The XMM-Newton survey of the Small Magellanic Cloud

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- The XMM-Newton survey
- Interesting individual sources
- Source catalogue
- Population studies (HMXBs, SNRs)
- Diffuse emission from the hot ISM

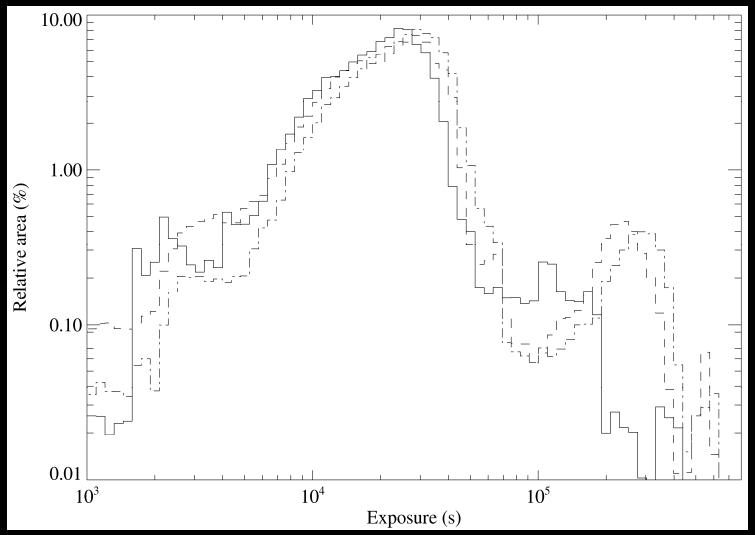
An XMM-Newton large project in collaboration with

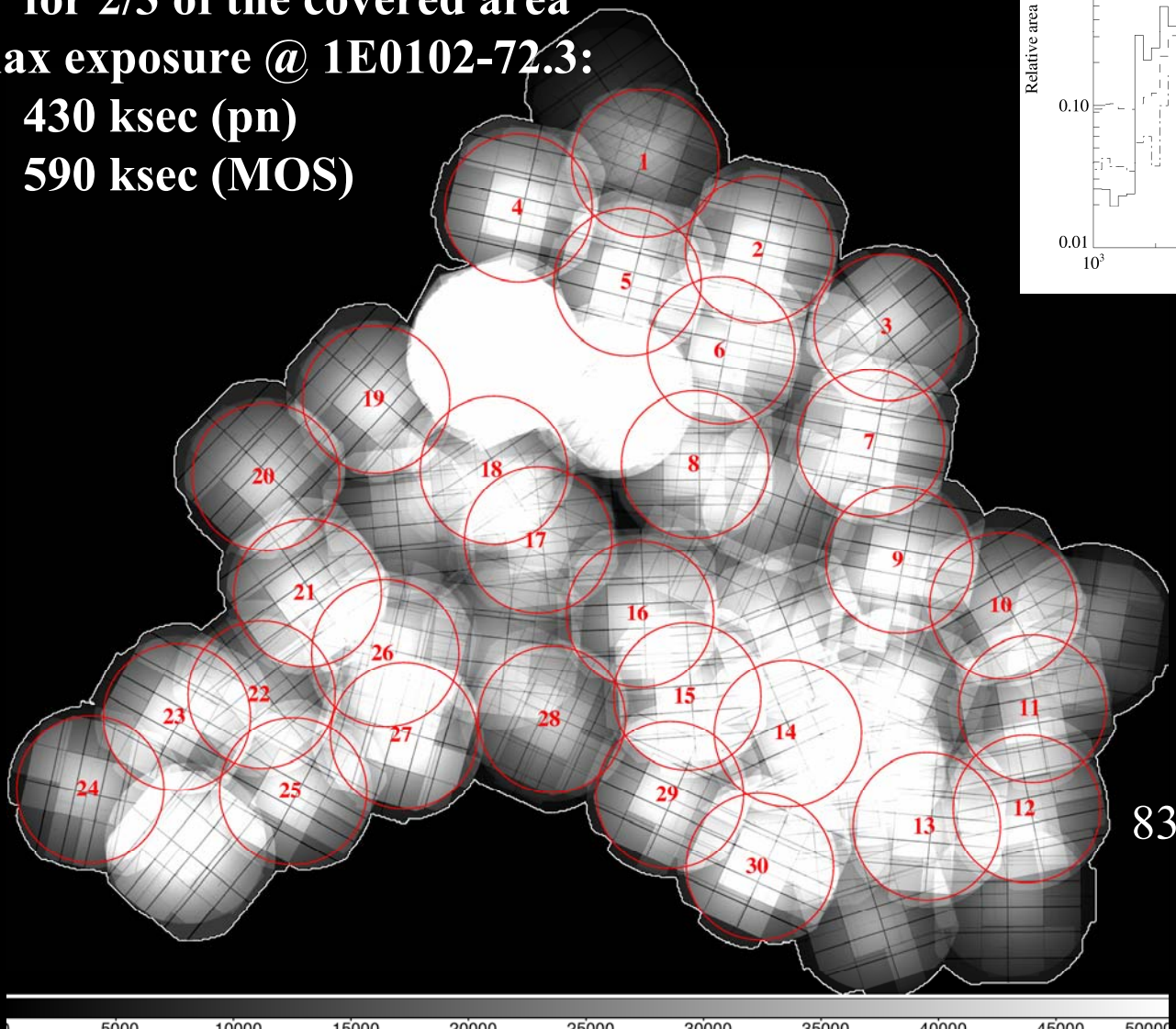
R. Sturm, J. Ballet, D. Bomans, D.A.H. Buckley, M.J. Coe, R. Corbet, M. Ehle, M.D. Filipovic, M. Gilfanov, D. Hatzidimitriou, N. La Palombara, S. Mereghetti, W. Pietsch, S. Snowden, A. Tiengo

X-ray Astronomy: towards the next 50 years! Milano, Italy, 1-5 October 2012

The XMM-Newton survey of the SMC

covered area of 5.5 square degrees
typical exposure: 20 – 30 ksec
for 2/3 of the covered area
max exposure @ 1E0102-72.3:
430 ksec (pn)
590 ksec (MOS)

