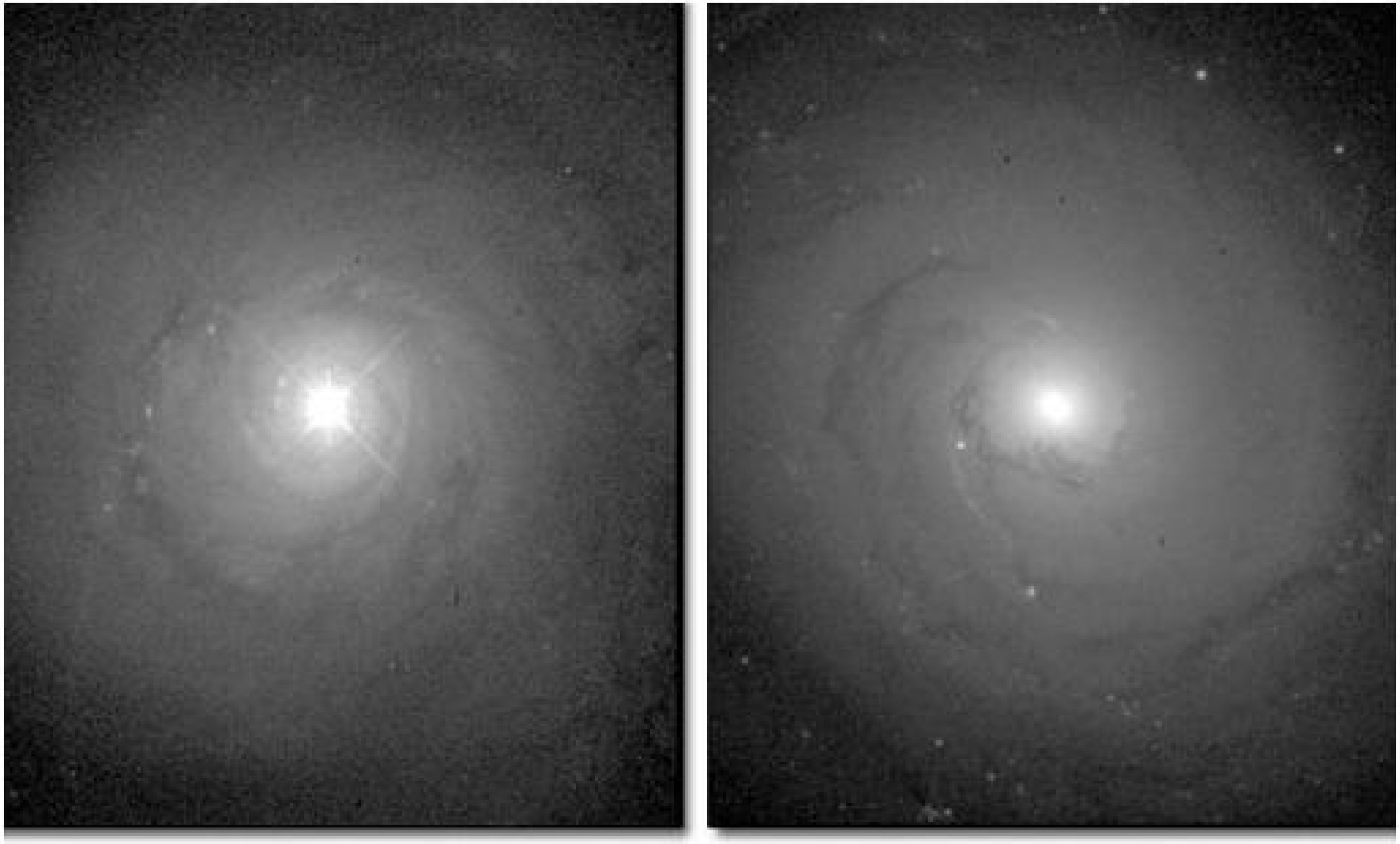
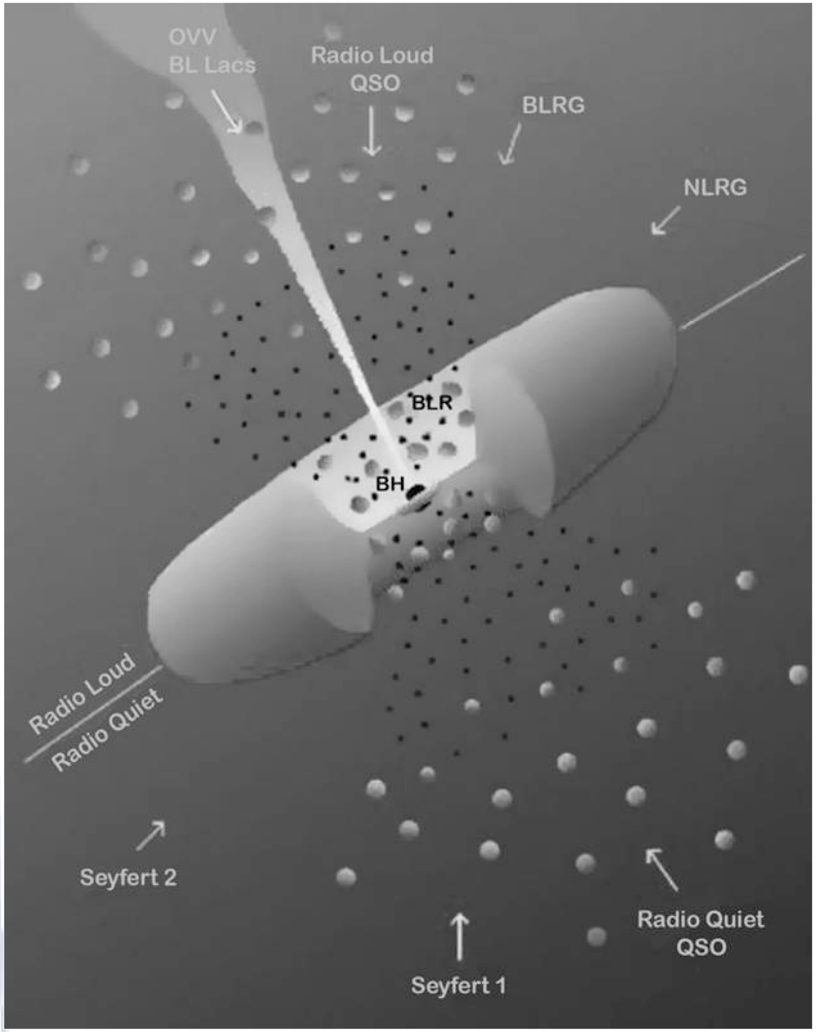
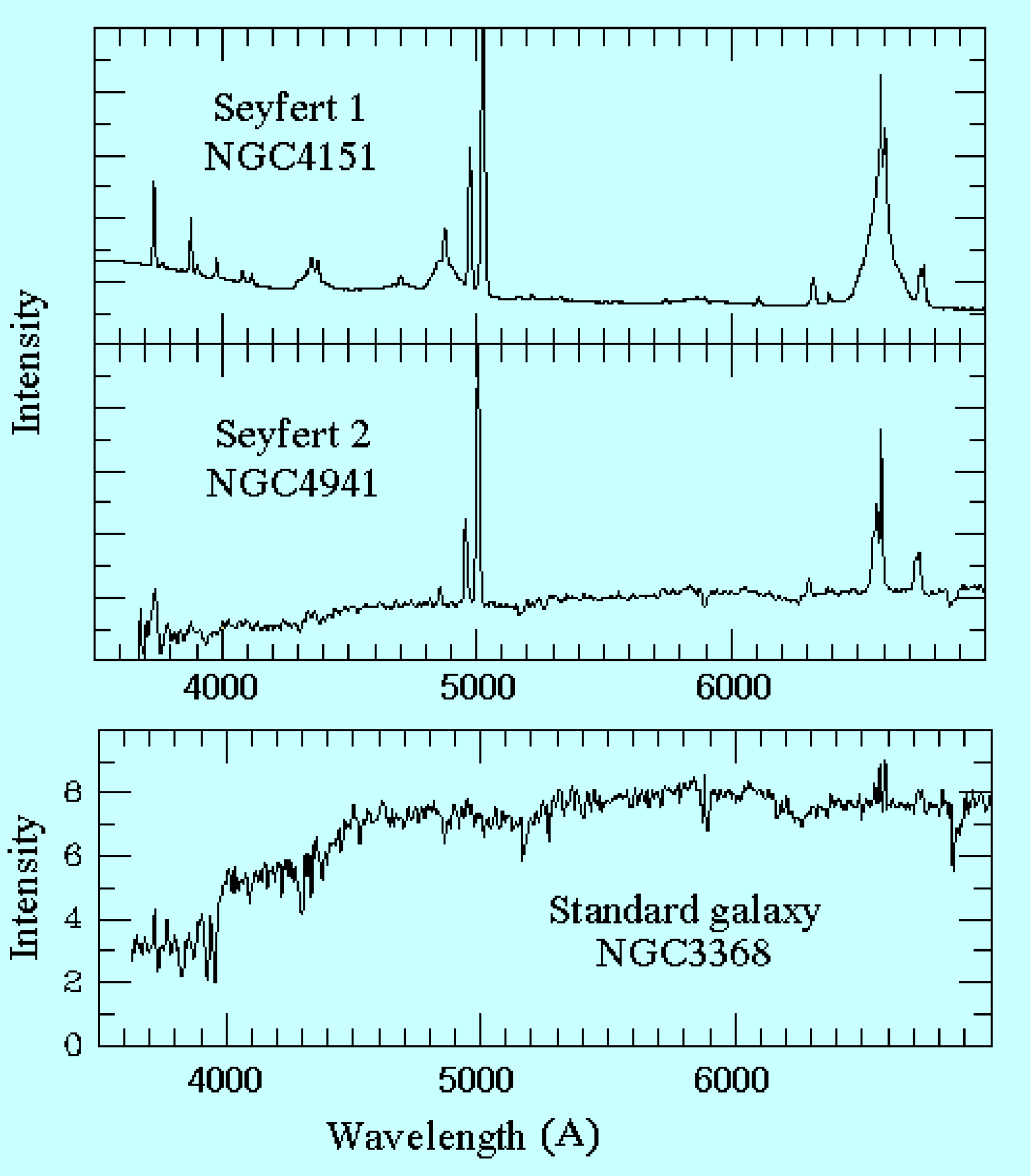
Active Galactic Nuclei (AGN)



Comparison between two nearby spiral galaxies of similar distance and type. AGN (left) and "normal galaxy" (right).

