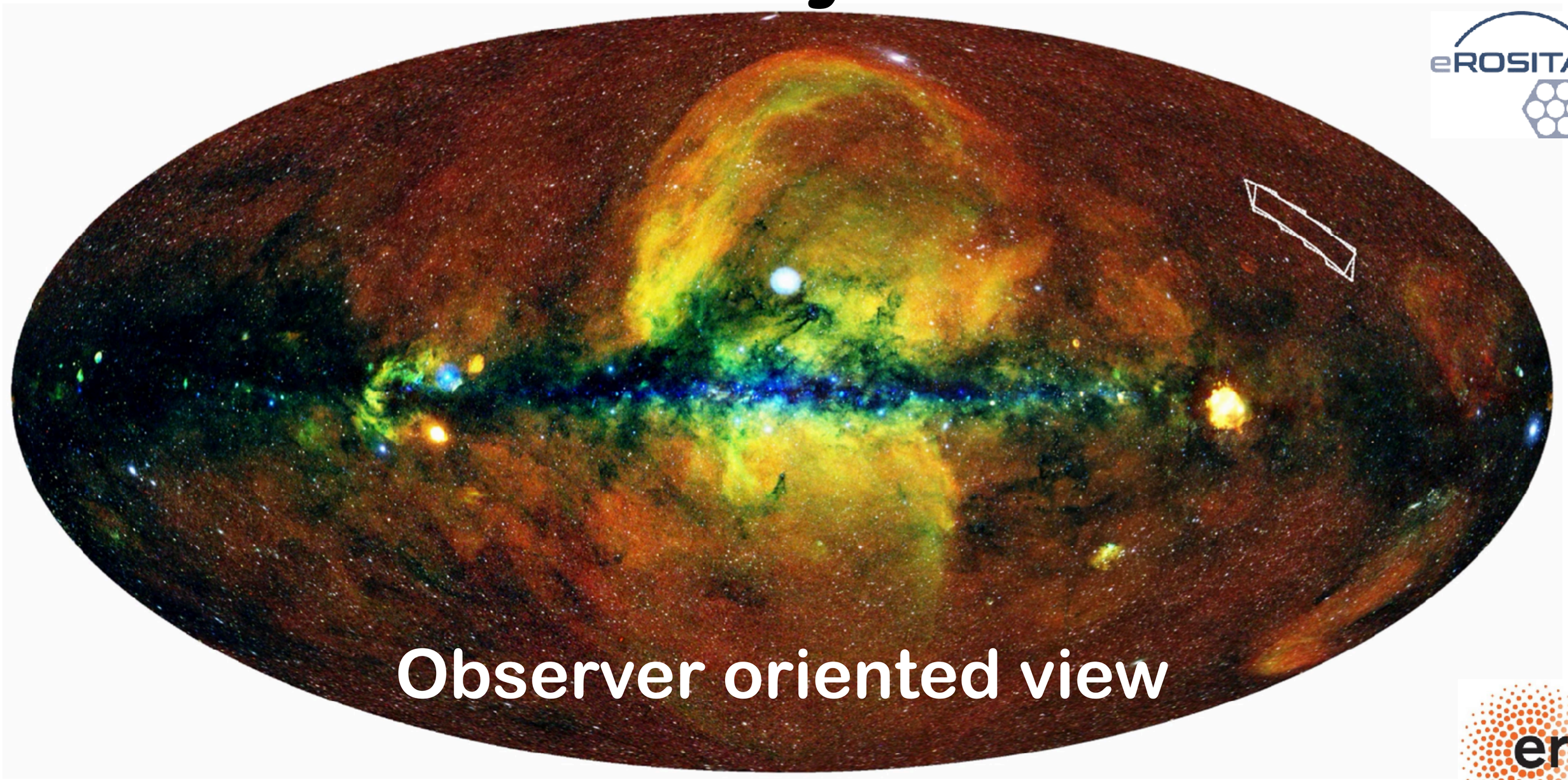
Diffuse X-ray emission



Gabriele Ponti (INAF-OA Brera, MPE) and the Hot Milk team

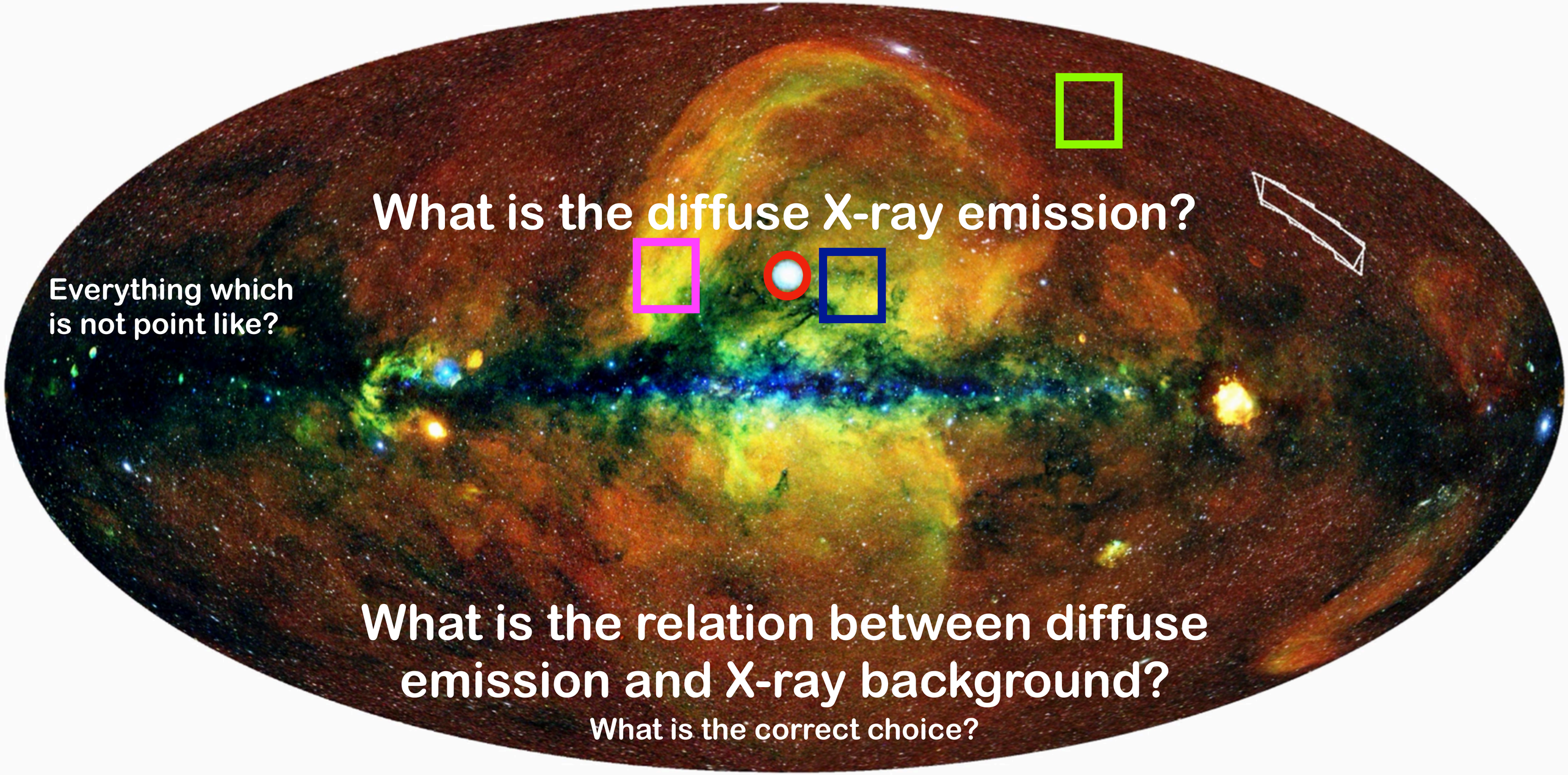
Outline

Composition of diffuse emission

Discussion of different components

The Hot Milk project
The hot phase of the Milky Way and Milky Way-like galaxies

What is the diffuse X-ray emission?



Short answer: None and all…

Long answer: We need to understand the composition of the X-ray diffuse emission and-or background!

Composition of the background

Instrumental background

Sky background (diffuse emission)

Composition of the background

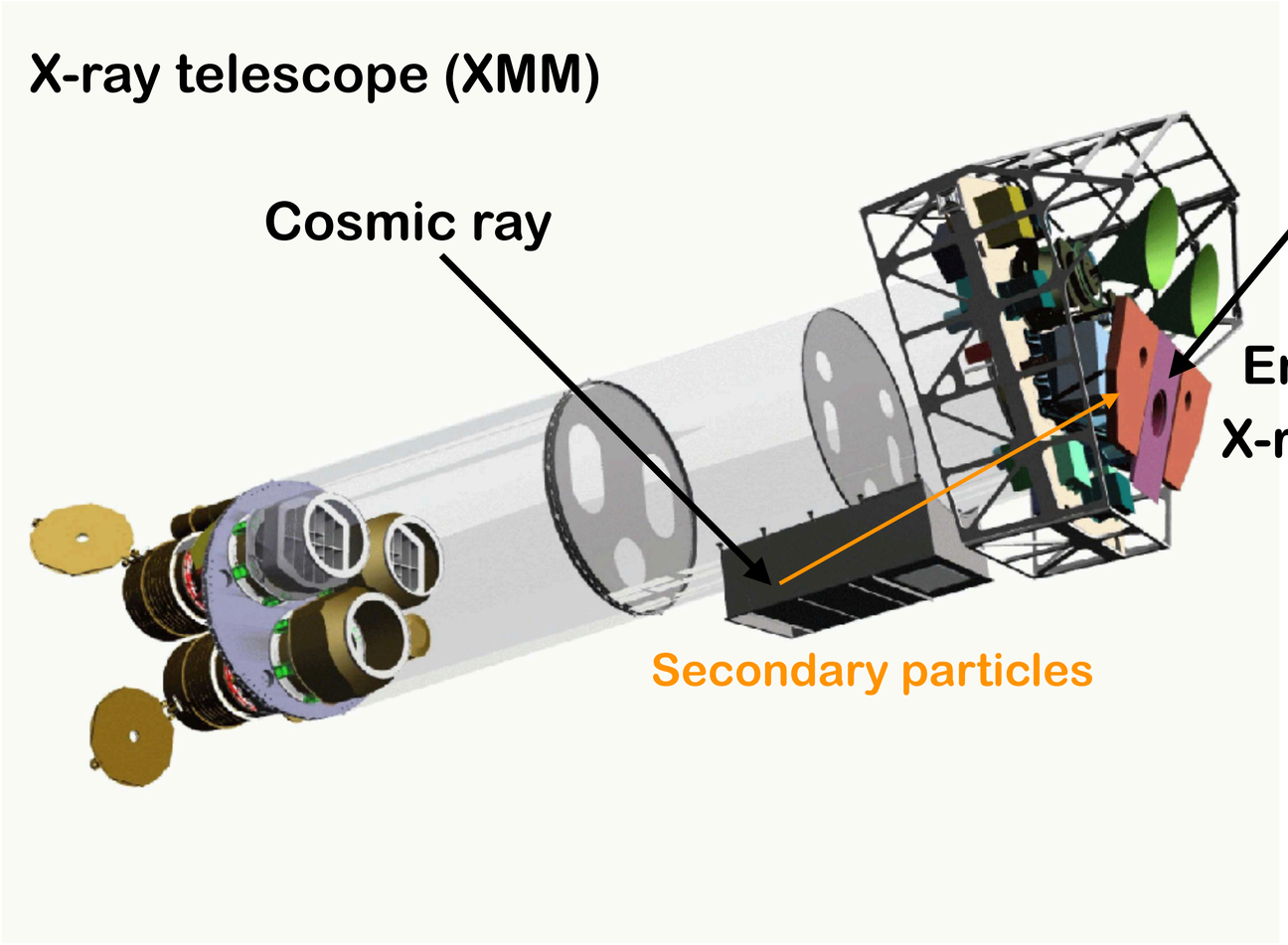
Instrumental background

Filter wheel closed emission

Composition of the background

Instrumental background

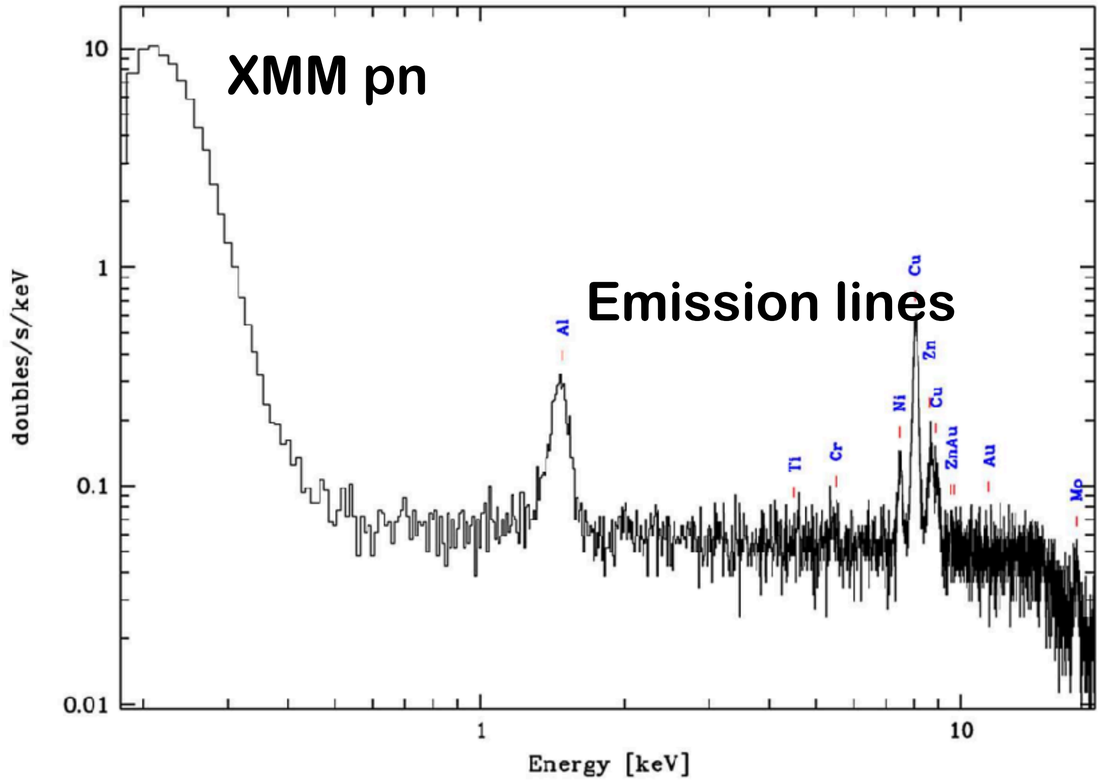
Filter wheel closed emission

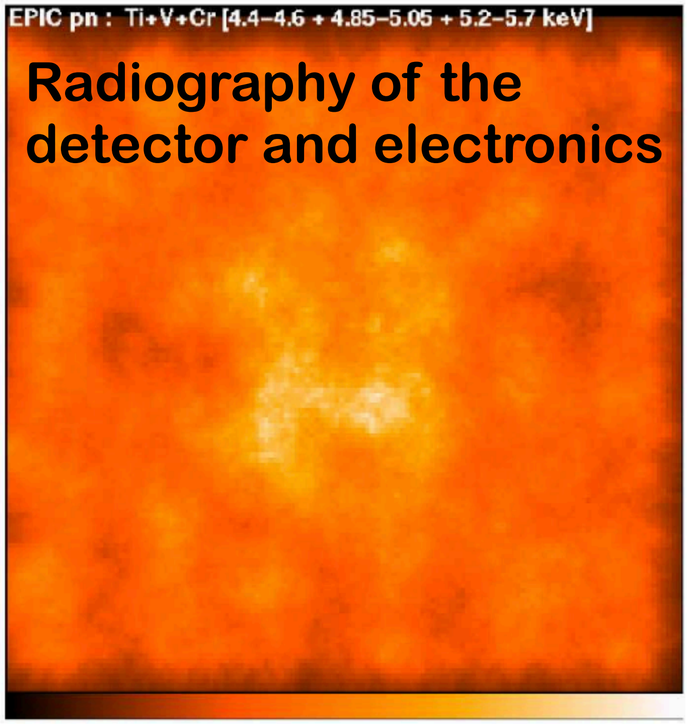


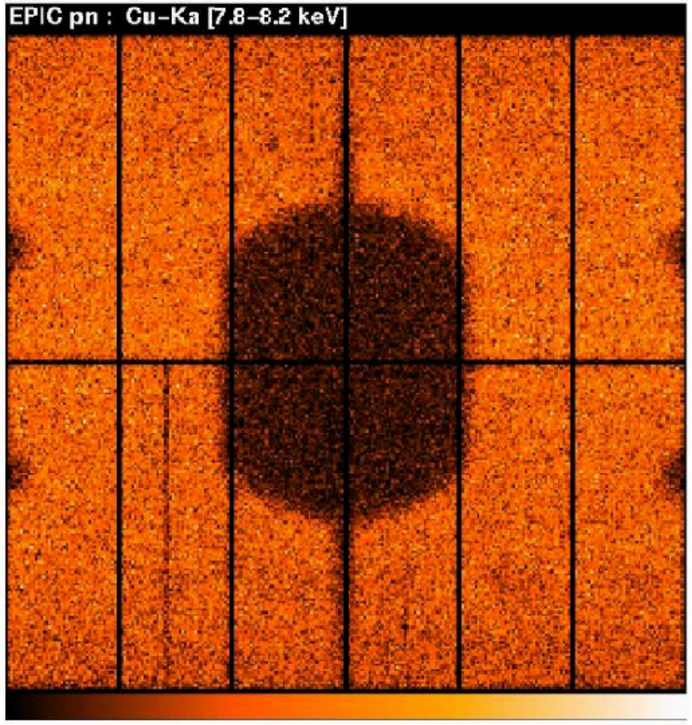
Composition of the b

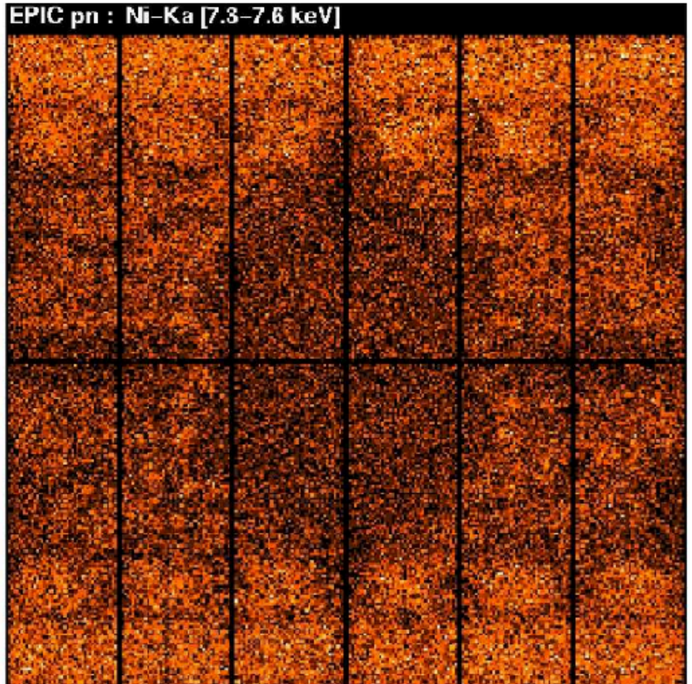
Instrumental background

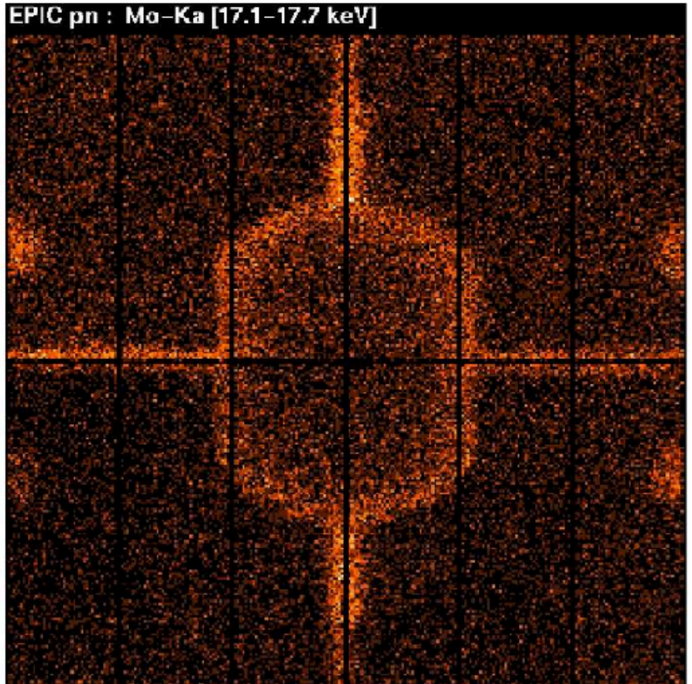
Filter wheel closed emission







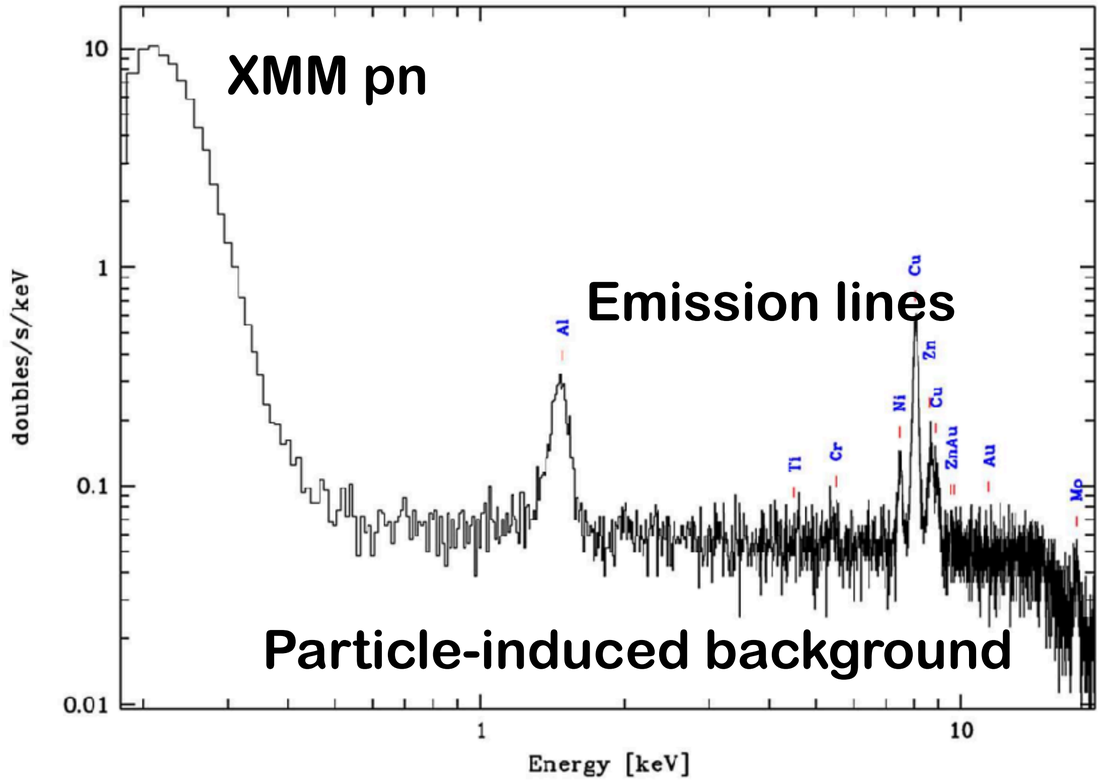


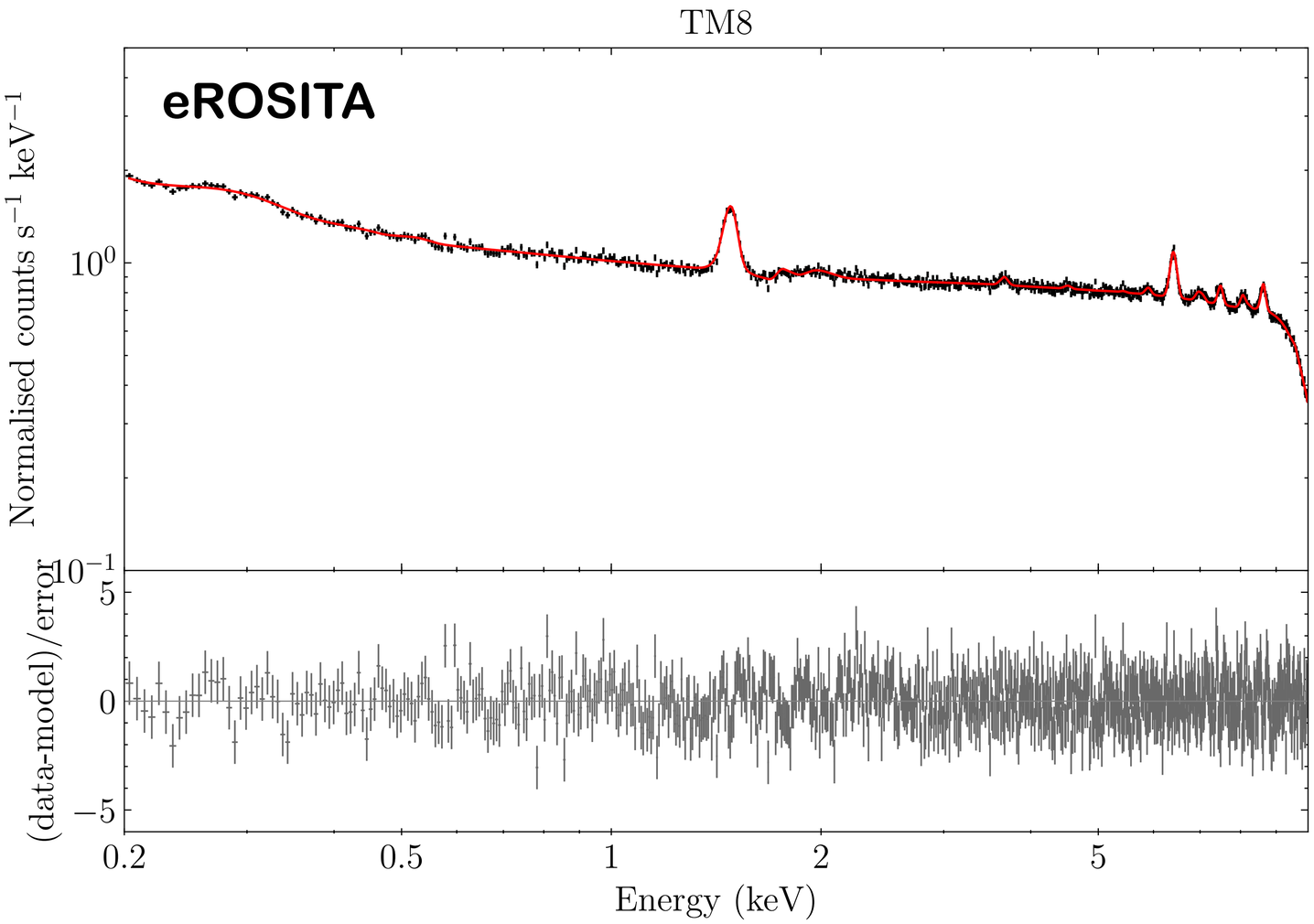


Composition of the background

Instrumental background

Filter wheel closed emission

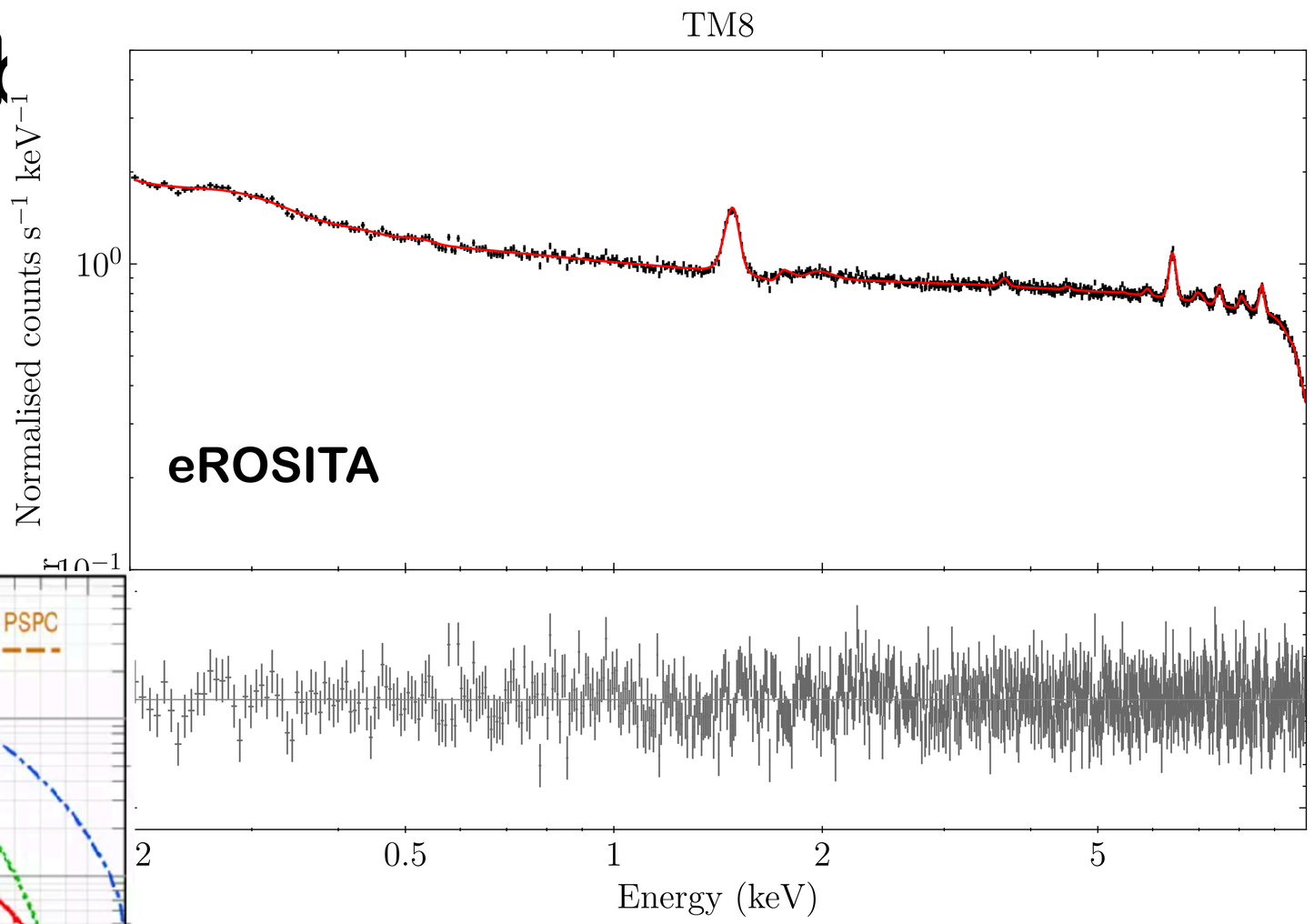




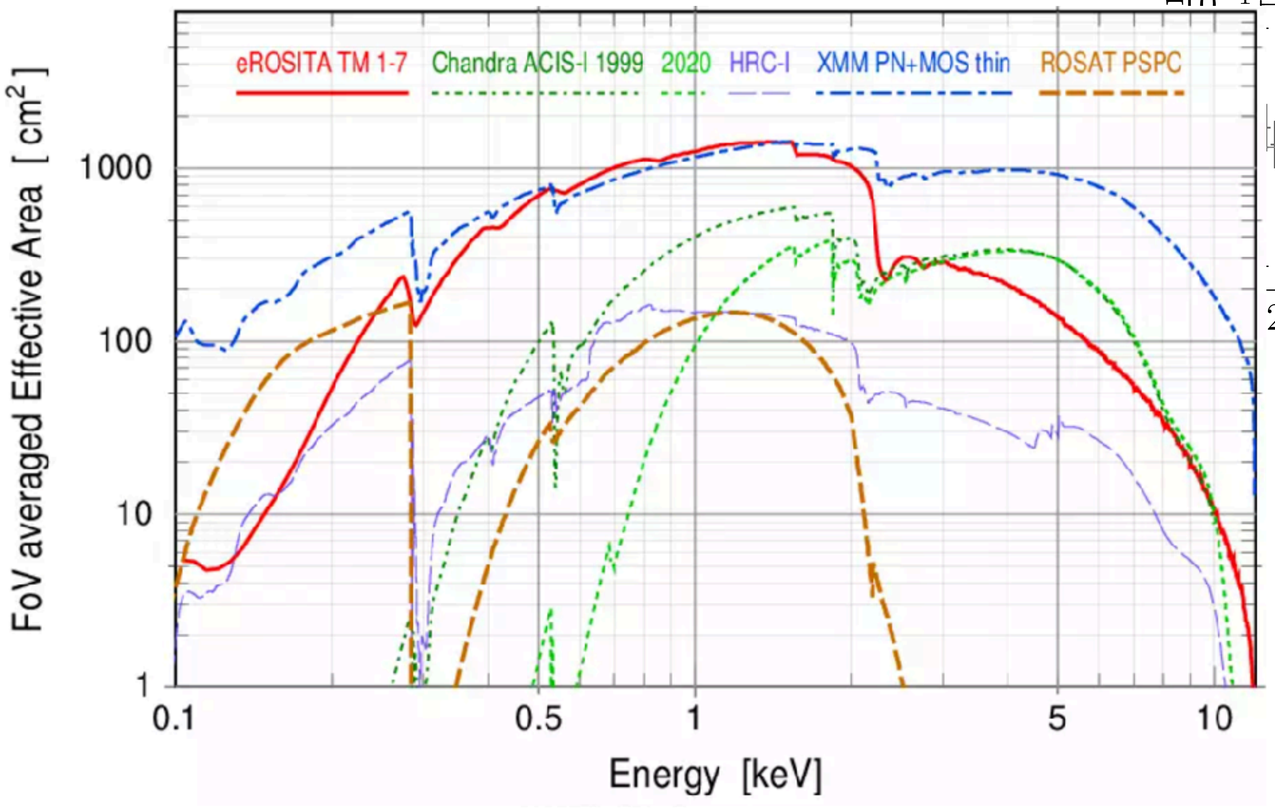
Composition of the b

Instrumental background

Filter wheel closed emission



eROSITA effective area

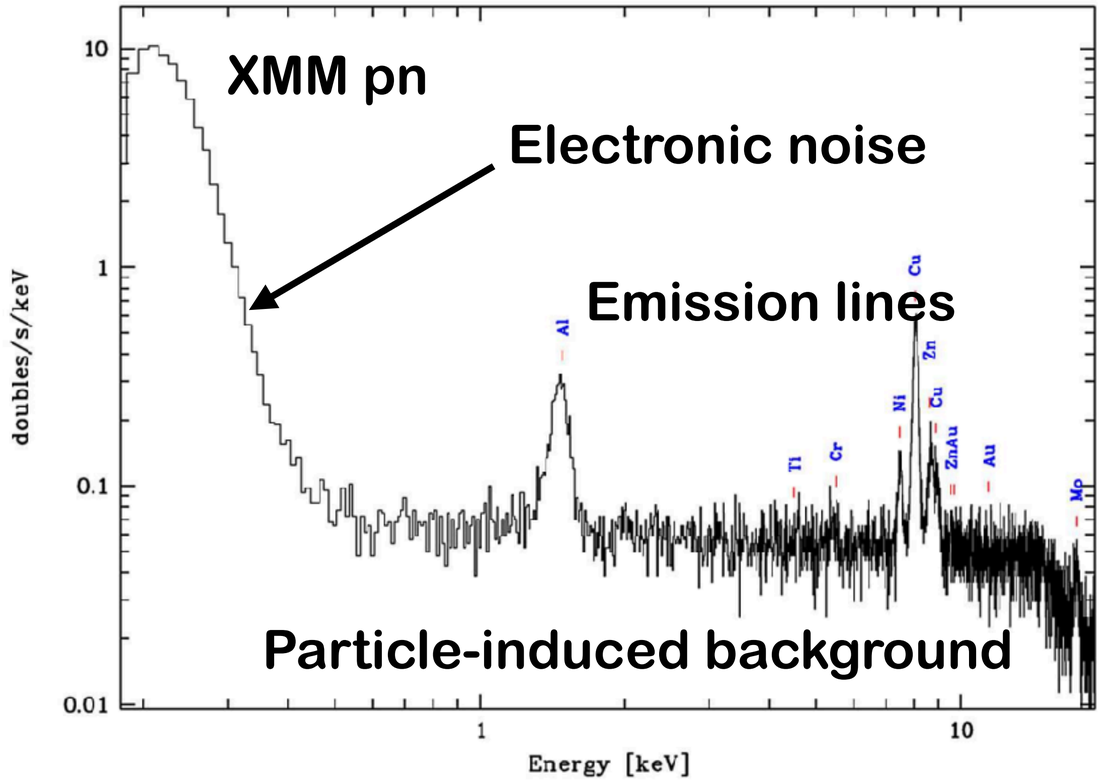


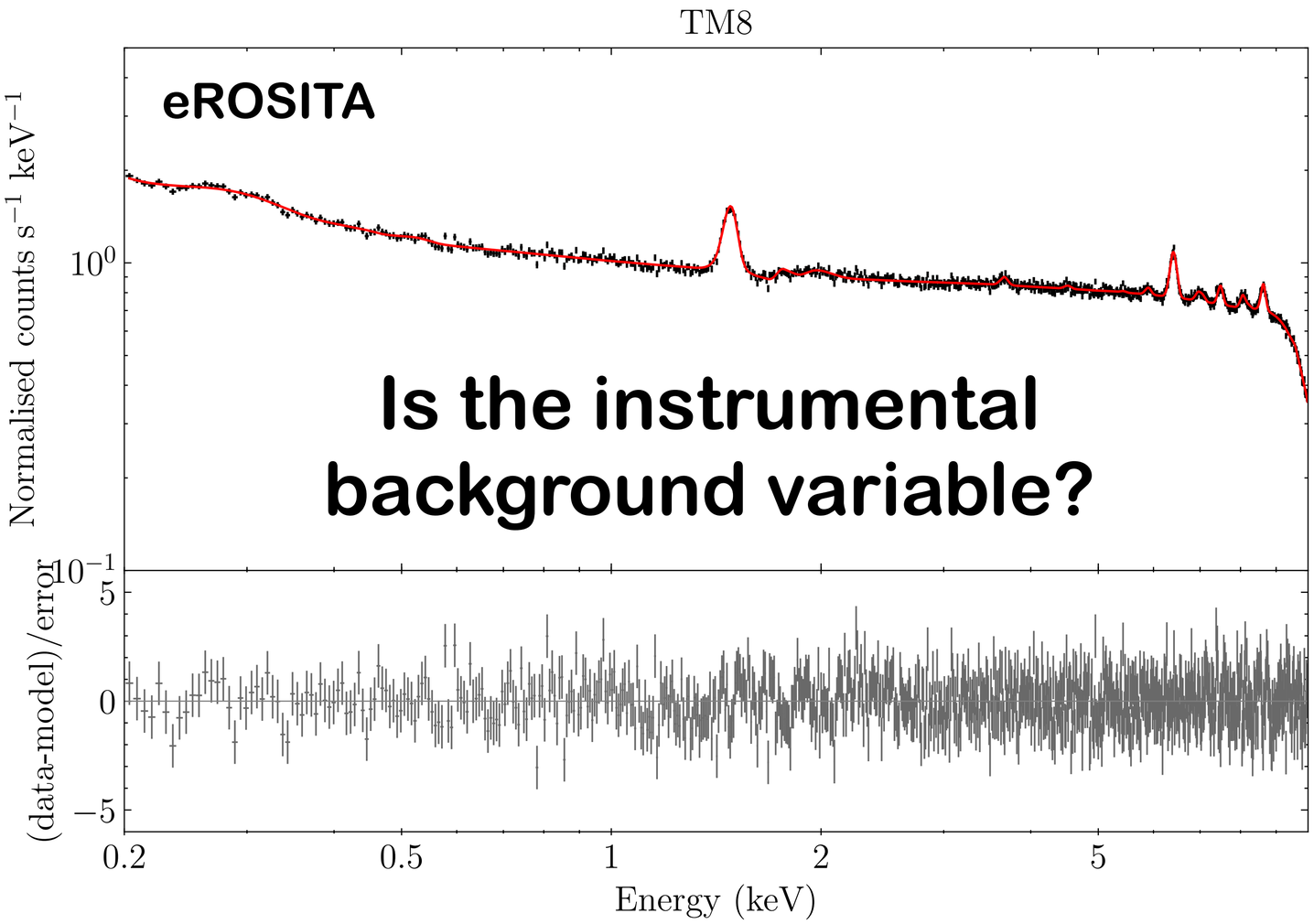
Instrumental background (FWC) is not focussed by the mirrors

Composition of the background

Instrumental background

Filter wheel closed emission





Composition of the background

Instrumental background

Filter wheel closed emission

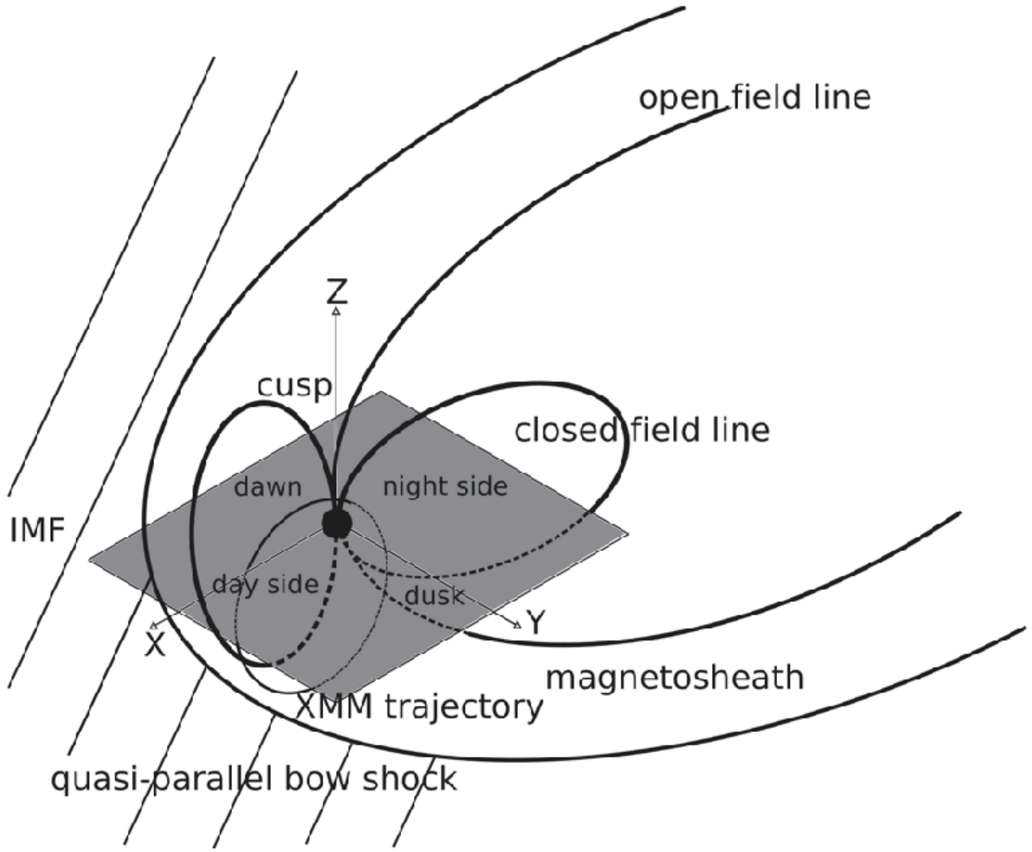
Soft protons flares

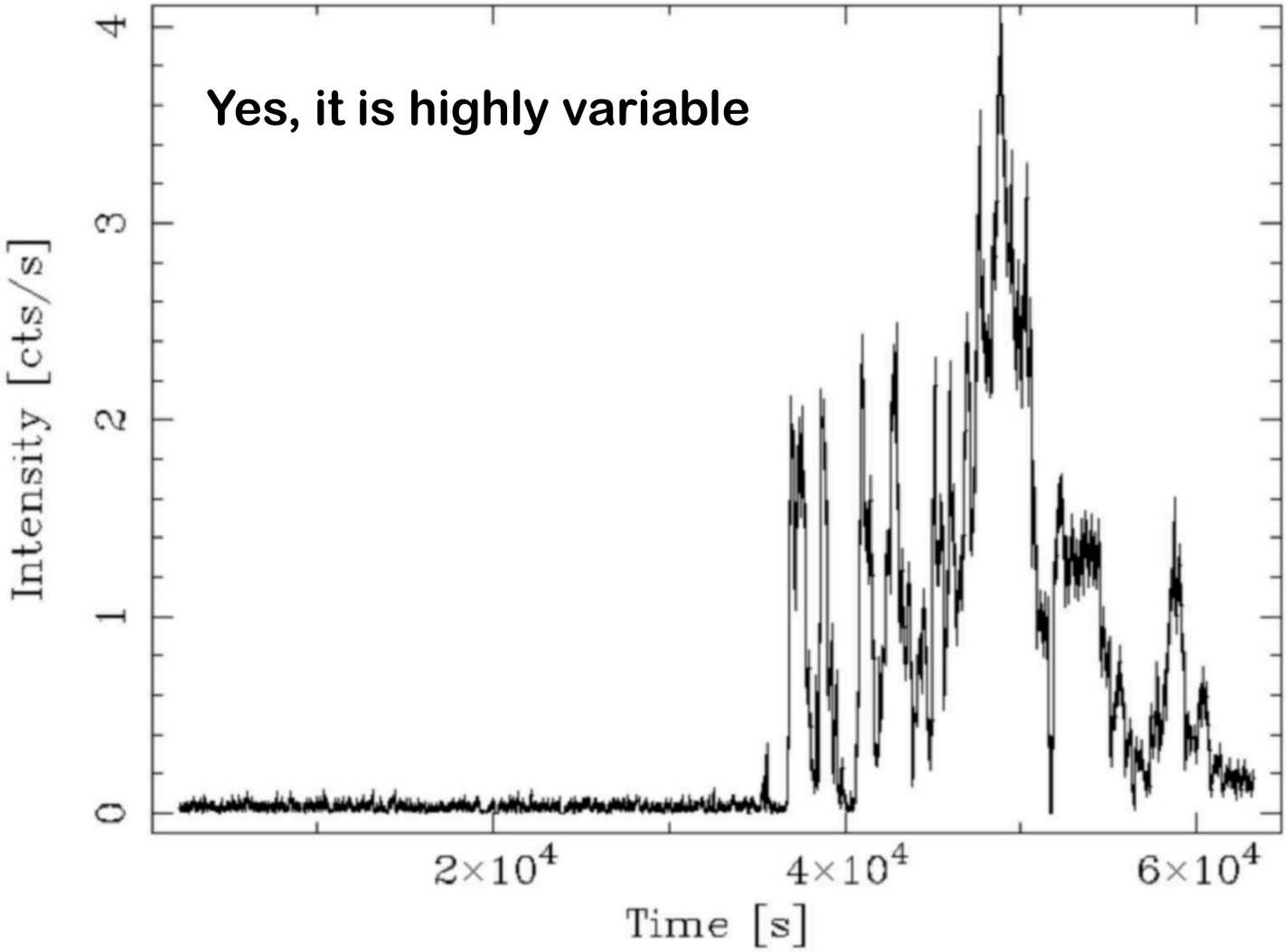
Composition of the background

Instrumental background

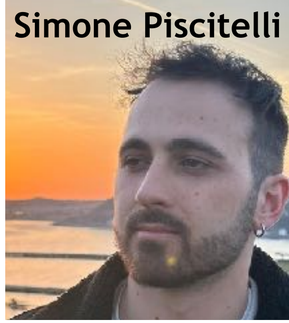
Filter wheel closed emission

Soft protons flares





Composition of the background

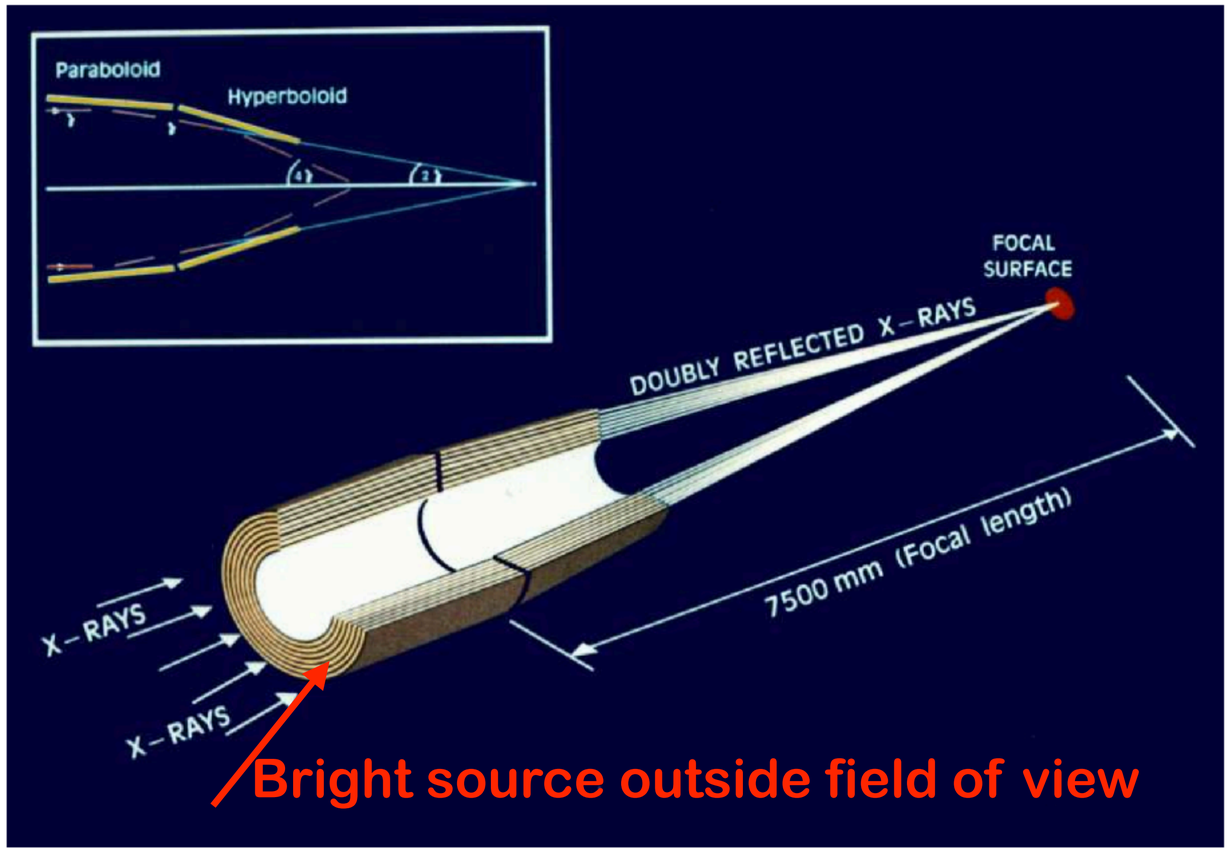


Instrumental background

Filter wheel closed emission

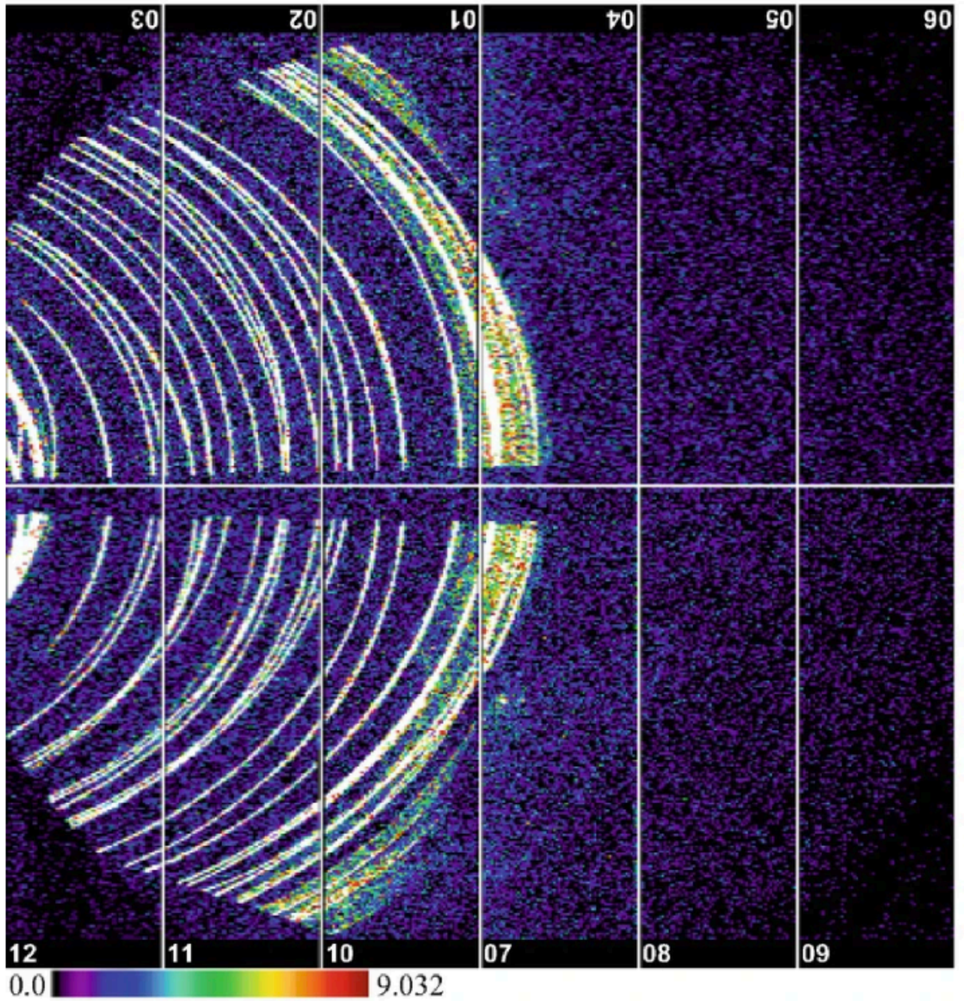
Soft protons flares

Stray-light

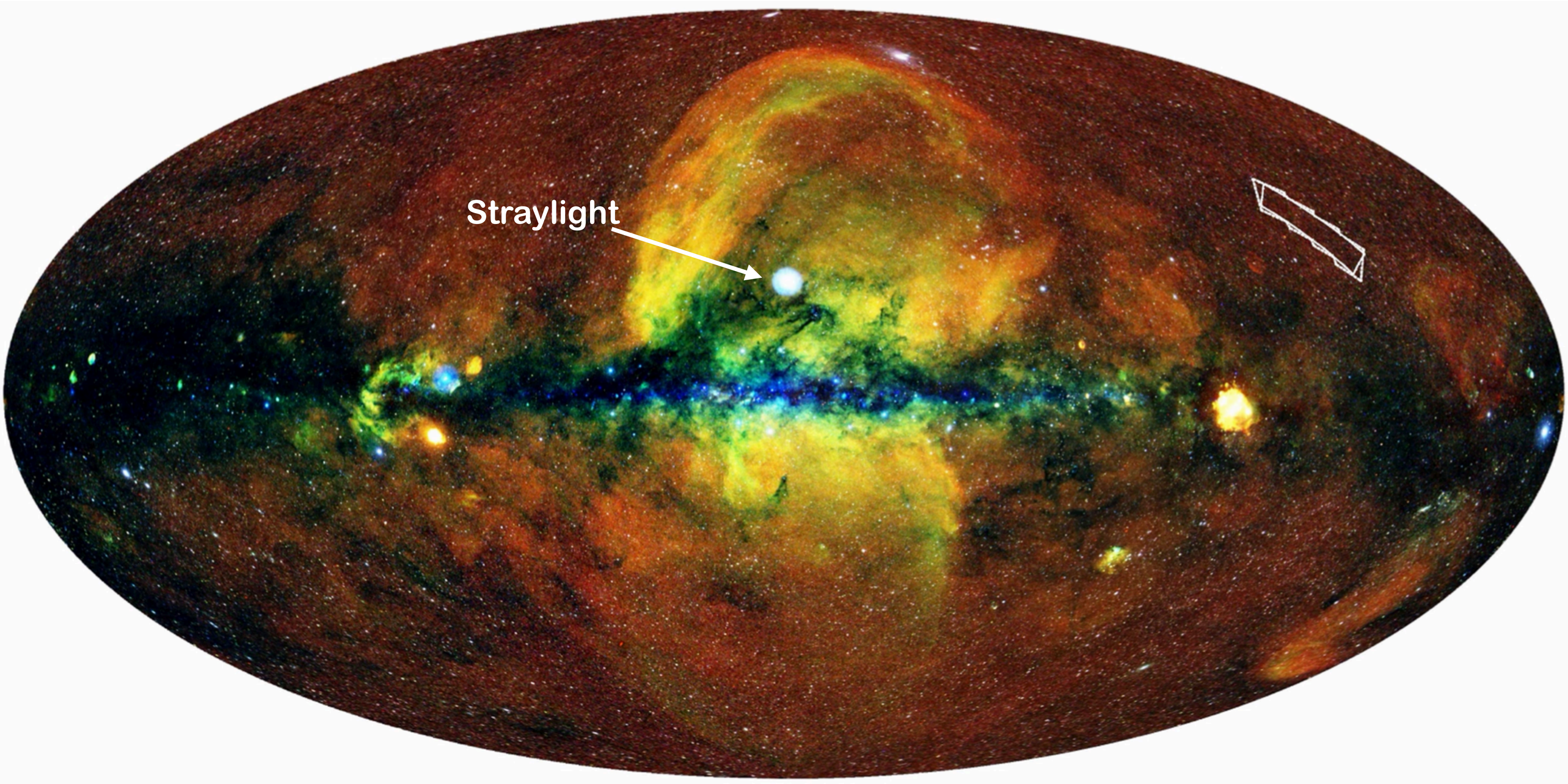


Enhanced background

Mori & Friedrich+22



Composition of the background



Composition of the background

Instrumental background

Filter wheel closed emission

Soft protons flares

Stray-light

Light leak, Optical loading, Ghost rays,
Out of time events, etc, etc, etc.

