STAR FORMATION & TIDAL INTERACTIONS IN WOLF – RAYET GALAXIES

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WOLF RAYET phase in Galaxies

Wolf Rayet specific spectroscopic line features indicate presence of wolf-rayet (most massive and the youngest) stars in the galaxy.

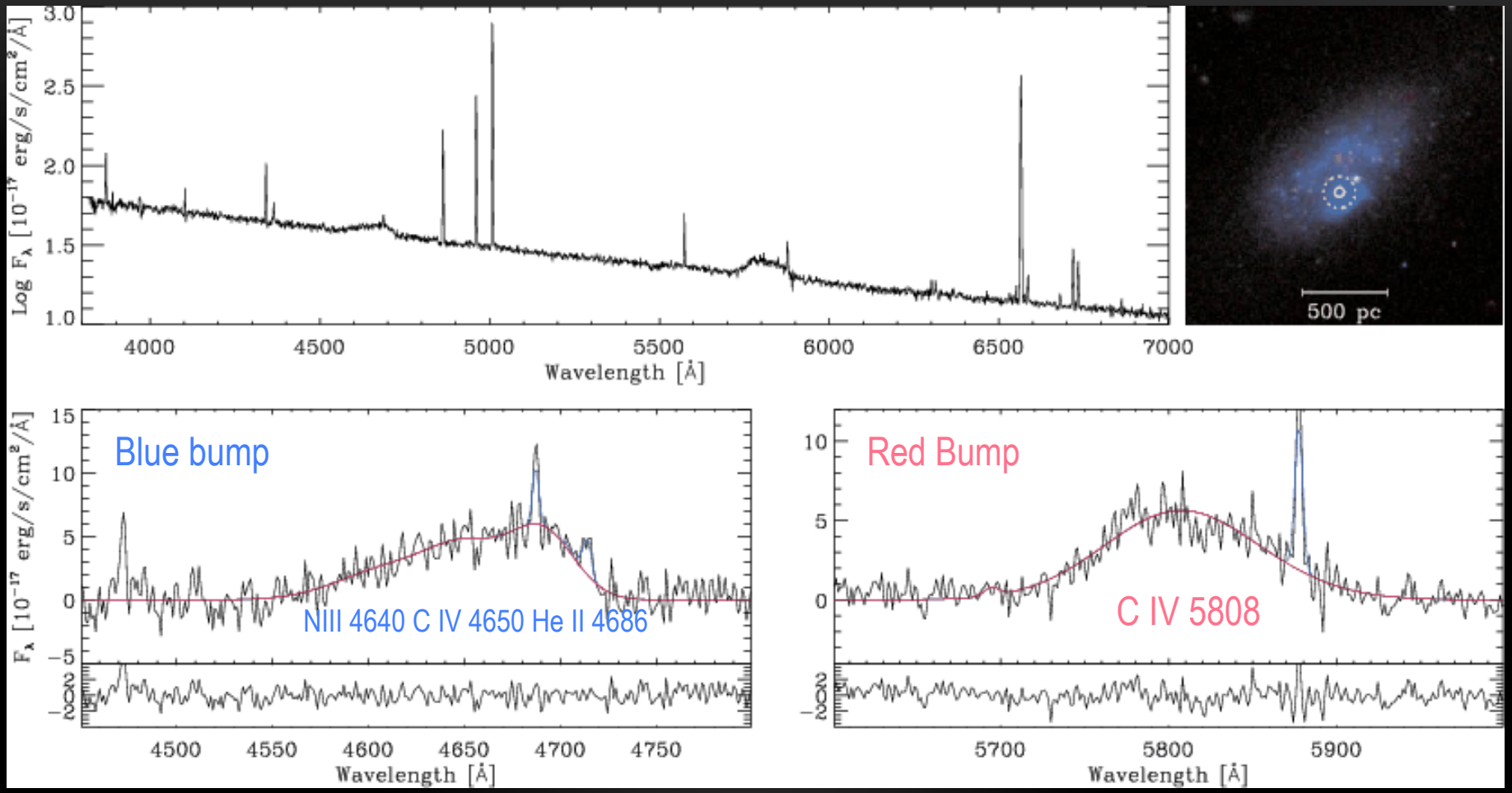
The WR phase:

- Appears nearly a 1-2 million year after the initiation of the star-burst
- Lasts only for about 5 million year or so.

- WR galaxies are therefore high temporal resolution tracers of the most recent episode of star formation activities in galaxies.

- That makes WR galaxies excellent objects to study triggering mechanisms of star formation in galaxies.

SDSS identification of WR galaxies (Brinchman, Kunth & Durret 2008)



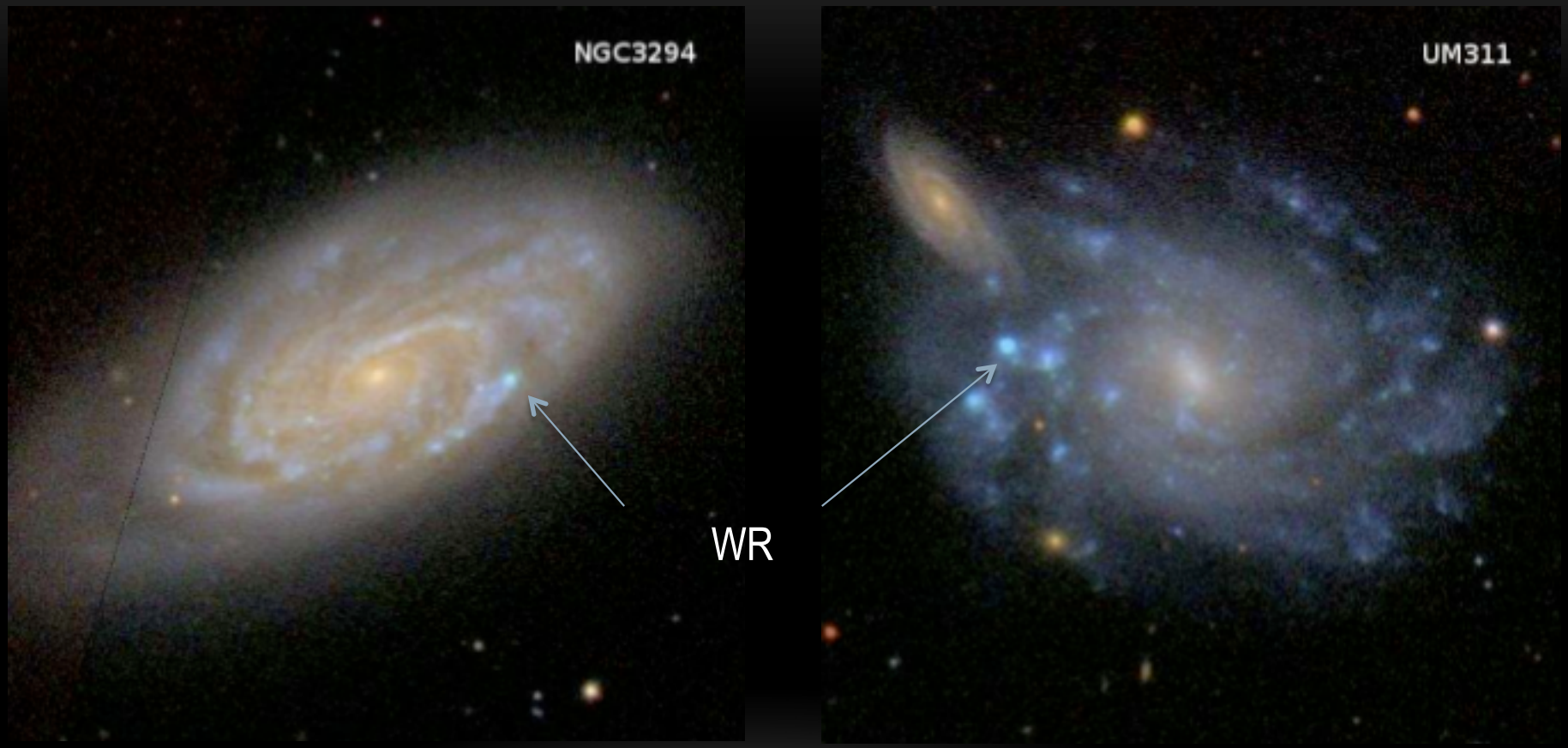
No. of WR galaxies identified are nearly 2000 in the nearby Universe (z < 0.2)

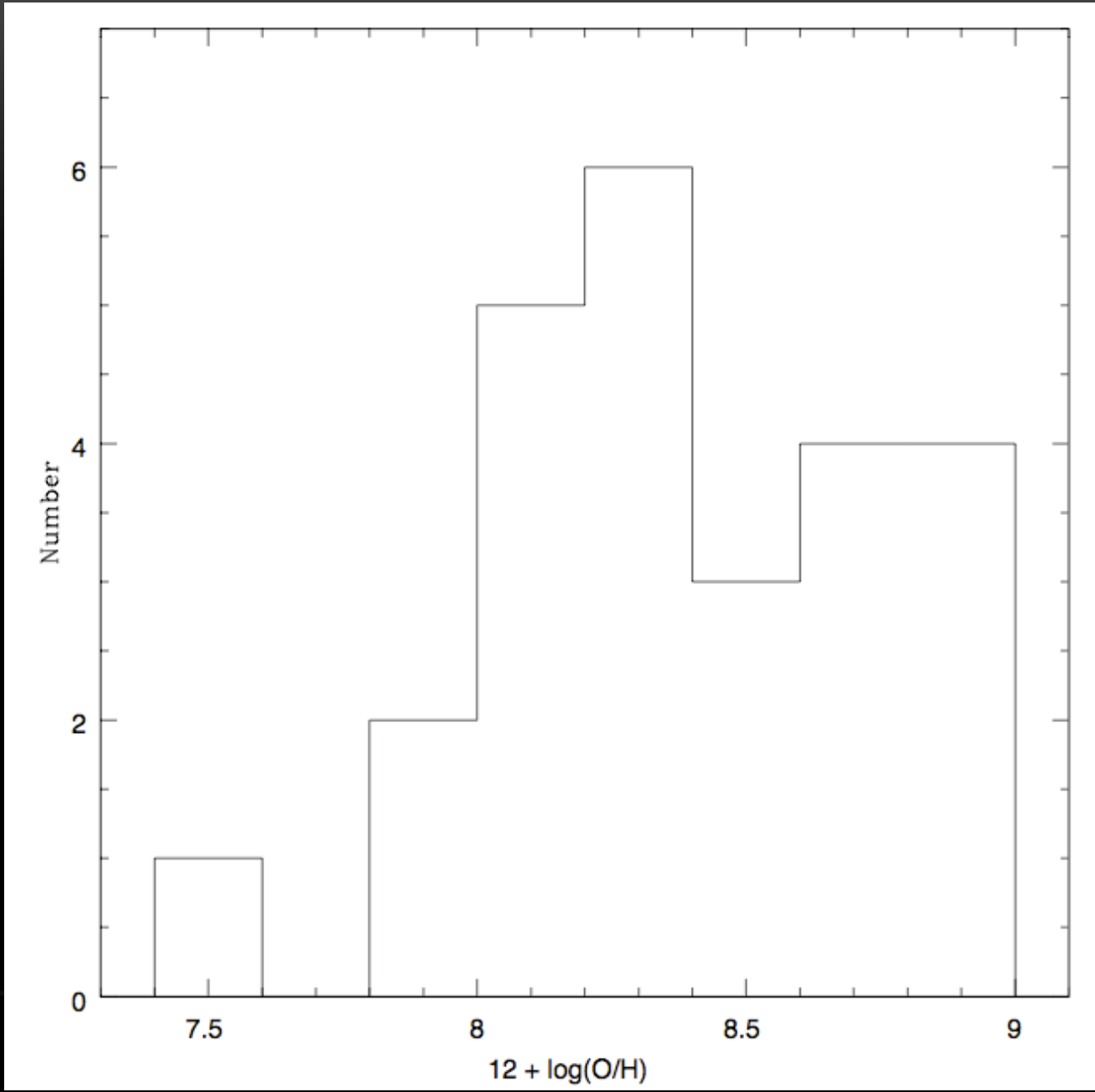
Hα and HI 21 cm-line surveys

- The overall star formation rates (SFR)
- The Hα morphology reveals mergers, tidal features??
- HI morphology reveals galaxy-galaxy interactions, faint companions such as HI cloud, LSB dwarfs etc.

