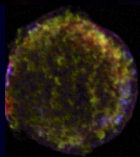
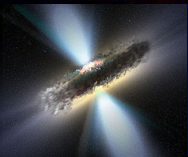


ATHENA: The Advanced Telescope for High Energy Astrophysics

The image shows the ATHENA satellite in space, oriented vertically. It has a long, cylindrical body with a large, rectangular panel extending from the top. The background is a deep blue space filled with stars and a bright, glowing nebula or galaxy structure. The satellite is illuminated from the side, highlighting its metallic surfaces and the texture of the panels.

Nicholas E. White, NASA/GSFC
On behalf of the Athena Study Team

- 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 reformulate L-class missions: European-led and funded
 - X-ray, Gravitational Wave and Jupiter Moon missions in competition for 2022 launch opportunity



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

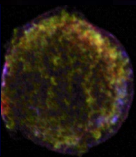
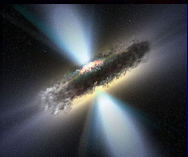
International cooperation: low-level contributions from JAXA and NASA.

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

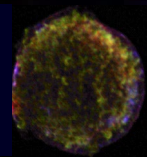
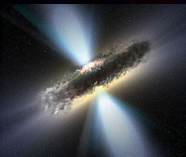
TRL ≥ 5 by early 2014 (by end of Phase A).

Targeting launch opportunity by end of 2022.

Implementation phase < 7 yr (including contingency).

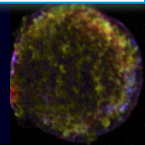
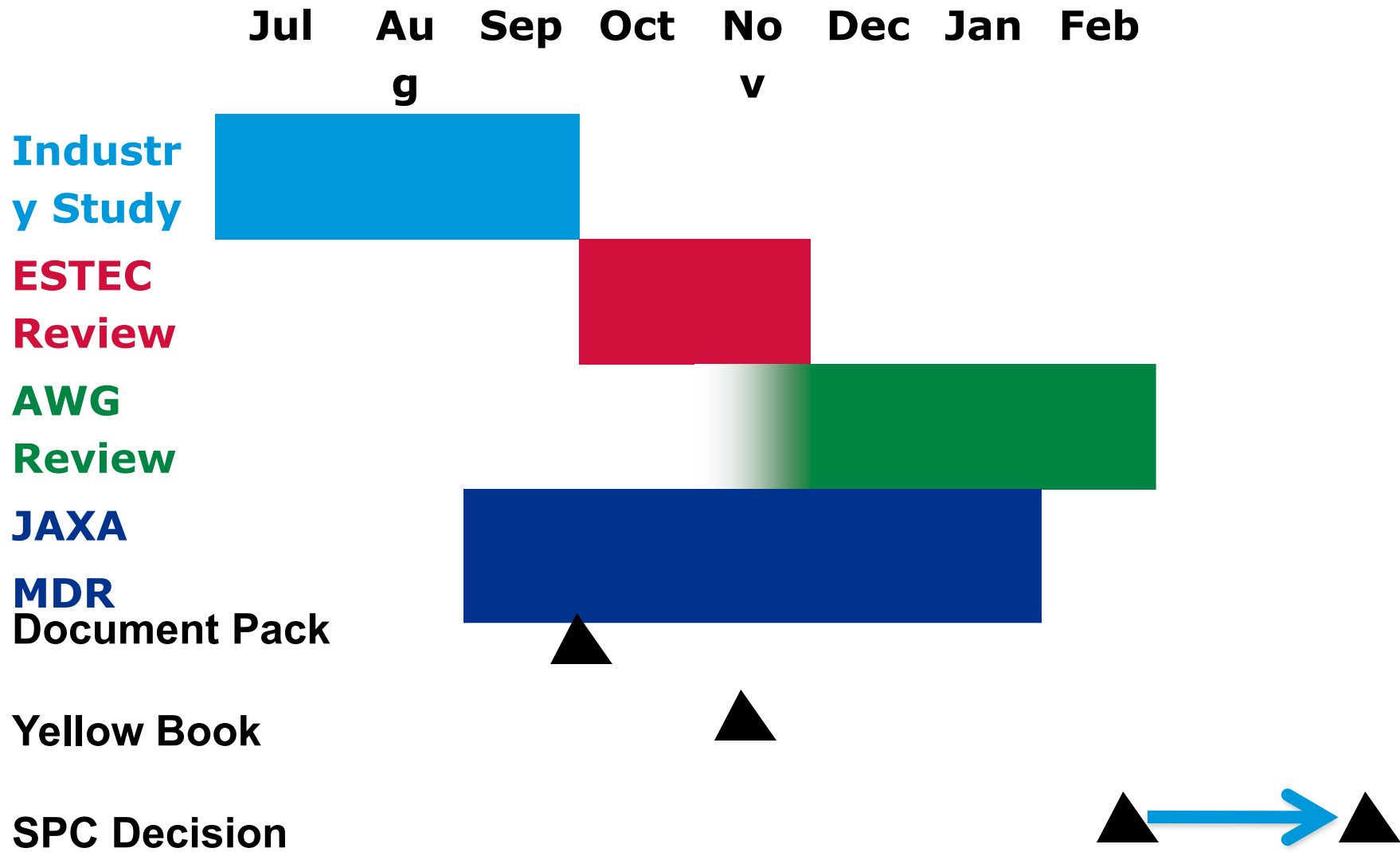


