Metal-poor Wolf-Rayet Galaxies unveiled from integral field spectroscopy

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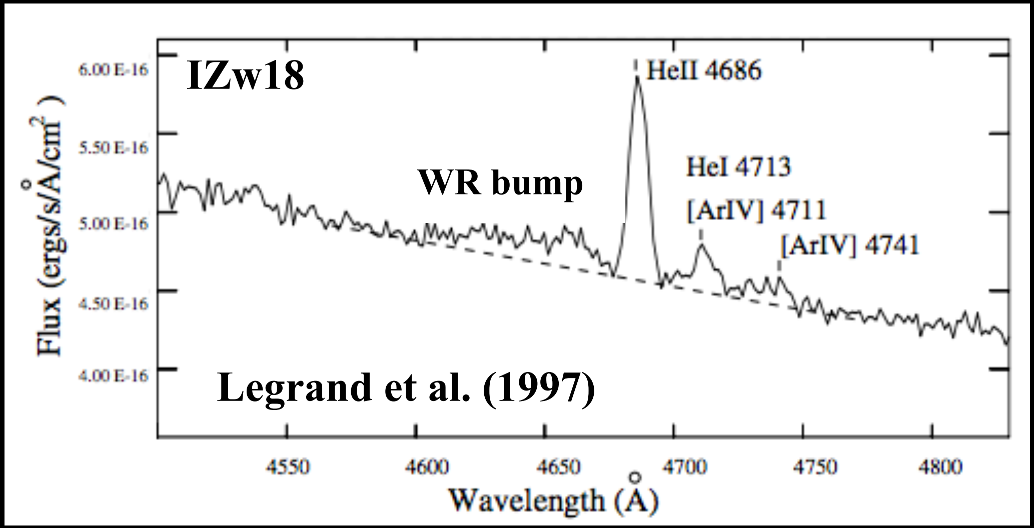
Proyecto ESTALLIDOS DE FORMACION ESTELAR

Estallidos de Formacion
Estelar en Galaxias

Granada 11th – 13th May 2015

Spatial correlation between massive stars and ionized gas in local metal-poor Wolf-Rayet galaxies

WR galaxies: starburst galaxies whose spectra show signatures from WR stars (broad feature at ~ 4680 A or **WR blue bump**)



Why are local metal-poor WR galaxies important ?

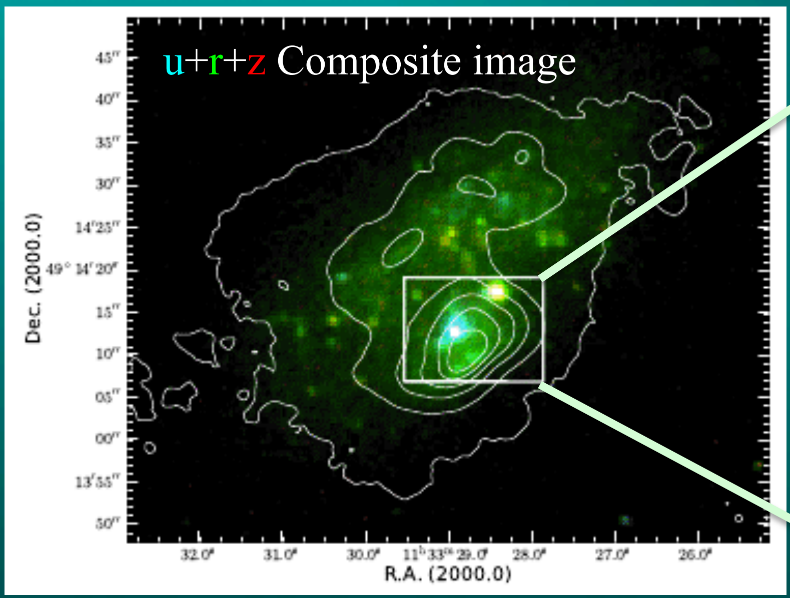
■ **“template” systems → understand the evolution and feedback from massive stars in distant starburst galaxies which cannot be studied to the same depth**

