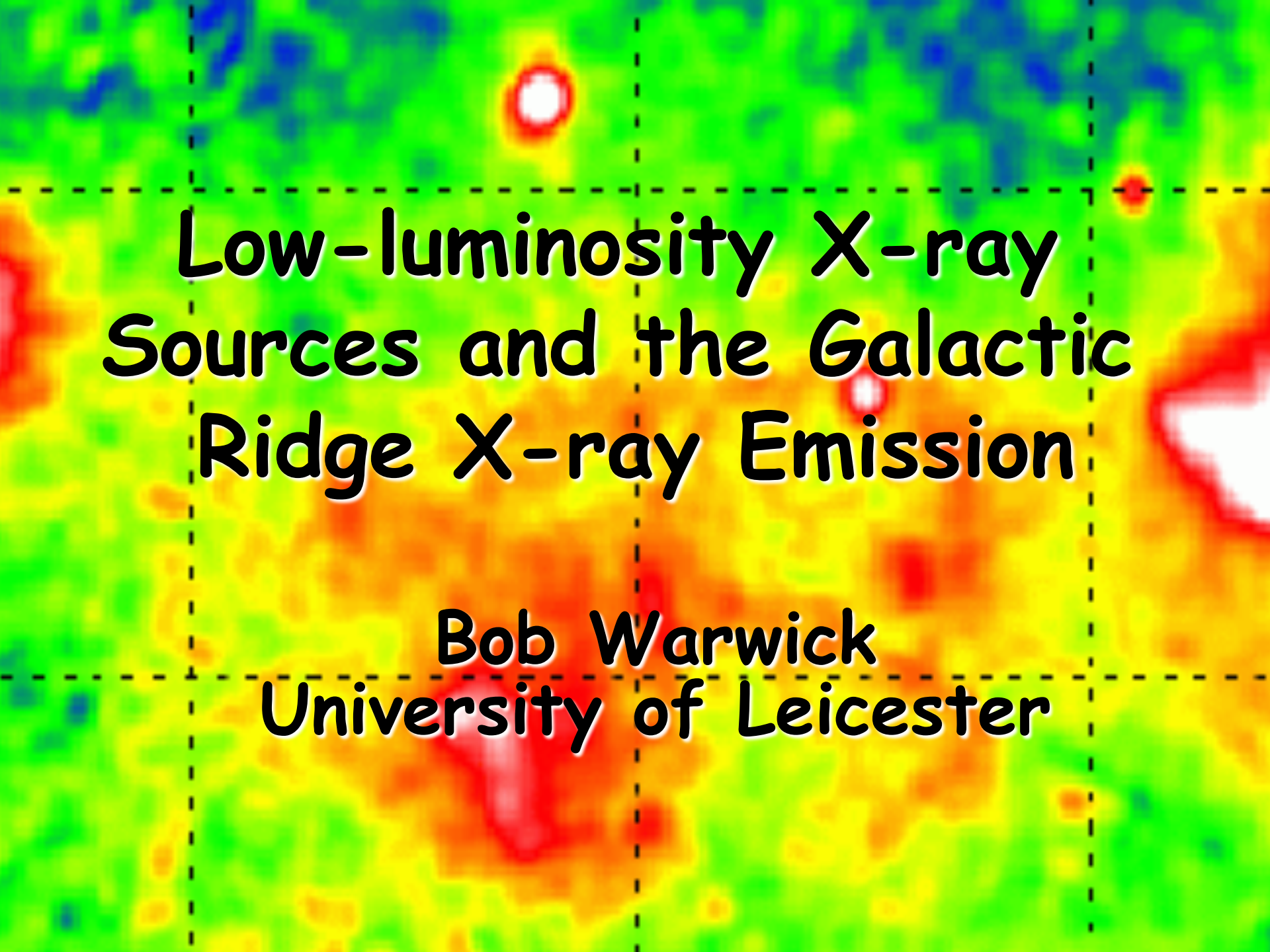
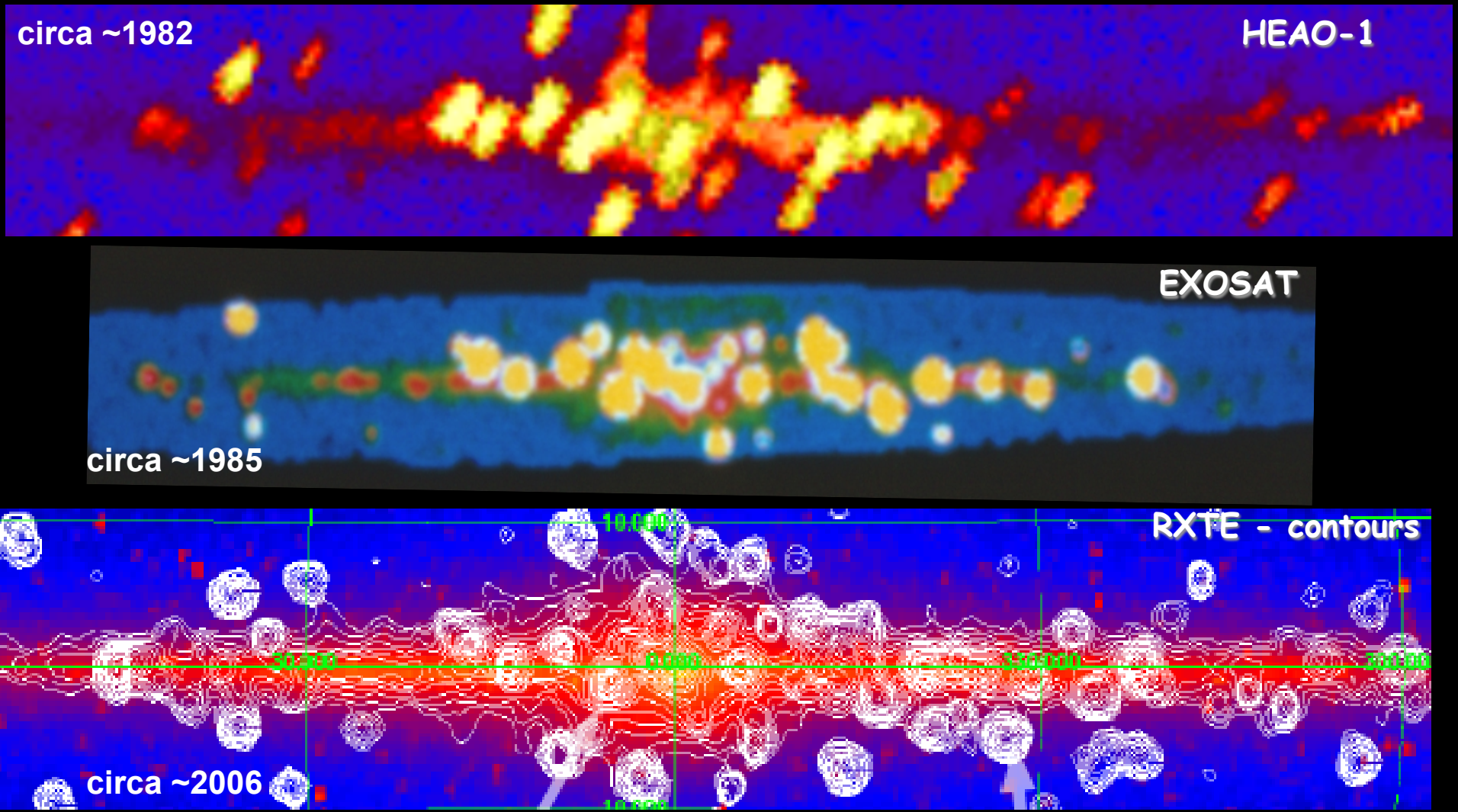
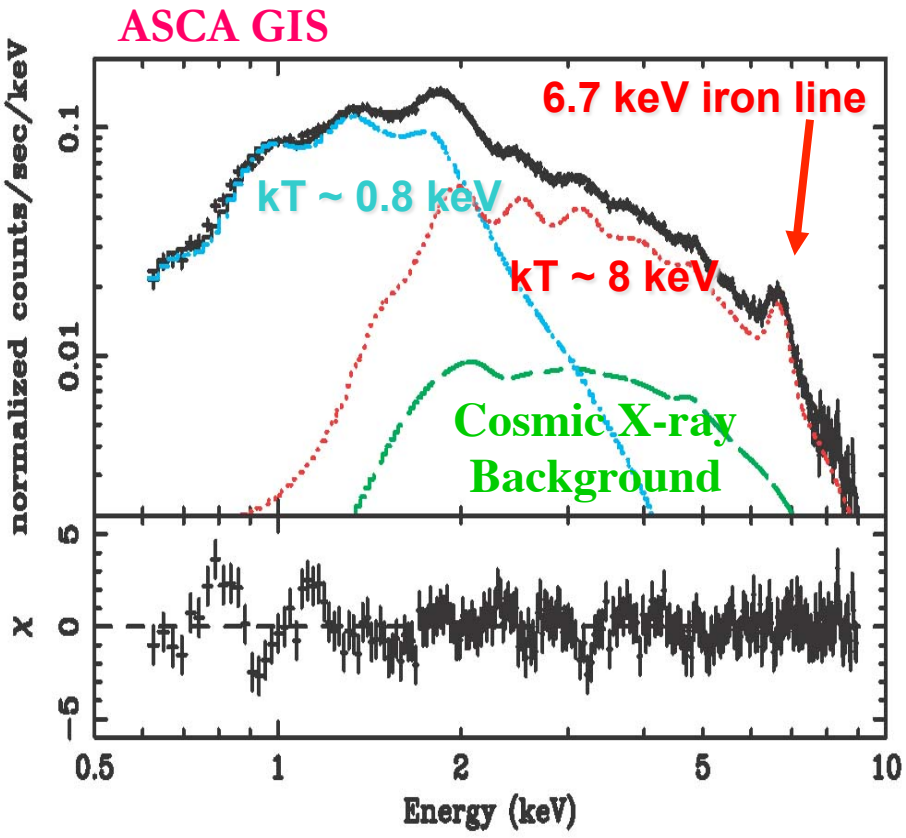

Low-luminosity X-ray Sources and the Galactic Ridge X-ray Emission
Bob Warwick
University of Leicester

The Galactic Ridge X-ray Emission (GRXE)



