ACRYLIC SCINTILLATOR PLANES IN NEUTRINO EXPERIMENTS

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SUMMARY

This note describes the design and initial operating experience with a large (4.5x4.5 m) acrylic scintillator plane in a neutrino experiment at Fermilab.

PHYSICAL DESCRIPTION

Scintillating plastic based on a substratum of poly-methyl-methacralate (PMMA) with a variety of chemical additives has won wide acceptance in high energy physics research during the past several years.[1,2] I describe here an application in a neutrino experiment where the simultaneous requirements of large area coverage and good single particle efficiency had to be satisfied.

The scintillator plane is made of two identical sections, each containing three pieces of scintillator with dimensions 243x152x2.5 cm, the largest size obtainable from the manufacturer. The relevant parameters of the scintillator are summarized in Table I and construction details of one of the two plane sections are shown in Figure 1.

TABLE I

Properties of Acrylic Scintillator

Manufacturer	-	Polycast Technology, Inc. 69 Southfield Avenue Stanford, CT 06902
Maximum Dimensions of Individual Sheets	-	243x152x2.5 cm
Substrate Material	-	PMMA
Chemical Additives (% by weight)	-	10 Napthalene 1 PPO .01 POPOP

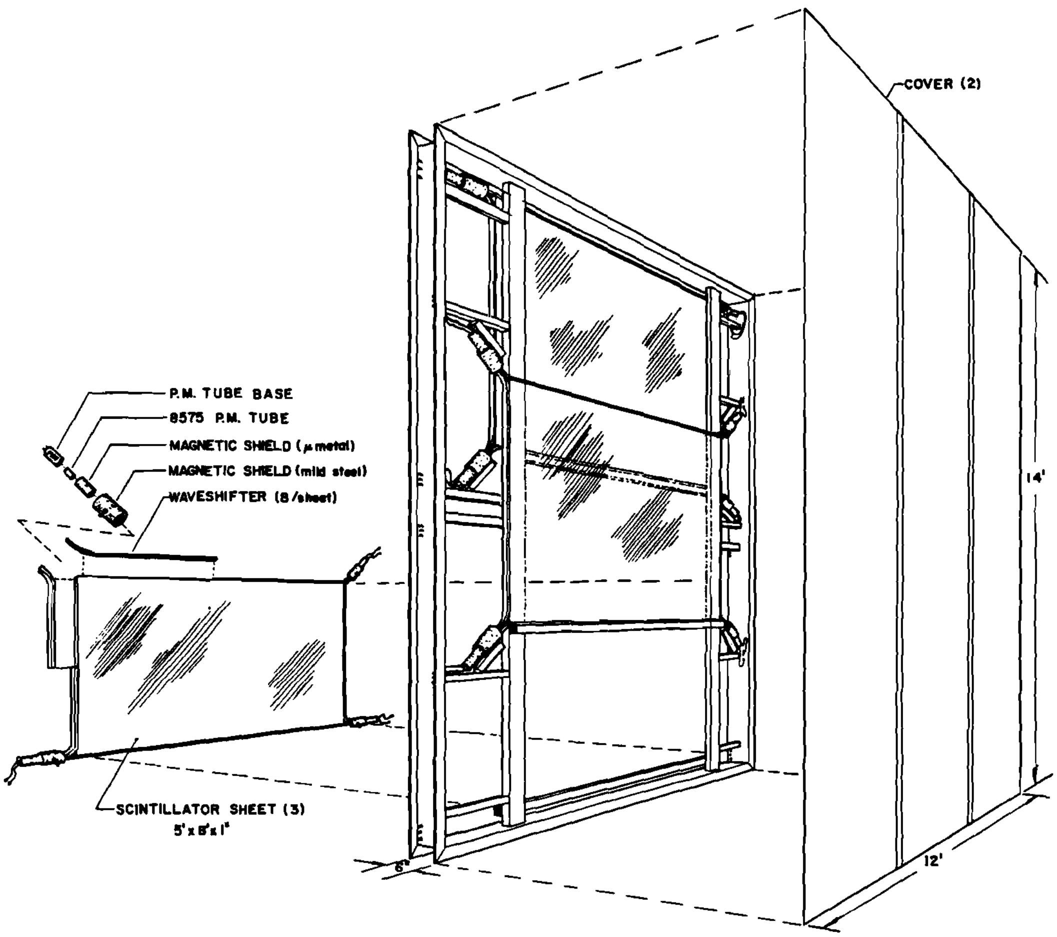

Figure 1. Structural features of a scintillator plane.

The scintillator light is gathered in wave shifter bars, described in Table II, that surround the scintillator on all four sides. There are four RCA 8575 photomultiplier tubes attached to each sheet, one at each corner. Each of these reads out the light from two wave shifter bars that are split in the middle optically isolating the two ends. The scintillator sheets arrive from the manufacturer with rough saw-cut edges which are then polished in our laboratory to near optical finish with a polishing machine that uses a diamond bit on its final pass. No special effort is made at maintaining an air gap between the shifter bar and the scintillator as the former is hand polished by the manufacturer and the resultant surface generally precludes the possibility of a good optical contact.

