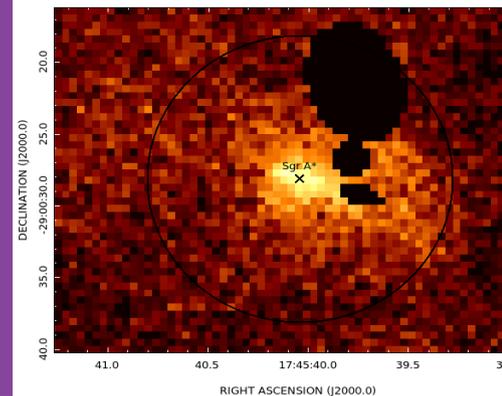
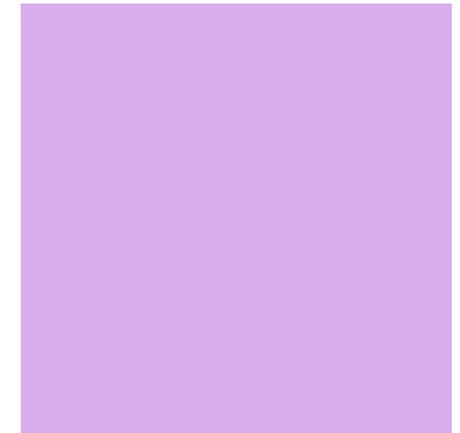


ATHENA

New generation X-ray
telescope



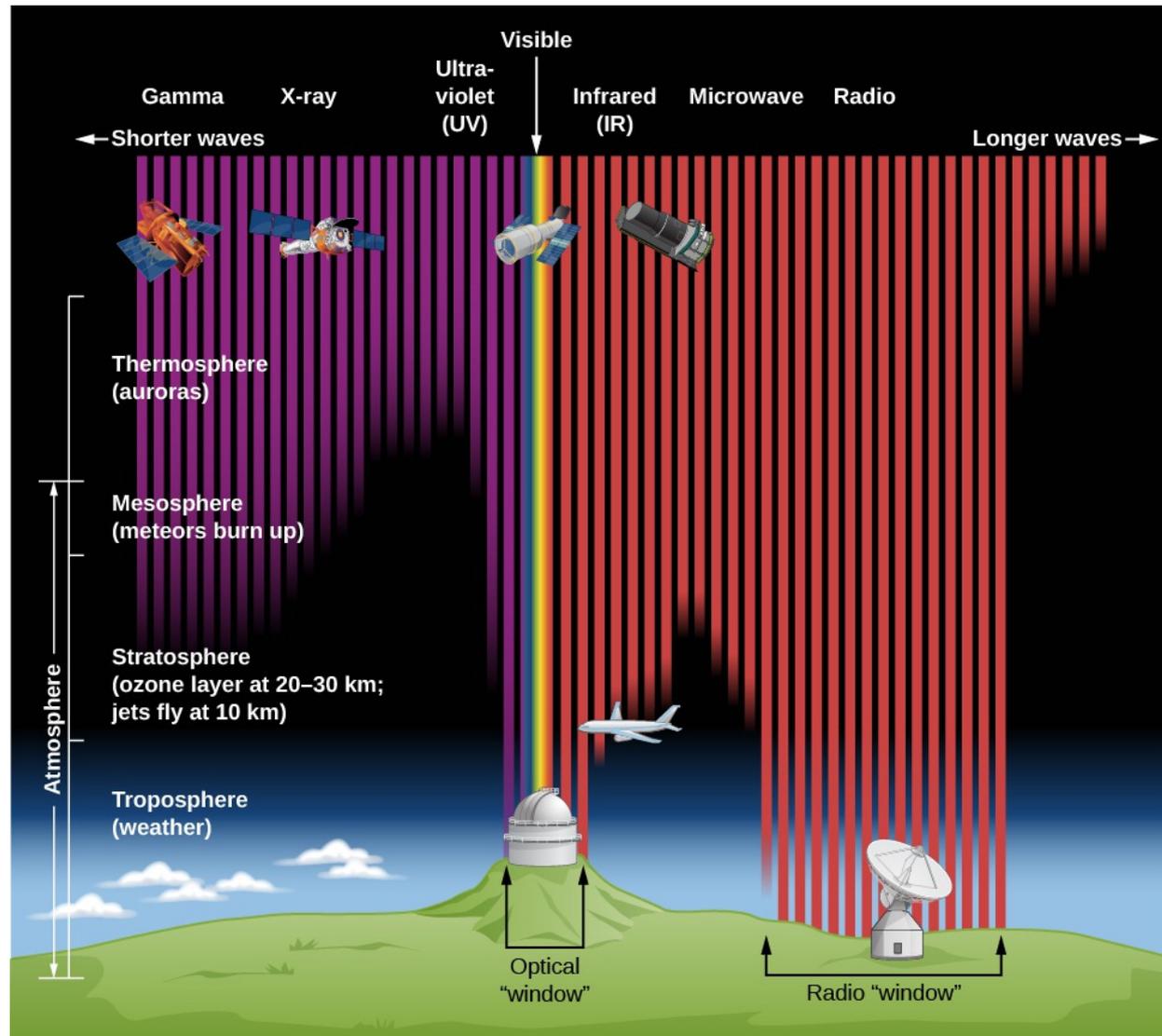
Agata Różańska

CAMK PAN, Warsaw



21.09.2017, Kraków, Astrofizyka Cząstek

Atmosphere is not transparent to X-rays



ATHENA – L2 mission of ESA Cosmic Vision (2015-2035)

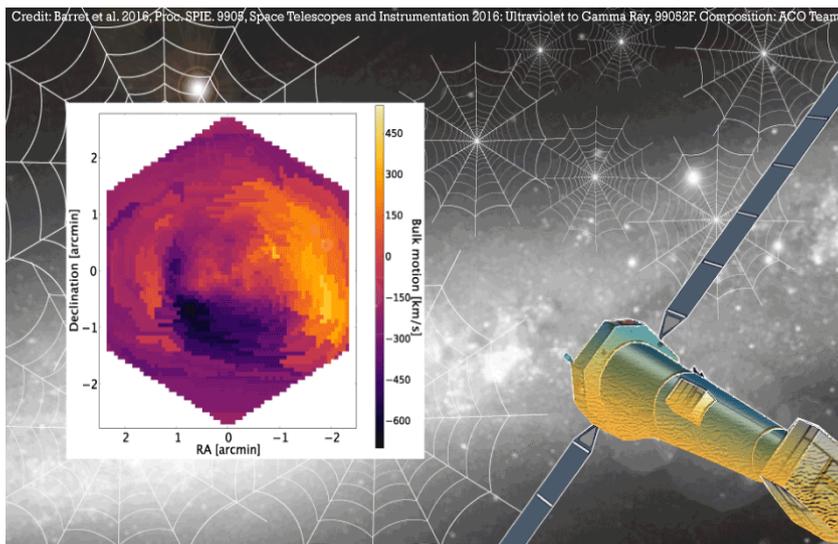
X-RAY SPECS

The European Space Agency is very close to finalizing the following line-up of large (L-class) missions.

Mission	Name	Launch date	Study targets
L1	JUICE	2022	The magnetic field of Jupiter's moon Ganymede
L2	Athena+	2028	Black holes and galaxy clusters.
L3	eLISA	2034	Gravitational ripples from black-hole mergers.

800+ scientist in ATHENA community

More info at: <http://www.the-athena-x-ray-observatory.eu>



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NEWS & CONFERENCES

The Athena X-ray Observatory: Community Support Portal

Athena: revealing the Hot and Energetic Universe

Credit: MPE, ESA and Athena Team

★ Latest activities & news

"The role of the background in past and future X-ray missions", by Silvano Molendi

Abstract: "Background has played an important role in X-ray missions, limiting the exploitation of science data in several and sometimes..."

[READ MORE +](#)

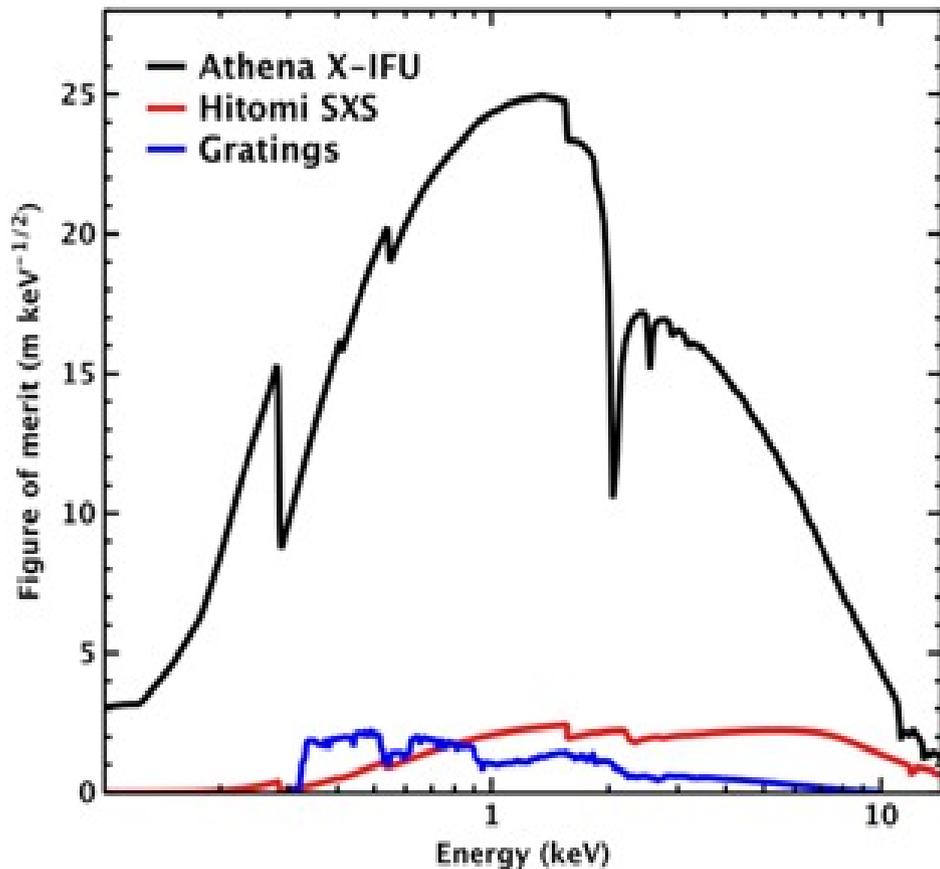
"Nuclear obscuration in active galactic nuclei", by Cristina Ramos Almeida and Claudio Ricci

Abstract: "The material surrounding accreting supermassive black holes connects the active galactic nucleus (AGN) with its host galaxy and, besides..."