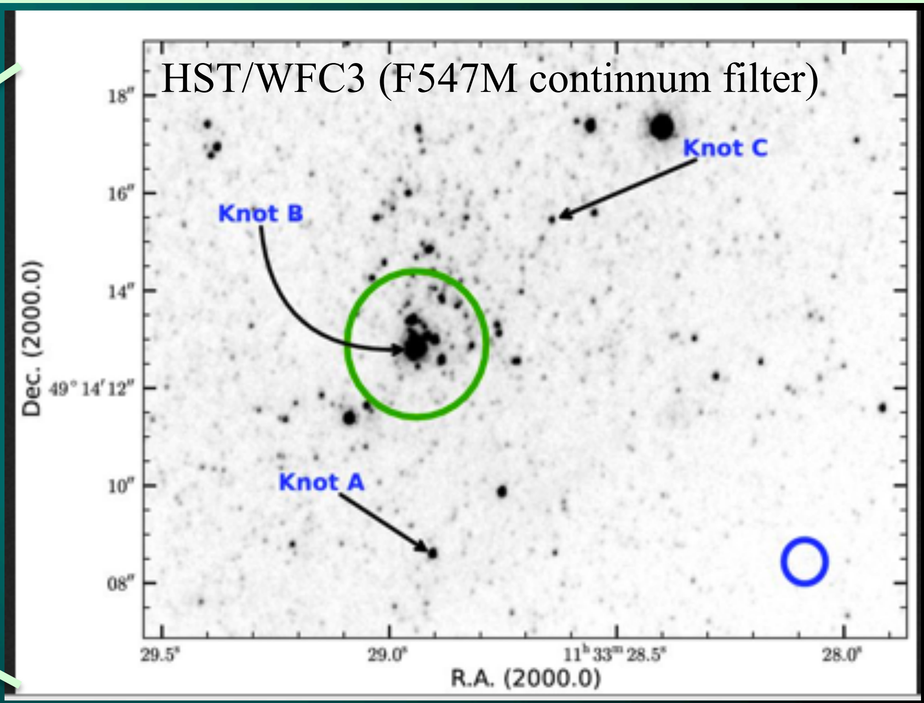
■ **Strong disagreement between observations and predictions for the WR content in metal-poor galaxies** (e.g. Papaderos+2006; Brinchmann+2008)**: more data are needed to constrain the models**

■ **The origin of high-ionization nebular lines, like HeII, is still an open issue** (e.g. Guseva+2001; Kehrig+2011; Schaerer 2012; Cassata+2013)

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

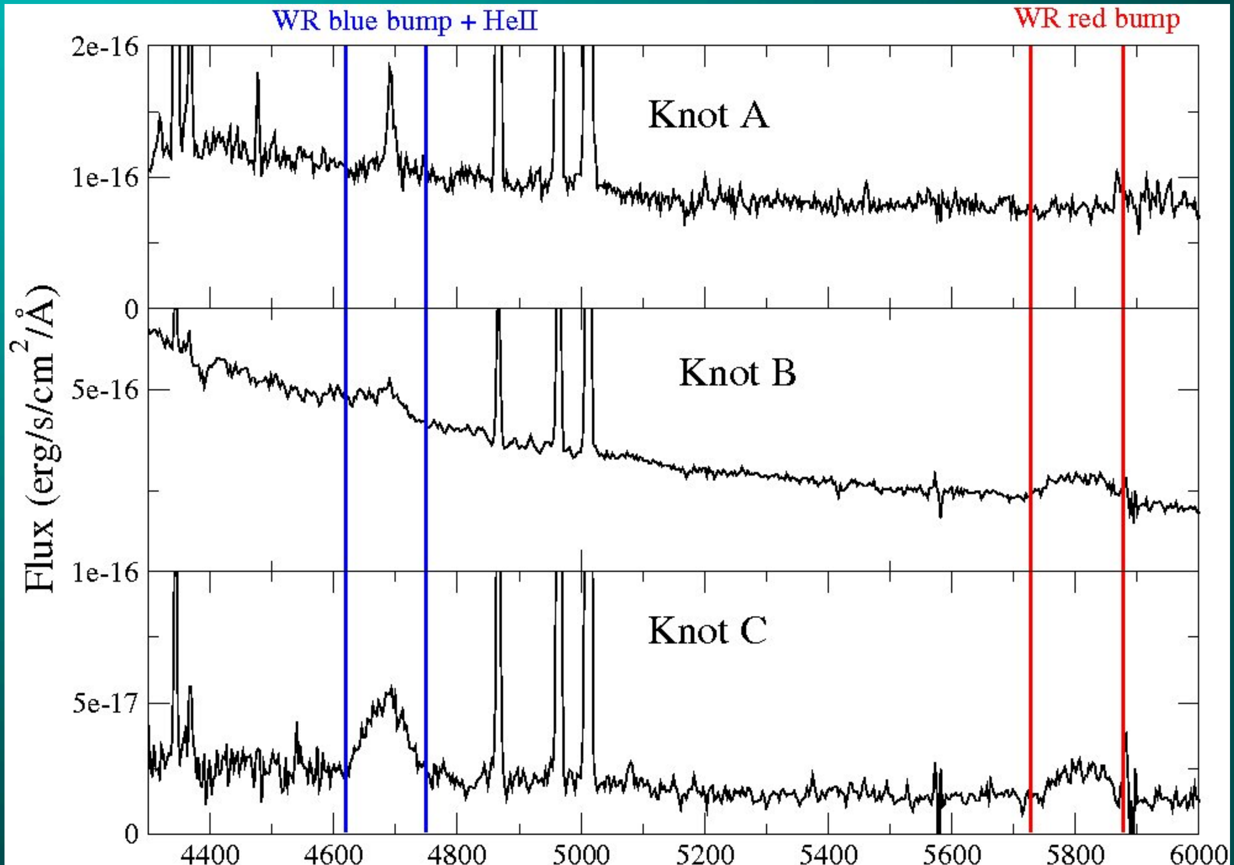
The first IFS study of Mrk178: the closest metal-poor WR HII galaxy (Kehrig+2013)





