Estallidos de Formacion Estelar en Galaxias

Integral Field Spectroscopy of HII galaxies with Wolf-Rayet signatures

Carolina Kehrig

Instituto de Astrofisica de Andalucia (IAA-CSIC)

Galaxies Meet GRBs at Cabo de Gata

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2D view on the interplay between massive stars and ionized gas in HII galaxies with Wolf-Rayet features using IFS

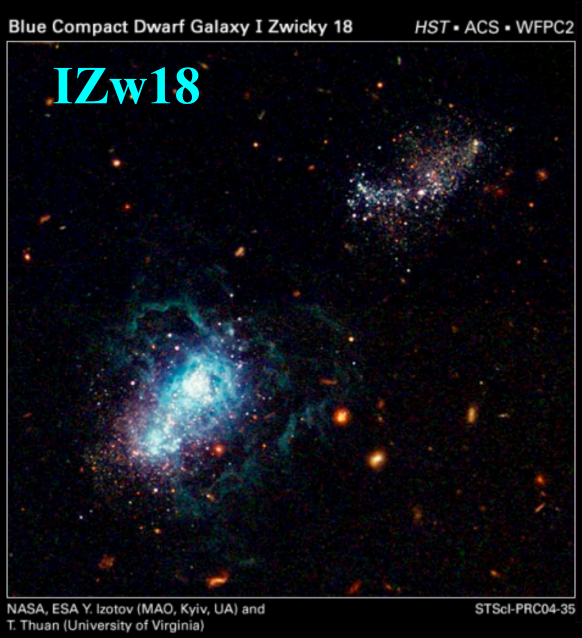
AIMS:

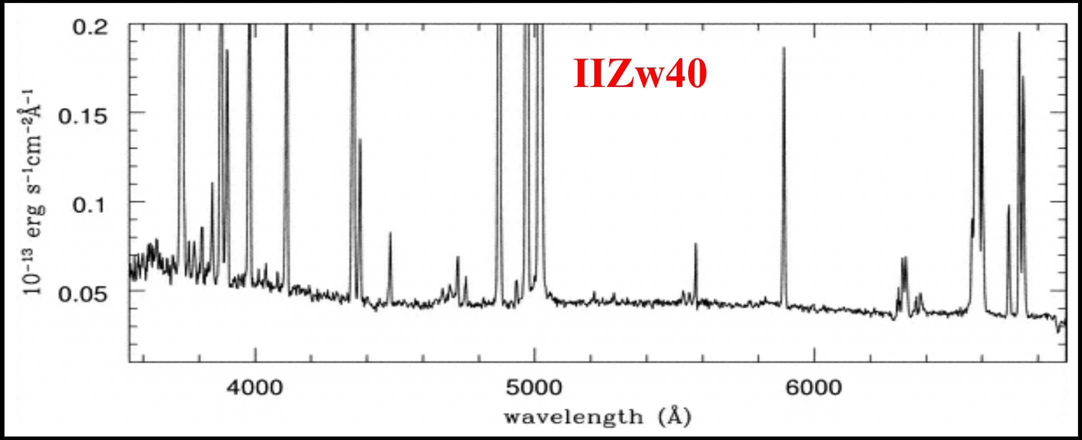
- Locate and characterize the Wolf-Rayet (WR) stars
- Chemical abundance of the ISM
- Gas excitation (origin of nebular HeII)

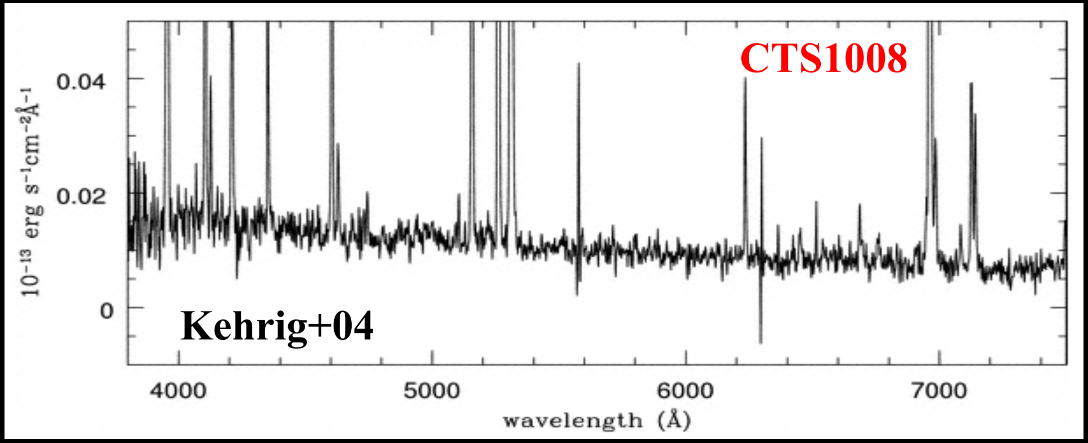
HII galaxies: general properties

- local, gas-rich star-forming systems

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

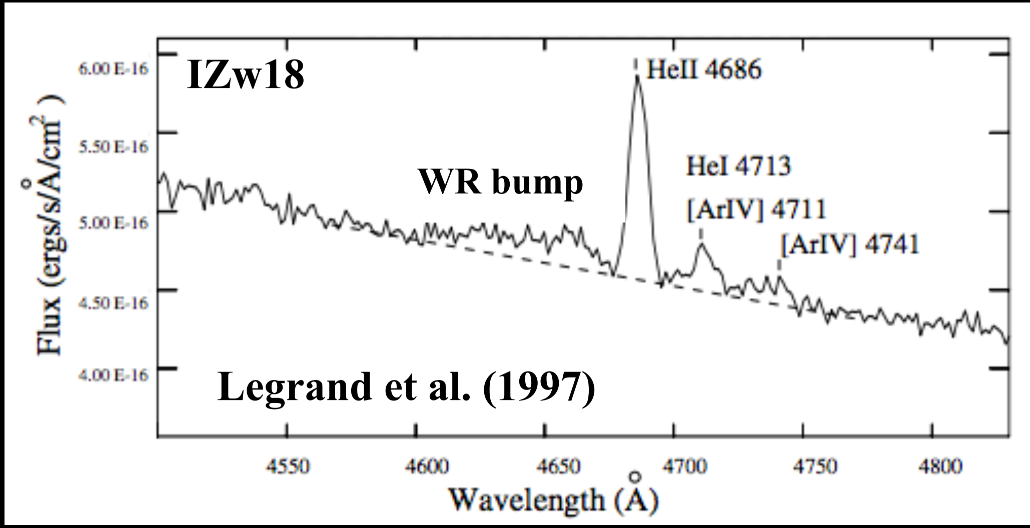






HII galaxies with WR features

- Wolf–Rayet (WR) signatures (broad bump at ~ 4680 Å) → the presence of WR stars (a late evolutionary phase of massive O stars; *e.g.* Crowther 2007), have been found in the spectra of some HII galaxies (*e.g.* Legrand+ 1997; Guseva+2000).



