

ATHENA:

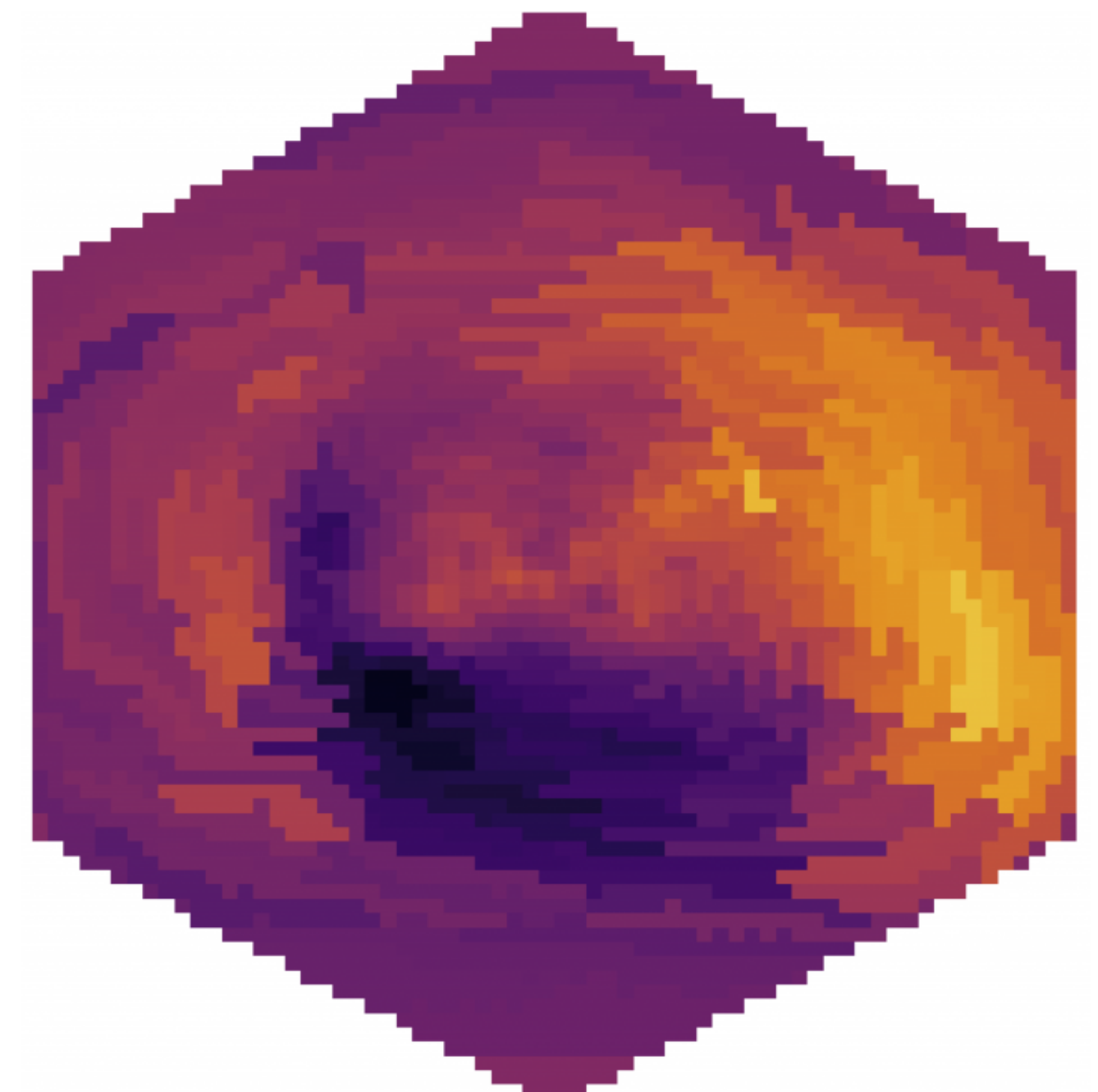
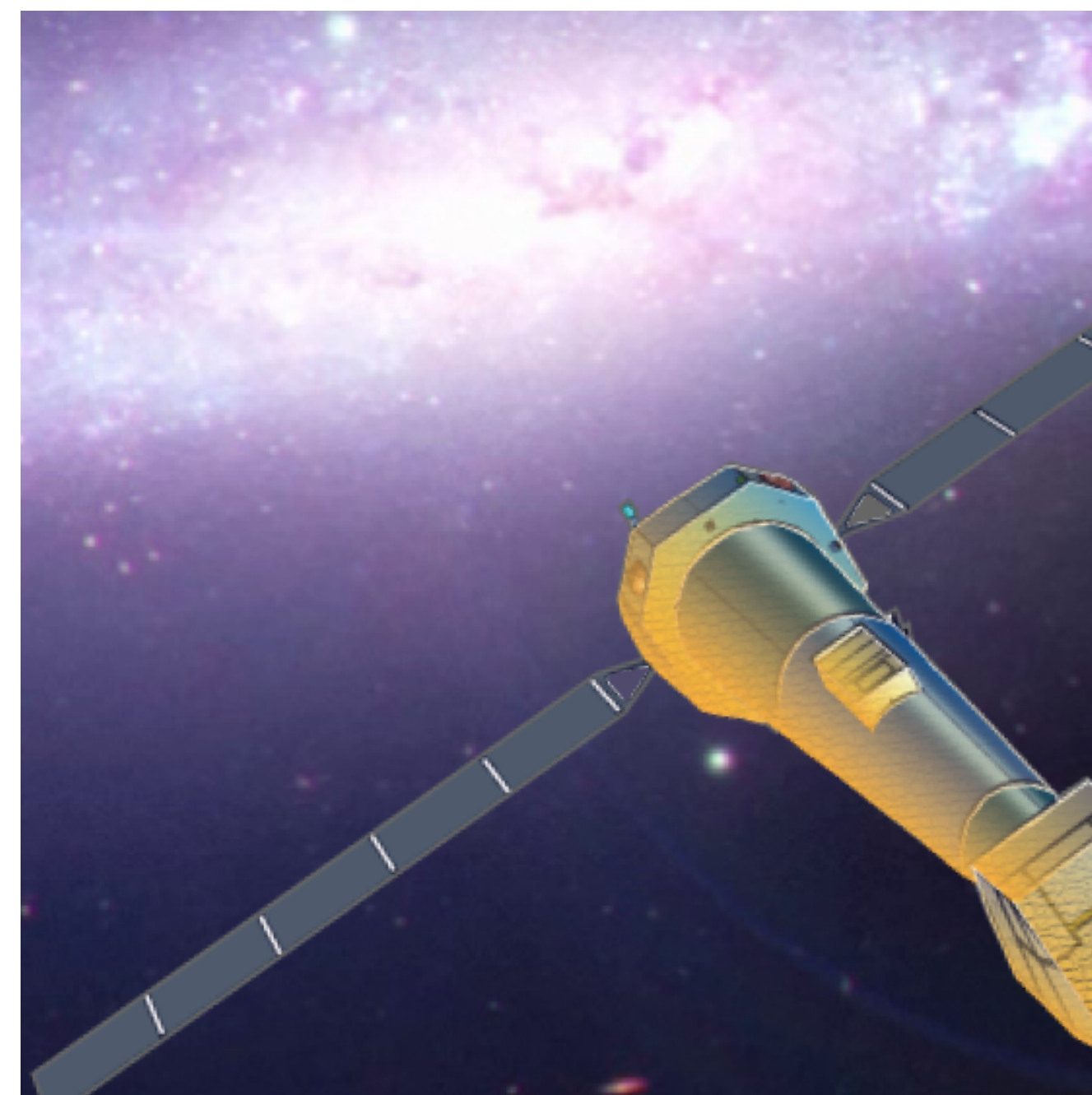
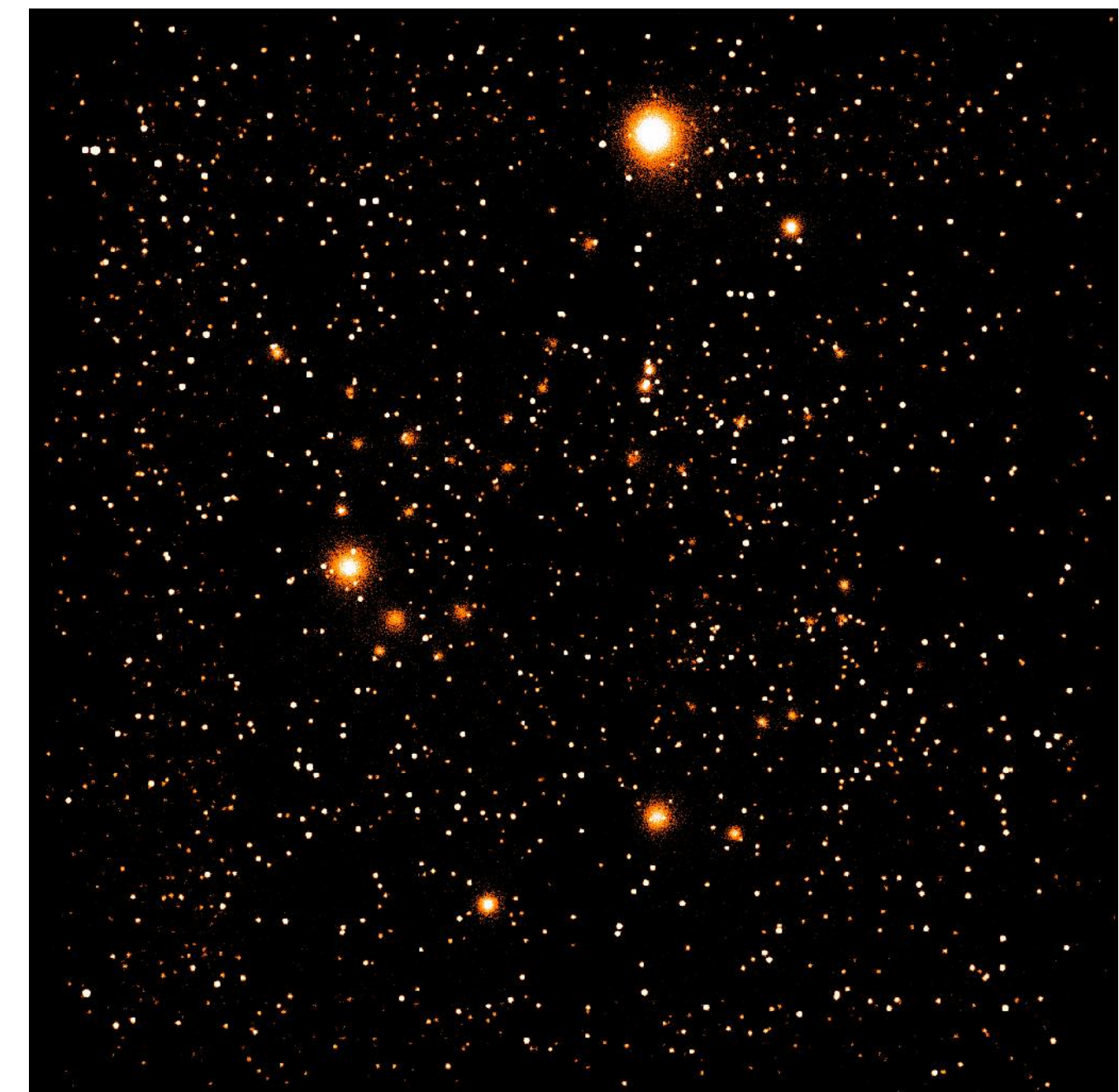
X-ray Observatory

Arne Rau

**(Project Scientist of DE-led
WFI Instrument)**

Max Planck Institute for Extraterrestrial Physics

AG Tagung, Stuttgart, Sep 19th 2019

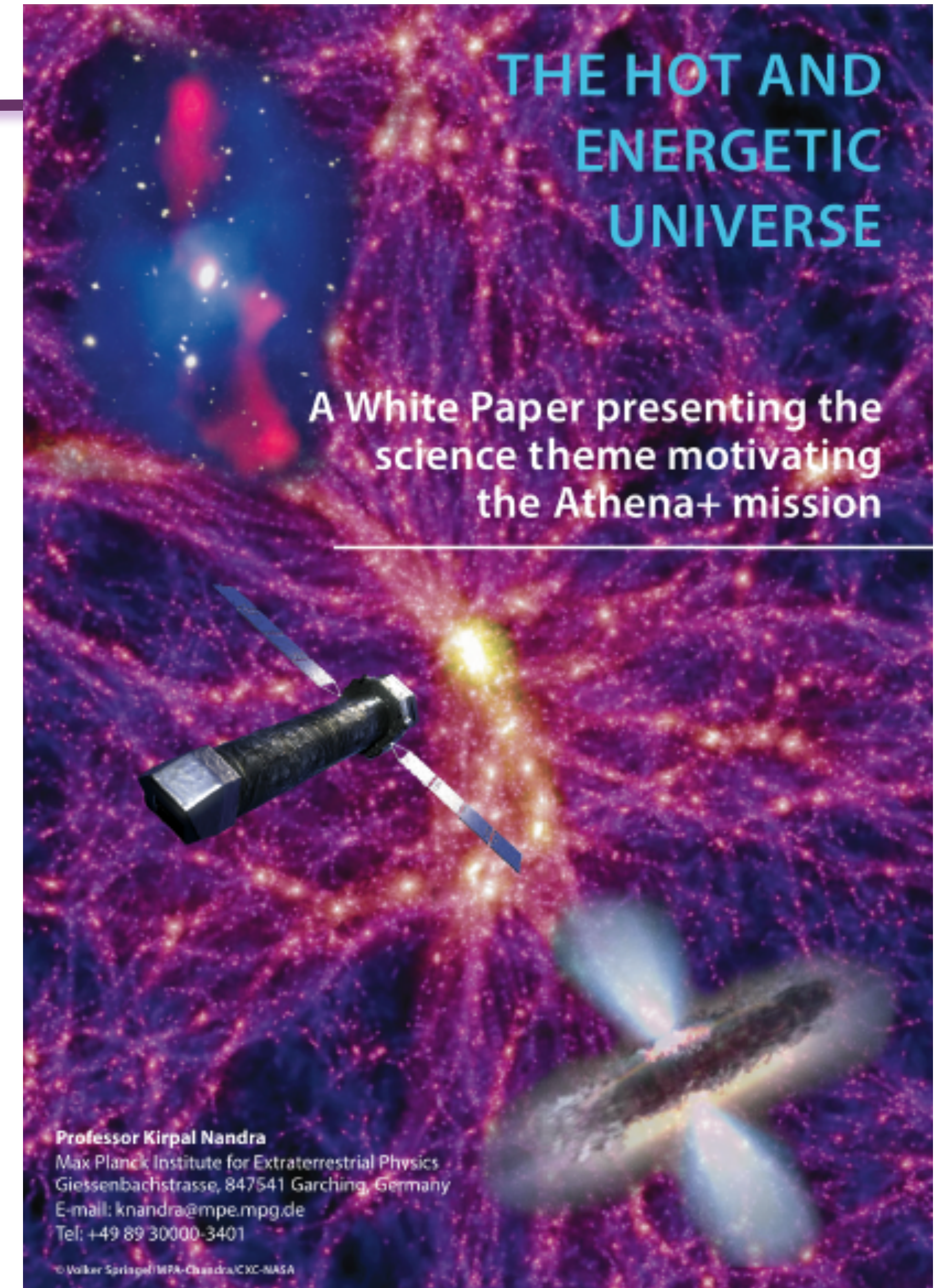


The ESA Mission to explore

**The Hot and Energetic
Universe**

The Hot and Energetic Universe

- Key Questions:
 - How does ordinary matter assemble into the large-scale structures we see today?
 - How do black holes grow and shape the Universe?
- Requires sensitive high resolution X-ray spectroscopy and deep wide field imaging
- Science theme selected by ESA in 2013 based on Senior Survey Committee recommendation
- Athena selected in 2014 as next large mission of ESA's Cosmic Vision program

