Suzaku Observation of the Galactic Ridge

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On behalf of Suzaku team

Contents of the talk

- Galactic Ridge observation at (l,b)=(28.46,-0.21)

(Ebisawa et al. 2007, PASJ 2nd Suzaku special issue)

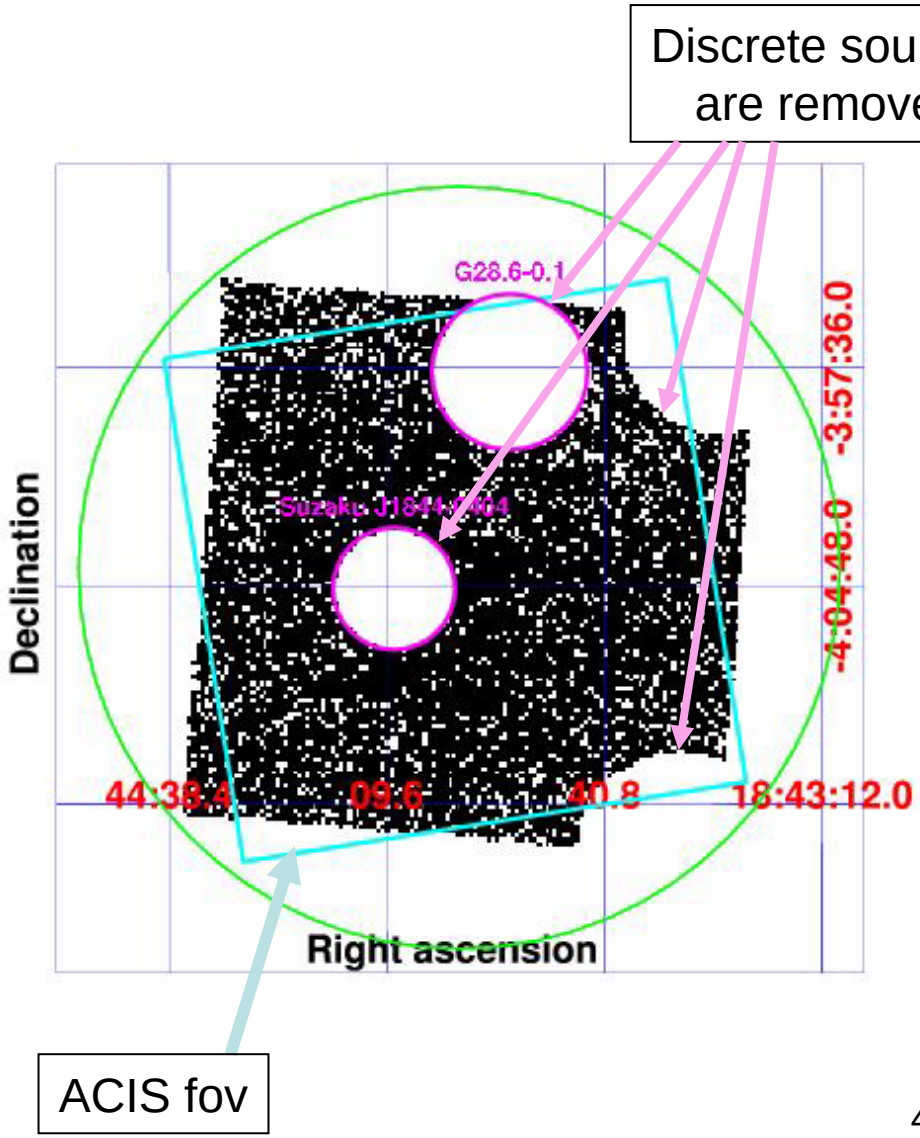
  - Iron line spectroscopy of the Galactic Ridge
  - Measurement of the absolute flux of the Galactic Ridge
- Some update of the Galactic Center results (Koyama et al. 2007, in preparation)
  - Spatial distribution of iron line emission
  - Spatial/spectral decomposition of the GC plasma

Origin of the Galactic Ridge X-ray Emission

- *Diffuse or Point sources?*
  - A big question for almost 30 years
  - Significant part of the Ridge emission unresolved
  - Chandra ultra-deep observation may give an answer
  - To reach ~10^{-17} erg/s/cm^2 (2-10 keV), ~ 10Msec observation will be required!
    - Practically impossible
  - Approved 900 ksec observation near the GC (AO9, Revnivtsev et al.) will provide some clue
- Plasma diagnostics
  - Can't we tell the origin of the GRXE from plasma diagnostics?