- **The Problem:**
 - Fit within ESA cost of <850M€ while retaining key IXO science
- **Solution:**
 - Lower Mass (Lower Mirror Effective Area)
 - Reduced Complexity (e.g. EOB, Mechanisms)
 - Fewer Instruments (6 to 2)
- **Tradeoff:**
 - Which Instruments? (XMS, WFI)
 - 1, 2 or 3 telescopes (1 keV vs 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



Black holes and accretion physics

Cosmic feedback

Large-scale structure of the Universe

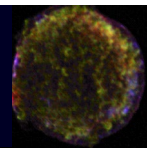
- Probe accretion in the strong field limit around black holes, and determine their spins. Determine the physical conditions in the densest observable form of matter.

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

- 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.



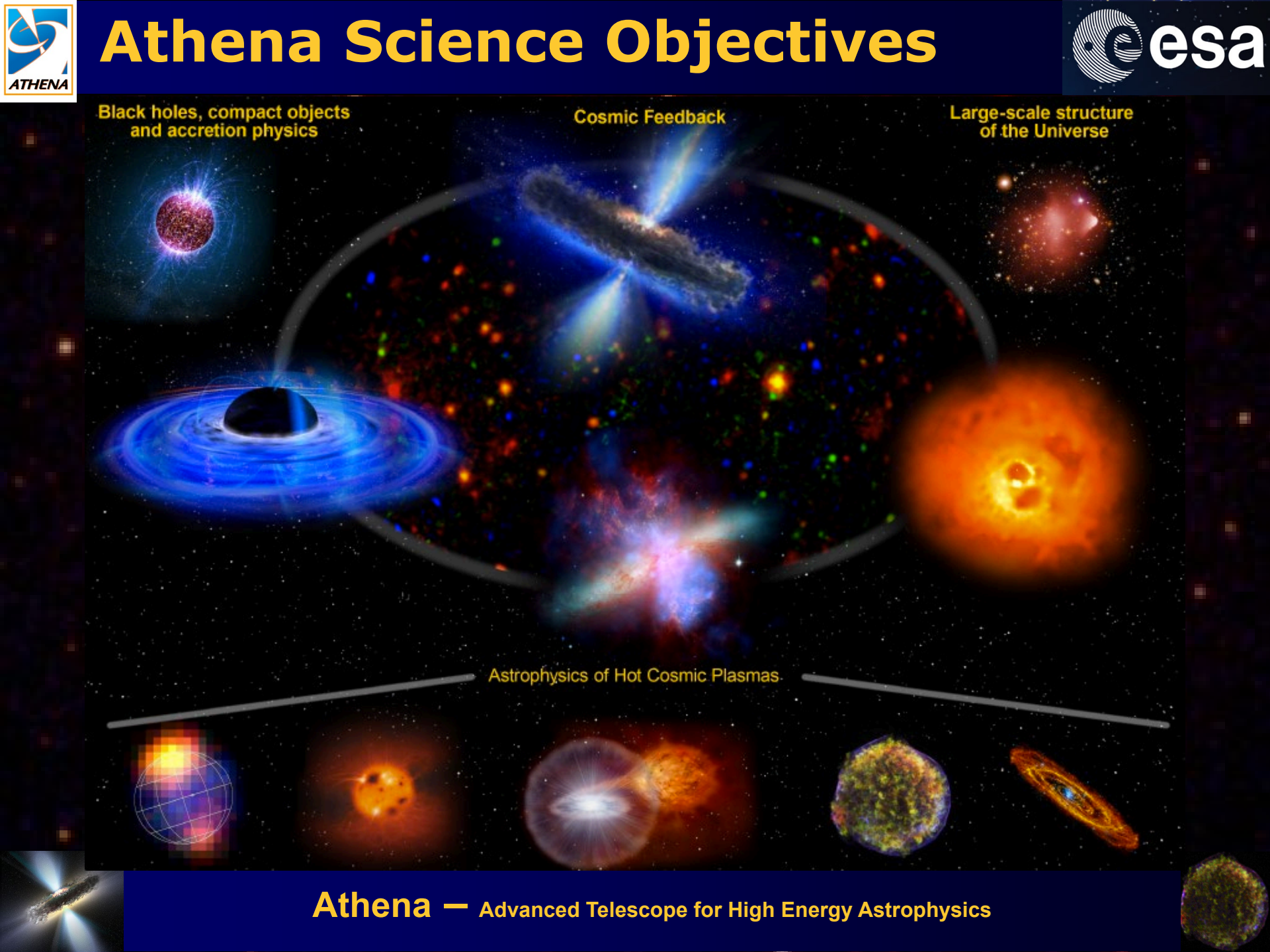
Black holes, compact objects
and accretion physics