- For the first time, we study the WR content in Mrk178 beyond its brightest star-forming knot uncovering new WR star clusters

- Locate the WR stars and study more precisely the effects on their environments



Kehrig+2013

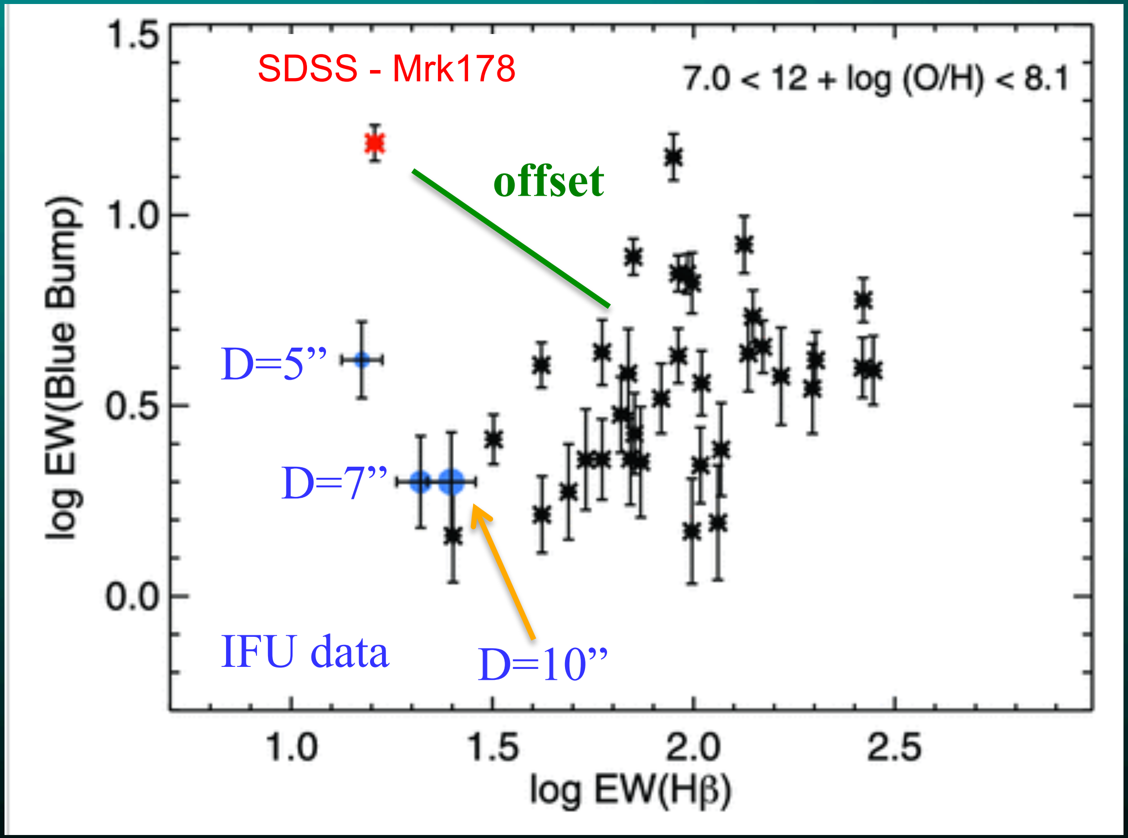
- Using Large/Small Magellanic Cloud-template WR stars, we empirically estimate a minimum of ~20 WR stars within our FOV

The strength of the broad WR features and its low metallicity (~ 1/10 $Z_{\odot}$) make Mrk178 an intriguing object !

