New X-ray lights on the supernova remnant population of the LMC

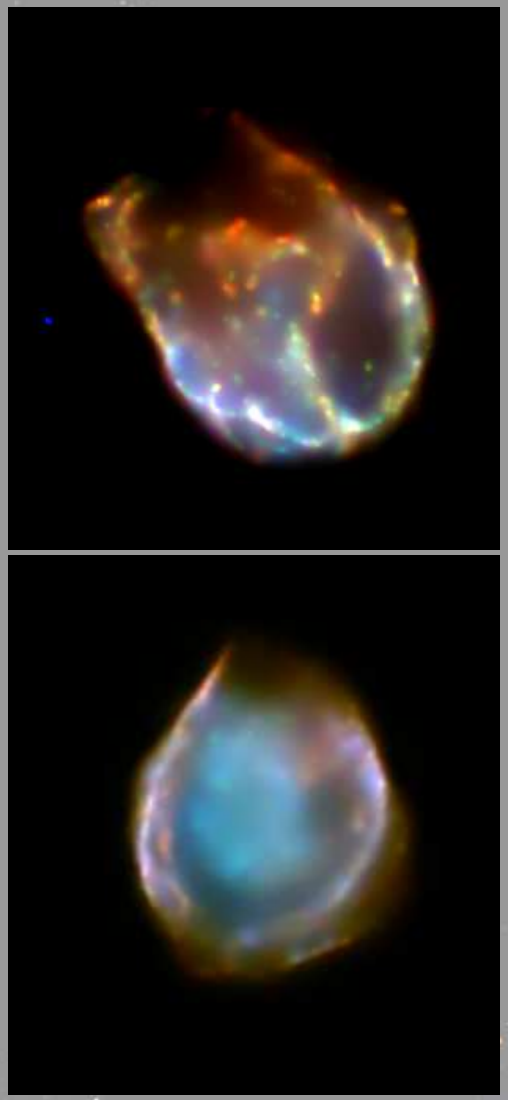
Pierre Maggi (MPE Garching)

and the XMM-Newton LMC survey collaboration:
F. Haberl (PI), G. Vasilopoulos, R. Sturm, W. Pietsch (MPE)
P. Kavanagh, M. Sasaki (Astronomische Institüt Tübingen)
L. Bozzetto, M. Filipović (University of Western Sidney)
Y.-H. Chu, R. A. Gruendl (University of Illinois)
S. D. Points, R. C. Smith (Cerro Tololo)
J. Dickel (University of New Mexico)

The X-ray Universe 2014
Trinity College Dublin, Ireland

16 June 2014

Outlines



N132D and DEM L71, two SNRs in the LMC

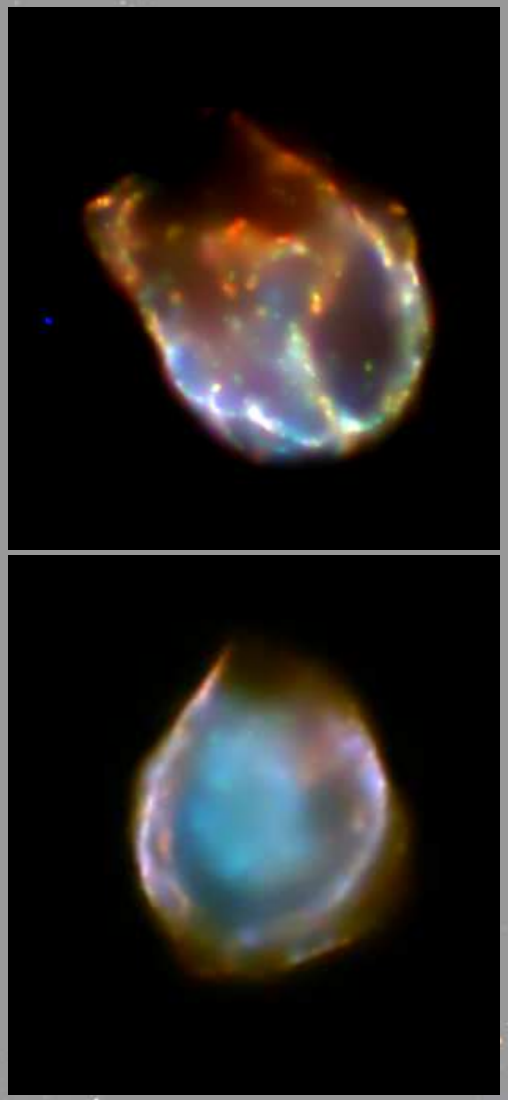
(Chandra SNR catalog)

- Rest of a supernova, either type Ia or core-collapse.

- Shape, heat, enrich, and mix up the ISM.
- Efficient cosmic-ray accelerator.
- Can be used to probe the ISM (abundance/density).
- Provides details about explosion mechanisms (asymmetries, nucleosynthesis yields).

Observational signatures

- X-ray emission
- Non-thermal (synchrotron) radio emission
- Optical line; enhanced [SII]/Hα
- High-velocity gas (> 100 km s^{-1})



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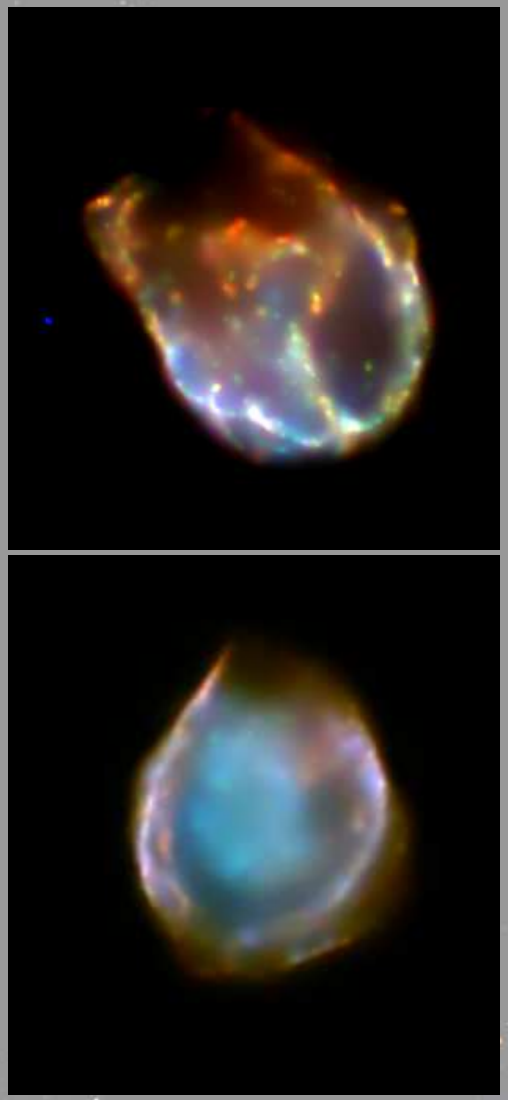

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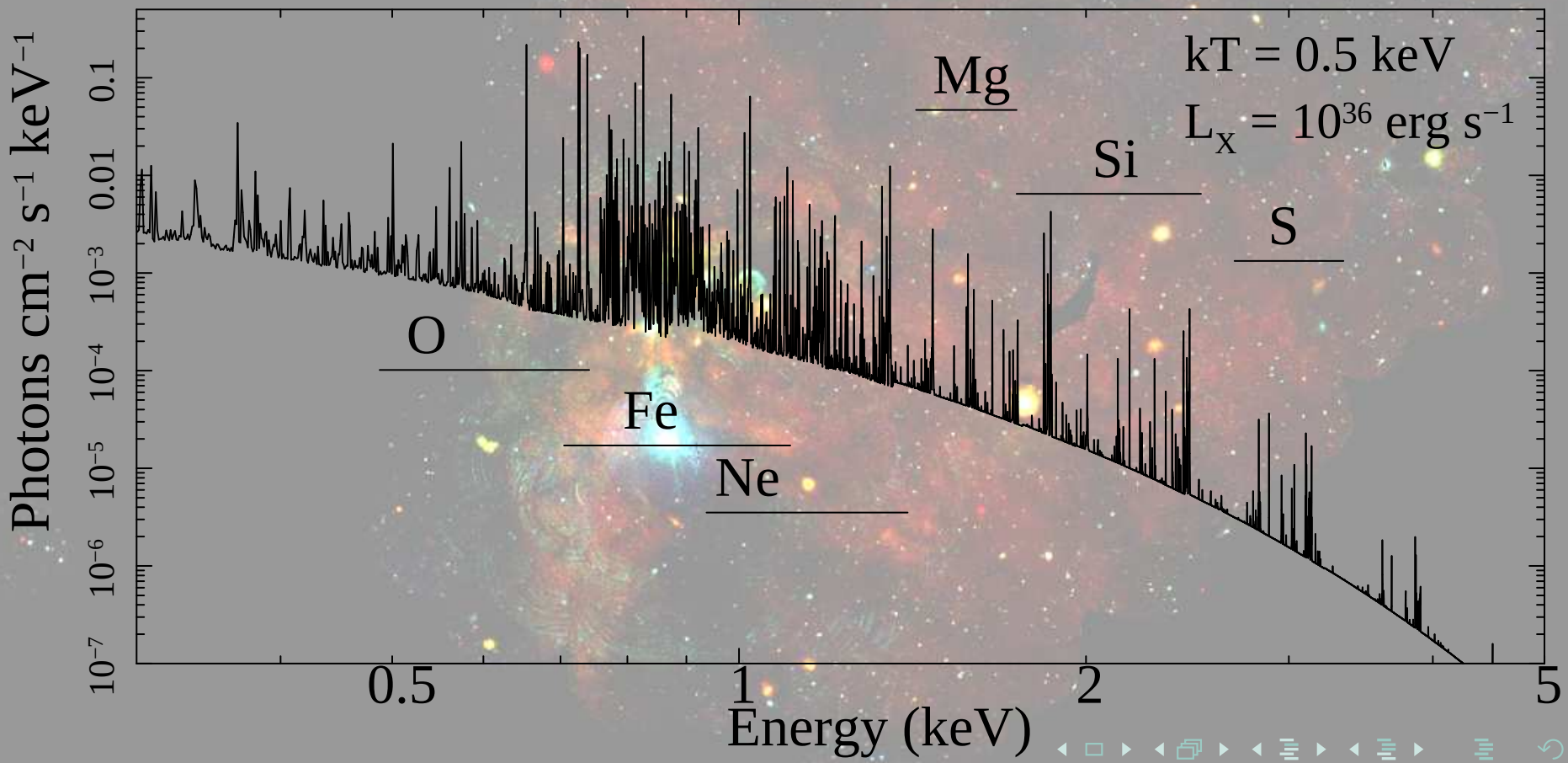
	MW	LMC
Distance	⊠	✓
Multi-λ coverage	✓	✓
Absorption	$N_H \sim 10^{22}$ cm^{-2} ⊠	$N_H \lesssim 10^{21}$ cm^{-2} ✓