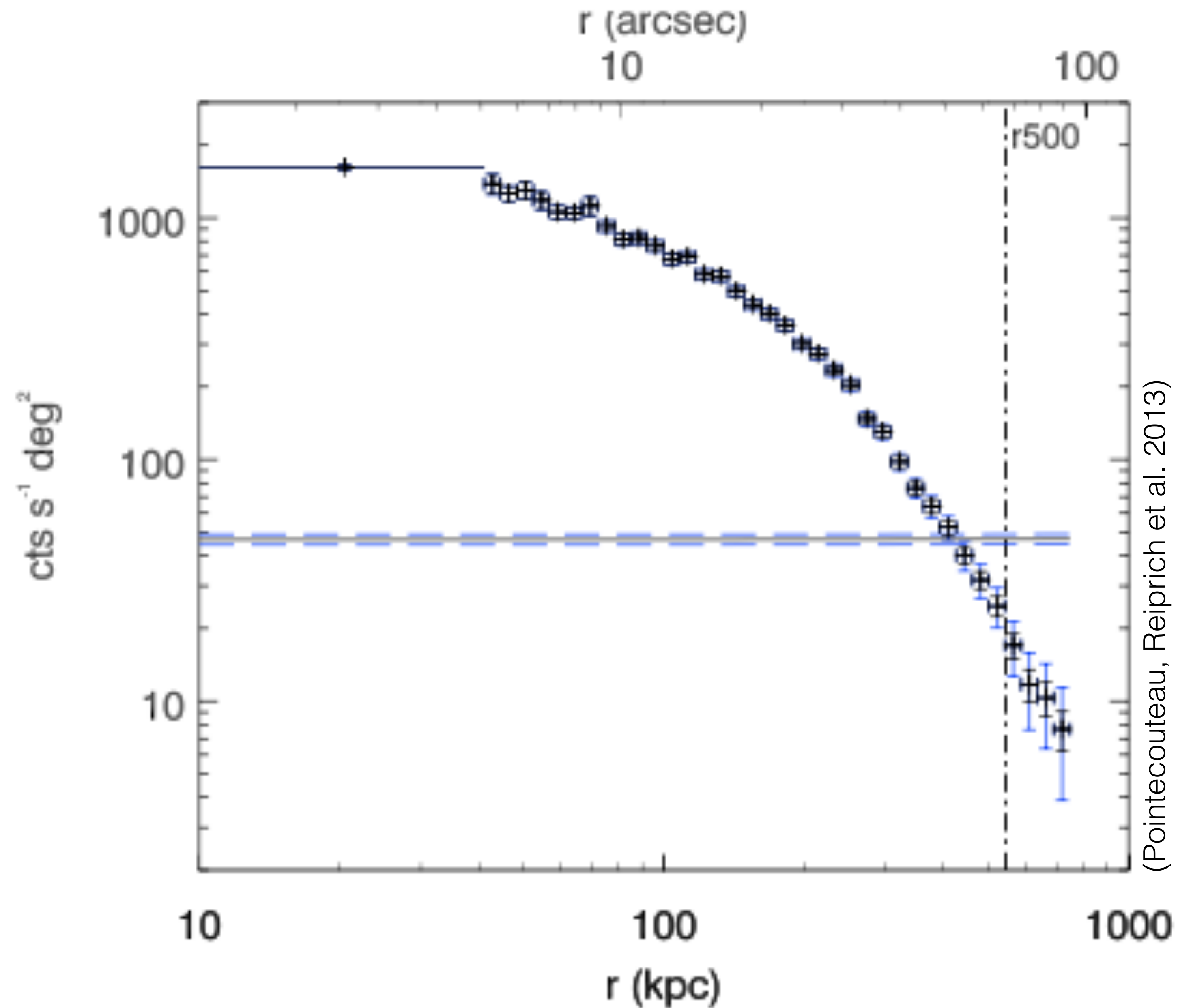


The Hot Universe

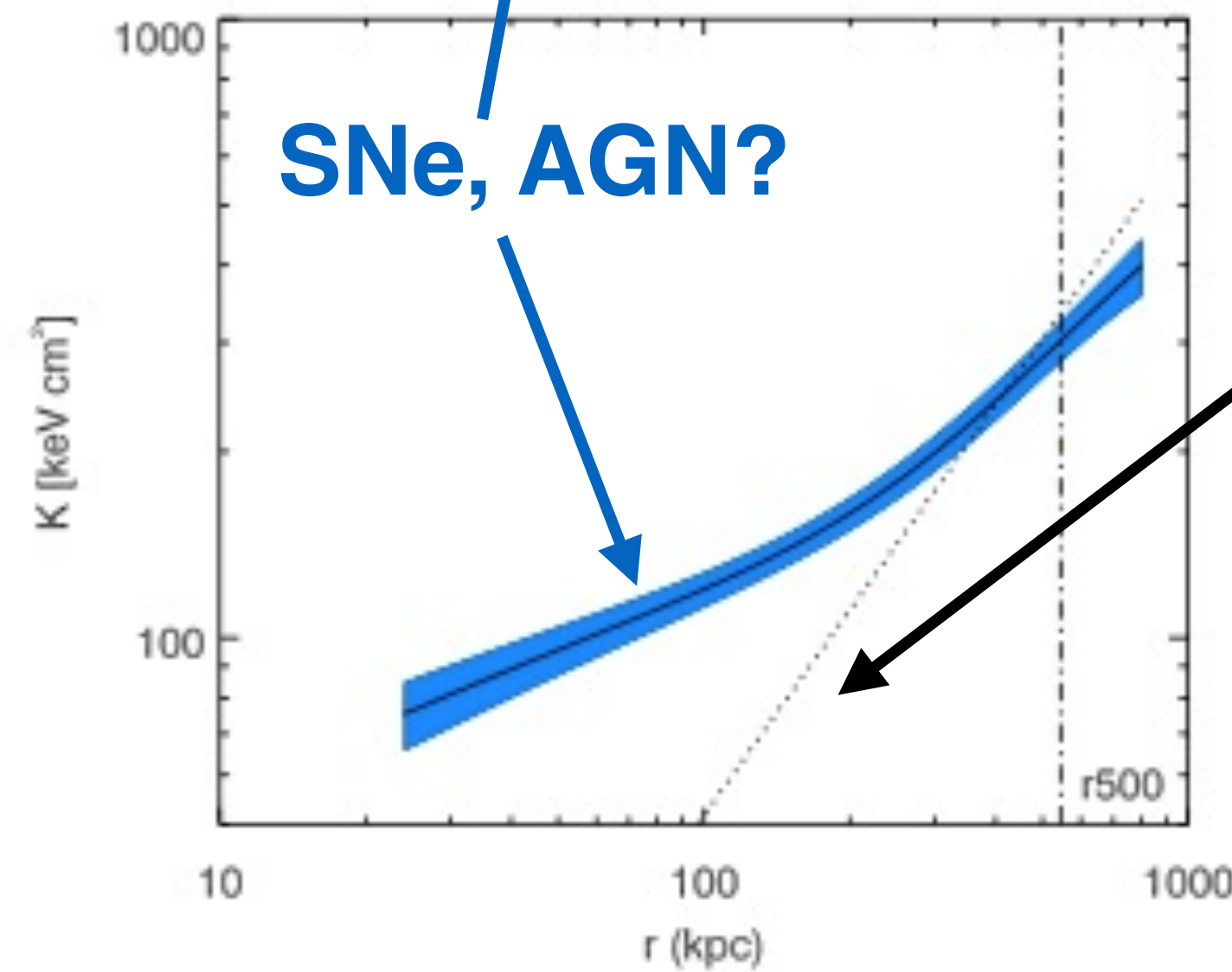
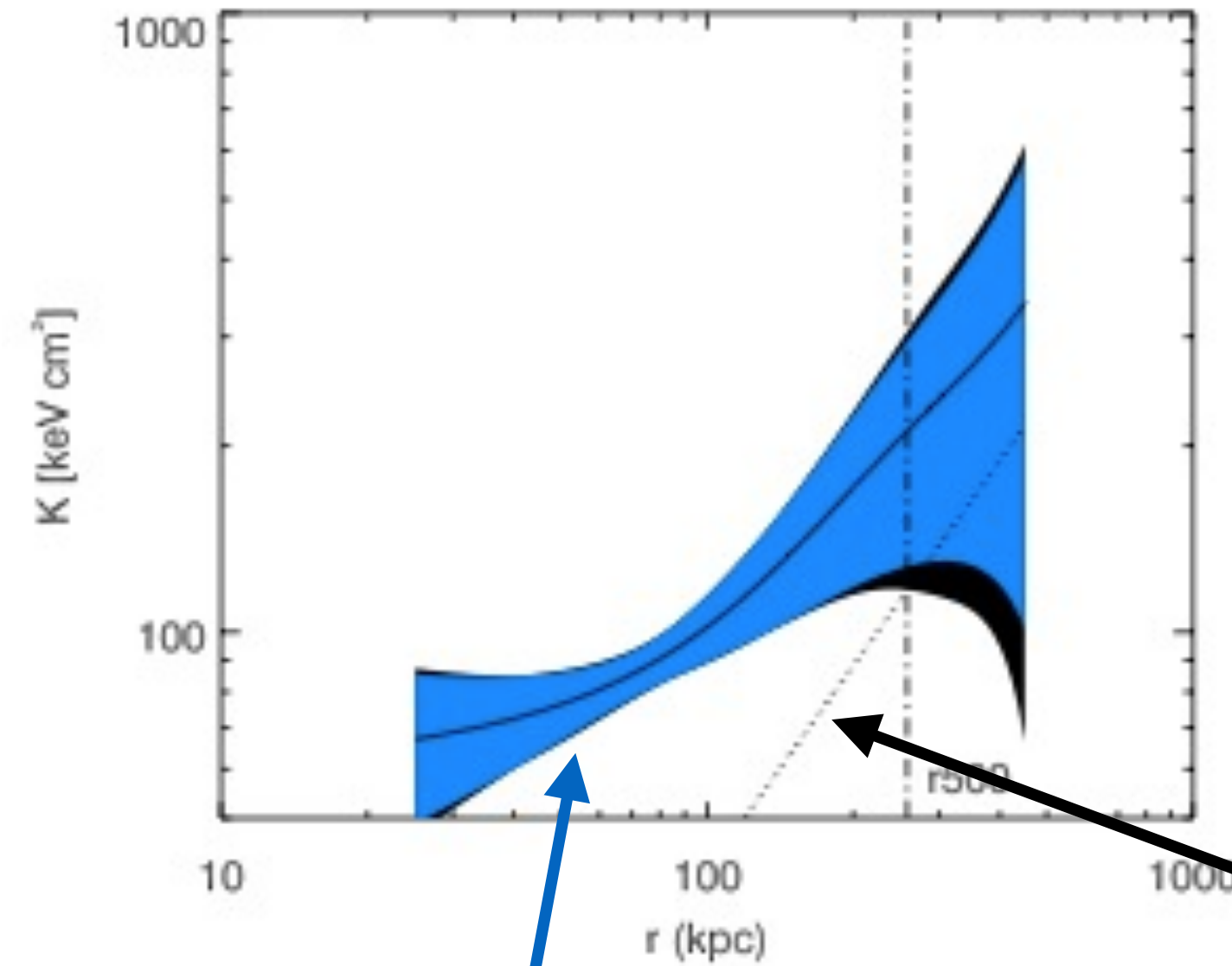
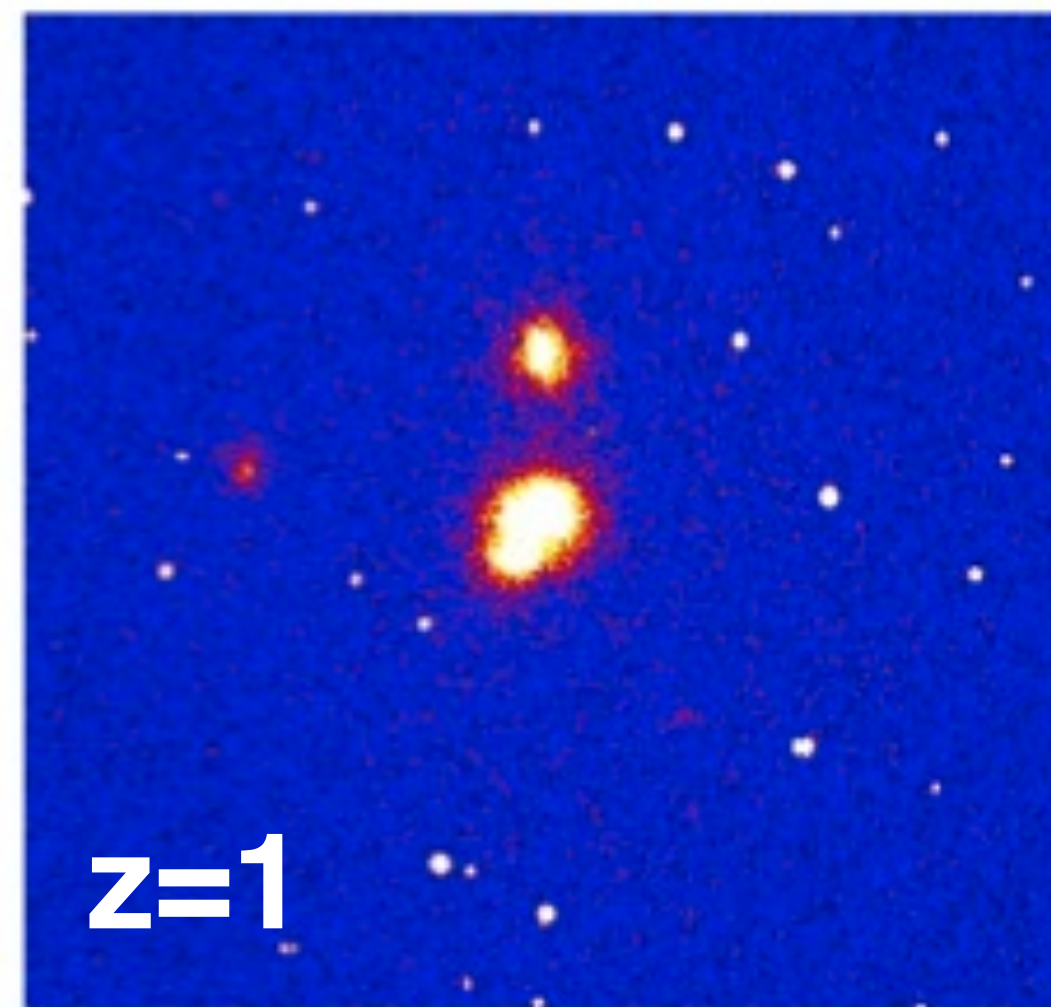
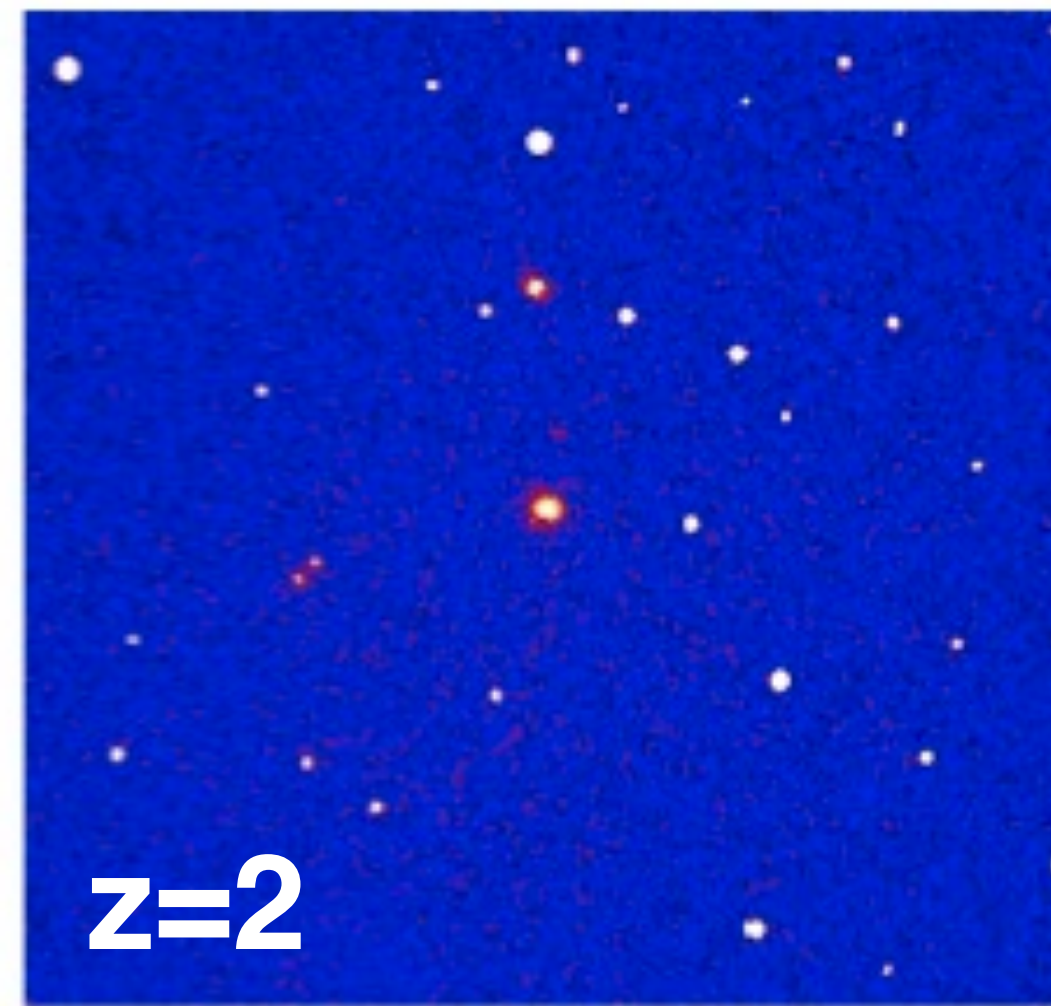


