Exploring X-ray binary populations as function of age and metallicity

Andreas Zezas

University of Crete, CfA

V. Antoniou, J. Hong, J. Drake, P. Plucinsky,
and the SMC XVP Team

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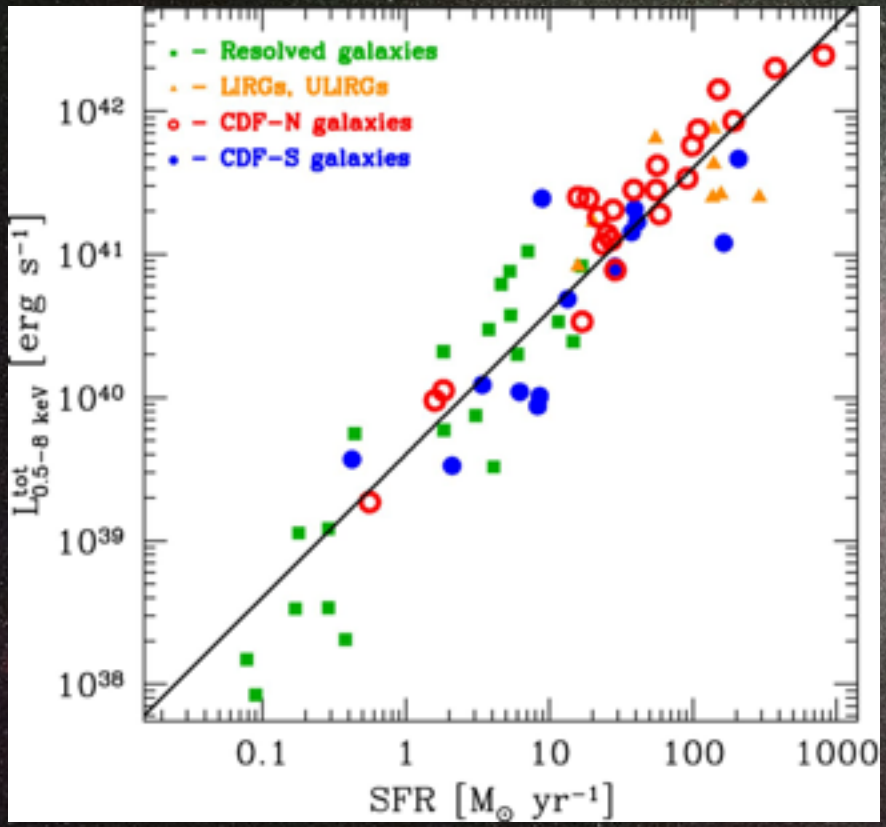
The SMC Chandra XVP Team

Vallia Antoniou (SAO)
William P. Blair (Johns Hopkins University)
Jeremy J. Drake (SAO)
Terrance Gaetz (SAO)
Frank Haberl (MPE)
JaeSub Hong (SAO)
Silas Laycock (U. Mass)
Knox S. Long (STScI)
Paul P. Plucinsky (SAO)
Manami Sasaki (Univ. Tübingen)
Ben Williams (University of Washington)
P. Frank Winkler (Middlebury College)
Nick J. Wright (Keel Univ)
Andreas Zezas (SAO / UoC)

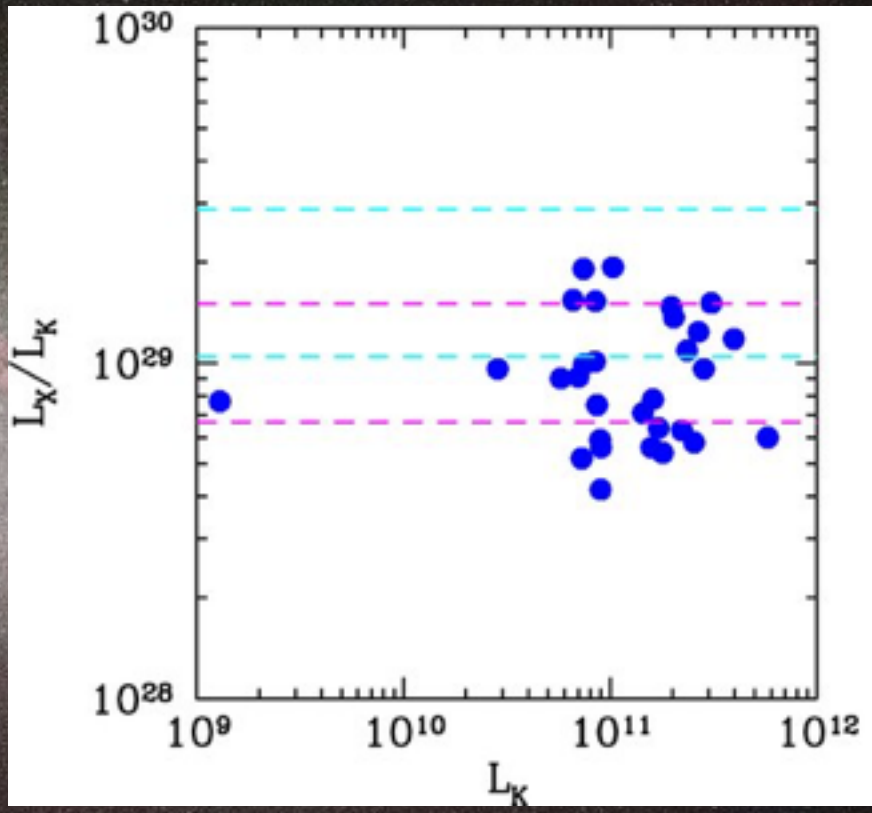
X-ray binary populations

HMXBs



Mineo et al. 2014

LMXBs



Boroson et al. 2011

X-ray binary populations

Fundamental :

- Dependence on age, Z

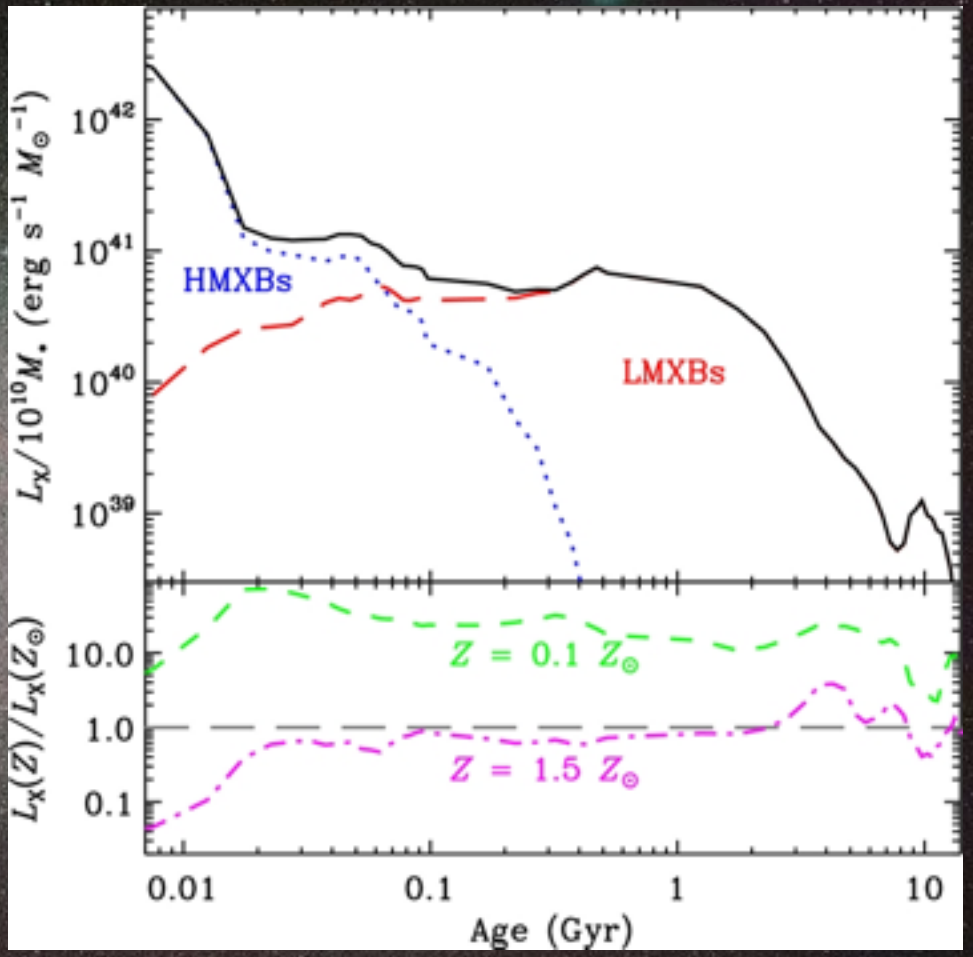
Only now start to explore

Important:

XRB formation/evolution

Modeling GW sources

XRB feedback in Cosmic Dawn



Fragos et al. 2013

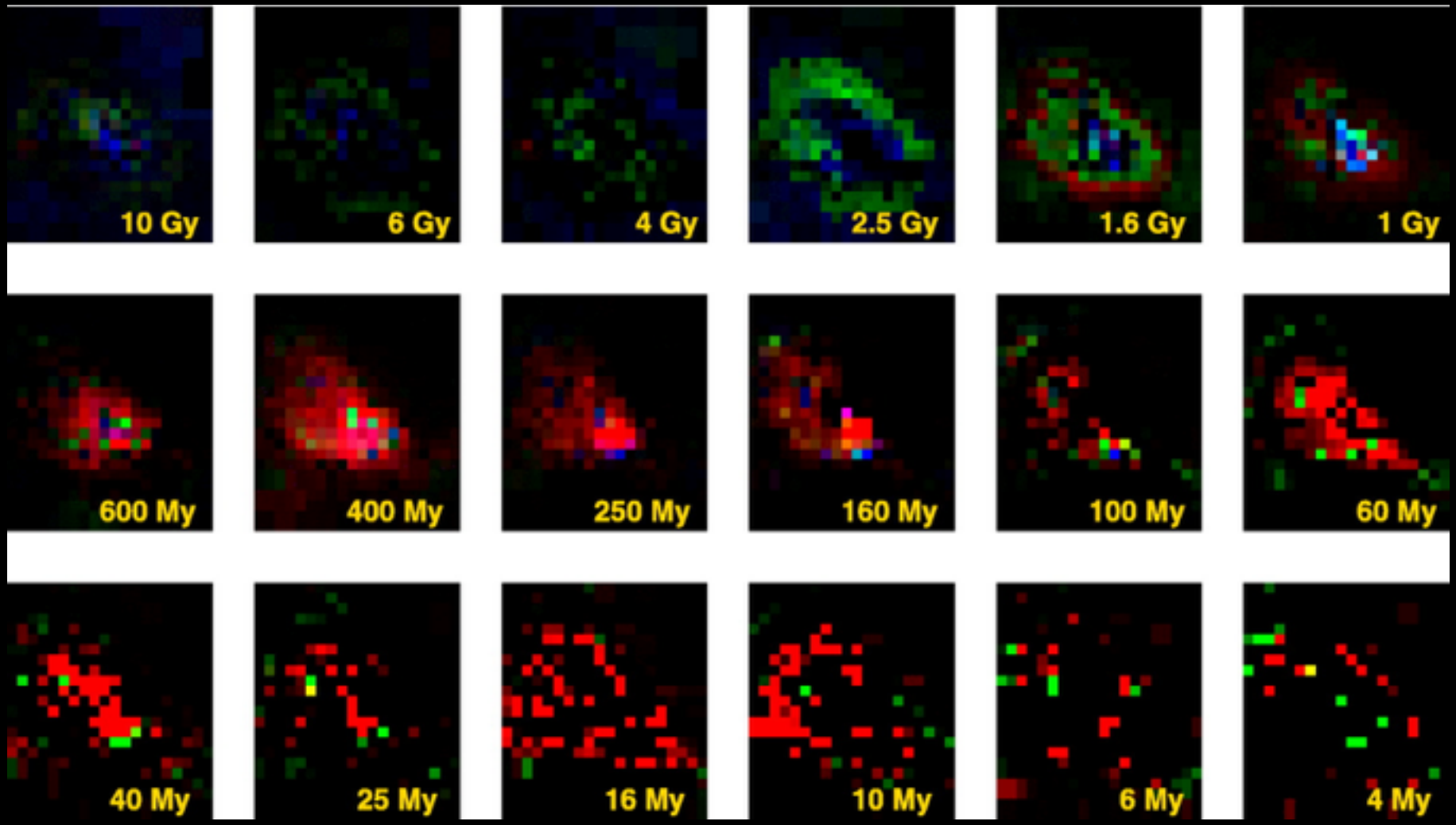
Magellanic Clouds

Nearest star-forming galaxies (50-60 kpc)

Advantages :

- Probe very faint populations (Lx ~10^{33} erg/s)
- Large populations of HMXBs
- Well determined star-formation history
  metallicity (1/5 Z◉ - 1/3 Z◉)

