

Surveys and Populations of Wolf-Rayet Stars

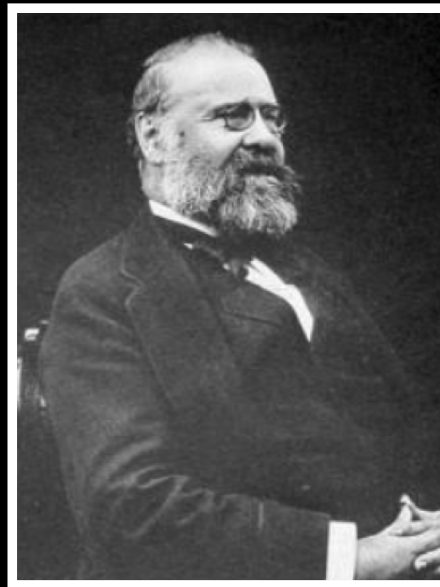
Kathryn Neugent

University of Washington

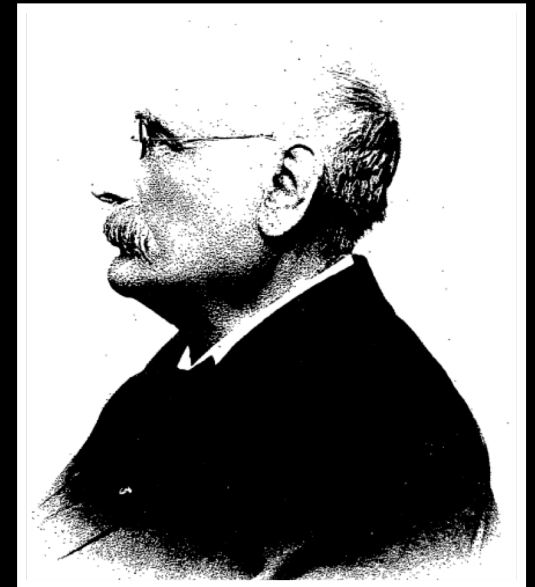
Lowell Observatory

Discovery

- 1867 at Paris Observatory
- Visual spectrometer
- Three stars in Cygnus with strong emission lines



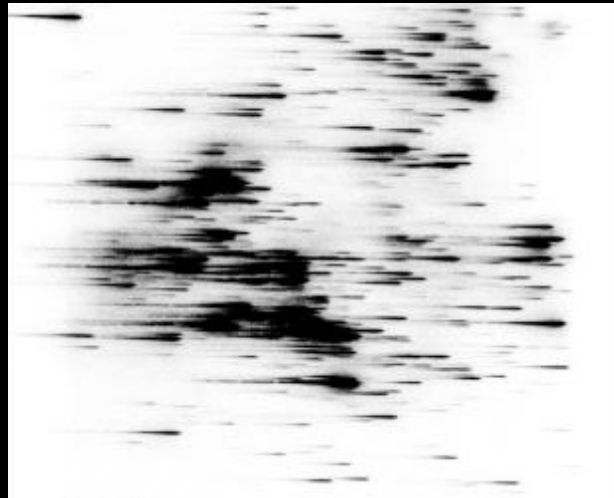
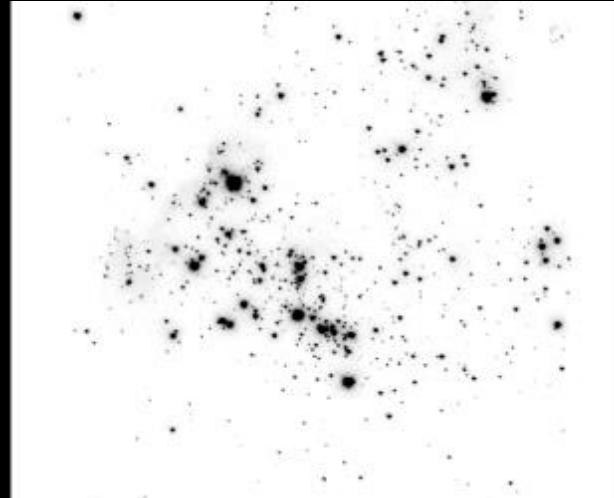
Georges Rayet
1839-1906

