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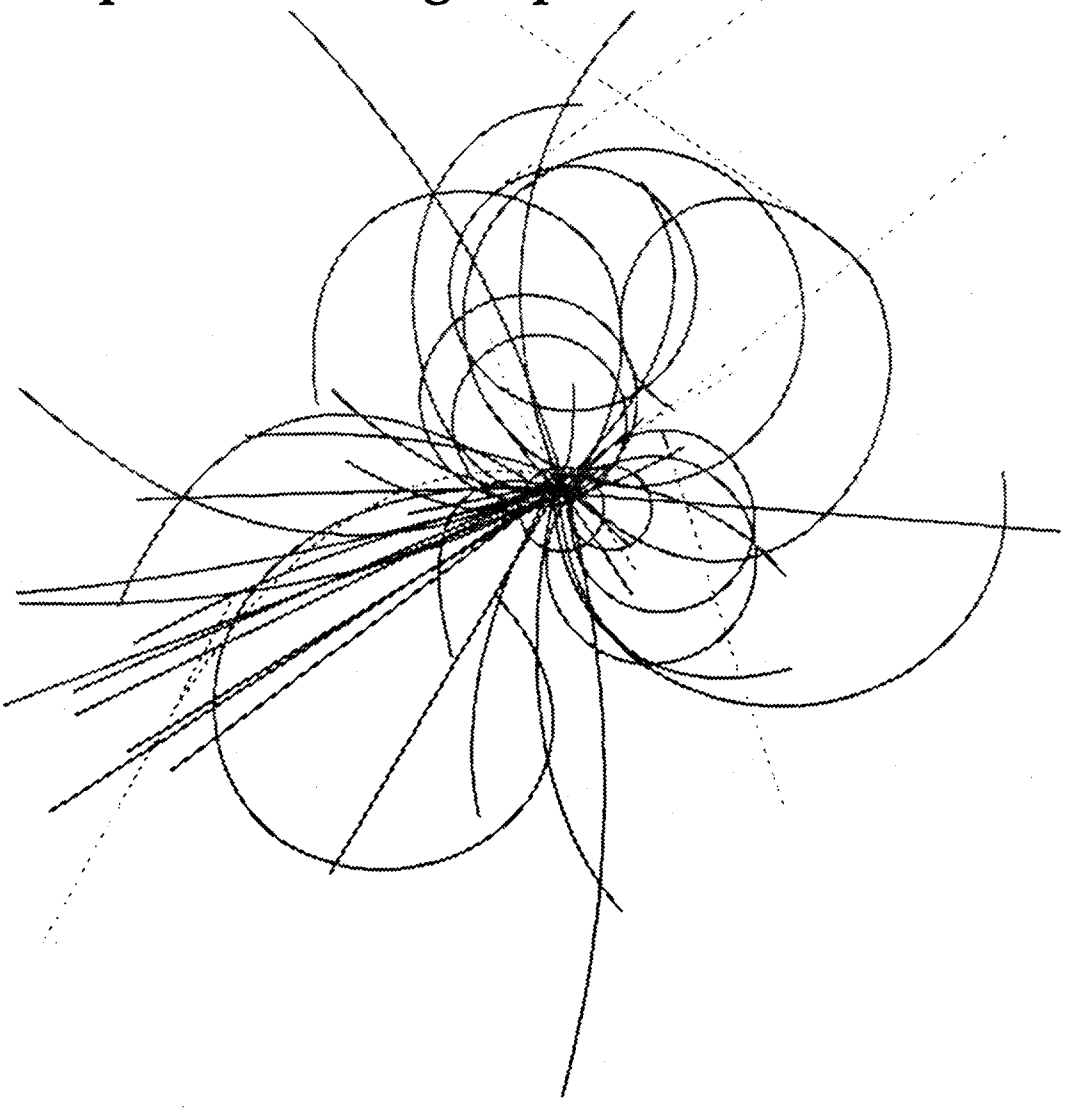

Cosmic Ray Test of SDC Prototype Muon Drift

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Cosmic ray tests of SDC Prototype Muon Drift Tubes.*

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Preliminary results are presented from cosmic ray tests of the SDC muon detector prototype module. The module consists of 30 drift cells. Each drift cell is a 9m long, 73mm inner diameter aluminum tube with simple field shaping electrodes. The anode wire is gold plated tungsten. The construction of the module makes use of the drift tubes as structural elements. The resolution and efficiency are approximately 200μm and 99%, respectively.

