Athena status

Didier Barret

Directeur de Recherches
Institut de Recherche en Astrophysique et Planétologie
CNRS, UPS, OMP, CNES
dbarret@irap.omp.eu

Treasures hidden in high-energy catalogues
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Conclusions

- Let me start with the Conclusions for a change…
- Athena is reaching an excellent level of definition: we have now a stable configuration for the instruments, the SIM and the overall S/C
  - No feasibility issue identified at S/C level
- Maximizing the science return of the mission in a constrained programmatic context has been and remains the top priority
  - Capabilities in many performance parameters improved by at least an order of magnitude compared to existing or planned facilities
- Stay connected with Athena and keep showing your support
  - We hope to see you all at the Athena Palermo conference

Athena

- Athena is the second large mission of the ESA Cosmic Vision
- The Hot and Energetic Universe
  - Follow the structuring and chemical enrichment of baryonic matter across cosmic times, from the first galaxy groups to the local massive clusters
    - Spatially resolved high resolution X-ray spectroscopy of hot gas trapped in dark matter potential wells to measure turbulence, bulk motions, abundances, temperatures…
  - Determine how black holes work and shape the Universe?
    - High resolution X-ray spectroscopy of accretion disks, winds and jets and their interaction with the surrounding, e.g. black hole feedback at different scales
  - Perform a complete census of black holes from their low mass seeds at very high redshifts to the first supermassive black holes found in AGNs
    - Wide field X-ray survey to measure luminosity functions and AGN properties as a function of redshift
- A multi-purpose X-ray observatory to explore planets, stars, compact objects, interstellar medium…

The path to Athena — I

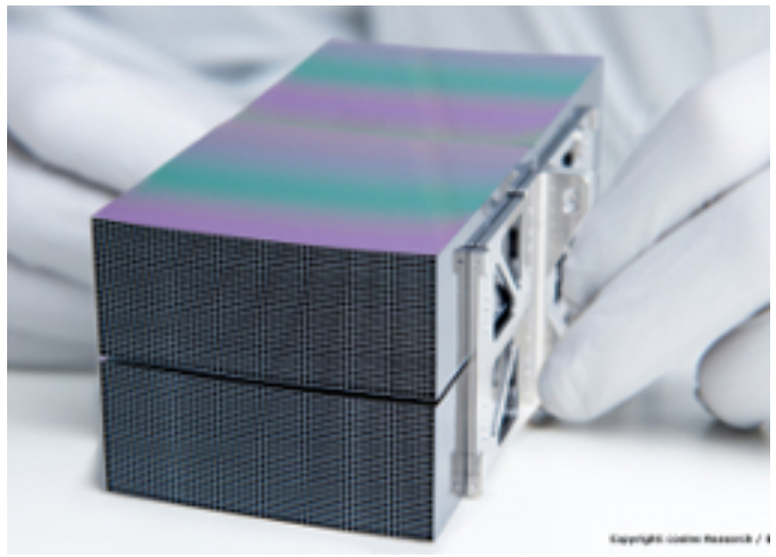
- The Athena science theme was selected in Nov. 2013
- The Athena mission proposal was selected in June 2014
- ESA internal study and competitive industrial studies started
  - Two mirror configurations studied: (large mirror) 2m^2 vers (small) 1.4 m^2
- ESA MCR panel conclusions (May 2016)
  - Athena S/C feasible, X-IFU (and instrument module) design needs consolidation, potential mass non compliance
  - Cost issue with both configurations
    - Transferring activities to ESA member states & optimizing international contributions considered
  - ESA MCR panel still recommended the large mirror configuration to be the baseline for follow-up industrial studies