- The observations are combined with data in other bands (far-ultraviolet from GALEX, far-infrared (IRAS etc.), 1.4 GHz radio (VLA-NVSS, FIRST) to constrain SFR.
- Internal extinction in galaxies & line contaminations in Hα band-pass filter is determined from the SDSS spectroscopic data (limited to 3" fibre diameter) – needed for accurate Hα photometry.

The WR region can be almost always identified as the brightest and the bluest region in the galaxy.

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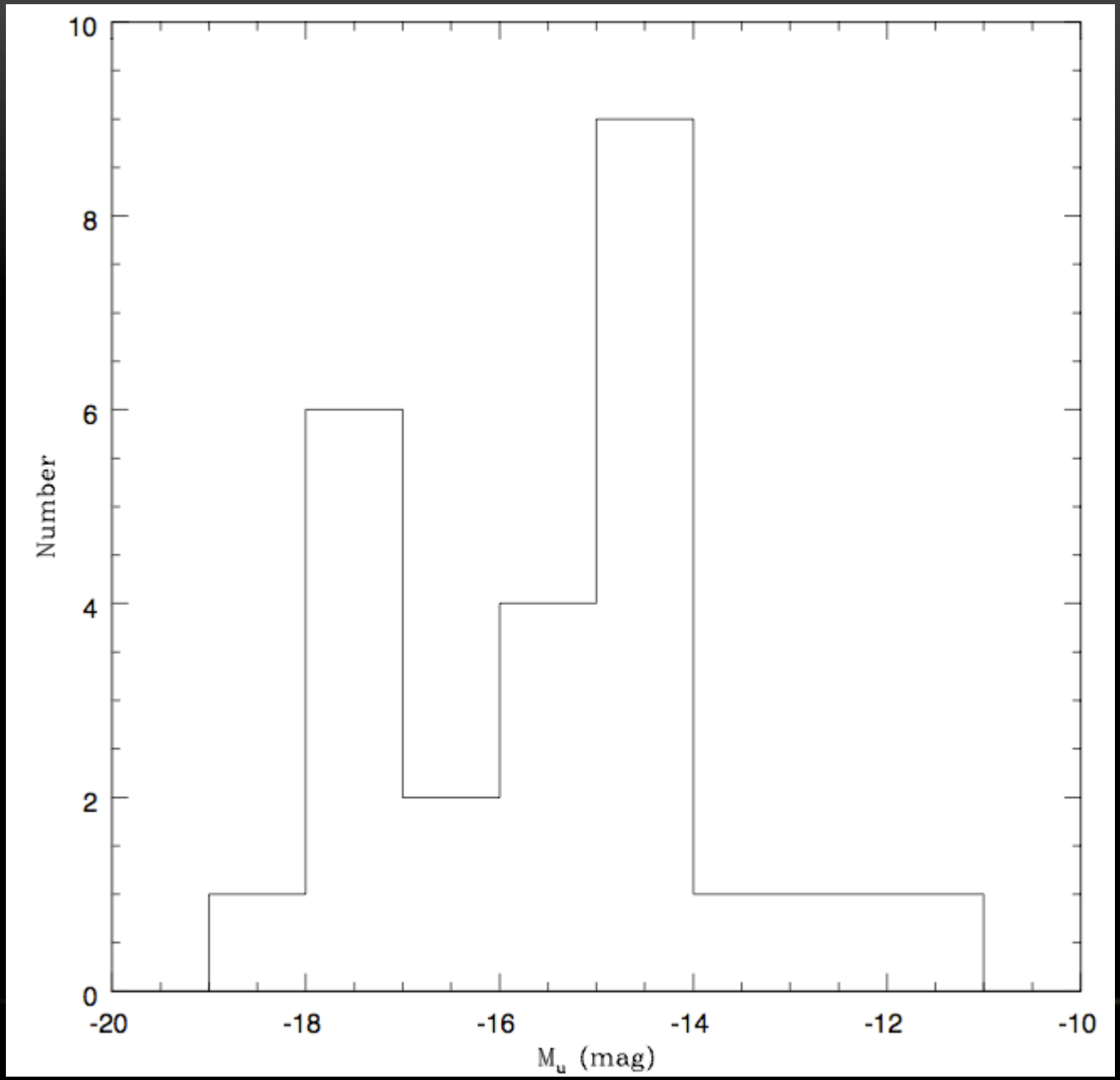
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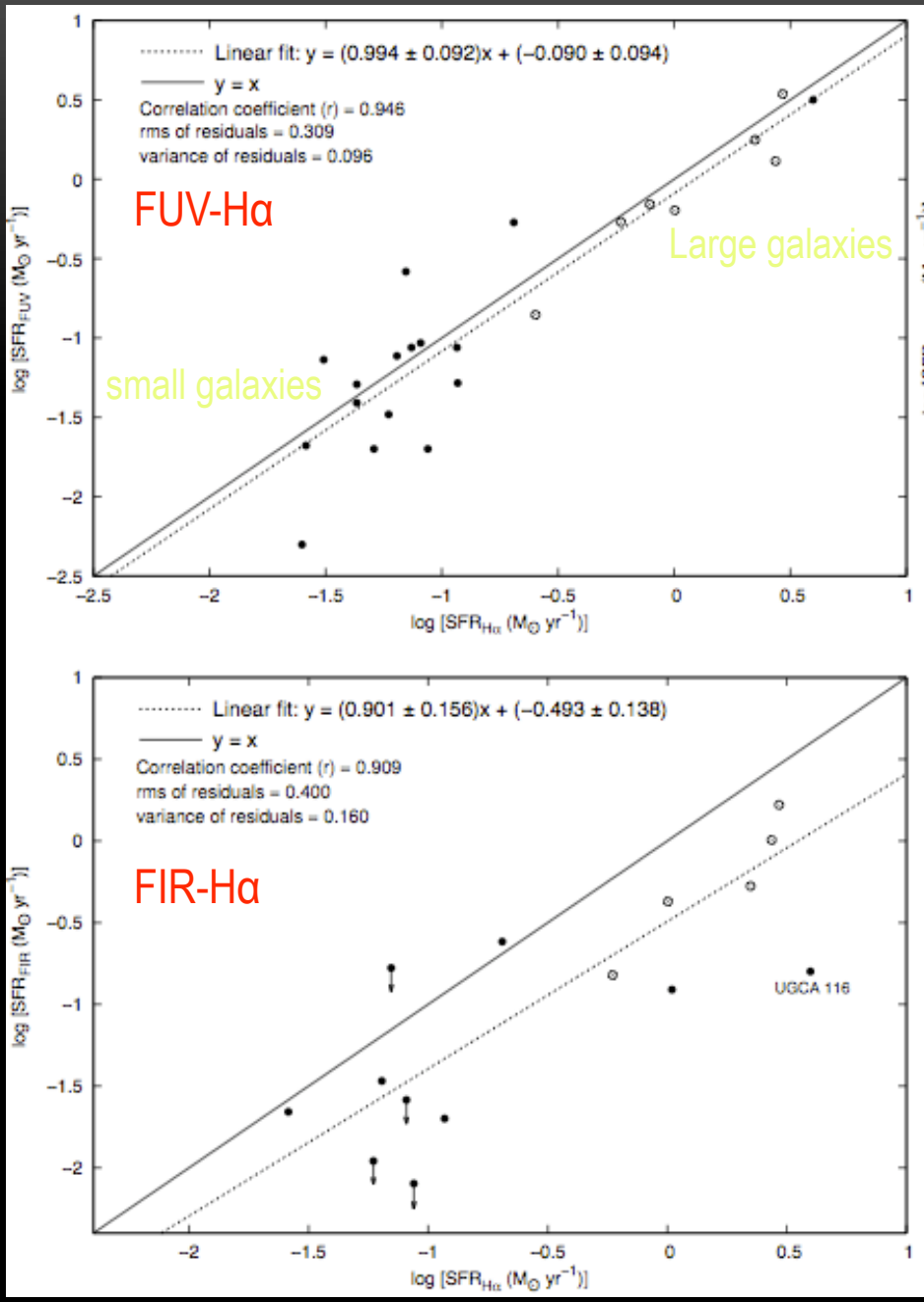
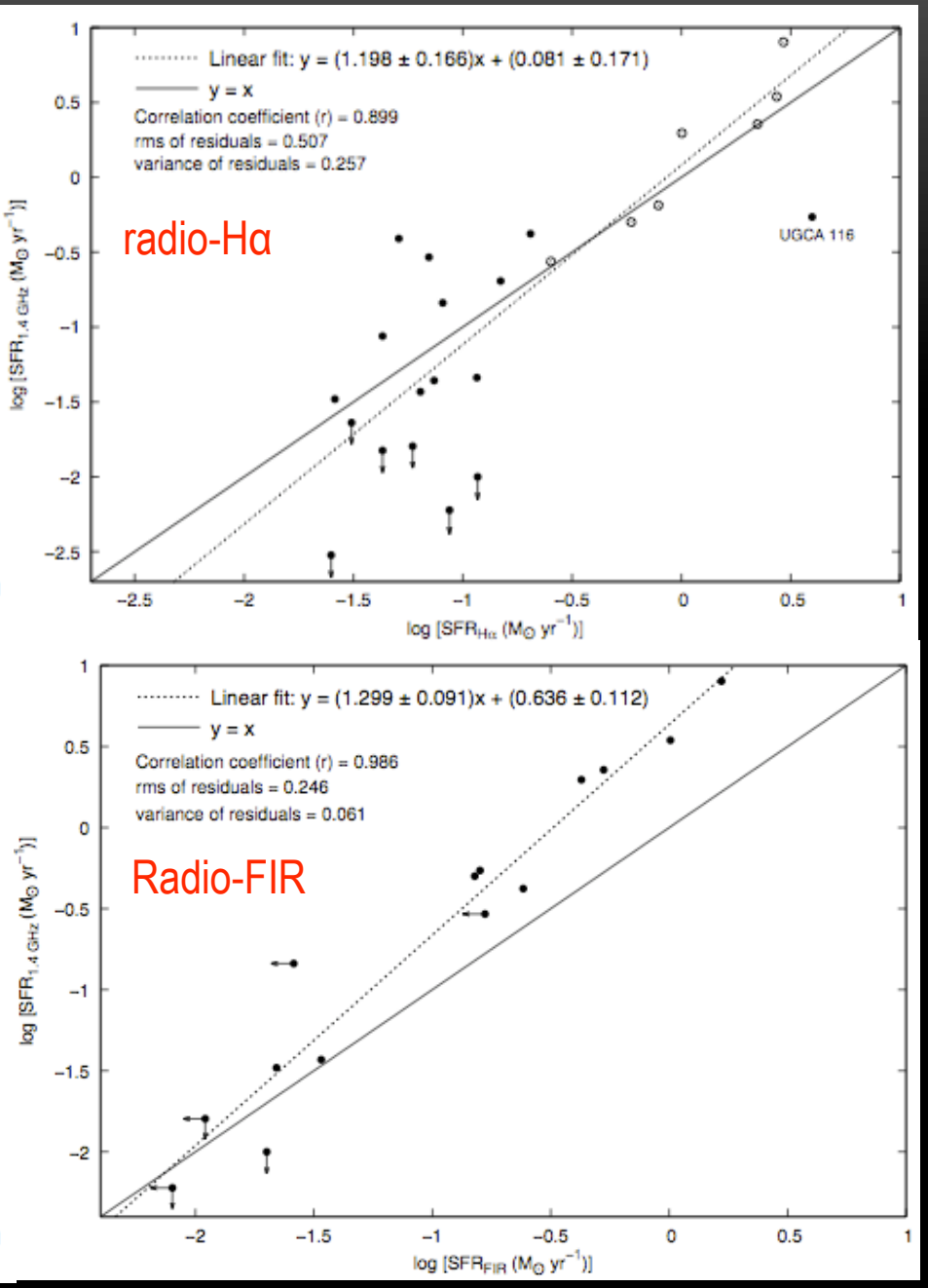
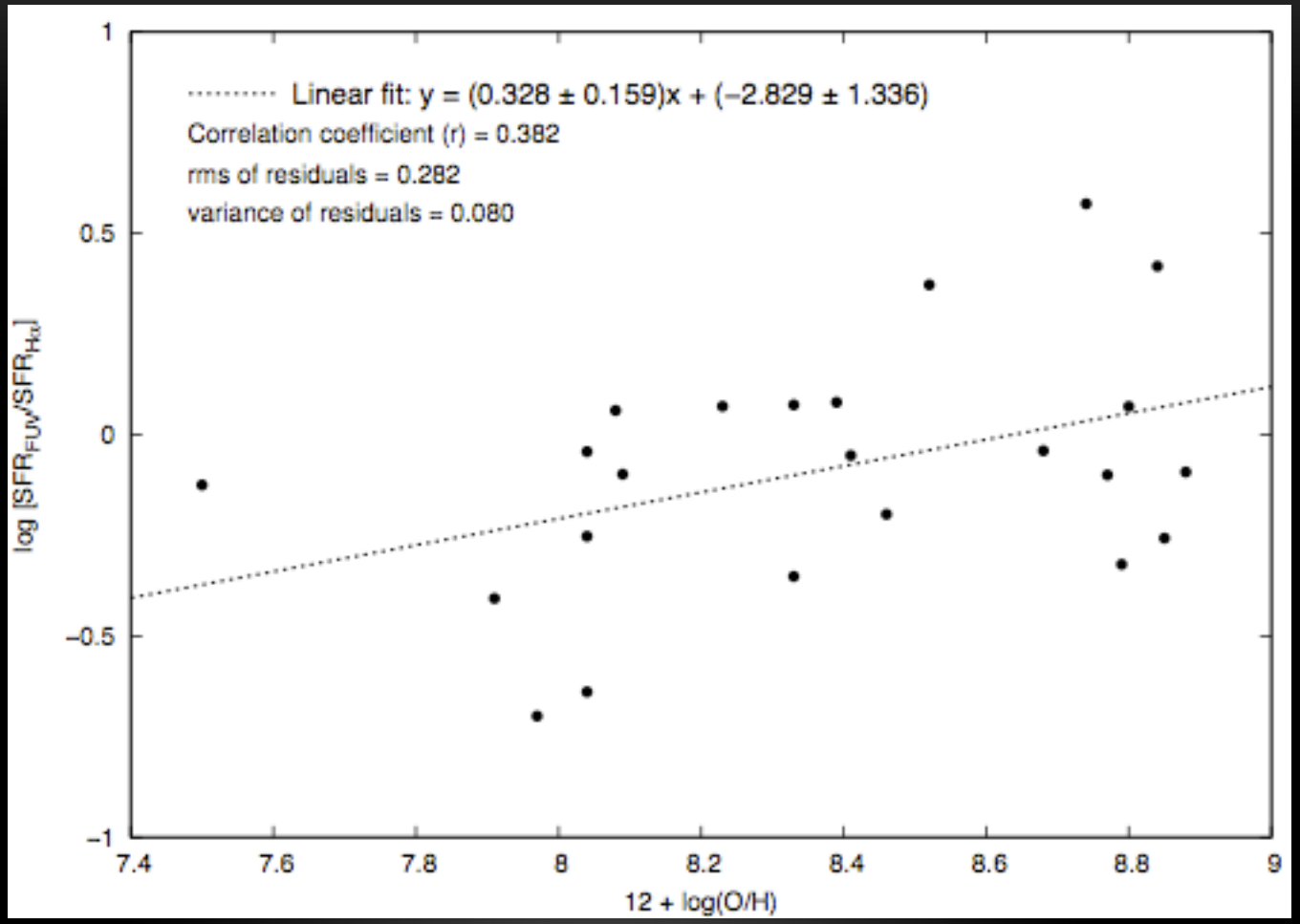




