Oxygen abundance from strong-line methods at extremely low metallicities

Authors:
A.B. Morales Luis, J. Sanchez Almeida, C. Muñoz Tuñon, J.A.L. Aguerri, E. Pérez-Montero, J.M. Vilchez, R. Terlevich and E. Terlevich.

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- Low-metallicity galaxies (Introduction & Search)
- Objetive: Low-metallicity galaxies for to complete calibration 12+log(O/H) vs log([NII]6583/Hα).
- We introduce N2 index
- We found problems at low metallicities with the calibration. Using models we try to explain these problems.

Introduction

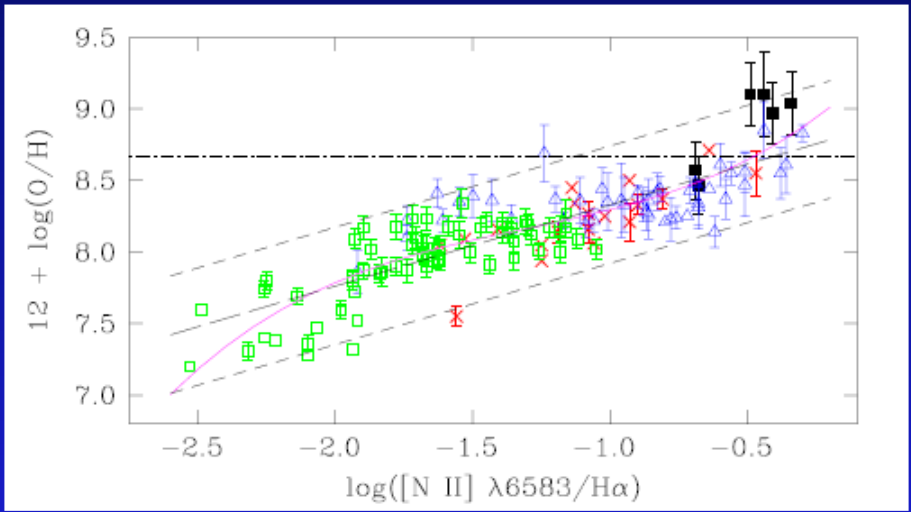
- Deficient metal galaxies are probably unevolved fossils from the early universe:
  - May be the principal building blocks of the Universe on large scales.
  - Play a crucial role in the cosmic scenary.
- Unfortunately, they are rare
- Bibliographic search: 130 galaxies with 12+log(O/H)<7.65 . (Morales-Luis et al. 2011)
- Systematic search: Using k-means with SDSS/DR7 spectra (Morales-Luis et al. 2011).
  - We added 11 low metallicity galaxies to our list.
- The classification is focused on a spectral region very sensitive to metallicity (Denicolo,Terlevich & Terlevich (2002), Pettini & Pagel(2004), Pérez-Montero & Contini (2009))
  - [NII]λ6548 ,Hαλ6563 and [NII]λ6583 region.

Introduction: N2 index

- The N2 index is defined (Denicolo, Terlevich & Terlevich (2002)):

  N2=log([NII]6583 / Hα)

  [Pettini & Pagel (2004)]

