SDSS GALAXIES WITH DOUBLE-PEAKED EMISSION LINES

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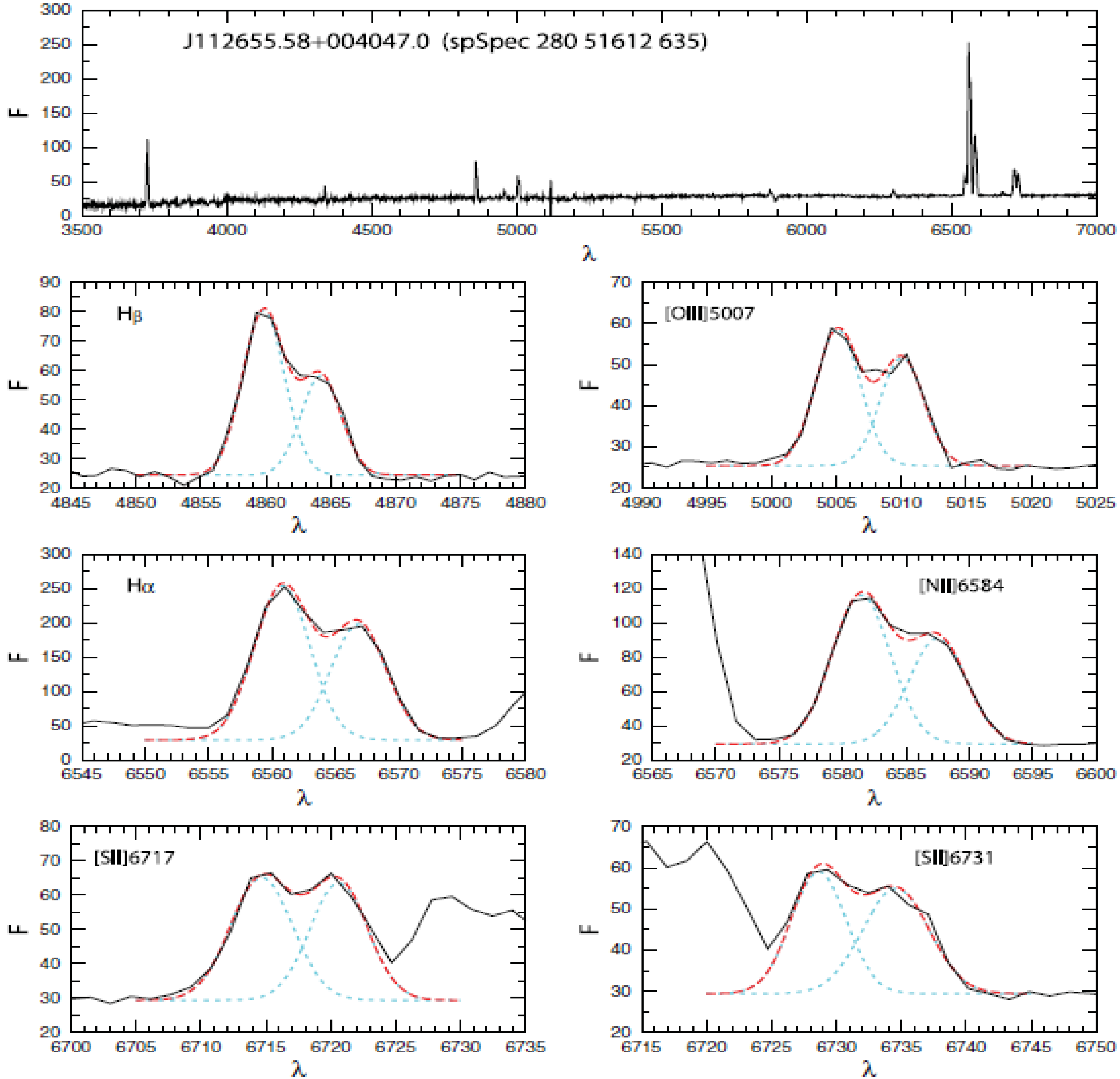
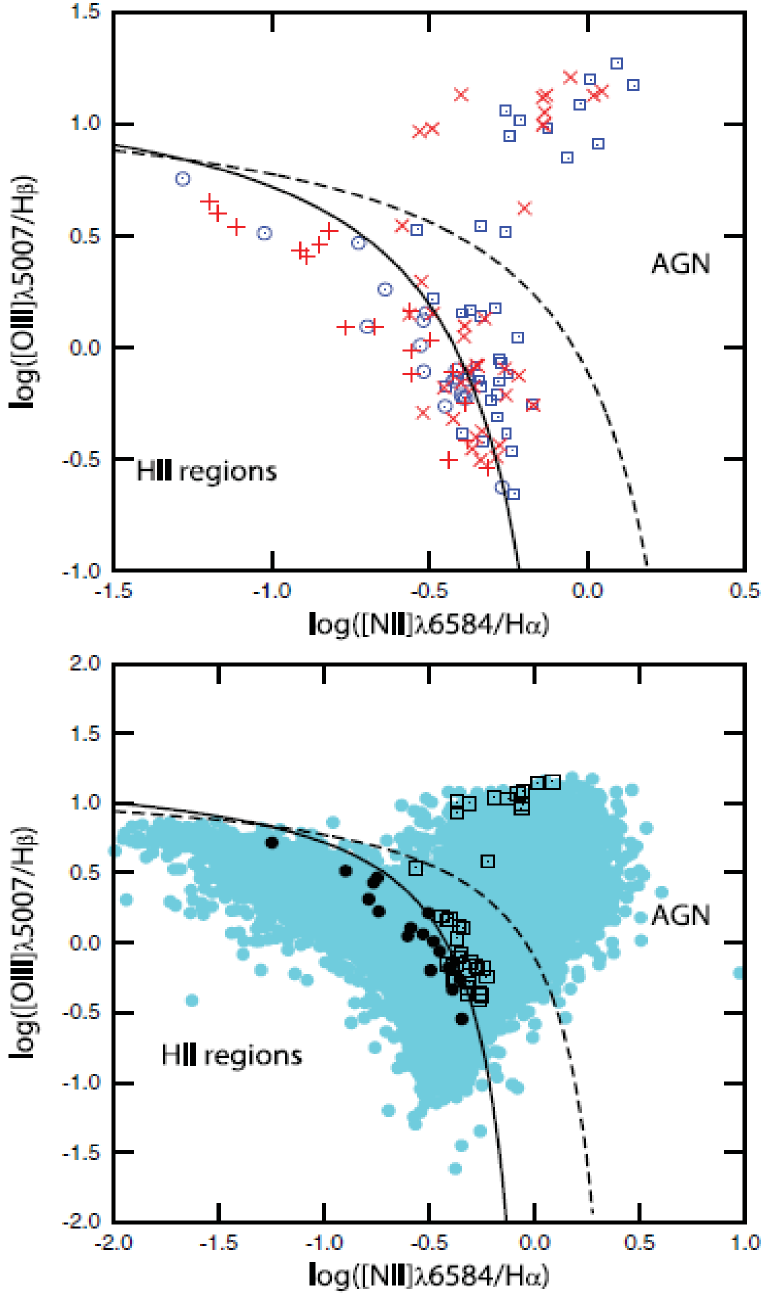
- While double-peaked emission lines have been extensively studied in AGNs, double-starbust galaxies are as yet unexplored
- SDSS Database (release 7)
  - Spectra: 3-arcsec diameter fibres.
  - At z=0.12 → ~7kpc (this means the spectrum is closer to a "global" spectrum of the galaxy)
- If two giant HII regions (associated with strong starbusts) are present in a galaxy, they will make a dominant contribution in the global spectrum, and a double peaked emission line profile may be expected.
- These systems may introduce errors in abundance determinations due to the mixing of two starbust events.
- **Establishing the abundances for each component as well as the "global" abundance will shed light on the impact of the double-peaked emission lines in global metallicity determinations.**

