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PERFORMANCE OF THE SOUDAN II HONEYCOMB DRIFT CHAMBERS

I. Ambats, D. Ayres, W. Barrett, J. Dawson, T. Fields,
M.C. Goodman, F. Lopez, E. May, L. Price, J. Schlereth and J. Thron
Argonne National Laboratory, Argonne Ill. 60430, USA

H. Courant, U. DasGupta, D. Feyma, K. Heller, S. Heppelman, K. Johns,
T. Joyce, M. Marshak, E. Peterson, D. Rosen, K. Ruddick, M. Shupe, and S. Werkema
University of Minnesota, Minneapolis MN 55455, USA

W. Allison, G. Barr, C. Brooks, J. Cobb,
R. Giles, A. Gilgrass, L. Kirby-Gallagher, D. Perkins, P. Shields and N. West
Oxford University, Oxford OX1 3RH, UK

J. Alner, D. Cockerill, C. Garcia, P. Litchfield,
G. Pearce, C. Roberts, E. Wallis, C. Woods and S. Yarker
Rutherford-Appleton Laboratory, Didcot, OX11, UK

D. Benjamin, T. Kafka, J. Kochocki, A. Mann, R. Milburn,
A. Napier, W. Oliver, B. Saitta, J. Schneps, K. Shaw, and N. Sundarlingam
Tufts University, Medford MA., 02155 USA

Abstract

The Soudan II nucleon decay project is in the process of building 260 identical 5-ton fine grained calorimeter modules for the study of nucleon decay and cosmic ray physics in the Soudan Iron Mine in Minnesota. Several of these modules have been studied on a cosmic ray test stand on the surface at Argonne National Lab. Several have been installed on location in the mine, 700 m under the surface (2200mwe overburden). In addition, many studies of trigger efficiency, pattern recognition and background rejection have been done using monte carlo techniques.

1. Description of the Detector. The detector is an iron calorimeter with high density ($2g/cm^3$) which emphasizes dE/dx measurement and excellent tracking. The detector has been described earlier. /1/ In brief, it consists of 256 modules identical modules with a total mass of 1.1 kton. Each module consists of formed steel sheets which are stacked in a honeycomb pattern. The array of holes is filled with resistive plastic (hytrel) tubes (ID=15 mm, OD=16 mm, length = 1 m) enclosed in mylar sheets lined with narrow copper sprips running perpendicular to the tube axes (bandolier). A negative 10kV electric potential is applied to the central of the 21 copper strips and successively lower voltages are applied to the other strips, until the potential is zero at each tube end. This provides a uniform axial drift field to transport ionization electrons from charged tracks along the full 50 cm drift distance within the module. Full three dimensional readout is obtained from the wire and strip locations and drift time digitization. In addition, the pulse height and shape of each hit is measured with 6-bit flash ADC's. A detailed description of the electronics is given in Reference /2/.

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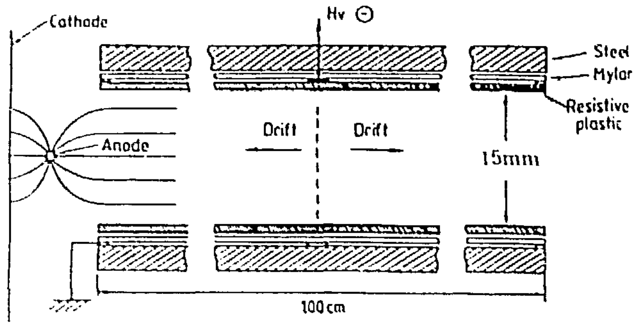

Figure 1: Cross section of a single drift tube. The drift field in the tube is 200 V/cm and the drift velocity .8 cm/μs.

A cutaway view of a single drift tube and wire is shown in Figure 1. Readout is performed on both the anode wire and cathode pad, which are 1 cm apart. A recent change in the design of the detector has been the addition of 0.5 mm of polystyrene sheets between the mylar and the steel. It was found that large areas of mylar do not reliably peform at its rated dielectric strength, but the addition of the polystyrene solved this problem.

2. Data from the Cosmic Ray Test Stand. A number of the modules have been tested in a cosmic ray test stand set up at Argonne National Laboratory and at the Rutherford Appleton Laboratory. Three triggers are used. A pulser trigger is employed which puts a known amount of charge onto each preamplifier. This has been used to check out the uniformity of the amplifiers, the performance of the data acquisition system, and the software used to unpack the data.

