ATHENA: The Advanced Telescope for High Energy Astrophysics

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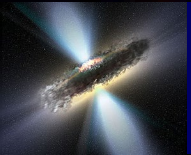
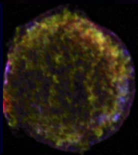
On behalf of the Athena Study Team

A Brief History of Athena

- Oct 2007 ESA selects XEUS as candidate L-mission
- June 2008 XEUS and Con-X merge → IXO
- Feb 2011 presentation of ESA IXO assessment study
- Feb/Mar 2011 Decadal Surveys, new budget realities
- **March 14th 2011:** ESA announces decision to re-formulate L-class missions: European-led and funded
  - X-ray, Gravitational Wave and Jupiter Moon missions in competition for 2022 launch opportunity





New L-class boundary conditions

ESA-led mission with ESA Cost at Completion < 850 M€

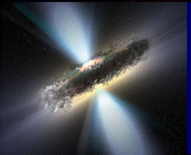
International cooperation: low-level contributions from JAXA and NASA.

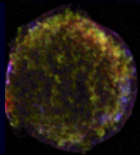
Instruments procured by ESA members states (< 200 M €) and/or partner agencies (e.g. JAXA and NASA).

TRL ≥ 5 by early 2014 (by end of Phase A).

Targeting launch opportunity by end of 2022.

Implementation phase < 7 yr (including contingency).

