Science with Constellation-X

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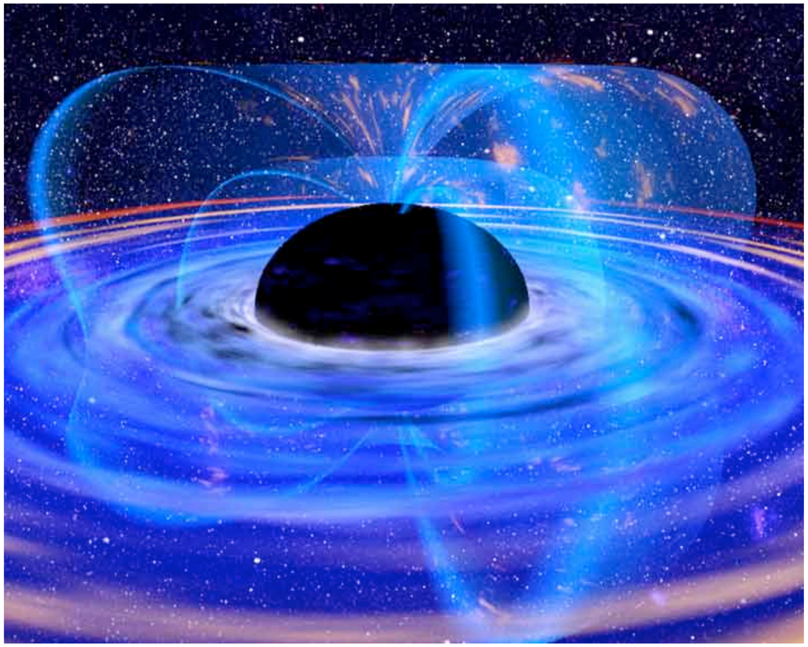
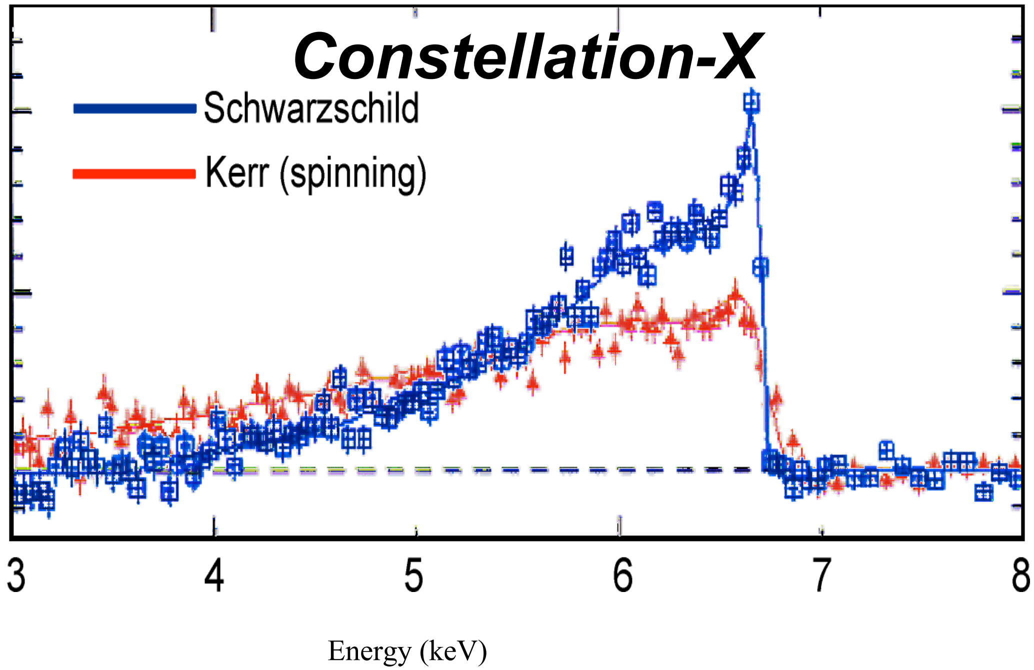
Black Hole Science with Con-X: 10^9 factor in mass, 10^9 factor in time

Examples of breadth of BH science:

- High signal-to-noise spectroscopy of Galactic BHs, black hole masses are well-constrained, precise masses allow for detailed measure of parameters such as spin **($<100\ M_{\odot}$)**
- Con-X has 200 μs timing resolution --> detailed timing analysis (QPO studies) of intermediate-mass black holes in local Universe **(10^3-$10^5\ M_{\odot}$)**
- Con-X will have the collecting area to identify nature of high-redshift quasars (**10^6-$10^{10}\ M_{\odot\hat{u}}$; $4 < z < 7$** *reaching times when the Universe was less than 10% its current age*)



Black Hole Science with Constellation-X

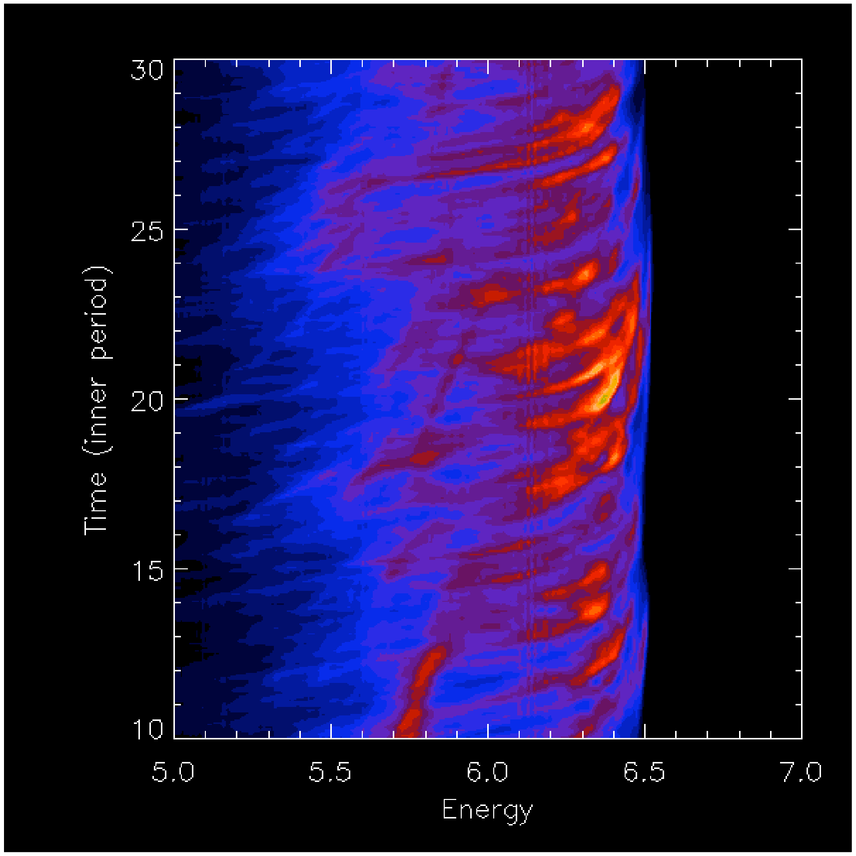


Constellation-X will probe close to the event horizon with 100 times better sensitivity to:

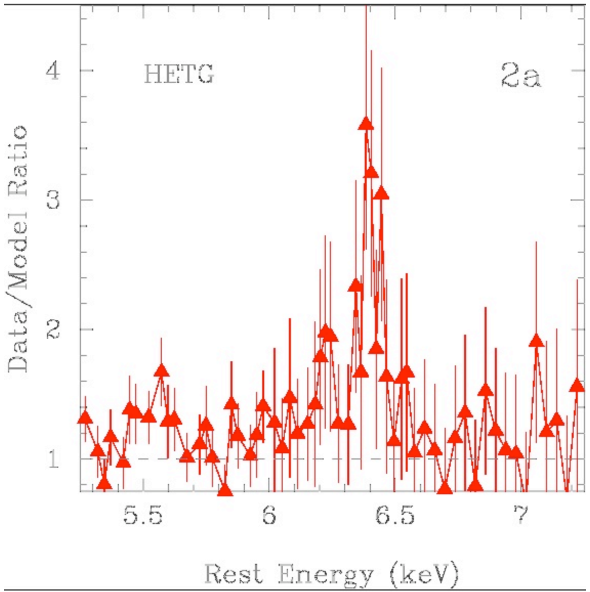
- ✓ Observe iron profile from the vicinity of the event horizon where strong gravity effects of General Relativity can be observed and determine black hole spin (*a* to ~10%)
- ✓ Pin down the evolution of black hole over a wide range of luminosity and redshift
- ✓ Constrain the role of Black Holes in Galaxy formation, and Cosmic Feedback

