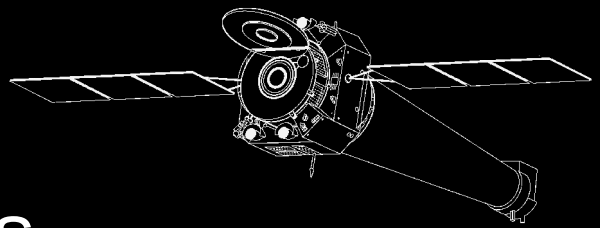
Beyond Chandra: accreting binary populations in the era of Lynx



Andreas Zezas

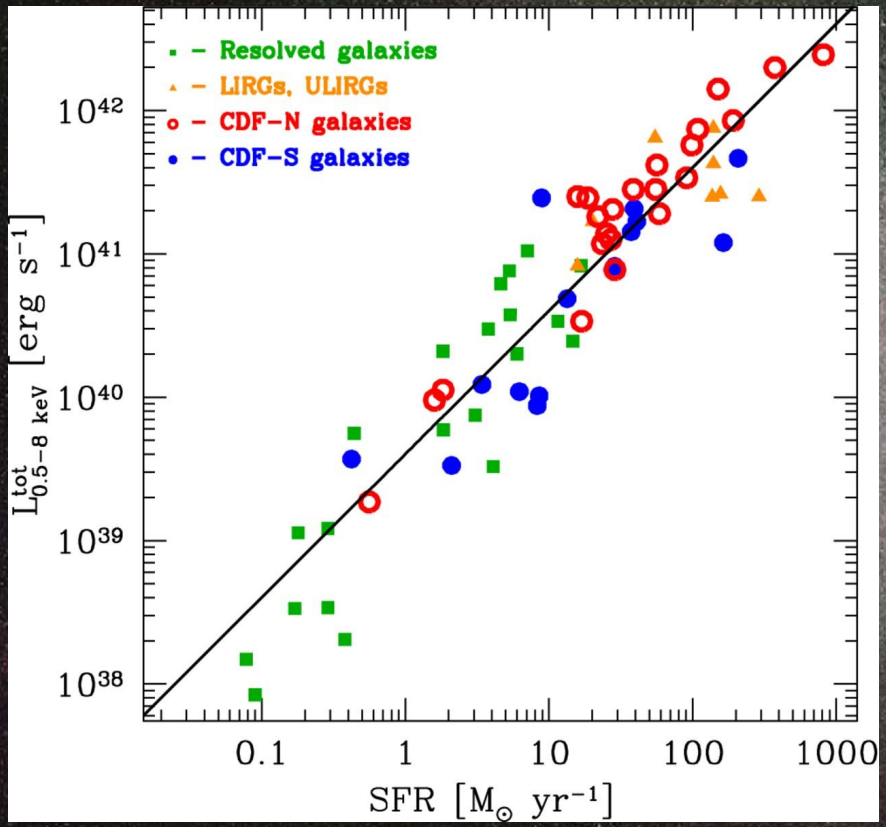
University of Crete, CfA

V. Antoniou, P. Sell, J. Andrews, T. Fragos

G. Fabbiano, A. Hornschemeier, A. Ptak

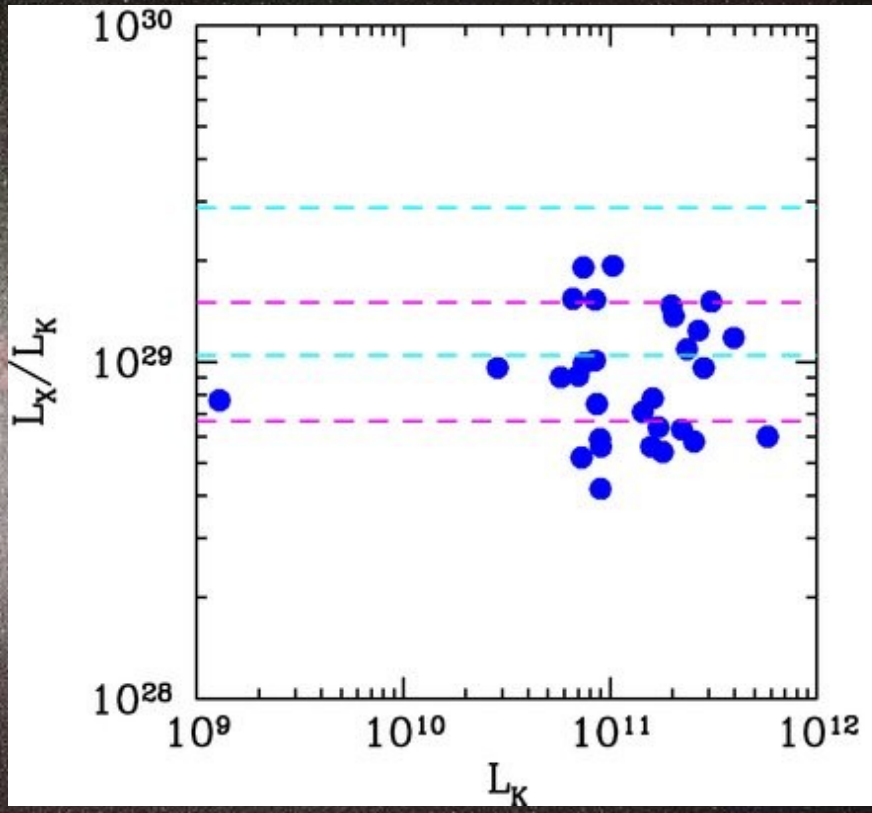
X-ray binary populations

HMXBs



Mineo et al. 2014

LMXBs



Boroson et al. 2011

X-ray binary populations

Fundamental :

- Dependence on age, Z

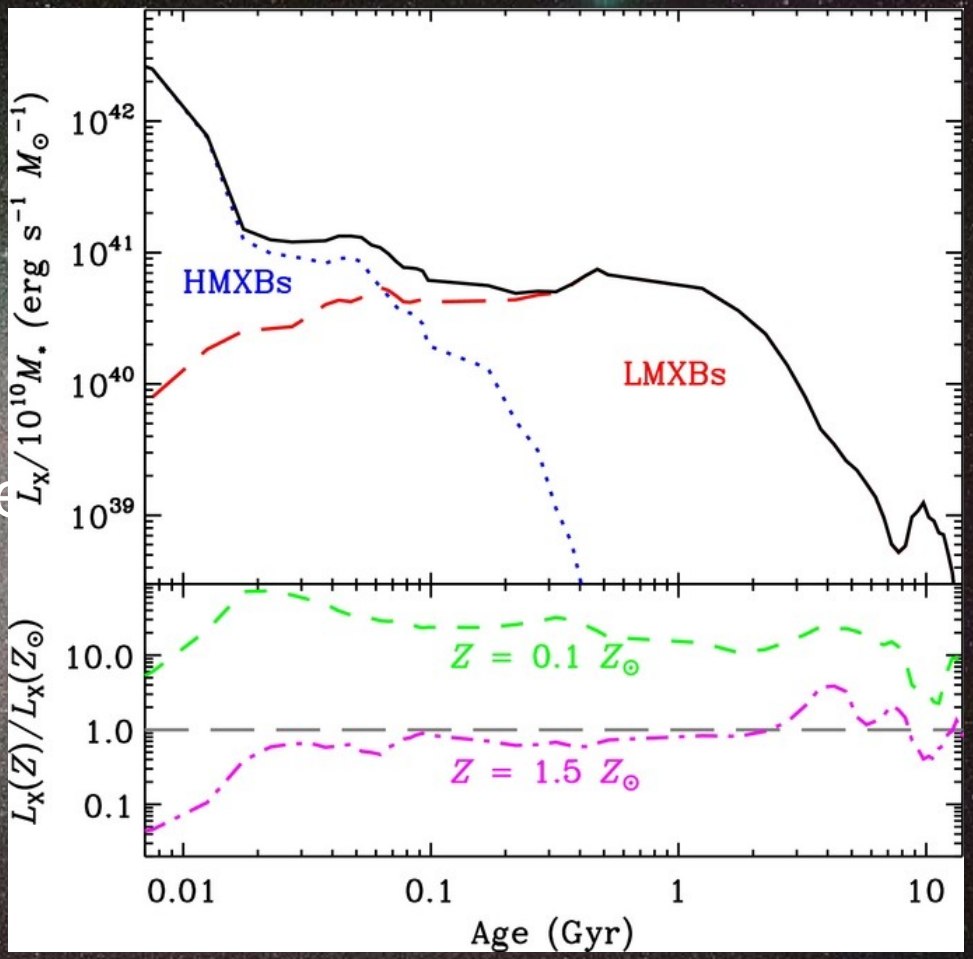
Only now start to explore

Important:

XRB formation/evolution

Modeling GW sources

XRB feedback in Cosmic Dawn



Fragos et al. 2013

The deep Chandra SMC Survey

A Chandra “X-ray Visionary Program”:

11 +3 Fields in the SMC (50-60 kpc)

2 x 50ksec exposures (1.1 + 0.3 Msec total)

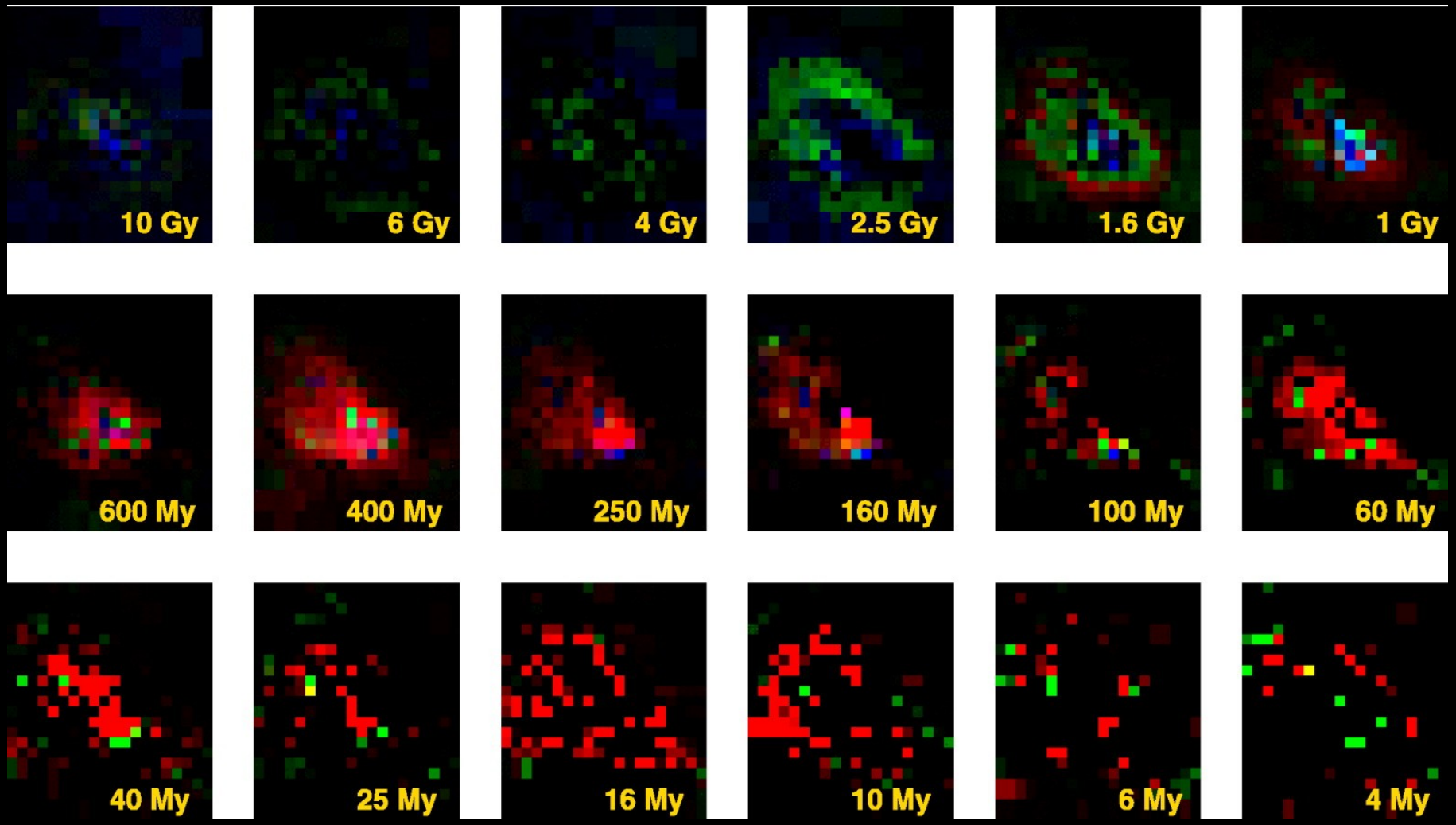
Key Goal

- A deep census of accreting pulsars (Lx ~10^{33} erg/s)
- HMXB formation efficiency at different ages

  Well determined star-formation history

  metallicity (1/5 $Z_{\odot}$ - 1/3 $Z_{\odot}$)