SMC star-formation history



0.05Z◉ 0.2Z◉ 0.4Z◉

Harris & Zaritsky, 2004

Magellanic Clouds

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Advantages :

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- Large populations of HMXBs
- Well determined star-formation history
  metallicity (1/5 Z◉ - 1/3 Z◉)

Unique laboratories for the study of HMXBs

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

The deep Chandra SMC Survey

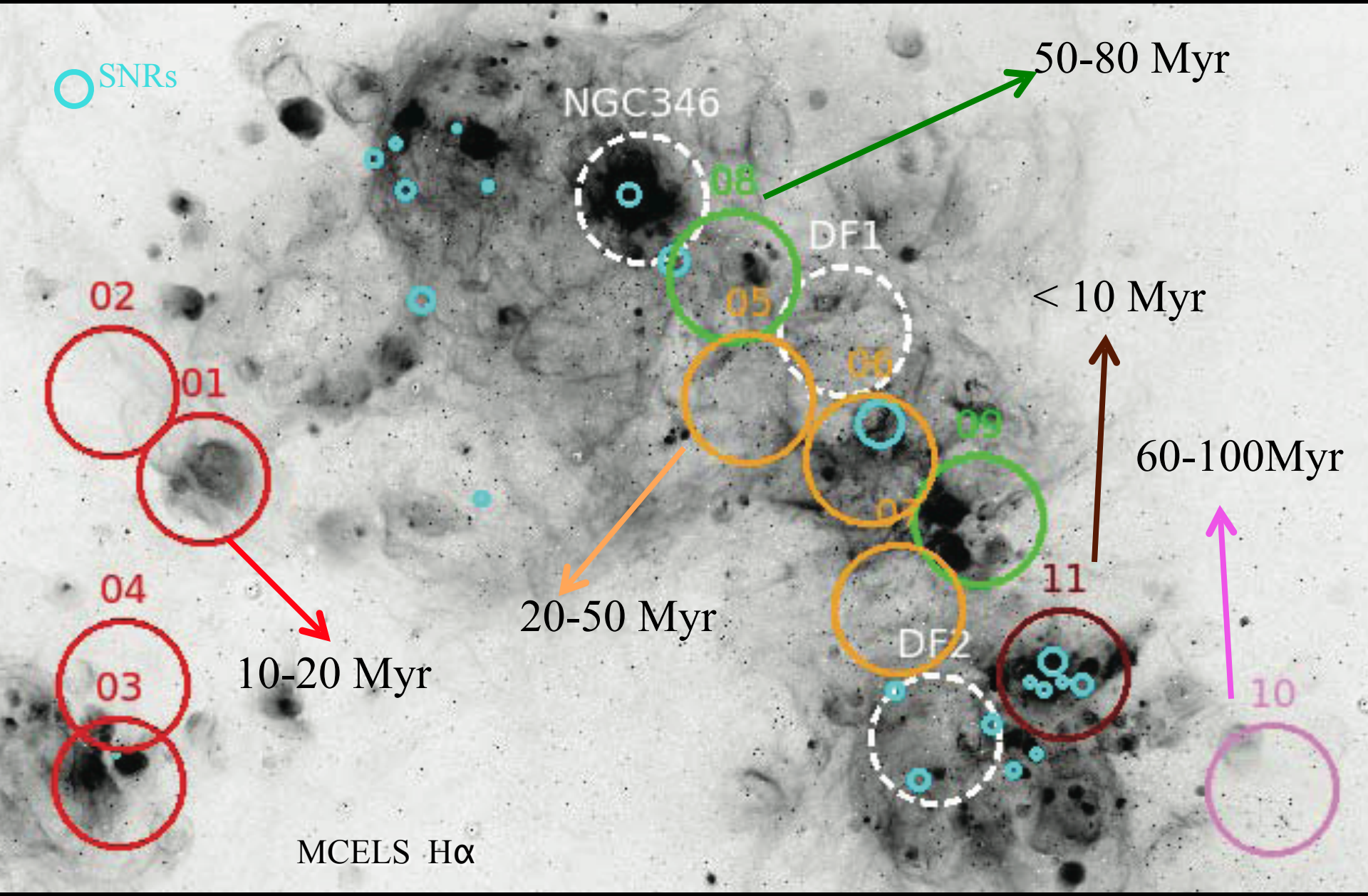
A Chandra "X-ray Visionary Program":

11 Fields in the SMC

2 x 50ksec exposures (1.1Msec total)

Goals:

- A deep census of accreting pulsars
- HMXB formation efficiency at different ages
- Long-term variability of accreting pulsars
- Detailed studies of SNRs
- Stars at low metallicity


SNRs
NGC346
08
DF1
05
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DF2
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50-80 Myr
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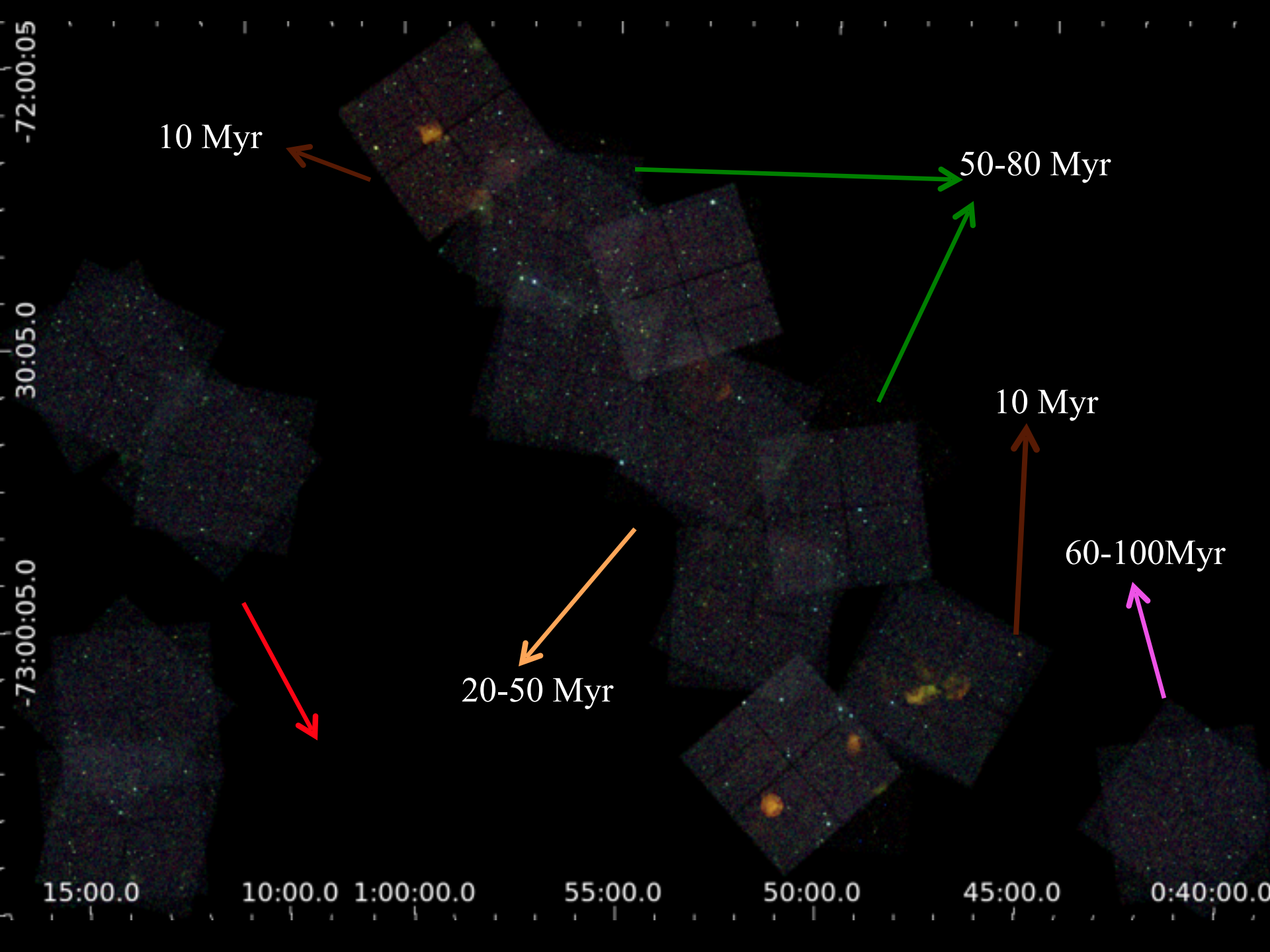
60-100Myr
20-50 Myr
10-20 Myr
MCELS Hα


10 Myr
50-80 Myr
10 Myr
60-100Myr
20-50 Myr
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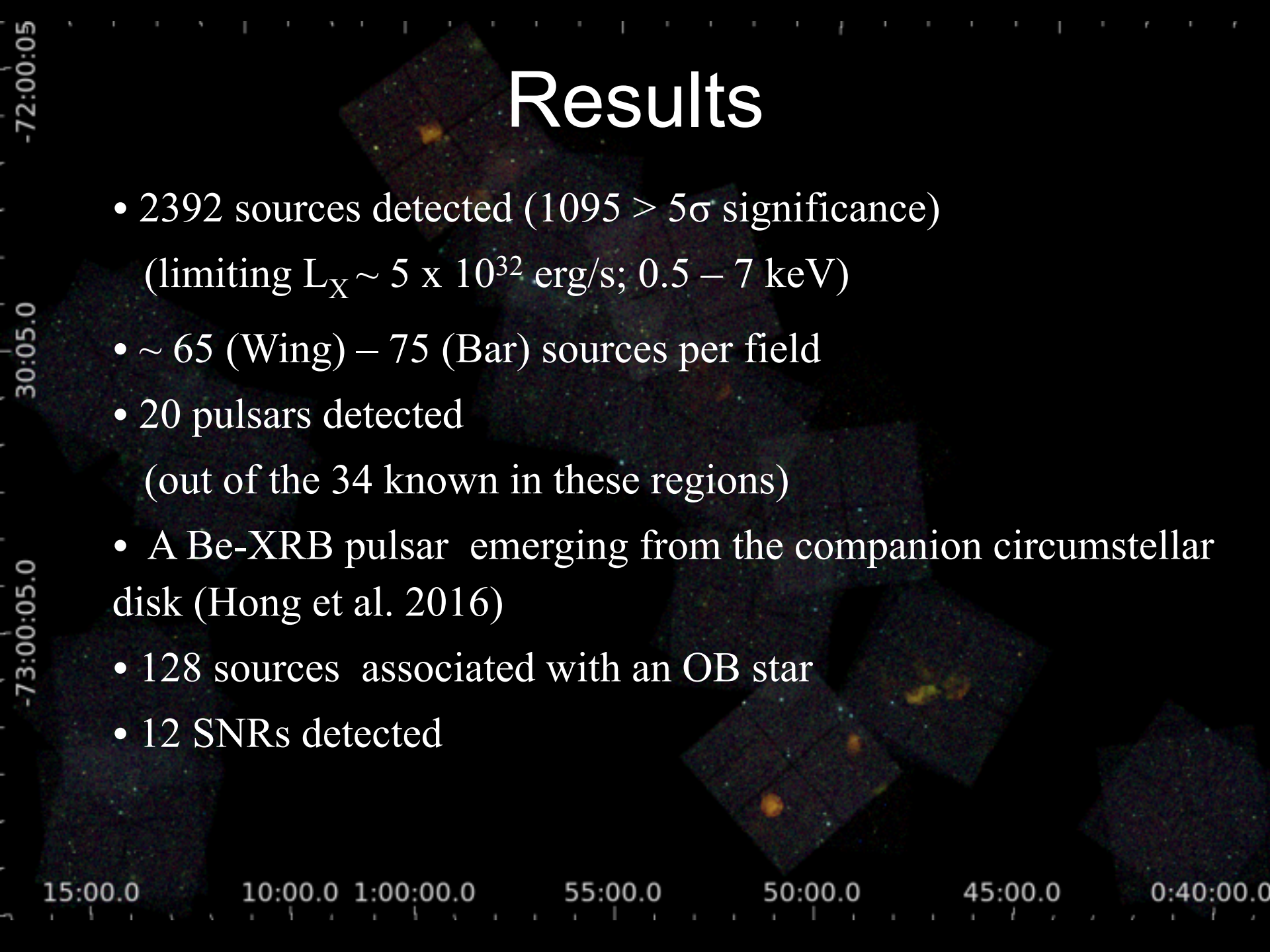
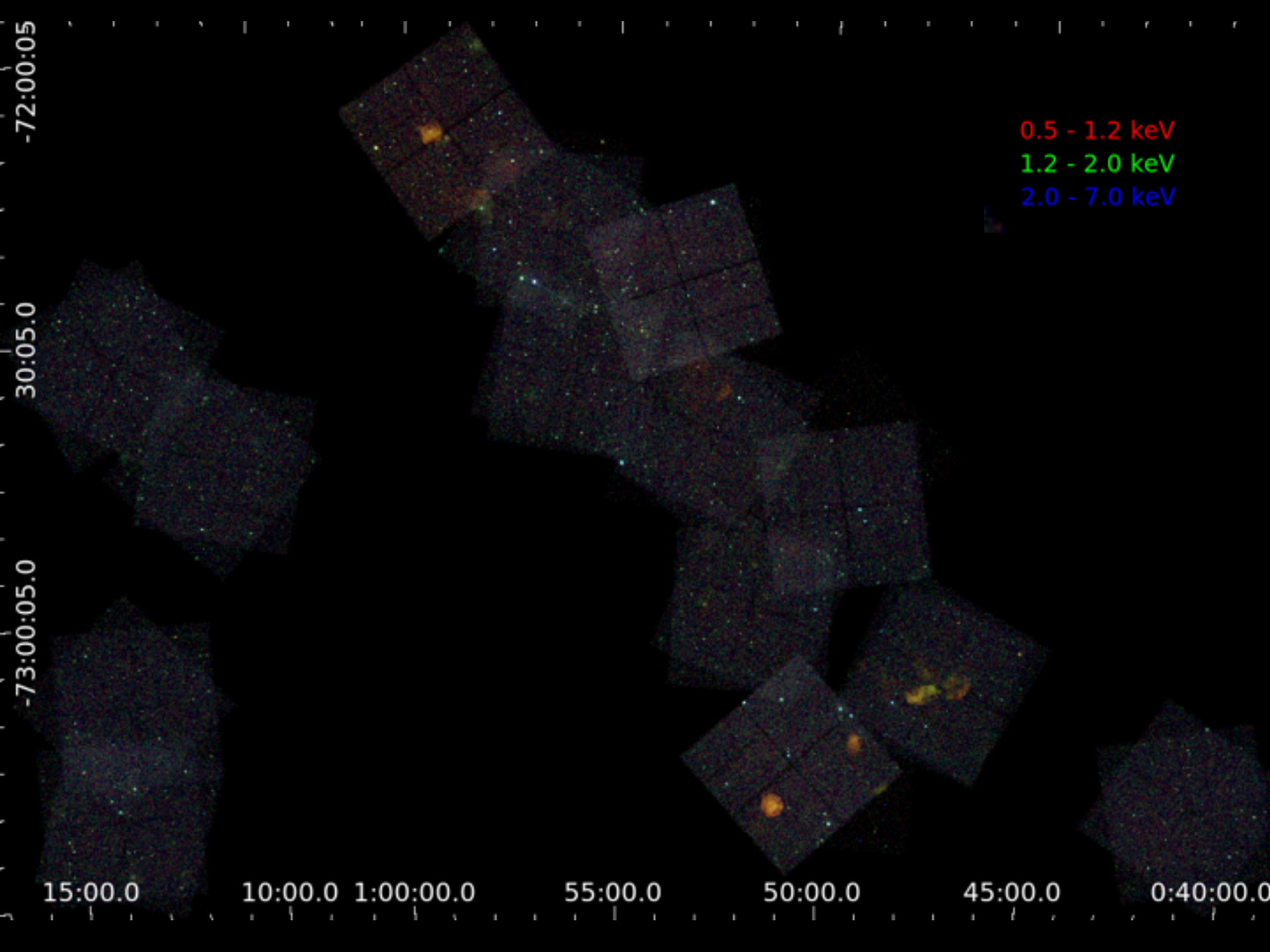
Results

