Searching for Wolf-Rayet Stars:
Progenitors of Type Ib/c Supernovae

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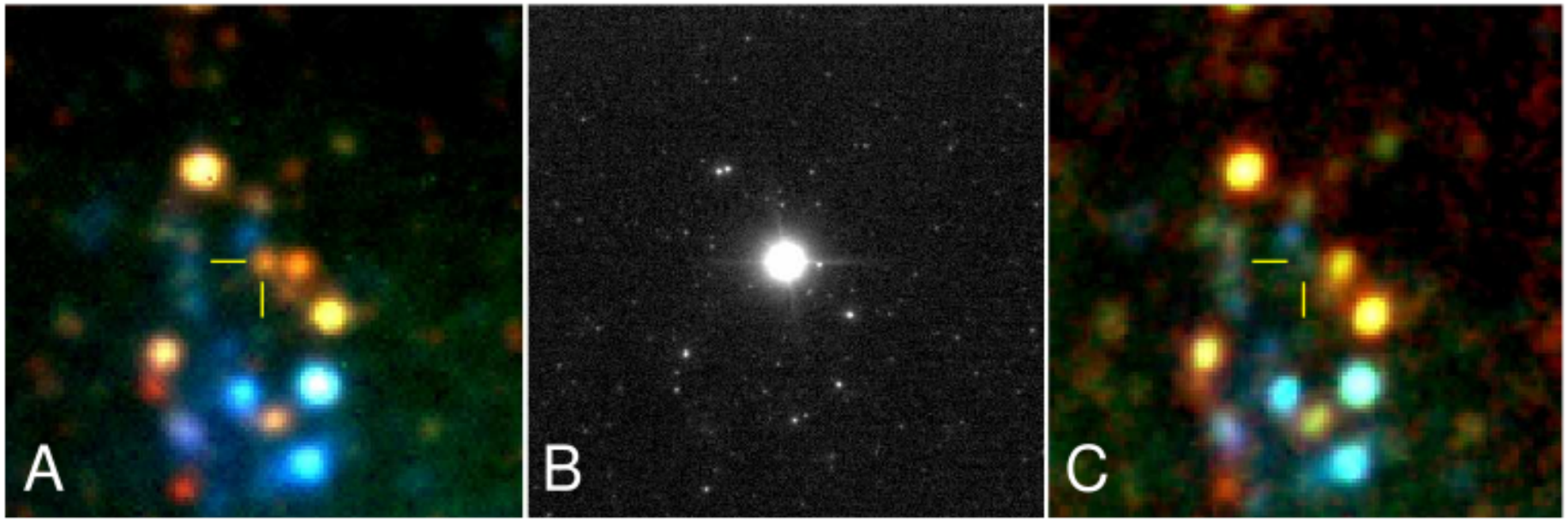
Death of Massive Stars: Supernovae & Gamma-Ray Bursts
Nikko, Japan, 2012

Type II-P SN 2008bk in NGC 7793



(Mattila et al 2008)

Predicted Evolutionary Paths

$\underline{M_{int} \sim 25\text{-}40 M_{sun}}$

O ⟶ BSG ⟶ RSG/LBV ⟶ WN(H-poor) ⟶ SNIb

$\underline{M_{int} \sim 40\text{-}75 M_{sun}}$

O ⟶ BSG ⟶ LBV ⟶ WN(H-poor) ⟶ WC ⟶ SNIc

$\underline{M_{int} > 75 M_{sun}}$

O ⟶ WN(H-rich) ⟶ LBV ⟶ WN(H-poor) ⟶ WC ⟶ SNIc

(Crowther et al 2007)

Predicted Evolutionary Paths

M_{int} ~25-40M_{sun}

O ⟶ BSG ⟶ RSG/LBV ⟶ WN(H-poor) ⟶ SNIb ?

M_{int} ~40-75M_{sun}

O ⟶ BSG ⟶ LBV ⟶ WN(H-poor) ⟶ WC ⟶ SNIc ?

M_{int} >75M_{sun}

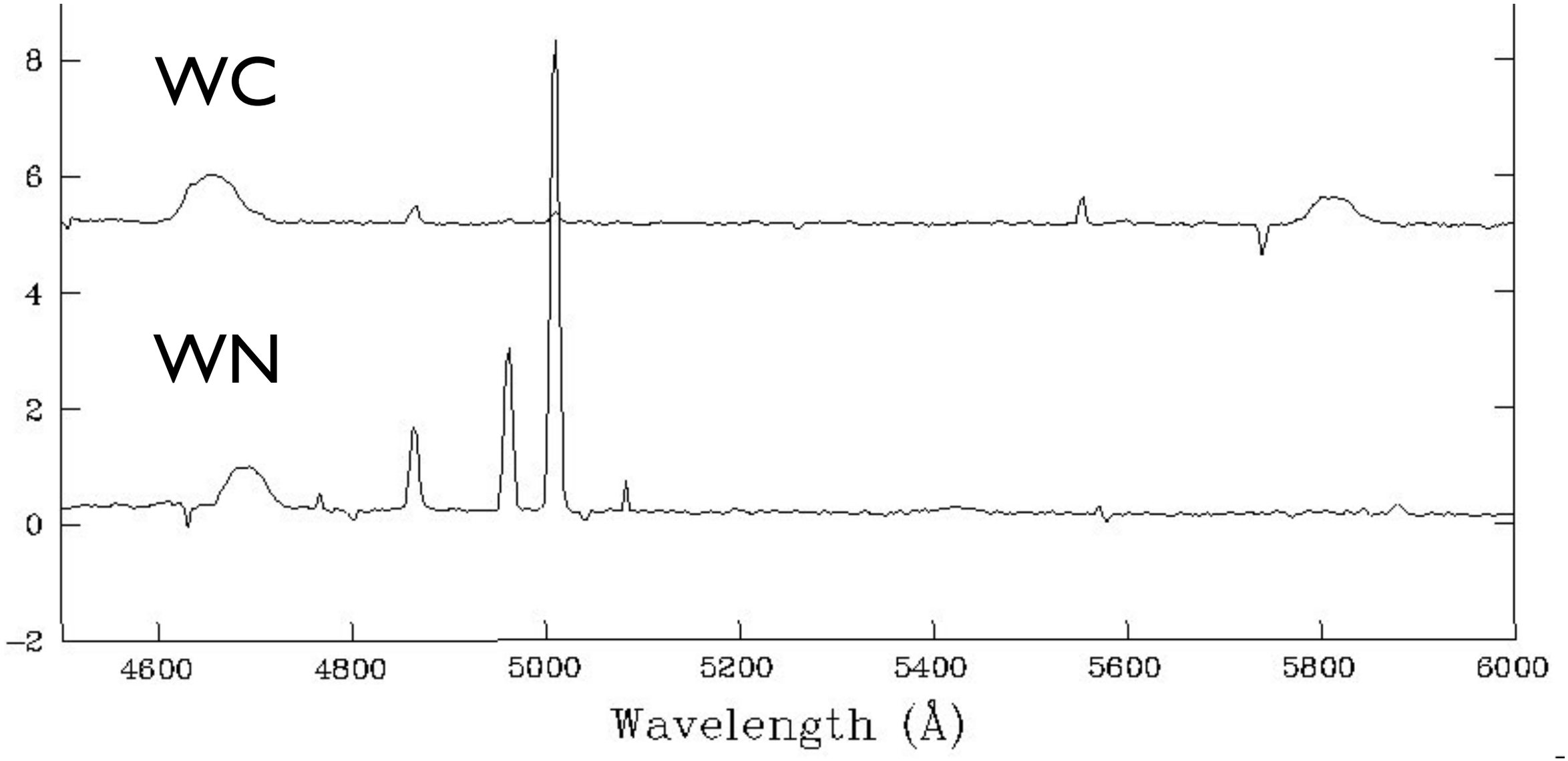
O ⟶ WN(H-rich) ⟶ LBV ⟶ WN(H-poor) ⟶ WC ⟶ SNIc ?

(Crowther et al 2007)

Wolf-Rayet Stars

(Evolved massive O-type stars)

WR stars have strong stellar winds which produce a unique emission line spectrum with broad lines of 30-300Ang.



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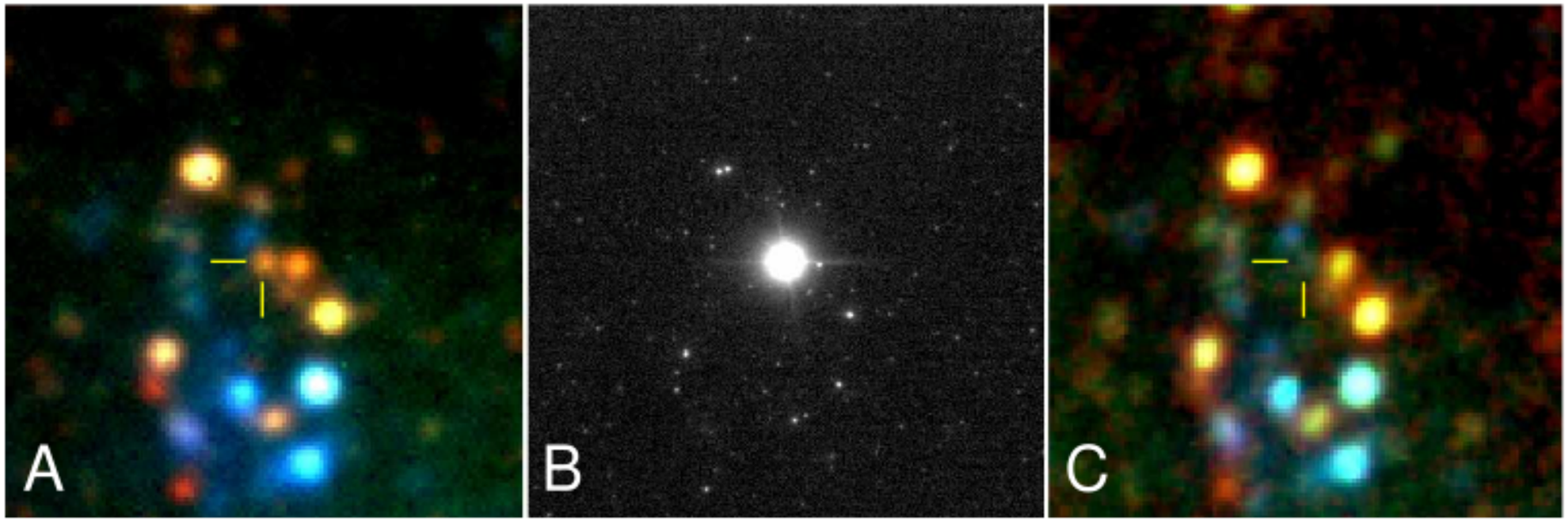
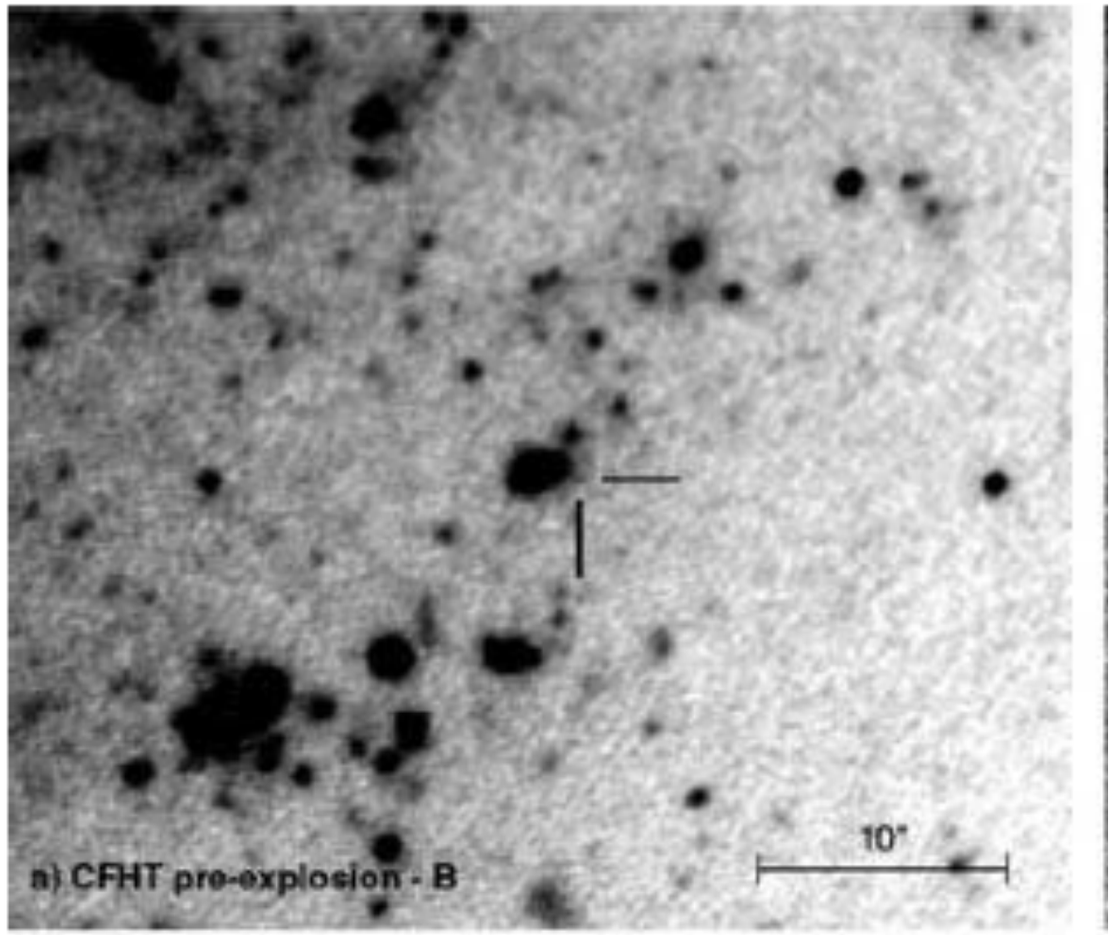


(Mattila et al 2008)

Type Ic SN 2002ap in M74

SN 2002ap was likely a low mass binary



(Crockett et al 2008)

Observations appear to predict otherwise....

