

# **ATHENA: The Advanced Telescope for High Energy Astrophysics**



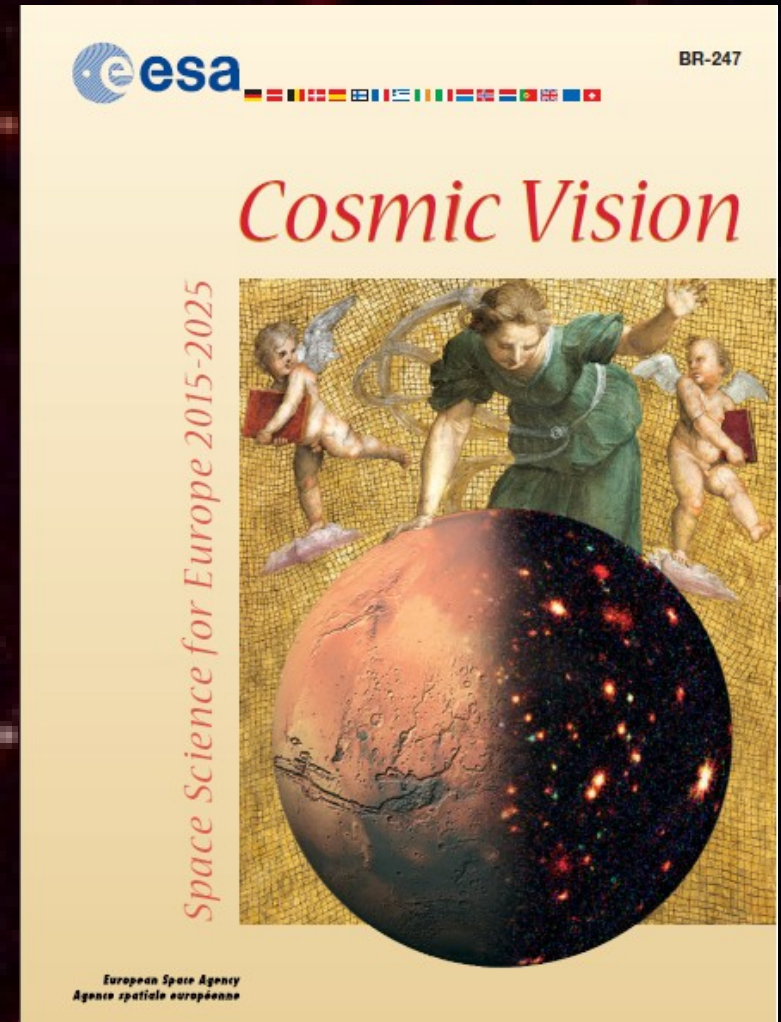
**Kirpal Nandra, MPE Garching**

**On behalf of the Athena Study Team**

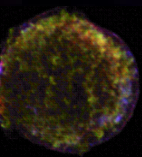
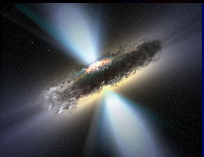
**The X-ray Universe 2011, Berlin, 29 June 2011**

- What are the fundamental physical laws of the Universe
  - Matter under extreme conditions
- How did the Universe originate and what is it made of?
  - The Universe taking shape
  - The evolving violent Universe

➔ Large X-ray Observatory



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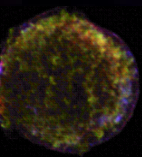
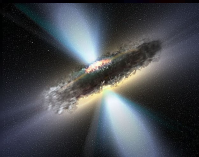
- Oct 2007 ESA selects XEUS as candidate L-mission
- June 2008 XEUS and Con-X merge → IXO
- Feb 2011 presentation of ESA IXO assessment study
- Feb/Mar 2011 Decadal Surveys, new budget realities

## New Plan Required!

**March 14<sup>th</sup> 2011:** ESA announces decision to re-formulate L-class missions: European-led.

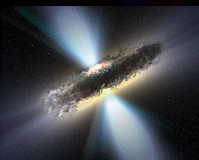
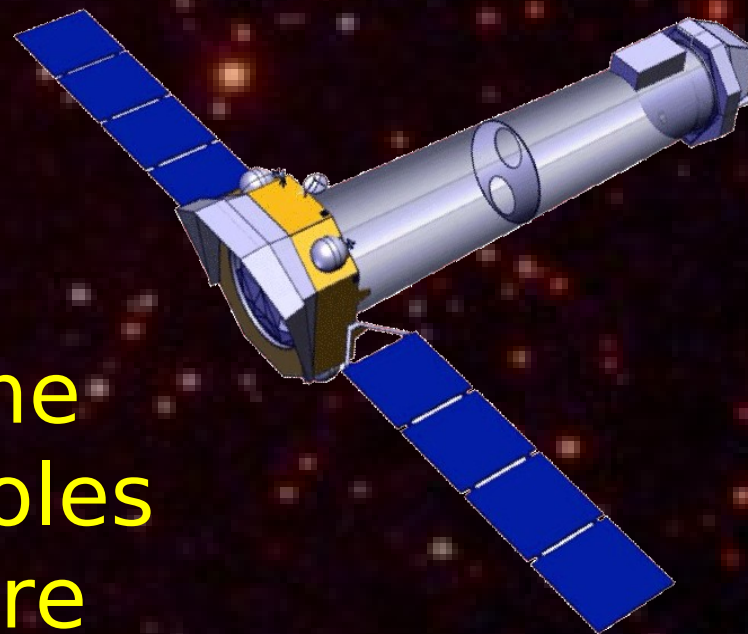
**Mar-Apr 2011:** New Study Team formed, rapid Scientific and Technical evaluation of options

