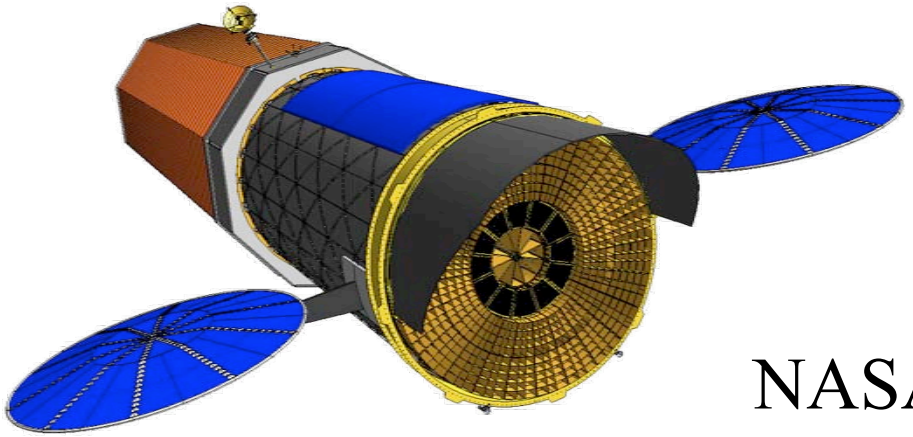
The International X-ray Observatory
IXO



Ann Hornschemeier

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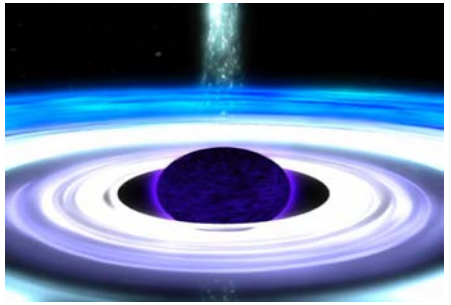
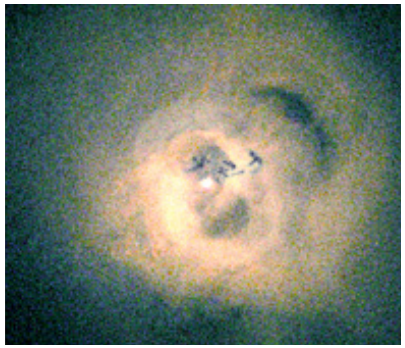
NASA GSFC

For Jay Bookbinder and the IXO Team

Main Science Topics

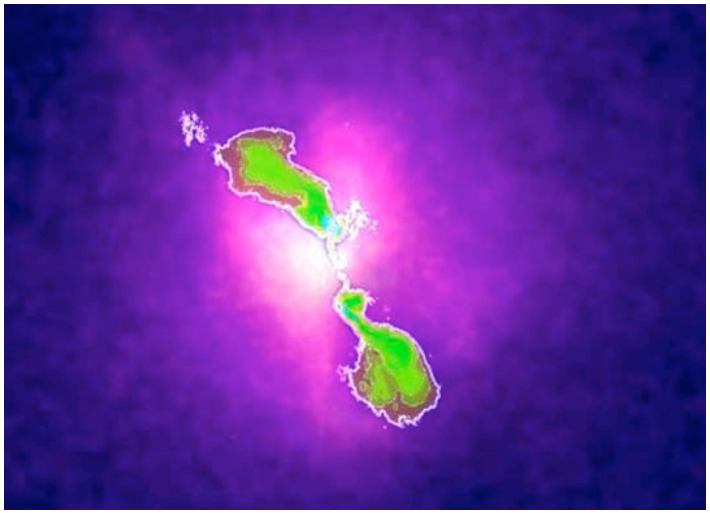
- Black Holes and Matter under Extreme Conditions
- Formation and Evolution of Galaxies, Clusters, and Large Scale Structure
- Life Cycles of Matter and Energy





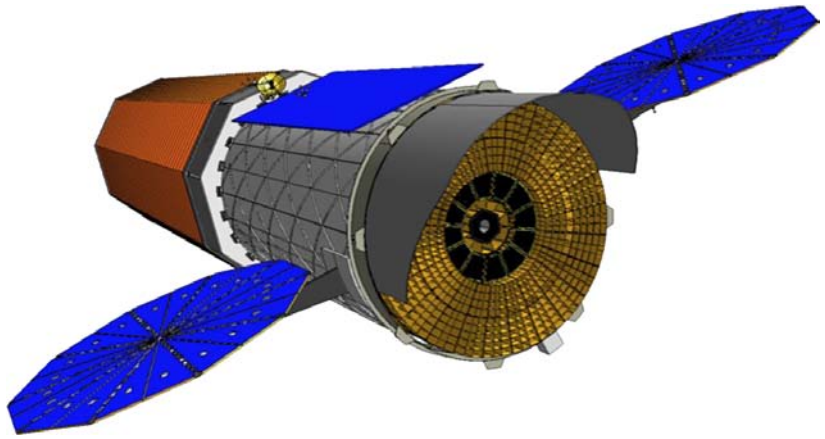
The International X-Ray Observatory

- What happens close to a black hole?
- When and how did super-massive black holes grow?
- How does large scale structure evolve?
- What is the connection between these processes?



