The Athena mission

Status and Community Preparation

Didier Barret

X-IFU Principal Investigator

Directeur de Recherche

Institut de Recherche en Astrophysique et Planétologie

CNRS, UPS, OMP, CNES

dbarret@irap.omp.eu

@DidierBarret

XCALIBUR 2019, WINCHESTER, JULY 15-19 TH, 2019

Thanks

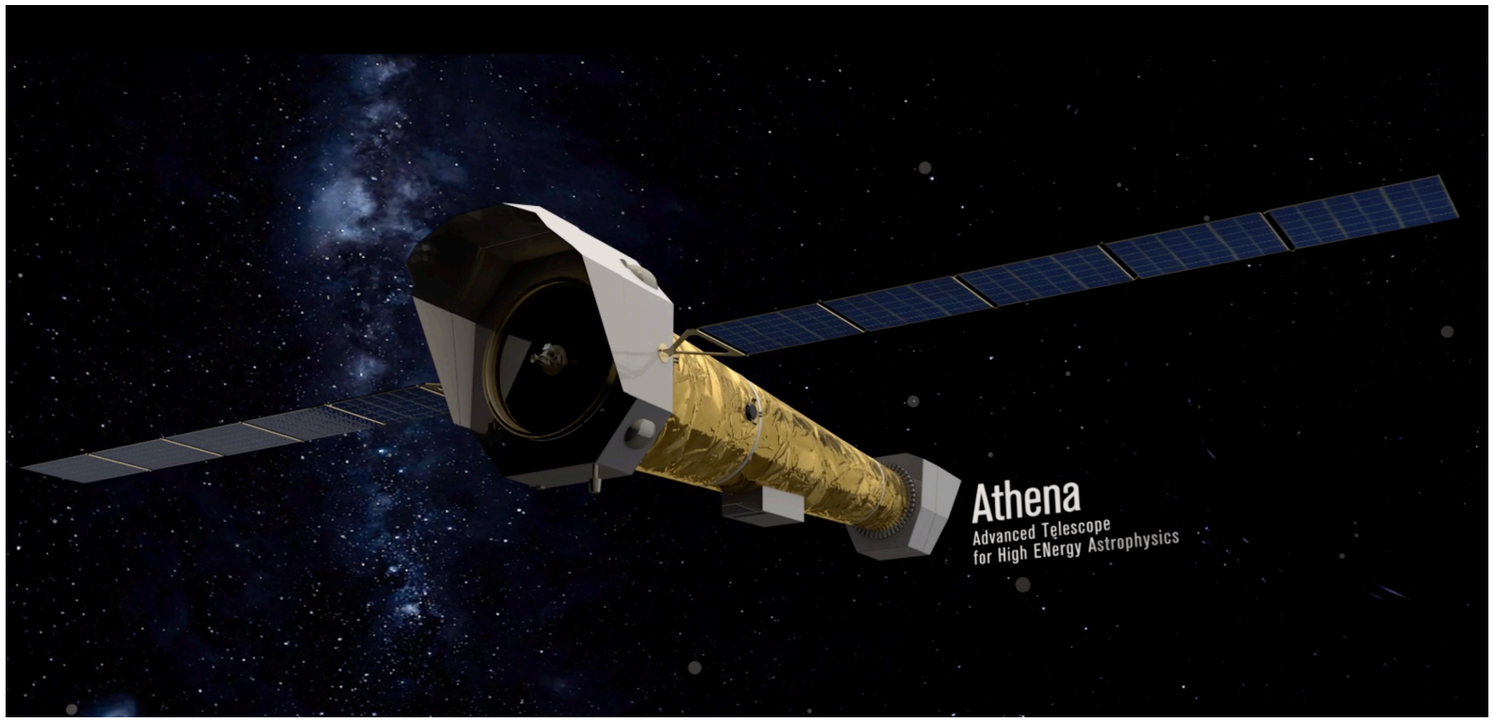
- Special thanks:
  - to the Athena Science Study Team: D. Barret, A. Decourchelle, A.C. Fabian, M. Guainazzi, J.W. den Herder, H. Matsumoto, K. Nandra, L. Piro, R. Smith, R. Willingale
  - to the Athena Working Group and Topical Panel chairs and members
  - to the ESA study team
  - to the Athena Community Office (ACO)
  - to the WFI instrument consortium
  - to the X-ray Integral Field Unit Consortium

Outline

- Brief recap of what Athena is
- Project status, including X-IFU and technology development status
- Athena organization and community involvement, including some aspects of the Athena science management plan
- Conclusions: We are on safe track for a launch in early 2030s

