Temporal Variation in the Filter-Wheel-Closed Data
November 6, 2008

I have compared the Filter-Wheel-Closed (FWC) data from REV<1130 with the FWC data from REV>1130 to determine whether we can detect long term temporal variation. The "new" data was reduced using the current SAS, while the "old" data had been reduced with previous versions of SAS, and is what appears in the FWC images in XMM-ESAS. In the following, I use the anomalous chip mode definitions from Kuntz & Snowden (2008).

1. Spatial Variation

The spatial variation of greatest interest would be relative changes in the response to the particle background, so a quantity of interest is (new/old - 1). I constructed images of each mode of each chip in each of four energy bands: soft (0.4-0.8 keV), lines (1.0-2.0), medium (2.5-5.0), and hard (5.0-14.0). Each chip image was then binned to six-by-six (about 10^4 original pixels per bin) which produced a signal-to-noise of roughly 3, 9, 6, and 10 respectively in the four energy bands for the ratio (new/old). The images of chips in the anomalous modes have considerably lower signal-to-noise ratios.

The first four columns of images displayed in Figure 1 are (new/old - 1) divided by the uncertainty in that quantity. The images were clipped at -3 and 3, and stretched from -3 to 3; black pixels having values less than or equal to -3 and white pixels having values greater than or equal to 3. The last column is the total FWC image with no binning.

Figure 2 shows histograms of (new/old - 1)/σ for all of the energies of all of the modes of all of the chips combined. The distribution is assymetric, with a significant negative tail. From Figure 1, one can see that the soft image contributes more to the negative tail than the harder images. I suspect that the negative tail is caused by a growing number of bad pixels, but have not had a chance to test this in a rigourous manner. However, bad pixels do would not explain the observation that negative tail is dominated by the softest band (which can be seen by counting the number of black pixels in each energy). However, since the soft band does has the lowest number of counts, the problem may be one of statistics.

What is more important is that we do not see large scale structure in these images; we do not seem to be seeing a large holes at the aimpoints, nor do we see any gradients. The uniformity of the images in Figure 1 suggests that the response to the particle background as a function of position is staying relatively constant.

2. Spectral Variation

I do not have the analysis of the temporal variation of the corner data completed, but it appears that the overall quiescent particle background rate has increased by a factor of roughly two over the last three years. This complicates the automated detection and exclusion of observations with anomalous chip modes, which may require temporal information.

That having been said, the FWC data appear to show the same behavior as the corner data. Figure 3 shows the spectra of the FWC data for each mode of each chip. I see little variation in the spectral shape. There may be a hint of some changes in MOS1-5S, but this may be a problem of removing observations that are nearly (or slightly) anomalous. There is also a hint of a change in the soft spectrum of MOS2-6S, which has not been seen to have anomalies.

3. Summary

The current brief analysis of the FWC data suggests that the MOS response to the quiescent particle background has not experienced spatially variable temporal changes, that is, if the reponse is temporally variable, that variation is the same across the detectors. The assymetry in (new/old - 1) may be due to the growing number of bad pixels, but remains to be tested. Similarly, we find no noticeable energy dependent change in the response to the quiescent particle background. From our initial analysis of the more recent corner data, the measured quiescent particle backgorund rates have been steadily increasing over the past several years, and the FWC data relect that change.

Although this analysis shows that the variation in the chip response to the particle background has been uniform, continued FWC observations are required to monitor any spatial variation in the response. The "corner data" are not sufficient to monitor spatial variation in the detector response.