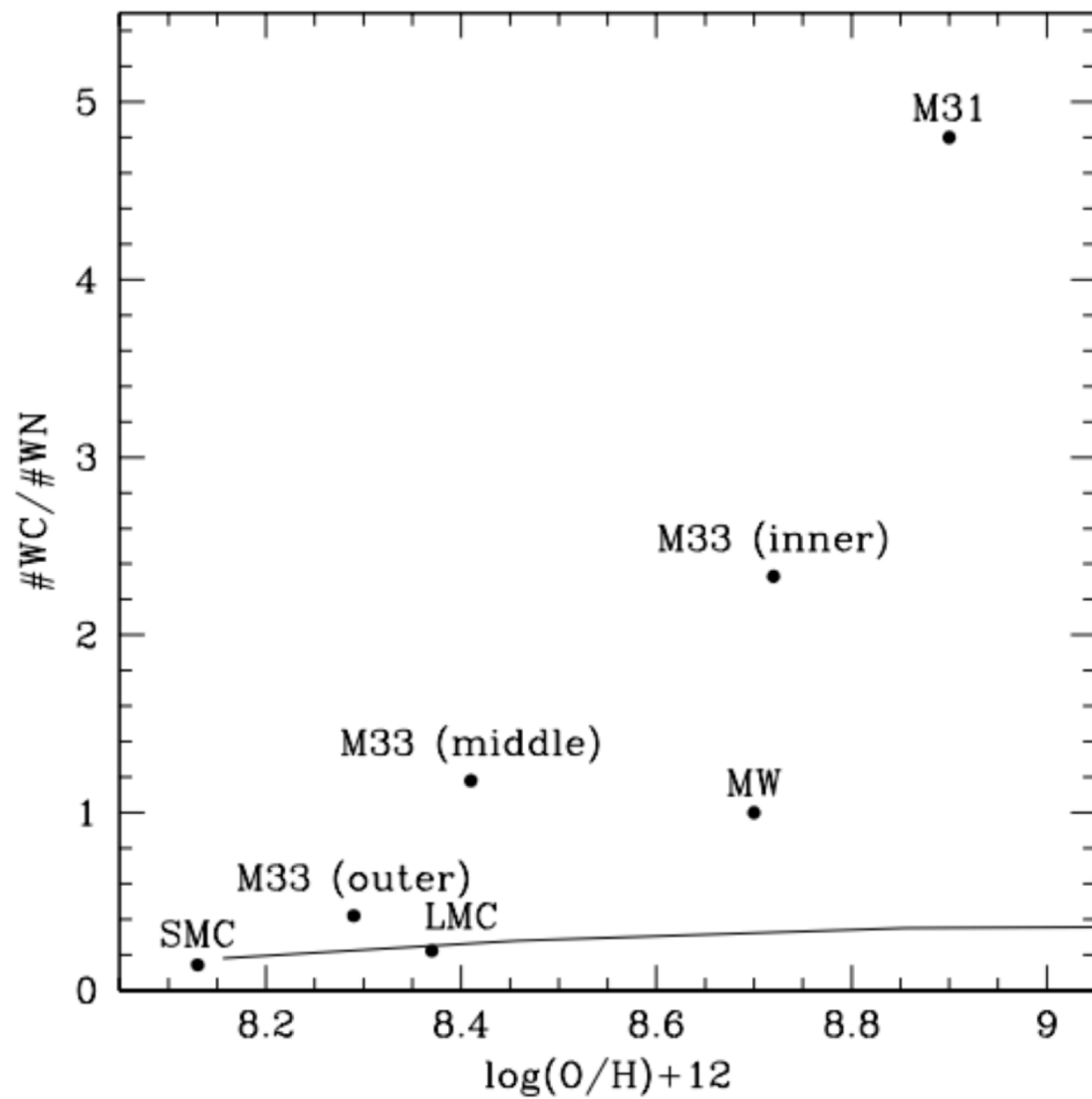


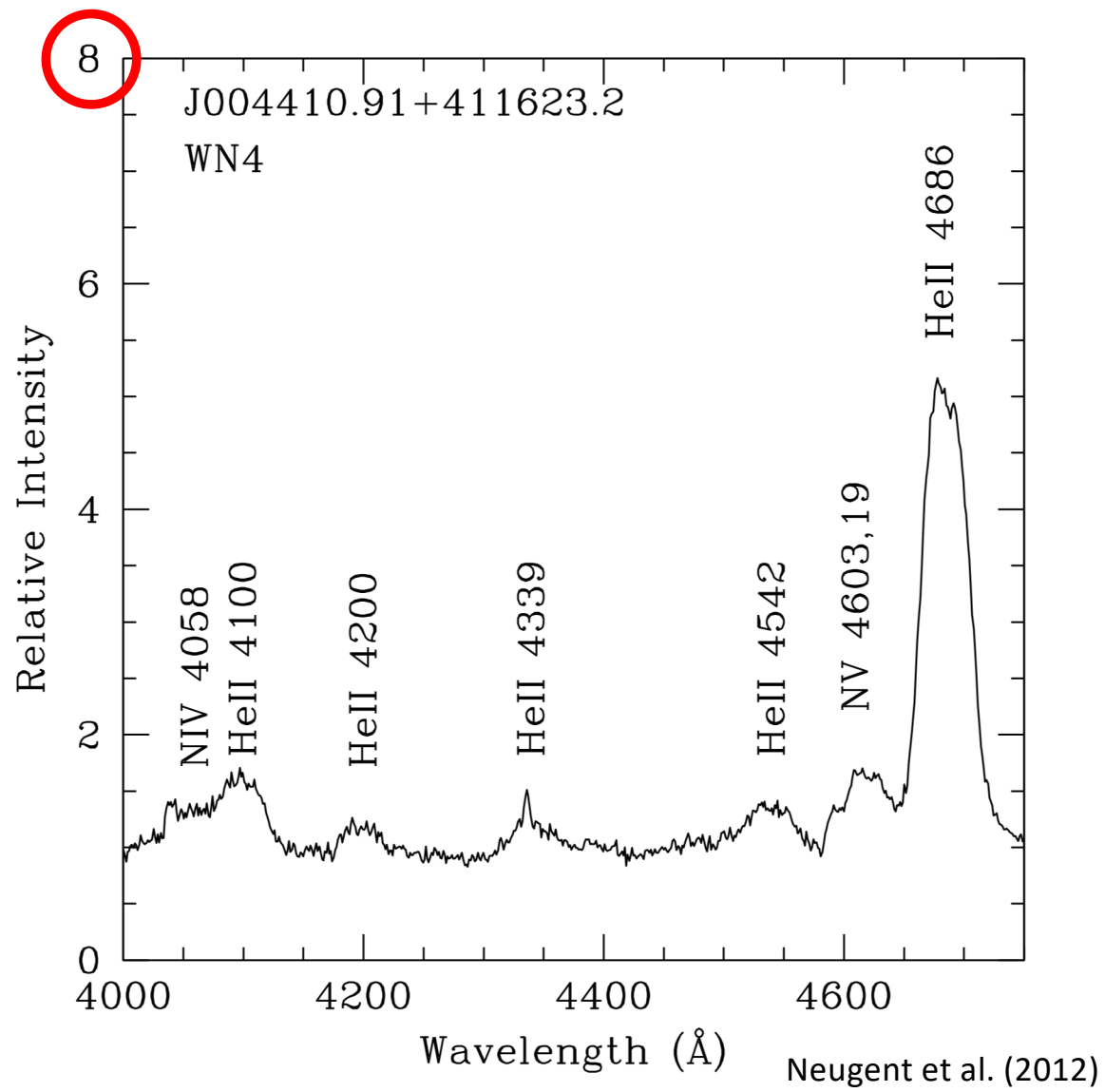
Charles Wolf
1827-1918

First Surveys

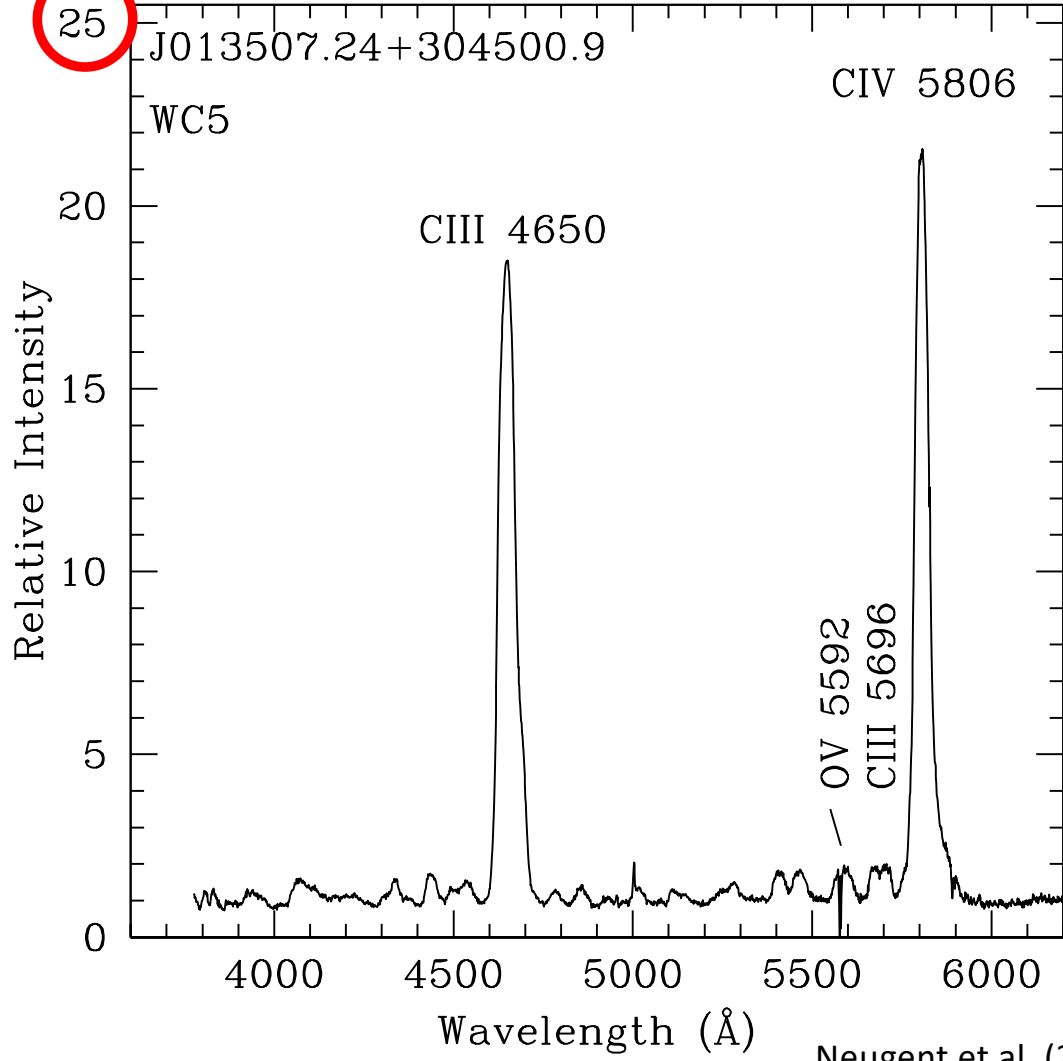
- Objective prism spectroscopy
- Interference filters (work of Azzopardi & Breysacher)
- CCDs!
- One-off discoveries





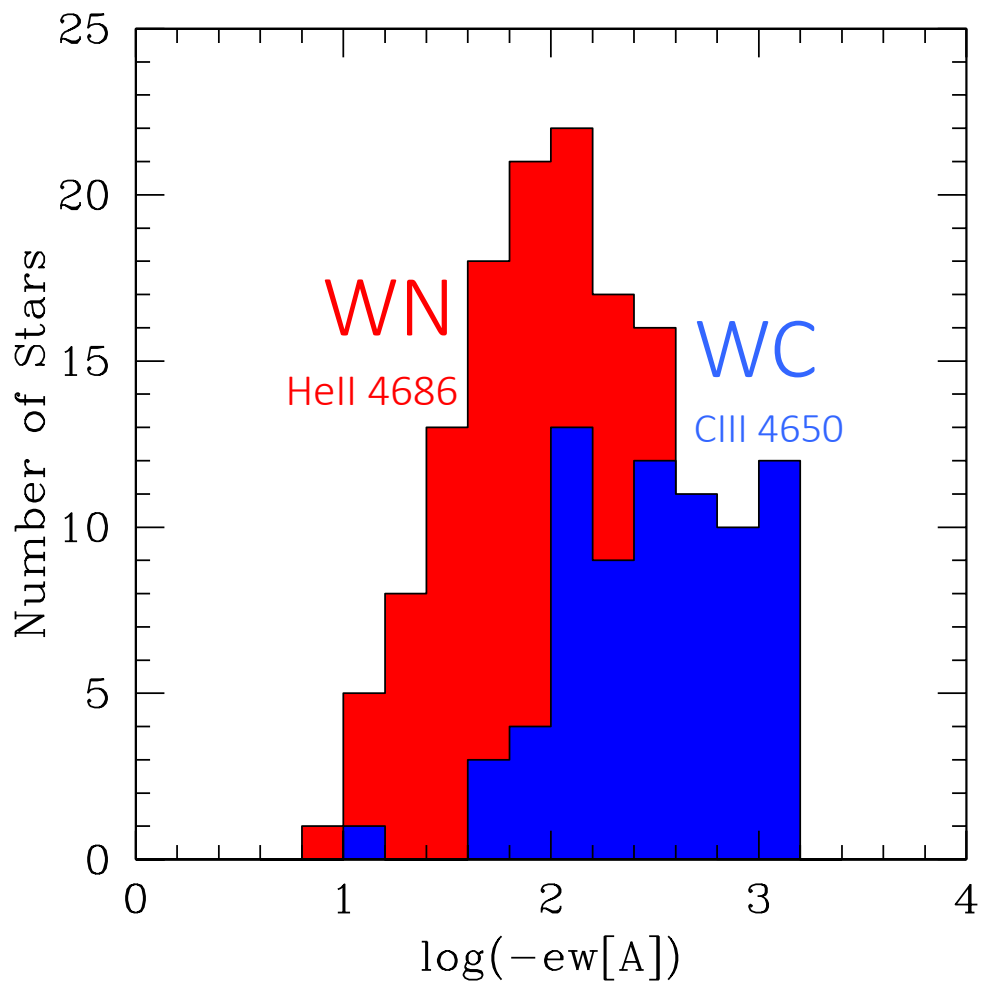


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Neugent et al. (2012)

Line Strengths of Galactic and LMC WRs



Massey & Johnson (1998)