Perseus Cluster: Optical

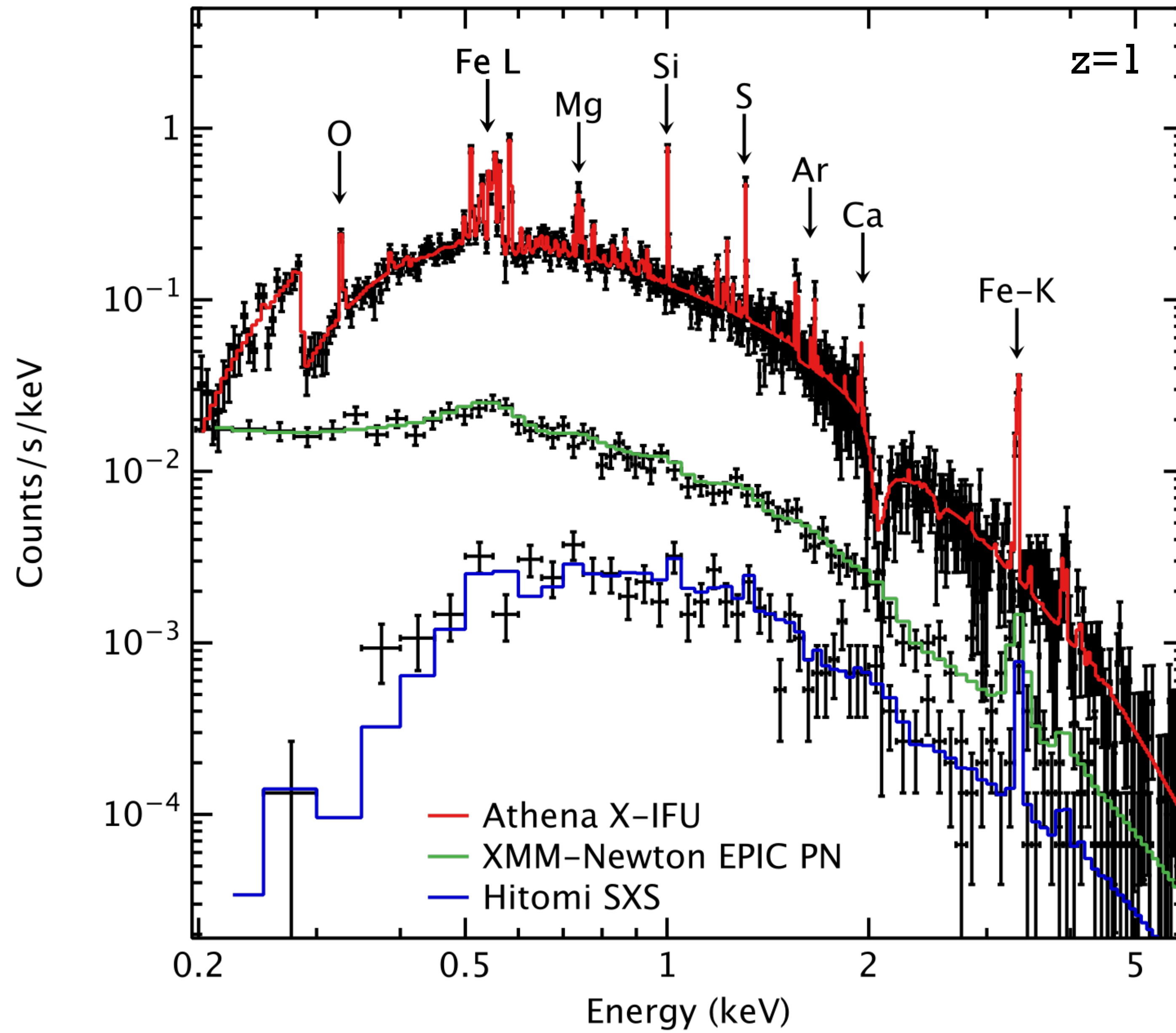
Thermal history of hot baryons in clusters up to $z \sim 2$



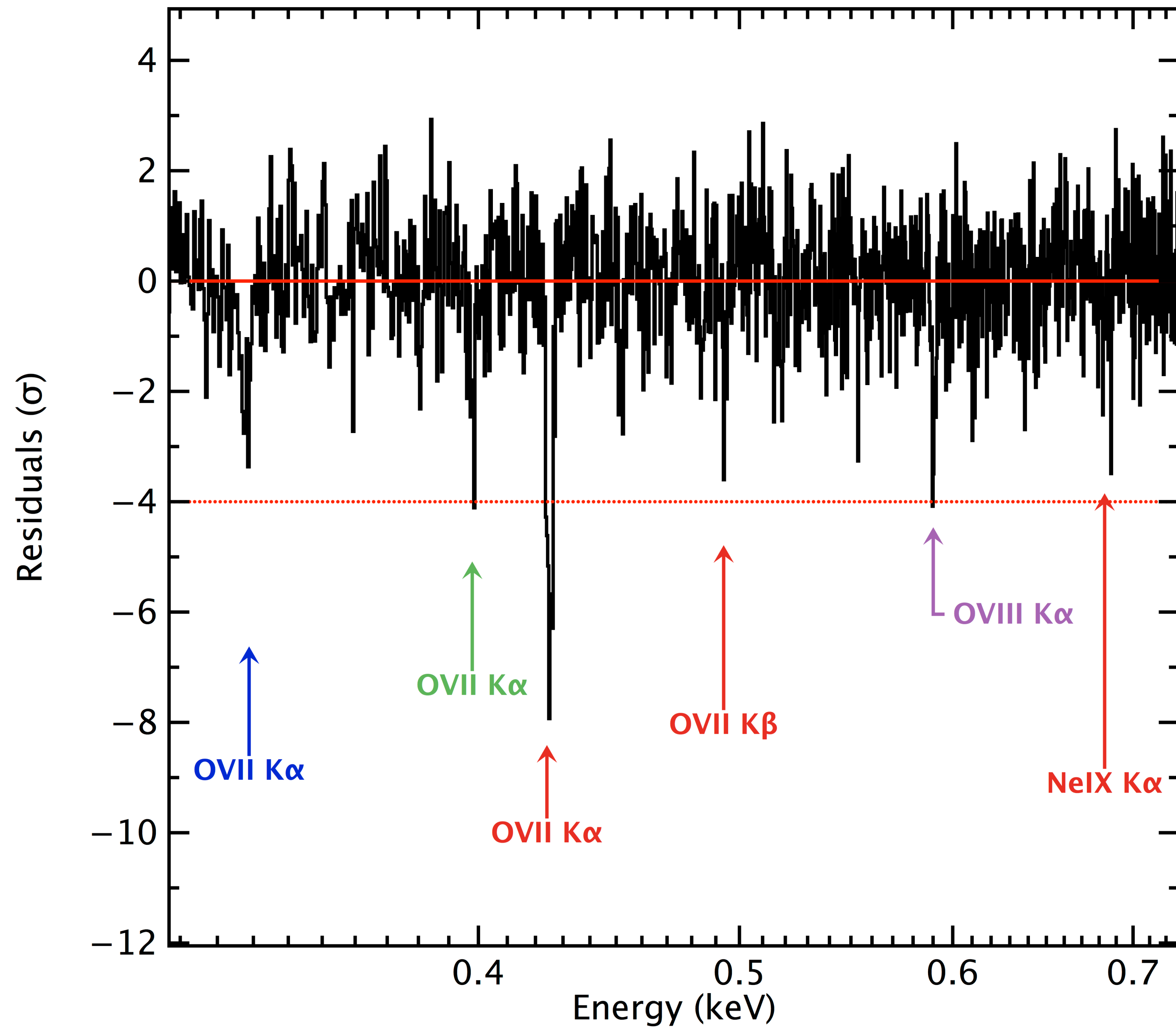
... one derives the entropy profile to study the energy deposition history and its evolution through cosmic time.



Chemical evolution of cluster gas



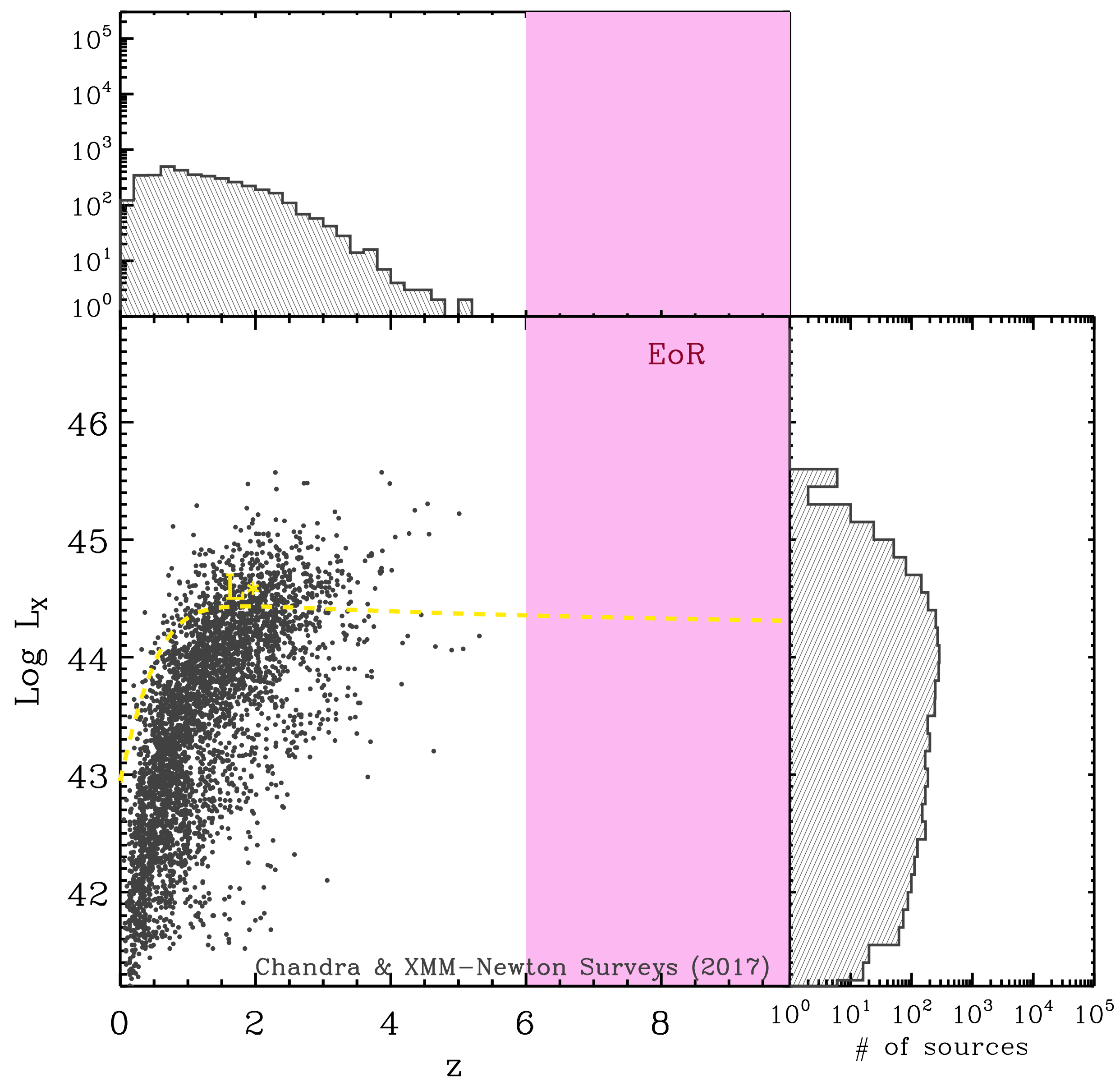
Missing baryons in the WHIM against bright GRBs and blazars



The Energetic Universe

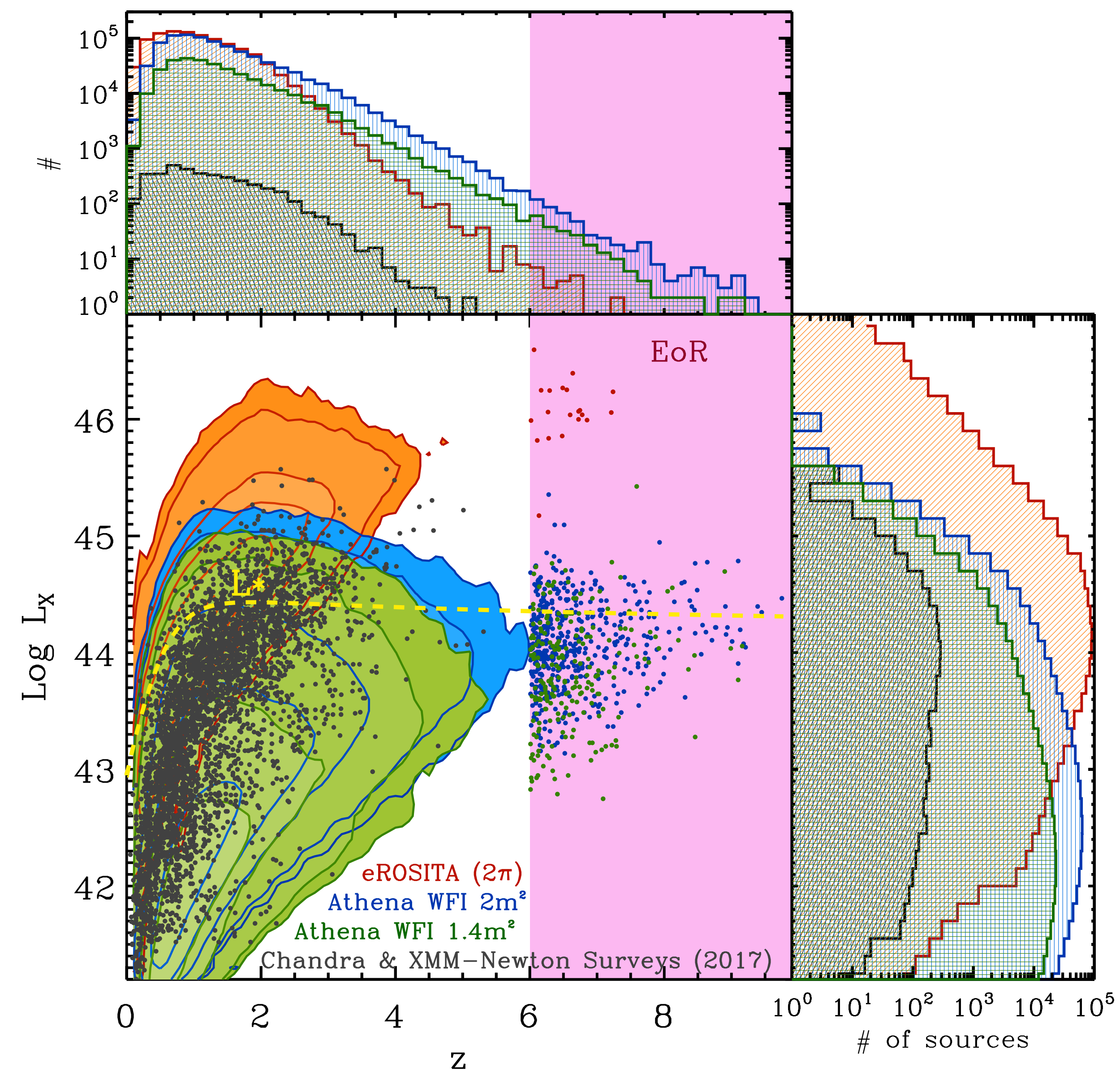
The early history of SMBH growth at $z > 6$

