Background Estimation for USA

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Abstract

The following document is a rough draft of my efforts so far in understanding the background for USA, the current status of the background model, and some ideas for future work. The data that I have used so far consists of all the housekeeping files up to 20 August 1999 (Total Coincidence Veto rates), and 8 days of blank sky observations (D151-D154 and D215-D218).

1 Introduction

The background consists mainly of two components: diffuse X-ray background, which is assumed to be constant as a function of satellite orbital position, and the instrumental (internal) background, which is due to interactions between radiation or particles in the orbital environment with the instrument. It is this variable component of the background which I am attempting to model. There are at least three ways in which we would like to know the background; we'd like to know first the number of counts we can expect as a function of latitude and longitude over the Earth. We would also like to have an idea of the time variability of the background power spectra, and finally, we would like to know the energy spectrum of the background and how this changes as a function of latitude and longitude over the Earth. I have so far concentrated mainly on the first of these cases (Counts vs. Position).

2 Background Counts vs. Position

2.1 Coincidence Veto Counts vs. Satellite Position

My first approximation to a background model is based on one parameter, which is the Total Coincidence Veto rate, recorded every sixteen seconds in the housekeeping files. It is assumed that the flux of particles at any given moment is well correlated with this veto rate. The number of photons created due to these particles will also (hopefully) be correlated with this rate. In figure 1 I have mapped out the average Coincidence Veto

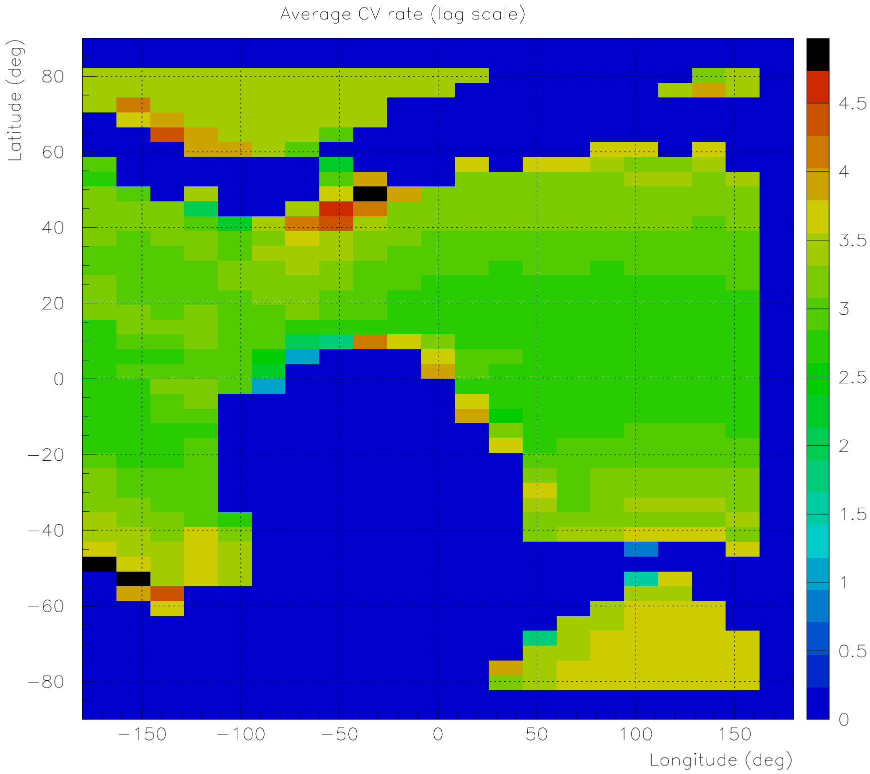


Figure 1: Average Coincidence Veto Rates (log scale)

rate, binned every 4 degrees in latitude and 18 degrees in longitude[1], using de data from all the housekeeping files up to 20 August 1999. In figure 2 I plot the standard deviation of this rate.

2.2 Comparison to H.C.Wen's Model

Taking the tables produced by H.C.Wen in his model for the charged particle backgrounds in USA, I interpolated for every data point for which we have a Coincidence Veto rate (i.e. the data that went into figures 1 and 2). I then plot the ratio of the average Coincidence Veto rate and the rate predicted by Han. I also plotted the standard deviation of this ratio. A value of 0 (Blue) in these plots simply means that no data was taken (this roughly corresponds to the particle belts and the SAA. As can be seen from the plots, there appears to be a factor of two difference between the observed CV rate and Han's model, except for a small region around latitude 20 degrees and longitude -150, where this ratio is as high as 4-5.

