THE DIFFUSE X-RAY EMISSION OF THE SMALL MAGELLANIC CLOUD

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On behalf of the XMM-Newton SMC large-program collaboration:

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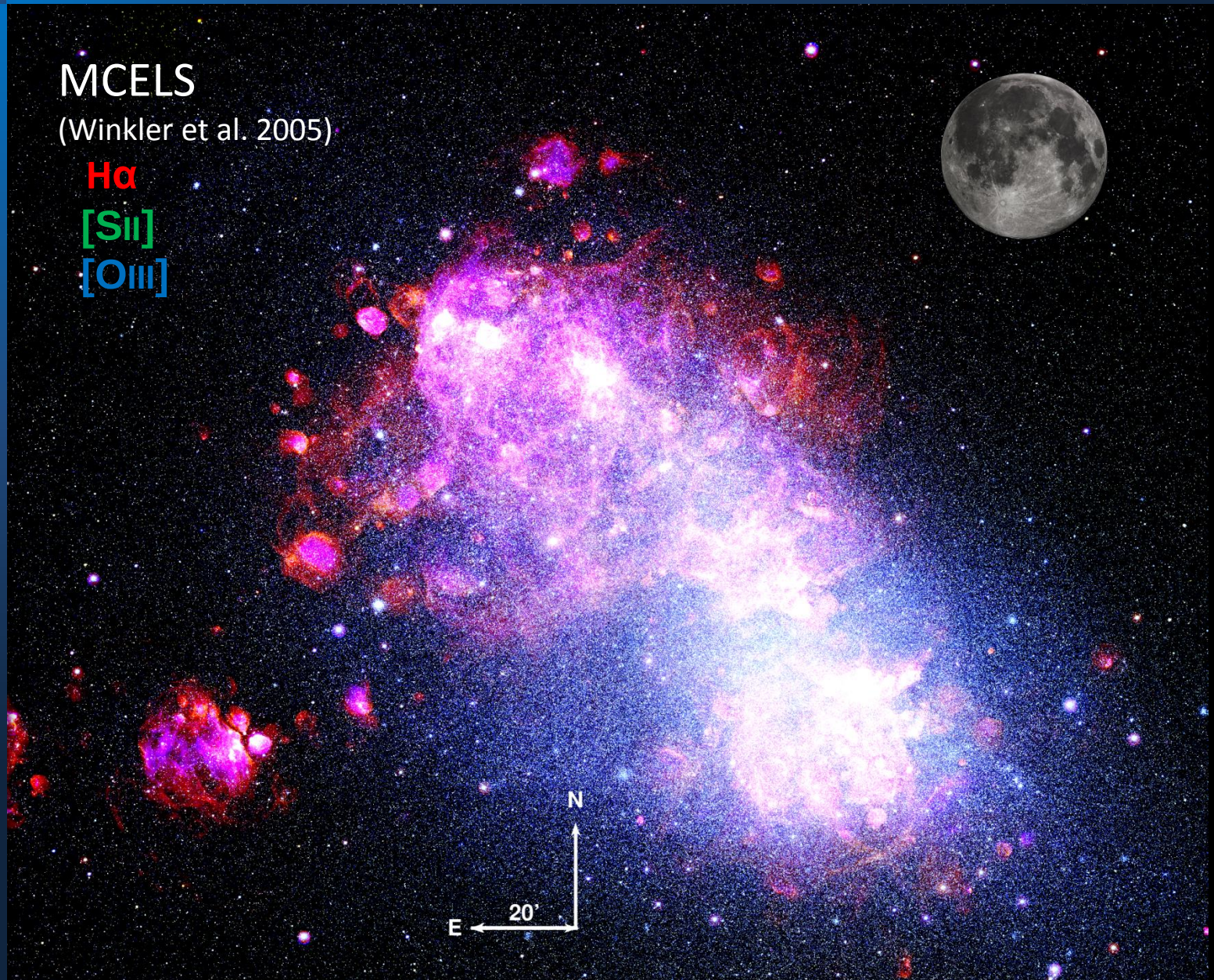
Motivation

- The interstellar medium (ISM) is a non-linear system with several components (gas, dust, magnetic field, etc.) and several phases (cool, warm, hot). The hot phase is studied best in X-rays.
- Energy input by SN explosions and stellar wind of massive stars
  ⇒ X-ray luminosity correlates with star formation
- Outflows in dwarf galaxies might escape into IGM/Galactic halo
- The Small Magellanic Cloud (SMC) is
  - the second nearest star-forming galaxy ($D = 60\ \mathrm{kpc}$)
  - a dwarf galaxy with low metallicity ($Z_{SMC} \sim 0.2\ Z_{\odot}$)
- Diffuse X-ray emission observed with:
  - EINSTEIN: $L_X \sim 10^{38-39}\mathrm{erg\ s^{-1}}$ (Wang & Wu 1992)
  - ROSAT: $L_X \sim 10^{37}\mathrm{erg\ s^{-1}}$, $T \sim 10^{6-7}\mathrm{K}$ (Sasaki et al. 2002)

The Small Magellanic Cloud



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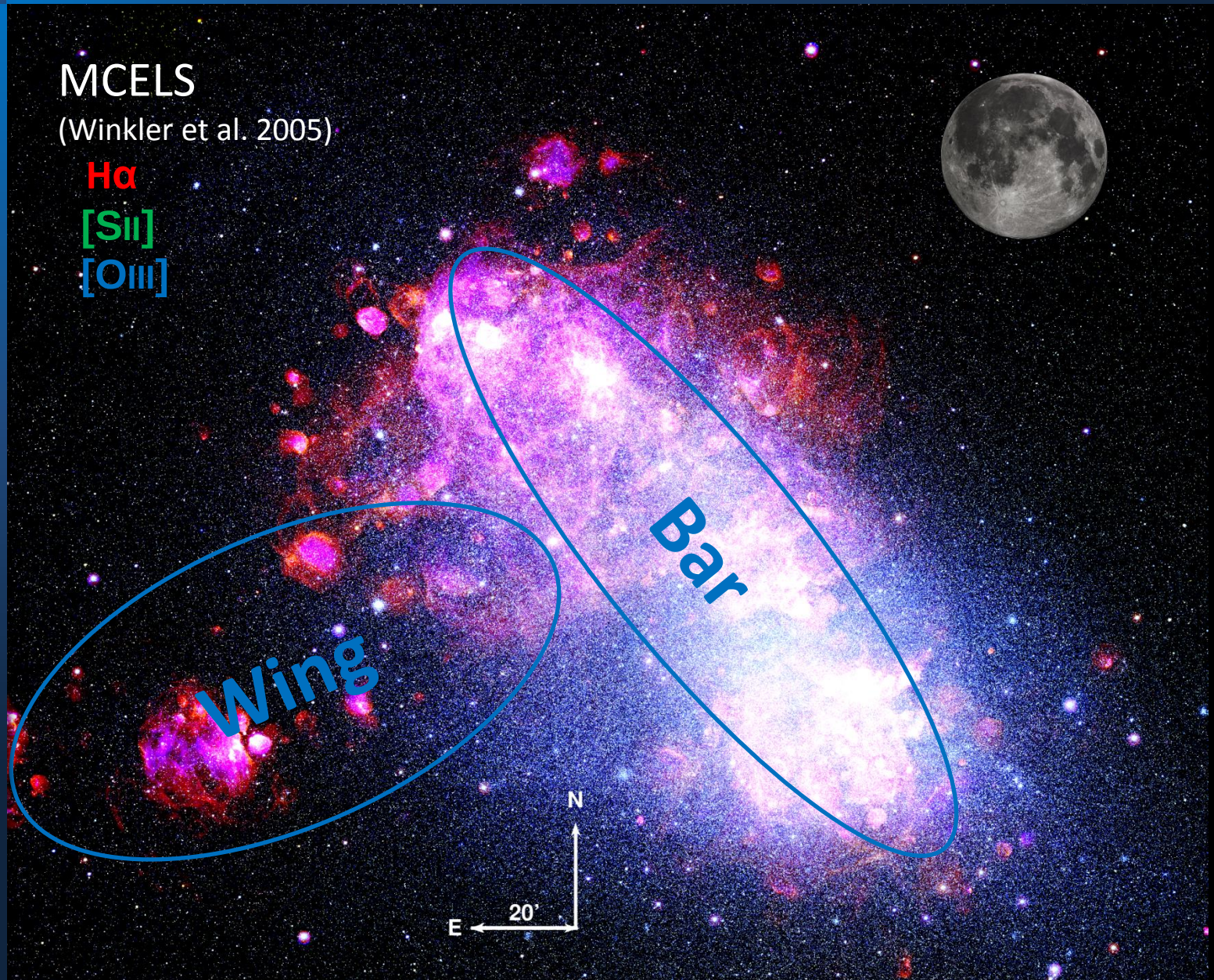

