WFI

ATHENA

The Wide Field Imager for Athena

Arne Rau (MPE, WFI Project Scientist)

The X-ray Universe 2017, Rome, June 6-9

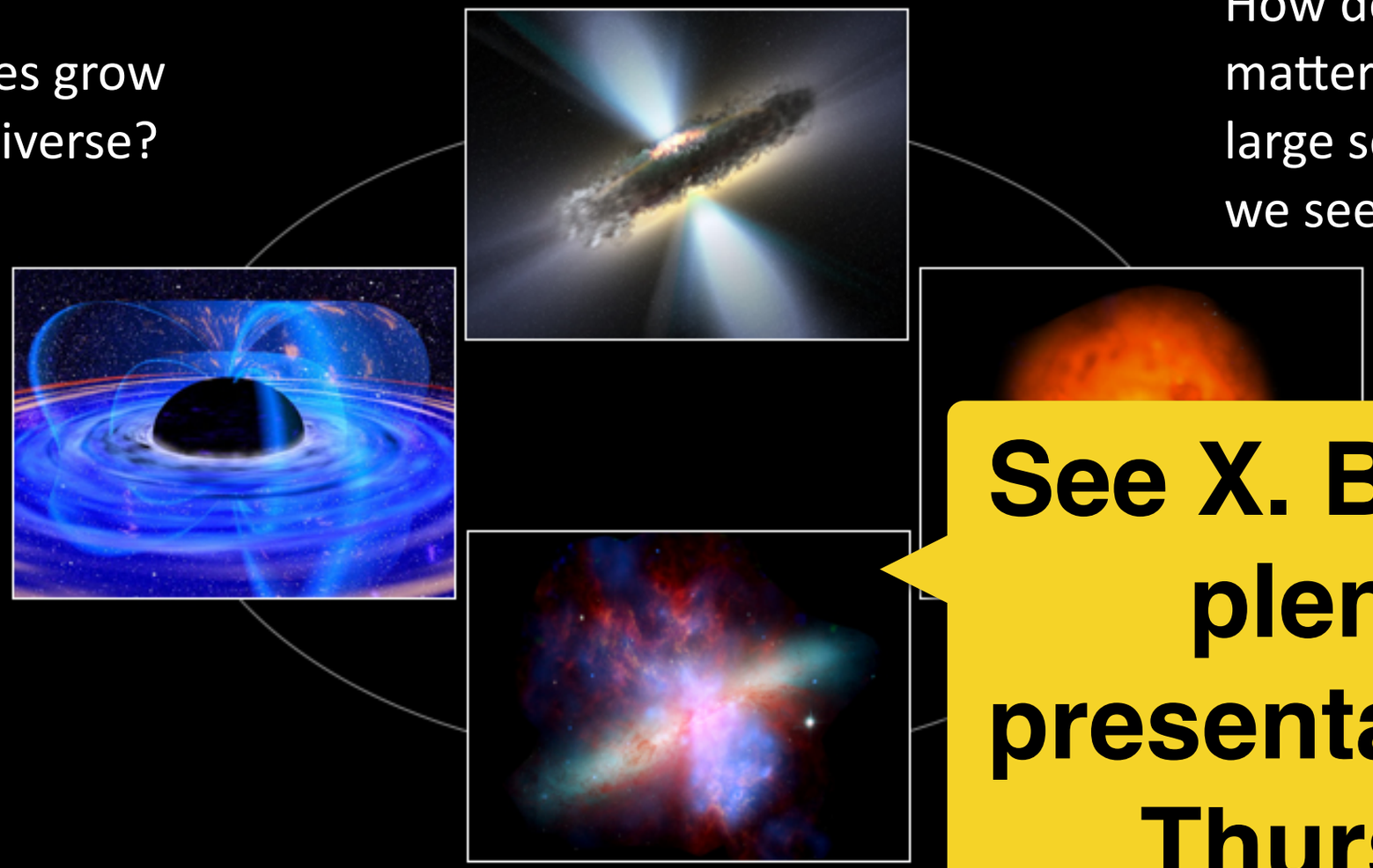
- WFI Science Drivers
- Key Science Requirements
- Instrument

WFI Science Drivers

The Hot and Energetic Universe

How do black holes grow and shape the Universe?

How does ordinary matter assemble into the large scale structures that we see today?



See X. Barcons' plenary presentation on Thursday

Nandra et al. 2013, arXiv 1306.2307

•Formation and Early Growth of Black Holes

–high-z population and seeds of SMBH

- Accretion through cosmic time
  - complete census of AGN at the peak of activity of the universe
- Accretion Physics
  - spins of compact objects
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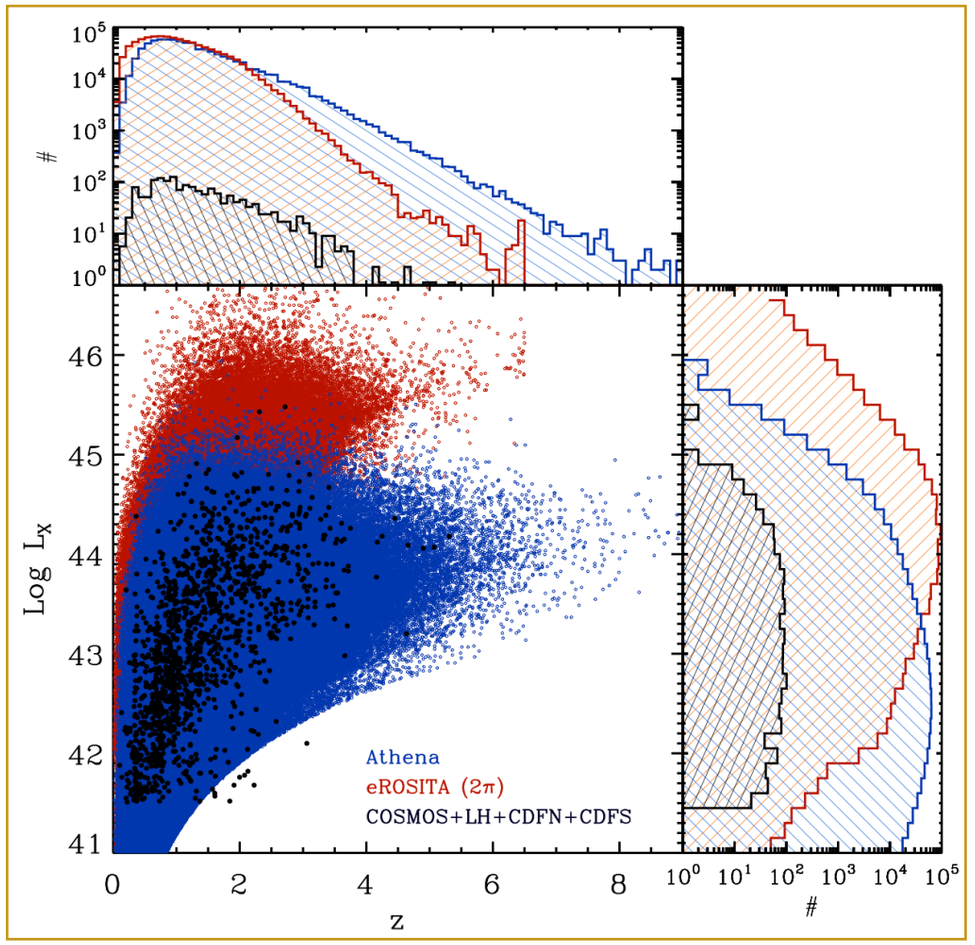

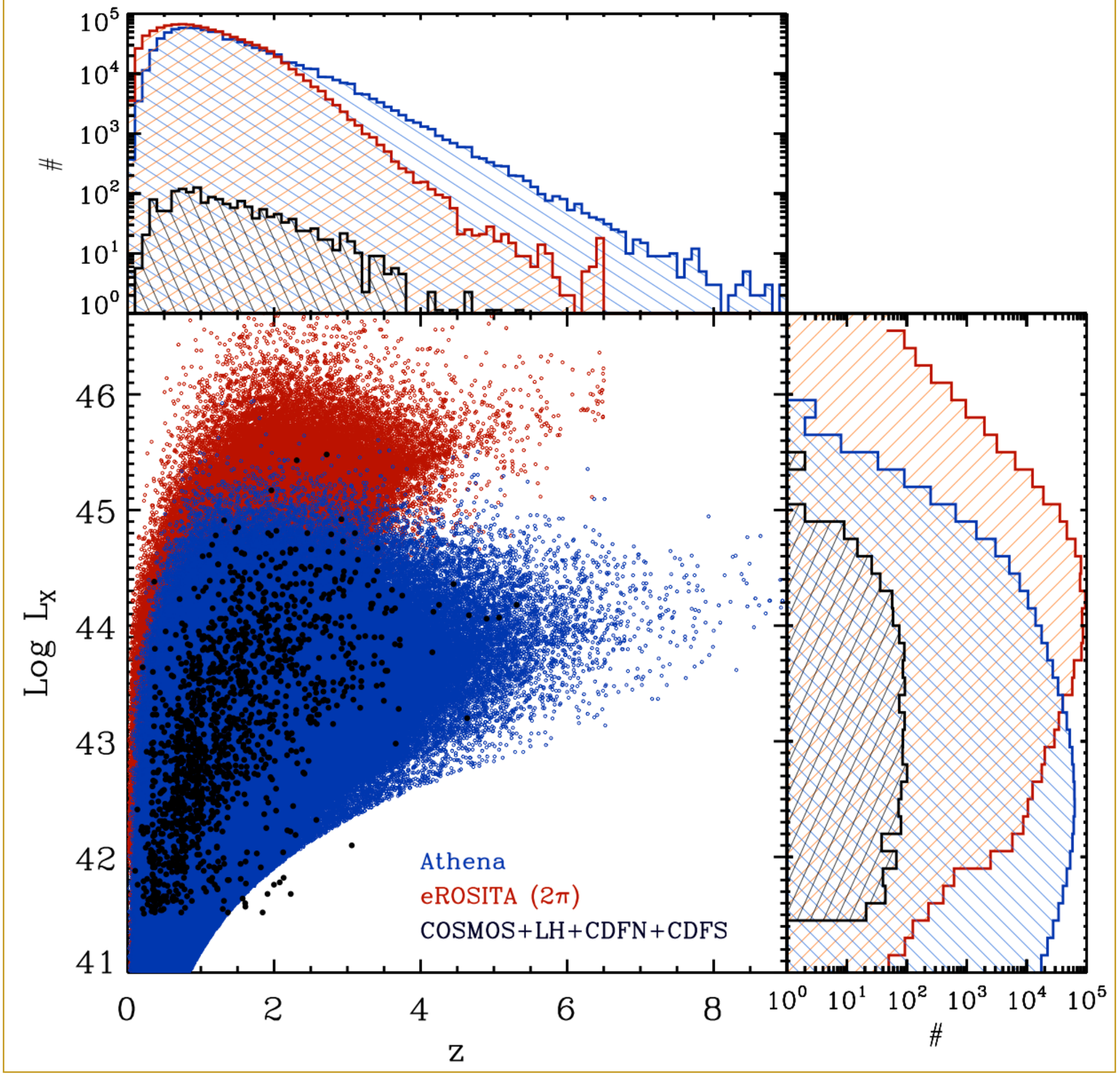

(Credit: A. Merloni)

z=6−8

PopIII seeds, Edd. limit
Massive seeds, Edd. limit
Massive seeds, 30% Edd.
PopIII seeds, 30% Edd.
Athena predicted

N(>flux) [deg⁻²]

10²
10
1
0.1

−17
−16.5
−16
−15.5

log flux [erg/s/cm²]

(Aird, Comastri et al. 2013)

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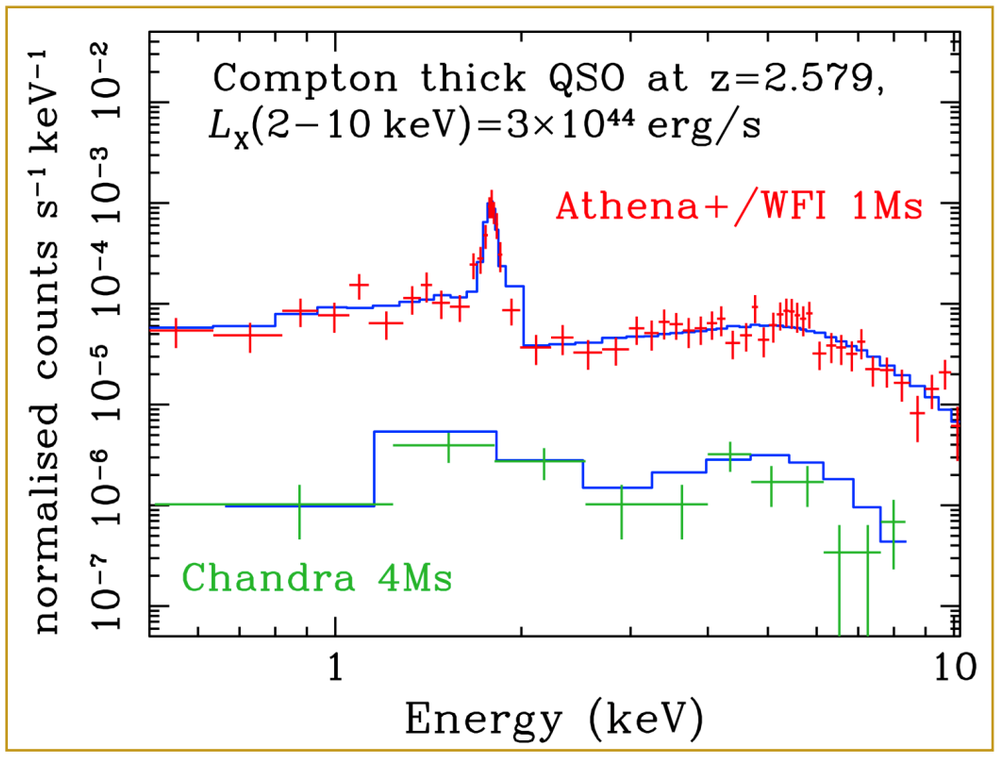

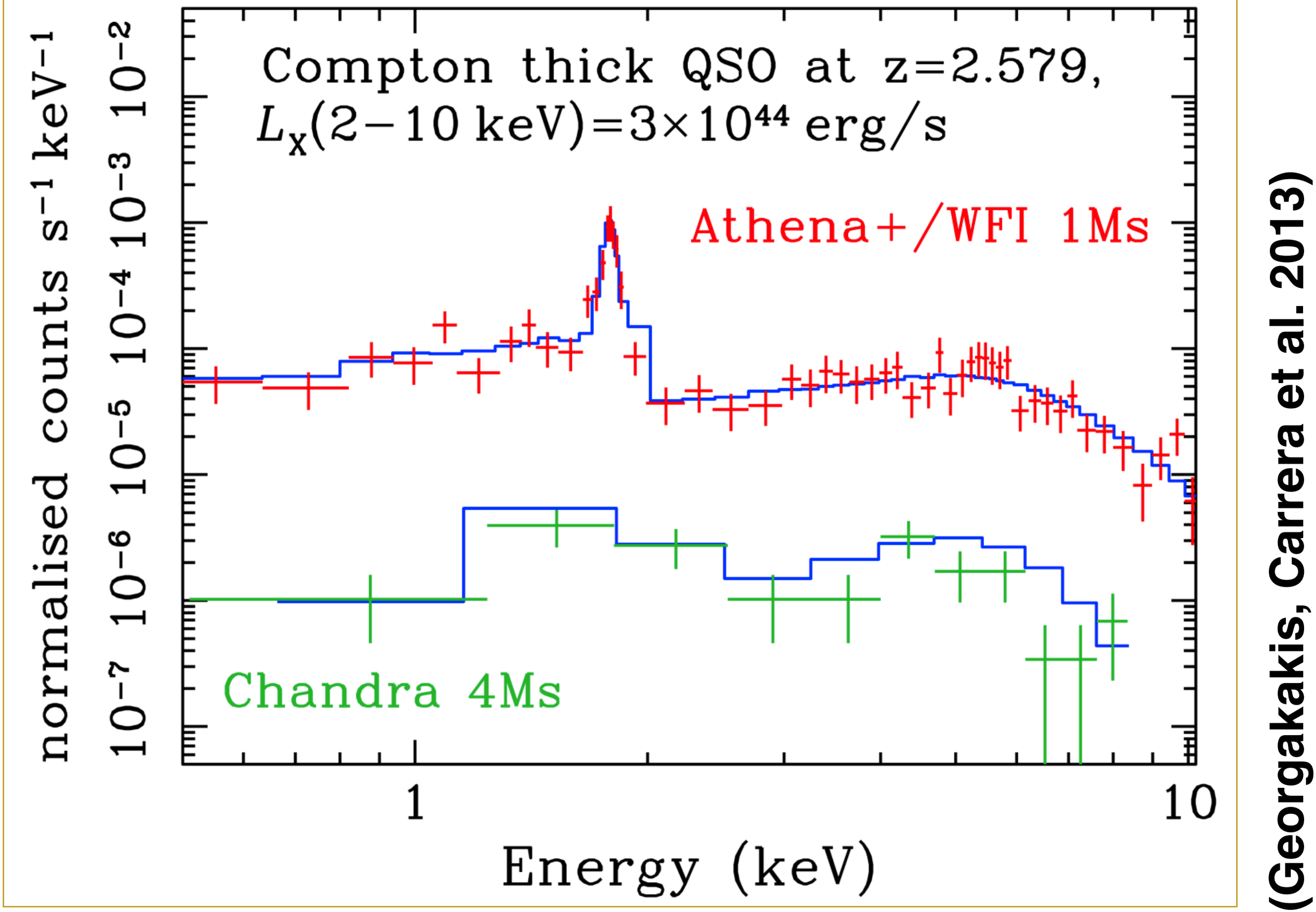

(Georgakakis, Carrera et al. 2013)

