Integral Field Spectroscopy of Blue Compact Dwarf Galaxies with Wolf-Rayet signatures

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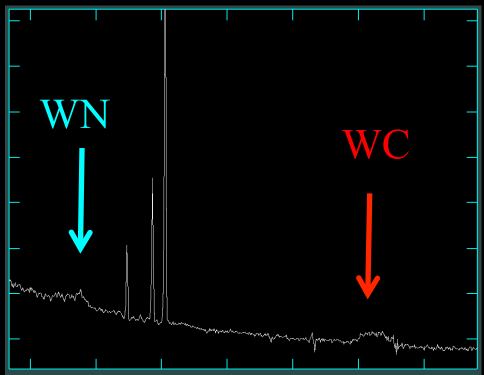
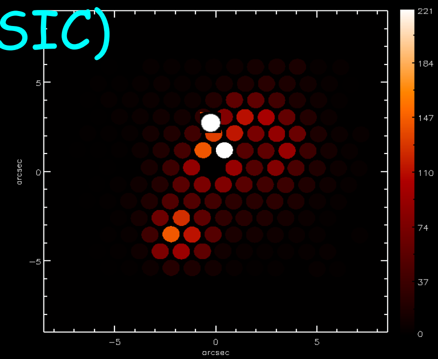




A Lowell Observatory Workshop: Star Formation in Dwarf Galaxies

June 19-22, 2012 - Flagstaff, Arizona

2D view on the interplay between massive stars and ionized gas in blue compact dwarf galaxies (BCDs) with Wolf-Rayet features using integral field spectroscopy

AIMS:

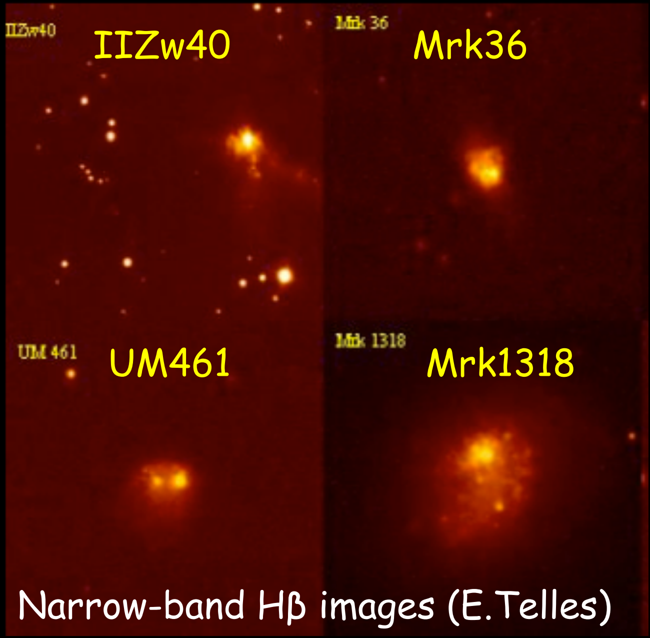
- Locate and characterize the Wolf-Rayet (WR) population
- Chemical abundance of the ISM (high N/O)
- Gas excitation (origin of nebular HeII)

} massive stars ?

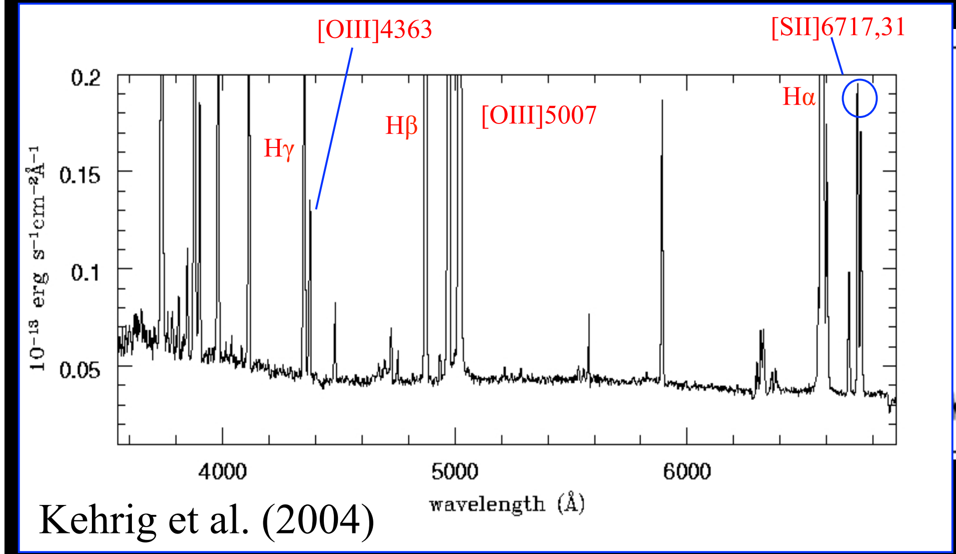
- Constrain the models at low metallicity
- Nebular morphology: HII region vs superbubble (evolutionary state of the gas)

Blue Compact Dwarf Galaxies: general properties

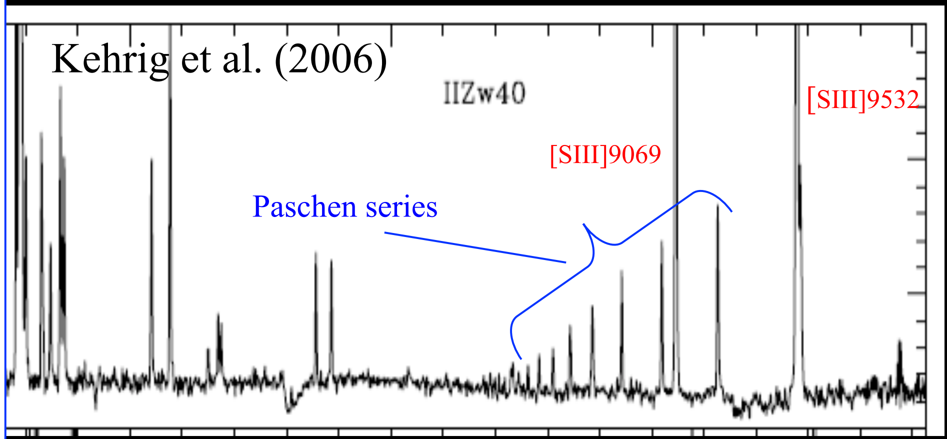
- local, gas- rich, dwarf systems with the observable properties dominated by a young stellar component (massive clusters of OB stars; e.g. Terlevich et al. 1991) → "simple" starburst



