

# First results on SNRs from the eROSITA All-Sky Survey

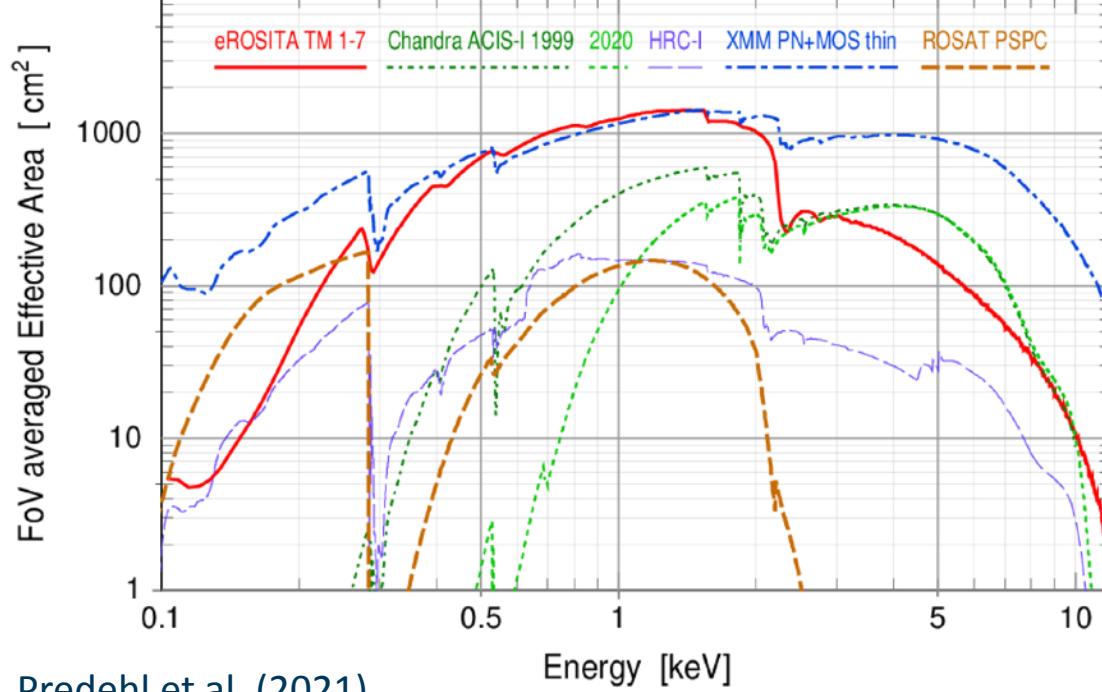
eROSITA



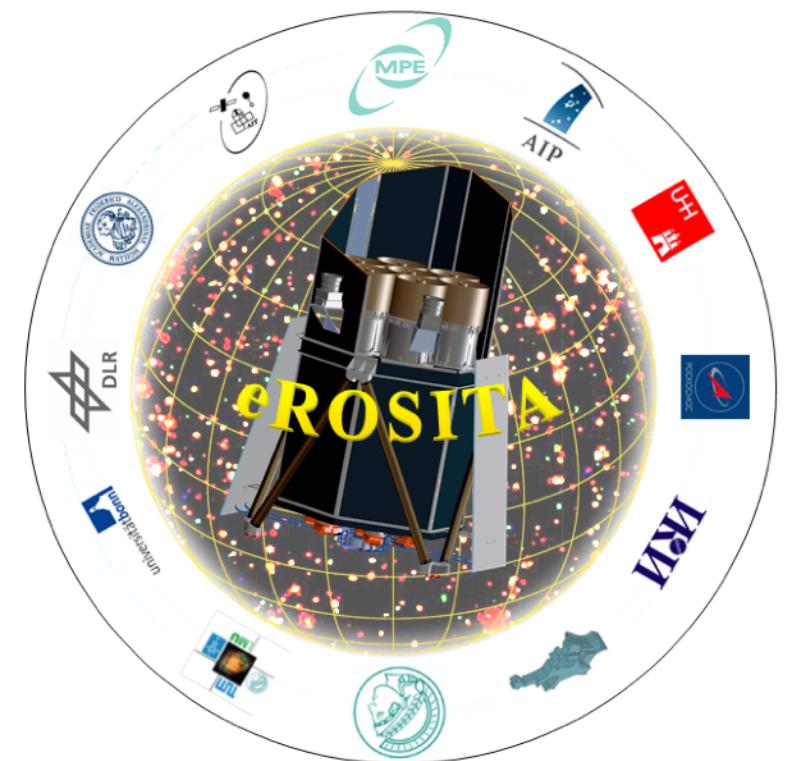
**Manami Sasaki**

Dr Karl Remeis Observatory  
Erlangen Centre for Astroparticle Physics

- “*extended ROentgen Survey with an Imaging Telescope Array*”
- Collaboration between Germany and Russia.
- German X-ray telescope on board the Russian "Spectrum-Roentgen-Gamma" (SRG) satellite.
- First all-sky survey in the soft to medium X-ray band from 0.2 to 10 keV with a spatial resolution of 26'' and spectral resolution of 80 eV at 1.5 keV.



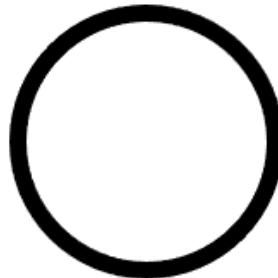
Predehl et al. (2021)



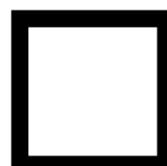
Moon diameter  
30 arcmin



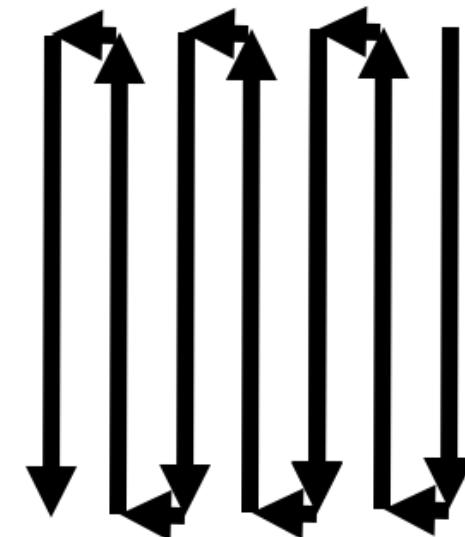
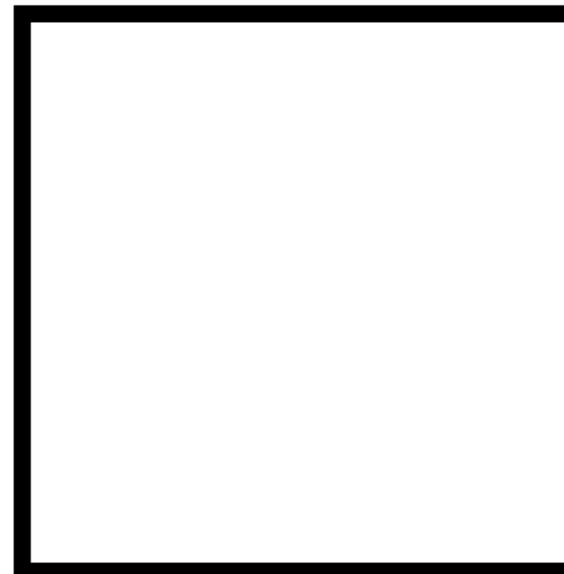
XMM-Newton  
Field of view ~ 30 arcmin



Chandra  
Field of view ~ 17 arcmin



eROSITA  
Field of view ~ 62 arcmin

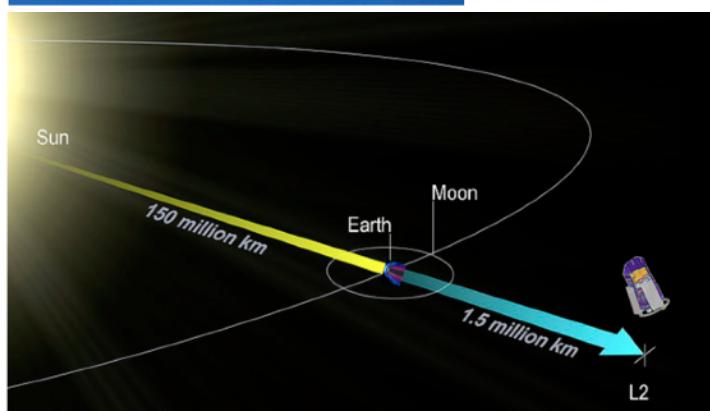
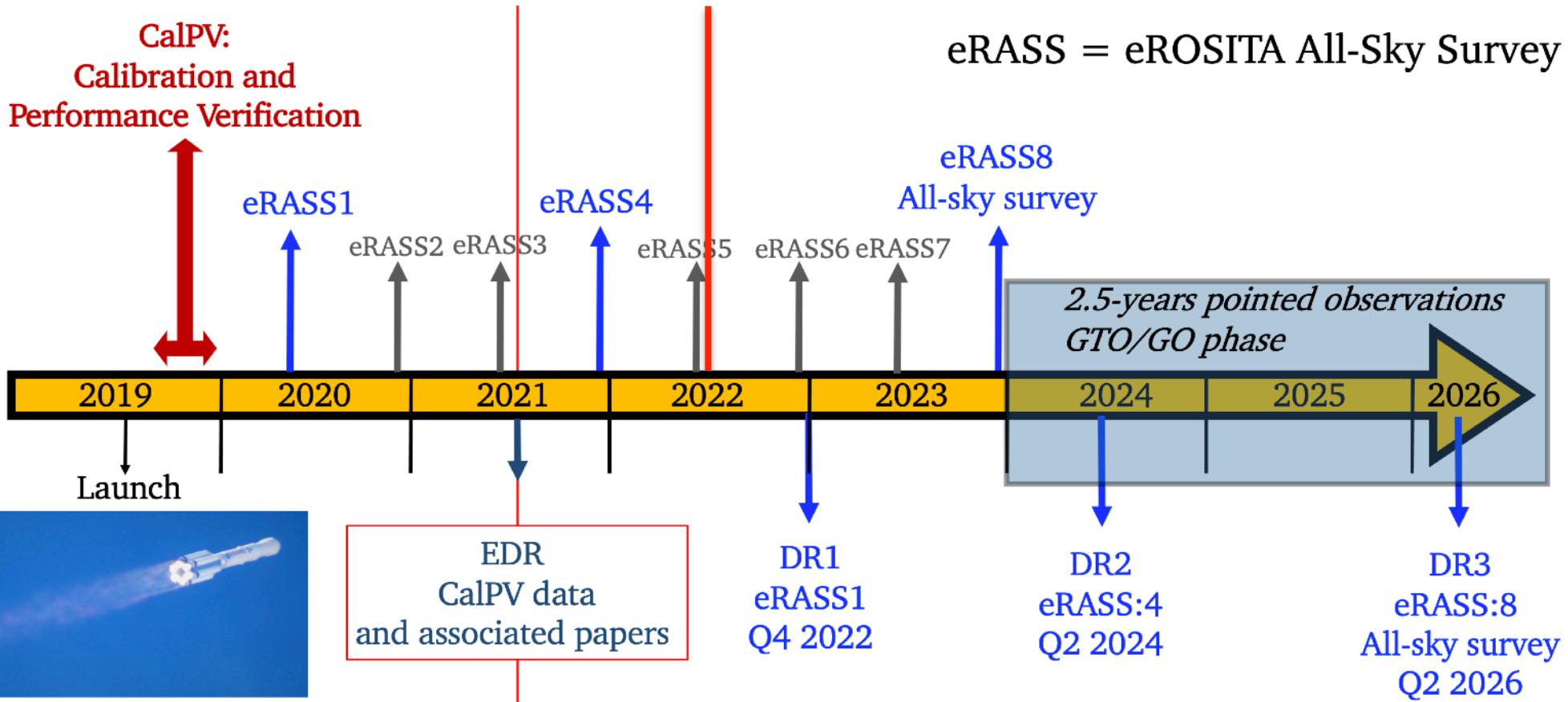


