XMM-NEWTON LEGACY CLUSTERS - AN INVESTIGATION INTO BACKGROUND REMOVAL.

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ABSTRACT

We investigate the treatment of background removal in the analysis of observations of galaxy clusters in the *XMM-Newton* Cluster Legacy project. Particularly for clusters that fill the field-of-view, care needs to be taken when removing the background from the source data. We compare various schemes for background removal, and evaluate their effect on the derived physical models such as temperature profiles of the clusters.

Key words: X-rays: diffuse background; X-rays: general.

1. INTRODUCTION

The *XMM-Newton* Cluster-Legacy project, undertaken by a consortium led by MPE, Garching, including the University of Birmingham and CEA, Saclay, involves a sample of 34 galaxy clusters observed with *XMM-Newton* (Böhringer et al., in prep). Correct treatment of the background is essential for analysing faint or diffuse sources. Using a local background region can be hazardous, due to the difference in vignetting between the source and local background regions. Using blank-sky background files can provide a better gauge of the background than a local background but care is still required to ensure that the background files are treated properly. Throughout this paper, the background files used are those of Read & Ponman (2003). In this paper we will look at the effect of different background subtraction methods on the temperature profiles of the cluster RXC0547-3152. This cluster was selected since it wasn't substantially affected by flaring.

2. USING BLANK-SKY BACKGROUND FILES

As discussed in §1, a local background subtraction causes problems due to vignetting. One of the possible solutions is to use the SAS task EVIGWEIGHT such that the photons are 'corrected' such that the events correspond to a flat detector. However, the events also contain non-vignetted particles which also get boosted by this task.

The blank-sky background files are a superposition of many *XMM-Newton* observations and need to be matched with the source dataset. The mean background count rate is different to that of the source data, and needs to be normalised accordingly. This can be done either by using the ratio of the exposure times, the high energy count rates or the out of field-of-view (FOV) count rates. The latter is used for the normalisation of the background in this paper unless specified otherwise.

The shape of the background also varies considerably at different count rates. Fig. 1 indicates the shape of the background spectrum at three different count rate cuts.

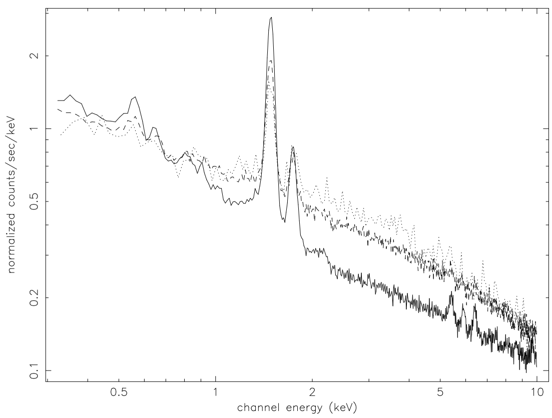

Figure 1. Count rates for MOS1 blank-sky background. The data have been scaled such that they are normalised to the same total integrated flux (Solid line: 0.1-0.2 c/s; Dashed line: 0.2-0.4 c/s; Solid line: 0.4-0.6 c/s)

Given the difference of shape in the background at different count rates, it is possible to do a count rate selected cut of the blank-sky background based on the mean count rate of the source data.

In Fig. 2 radial temperature profiles are plotted using the

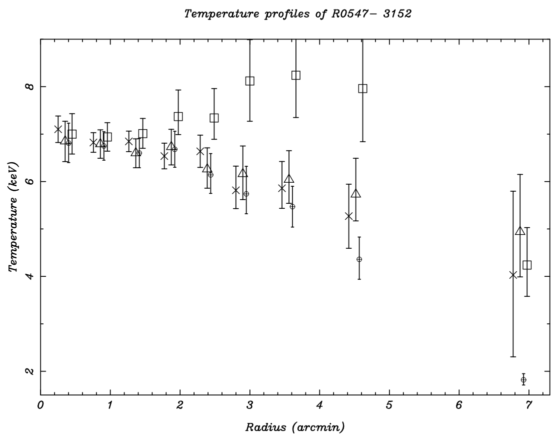

Figure 2. Temperature profile of RXJ0547-3152 using different background subtraction methods (Triangles:local background; Circles: Scaled blank background by out of FOV count rate; Squares: Scaled and count rate selected blank background; Crosses: Scaled by high energy count rate and double subtracted blank-sky background.)

