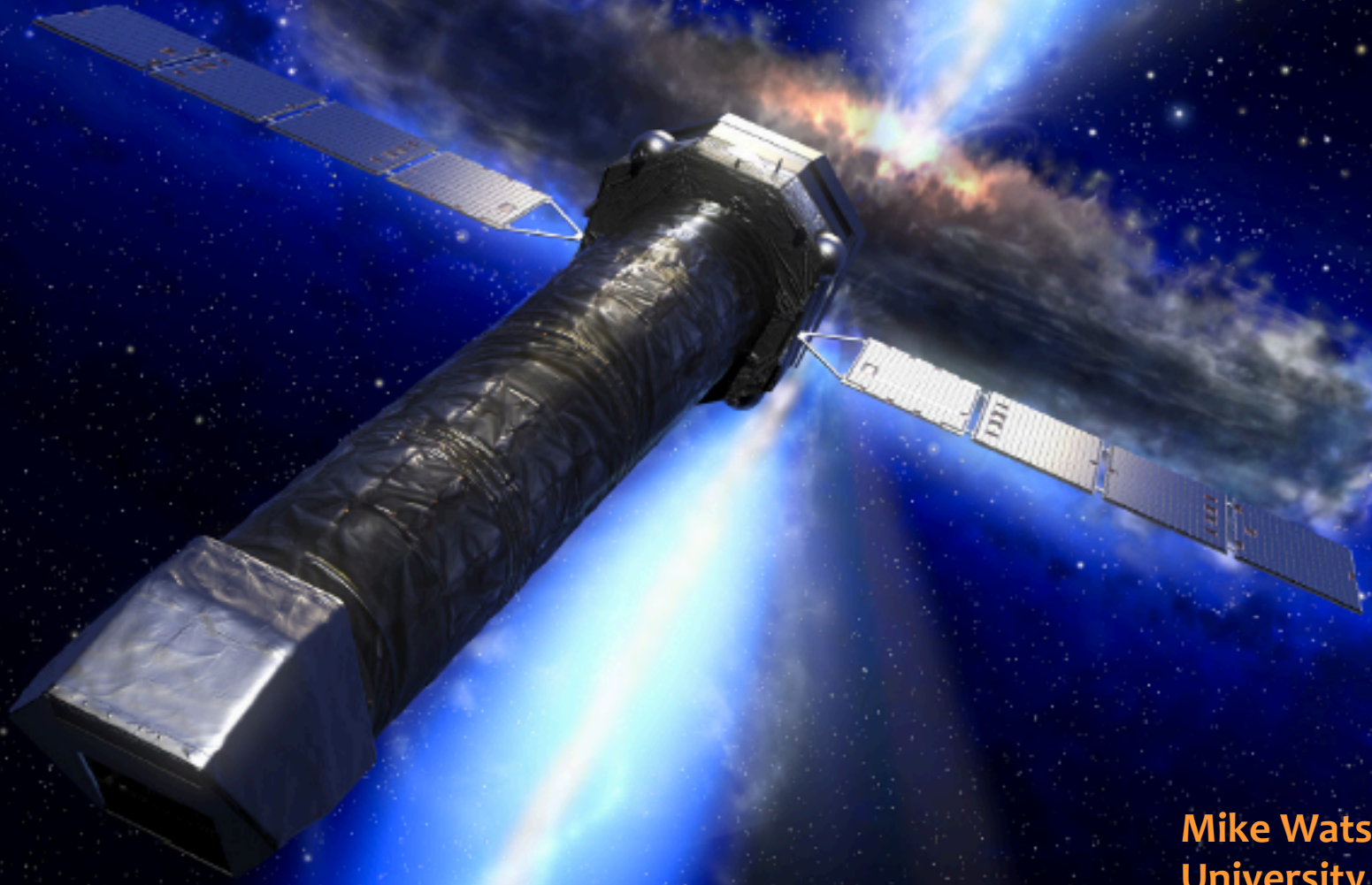


Athena → Athena+

**Towards a European
Large X-ray Observatory**

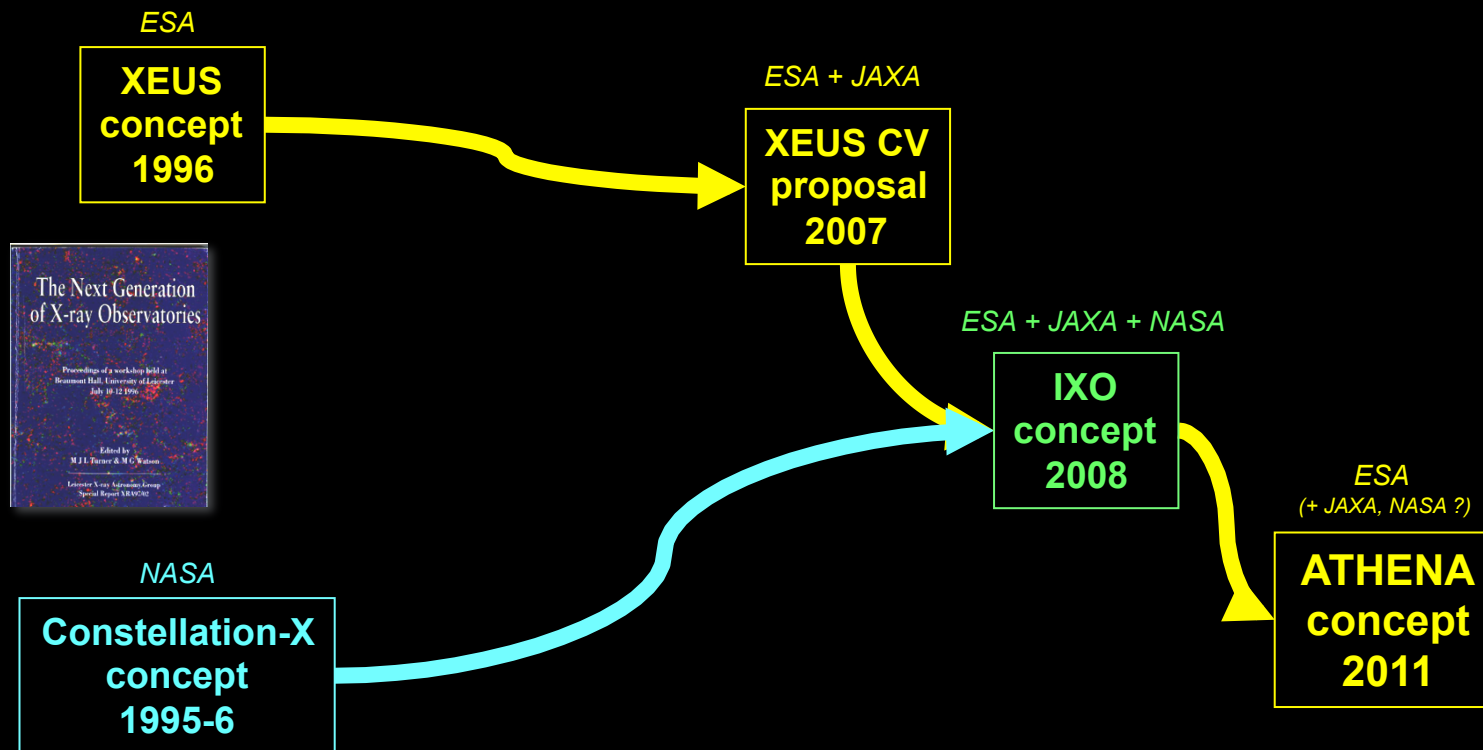


**Mike Watson
University of Leicester**

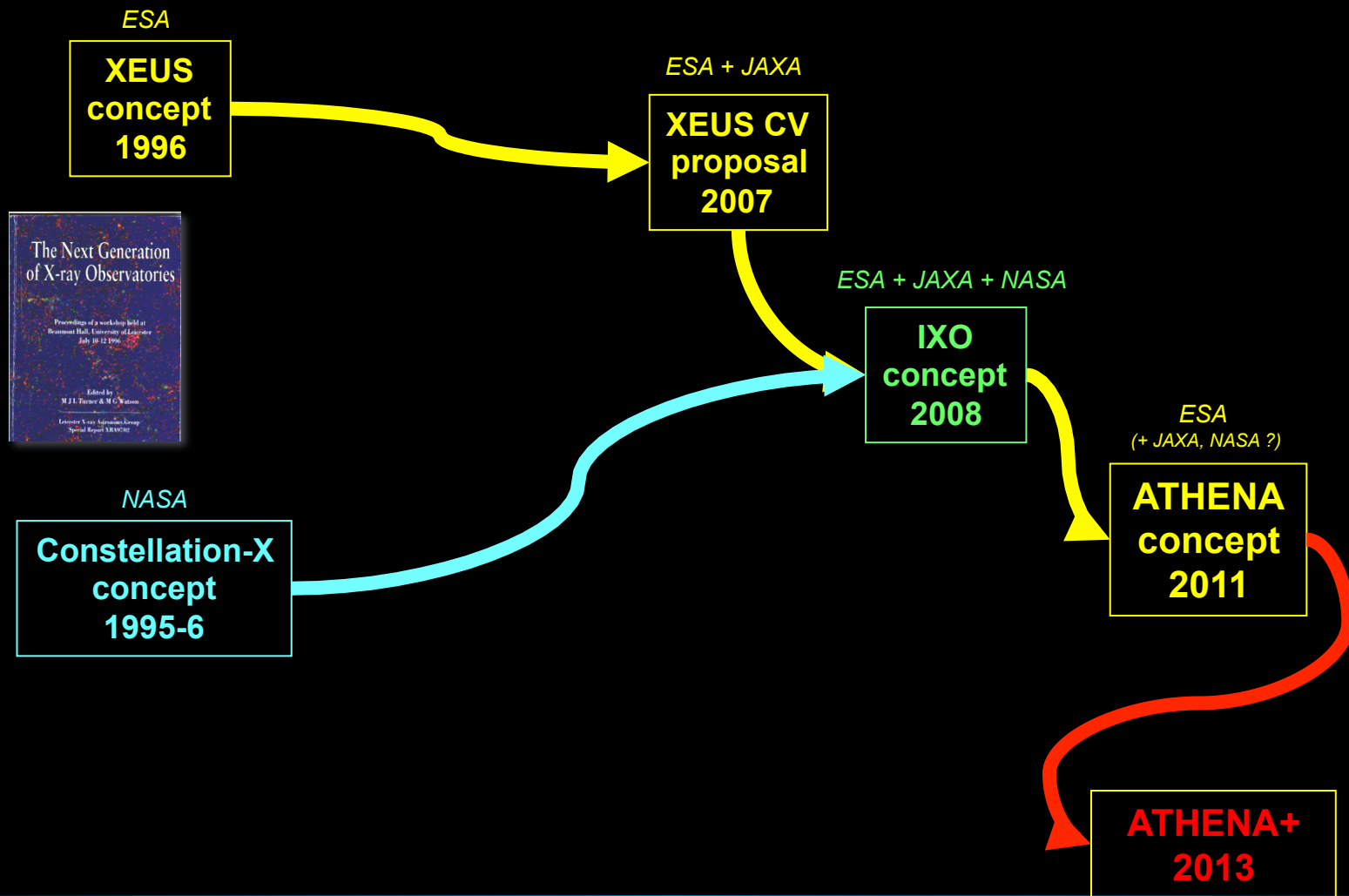
Topics

- Brief history and context
 - New ESA approach to L-class selection
 - The Athena+ concept
-
- Credits: Athena & Athena+ teams

The road to a next generation X-ray observatory



The road to a next generation X-ray observatory



Athena+

ESA L2/L3 missions: new approach

- **Science themes** for L2 and L3 chosen this year