The scatter is large among dwarf WR galaxies: Extinction estimates?, radio deficient?, SFR calibration?

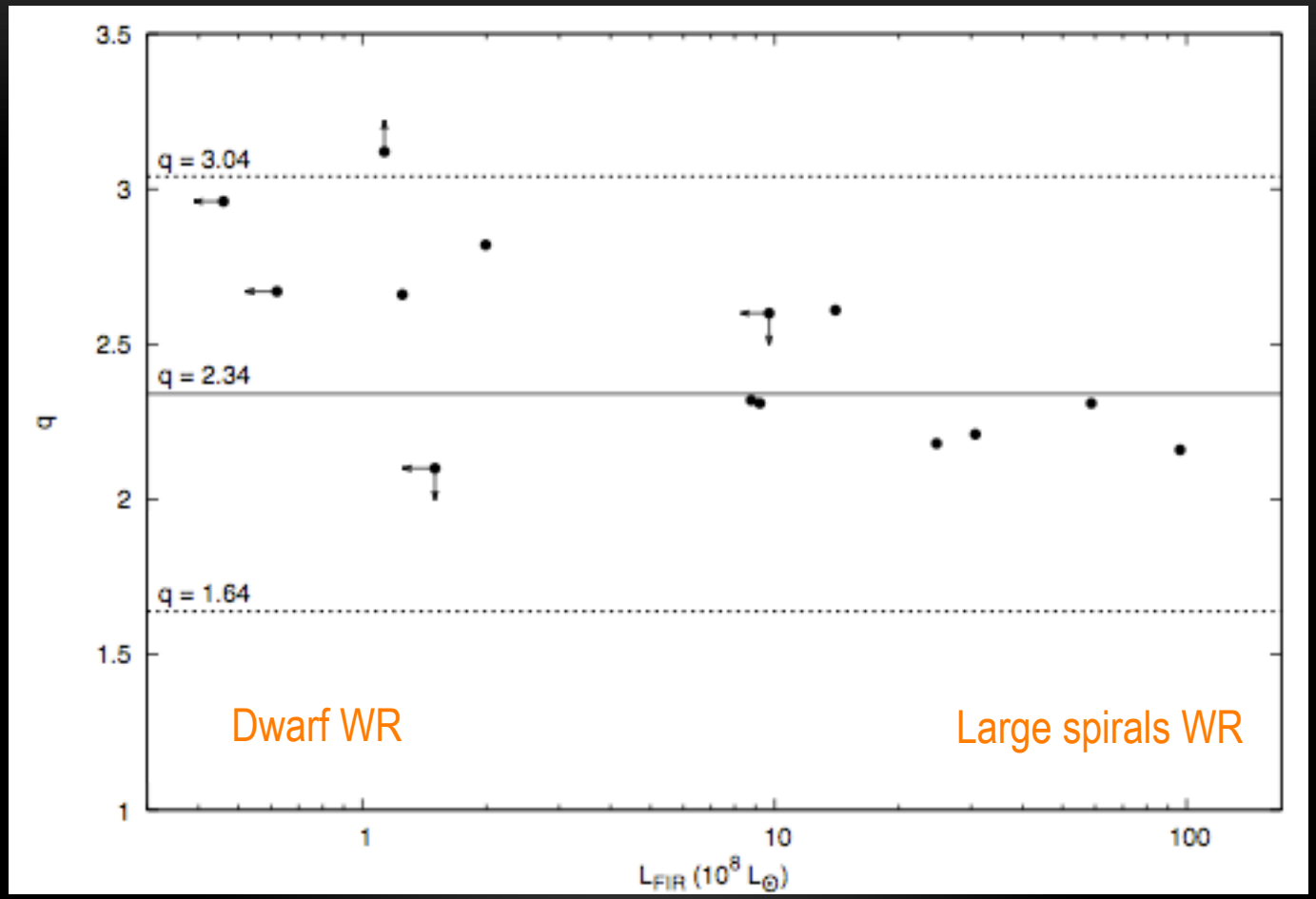
SFR (FUV/Hα) ratio has slight dependence on metallicity

SFR-flux calibration issue ?



Such a trend was also seen in another sample of WR galaxies by Lopez-Sanchez (2010)

‘q’ (radio-FIR correlation) parameter hints at a possible trend within the normal scatter limits from Yun et al. (2001)



Indicates radio deficiency in dwarf WR galaxies : Starburst is still young and has not produced enough supernova events responsible for radio emission.

Mrk 996 – dwarf WR galaxy: A case study

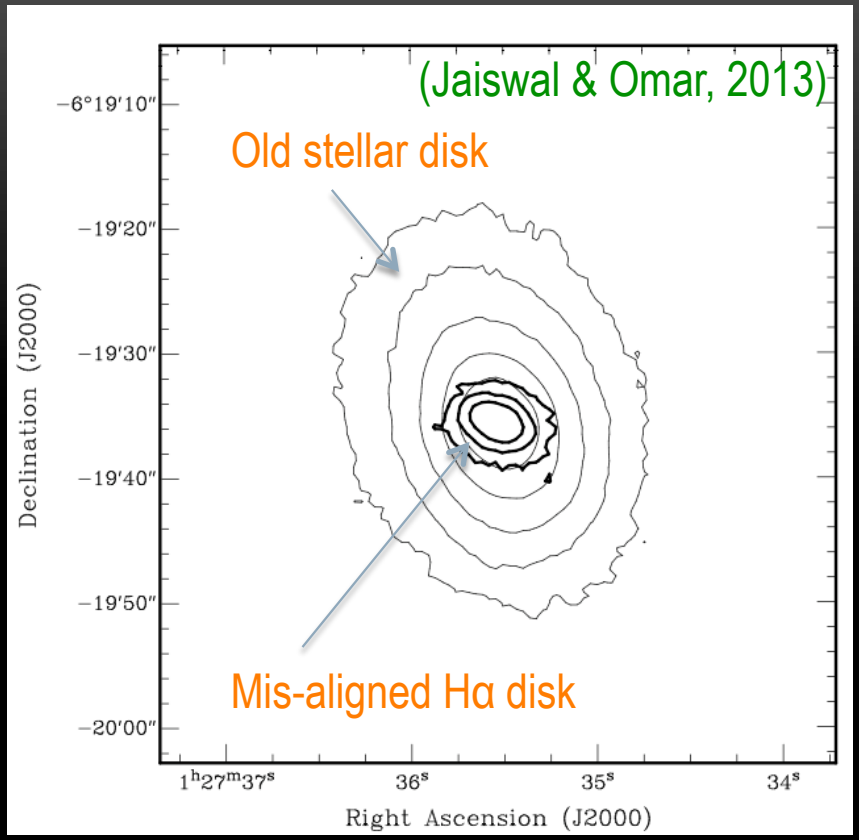
Metallicity = 0.2 solar

SFR (Hα & FIR) estimates as 0.5 M/yr, (corrected for low metallicity, line contaminations, & extinction)