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–spins of compact objects

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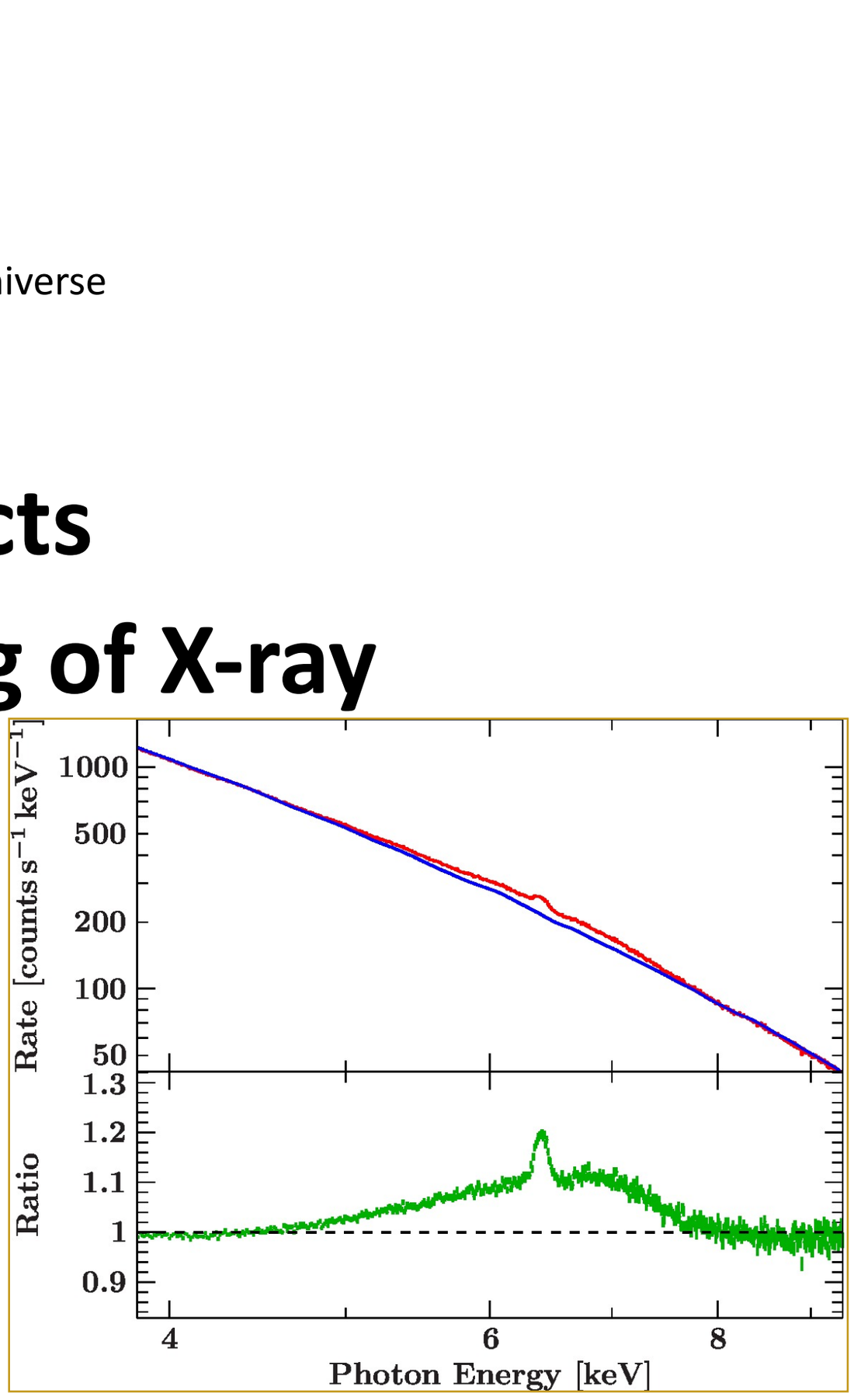
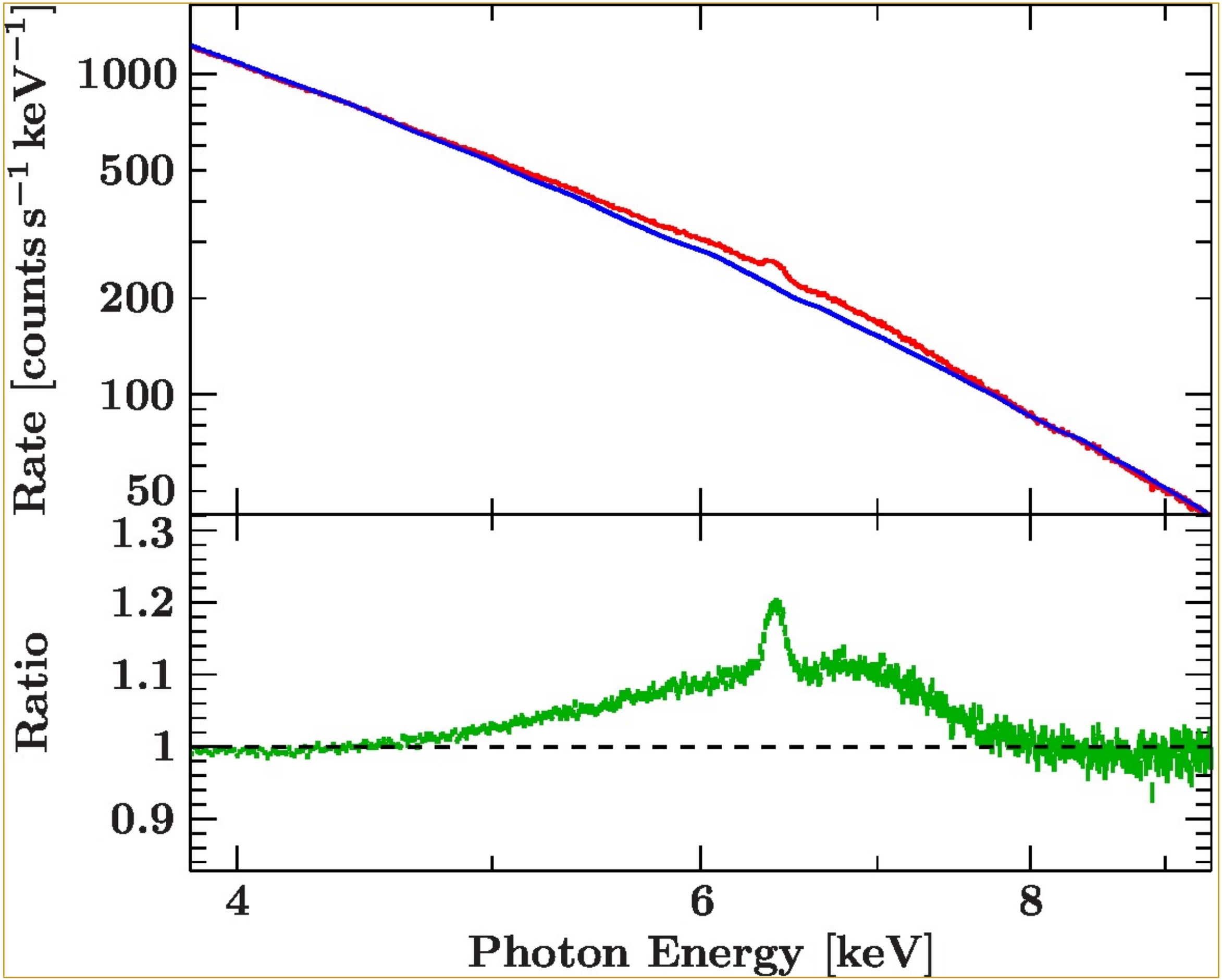
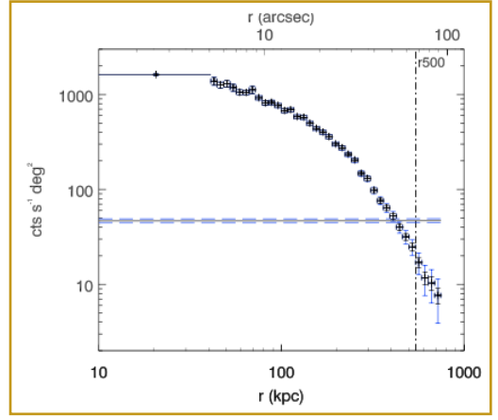
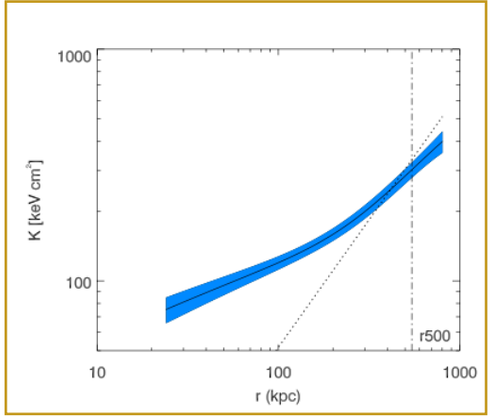




(Motch, Wilms et al. 2013)





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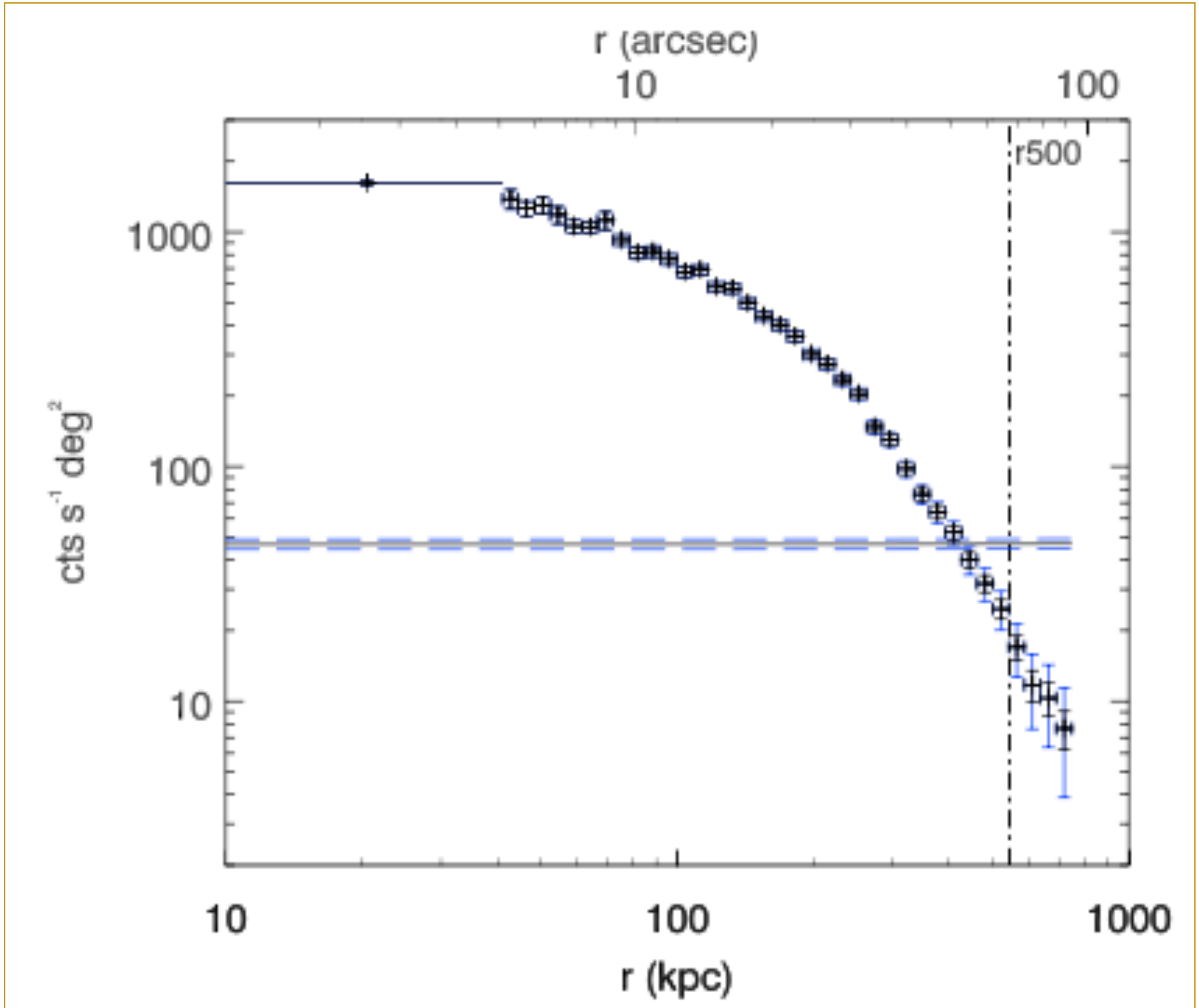
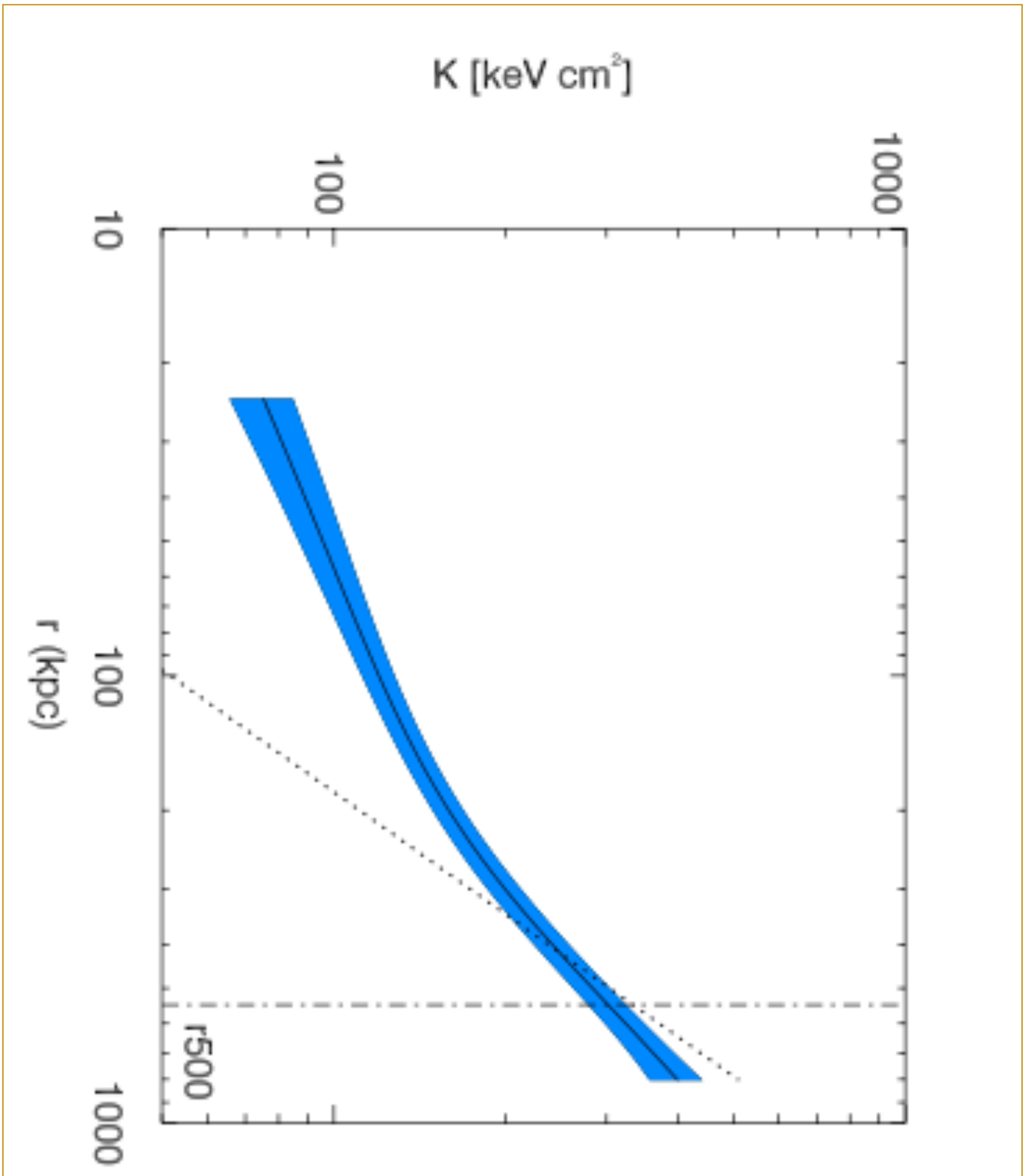