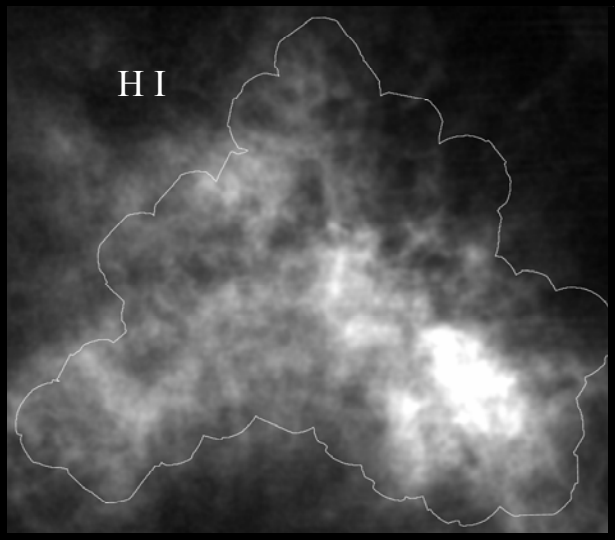


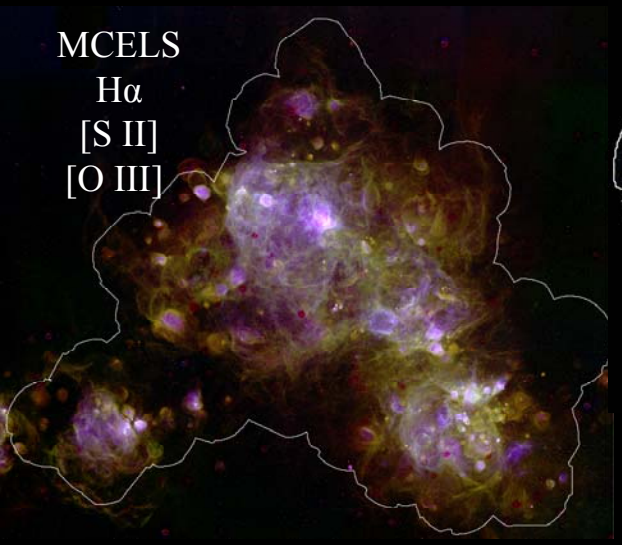


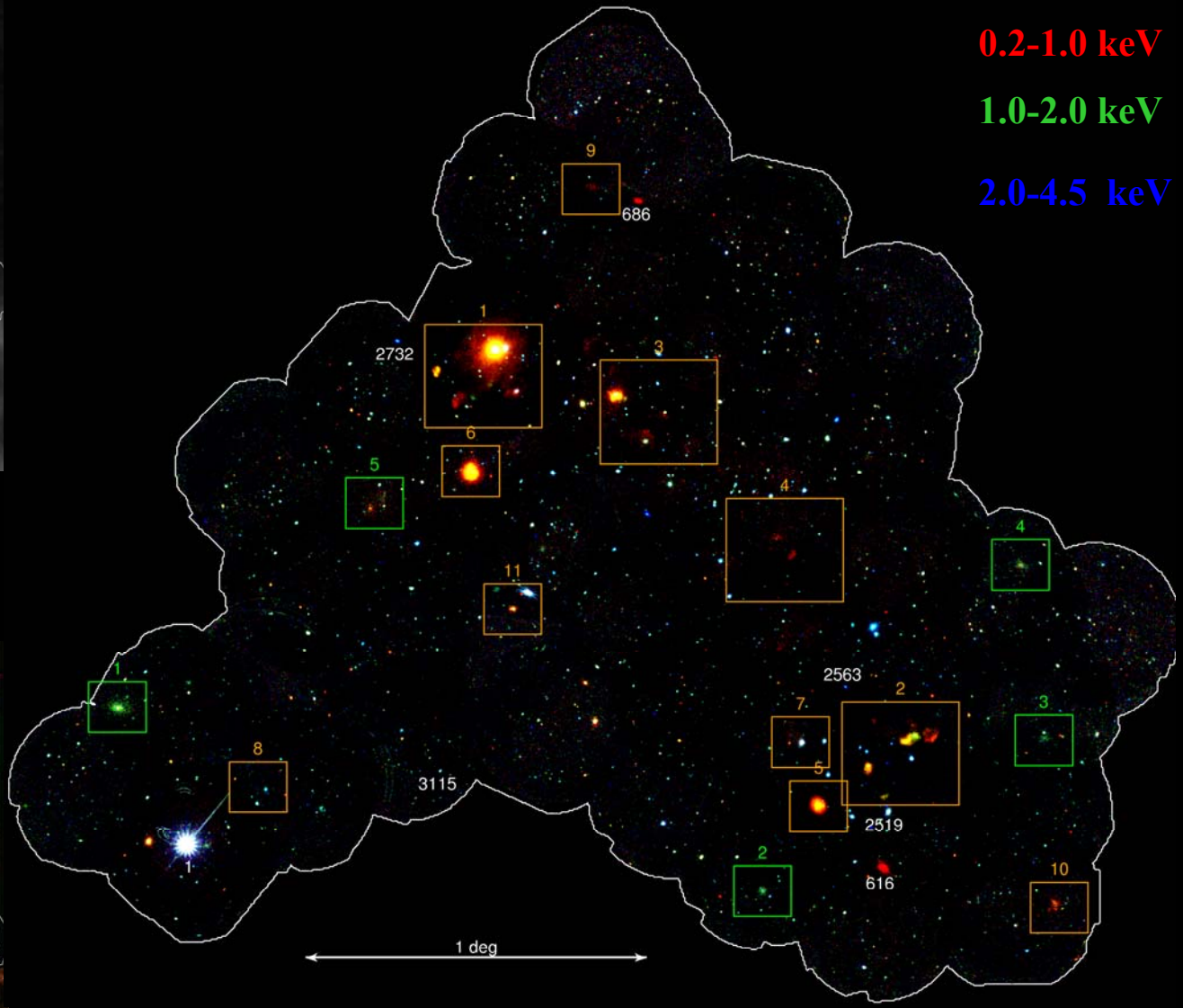
30 fields (33 pointings)
Large Project
May 2009 – March 2010