DATASET:

- In Pilyugin, Vílchez, Cedrés & Thuan 2010, MNRAS, 403, 896 the full SDSS database was visually inspected.
- Several hundreds of spectra from double peaked galaxies from SDSS database were extracted.
- Two Gaussians were fitted to the emission lines Hα, Hβ, [OIII]λ5007, [NII]λ6568, [SII]λ6717 and [SII]λ6731.
- 55 spectra were selected where the fit was reliable.



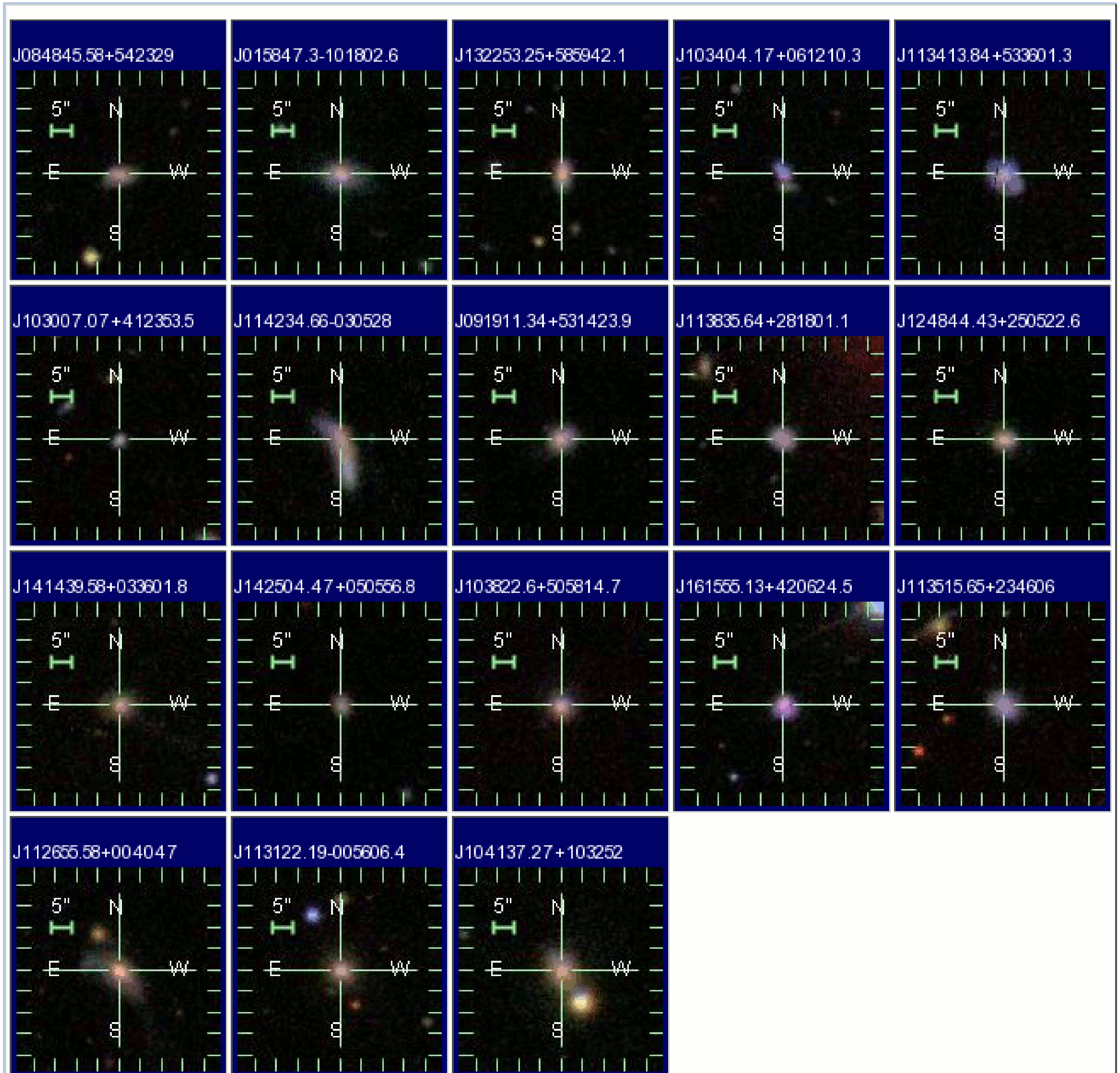
J112655.58+004047.0 (spSpec 280 51612 635)
Hβ
[OIII]5007
Hα
[NII]6584
[SII]6717
[SII]6731
F
λ



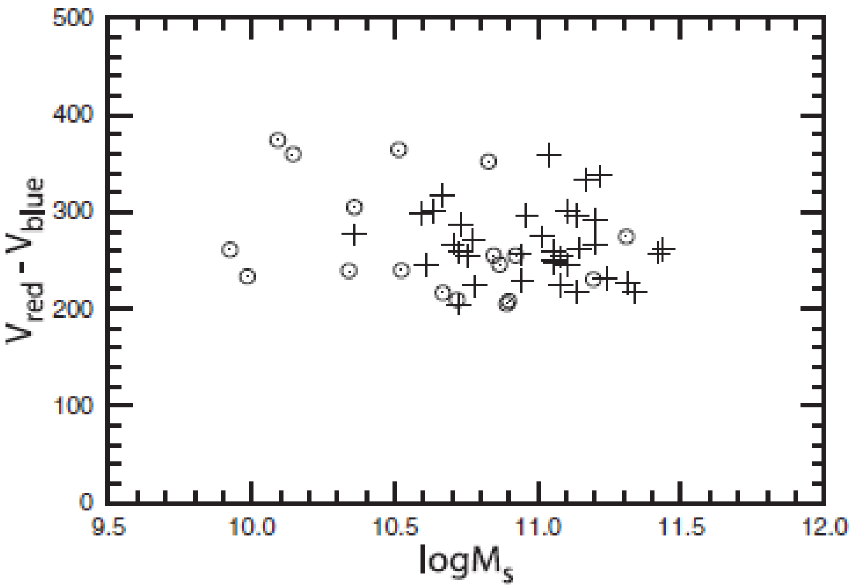
Light-blue dots: large sample of emission-line SDSS galaxies from Thuan et al. (2010).

