Field of View of the PCA

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This document summarizes our knowledge of the PCA field of view. A postscript version is available.

The collimator for each PCU is constructed of corrugated sheets of beryllium copper coated with a tin-antimony (95/5) solder. The resulting collimator cells are hexagonal; 2 of the six walls are double thickness. The nominal dimension of the cells is 0.125 inch (flat to flat) across, 8 inch in length, and 0.0027 inch thick. The solder coating was 0.0002 inch with a layer of 0.00005 inch of nickel between the beryllium copper and the solder. Optical measurements of the collimators reveal a rounded top, modelled as a random spread of orientations of the collimator tubes. Our model of the collimator field of view is the response from an ensemble of perfect hexagonal tubes each of which has been randomly offset from the vertical by a small angle. The offset angle is sampled from a zero mean gaussian distribution with standard deviation 6 arcmin, and the model response is taken by scaling from the peak response of the sum of a large number of such randomly offset hexagonal responses. This value for sigma was that which gave the best fit to the scanning data from the Crab nebula.

Relative PCU pointing

The relative position of the center of each collimator field of view and the relative open area has been calibrated by scanning observations of the Crab nebula, and are summarized in table. The spacecraft y and z offsets (SC(y) and SC(z)) are the boresite offsets in the Y and Z RXTE spacecraft coordinate system, and are components of an orthonormal vector, with the science axis very close to X = 1. The relative areas are normalized to PCU3, which has the largest throughput.

PCU	SC(y)	SC(z)	relative area
1	-0.0000385	0.000629	0.9912
2	0.0001046	0.000529	0.9947
3	-0.000050	0.000746	1.000
4	0.000294	0.00134	0.9410
5	0.000290	0.00197	0.9277

Models of the Collimator

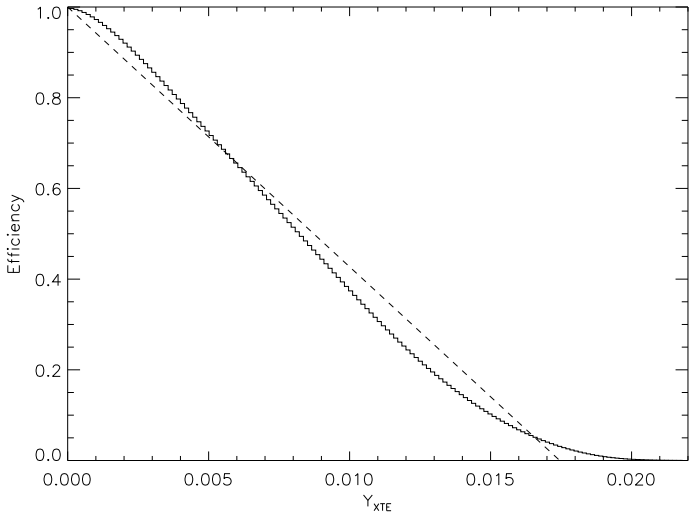

Figure 1: Collimator model versus SC y axis. Triangular approximation is shown for comparison.

Fits files which contain the collimator models can be found within the caldb in /caldb/data/xte/pca/bcf/collresp/96jun05, with the names p0coll_96jun05.fits, p1coll_96jun05.fits, etc. for the individual detectors, and a cube for the pca in pcacoll_96jun05.fits

We present in figure 1 a cut along the spacecraft y axis for one collimator module; for comparison we also show a triangular response which reaches zero at 1 degree. (the horizontal axis is in units of the spacecraft coordinate y, which for these small angles is approximately radians). The effective solid angle of the model is less than that of the triangular approximation. (A cut through the perpendicular direction is qualitatively similar though different in details.) The integral of the collimator model is 0.000297 sr while the integral over the traingular approximation is 0.00032 sr.

Figure 2 illustrates the difference in the solid angle by plotting the differential solid angle as a function of radius for the two cases. Here

$$sin(\theta) = \sqrt{(Y^2 + Z^2)} \tag{1}$$

where θ is the angle from the vertical (X-axis) and Y and Z are the SC coordinates. The integration is done over the collimator model. Note that the triangular model is larger, primarily at angles betwee 0.5 and 1 degree.

