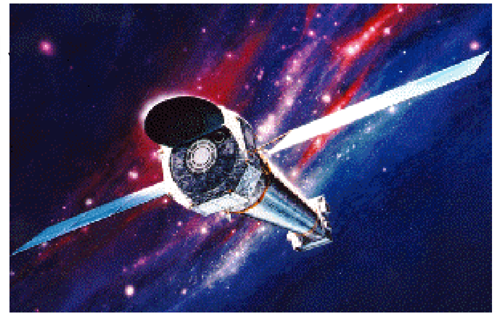
Current and future high-resolution X-ray missions and their atomic data needs

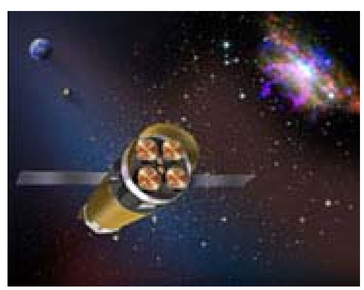
Randall Smith
JHU & NASA/GSFC

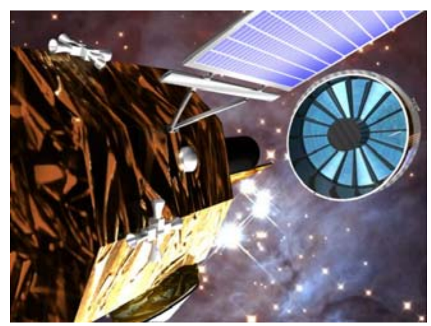
- **Existing Missions**
  - Chandra
  - XMM-Newton

