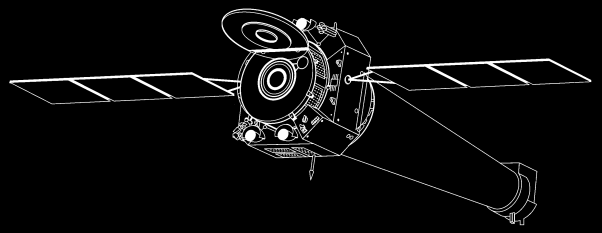
X-ray source populations in nearby galaxies



Andreas Zezas

Harvard-Smithsonian Center for Astrophysics

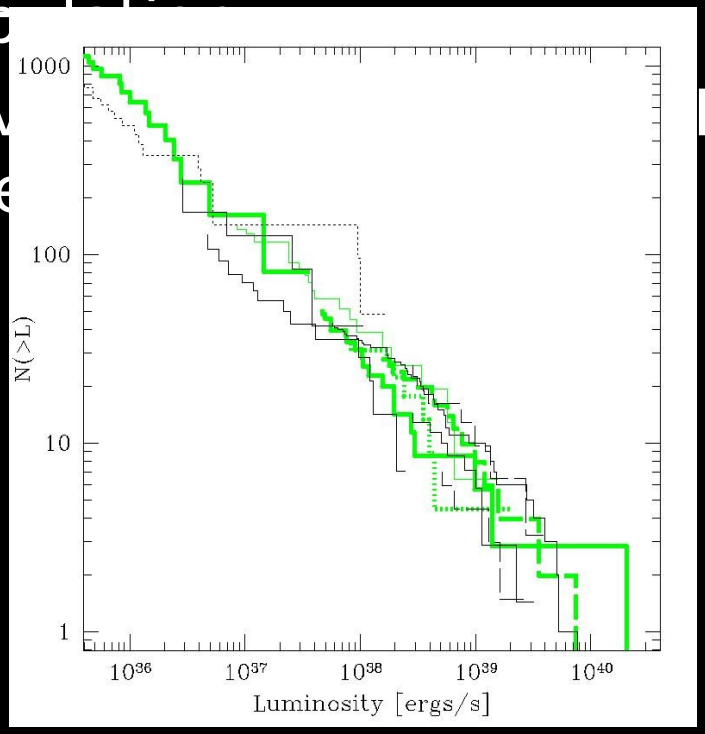
In collaboration with:

K. Gazeas, V. Antoniou, P. Sell, D. Pooley, J. Nantais, V. Kalogera

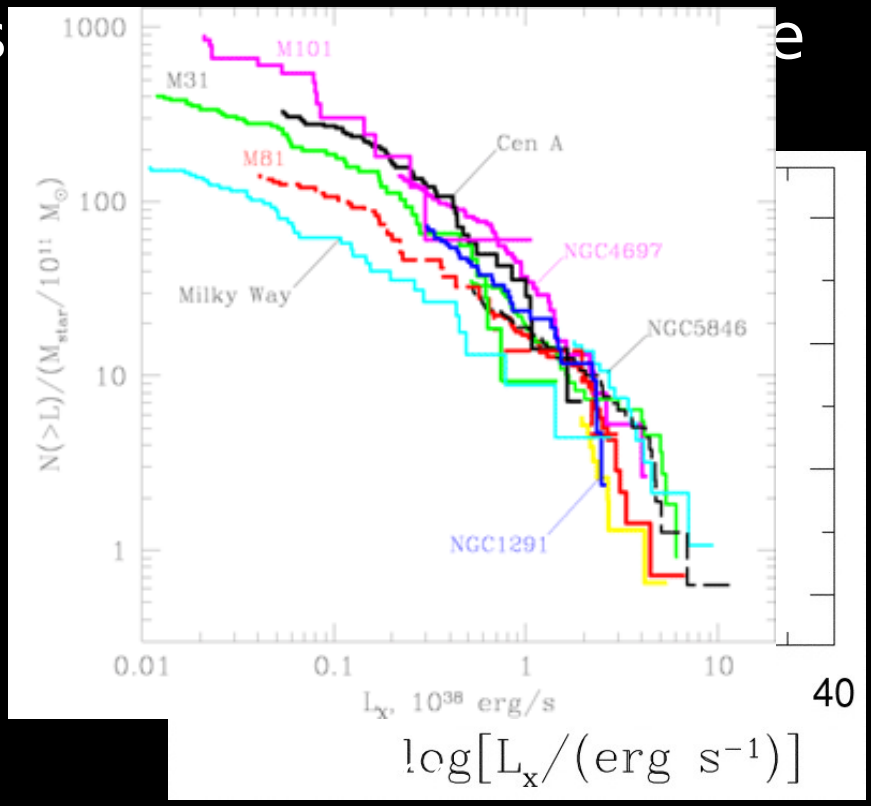
X-ray source populations

- There is evidence for a common XLF describing different XRB populations (e.g. Grimm etal 2002, Zezas & Fabbiano 2002; Kilgard etal. 2002; Colbert etal. 2004)

... but little is known about variations within each po... s... e ev... H... Be...