Two components of integrated spectrum





Goals

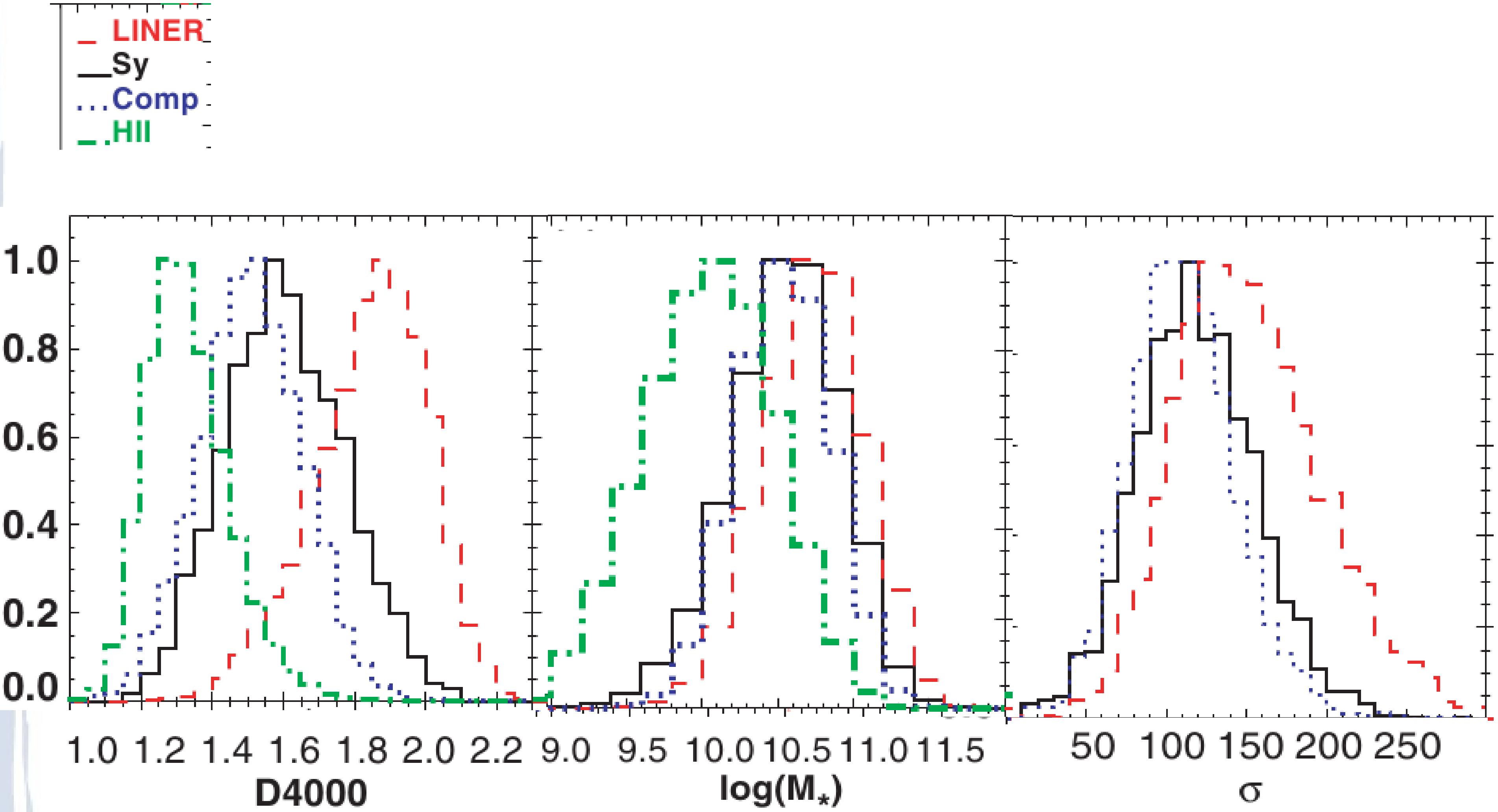
Build a method which will distinguish each components of the AGN spectra:

- stars
- gas
- AGN continuum

Analysis the interaction between AGN and surrounding gas:

- fuelling
- effects of AGN on surrounding gas and on star formation

Stellar population analysis in galaxies



Kewley et al. 2006

Relation between gas and SP properties in galaxies

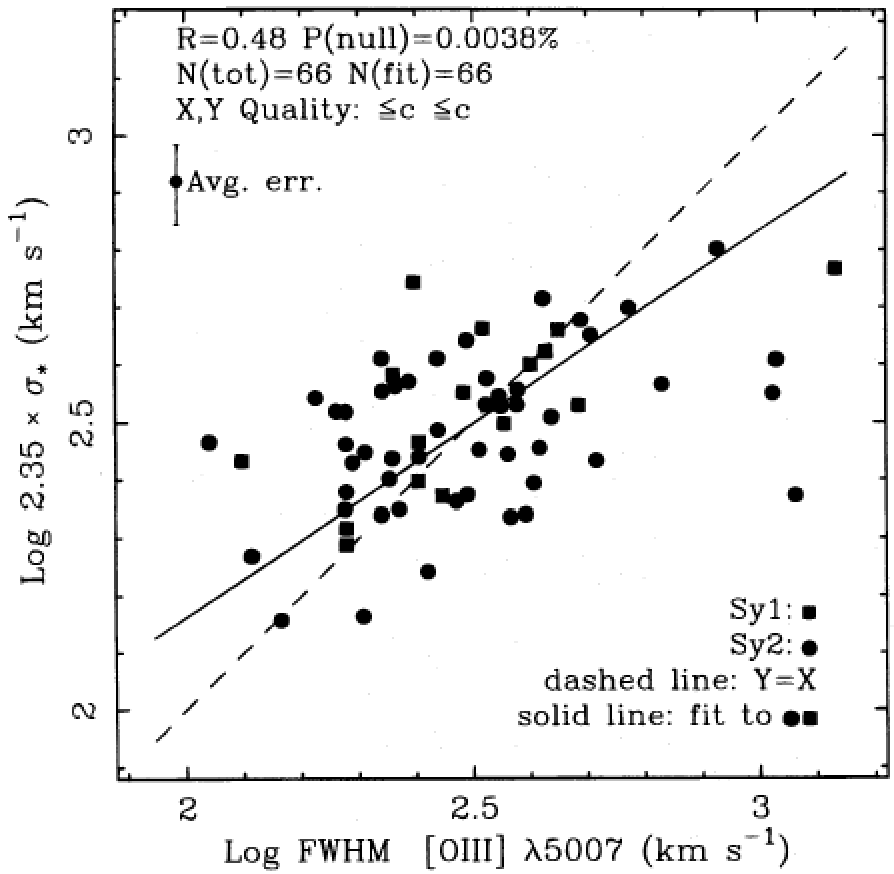


FIG. 5.—$FWHM_{[O\,III]}$ vs. $FWHM_*$ is shown. The solid line is a fit using the OLS bisector method (see § 2), and the dashed line shows $X = Y$. Objects with qualities $Q(\sigma) \leq c$ and $Q(FWHM_{[O\,III]}) \leq c$ are plotted.

Nelson & Whittle 1996

Methods for removing the starlight from an integrated spectrum

-The spectrum of an off-nuclear position within the same galaxy (e.g. Storchi-Bergman et al. 1993)

-The spectrum of a different similar galaxy devoid of emission lines (Ho, Filippenko & Sargent, 1993)

-Model spectrum constructed from population synthesis techniques, using as input a library of spectra of
either individual stars (e.g. Keel et al. 1983)
or synthesis models (e.g. Sarzi et al. 2005)

Full spectrum fitting

- Uses all informations from the spectrum
- Insensitive to the extinction and flux calibration
- Well suited when the resolution is comparable with the physical broadening (10 km/s < σ < 200 km/s)
- Fits simultaneously LOSVD and stellar parameters

Full spectrum fitting: ULySS

ULySS (University of Lyon Spectroscopic analysis Software) is an Open-source software package written in the GDL/IDL language to analyse astronomical data (Koleva et al. 2009)

Package is used to study stellar populations of galaxies and star clusters and atmospheric parameters of stars.