The path to Athena — II

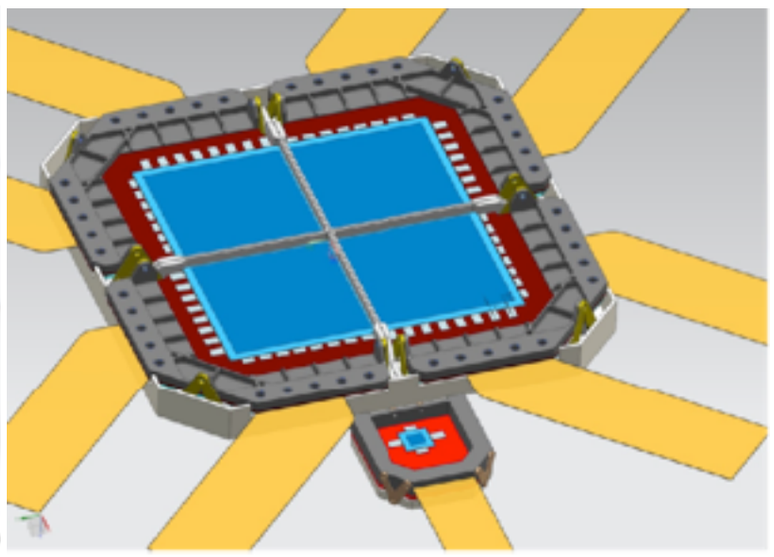
- System level mass non compliance remained throughout 2017
  - Proposal was formulated to remove the outer row of the mirror, assuming the instruments would remain within their strict mass allocation
- X-IFU design consolidation focussed on cryogenic chain and required thermal budget margins while keeping the mass budget under control
  - Slow convergence was reached early 2018 with a robust design meeting the top level performance requirements
- L mission cost-cap confirmed, hence Athena remained over cost
  - Cost saving options agreed by the Athena Science Study Team in Dec. 17
    - 1 keV effective area reduction, reduction of mission lifetime, reduction of ToO support, optimization of international contributions, more activities performed by the P/L team

Athena as it stands today

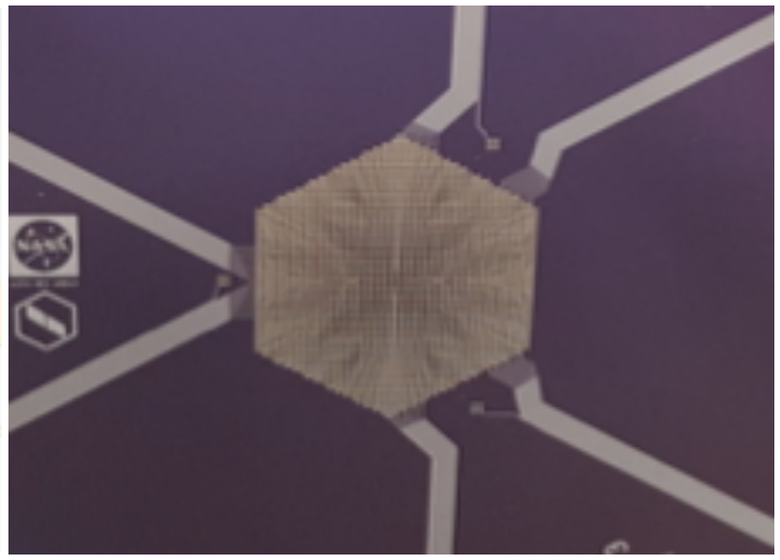
- Large aperture X-ray telescope and two focal plane instruments
  - Innovative Silicon Pore Optics: ESA procurement
    - 5” Half Energy Width (HEW), 1.4 m^2 at 1 keV and 0.25 m^2 at 6 keV (unchanged)
    - Mounted on a hexapod mechanism enabling tilting and defocussing
  - WFI: A wide field imager: PI K. Nandra (MPE, DE)
    - Active Pixel Sensors: 0.2-12 keV, 100 eV, 1”, 40’ x 40’
    - Fast chip for very bright point sources
  - X-IFU: A high resolution X-ray spectrometer: PI D. Barret (IRAP, FR)
    - Superconducting Transition Edge Sensors cooled at ~100 mK: 0.2-12 keV, 2.5 eV, 5’ FoV, 5”



A SPO mirror module (Credits ESA)



