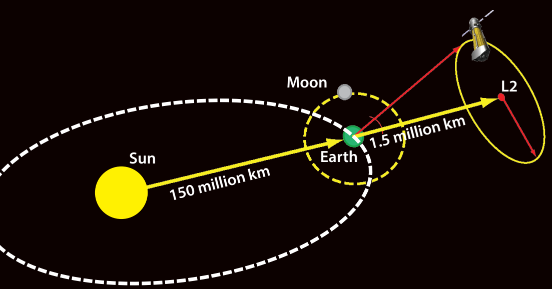
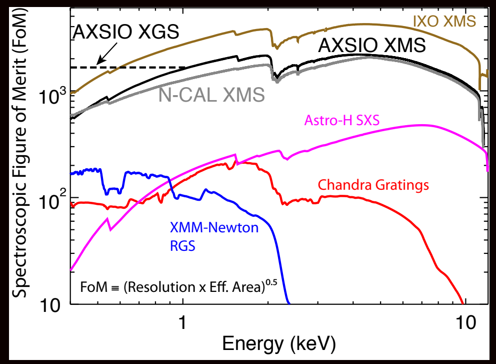
MISSION OVERVIEW

Two possible mission implementations, ***AXSIO*** (Advanced X-ray Spectroscopic Imaging Observatory) and N-CAL (Notional Calorimeter), are discussed in the PCOS ***X-ray Mission Concepts Study*** report*. Both use simple spacecraft with fixed optical benches.



The satellite will be launched into a zero delta-V L2 insertion orbit, ensuring high (>80%) efficiency for observations with a stable environment and no eclipse periods.



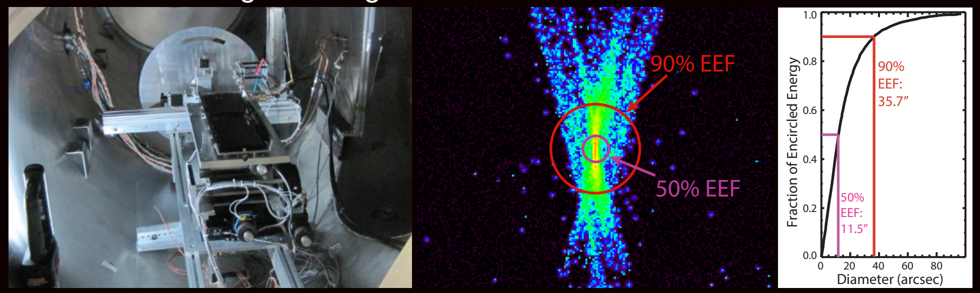
The above figure shows ***AXSIO*** and N-CAL spectroscopic figure of merit compared to ***Chandra***, ***XMM-Newton***, and the proposed ***IXO*** spectrometers. The major increases in capabilities of ***AXSIO*** or N-CAL are needed to perform the majority of the breakthrough ***IXO*** science recommended by the 2010 Decadal Survey.

KEY REQUIREMENTS

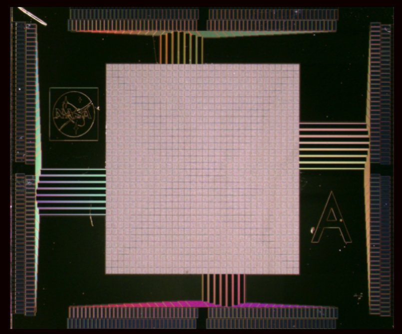
Spectral Revolving Power:	<3 eV from 0.3–7 keV $\lambda/\Delta\lambda$=3000 from 0.3–1.0 keV
Bandpass:	0.3–12 keV
Effective Area:	0.5 / 0.9 m^2 @1.25 keV (N-CAL / AXSIO) 0.2 m^2@6 keV 0.1 m^2@1 keV
Angular Resolution:	10" HPD with 5" goal
Field of View:	~4 × 4 arcmin^2
Temporal Resolution:	100 µs
Mission Lifetime:	Three years, with 10-year goal