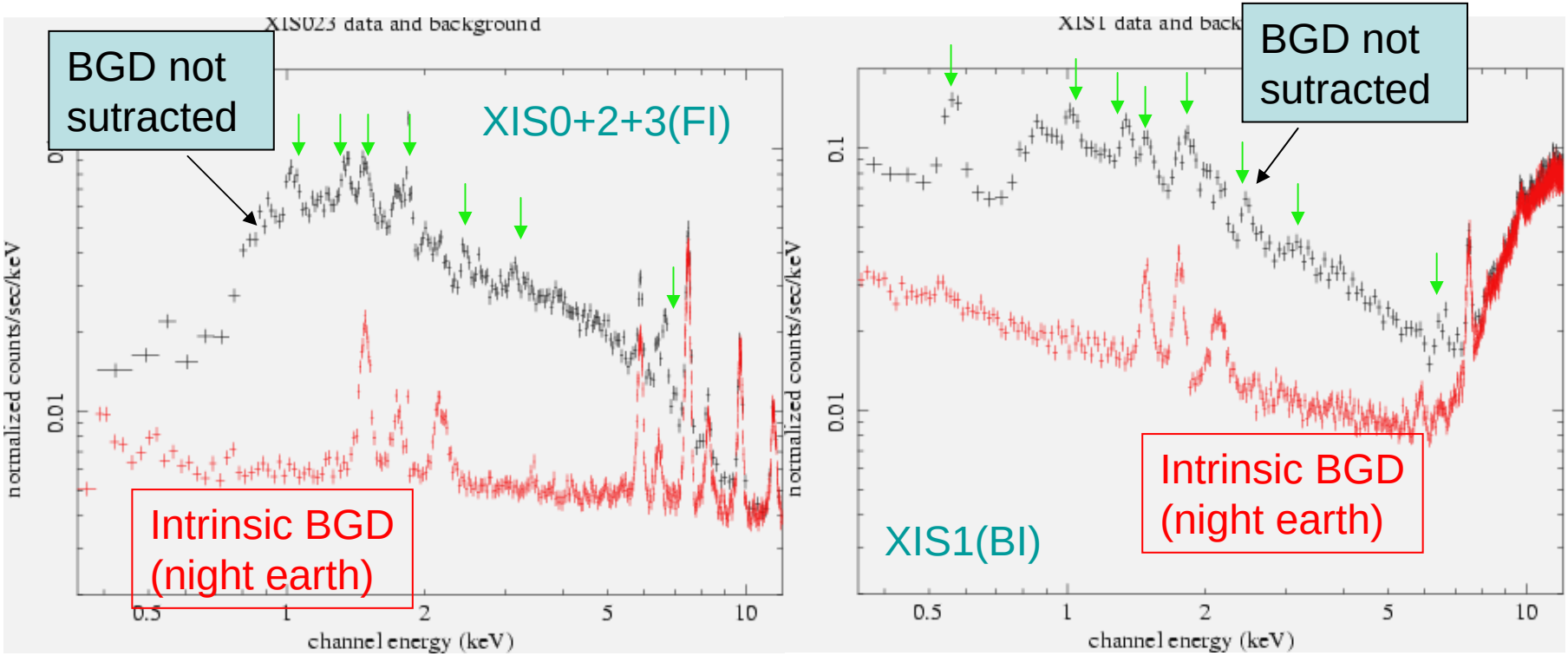
Suzaku Observations

- Same pointing as Chandra AO1 location (l,b)=(28.46, -0.21)
- 2005 Oct 28, 100 ksec
  - Early phase, hardly spectral degradation
  - We used only this data
- 2006 Oct 15, 100 ksec
  - Spaced Charge-Injection (SCI) adopted to recover spectral resolution
  - Calibration and BGD study more difficult; being analyzed