Composition of the background

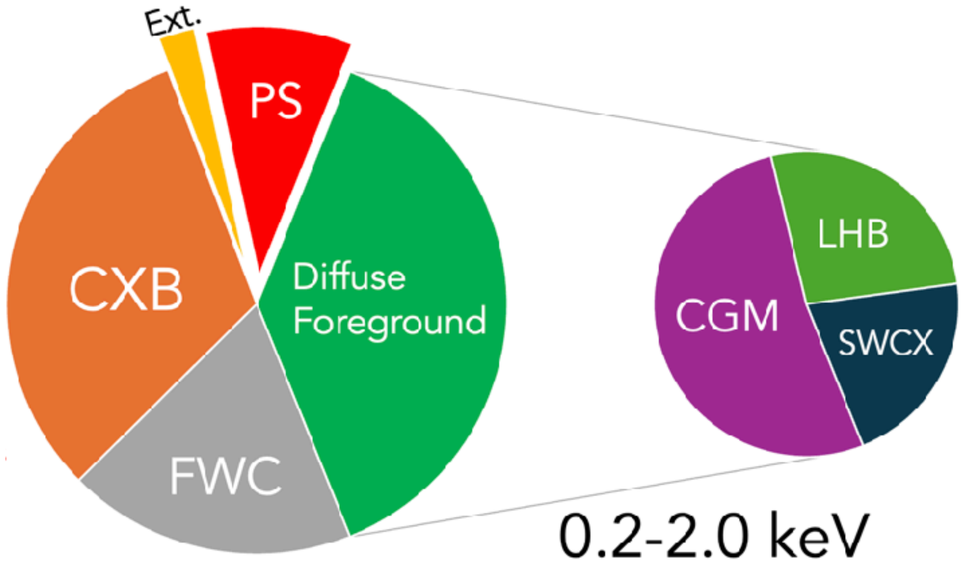
Instrumental background

Filter wheel closed emission

Soft protons flares

Stray-light

Light leak, Optical loading, Ghost rays,
Out of time events, etc, etc, etc.



Sky background (diffuse emission)

Solar wind charge exchange

Local hot bubble

Hot interstellar medium

Galactic ridge X-ray emission

Hot circumgalactic medium

Galactic outflow

Cosmic X-ray background

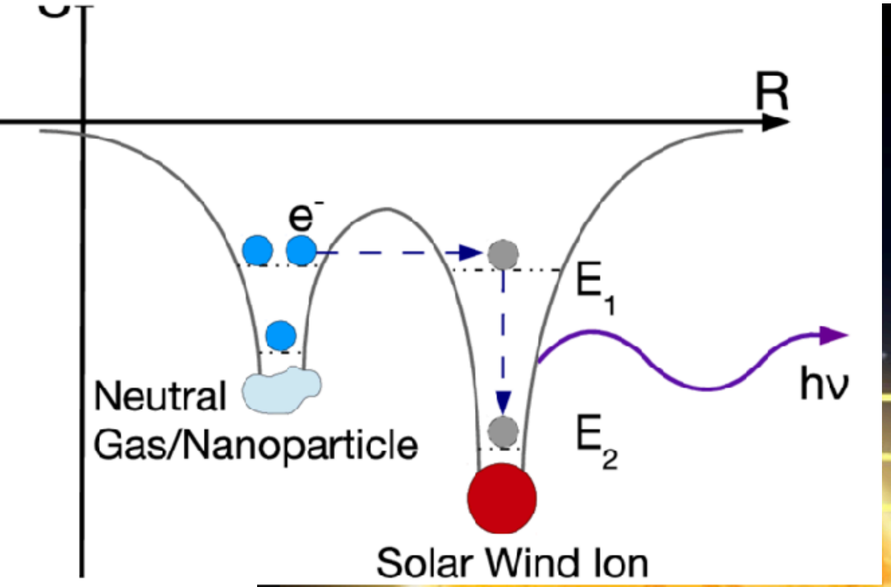
X-Diffuse
1) SWCX
2) LHB - ISM
3) Galactic ridge
4) Hot CGM
5) Outflow
6) CXB

Everything which is not point like?

Absorption: complicating factor…

Point sources or diffuse emission?

Solar wind charge exchange



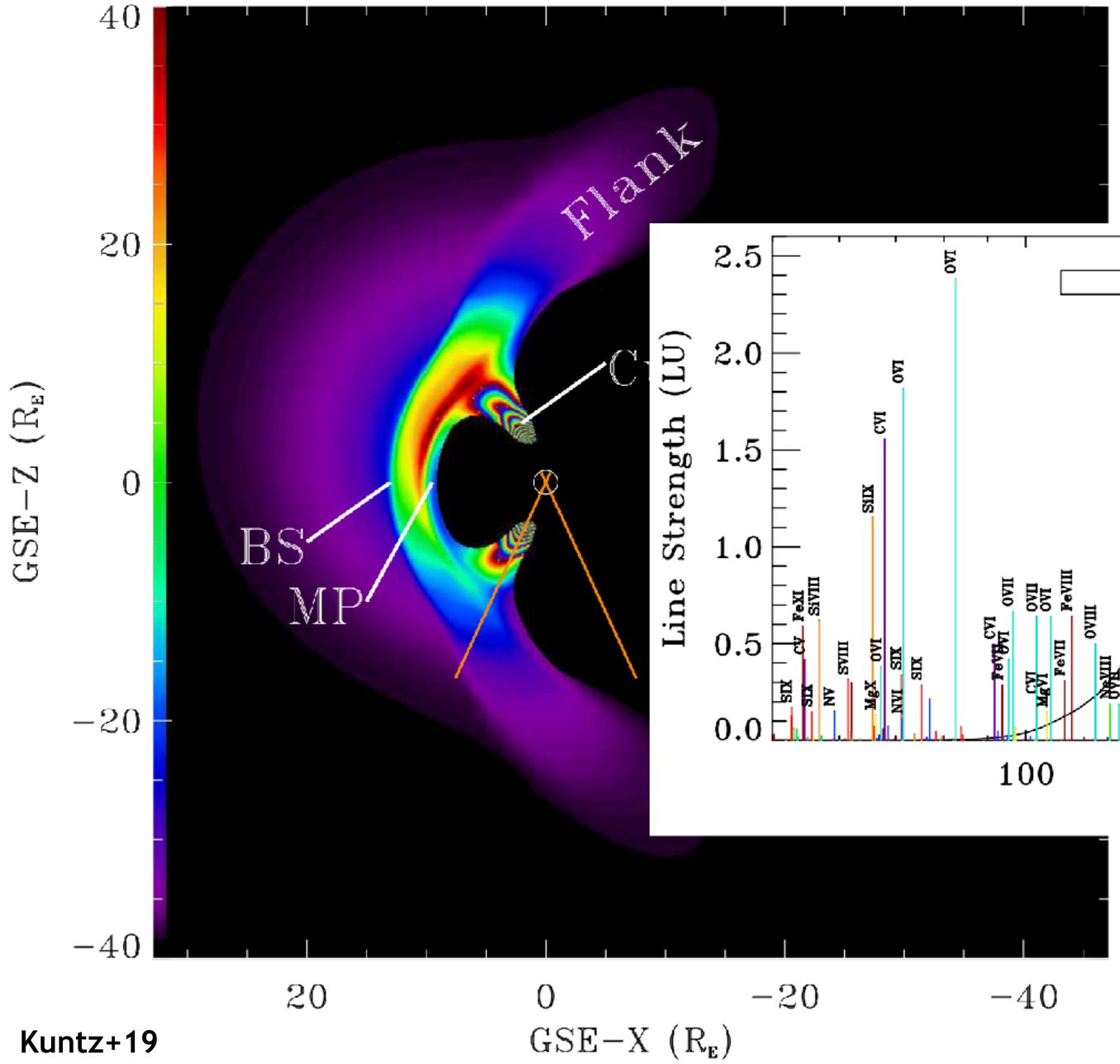
X-Diffuse

1) SWCX
2) LHB - ISM
3) Galactic ridge
4) Hot CGM
5) Outflow
6) CXB

Solar wind charge exchange

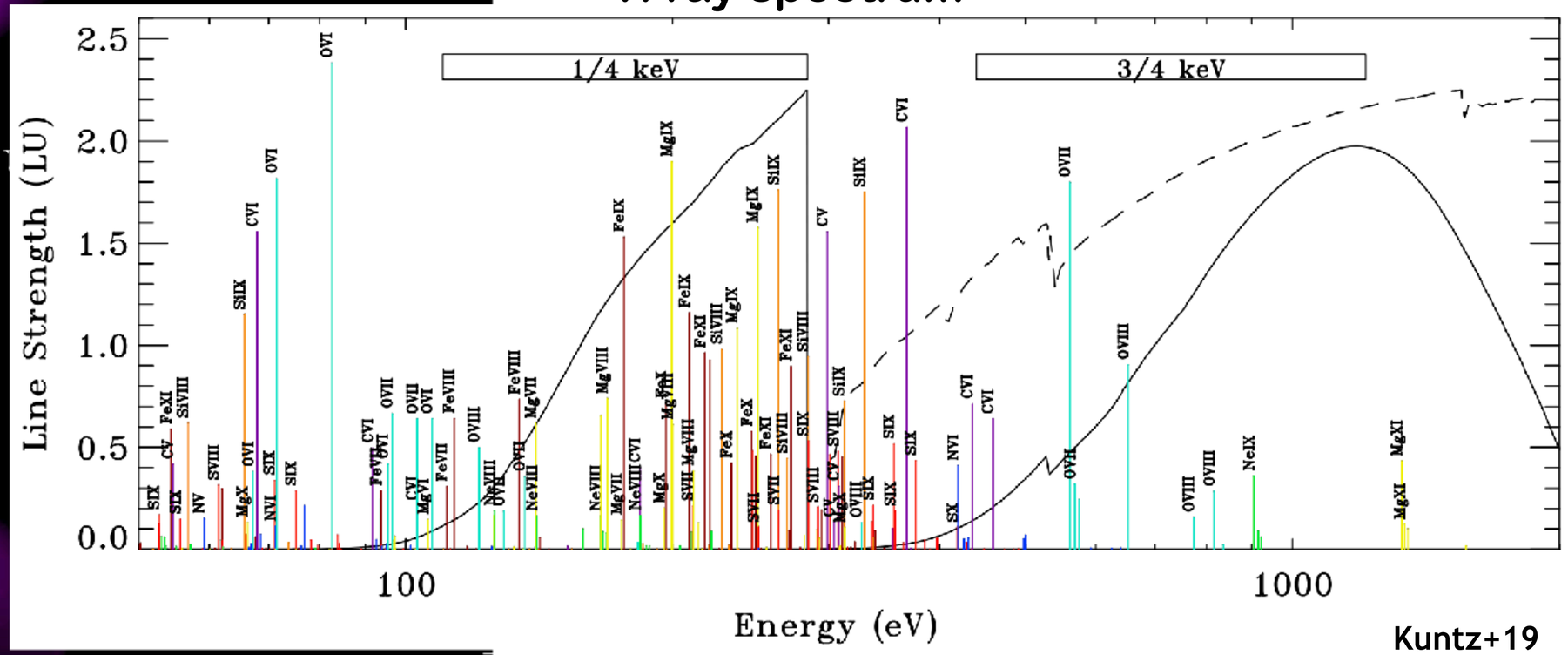
X-Diffuse
1) SWCX
2) LHB - ISM
3) Galactic ridge
4) Hot CGM
5) Outflow
6) CXB

Geo-coronal component



Kuntz+19

X-ray spectrum



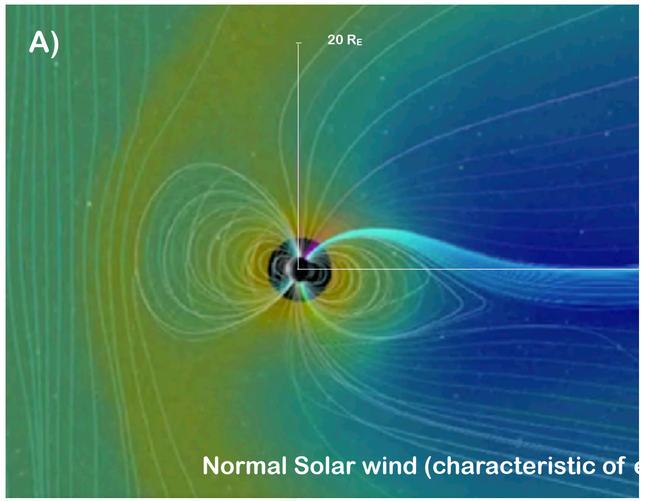
Kuntz+19

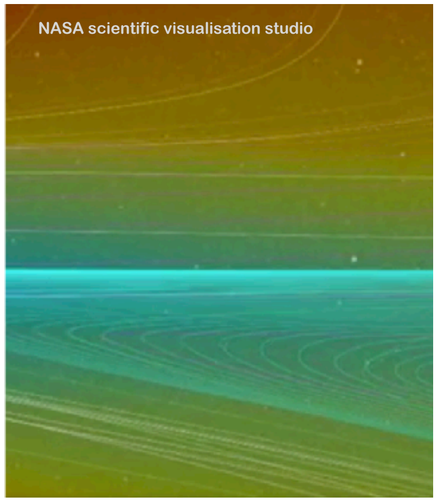
Is eROSITA affected by this emission?

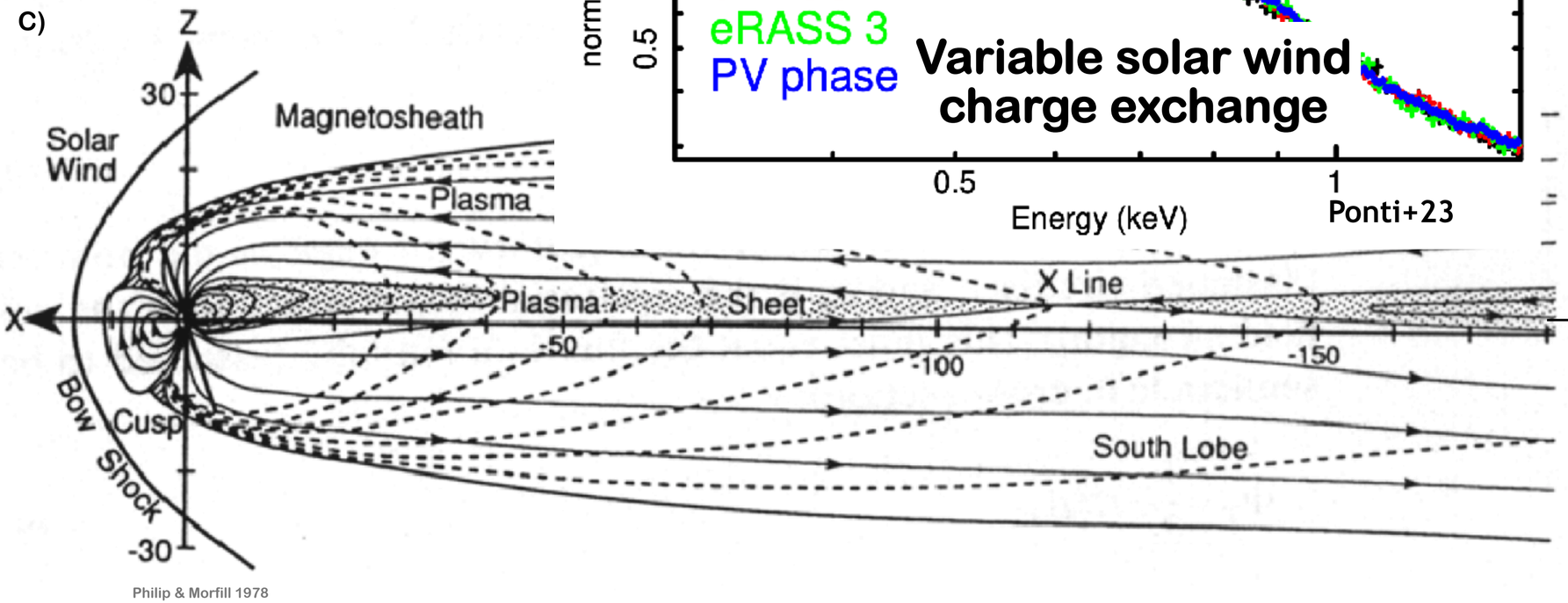
Heliospheric component?

Diffuse X-ray emission from Heliosphere

X-Diffuse
1) SWCX
2) LHB - ISM
3) Galactic ridge
4) Hot CGM
5) Outflow
6) CXB

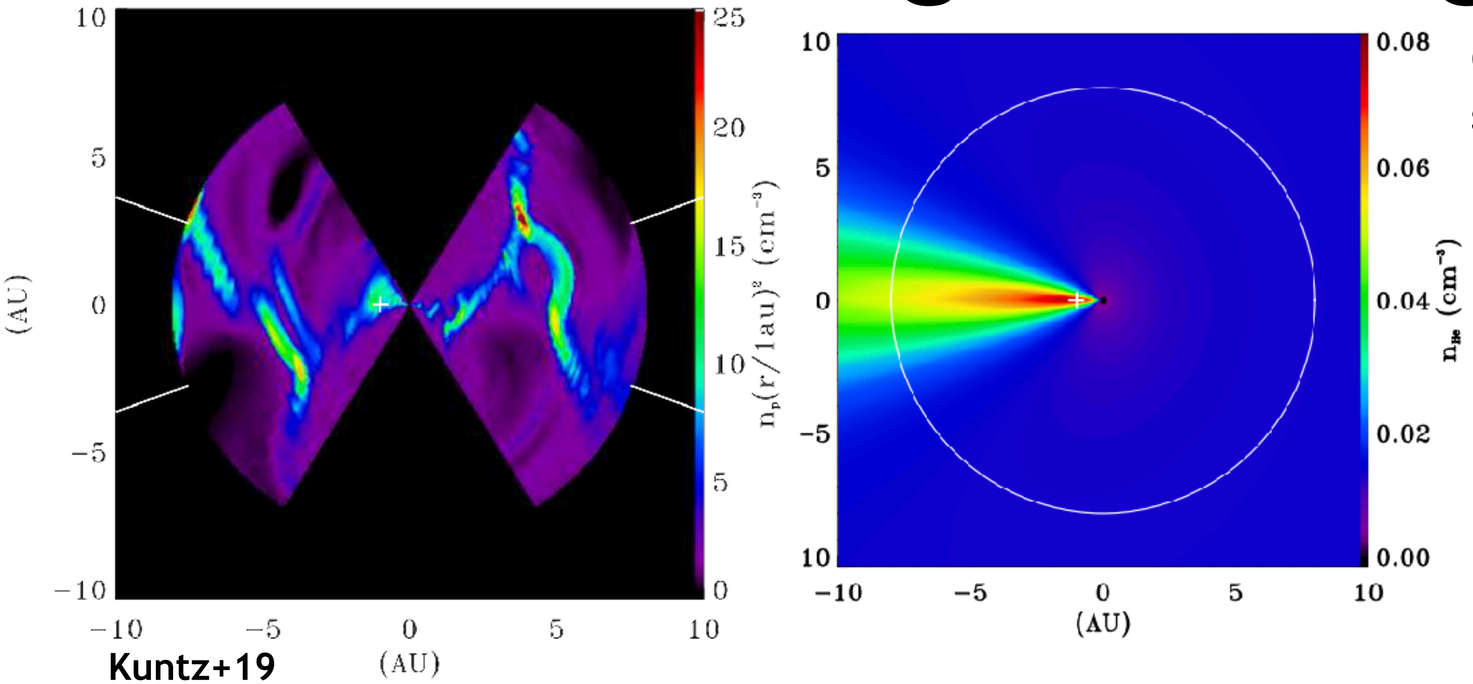




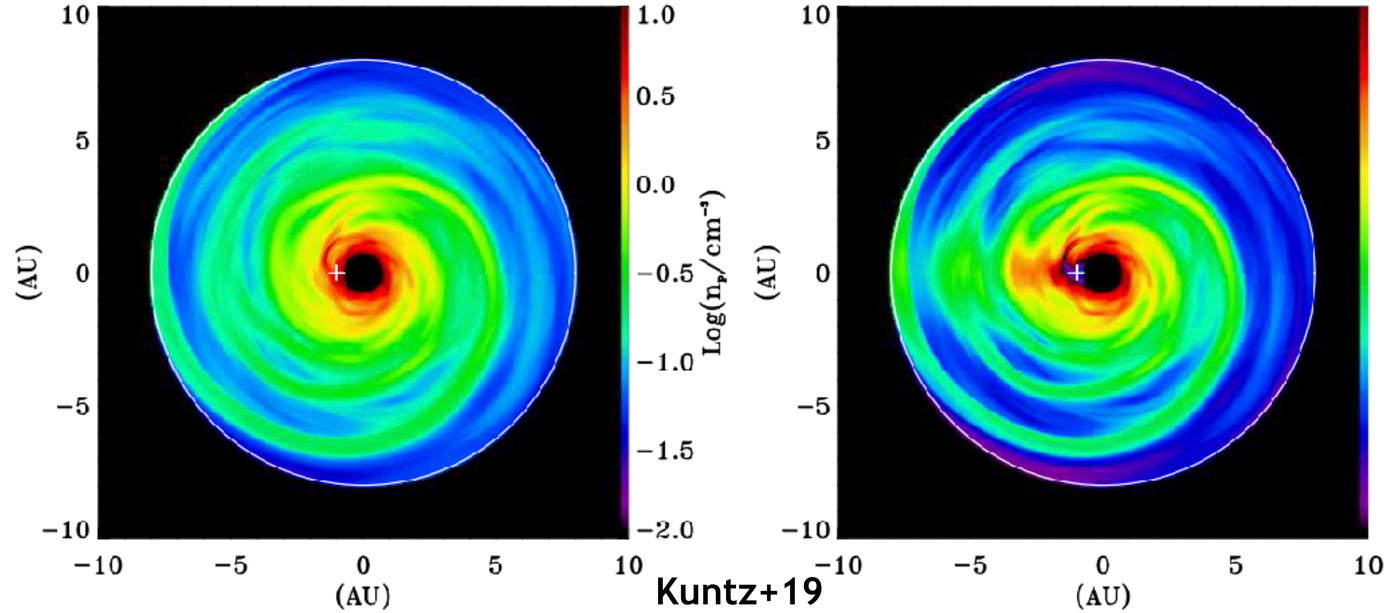


Dennerl, GP+subm.

Solar wind charge exchange



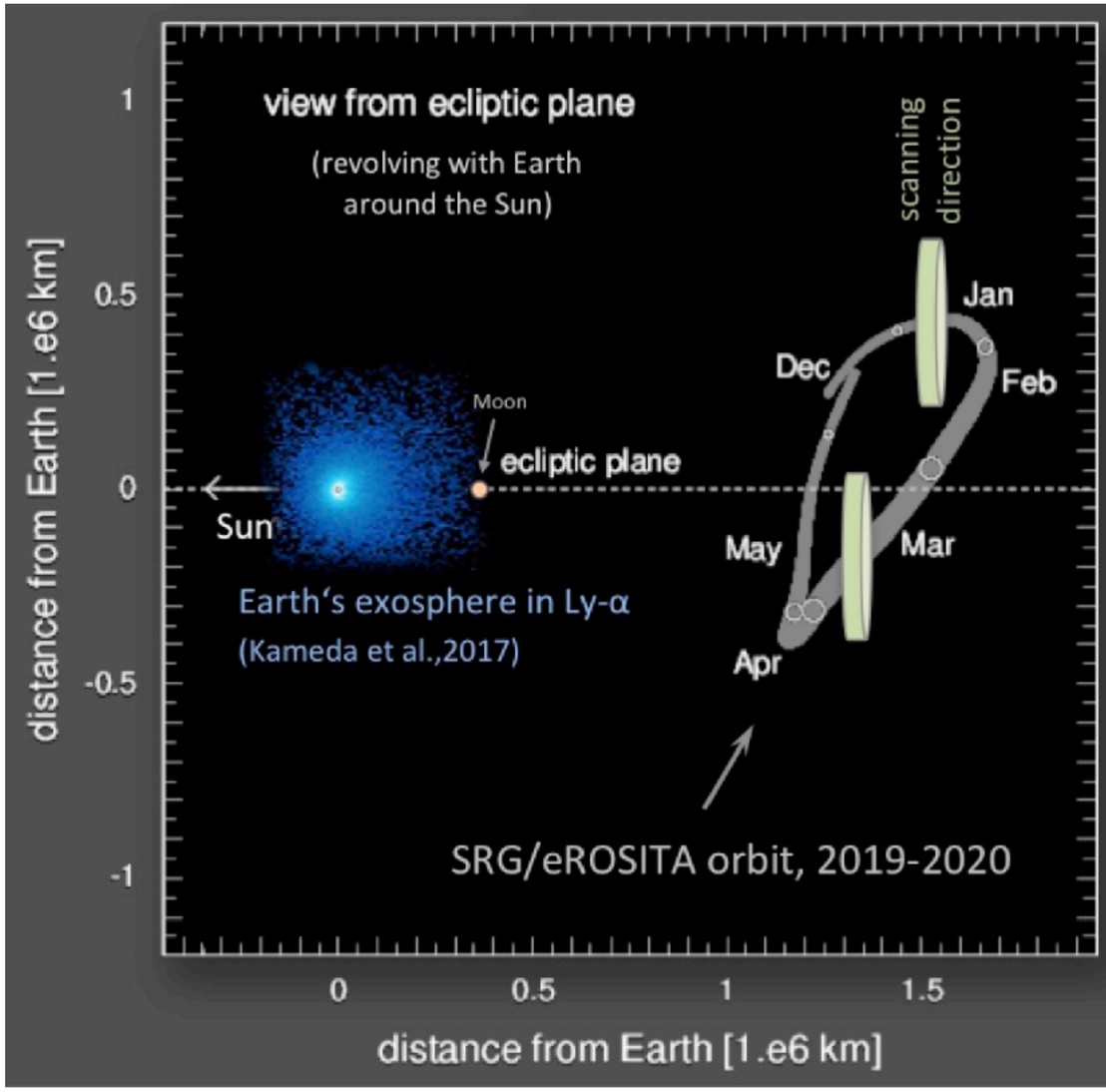
Kuntz+19



Kuntz+19

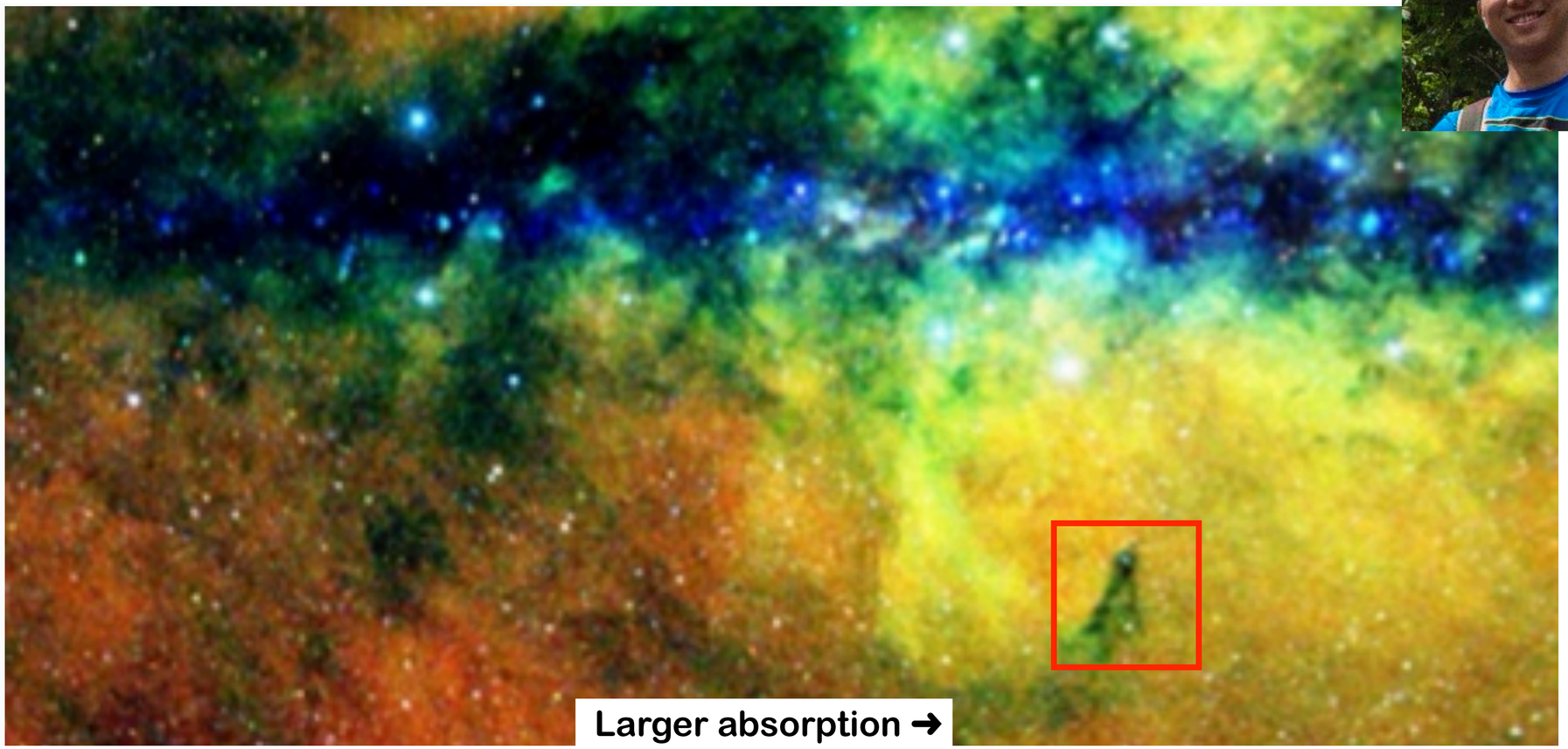
Characterisation of heliospheric solar wind charge exchange

Dennerl, GP+subm.

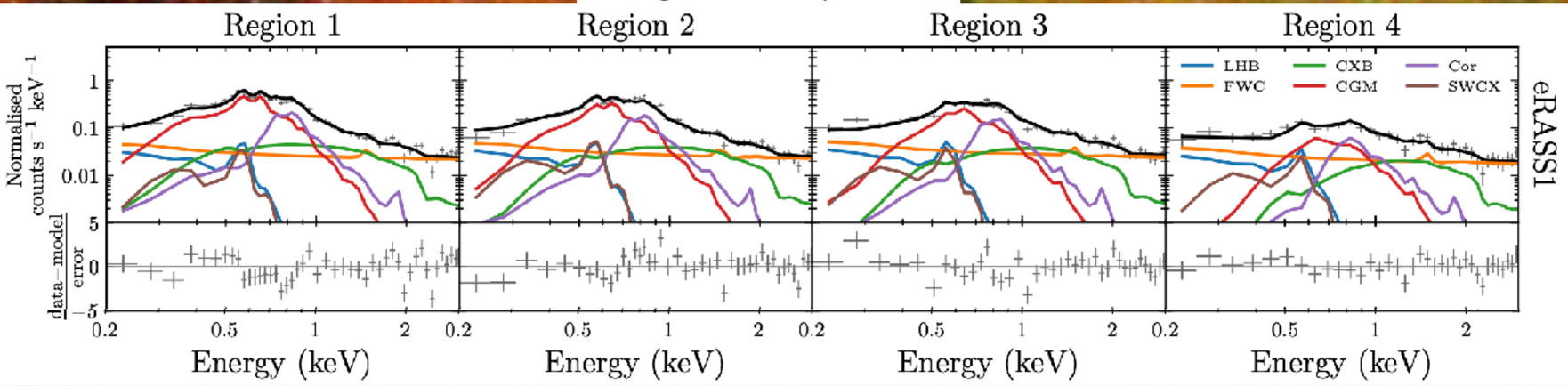


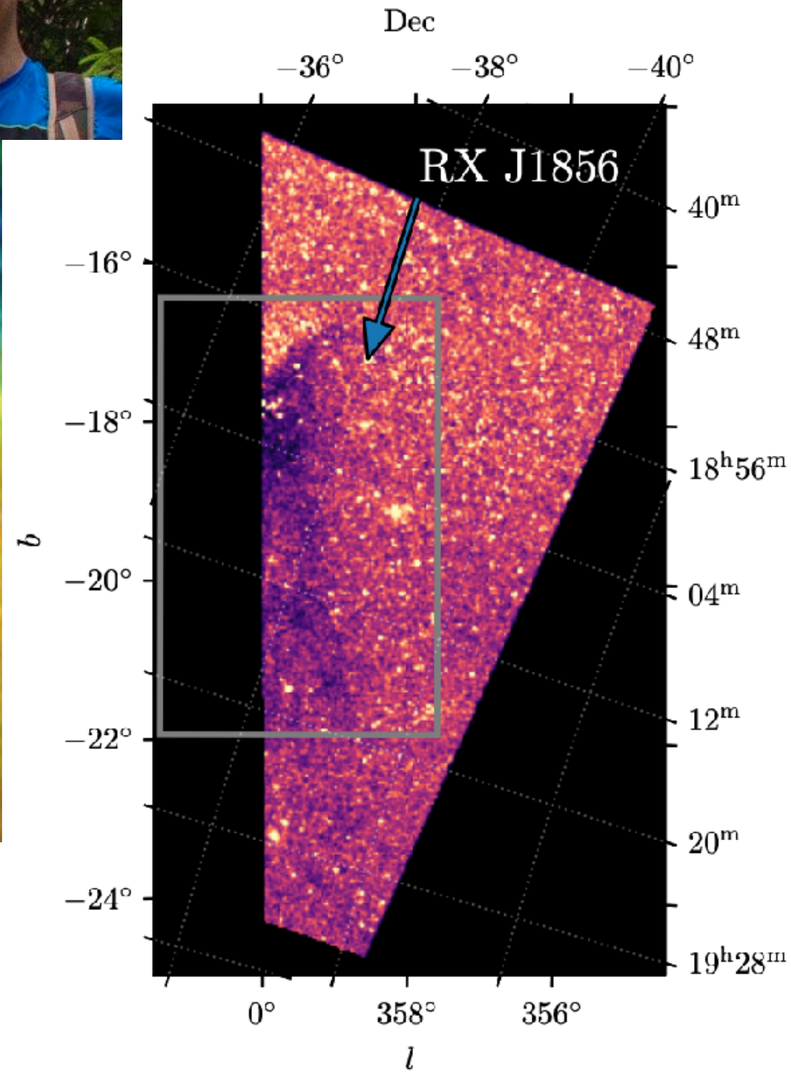
Local hot bubble

X-Diffuse
1) SWCX
2) LHB - ISM



Larger absorption ➜



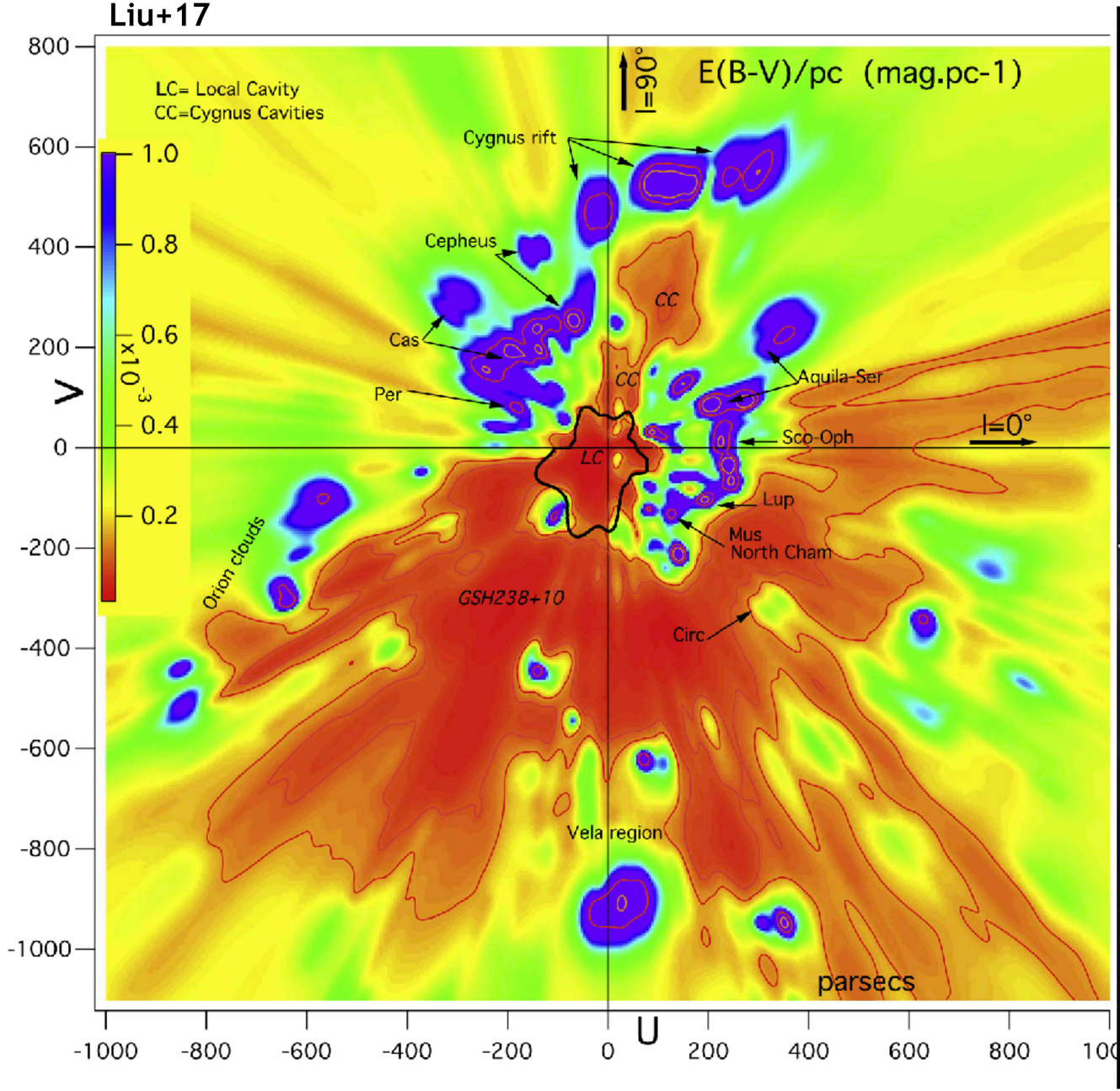


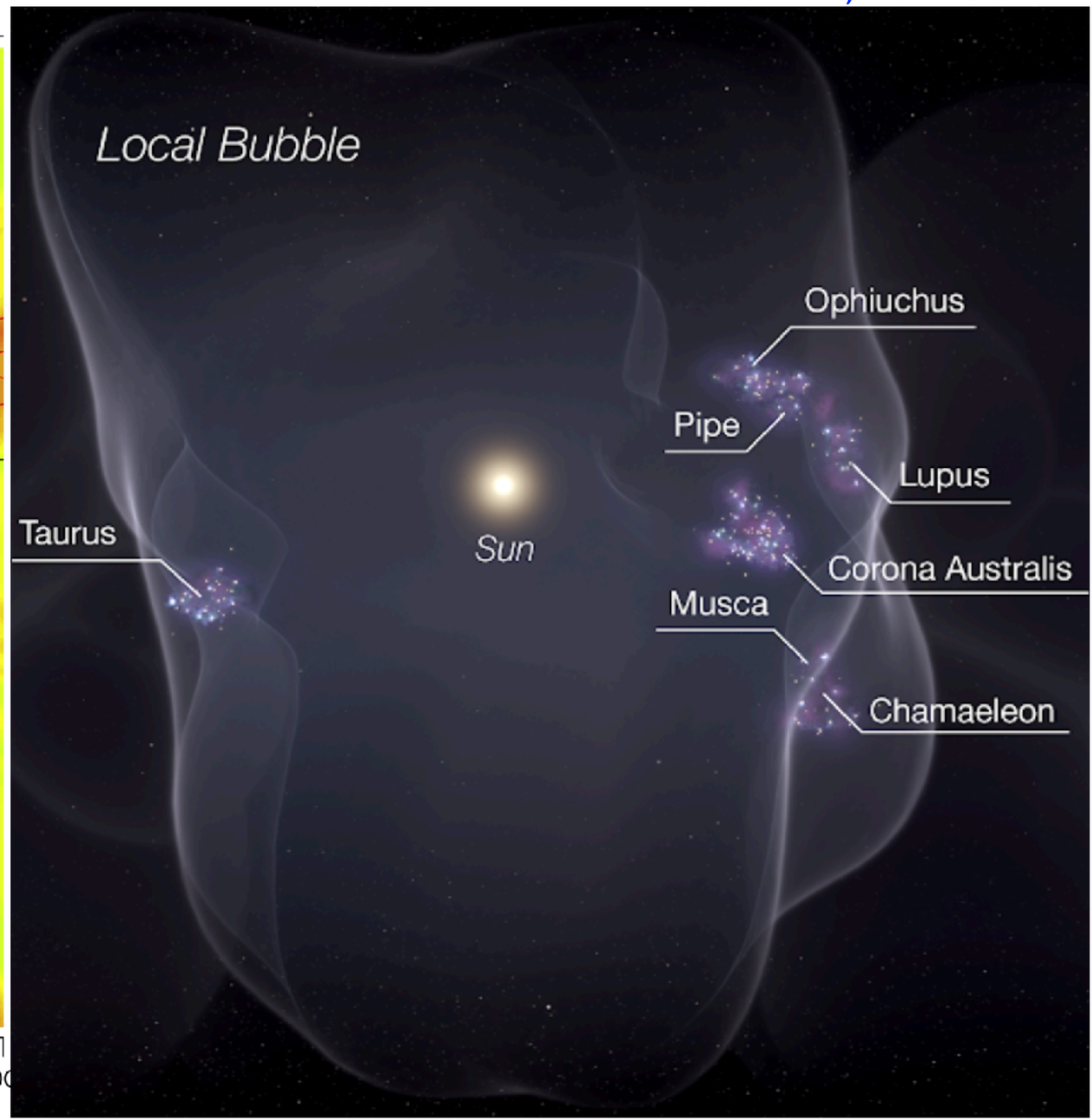
Yeung +23

Local hot bubble

X-Diffuse
1) SWCX
2) LHB - ISM

Liu+17

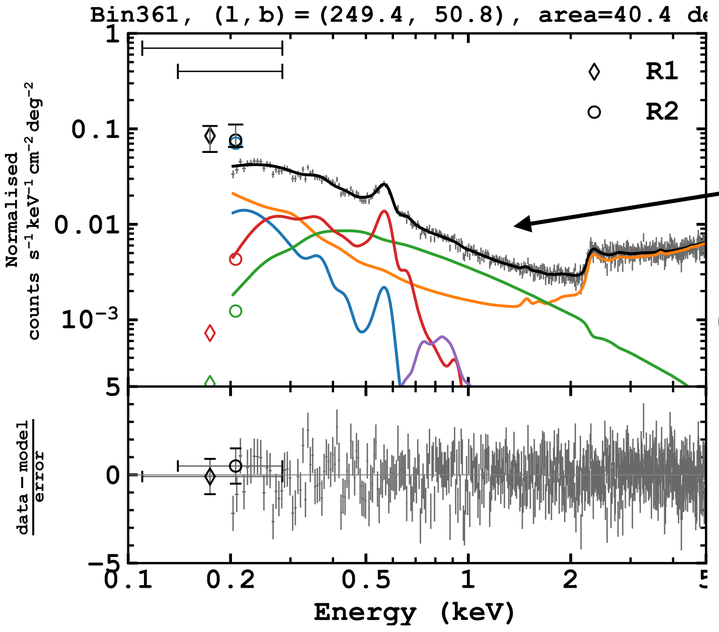


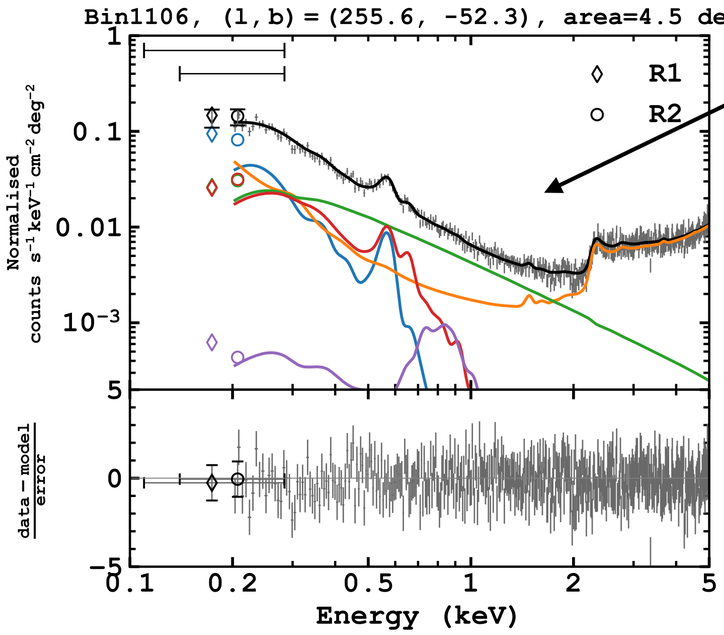


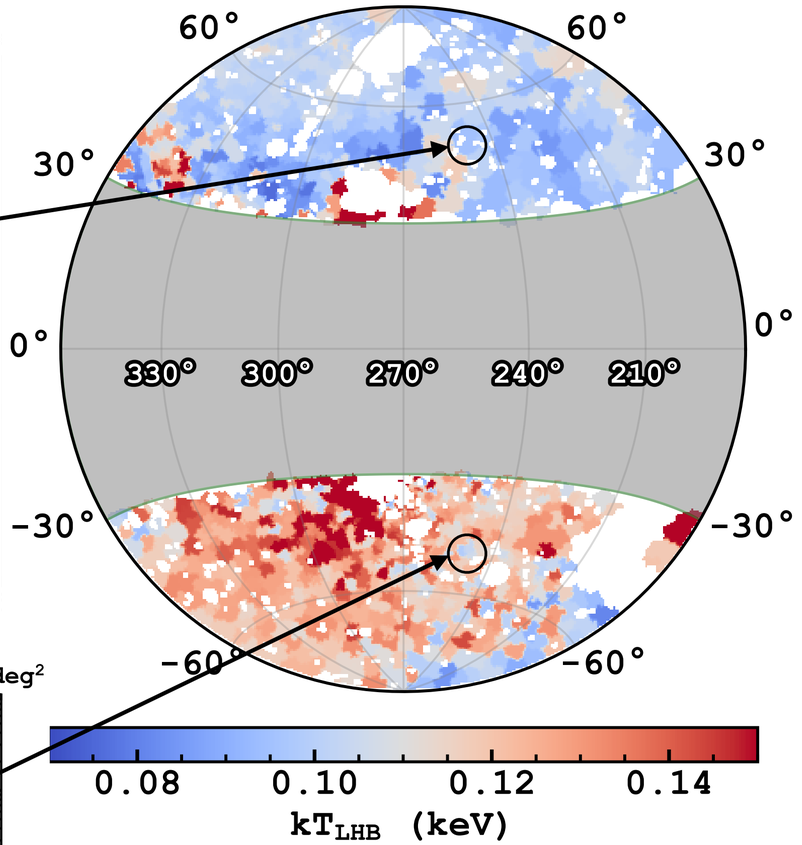
A Bubbly Origin

for Stars Around the Sun

Diffuse X-ray emission: local hot bubble







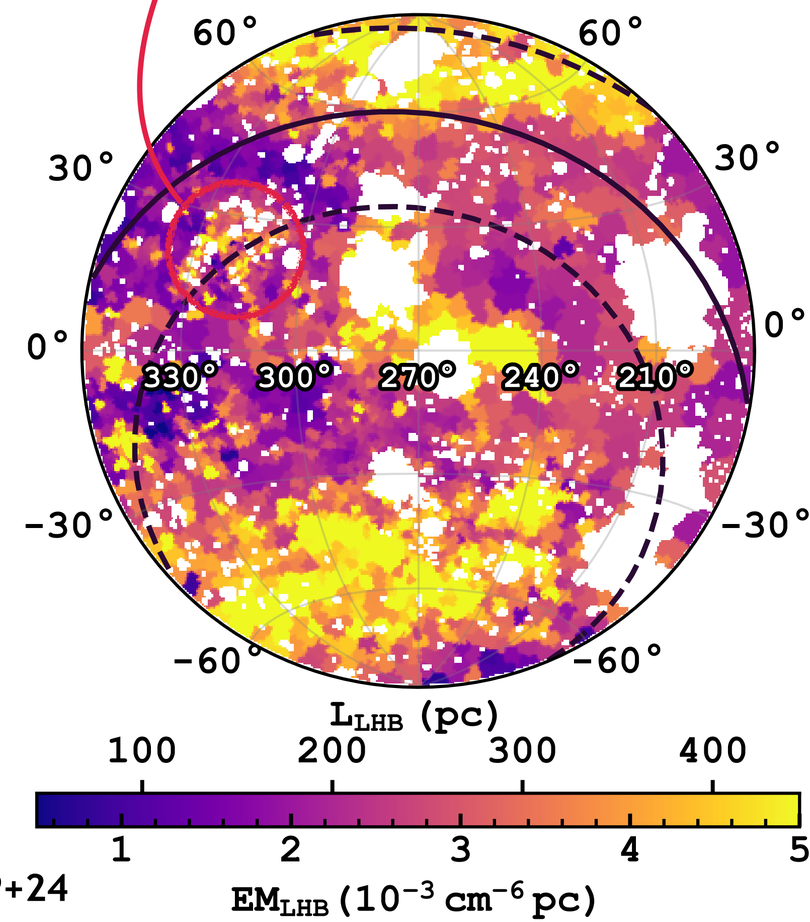
X-Diffuse

1) SWCX
2) LHB - ISM
3) Galactic ridge
4) Hot CGM
5) Outflow
6) CXB

LHB hotter in southern hemisphere

Yeung, GP+24

Interstellar tunnels filled with hot plasma



Yeung, GP+24

Diffuse X-ray emission: local hot bubble

X-Diffuse
1) SWCX
2) LHB - ISM
3) Galactic ridge
4) Hot CGM
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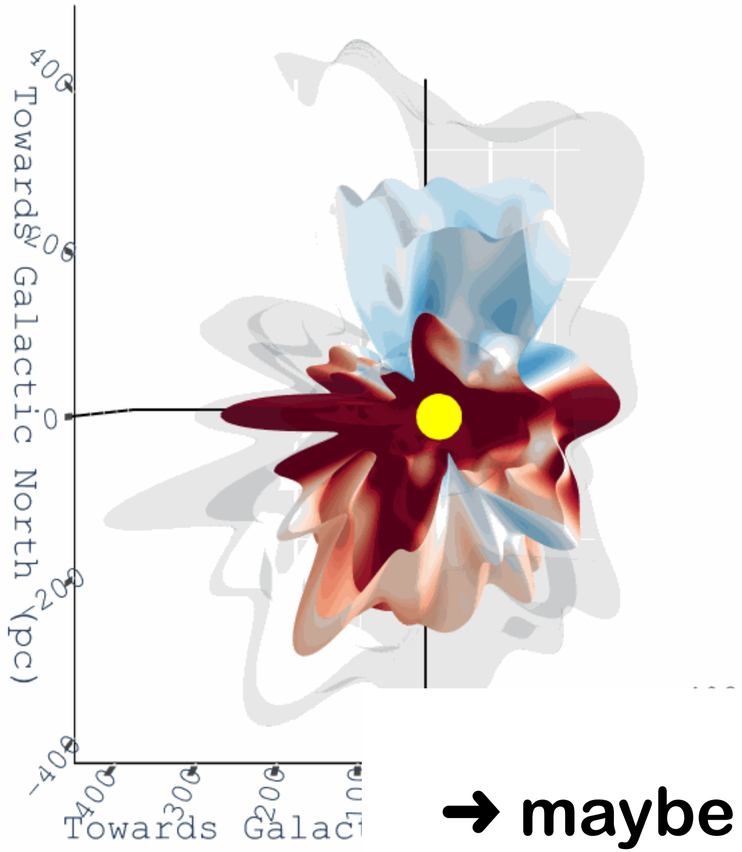
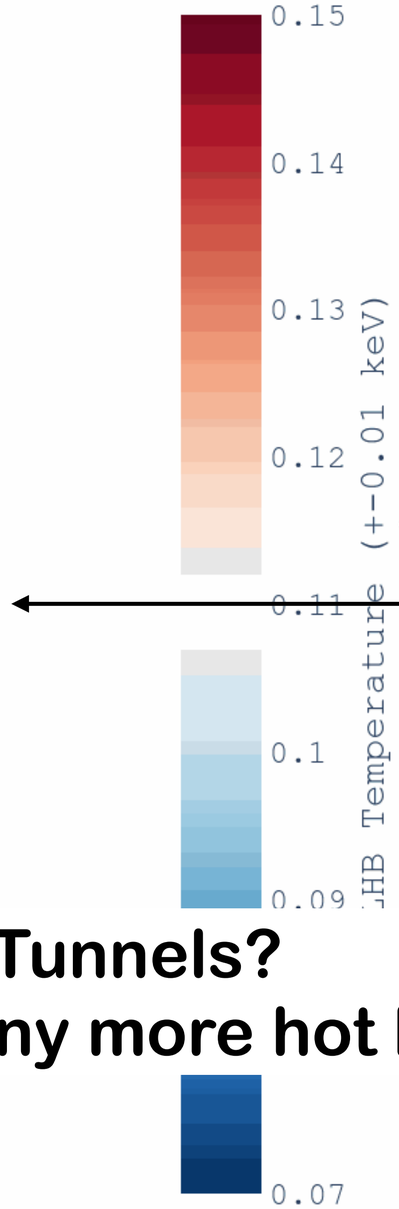
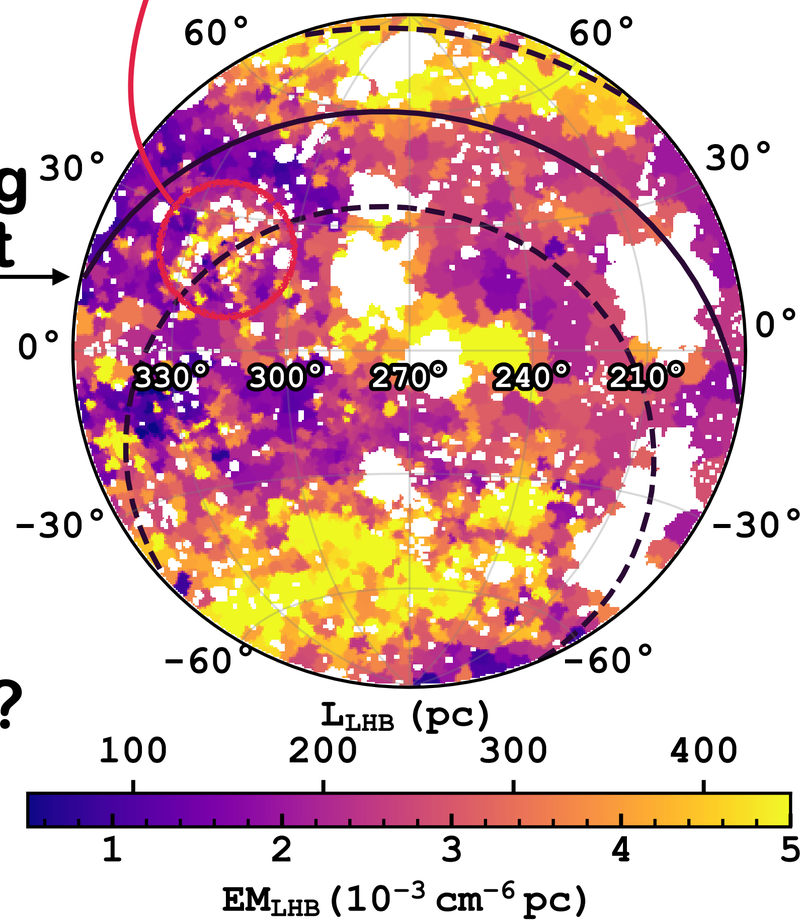
6) CXB





Assuming constant density

Interstellar tunnels filled with hot plasma



Tunnels?