[1] I chose this binning to be consistent with Han Wen's binning in his model.

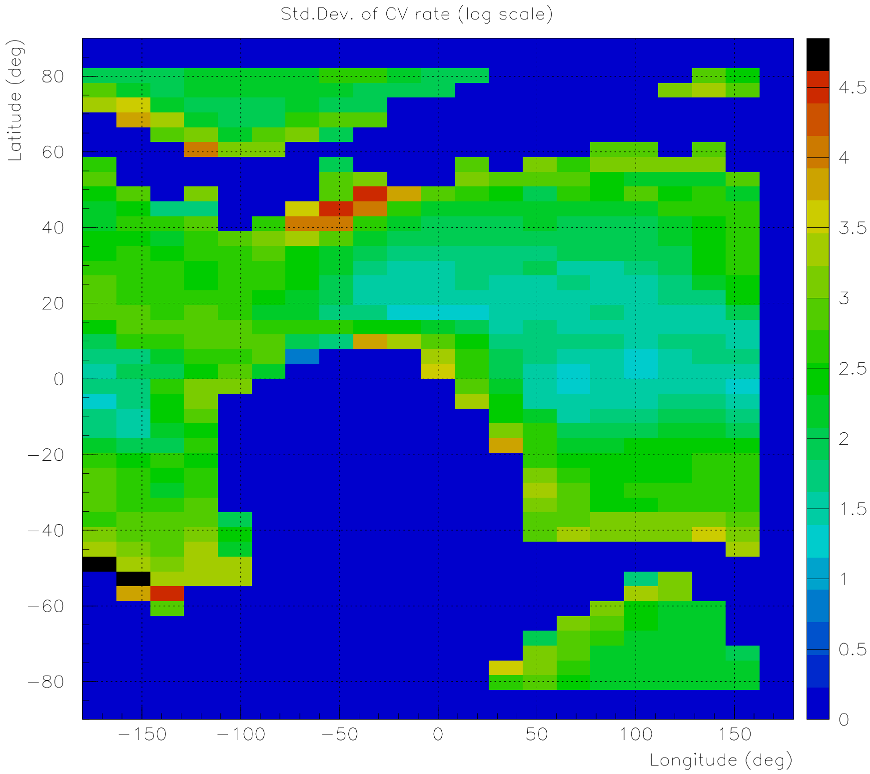


Figure 2: Std. Dev. of Coincidence Veto Rates (log scale)

3 Blank-Sky Observations

I looked at blanksky observations for 8 different days (151-154 and 215-218). As can be seen from the plots, this ratio can be fit by a Gaussian, but unfortunately the fit for the two different sets of data is very different. Let the total number of photons received by USA be given by $C(t) = S(t) + B(t)$, where S represents the photons coming from the source and B represents the background photons. We will assume that the background is of the form $B(t) = a \times CV(t) + b$. By looking at blank-sky observations (where $S(t) = 0$), we can hope to get a picture of what the background is like. This is probably an oversimplification, and we may need to add more terms to this expression. By looking at the ratio $\frac{B(t)}{CV(t)}$ we can also expect to determine some mean value for the constants a and b. (See figures 5 through 7). Unfortunately, from the data that I have looked at so far, these values do not seem to be constant. There is a factor of two difference between the data gathered on days 151-154 and that gathered on days 215-218. Figure 5 clearly shows a relationship between the coincidence veto rate and the number of photons detected in the chamber. The slope of this line is roughly 7

