# Metallicity and star formation history of HII galaxies from tailored models

Enrique Pérez Montero
Instituto de Astrofísica de Andalucía – CSIC
in collaboration with R. García-Benito (KIAA, UAM),
G.F. Hägele (UAM, La Plata), A.I. Díaz (UAM)

8th Workshop "Estallidos de formación estelar en galaxias" Salobreña, March, 8-10, 2010

# The nature of HII galaxies

Dwarf, luminous, low-mass starbursts of blue colors, emission line-like spectra, gas-rich and metal-poor.

Some very interesting questions about them:

- Do they resemble the building blocks of our Universe?
- Are they fundamental to derive the primordial helium?
- Are they really young objects?
- What did trigger their high SFRs?

# The metal content of HII galaxies

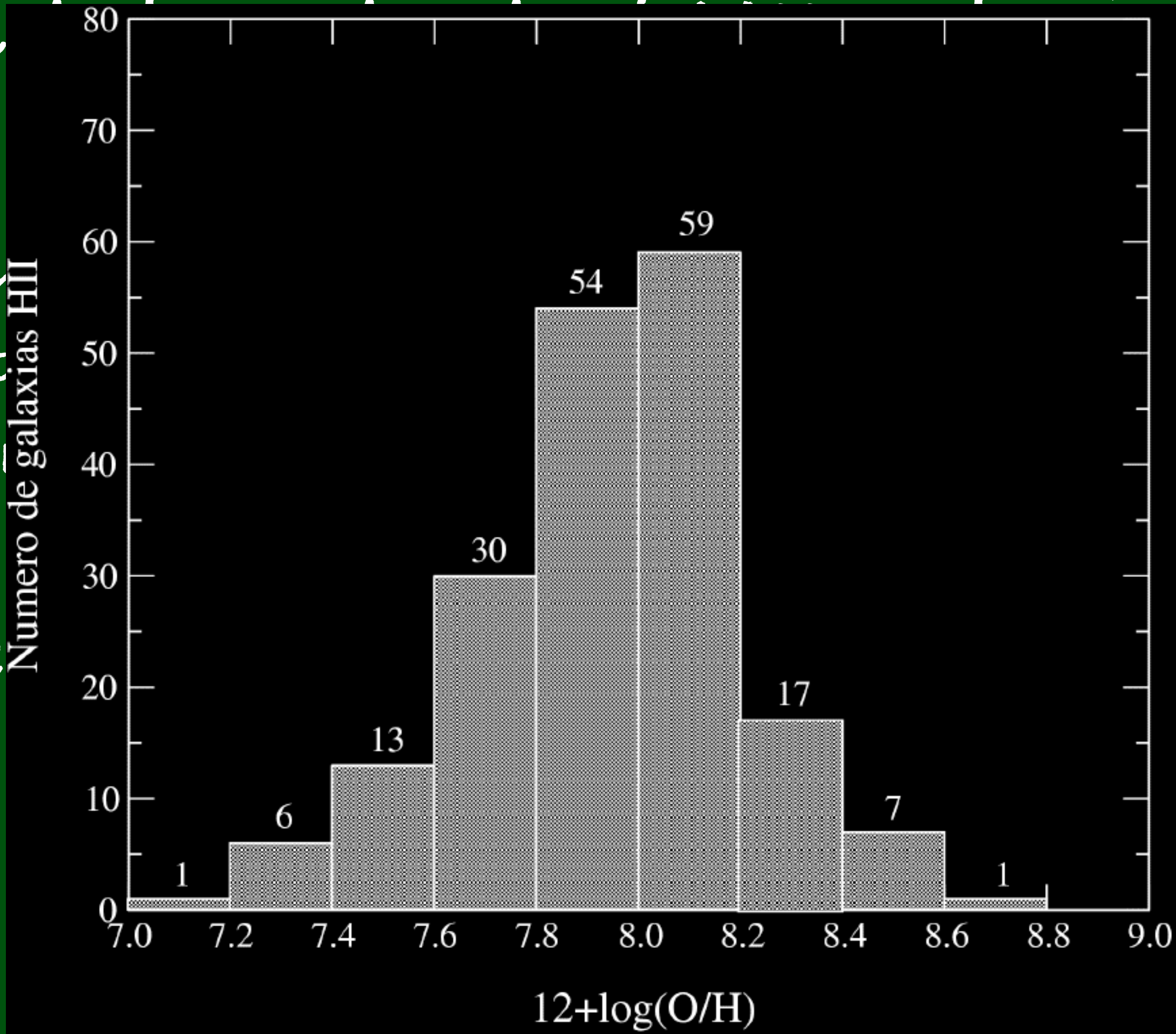
They usually occupy the low end in the metallicity distributions of starburst galaxies and ionized gaseous nebulae, but …

Are they really metal-poor objects? Is there an ADF in this type of objects?