- 2392 sources detected (1095 > 5σ significance)
  (limiting $L_X \sim 5 \times 10^{32}$ erg/s; 0.5 – 7 keV)
- ~ 65 (Wing) – 75 (Bar) sources per field
- 20 pulsars detected
  (out of the 34 known in these regions)
- A Be-XRB pulsar emerging from the companion circumstellar disk (Hong et al. 2016)
- 128 sources associated with an OB star
- 12 SNRs detected




0.5 - 1.2 keV
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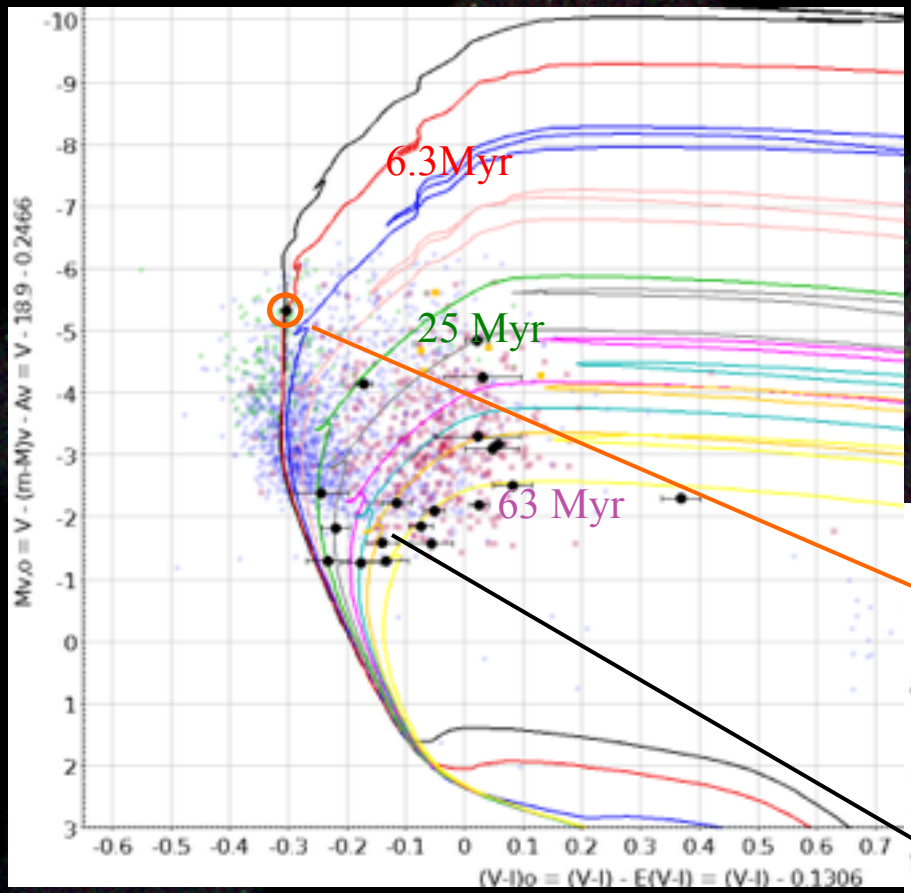
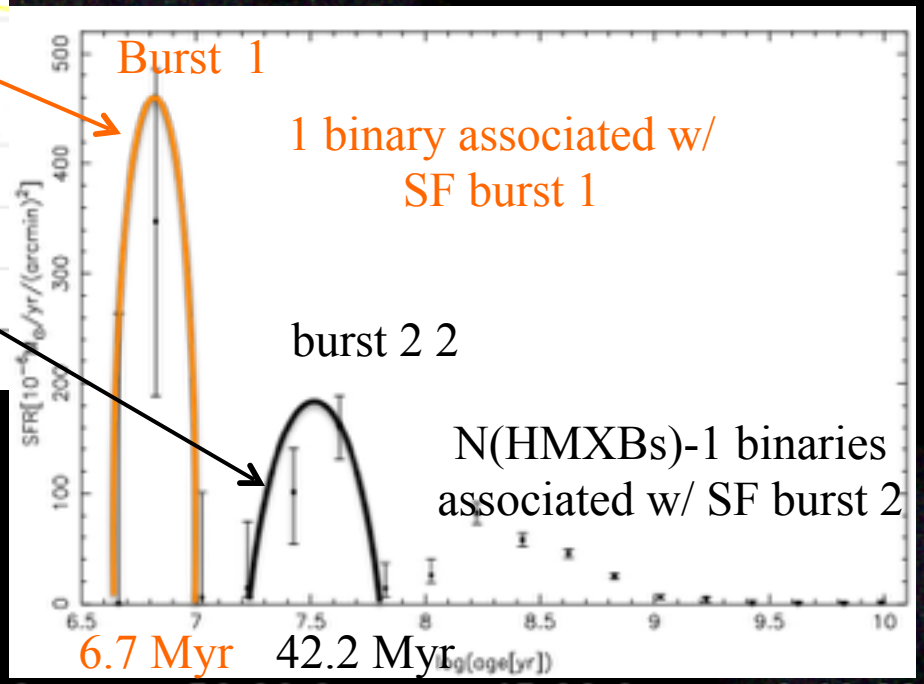
HMXB classification





Antoniou et al, in prep.

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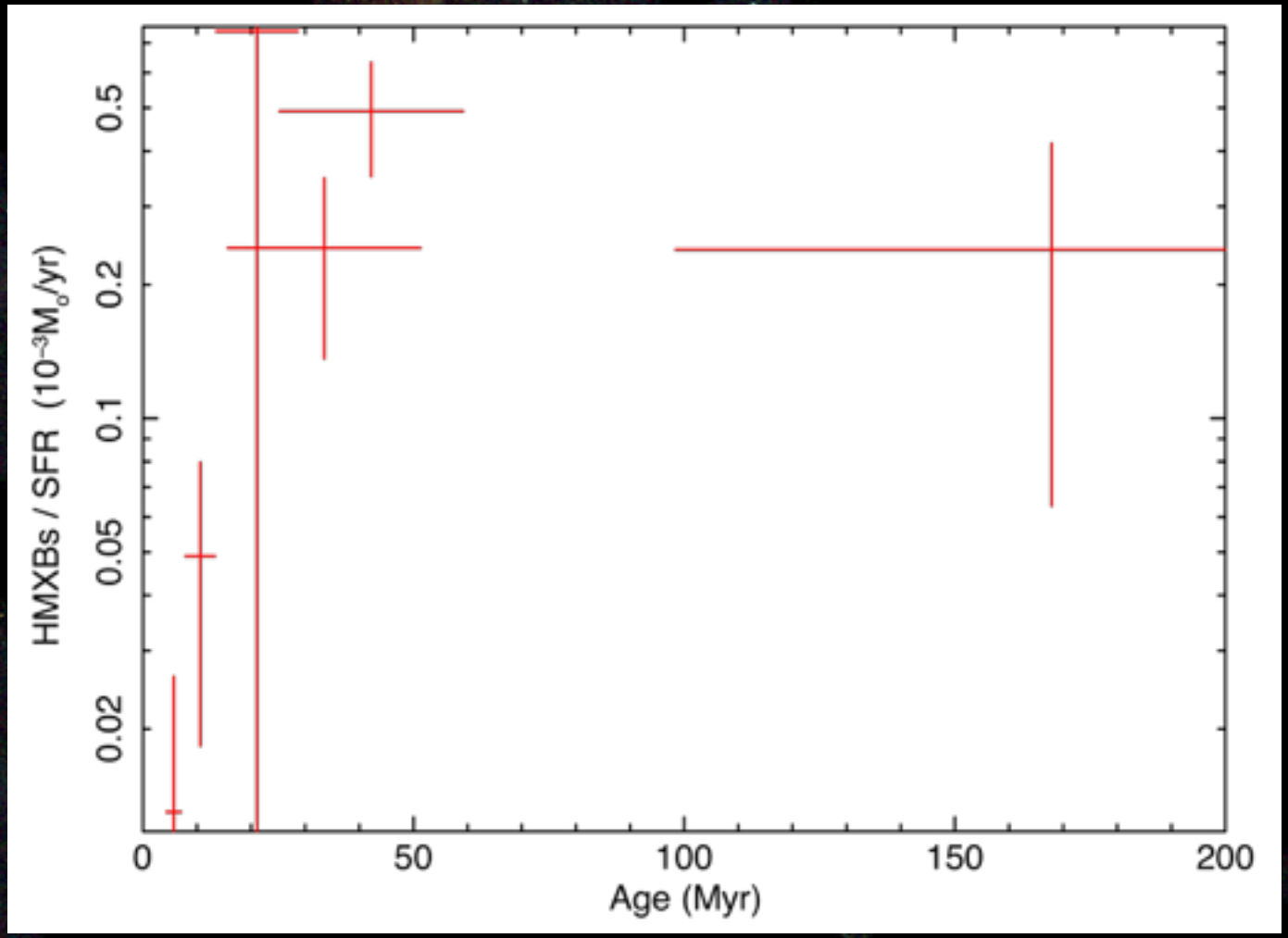
Highlight: HMXB formation efficiency



Antoniou et al, in prep.