Cosmic Feedback

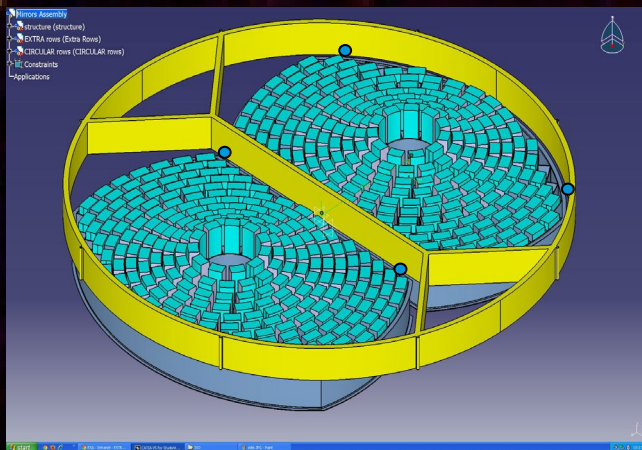
Large-scale structure
of the Universe

Astrophysics of Hot Cosmic Plasmas

Athena — Advanced Telescope for High Energy Astrophysics



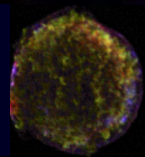
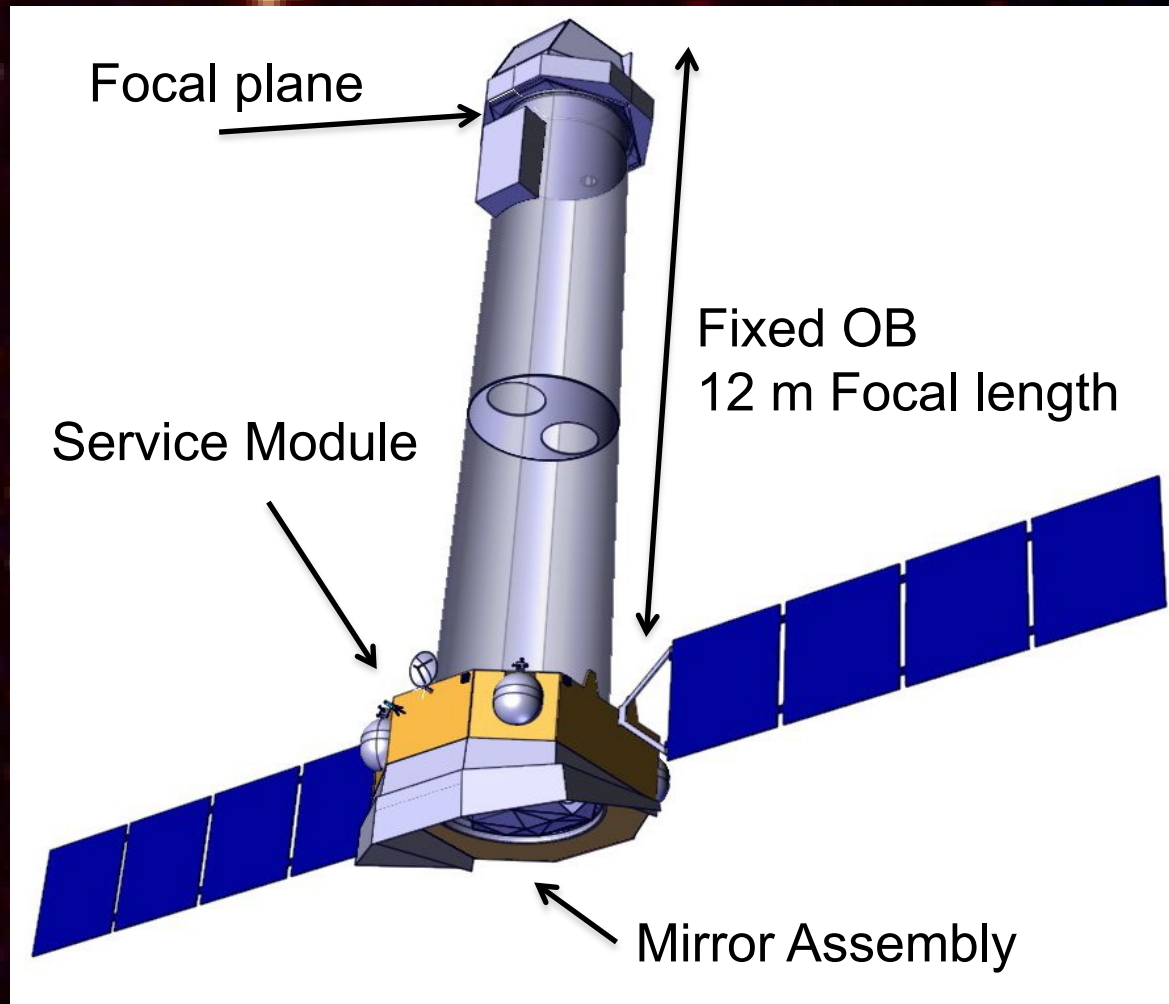
Effective Area	<p>1 m² @1.25 keV (goal 1.2 m²)</p> <p>0.5 m² @ 6 keV (goal 0.7 m²)</p>	<p>Black hole evolution, large scale structure</p> <p>Strong gravity, cosmic feedback</p>
Spectral Resolution (FWHM)	<p>$\Delta E = 3 \text{ eV (@6keV)}$ within 2 x 2 arc min</p> <p>(goal 2.5 eV and 4x3 arc min)</p> <p>$\Delta E = 150 \text{ eV}$ at 6 keV within 25 arc min diam</p> <p>(goal of 125 eV and >30 arc min)</p>	<p>Large scale structure, Cosmic Feedback</p> <p>Black Hole evolution, Large scale structure</p>
Angular Resolution	<p>10 arc sec HPD (0.1 – 7 keV)</p> <p>(goal of 5 arc sec)</p>	<p>Black hole evolution, Cosmic feedback, Large Scale Structure</p>
Count Rate	<p>1 Crab with >90% throughput.</p> <p>$\Delta E < 200 \text{ eV @ 6keV (0.3 – 15 keV)}$</p>	<p>Strong gravity</p>
Astrometry	<p>1.5 arcsec at 3σ confidence</p>	<p>Black hole evolution</p>
Absolute Timing	<p>100 μsec</p>	<p>Compact Objects</p>