ULySS fits a spectrum with a linear combination of non-linear components convolved with a line-of-sight velocity distribution (LOSVD) and multiplied by a polynomial continuum.

The stellar population models are spline interpolated over an age-metallicity grid of models, generated with PEGASE.HR.

Modelling the integrated AGN spectrum

We added new components in the ULySS model: a featureless continuum, represented with a power law function, and emission lines, represented with Gaussian or Gauss Hermit functions.

$$M(x) = P(x)([w_0 T(x) \otimes G(x)] + w_1 C(x) + \sum_{i=2}^{n} w_i S_i(x)),$$

T(x)-single stellar population (SSP) model

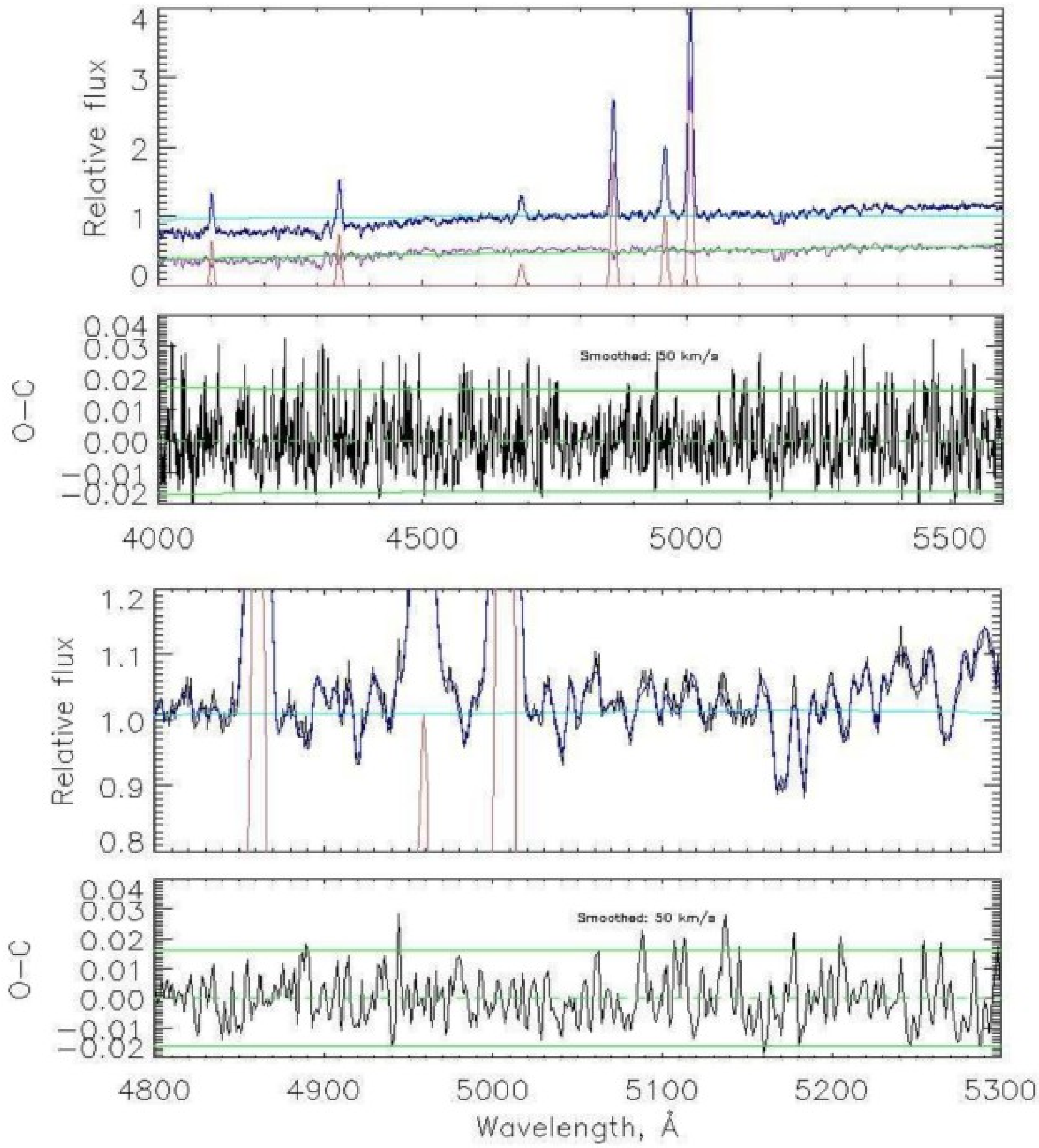
G(x)-Gaussian/Gauss-Hermit broadening function

C(x)-AGN continuum model represented by power law function

P(x)-multiplicative polynomial

S(x)-emission line model

SP analysis in AGN spectra: Simulations



Fit of the simulated spectra with 50% of the AGN contribution and SNR=35.

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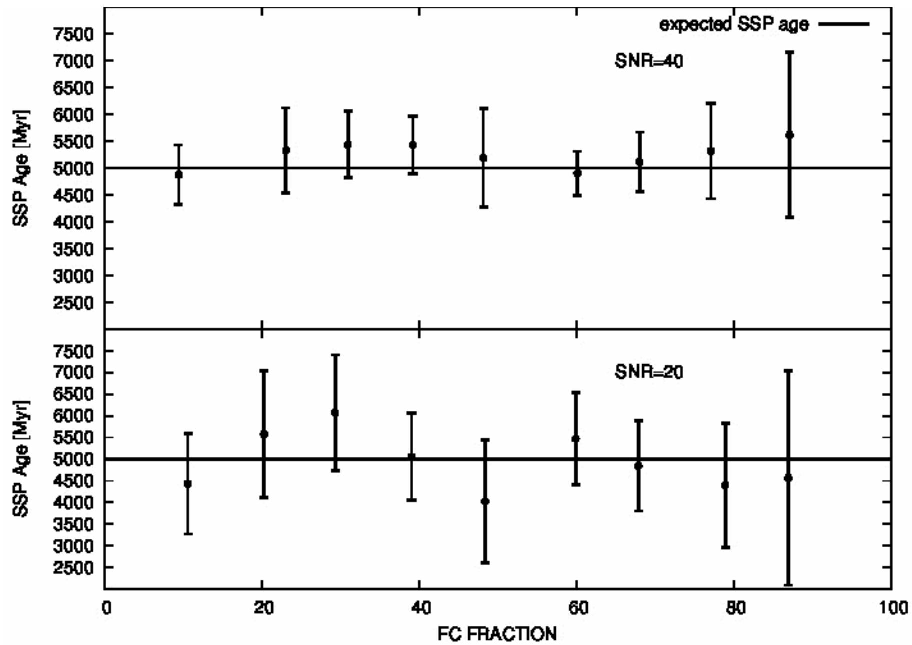
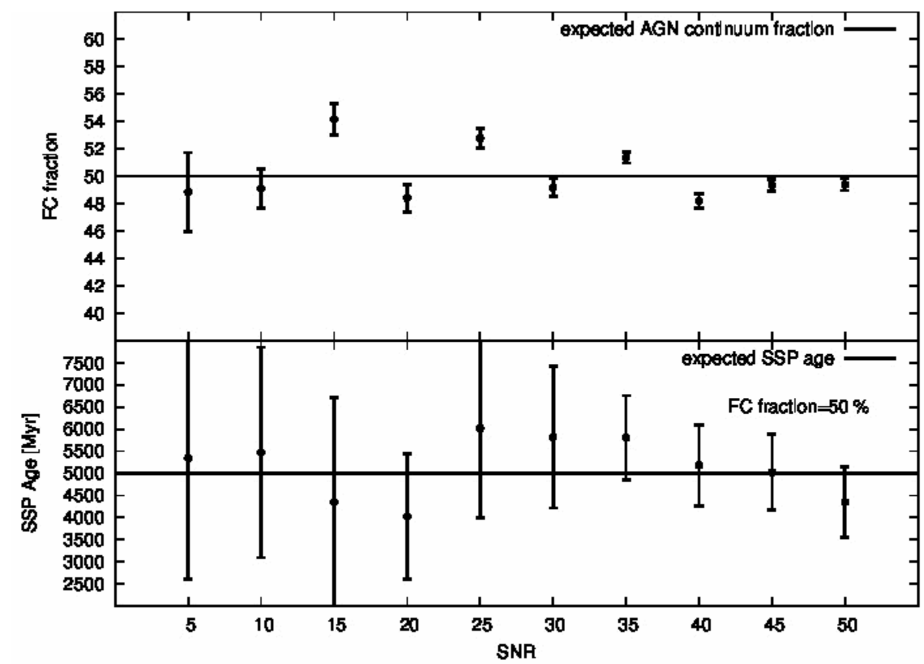
SP analysis in AGN spectra: Simulations



The restored SSP ages from the single best fit for different FC contributions to the total spectrum (10%-90%) in the cases of SNR=40 (top panel) and SNR=20 (bottom panel).



The restored SSP age (top panel) and AGN continuum fraction (bottom panel) from the single best fit for different signal-to-noise ratio (SNR=5-50) in the case of 50% of FC contribution.