SN2005V

SN2003jg

SN2007gr

SN2004gt

SN2001B

SN2002ap

SN2005ae

SN2001ci

SN2000ew

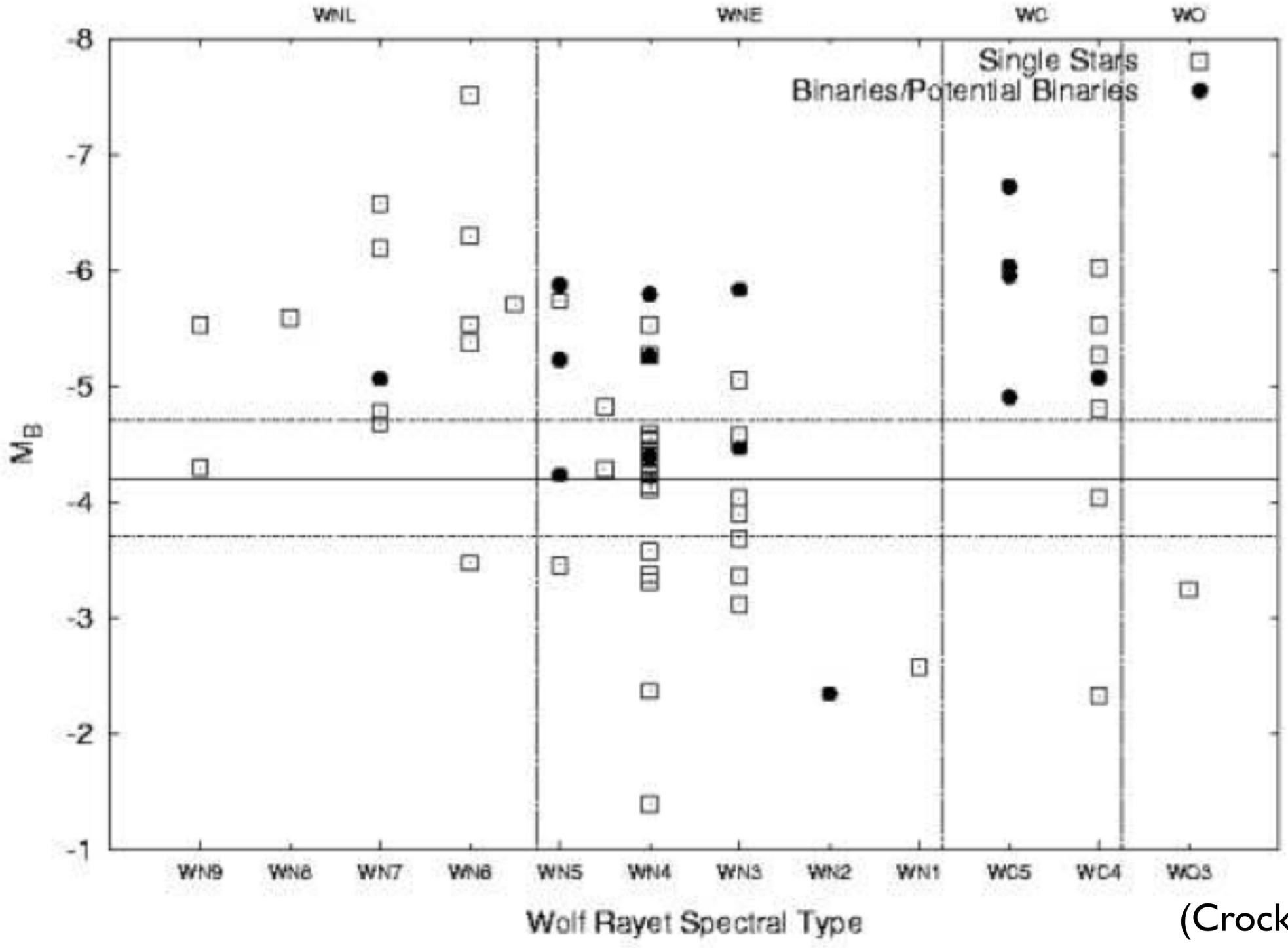
SN2004gn

SN2005cz

SN2000ds

SN2010hp

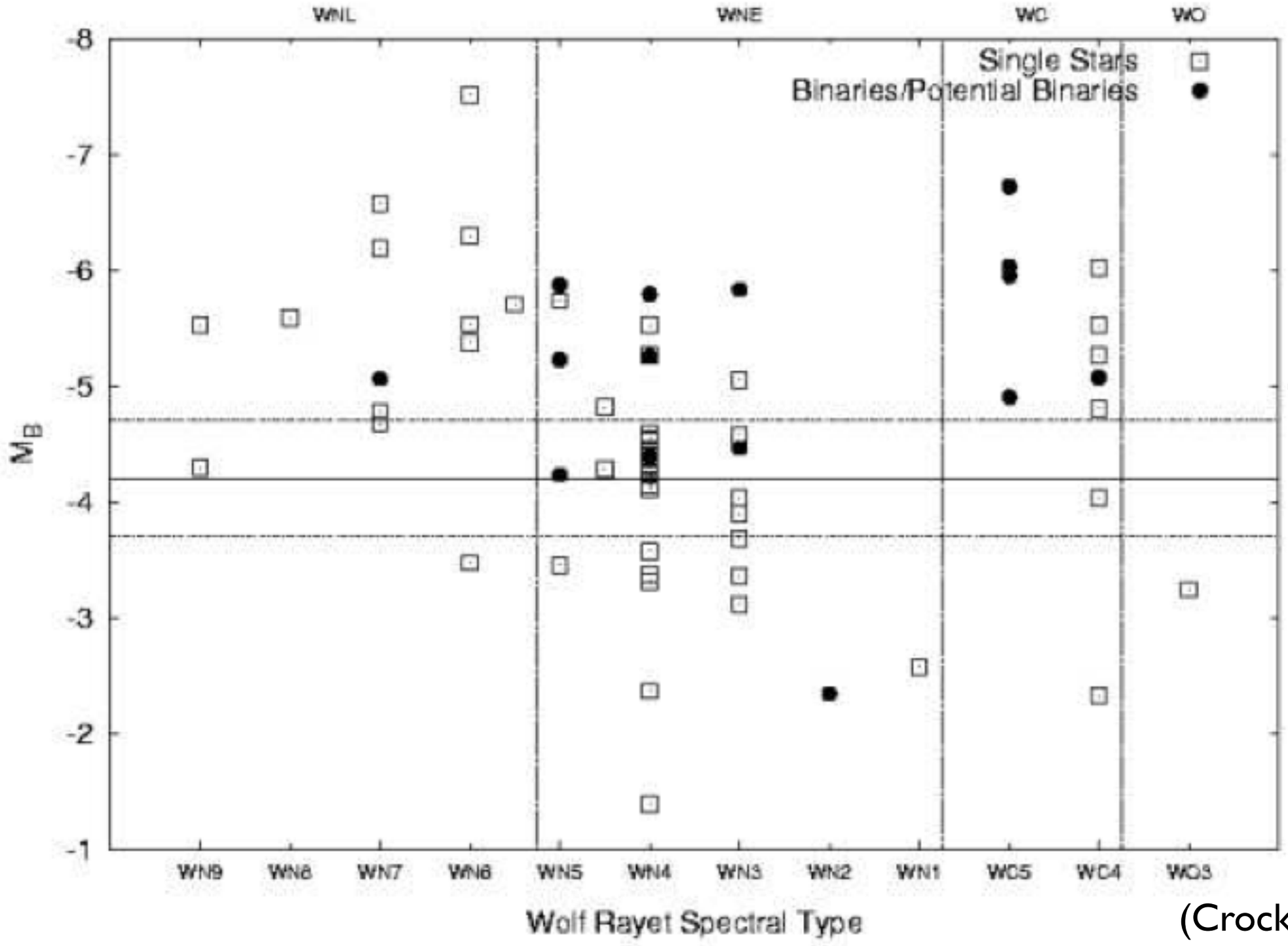
WR Stars in the LMC



SN2002ap limits

(Crockett et al 2008)

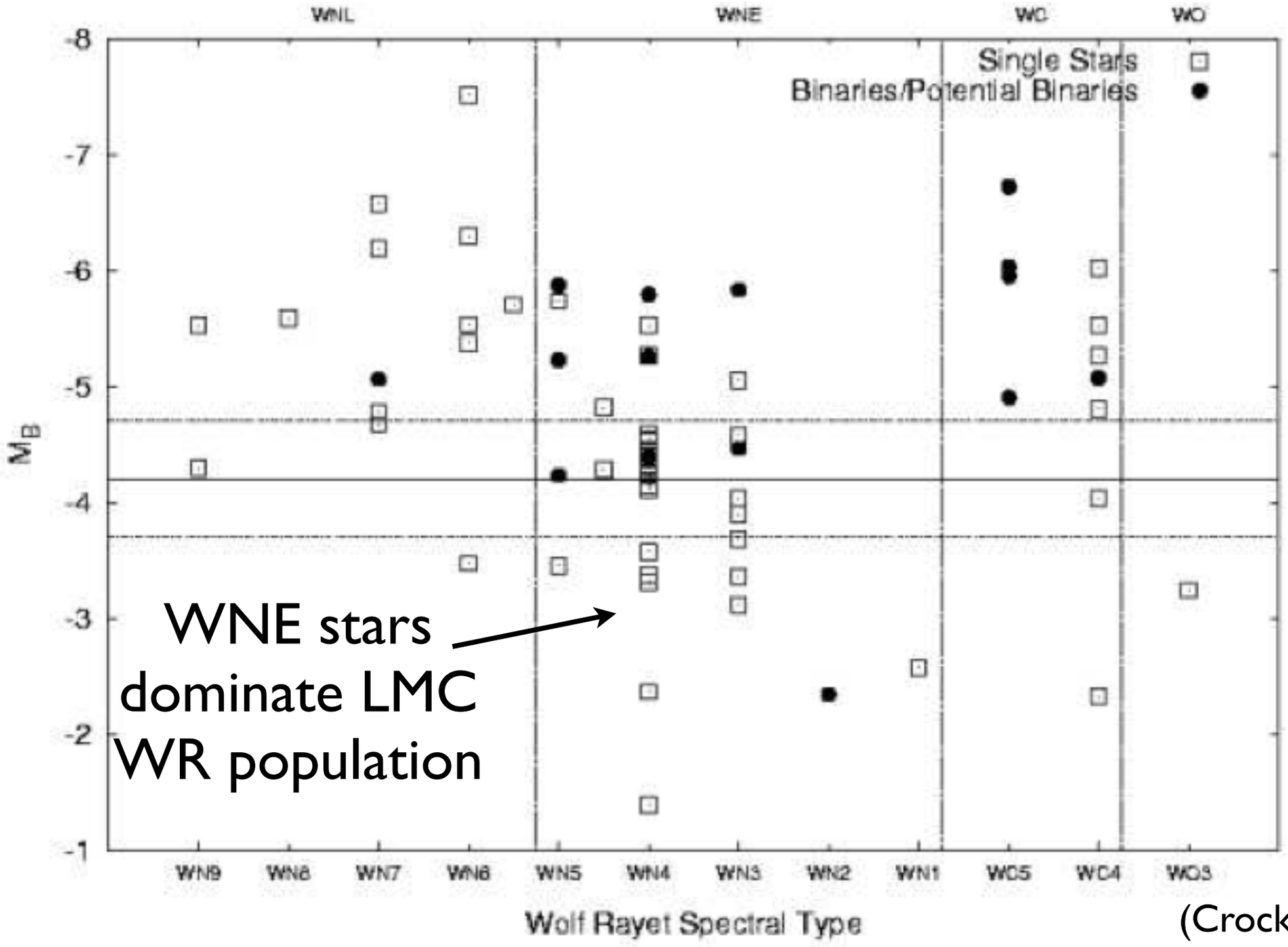
WR Stars in the LMC



~90% of the LMC WR population detected

(Crockett et al 2008)

WR Stars in the LMC

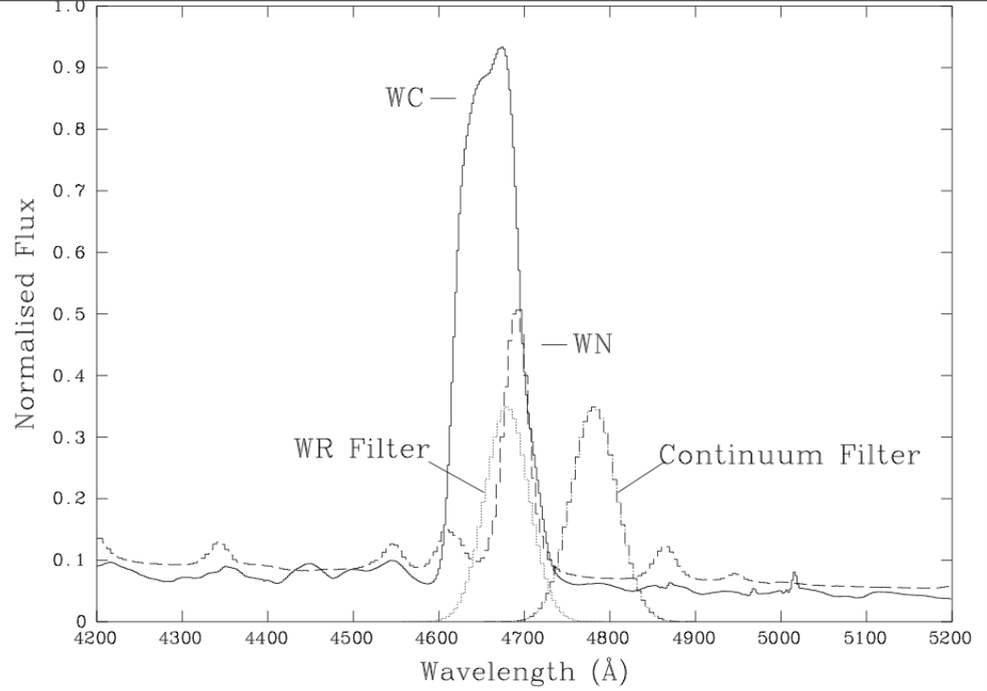


WNE stars dominate LMC WR population

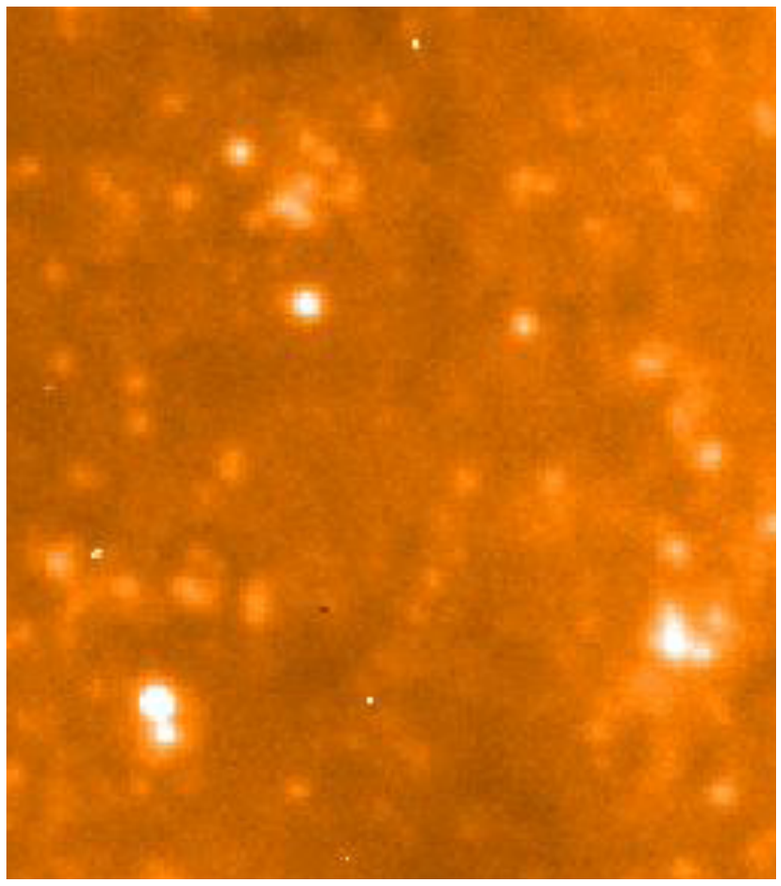
~90% of the LMC WR population detected

(Crockett et al 2008)

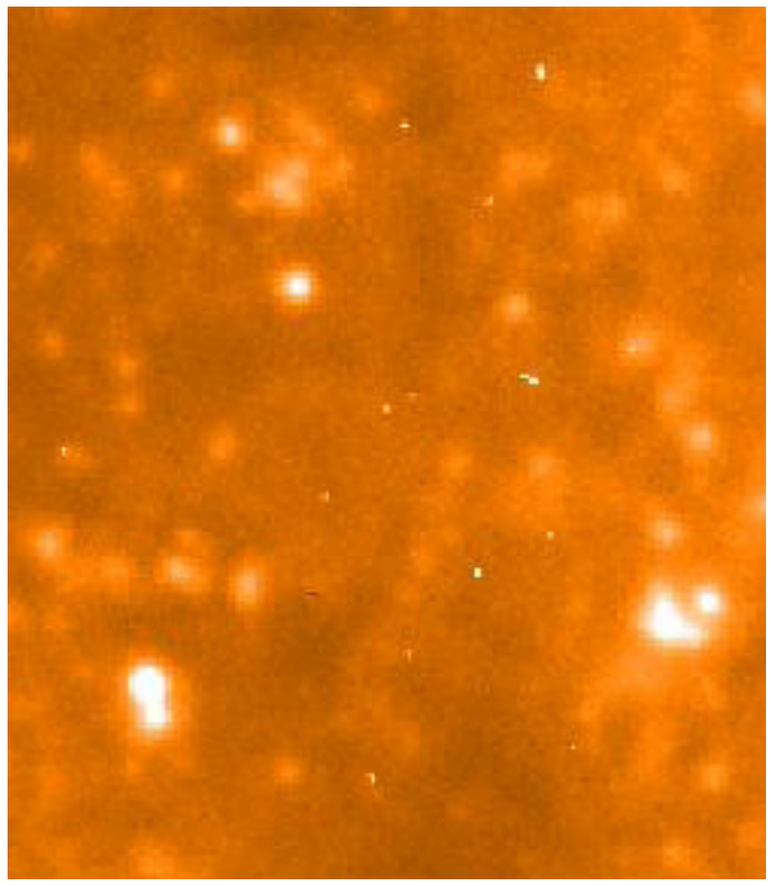
So how do we confirm a WR-SN connection?