- Expected 1.4 GHz radio flux

  non-thermal ~ 5 mJy
  thermal ~ 0.5 mJy

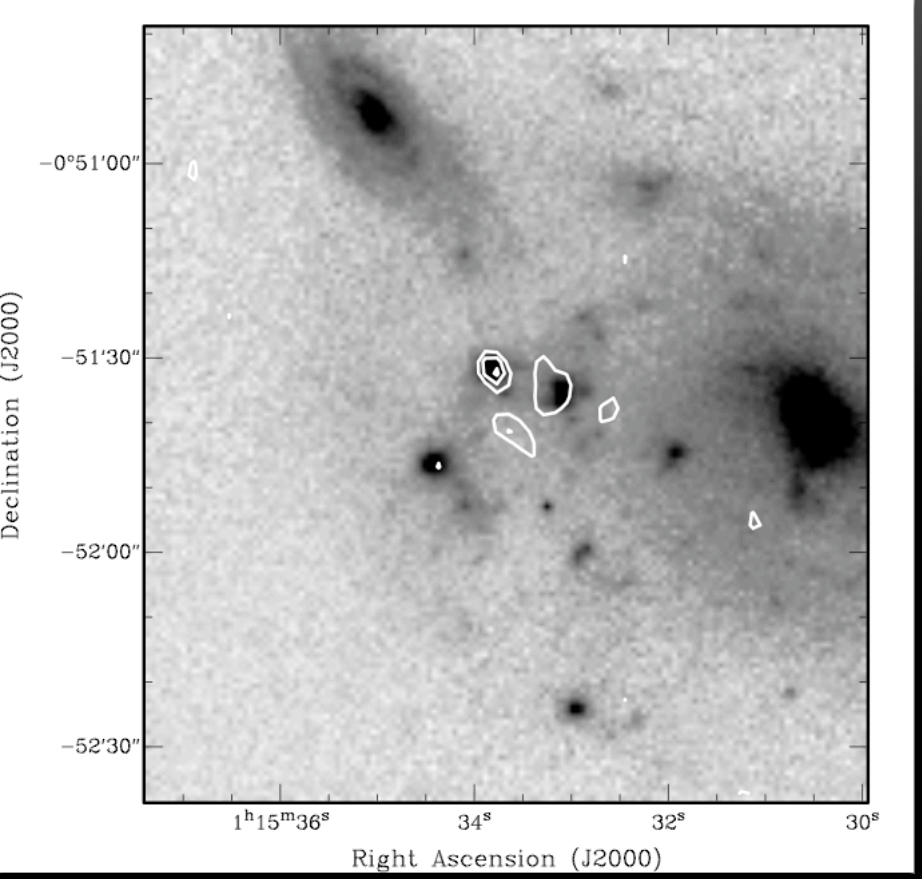
- Detected flux @ 1.4 GHz
  = 0.5 (+/- 0.2) mJy

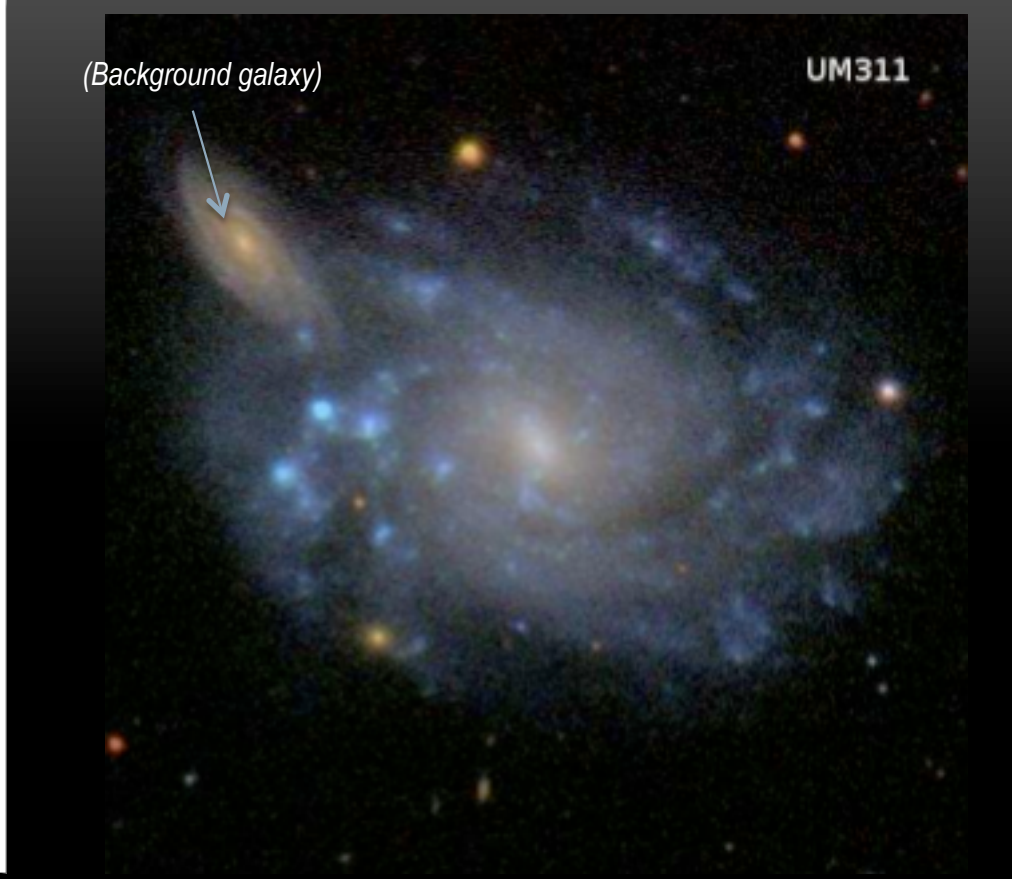


- Indicates that supernovae events have not taken place from the present episode of massive star formation in the galaxy. (Radio deficient galaxy in radio-FIR correlation)

- Supported by large N/O ratio in the galaxy compared to other dwarf galaxies.

- Mrk 996 is a very recent merger as revealed by Hα observations.





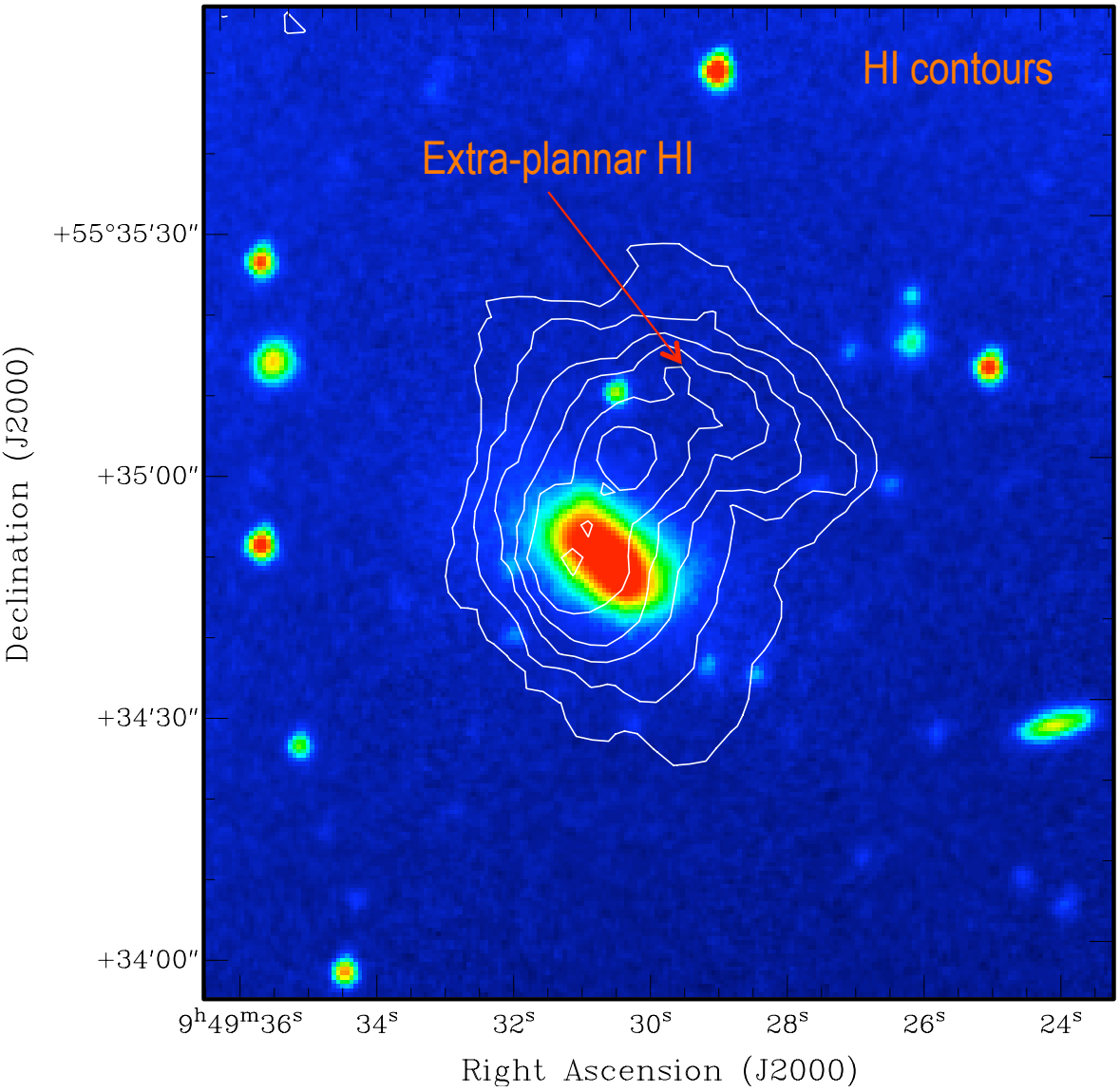
1.4 GHz radio continuum contours on optical image

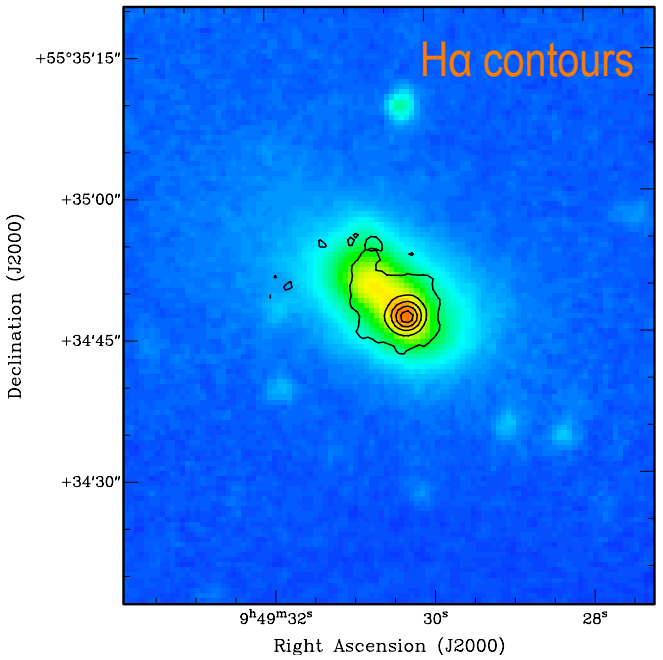
UM 311 (v=1675 km/s) is a HII region complex on the face on spiral galaxy NGC 450 (v=1761 km/s)

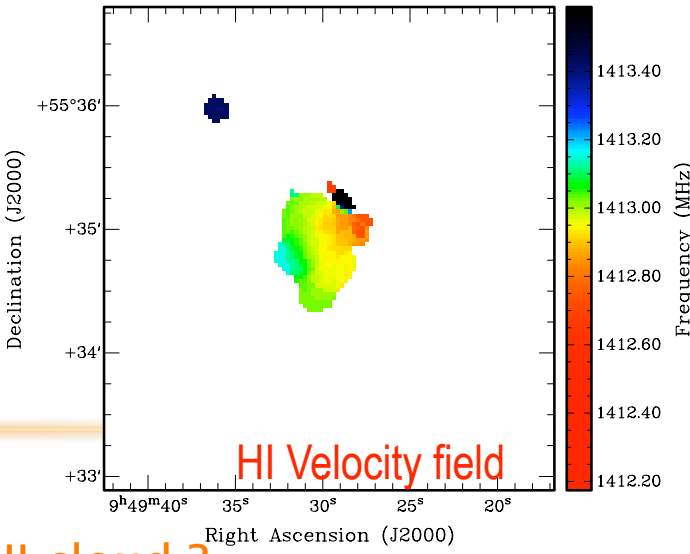
- radio emission is seen from this complex
- CO emission is also detected from UM 311 *(Cormier et al. 2014)*

➢ Indicates that UM 311 complex is a dwarf galaxy undergoing minor interaction with NGC 450.