**April 29<sup>th</sup> 2011:** Baseline mission chosen by Athena Study Team (AST) - **"The Event"**

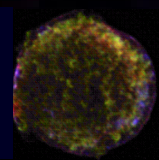


## ATHENA!

Revealing the Extreme  
Universe from Black Holes  
to Large Scale Structure

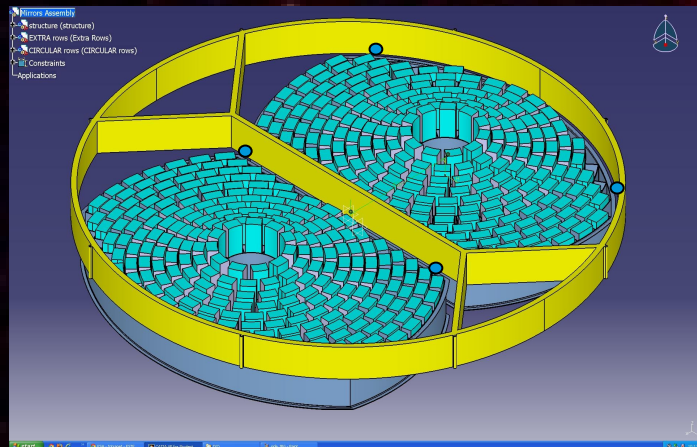


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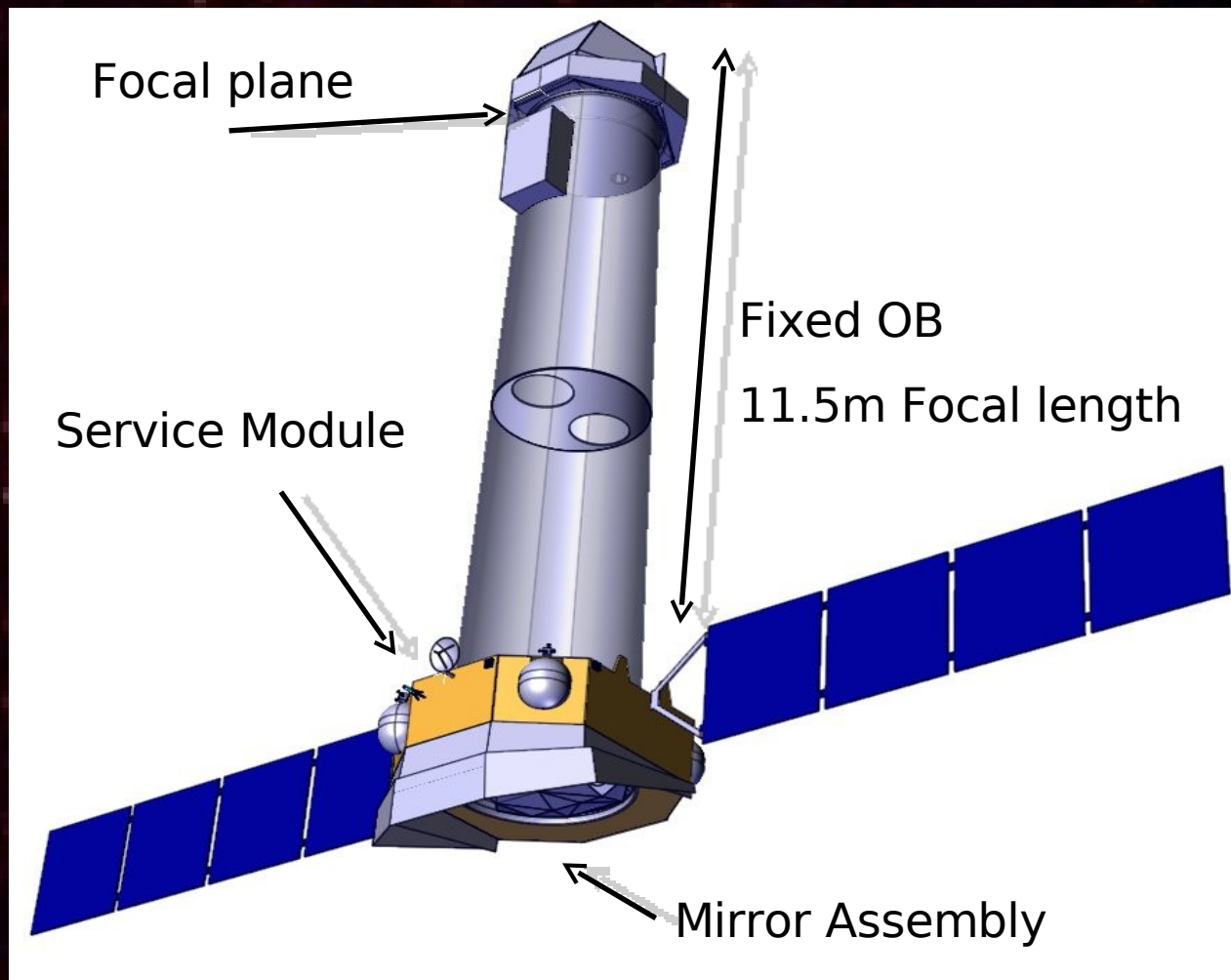
- **The Problem:**
  - Reduce ESA cost (<850M€) x2 cf. IXO, maximum science
- **Solutions:**
  - Lower Mass (Mirror Effective Area)
  - Reduced Complexity (e.g. EOB, Mechanisms)
  - Fewer Instruments
- **Tradeoffs:**
  - Which Instruments? (XMS, WFI)
  - 1, 2 or 3 telescopes (1 keV vs 6 keV science)
- **Process:**
  - 11 Scientific “Task Teams” set up to investigate science potential and impact of tradeoffs
  - Broad involvement (100+ scientists), very short timescale
  - Presentations and discussion at ESTEC 28<sup>th</sup> April



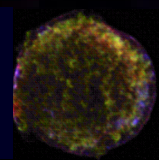


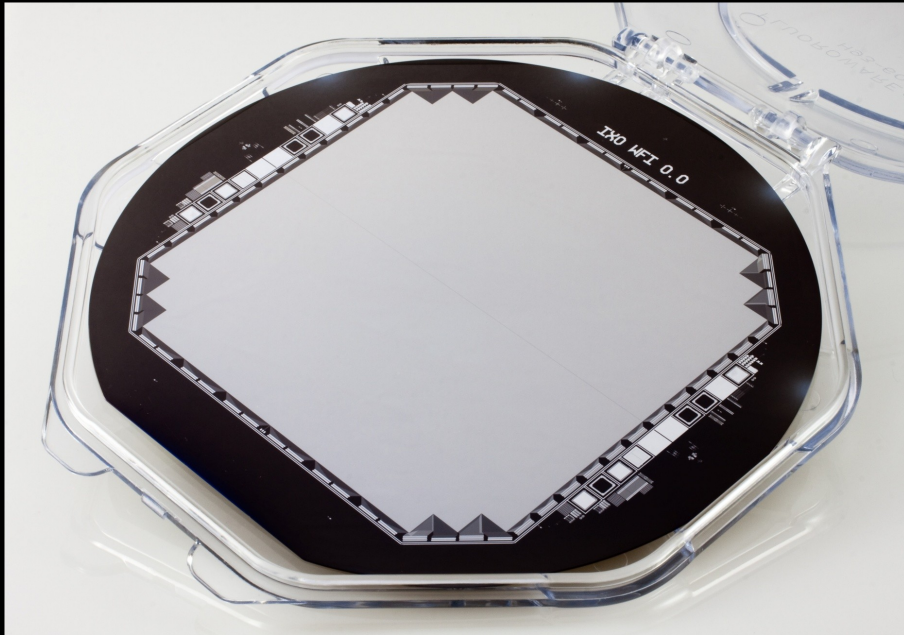
**ESA Silicon Pore Optics  
“OWL” design  
5-10” resolution**

**Ariane V launch to L2  
5yr nominal mission**

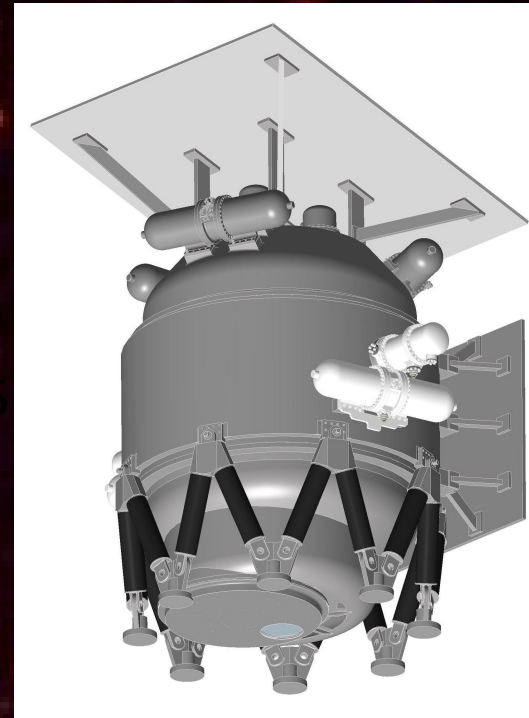


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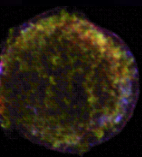
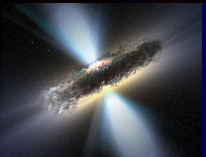


Wide Field Imager (WFI)



Microcalorimeter (XMS)

JAXA, NASA contributions



Black holes, compact objects and accretion physics

Study the behaviour of matter moving around black holes and other compact objects. Probe matter under strong gravity and high density conditions.