Wolf-Rayet stars
in M31 and M33

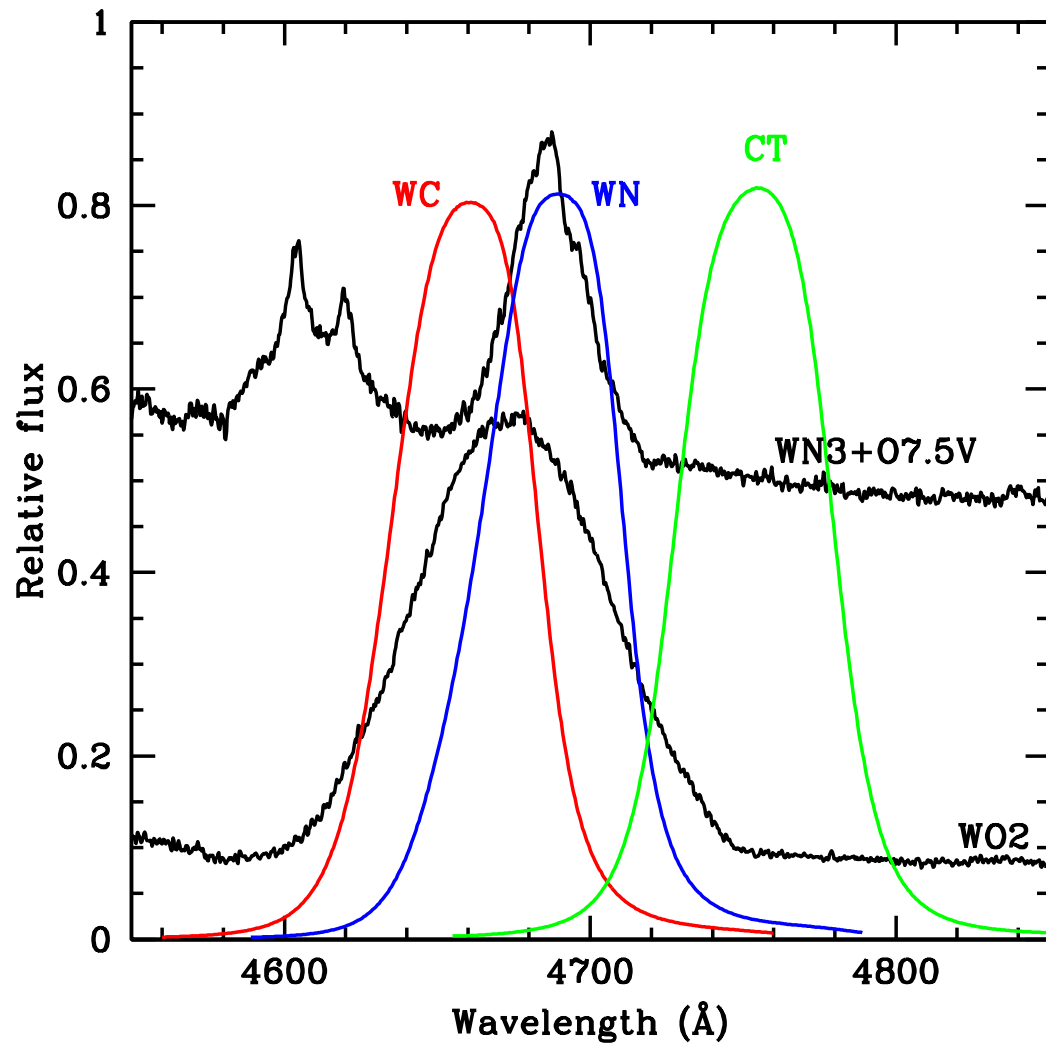
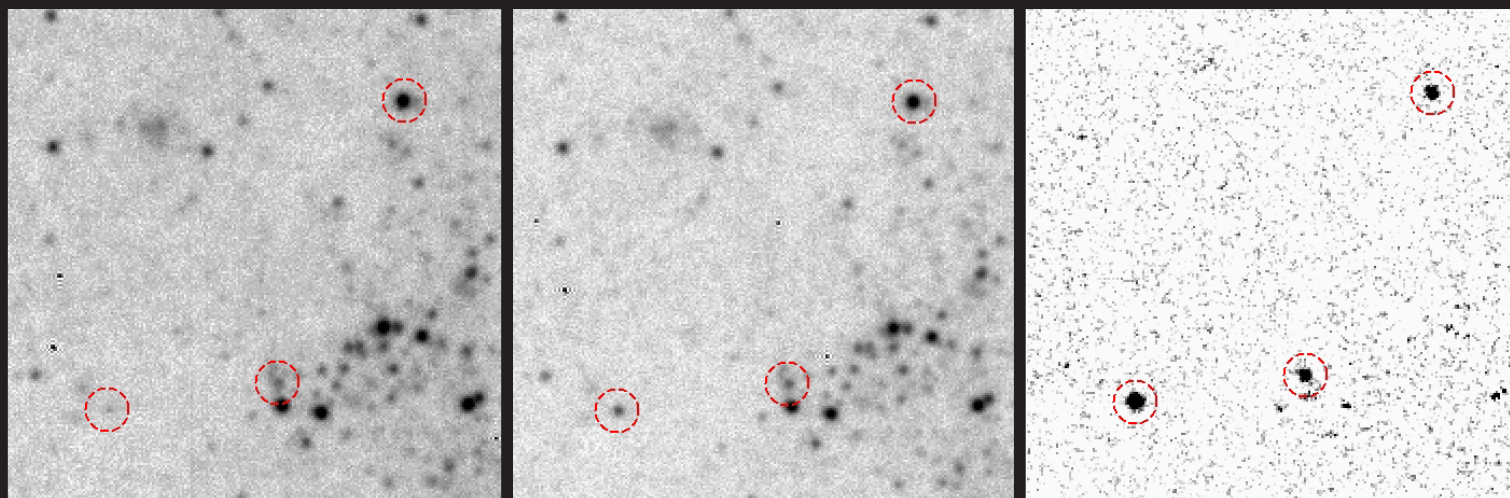


Image Subtraction



Continuum

WN

Result

Image subtraction program: Yuan & Akerlof (2008)