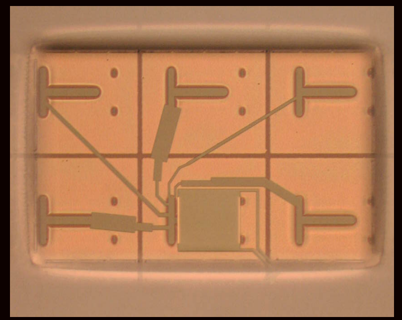
OPTICS

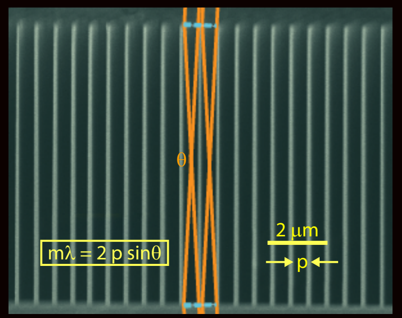
High-throughput, high-resolution, segmented X-ray optics form the core of the mission. Mirrors constructed from thermally formed glass segments will provide high angular resolution and a substantial increase in effective area per unit mass over previous X-ray mirrors. Current mirror prototypes have angular resolution equal to 10 arcsec. The resolution obtained here is the highest to date for this technology and is four times better than the segmented glass flown on ***NuSTAR***.

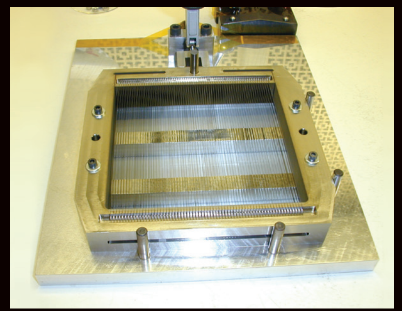


DETECTORS









X-ray Microcalorimeter Spectrometer (XMS) provides imaging high-resolution spectroscopy (ΔE = 2.5eV) with a closed-loop cyrocooler and no expendable cryogen. Shown here is a 32 x 32 array of transition-edge sensors (TES) designed for the ***IXO*** mission, similar to those being considered for ***AXSIO*** and N-CAL. Similar arrays have already shown average resolution of 3 eV or better.

These arrays will be extended using "hydra" transition-edge sensor (TES) designs which mount multiple X-ray absorbing pixels on a single TES, as shown at left. This would allow for more pixels and bigger field of view.

X-ray Grating Spectrometer (XGS) provides high-resolution dispersive spectroscopy—$\lambda/\Delta\lambda \geq 3000$ at energies below 1 keV. Two approaches, using either critical angle transmission gratings (top left) or off-plane gratings (bottom left), are under development.

The XGS is included in the ***AXSIO*** design, and was considered as a possible addition to the N-CAL design described in the PCOS X-ray Study Report.

*The X-ray study report can be found on the NASA PCOS web site http://pcos.gsfc.nasa.gov

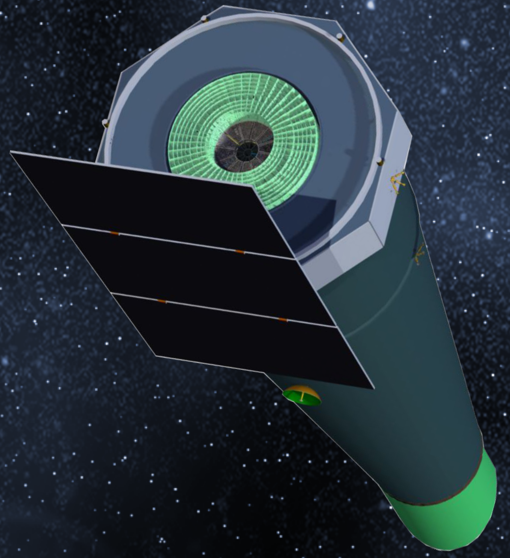
NP-2012-12-363-GSFC

National Aeronautics and Space Administration

X-RAY SPECTROSCOPIC IMAGING

Exploring the science enabled by combining the power of lightweight precision optics with high spectral resolution detectors