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

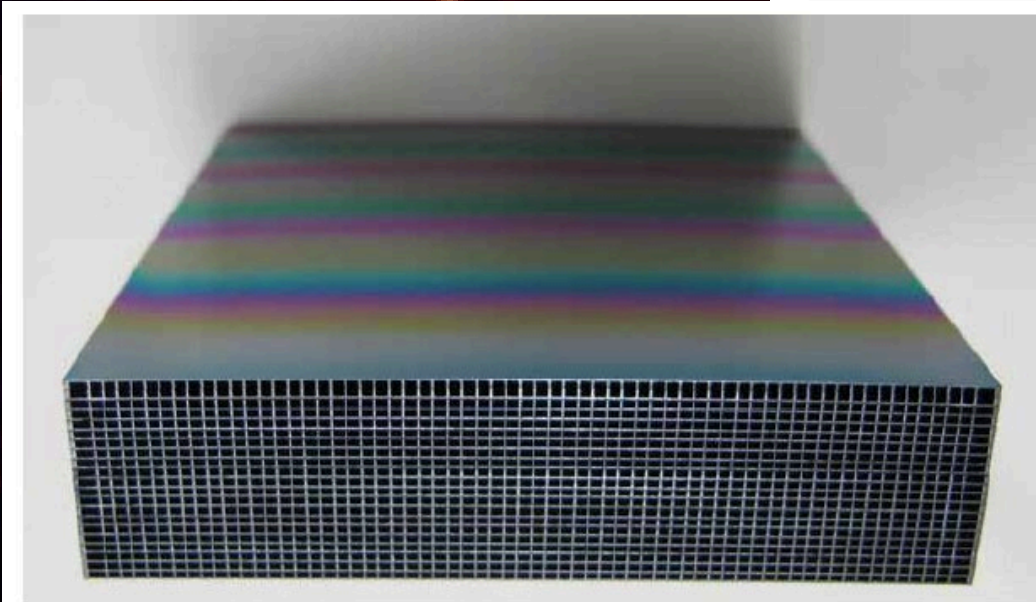
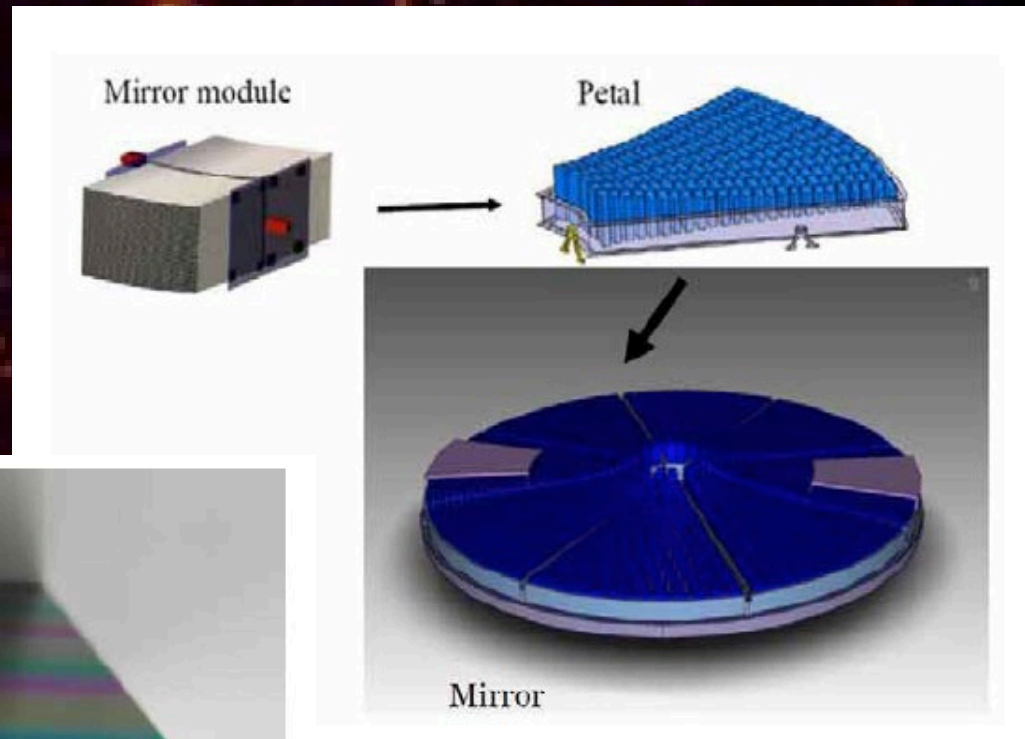
Ariane V launch to L2
5yr nominal mission



