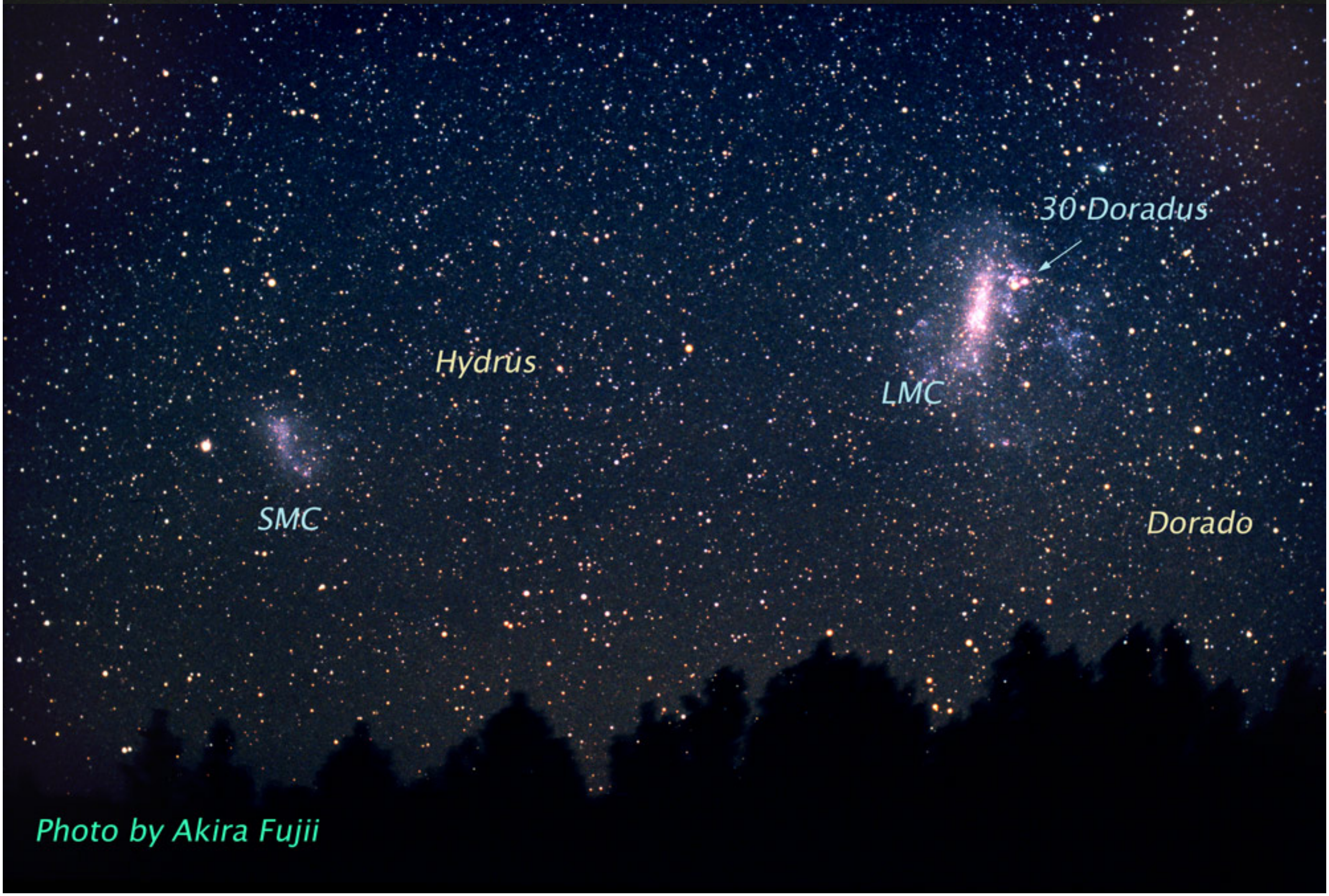
Young X-ray binaries in low-metallicity star-forming galaxies

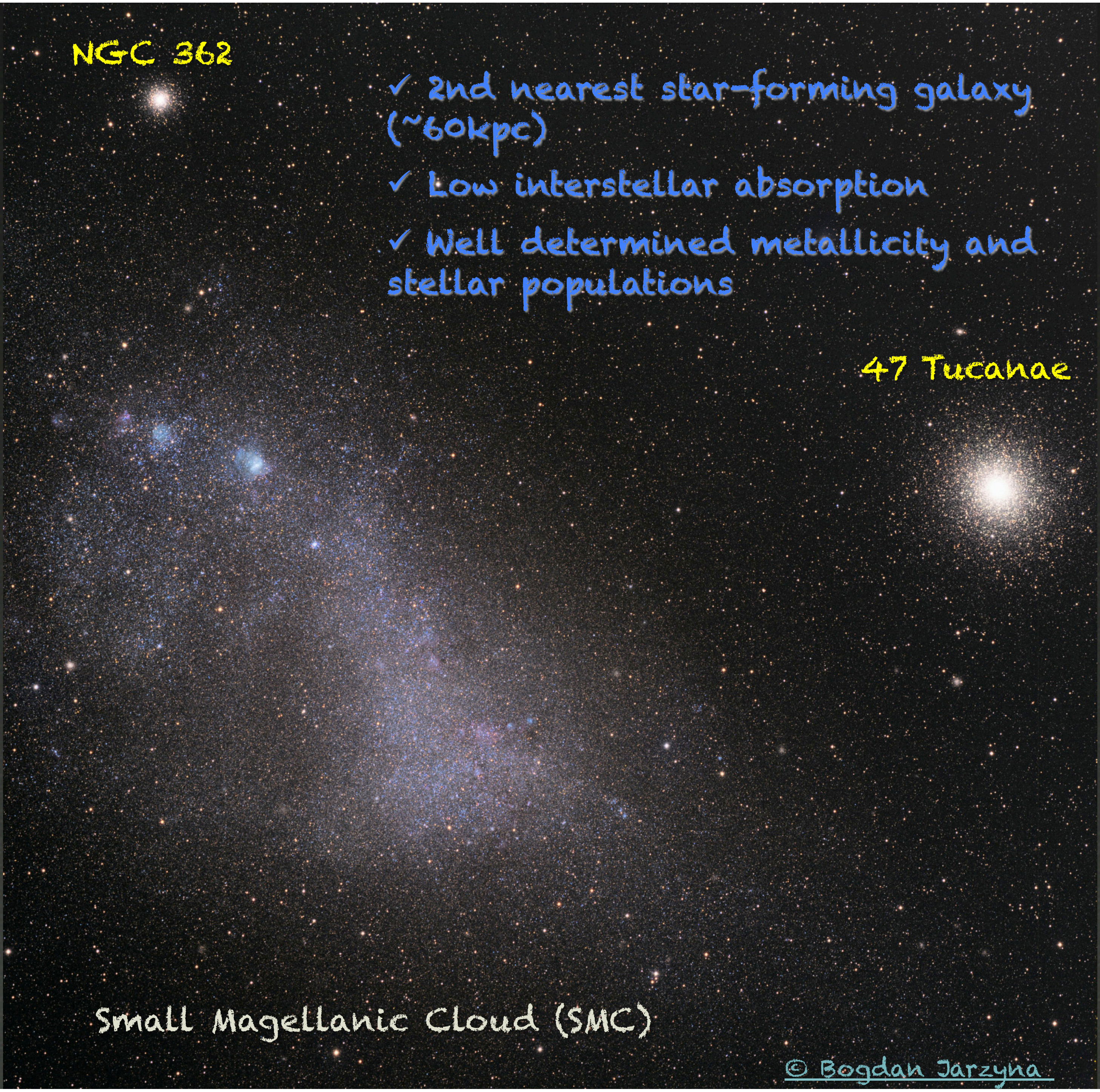
VALLIA ANTONIOU
IOWA STATE UNIVERSITY

High Energy View of Accreting Objects: AGN and X-ray Binaries
Agios Nikolaos, Crete, Greece
5 - 14 October 2010