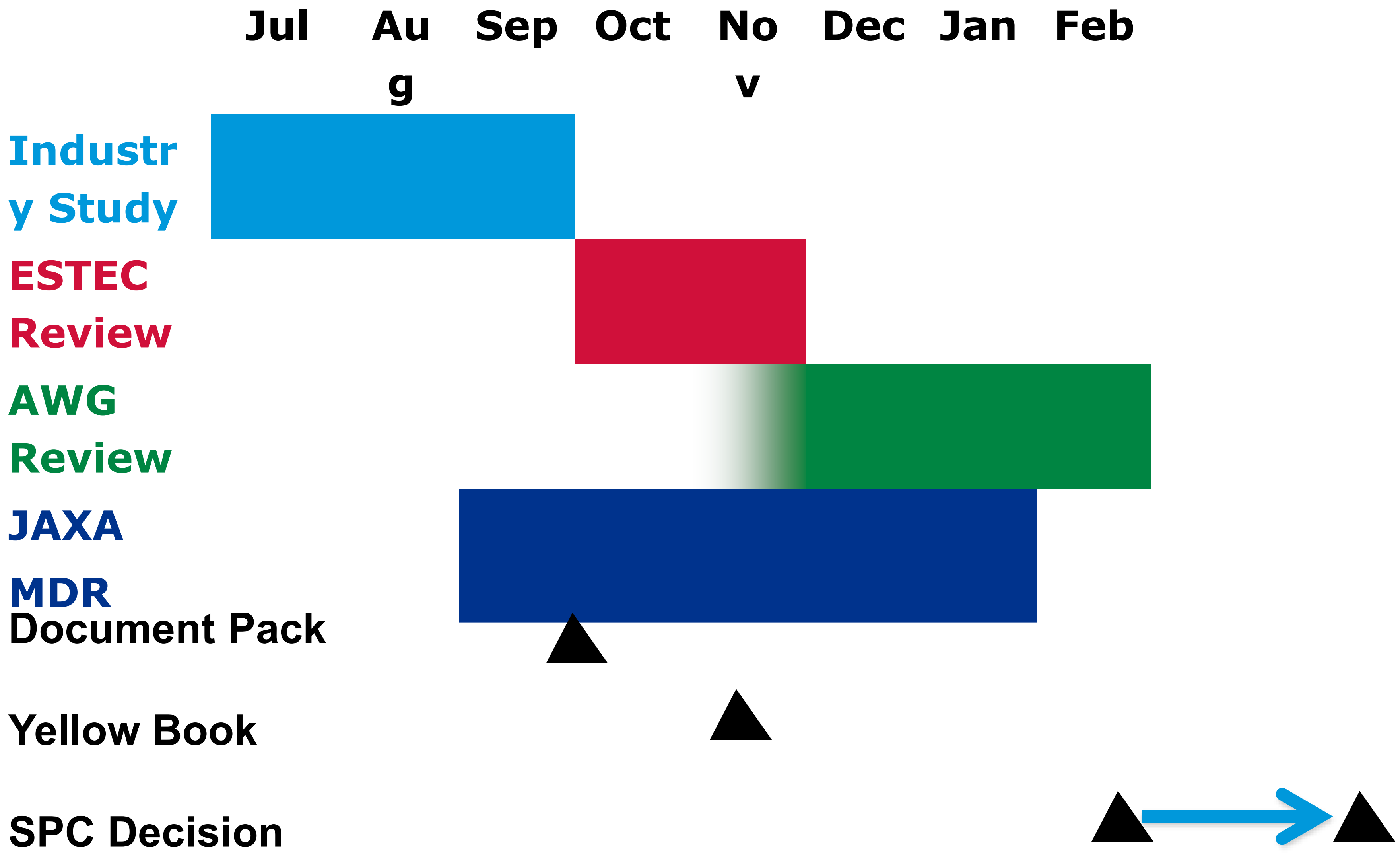




The Reformulation Process

- **The Problem:**
  - Fit within ESA cost of <850M€ while retaining key IXO science
- **Solution:**
  - Lower Mass (Lower Mirror Effective Area)
  - Reduced Complexity (e.g. EOB, Mechanisms)
  - Fewer Instruments (6 to 2)
- **Tradeoff:**
  - Which Instruments? (XMS, WFI)
  - 1, 2 or 3 telescopes (1 keV vs 6 keV science)
- **Process:**
  - 11 Scientific "Task Teams" set up to investigate science potential and impact of tradeoffs
  - Broad involvement (100+ scientists), very short timescale
  - Presentations and discussion at ESTEC 28th April
  - Science Team Meeting at MPE June 14-15

ATHENA: Steps



Athena Science Objectives

Black holes and accretion physics

- Probe accretion in the strong field limit around black holes, and determine their spins. Determine the physical conditions in the densest observable form of matter.

Cosmic feedback

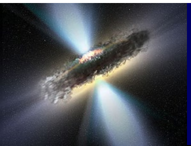
- Reveal the physics of cosmic feedback on all scales, and quantify its relationship with black hole growth and galaxy evolution.

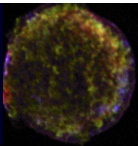
Large-scale structure of the Universe

- Trace the formation and evolution of large-scale structure via hot baryons in galaxy clusters, groups and the intergalactic medium comprising the cosmic web.