# The m… s

They usu… licity
distribut… ed
gaseous …

Are they … ADF in
this type



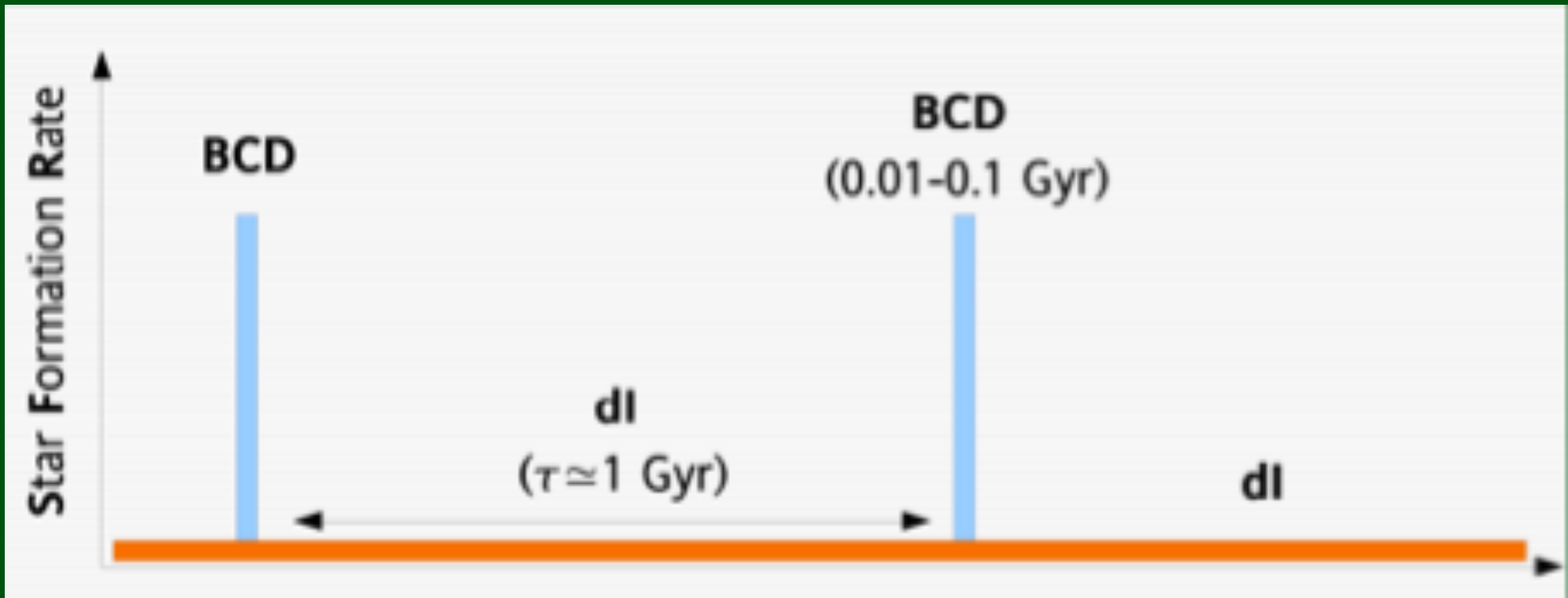
# The metal content of HII galaxies

They usually occupy the low end in the metallicity distributions of starburst galaxies and ionized gaseous nebulae, but ...

Are they really metal-poor objects? Is there an ADF in this type of objects?

# The SFH of HII galaxies

Most of them present old stellar populations, although there is a discrepancy about a continuous SFR or recursive episodes of star formation (e.g. Terlevich, 2004; Sánchez-Almeida+, 2008; Papaderos+, in prep.)



# Motivation and methodology

We want to shed some light about the Z and SFH of HII galaxies by means of:

Good spectrophotometrical observations (ISIS, TWIN) in a wide spectral range of a sample of HII galaxies (SDSS), synthetic stellar fitting of their SEDs (STARLIGHT), derivation of the properties of the ionizing population (STARBURST99) and photoionization modeling of the ionized gas (CLOUDY)

# Data sample

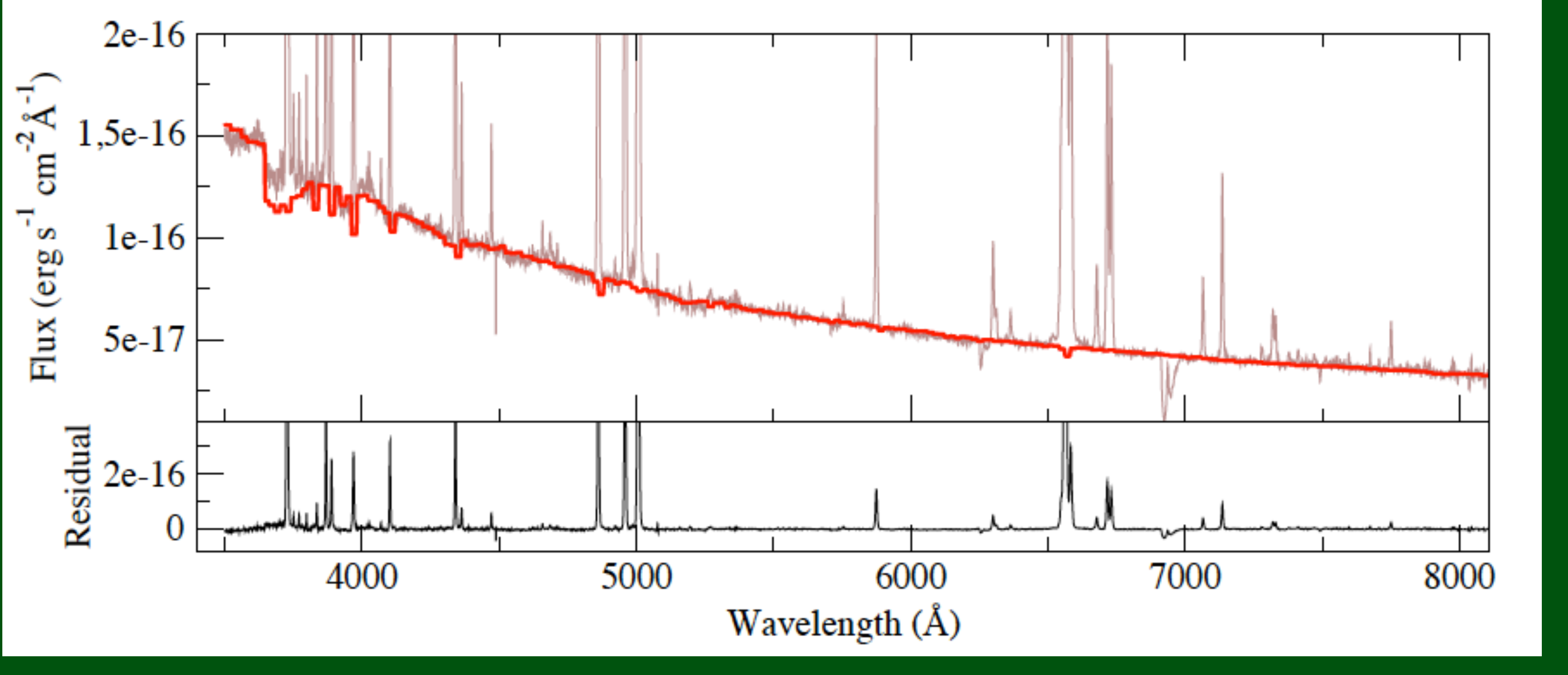
## High precision long-slit data from ISIS/TWIN