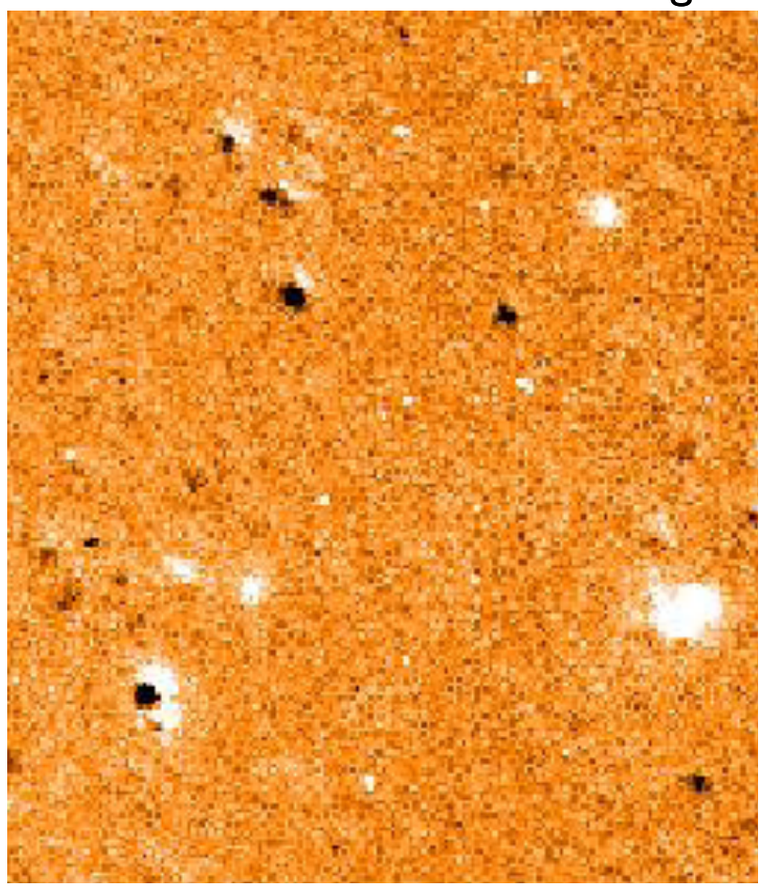
Continuum



He II narrow-band filter

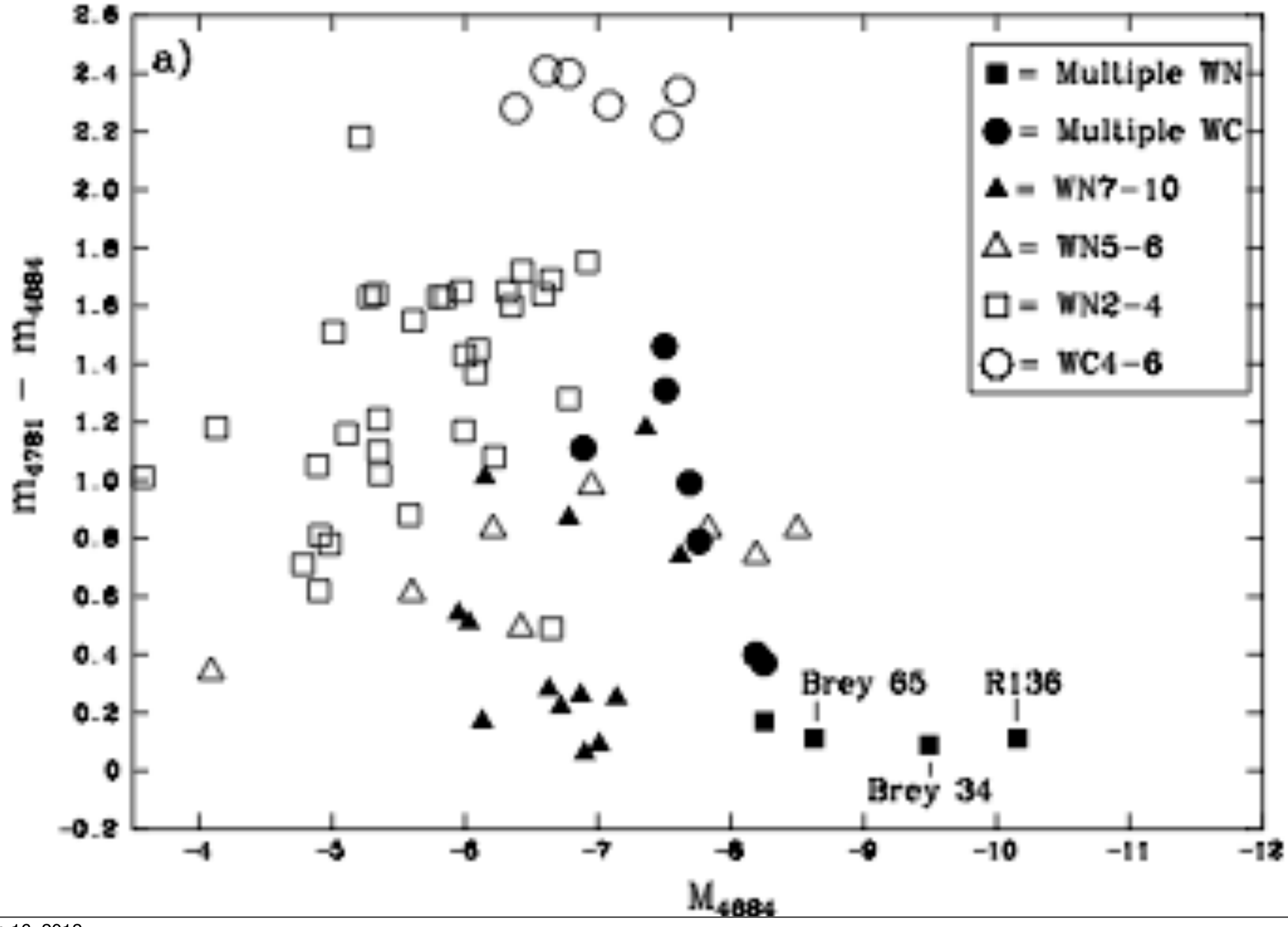


Continuum Subtracted He II Image



Narrow-band imaging techniques have been successful in detecting WR stars in nearby galaxies.

But Line Dilution is a problem...



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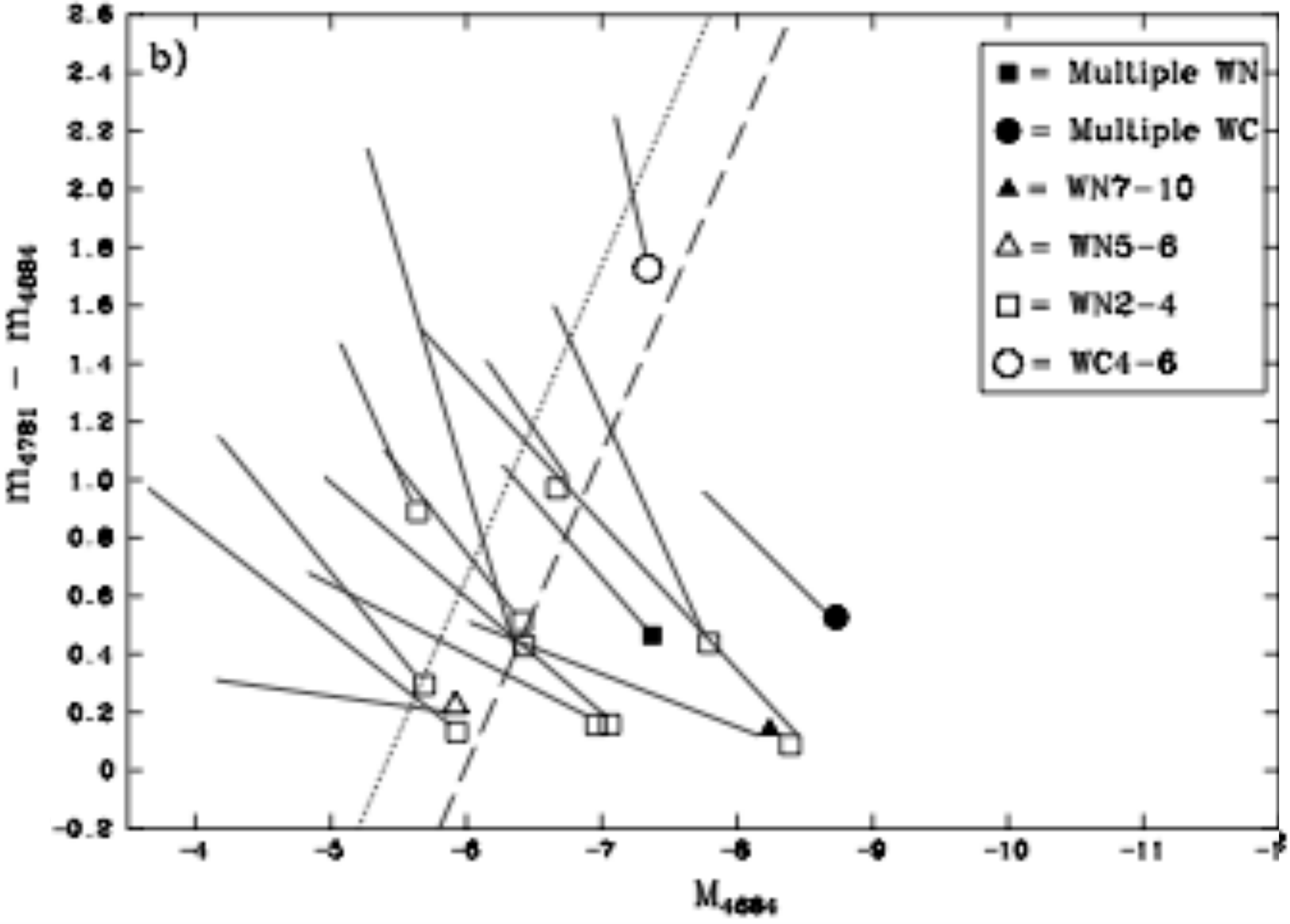
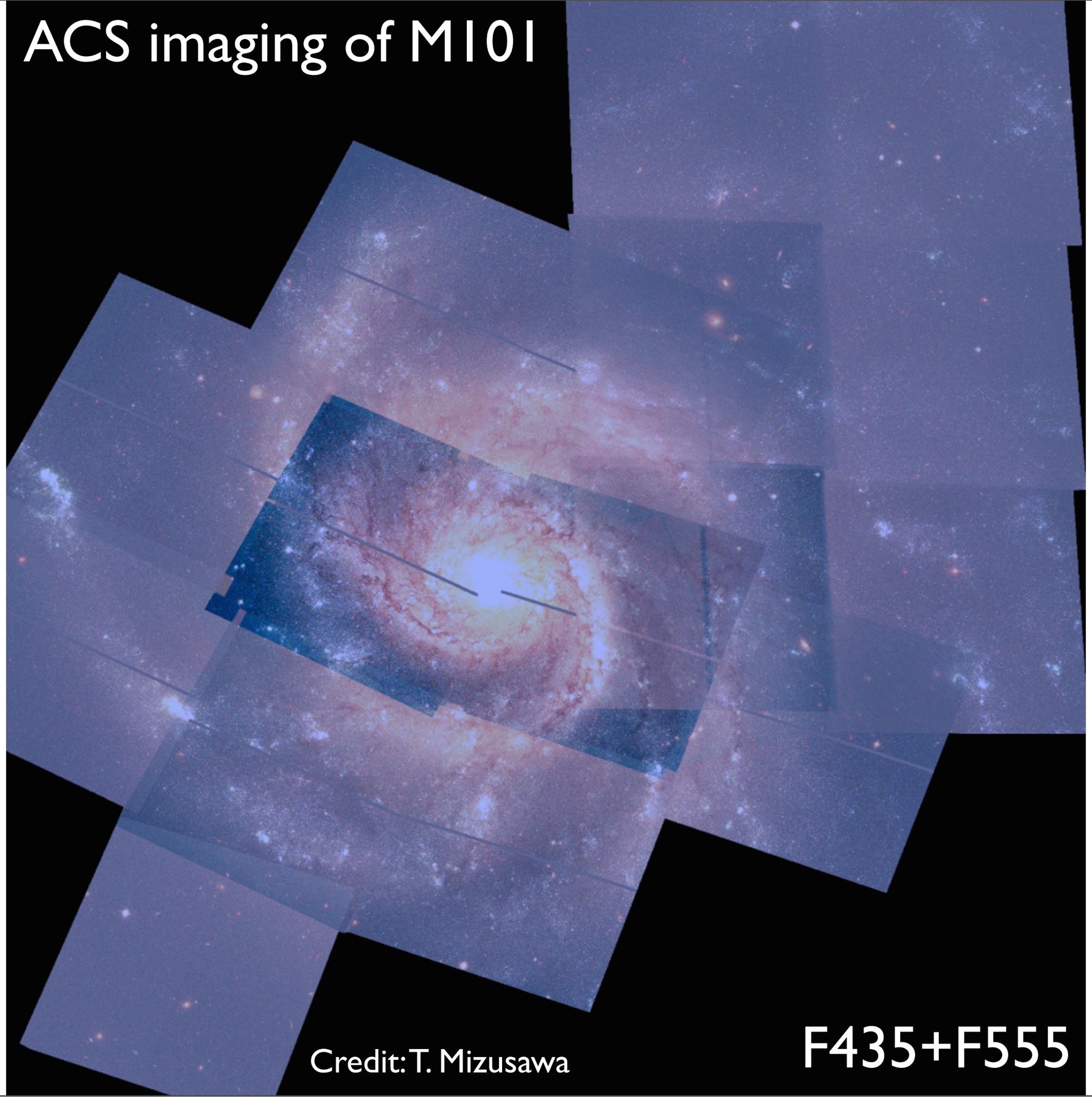
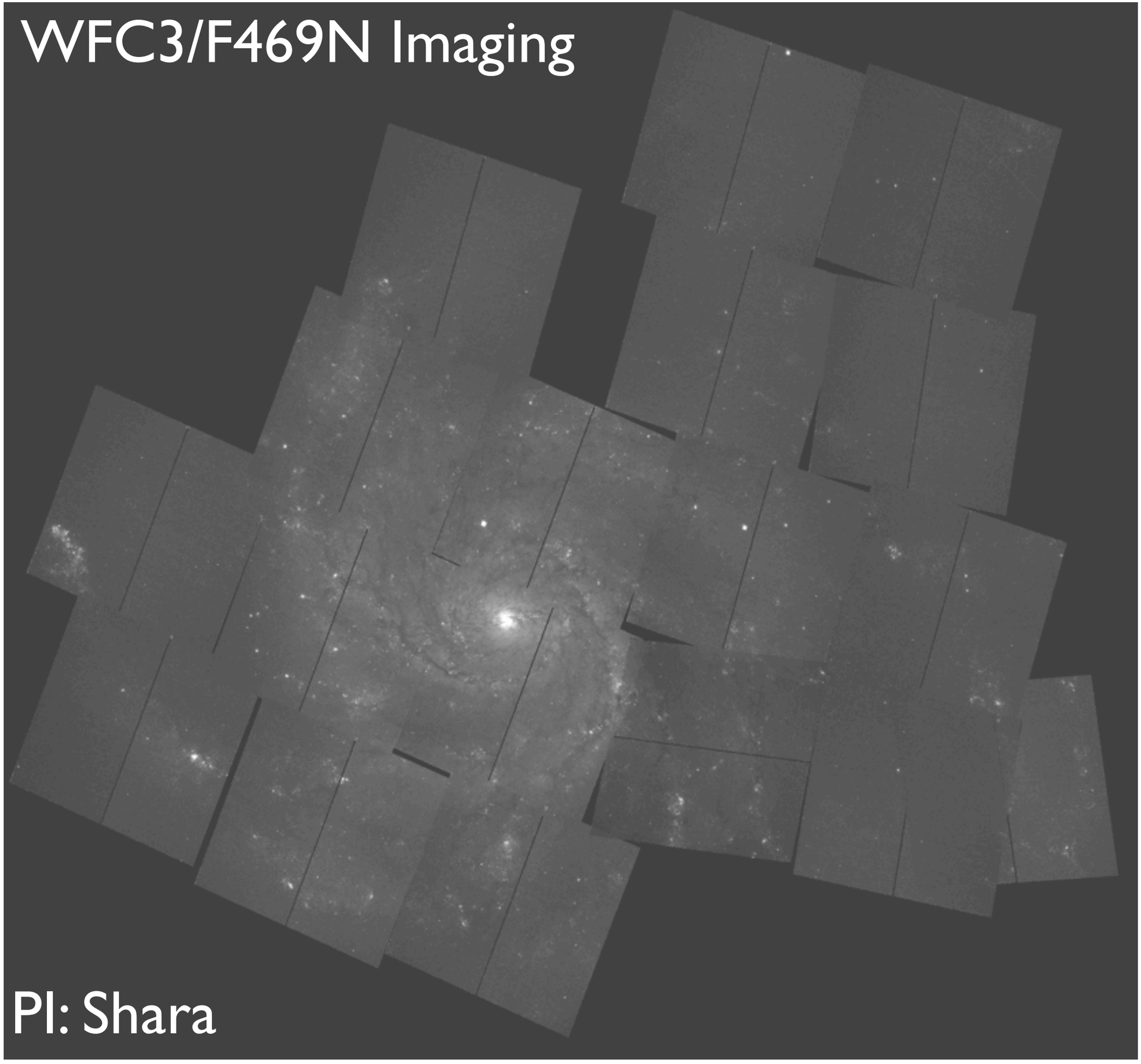