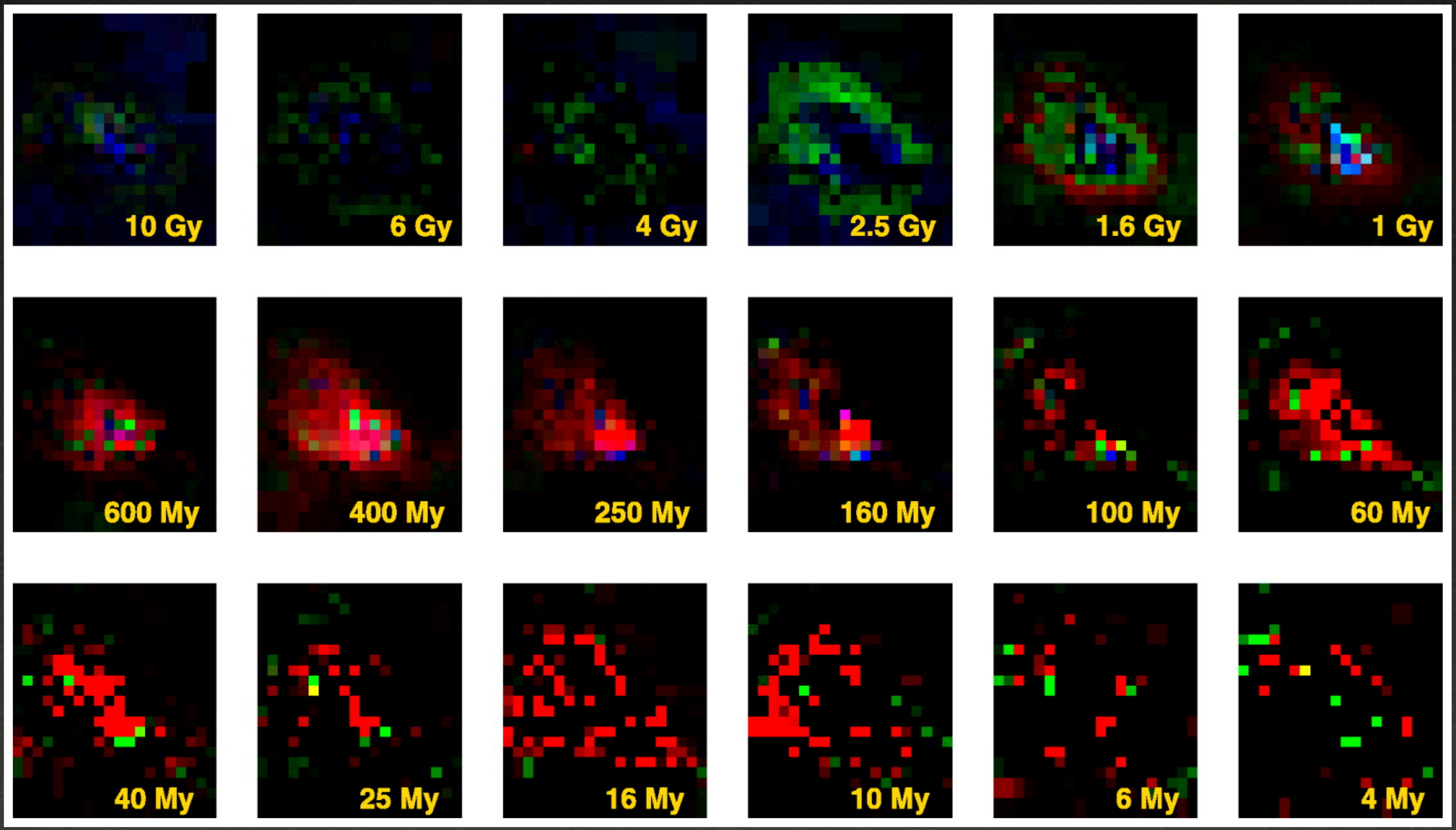
Our nearest star-forming galaxies



- ✓ 2nd nearest star-forming galaxy (~60kpc)
- ✓ Low interstellar absorption
- ✓ Well determined metallicity and stellar populations



Star-formation history of the SMC



Z = 0.008 <-> [Fe/H] = -0.4

Z = 0.004 <-> [Fe/H] = -0.7

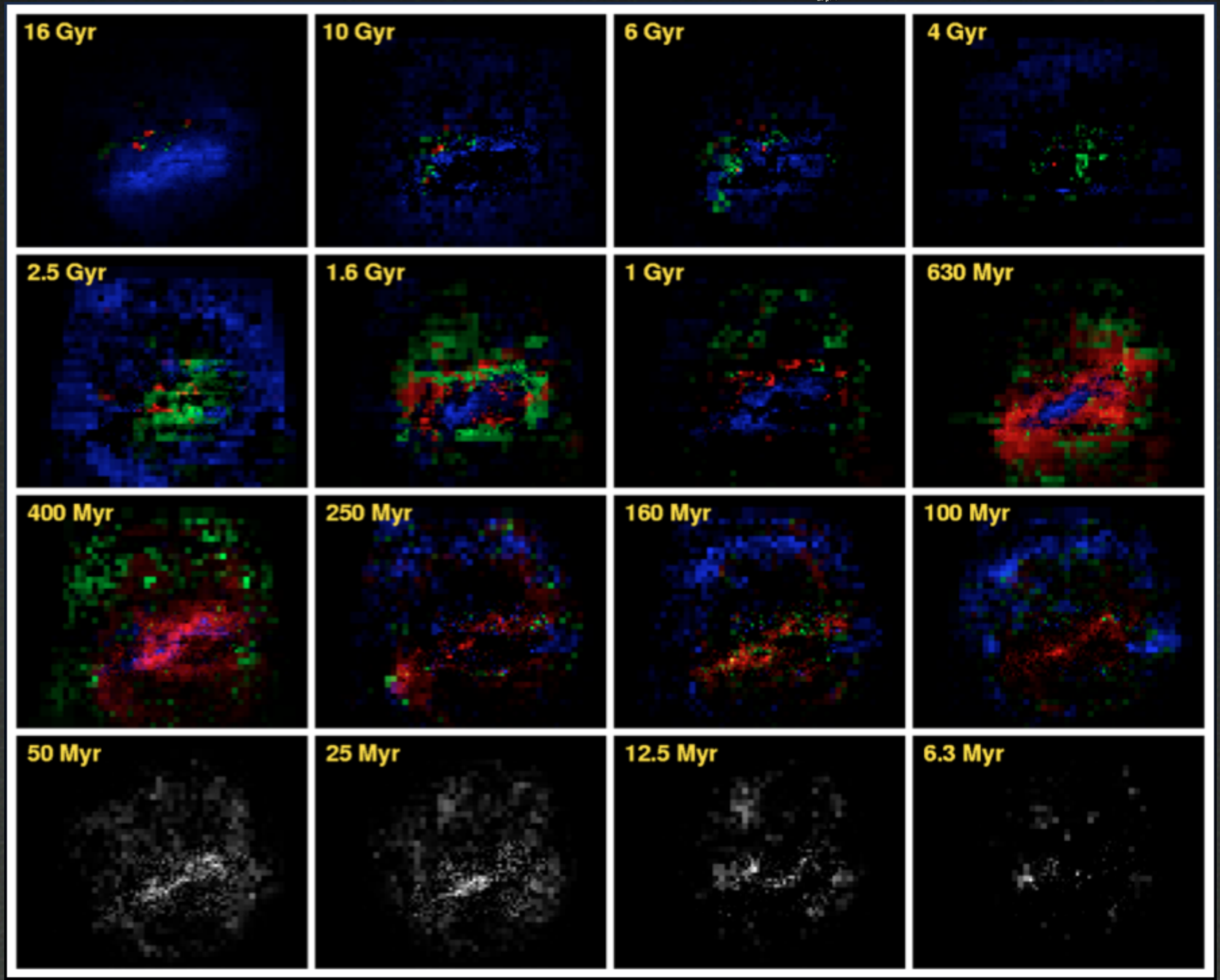
Z = 0.001 <-> [Fe/H] = -1.3

pixel value proportional to the subregion's SFR

Harris & Zaritsky (2004)


Large Magellanic Cloud
30 Doradus
✓ nearest star-forming galaxy (~50kpc)
✓ Low interstellar absorption
✓ Well determined metallicity and stellar populations
Photo by David Malin

