

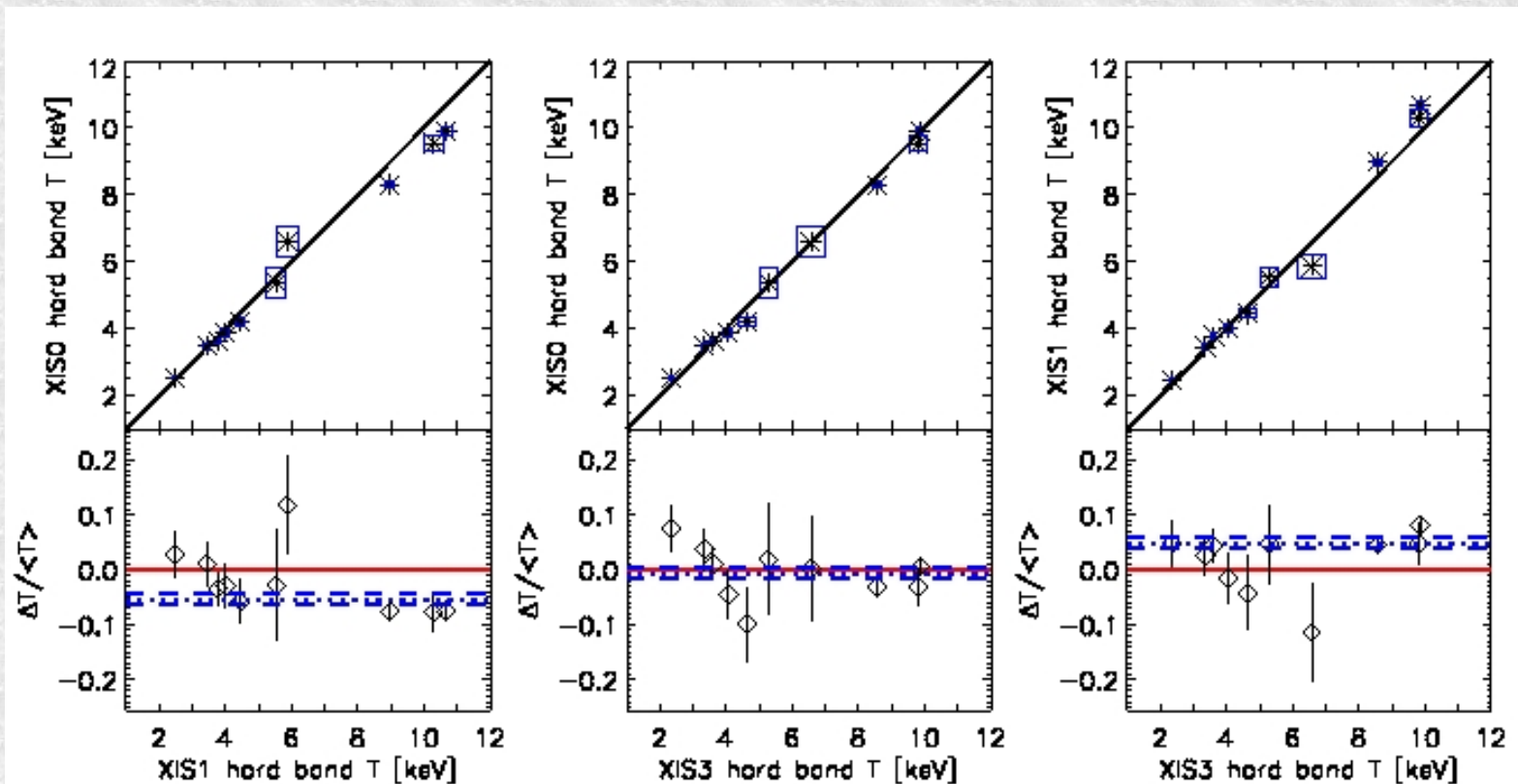
**Cross-calibration of Suzaku  
XIS and XMM-Newton EPIC  
using clusters of galaxies  
(arXIV:1301.2947)**

**K. Kettula, J. Nevalainen & E. Miller**

- ★ Spectroscopic analysis of clusters using two stages of calibration: CALDB 20080709 and CALDB 20110608
- ★ Sample contains 11 ~ relaxed clusters observed with both Suzaku and XMM: A1060, A1795, A262, A3112, A496, AWM7, Centaurus, Coma, Ophiuchus, Triangulum
- ★ Fit with 1-T MEKAL model in 0.5-2.0 and 2.0-7.0 keV bands
- ★ Extraction regions 3-6 arcmin in order to
  - ◆ Minimise PSF scatter to and from the extraction region (area wider than PSF).
  - ◆ Minimise PSF scatter from the cool core.
  - ◆ Not too large region to minimize background effects (bkg a few % of cluster emission)
- ★ Cluster center/FOV center offsets  $< 1'$ , except A2199  $4'$