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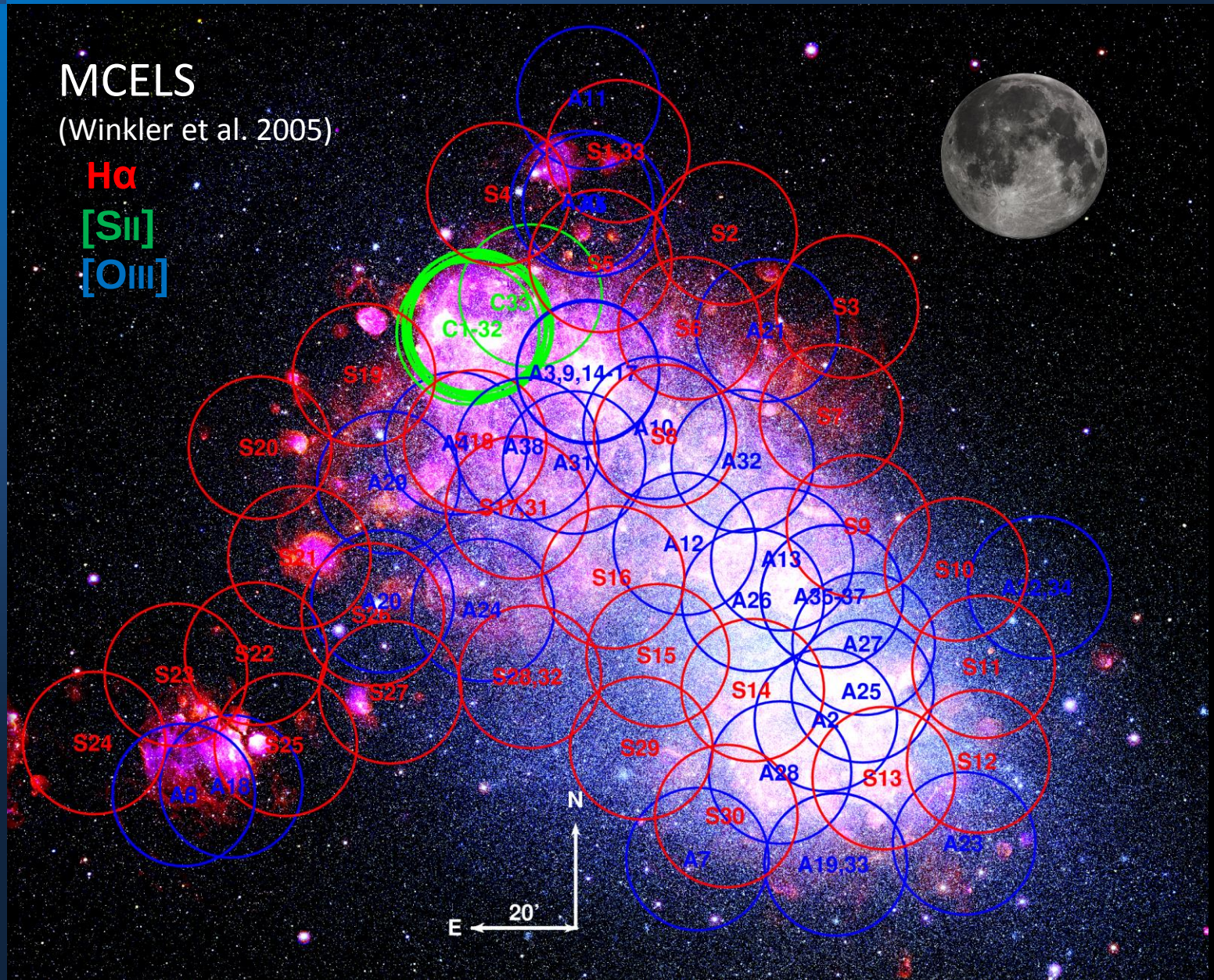
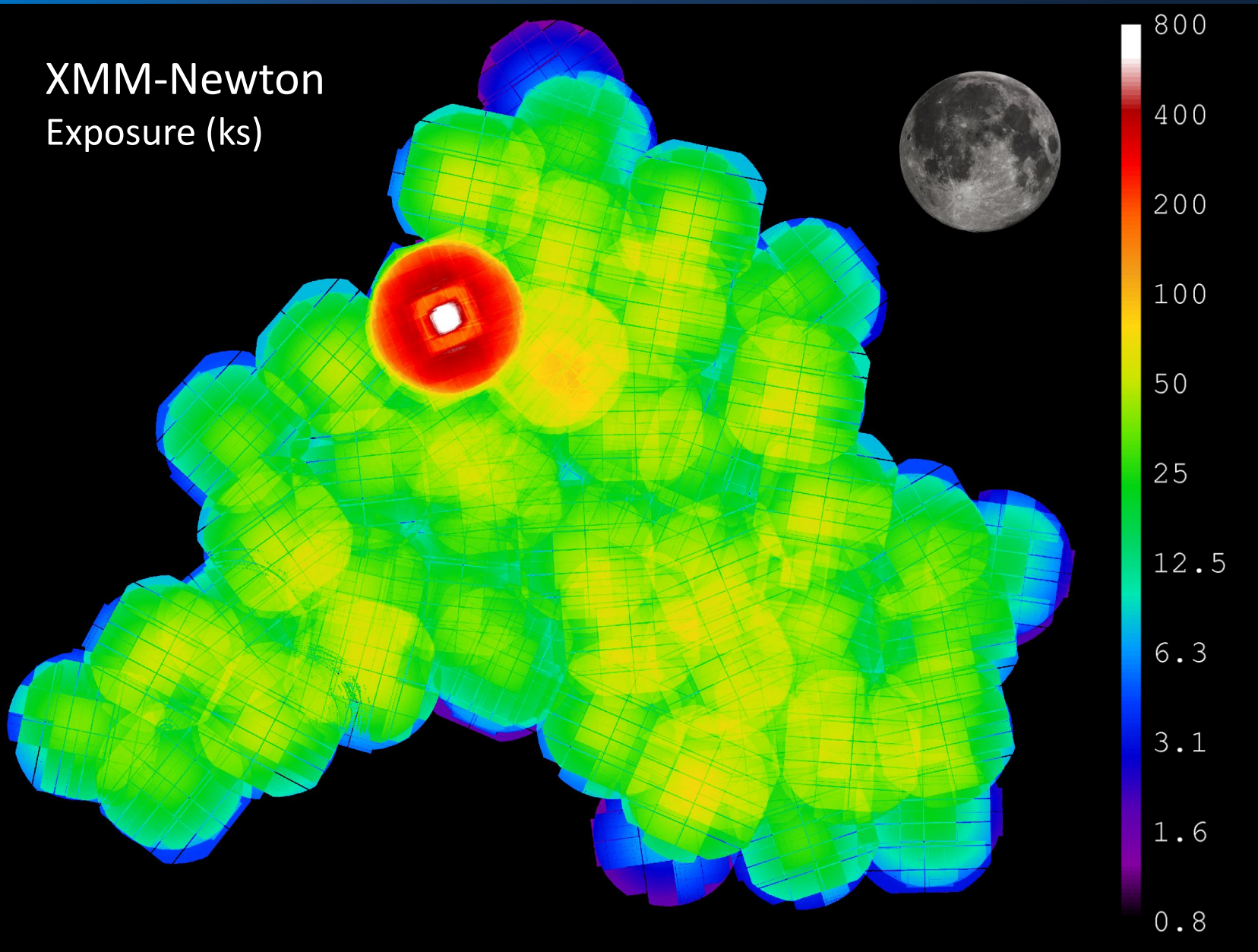
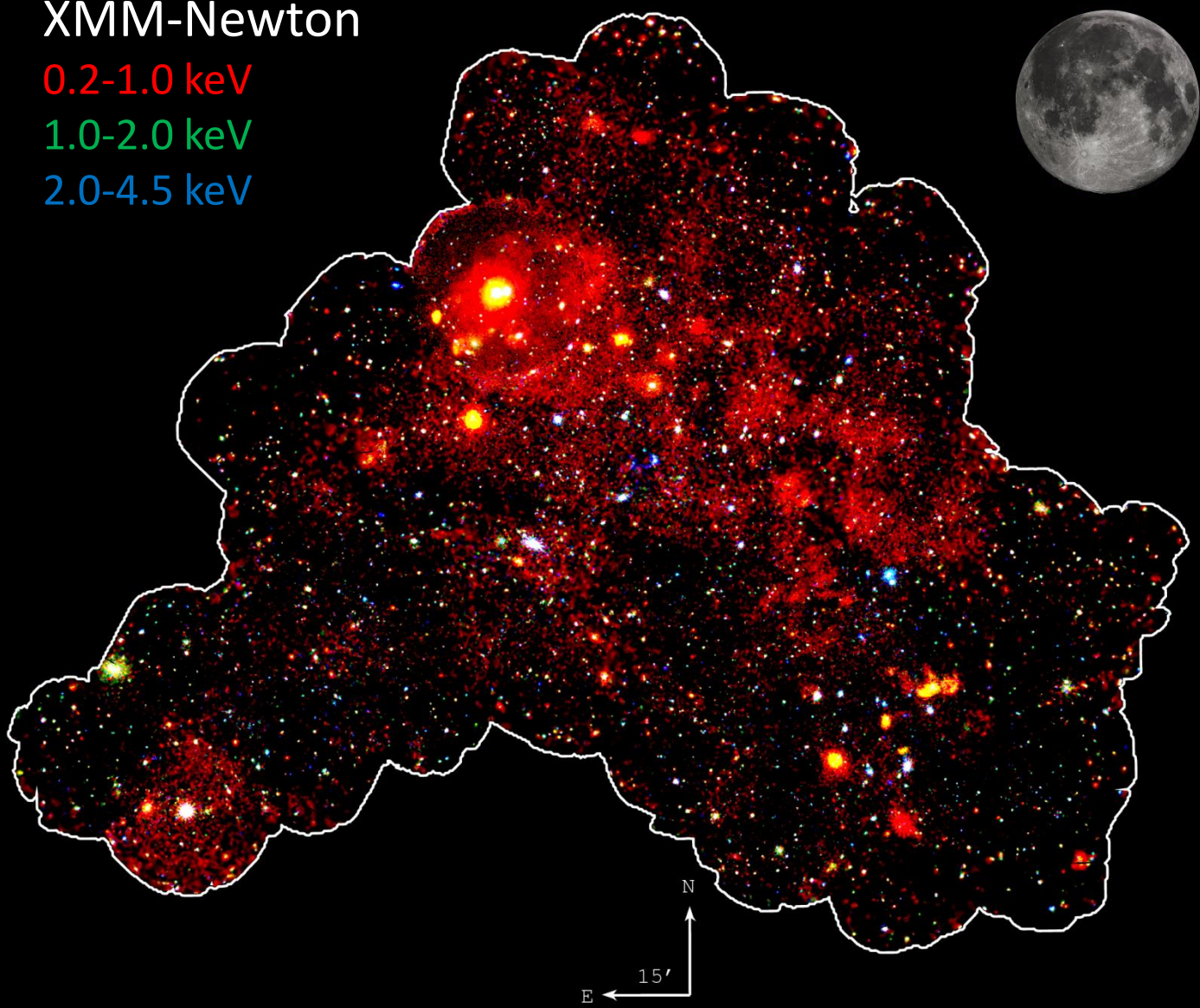