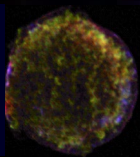
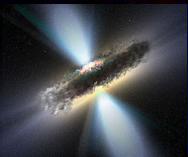
Angular resolution of 5-10 arc sec

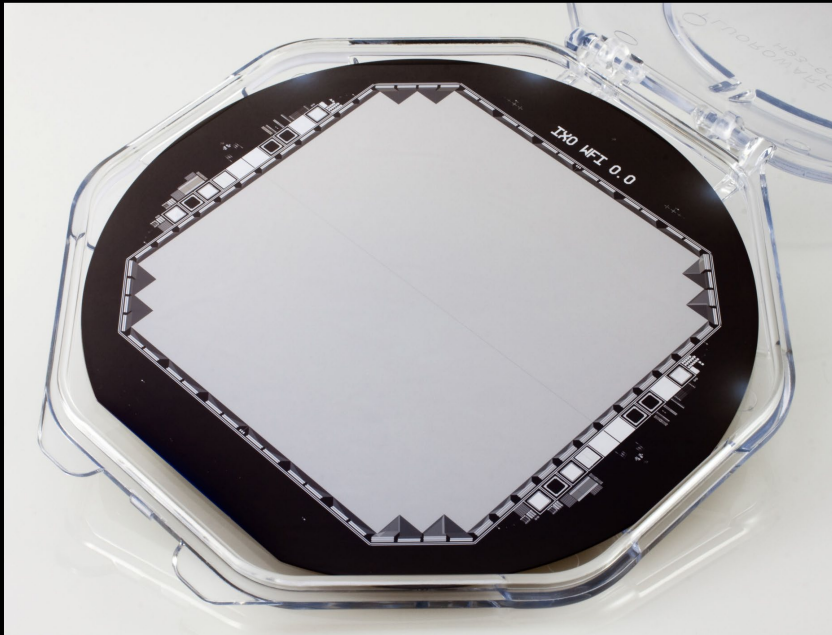
Lightweight Silicon optics verses heavier Nickel for XMM-Newton

Allows ~1 sq m area for Ariane V

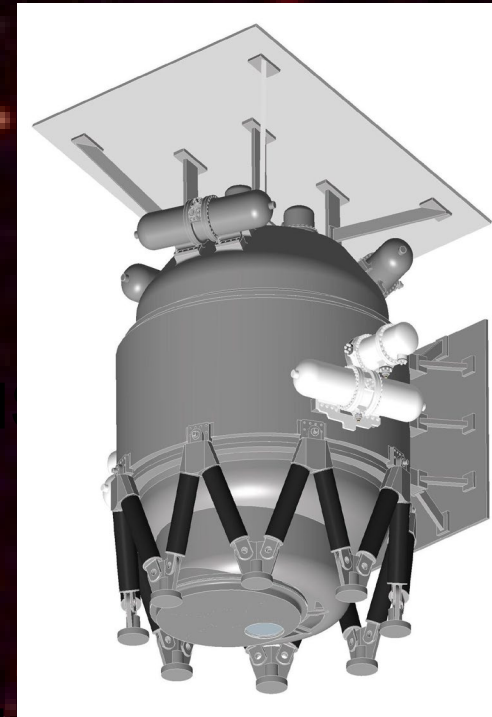


Silicon plates from semiconductor industry, with robotic production

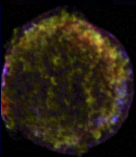
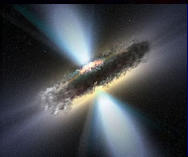