➜ maybe many more hot bubbles?

Yeung, GP+24

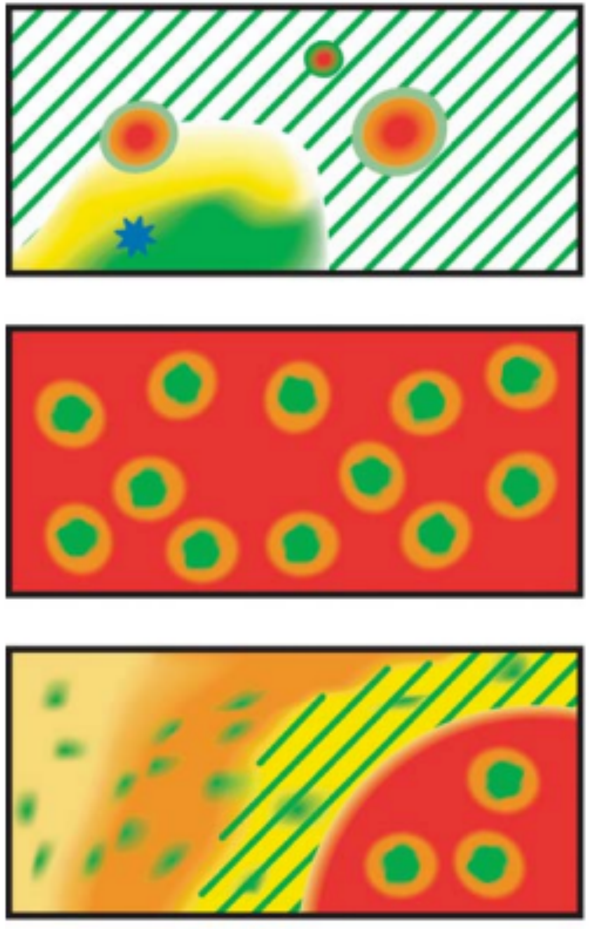
What is the interstellar medium made of?

X-Diffuse
1) SWCX
2) LHB - ISM

Table 1: Components of the interstellar medium[3]

Component	Fractional volume	Scale height (pc)	Temperature (K)	Density (particles/cm^3)	State of hydrogen	Primary observational techniques
Molecular clouds	< 1%	80				
Cold neutral medium (CNM)						
Warm neutral medium (WNM)						
Warm ionized medium (WIM)	20–50%	100				
H II regions	< 1%	70				
Coronal gas Hot ionized medium (HIM)	30–70%	1000–3000	10^6–10^7	10^{-4}–10^{-2}	Ionized (metals also highly ionized)	absorption lines of highly ionized metals, primarily in the ultraviolet

Hot
Warm-hot
Warm HII
Warm HI
Cold HI



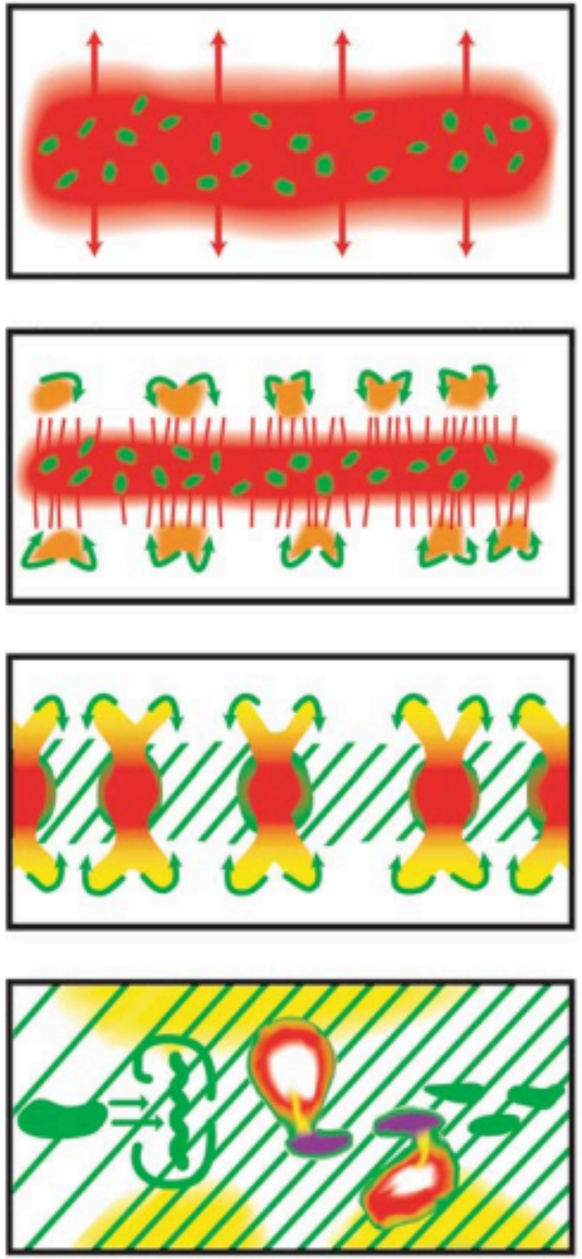
Wikipedia

Warm intercloud gas
- Local SNRs
- Ionized regions

Hot intercloud gas
- Dilute SNRs
- Evaporating clouds
- Ionized surfaces

Tepid intercloud gas
- Local hotter regions
- Evaporating clouds

Cox 05



Thermal wind
- From escaping hot intercloud gas

Or, a hot halo

Galactic fountain 1
- From escaping hot intercloud gas which cools

Galactic fountain 2
- From superbubbles breaking out above the disk

Thick quiescent disk
- Superbubbles confined
- Spiral density waves
- Ionization mechanism?

What is the interstellar medium made of?

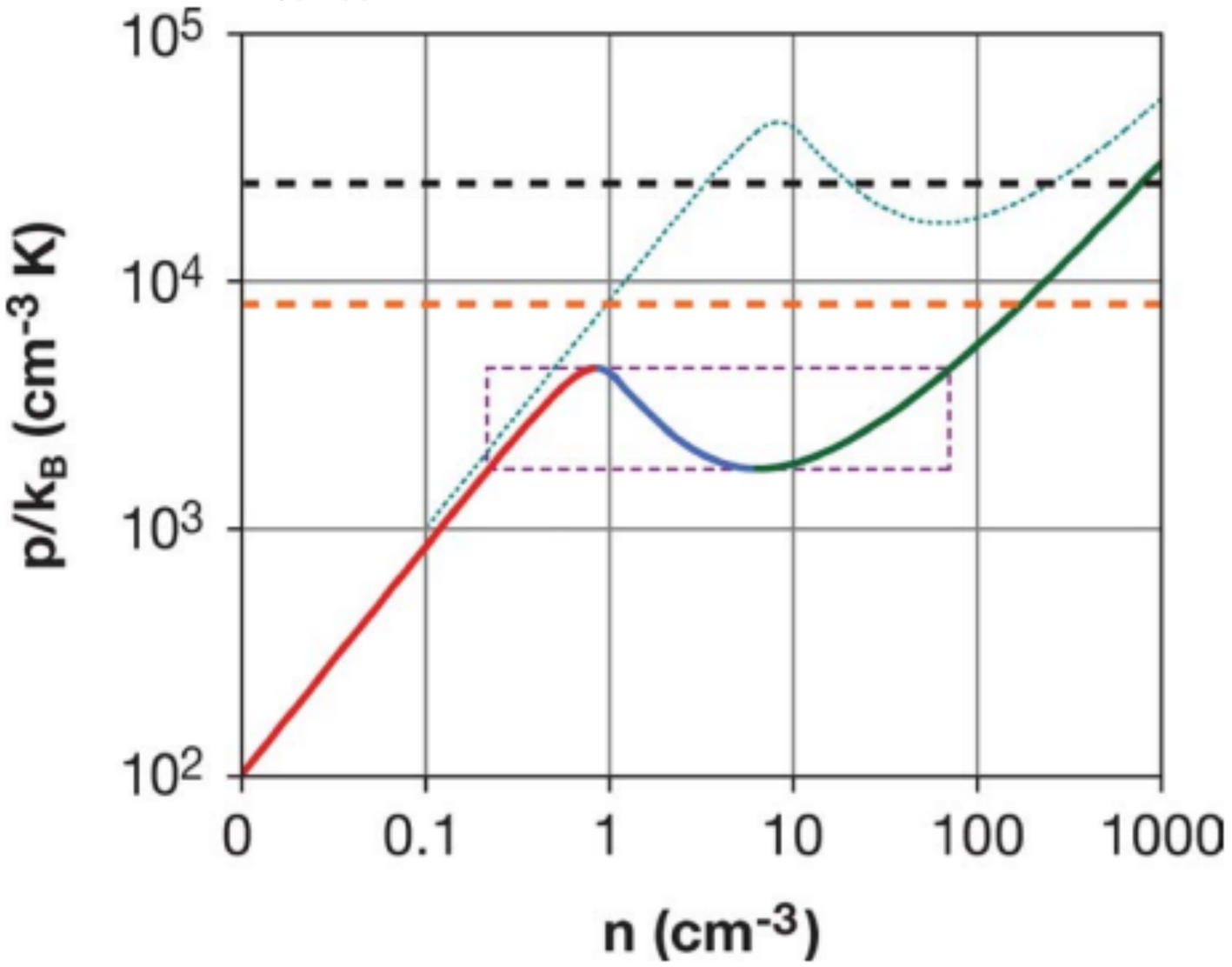
X-Diffuse
1) SWCX
2) LHB - ISM
3) Galactic ridge
4) Hot CGM
5) Outflow
6) CXB

Table 1: Components of the interstellar medium[3]

Component	Fractional volume	Scale height (pc)	Temperature (K)	Density (particles/cm^3)	State of hydrogen	Primary observational techniques
Molecular clouds	< 1%	80	10–20	10^2–10^6	molecular	Radio and infrared molecular emission and absorption lines
Cold neutral medium (CNM)	1–5%	100–300	50–100	20–50	neutral atomic	H I 21 cm line absorption
Warm neutral medium (WNM)	10–20%	300–400	6000–10000	0.2–0.5	neutral atomic	H I 21 cm line emission
Warm ionized medium (WIM)	20–50%	1000	8000	0.2–0.5	ionized	Hα emission and pulsar dispersion
H II regions	< 1%	70	8000	10^2–10^4	ionized	Hα emission, pulsar dispersion, and radio recombination lines
Coronal gas Hot ionized medium (HIM)	30–70%	1000–3000	10^6–10^7	10^{-4}–10^{-2}	ionized (metals also highly ionized)	X-ray emission; absorption lines of highly ionized metals, primarily in the ultraviolet

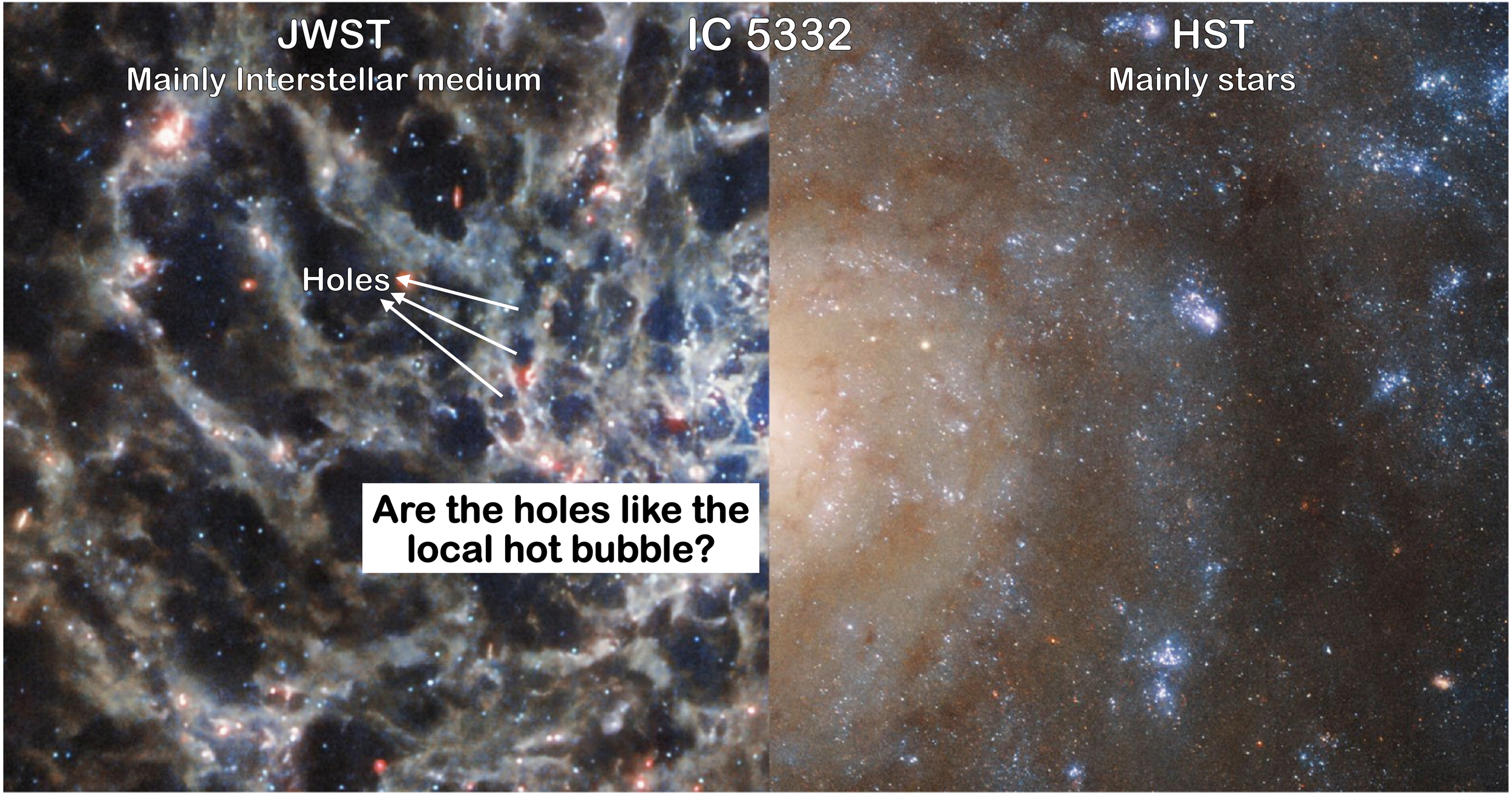
Wikipedia

Cox 05

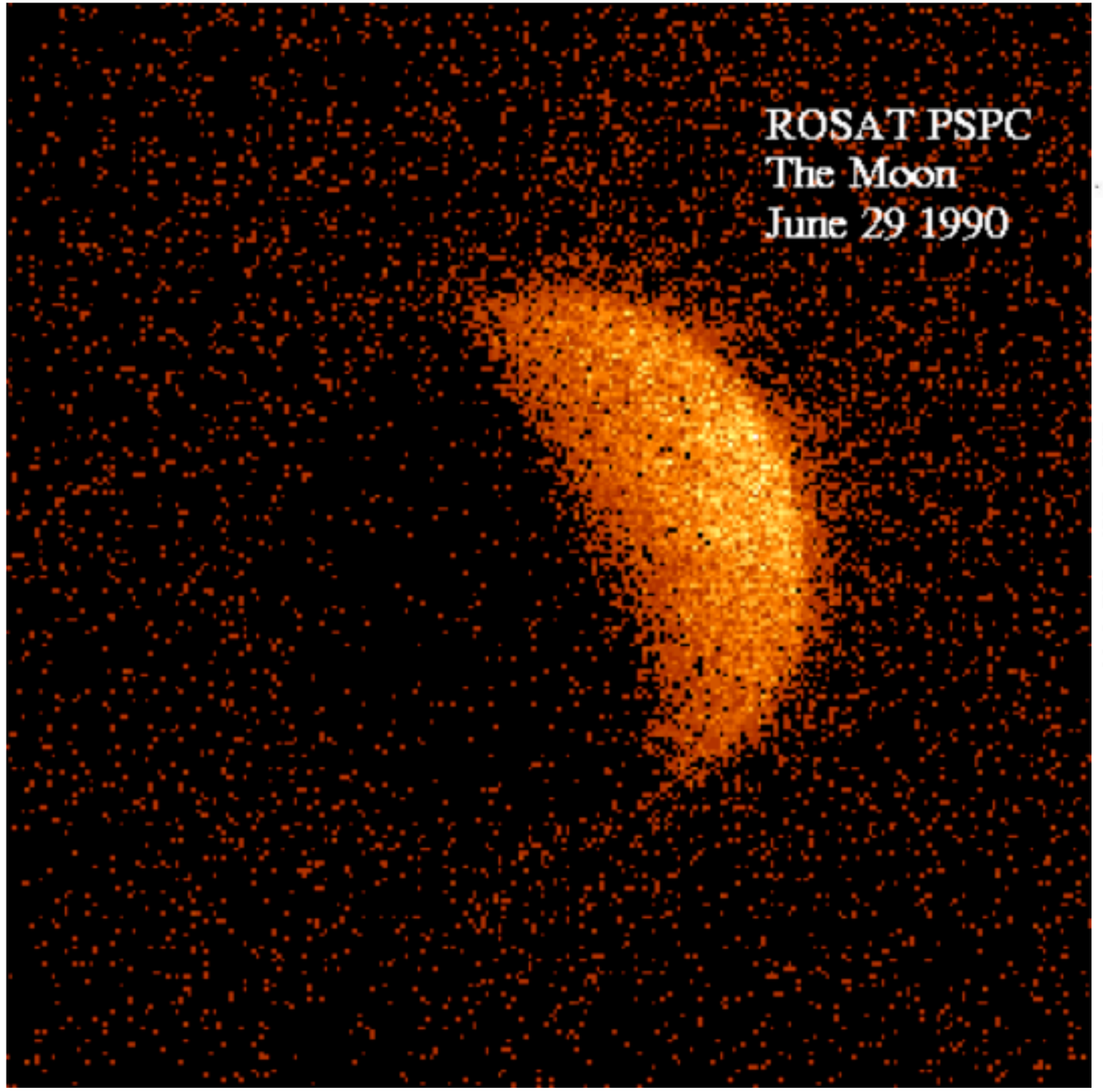


Diffuse X-ray emission: local hot bubble

X-Diffuse
1) SWCX
2) LHB - ISM

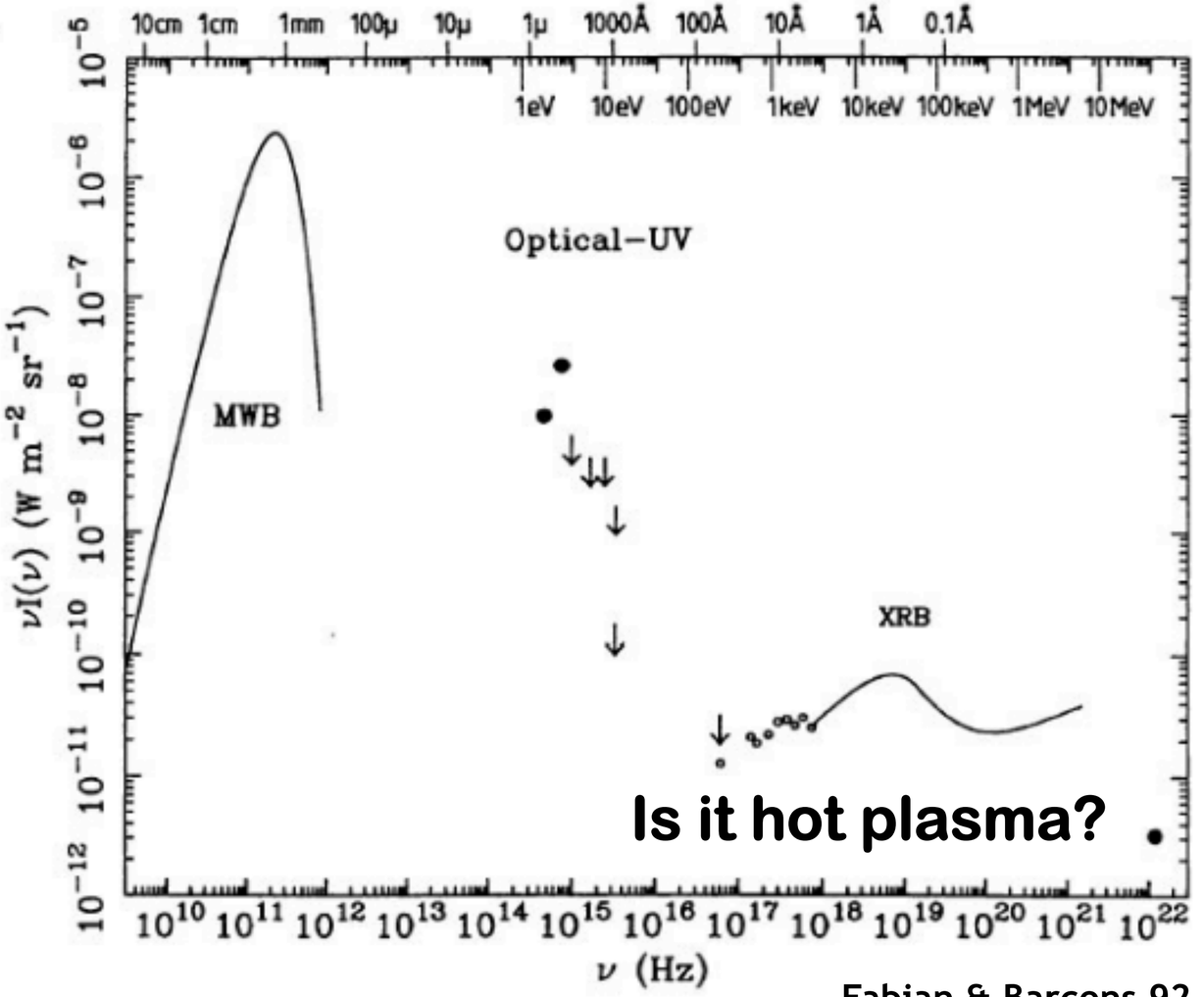


The Cosmic X-ray background



X-Diffuse
1) SWCX
2) LHB - ISM
3) Galactic ridge
4) Hot CGM
5) Outflow
6) CXB

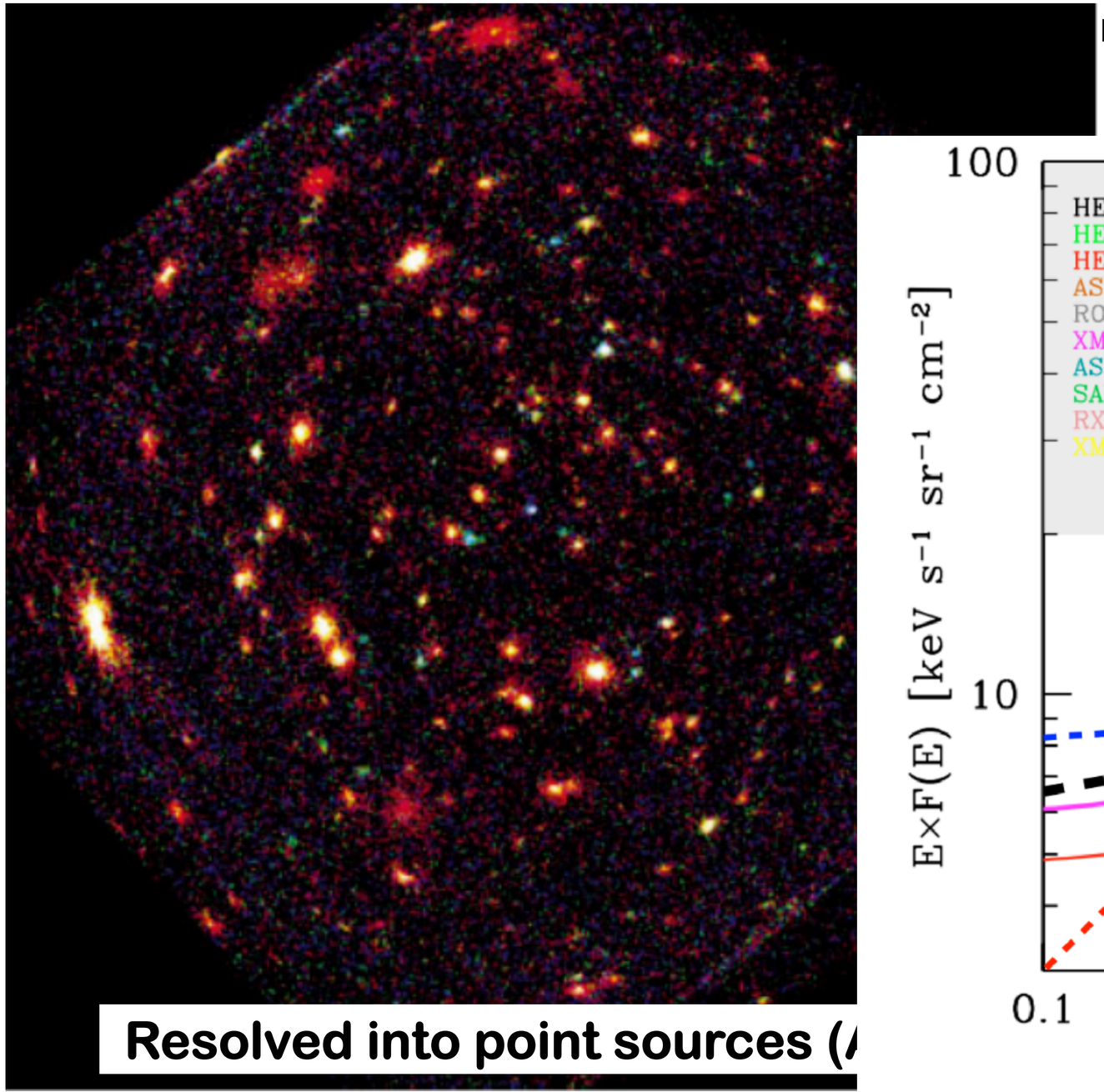
Spectrum



Is it hot plasma?

Fabian & Barcons 92

The Cosmic X-ray background

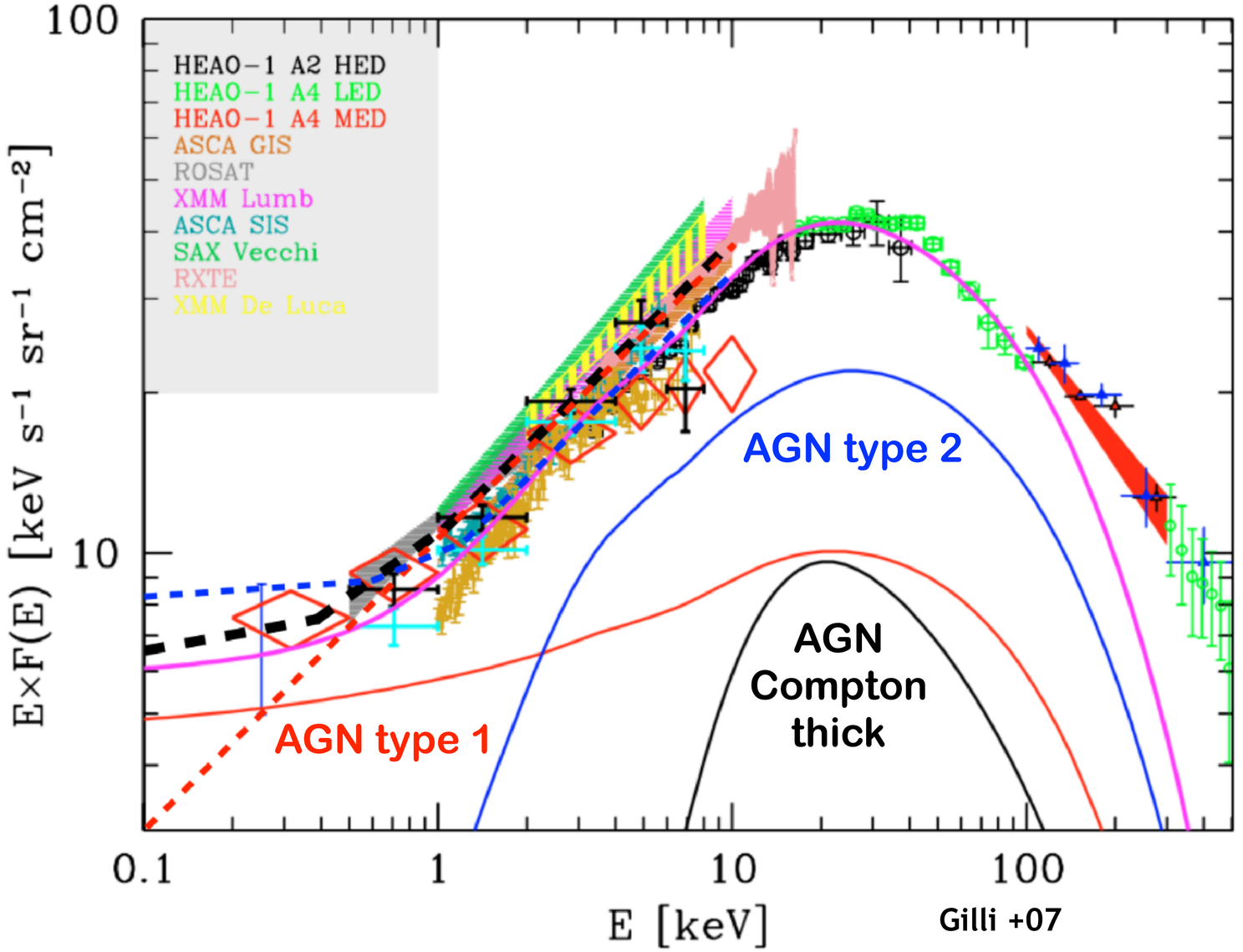


Hasinger +01

Resolved into point sources (A

X-Diffuse
1) SWCX
2) LHB - ISM
3) Galactic ridge
4) Hot CGM
5) Outflow
6) CXB

Spectrum

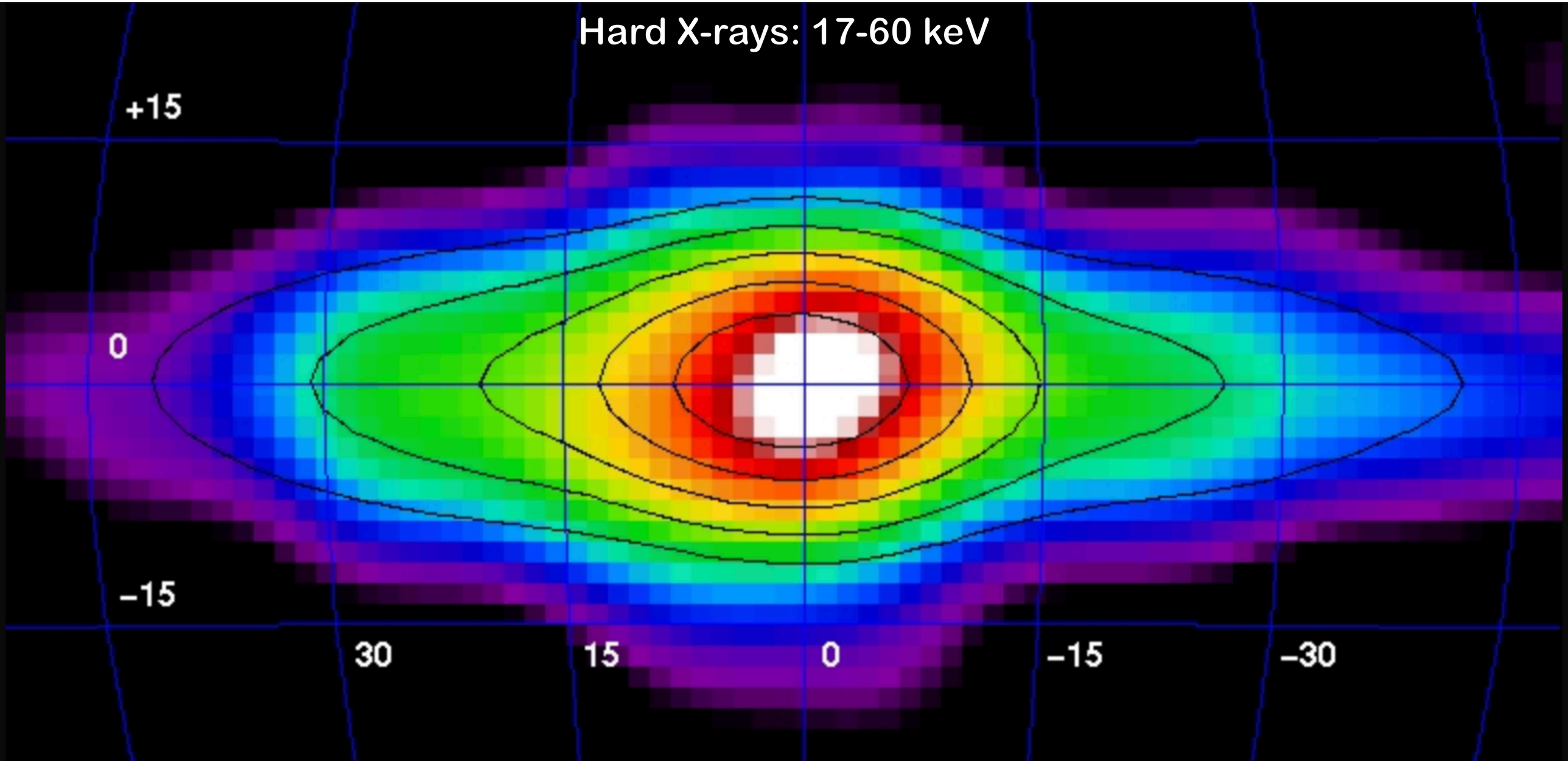


Gilli +07

The Galactic ridge X-ray emission

Krivonos +07

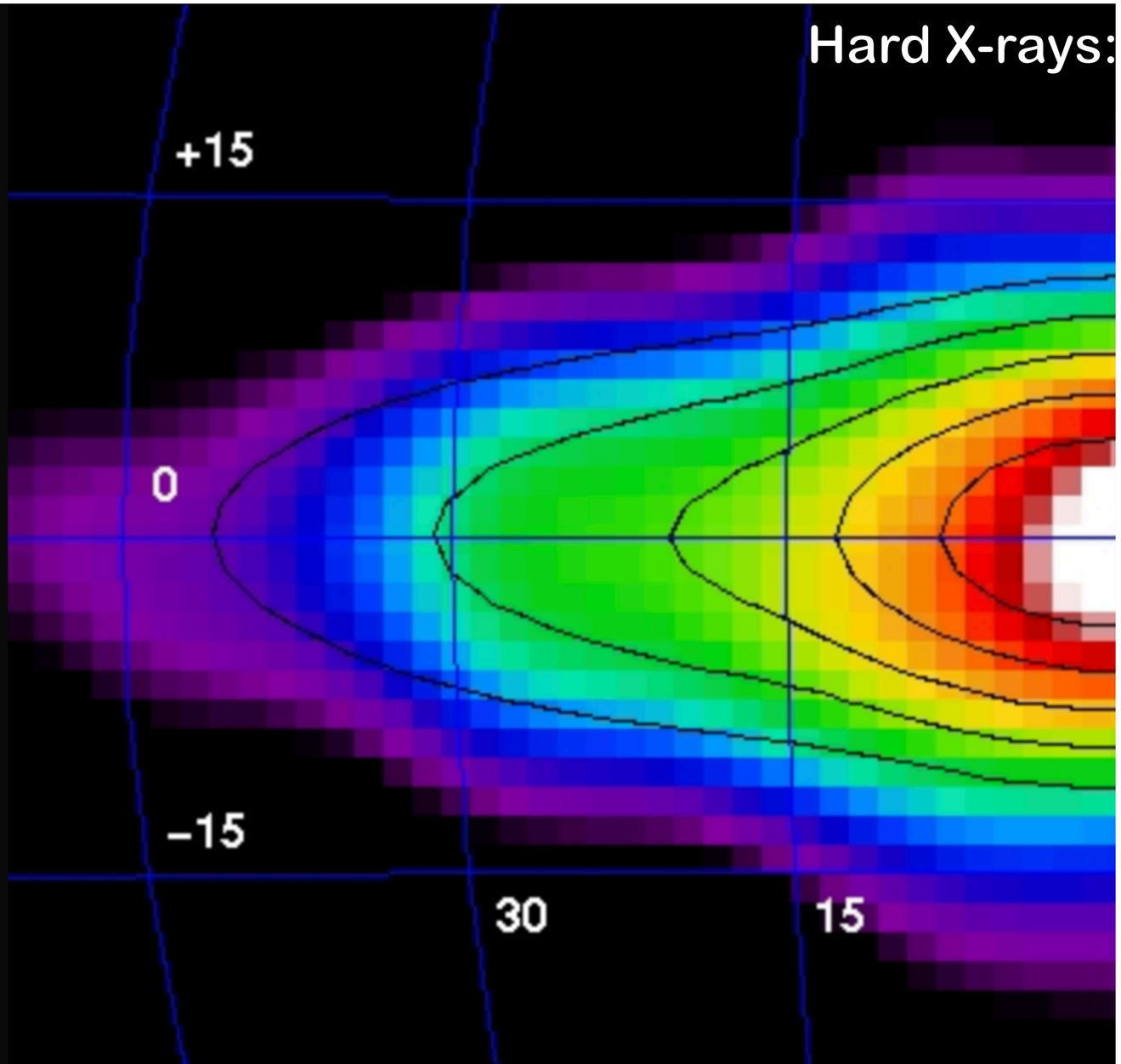
X-Diffuse
1) SWCX
2) LHB - ISM
3) Galactic ridge



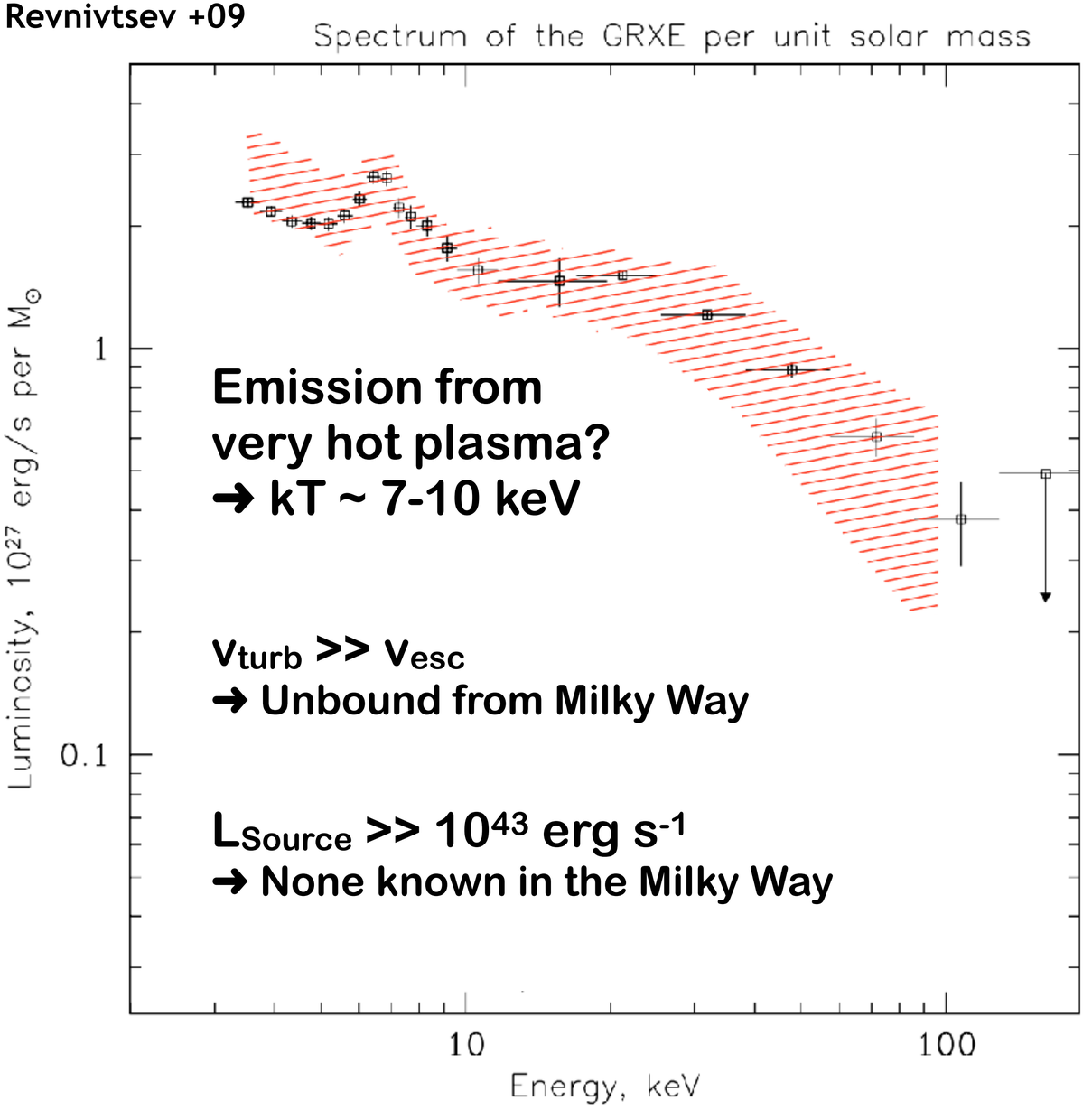
The Galactic ridge X-ray emission

X-Diffuse
1) SWCX
2) LHB - ISM
3) Galactic ridge

Krivonos +07



Revnivtsev +09



Emission from very hot plasma?
➜ kT ~ 7-10 keV

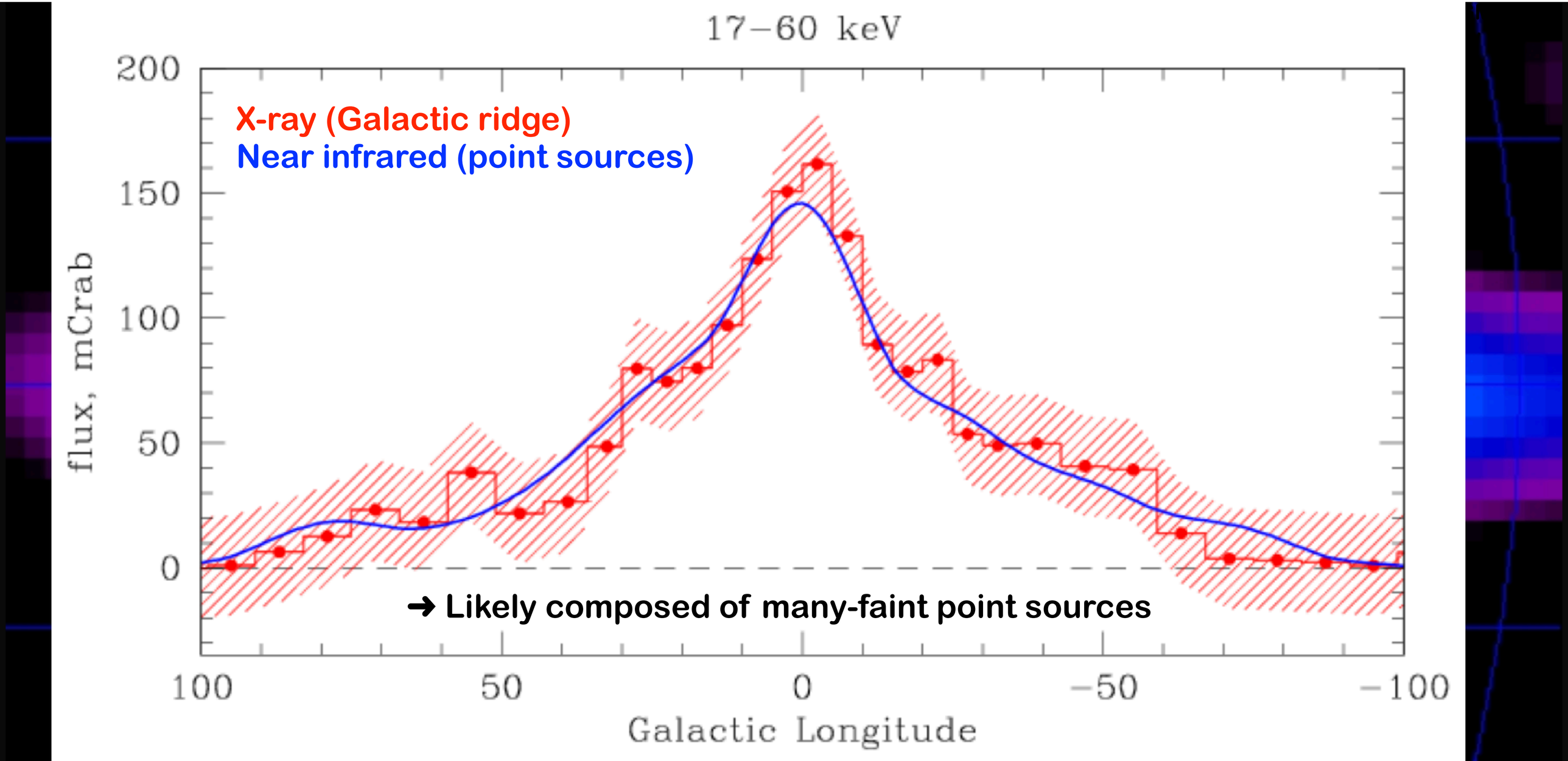
$v_{turb} >> v_{esc}$
➜ Unbound from Milky Way