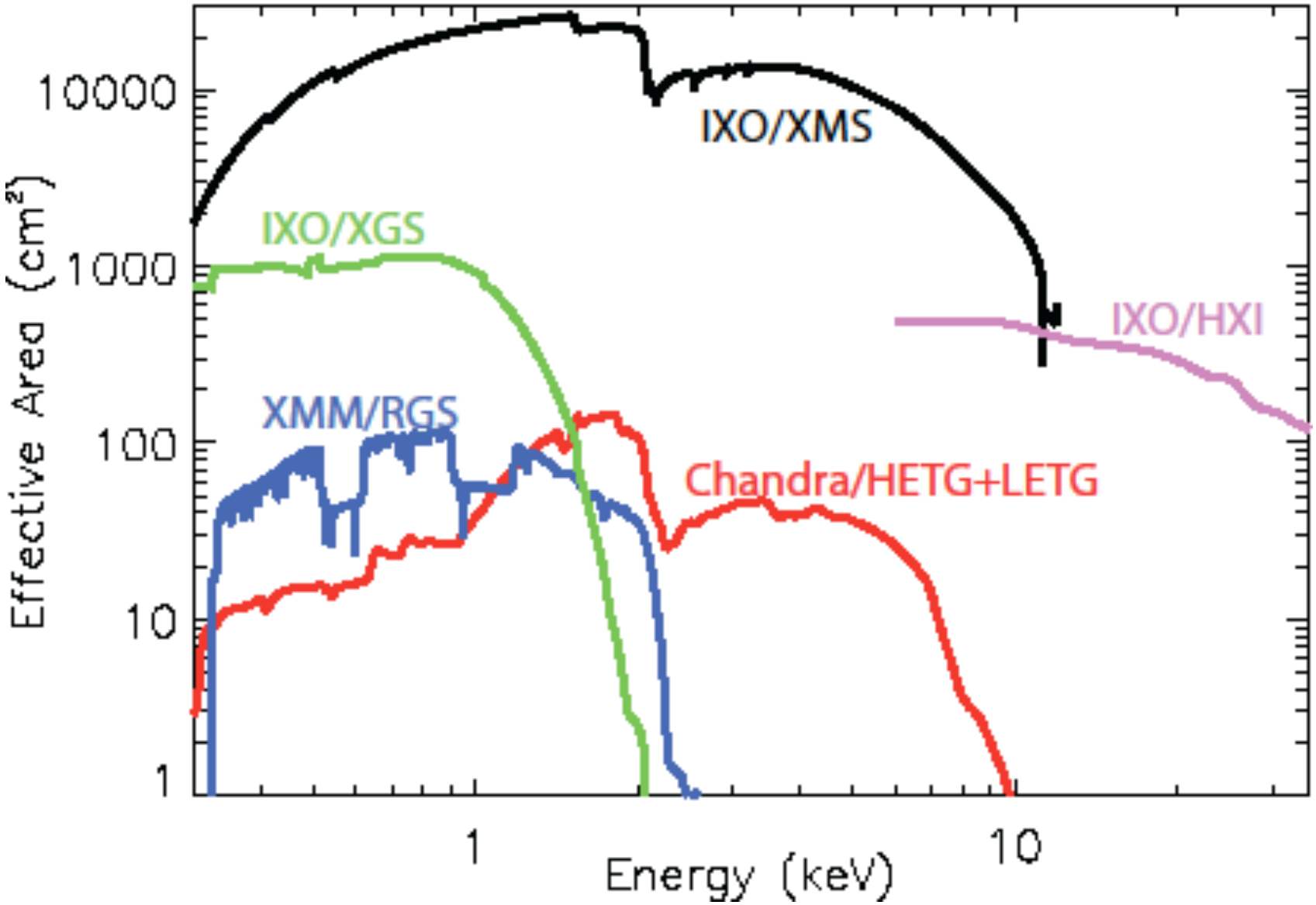
Hydra A Galaxy Cluster

A 100-fold increase in effective area for high-resolution spectroscopy, along with wide field of view imaging, polarimetry & timing



- 20 m focal length
- Mass ~6100 kg (40% margin)
- EELV or Ariane V
- L2 orbit
- 5 year lifetime; 10 year goal

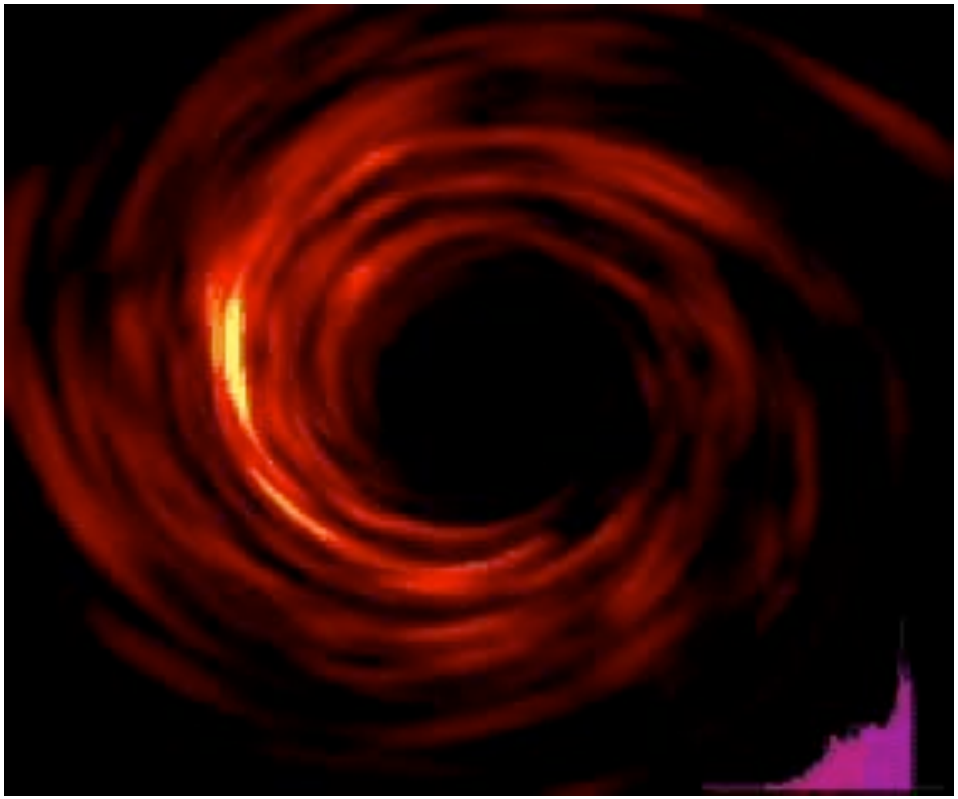
Effective area comparison with previous missions



Testing GR: Black Hole Spin

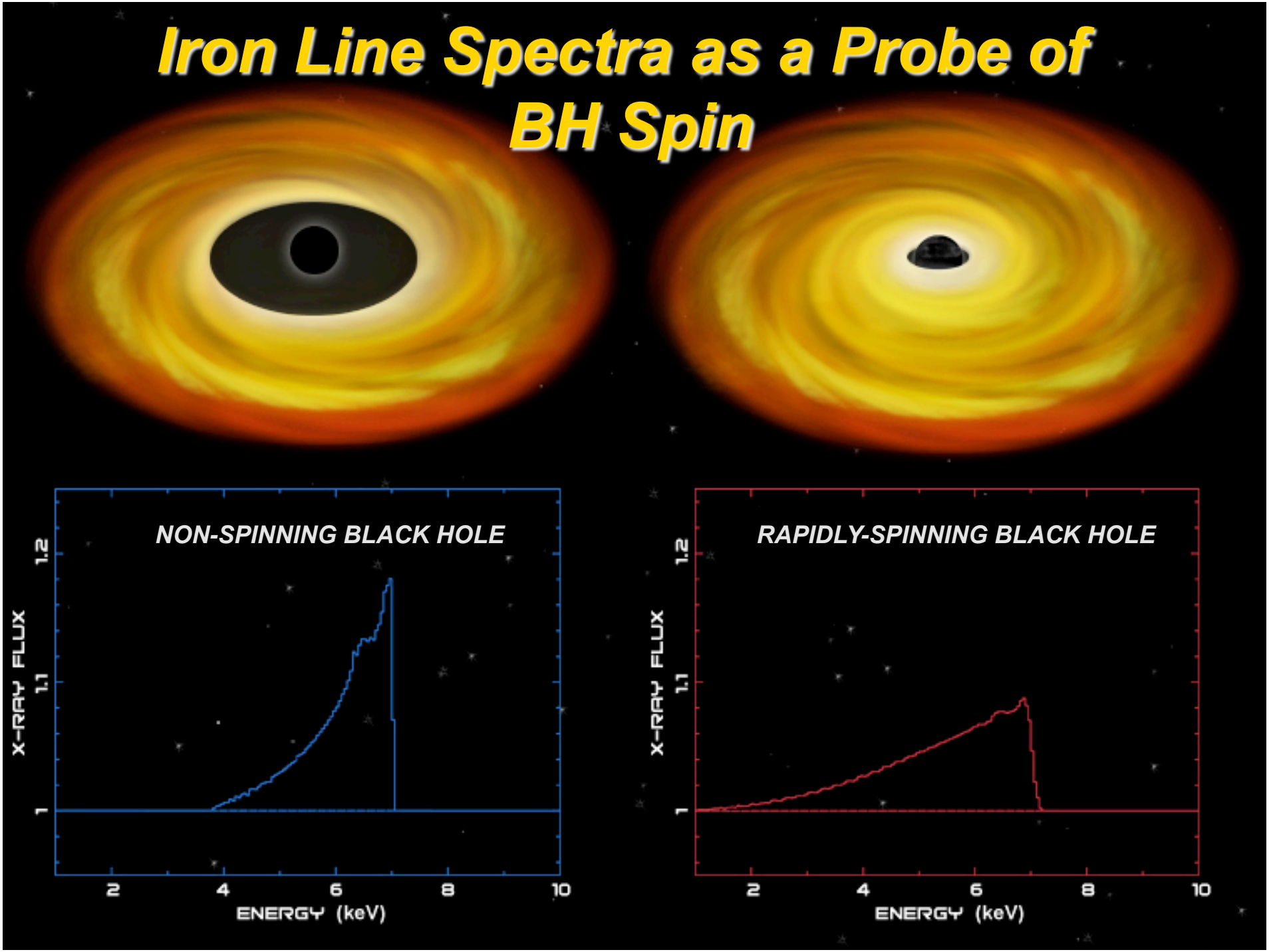
IXO will study detailed line variability on orbital times scale close to event horizon in nearby supermassive Black Holes:

- ✓ *Dynamics of individual "X-ray bright spots" in disk to determine mass and spin*
- ✓ *Quantitative measure of orbital dynamics: Test the Kerr metric*



Magneto-hydro-dynamic simulations of accretion disk surrounding a Black Hole (Armitage & Reynolds 2003)

Iron Line Spectra as a Probe of BH Spin



Supermassive Black Hole Spin & Growth

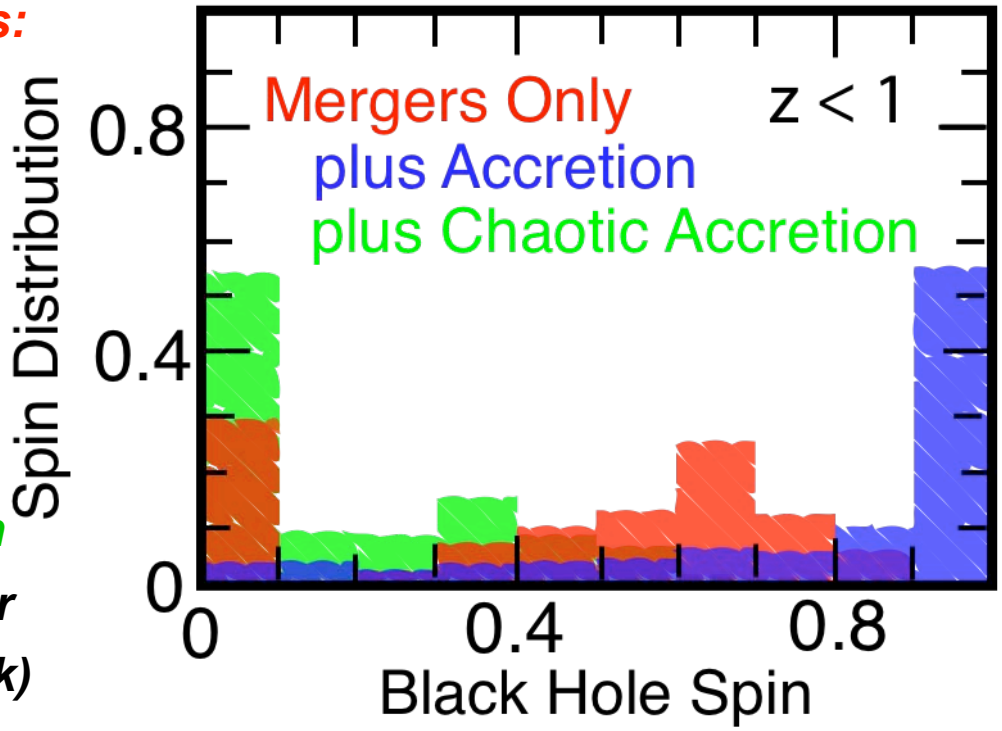
Merger-only of similar mass BHs:

broad distribution of spins

Mergers with standard accretion: ***mostly maximally spinning black holes***

Mergers plus chaotic accretion

(growth from absorbing smaller (0.1%) SMBHs, no accretion disk) leads to slow rotation.