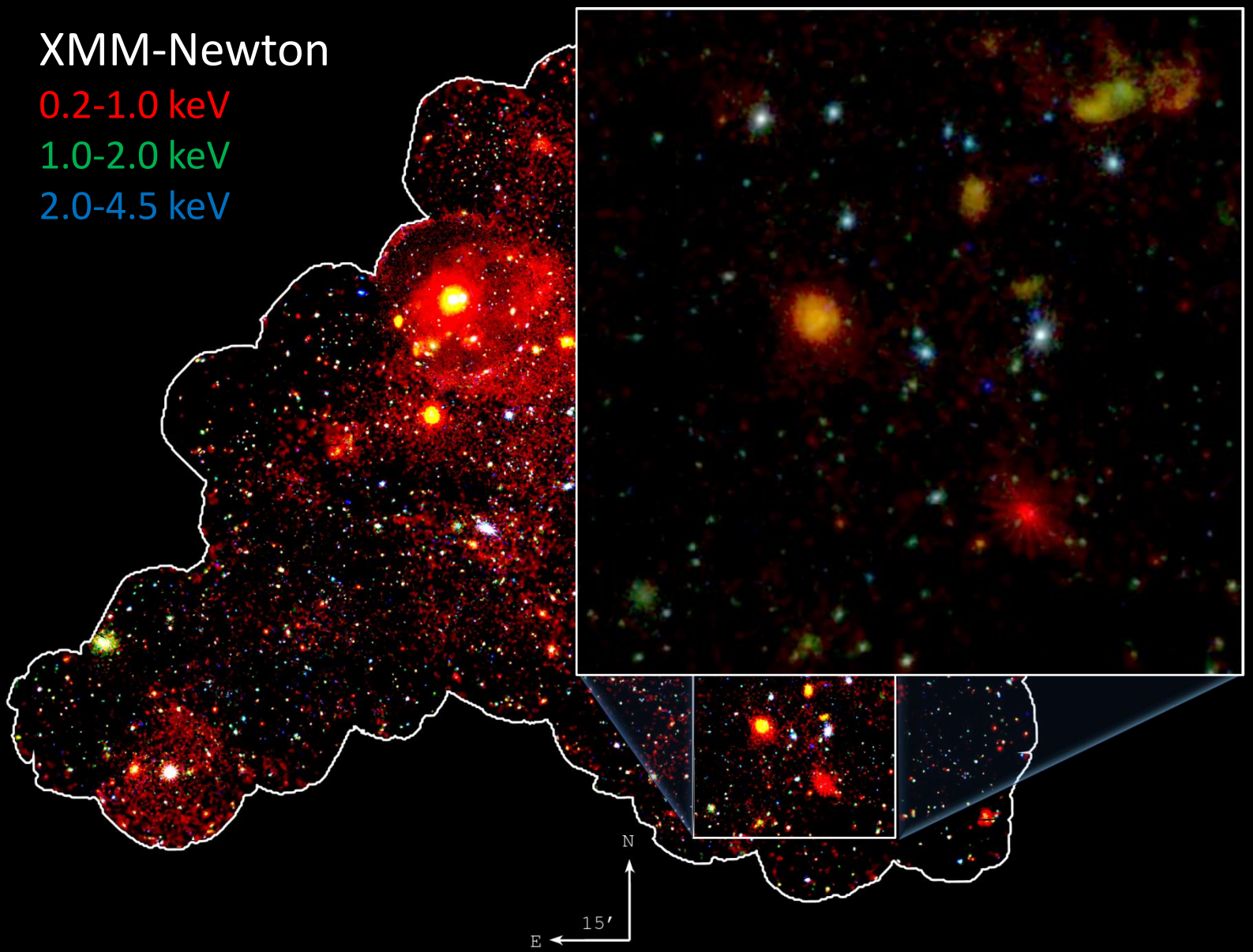
The XMM-Newton SMC survey



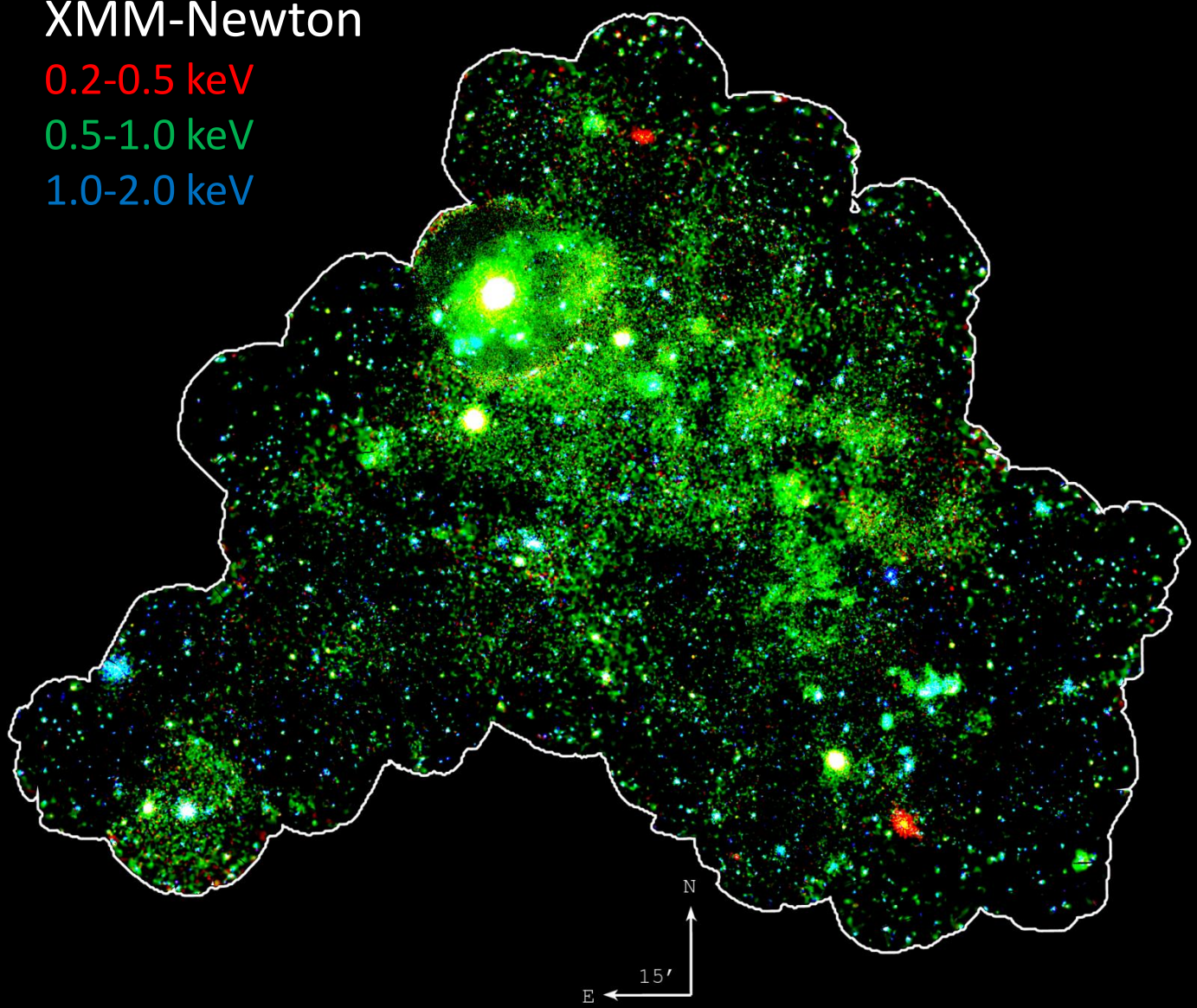
The Small Magellanic Cloud in X-rays



The Small Magellanic Cloud in X-rays



Comparison with ROSAT



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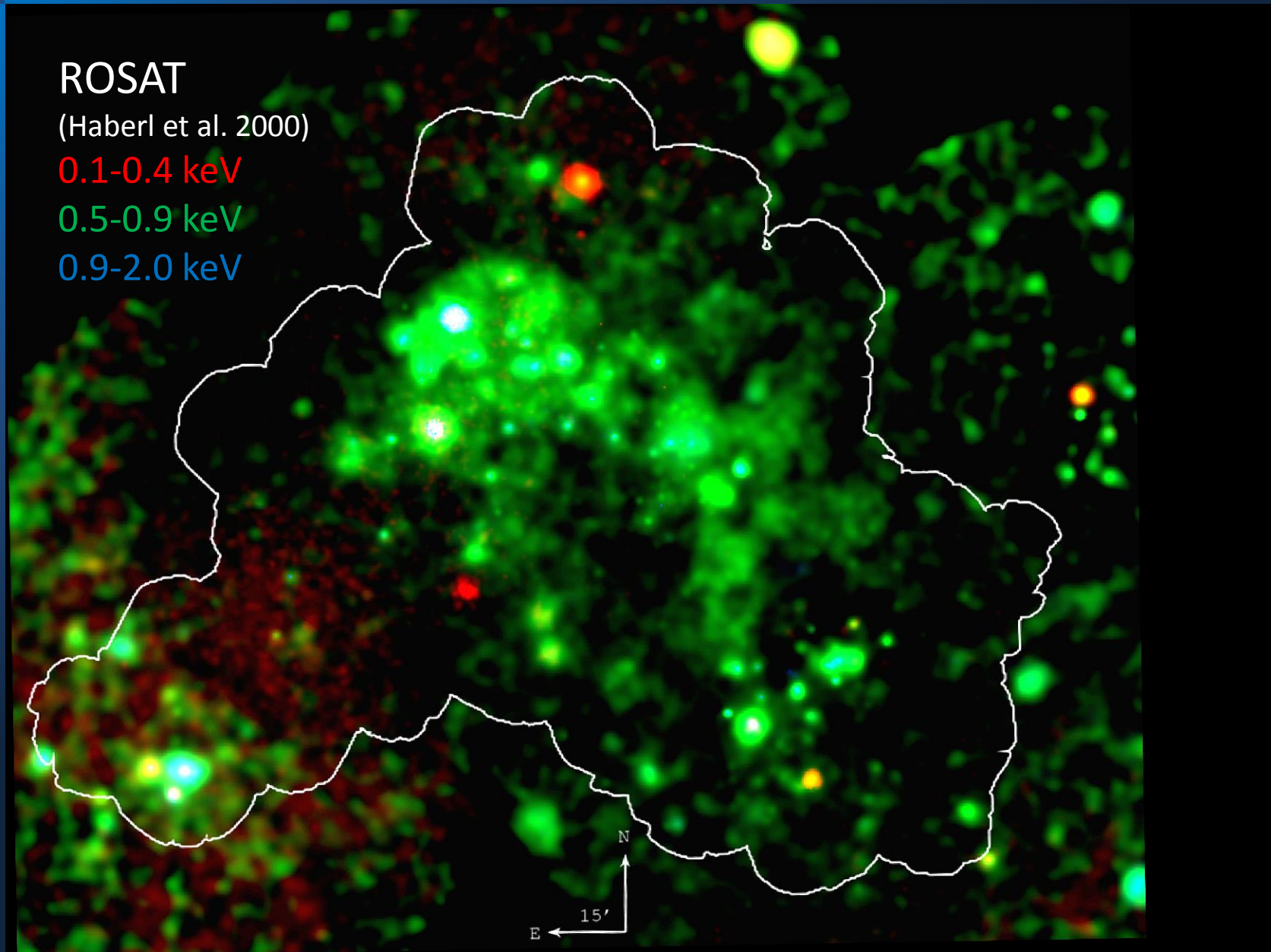
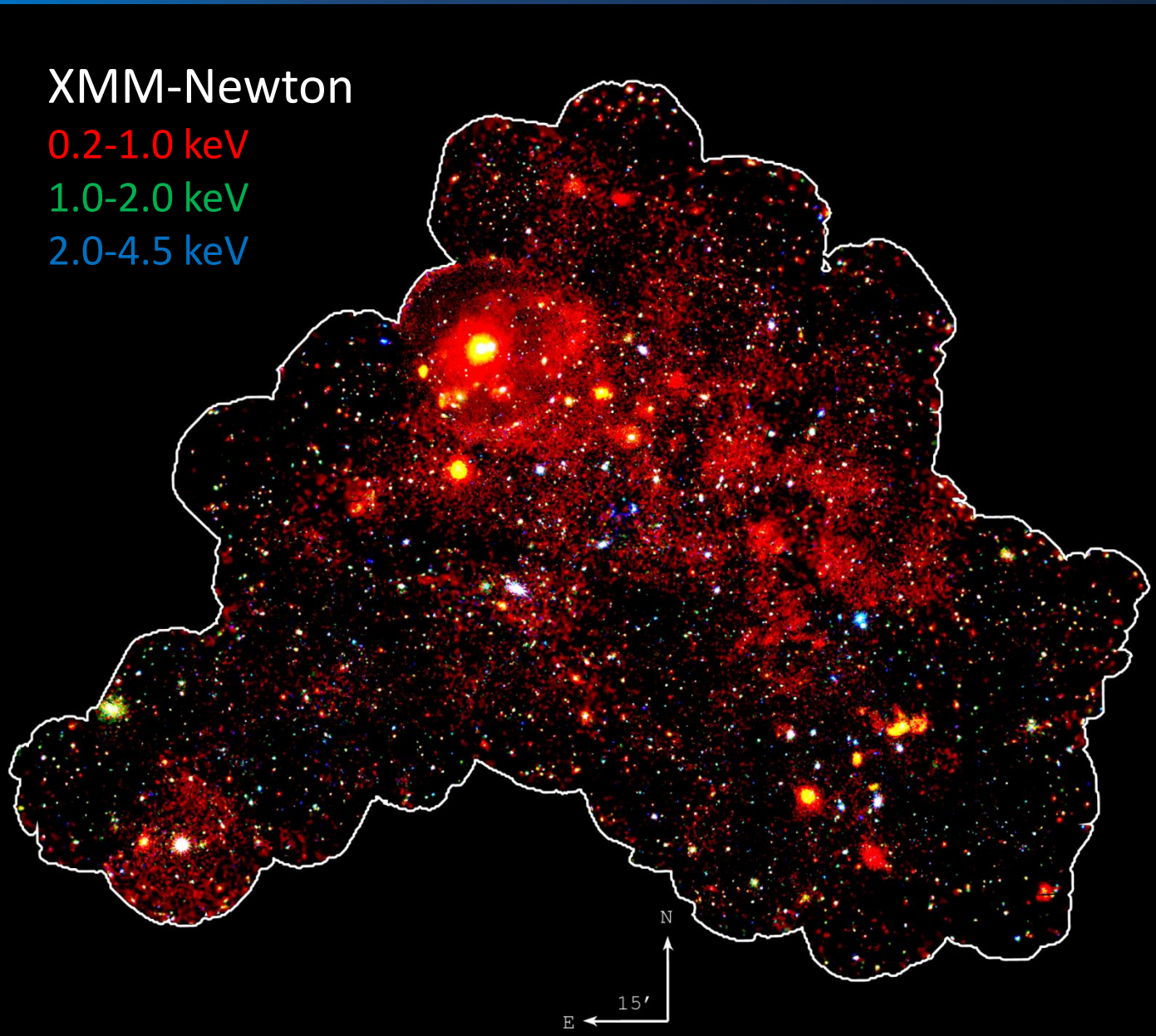


Analysis of the diffuse emission



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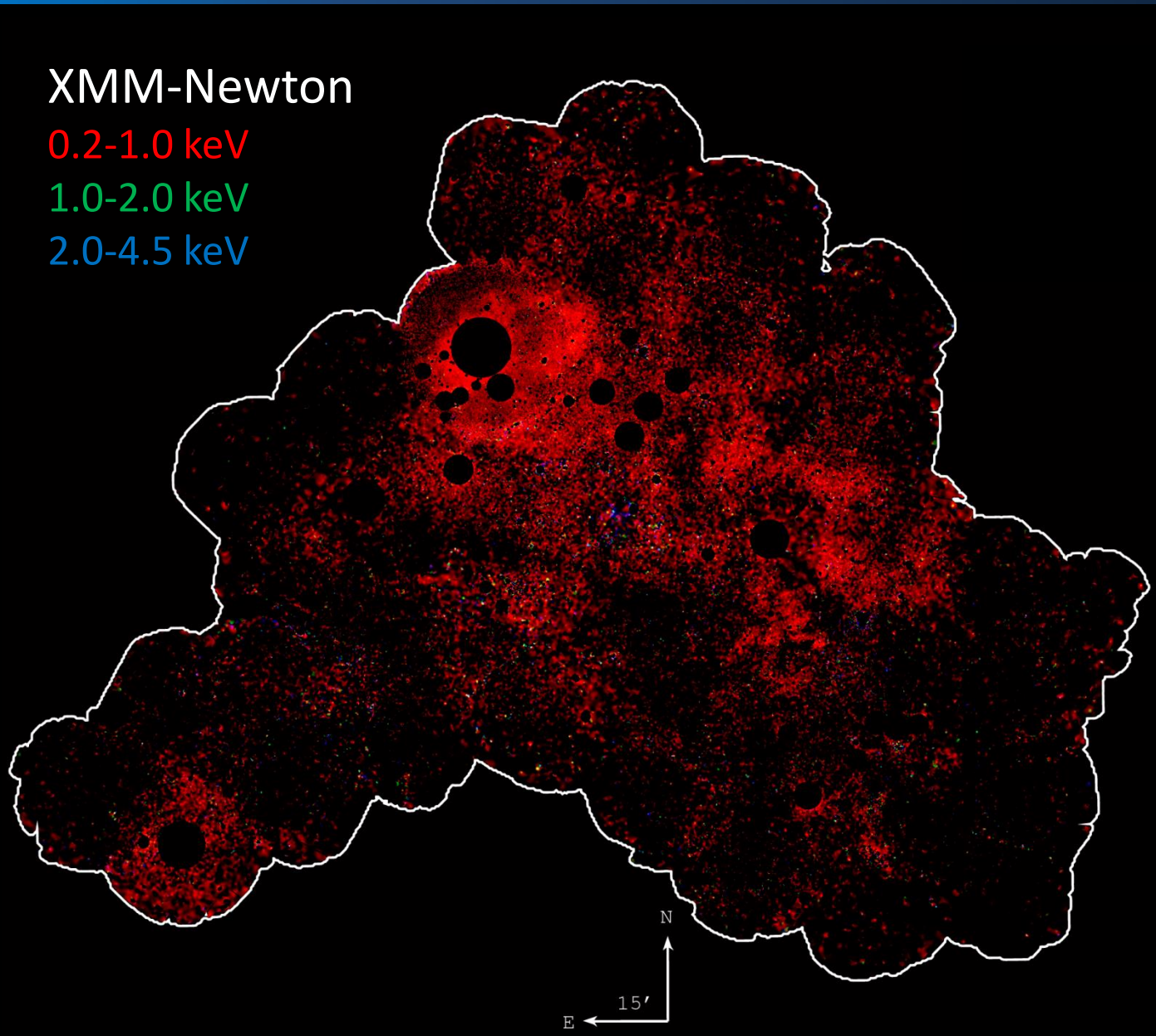

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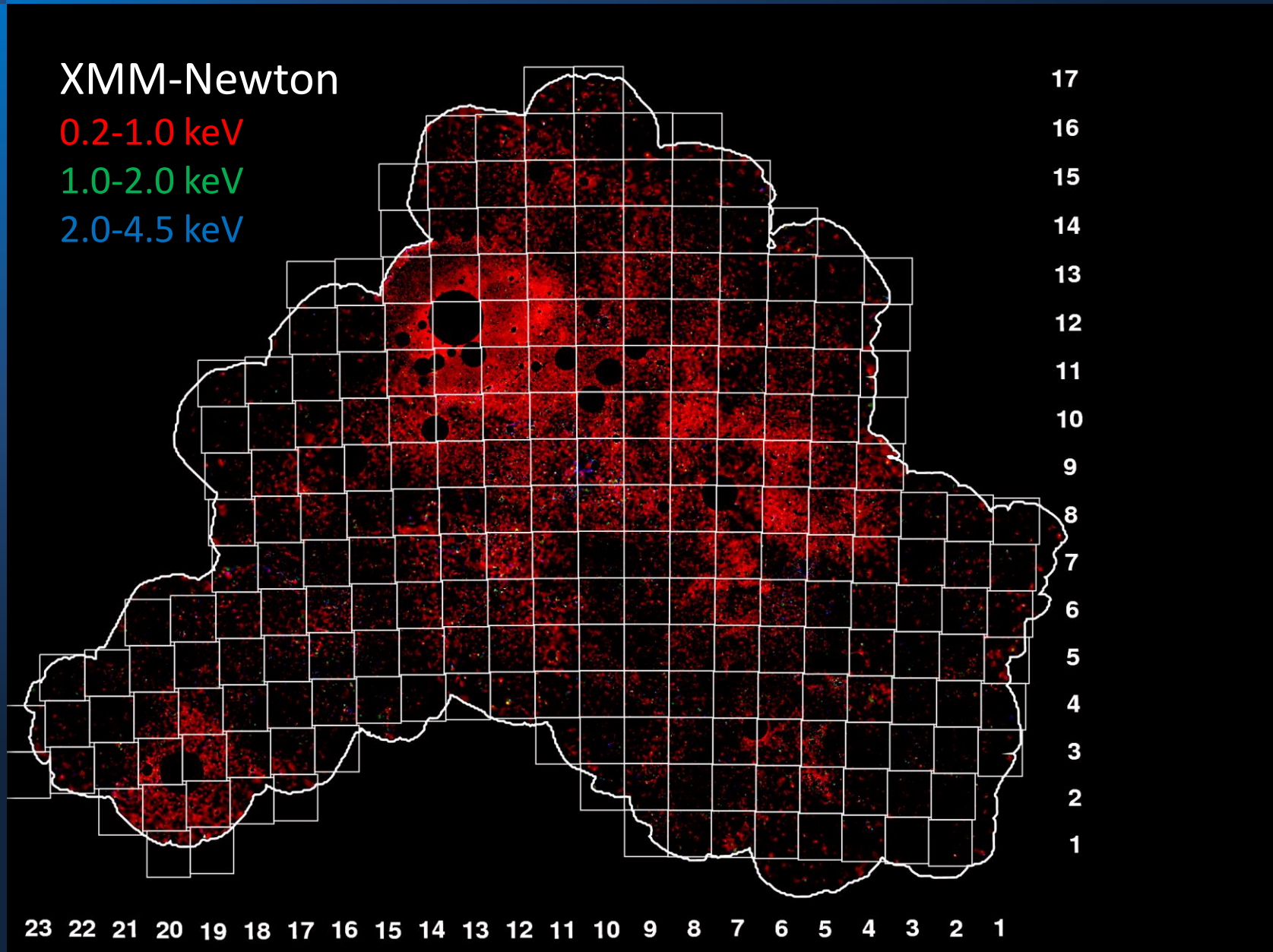