+ archival pointings

83 PN + 86 MOS exposures
noisy MOS CCDs removed
bg flare screening







Supersoft X-ray sources

Supernova Remnants

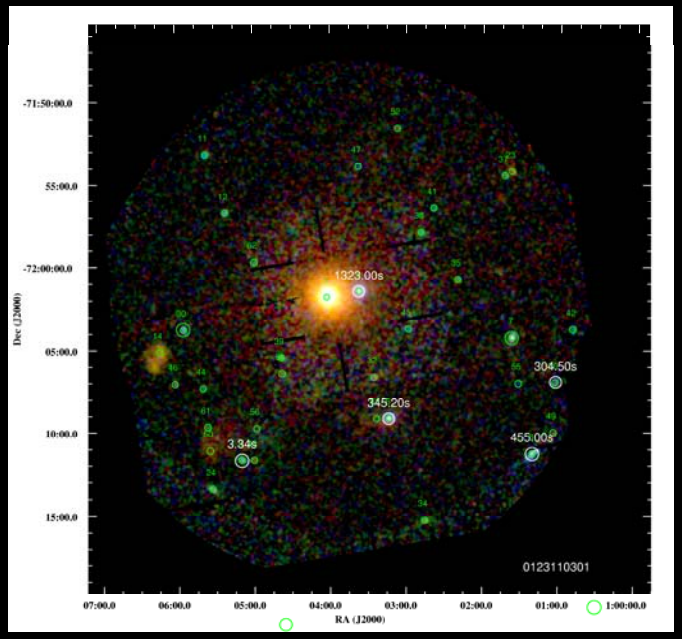
Foreground stars

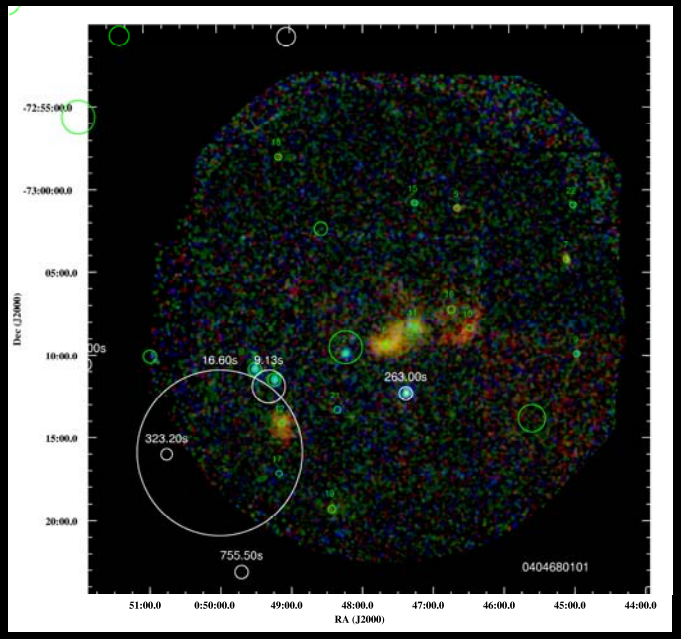
Galaxy Clusters

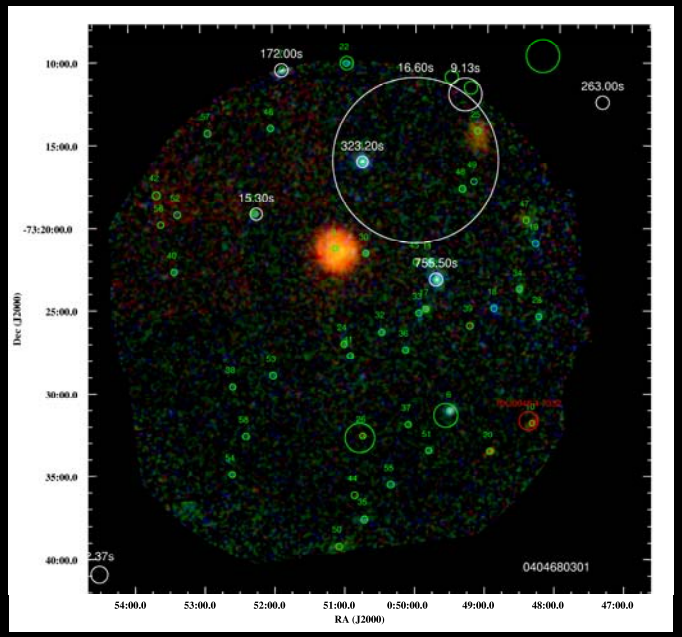
Background AGN

HMXBs

Catalogue of discrete sources







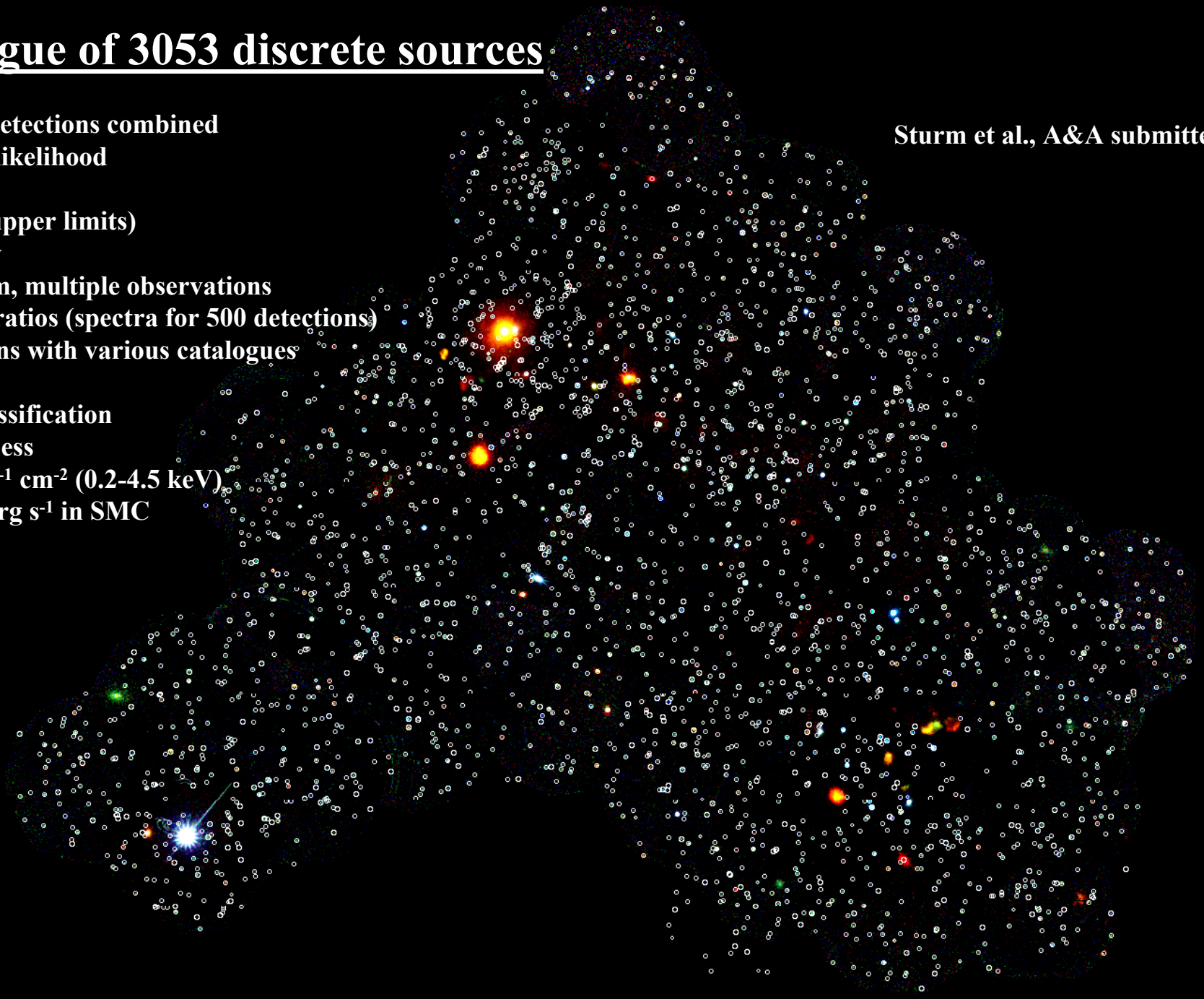
- astrometric boresight correction
- careful data selection (low background)
- source detection simultaneously on 15 images
  5 energy bands, 3 EPIC instruments
  0.2-0.5 / 0.5-1.0 / 1.0-2.0 / 2.0-4.5 / 4.5-12 keV

- 5236 detections after manual screening
  (multiple detections in extended regions, oot events)
- 3053 individual sources
  2126 are detected once
  927 with multiple detections (maximum 34)

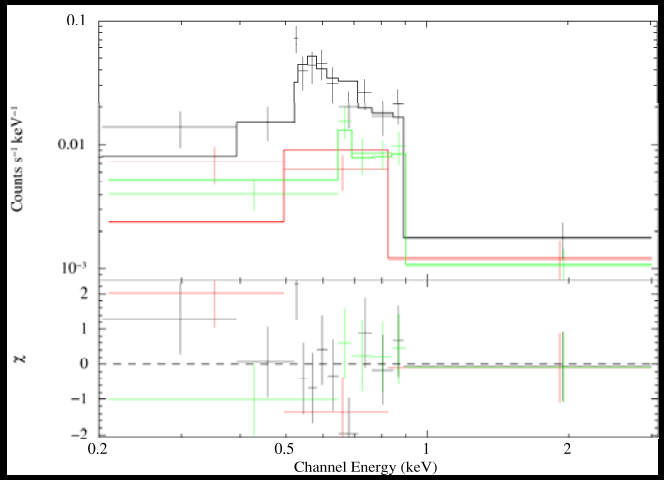
Catalogue of 3053 discrete sources

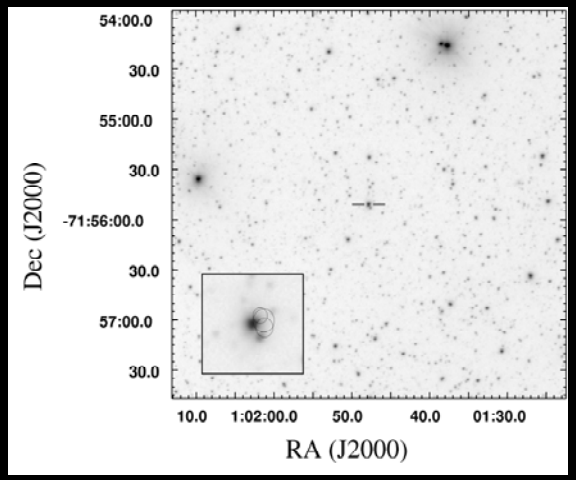
- multiple detections combined
- detection likelihood
- position
- fluxes (+ upper limits)
- variability
  short-term, multiple observations
- hardness ratios (spectra for 500 detections)
- correlations with various catalogues
- f_x/f_{opt}
- source classification
- completeness
  10^{-14} erg s^{-1} cm^{-2} (0.2-4.5 keV)
  4.3×10^{33} erg s^{-1} in SMC