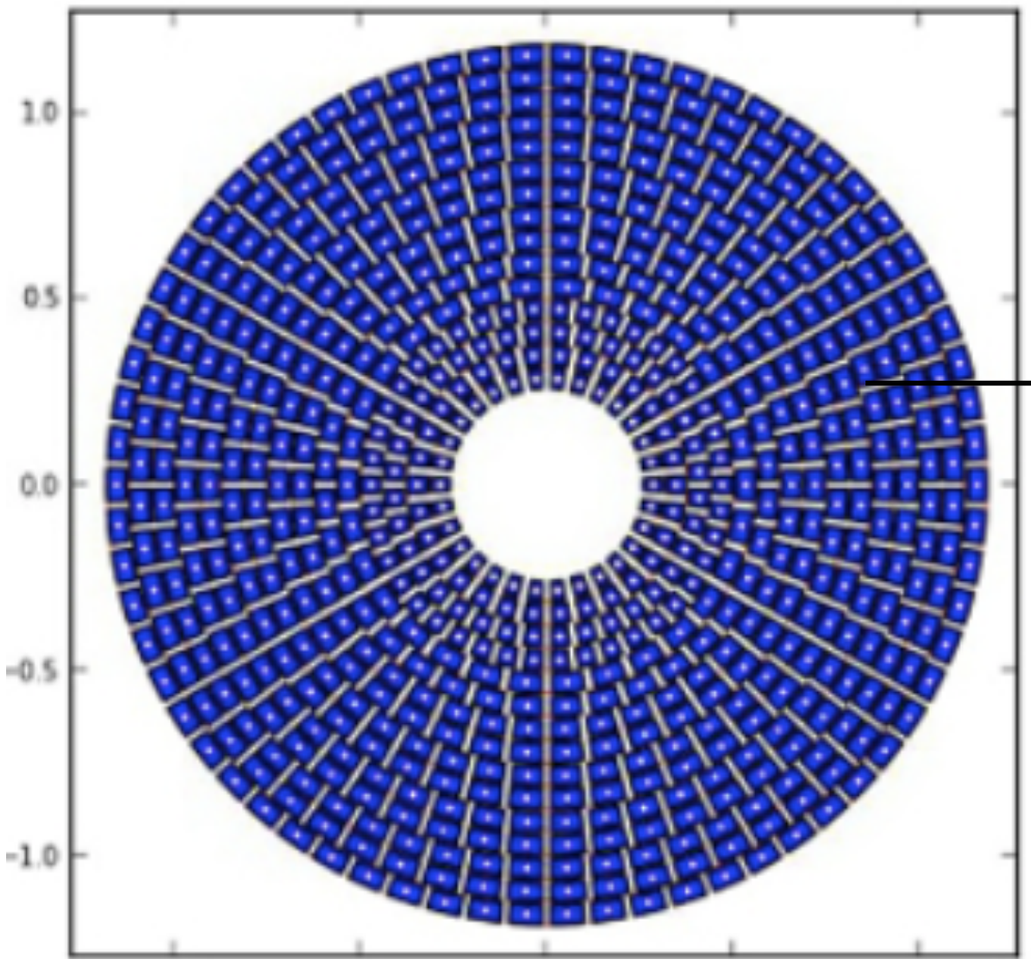
Athena

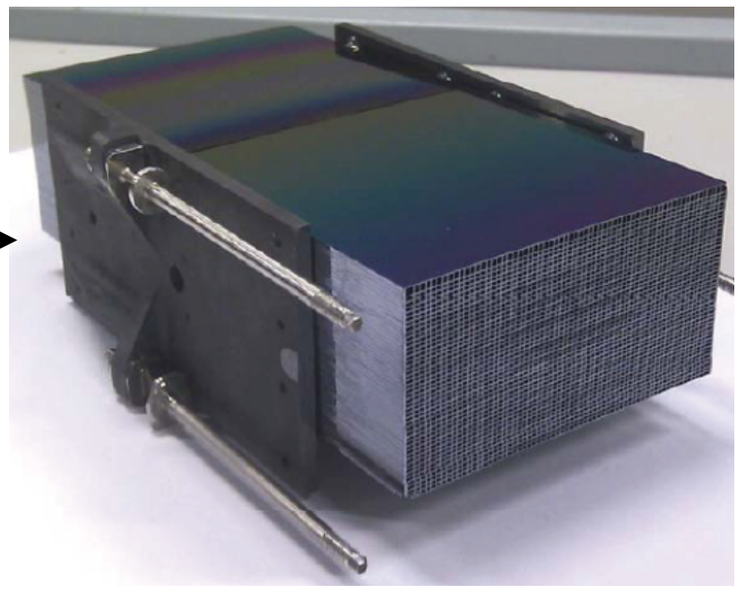
- Athena: Advanced Telescope for High ENergy Astrophysics
- Second Large mission of the European Space Agency Cosmic Vision Science program (the third being the LISA gravitational wave mission)
- Dedicated to The Hot and Energetic Universe
  - With broad impacts in many corners of astrophysics: stars, galaxies, planets… which define the Observatory science of Athena
- One large aperture telescope and two complementary instruments



The Athena science payload : Mirror

- Single monolithic large aperture grazing incidence movable X-ray telescope
  - Silicon Pore Optics developed by ESA
  - 1.4 m2 @ 1 keV, 0.25 m2 @ 6 keV (requirements)
  - 5” (HEW) requirement