- Return to “cornerstone” approach for large missions (cf H2000)
- Budget ~€1bn ESA cost (plus ~€200M ESA MS)
- ESA-led, max. ~20% “non-critical” international contributions OK
- New process defined and has already started



Next steps: building on the Athena concept

Athena mission was not fundamentally flawed

- *Came very close to being selected for L1*
- *Cost, technical readiness, schedule all OK (c.f. NGO)*
- *Issues: conservative design, TRL of some elements ...*

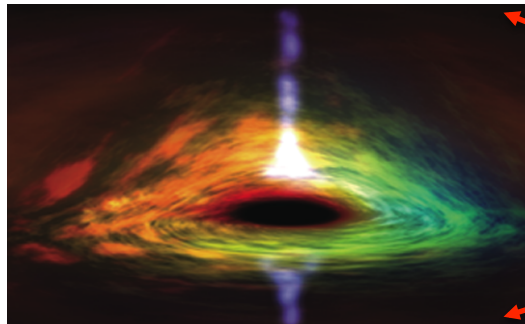
Plan: Athena+

- **White Paper: Revealing the Hot and Energetic Universe - From Large scale structures to accreting Black Holes**
- **Strawman mission: Athena+ concept**
- *... and hope to be selected*

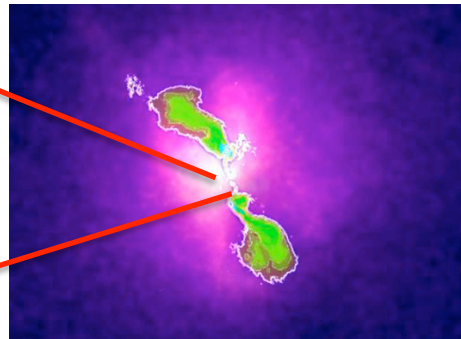
Science Theme for Athena+

Revealing the Hot and Energetic Universe: From Large Scale Structure to accreting Black Holes

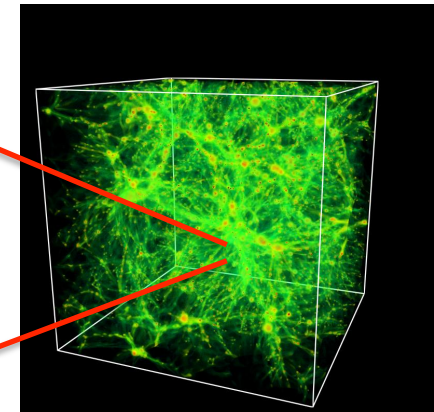
- **Where are the hot baryons and how do they evolve?**
- **How do black holes grow and how do they shape the Universe?**
- **The Astrophysics of the hot, energetic Universe**



