A Measurement of the Density of Minos Scintillator Strips
Minos DocDB-2080

Alysia Marino, Fermilab

July 21, 2006

Abstract

This document describes a measurement of the density of the scintillator strips in the Minos detector. The mass and volume of water displaced by 14 pieces of scintillator strips (from different extrusion batches) were measured. The resulting value for the scintillator strip density is 1.046±0.004 g/cc.

1 Introduction

This document describes the results of a recent measurement of the density of Minos scintillator strips. Presently in the Monte Carlo simulations of the detector and the reconstruction software are using a value of 1.032 g/cc, which is the value in Particle Data Group book for polystyrene [1]. However the data tables available from the Particle Data Group website for the muon range in various materials (also published in [2]) use a value of 1.06 g/cc for polystyrene. Since the density affects the energy deposition by changed particles that travel through the detector, it is desirable to have a measurement made of the particular polystyrene extrusions used in the Minos detector.

2 Method and Measurements

14 different labeled Minos extrusion samples were obtained from Argonne National Laboratory. These strips did include the layer of TiO_2, but there

was no wavelength-shifting fiber glued into the channel. The method used here is the long-established Archimedes' Principle of determining the density by dividing the mass of the strip by the volume of water that it displaces.

The mass was determined using an analytical balance. The mass value given on the balance for a strip was reproducible to 0.01 g. By using a standard weight, the absolute calibration of the balance was found to be accurate to 0.1 g.

To determine the volume, the strip was placed in a graduated cylinder filled with tap water. [1] The strips were also agitated to knock off any large air bubbles adhering to the strip. The finest gradations on the cylinder were 5 ml, and the author rounded the volumes to the nearest ml by eye, for an uncertainty of 0.5 ml on each volume reading. Since the volume of the strip is determined by the difference between the volume before the strip is added and after the strip is added, the total uncertainty on the volume is the combination of two volume measurements, or 0.7 ml. The results of the measurements are given in Table 1. The uncertainty given on each density determination is dominated by the 0.7 ml uncertainty on the volume. The 0.01 g uncertainty on the reproducibility of the mass measurements contribute only a tiny amount. (The 0.1 g uncertainty on the absolute accuracy of the balance will be treated as a systematic uncertainty later on and is not included in this table.)

3 Summary and Conclusions

The average the 14 density measurements in the previous section is 1.0457 ± 0.0033 g/cc. Since the uncertainties on each measurement given in Table 1 were determined by the resolution of the graduated cylinder and the balance, they are uncorrelated and have been added in quadrature. However, there is an additional source of correlated systematic uncertainty that was not included in Table 1. The absolute calibration of the analytical balance is believed to be accurate to 0.1g. This gives an additional systematic uncertainty of roughly 0.002 g/cc. Combining the correlated and uncorrelated uncertainties yields a measurement of 1.046 ± 0.004 g/cc. It is recommended that the value of the scintillator density in the Minos software be changed to reflect this.

Many thanks to Dave Ayres for locating the scintillator pieces at Argonne and delivering them to FNAL and to Anna Pla-Dalmau and her technicians

[1] The author notes that the strips sink in tap water.

Table 1: This table gives the results of density measurements on 14 different samples of Minos scintillator extrusion.

Extrusion	Volume (ml)	Mass (g)	Density (g/cc)
27762	47	50.2	1.0681$\pm$ 0.0159
29187	59	61.17	1.0368 $\pm$ 0.0123
30199	60	62.89	1.0482 $\pm$ 0.0122
27470	61.5	63.49	1.0324 $\pm$ 0.0118
28777	65	67.49	1.0383 $\pm$ 0.0112
27248	63	66.28	1.0521 $\pm$ 0.0117
27092	60	63.53	1.0588 $\pm$ 0.0124
29833	61	64.00	1.0492 $\pm$ 0.0120
27263	63	65.52	1.0400 $\pm$ 0.0116
26847	62.5	65.41	1.0466 $\pm$ 0.0117
28392	58	59.94	1.0334 $\pm$ 0.0125
27257	64	65.98	1.0309 $\pm$ 0.0113
28714	65	67.33	1.0358 $\pm$ 0.0112
28356	56	59.85	1.0688 $\pm$ 0.0134

for allowing me to borrow their equipment to perform this measurement in their lab.

References

[1] Particle Data Group, "Review of Particle Physics", *Phys Lett B*, **592**, (2004)

[2] Groom, D.E., Mokhov, N.V, and S.I. Striganov , "Muon Stopping Power and Range Tables", *Atomic and Nuclear Data Tables*, **78**, 183-356 (2001)