X-ray Spectrum of the GRXE



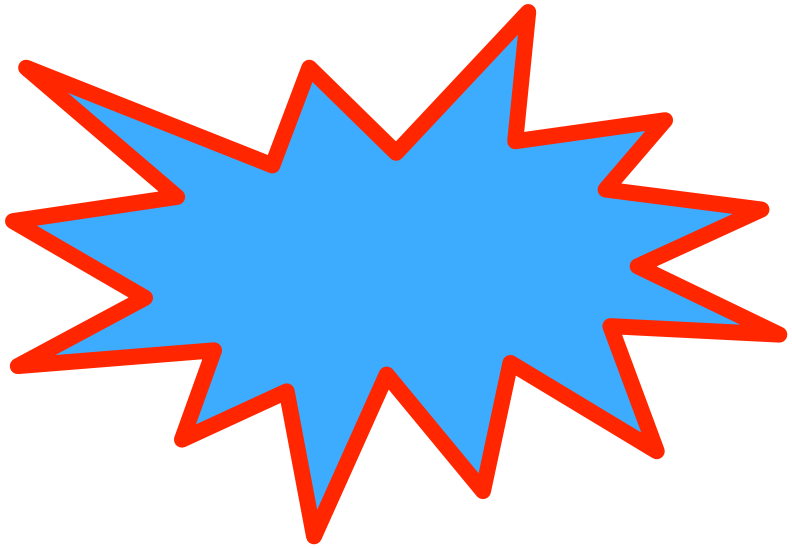
Kaneda et al. 1997

Above 4 keV:

- Hard thermal continuum (kT ~ 5-10 keV)
- He-like and H-like Fe Kα lines (6.67/6.96 keV)

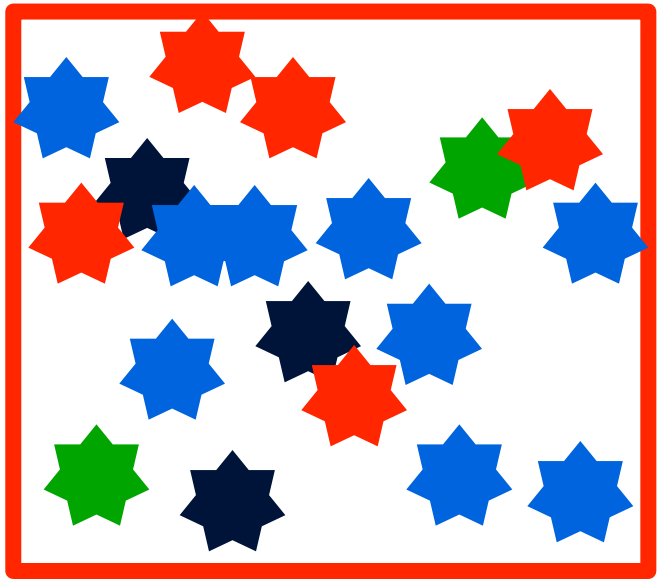
"Origin of the GRXE"

Very hot diffuse plasma



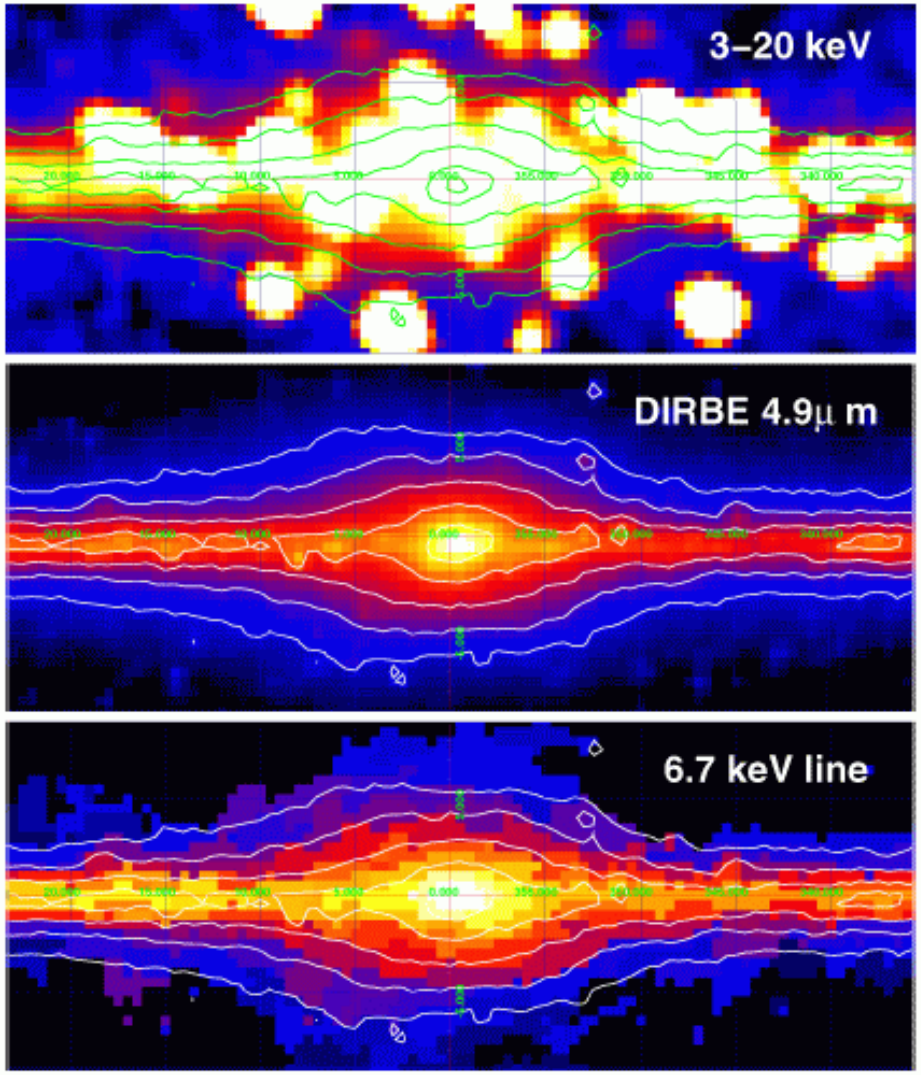
Unbound ➔ Needs 10^{43} erg s^{-1} to replenish?

Emission of unresolved sources

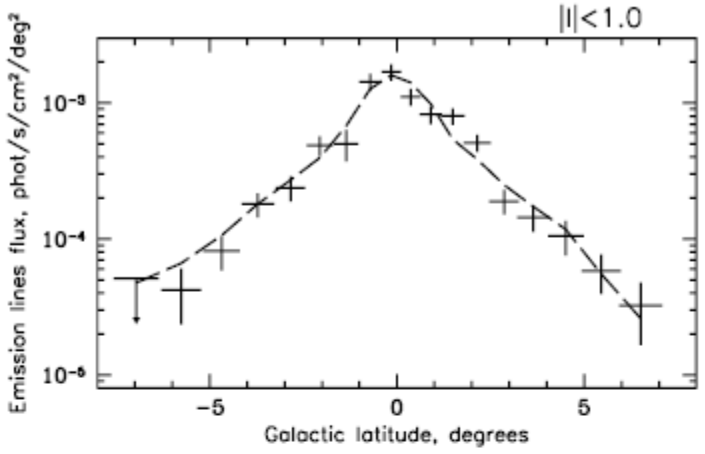


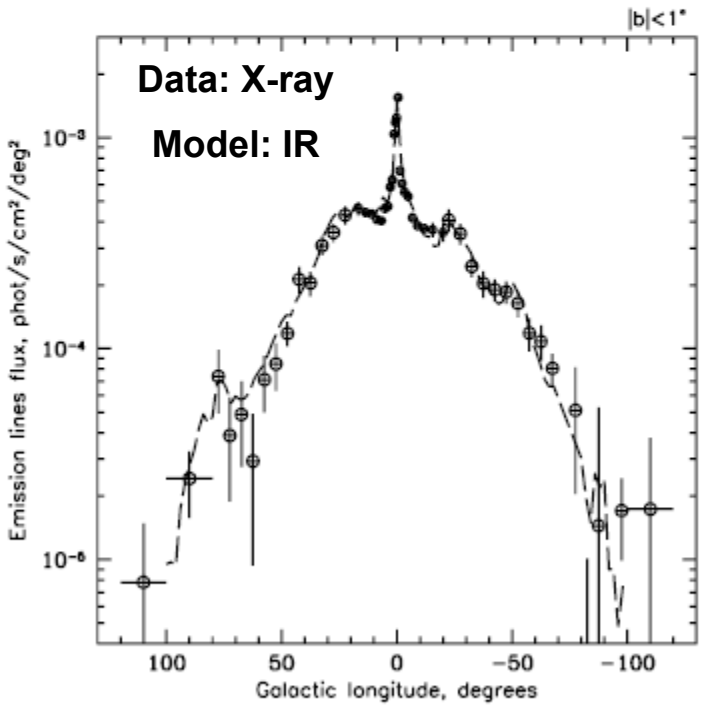
What Galactic source population(s)?