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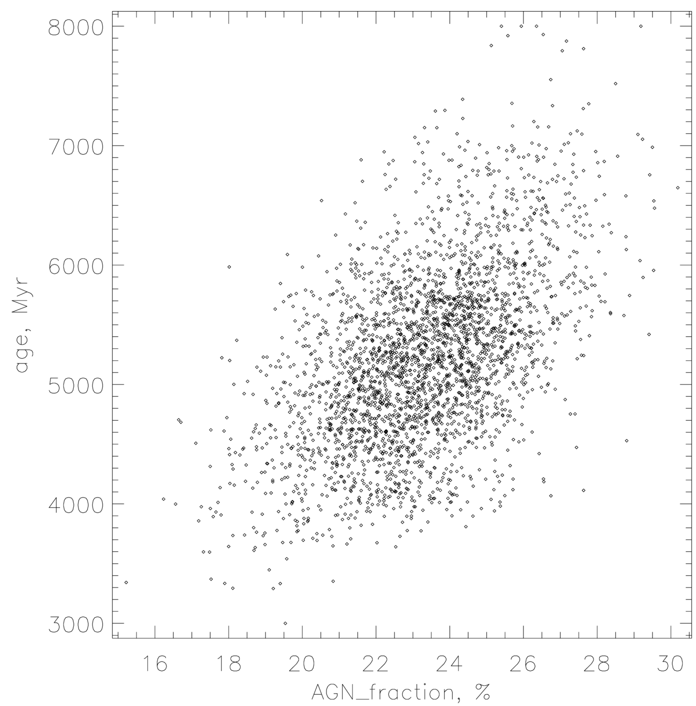
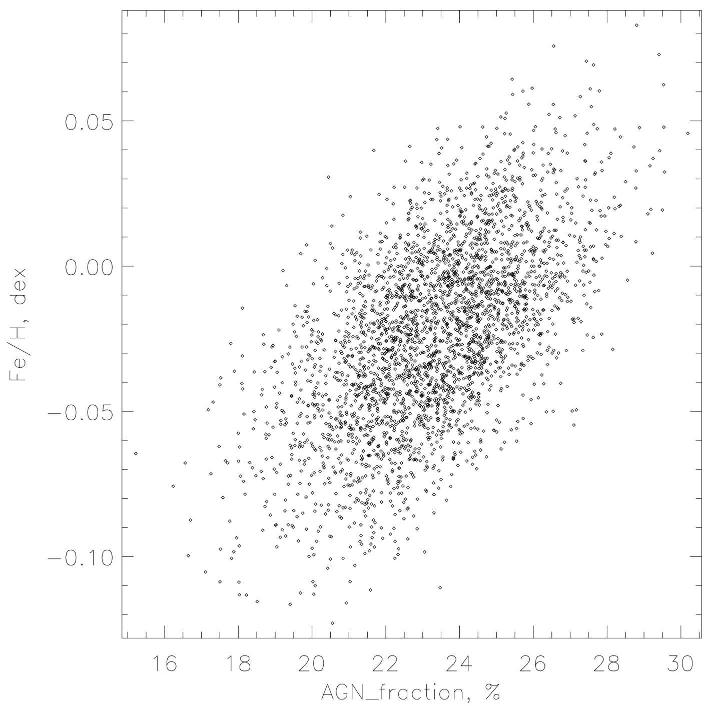
SP analysis in AGN spectra: Simulations





Result of the 3000 Monte Carlo simulations for the case of 75% (left) of the SP contribution to the continuum. Plots represents dependences between the AGN continuum contribution and (a) the metallicity of the dominated stellar population (b) mean stellar population age.

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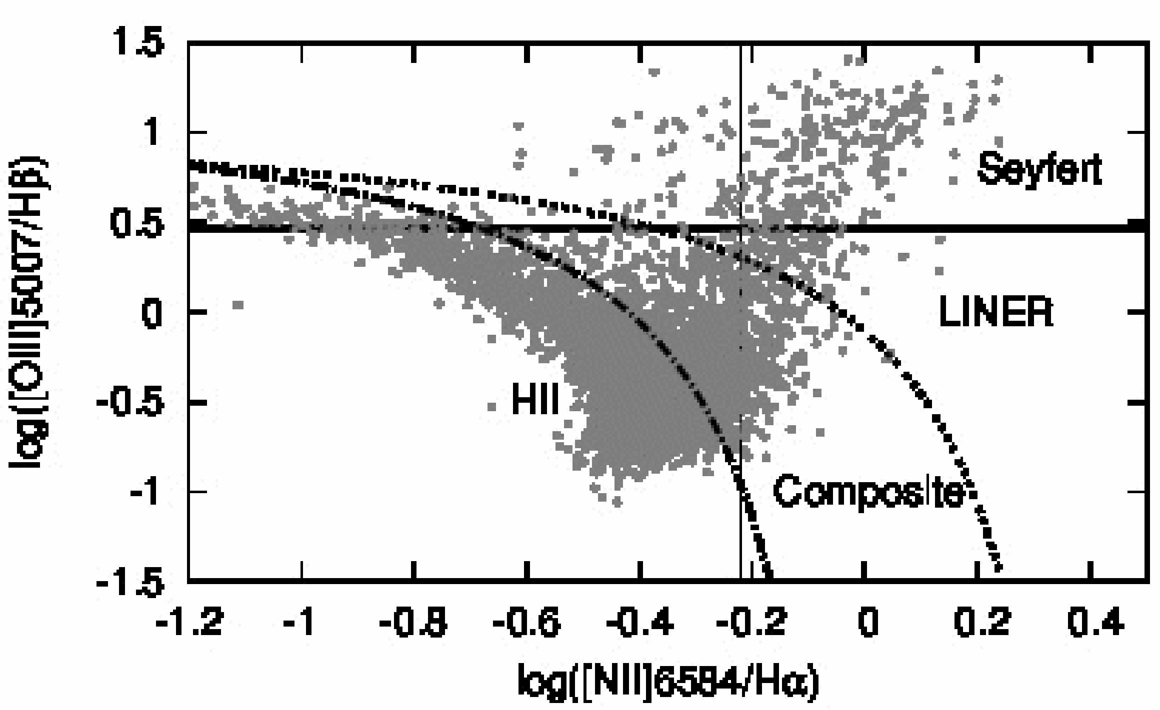
Application of the method on the Type 2 objects



Sample contains: 229 Sy 2s,
89 LINERs,
3117 HII galaxies
1078 composite objects

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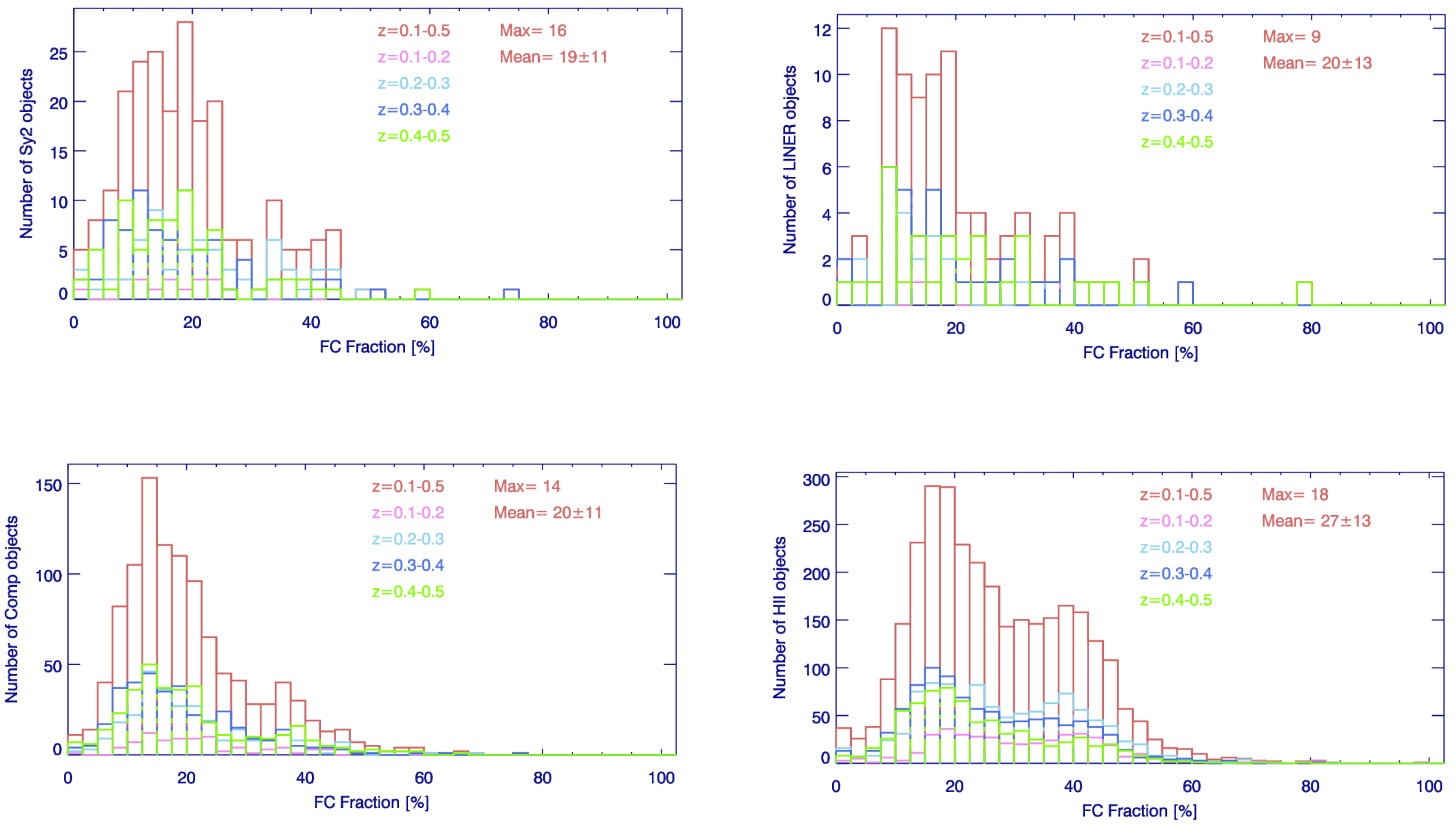
Application of the method on the Type 2 objects