Mrk178: aperture effects on the detection of WR features

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

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



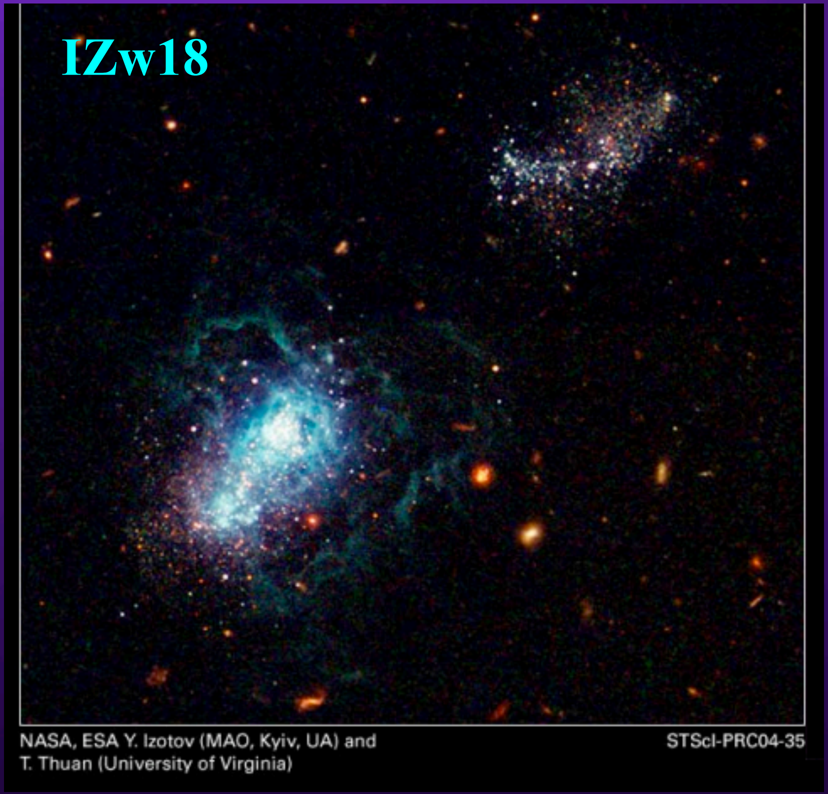
- Mrk178 gets closer to the bulk of metal-poor systems as the aperture size increases. The offset is caused by aperture effects

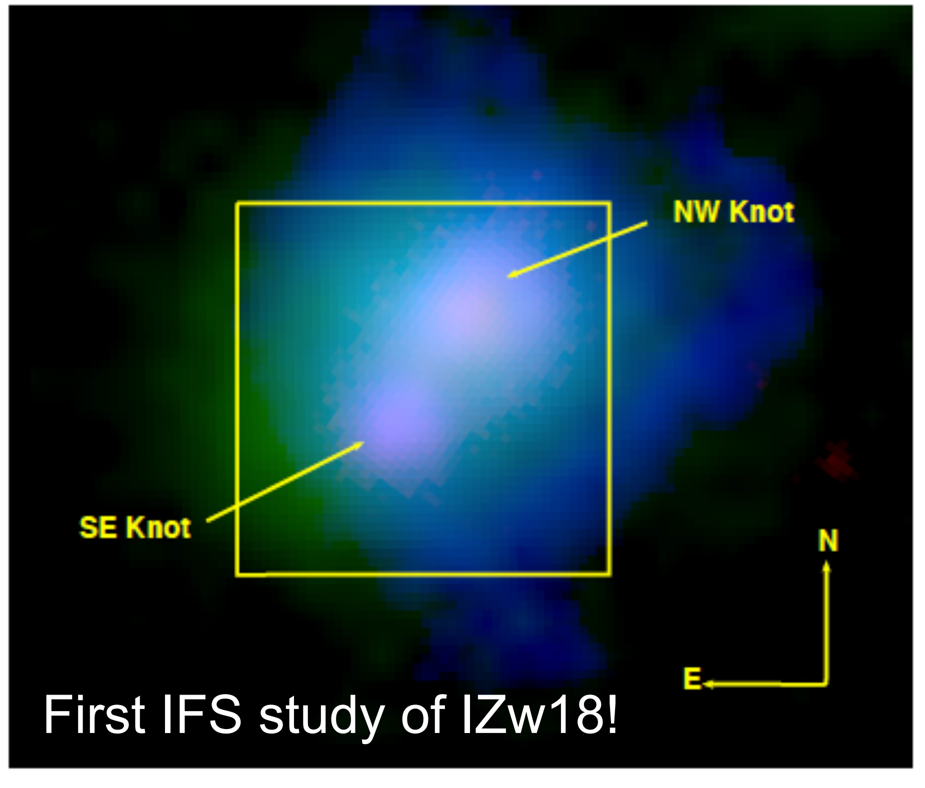
- For apertures with D > 10”, we no longer detect the WR bump