Star-formation history of the LMC



Z = 0.008 <-> [Fe/H] = -0.4

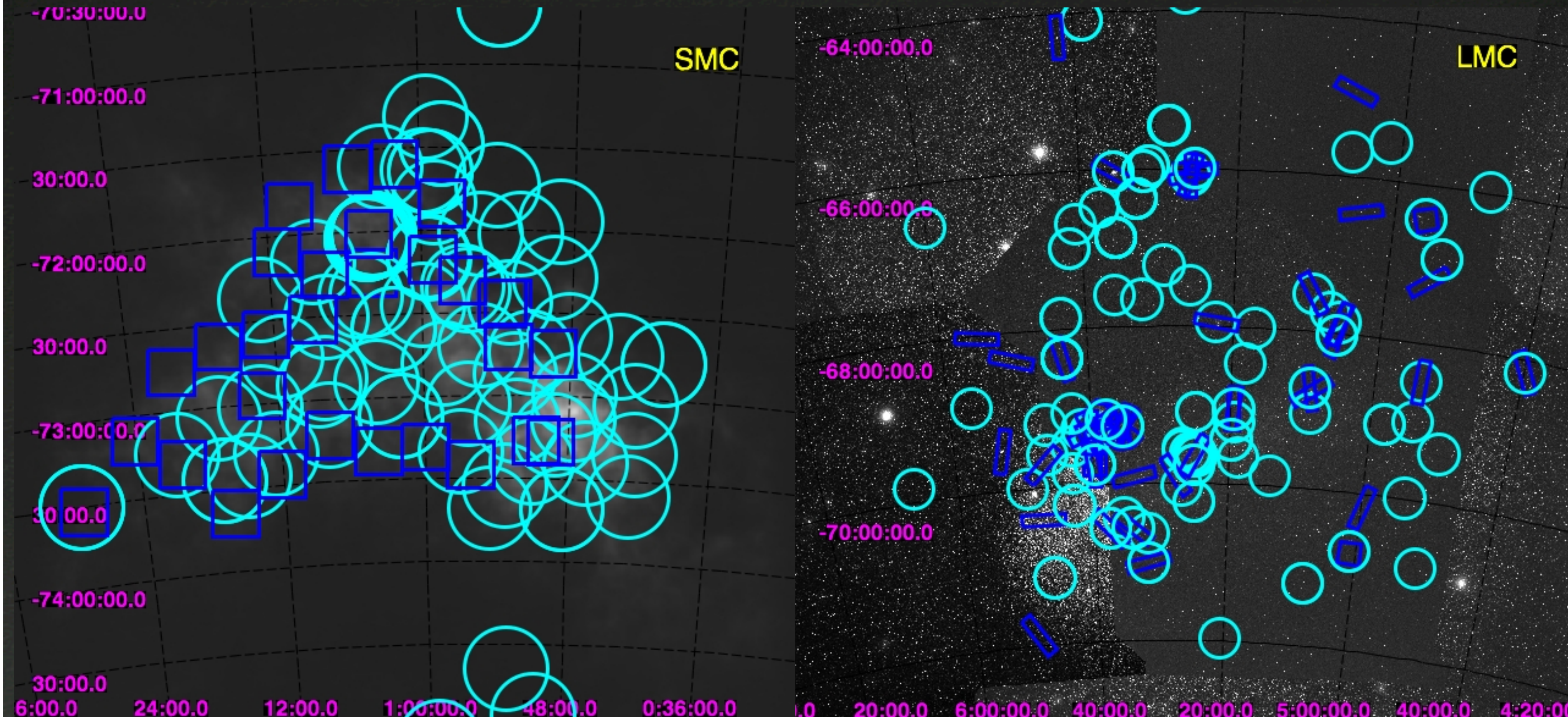
Z = 0.004 <-> [Fe/H] = -0.7

Z = 0.001 <-> [Fe/H] = -1.3

pixel value proportional to the subregion's SFR

Harris & Zaritsky (2009)

X-ray observations of the MCs



Z~1/5 $Z_\odot$ Z~1/3 $Z_\odot$

Young X-ray binary populations

SMC

~100 HMXBs so far known (literature):

- 67 Be-XRBs with confirmed spectral types
- 1 SG-XRB (SMC X-1; Wing)
- ~30 hard X-ray sources with early-type c/parts

LMC

~40 HMXBs so far known (literature):

- 11 Be-XRBs with confirmed spectral types
- 0 SG-XRB
- 28 hard X-ray sources with early-type c/parts

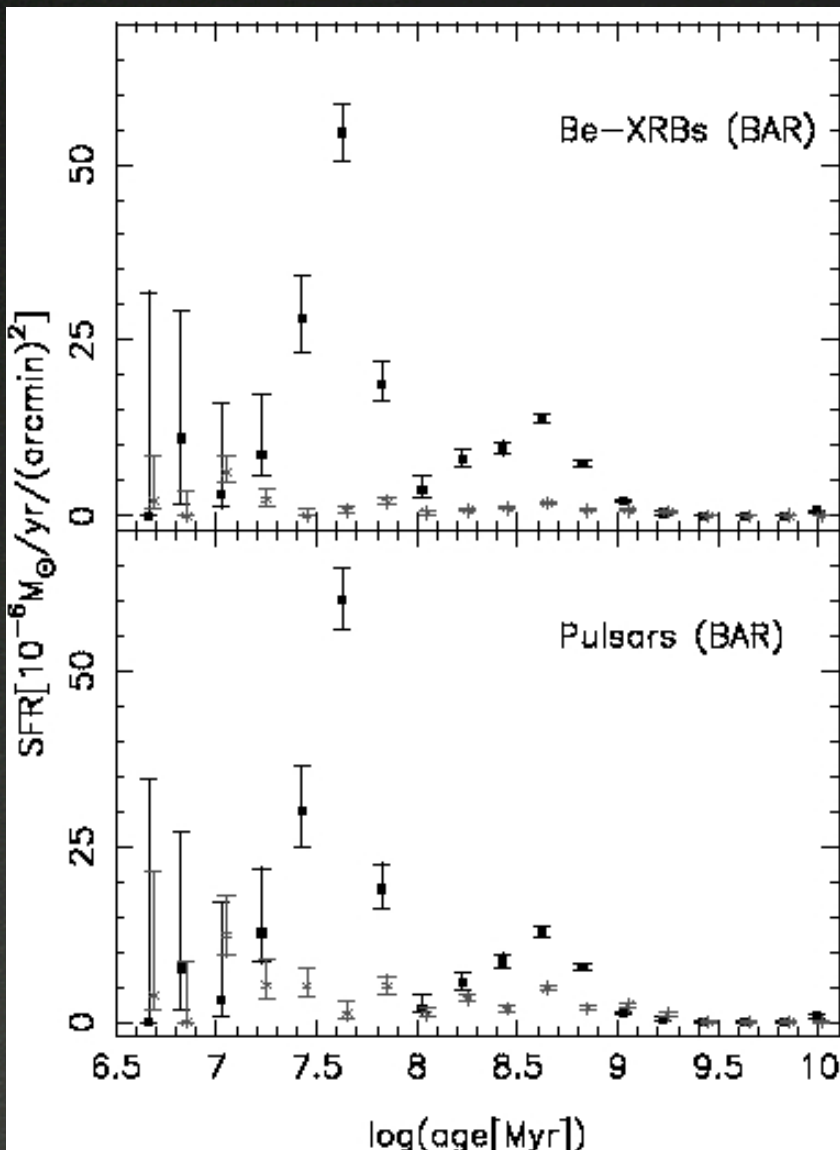
What do we know so far?

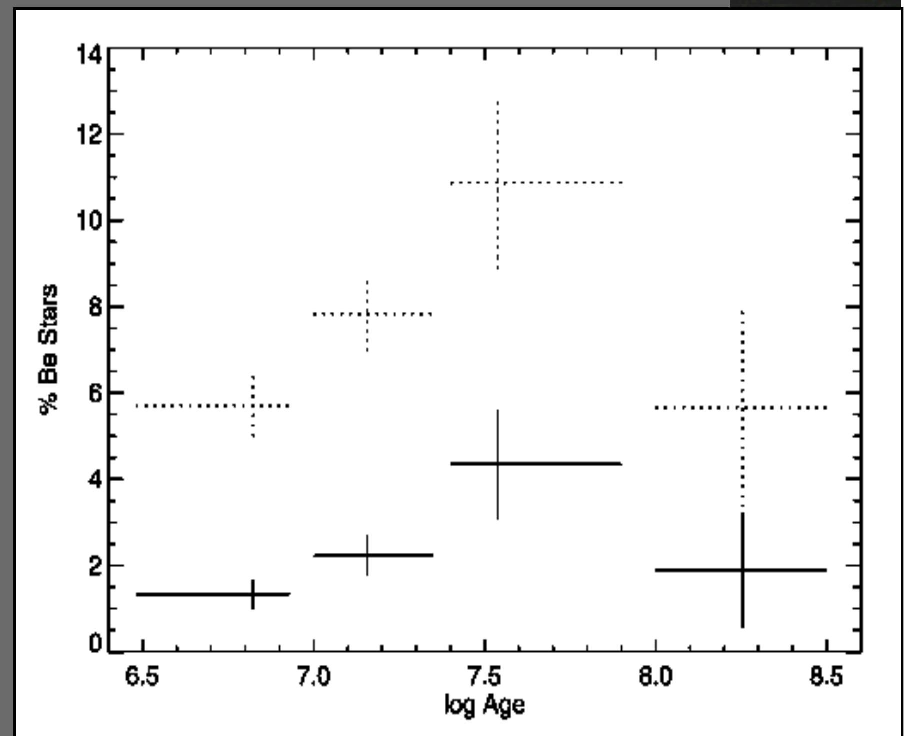
Be-XRBs in the SMC

- are observed in regions with SFR bursts at ~25-60 Myr

- regions with strong but more recent SF (e.g., the Wing) are deficient in Be-XRBs

What do we know so far?