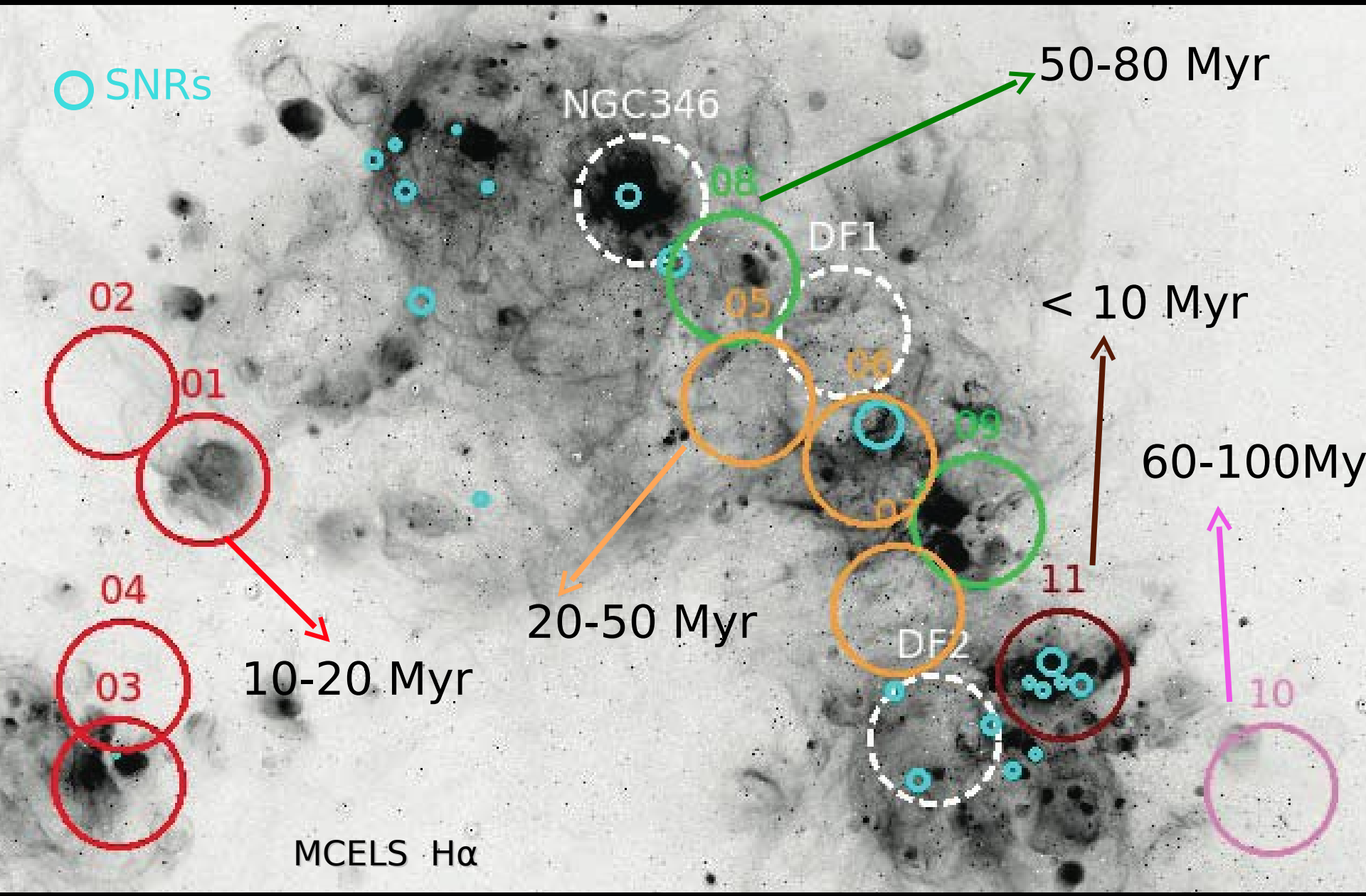
SMC star-formation history

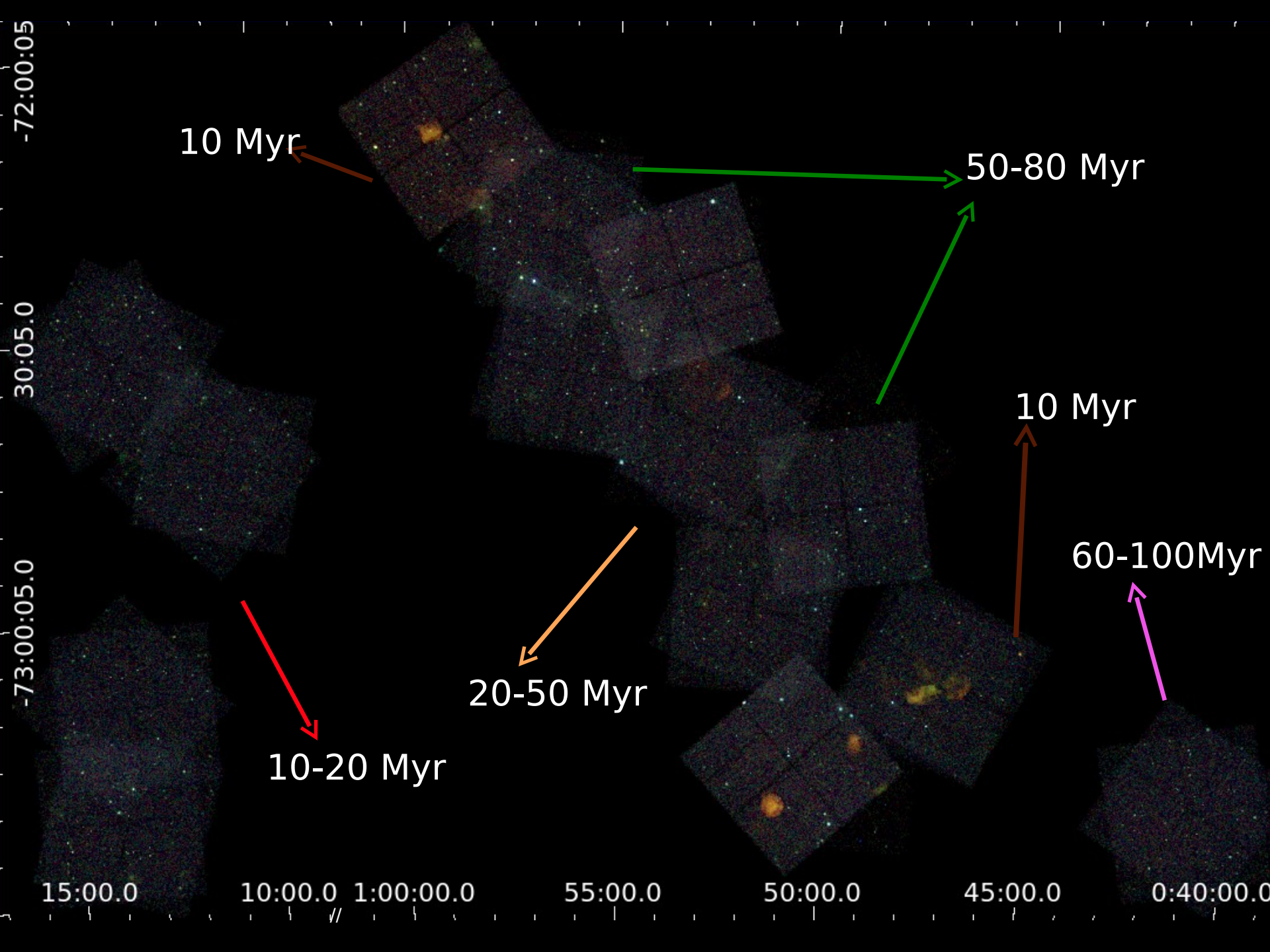


0.05Z⊙ 0.2Z⊙ 0.4Z⊙

Harris & Zaritsky, 2004

SMC: The deep Chandra Survey




10 Myr
50-80 Myr
10 Myr
60-100Myr
20-50 Myr
10-20 Myr
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-73:00:05.0
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45:00.0
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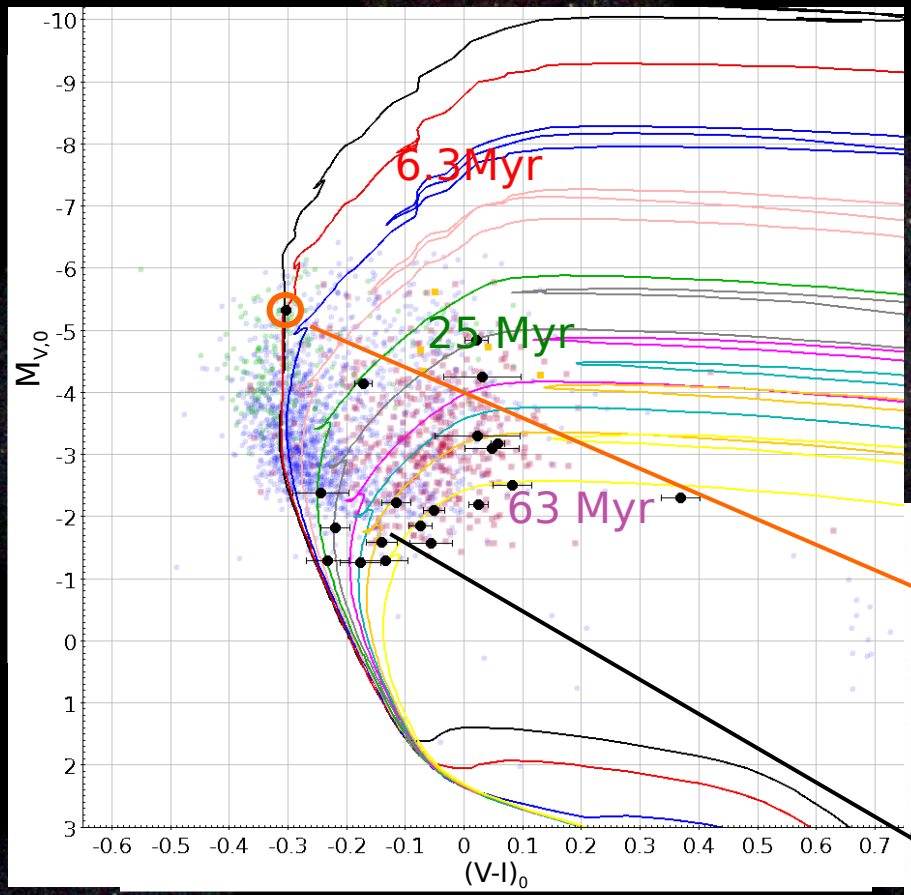
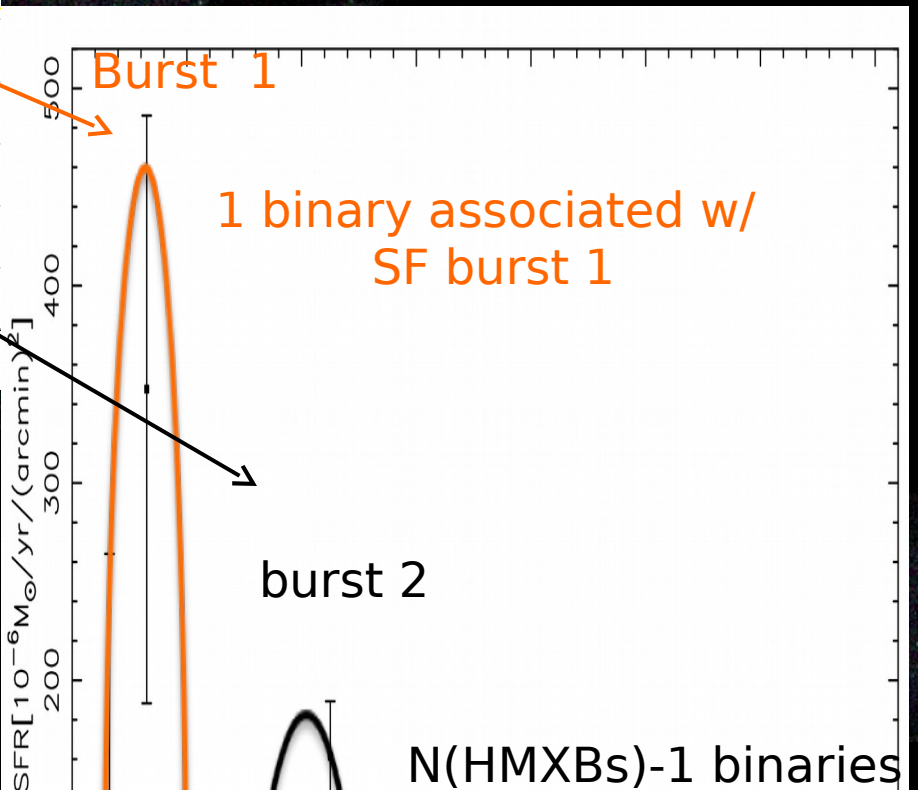
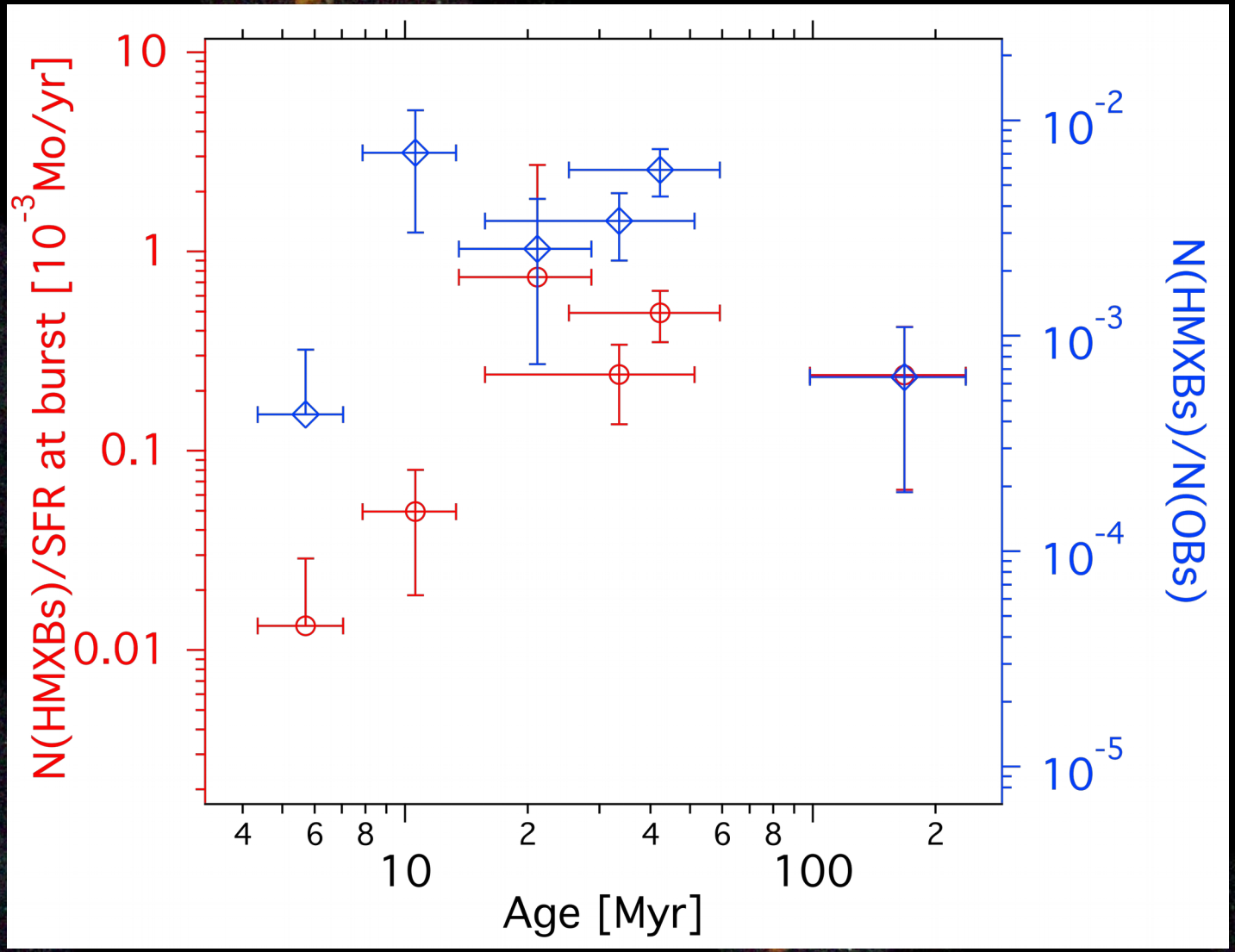
HMXB classification