- Single star, non-rotating stellar evolution models fail in reproducing the WR content in low-metallicity environments (e.g. Papaderos+06; Brinchmann+08)

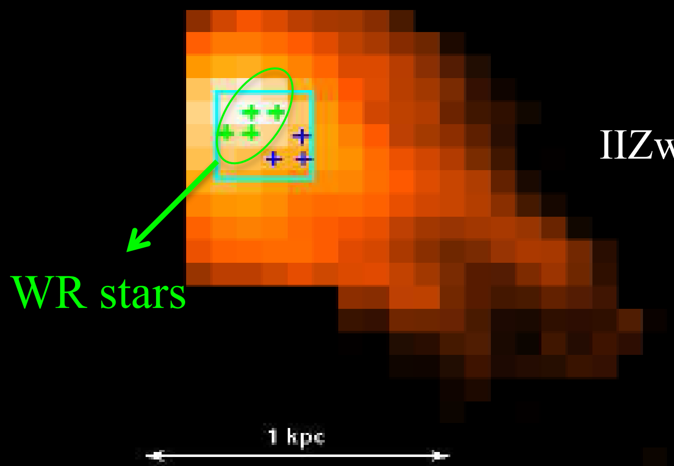
- The investigation of the WR content in metal-poor galaxies → to test stellar evolutionary models at low metallicities where more data are needed to constrain these models

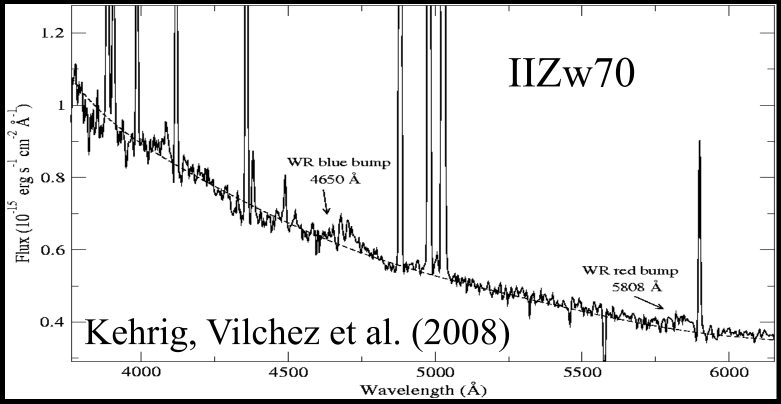
HII galaxies with WR signature: IFS as a suitable tool

- 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; Kehrig+2013)