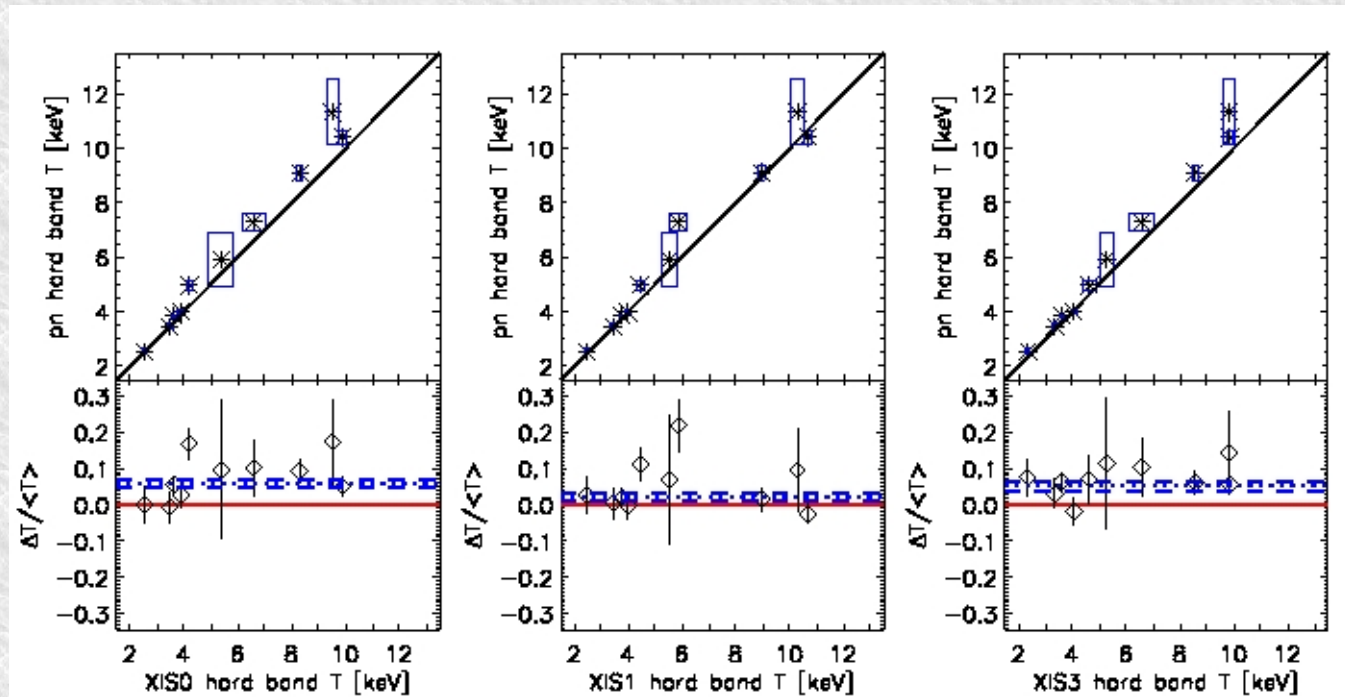
# XIS hard band

- ★ XIS0/XIS3 temperatures differ only by 1% ( $0.6\sigma$ )
- ★ XIS1 temperatures 5% ( $5-6\sigma$ ) higher



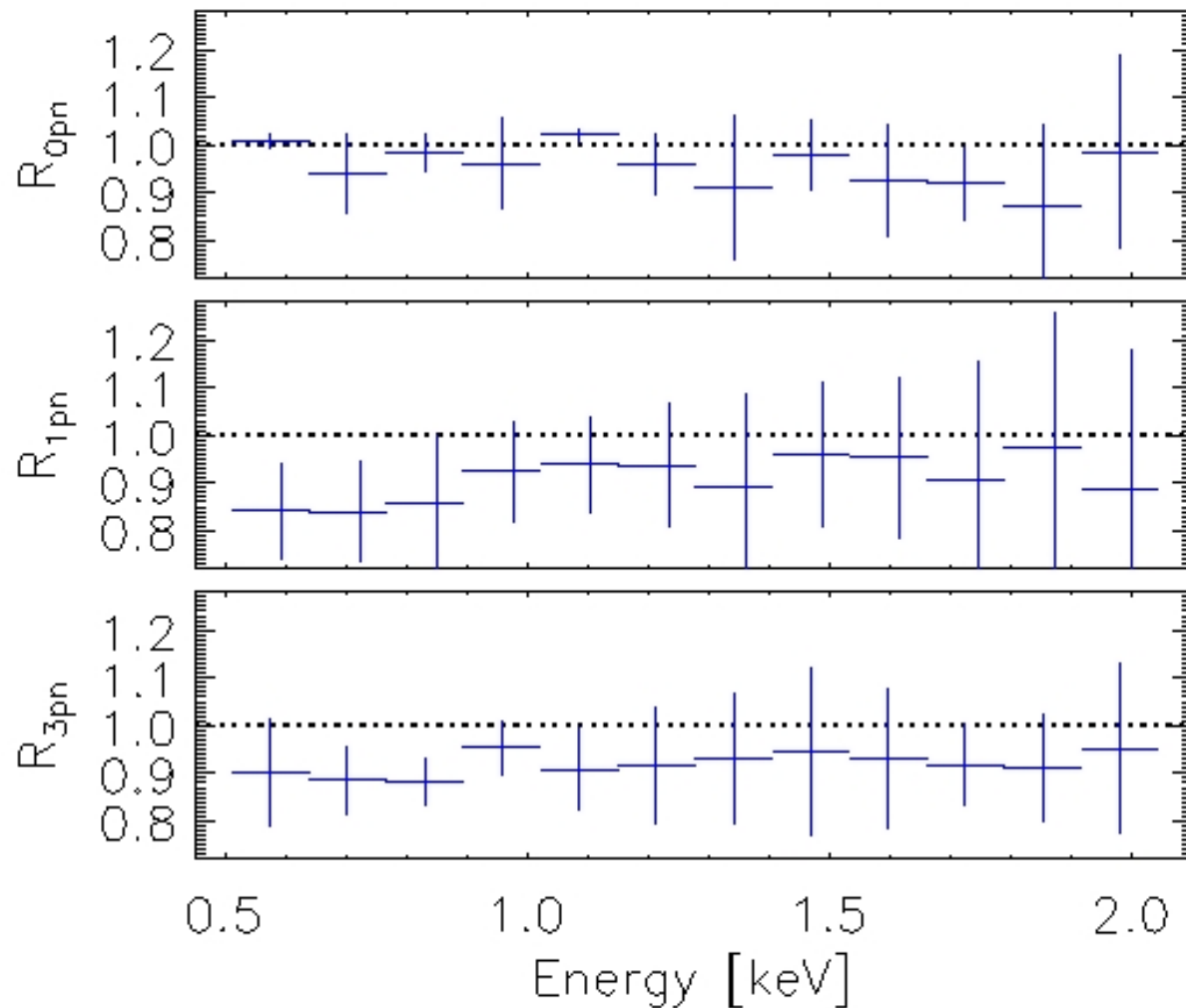
# XIS/pn hard band

- ★ XIS1/pn differ only by 2% ( $1\sigma$ ). pn should be OK (Nevalainen et al., 2010) → XIS1 should be OK
- ★ XIS0 and XIS3 5% lower than pn. Suggested that XIS0 and XIS3 have a bit too hard effective area shape in 2-7 keV band.