Scanning feature

**3 Observing modes:**  
continuous scan (survey), field scan, pointing

Credit: A. Merloni (MPE)

# Timeline



Credit: A. Merloni (MPE)

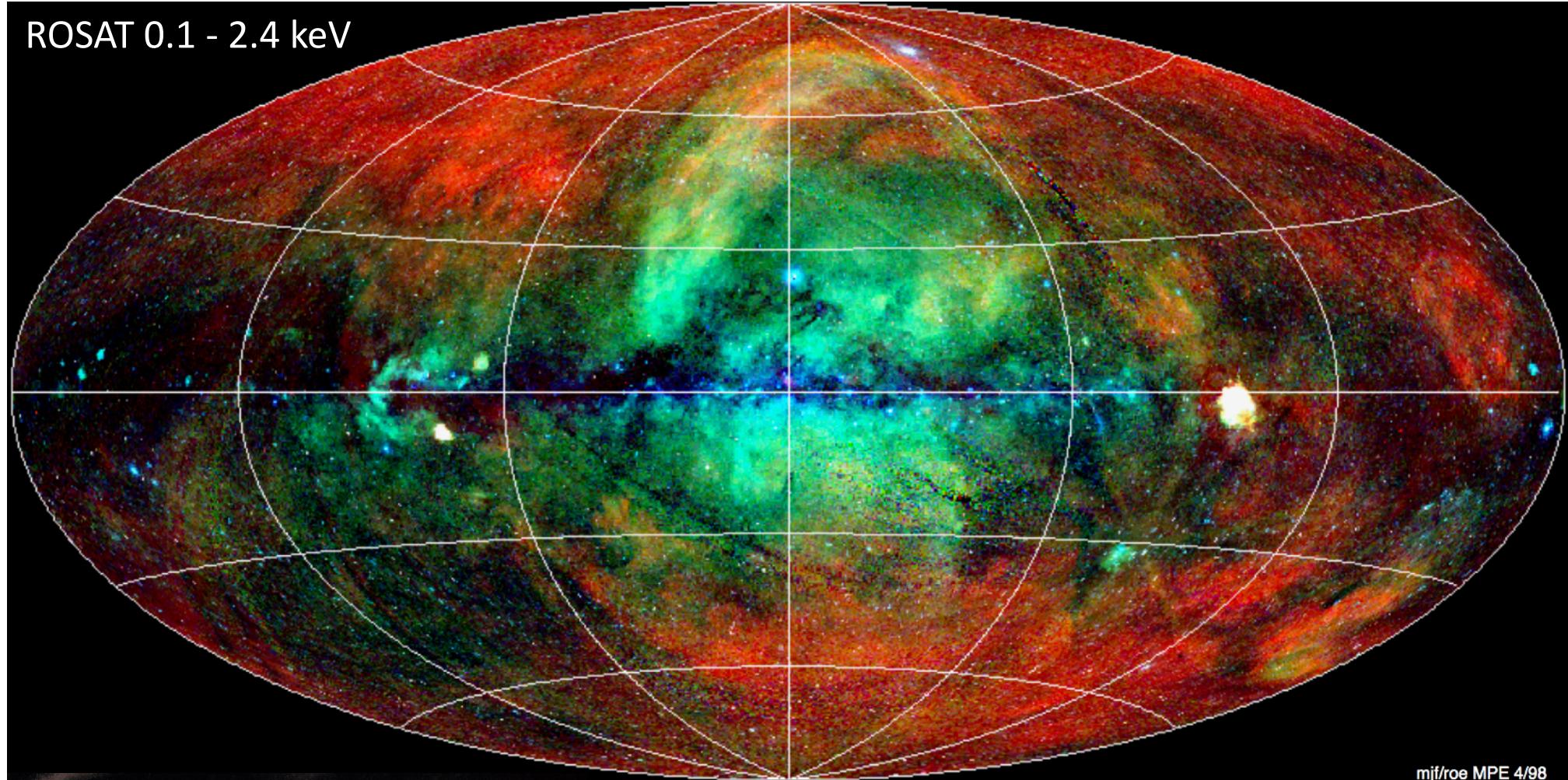
- June 28, 2021
- **Public release of data by the German eROSITA Consortium (eROSITA-DE):**
  - observations obtained during Cal-PV program: mid-September and mid-December 2019,
  - approx. 30 different sky fields of distinct covered area and deep source catalogues of some of these observations.
- **Public release the eROSITA Science Analysis Software System (eSASS)**
- **Online documentation:**
  - description of the observations and catalogues,
  - description of the eSASS software,
  - a guide to eROSITA data analysis,
  - technical information about eROSITA,
  - help forum.