| Object ID | hereafter ID | Publication (Telescope) | redshift | log L(Hα) (erg · $s^{-1}$) | 12+log(O/H) | Other names |
|---|---|---|---|---|---|---|
| SDSS J002101.03+005248.1 | J0021 | H06 (WHT) | 0.098 | 42.13 | 8.10 ± 0.04 | UM228, SHOC 11 |
| SDSS J003218.60+150014.2 | J0032 | H06 (WHT) | 0.018 | 40.30 | 7.93 ± 0.03 | SHOC 22 |
| SDSS J145506.06+380816.6 | J1455 | H08 (CAHA - 3.5 m.) | 0.028 | 40.84 | 7.94 ± 0.03 | CG 576 |
| SDSS J150909.03+454308.8 | J1509 | H08 (CAHA - 3.5 m.) | 0.048 | 41.26 | 8.19 ± 0.03 | CG 642 |
| SDSS J152817.18+395650.4 | J1528 | H08 (CAHA - 3.5 m.) | 0.064 | 41.63 | 8.17 ± 0.04 | |
| SDSS J154054.31+565138.9 | J1540 | H08 (CAHA - 3.5 m.) | 0.011 | 39.65 | 8.07 ± 0.05 | SHOC 513 |
| SDSS J161623.53+470202.3 | J1616 | H08 (CAHA - 3.5 m.) | 0.002 | 38.93 | 8.01 ± 0.03 | |
| SDSS J162410.11-002202.5 | J1624 | H06 (WHT) | 0.031 | 41.48 | 8.05 ± 0.02 | SHOC 536 |
| SDSS J165712.75+321141.4 | J1657 | H08 (CAHA - 3.5 m.) | 0.038 | 40.74 | 7.99 ± 0.04 | |
| SDSS J172906.56+565319.4 | J1729 | H08 (CAHA - 3.5 m.) | 0.016 | 40.57 | 8.08 ± 0.04 | SHOC 575 |

In the range 3500 Å – 1 μm. All the objects have at least 4 electron temperatures ([OII], [OIII], [SII] and [SIII]), implying quite precise abundance determinations (Hägele+, 2006; Hägele+, 2008).

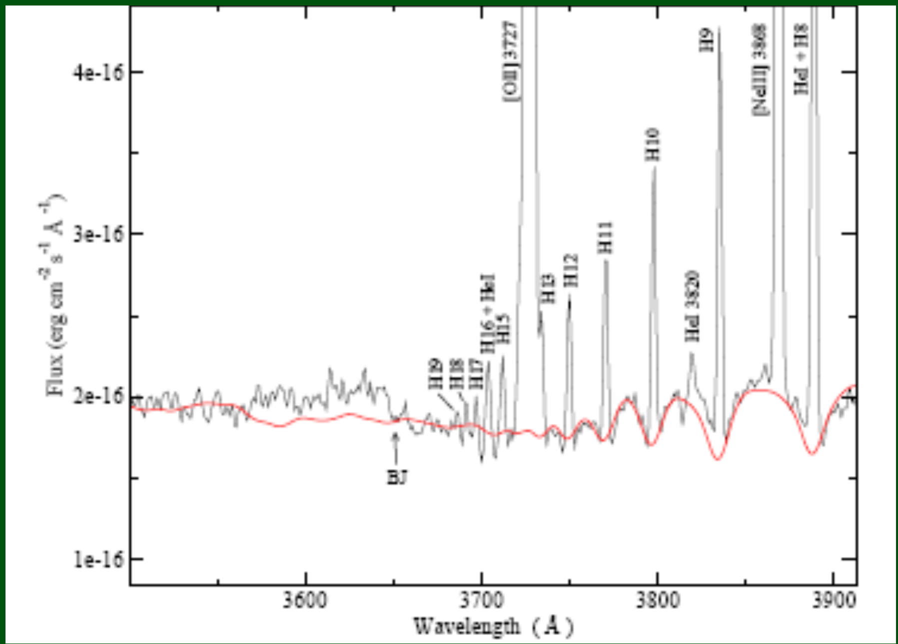
# Fitting of the observed SED

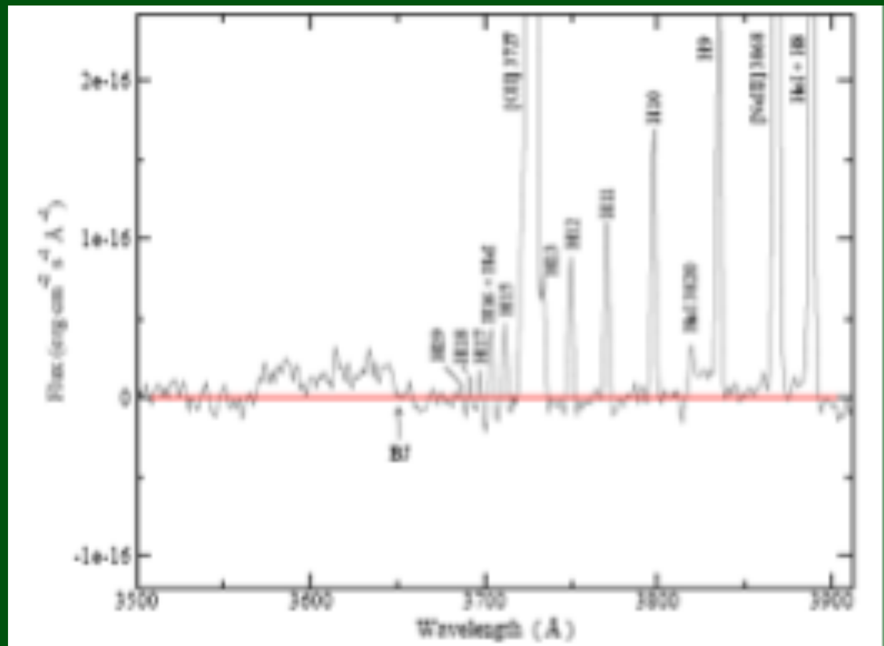
## Use of STARLIGHT with STARBURST99 libraries