ACS imaging of M101

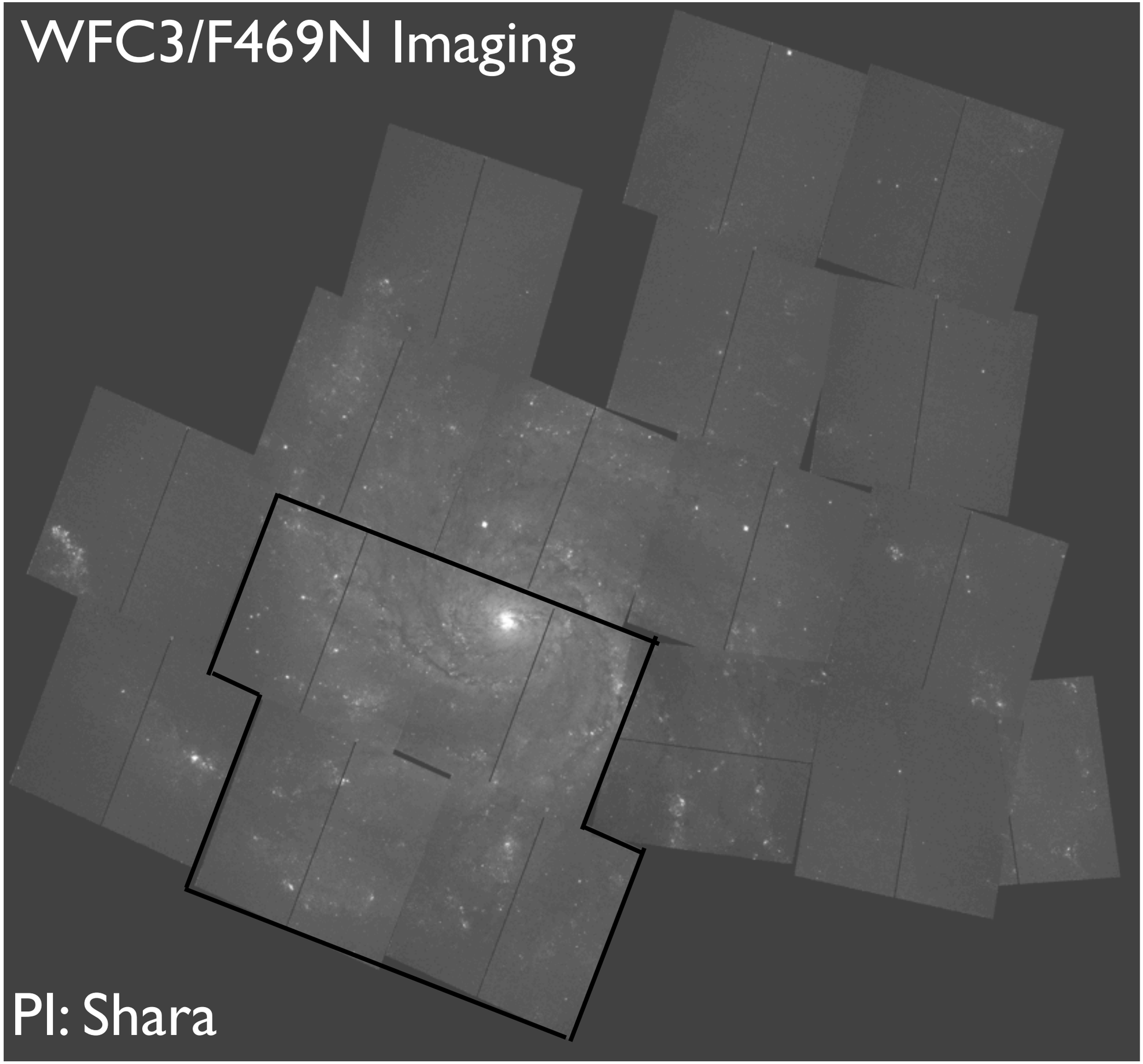


WFC3/F469N Imaging



PI: Shara

WFC3/F469N Imaging



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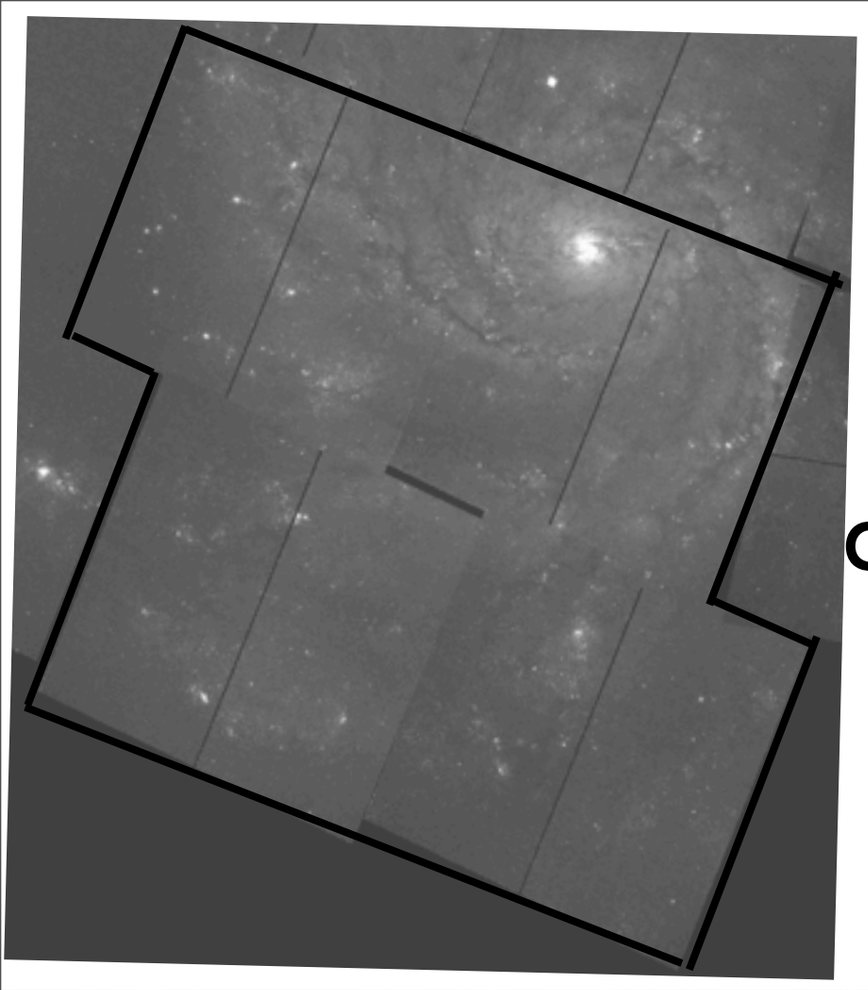
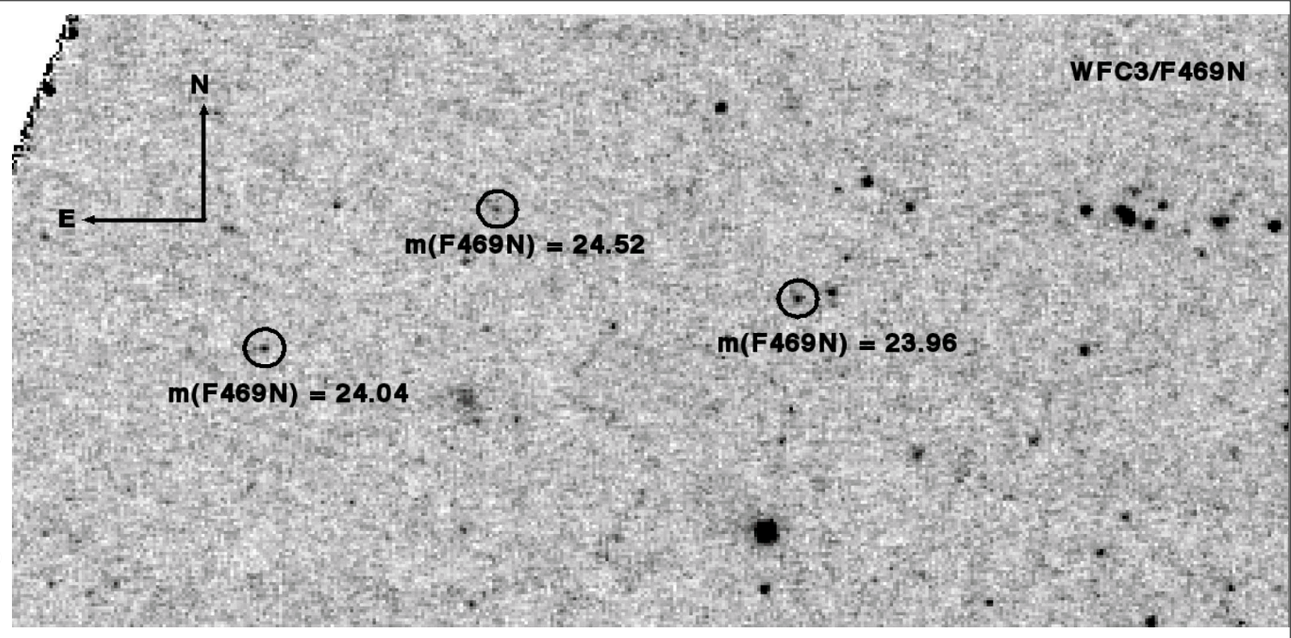
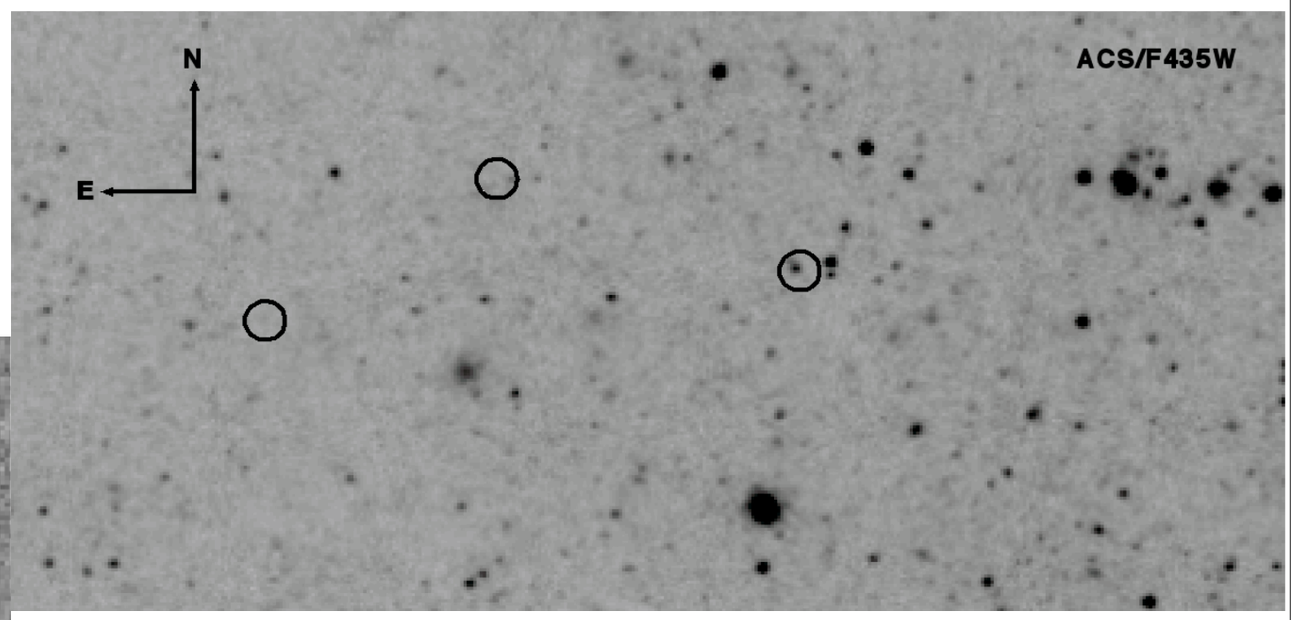
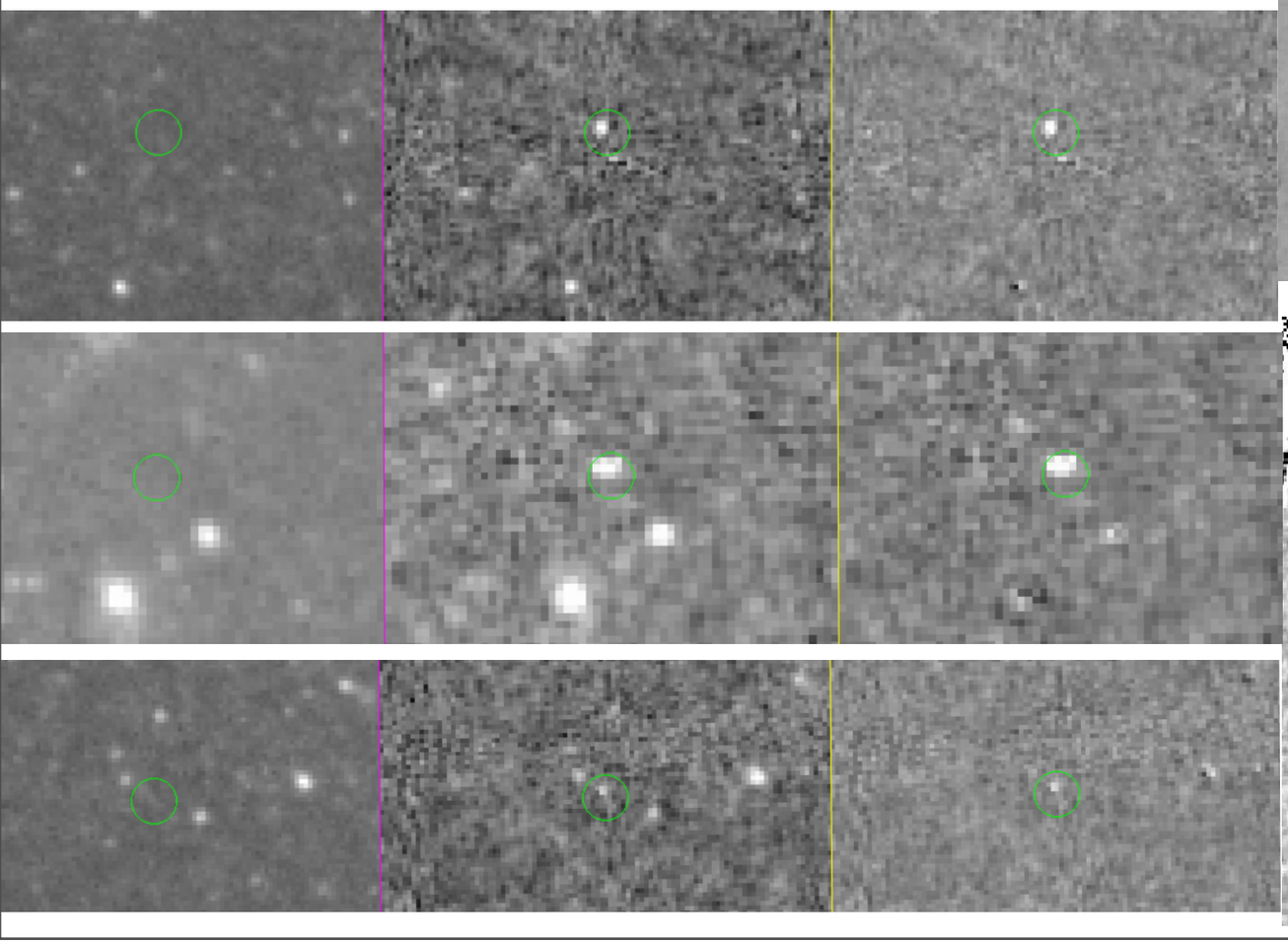
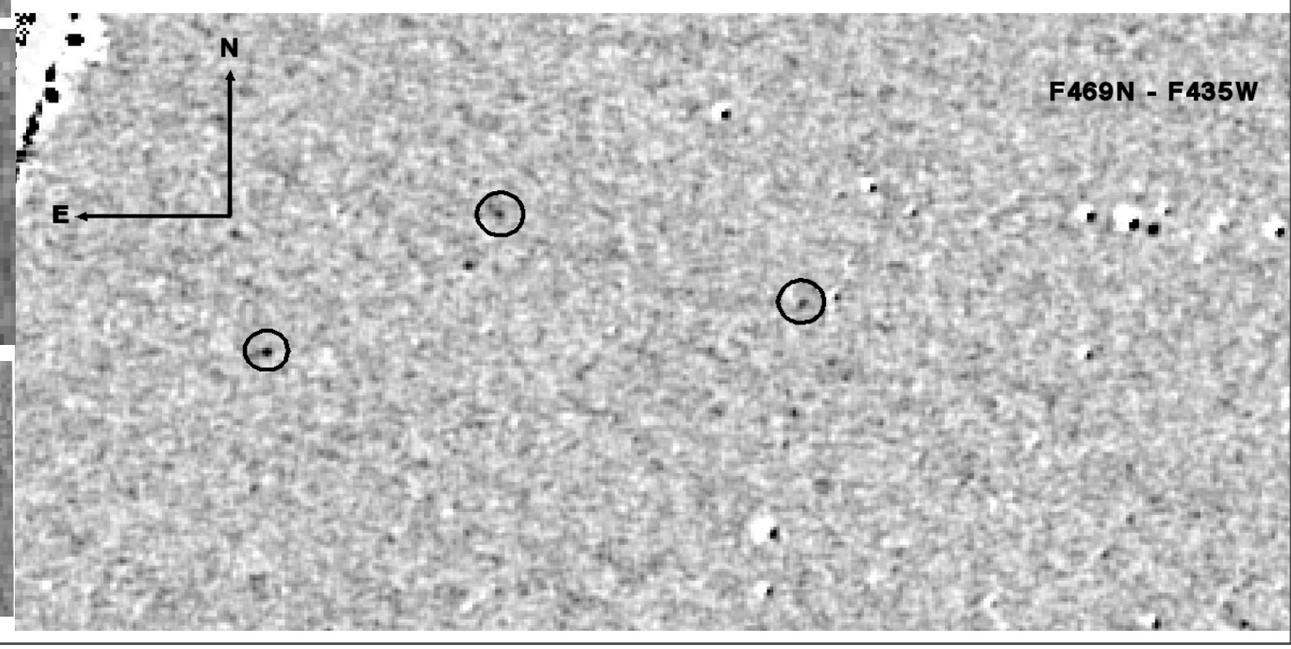