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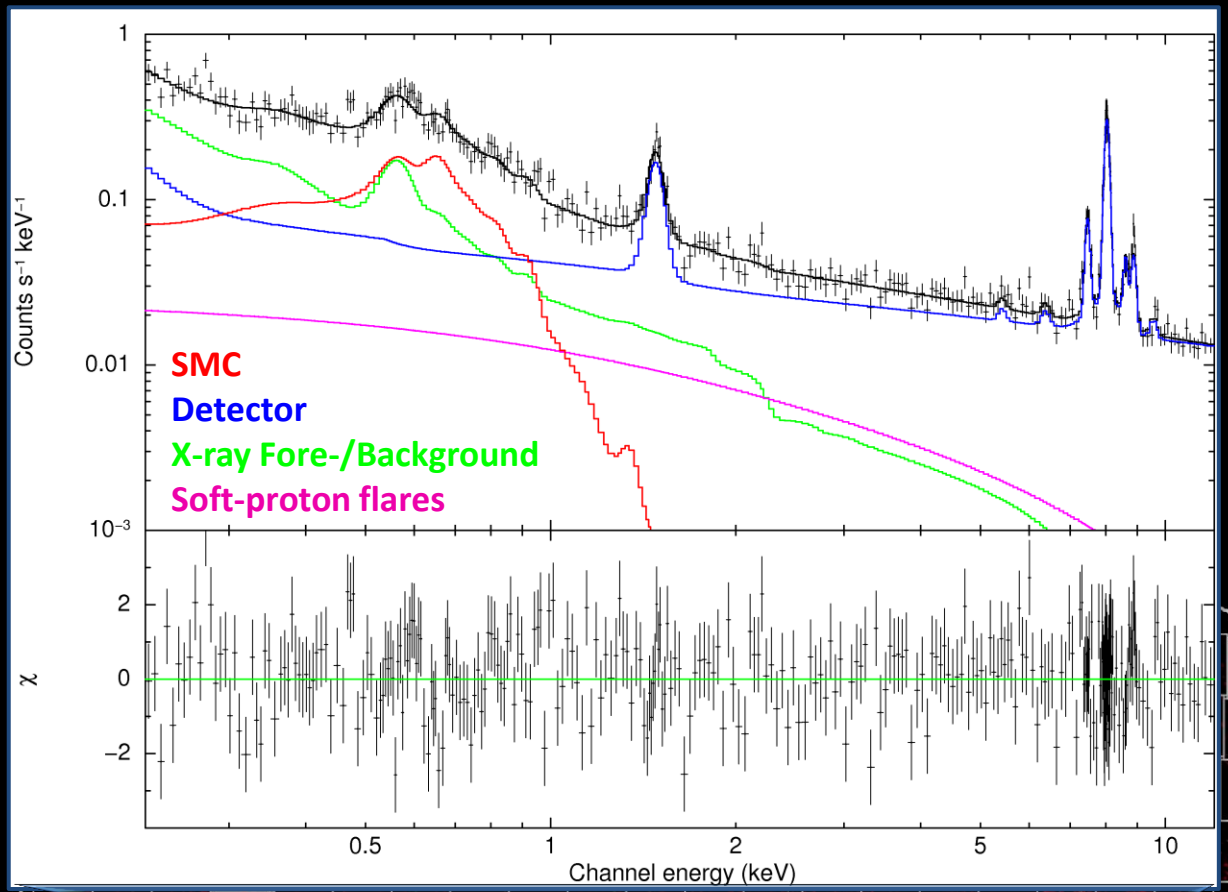

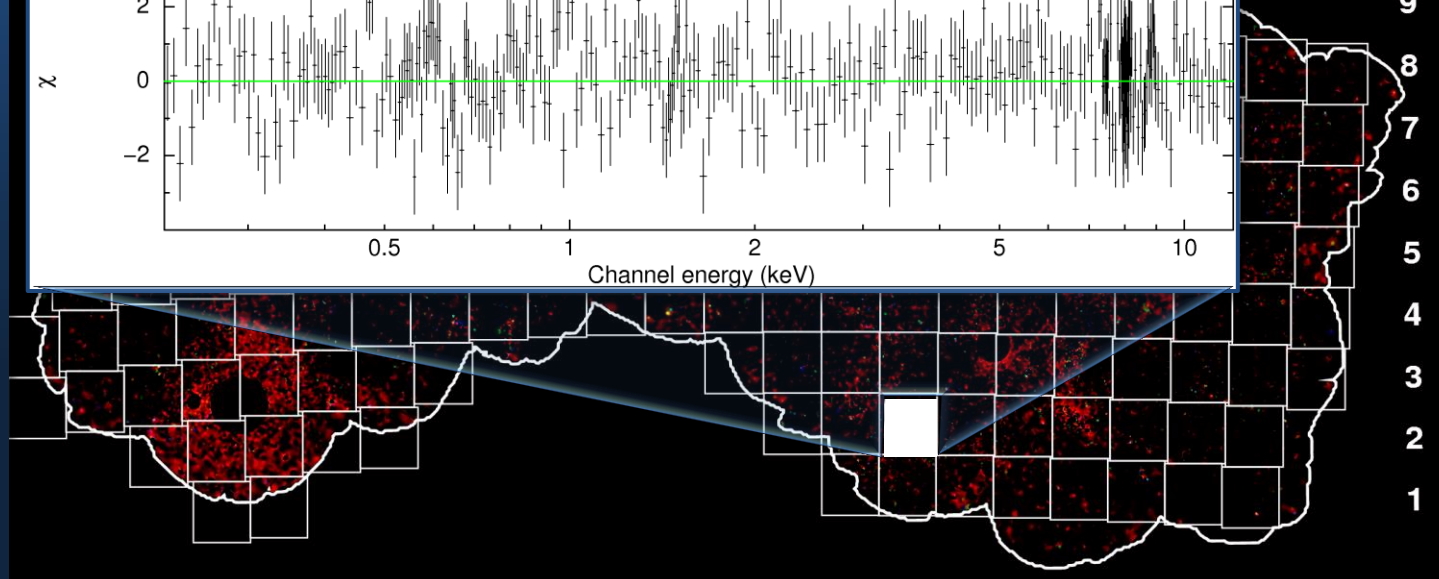

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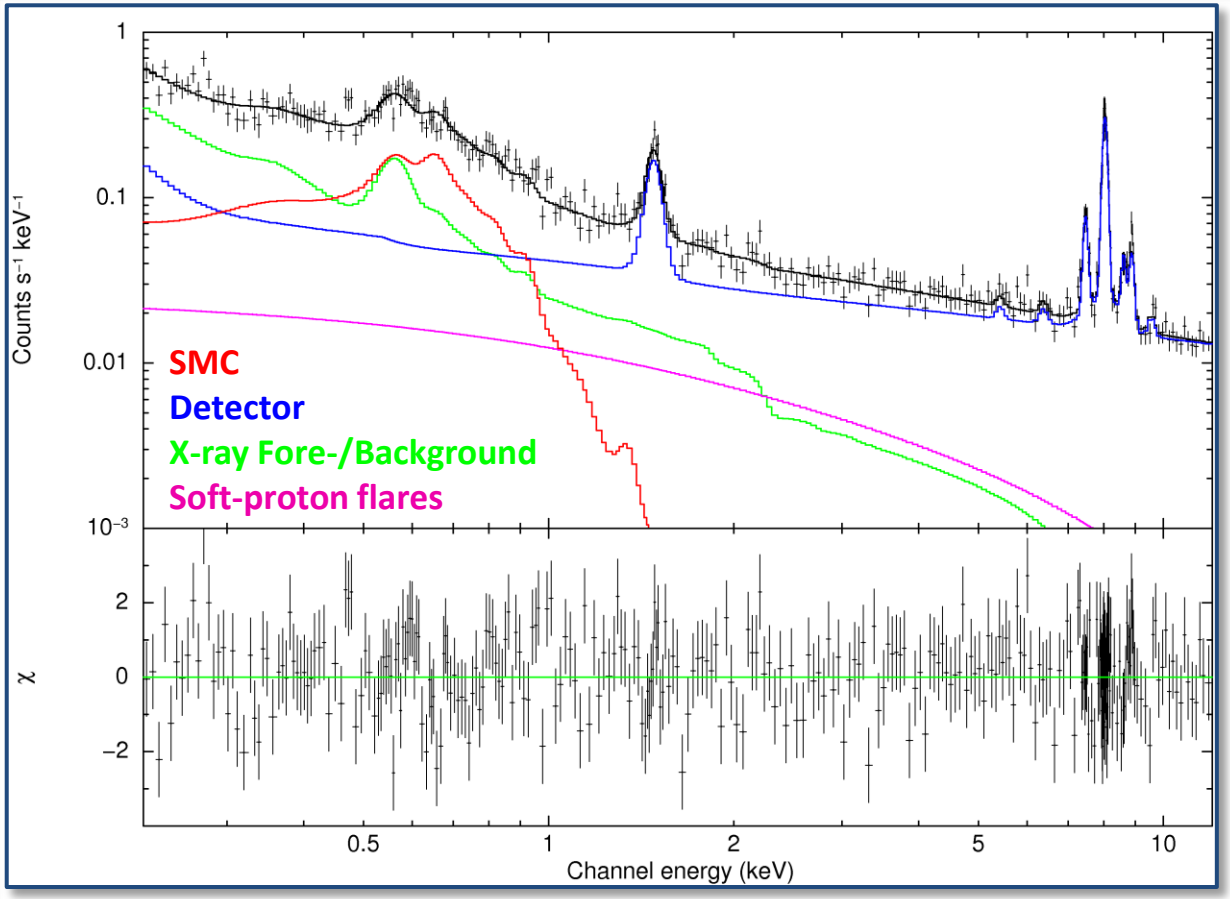


In total:

240 regions

647 spectra of EPIC-pn

$S_{smc} = \text{phabs}_{Gal} * \text{phabs}_{smc} * \text{APEC}$

$S_{xrb} = \text{APEC} + \text{phabs}_{Gal} * (\text{APEC} + \text{APEC} + \text{phabs}_{smc} * \text{PL})$

