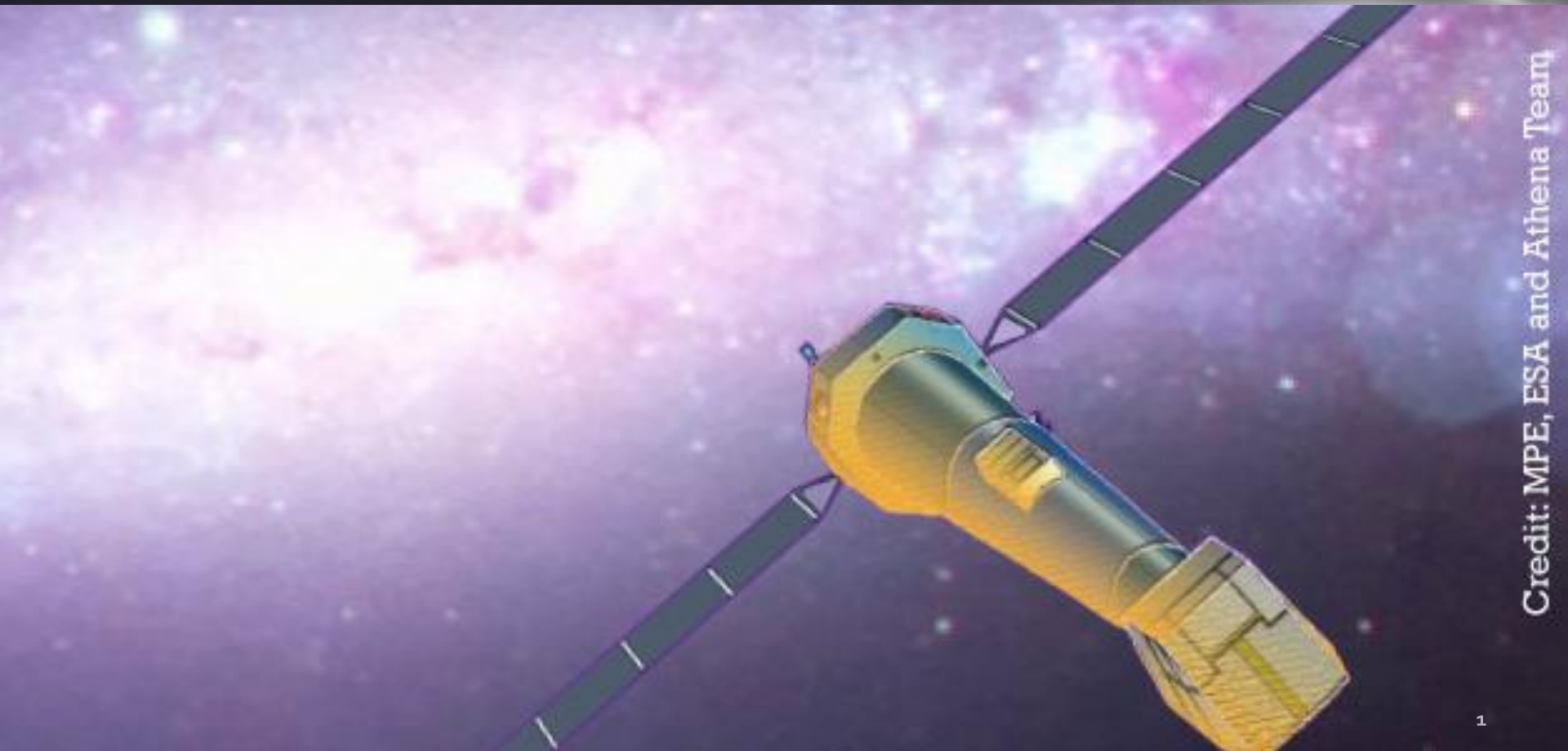
The Athena X-ray observatory and the Liège contribution to the X-IFU instrument

Lionel Jacques, Yaël Nazé, Gregor Rauw, Tanguy Thibert



What is ATHENA?

ATHENA = Advanced Telescope for High-ENergy Astrophysics

= 2nd L-class mission of ESA's Cosmic Vision program selected to address the questions about "The Hot and Energetic Universe".