# Fitting of the observed SED

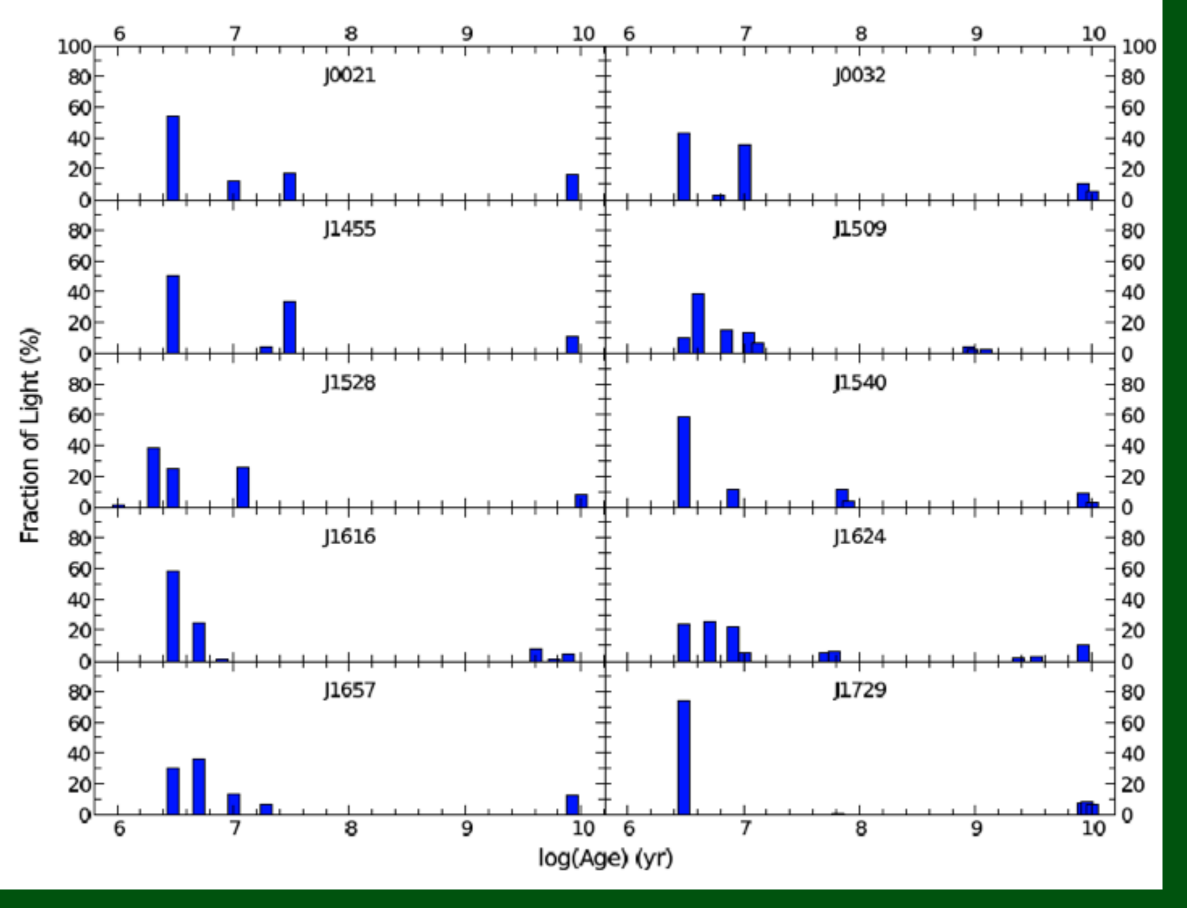
## The accuracy of the removal of the underlying continuum



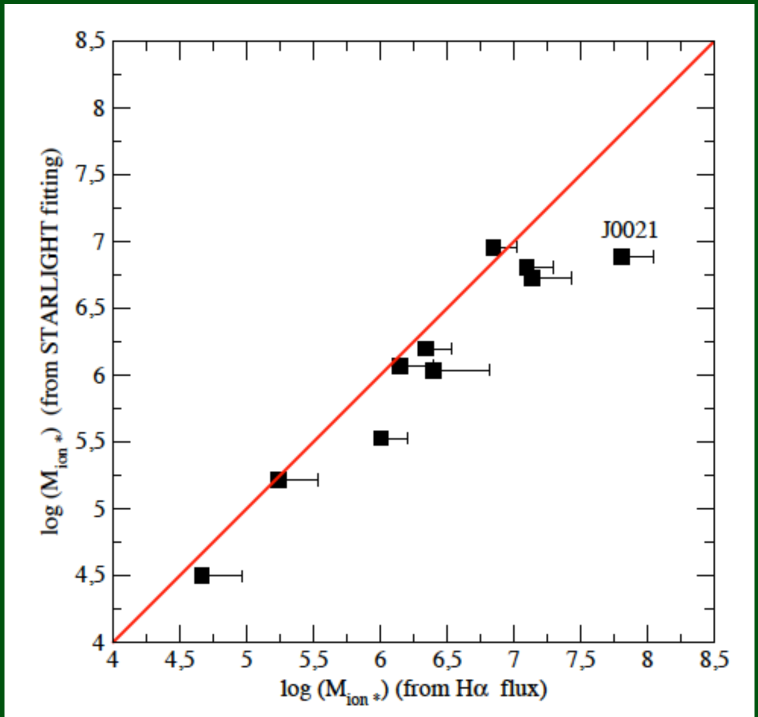
# Fitting of the observed SED

## STARLIGHT confirms recursive SFHs in BCDs



# Fitting of the observed SED

## Stellar masses of the ionizing populations




$$\log M_{ion*} = \log L(H\alpha) - 0.86 \cdot \log EW(H\beta) - 32.61$$

(Díaz, 1998)