Grimm, Gilfanov, Sunyaev, 2002



M81: a case study

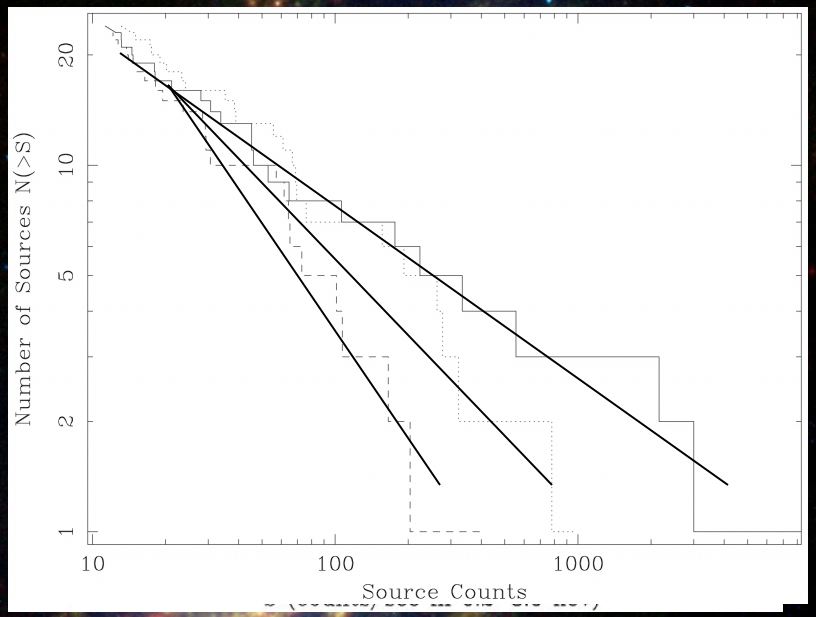
Extensively studied in virtually every waveband

Nearby (3.6 Mpc) :

- Detect the bulk of active X-ray binaries
- Identify optical counterparts
- Resolve star-clusters, and measure structural parameters

X-rays : Deep exposures (PI D. Swartz) and monitoring campaign (PI D. Pooley)

Several populations of X-ray sources



Swartz etal 2003

Pennant etal 2000

Prime target to study star-formation *and* its relation to X-ray binary populations

Gordon etal 2004

Description of the Chandra observations

13 ACIS-S pointings (PI D. Pooley)

Cover ~50% of D25

Exposure : ~10-15ksec

Detection limit : ~10^{37}erg/s in each pointing
(2×10^{37} erg/s @ 90% compl.)

~6×10^{35} erg/s in combined exposure
(4×10^{36} erg/s @ 90% compl.)

Chandra observations : First results

50-60 sources in each pointing

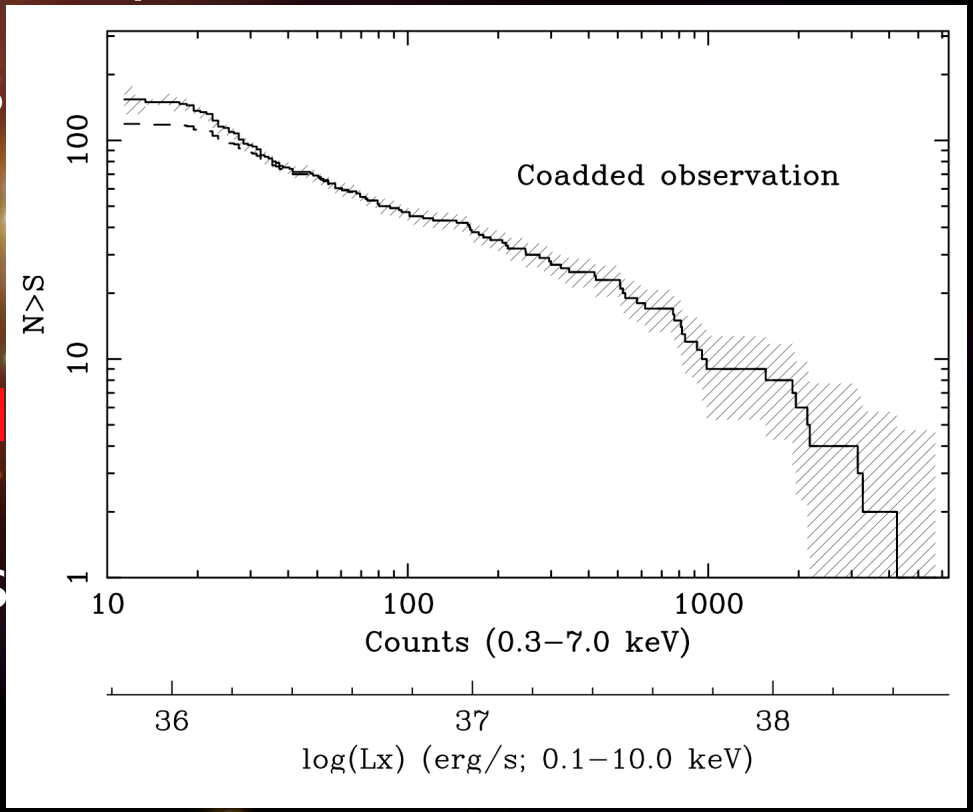
120 sources in coadded exposure

(~35 backgr. sources

XLFs do not vary

(see poster by Paul Sell

Consistent with results on Antennae and other star-forming galaxies (Zezas etal 2007)



HST observations

HST-ACS BVI imaging of entire galaxy

Combination of P10540 (I-band; PI J. Huchra) and P10584 (BV-bands; PI A. Zezas)

Total of 29 ACS fields (24+39 orbits)

B,V-band exposure : 1200 sec (~27 mag at S/N=10)

I-band exposure : 1650 sec (~27 mag at S/N=10)