The physics of feedback

Study the physics of feedback on all astrophysical scales, from stars and compact objects to galaxies and clusters.

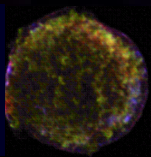
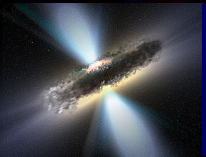
Cosmic evolution of SMBH in galaxies and large-scale structure of the Universe

Determine how SMBH grow, often in obscured environments and trace the formation of Large Scale Structure through the fate of hot baryons in galaxy clusters, studying their structure and evolution.

Astrophysics of hot cosmic plasmas

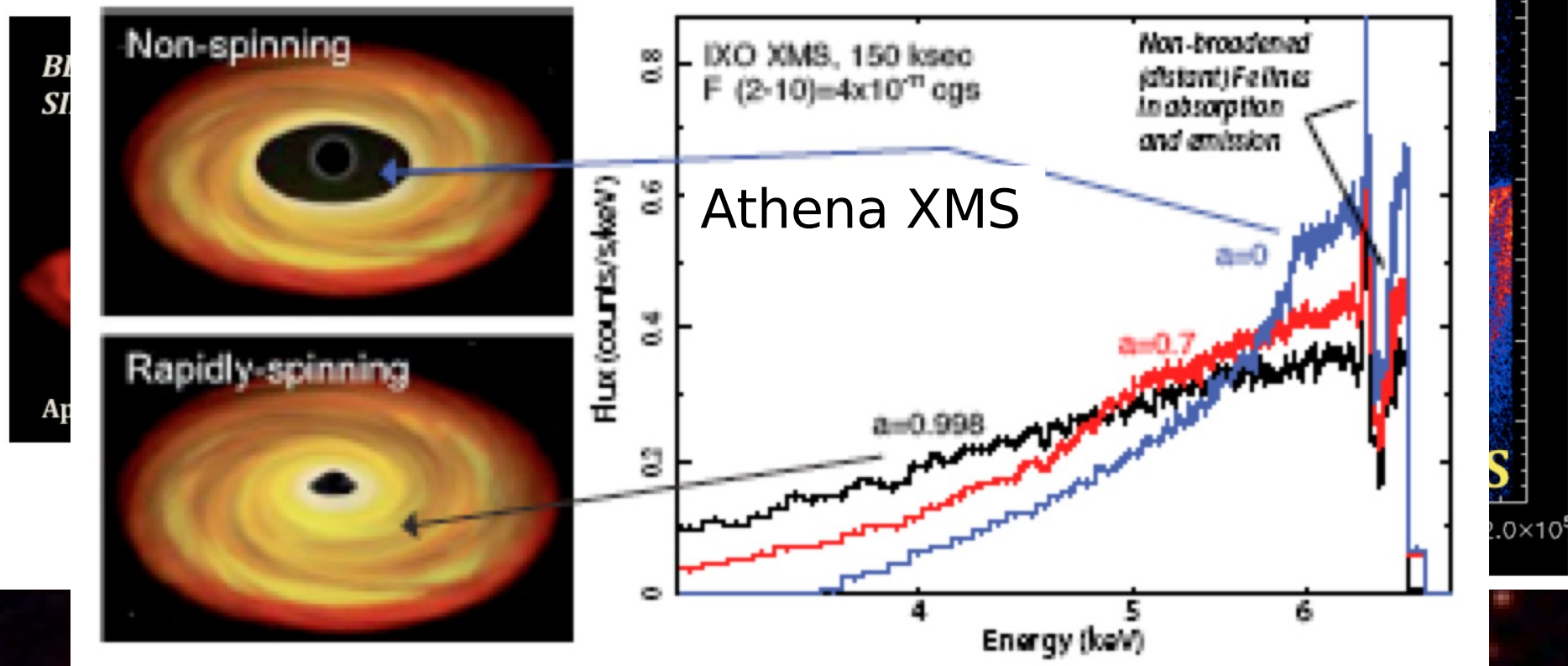
Diagnose hot cosmic plasmas on all astrophysical environments via spatially resolved high resolution X-ray spectroscopy

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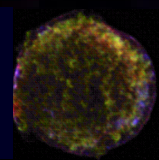




M. Cappi, C. Reynolds, L. Brenneman



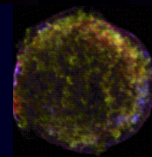
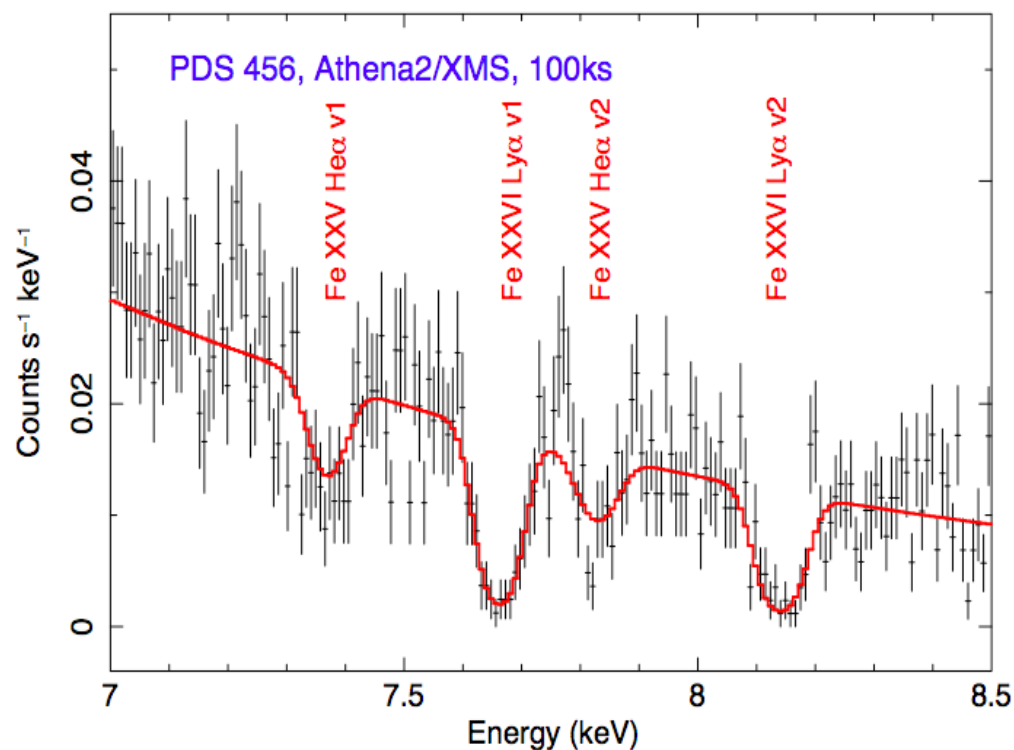
AGN, BHB, NS binaries, Sgr A\*, ULX, CVs etc.