# Fitting of the observed SED

## The correction to EW(Hβ) is not larger than 10%

| Object ID | A(V) (mag) | log $M_*$ ($M_\odot$) | log $M_{ion*}$ ($M_\odot$) | % $M_{ion*}$ | EW(H$\beta$) obs. (Å) | EW(H$\beta$)$cor$ (Å) |
|---|---|---|---|---|---|---|
| J0021 | 0.01 | 9.40 | 6.89 | 0.31 | 97 | 110 |
| J0032 | 0.17 | 8.15 | 5.53 | 0.24 | 90 | 119 |
| J1455 | 0.09 | 8.42 | 6.04 | 0.42 | 133 | 146 |
| J1509 | 0.58 | 8.08 | 6.96 | 7.57 | 123 | 135 |
| J1528 | 0.25 | 8.92 | 6.81 | 0.78 | 171 | 191 |
| J1540 | 0.42 | 7.51 | 5.22 | 0.52 | 122 | 124 |
| J1616 | -0.11 | 6.55 | 4.50 | 0.89 | 83 | 83 |
| J1624 | 0.60 | 8.88 | 5.73 | 0.07 | 101 | 107 |
| J1657 | 0.16 | 8.45 | 6.20 | 0.56 | 118 | 132 |
| J1729 | 0.27 | 8.65 | 6.07 | 0.26 | 126 | 126 |

# Photoionization tailored models

To fit the observed EW(Hβ) it is necessary to get an estimate of the dust absorption factor.

$$Q(H) = f_d \cdot Q_{obs}(H)$$

Therefore, a first grid of CLOUDY models is produced to fit the observed emission lines.

# Photoionization tailored models

Code: CLOUDY v. 06.02

Stellar atmospheres: STARBURST99 (high mass loss Geneva tracks)

Metallicity: Derived O, S, N, Ar, Ne, Fe and He (rest scaled to solar proportions)

Density: Constant as derived from [SII]

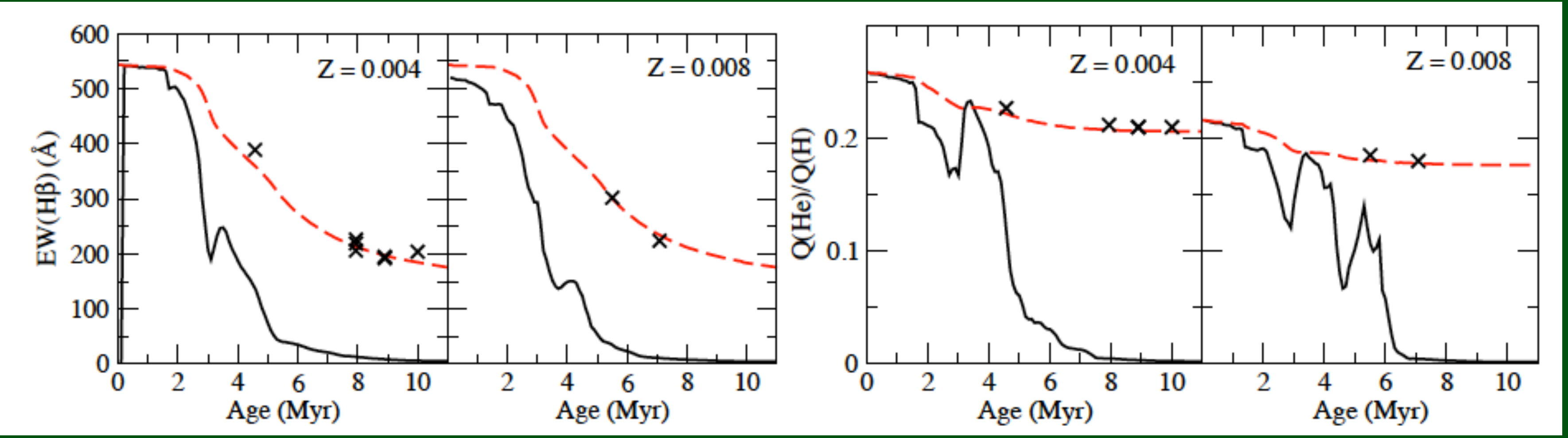
Fitted lines: [OII] 3727 Å, [OIII] 4363, 4959, 5007 Å, [SII] 6717, 6731 Å, [SIII] 9069, 9532 Å, [NII] 6548, 6584 Å.

