



A Statistical Study of HII galaxies properties in the local universe. The metallicity distribution of the ionized ISM in local HII galaxies.

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Motivations.

Hasn't this work been done before?
Yes and no. It has been carried out for objects showing [OIII]λ4363. In this study we consider sources both with and without this line, and compare them.

OK, but why?
Because of our interest in higher redshift LCBGs. Since such galaxies are much more distant their study is more difficult. By studying LCBG-like sources in the local universe we can draw a picture of what we can expect to see in the distant universe.

Our approach.

The selected sample.

We have collected, from published data on HII galaxies, the strong emission lines: [OII]λ3727, [OIII] λλ4959,5007 and [SII]λλ6716,6731.

We have used the data from these 19 references.
The sample consists on 236 objects with [OIII]λ4363 and 214 sources without it.

1 Lequeux *et al.* 1979, A&A 80, 155.
2 French 1980,ApJ 240,41.
3 Kunth & Sargent 1983, ApJ 273, 81.
4 Dinnerstein & Shields 1986, ApJ 311, 45.
5 Moles *et al.* 1990, A&A 228, 310.
6 Terlevich *et al.* 1991, A&AS 91, 285.
7 Peña *et al.* 1991, A&A, 251, 417.
8 Pagel *et al.* 1992, MNRAS 255,325.
9 Skillman & Kennicutt 1993, ApJ 411, 655.
10 Masegosa *et al.* 1994, ApJ 420, 576.
11 Skillman *et al.* 1994, ApJ 431, 172S.
12 Searle & Sargent 1972, ApJ 173, 25.
13 Izotov *et al.* 1994, ApJ 435, 647.
14 Thuan *et al.* 1995, ApJ, 445, 108.
15 Salzer *et al.* 1995, AJ 109, 2376.
16 Izotov *et al.* 1997, ApJS 108, 1.
17 Izotov & Thuan 1998, ApJ 500, 188.
18 Guseva *et al.* 2000, ApJ 531, 776.
19 Popescu & Hopp 2000, A&AS 142, 247.

Objects with *vs.* Objects without [OIII]λ4363.

The distributions studied.

In order to establish which are the differences between objects showing [OIII]λ4363 and those that do not show that line, the following properties distribution have been calculated.

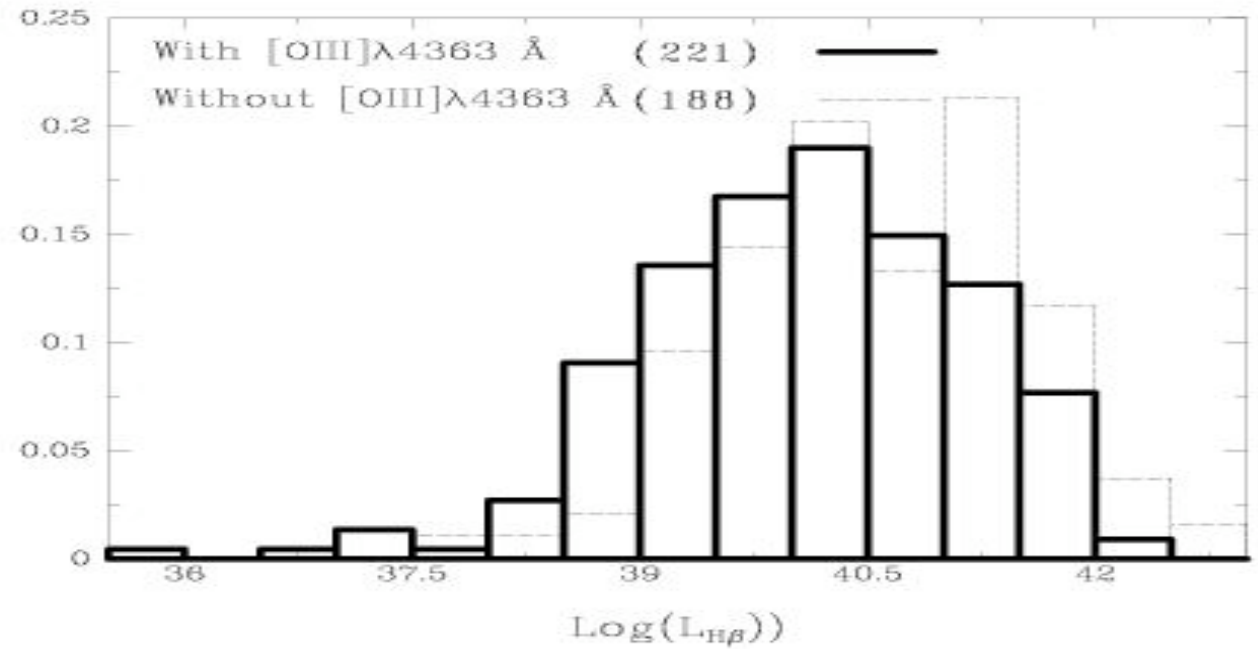
- Hβ luminosity.
- Redshift.
- Observed Hβ flux.
- Extinction.
- Blue absolute magnitude.
- Hβ equivalent width.
- [OIII]λλ4959+5007/[OII]λ3727.
- Mass of the ionizing cluster.
- Mass of ionized gas.
- Oxygen abundance.

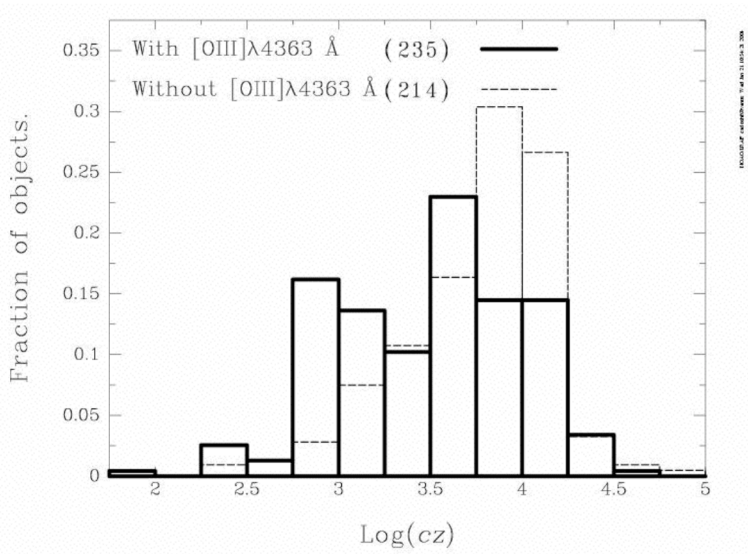
The cosmology used is H_0=70 km s^{-1} Mpc^{-1}, q_0=-0.55.

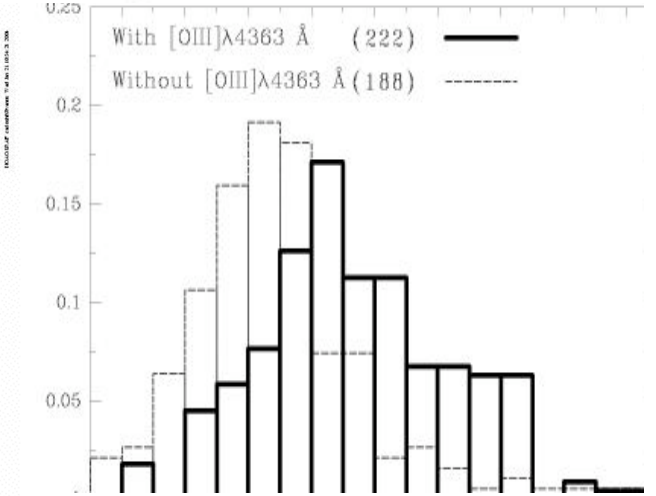
Objects with *vs.* Objects without [OIII]λ4363.

Hβ luminosity, redshift distribution and observed Hβ flux

The luminosities of the two subsamples are pretty much the same, although it is somewhat higher for objects **WITHOUT** [OIII]λ4363. However, objects without [OIII]λ4363 are more distant, on average, therefore objects with [OIII]λ4363 have a higher Hβ observed flux.



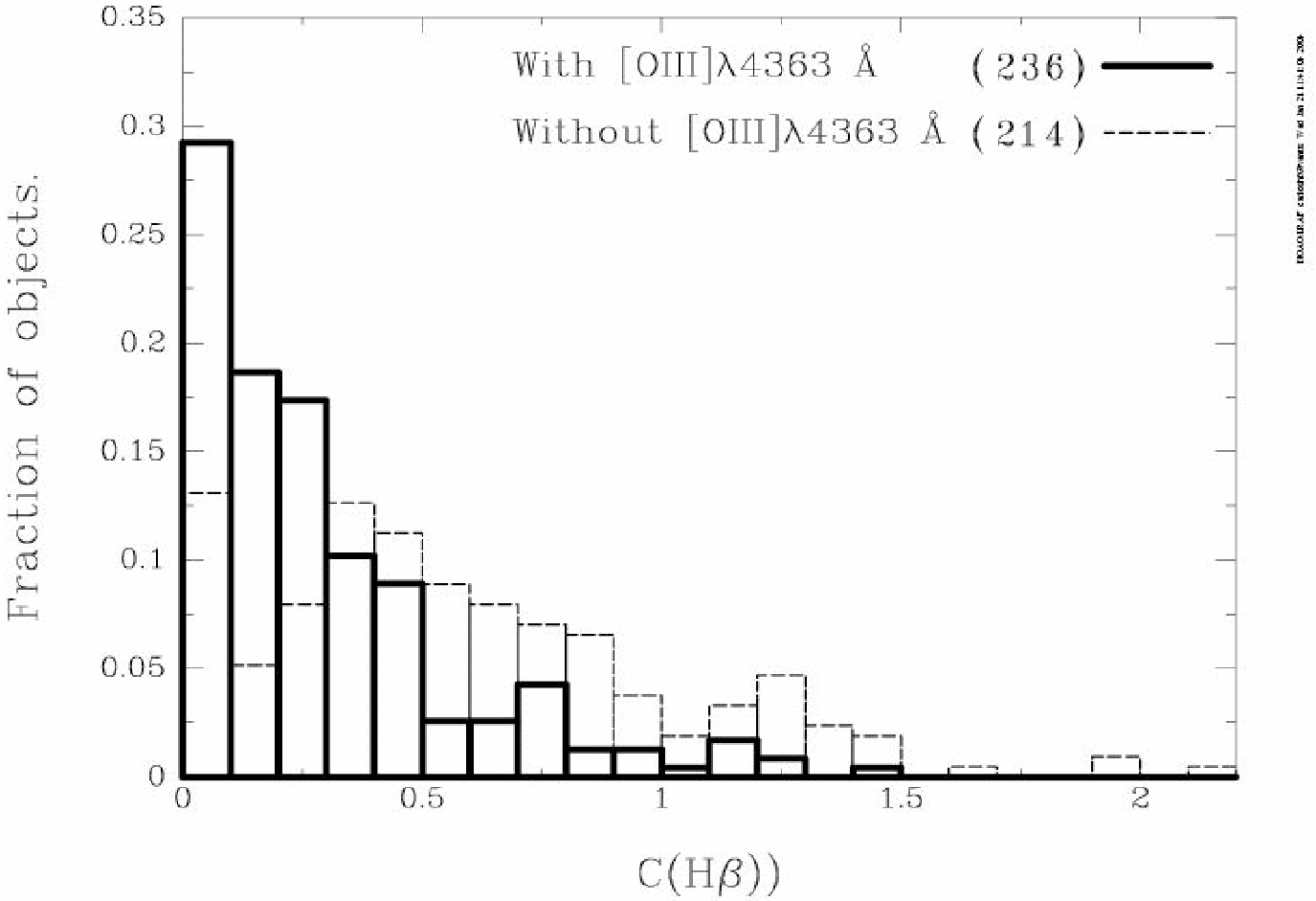




Objects with *vs.* Objects without [OIII]λ4363.