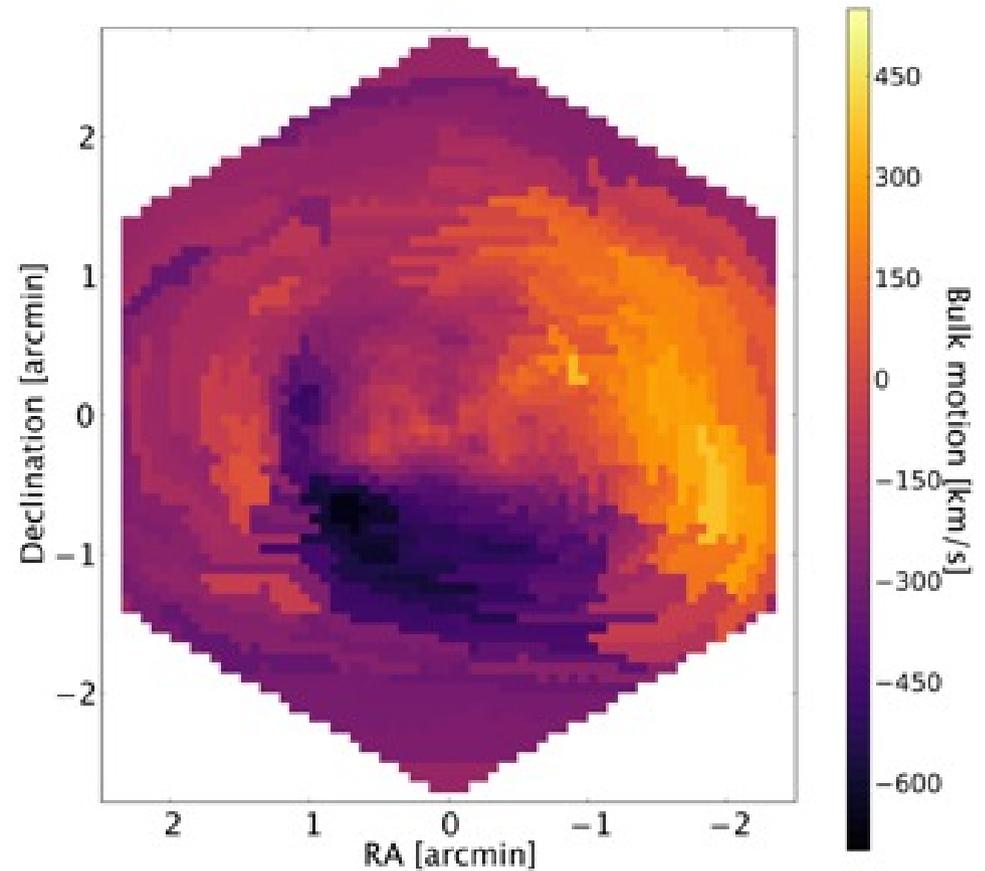
21.09.2017, Kraków, Astrofizyka Cząstek

A revolutionary mix of science performance

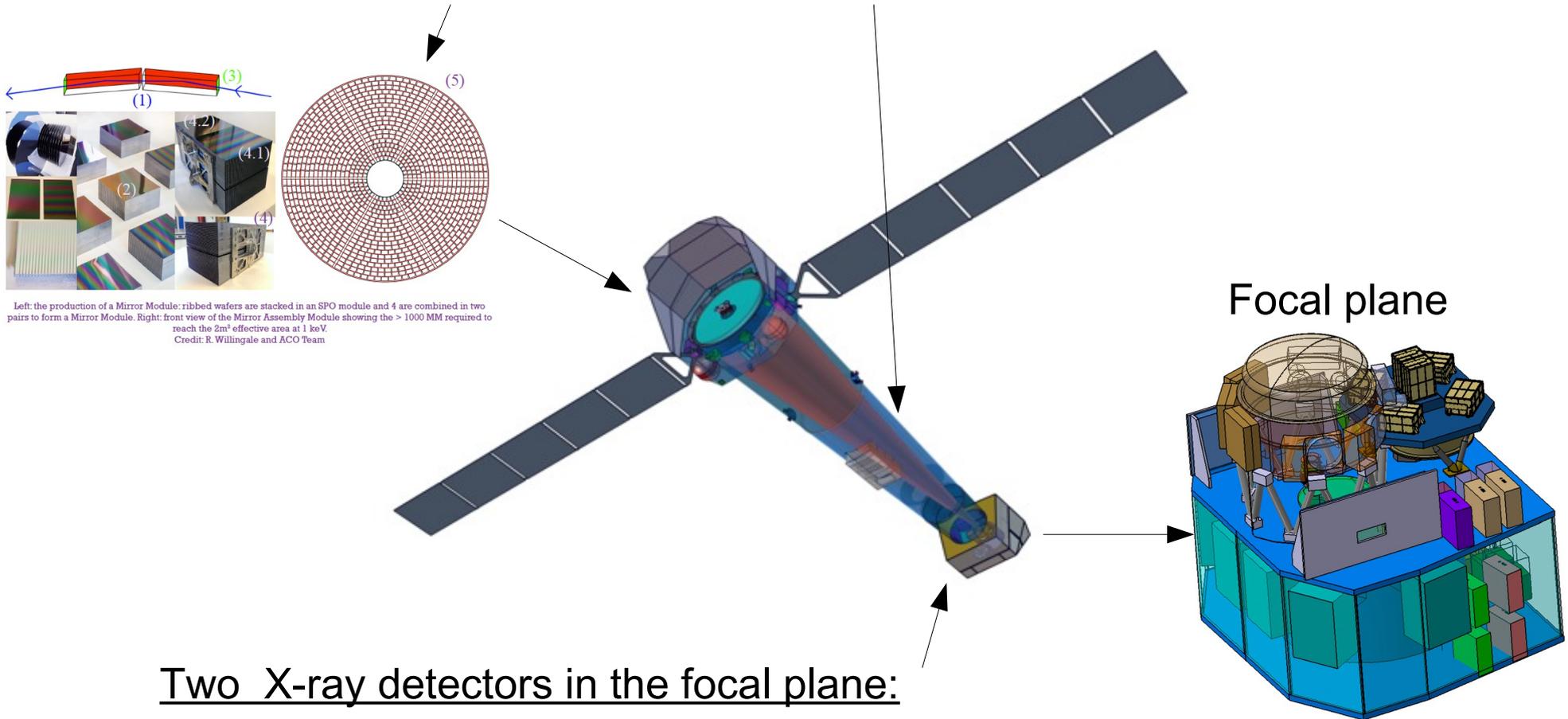
Effective area per energy resolution element



Simulated velocity map at a 5" pixel resolution



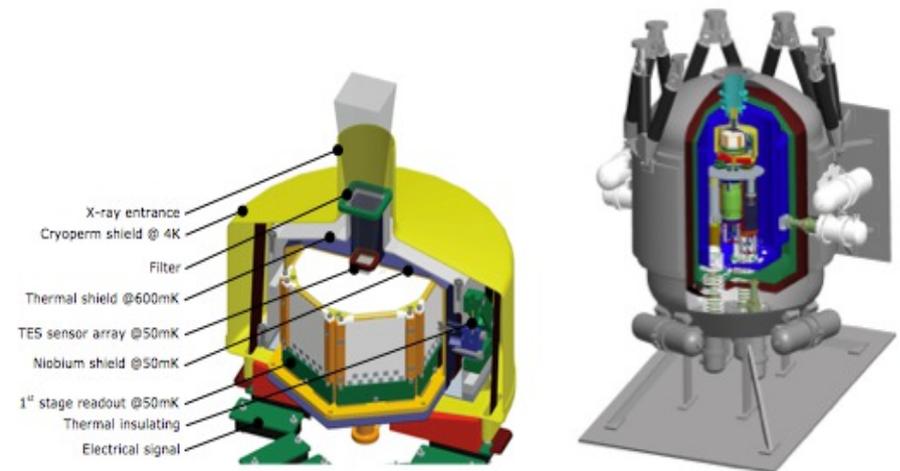
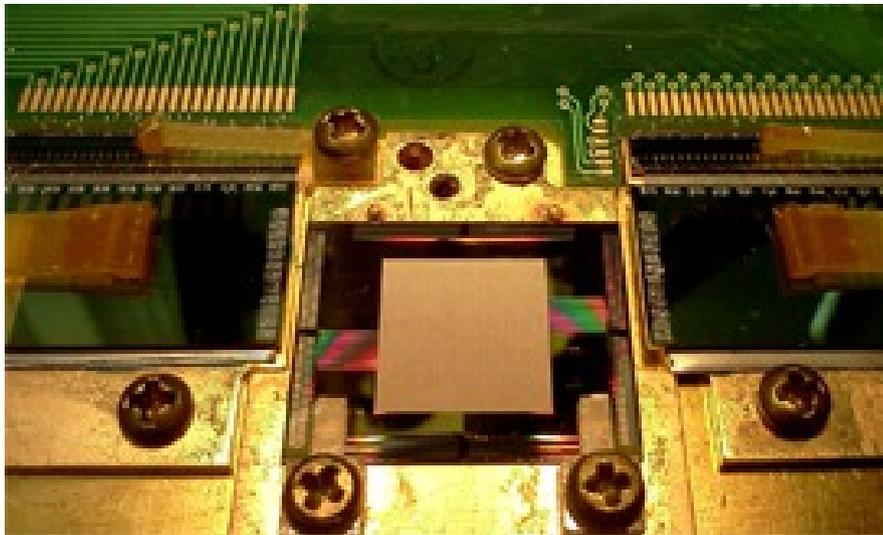
ATHENA is a single telescope with 12 m focal length



1. **X-IFU** – **X**-ray **I**ntegral **F**ield **U**nit 0.3-12. keV
2. **WFI** – **W**ide **F**ield **M**onitor 0.1-15. keV

X-IFU, 0.3 – 12.0 keV

- X-ray Micro-calorimeter Spectrometer (XMS)
- The detector consists of an array of 3840 absorbers (TES)
- Limited FoV – 5' x 5' (goal is 7' x 7')
- Count rate capability – 1 mCrab point source with 90%
- Energy resolution: 2.5 eV at 1 keV. Cryogen free cooling techniques: 50 mK



JAXA three times have tried to use micro-calorimeter

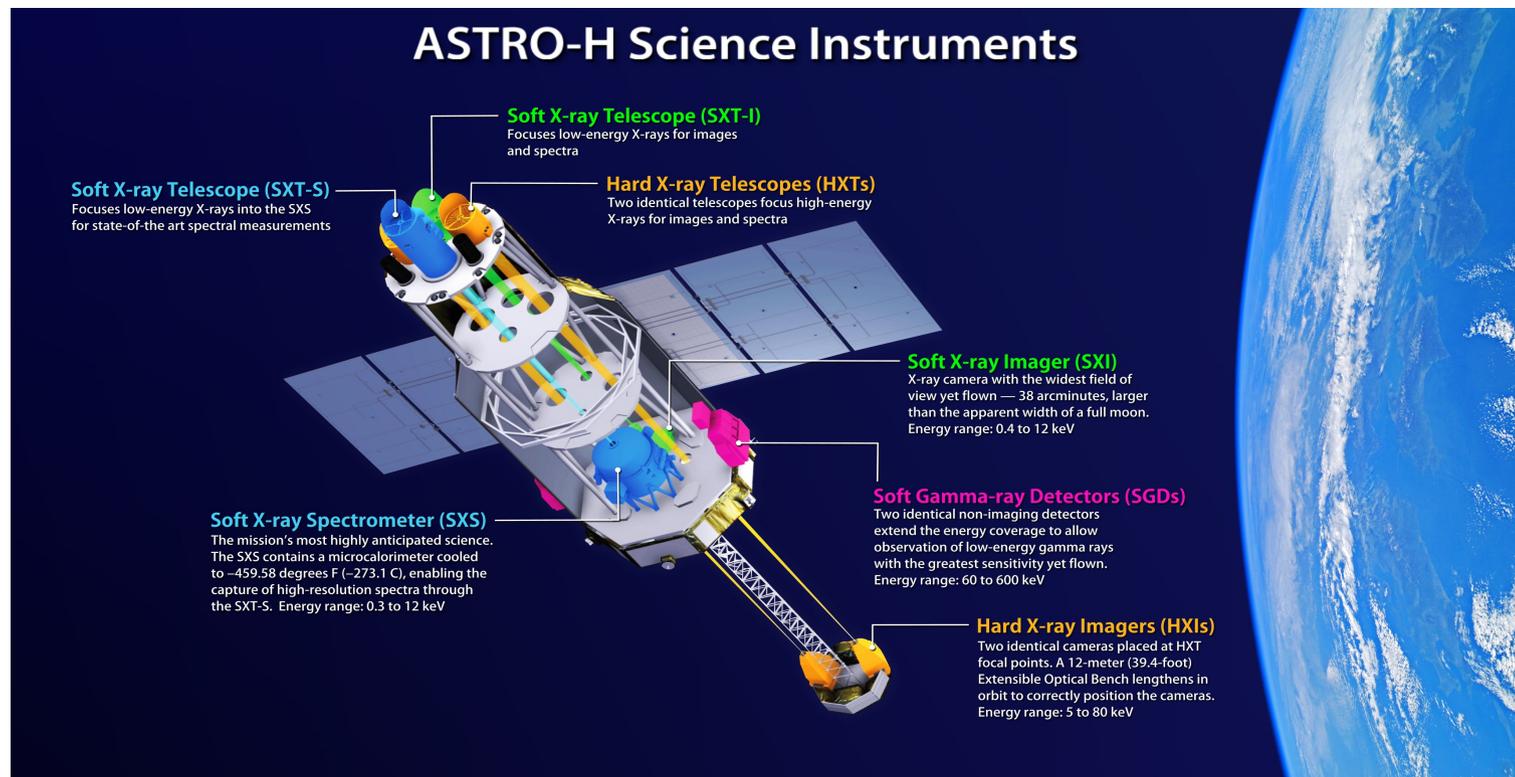
- 2000 – ASTRO-E has been lost in the ocean during launch

JAXA three times have tried to use micro-calorimeter

- 2000 – ASTRO-E has been lost in the ocean during launch
- 2005 – SUZAKU (ASTRO-EII) has lost all liquid helium, and micro-calorimeter does not work

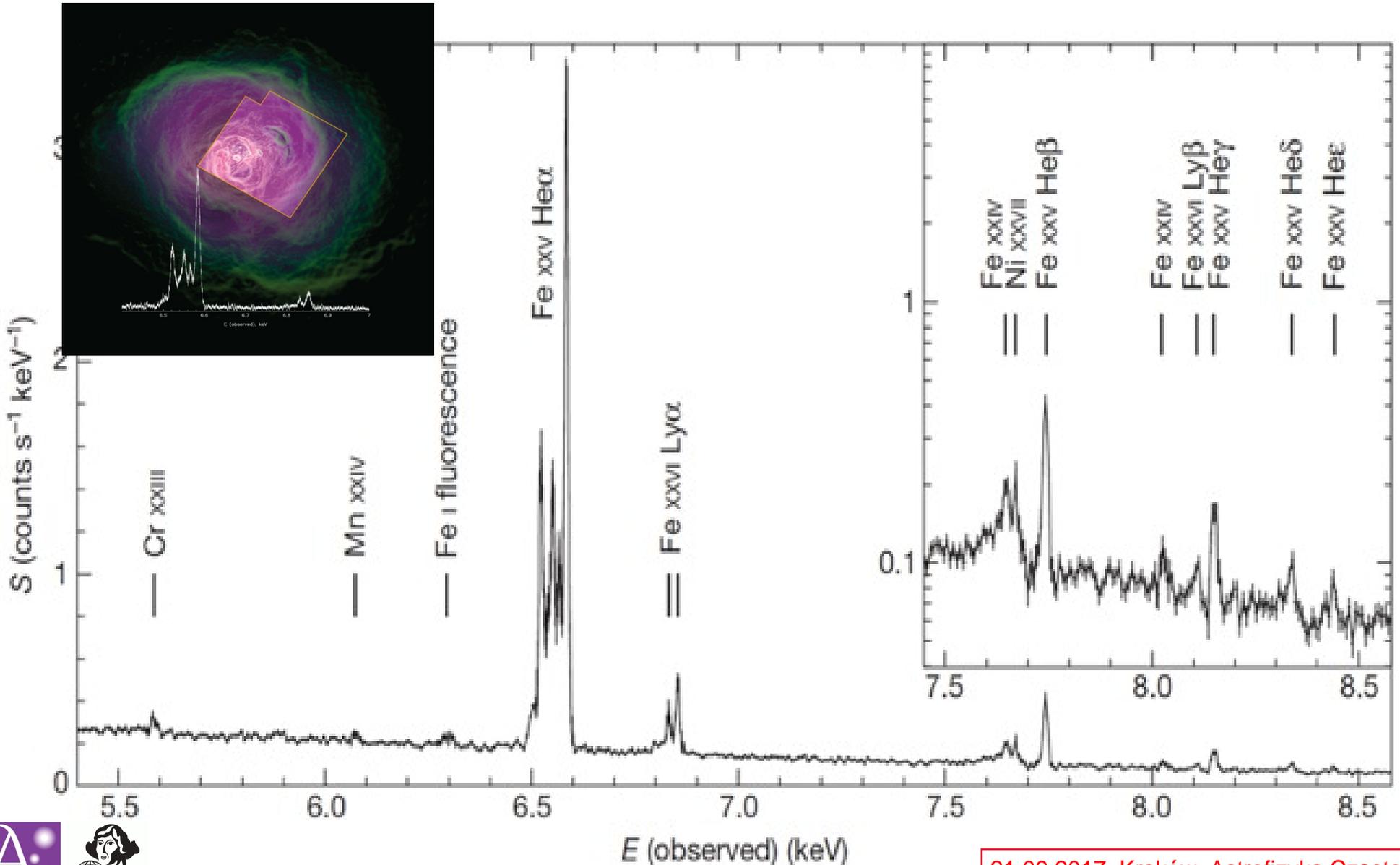
JAXA three times have tried to use micro-calorimeter