Looking ahead: The LMC

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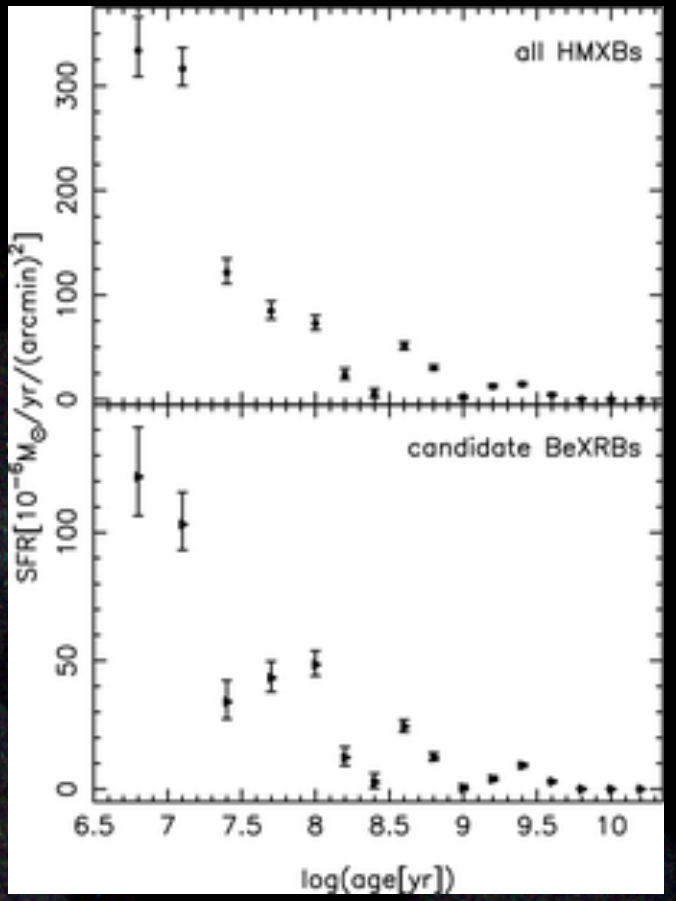
lo

•Metal



Antoniou & Zezas 2016

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Looking ahead: The LMC

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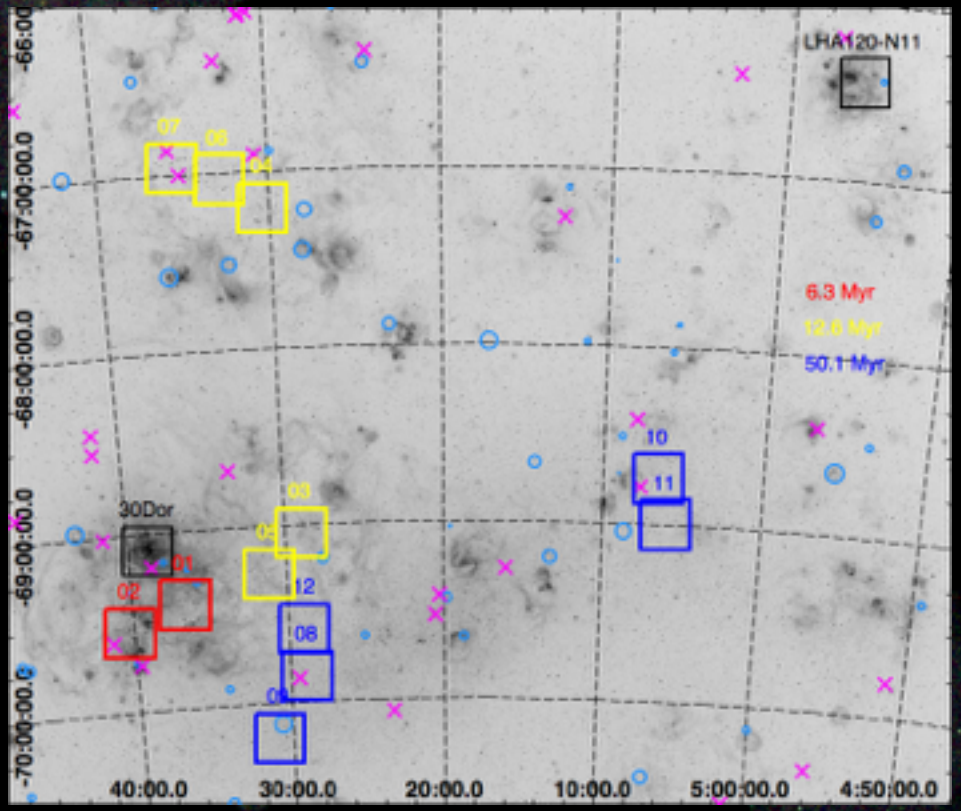

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Looking ahead: Other galaxies

Goal:

mplete picture of

Need:

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-
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Looking further ahead: X-ray Surveyor

Critical:

- Spatial reso
  - Source c
  - Multi-λ

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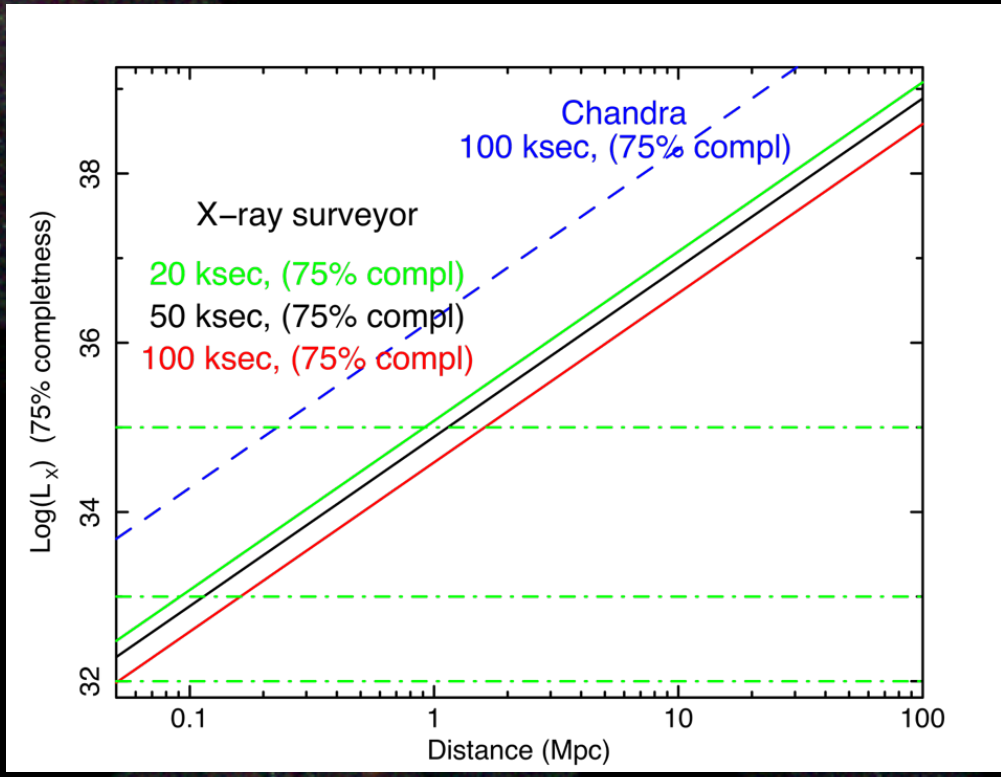

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Chandra
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Compa
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Ex
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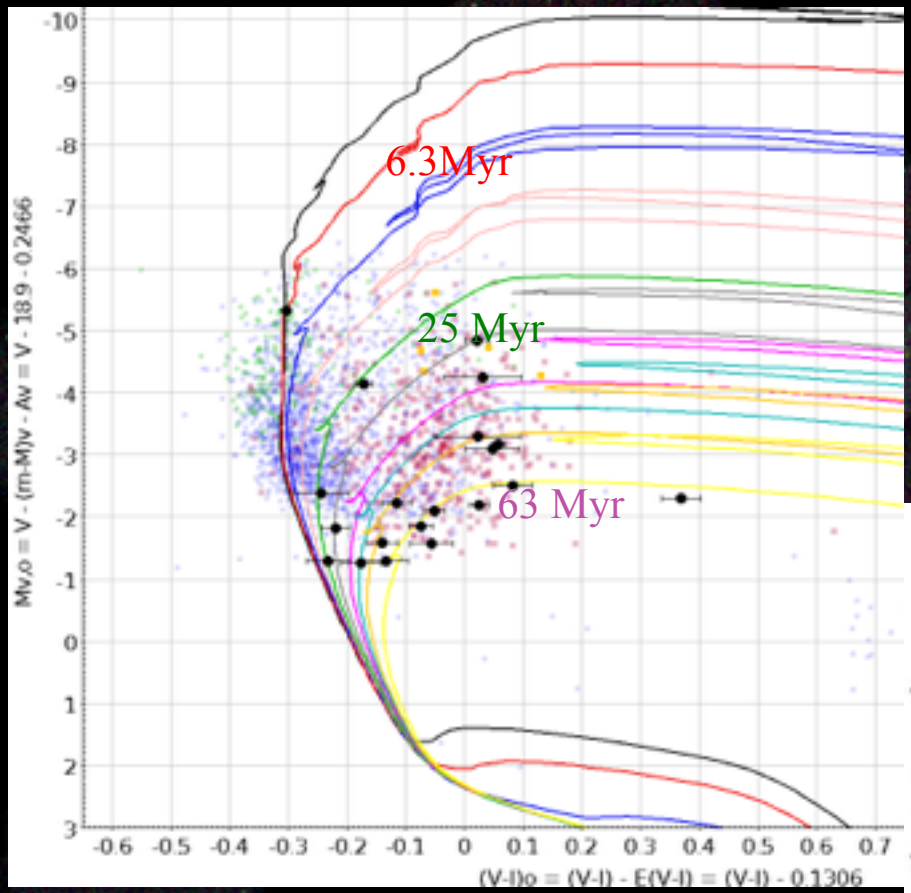
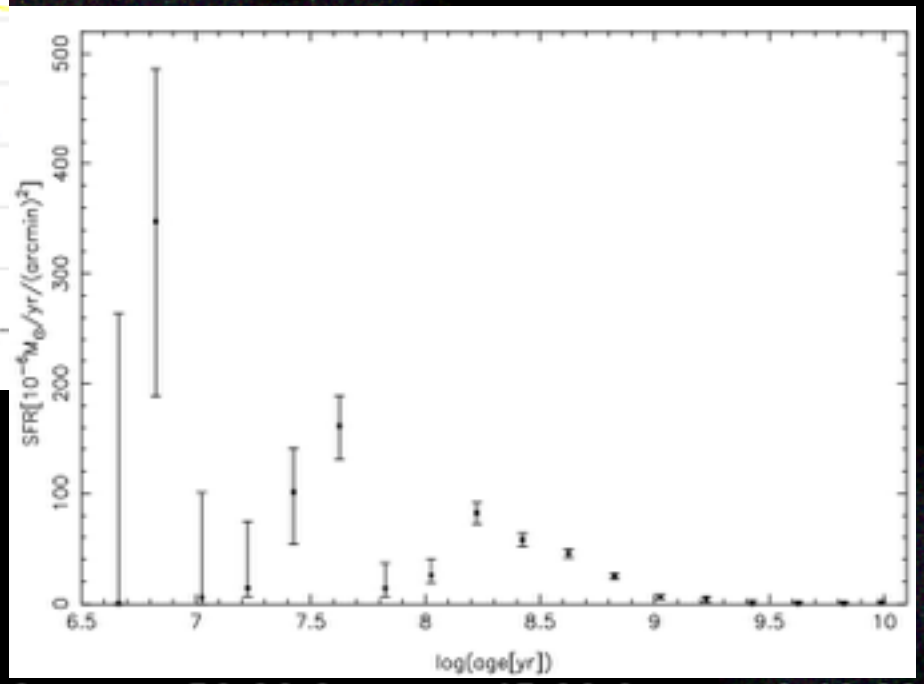
Be