1.Introduction

The purpose of the SDC muon system is to identify muon trajectories and to provide a level-one trigger based on the transverse momentum of the muon. The drift cell is optimized to meet these requirements.

The key elements of our design are the use of field shaping with the drift direction normal to the high momentum tracks, the arrangement of the detectors into projective towers, and the mechanical stabilization of large blocks of detectors by epoxy bonding all components together to form monolithic modules. Field shaping is required to provide good resolution and the necessary two-track separation. The tubes are arranged within a module as layers of parallel tubes. The largest modules, for example, have four layers of θ, four layers of φ and two layer of stereo tubes, see Figure 1. The anode wire is fixed by the end cap of the tube and located by a CNC-milled endplate. The basic approach in this design is to :

1. separate the fabrication of the drift cells from that of the module;
2. to make use of the drift tubes as structural elements of the modules;and
3. to establish the alignment and orientation of the drift cells within a module by the drift tube end caps and the module end plates.

Table 1
Design parameters of Prototype.

Radius	36mm
Wall Thickness	1.6mm
Wire Diameter	50μm
Wire Material	Gold plated Tungsten
Wire Tension	300 grams
Gas Mixture	Ar/CO_2 90:10
Gas Gain	$\sim 10^5$

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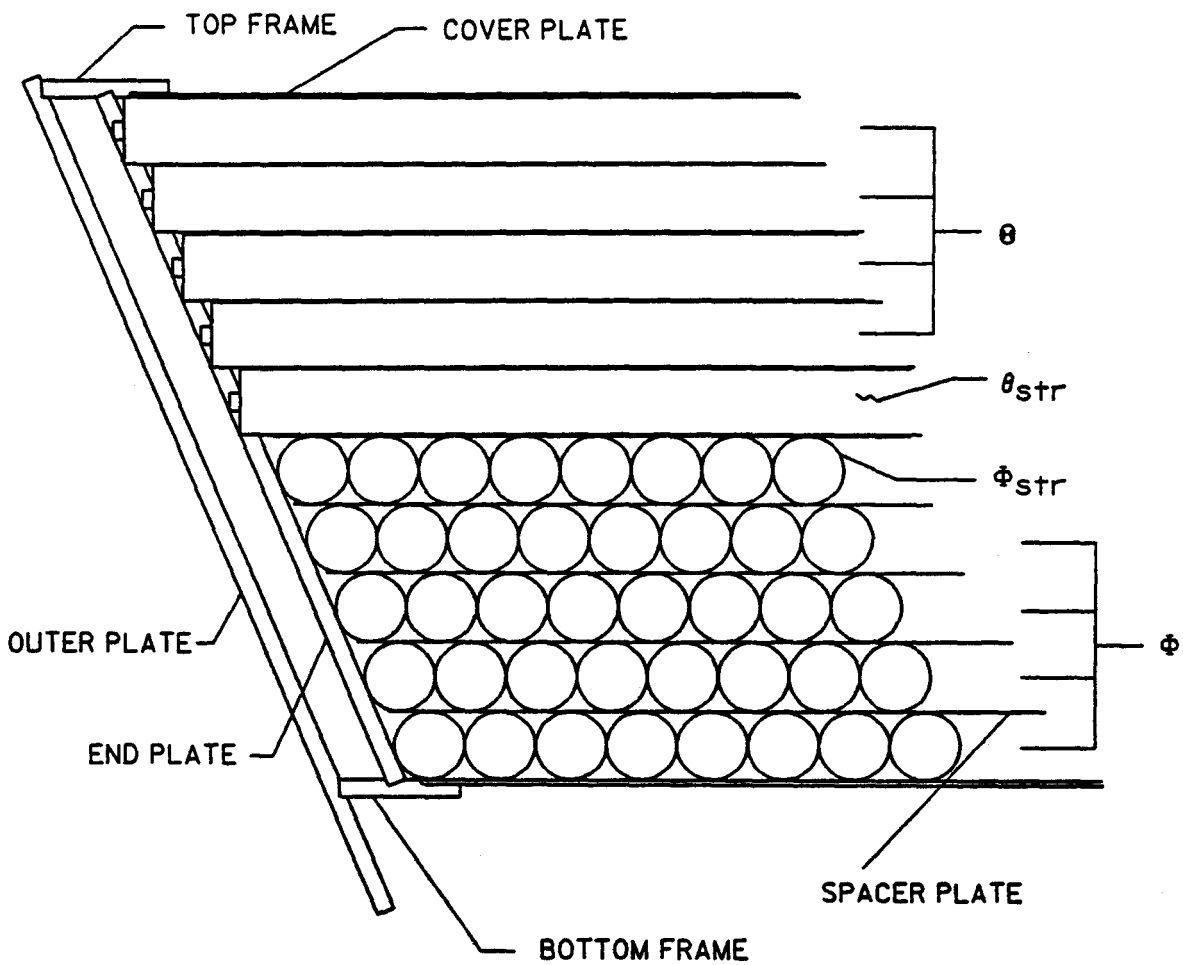