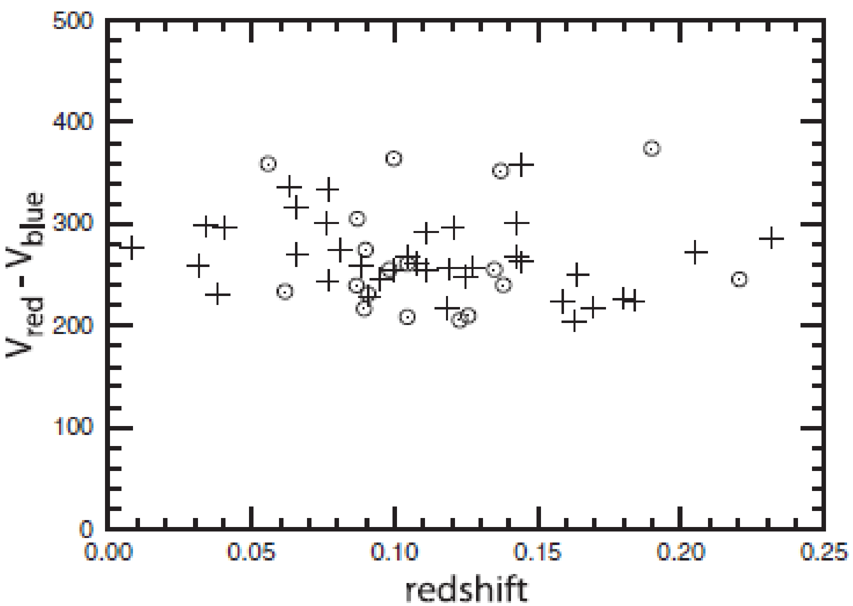
STARBUSTS - AGNs

- Subsample A: 18 galaxies, both components (blue and red) are starburst-like objects
- Subsample B: 37 galaxies. One or both components show non-thermal ionization.
- All galaxies in both samples show narrow lines.
- Separation lines:
  - Continuous line: Kauffmann et al. (2003)
  - Dashed line: Kewley et al. (2001)


J084845.58+542329
J015847.3-101802.6
J132253.25+585942.1
J103404.17+061210.3
J113413.84+533601.3
J103007.07+412353.5
J114234.66-030528
J091911.34+531423.9
J113835.64+281801.1
J124844.43+250522.6
J141439.58+033601.8
J142504.47+050556.8
J103822.6+505814.7
J161555.13+420624.5
J113515.65+234606
J112655.58+004047
J113122.19-005606.4
J104137.27+103252

VELOCITY SEPARATION





- The difference between the radial velocities in the blue and red components was determined from the mean value of the differences for individual lines
- Differences in the radial velocity range between 200 and 400 km/s
- There is not correlation with stellar mass nor with redshift
- Galaxies with AGN-like spectra seem to be (on average) more massive than subsample A galaxies.
- The lower-limit difference (~200 km/s) is defined by the requirement that the two peaks in the line profile should be clearly separated.
- Depending on the inclination, the rotation velocity of a large spiral galaxy can be in the range of 200-600 km/s (Pilyugin, Vílchez & Contini, 2004). The largest difference between radial velocities between the blue and red components (400 km/s) in our sample is well within this range.

OXYGEN AND NITROGEN ABUNDANCES

- Not possible to divide the [OII]λλ3727+3729 doublet into blue and red components.
- We used NS-calibration to determine abundances and the t_2 electron temperatures (Pilyugin & Mattsson 2011).
- This calibration express the abundance of oxygen and nitrogen in terms of the fluxes of O^{++}, N^{+} and S^{+}.