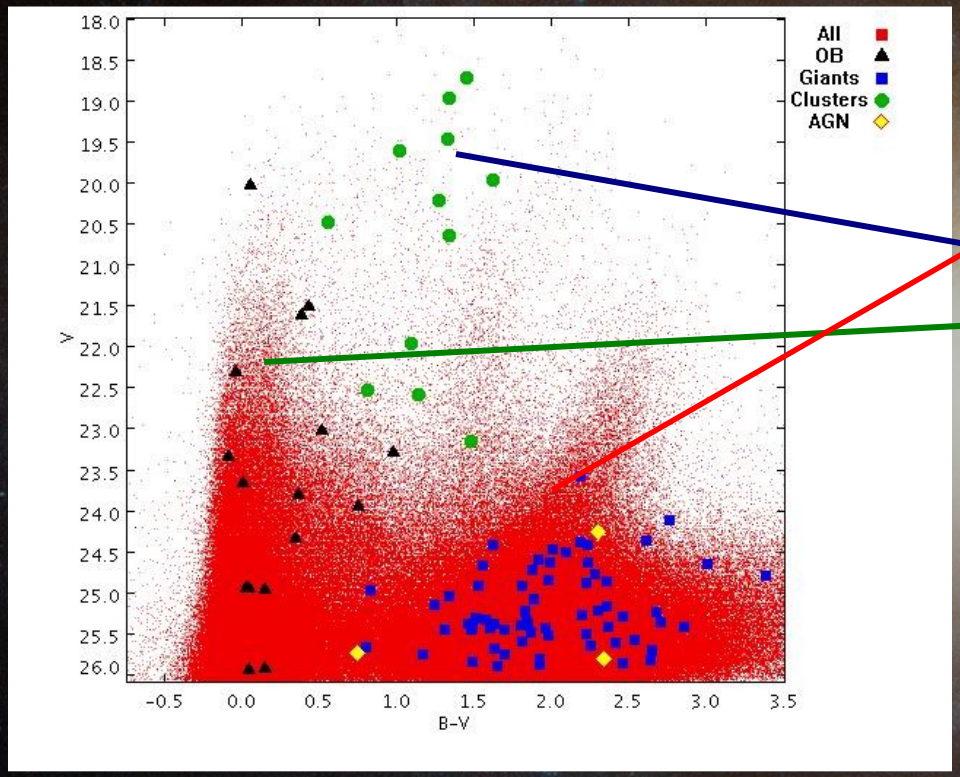
Goal : Detect all star-clusters, and bulk of OB

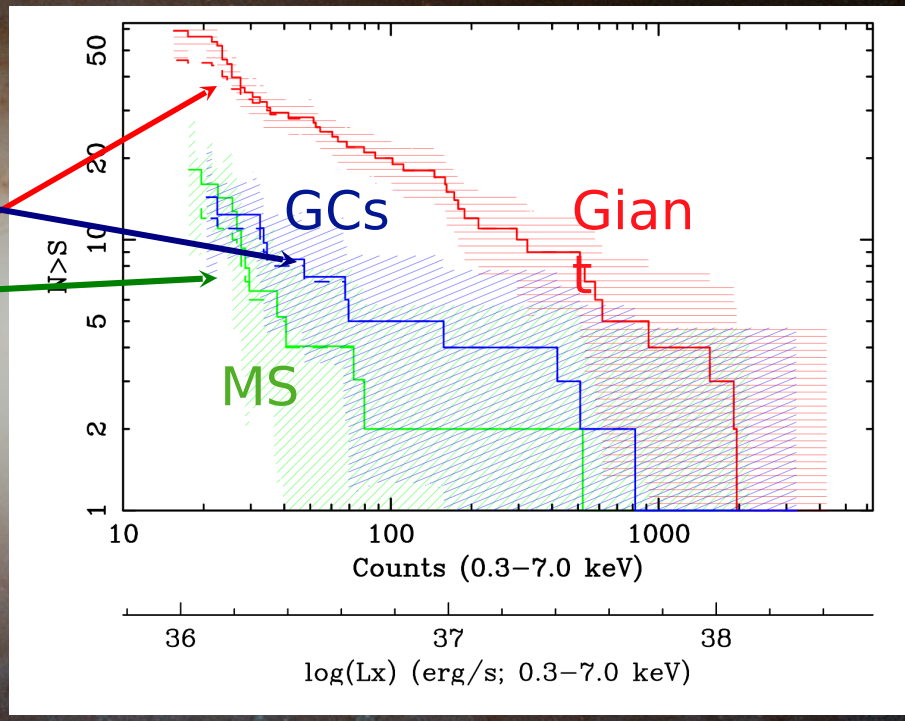
Bulge and inner disk

Comparison with Chandra

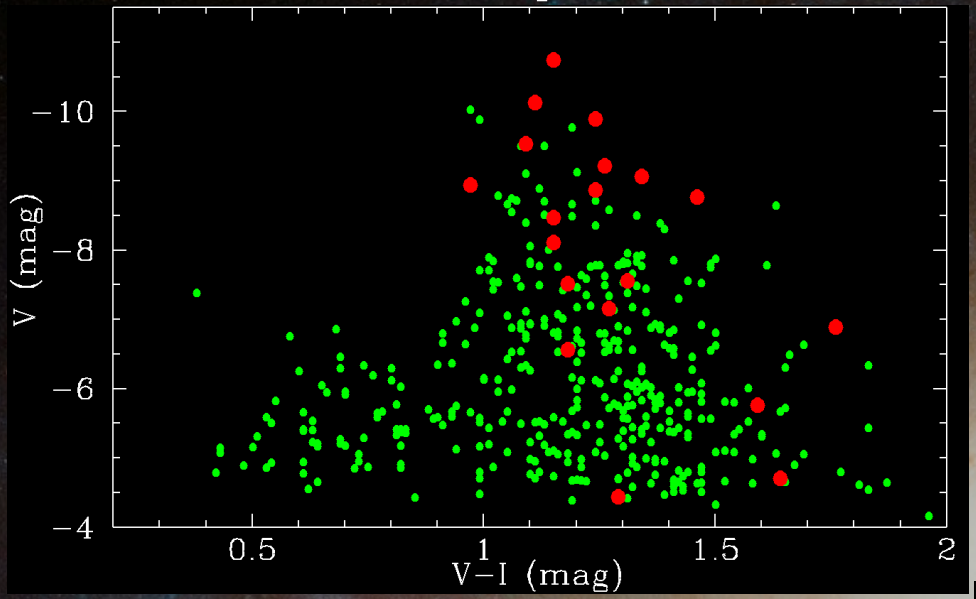
- Chandra-HST astrometric registration : < 0.4”
- Very high chance coincidence rate
- Cross-correlate with different source types
  - OB stars
  - Bright giants /supergiants