(Pointecouteau, Reiprich et al. 2013)



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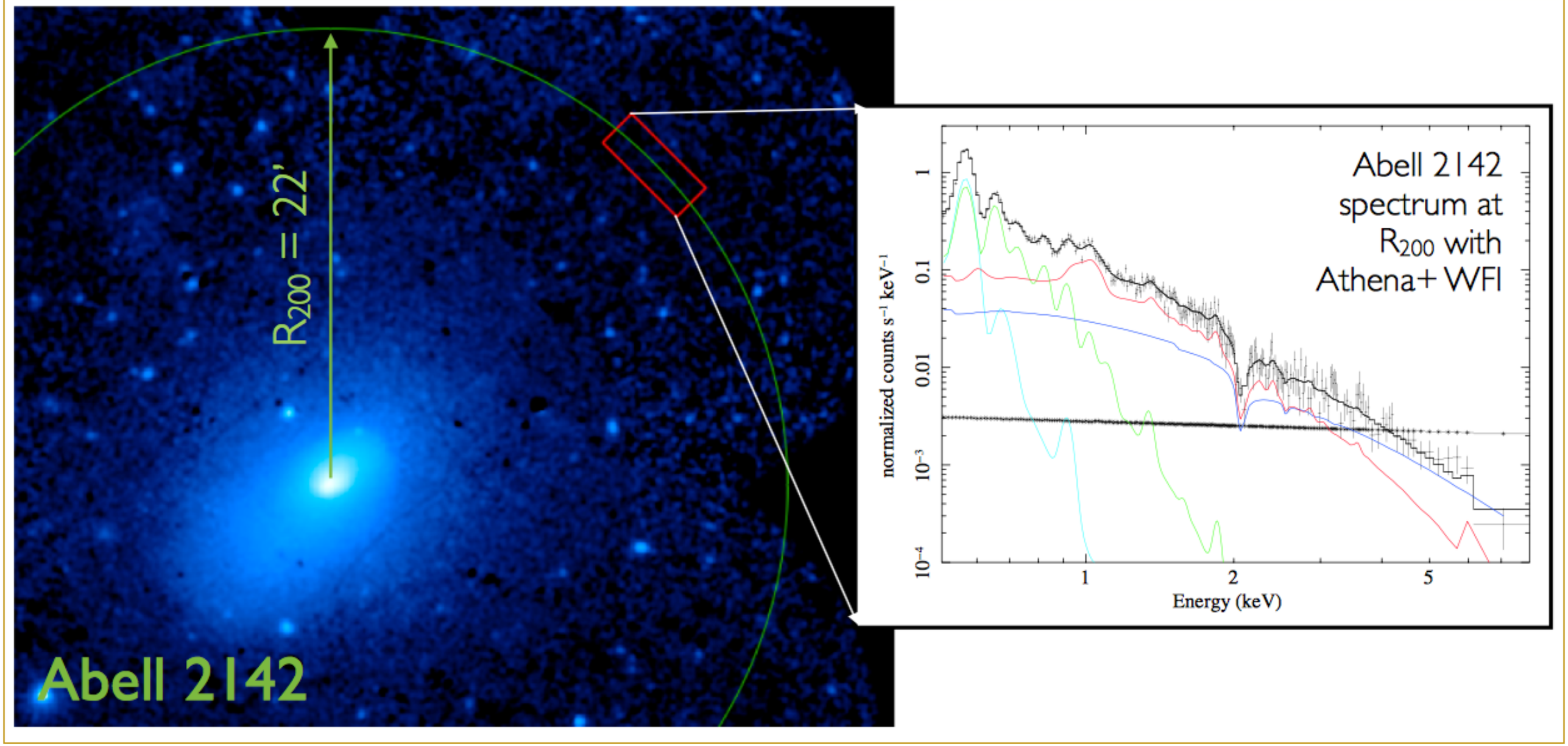

(Ettori, Pratt et al. 2013)

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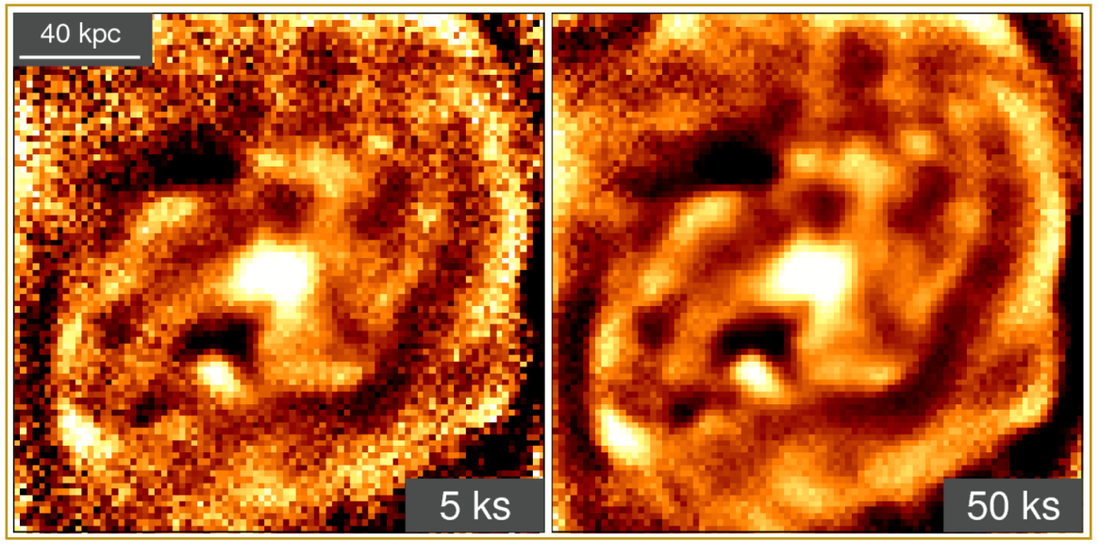
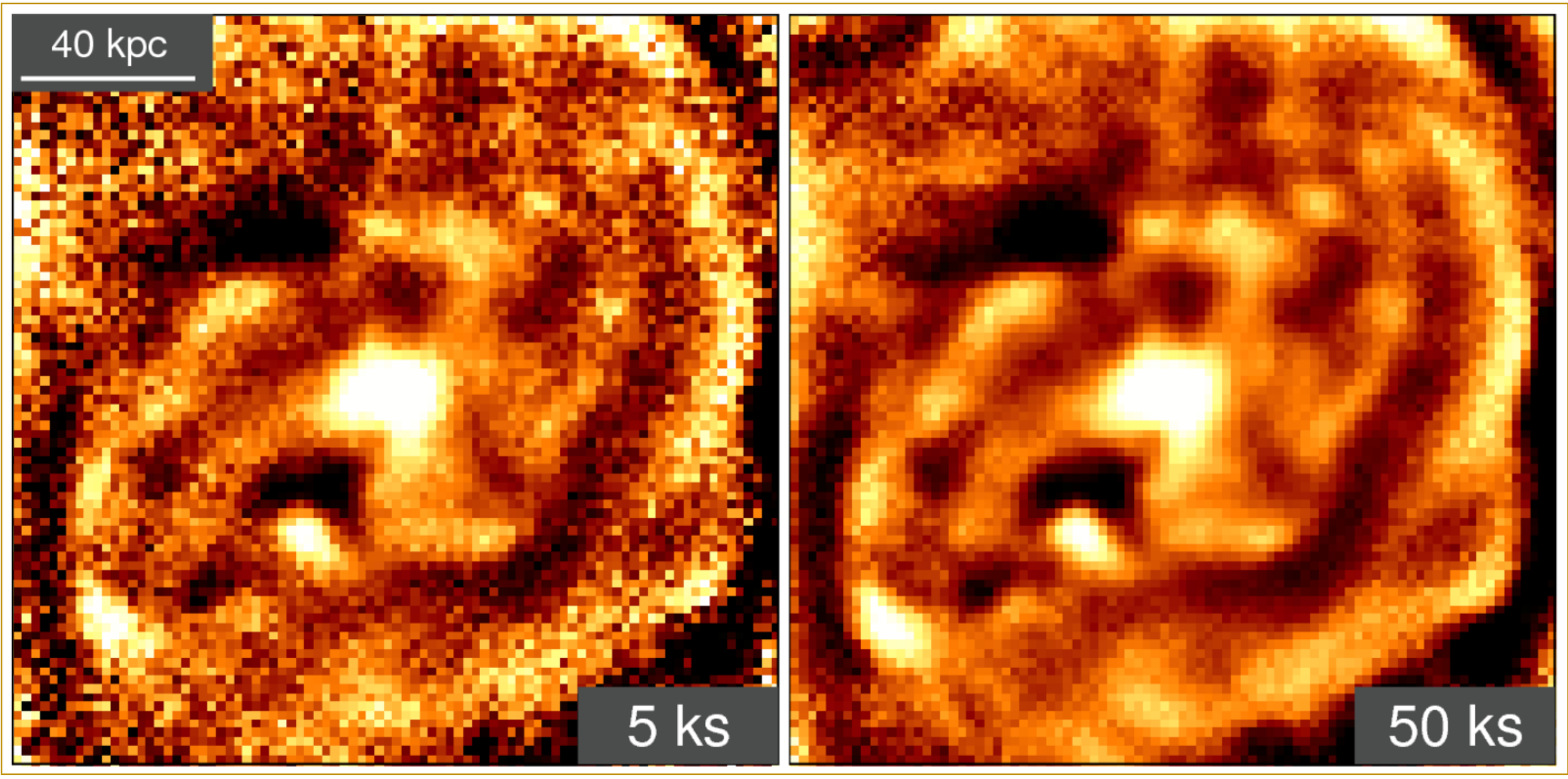
  - **AGN ripples**

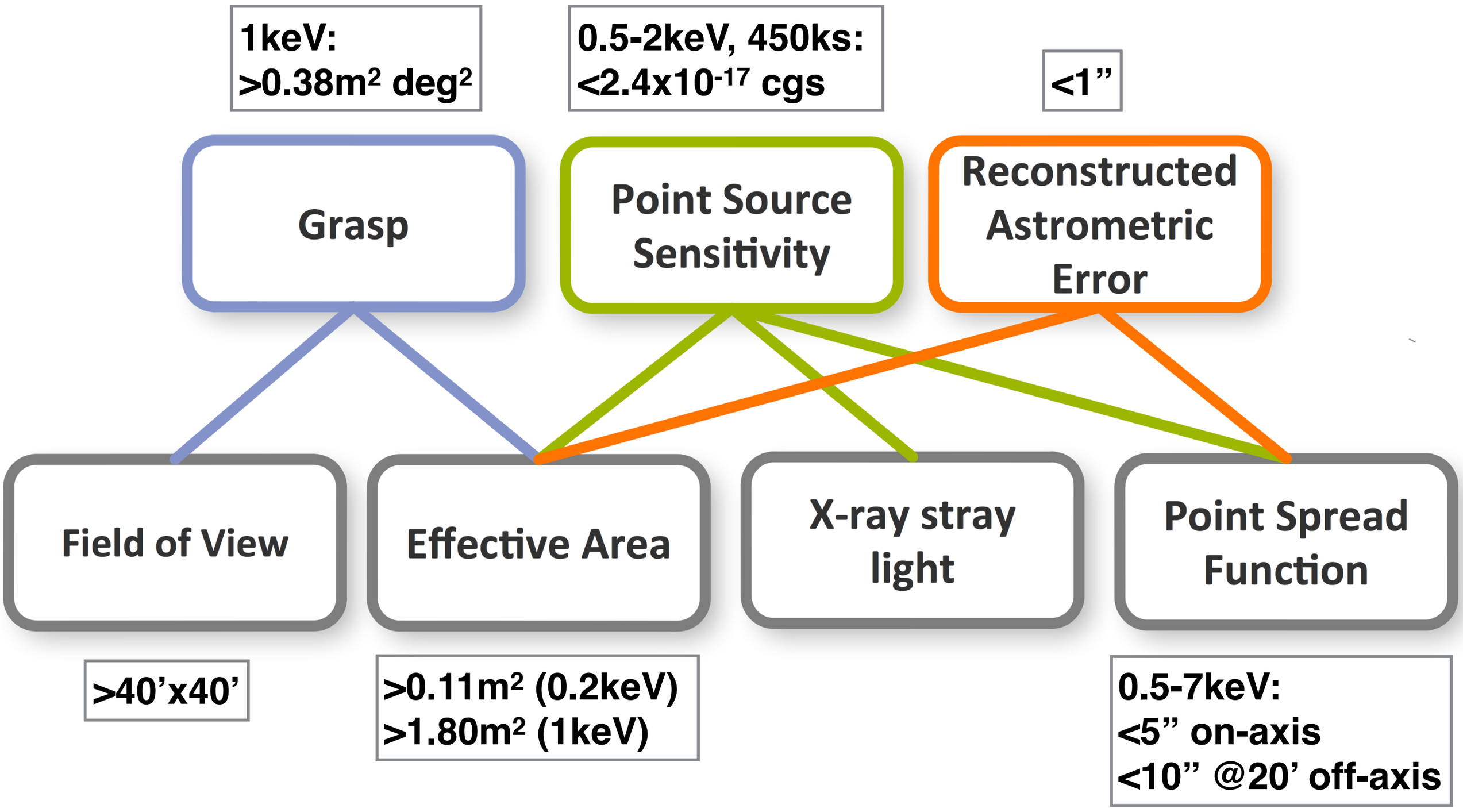




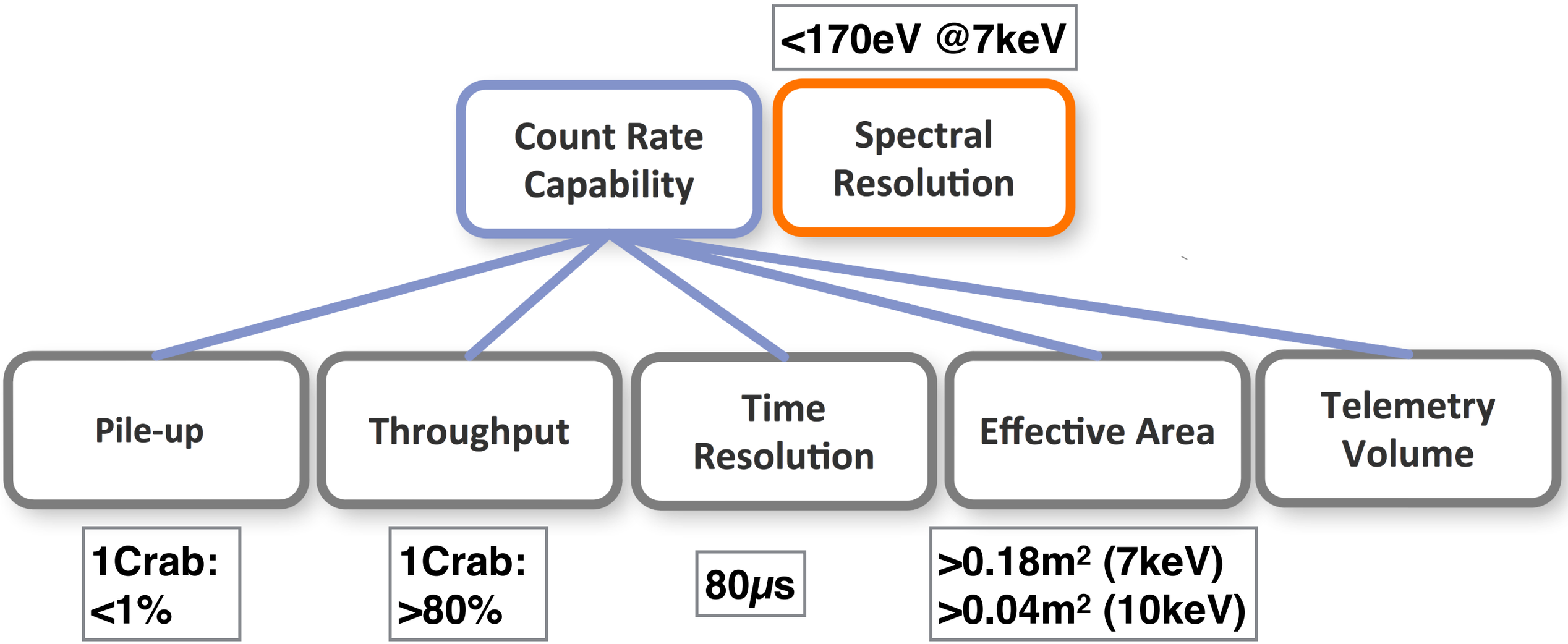
(Croston, Sanders et al. 2013)