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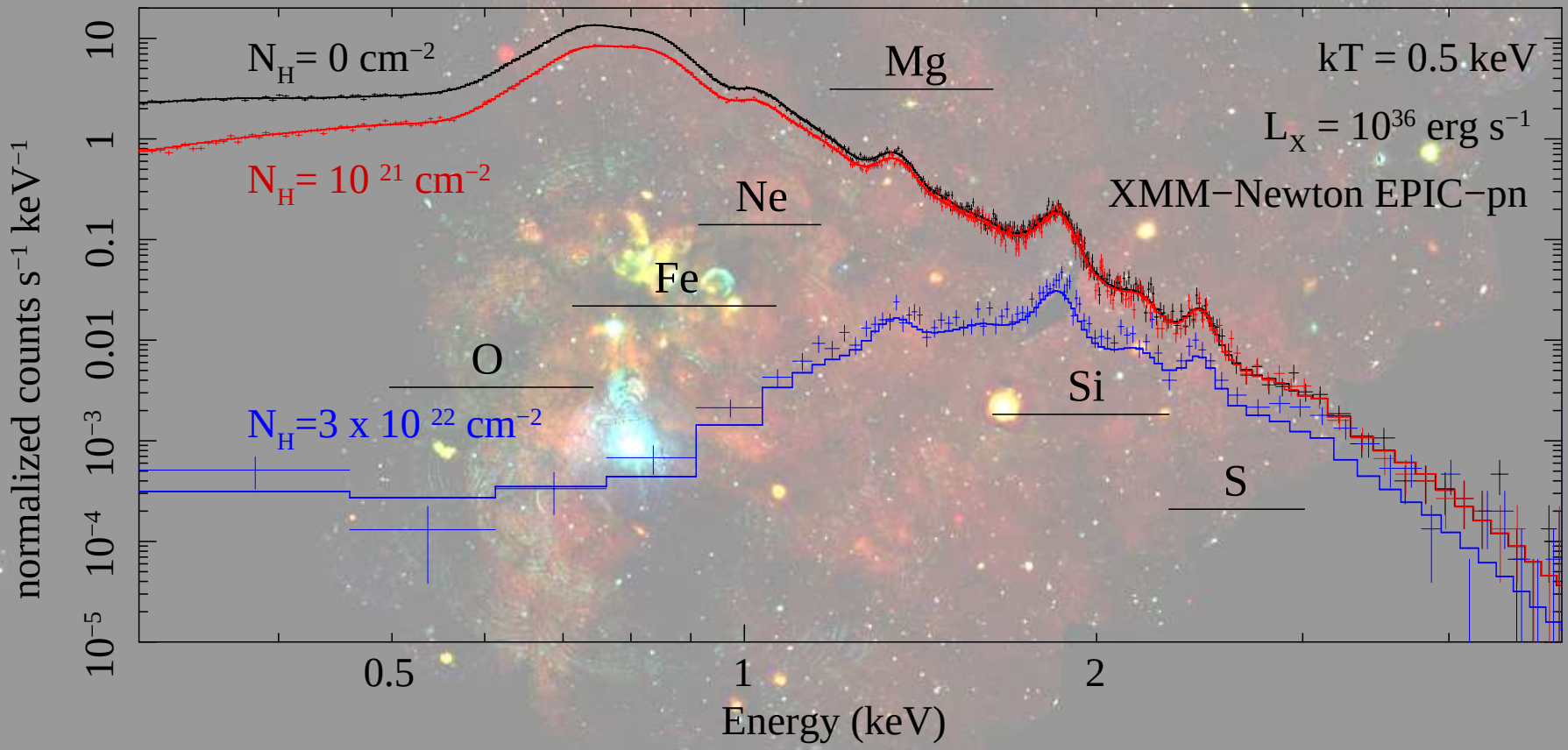
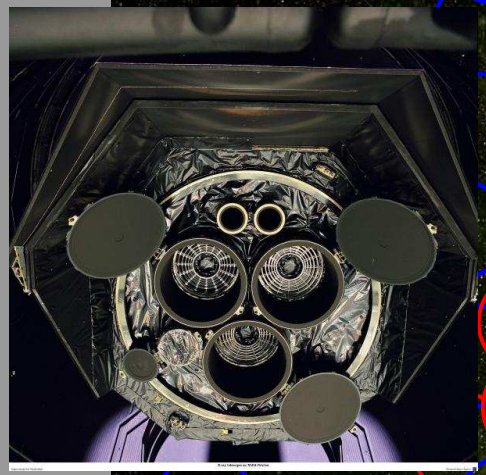


Data from MCELS (Smith et al. 2000)

[SII]

Hα

[OIII]



1.8 Ms VLP [PI: F. Haberl]

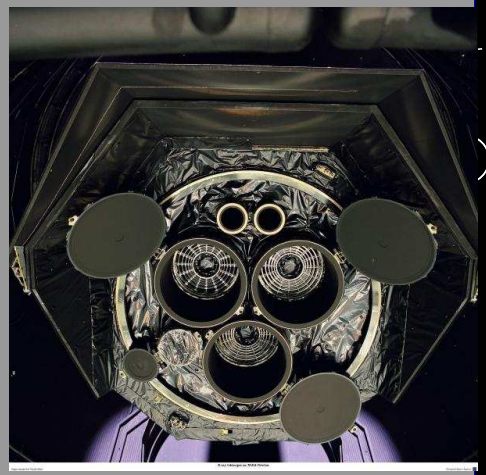
Review talk by F. Haberl
Tuesday plenary at 11:00