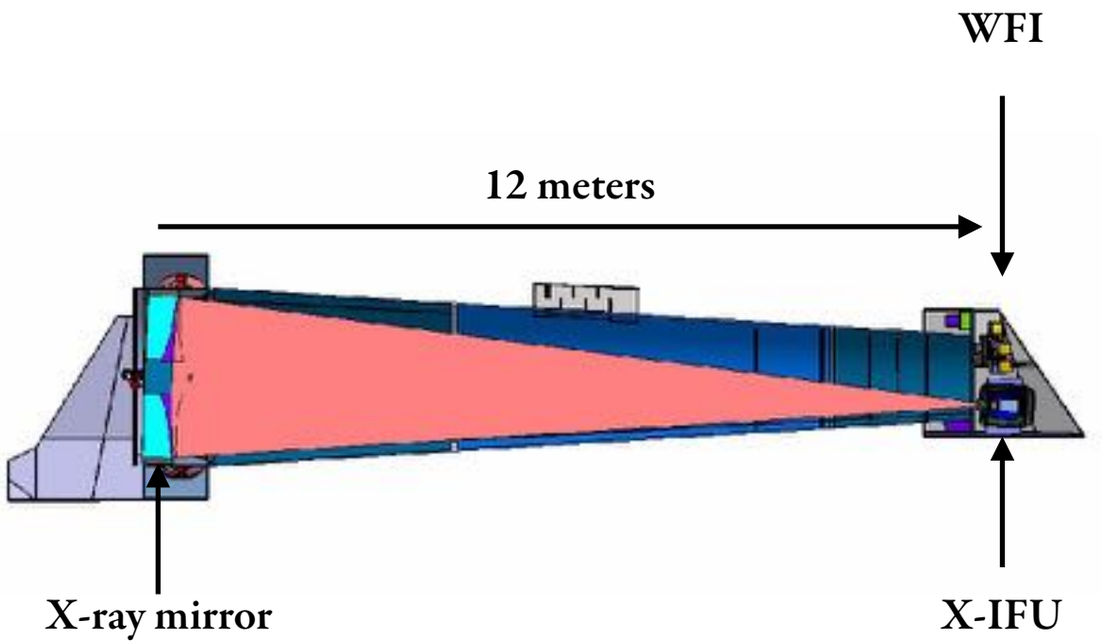
The WFI focal plane (Credits MPE)



The TES array (Credits NASA/GSFC)

The Athena mission profile

- Large spacecraft: ~7 tons (compliant with launcher capability)
- Launched by Ariane 6 at L2 (possibly L1 for better environment)
- 4 year mission lifetime (still designed for 10 years)
- ToO capability: 4 hour response time, 40% of cases (working days)
- Science Ground Segment: SOC/MOC and 2 Instrument Science Centers



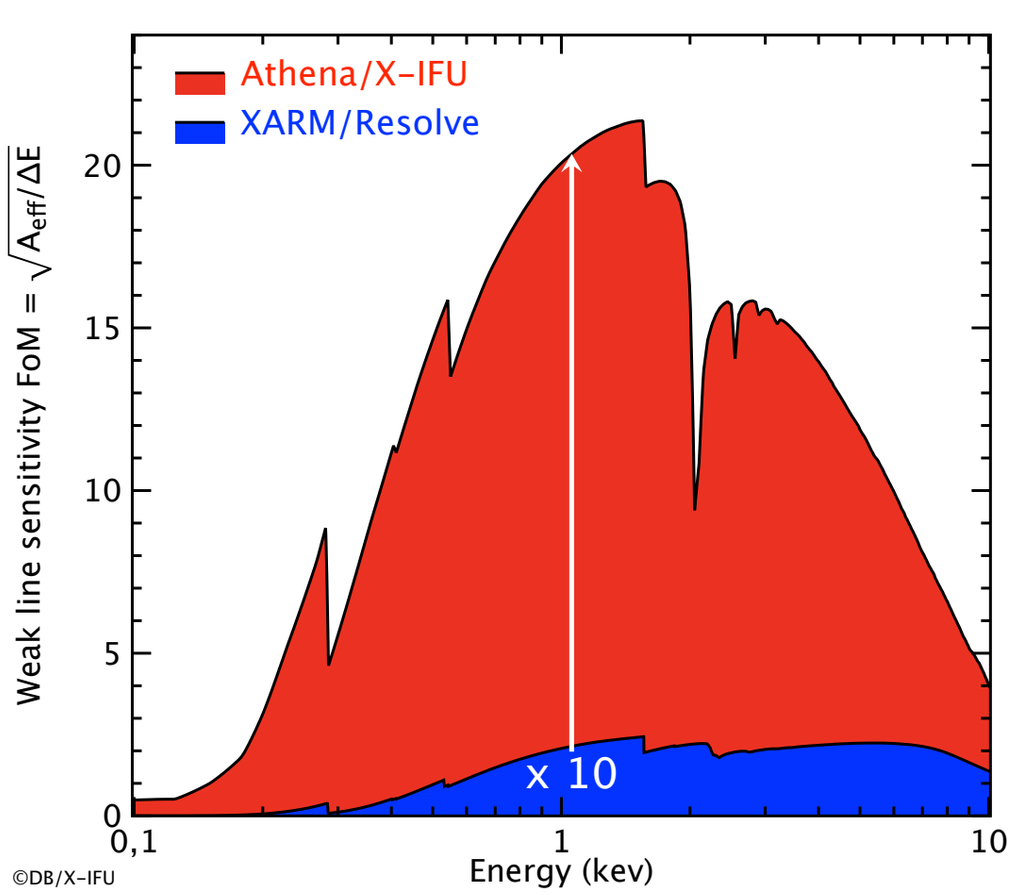
The Athena spacecraft (Credits: ESA)