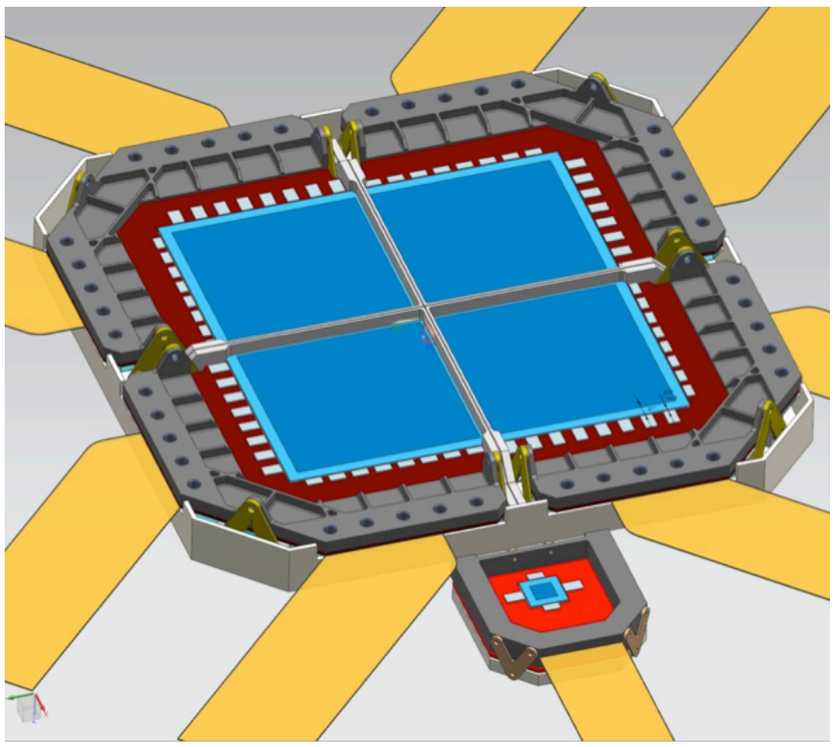


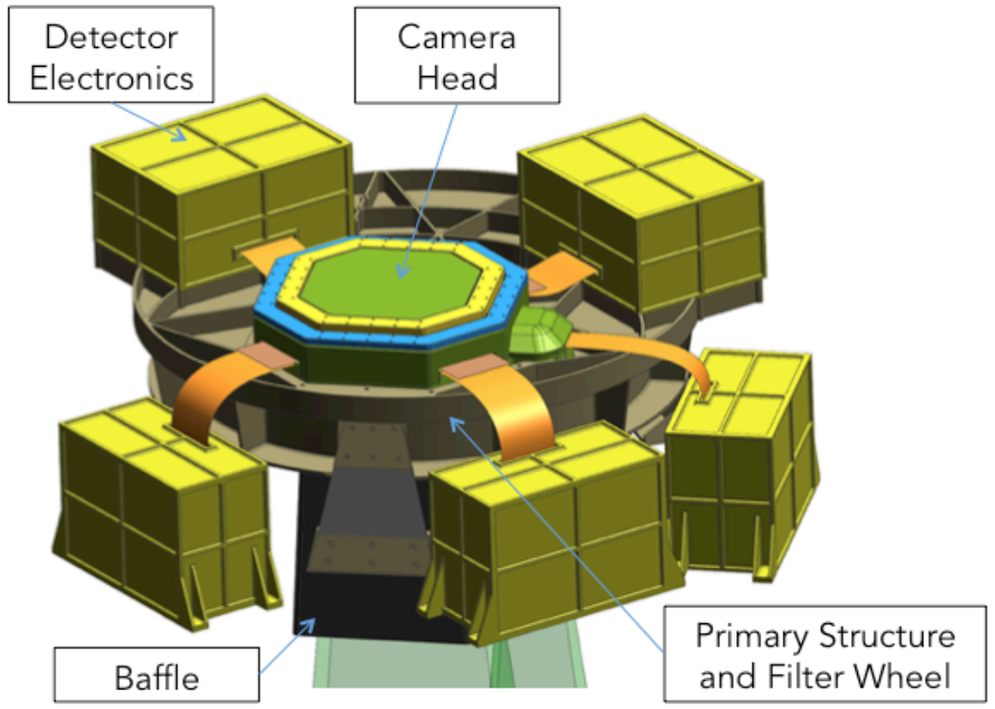


Credits: R. Willingale — ESA/Cosine

The Athena science payload: WFI

- Wide Field Imager (WFI) — PI K. Nandra (MPE)
  - Silicon Active Pixel Detector based on DEPFET technology
  - <80 (<170) eV spectral resolution @ 1 (7) keV
  - 2.2′′ pixel size (PSF oversampling)
  - Field of view: 40′×40′ square
  - Separate chip for fast readout of brightest sources
  - Consortium led by MPE, with other European partners (DE, AT, DK, FR, IT, PL, UK, CH, P & GR) and NASA

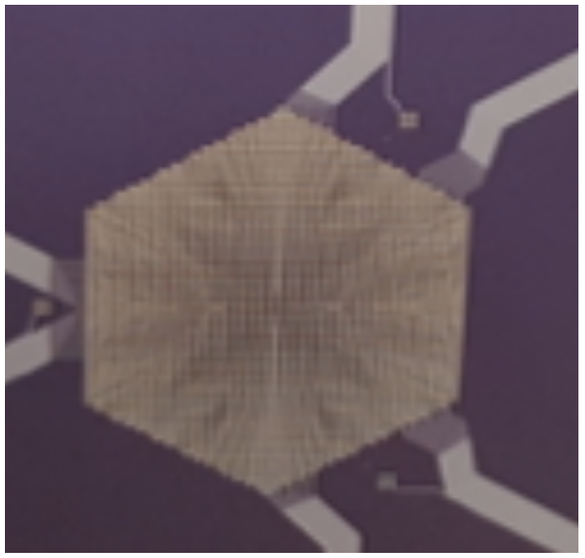


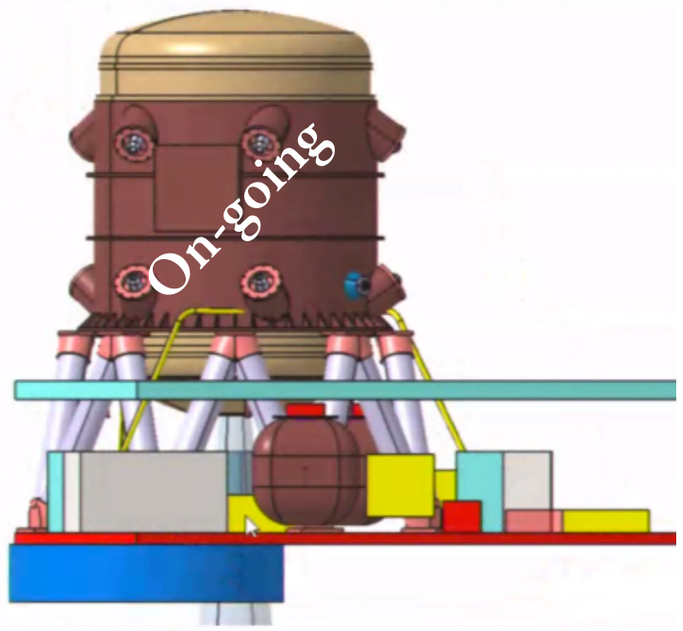


Credits: MPE and WFI team

The Athena science payload : X-IFU

- X-ray Integral Field Unit (X-IFU): Co-PIs: J.W den Herder (SRON) & L. Piro (INAF)
  - Large format micro-calorimeter array (Transition Edge Sensors)
  - 2.5 eV spectral resolution up to 7 keV (frequency domain multiplexing)
  - 5' hexagonal field of view (equivalent diameter)
  - Low background due to a cryogenic anti-coïncidence detector
  - Capability to observe bright sources (1 Crab) thanks to the mirror defocussing
  - Cryogenic instrument cooled down to 50 mK by a multi-stage cryogenic chain
  - Consortium led by IRAP/CNES-F, with NL and IT and further ESA member state contributions from BE, CZ, FI, DE, IR, PL, ES, CH and contributions from Japan and the United States