GRXE 6.7-keV line ➔➔ Galactic NIR light



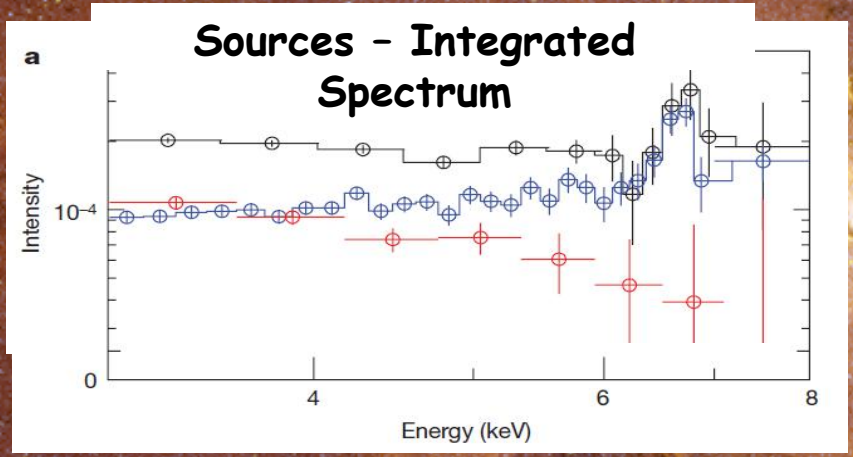
Revnivtsev et al 2006



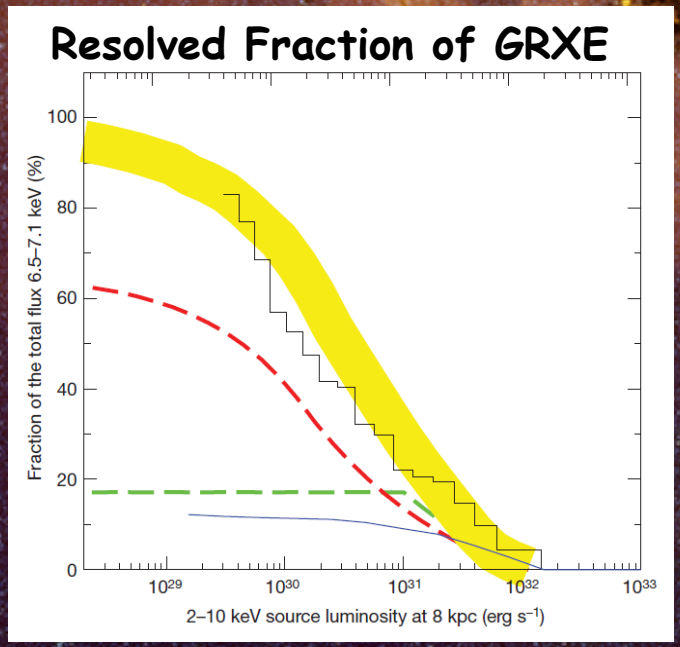


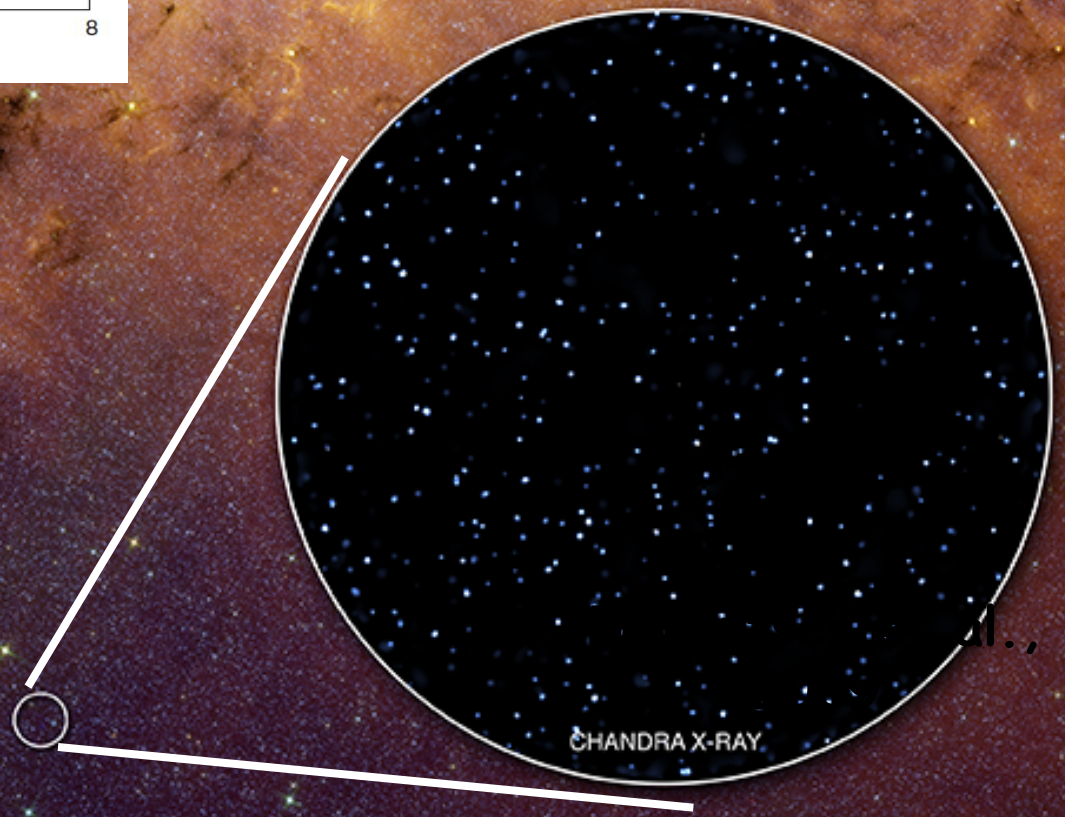
Resolving the Galactic Ridge X-ray Emission in a 1 Msec Chandra Observation

[Revnivtsev et al., 2009]



~ 8 x 10^4 sources per deg^2

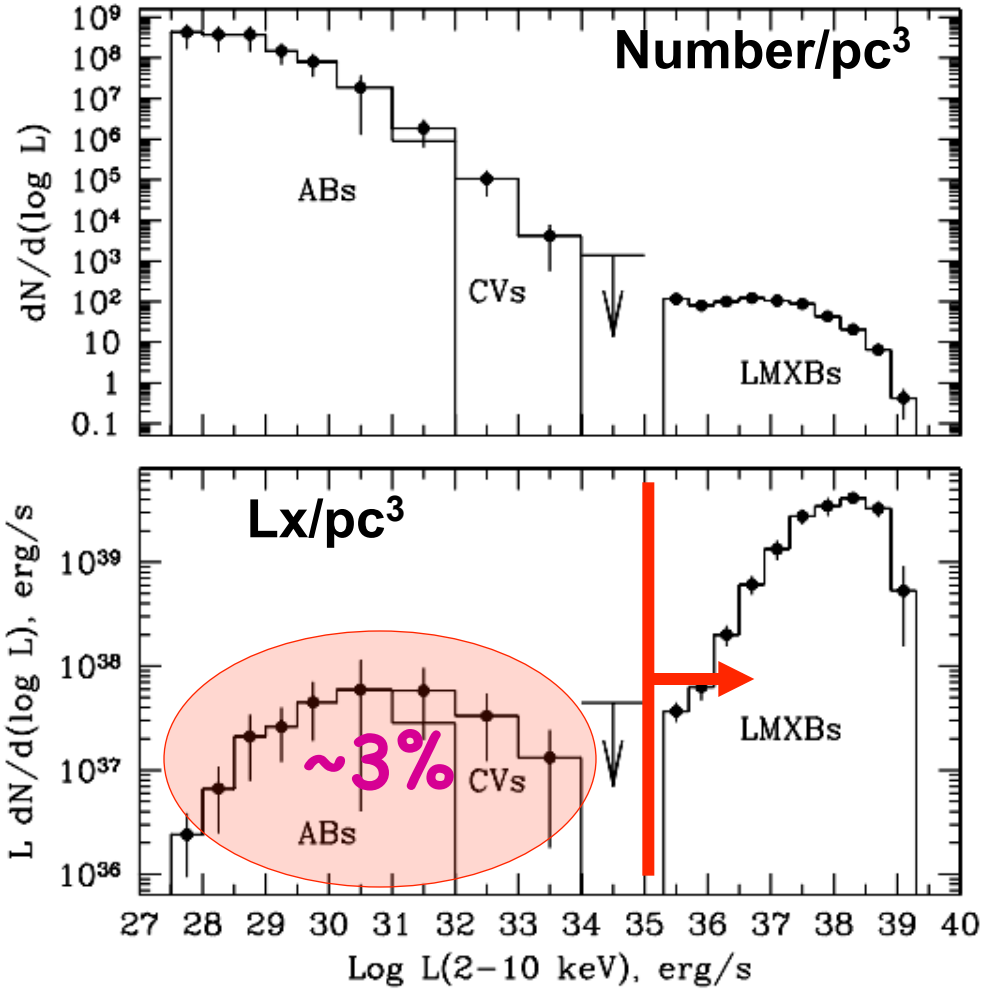




INFRARED

X-ray Luminosity Function (XLF) of Galactic Source Populations

➔ Luminous XRBs + CVs + Coronally-active stars and binaries (ABs)



Local volume emissivity of active stars and CVs = 4.5 ± 0.9 x 10^{27} erg/s (2-10 keV) per $M_\odot$

Sazonov et al., 2006; Revnivtsev et al., 2006

A new hard-band selected sample of X-ray sources extracted from the XMM Slew Survey (Saxton et al 2008)

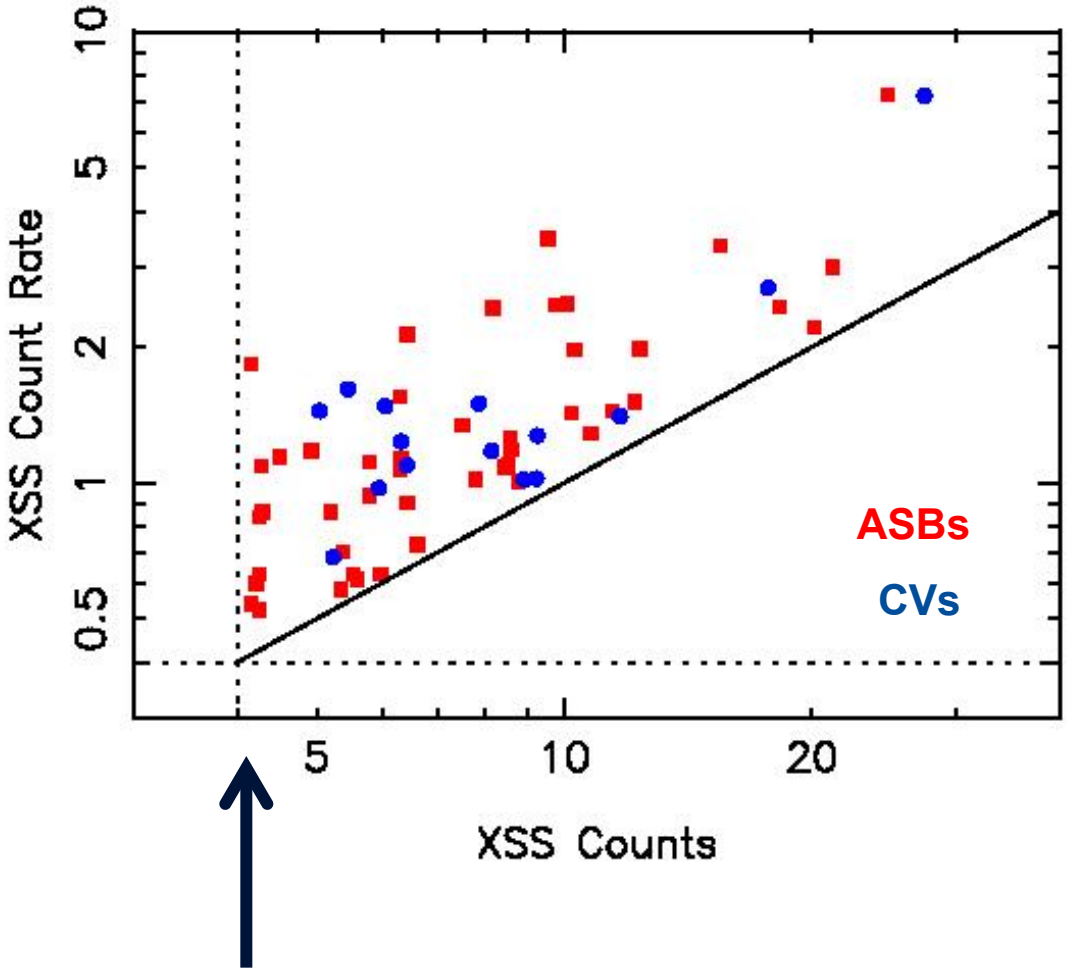
Initial sample of 487 "detections"