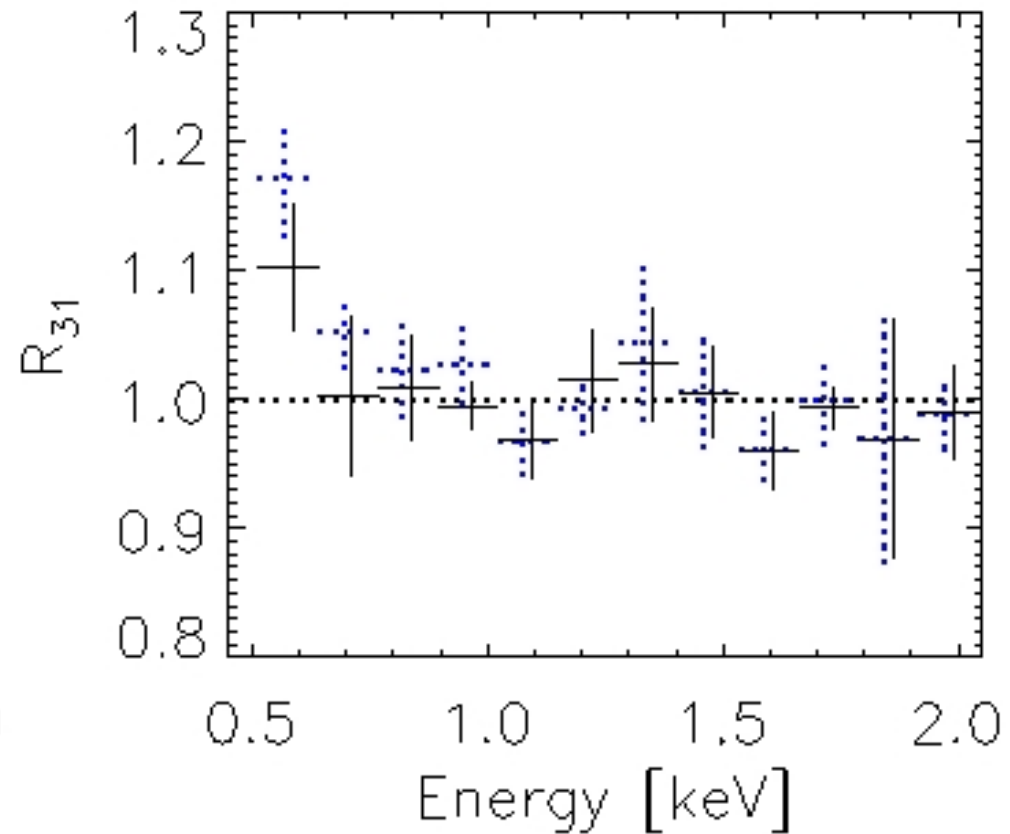
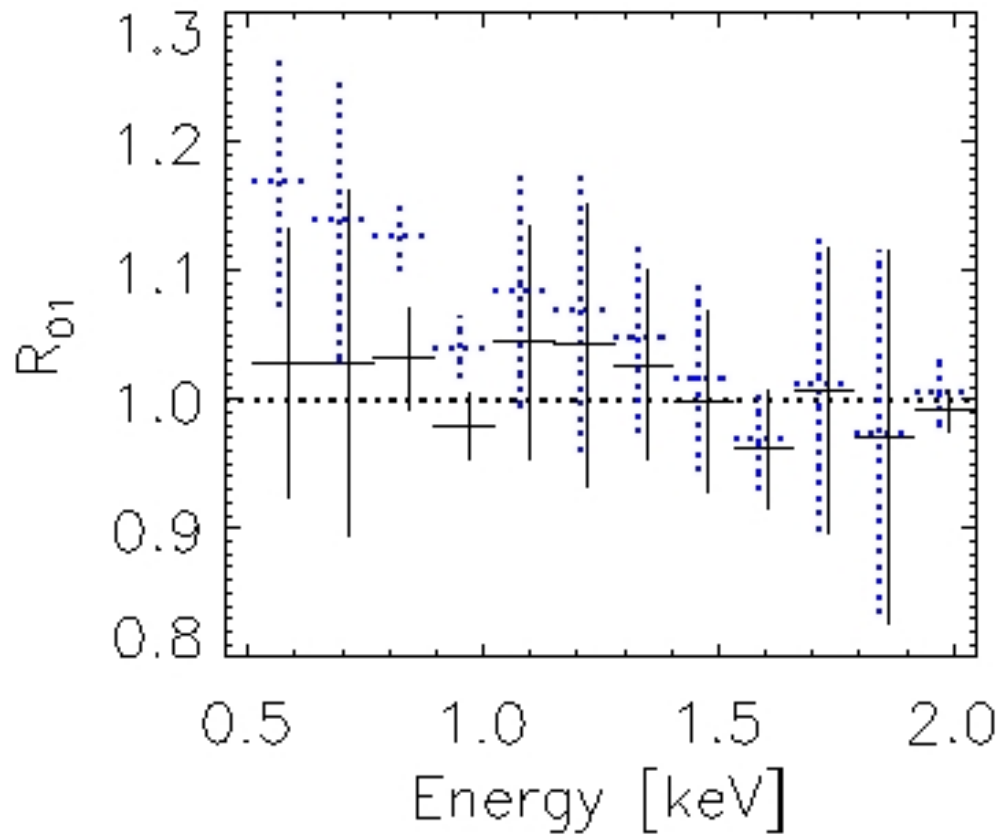


# XIS pn soft band

- ★ XIS1/XIS3 kT differ a bit (7%) but not very significantly ( $2.5\sigma$ )
- ★ XIS0 yields 30% and 20% lower ( $10\sigma$ ) temperatures.