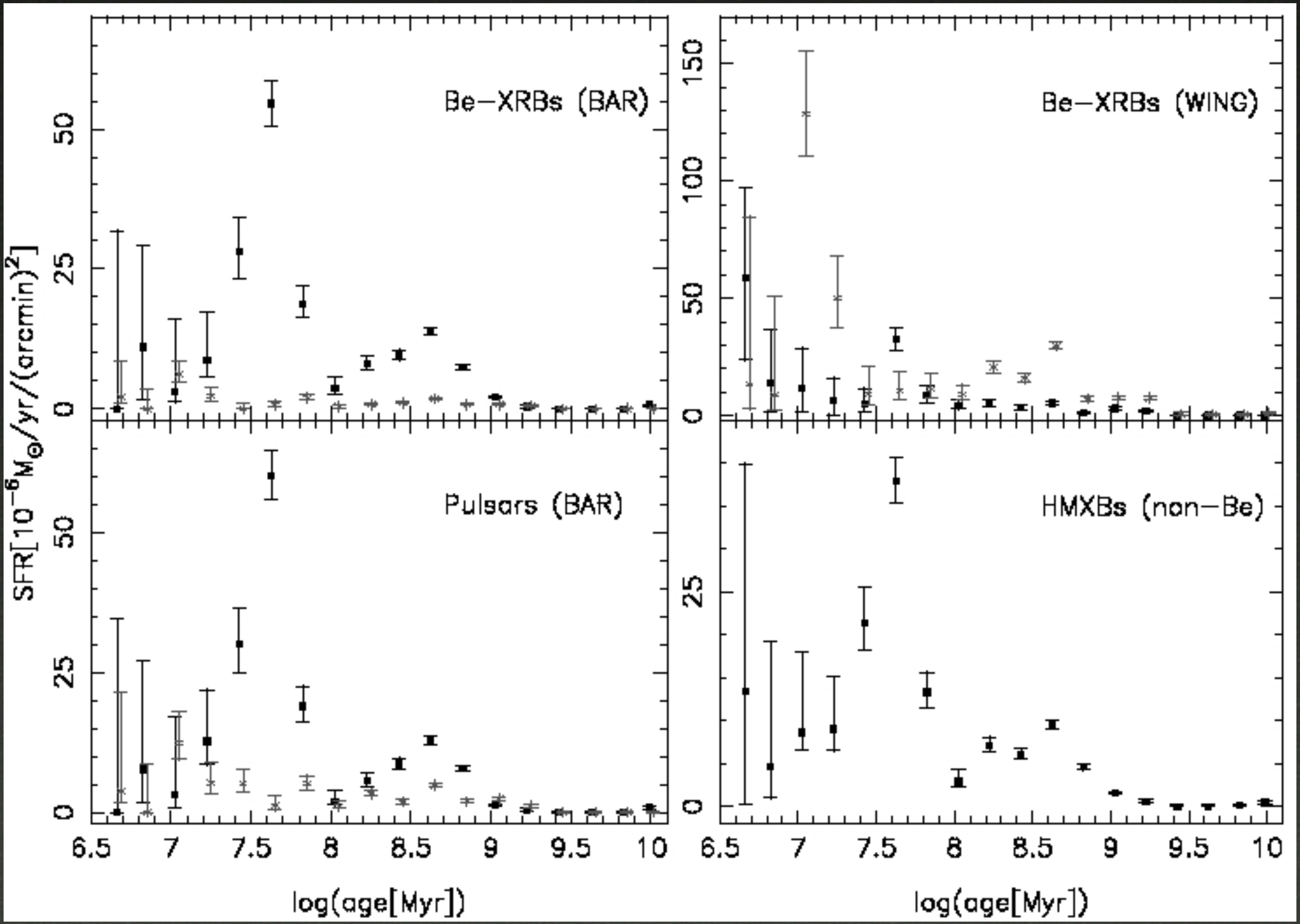




McSwain & Gies (2005)

Antoniou et al. 2010, ApJL, 716, 140

What do we know so far?



Antoniou et al. 2010, ApJL, 716, 140

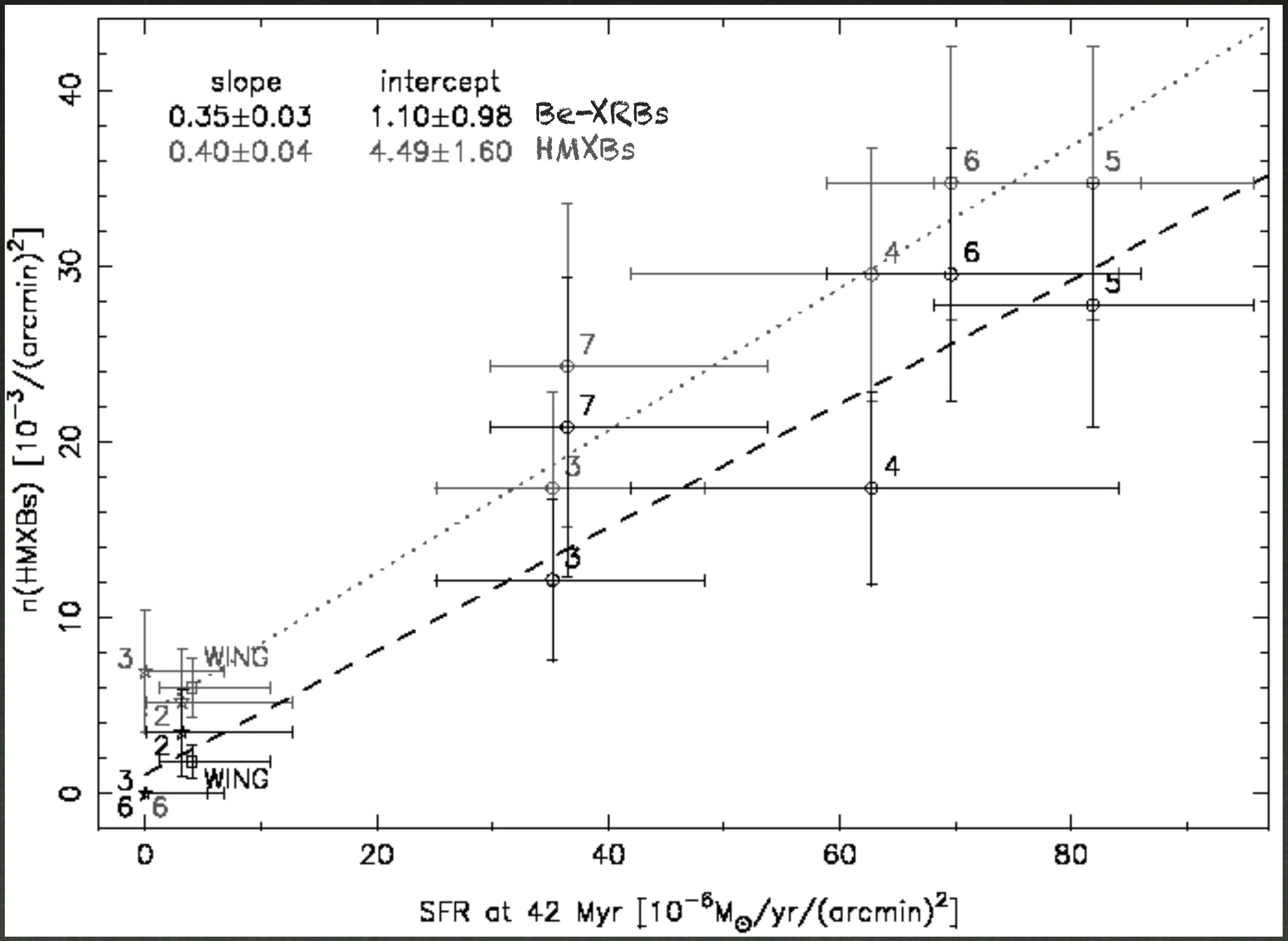
What do we know so far?

Be-XRBs in the SMC

- strong evidence for correlation of their number with the SFR at the age of maximum Be-star formation

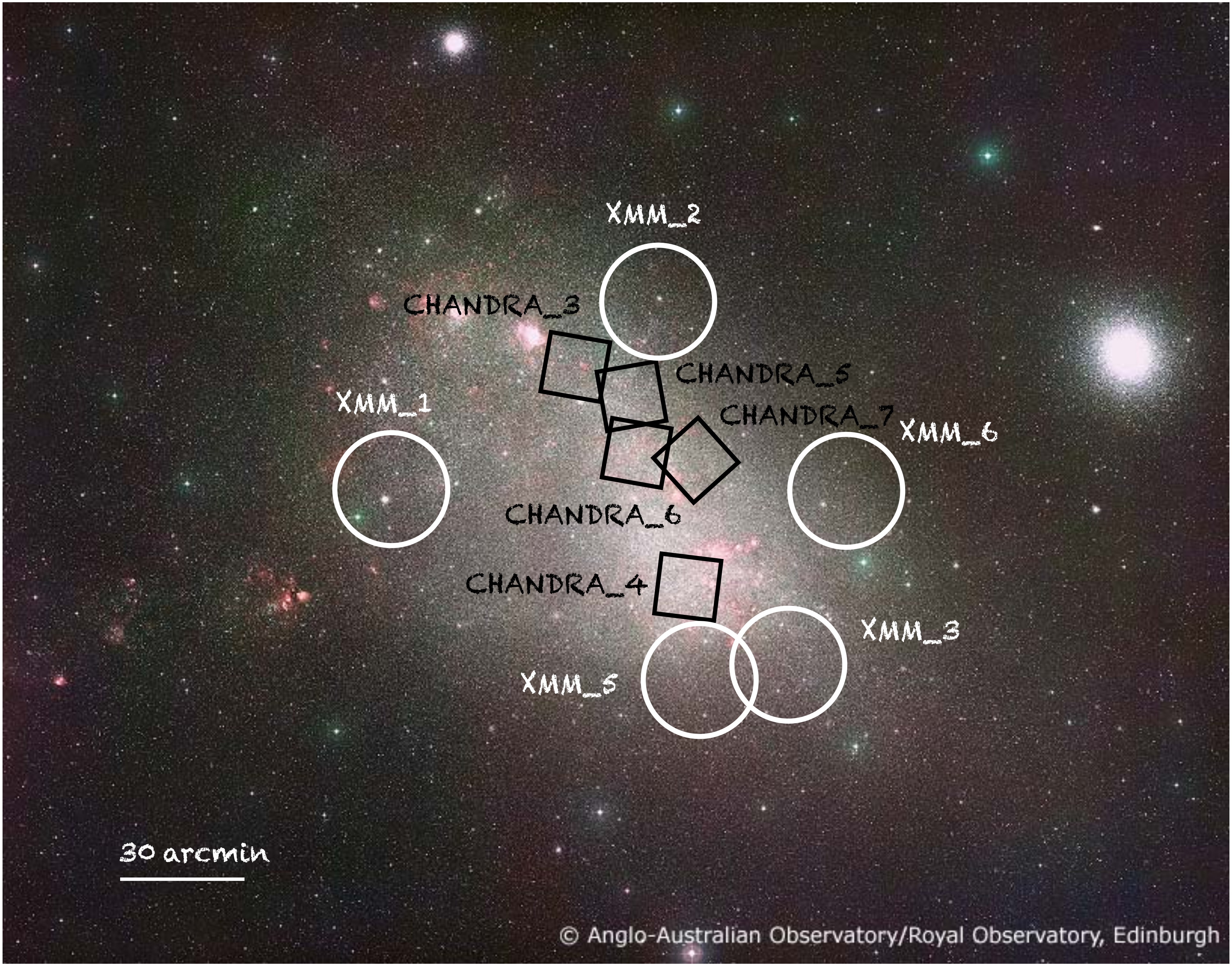
- strong correlation of the young X-ray sources with the stellar population in scales of few arcminutes implies relatively small SN kicks during the formation of the compact object

What do we know so far?