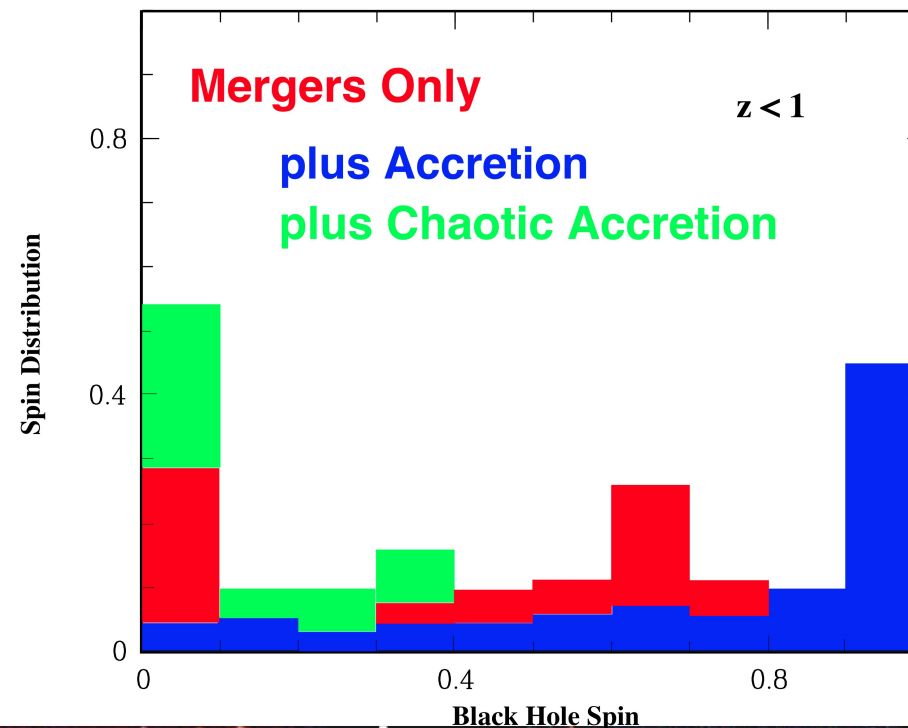
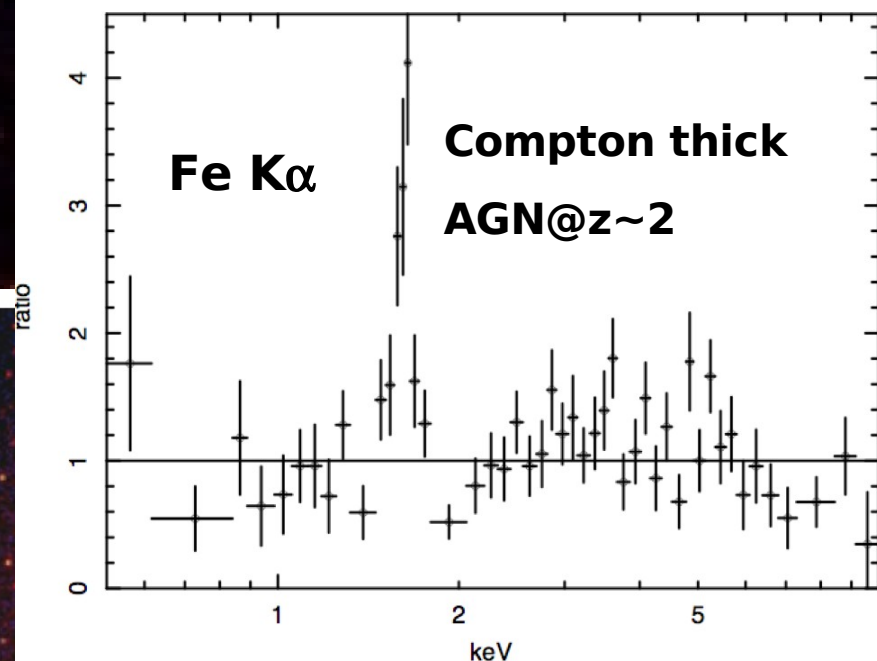
A. Fabian, J. Sanders

XMM MOS

## AGN feedback via outflows



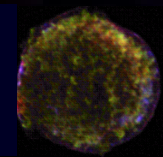
## A. Comastri



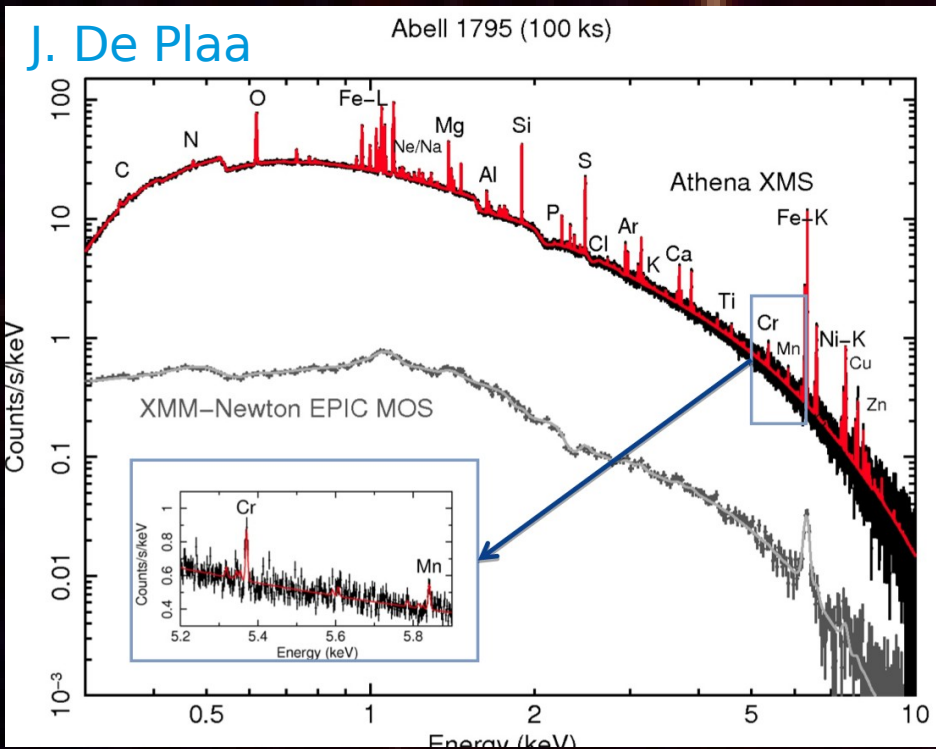
AGN census at  $z > 6$ ? goal PSF (5") and WFI FOV ( $> 30'$ )