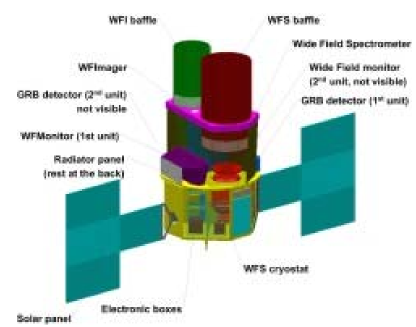


- **Short-term Missions (< 5 years)**
  - Spectrum-X Gamma
  - NeXT

- **Longer-term Missions (5+ years)**
  - Constellation-X
  - XEUS
  - EDGE



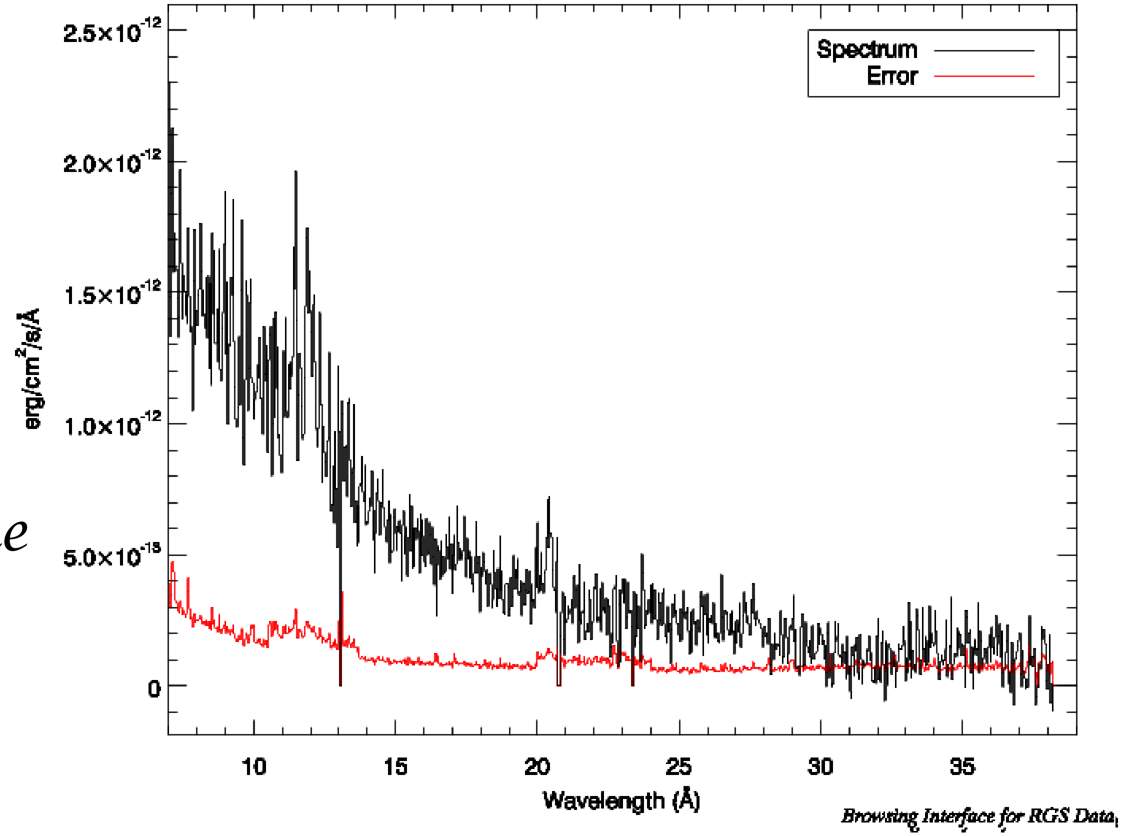




- XMM Reflection Grating Spectrometer
  - 2 units, RGS1, RGS2
  - Range 7Å - 38Å; Δλ ~ 0.06Å; R ~ 300

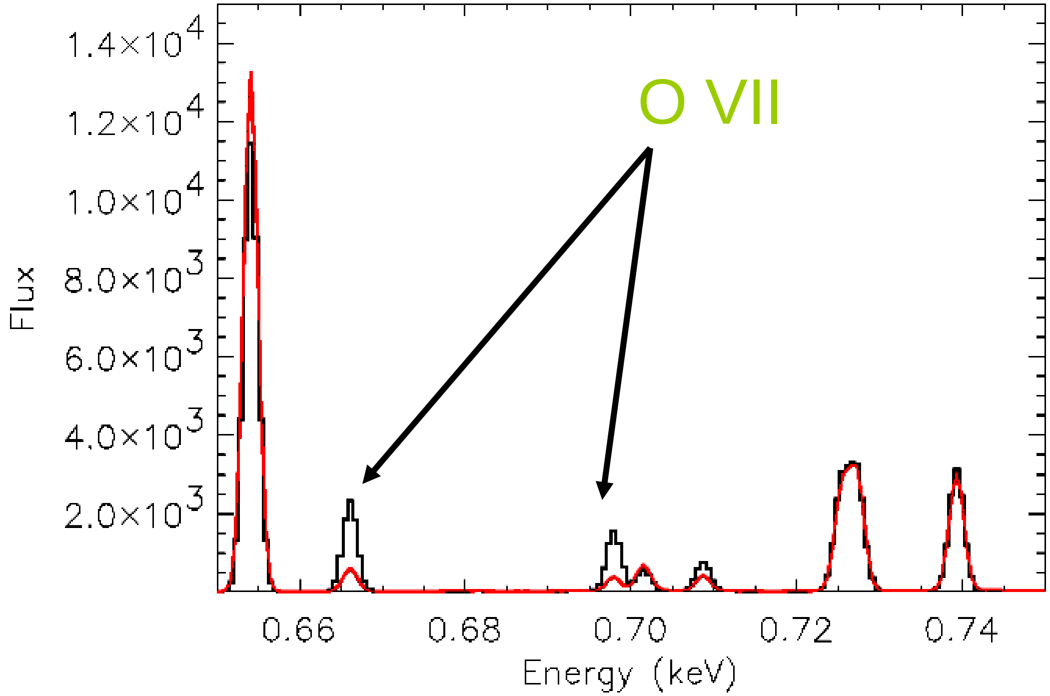
*For **bright** point or slightly (<1') extended sources, the RGS is very powerful.*

*For **fainter** sources (A3112), the spectra aren't as clear.*



- Chandra HETG: (HEG, MEG)
  - Range 1.2-31Å, $\Delta\lambda$=0.012Å, 0.023Å
  - Highest resolution of any available instrument, although effective area **tiny**.
- Chandra LETG:
  - Range 1.2-175Å
  - $\Delta\lambda$=0.05Å
- Blending still an issue

A shock (with kT~0.7 keV) seen with CCD



A one temperature, fixed $n_e t$ ionizing collisional plasma model fits the data quite well.