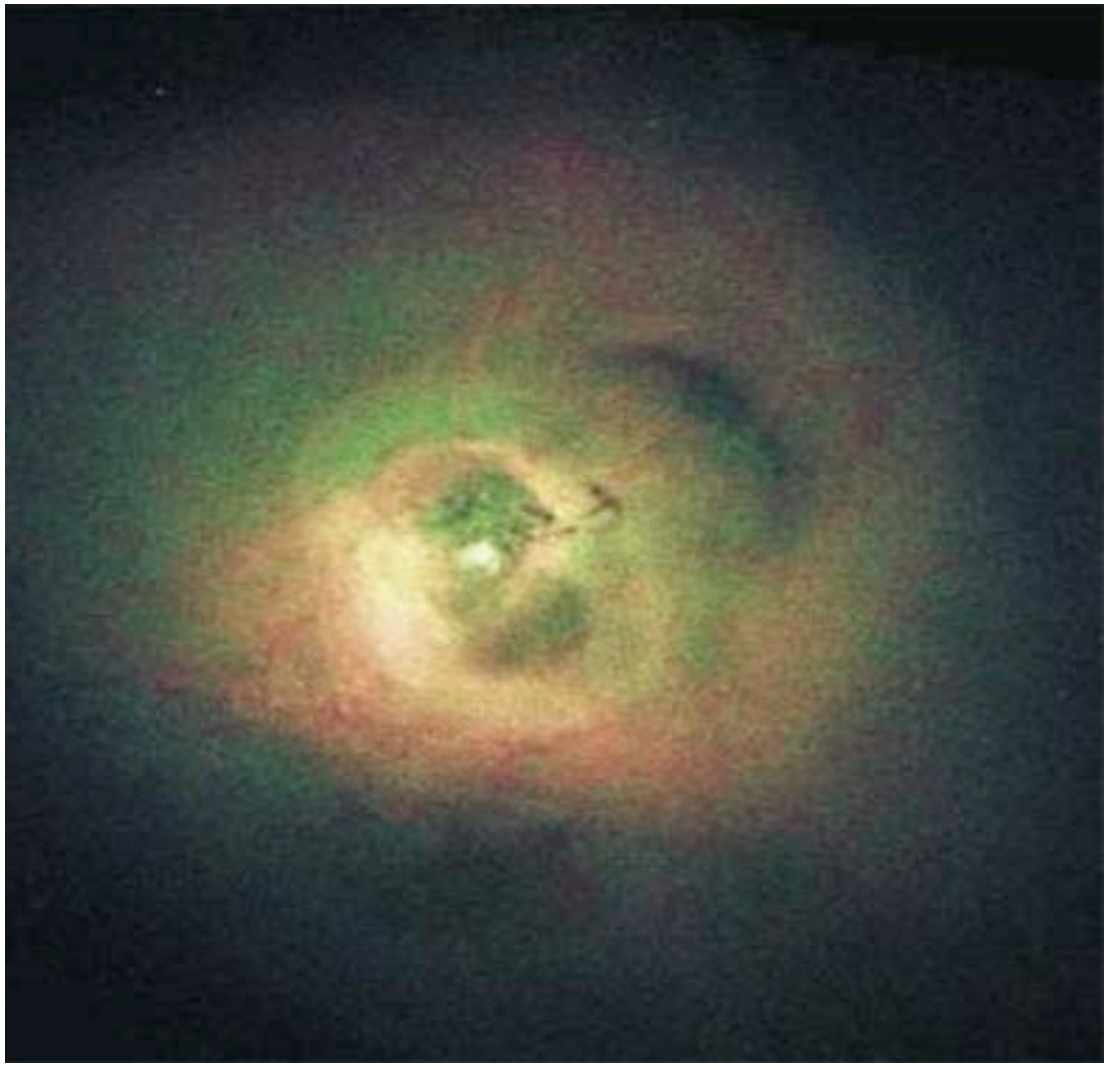
based on Berti & Volonteri (2008)

Cosmic Feedback

Supermassive black hole feedback must regulate the growth of galaxies and clusters of galaxies

Velocity measurements crucial to determine heating and state of hot gas found within clusters of galaxies

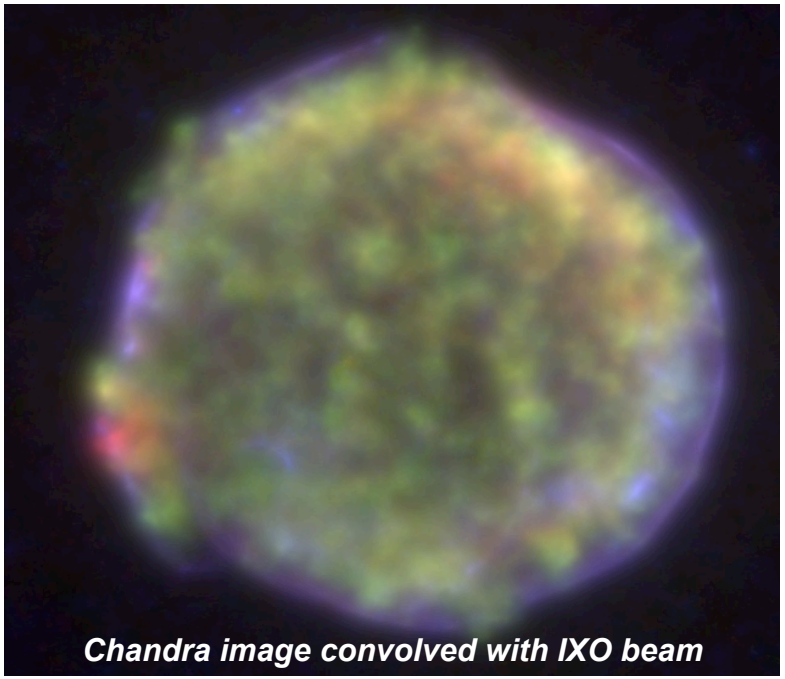
IXO will probe this hot gas through velocity measurements accurate to the required ~100km/s



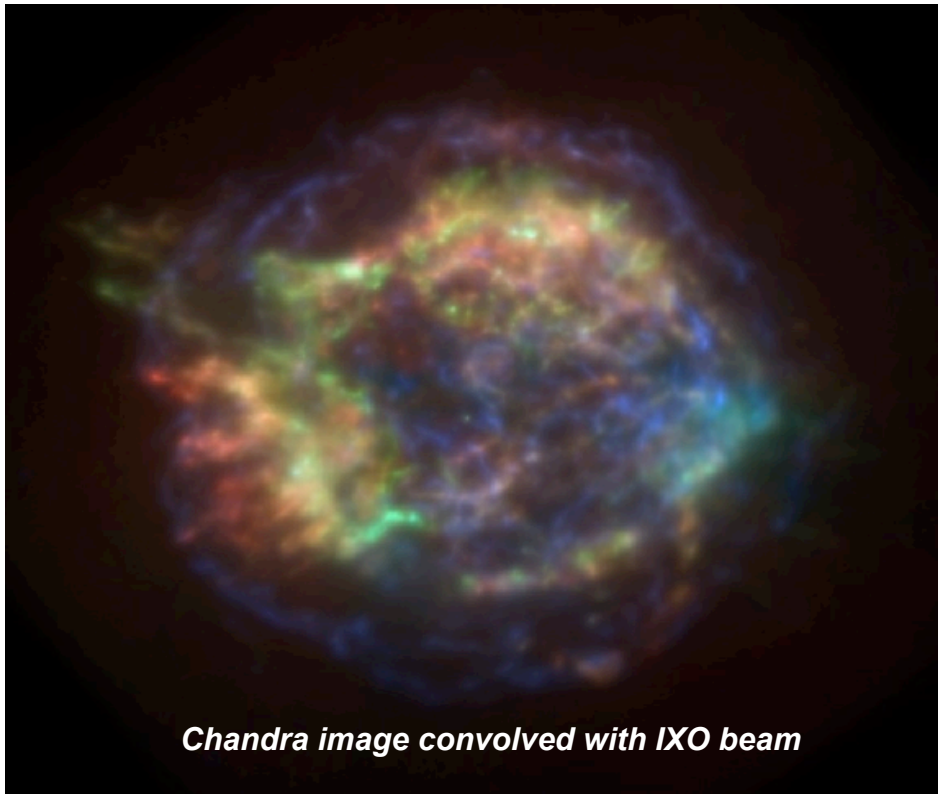
Forming the Elements

- **Uniquely** illuminate the composition and dynamics of the shocked ejecta and ambient medium