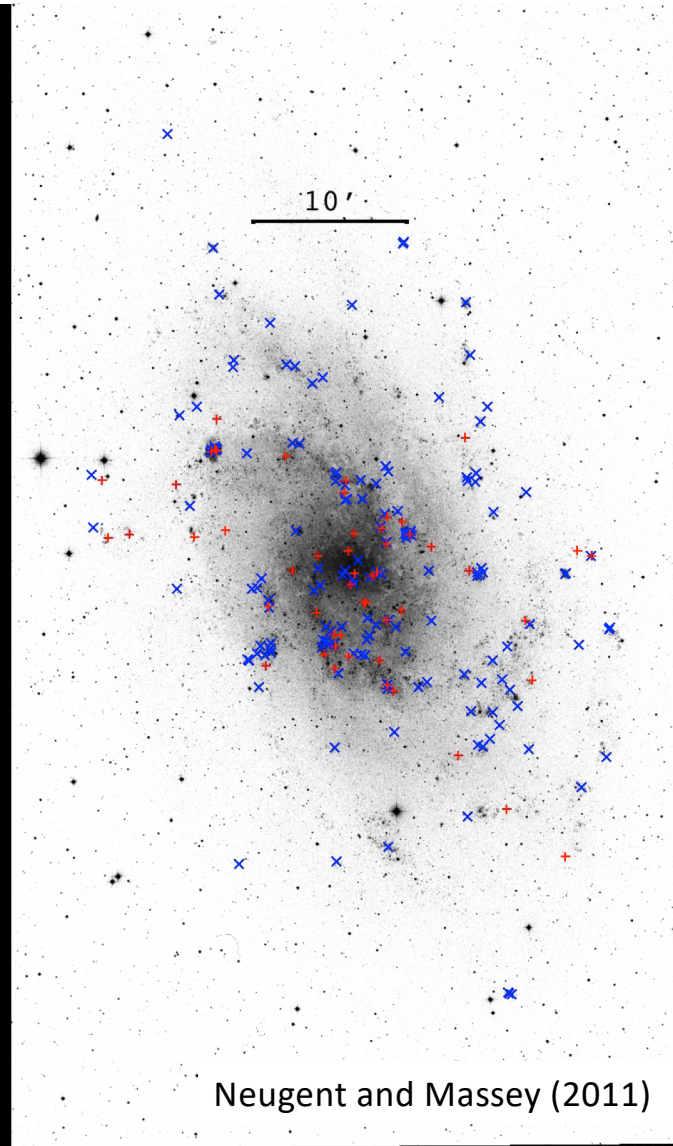
M33

x = WN

+ = WC

206 WRs

54 new WRs



M33

x = WN

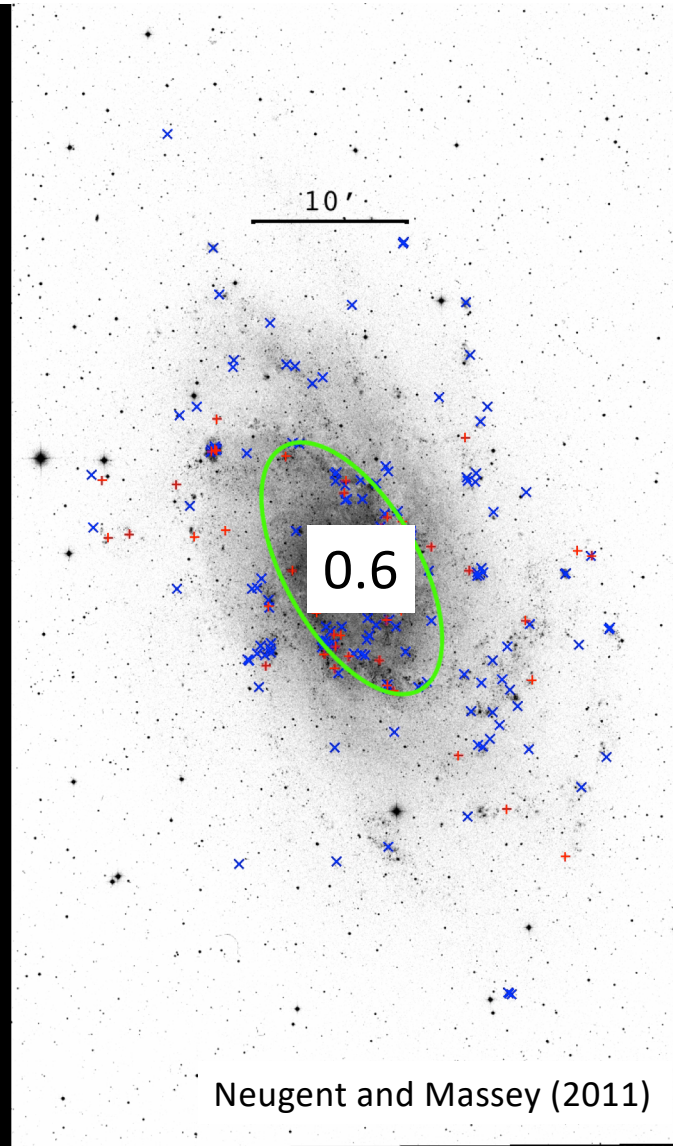
+ = WC

206 WRs

54 new WRs

Inner region: solar metallicity

$$26/45 = 0.6$$



M33

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206 WRs

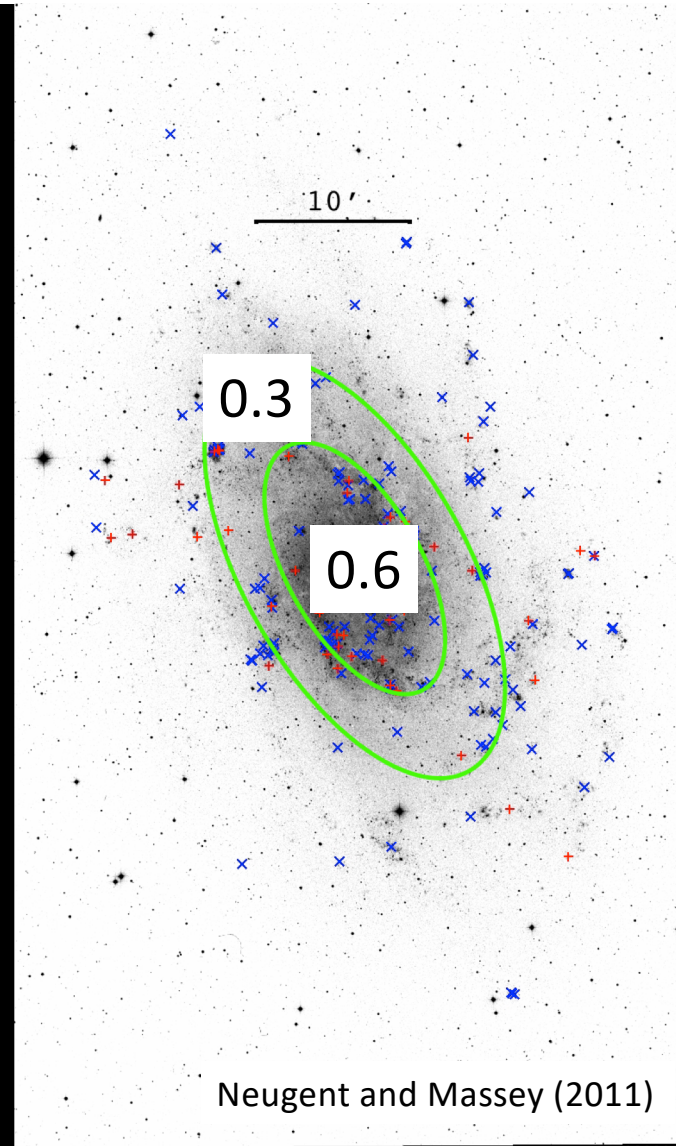
54 new WRs

Inner region: solar metallicity

$$26/45 = 0.6$$

Middle region: 0.5x solar

$$15/54 = 0.3$$



M33

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+ = WC

206 WRs

54 new WRs

Inner region: solar metallicity

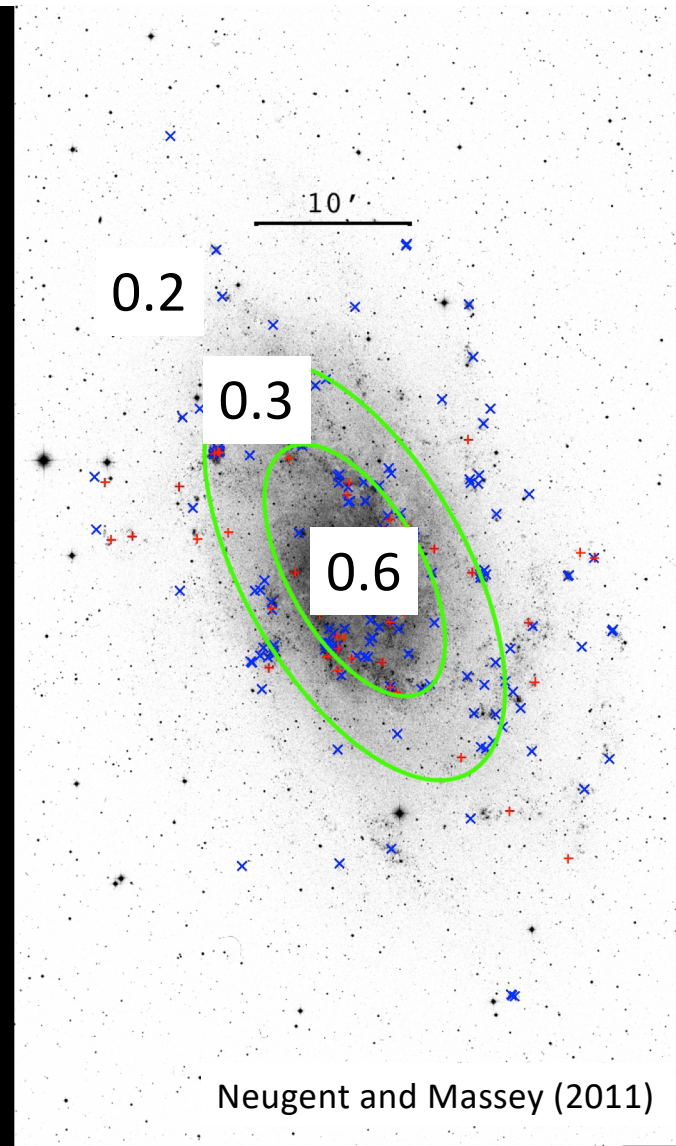
$$26/45 = 0.6$$

Middle region: 0.5x solar

$$15/54 = 0.3$$

Outer region: 0.4x solar

$$12/54 = 0.2$$





M31

x = WN

+ = WC

154 known WRs
107 newly discovered

Neugent et al. (2012)

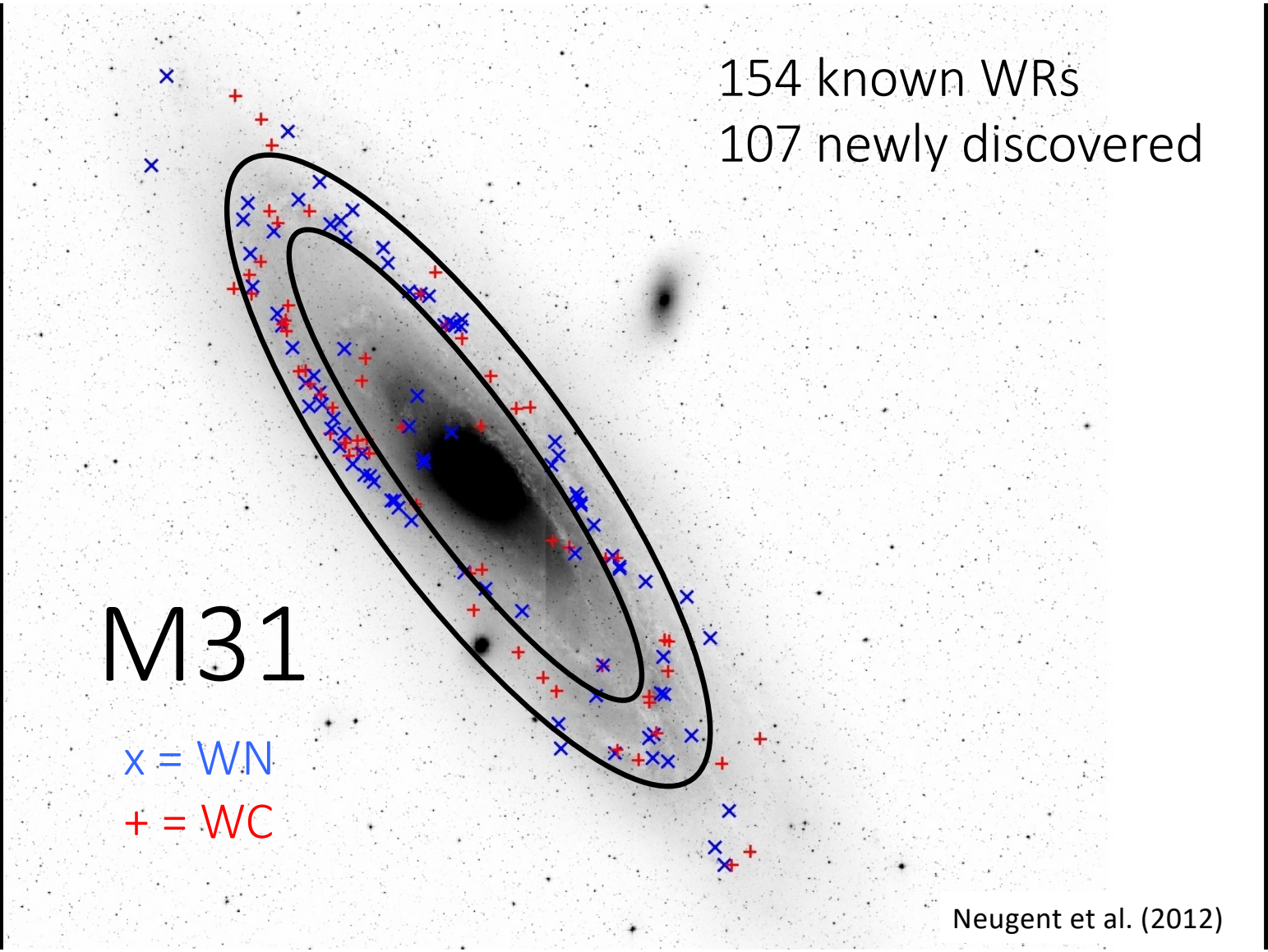
M31

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Neugent et al. (2012)