Dwarf WR galaxy

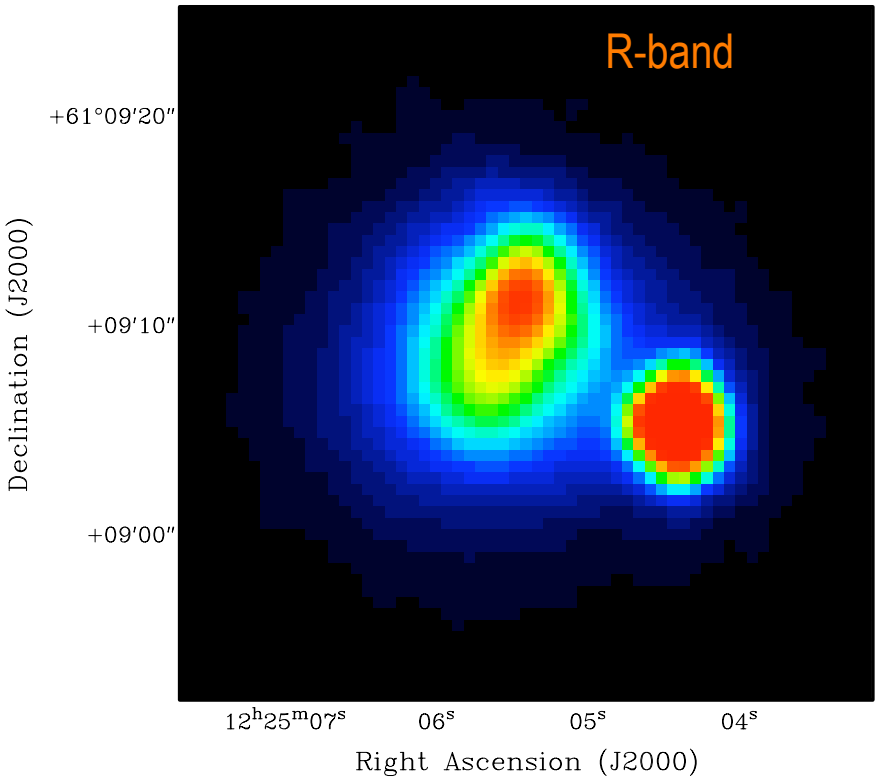


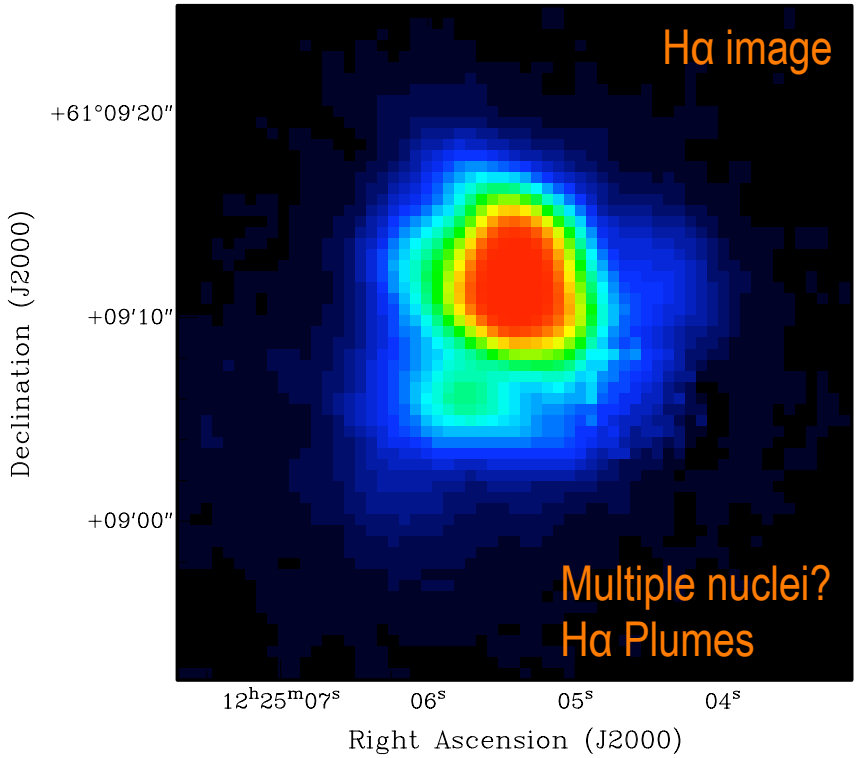




Early type galaxy; Gas disk (?) misaligned with stellar disk.

➢ Accretion of HI? Interaction with HI cloud ?

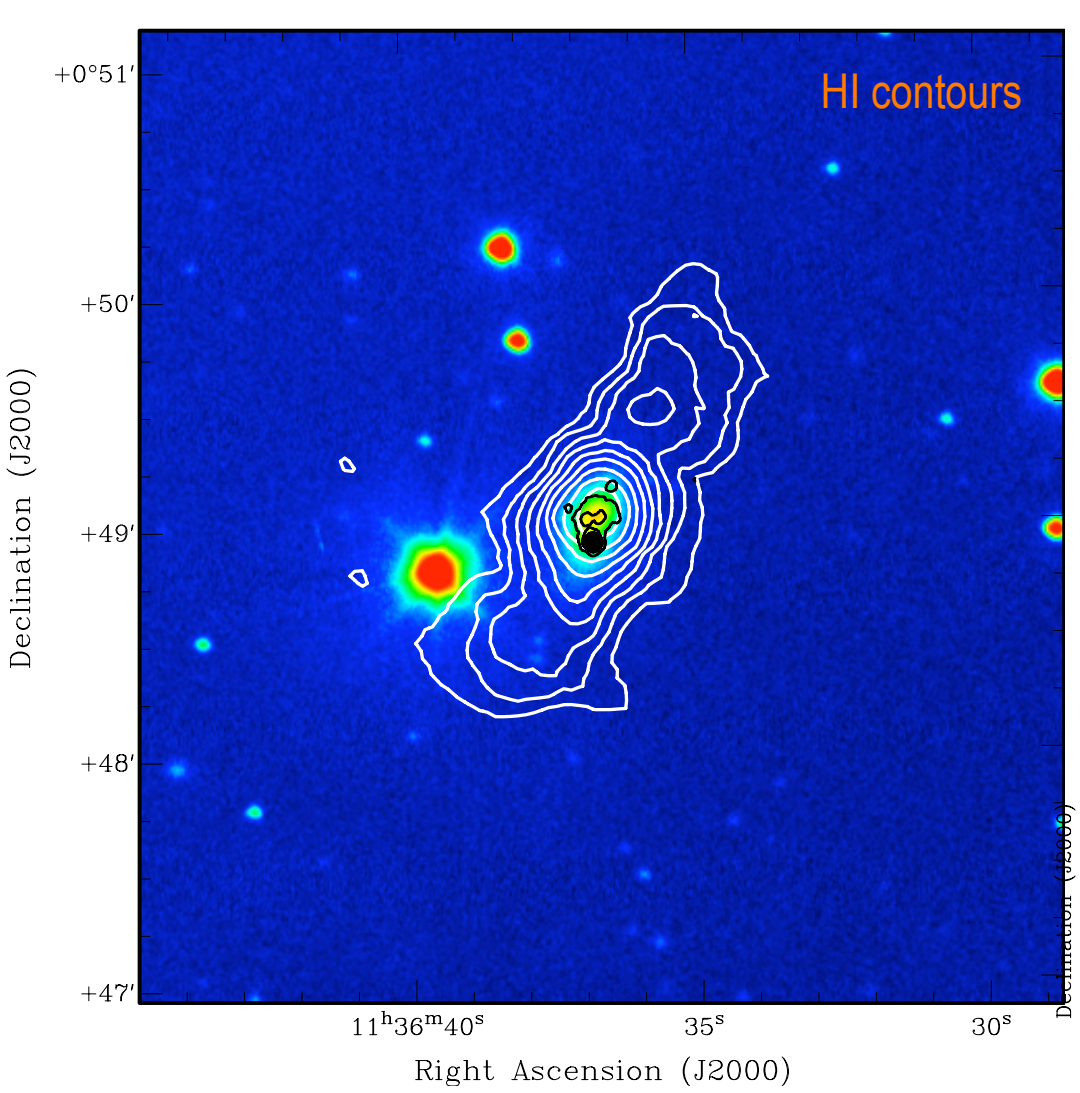


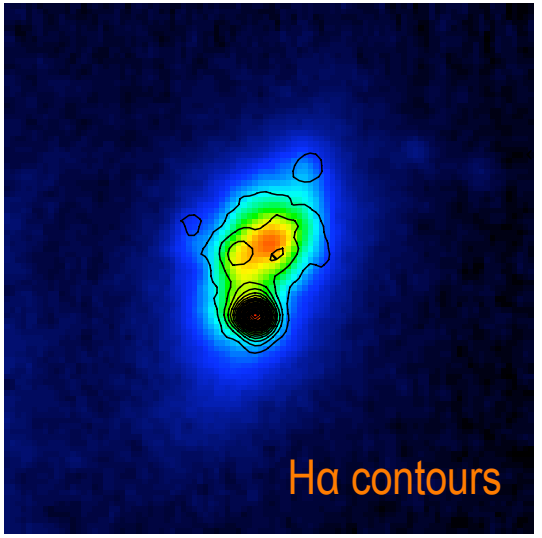


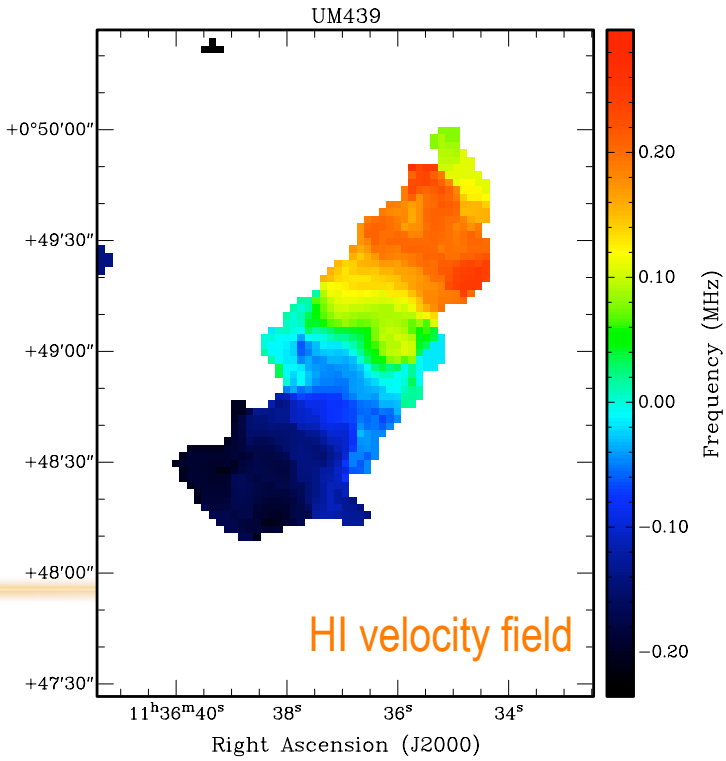
- No HI detection;