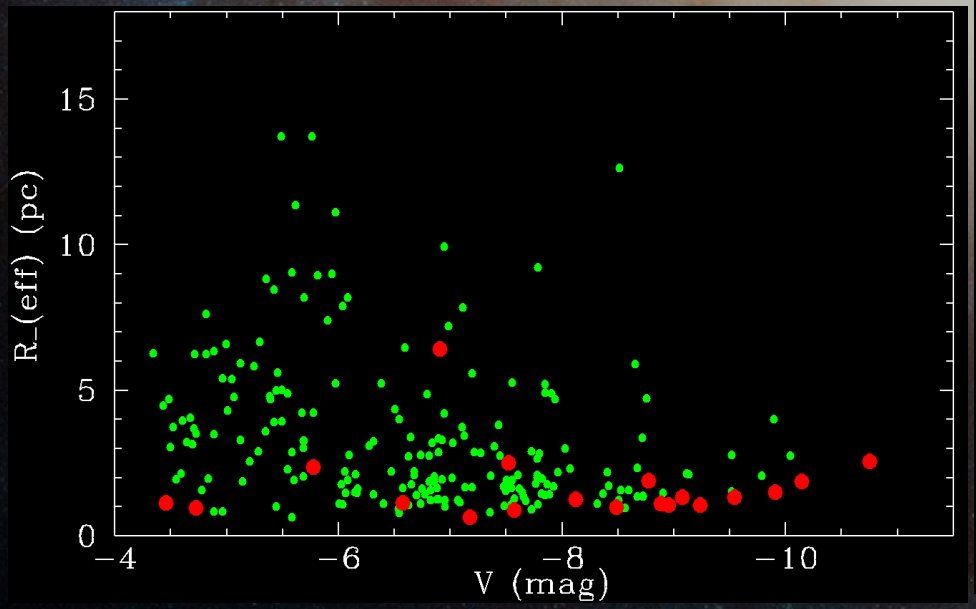
Comparison with Chandra

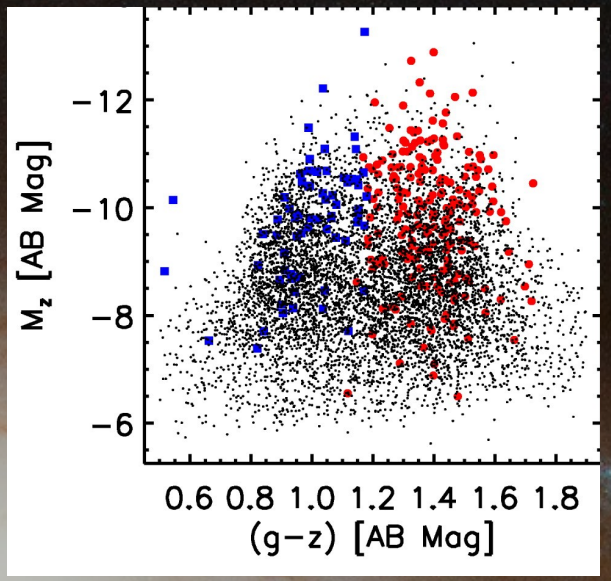




Comparison with Chandra







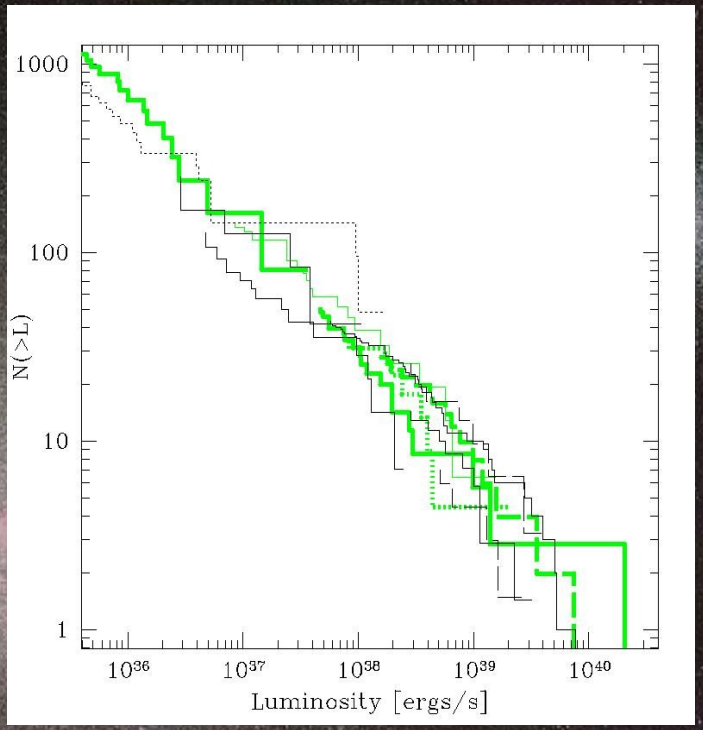
Sivakoff etal 1997

Star-forming galaxies

Common overall XLF, but

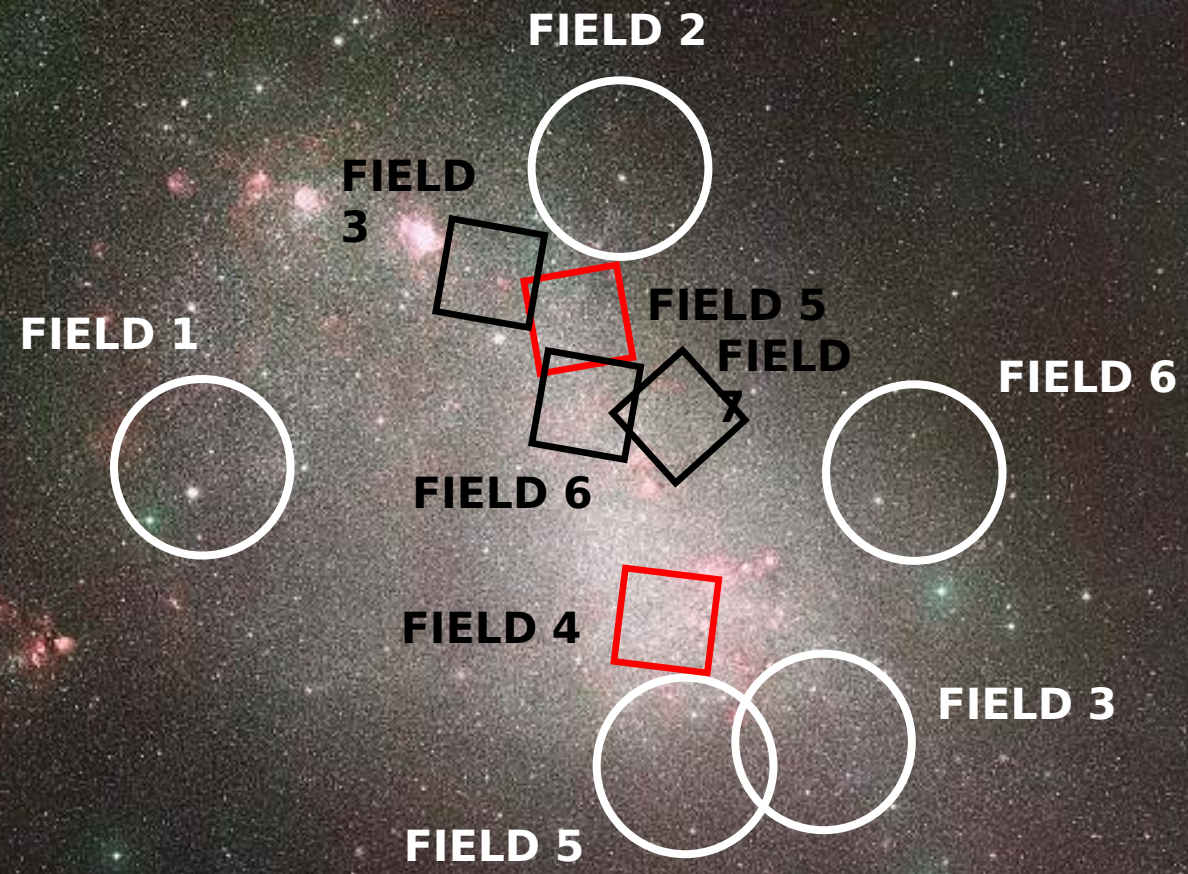
- Are there differences between populations ?