Extinction.

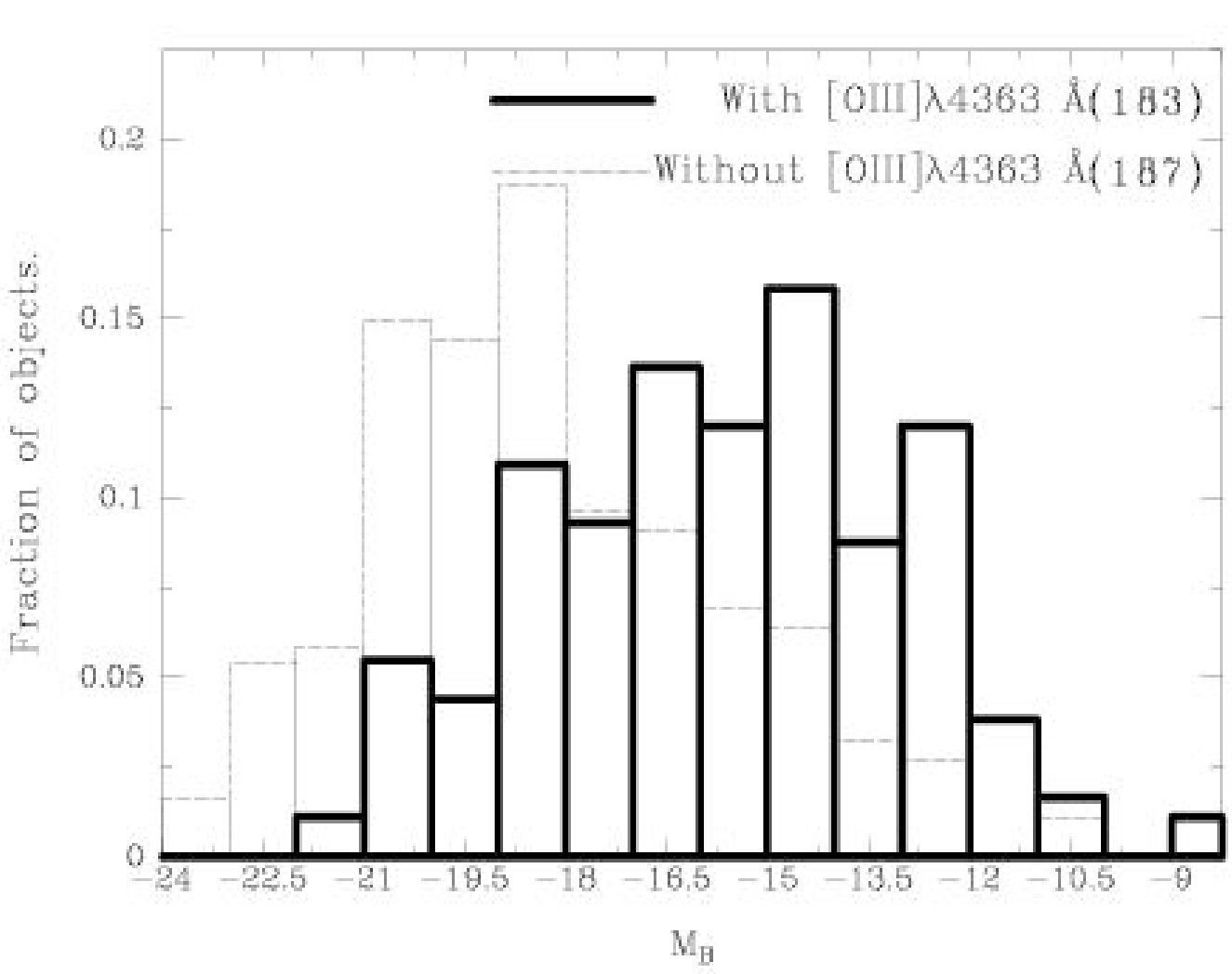
Objects with [OIII]λ4363 have a lower extinction. In particular, most objects with [OIII]λ4363 have a c(Hβ) value lower than 0.50, while this is the median value for those objects **without** the auroral line.



Objects with *vs.* Objects without [OIII]λ4363.

Blue absolute magnitude.

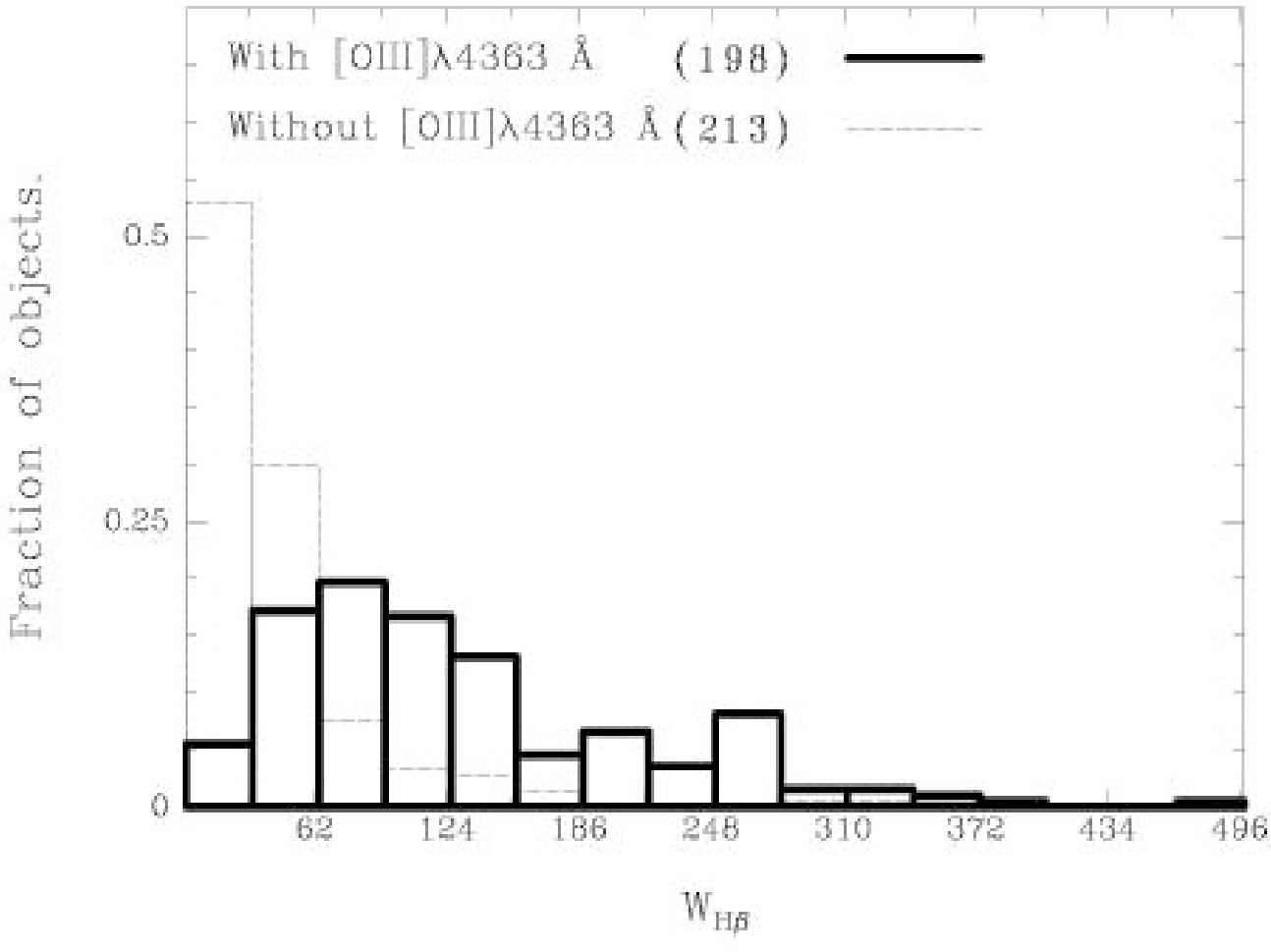
Objects without [OIII]λ4363 have a stronger continuum.



Objects with *vs.* Objects without [OIII]λ4363.

Hβ equivalent width.

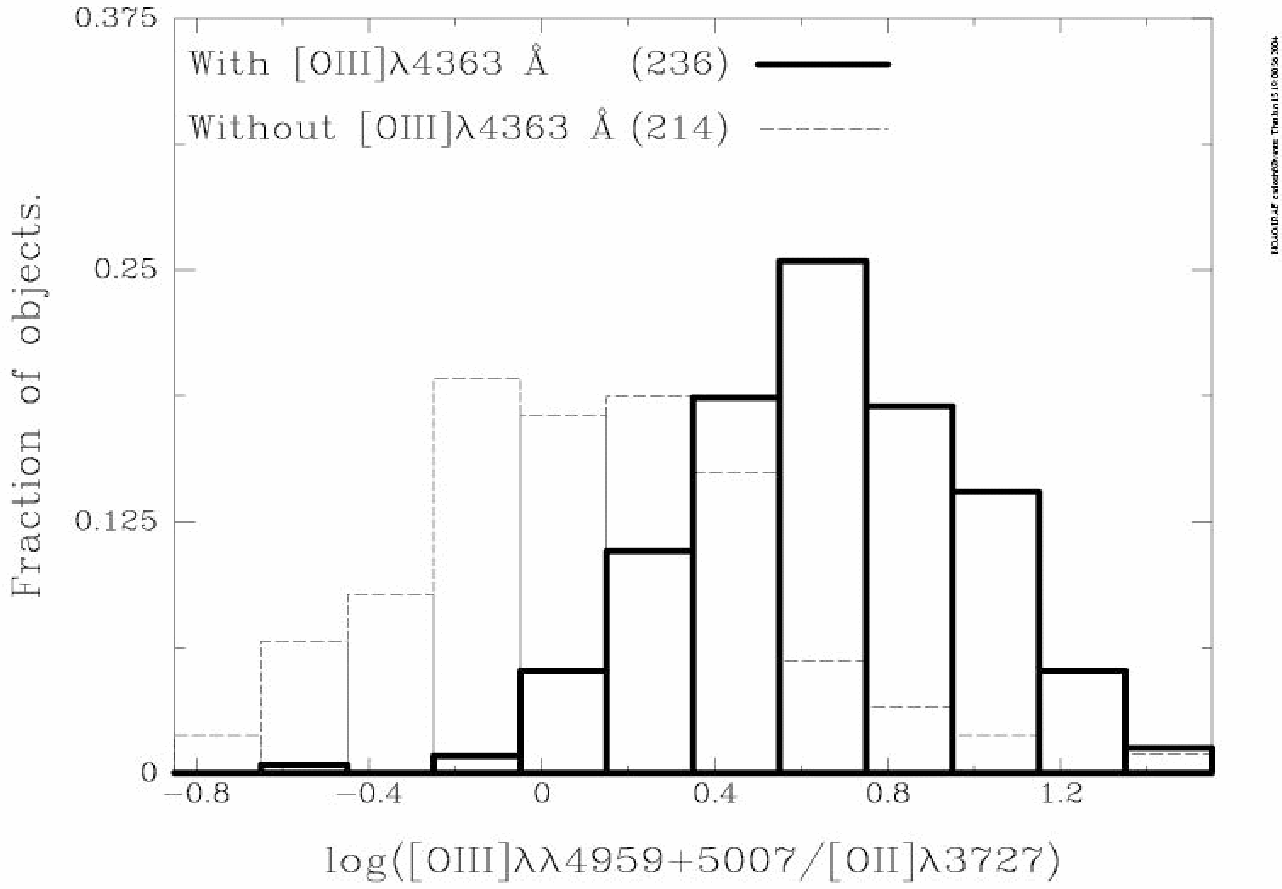
The Wβ distributions for the two subsamples greatly differ. This segregation affects not only the mean value of the equivalent width but the shape of the distribution as well.