**Current XMM/
Chandra knowledge
limited to $z < 4$.**



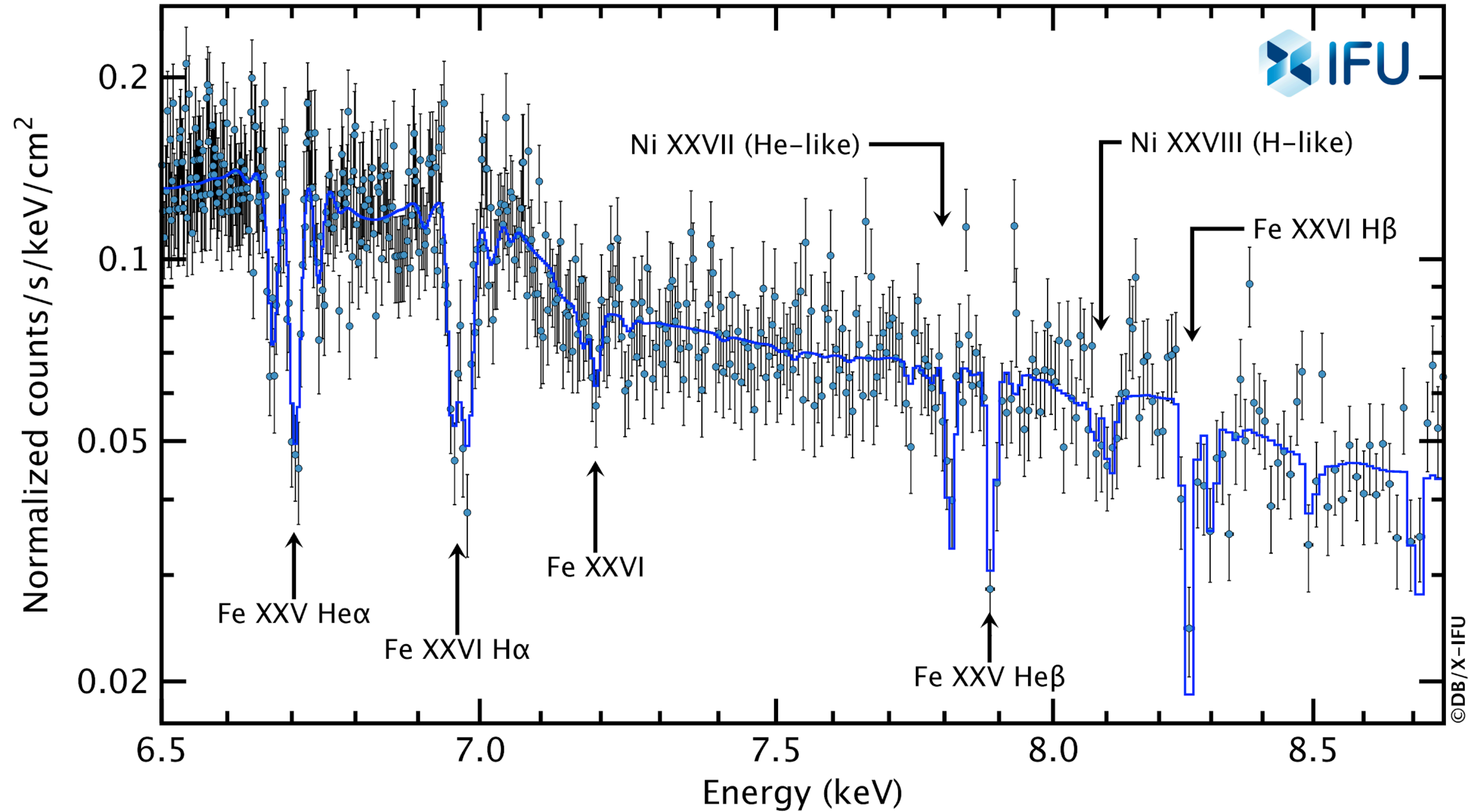
(Fig. from A. Merloni)

eROSITA can touch $z \sim 6$, but Athena/WFI is needed to gather statistical sample.

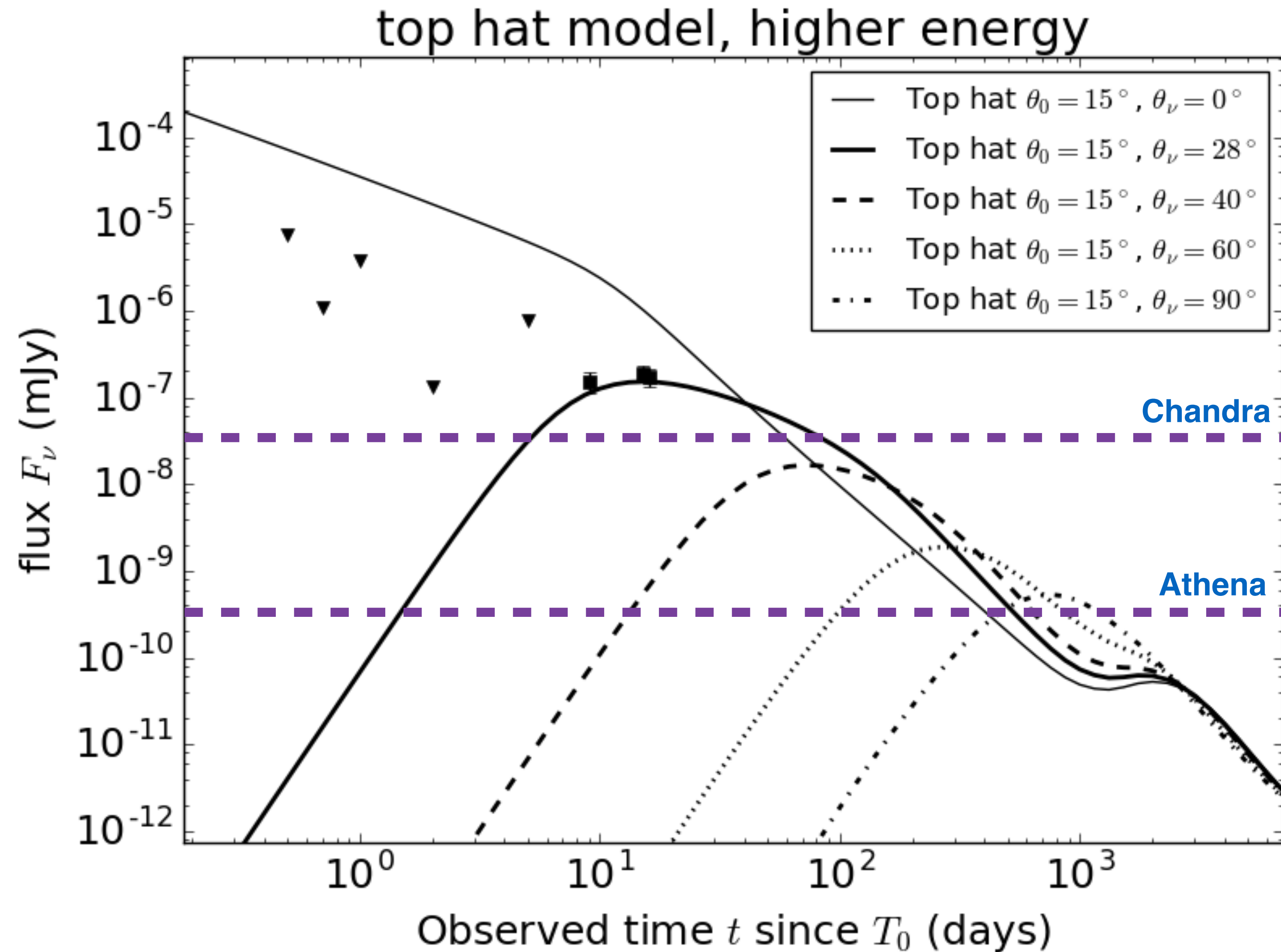


(Fig. from A. Merloni)

Spins and Accretion History of Stellar Mass Black holes



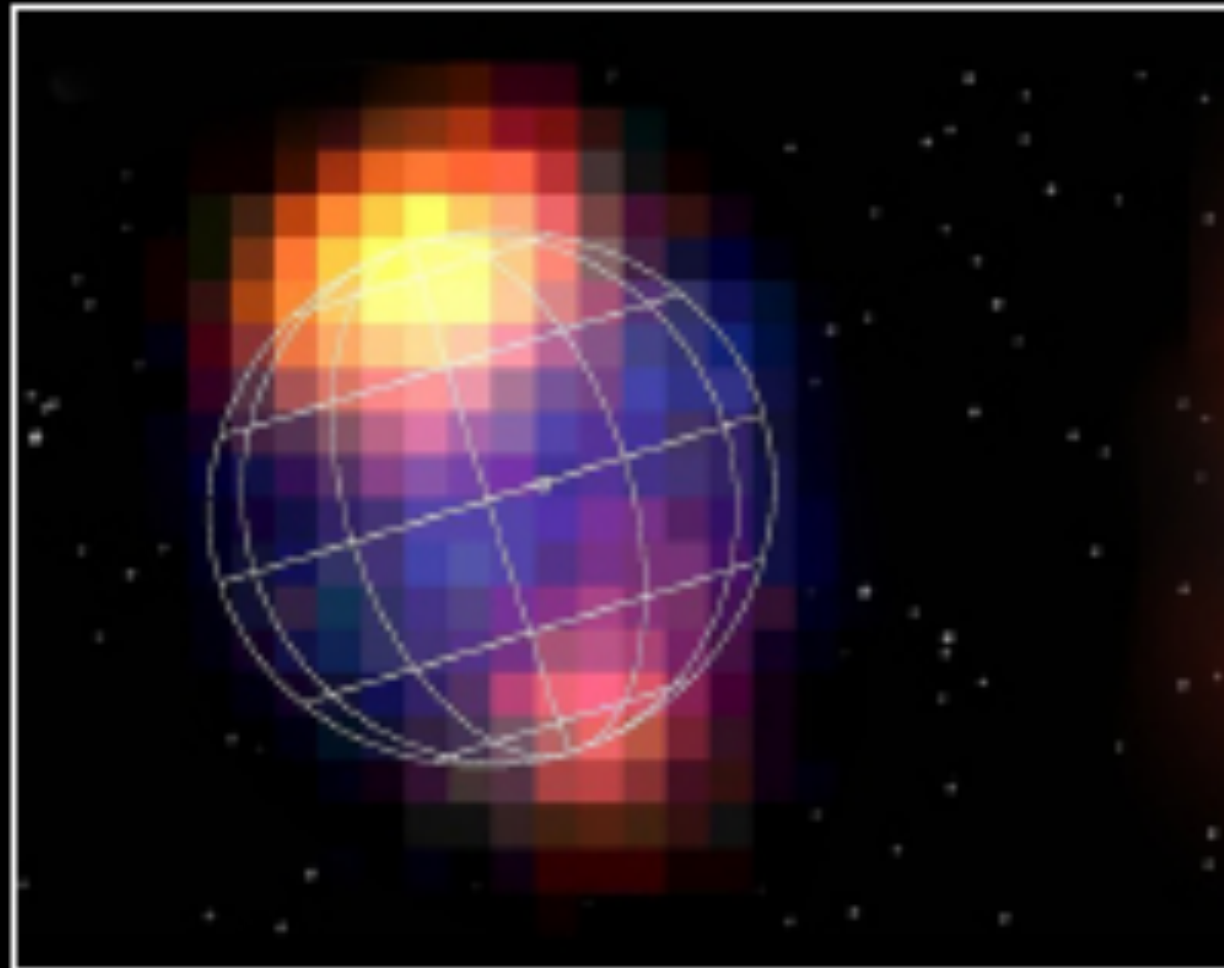
Luminous extragalactic transients (GW counterparts (below), TDEs, etc.)



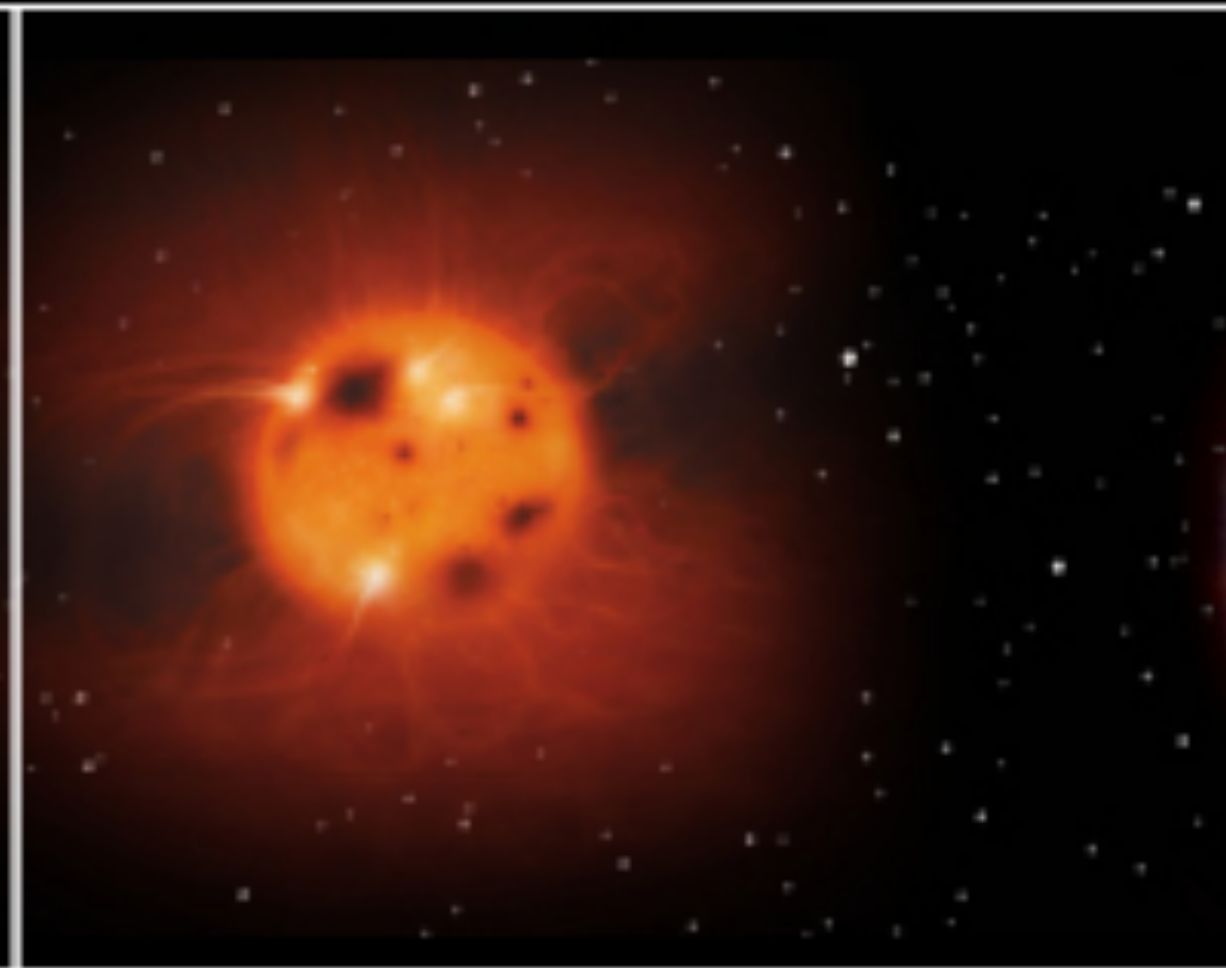
Fast response to transients opens up new window to early Universe