Black Hole Accretion



Feedback Processes

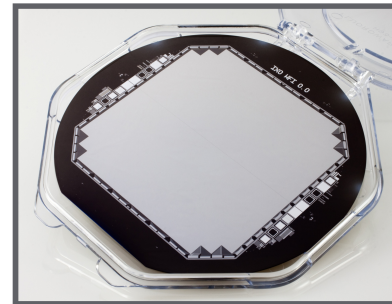
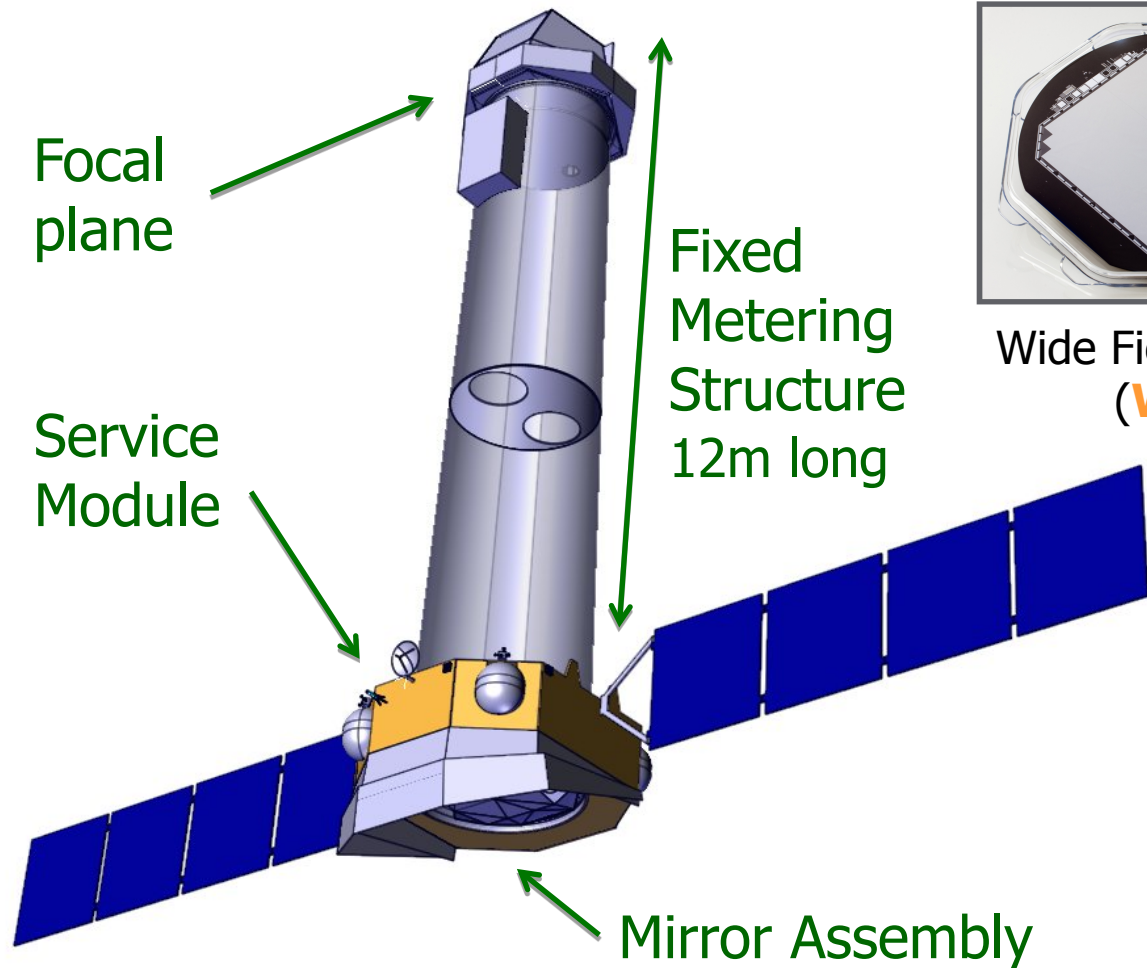


Cosmic Web

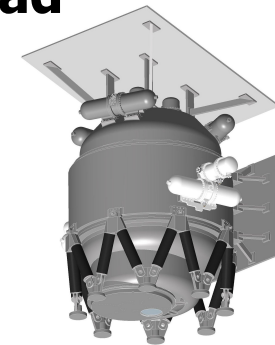
Athena in 2012

Ariane V launch to L2, 5yr nominal mission

Payload

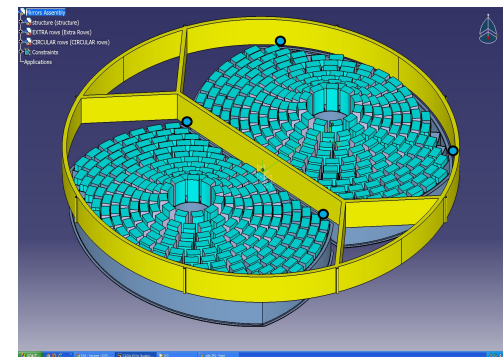


Wide Field Imager
(**WFI**)



X-ray Microcalorimeter
Spectrometer
(**XMS**)

ESA Silicon Pore X-ray Optics
5 - 10" resolution



Athena → Athena+ evolution

MISSION, SPACECRAFT

- no major change (L2 orbit, 12 m focal length, SPO optics)
- but single telescope, 2 focal plane instruments with interchange mechanism

OPTICS

- increased effective area (x2 approx)
 - 500→1000 modules, 3m outer diameter
- 5" PSF requirement (3" goal)
 - ambitious but plausible

