

Reflection-dominated CT AGN
candidates — first
SRG/eROSITA results from the
Eastern Galactic hemisphere

M. Belvedersky (IKI RAS)

M. Gilfanov (IKI RAS, MPA)

P. Medvedev (IKI RAS)

Problem: Compton-thick AGN fraction

Within $z \approx 1.0$:

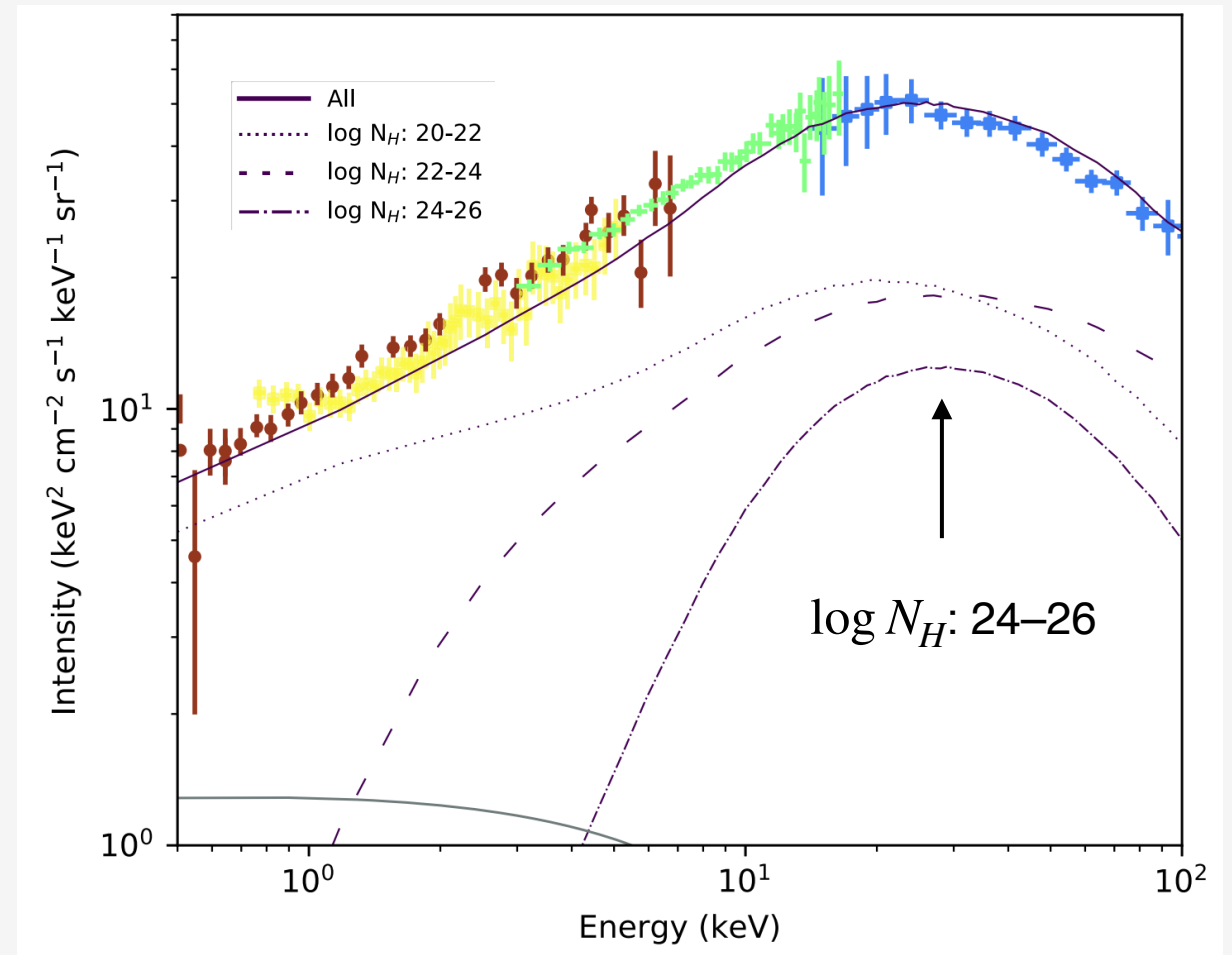
$56\% \pm 7\%$ of all AGNs are
Compton-thick
Ananna et al. 2019

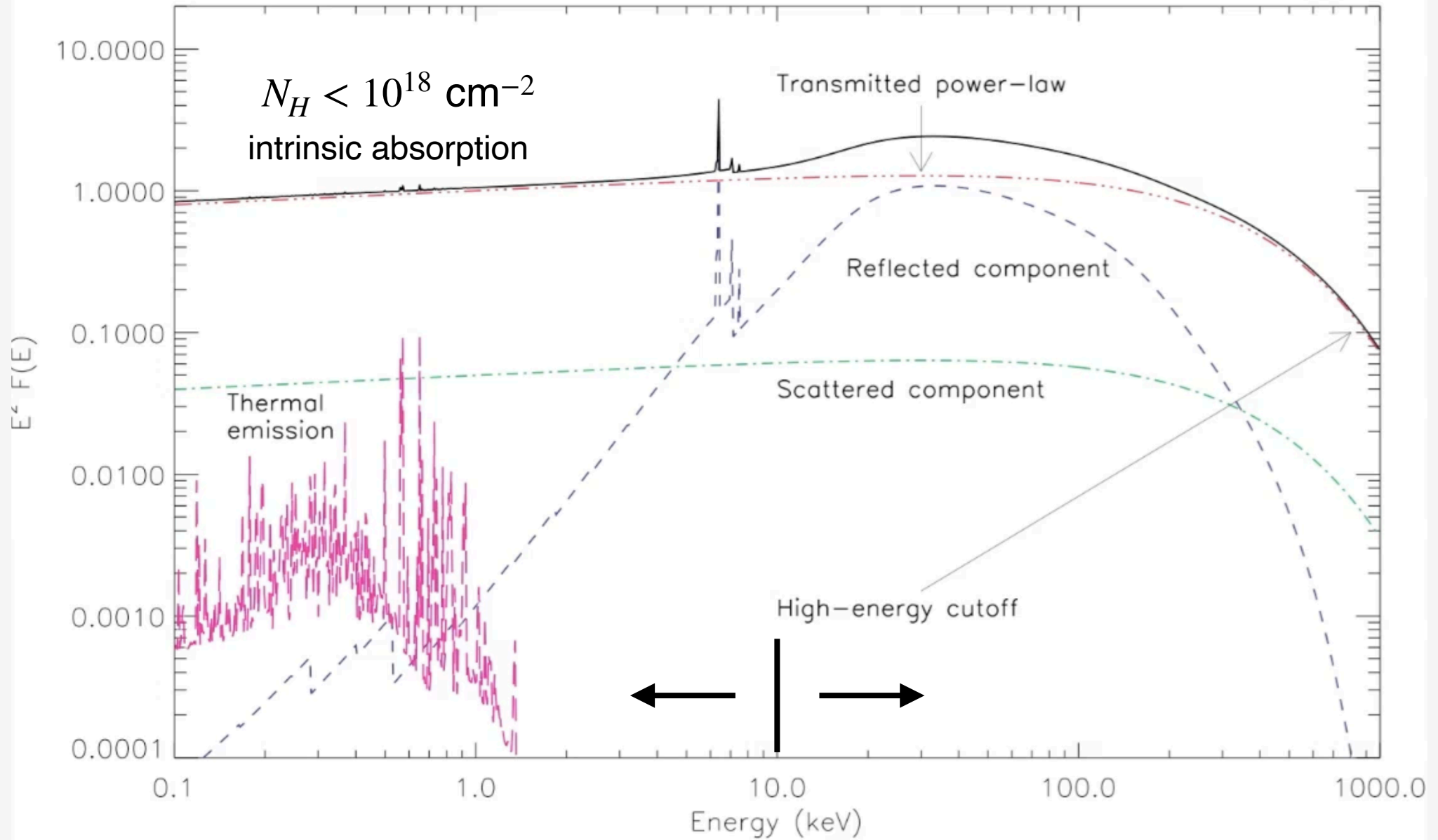
... $38\% \pm 8\%$ of the total
Buchner et al. 2015