Antoniou et al, 2017

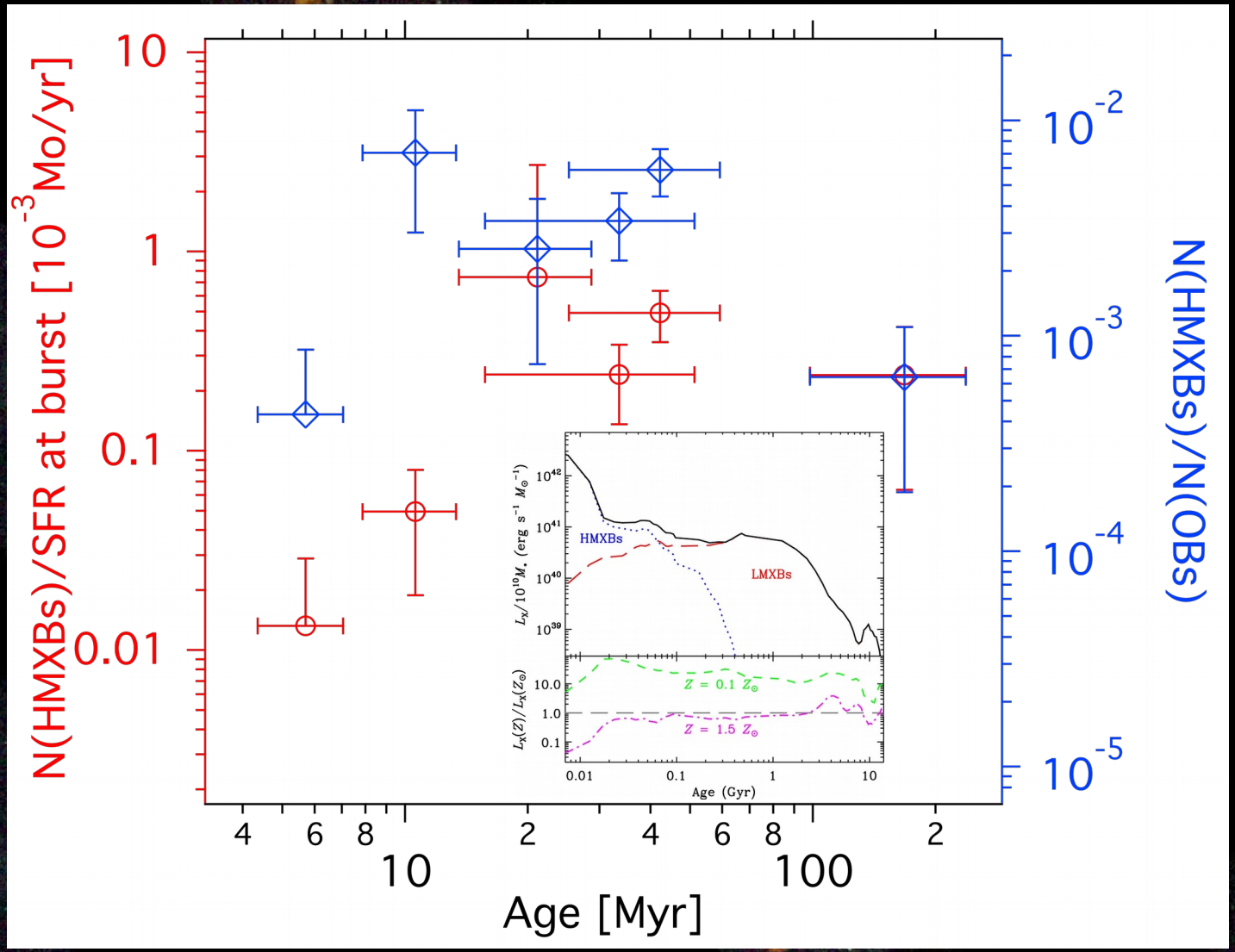


HMXB formation efficiency



Antoniou et al, 2017

HMXB formation efficiency



Antoniou et al, 2017

M81

Grand design spiral galaxy (3.6 Mpc)

Advantages :

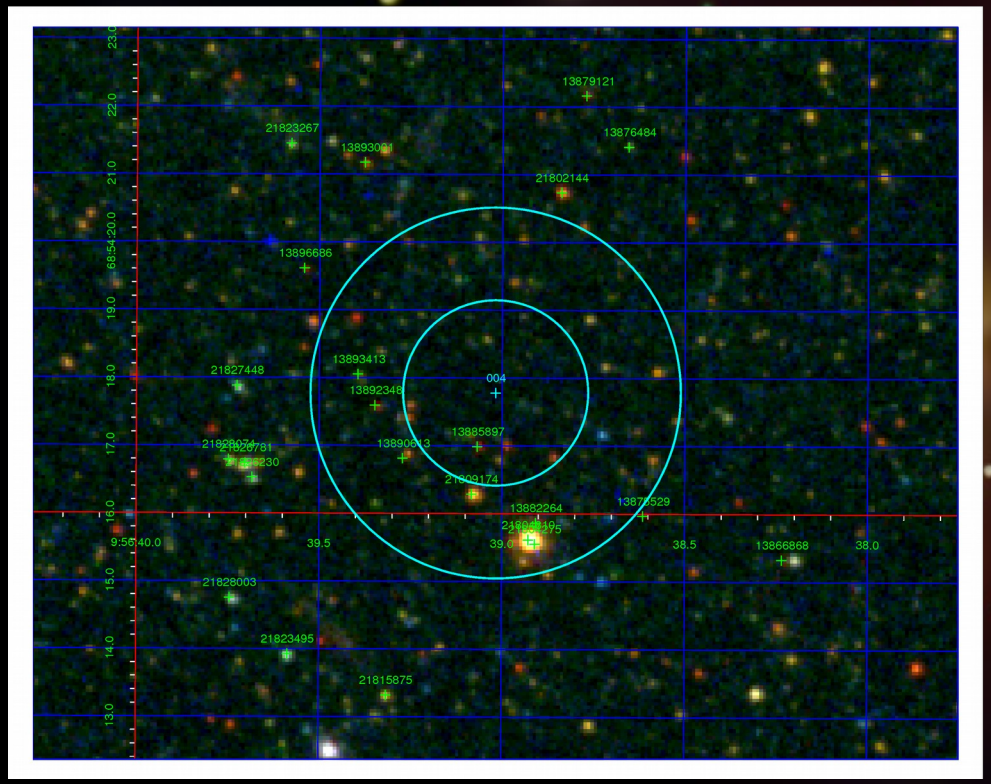
- Complete HST coverage
- Deep Chandra coverage

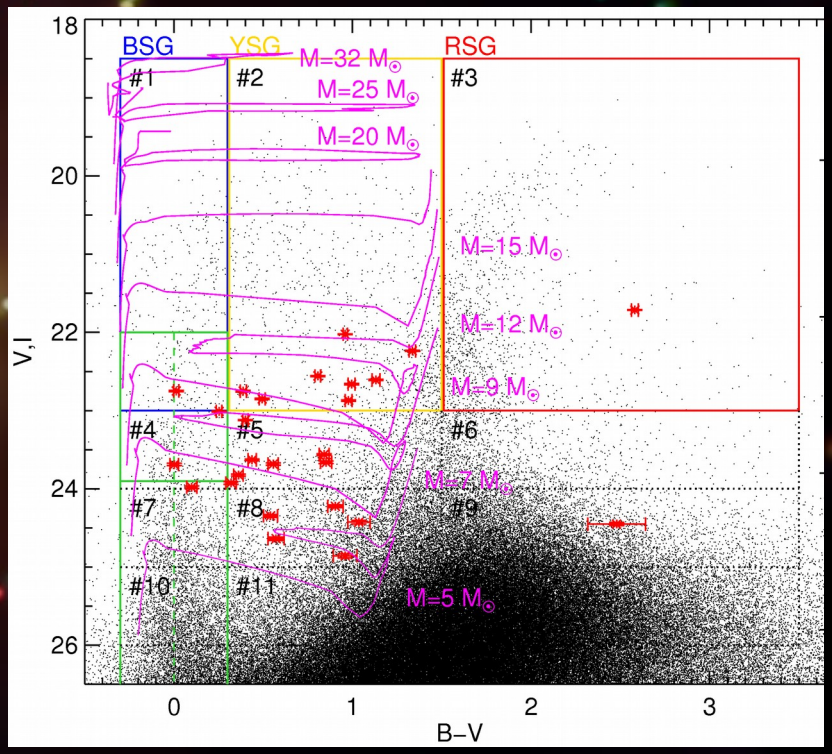
Sell et al. 2011; Swartz et al.

Measure directly formation efficiency of different XRB classes

M81

Optical counterparts : Donor star classification

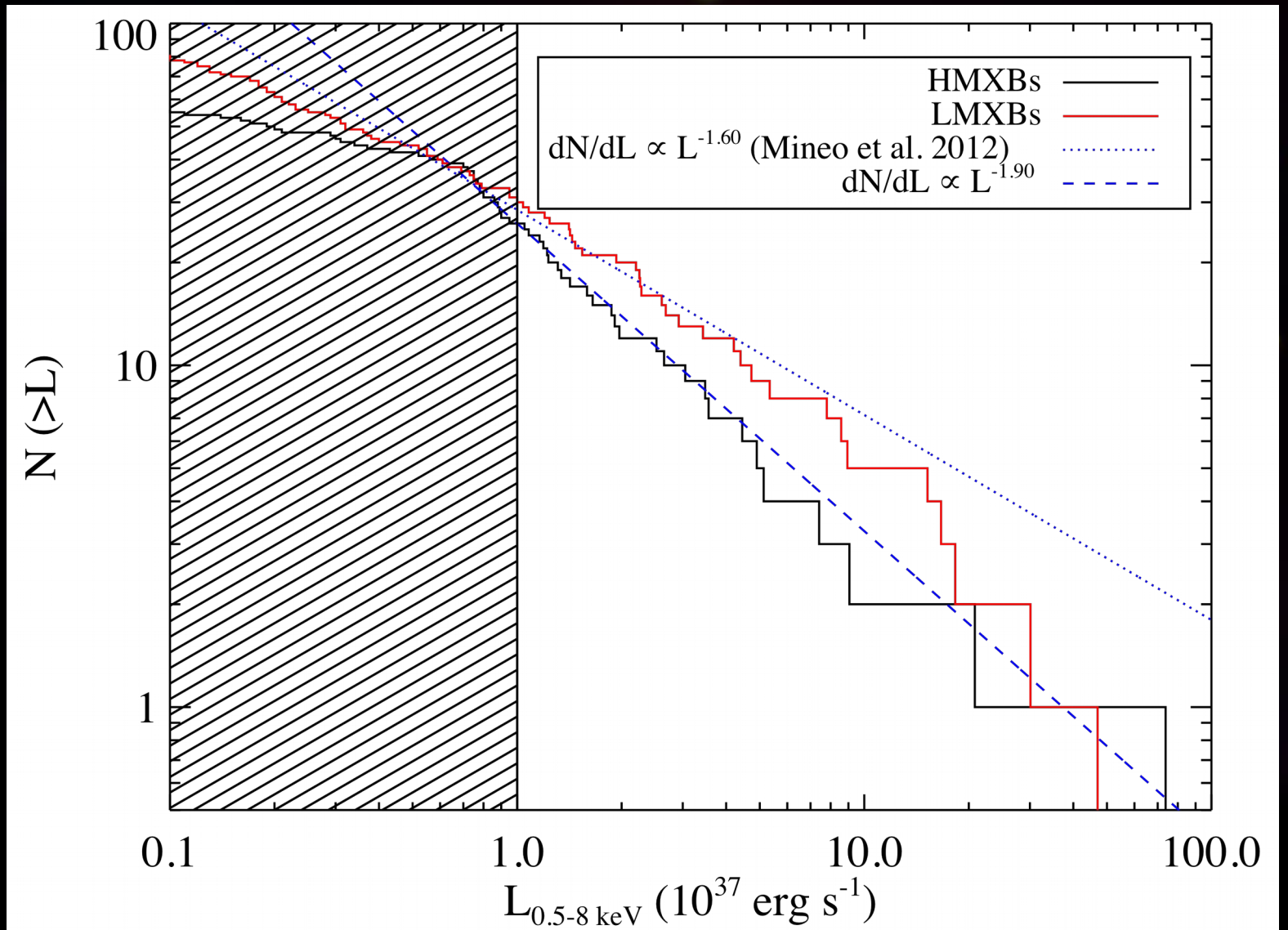




P. Sell et al.

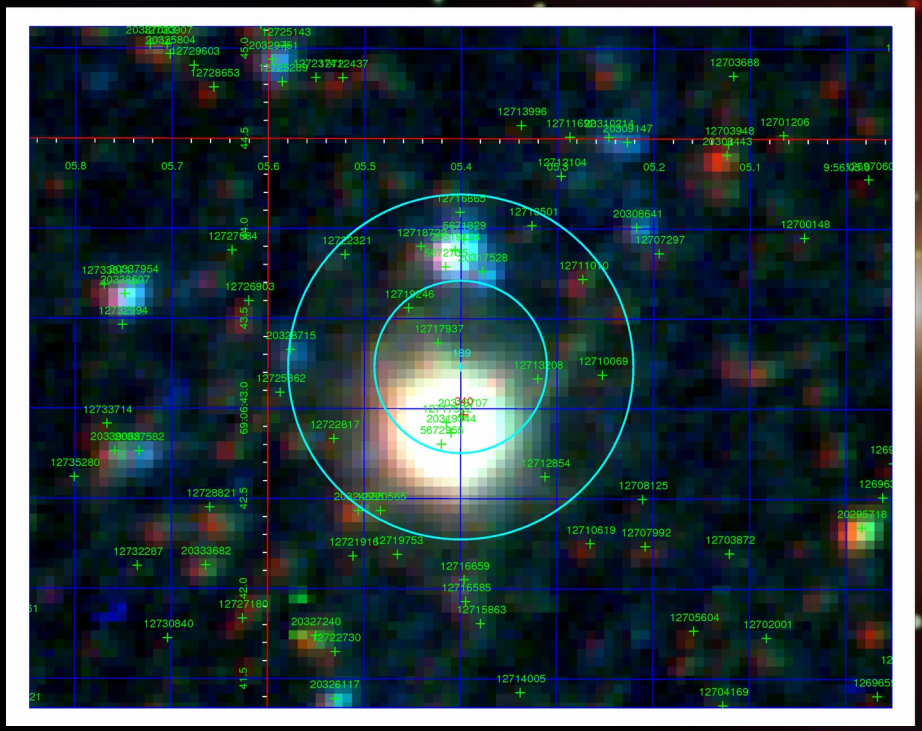
M81

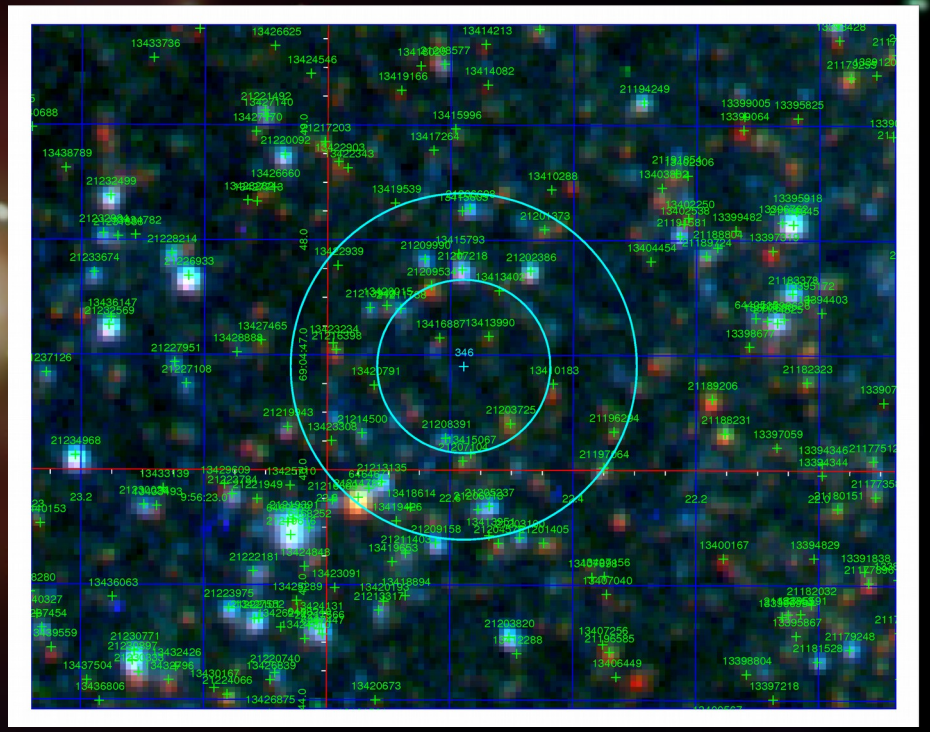
XLFs for different source classes (Sell et al.)