- 2000 – ASTRO-E has been lost in the ocean during launch
- 2005 – SUZAKU (ASTRO-EII) has lost all liquid helium, and micro-calorimeter does not work
- 2016 – ASTRO-H, launched on Feb. 2016, renamed as HITOMI, lost on March 2016 due to the software mistake



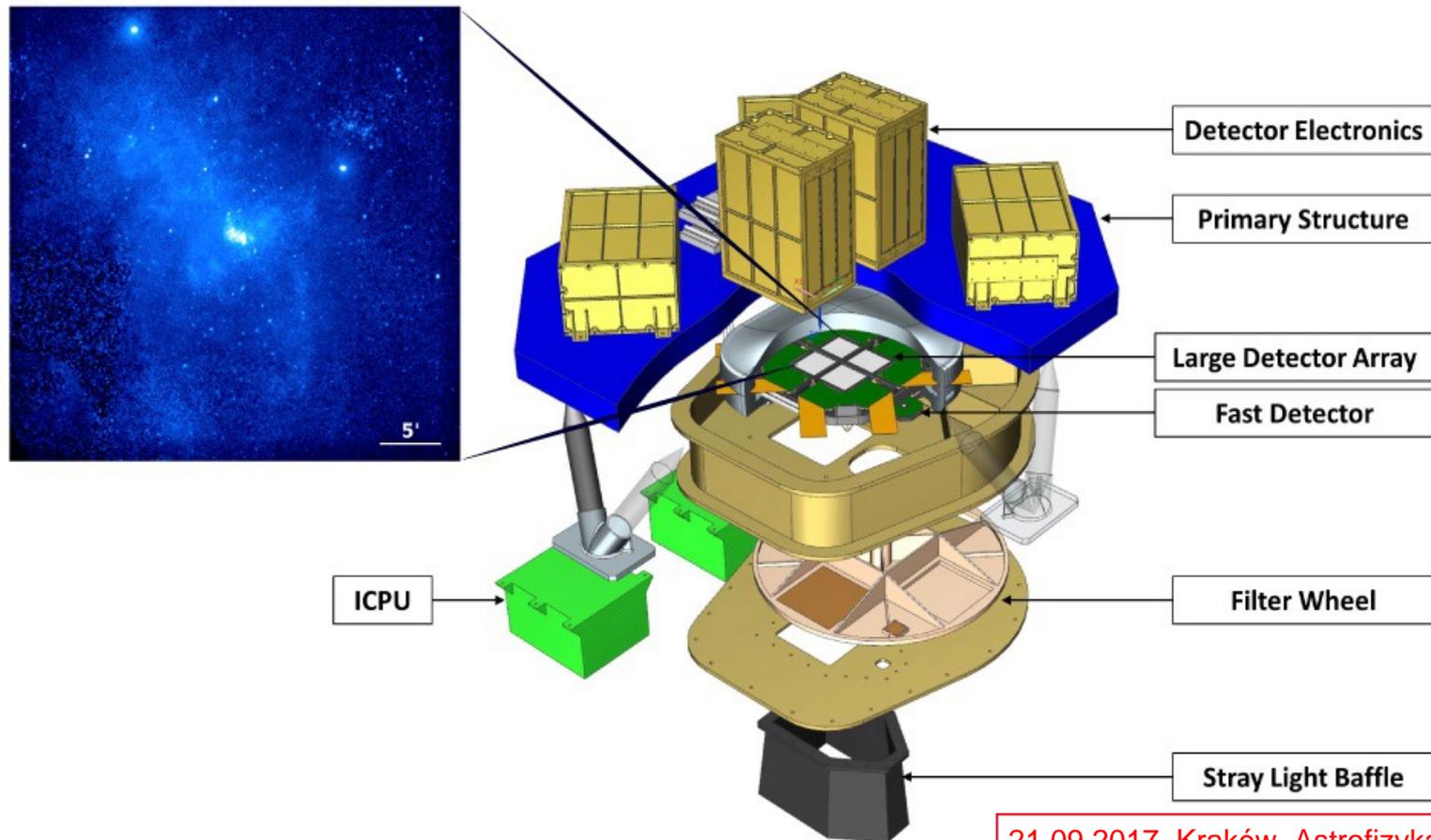
The best X-ray spectrum ever seen by human eye

- The core of the Perseus Cluster with HITOMI/SXS – **Nature 2016**



WFI (wide field imager) 0.1-15.0 keV

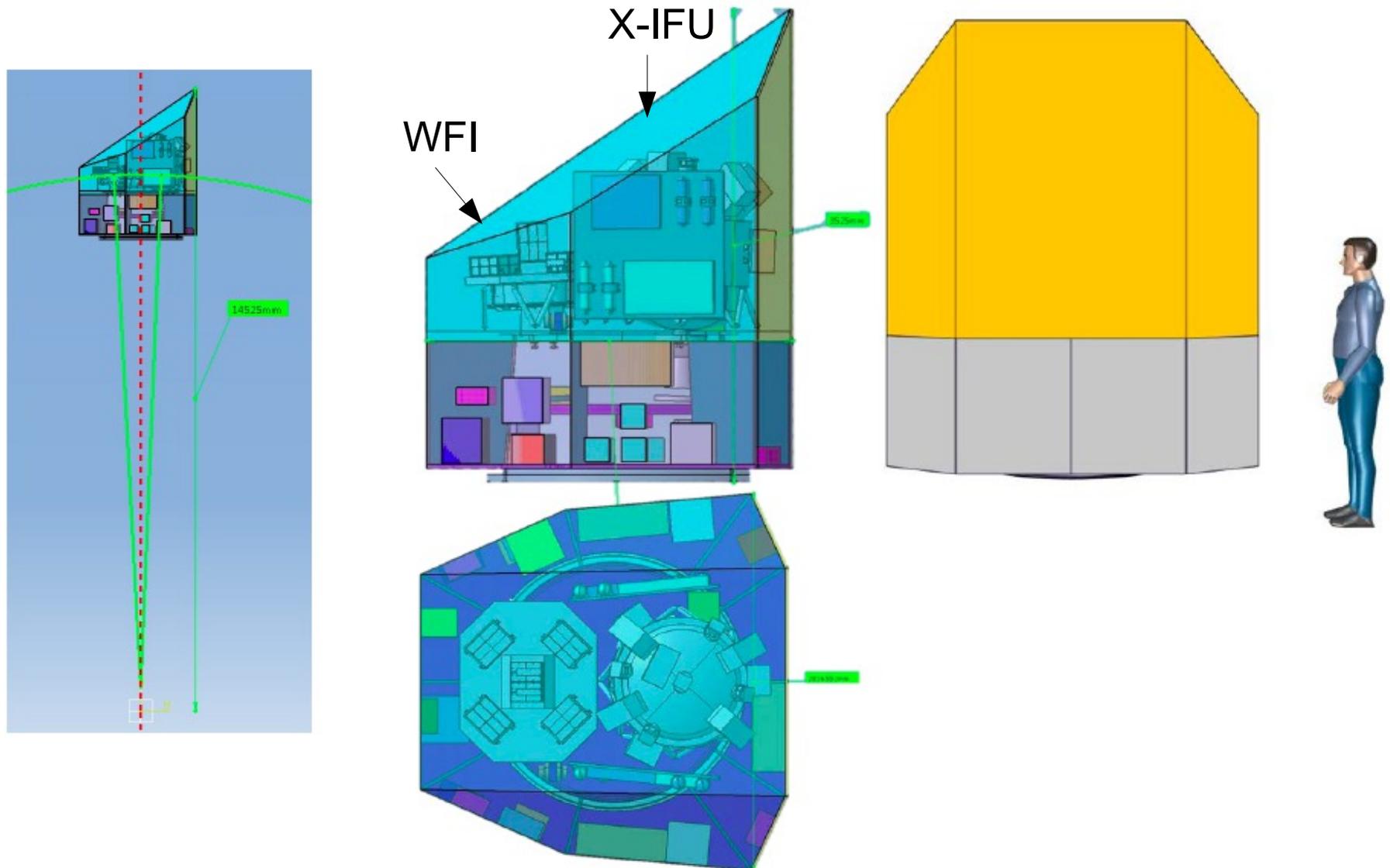
- FoV 40' x 40', Energy resolution 150 at 6 keV
- Readout time of 8 μ s and a count rate capability of > 1 Crab with 80% throughput