- Our Chandra Shallow Survey (circles) / our XMM-Newton (asterisks) fields
- "WING" point: XMM-Newton field 1 and 4 fields from the Chandra Wing survey (P.I. M. Coe)

Antoniou et al. 2010, ApJL, 716, 140

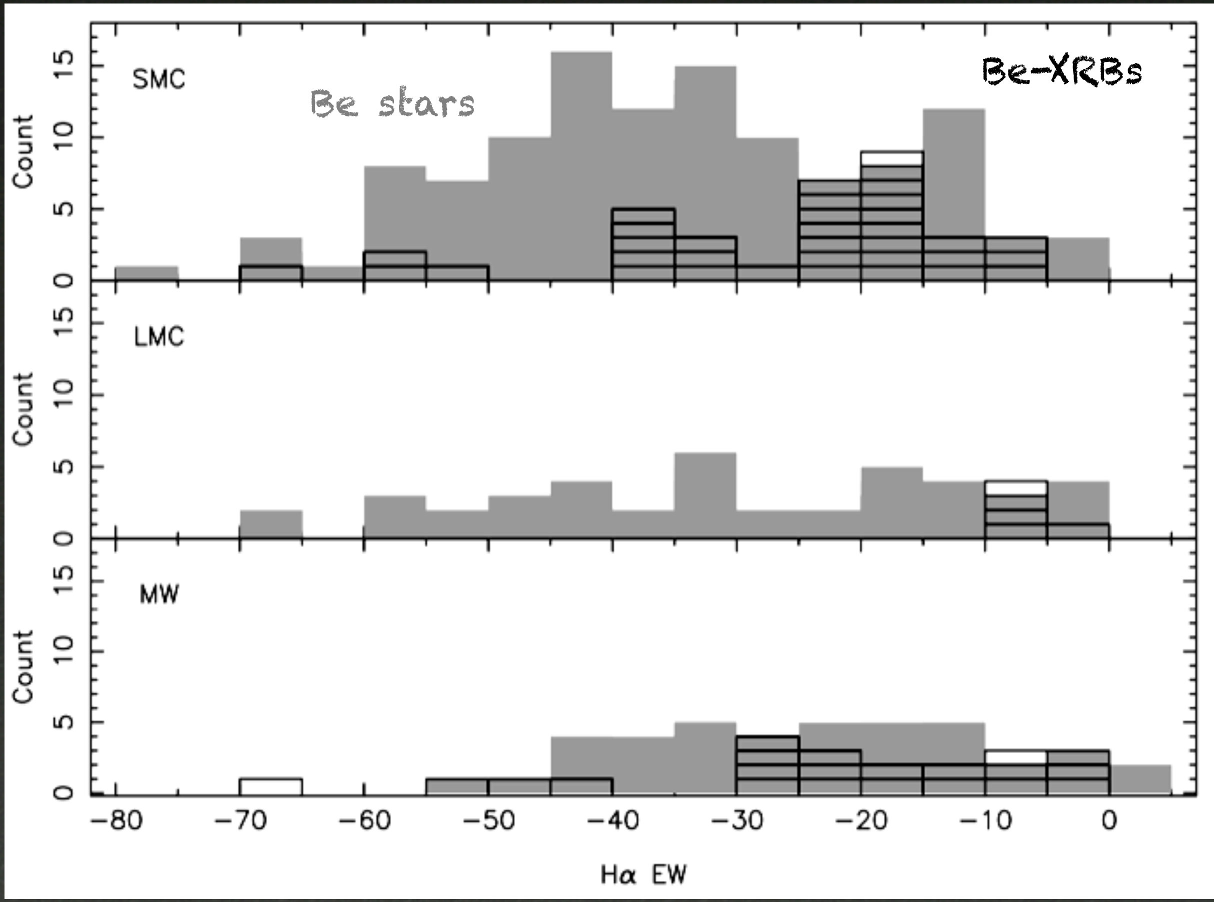


XMM_2
CHANDRA_3
CHANDRA_5
CHANDRA_7
XMM_1
XMM_6
CHANDRA_6
CHANDRA_4
XMM_3
XMM_5
30 arcmin
© Anglo-Australian Observatory/Royal Observatory, Edinburgh

Do the same conclusions hold for the LMC?

.... Things are a bit more complicated!

Hα emission of Be stars

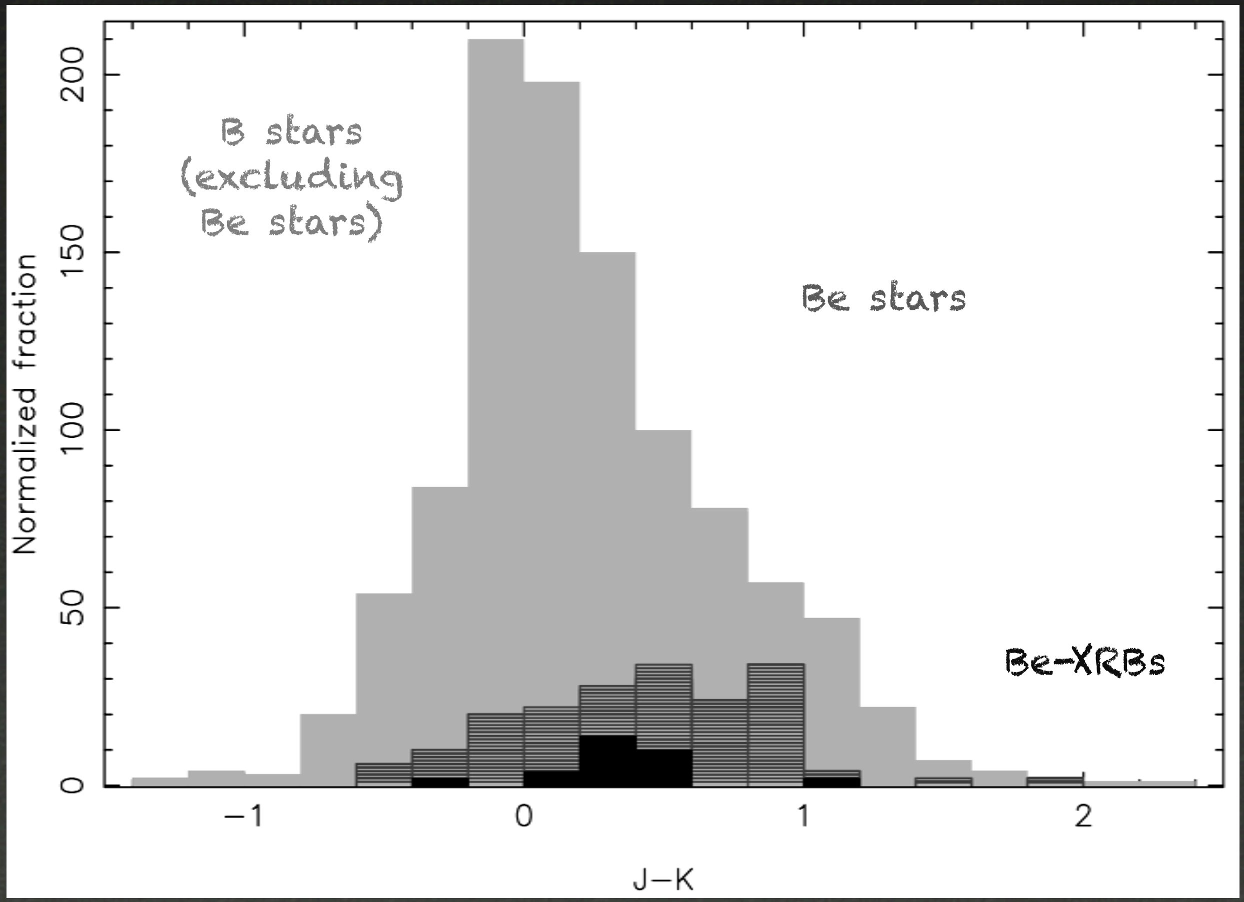


SMC: Be stars in XRBs have on average a lower Hα EW when compared to Be stars, due to the truncation of the disk by the compact object (Reig et al. 1997 and Zamanov et al. 2001)