$L_{Source} >> 10^{43}$ erg s^{-1}
➜ None known in the Milky Way

The Galactic ridge X-ray emission

Krivonos +07

X-Diffuse
1) SWCX
2) LHB - ISM
3) Galactic ridge

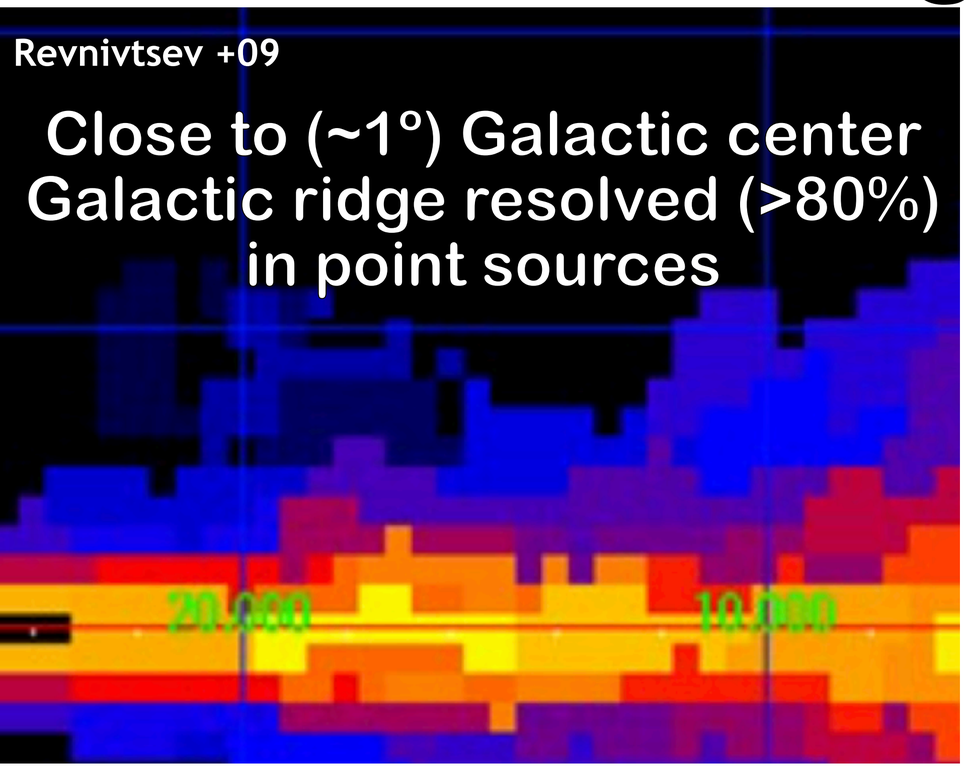


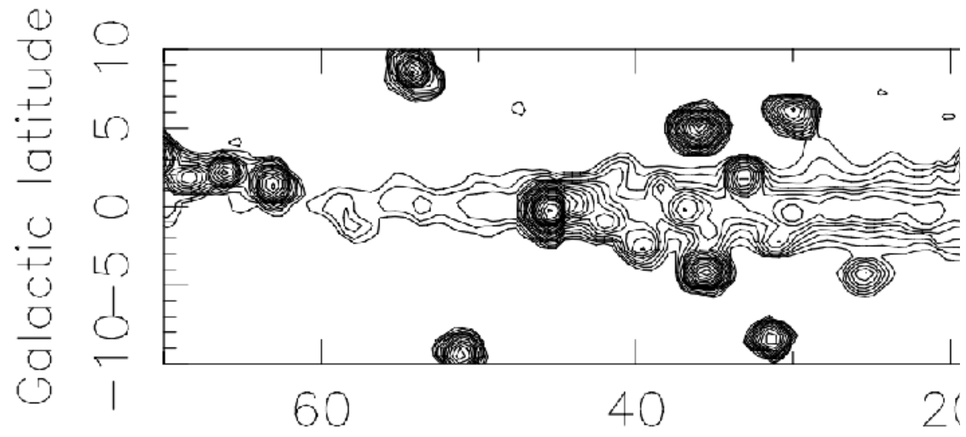
The Galactic ridge X-ray emission

X-Diffuse
1) SWCX
2) LHB - ISM
3) Galactic ridge

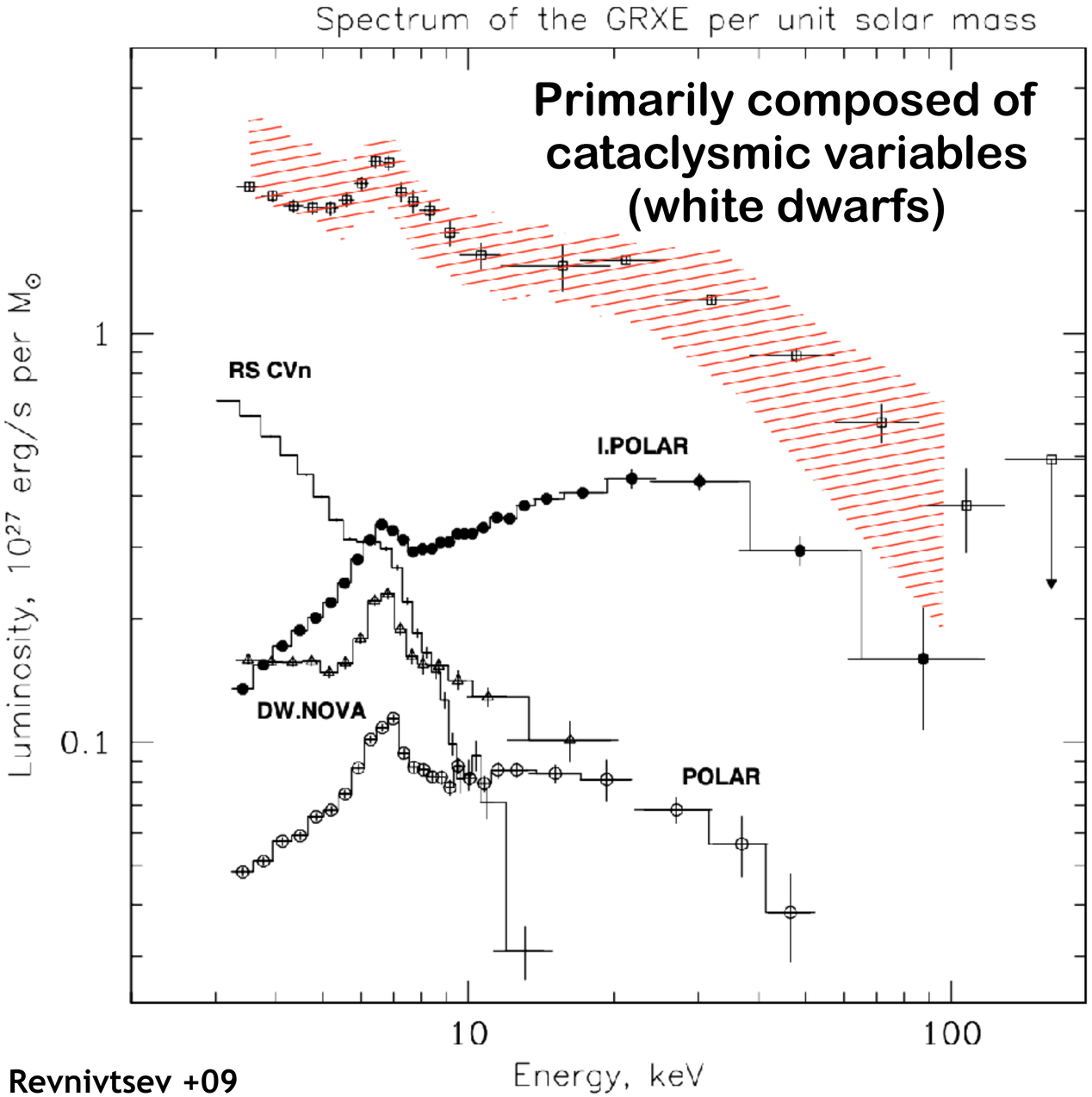
Revnivtsev +09

Close to (~1°) Galactic center
Galactic ridge resolved (>80%)
in point sources

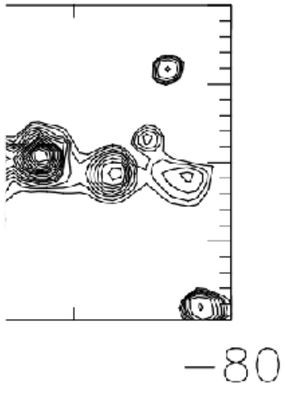




Revnivtsev +09



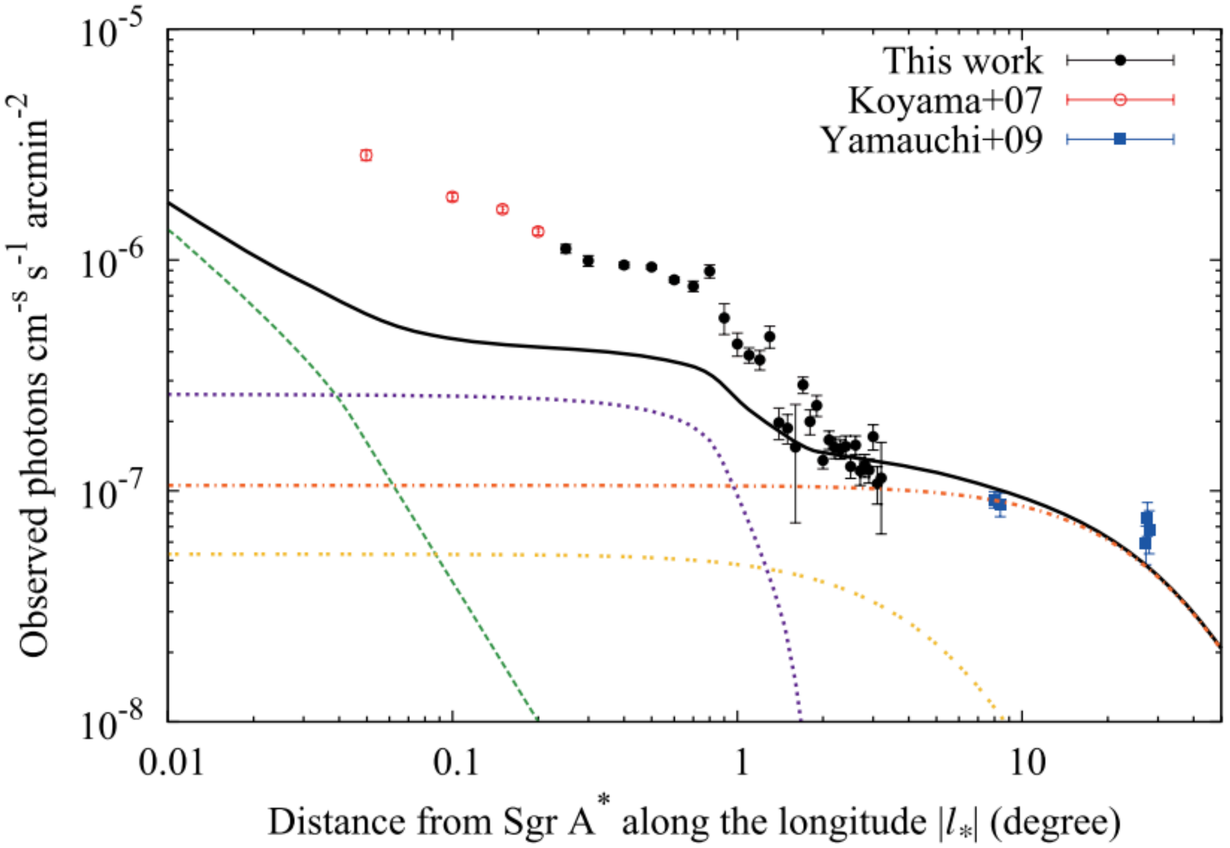
Revnivtsev +09

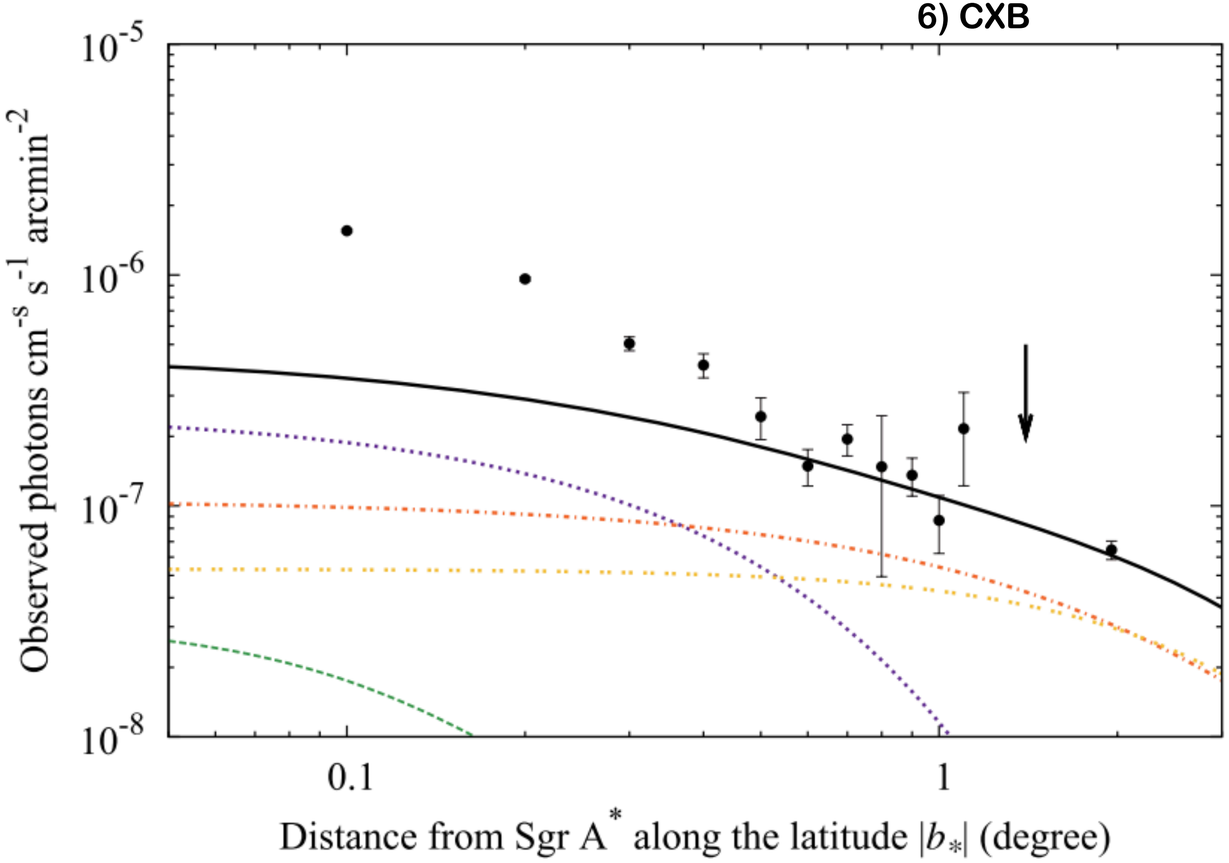


The Galactic ridge X-ray emission

X-Diffuse
1) SWCX
2) LHB - ISM
3) Galactic ridge
4) Hot CGM
5) Outflow
6) CXB

Uchiyama +11





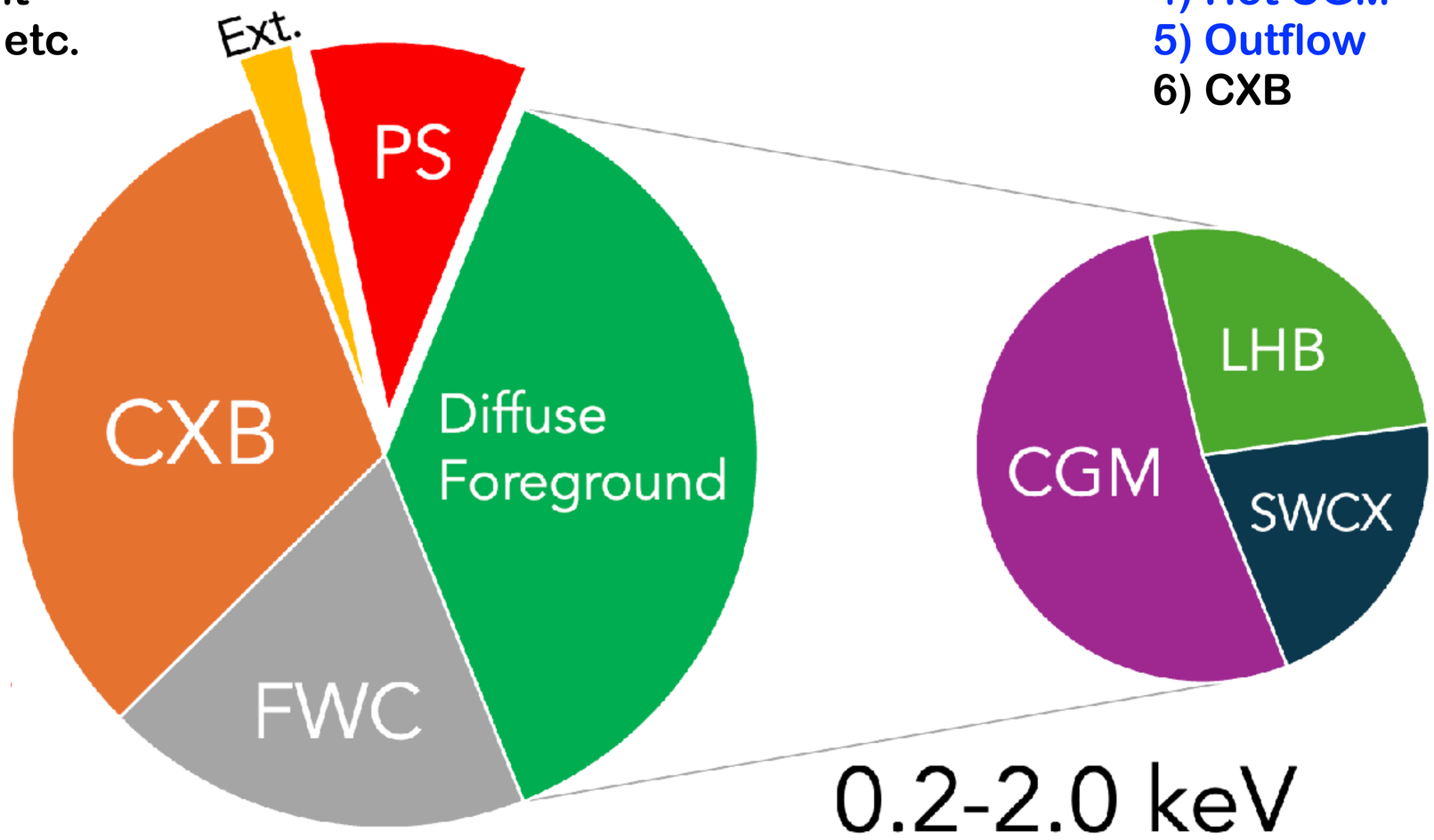
Very hot plasma exists within 1° from Sgr A*
$L > 10^{41}$ erg s^{-1}

Is this true???

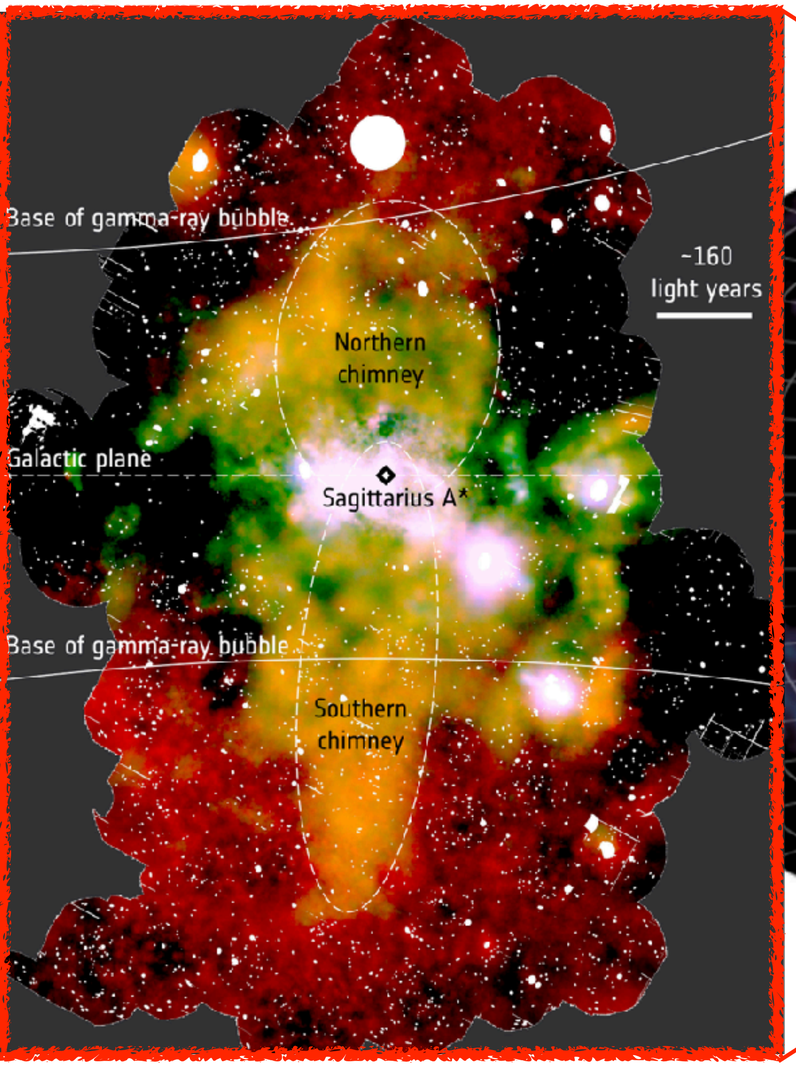
Short summary:

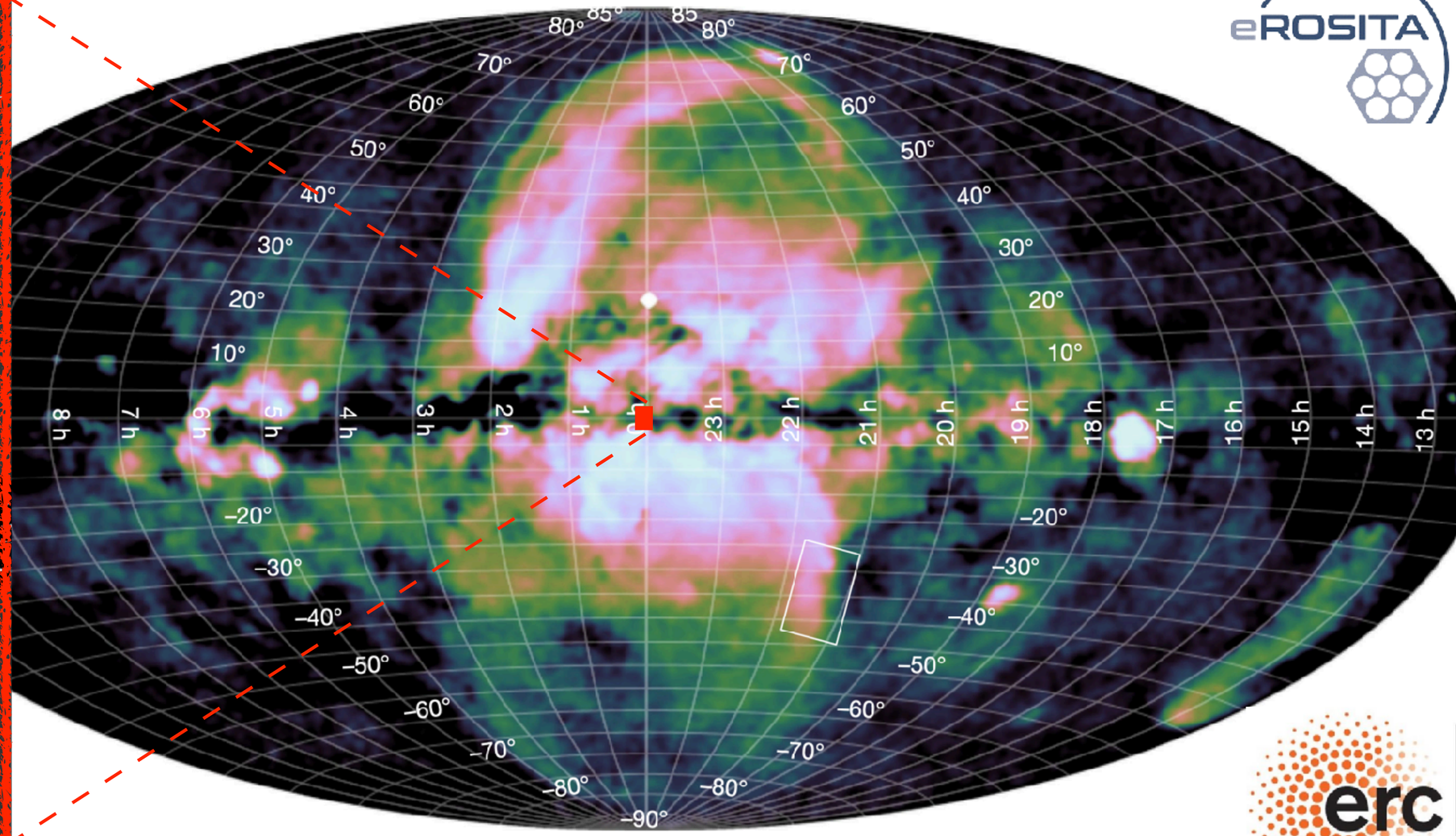
Back-Instrumental
1) FWC
2) Soft protons
3) Straylight
4) etc. etc. etc.

X-Diffuse
1) SWCX
2) LHB - ISM
3) Galactic ridge
4) Hot CGM
5) Outflow
6) CXB



The hot phase of the Milky Way





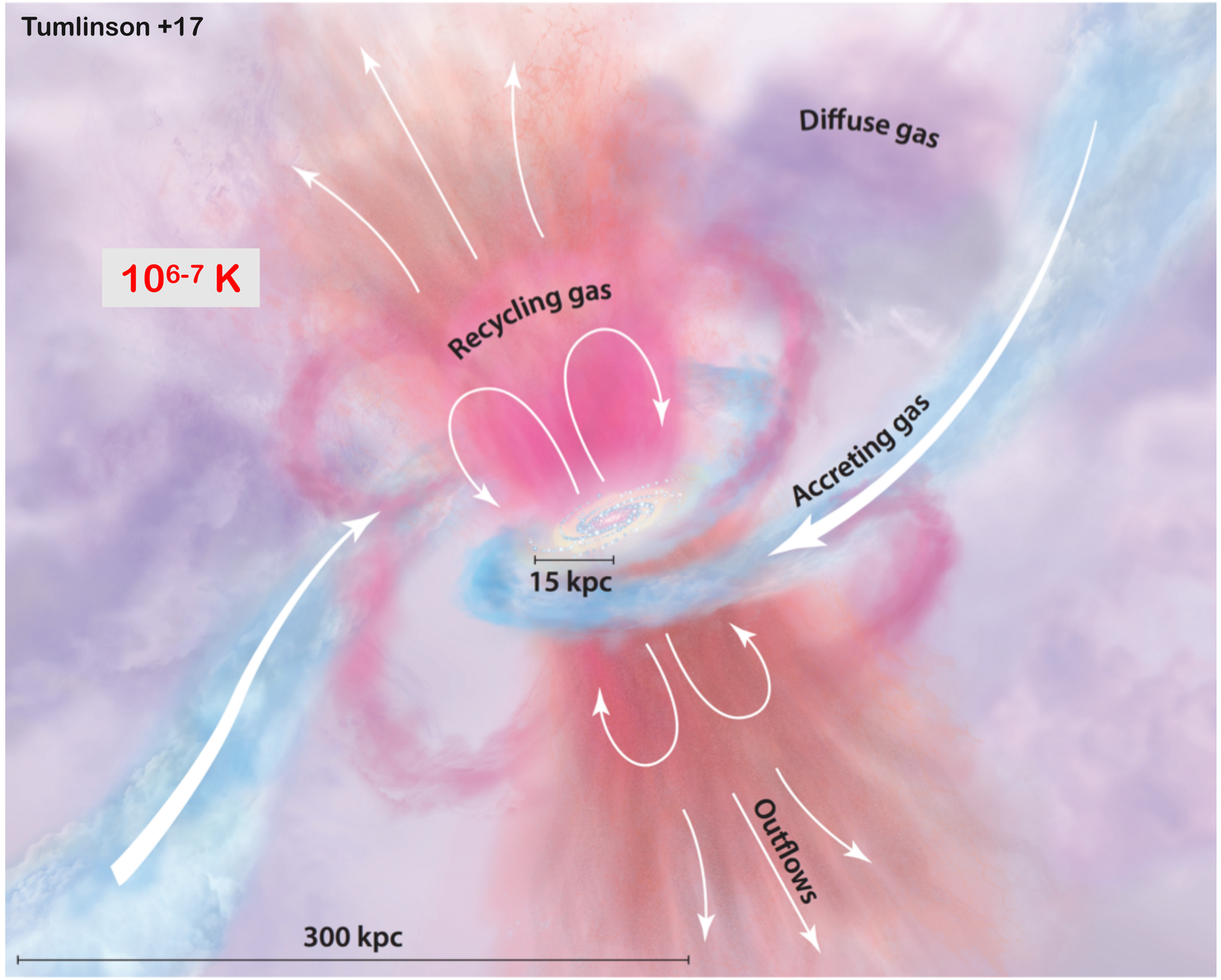
Gabriele Ponti (INAF-OA Brera, MPE) and the Hot Milk team

X. Zheng, N. Locatelli, M. Yeung, H. Zhang, Y. Zhang, K. Anastasopoulou, S. Mondal, G. Stel, S. Mackey, J. Knies, T. Liu, J. Comparat, K. Dennerl, A. Merloni, J. Sanders, M. Sasaki, M. Morris, K. Egg, M. Freyberg, S. Shreeram, A. Strong

How do galaxies evolve?

NGC 7331 Hubble

The Baryon cycle



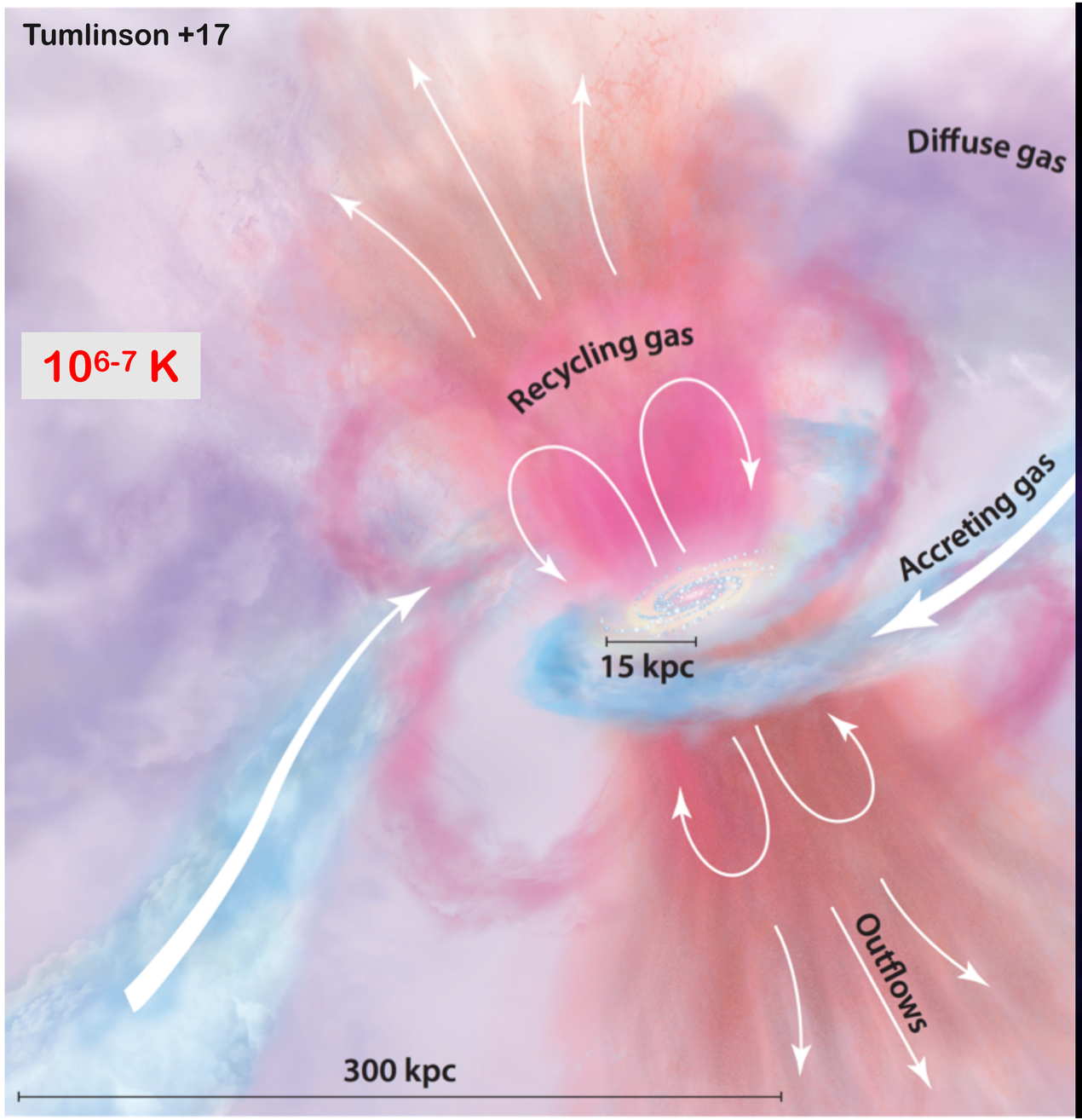
Hot Baryons:

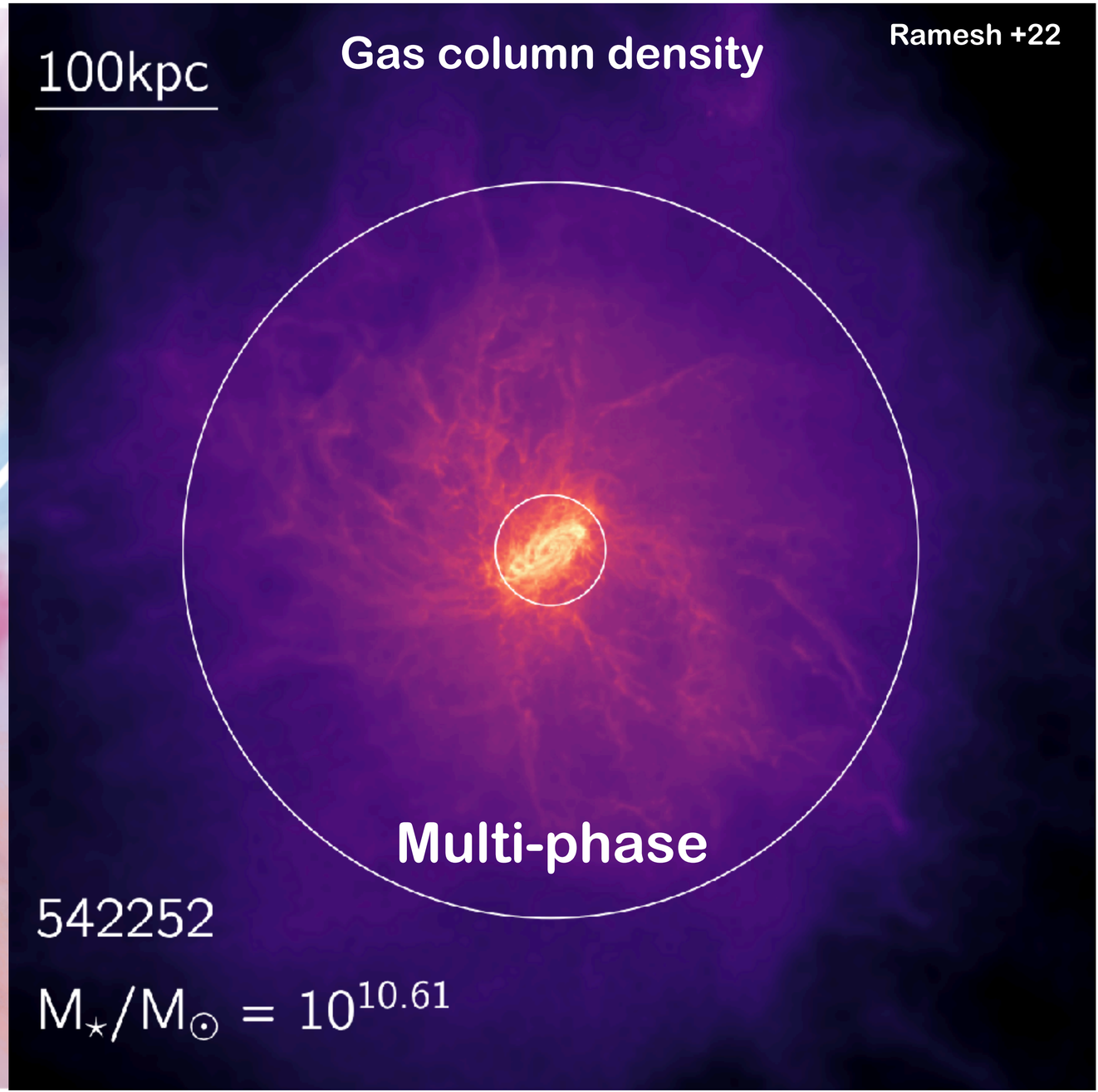
Bulk of Baryons

Re-condensation

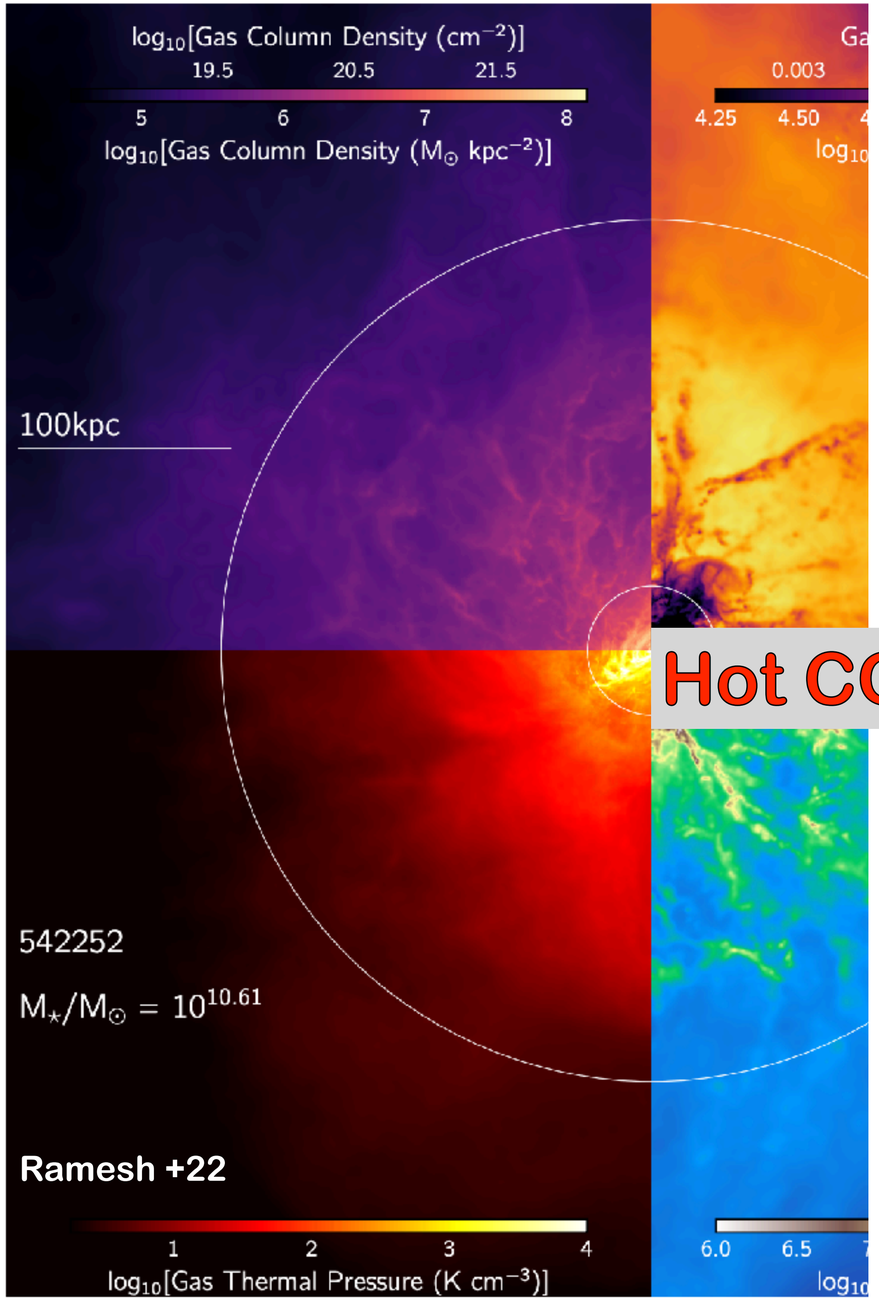
Driver outflows

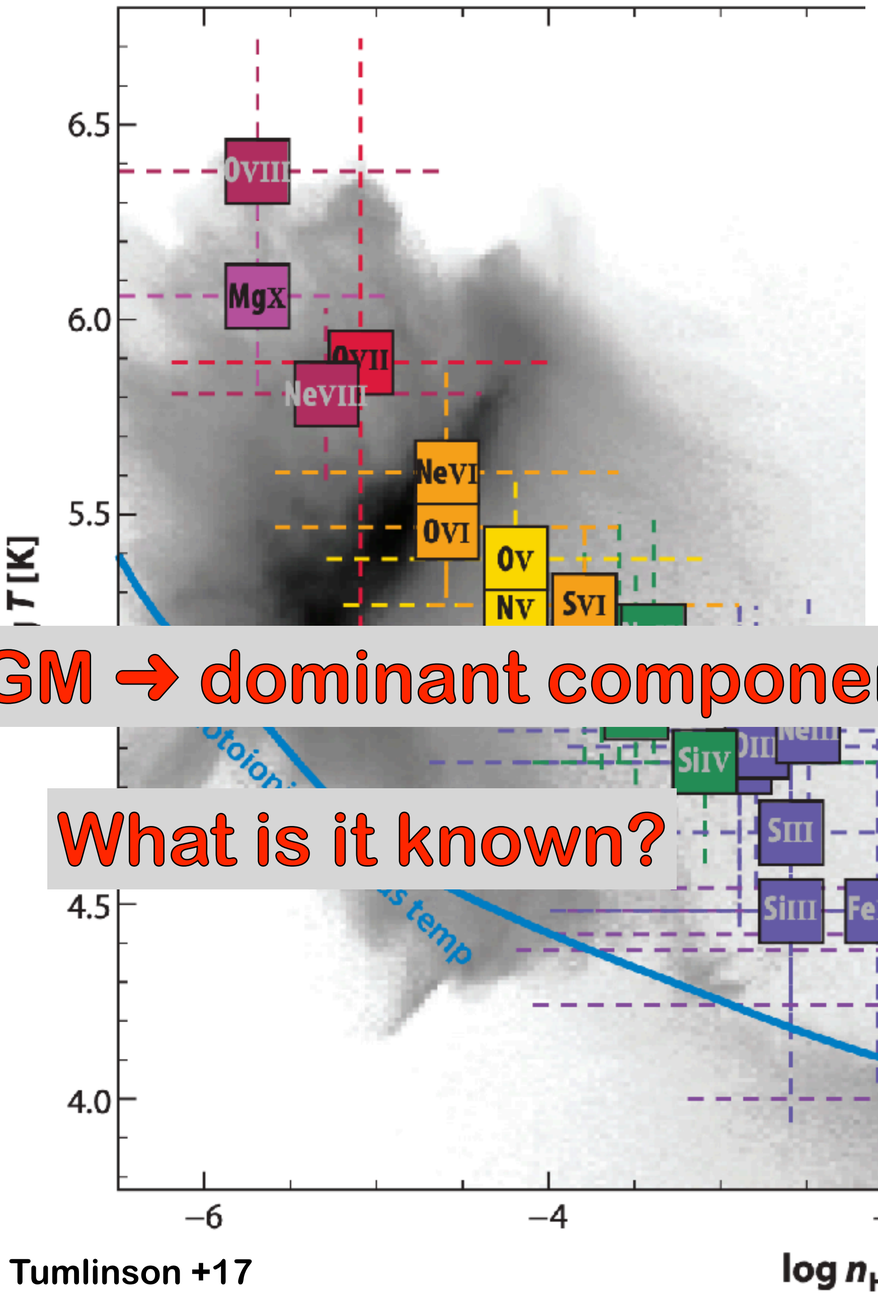
The CGM in realistic simulations

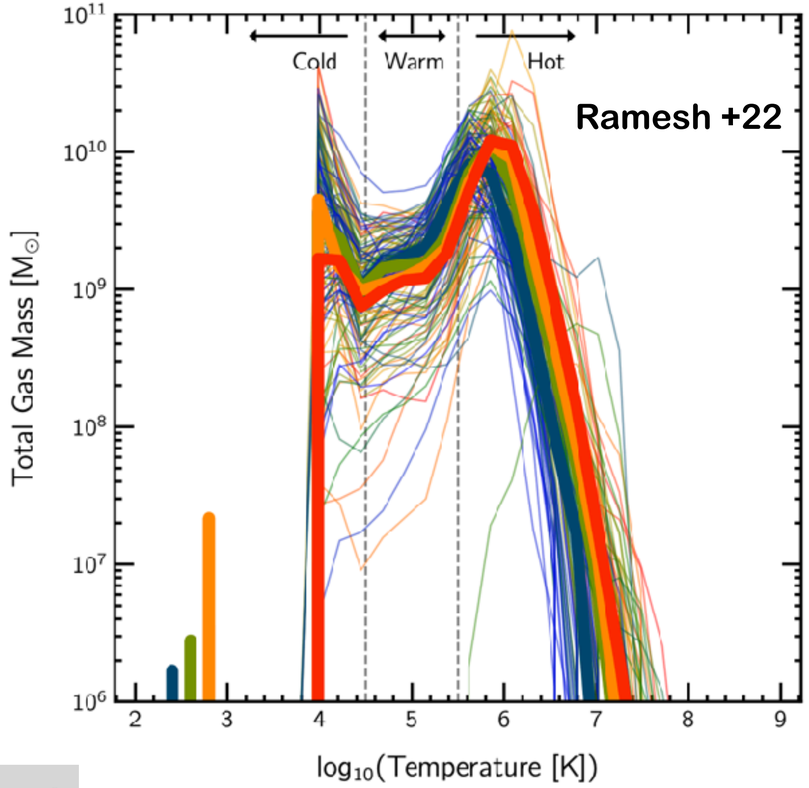




The CGM is hot and multi-phase



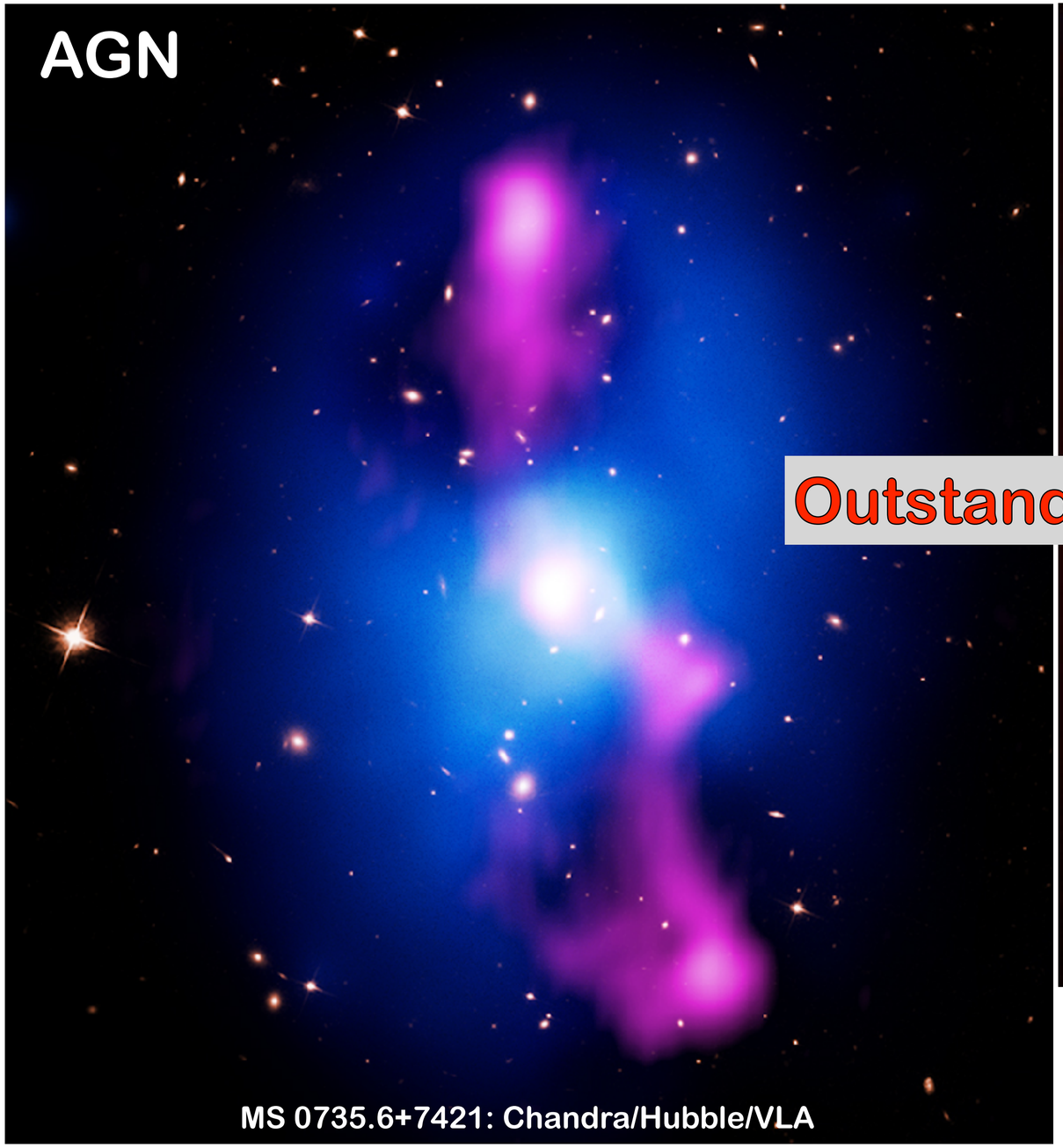


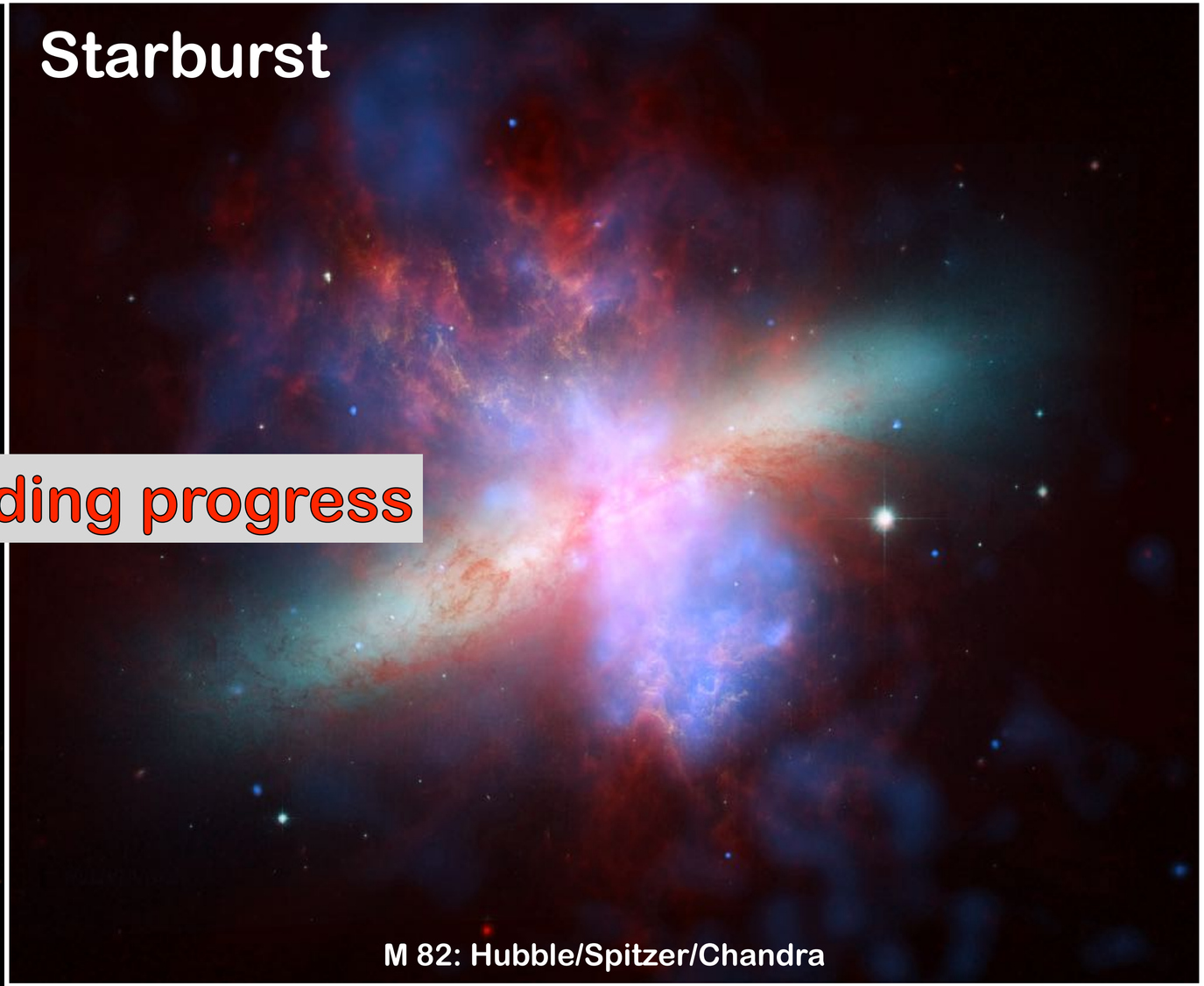


Hot CGM → dominant component

What is it known?

AGN and Starbursts influence CGM





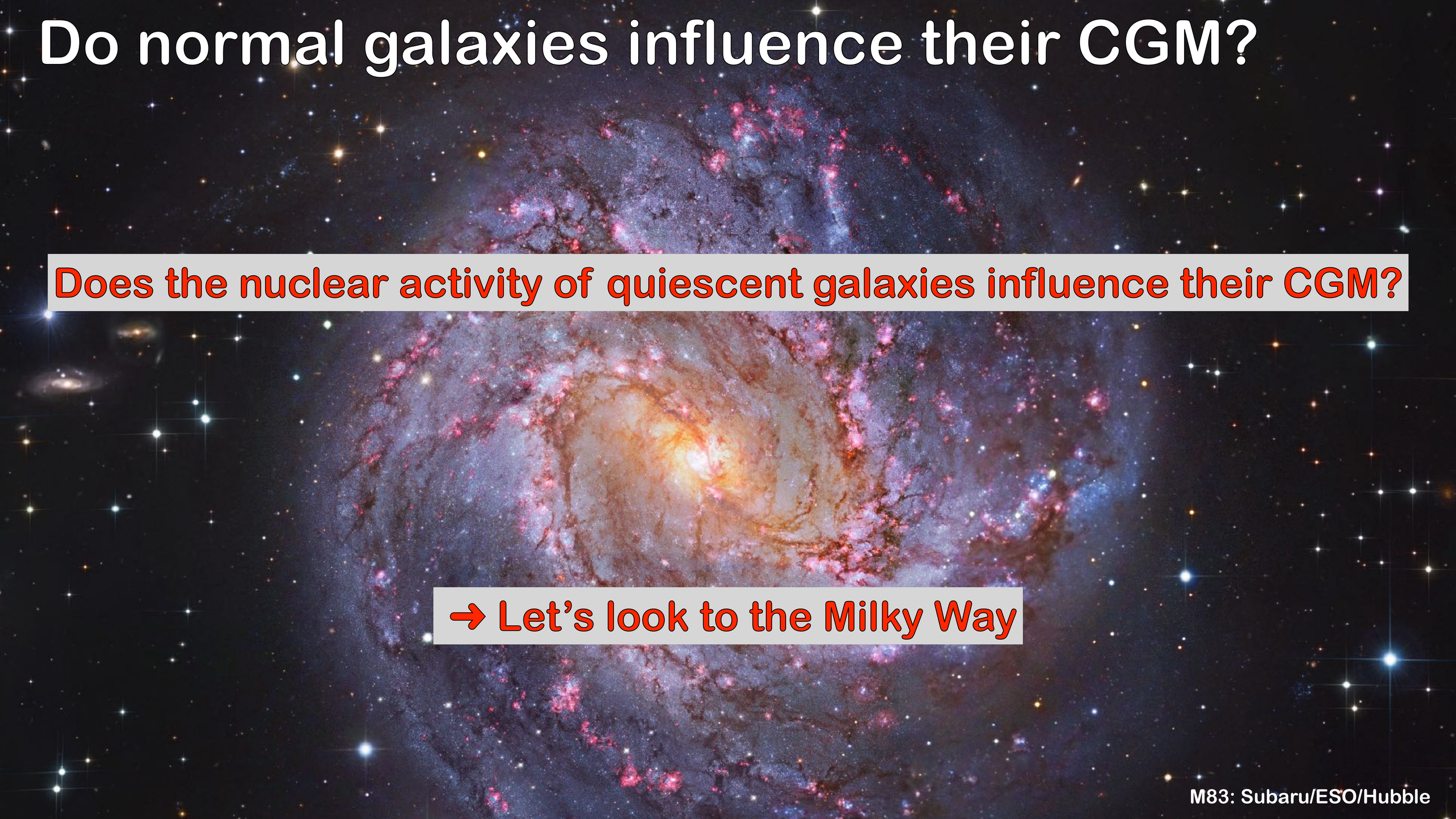
Outstanding progress

➜ Understand feedback between nucleus and CGM

Do normal galaxies influence their CGM?

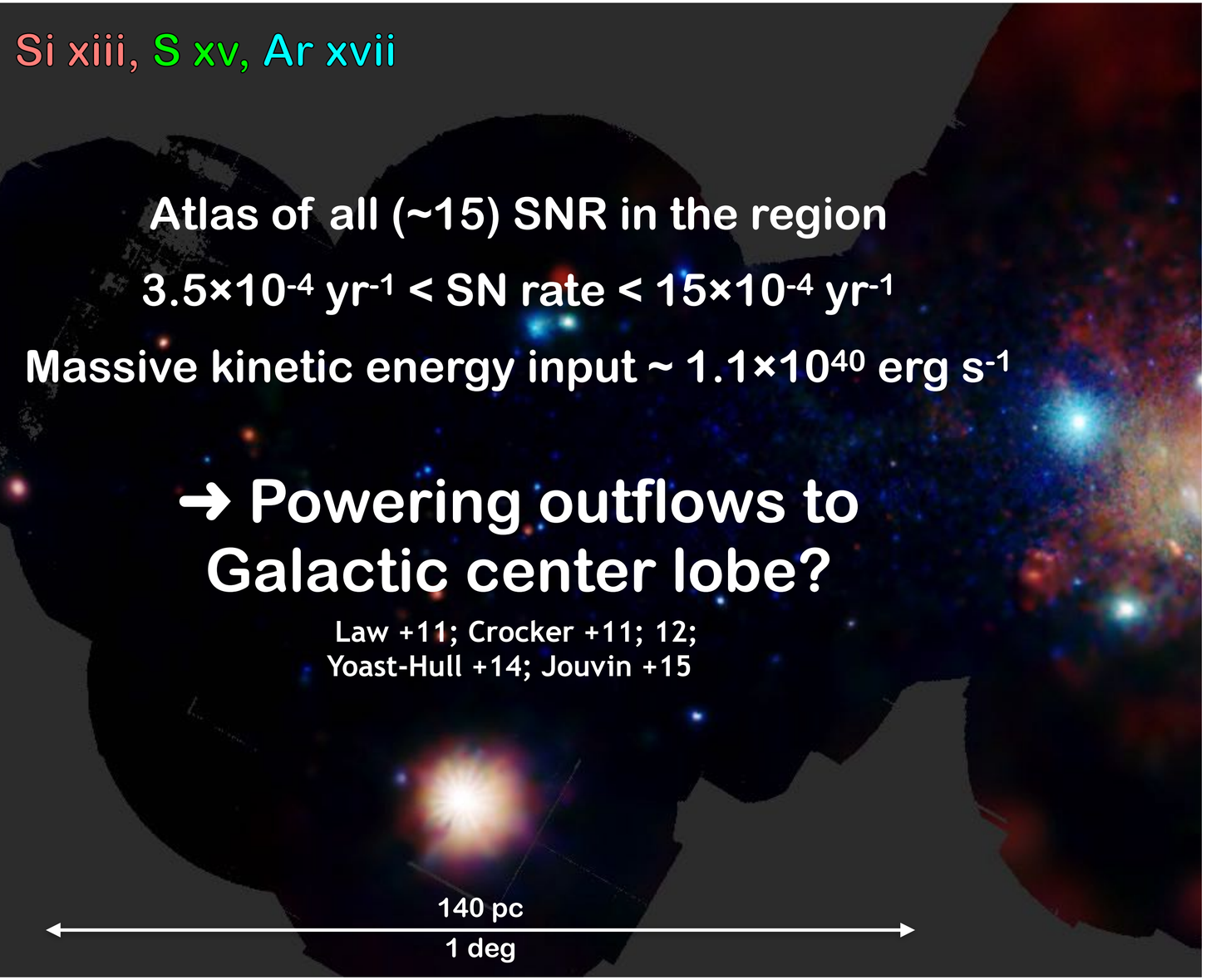
Does the nuclear activity of quiescent galaxies influence their CGM?