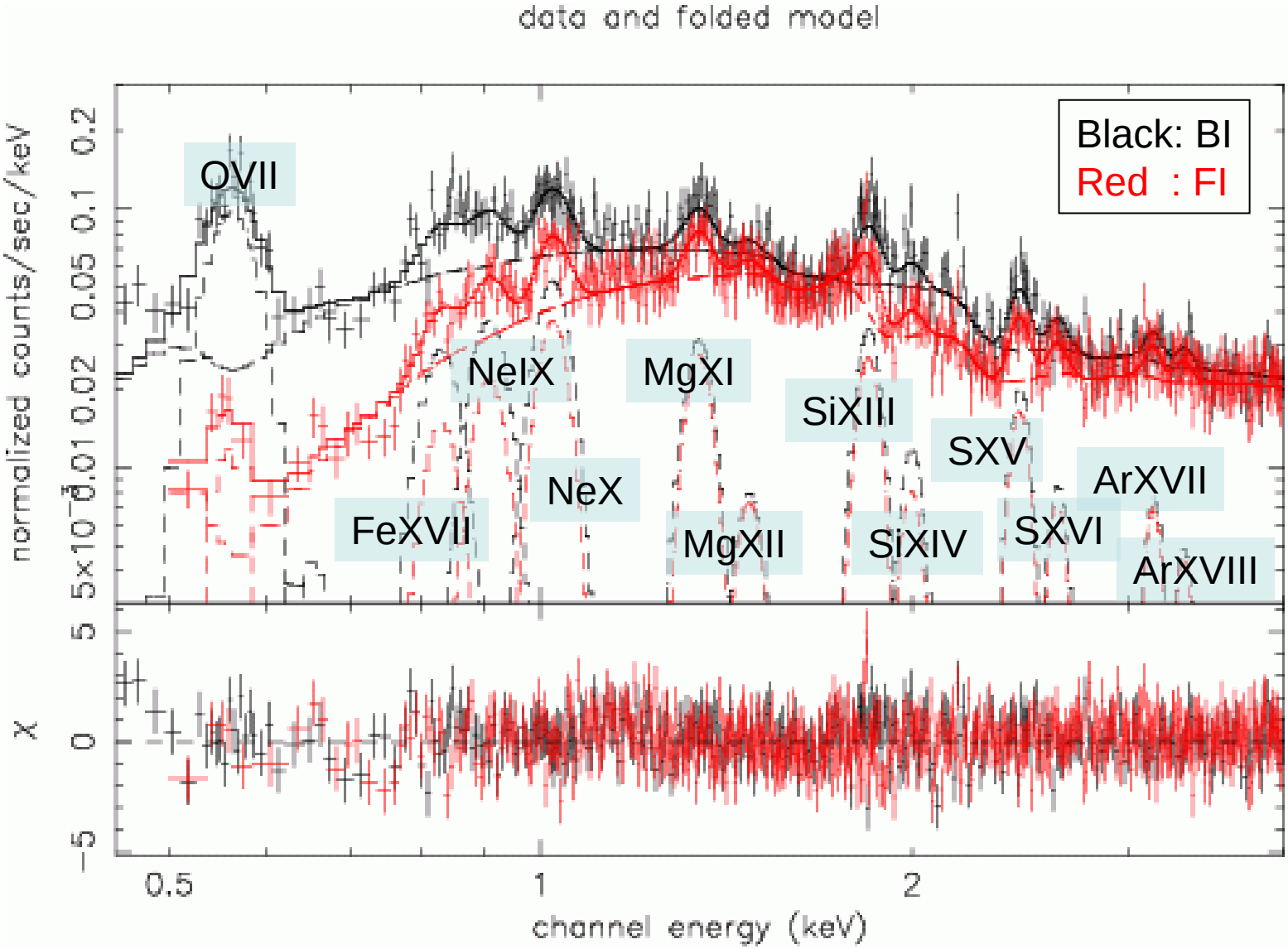
Characteristics of Suzaku XIS (X-ray Imaging Spectrometer)

- Suzaku XIS consists of three Front Illuminated (FI) CCD chips and one Back Illuminated (BI) chip
- BI has better low energy efficiency, while FI has lower background