$$Z_O = 8.454 - 0.216 \log R_3 - 0.362 \log S_2 - 0.101 \log(N_2/S_2), \quad \text{for} \quad \log N_2 > -0.1,$$

$$Z_O = 8.456 + 0.082 \log R_3 + 0.391 \log N_2 + 0.290 \log(N_2/S_2), \quad \text{for} \quad \log N_2 < -0.1,\ \log(N_2/S_2) > -0.25,$$

$$Z_O = 7.881 + 0.929 \log R_3 + 0.650 \log N_2 + 0.025 \log(N_2/S_2), \quad \text{for} \quad \log N_2 < -0.1,\ \log(N_2/S_2) < -0.25.$$

$$Z_N = 7.414 - 0.383 \log R_3 + 0.119 \log S_2 + 0.988 \log(N_2/S_2), \quad \text{for} \quad \log N_2 > -0.1,$$

$$Z_N = 7.250 + 0.078 \log R_3 + 0.529 \log N_2 + 0.906 \log(N_2/S_2), \quad \text{for} \quad \log N_2 < -0.1,\ \log(N_2/S_2) > -0.25,$$

$$Z_N = 6.599 + 0.888 \log R_3 + 0.663 \log N_2 + 0.371 \log(N_2/S_2), \quad \text{for} \quad \log N_2 < -0.1,\ \log(N_2/S_2) < -0.25.$$

OXYGEN AND NITROGEN ABUNDANCES

- For the global spectra (sum of blue and red components) it is possible to measure the [OII]λλ3727+3729 doublet.
- A new calibration will be employed to determine the oxygen and nitrogen abundances: ON-calibration (Pilyugin, Vílchez & Thuan 2010).
- Derived using spectra of HII regions with well measured electron temperatures as calibration data points.

$$12 + \log(\mathrm{O/H})_{\mathrm{ON}} = 8.606 - 0.105 \log R_3 - 0.410 \log R_2 - 0.150 \log(N_2/R_2) \text{ if } \log N_2 > -0.1$$

$$12 + \log(\mathrm{O/H})_{\mathrm{ON}} = 8.642 + 0.077 \log R_3 + 0.411 \log R_2 + 0.601 \log(N_2/R_2) \text{ if } \log N_2 < -0.1, \ \log(N_2/S_2) > -0.25$$

$$12 + \log(\mathrm{O/H})_{\mathrm{ON}} = 8.013 + 0.905 \log R_3 + 0.602 \log R_2 + 0.751 \log(N_2/R_2) \text{ if } \log N_2 < -0.1, \ \log(N_2/S_2) < -0.25.$$

$$12 + \log(\mathrm{N/H})_{\mathrm{ON}} = 7.955 + 0.048 \log R_3 - 0.171 \log N_2 + 1.015 \log(N_2/R_2) \text{ if } \log N_2 > -0.1$$

$$12 + \log(\mathrm{N/H})_{\mathrm{ON}} = 7.928 + 0.291 \log R_3 + 0.454 \log N_2 + 0.953 \log(N_2/R_2) \text{ if } \log N_2 < -0.1, \ \log(N_2/S_2) > -0.25$$

$$12 + \log(\mathrm{N/H})_{\mathrm{ON}} = 7.505 + 0.839 \log R_3 + 0.492 \log N_2 + 0.970 \log(N_2/R_2) \text{ if } \log N_2 < -0.1, \ \log(N_2/S_2) < -0.25.$$