M31

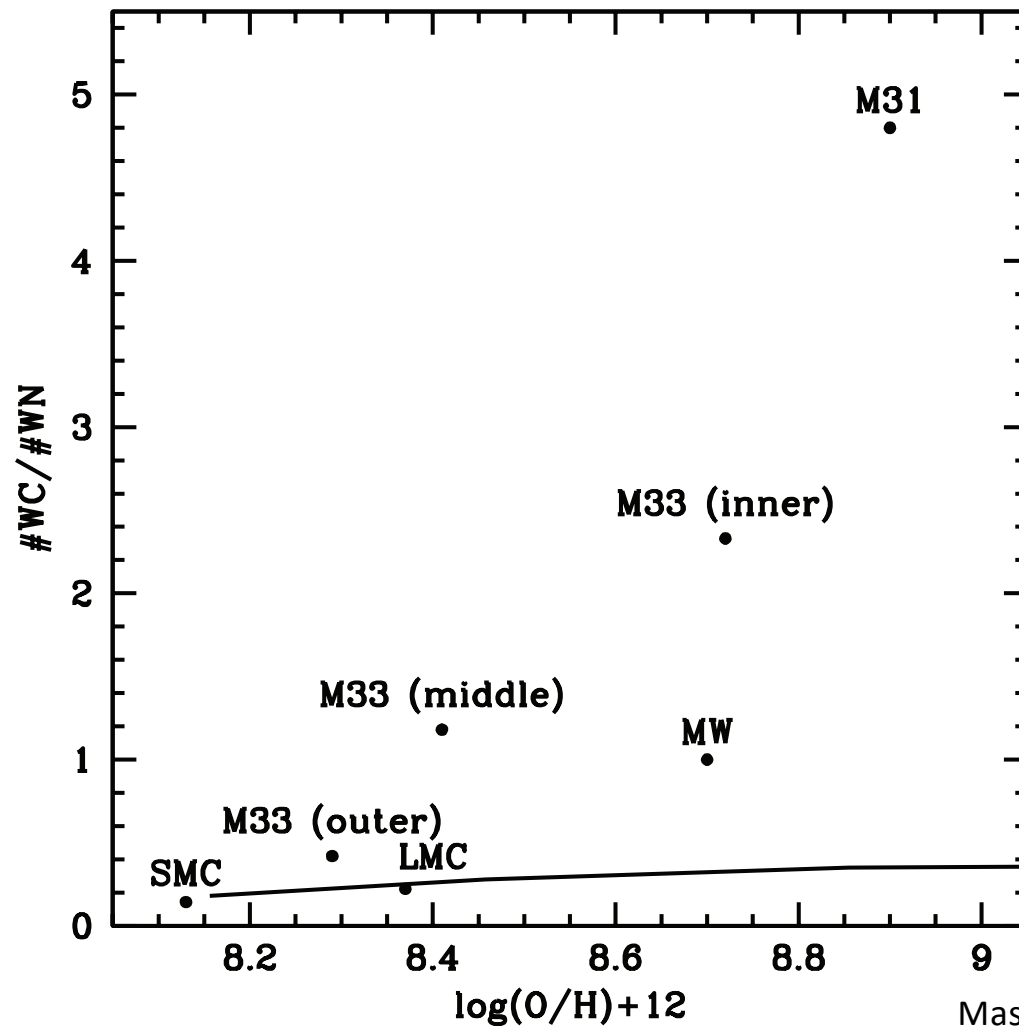
x = WN

+ = WC

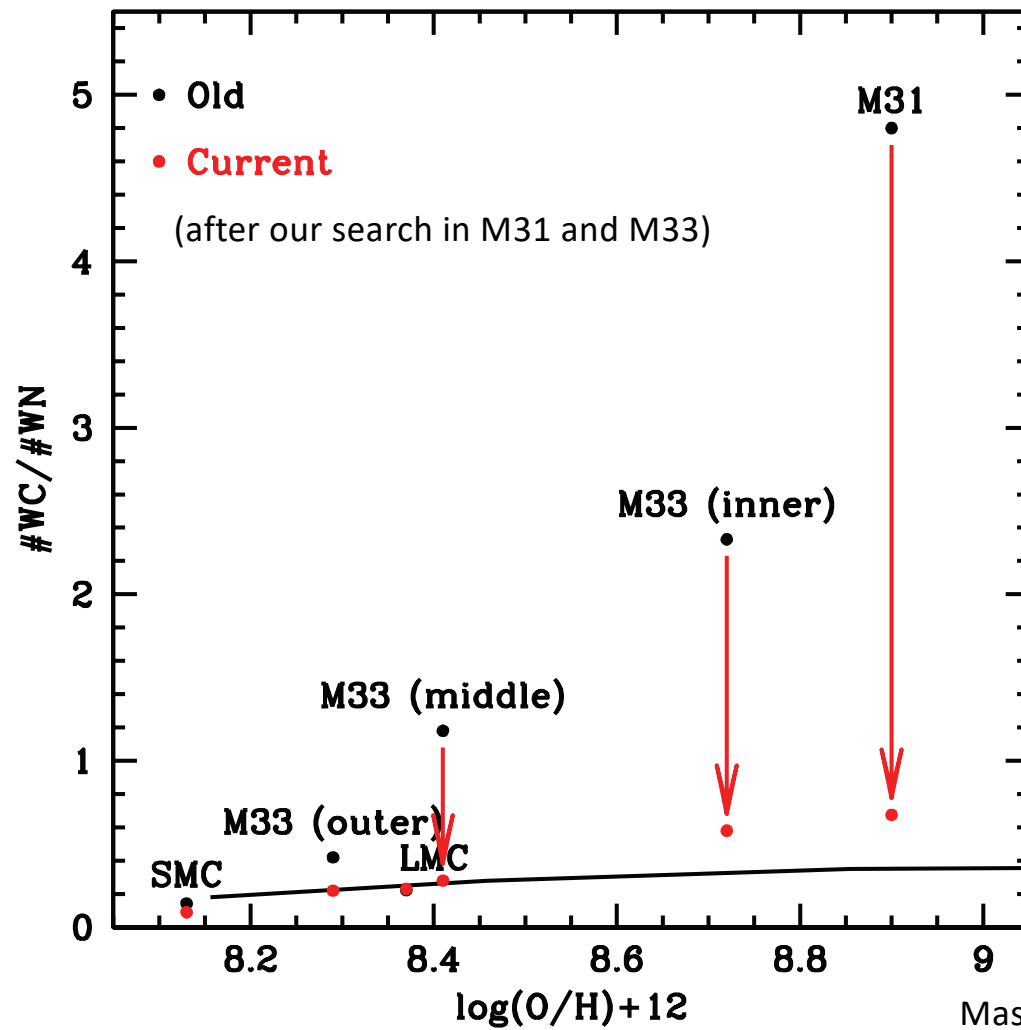
154 known WRs
107 newly discovered

1.6x solar
 $WC/WN = 62/92$
 $= 0.7$

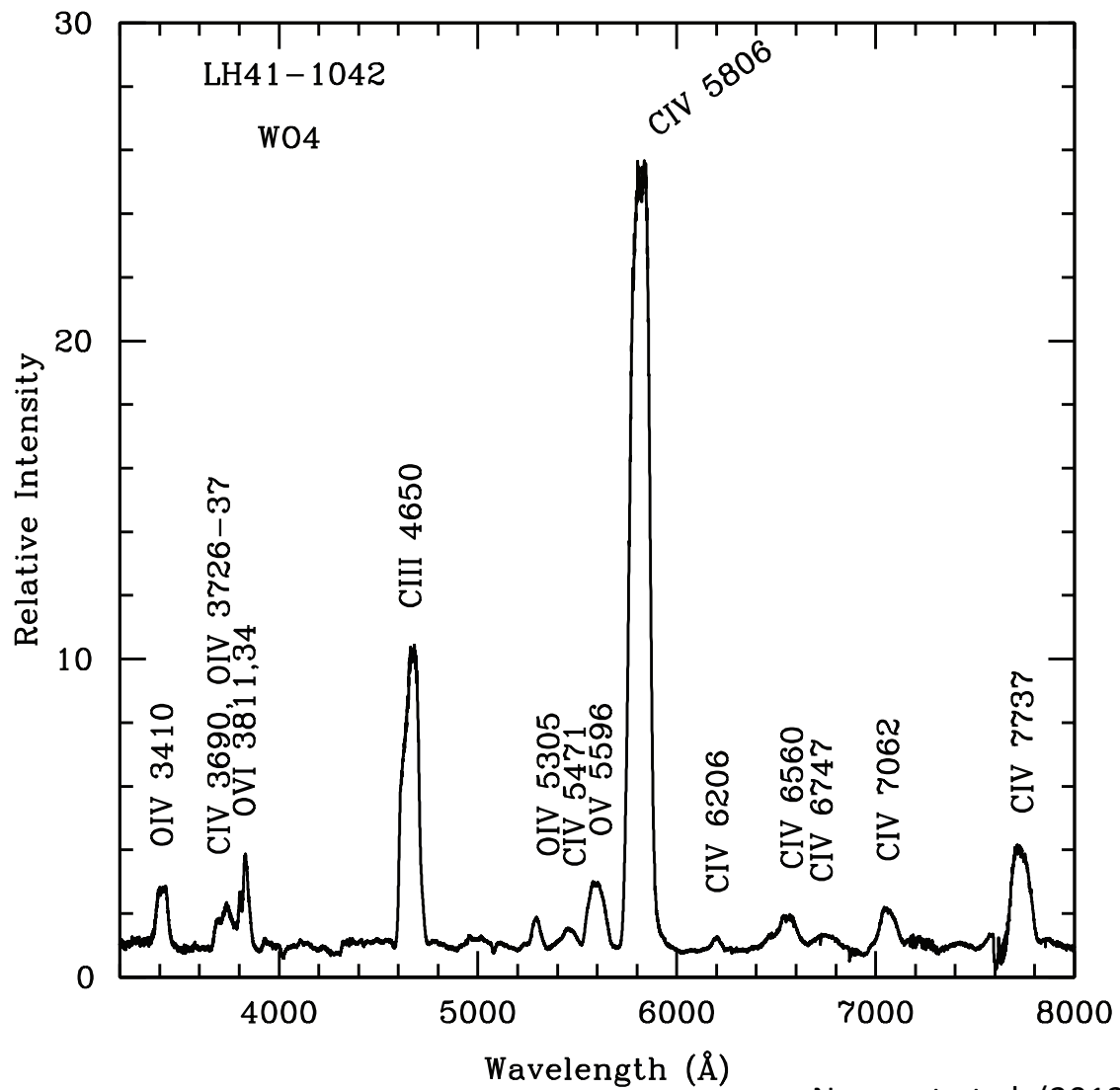
Neugent et al. (2012)