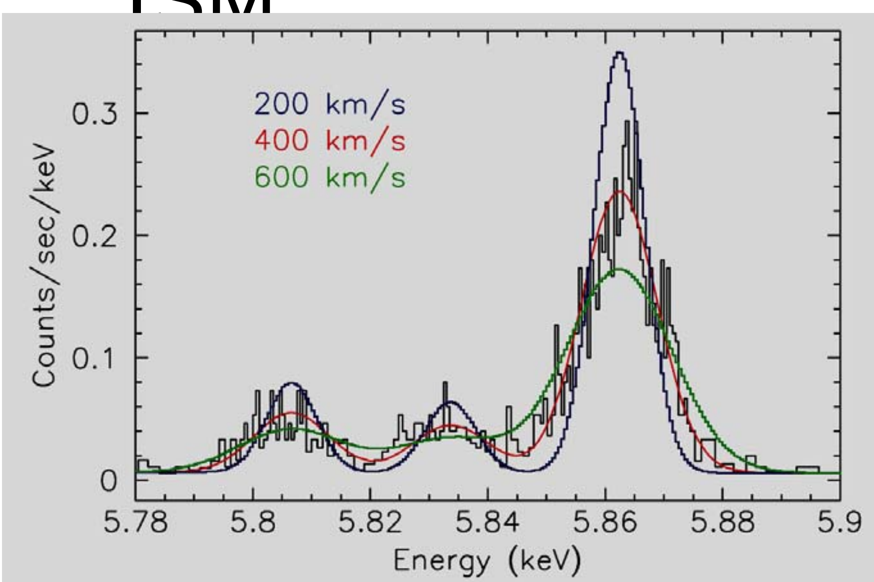
But with higher resolution and more effective area...

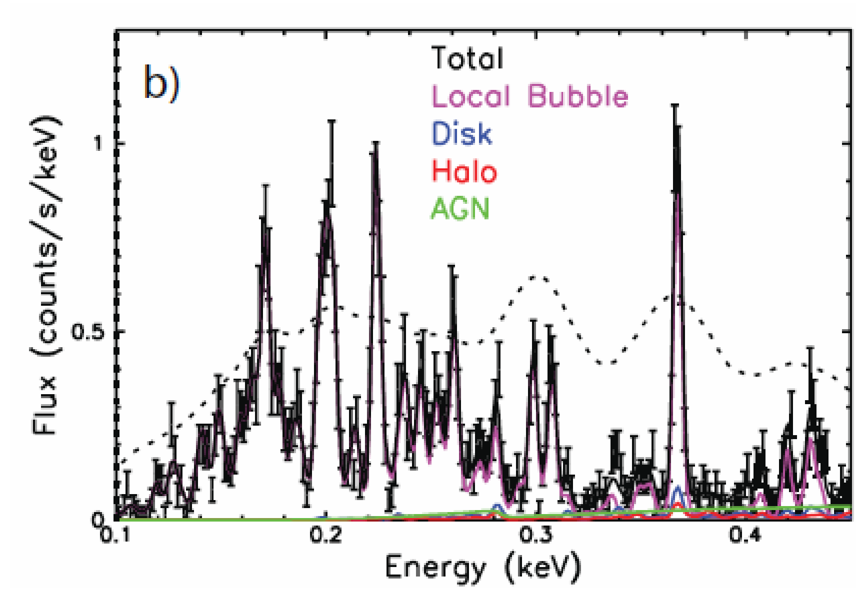
...the fixed $n_e t$ model fails, a distribution is needed.

- Why always a 1-50Å (0.25-10 keV) range?
  - Top end set by elemental abundances; Ni the last abundant element: all lines have λ > 1Å.
  - Low end set by absorption
    - "Minimal" absorption is ~10^{20} cm^{-2}.
    - At 50Å, this absorption leads to τ ~ 0.5
- Resolution needed limited (in part) by thermal