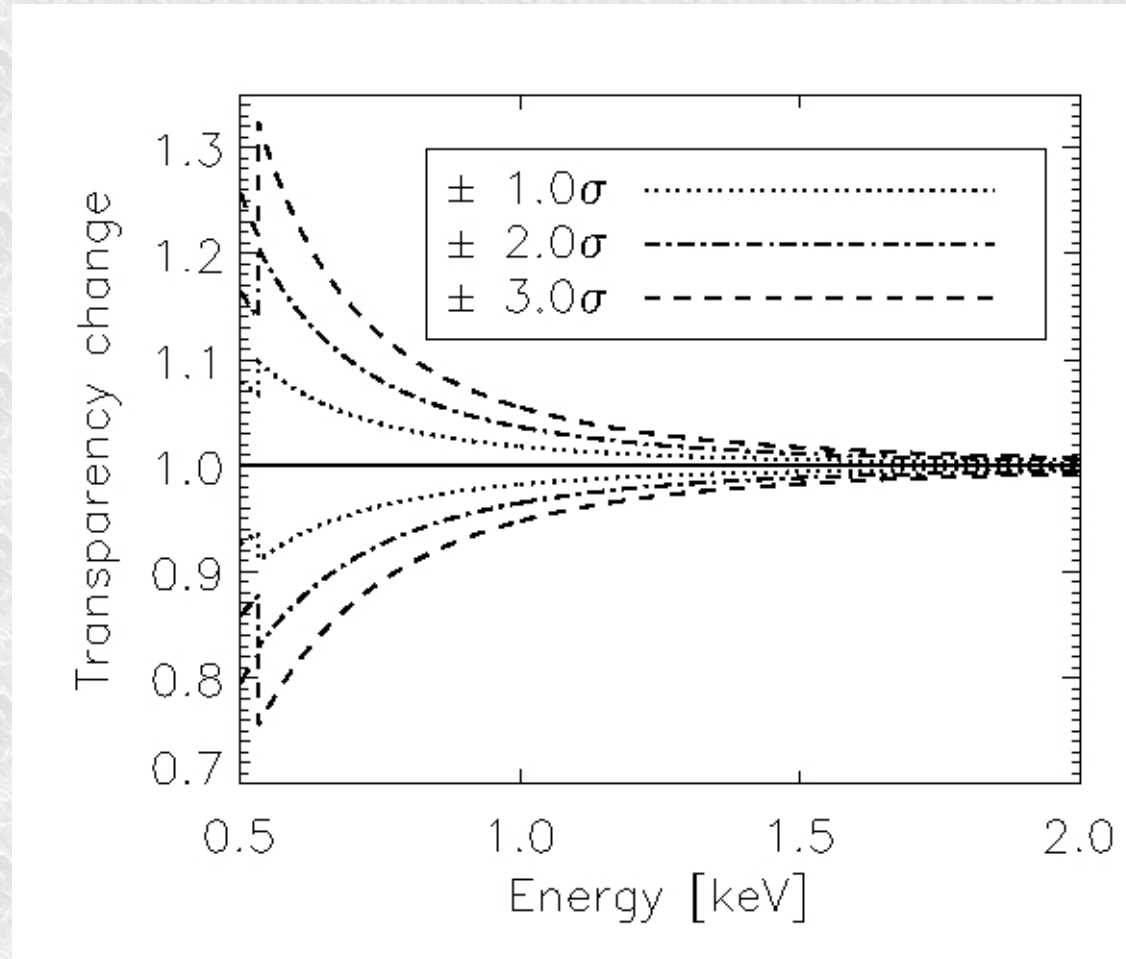


# XIS soft stack residuals

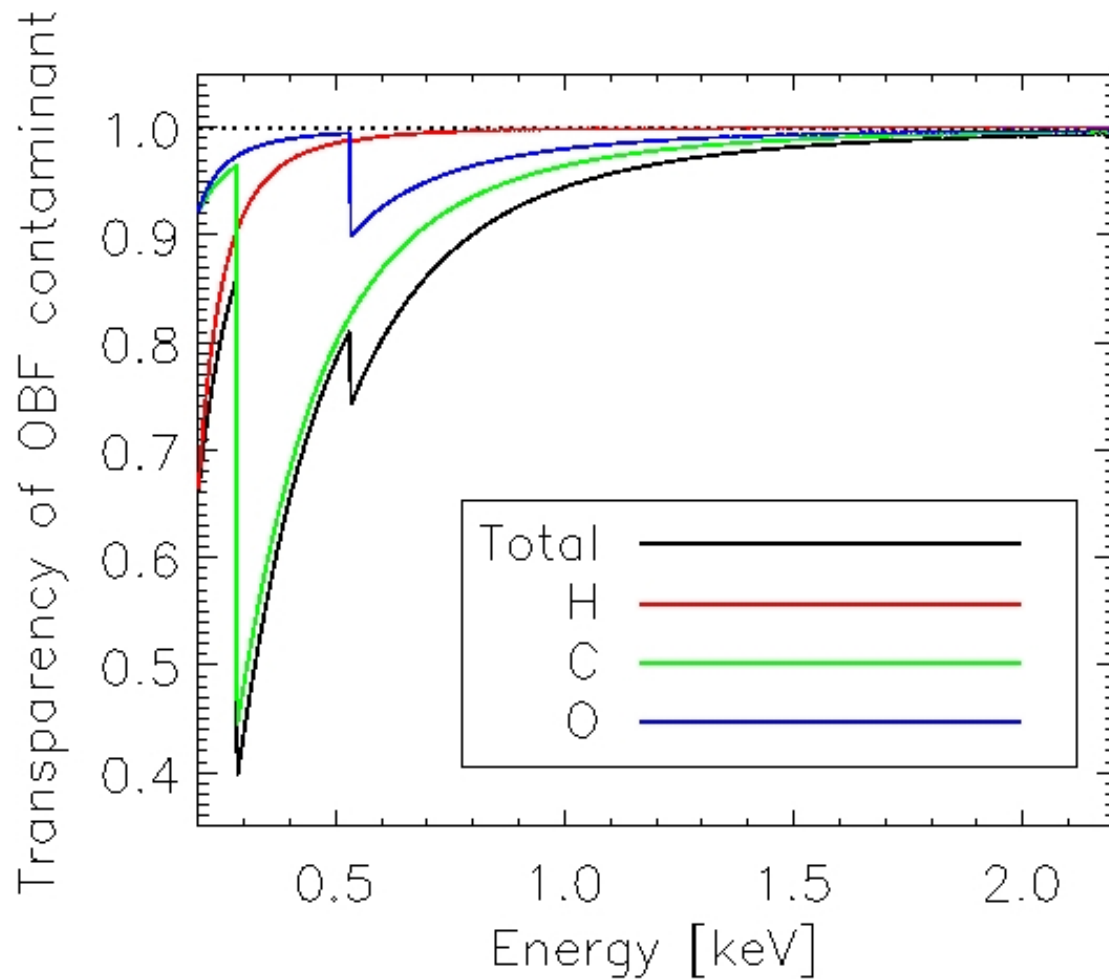


# Is the contaminate to blame?

- ★ We used a local XSPEC model hcorat to investigate the contaminate absorption effect
- ★ We used  $0.8 \times 10^{18} \text{ cm}^{-2}$  as reference O column density for 2007 epoch
- ★ Varying  $N_{\text{O}}$ , the effective area energies due to O edge
- ★ Varying O column by  $3\sigma$  (the reported O measurement stat. + sys uncertainty is  $\pm 5 \times 10^{16} \text{ cm}^{-2}$ ) yields 20% effect as required by the clusters by minimum.