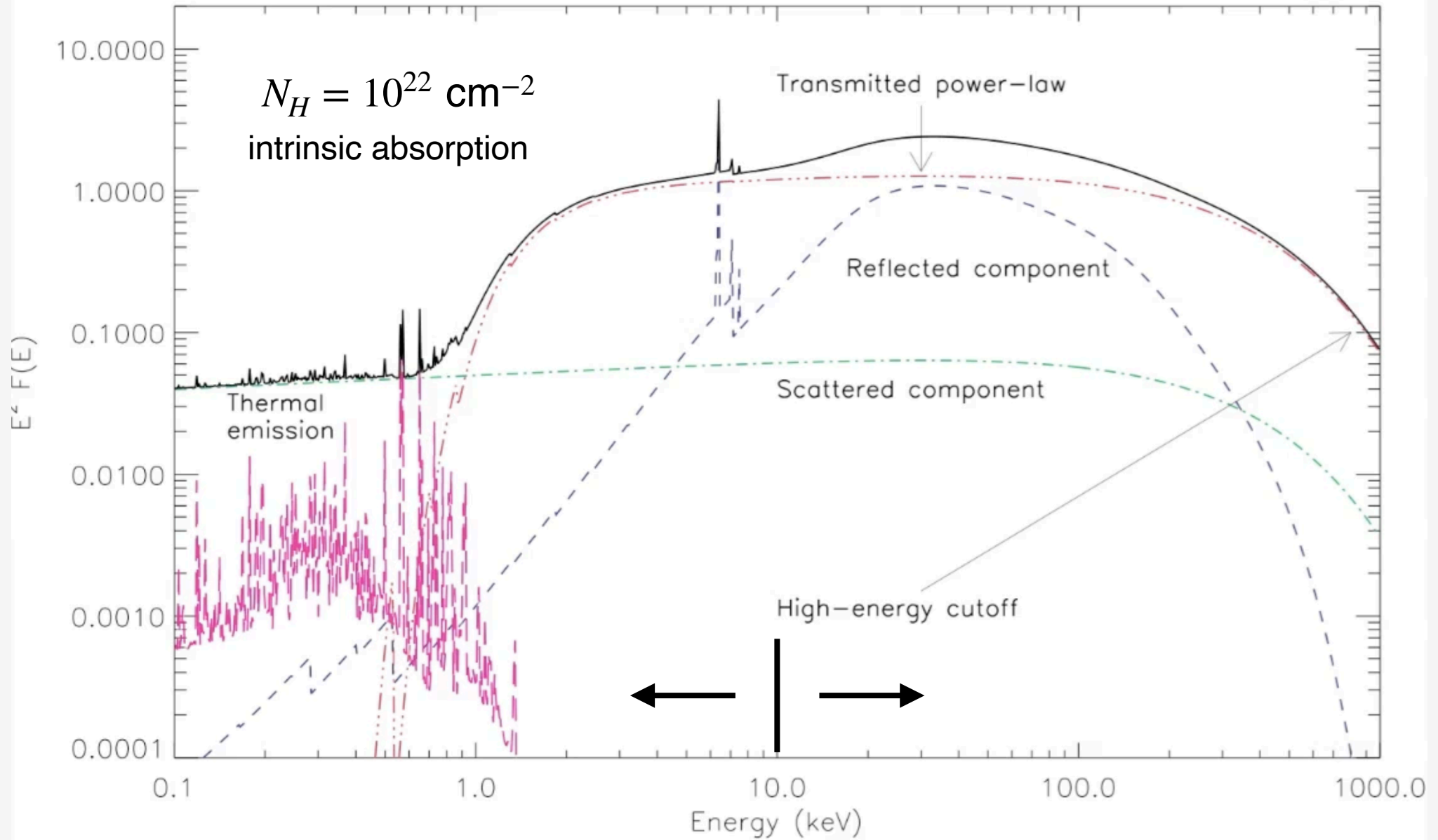
**CT AGN arguably constitute
the most elusive class of
sources**

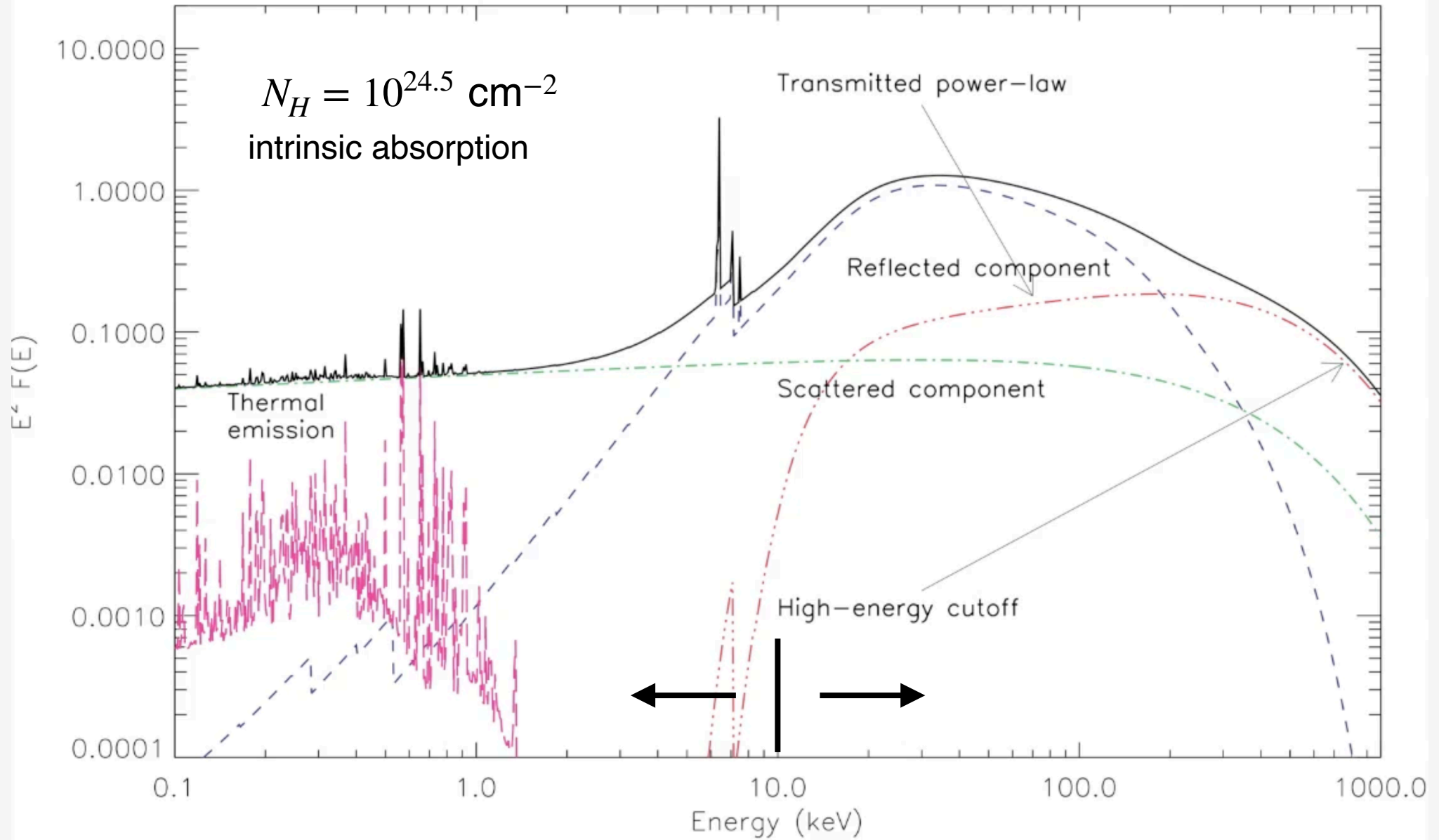
Georgantopoulos 2024

Cosmic X-ray Background
(population synthesis model)