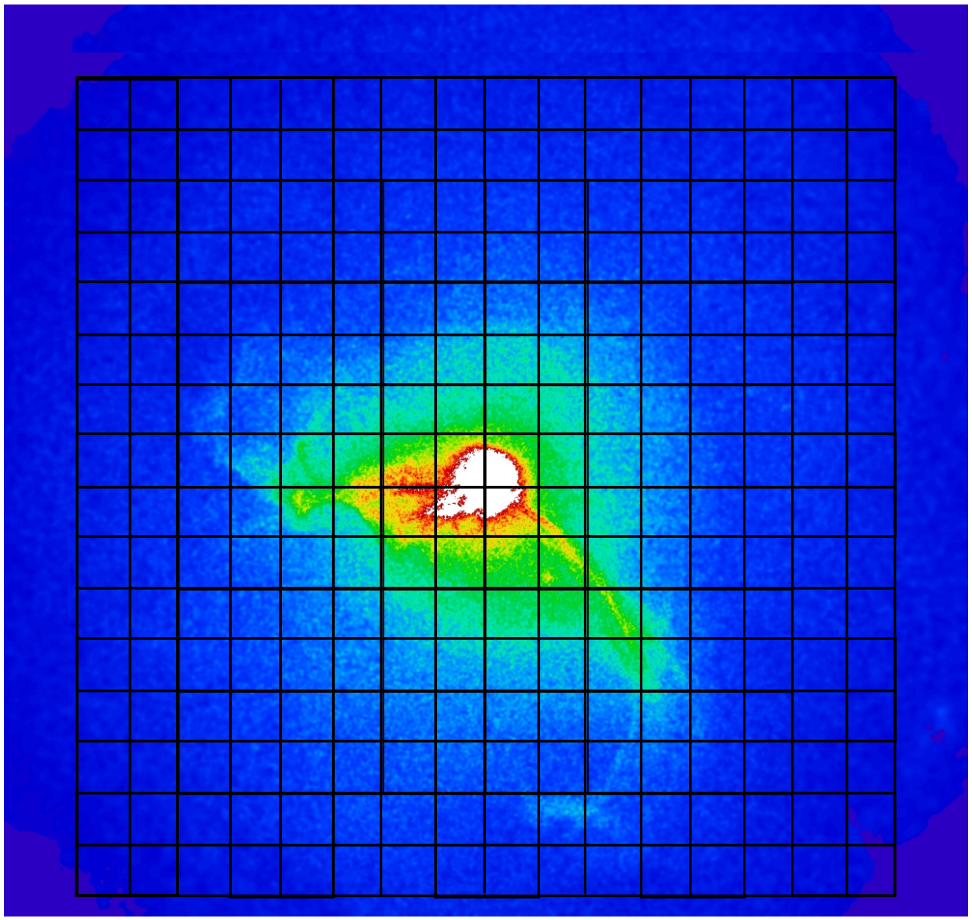
$$R = 410\sqrt{\frac{M_{\rm amu}}{T_{\rm keV}}} \leq 3000$$

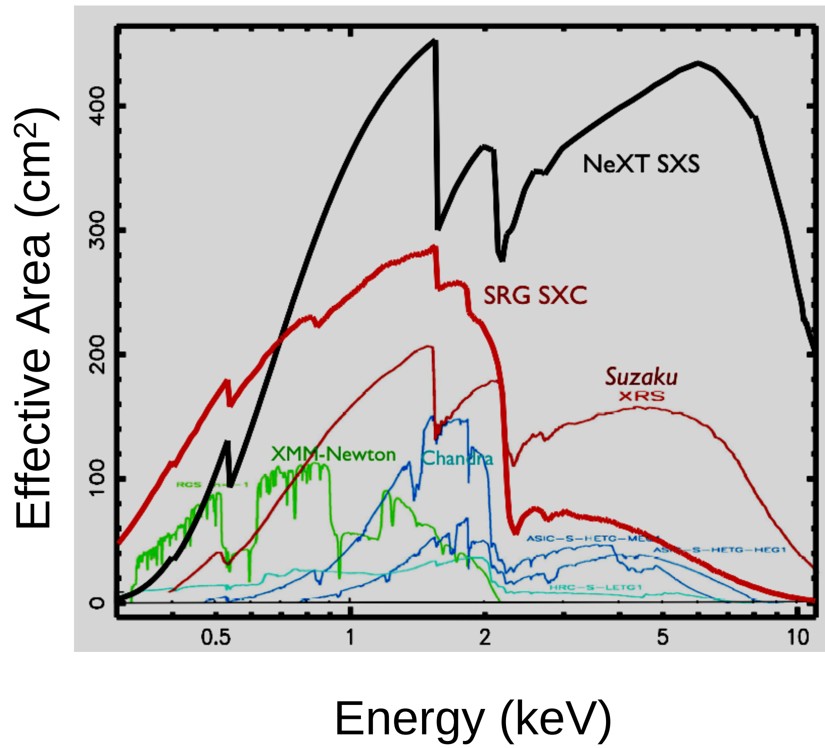
- Spectrum-X Gamma (Launch 2011)
  - Russian, German, Dutch, Japanese & US
  - All-sky survey with R ~ 100 CCDs
  - Also X-ray calorimeter: ΔE ~ 4 eV
- Planned Science: Galaxy Clusters, Local ISM