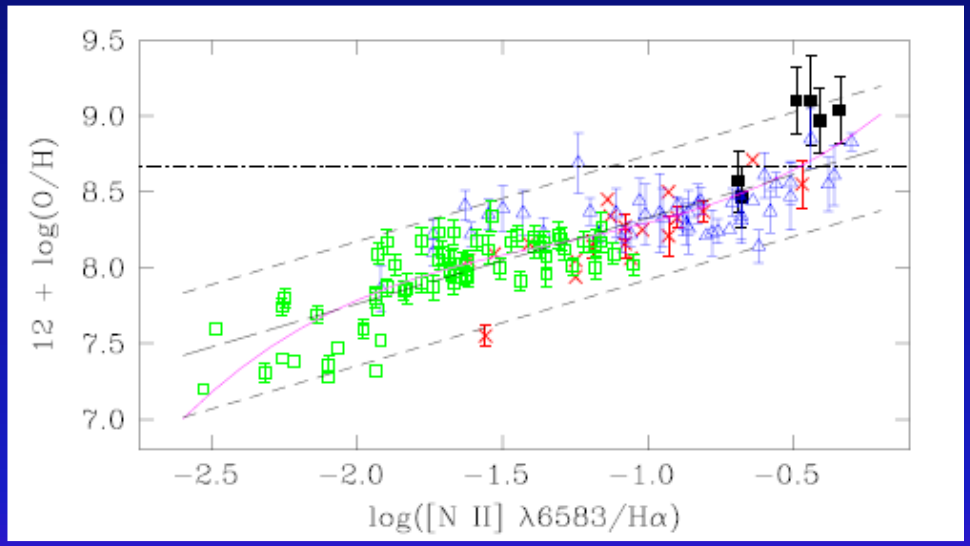


- It is obtained using **only HII regions with values of (O/H) determined via the T_e method** or with detailed photoionization modelling.
- Used to obtain oxygen abundance when we do not have all the lines that we need.

Introduction: N2 index

- Advantages compared to the more familiar R_{23} (another method):
  - It has a **monotonic behaviour** with (O/H) , R_{23} has a double-valued character.
  - It relies on ratios of emission lines which are close in wavelength =>

=> **Does not depend on reddening correction and flux calibration of spectra**.



- Main interest: To apply it with **high-redshift galaxies**.
  - Ex.: Genzel et al. 2011=> z~2 (12+log(O/H)=[8.25,8.69])
  - Ex.: Rix et al. 2004 => Q1307-BM1163 z=1.411 (12+log(O/H)=8.53)

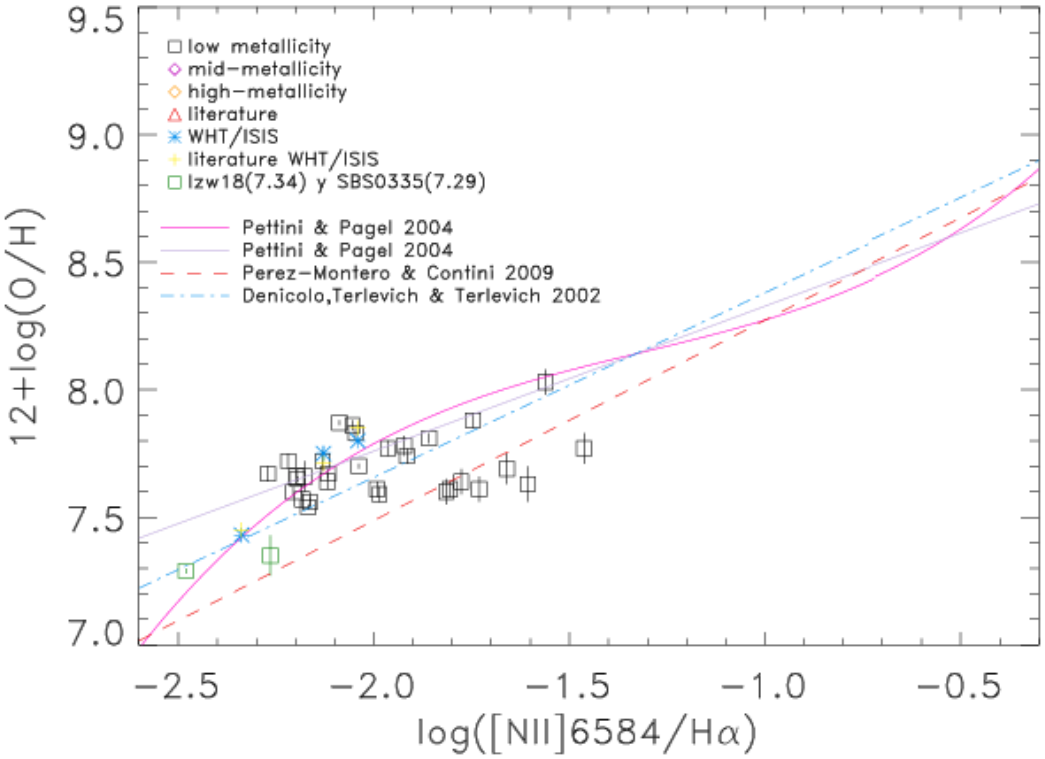
Objetive

- We wanted to complete the sample of low metallicity galaxies to check the fit in this area.