M81

Limitations of Chandra : variable under-sampled PSF

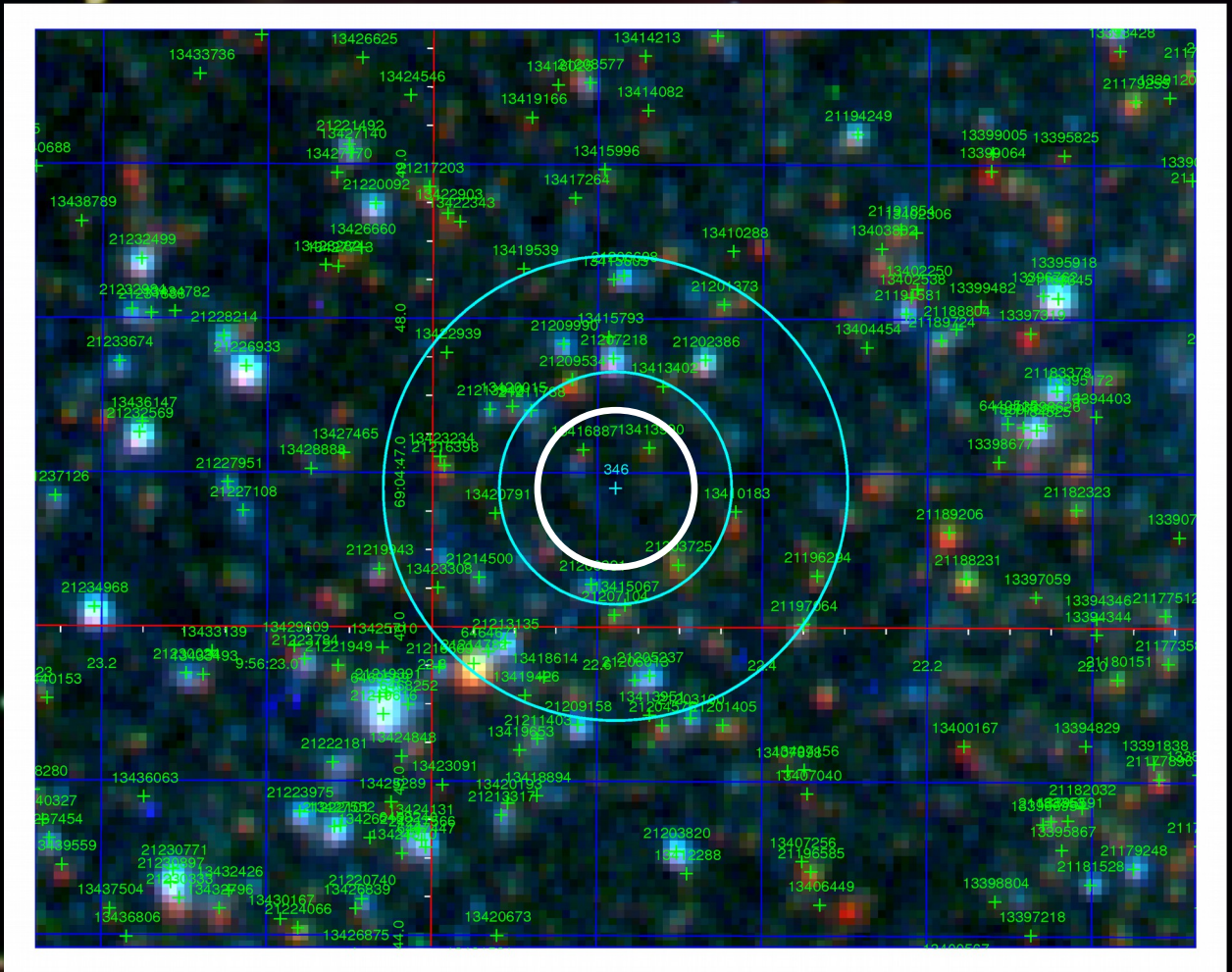




From Chandra to Lynx

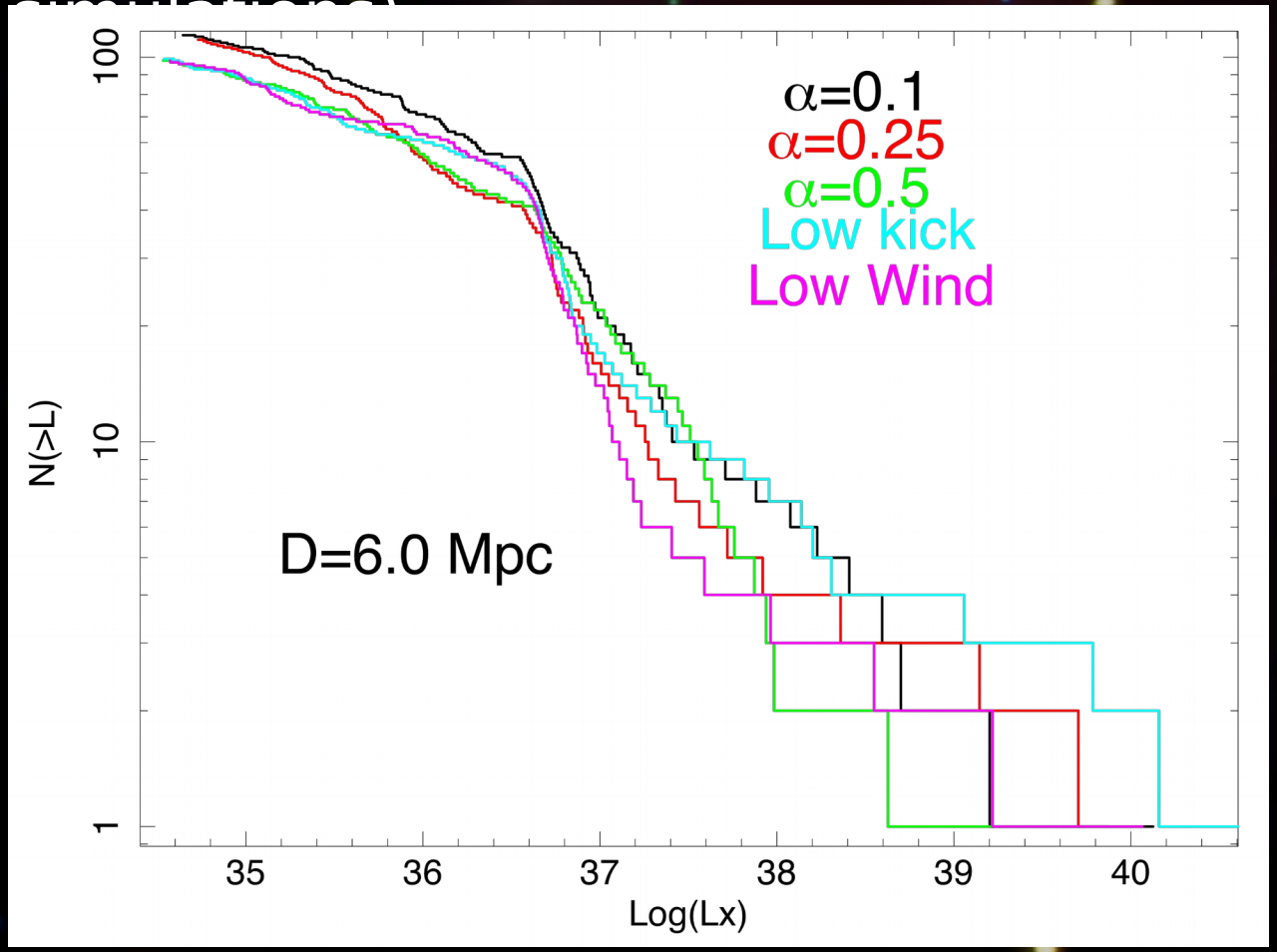
With well-sampled 0.5” PSF across the field we can:

Characterize X-ray sources



From Chandra to Lynx

With 0.5” resolution and 2m² we can reach fainter populations (end-to-end simulations)



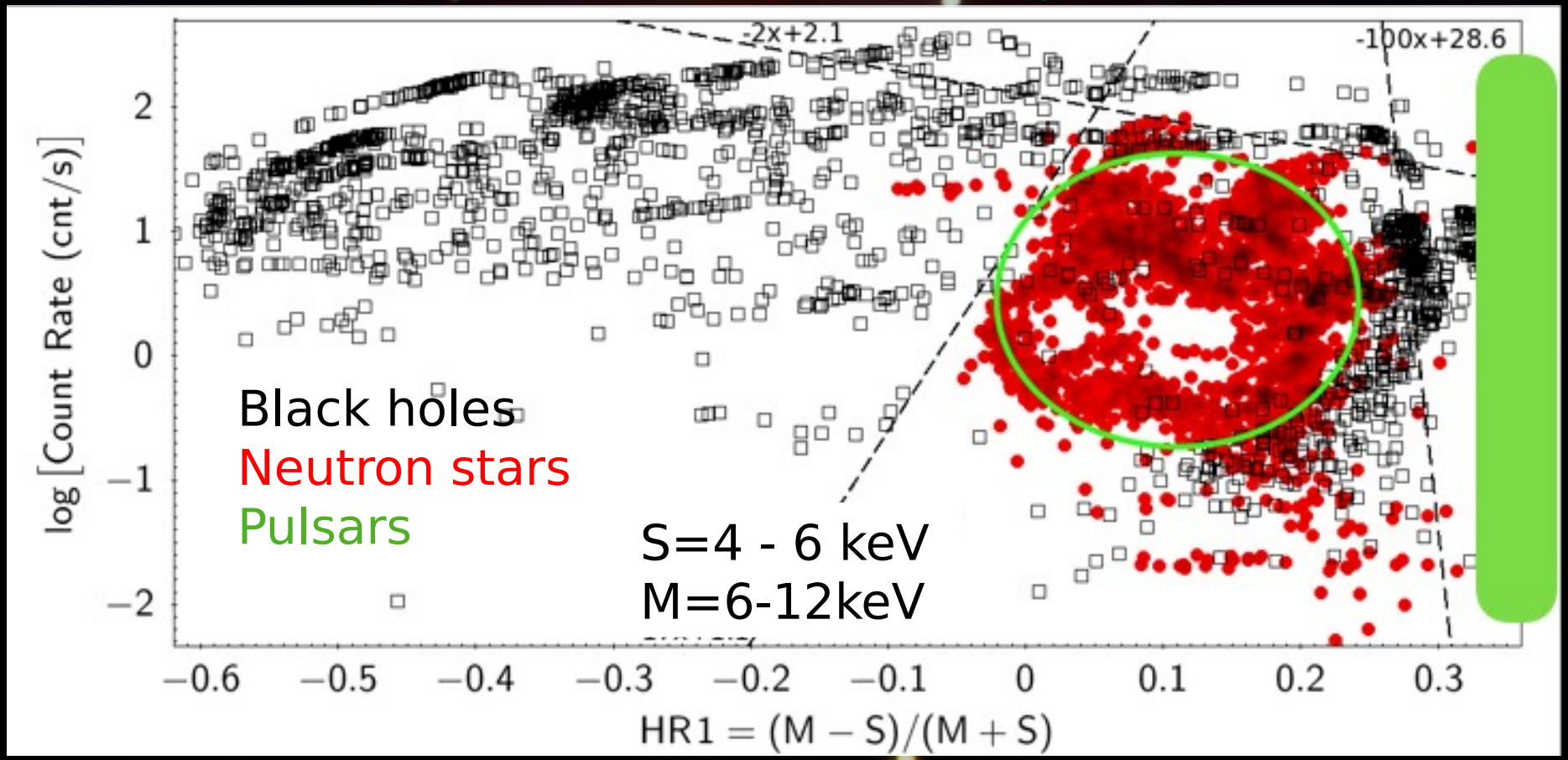
Pop. Synthesis

Andrews et al.