Iron Line Variability

- Constellation-X will allow detailed study of line variability
- See effects of non-axisymmetric structure orbiting in disk
  - ✓ Follow dynamics of individual "blobs" in disk
  - ✓ Quantitative test of orbital dynamics in strong gravity regime



Armitage & Reynolds (2003)



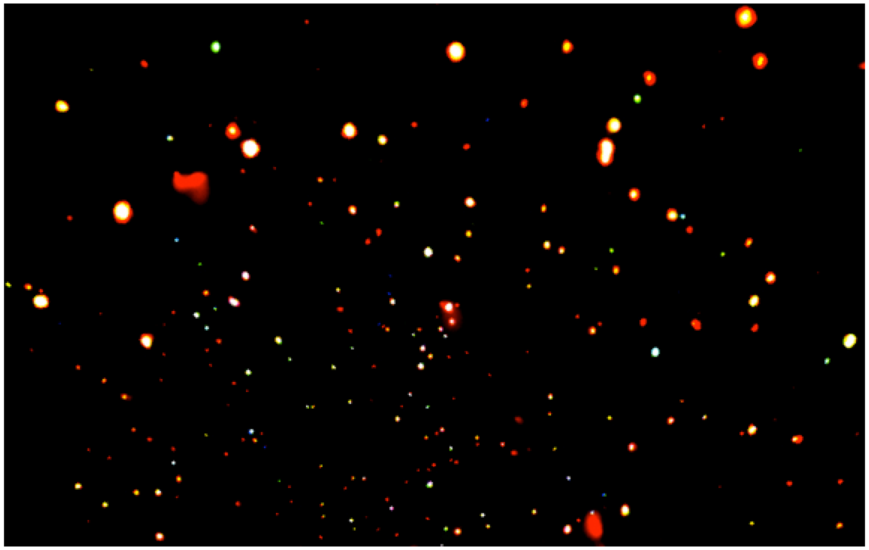
Chandra-HETG data on NGC3516 (Turner et al. 2002)

Evidence for non-axisymmetric structure may already have been seen by Chandra and XMM-Newton… Constellation-X area needed to confirm and utilize as GR probes

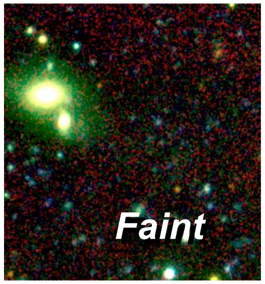
The Chandra Deep Fields

Chandra has resolved the X-ray background into active galactic nuclei (AGN) with a space density of a few thousand per sq deg

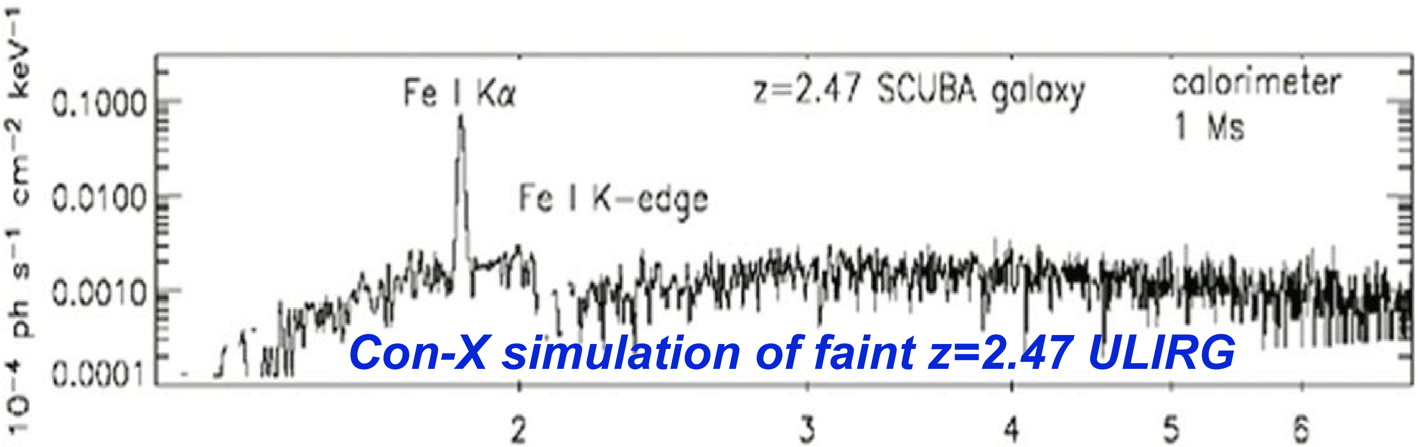
2 Megasecond Observation of the CDF-N
(Alexander et al. 2003)



