

Looking for High-Mass X-ray Binaries in the Small Magellanic Cloud

Grigoris Maravelias ⁽¹⁾

A. Zezas ^(1,2,3)

V. Antoniou ⁽³⁾

D. Hatzidimitriou ⁽⁴⁾

F. Haberl ⁽⁵⁾

(1) Univ. of Crete, Greece

(2) IESL-FORTH, Greece

(3) Harvard-Smithsonian CfA, USA

(4) Univ. of Athens, Greece

(5) Max Planck Institute for Extraterrestrial Physics, Germany

- Quick Introduction (HMXBs / SMC)
- Comparison of SMC/MW HMXBs
- New photometric survey
- Conclusions

High-Mass X-ray Binaries

Compact object (NS or BH)

+

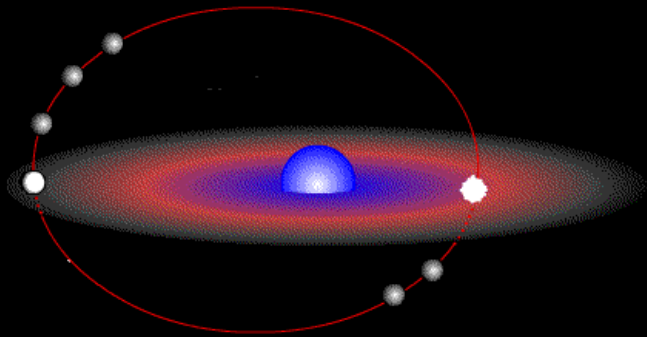
early type OB star

($M > 8 M_{\text{solar}}$)

Be X-ray Binaries (Be V-III)

decretion disk

© NASA



Supergiant X-ray Binaries (I-II)

Roche-lobe overflow/stellar winds

© ESA



Why do we care ?

- Extreme conditions: gravity and magnetic field
- Be formation/dissipation of the equatorial disk
- Interaction between the Be's disk and NS
- Binary: eccentricity, masses, long-term evolution

The Small Magellanic Cloud laboratory

- > Galaxy: extinction and distance uncertainties
- > other galaxies: large distances
- > SMC: contains the biggest uniform population
 - _ Can detect sources down to $L_x \sim 10^{33} \text{ erg s}^{-1}$ (non outbursting)
 - _ Well determined & uniform distance
 - _ Relatively low intergalactic extinction
 - _ Low line-of-sight depth of young, central stellar populations
 - _ Relatively uniform metallicity
 - _ Well-determined star formation history
 - _ Large number of candidate BeXRBs ($\sim 80^*$)

...but not confirmed !