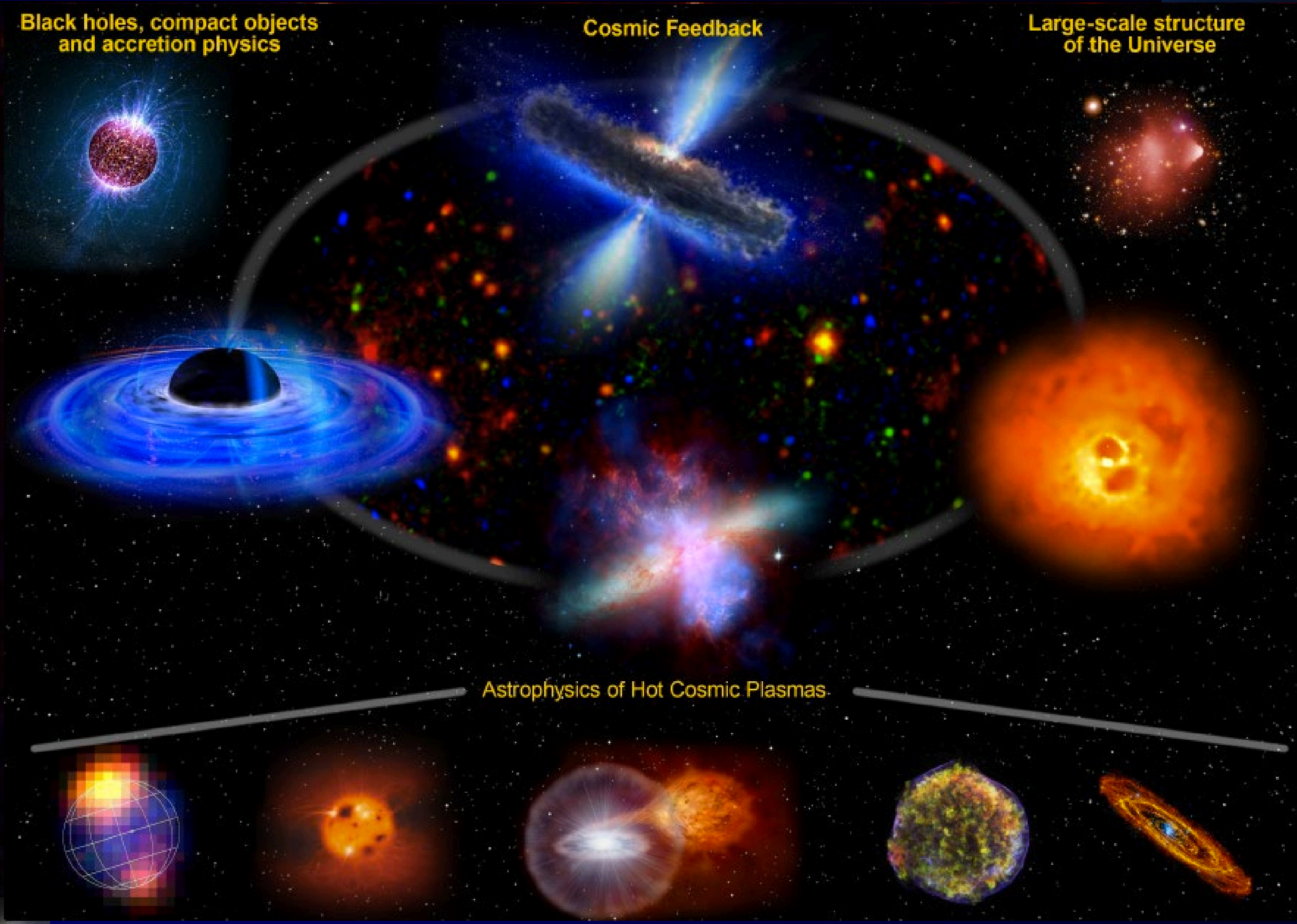
Astrophysics of hot cosmic plasmas

- Diagnose hot cosmic plasmas in all astrophysical environments via X-ray imaging and high resolution X-ray spectroscopy.



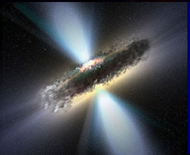


Athena Science Objectives

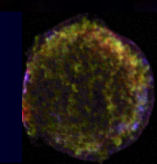


Athena Science Requirements

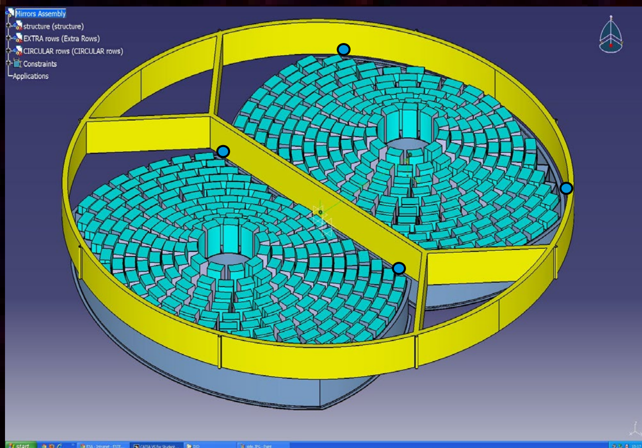
Effective Area	1 m^2 @1.25 keV (goal 1.2 m^2) 0. 5 m^2 @ 6 keV (goal 0.7 m^2)	Black hole evolution, large scale structure Strong gravity, cosmic feedback
Spectral Resolution (FWHM)	ΔE = 3 eV (@6keV) within 2 x 2 arc min (goal 2.5 eV and 4x3 arc min) ΔE =150 eV at 6 keV within 25 arc min diam (goal of 125 eV and >30 arc min)	Large scale structure, Cosmic Feedback Black Hole evolution, Large scale structure
Angular Resolution	10 arc sec HPD (0.1 – 7 keV) (goal of 5 arc sec)	Black hole evolution, Cosmic feedback, Large Scale Structure
Count Rate	1 Crab with >90% throughput. ΔE < 200 eV @ 6keV (0.3 – 15 keV)	Strong gravity
Astrometry	1.5 arcsec at 3σ confidence	Black hole evolution
Absolute Timing	100 µsec	Compact Objects