Narrow-band Hβ images (E.Telles)

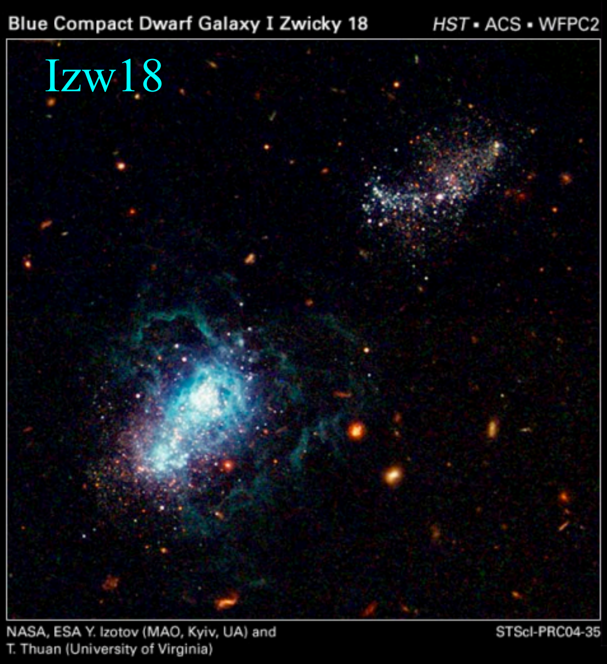


Kehrig et al. (2004)

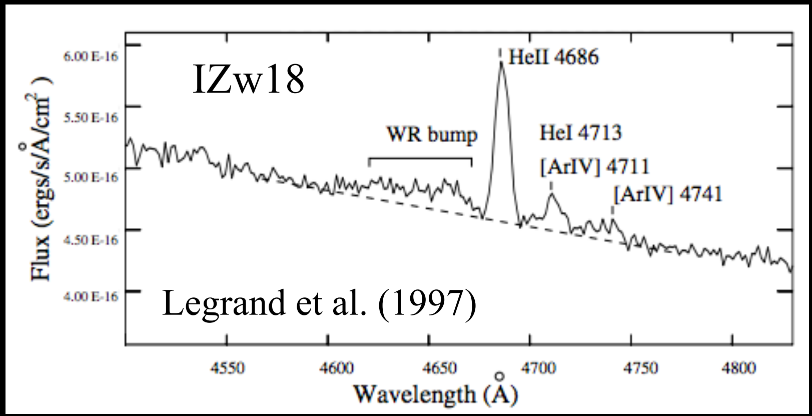


Blue Compact Dwarf Galaxies: general properties

■ low metallicity [7.2 < 12+log(O/H) < 8.3]: the most metal poor galaxies known belong to this class of objects

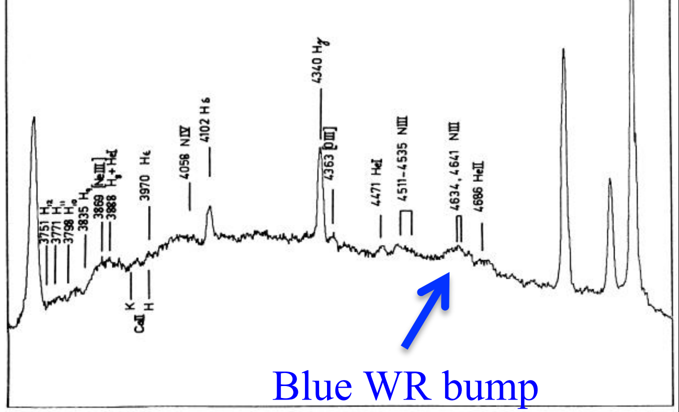


■ WR features found in spectra of low metallicity objects



WR galaxies: general properties

- Integrated spectra show signatures from WR stars (most commonly a broad HeII4686 feature – blue WR bump) → WR galaxies



He2-10: first object in which such feature was recognized (Allen et al. 1976)

- WR "galaxies" found among wide variety of galactic types (e.g. Brinchmann et al. 2008)

- "WR galaxy" (Osterbrock & Cohen 1982; Conti 1991) should be used with caution – depending on the distance and spatial extension of the observation, the region may be a single HII region with few WR stars or the nucleus of a powerful starburst

- The minimum common property of all WR galaxies: ongoing or recent SF which produce the progenitor massive stars

- The presence of WR feature → the properties of WR stars, massive star evolution