Massey et al. (2015)



Massey et al. (2015)



Neugent et al. (2012)

Wolf-Rayet stars
in the LMC and SMC

SMC

no new WRs

12 known total

Neugent et al. (2018)



LMC

16 new WRs

1 WO

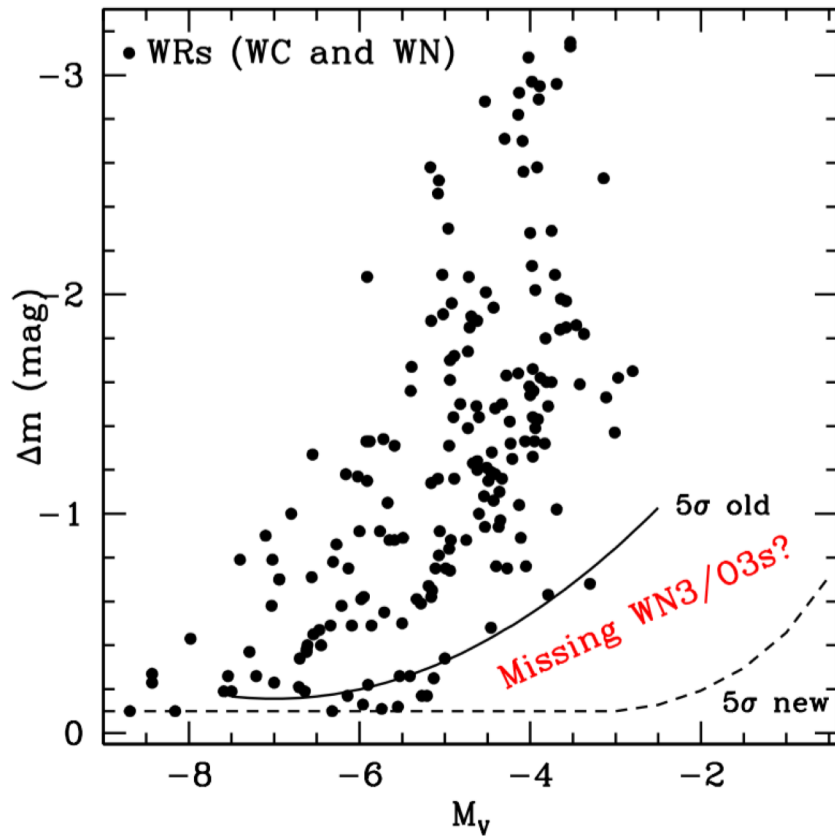
15 WNs

152 known total

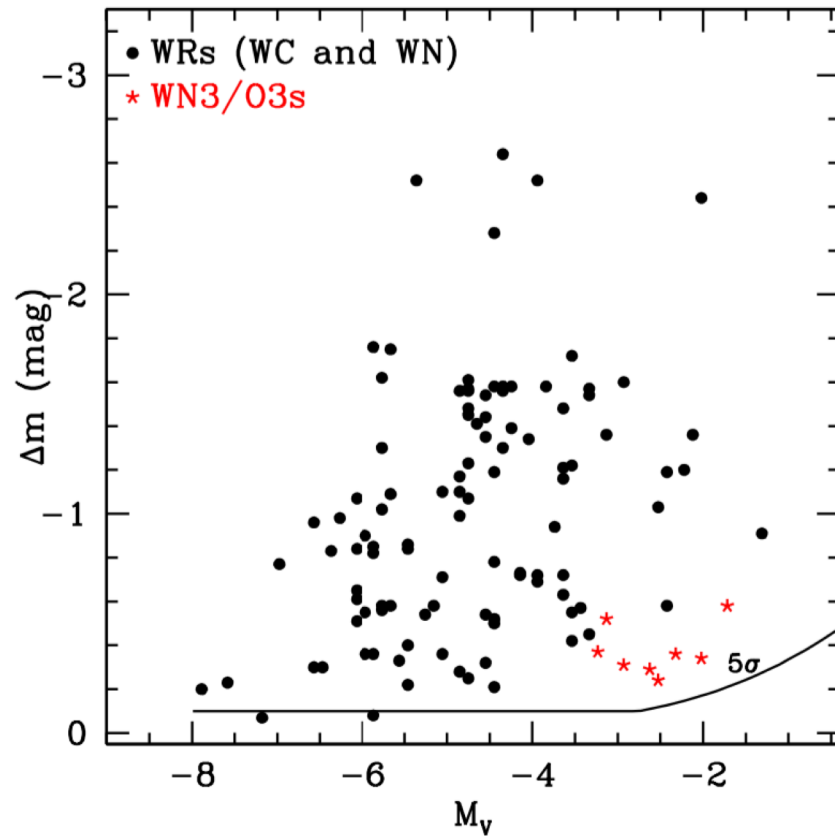
Neugent et al. (2018)