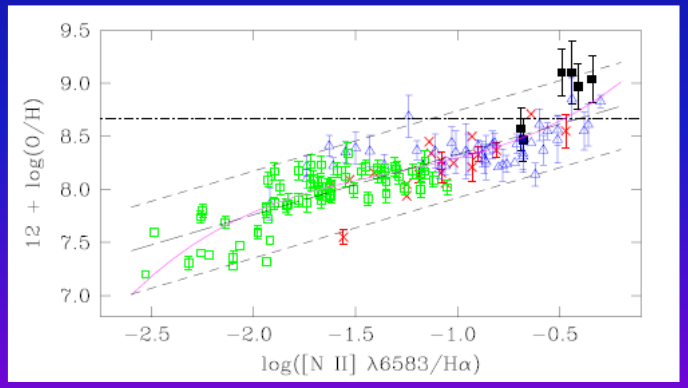
- We used all the low metallicity galaxies with spectrum in SDSS/DR7 (Table 2 Morales-Luis et al. 2011).
  - 31 galaxies that have spectrum with all the lines that we need.
  - We added IZw18 and SBS0335-052 (WHT/ISIS spectra)

- 12+log(O/H) is determined with T_e method. (Perez-Montero & Diaz 2003, Guillermo Hägele Thesis)

Analysis



- It has a tendency to be constant at low metallicities.

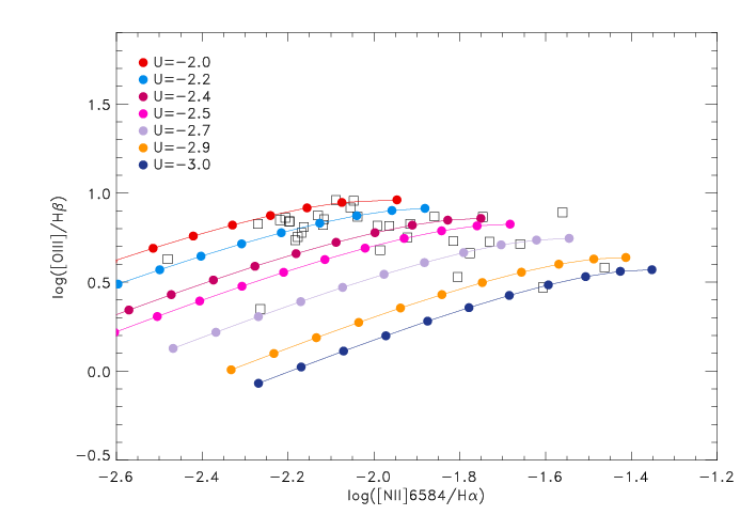


- Pettini & Pagel plot shows a similar tendency.

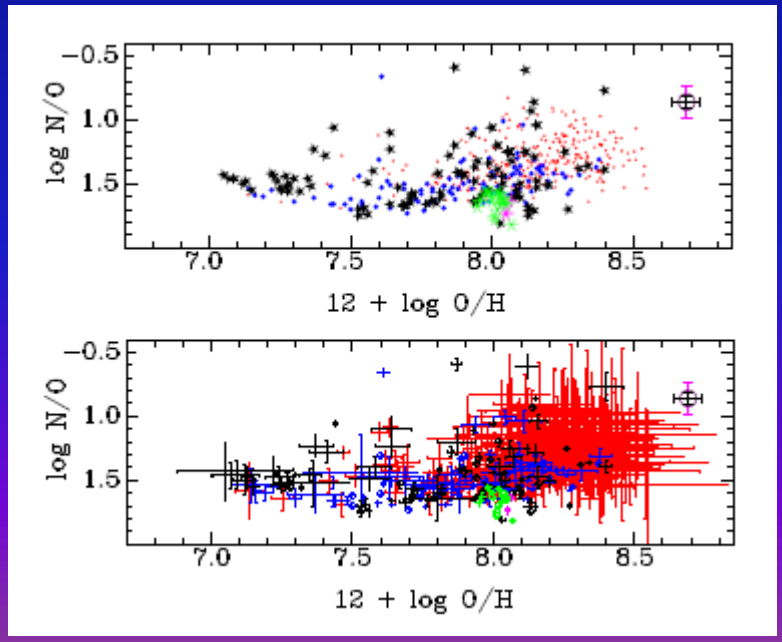
Analysis

- Two reasons:
  - Variations in the ionization parameter (number of ionization photons by hydrogen atom)
  - log(N/O) greater than expected.
- We use CLOUDY models (Ferland et al. 1998)