XIS is powerful for spectral study of faint diffuse sources

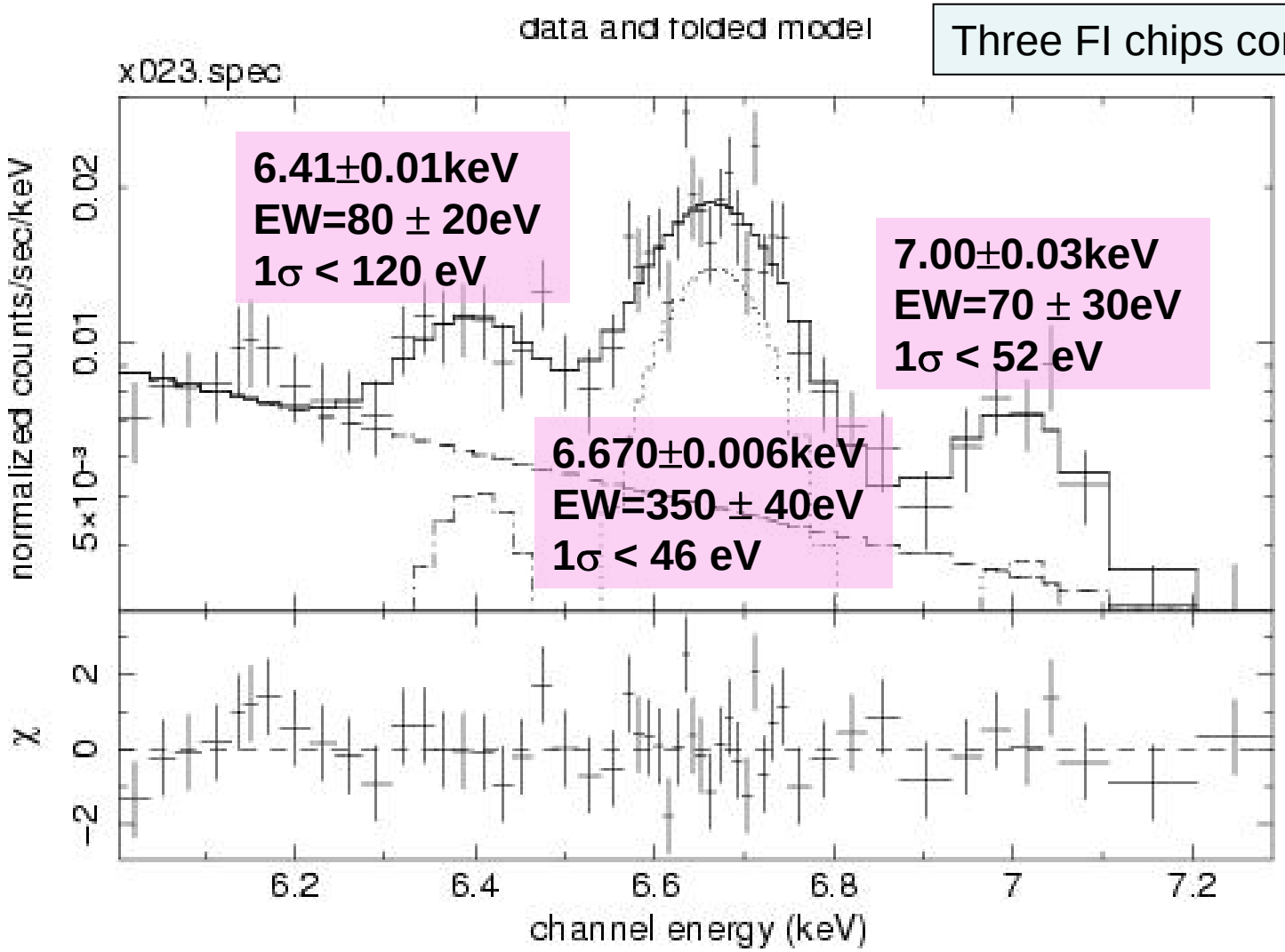
Low energy spectra



Many emission lines as expected from muli-temperature plasma

Iron lines

Three FI chips combined



Three *narrow* lines are resolved for the first time

Origin of the 6.670 and 7.00 keV lines

- Collisional Ionization Equilibrium (CIE) plasma most probable
  - Theoretical FeXV line energy 6.680-6.685 keV
  - Observed energy is 6.670 ± 0.006 keV
  - [FeXXVI/FeXXV]~0.2 consistent with kT=5 ~ 8 keV plasma
- Non-Ionization Equilibrium (NIE) model → unlikely
  - In NIE, iron ions are less ionized than FeXXV
  - Suggested by low line energies 6.61 ± 0.04keV (ASCA;Kaneda et al. 1997) or $6.52 \pm {}^{0.08}_{0.14}$ keV (Chandra; Ebisawa et al. 2005)
  - ASCA and Chandra *single line* energies contaminated by the 6.4 keV line
    - If fitted with three lines, ASCA and Chandra agree with Suzaku
- Charge Exchange model → unlikely
  - Broad line ($1\sigma > 70$ eV) expected due to cosmic-ray bulk motion (ASCA; Tanaka 2002)
  - Observed 1 σ width <50 eV