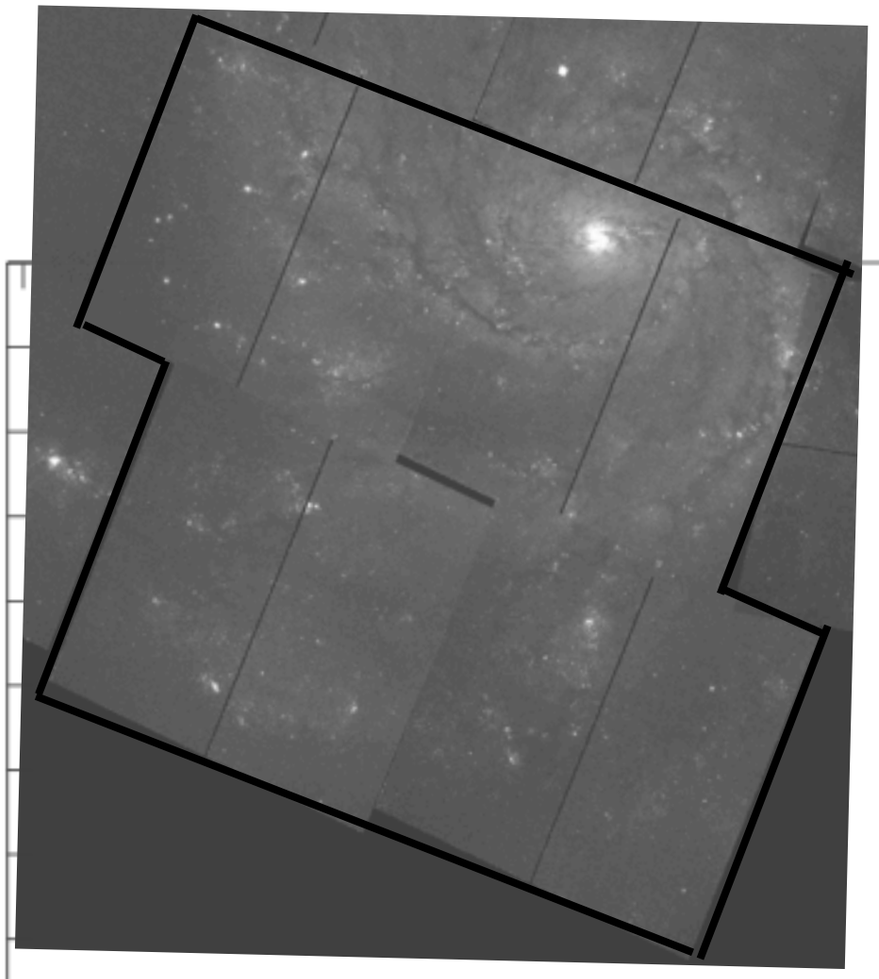
641 WR candidates





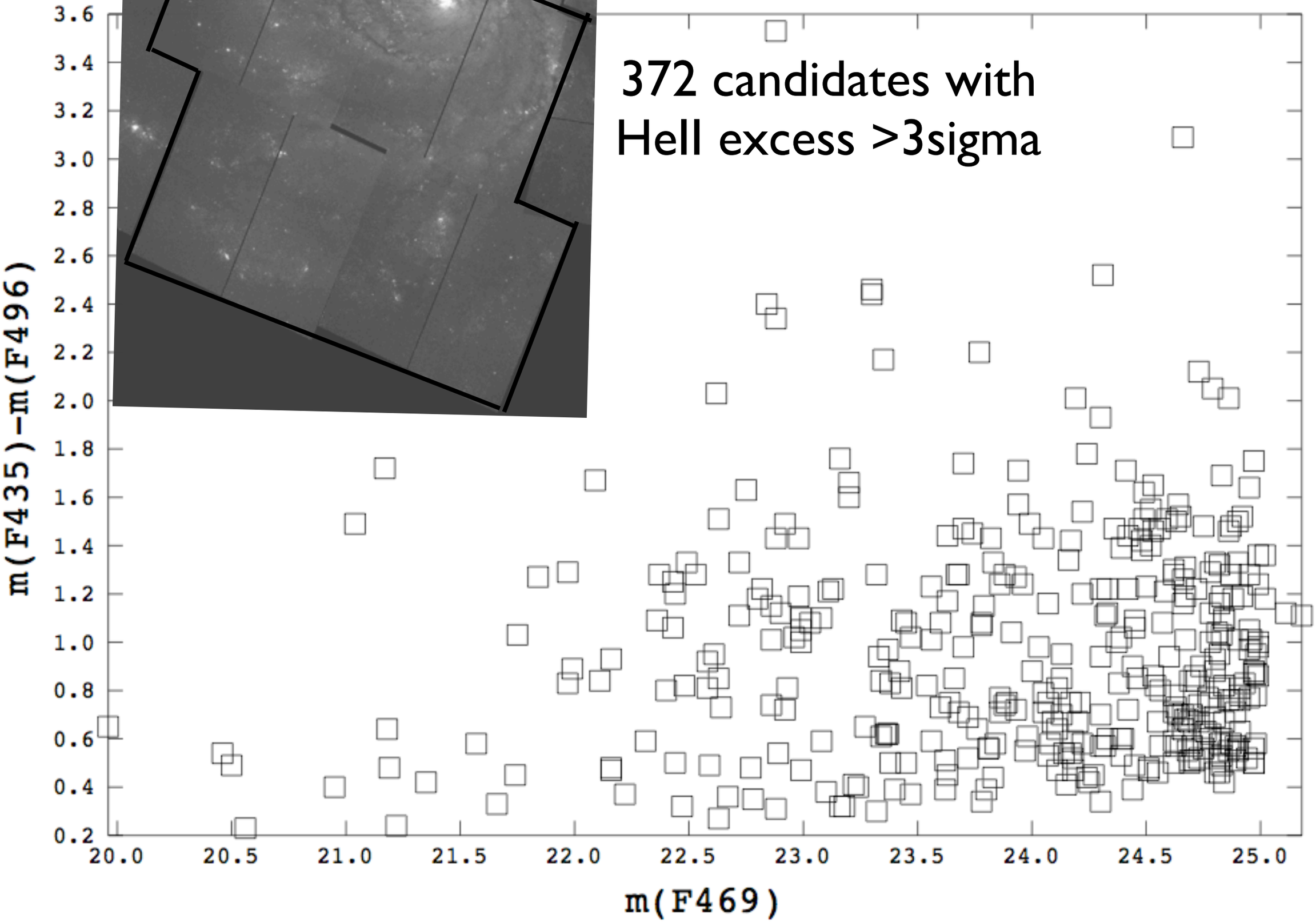




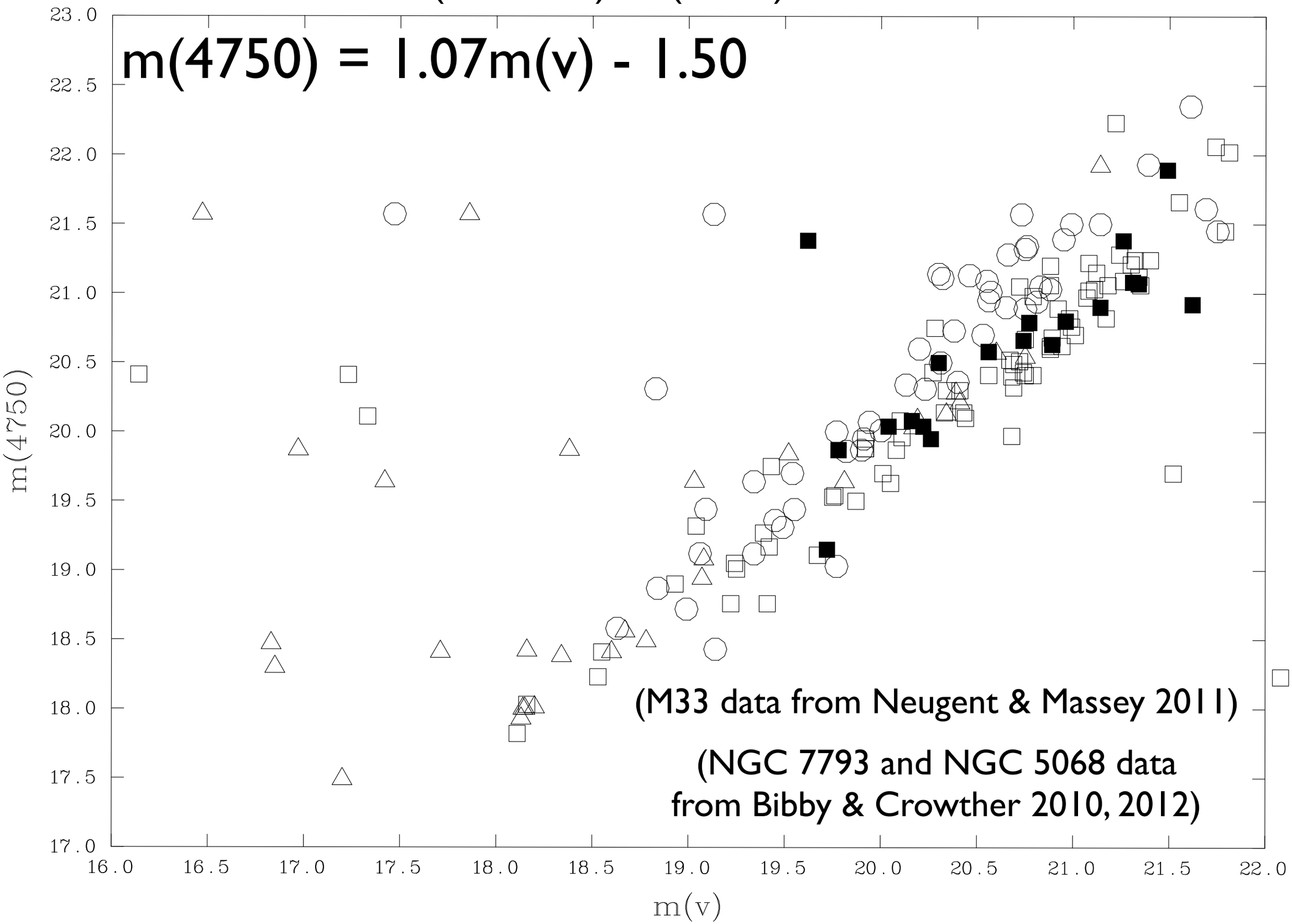


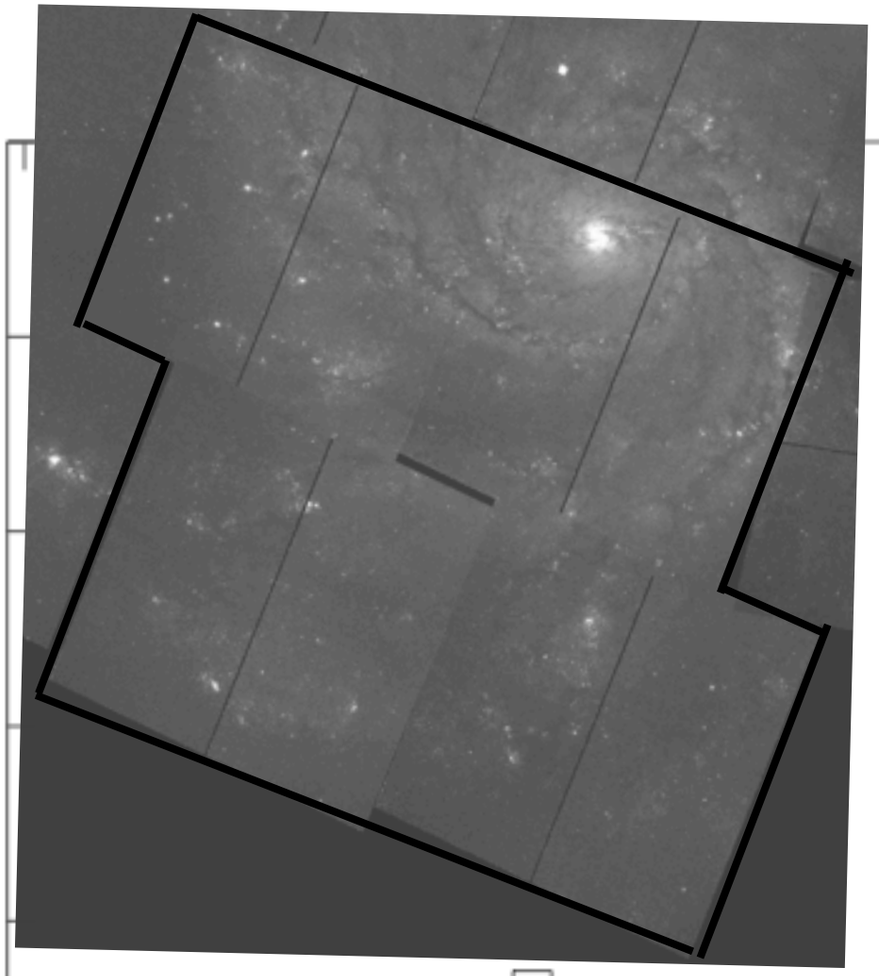
Note: Cut-off imposed at m(F469)>25mag

372 candidates with
Hell excess >3sigma



Photometry of candidates in M33, NGC 7993 & NGC 5068 for m(F435W)-m(cont) relation