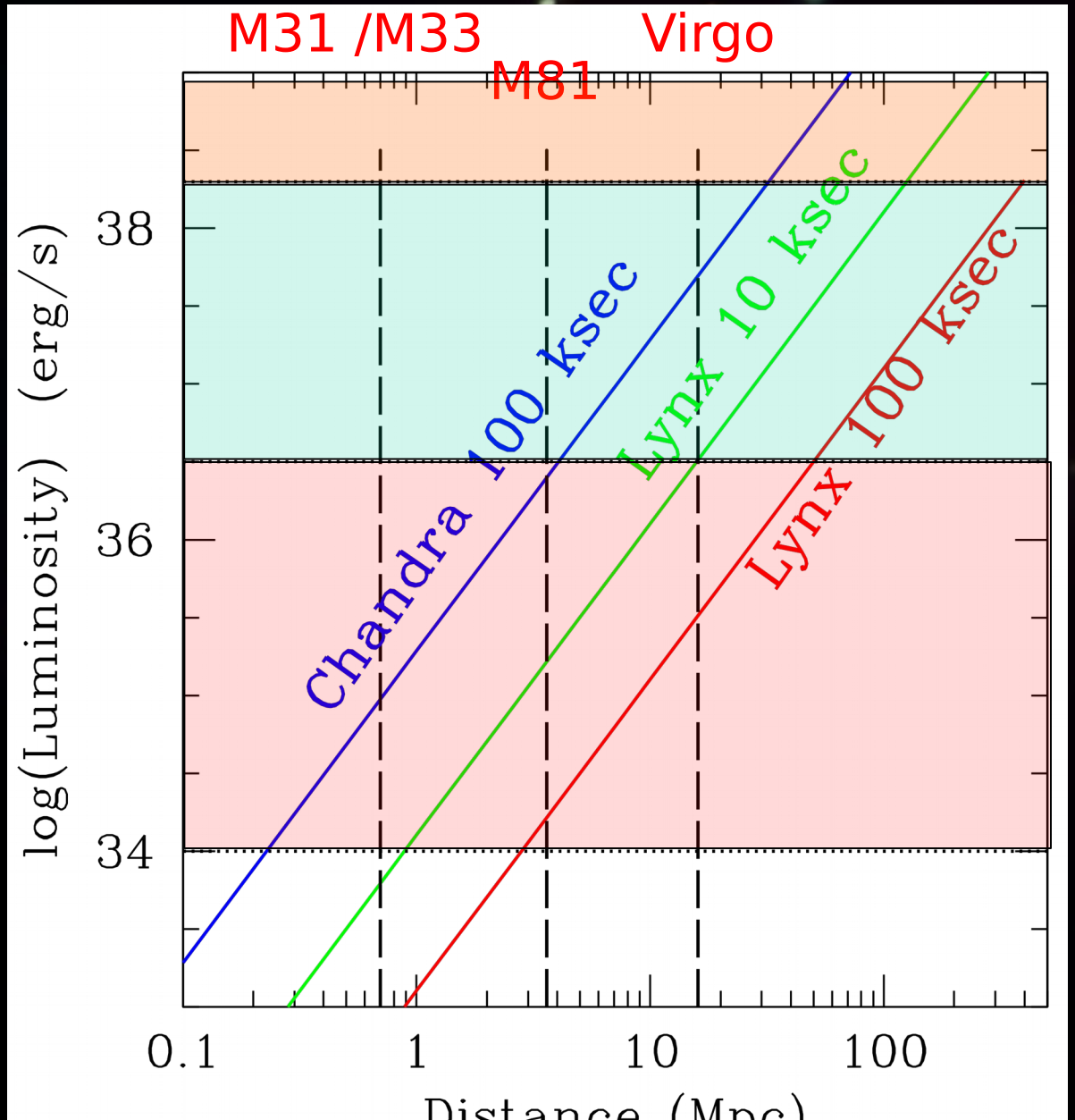
Chandra to Lynx

With extended energy coverage we can

Classify compact objects

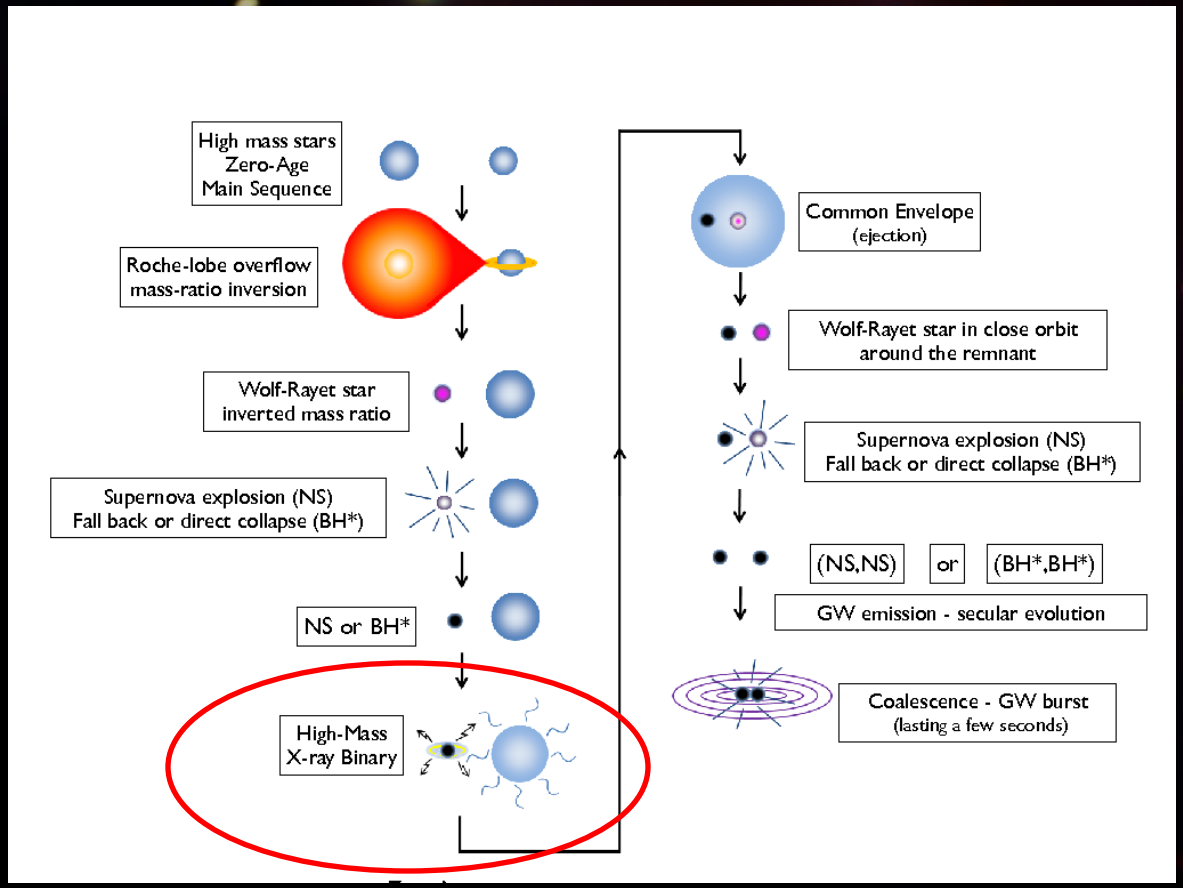


Lynx discovery space



Why bother ?

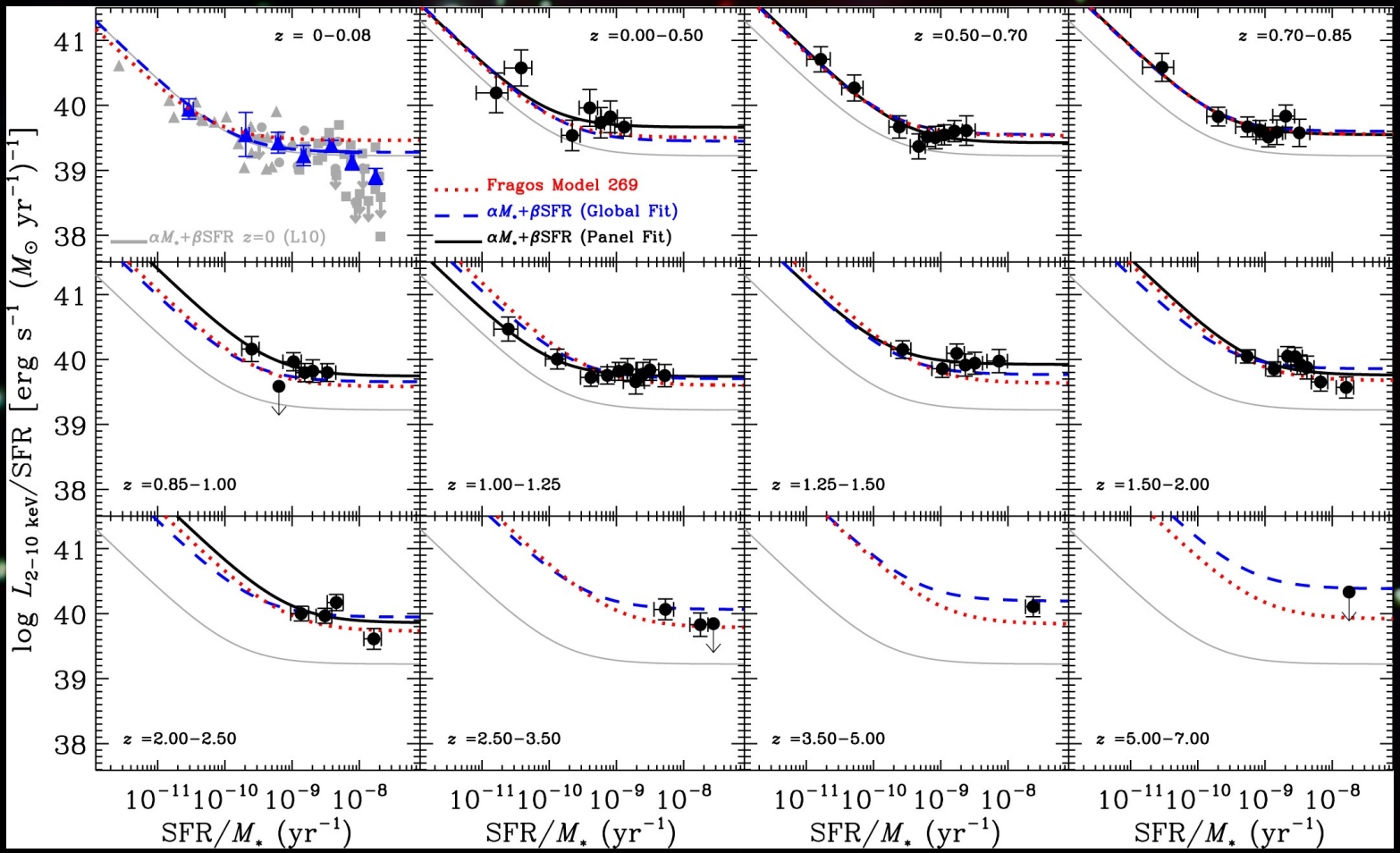
- X-ray binaries key for high-profile science
  - Gravitational wave sources



Marchant et al., 2016

Why bother ?

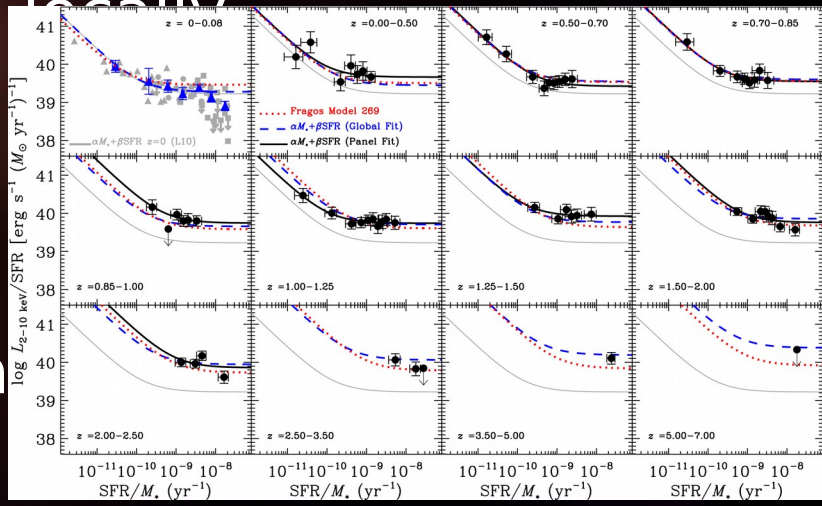
- X-ray binaries key for high-profile science
  - Cosmological evolution of galaxies and compact



Lehmer et al., 2016

Why bother ?

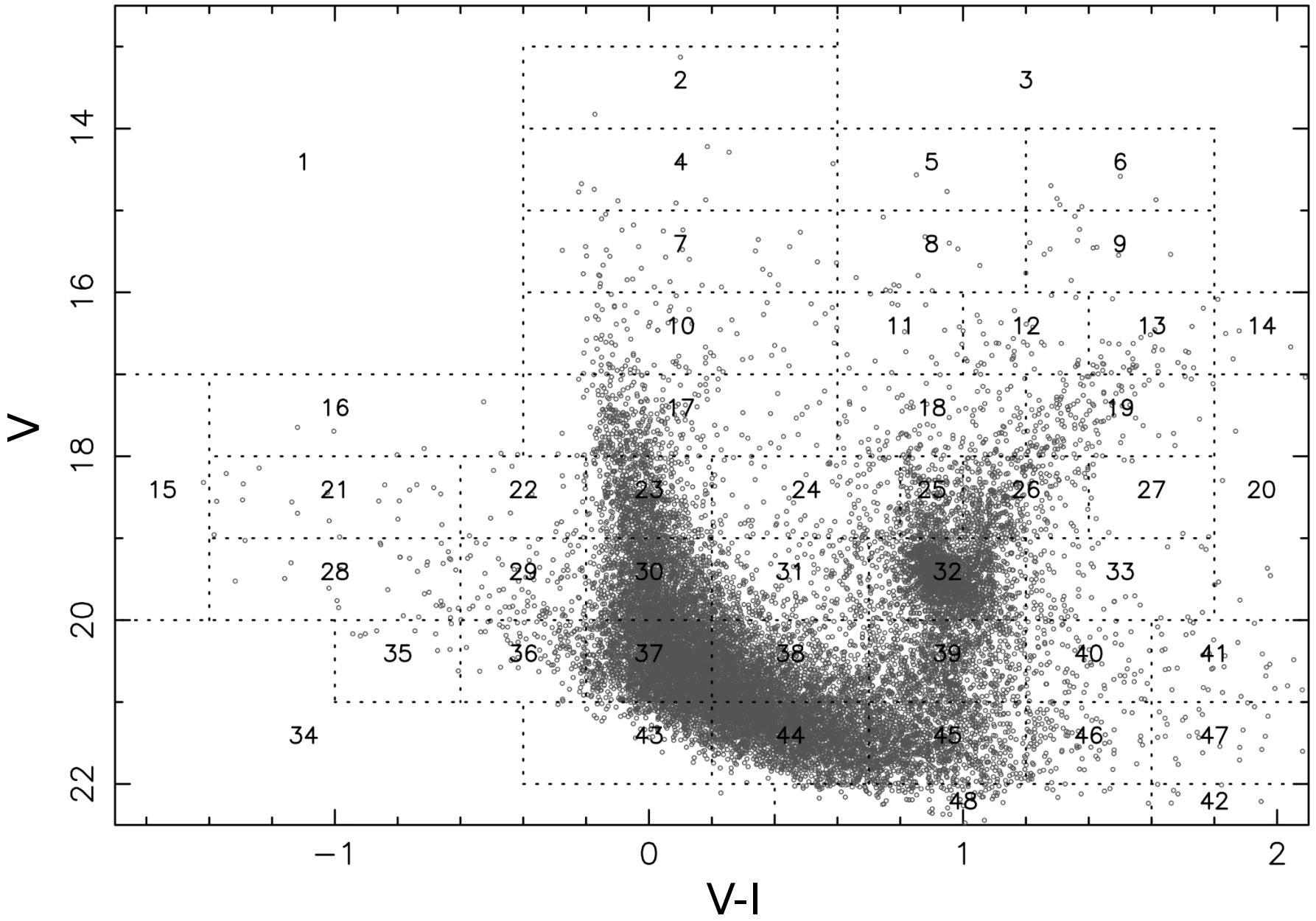
- X-ray binaries key for high-profile science
  - Cosmological evolution of galaxies and compact objects
  - Models need to be calibrated locally
    - Source statistics
    - Known environment
    - Source classification critical