LMC & Milky Way: the comparison is hampered by the small size of the samples

Antoniou et al. 2009, ApJ, 707, 1080

Infrared-excess of SMC Be stars



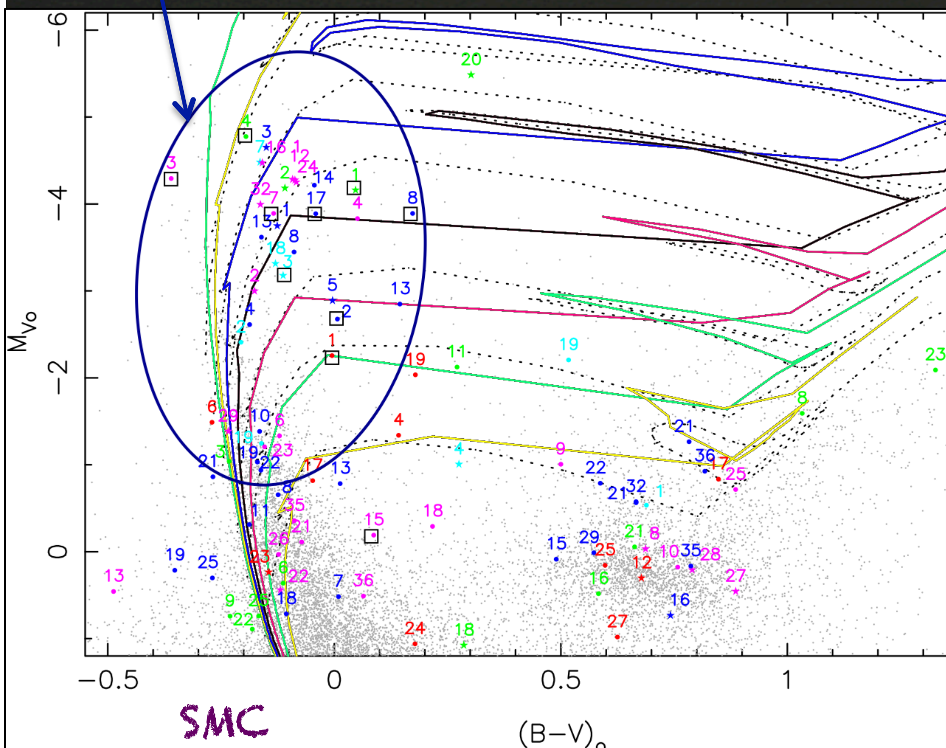
Be stars exhibit infrared excess due to the disk contribution to the continuum emission

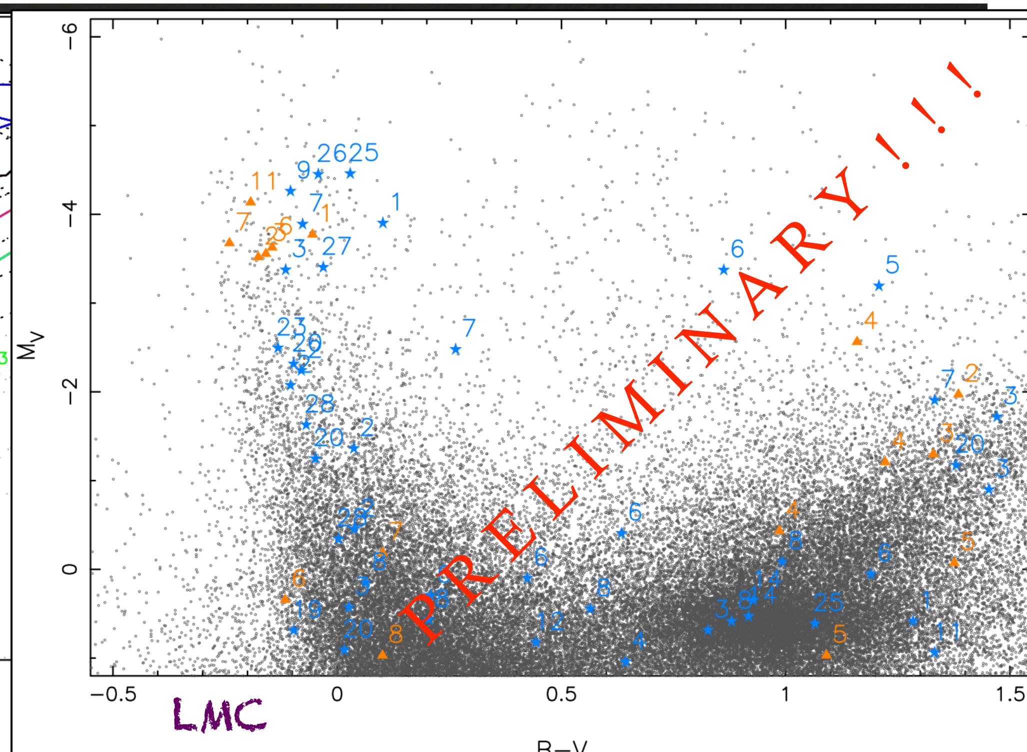
Antoniou et al. 2009, ApJ, 707, 1080

Comparison of MCs XRB populations

locus of OB stars
(2dF spectra;
Evans et al. (2004)

Geneva isochrones (top to bottom):
8.7 Myr, 15.5 Myr, 27.5 Myr, 49.0 Myr, 87.1 Myr, 154.9 Myr, 275.4Myr, …





5 Chandra Shallow fields
(~ 10 ks each)

Antoniou et al. 2009, ApJ, 697, 1695

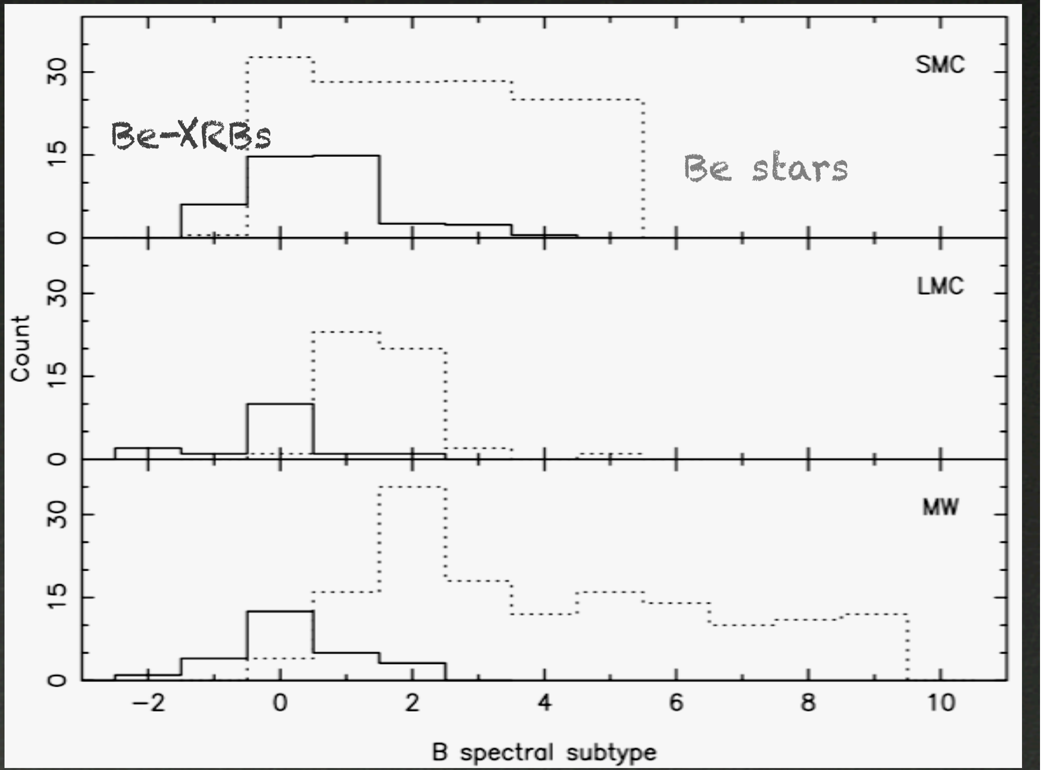
MCPS c/parts of all known
Be-XRBs & HMXBs
within 5"

Antoniou et al. 2011, in prep.

