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DETECTOR UPGRADE FOR (p,n) POLARIMETRY

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The detector array used for (p,n) experiments has been upgraded to achieve improved reliability and better resolution for use in neutron polarimetry as well as for simple time-of-flight spectroscopy. The original detectors were $6 \times 6 \times 40$ inch plastic scintillators coupled to 5-inch RCA 4522 photomultipliers with slightly tapered acrylic light guides.

The original packaging was mechanically unsound and the light joints frequently separated. Also, the 6-inch thickness was too great for optimal time resolution when the detectors were used in the polarimeter configuration, that is, transverse to the flight path. In anticipation of using the detectors in vertical as well as horizontal configurations for future polarimetry with different spin orientations, we desired packages that had sufficient mechanical integrity to stand up to frequent reorientation. We chose to go to 2-inch photomultipliers in CERN bases which incorporate spring loading to keep the tube pressed against the light guide. In addition we decided to remake the scintillators into $4 \times 6 \times 40$ inch bars.

The Amperex XP2262 tubes that we used have a useful photocathode diameter of only 44 mm with an area of about 15 cm^2 compared the 150 cm^2 area of the end of the scintillator. In order not to degrade the performance unacceptably by the areal mismatch we designed light guides to capture the rays making small angles with respect to the axis and to discard the large angle rays. Since the small angle rays arrive first, this design preserves the fast rising part of the pulse, and the unavoidable light loss occurs in the latter part of the pulse.

The new detector system has been used in two recent runs for E296 and E320 in both transverse and longitudinal modes. The results showed that the position resolution is improved from 5 cm to typically 3.5 cm.

The parabolic light guide (Fig. 1) is chosen for its characteristic property that only photons travelling at small angles with respect to the axis will be transmitted. Eliminating larger angle rays reduces the rise time variation of the anode signals with respect to distance betweeen the scintillation and the photomultiplier. The calculated transmission properties

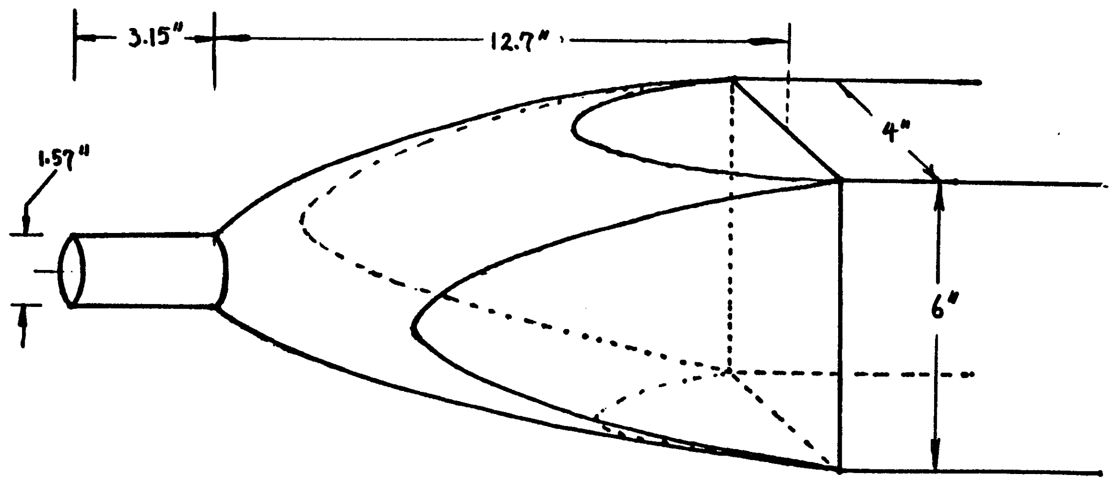

Figure 1. The parabolic light guide.

of three different kinds of light guides are shown in Fig. 2 for comparison. The ordinate is the fraction of photons reaching the photomultiplier for the emission angle indicated on the abscissa. The result is generated using a Monte Carlo program assuming isotropic photon illumination. The plot clearly shows that the parabolic light guide has a better transmision property in that larger angle incident photons are filtered out while smaller incident angle photons are kept.

Figure 3 is the Monte Carlo calculation showing the rise time of anode signals vs the position of the photon origin. Two results are plotted for comparison. One is for the old detector with a short (~1.5 inch) light guide and a 5-inch tube. The other is for the new detector with a parabolic light guide using a 2-inch tube.

The position resolution was inferred by using the detector stack as a cosmic ray hodoscope and projecting muon tracks through the array. For scale, consider that the photon transit time for the 3.5 cm quoted as the FWHM position resolution is about 180 ps. Cosmic ray muon tracks are used during data acquisition for end to end gain matching, calibration, and gain stabilization.