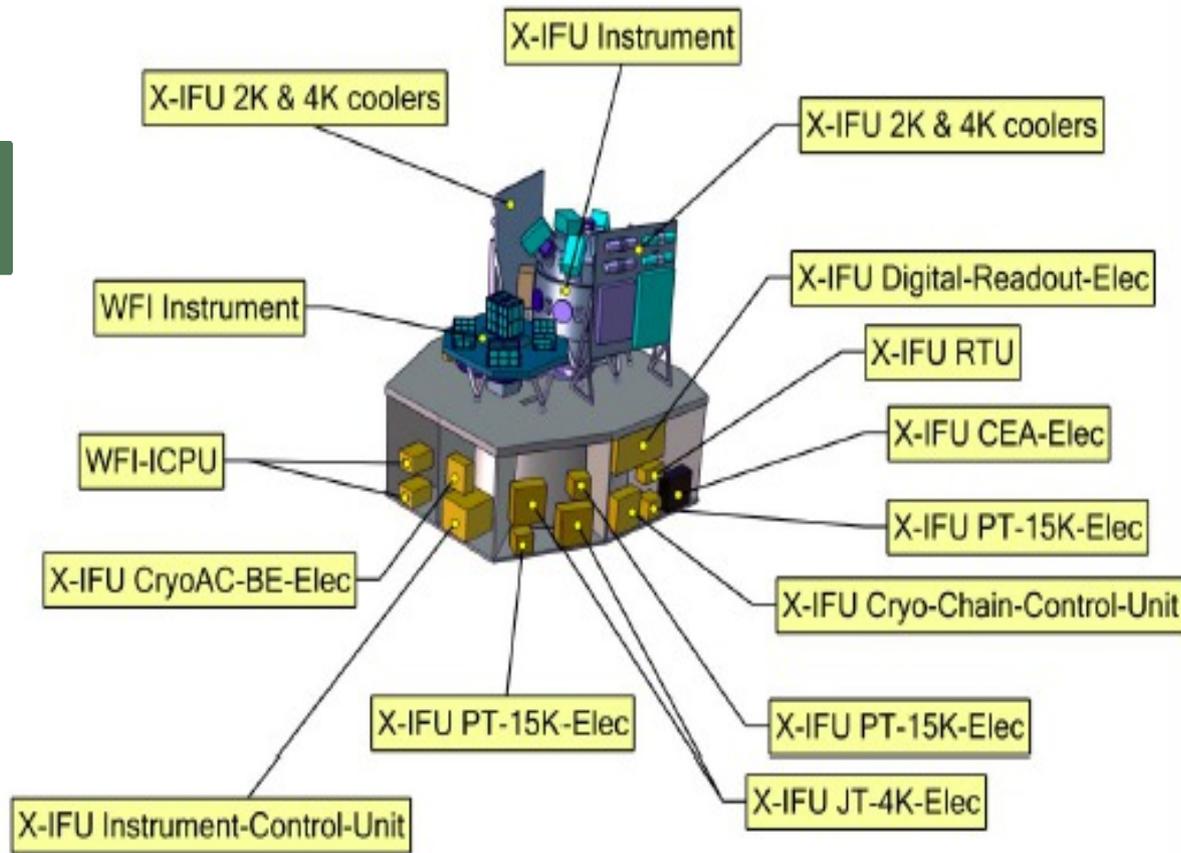
Credit: WFI team

21.09.2017, Kraków, Astrofizyka Cząstek

Focal plane concept by ESA

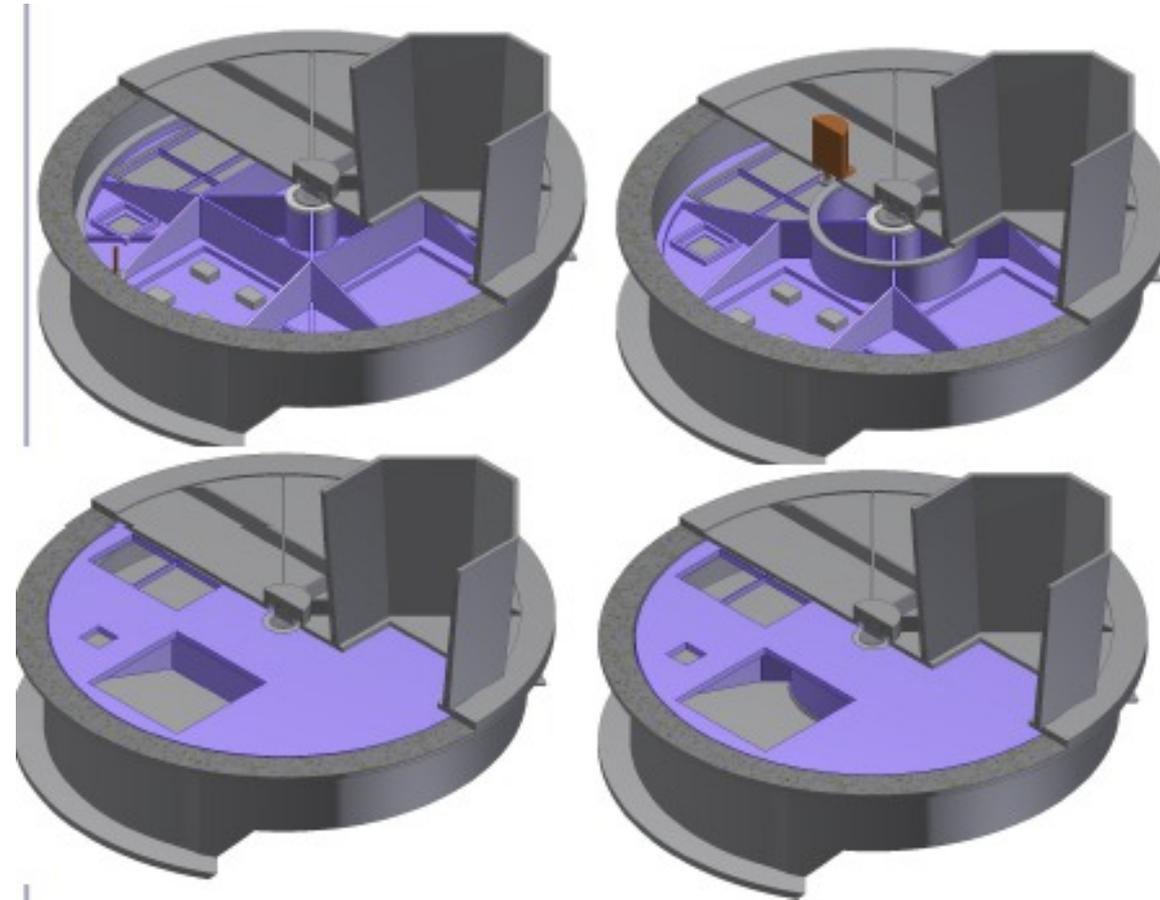


Focal plane concept by ESA



WFI team invited us to make

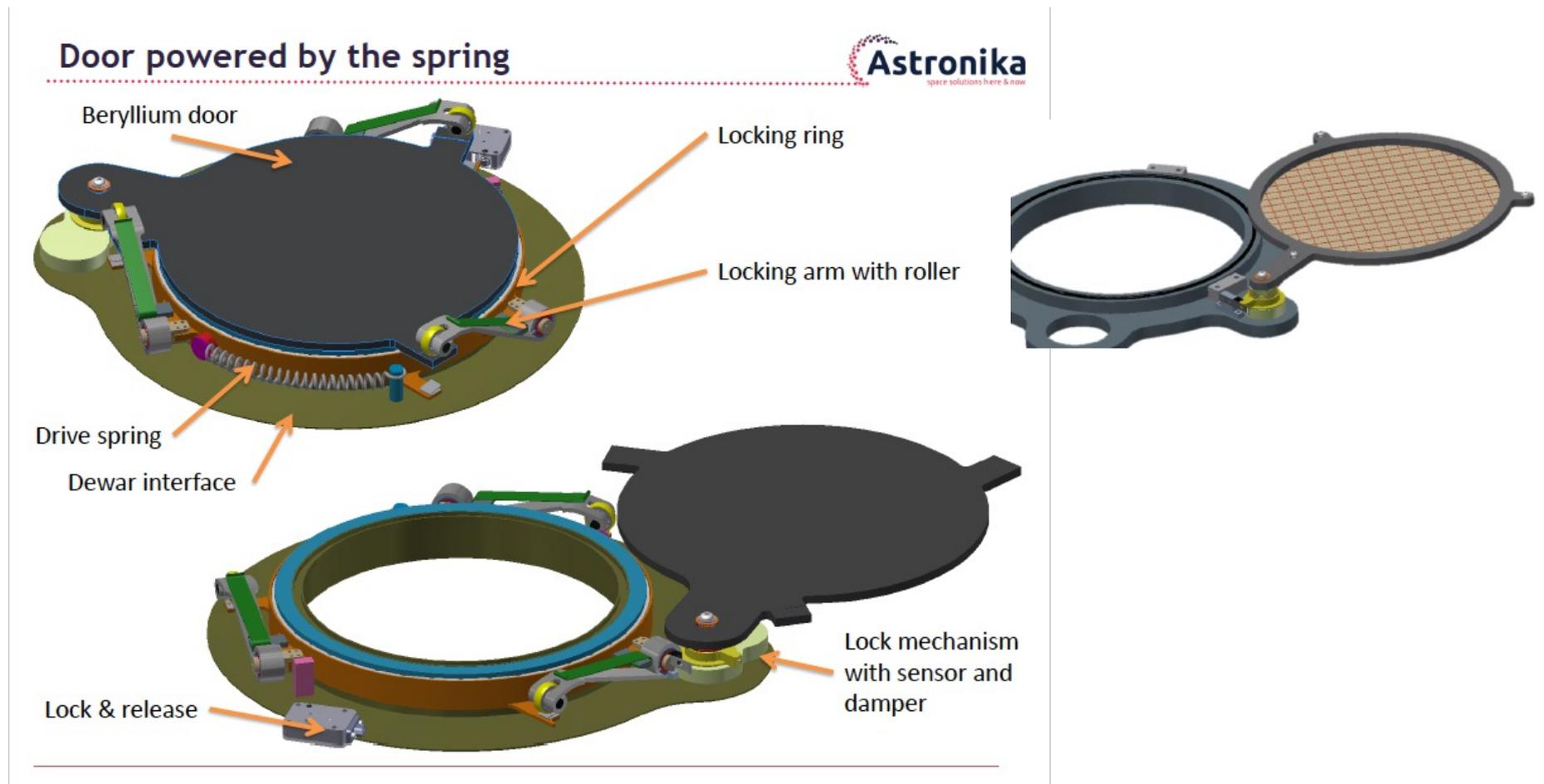
Filter Wheel
Assembly by
Mirosław Rataj
From CBK PAN



4 variants

X-IFU team invited us to make

- Dewar door for cylinder by Bartosz Kędziora



X-IFU and WFI teams invited us to make

- Power distribution unit by Konrad Skup from CBK PAN

PDU Concept

X-FU	UNIT	Number unit	Primary Power W								
			OFF	COOLDOWN (Detektor)	INITIALIZE	READY	OBSERVE	EXPERTISE	REGENERATE	COOLDOWN (Shield)	STANDBY
	PT15K	4 or 5	0	1500	1200	1200	1200	1200	1200	1500	0
	JT4K (JAXA)	1	0	90	90	90	90	90	90	90	0
	JT2K	1	0	100	100	100	100	100	100	100	0
	Total Coolers	0	0	1690	1390	1390	1390	1390	1390	1690	0
	ADR (50mK) Electronics	1	0	0	5	5	5	5	5	0	0
	PT15K Electronics	5	0	750	600	600	600	600	600	750	0
	JT4K Electronics	1	0	45	45	45	45	45	45	45	0
	JT2K Electronics	1	0	50	50	50	50	50	50	50	0
	Total Coolers Electronics	0	0	845	700	700	700	700	700	845	0
	Total Coolers Electronics + 20 % DMM	0	0	1014	840	840	840	840	840	1014	0
	Total Coolers + Electronics with 20 % DMM	0	0	2704	2230	2230	2230	2230	2230	2704	0
	Filter Wheel	1	0	0	36	36	36	36	36	0	0
	Modulated X Ray Source	1	0	0	16	16	16	16	16	0	0
	WFEE	6	0	0	20	20	20	20	20	0	0
	CryoAc WFEE (x4)	4	0	0	6	6	6	6	6	0	0
	CryoAc BEE	1	0	0	15	15	15	15	15	0	0
	DRE (functional chain x6)	6	0	0	438	438	438	438	438	0	0
	ICU	1	0	20	20	20	20	20	20	20	20
	CCLU	1	0	20	20	20	20	20	20	20	20
	PDU	1	0	5	5	5	5	5	5	5	5
	Total Warm Units	0	0	45	576	576	576	576	576	45	45
	Total Warm Units + 20 % DMM	0	0	54	691	691	691	691	691	54	54
	TOTAL	0	0	2580	2921	2921	2921	2921	2921	2580	45
	TOTAL with 20% DMM	0	0	2758	2921	2921	2921	2921	2921	2758	54

Note: If optimistic assumed the PDU has efficiency of 90%, then ~200W would be dissipated on PDU, may not be atrivial task from thermal point of view to remove this heat. Assumption is it will dissipate 2.5-5W.

ATHENA has great collaboration

- Polish ATHENA-PL scientific consortium is under construction
- We have been invited to make satellite components
- Our hardware development will be paid by PRODEX ESA project
- Since 2014 we have participated in about 24 meetings

More info at: <http://www.athena.camk.edu.pl>



The image shows a screenshot of the ATHENA Polish Website. The banner features a classical bust of Athena on the left, the text "Advanced Telescope for High Energy Astrophysics" in a serif font, and "ATHENA POLISH WEBSITE" in a bold, sans-serif font. Below the banner, there is a section titled "Teleskop rentgenowski ATHENA" with a paragraph of text in Polish. To the right, there is a navigation menu with the following items: "O projekcie", "Zespół", "Linki", "Spotkania", "Wystąpienia", and "Publikacje". The menu also includes small flags of Poland and the UK.

Advanced Telescope for High Energy Astrophysics

ATHENA

POLISH WEBSITE

Teleskop rentgenowski ATHENA

Znajdujesz się na oficjalnej stronie informującej o uczestnictwie polskich naukowców oraz inżynierów w budowie misji satelitarnej ATHENA. ATHENA to nowej generacji teleskop rentgenowski zaakceptowany przez Europejską Agencję Kosmiczną z planem wyniesienia na orbitę w roku 2028.

