Searching WR populations in BCD galaxies with PMAS: The case of Mrk930

Enrique Pérez-Montero (IAA-CSIC)

and the collaboration of

J.M. Vílchez (IAA-CSIC), G.F. Hägele (UAM), M.Mollá (CIEMAT), R.García-Benito (UAM), A.I.Díaz (UAM) & D. Martín-Gordón (IAA-CSIC)

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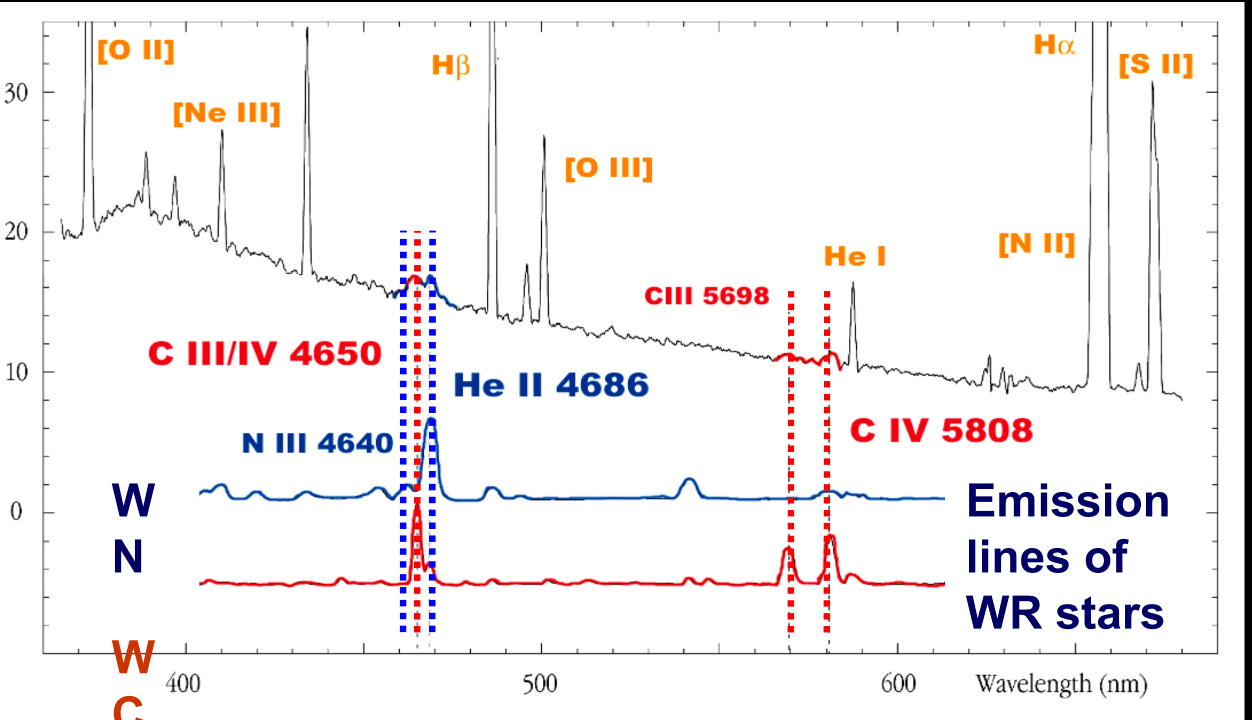
Outline

- WR galaxies: opportunities and problems
- PMAS observations
- So far analyzed: The case of Mrk930
- Future work and prospects

Wolf-Rayet galaxies

This term (Osterbrock & Cohen , 1982) denotes star forming systems with WR broad emission at 4650 Å (NIII, CIII/CIV, HeII) and 5808 Å (CIV) originated in the stellar winds from WN and WC stars.

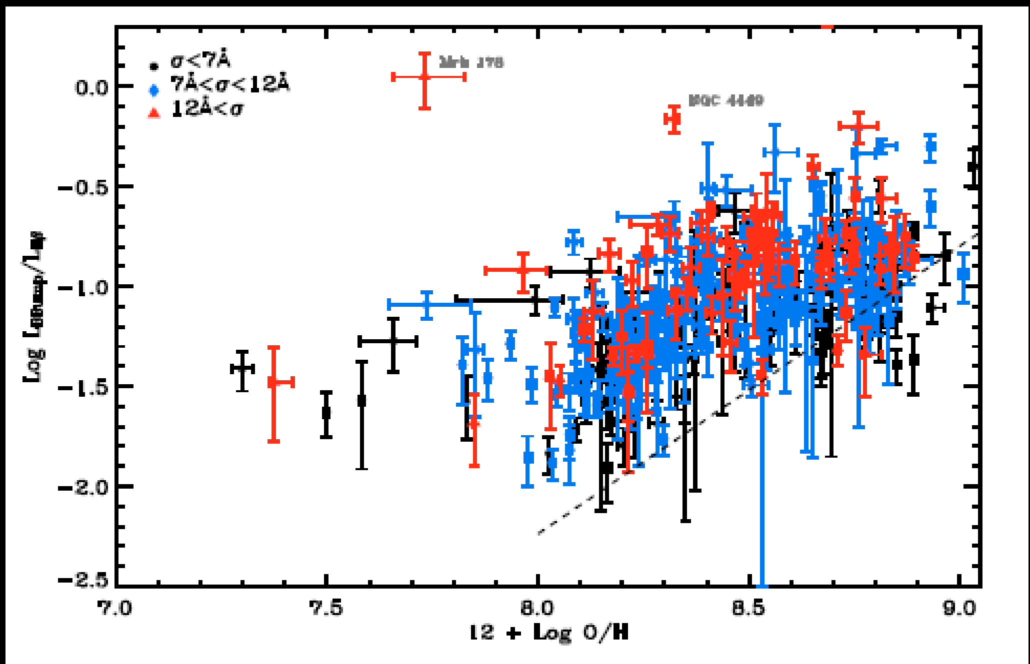
They include from BCDs to massive spirals and even AGNs



Spectrum of HII Region -014+081 in NGC 4254

Wolf-Rayet populations

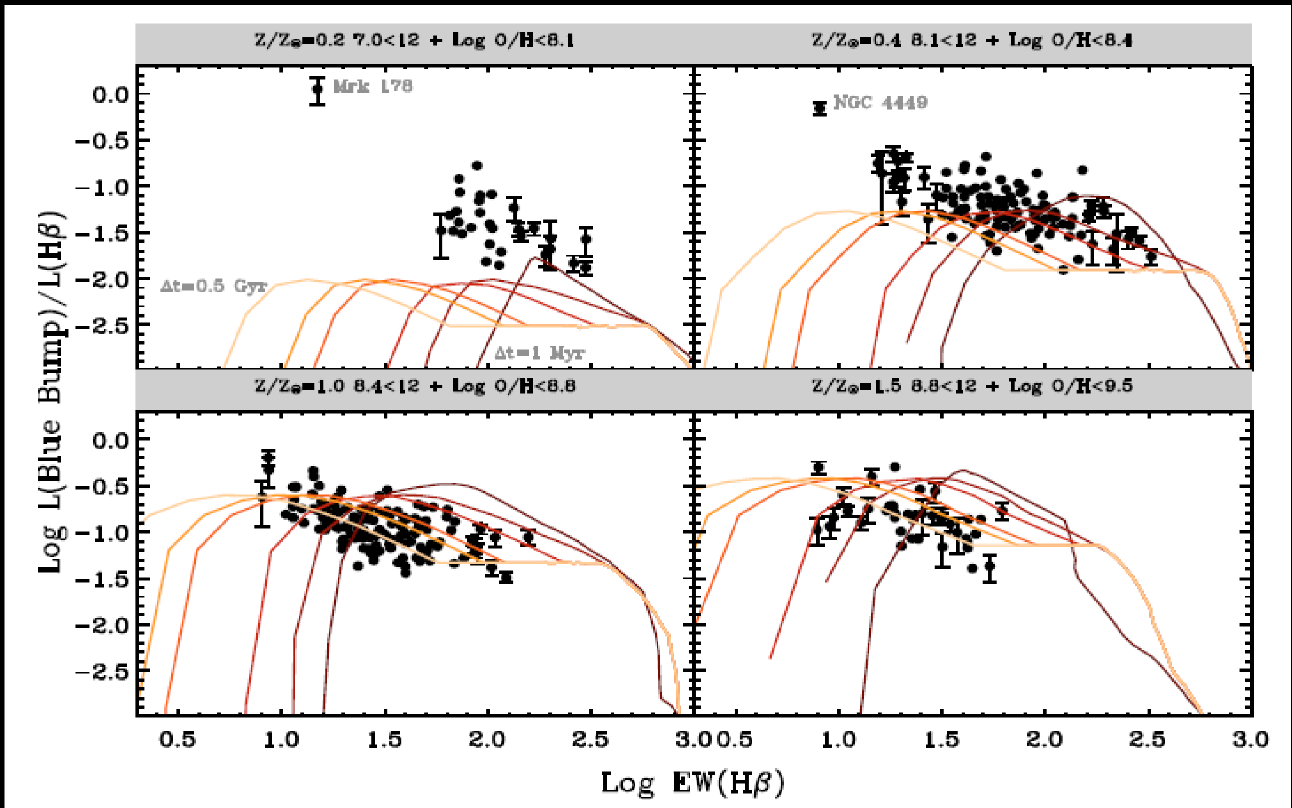
WR populations are useful to constrain properties of the ionizing stellar populations as they are only detectable between 2 and 5 Myr after the beginning of the burst.
They can be used to constrain the upper limit of the IMF.
The luminosity of the WR bumps strongly depend on the metallicity of the stars.



SDSS WR galaxies
Brinchmann et al. (2008)

Wolf-Rayet populations

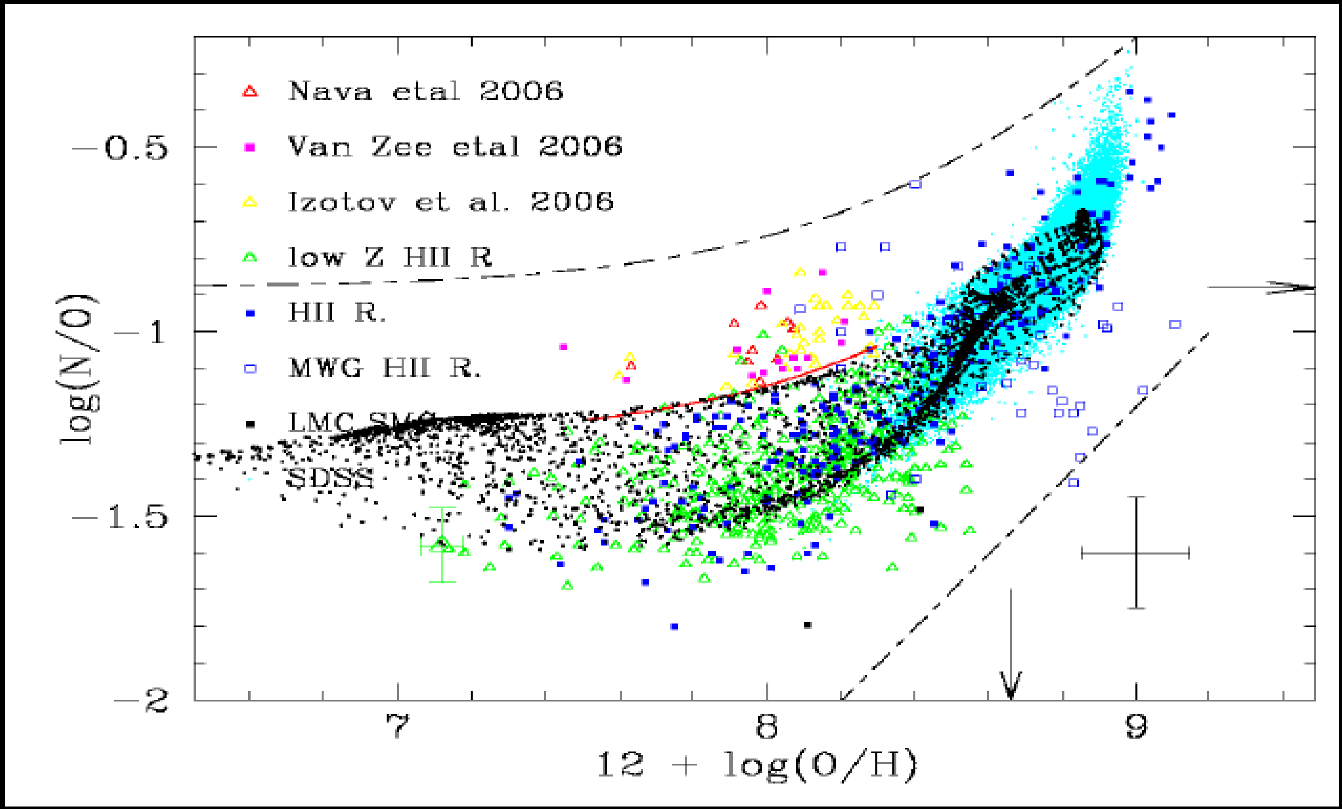
However, there is a disagreement between the observed luminosities of WR bumps and those predicted by evolutionary synthesis models.
Between the possible causes: binary channel (Han et al. 2007), rotation (Meynet et al., 2005) but geometrical effects, too.