Geometry: Thick shell

Number of ionizing photons: As derived from Hα

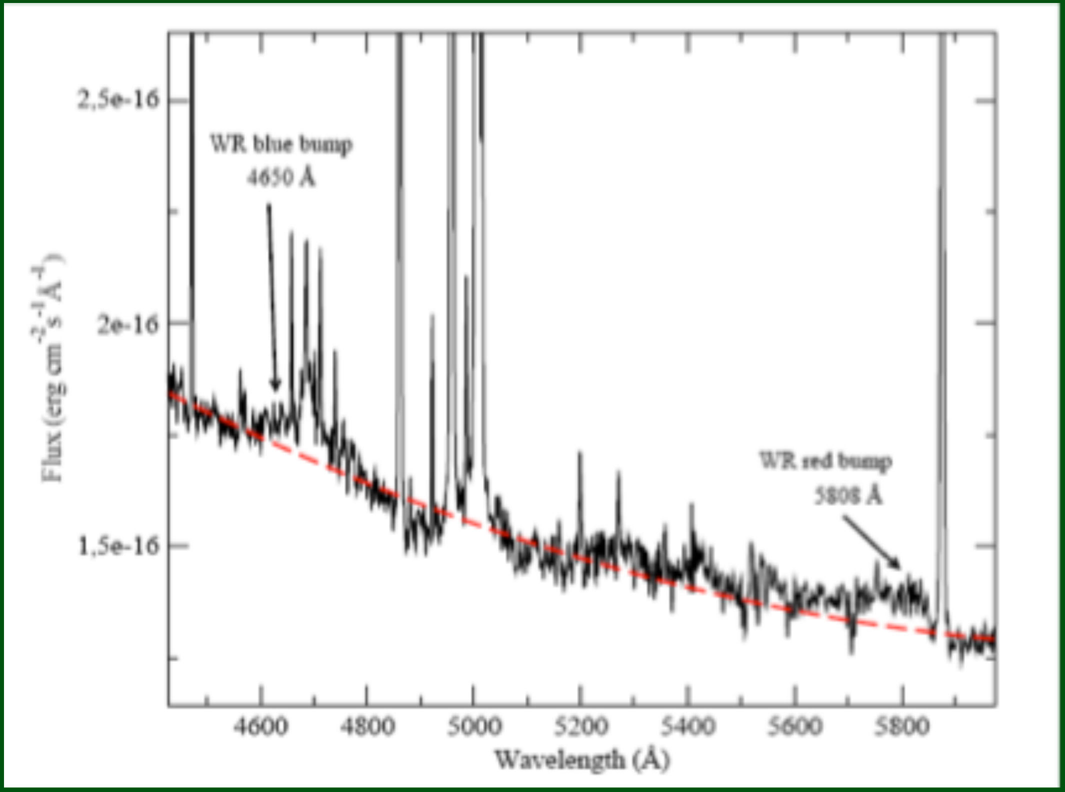
# Photoionization tailored models

## Taking dust absorption factors derived from models lead to continuous SFHs during the burst



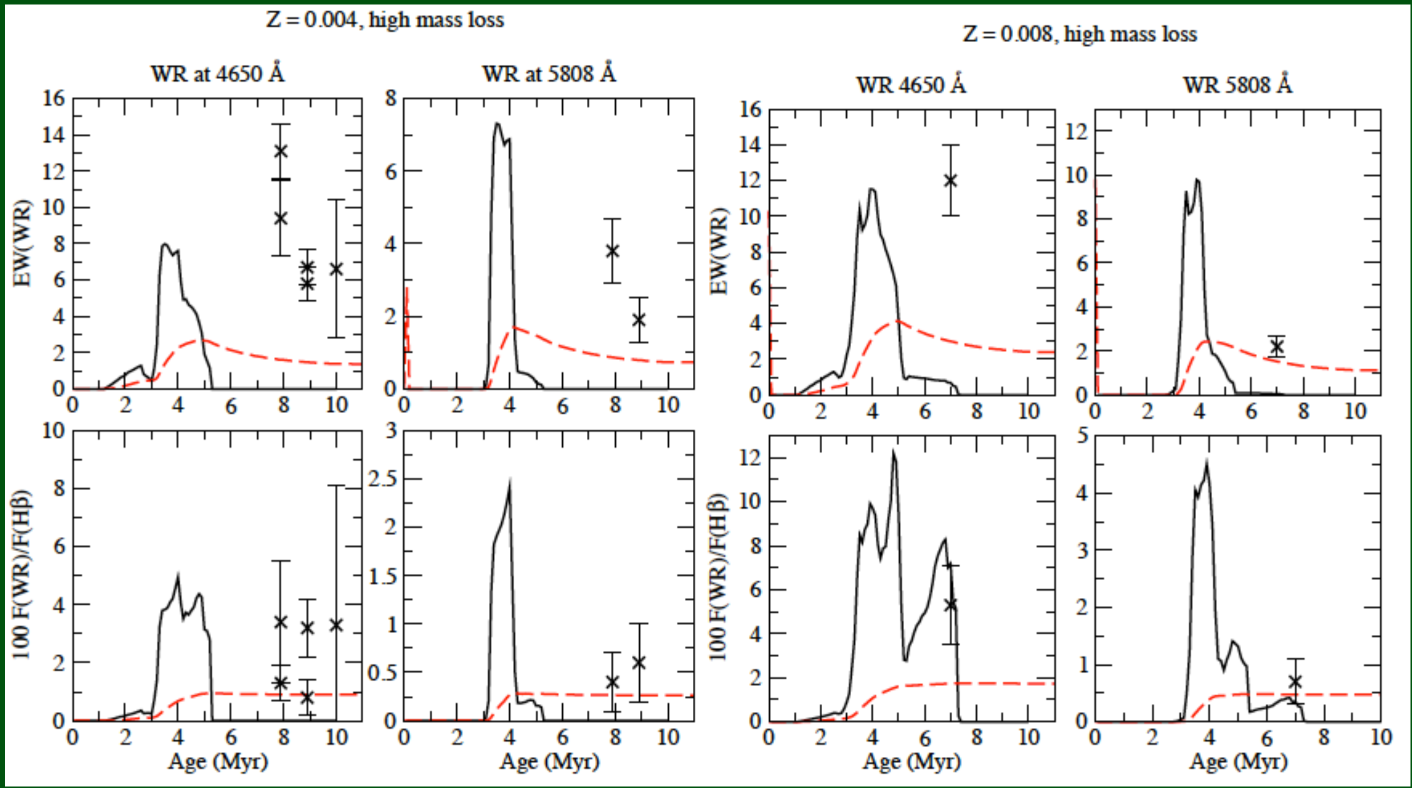
# Wolf-Rayet populations

The WR blue bump at 4650 Å was detected in seven of the objects and the WR red bump at 5808 Å in three.