Key Science Requirements

Key science requirements for high-z AGN:



Key science requirements for GBH spin:

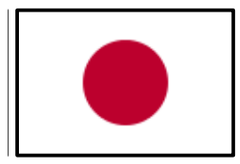


Hardware Implementation

WFI Proto-Consortium

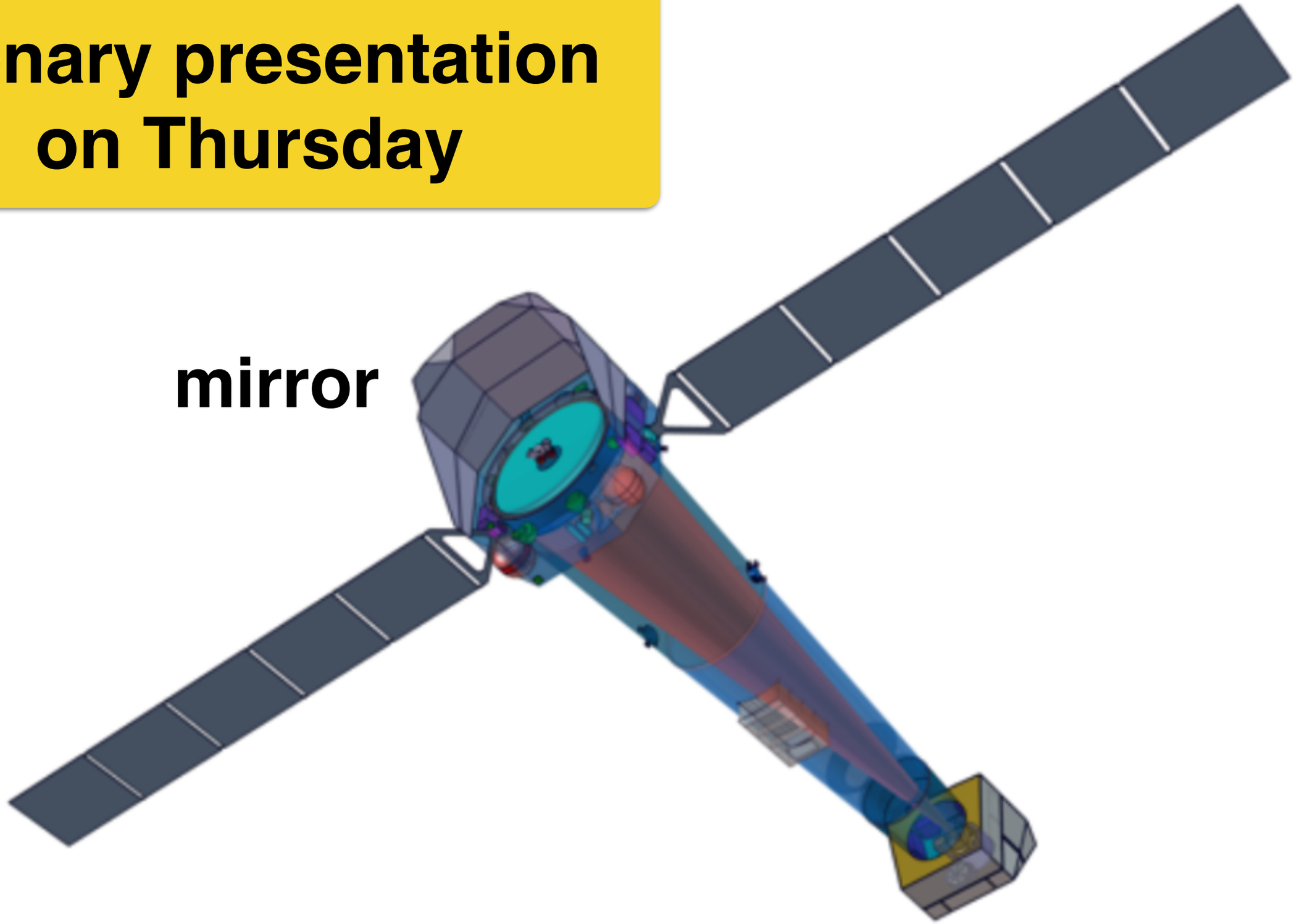
Germany, Austria, Denmark, France, Great Britain, Italy, Poland, Portugal, Switzerland, Greece, USA

+ potential partners: Japan

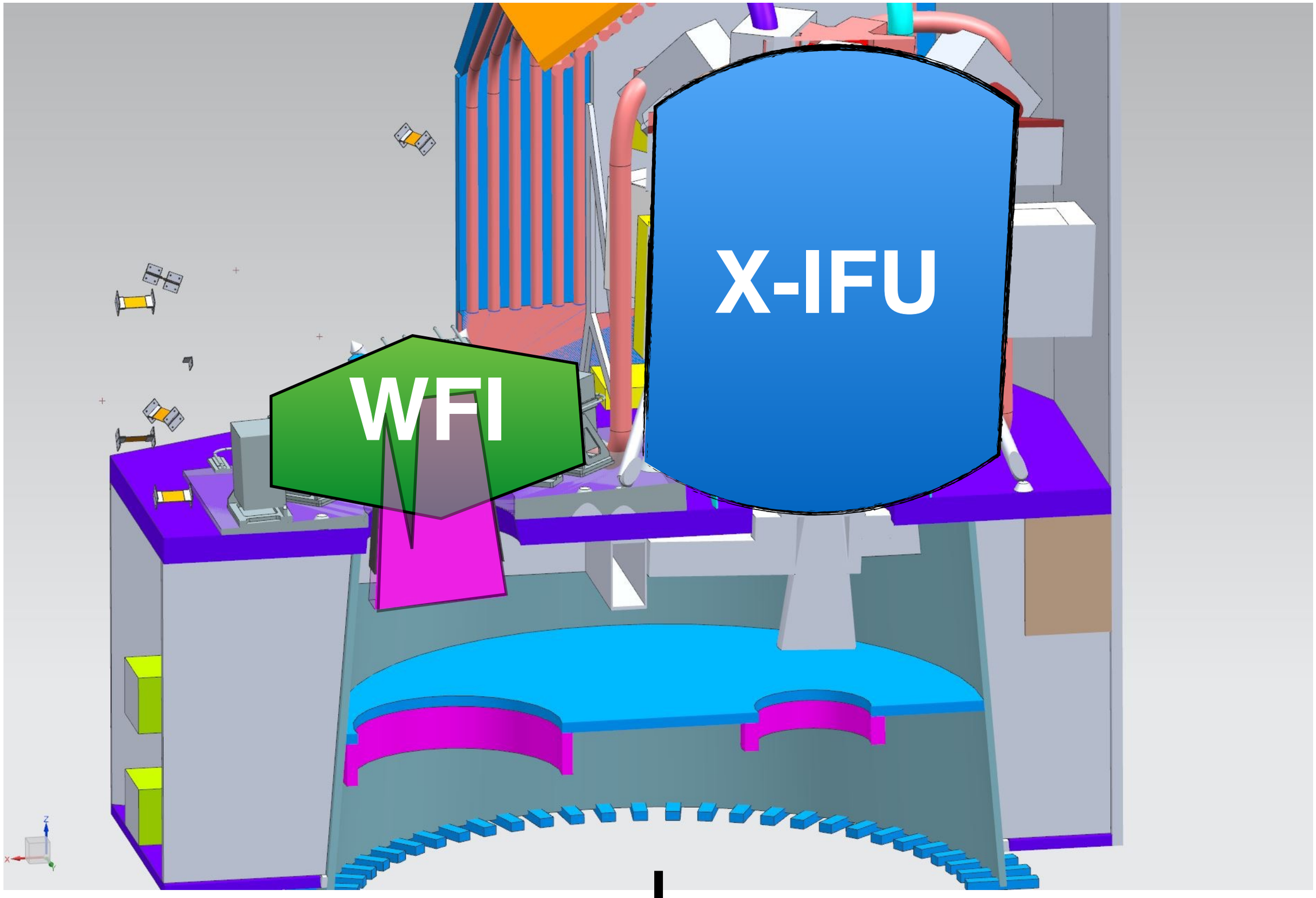


Principal Investigator: Paul Nandra (MPE)
Project Manager: Norbert Meidinger (MPE)
Project Scientist: Arne Rau (MPE)

See M. Guainazzi's plenary presentation on Thursday

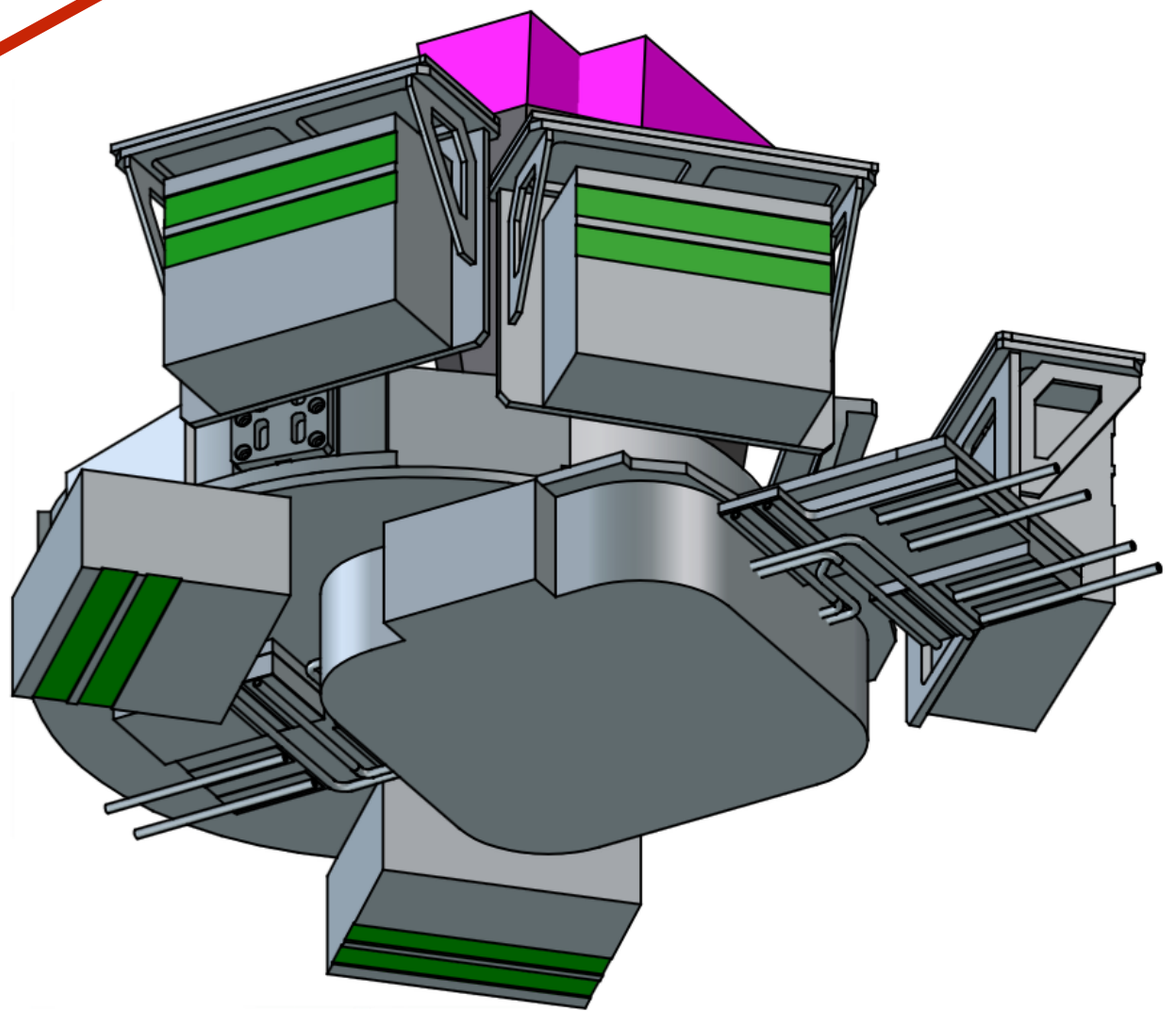


(Credit: ESA CDF)



Athena Mirror System

ATHENA Mirrors



ATHENA
Mirror System

Baffle

Primary
Structure

Filter Wheel

Close/Open

Filter/Cal. Sour.