Objects with *vs.* Objects without [OIII]λ4363.

log([OIII]ll4959+5007/[OII]l3727) distribution.

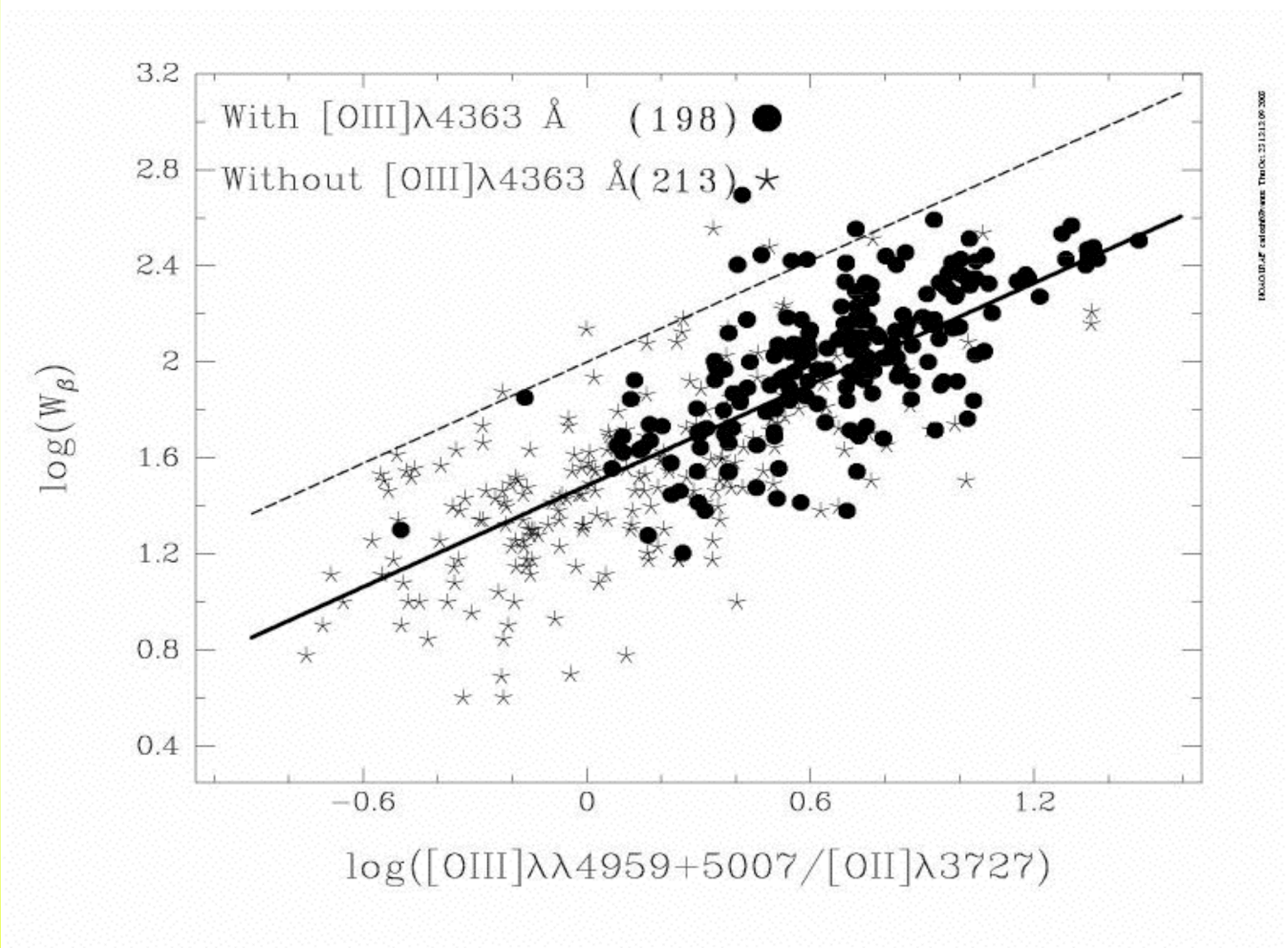
The ionization is undoubtfully higher for objects showing [OIII]λ4363.



Objects with *vs.* Objects without [OIII]λ4363.

The Wβ *vs.* log([OIII]λλ4959+5007/[OII]λ3727) relation upper envelope.

The upper envelope of this relationship (dashed line) is used to derive the mass of the ionizing cluster. It is used since it will likely be less affected by the underlying population.

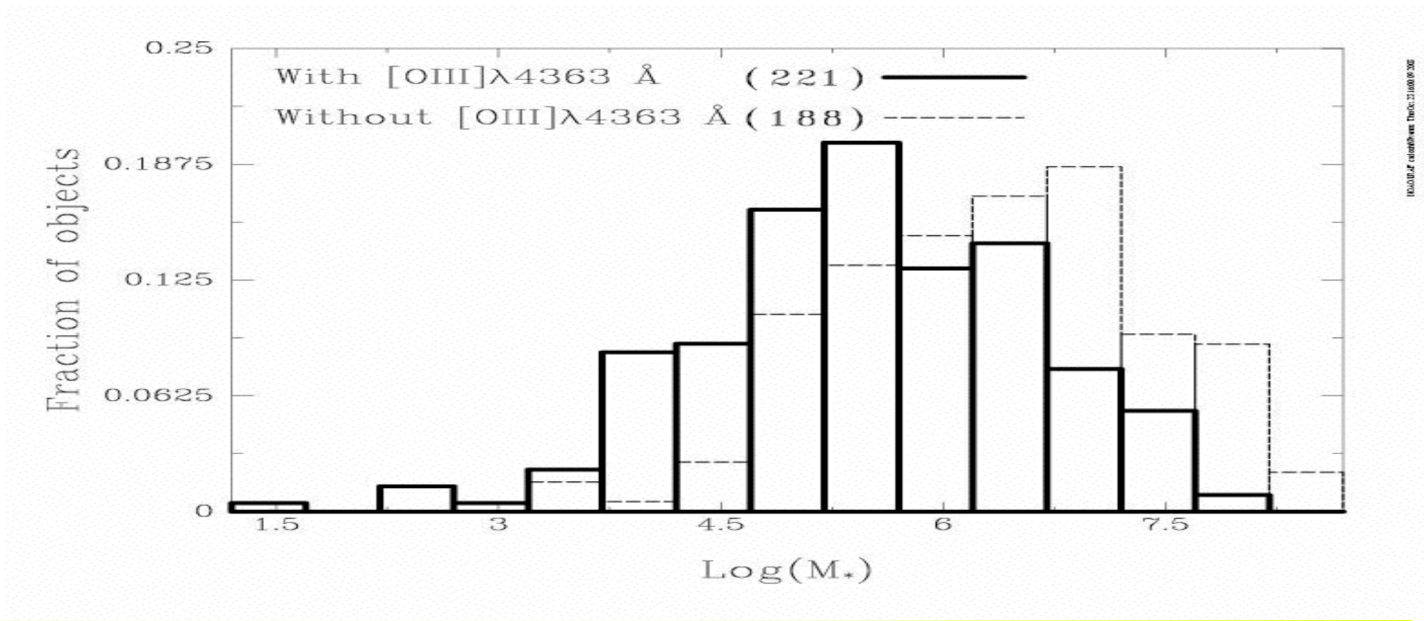


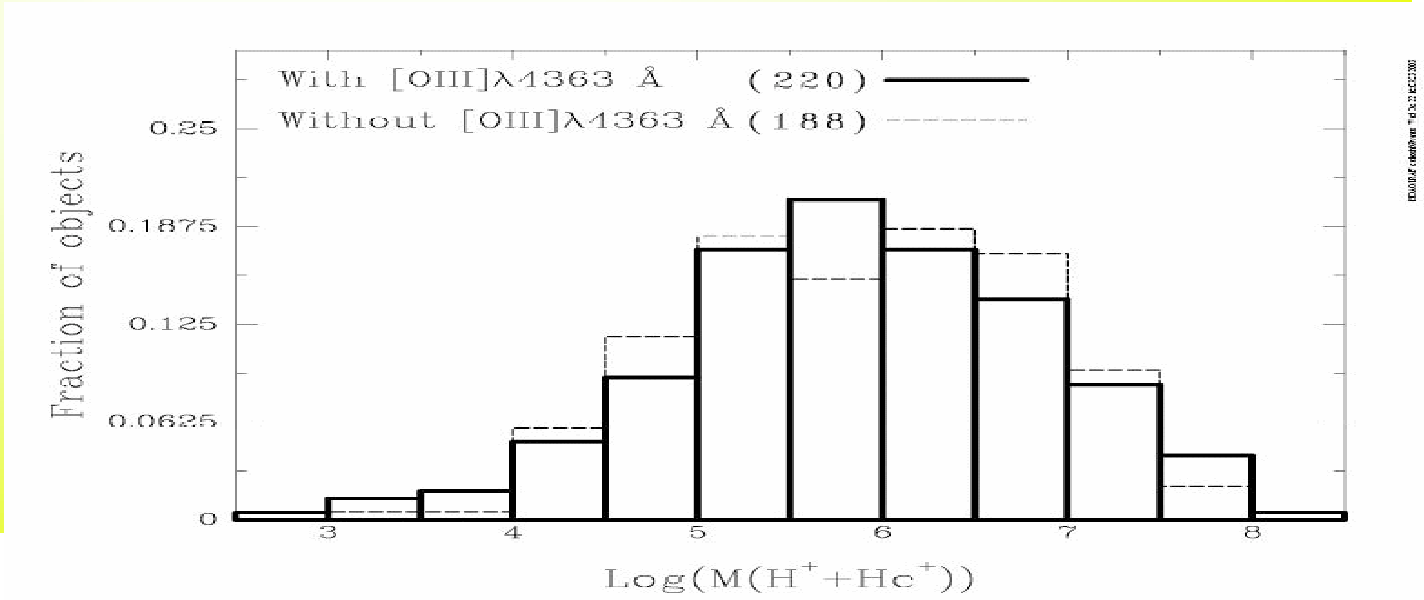
log(Q(H)/M$_*$)=44.8+0.86 log(Wβ).

Objects with *vs.* Objects without [OIII]λ4363.

Mass of the ionizing cluster.(Lower limit). Mass of ionized gas.

The ionizing star cluster distributions do not allow to think that there is a clear segregation in this property.
The distribution of $M(H^+ + He^+)$ for the two subsamples overlap.





Objects with *vs.* Objects without [OIII]λ4363.

Metallicity derivation method. (1)

For objects with [OIII]λ4363, the direct method was used.