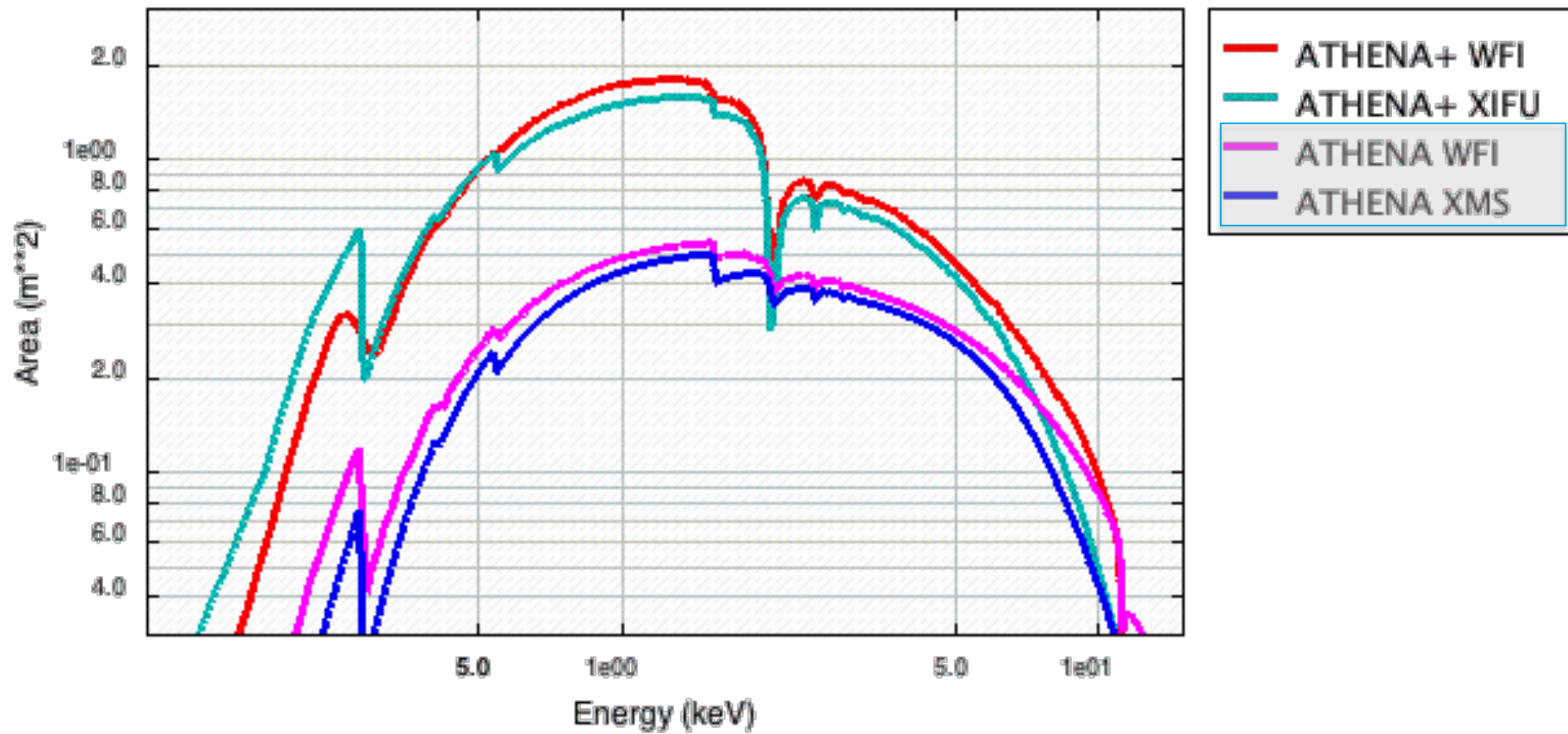
INSTRUMENTS

- no major change
- increased FOVs
- improved energy resolution for XMS (now XIFU)