HMXB classification

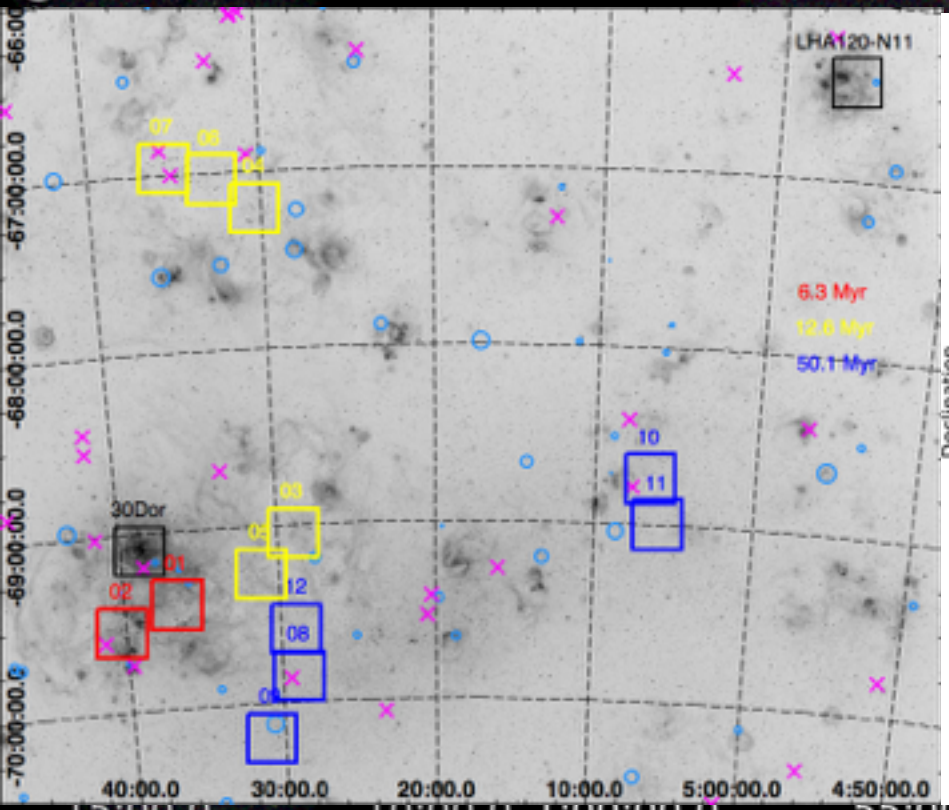


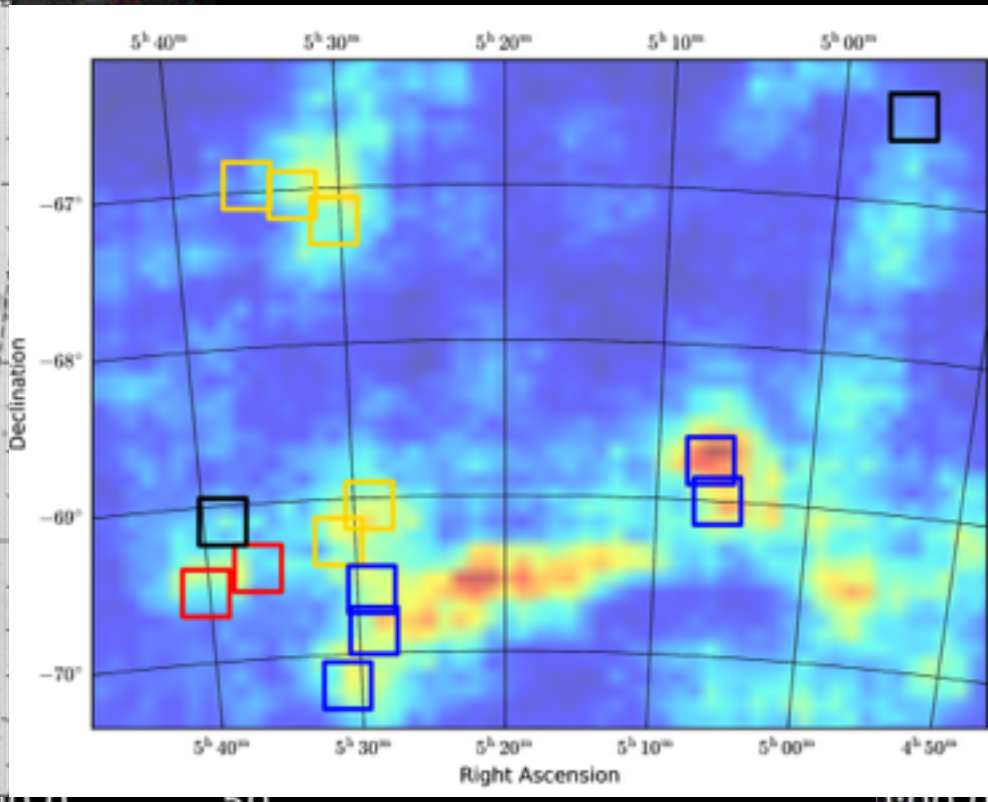


Looking ahead: The LMC

servations of reg

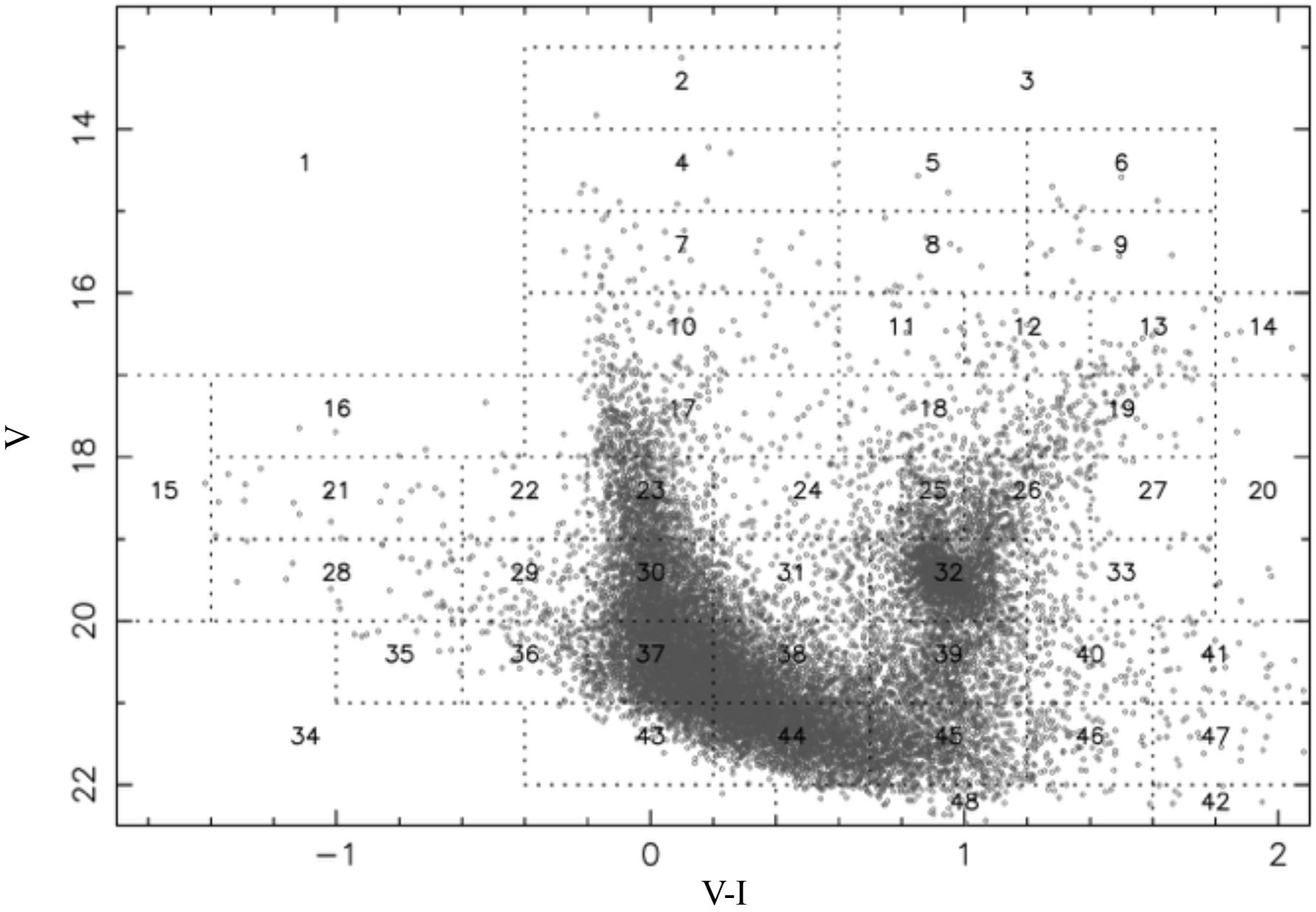
sim MC



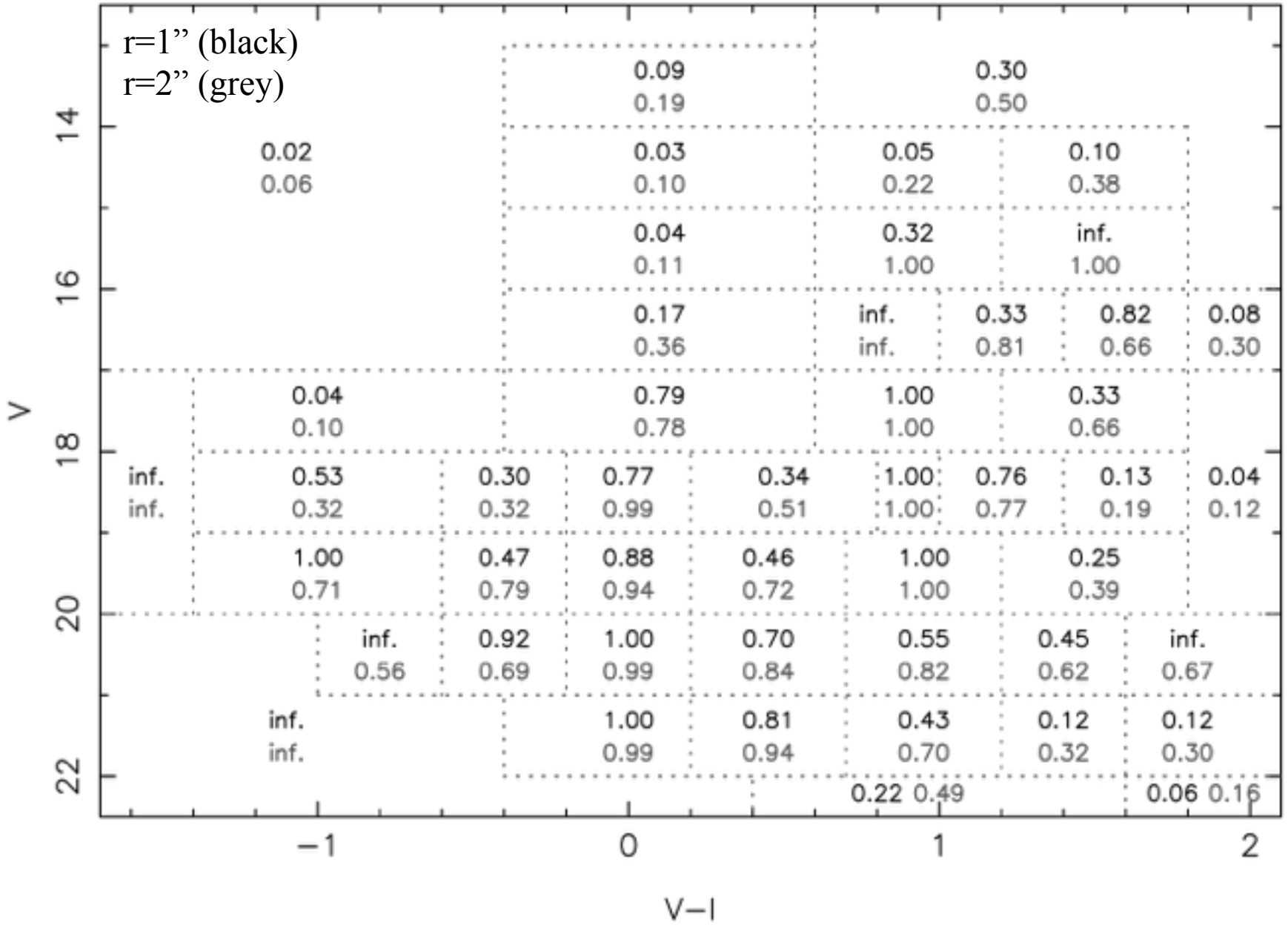


Andrews et al, in prep.

Chance coincidence



Chance coincidence



The deep Chandra SMC Survey

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11 Fields

2 x 50ksec exposures (1.1Msec total)