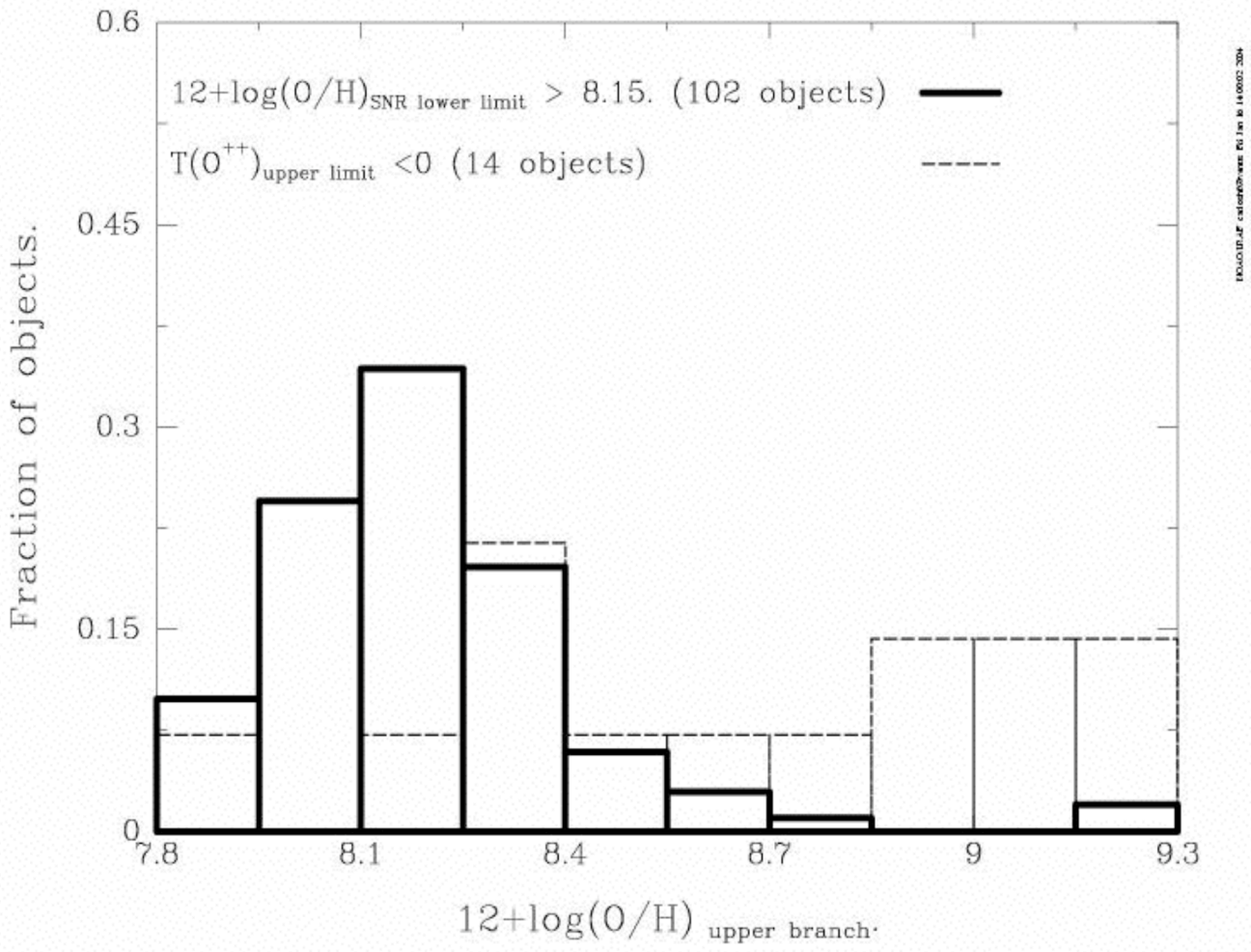
For objects without [OIII]λ4363, the following method was used:

- We dived into the literature in the search for *snr* info. A lower limit to 12+log(O/H) was derived. Only two references gave this info. Other two gave clues and the remaining 15 said nothing.
- The *snr* translates into an upper limit to the [OIII] auroral line strength. This requires (i) The FWHM, (ii) Wβ and (iii) The error per resolution element is assumed to follow a Poisson distribution.
- Using this upper limit to [OIII]λ4363, an electron temperature is derived. The values of [OIII]λλ4959+5007/Hβ and c(Hβ) are needed in this step. The actual electron temperature has to be cooler than this limit.
- Since the ratios [OII]λ3727/Hβ and [OIII]λλ4959+5007/Hβ are known, a limit to the oxygen abundance can be set, using the same code used to derive 12+log(O/H) for objects with [OIII]λ4363.
- Objects with a lower limit greater than 8.15 were culled. These objects were further divided into two categories. High ionization objects ([OIII]/[OII]>1) and low ionization ones, ([OIII]/[OII]<1). Pilyugin's calibration for the upper branch of the R23-12+log(O/H) calibration was used for the first ones, while an empirical calibration was devised and used for the other category.

Objects with *vs.* Objects without [OIII]λ4363.

Metallicity derivation method. (2)

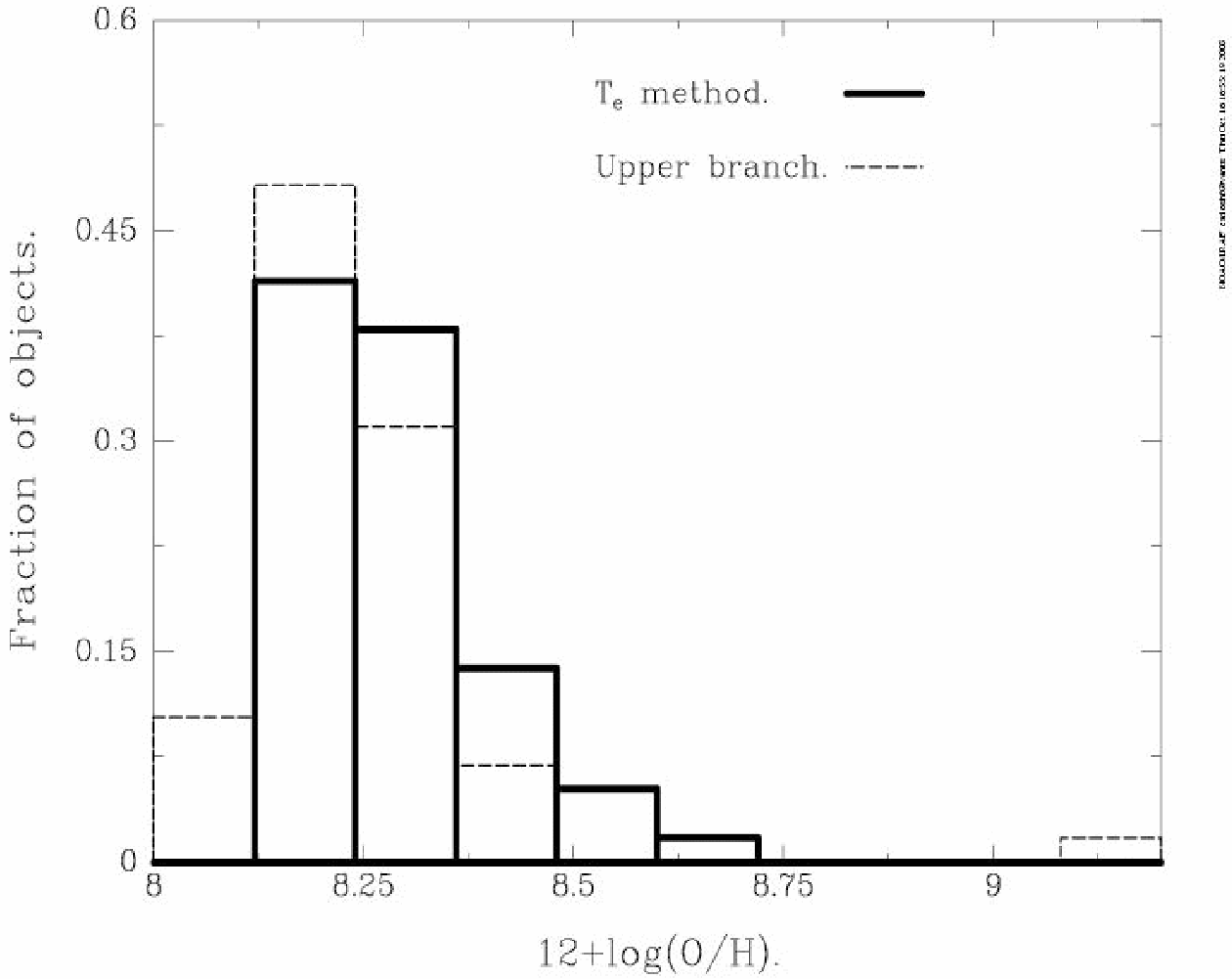
Metallicity distribution for objects **without** [OIII]λ4363 with 12+log(O/H)>8.15. Objects for which this analysis gave unphysical results are presented too. The oxygen abundance was calculated in all cases using Pilyugin's calibration for the upper branch.



Objects with *vs.* Objects without [OIII]λ4363.

Metallicity derivation method. (3) Sanity check 1.

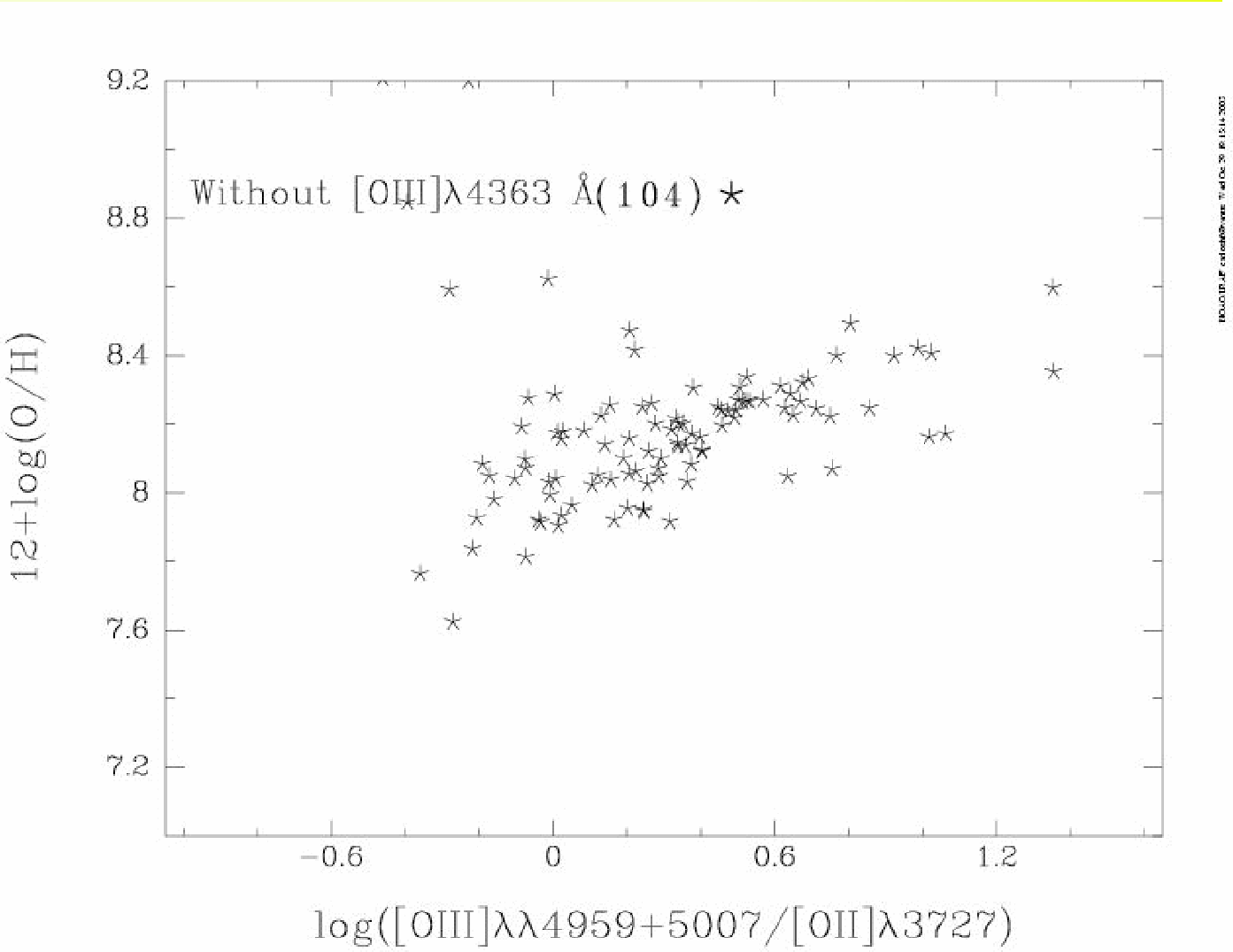
The metallicity distribution for objects **WITH** [OIII]λ4363 whose oxygen abundance is greater than 8.15 is compared to the distribution that would result from the use of Pilyugin's calibration for the upper branch for those objects.
The agreement is reasonably good.