Main science questions:

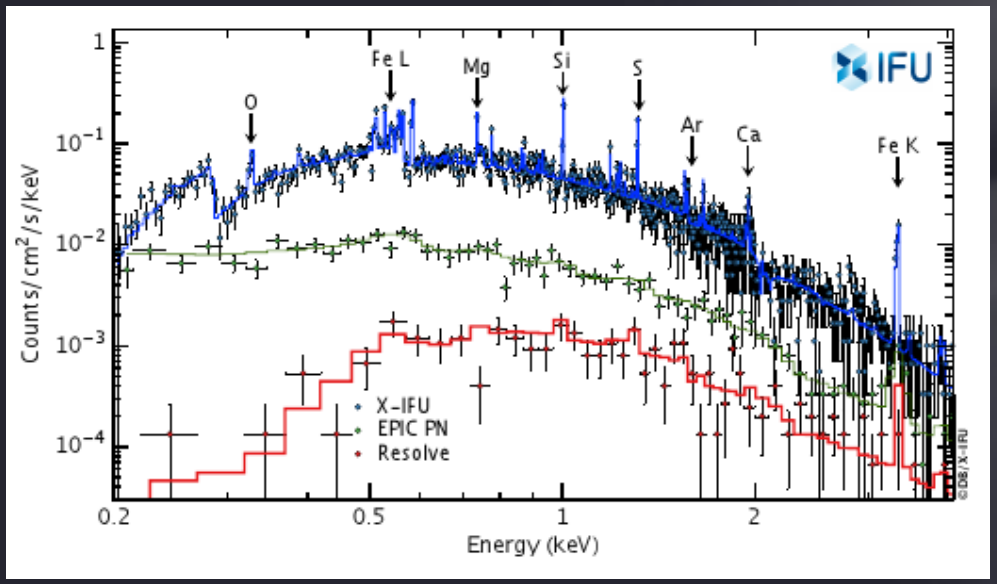
- How did ordinary matter assemble into the large-scale structure we see today?
- How do black holes grow and shape the Universe?
- Many other topics in most areas of astrophysics that can be addressed with a next generation X-ray observatory.

The High-Energy Astrophysics Group (GAPHE) and the Centre Spatial de Liège (CSL) are actively involved in the project.

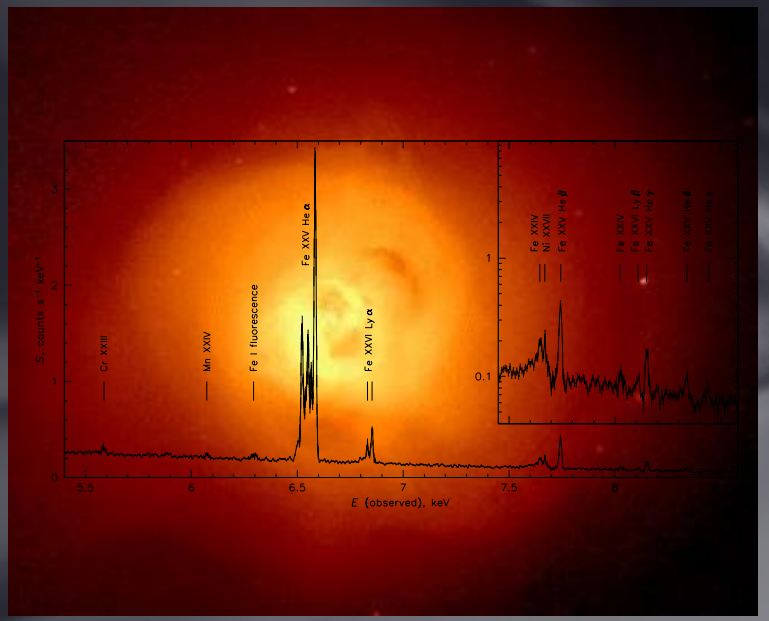
What ATHENA can do for you… (1)

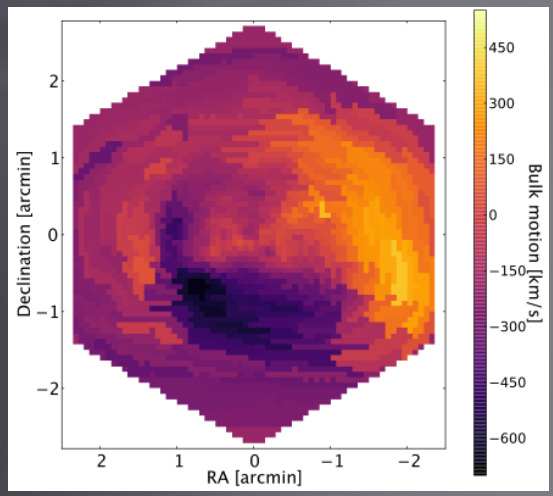
Studies of the hot gas in galaxy clusters:

- investigate origin of chemical elements,
- investigate turbulence (down to 20 km s^{-1}) and AGN feedback,
- etc.