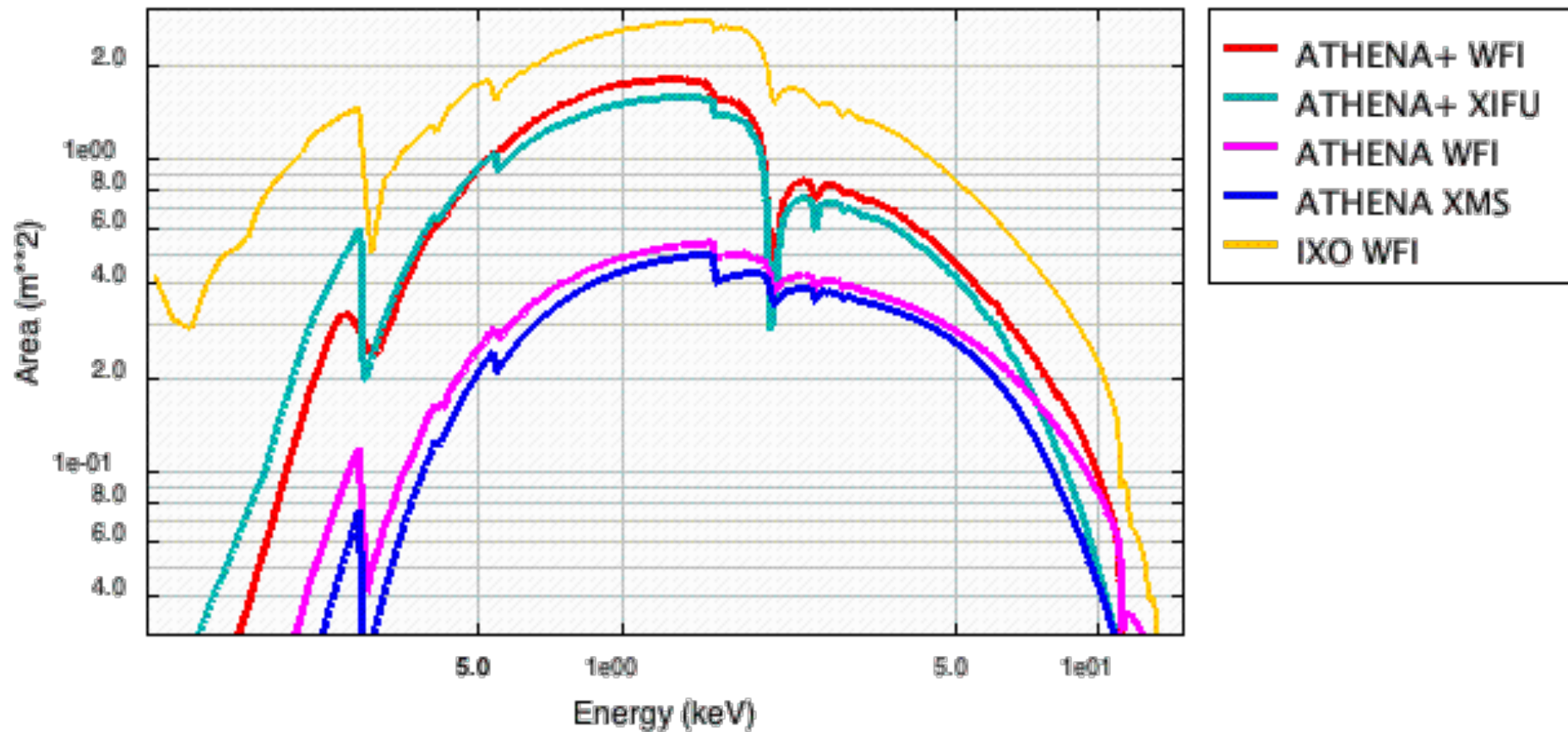
Athena+: Science Requirements

	Requirement	Driver
Effective Area	2m ² @ 1 keV (goal 2.5m ²) 0.25 m ² @ 6 keV (goal 0.3m ²)	Black hole evolution Large scale structure Strong gravity
Angular Resolution	5'' (goal of 3'')	Black Hole Evolution Large Scale structure
Fields of view	WFI: 40' diameter (goal 50') XMS: 5' x 5' (goal 7' x 7')	Black Hole Evolution
Spectral resolution	150 eV @ 6 keV (WFI) 2.5 eV (XMS) (goal 1 eV central)	Black Hole Evolution Large Scale Structure
Count rate capability	>1 Crab	Strong Gravity
Timing resolution	50 μs	Strong Gravity
TOO response	8 hours (2 hours goal)	Large Scale Structure