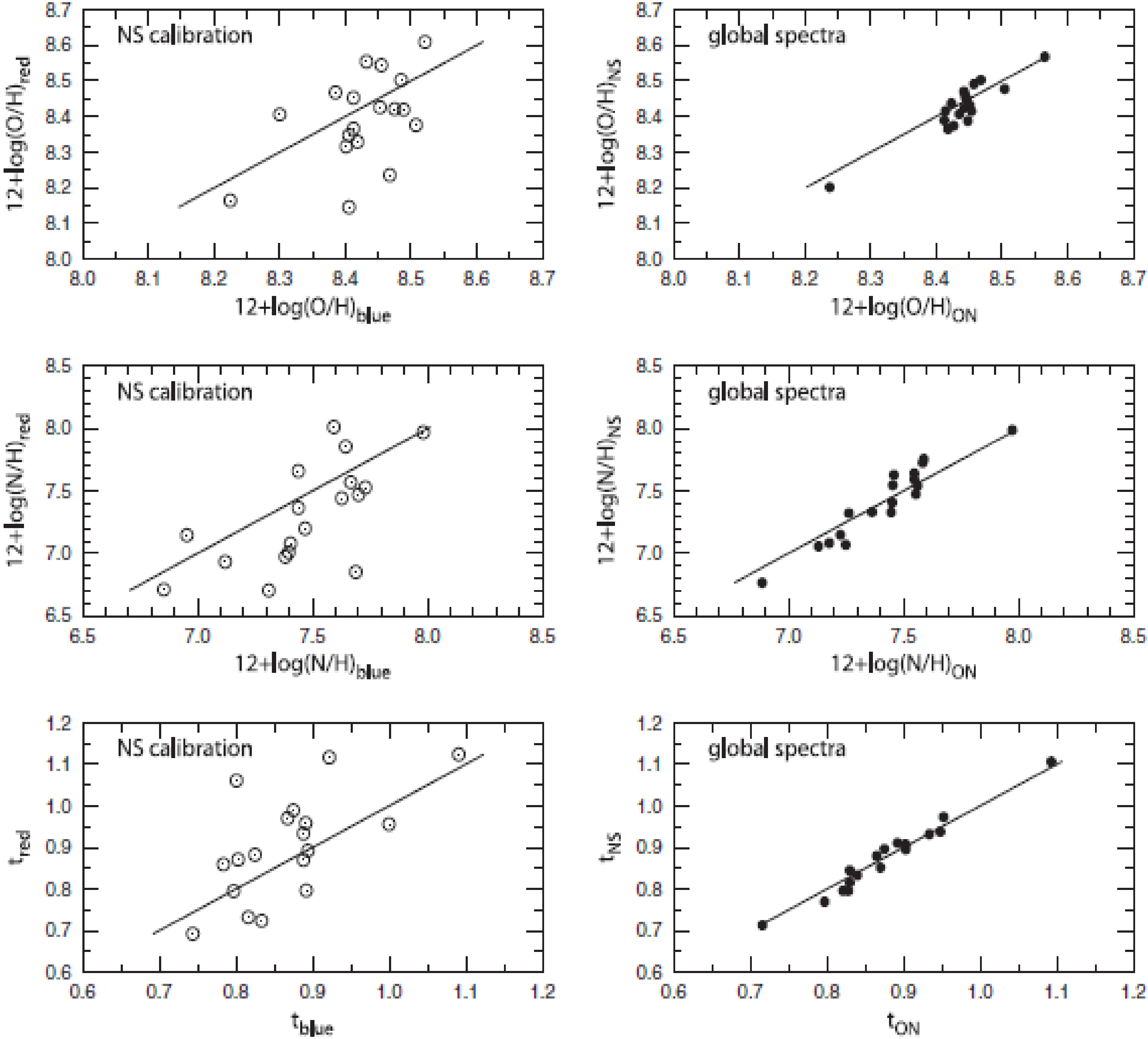
$$R_2 = [\mathrm{O\,II}]\lambda 3727 + \lambda 3729 = I_{[\mathrm{O\,II}]\lambda 3727+\lambda 3729} / I_{\mathrm{H}\beta},$$

$$N_2 = [\mathrm{N\,II}]\lambda 6548 + \lambda 6584 = I_{[\mathrm{N\,II}]\lambda 6548+\lambda 6584} / I_{\mathrm{H}\beta},$$

$$S_2 = [\mathrm{S\,II}]\lambda 6717 + \lambda 6731 = I_{[\mathrm{S\,II}]\lambda 6717+\lambda 6731} / I_{\mathrm{H}\beta},$$