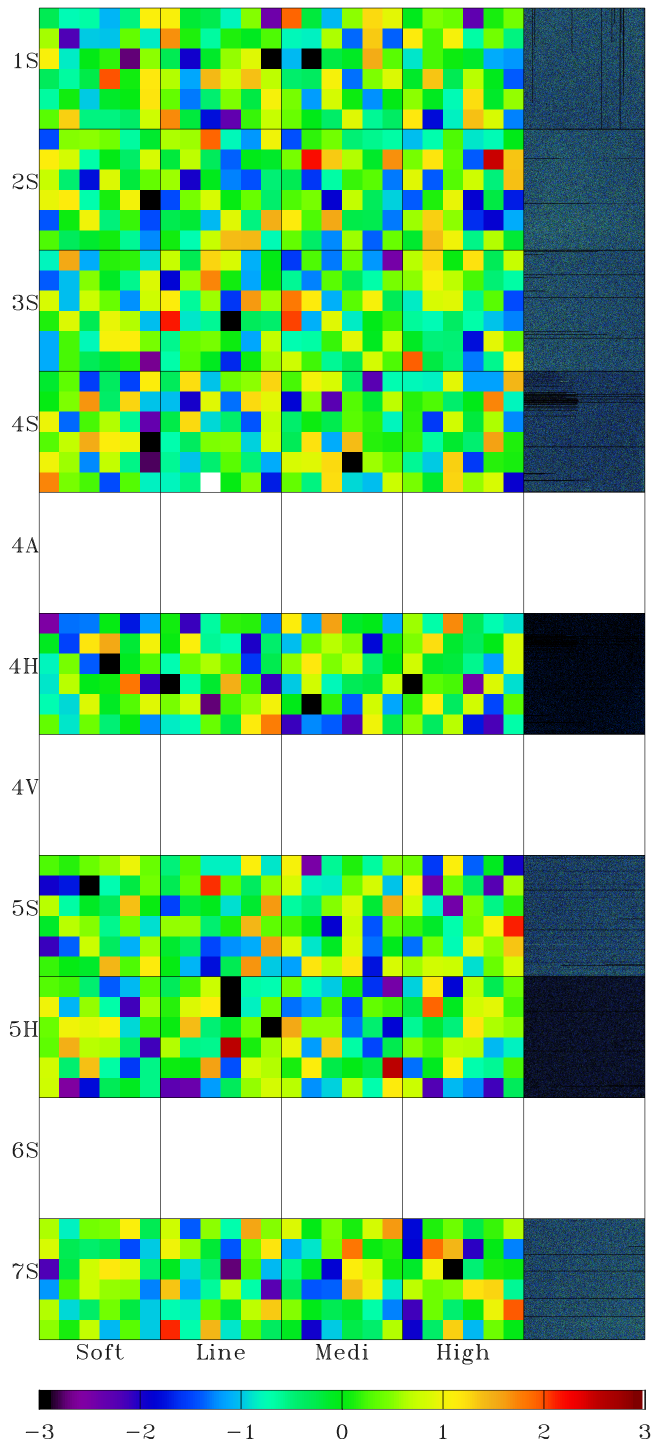

Fig. 1.— Images of the FWC data for each mode of each chip of MOS1 binned to six-by-six. The displayed quantity is (new/old - 1)/σ, where σ is the uncertainty in new/old. The first column is for 0.4-0.8 keV, the second column is for 1.0-2.0 keV (essentially the Al and Si lines), the third column is for 2.5-5.0 keV (featureless continuum), and the fourth column is for 5.0-14.0 keV. The images were clipped at $|(\text{new/old} - 1)/\sigma| > 3.0$ and stretched to the same limits. Black is the lower limit while white is the higher limit. The fifth column is an unbinned image of the FWC data for all energies. The orientation of the chips is that found in detector coordinates. The stretch of each image is from zero to four counts/pixel. The white rows are chip states without data in the FWC update.

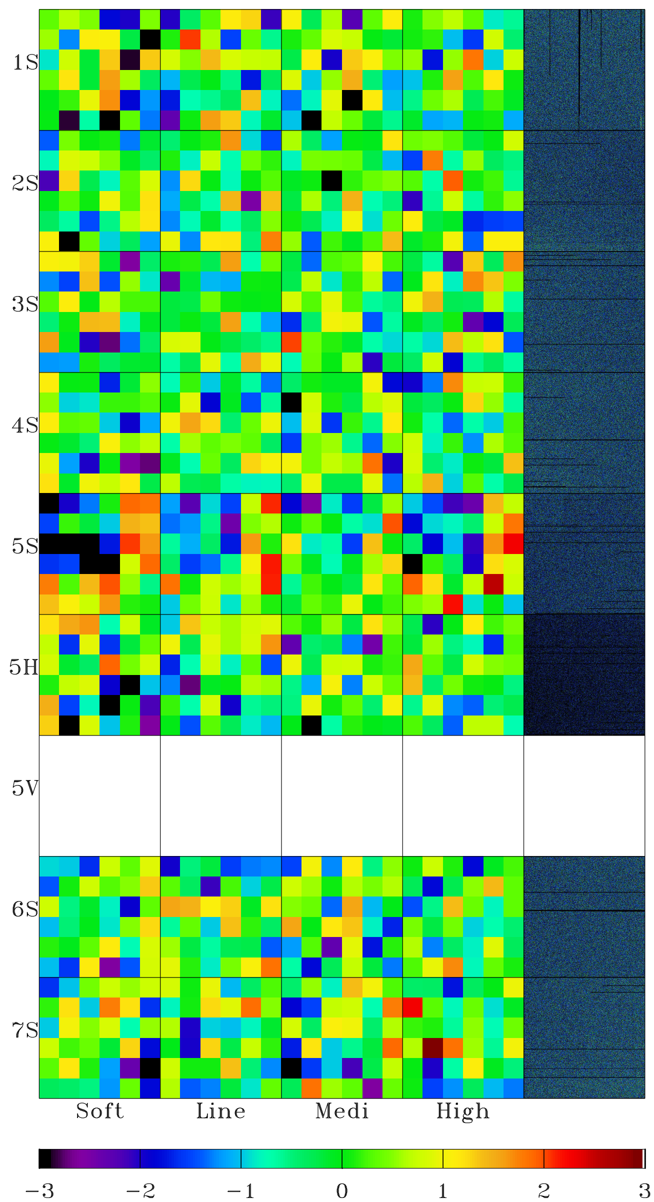

Fig. 1.— *continued:* For MOS2.