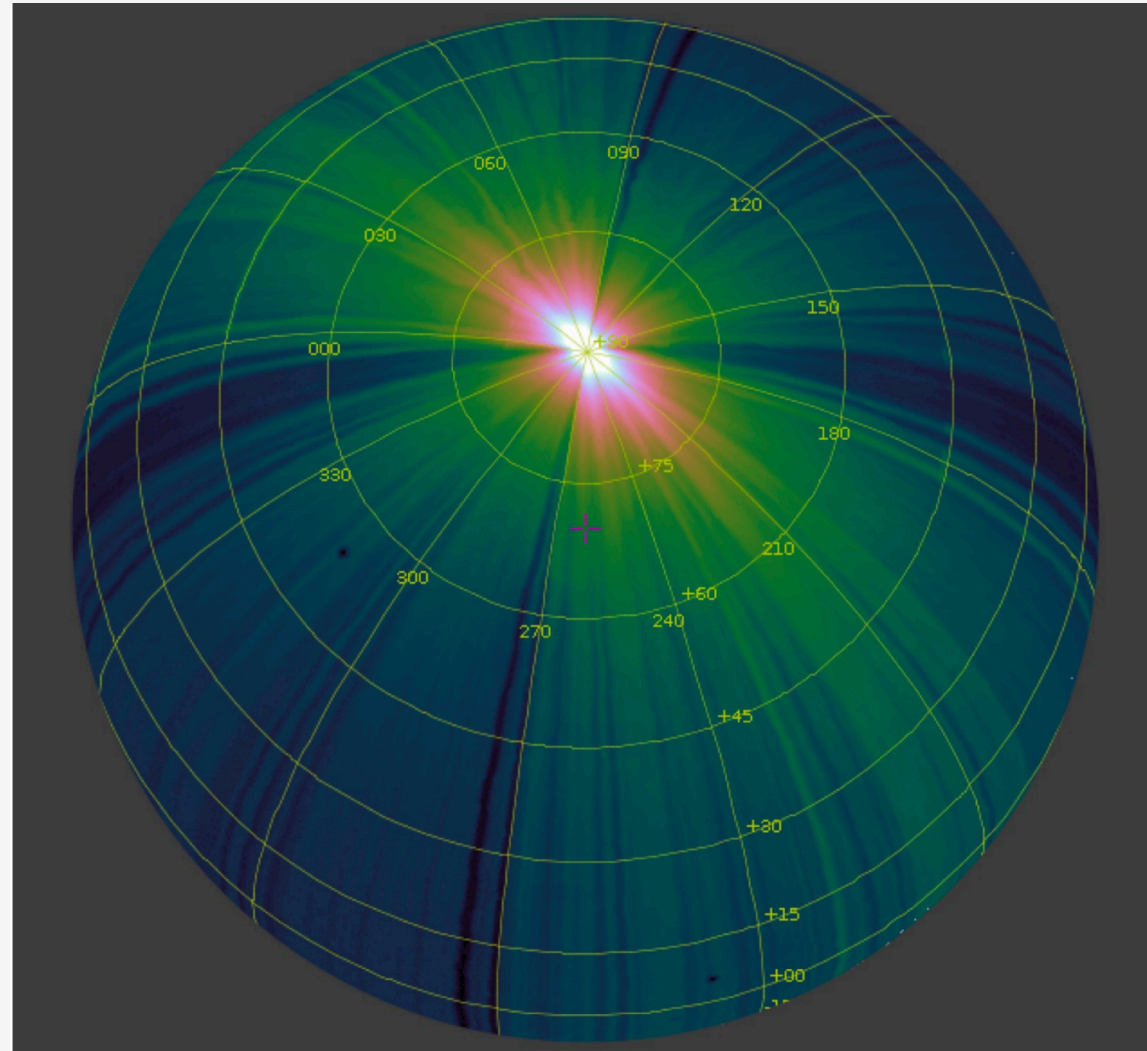






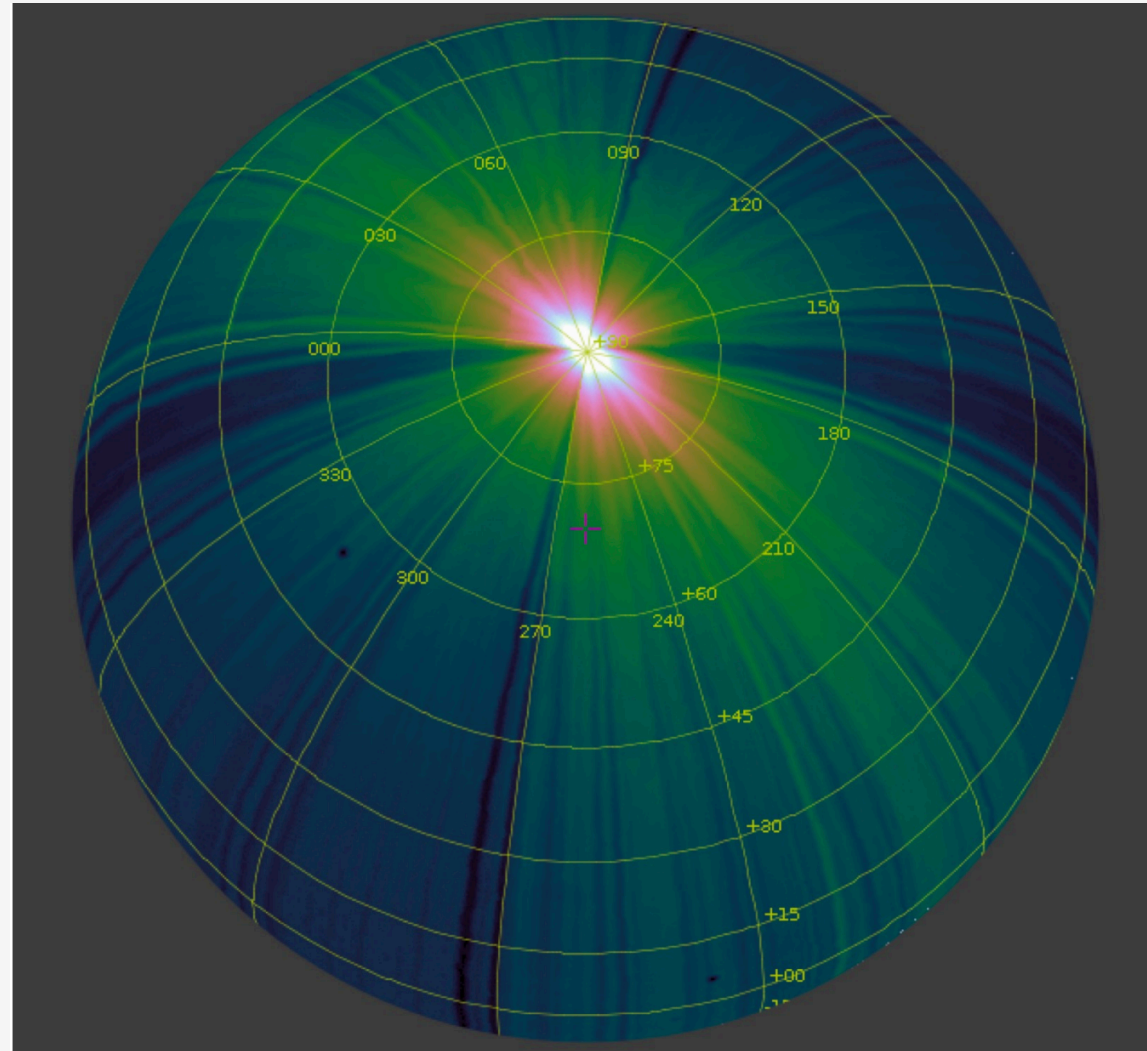
- Large field of view, all sky survey

Eastern Galactic hemisphere exposure map



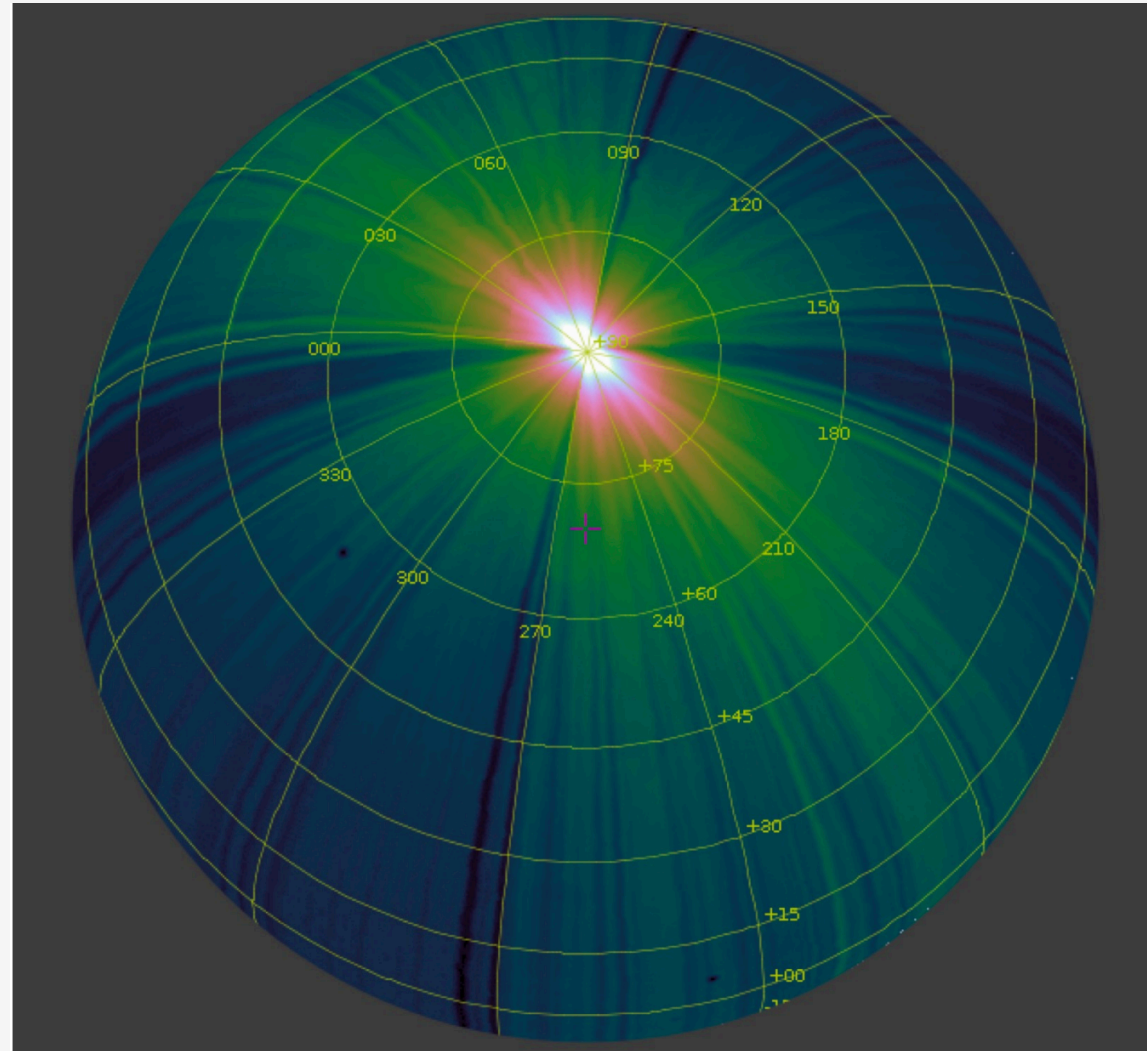
- Large field of view, all sky survey
- Operates below 10 keV