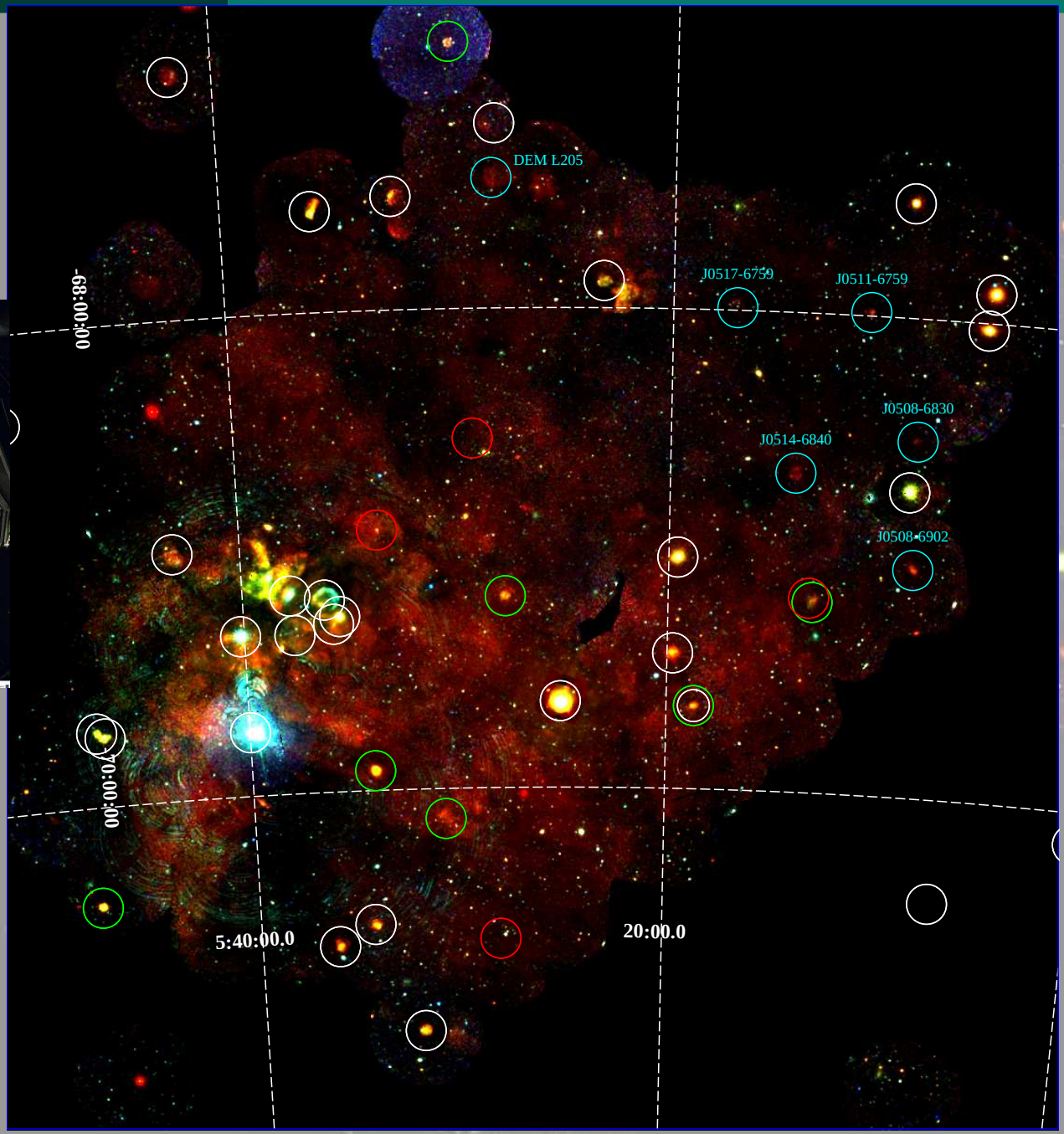
N

E

30'

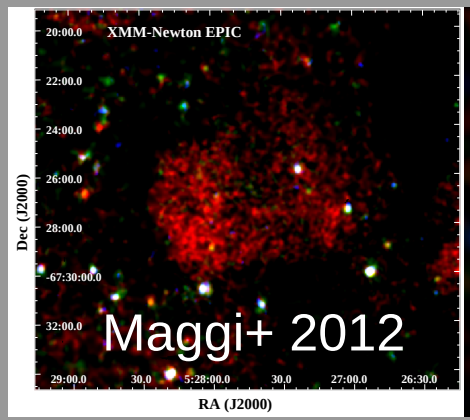
0.2 – 1 keV
1 – 2 keV
2 – 4.5 keV

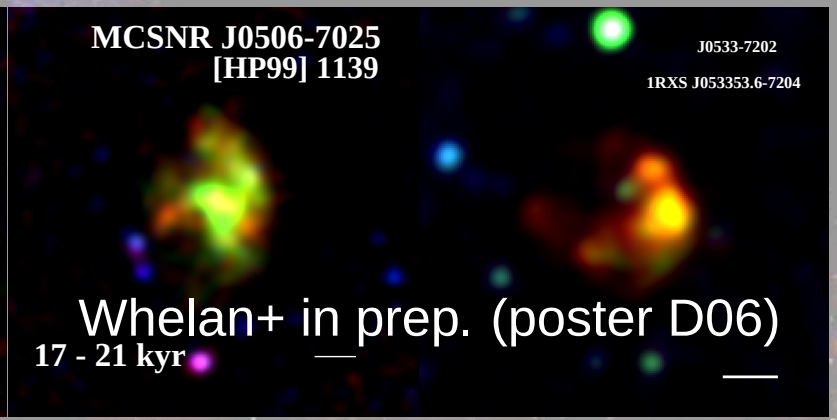


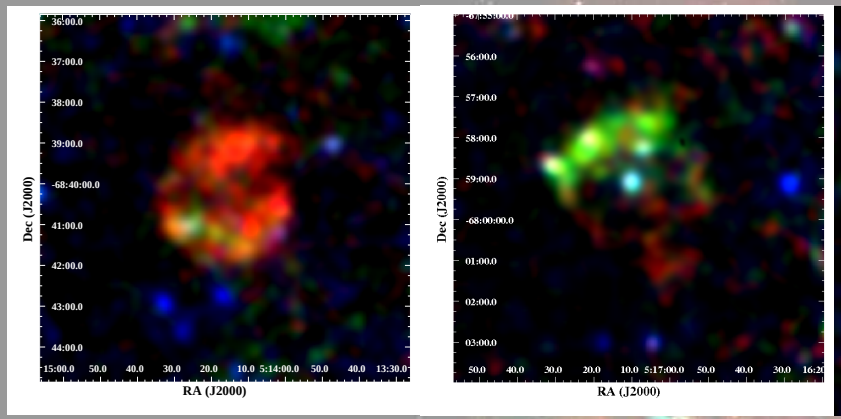


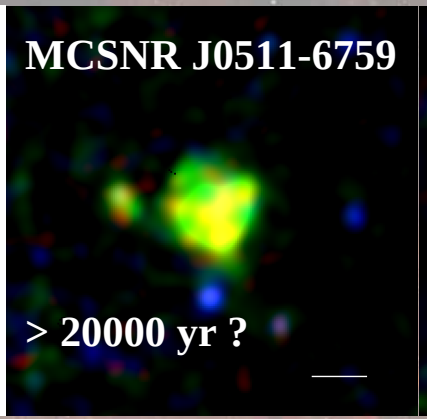
Identification of SNRs

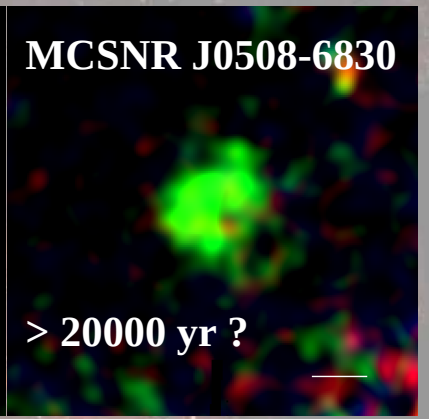
1. Exclude point sources (background AGN, Galactic stars, XRBs).
2. Exclude non-SNRs extended sources :
   - Superbubbles (optically bright)
   - Galaxy clusters (hotter temperature)
   - Diffuse emission (easy to spot in mosaicked image)
3. Check that X-ray properties (size and soft emission) are indicative of a SNR.
4. Check that there are enough counts for a meaningful analysis.





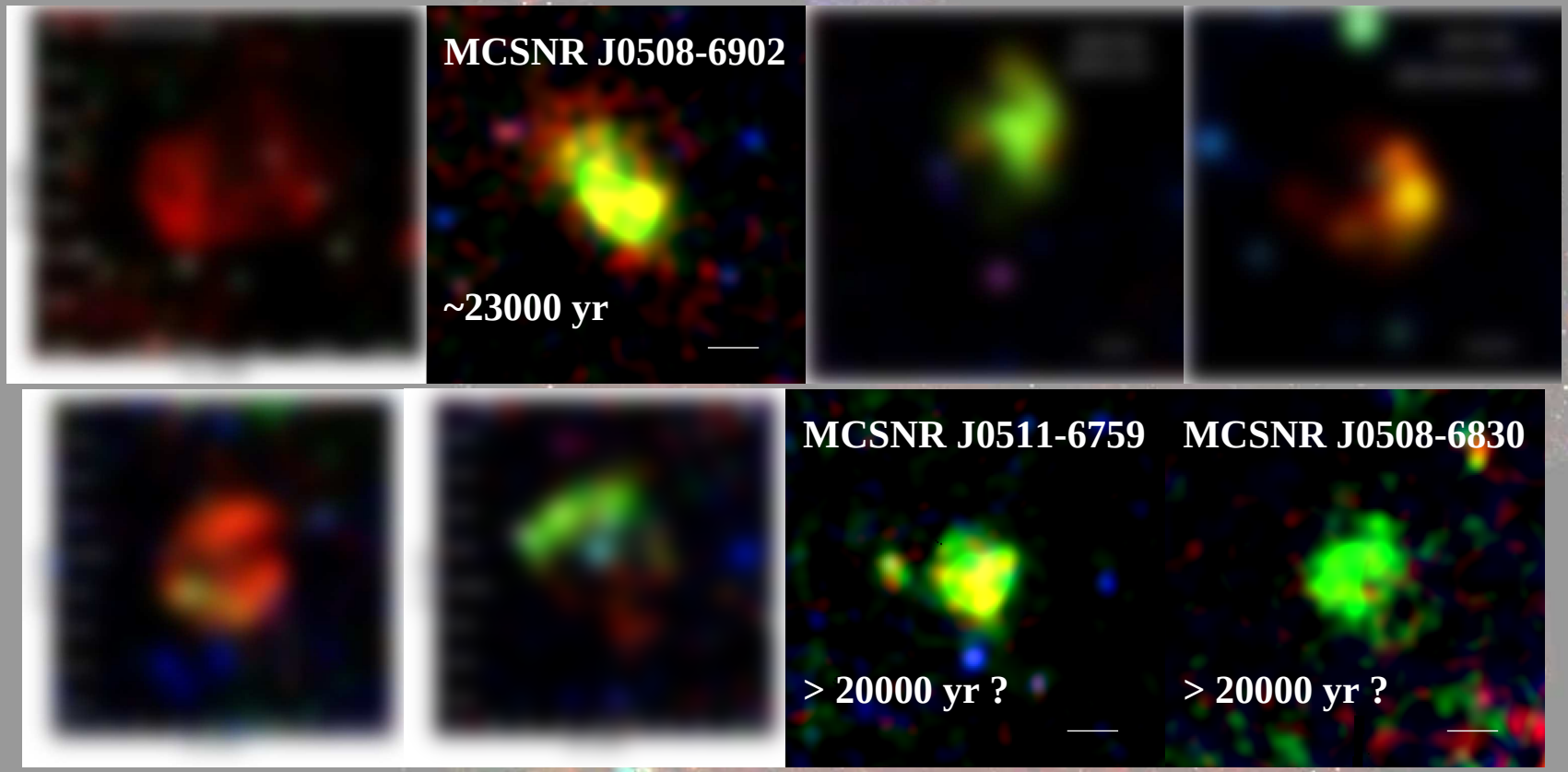






Maggi+ 2014

- Now more than 60 SNRs and still counting
- Multi-wavelengths studies → properties (density, abundance, age, ...)
- The faint end of the population
- Probe a variety of ISM environment