Objects with *vs.* Objects without [OIII]λ4363.

Metallicity derivation method. (4) Sanity check 2.

The metallicity of objects **WITHOUT** [OIII]4363 whose oxygen abundance is greater than 8.15, as calculated from Pilyugin's calibration is plotted against log([OIII]/[OII]).
The increase in metallicity with log([OIII]/[OII]) is somewhat worrying. Is it real, or just an artifact introduced by the calibration used?

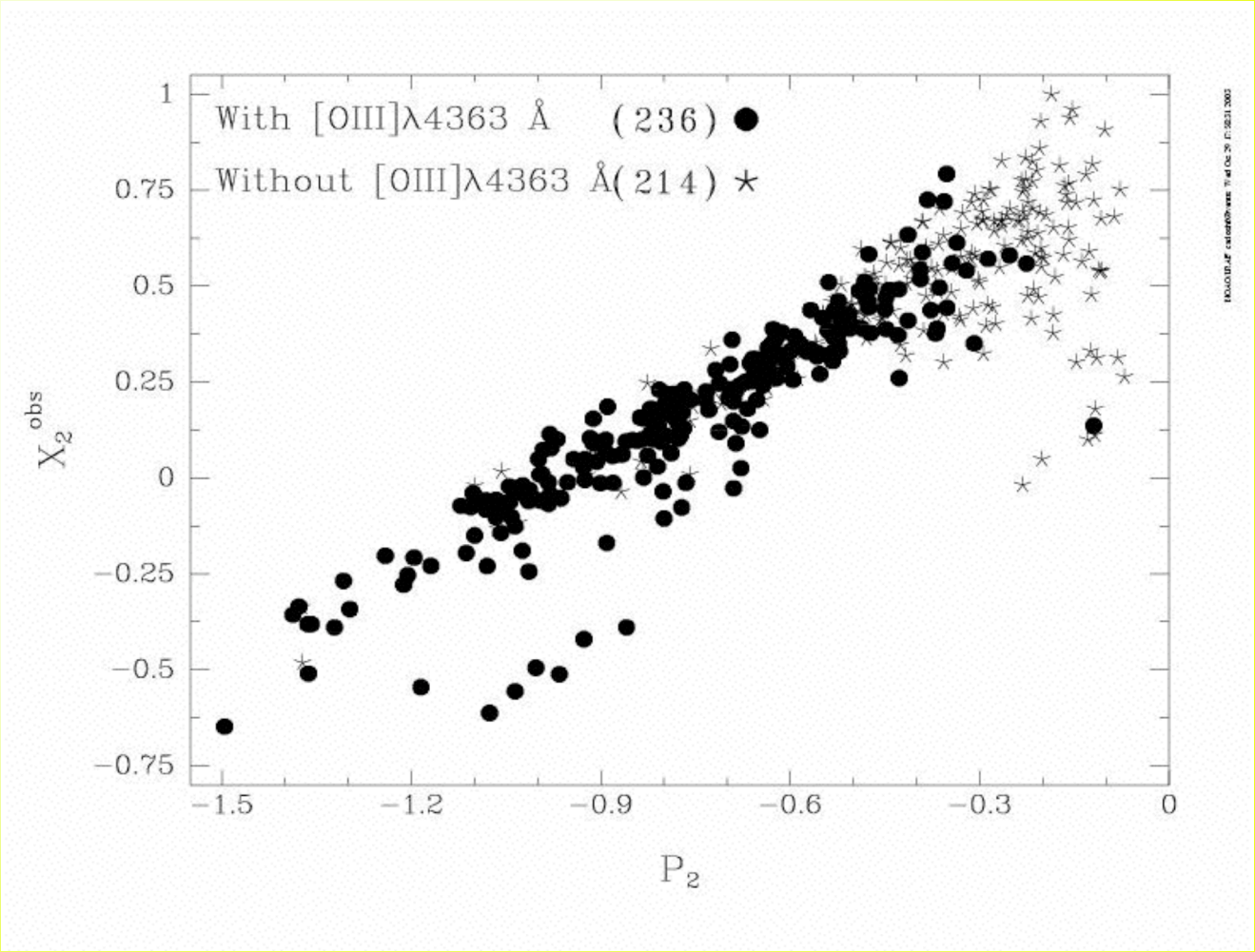


Objects with *vs.* Objects without [OIII]λ4363.

Metallicity derivation method. (5)

The problem with low ionization sources.

Pilyugin's calibration for the upper branch does not work for low-ionization objects. Very few low ionization sources with metallicities derived using the temperature-sensitive method were used to derive this calibration. For this reason the calibration loses accuracy in this regime.



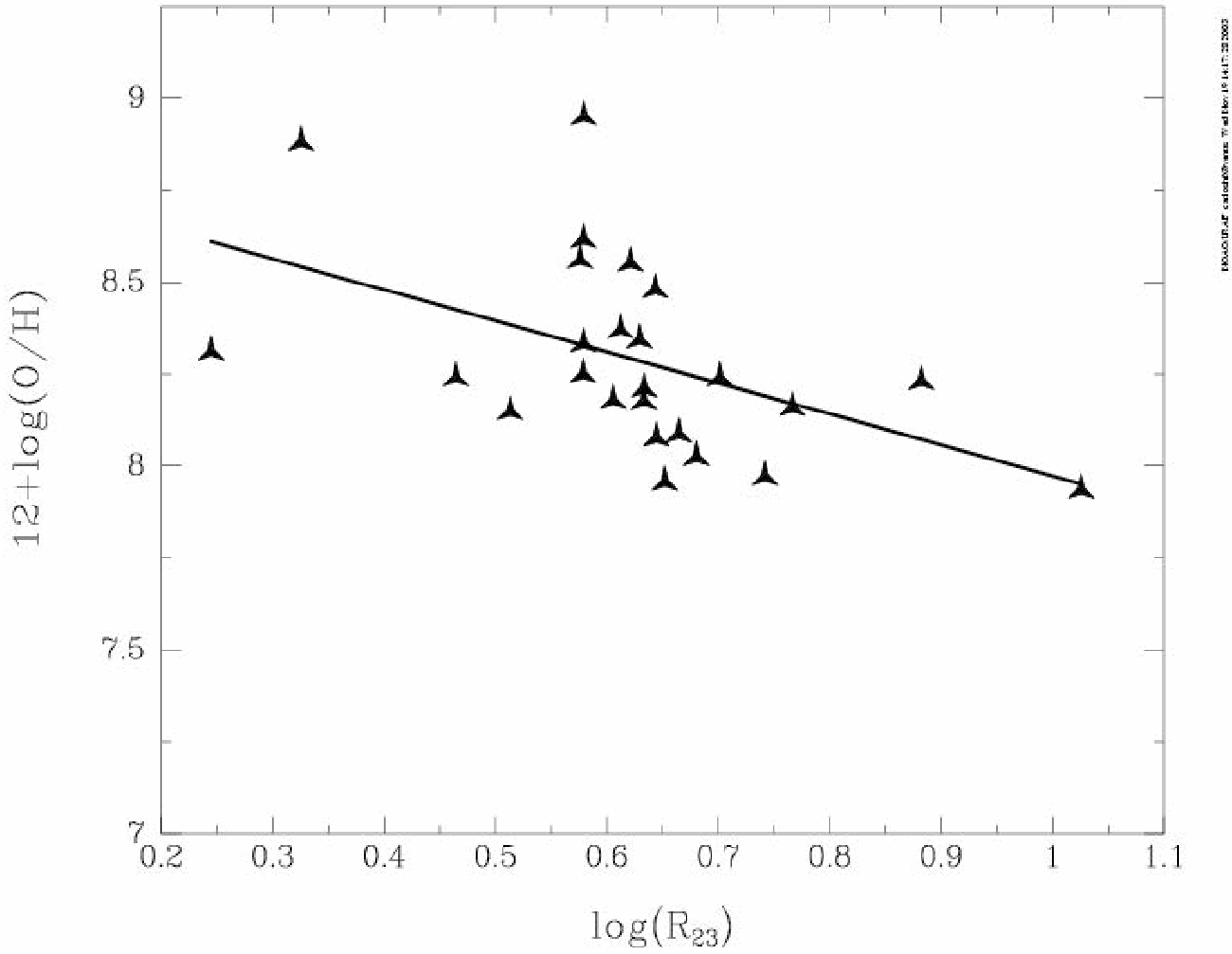
$X_2=\log([OII]/H\beta)$. $P_2=X_2-\log(R_{23})$

Objects with *vs.* Objects without [OIII]λ4363.

Metallicity derivation method. (6)

The low-ionization calibration.