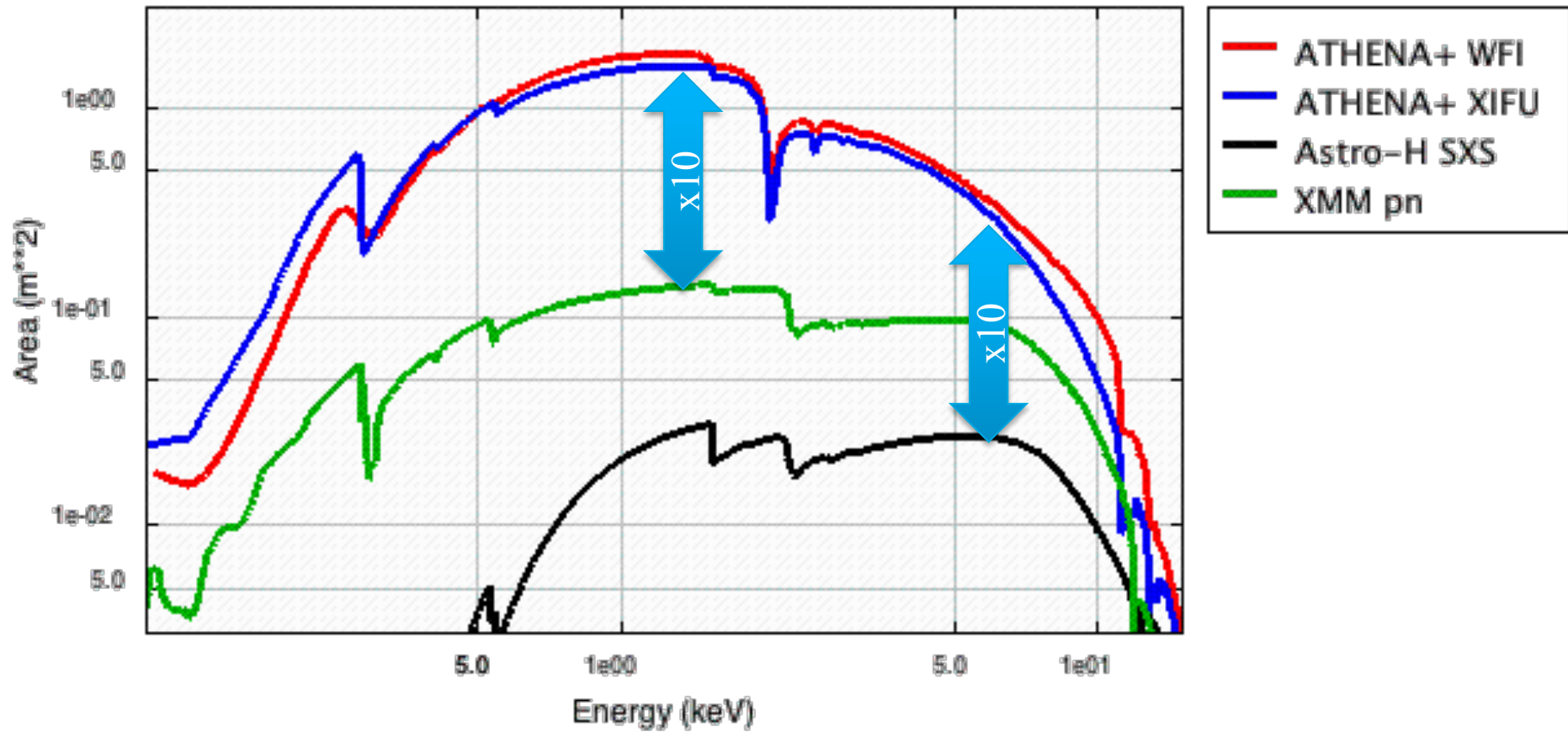
Effective areas



Effective areas

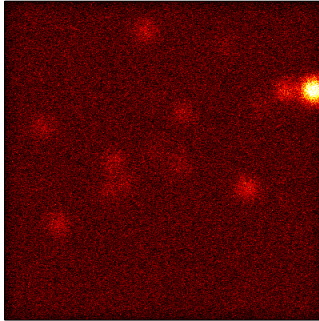


Effective areas



Angular resolution

< 7 arcmin >

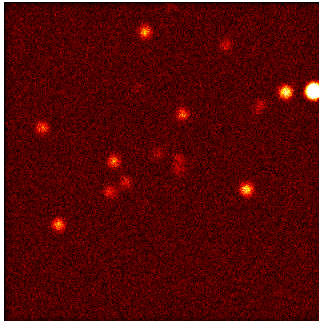


FWHM=10 arcsec

requirement

Athena

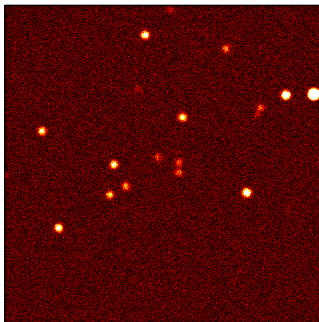
Athena+



FWHM=5 arcsec

goal

requirement



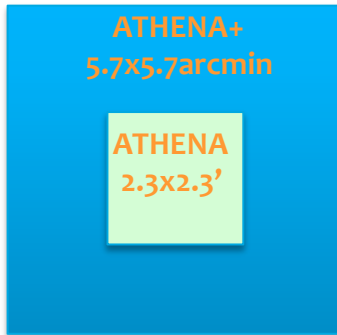
FWHM=3 arcsec

goal

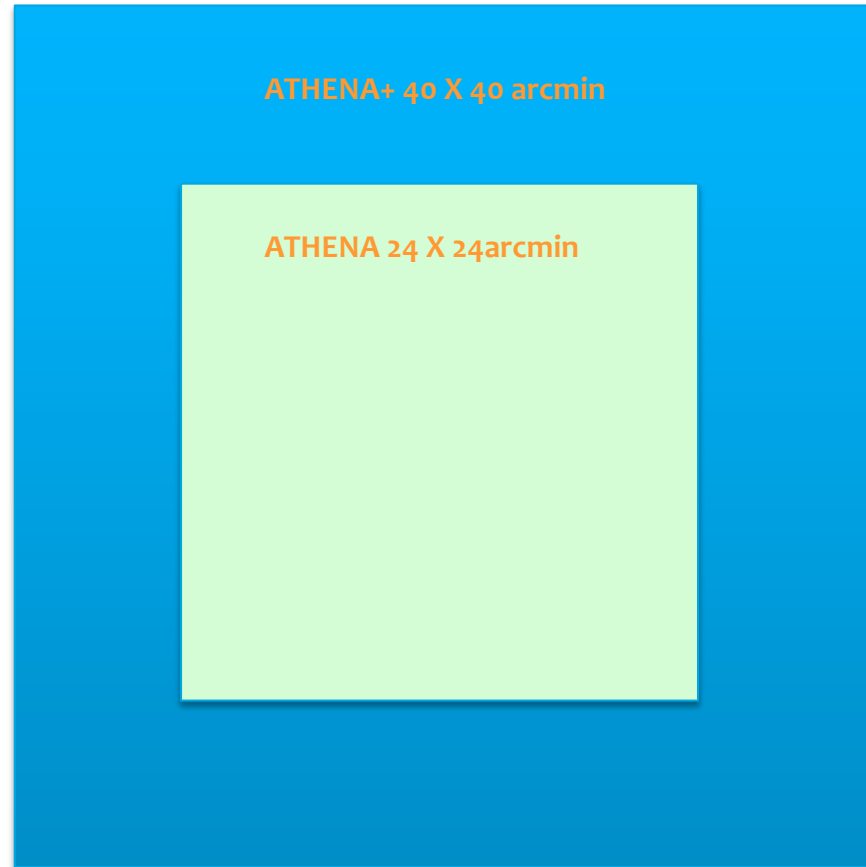
Athena+

FOV sizes

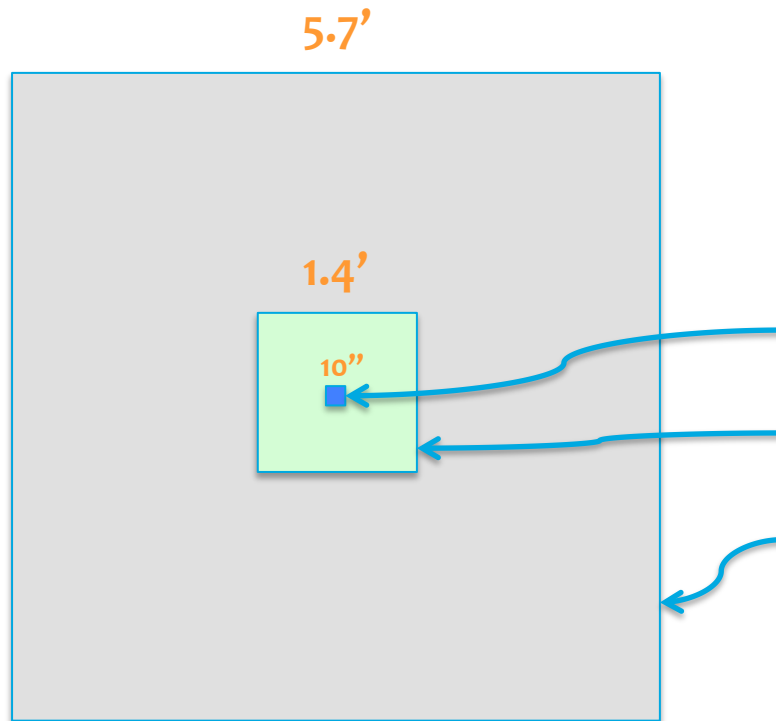
XMS
(XIFU)



WFI



X-ray IFU design options (geometry TBC)



region	area / format	pixel size	ΔE	Comment
central	10"x10" 10x10	~1" 50 μ m	1.5 eV @1keV	$E_{\max} \sim 2.5$ keV lower count rate limit
inner	1.4'x1.4' 20x20	~4" 250 μ m	2.5 eV @6keV	
outer	5.7'x5.7' 40x40	~9" 500 μ m	8 eV @6keV	40x40 array with 10x10 'hole'