- What is the formation efficiency of X-ray binaries ?



Grimm, Gilfanov, Sunyaev, 2002

The low-luminosity end: SMC



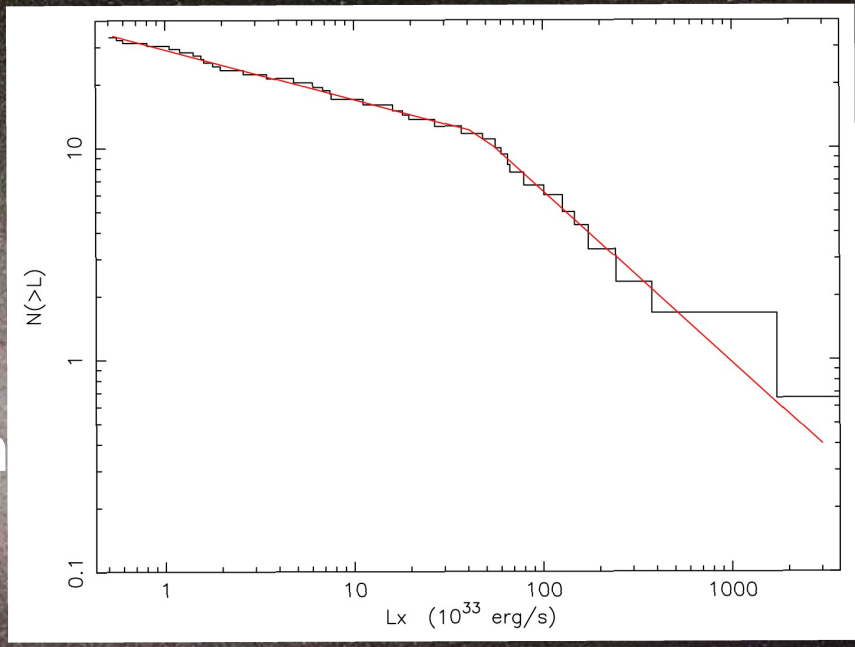
The low-luminosity end: SMC

The luminosity function:

Flat slope : $\alpha \sim 0.35$

Indication for break

consistent with accretion in a inhomogeneous environment and the onset of the propeller effect.



Zezas etal, in prep.