CLOUDY MODELS $-3 \leq \log U \leq -2$



(Guseva et al. (2011))



Analysis

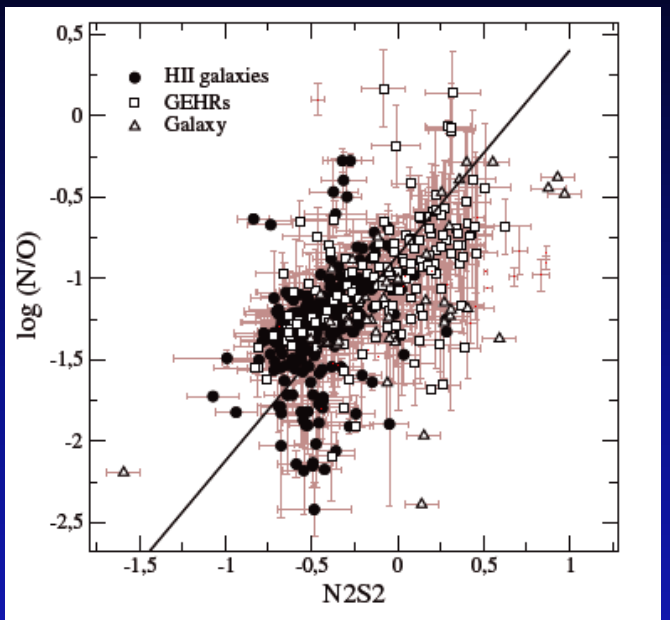
- No [OII]3727 => No direct N/O
- We calcule N/O using index N2S2 (Pérez-Montero & Contini (2009) (lines are close to Hα)

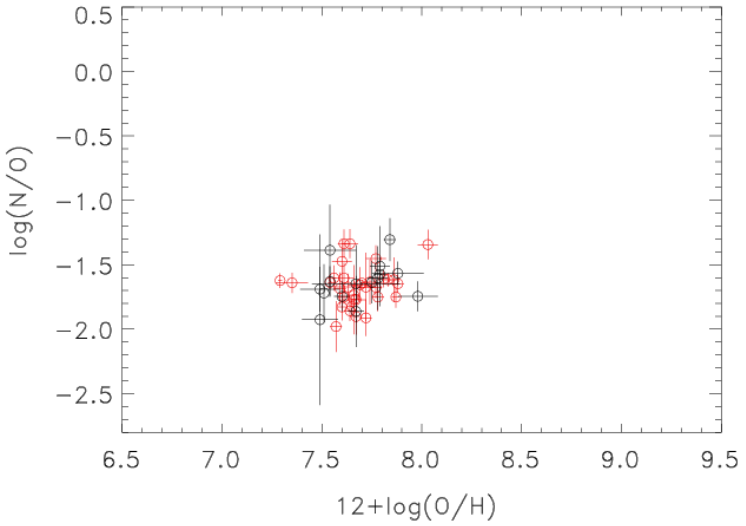
$$\mathrm{N2S2} = \log\left[\frac{I([\mathrm{N\,II}]6584\ \text{Å})}{I([\mathrm{S\,II}]6717, 6731\ \text{Å})}\right].$$

$$\log(\mathrm{N/O}) = 1.26\mathrm{N2S2} - 0.86$$

- Models with:
  - -1.6 ≤ log (N/O) ≤ -1.2
  - -3 ≤ log U ≤ -2
  - 7.16 ≤ 12+log(O/H) ≤ 8.16