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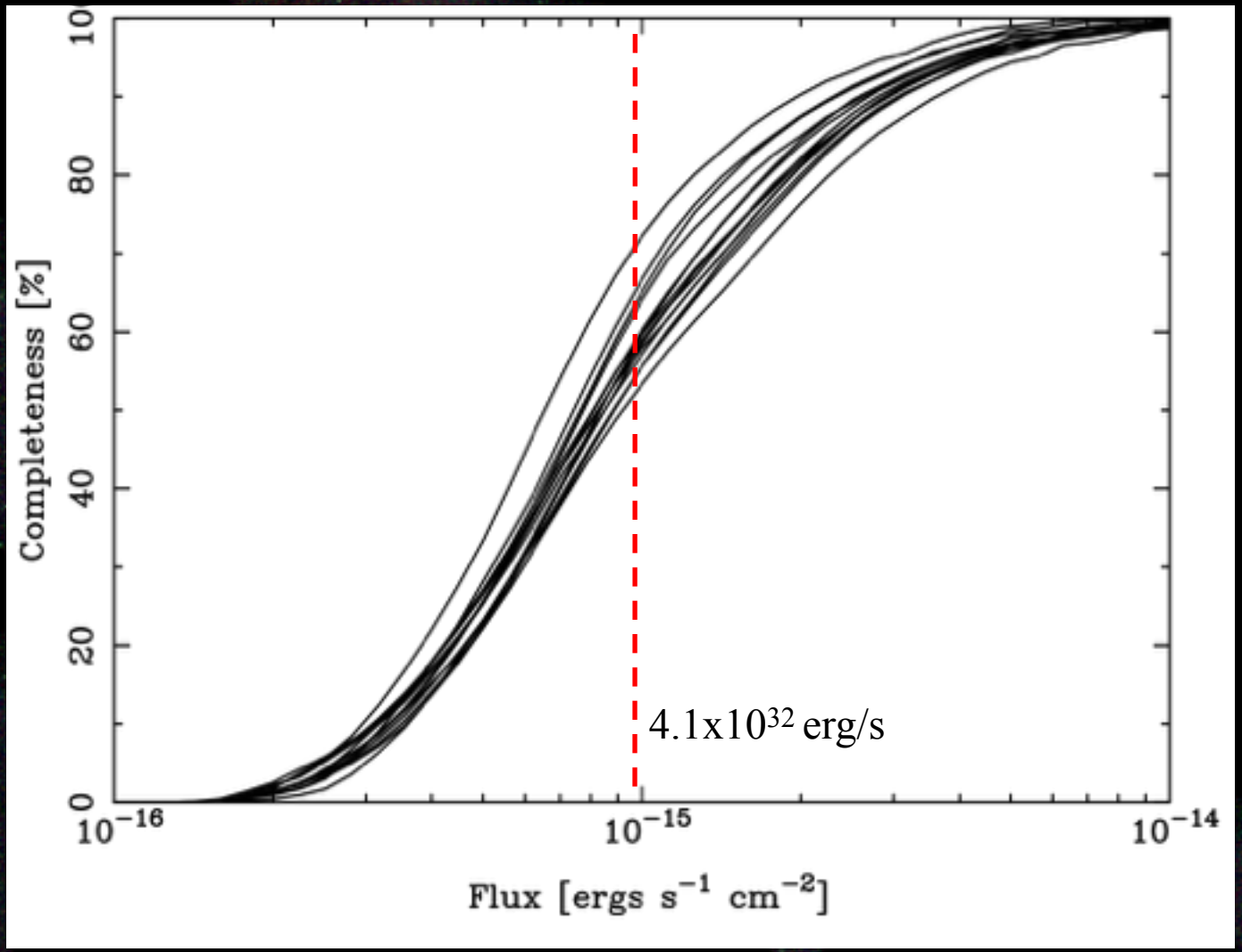
- HMXB formation efficiency at different ages
- Long-term variability of accreting pulsars
- Detailed studies of SNRs
- Stars at low metallicity

Survey sensitivity



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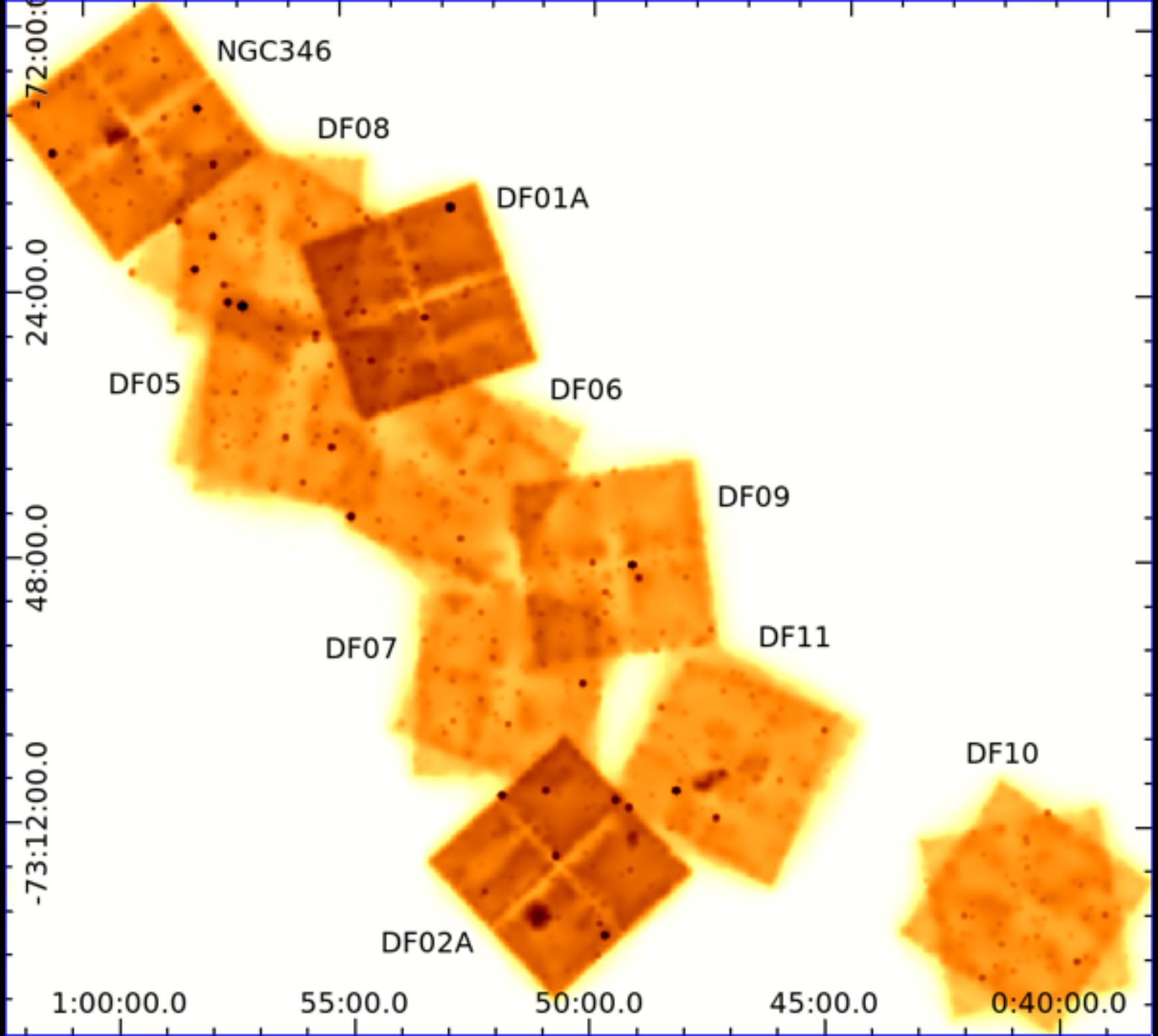
NGC346
DF08
DF01A
DF05
DF06
DF09
DF07
DF11
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DF02A
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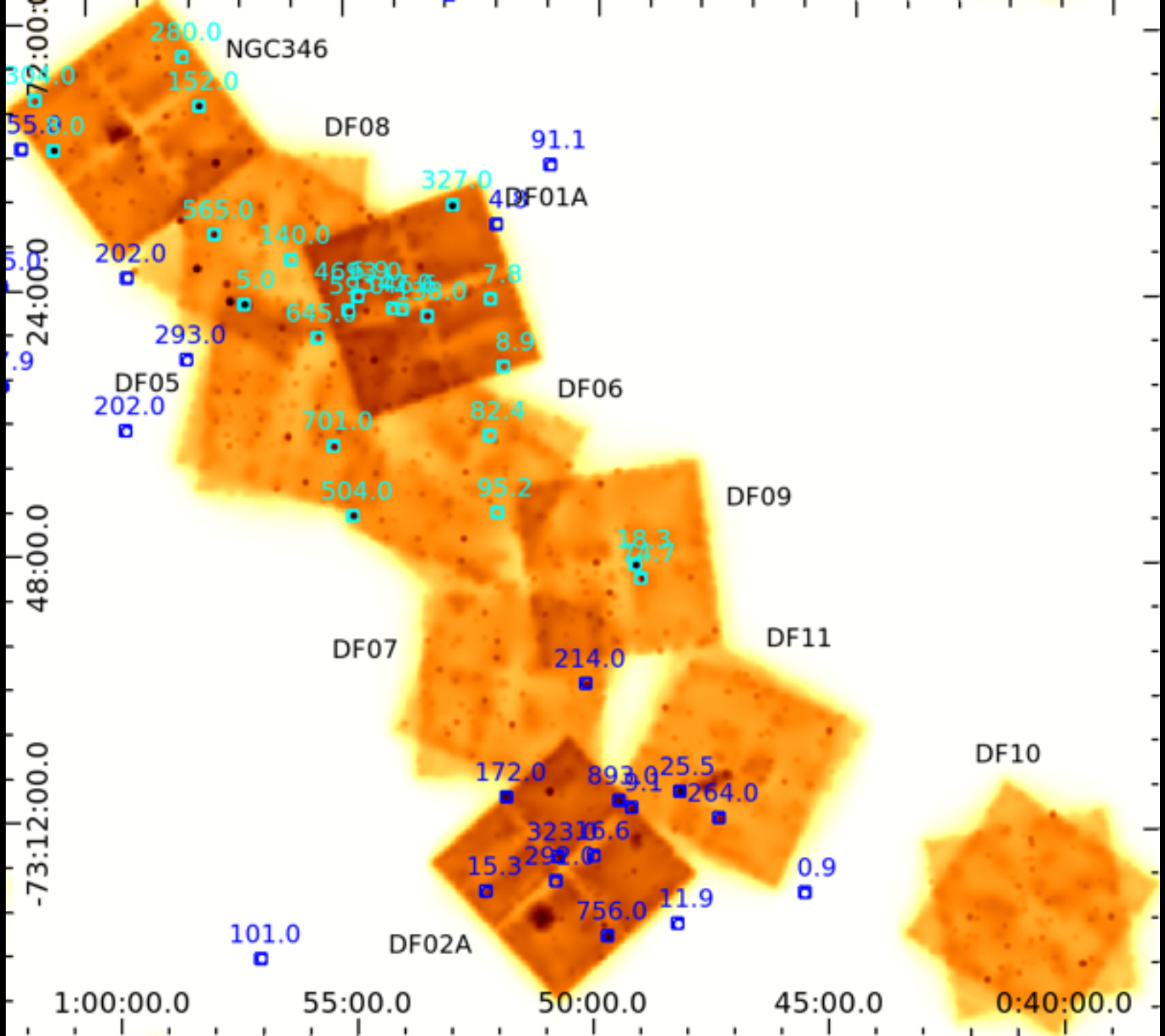
NGC346
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DF05
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DF02A
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202.0
5.0
645.0
293.0
7.8
8.9
202.0
701.0
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214.0
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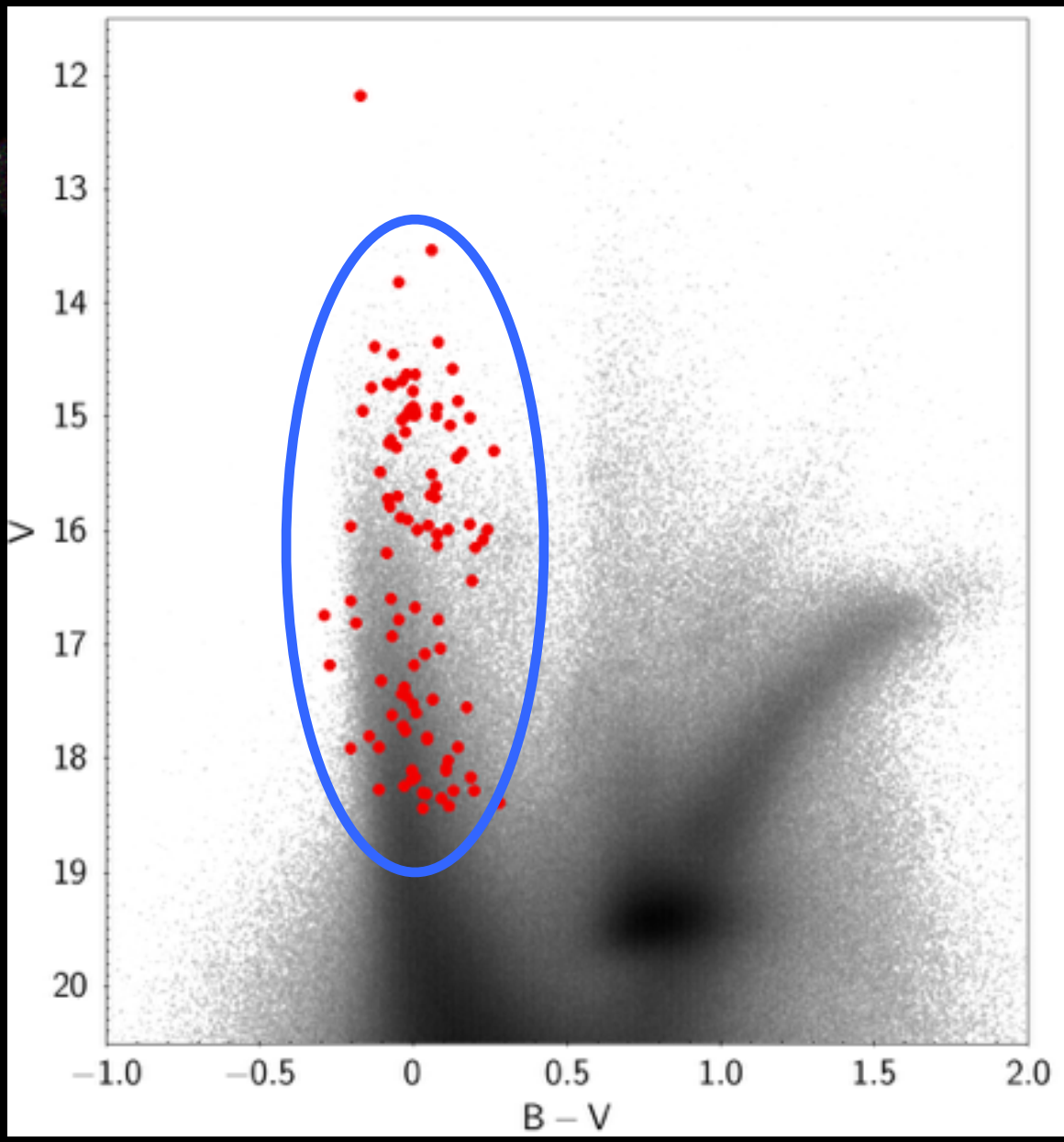
12
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−0.5
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B − V