Figure 1. Cross-Section of Typical Module.

The drift cells are aluminum tubes with circular cross section and simple field shaping electrodes, see Figure 2. Each of the cells is a complete and independent, fully functional drift tube with all of the necessary passive interface components built into the end caps. The prototype tube design parameters are given in Table 1.[1] The required resolution of each drift tube in the SDC detector is 250μm.[2]

The use of round tubes in this design avoids the need for mid-span supports for the anode wire. It also allows the drift direction to be optimized for each individual tube location by simple rotation of the tube.

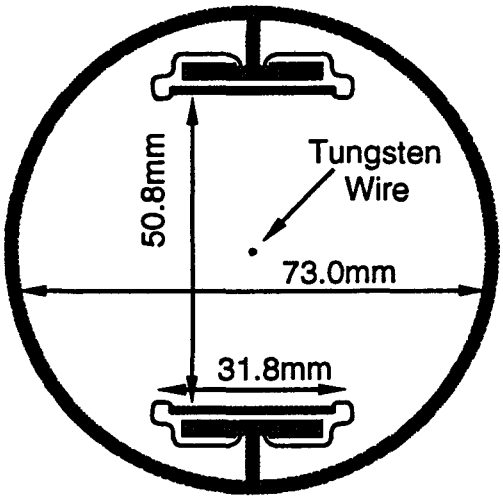

Figure 2. Cross section of a drift tube.

2.Cosmic ray test setup

The detector prototype module consists of an array of 30, 9m tubes which are arranged in four layers in rows of 7,8,7,8 as shown in Figure 3. The tubes are staggered to form projective towers as shown in Figure 4. The offset of tubes in adjacent layers in the prototype is approximately 1/3 cell to avoid having the anode wire and wall of the above tube aligned.

Scintillation trigger counters are mounted on top and bottom of the module to trigger on cosmic ray muons and provide a t=0. Each counter is 76mm × 400mm × 5mm. The cosmic ray energy spectrum