- WR galaxy samples based on single fiber/long-slit spectrum may be biased in the sense that WR signatures can escape detection (see also Miralles-Caballero et al.)

The extended HeII4686-emitting region in IZw18 unveiled: clues for peculiar ionizing sources

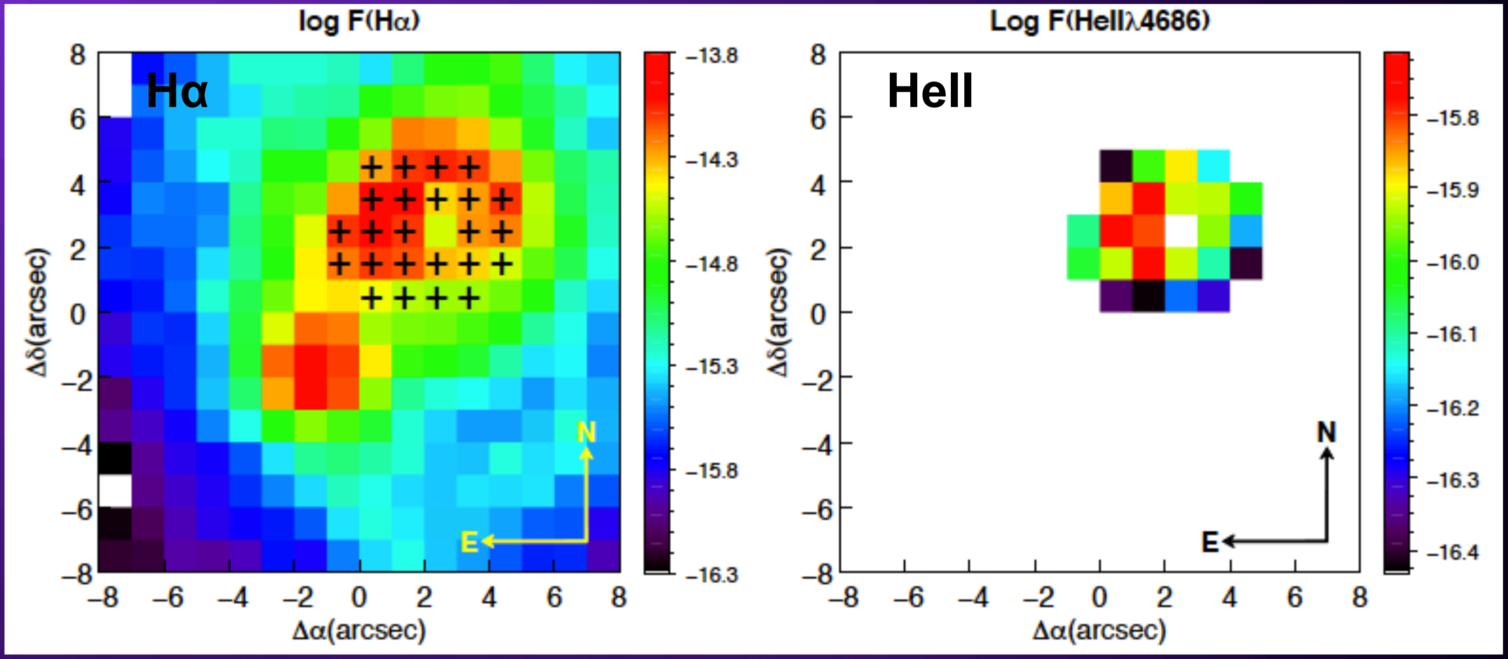
(Kehrig,Vilchez,Perez-Montero,Iglesias-Paramo+2015, ApJL,801,March)