Observatory Science

Solar System



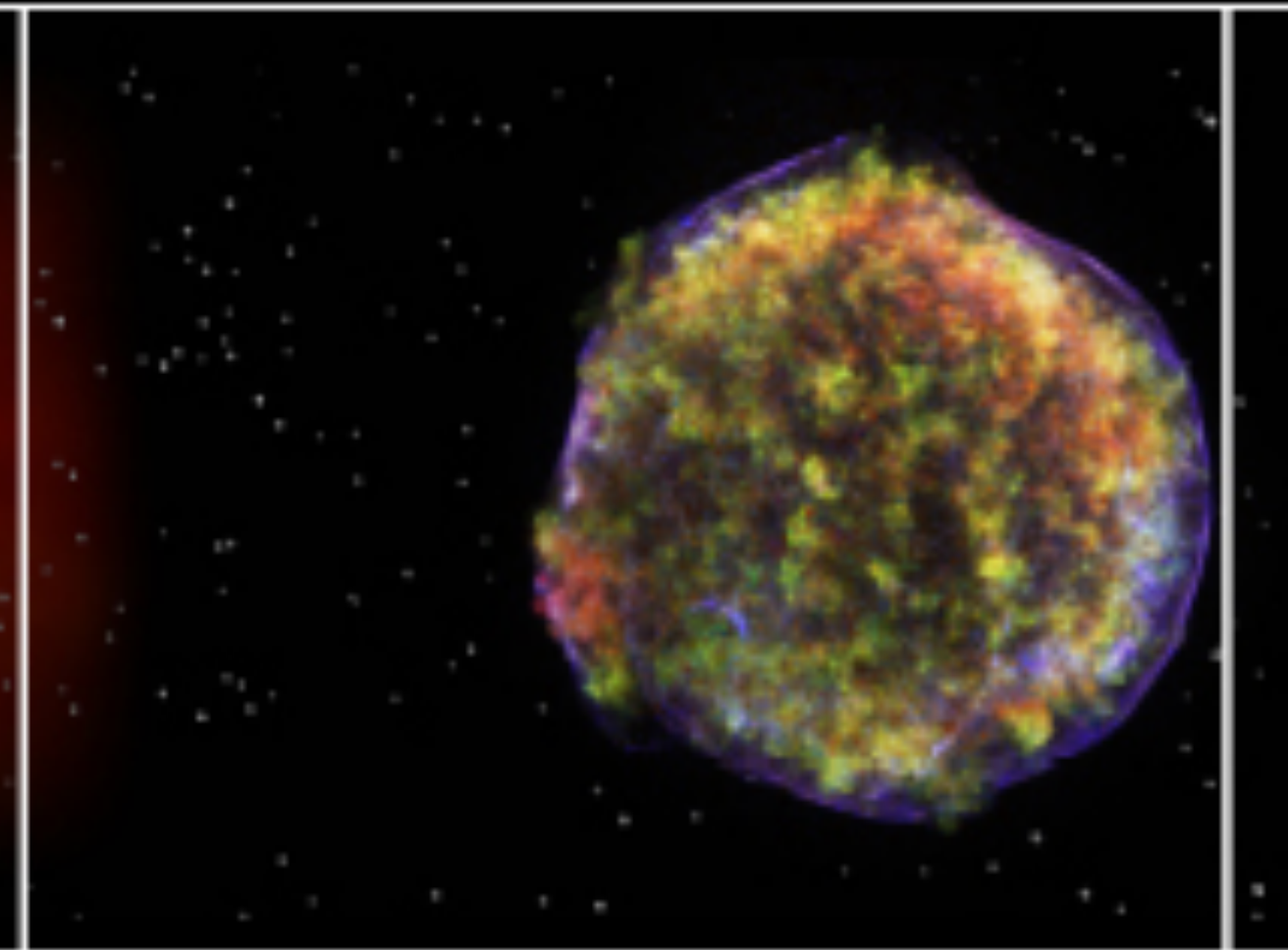
Stars



Stellar
Endpoints



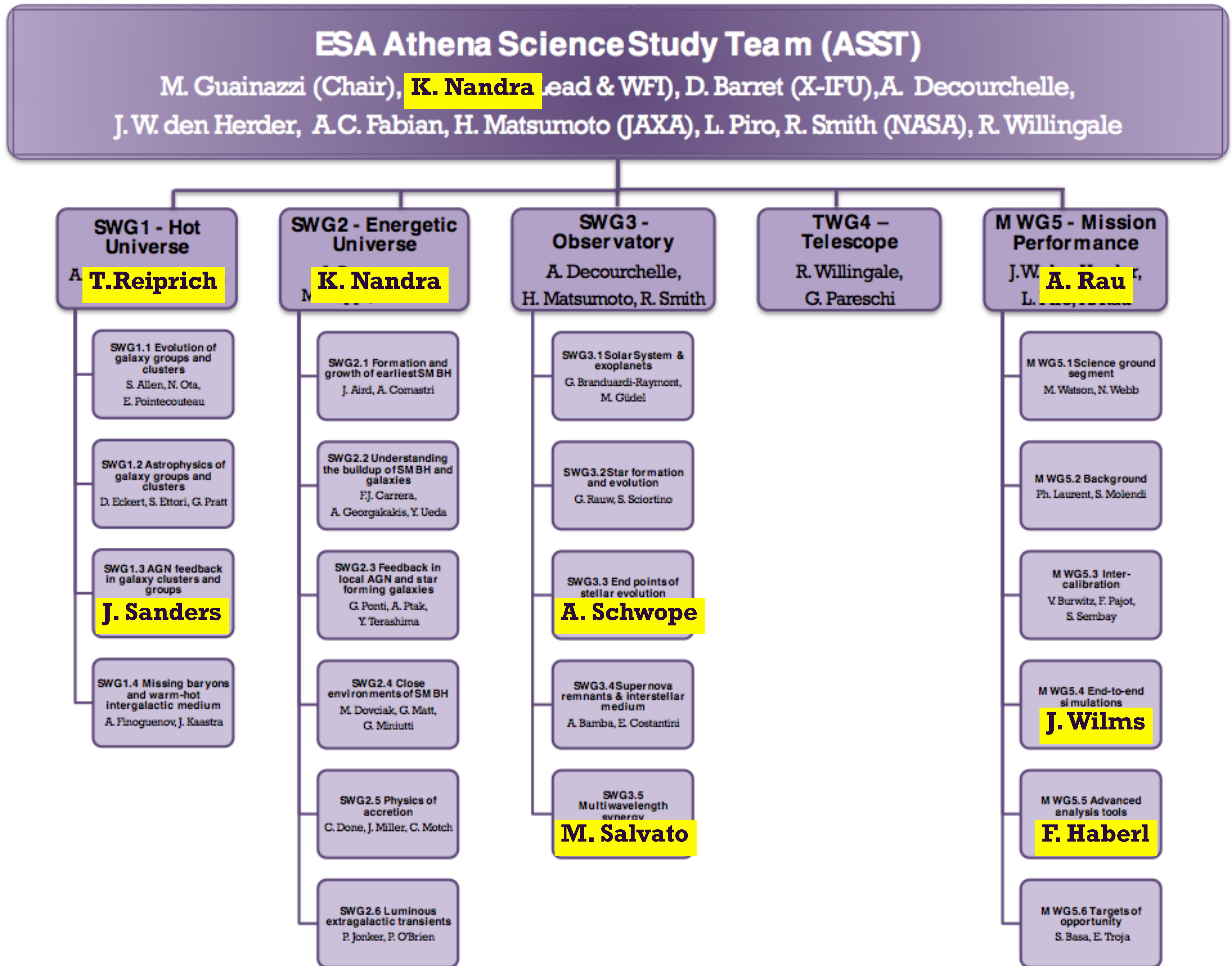
SNRs



Athena Science Requirements

Parameter	value	enables (driving science goals)
Effective area at 1 keV	$\geq 1.4 \text{ m}^2$	Early groups, cluster entropy and metal evolution, WHIM, high redshift AGN, census AGN, first generation of stars
Effective area at 6 keV	0.25 m^2	Cluster energetics (gas bulk motions and turbulence), AGN winds & outflows, SMBH & GBH spins
PSF HEW ($\leq 7 \text{ keV}$)	5'' on axis, 10'' off axis	High z AGN, census of AGN, early groups, AGN feedback on cluster scales
X-IFU spectral resolution	2.5 eV $0.2\text{-}12 \text{ keV}$	WHIM, cluster hot gas energetics and AGN feedback on cluster scales, energetics of AGN outflows at $z\sim 1\text{-}4$
X-IFU FoV	5' effective diameter	Metal production & dispersal, cluster energetics, WHIM
X-IFU background	$< 5 \cdot 10^{-3} \text{ counts/s/cm}^2/\text{keV}$ $2\text{-}10\text{keV}$	Cluster energetics & AGN feedback on cluster scales, metal production & dispersal
WFI spectral resolution	$< 80\text{eV (1keV)}$ & $< 170\text{eV (7keV)}$	GBH spin, reverberation mapping
WFI FoV	40' x 40'	High-z AGN, census AGN, early groups, cluster entropy evolution, jet-induced cluster ripples
WFI count rate	1 Crab $> 80\%$	GBH spin, reverberation mapping, accretion physics
WFI background	$< 5 \cdot 10^{-3} \text{ counts/s/cm}^2/\text{keV}$ $2\text{-}7\text{keV}$	Cluster entropy, cluster feedback, census AGN at $z\sim 1\text{-}4$
Recons. astrometric error	1'' (3s)	High z AGNs
GRB trigger efficiency	50%	WHIM
ToO reaction time	$\leq 4 \text{ hours}$	WHIM, first generation of stars

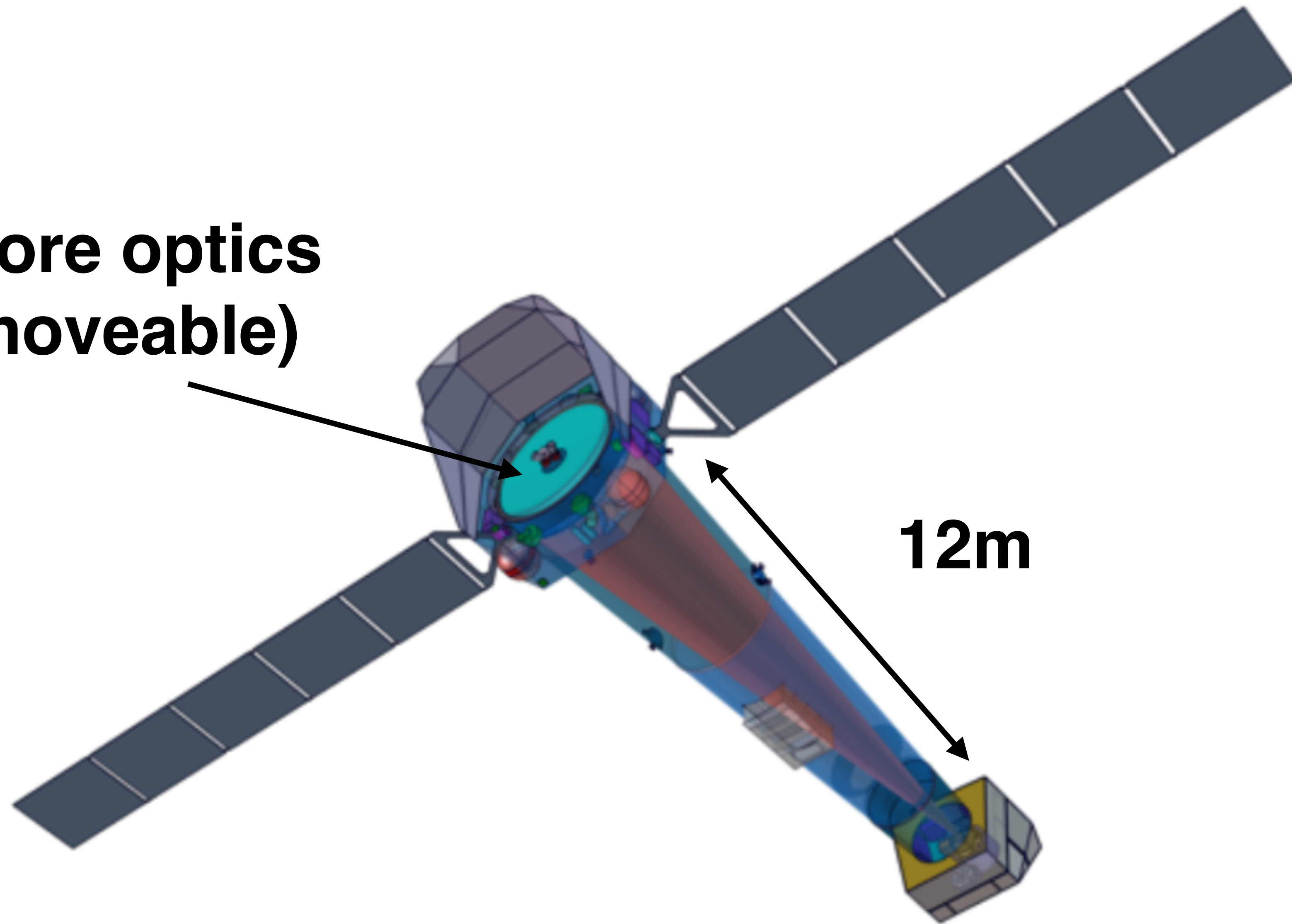
Athena Community Structure



***: DE based**

Mission Profile

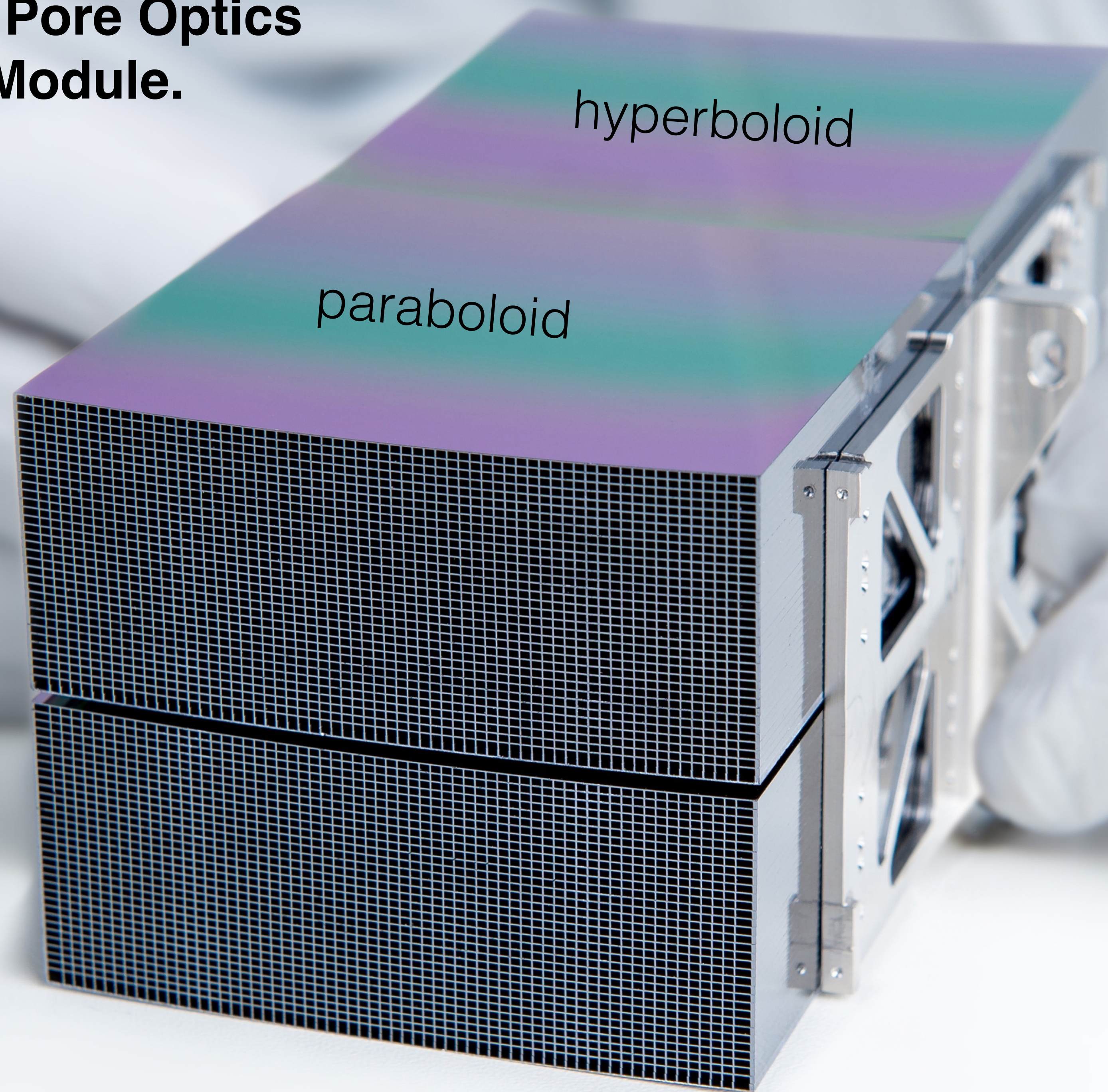
**silicon pore optics
mirror (moveable)**