SDSS WR galaxies
Brinchmann et al. (2008)

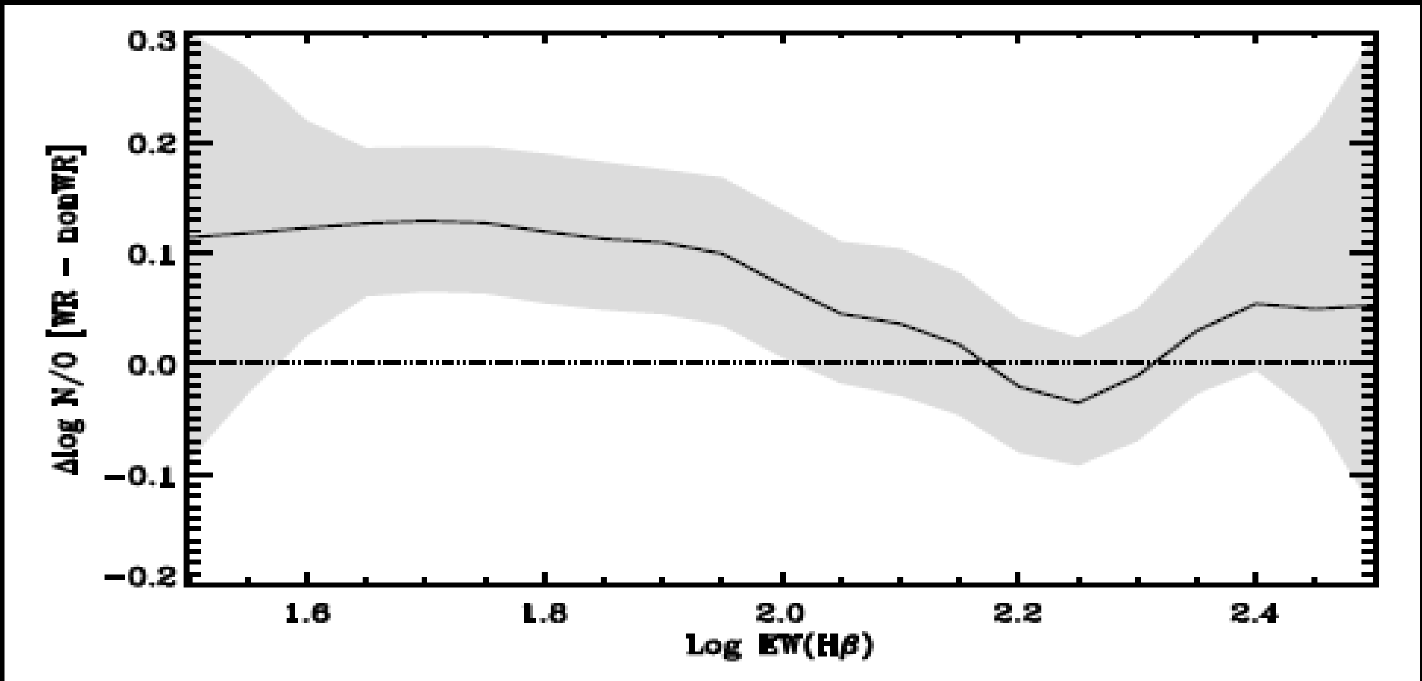
The N/O problem

Nitrogen can have either a primary origin (mainly produced by massive stars) or secondary (by intermediate mass stars).
The N/O vs. O/H plot can be reproduced by chemical evolution models, but the high N/O ratios observed in some BCDs are an exception.



The N/O problem

Evidences of an enrichment of N have been found in several WR galaxies: HS0837+4717 (Pustilnik et al., 2004), NGC 5253 (López-Sánchez et al.) and the SDSS catalogue of WR galaxies (Brinchmann et al., 2008).

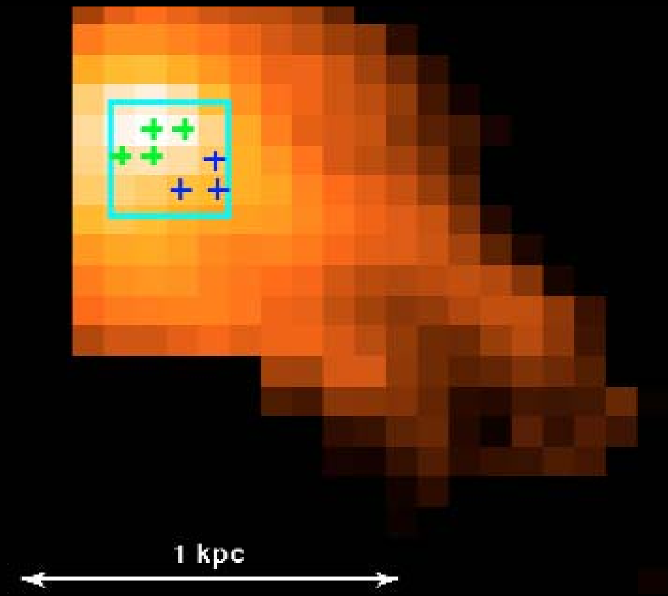


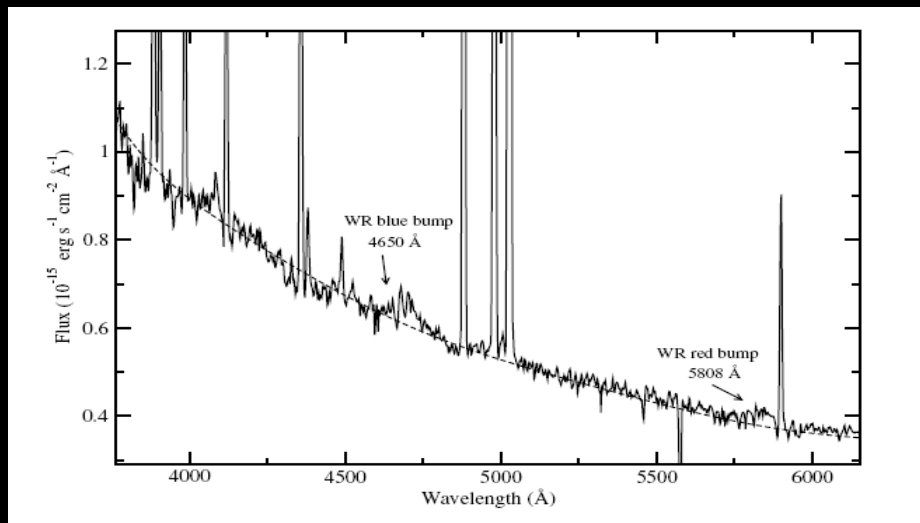
SDSS WR galaxies
Brinchmann et al. (2008)

IFUs as a suitable tool

IFUs allow us to:

- Measure the total emission of WR bumps
- Relate it to the corresponding Balmer emission
- Locate the position of WR stars
- Find WR emission where they were not detected before (e.g. IIZw70, Kehrig et al., 2008)
- Link the presence of WR stars to local chemical enrichment.





PMAS program

A PMAS program was proposed to observe BCD galaxies with WR emission and/or an excess in the N/O ratio.

The aims of this proposal:

- Is the discrepancy between the observations and models of WR features due to geometrical effects ?
- Is there an instantaneous enrichment of the ISM around WR stars, or there are long delays ?
- Are WR stars a source of chemical and excitation inhomogeneities in the large massive clusters seen in HII galaxies ?

PMAS observations

Two nights were awarded: October 29th and 30th 2008 to observe with PMAS in C.A.H.A. 3.5 m.

First night: Closed by bad weather conditions

Second night: A huge thermal variation between the dome and outwards implied very high seeing (~2'')

Lens array mode, with magnification 1''x1''. Enough to observe star forming knots of BCDs.

Grating 600 (0.8 A/pix) to cover from 3600 to 6900 A. In two spectral ranges.

Three galaxies were observed at air masses lower than 1.25 to avoid differential atmospheric refraction effects.

The observed sample

Three objects were observed during the one night bservations:

	12+log(O/H)	Log(N/O)	WR	t exp.	Ref.
Mrk 930	8.06	-1.39	YES	2400	IT98
HS 0128+0832	8.10	-0.93	NO	3900	IT04
HS 0837+4717	7.64	-0.83	YES	3300	P04

Reduction

The reduction and analysis has been made using a combination of R3D and IRAF.

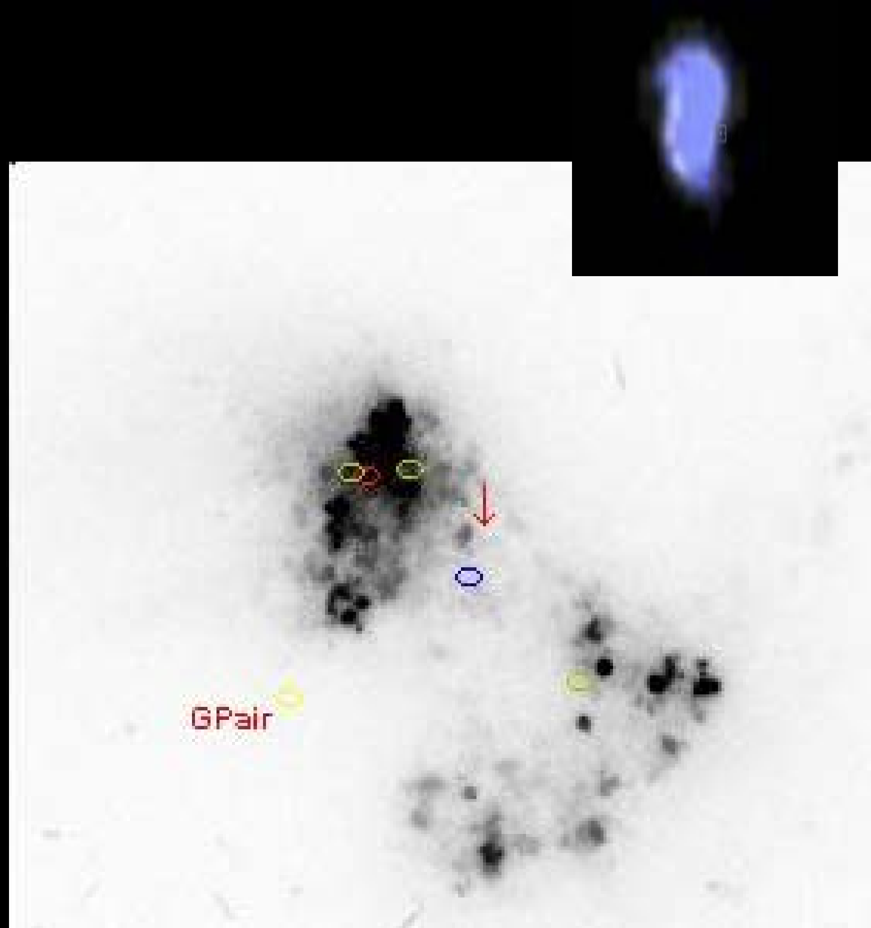
Main problems I have found:

- Distortion correction ([OII] near to the edge)
- Wavelength calibration (header incompatibilities)
- Flux calibration (inconsistencies between IRAF and R3D)
- Differential atmospheric refraction
- Emission-lines analysis with spatial resolution (weak lines and [OII])

MaRKarian 930

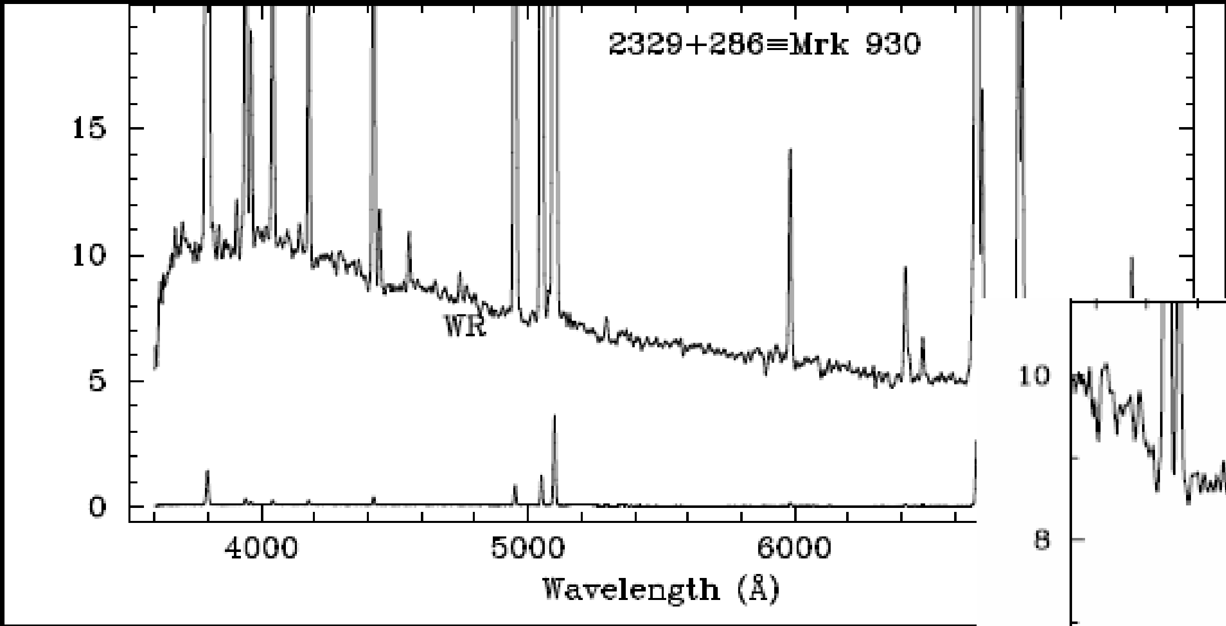
R.A. = 23h31m58.3s
D= +28d56m50s
V = 5485 km/s (D~75 Mpc)
1 arc sec = 350 pc
Size = 0.43 x 0.35 arcmin
Mag = 15.0 B