A second trigger is an internal one to detect the ionization from 26 Fe^{55} sources which have been placed throughout the detector. This has been used to study pulse widths, attenuation of the signal along the drift direction, uniformity across the anode and cathode planes, and stability. The Fe^{55} sources have also been used to monitor the purity of the gas in the gas system. Figure 2 shows the pulse height spectrum from one of the Fe^{55} sources in one of the modules. The 10% resolution is well within the overall detector design goal of 20%, althought the resolution will be degraded due to gain variations and less predictable sources of ionization (e.g. charged tracks which cross the hytrel tubes). Good pulse height resolution enables this detector to measure the ionization rise at the end of a charged particle track which ranges out. This gives us the ability to determine track direction, which is a powerful handle on rejecting many backgrounds to proton decay.

The third trigger is made by scintillation counters placed above the top and below the bottom of the module. There is 15 cm of iron absorber between the bottom counter and the module to ensure a high enough energy muon spectrum that multiple scattering is not large. These muons illuminate the entire volume of the modules and allow detailed uniformity and other performance studies.

Figure 3 shows the average anode pulse height for hits on a track as a function of anode number. Data has been included from fully reconstructed tracks. This process involves matching anode and cathode hits and requiring that there be only one track in the detector. Anode and cathode hits are matched using the leading time edge of the

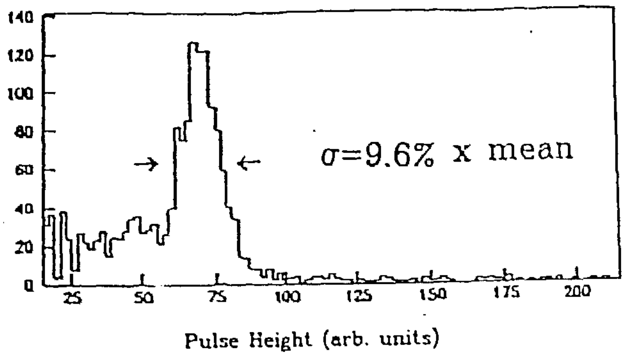

Figure 2: Fe^{55} Spectrum

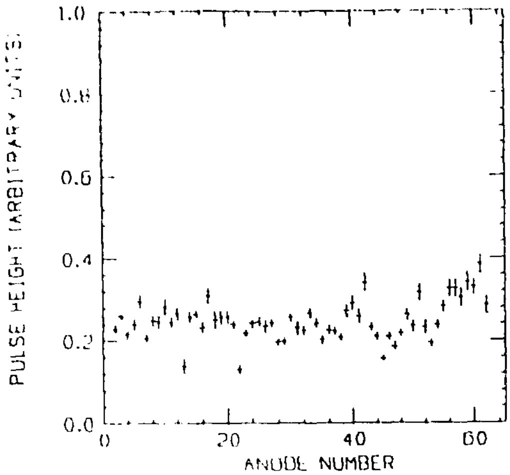

Figure 3: Average Anode Pulse Heights

pulses. Additional information is available from the pulse shapes themselves. This results in a fully reconstructed three dimensional track. Individual anode and cathode views for a track which traversed the entire height of the detector are shown in Figures 4a and 4b.

The most sensitive indication that ionization from charged particles is correctly being handled by the drift chamber and the reconstruction program is the distribution of the residual between the location of the fitted track and the individual position measurement. The rms x-residual is shown in Figure 5a. The mean value of .47 cm matches well the expected mean value of .43 cm based on the anode spacing. The rms z-residual (in the drift direction) is shown in Figure 5b. This shows, among other things, that the tube to tube drift velocity variation is less than 1%.

3. Further Studies We are continuing to test modules in the cosmic ray test stand as they are being produced. Tests are designed to ensure that the required uniformity and stability in pulse height response is achieved. Further study of stopping muons and bremsstrahlung events are planned in the cosmic ray test stand, which will further measure module performance. It is planned to place a number of modules in a neutrino test beam in 1988 or 1989 in order to study the detailed characteristics of background events to proton decay. And there will be a test beam run at Rutherford Appleton Lab using pions, electrons and muons in the range of energies expected from nucleon decays.

References

1. Ayres et al., Proc. 19th ICRC, La Jolla, 8,267, (1985); Ayres et al., "The Soudan 2 Nucleon Decay Experiment: Description and Status Report", Argonne Report ANL-HEP-PR-84-30 (1984).