*<http://xray.sai.msu.ru/~raguzova/BeXcat/>

Spectroscopic surveys

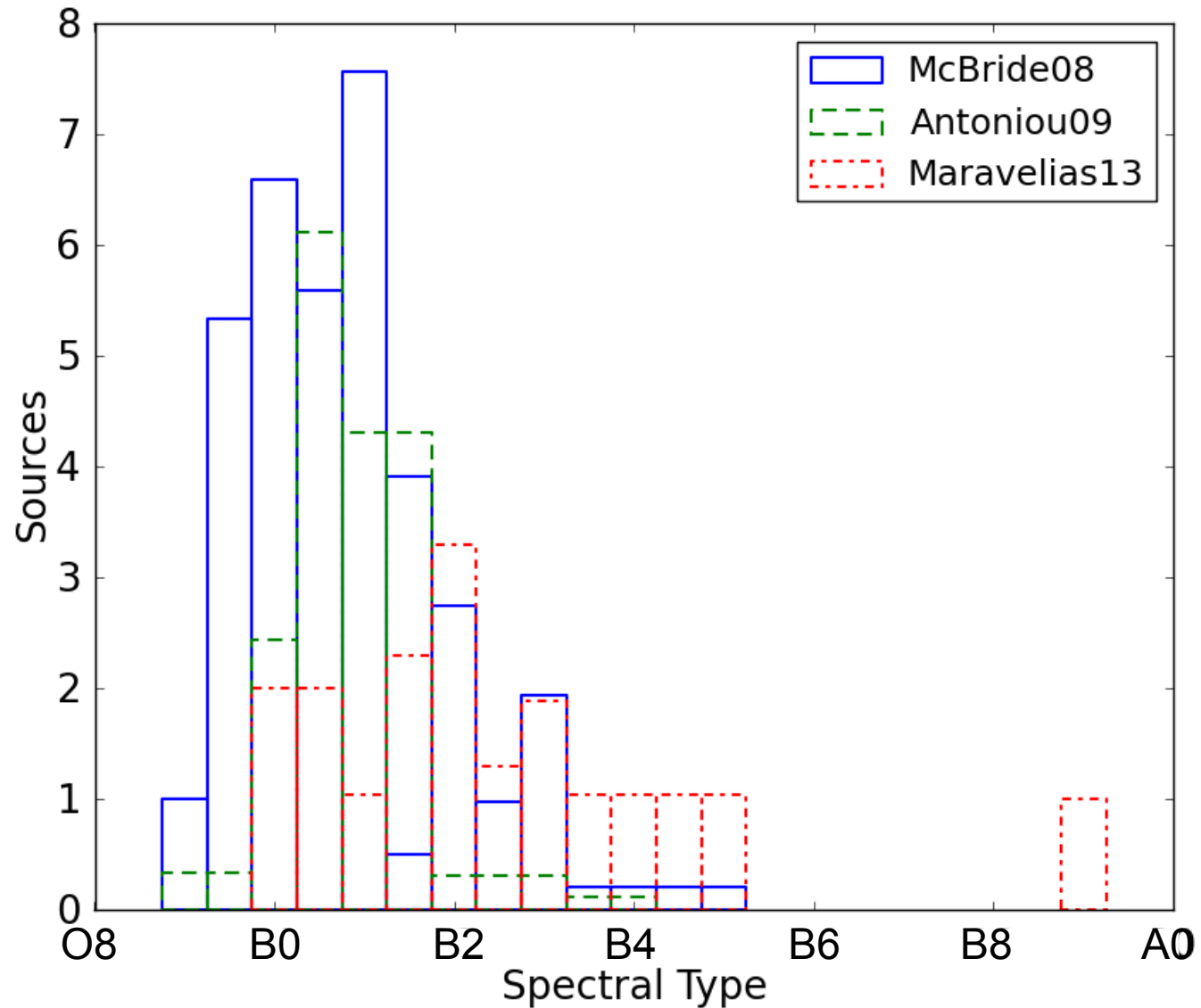
Dedicated studies

→ McBride et al. 2008 :
37 objects

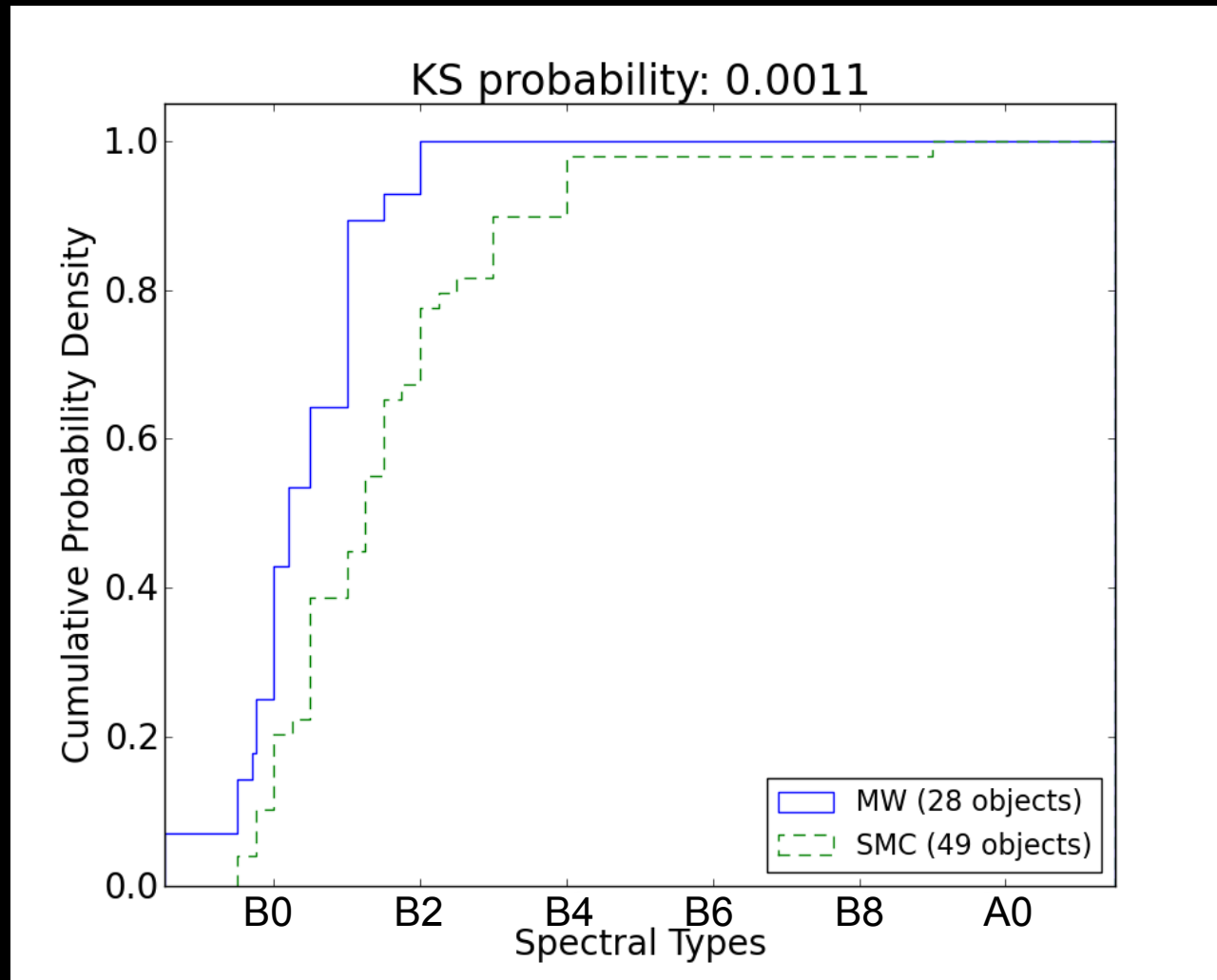
→ Antoniou et al. 2009 :