$S_X > 3 \times 10^{-12}$ erg s^{-1} cm^{-2} (2-10 keV)

Extragalactic sample of 219 sources (Warwick et al. 2013)

Galactic sample of 62 sources (Warwick 2014)

An XSS hard-band selected sample of low-luminosity Galactic X-ray sources



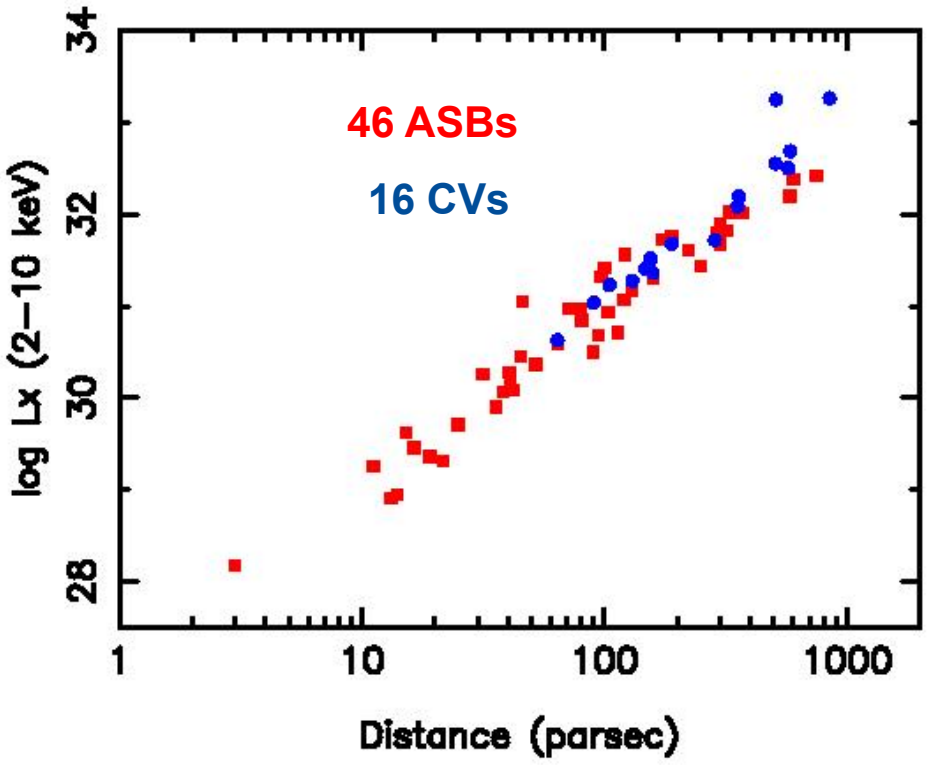
"Count-limited" sample

46 ASBs → coronally-active dwarf stars and binary systems

16 CVs → magnetic & non-magnetic cataclysmic variables

Warwick 2014

Source distances are the key → X-ray luminosities, space densities etc..



★★★ The ***coronally-active stars and binaries*** are preferentially observed in the 2-10 keV band during ***flare states***. ★★★

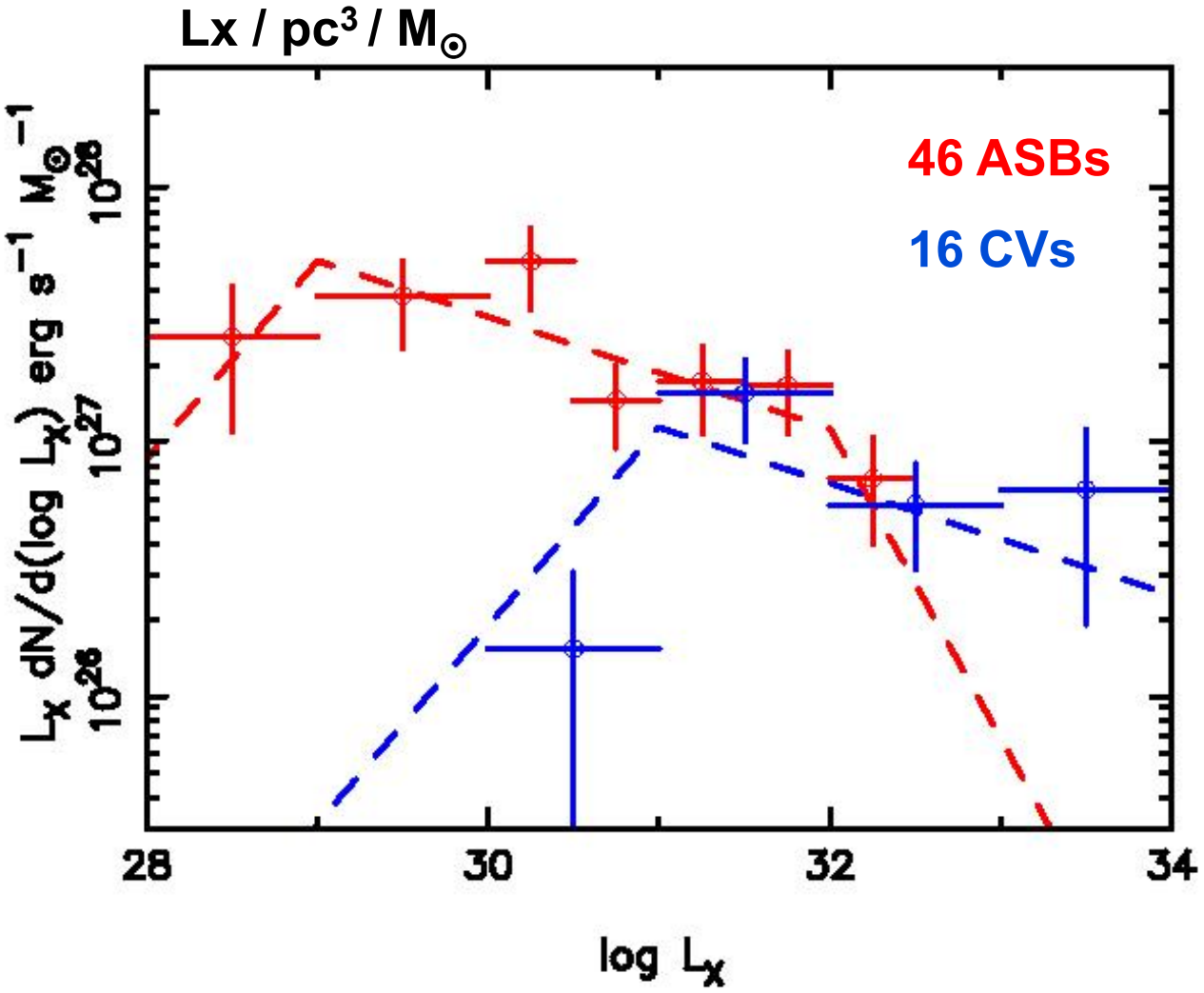
Spectral Assumptions:

Count/s → X-ray flux → X-ray luminosity

ASBs: $kT = 3.5 \times 10^7$ K (3 keV) *apec* plasma with $Z=0.4\ Z_\odot$

CVs: $kT = 10$ keV *thermal bremsstrahlung* + Fe lines

Derived X-ray Luminosity Functions



Local volume emissivity of ASBs:

= 1.08 ± 0.16 x 10^{28} erg/s (2-10 keV) / $M_\odot$

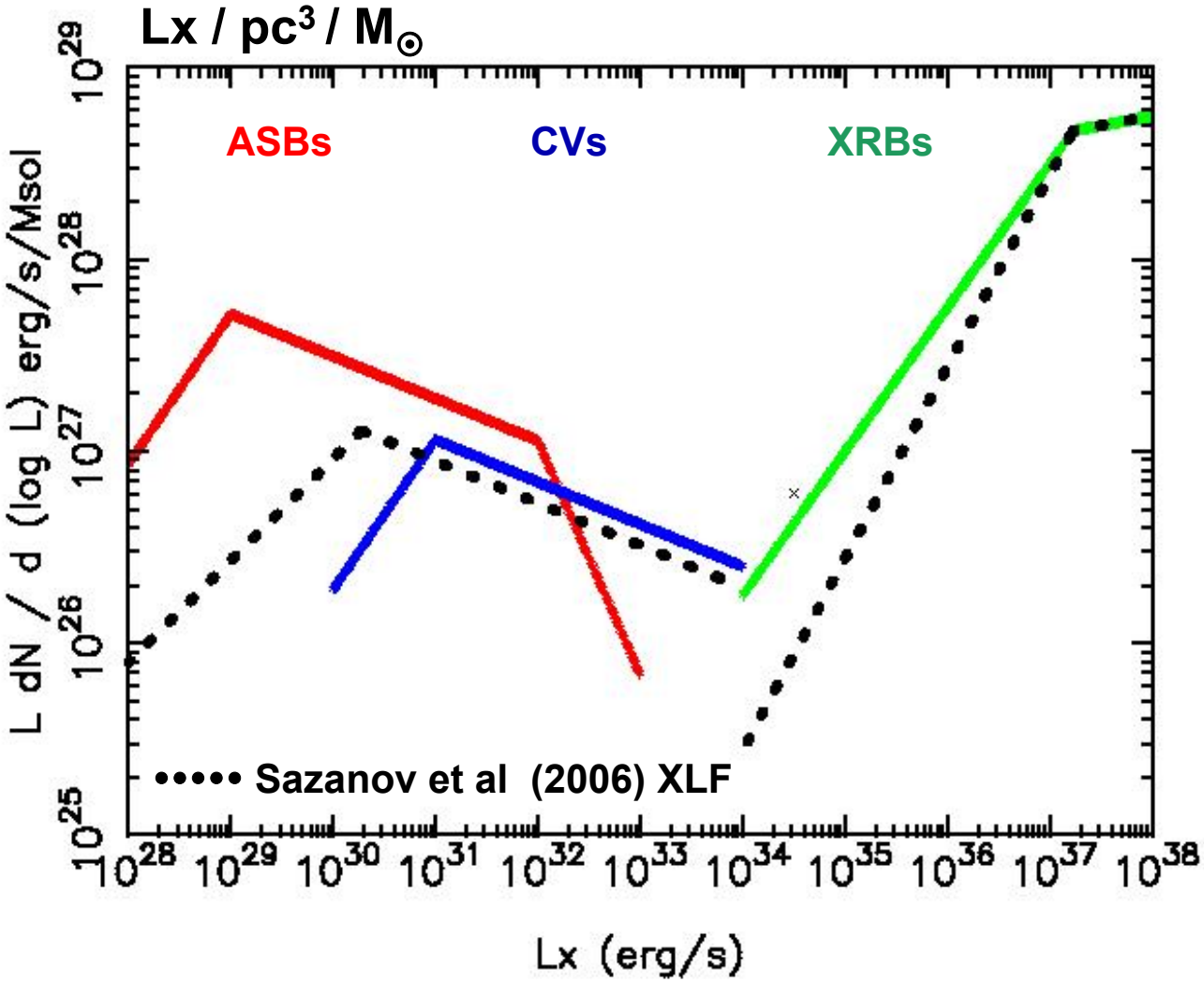
Local volume emissivity of CVs:

= 2.5 ± 0.6 x 10^{27} erg/s (2-10 keV) / $M_\odot$

[Referenced to a local mass density of 0.04 $M_\odot$/ pc^3]

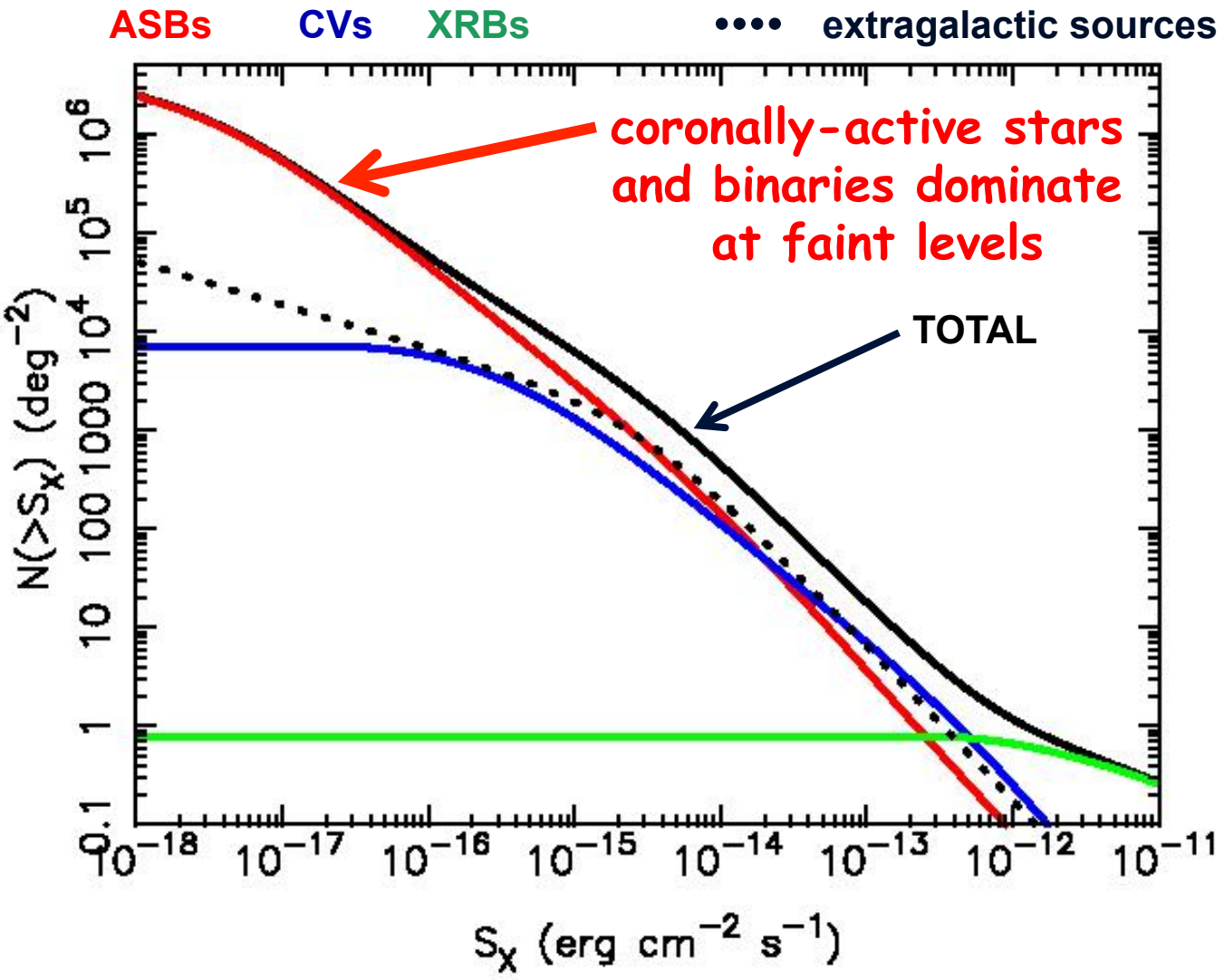
Warwick 2014

Derived 2-10 keV X-ray Luminosity Functions



Warwick 2014

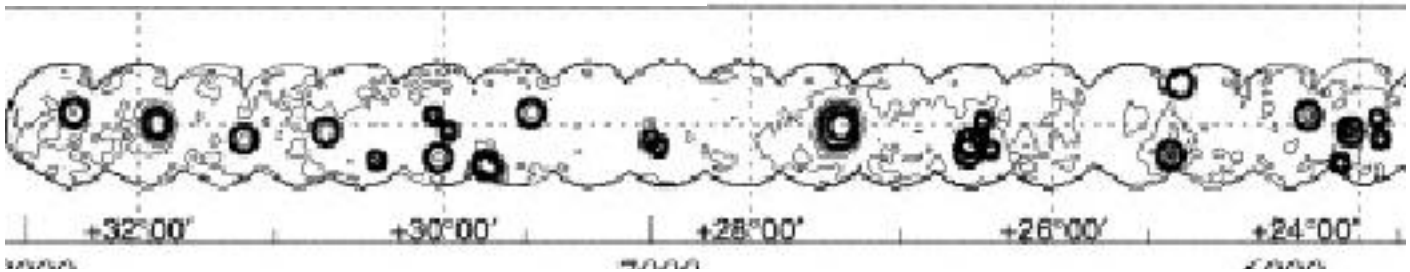
Predicted 2-10 keV Source Counts in the Galactic Plane at l = 28.5°