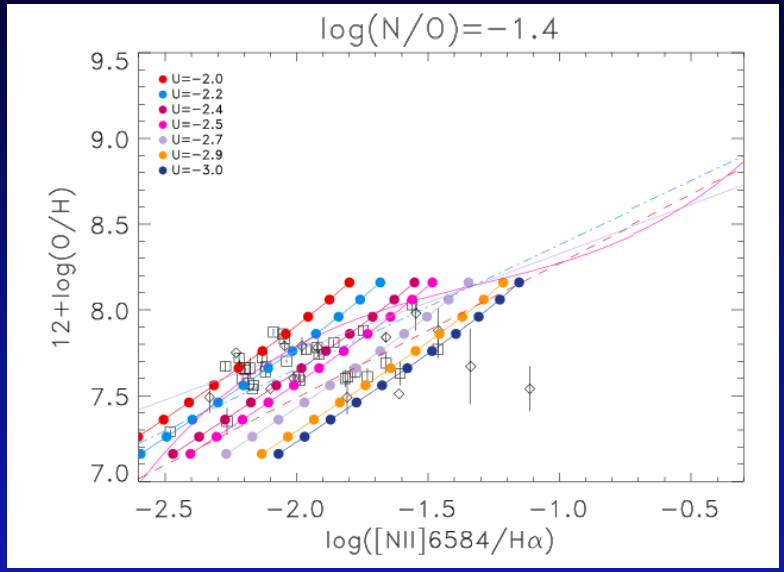
Pérez-Montero & Contini (2009)

