National Aeronautics and Space Administration
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CONSTELLATION X-RAY OBSERVATORY

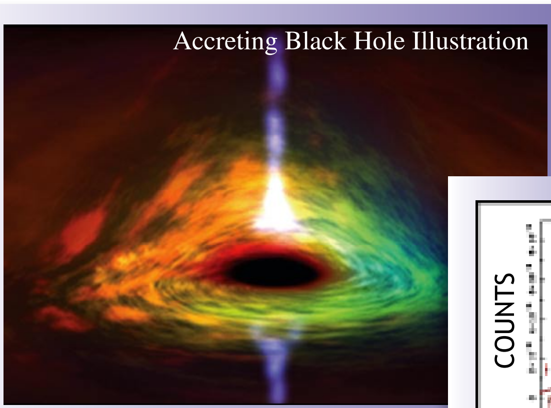
A Beyond Einstein Great Observatory

Understanding the Mysteries of Black Holes, Dark Matter, and Dark Energy.

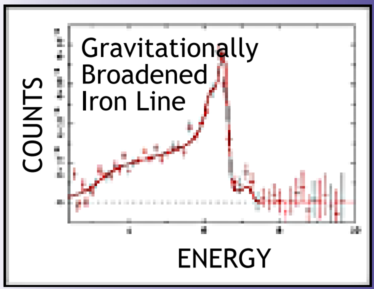
What happens to space, time, and matter at the edge of a black hole? Con-X will:

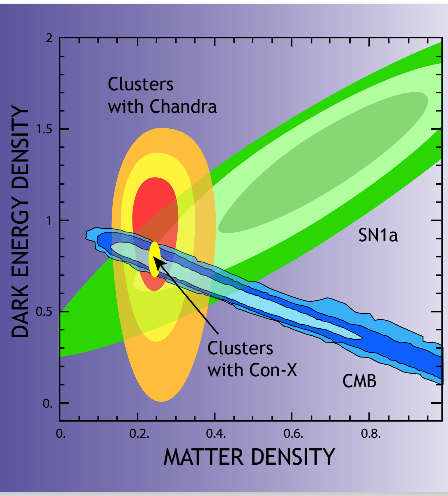
- test General Relativity in extreme gravity near the black hole event horizon,
- measure the spin of black holes, and
- make the first "movies" of matter spiraling into a black hole.

BLACK HOLES



Accreting Black Hole Illustration





DARK ENERGY

Of what is the Universe made? Con-X will:

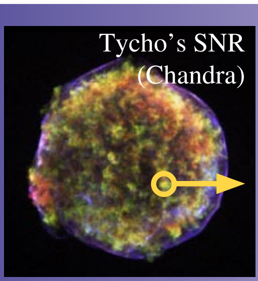
- observe clusters and the growth of structure to measure the expansion of the Universe (thus measuring properties of Dark Energy),
- measure the Dark Matter content of galaxies, groups, and clusters, and
- search for the missing baryons in the Cosmic Web.

COSMIC FEEDBACK

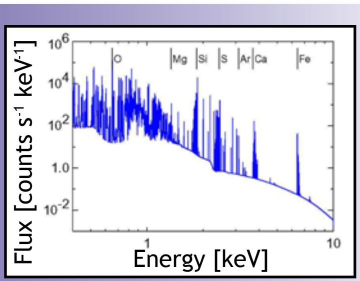
Perseus galaxy cluster (Chandra)

How did the Universe come to look like it does now? Con-X will:

- increase understanding of the connection between the growth of supermassive black holes and host galaxies (e.g., is accretion self-regulated by black hole outflows?), and
- study the superwind feedback mechanism in starburst galaxies.



Tycho's SNR (Chandra)



LIFE CYCLES OF MATTER

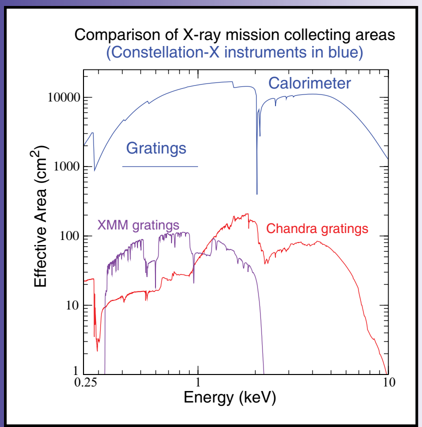
What is the origin of atoms in stars, planets, and living organisms? Con-X will:

- trace the formation of individual elements in supernova explosions,
- probe the formation of stars and planets, and
- determine the nature of superdense matter in neutron stars.