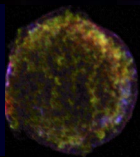
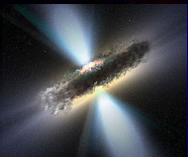
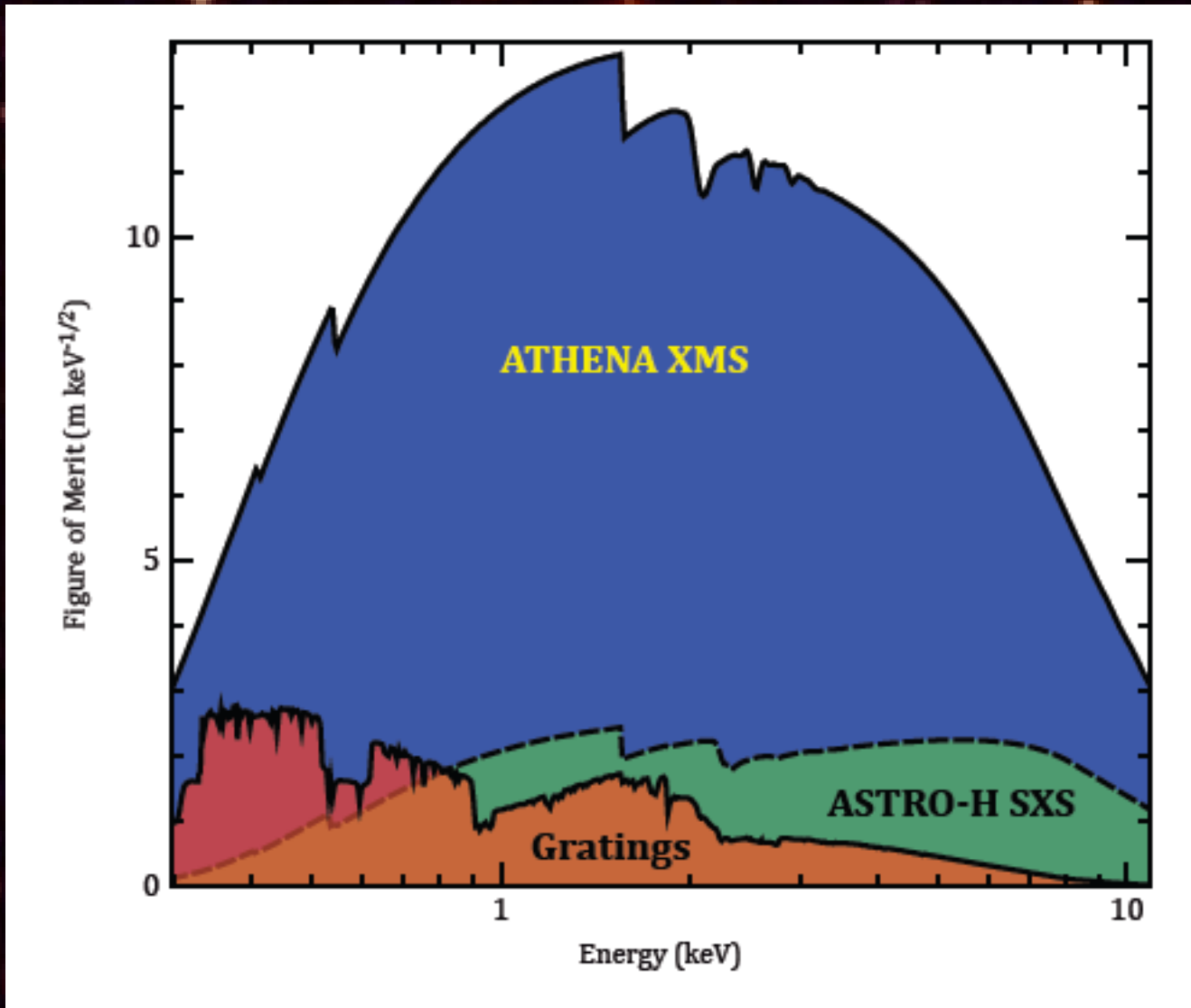