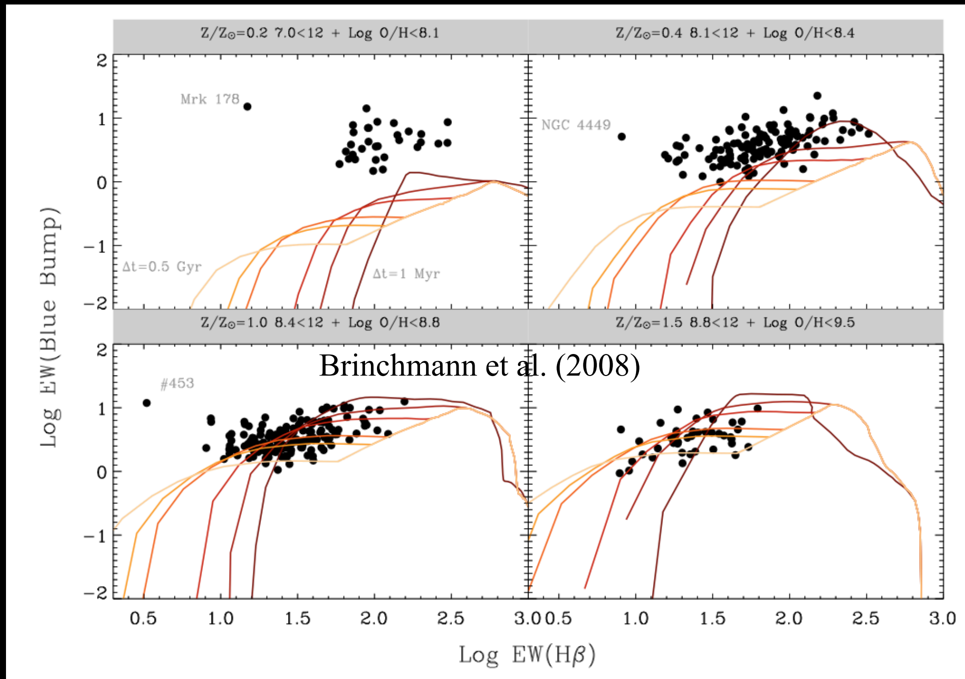
Why local metal poor objects with WR signatures ?

■ "template" systems → understand distant starburst galaxies which cannot be studied to the same depth - WR galaxies are useful templates of young starbursts which show WR features (e.g. Sharpley et al. 2003)

■ the precise location of the WR stars we can determine quantitatively the effects (or no effects) on the properties of the gas (abundances, ionization, etc)

■ Strong disagreement between observations and predictions for the evolution of WR features: more data on WR galaxies is needed to constrain the models

EW(WR bump) vs EW(Hβ)



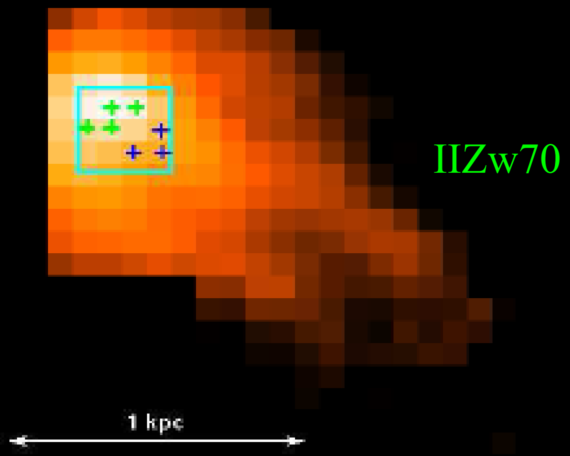
Brinchmann et al. (2008)

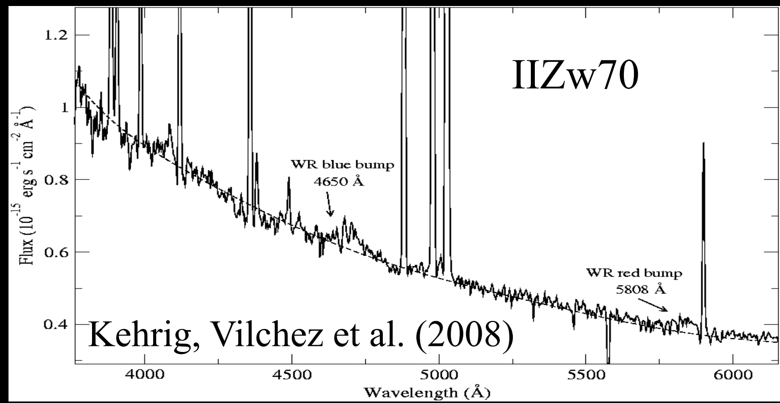
Blue Compact Dwarf Galaxies with WR signature: IFS as a suitable tool

- long-slit may fail in detecting the WR bumps (faintness and spatial distribution of WR stars across the galaxy)

- Locate the WR stars and find them where they were not detected before! (e.g. Kehrig, Vilchez et al. 2008)

Powerful of ISF in finding WR stars



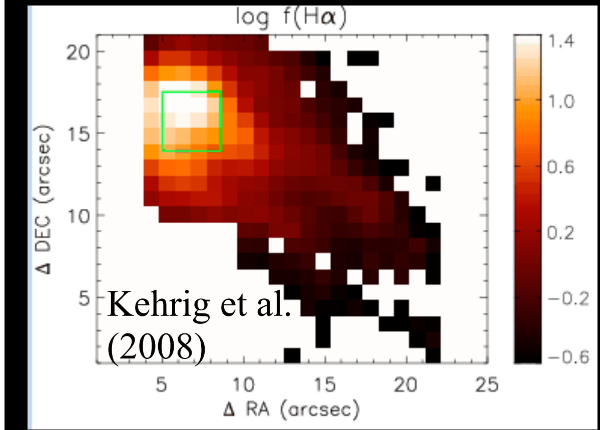


- Lowers the difficulty when doing the spatial correlation between WR stars and nebular properties (e.g De mello 1998)

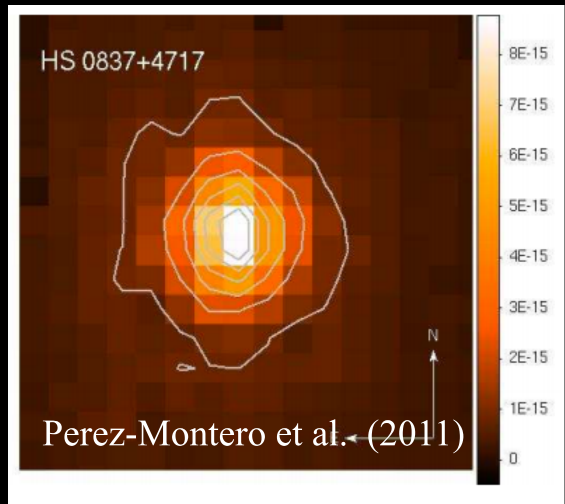
Results: Ha maps

- **Sample:** 15 WR galaxies taken with PMAS (3.5m CAHA) and INTEGRAL (4.2m WHT)