- NeXT (Launch 2012)
  - Japanese & US collaboration; funding in progress
  - Multiple science goals; ΔE = 4-5 eV, HEW ~ 1.5'



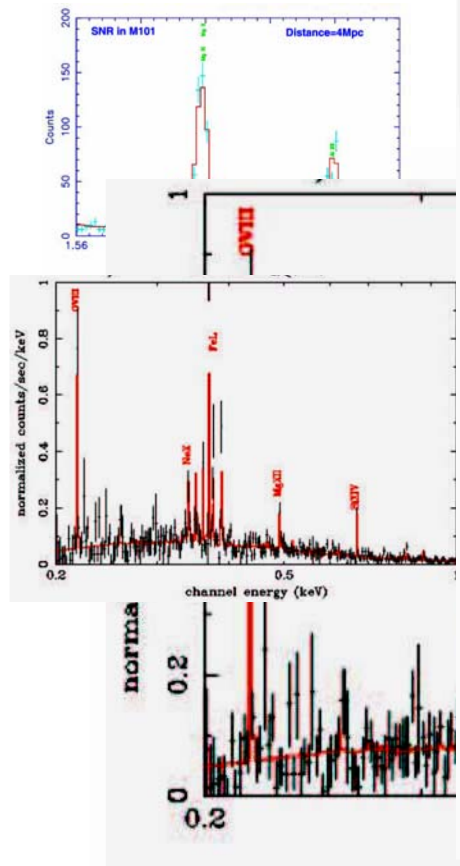


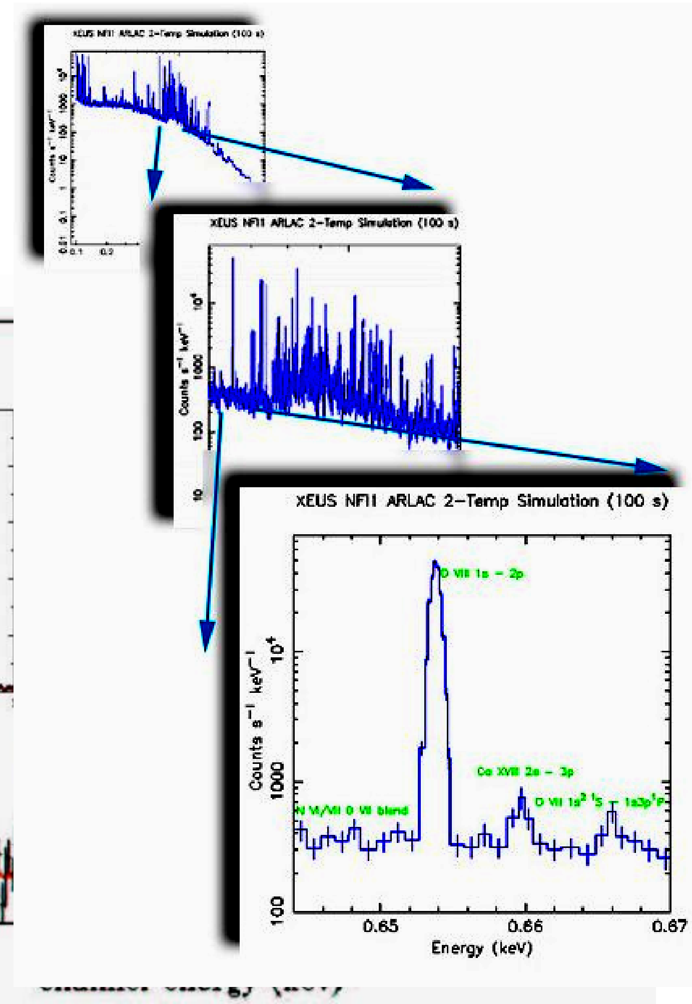
- XEUS (ESA Cosmic Vision Mission)
  - 45" FOV region with R = 500-1000
  - Imaging of 2-5" HEW