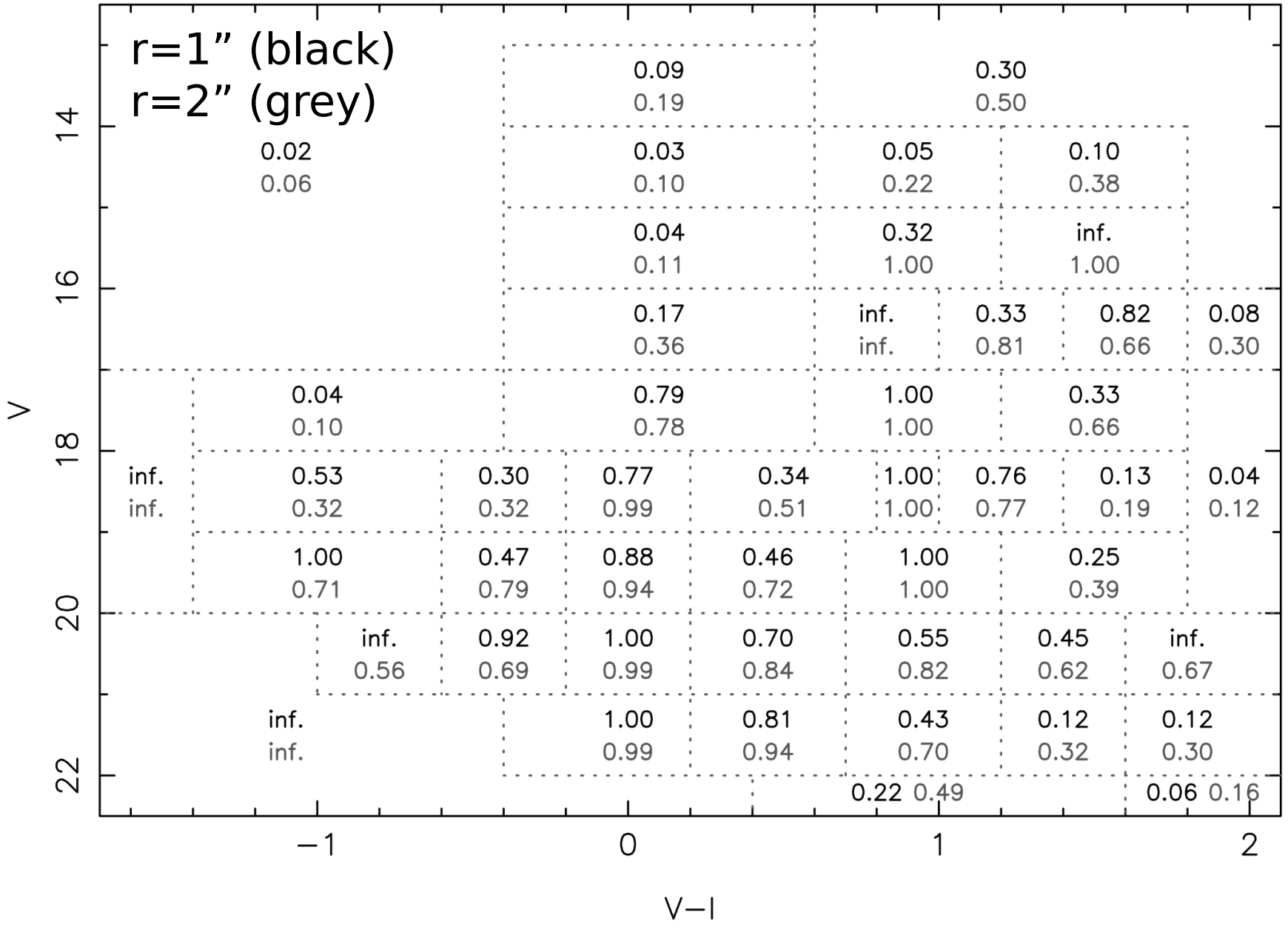
Summary

- X-ray binaries key for high-profile science
  - Cosmological evolution of galaxies and compact objects
  - Gravitational wave sources
- But : Chandra reaches only the tip of the iceberg
- Next major leap requires Lynx:
  - ✓ Identification of multi-λ counterparts
  - ✓ Larger samples (statistics, diversity)
  - ✓ Extended energy coverage ?
- Synergy with 30m telescopes, JWST, GW detectors

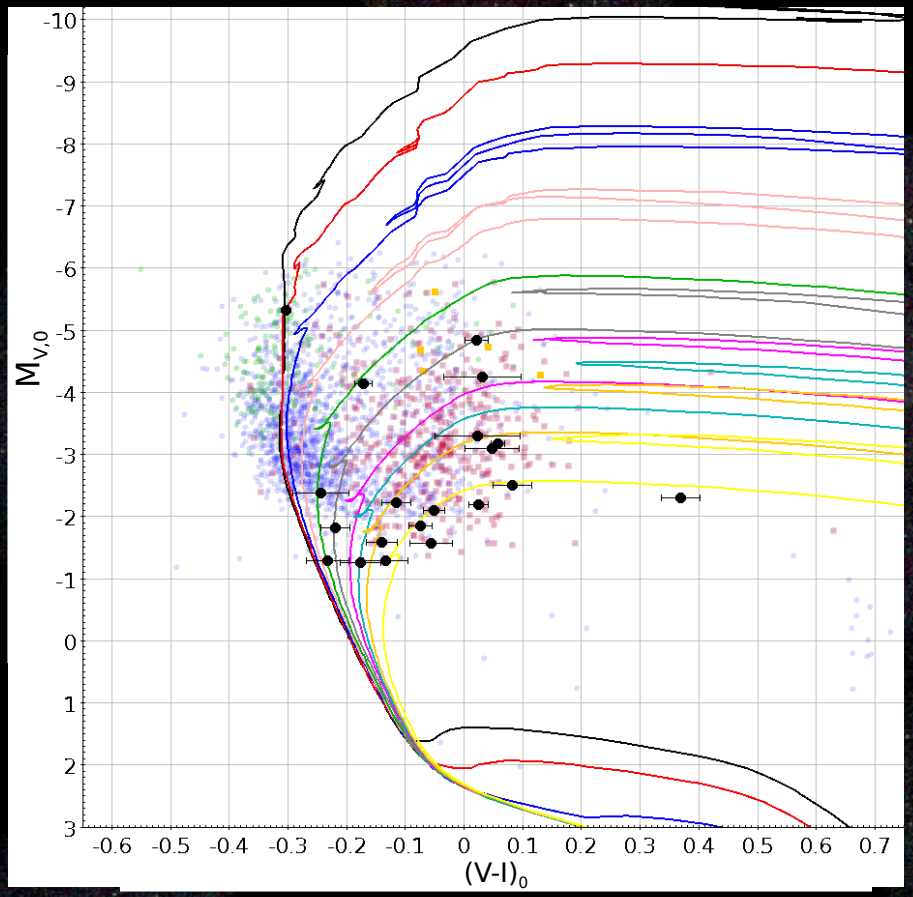
Chance coincidence



Chance coincidence

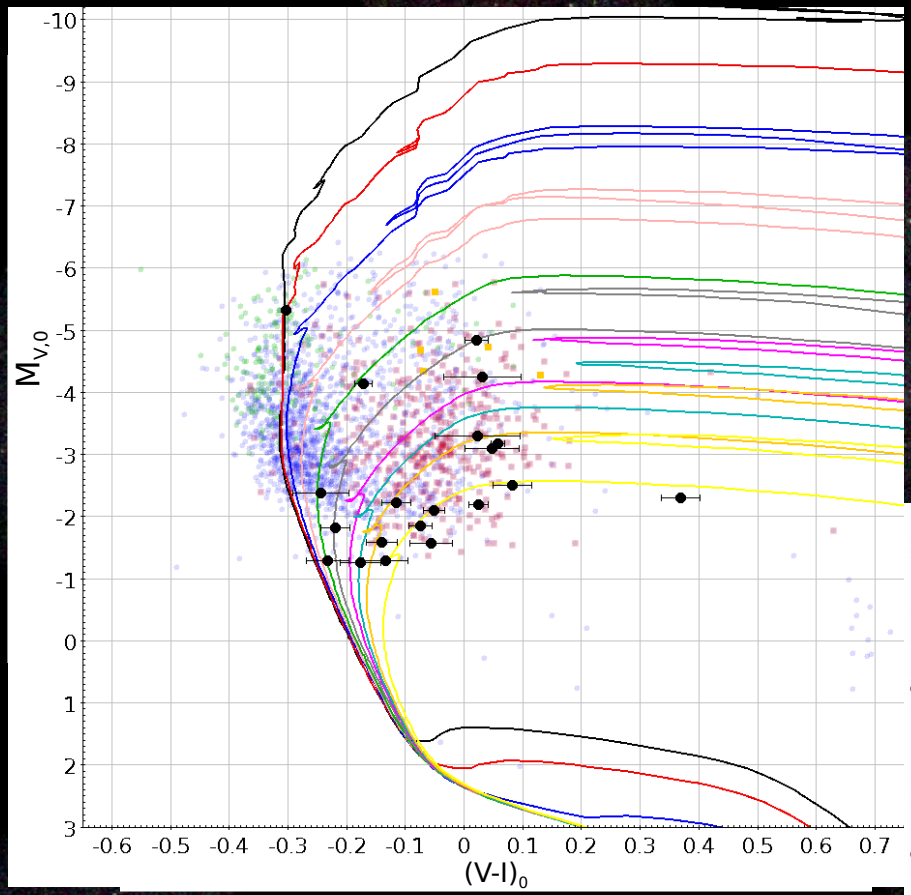


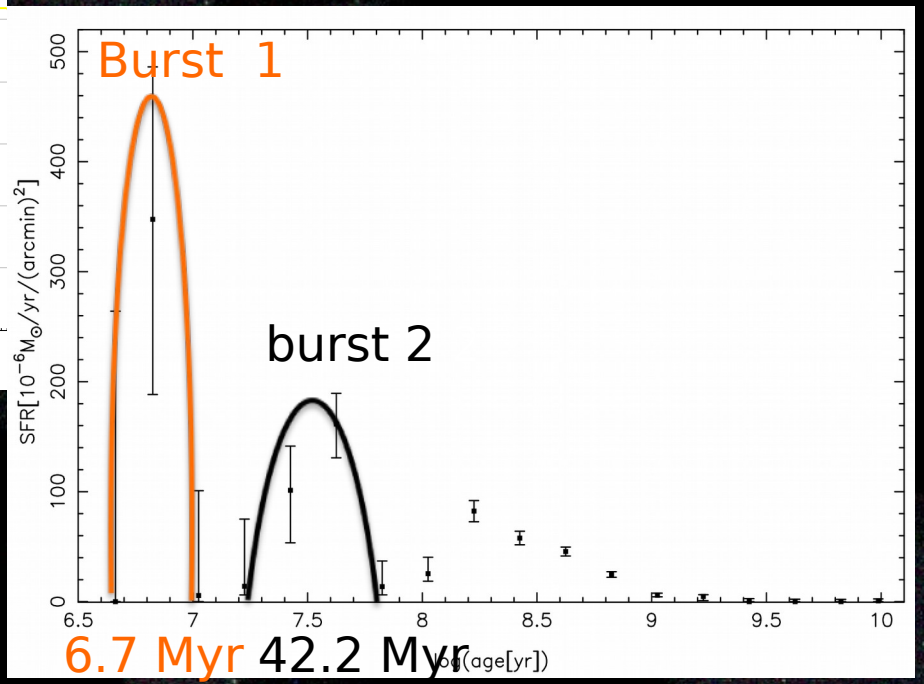
HMXB classification



Antoniou et al, 2017

HMXB classification



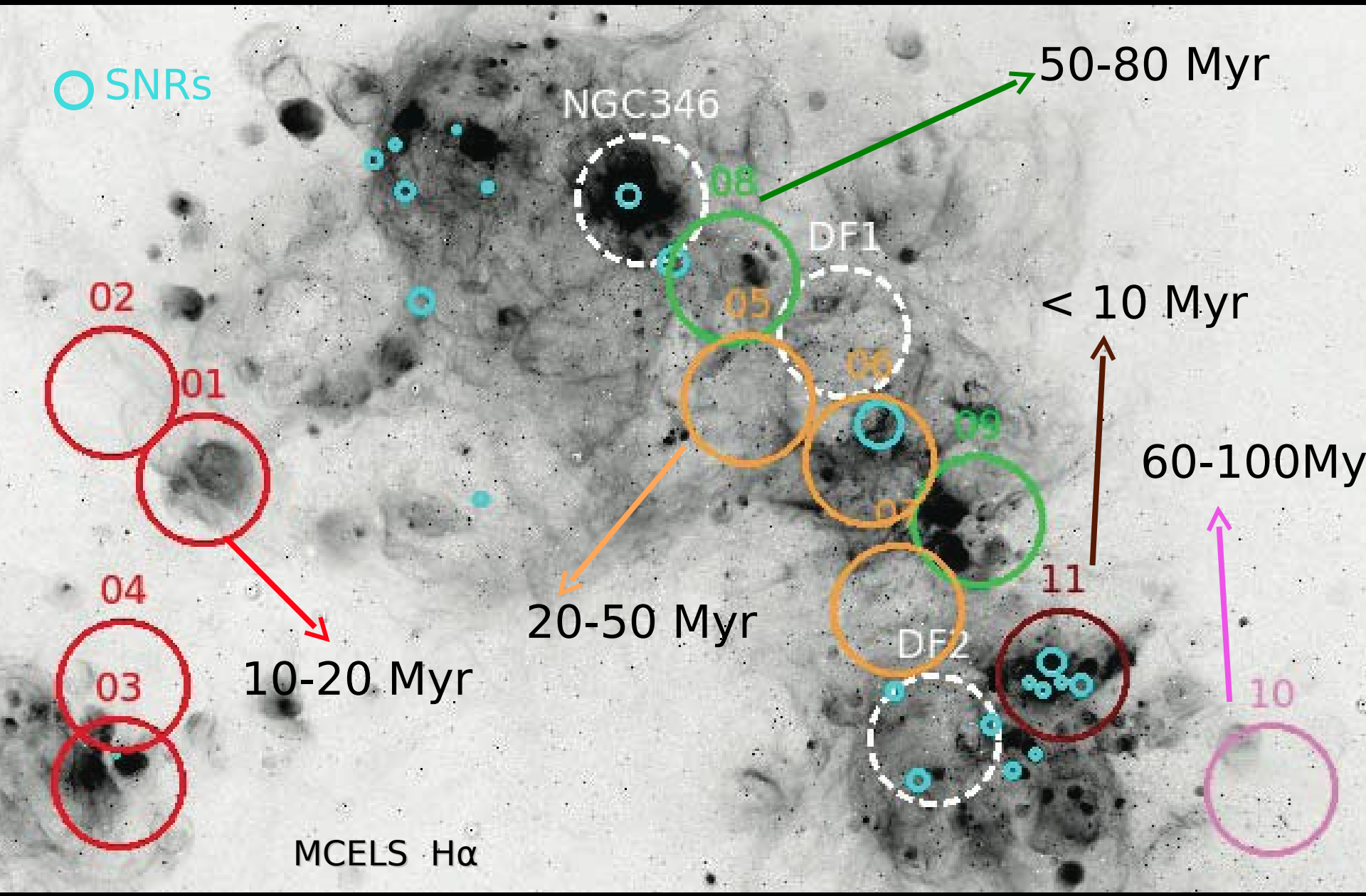


Antoniou et al, 2017

Results

- 2393 sources detected (1095 > 5σ significance)
  (limiting $L_X \sim 3.5 \times 10^{32}$ erg/s; 0.5 – 7 keV @ 50% compl.)
- ~ 65 (Wing) – 75 (Bar) sources per field
- 21 pulsars detected (Hong et al. 2017)
  (out of the 34 known in these regions)
- A Be-XRB pulsar emerging from the companion circumstellar disk (Hong et al. 2016)
- 12 SNRs detected
- 128 sources associated with an OB star