<https://erosita.mpe.mpg.de/edr/>

# ROSAT All-Sky Survey



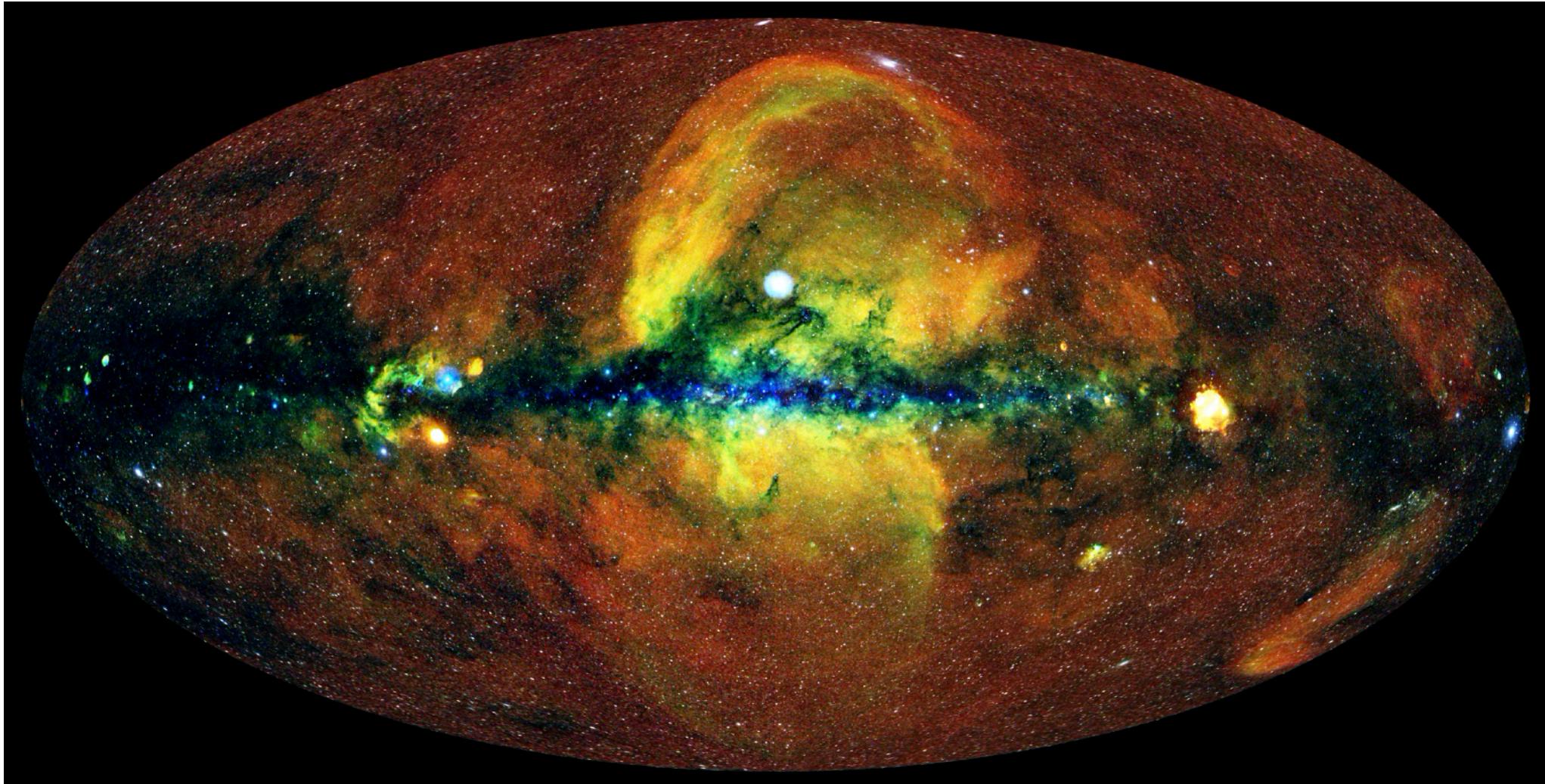
ROSAT 0.1 - 2.4 keV



mjt/roe MPE 4/98

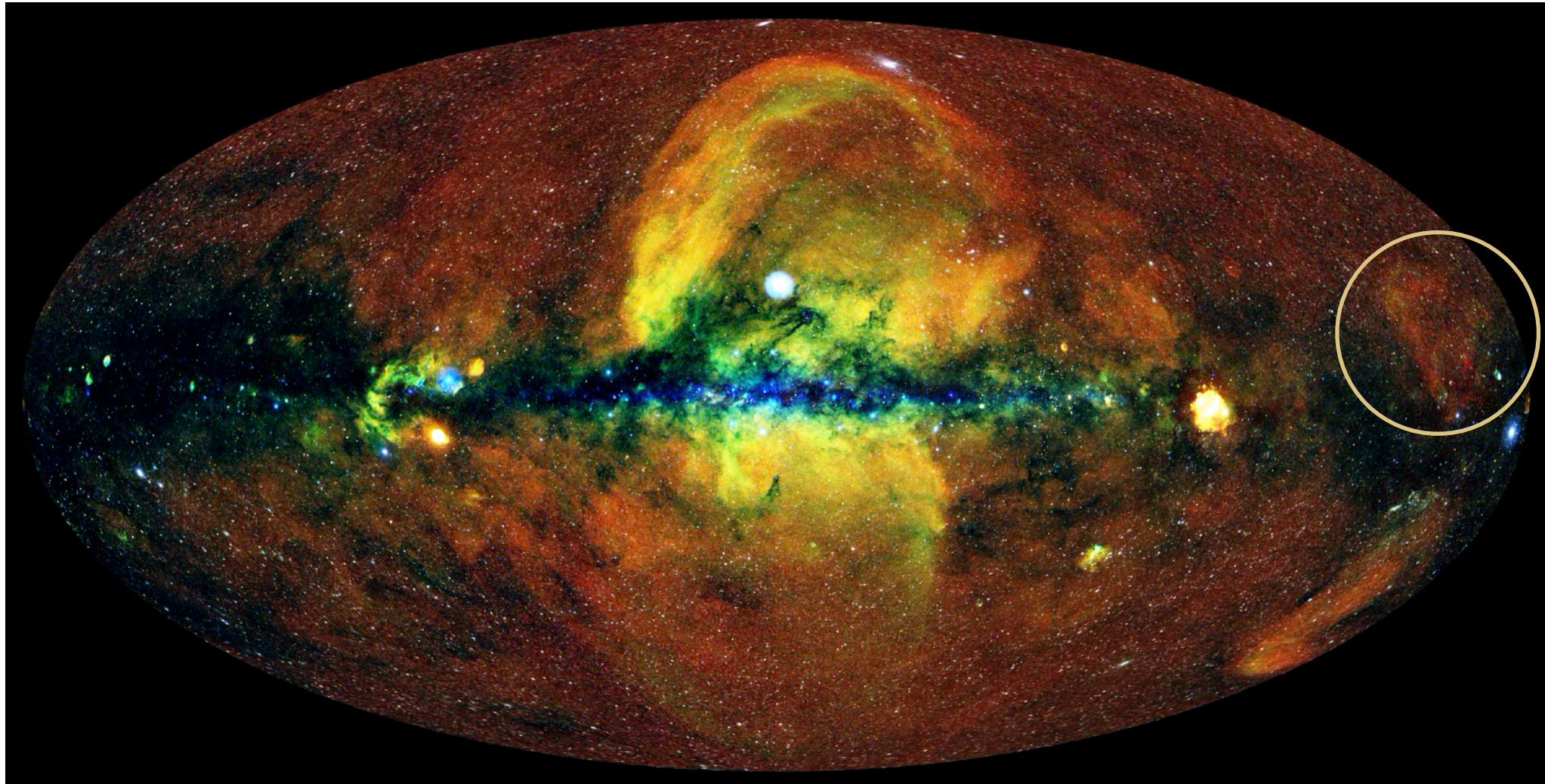


Image credit: EADS Astrium



J. Sanders, H. Brunner (MPE), E. Churazov, M. Gilfanov (IKI), and eSASS team

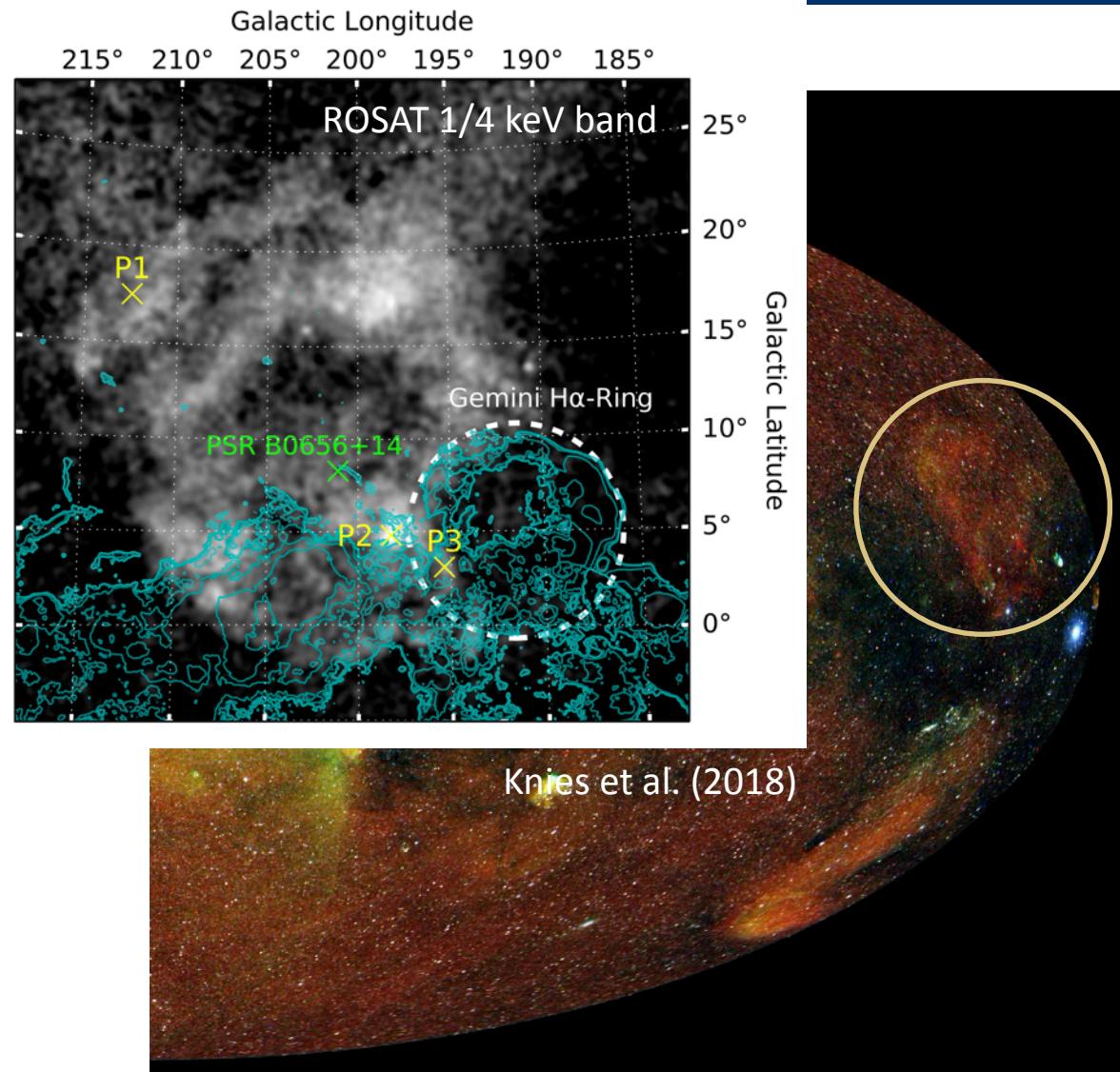
# Monogem Ring



J. Sanders, H. Brunner (MPE), E. Churazov, M. Gilfanov (IKI), and eSASS team

# Monogem Ring

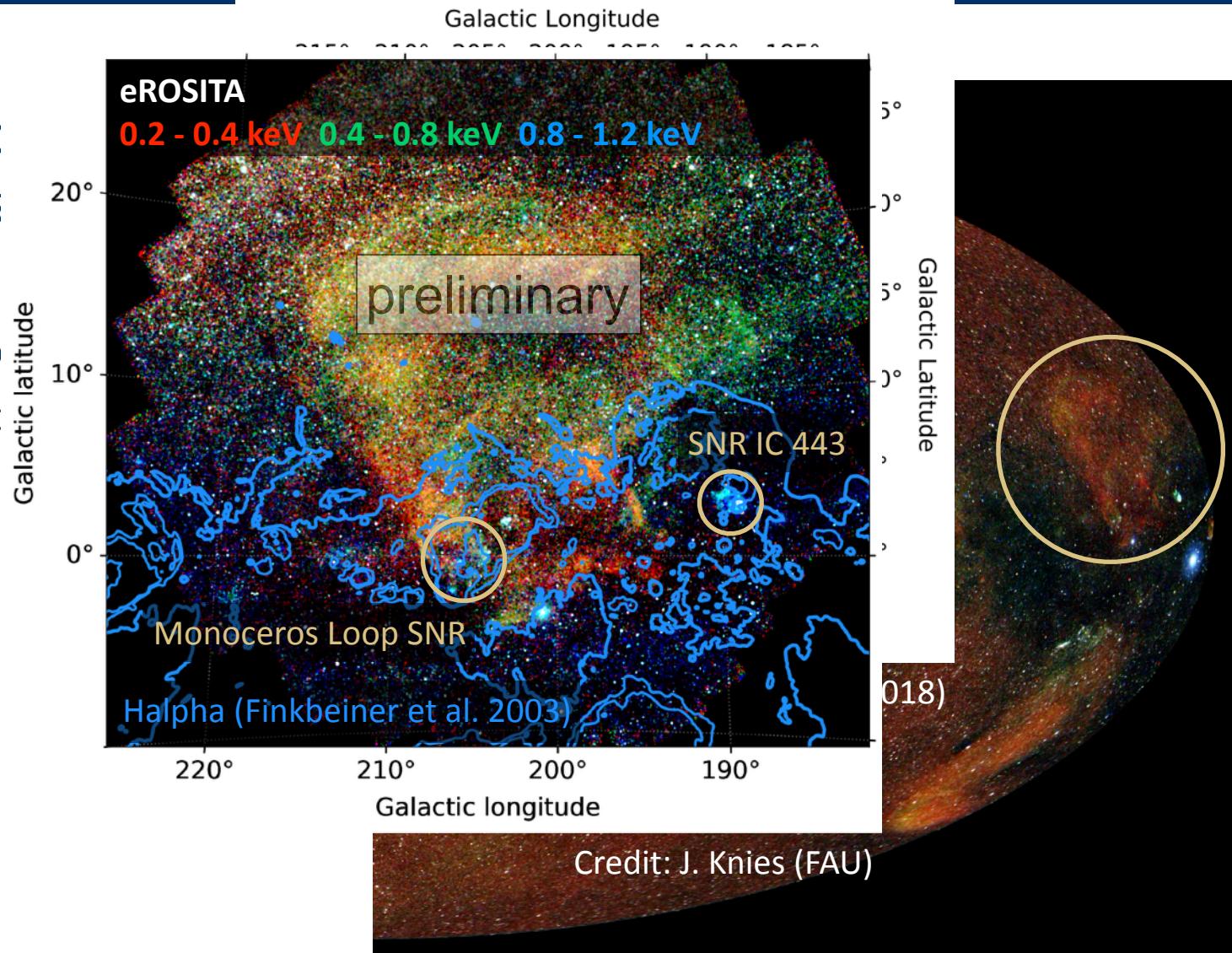
- Old nearby SNR
- D=300pc, age about 70 kyr
- Very large extent of 25°
- Emission very soft < 1 keV
- C IV emission in Far-UV
- Difficult to study due to large extent