20 objects

→ Maravelias et al. 2013
(MNRAS subm.) :
21 objects

... confirming 49 BeXRBs



Comparing SMC and MW BeXRB populations (spectral types)



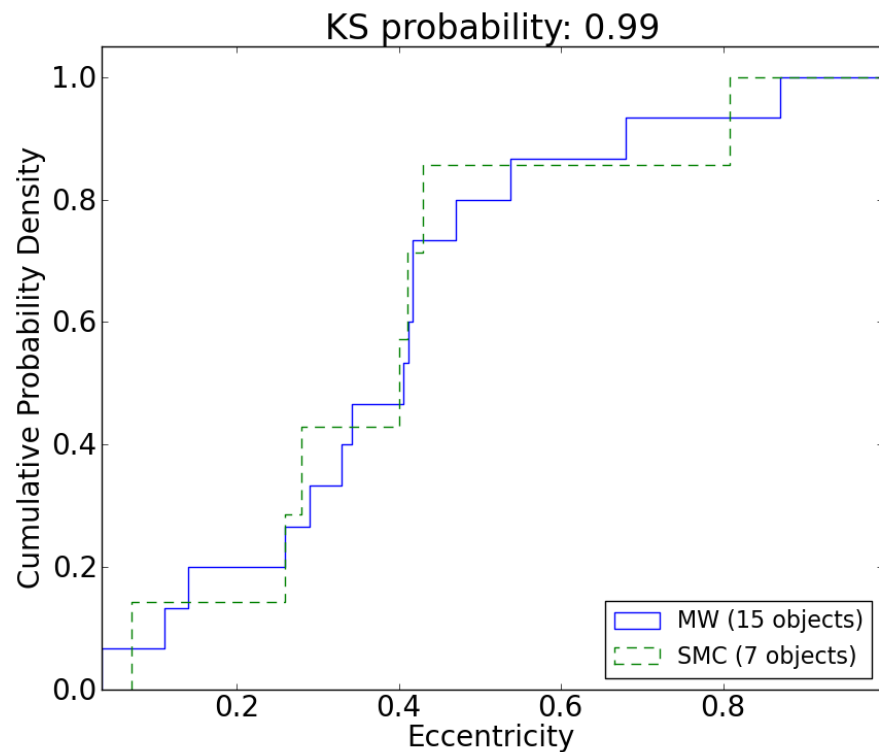
MW:
Reig 2011

SMC:

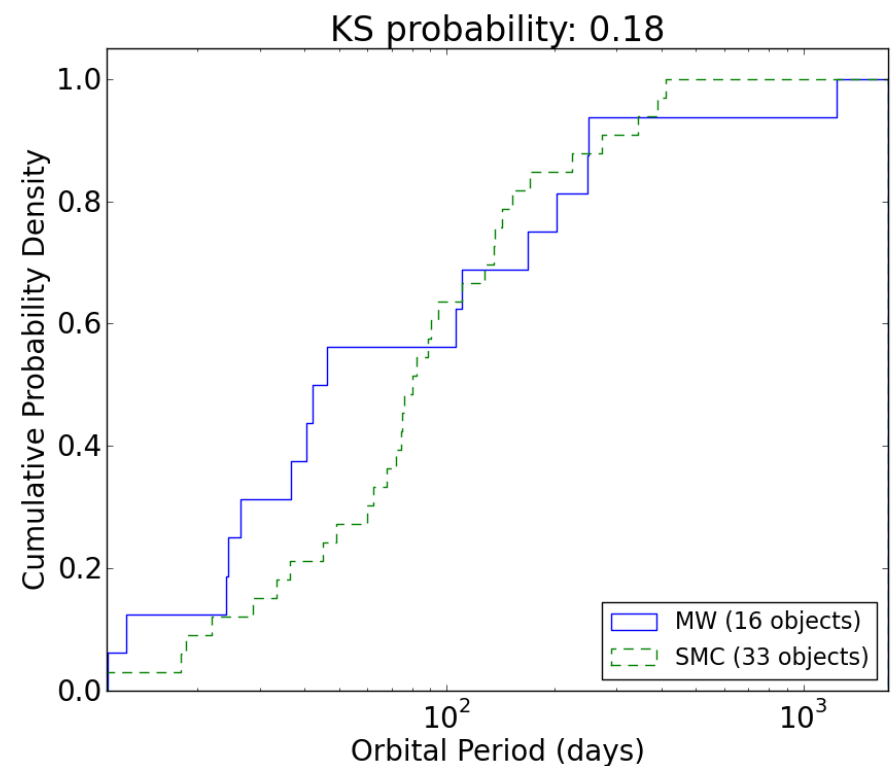
McBride et al. 2008
Antoniou et al. 2009
Maravelias et al. 2013
(MNRAS subm.)

Marginal difference ?

Comparing SMC and MW BeXRB populations (orbital periods+eccentricities)



MW/SMC: Townsend et al. 2011



MW: Townsend et al. 2011

SMC: Rajoelimanana et al. 2011

No indication of difference

Supernova kick velocities

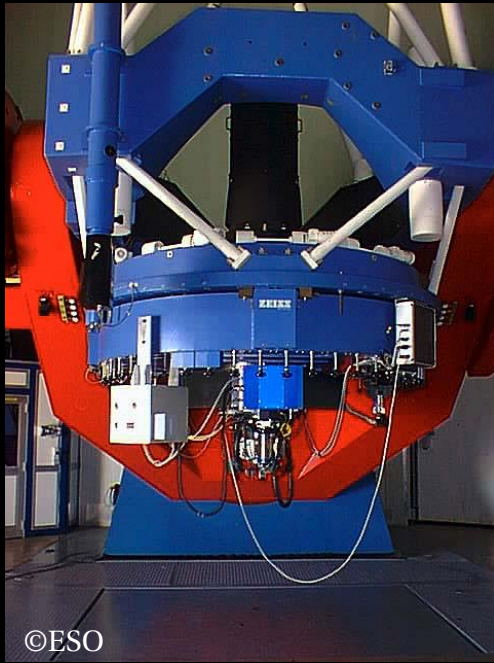
- Not so different spectral-type distributions
(similar donor-mass distributions)
- Similar eccentricities
- Similar orbital periods



*similar
supernova
kicks*

MW BeXRBs: $v \sim 15 \pm 6$ km/s (van den Heuvel et al. 2000)