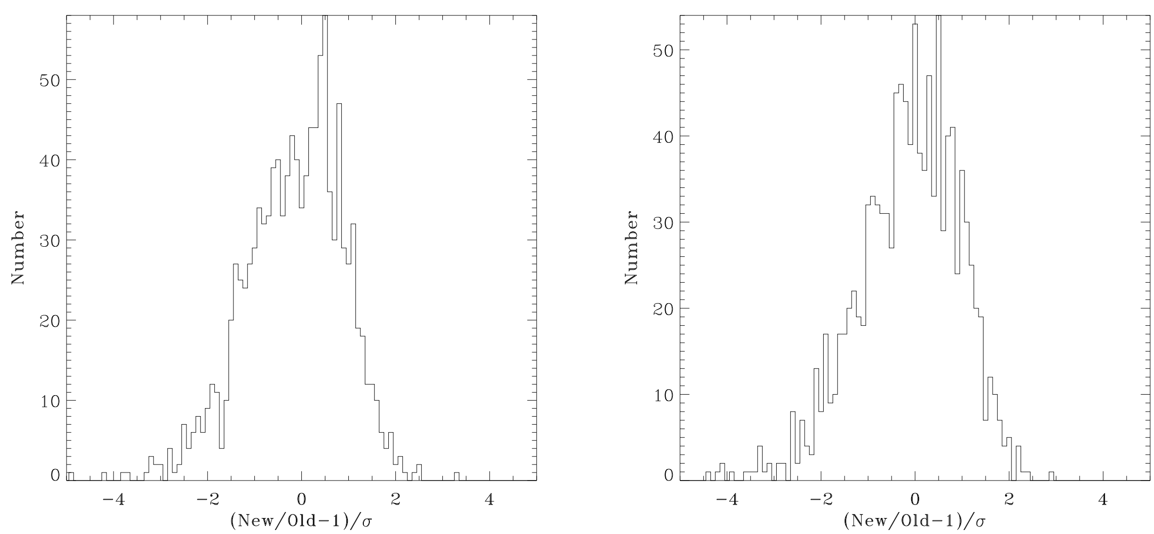

Fig. 2.— Histograms of the quantity (new/old - 1)/σ for MOS1 (left) and MOS2 (right). The histograms was formed from all of the pixels in all of the modes of all of the chips in the four energy bins shown in the previous figures.