J. Sanders, H. Brunner (MPE), E. Churazov, M. Gilfanov (IKI), and eSASS team

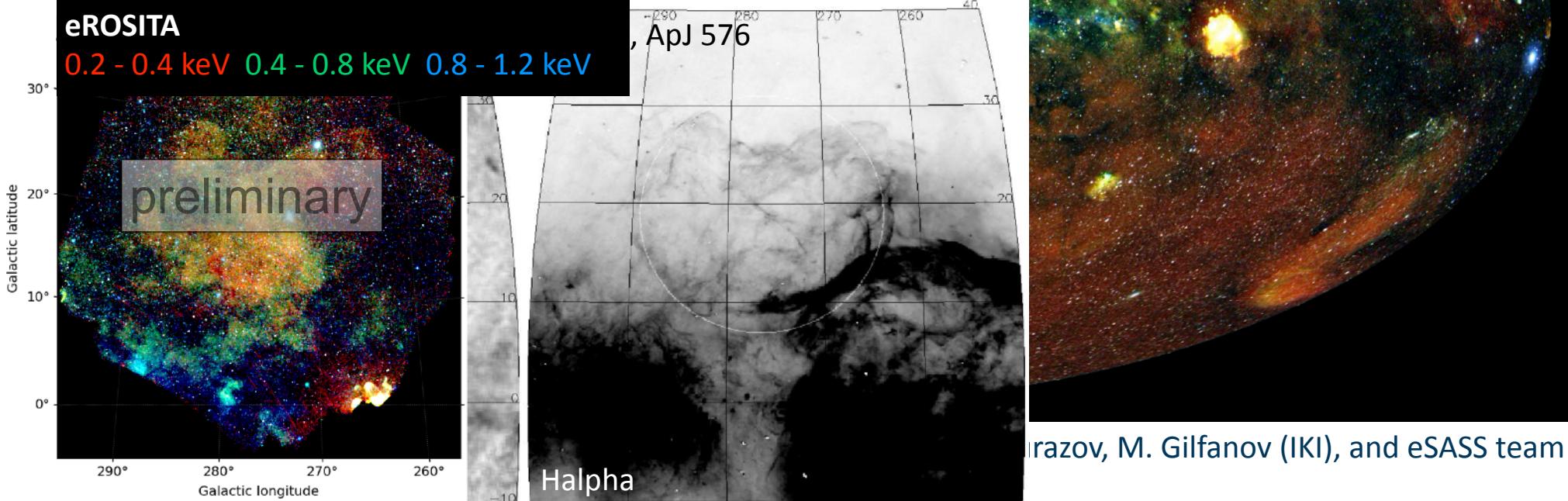
# Monogem Ring

- Old nearby SNR
- D=300pc, age about 70Myr
- Very large extent of 25°
- Emission very soft < 1keV
- C IV emission in Far-UV
- Difficult to study due to large extent
- Full coverage with eROSITA at CCD resolution
- Close distance → Possible to study SNR and its interaction with the ISM in detail



J. Sanders, H. Brunner (MPE), E. Churazov, M. Gilfanov (IKI), and eSASS team

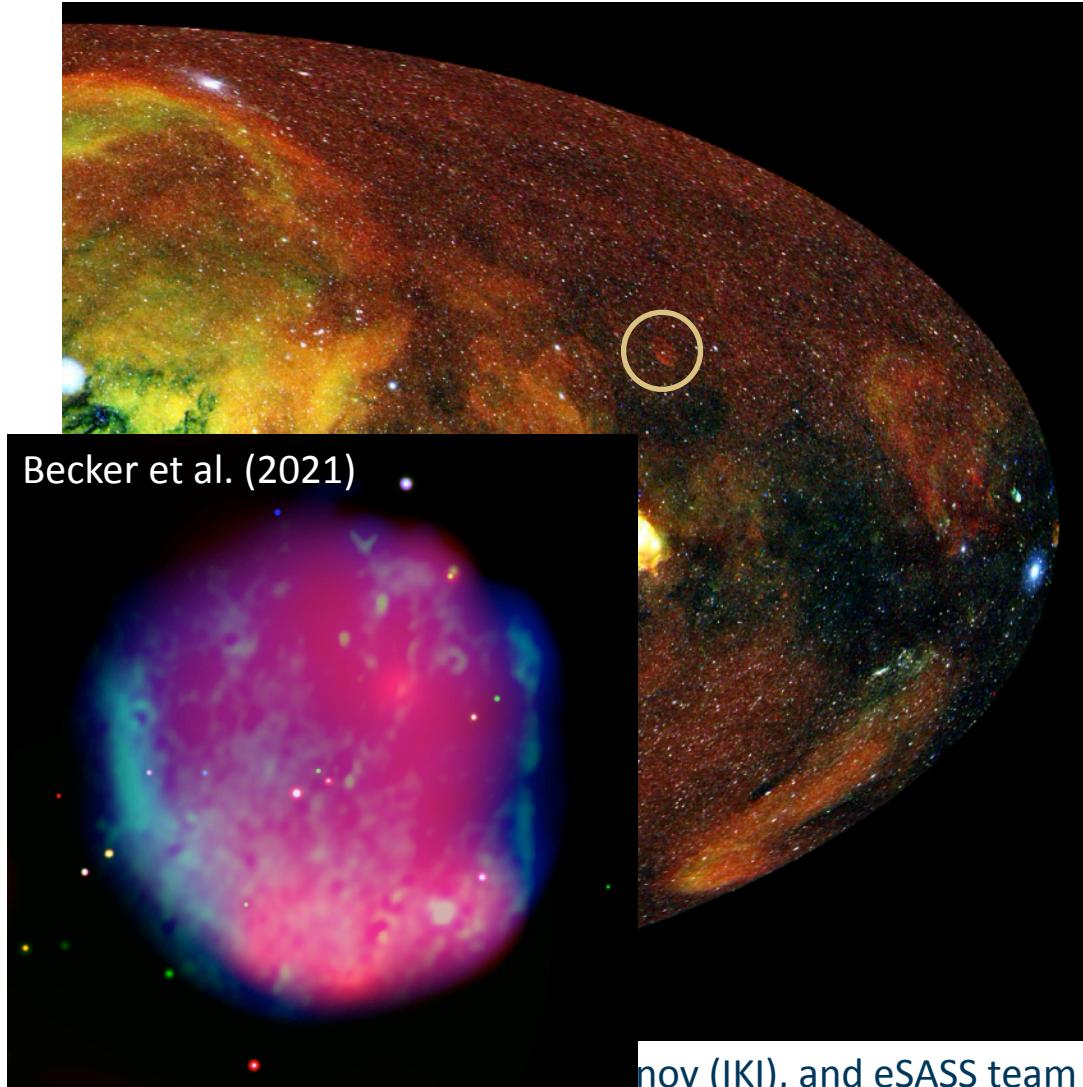
- Nearby SNR candidate
- D < 240 pc, age > 1 Myr?
- Gamma-Ray emission at 1.8 MeV ( $^{26}\text{Al}$ )
- Very large extent of  $25^\circ$
- Low absorption <  $10^{21} \text{ cm}^{-2}$
- FUV filaments (Fesen et al., 2021)



Credit: J. Knies (FAU)

- About 1200 SNRs are expected in the Milky Way, only 300 are known.
- Newly detected SNR, confirmed in radio
- Low absorption  $N_H = 3.6 \times 10^{20} \text{ cm}^{-2}$
- Low temperature  $kT = 0.11 \text{ keV}$
- Middle-aged nearby ( $D \sim 500 \text{ pc}$ ) SNR

eROSITA/MPE (X-ray, magenta)  
CHIPASS/SPASS/N. Hurley-Walker,  
ICRAR-Curtin (Radio, blue)



# Vela and Friends

Camilloni, Mayer, Becker, Predehl, et al. (in prep.)

SRG/eROSITA

Vela and Friends

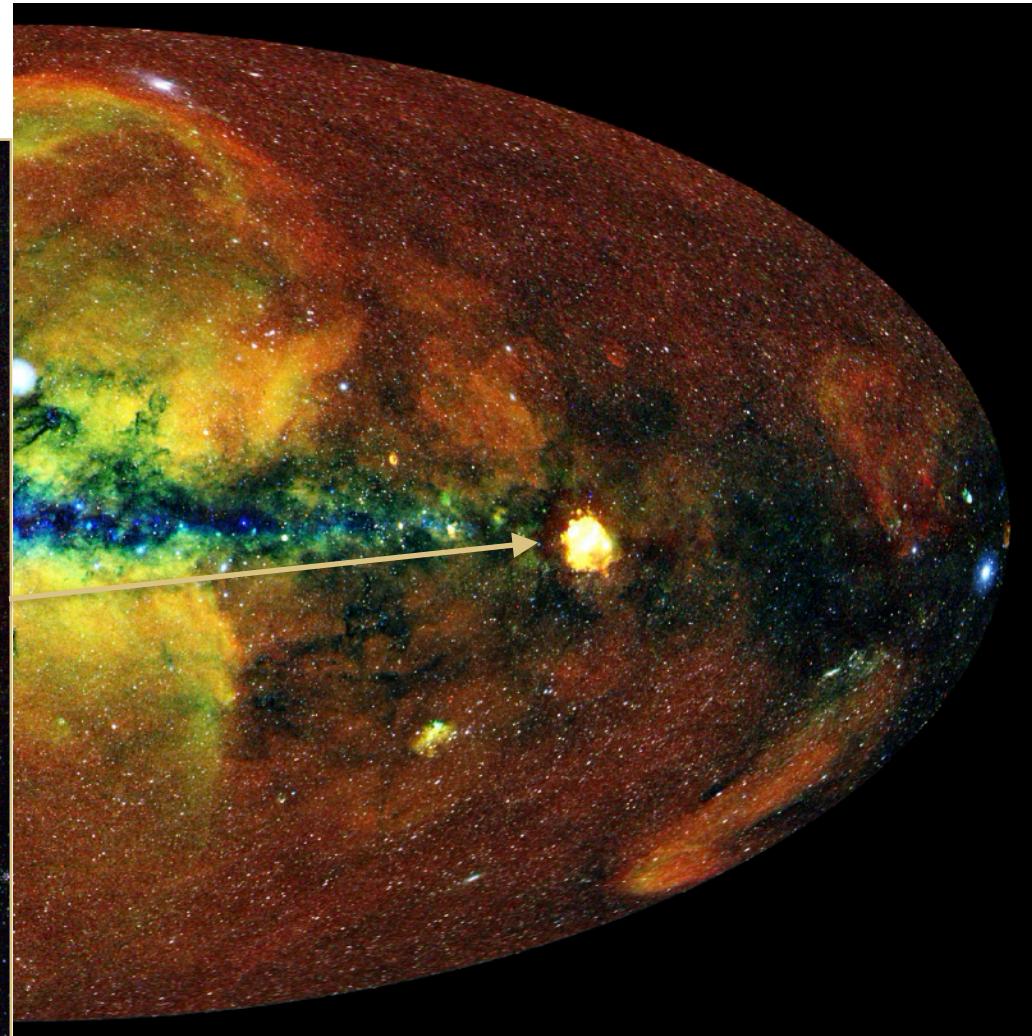
Puppis A

Vela Pulsar

Vela Junior

2 degrees

MPE



nner (MPE), E. Churazov, M. Gilfanov (IKI), and eSASS team

# Puppis A SNR

Camilloni, Mayer, Becker, Predehl, et al. (in prep.)