Eastern Galactic hemisphere exposure map



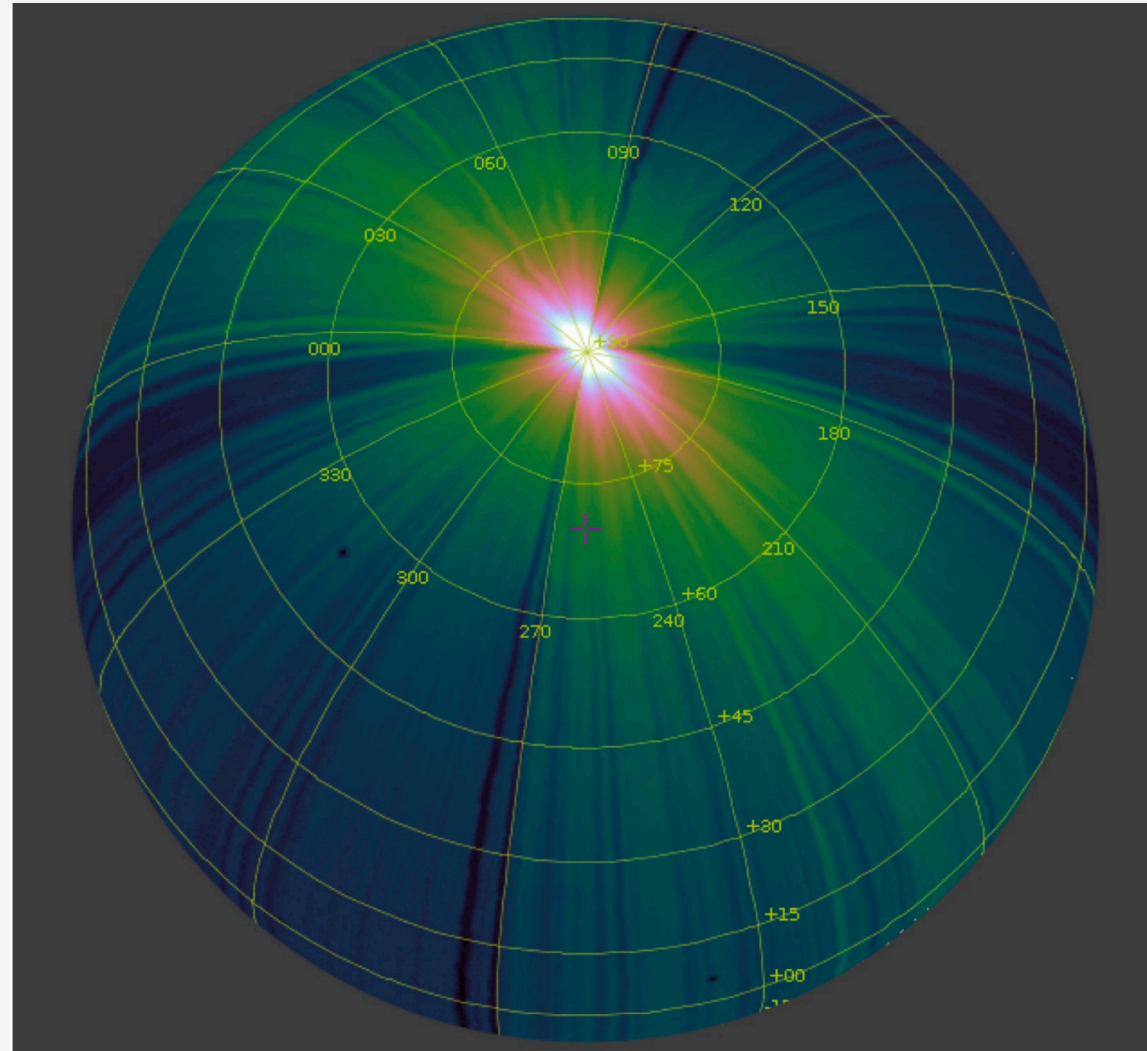
- Large field of view, all sky survey
- Operates below 10 keV
- What are the features of heavily obscured AGNs below 10 keV?

Eastern Galactic hemisphere exposure map



- Large field of view, all sky survey
- Operates below 10 keV
- What are the features of heavily obscured AGNs below 10 keV?
- The exposure is uneven

Eastern Galactic hemisphere exposure map

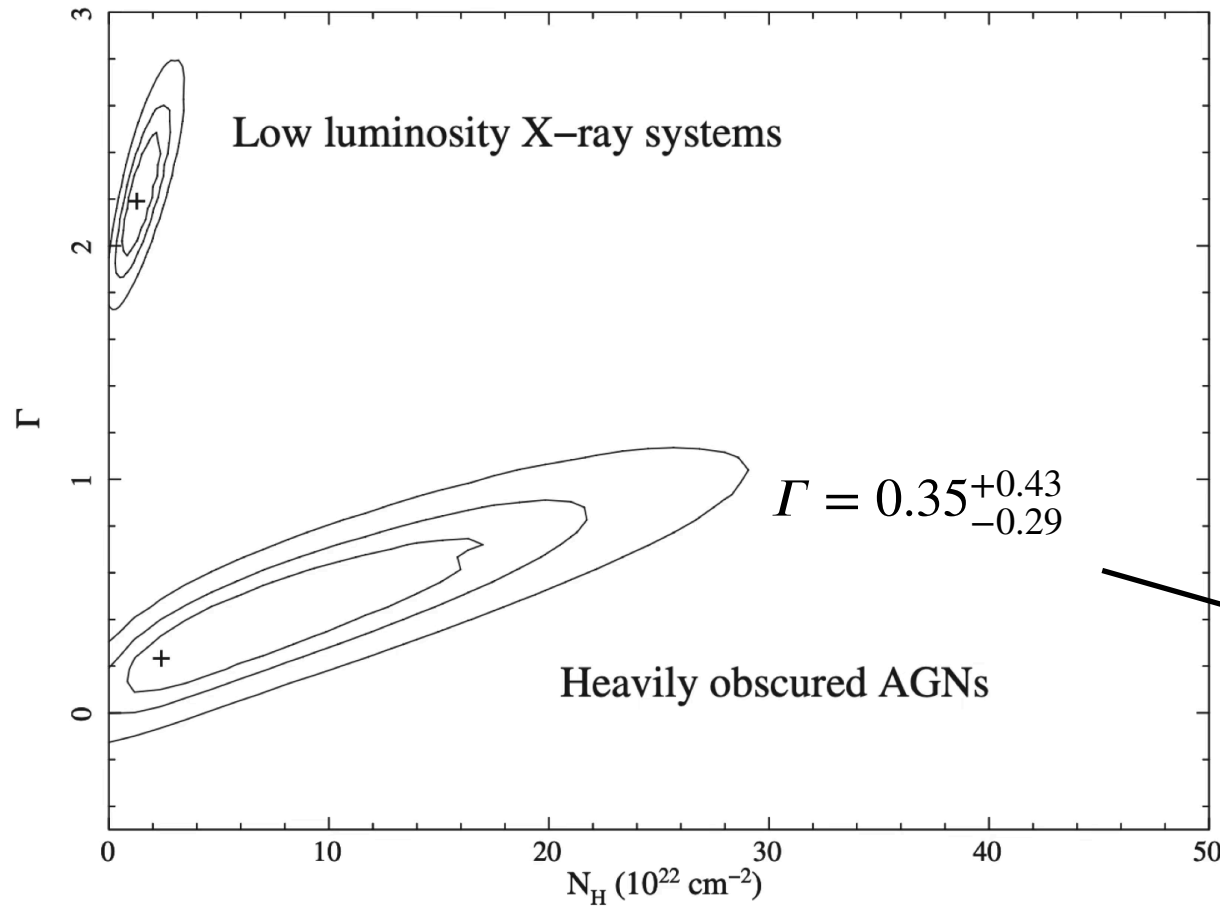


The goal of our work

Find heavily obscured (Compton-thick) AGN candidates in SRG/eROSITA Eastern Galactic hemisphere survey with a simple yet reliable method

CT AGN photon indexes below 10 keV

Alexander, Bauer, Brandt et al. 2011



Flat intrinsic X-ray spectral slope is inconsistent with

- that found for typical AGNs and
- that expected from the inverse Compton scattering of accretion-disk photons i.e., the X-ray emitting "corona"

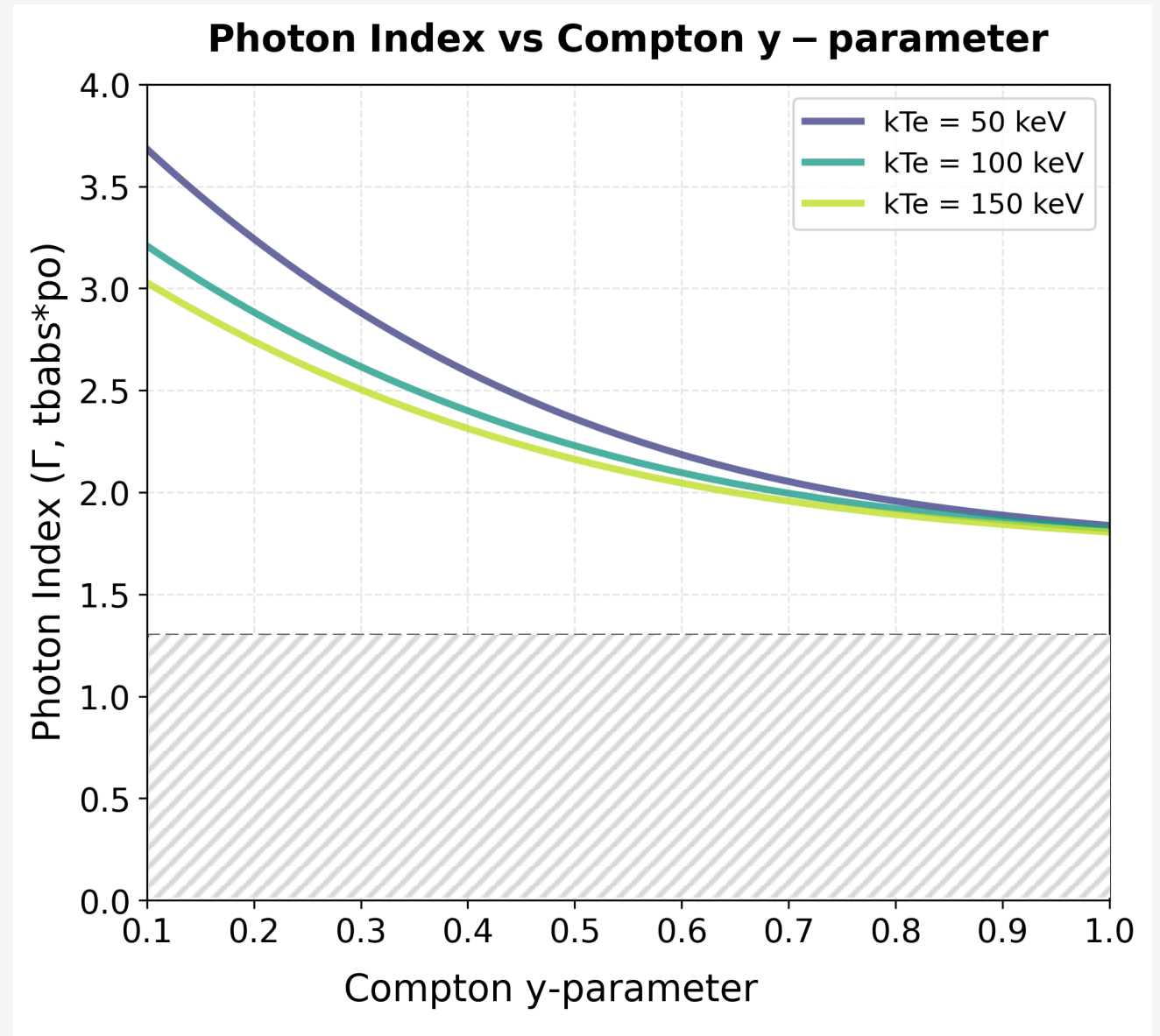
Haardt & Maraschi 1993; Mushotzky et al. 1993;
Reynolds & Nowak 2003