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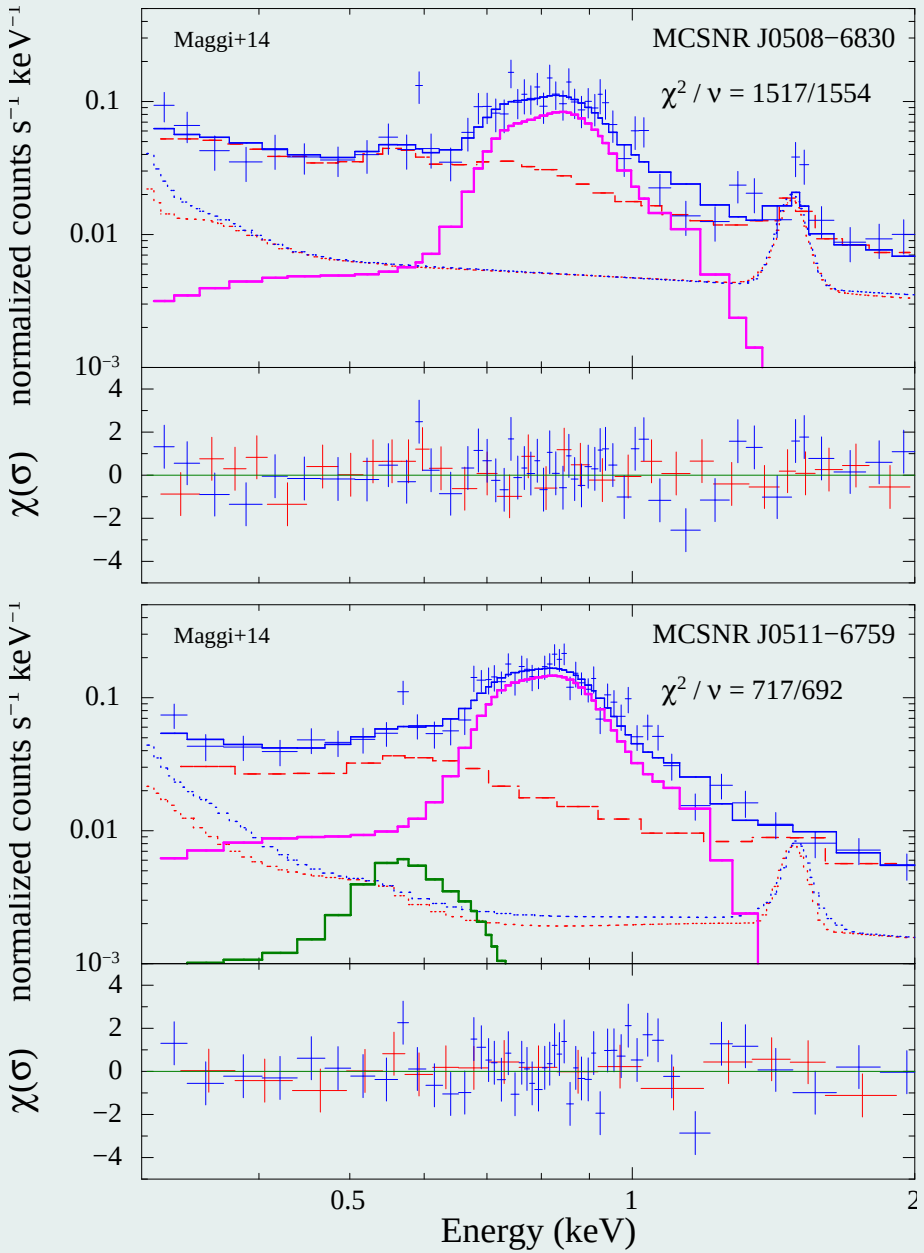
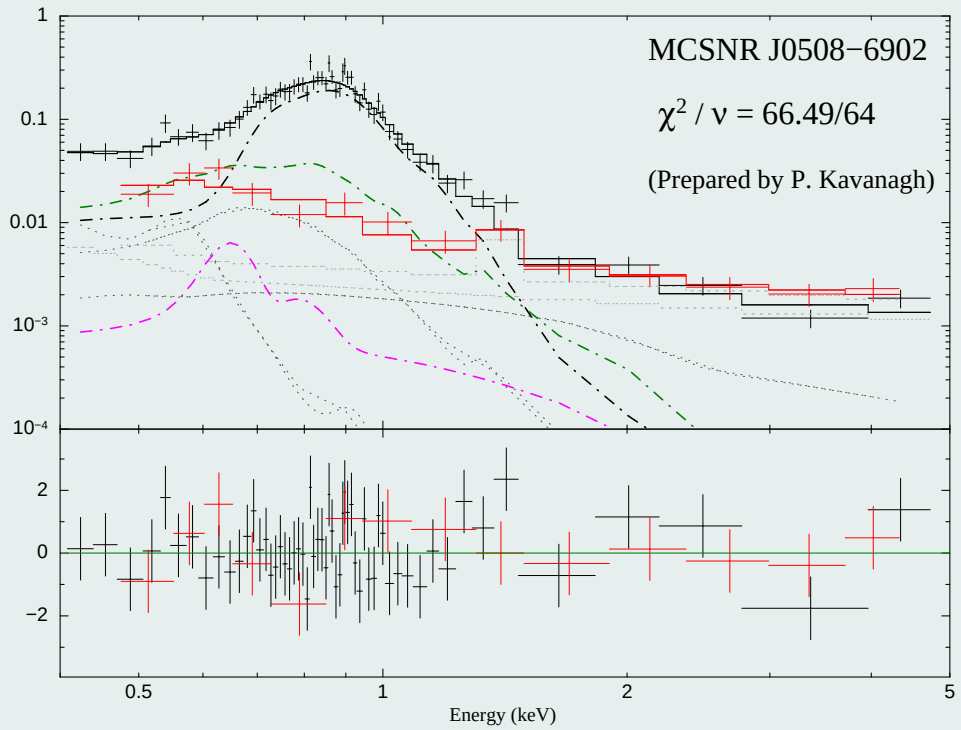