HST Image of Optically Faint CXRB source

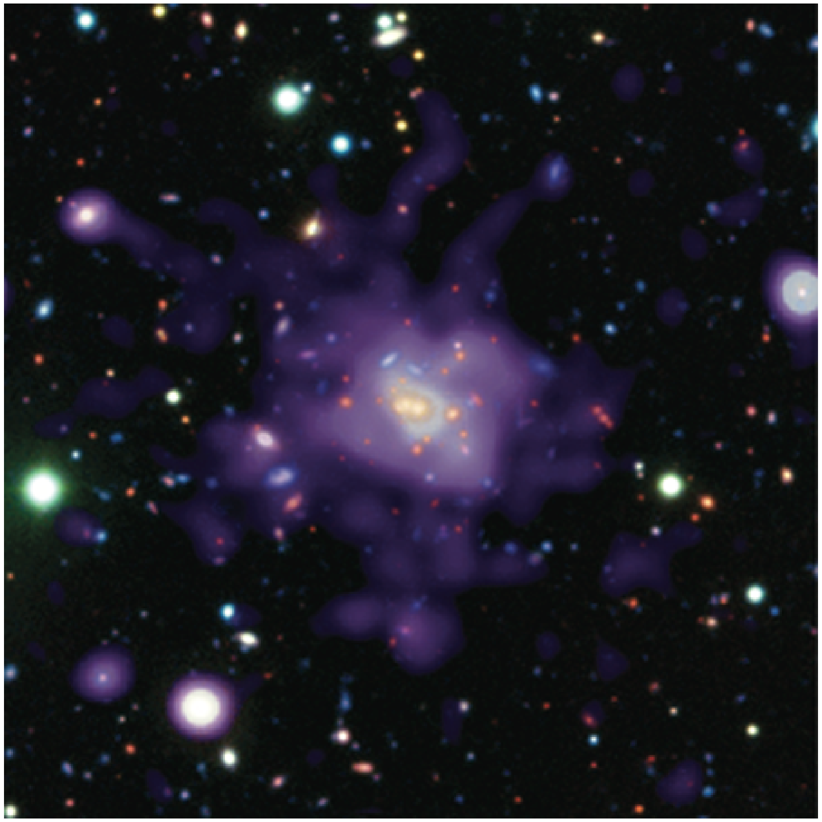


- Constellation-X will gather high-resolution X-ray spectra of the elusive optically faint X-ra



Con-X simulation of faint z=2.47 ULIRG

Clusters and Groups of Galaxies



RDCS 1252.9-2927:
z=1.2 cluster
(Rosati et al.2004)

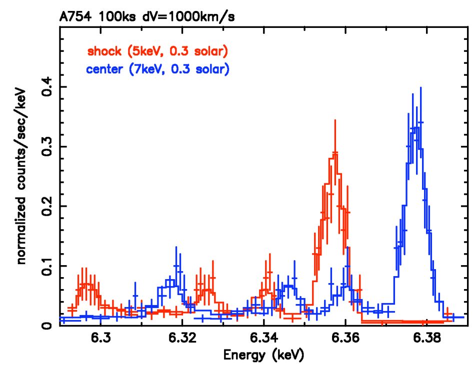
- Largest gravitationally bound structures in the Universe, most of the normal, baryonic matter lies in the hot X-ray emitting gas (10^6 - 10^8 K)
- Clusters are key to understanding the growth of structure in the Universe