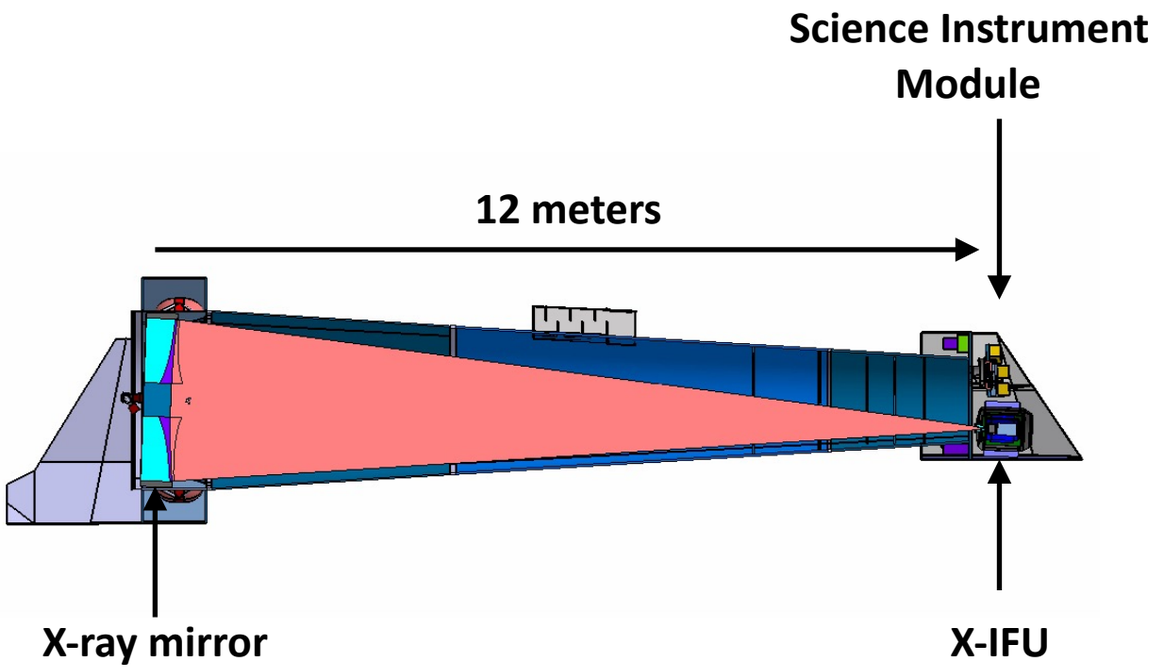


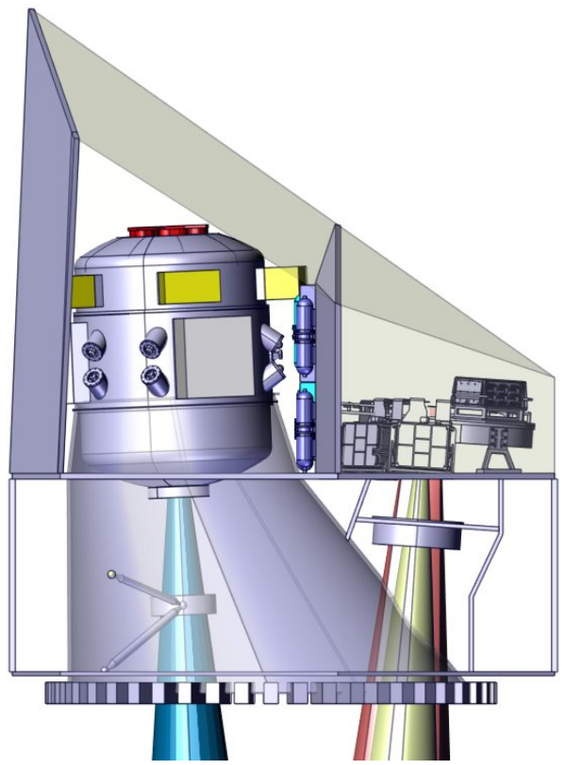


Credits: NASA/GSFC & CNES/IRAP/ESA and X-IFU team

The Athena spacecraft

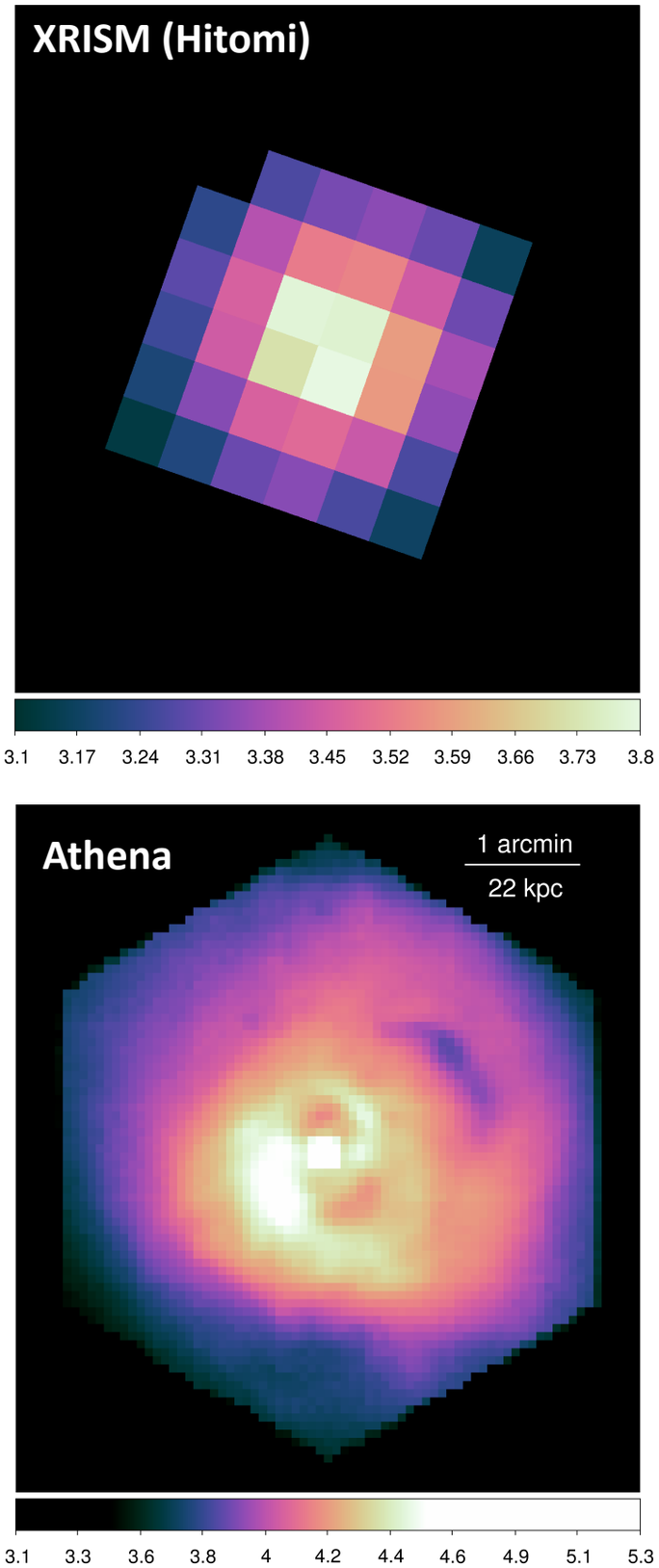
- Focal length: 12 meters (total height about 15 meters)
- Overall mass: 7 tons (X-IFU ~ 1 ton)
- 7 kWatts