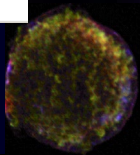
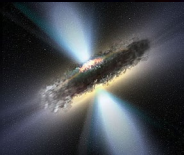
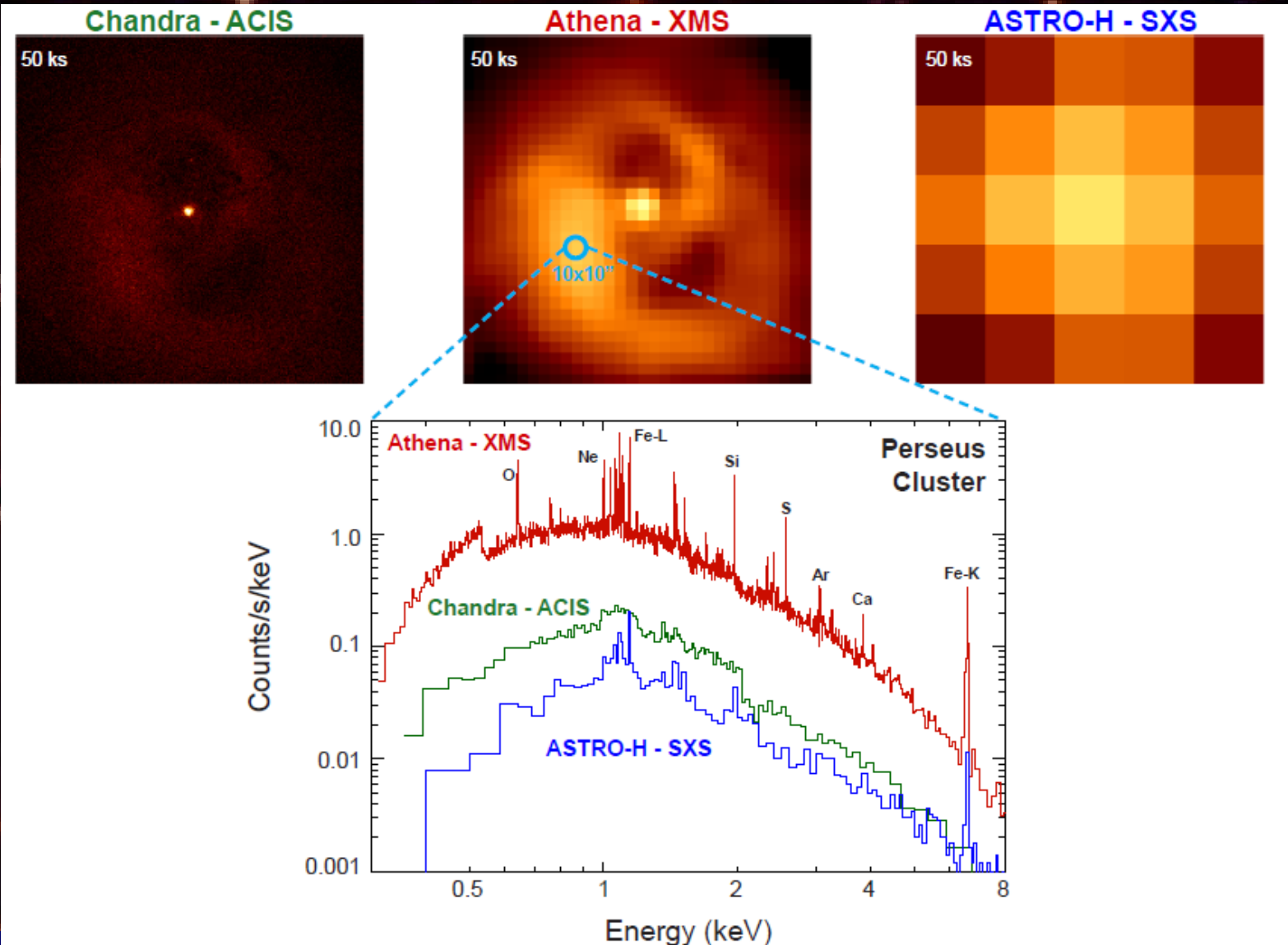
Wide Field Imager (WFI)
25 x 25 arc min FOV
150 eV @ 6 keV

