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SDC
SOLENOIDAL DETECTOR NOTES

GREEN EXTENDED PHOTOTUBES

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The cathode quantum efficiency of the green extended phototube R580-17 made by Hamamatsu Corporation is approximately 40% more efficient as compared to the bi-alkali R329 for light from the green fiber BCF91A made by Bicron Corporation.

The SDC calorimeter has decided to use green extended photocathode phototubes for the measurement of the light output of the scintillator tile with wavelength shifting (WLS) fiber. Several manufacturers have developed newer bi-alkali photocathodes which have a higher quantum efficiency for the green light. The spectrum of WLS fiber, the BICRON BCF91A which uses the K27 fluor peaks at 495 nm. The Hamamatsu corporation loaned two such phototubes for evaluation.

The quantum efficiency of two green extended phototubes made by Hamamatsu Corporation of the type R580-17 were measured. These tubes were compared with the standard bi-alkali phototube, the Hamamatsu R329. The R580 is a 10 stage 3.8 cm diameter phototube while the R329 is a 12 stage, 5 cm diameter phototube. The quantum efficiency of these tubes were measured using the fiber BCF91A made by Bicron Corporation. The longer the fiber, the more attenuation of the shorter wavelengths due to self absorption. Figure 1 shows the emission spectrum of a 20 cm long BCF91A where the color is green.

The measurement used a 10 cm x 10 cm x 0.4 cm scintillator tile SCSN38 made by Kuraray Corporation. The edges of the tile were diamond cut and painted white by Bicron BC620 paint. The tile was grooved in a "sigma" pattern with the groove size 1.2 mm and 1.5 mm deep. The BCF91A fiber inserted in the groove had a diameter of 1 mm and one end was mirrored by aluminum sputtering. Before each mirroring, both ends of the fiber were diamond cut to ensure a right angle. The tile was wrapped in Tyvek white reflecting paper (made by Dupont Corporation) and the whole assembly placed in a cosmic muon telescope. In order to insure minimum ionizing particles, the telescope had three 8 cm x 8 cm scintillators, with a 5 cm lead between the first and second scintillator tiles. The order of the test setup, vertically down was: 1) telescope scintillator; 2) sample to be measured; 3) 5 cm lead; 4) telescope scintillator and 5) telescope scintillator. A triple coincidence of the three telescope scintillators was the cosmic muon trigger signal. The sample tile with the fiber was connected to various phototubes. To determine the number of photoelectrons for each tube, the pulse height was measured by a Lecroy 2249A ADC in a CAMAC crate connected to a 486 PC computer. The single photoelectron pulse height was determined by pulling the fiber back from the surface of the phototube, until the efficiency was about 10%, ensuring the production of single photoelectrons. The ratio of the pulse height averages is the number of photoelectrons. The R329 had a potential of 2,500 volts while the R580-17 originally had 1,600 volts. Since the errors were very large with 1,600 volts, the potential was raised to 1,700 volts to increase the pulse height. The pulse height increased by 50% and the quantum efficiency was computed more accurately.

The number of measured photoelectrons per minimum ionizing cosmic muon are as follows:

1) R580-17; serial 2163; Number of photoelectrons = 10.4.

2) R580-17; serial 2175; Number of photoelectrons = 10.3.

3) R329; serial 4569; Number of photoelectrons = 7.5.

4) R329; serial 4570; Number of photoelectrons = 7.4.

Note: Phototube R580-17 (#2163) has 1.4 times the gain of R580-17 (#2175).

The two R329 phototubes were bought very recently, while our older R329 phototubes, purchased seven years ago had a lower quantum efficiency. The single photoelectron peak for the R580-17 is only a few counts above pedestal and the estimated error is about 10%. This translates to 10% error for the R580-17 measurements, while the error for the R329 is about 3%. Since our sample is small, the conclusion is that the quantum efficiency of the photocathode is about 40% ± 10% higher for the green extended phototube versus the regular bi-alkali photocathode for the spectra of BCF91A.

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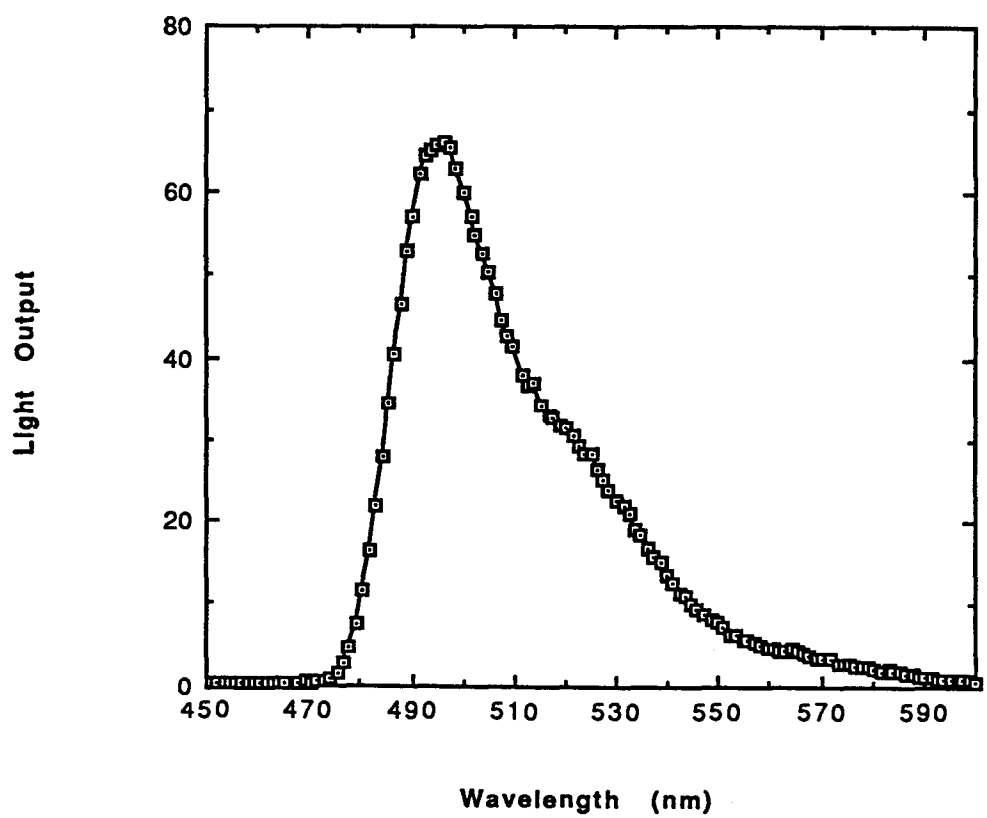

Figure 1: Emission spectrum of BCF91A (K27 fluor) fiber.