Athena+ team

ATHENA+ Coordination Group

Kirpal Nandra, chair (MPE, D)

Xavier Barcons (IFCA, ES)

Didier Barret (IRAP, F)

Andy C. Fabian, (Cambridge, UK)

Jan-Willem den Herder (SRON, NL)

Luigi Piro (IASF, I)

Mike Watson (Leicester, UK)

X-TASAT (X-ray Technology Activities Science Advisory Team, ESA committee)

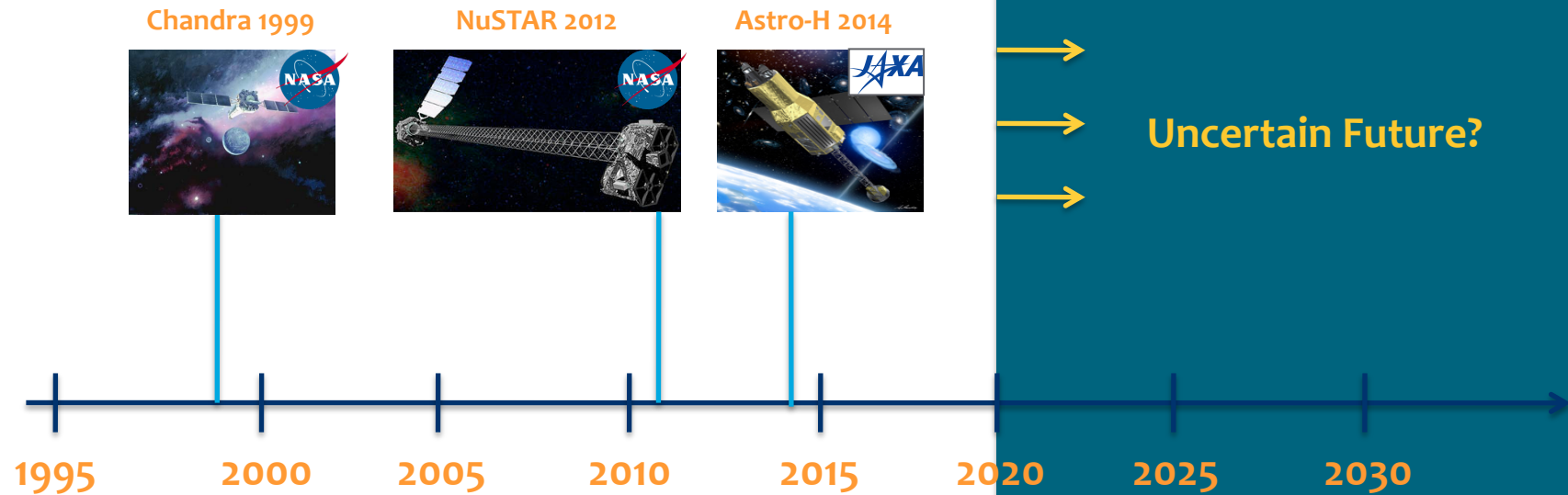
+ Telescope Working Group (Dick Willingale)

+ 11 Science Working Groups

Website: <http://the-athena-x-ray-observatory.eu>

preliminary response matrices available

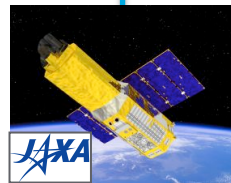
X-ray Observatories: Timeline



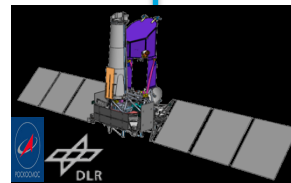
Uncertain Future?



XMM-1999



Suzaku 2005



Spektr-RG 2014

+ASTROSAT (India), HXMT (China)



Athena+ 2028?

Athena+

slide courtesy K Nandra

end