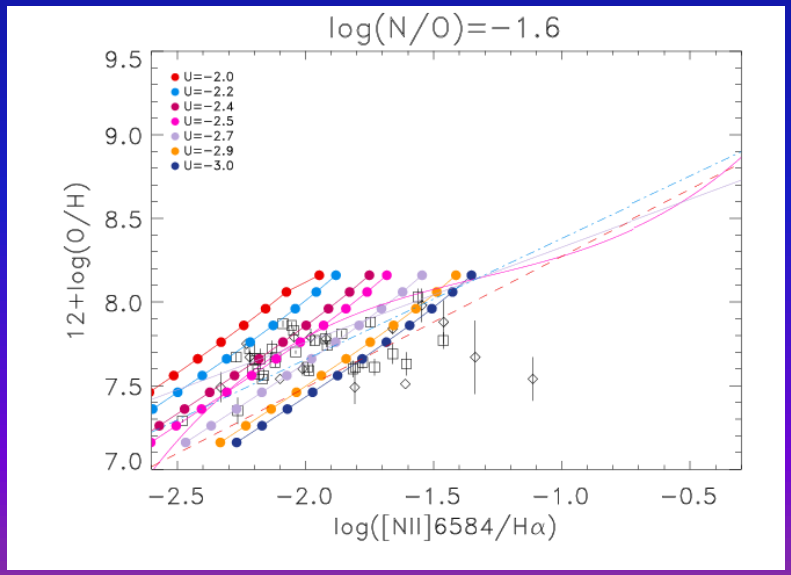


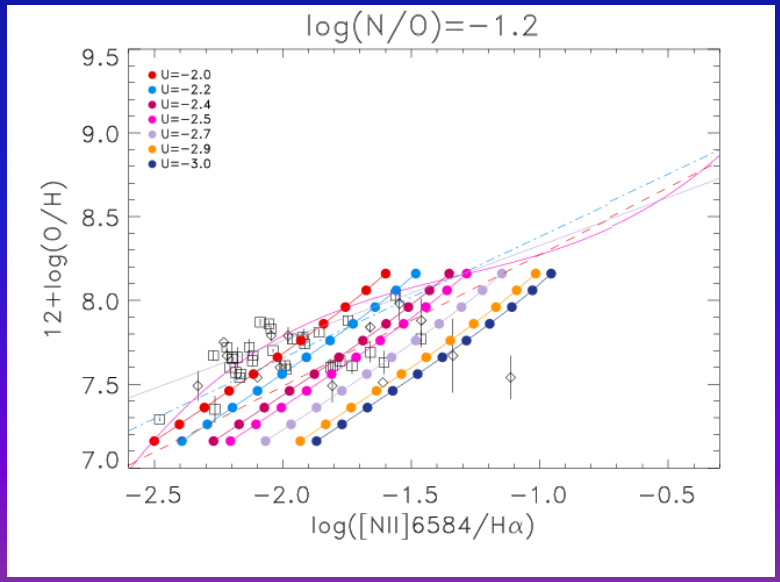


Analysis

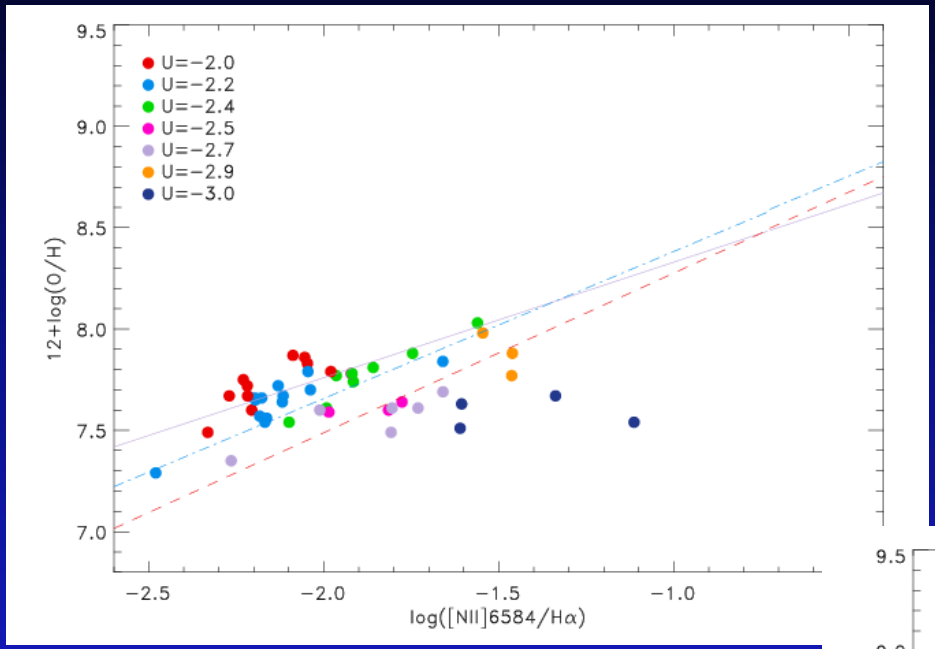
- With these grids we can cover all points
- Also we can know the ionization parameter using these grids, N/O and 12+log(O/H)