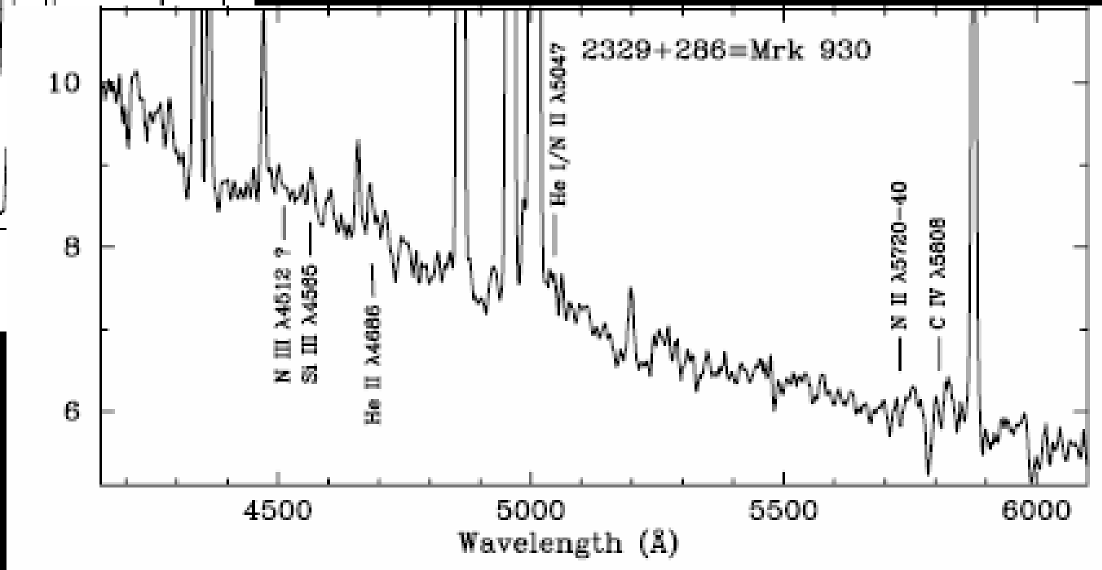
Two of the three sources in Mrk 930 lie at very nearly the same velocity. Source b is the brightest source to the south of the galaxy. A second elongated object lying to the north of b is divided into source a1 and a2 with a1 lying closest to b at a projected distance of 1.7 kpc. One kpc separates the two halves of the northern source which has a velocity gradient along its length 30 (+/-32) km/s (Nordgren et al., 1995)



Long slit observations

Observed by Izotov & Thuan (1998) with Kitt Peak 2.1 m and slit width 2''.
Catalogued as WR galaxy. The WR content was analyzed by Guseva et al. (2000)

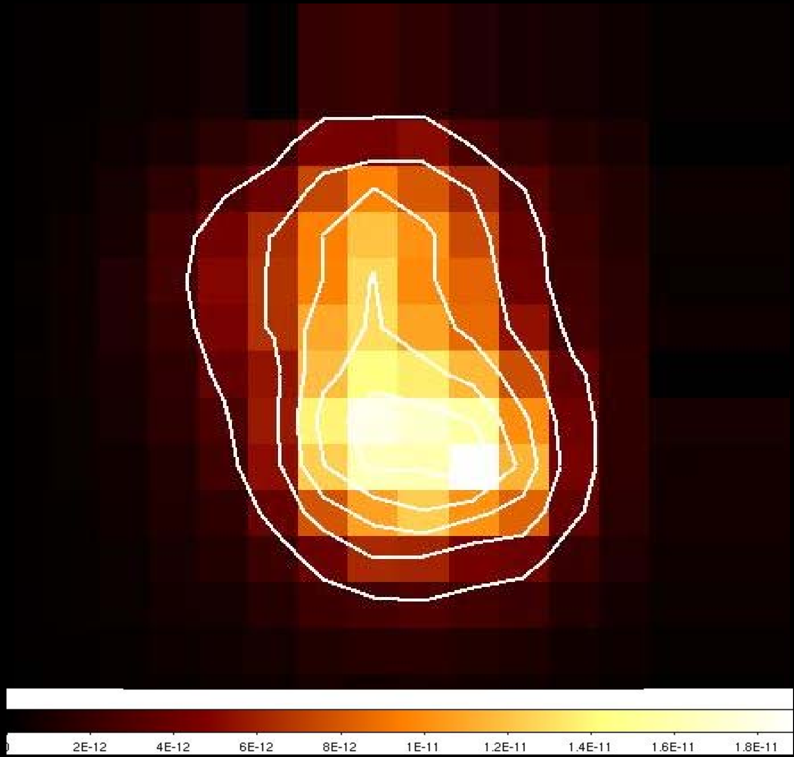




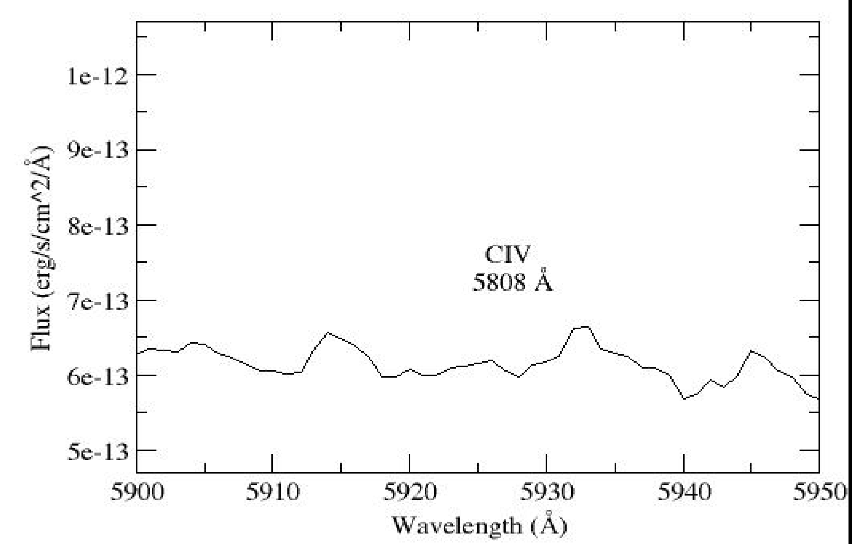
Hα profile

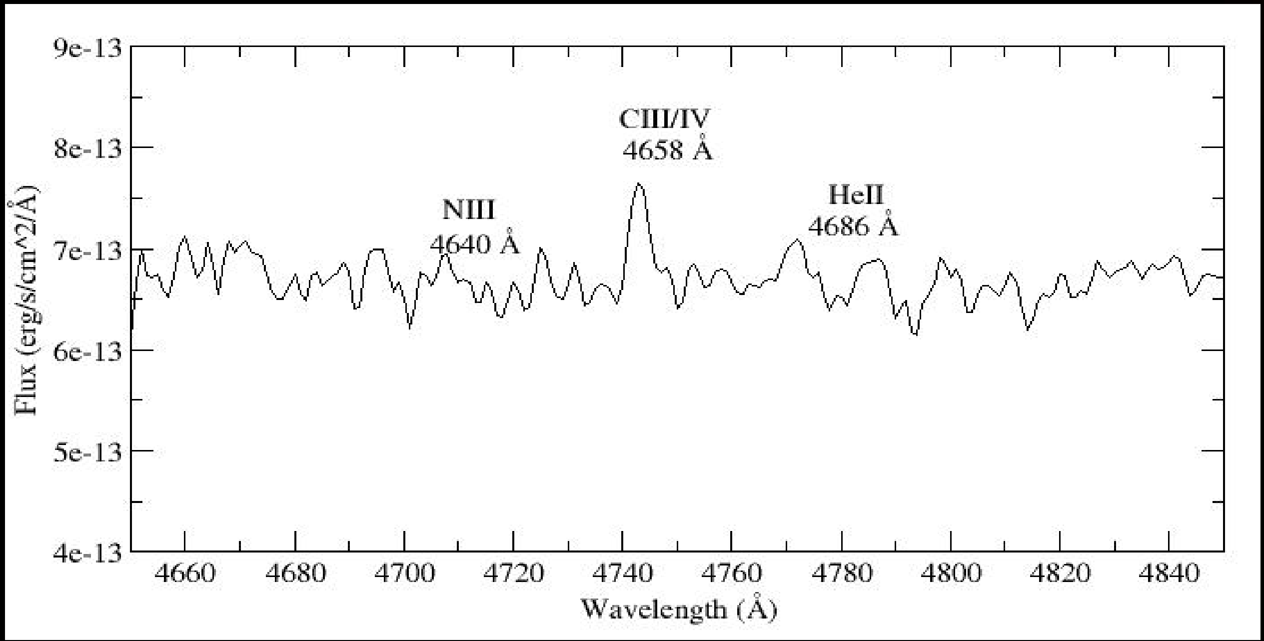
Same elongated shape (3x4 kpc size), but no clear evidence of individual knots.

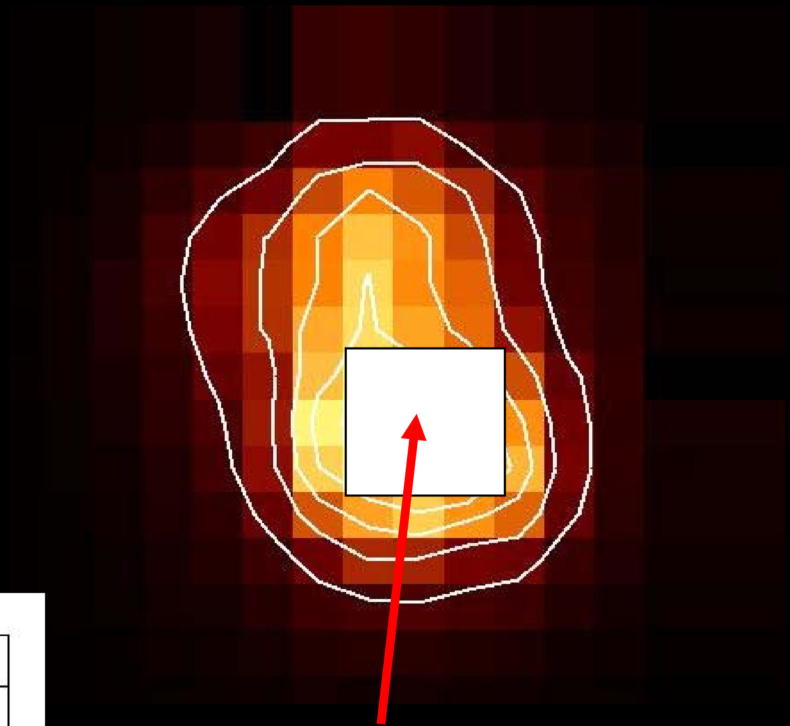
The maximum in Halpha is consistent with the position of the most luminous star forming knots.