DEPFET
Large Sensor Array
Fast Sensor

Graded-Z Shield

CFE

AFE

Detector Board

Proton

Shield

Camera Head

DEPFET Heatpipe

FEE Heatpipe

Detector Electronics

Frame Processor

Power Conditioner

Instrument Control and Power-distribution Unit

Centra Processing Module

Power Distribution Unit

Analog Interface Board

Science Products Module

S/C com I/F nom

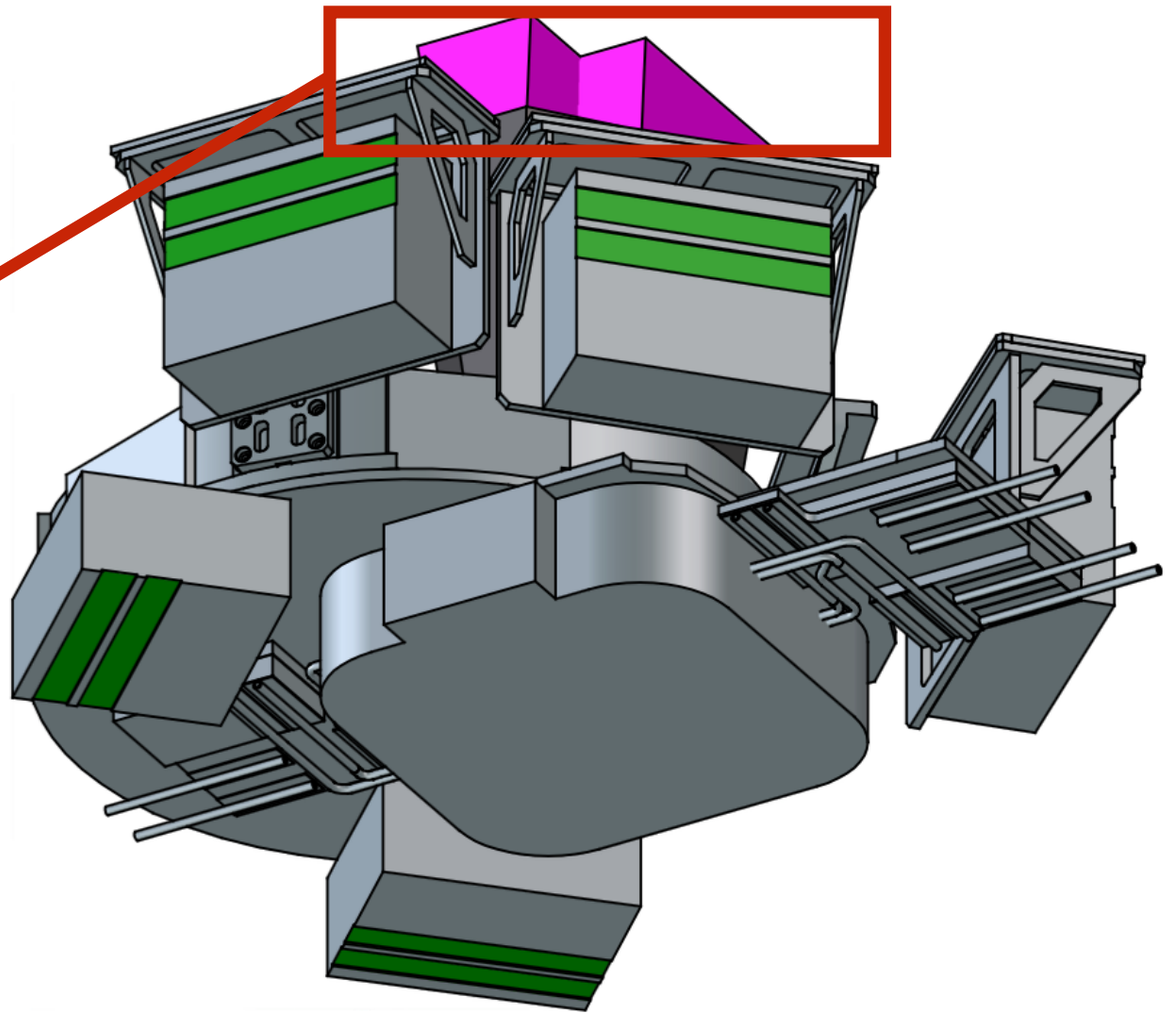
S/C com I/F red

S/C power nom

S/C power red

Spacecraft

ATHENA Mirrors



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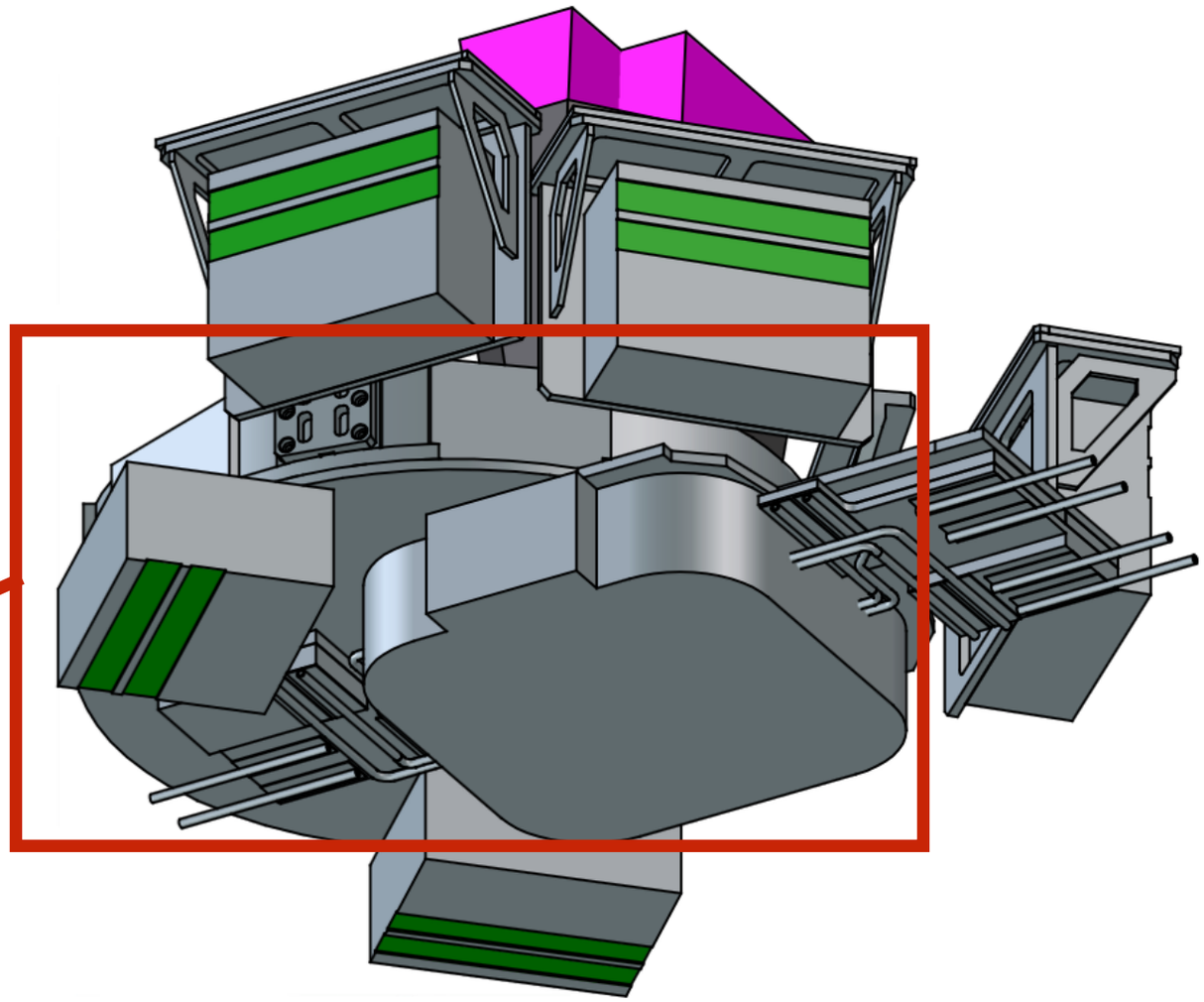

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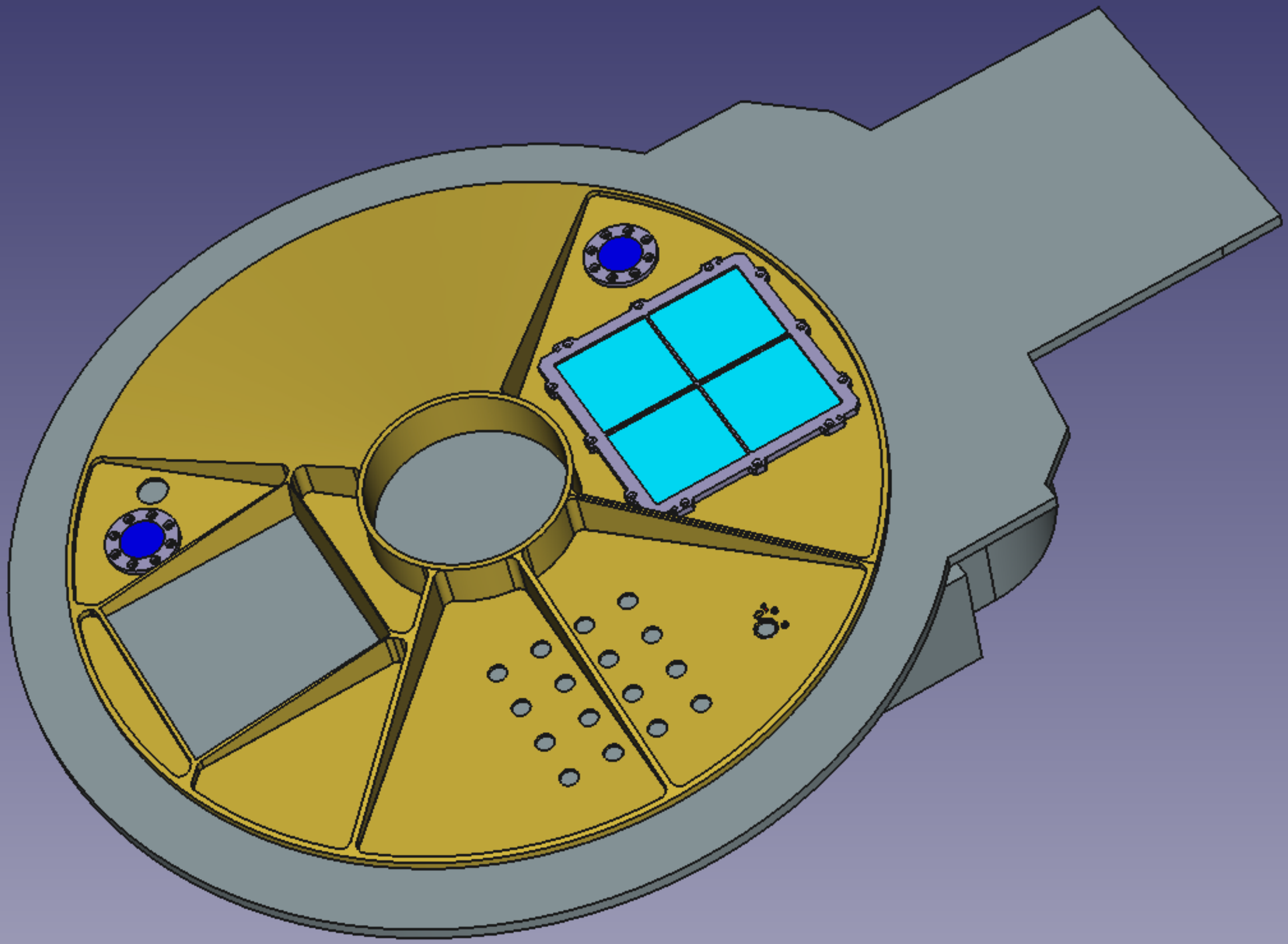
Spacecraft



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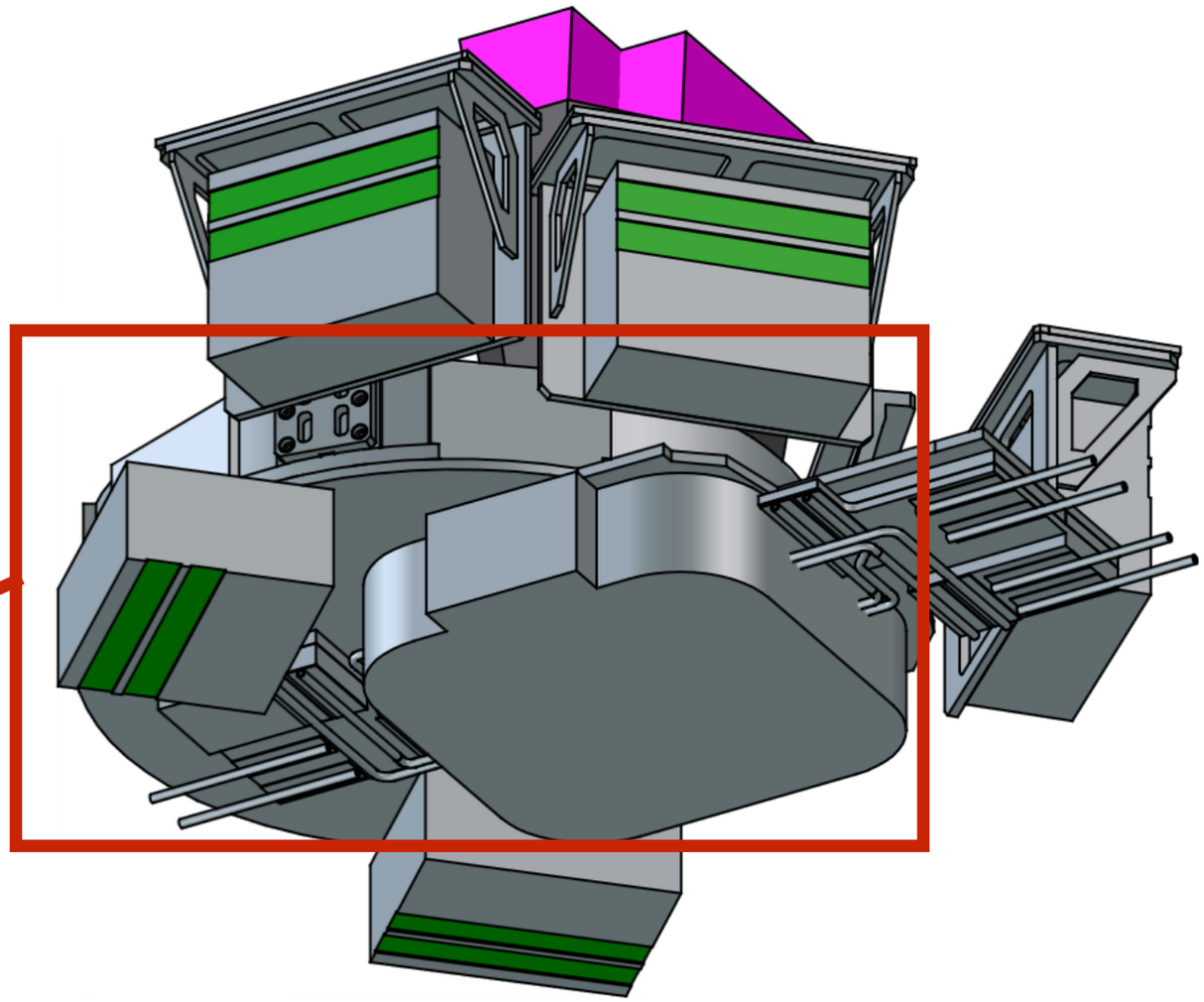

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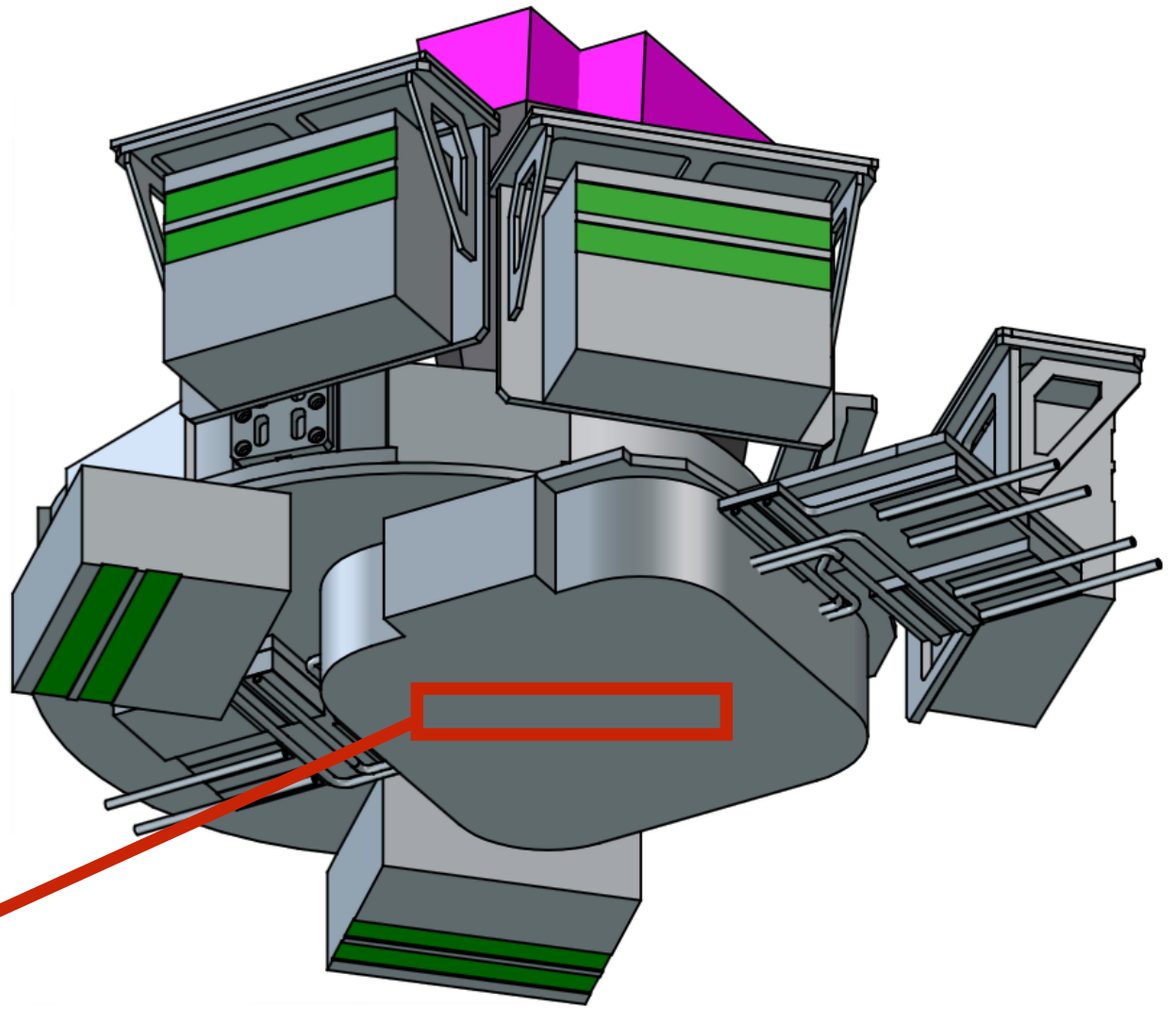
ATHENA Mirrors