- 4 year nominal mission lifetime with consumables/mechanical parts designed for 10 years
- Agile satellite to respond to ToO alerts in a few hours
- Launch to halo orbit L2 (or L1) by Ariane 6

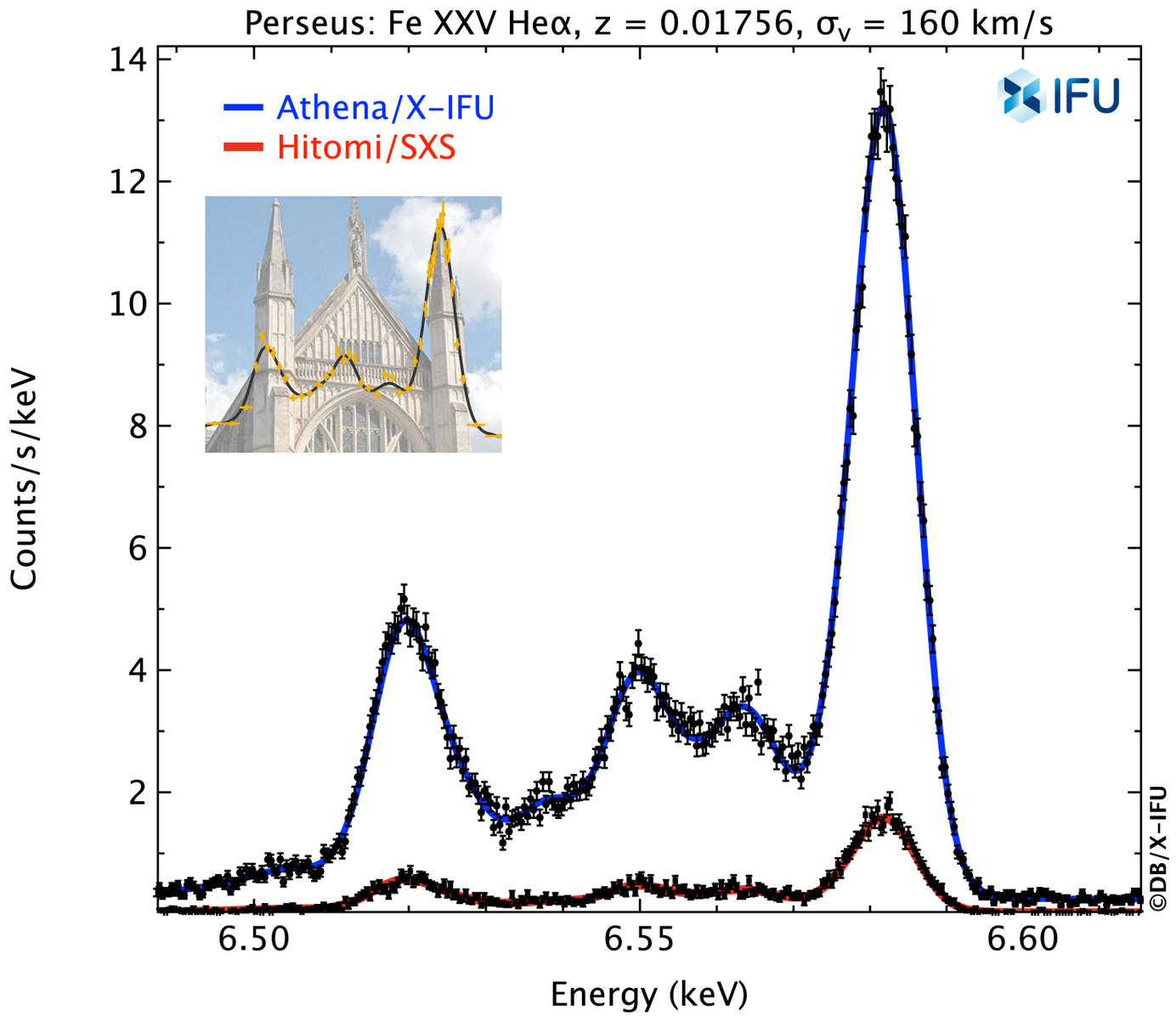




The Athena satellite and the Science Instrument Module (Credits to ESA)(credits to ESA)