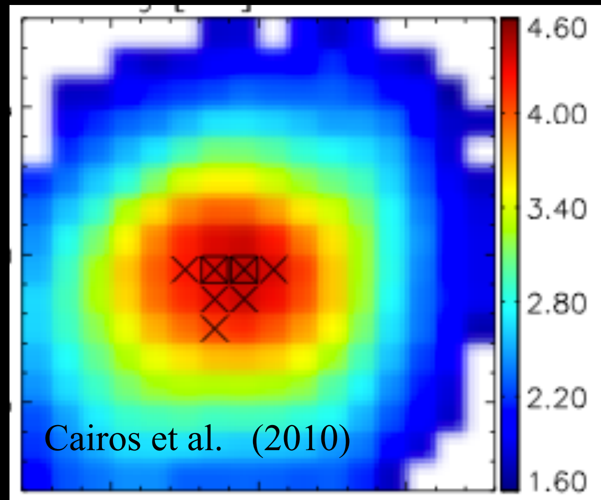
IIZw70 (1" ~ 80 pc)



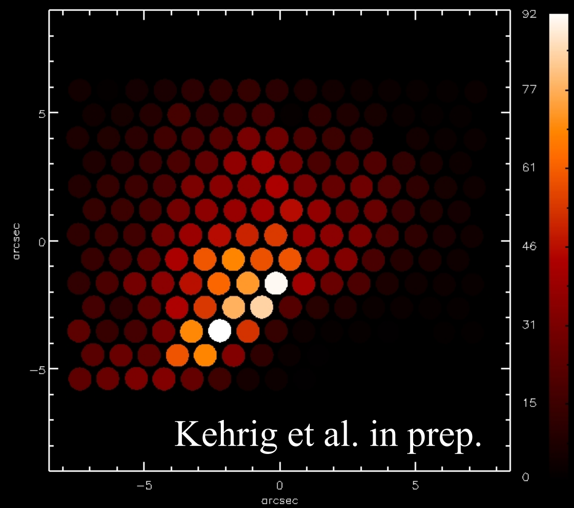
HS0837+4717



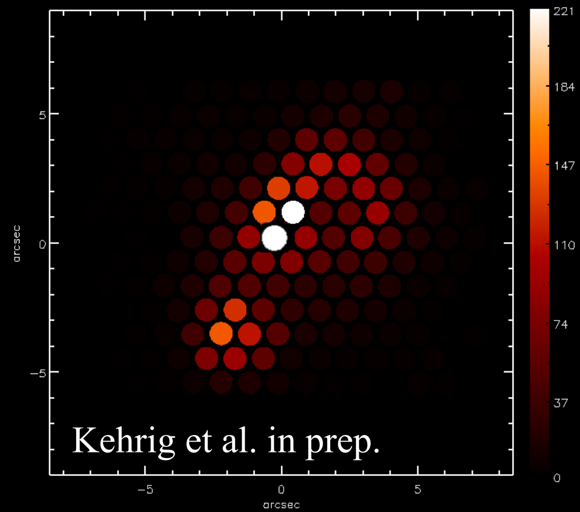
Mrk475 (1" ~ 50 pc)



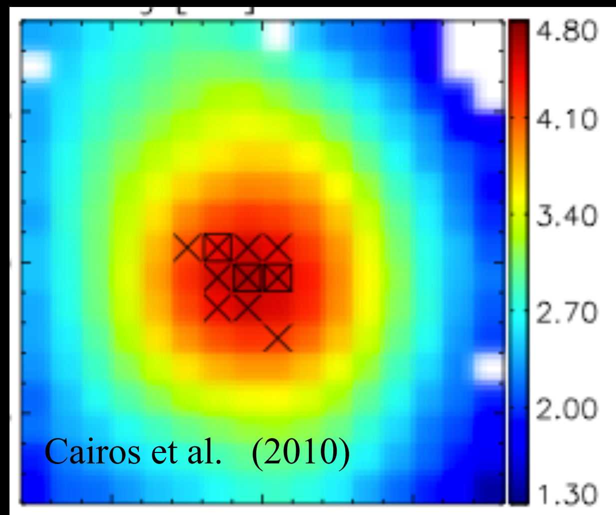
Mrk178 (1" ~ 20 pc)



Izw18 (1" ~ 70 pc)

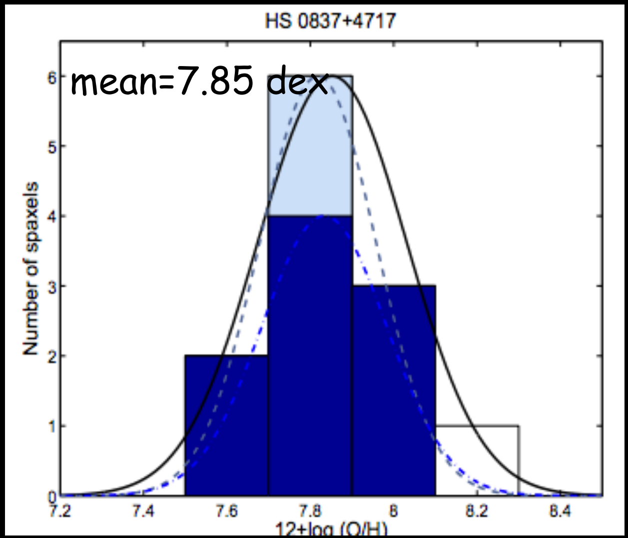


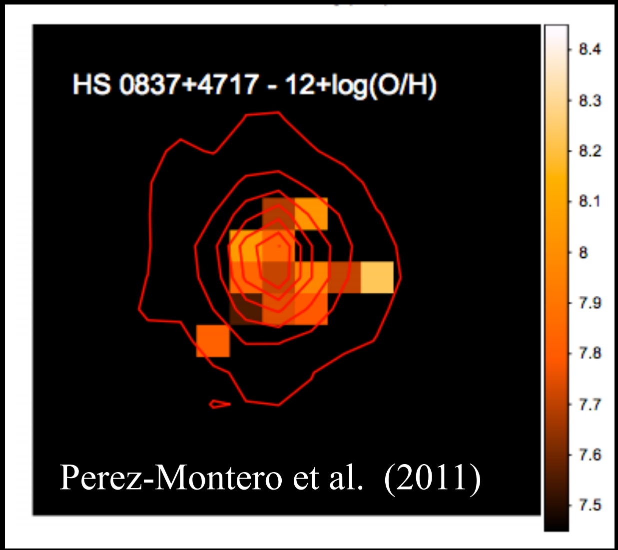
Mrk750 (1" ~ 25 pc)