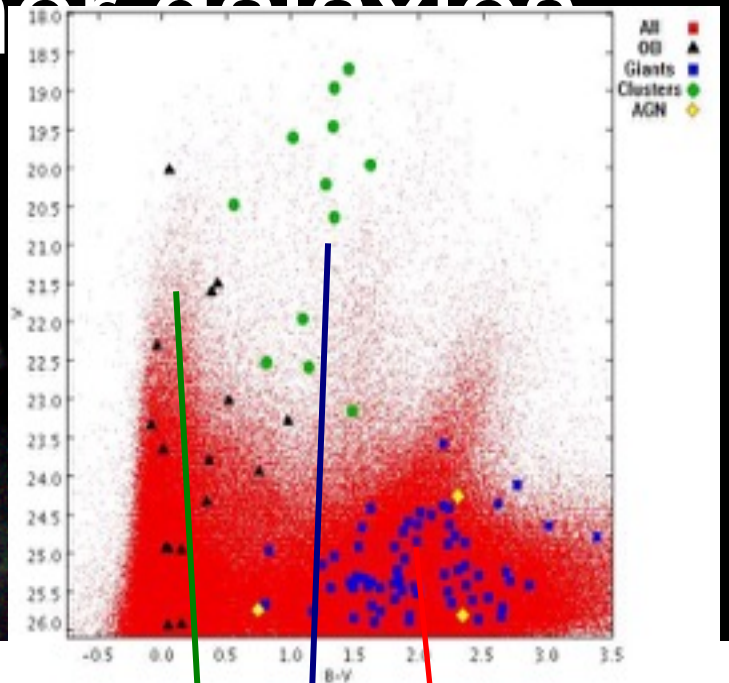
Looking ahead: Other galaxies

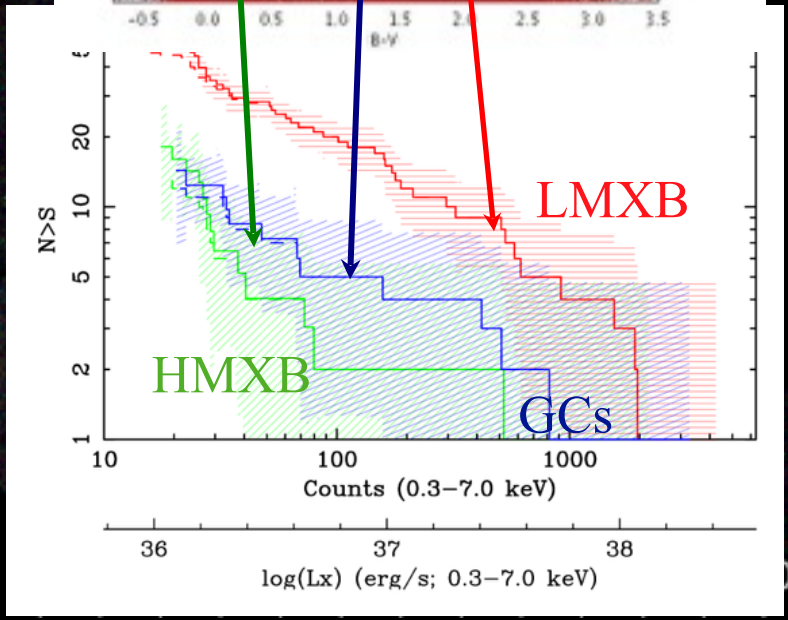
Goal:

plete picture of
n/evolution

Need:

- Cover tallicity
  space
  D
-





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Indicatio

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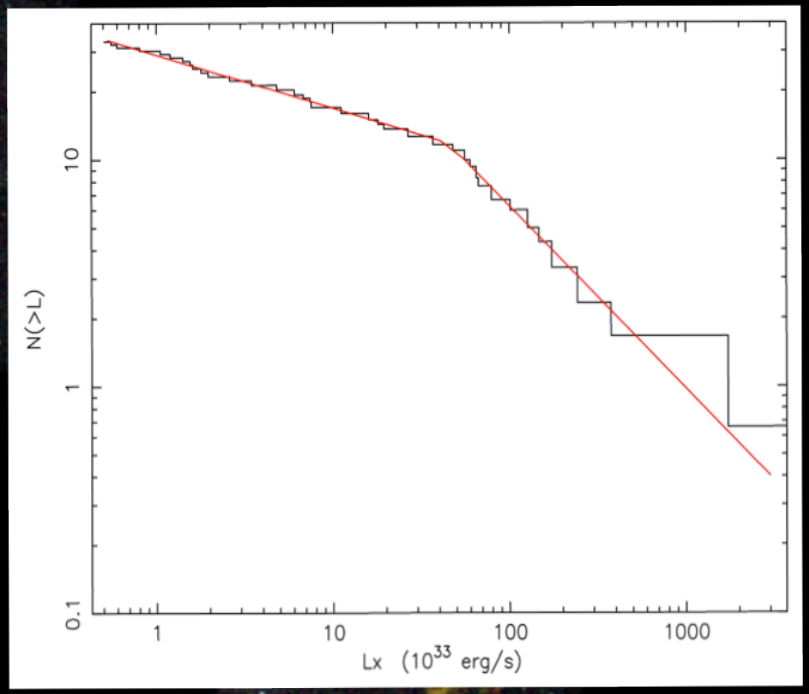
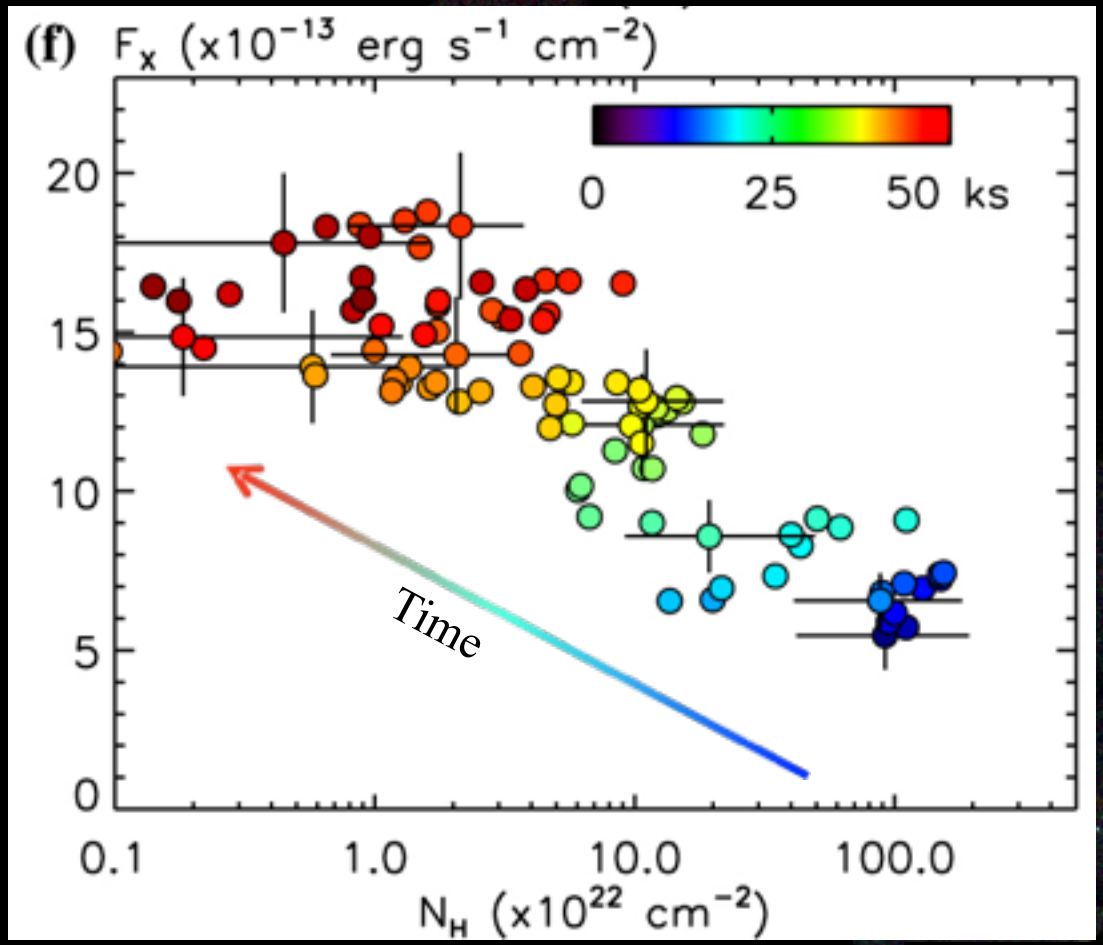
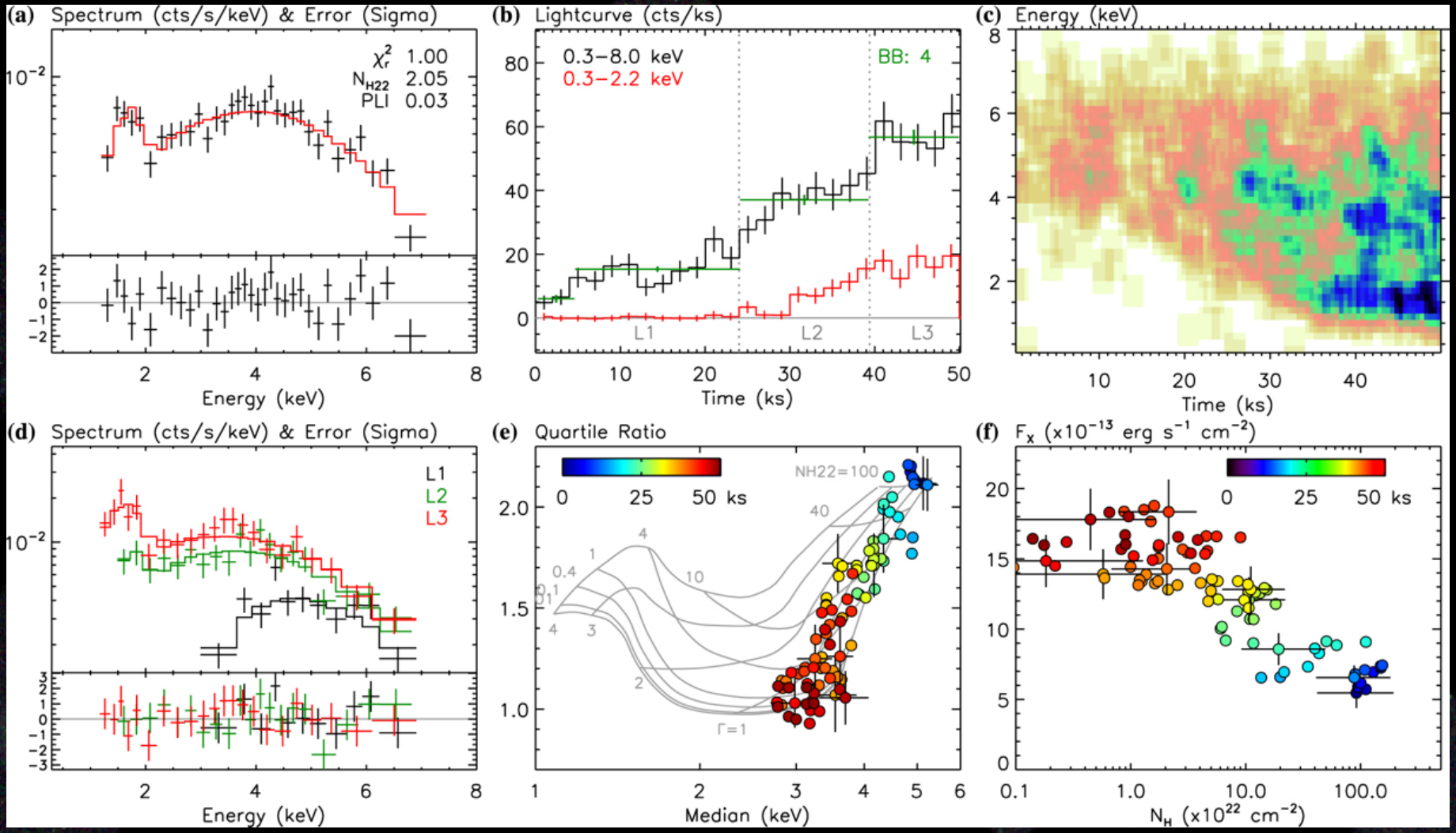
Shtyk