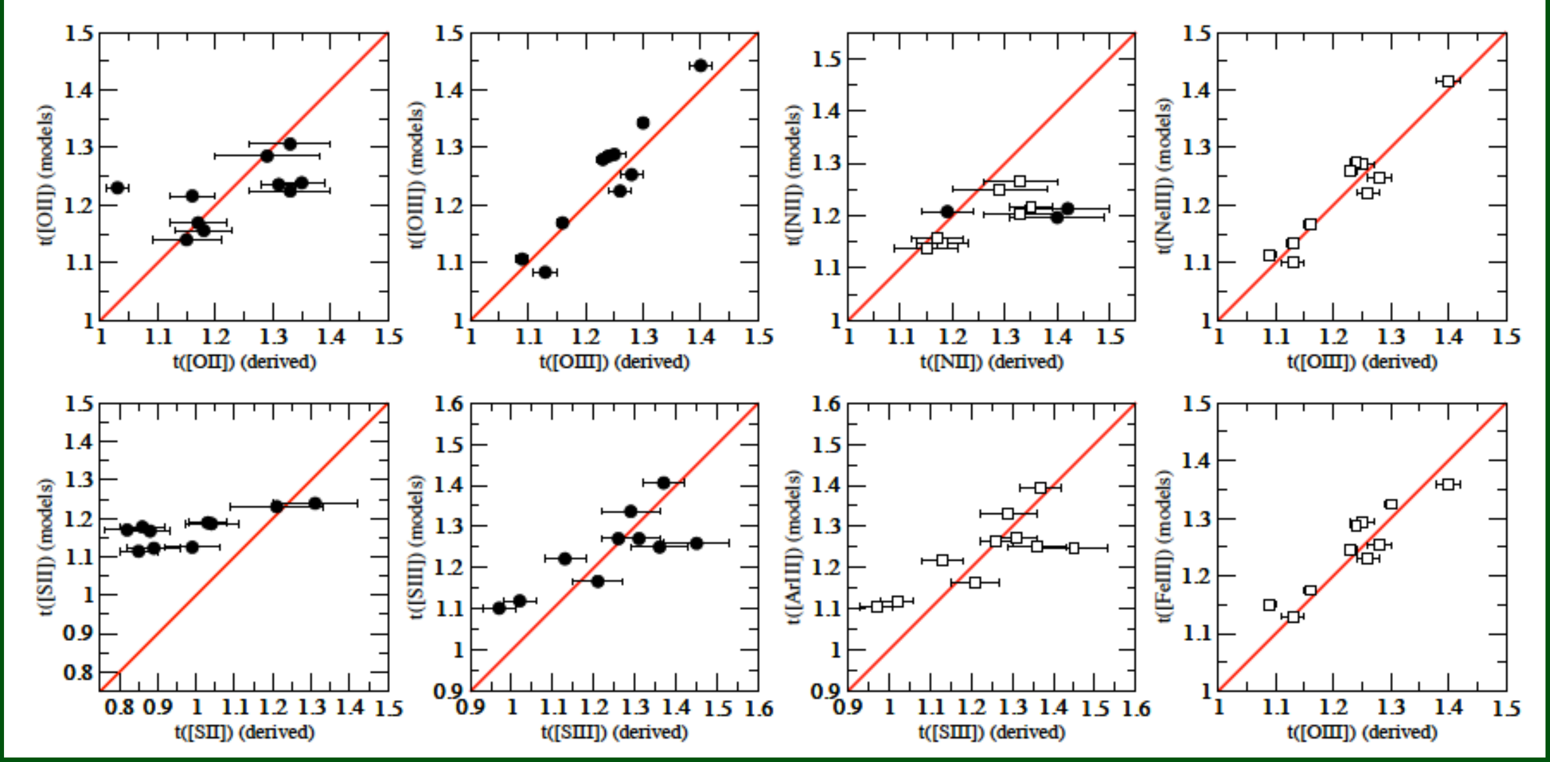
# Wolf-Rayet populations

Even taking dust absorption factors and nebular continuum the L and EW of WRs are not well reproduced



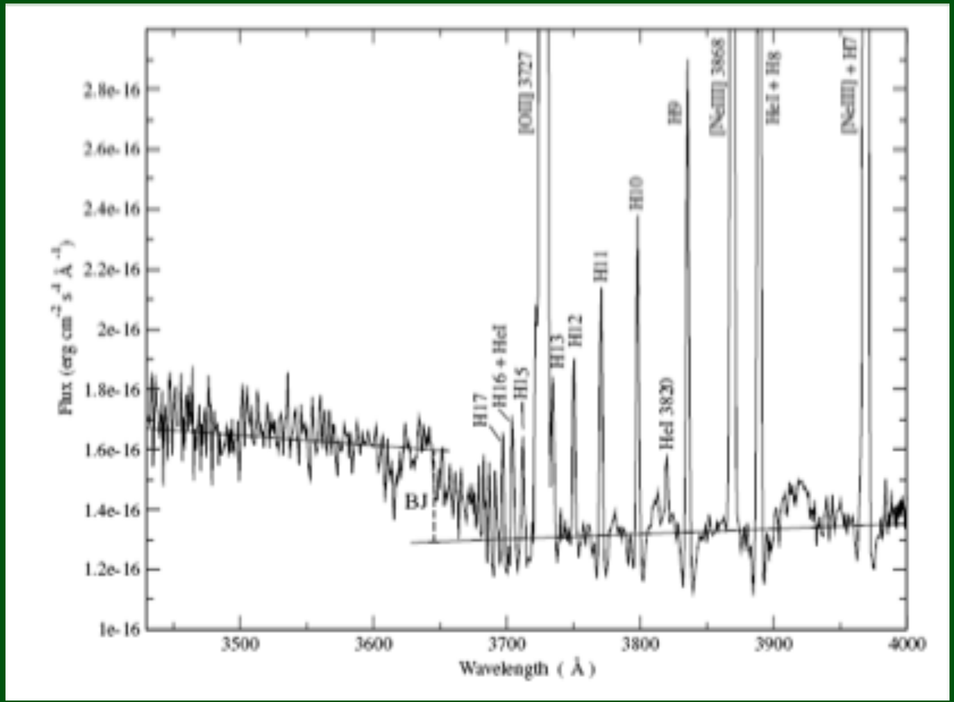
# Thermal structure

All electron temperatures, with the exception of [SII], are well reproduced.