Results: chemical abundances

Distribution of O/H



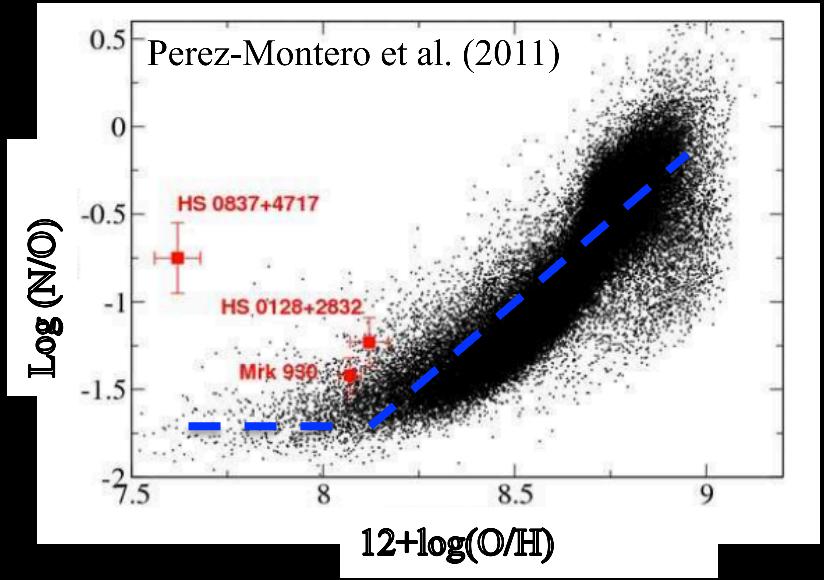


- O/H from Te[OIII]4363 and empirical methods
- The variations in the derived O/H are not statistically significant

Chemical homogeneous on spatial scales of ~ 20 – 1000 pc → freshly elements produced in massive stars remain unmixed with the ISM and reside in another phase of the ISM (Tenorio Tagle 1996; Kobulnicky & Skillman 1997)

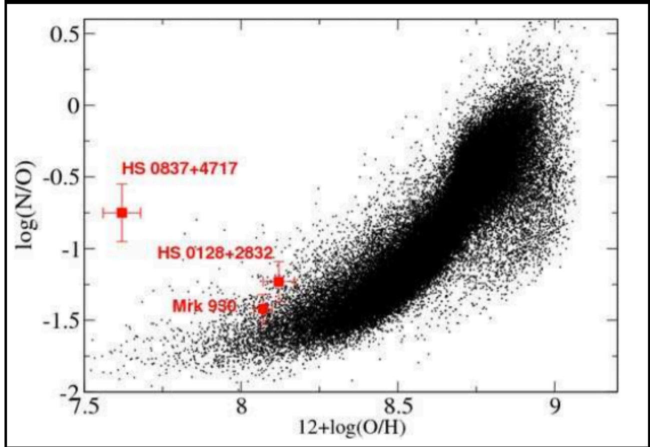
Results: N overabundant Blue Compact Dwarf Galaxies

■ N/O vs. O/H: bimodal behaviour related to nature of N and sensitivity of O yields to metallicity; a strong slope for metal rich regions (well-explained by its secondary nature) and flat line and some high N/O values at low metallicity → important primary production at early evolutionary times



■ Some objects with WR stars and N enrichment over different spatial scales can be found in the literature (Esteban & Vilchez 1992; Brinchmann et al. 2008; James et al. 2009; Fernandez-Martin et al. 2012; Garcia-Benito & Perez-Montero et al. 2012)

Results: The N/O problem

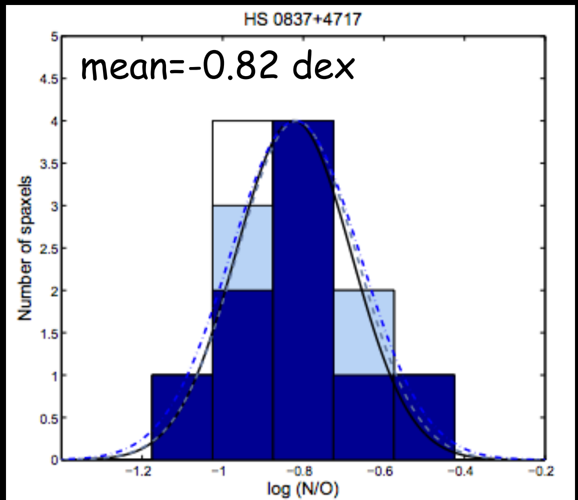


■ How to explain these high N/O values ?