$S_{det} = \text{Readout noise} + \text{CONTINUUM} + \text{LINES}$

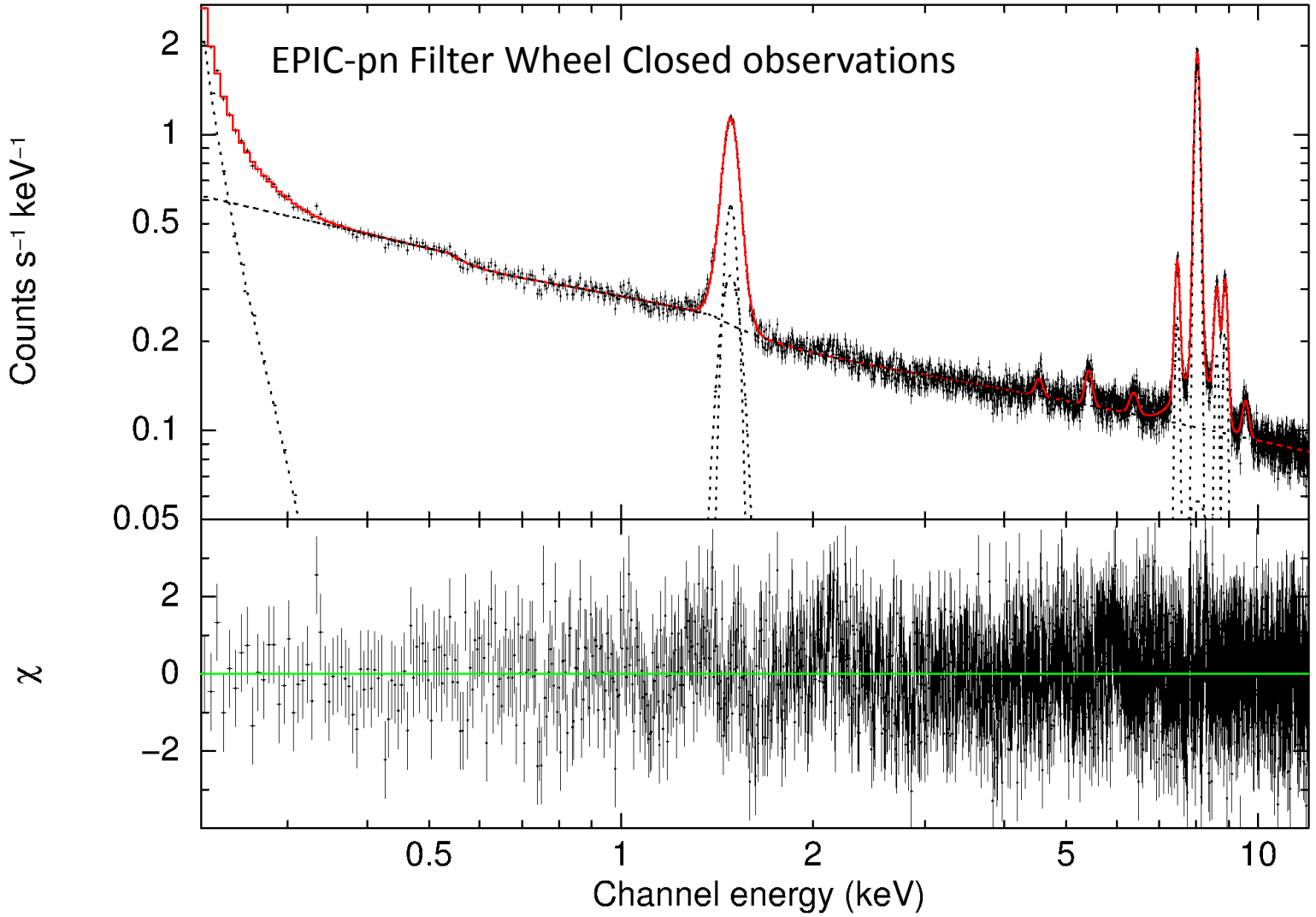
Parameters

N_H^{smc}, T_{smc}, EM

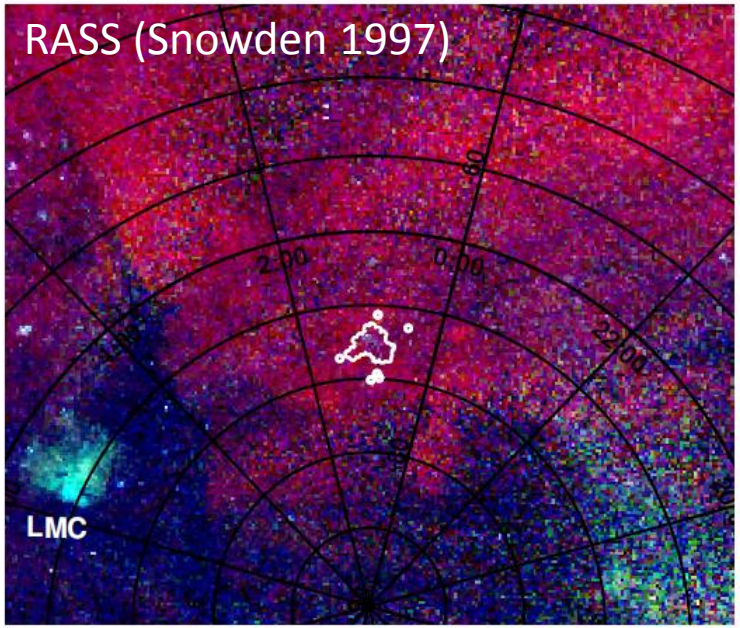
none

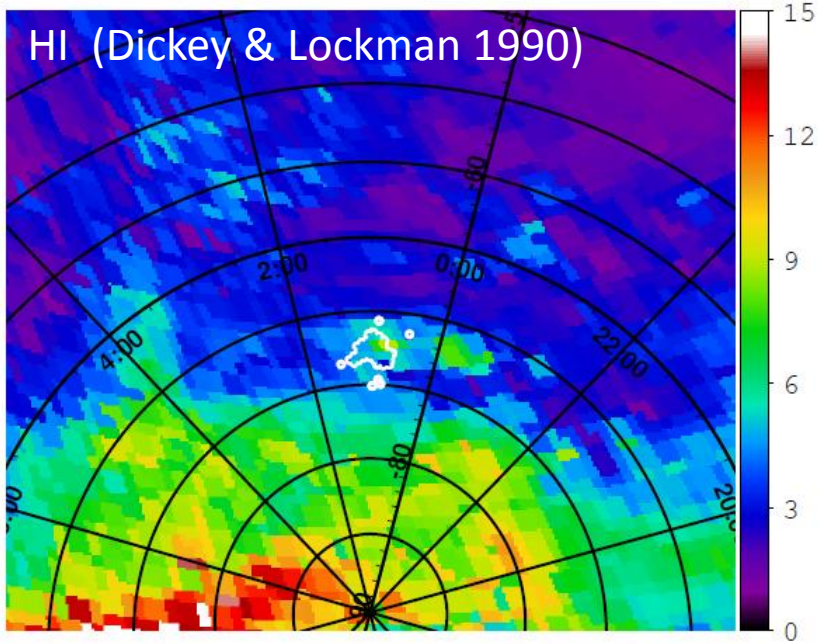
$N_{readout}, N_{cont}$

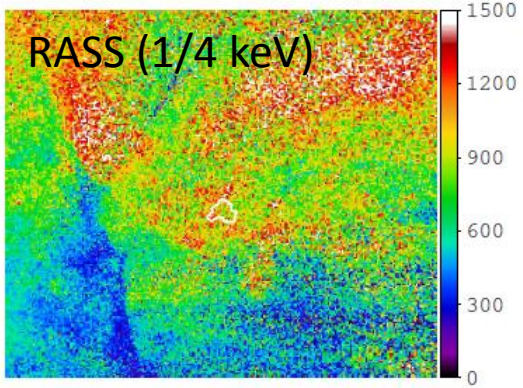
Detector background

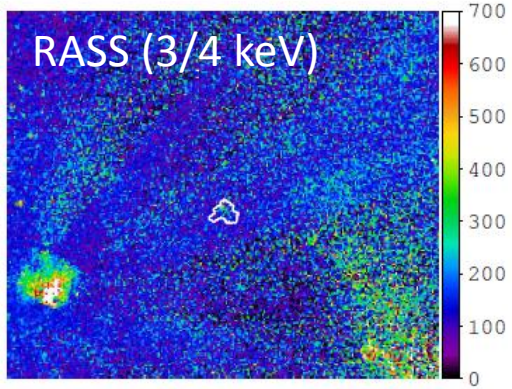


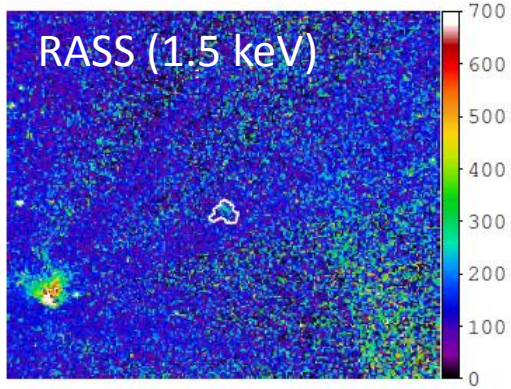
X-ray fore- & background



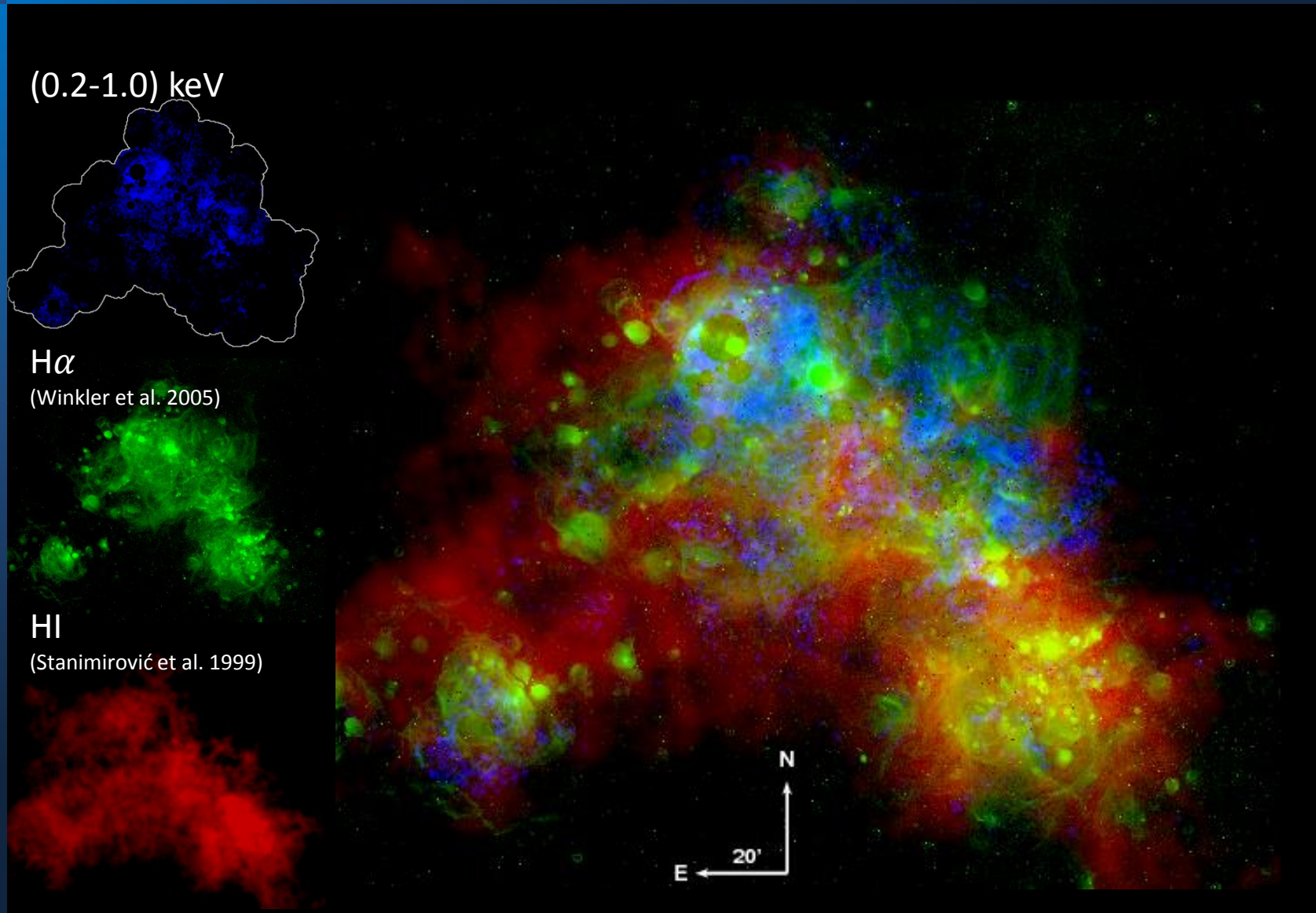




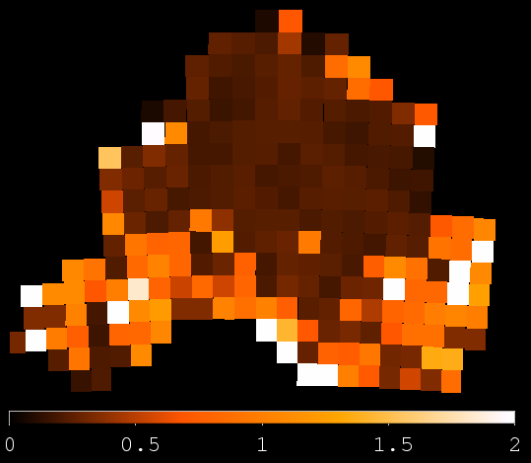




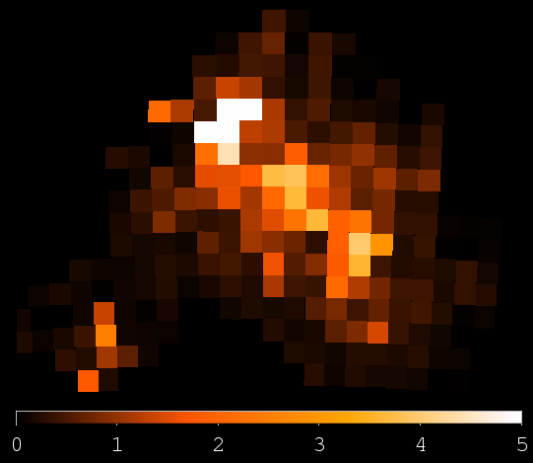
Morphology of the ISM



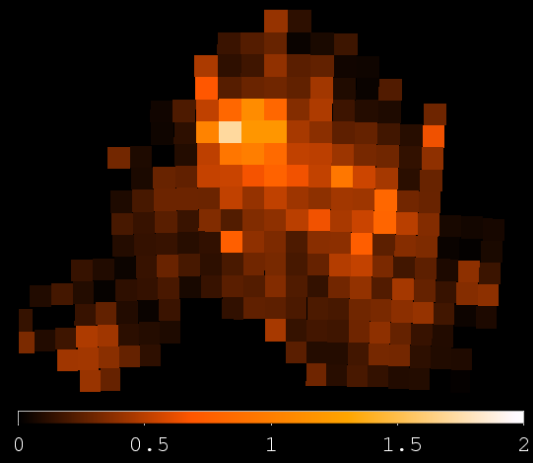
The spectral properties of the hot ISM



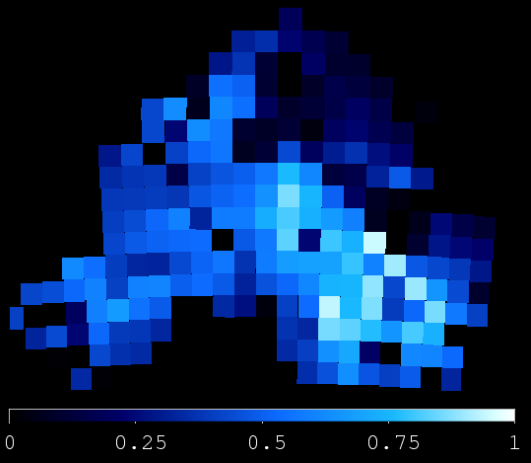
kT [keV]



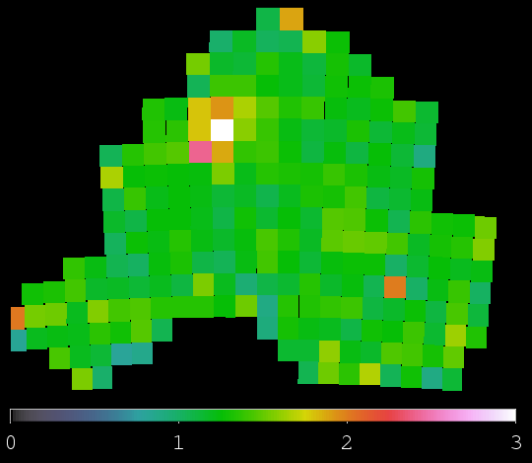
L [10^{11}erg s^{-1} arcsec^{-2}]