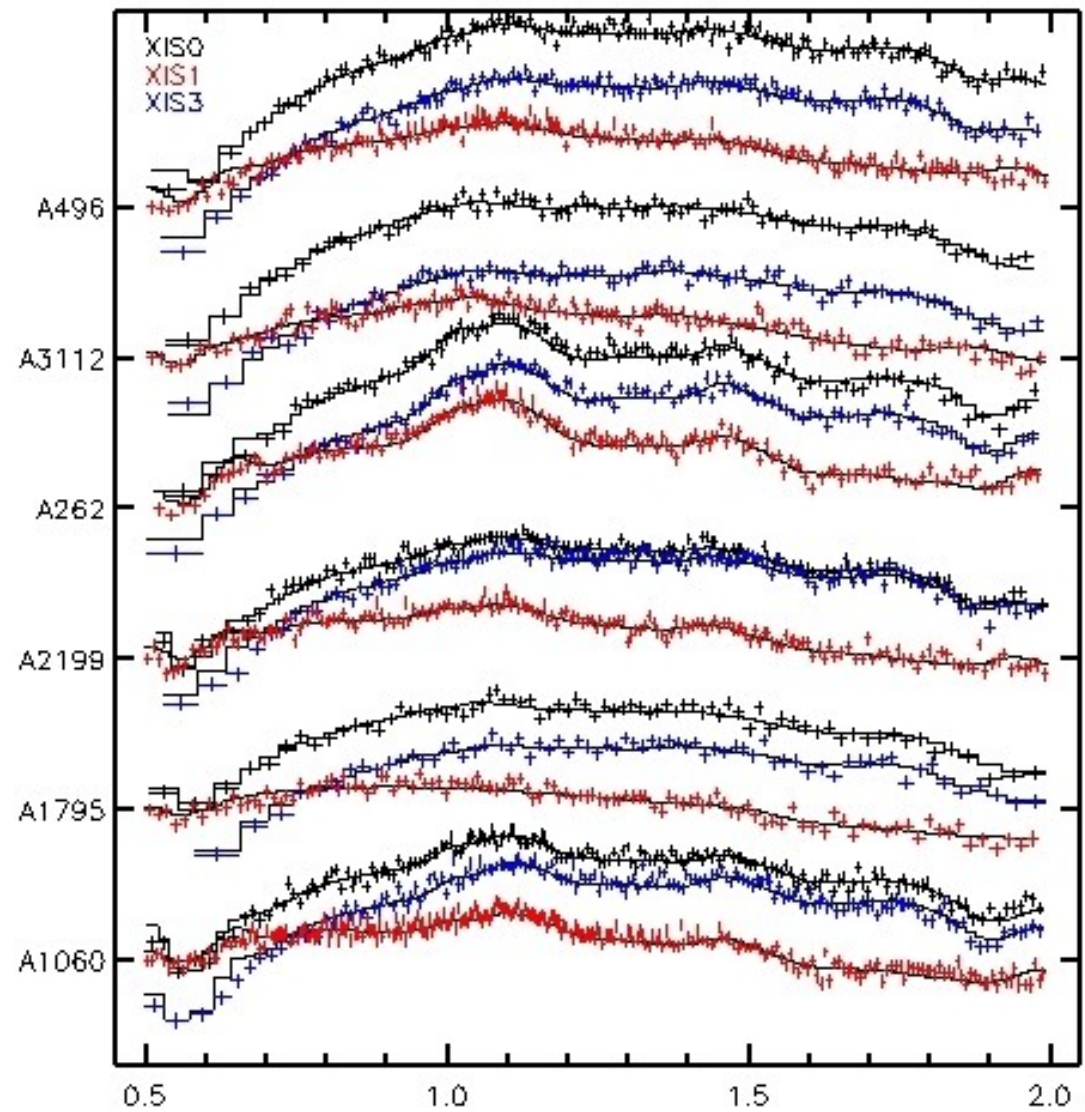
# Transparency of the contaminant





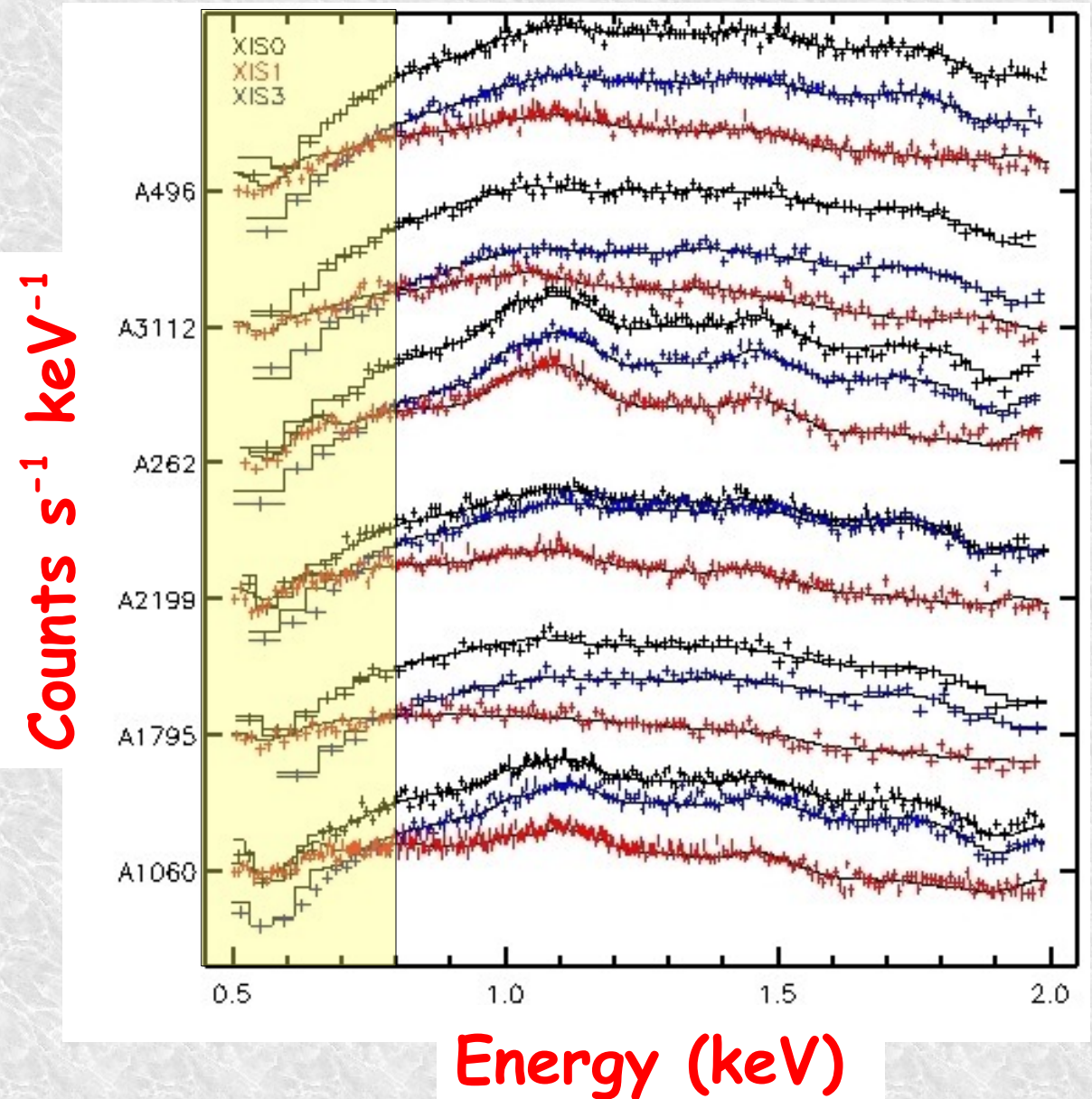
# We can measure the total O column with clusters

Counts  $s^{-1} \text{ keV}^{-1}$



Energy (keV)