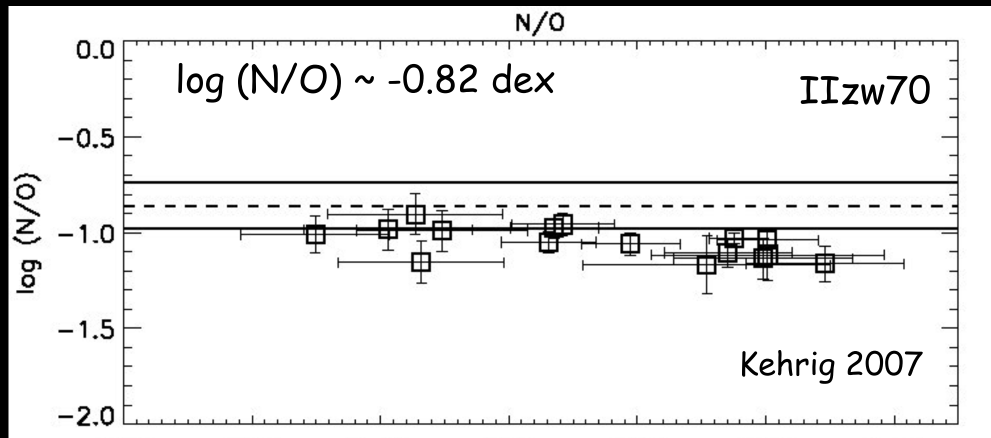
- WR stars via stellar winds (Brinchmann et al. 2008 and references therein)

- Inflows of unriched gas (Köppen & Hensler 2005)

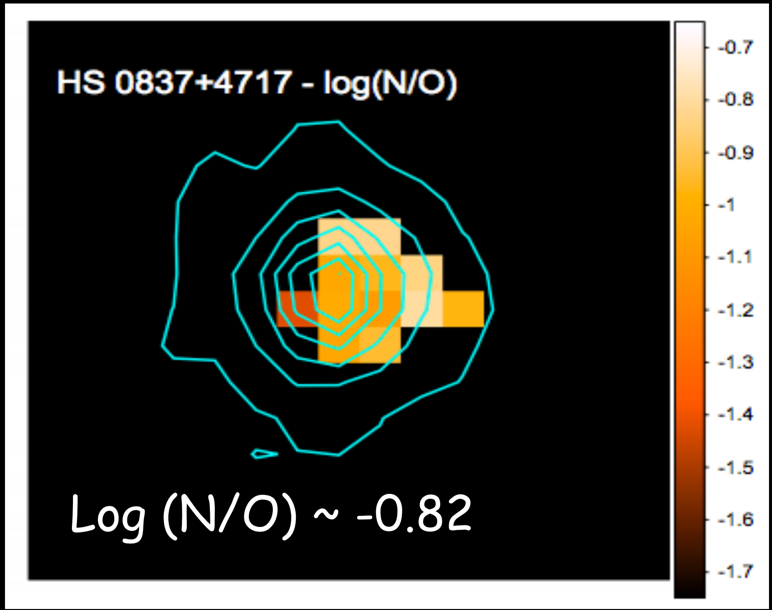
log(N/O)



- Differences in the star formation rate (e.g. Henry et al. 2000; Molla et al. 2006)



Results: The N/O problem

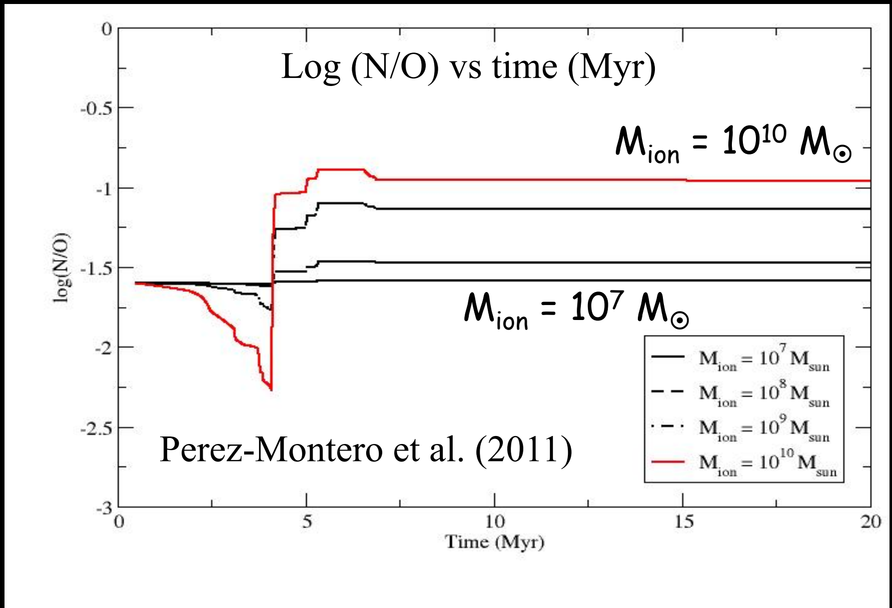


- N/O constant on spatial scales of few kpc

- Can WR stars be the source of the global N pollution detected in our sample of BCD galaxies ?

Evolution of N/O for a spherical gaseous distribution with r= 1kpc, initial 12+log(O/H) =8.0 and log(N/O)= -1.6 which is polluted by stellar winds from massive stellar clusters (chemical yields from Molla & Terlevich 2012)

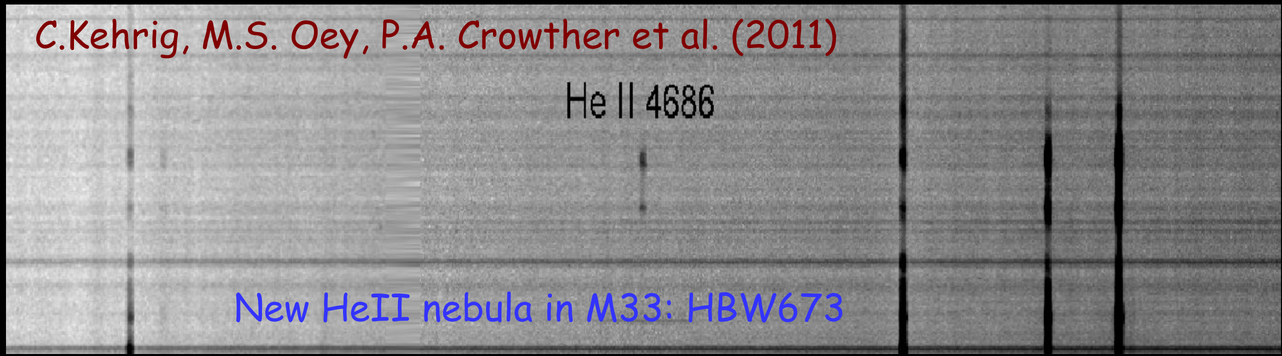
The effects are only perceptible for $M_{ion} > 10^8 M_\odot$ much higher than the ionizing masses estimated in these objects