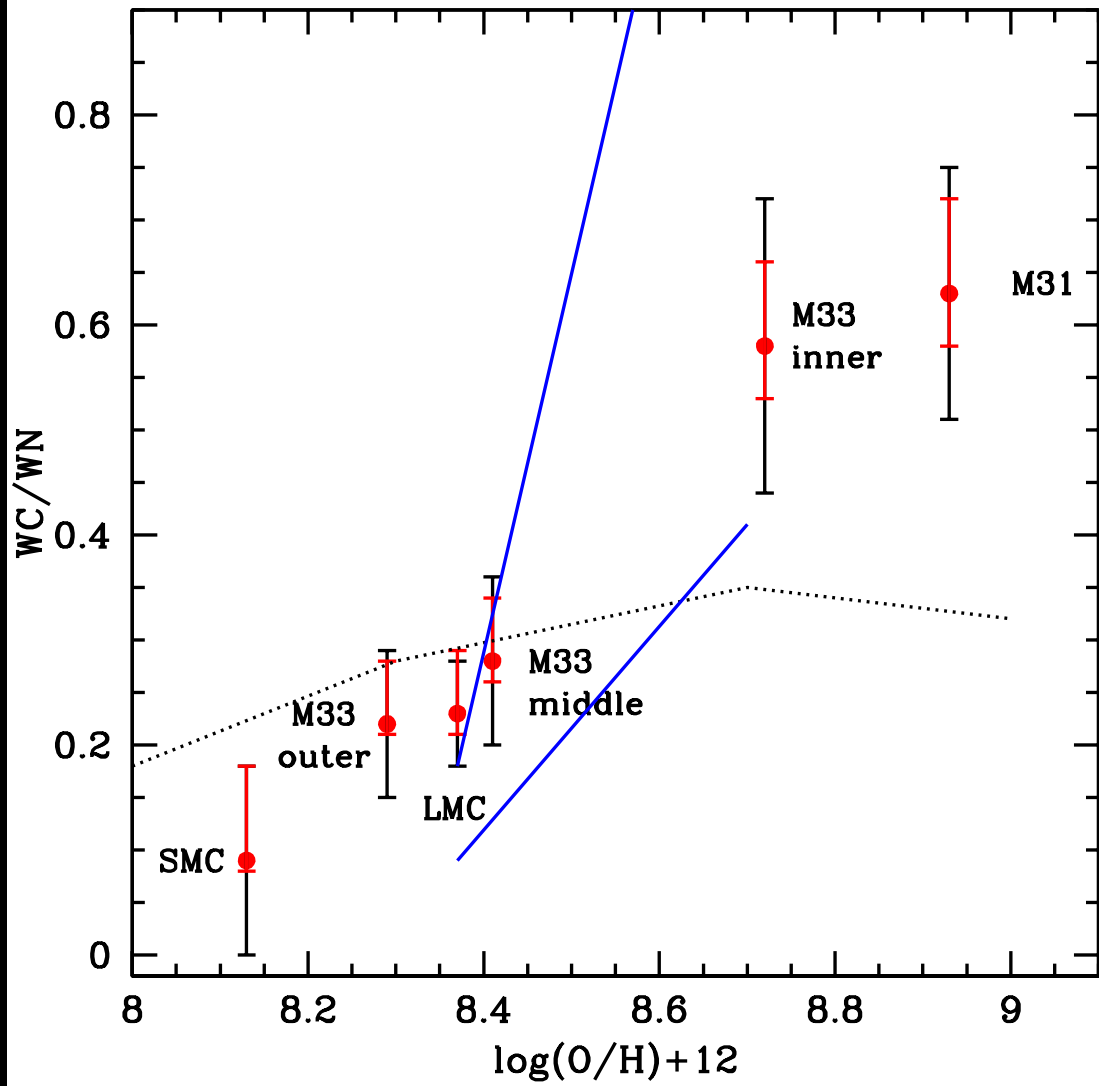


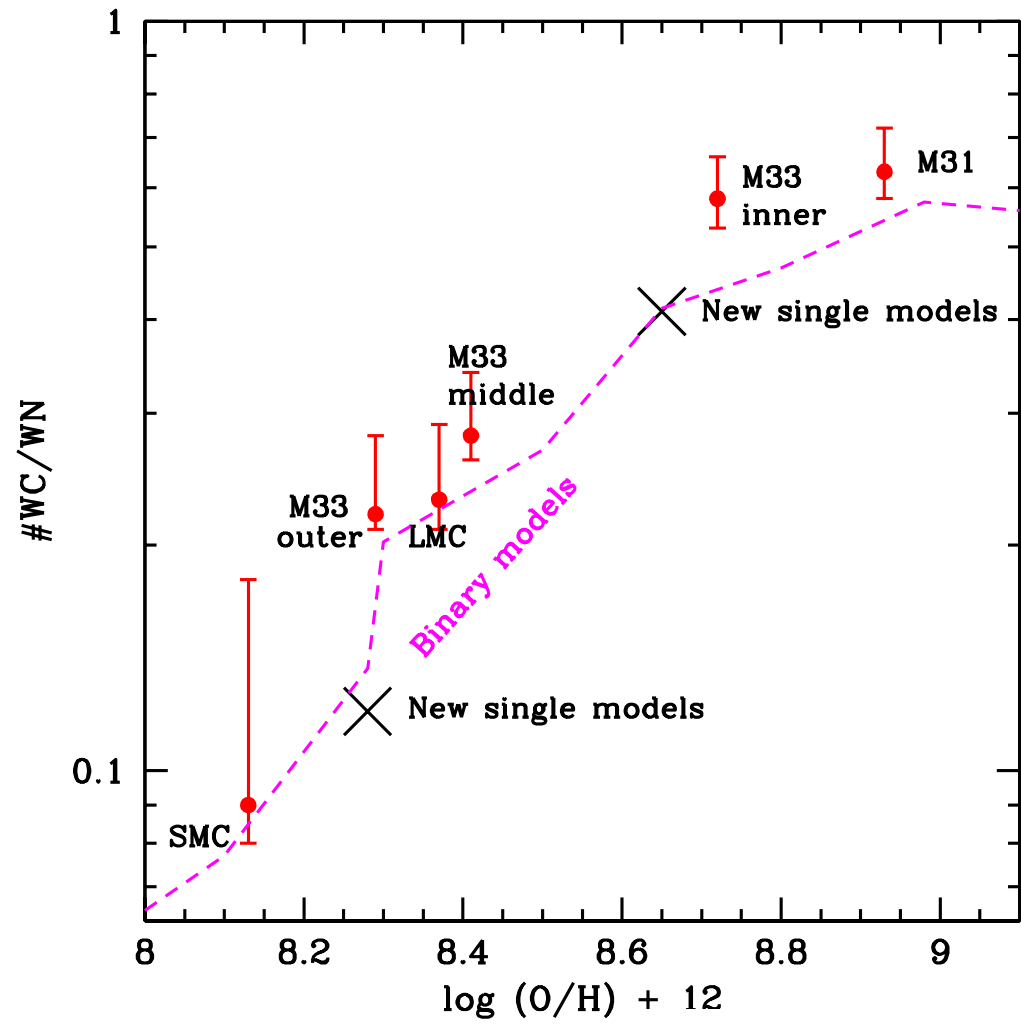
M33 Completeness



LMC Completeness







BPASS 2.0 & Geneva Models

Wolf-Rayet stars
in other Local Group galaxies

IC 1613

1 WO

D'Odorico & Rosa (1982)



IC 10

29 WRs

WC/WN = 1

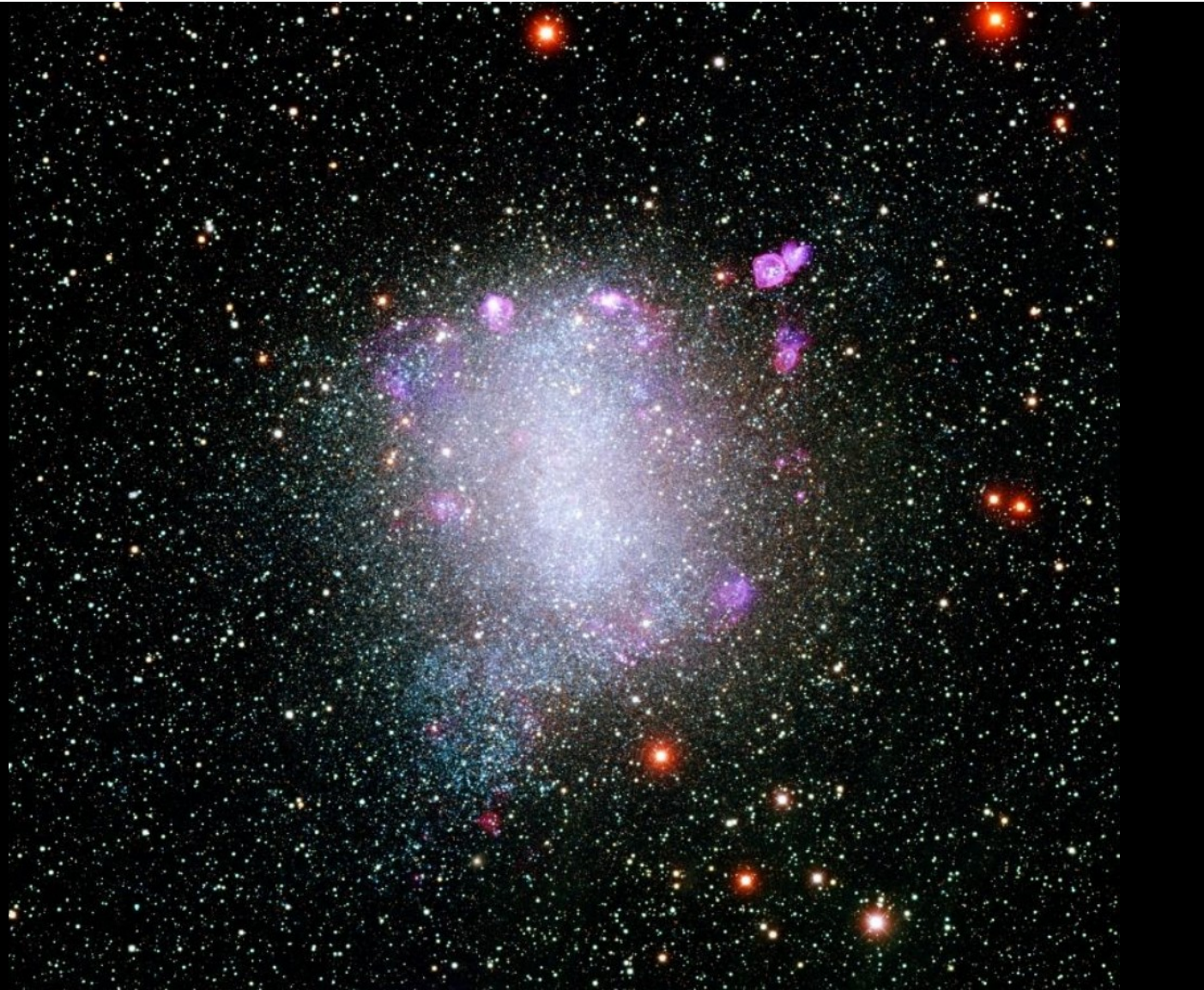
Tehrani et al. (2017)



NGC 6822

4 WNs

Armandroff & Massey 1991



Wolf-Rayet stars
in non-Local Group galaxies

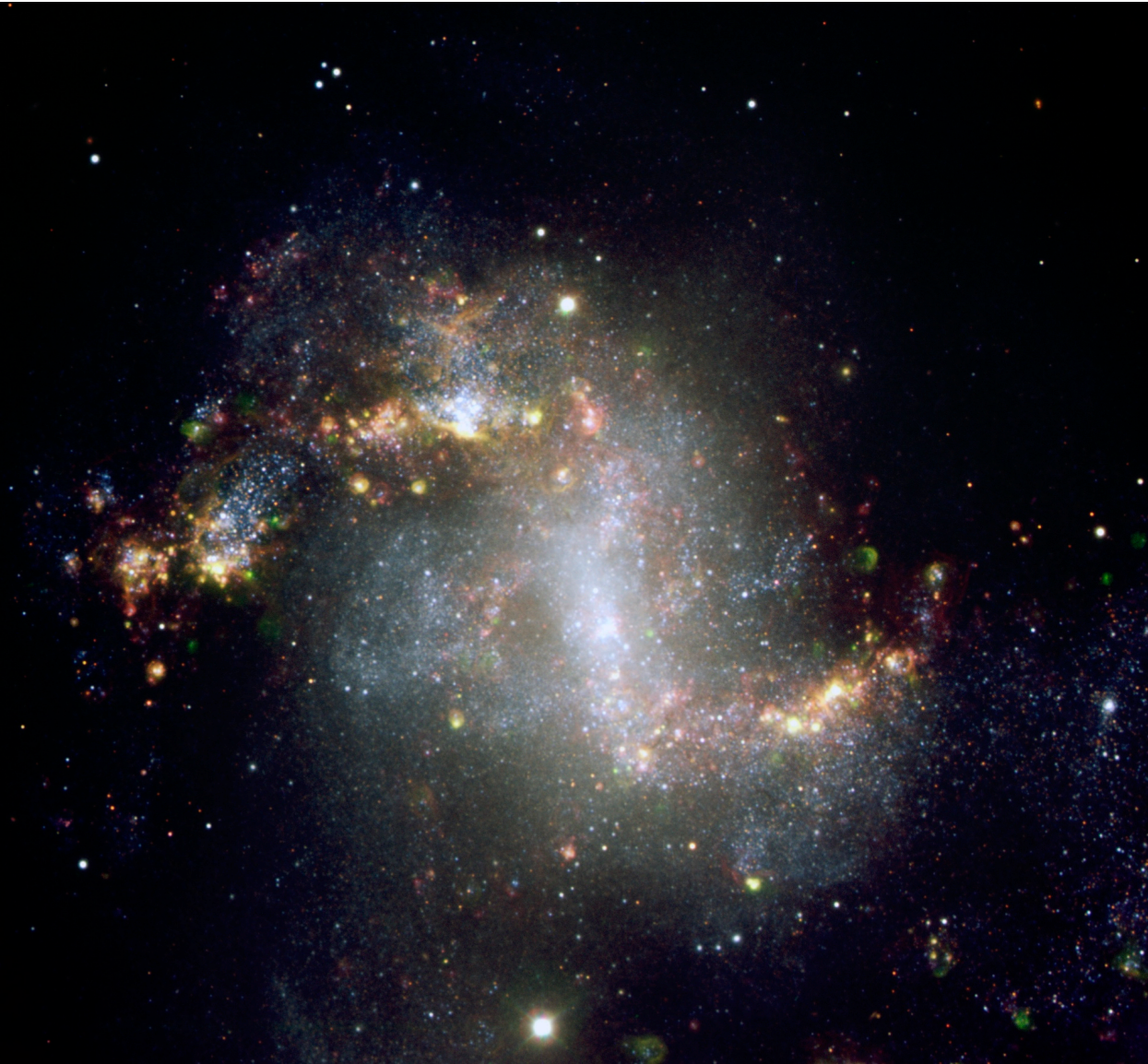
NGC 1313

83 spectroscopically
confirmed

Predict 115

$WC/WN = 0.4$

Hadfield & Crowther (2007)