2. Dawson et al., IEEE Trans. Nucl. Sci., NS-32, 221 (1985).

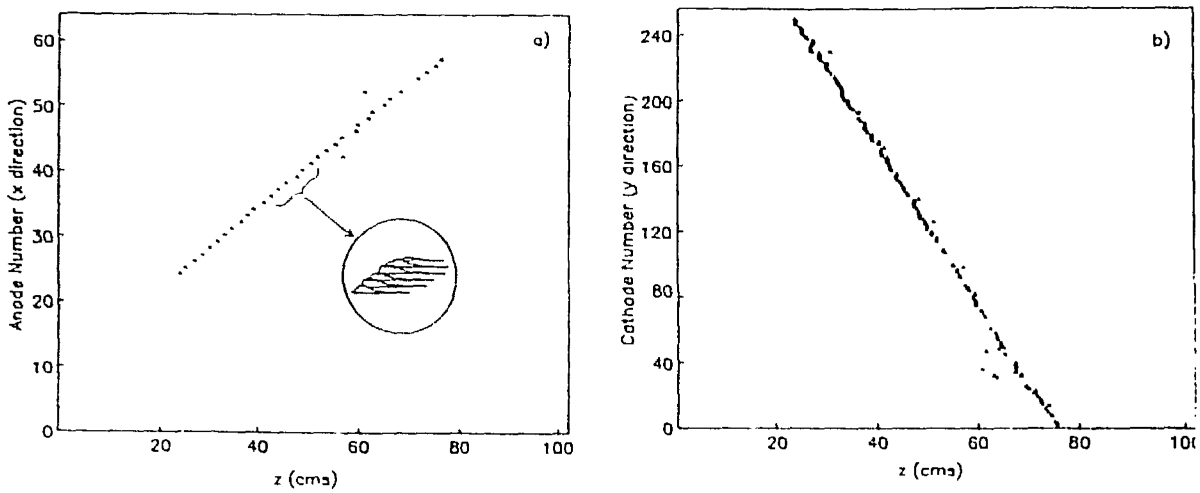

Figure 4: (a) Anode and (b) cathode views of a track which traversed the entire detector. Plotted are the channel number versus the drift time down the tube. The blowup shows the pulse structure that we measure from each tube.

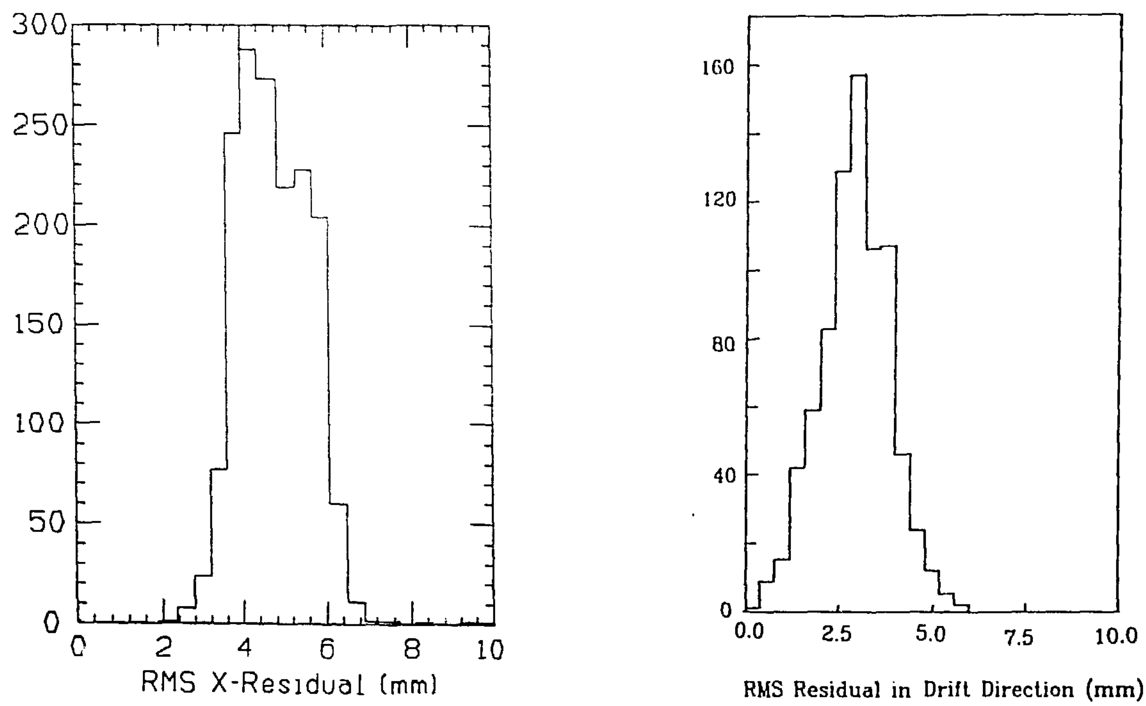

Figure 5: RMS residuals in the x direction (a) and the drift direction (b). Reconstructed cosmic ray muons are used