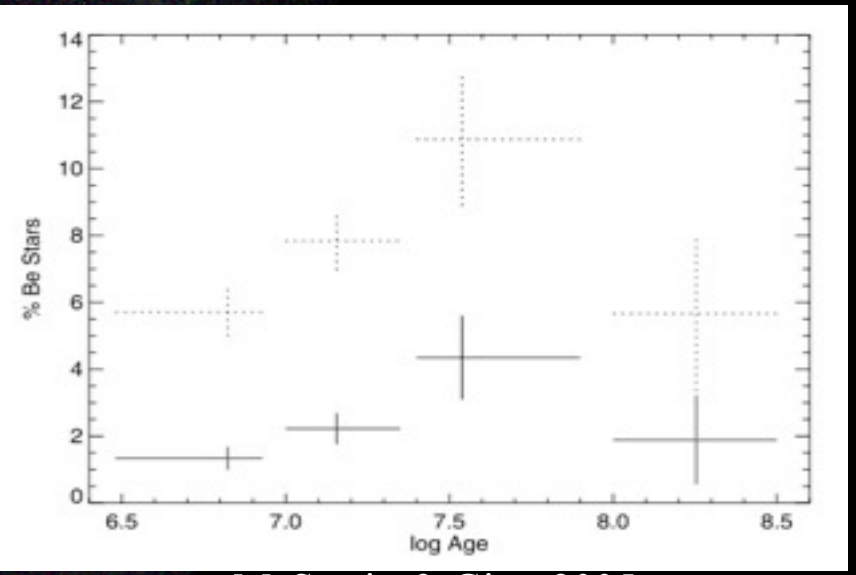


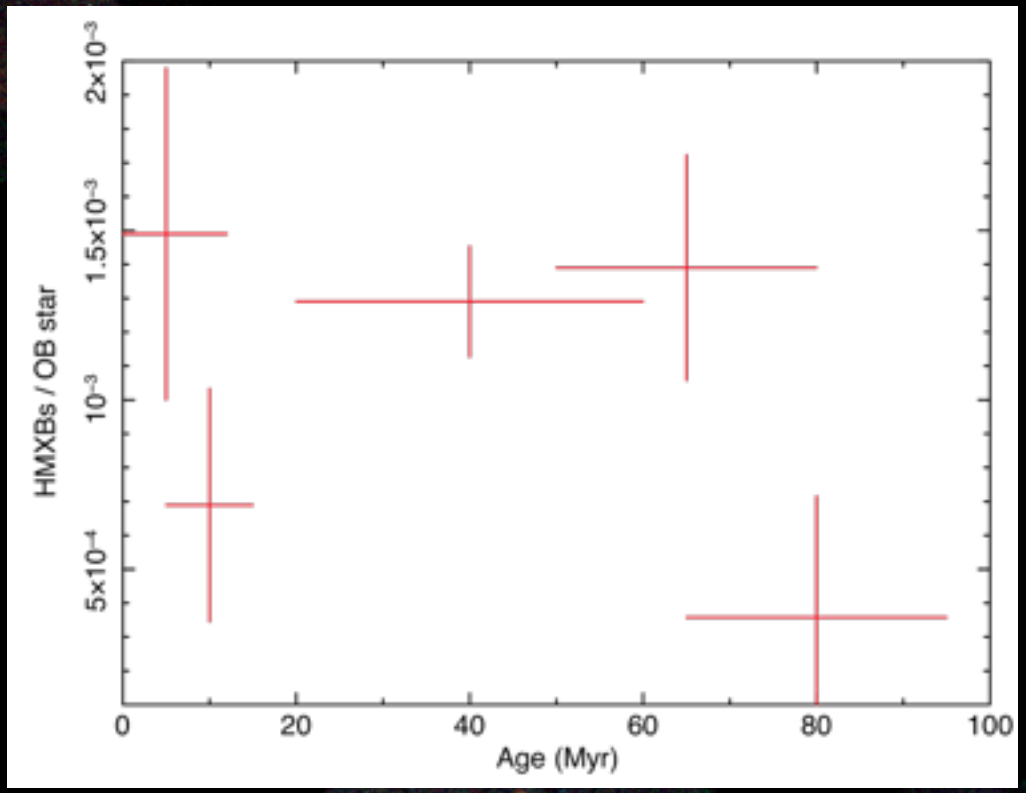


Hong et al. 2016


(a) Spectrum (cts/s/keV) & Error (Sigma)
χ^2_r 1.00
N_{H22} 2.05
PLI 0.03
Energy (keV)
(b) Lightcurve (cts/ks)
0.3–8.0 keV
0.3–2.2 keV
BB: 4
L1
L2
L3
Time (ks)
(c) Energy (keV)
Time (ks)
(d) Spectrum (cts/s/keV) & Error (Sigma)
L1
L2
L3
Energy (keV)
(e) Quartile Ratio
0 25 50 ks
NH22=100
40
10
4
1
0.4
0.1
3
2
Γ=1
Median (keV)
(f) F_x ($\times 10^{-13}$ erg s^{-1} cm^{-2})
0 25 50 ks
N_H ($\times 10^{22}$ cm^{-2})

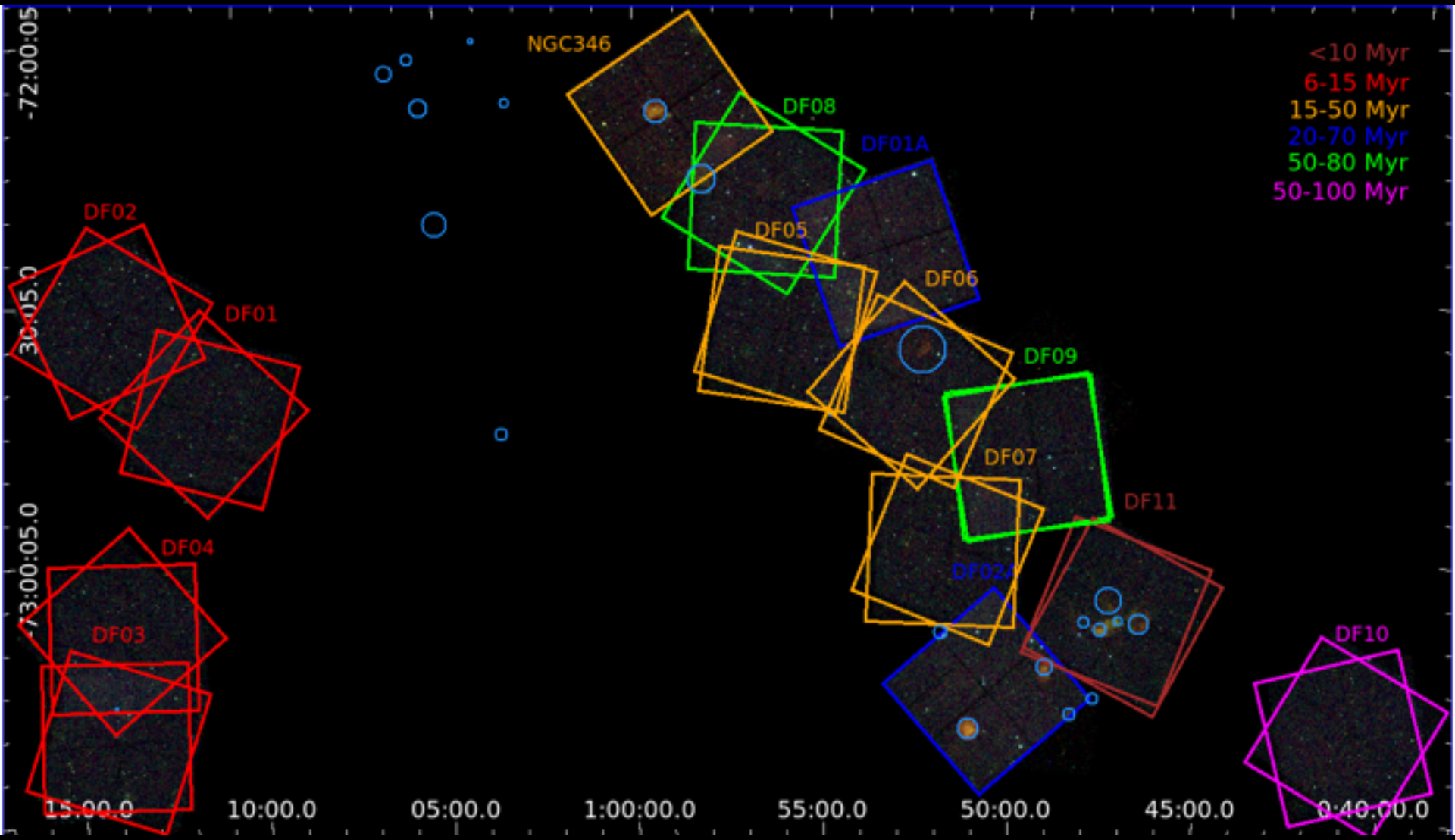
ncy

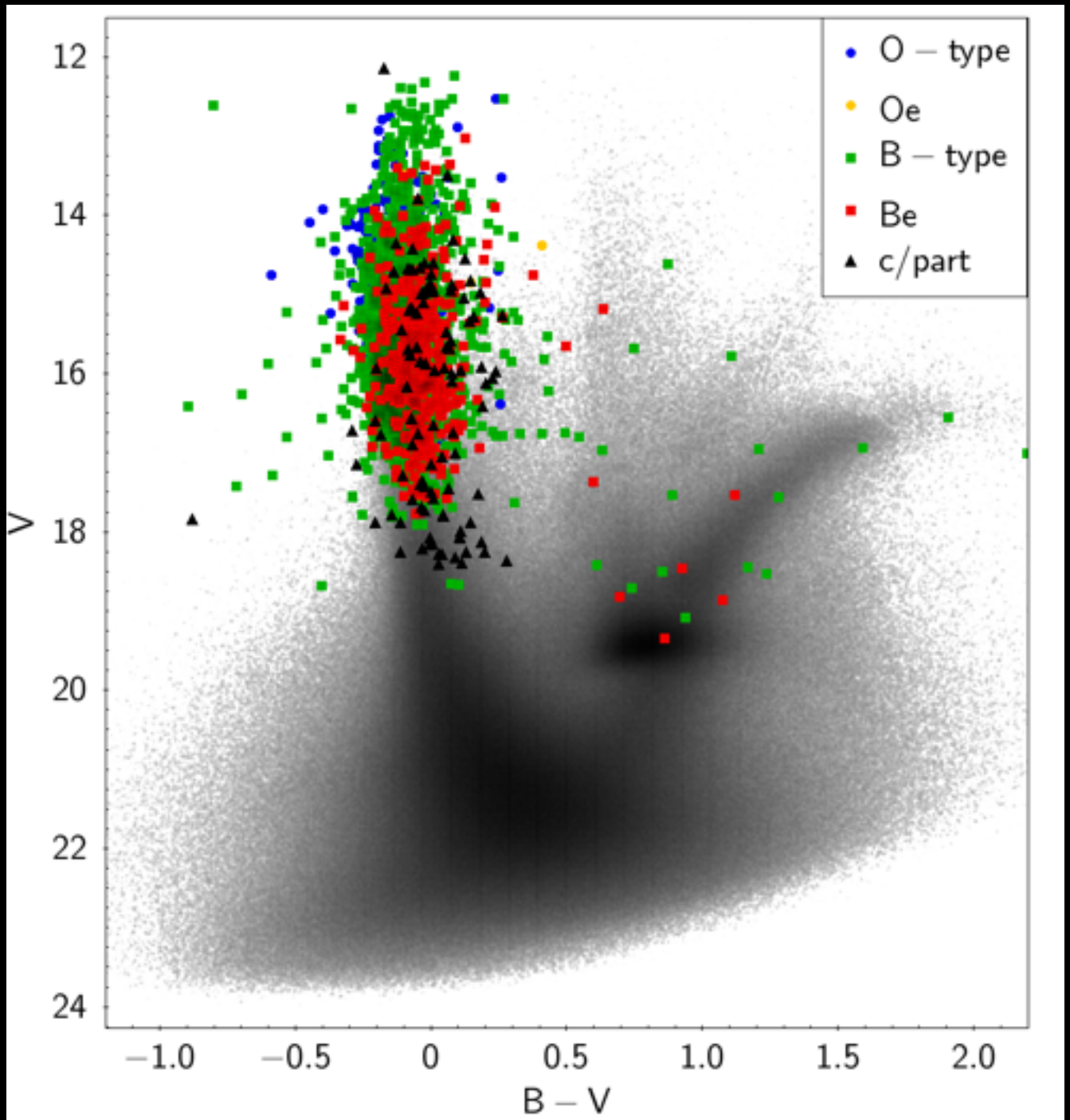




McSwain & Gies, 2005

First results




O – type
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B – type
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B – V
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