Power of IFS in finding WR stars

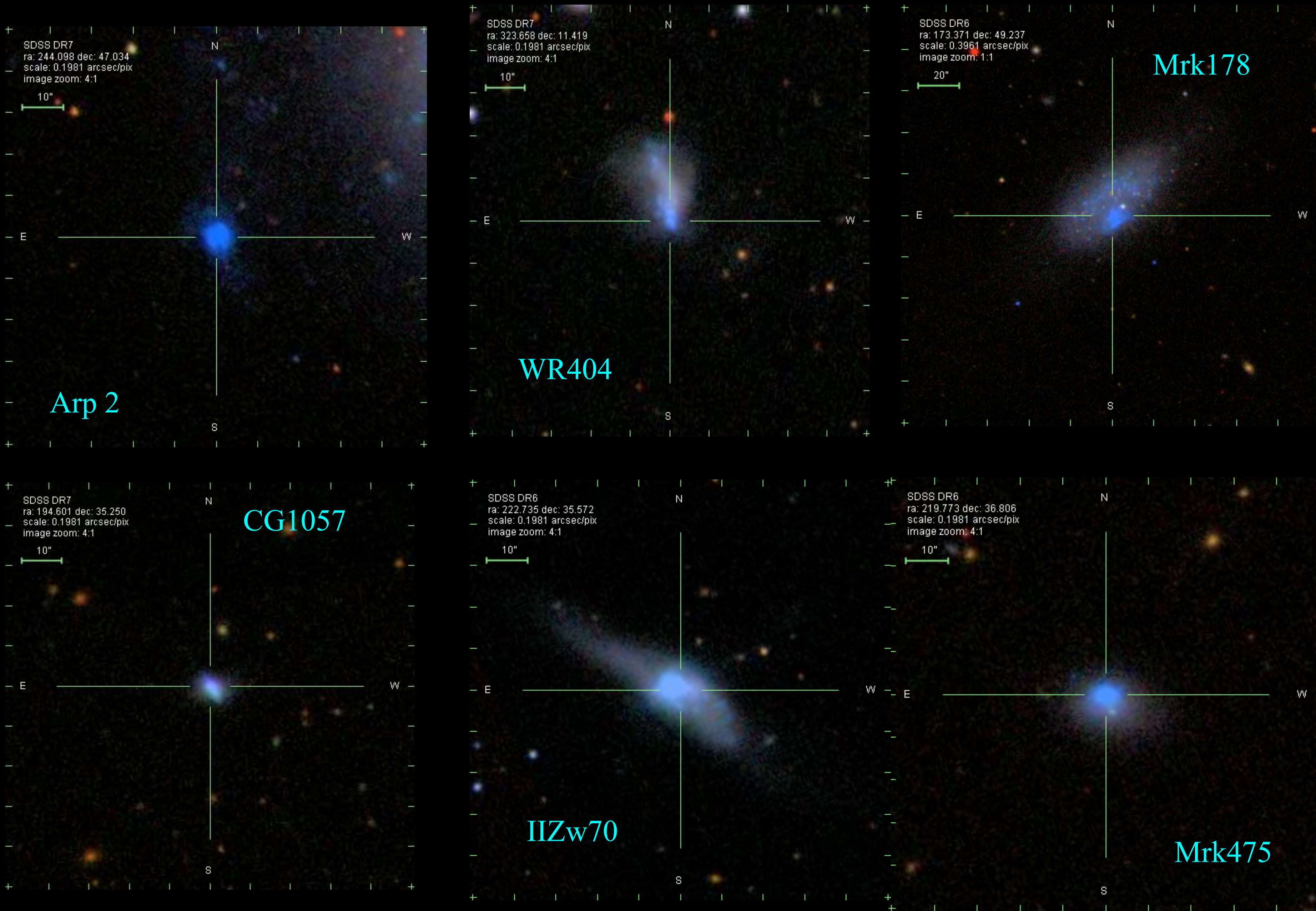




- Lowers the difficulty when doing the spatial correlation between WR stars and nebular properties (e.g De mello 1998)

- Formation and thereabouts of GRBs/SN progenitors may benefit from 2D study of metal-poor WR galaxies

IFU data of 15 metal-poor WR galaxies (PMAS at 3.5m CAHA)



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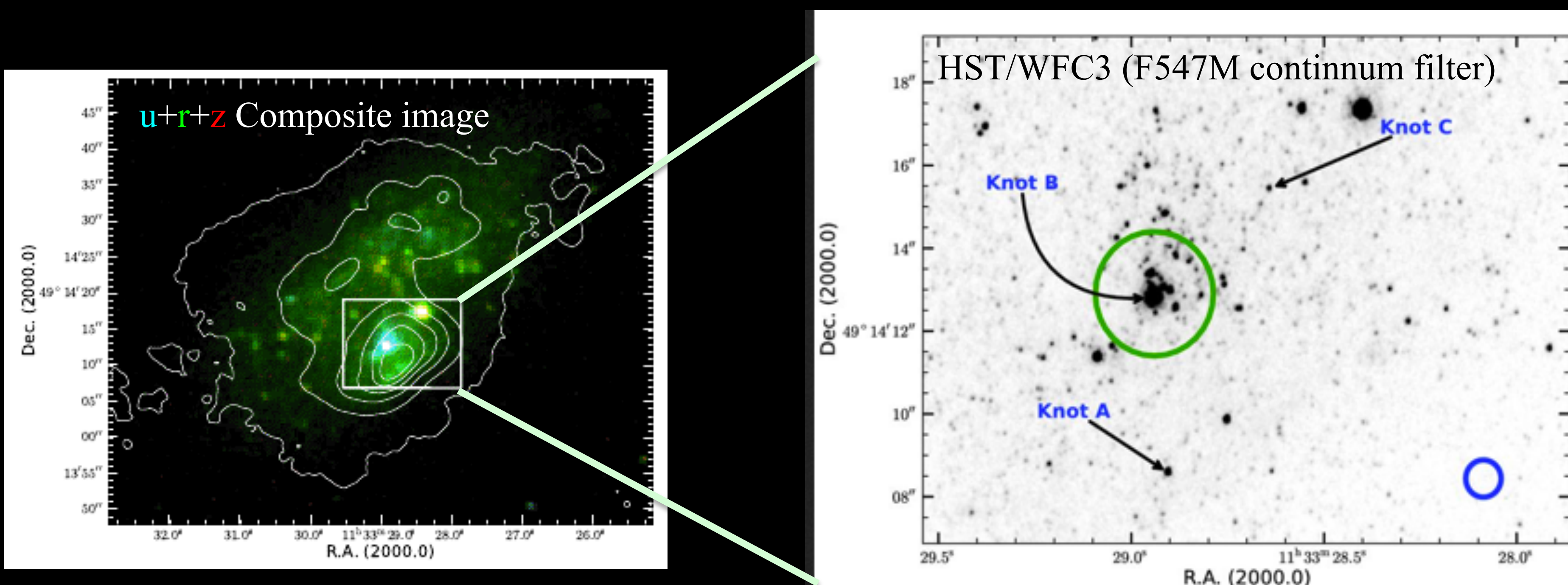
Uncovering multiple Wolf–Rayet star clusters and the ionized ISM in Mrk 178: the closest metal-poor Wolf–Rayet H II galaxy