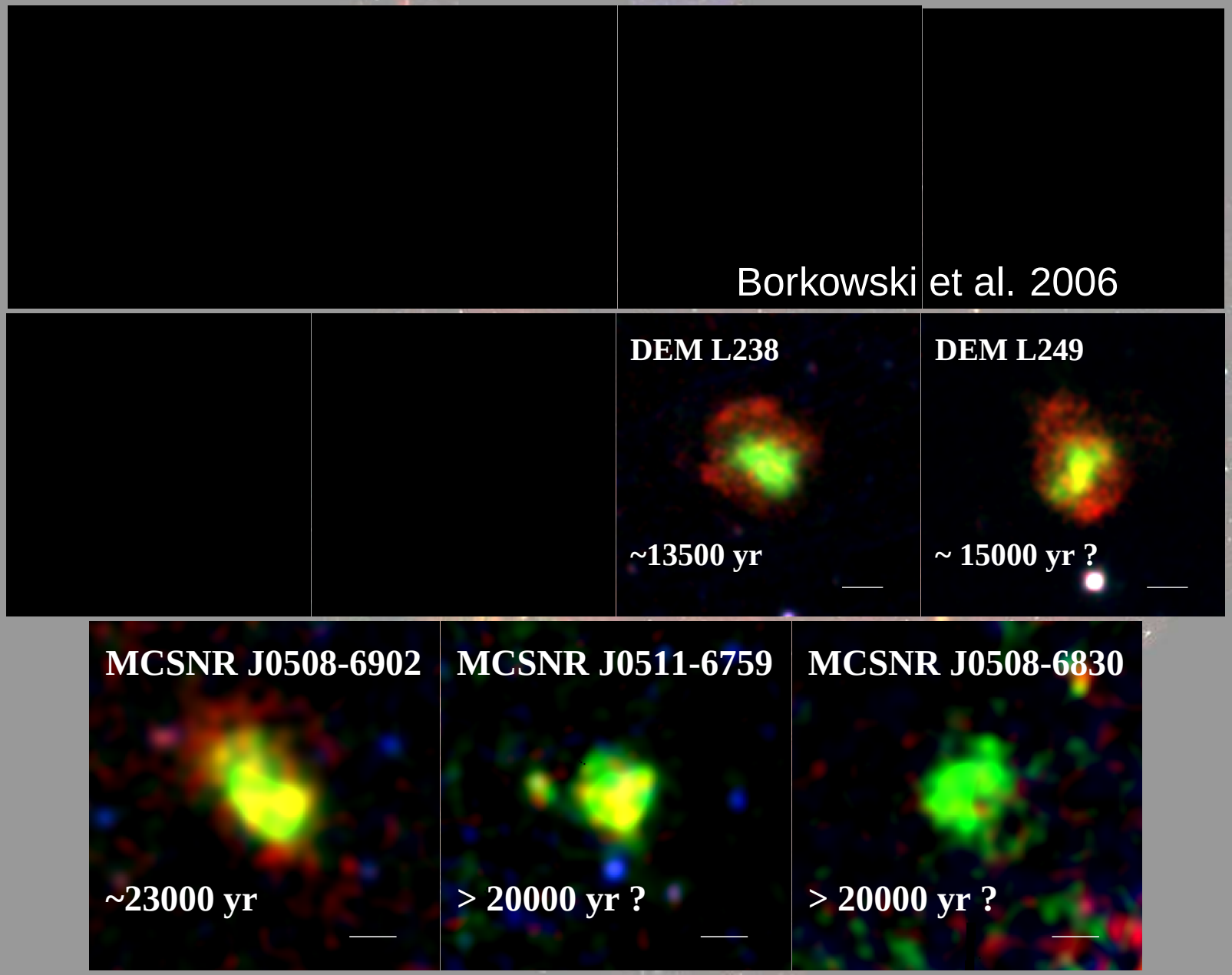
Bozzetto et al. 2014

Iron-rich gas in the interior

- kT is 0.6 keV – 0.8 keV
- long ionisation age ($\tau = n_e t$)
- $M_{\rm Fe}$ is 0.5 $M_\odot$ to 1.2 $M_\odot$ for J0508-6830 and J0511-6759
- $M_{\rm Fe}$ is 0.5 – 1.8 $M_\odot$ (J0508-6902)

Could NOT be observed in the Galaxy

The Evolution of the type Ia SNRs



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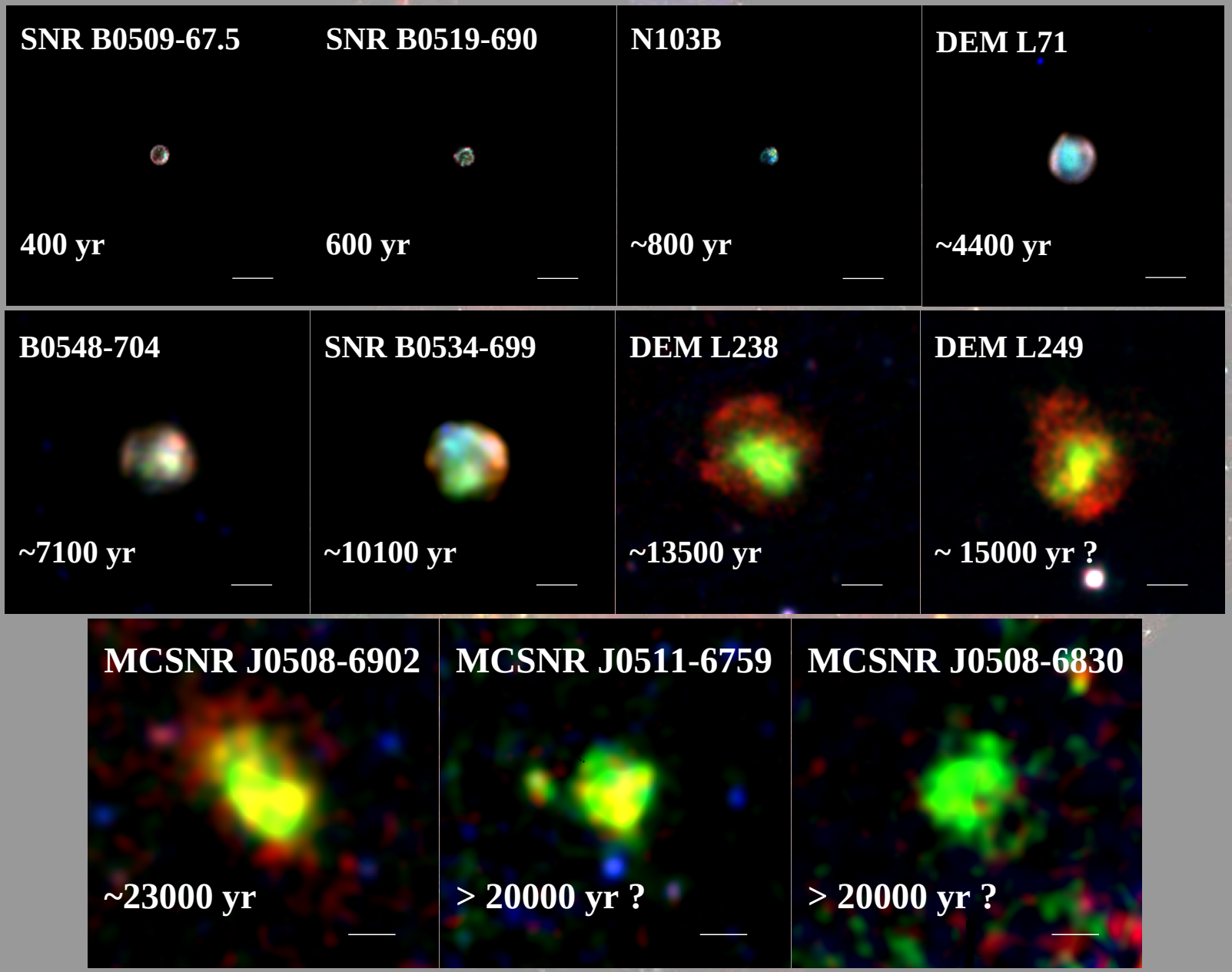


Work in progress

Complete spectral (re-)analysis

- Homogeneous : allows comparison of properties (kT, ionisation age, abundances)
- Derive accurate flux; better than simple count rate conversion

$\hookrightarrow$ Production of the most complete, homogeneous, accurate catalogue of the X-ray properties of LMC SNRs

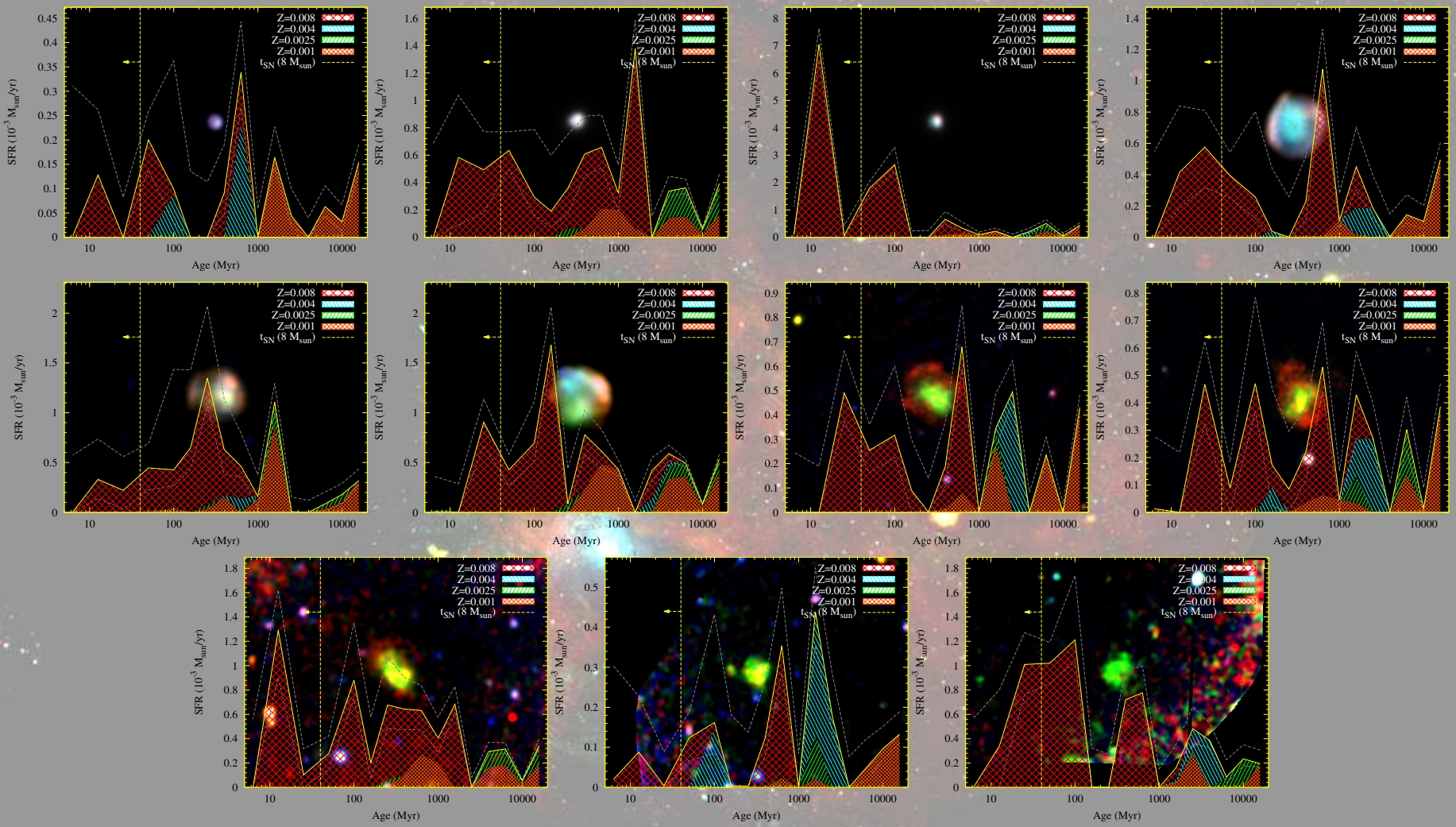
Combine with information on :