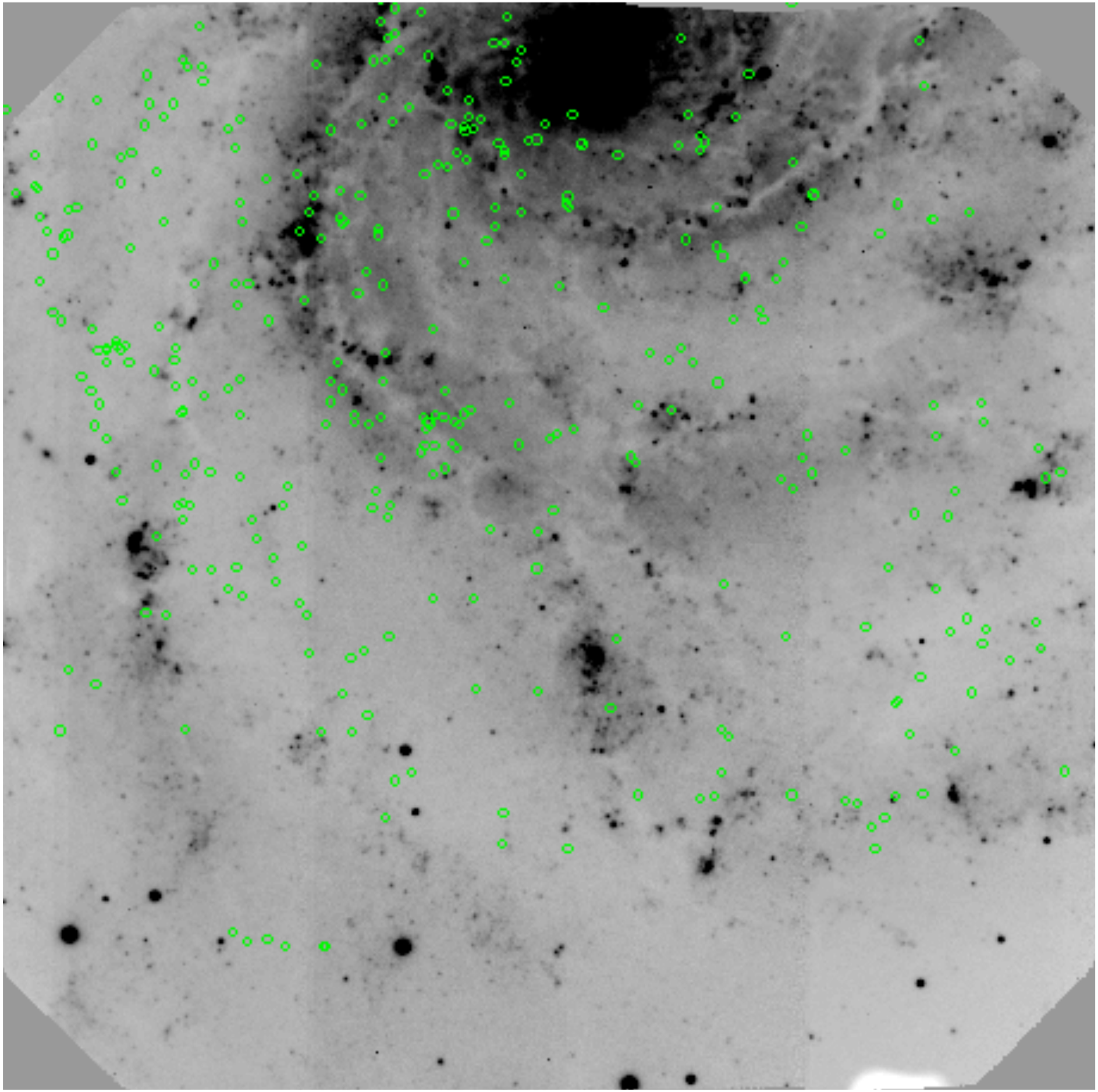


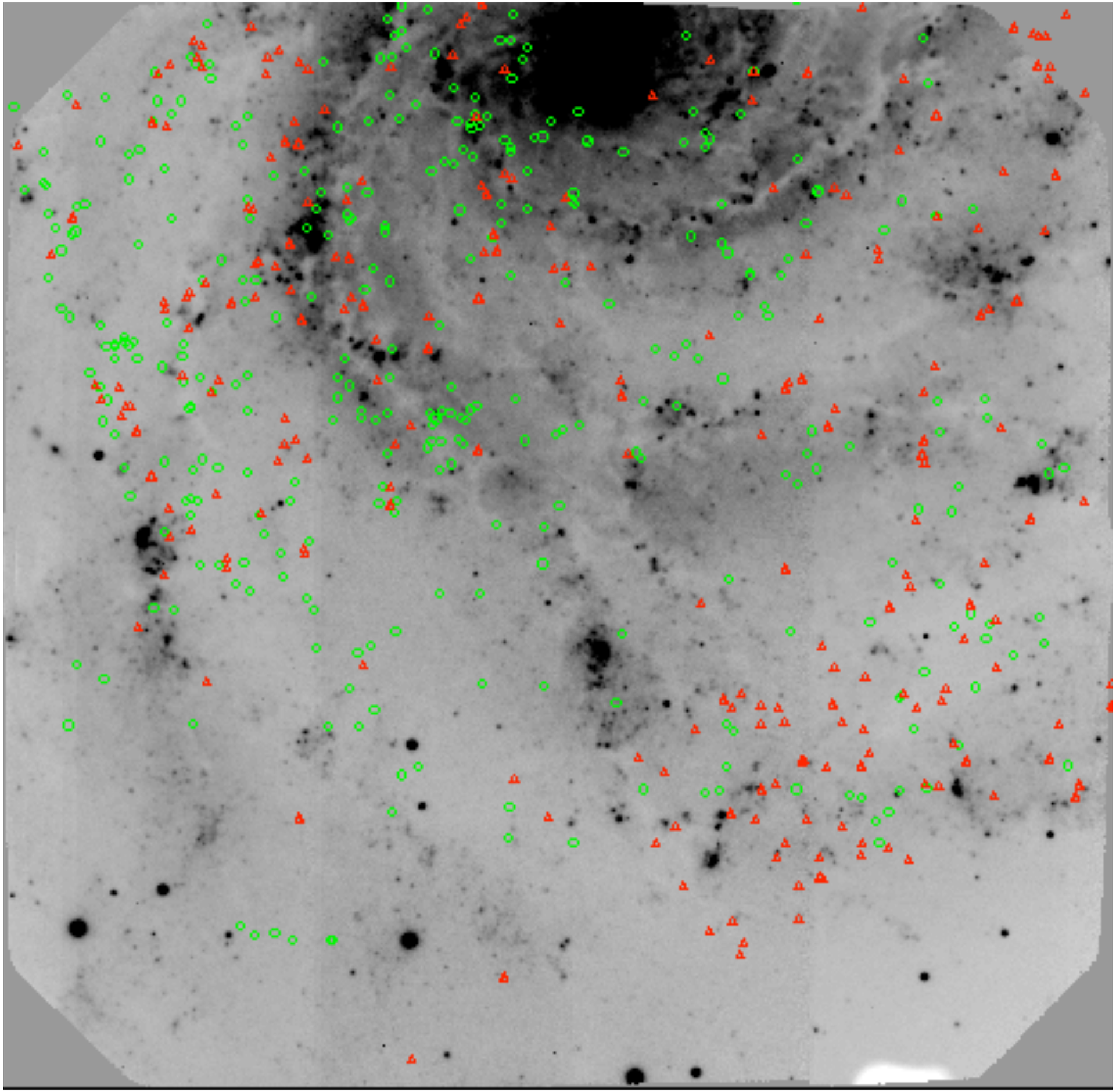


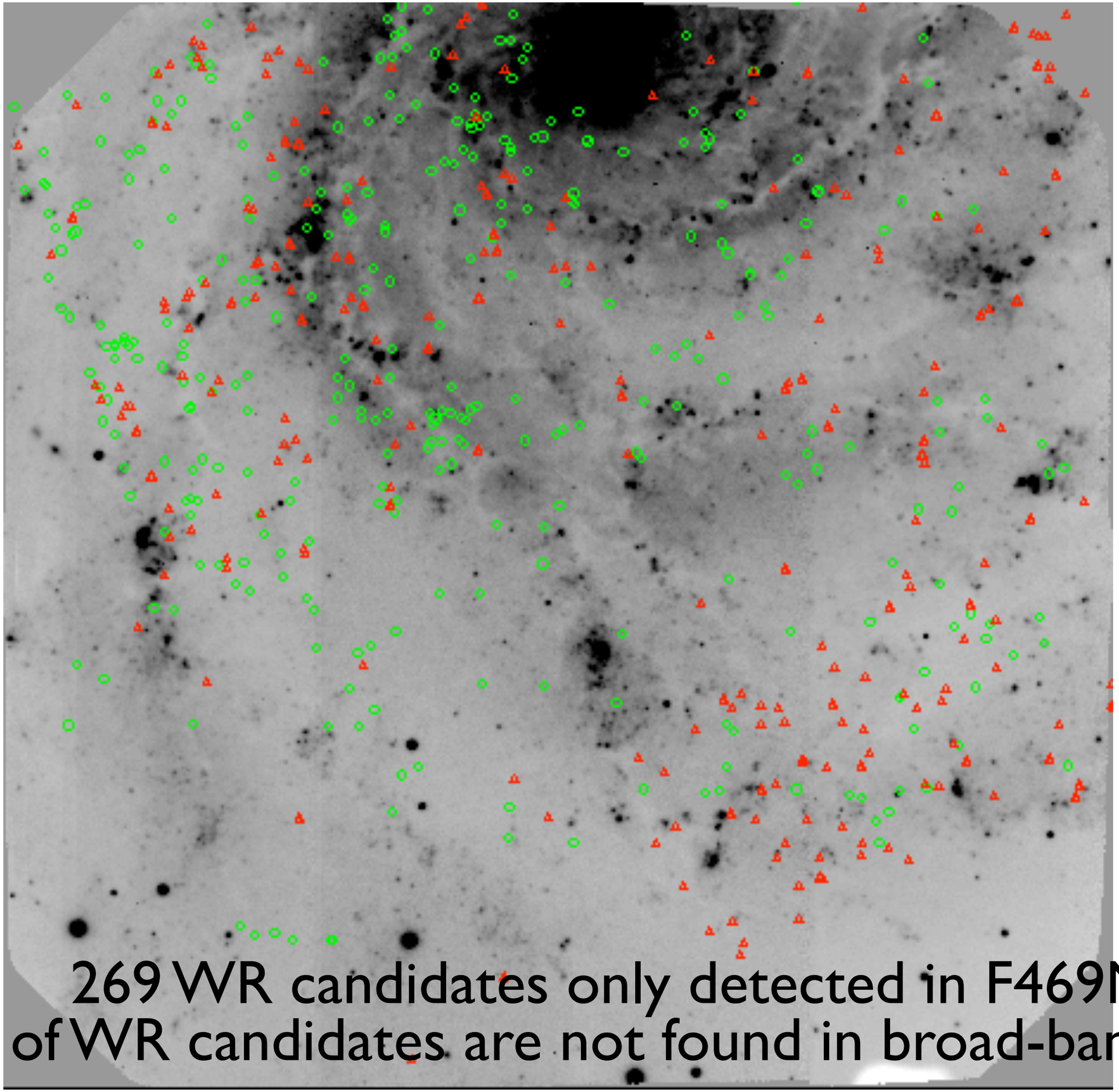
372 candidates with
Hell excess >3sigma

m(475)−m(469)

m(F469)