The Ariane 6 launcher (Credits: Ariane Espace)

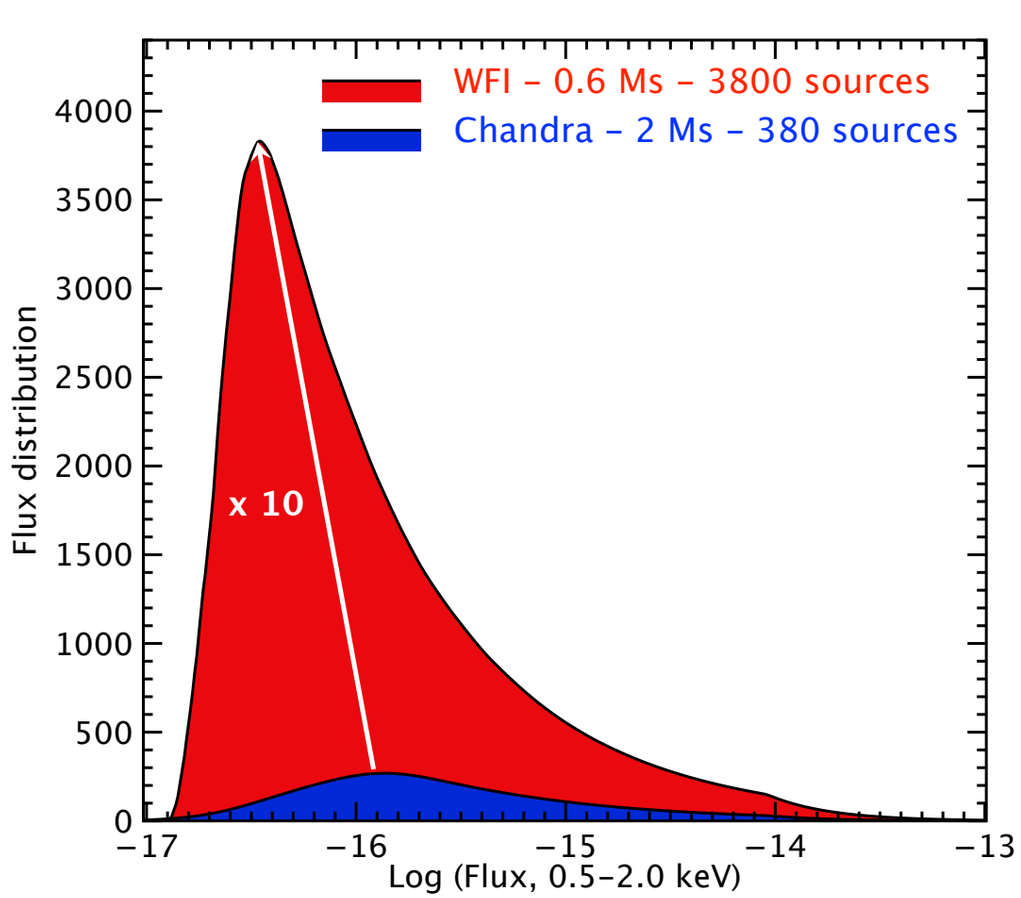
A breakthrough machine

- Weak line sensitivity combines effective area and spectral resolution
  - 10 times better sensitivity at 1 keV than XARM (on 5" scales versus 1')
- Survey speed combines effective area and field of view (grasp)
  - 10 times more sources per pointing than Chandra in 3 times less observing time

Credits: X-IFU team & J. Aird/A. Rau (WFI team)