➜ Let's look to the Milky Way



M83: Subaru/ESO/Hubble

Hot plasma to trace past activity



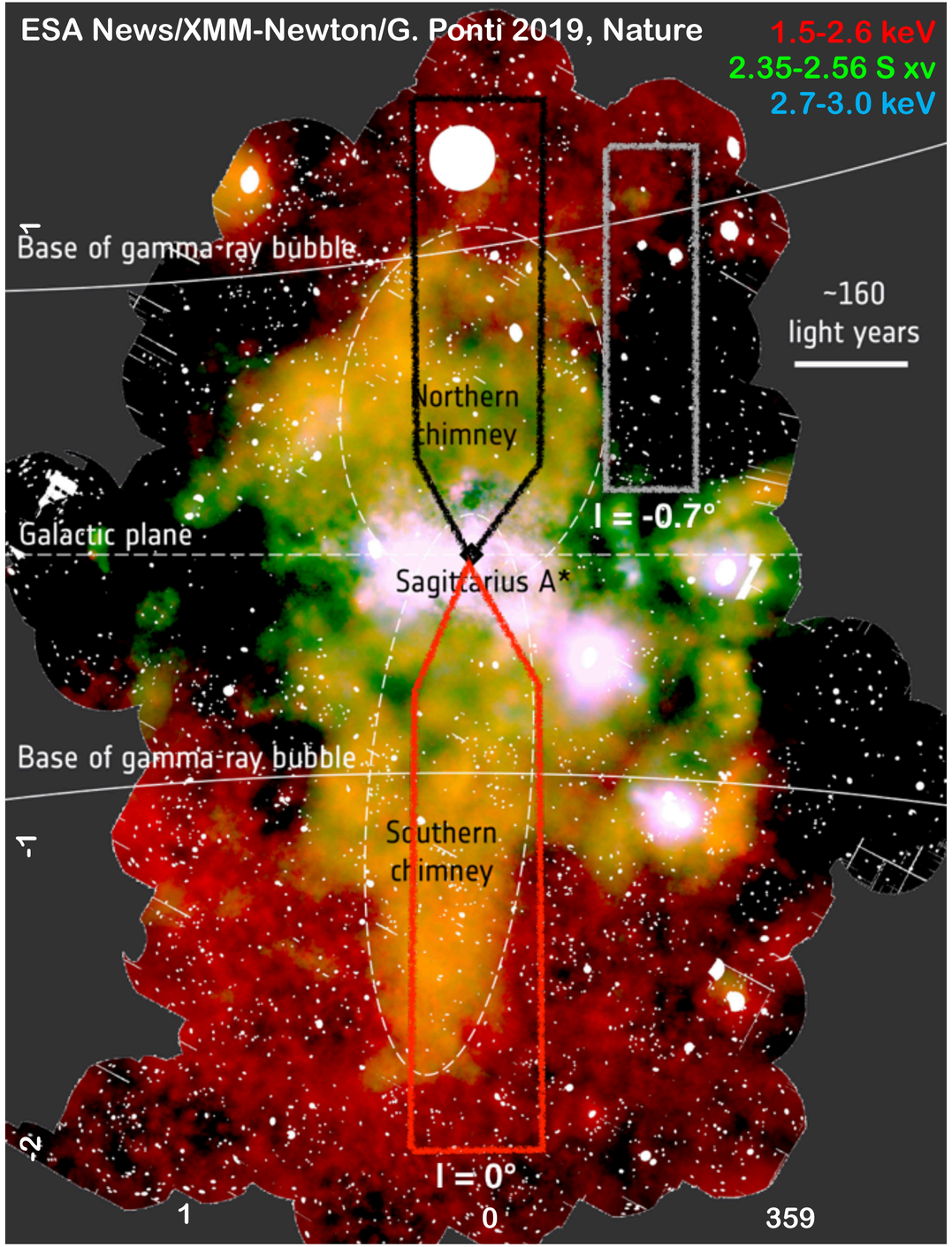
Ponti +15

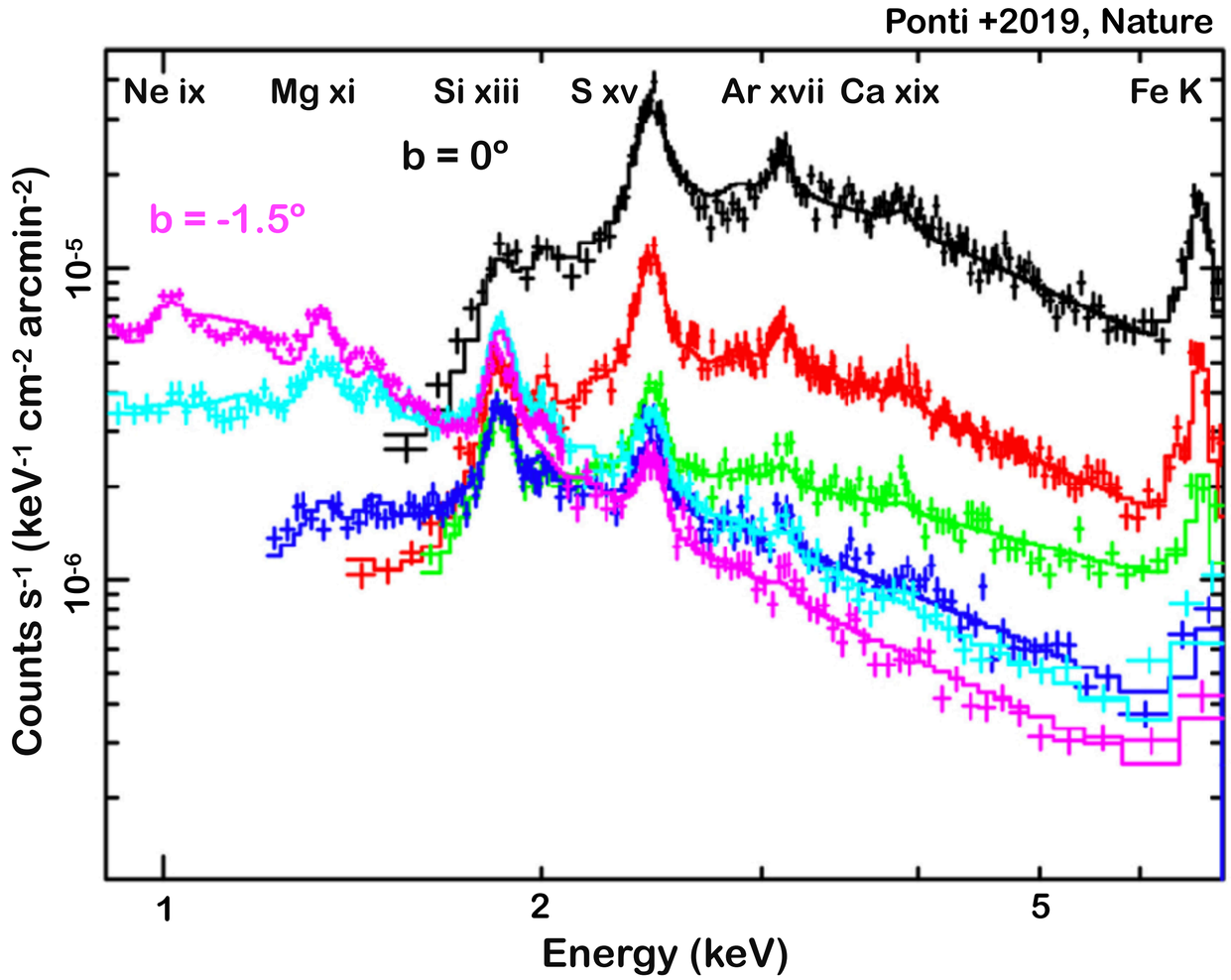
ATLAS OF DIFFUSE X-RAY EMITTING FEATURES

Name	Other name	Coordinates (l, b)	Size arcsec	References
STAR CLUSTERS:				
Central star cluster		359.9442, -0.046	0.33	45,116,117,118
Quintuplet		0.1604, -0.0591	0.5	1,63,11
Arches	G0.12+0.02	0.1217, 0.0188	0.7	1,2,3,4,5,6,7,8,9,39,40,11
Sh2-10	DB00-6	0.3072,-0.2000	1.92	10,11,12,63,11
Sh2-17	DB00-58	0.0013, 0.1588	1.65	13,63,11
DB00-05	G0.33-0.18	0.31 -0.19	0.4	22,63,11
SNR - BUBBLES - SUPER-BUBBLES:				
G359.0-0.9	G358.5-0.9 - G359.1-0.9	359.03,-0.96	26 × 20	X-R 48,51,75,76,81,119,120
G359.07-0.02	G359.0-0.0	359.07,-0.02	22 × 10	R 14,48,51,66
	G359.12-0.05	359.12,-0.05	24 × 16	X 66
G359.10-0.5		359.10,-0.51	22 × 22	X-R 37,48,51,56,74,75,81,120,121
G359.41-0.12		359.41,-0.12	3.5 × 5.0	X 14
Chimney		359.46,+0.04	6.8 × 2.3	X 14
G359.73-0.35‡		359.73,-0.35	4	X 58
G359.77-0.09	Superbubble	359.84,-0.14	20 × 16	X 15,16,17,58
	G359.79-026♮	359.79,-0.26	8 × 5.2	X 15,16,17,58
	G0.0-0.16††	0.00,-0.16		X This work
G359.87+0.44	Cane	359.87,+0.44	11 × 5	R 48
	G359.85+0.39			
20pc Sgr A*'s lobes		359.94, -0.04	5.88	R 32,33,34,17
G359.92-0.09‡	Parachute - G359.93-0.07	359.93,-0.09	1	R 35,38,43,47,58,60,61
Sgr A East	G0.0+0.0	359.963, -0.053	3.2 × 2.5	X-R 5,18,19,20,48,75,81
G0.1-0.1	Arc Bubble	0.109,-0.108	13.6 × 11	X This work
	G0.13,-0.12♭	0.13,-0.12	3 × 3	X 17
G0.224-0.032		0.224,-0.032	2.3 × 4.6	X This work
G0.30+0.04	G0.3+0.0	0.34,+0.045	14 × 8.8	R 21,48,51,81,82
	G0.34+0.05			
	G0.33+0.04			
G0.40-0.02	Suzaku J1746.4-2835.4	0.40,-0.02	4.7 × 7.4	X 22
	G0.42-0.04			
G0.52-0.046		0.519,-0.046◇	2.4 × 5.1	This work
G0.57-0.001		0.57,-0.001	1.5 × 2.9	This work
G0.57-0.018†	CXO J174702.6-282733	0.570,-0.018	0.2	X 23,24,58,59,68,80
G0.61+0.01†	Suzaku J1747.0-2824.5	0.61,+0.01	2.2 × 4.8	X 22,65,79
G0.9+01♡	SNR 0.9+0.1	0.867,+0.073	7.6 × 7.2	R 25,26,27,28,29,48,75,81,82
DS1	G1.2-0.0	1.17,+0.00	3.4 × 6.9	X 31
Sgr D SNR	G1.02-0.18	1.02,-0.17	10 × 8.0	R 30,31,48,51,75,77,81,82
	G1.05-0.15			
	G1.05-0.1			
	G1.0-0.1			
G1.4-0.1		1.4,-0.10	10 × 10	R 73,81,82

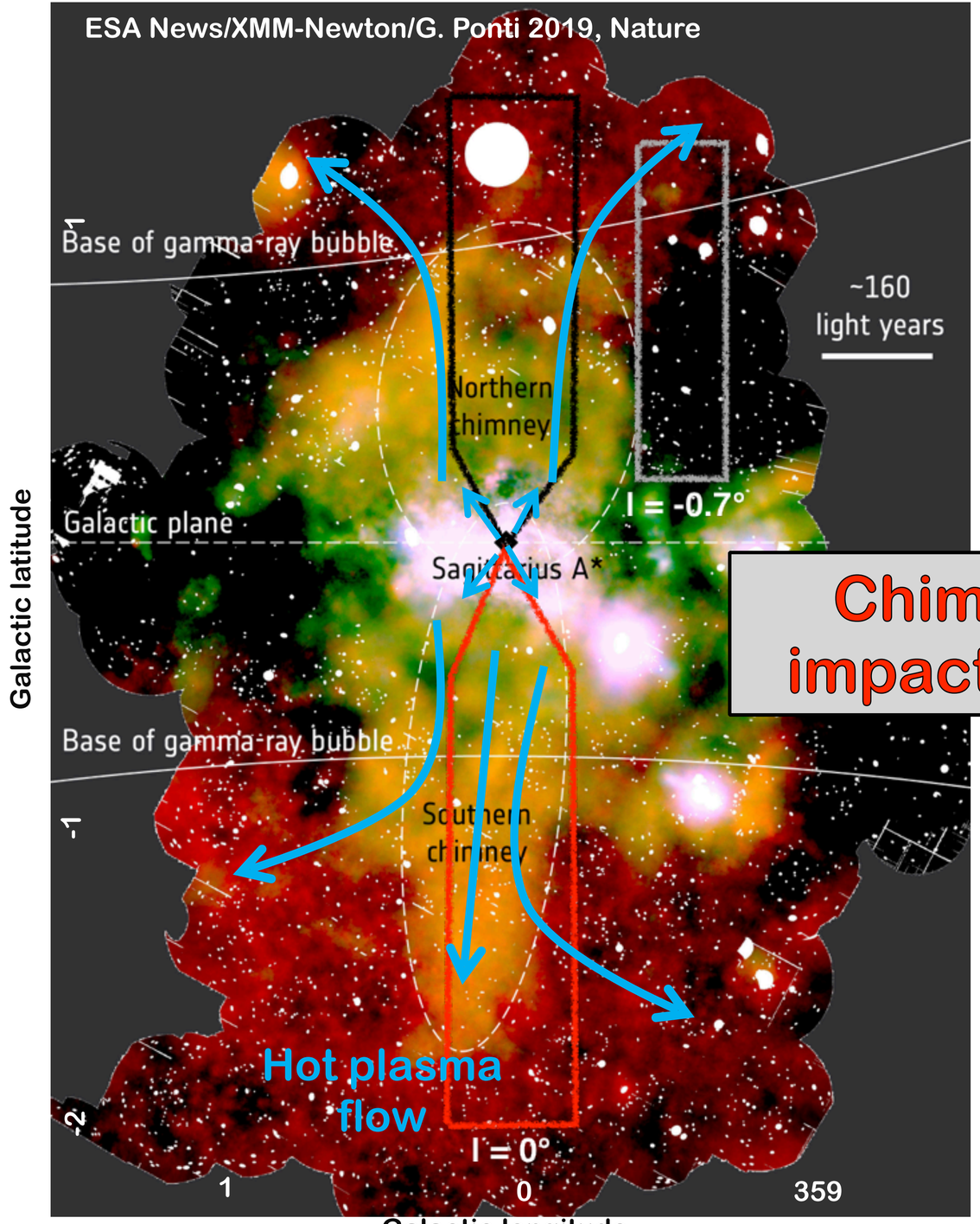
Ponti +15

The Galactic center Chimneys

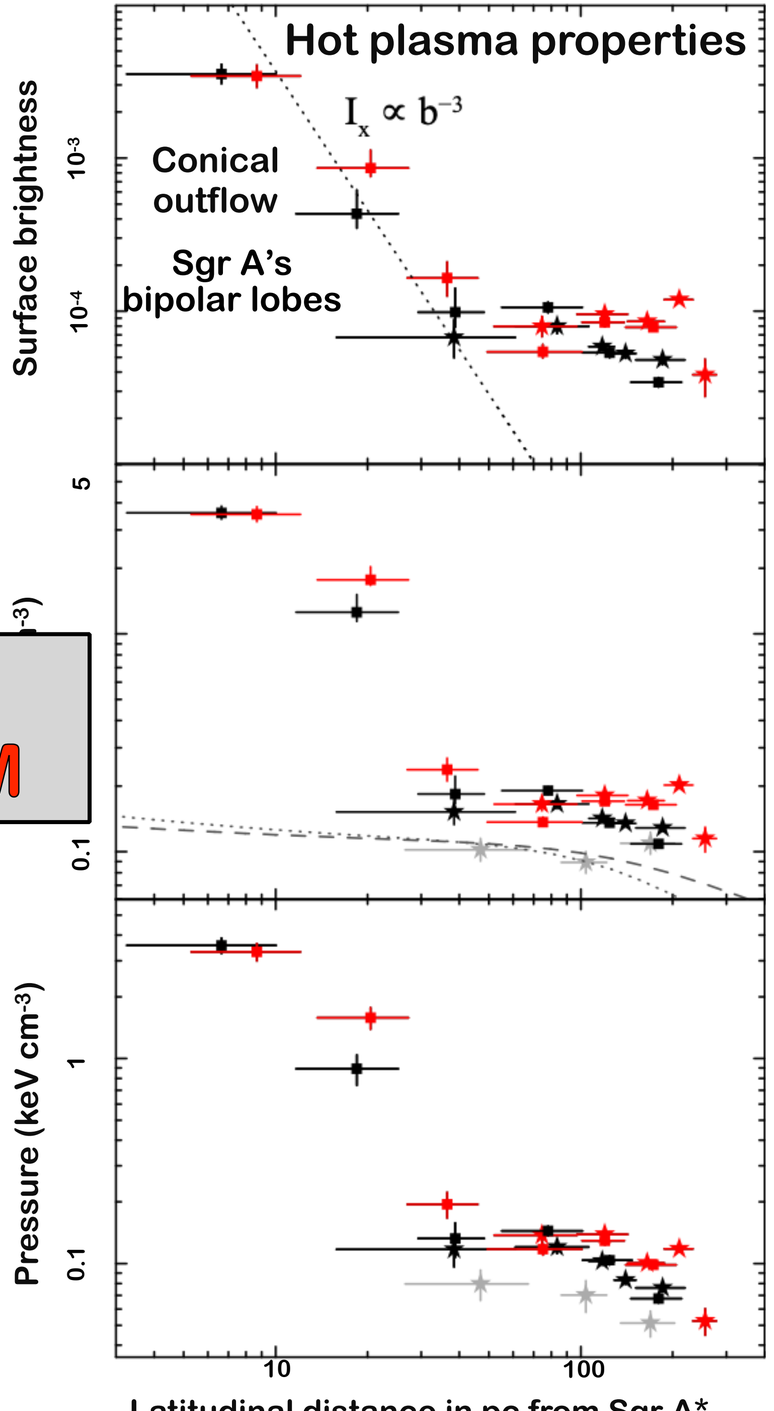




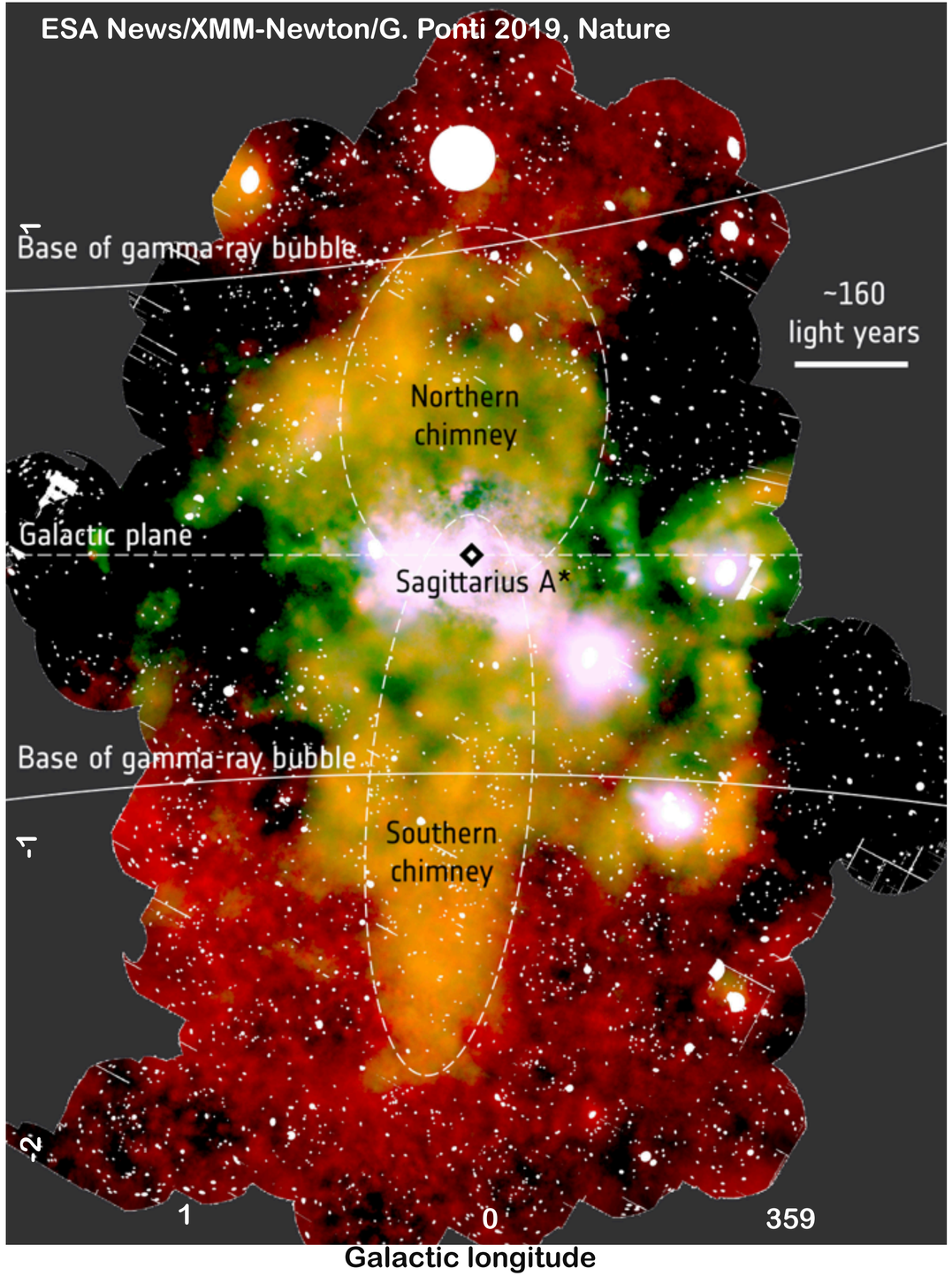
➜ Measure kT, n, p, abundances of hot plasma

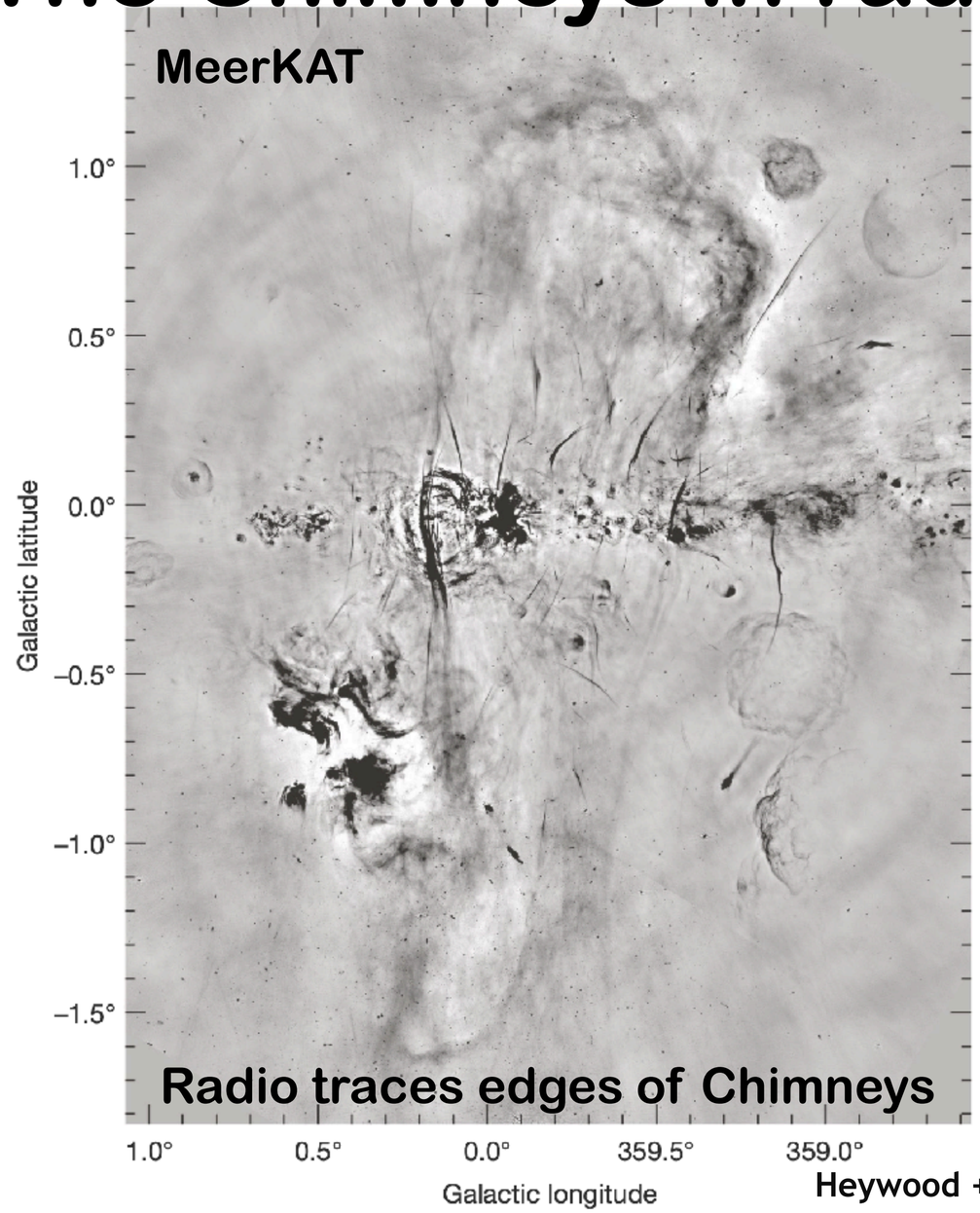


Chimneys → impact on CGM



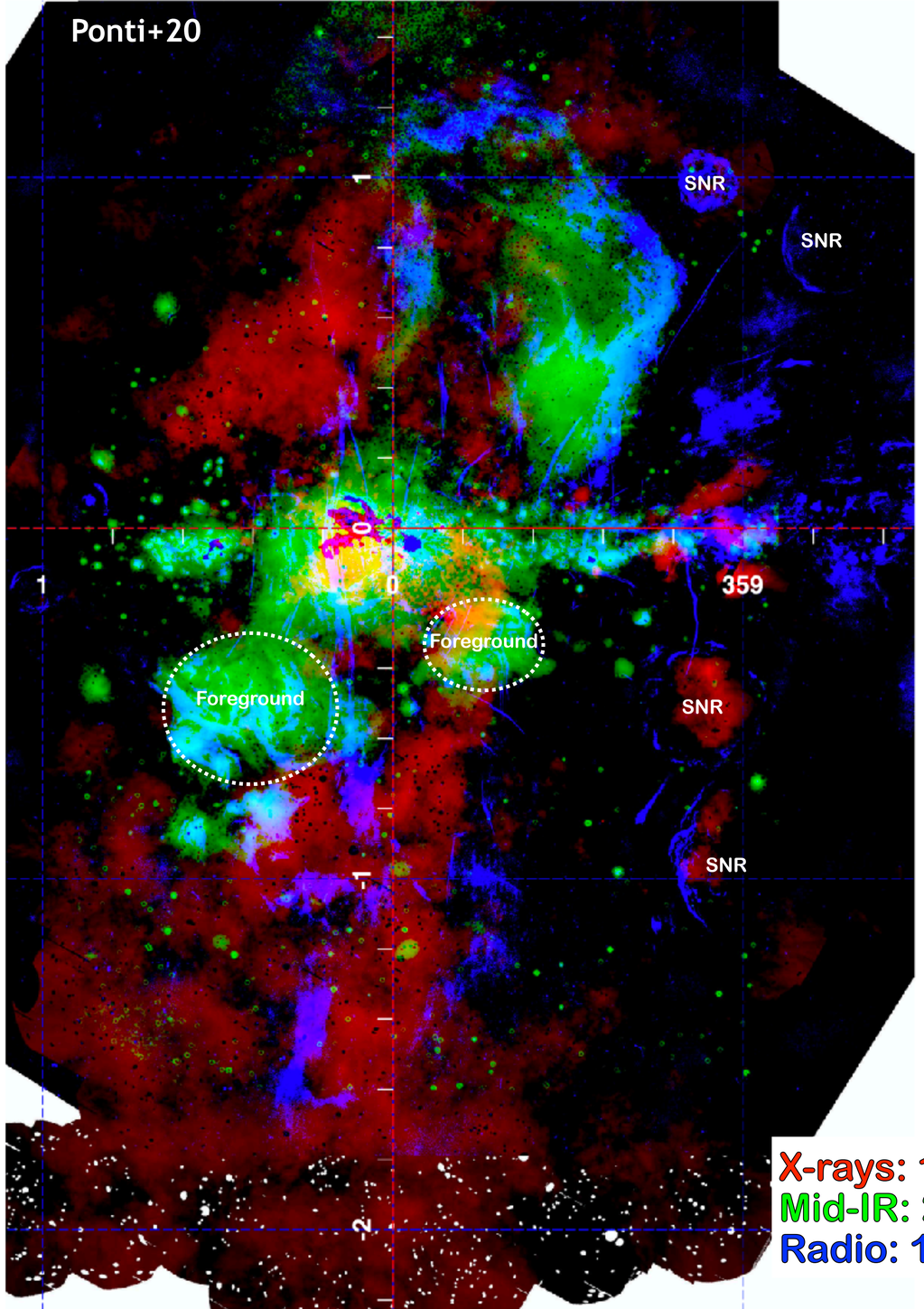
The Chimneys in radio





Heywood +19, Nature

Outflow has radio counterpart



Multi-phase multi-epoch Galactic outflow

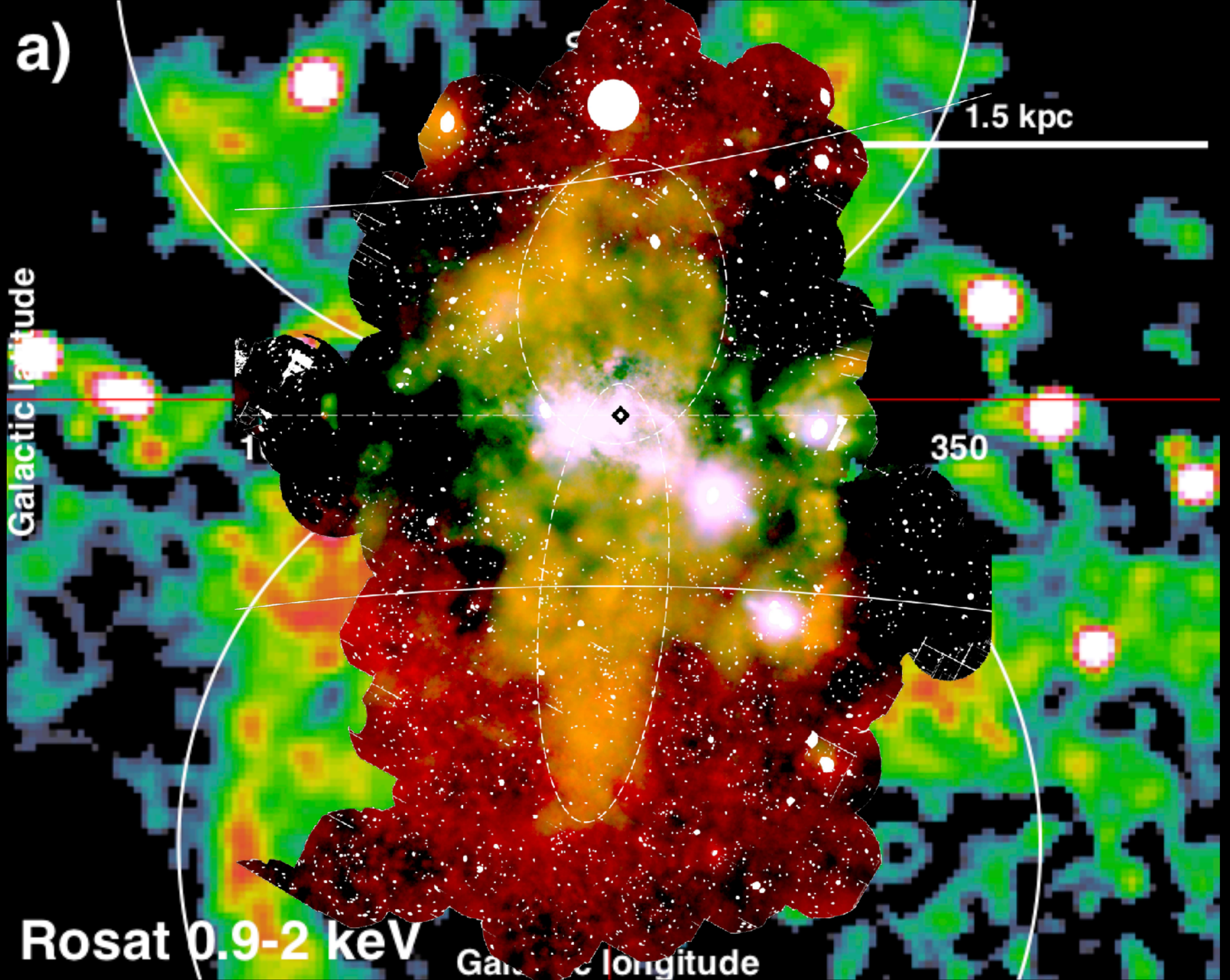
Hot plasma (X-rays)
warm dust (mid-IR)
shocks (radio)

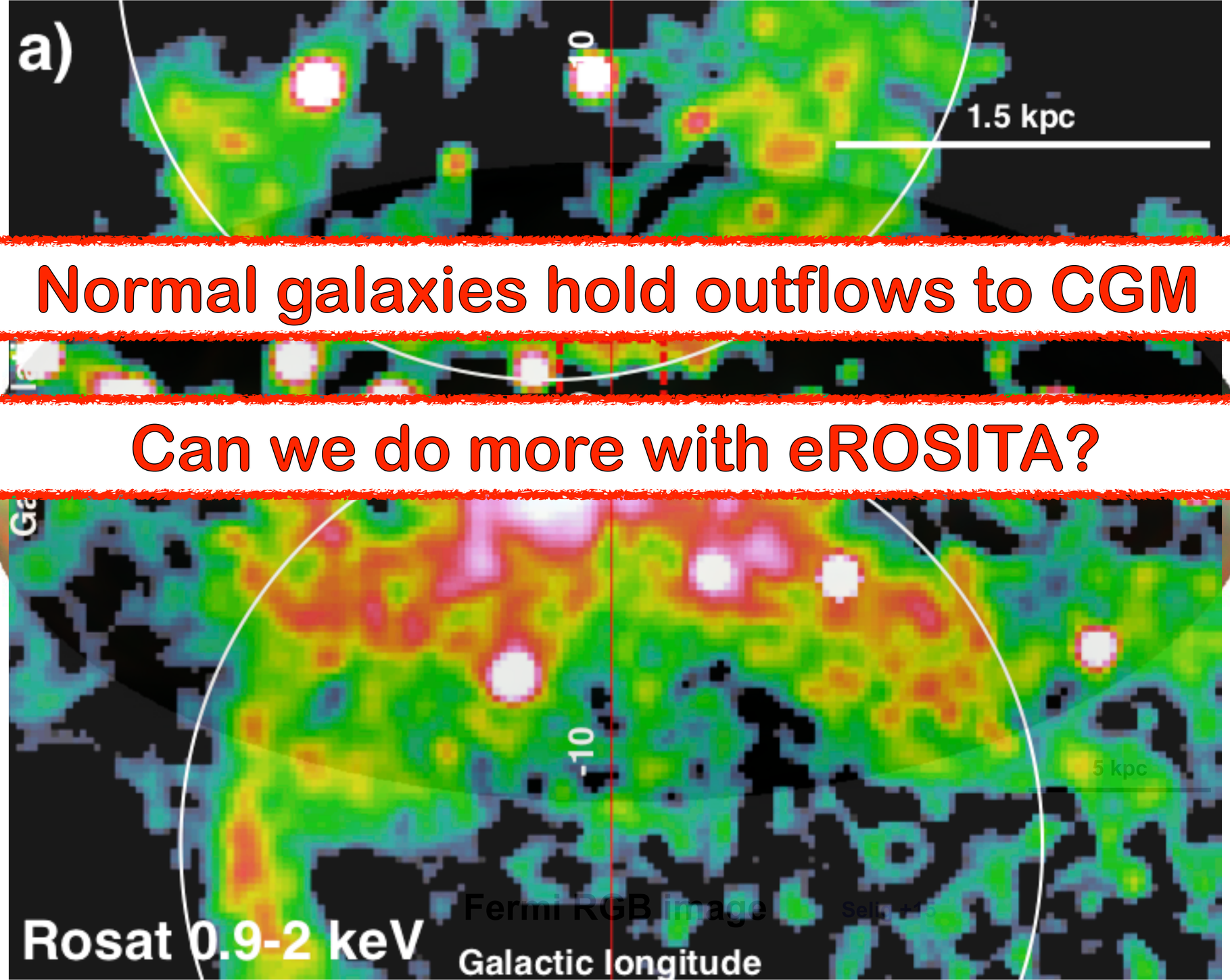
➜ Coherent features on > 10^2 pc scales

➜ Deeply interconnected and linked to the Galactic outflow

➜ Strong shocks at the chimney-ISM interface

X-rays: 1.5-2.6 keV
Mid-IR: 22.2/12.08 μm
Radio: 1.284 GHz


a)
1.5 kpc
350
Galactic latitude
Rosat 0.9-2 keV



Normal galaxies hold outflows to CGM

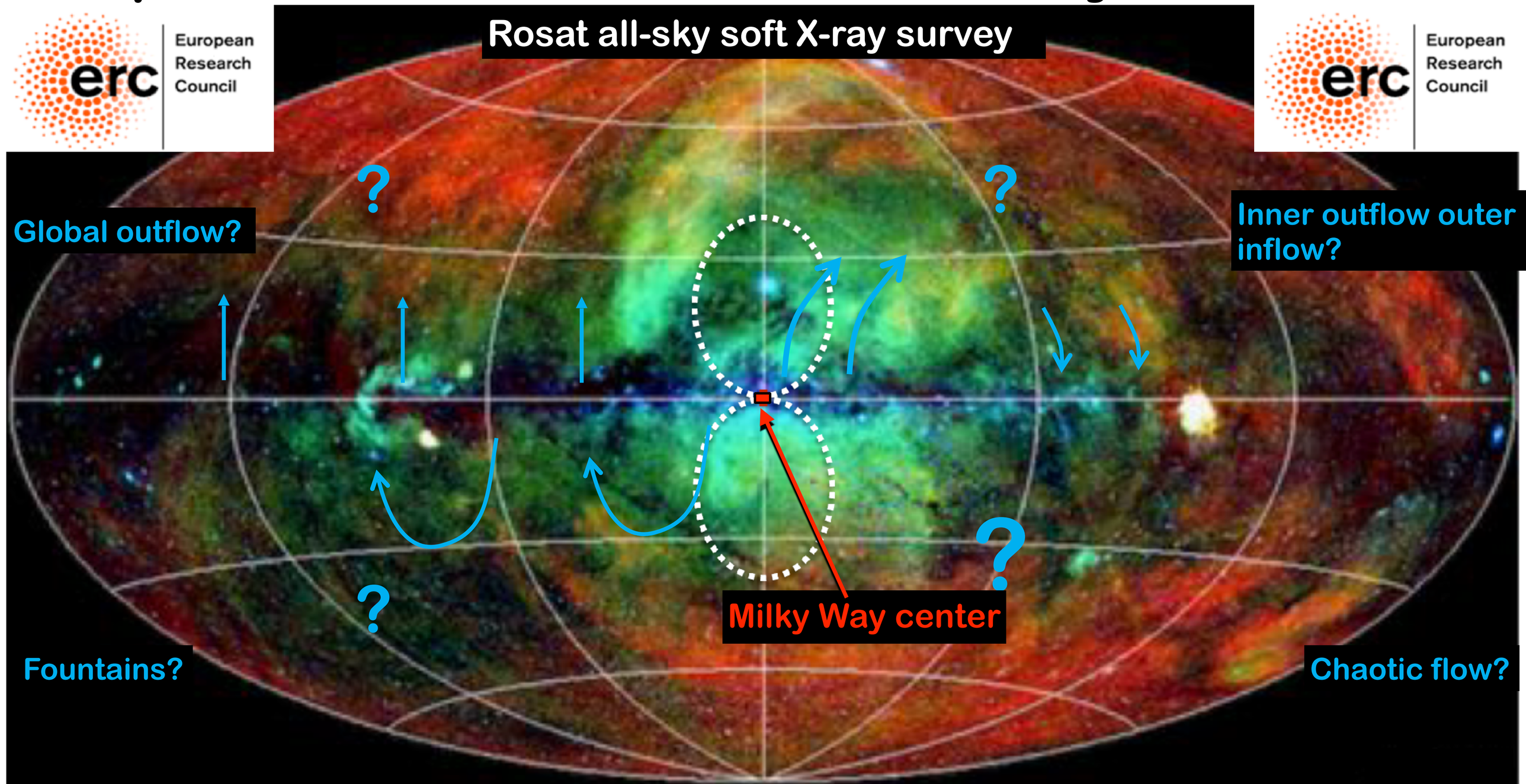
Can we do more with eROSITA?

eROSITA (Spektr-RG)'s launch

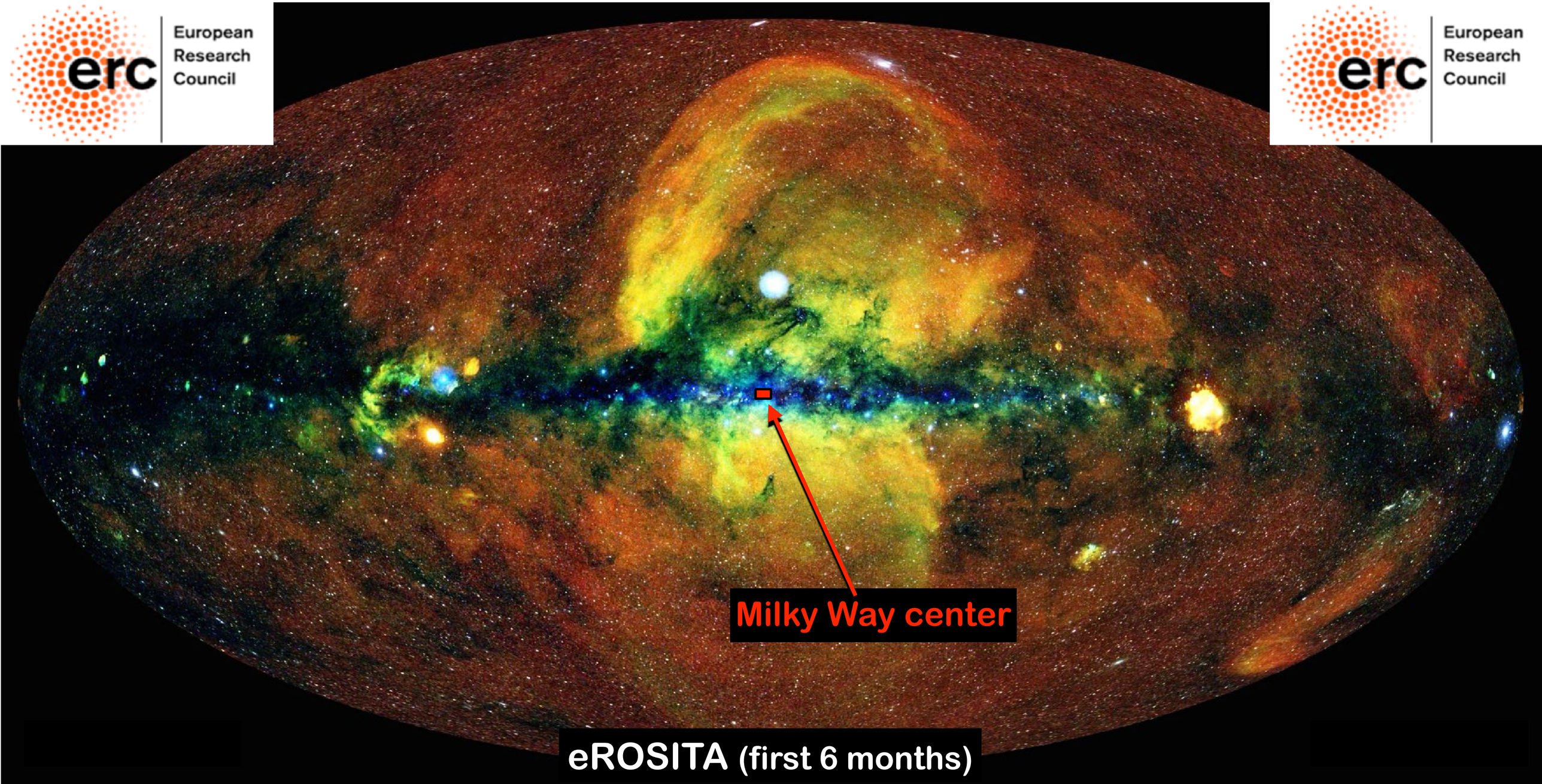
Baikonur, July 13th, 2019

Source: Roscosmos

Map the flows of hot Galactic Baryons



Map the flows of hot Galactic Baryons

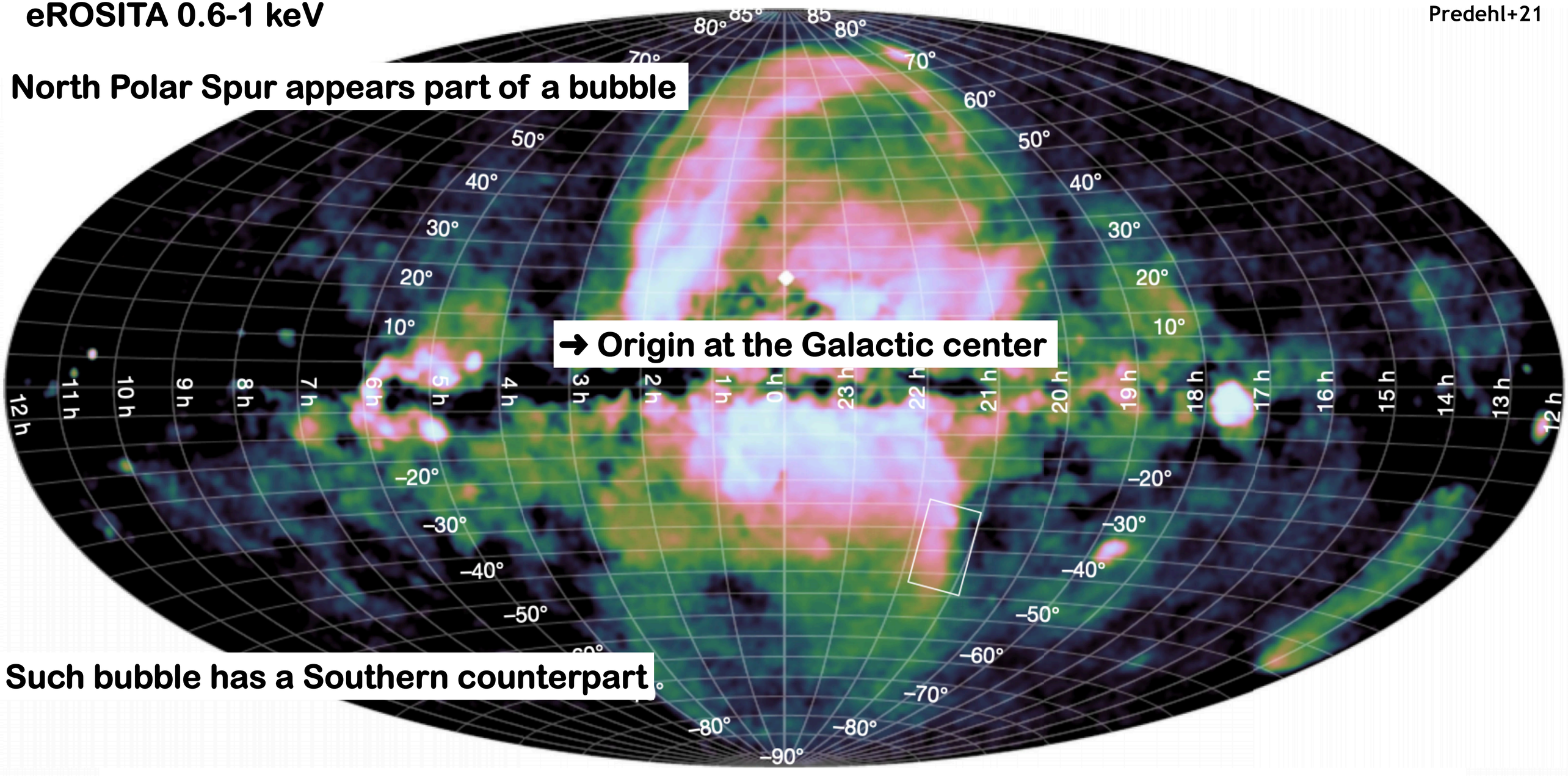


Discovery of the eROSITA bubbles!

eROSITA 0.6-1 keV

Predehl+21

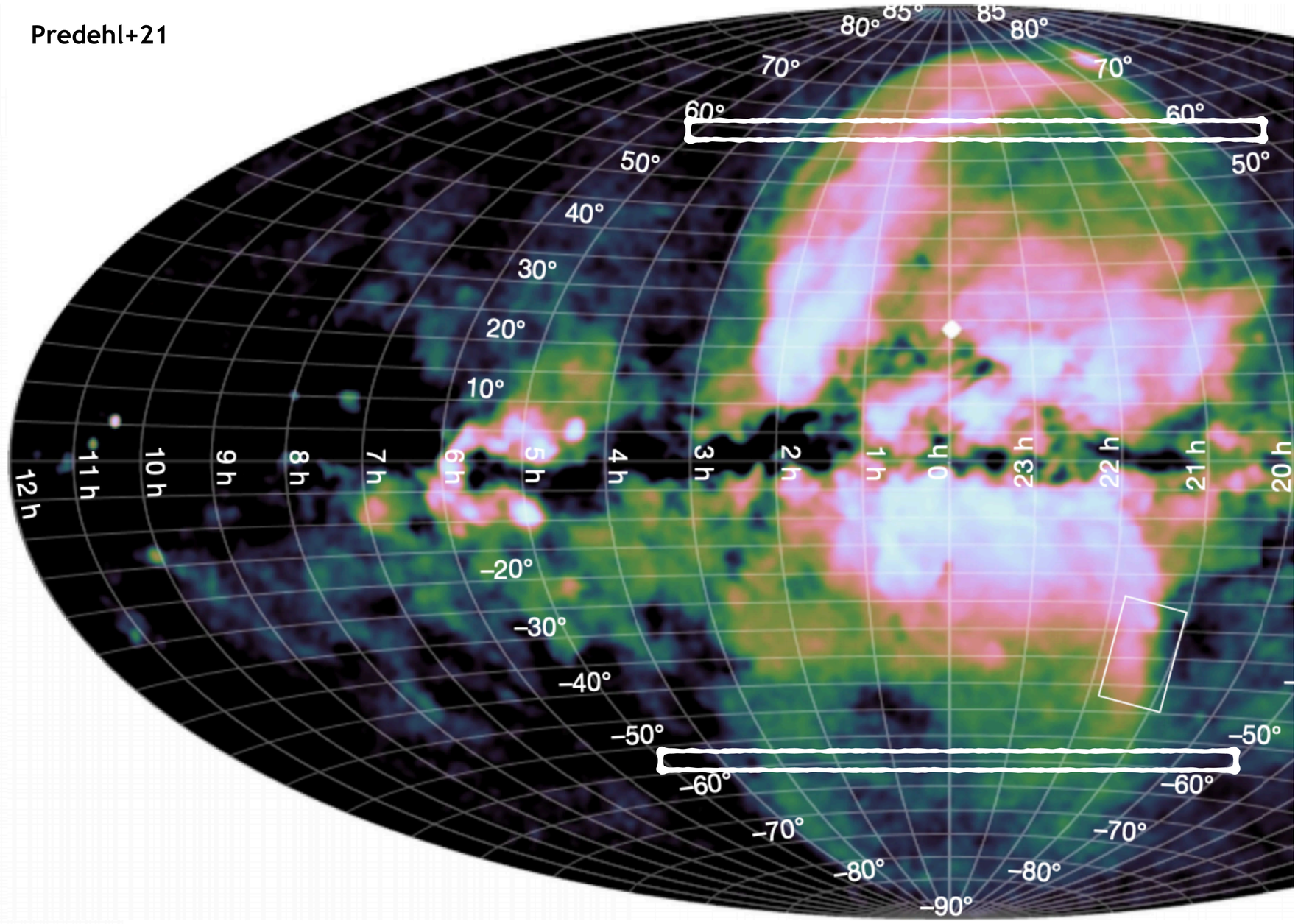
North Polar Spur appears part of a bubble

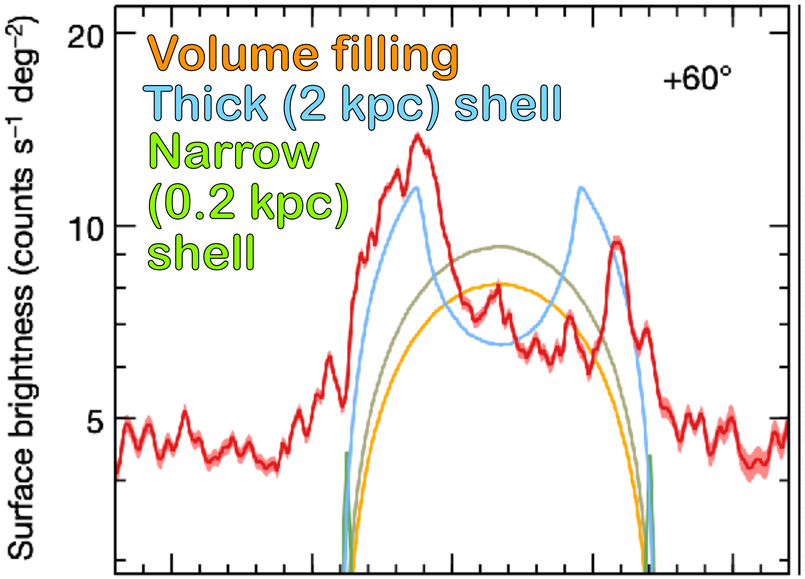


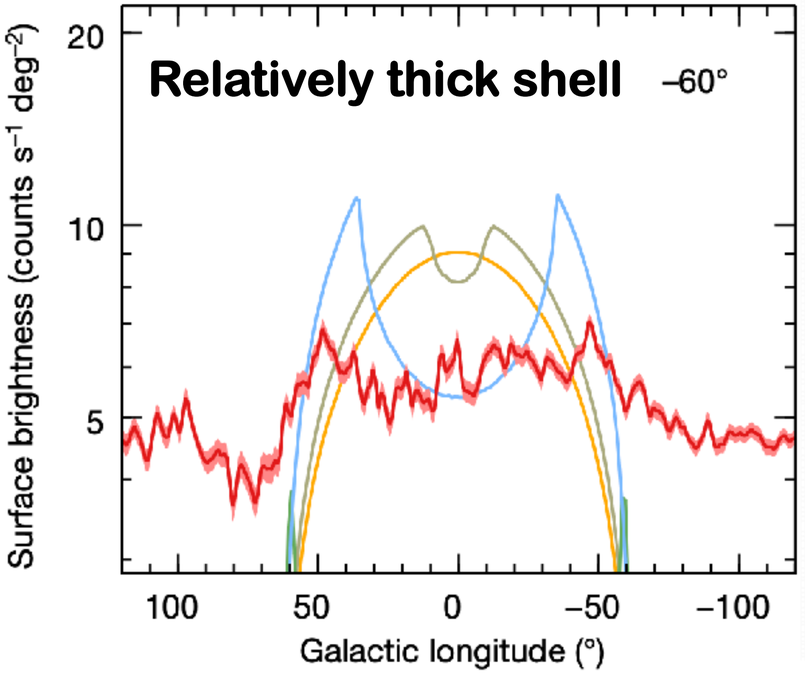
Such bubble has a Southern counterpart

Is the plasma volume filling? Shock heated?