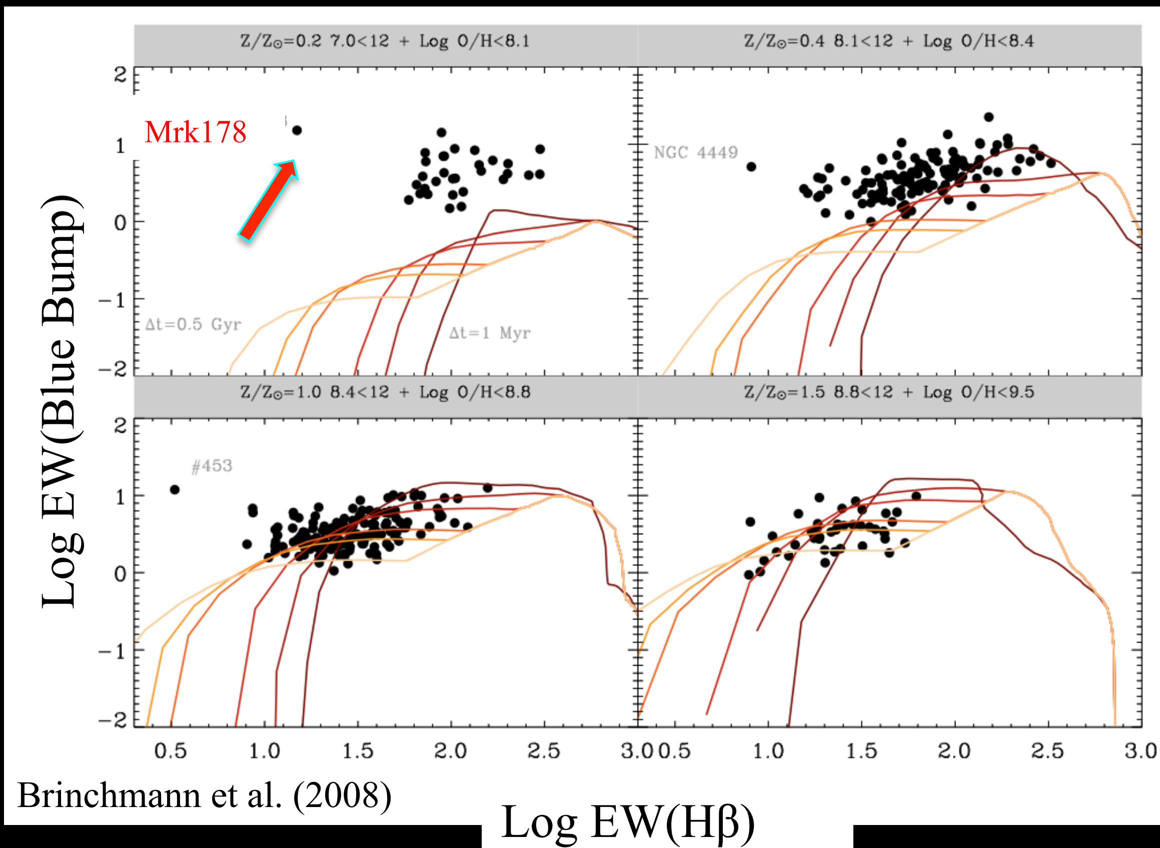
C. Kehrig,[1] E. Pérez-Montero,[1] J. M. Vílchez,[1] J. Brinchmann,[2] D. Kunth,[3] R. García-Benito,[1] P. A. Crowther,[4] J. Hernández-Fernández,[5] F. Durret,[3] T. Contini,[6,7] A. Fernández-Martín[1] and B. L. James[8]

- The first 2D spectroscopic study of Mrk 178
- The study of the WR content has been extended beyond its brightest star-forming knot uncovering new WR star clusters
- Locate the WR stars → study more precisely the effects on their environments



Mrk178: an intriguing object

- The strength of the broad WR features and its low metallicity(~ 1/10 $Z_{\odot}$)



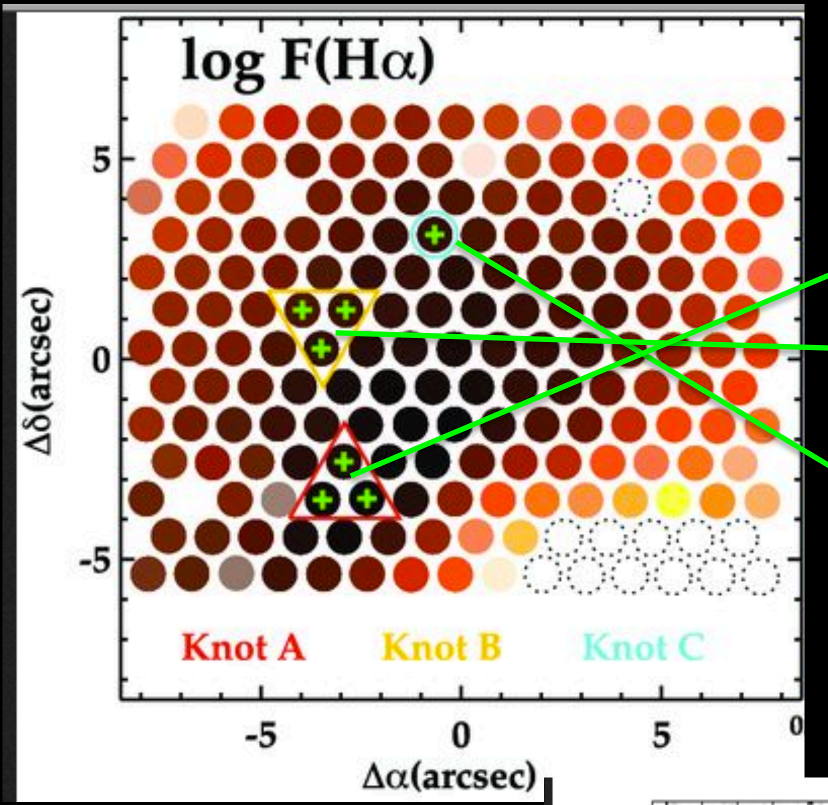
Brinchmann et al. (2008)

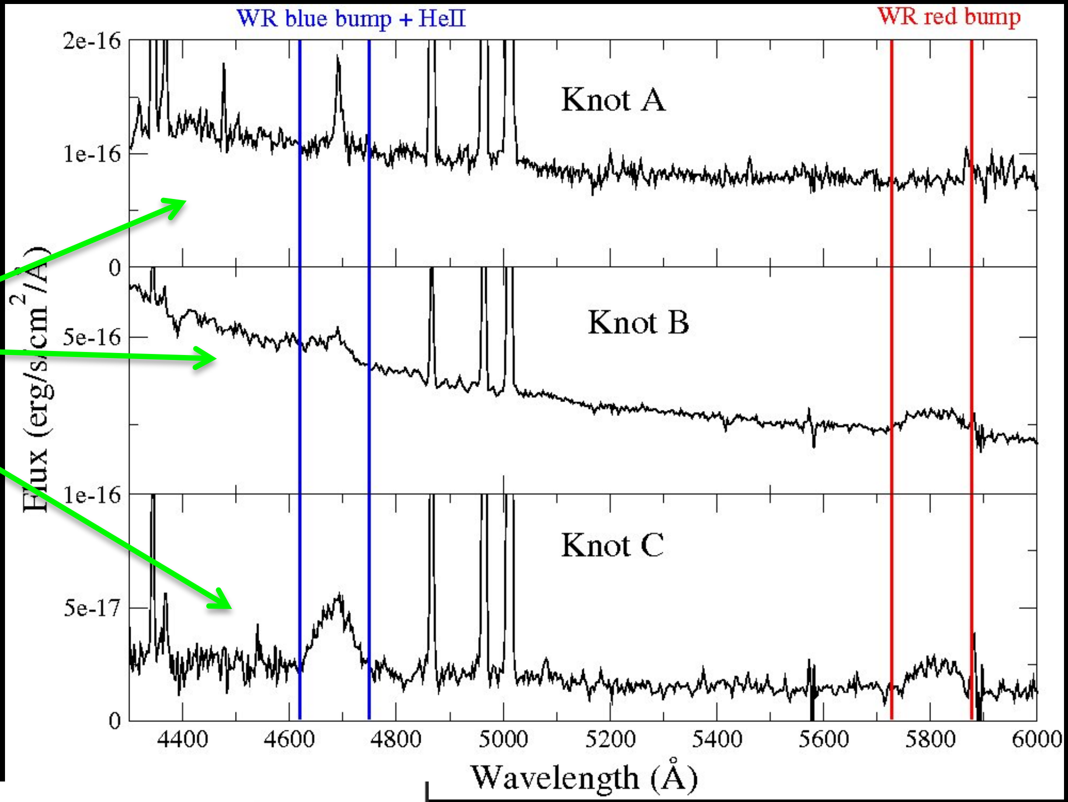
- Mrk178 as a significant outlier among WR galaxies from SDSS