Featureless continuum contribution



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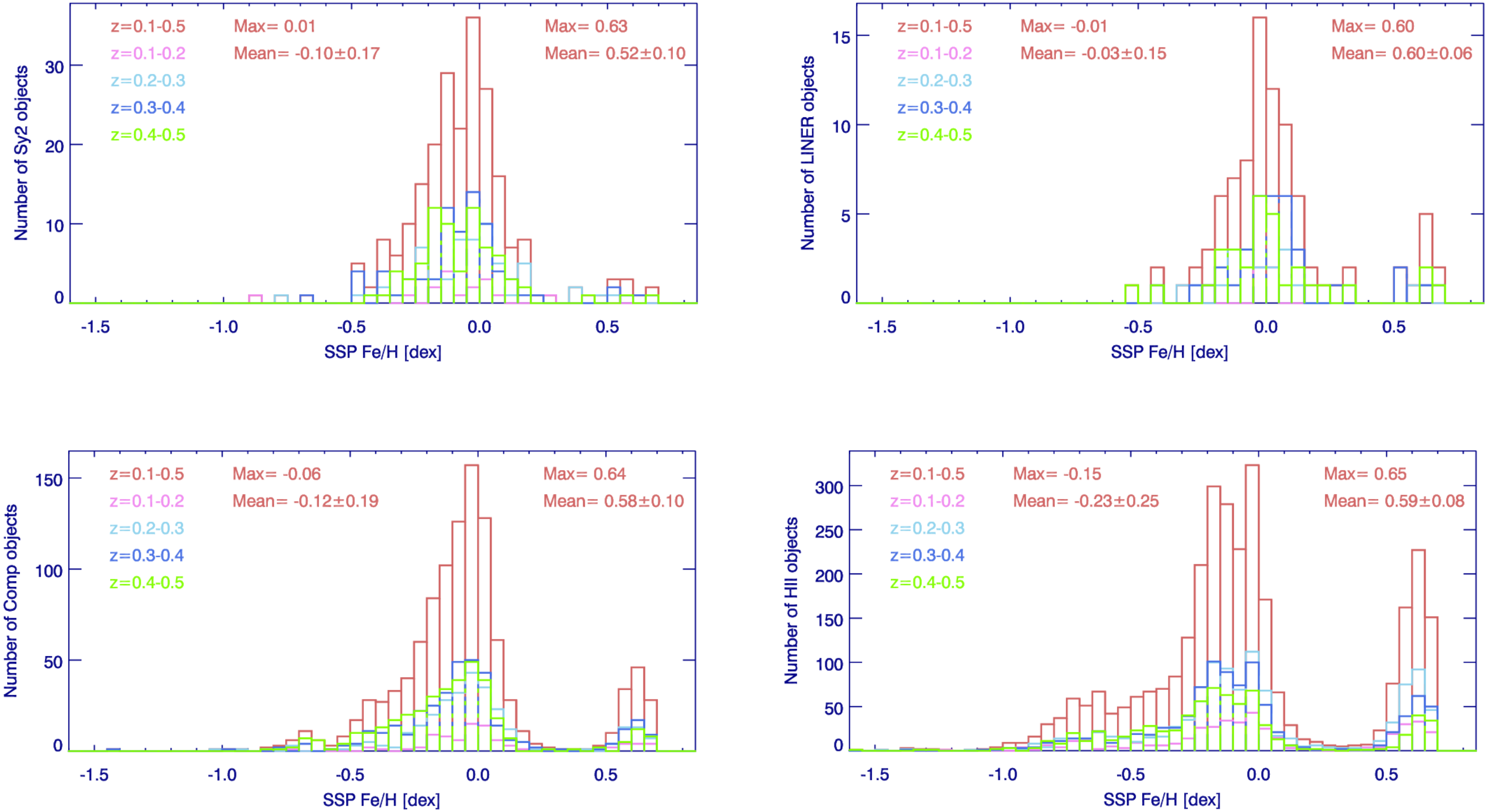
Application of the method on the Type 2 objects

Stellar population metallicity



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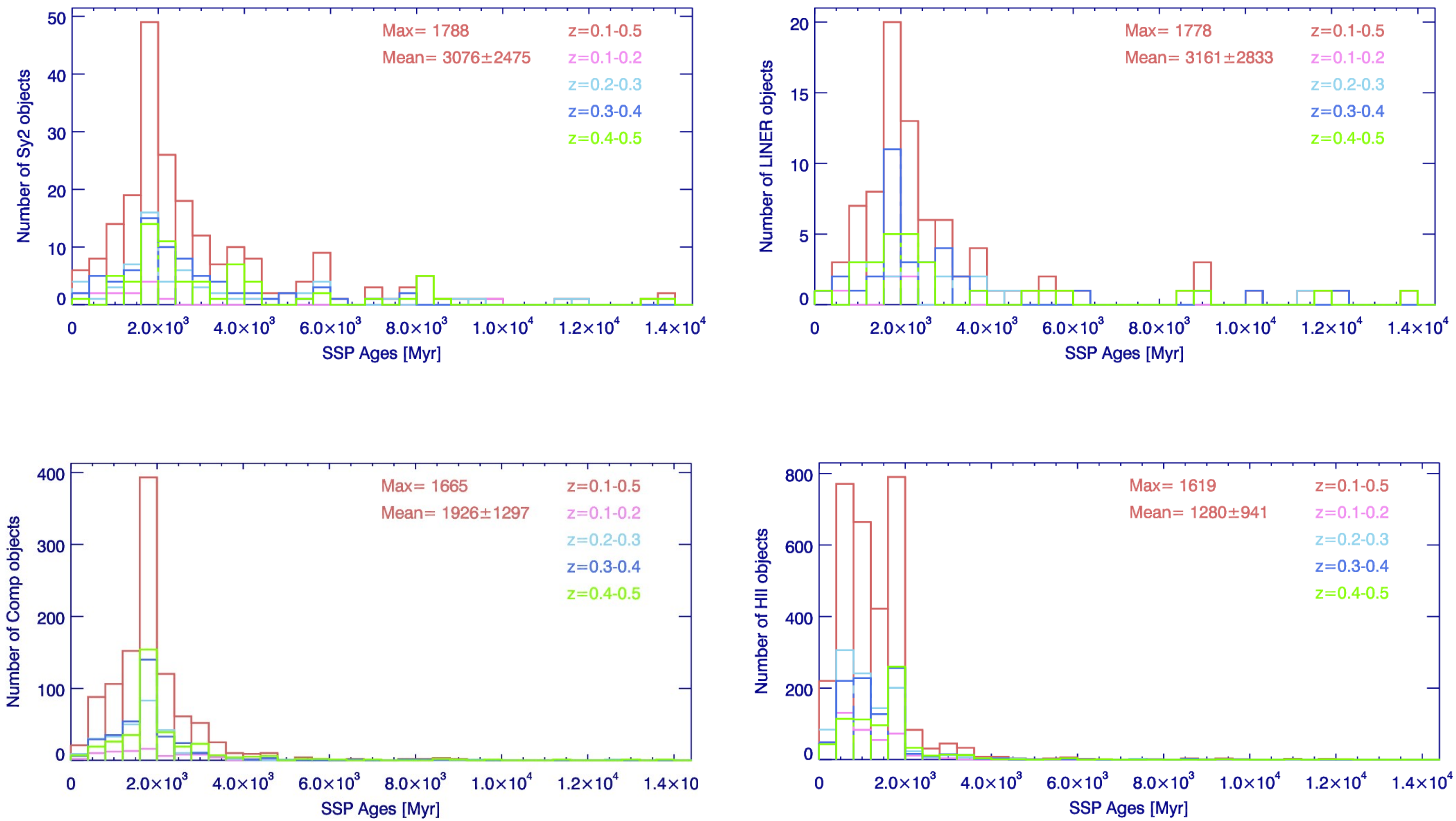
Application of the method on the Type 2 objects