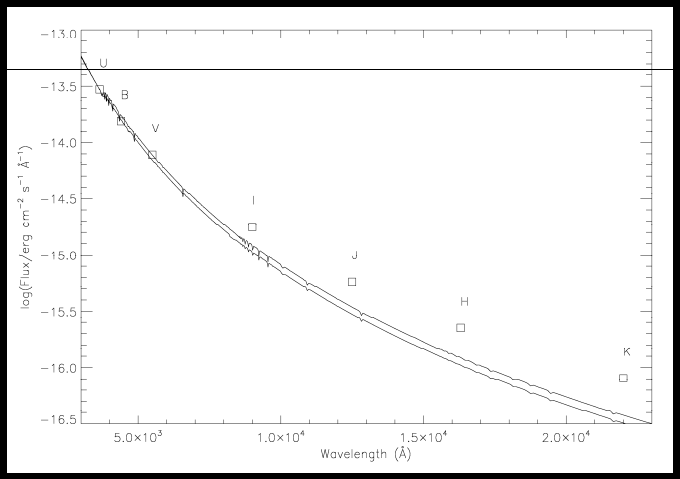
Sturm et al., A&A submitted

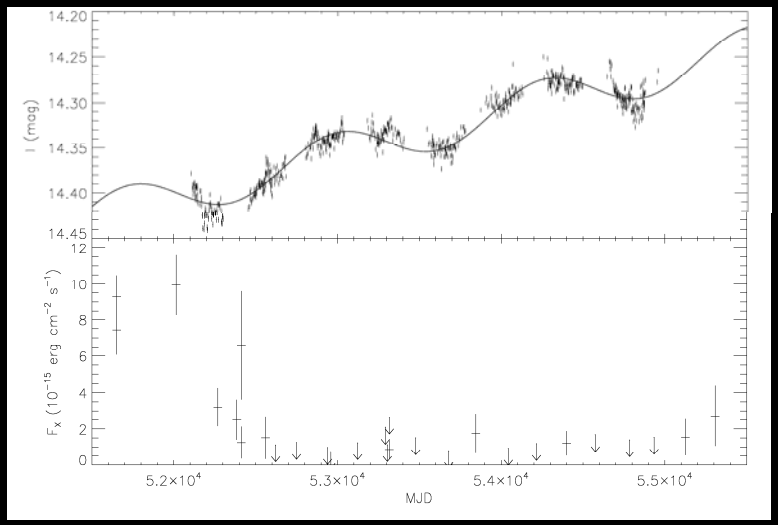


The first Be/WD binary candidate in the SMC









faint SSS

Be star counterpart

anticorrelation optical/X-ray?

build-up of Be disc absorbs soft X-rays

Sturm et al. 2012, A&A 537, A76

similar system in LMC:

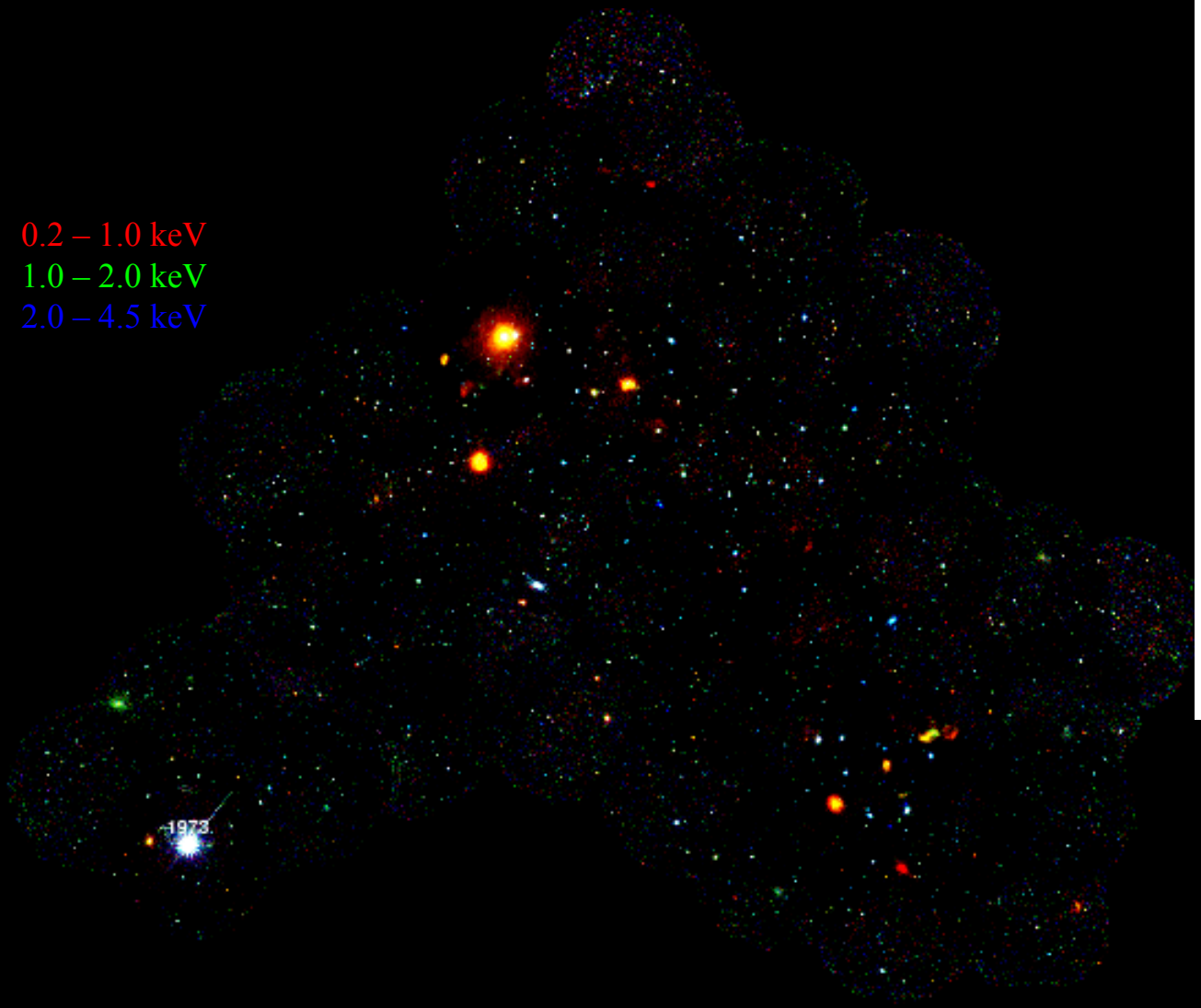
Kahabka et al. 2006, A&A 458, 285

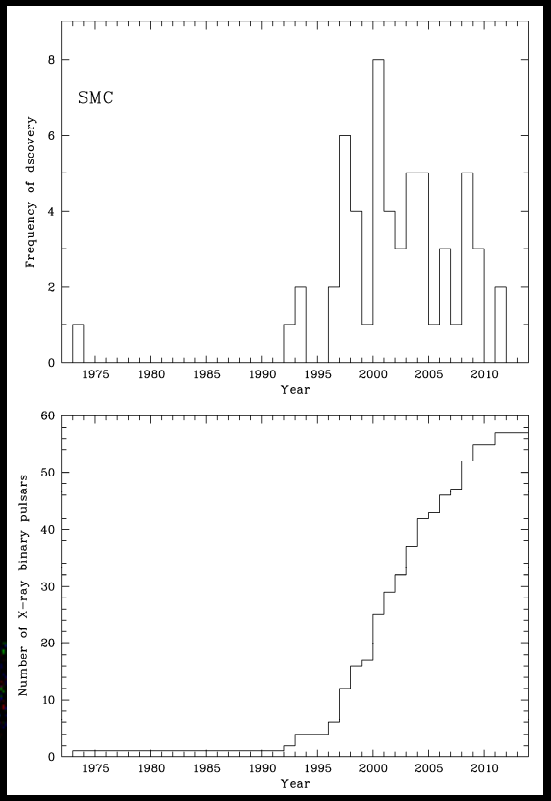
SSS outburst in Be-system in SMC wing:

MAXI J1305-704 (Li et al. 2012, arXiv1207.5023)