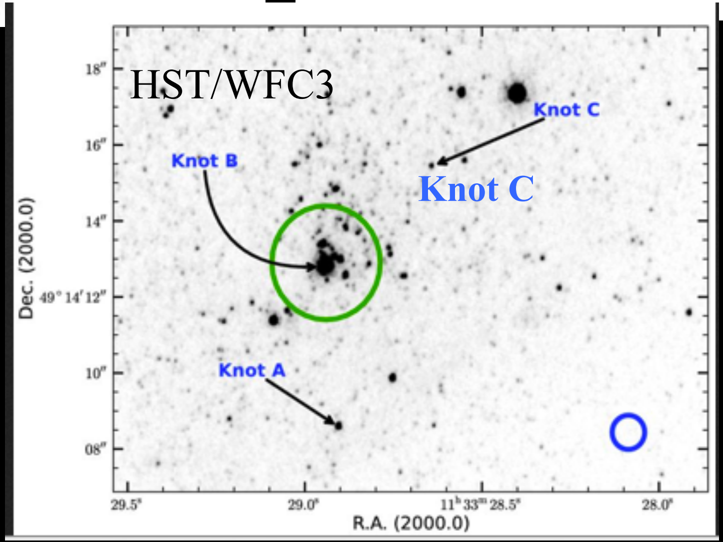
↓

strongest WR feature relative to Hβ of any galaxy in their sample

Mrk178: locating and characterizing WR stars



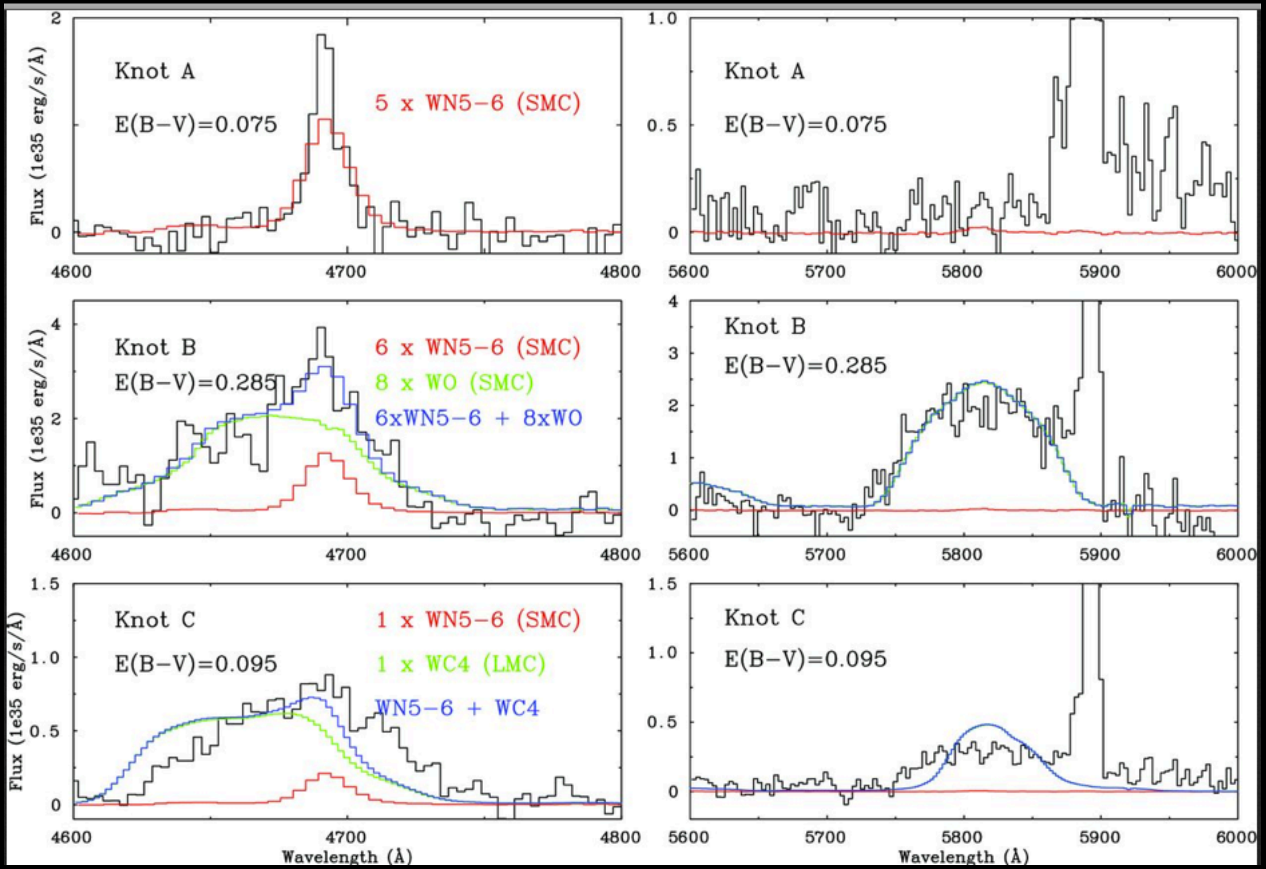




Mrk178: locating and characterizing WR stars

- Using Large/Small Magellanic Cloud-template WR stars, we empirically estimate a minimum of ~20 WR stars within our FOV

the comparison between the observed WR bumps and the WR template spectra [WN stars, WC/WO stars and composite WN+WC/WO stars]