Stellar population ages



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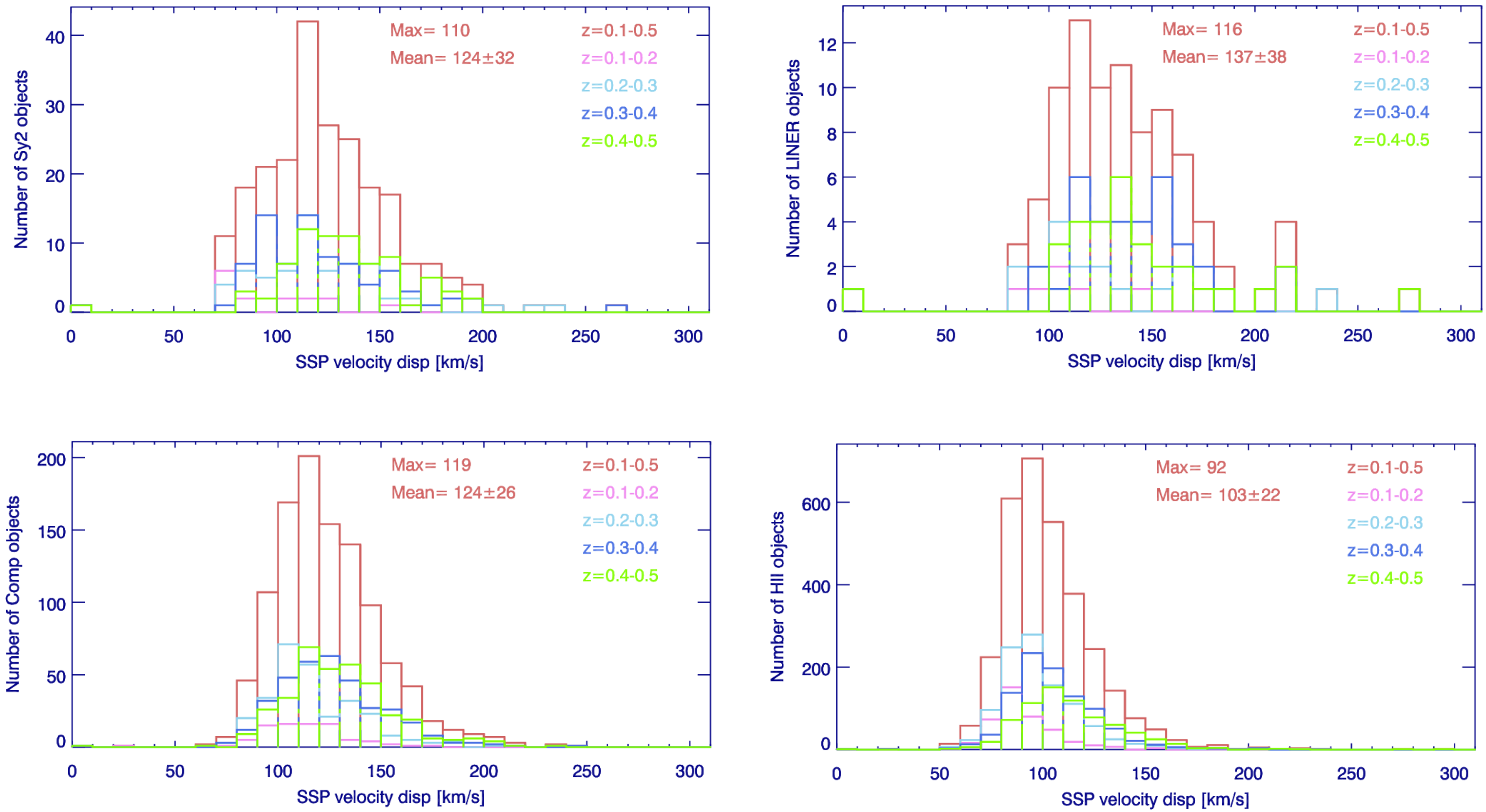
Application of the method on the Type 2 objects

Stellar population velocity distribution



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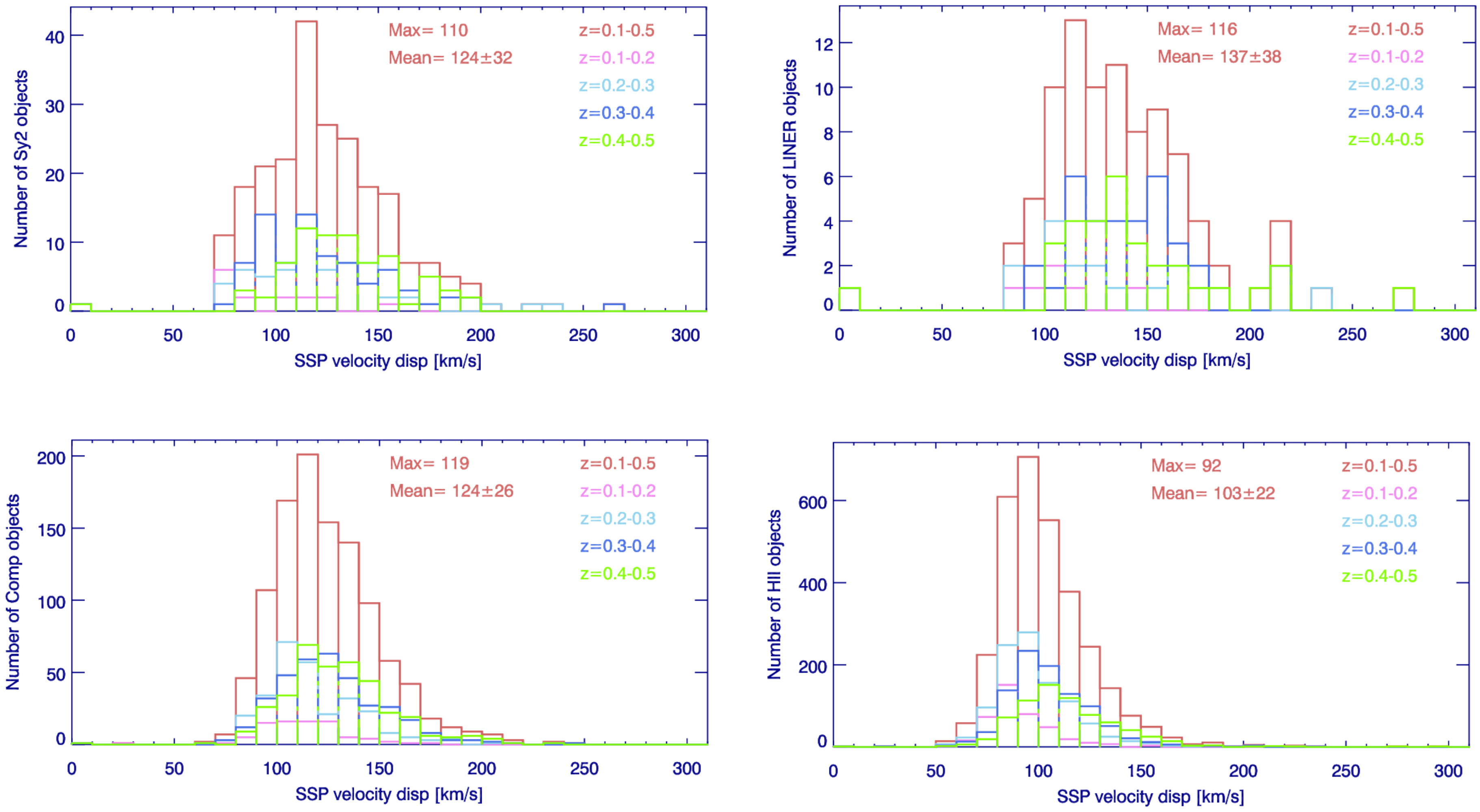