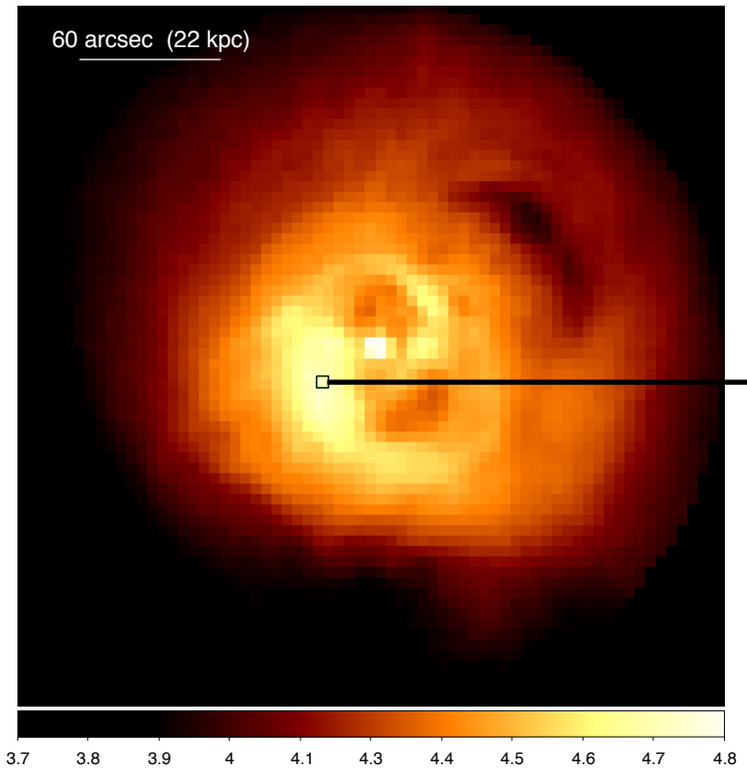
Weak line sensitivity comparison between X-IFU and XARM



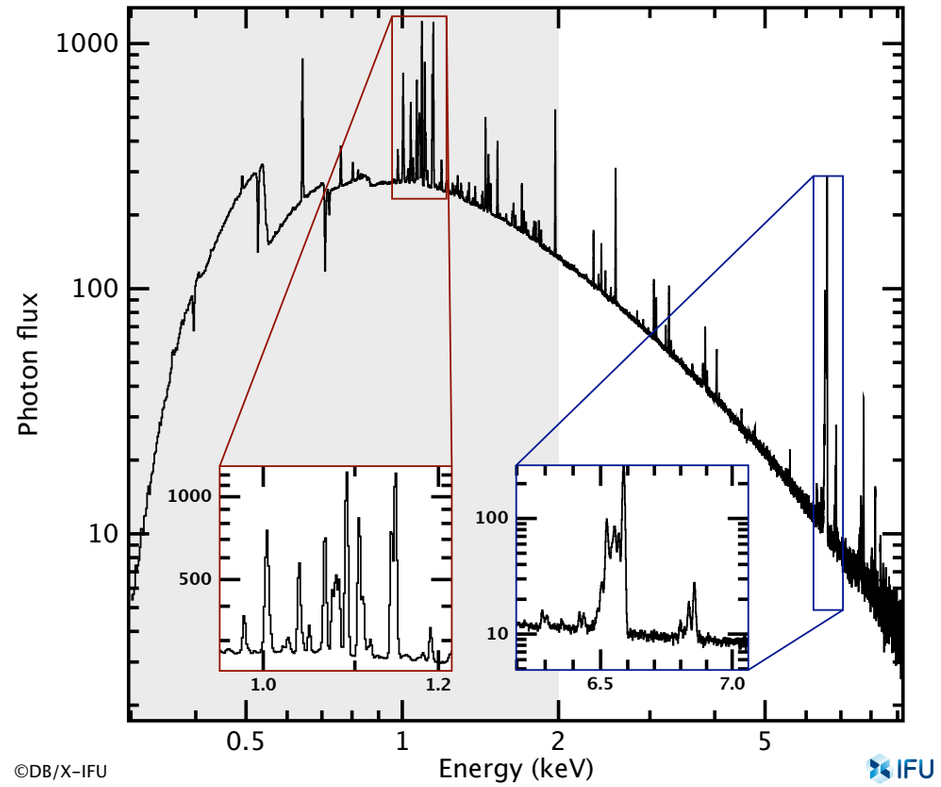
Flux distribution comparison between WFI and Chandra deep pointings

A true integral field unit

- Hitomi demonstrated the power of spatially resolved high-resolution X-ray spectroscopy
- Each X-IFU pixel will provides a high resolution spectrum on 5" scale
  - To provide measures of the abundance, velocity, turbulence, density…
    - ➡ To enable the study of the energetics of black hole feedback in clusters