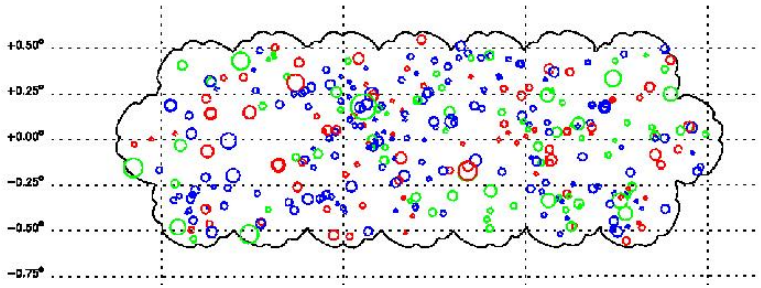
Warwick 2014

Comparison with Observations

ASCA – Sugizaki et al 2001

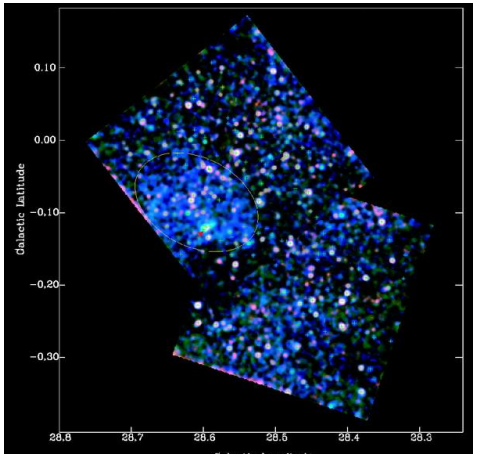


XMM – Hands et al 2004



l = 19°-22°

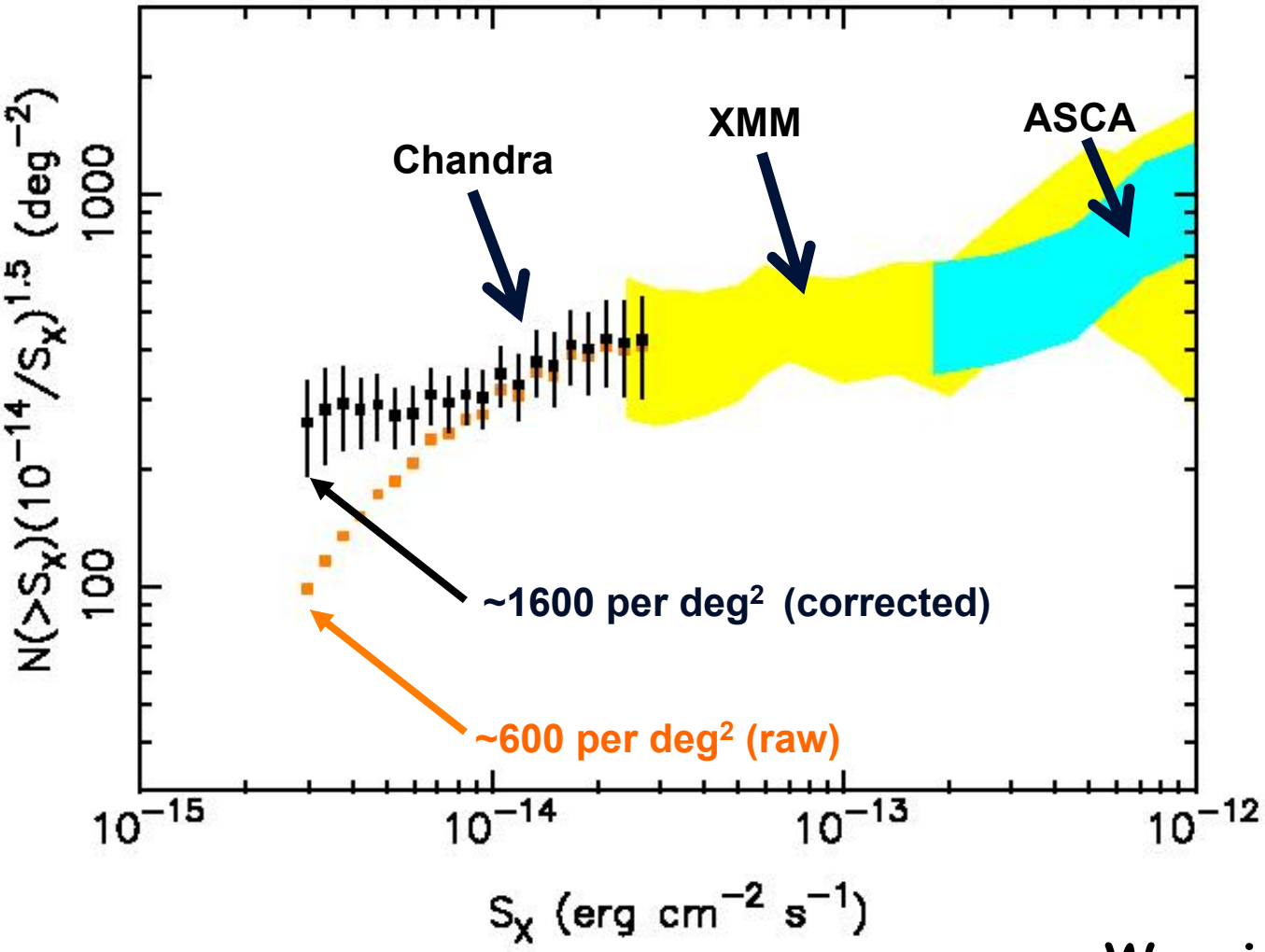
Chandra – Ebisawa et al 2005



l = 28.5°

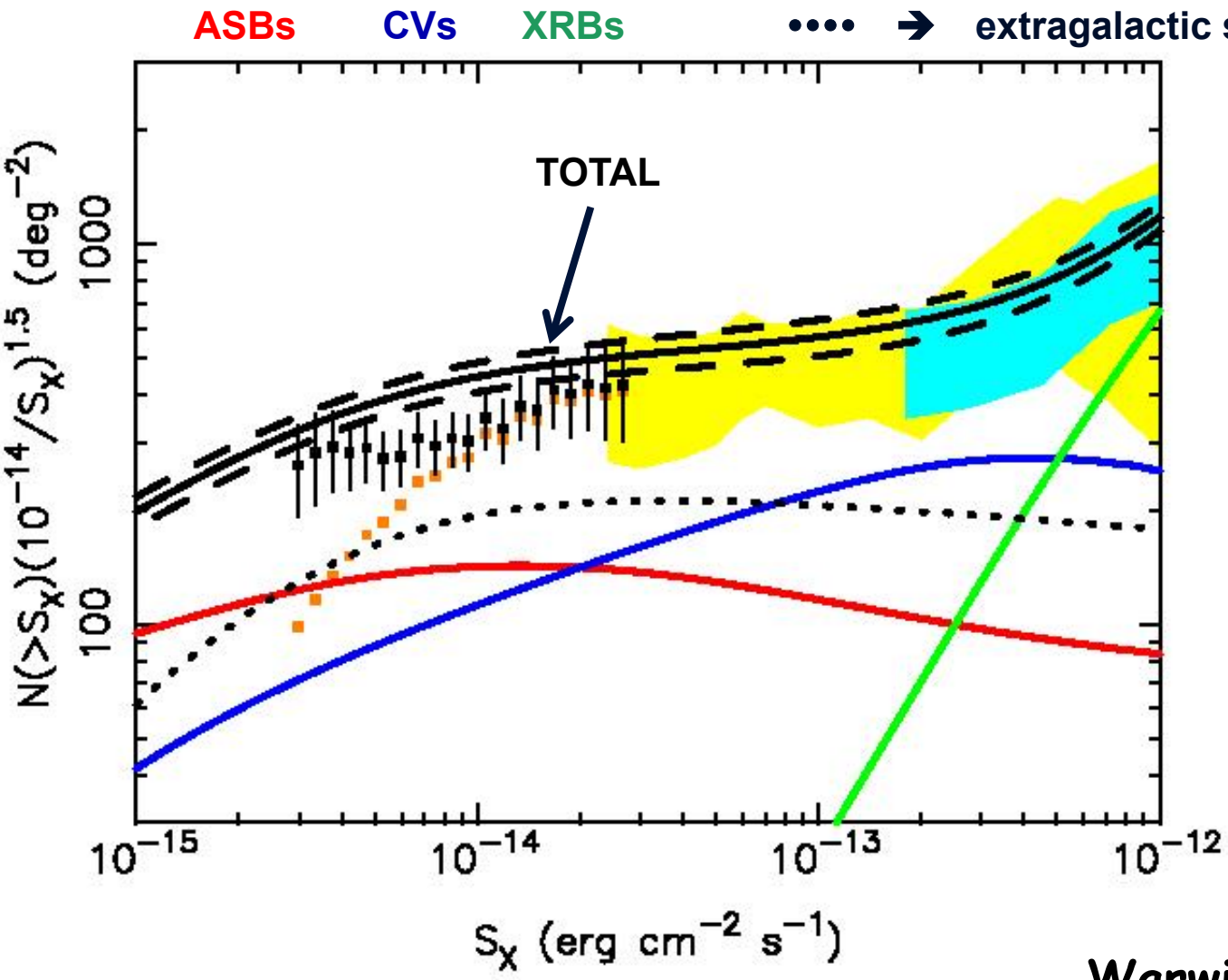
2 x 100 ks

Observed 2-10 keV Source Counts [normalized to $(S_X/10^{-14})^{-1.5}$]



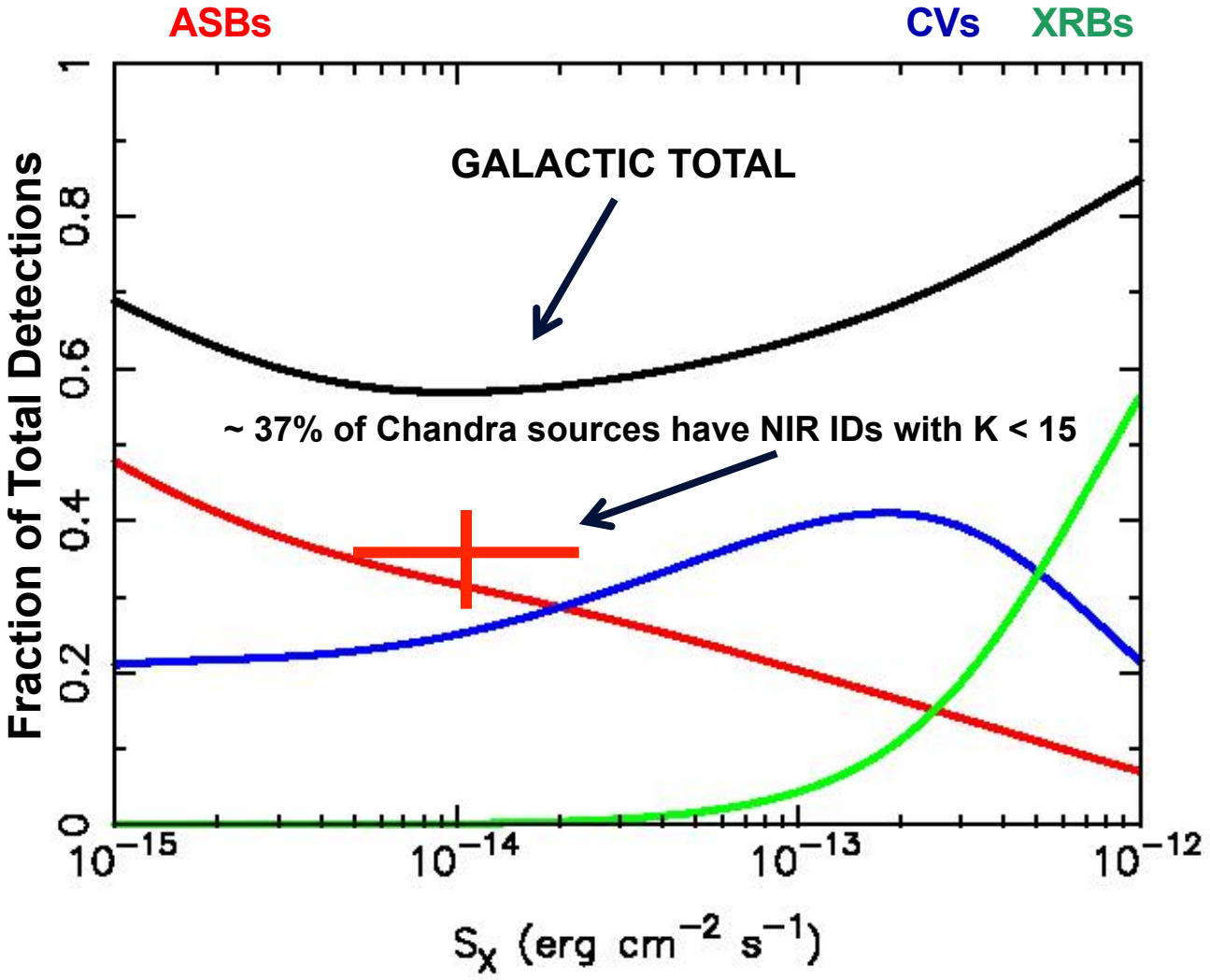
Warwick 2014

Observed Versus Predicted Source Counts [normalized to $(S_X/10^{-14})^{-1.5}$]