The 2000 NRC Decadal Survey (*Astronomy and Astrophysics in the New Millennium*) ***ranked Con-X next in priority after JWST*** among major space-based initiatives. These Decadal Survey priorities were re-affirmed by a 2005 NRC Mid-Course Review. Con-X addresses 8 of the 11 questions discussed in the *Quarks to Cosmos* NRC report.

http://constellation.gsfc.nasa.gov

Constellation-X: Mission and Technology



Con-X effective area vs energy compared to Chandra and XMM spectrometers. The upper curve is for the calorimeter and the straight line indicates the gratings requirement of 1000 cm^2. The 100-fold increase in collecting area provides for breakthrough science.

MISSION OVERVIEW

- L2 orbit for high viewing efficiency and stable thermal environment
- 5 year lifetime with 10 year goal
- Technically ready, well understood, mission with simple spacecraft

KEY REQUIREMENTS

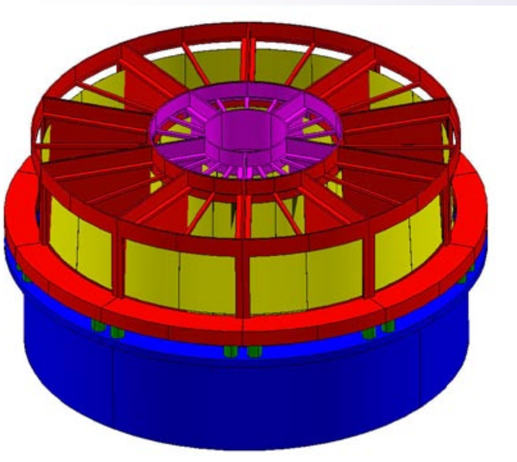
Bandpass: 0.25 to 40 keV

Area: 15000 cm^2@1.25 keV, 6000 cm^2@6 keV

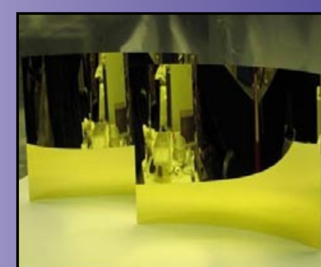
Angular Resolution:
15″ HPD, 5″ goal, for SXT

Spectral Revolving Power (FWHM):
~ 1200 from 0.4 to 1 keV
> 1500 at 6.0 keV

MIRRORS



- Spectroscopy X-ray Telescope (SXT) mirror technologies derive directly from flight programs (XMM-Newton, Suzaku) but with improved figure accuracy and reduced mass.
- Assembled from 72 separate 30-degree wedges into a circular mirror. Each SXT has a 1.3 m outer diameter and 163 mirror shells.
- Con-X uses thermally slumped glass coated with iridium.



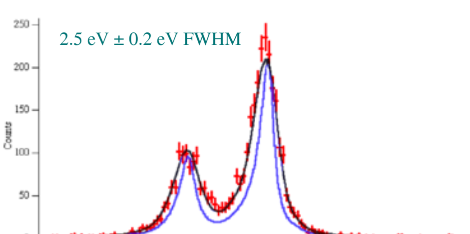
Left: A mirror segment is being taken off the mandrel on which it has been thermally formed.
Right: Two slumped glass segments coated with gold.

SCIENCE INSTRUMENTS

X-ray Microcalorimeter Spectrometer (XMS). Provides imaging, non-dispersive, high resolution spectroscopy at SXT focus. Superconducting device, closed loop cyro-cooler, no stored (expendable) cryogen.

Prototype showing arrays of XMS chips & associated SQUID amplifiers

XMS Development Progress. An 8×8 development Transition Edge Sensor calorimeter array with 250 μm pixels has been developed. These devices are "flight-like" and have achieved the required spectral resolution.



Spectrum from the TES development array.

Additional Technology:
There is a planned competitive instrument/technology selection to provide additional performance at energies below 0.5 keV and above 10 keV. Candidate technologies include:

- gratings with E/ΔE ~1000 at energies below 1 keV
- hard X-ray detectors with sensitivity up to 40 keV
- multi-layer enhancement to the optics to provide more area at E > 10 keV

X-ray spectroscopy now rivals the optical for breadth and depth of science. The technologies needed for Con-X are well understood and performance has been demonstrated.

Smithsonian

Goddard Space Flight Center

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