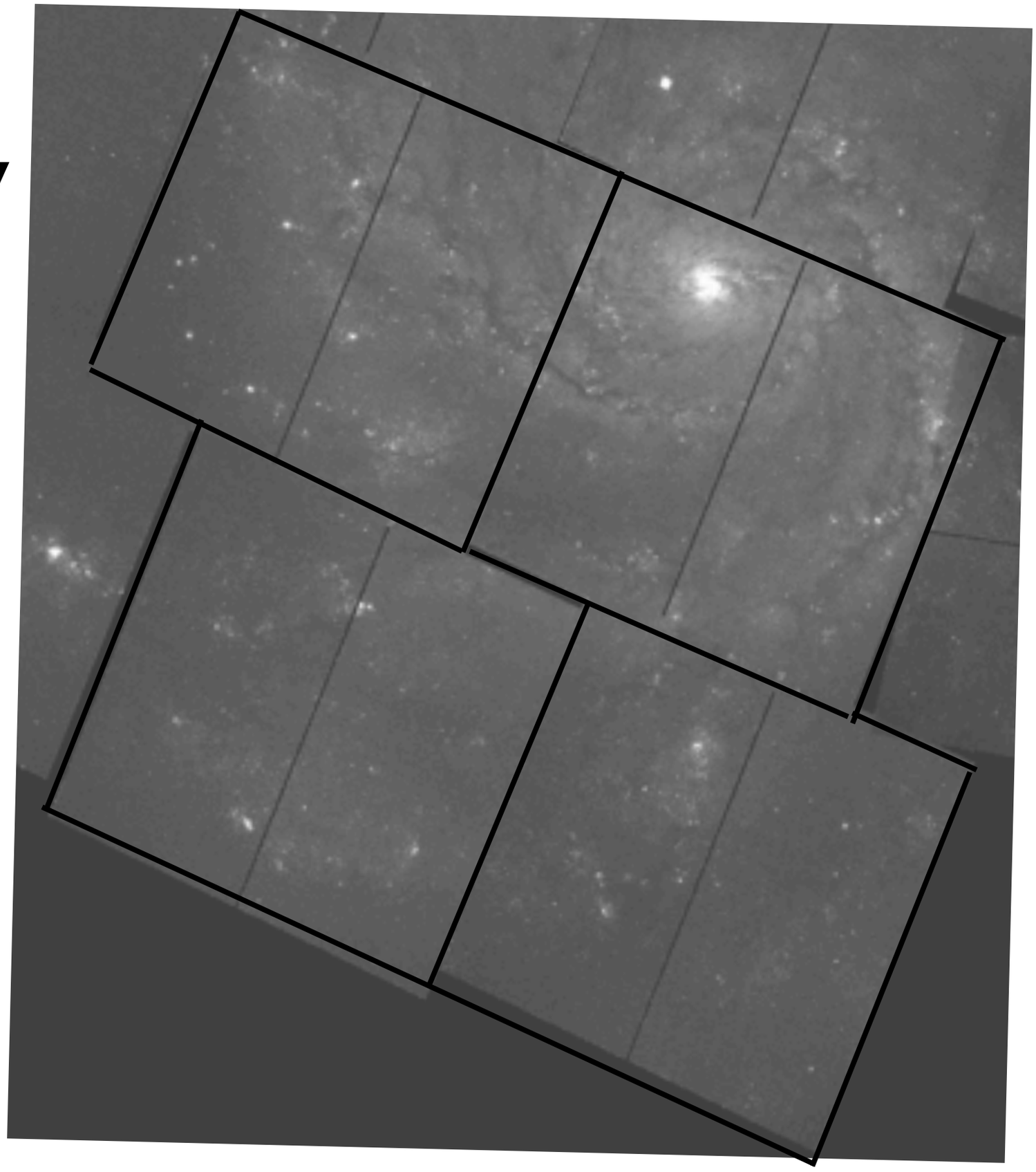




269 WR candidates only detected in F469N

42% of WR candidates are not found in broad-band images

Number of WR in each region



Sigma = 67
Hell =57

85%

Sigma = 214
Hell =112

52%

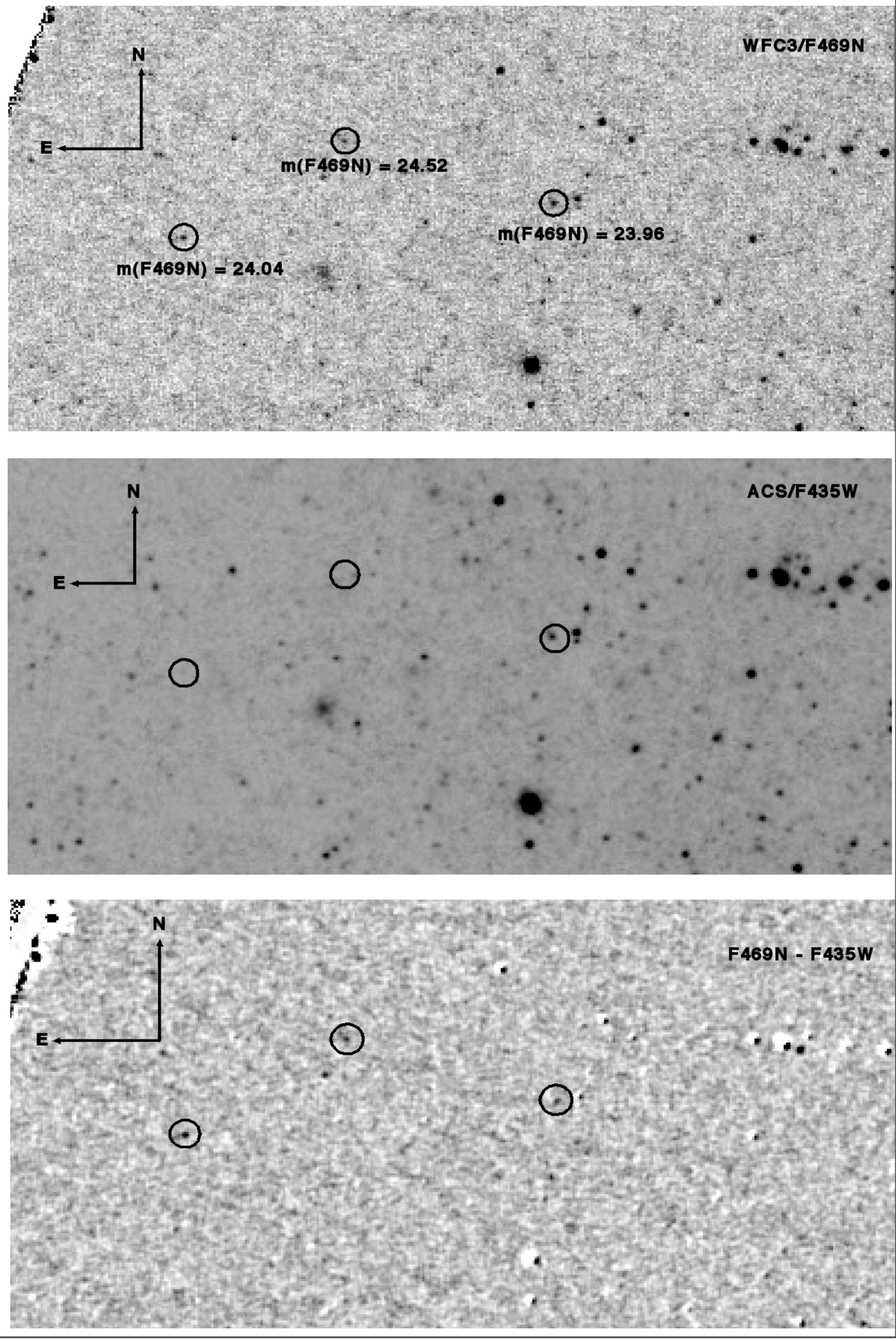
Sigma = 55
Hell = 91

165%

Sigma = 36
Hell = 9

25%

How does resolution affect our detections?



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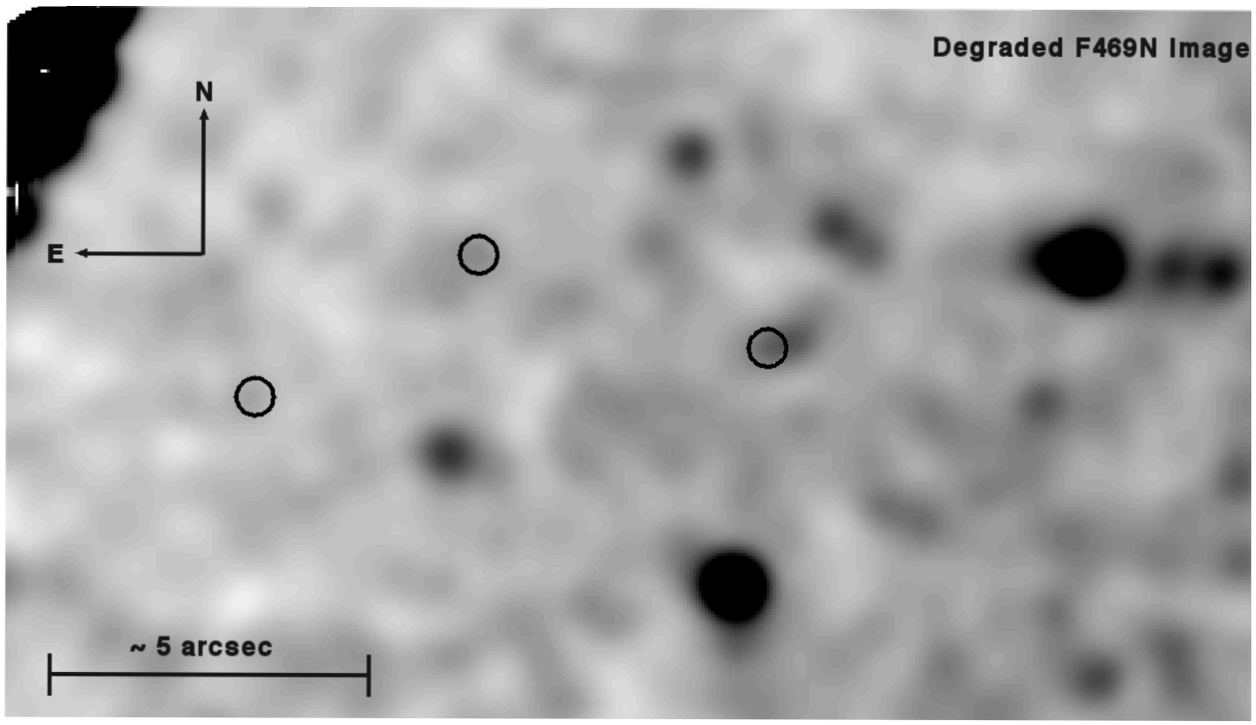
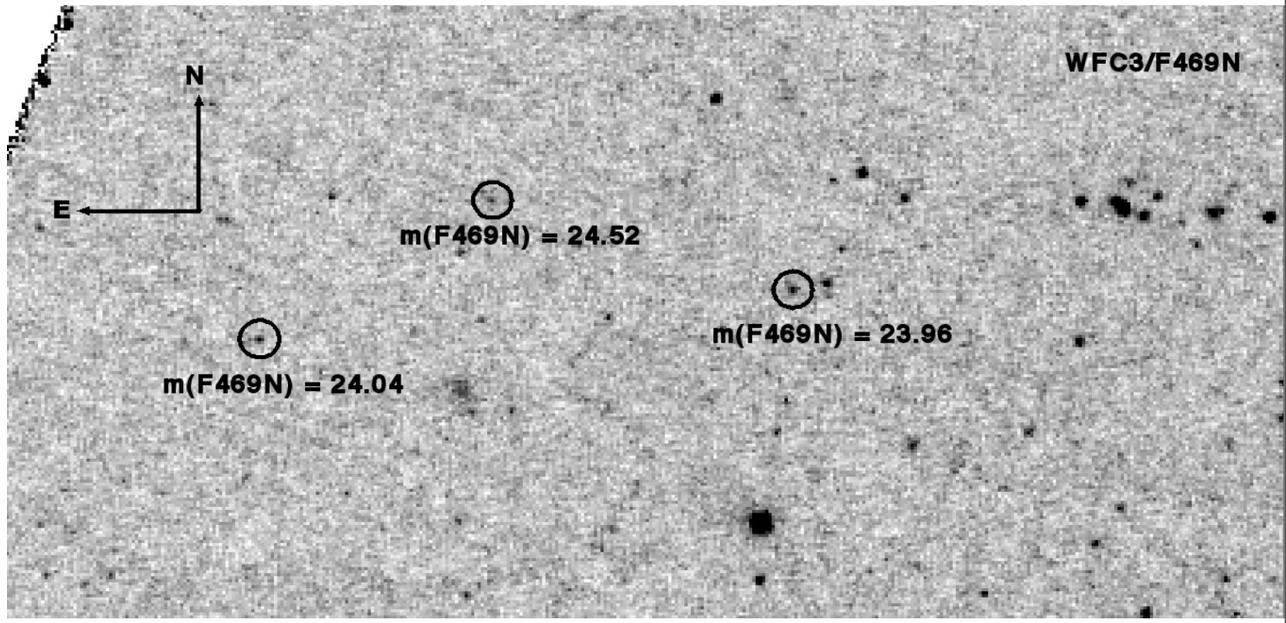
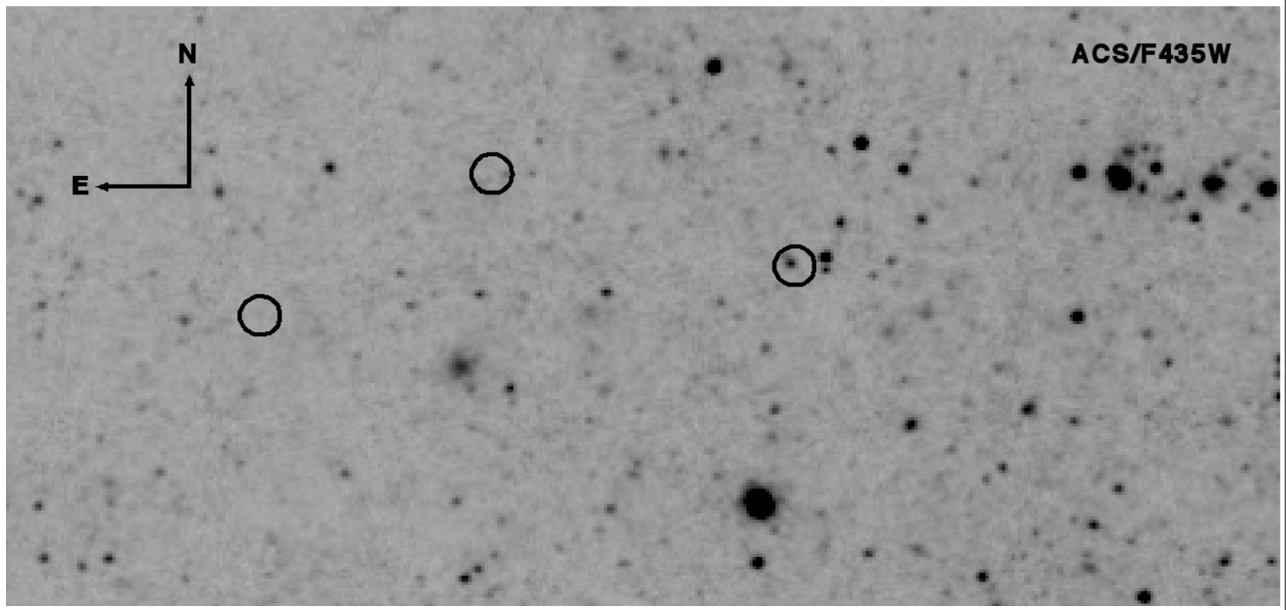
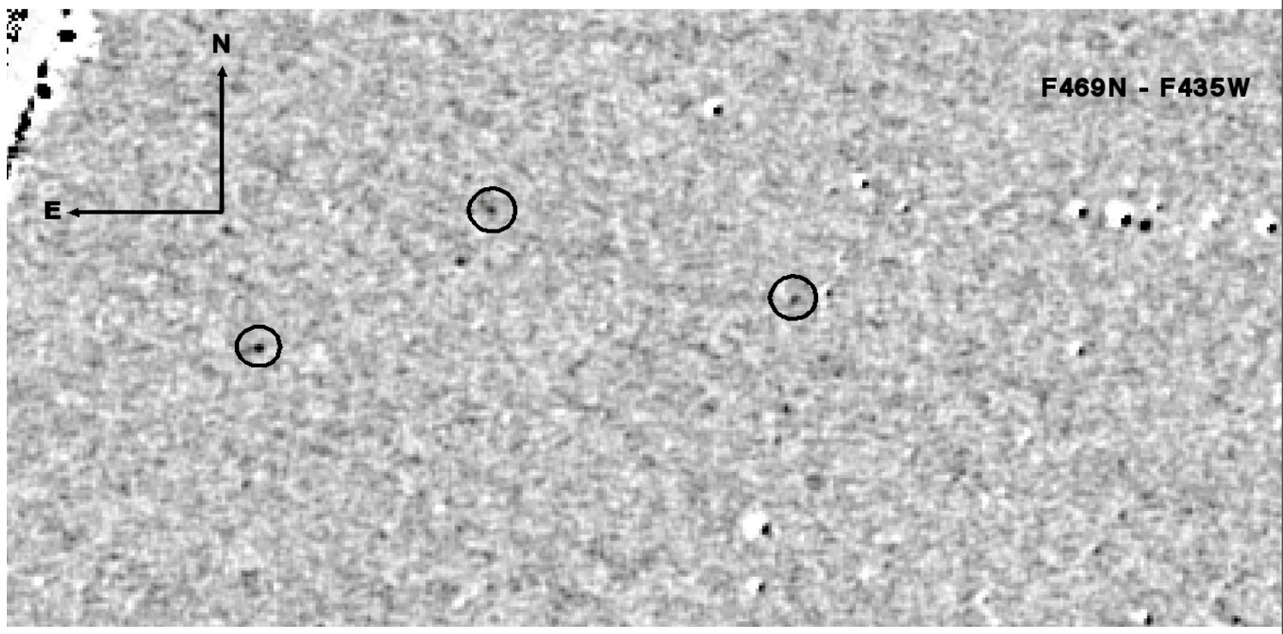






FWHM~0.8”
Much harder to detect the WR stars...
Only one is detected in the continuum subtracted image



WFC3/F469N Imaging

$\log(O/H)+12 = 9.2 - 0.91\ (R/r_{25})$ dex

(Bresolin 2007)