O projekcie

Zespół

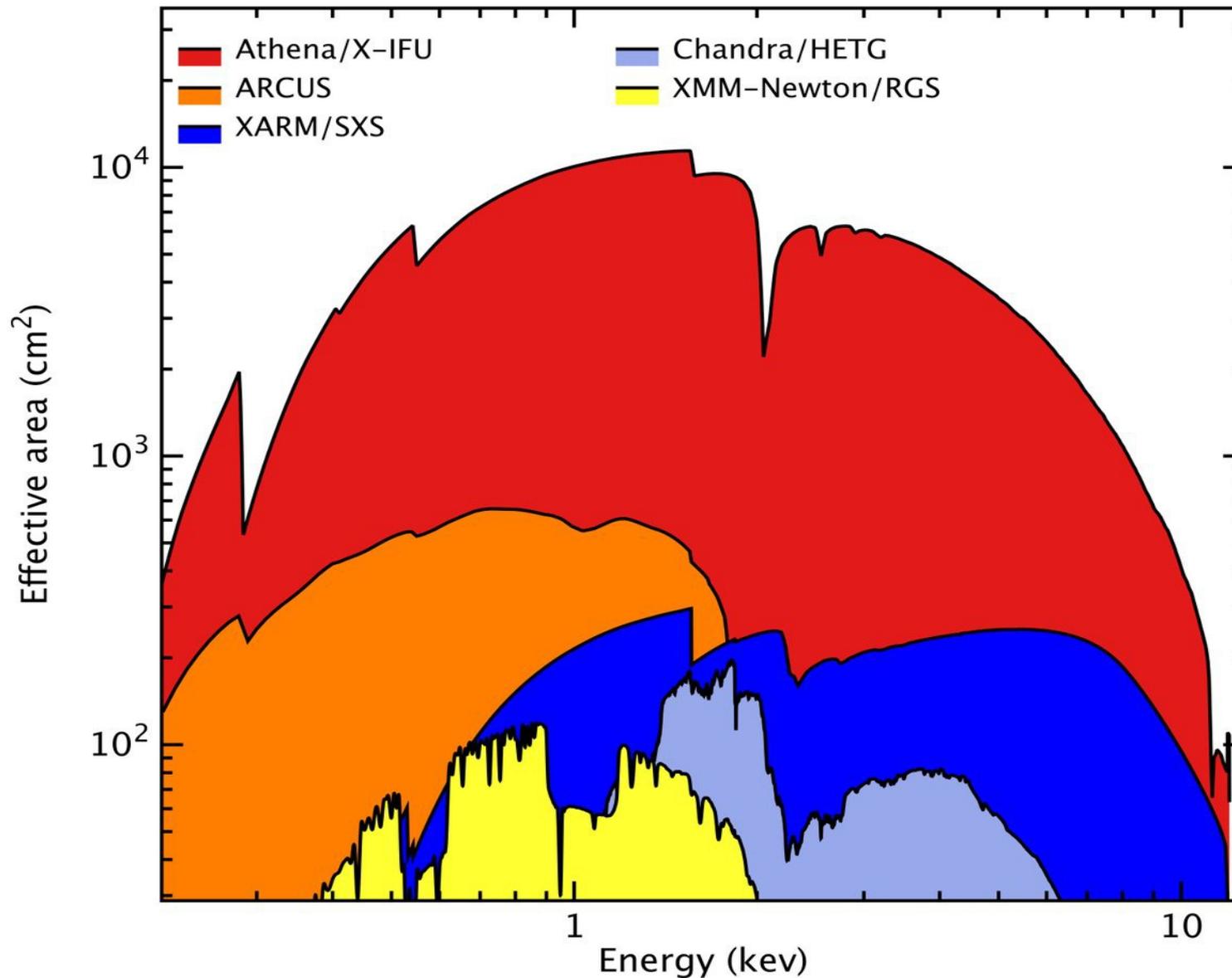
Linki

Spotkania

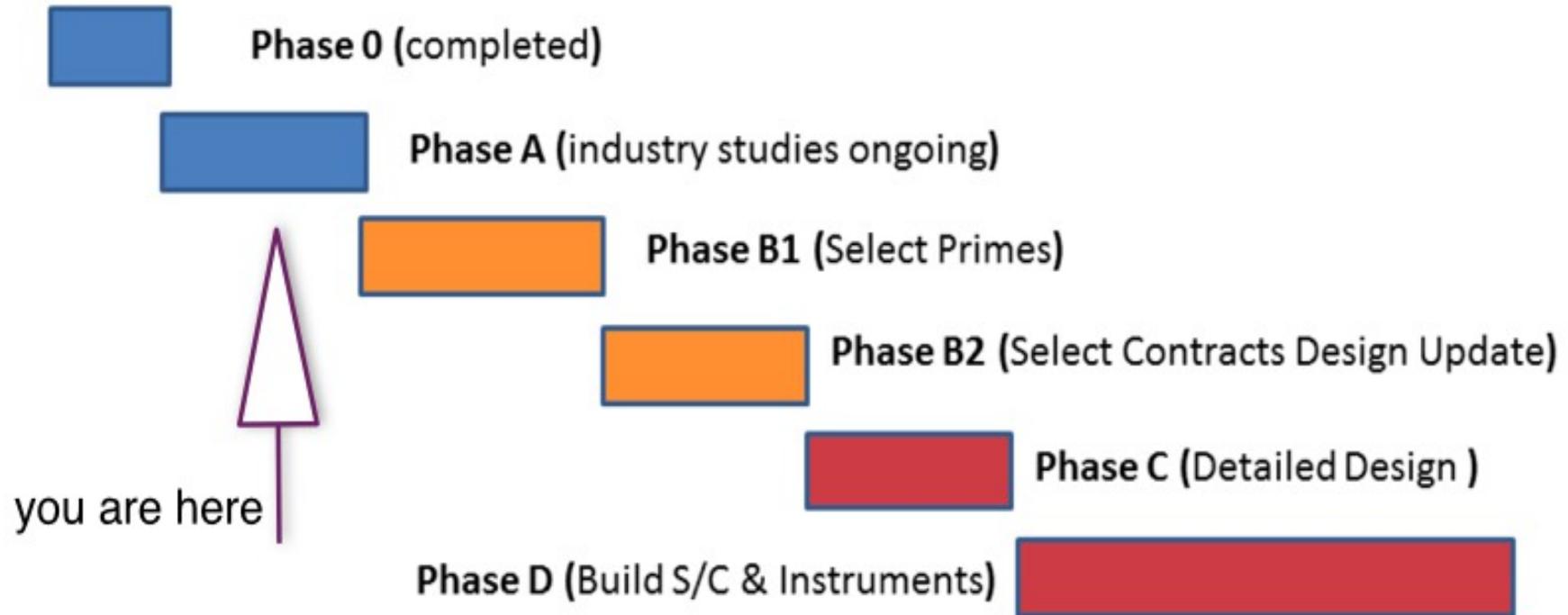
Wystąpienia

Publikacje

Effective area of the ATHENA telescope



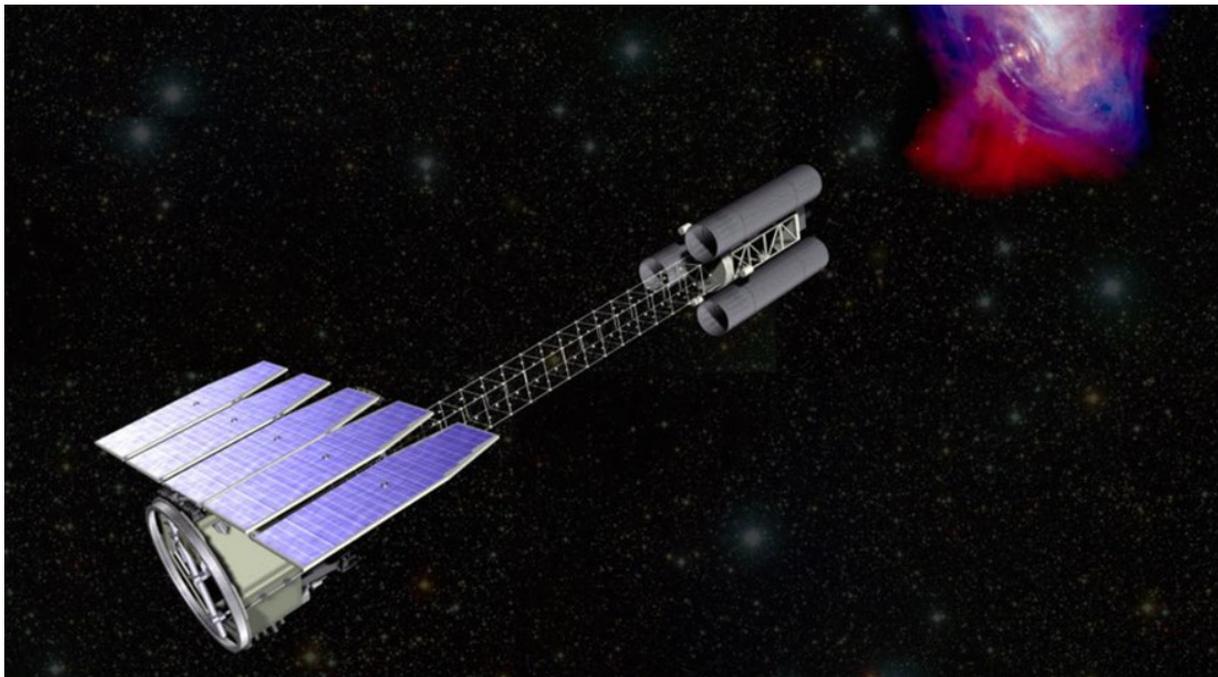
Effective area of the ATHENA telescope



Next key date: Athena "adoption" in the ESA Science Program: **2020**

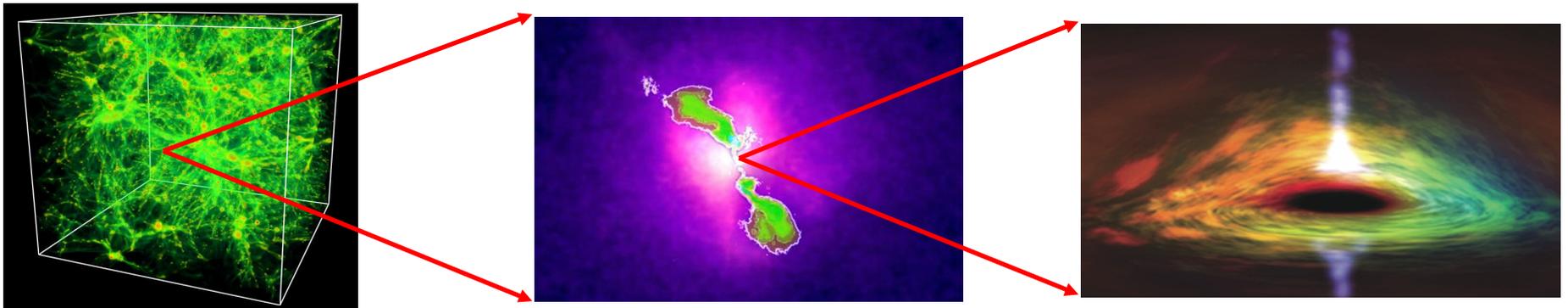
The other X-ray missions:

- HARM/SXS - new Hitomi – by JAXA
- ARCUS with gratings – 2023 by NASA
- XIPE – polarimeter by ESA – M4 mission not yet selected
- IXPE – polarimeter by NASA – selected to be launched at 2020
- eXTP – new timing and polarimetry mission – by China + ESA



Science scheme - The Hot Energetic Universe

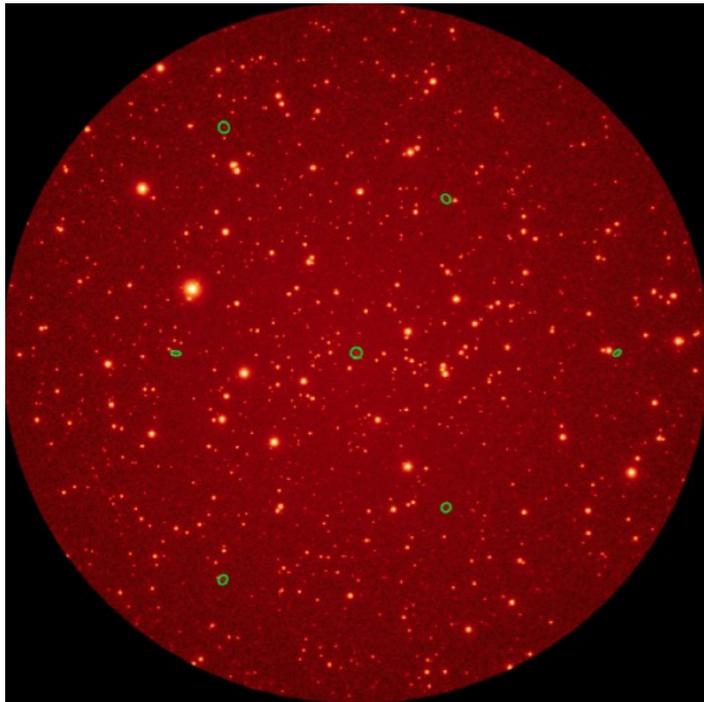
- **Hot Universe:** How does ordinary matter assemble in large scale structures that we see today?
- > 50 % of the baryons today are in a hot ($>10^6$ K) phase
- There are as many hot ($>10^7$ K) baryons in clusters as in stars over the entire Universe
- **Energetic Universe:** How do black holes grow and shape the Universe?
- 15 % of the (luminous) energy in the Universe is from accretion



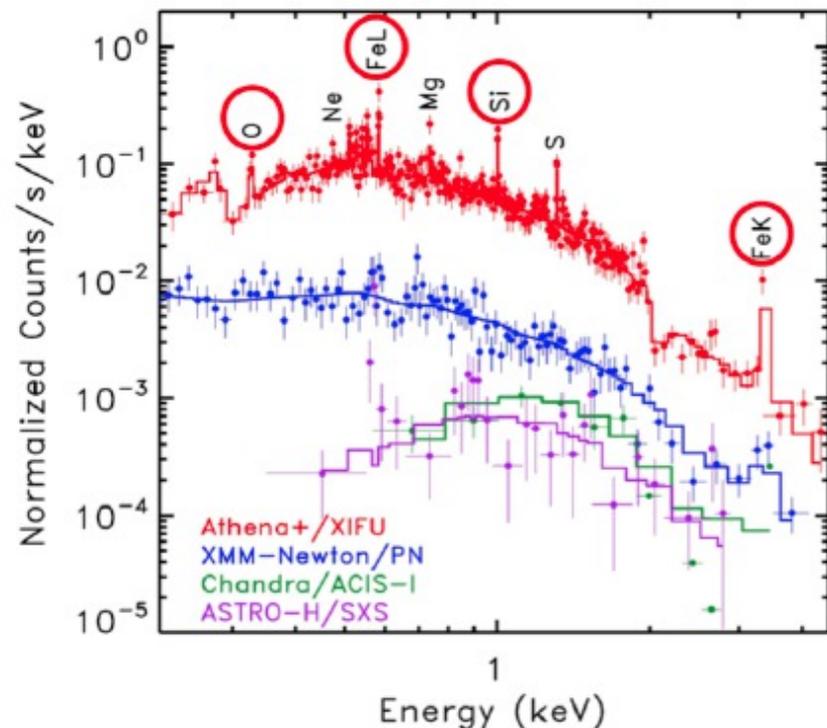
The formation and evolution of clusters

- What is the interplay of galaxy, SBH and intergalactic gas?
- What are the processes driving the evolution of chemical enrichment of the hot diffuse gas in large-scale structure?
- How and when did the first galaxy groups form?

WFI 100 ks 50'x50'

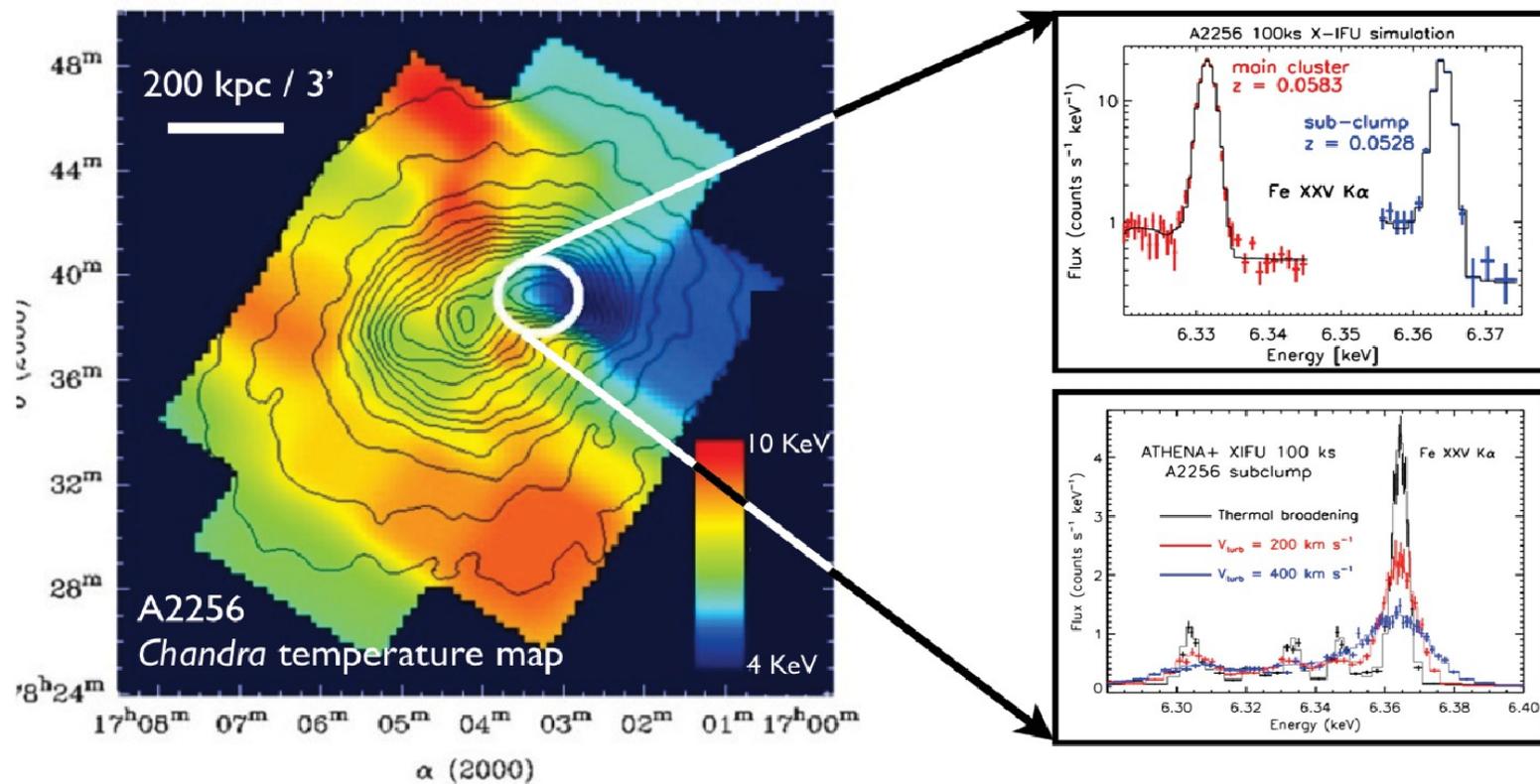


Cluster $z=1$ $kT = 3$ keV



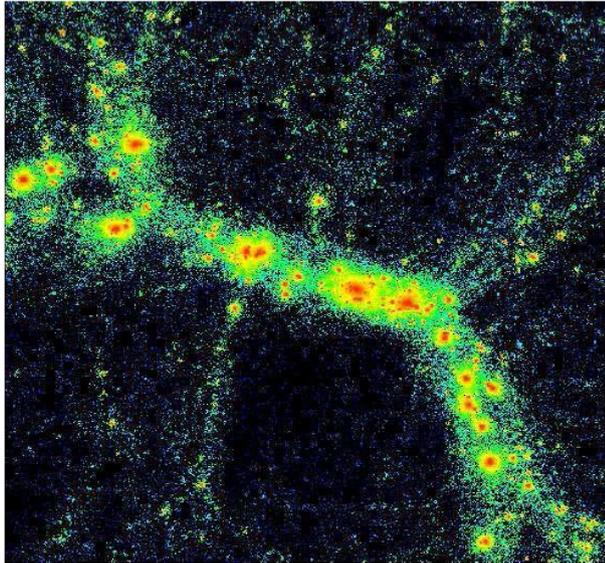
The formation and evolution of clusters

- How do hot diffuse baryons accrete and dynamically evolve?
- How and when was the energy in the ICM generated?
- Where and when are heavy elements produced?