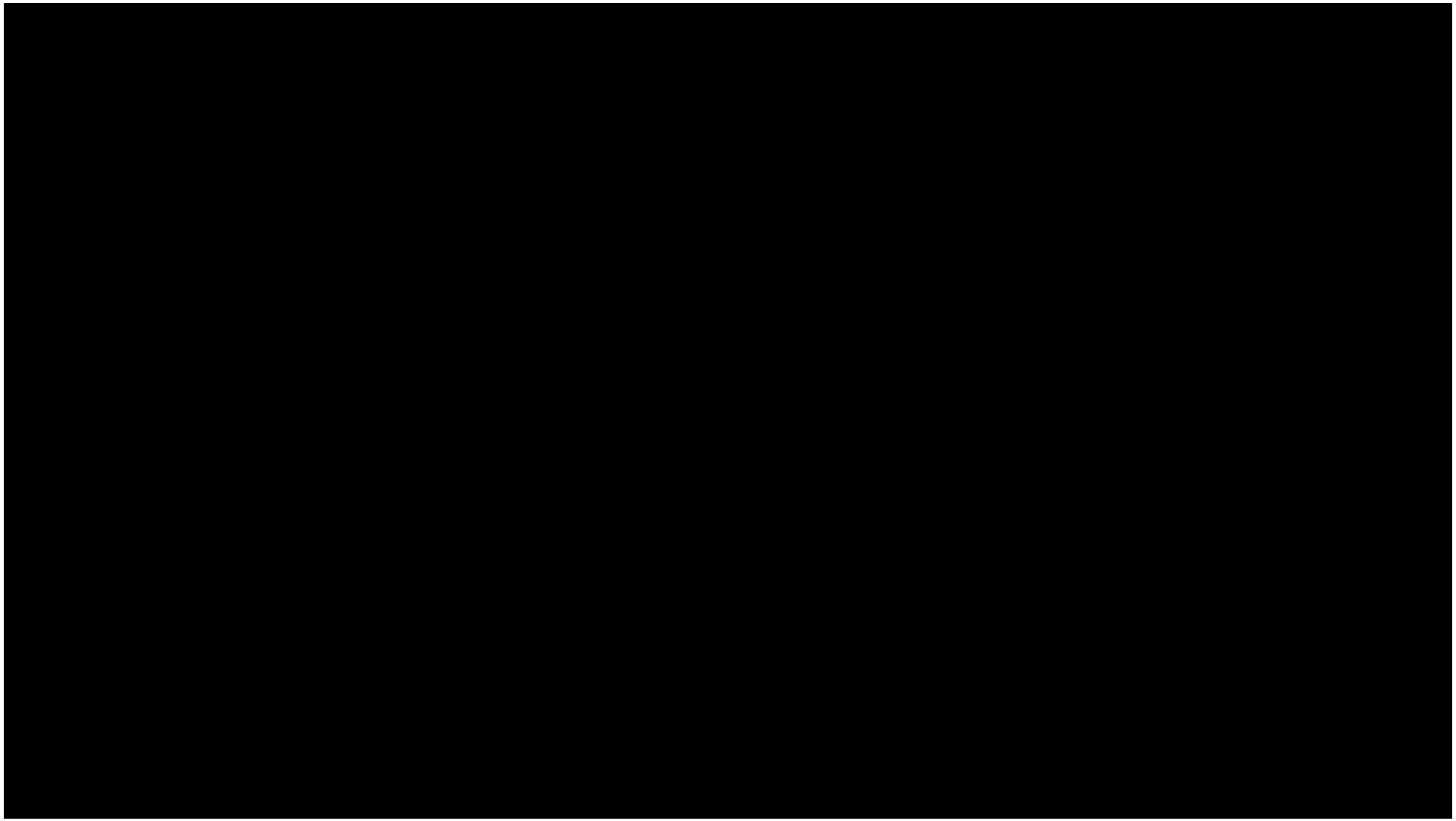
- offer a 3-D view of SN remnant ejecta – in an individual point-like SN, only sample line-of-sight