Credit: J. Aird

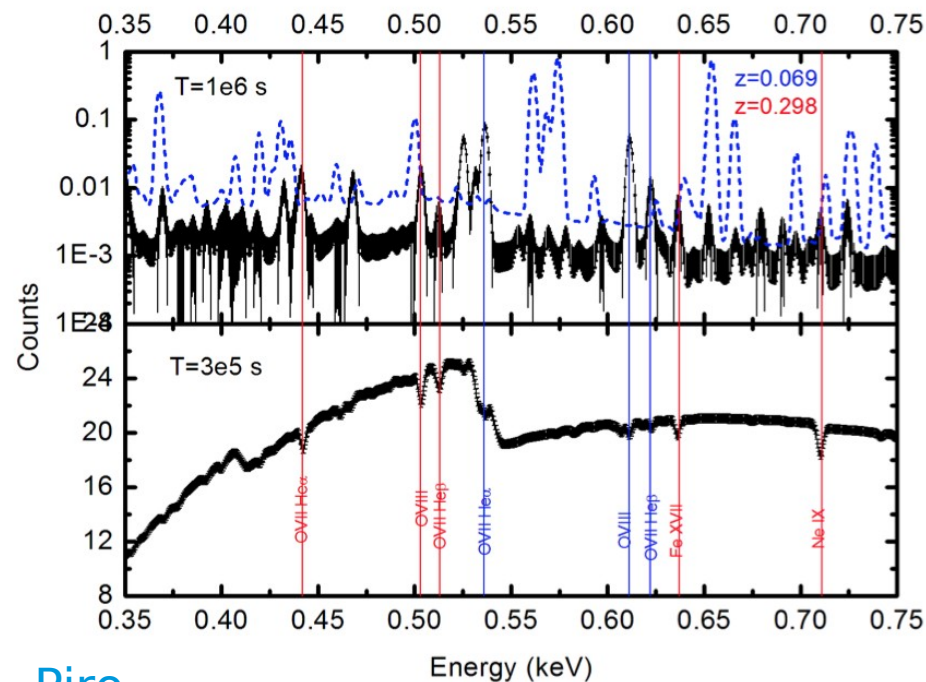
7" PSF



## Clusters



## Missing Baryons/WHIM

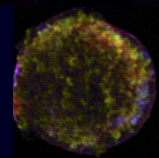
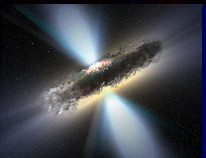


L. Piro

WFI: group, clusters census to  $z > 2$   
XMS: baryon physics, mass proxies

→ COSMOLOGY

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Charge exchange in Solar System bodies:  
planetary atmospheres, comets, etc.

Stellar evolution:

Young Stellar Objects

Cool stars

Massive stars, mass loss, magnetic fields, etc.

Supernovae and Supernova remnants

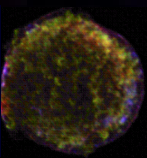
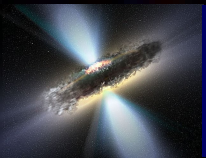
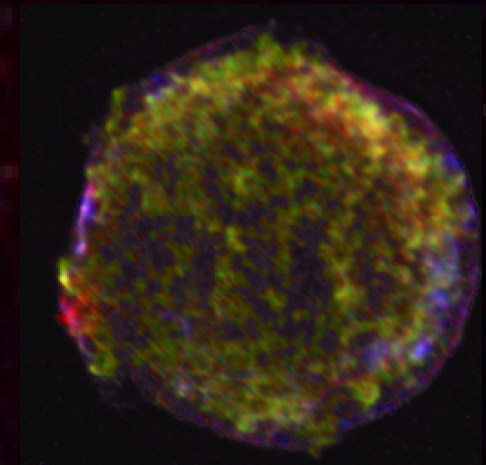
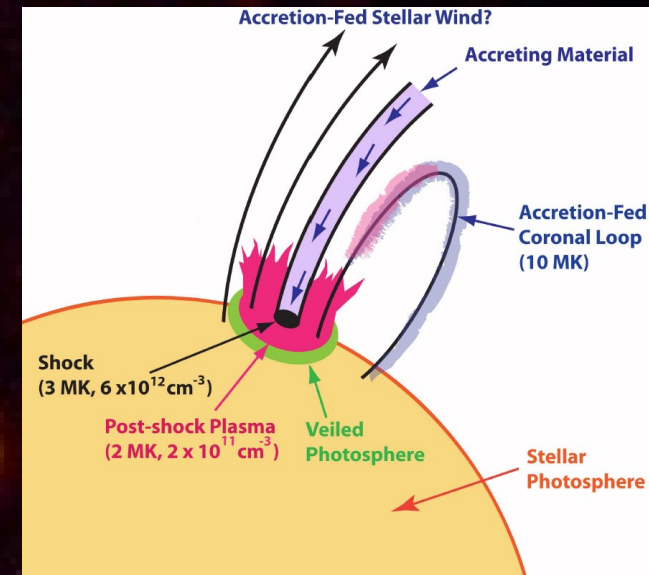
Winds and absorption studies in X-ray binaries

Cataclysmic variables

X-ray binary populations in external galaxies

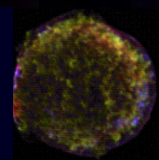
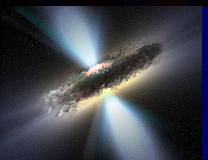
The ISM of our galaxy

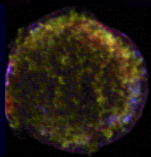
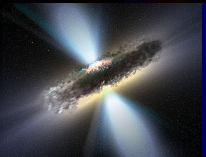
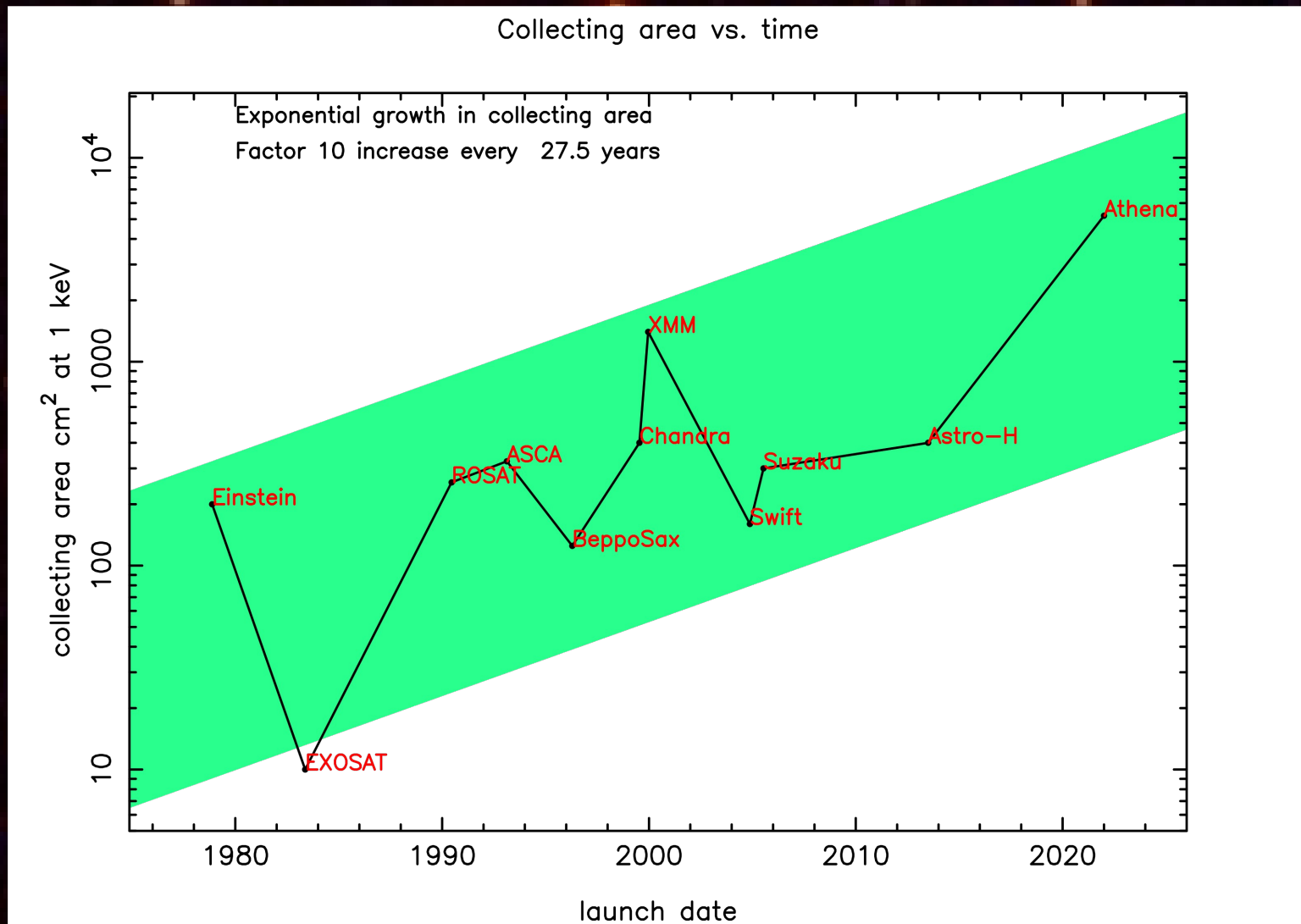
And many many more....