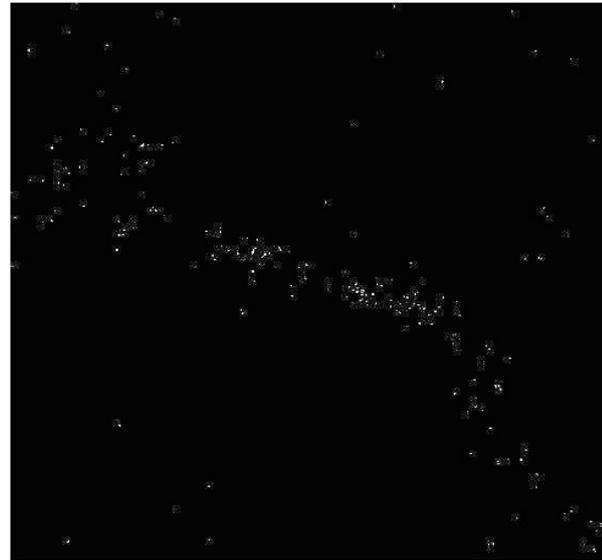


Missing baryons in simulations, Suto et al. 2004

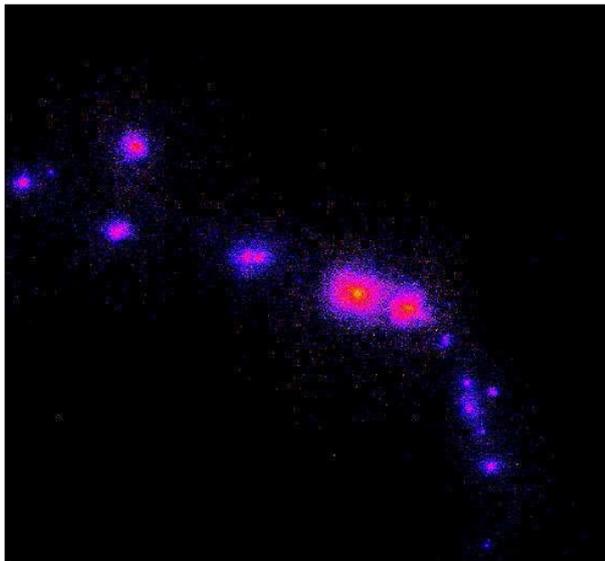
Dark Matter
26.8 %



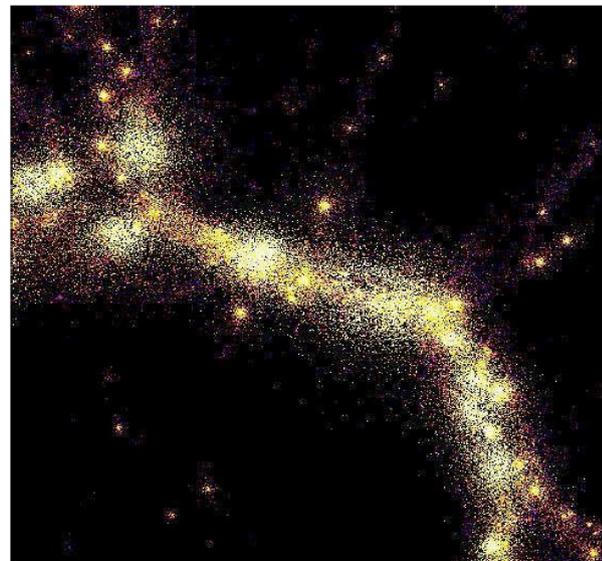
Galaxies,
incl. Stars
 $T \leq 10^4 K$



Clusters
 $T > 10^7 K$

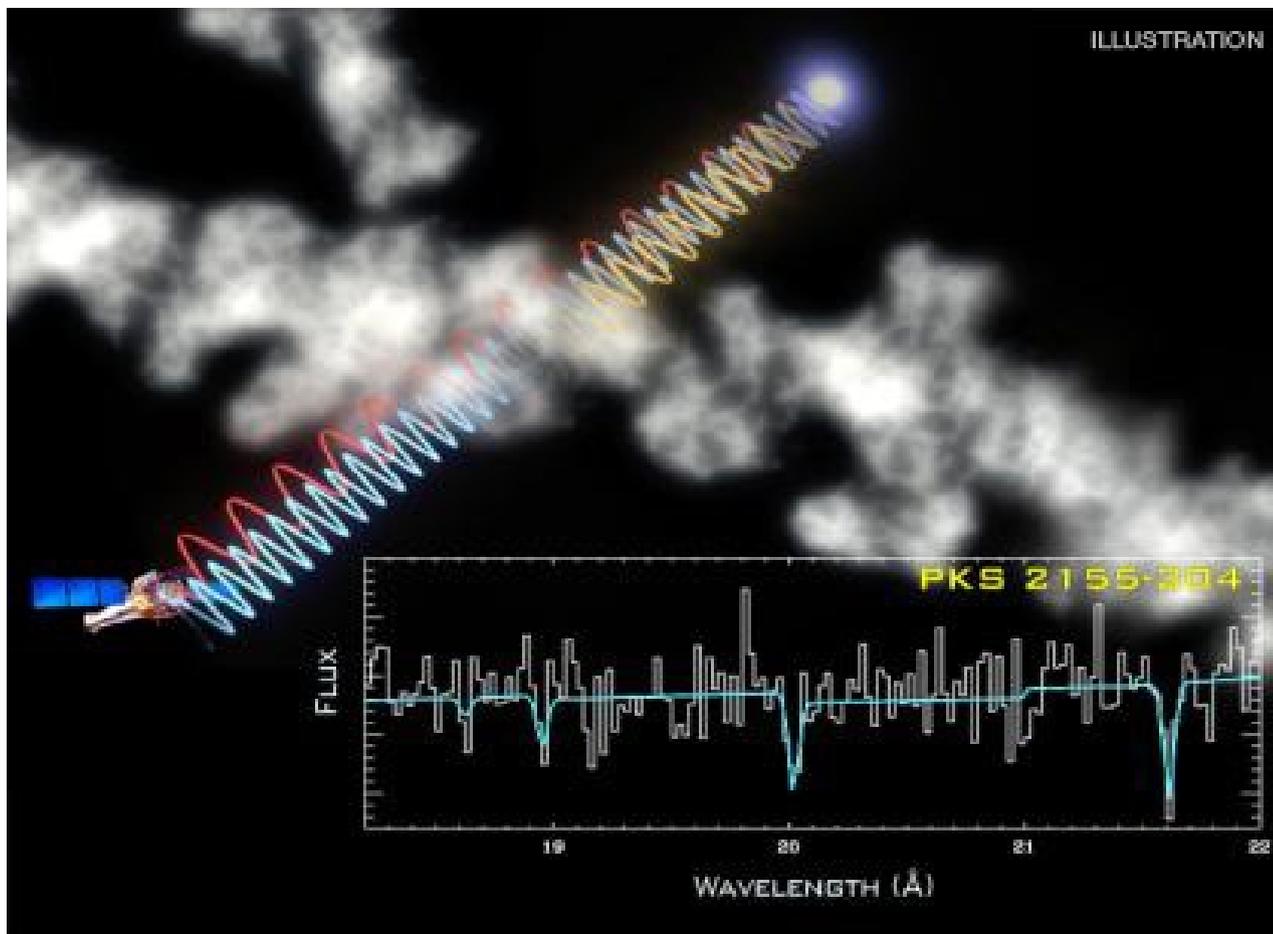


WHIM
 $10^5 < T < 10^7 K$



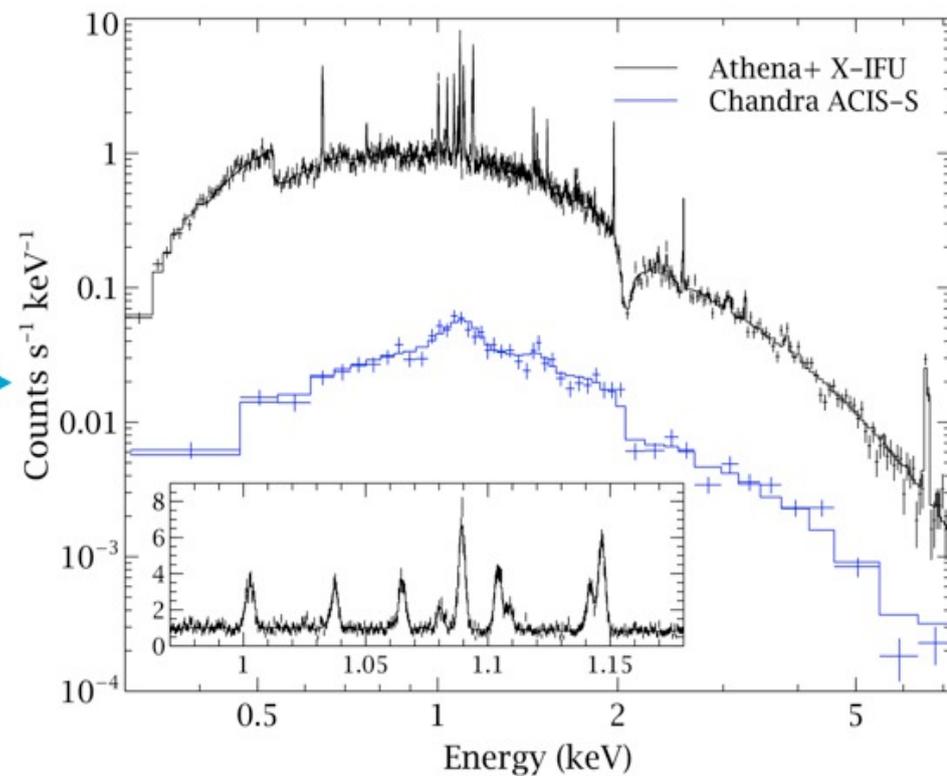
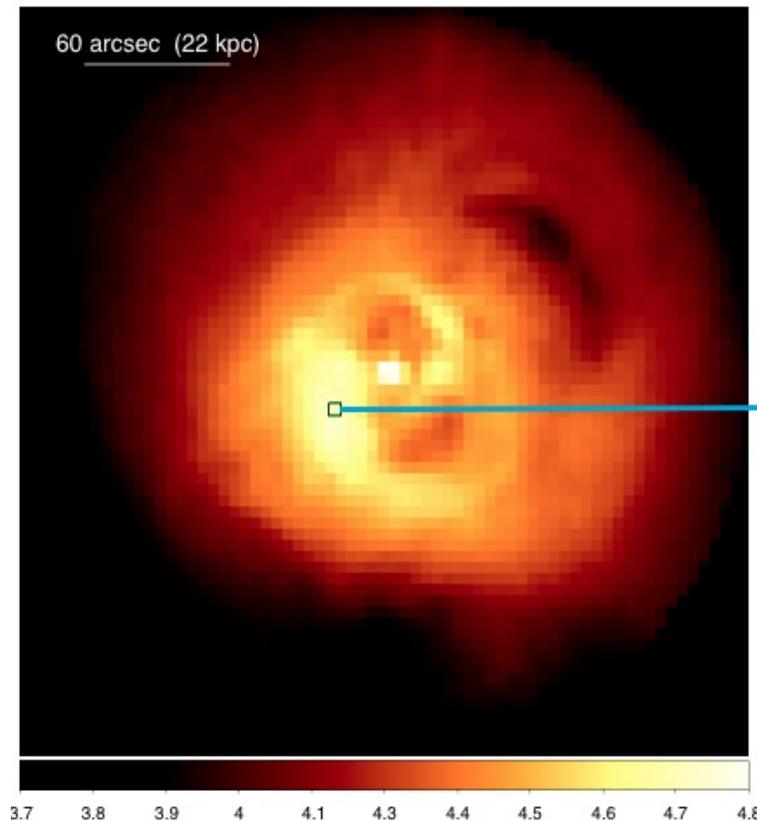
Missing baryons

- How to detect WHIM? All atomic spectral features are narrow
- Need for high spectral resolution