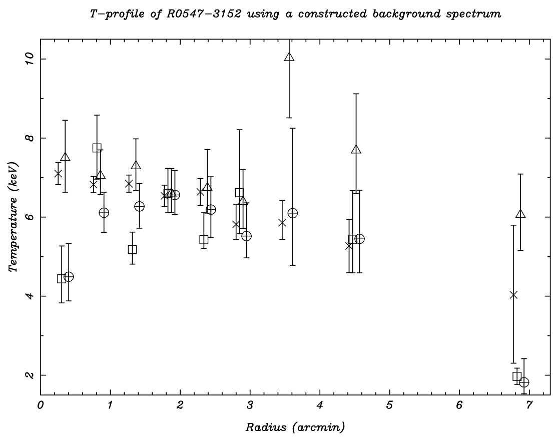

Figure 3. Temperature profiles comparing blank-sky background subtraction with constructed backgrounds (Cross: Blank sky background scaled by high energy count rates and double subtracted; Square: Constructed background with all parameters allowed to float; Circle: Constructed background ($\Gamma = 1.4$); Triangle: Constructed background ($\Gamma = 0$))

same annular bins for four different methods of background subtraction. Firstly, a local background (triangle) is plotted with the events weighted for vignetting. Secondly a blank-sky background is used that has been scaled by out of FOV count rates (circle). The events are not vignetting-corrected here as the same region is used for the source and background spectra. Thirdly, a background scaled by out of FOV and cleaned based on the mean count rate of the source is plotted (square).This is also not corrected for vignetting. Finally, a temperature profile scaled by high energy count rates and double subtracted based on the soft excess is plotted (cross). The events here are corrected for vignetting as the double subtraction involves using a different region of the camera to determine the soft excess.

The differences between derived temperatures, particularly at high radius, indicate the need for further review of the methods of background subtraction. The small errors at high radius for the blank-sky background are the result of a poor χ^2 fit. This would imply that a simple scaling of the background results in satisfactory fits in high surface brightness regions, but represents low surface brightness regions poorly. This could be improved by subtracting a soft excess (double subtraction) off the spectra.

The background scaling ought to be applied to the background events file before any cleaning is done based on the source cut. A scaling of the spectrum, as with the two background files scaled by the out of FOV, may result in parts of the background spectrum being clipped unnecessarily. This process may cause the wrong selection of the background count rate when clipping based on the source count rate leading to peculiar temperatures as seen in the outer bins.

3. USING A CONSTRUCTED BACKGROUND

Using a method designed by Snowden and Kuntz, the background can be decomposed into several components, each of which can be modelled or extracted from source data. The quiescent particle background spectrum is determined by scaling out of FOV spectra with the closed filter wheel spectra. The soft proton background is modelled using *ROSAT* All Sky Survey (RASS) data which is fitted in XSPEC. The Al and Si lines are modelled by gaussians (also fitted in XSPEC). Finally, the cosmic background is modelled by three thermal components and a powerlaw (fitted through XSPEC). One of the limitations of this method is that this is only applicable to the MOS cameras due to PN having insufficient out of FOV regions.

When a constructed background (triangle) was compared to a blank sky background (cross) in Fig. 3, the fits at low radius were considerably lower than expected. We determined this to be due to the powerlaw component in the cosmic background softening the spectrum at low radii. Two permutations for varying the spectral index (Γ) were tried i.e. removing the component (triangle); and fixing it at the value 1.4 (circle). This method clearly needs further study to reproduce blank sky background spectra, but could be a powerful tool for background subtraction, particularly if the source covers the entire FOV and double subtraction is not possible.

REFERENCES

Böhringer et al., in preparation.

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