SRG/eROSITA

Vela and Friends

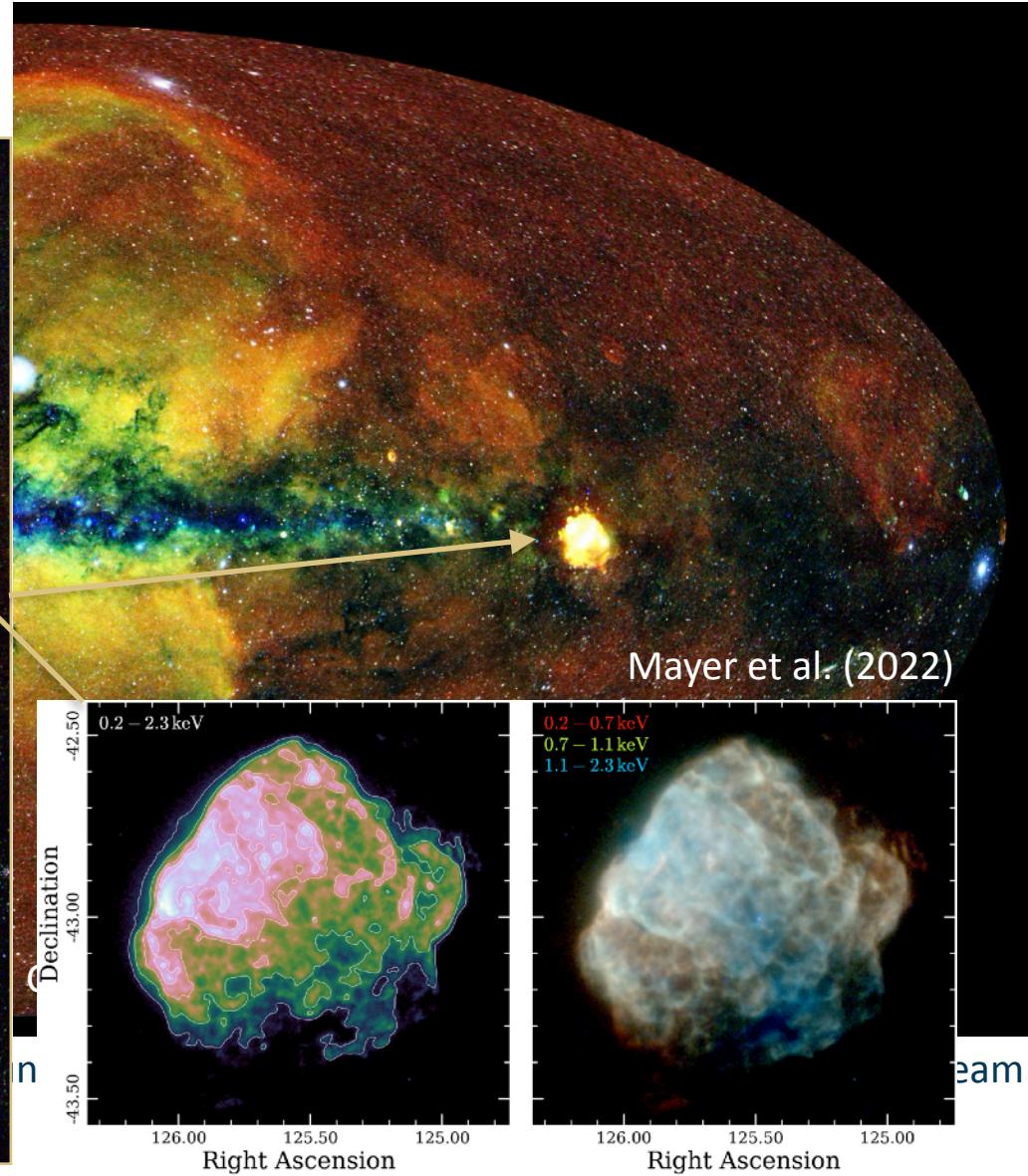
Puppis A

Vela Pulsar

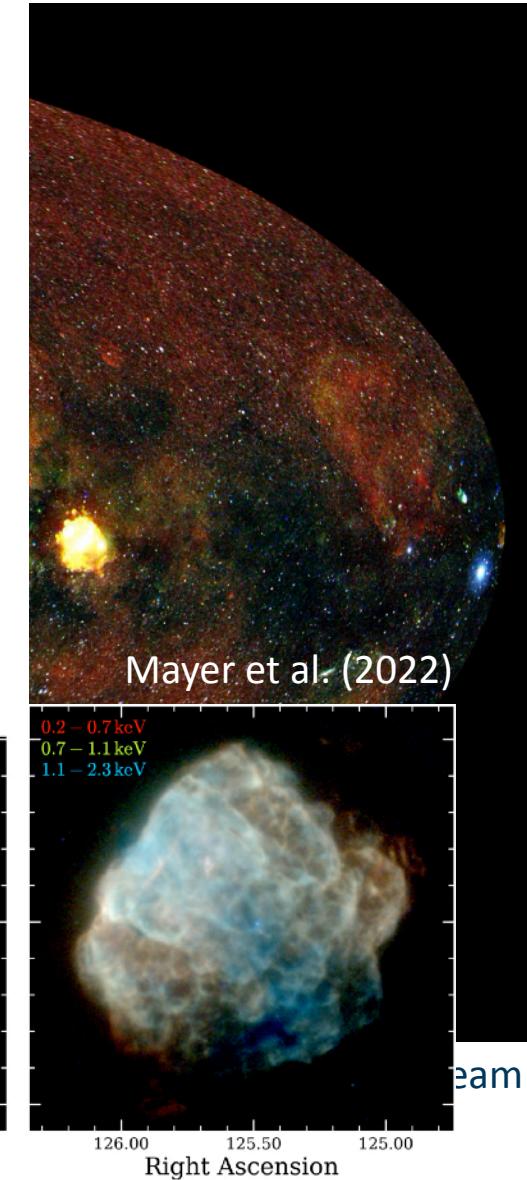
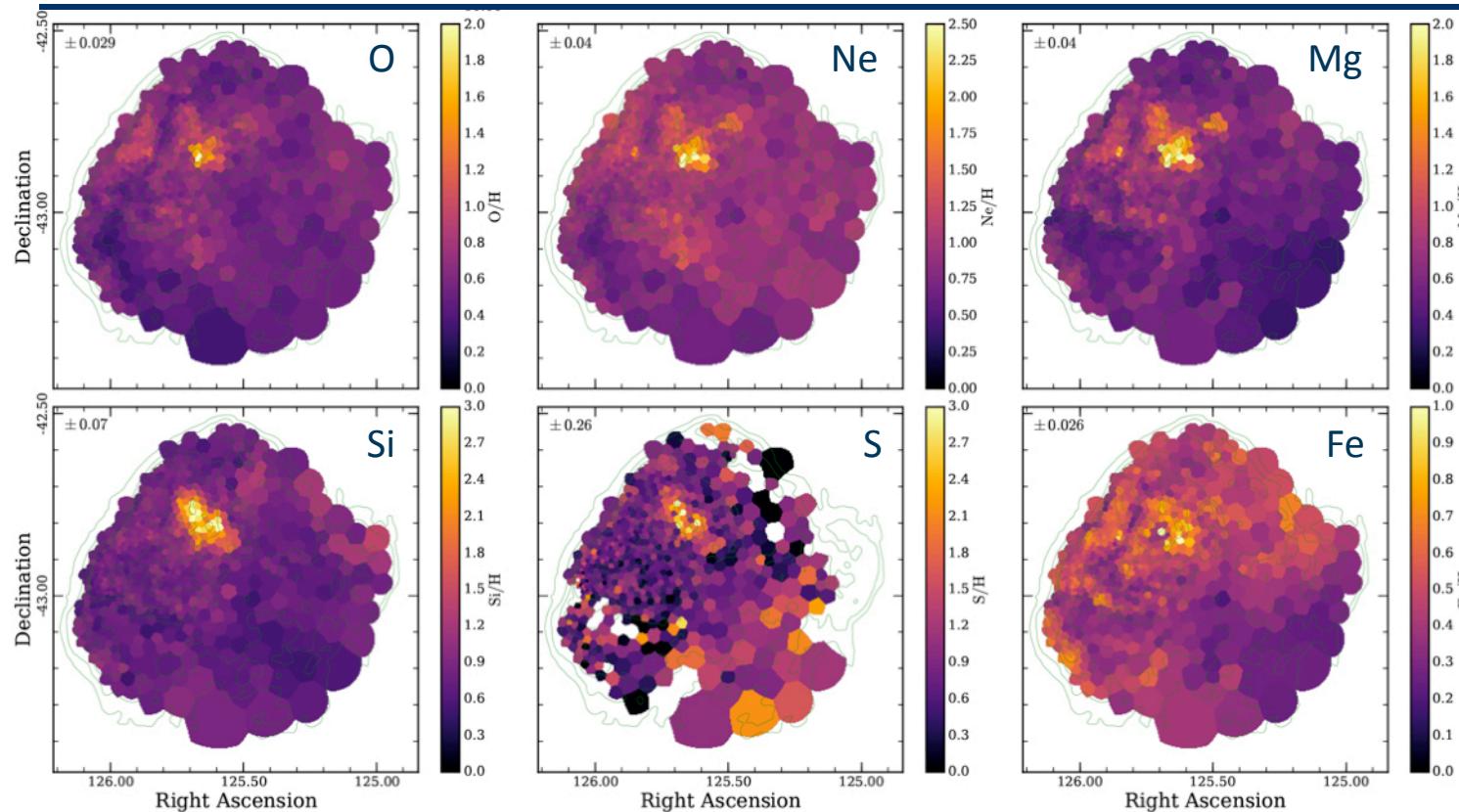
Vela Junior