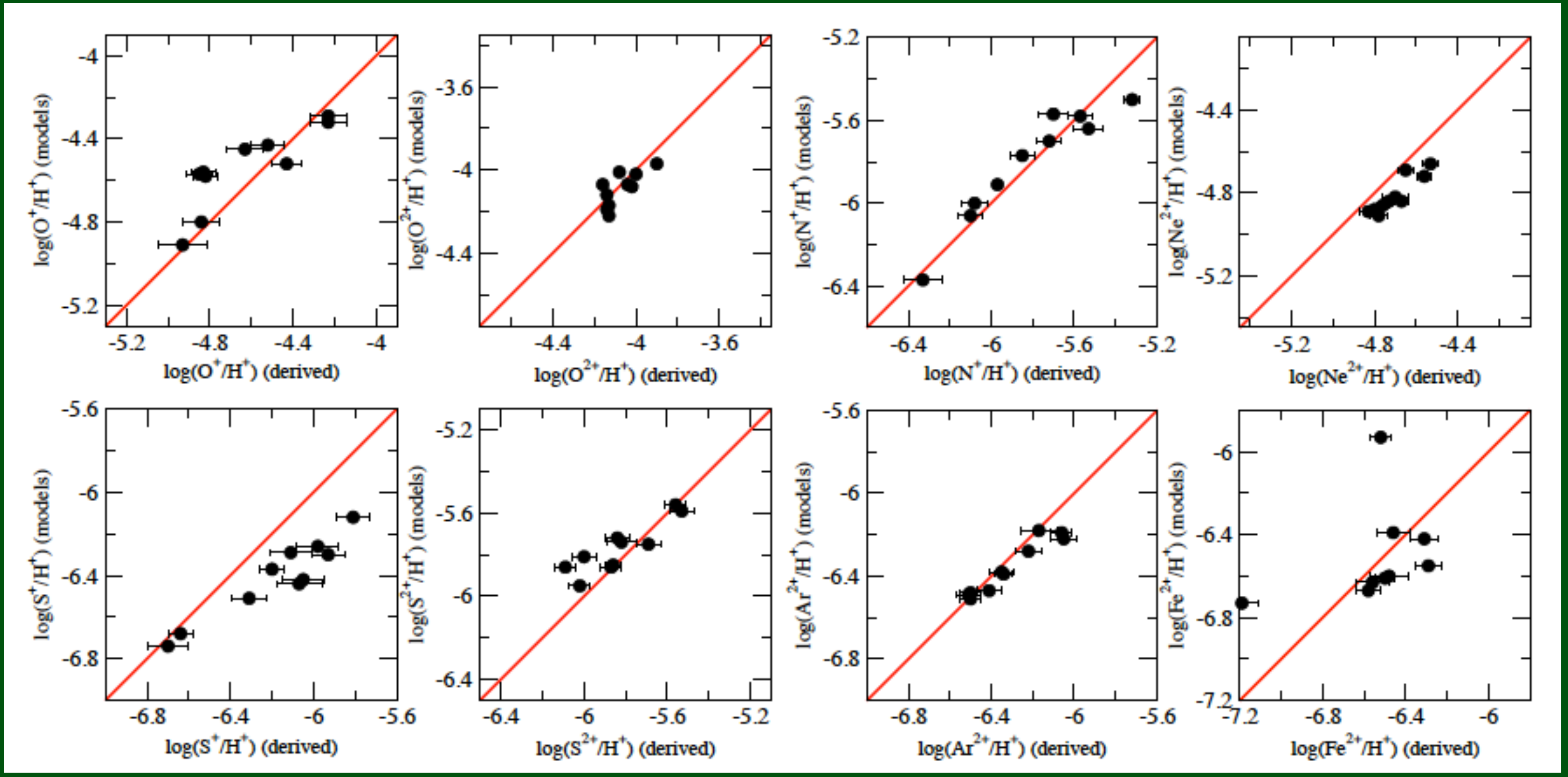
# Thermal structure

The fluctuations of temperature ($t^2$) derived from models is zero, in agreement with the measurements of the Balmer jump in three of the objects. No ADF is expected.



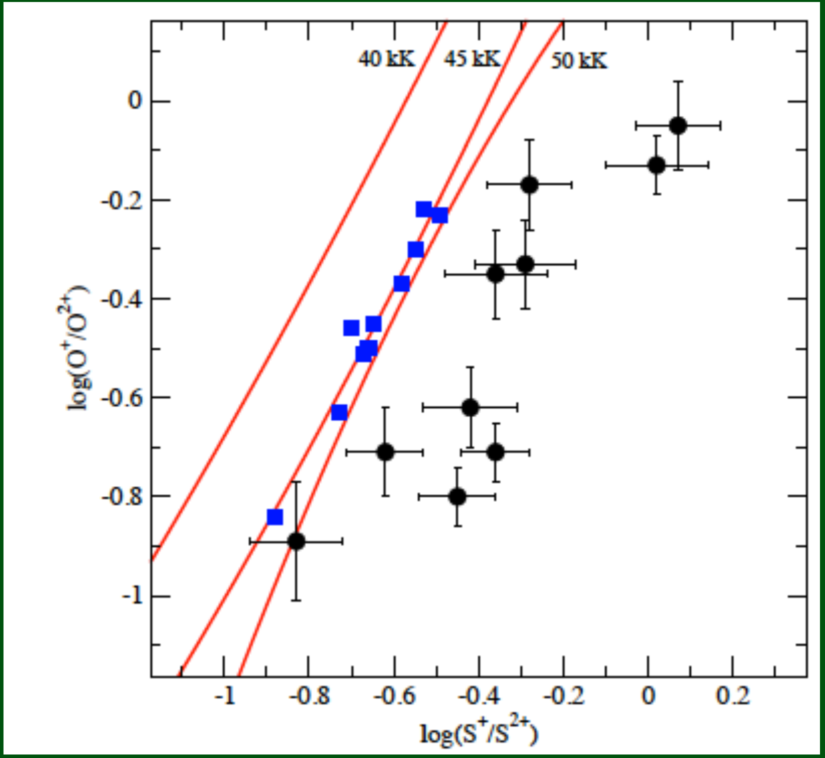
# Ionic structure

## The ionic abundances derived from CELs are well reproduced, except $S^+$



# Equivalent effective temperature

$T_*$ can be overestimated as derived from emission lines in HII galaxies due to geometrical effects.




$$\eta = \frac{O^{+}/O^{2+}}{S^{+}/S^{2+}}$$

(Vílchez & Pagel, 1988)

# Summary and conclusions

- SED fitting of HII galaxies show a global recursive SFH and allows the partial correction of EW(Hβ).
- Photoionization models are required to correct EW(H ) and characterize the ionizing stellar population.
- Although WR bumps are not detected in all the sample, WR stars may be present in all these objects.
- The thermal and ionic nebular structure is well reproduced by models using only CELS. No ADF is required in these objects.
- The overestimation of t([SII]) can affect the determination of $T_*$ using the η parameter.

# Thanks for your attention !!! :-)

E. Pérez-Montero, R. García-Benito, G. F. Hägele & A. I. Díaz, 2010, MNRAS (in press), astro-ph 1001.4828