Simulated ATHENA/X-IFU 150 ks observation of galaxy group at z = 1. Barret, Cappi et al. 2019, XIFU-SN-XI-09012019-IRAP



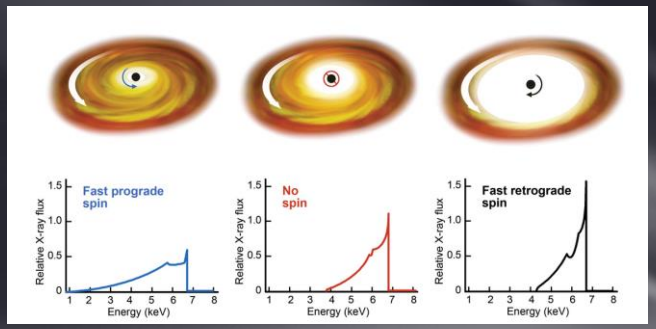


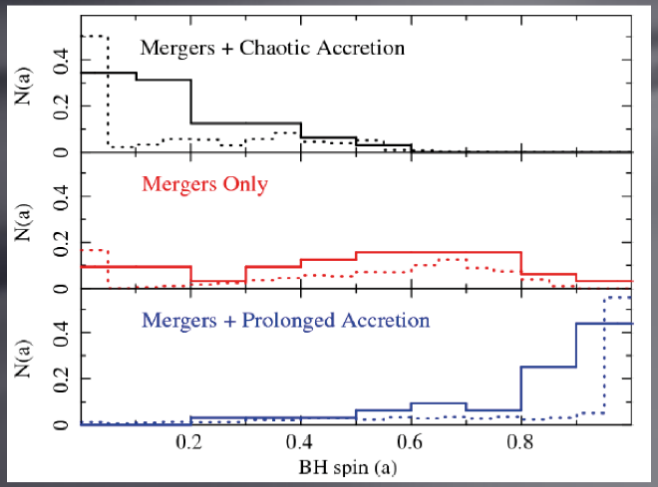
Simulated ATHENA/X-IFU 50 ks observation of central part of Perseus cluster. Barret, et al. 2016, SPIE 9905

What ATHENA can do for you… (2)

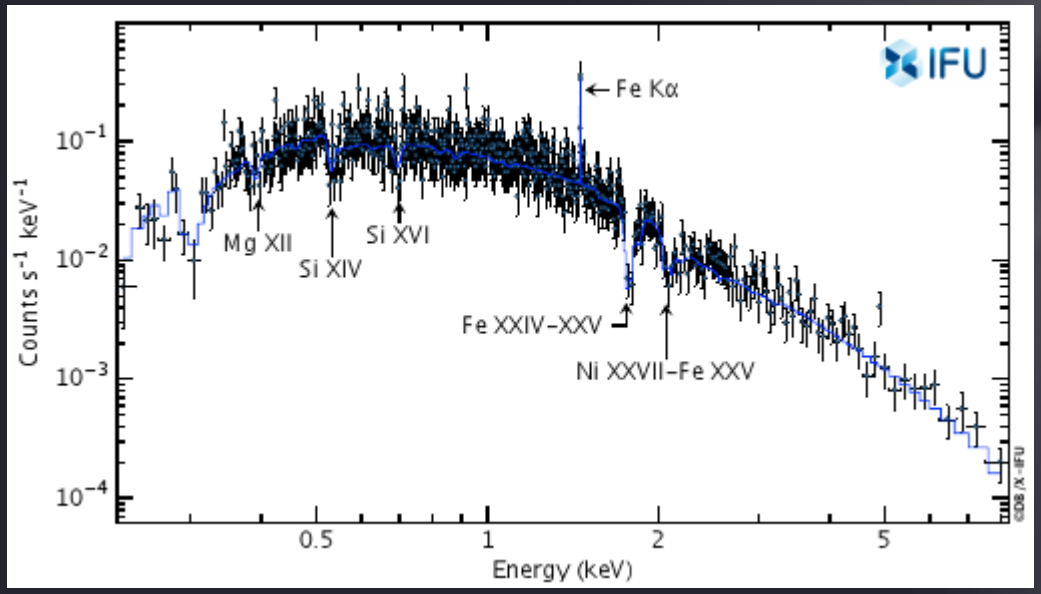
Studies of AGN at different redshifts:

- measure SMBH spins through Fe line spectroscopy as a function of *z*,
- investigate AGN-driven winds and ultra-fast outflows
- etc.