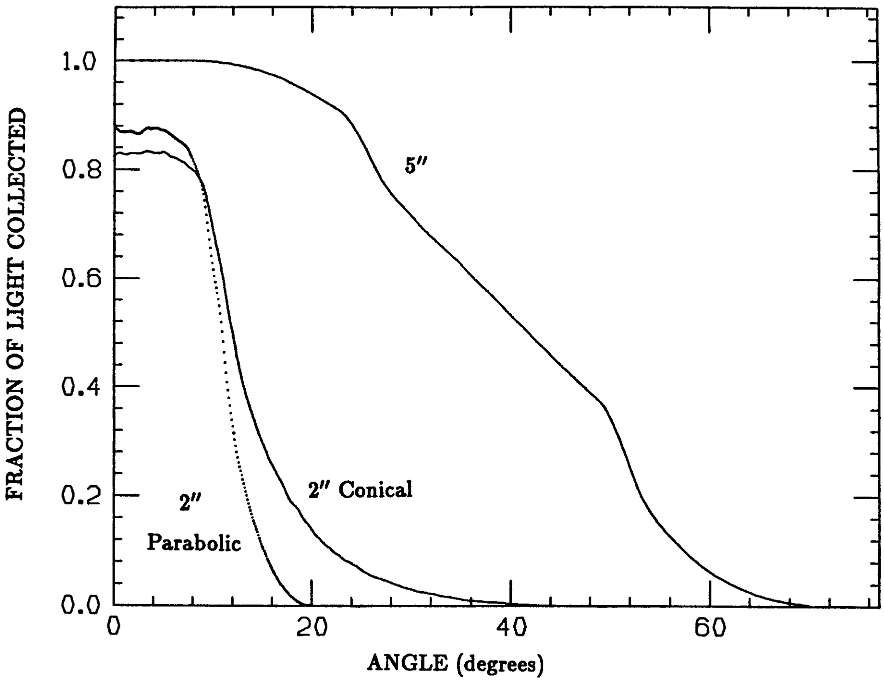

Figure 2. Transmision vs angle. This figure shows the fraction of photons passing through the light guide vs angle of travel. Three different light guides are compared. One is the 1.5-inches light guide used in the old detector with a 5-inch tube. The second is a conical guide with a 2-inch tube. The third is a parabolic guide with 2-inch tube.

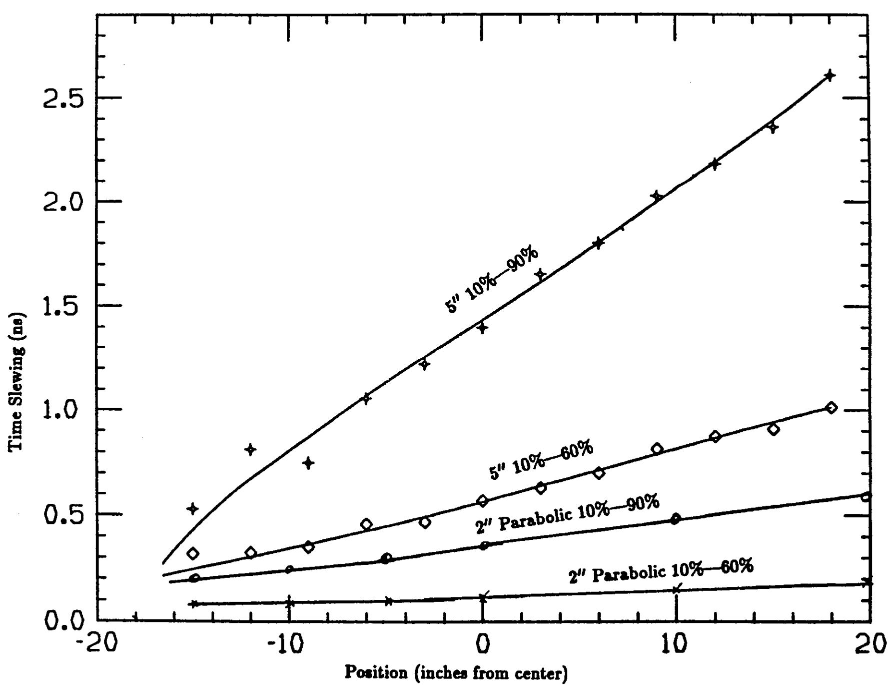

Figure 3. The rise time in ns vs the photon origin. The position is in inches.