WR emission

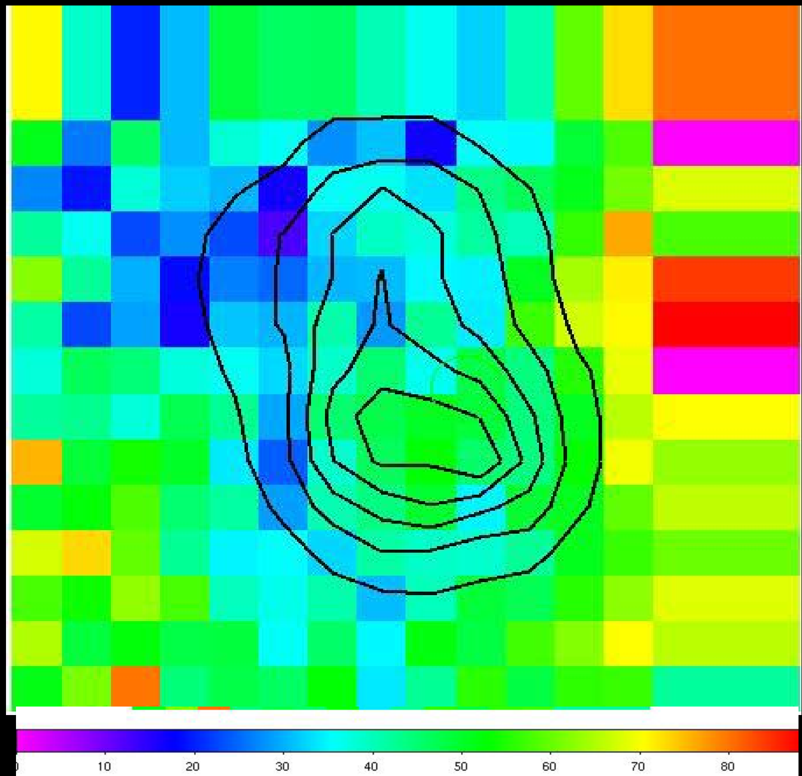




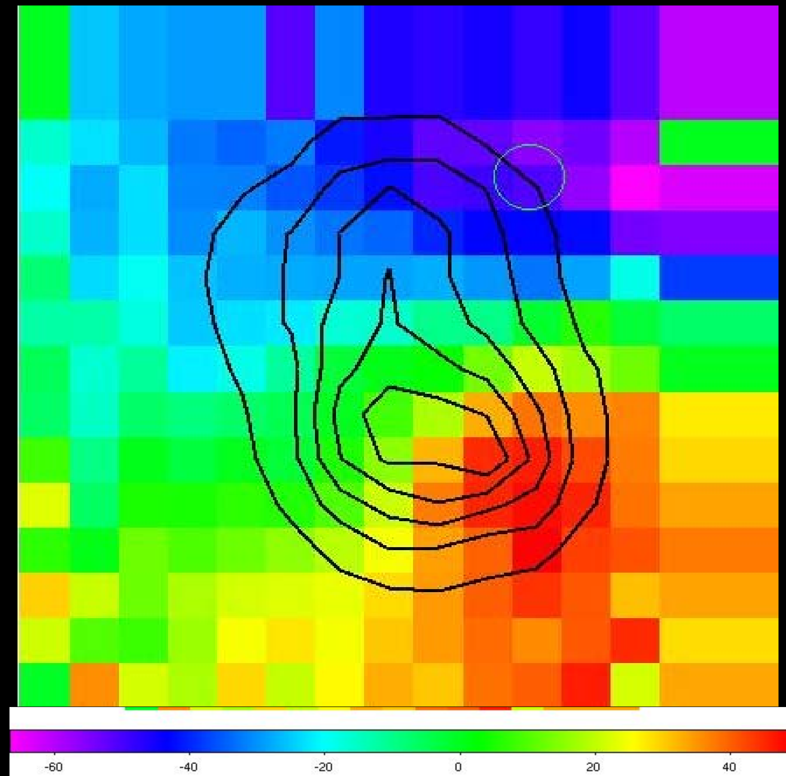


1 kpc^2
WR emission
(WC stars?)

Kinematics with Hα



Velocity dispersion



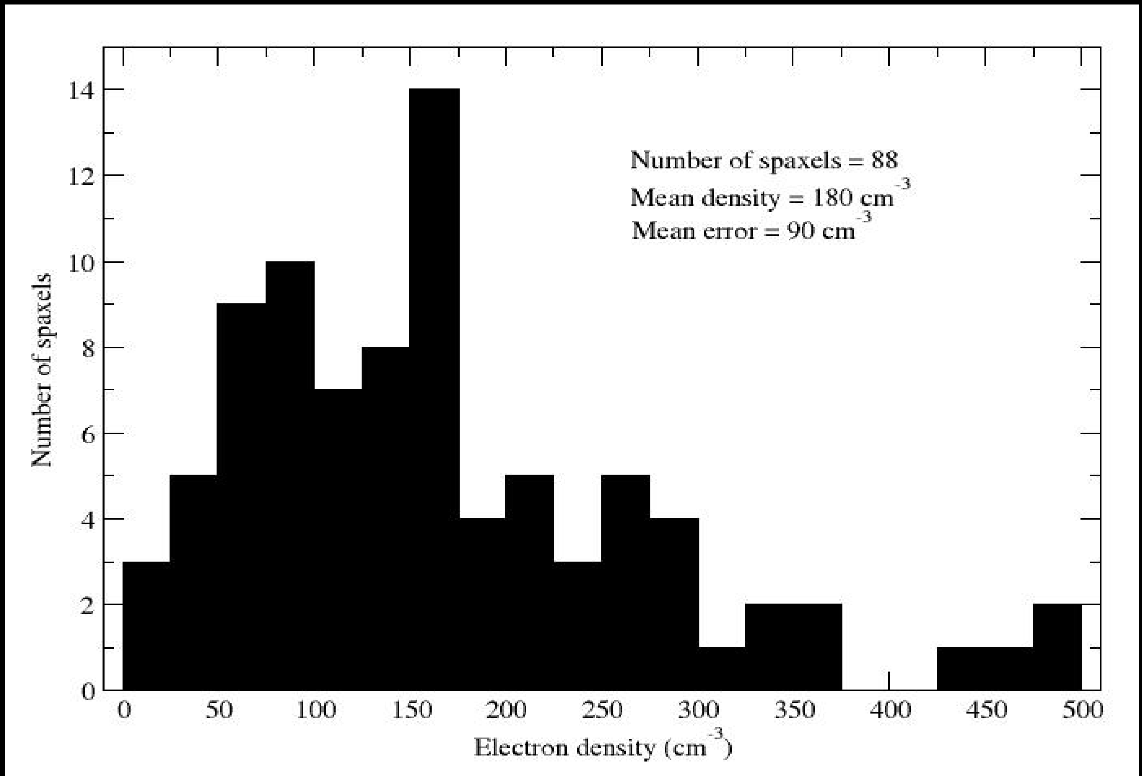
Radial velocity

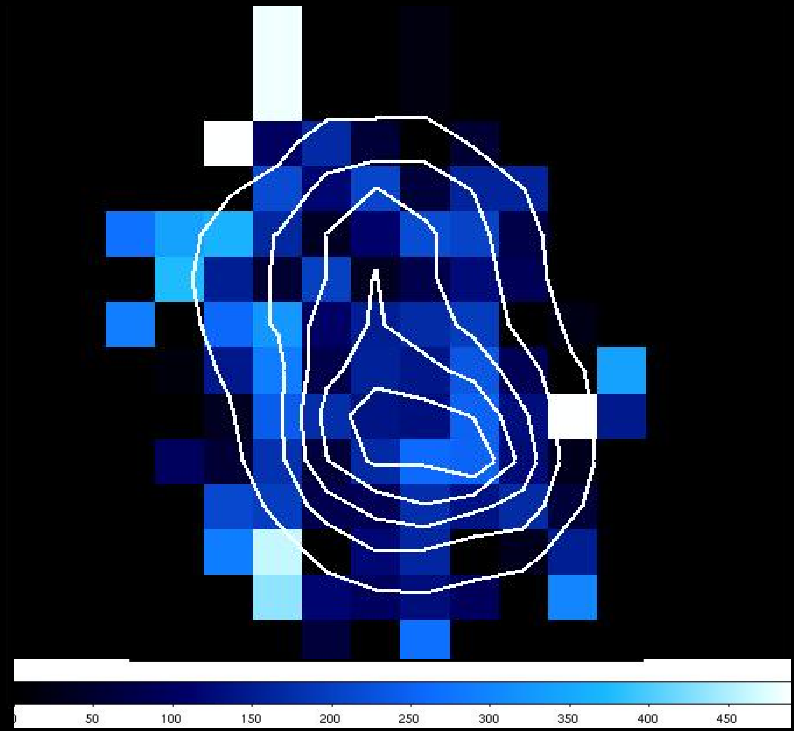
Density

n(SII)