Dovciak, Matt et al. 2013: arXiv 1306.2331

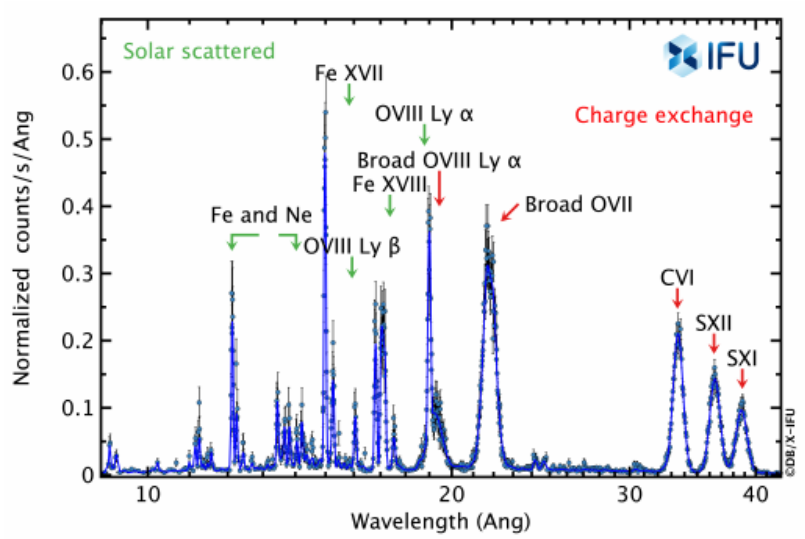


Simulated ATHENA/X-IFU 50 ks observation of luminous QSO @ z = 3.4 with ultra-fast outflow. Barret, Cappi et al. 2019, XIFU-SN-XI-09012019-IRAP

What ATHENA can do for you… (3)

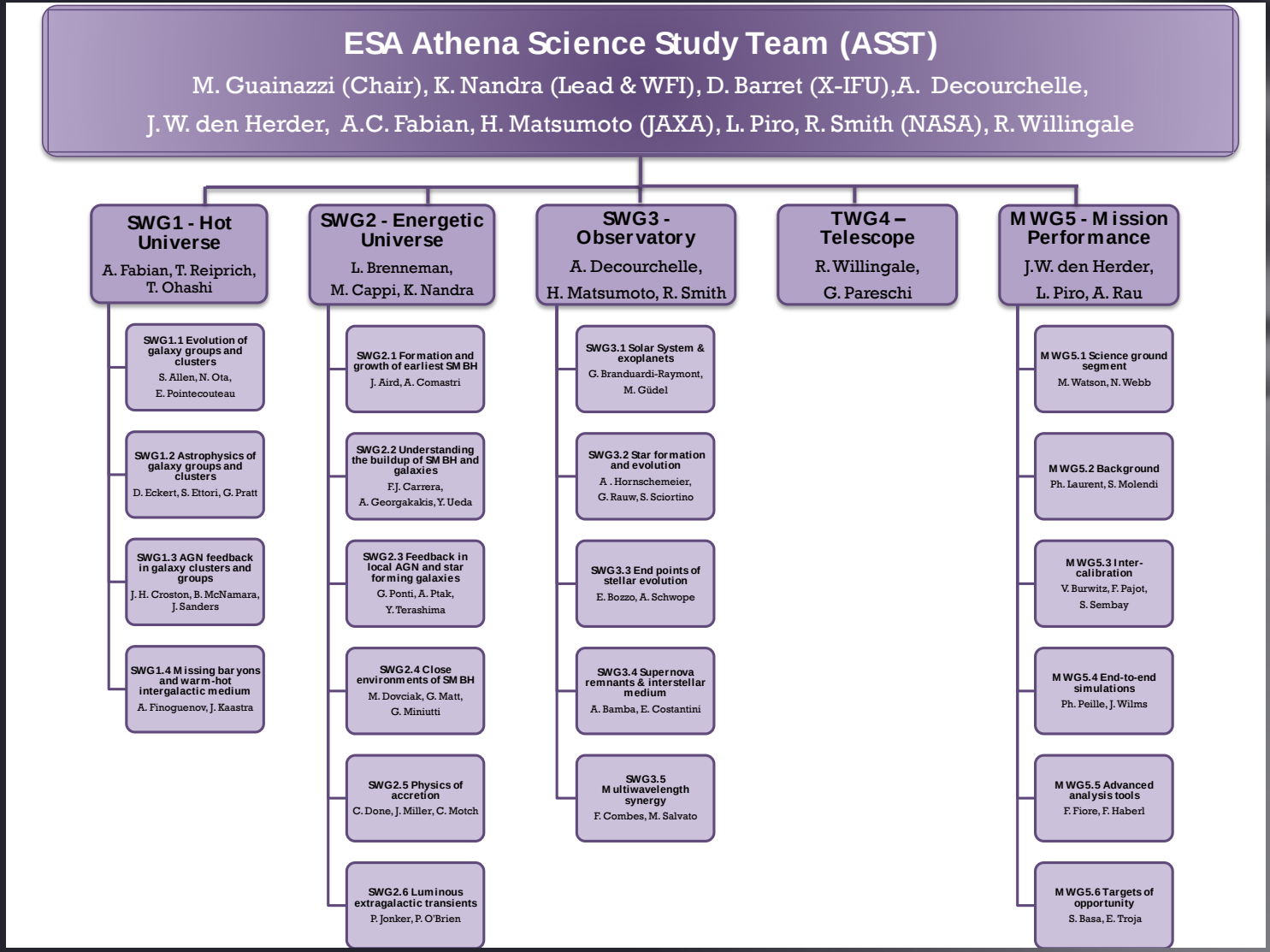
Many other science topics:

- Chasing the transient Universe (GRBs, GW events, tidal disruption events)
- Star formation and evolution (PMS, stellar winds, magnetic activity)
- End points of stellar evolution (X-ray binaries, neutron stars, white dwarfs)
- Supernova remnants and the interstellar medium
- The Solar System and exo-planets



Simulated ATHENA/X-IFU 20 ks observation of Jupiter.
Barret, Cappi et al. 2019, XIFU-SN-XI-09012019-IRAP

What you can do for ATHENA…

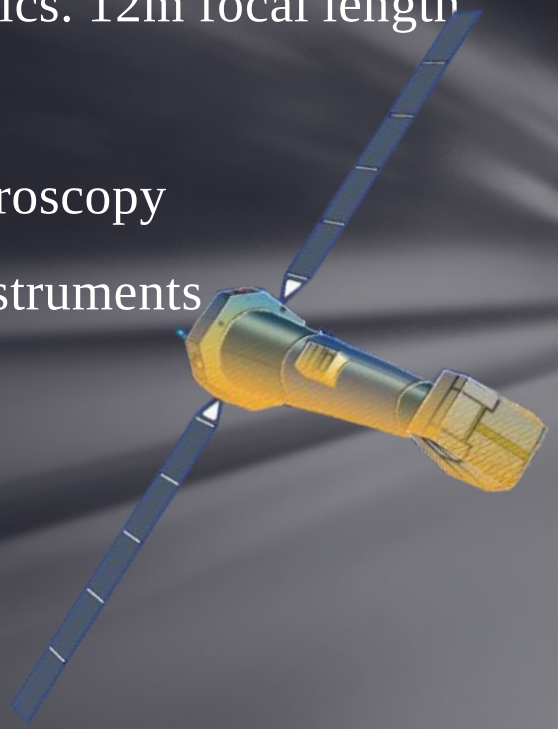


More info at www.the-athena-x-ray-observatory.eu

What you can do for ATHENA…

ATHENA spacecraft and project status

- Single telescope, using light-weight Si pore optics. 12m focal length
- WFI: sensitive imaging & timing
- X-IFU: spatially resolved high-resolution spectroscopy
- Movable mirror assembly to switch between instruments
- Launch 2031, Ariane 6.4, L2 halo orbit (TBC)
- Lifetime: 4 yr +Possible extensions