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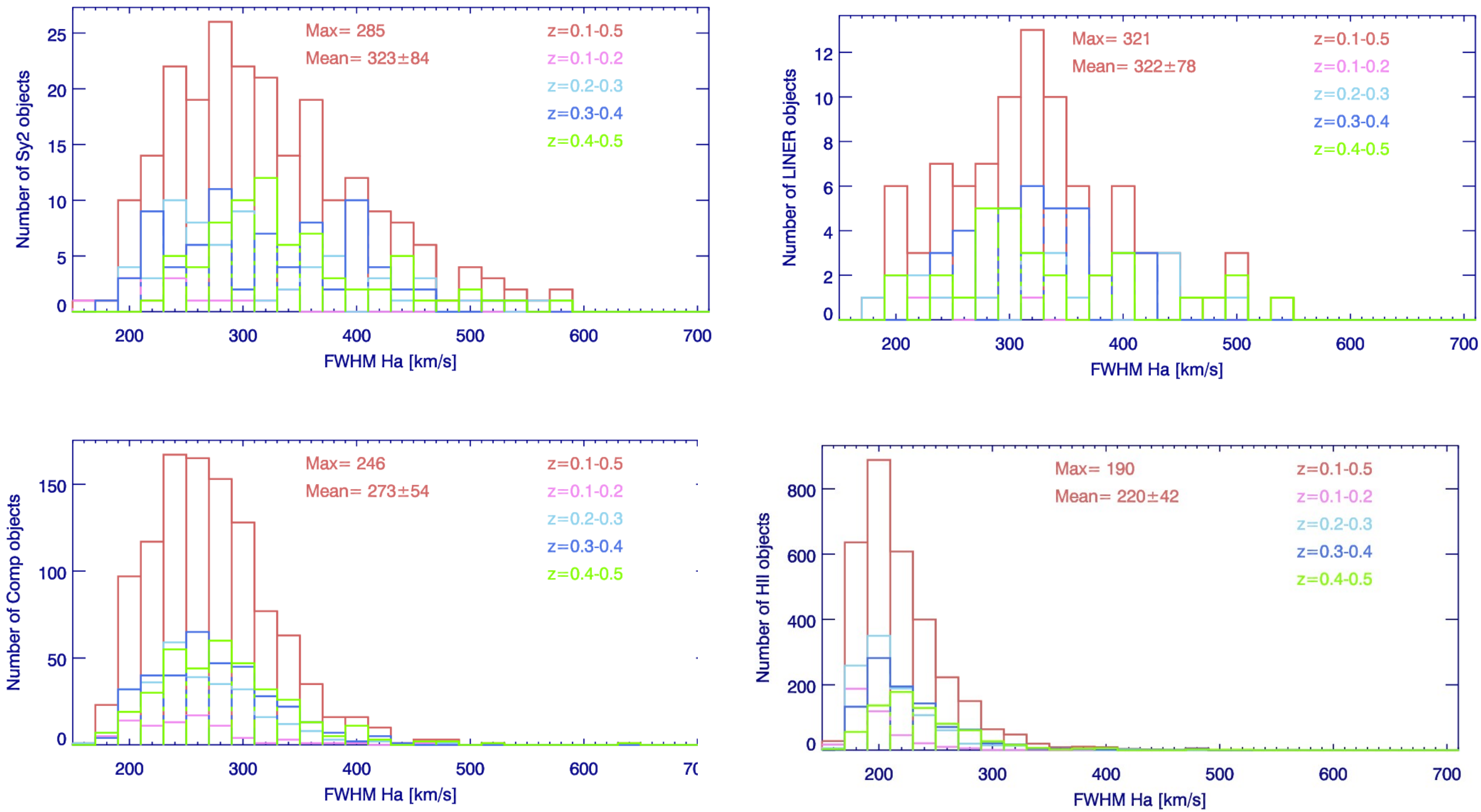
Application of the method on the Type 2 objects

FWHM of Hα emission line



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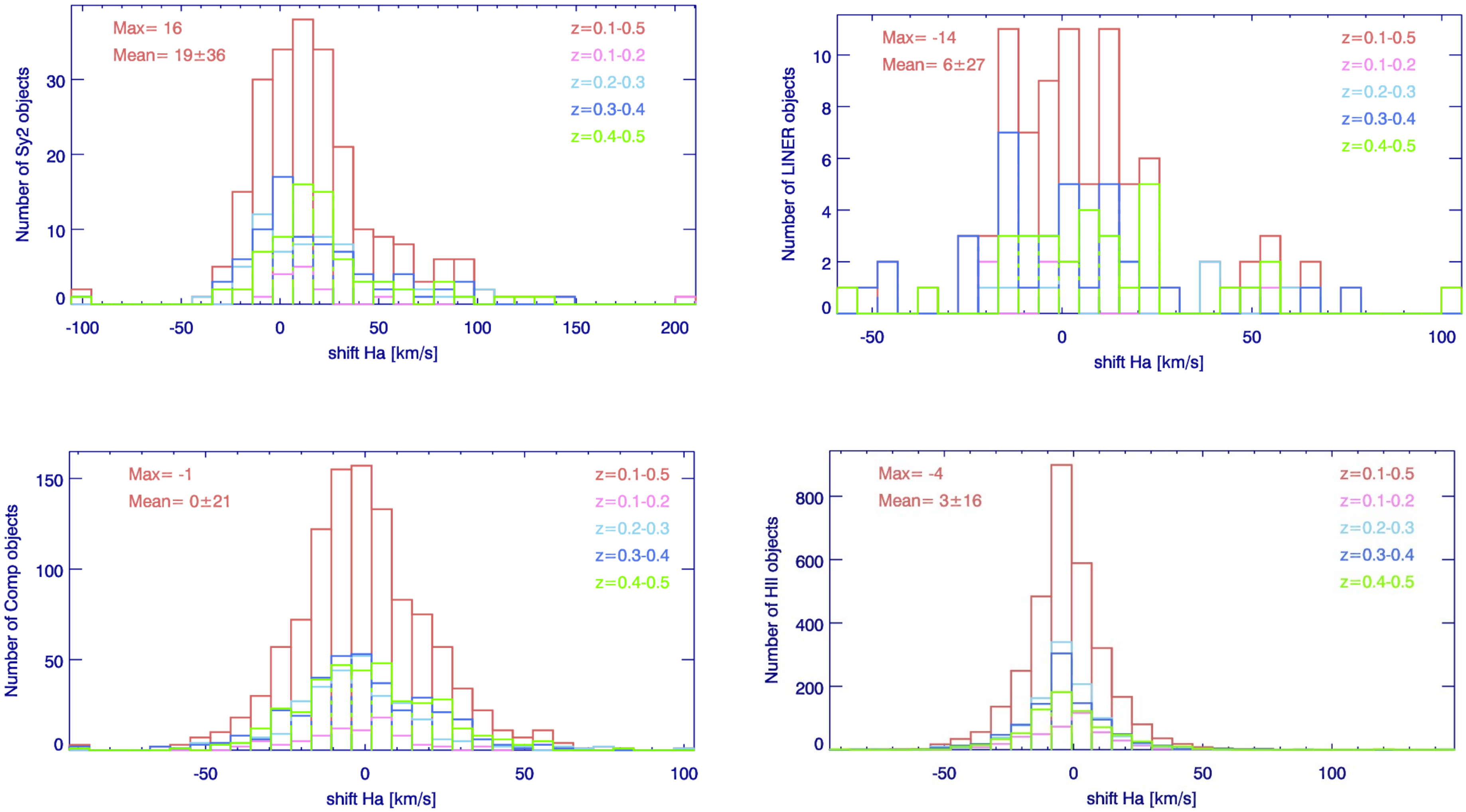
Application of the method on the Type 2 objects

Shift of Hα emission line



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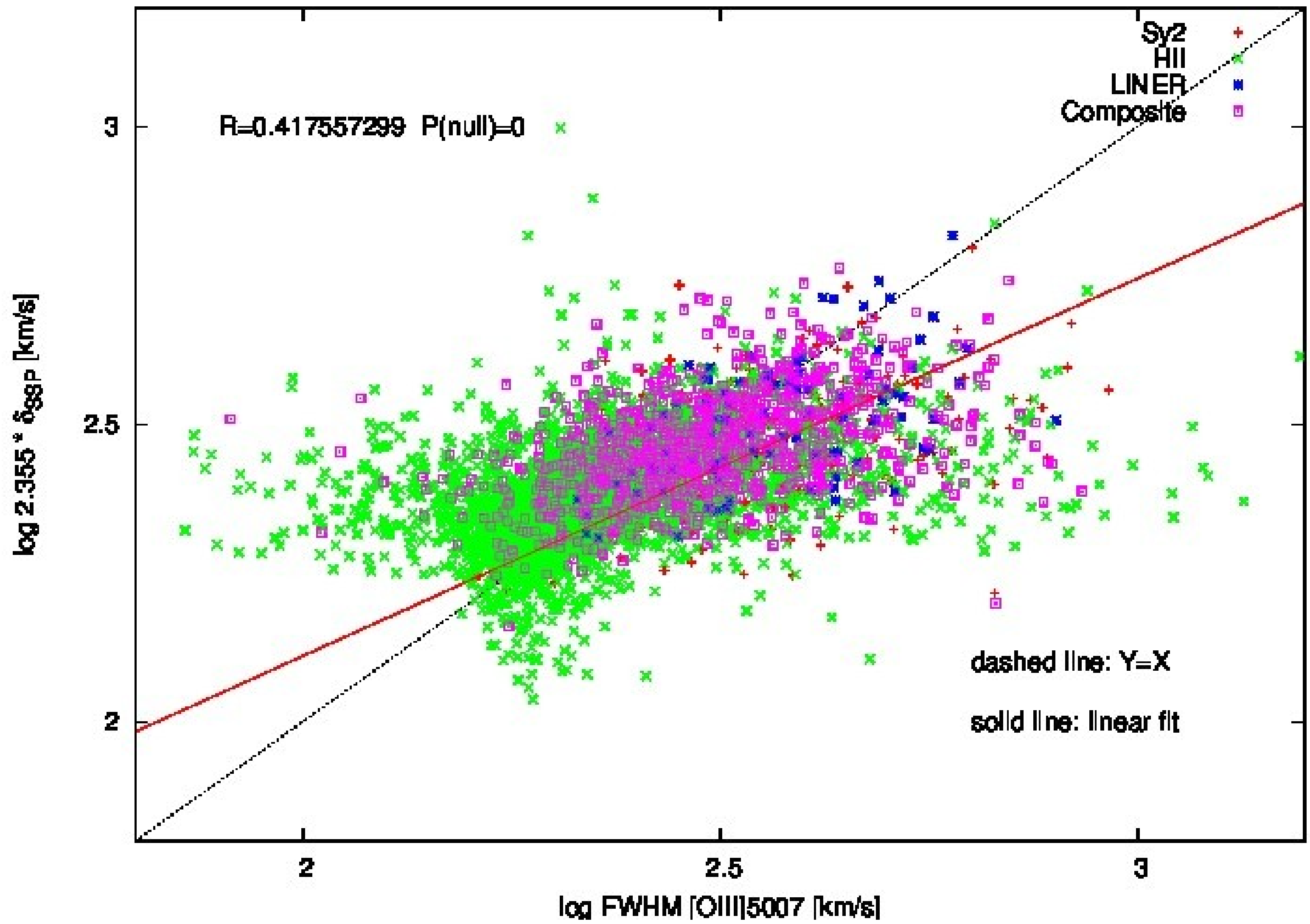
Relation between gas and SP properties in galaxies