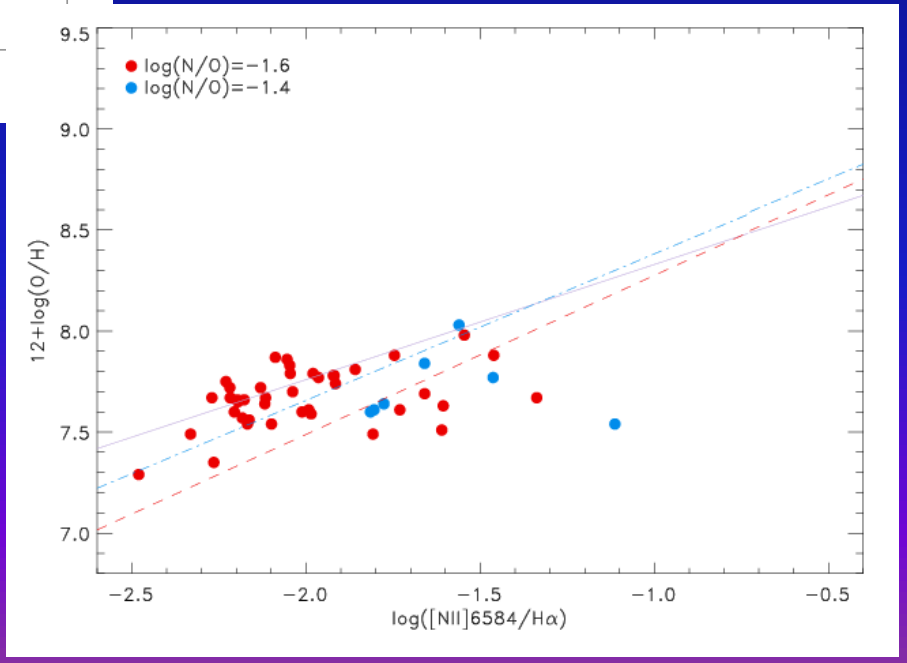


Analysis



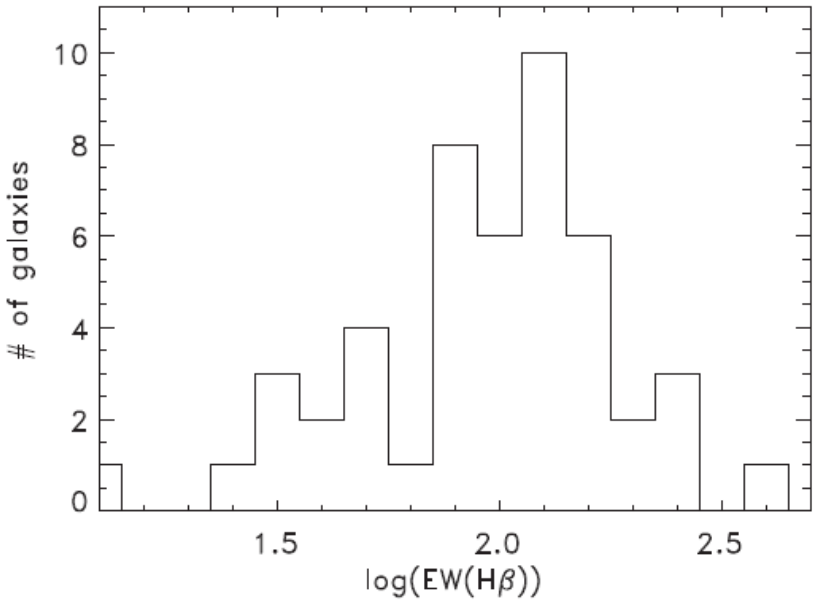
- Separating by ionization parameter.
- The tendency of the oxygen abundance to be constant can be explained by a decrease in the ionization parameter

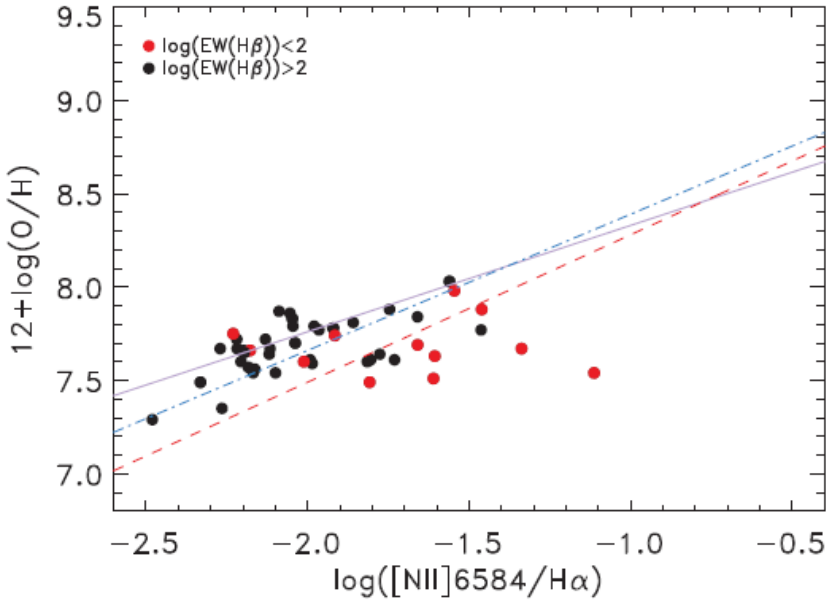
- Separating by N/O.
- The tendency of the oxygen abundance to be constant can be explained by a increased in the ratio N/O



Analysis

- Why the ionization parameter decrease?





- EW(Hβ) is an evolution indicator (EW(Hβ) decrease => more evolved)
- We separate galaxies with the lowest values of EW(Hβ) (red points).
- Galaxies with lower ionization parameter are the most evolved

Conclusion

- 12 + log(O/H) has a tendency to be constant with N2 for two reasons:
  - Variations in the ionization parameter
  - Variations in N/O.
- If we want to use N2 index, we must take into acount N/O and the ionization parameter.
  - We can have N/O using N2S2, because we have [SII] lines close to Hα.
  - With N/O, 12+log(O/H) and grids of models we can obtain U (ionization parameter)