# Athena Science Requirements

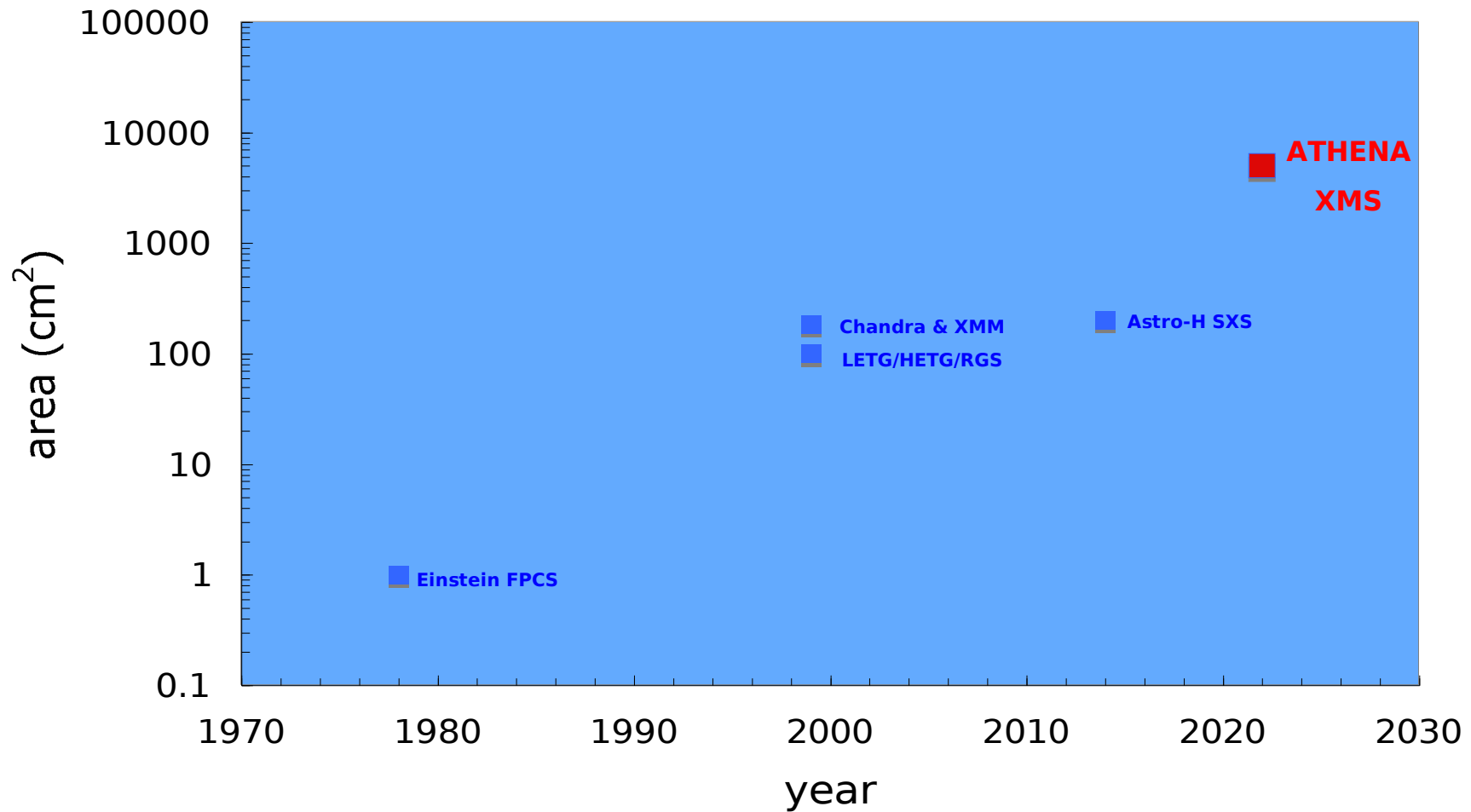
<b>Effective Area</b>	<b>1 m<sup>2</sup> @1.25 keV (goal 1.2 m<sup>2</sup>)</b> <b>0.5 m<sup>2</sup> @ 6 keV (goal 0.7 m<sup>2</sup>)</b>	<b>Black hole evolution, large scale structure</b> <b>Strong gravity, cosmic feedback</b>
<b>Spectral Resolution (FWHM)</b>	<b><math>\Delta E = 3</math> eV (@6keV) within 2 x 2 arc min</b> <b>(goal 2.5 eV and 4x3 arc min)</b> <b><math>\Delta E = 150</math> eV at 6 keV within 25 arc min diam</b>	<b>Large scale structure, Cosmic Feedback</b> <b>Black Hole evolution, Large scale structure</b>
<b>Angular Resolution</b>	<b>10 arc sec HPD (0.1 – 7 keV)</b> <b>(goal of 5 arc sec)</b>	<b>Black hole evolution, Cosmic feedback, Large Scale Structure</b>
<b>Count Rate</b>	<b>1 Crab with &gt;90% throughput.</b> <b><math>\Delta E &lt; 200</math> eV @ 6keV (0.3 – 15 keV)</b>	<b>Strong gravity</b>
<b>Astrometry</b>	<b>1.5 arcsec at 3<math>\sigma</math> confidence</b>	<b>Black hole evolution</b>
<b>Absolute Timing</b>	<b>100 <math>\mu</math>sec</b>	<b>Compact Objects</b>