The 2010 Decadal Survey, New Worlds, New Horizons in Astronomy and Astrophysics, *noted that "Large-aperture,time-resolved, high-resolution X-ray spectroscopy is required for future progress" on the most fundamental questions in astrophysics, ranging from the structure of space-time around black holes and quantum chromodynamics in neutron stars to cosmic evolution and the formation of structure in the Universe. The survey also found that "The key component … is an X-ray microcalorimeter spectrometer—[a several arcminute] array that measures X-ray energy with an accuracy of roughly 1 part per 1,000." Missions costing $1–1.5B would provide quantum leaps in spectroscopic capability.*



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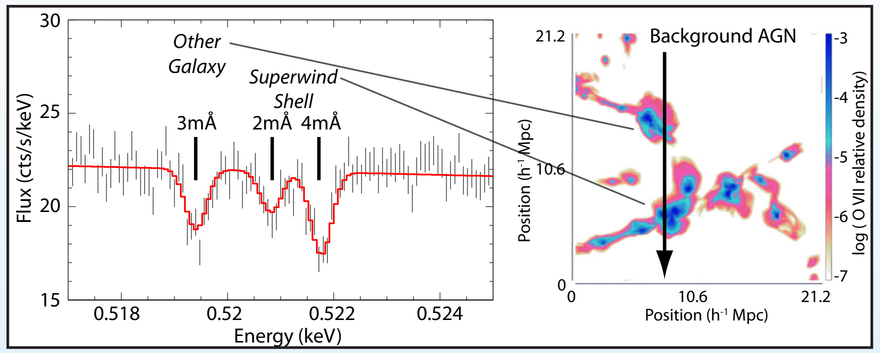
SCIENCE CAPABILITIES

LARGE-SCALE STRUCTURE & CREATION OF ELEMENTS

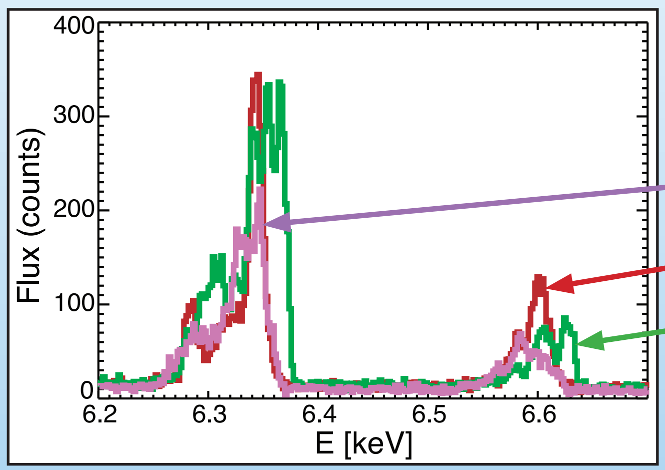
Missing baryons and the Intergalactic Medium

