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Light Yield of Hexagonal Versus Square Cross-section Crystals

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The use of hexagonal cross-section crystals rather than the more conventional trapezoidal shape for the BaBar CsI end cap calorimeter is currently under consideration. This geometry may offer a cost reduction since one size of crystal can be used for the entire endcap, however it is important to check that the light yield of the two geometries is comparable. We have compared the scintillation light yield of a hexagonal tapered crystal to a square tapered crystal. We select two square non-tapered crystals of equivalent dimensions, surface preparation (polished, not compensated , teflon wrapped), vendor (Crismatec) and light yield. The crystals are then cut into a hexagonal tapered crystal and a square tapered crystal. The cross-sectional area of front and back faces, the length , the taper, and the surface preparation (polished, not compensated, teflon wrapped) are identical. We observe that the hexagonal tapered crystal yields 25±5 % more scintillation light than the square tapered crystal when irradiated by the same gamma source (^{22}Na).

We select two rectangular non-tapered crystals of length 230 mm and square cross section 63mm X 63mm (Figure 1). The two crystals are from the same vendor (Crismatec) and were originally compensated by the vendor. Compensation is the process of degrading the surface of the crystal so that the light yield is uniform along its length. The compensation is removed by polishing so that the two crystals are now identical. They are denoted by C1 and C2. C1 is unblemished while C2 has an open grain boundary midway along its length which extends 1 cm in from the surface. Both crystals are wrapped in three layers of 1.5 mil (38μm) Teflon.

The light yield is measured with a Hamamatsu R669 tube. The spectral response of this tube is shown in figure 2. The photo-cathode is cylindrical with radius 25mm. The light yield is measured relative to small cylindrical crystal of radius 12.5 mm length 25mm. The photo-cathode is placed directly against the crystal with no air gap. A collimated ^{22}Na source is used to irradiate the crystal and the crystal is scanned along its length at 30mm intervals.

Errors in this measurement come from several sources. The sensitivity of the photo cathode is not uniform across its entire face. Any non-uniformities of light transmission across the face of the crystal will make the measurement sensitive to the relative position of crystal and photo cathode. In addition there are drifts in the photo tube gain. To estimate the effect of these errors we measure the same crystal 10 times, each time disassembling the setup, over a period of 24 hours. We find a variation of 5 % and assign this as the error of each measurement.

Table 1 shows the results of the scan for crystals C1 and C2 which become the square and hexagonal crystal respectively. Also tabulated is the average value of the scan. Figure 3 shows a plot of these values versus position on the the crystal. The average light yield of C1 is slightly higher than C2. To compare the hexagonal to the square crystal we first multply by a correction factor to take account of the slight difference in C1 and C2.

$$square^* = \frac{C2}{C1}.square = \frac{23.5 \pm 0.5}{24.2 \pm 0.6}.22.1 \pm 0.5 = 21.5 \pm 0.8.$$

Then

$$\frac{hex}{square^*} = \frac{26.9 \pm 0.5}{21.5 \pm 0.8} = 1.25 \pm 0.05$$

The hexagonal crystal gives 25±5% more light that the square crystal.

Source position (from back face) mm	C1 LY %	Square LY %	C2 LY %	Hexagonal LY %
30	25.4±1.3	25.2±1.3	24.3±1.2	28.8±1.4
60	24.8±1.2	23.9±1.2	23.7±1.2	27.4±1.4
90	23.7±1.2	23.1±1.2	23.5±1.2	26.9±1.3
120	23.6±1.2	22.0±1.1	23.4±1.2	26.9±1.3
150	23.8±1.2	21.3±1.1	23.5±1.2	25.9±1.3
180	23.6±1.2	21.1±1.1	22.8±1.1	25.7±1.3
Average	24.2±0.6	22.1±1.1	23.5±0.5	26.9±0.5

Table 1: Light yield (LY) for the four crystals relative to standard crystal.