Athena – Advanced Telescope for High Energy Astrophysics



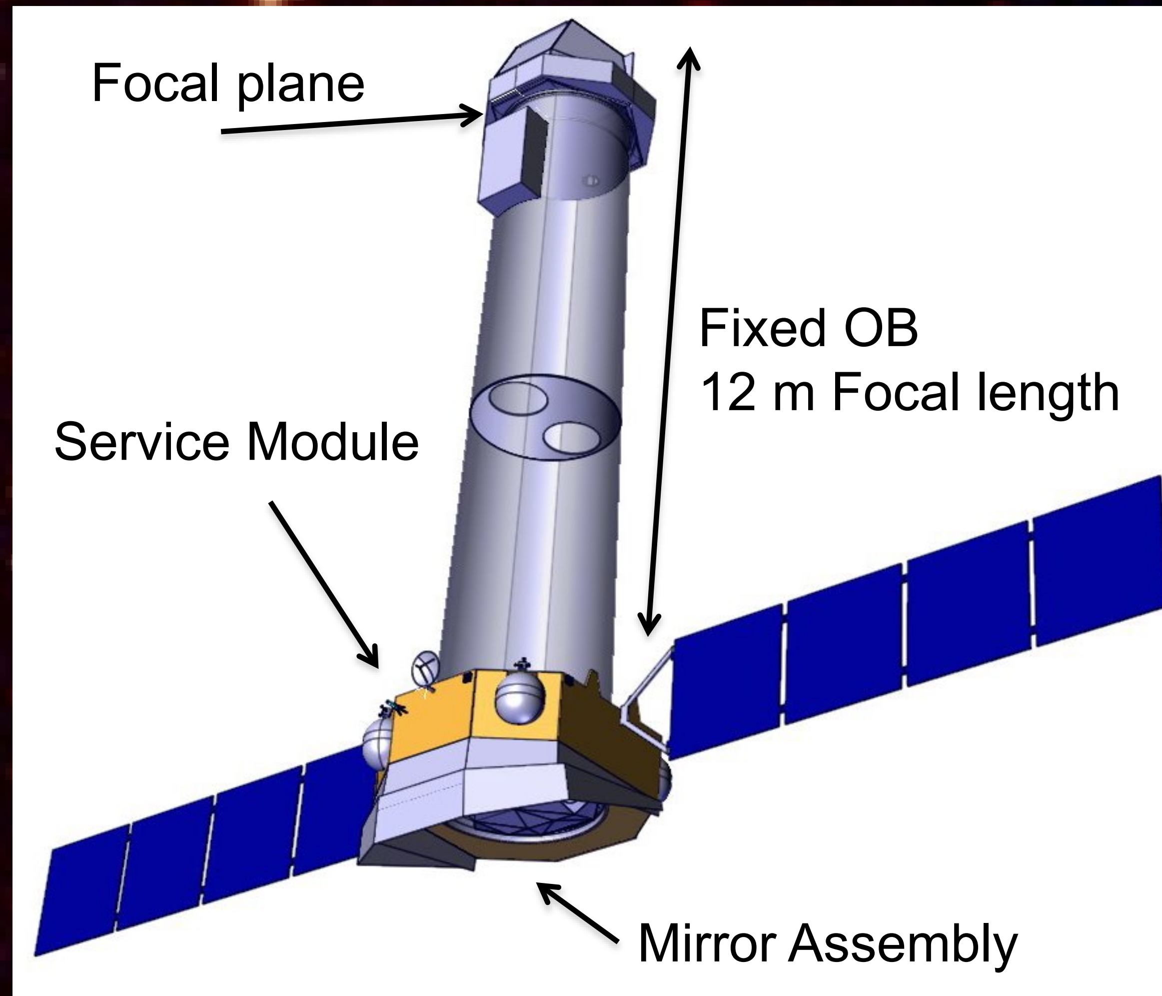
Athena Implementation



Two telescopes with total 1 sq m area and 10” resolution (5” goal) with single fixed instrument at each focal plane