Predehl+21



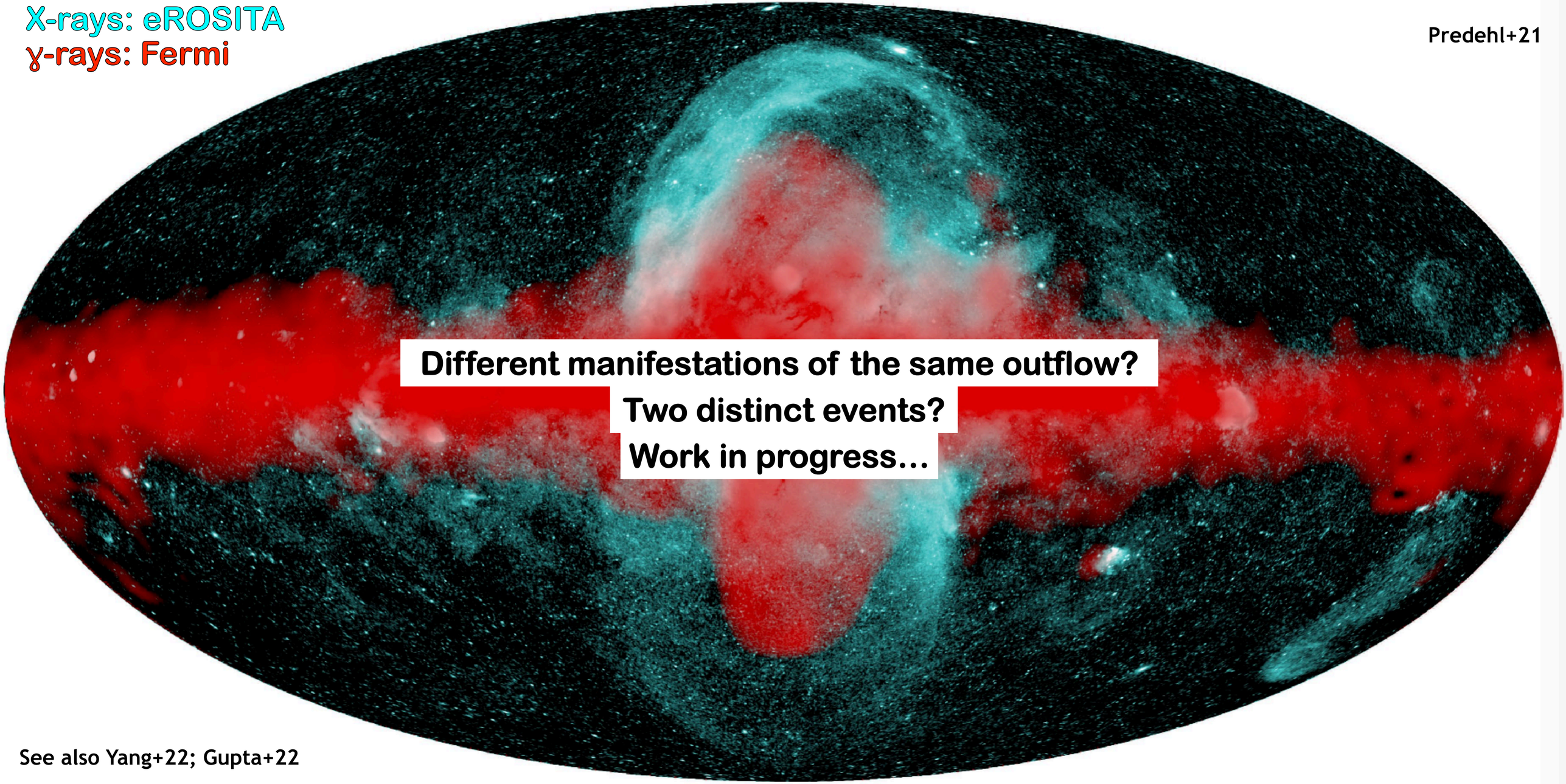




Connection between Fermi & eROSITA bubble

X-rays: eROSITA
γ-rays: Fermi

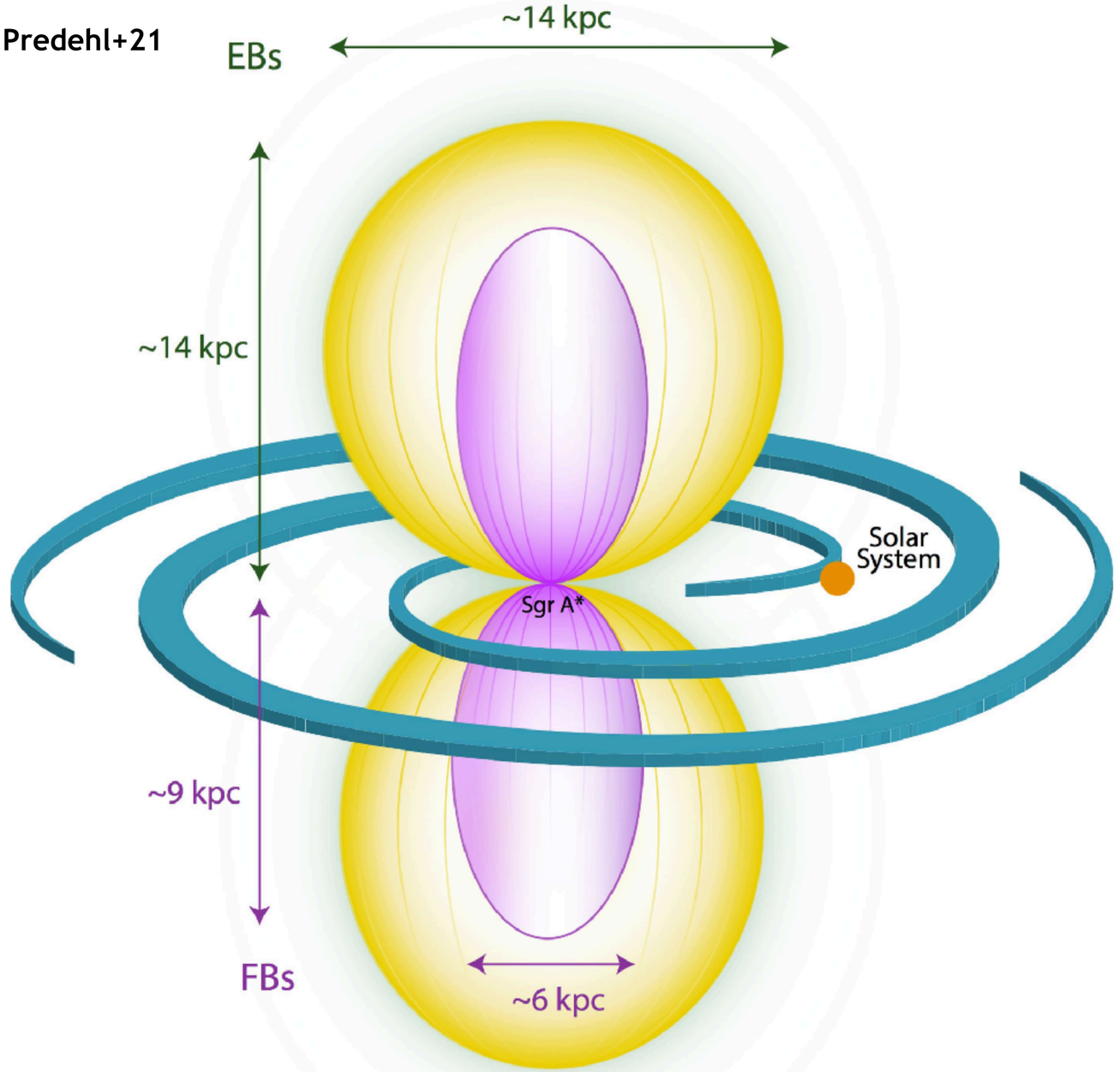
Predehl+21



See also Yang+22; Gupta+22

Properties of the eROSITA bubbles!

Predehl+21



Summary of properties

Distance:	GC ~8 kpc
Brightness:	6×10^{38} erg s^{-1}
kT:	0.3 keV
T_{cool}:	1.9×10^{8} yr
E_{Ther}:	1.3×10^{56} erg

➜ 10 times larger volume

➜ 10 times more energy than Fermi bubbles

To inflate ➜ L~10^{41} erg s^{-1} for few 10^{7} yr

➜ Strong impact on CGM!

Other traces of the outflow? Very hot plasma

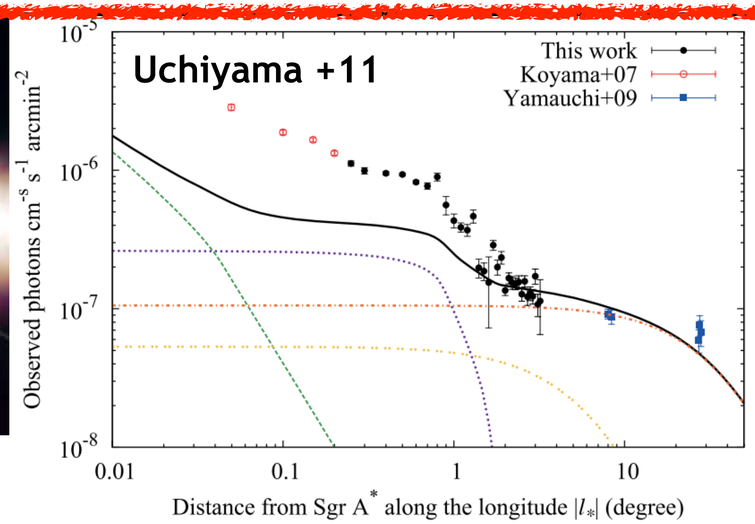
Si xiii, S xv, Ar xvii

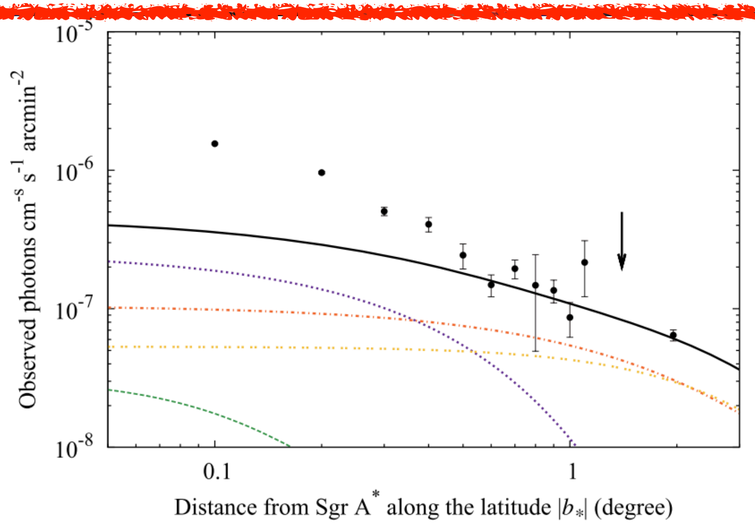
eROSITA bubbles $L \sim 10^{41}$ erg s^{-1} for few 10^7 yr

Sgr A*'s recent activity ➜ No hope…

Recent star formation:
Massive kinetic energy input ~ 1.1×10^{40} erg s^{-1}

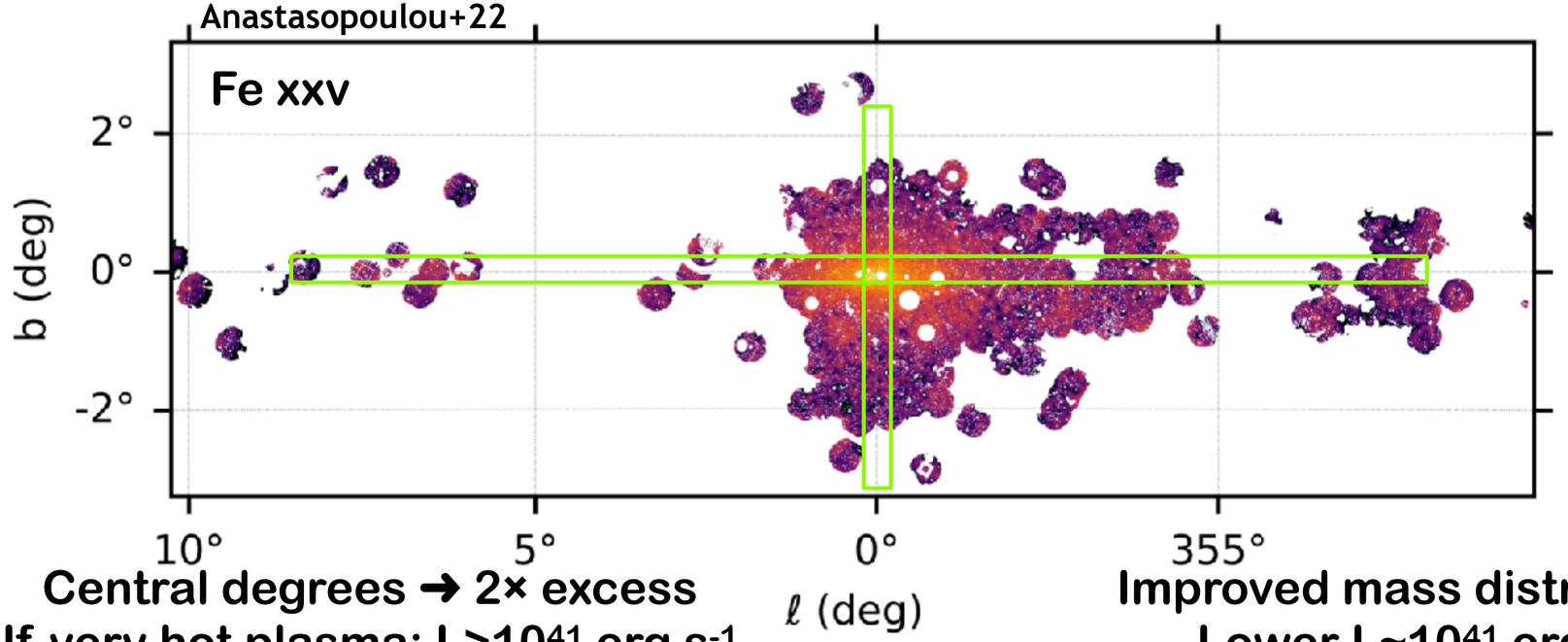
Excess of very hot plasma within central degree?
$L > 10^{41}$ erg s^{-1} Uchiyama +11





Other traces of the outflow? Very hot plasma

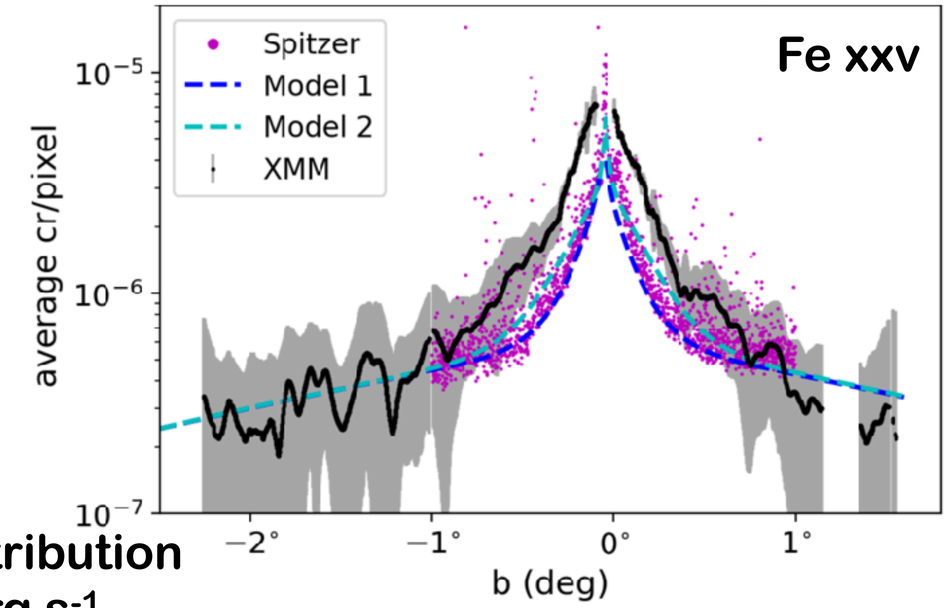
Anastasopoulou+22



Central degrees ➜ 2× excess

If very hot plasma: L>10^{41} erg s^{-1}

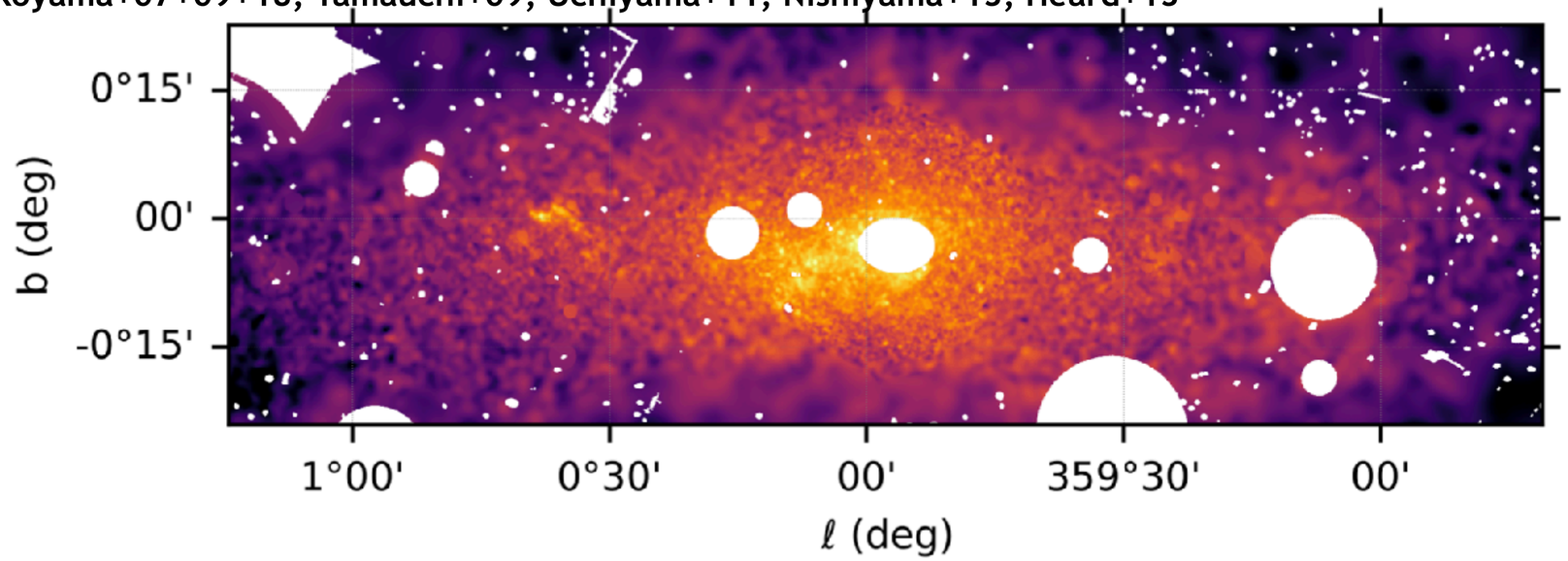
Anastasopoulou+22

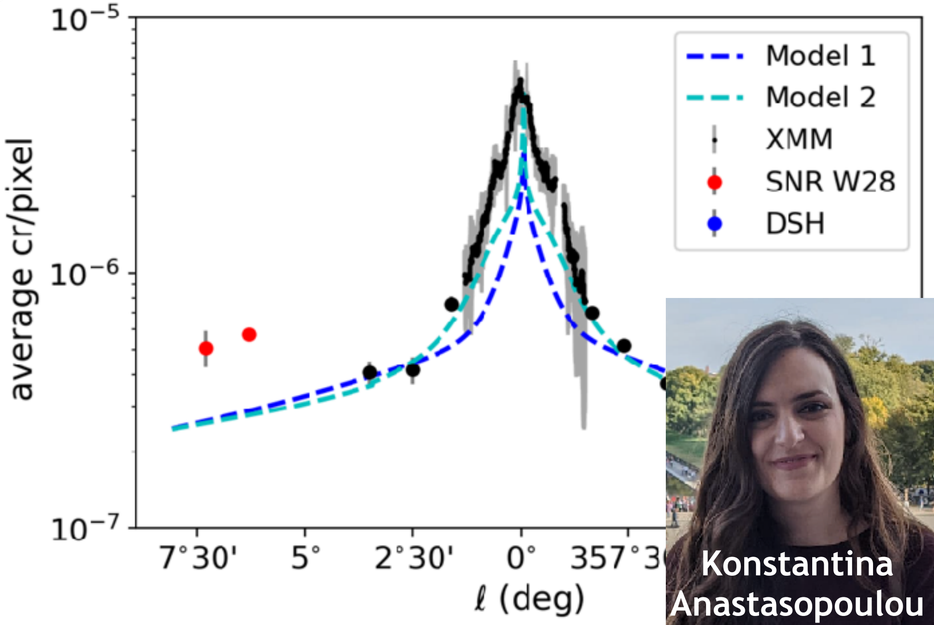


Improved mass distribution

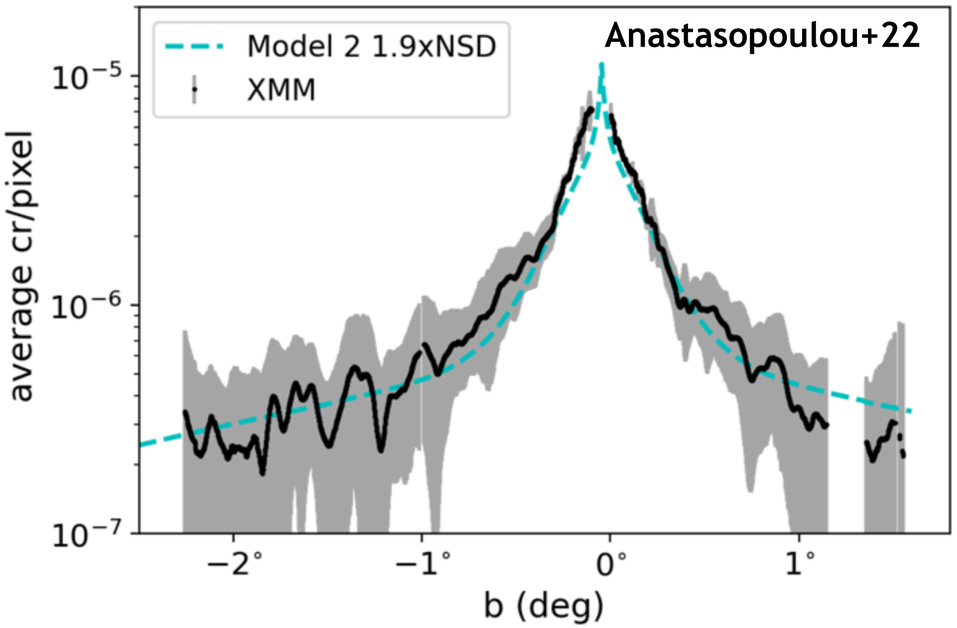
Lower L~10^{41} erg s^{-1}

Koyama+07+09+18; Yamauchi+09; Uchiyama+11; Nishiyama+13; Heard+13

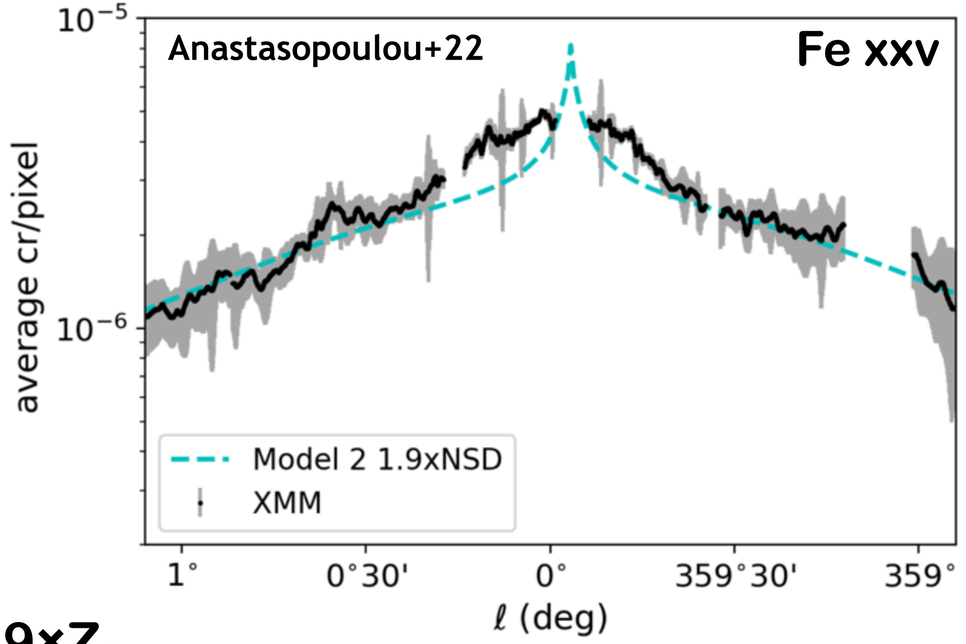


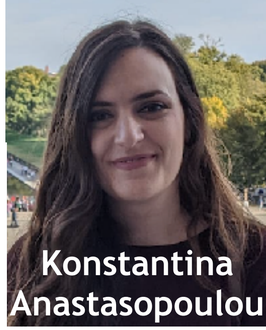


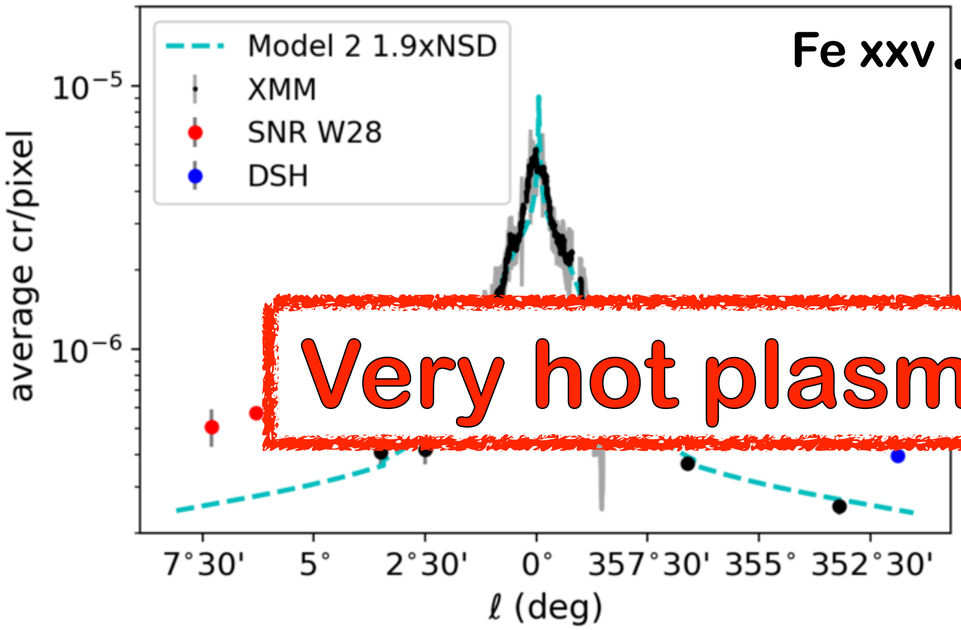
Almost no excess if $Z_{Fe} = 1.9 \times Z_{\odot}$



Fe xxv profile similar to scaled up mass profile



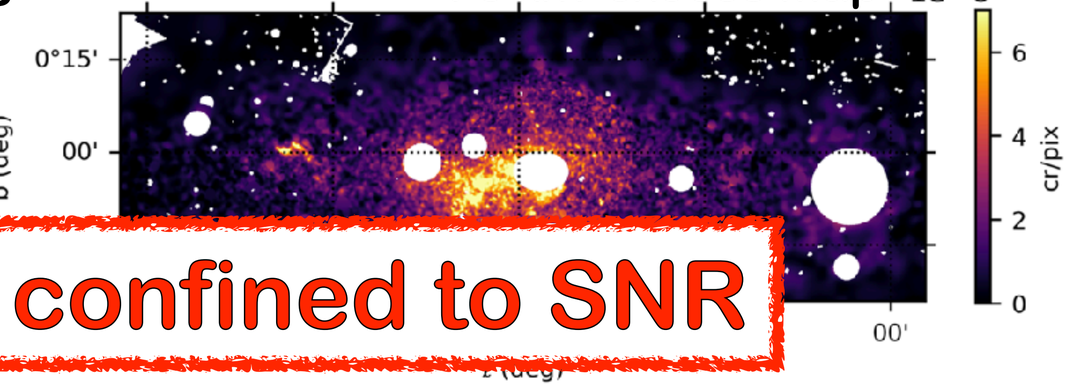




For $Z_{Fe} = 1.9 \times Z_{\odot}$
➜ L~few×10^{40} erg s^{-1}

➜ Not enough for eROSITA bubbles!

Fe xxv excess map



Very hot plasma at the GC confined to SNR

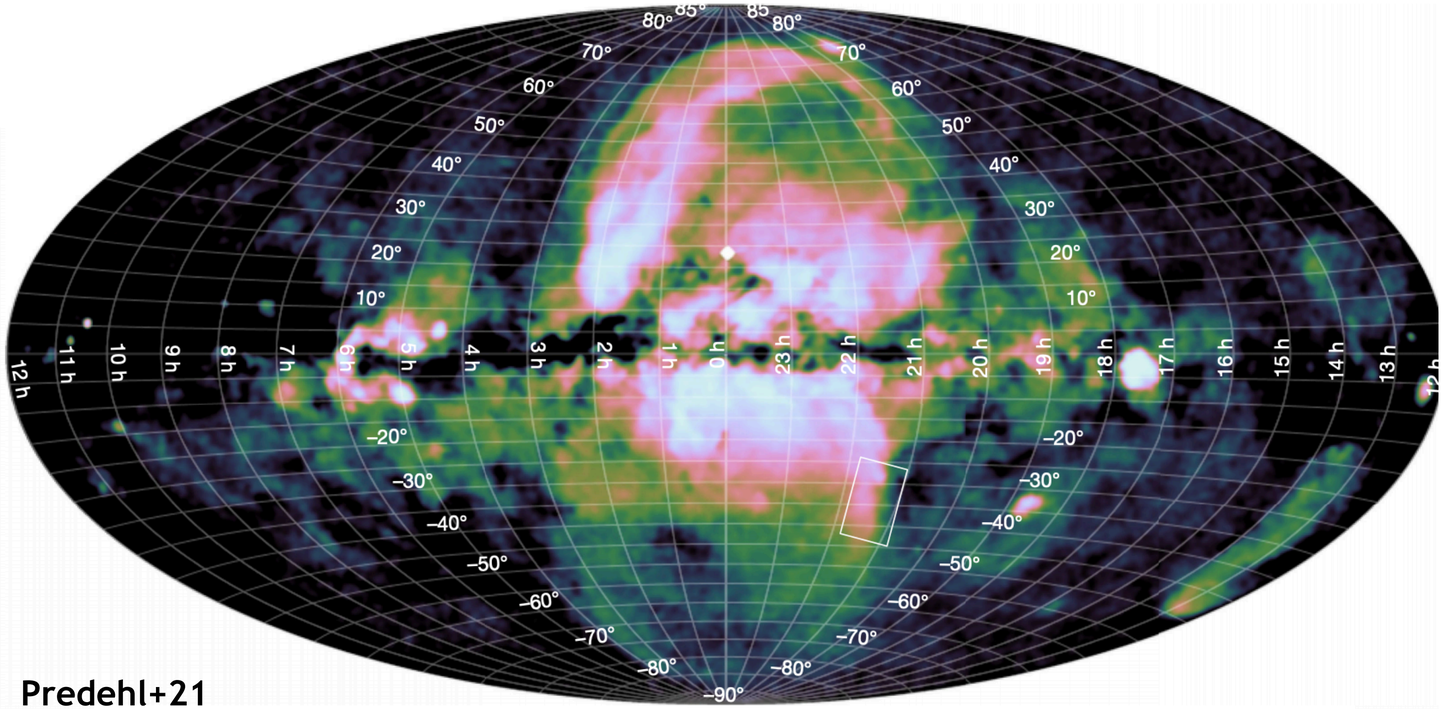
Very hot plasma ➜ known SNR

Are eROSITA bubbles common in galaxies?

Pillepich+21

Milky Way galaxies in TNG (cosmological) simulations

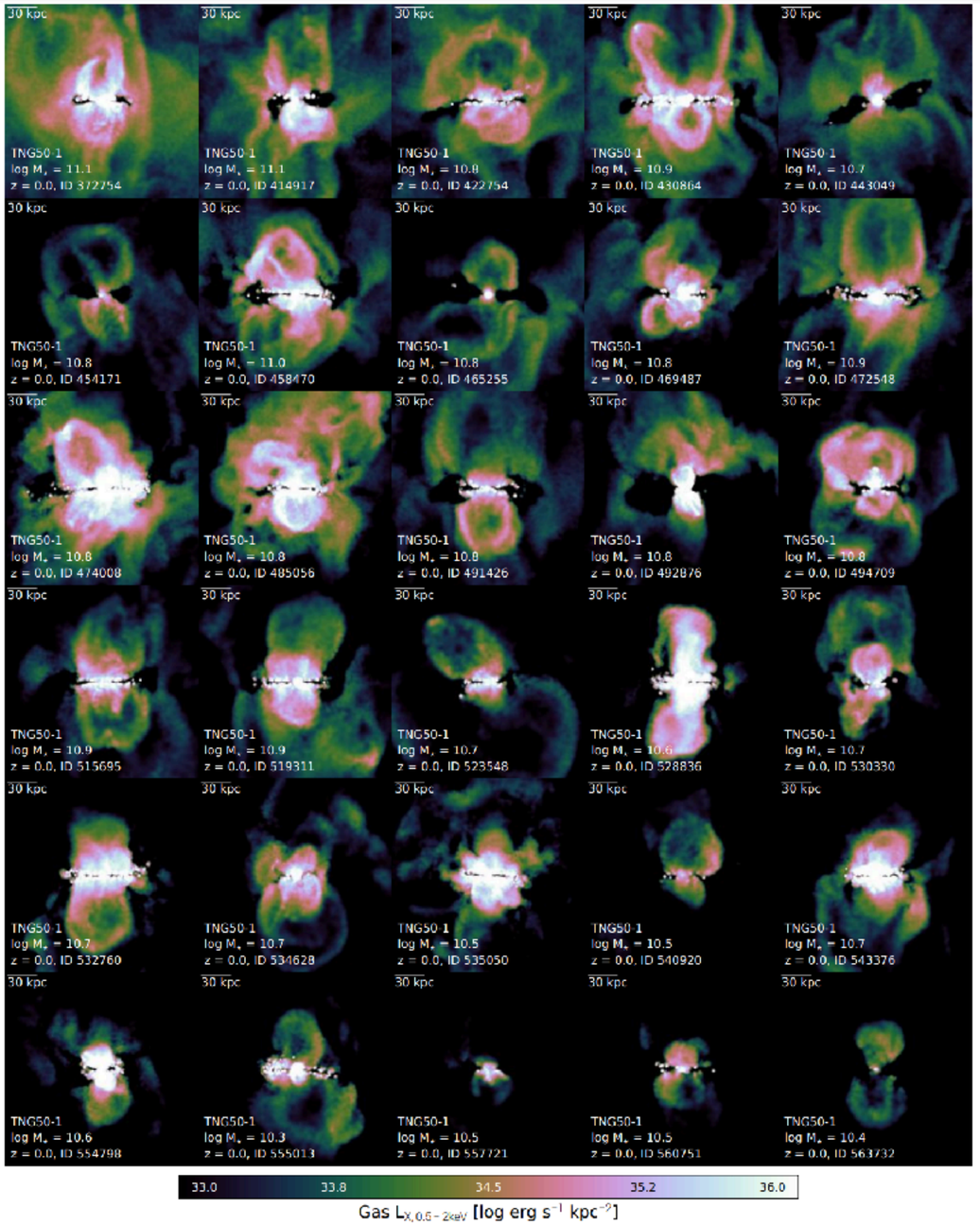
➜ Most galaxies posses X-ray bubbles



Predehl+21

eROSITA bubbles

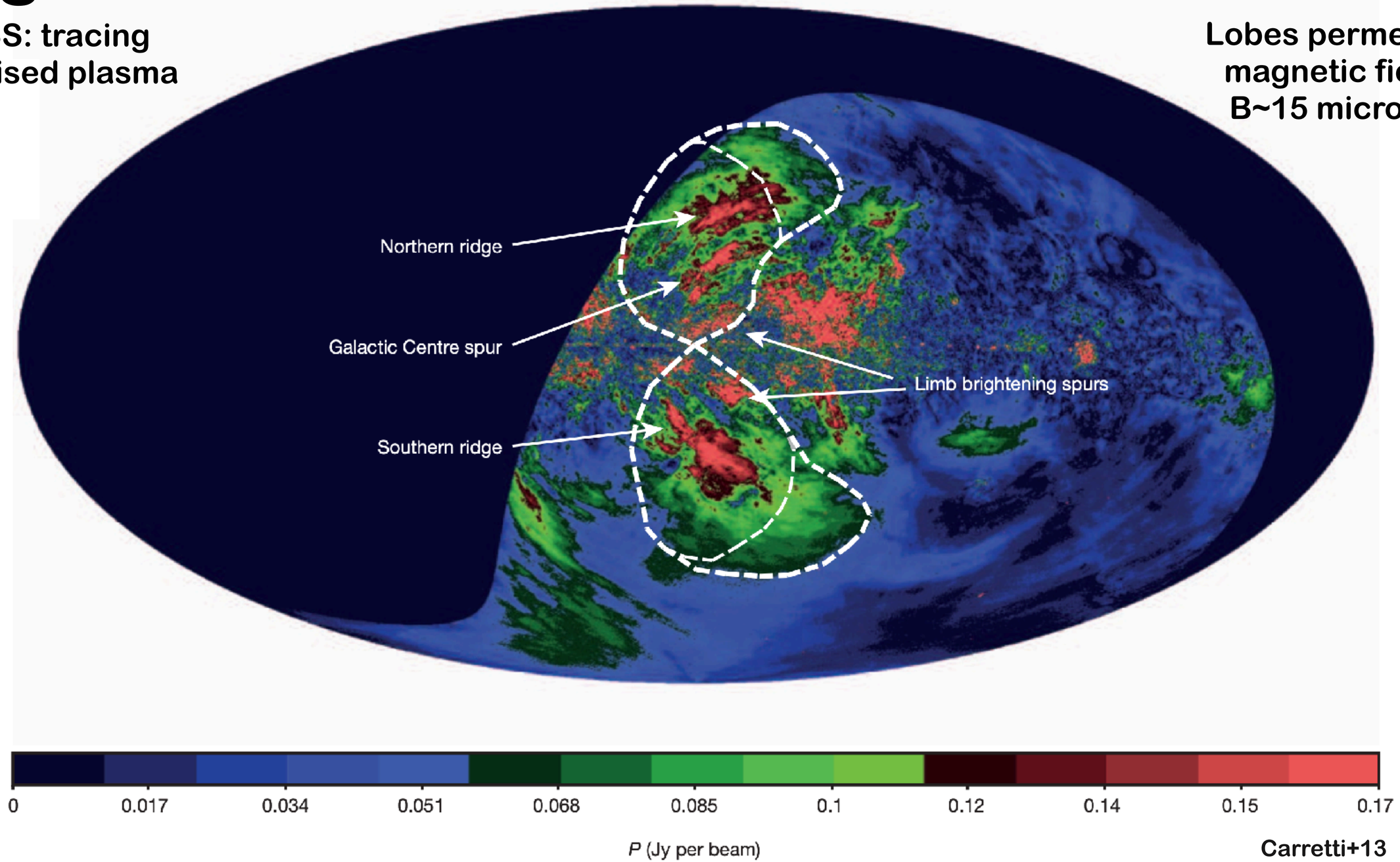
Prediction: eROSITA bubbles
➜ common in galaxies!



Magnetised outflow from the Galactic center

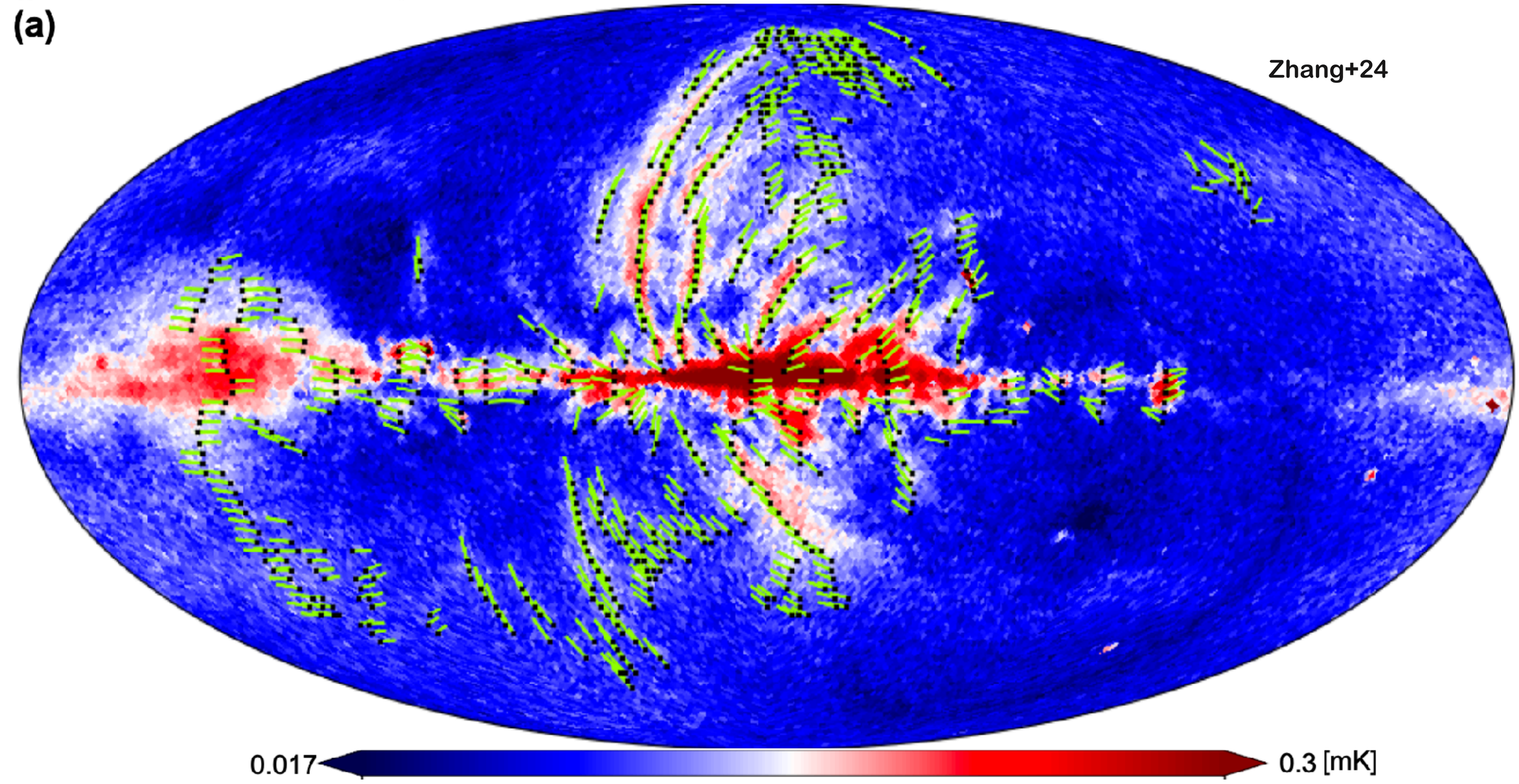
S-PASS: tracing magnetised plasma

Lobes permeated by magnetic fields of B~15 microgauss



Carretti+13

Magnetised spurs emerging from the disc



Polarised synchrotron intensity from WMAP (22.8 GHz)

Magnetic field direction from polarised synchrotron

The non-thermal component of the outflow

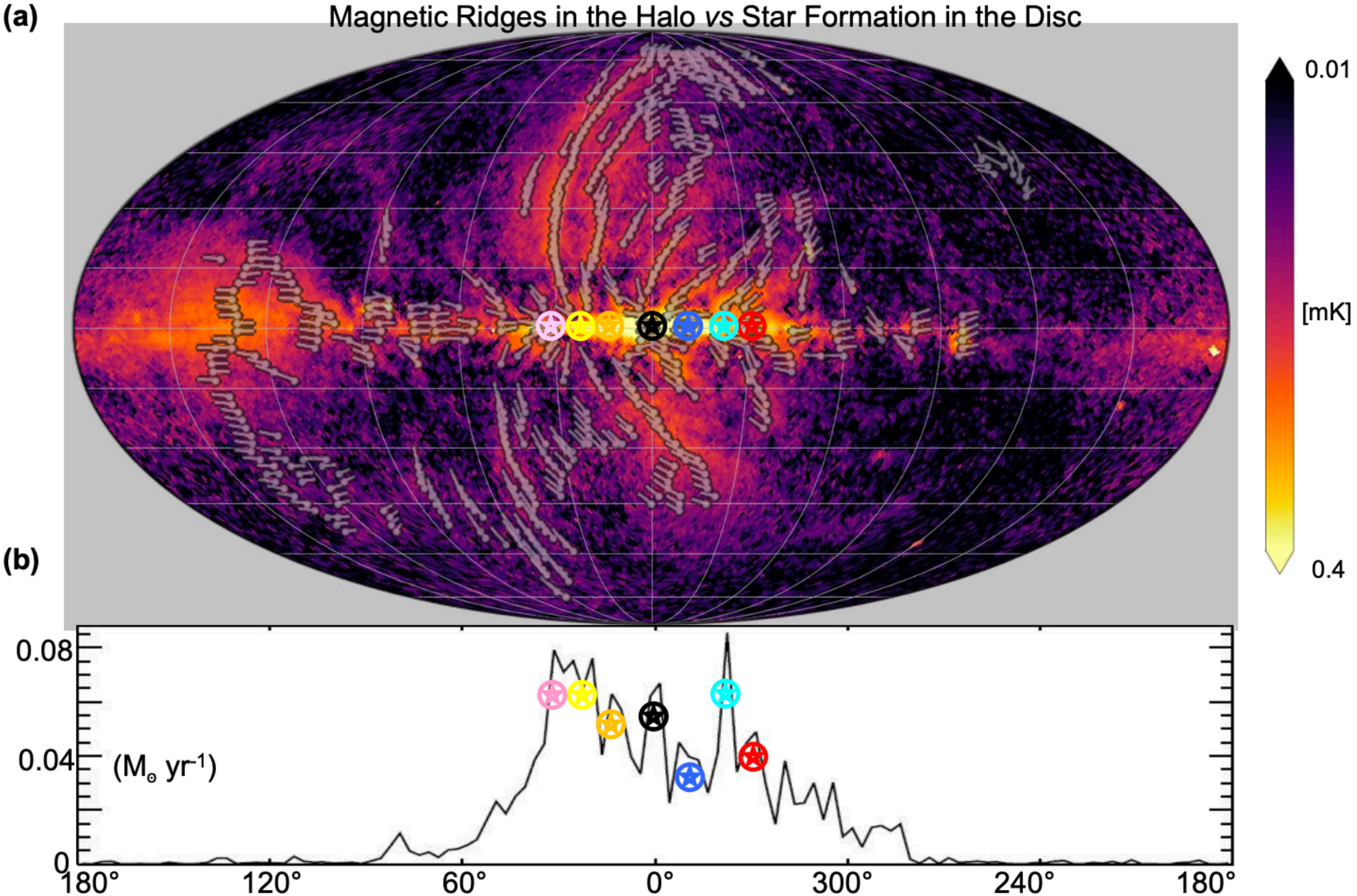
Polarised synchrotron intensity: WMAP 22.8 GHz
X-rays: eROSITA 0.6-1 keV
Magnetic field direction

Zhang+24

Galactic outflow ➜ shaping the magnetic halo

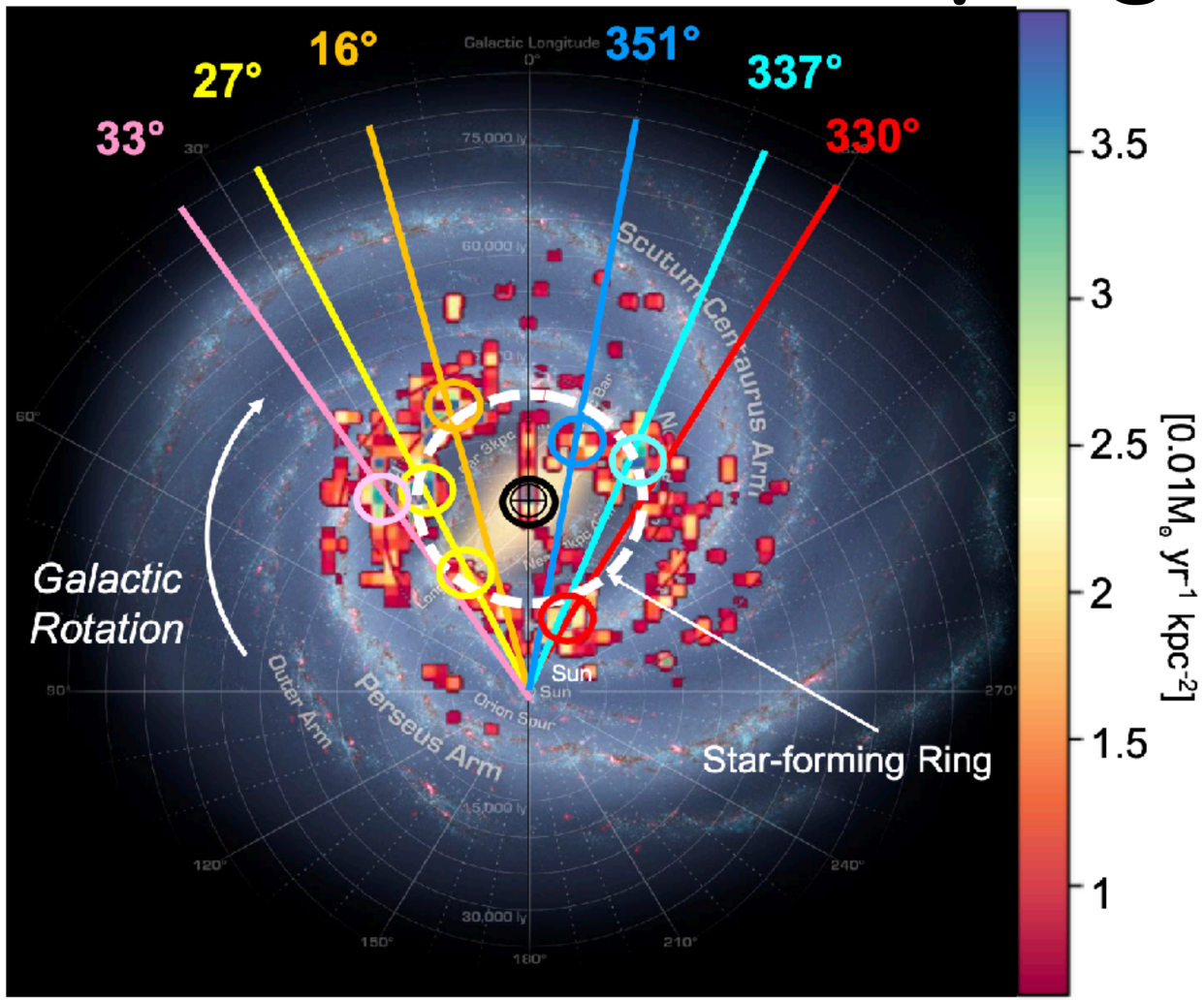
Outflow associated with star forming ring