2 degrees

MPE



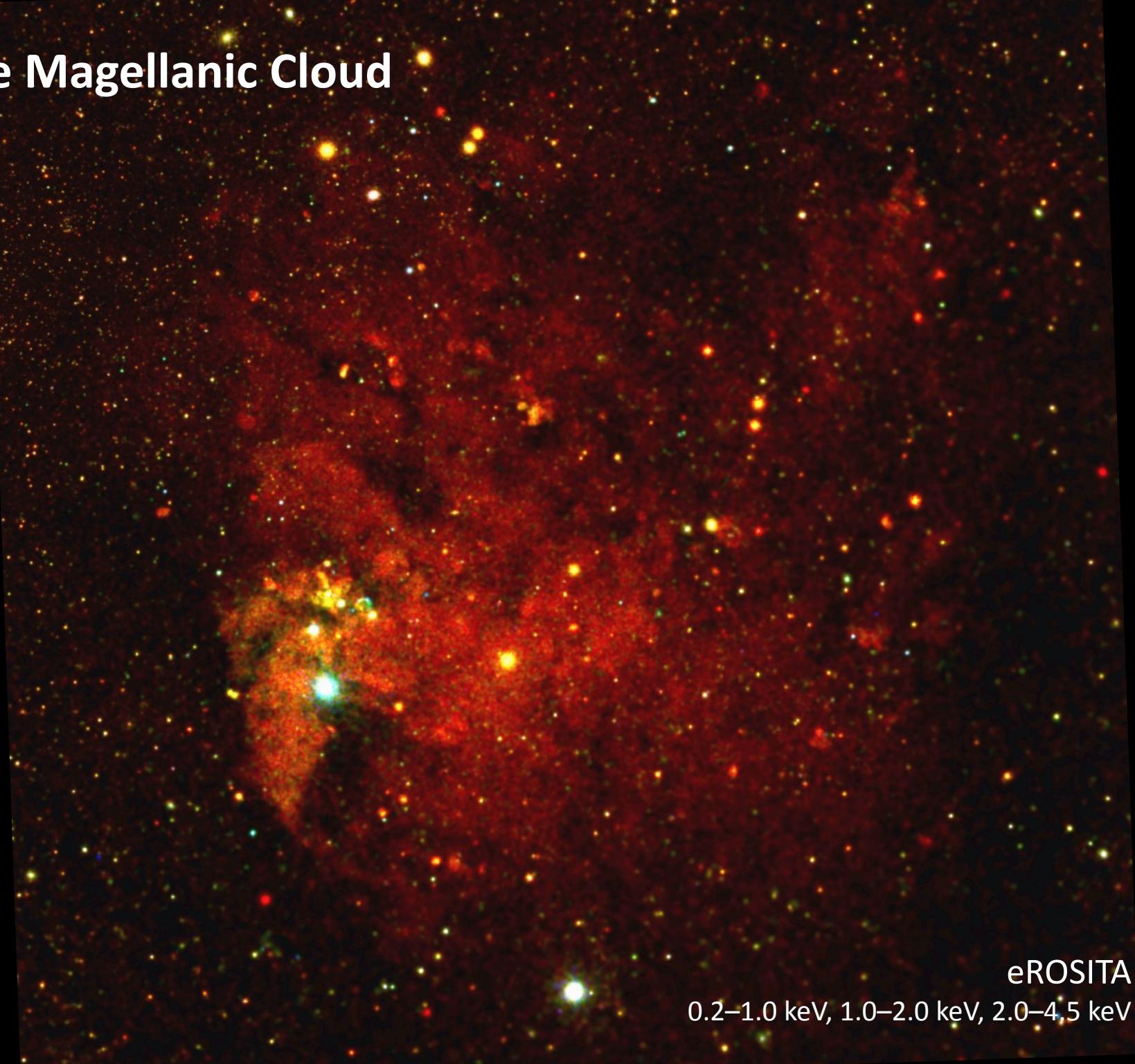
# Puppis A SNR



See ePoster by  
Martin Mayer

J. Sanders, H. Brun

# Large Magellanic Cloud



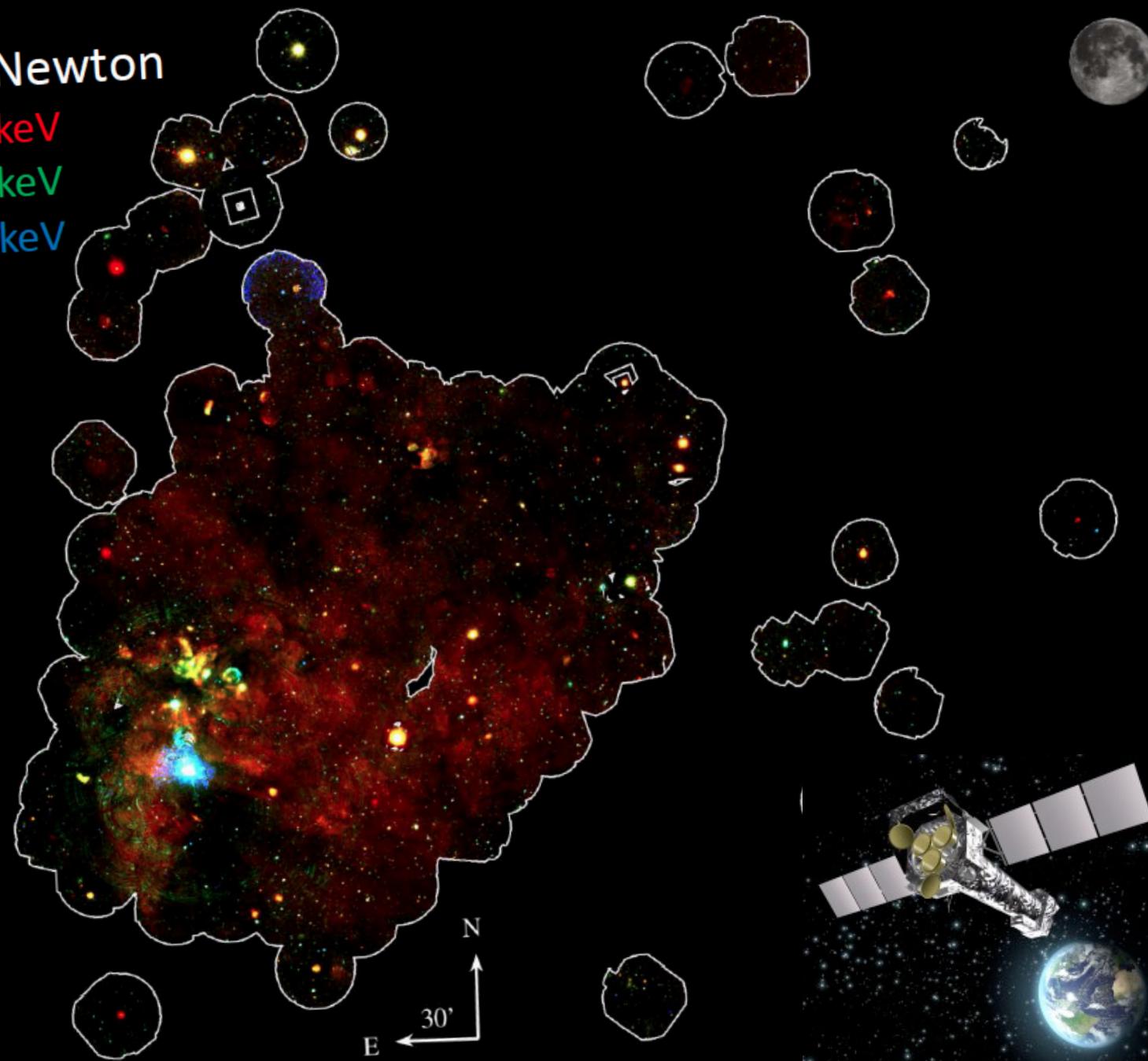
eROSITA  
0.2–1.0 keV, 1.0–2.0 keV, 2.0–4.5 keV

XMM-Newton

0.2-1.0 keV

1.0-2.0 keV

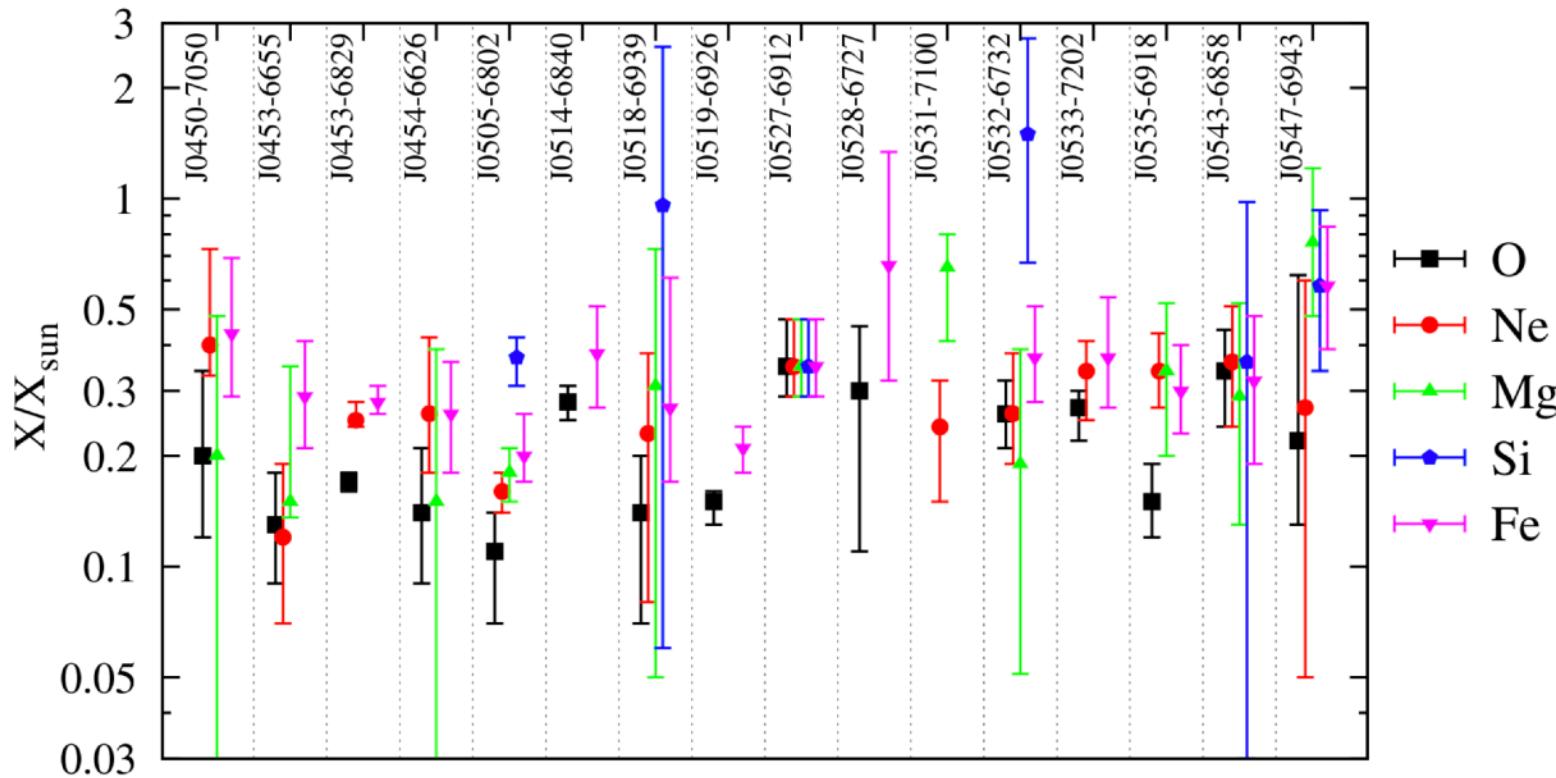
2.0-4.5 keV



Large Magellanic Cloud

XMM-Newton LMC Survey  
Credit: F. Haberl (MPE)