TABLE II

PROPERTIES OF WAVE SHIFTER BARS

Manufacturer	-	Polytech, Inc. 708 West Madison Owensville, MO 65066
Dimensions	- -	Cross-section 2.6x1.5 cm Lengths 137 or 91 cm Some had 45^{o} bends in last 15cm
Material	-	Cast acrylic
Chemical Additive	-	BBQ 4820/76B 140 mg/liter

While the construction procedures are straight-forward it is appropriate to mention some of the details. Since the plane is mounted in the experiment between two magnetized iron toroids, the tubes have to be shielded from the magnetic field. This is achieved by supporting the tubes and bases in heavy (1 cm thick) iron shields and then attaching these to the interior structure by means of welded bolts. The individual scintillator sheets are wrapped in thin aluminized mylar film, mainly to prevent the accumulation of dust, but the final light seal is ensured by covering the whole frame, front and back, with aluminum sheet. The only external connections are co-axial bulkhead connectors passing through the vertical support members. There are three connectors for each tube, two to carry signals out and one to bring high voltage in. The whole counter assembly is suspended by means of rollers from a steel I-beam permitting rapid positioning of the plane relative to the beam line.

RESULTS

The photomultiplier-base assemblies were first calibrated in the laboratory for absolute gain and in all tests were run at the same gain of about $6x10^7$. Two kinds of test were performed: a test with cosmic ray muons to measure the pulse-height distributions and a test with a beam of momentum-analyzed calibration muons to measure the timing dispersion.

In the cosmic ray test the scintillator plane was sandwiched between two paddles of a three paddle scintillator telescope,its efficiency was measured and its pulse height recorded. A typical pulse-height spectrum, with pedestal added is shown in Figure 2. This distribution is consistent with our Monte Carlo based estimates of 12-14 photoelectrons being recorded. This is is gratifying as the measurement was done at the center of the scintillator, the worst position for light output. Although only one scintillator sheet was tested with this procedure, it is expected that the others would yield similar results being of identical construction.

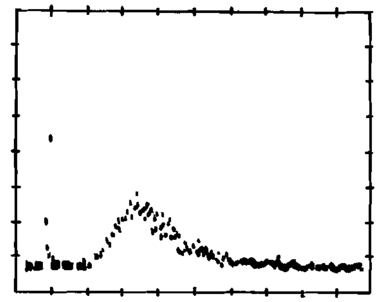

Figure 2. Typical summed pulse height spectrum from four tubes.

In the test with a beam of calibration muons the scintillator plane was inserted into the detector between two 3 cm magnetized iron toroids in such a manner that the undeflected moon beam struck the center scintillator about 30 cm west of and 50 cm below its center. In the course of the tests the beam was swept vertically so that the top and bottom scintillators were illuminated as well. The test consisted of summing the outputs of the four tubes of a given scintillator, discriminating the sum and using the resulting pulse to stop an LRS 2228A octal TDC which had previously been started by the same muon traversing a small "beam" counter. A typical time spectrum, in this instance from the center counter, is shown in Figure 3. A resolution of less than 3 ns is seen to be achieved. This number must be viewed as an upper limit as no attempt was made to eliminate the possible 1-2 ns timing discrepancies among the four individual tubes.

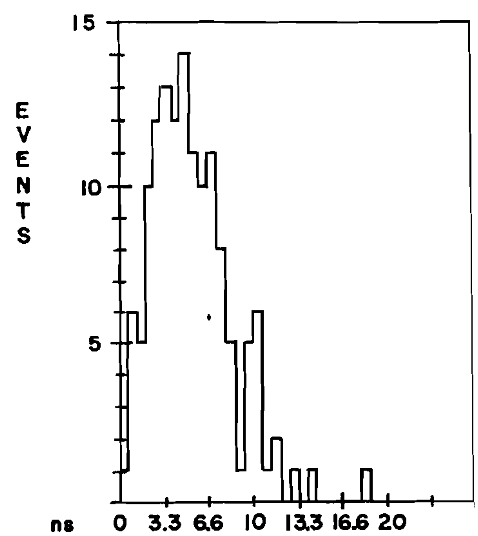

Figure 3. Timing dispersion of a single scintillator sheet.

CONCLUSIONS

The acrylic scintillator plane has excellent performance both in efficiency and in timing, is relatively inexpensive and easy to construct and thus is an attractive solution to the problem of building large area scintillator walls in high energy physics experiments. In our instance the timing resolution achieved is more than adequate for this plane to be used as the start or stop pulse with a system of drift proportional tubes.

ACKNOWLEDGMENT

This work was supported by NSF grant PHY-8117256.

REFERENCES

1. B. Barish et al., California Institute of Technology preprint CALT 68 - 623

2. W. Selove et al. Nuclear Instruments and Methods 161, 233 (1979).