From XRISM to Athena: Perseus





Credits: J. Sanders

Project status

- Instrument consortia formally appointed by ESA (Dec 2018)
- Both instruments successfully completed their feasibility study phase (Phase A) and can now proceed to phase B1 (since April 2019)
  - Their baseline designs meet the performance requirements
  - Actions raised by the review are being implemented with the goal of :
    - consolidating our baseline designs and interfaces with the spacecraft
    - consolidating and running our technology developments plans
    - consolidating the programatic aspects
- Next review to come (Sept. 2019): End of phase A review at mission level (including mirror and spacecraft as ESA led elements), so-called Mission Formulation Review (MFR)
  - According to the ESA study team: ***Athena is in good shape for MFR***

X-IFU status

- X-IFU passed the IPRR with a baseline declared feasible
  - Micro-vibrations and cooling chain complexity identified as risks
- Delta-study conducted by ESA & CNES to see how the science instrument module could ease the accommodation of the X-IFU
  - By providing more passive cooling to the instrument in a so-called « cryo-SIM » configuration
- Management meeting of July 8th concluded that the baseline configuration is confirmed weighting benefits versus overall system complexity
- No disruption of activities, and optimizations are now under investigation as part of the normal phase B1
  - To address micro-vibrations
  - To reduce the number of coolers
    - At iso-performances

Technology: optics

- Vigorous optics development plan on-going at ESA/Cosine:
  - Steady and continuous improvement in the optics towards 5” HEW
- A sensitivity analysis led by the ASST concluded that a resolution of 6.5” has a clear negative impact on a number of Athena science objectives, with the impact considered very severe if the HEW were to degrade to >8”
  - WFI science more severely impacted than X-IFU science
    - Today 7” is achieved on 70% of the plate area
- Angular resolution optimization activities will continue beyond MFR
- Various coatings for the optics under investigation (Ir, Ir+SiC), as well as ways of maximizing the effective area of the mirror at both 1 and 7 keV

Technology: instruments

- Prime focus is X-IFU
- Consistent assessment of the level of readiness of X-IFU critical technologies between ESA and X-IFU team
  - On track for mission adoption although schedule is tight
  - Significant progresses made towards reaching 2.5 eV resolution with the baseline frequency domain multiplexing
    - System level demonstration to be performed by the demonstrator of the X-IFU cooling chain to include a demonstrator of the focal plane assembly (32 x 32 TES array) and readout electronics
- Technology demonstration to be completed by mission adoption in Q3-4/21
- 10 year implementation time to launch in early 2030's
  - 6 month provision of the calibration time for X-IFU !

Athena organization

- The Athena Science Study Team is an ESA-appointed body of astronomers, including the ESA Study Scientist, the instrument PIs and international representatives from JAXA and NASA.
  - Define the scientific requirements of the mission and to advise ESA on all aspects related to the scientific performance of Athena.
- The ASST has nominated 5 Working Groups on:
  - Hot Universe, Energetic Universe, Observatory Science, Telescope, Mission performance
  - And 21 topical panels covering sub-topics
    - Yearly calls enable you to join
- The WG advise the ASST which in turn advises the ESA study team
  - e.g. consolidating science requirements, evaluating the impact of performance changes, providing inputs on calibration, etc.
  - Refinements to the organization to be discussed with the Chairs (Dec 2019)

Athena Community Office (ACO)

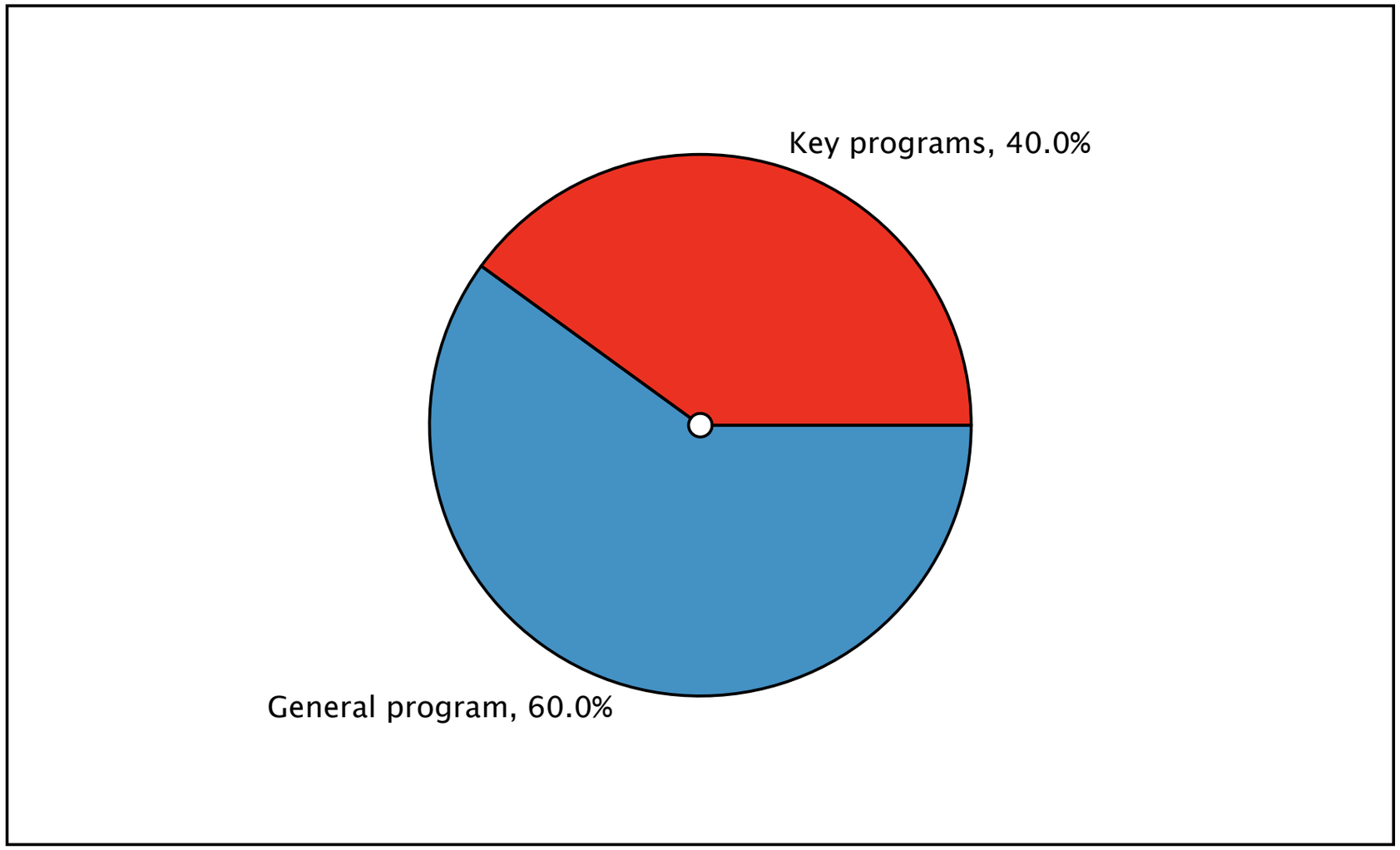
- The Athena community gathers today about 800 researchers
  - Bringing their expertise and the advises to the project is key
  - Major effort required to get the community involved
- To run it, the ASST appointed the Athena Community Office to :
  - Organize and optimize community efforts
  - Pass on the information from the ASST to the community
  - Develop communication and outreach activities around Athena
    - Led by IFCA (CSIC-UC) in Spain, with contributions from IRAP, MPE and UniGe
- More info at www.the-athena-x-ray-observatory.eu and on the social networks