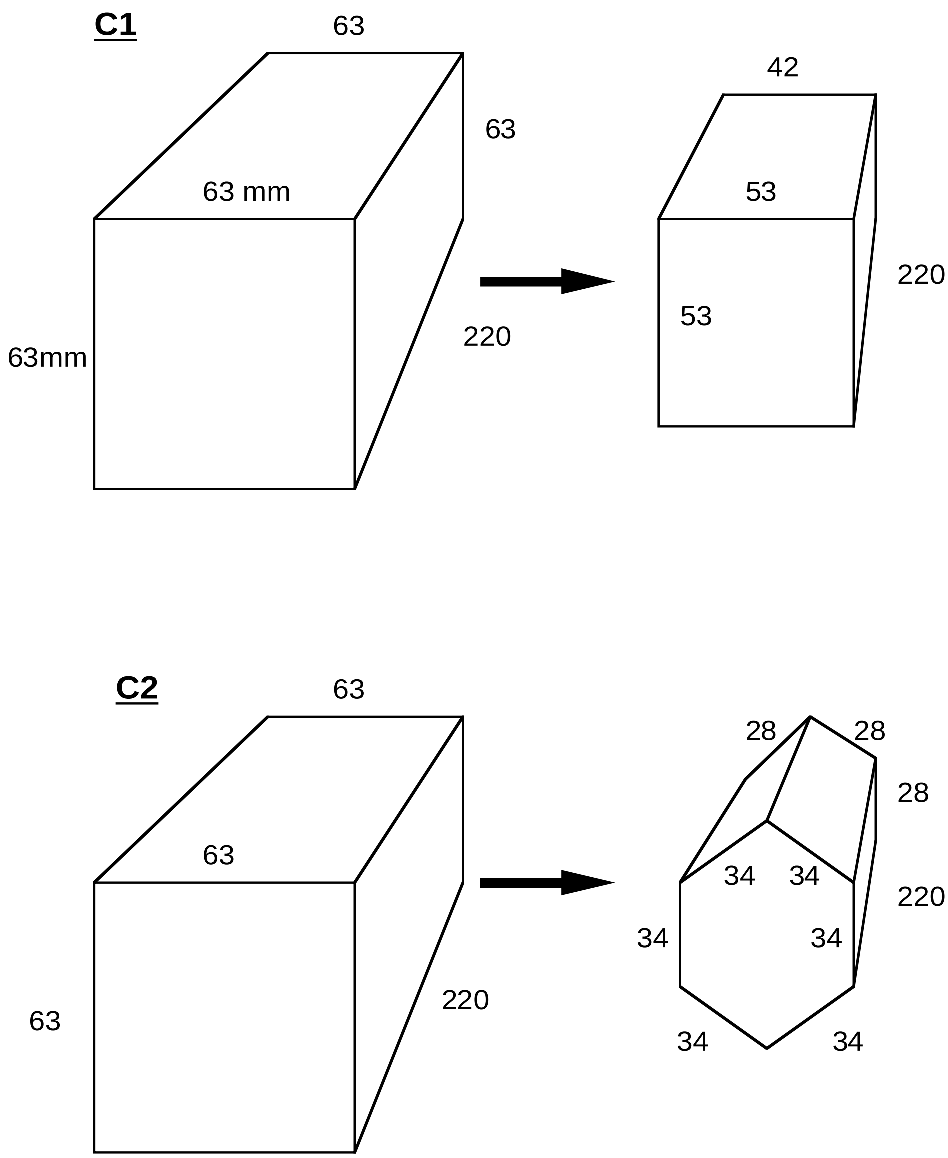

Figure 1: Dimensions of test crystals

Figure 2: Spectral response of Phototube

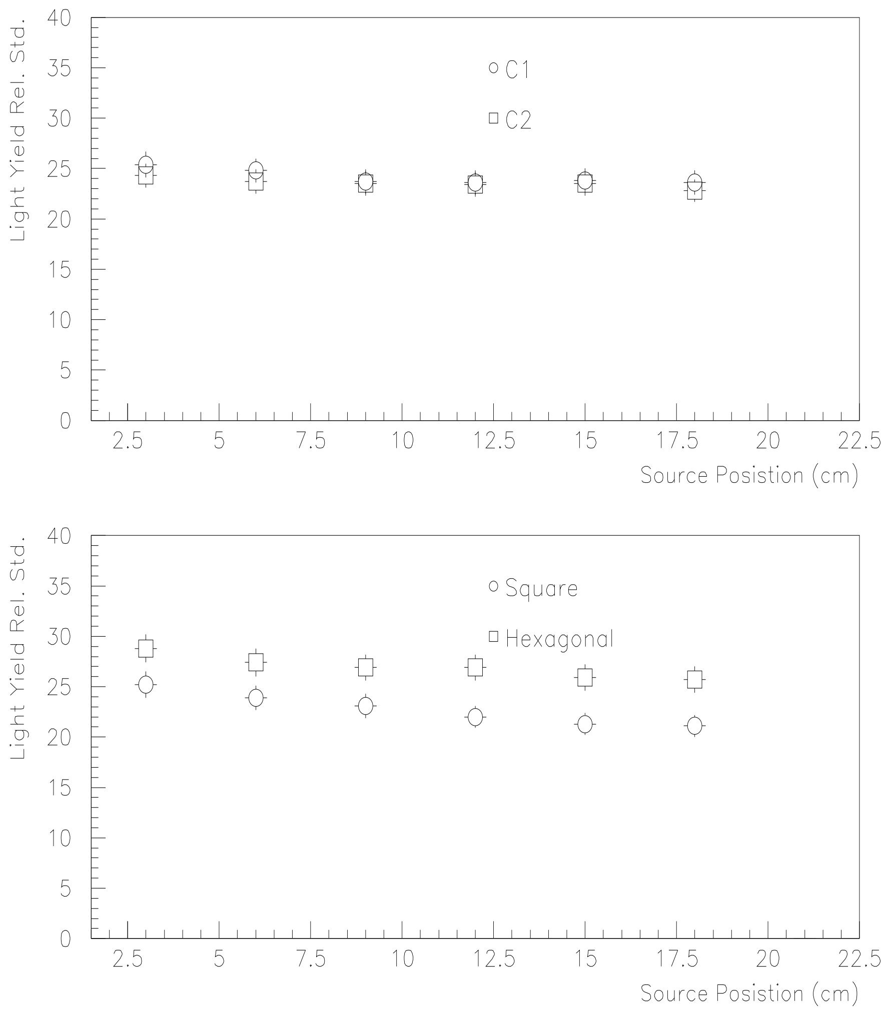

Figure 3: Light Yield versus source position for C1,C2,square and hexagonal crystals