Origin of the 6.41 ± 0.01 keV line

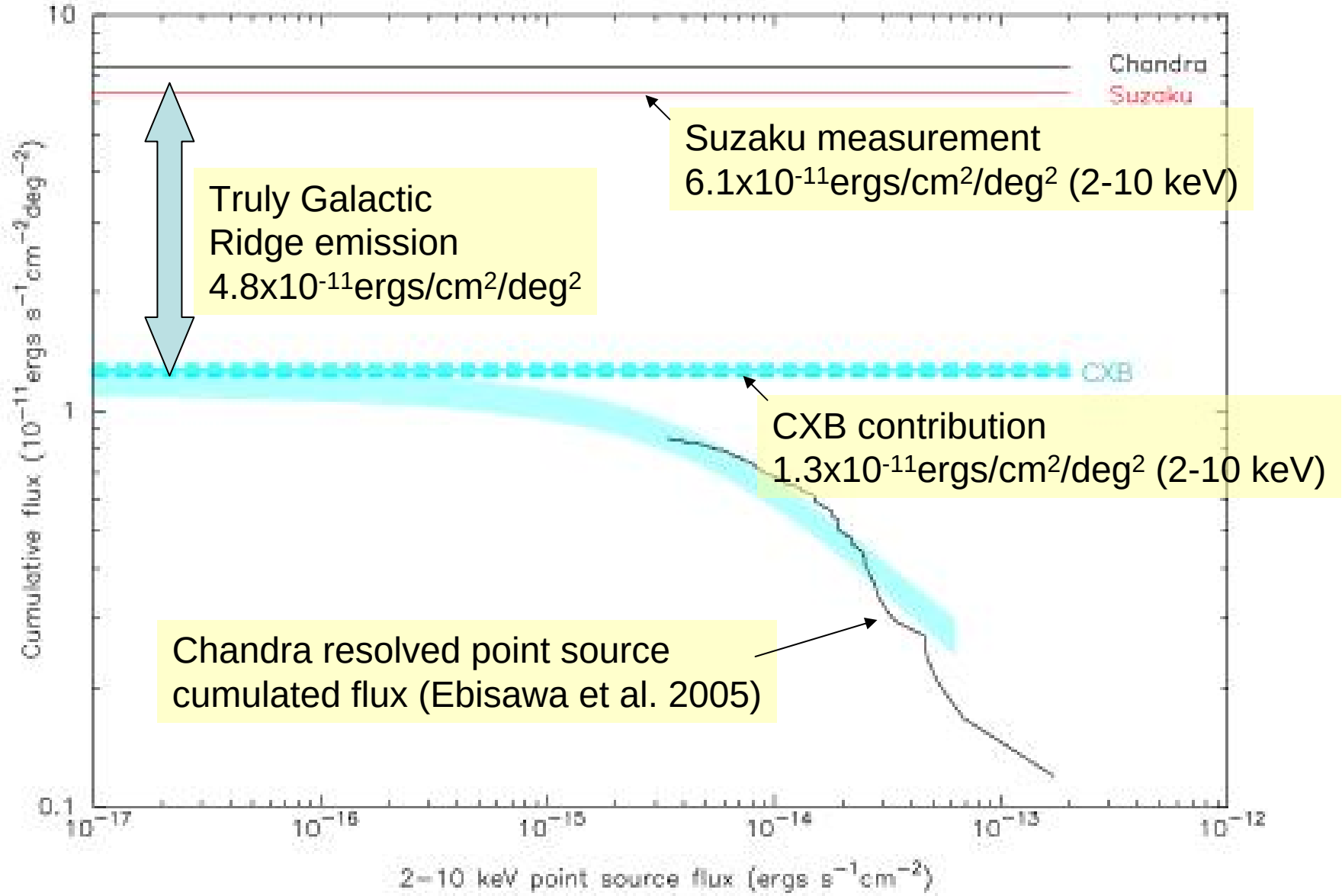
- Fluorescent line from low ionized (<FeX) iron
- Presence of cold, low ionized material on the Galactic Ridge
- Diffuse source?
  - Interaction of cosmic-ray electrons and interstellar medium (e.g. Valinia et al. 2002)
- Point sources?
  - Reflection from white-dwarf surface?
- *See GC results on spatial distribution*

Future iron line diagnostics

- Fe XXV line from CIE plasma is established
- Future calorimeter mission ($\Delta E \sim 6$ eV) is able to resolve this triplet
  - Resonance (w) 6699 eV
  - Inter-combination (x,y) 6680 and 6665 eV
  - Forbidden (z) 6634 eV
- Inter-combination and forbidden lines are density sensitive
- Diffuse model and point source models have orders of magnitude different plasma densities
  - Diffuse model, Ne ~ 10^{-3}cm^{-3}
    - Tenuous plasma (corona) → relatively strong forbidden line
  - Point source, Ne ~ 10^{15}cm^{-3} (magnetic CV)
    - Dense plasma → no/very little forbidden line

Absolute flux of the GRXE

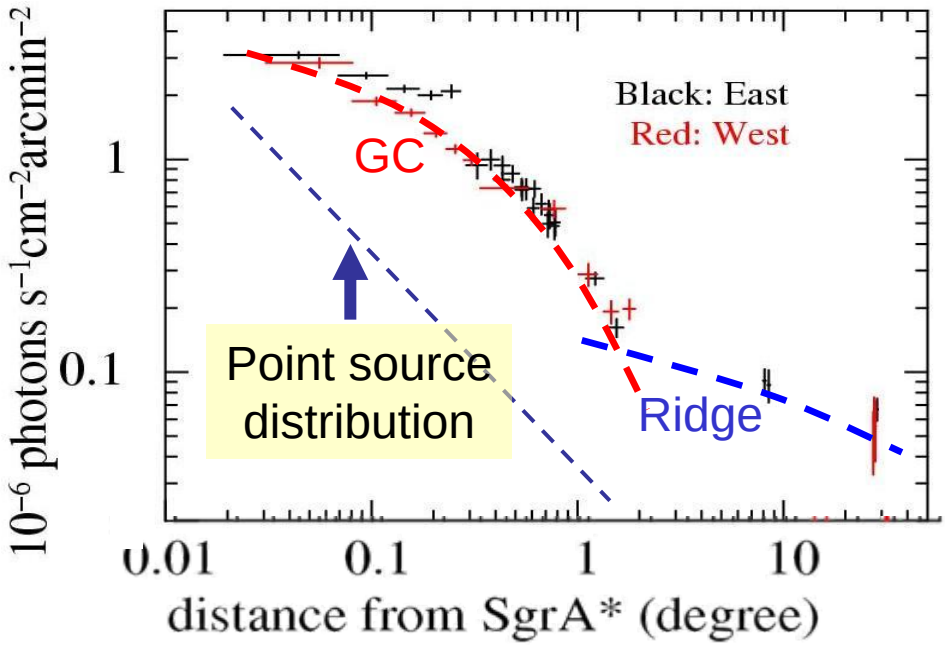
- Mirror response function for diffuse emission calculated via ray-tracing
- Non-X-ray background estimated from night earth observation
- Point source brighter than 2×10^{-13} erg/s/cm^2 excluded
- We measure the absolute X-ray flux on the Galactic Plane as 6.1×10^{-11} erg/s/cm^2/deg^2 (2-10 keV)
  - consistent with Chandra result (Ebisawa et al. 2005) within 20 %
- Estimate CXB penetrating the Galactic Plane
  - 1.3×10^{-11}erg/s/cm^2/deg^2, assuming $N_H \sim 6 \times 10^{22}$cm^{-2}
- The Galactic Ridge Emission flux at (l,b)=(28.46,-0.21) is 4.8×10^{-11} erg/s/cm^2/deg^2 (2-10 keV)
  - Excluding extragalactic sources
  - Excluding point sources brighter than 2×10^{-13} erg/s/cm^2