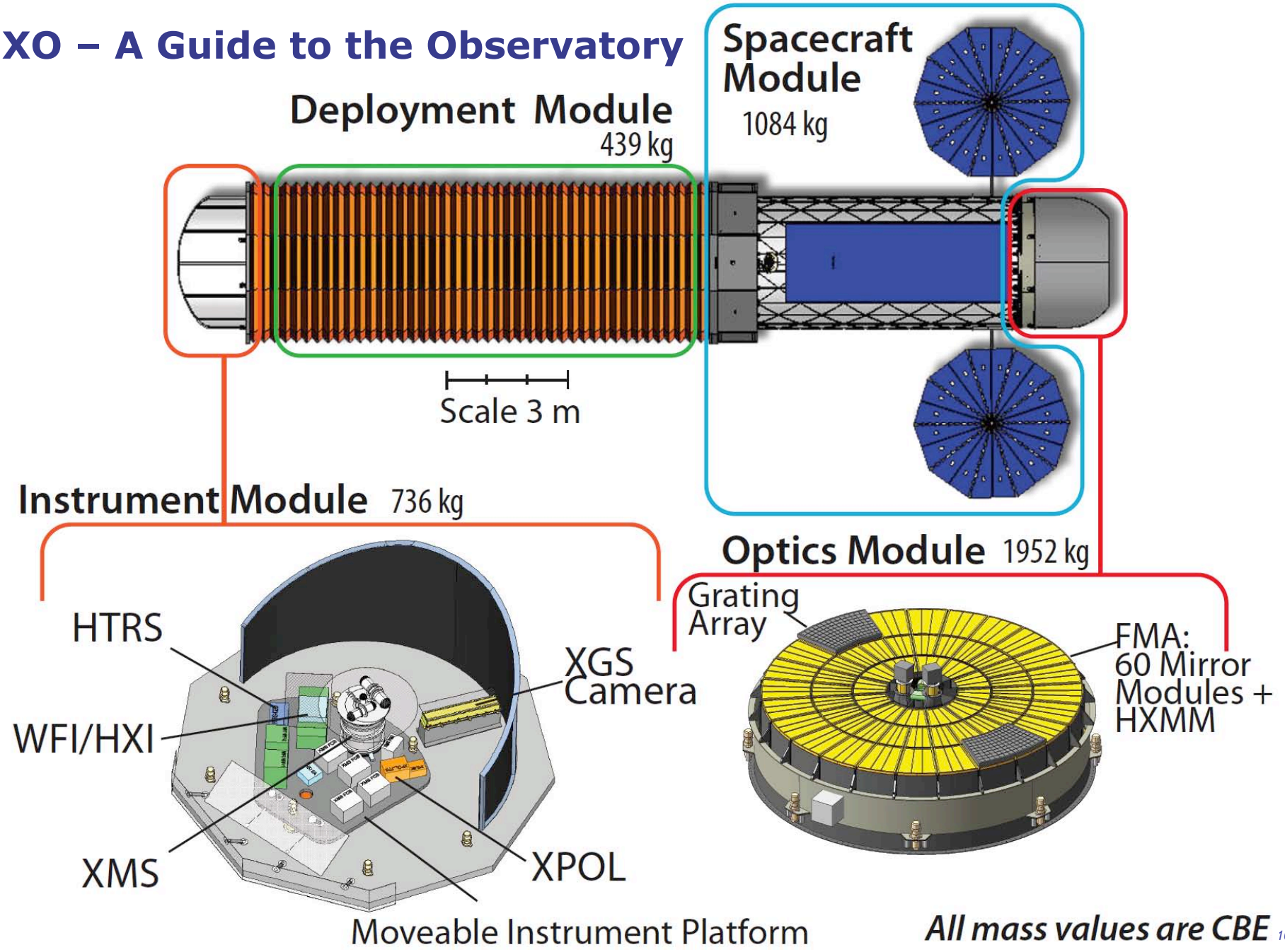
Chandra image convolved with IXO beam



Chandra image convolved with IXO beam

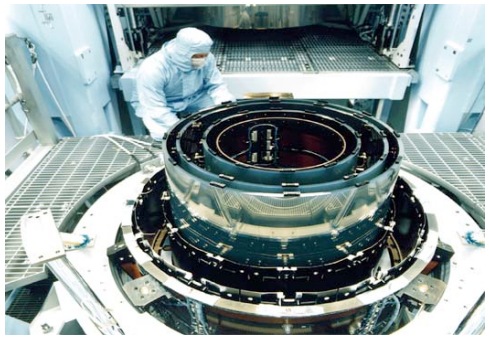


IXO – A Guide to the Observatory

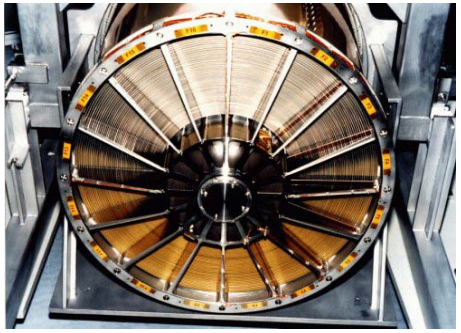


All mass values are CBE

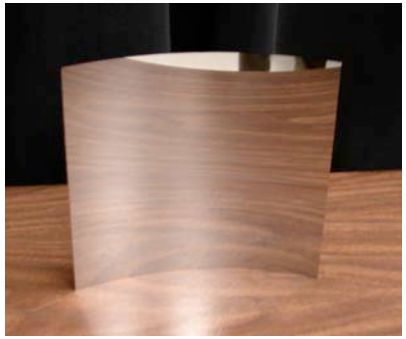
Optics Technologies: The Challenge of Resolution and Mass



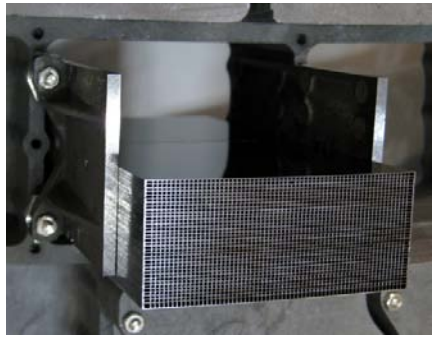
CHANDRA
0.5”
18500 kg/m²



XMM-NEWTON
14”
2300 kg/m²



Slumped Glass
5”
~270 kg/m²

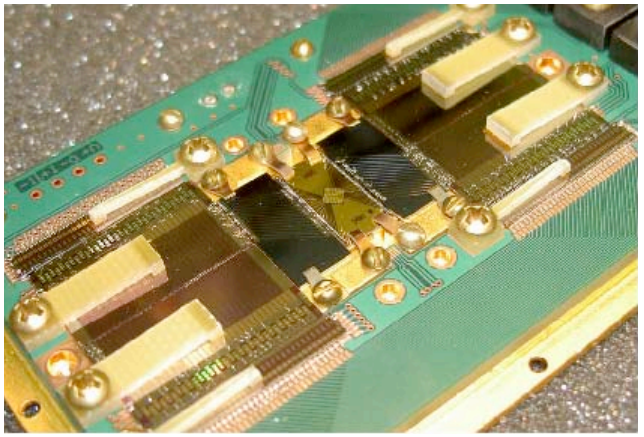


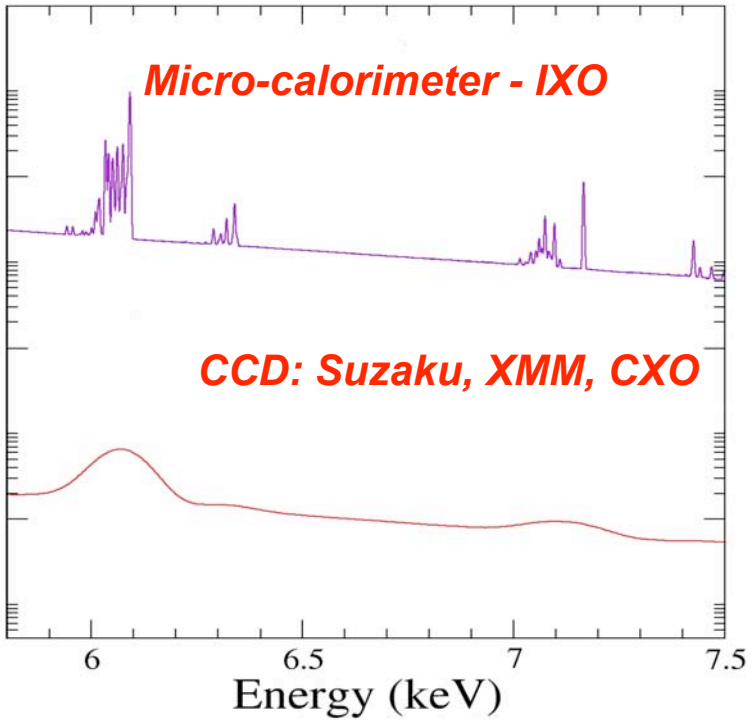
Si-HPO
5”
~200 kg/m²

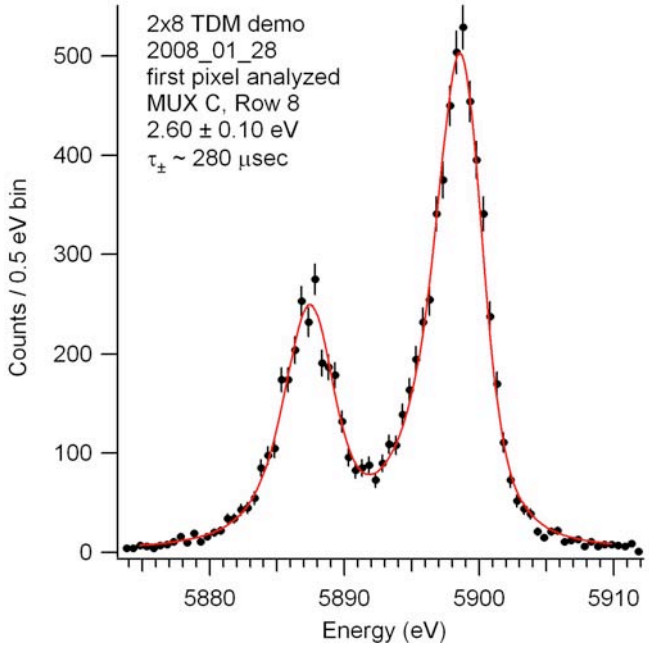
IXO Options

Example of Next Generation Instrument Capability: X-ray Micro-calorimeter Spectrometer (XMS)