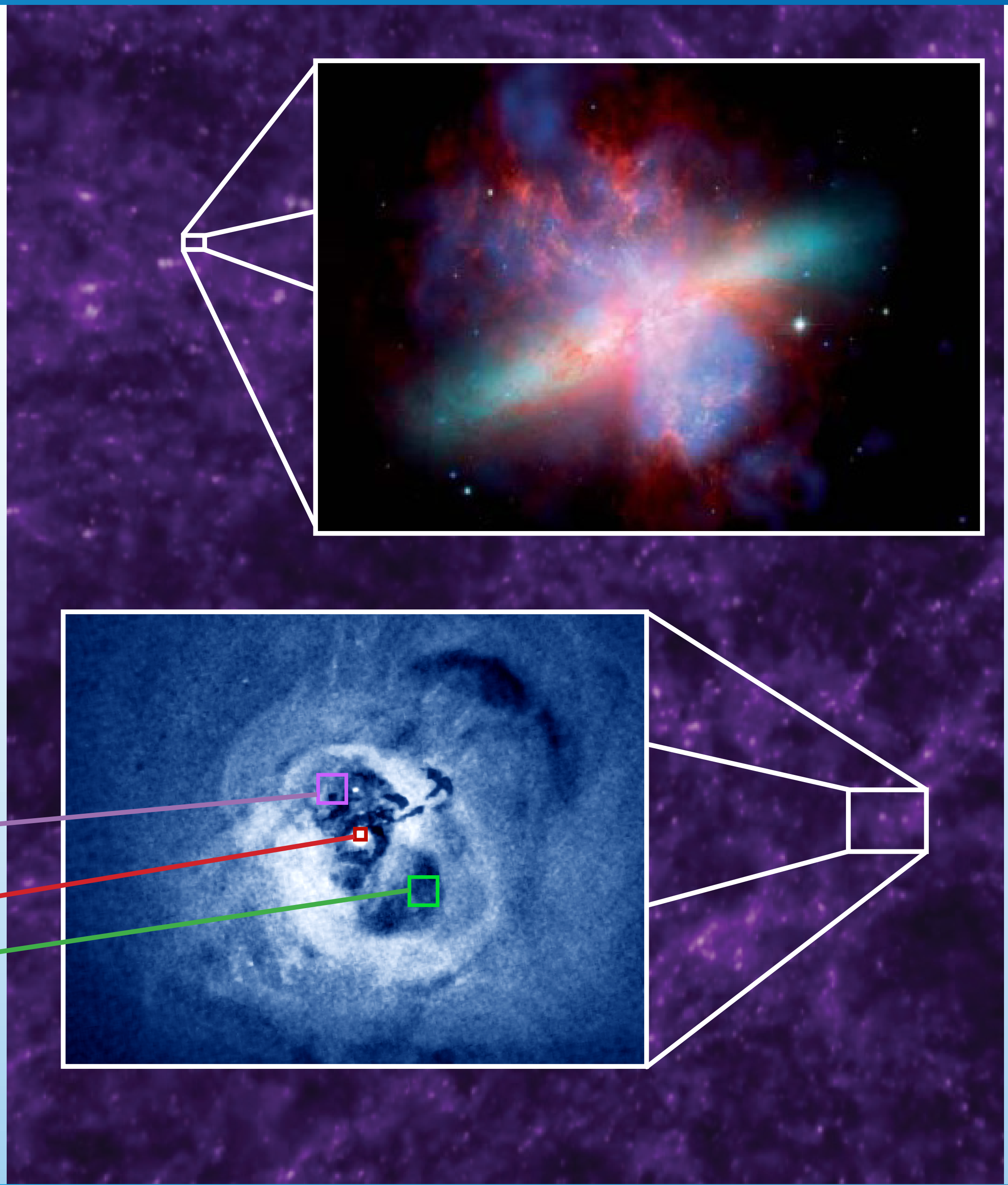
Find the missing baryons at low-z by characterizing hundreds of absorption systems seen against background targets.



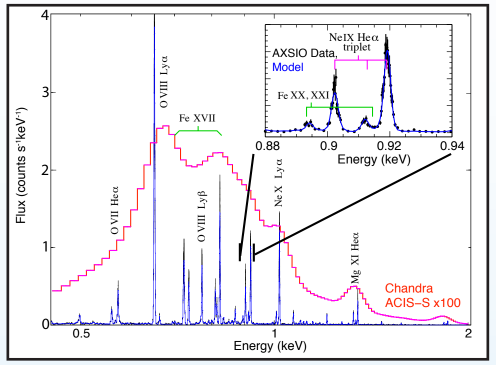
Cosmic Feedback and Cluster Evolution

Measure feedback from supermassive black holes (SMBH) in galaxies and clusters by measuring the temperature, emissivity, and velocities both from the core and in the walls of the buoyant bubbles created as part of the feedback process. Establish the origin of excess entropy in clusters by studying their precursors at early epochs, z > 1.





CHEMICAL EVOLUTION ALONG COSMIC TIME

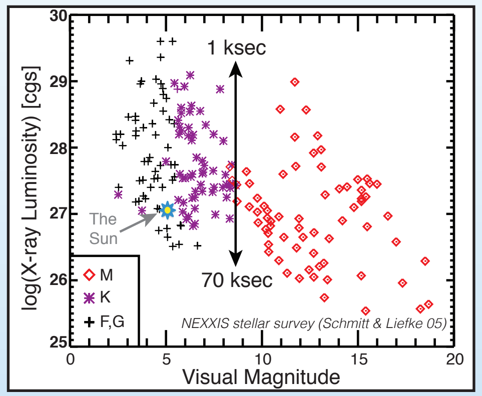


Determine the epoch and mechanism of dispersion of chemical elements in the early intracluster medium.