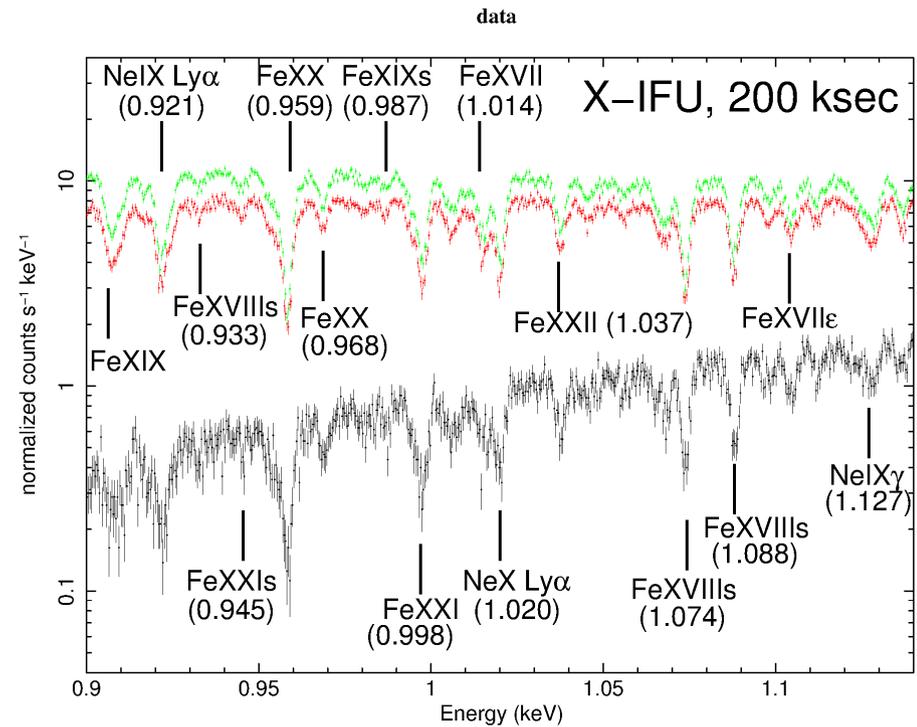
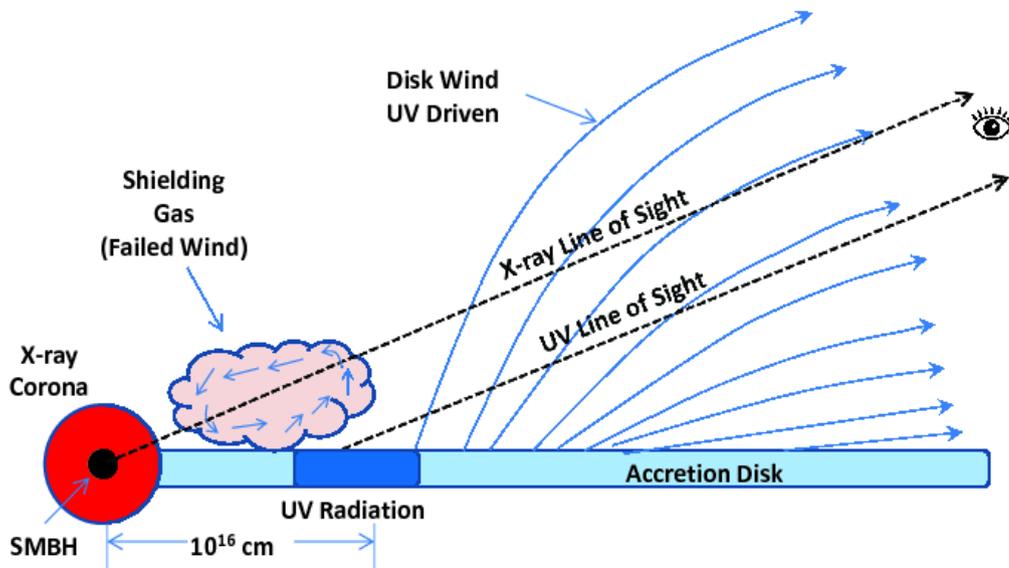
The AGN feedback in cluster of galaxies

- How do jets from AGN dissipate their mechanical energy in hot intracluster medium? How it affects hot gas distribution?
- Establish how AGN feedback regulates gas cooling in groups and clusters



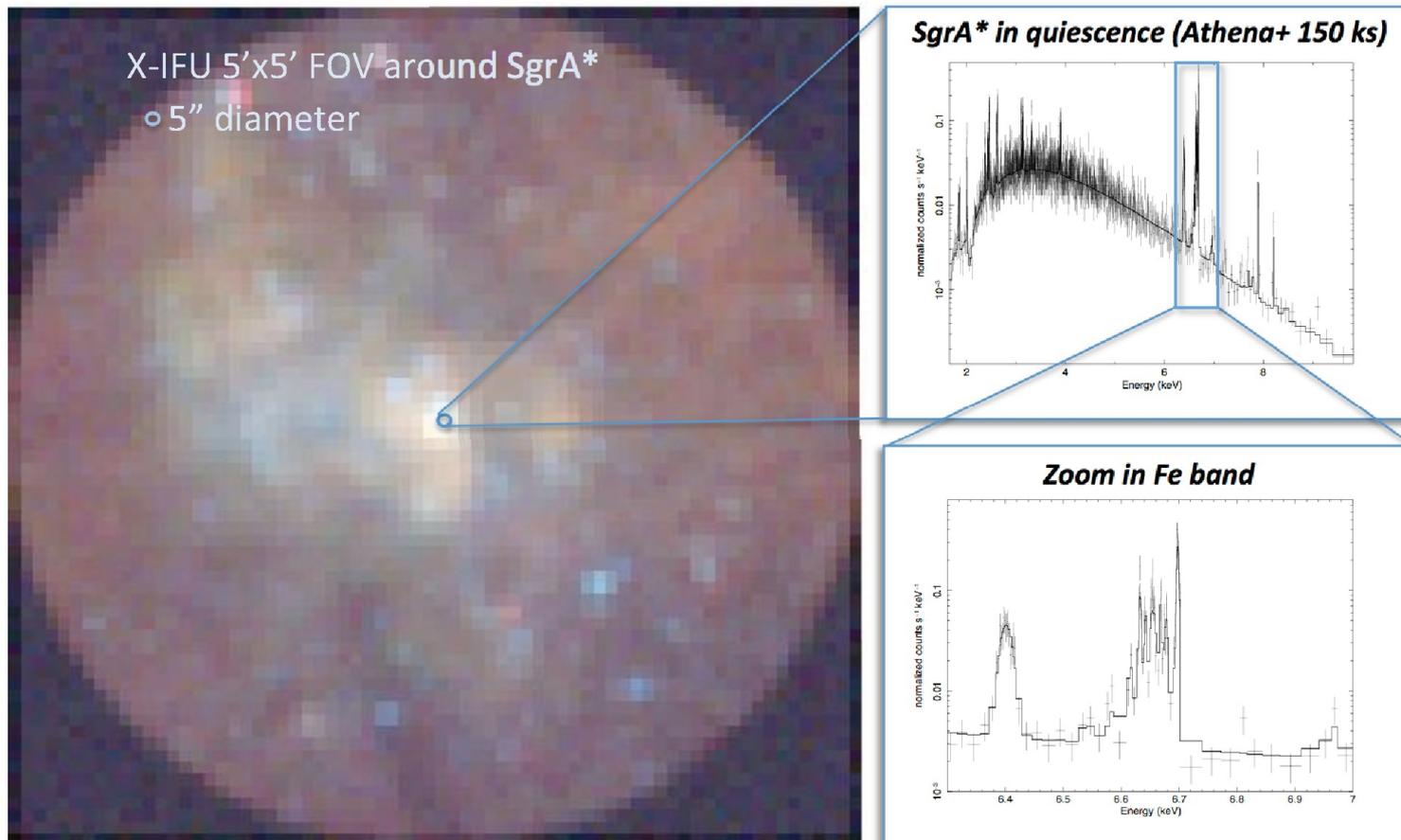
Astrophysics of feedback, outflows and winds in AGN

- How do accretion disks around black holes launch winds and how much energy do these carry?
- How are the energy and metals transferred into the medium?



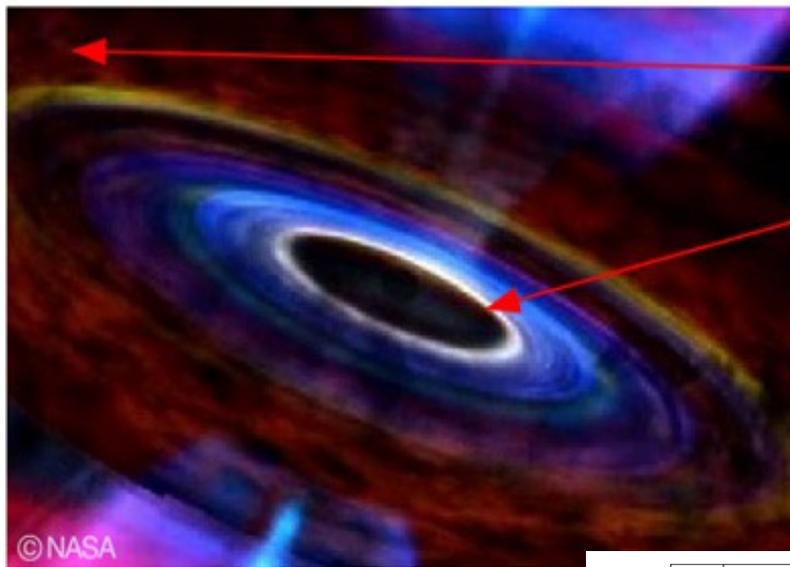
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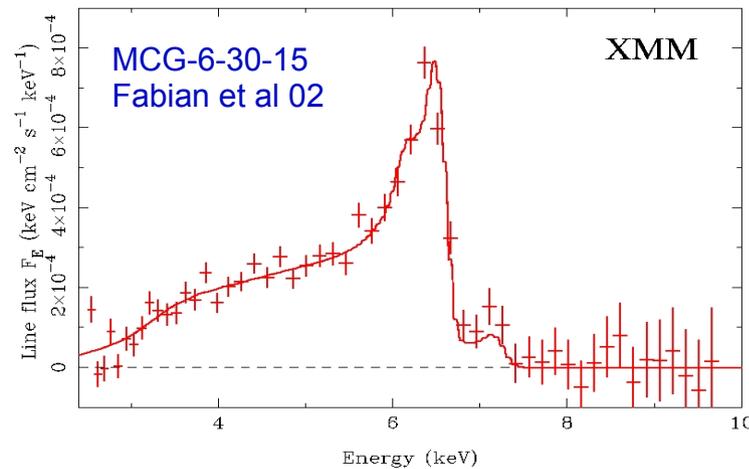
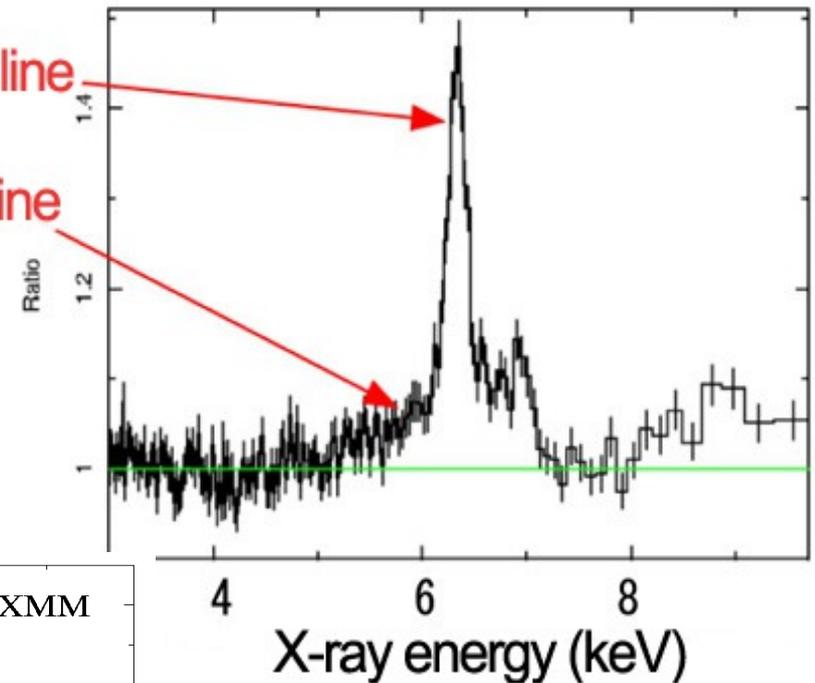
Close environment of supermassive black holes

- Fluorescent iron line profile from accreting black holes
- Black hole spin



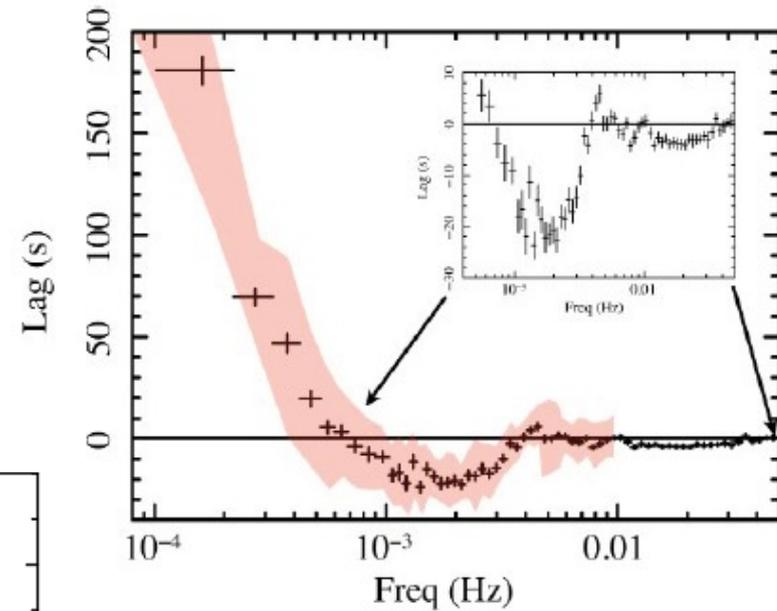
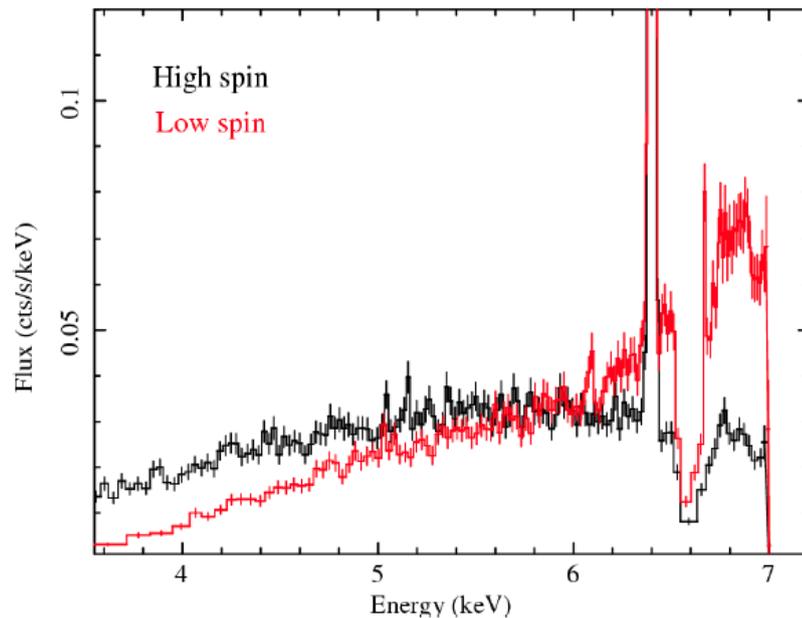
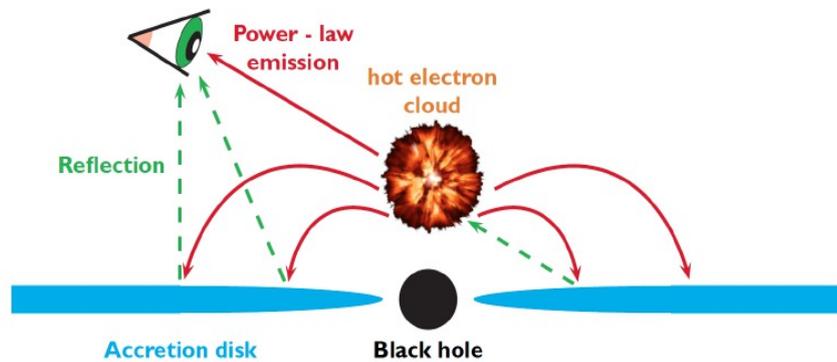
Narrow emission line