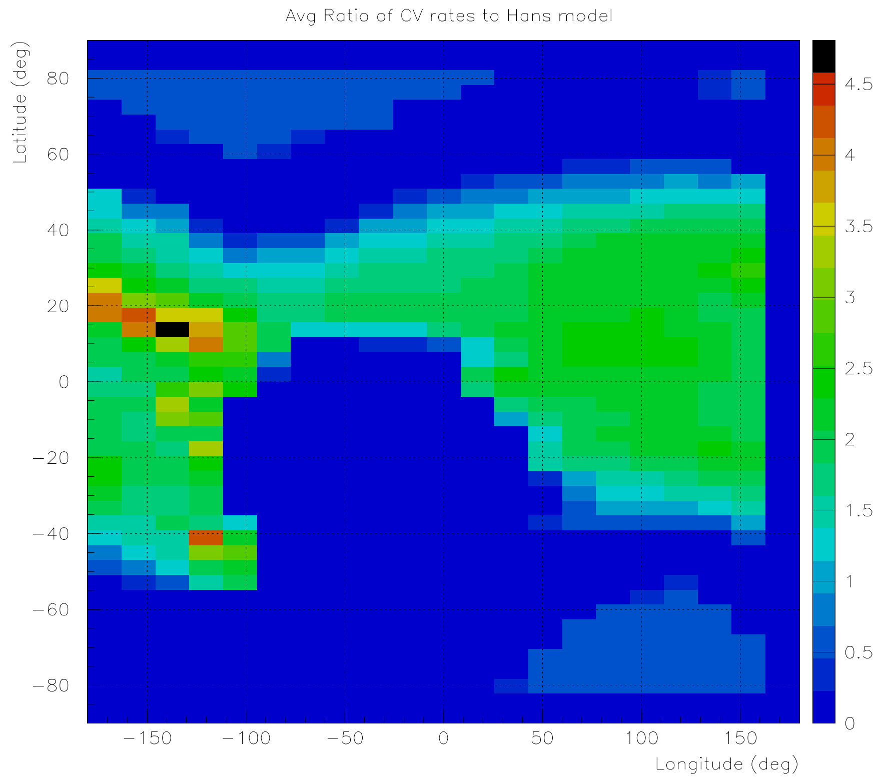


Figure 3: Average ratio of CV rates to Han's model

4 Normalised Energy Spectra

In figure 8 I plot several normalised energy spectra ($\Sigma counts = 1$) for some blank sky observations in mode 1 (16 channels). Channels 0 and 15 appear to contain most of the counts. There is also a line quite visible at around channel 6-7.

5 Conclusions and Future Work

To get a clearer picture of the background we need to look at more data. In particular, I plan to run all the available blank-sky observations through my programs. I plan to make some better cuts on the data, to leave out certain regions where the count rates are excessively high (CV¿ 3000-4000?) since no useful science will probably be carried out in these regions anyway. I cannot explain, at this point, where the factor of two between the observations from D151-154 and D215-218 comes from, though I suspect it may have to do with the fact that during D151-154 USA still had both detectors in operation. After determining the parameters of the background model (a and b), I plan to test it on some blank-sky observations that were not used to produce the model; I will then try and determine how well the model fits the observed data by subtracting the estimate produced by the model from the actual data and see whether the result is consistent with zero (do a chi squared test). If the model is not good enough, it may be