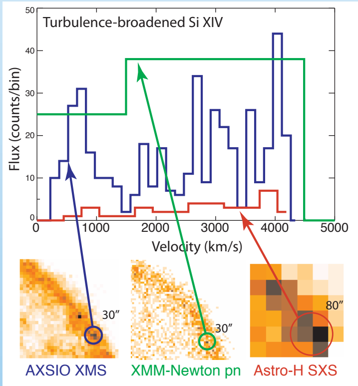
Image outflows of metal-enriched plasma in starburst galaxies to assess the impact on galaxy evolution and recent evolution of the intergalactic medium.

Survey of Normal Stars

Understand typical ranges of standard stellar parameters such as rotation, flaring, and loop filling factors with an unbiased survey of solar-type and other nearby (< 20 pc) normal stars. Measuring temperatures, densities, and velocities can be done in modest (1–70 ksec) exposure times, with adequate area to observe and diagnose parameters from short-lived flares as well.

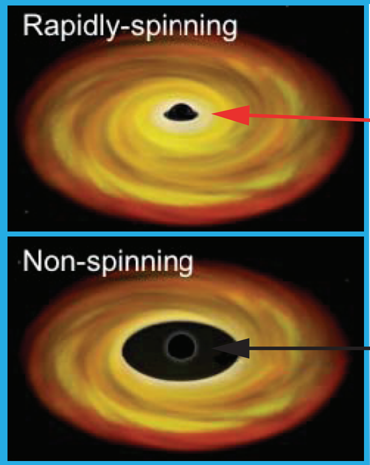


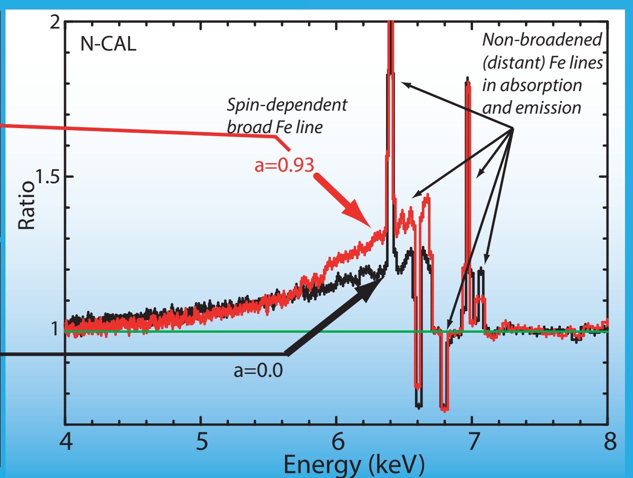
Turbulent Mixing of Supernova Ejecta



Measure ejecta mixing in supernova remnant (SNR) shock fronts via the spatially resolved turbulent broadening of strong emission lines. Although ***XMM-Newton*** can spatially resolve features in this hydro simulation of the Tycho SNR, and ***Astro-H*** will be able to measure line broadening in large regions, only ***AXSIO*** or N-CAL can image and resolve the broadening in individual knots of ejecta to reveal how a young SNR ejects metals into the ISM and beyond.

CO-EVOLUTION OF GALAXIES & THEIR SUPERMASSIVE BLACK HOLES





Strong gravity and accretion physics

Probe strong-field General Relativity by Doppler mapping the innermost regions of accretion disks

Survey spin of stellar and SMBH via spectroscopy and timing to constrain their growth history and origin.

Cosmic growth of SMBH

Determine the growth mechanism of low-redshift SMBH by measuring their spin distribution.

Characterize the energetics of the obscured growth phase of SMBH between z~1–3.

Observe young (z ~6–10) growing massive black holes identified from other observatories.