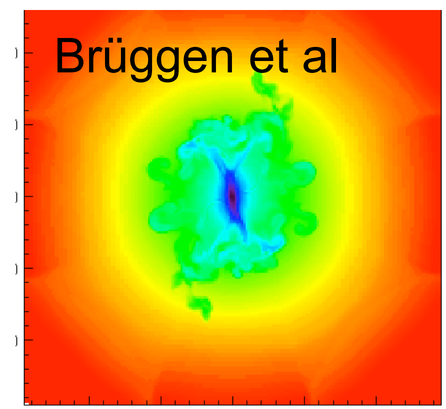
AGN Feedback and Clusters of Galaxies

Large scale-structure simulations require AGN feedback to regulate the growth of massive galaxies (e.g., Di Matteo et al. 2005, Croton et al. 2005)

Chandra & XMM have shown that accreting black holes affect their environments over megaparsec distances through heating the intra-cluster/inter-galactic medium (ICM/IGM)

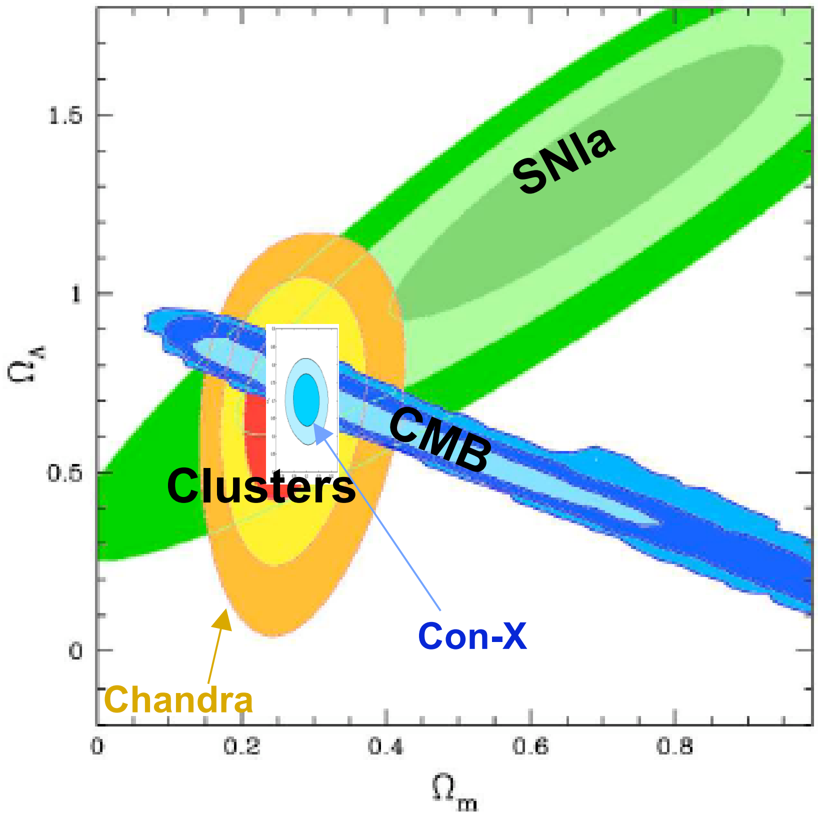
- Non-dispersive X-ray spectroscopy by Constellation-X will probe the hot ICM/IGM (Begelman et al. 2003,2005) by velocity measurements to establish a connection between heating phenomena and the AGN
  - The Con-X spectral resolution (<4 eV) will probe the ICM_s velocity field to 200 km/s or less
  - Map the bubbles_ velocity field and determine whether they are rising and/or expanding
  - AGN-induced turbulence in the ICM can be detected and spatially mapped
  - Con-X will measure abundance gradients (e.g., Brüggen et al.), which can show e.g., the extent of entrainment by the rising bubbles, and information about the ionization mechanisms in the cluster gas





Cosmological Parameters with Constellation-X

(Allen et al. 2004)