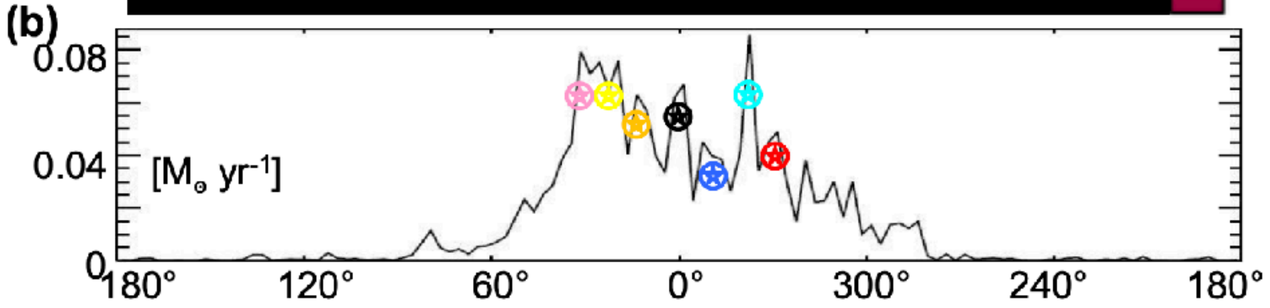
Zhang+24



The Galactic outflow plugs on star forming ring

Zhang+24





Hershel: 3-D map of star formation rate

Elia +22

Clumps with SFR > 0.02 $M_\odot$ yr^{-1} kpc^{-2}
(able to launch galactic super winds)

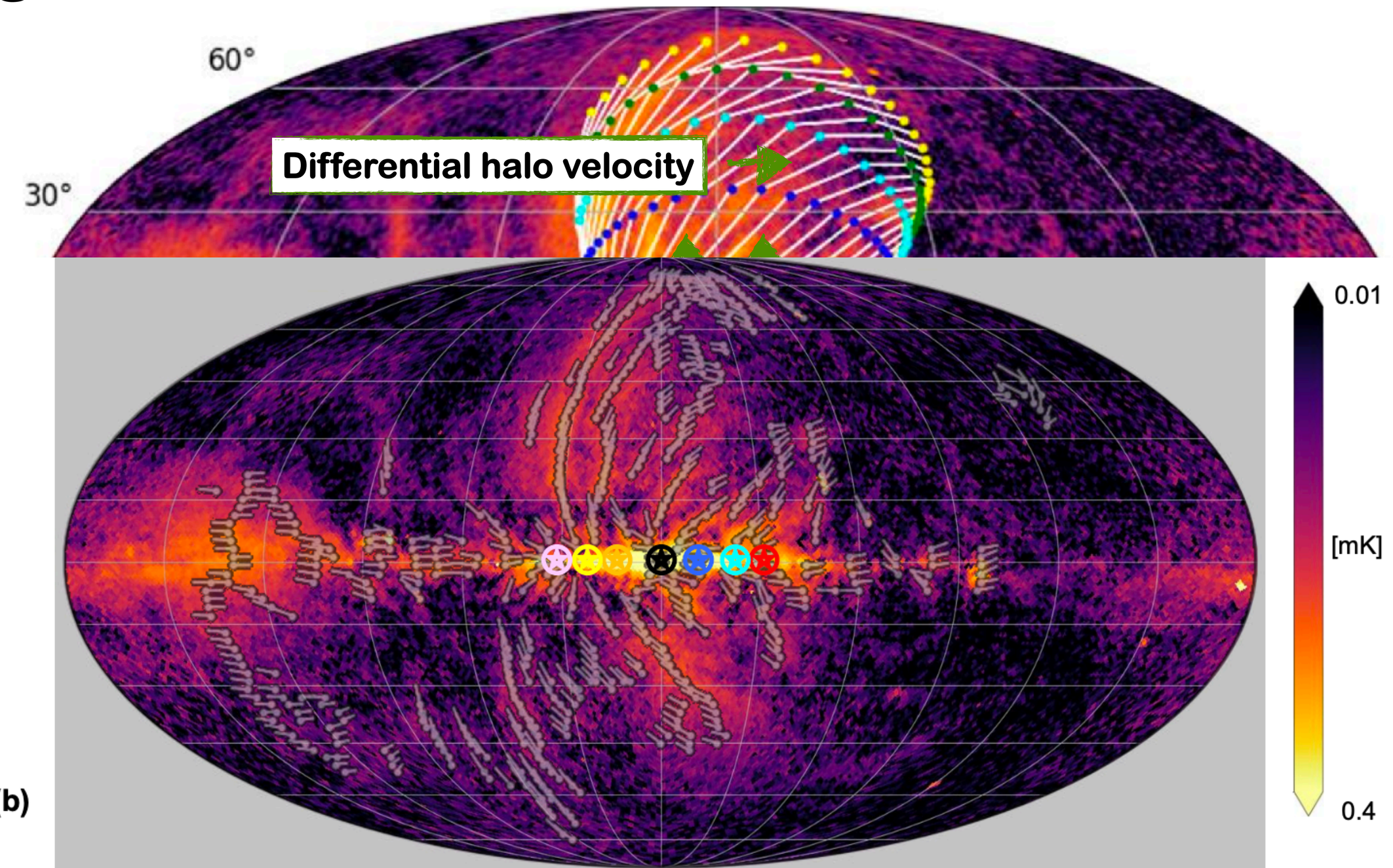
Feet of magnetic spurs ➜ star forming clumps

SFR_{Ring} ~ 1 $M_\odot$ yr^{-1} (SFR_{CMZ} ~ 0.1 $M_\odot$ yr^{-1})

3 kpc star forming ring ➜ contribution to Galactic outflow

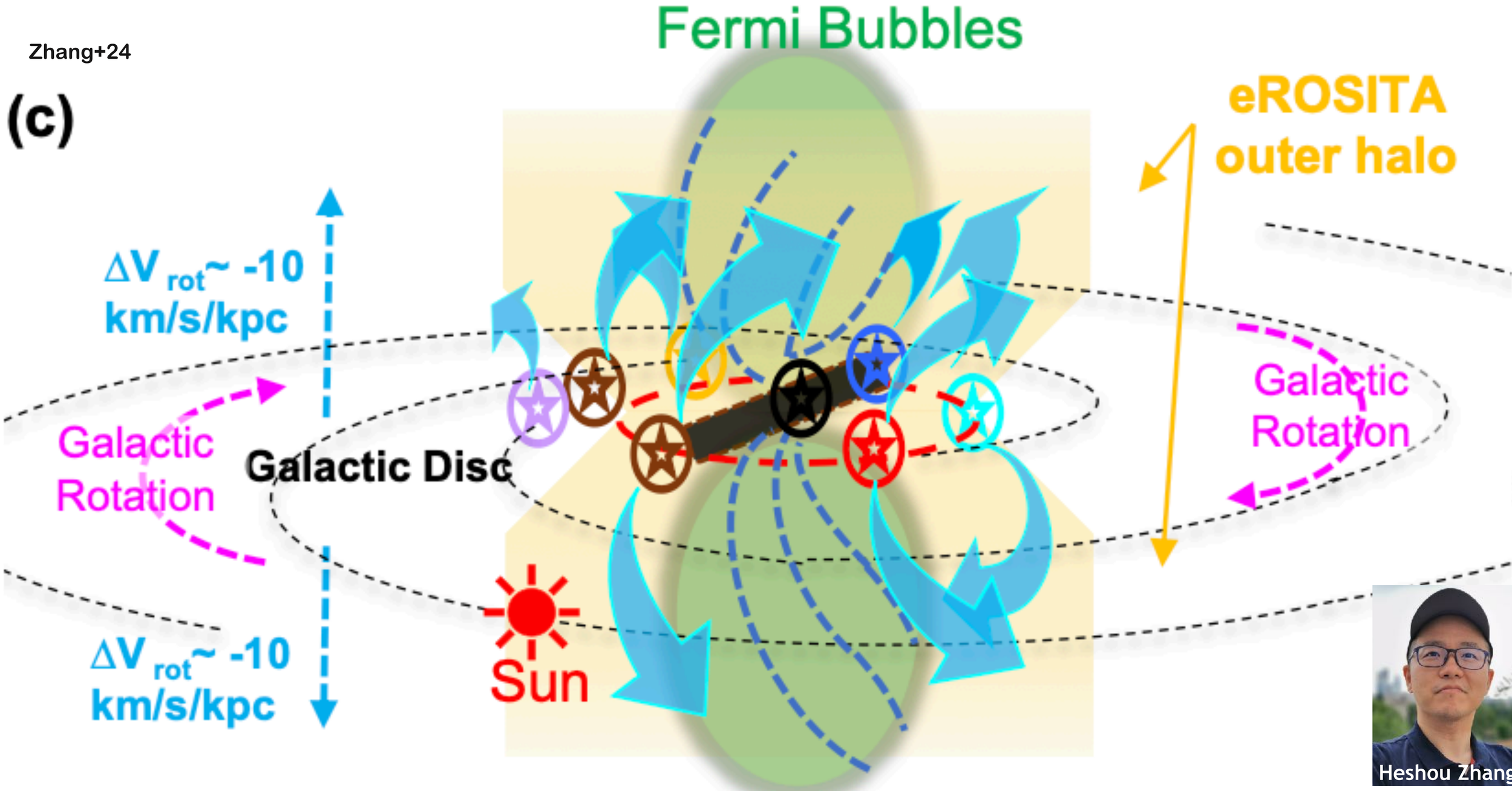
Magnetic field line feel halo differential rotation

Zhang+24



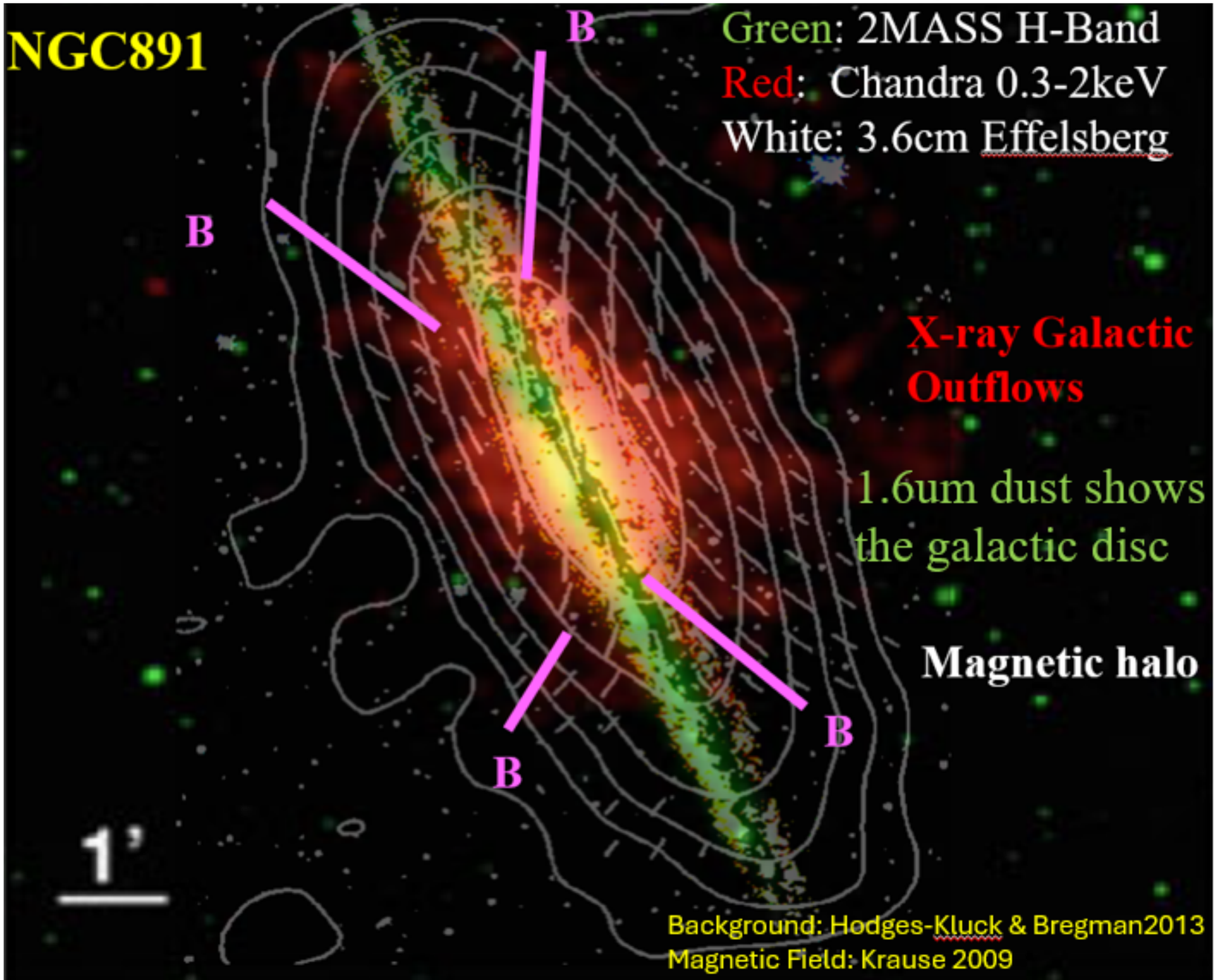
An updated picture of the Galactic outflow

Zhang+24

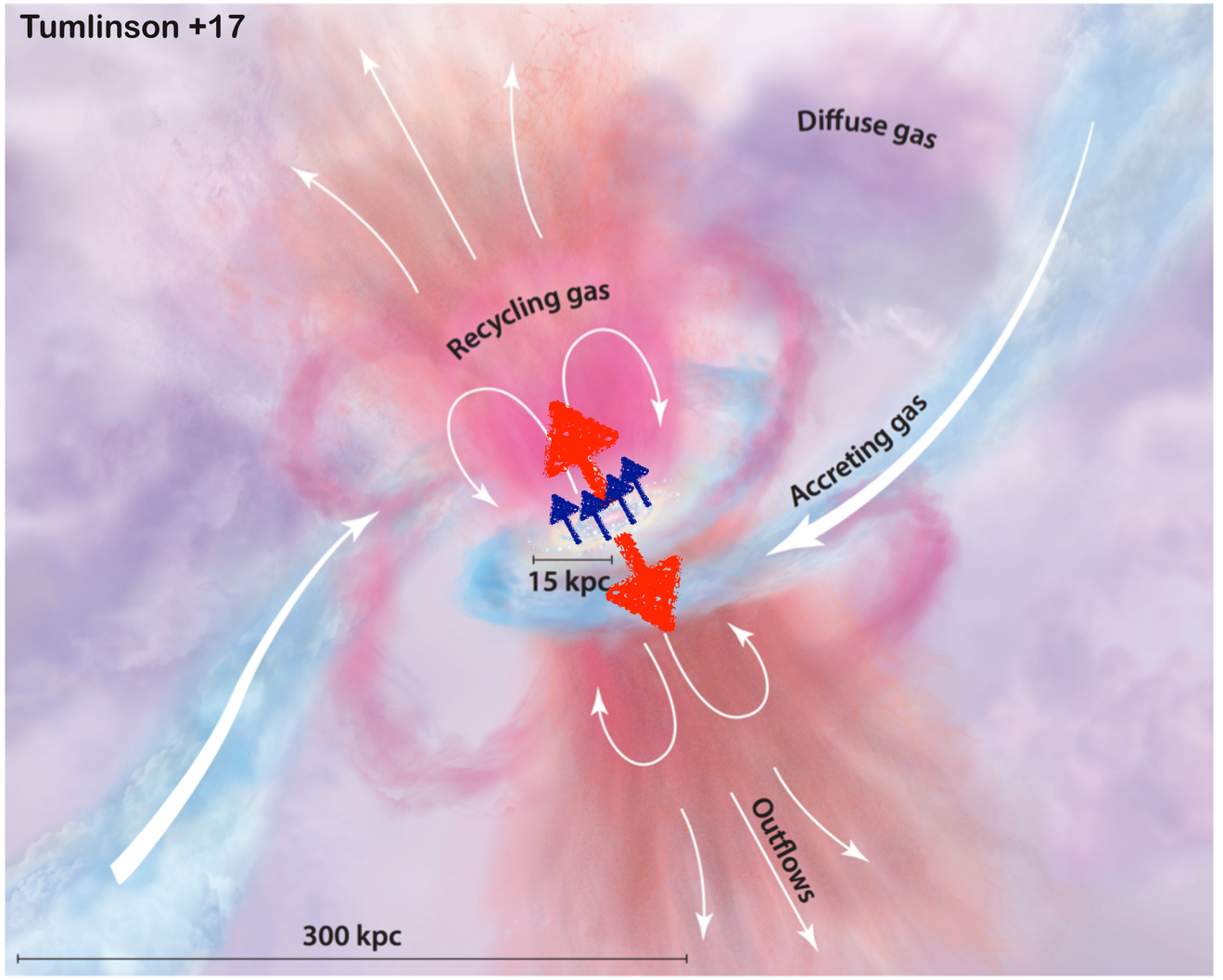


Magnetic halos are common in galaxies

Zhang+24



The Milky Way has a powerful outflow!

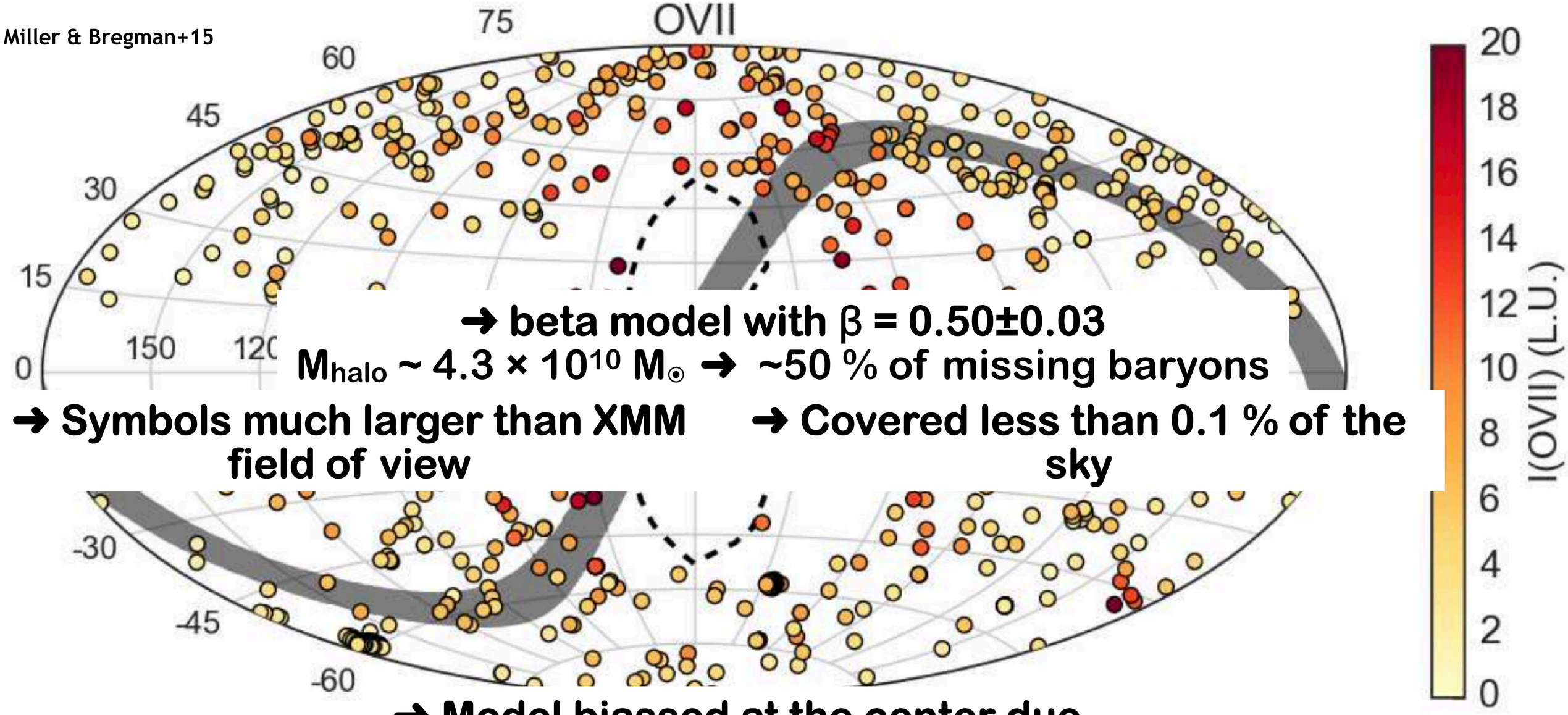


Does the Milky Way host a hot CGM?

The view before eROSITA…

All XMM archive to study the Milky Way CGM

Miller & Bregman+15



➜ beta model with $\beta = 0.50 \pm 0.03$

$M_{halo} \sim 4.3 \times 10^{10}\ M_{\odot}$ ➜ ~50 % of missing baryons

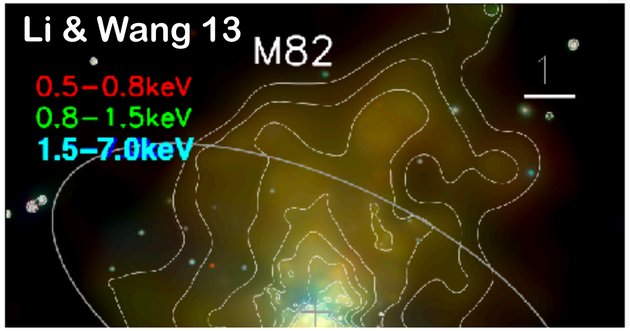
➜ Symbols much larger than XMM field of view

➜ Covered less than 0.1 % of the sky

➜ Model biassed at the center due to the eROSITA bubbles

Miller & Bregman+15

Chandra survey of edge-on spiral galaxies

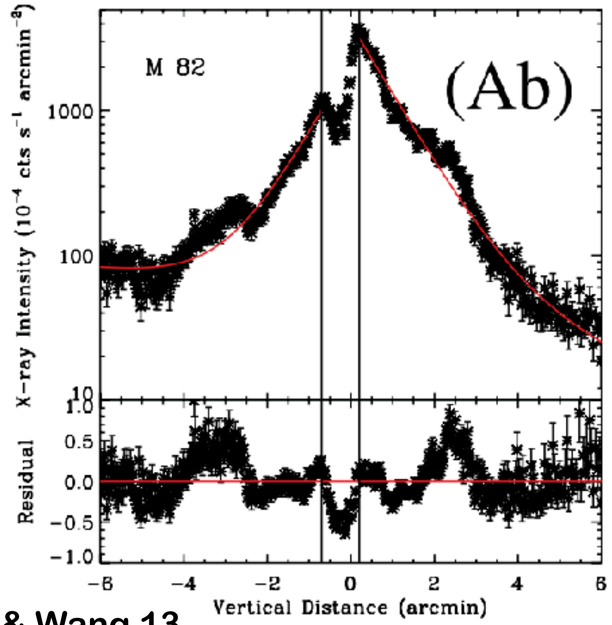


Apart from outflows in special cases (e.g. M82)

➜ Little evidence for an extended halo

Emission from disc-halo interface

(charge exchange? galactic atmosphere?)



Li & Wang 13

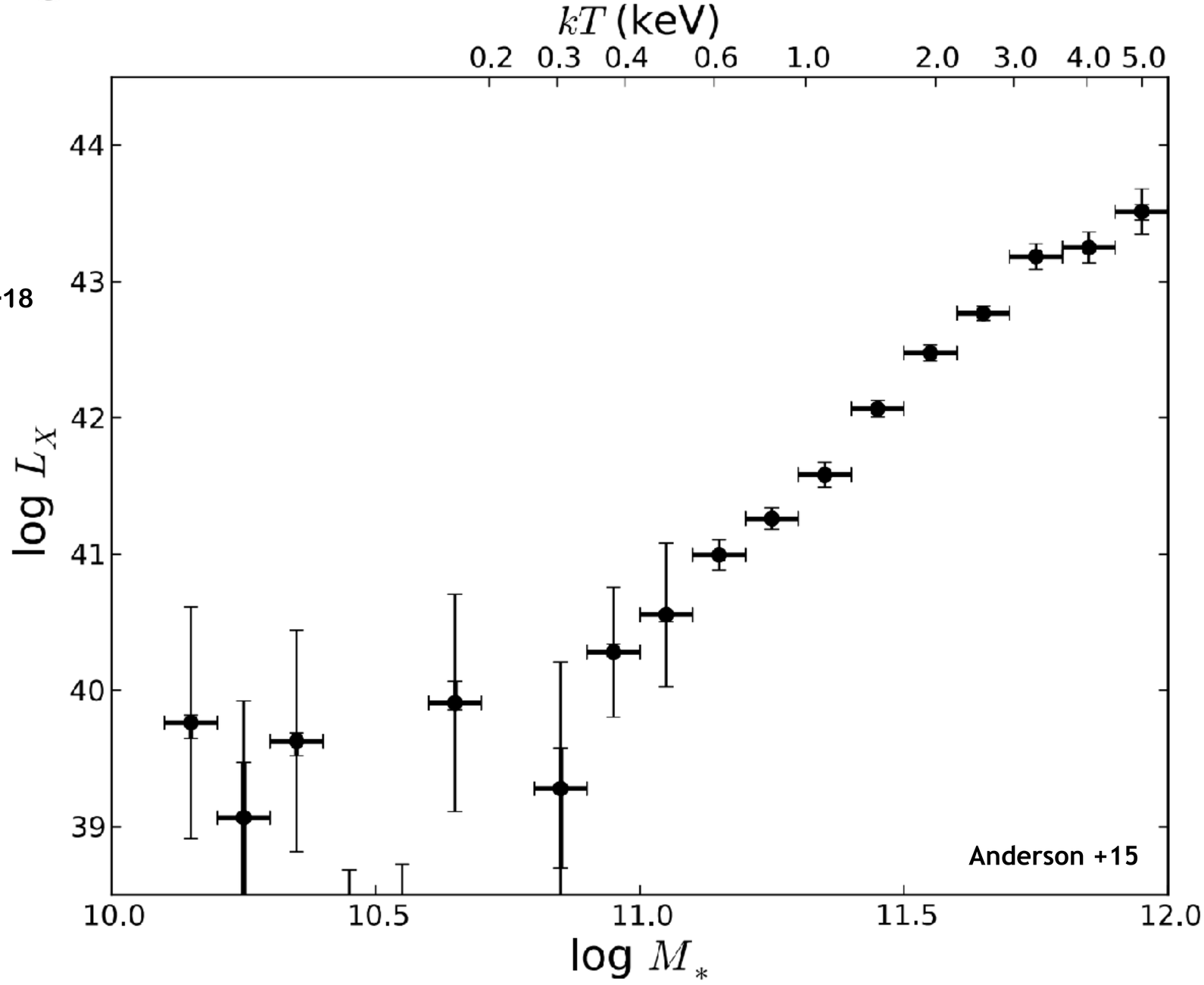
How can we form galaxies without a hot halo?

With cold clouds ➜ $t_{cooling}$ is short ➜ no more hot CGM

Marinacci+11; Voit+17; McCourt+18

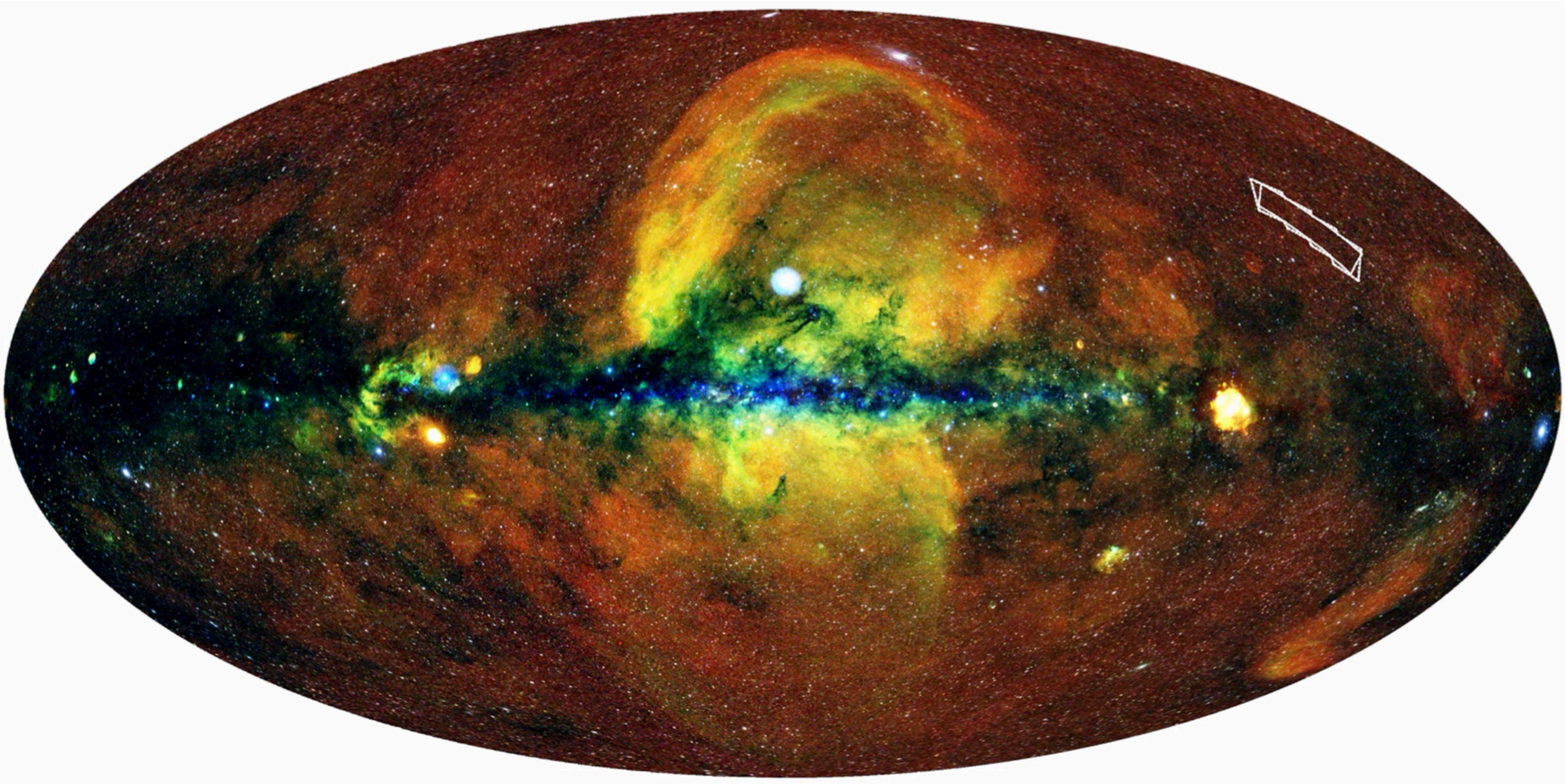
ROSAT stacks of brightest central galaxies

➜ An extended hot halo is present around massive galaxies



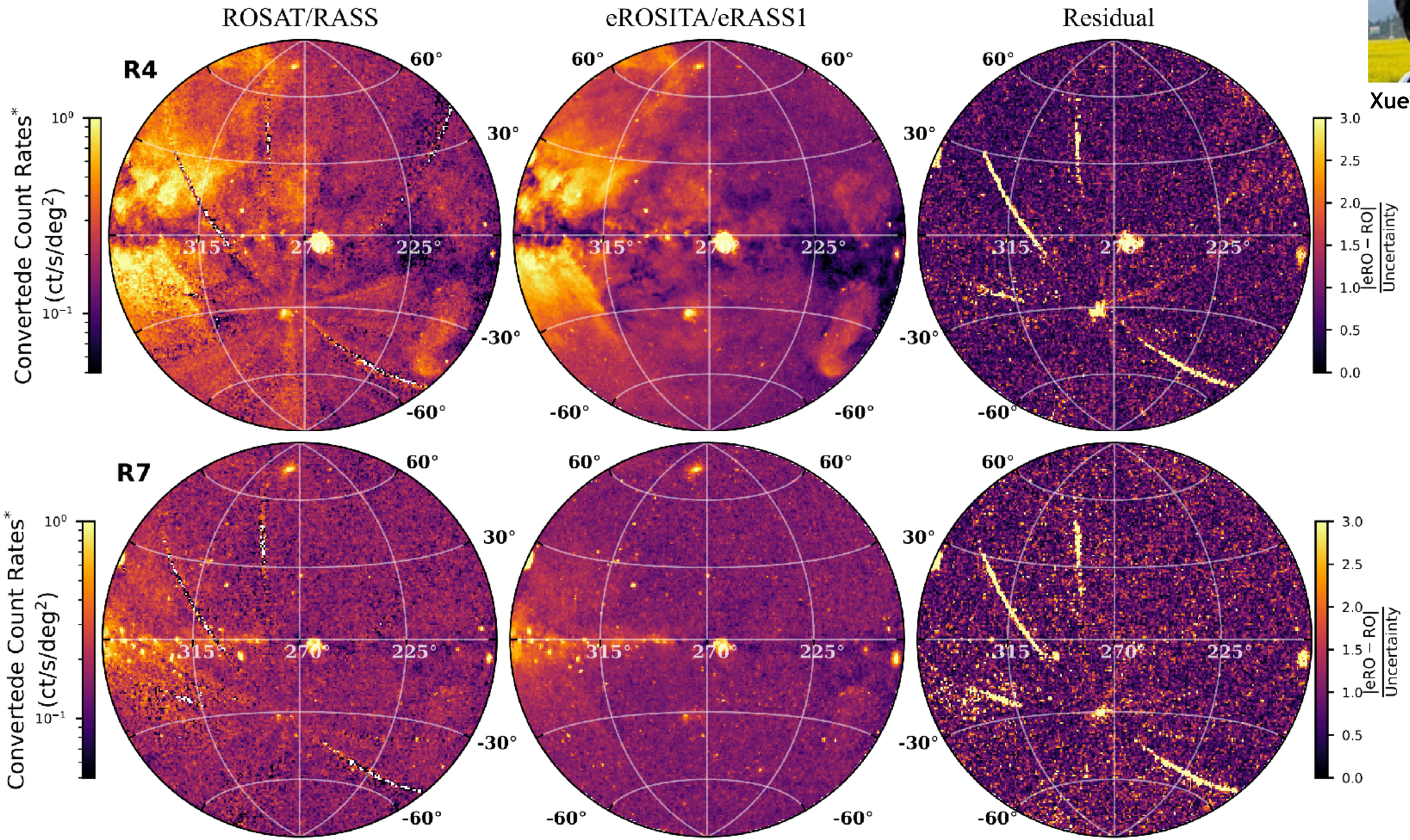
Then eROSITA arrives….

The soft X-ray Universe: eROSITA images…



The half sky images of eROSITA

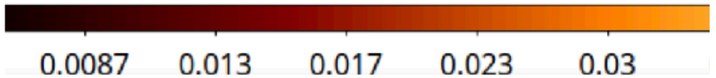
Xueying Zheng

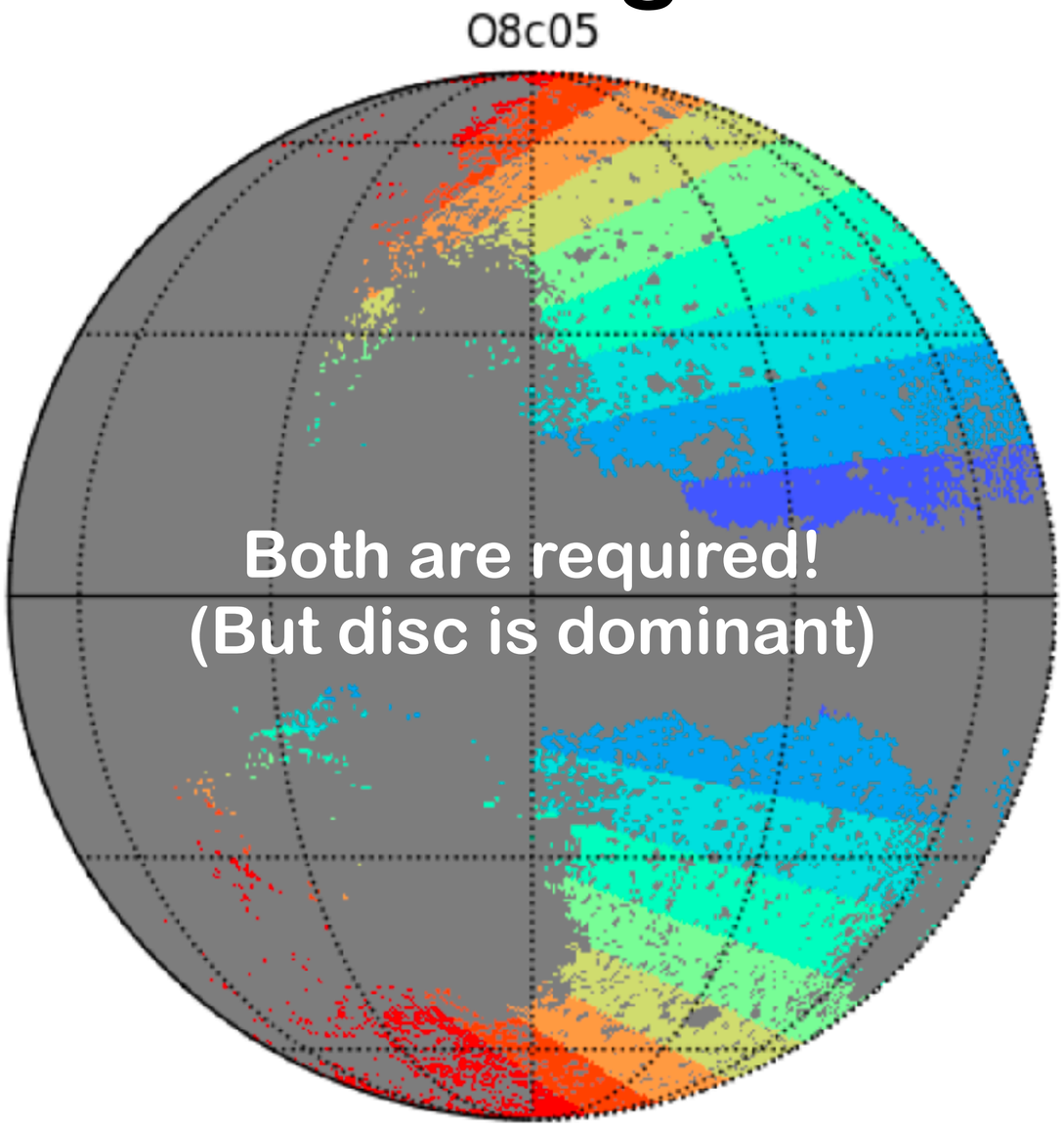


Morphology of the circumgalactic medium

Xueying Zheng

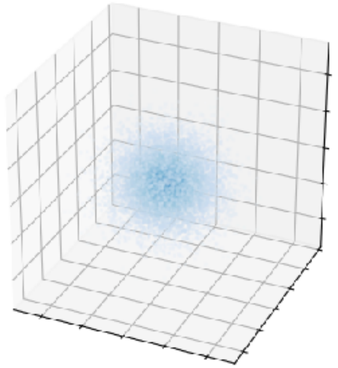
Zheng, GP+24



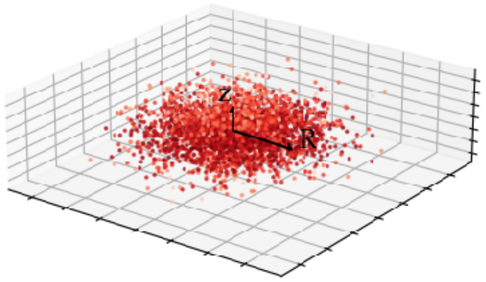


Nicola Locatelli

Spherical halo?
(beta model?)



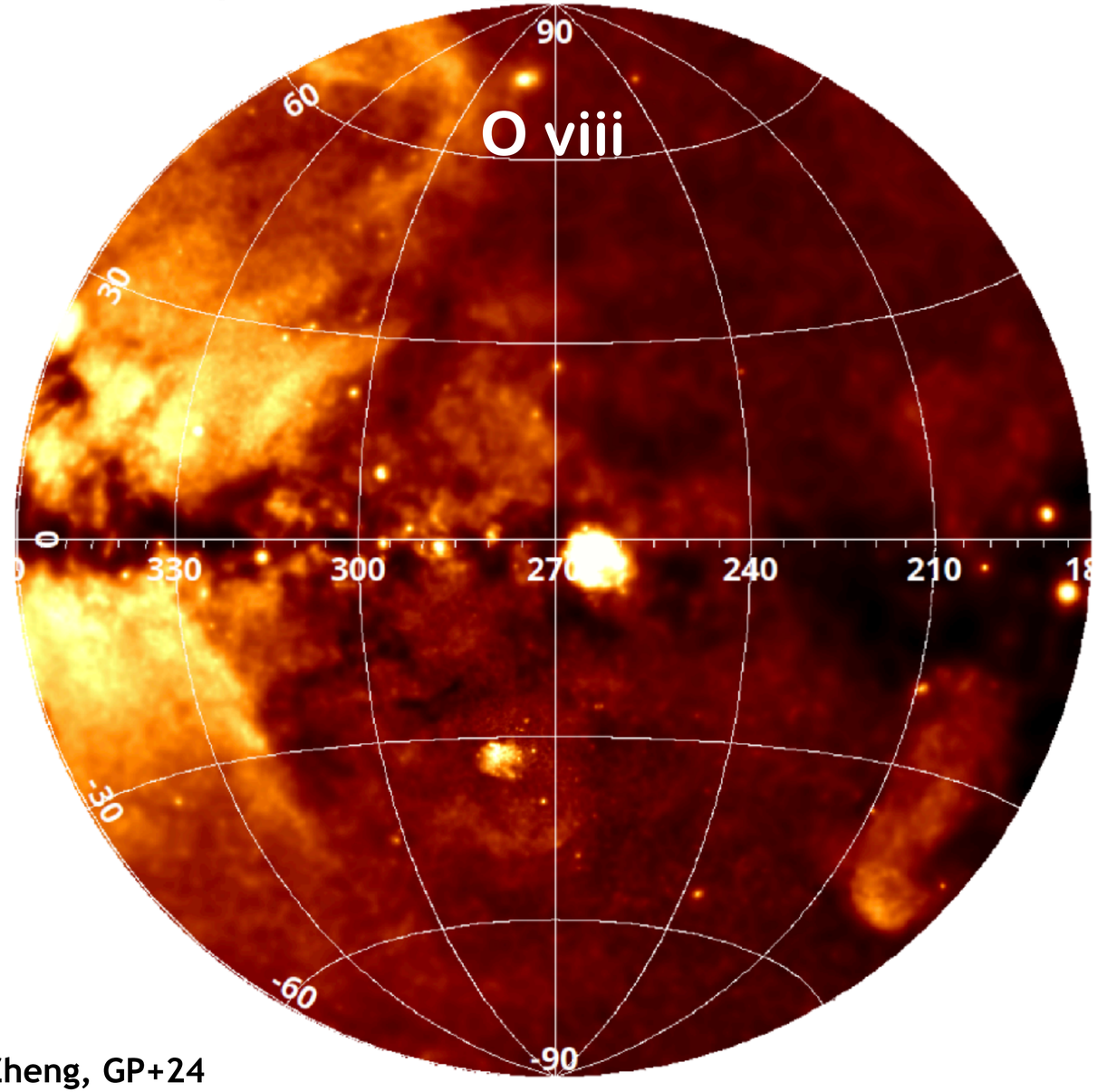
Or Exponential disc?
(corona? stars?)



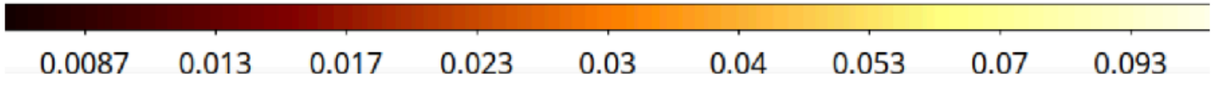
Locatelli, GP+24a; see also Bluem+22

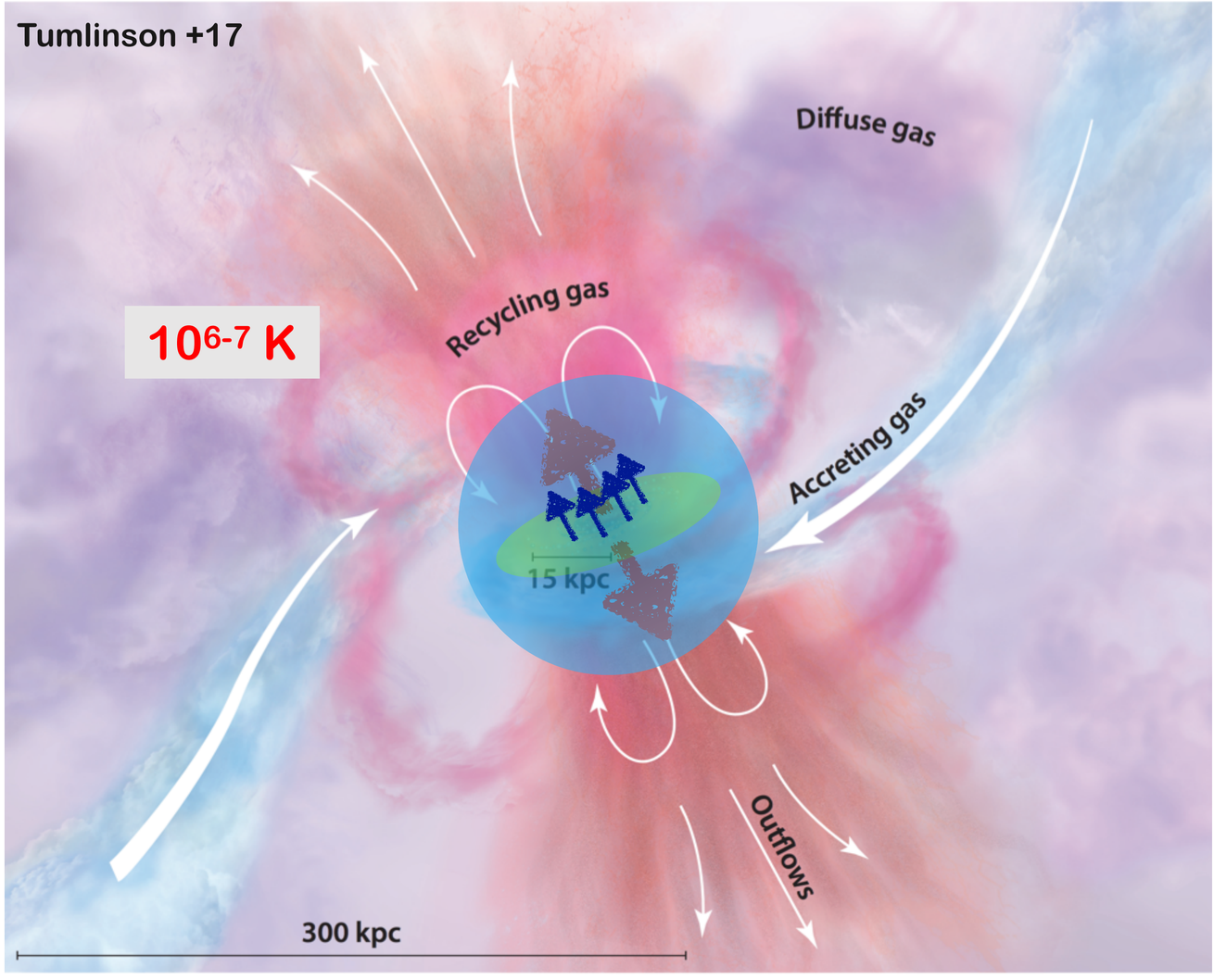
Morphology of the circumgalactic medium

Nicola Locatelli



Zheng, GP+24

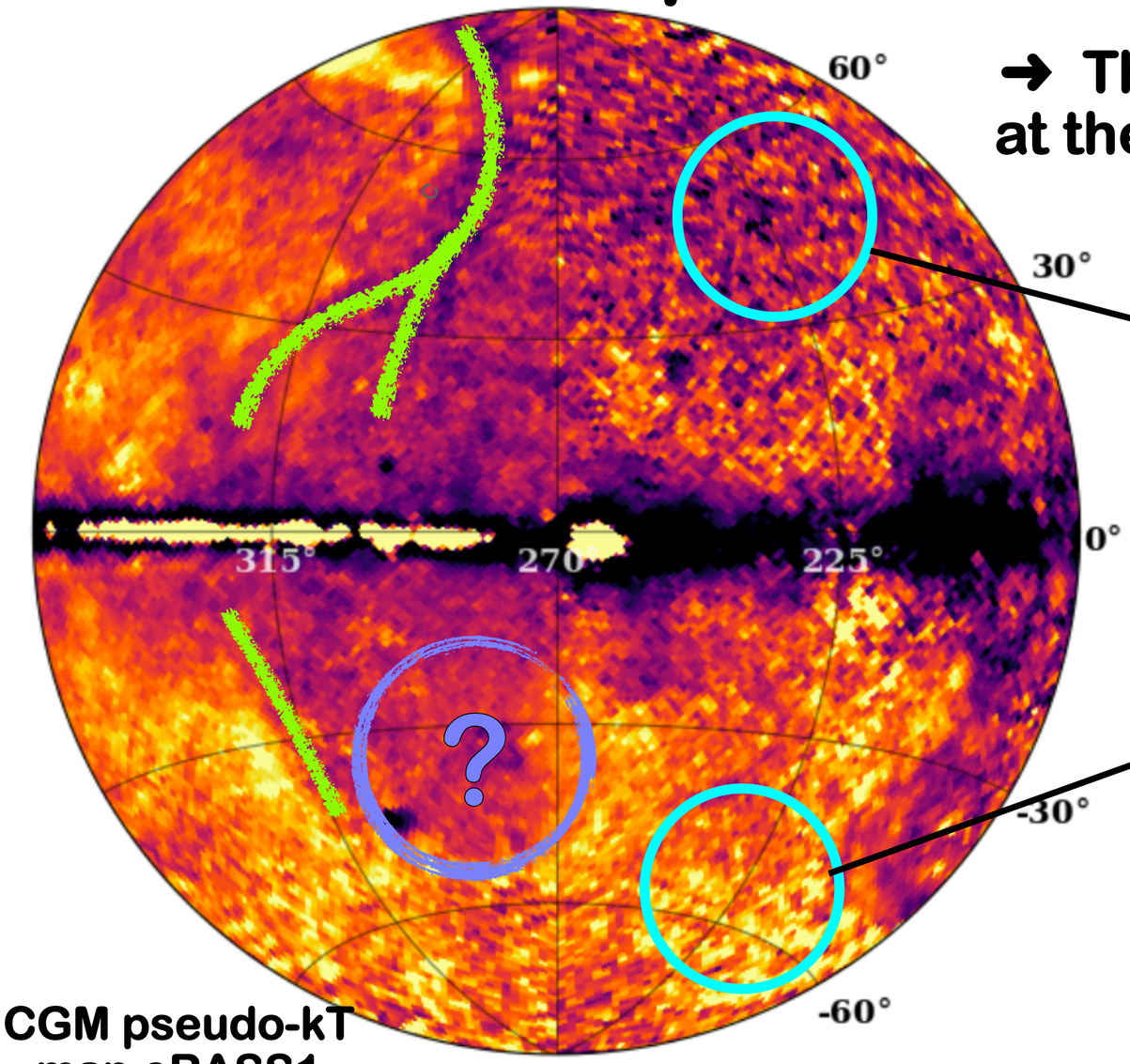


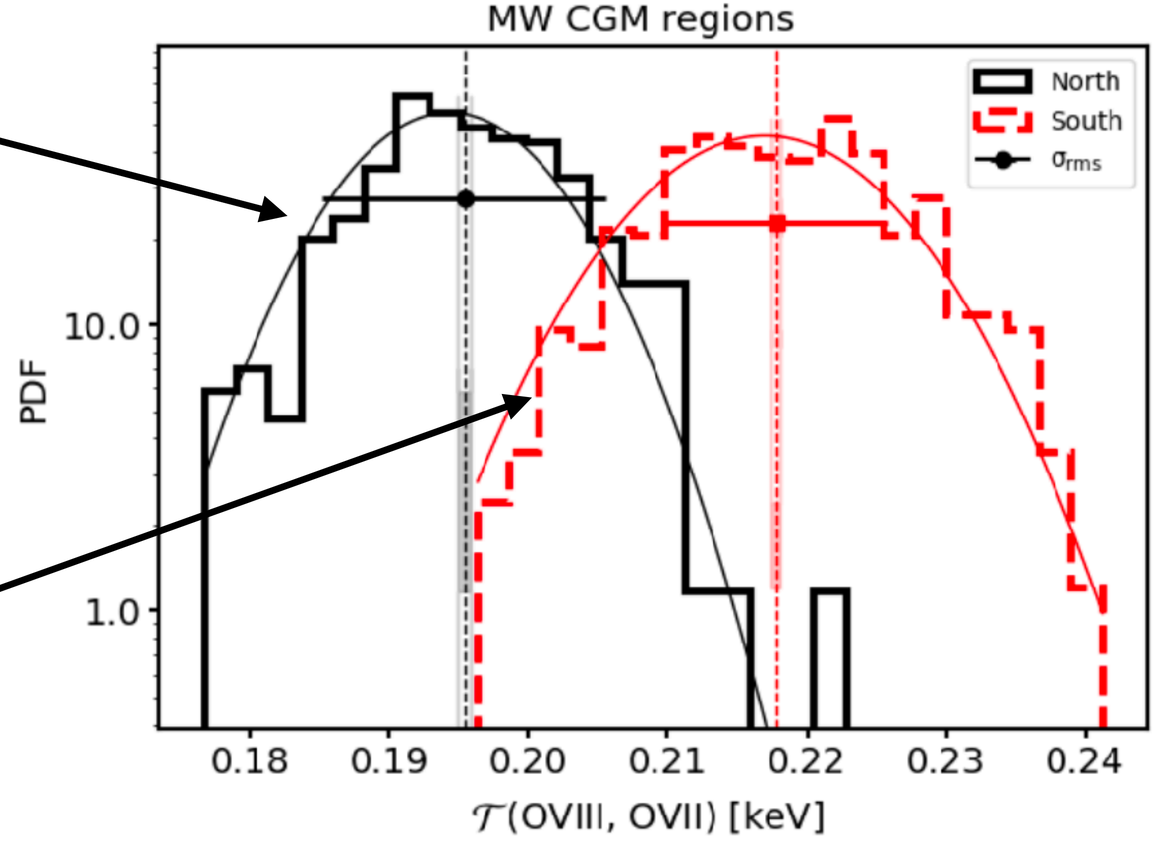


Pseudo-temperature map from Oviii/Ovii

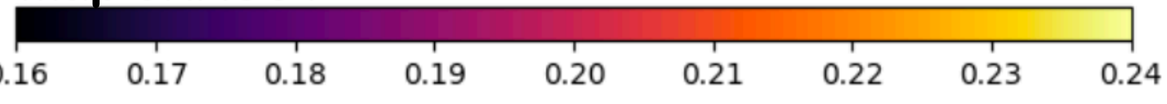
Xueying Zheng

➜ Thick (~10º) shell of (colder?) plasma at the interface with the Galactic outflow