- ***Thermal detection of individual X-ray photons***
  - ***High spectral resolution***
  - ***ΔE very nearly constant with E***
  - ***High intrinsic quantum efficiency***



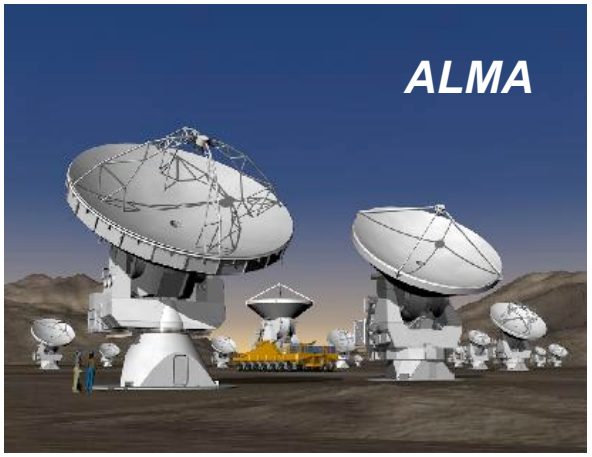


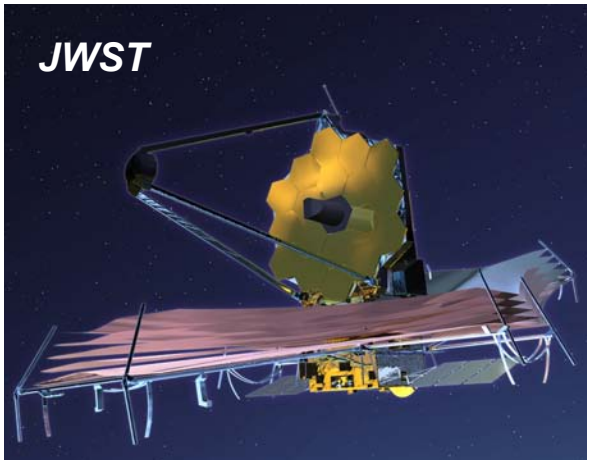


Energy resolution of 2.6 eV

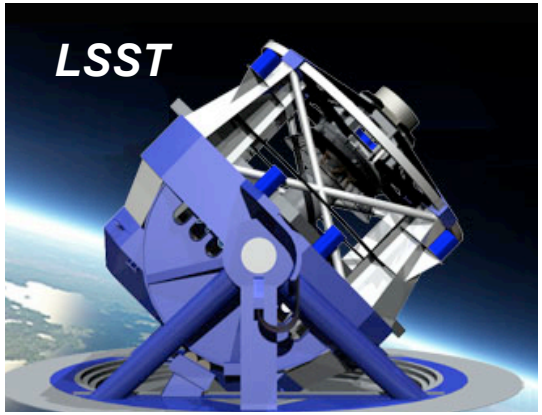
IXO: A Future Great Observatory

Sub-mm

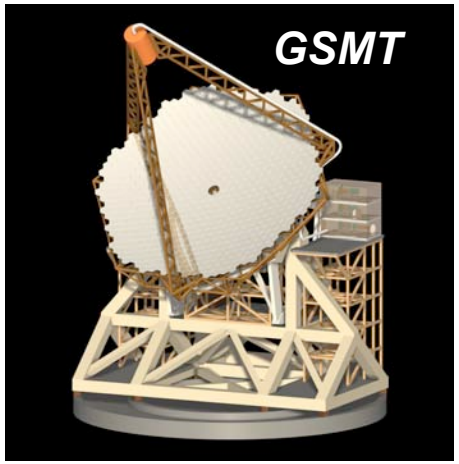


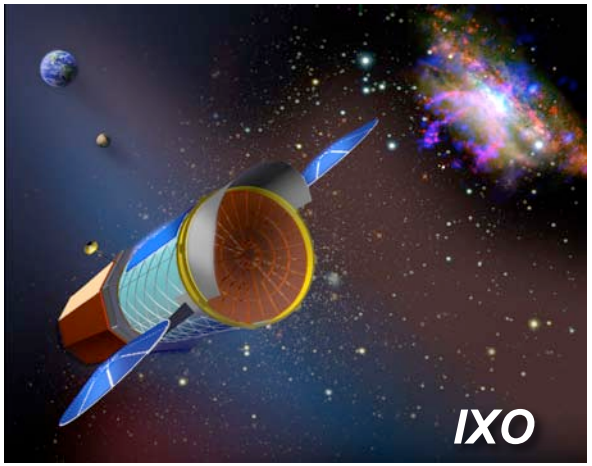


IR



Optical

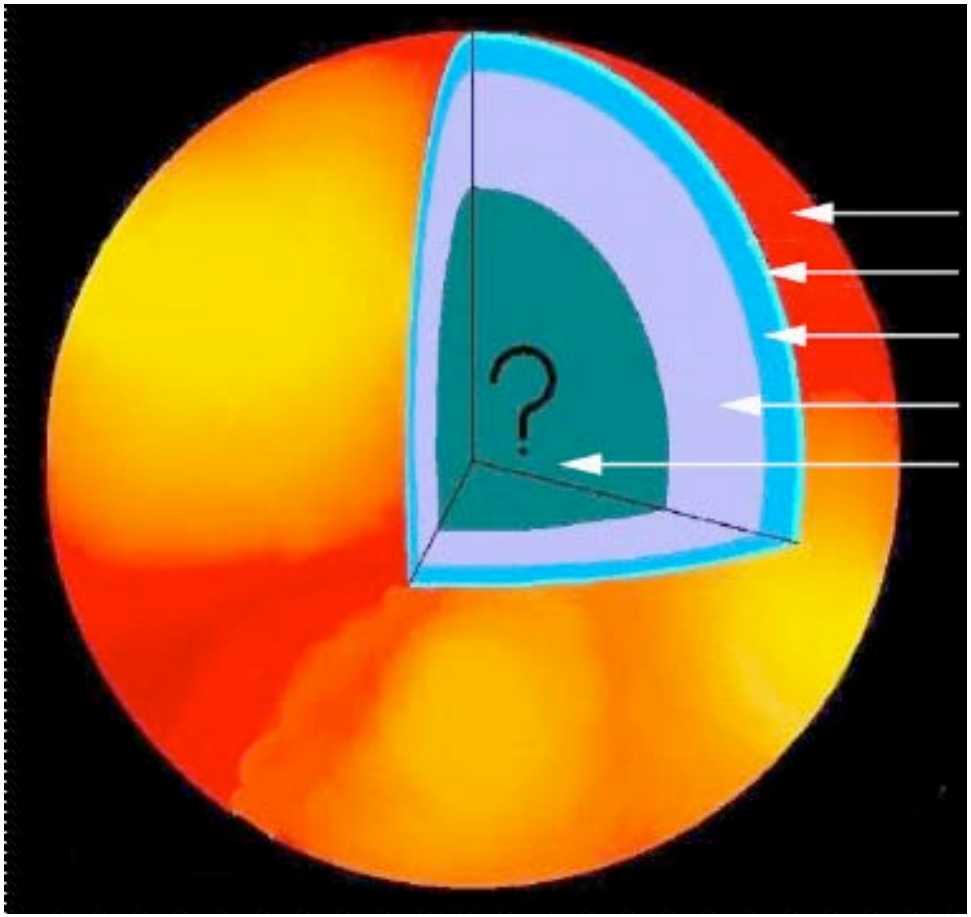




X-ray

The two order of magnitude increase in capability of IXO is well matched to that of other large facilities planned for the 2010-2020 decade