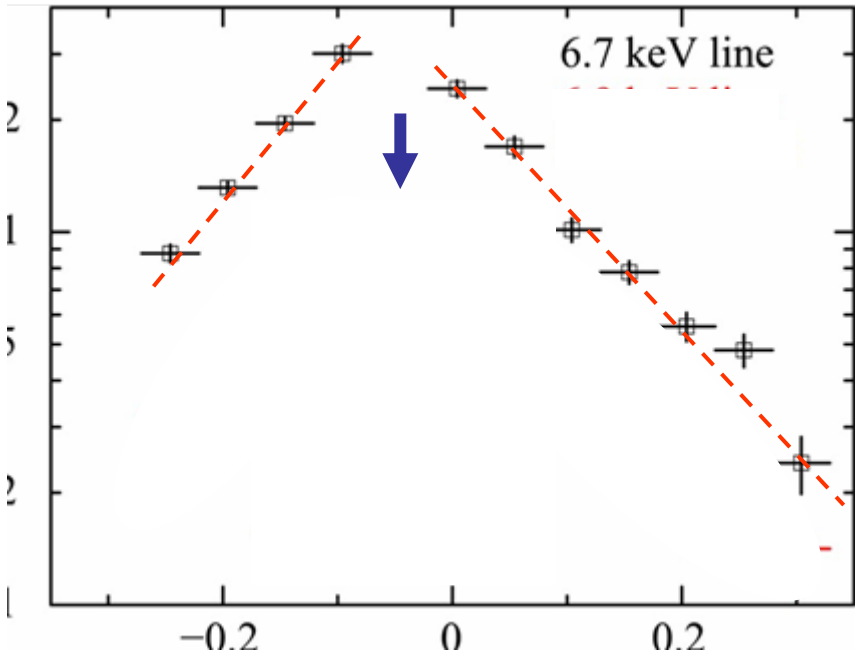


- Majority of the GRXE unresolved yet

Suzaku Galactic Center result update (Koyama et al. 2007)

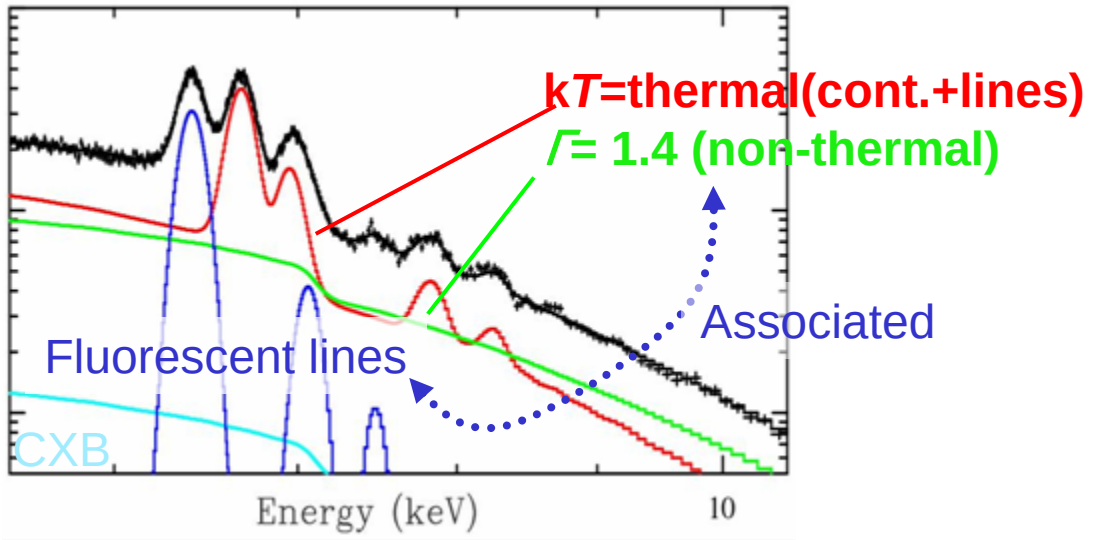
Distance from Sgr A vs 6.7 keV line flux