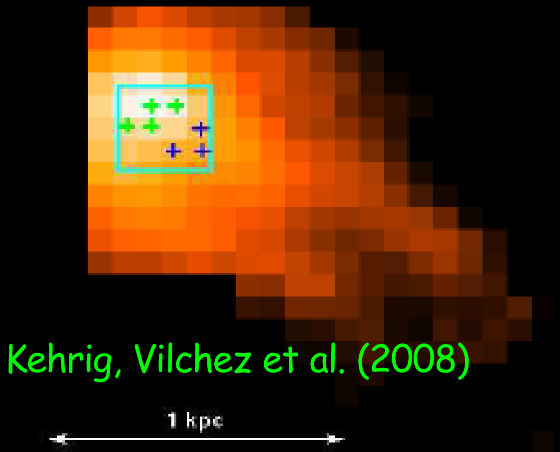
Massive stars seem not to be responsible for the high N/O values which concur with previous findings (Kobulnicky & Skillman 1996; Buckalew & Kobulnicky 2005; Amorin et al. 2012)

Results: excitation sources → the origin of nebular HeII4686 ?

- Usually nebular HeII is associated with WR stars but several studies have demonstrated that it is not always the case. From GMOS spectroscopy of HeII nebulae in M33:



- Shirazi & Brinchmann (2012) → a large fraction of HeII-emitting galaxies do not show WR features and this fraction increases systematically with decreasing metallicity : spatial separation between WR stars and the region emitting HeII emission can be a possible explanation for non-detection of WR features in these galaxies → IFS ideal technique to test it!

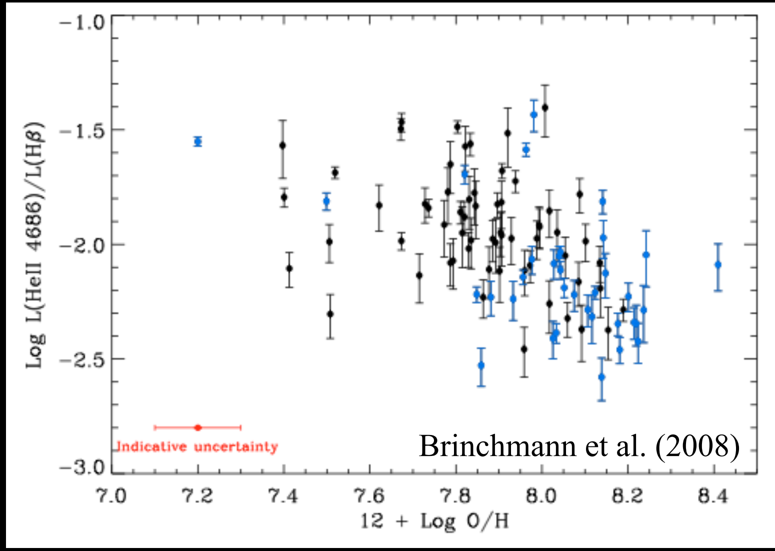


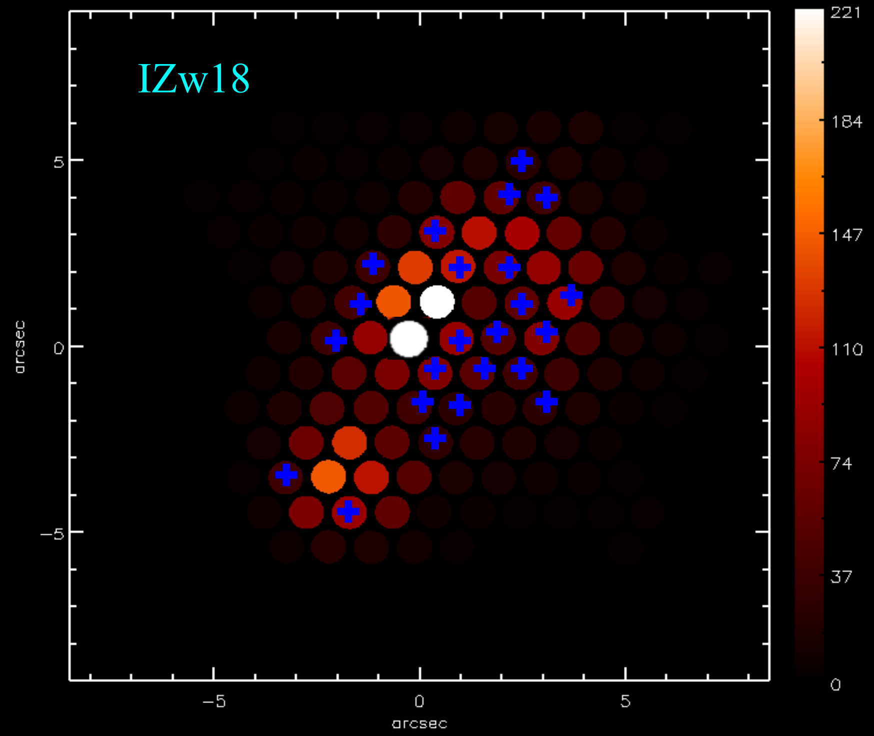
- Different mechanisms (ex: shocks) responsible for producing HeII4686 line apart from WR stars in these galaxies (e.g Garnett 1991)

Results: The origin of nebular HeII4686

- Nebular HeII tend to be brighter in low metallicity systems and it is seen in high-z galaxies (Brinchmann et al. 2008, Schaerer 2008) → offers a probe to infer properties such as metallicities, ionizing fluxes from starbursts for distant star-forming regions