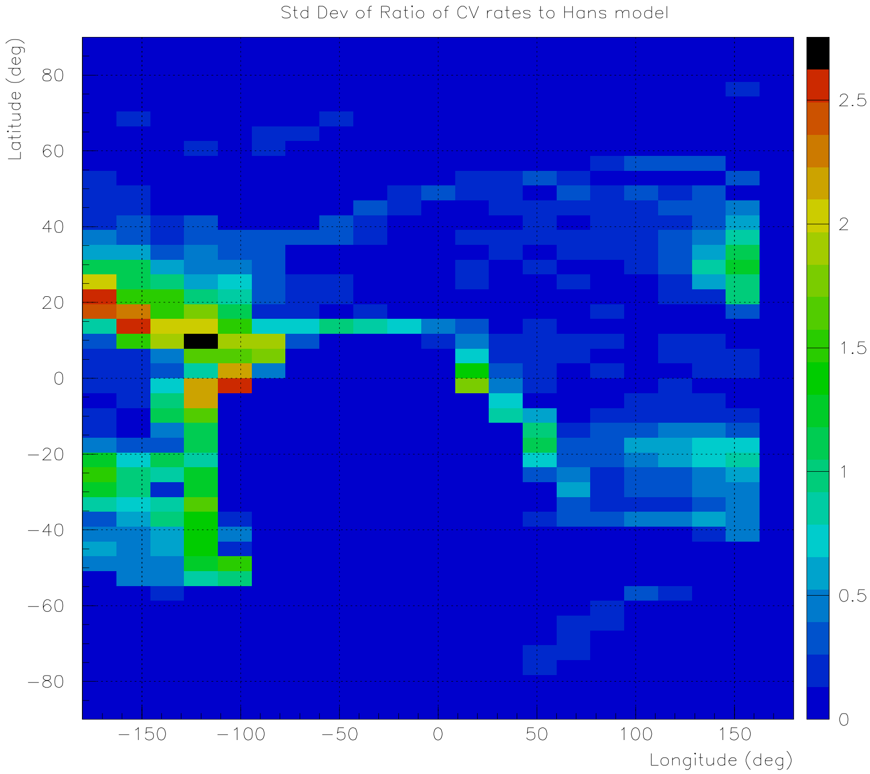


Figure 4: Std Dev of the ratio of CV rates to Han's model

necessary to include an extra parameter to take into account the possible activation of the instrument as it