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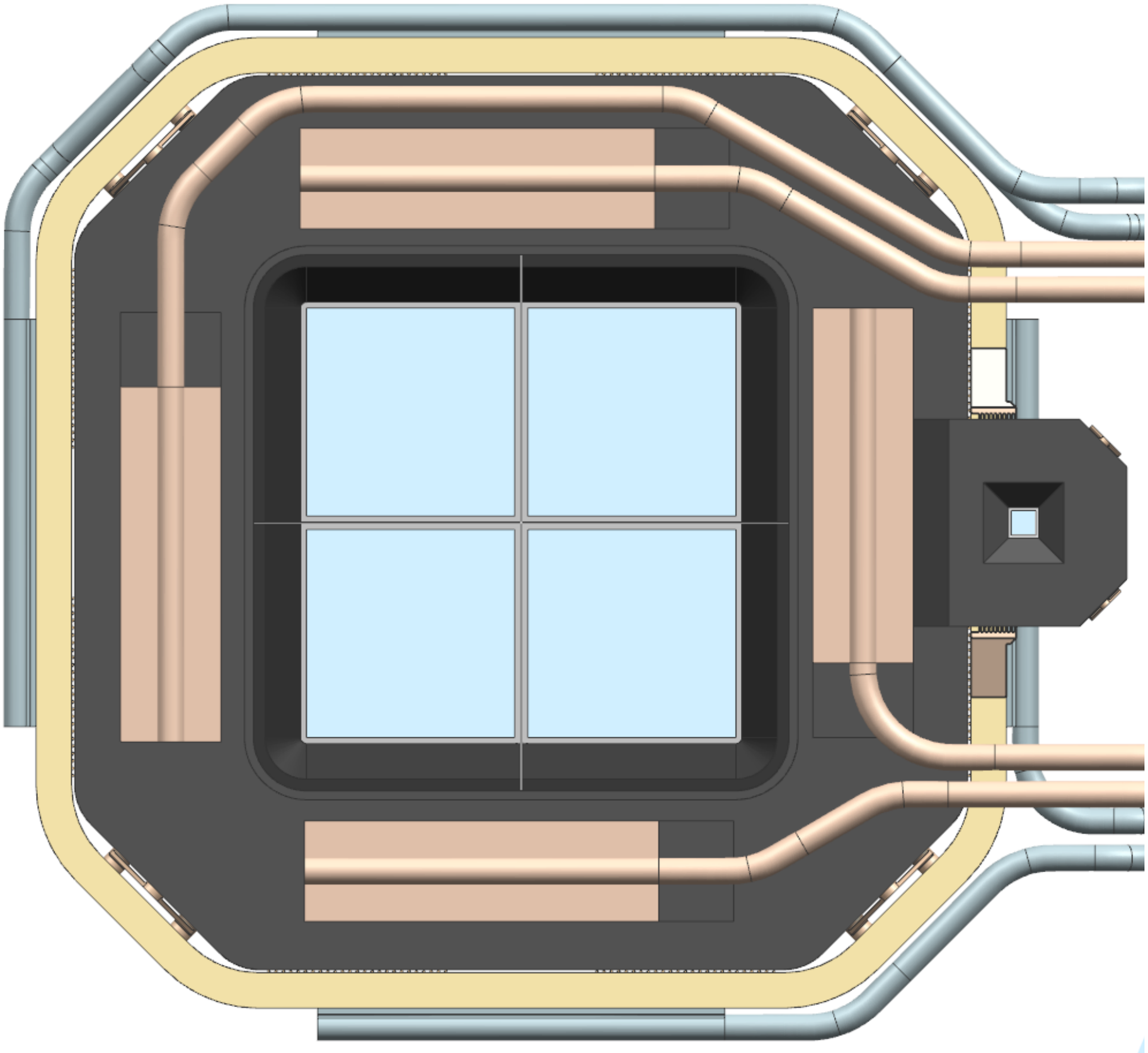
Spacecraft

Focal Plane



Large Detector

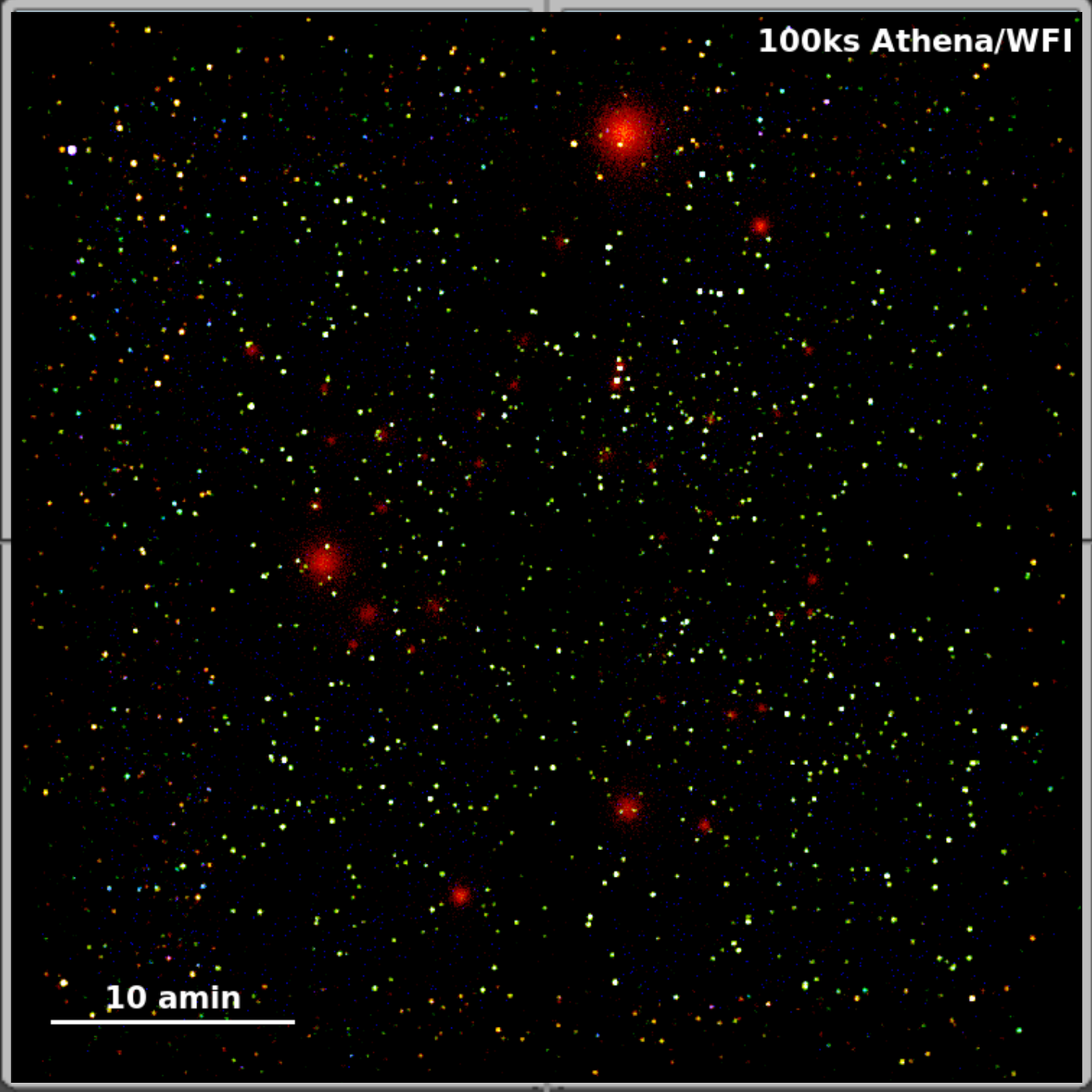
- 40’x40
- 4x512x512 pxl
- <5ms/frame
  <10µs/row

Fast Detector

- defocused
- 64x64(/2) pxl
- <80µs/frame
  <2.5µs/row

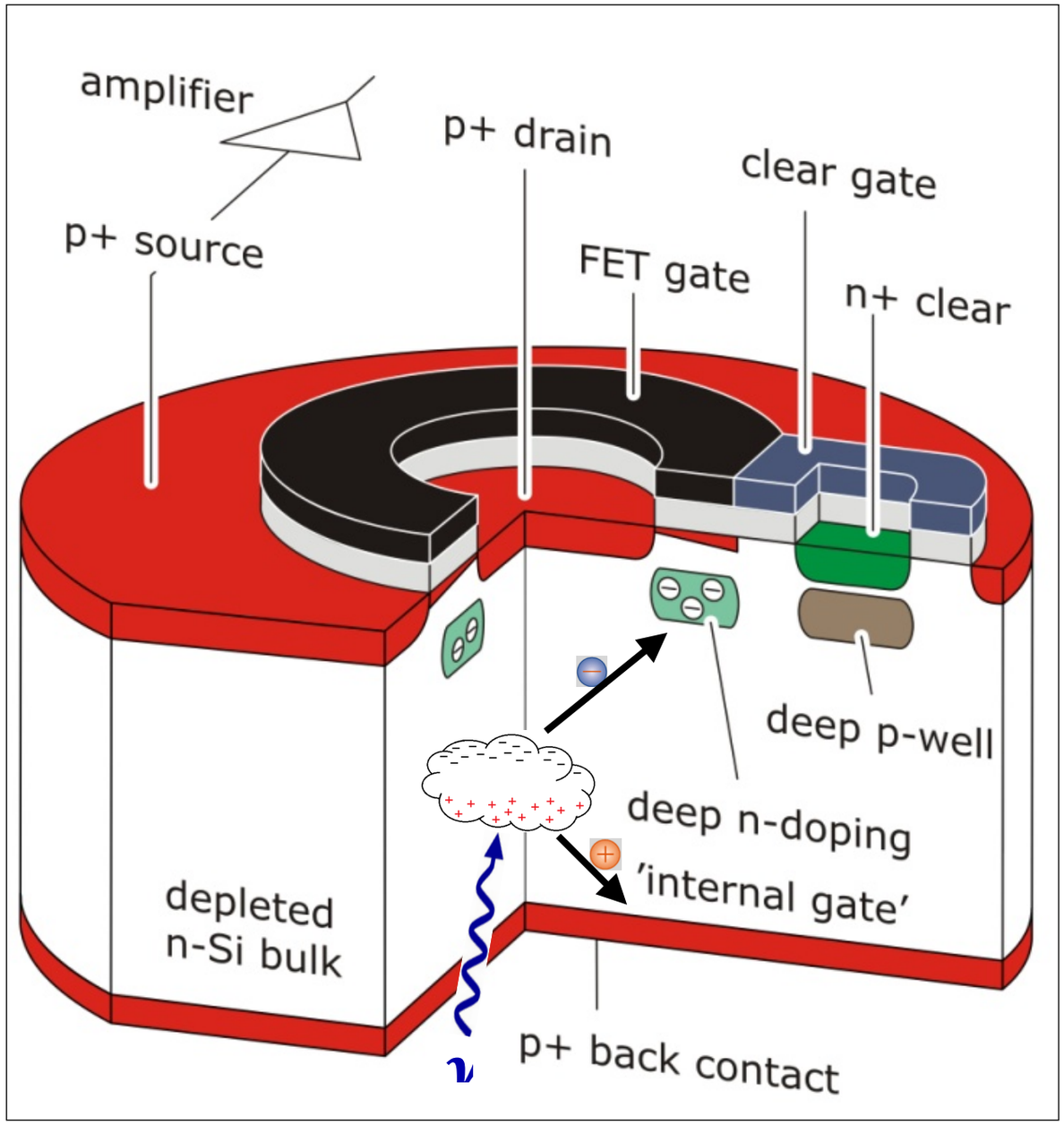
Both

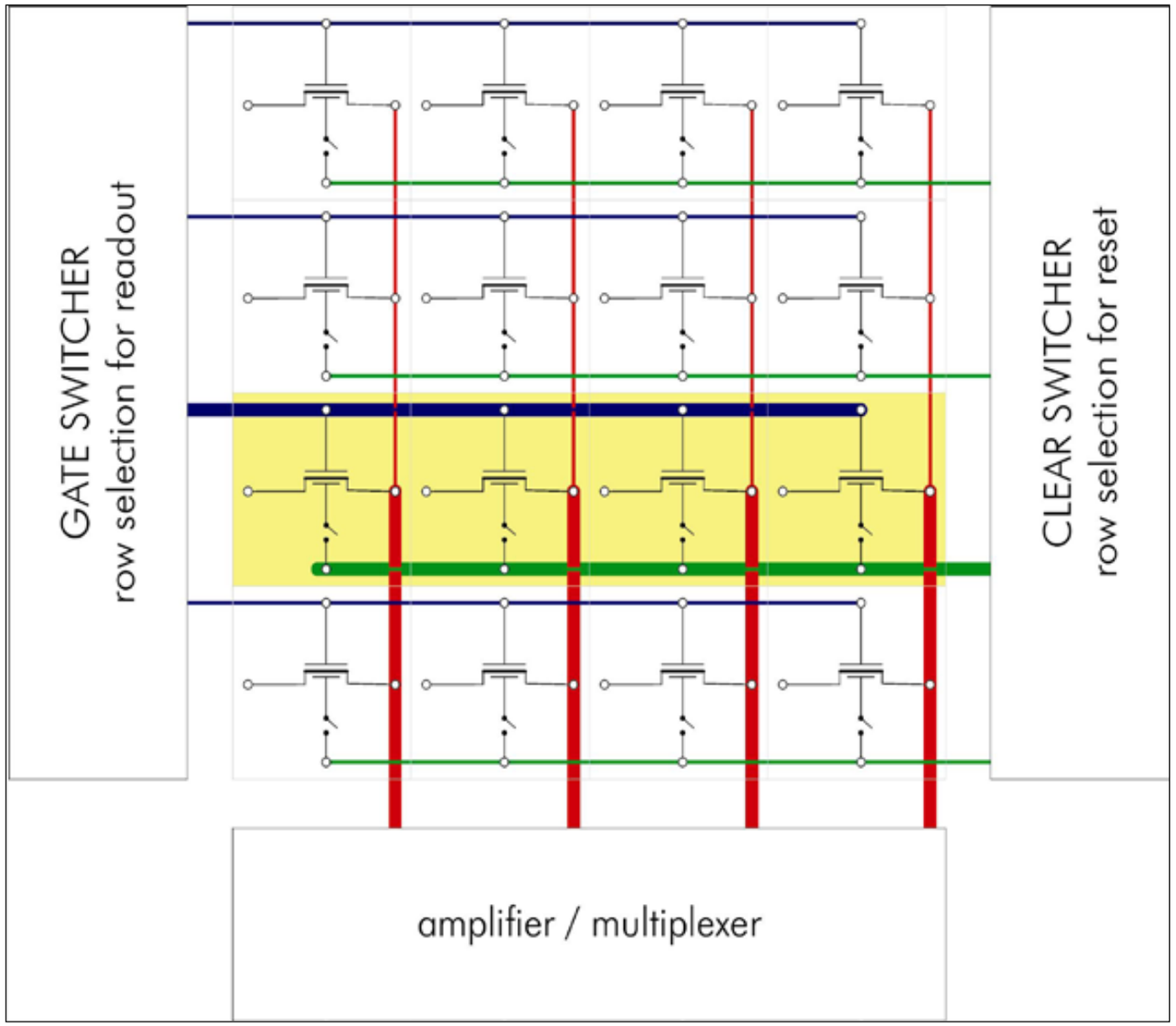
- 130µmx130µm
- DEPFET technology



SIXTE simulation

The WFI uses matrices of DEPFET active pixel sensors where all pixels in one active row are read out simultaneously.