Multiple nuclei – merger?, mostly ionized gas in the galaxy

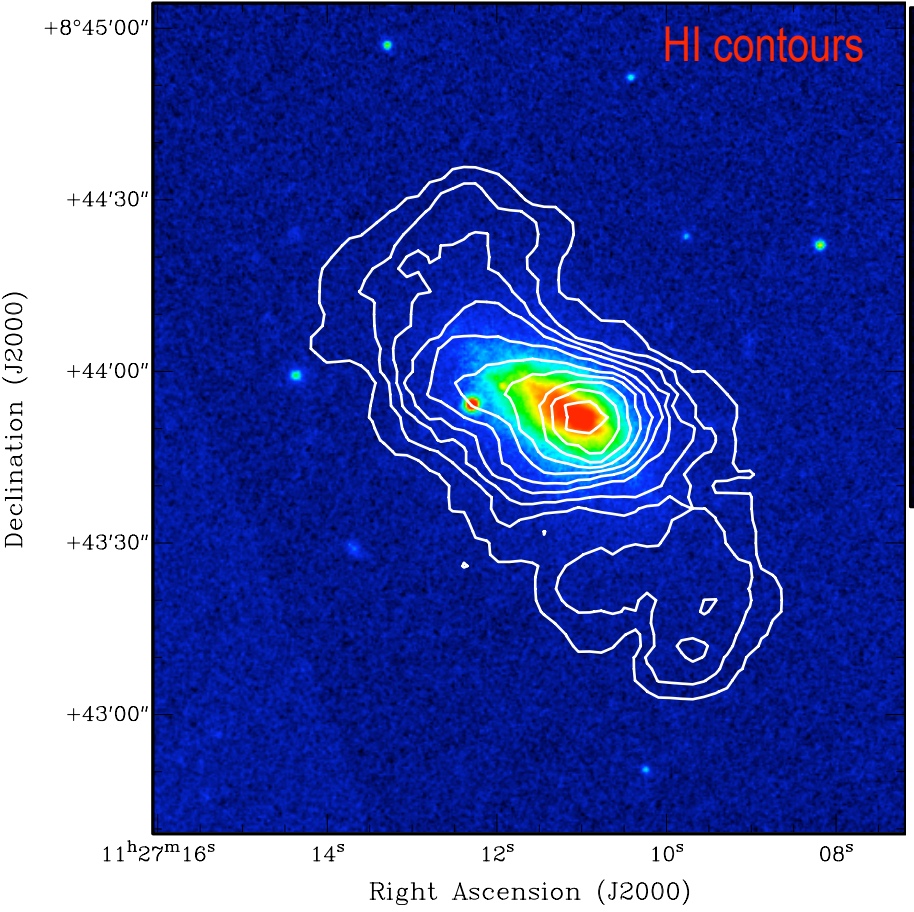
[Hα EW ~ 363 (intense star-burst)]

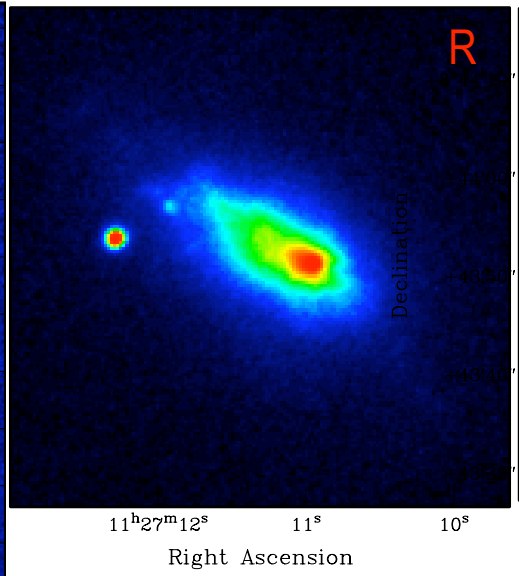


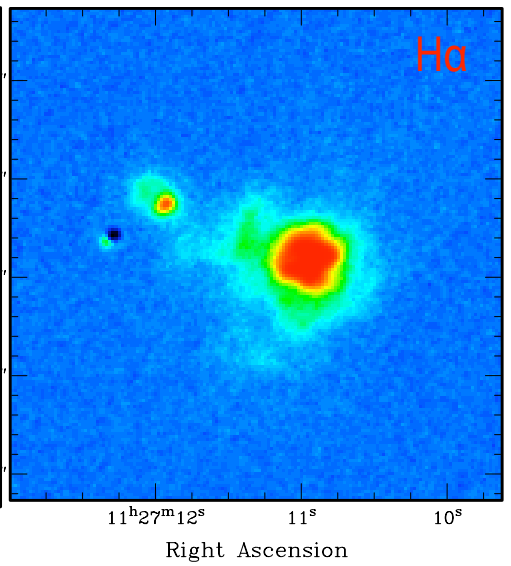


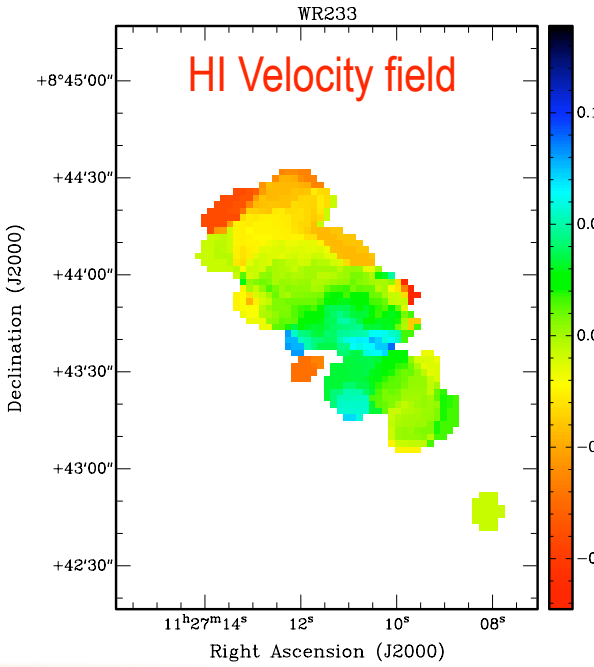


Irregular HI velocity field (multiple systems)
Indicates merger? Or accretion?