goes through the South Atlantic Anomaly (i.e. its SAA history), like RXTE has done.

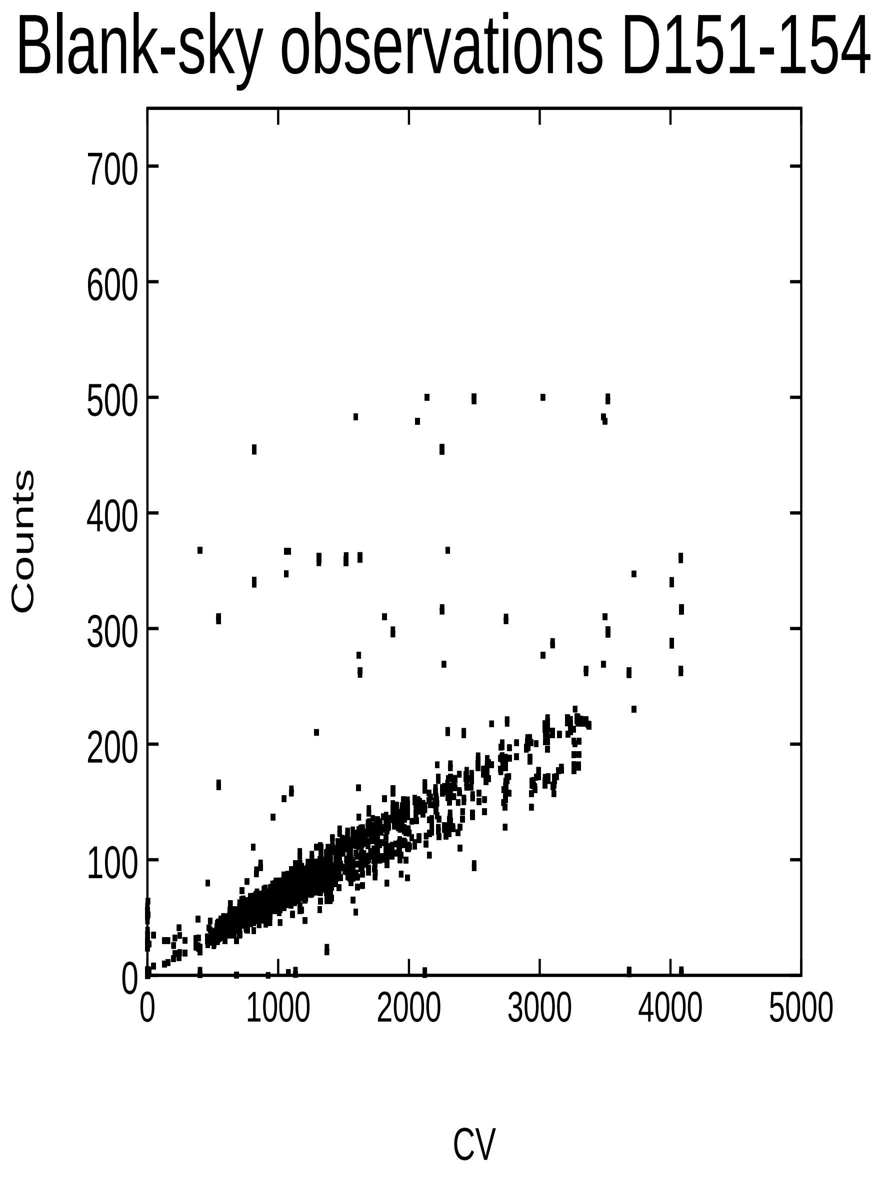
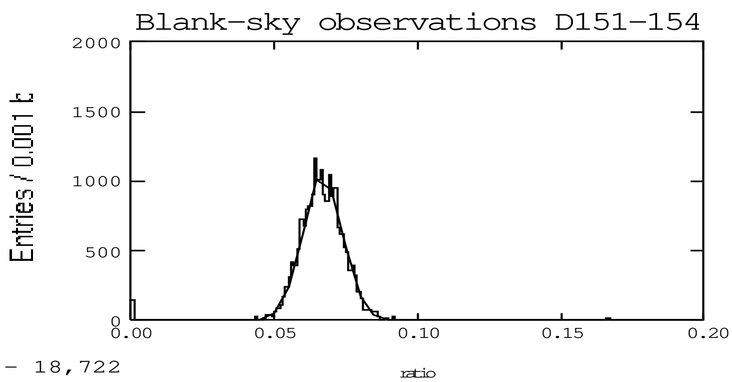
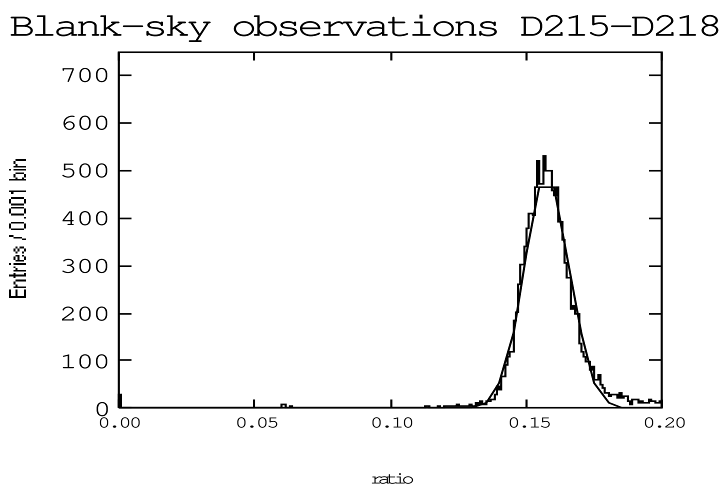