# XMM-Newton: SNRs and ISM Abundances

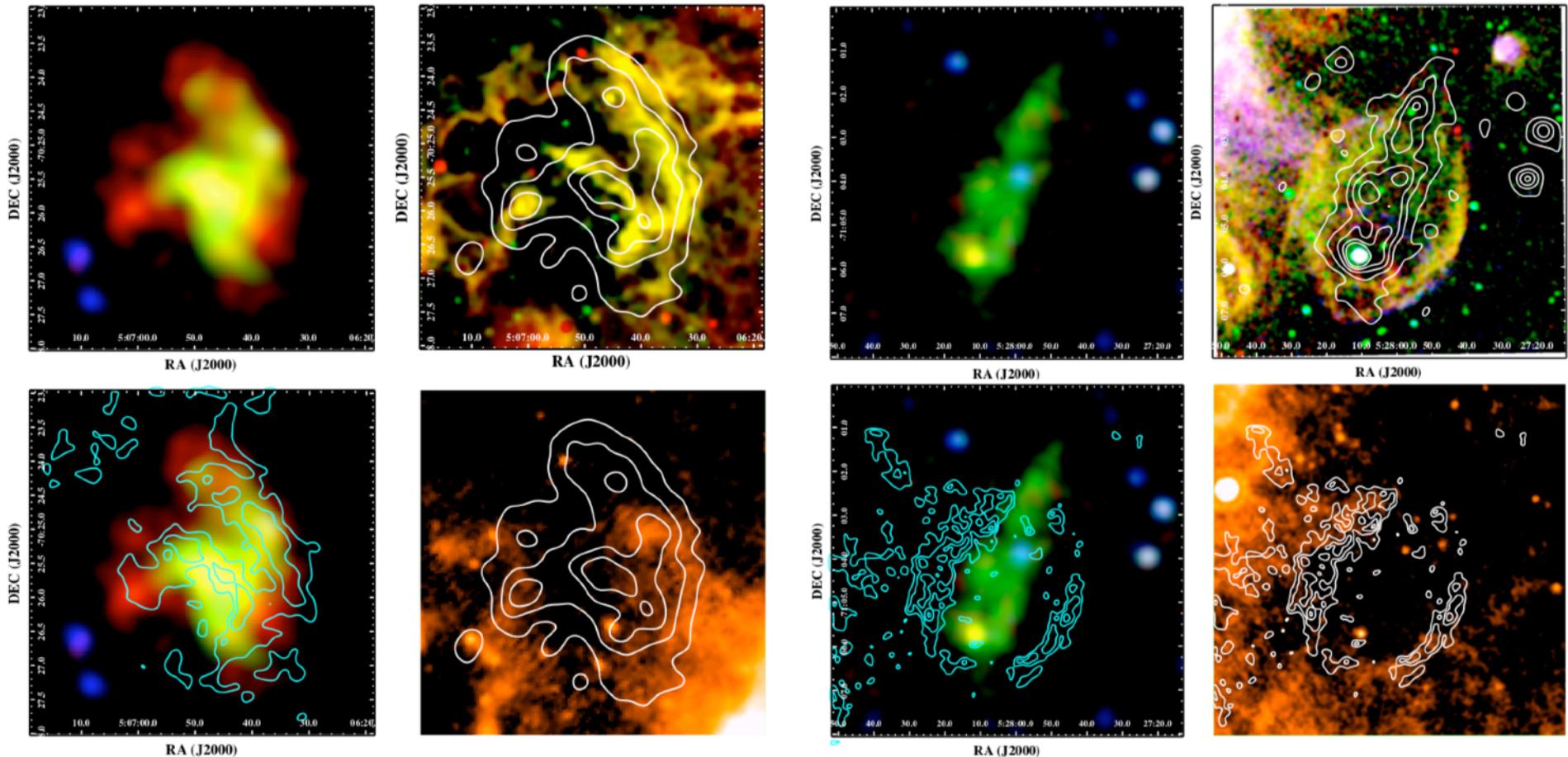


Element	$X/X_{\odot}$	$N$	rms	$12 + \log(X/H)$	Hughes et al. (1998)	RD92
	(1)	(2)	(3)			
O	0.21	15	0.08	$8.01^{+0.14}_{-0.21}$	$8.21 \pm 0.07$	$8.35 \pm 0.06$
Ne	0.28	13	0.08	$7.39^{+0.11}_{-0.15}$	$7.55 \pm 0.08$	$7.61 \pm 0.05$
Mg	0.33	11	0.19	$6.92^{+0.20}_{-0.37}$	$7.08 \pm 0.07$	$7.47 \pm 0.13$
Si	0.69	6	0.42	$7.11^{+0.20}_{-0.41}$	$7.04 \pm 0.08$	$7.81^a$
Fe	0.35	15	0.12	$6.97^{+0.13}_{-0.18}$	$7.01 \pm 0.11$	$7.23 \pm 0.14$

Maggi et al. (2016)

# XMM-Newton: Fe-rich Type Ia SNRs

SNRs J0506-7025 and J0527-7104 in the LMC



XMM-Newton EPIC (red: 0.3 - 0.7 keV,  
green: 0.7 - 1.1 keV, blue: 1.1 - 4.2 keV)

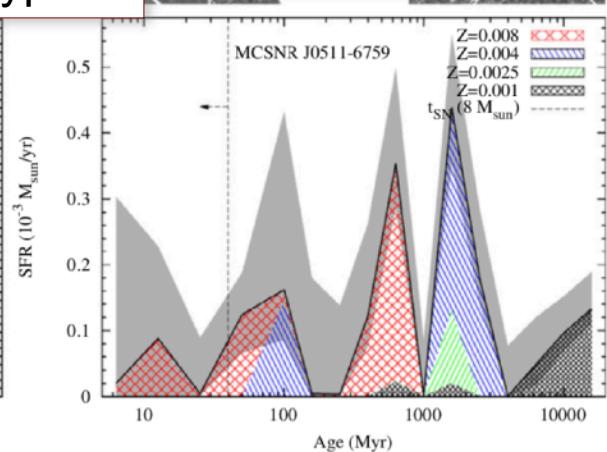
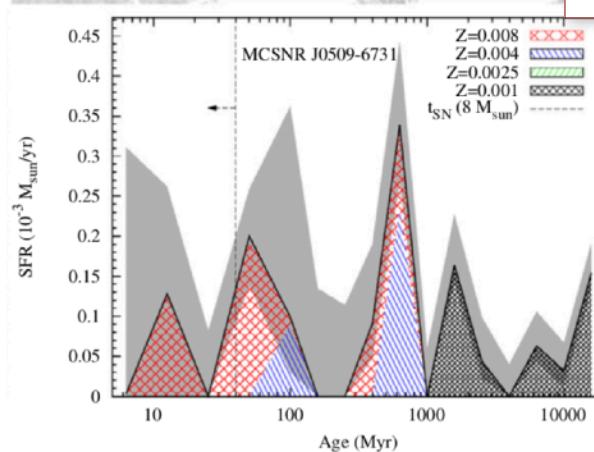
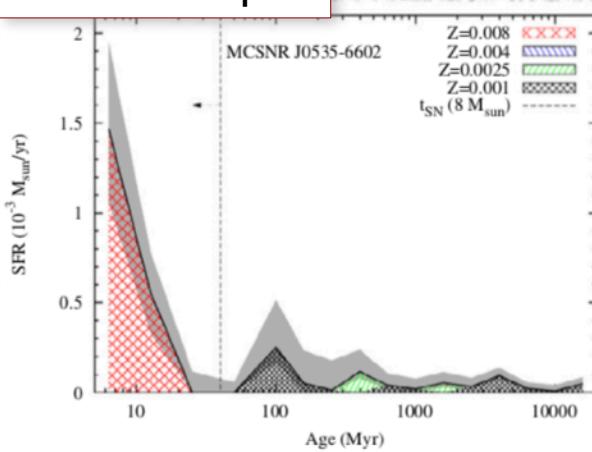
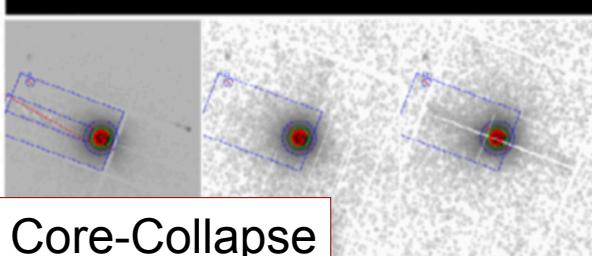
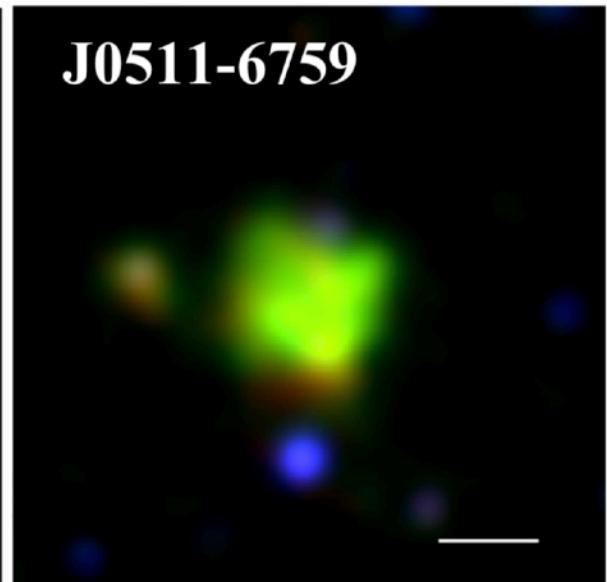
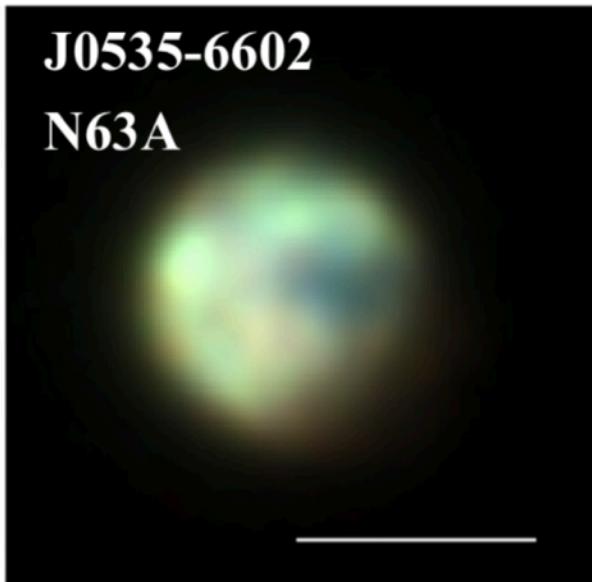
MCELS (red: H $\alpha$ , green: [S II], blue:  
[O III]) with X-ray contours

XMM-Newton EPIC RGB with contours  
for [S II]/H $\alpha$  = 0.67

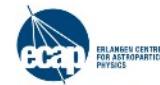
Spitzer MIPS 24  $\mu$ m image with  
contours for [S II]/H $\alpha$  = 0.67

Kavanagh et al. (2016)