CGM pseudo-kT map eRASS1

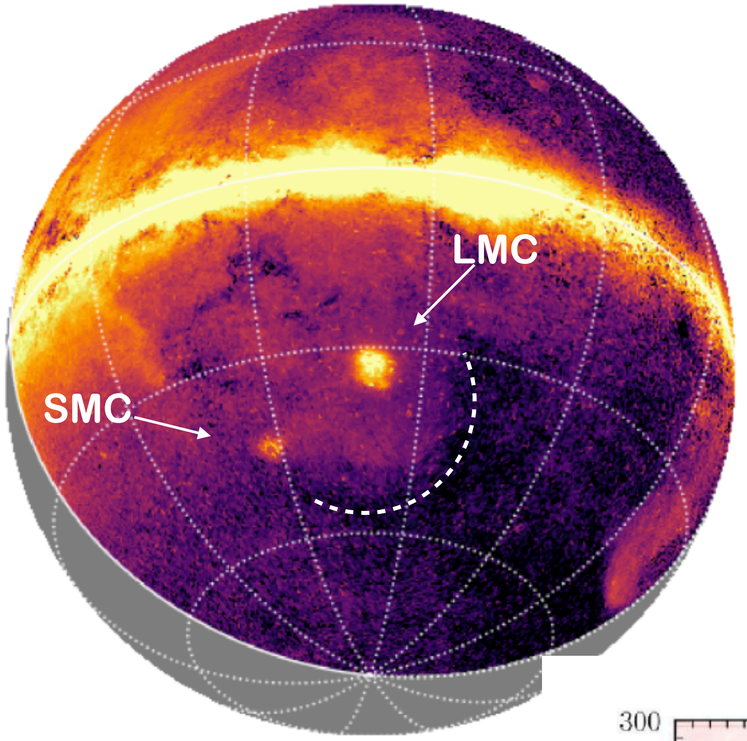


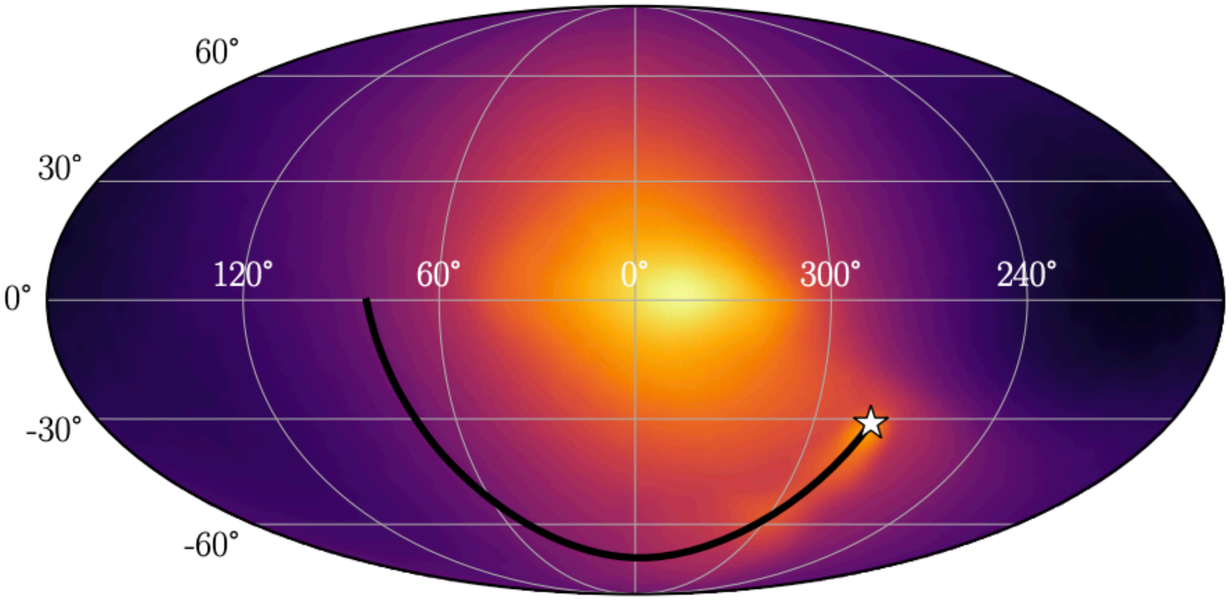
Zheng, GP+24

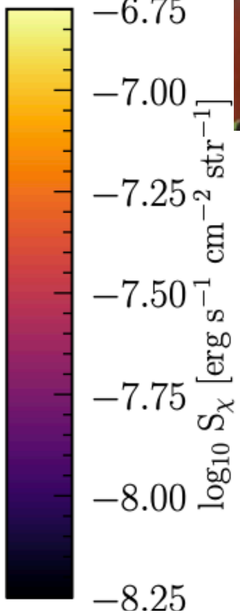
➜ ΔkT_{CGM} ~ 12% between north and south

➜ ΔkT_{CGM} ~ 2.7% on small (2º-20º) scales

The Goat Horn around the LMC

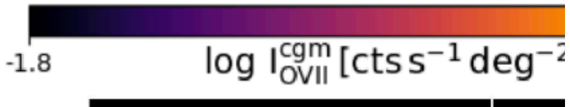


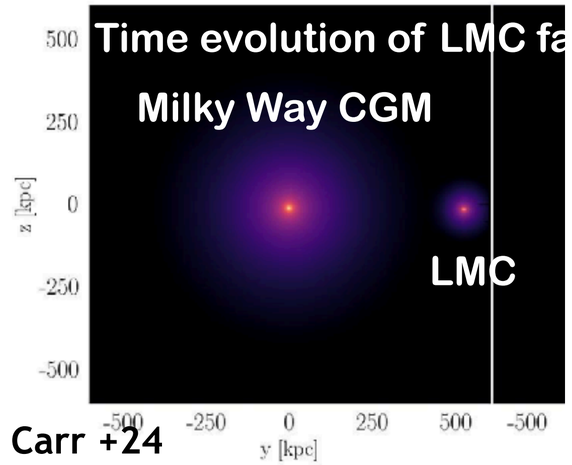




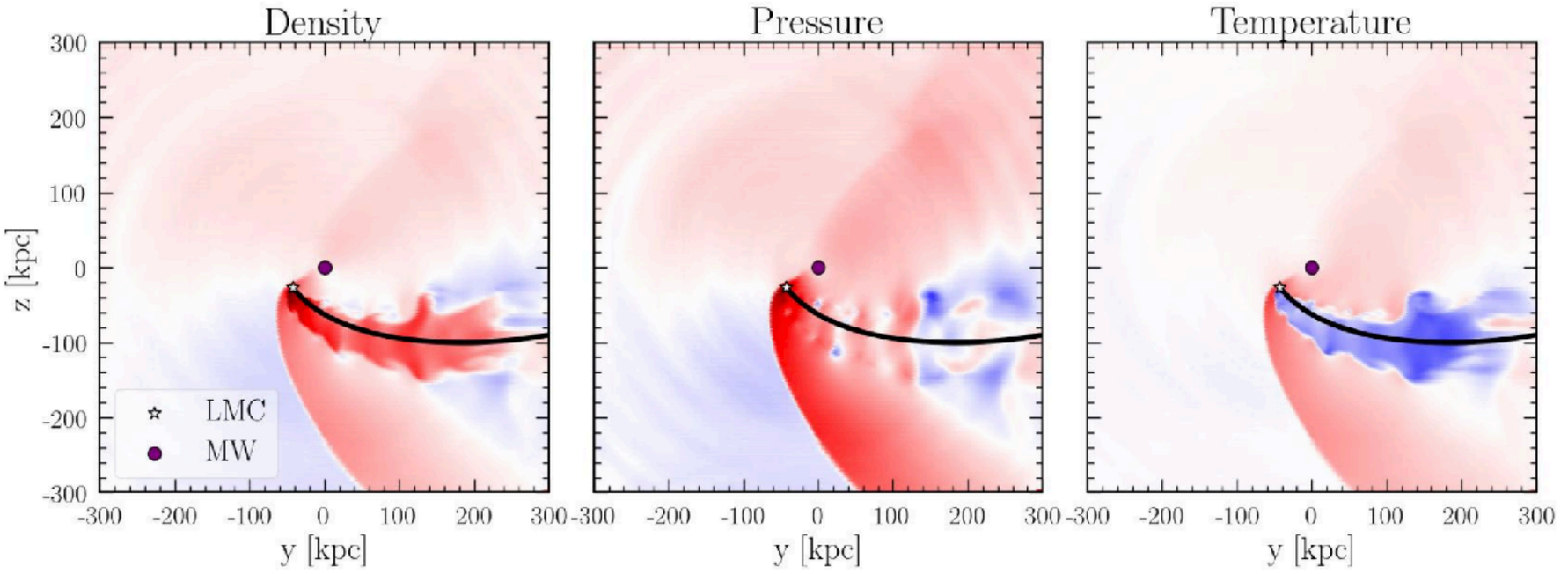
Nicola Locatelli

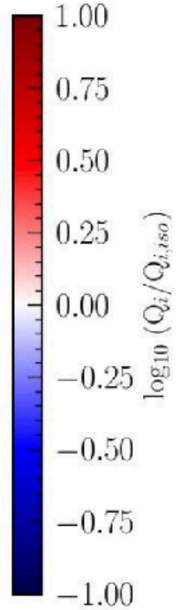
Carr +24



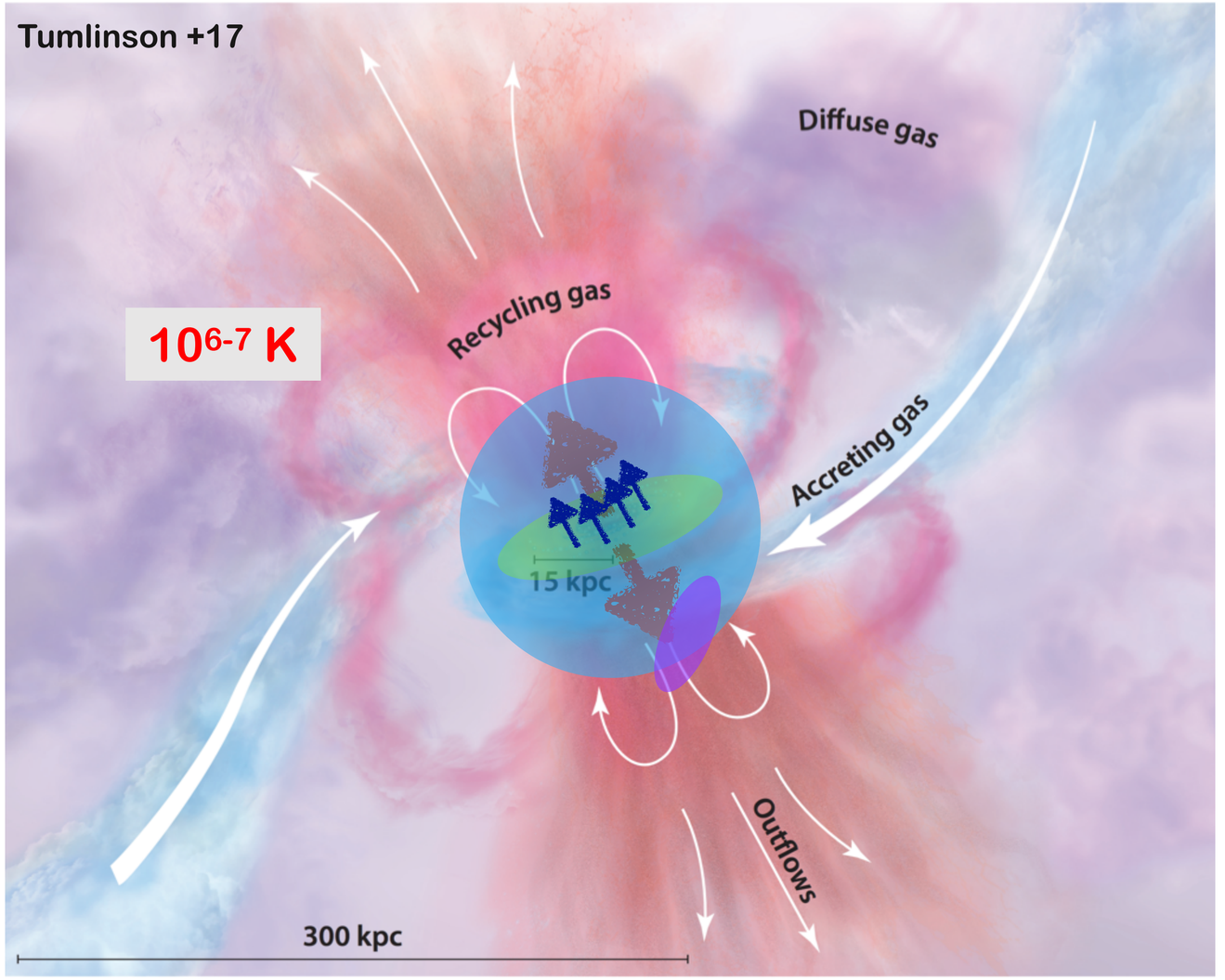


Carr +24



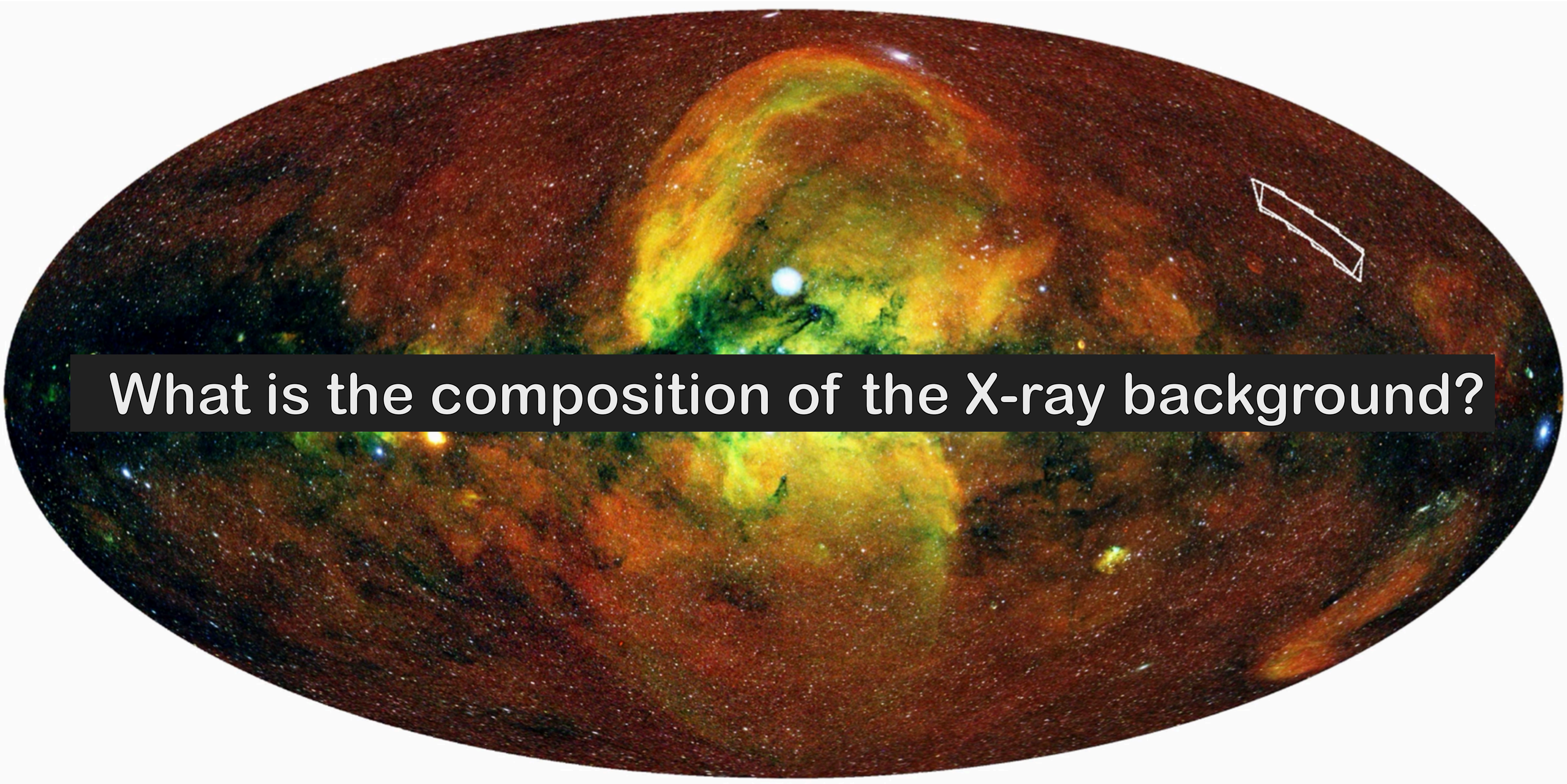


The merging of the LMC's CGM with ours

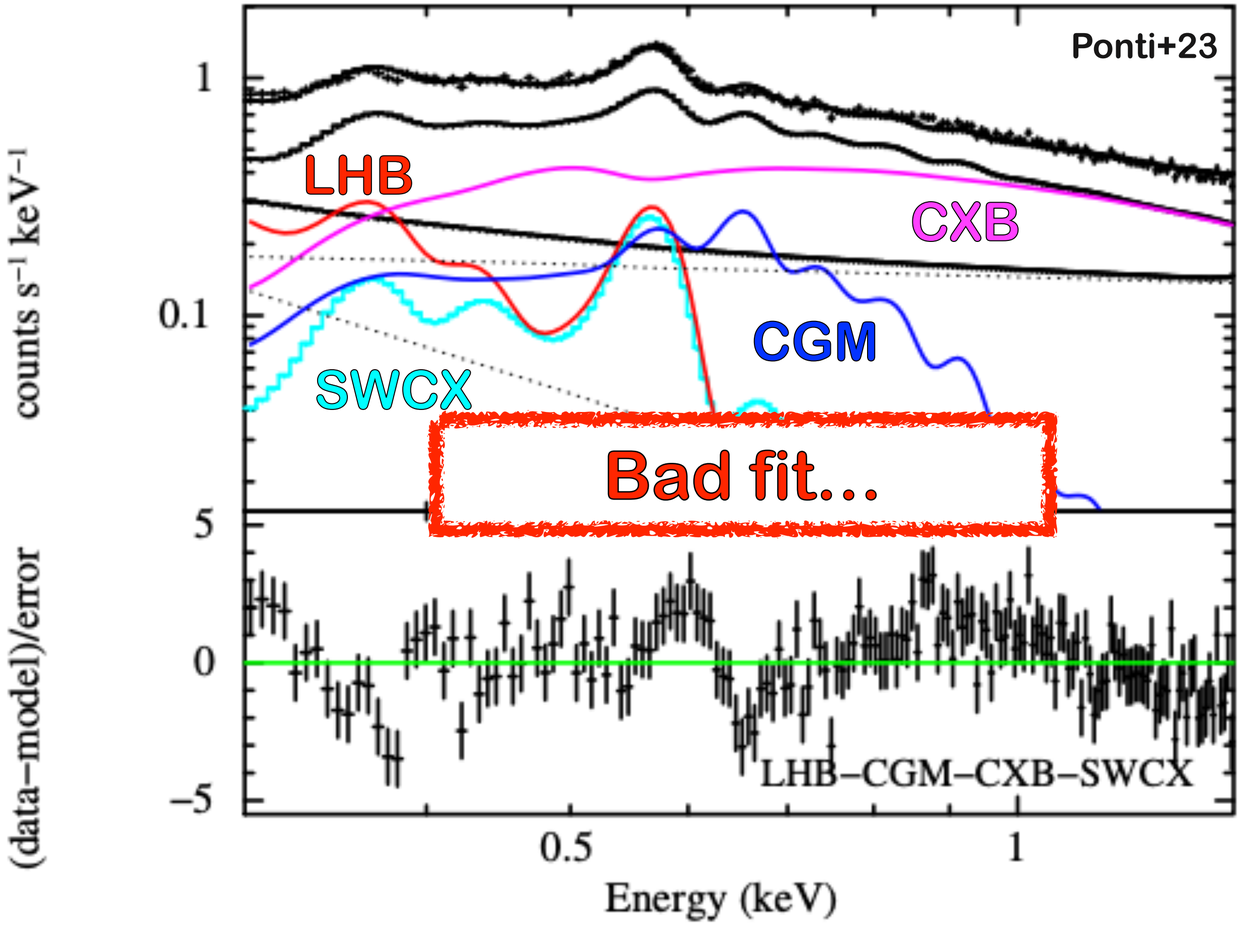


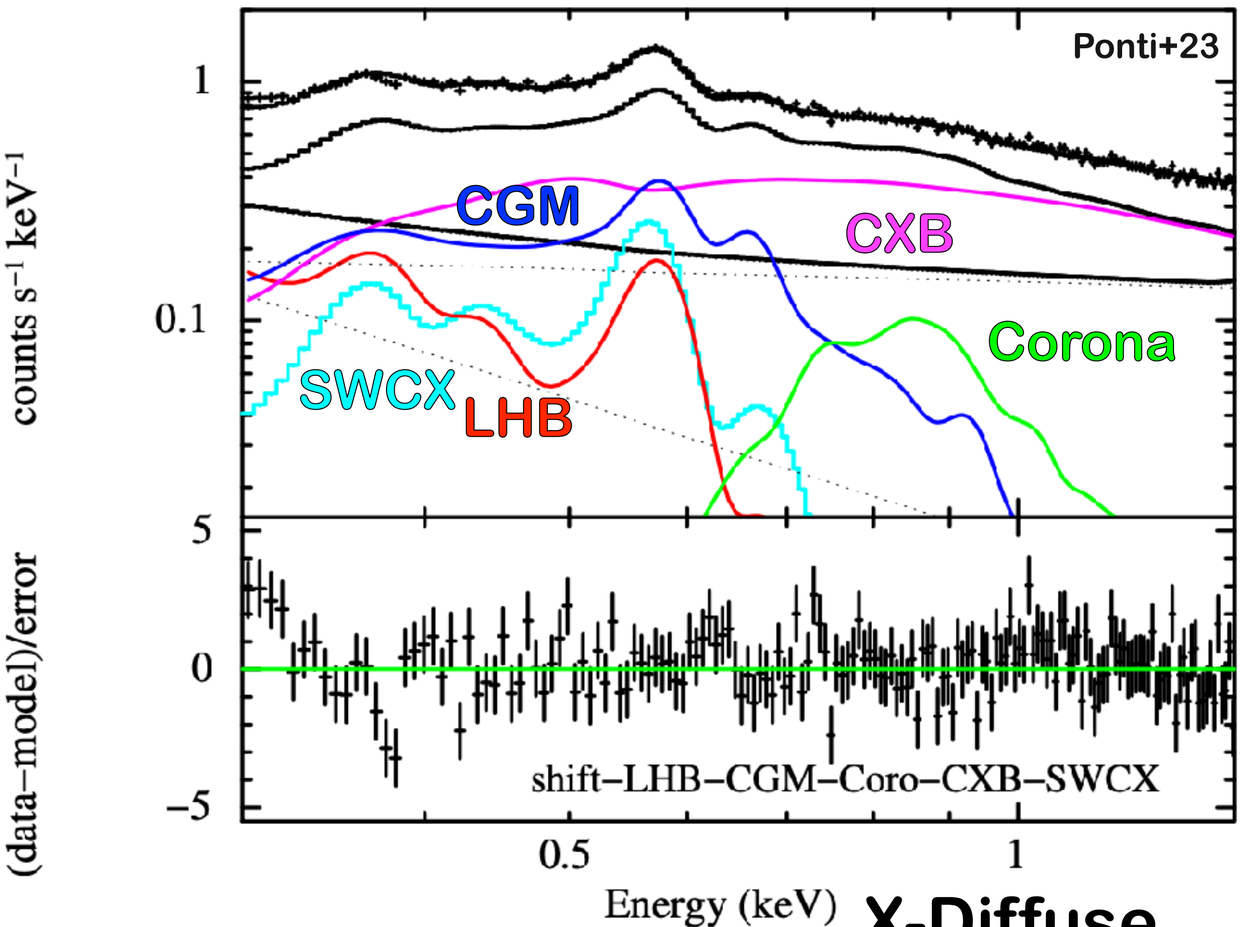
The power of eROSITA's spectra

Decomposing the soft X-ray background



The warm-hot CGM in the eFEDS field





LHB: Local hot bubble

CGM: Circum Galactic medium

CXB: Cosmic X-ray background

SWCX: Solar wind charge exchange

kT_{Halo} = 0.153 - 0.178 keV ~ kTvir

Uncertainty on CXB

Abun = 0.05 - 0.10 $Z_\odot$

Corona ➜ Required!

kT_{Coro} = 0.4 - 0.7 keV

X-Diffuse

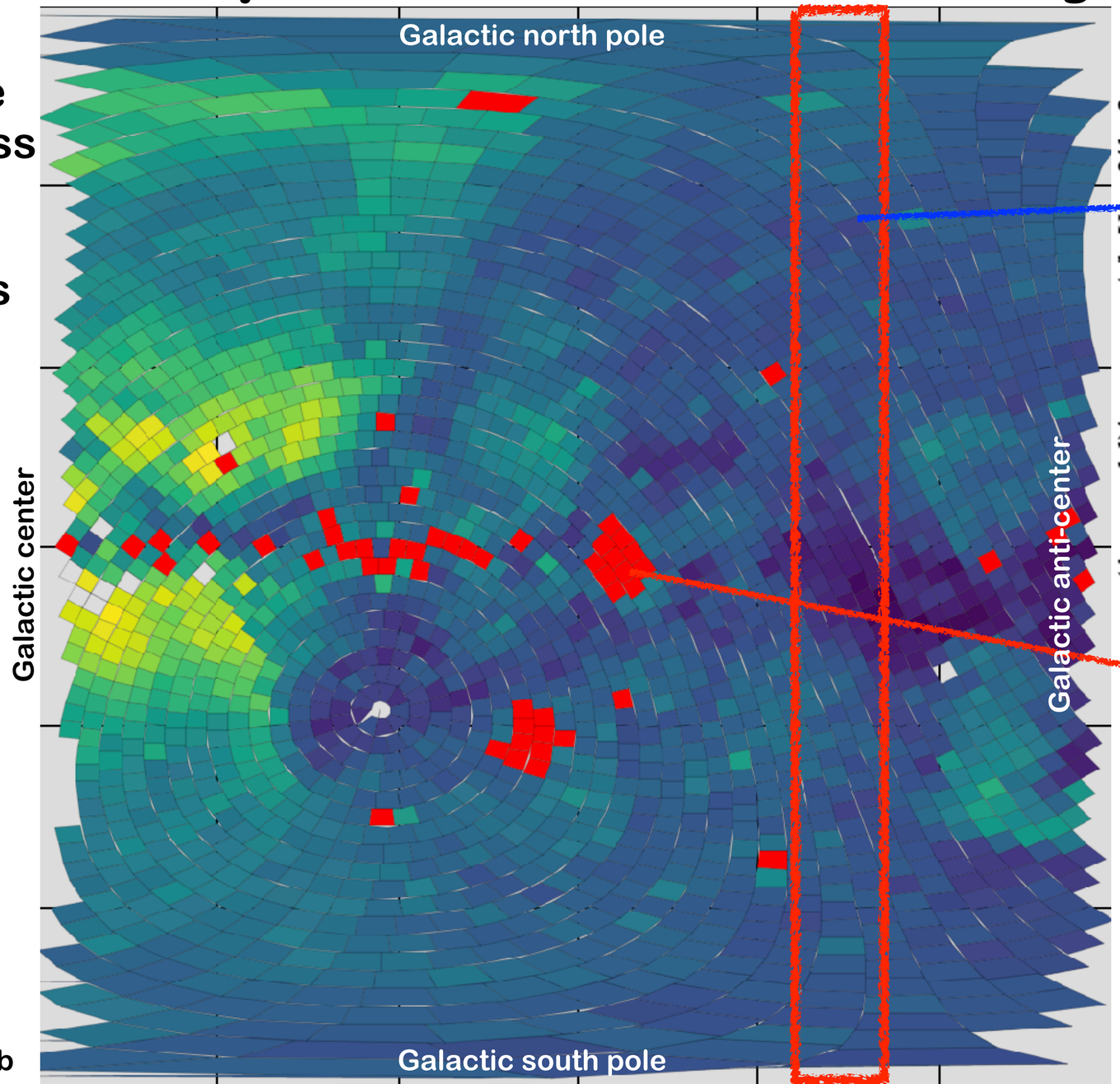
1) SWCX
2) LHB - ISM
3) Galactic ridge
4) Hot CGM
5) Outflow
6) CXB
7) Corona!

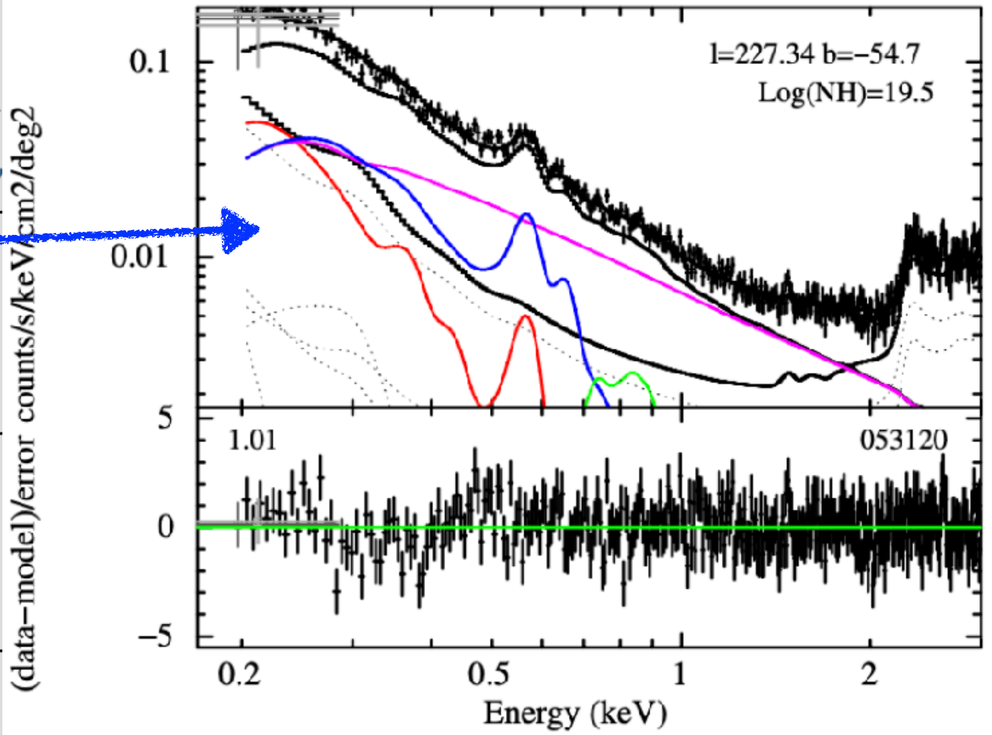
The power of eROSITA's spectra over the half sky

The composition of the X-ray background

Surface brightness

Sky Tiles 3×3°



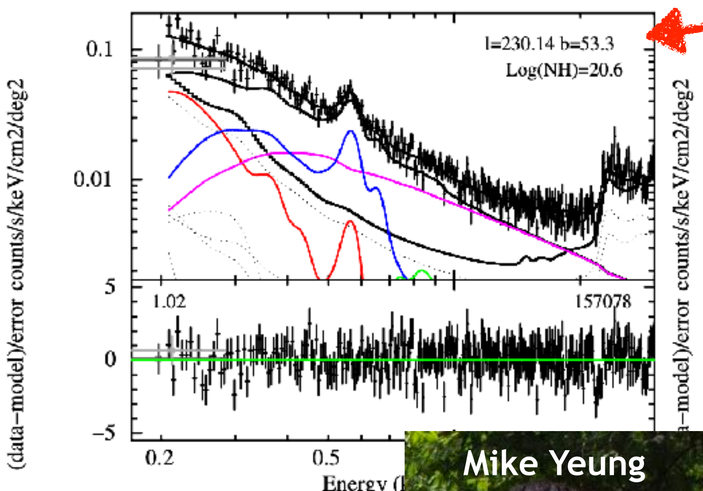


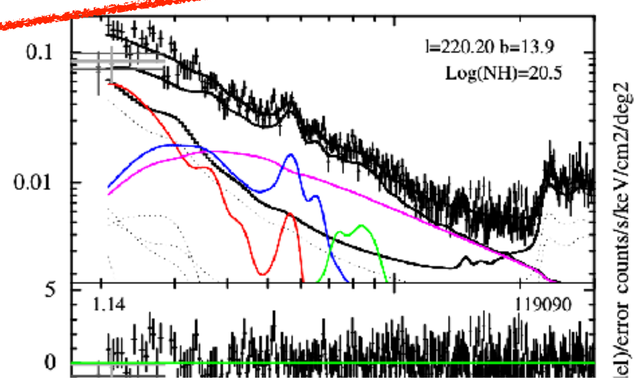
$\chi^2_{red} > 1.5$

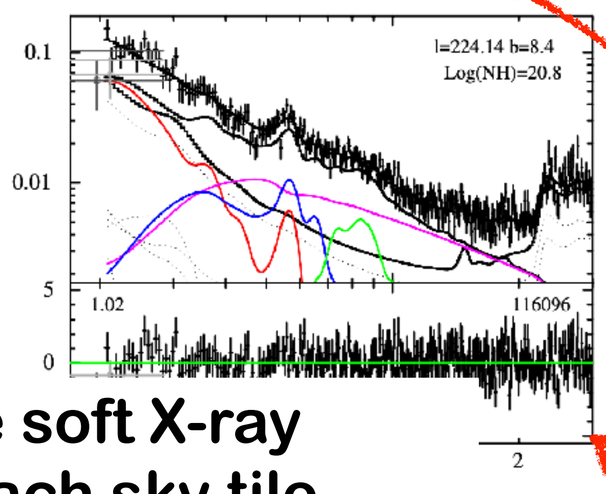
Good fit over most of the sky even with oversimplified model

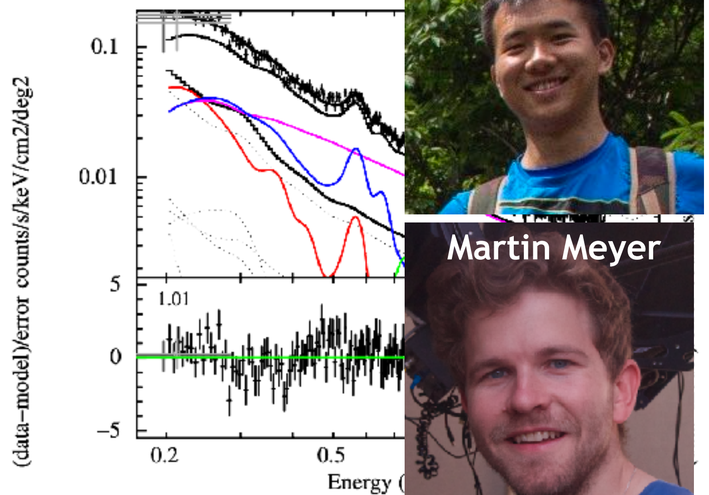
Ponti+sub

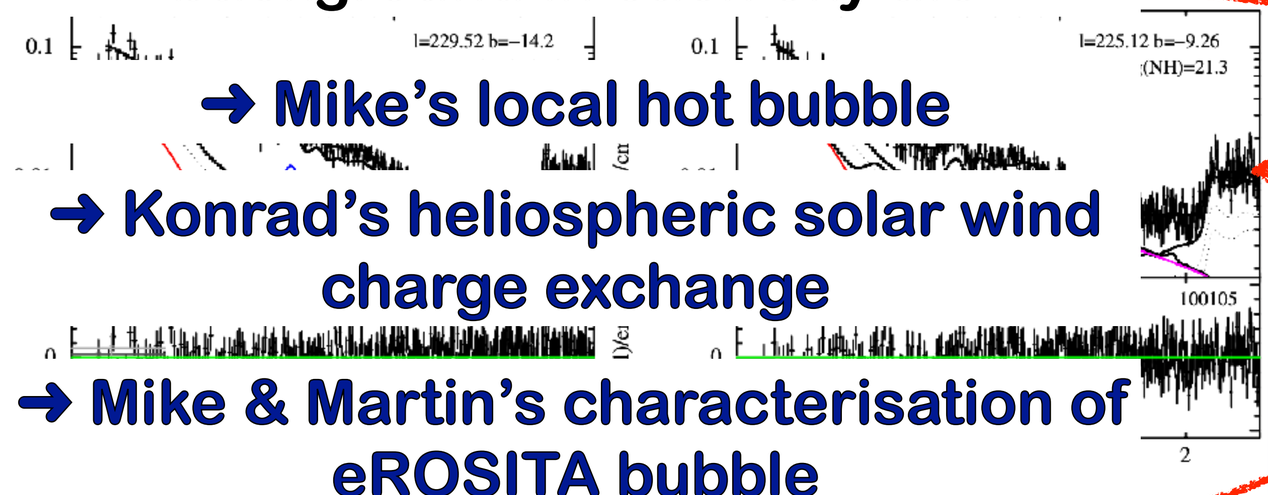
Spectral variations over the half-sky











Determining the soft X-ray background in each sky tile

➜ Mike's local hot bubble

➜ Konrad's heliospheric solar wind charge exchange

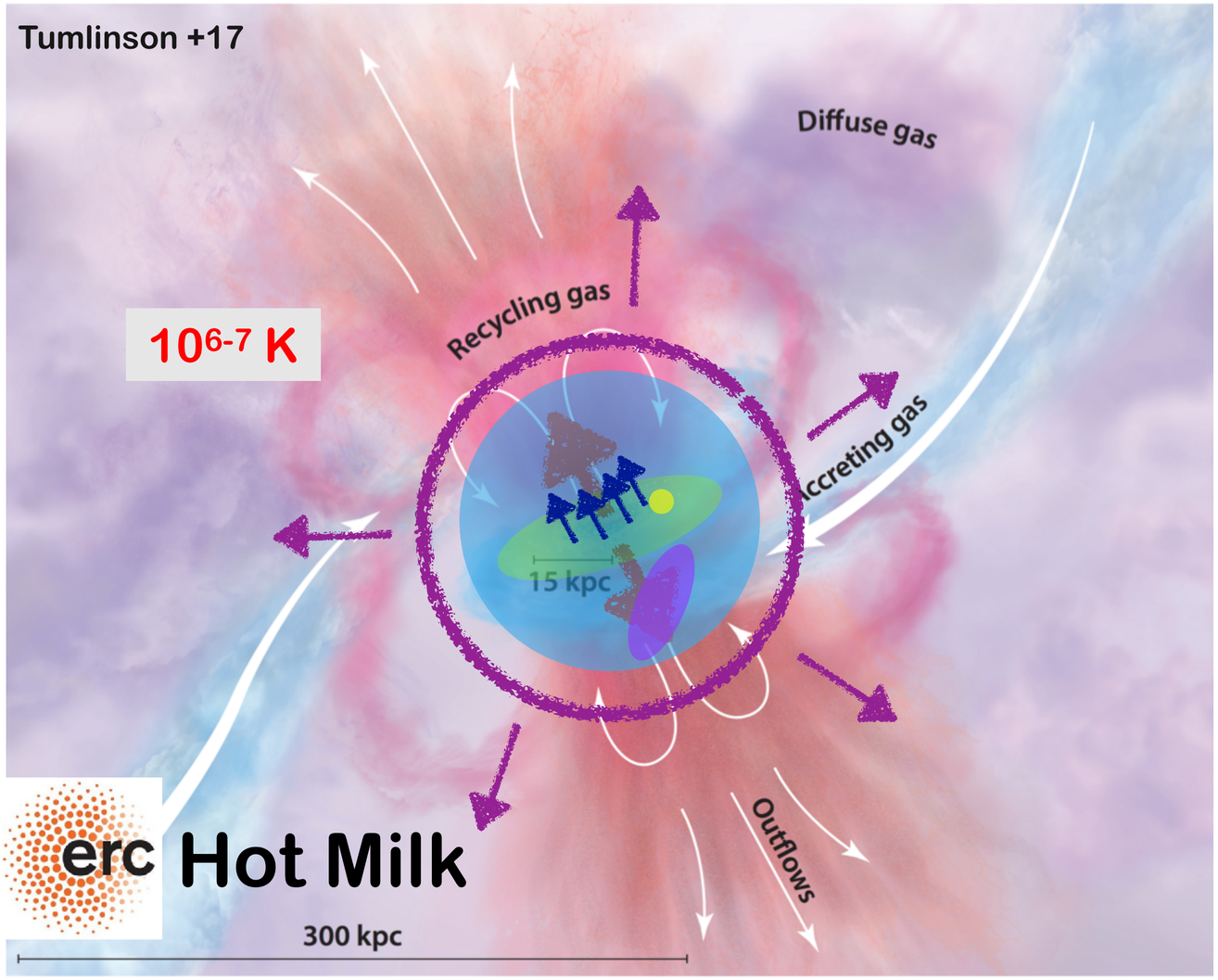
➜ Mike & Martin's characterisation of eROSITA bubble

Measuring CGM physical properties from spectra

Ponti+sub

Ponti+sub

Our new view of the hot CGM



Yes, also quiescent galaxies have powerful outflows
Predehl+20; Yang+22; Mou+23; Gupta+23; Sharkar 24; Zhang+24

Shell at the edge between outflow & unperturbed CGM Zheng+24

We constrain the temperature fluctuations of the CGM Zheng+24

Virial halo (β model) **+ hotter disc component**
Bluem +22; Ponti+23; Locatelli+24a

Is Goat Horn the collision of LMC & MW?
Locatelli+24b; Carr+24

Deeper view of local interstellar medium
Yeung+23;+24

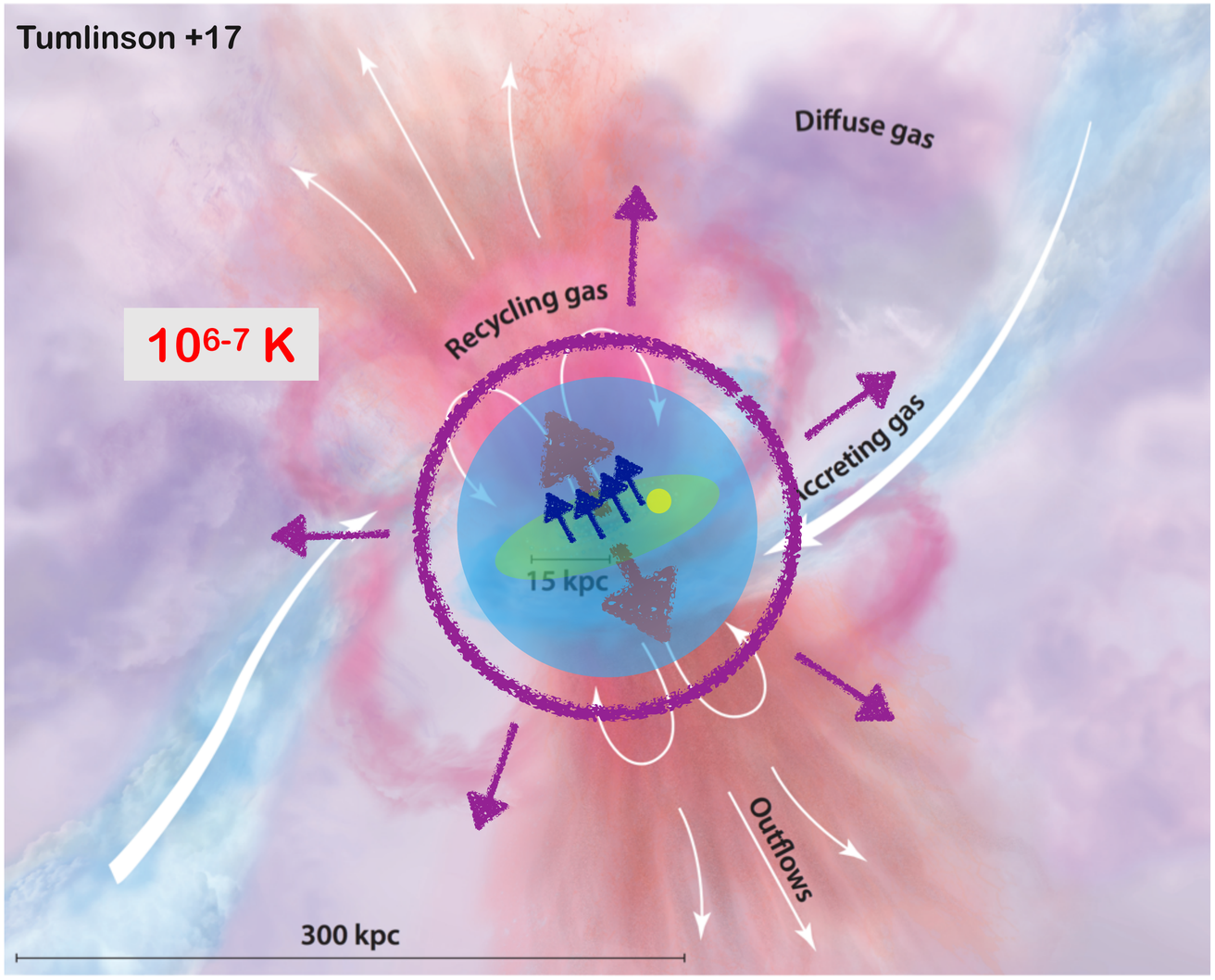
Characterisation of heliospheric emission
Dennerl+24

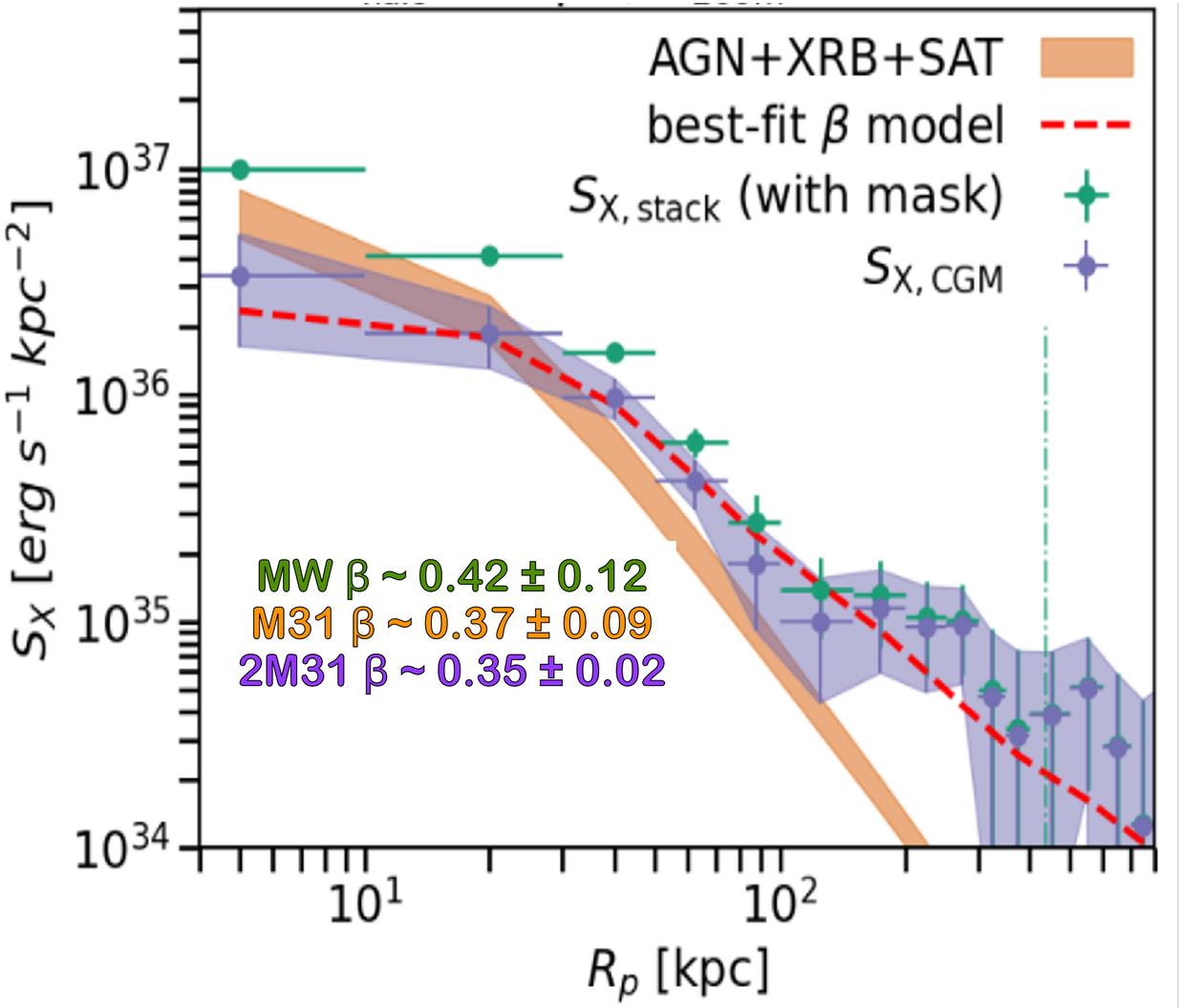
Great!

But do other galaxies have hot CGM?
Can we go beyond few tens kpc?

Our new view of the hot CGM

Yi Zhang

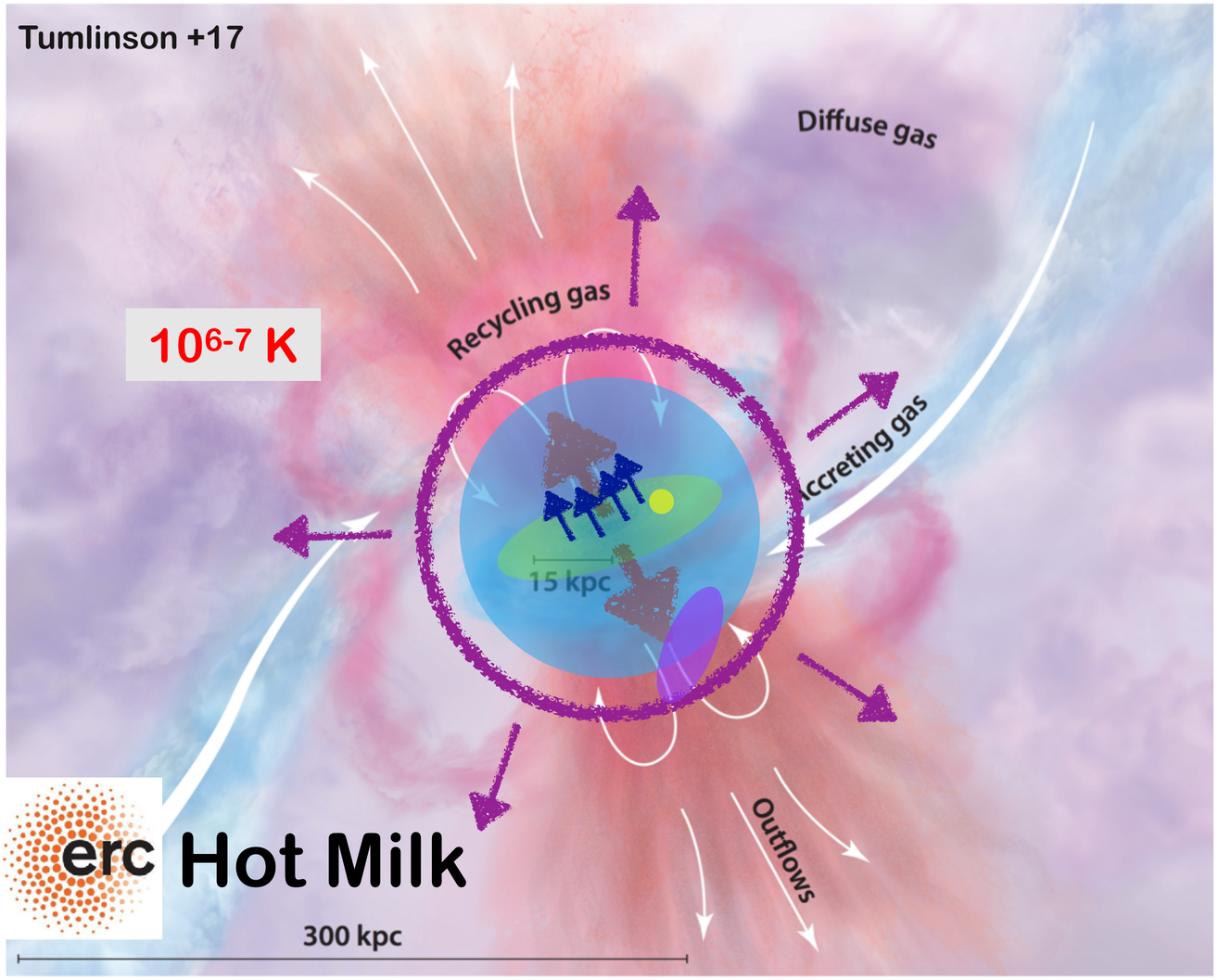




Yes, Milky Way-like galaxies do have hot CGM with β~0.4

Zhang+24a; +24b; +24c

Conclusions: Our new view of the hot CGM



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Yes, Milky Way-like galaxies do have hot CGM with β~0.4 Zhang+24a; +24b; +24c

The eROSITA bubbles have a non-thermal component

➜ The star forming ring at the end of the bar contributes to the Galactic outflow Zhang +24a

Final summary:

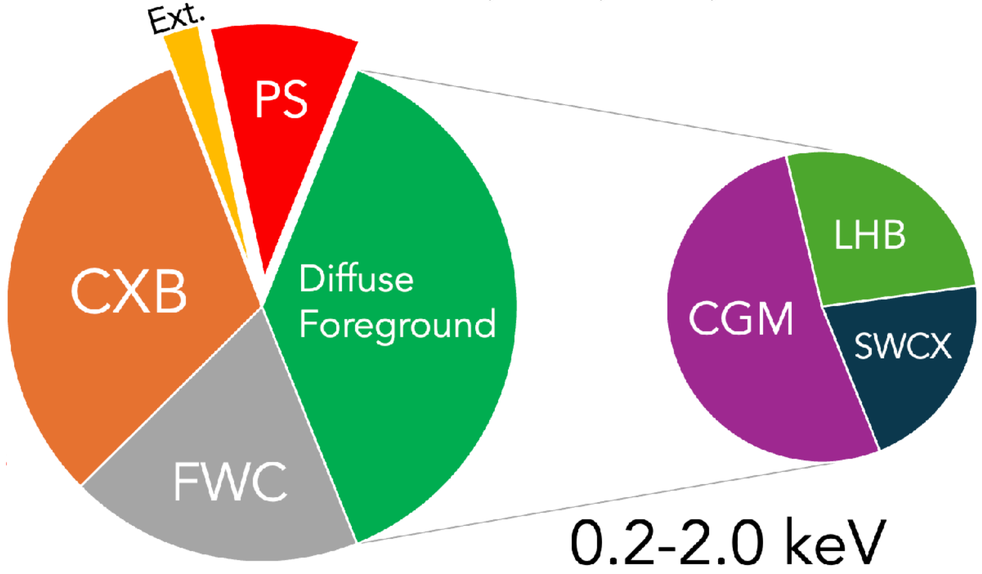
Instrumental background

Filter wheel closed emission

Soft protons flares

Stray-light

Light leak, Optical loading, Ghost rays,
Out of time events, etc, etc, etc.



Sky background (diffuse emission)

Solar wind charge exchange

Local hot bubble

Hot interstellar medium

Galactic ridge X-ray emission

Hot circumgalactic medium

Galactic outflow

Cosmic X-ray background

Absorption: complicating factor…

Point sources or diffuse emission?