These properties are consistent with a reflection-dominated spectrum, such as that typically identified in Compton-thick AGNs and some heavily obscured Compton-thin AGNs

George & Fabian 1991; Matt et al. 1996, 2000; Ueda et al. 2007; Eguchi et al. 2009; Comastri et al. 2010

Reflected X-ray emission is characterized by the hard flat spectrum

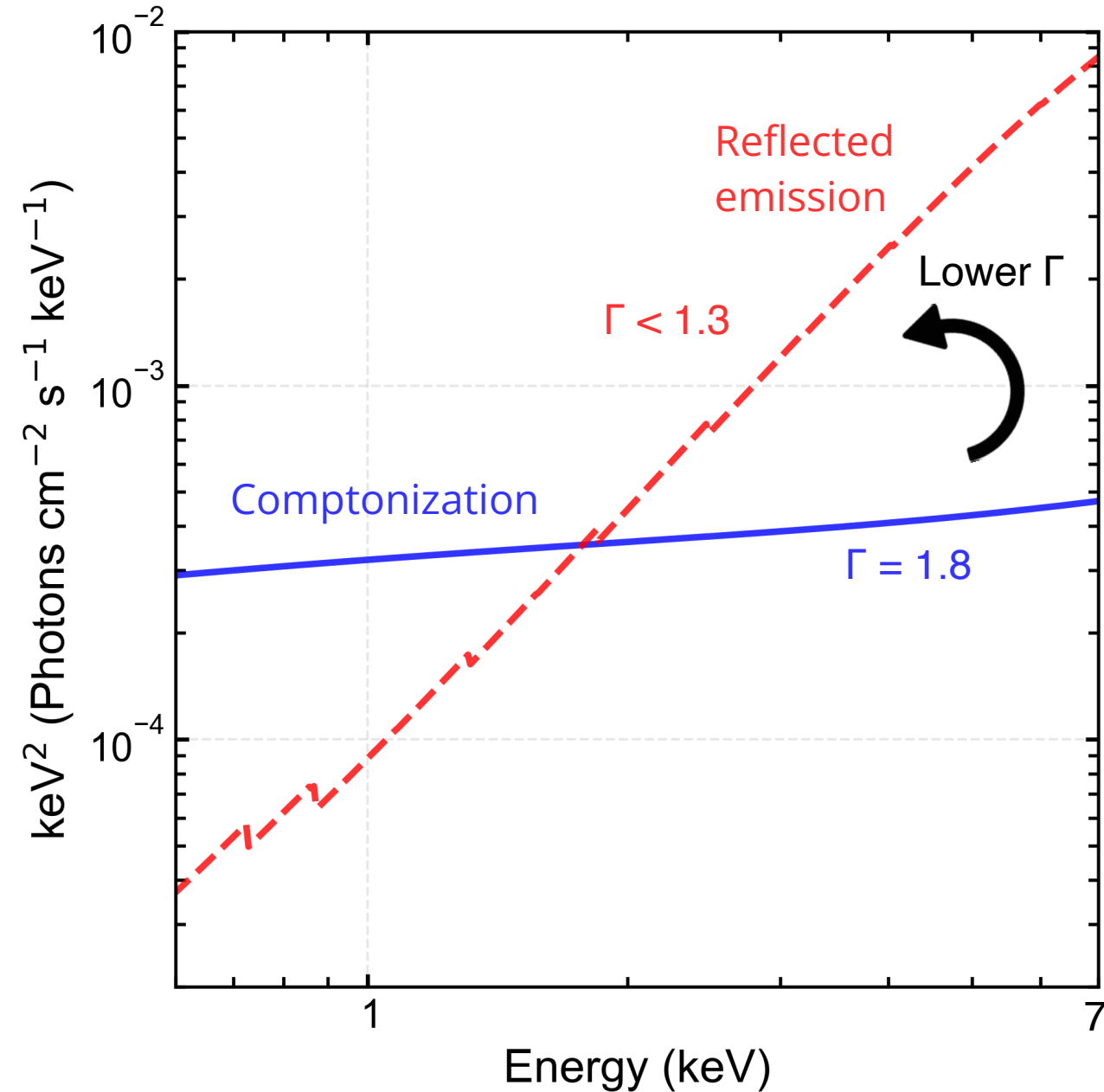
- Typical AGN has a photon index (Γ) about 2 ± 0.2
Nandra & Pounds 1994;
Liu et al. 2022
- An AGN with $\Gamma < 1.3$ can be explained by the reflection-dominated spectrum



Hard and flat X-ray spectra

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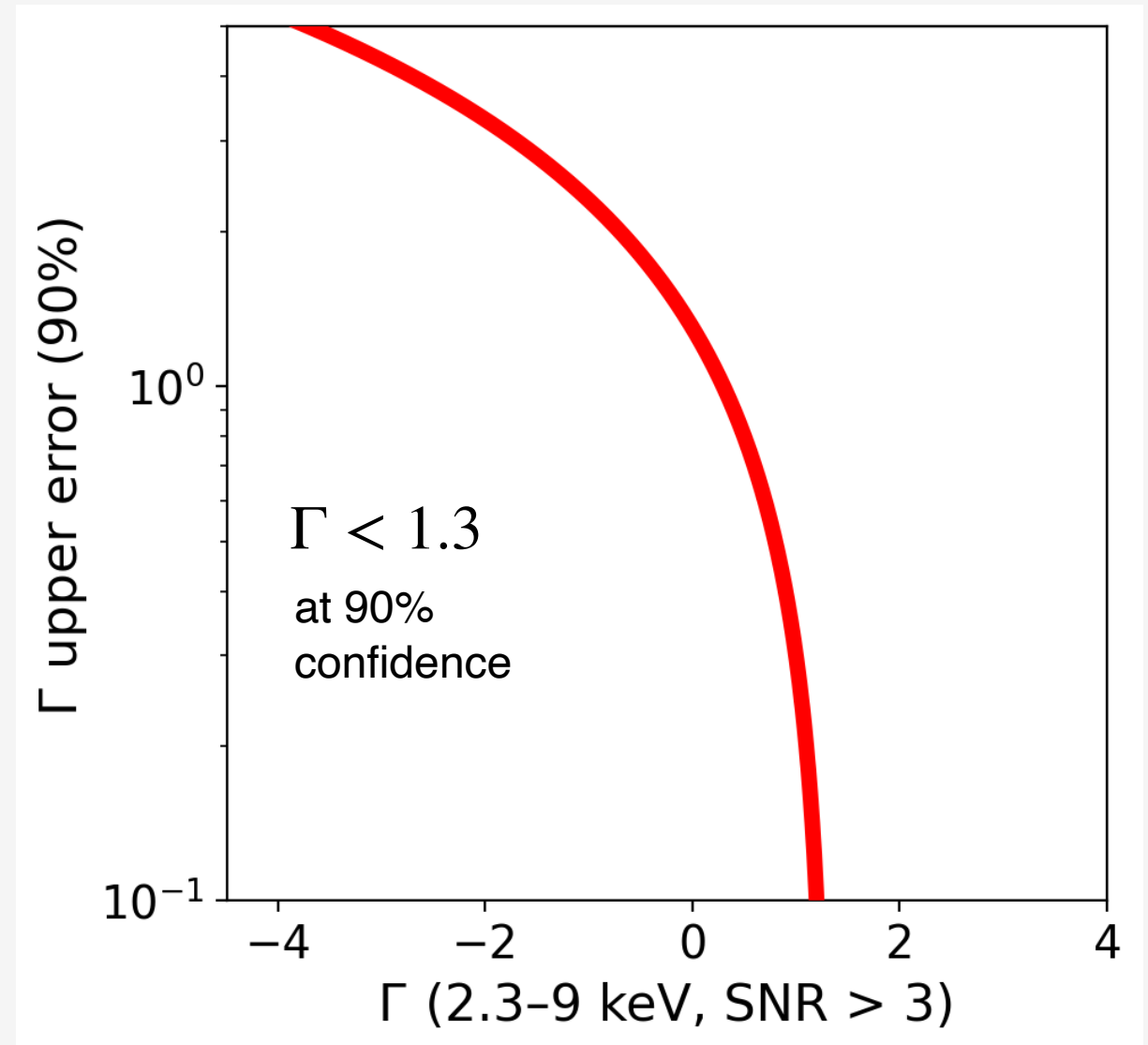
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eROSITA Eastern Galactic hemisphere: extremely hard sources

- Energy band is limited to exclude the soft excess
- Photon index 90% upper bound was measured in 2.3–9 keV
- **Up to 600 sources** have $\Gamma < 1.3$ at 90% confidence