SMC: The deep Chandra Survey



Magellanic Clouds

Nearest star-forming galaxies (50-60 kpc)

Advantages :

- Probe very faint populations (Lx ~10^{33} erg/s)
- Large populations of HMXBs (e.g. Haberl & Sturm 2016)
- Well determined star-formation history
  metallicity (1/5 $Z_{\odot}$ - 1/3 $Z_{\odot}$)

Magellanic Clouds

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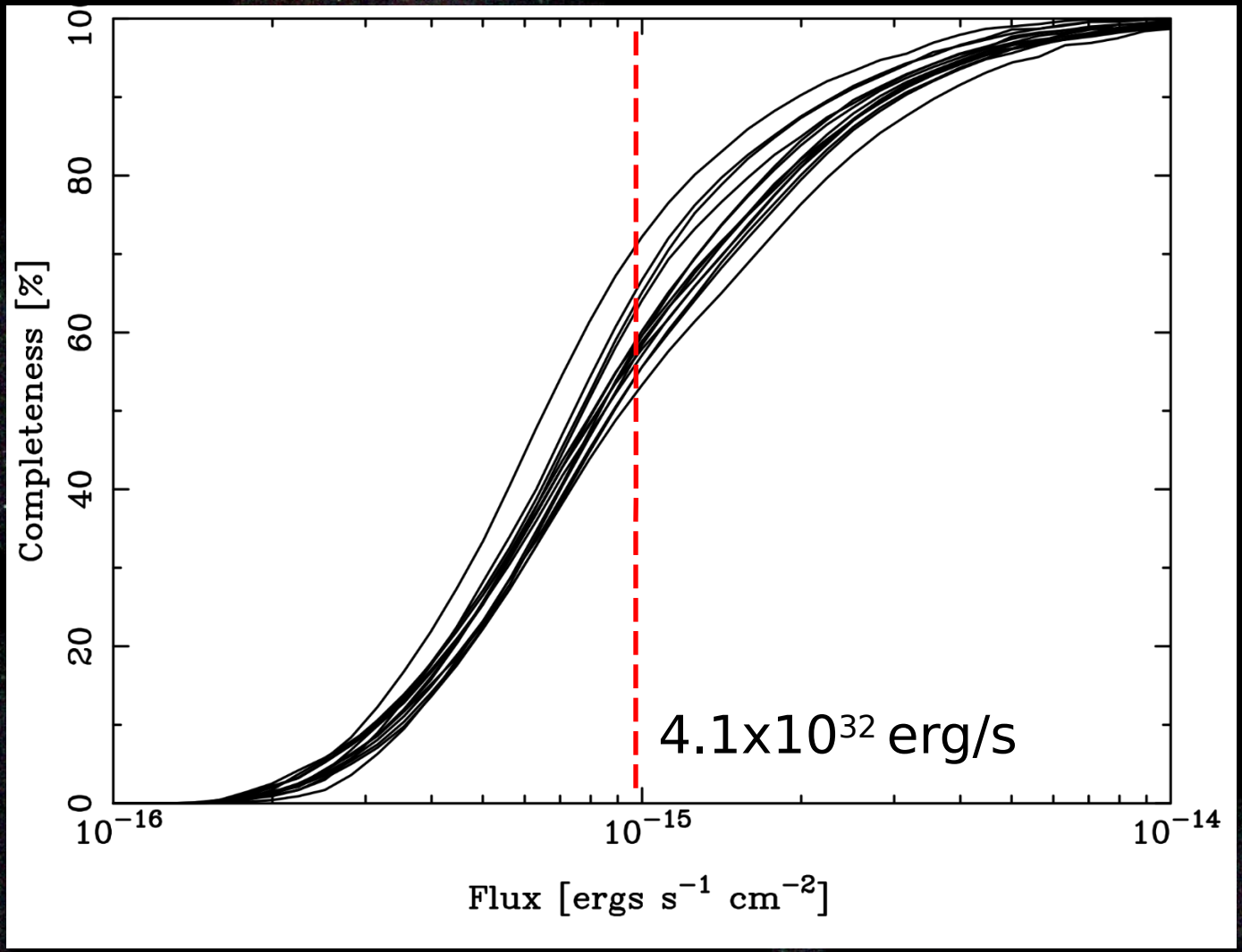
- Well determined star-formation history
  metallicity (1/5 $Z_{\odot}$ - 1/3 $Z_{\odot}$)

Unique laboratories for the study of HMXBs

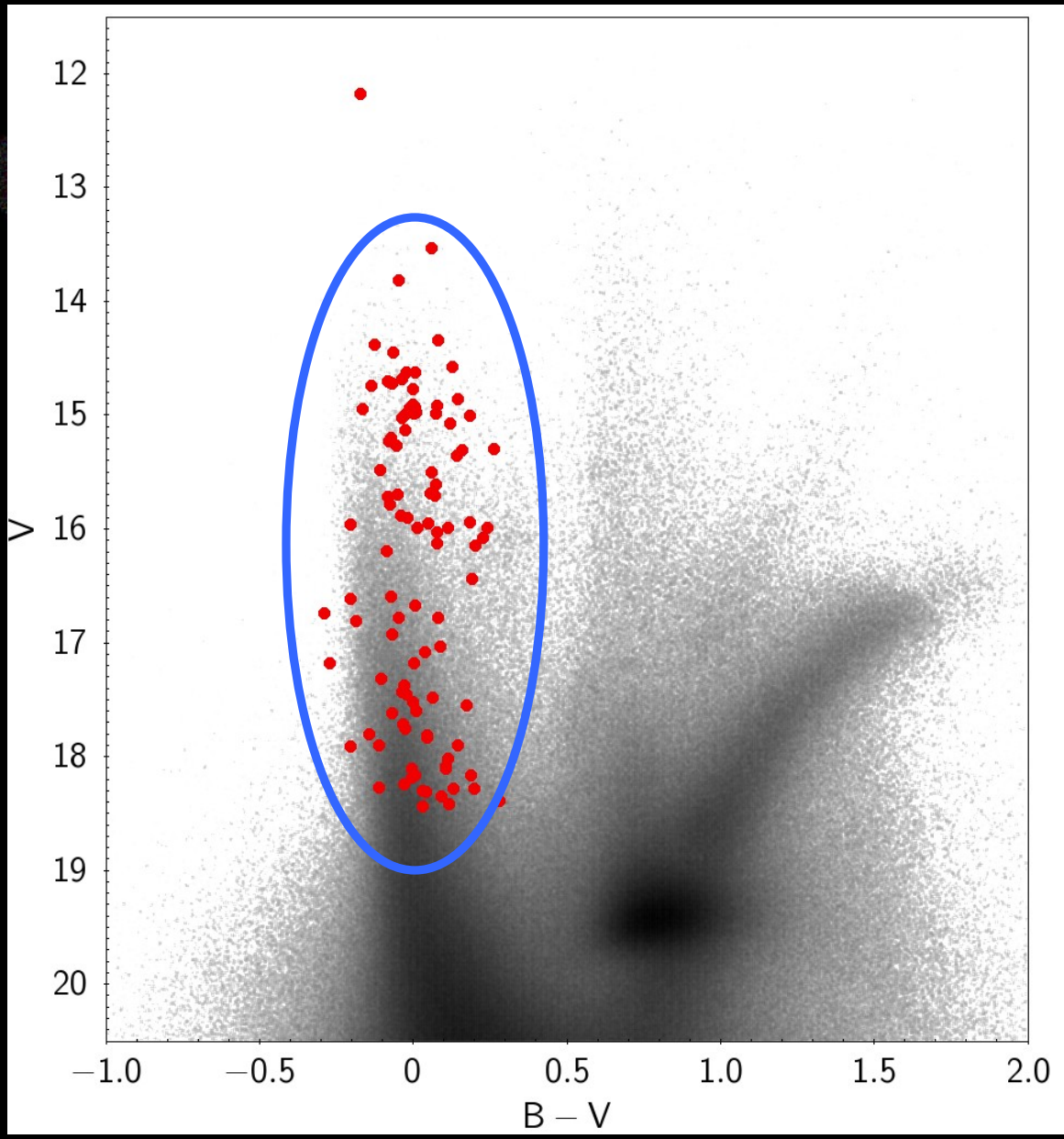
Address: formation efficiency of XRBs
accretion physics, interaction of accretion flow and magnetic fields.

Survey sensitivity



First results

105 HMXB candidates down to 5×10^{32} erg/s

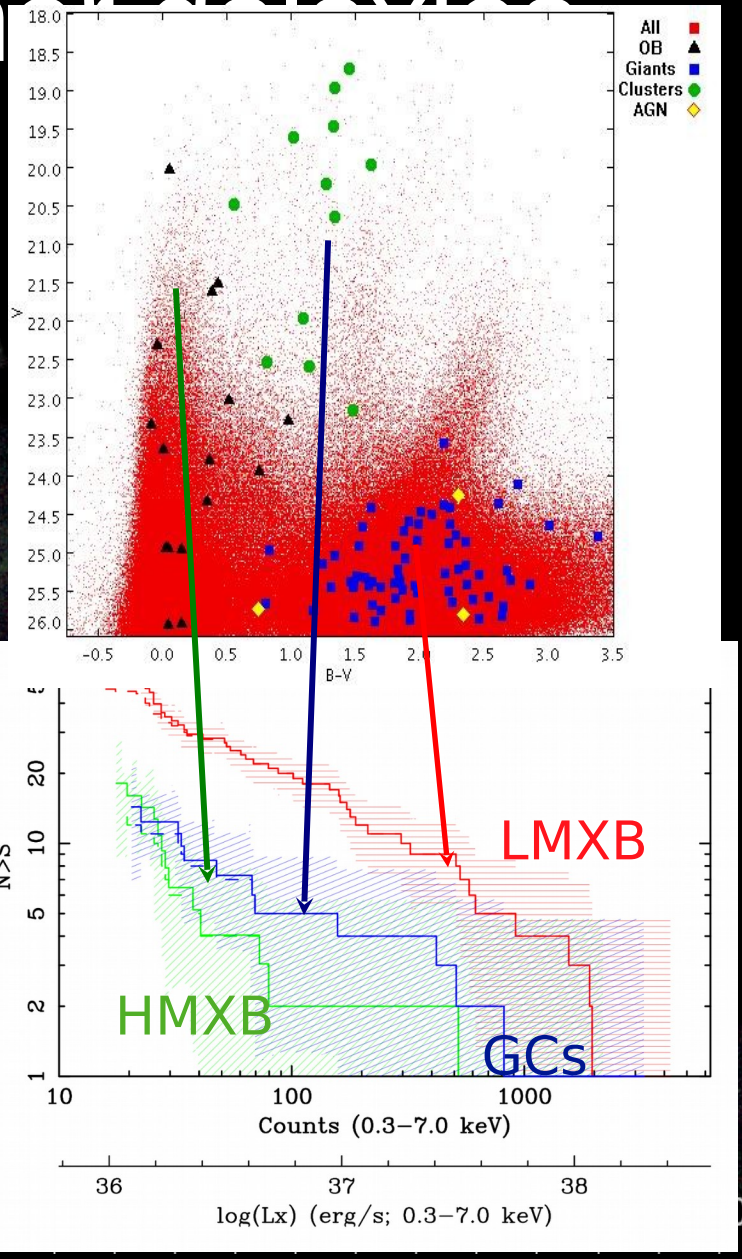


Looking ahead: Other galaxies

Goal: A more complete picture of XRB formation/evolution

Need:

- Cover age / metallicity space
  - Deep observations
- Uniform sensitivity
- Chandra – HST synergy



First results

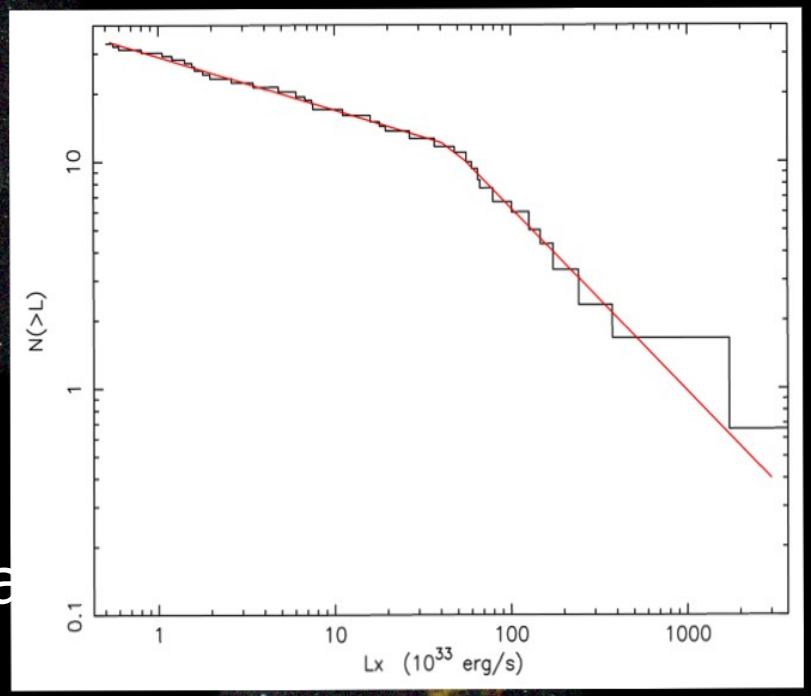
The luminosity function:

Flat slope : α ~0.2 / 0.8

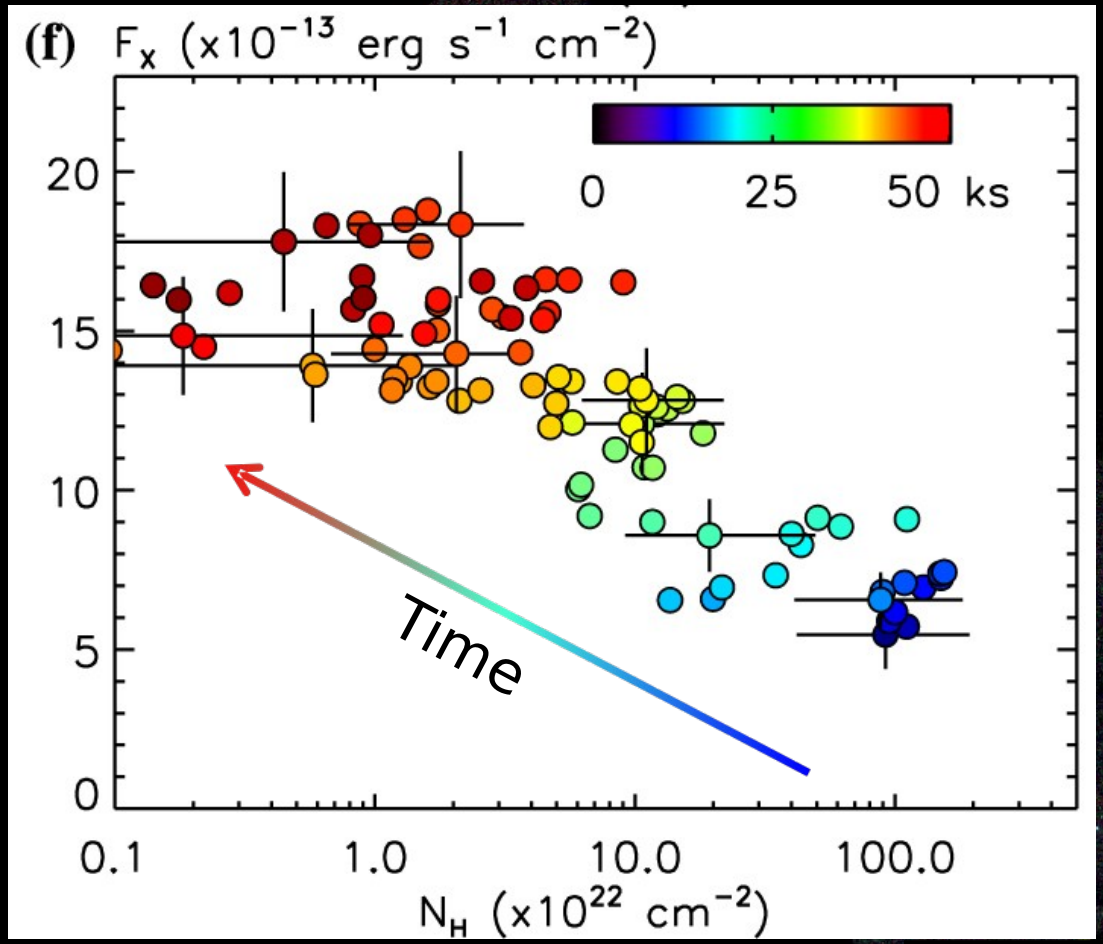
Indication for break at

3×10^{34} erg/s

consistent with accretion in a inhomogeneous environment and the onset of the propeller effect (c.f. Shtykovskiy & Gilfanov 2004).

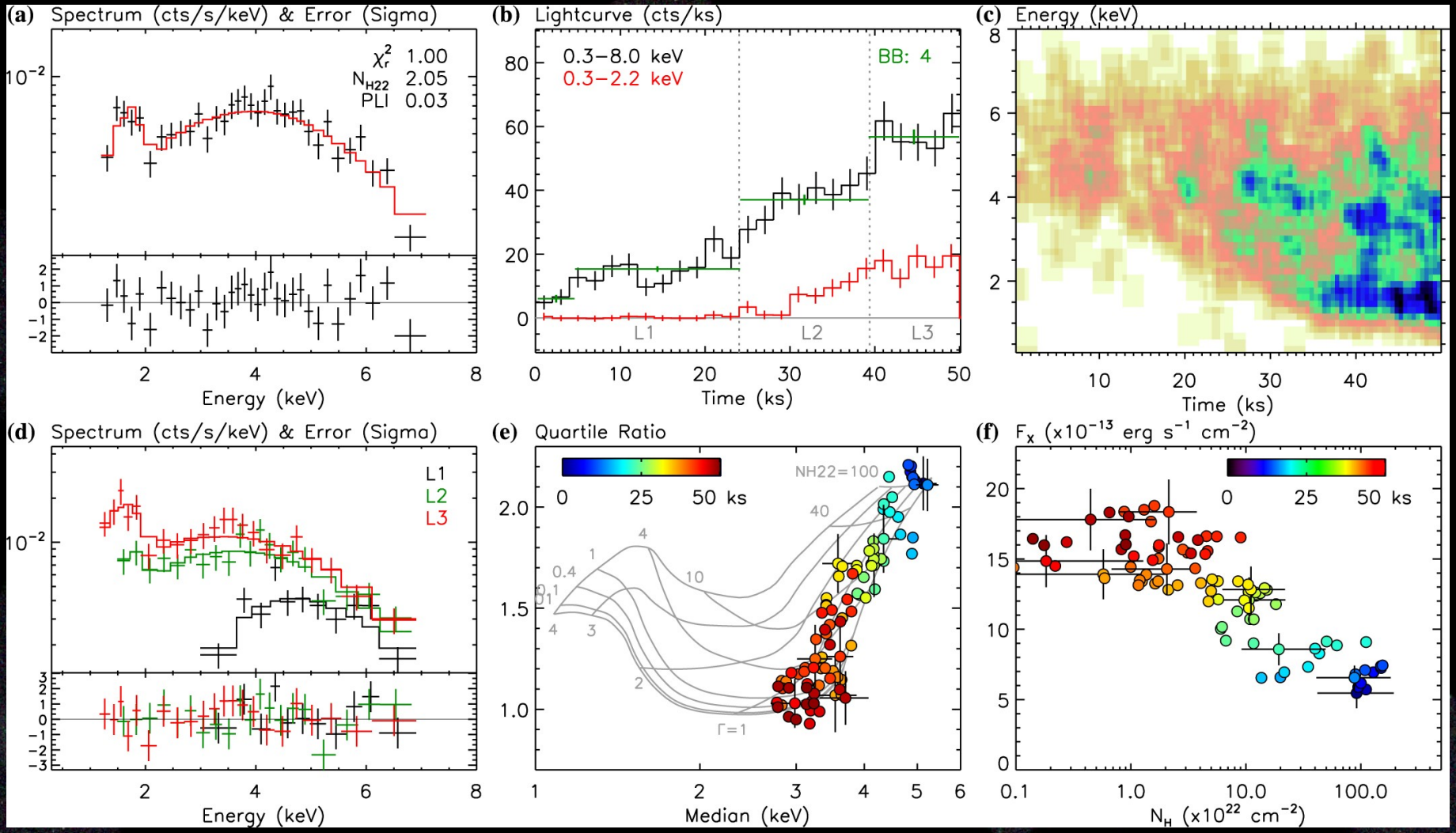


First results

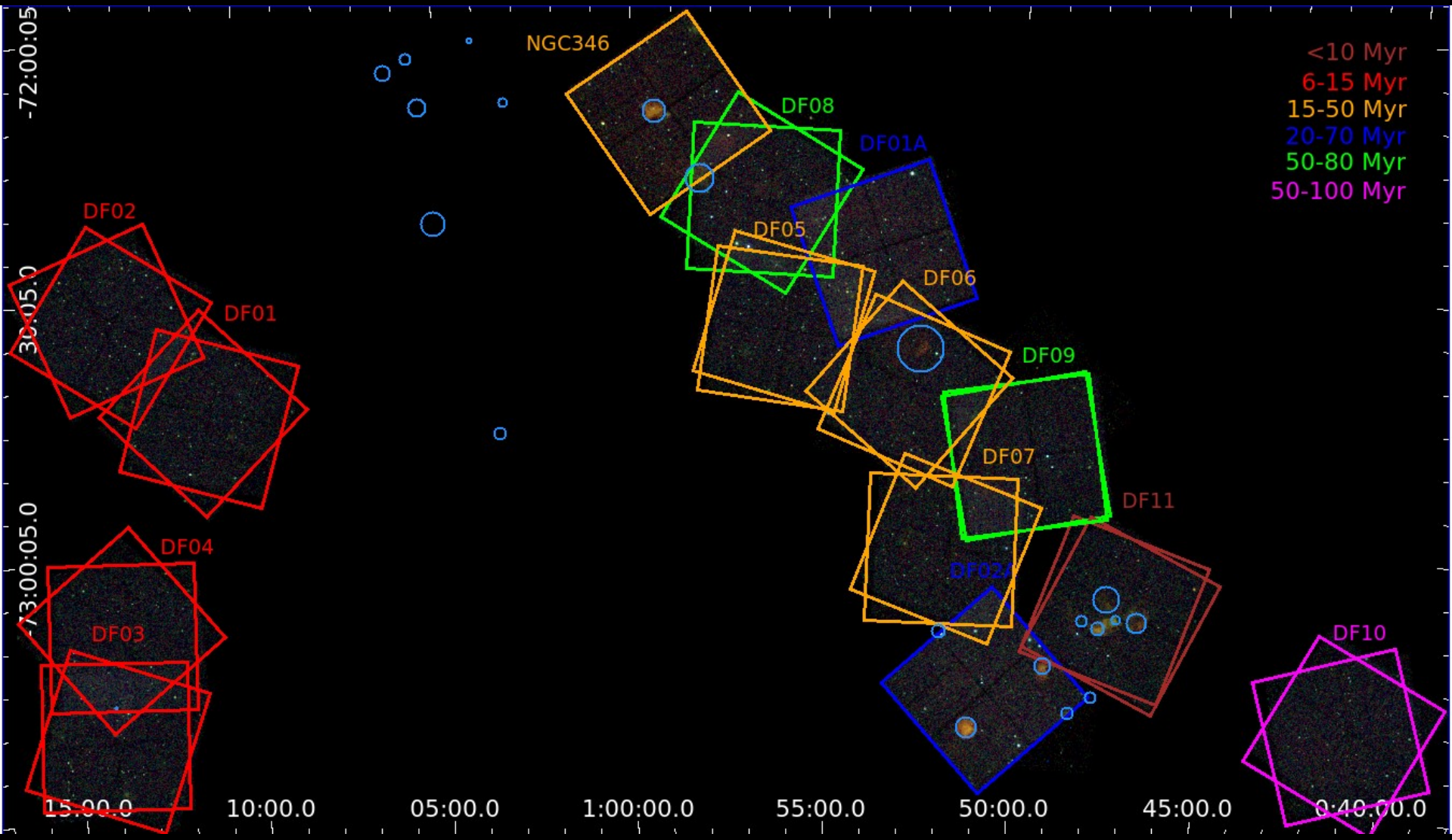


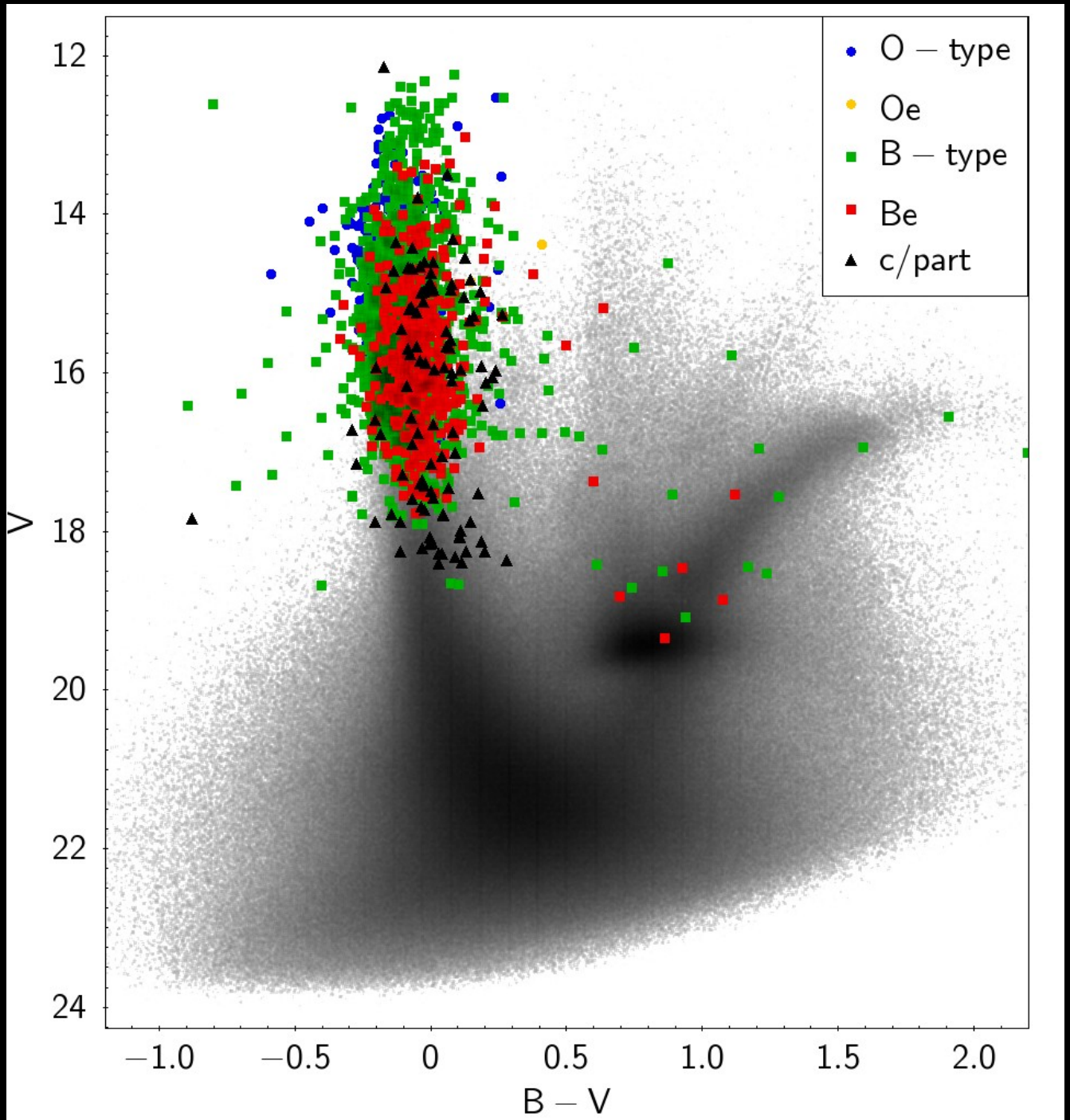
Hong et al. 2016

First results



First results




O – type
Oe
B – type
Be
c/part
V
B – V
12
14
16
18
20
22
24
−1.0
−0.5
0
0.5
1.0
1.5
2.0