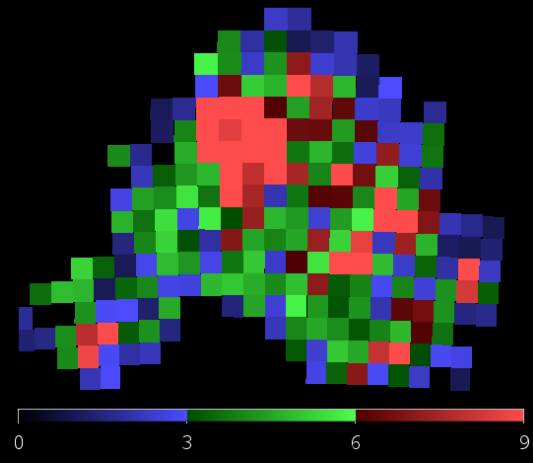
F [10^{-18}erg cm^{-2} s^{-1} arcsec^{-2}]



N_H^{smc} [10^{22}cm^{-2}]

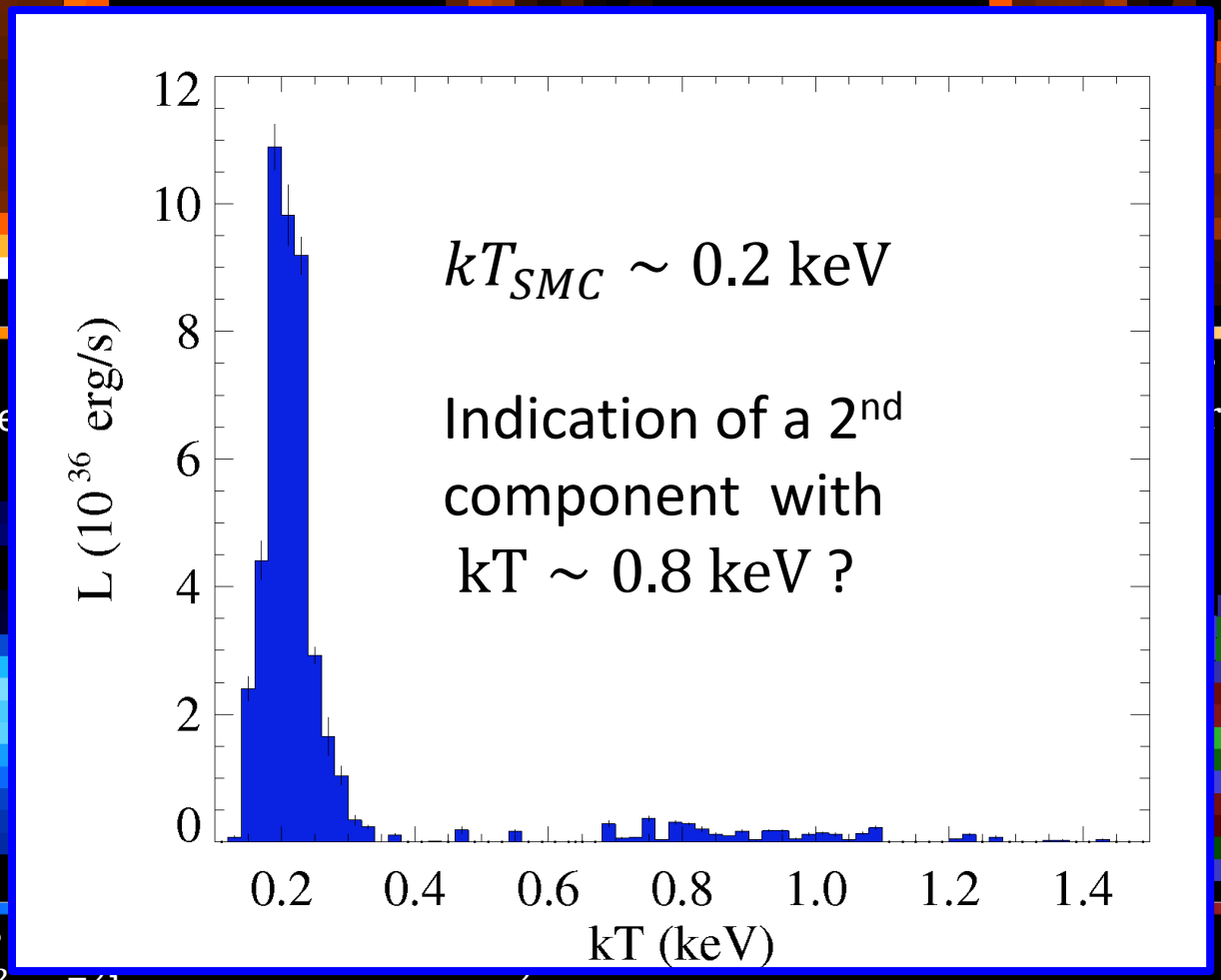


χ_ν^2

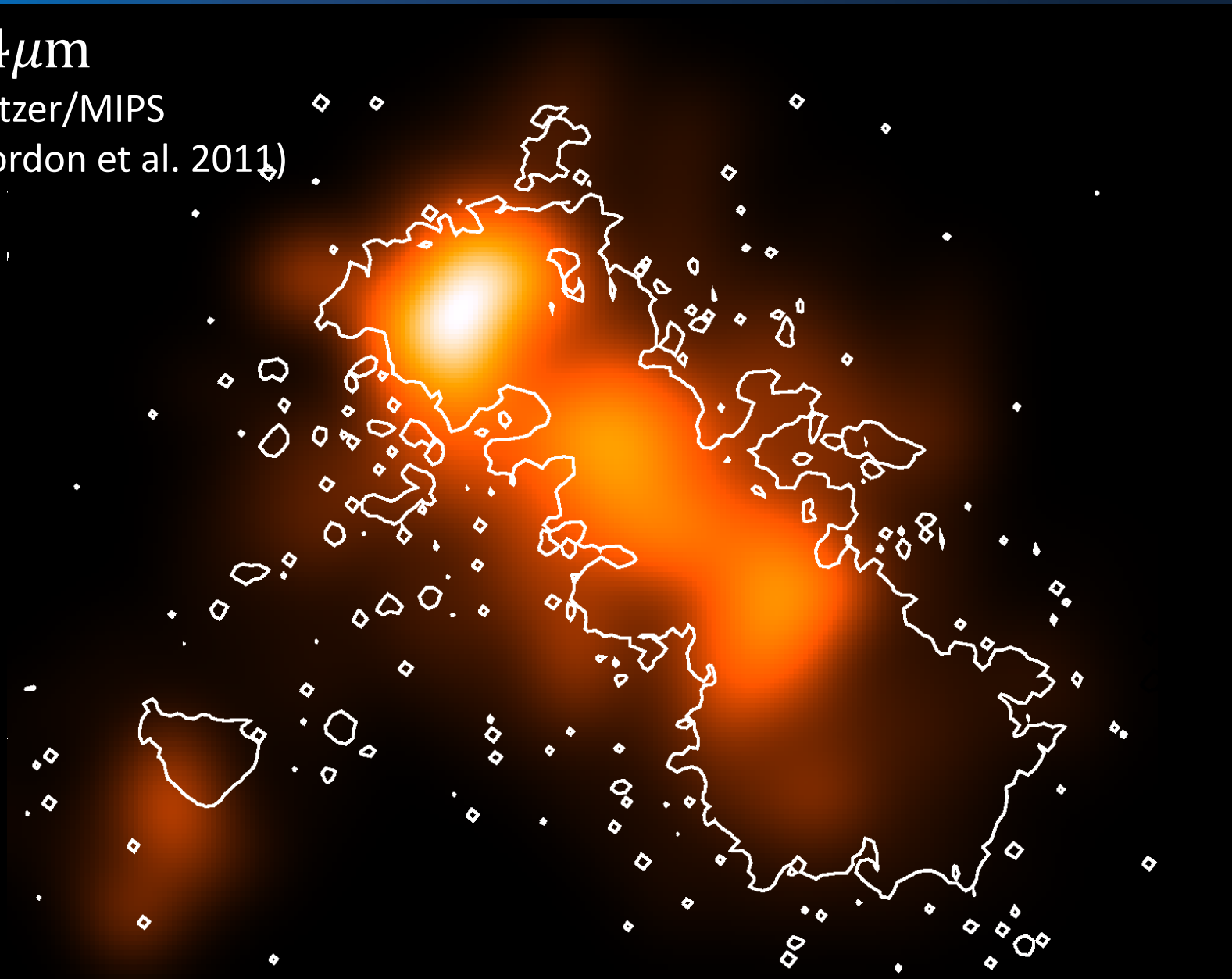


Significance [σ]

The spectral properties of the hot ISM



Origin of the diffuse emission



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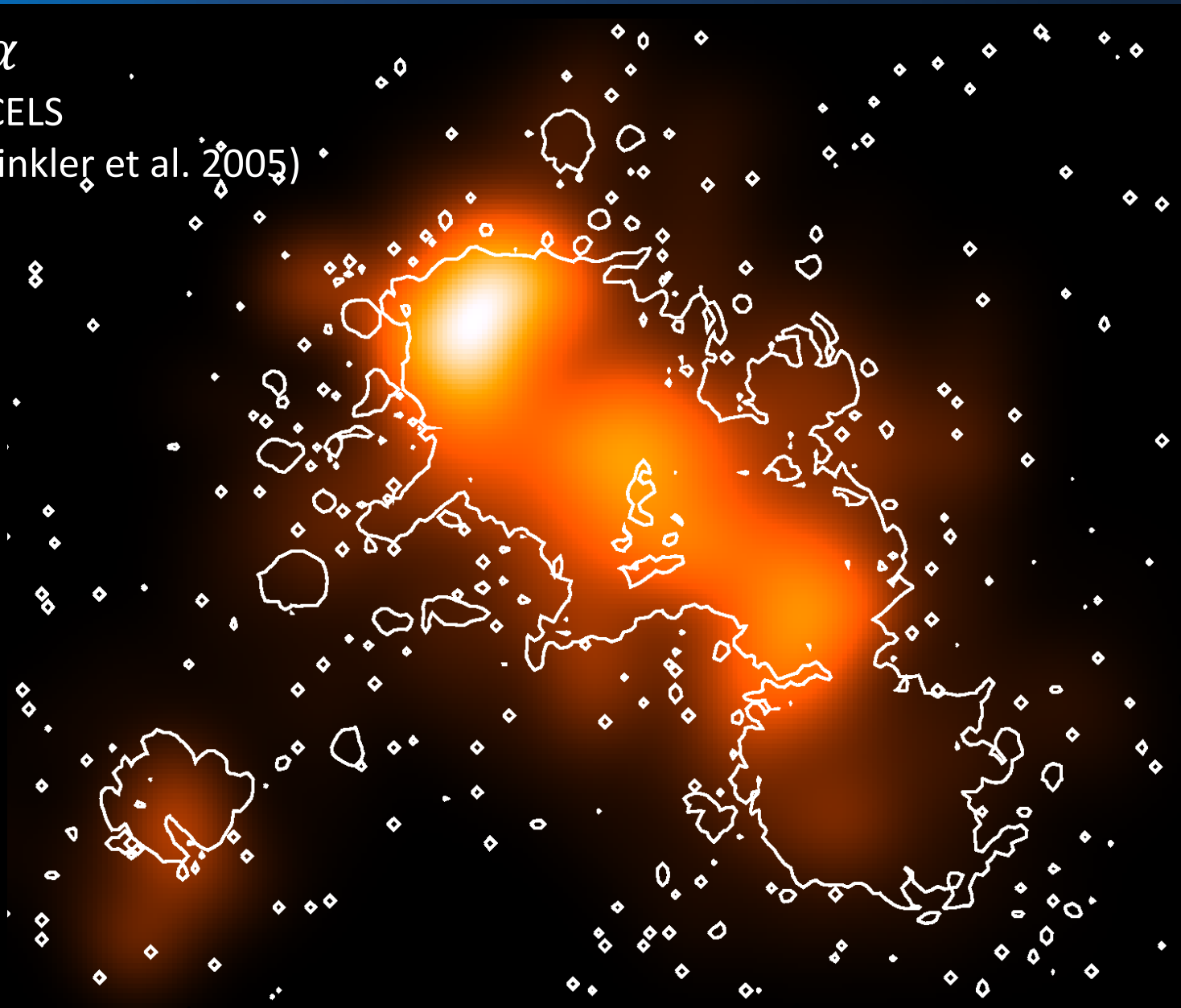