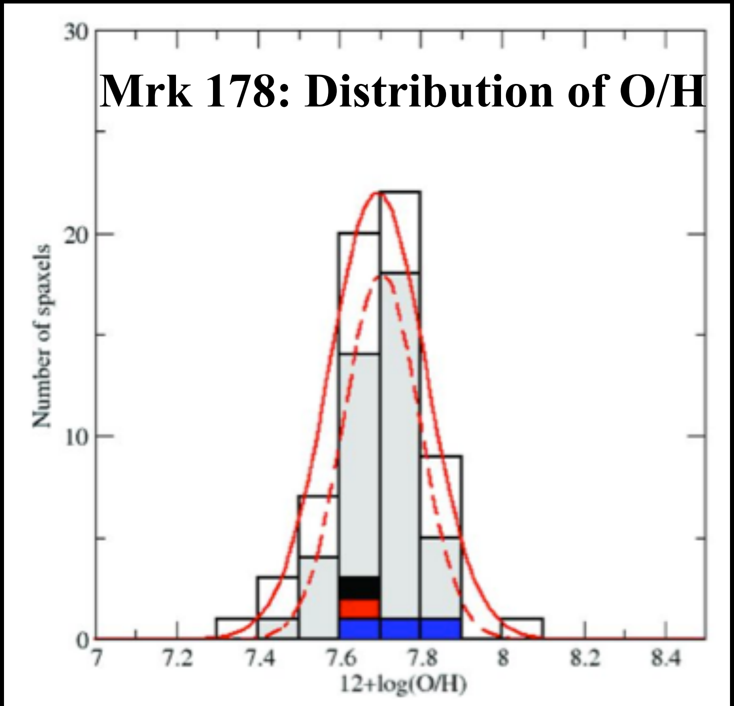


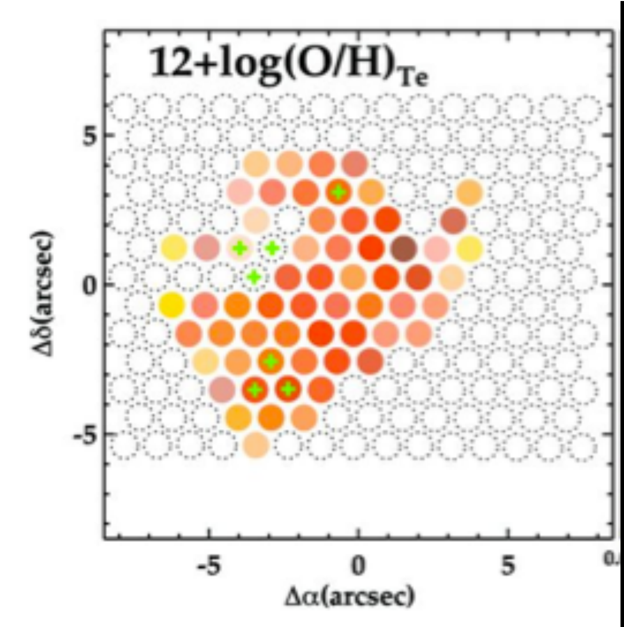
~ 5 x WN5-6 stars

~ 6 x WN5-6 stars + 8 x WO stars

~ 1 x WN5-6 stars + 1 x WC4 star

Mrk178: oxygen abundance



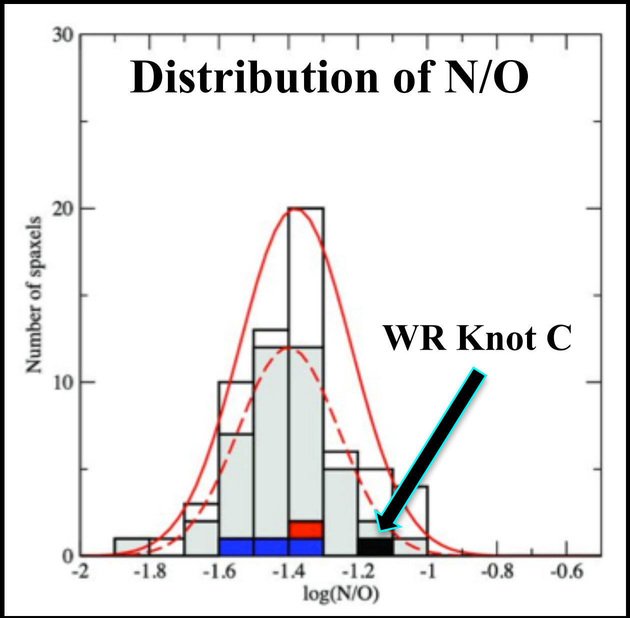


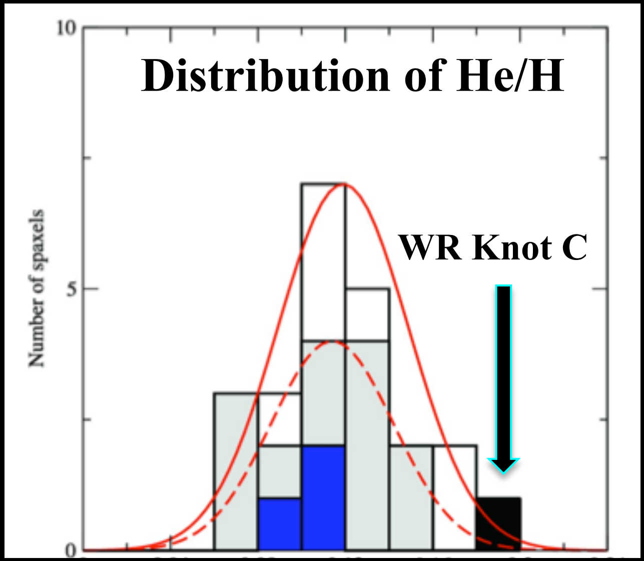
- O/H from Te[OIII]4363

- The variations in the derived O/H are not statistically significant

Chemically homogeneous ISM on spatial scales of hundreds of pc (e.g. Lee & Skillman 1997; Kehrig+04; Perez-Montero+09; Cairos+09)