ESA Silicon Pore Optics

Ariane V launch to L2
5yr nominal mission

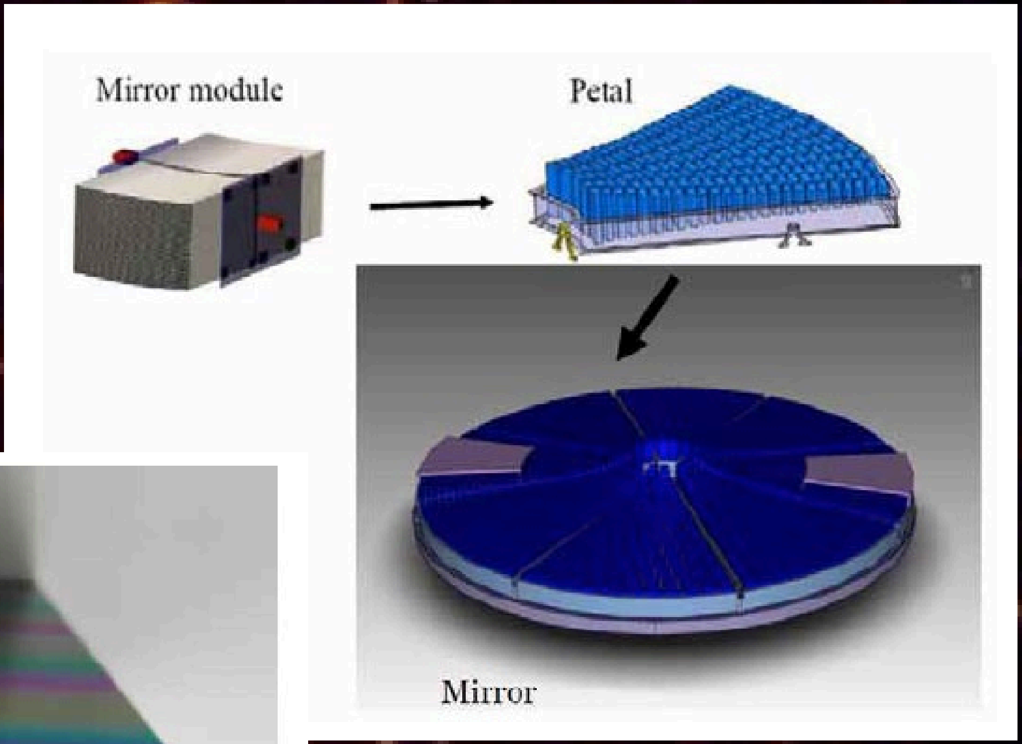


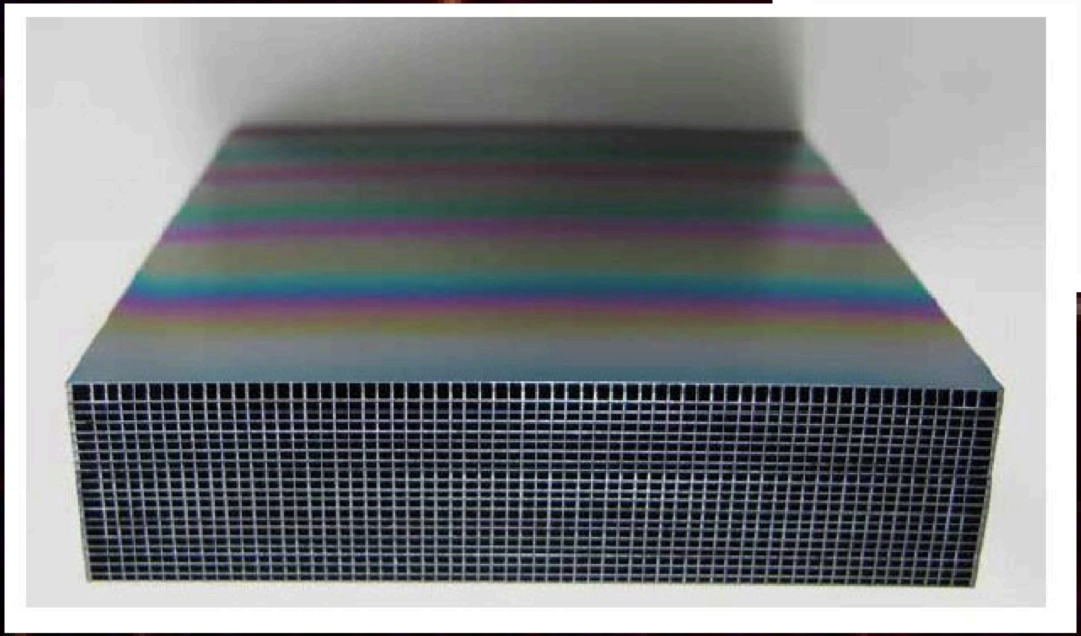
Athena Silicon Pore Optics

Angular resolution of 5-10 arc sec

Lightweight Silicon optics verses heavier Nickel for XMM-Newton