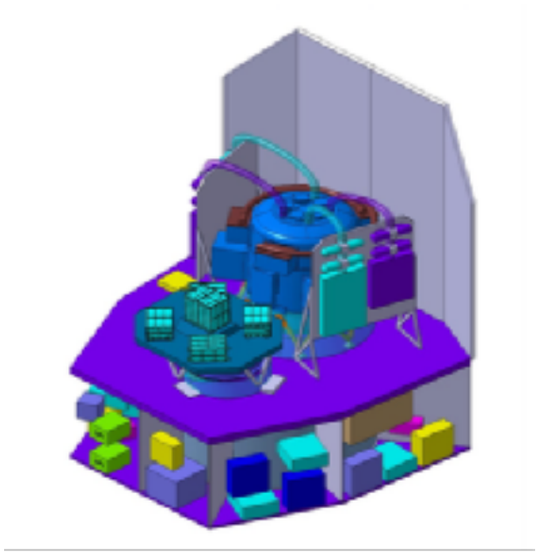
Perseus cluster observations (credits J. Sanders)



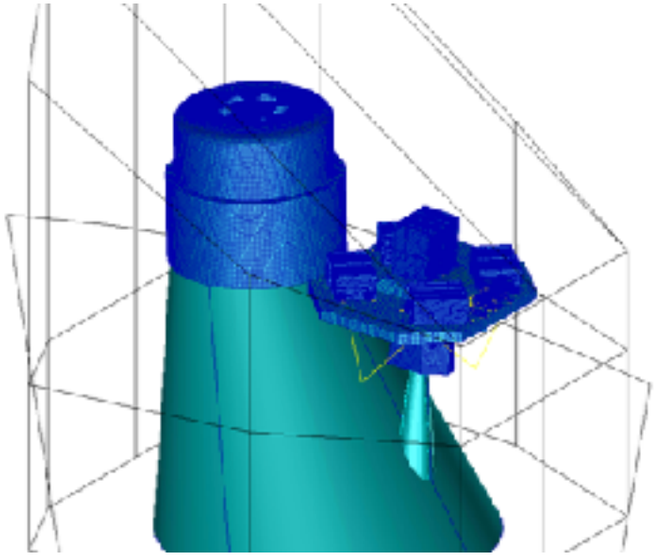
High quality X-ray spectrum per pixel

What next?

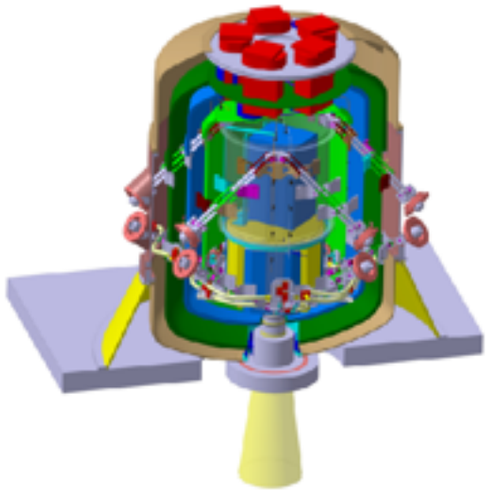
- Optimizing the Science Instrument Module (SIM) configuration
  - Slanted cone configuration saves mass, enables modularity, reduce launch loads to X-IFU
- Technology demonstration on-going
- Consolidating the already robust X-IFU baseline configuration
  - Last round of instrument optimization to give us performance margins
- Keep working on the cost…



Old SIM configuration (Credits: ESA)



The slanted cone approach (Credits: ESA)



Current X-IFU configuration (Credits: CNES)

What next?

- Angular resolution improvement (up to Q3/19)
  - Review of recent progresses held yesterday at ESA
  - Progresses to be monitored closely with the Athena Science Study Team
    - Sensitivity of core scientific objectives to angular resolution to be assessed
- Formalization of the instrument consortia triggered before summer
- Short term schedule:
  - Instrument Preliminary Requirement Review (Q4/18)
  - Mission Formulation Review (Q3-4/19)
    - Stop iterating on mirror module angular resolution improvement
  - Mission Adoption Review (Q3-4/21)
- Implementation phase of about 10 years still subject to optimization
  - Brings the launch date in the early 30s

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