The large BeXRB population of the SMC

0.2 – 1.0 keV
1.0 – 2.0 keV
2.0 – 4.5 keV

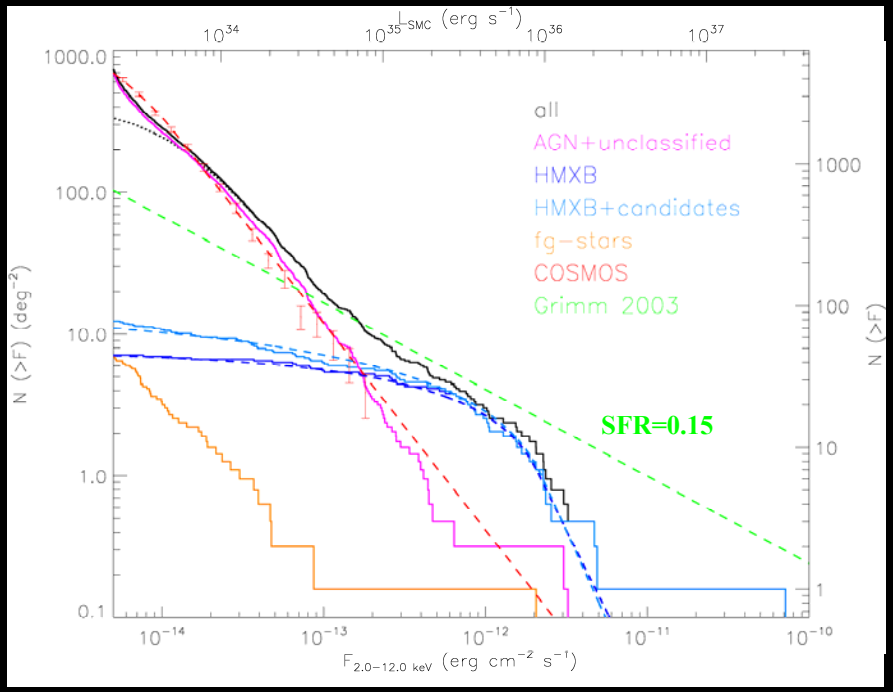




57 HMXB pulsars
53 with known position

Many discoveries of X-ray transients with RXTE, ASCA, ROSAT, BeppoSAX
Chandra and XMM-Newton can do spectral and timing analysis down to 10^{34} erg/s

Luminosity function of HMXBs



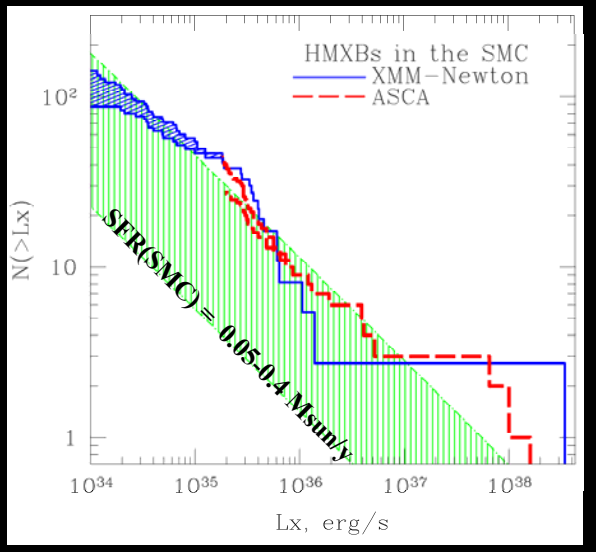
HMXBs in the SMC:
α_1 = 0.64 (+0.13/-0.17)
α_2 = 3.3 (+2.2/-1.4)

A different HMXB population !

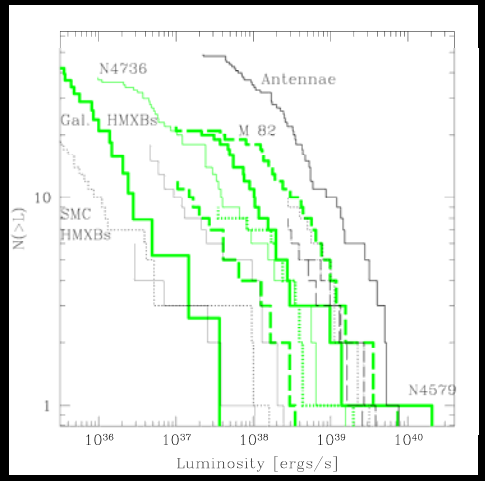
~40 new faint candidates

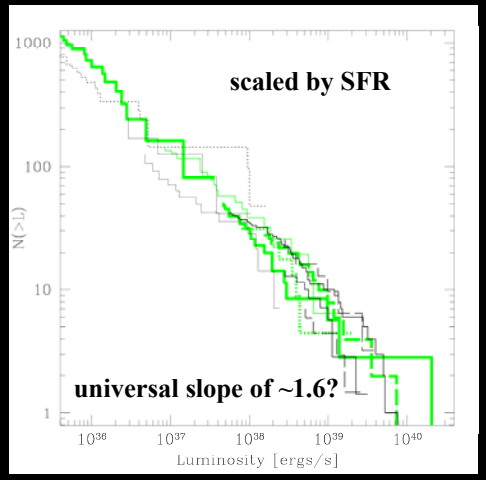
L_{break} ~ 10^{36} erg/s
- **propeller effect?**
- **transient – peristent?**