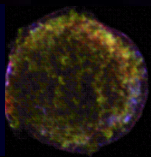
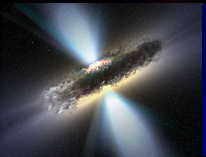
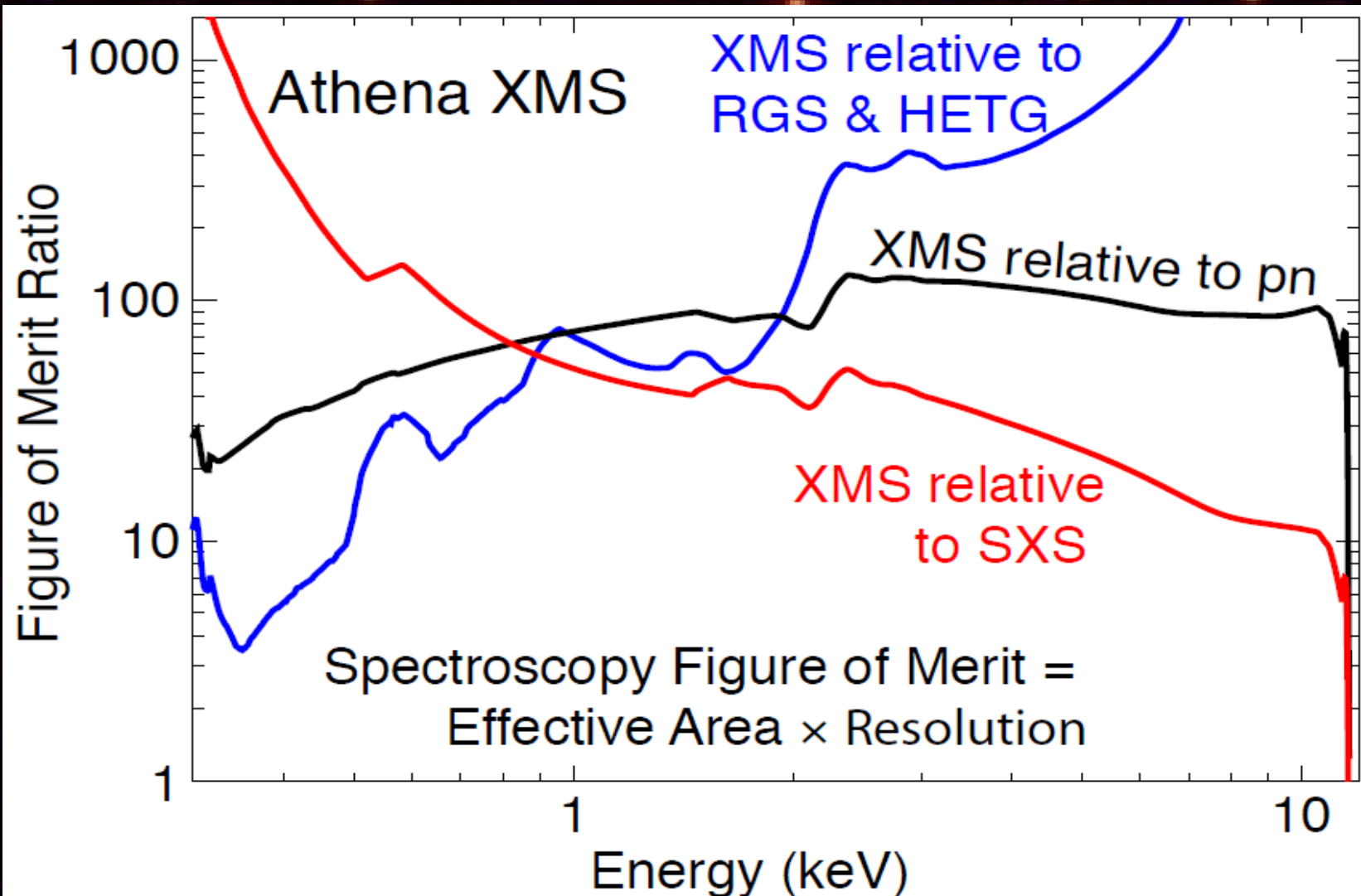


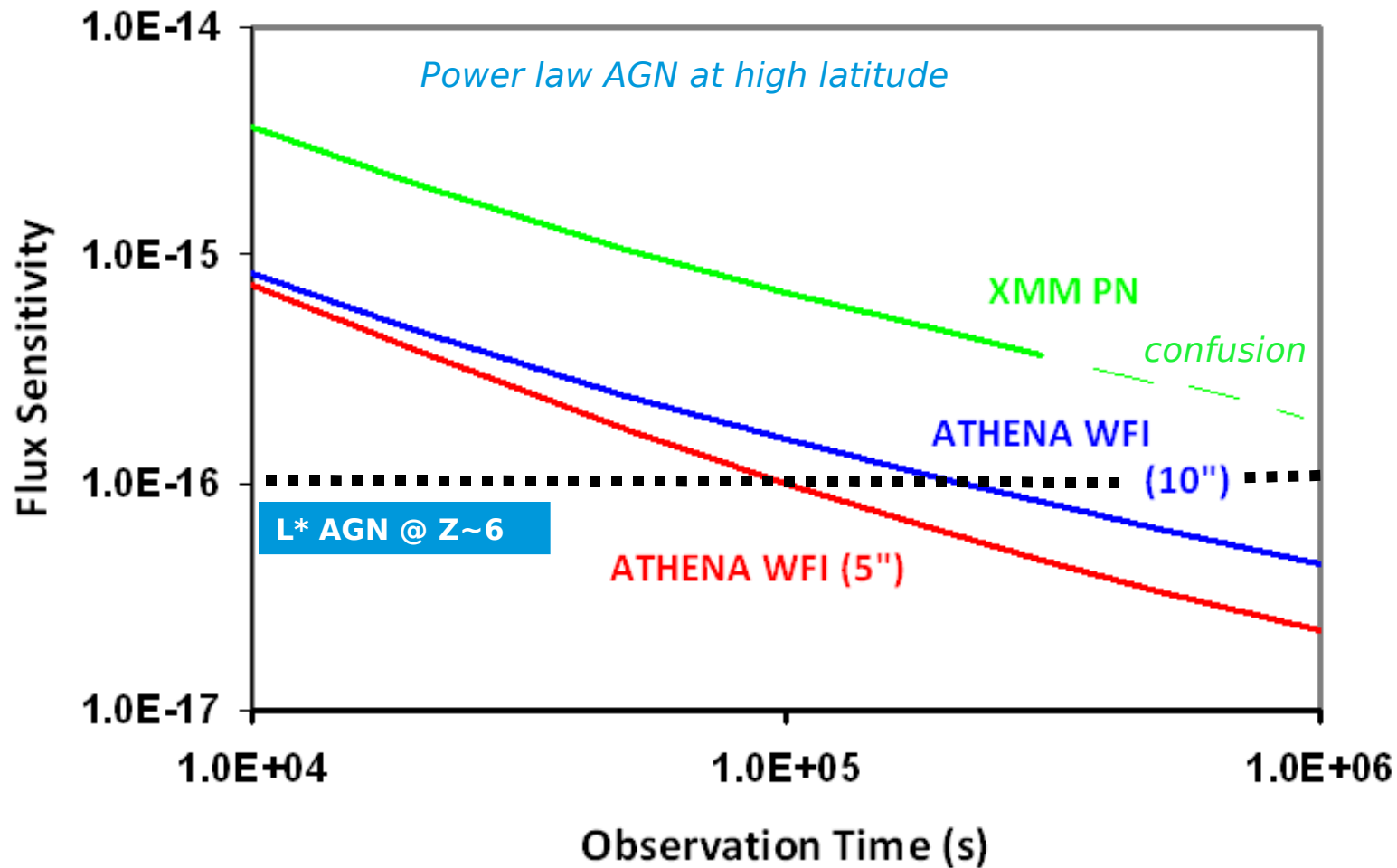
# Effective area evolution

high spectral resolution instruments ( $E/\Delta E > 100$ )