Mrk178: N/O and He/H abundance





- WR Knot C appears to present a higher N/O

- WR Knot C also shows a higher He/H

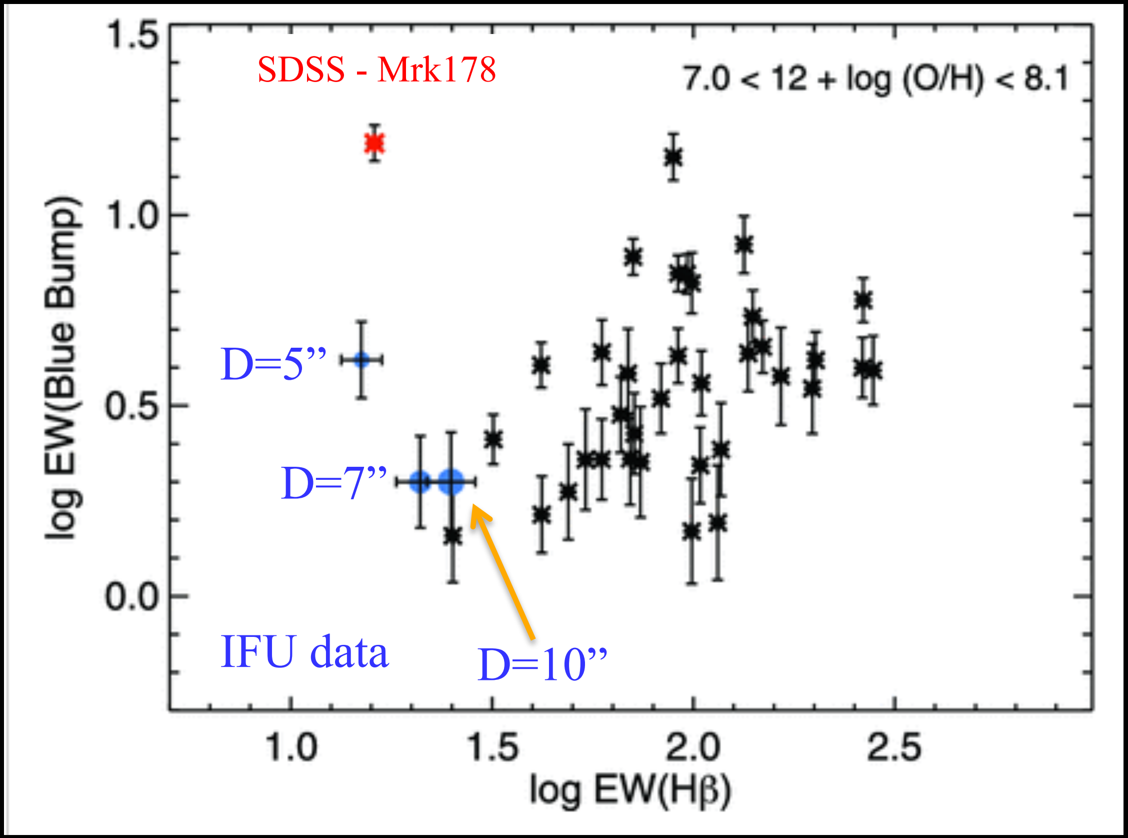
- Localized N and He enrichment, spatially correlated with WR Knot C (size ~ 20 pc)

Chemical enrichment associated with WR stars has been found previously in other dwarf galaxies (e.g. Lopez-Sanchez et al. 2011; Monreal-Ibero et al. 2010; Perez-Montero et al. 2013)

Mrk178: aperture effects on the detection of WR features

- WR galaxies from SDSS DR7: the most deviant point belongs to Mrk178

- From our IFU data: 1D spectra by combining fibers within circular apertures of increasing diameters



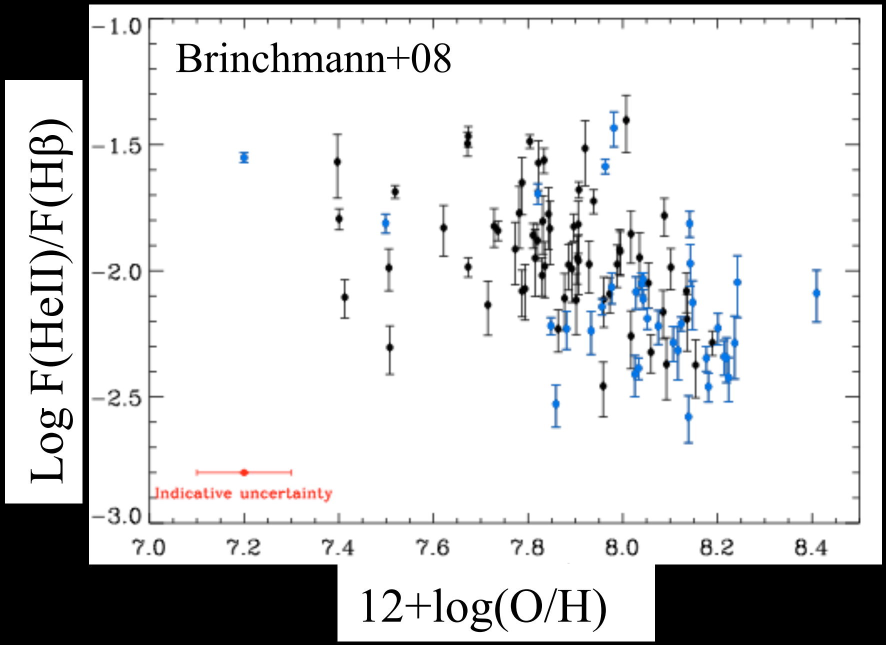
- Mrk178 gets closer to the bulk of metal-poor systems as the aperture size increases