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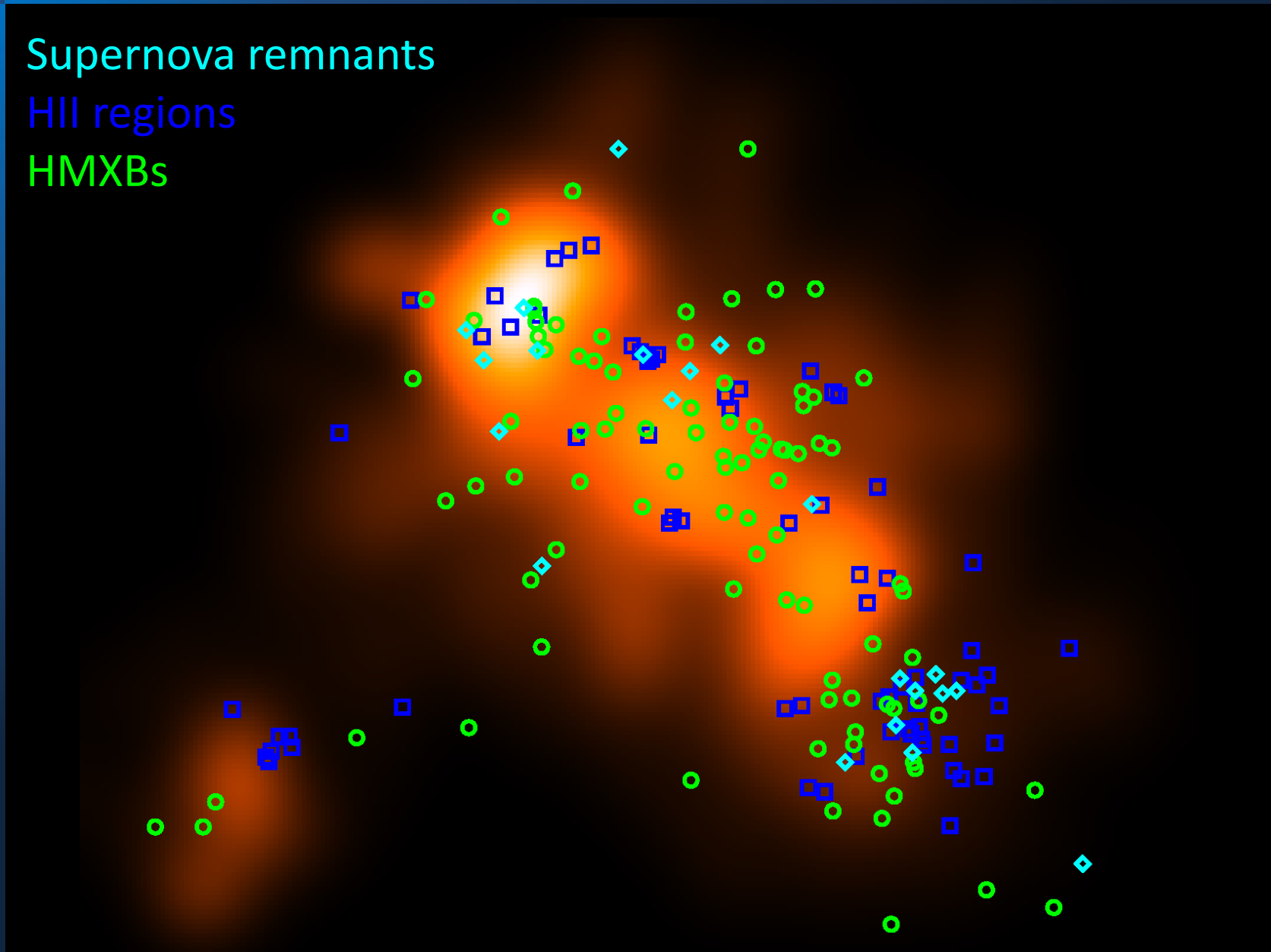
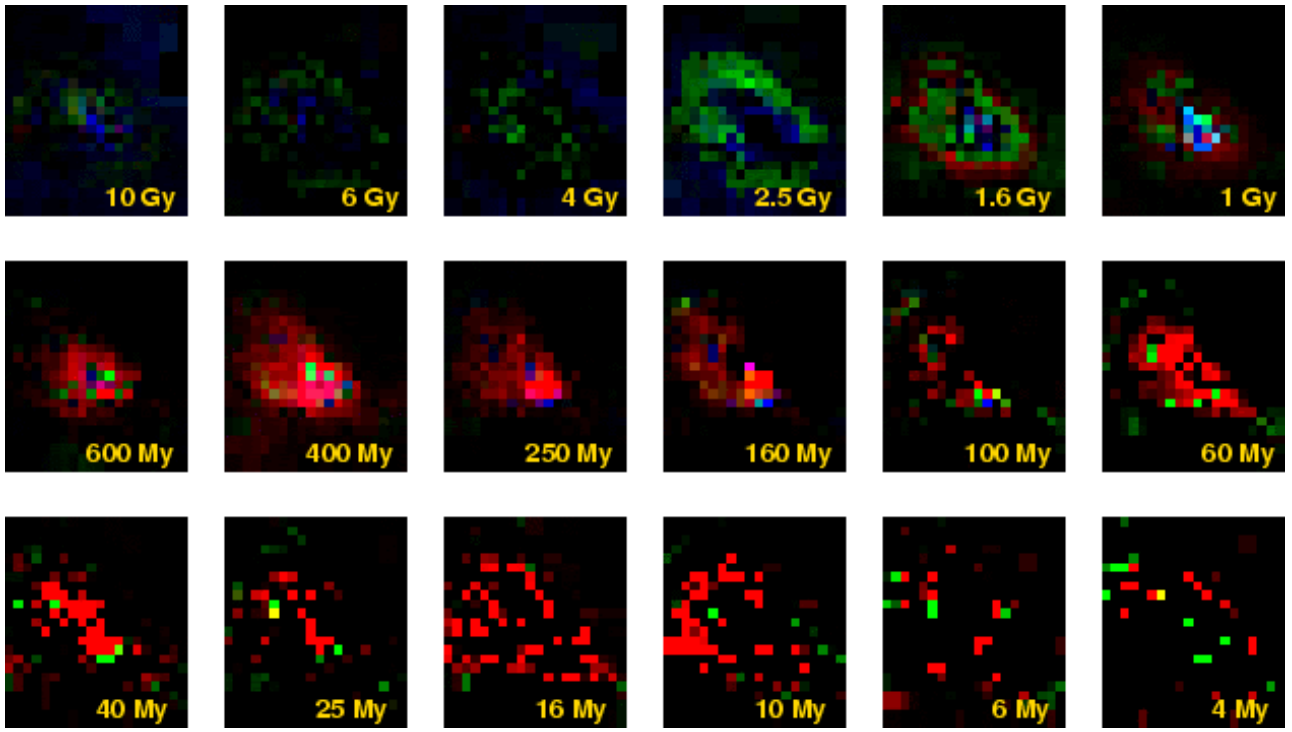
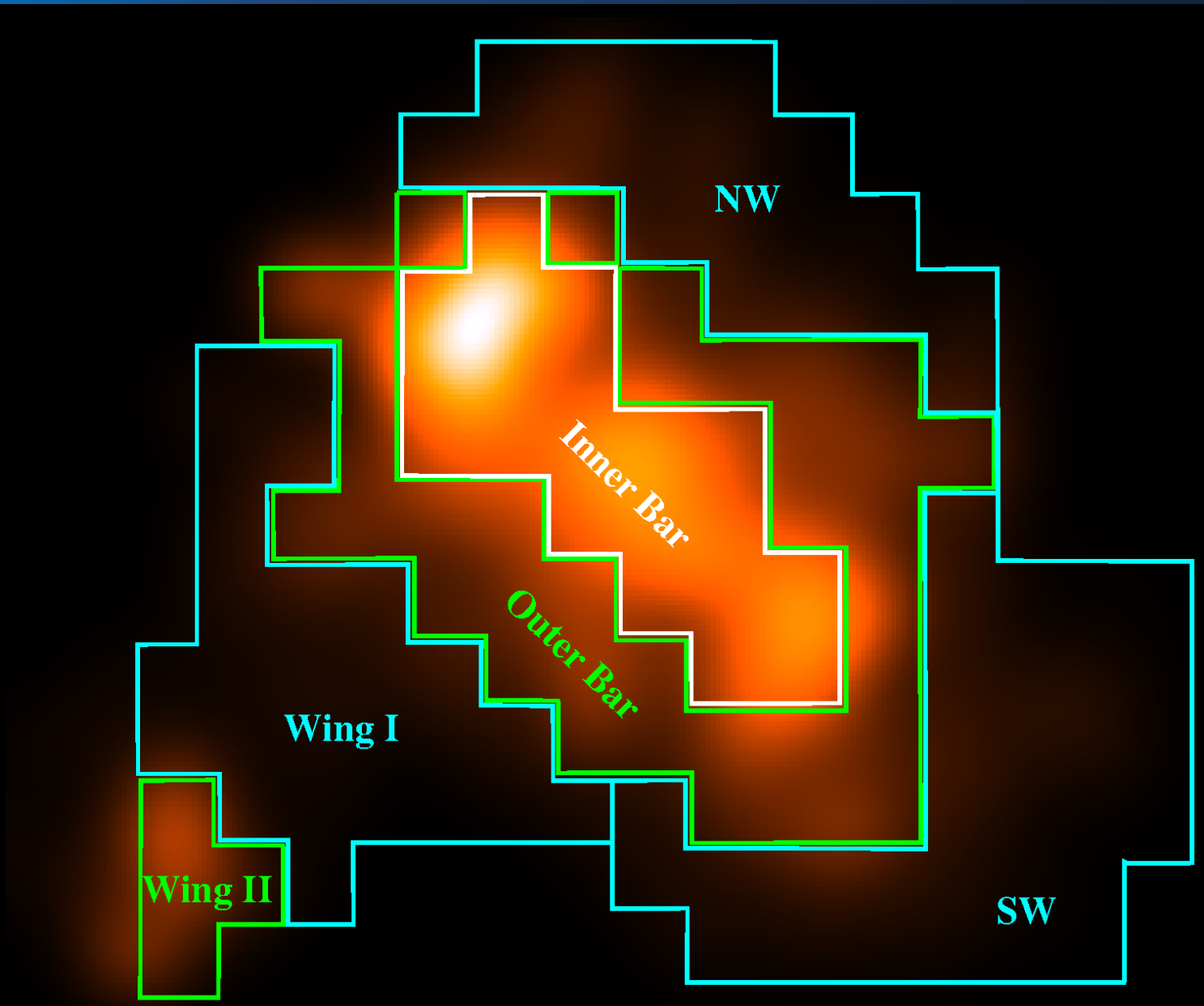


Comparison with star-formation history



The SMC has a well mapped star-formation history (Harris & Zaritsky 2004)

Comparison with star-formation history



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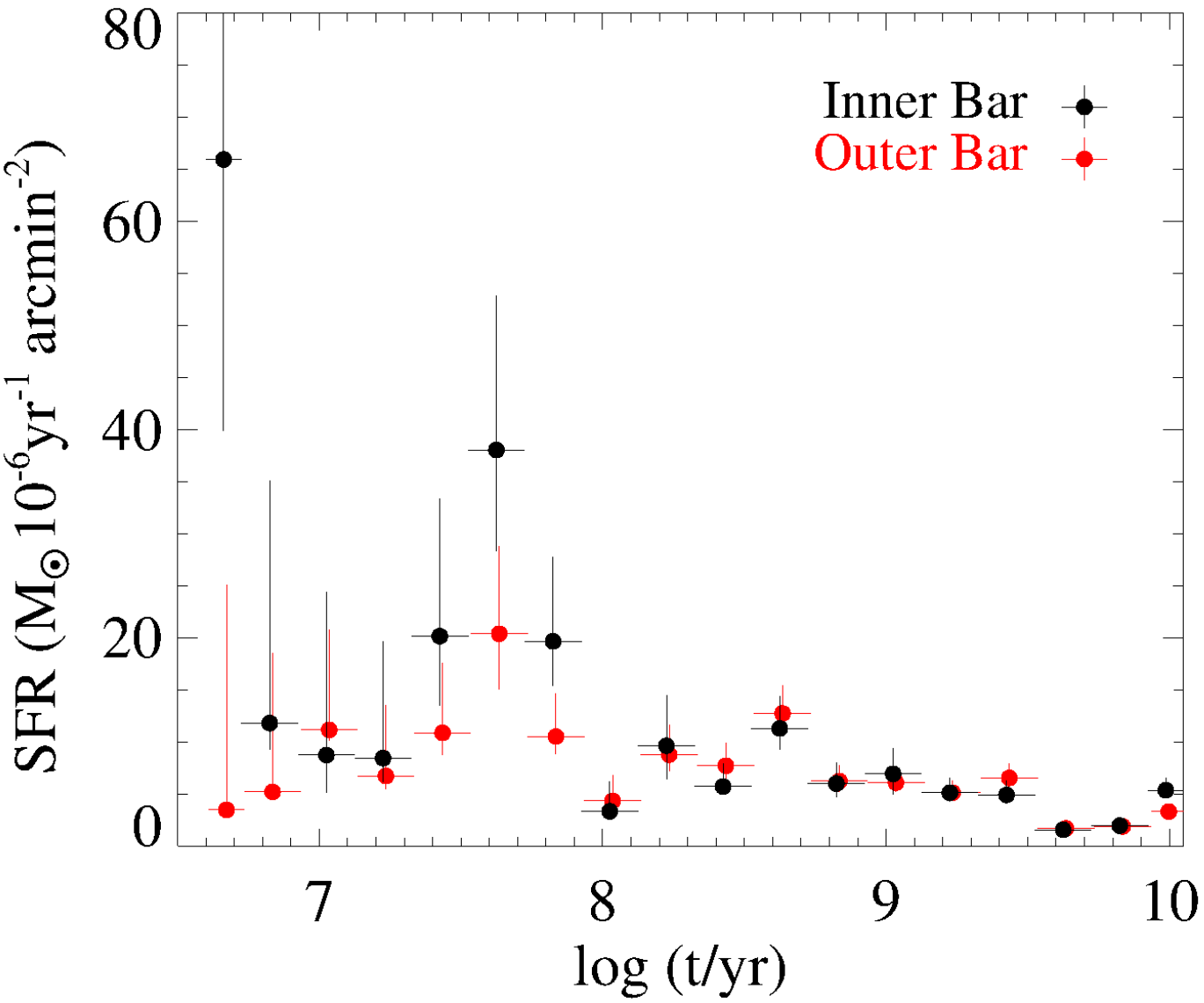