1st DEPFET Prototype Production (Autumn ’16)

2 objectives

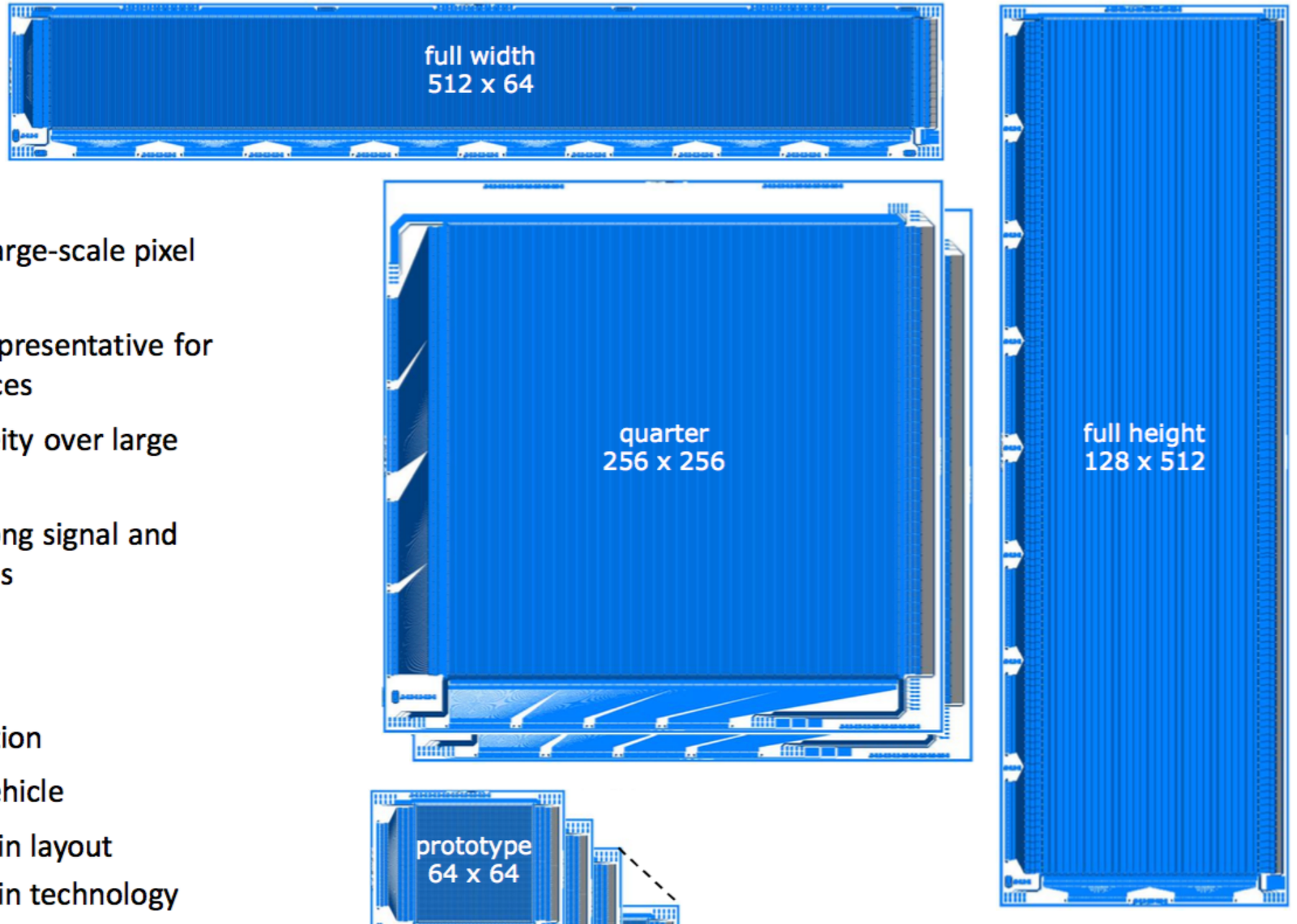
operation of large-scale pixel detectors

- formats representative for flight devices
- homogeneity over large area
- effect of long signal and supply lines

DePFET evolution

64 x 64 test vehicle

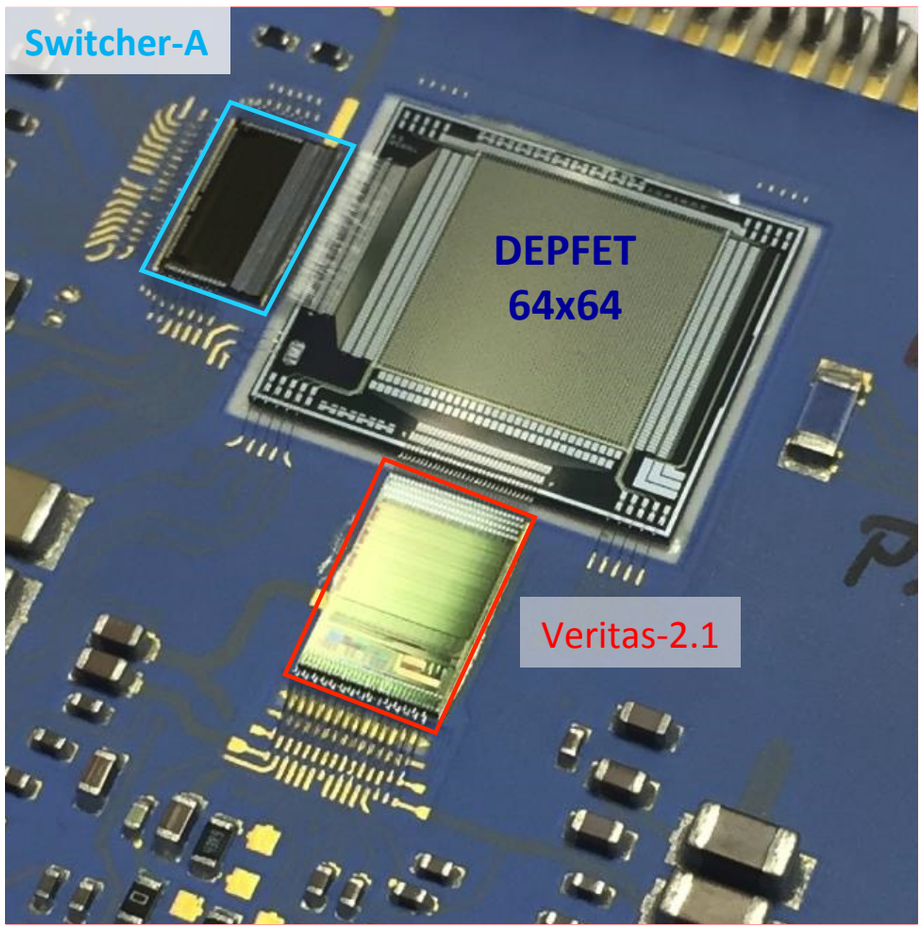
- variations in layout
- variations in technology
- variations in readout



(Courtesy: P. Lechner)

1st production of the WFI DEPFETs finished:

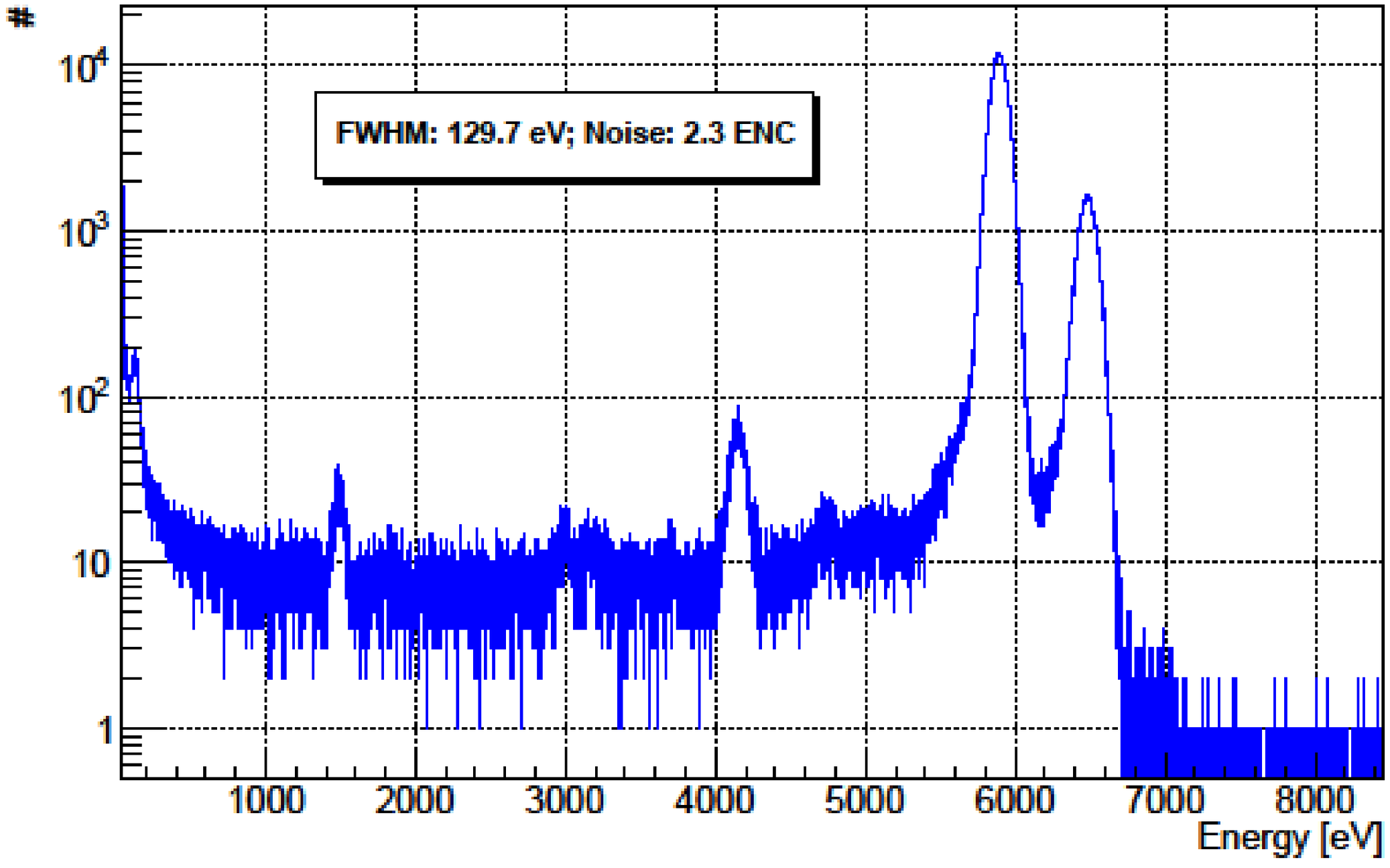
- all technology parameters in spec
- good pixel yield
- yield-limiting factor identified
- counter actions defined, test project started
- devices tested at MPE



flight devices

- pre-flight production start in mid-’17

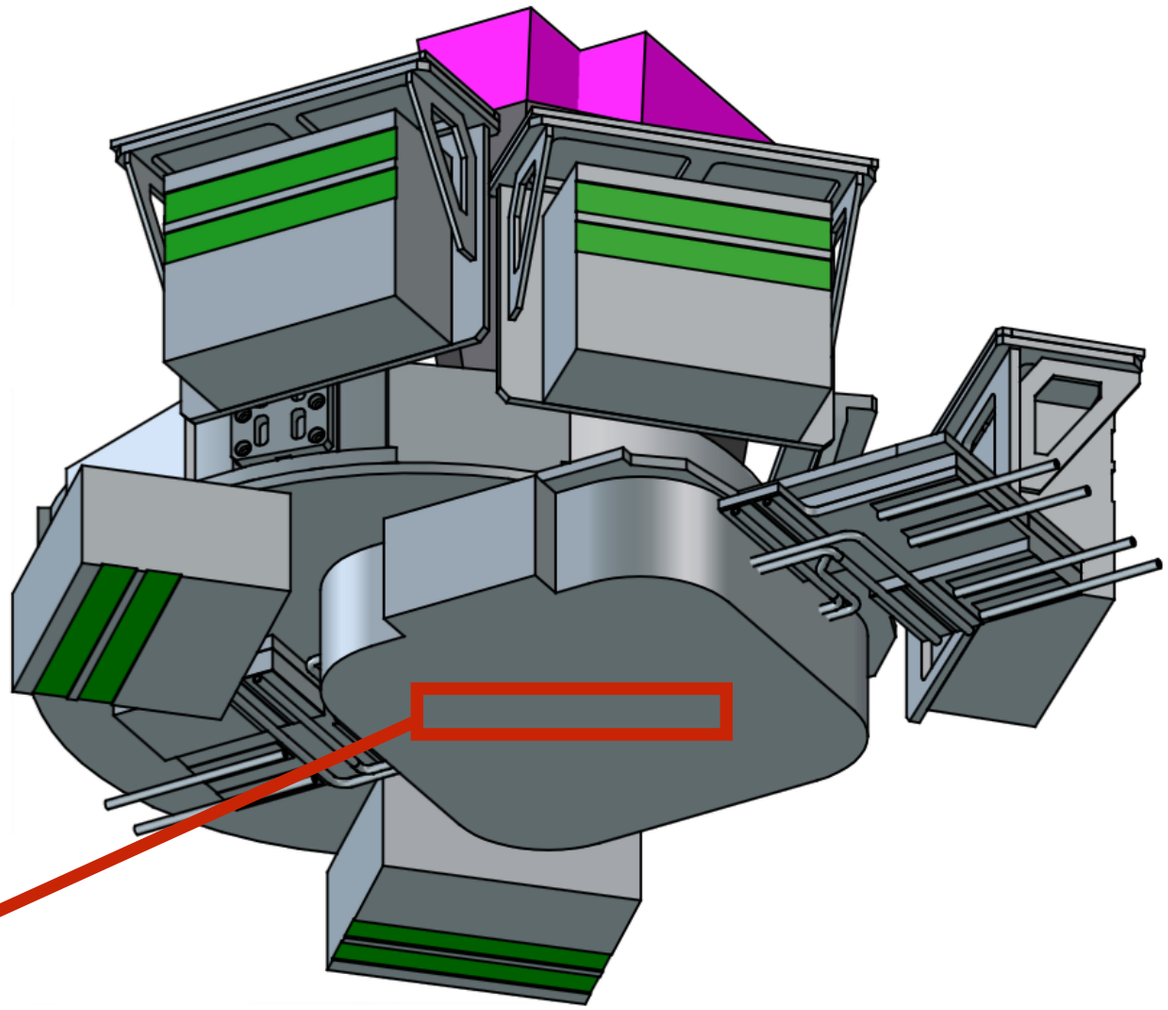
Excellent spectroscopic performance achieved for 64x64 matrix under nominal operation conditions.



σ = **2.3 el. ENC**, **FWHM(5.9keV) = 130 eV**

measured @ 2.5µs/row (= req. for FD)

ATHENA Mirrors



ATHENA
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Baffle

Primary Structure

Filter Wheel

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Filter/Cal. Sour.