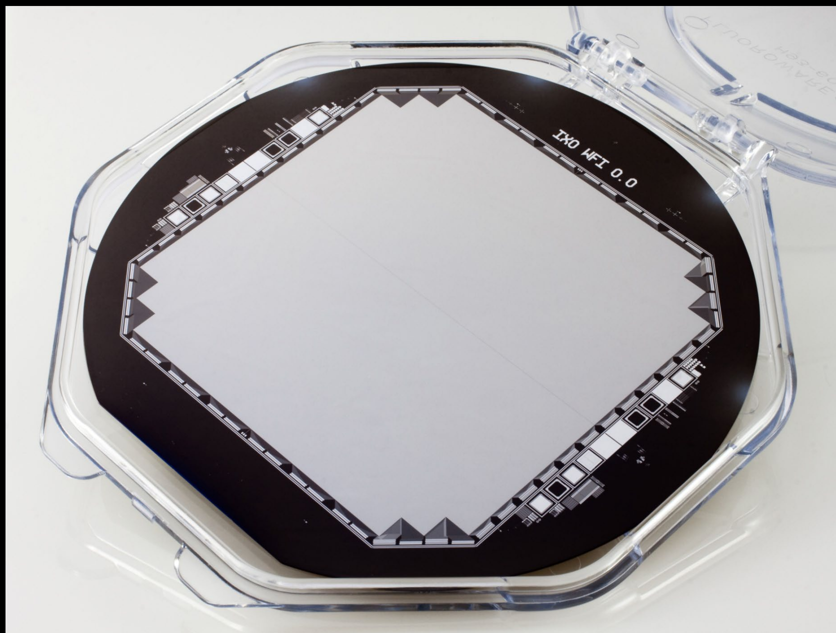
Allows ~1 sq m area for Arianne V





Silicon plates from semi-conductor industry, with robotic production

Two Athena Instruments



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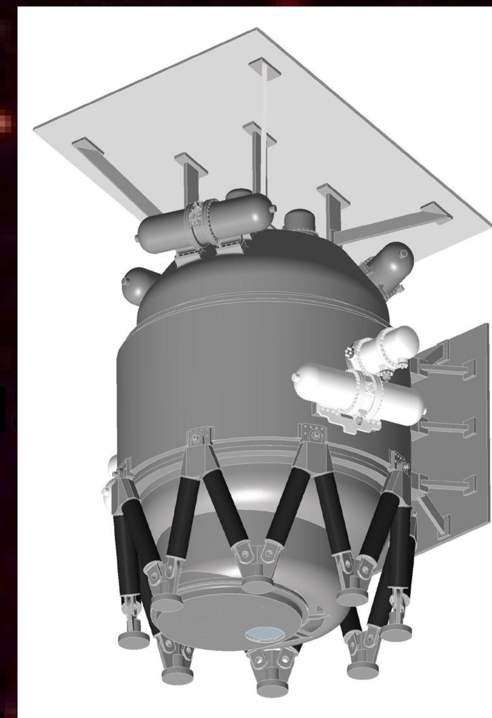
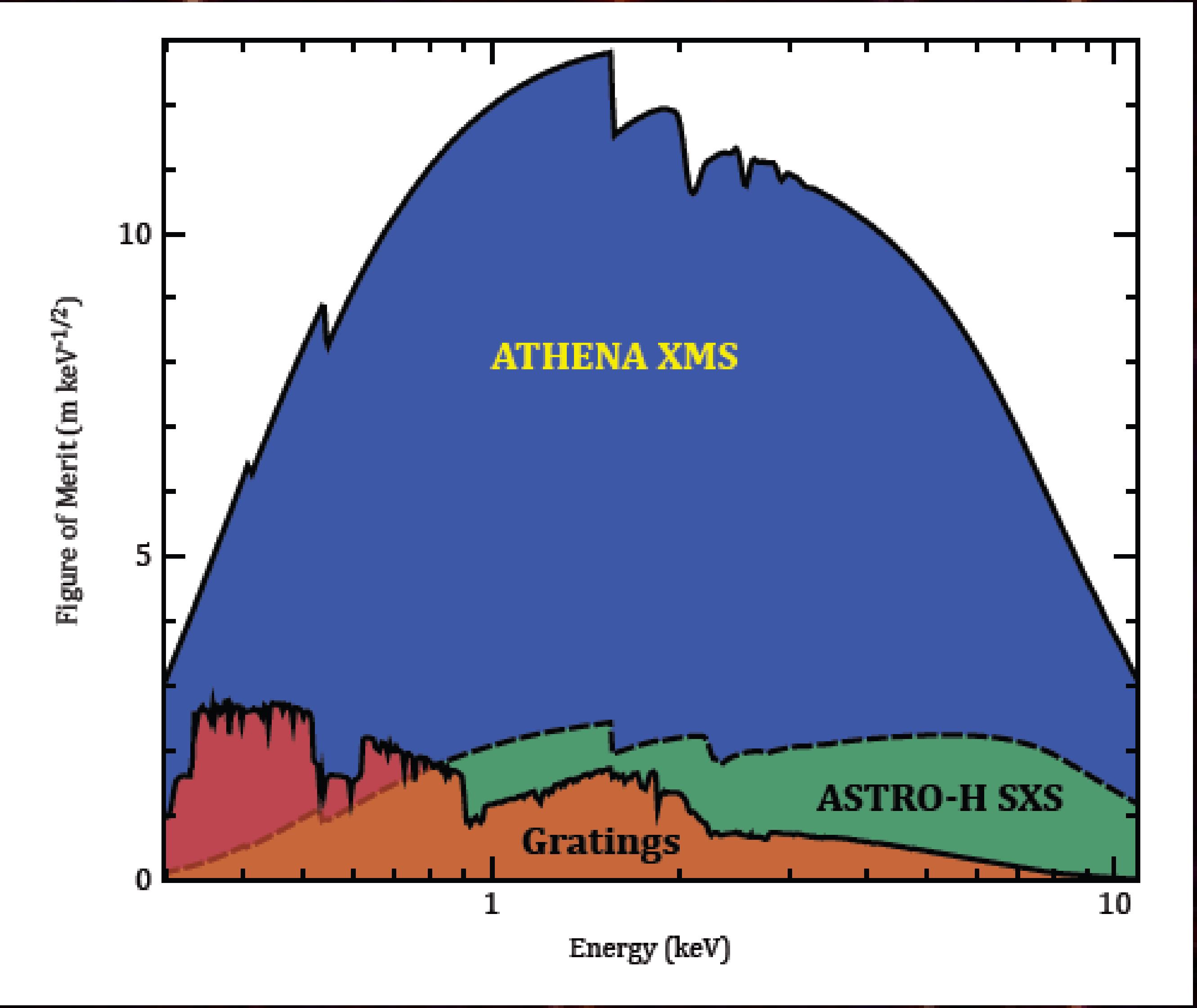