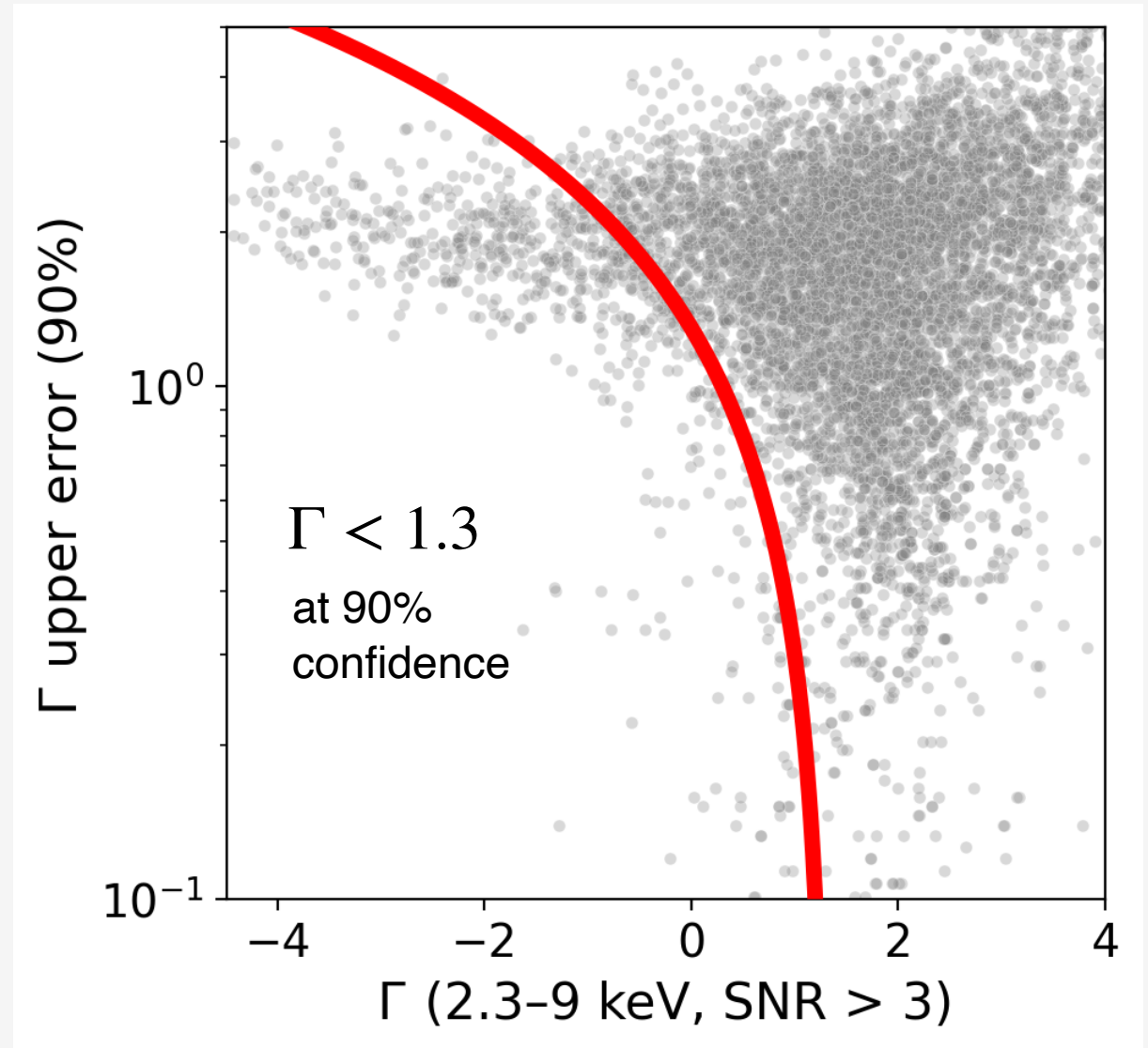
For Lockman Hole (81 source):
arxiv.org/abs/2501.08076



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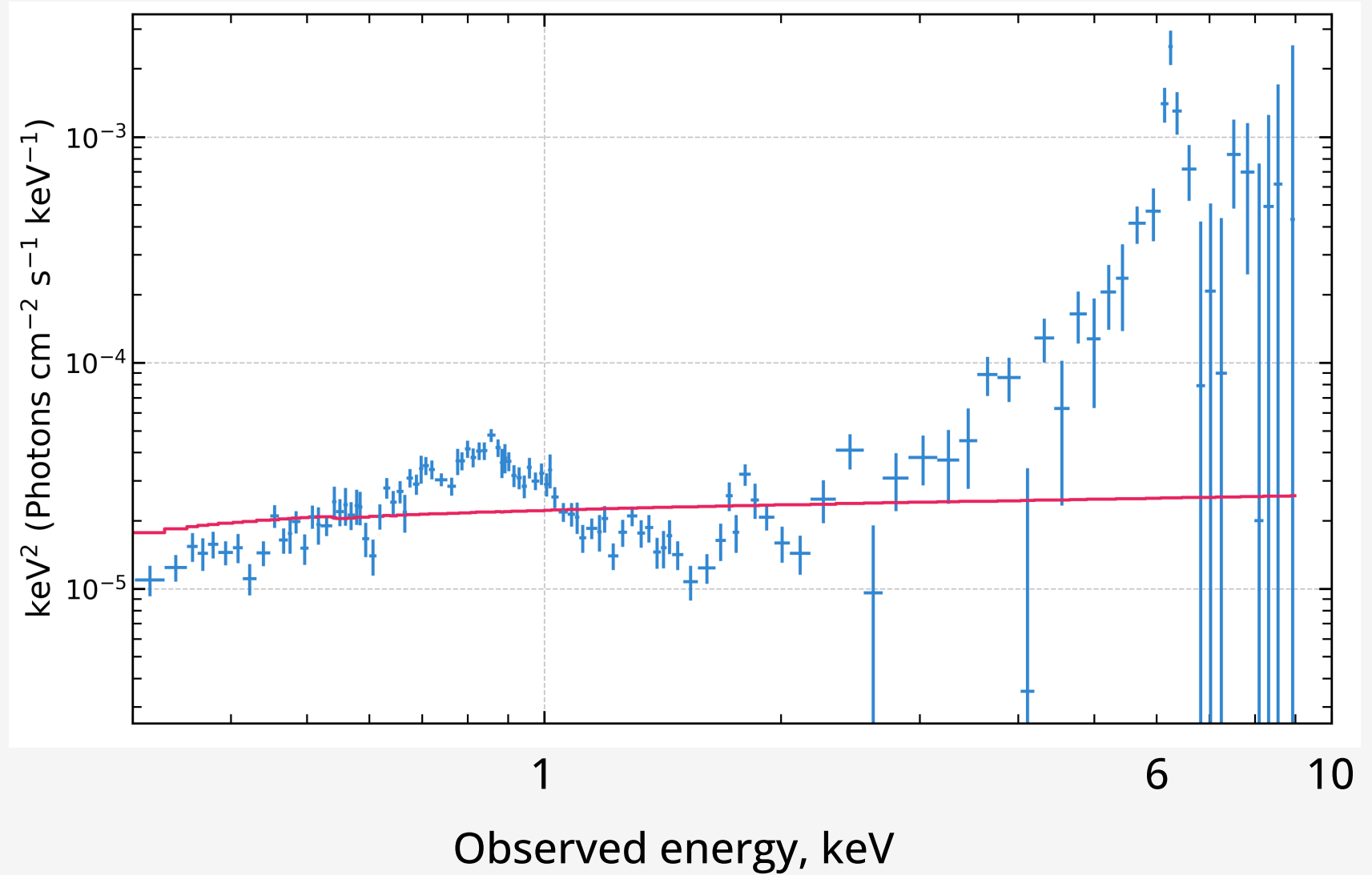


Well-known reflection-dominated CT AGN

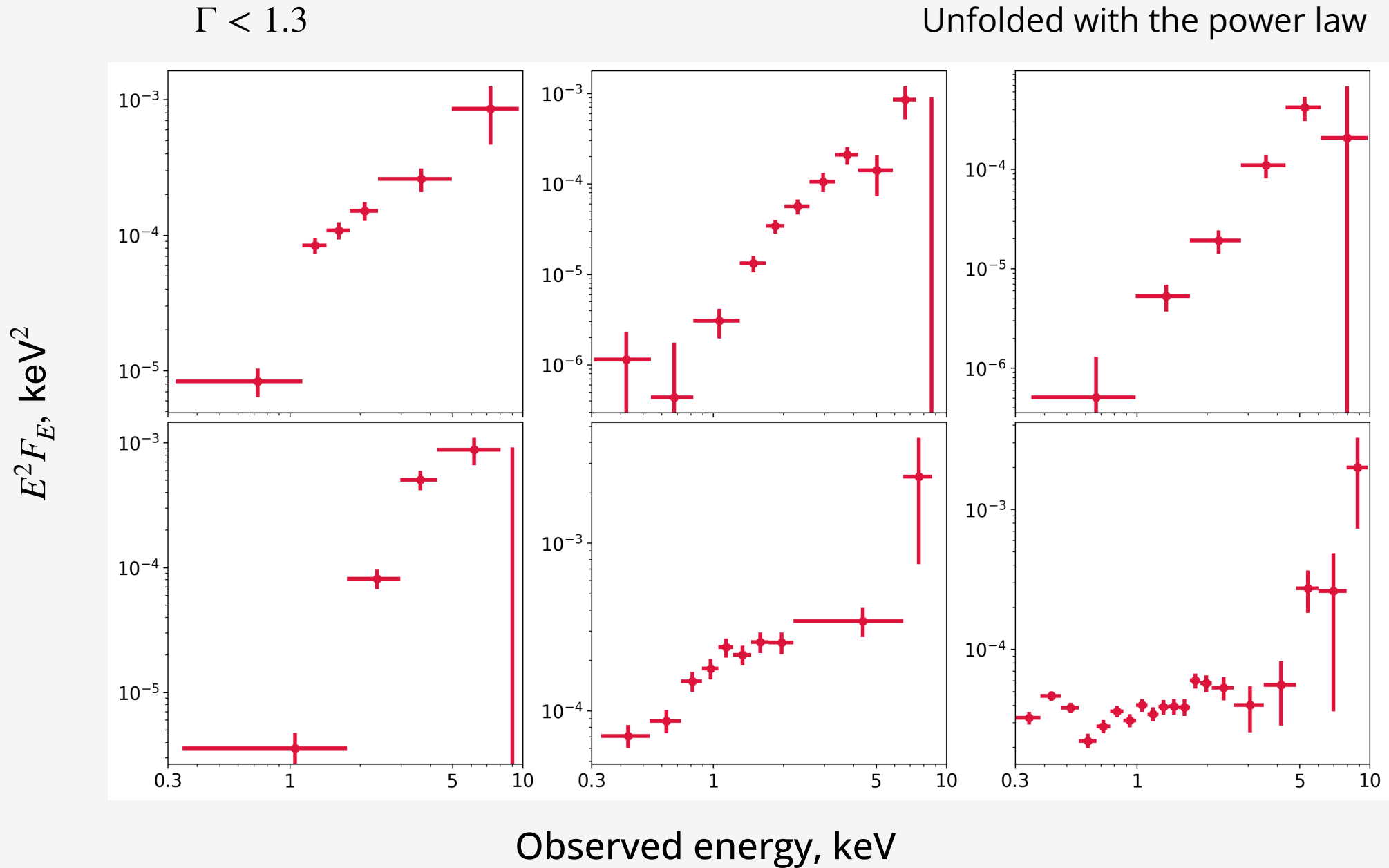
NGC 6552



SRG/eROSITA spectrum



Extremely hard SRG/eROSITA sources



NuSTAR Cycle 12 proposal (approved)