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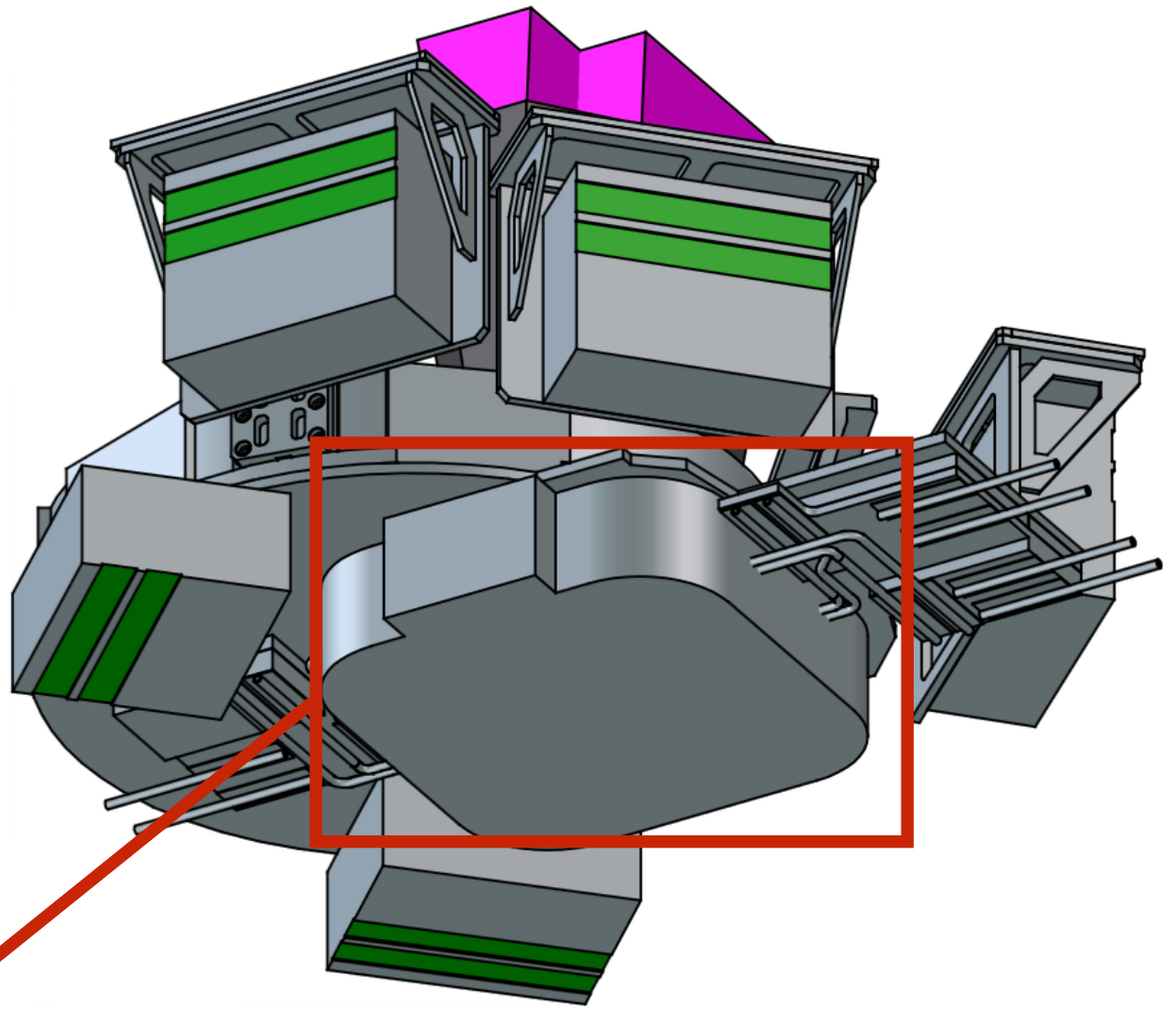

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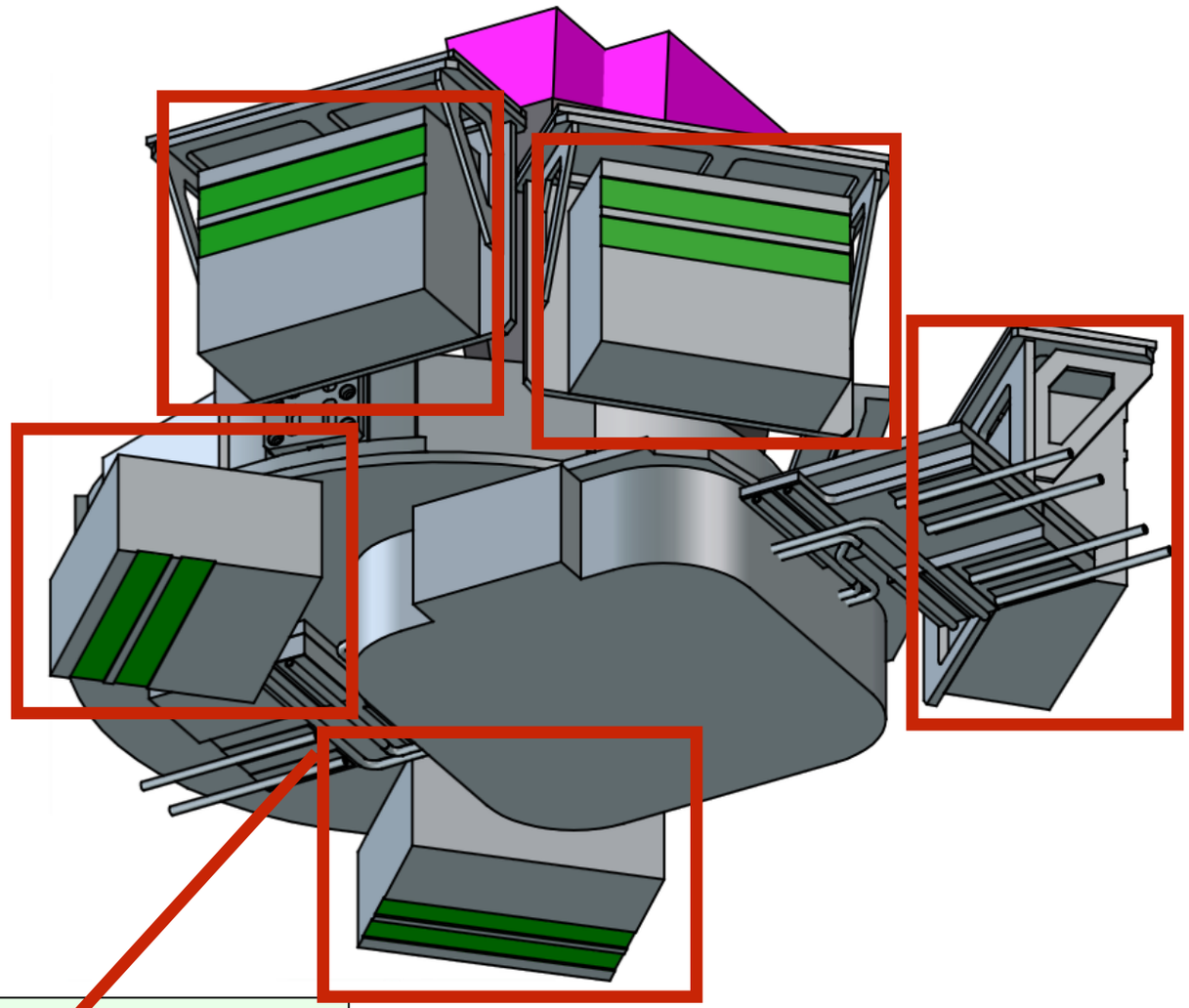

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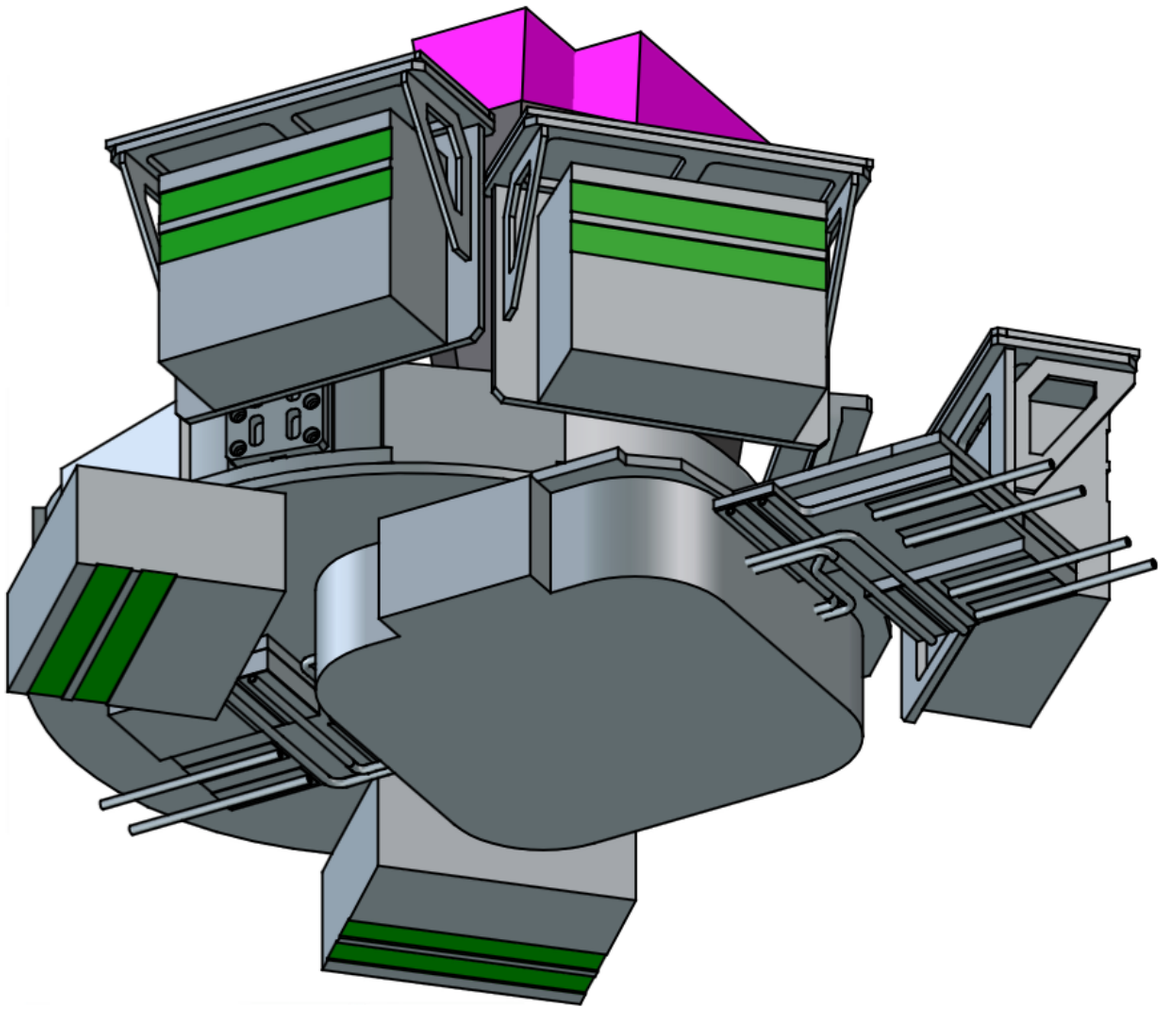

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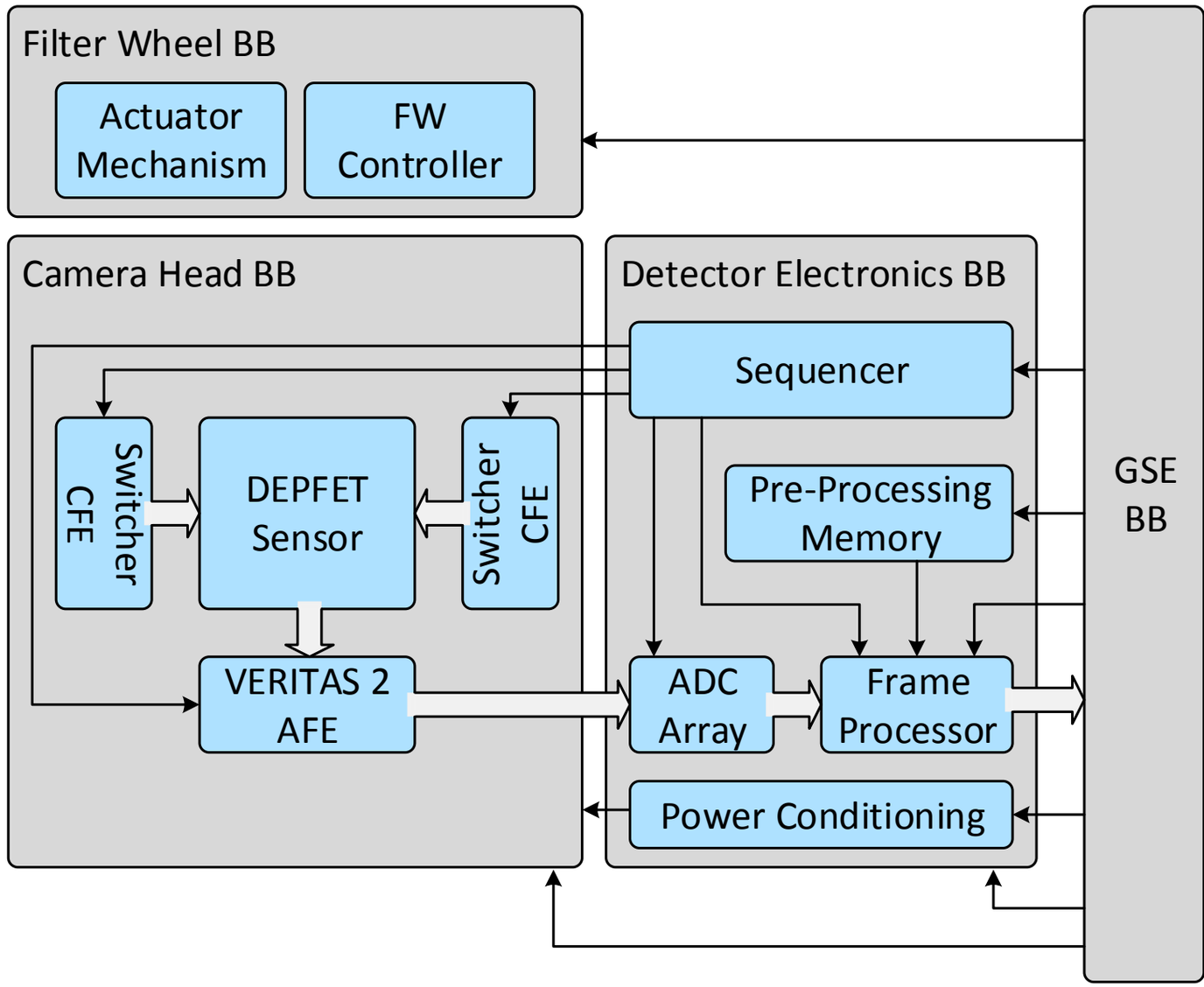
Spacecraft

2015-2018 WFI Technology Development Activity

Filter-Wheel:
optical blocking filter.
Critical: ac. noise during launch

Detector:
DEPFET sensors + FEE ASICs.
Critical: Performance verification

Detector Electronics:
power conditioning +
pre-processing.
Critical: real-time pre-processing



Parameter	Value
Energy Range	0.2-15 keV
Field of View	40’ x 40’
Angular Resolution **Pixel Size**	PSF=5`` (on-axis) 130 x 130 $\mu m^2$ (2.2``)
Large DEPFET detector	1024 x 1024 pixel (4 quadrants) ≈ 14cmx14cm
Fast DEPFET detector	64 x 64 pixel (split full frame mode - 2 halves readout)
Operating mode	Rolling shutter
Operating time	Nonstop possible
Quantum efficiency (on-chip + ext. filter)	20% @ 277 eV 80% @ 1 keV 90% @ 10 keV
Energy Resolution	FWHM(1 keV) ≤ 80 eV (end of life) FWHM(7 keV) ≤ 170 eV (end of life)
Time Resolution full frame Fast detector Large detector	 80 µs <5 ms
Count Rate Capability	Fast DEPFET (defocused) 1 Crab: >80% throughput, <1% pile-up
Particle Background (L2 orbit)	$< 5 \times 10^{-3}$ cts cm^{-2} s^{-1} keV^{-1}

http://www.mpe.mpg.de/ATHENA-WFI/