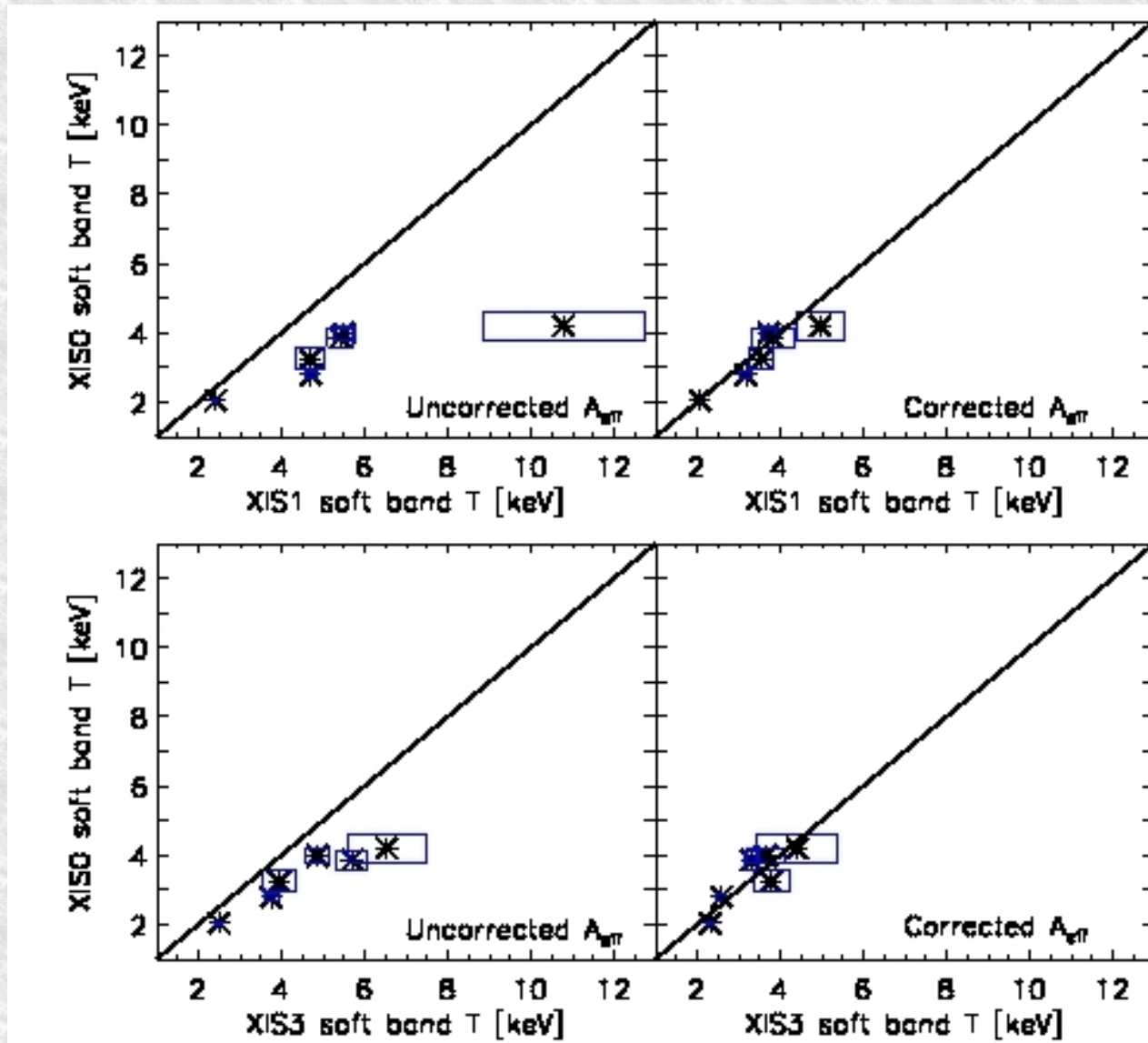
# We can measure the total O column with clusters