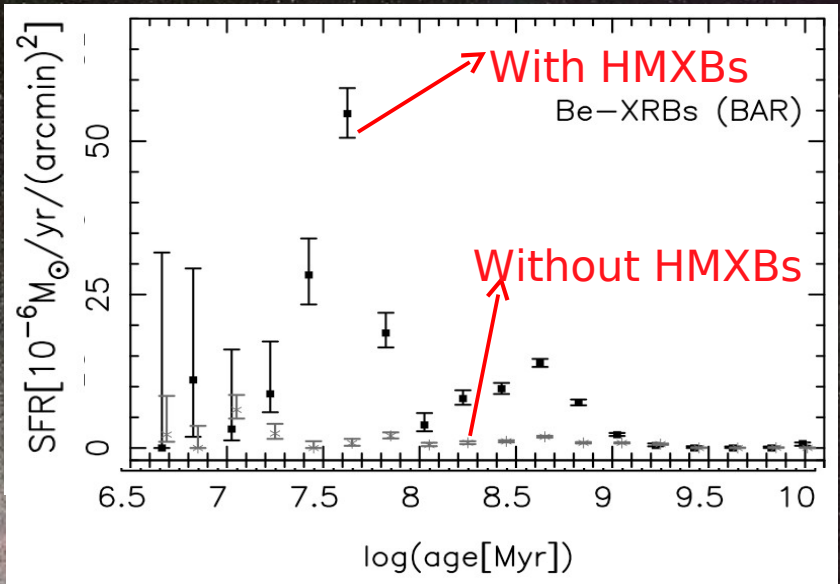
Relation with star-formation

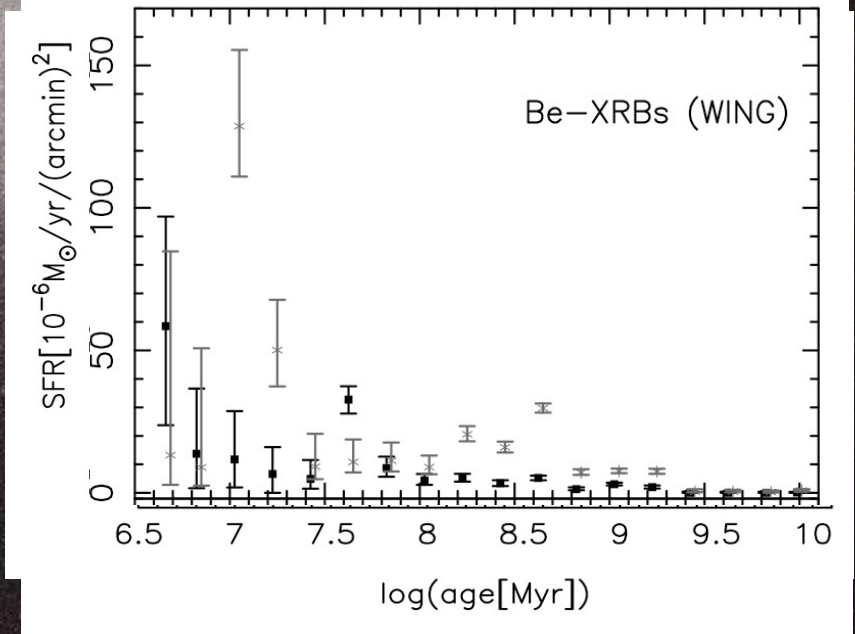
Enhanced formation of X-ray binaries in the 30-70 Myr range.

Consistent with peak in Be-star phenomenon at these ages

Explains large number of XRBs in the SMC

Evidence for small kicks (c.f. van den Heuvel etal. 2000; Coe 2005)



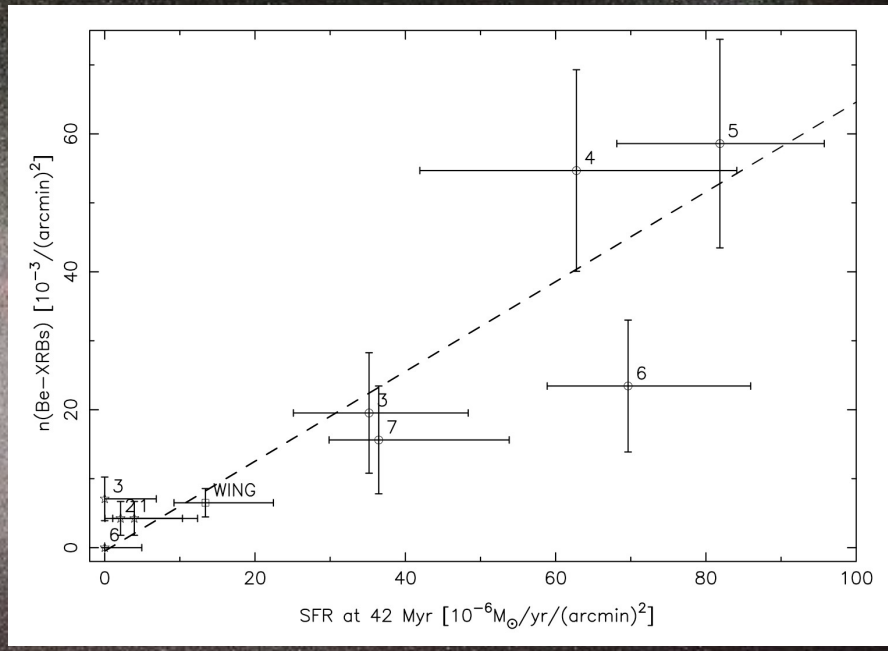


Relation with star-formation

Relation between Be-XRBs and SFR of parent population:

$(1.6\pm0.6)\times10^{-3}$ XRBs /($M_{\odot}$/yr)

Extend relation based on studies of more distant galaxies to much lower luminosities.



Antoniou etal subm.