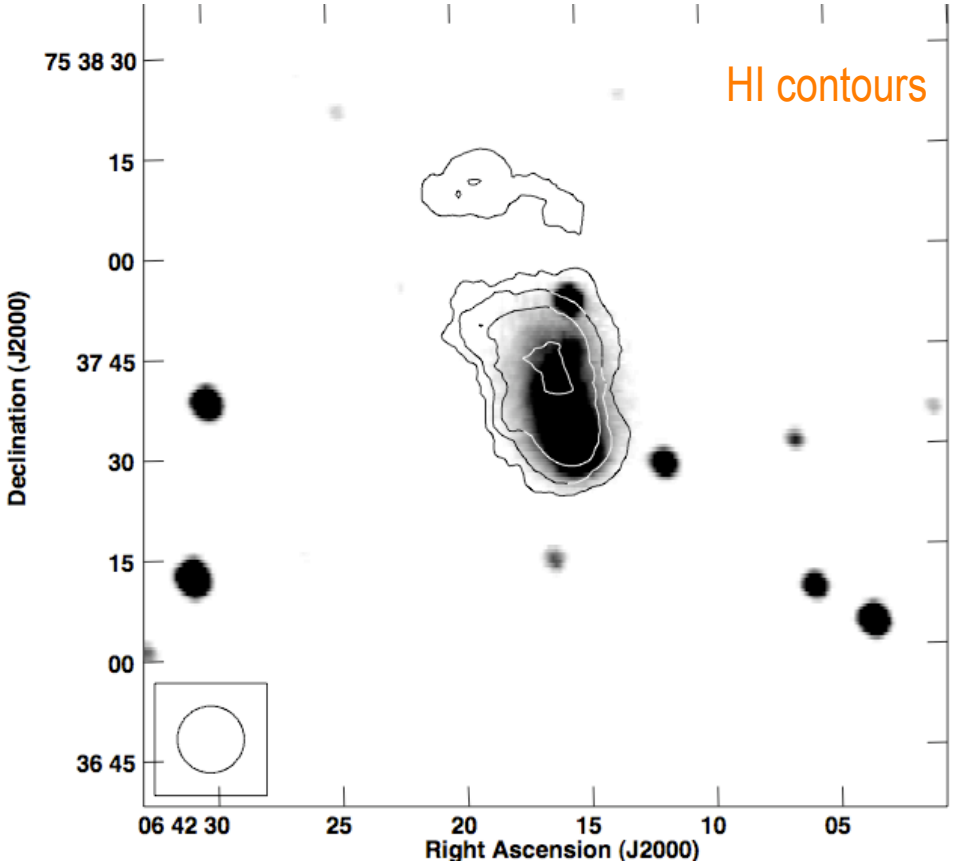


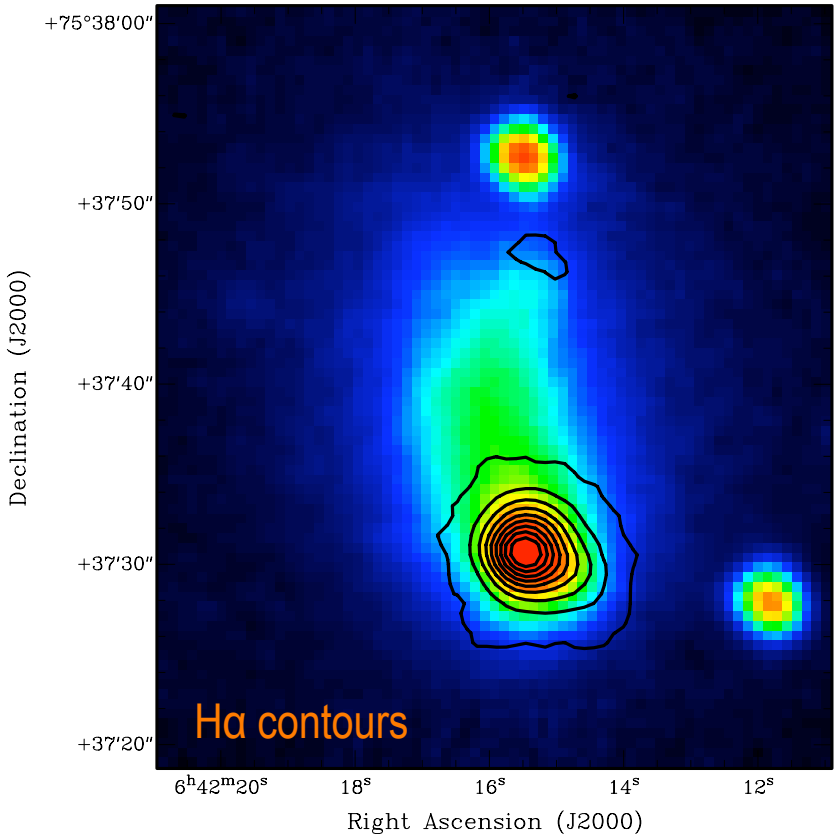




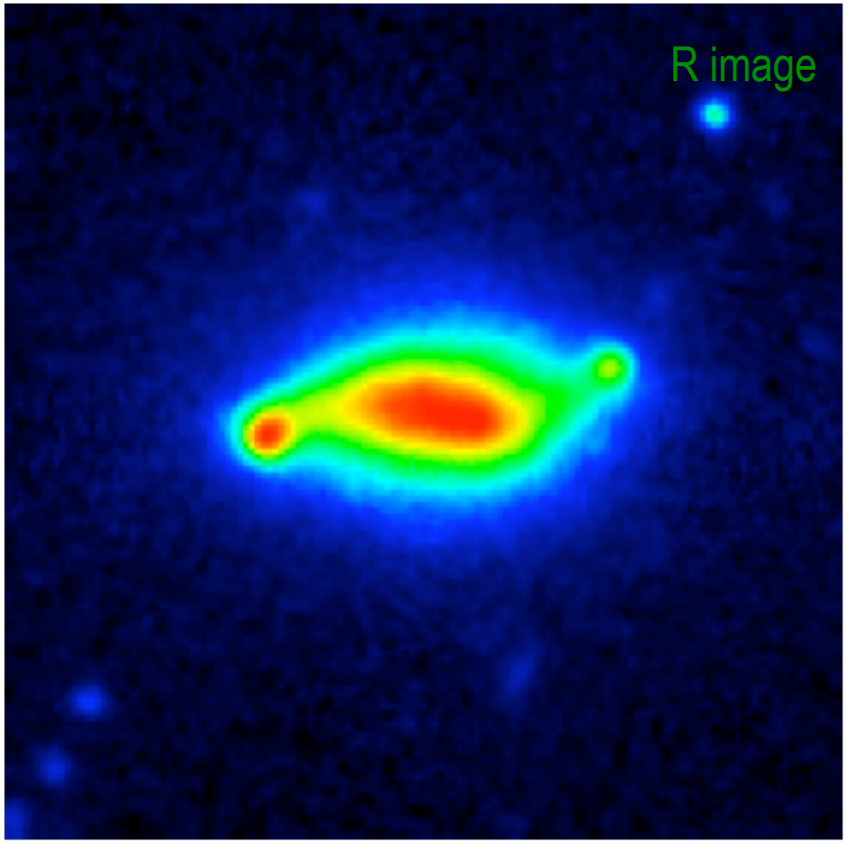
Multiple nuclei, plumes in Hα?
EW = 82 A (star-burst)

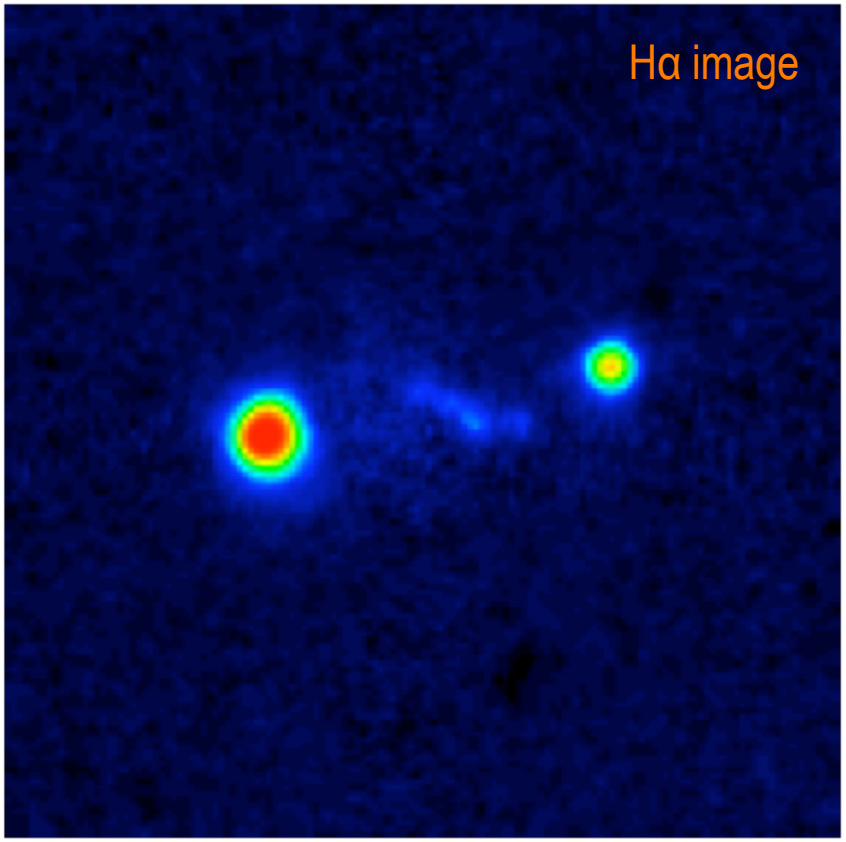
HI velocity field is irregular
Interaction with HI clouds/dwarf galaxy?



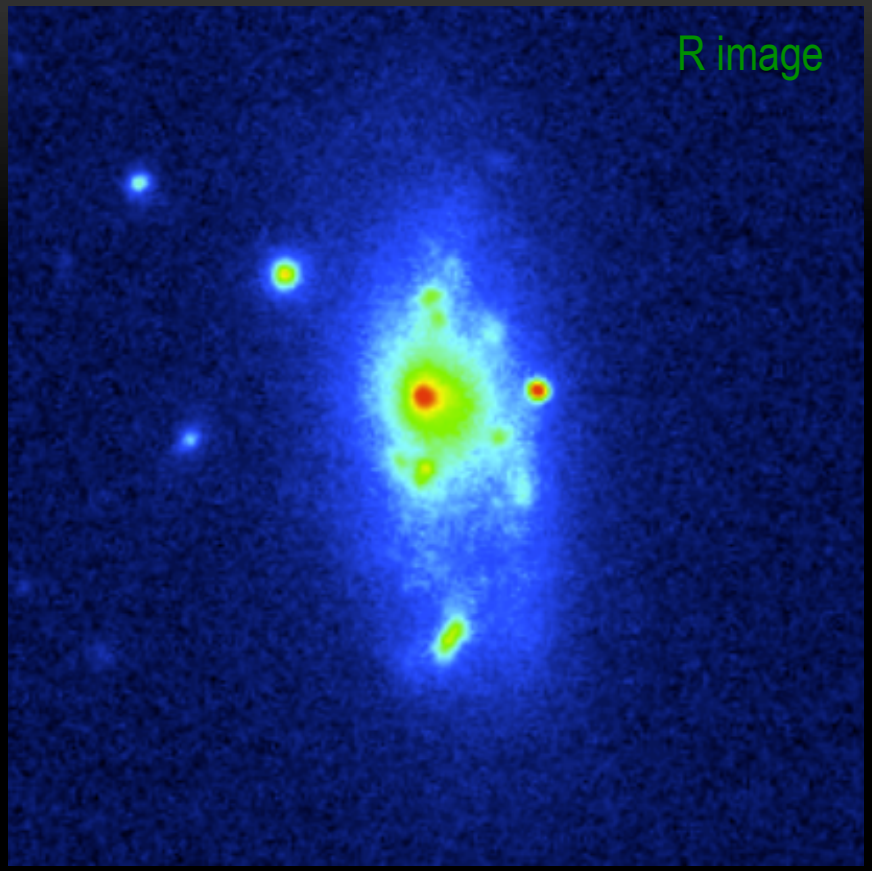


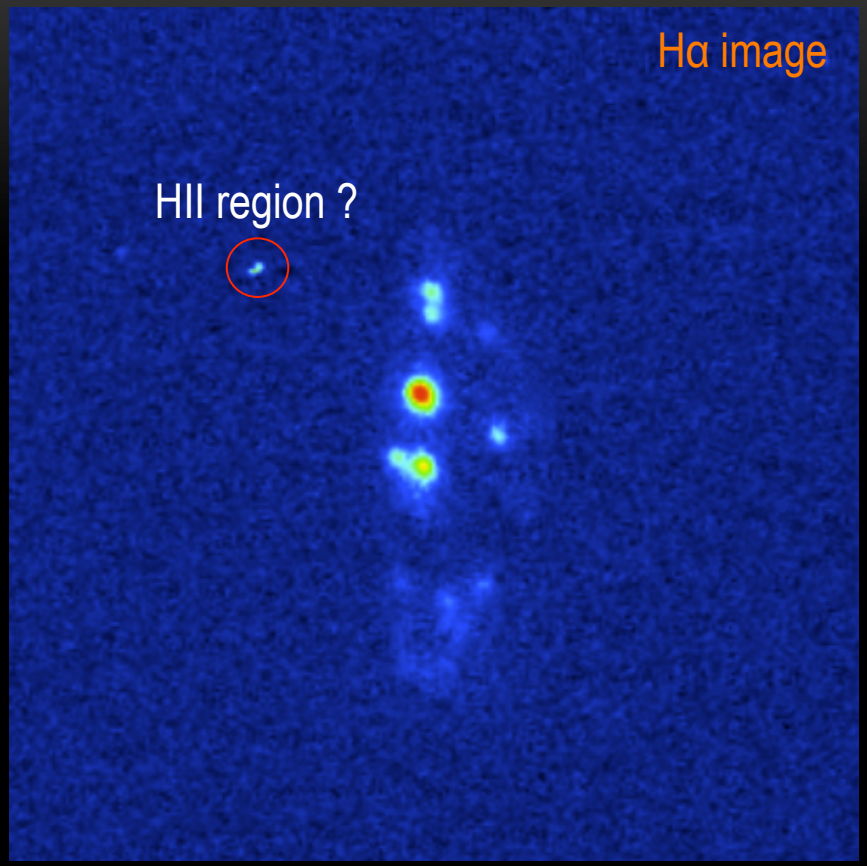
HI clouds/interaction with dwarf galaxy?