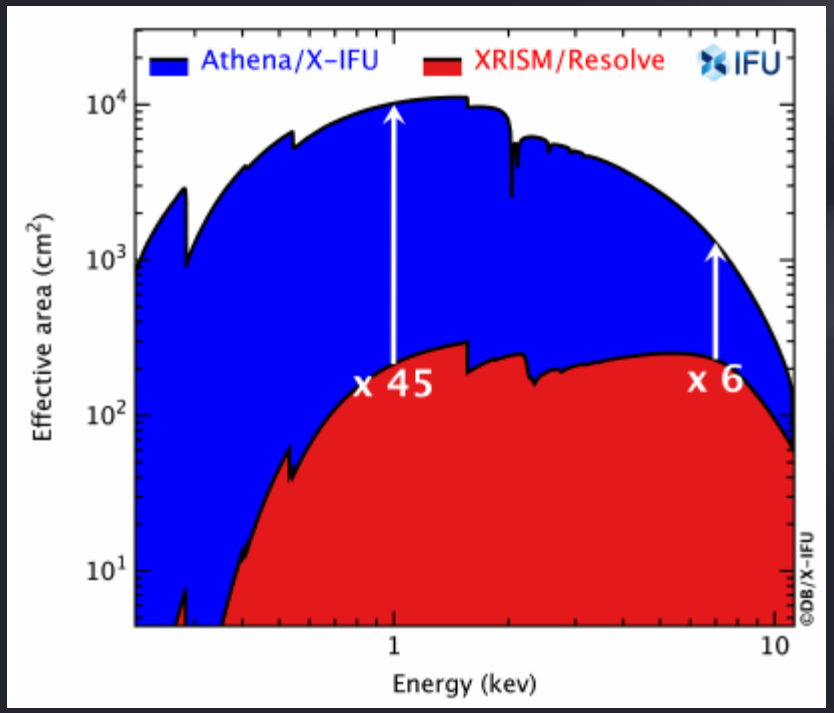
Parameter	Value
Effective area at 1 keV	≥1.4 m^2
Effective area at 6 keV	0.25 m^2
PSF HEW (≤ 7 keV)	5'' on axis, 10'' off axis
X-IFU spectral resolution	2.5 eV 0.2-12 keV
X-IFU FoV	5' effective diameter
WFI spectral resolution	150 eV <80eV (1keV) & <170eV (7keV)
WFI FoV	40' x 40'
ToO reaction time	≤ 4 hours

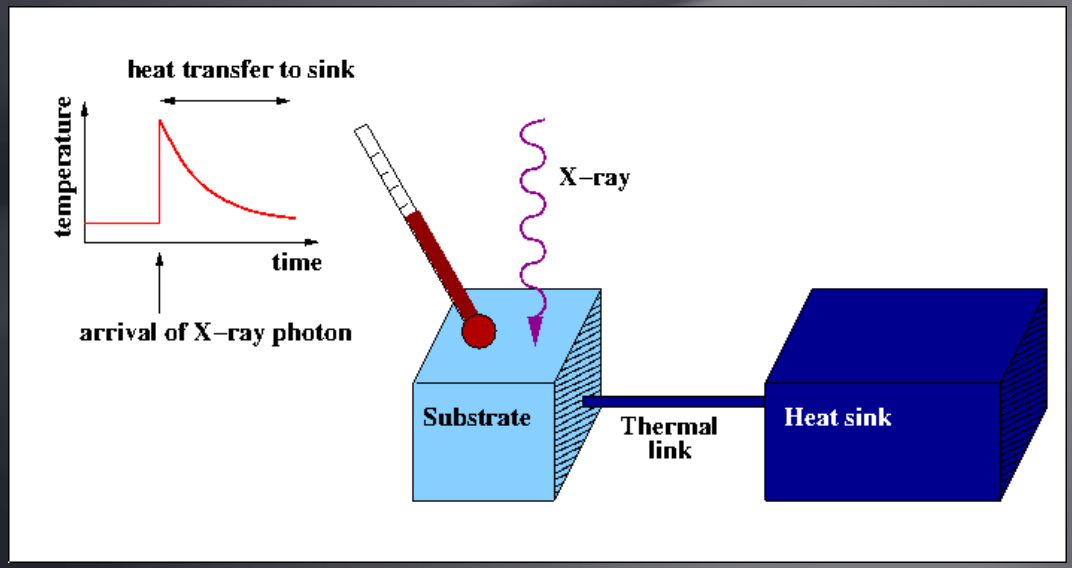
Phase A ongoing.
Mission baseline was modified *to match mass- and cost-constraints*:

- 15-row mirror (instead of 20): effective area @ 1 keV from 2m^2 to 1.4m^2
- nominal lifetime 4 years (instead of 5)