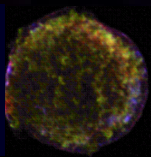
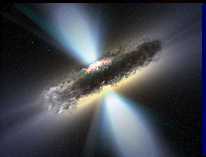


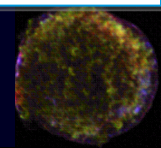
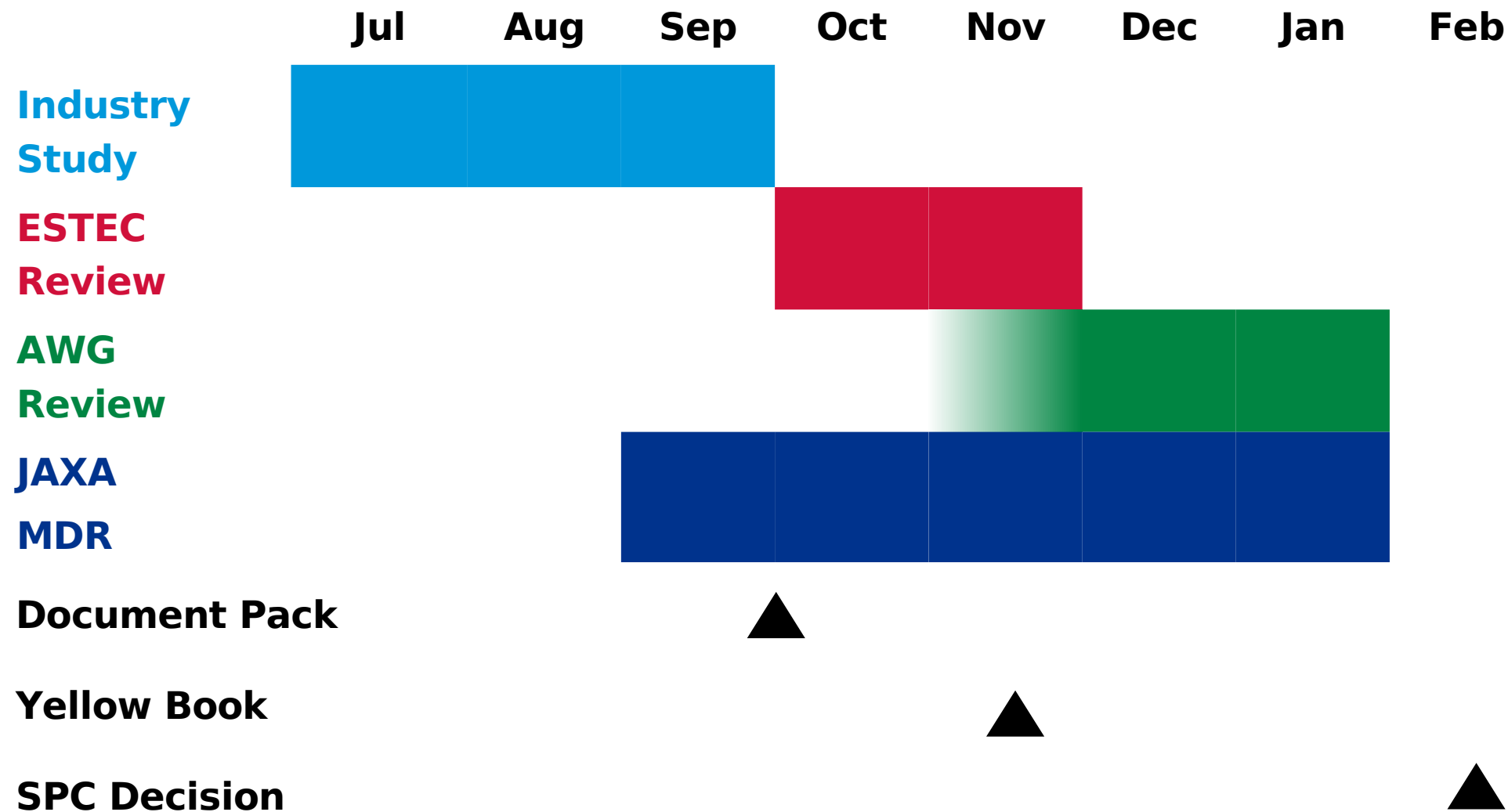






At 1Ms with 10" resolution, the sensitivity of  $\sim 4 \cdot 10^{-17}$  is comparable with confusion limit

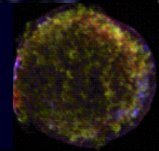
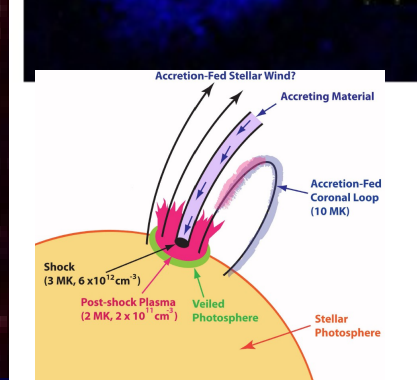
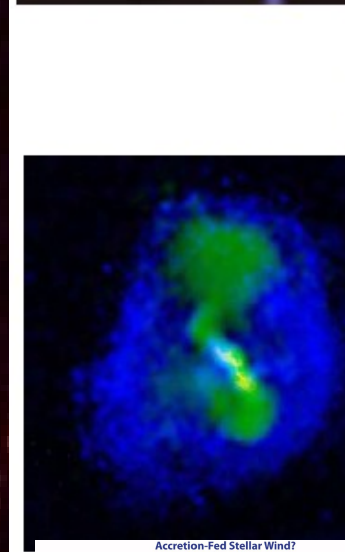
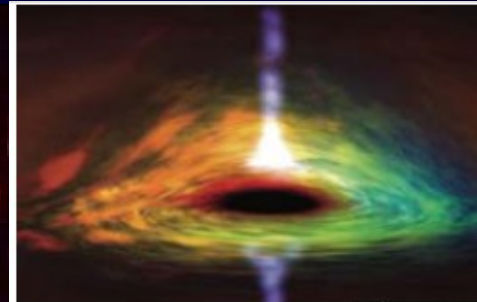




- Athena is **the** next generation facility-class X-ray observatory
- Will address key topics in astrophysics, but broad based
- Major opportunity for European leadership in X-ray astronomy
- Stiff Competition (LISA, Laplace)
- Community support essential
- Lots of work/help needed!

Sign up as an Athena supporter here:

<https://lists.mpe.mpg.de/mailman/listinfo/athena-supporters>





# THE END

END

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