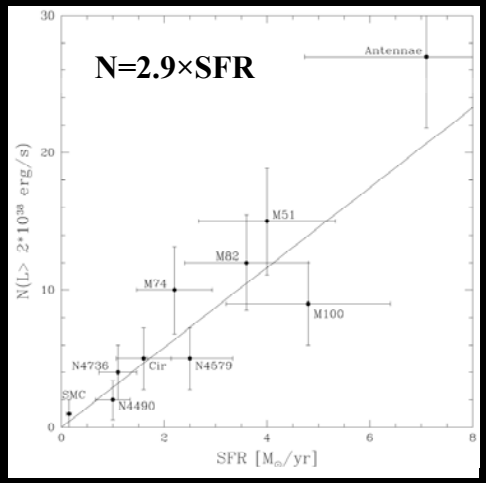
Sturm et al. 2012, A&A submitted



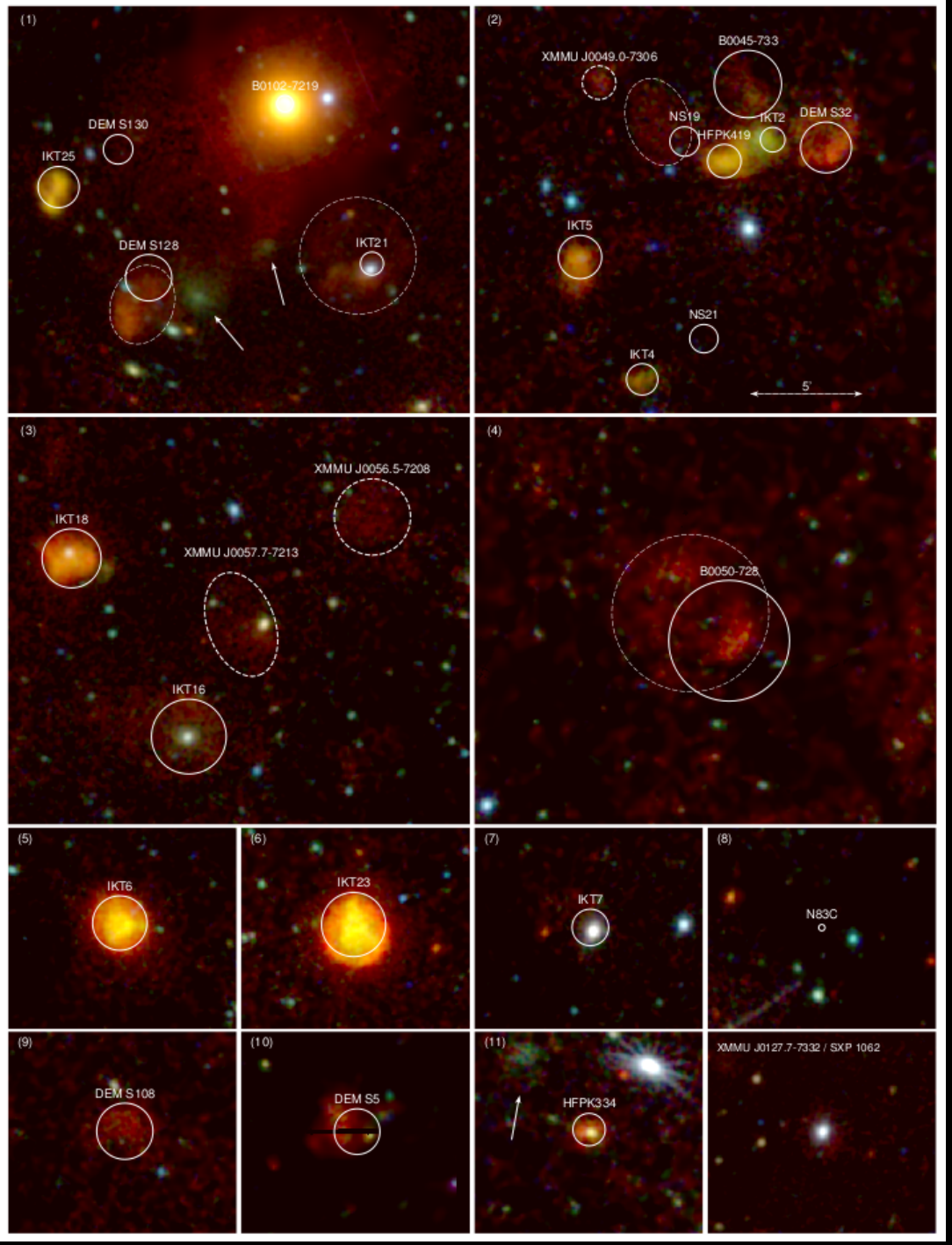
Shtykovskiy & Gilfanov 2005, MNRAS 362,879







Grimm et al. 2003, MNRAS 339,793



Supernova Remnants

synoptic study of 13 known SNRs
van der Heyden et al. 2004,A&A 421, 1031
X-ray morphology, spectra

complete sample down to
a few 10^{-14} erg cm^{-2} s arcmin^{-2}

improved images
pn and MOS
out-of-time events subtracted (pn)
detector background subtracted
vignetting corrected

a number of SNRs show larger extent as in
Badenes et al. 2010, MNRAS 407, 1301

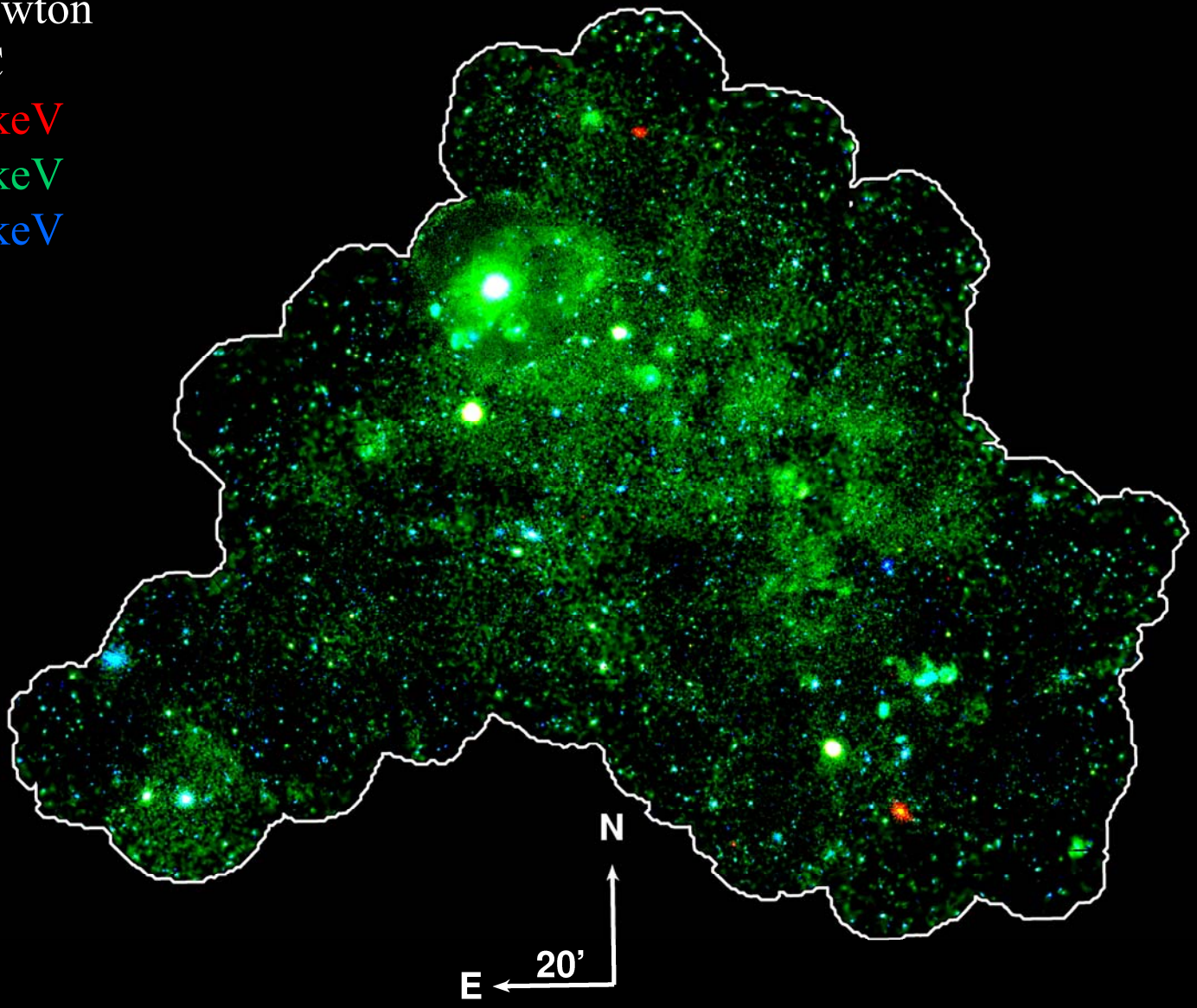
new candidates with low surface brightness
and large extent

no SNR at position of IKT 7 (172s Be XRB)
no detection of DEM S130, NS21 and N83C