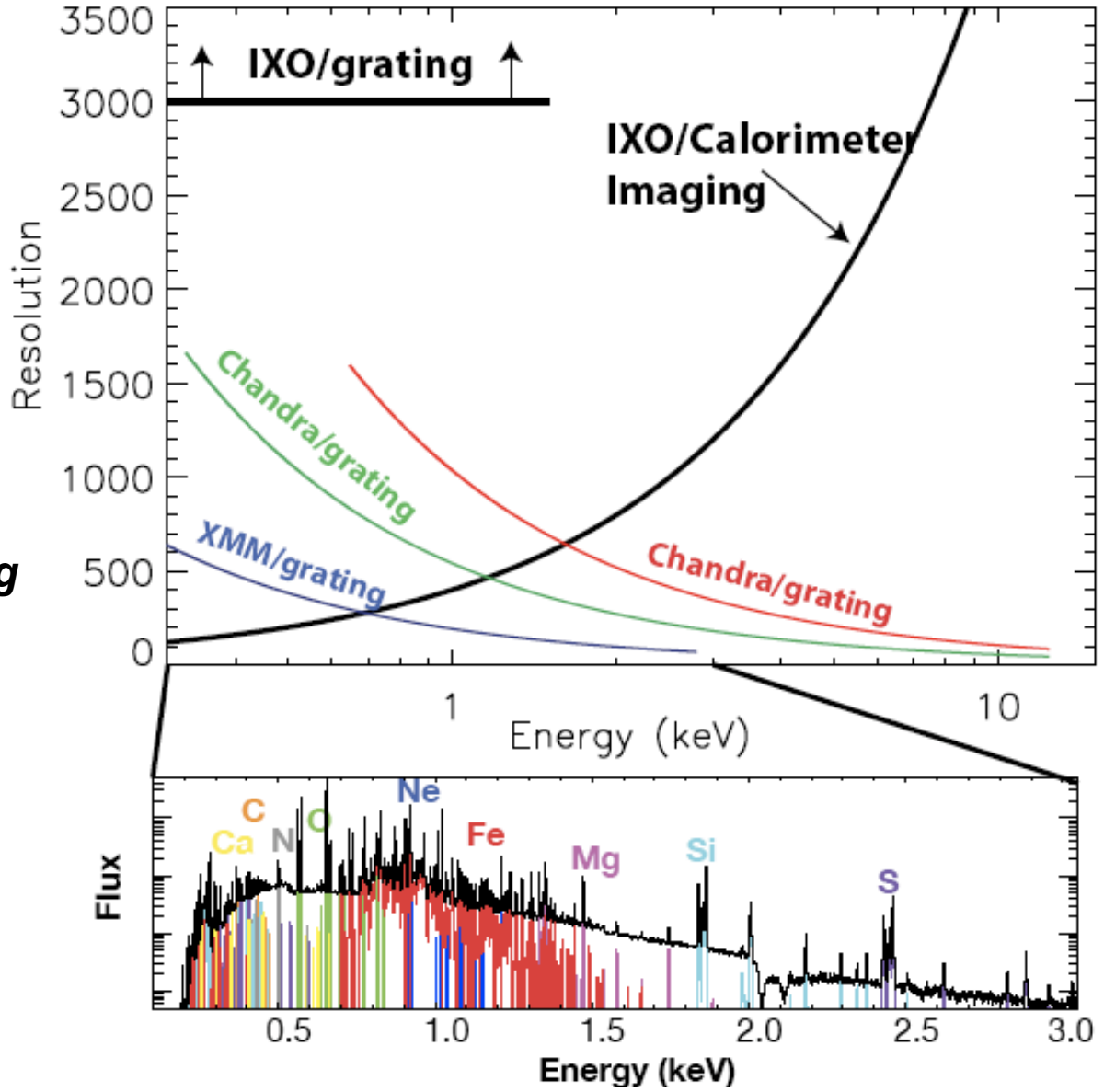
Neutron Star Equation of State



- Outer crust 'normal', but core uncertain.
- Hard to extrapolate from normal nuclei (~50% protons) to the high-density regime of nearly 0% proton fraction.
- EOS models depend upon assumptions made about the phase of matter in the core: (e.g., hadrons, Bose-Einstein condensates, quark matter).
- Each new phase increases the compressibility of the star, allowing for a smaller NS.

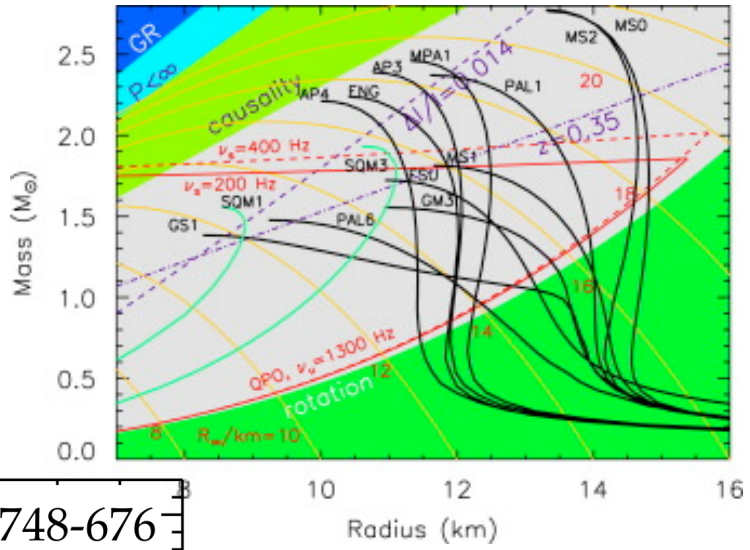
Spectral Capability

The IXO energy band contains the K-line transitions of 25 elements Carbon through Zinc allowing simultaneous direct abundance determinations using line-to-continuum ratios, plasma diagnostics and at iron K bulk velocities of 100 km/s



Neutron Star Equation of State

With measurements of EXO 0748-676 and a dozen other suitable sources, IXO will define the EOS for neutron star matter and answer long-standing questions about QCD.



Lattimer & Prakash 2007