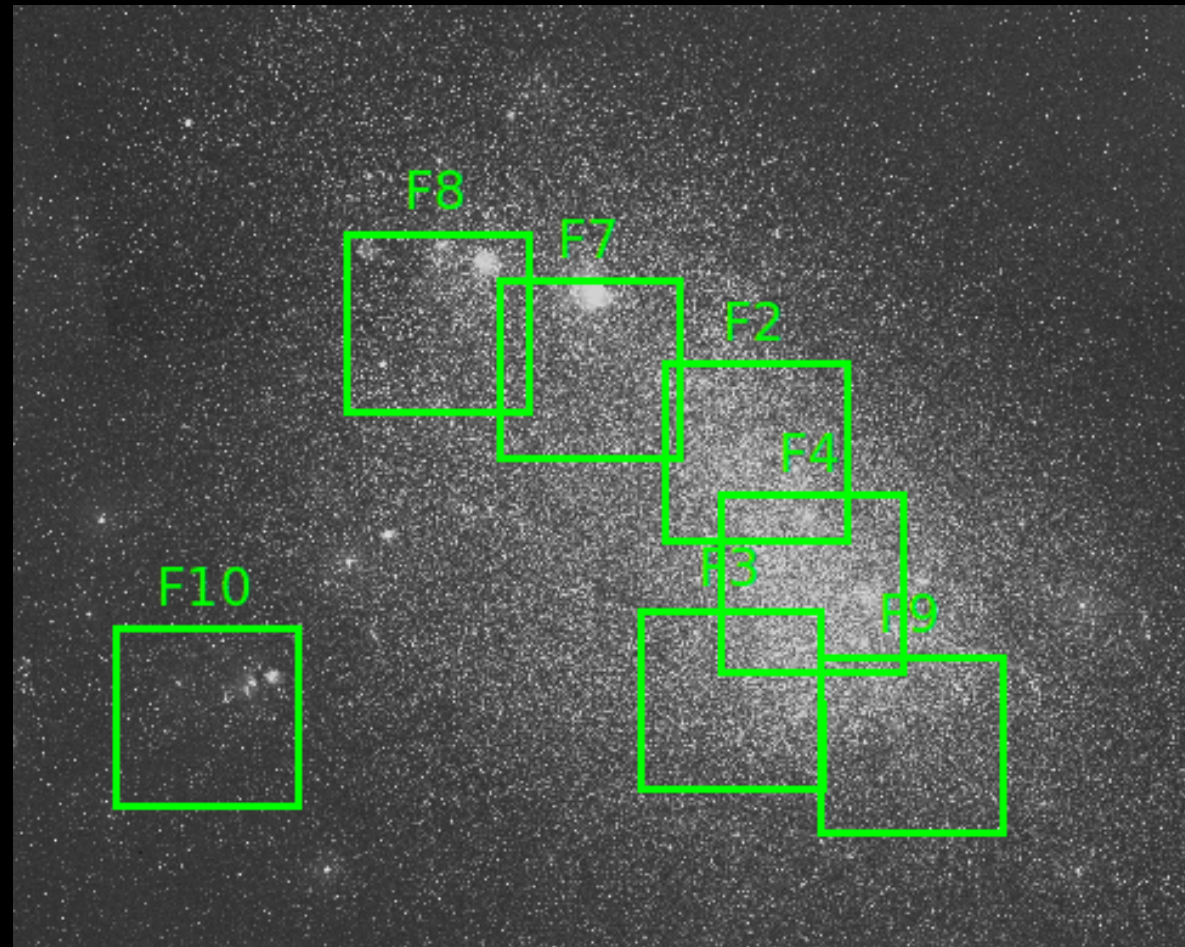
SMC BeXRBs: $v \sim 30$ km/s (Coe 2005),
 $v < 15 - 20$ km/s (Antoniou et al. 2010)



H α wide field imaging

- > Using: Wide Field Imager camera of 2.2m MPG/ESO
- > Observing: 16-17 November, 2011
- > 7 fields of 34'x33' @ Rc / H α filters

- > Data reduction: THELI v2.6.2
 - bias, flat-fielding
 - astrometry (SExtractor, Scamp)
 - mosaic (Swarp)
- > Analysis: PSF photometry (IRAF/DAOPHOT)
 1. detect all stellar sources on the Rc image
 2. photometry on H α image



Selecting H α emitting sources

> Detect sources:

- subtract continuum
- account for difference of the two bands and their zeropoints