The nearby lowest-metallicity galaxy and our best local analog of faraway starbursts (e.g., Skillman & Kennicutt 1993; Vilchez & Iglesias-Paramo 1998; Izotov+1999, Thuan+2004, Papaderos & Ostlin 2012)

We discovered a large (D ~ 400 pc) nebular HeII4686-emitting region



- The presence of HeII emission in IZw18 has been reported before (e.g., Izotov+1997, Vilchez & Iglesias-Paramo 1998)

- Our IFU data reveal for the first time: total spatial extent and precise location of the HeII region, and the corresponding total HeII-ionizing flux in IZw18!

Why is this study relevant ?

- Nebular HeII emission ➔ the existence of a hard radiation field (E ≥ 54ev)

- HeII-emitters are observed to be more frequent among high-z galaxies than for local objects (Kehrig+2011; Cassata+2013)

- HeII lines: one of the best tracers of PopIII-stars (the first very hot metal-free stars) in high-z galaxies (e.g., Schaerer 2003) ➔ such stars are believed to have contributed to the universe's reionization (e.g., Bromm 2013)

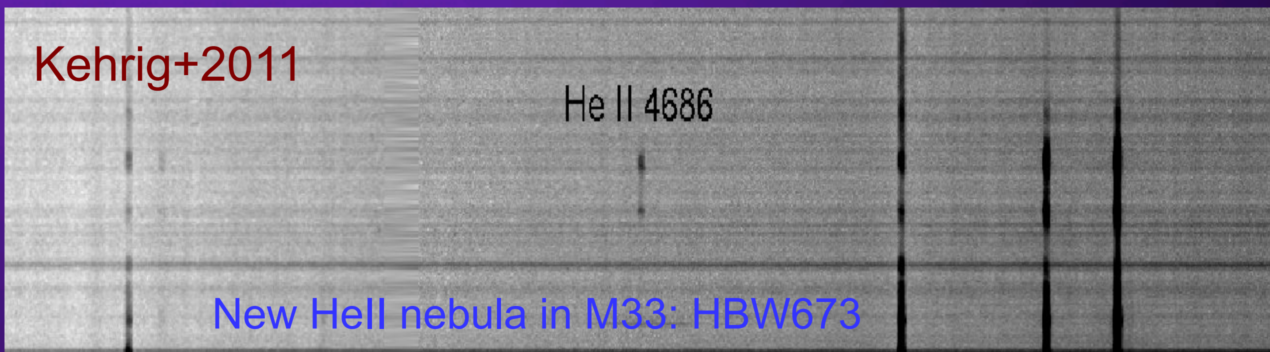
- One of the main science drivers for next-generation telescopes: searches for PopIII objects

- Before interpreting the emission-line spectra of distant galaxies, it is crucial to understand the formation of high-ionization lines in the nearby universe

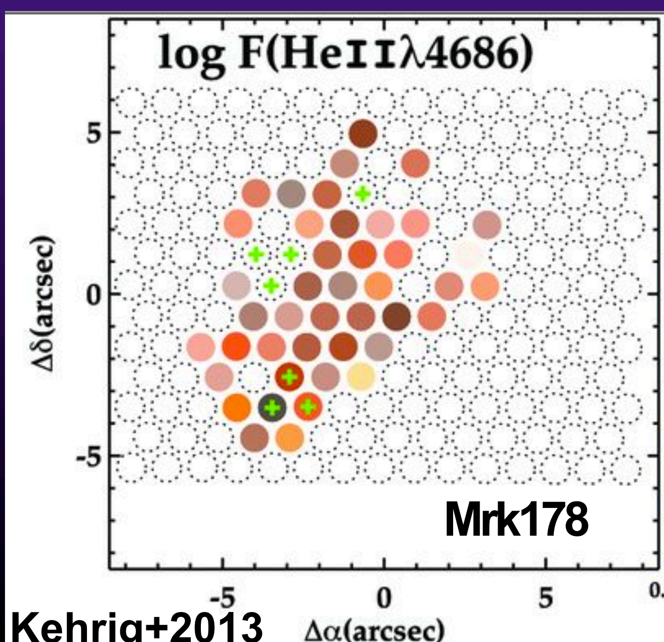
IZw18 is the ideal place to perform this study!!