SVM

Wide Field Imager (WFI)
25 x 25 arc min FOV
150 eV @ 6 keV

Microcalorimeter (XMS)
2.4 x 2.4 arc min FOV
3 eV @ 6 KeV

Figure of Merit: XMS Detection of Lines



Cluster Feedback Observations

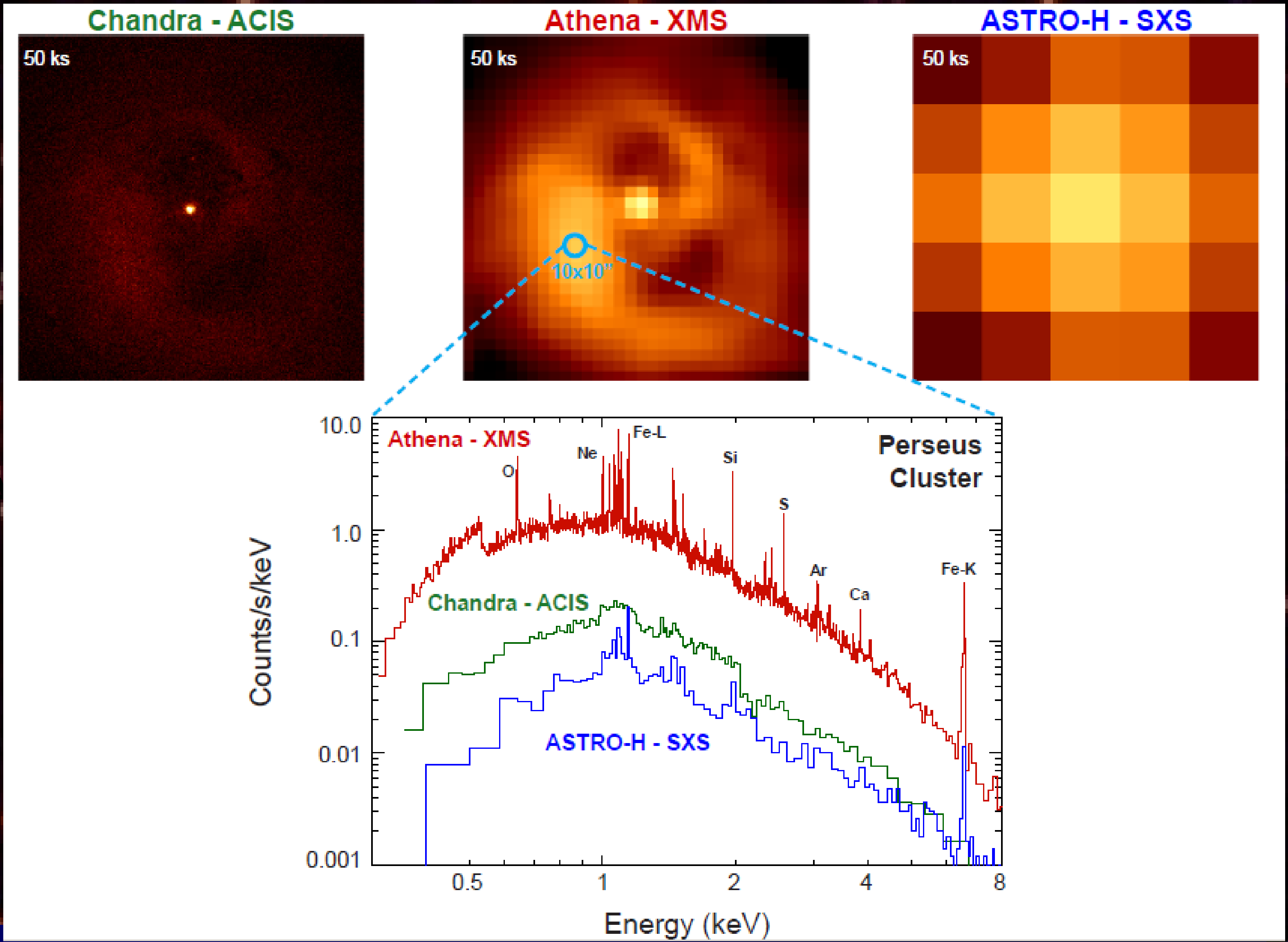
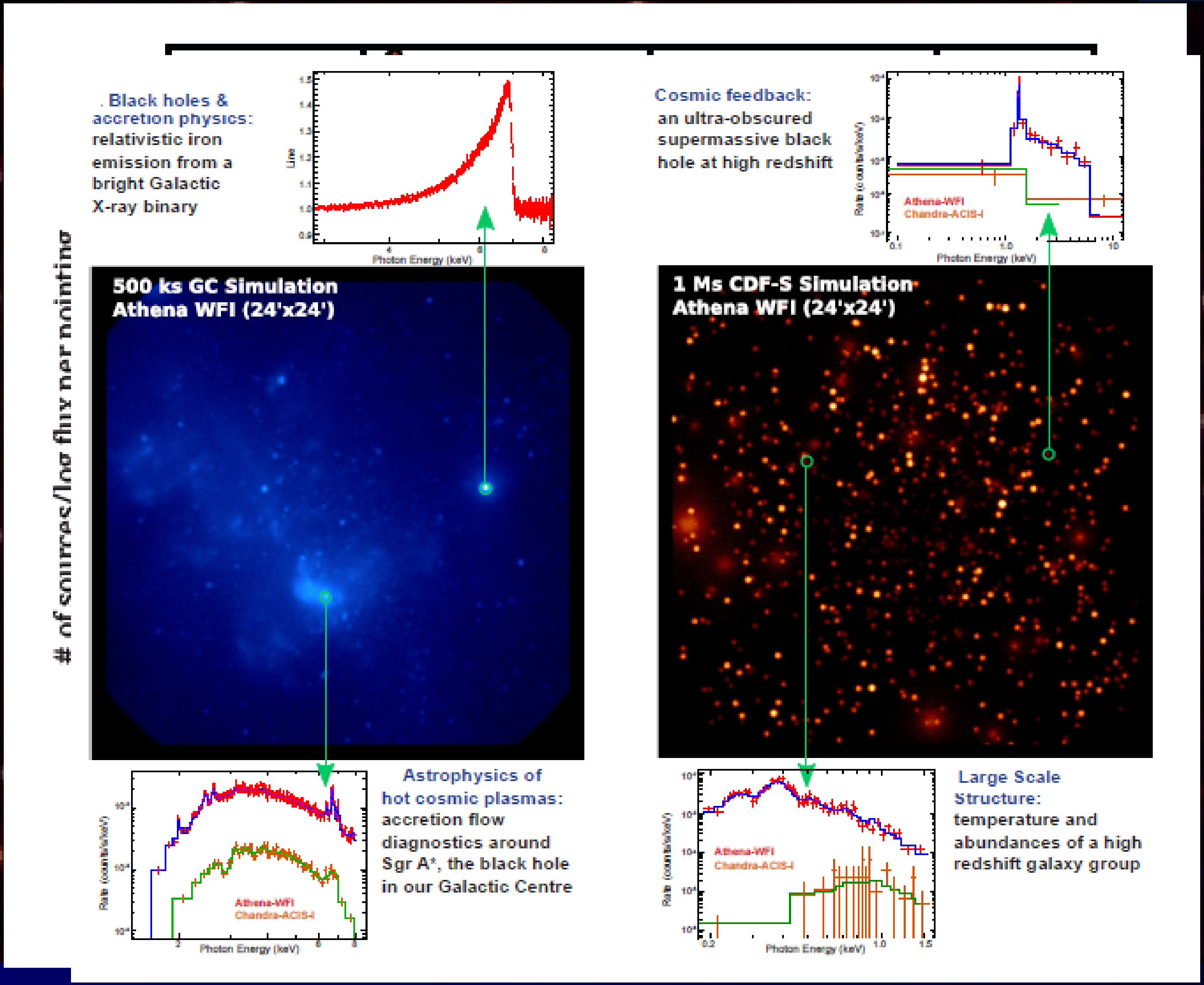
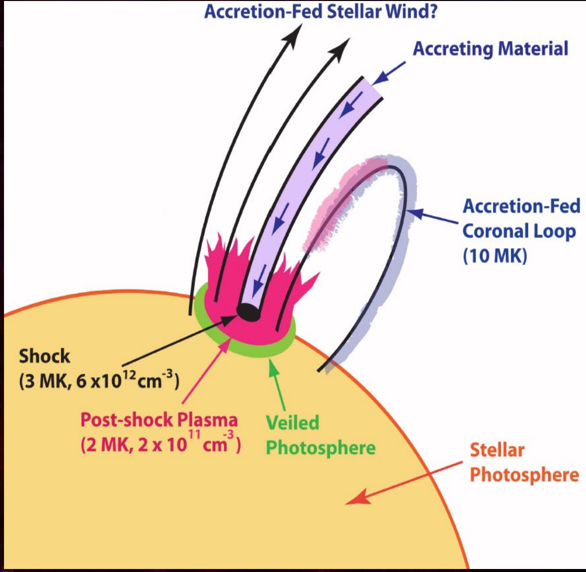