Summary

- Monitoring observations show that XLFs do not vary
- Multi-wavelength associations very useful for classifying X-ray sources and dissecting overall population.
- GC populations in M81 are consistent with ET galaxy GCs
- Strong dependence of HMXB populations on age.
- Need : systematic observations of nearby galaxies (e.g. XSINGs)

  multiwavelength coverage
- Comparison with predictions from X-ray binary

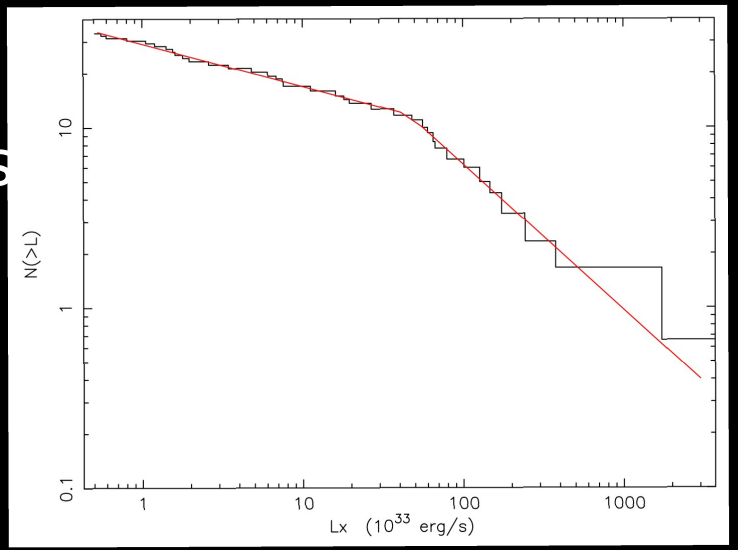
What comes next …

Current studies require significant investment of Chandra time (100s ksec per object)

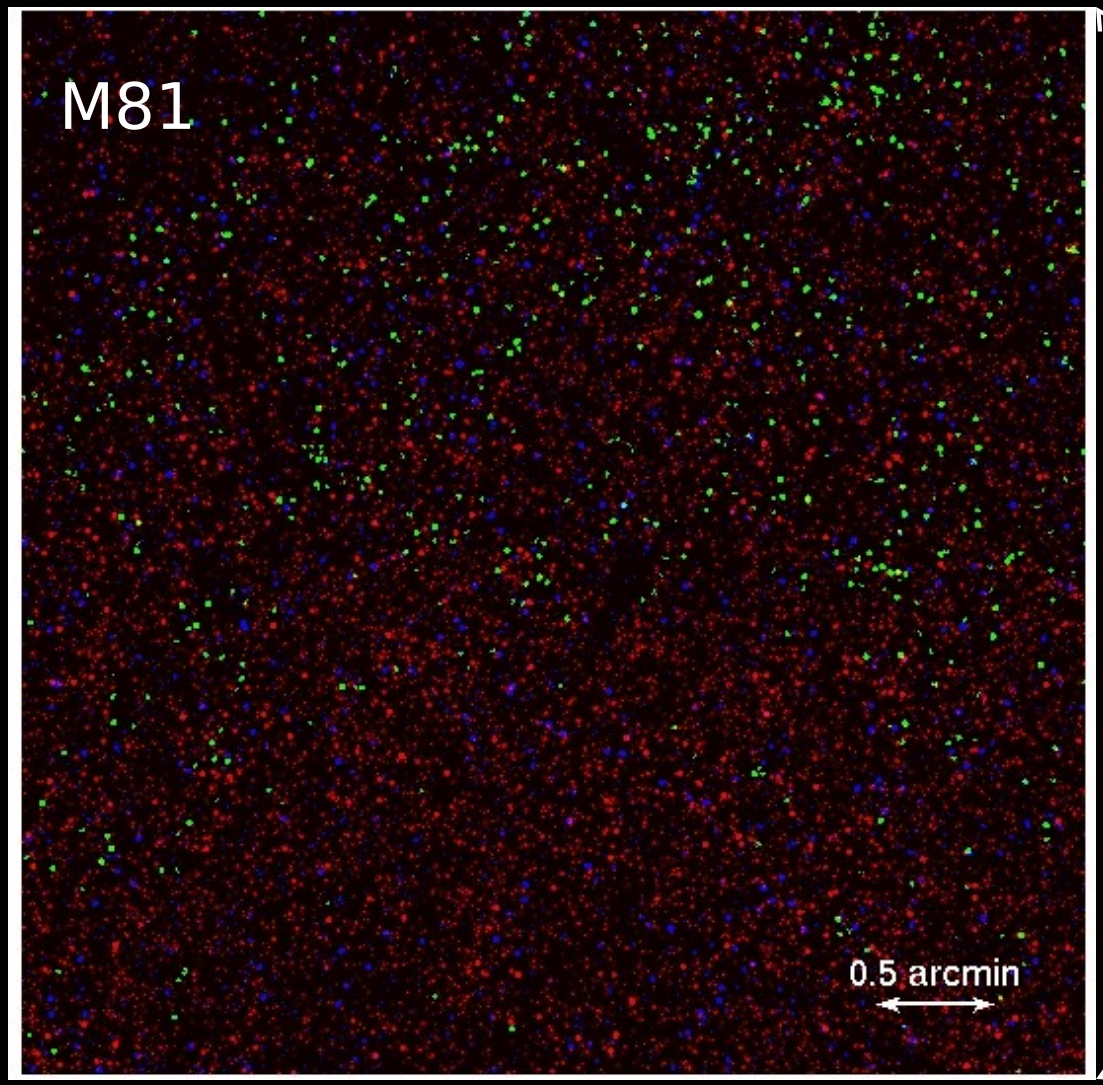
… and still cannot address the spectral/timing properties of the majority of objects

IXO will be very important for such studies in nearby galaxies

- accretion physics in low luminos
- detailed studies of relatively isolated sources (incl ULXs)