A lack of understanding of HeII emitters at low redshift

Several mechanisms (hot WR stars, shocks, X-ray sources) have been proposed to explain the HeII ionization in HII galaxies/HII regions (e.g., Garnett+1991; Schaerer 1996; Thuan & Izotov 2005). **However …**



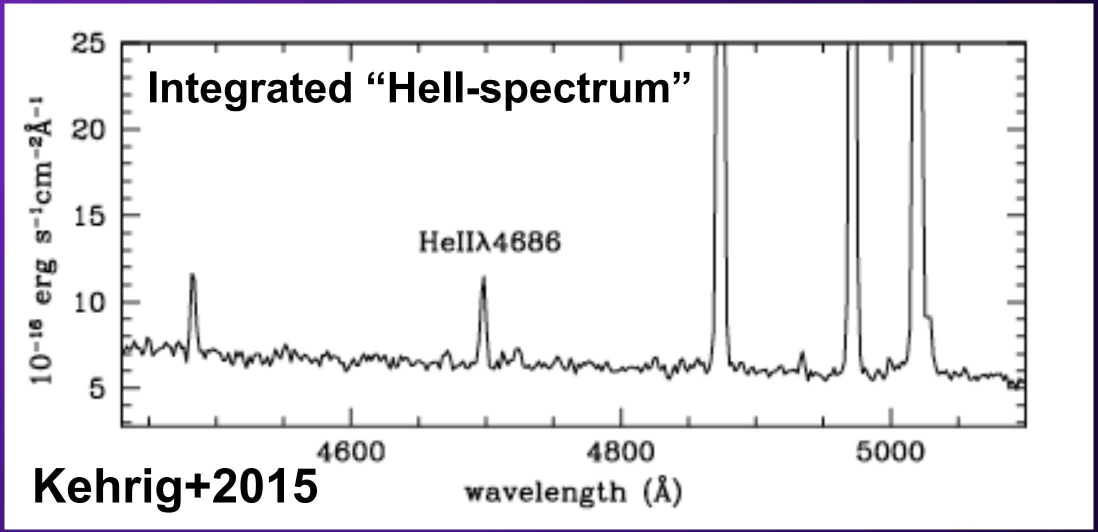
2 new HeII nebulae in M33 not associated with any hot massive star!



Mrk178: HeII emission is extended and goes much beyond the location of WR stars

Shirazi & Brinchmann (2012): 40% of the HeII-emitting galaxies from SDSS do not show WR features (see also Guseva et al. 2001)

What is the main source powering nebular HeII emission in IZw18 ?