The offset is not real and is caused by aperture effects

- For apertures with D > 10”, we no longer detect the WR bump

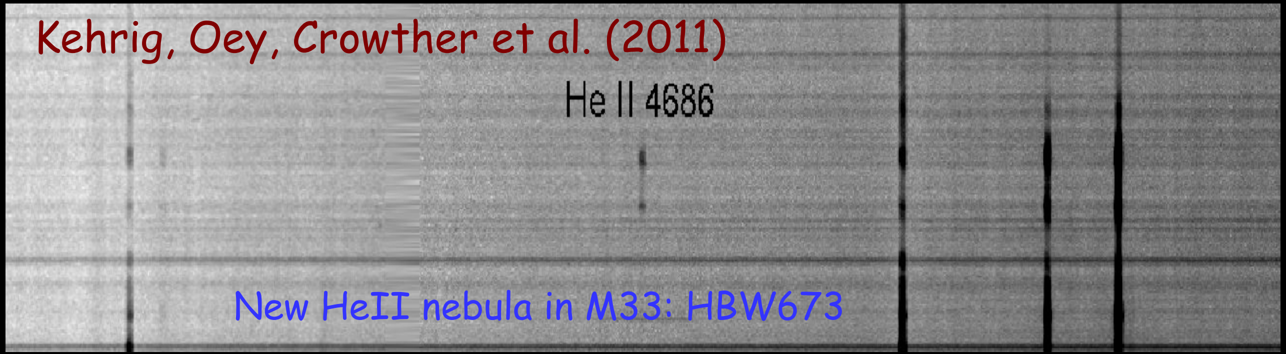
The power of IFS for investigating issues related to aperture effects !

excitation sources → the origin of nebular HeII emission



- HeII tend to be brighter in low metallicity systems and it is seen in high-z galaxies (e.g. Schaerer 2008) → offers a probe to infer properties of distant star-forming regions and search for PopIII stars

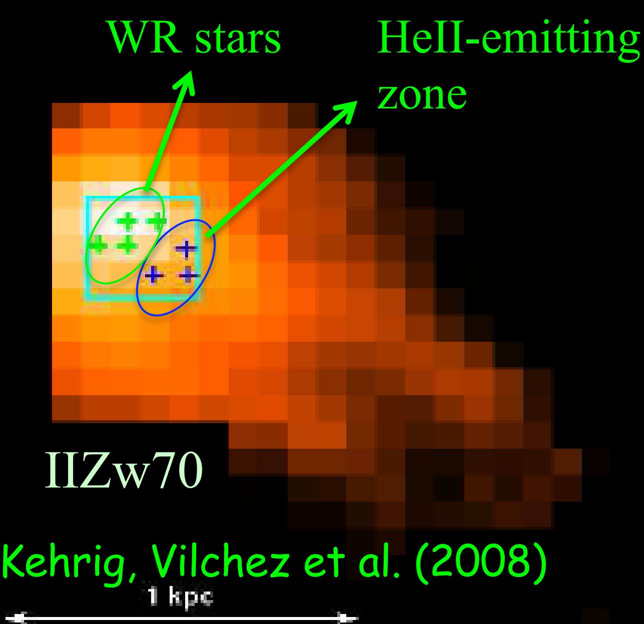
- Usually nebular HeII is associated with WR stars but several studies have demonstrated that it is not always the case (e.g. Pakull et al. 2010; M.Pakull's talk). From GMOS spectroscopy of HeII nebulae in M33:



The origin of nebular HeII emission

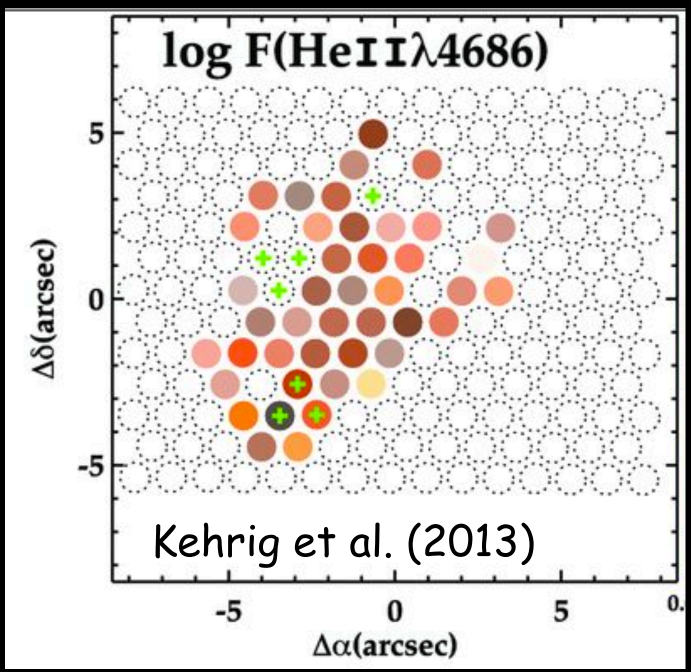
- Shirazi & Brinchmann (2012) → a large fraction of HeII-emitting galaxies do not show WR features and this fraction increases systematically with decreasing Z

- Different mechanisms (ex: shocks) responsible for producing HeII line apart from WR stars (e.g Pakull & Motch 1989; Garnett+91) & spatial separation between WR stars and the HeII-emitting zone can be a possible explanation for non-detection of WR features



Kehrig, Vilchez et al. (2008)

Mrk 178



Kehrig et al. (2013)

- Mrk178: HeII emission is extended and not always coincident with the location of WR stars: an effect of the mechanical energy input by the WR star winds

Summary & Conclusions

- We have initiated a programme to investigate metal-poor WR galaxies using IFS

On Mrk 178, the closest metal-poor WR HII galaxy, our main results are:

- We defined 3 WR knots from which 2 were identified for the first time here

- By using SMC/LMC template WR stars, we estimate a minimum of ~ 20 WR stars, already higher than that found in the literature

- Localized N and He enrichment, spatially correlated with WR stars, is suggested by our analysis

- Spatial offset between nebular HeII emission and WR stars can be explained based on mechanical energy arguments and does not rule out WR stars as the HeII ionization source

- We study aperture effects on the detection and measurements of WR features → WR galaxy samples constructed on single fibre/long-slit spectrum basis may be biased in the sense that WR features can scape detection depending on the distance of the object and on the aperture size