Haberl et al. 2012, A&A 545, A128

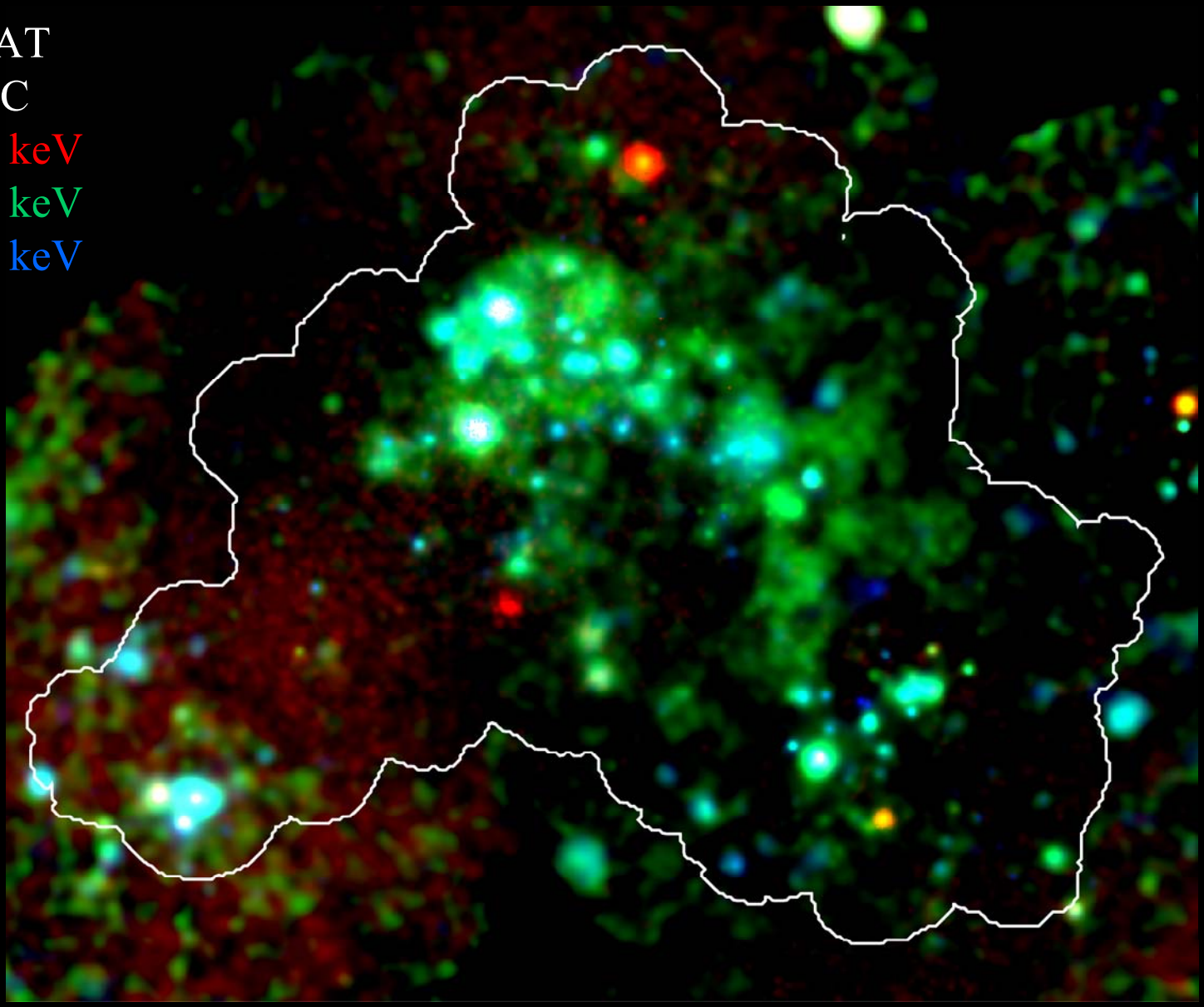
Diffuse emission from the hot ISM

XMM-Newton
EPIC
0.2-0.5 keV
0.5-1.0 keV
1.0-2.0 keV

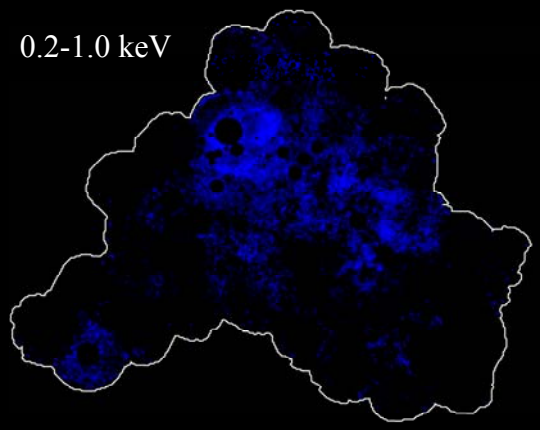


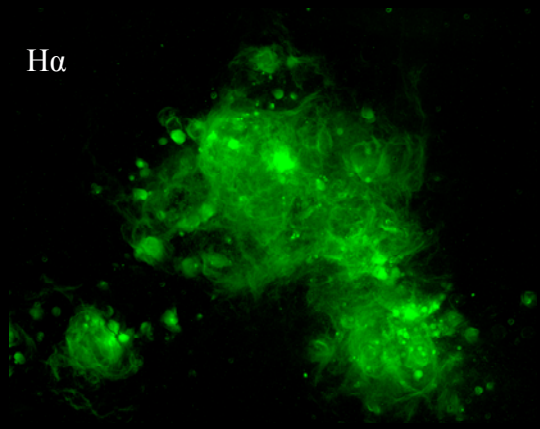
Diffuse emission from the hot ISM

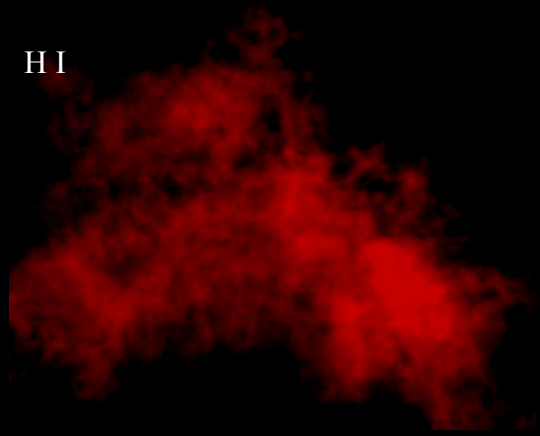
ROSAT
PSPC
0.1-0.4 keV
0.5-0.9 keV
0.9-2.0 keV