NGC 7793

52 spectroscopically
confirmed

Predict 100

Bibby et al. (2010)



NGC 5068

64 spectroscopically
confirmed

Predict 200-300

Bibby et al. (2012)



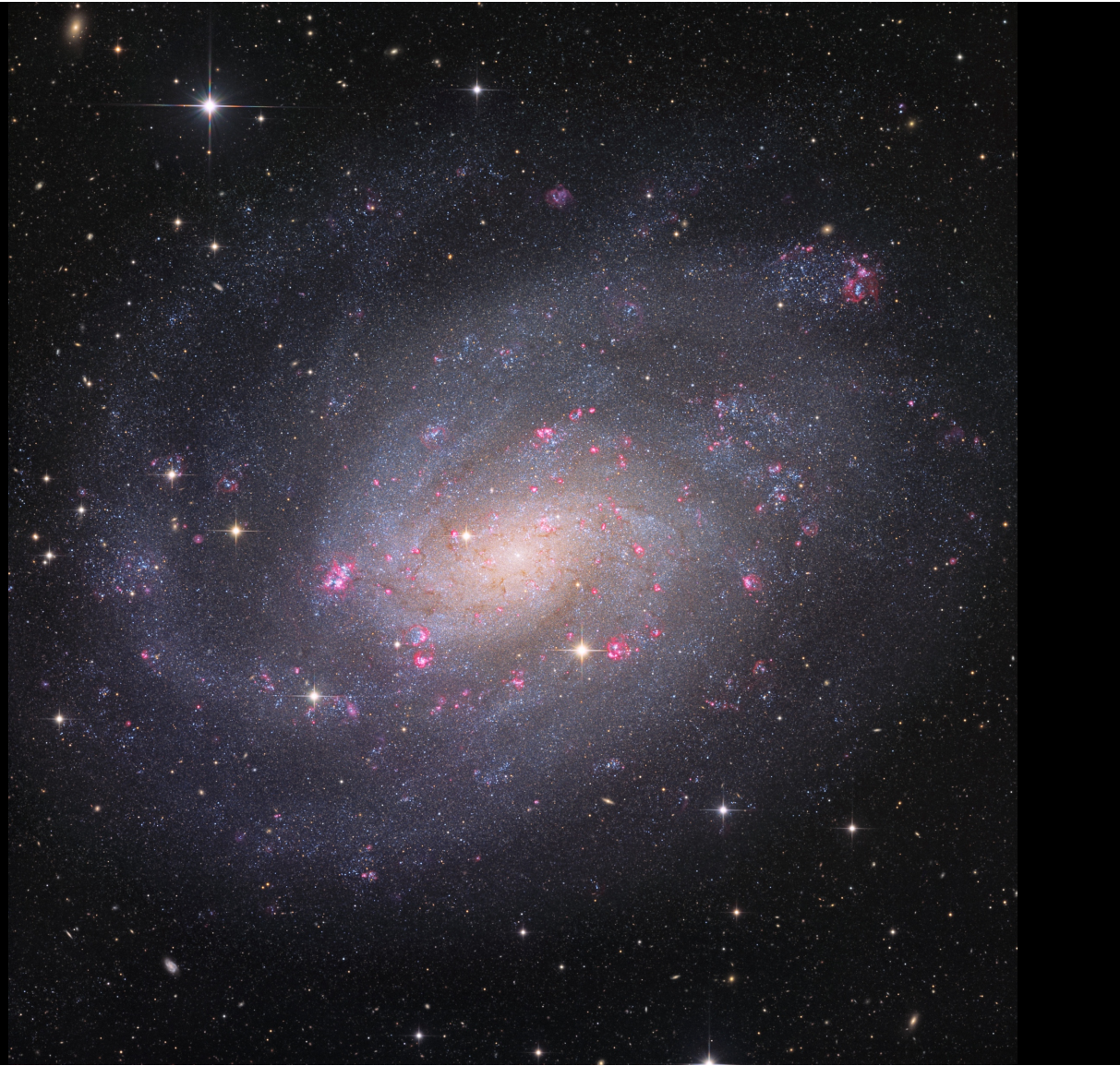
NGC 300 (inner)

30 spectroscopically
confirmed

Predict 40

$WC/WN = 0.7-0.9$

Schild et al. (2003)



M 83

presence of WRs in
131 regions

Predict 1100

$WC/WN = 1.2$

Hadfield et al. (2005)



M101

10 spectroscopically
confirmed

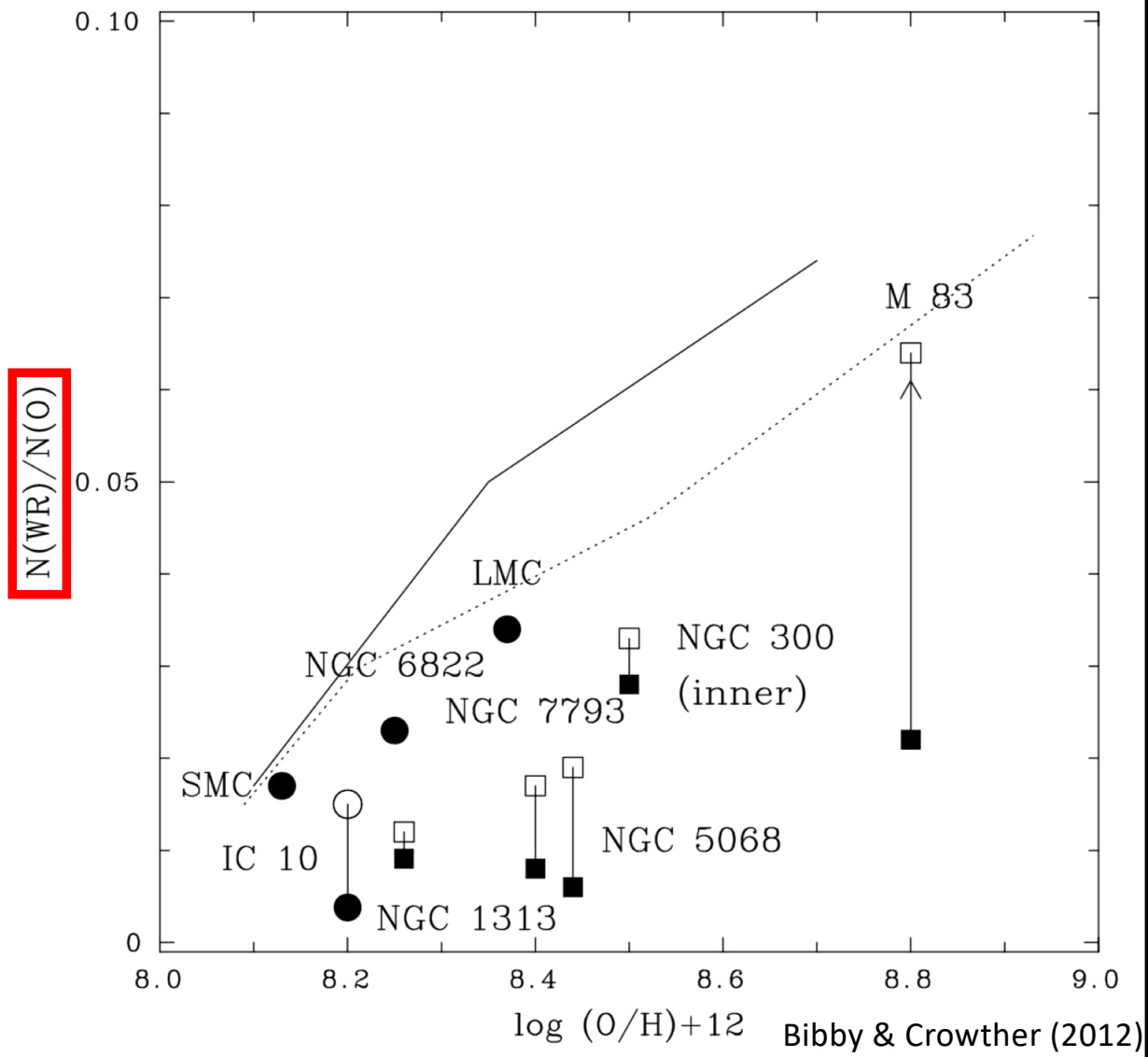
Predict 2,000-3,000

WC/WN ratio is
too incomplete

Shara et al. (2013)

Pledger et al. (2018)





What's Next?

- More data needed:
 - Faint-lined WNs
 - Better populations of O-stars (remember Phil Massey's talk ...)
- Milky Way; GAIA (see next two talks)
- Expand beyond the Local Group