X-IFU

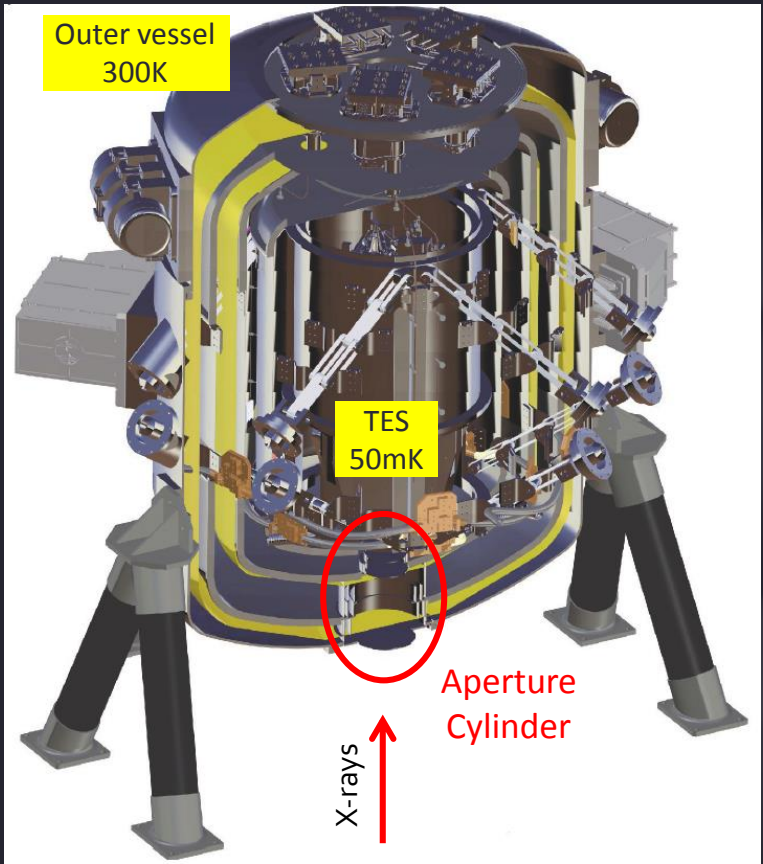
- X-ray Integral Field Unit: cryogenic imaging spectrometer, based on Transition Edge Sensors, operated at 50 mK
- Energy resolution 2.5 eV @ < 7 keV, FoV 5′ diameter, pixel size <5′′
- Consortium led by IRAP & CNES , with Netherlands and Italy and many other partner countries (B, CZ, FIN, D, IRL, PL, E, CH, JAP, USA).





Collecting area of ATHENA/X-IFU compared to XRISM/Resolve.
Barret, Cappi et al. 2019, XIFU-SN-XI-09012019-IRAP

X-IFU Aperture Cylinder (ApC)



X-IFU Dewar

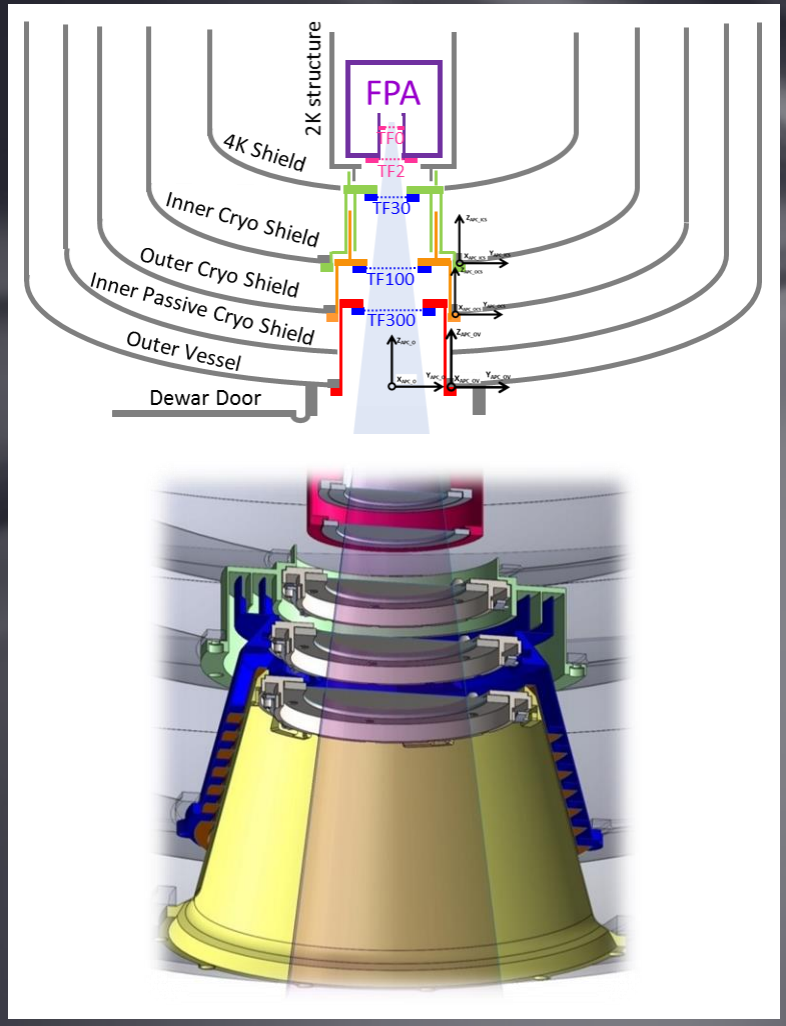
- Connects the warm outer space and the cold interior of the cryostat
- Allows X-rays photons to reach the detector, while blocking other energy sources (heat, visible, EMC)
- Prevents “leakage of the cold”