How to get engaged and prepared?

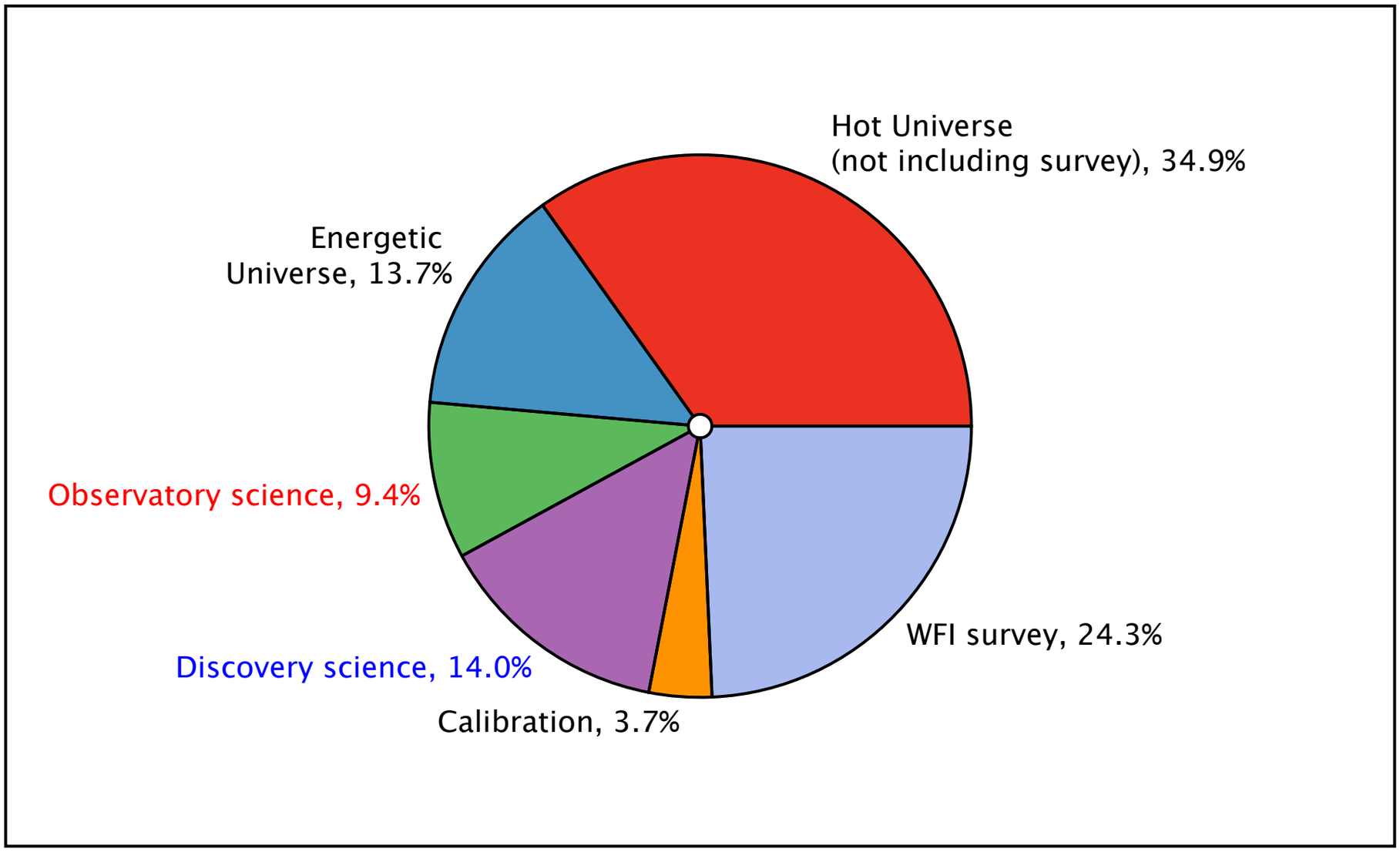
- Joining the consortia providing the instruments and their associated Instrument Science Centers (ISCs);
  - A bit late for the instruments, but opportunities may remain for the ISCs
- Joining or being part of one of the topical panels
  - Getting trained through SIXTE workshop
  - Participating to activities: e.g. a series of refereed journal papers will be prepared in time for mission adoption (for the so-called red book):
    - List of papers will be based on the received topical panel chair proposals
    - Complete and uniform coverage of existing science goals of Athena, as well as possible new science ideas discussed
- Get to work or /support XRISM/Resolve data, ensuring that special needs for X-IFU will be properly fed to the system (e.g. new tools)
- Becoming an Athena guest observers, and joining Key Programme team and in their preparatory work