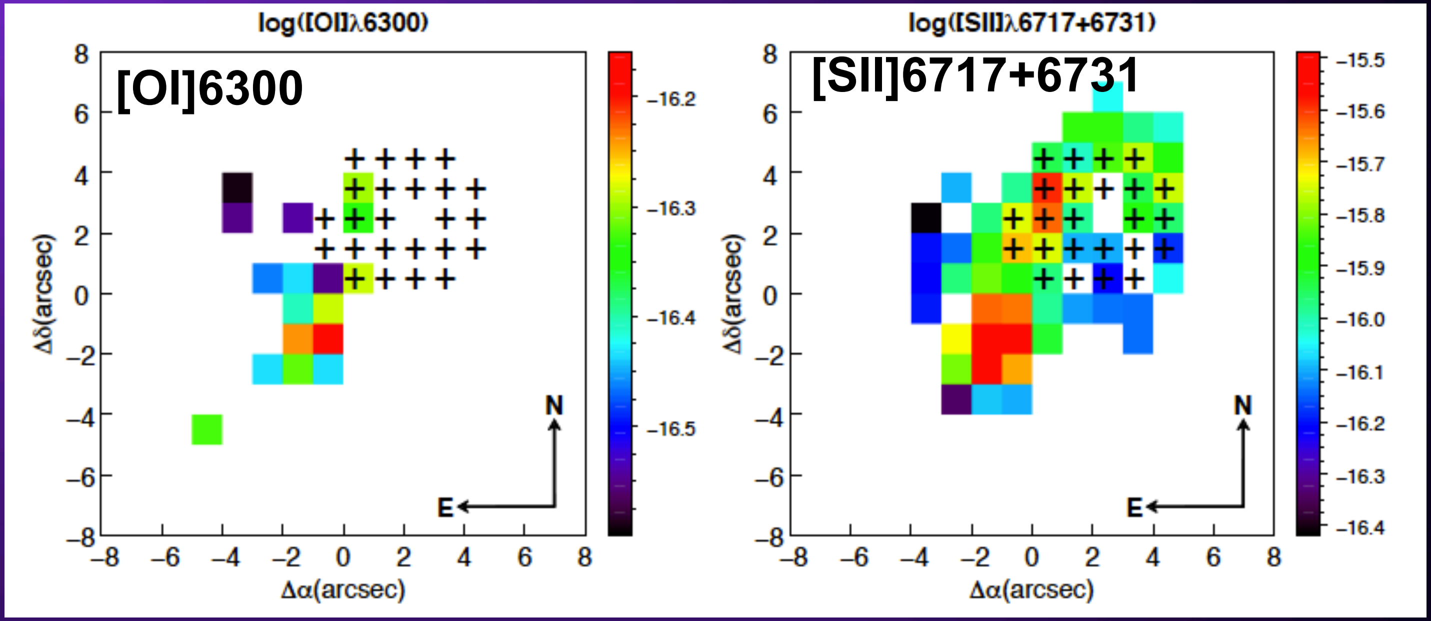


L(HeII4686) = 1.12 x 10^{38} erg/s → Q(HeII)$_{obs}$ = 1.33 x 10^{50} photon/s

1) WR stars ? based on the HeII-ionizing flux expected from IZw18-like WRs (Crowther & Hadfield 2006), ≥ 100 WRs is required to explain the Q(HeII)$_{obs}$, but such very large WR population is **not compatible with:**

- **(> 8 times) Total stellar mass of the NW cluster**
- **WR/O stars ratio at the metallicity of IZw18** (e.g. Maeder & Meynet 2012)
- **State-of-the-art stellar evolutionary models for single massive stars in low-Z environments** (Leitherer+2014)

2) Shocks ? Spectral features of shock ionization indicate that the HeII region is unlikely to be produced by shocks



3) X-ray binaries ? CLOUDY photoionization model using as input a SED with the characteristics reported for the single X-ray binary in IZw18 (Thuan +2004) give L(HeII4686) < 100 L(HeII4686)$_{obs}$

Conventional HeII-ionizing sources (WRs, shocks, X-ray binaries) are not sufficient to explain the observed HeII emission in IZw18.

Peculiar very hot stars in IZw18
1) very massive, metal-poor O stars … ?

Compare the observations with HeII-ionizing fluxes from current wind models of very massive O stars at the metallicity of IZw18 (Kudritzki 2002):

300 $M_\odot$ star hottest models → ~ 20 stars would be needed

↓

The number of very massive, metal-poor O stars derived would imply a cluster mass much higher than the total stellar mass of the NW knot

These models cannot explain the highest values of HeII4686/Hβ (~ 0.08) observed

Peculiar very hot stars in IZw18
2) metal-free ionizing stars (or PopIII-stars) … ?

Searches for PopIII-hosting galaxies have been carried out using HeII lines because of the strong UV radiation expected at (nearly) zero metallicity

Schaerer (2003): burst models cannot explain the $Q(\mathrm{HeII})_{obs}$ when $Z \geq 10^{-5}$ → **HeII emission due to stellar photoionisation is limited to very small metallicities and Population III objects**

Compare the observations with HeII-ionizing fluxes from state-of-the-art models for rotating Z=0 stars (Yoon+2012):

- 150 $M_\odot$ (100 $M_\odot$) star models → 8–10 (13-15) stars are needed

- The harder spectra of these stellar models can explain the highest values of HeII4686/Hβ

- Lebouteiller+2013: metal-free gas pockets could provide the raw material for making such (nearly) metal-free stars in IZw18

We invoke the PopIII-stars scenario in IZw18 for the first time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Imprimir

Una galaxia enana permite conocer el pasado del universo

- Es la galaxia IZw18, la más pobre en metales del universo cercano
- Tiene una región muy extensa de helio ionizado
- Los investigadores del IAA han estudiado el origen de esta radiación

Ampliar foto

La galaxia IZw18 captado por el Hubble, ACS y WFPC2 NASA, ESA, Y. Izotov (MAO, Kyiv, UA) y T. Thuan (Universidad de Virginia)

This scenario works, and it is apparently getting popular (see poster proceeding by Heap+2015,april)

Great impact on the media (radio,TV, newspapers)

New exciting results on IZw18 are coming soon again!