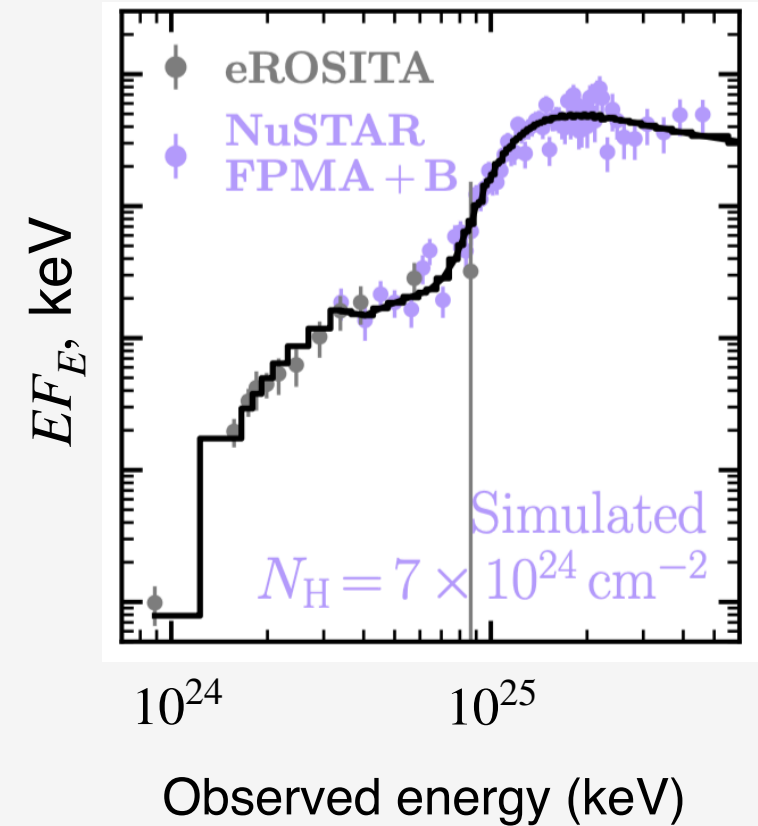
Credit:
D. Stern (PI)
M. Belvedersky
M. Gilfanov
P. Boorman
et al.

Target	spec-z
SRGe J1558+1530	0.264
SRGe J1646+7931	0.526
SRGe J1757+6428	0.340
SRGe J1804+6640	0.920
SRGe J1821+6527	0.295
SRGe J1918+7051	0.100
SRGe J1954+8006	0.159

- *BNsphere* model for line-of-sight column density and then simulated with NuSTAR using an exposure of 20 ks
- The faintest target in the sample will be sufficiently detected to perform detailed spectral modeling



Simulated spectrum



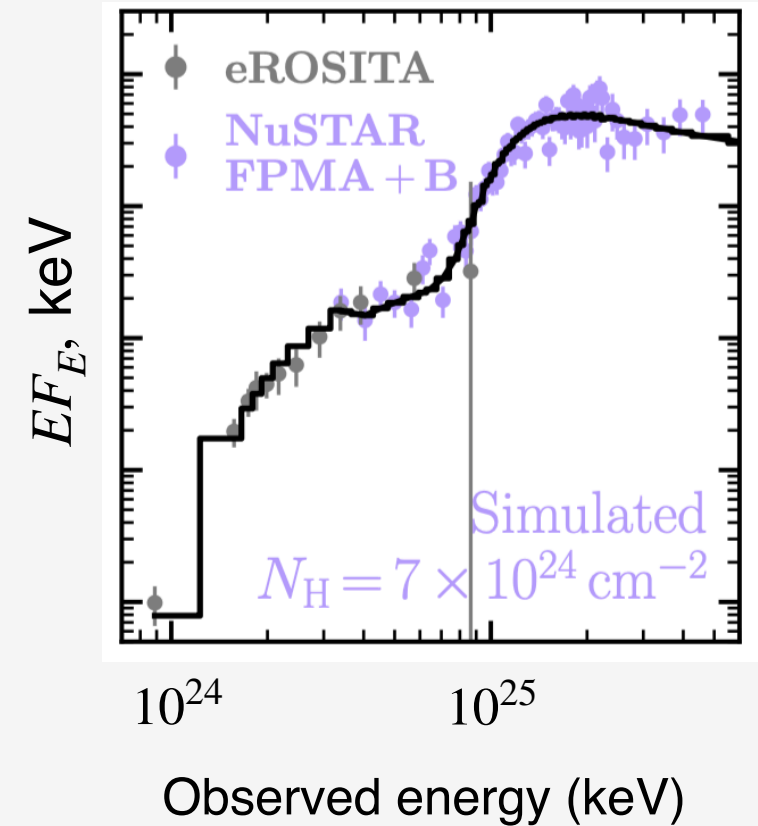
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Target	spec-z	type
SRGe J1558+1530	0.264	1
SRGe J1646+7931	0.526	1.9
SRGe J1757+6428	0.340	1
SRGe J1804+6640	0.920	1
SRGe J1821+6527	0.295	2
SRGe J1918+7051	0.100	2
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Simulated spectrum



Obscured AGN in optical and in X-rays: Type 1 vs Type 2

[Mountrichas et al. 2021](#)

*There is a small number of sources (~15% of the sample) that **present broad lines in their spectra, but they show strong indications of obscuration**, based on SED analysis. These could be systems that are viewed face on and have an extended dust component along the polar direction.*

[Kamraj et al. 2019](#)

*We find this source to be **highly X-ray obscured**, with column densities exceeding 10^{23} cm^{-2} across all epochs of X-ray observations, spanning an 8 yr period. However, the source exhibits prominent broad optical emission lines, **consistent with an unobscured Type 1 AGN classification**.*

[Cox et al. 2025](#)

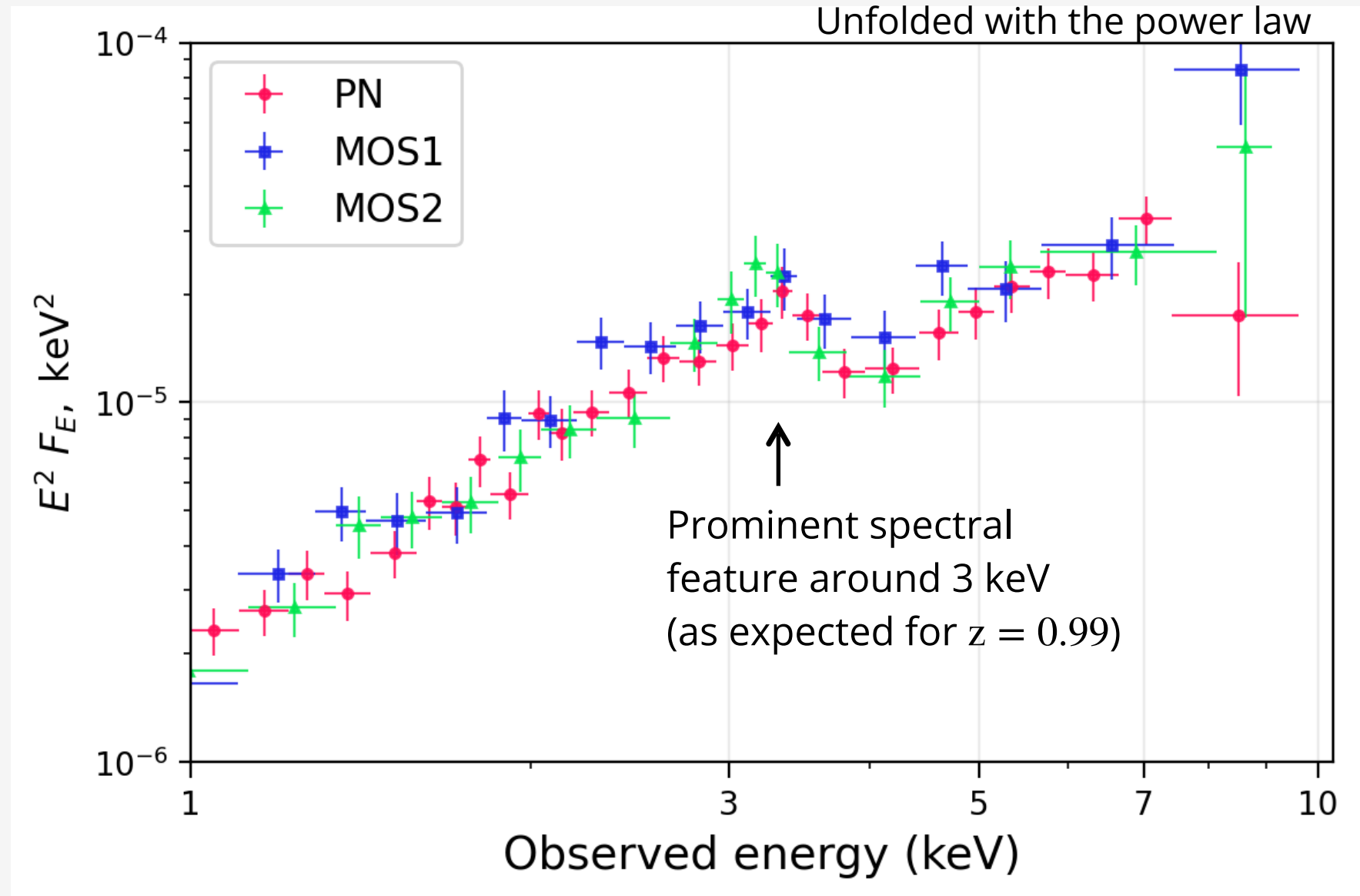
It should also be noted that although we exclude Seyfert 1 galaxies from our selection, they can also be obscured in the X-rays (e.g., G. Risaliti et al. 2001, 2007; A. Merloni et al. 2014; G. Miniutti et al. 2014; T. T. Shimizu et al. 2018; R. Serafinelli et al. 2023).