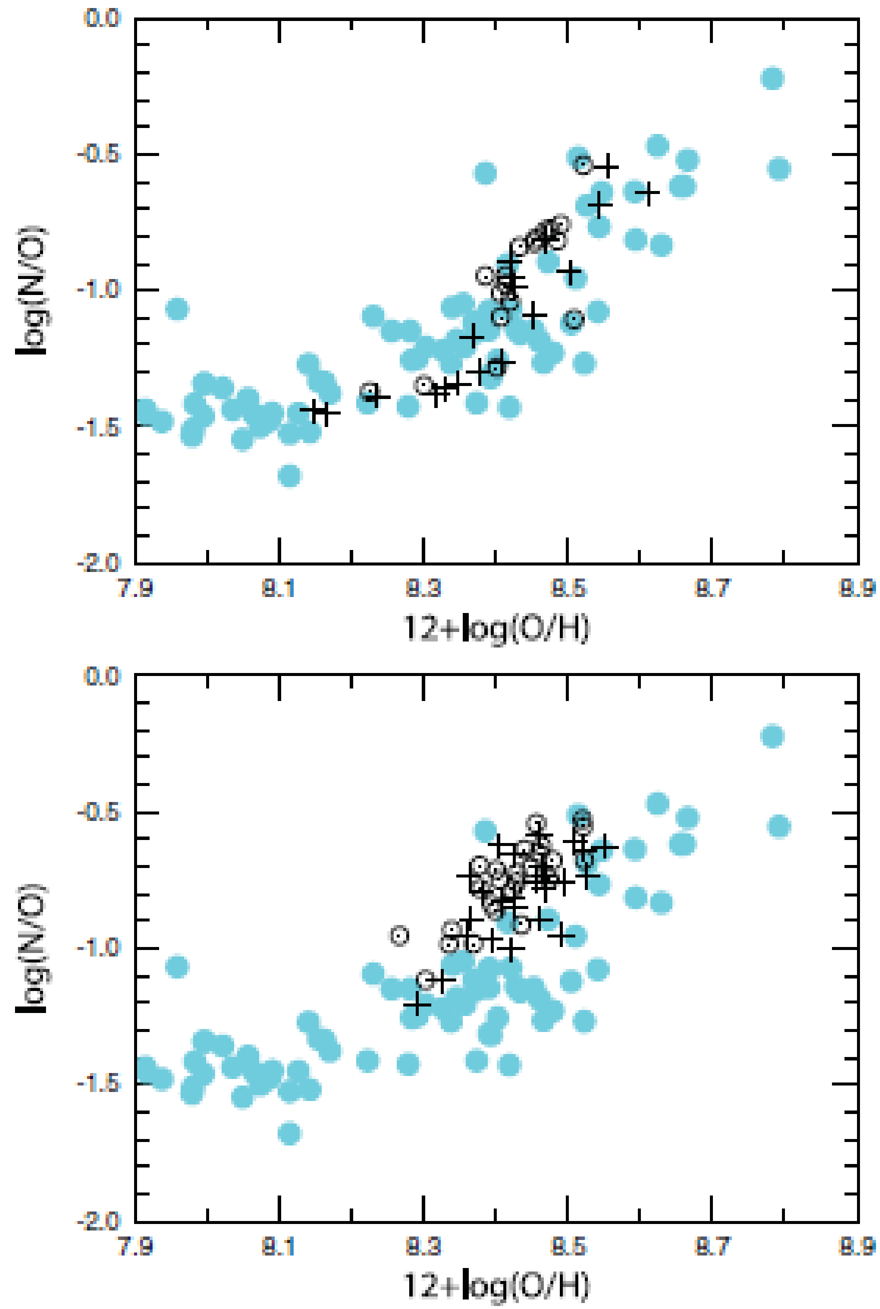
$$R_3 = [\mathrm{O\,III}]\lambda 4959 + \lambda 5007 = I_{[\mathrm{O\,III}]\lambda 4959+\lambda 5007} / I_{\mathrm{H}\beta},$$

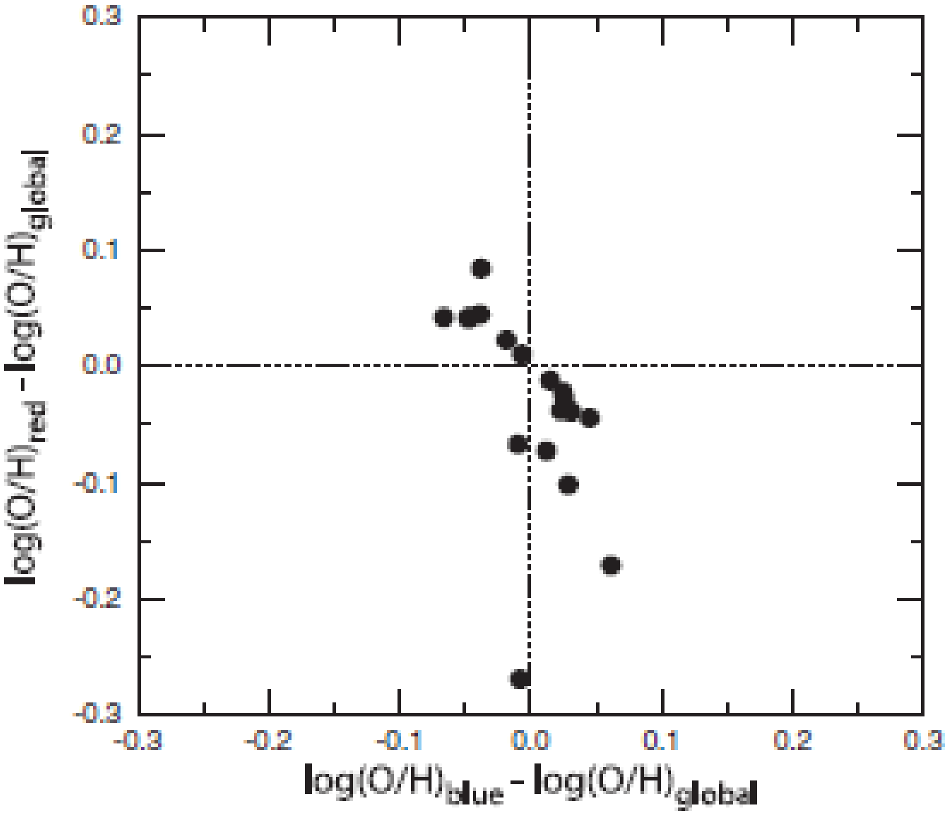
$$R_{23} = R_2 + R_3.$$



NS calibration
12+log(O/H)red
12+log(O/H)blue
global spectra
12+log(O/H)NS
12+log(O/H)ON
12+log(N/H)red
12+log(N/H)blue
12+log(N/H)NS
12+log(N/H)ON
tred
tblue
tNS
tON