PI: Shara

WFC3/F469N Imaging

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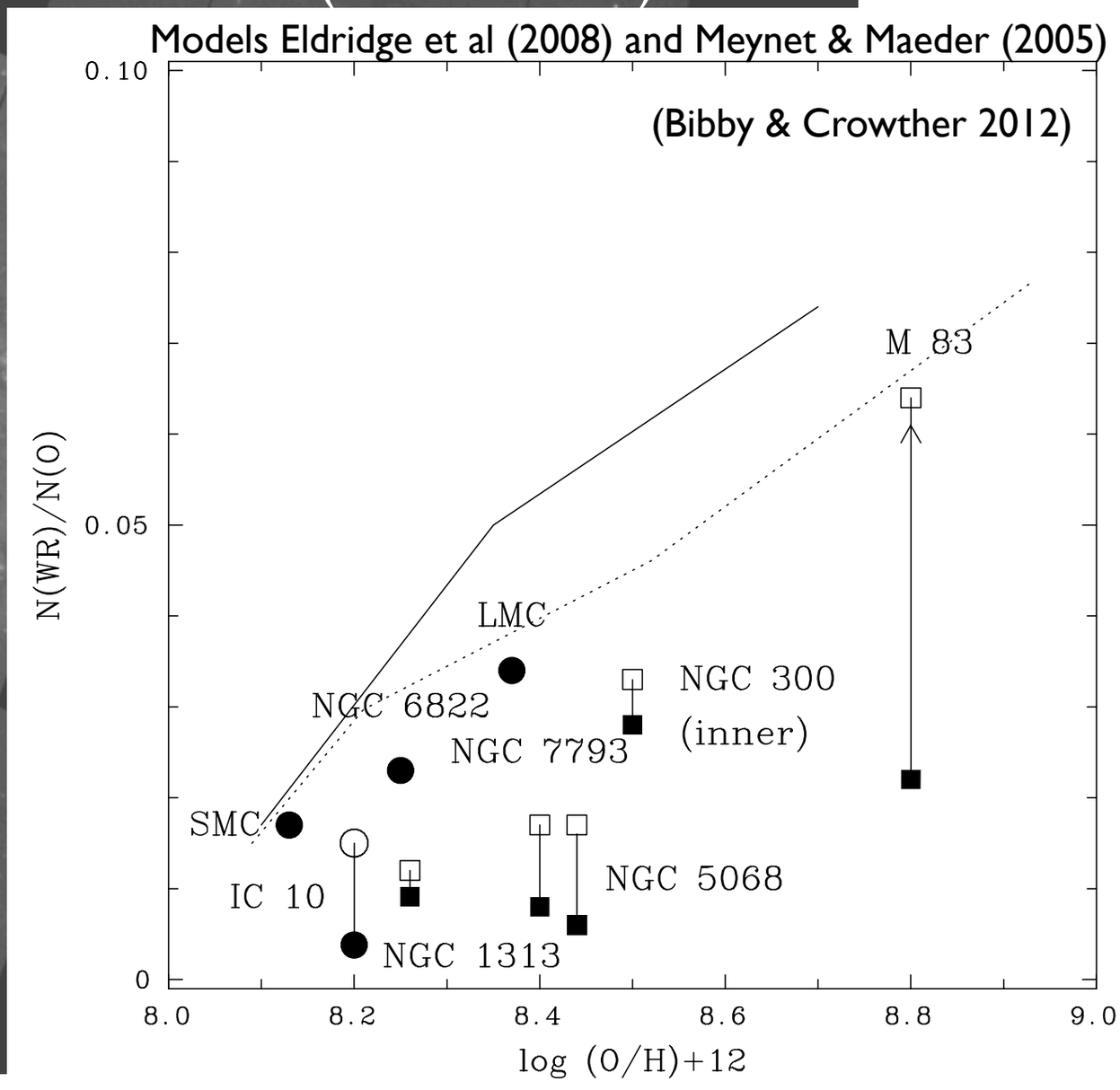
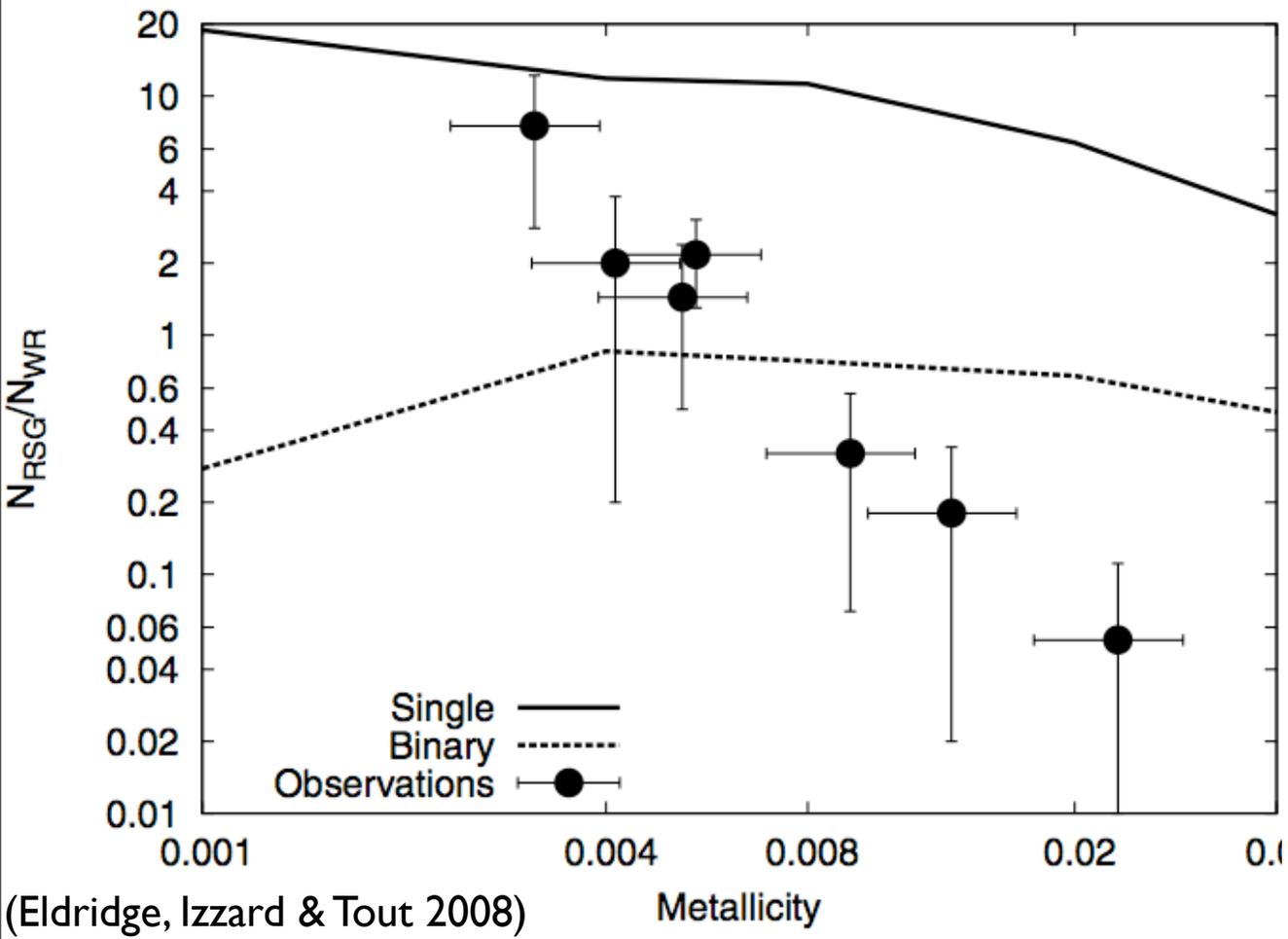
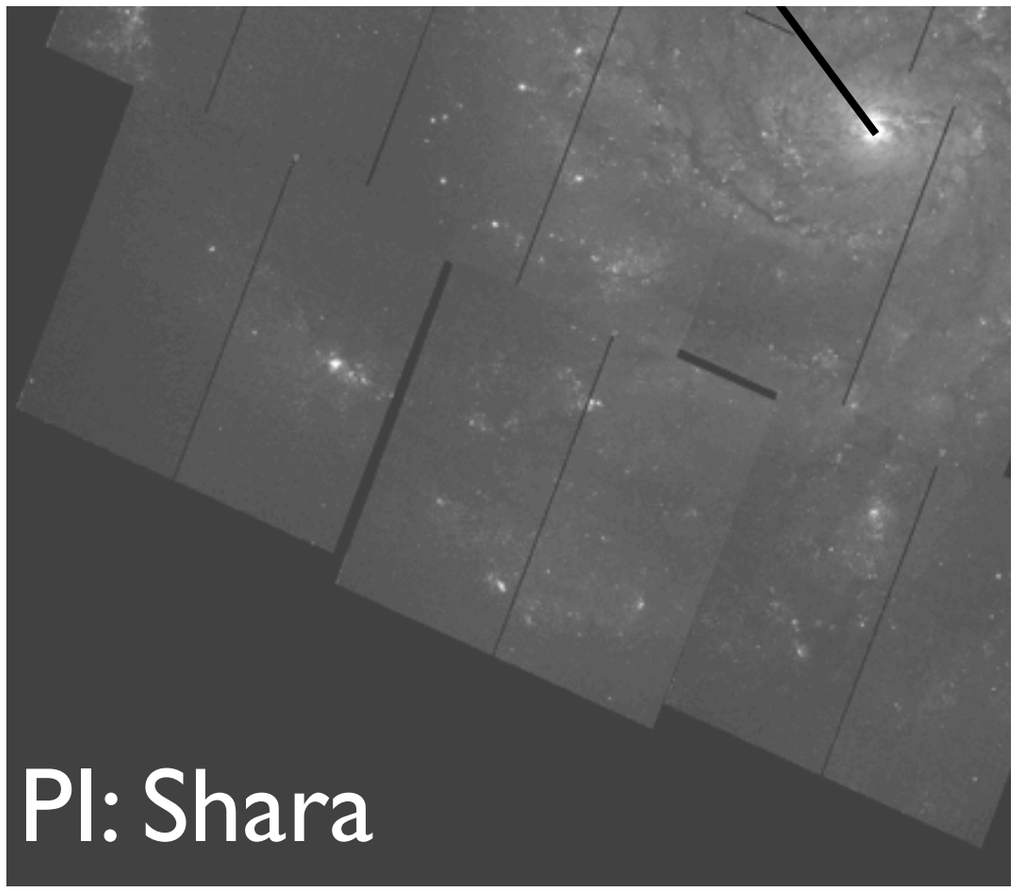
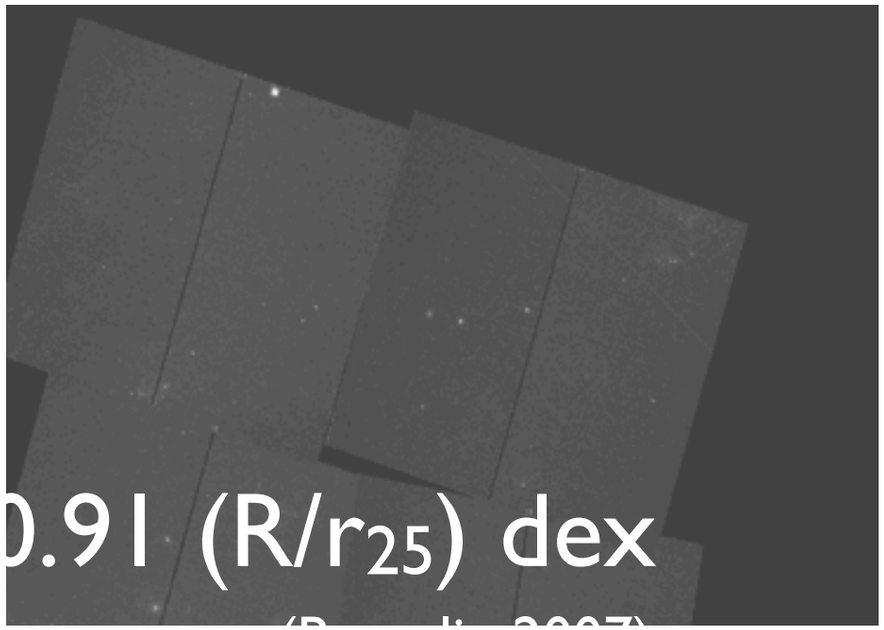
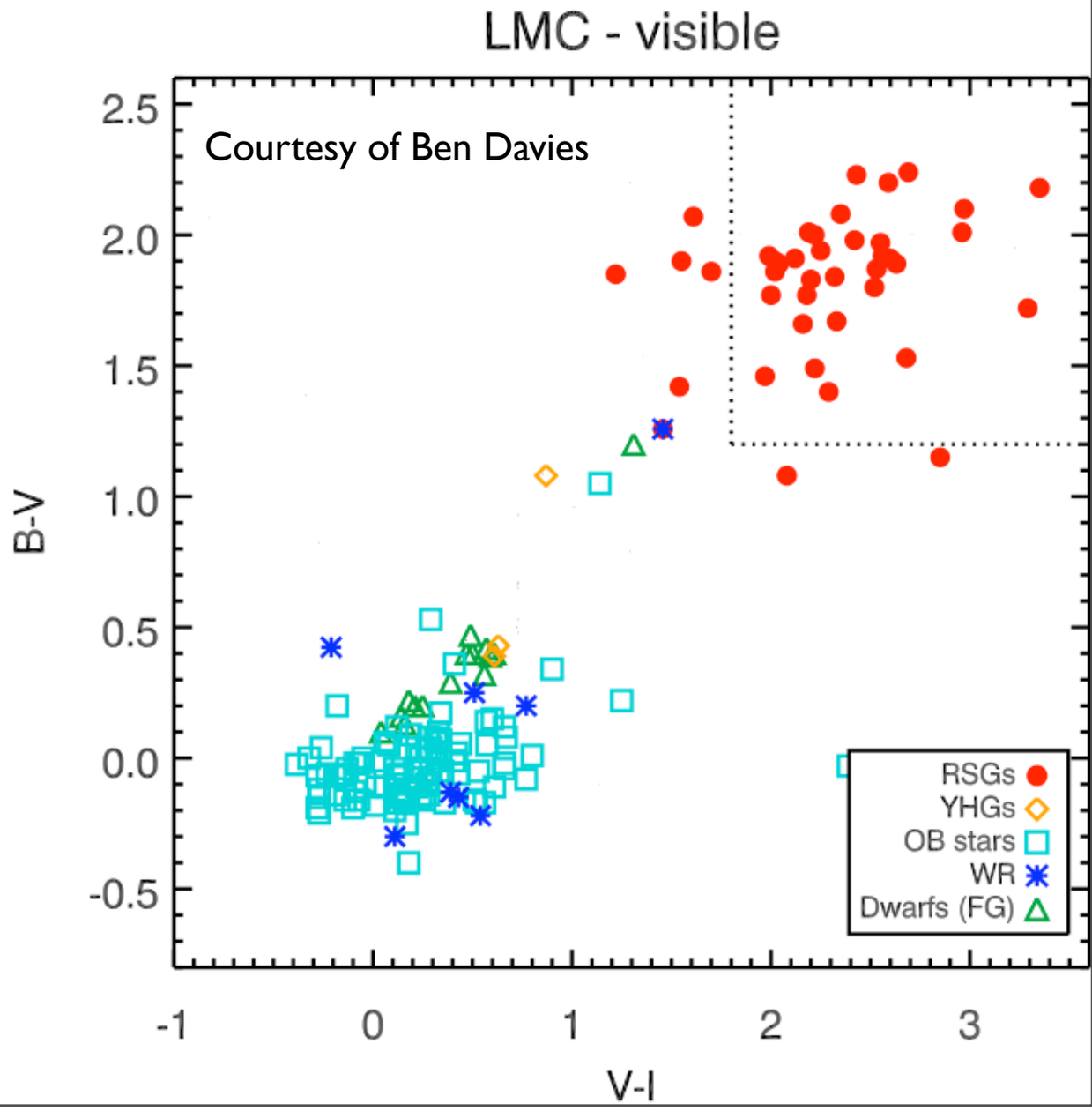




(Eldridge, Izzard & Tout 2008)







Future Work:

How many WR stars would be detected in ground-based imaging... by degrading HST data?

How WR/O star ratio changes over radius, hence metallicity, of the galaxy?

How the WR/RSG ratio changes over the galaxy?

Association of WR stars with HII regions?

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Association of WR stars with HII regions?

By completing our WR survey of M101 and other galaxies we can further assess the validity of WR stars as supernova progenitors.