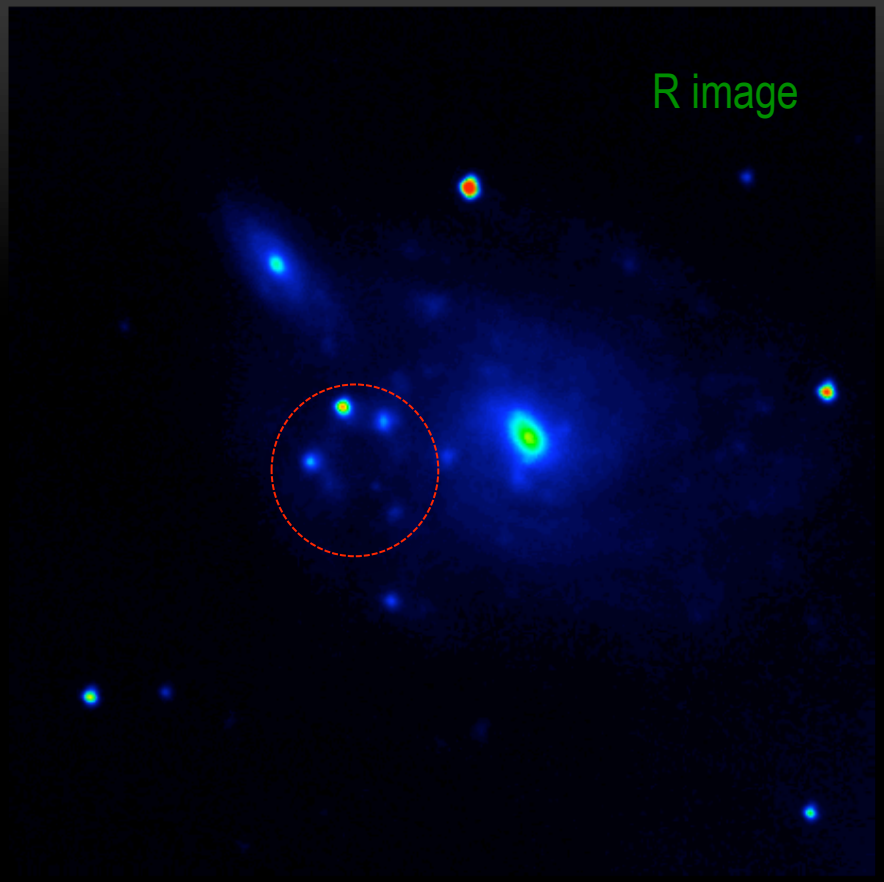




No HI data obtained yet.
Very intriguing star formation morphology


R image


Hα image
HII region ?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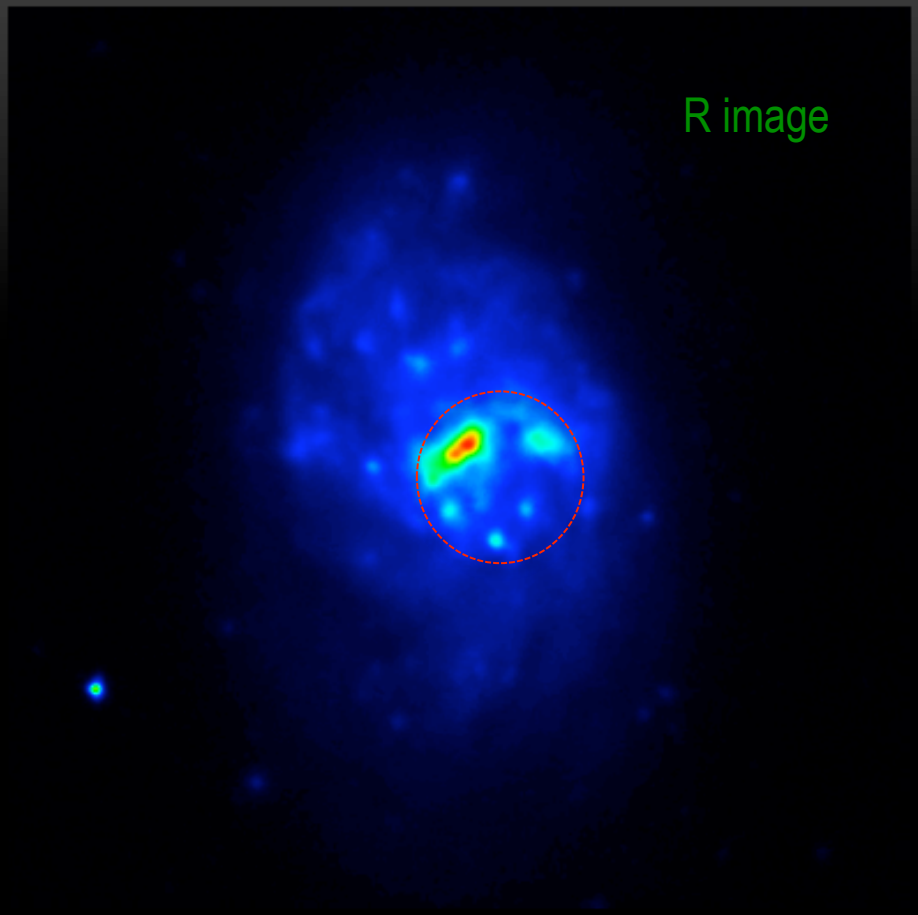
Hα image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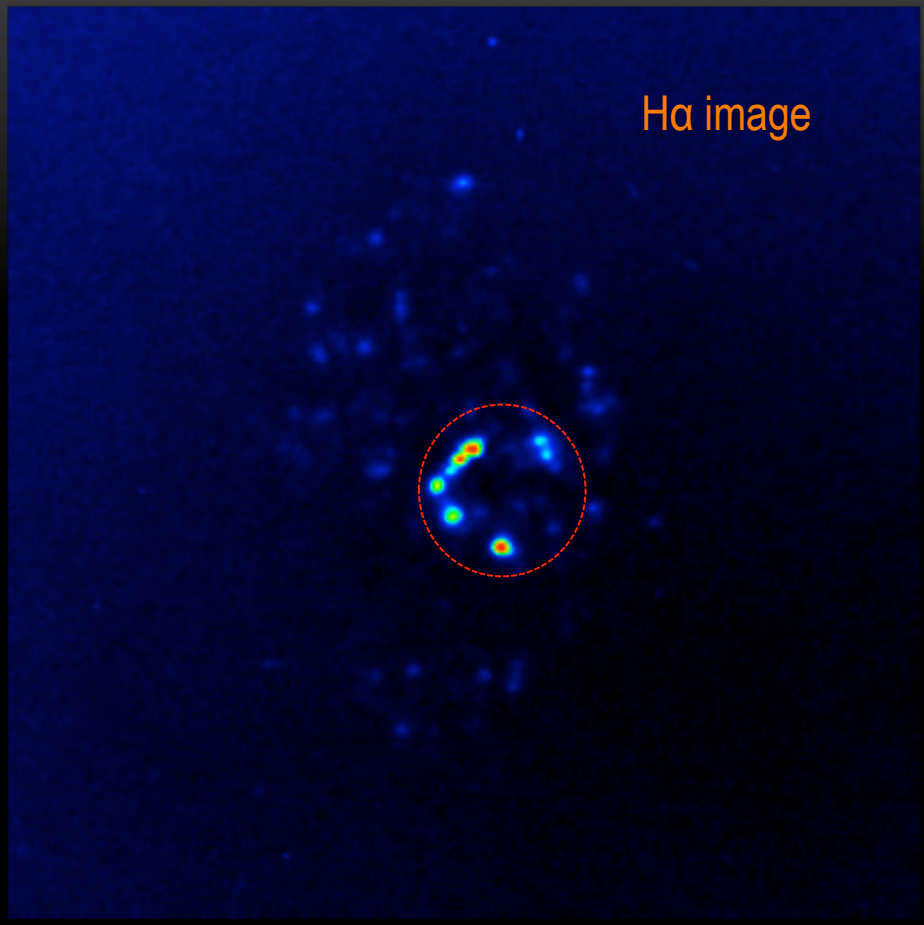
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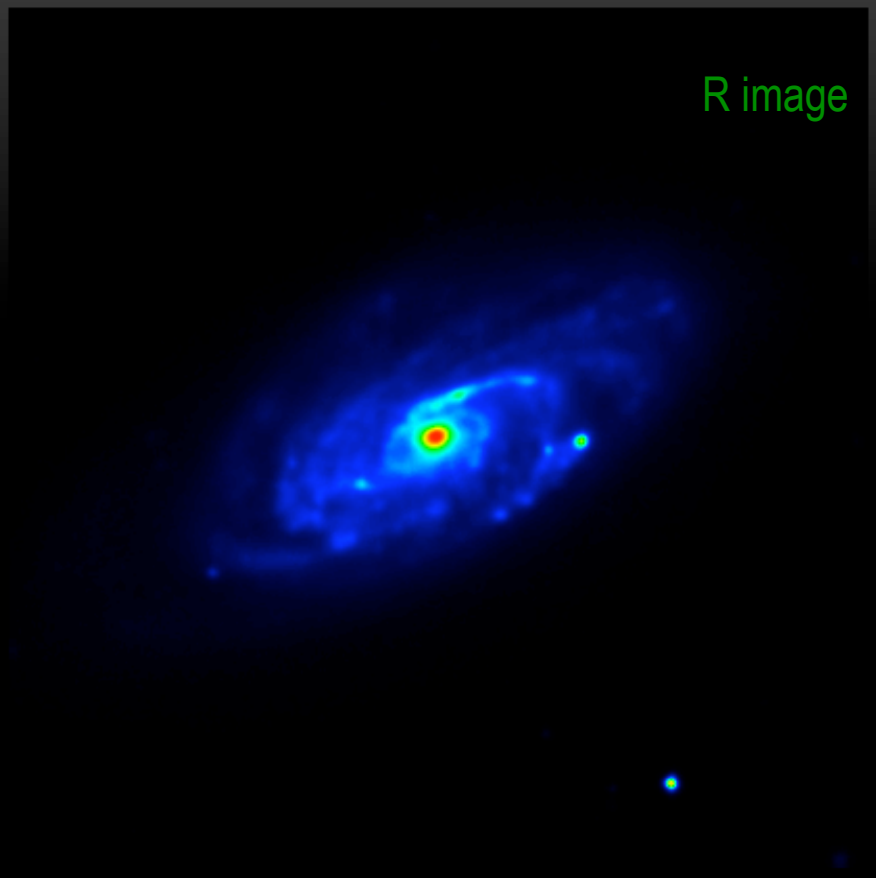
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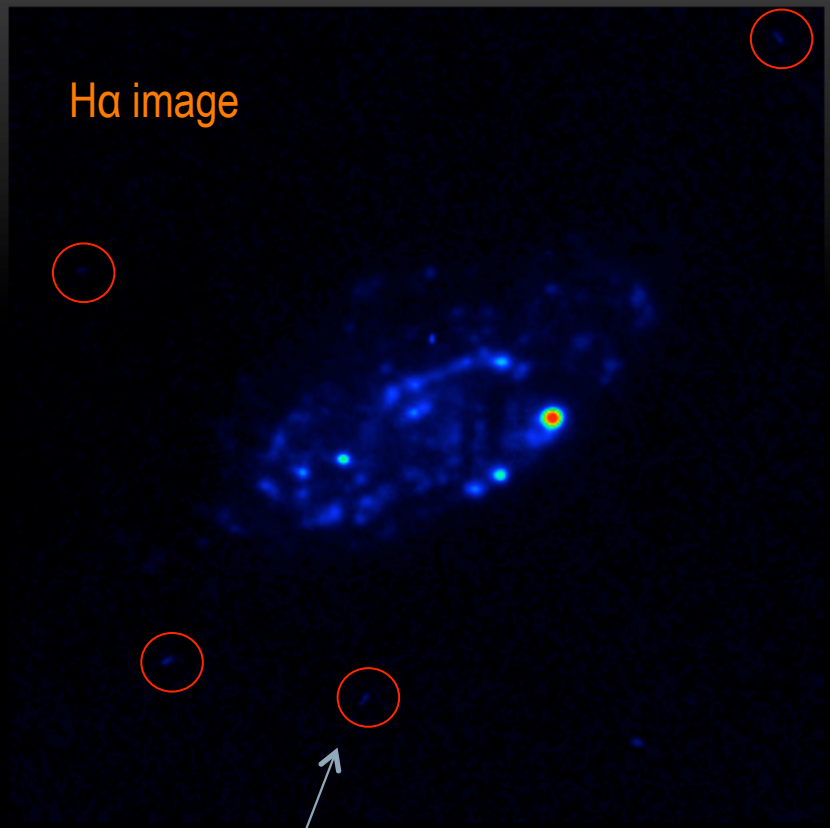
Hα image
HII region ?

Summary

- We find that Wolf-Rayet region in galaxies is always associated with a distinct brightest HII region in the galaxy.
- The Hα image reveal intense star formation with hints of multiple nuclei, misaligned Hα disks – indicative of merger or interactions.
- HI images/velocity field in many cases – supports the interaction hypothesis. The interactions appear to be minor (with low mass objects like dwarfs, HI clouds?)
- Accretion of gas in these galaxies – a good possibility.
- WR galaxies are ideal objects to study star-burst triggers in galaxies.
- Dwarfs WR galaxies appear radio-deficient in radio-FIR correlation.