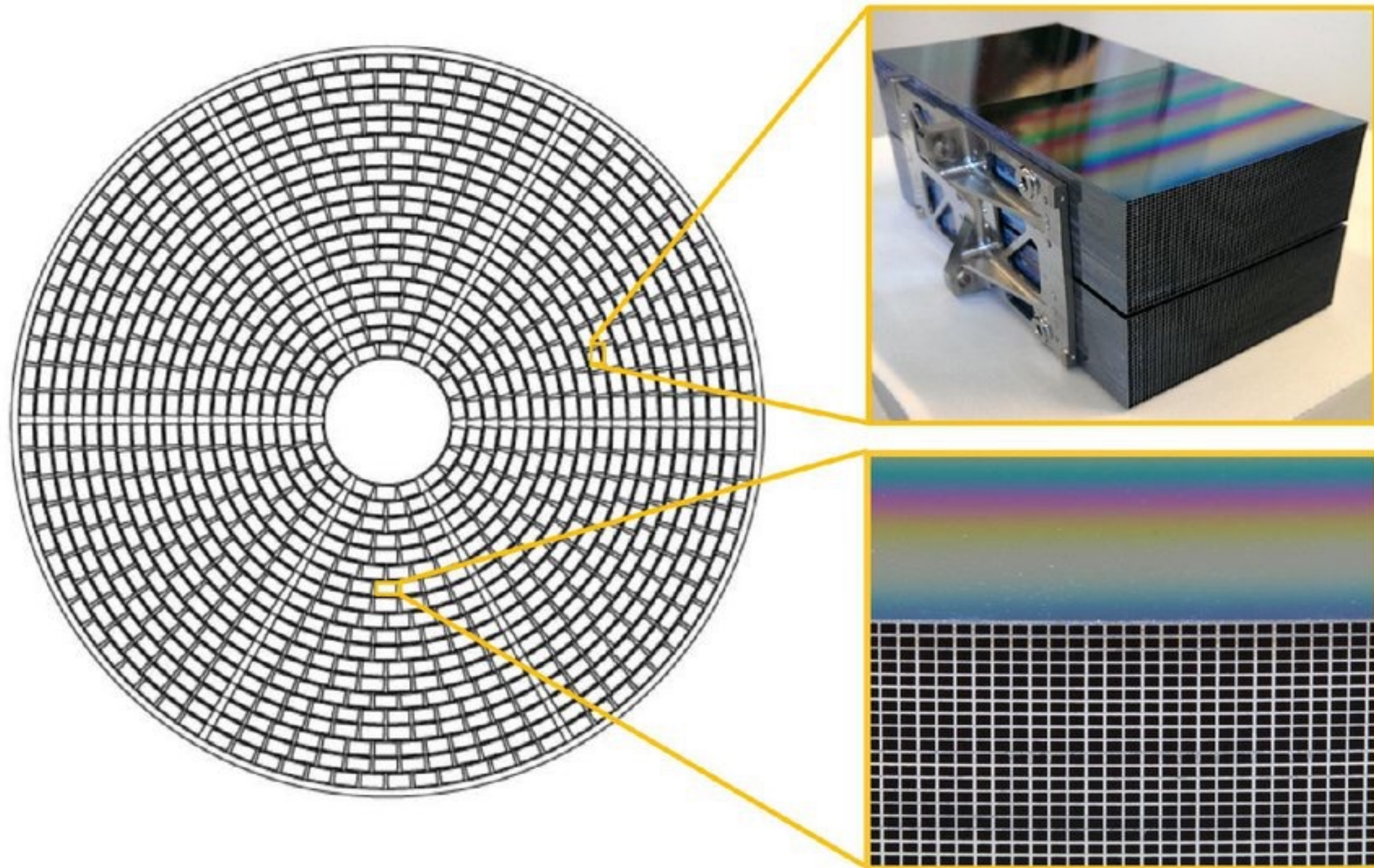
12m

**science
instruments**

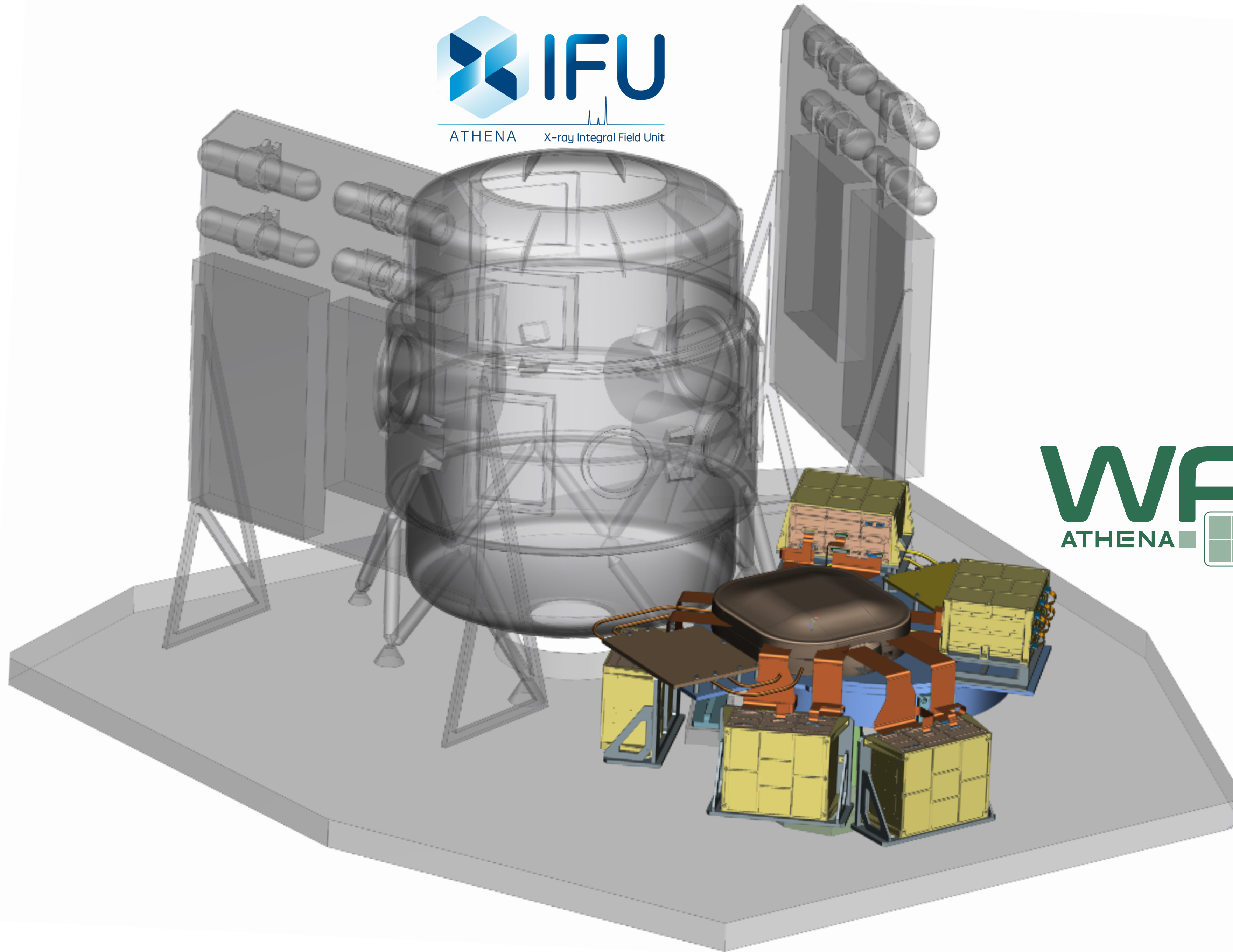
Silicon Pore Optics Mirror Module.



~680 Mirror Modules are needed for the Athena Mirror

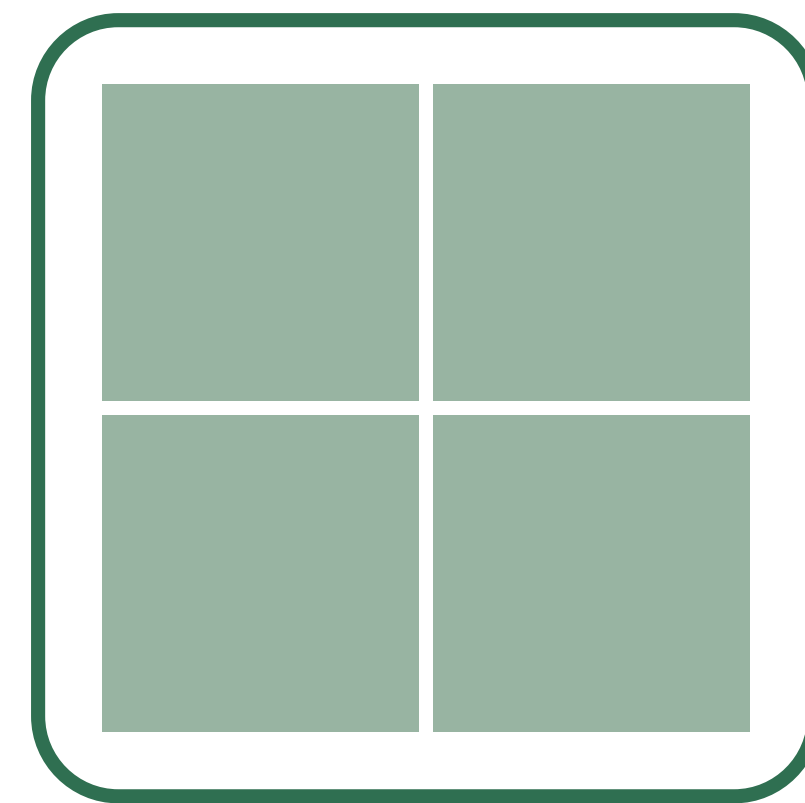


(Wille et al. 2015)

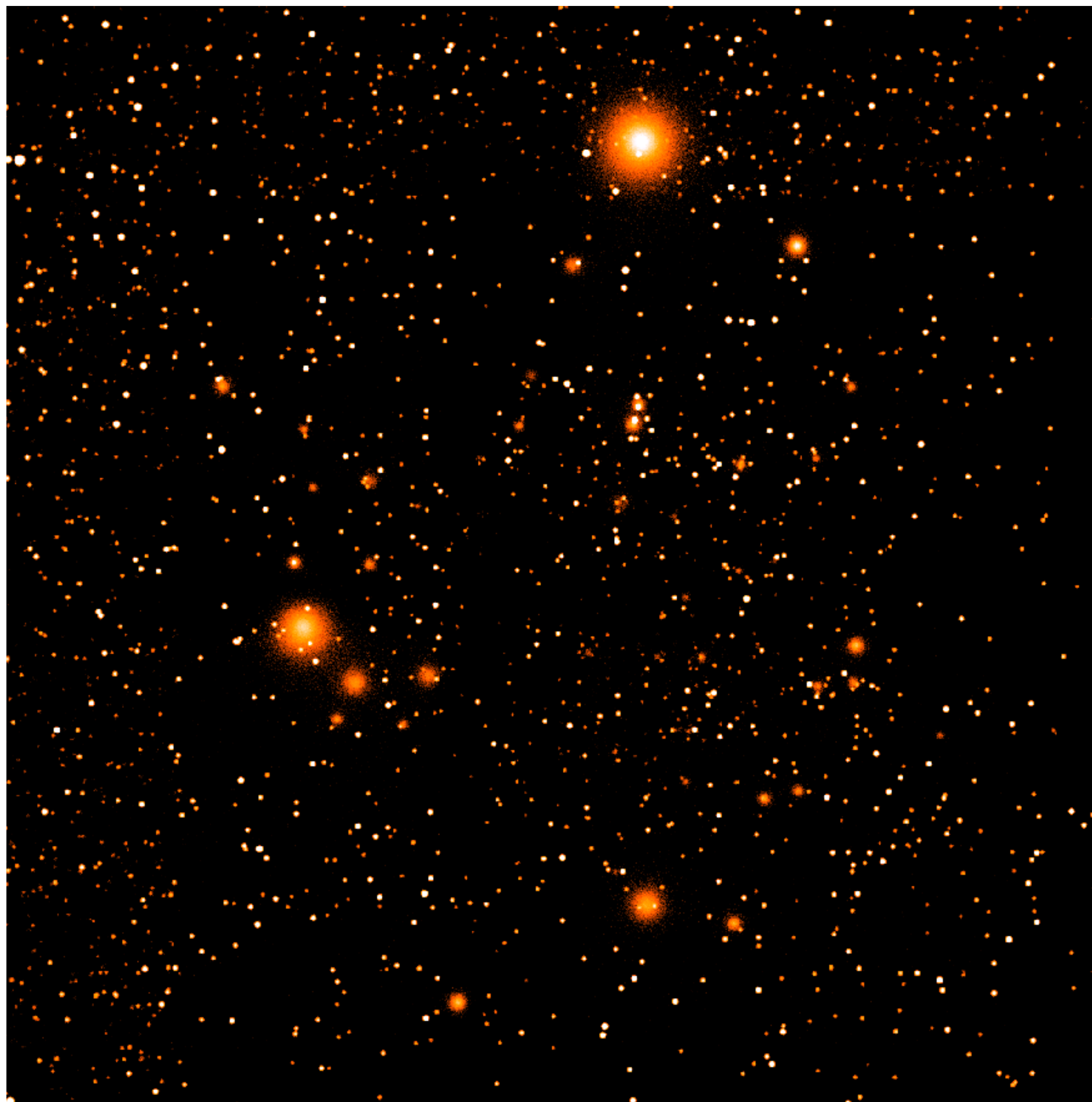


WVFI

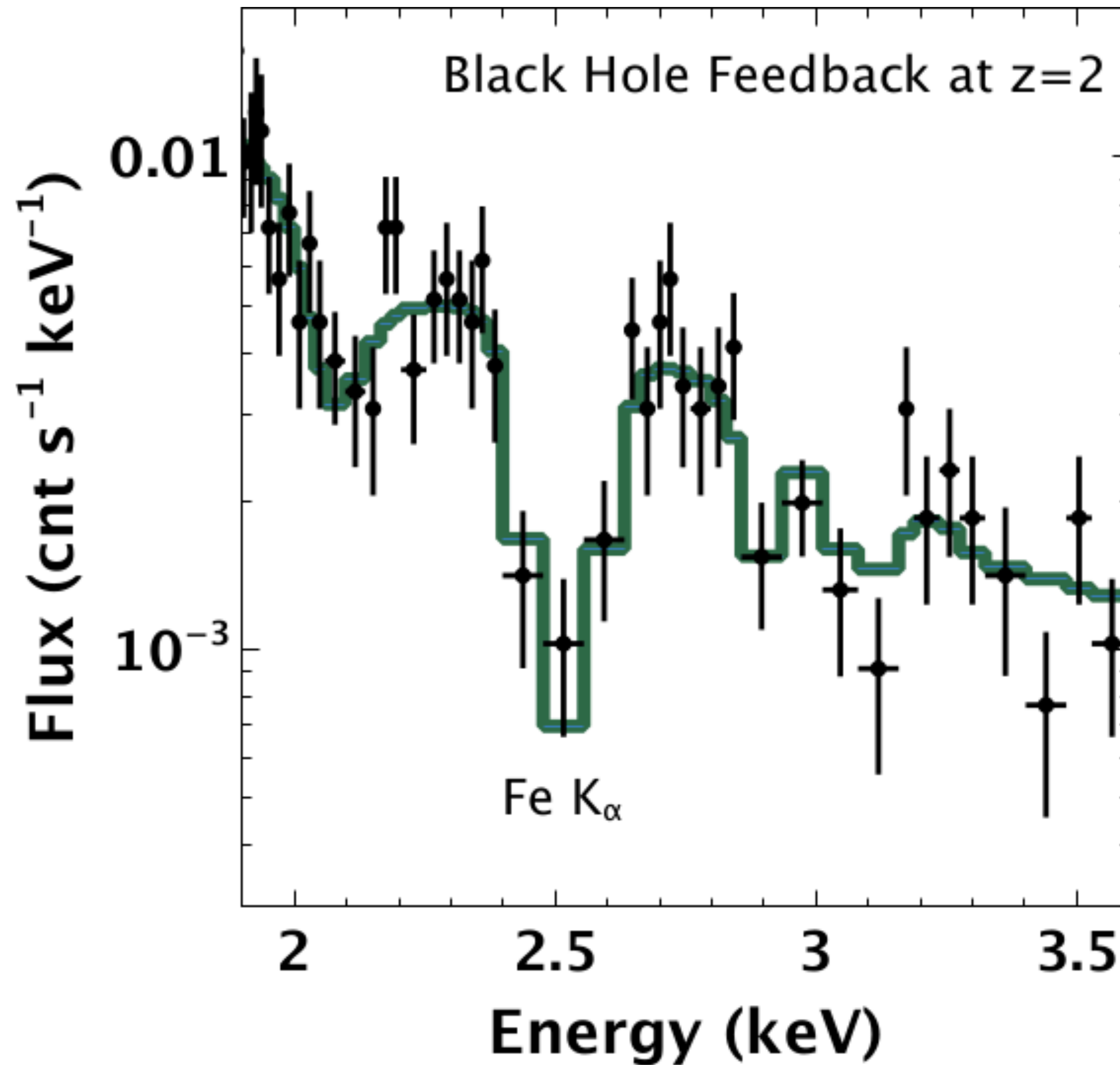
ATHENA



- Silicon Active Pixel Detector based on DEPFET technology
- Optimised for sensitive **wide-field imaging** and **intermediate resolution spectroscopy**, up to **very bright sources**
- Large Detector Array and Fast Detector (separate chip for fast readout of brightest sources)



- Field of view: $40' \times 40'$ square
- $2.2''$ pixel size (PSF sampling)



■ <80 (<170) eV spectral resol. @ 1 (7) keV

CONSORTIUM



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DEGLI STUDI
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University



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Max-Planck-Institut für
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University of
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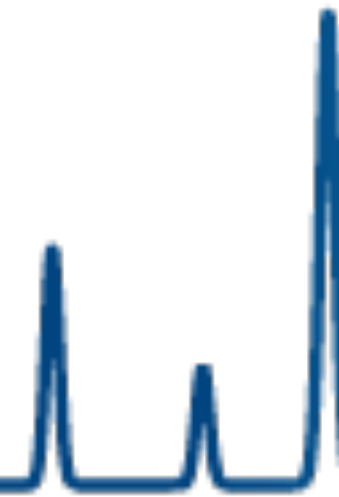
Massachusetts
Institute of
Technology