Type of observing programs

- KP require the study of well-chosen samples of objects with particular properties
- Key Programs (KP) will be defined before launch by an ad'hoc committee taking consideration of the evolution of the scientific landscape

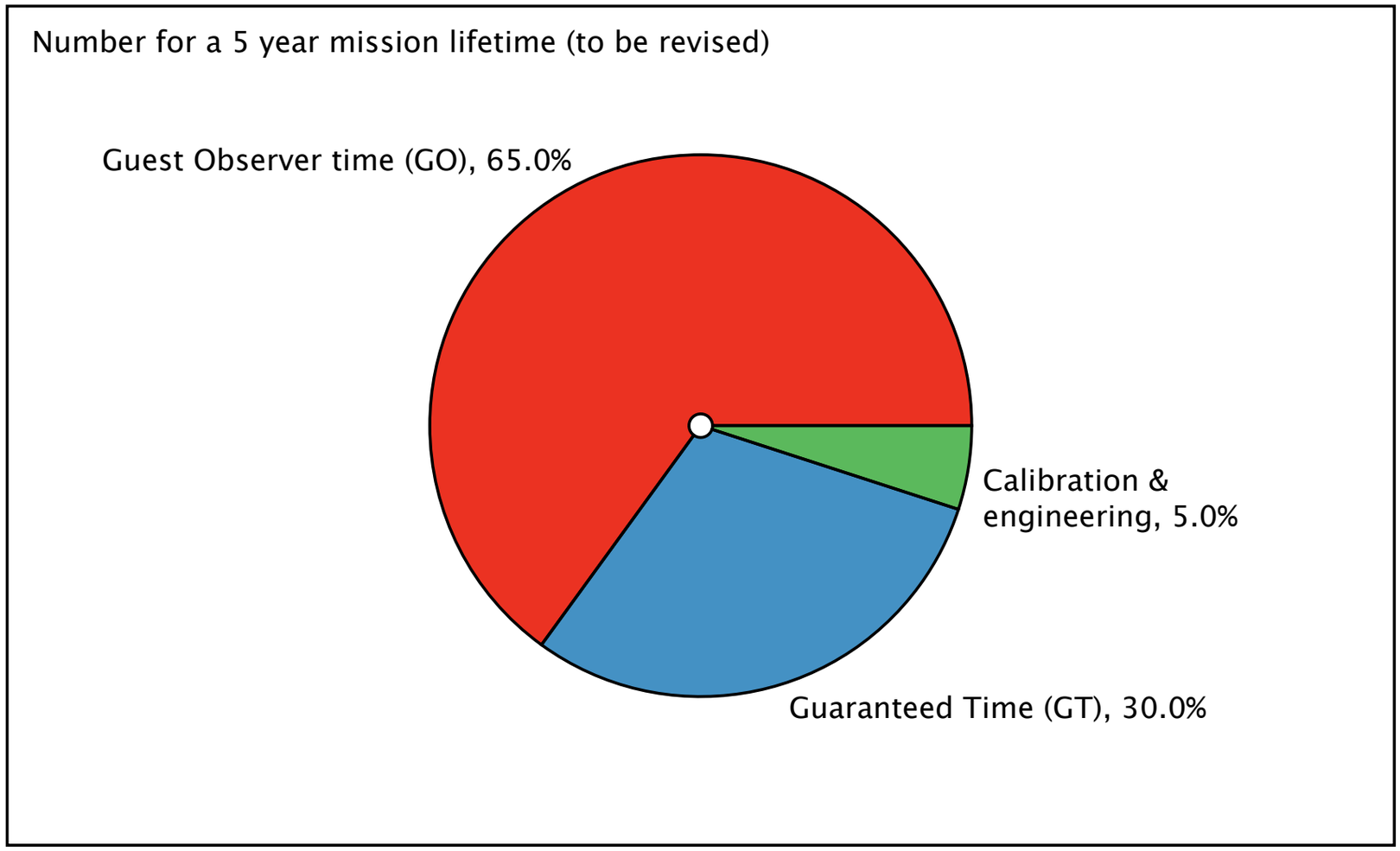


Observing time split



- Core science program defines today about 73 % of the available observing time (=107 Ms over a 4 year mission lifetime with 85% efficiency)
  - Numbers to be taken as indicative as they depend on the mission performance

Types of observing times



- Guaranteed Time (24%, tbc) and Guest Observer time (16%) to be spent on Key Programs, the rest being used for the General Program
  - GT will reduce to 5% (tbc) during mission extension
- Pending approval by the ESA Science Program Committee at the time of mission adoption (Q4/2021)

Conclusions

- Athena is your next large X-ray observatory
- Athena has revolutionary X-ray capabilities
  - Spatially resolved high resolution spectroscopy
  - Wide field imaging
- XRISM will open a new era of X-ray astronomy
  - Challenges for XRISM/Athena: calibration, background (+CX), atomic physics, data analysis
- Athena is now on the safe path for a launch in the early 2030s
  - Case is made to have overlap between Athena and LISA
- Keep using XMM-Newton/Chandra, get ready for XRISM, and keep supporting and promoting Athena
  - And start now preparing for the post-Athena mission in the voyage2050 for the long term science planning of ESA