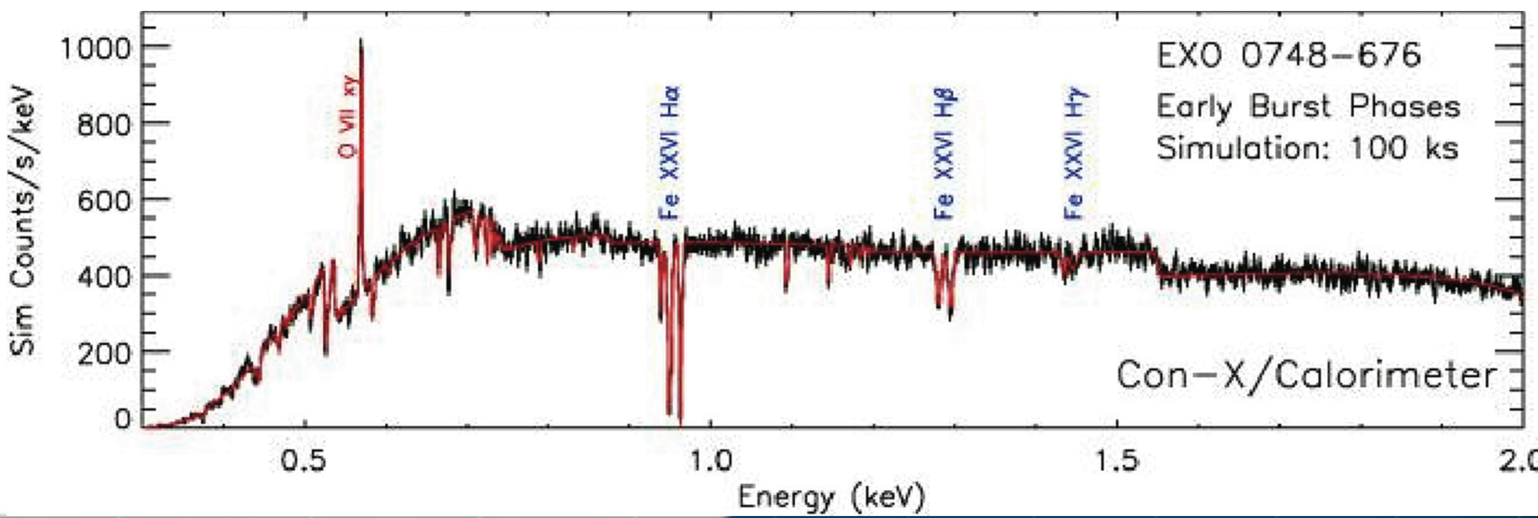


- Clusters CAN be used as 'standard' candles – kT, Fx, size -> Distance, 26 Chandra clusters 2004 MNRAS
- A large snapshot survey followed by deeper spectroscopic observations of relaxed clusters will achieve f_{gas} measurements to better than 5% for individual clusters:
  - Corresponds to Ω_M=0.300±0.007, Ω_Λ=0.700±0.047
  - For flat evolving DE model,

    w_0 = -1.00±0.15, w' = 0.00±0.27

Fundamental Physics with Neutron Stars

- Densest states of matter
- Mass & radius depends directly on interactions between e.g., protons, neutrons & their constituent quarks
- Accreting sources provide rich supply of metals: thermonuclear X-ray bursts produce rich absorption spectra (J. Cottam talk on Wednesday on EXO 0748-676)
- Absorption spectra provide a direct measure of gravitational redshift at surface of the star
- Con-X will provide many higher S/N measurements of X-ray burst absorption spectra (*ALSO: pulse shapes of burst oscillations encode information on the neutron star mass and radius*)
- NS radii will be measured to a few percent (compare with 9.5-15 km constraints for EXO 0748-676)



Community Input for NAS review

- Contributions are invited on prospective Con-X science programs

- Science team leaders for NAS review:
  - C. Reynolds (UMd): **Supermassive Black Holes, GR, BH Spin**
  - R. Mushotzky (GSFC): **Galaxy Clusters, Feedback, BH Evolution**
  - J. Hughes (Rutgers): **Supernova Remnants**
  - J. Bregman (UMich): **Warm-Hot IGM**
  - T. Strohmayer (GSFC) **Neutron Stars & Fundamental Physics**
  - J. Drake (SAO): **Stars, Life Cycles of Matter**

- Contact these leaders and/or

Michael Garcia (garcia@cfa.harvard.edu) to get involved!

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