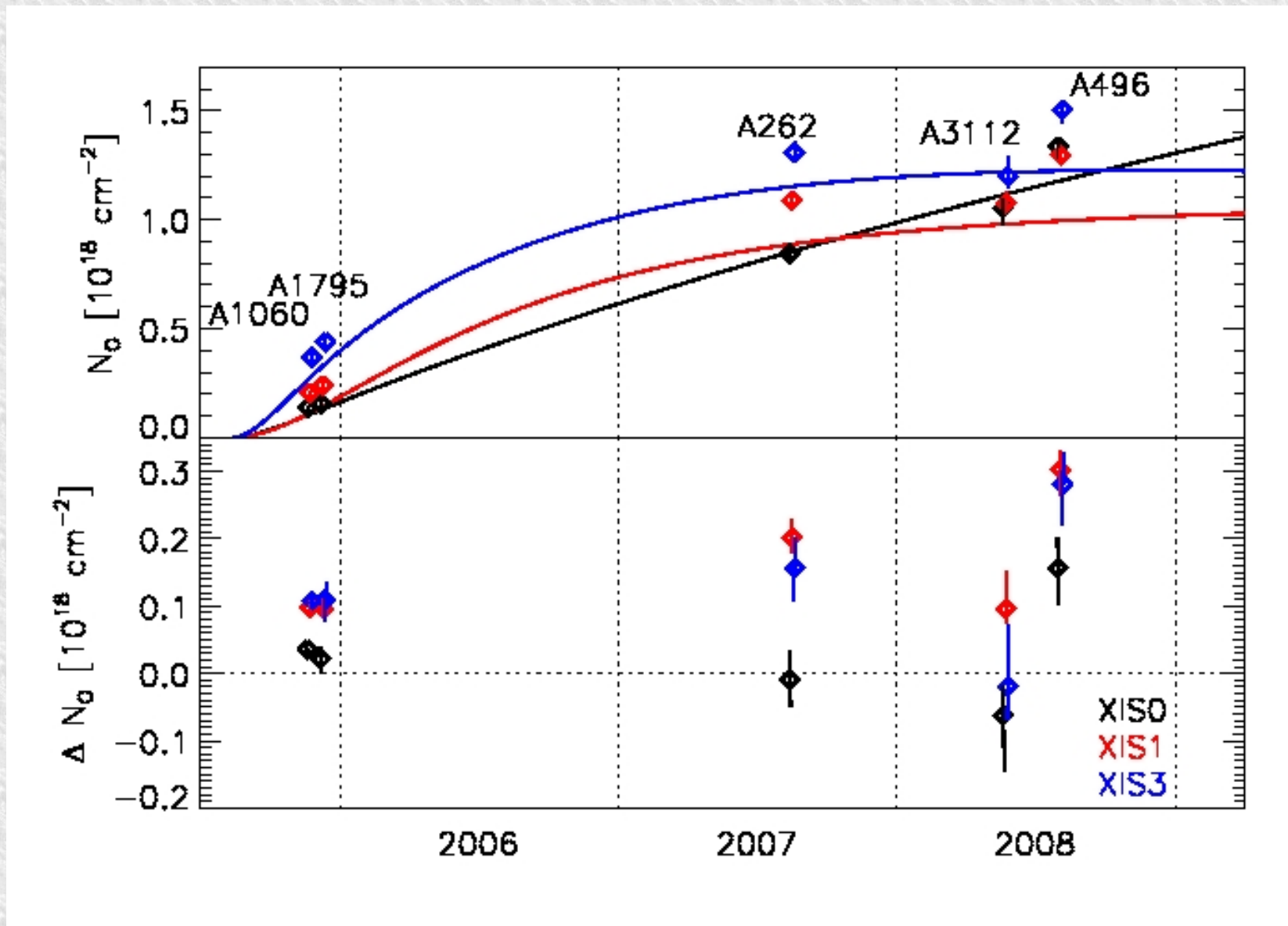
# Fitting the arf

- ★ We fit the XISO,1,3 cluster spectra simultaneously with a model where temperatures are forced equal and the models multiplied by a local XSPEC contaminate model **hcorat**
- ★ H/C fixed to CALBD value
- ★ O/C fixed to time dependent CALDB value
- ★ We allow only the O column density to vary, in order