n(IT98) = 58 ± 36 cm^{-3}

n(WR) = 130 ± 56 cm^{-3}



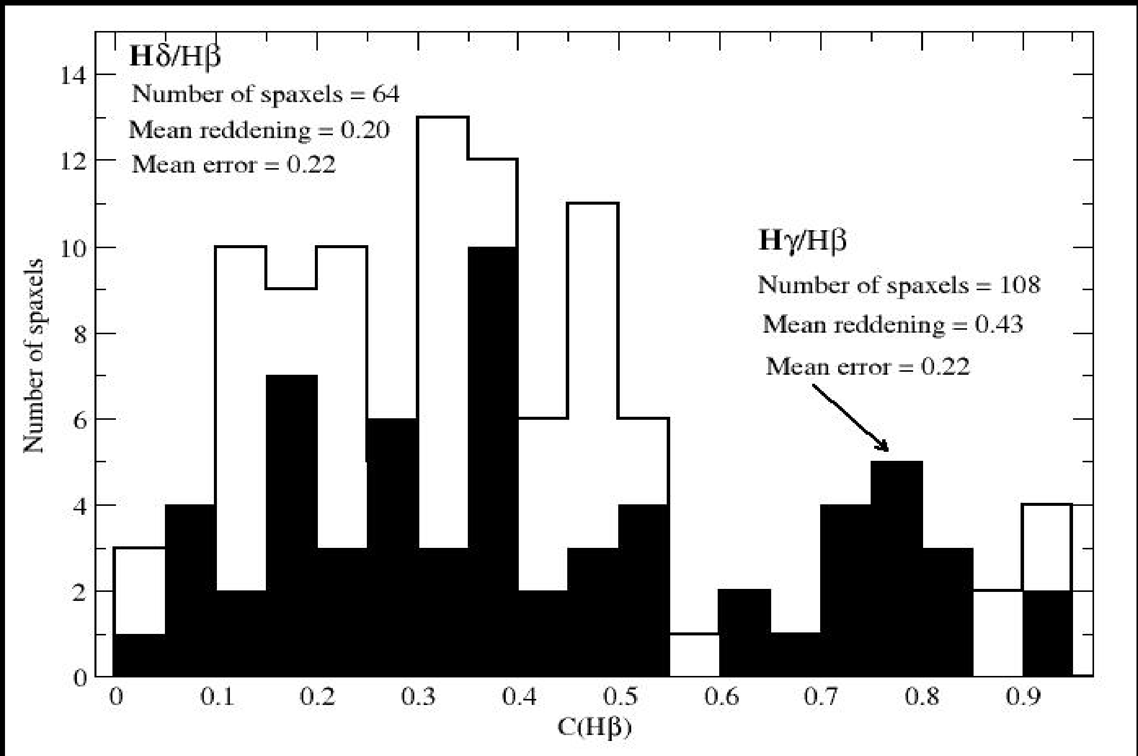


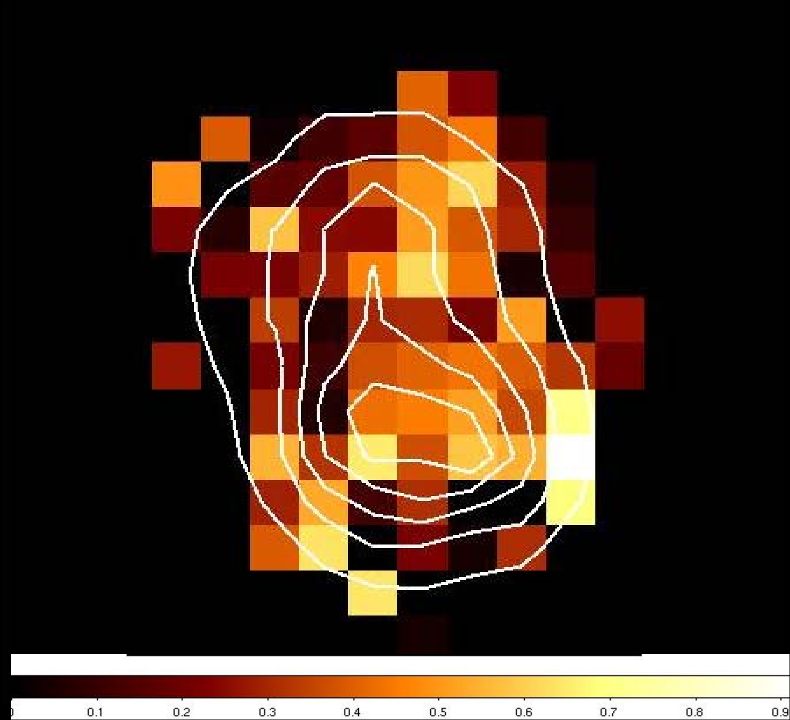
Reddening

Hγ/Hβ, Hδ/Hβ

C(IT98) = 0.25

C(WR) = 0.53



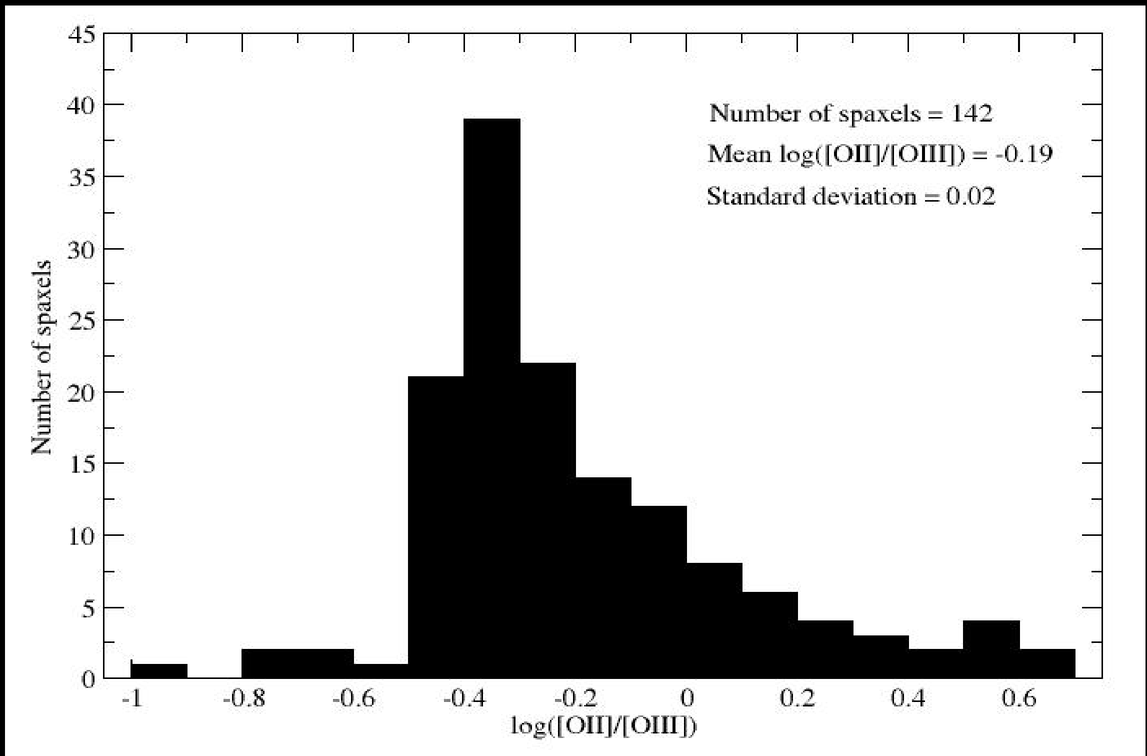


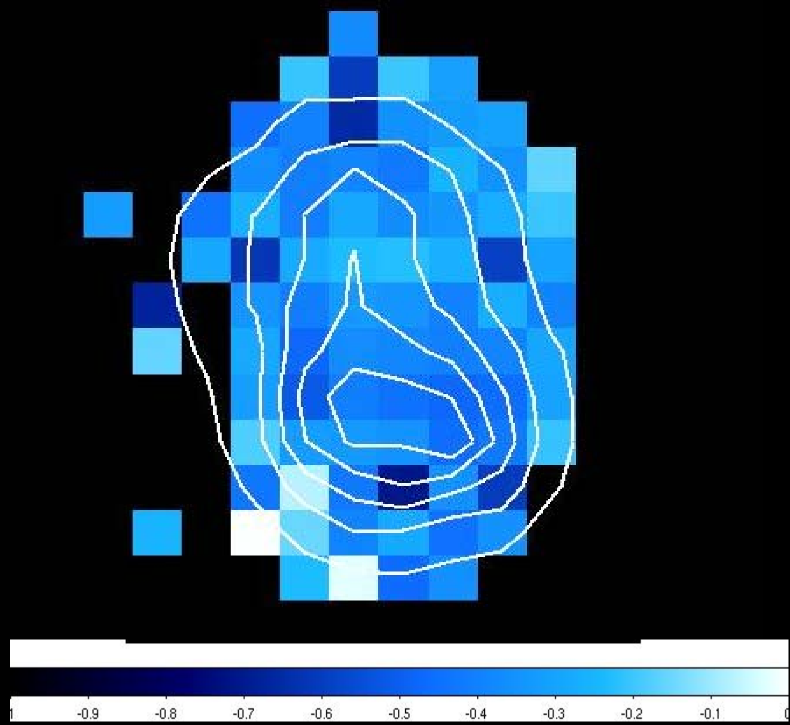
Excitation

Log ([OII]/[OIII])

log [OII]/[OIII] (IT98) = -0.37

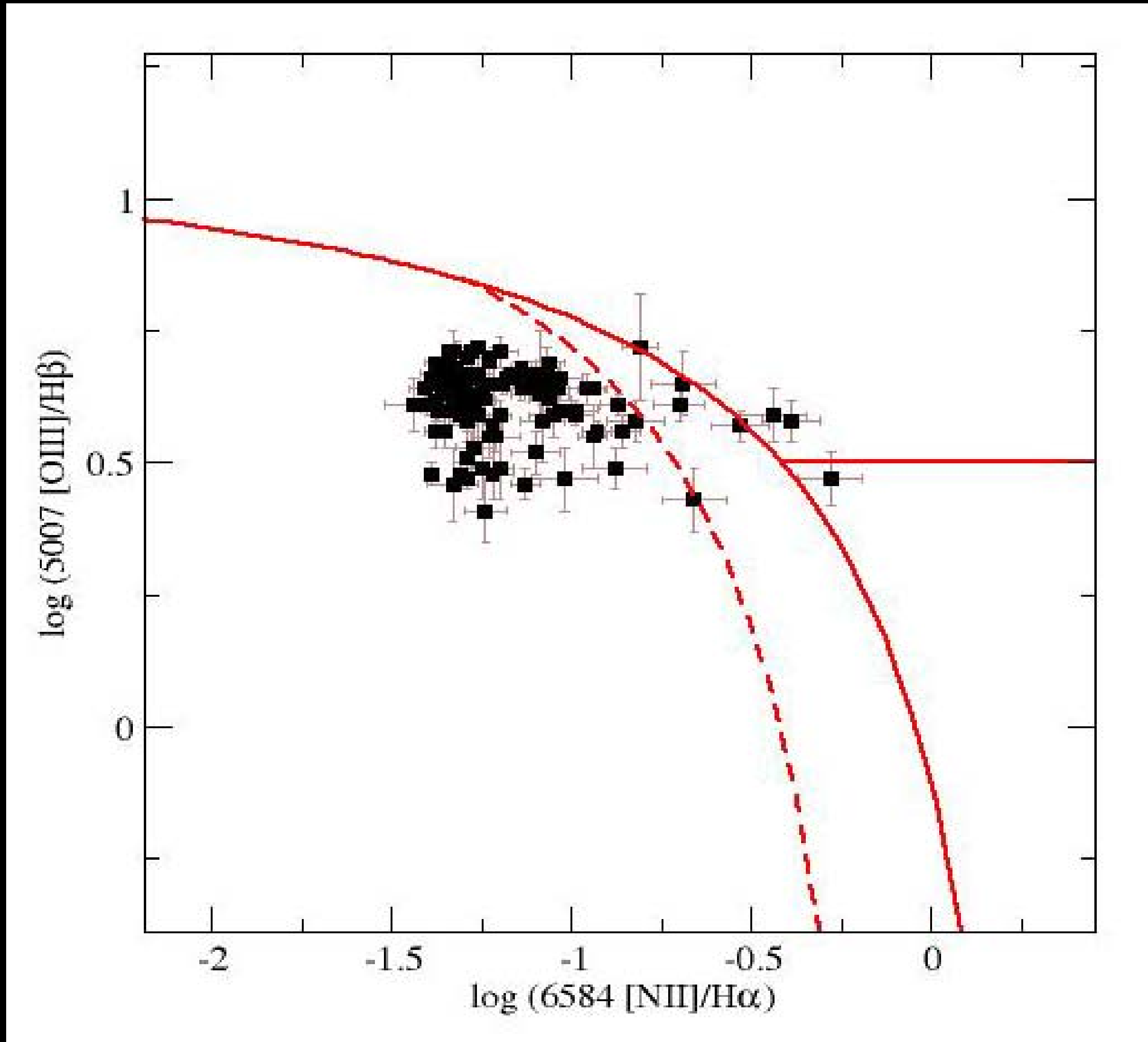
log [OII]/[OIII] (WR) = -0.40





Excitation

[NII]/Hα vs. [OIII]/Hβ

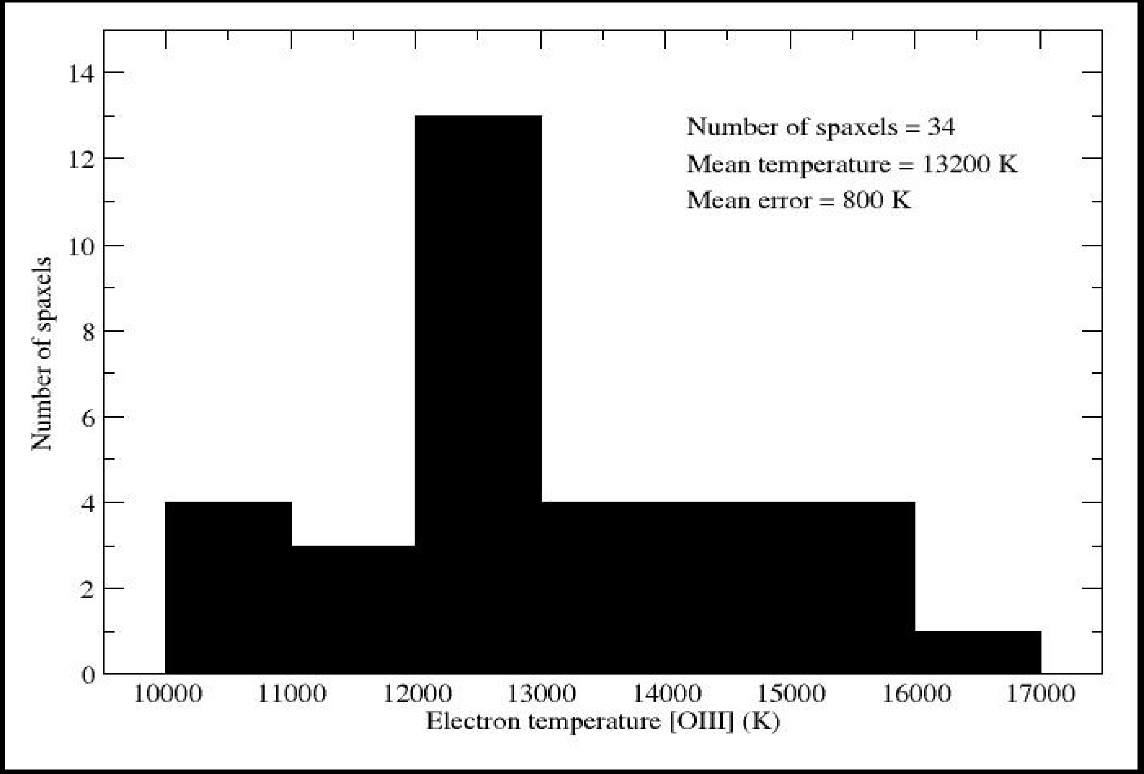


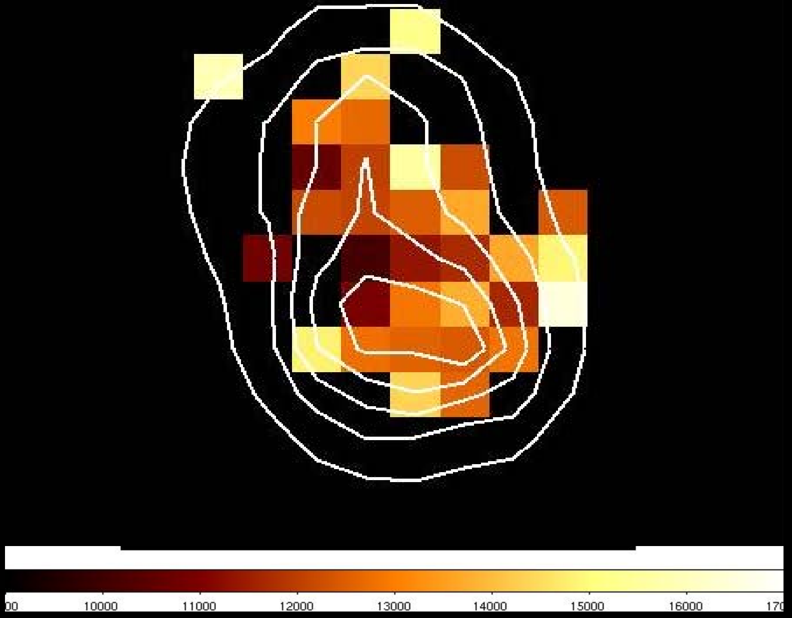
Electron temperature

T(OIII)