Iron line and point sources have different spatial distribution around GC

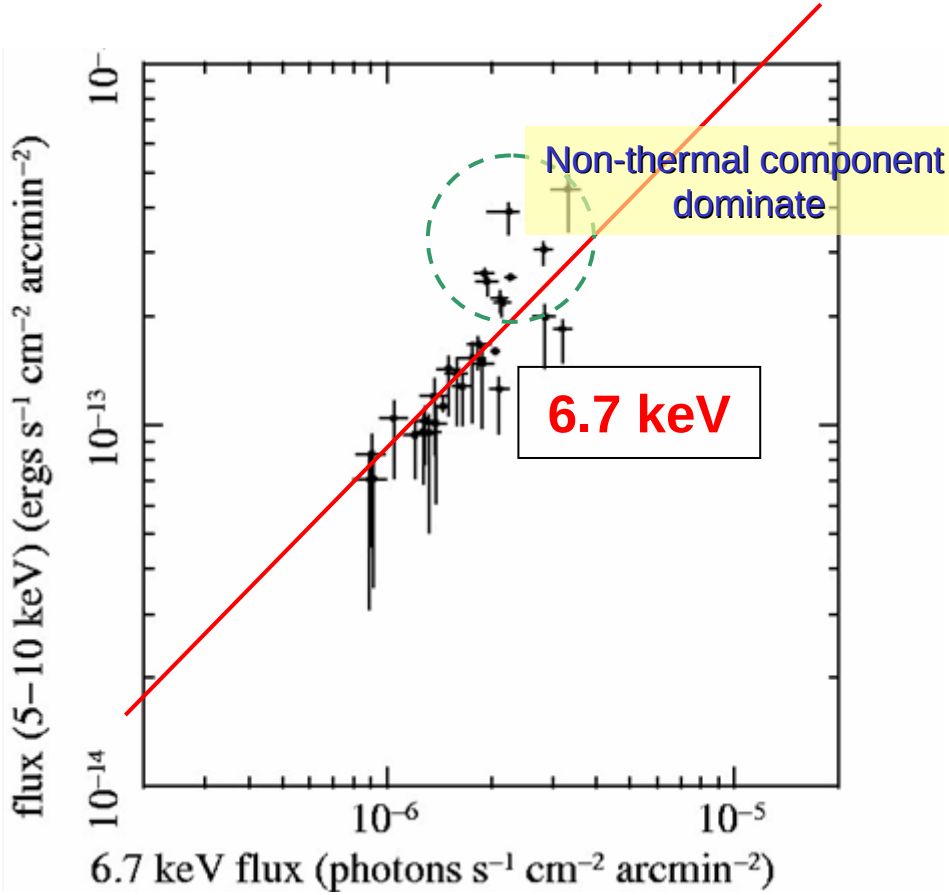
GC region spectral decompsition

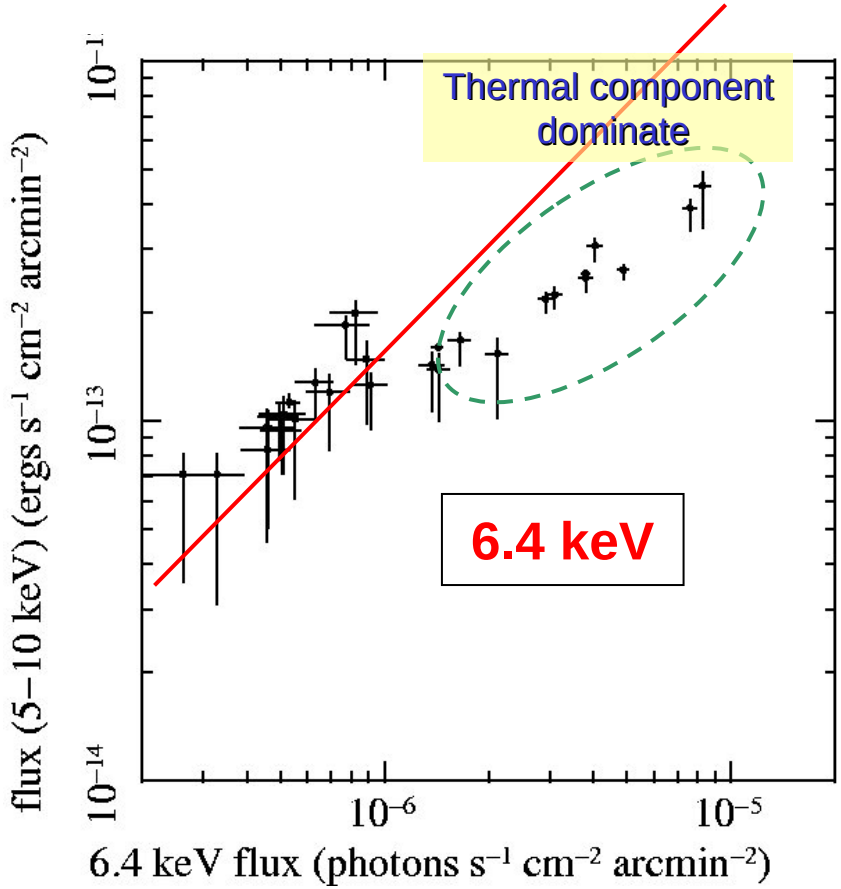


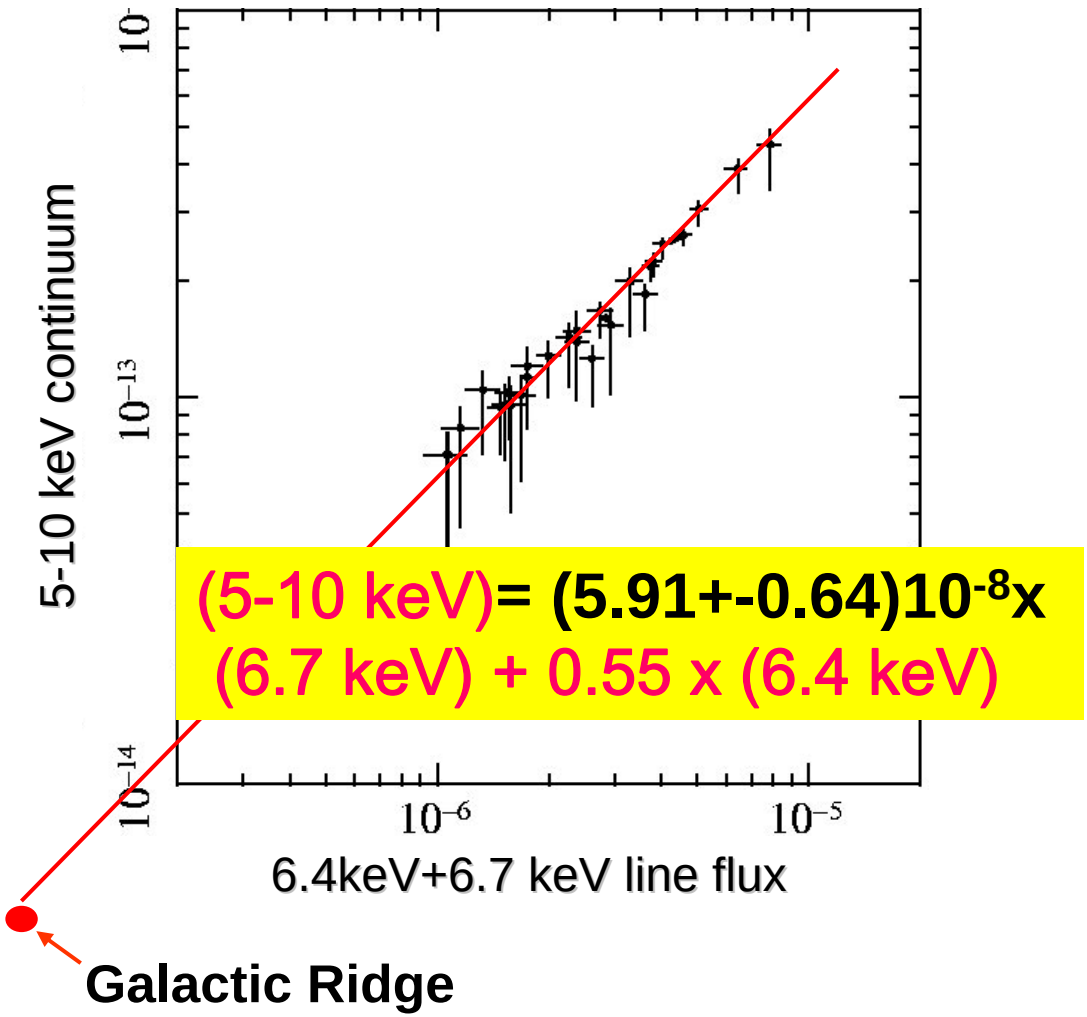
- 6.7 keV and 7 keV lines are associated with thermal continuum
- 6.4 keV line and non-thermal continuum associated

Spatial variance of continuum-line correlation

- 5-10 keV continuum is the sum of thermal and non-thermal components
- Making use of spatial information, we may decompose them







- The 5-10 keV continuum is composed of the two component associated with the 6.7 keV line (thermal component) and that associated with the 6.4 keV line (non-thermal component)
- Composition of the two different plasma components is spatially variable around the GC region