ATHENA

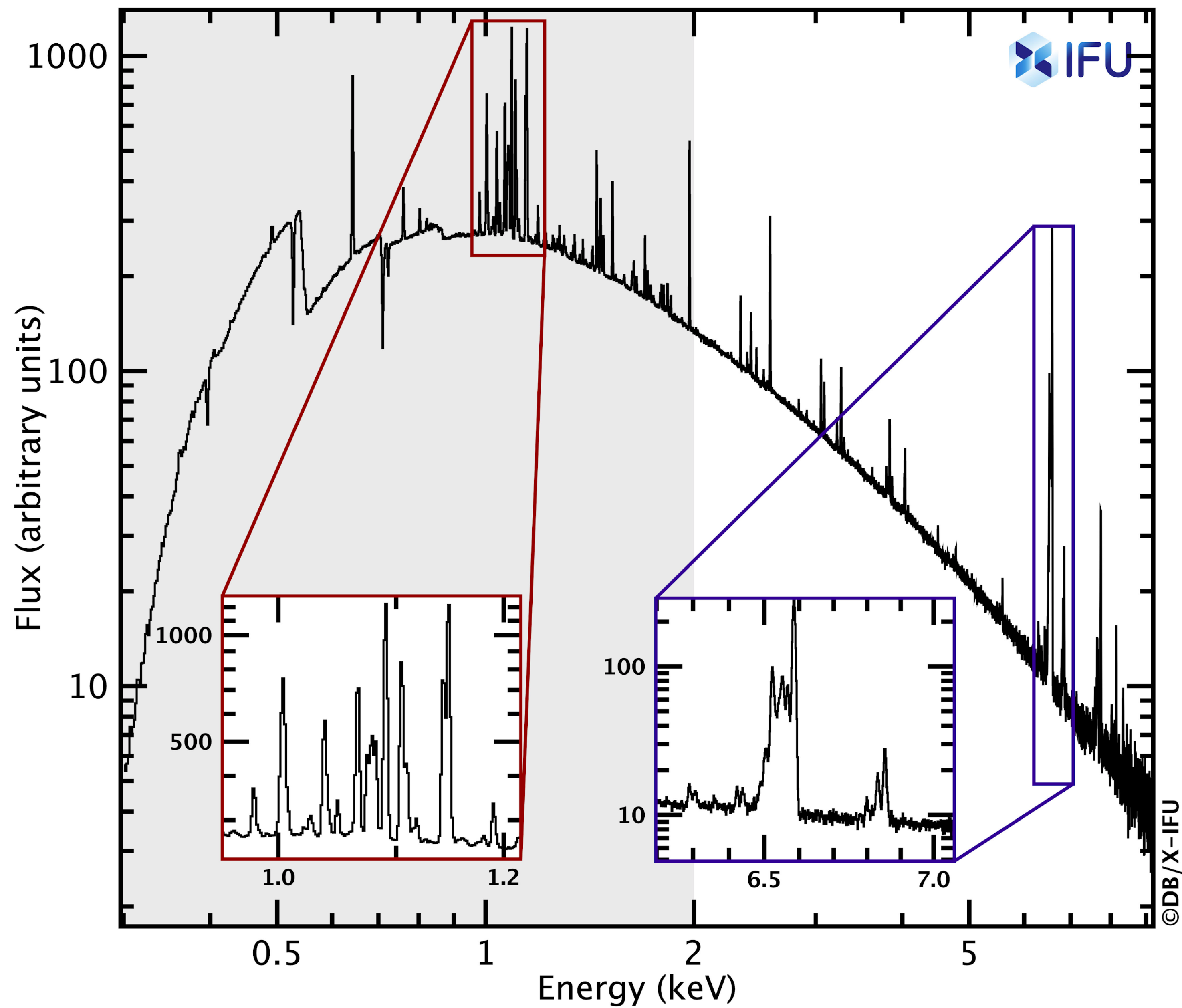
IFU



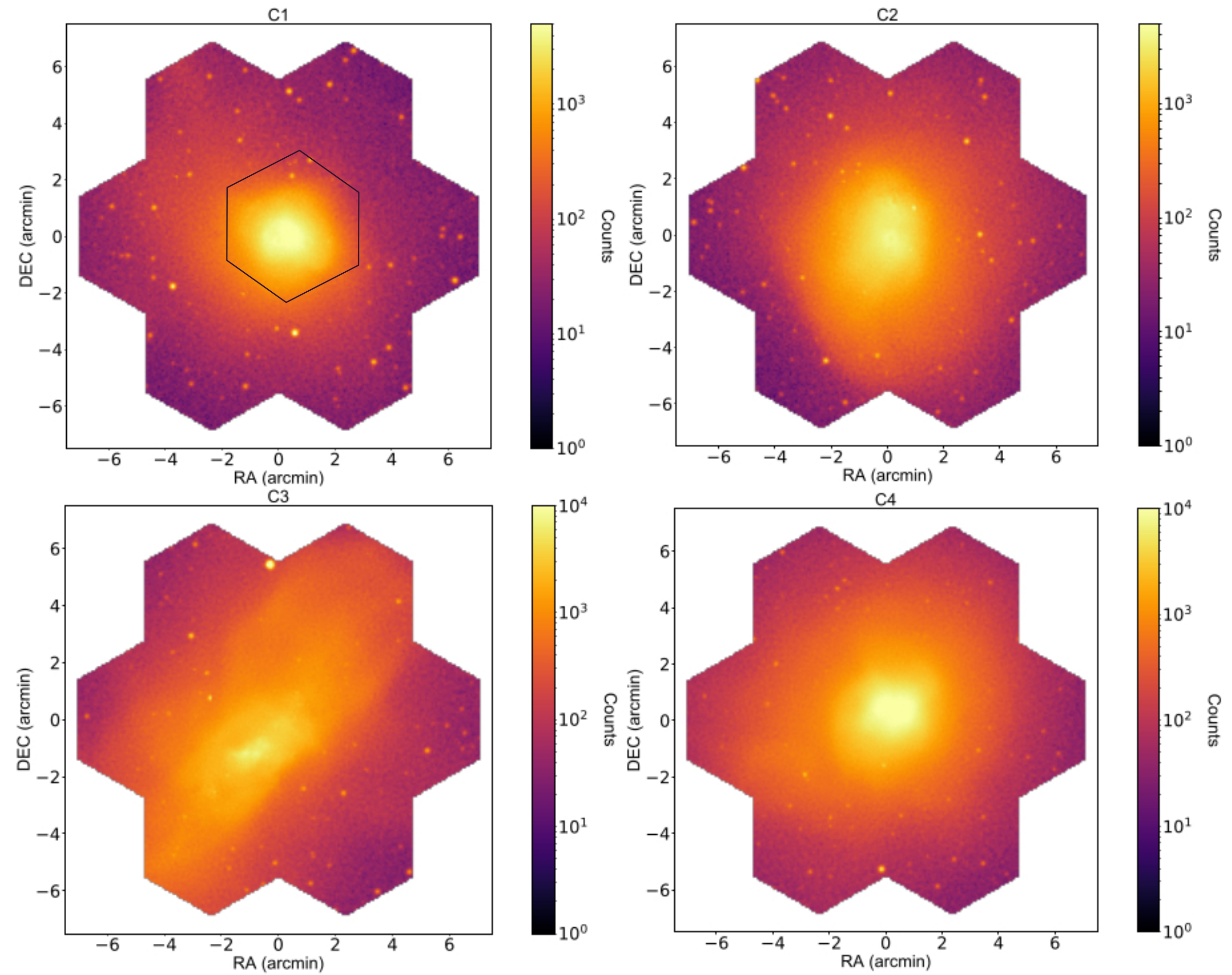
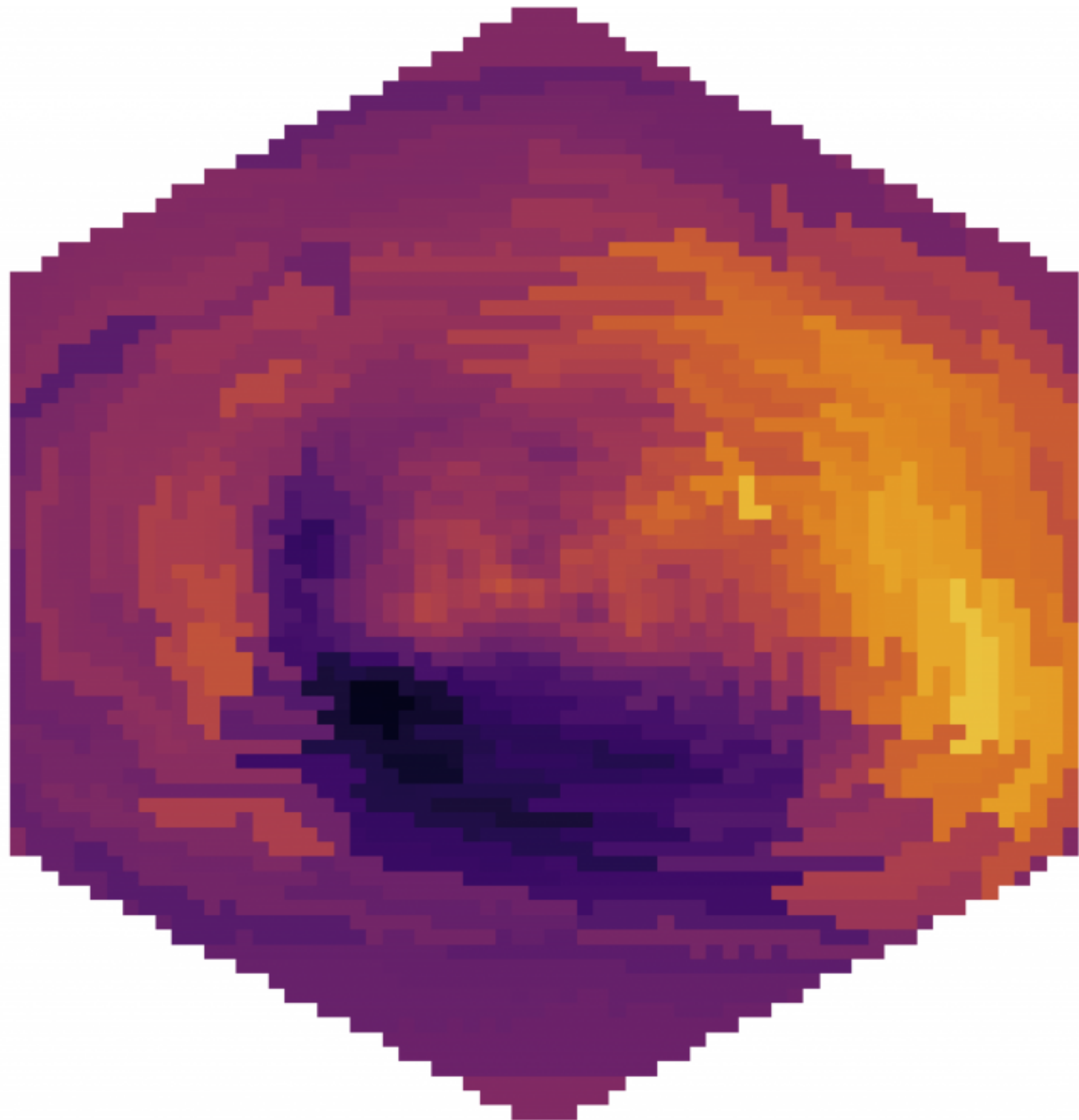
X-ray Integral Field Unit

X-ray Integral Field Unit (X-IFU)

- Cryogenic imaging spectrometer, based on Transition Edge Sensors, operated at 50 mK featuring an active cryogenic background rejection subsystem
- Providing both **spatially-resolved high spectral resolution** and **high count rate capability**



■ 2.5 eV energy resolution <7 keV



- FoV 5' diameter
- Pixel size $< 5''$



INAF

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HIROSHIMA UNIVERSITY



Launch ~2031
L2 orbit (or L1?)
Ariane 64

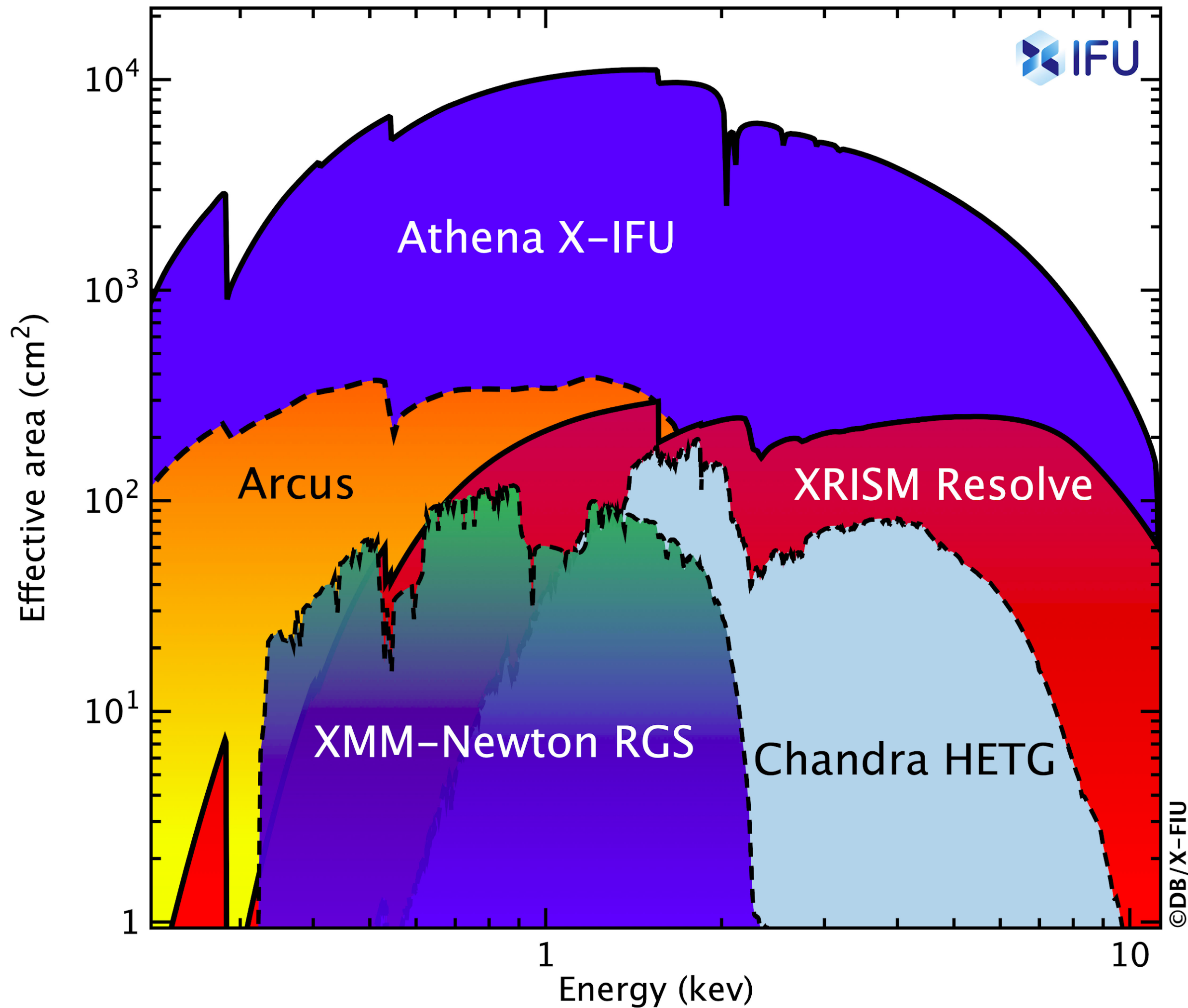
Mass ~7100 kg
Power ~10,000 W
>4 yr mission