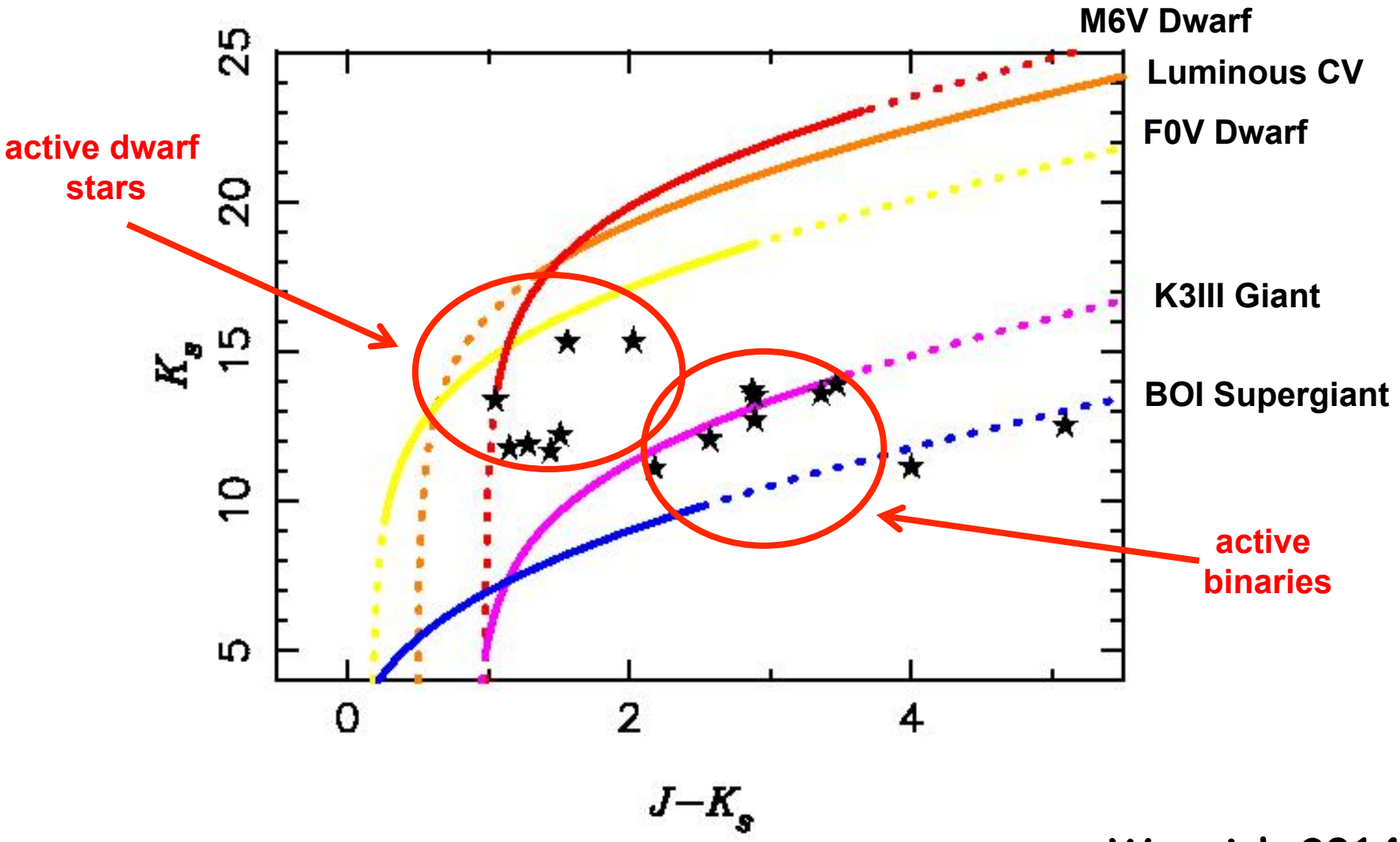
Warwick 2014

Make-up of the X-ray source population on the Galactic Plane (at l = 28.5°)



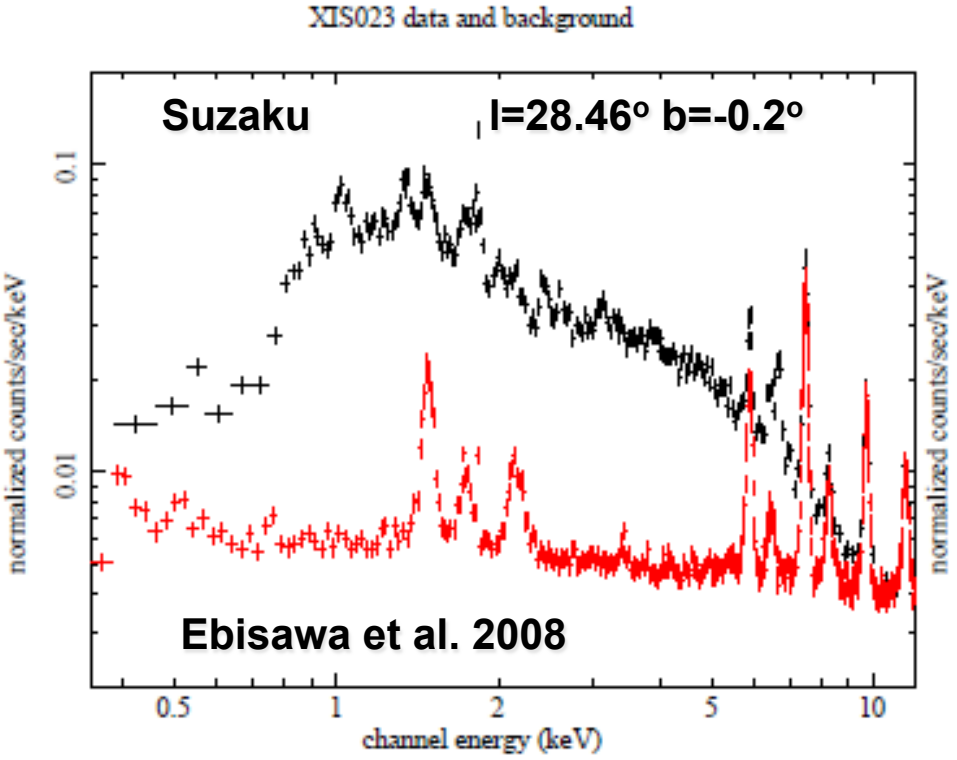
Warwick 2014

Make-up of the active star population at $S_X \sim 10^{-14}$ erg s^{-1} cm^{-2} (based on Ebisawa et al 2005 NIR data)



Warwick 2014

Matching the intensity and X-ray spectrum of the GRXE

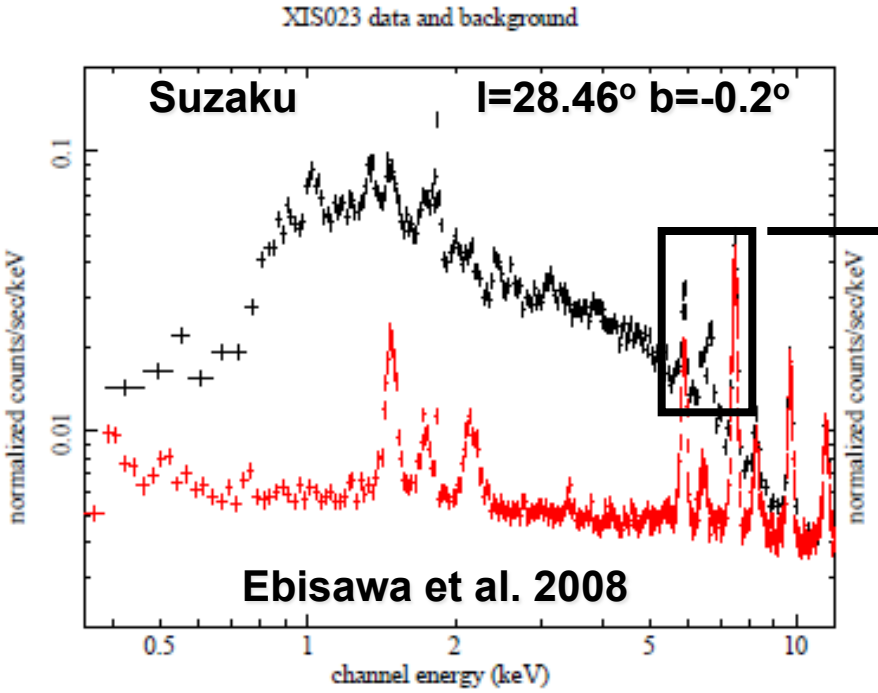


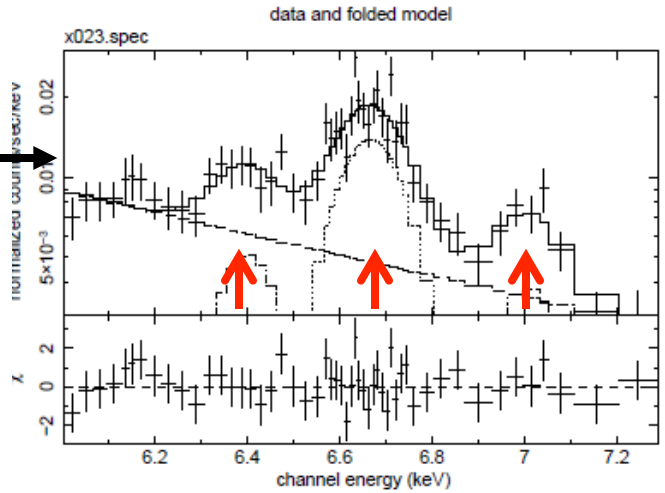
GRXE Surface Brightness (after subtracting the CXB)

= 4.8 x 10^{-11} erg/s/cm^2 /deg^2 (2-10 keV)