F(HeII)/F(Hβ) vs 12+log(O/H)

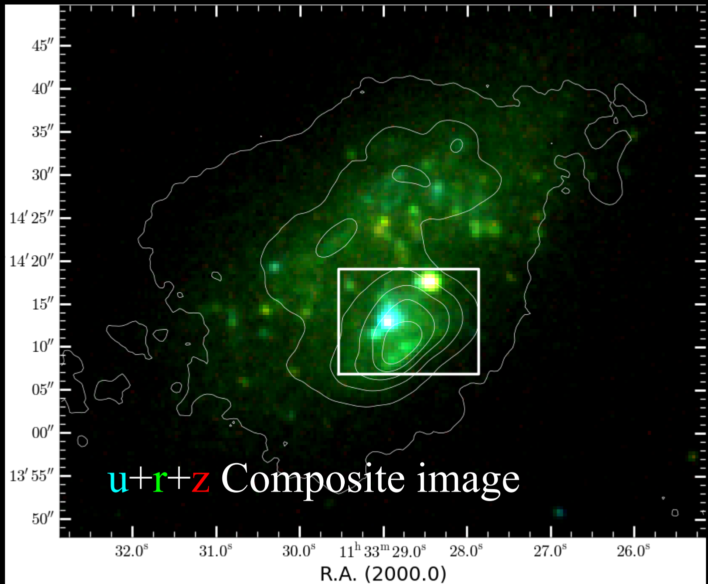




HeII spatially extended → WR stars might not be the only source of high-energy photons (E > 54 eV)

Preliminary Results: Mrk178 as a suitable object to our project

- Nearby object: distance ~ 4 Mpc → study separately different star-forming knots
- Locate the WR stars → study more precisely the "local" effects on their environments (large apertures reflect the global properties instead of individual star clusters)



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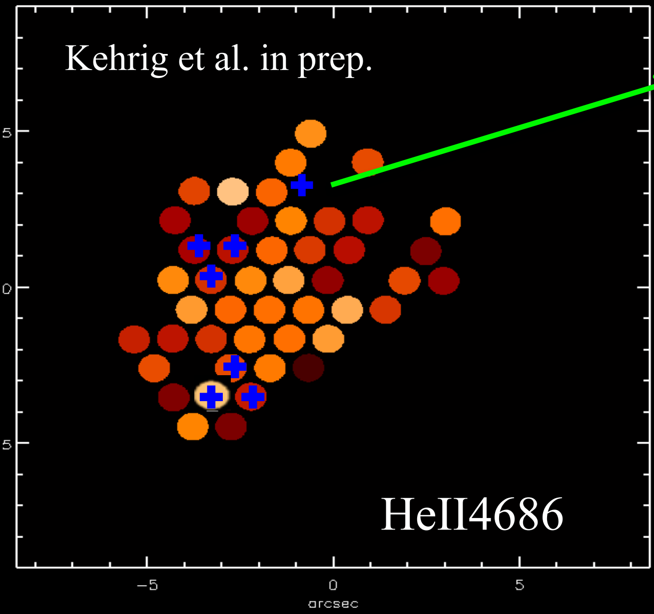

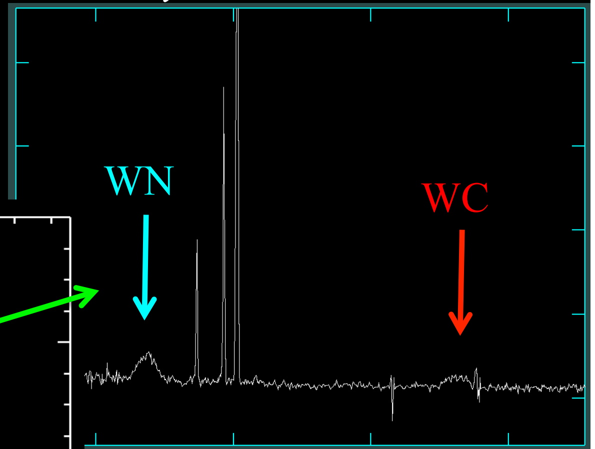

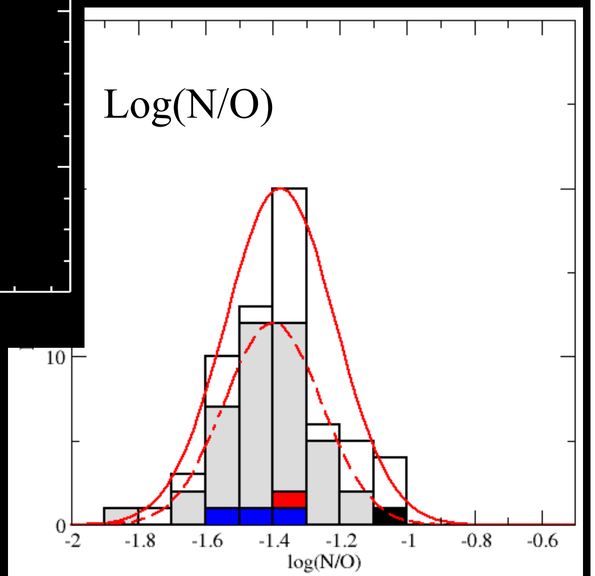

Summary

- Flat chemical abundance profiles appear to the rule in low-mass galaxies even though the expected yield of heavy elements produced by massive stars in young starbursts is substantial (ex: 40 $M_{\odot}$ star $\rightarrow$ ~ 7 $M_{\odot}$ of O)

- Global process, affecting the metal content of the whole galaxy (e.g. inflow of gas) is needed to produce the N/O excess in these objects

- WR stars might not be a significant contributor to abundance variations on timescales comparable to the lifetimes of the HII regions

- Nebular HeII might be associated with other excitation sources apart from WR star ionization

- Extend the sample (size and range of metallicity) to distinguish between different scenarios for metal enrichment of ISM and investigate metallicity trends