T(IT98) = 12300 ± 400 K

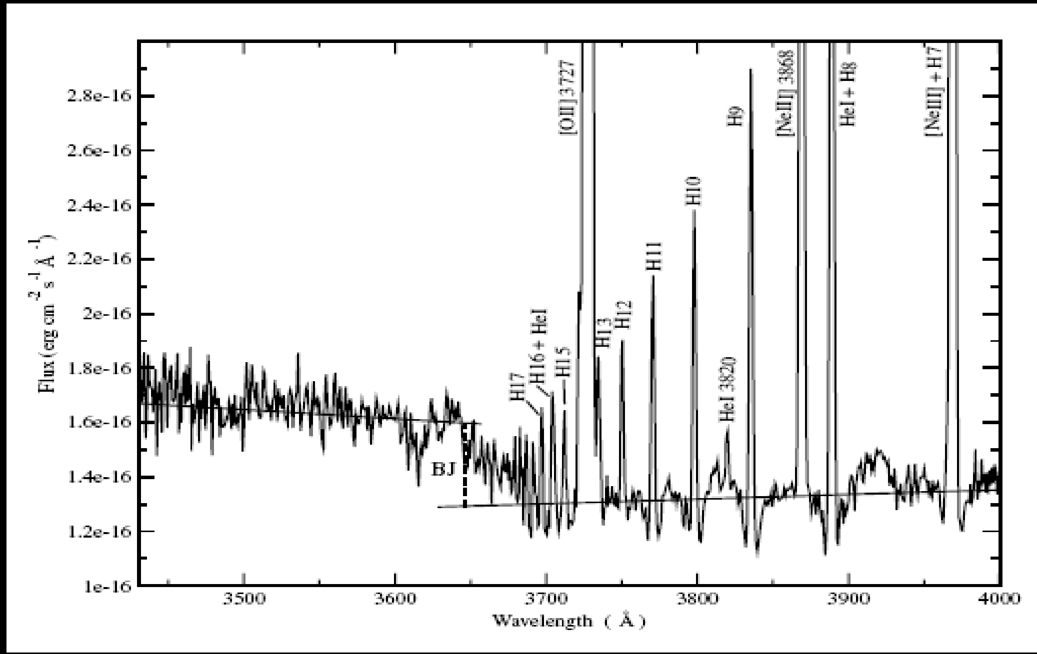
T(WR) = 12400 ± 700 K





Electron temperature

The homogeneity in temperture and excitation in this object is consitent with the detection of no fluctuations of temperature in HII galaxies (e.g. Hägele et al., 2006, Guseva et al., 2006)



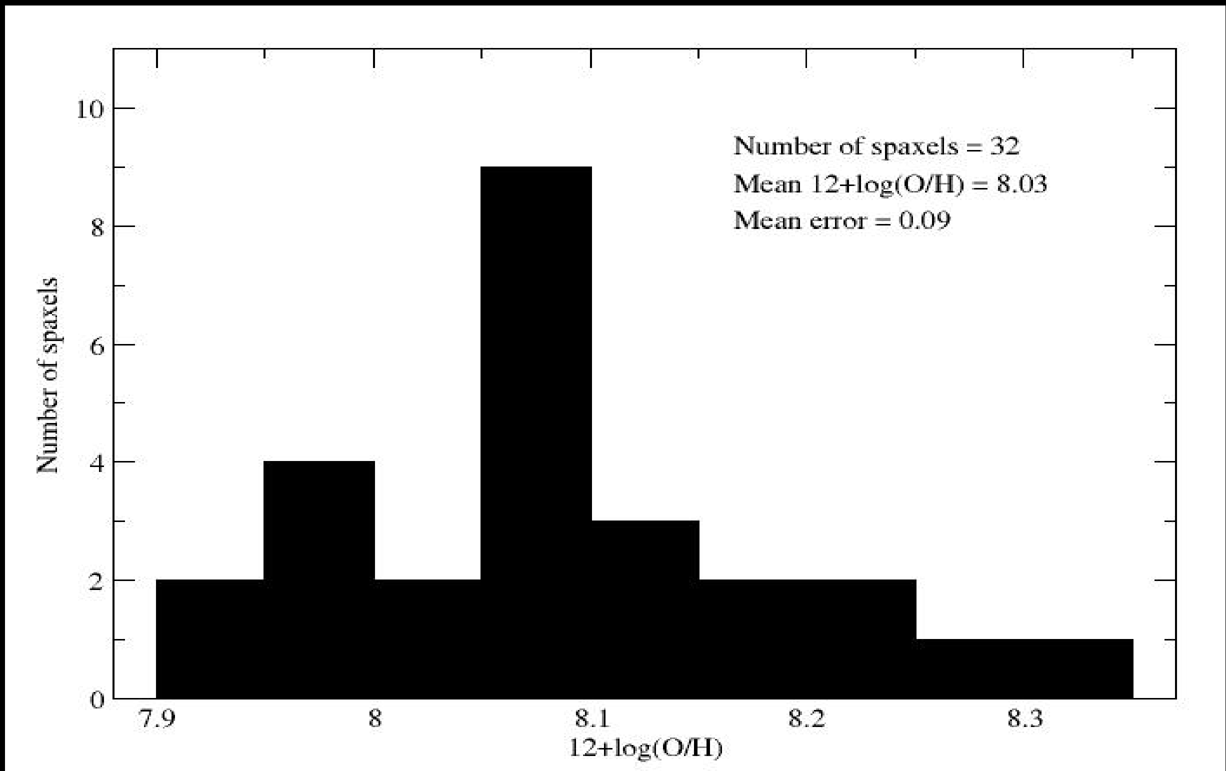
Name	T_0	t^2
SDSS J002101.03+005248.1	1.24 ± 0.35	$0.004^{+0.044}_{-0.004}$
SDSS J003218.60+150014.2	1.08 ± 0.21	0.066 ± 0.026
SDSS J162410.11-002202.5	1.24 ± 0.30	$0.001^{+0.037}_{-0.001}$

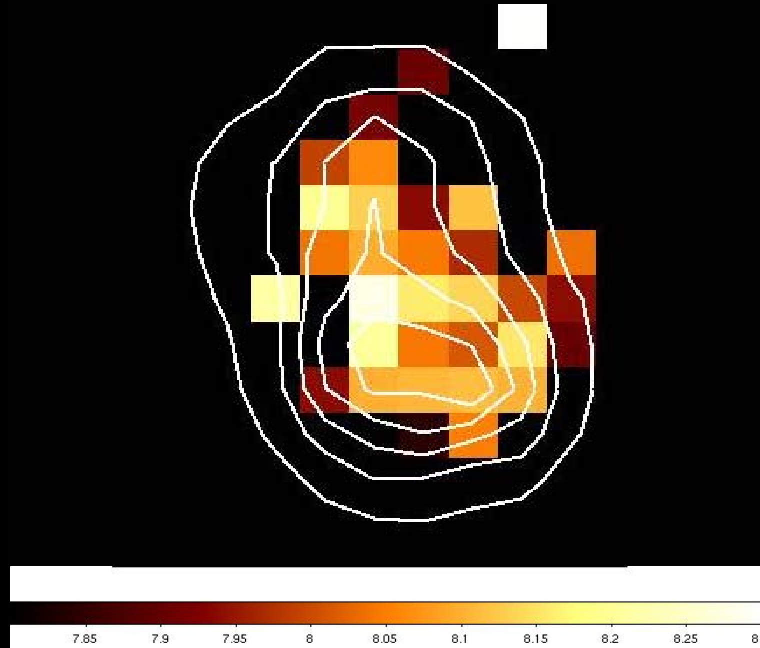
T_0 in 10^4 K. Note that t^2 is always greater than zero.