to find the best effective area when keeping the emission model fixed
- ★ The best-fit yields the required change in O column density  $\Delta N_o$

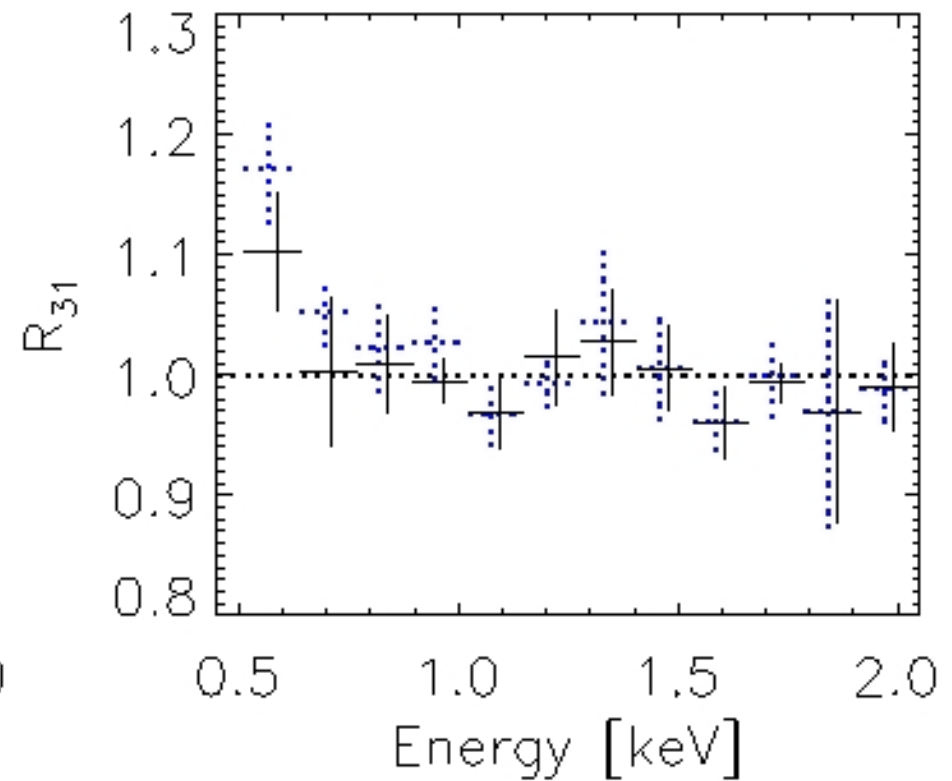
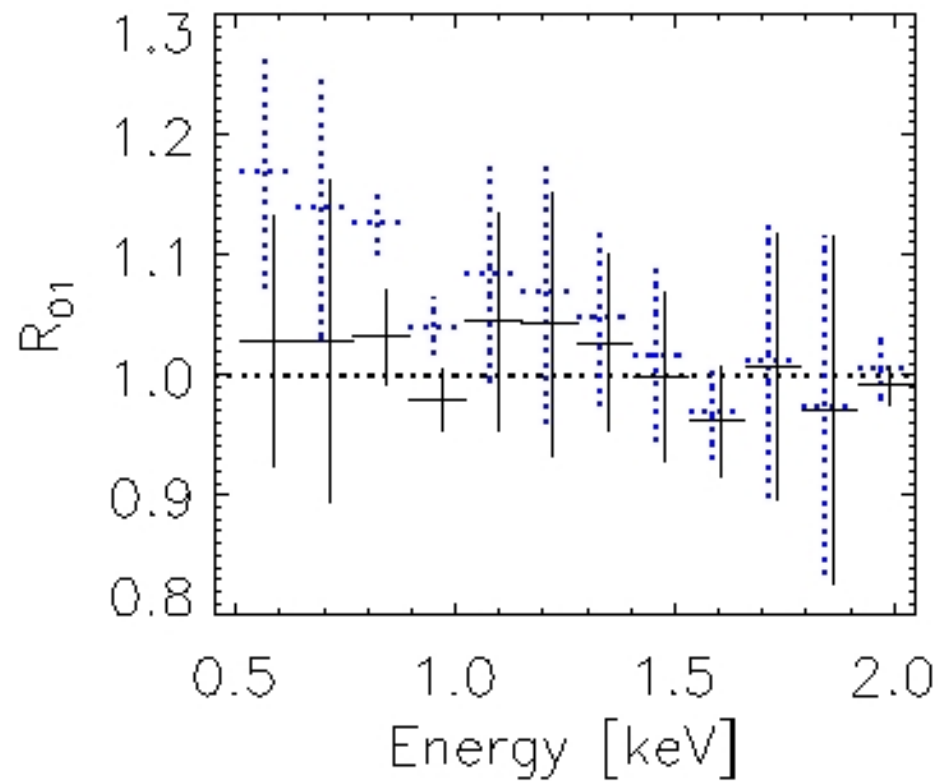
# Temperatures using modified response



# Required column densities



# Soft band stack residuals



# Summary of temperatures