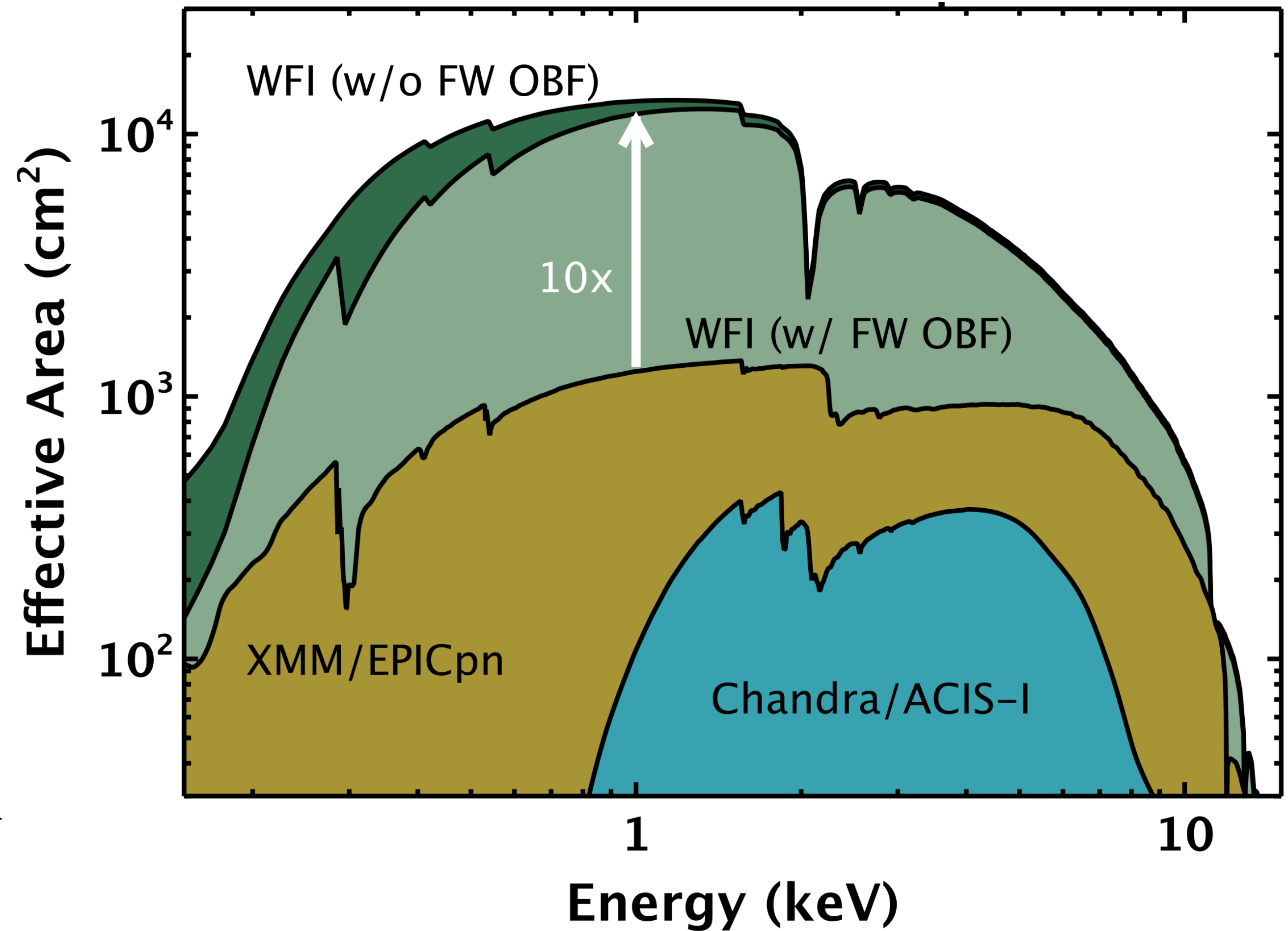
Performance

Athena is a large effective area mission

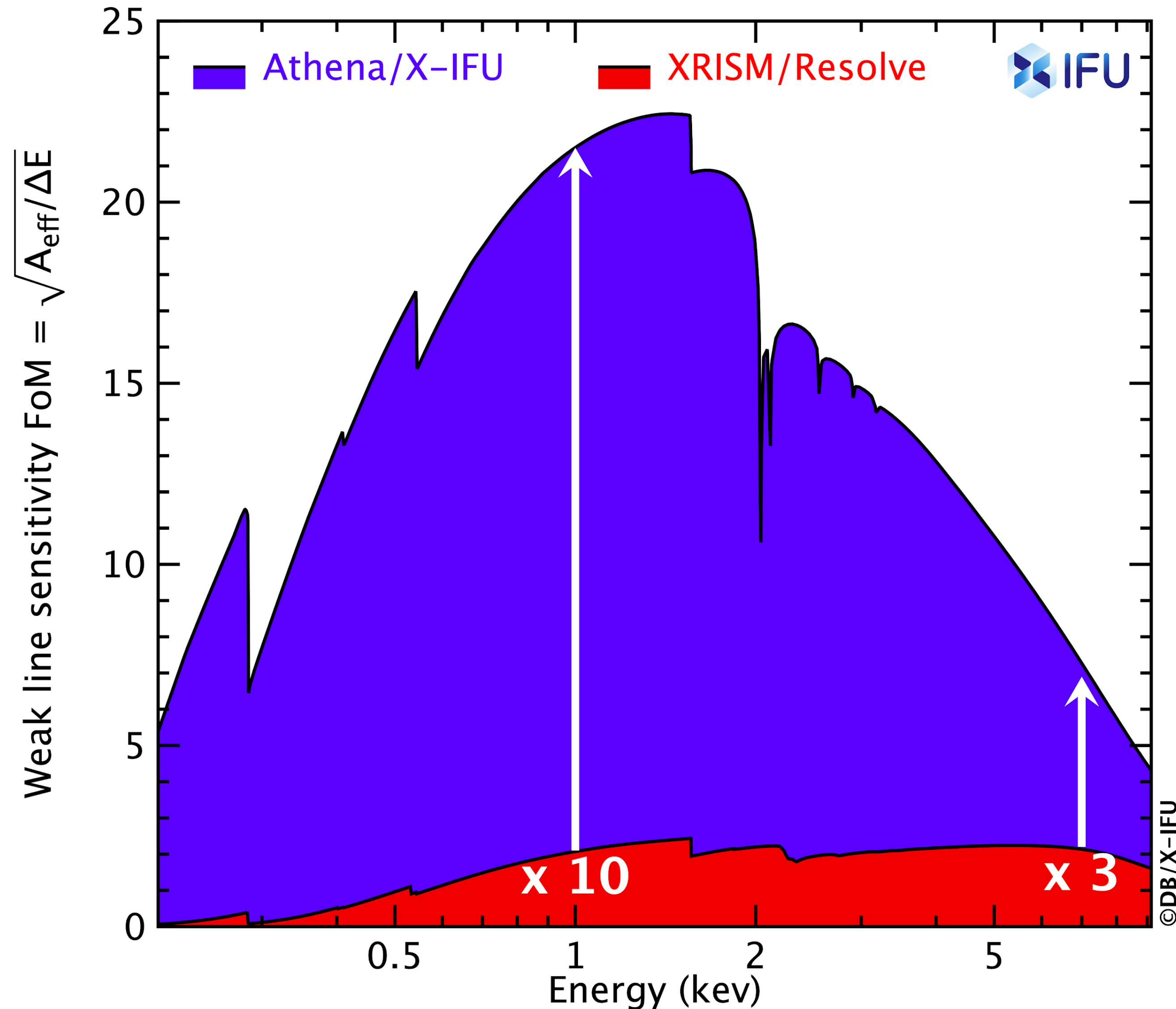
X-IFU



WFI

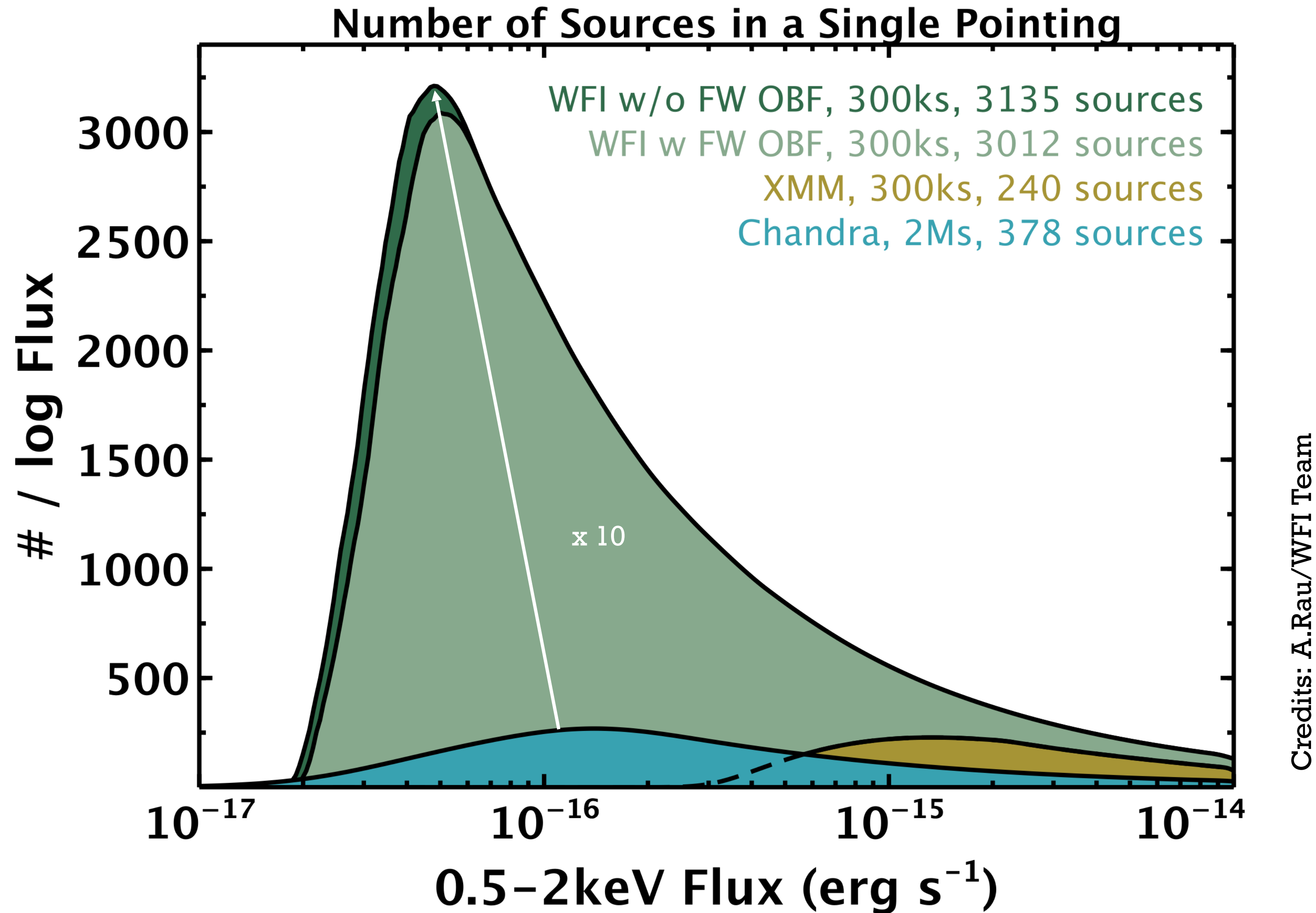


Athena: a transformational observatory



Weak line sensitivity comparison between X-IFU and XRISM

Athena: a transformational observatory



Number of sources per log flux that can be detected in a single pointing with WFI compared to XMM-Newton & Chandra

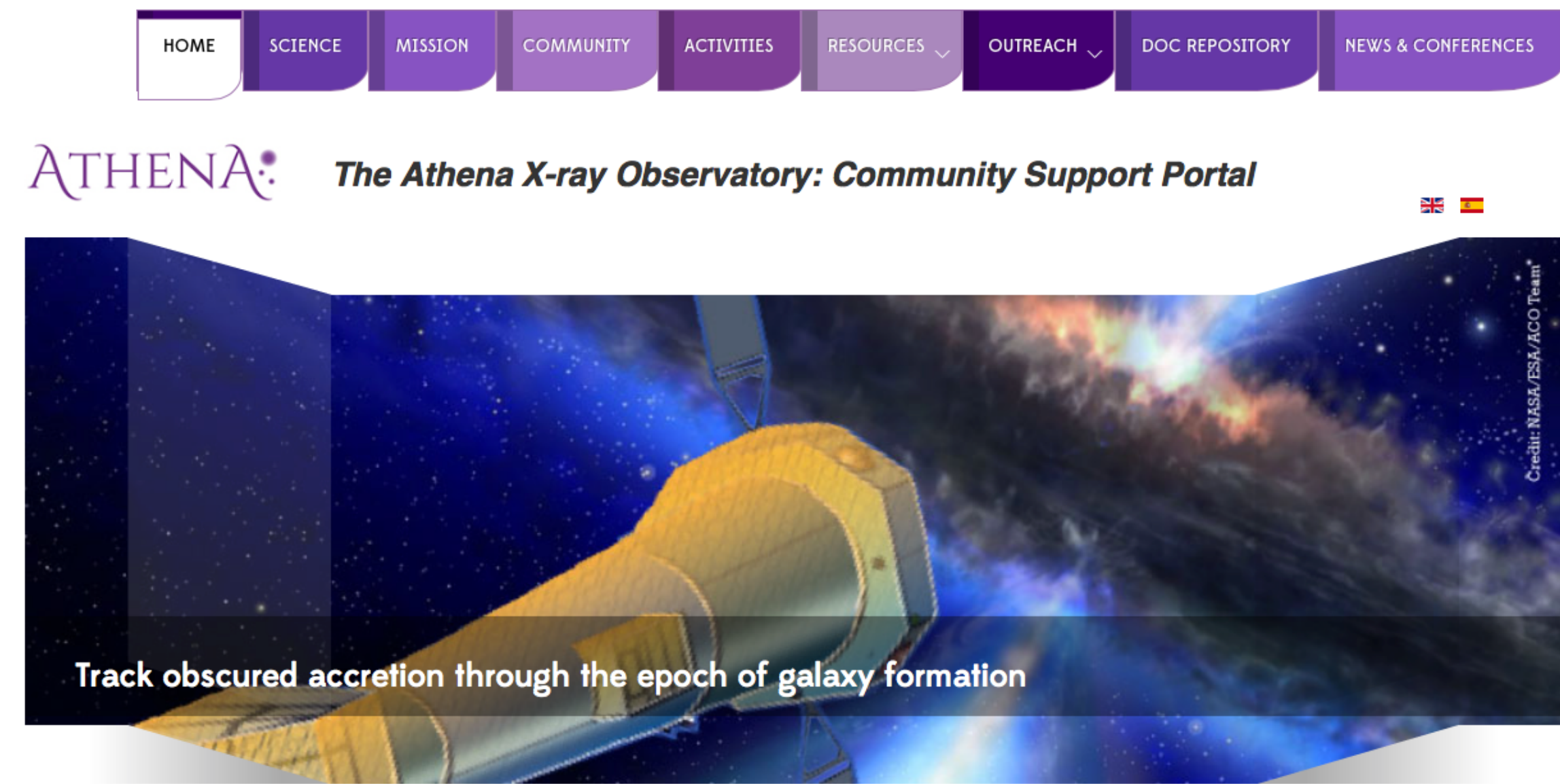
Athena Mission Summary

- Athena addresses key questions in high energy astrophysics via **high resolution spectroscopy and wide-field imaging**
- **ESA Flagship observatory** with capabilities far exceeding current facilities in many respects

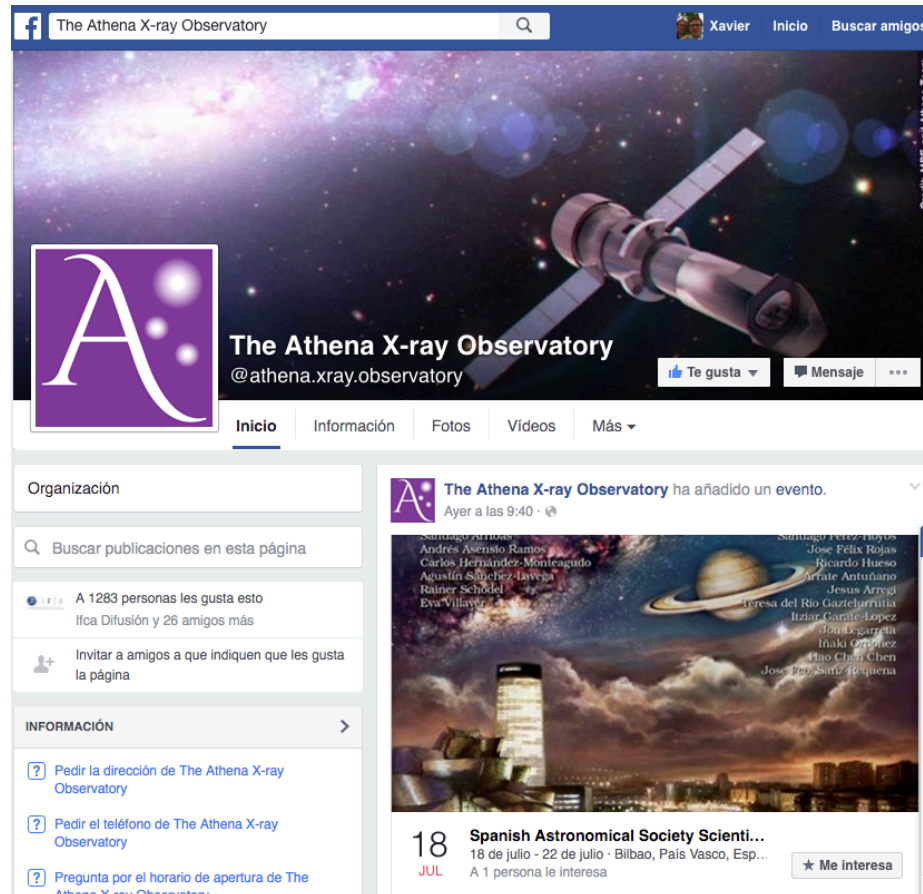
Schedule and Milestones

- Instrument Consortium Consolidation, teams confirmed Dec 2018
- WFI Instrument I-PRR successfully completed Dec 2018
- X-IFU I-PRR successfully completed in April 2019
- **Mission Formulation Review (MFR) just started; ends Phase A**
- **Mission Adoption Review (MAR) Nov 2021; ends Phase B1**
- **Launch currently expected ~2031**

All things related to Athena can be obtained from the Community Office: <http://www.the-athena-x-ray-observatory.eu>



★ Latest activities & news



Web page
Newsletter
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