→ Under CSL responsibility

Aperture Cylinder (ApC)

Main requirements

1. Thermal Filter support functions
   - Mechanical support for Filters
   - Accessibility for late Filters integration
   - Enables physical integrity of Filters
2. Thermal functions
   - Conductive interface for Filters
   - Radiative shielding at Dewar entrance
3. Optical aperture and baffling functions
4. Protection from contamination
   - Barrier from Dewar inner contamination
   - Heating capability
5. EMC continuity of Dewar Faraday cage
6. Venting of ApC cavities
7. T° housekeeping + TRP

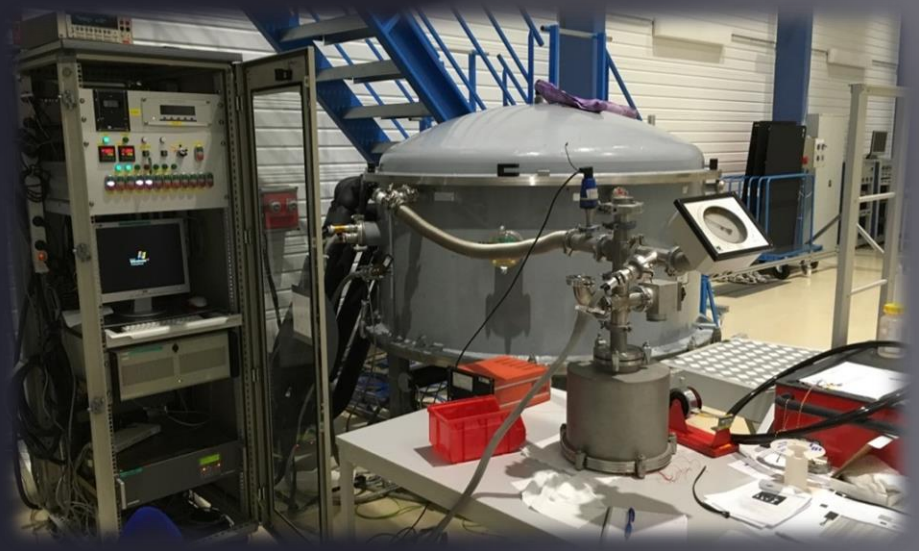


Timeline

Now : end of phase A (I-PRR)

Belgian activity:

1. Support to X-IFU Consortium to define the instrument (tech + science)
2. Aperture cylinder pre-design
3. Demonstration models to validate by test critical design aspects



Conclusions

ATHENA will be the most sensitive X-ray observatory ever. It will lead to substantial breakthroughs in nearly all fields of astrophysics.
X-IFU is an essential ingredient of this mission.
CSL and GAPHE contribute to X-IFU at the hardware and software level.
X-IFU consortium meeting #11 will take place in Liège (6 – 11 April 2020).

Find out more about ATHENA and X-IFU

- Web: www.the-athena-x-ray-observatory.eu , x-ifu.irap.omp.eu
- Twitter: @AthenaXobs
- Facebook: The Athena X-ray Observatory
- Athena Community Office email: aco@ifca.unican.es

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