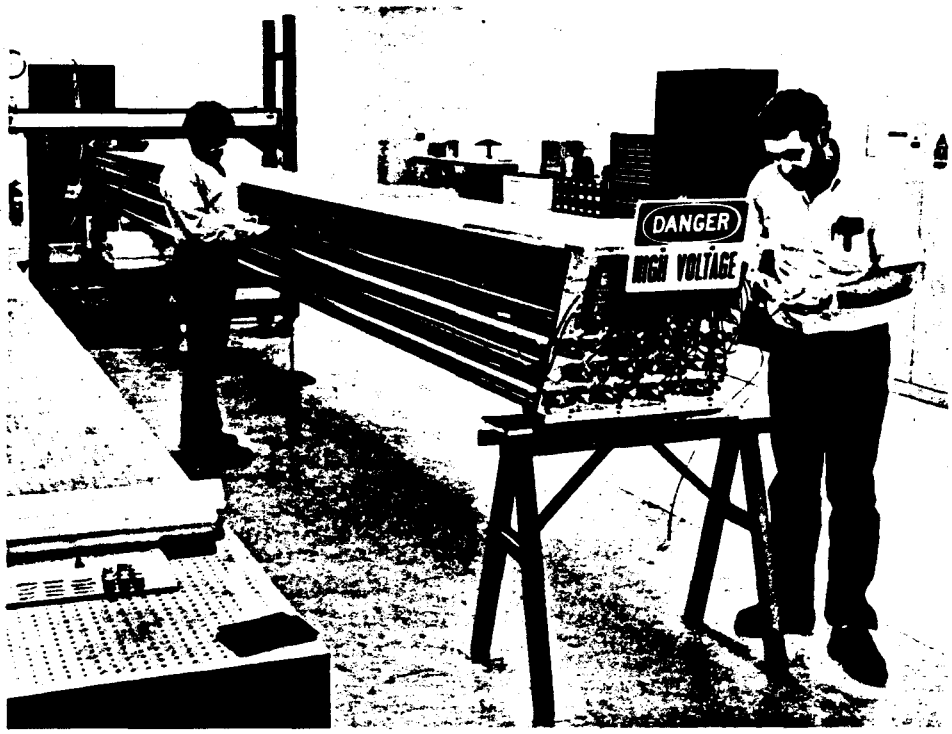

Figure 3. Prototype Module.

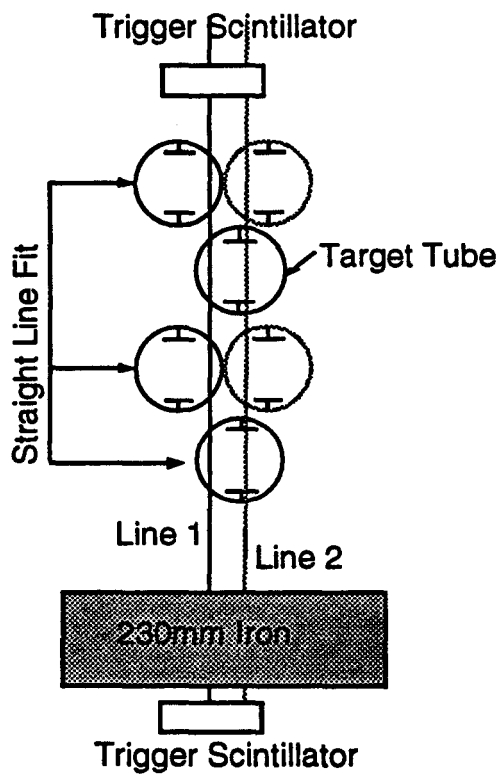

Figure 4. Prototype setup for resolution and efficiency study.

is hardened by 230mm of iron. This insures that the muon momentum is greater than 300MeV/c.

The data acquisition system is based on CAMAC controlled by an IBM PC. The drift tube readout consists of an amplifier and discriminator (Nanometric N-277) and multihit TDC (LeCroy 2277).

Table 2.
Efficiencies†

HV Anode	Electrode	Drift Field	Efficiency
4.10kV	2.40kV	650V/cm	0.985
4.65kV	3.40kV	828V/cm	0.993
5.25kV	4.40kV	1010V/cm	0.989

3.Analysis of Data and results

Three tubes as shown in Figure 4 are used to define a straight line, and the remaining tube is used to measure the efficiency and resolution by calculating the residual from the straight line. As can be seen in Figure 3, the distribution of the residuals is a typical gaussian shape with a tail extending to several millimeters. The tail is probably the result of large-angle multiple scattering. We fit the distribution shown in Figure 5 to the sum of two gaussians, one to determine the resolution and the other to account for the tail.

We assume all tubes have the same resolution. Therefore the individual tube resolution, σ_t, can be obtained using the following relation:

$$\sigma_t = \frac{\sqrt{3}}{2}\sigma_f, \qquad (1)$$

where σ_f is the fitted value.

We have taken data for three different combinations of anode and electrode voltages chosen to have the same gas gain. Table 2 shows the measured efficiency for the three sets.