Oxygen abundance
Direct method

12+log(O/H)(IT98) = 8.06 ± 0.03

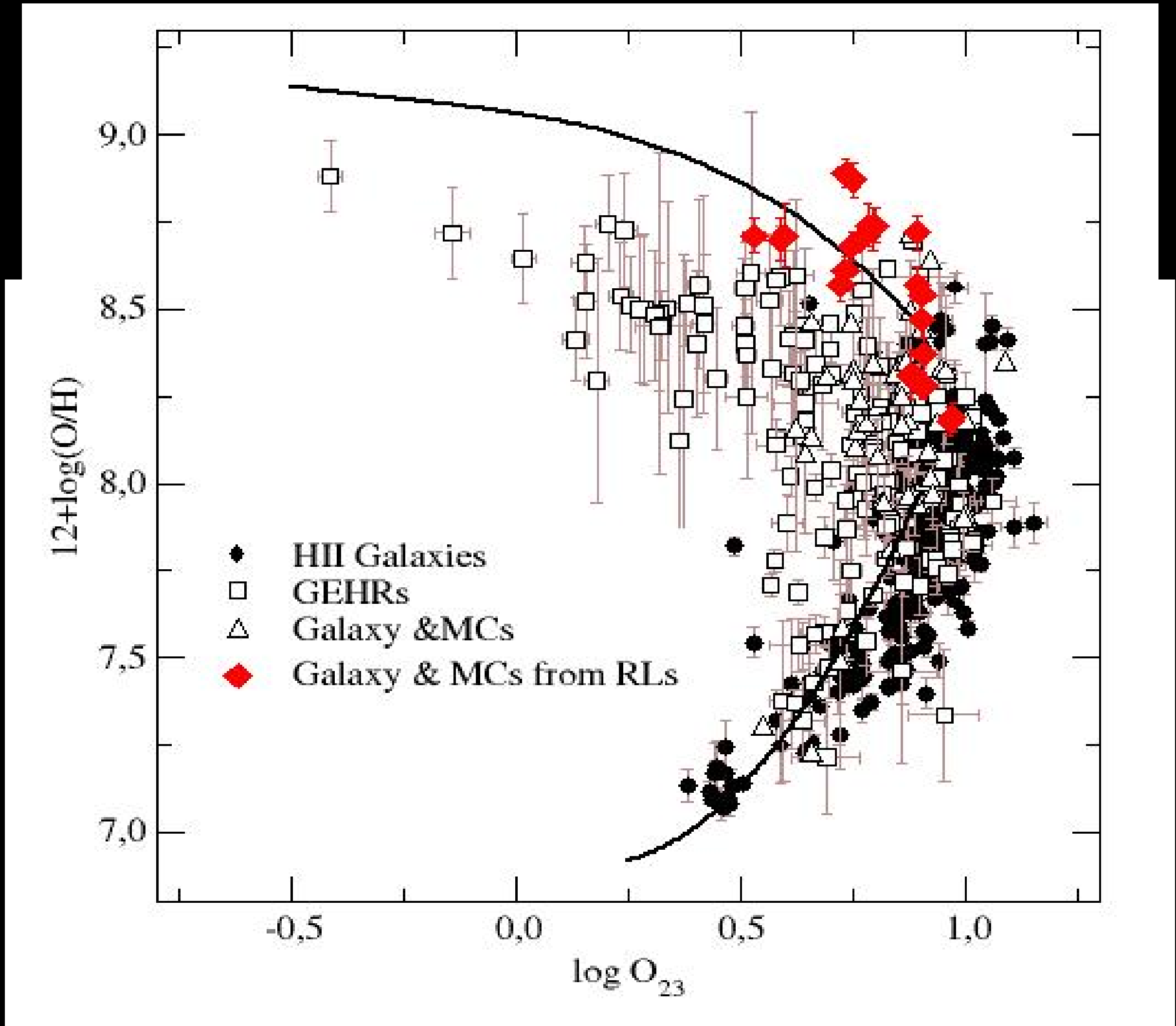
12+log(O/H)(WR) = 8.09 ± 0.09

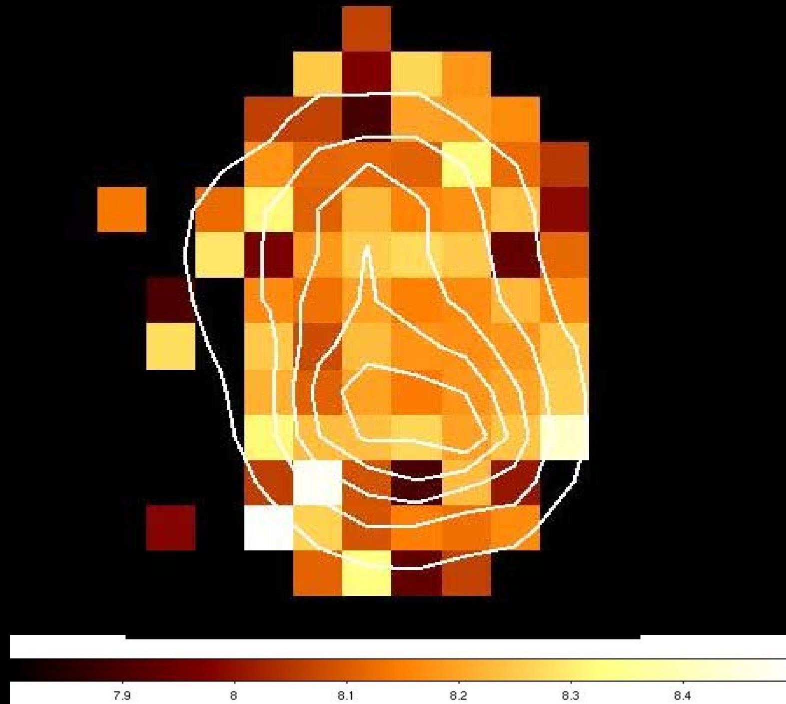




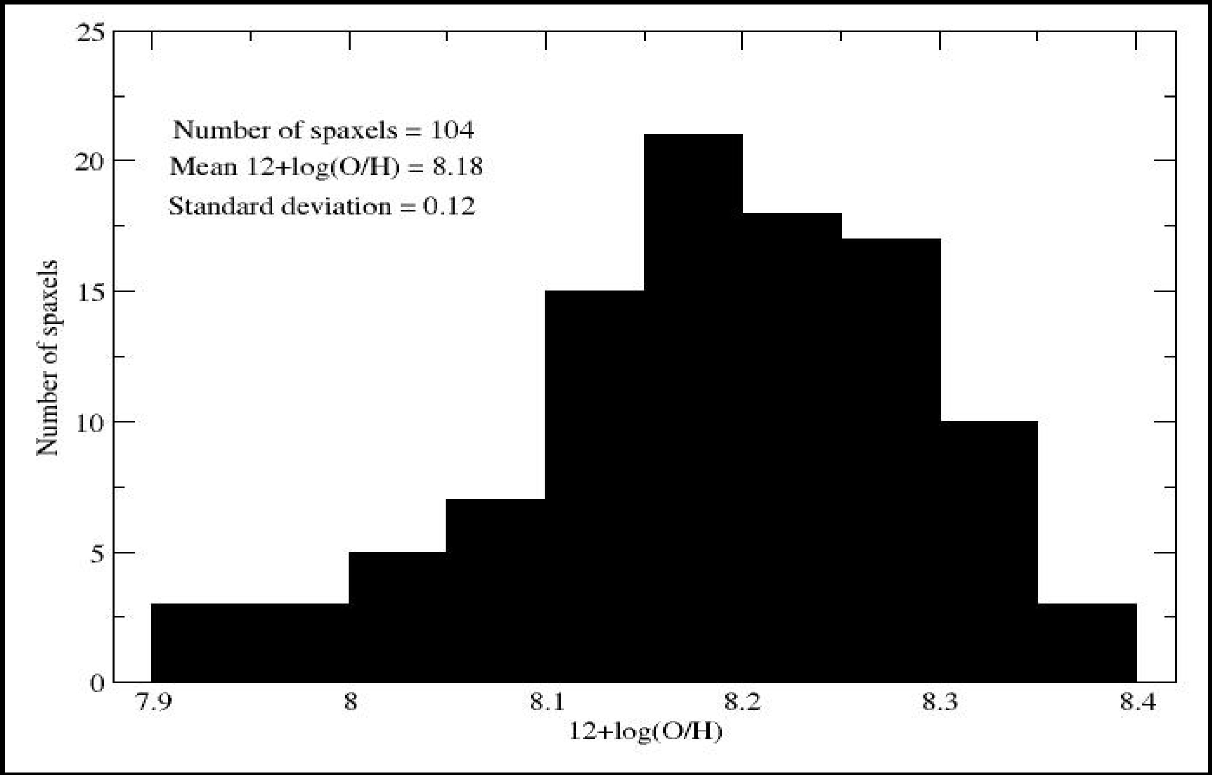
Oxygen abundance

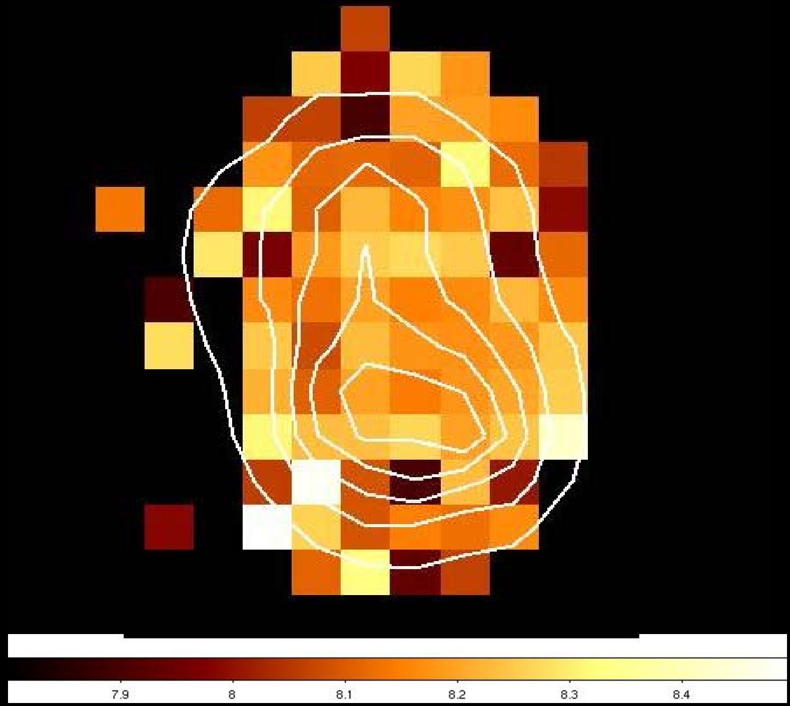
R23 McGaugh



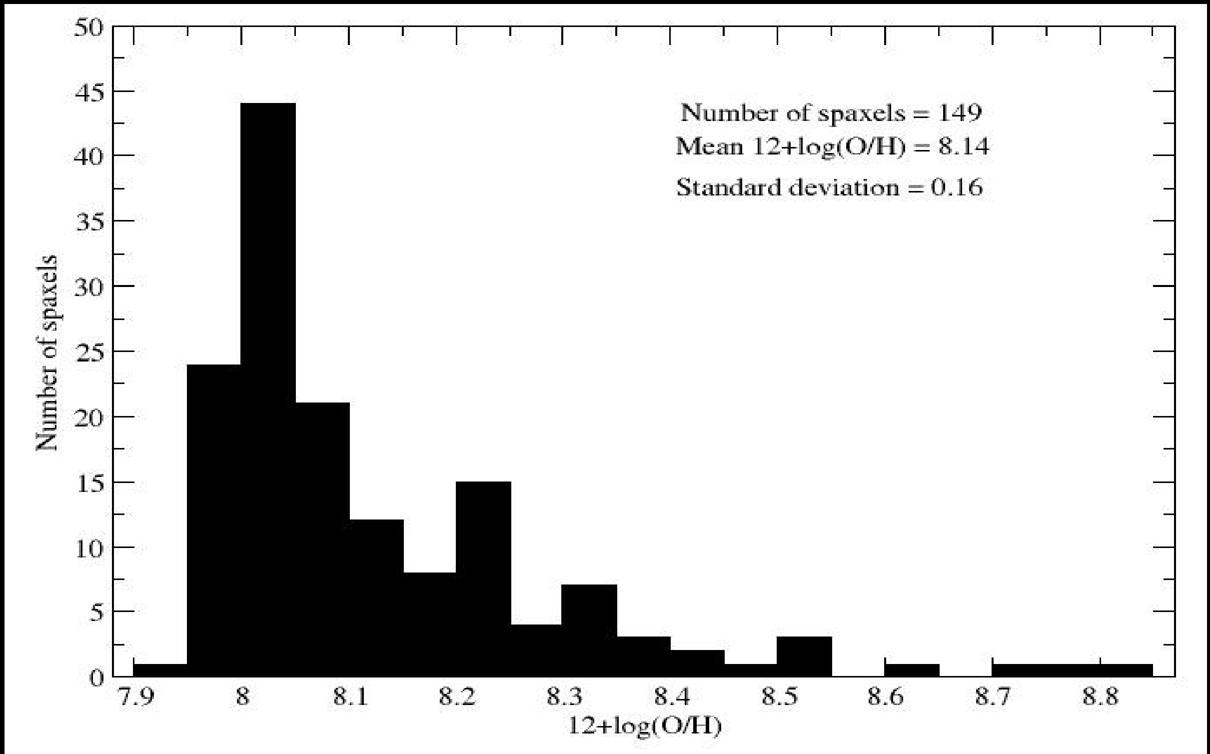


Oxygen abundance
R23 McGaugh



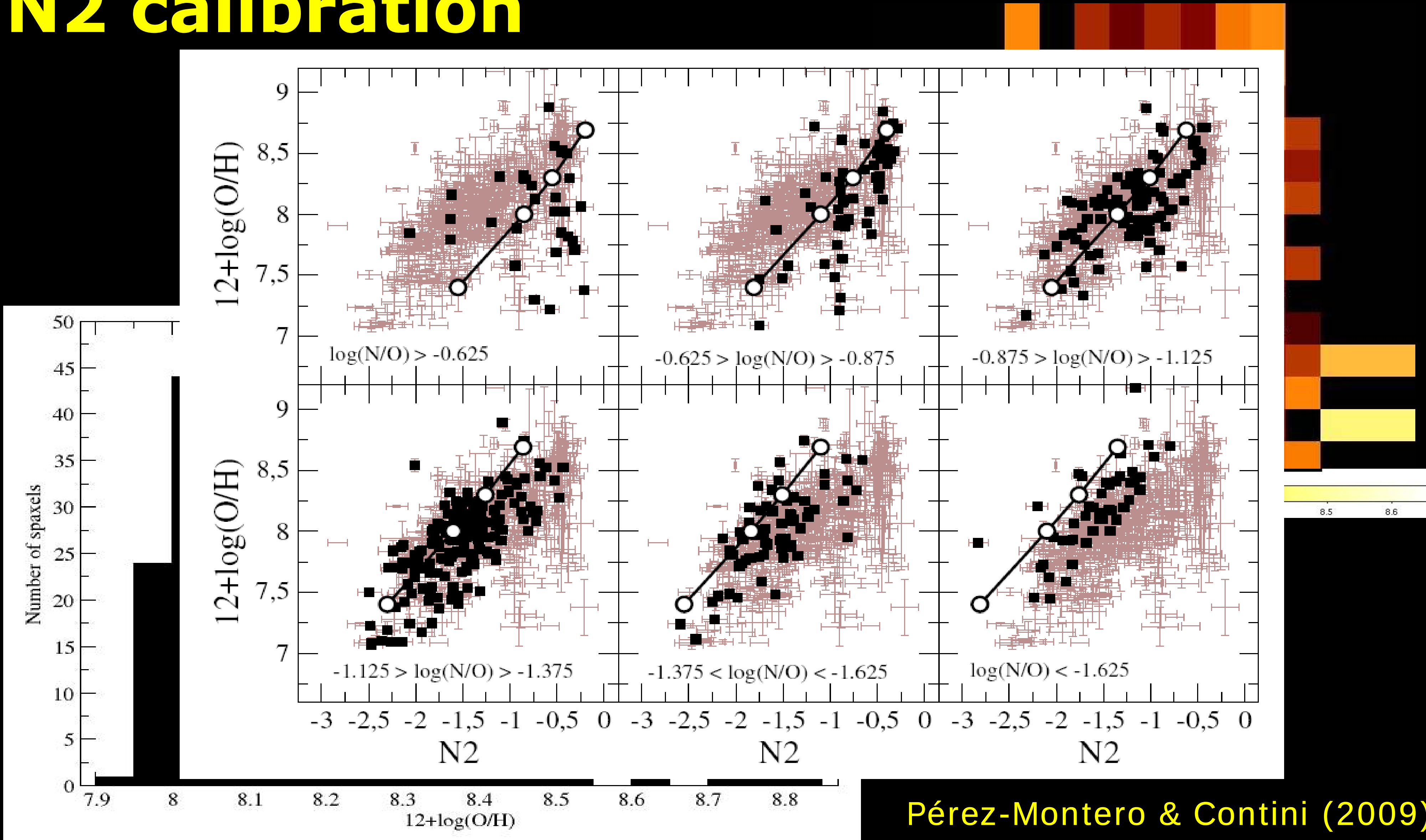


Oxygen abundance
N2 calibration



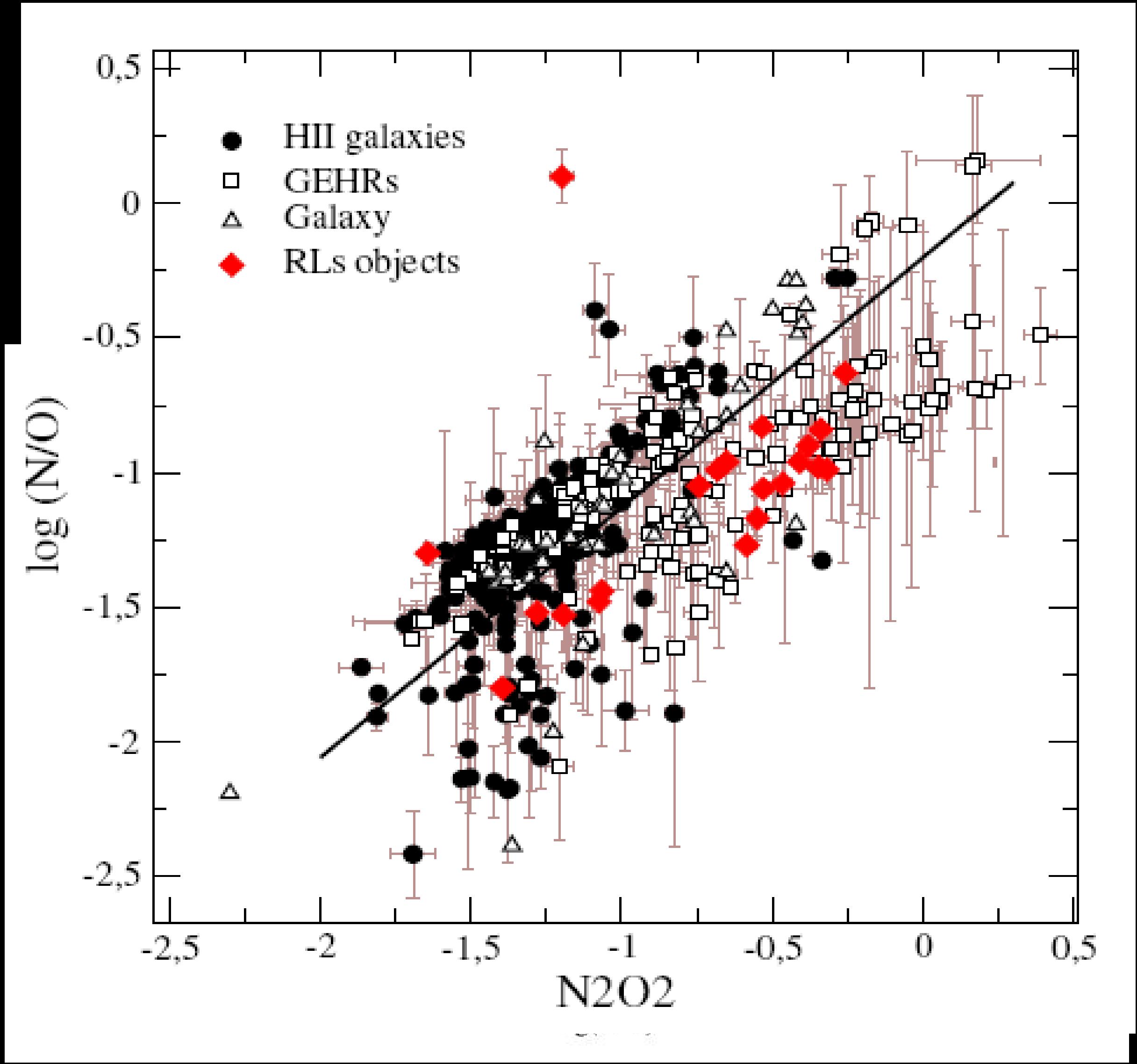
Pérez-Montero & Contini (2009)