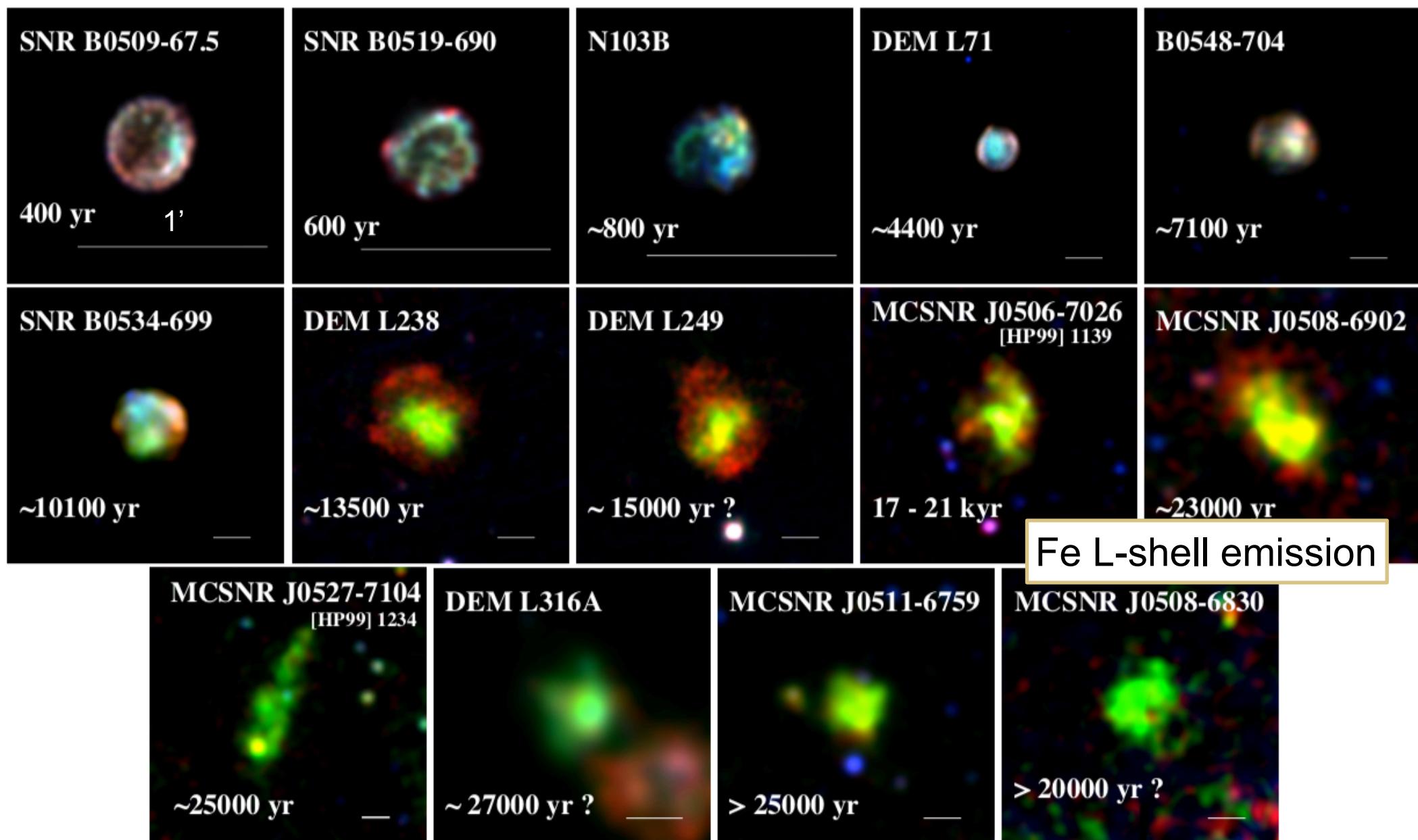
# XMM-Newton: SNRs and Stellar Populations



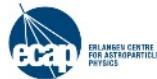
# XMM-Newton: Type Ia SNR Evolution



FAU



# XMM-Newton: Core-collapse SNR Morphologies



FAU  
ERLANGEN CENTRE  
FOR ASTROPARTICLE  
PHYSICS



# eROSITA LMC SNR Catalogue



Green: known SNRs

(Maggi et al., 2016, Maitra et al., 2019 )

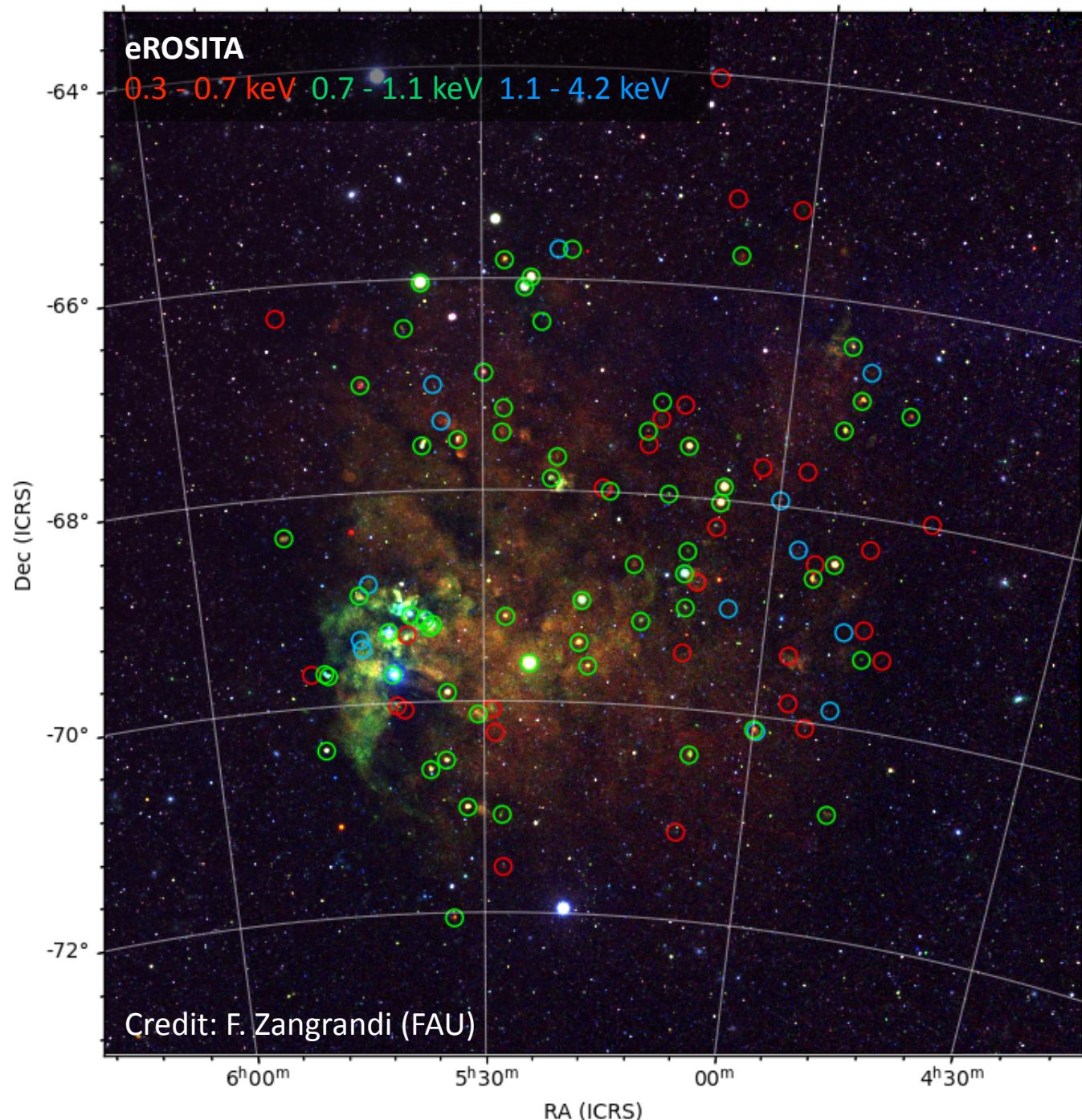
Red: SNR candidates

(Yew et al., 2020, optical,  
Bozzetto et al., 2017, radio)

Blue: new SNR candidates

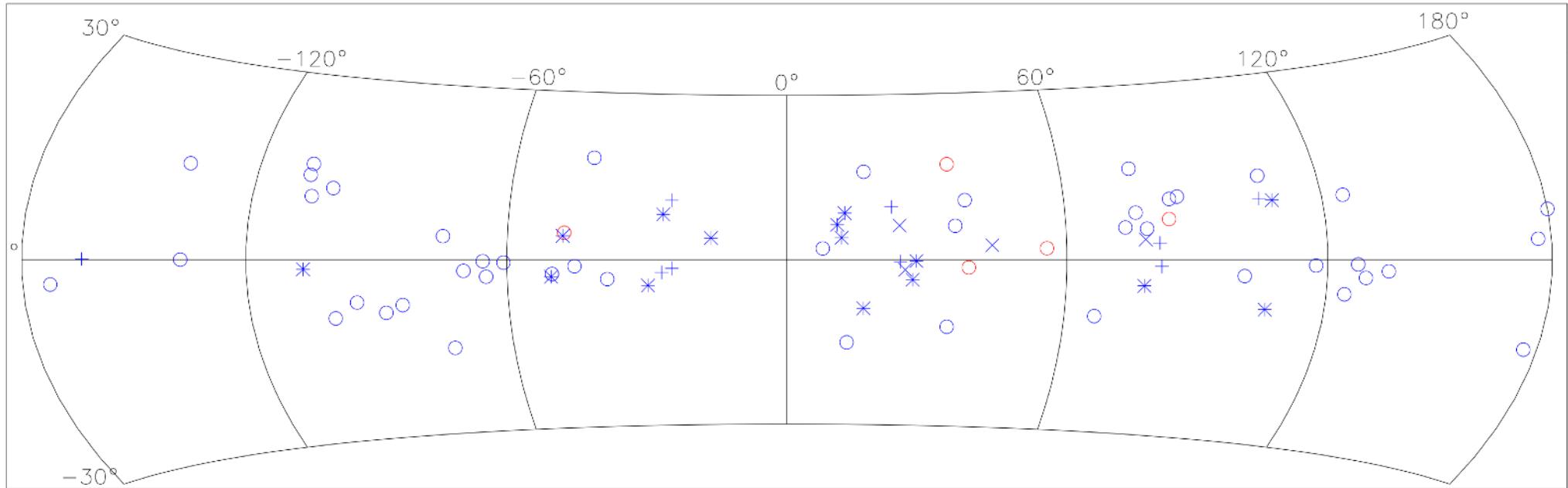
(ASKAP, Bozzetto et al., 2022)

- Image and spectral analysis of brighter SNRs
- Flux and hardness ratio studies of fainter SNRs
- Upper limits for undetected SNRs



# SNRs with eROSITA

- Study large nearby Galactic SNRs in detail (Monogem Ring, Antlia, Vela)
- New detections of SNRs in the Milky Way (e.g., Hoinga SNR)
- Catalogue of SNRs in the Milky Way
- SNRs as particles accelerators (TeV sources)
- Complete sample of SNRs in the Magellanic Clouds, down to  $L \approx 6 \times 10^{33} \text{ erg s}^{-1}$  and  $2 \times 10^{34} \text{ erg s}^{-1}$  for the LMC and SMC, respectively.



ROSAT All-Sky Survey SNR candidates. Credit: W. Becker (MPE)