Spectral type distributions of optical counterparts

*** Be-XRBs distributions:**

- not definite if the SMC systems follow a different distribution when compared to the Galactic and LMC ones (in agreement with McBride et al. 2008)
- similar spectral-type distributions between LMC and Galactic Be-XRBs (note the small size of the samples; in agreement with Negueruela & Coe 2002)



*** distributions of Be-XRBs and Be stars:**

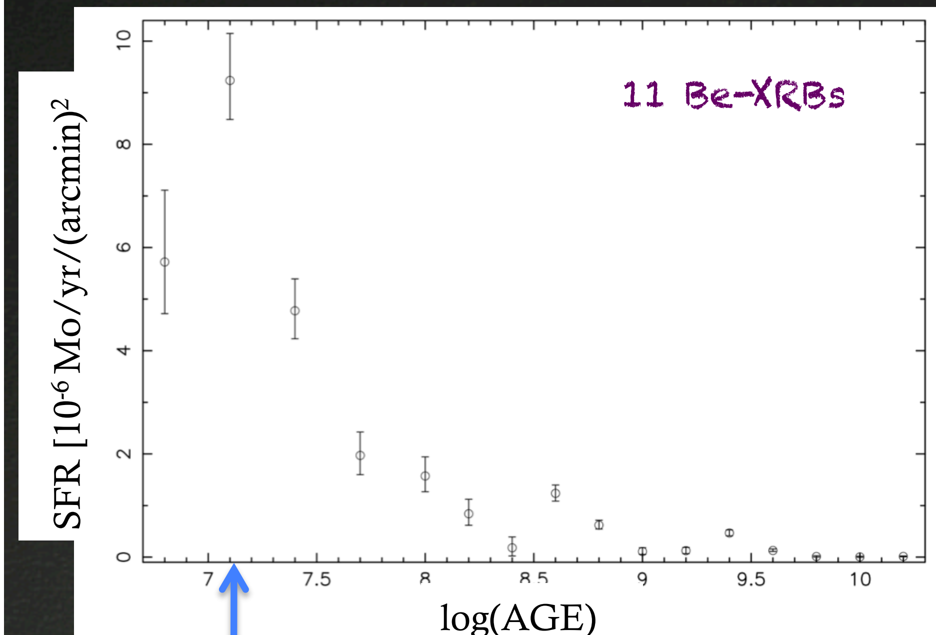
consistent in the SMC, in contrast to the Milky Way populations (in agreement with Negueruela, 1998)

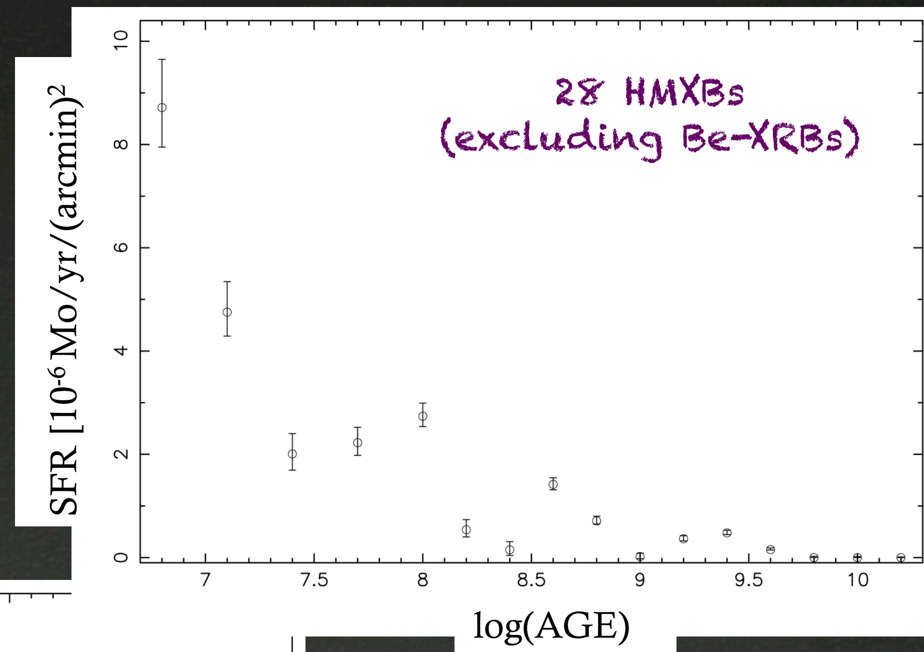
*** Be stars distributions:**

similar between the MCs samples, no evidence for differences between the MCs and the Milky Way.