For instrumental magnitudes: $\text{mag}_{H\alpha} = \text{mag}_{Rc} + a$

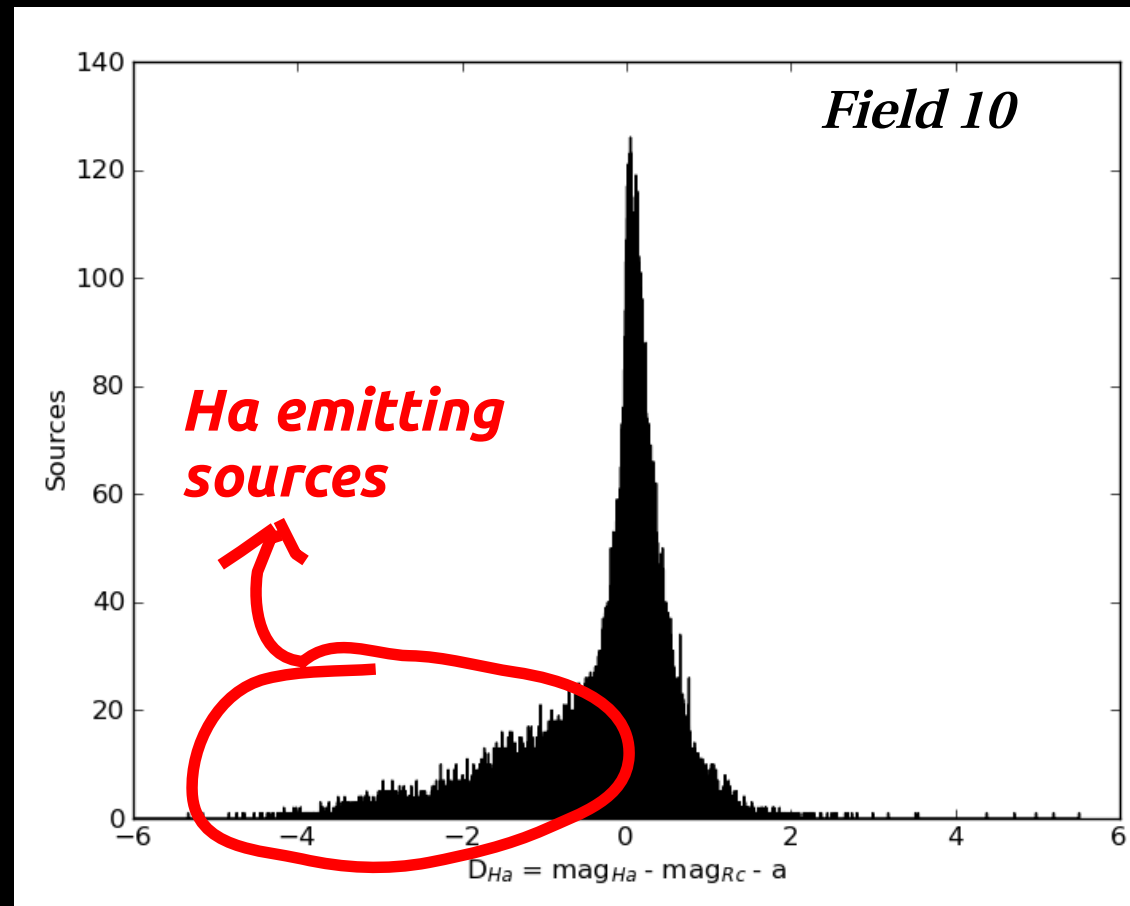
> Select emission line sources:

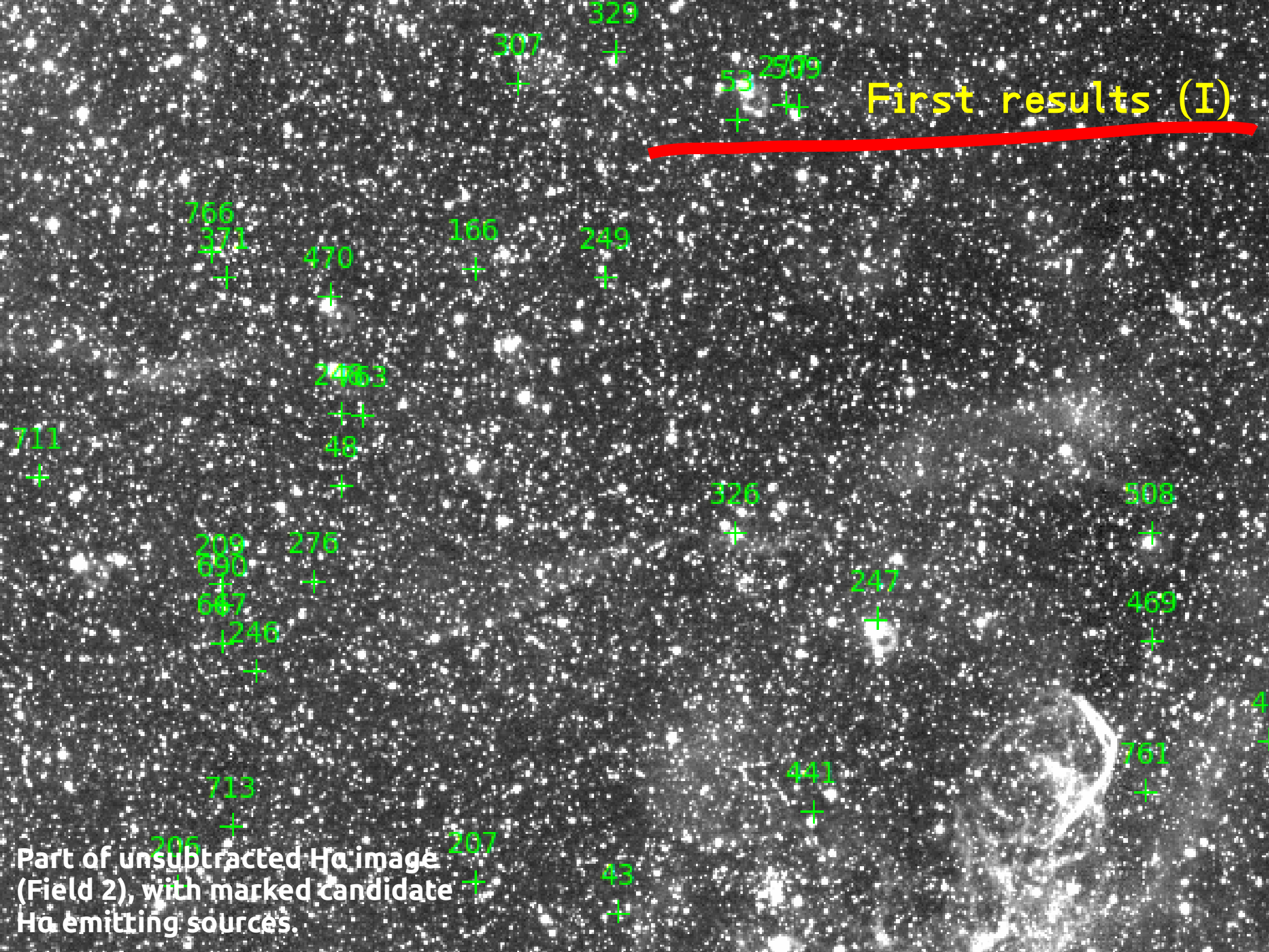
- measure $D_{H\alpha} = \text{mag}_{H\alpha} - \text{mag}_{Rc} - a$
- candidate sources:

$$D_{H\alpha} / \delta D_{H\alpha} < -5$$

secure sources:

$$D_{H\alpha} / \delta D_{H\alpha} < -10$$





Part of unsubtracted H α image
(Field 2), with marked candidate
H α emitting sources.

First results (II)

**matches / X-ray sources in field*
Working list of confirmed and candidate HMXBs

<i>FIELD</i>	<i># Candidates</i>	<i># Secure</i>	<i># Matches *</i>
8	15803	4577	6/8
7	20499	7382	13/14
2	12133	2840	13/20
10	7749	2680	1/1
9	27853	6784	1/1

→ Majority of sources in Working List are indeed
H α emission objects > prime BeXRB candidates

(other sources: most likely foreground stars or background AGN)

- Investigate SMC/MW BeXRB populations :
 - spectral types, orbital periods, and eccentricities
 - > no definitive differences
- Similar supernova kicks for SMC/MW BeXRBs
- Increase sample: first results from a photometric survey yields
 - at least 24 000 H α emitting sources (84 000 candidates)
 - > find the candidate BeXRBs
 - > spectroscopic follow-up
- Analyse 2 more fields from WFI and 9 from MOSAIC II (CTIO)