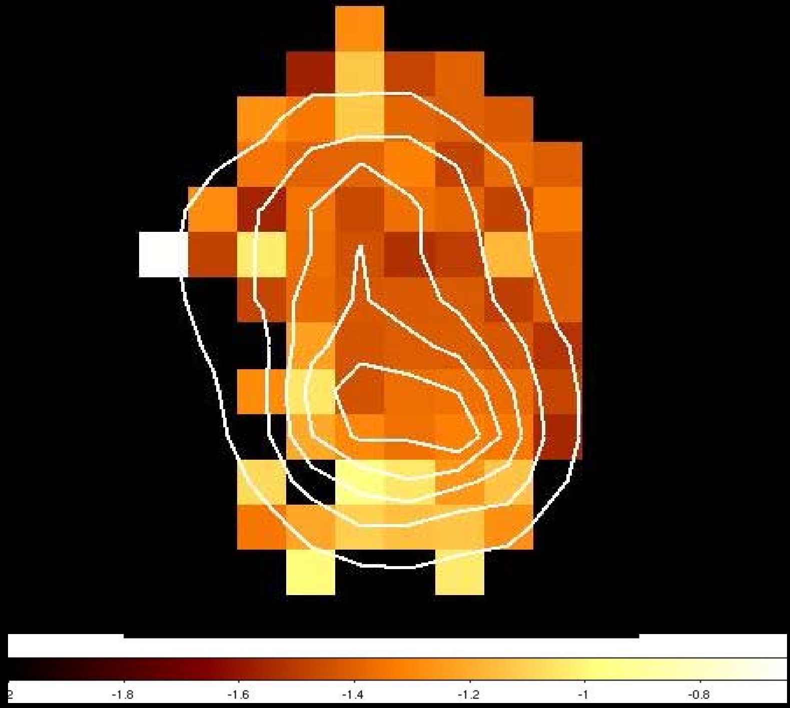
Oxygen abundance
N2 calibration



Pérez-Montero & Contini (2009)

N/O abundance
N2O2 calibration



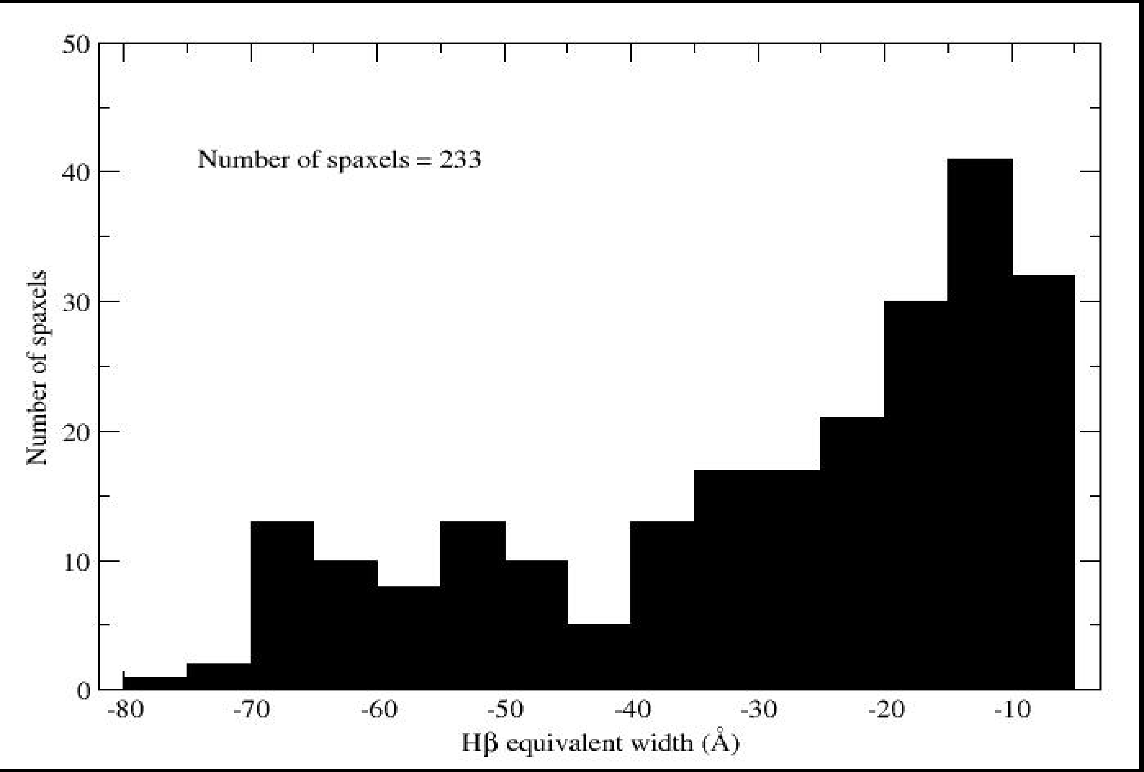


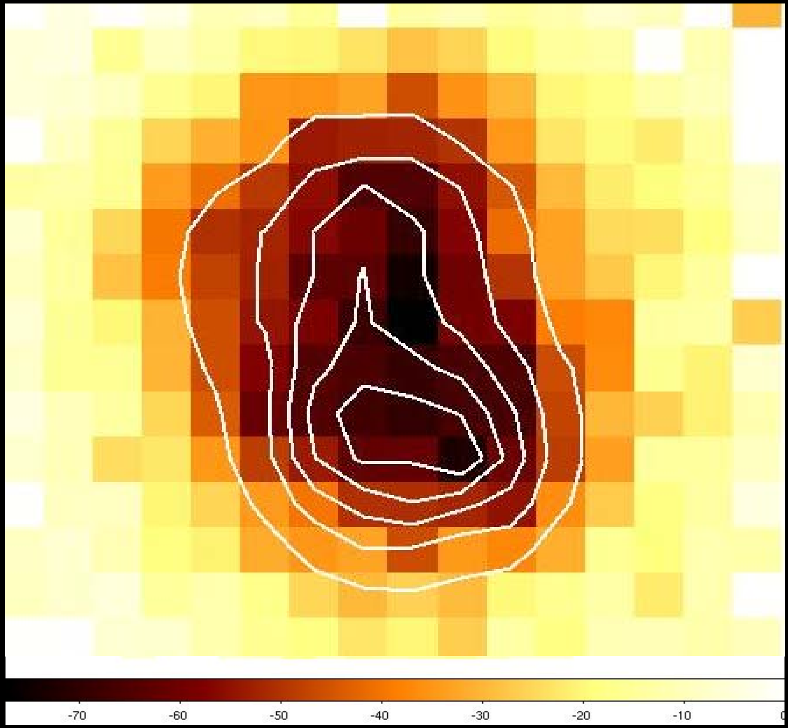
Pérez-Montero & Contini (2009)

EW(Hβ)

EW(IT98) = -93 Å

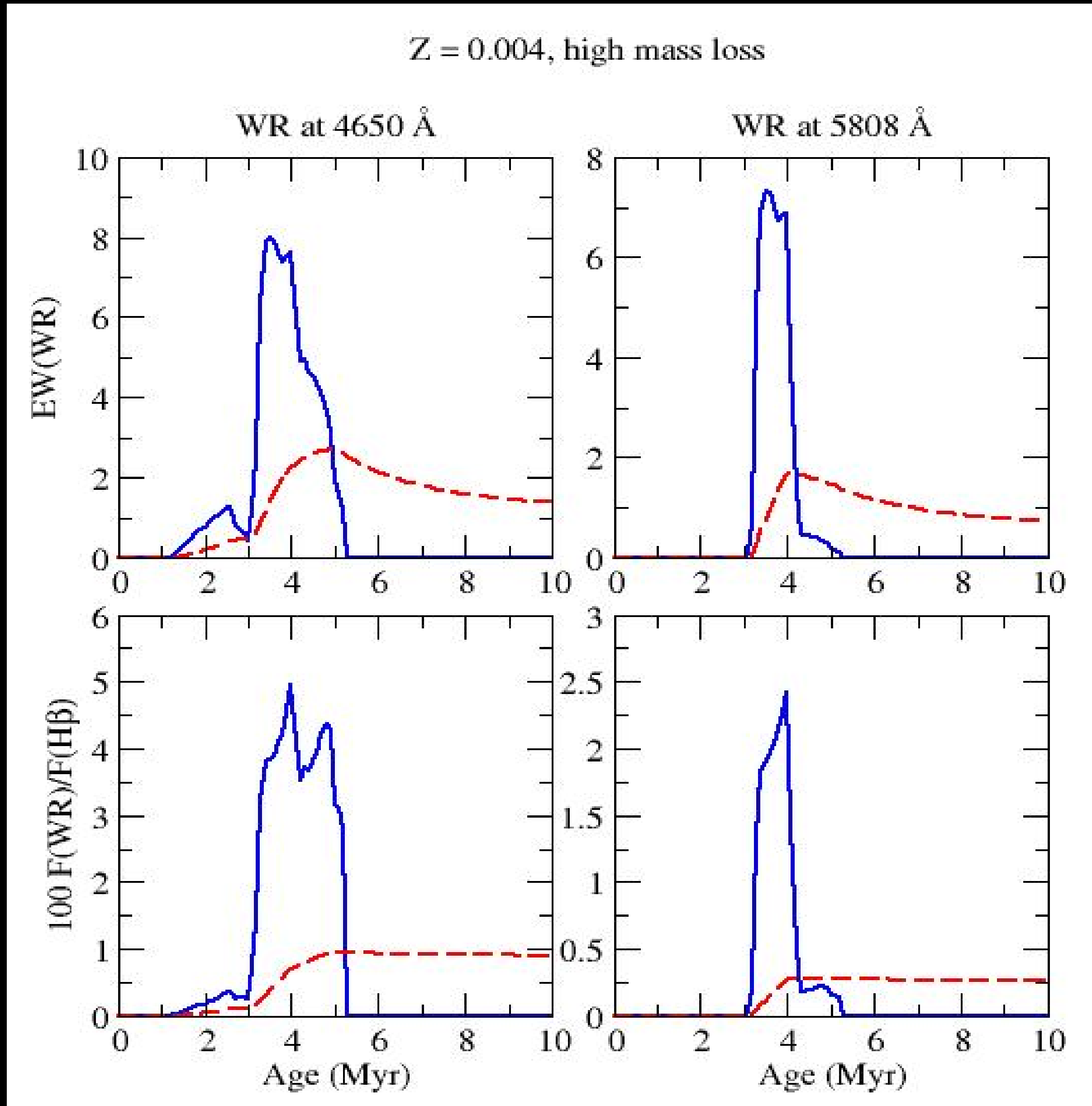
EW(WR) = -64 Å





WR populations

	Blue bump	Red bump
This work		
F(WR)	2.68 ± 0.27	2.95 ± 0.25
EW(WR)	1.56 ± 0.36	0.34 ± 0.03
Guseva et al. (2000)		
F(WR)	0.43 ± 0.04	0.34 ± 0.03
EW(WR)	2.53 ± 0.28	3.24 ± 0.38



Future programs

- To analyse the two other observed galaxies (especially HS0837+4717)

- Next week: Beginning of the program to observe of WR galaxies of the SDSS catalogue with PMAS (cols: J. M. Vílchez, J. Brinchmann, D. Kunth & C. Kehrig): 4 nights have been awarded. We plan to observe 5 WR galaxies of low metallicity.

Summary

- PMAS/PPAK is a suitable instrument to study the real content of WR stars in galaxies and to characterize them in relation with the whole cluster.
- The previous analysis of Mrk930 reveals that most of its WR content must be WC stars, and no nitrogen enrichment is found.
- The homogeneity in excitation, temperature and abundance is remarkable in spatial scales of the order of 3-4 kpc.