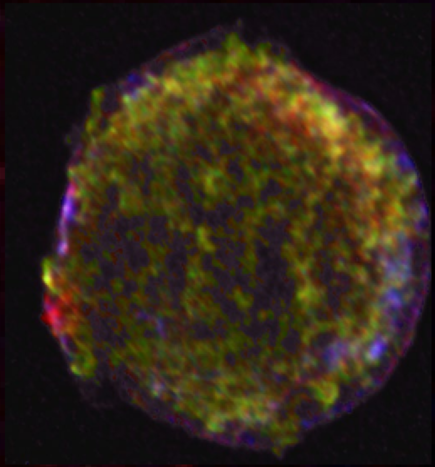
Figure of Merit: WFI Survey Capability



Astrophysics of hot cosmic plasmas

- Charge exchange in Solar System bodies: planetary atmospheres, comets, etc.
- Stellar evolution:
- Young Stellar Objects
- Cool stars
- Massive stars, mass loss, magnetic fields, etc.
- Supernovae and Supernova remnants
- Winds and absorption studies in X-ray binaries
- Cataclysmic variables
- X-ray binary populations in external galaxies
- The ISM of our galaxy
- And many many more….





Possible NASA Athena Contributions

Current plan is still for NASA instrument participation via Mission of Opportunity call in Oct/Nov 2012

The following possible NASA contributions have been discussed

Instrument contributions

- **XMS: A TES array, readout electronics and 3 stage ADR**
- WFI: Electronics and software

Infrastructure contributions

- Use of the X-ray Calibration Facility at MSFC

Support for US Guest Observers similar to that for e.g. XMM-Newton

- Contributions to data analysis software

Athena study focus is on XMS contribution as part of SRON led consortium

- Funding of $574K in FY12 approved to develop Athena (and AXSIO) XMS technology (GSFC and NIST)