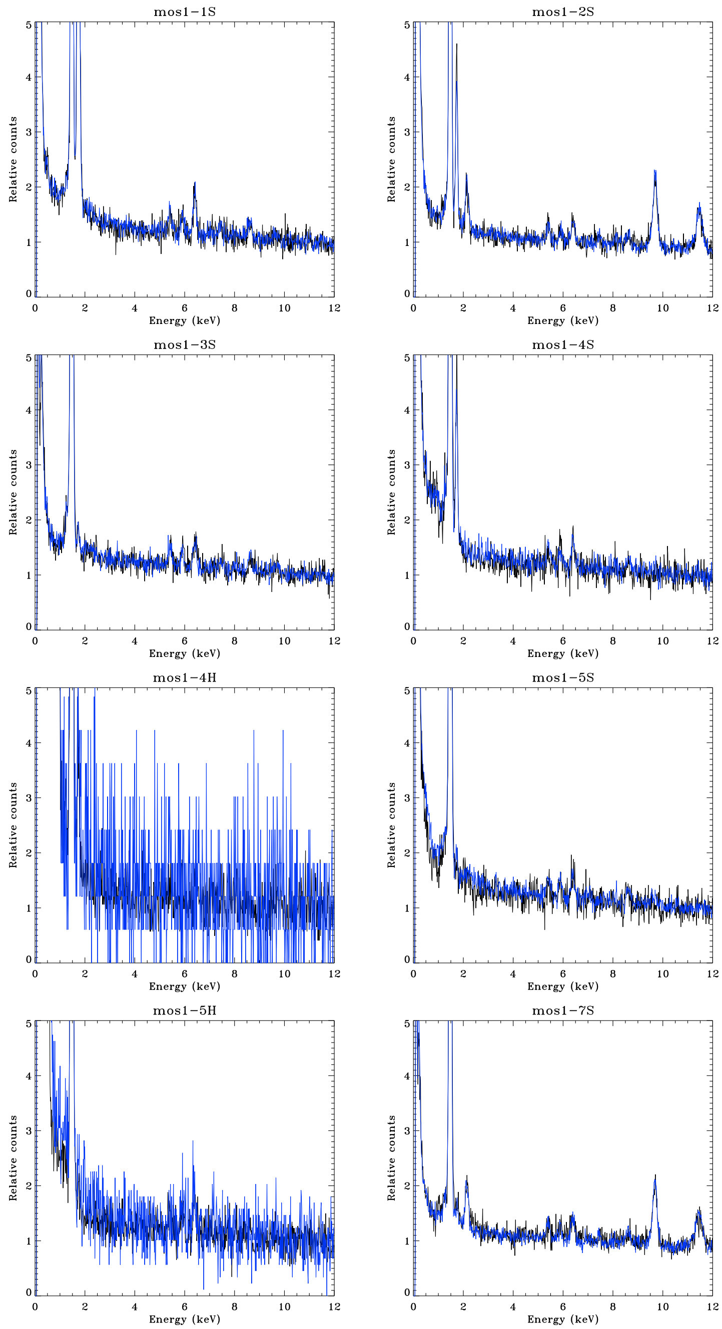

Fig. 3.— A comparison of the old FWC spectra (black) and the new FWC spectra (blue) from MOS1. Each spectrum has been normalized to unity in the 8.0-12.0 keV band.

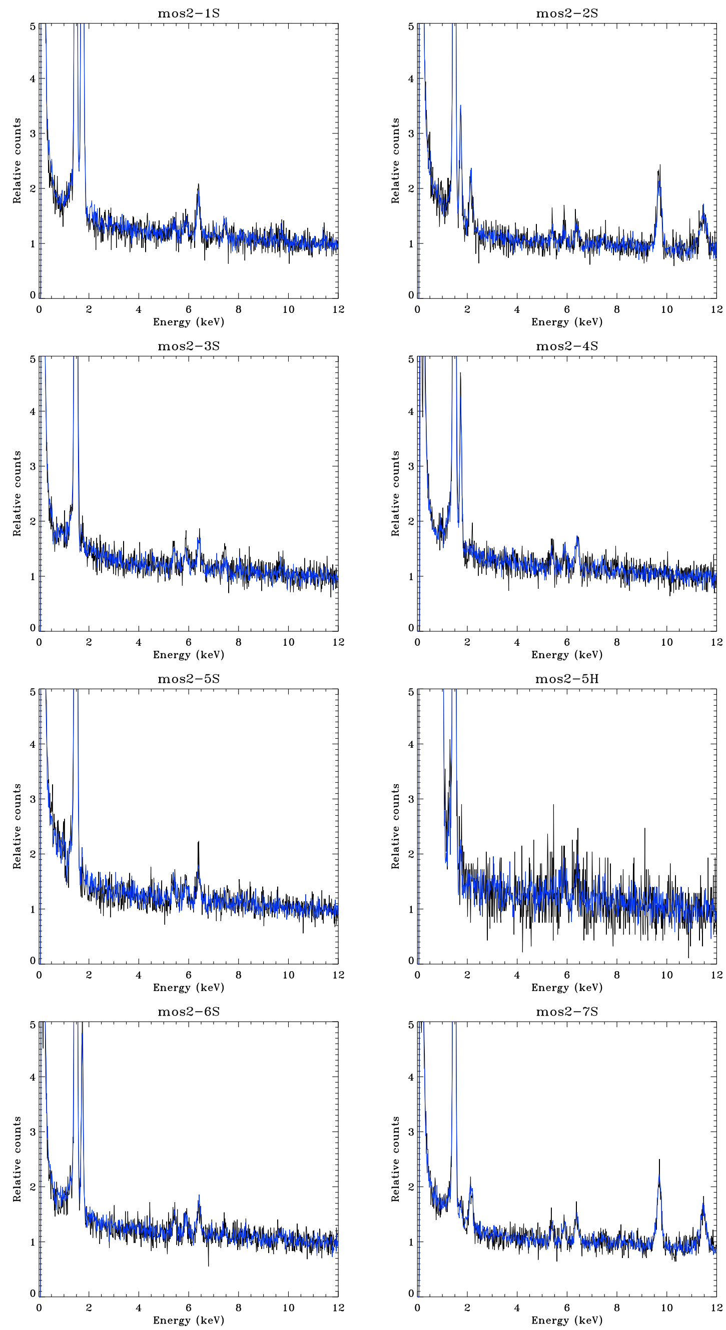

Fig. 3.— *continued:* For MOS2.