He-like Mg, Al from SNR in nearby galaxy

Distant galaxy clusters to see O, Ne, Mg, Si & Fe

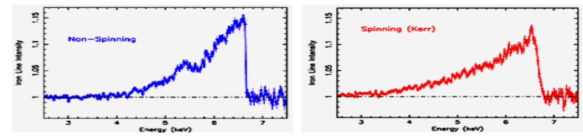
Detailed ion diagnostics for stars



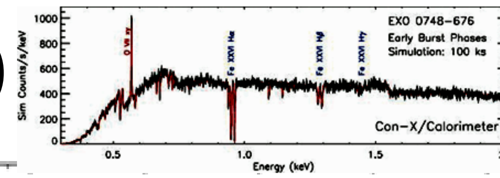


- Constellation-X (primarily US)
  - ΔE = 2 eV, FOV ~ 10’, 15” FWHM

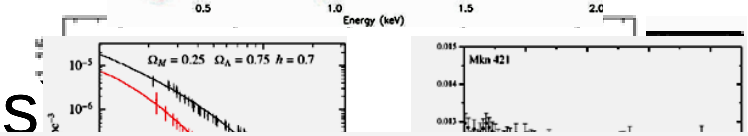
Black Hole Physics (Fe lines)

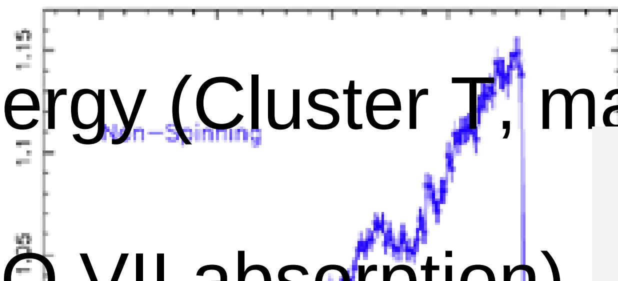


Neutron Star EOS (O, Fe lines)

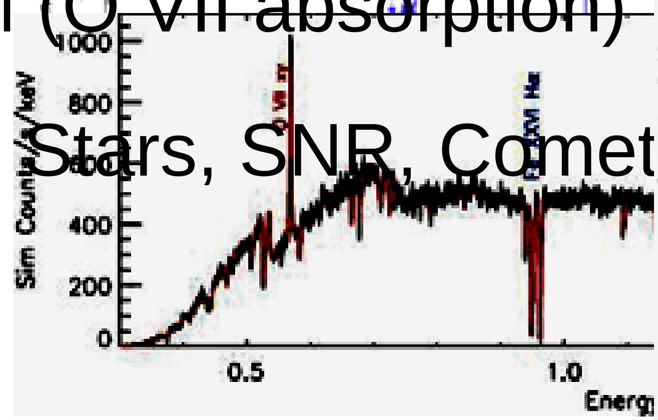


Dark Energy (Cluster T, mass

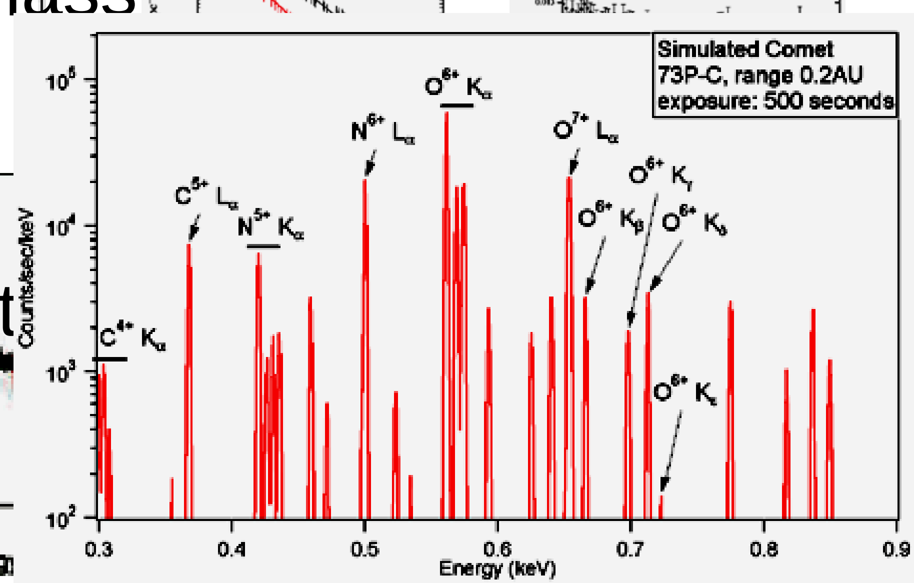




WHIM (O VII absorption)