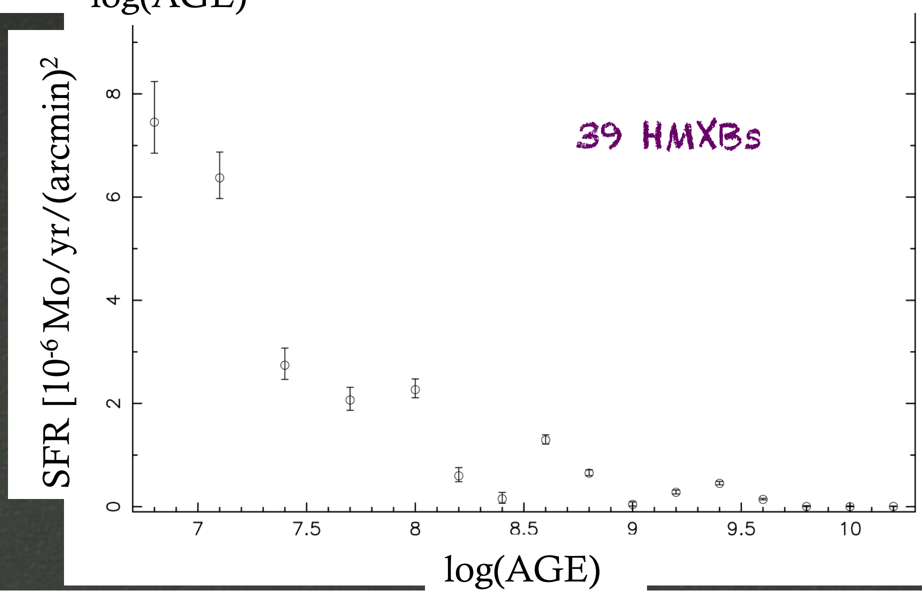
Antoniou et al. 2009, ApJ, 707, 1080

SFH & XRBs in the LMC



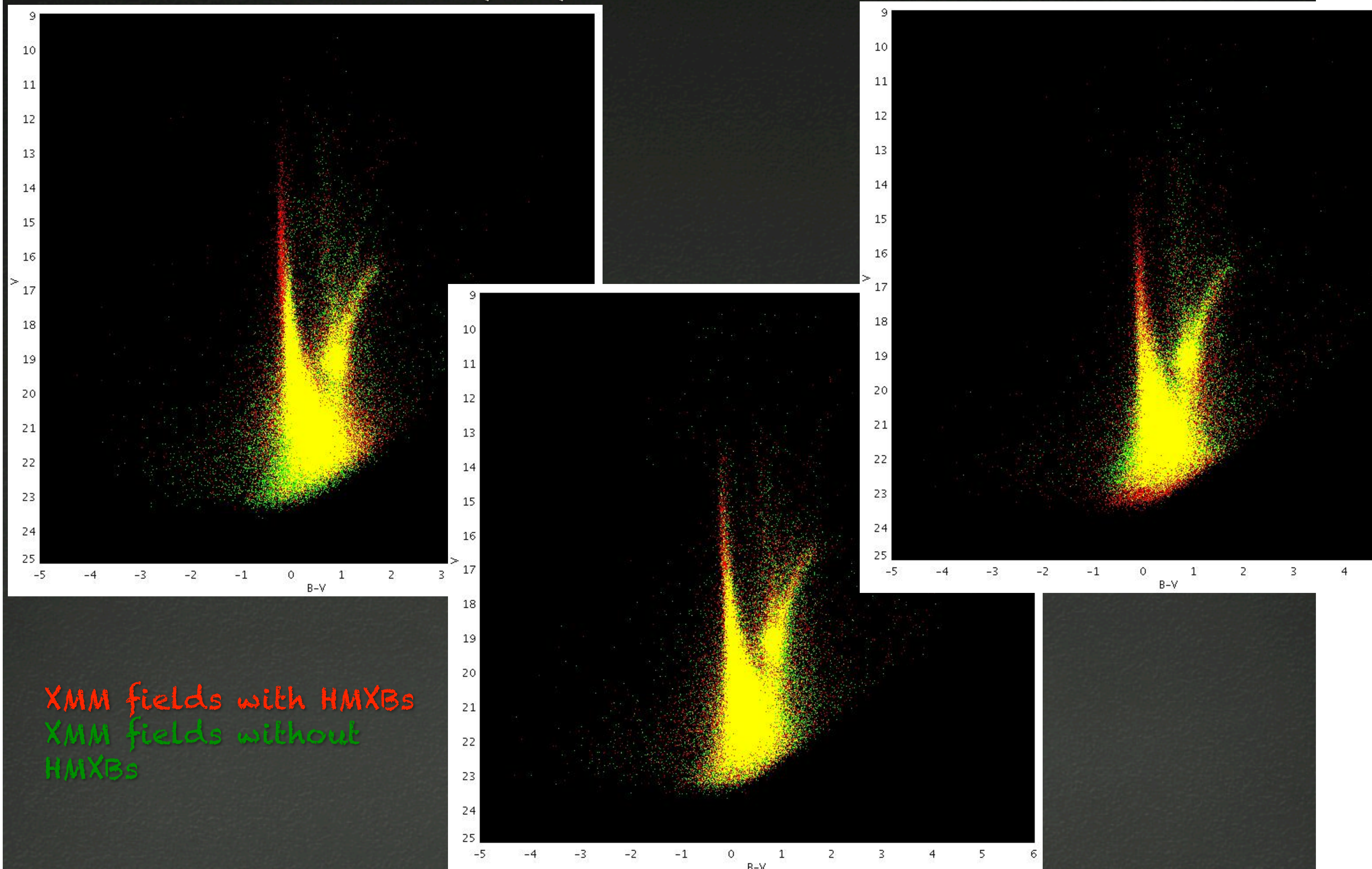


~ 6-25 Myr with a SF peak at ~ 12.5 Myr



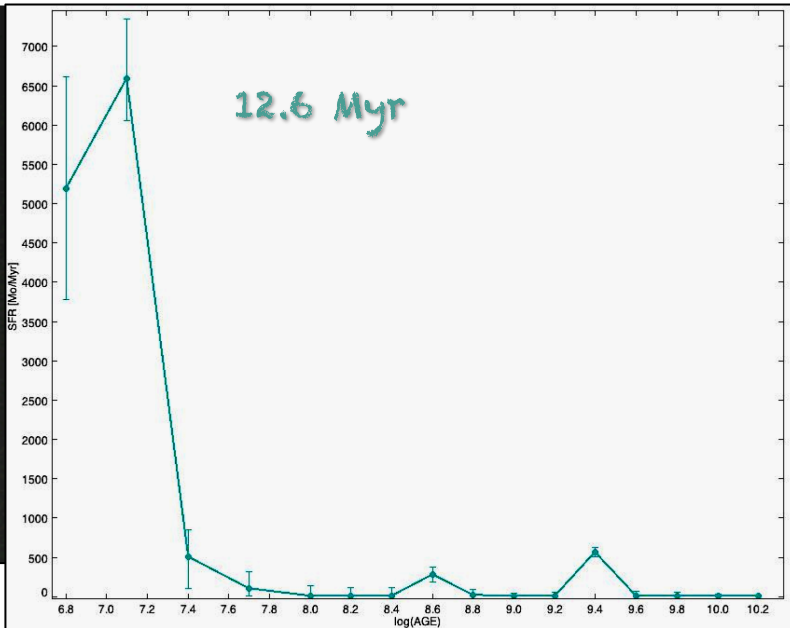
Antoniou et al. 2011, in prep.

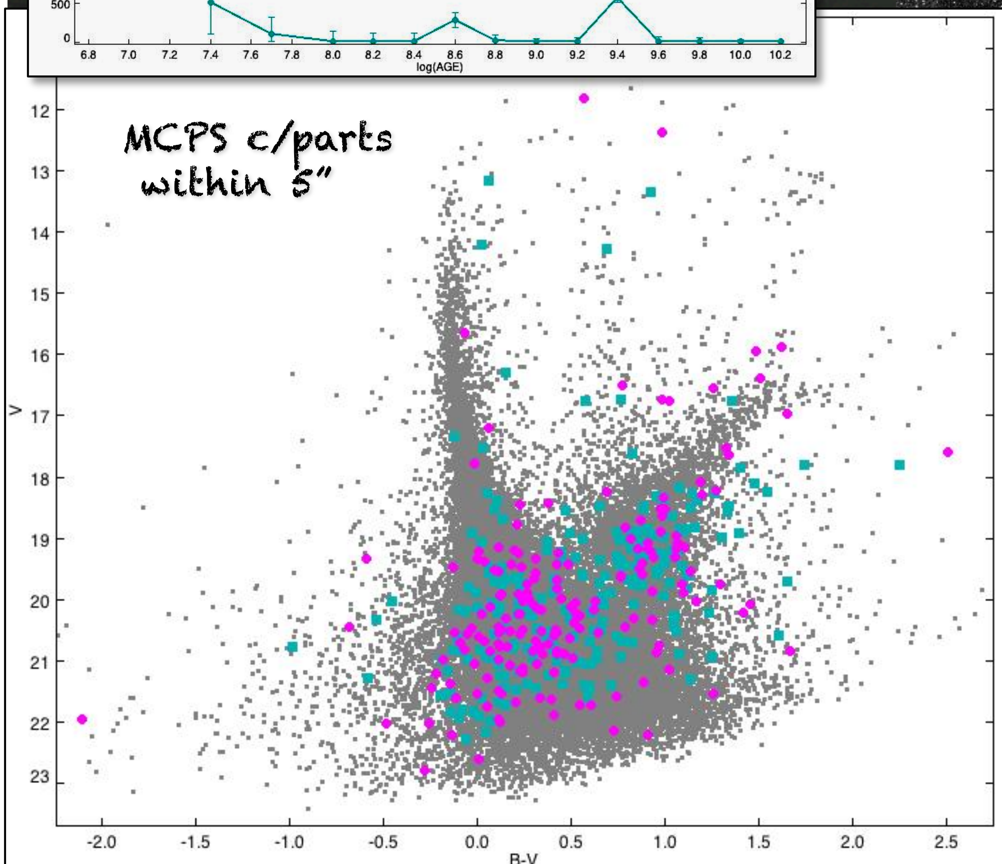
Parent stellar populations of LMC HMXBs

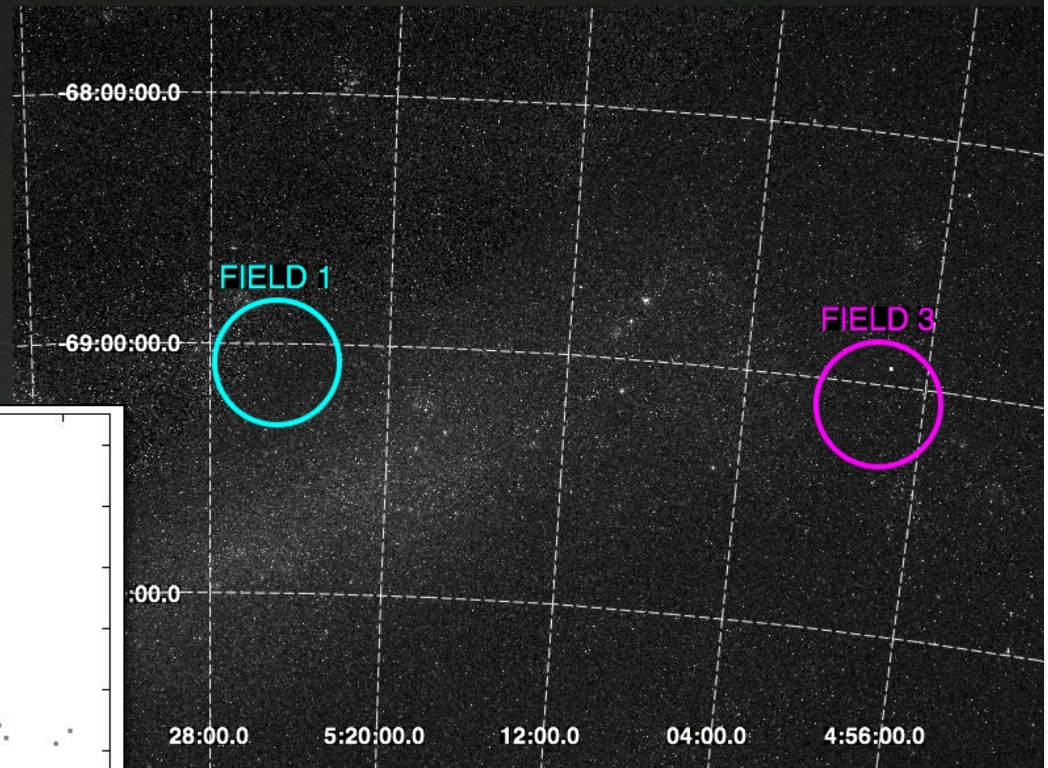


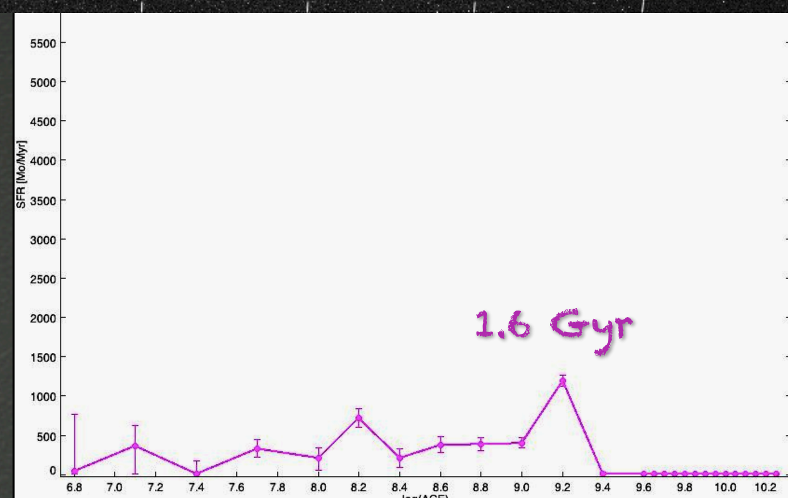
XMM fields with HMXBs
XMM fields without HMXBs

New XMM obs. of LMC









What do we need?

(a) How does the metallicity affect the evolution channel of the XRBs?

(b) What is the effect of the SF of the underlying stellar populations in the XRB formation?

(c) How does the shape of the XLF change?

- OPTICAL STUDIES..... (among the others) for determination of the metallicity of each region of interest

- X-RAYS STUDIES..... in order to have a statistically meaningful sample of young XRBs (especially at the LMC)

- DETAILED THEORETICAL MODELING..... The quality of the observational results must be matched by that of theoretical models at a similar level of sophistication

Conclusions

- The first direct determination of the number of XRBs per unit SFR of the *parent* population (performed for the SMC, stay tuned for the LMC)

- Age & metallicity play an important role in the formation of young XRBs (not yet fully understood)

- If you want to study the HMXBs population of the MCs, then look at regions with stellar populations of the age of ~25-60 Myr for the SMC and ~6-25 Myr for the LMC!