SRGe J105149.5+573244: archival XMM data

Found with SRG/eROSITA
in Lockman hole region

An archival >1 Ms
exposure XMM-Newton
observation is available

spec $z = 0.99$



SRGe J105149.5+573244: X-ray reflection

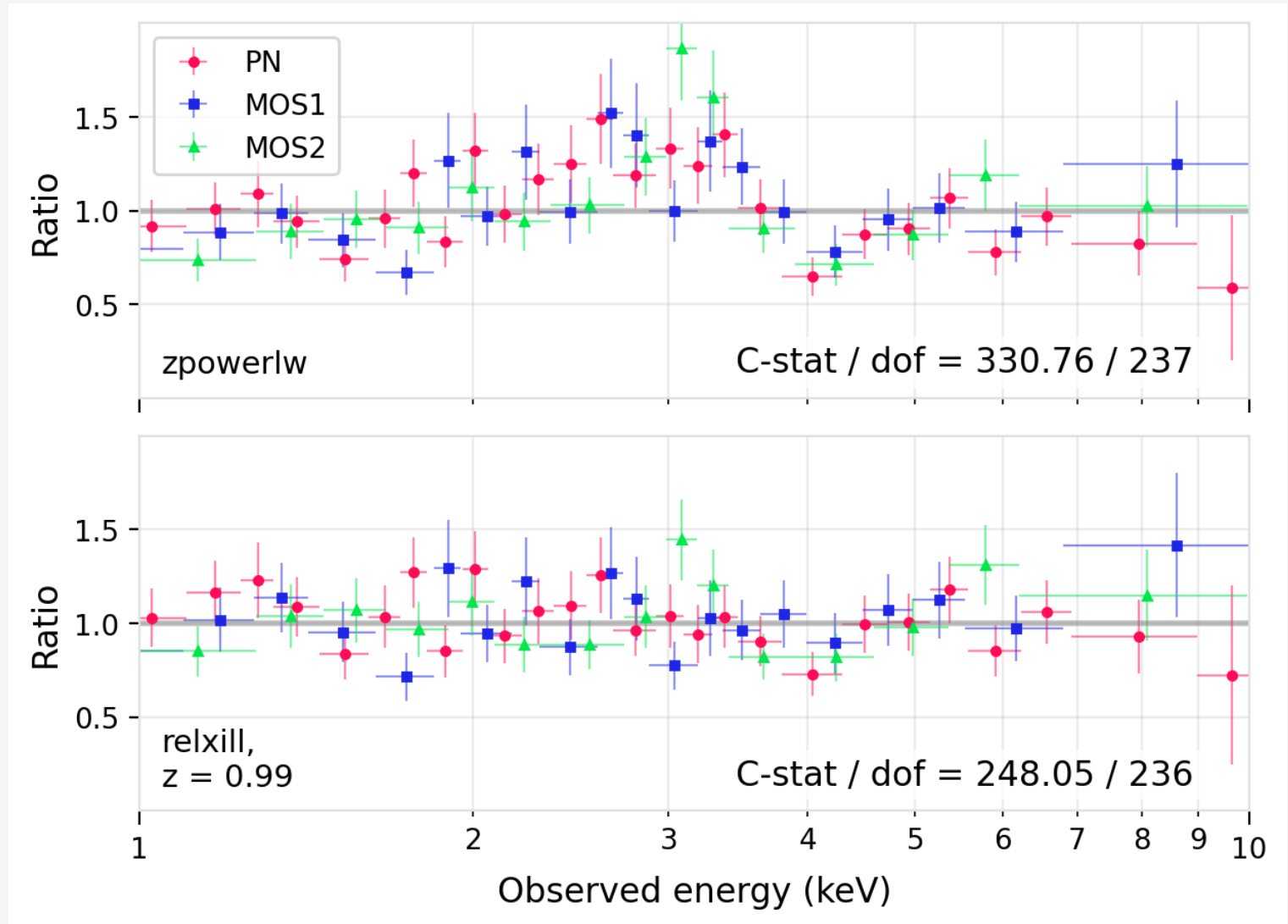
An archival ~ 1 Ms exposure

XMM-Newton observation of
SRGe J105149.5+573244

spec $z = 0.99$

Two possible scenarios:

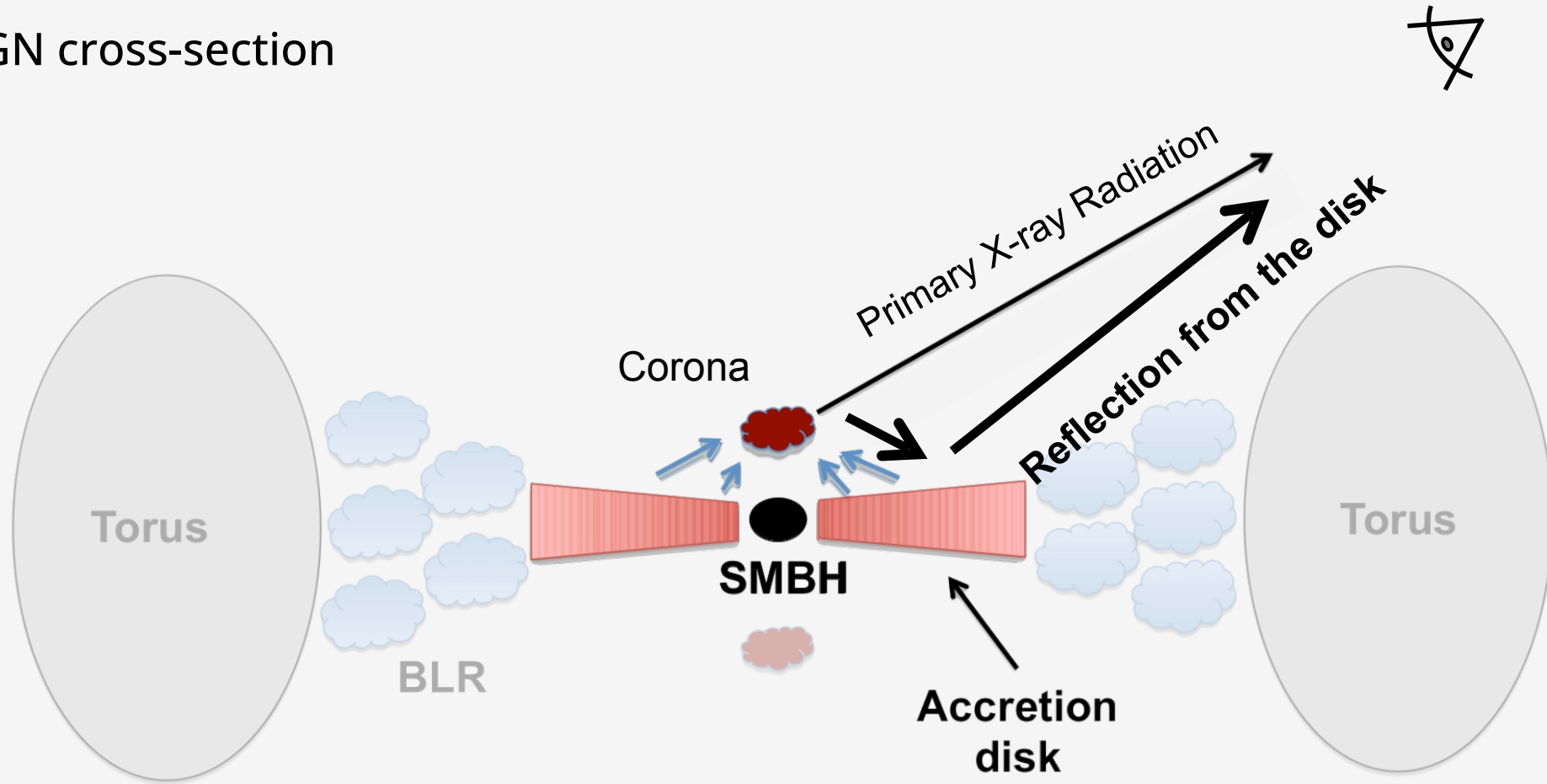
- Disk reflection (broadened Fe line) — why we do not see the direct emission?
- Torus reflector (K-edge) — why Fe line equivalent width < 100 eV?



$$\text{Refl frac} = -1 \quad R_{in} < 5r_g \quad A_{fe} \approx 0.9 \quad a > 0.9$$

X-ray disk reflection in AGNs

An AGN cross-section



Based on C. Ricci
claudioricci.eu/research

Results

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- There are well-known heavily obscured reflection-dominated AGNs among them
- Archival XMM-Newton data for SRGe J105149.5+573244 shows spectral feature near 6.4 keV (rest frame) that can be explained by the reflected emission
- 7 targets were approved for the NuSTAR observations (Cycle 12)