Other: Stars, SNR, Comet

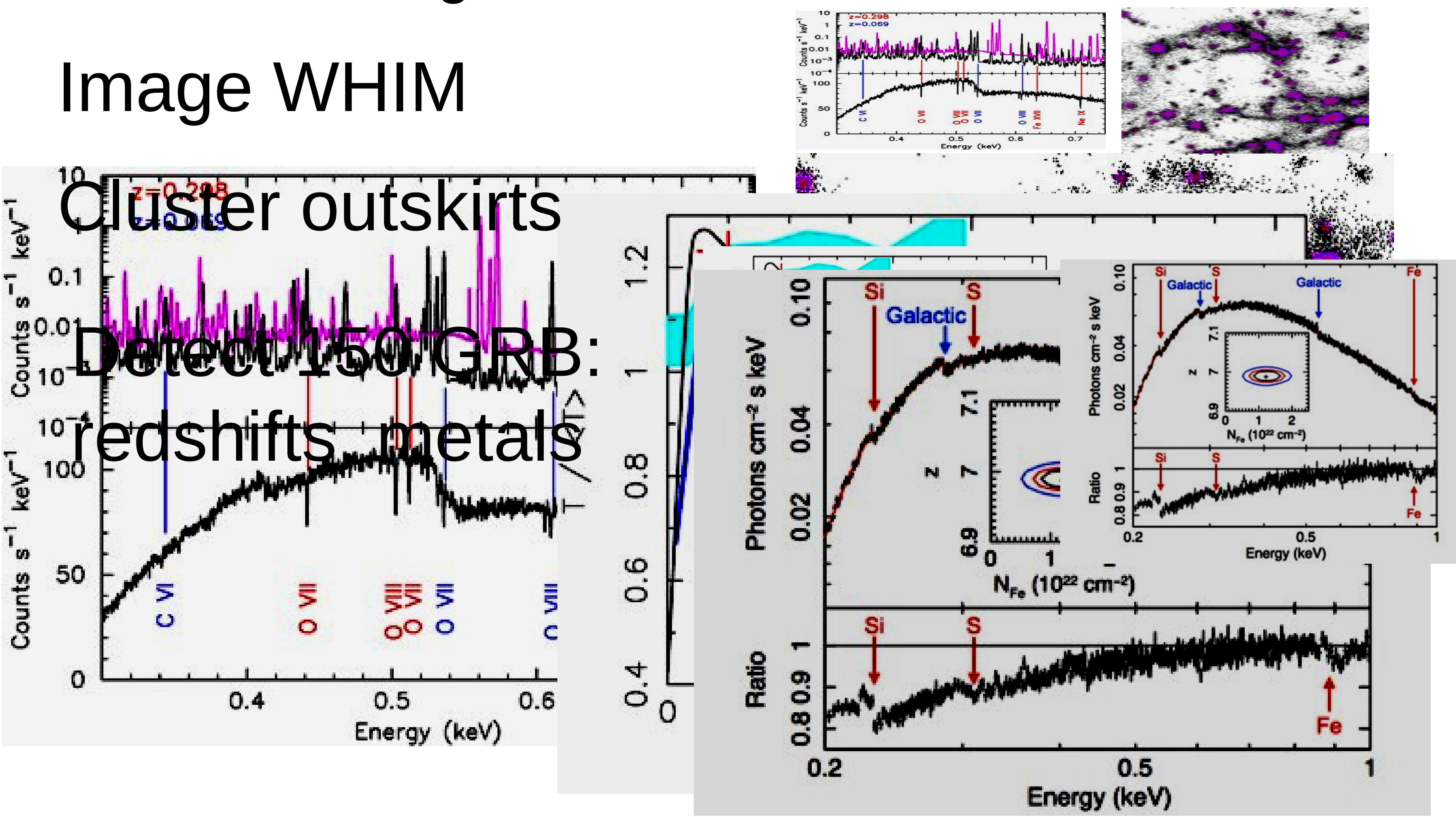


- EDGE (Italian, Dutch, ESA; unfunded)
  - ΔE =1 eV goal, 3 eV baseline.