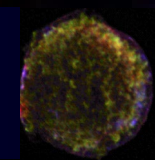
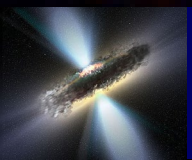
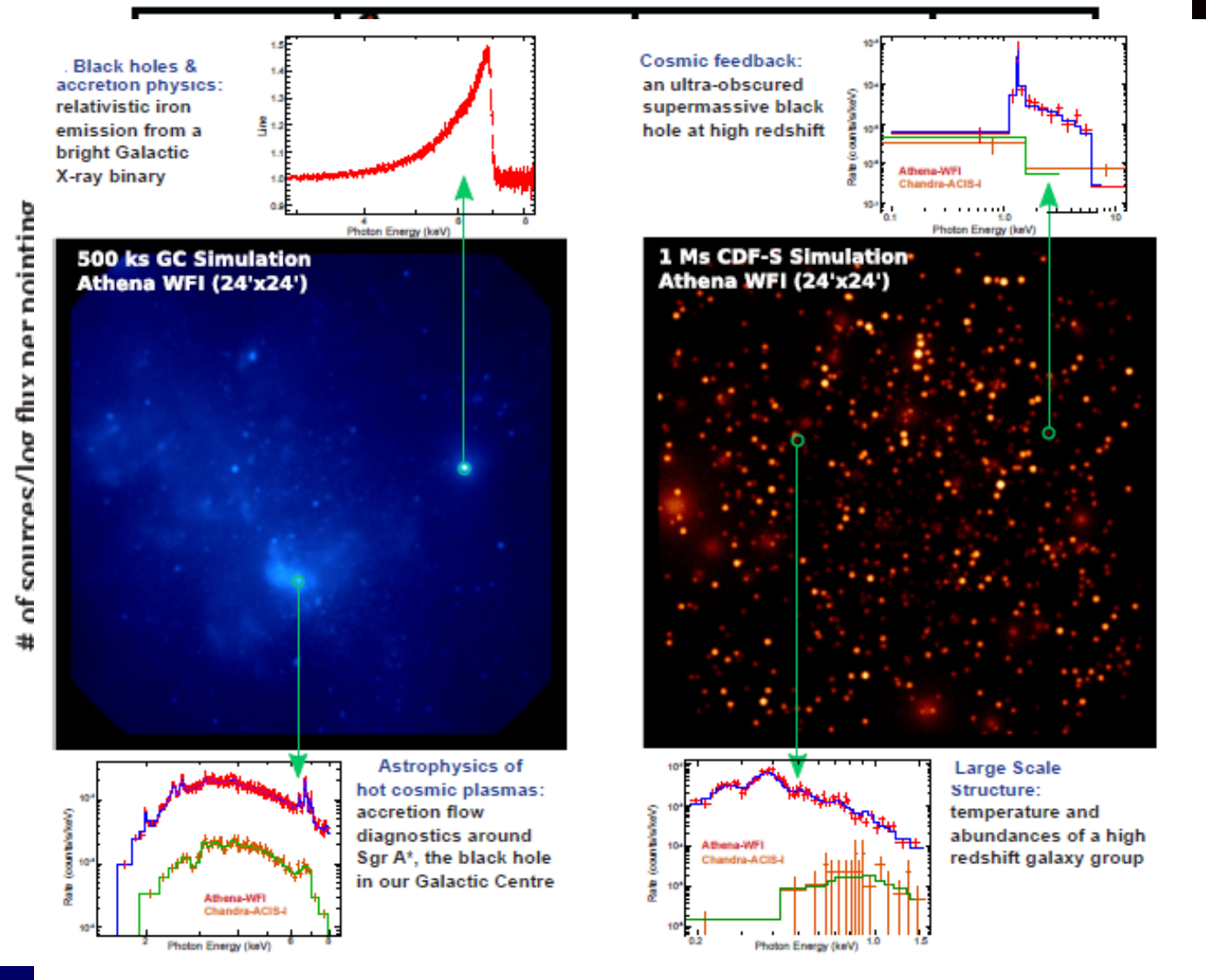


Microcalorimeter (XMS)
2.4 x 2.4 arc min FOV
3 eV @ 6 KeV









**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

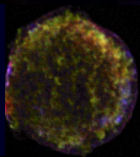
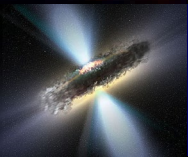
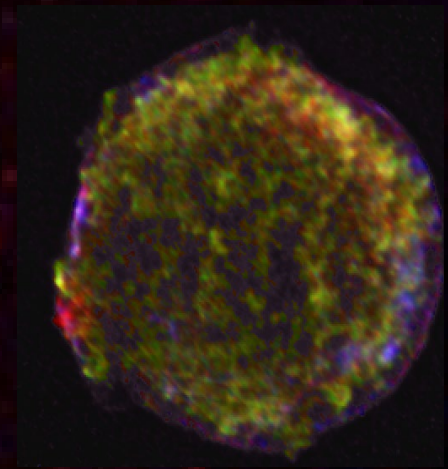
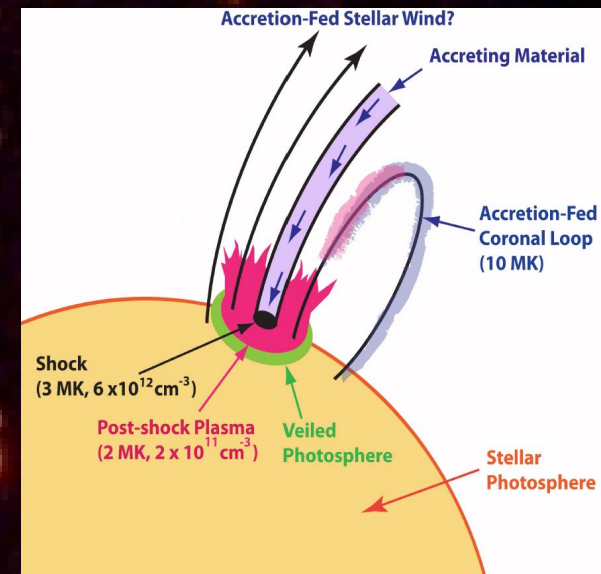
Winds and absorption studies in X-ray binaries

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 for NASA instrument participation via Mission of Opportunity call in Oct/Nov 2012 in competition with other possible proposals

ESA management view as high risk any dependence on an unconfirmed NASA contribution, so baseline assumes 100% European mission

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 Dutch led consortium

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

Questions?