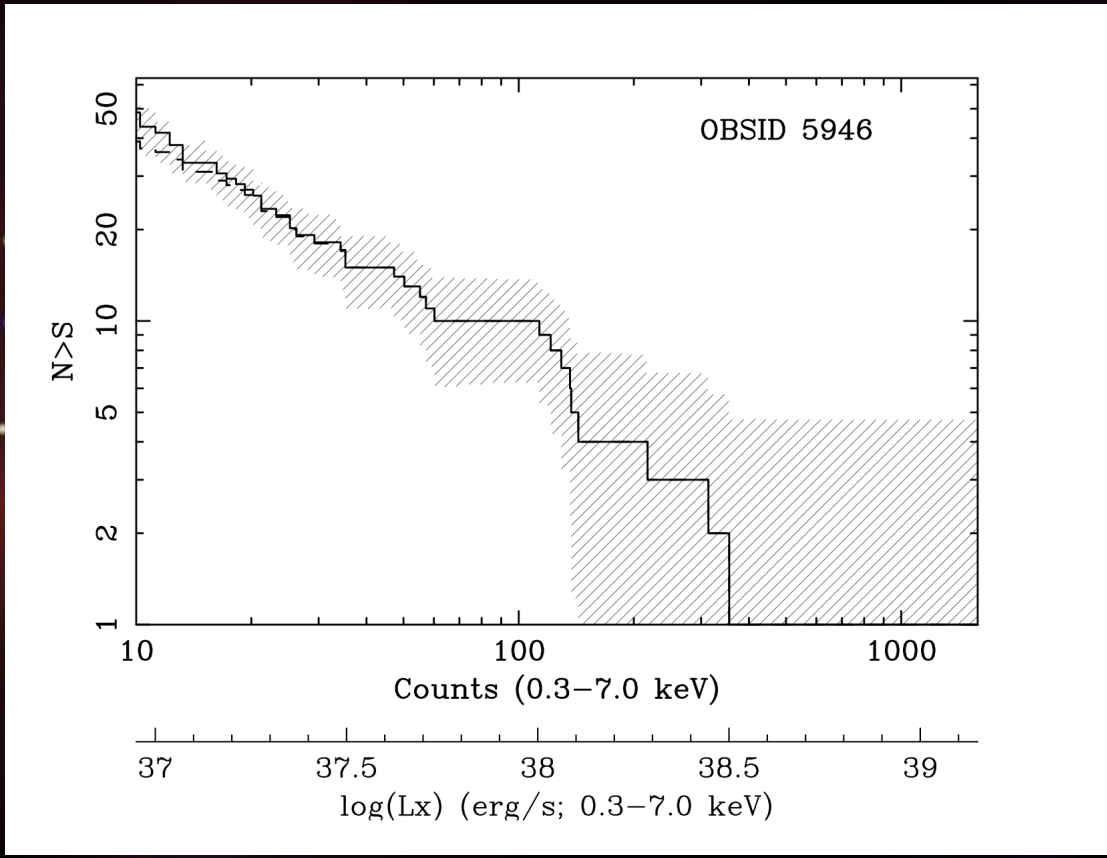
What comes next …



100 ksec Gen-X simulation : Detection limit ~10^{34} erg/s

Chandra observations : First results

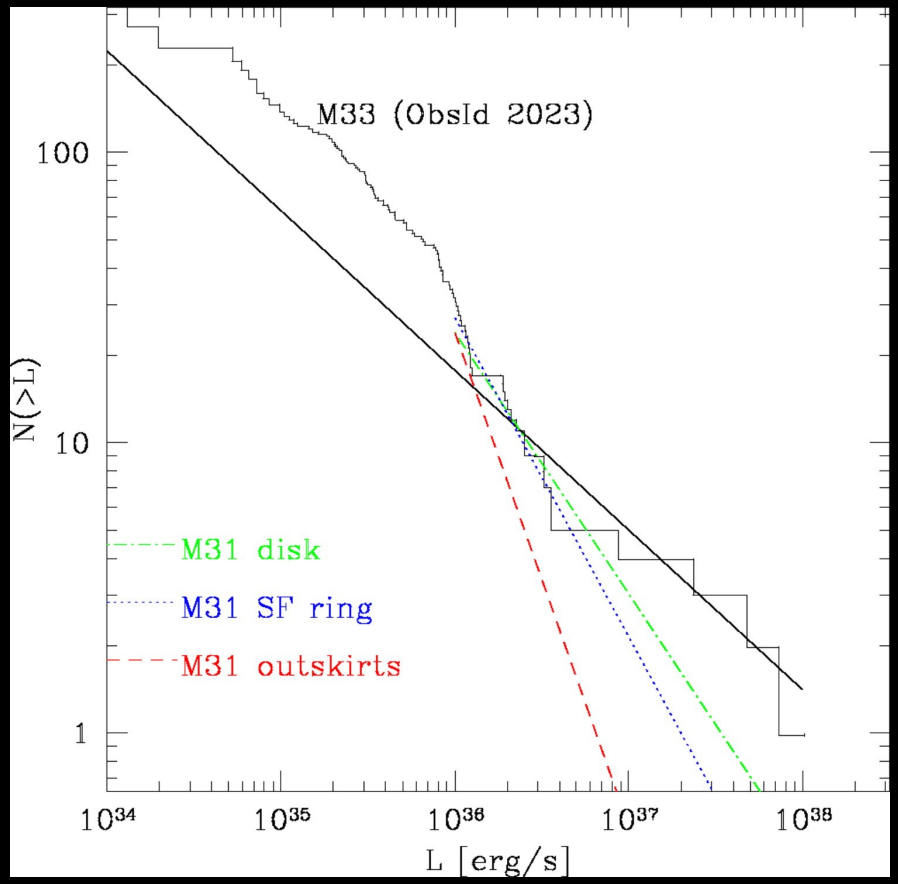
XLFs do not vary



Consistent with results from the Antennae and other star-forming galaxies

Spiral galaxies

There is strong evidence for different populations in star-forming galaxies (arms, bulge, inter-arm regions)



Grimm etal 2006

However, little is known about the properties of those X-ray sources.

Extragalactic X-ray source populations

Advantages:

- Often better distance determinations

- Less affected by obscuration

- Can study large samples of diverse types of sources and their connection to their parent stellar populations

Focus:

High Mass X-ray binaries (spiral, star-forming galaxies)