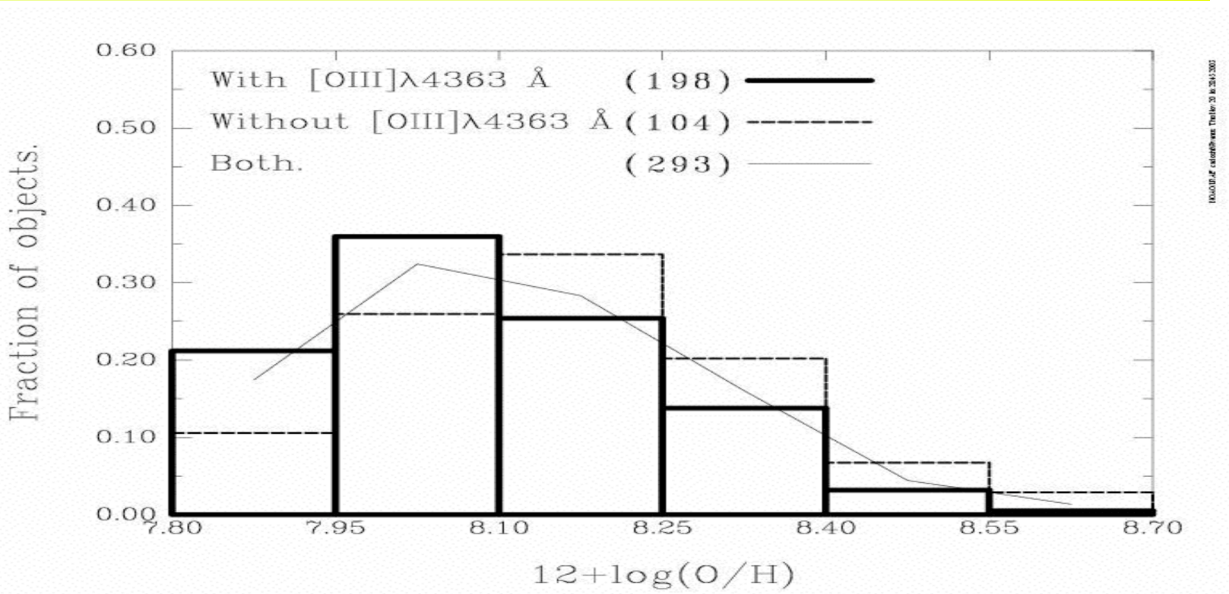
This calibration is based on 26 high-metallicity, low ionization galactic Giant HII regions and HII galaxies. The calibration only depends on ([OIII]+[OII])/Hβ. The dispersion is somewhat high, the *rms* being around 0.30dex.

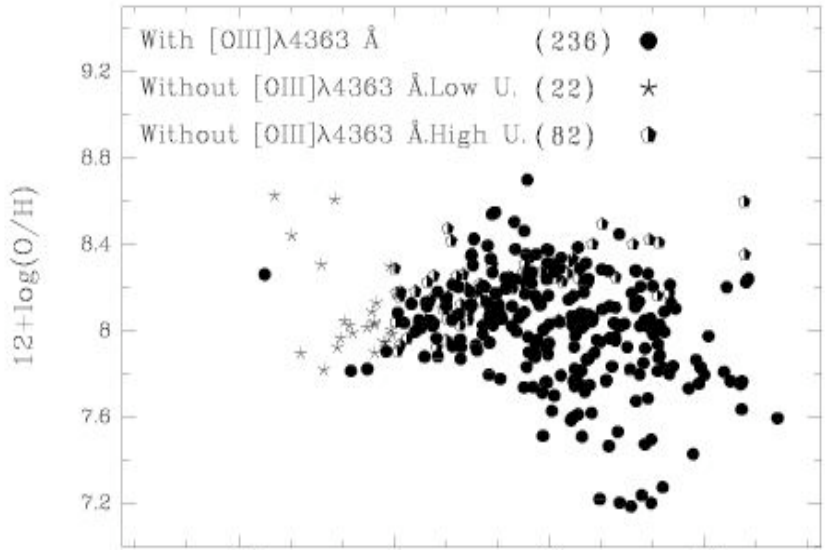


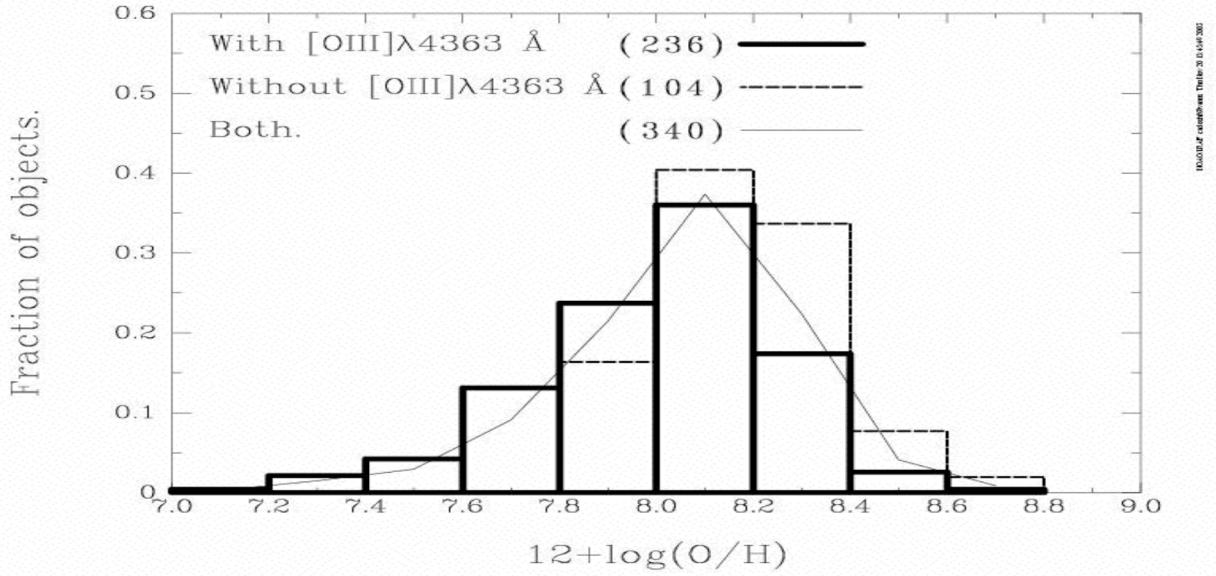
Objects with *vs.* Objects without [OIII]λ4363.

Oxygen abundance distributions.

Surprisingly, the metallicity distributions are not very different. Objects without [OIII]4363 have a slightly higher oxygen abundance, though.







Objects with *vs.* Objects without [OIII]λ4363.

From the previous distributions we can draw the conclussions summarized here:

- There are several observational issues taunting the detection of [OIII]λ4363. Since galaxies without this line have a higher dust content and are more distant their spectra will tipically have lower *s/n* ratios. This plays against the detection of [OIII]λ4363.
- The [OIII]λλ4959+5007/[OII]λ3727 and Wβ distributions clearly differ. The Wβ *vs.* [OIII]4959+5007/[OII]3727 relation might indicate that there is an evolutionary liaison between the two subsamples.
- The mass of the ionizing cluster, and the mass of ionized gas are pretty much the same for both subsamples. Ditto for the luminosity. The continuum, however is stronger in objects without [OIII]4363.
- The oxygen abundance distributions are very similar.

The LCBG-like subsample.

Definition.

LCBGs are luminous (M_B brighter than -17.5), compact (μ_B<21.0 mag arcsec^{-2}), and blue (B-V< 0.6) galaxies undergoing a major starburst.

From the two subsamples, we have selected objects with:

- M_B brighter than -17.5.
- 1.57<([OIII]λ5007·W_{3727})/([OII]λ3727·$W_{4959+5007}$). This condition serves as a surrogate for the color condition. Most objects from Terlevich *et al.* (1991) satisfy this requirement..
- With the data at hand, no condition on the surface brightness can be imposed.

50 objects with [OIII]4363 matched these tests. 117 objects without did it too.

This defines the LCBG-like subsample.

The LCBG-like subsample.

The distributions compared.

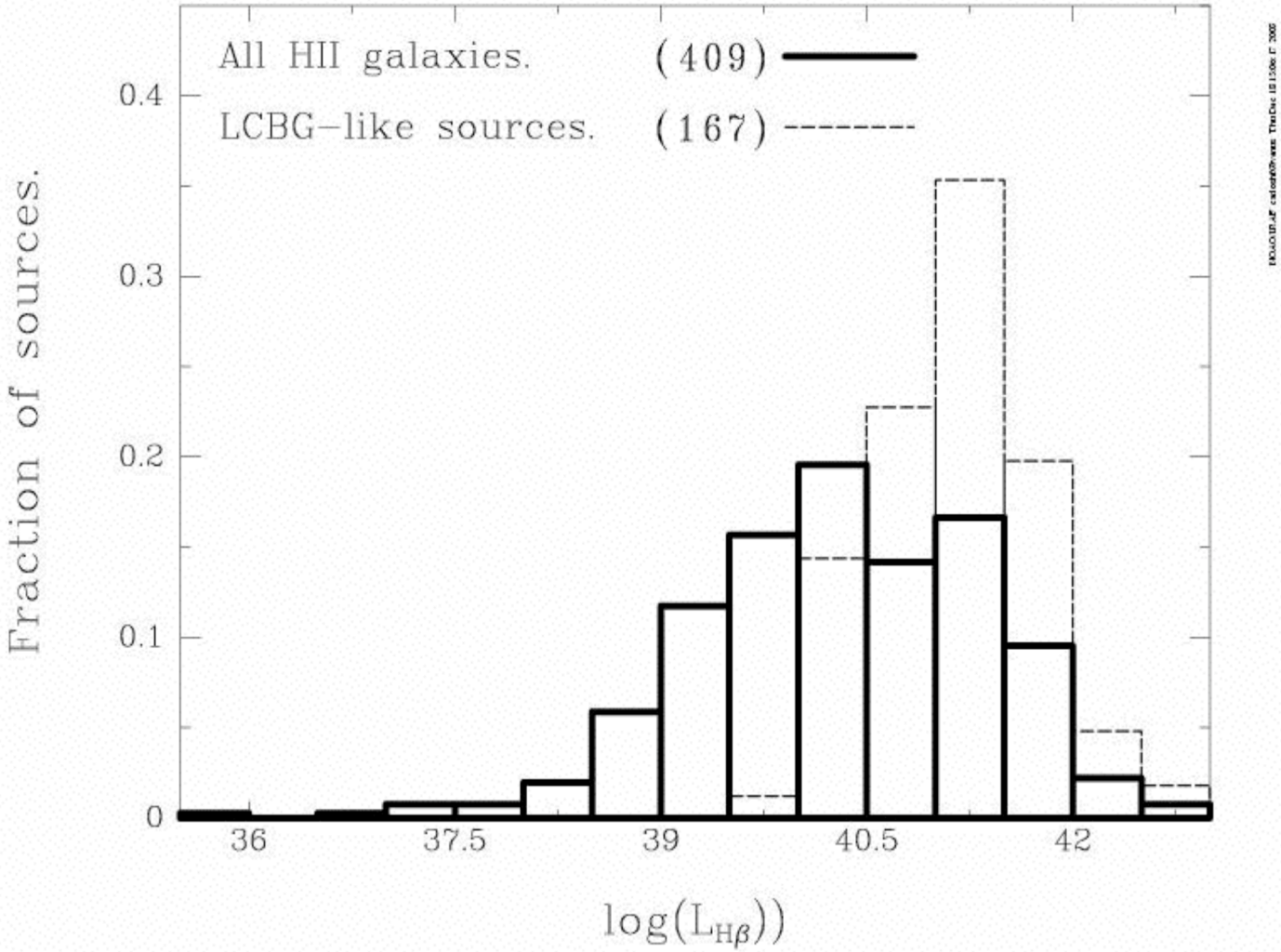
We have repeated the preceeding study, this time comparing the distribution of LCBG-like HII galaxies against the whole population. In particular we present distributions for:

- Hβ luminosity.
- Hβ equivalent width.
- [OIII]λλ4959+5007/λ[OII]3727.
- Extinction.
- Oxygen abundance.

The LCBG-like subsample.

Hβ luminosity.