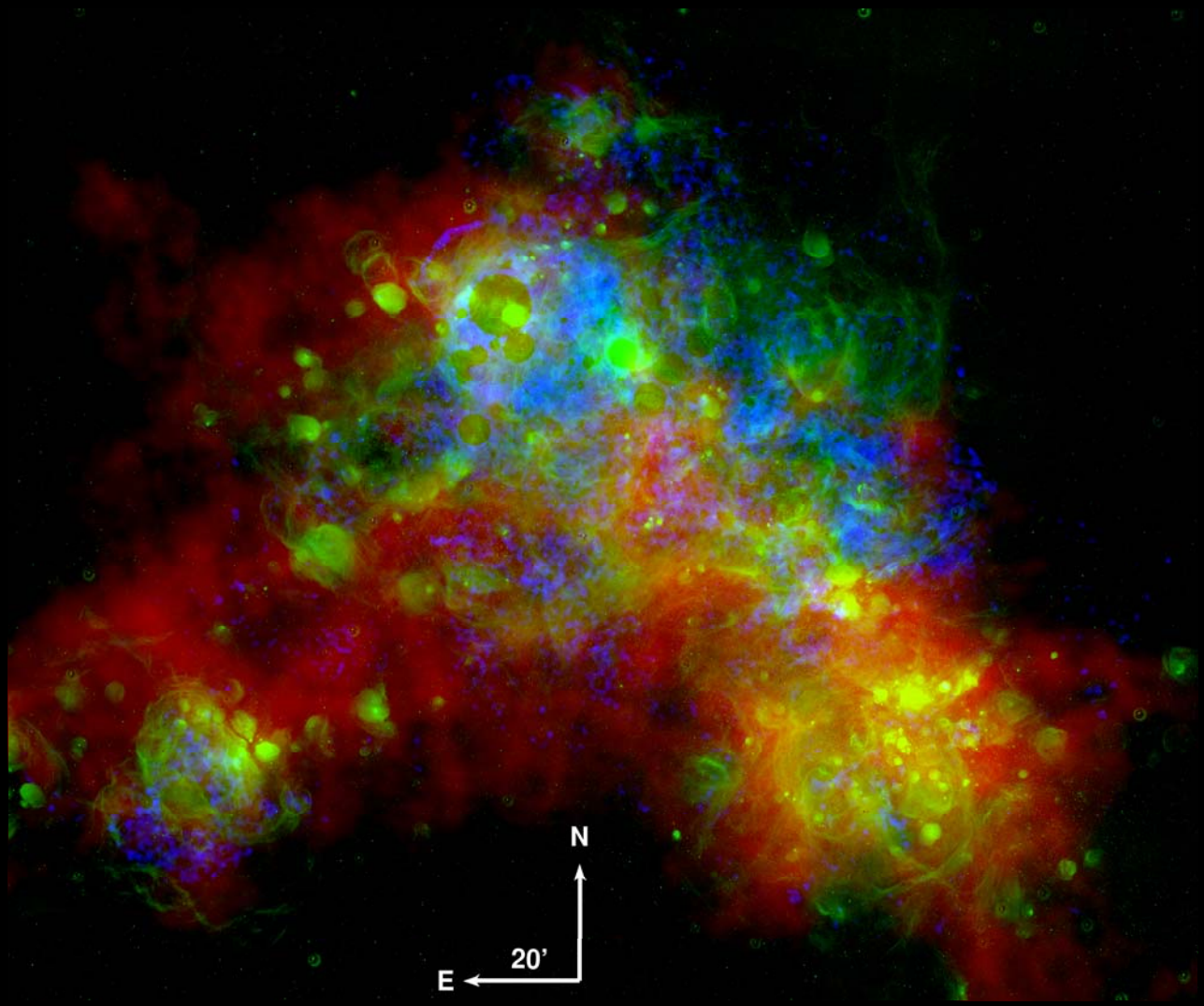


Diffuse emission from the hot ISM



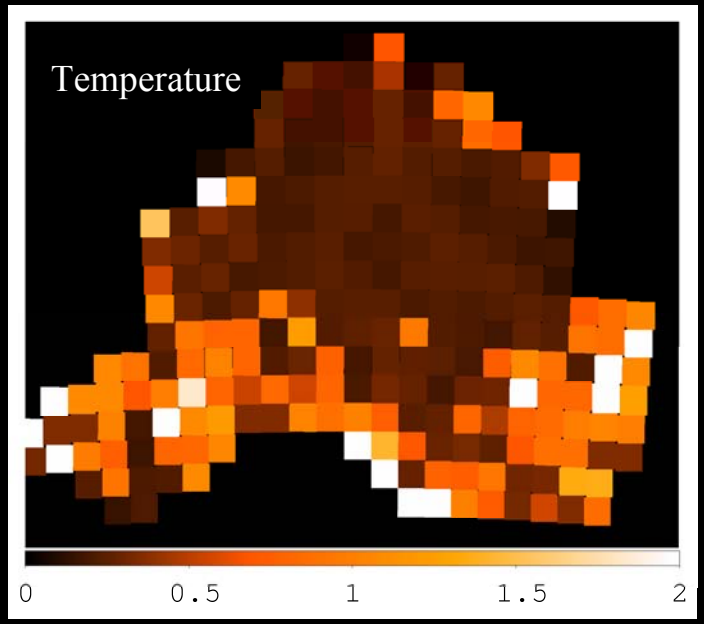


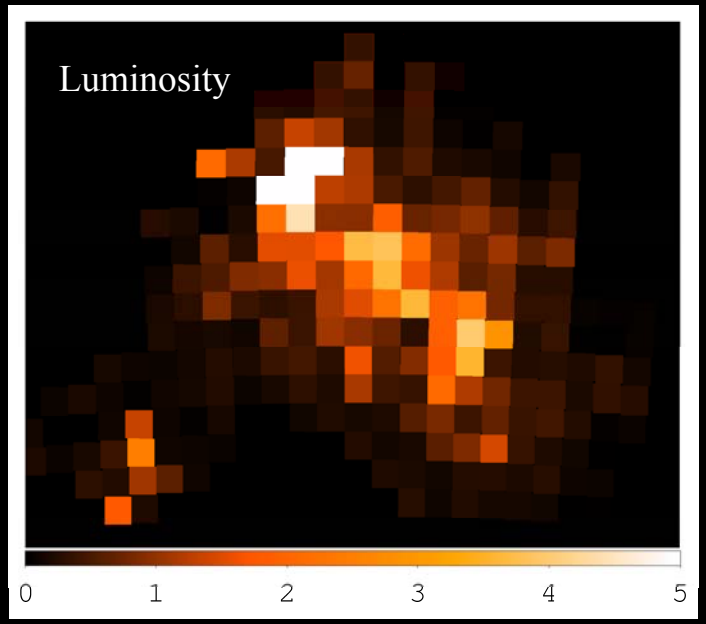




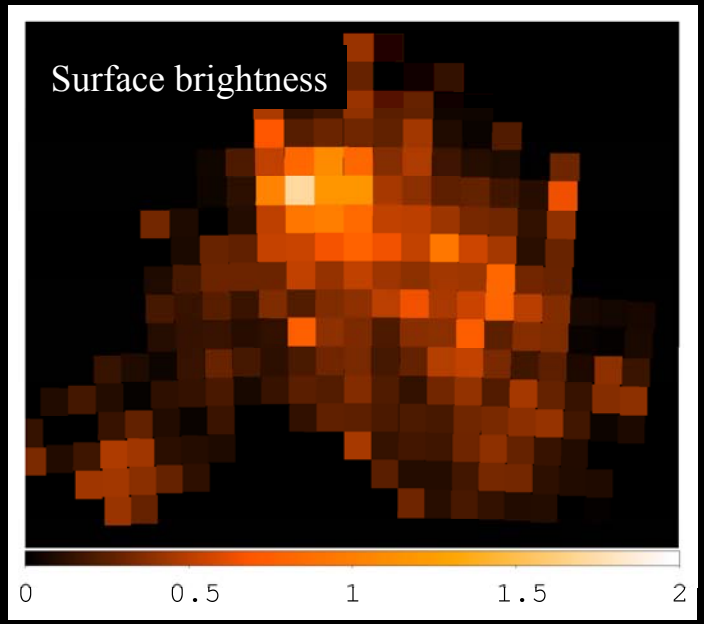
Sturm et al. in preparation

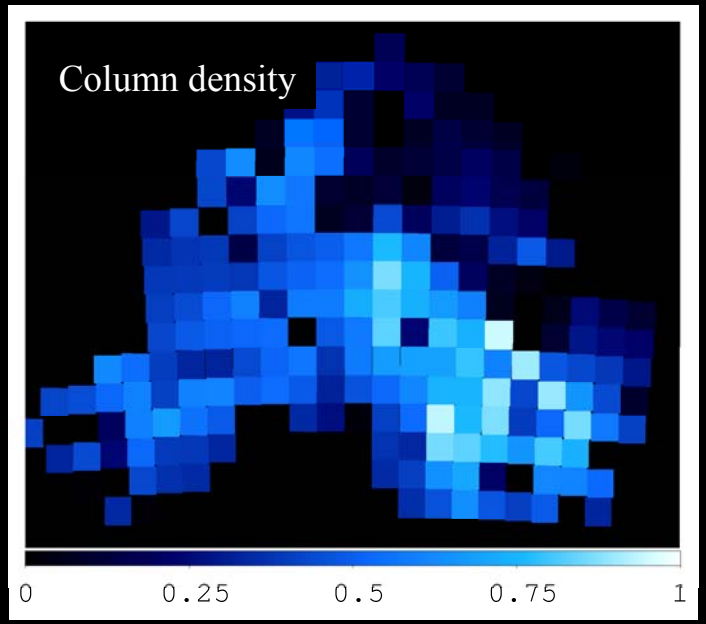
Diffuse emission from the hot ISM





Total:
7.1×10^{36} erg s^{-1}
absorption corrected:
4.0×10^{37} erg s^{-1}
(a factor of ~4 higher than from ROSAT due to higher absorption)





Sturm et al.
in preparation

Summary

The XMM-Newton survey of the SMC provides a unique data set
for X-ray source population studies.
It complements surveys at other wavelengths.

- Supernova remnants
  - Complete (surface brightness limited) sample
  - XMM can detect large, low kT (old) remnants
  - Interaction with their environment
- High Mass X-ray binaries
  - A large population of Be/X-ray binaries in the SMC
  - Allows statistical studies (XLF, SFH, spin – orbital periods)
- Supersoft X-ray sources
  - Discovered as a heterogeneous class of X-ray sources in the MCs
  - The nature of faint SSS: PN, symbiotic systems, Be/WD binaries

Most comprehensive source catalogue of the SMC region

- X-ray properties (energy spectrum, temporal behaviour)
- Information from other wavelength (radio, optical)
- Foreground (stars) and background (AGN) objects