Continuum spectrum (>4 keV) ~ CIE plasma at ~ 4 keV

Matching the intensity and X-ray spectrum of the GRXE





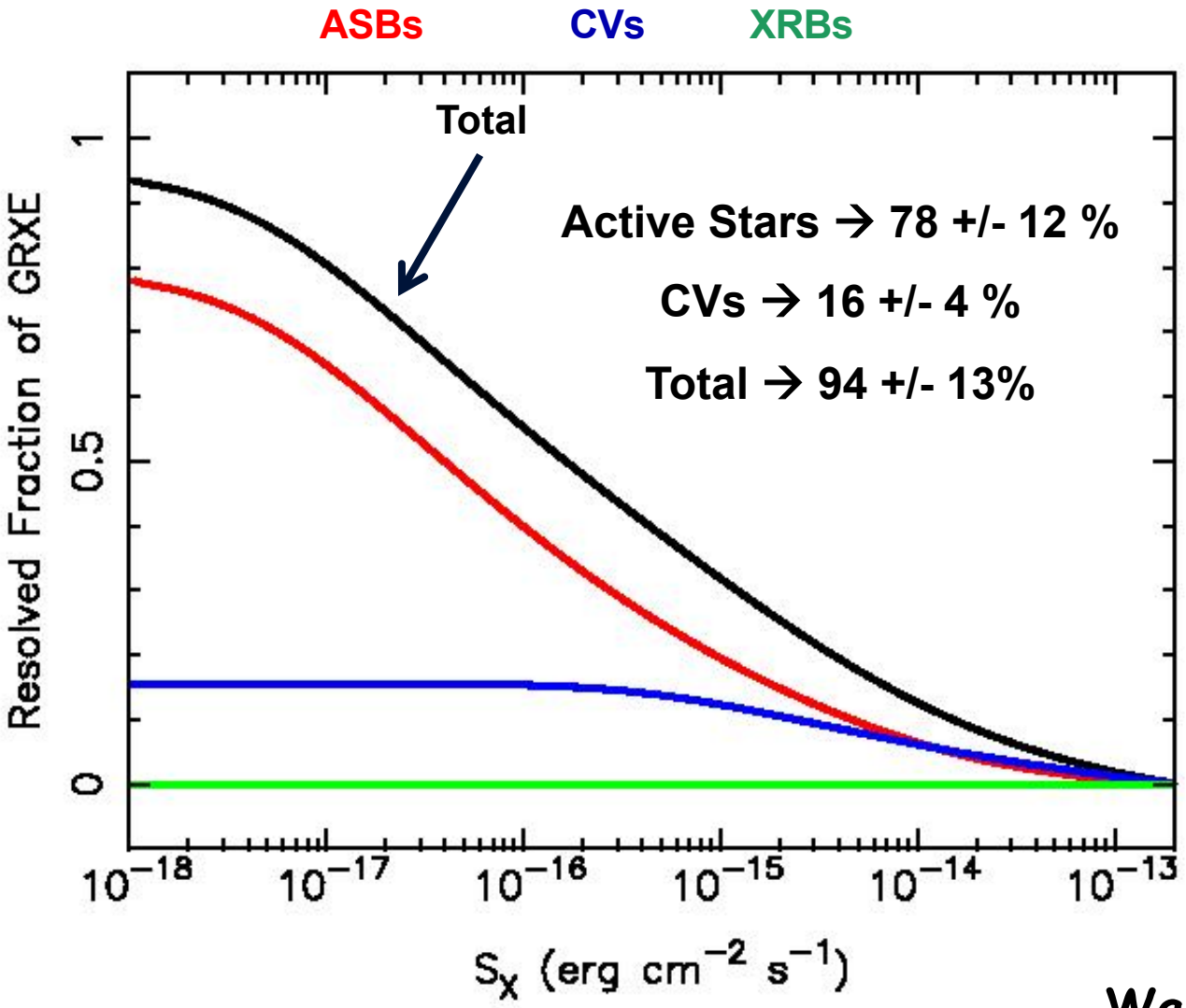
Fe-K Line Equivalent Widths

6.4-keV line → 80 +/- 20 eV

6.67-keV line → 350 +/- 40 eV

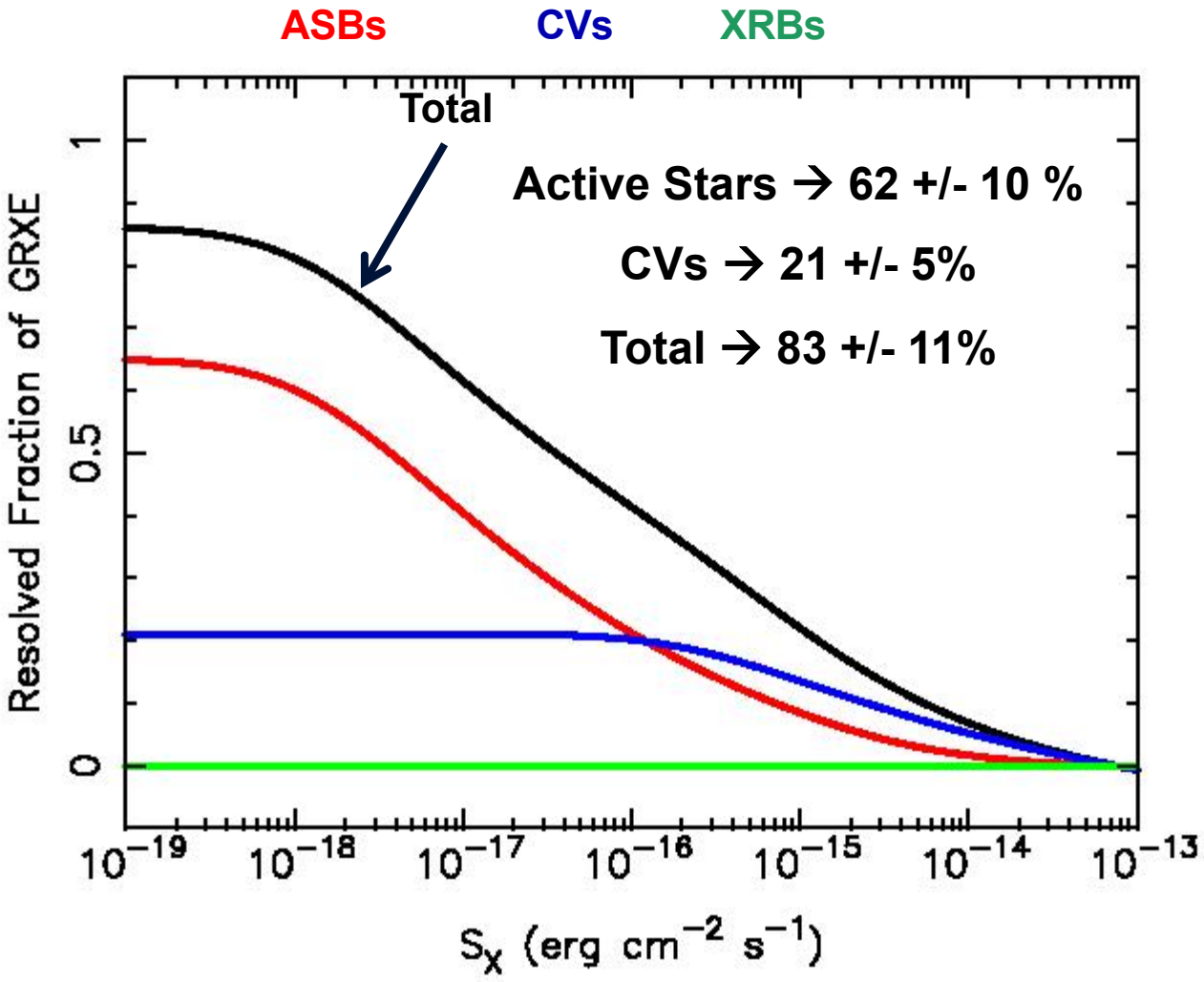
6.96-keV line → 70 +/- 30 eV

Matching the intensity of the GRXE in the 2-10 keV band



Warwick 2014

Matching the intensity of the GRXE in the harder 6-10 keV band



Warwick 2014

Matching the measured equivalent widths of the 6.7/6.9-keV Fe-K lines

Step 1: Assume 20% contribution from CVs:

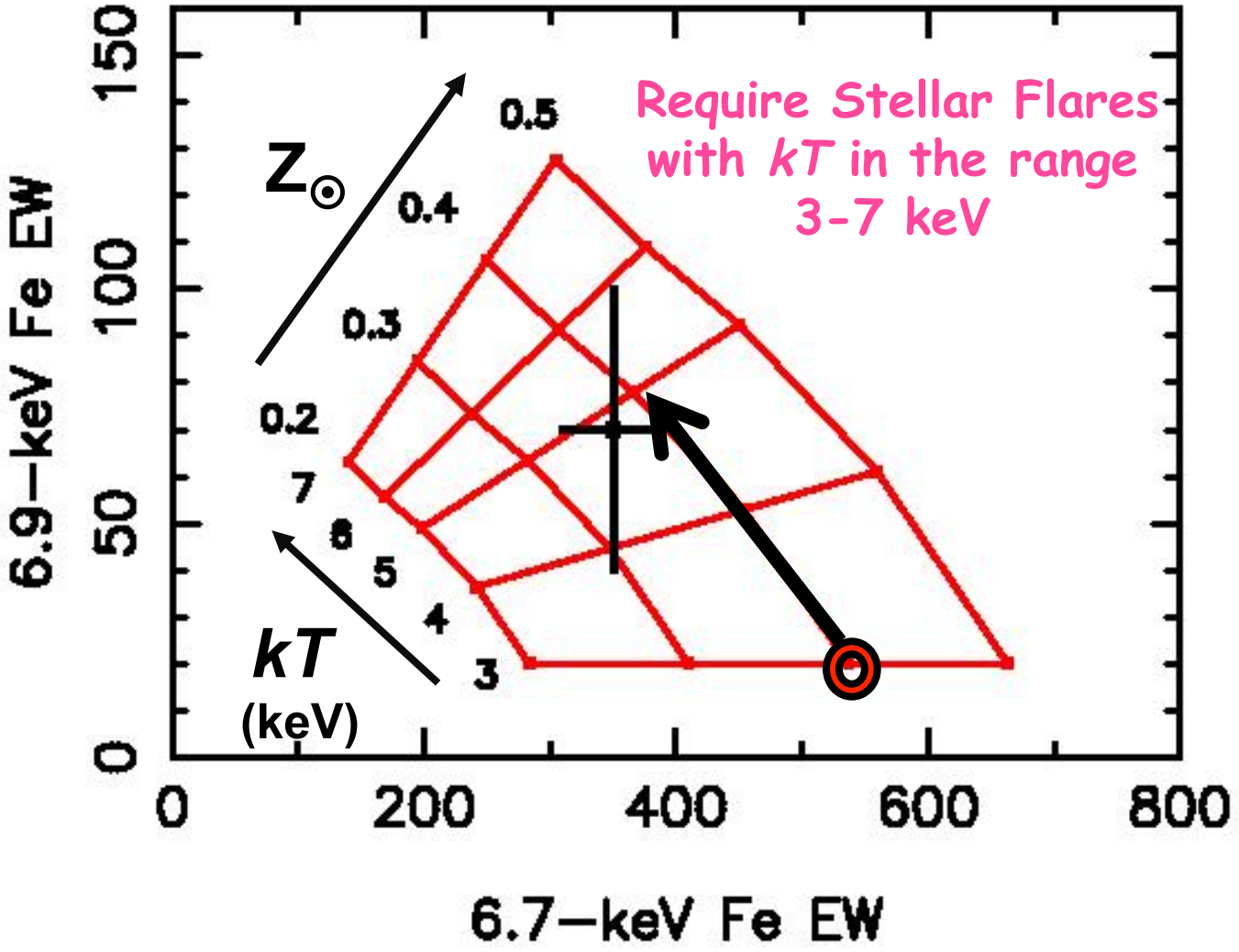
6.7-keV line EW ~ 150 eV

6.9-keV line EW ~ 100 eV

[eg. Warwick et al. 2013]

Step 2: Add 60%+ contribution from ASBs

Matching the Fe-K line EWs by varying the ASB *temperature* (*kT*) and *abundance* (*Z*).



Matching the ~100 eV EW of the 6.4-keV Fe fluorescence line in the GRXE.

Step 1: Assume 20% contribution from CVs:

6.4-keV line EW ~50-100 eV

Step 2: Assume 60%+ contribution from ASBs:

6.4-keV line emission → not generally seen!

Step 3: Assume 10%+ contribution from radiation of XRBs scattered by the ISM:

6.4-keV line EW ~1000 eV (wrt scattered continuum)

[NEXT TALK!]

Conclusions

- We have derived new estimates of the X-ray Luminosity Function (XLF) of coronally-active stars (ASBs) and CVs in the 2—10 keV band.
- Implied X-ray volume emissivity of ASBs+CVs is a factor 2-3 higher than previous estimates (for this hard band).
- ASBs dominate the 2-10 keV X-ray source counts in the Galactic plane at faint fluxes and contribute 60%+ of the GRXE intensity.
- ASBs + CVs + scattered emission can provide a match to the observed spectral form of GXRE including the EWs of the Fe-K lines.