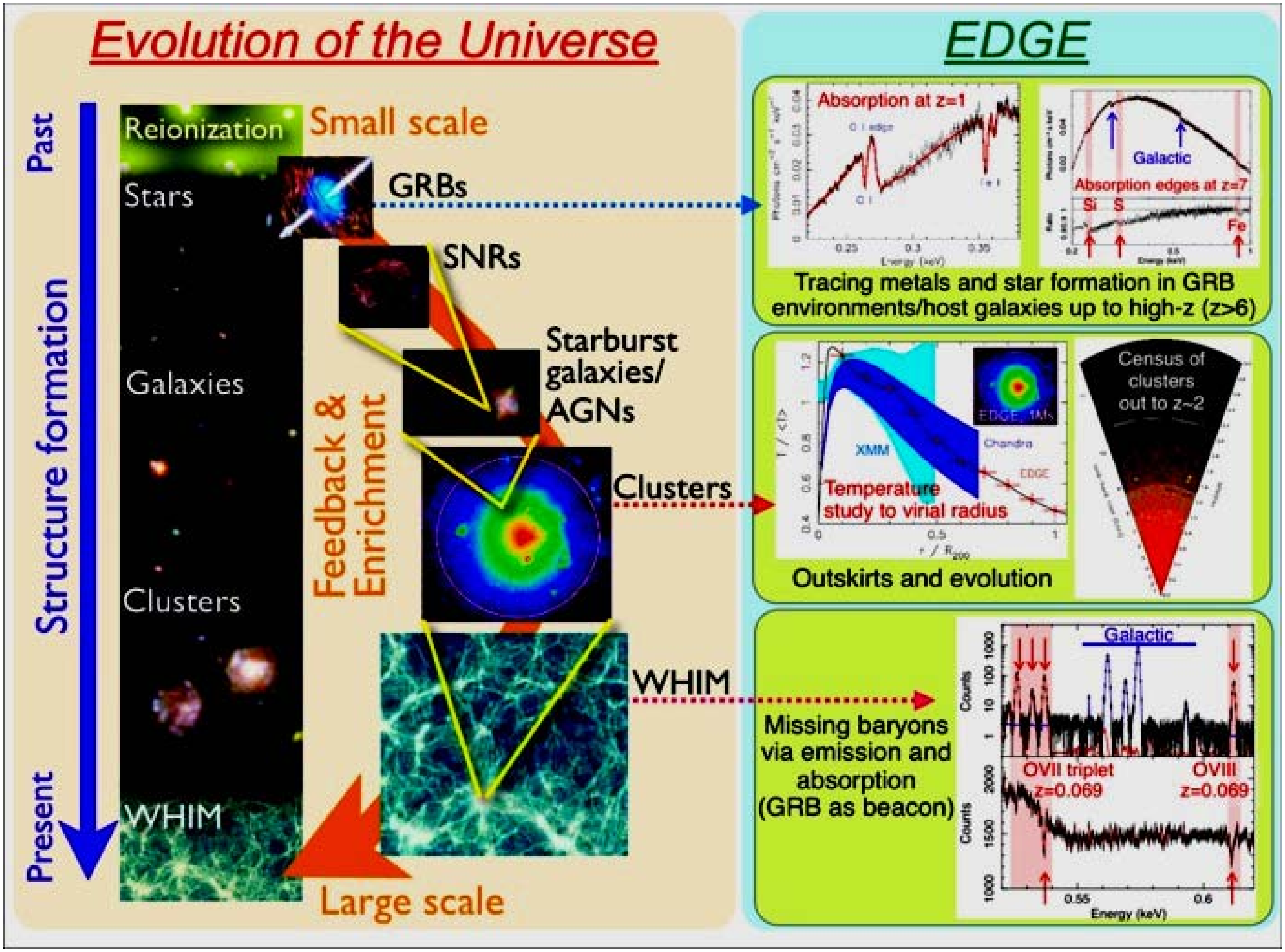
Image WHIM

Cluster outskirts

Detect 150 GRB: redshifts, metals



- Resolution (~1000) will not improve (much).
- Effective area will increase by 10-1000x
- Mission science based on well-known lines.
  - Unlike Chandra, XMM, no ‘fear’ of Fe L shell
  - But no plans to use them either
- Better error limits on known lines desired.
- Z>30 elements out of bounds; Con-X won’t see in Cas A in 1 Msec of observing.
- We probably don’t know what we really need.


Evolution of the Universe
EDGE
Past
Structure formation
Present
Reionization
Stars
Galaxies
Clusters
WHIM
Small scale
GRBs
SNRs
Starburst galaxies/ AGNs
Clusters
WHIM
Feedback & Enrichment
Large scale
Absorption at z=1
Galactic
Absorption edges at z=7
Si
S
Fe
Tracing metals and star formation in GRB environments/host galaxies up to high-z (z>6)
XMM
Chandra
EDGE
Temperature study to virial radius
Census of clusters out to z~2
Outskirts and evolution
Missing baryons via emission and absorption (GRB as beacon)
Galactic
OVII triplet z=0.069
OVIII z=0.069
Energy (keV)