- type of SN origin, if known
- local Star Formation History

Preliminary results : "SFH-typing"

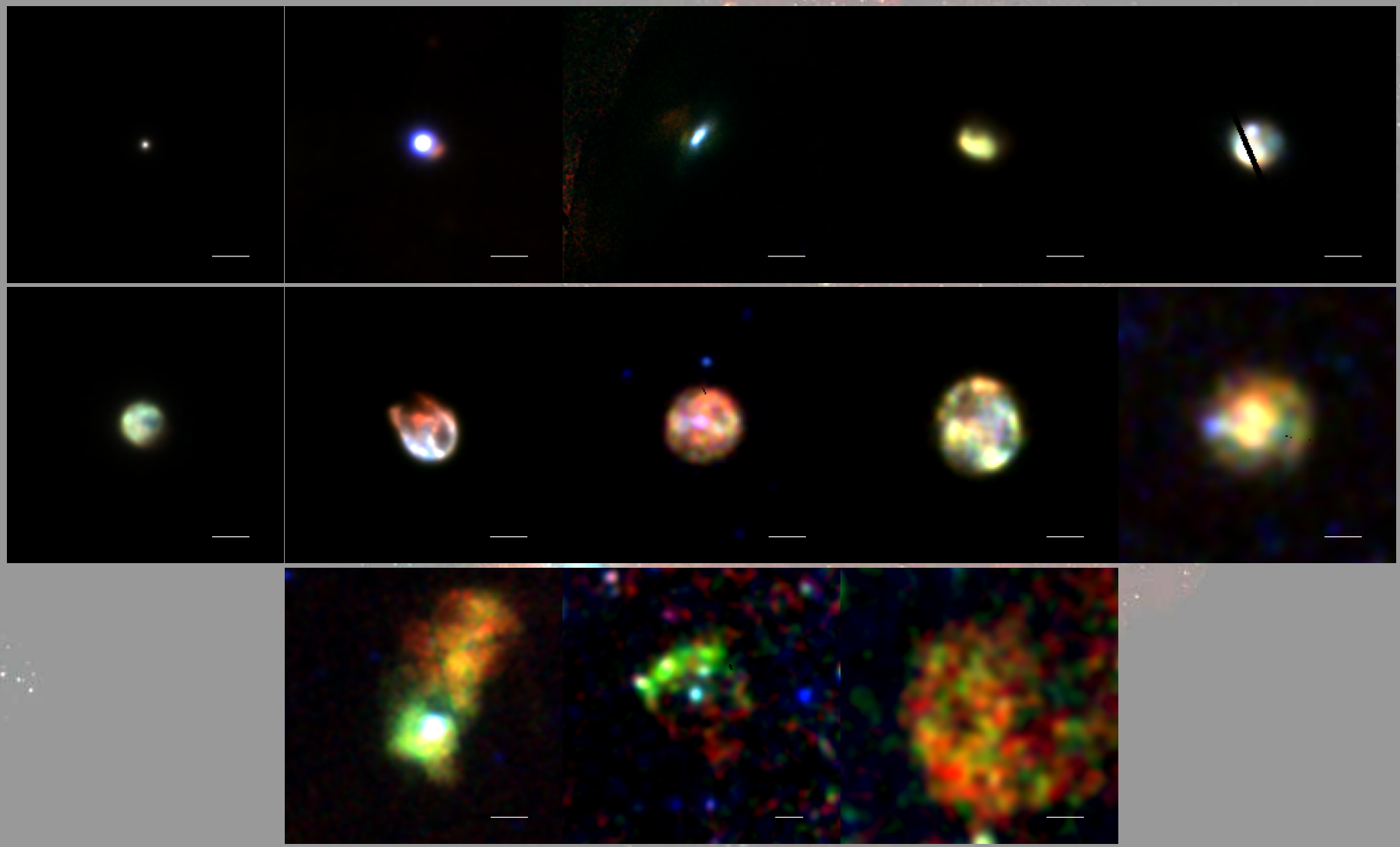
Star Formation History in the neighbourhood of **type Ia SNRs**

Star formation rate vs. cosmic time (from the LMC SFH maps of Harris & Zaritsky 2009)



Preliminary results : "SFH-typing" (2)

Idem, for the population of **core-collapse SNRs**



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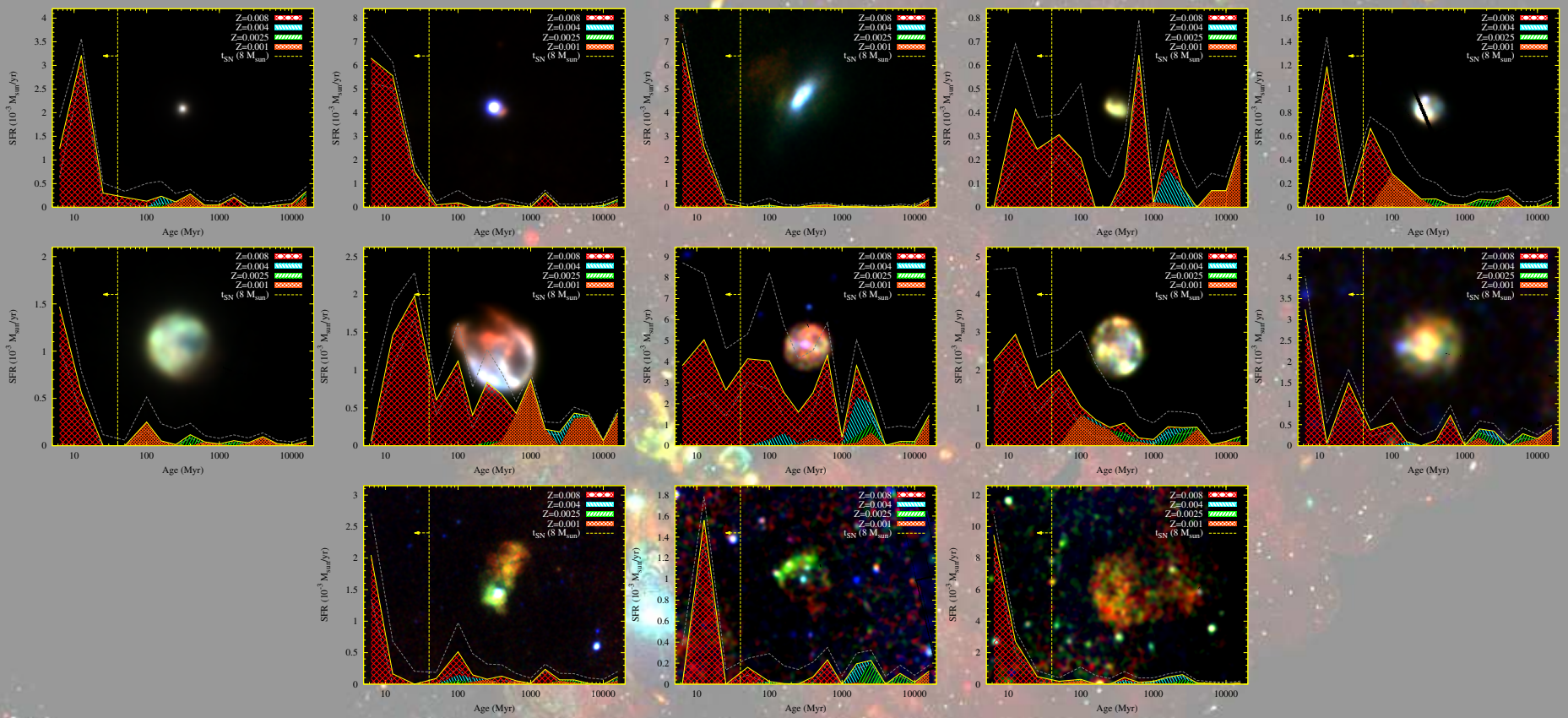
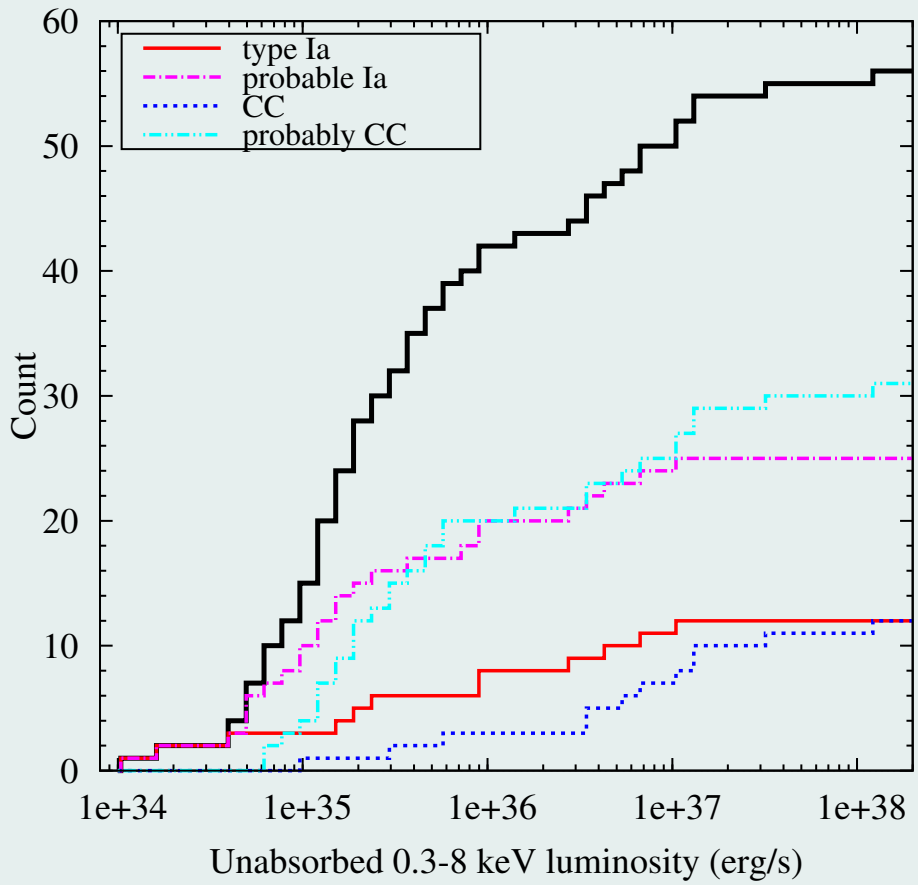