- The O/H-N/O diagram serves to test the correctness of the determination of the oxygen and nitrogen abundances.
  - If [NII] fluxes are produced by non-thermal radiation, the NS calibration on these galaxies will result in too high nitrogen abundances.
- Upper panel: Sample A
- Lower panel: Galaxies in sample B between the two division lines in the BPT diagram (Kauffmann et al. 2003 and Kewley et al. 2001).
- Light blue dots: HII regions with T_e abundances from Pilyugin et al. (2010)





- Comparison between the metallicity in the blue and red components and the global metallicity for subsample A galaxies.
- There is an anticorrelation between the two abundances.
- The global oxygen abundance obtained using NS calibration is between the oxygen abundances of the blue and red components.

CONCLUSIONS

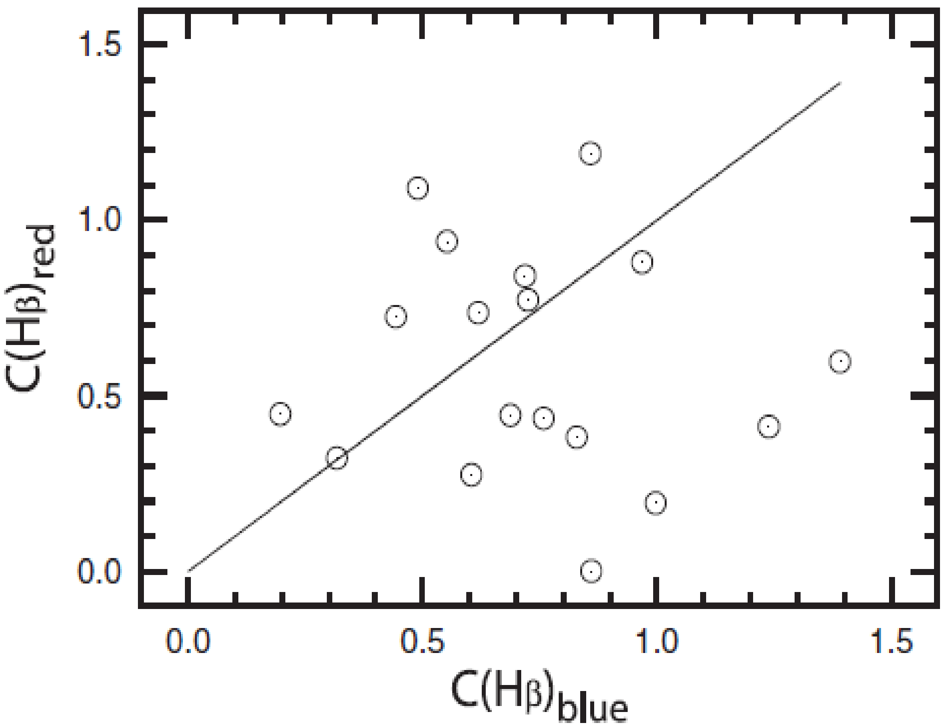
- Hundreds of galaxies with double-peaked lines from SDSS were inspected.
- For 55 of those galaxies, a reliable decomposition of the emission lines was found.
  - A subsample of 18 galaxies with double peaked emission lines where both components belong to photo-ionized objects was obtained.
  - A subsample of 37 galaxies with one or both components showed non-thermal ionization was obtained.
- The differences between radial velocities of blue and red components lie between 200-400 km/s.
- The oxygen and nitrogen abundances, as well as the electron temperatures, for each component and for the global spectra, using the NS calibration, were obtained.
- The global metallicity lays typically in between the oxygen abundance of the blue and red components.
- The ON calibration and NS calibration are in good agreement (abundances and temperatures)

CONCLUSIONS

- Most possible scenario:

  Two giant HII regions located at different positions inside the disc (one region may be associated with circumnuclear star formation).

  HOWEVER two starbusts in two different galaxies, projected on top of each other, cannot be excluded.



- If the radiation from a star-forming region in a more distant galaxy passes through a less distant one, the extinction of the red component should be larger than the extinction of the blue component
- There is no correlation between blue and red components' extinction.
- However, the more distant galaxy can have slightly lower radial velocity than the less distant one due to the random component of their radial velocity