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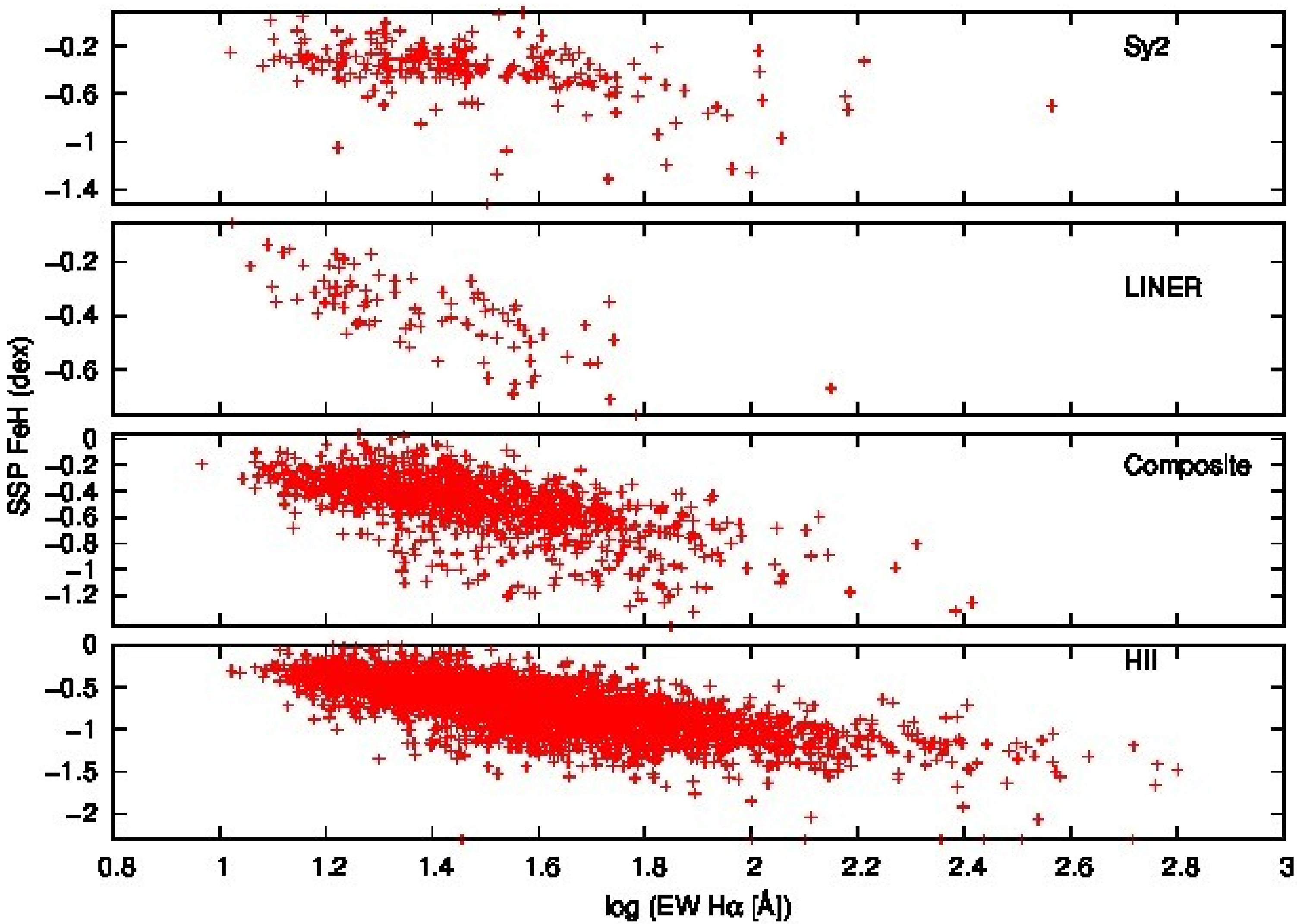

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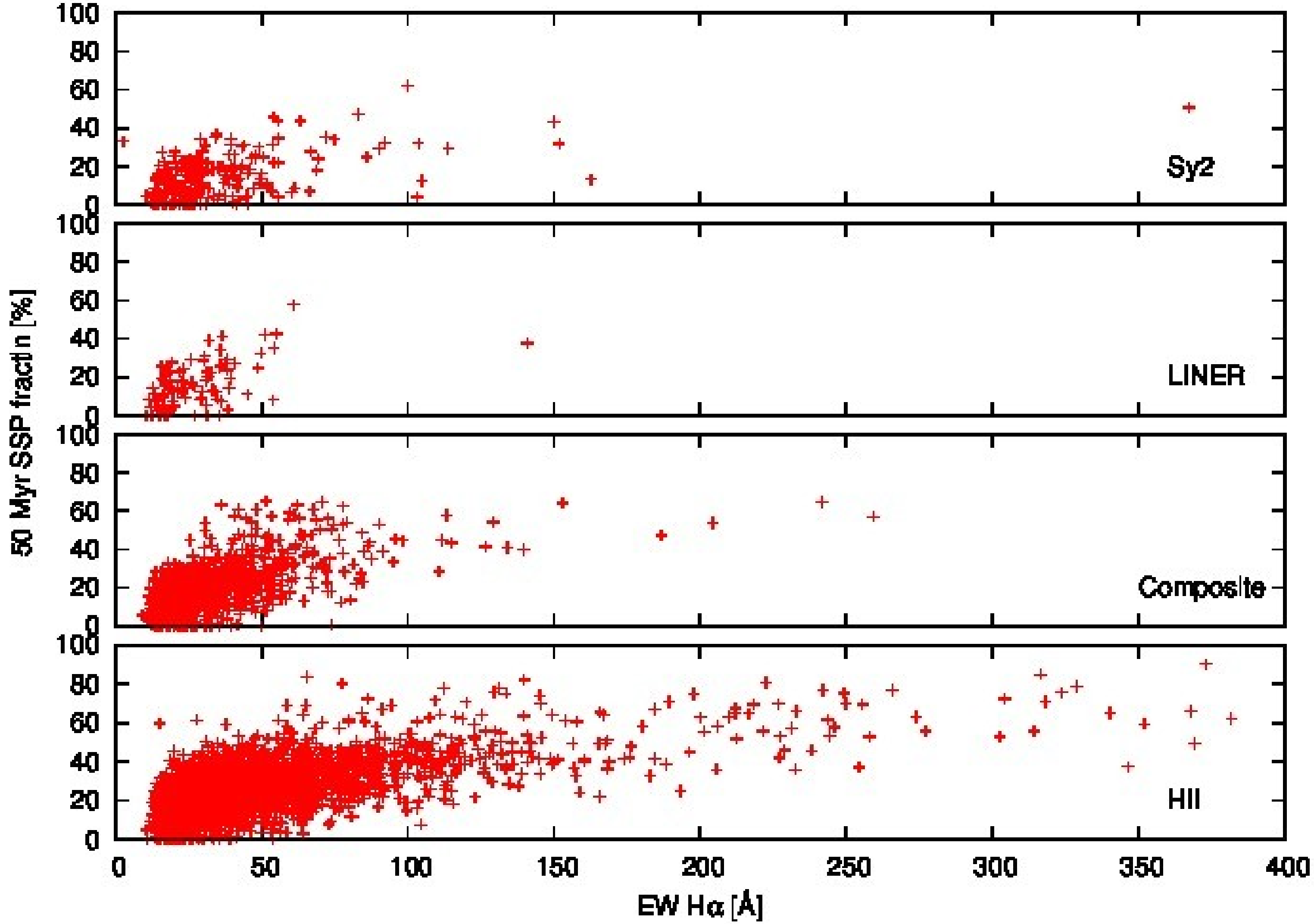
Relation between gas and SP properties in galaxies



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Conclusions

We built a method for simultaneous analysis of all components of integrated AGN spectra.

- **Analysis showed that our method efficiently restores:**
  - **FC contribution to AGN spectrum**
  - **kinematics, age, and metallicity of the underlying SP in AGN spectra**
  - **kinematic properties of the gas**
  - **The accuracy of the results obtained for SP properties decrease with FC contribution.**

Conclusions

Application of the method to the spectra of Type 2 galaxies:

- **Sy2s, LINERs and composite objects have the same distribution of SP ages in the first kpc;**

- **we noticed that the metallicity in the Sy2 and LINERs is mainly Solar-like, while HII regions and composite objects are characterised with sub-solar metallicity;**

- **We showed that spectra of Type 2 galaxies can be distinguished according to the FWHM of their emission lines.**