Figure 5: Ratio of Blank Sky Counts to CV



Entries - 18,722
average x-value - 0.066715576
Standard deviation of x - 0.01137524
Function overplotted
18056.719 * N(0.0668455, 0.0068994113)
Chi-squared per dF - 3.4125204 (dF= 197)



Entries - 10,752
average x-value - 0.15768935
Standard deviation of x - 0.013668516
Function overplotted
10177.693 * N(0.15746407, 0.008349845)
Chi-squared per dF - 2.9152865 (dF= 197)

Figure 6: Ratio of Blank Sky Counts to CV

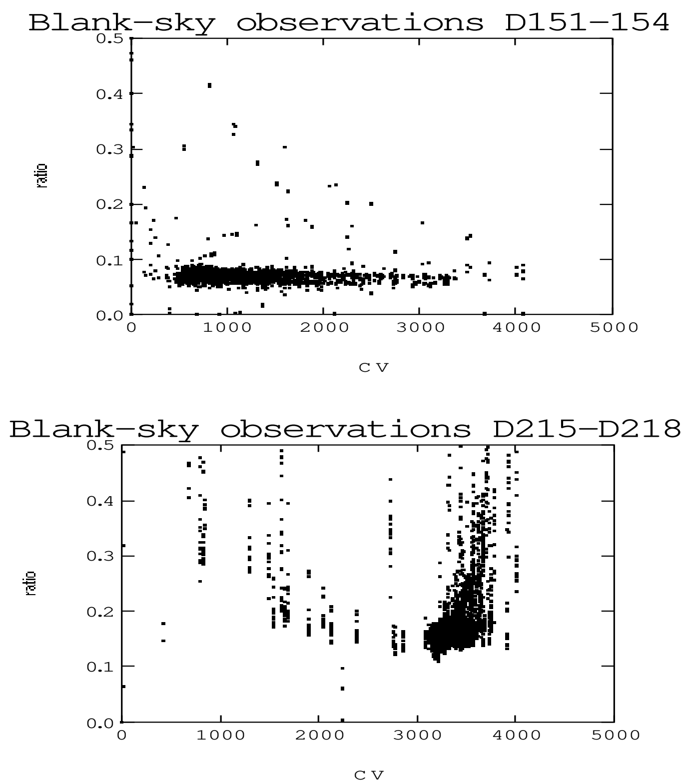


Figure 7: Ratio of Blank Sky Counts to CV

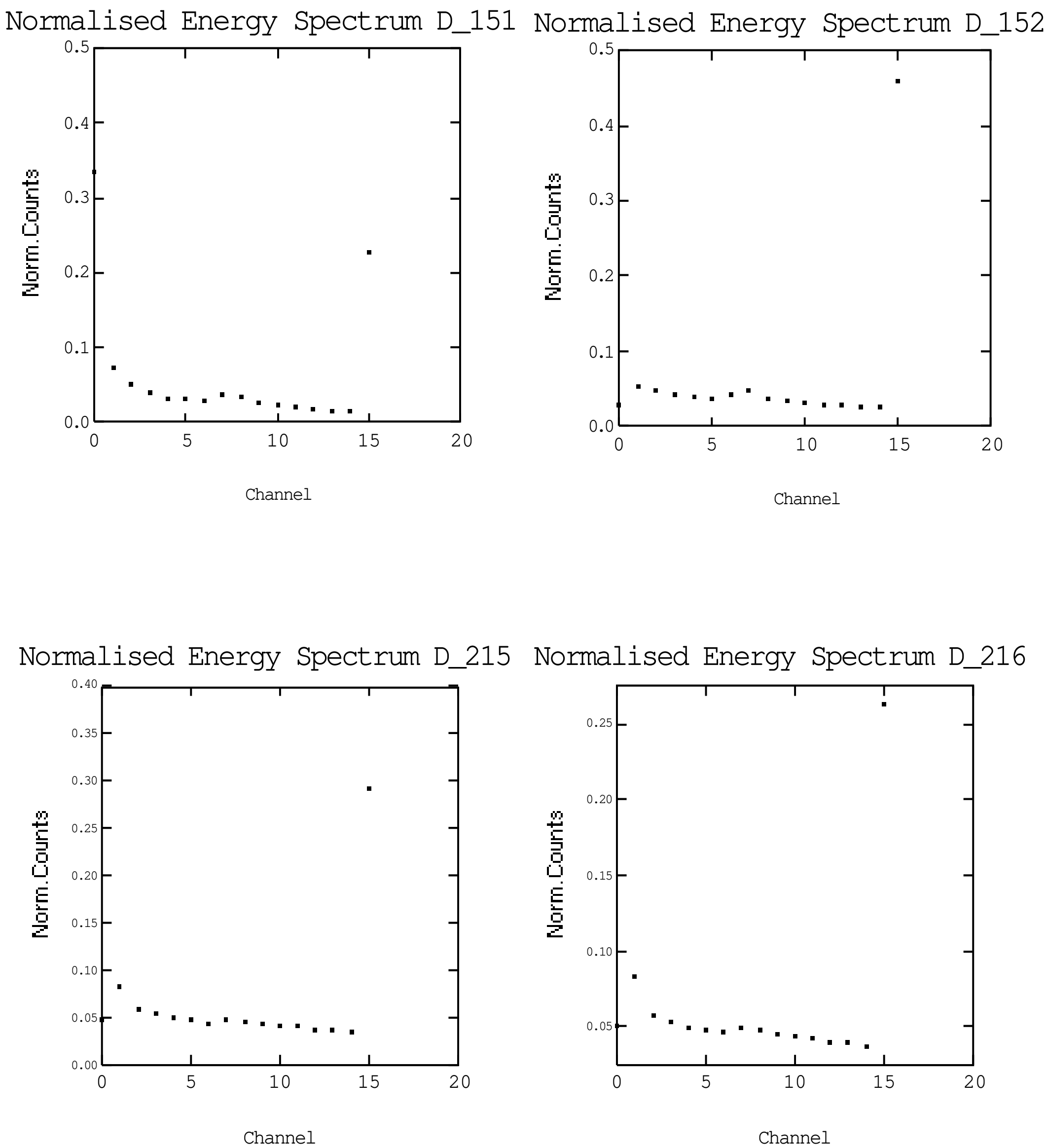


Figure 8: Normalised Energy Spectra