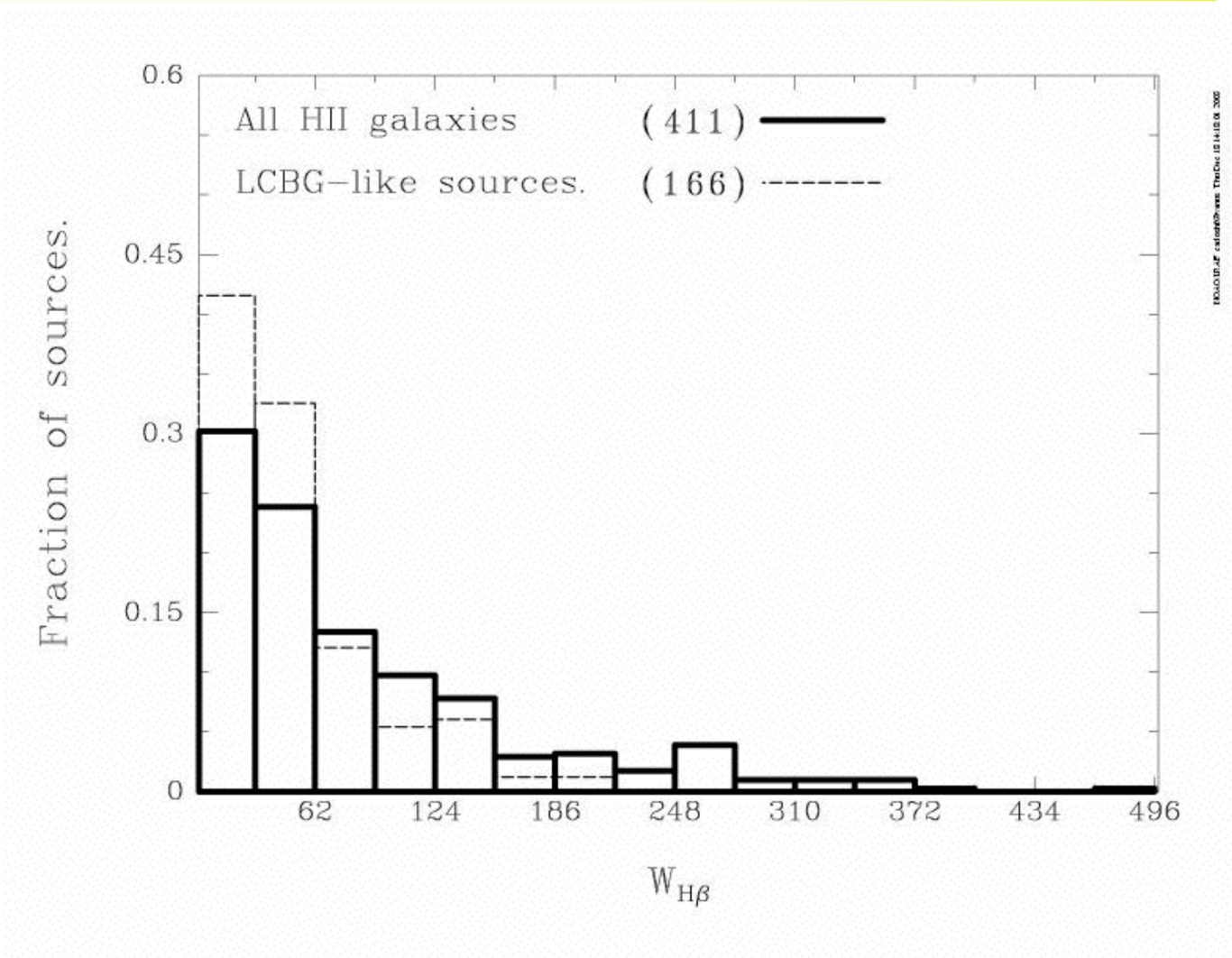
LCBG-like objects show a higher line luminosity. Their luminosity distribution is also more peaked.



The LCBG-like subsample.

Hβ equivalent width.

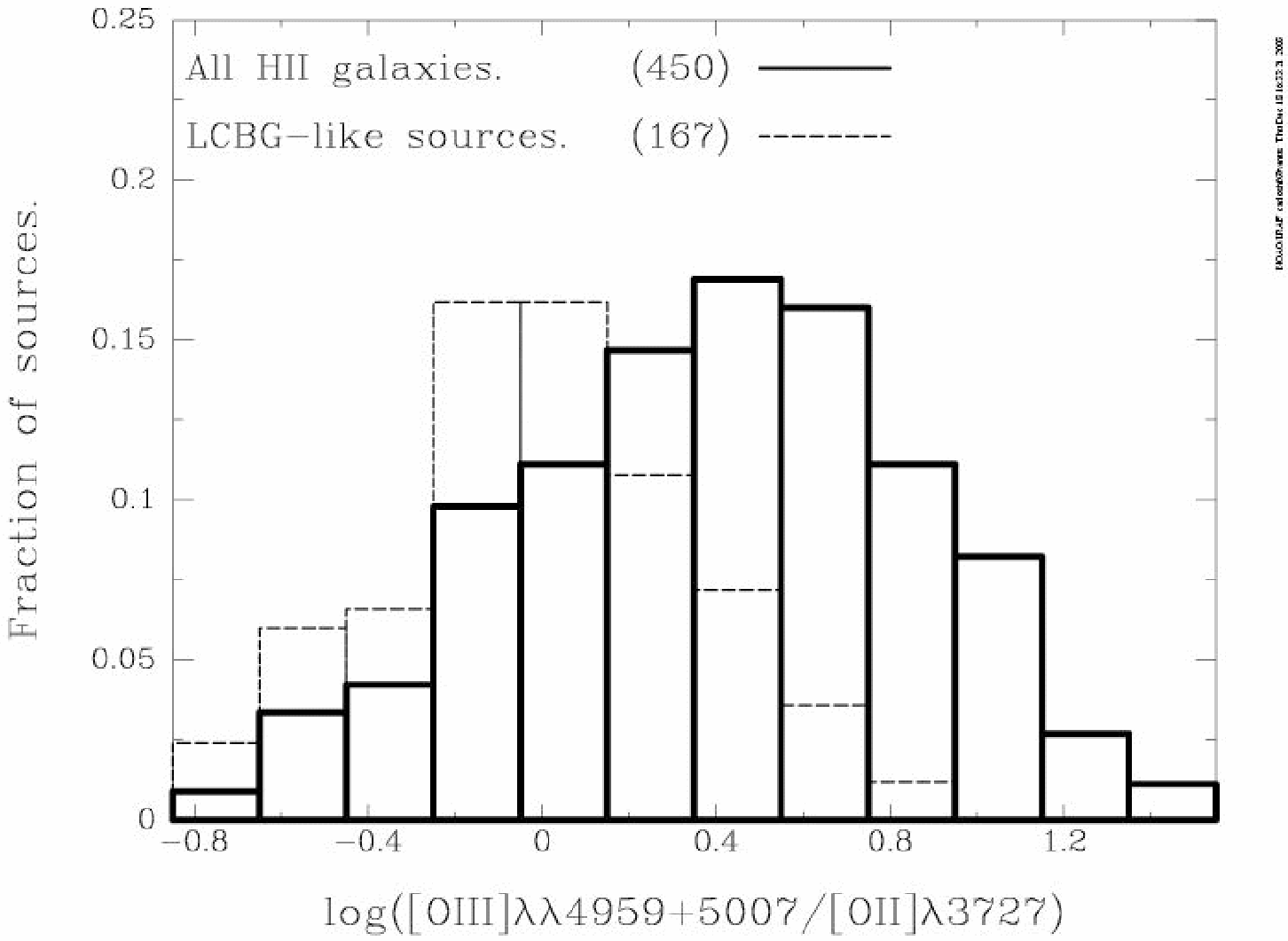
LCBG-like sources have a lower Hβ equivalent width. However, the segregation between the two distribution is not as evident as in the L(Hβ) case.



The LCBG-like subsample.

log([OIII]λλ4959+5007/[OII]λ3727)

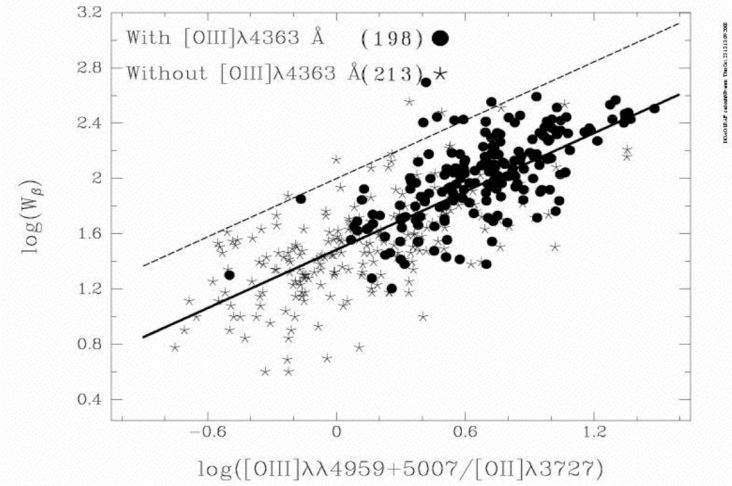
LCBG-like sources present a lower excitation.

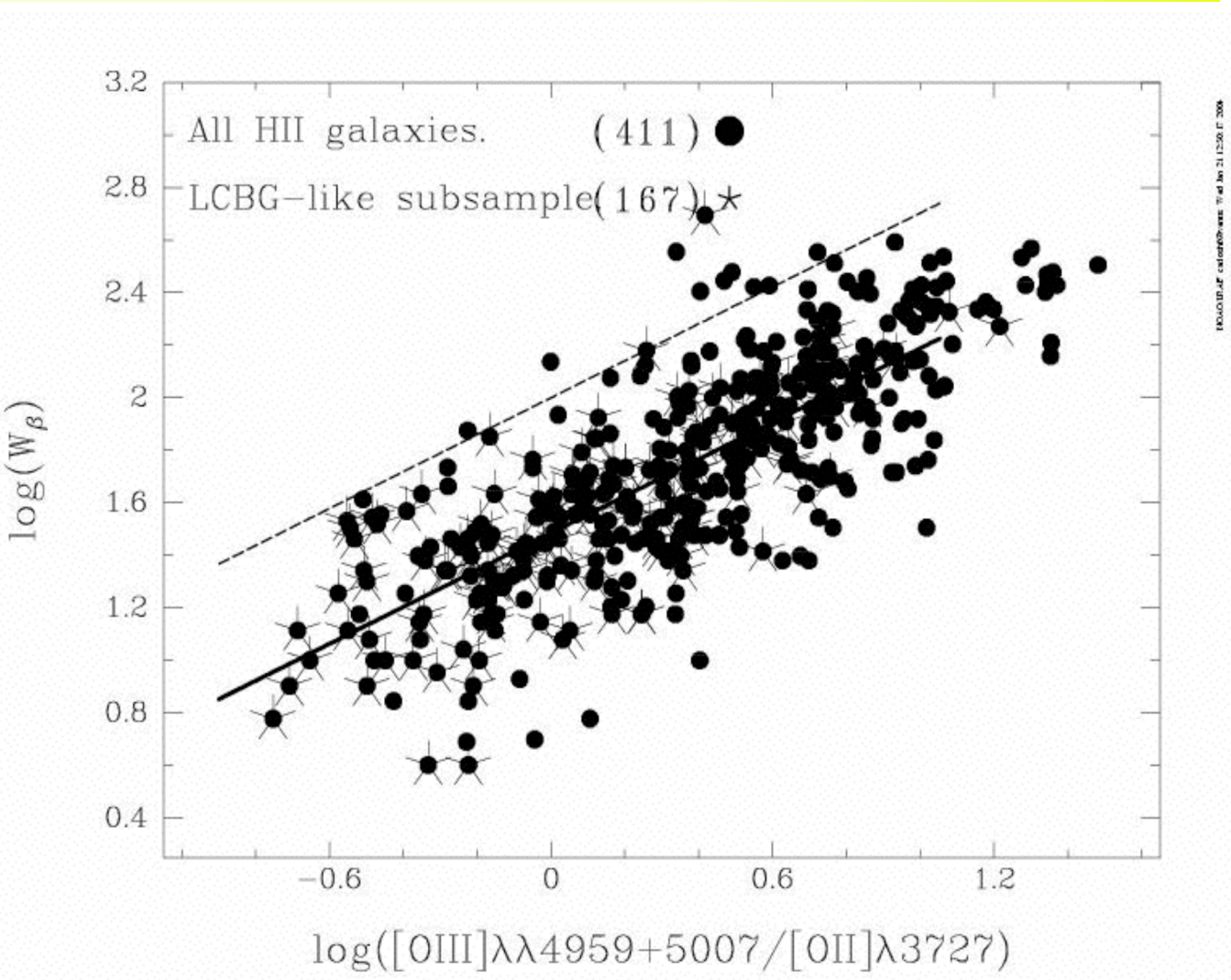


The LCBG-like subsample.