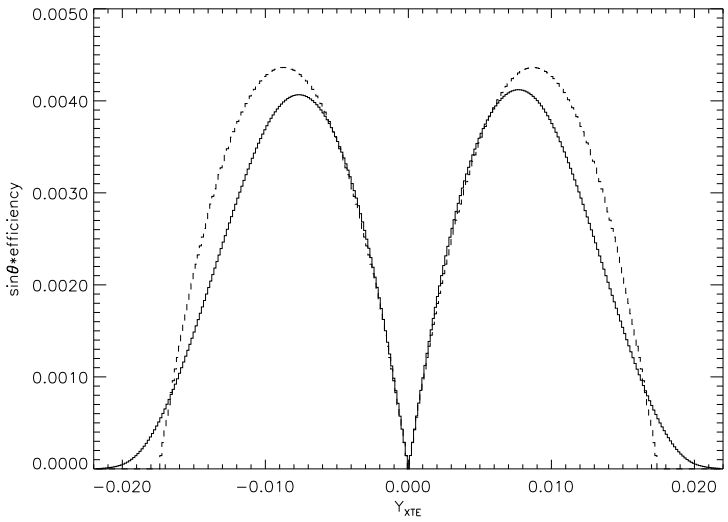

Figure 2: Differential solid angle of the collimator model and the triangular approximation

Finally, figure 3 shows the net response for the entire PCA. This figure represents the sum of 5 collimator response, with offsets and relative areas as shown in the table. Since the end of January 1996, the spacecraft science axis has been defined as y=0.0, z=0.00070. As of this date, we have not measured any energy dependence in the collimator response; our limits are that the collimator response is independent of energy to better than 5%. Future investigations will provide better limits or measurements of the energy dependence and produce a map of residuals between the total response and our estimate.

Solid angle of the Collimator

The linear approximation for the response, $f = 1 - r/r_0$ where r_0 is equal to 1 deg, overestimates the solid angle. Integrating $f(r)sin(r)d\Omega$ over $0 \leq \theta \leq 2\pi$ and $0 \leq r \leq r_0$, and keeping terms to order r_0^4 gives $(\pi/3.0)r_0^2(1-r_0^2) = 0.000318897$ (for $r_0 = 1$ deg). This compares with 0.000320578 from integrating this response numerically.

Integrating the summed responses numerically for all the PCUs, using the model file pcacoll_v100.2, we get 0.00029703, or about 8% less.

This is approximately the effective solid angle of a linearly falling response out to r_0 if $r_0 = 0.965$ deg. Put another way, this is the solid angle

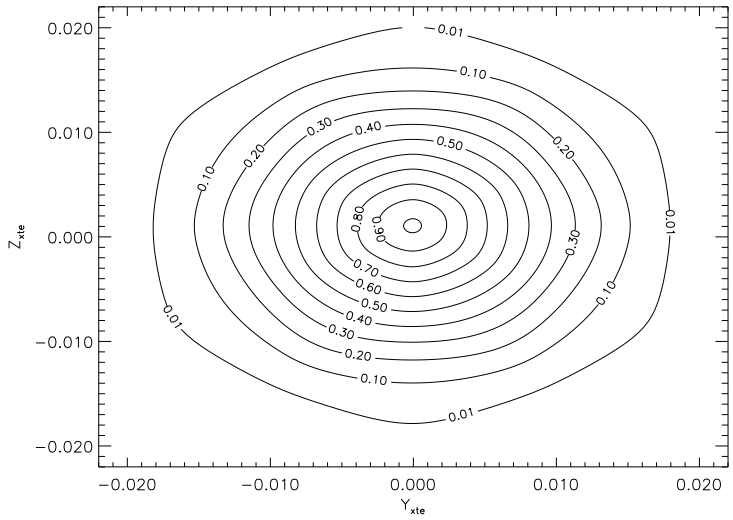

Figure 3: Model response of the entire PCA

you get by integrating a flat (unit) response from r= 0 to 0.55712 degrees.