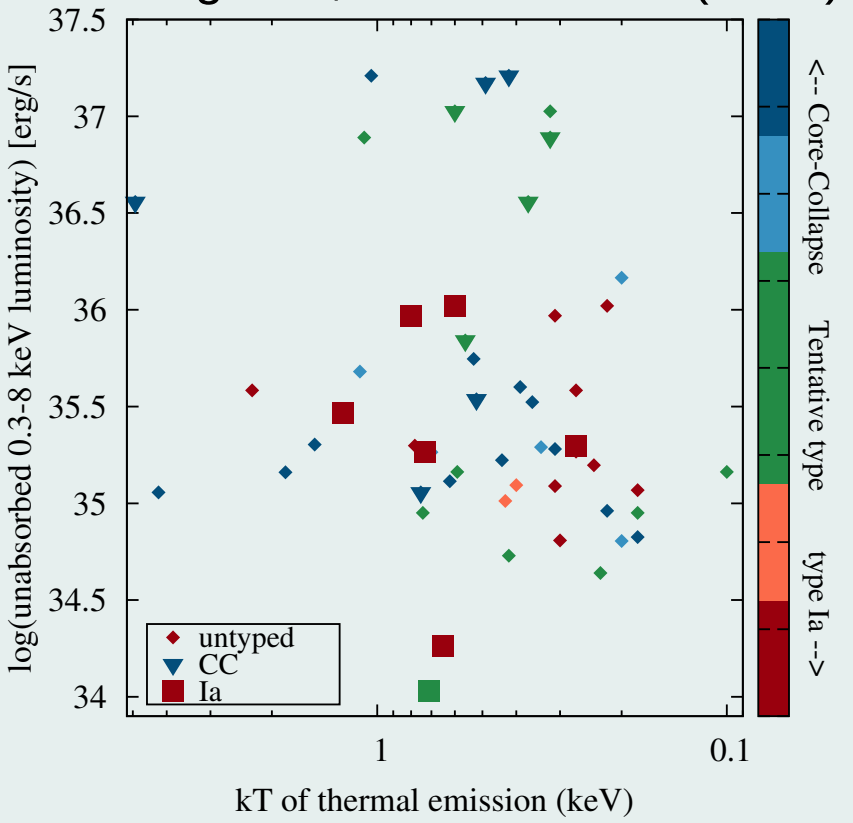
$\Longrightarrow$ Distinguish likely type Ia and Core-Collapse SNRs, based on relative stellar masses formed "recently" and "long time ago"

Cumulative X-ray luminosity function



Luminosity vs. X-ray temperature

"H-R diagram", as in Arbutina (2014)



- The population of definitive and likely type Ia SNRs dominates the faint end.
- At same temperature, type Ia SNRs tend to have lower luminosities.

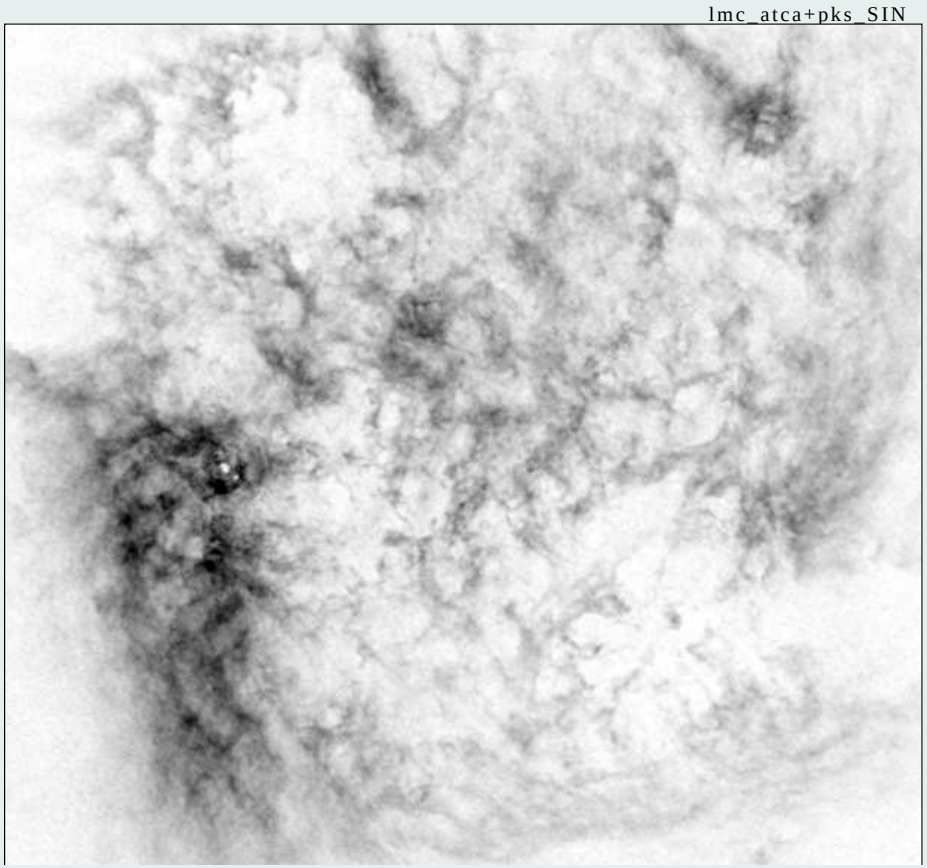
⇒ Likely an effect of the low density media where type Ia SD explode, compared to the denser star-forming region hosting core-collapse SNRs.

On the spatial distribution of LMC SNRs

"O Remnants, where art thou ?"

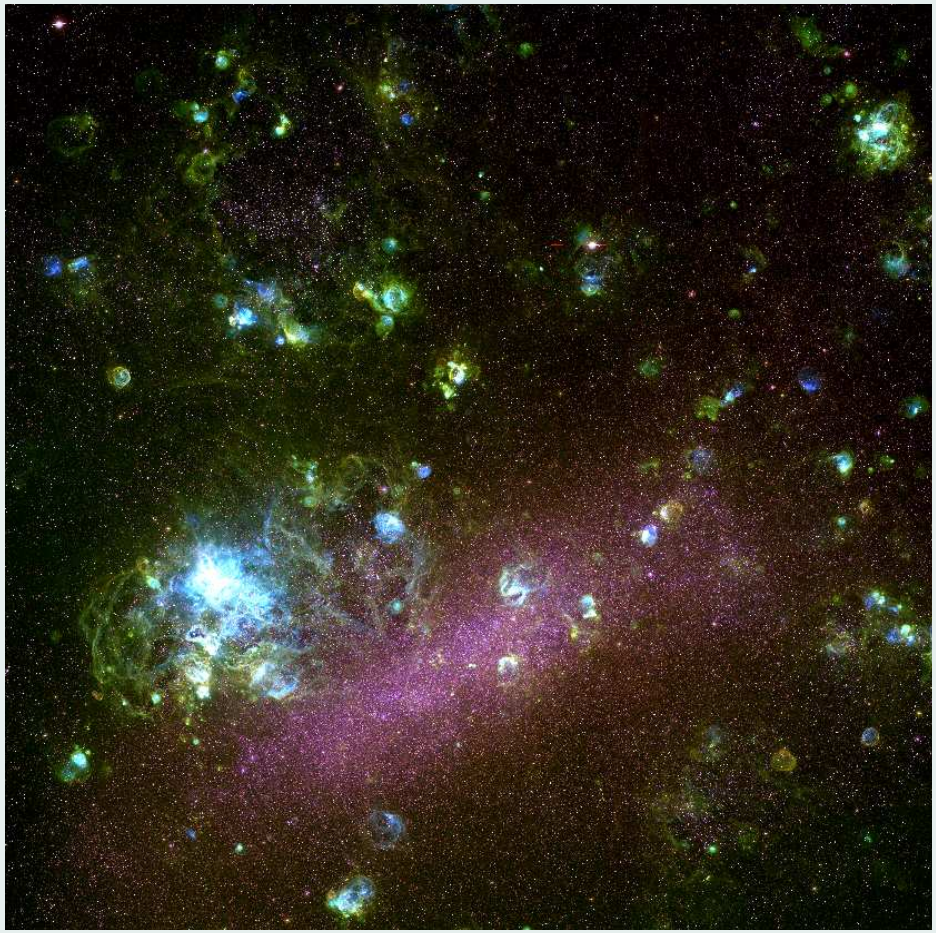
Neutral Hydrogen

H I map from Kim et al. (2003)