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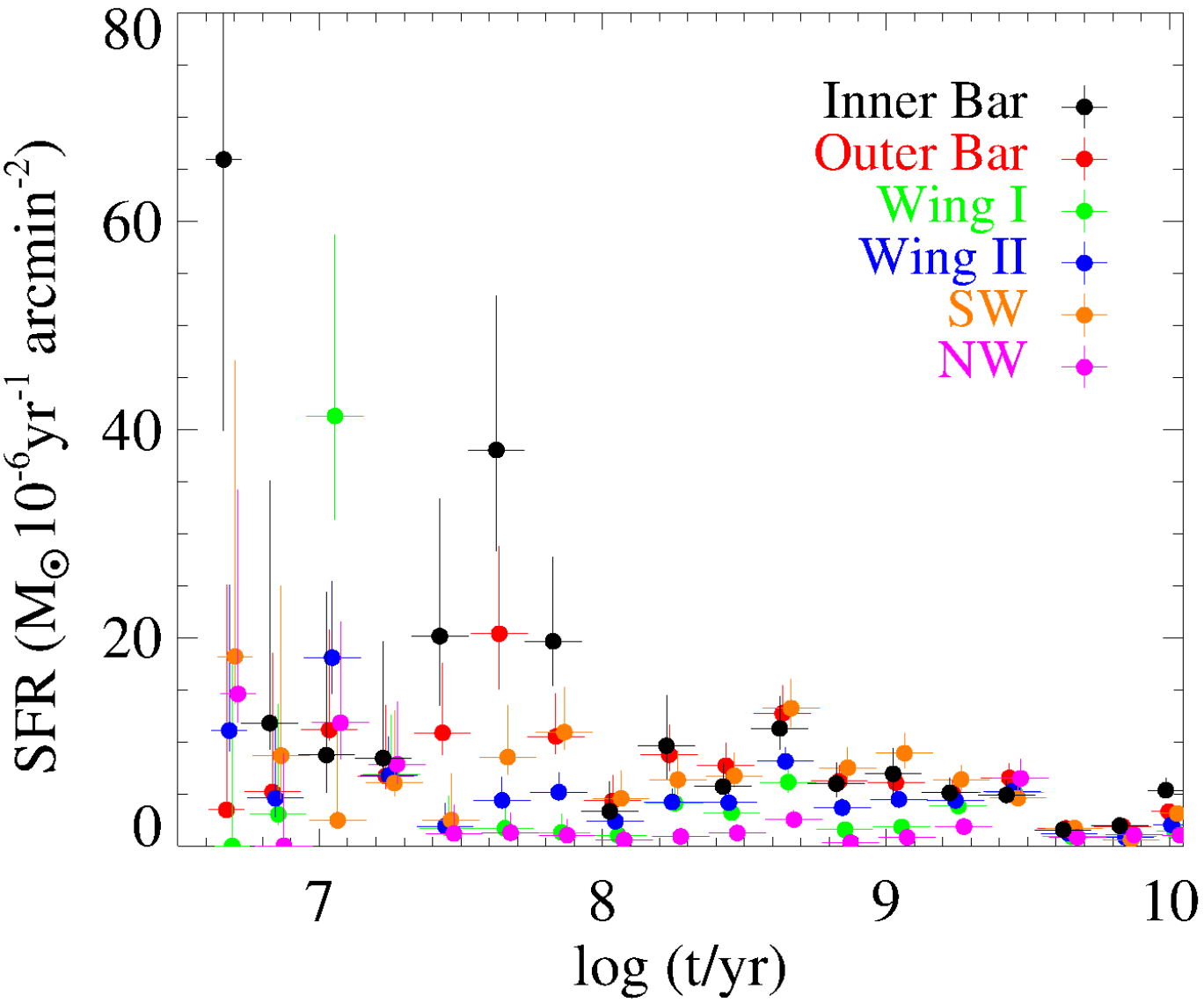

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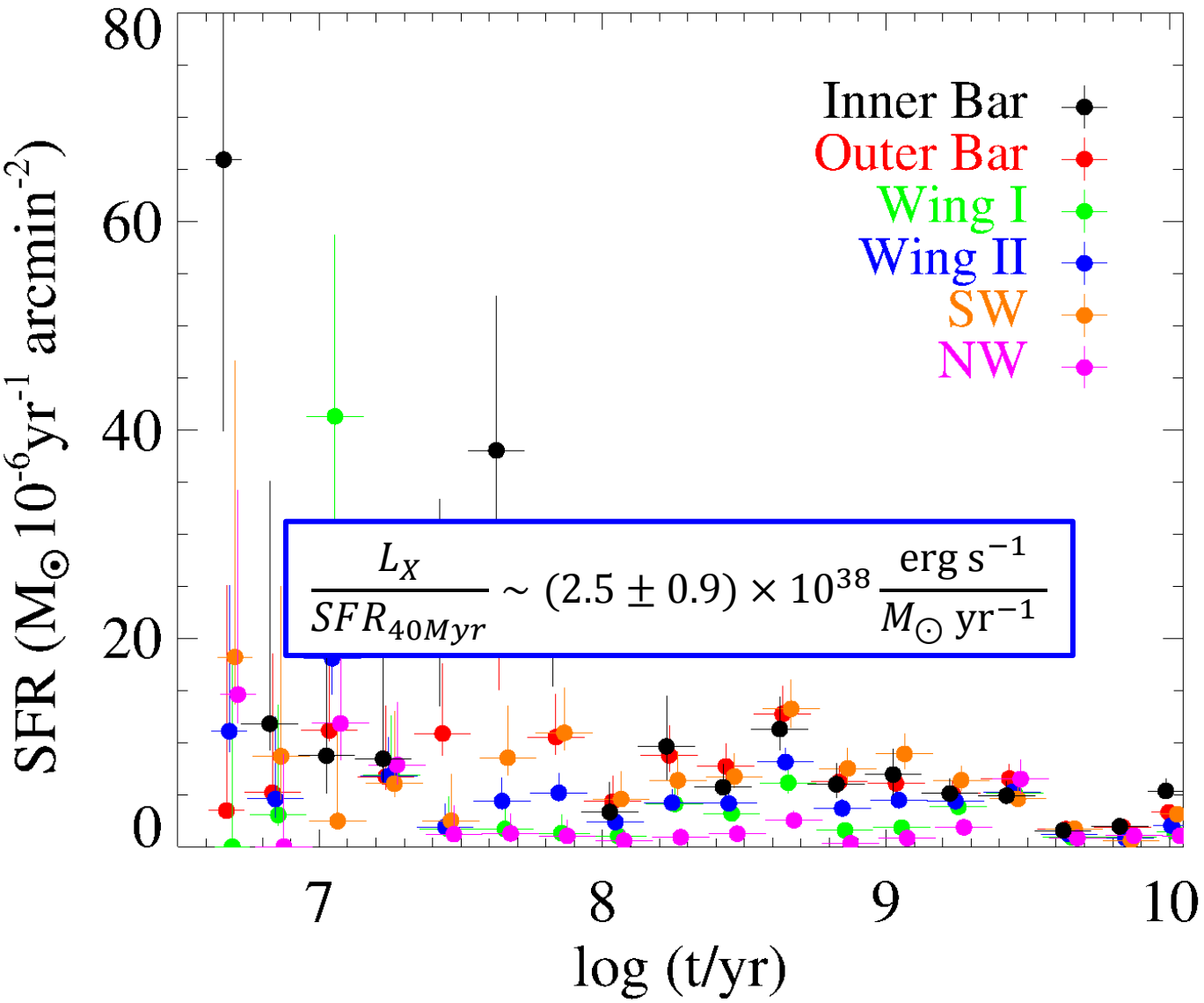
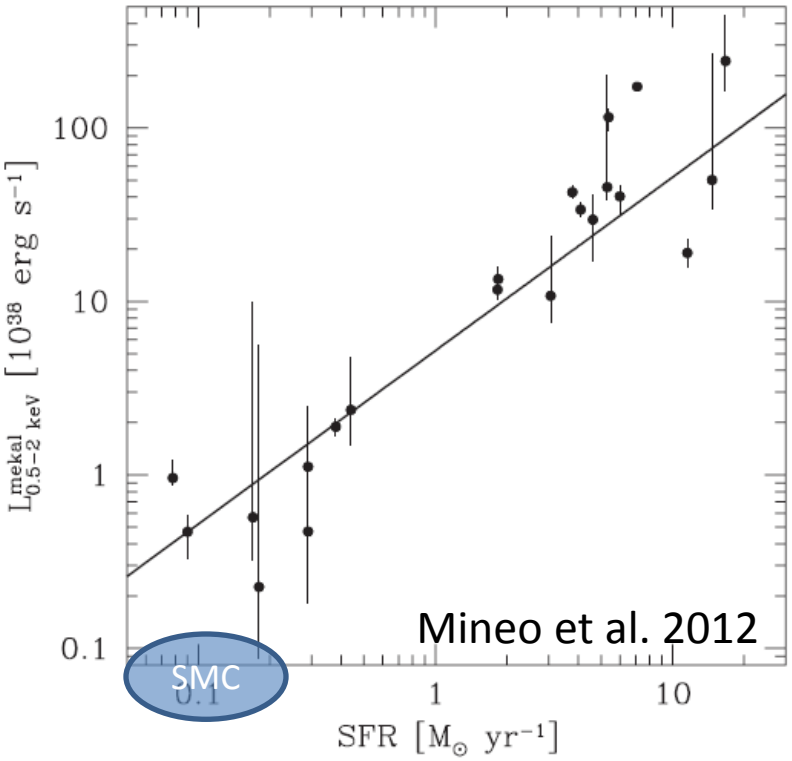
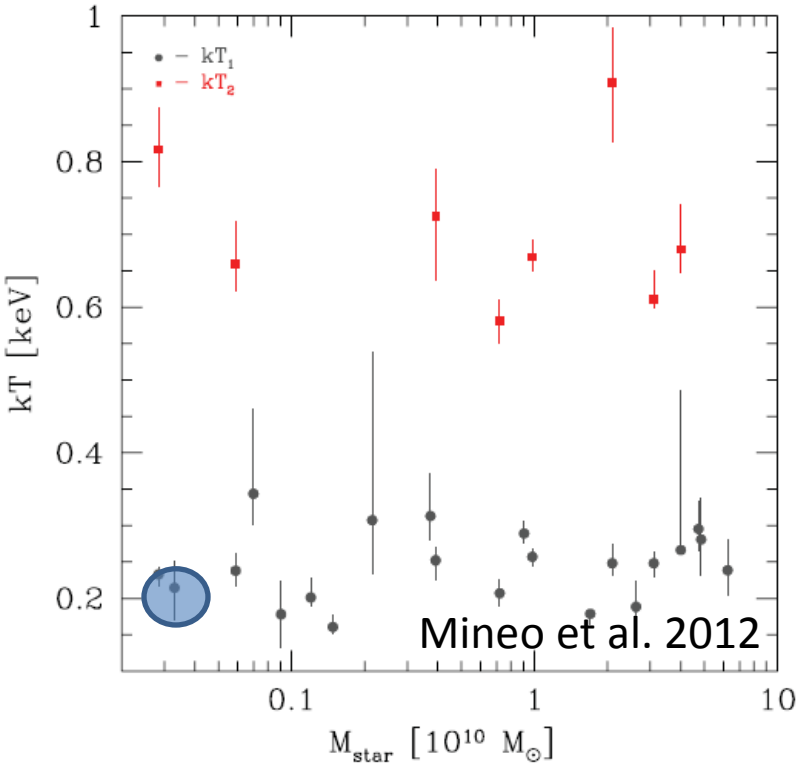


Comparison with other galaxies

Nearby late-type galaxies:





The Small Magellanic Cloud:

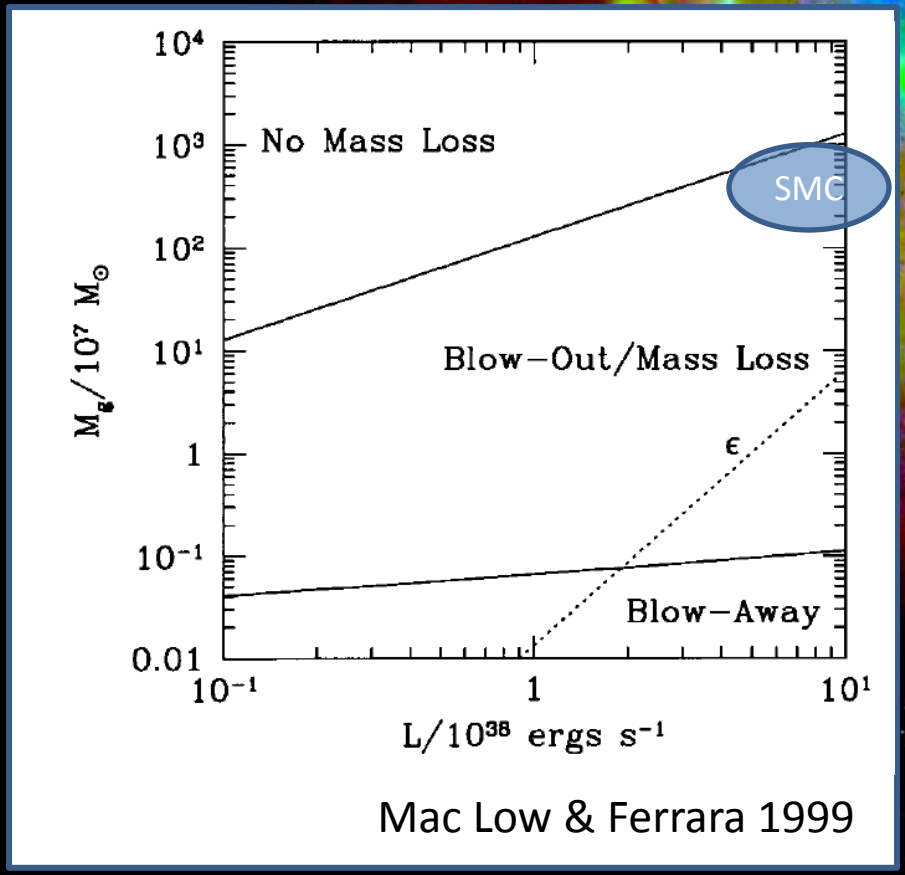
$L^{int}_{0.2-2.0\ keV} = 4.0 \times 10^{37} \mathrm{erg\ s^{-1}}$

$L^{obs}_{0.2-2.0\ keV} = 7.1 \times 10^{36} \mathrm{erg\ s^{-1}}$

Likely lower, because $Z_{SMC} \sim 0.2\ Z_\odot$

$kT \sim 0.2$ keV

The possibility of outflows



Mac Low & Ferrara 1999

Summary

- We developed a method to analyze EPIC-pn observations of diffuse X-ray emission with low surface brightness.
- The results of the morphological and spectral analysis are discussed in the context of complimentary optical and radio data.
- Diffuse X-ray emission is found in the northern bar of the SMC and the DEM S 157 but *not* in the southern bar.
- The diffuse X-ray emission is characterized with a temperature of $kT \sim 0.2$ keV, a luminosity of $L^{obs}_{0.2-2.0\,keV} = 7.1 \times 10^{36}\,\mathrm{erg\ s^{-1}}$, and strong absorption in some regions.
- The morphology and spectral parameters confirm the hot ISM as the origin of the diffuse X-ray emission.
- The intrinsic luminosity correlates well with the star formation about 40 Myrs ago.

References

- First version of this study: R. Sturm, PhD thesis, TUM 2012
  http://nbn-resolving.de/urn/resolver.pl?urn:nbn:de:bvb:91-diss-20121212-1115619-0-5

  A&A paper in preparation

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