It is possible to take two combinations of three tubes to define a line in the target tube. Line 1 in Figure 4 covers the region between the wall and the mid point of the wire (wall side). Line 2 covers the region between the wire and the mid

† Statistical Error ~ 0.003

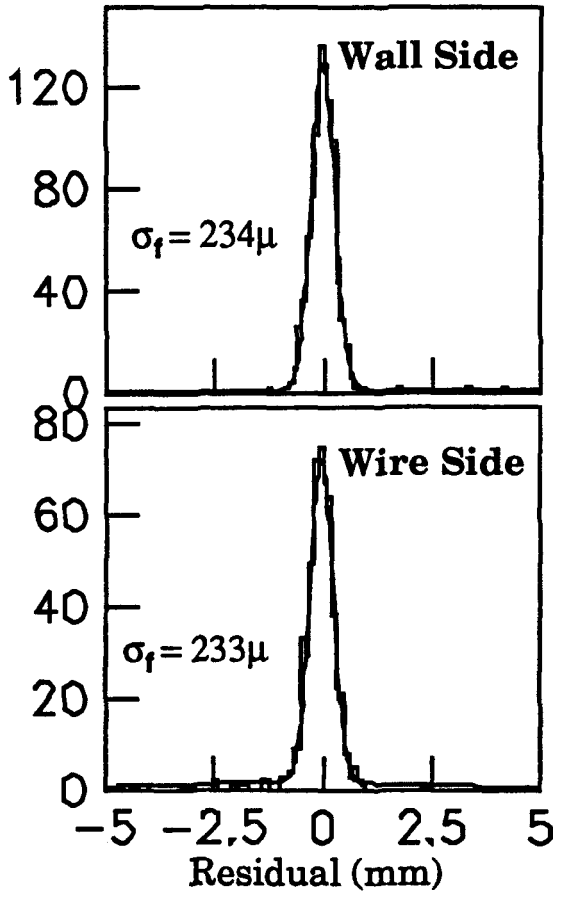

Figure 5. Residual Distribution. Top shows wall side configuration and bottom shows wire side. σ_f is result of fitting.

point (wire side). Figure 5 shows the residual plot of wire side and wall side near the readout end with 4.65kV and 3.40kV on anode and electrode, respectively. No difference is observed. From eq.1 we conclude that the single tube resolution $\sigma_t = 203\mu m$.

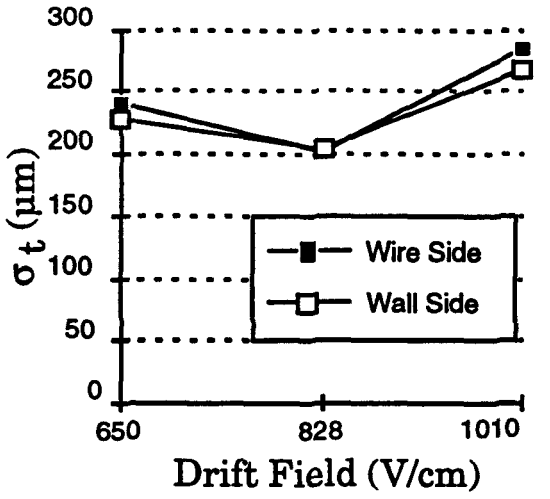

Figure 6. Drift Field vs Resolution. Closed square shows "wire side" configuration and open square shown "wall side" and both are at readout end.

The tube resolution, σ_t, is not very sensitive to the anode/electrode voltage combinations as shown in Figure 6. However, there seems to be a minimum in the region of 828V/cm.

In this analysis we have ignored small-angle multiple scattering effects. Therefore, the single tube resolution is probably better than the above value.

4.Summary

We measured the efficiency and resolution of 9m drift tubes in a prototype SDC muon module using cosmic ray muons where E_μ > 300MeV. The efficiency is found to be approximately 99% and the resolution about 200μm. This verifies that the achievable resolution is less than the design goal of 250μm for a single tube.[2]

5.Acknowledgements

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Reference

1. SDC Muon Detector Design Barrel and Intermediate Chambers Round Tube Option University of Washington/SSCL Design, SDC-91-135, SDC note, Superconducting Super Collider Laboratory, Dallas Texas.

2. SDC Technical Design Report, SDC-92-201, SDC note, Superconducting Super Collider Laboratory, Dallas Texas.