Hβ equivalent width *vs.*
log([OIII]λλ4959+5007/[OII]λ3727)

In this plot, it is made clear that LCBG-like sources show properties more similar to those galaxies **without** [OIII]λ4363.

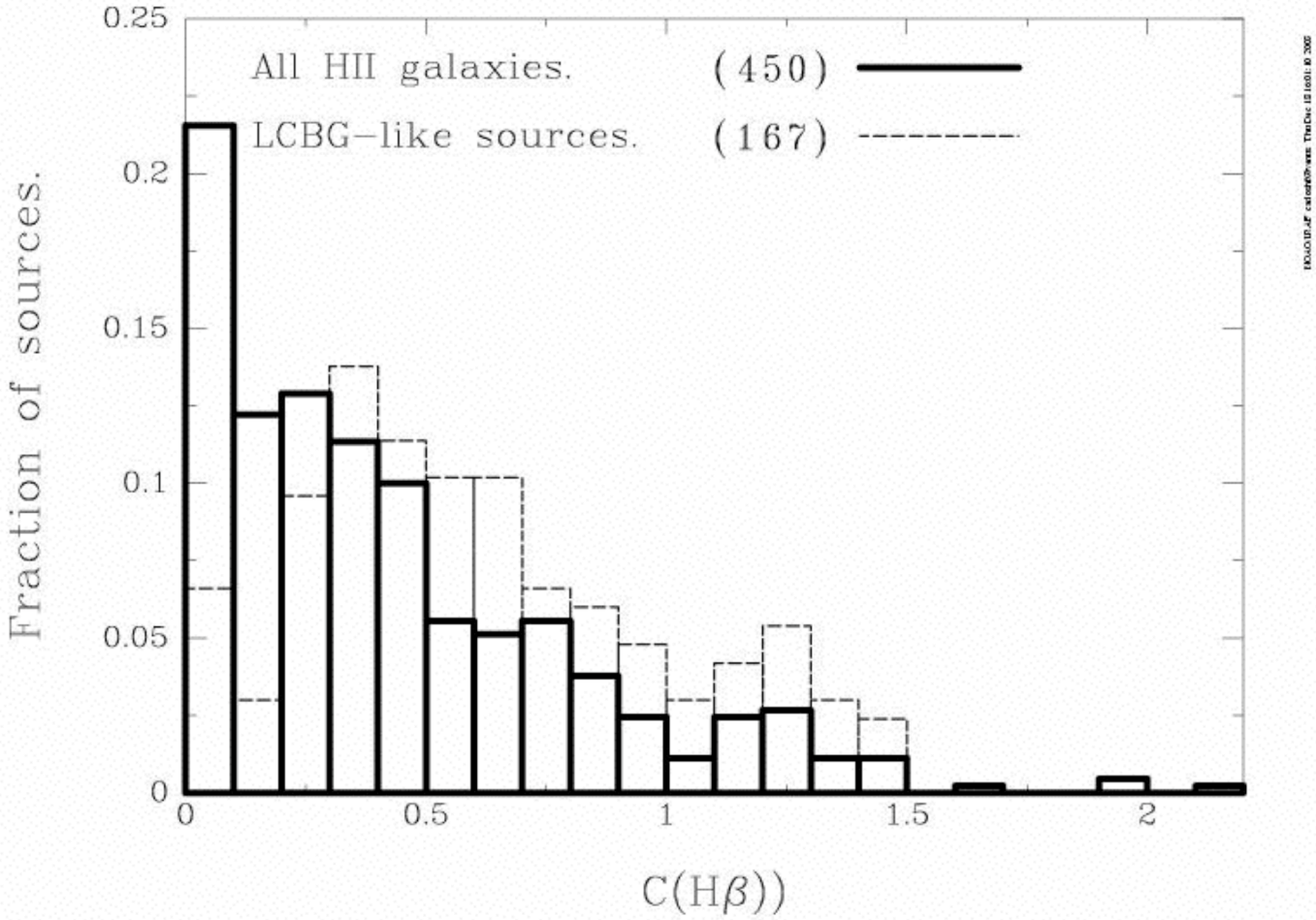




The LCBG-like subsample.

Logarithmic extinction.

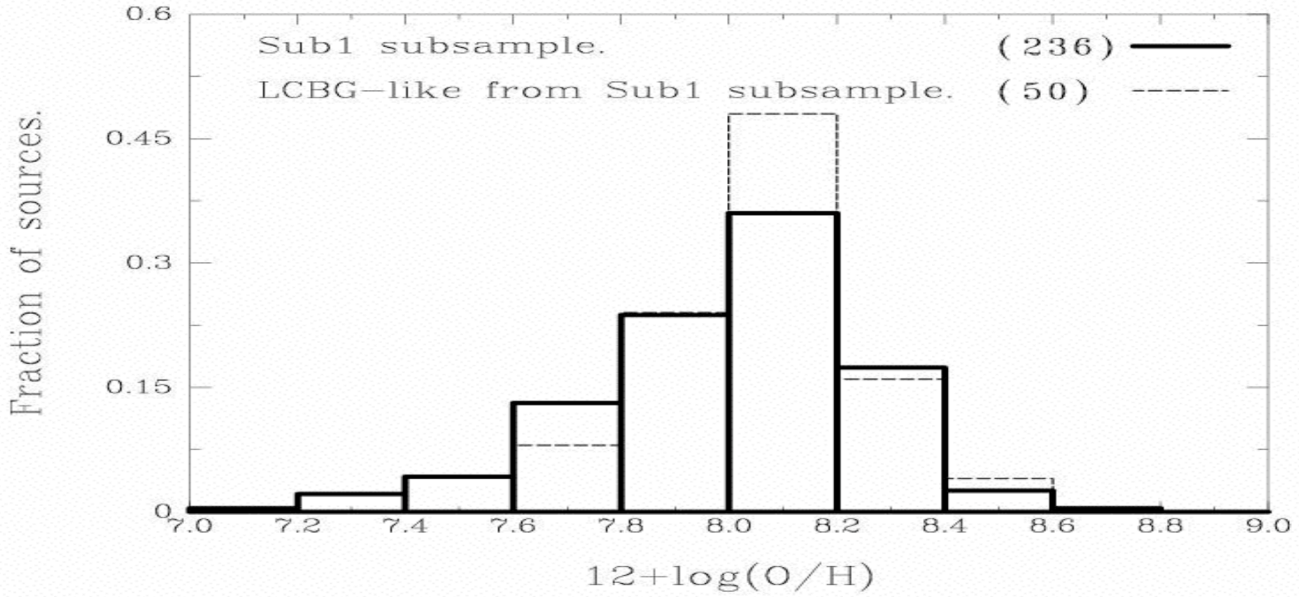
LCBG-like sources have a higher C(Hβ). The distribution shapes are also different. There is a lack of LBCG-like sources at low extinction.

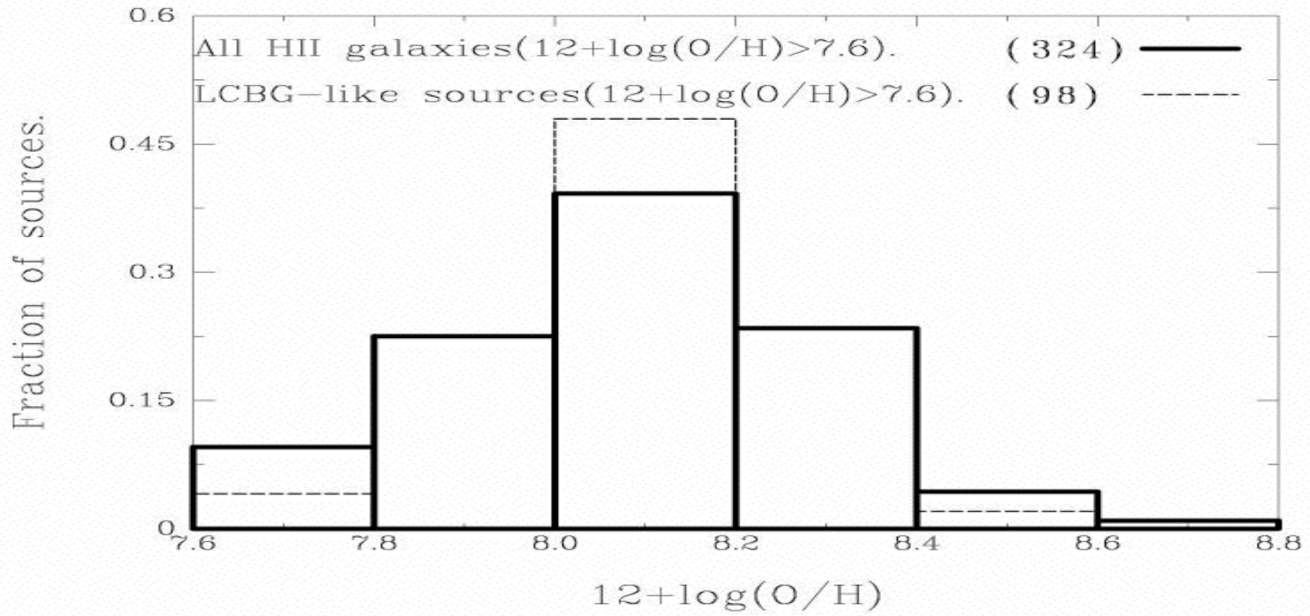


The LCBG-like subsample.

Oxygen abundance.

According to these distributions, more luminous HII galaxies show metallicities similar to less luminous sources. There is, however, a higher occupation number at 12+log(O/H)=8.1





The LCBG-like subsample.

This study yields the following information:

- LCBG-like HII galaxies show higher line luminosities. In spite of their stronger line luminosities, LCBG-like sources present lower equivalent widths.
- The ionization ratio [OIII]λλ4959+5007/[OII]λ3727 is lower for LCBG-like objects.
- There is a deficit of LCBG-like galaxies among galaxies with low c(Hβ) values.
- The oxygen abundance distributions are remarkably similar, except for very low metallicity objects (12+log(O/H)<7.7). In this range there are not galaxies without [OIII]λ4363. LCBG-like objects show a preferred metallicity around 12+log(O/H)=8.1 dex.
- If you are searching for local galaxies to compare with the general properties of high redshift LCBGs, galaxies without [OIII]λ4363 are your best bet.

References.

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