Stars and ionised gas

MCELS emission-line images



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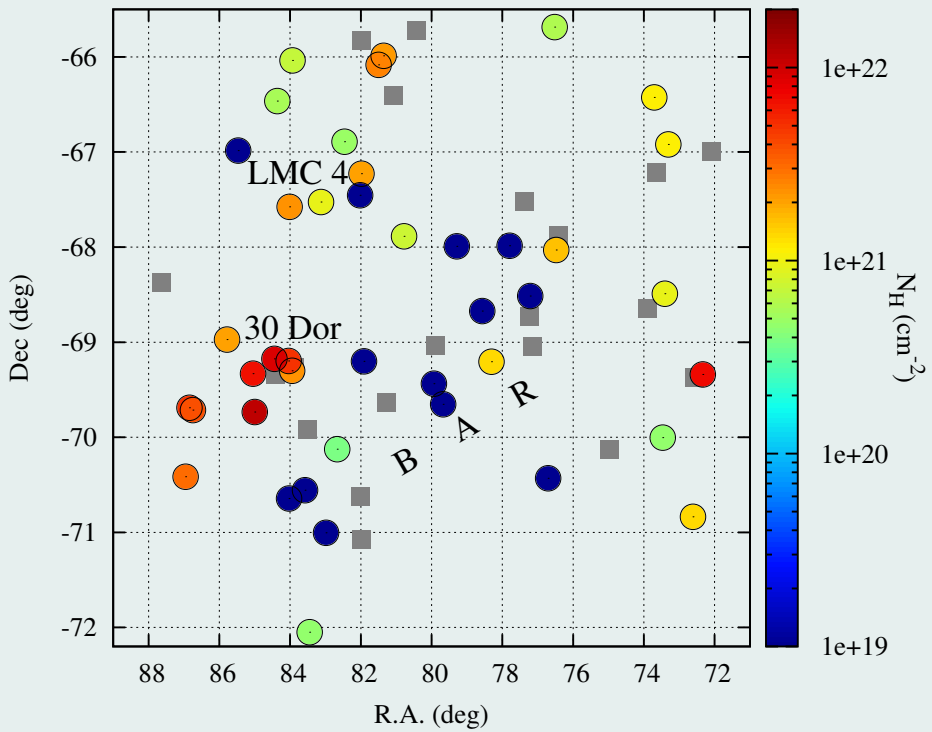
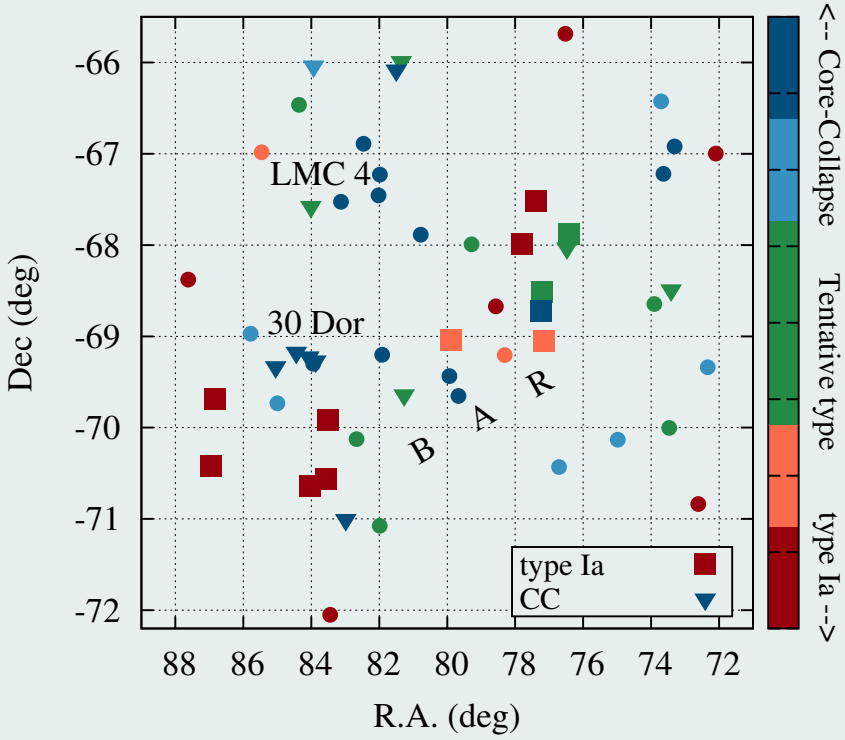
SNRs and X-ray-derived N_H



- "stellar" bar in front

Tentative SN type

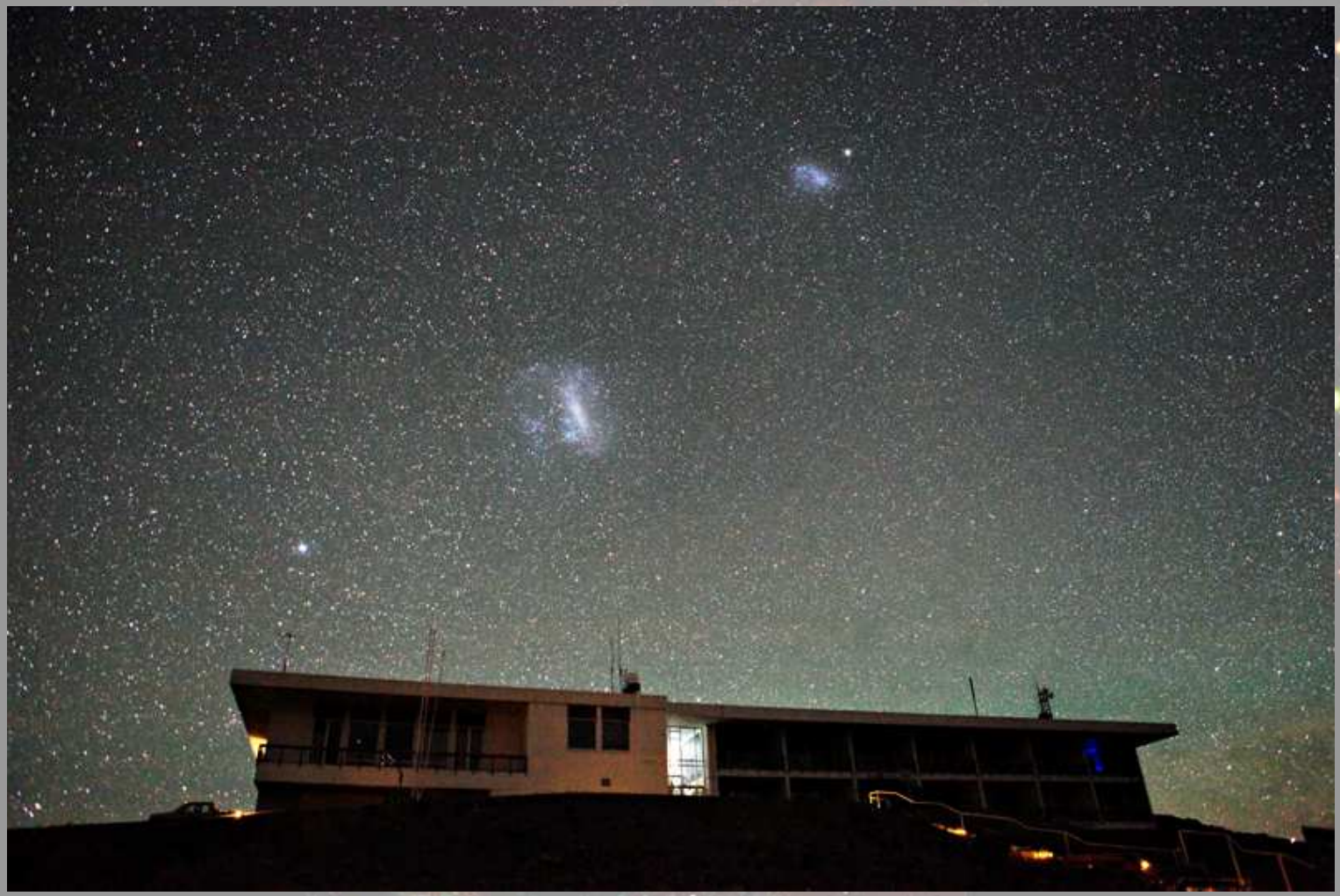


- Star-forming regions visible

- The LMC is an ideal laboratory for the study of supernova remnants.
- XMM-Newton Large Programme survey found new, fainter SNRs, and revealed hidden details of those previously known.
  - They exemplify the impact of the host galaxy/environment on late-time morphological evolution of SNRs.
  - Three are iron-rich (type Ia) remnants $\mapsto$ the oldest known.
- A complete sample allows the study of the
  - spatial distribution of remnants in the LMC (w/ respect to the various local stellar populations),
  - X-ray luminosity function (even the faint end)

  with unprecedented quality (compared to M31, M33, MW).

Keep observing the Clouds !



A view of the night sky over La Silla Observatory, Chile