Broad emission line



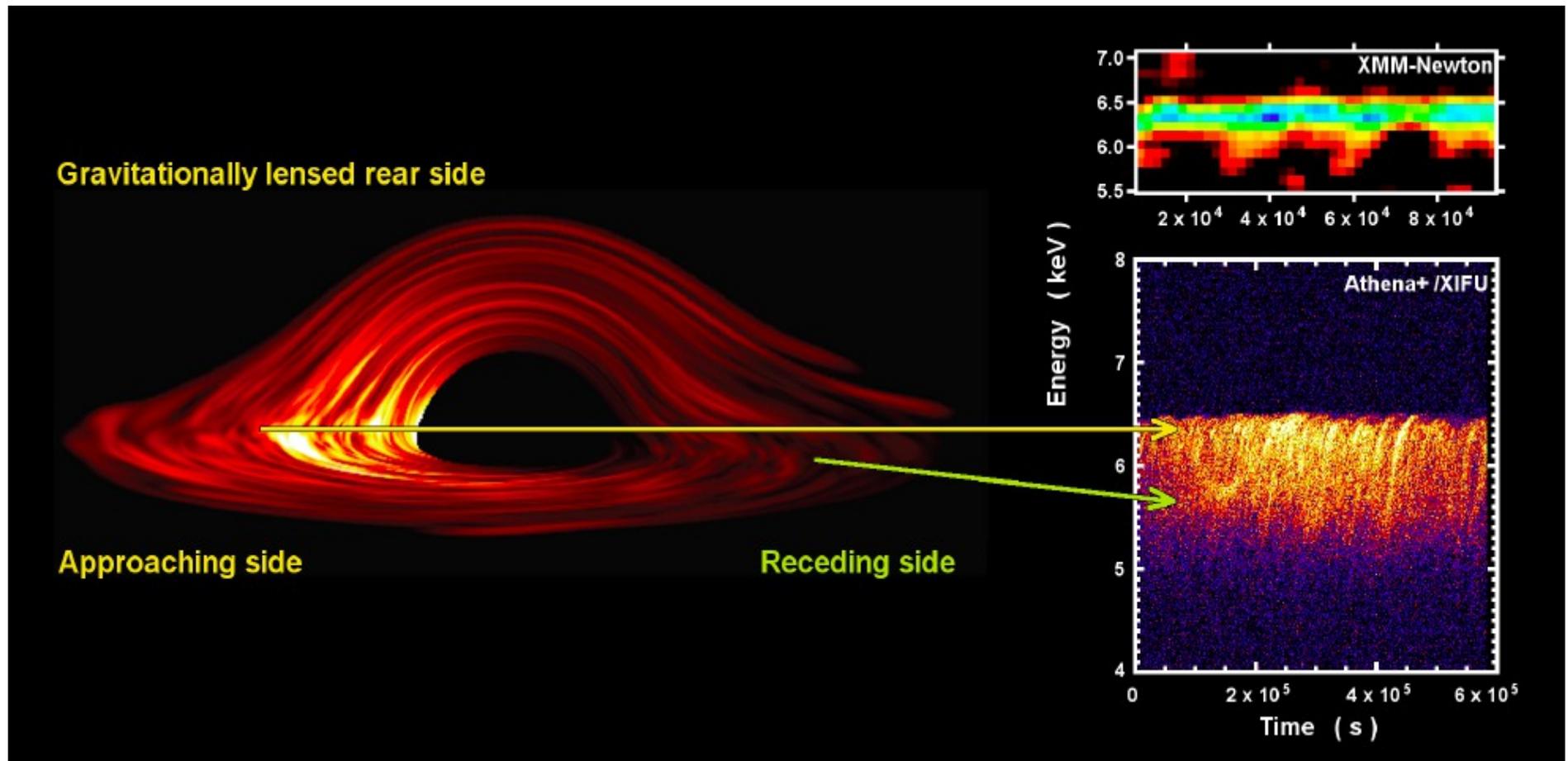
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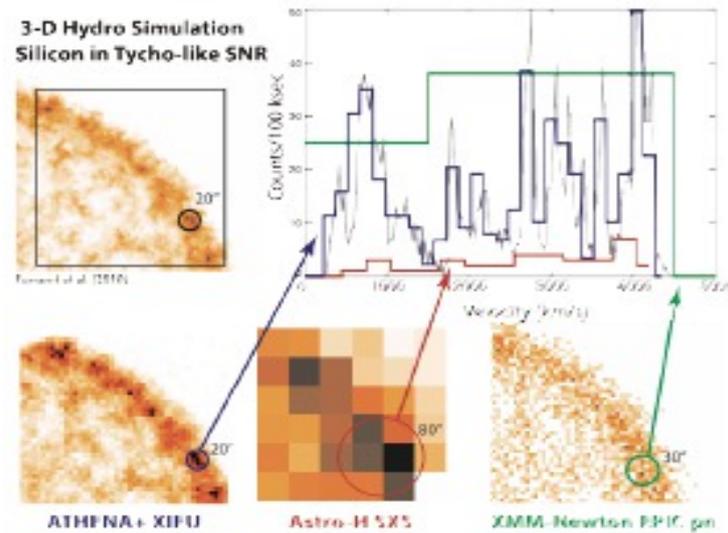
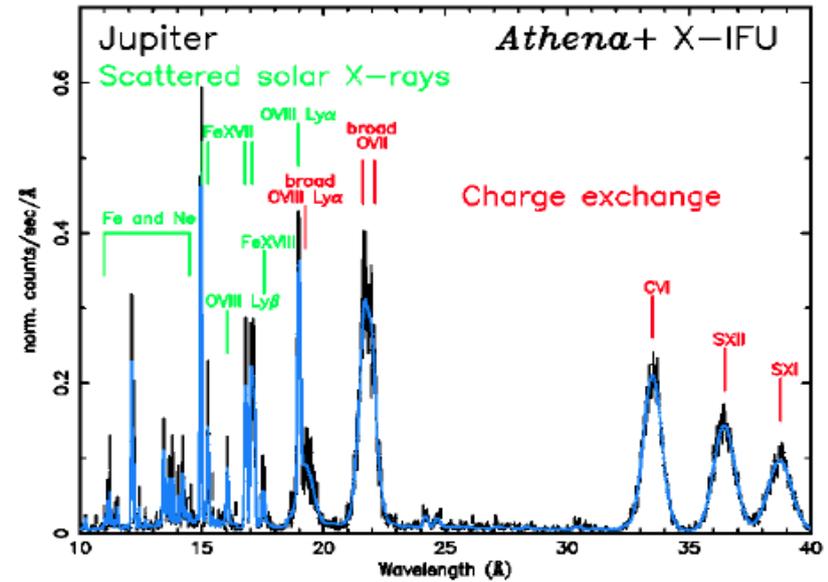
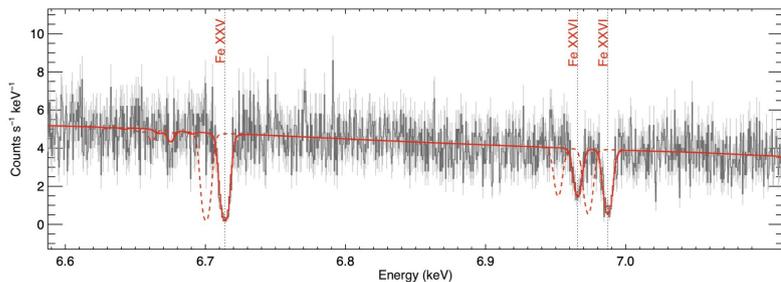
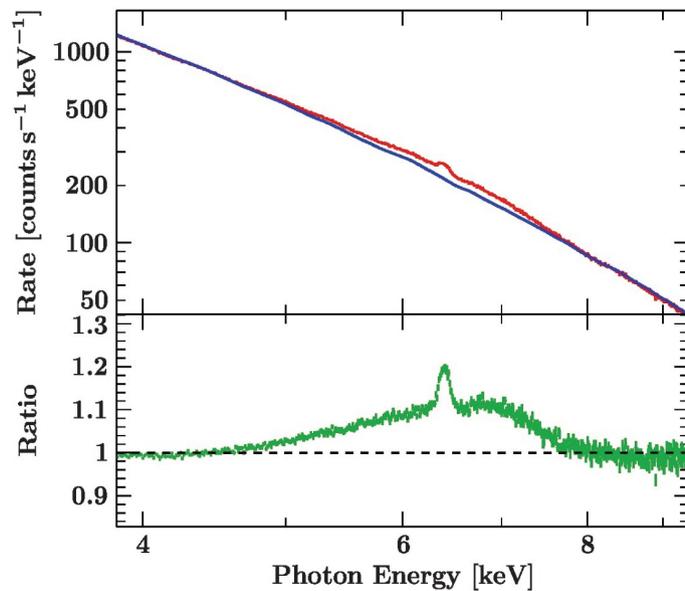
Close environment of supermassive black holes

- Time resolved spectroscopy puts constraints on the geometry of disk and corona



Observatory science questions

- Solar system and exoplanets
- End points of stellar evolution
- Supernova remnants



Conclusions – ATHENA in the context of 2020s

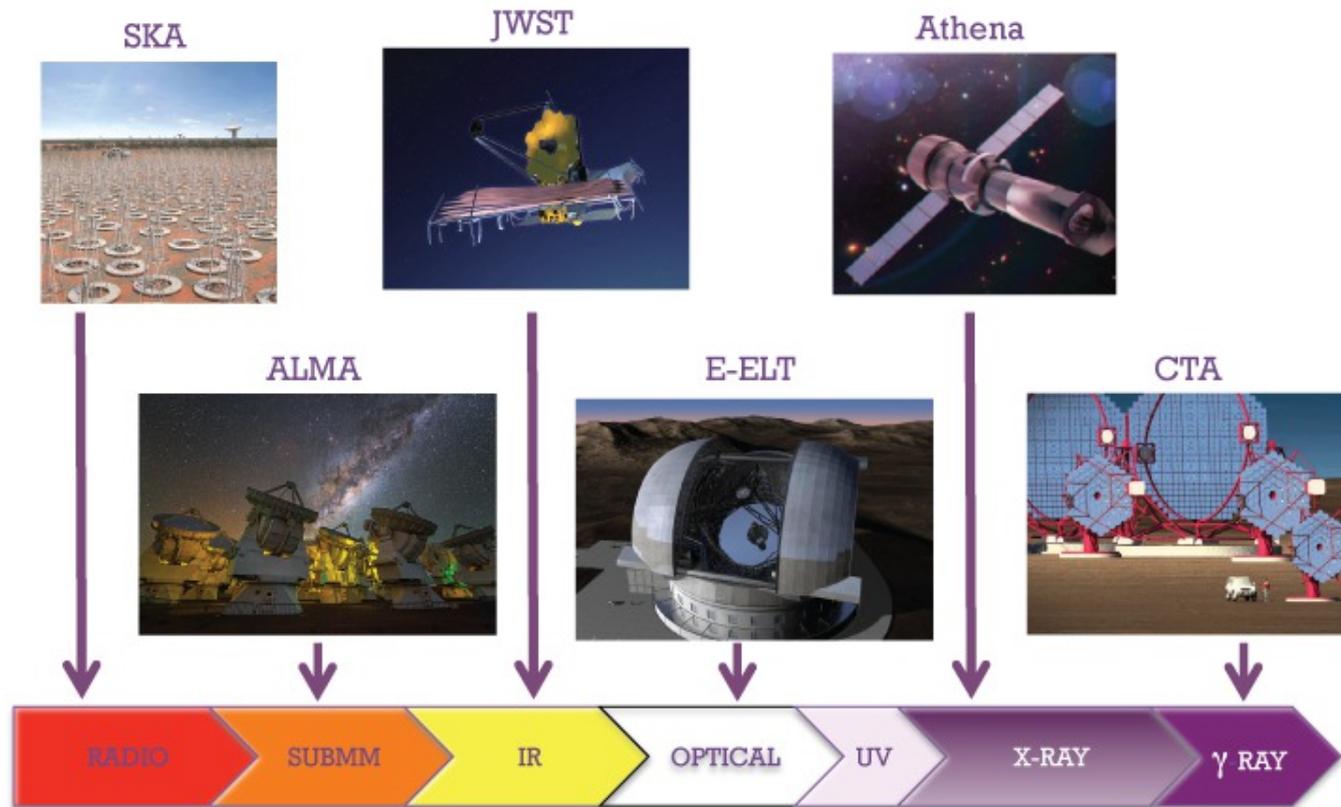
Synergies with Athena

Matteo Guainazzi (SCI-S/ESA, ESTEC, Noordwijk, The Netherlands)

Astrophysics Mission Synergy Workshop,

Cahill Center for Astronomy and Astrophysics. March 31st, 2017

Credit: SKA, ESO, NASA, CTA & ACO Team



Conclusions – ATHENA in the context of 2020s

Synergies with Athena

