A Solenoidal Tracking System for the Stage I Detector in Hall D

James A. Mueller
Department of Physics and Astronomy, University of Pittsburgh
Pittsburgh,PA 15260

The Stage I design[1] for the Hall D detector contains central tracking within a solenoidal magnetic field. The exact details of the tracking system have not been specified. It is assumed that the detector will consist of a set of cylindrical chambers covering regions at large angle to the beam, and planar chambers covering the smaller angles. In this writeup, I will first examine the question of how long the cylindrical section should be. Then I will propose an initial design for the tracking system and calculate the momentum resoluution that might be achieved by such a system. These studies use the TRACKERR program[2] available from the FREEHEP ftp site (freehep.scri.fsu.edu).

Trackerr is a program which will calculate the error matrix at the origin for charged particles in a solenoidal field using the Billoir[3] method. The user describes the geometry, material, and resolutions of the detectors in a simple text file which is read by the program. The momentum and direction of the particles to be analyzed are also specified there. There is not enough space here to adaquately describe this program, so I refer the reader to the program documenation.

We begin by examining two limiting cases.

- A massless cylindrical detector which fills the entire length of the solenoid between the radii of 4 and 60 cm.
- A massless disk geometry filling the solenoid between the same two radii beginning 5 cm downstream of a 30 cm long target.

The relative uncertainties (in percent) are presented in Figure 1. The results are for 5 different total momenta representing the spectrum expected in a Stage I experiment.[4] They are graphed verses the pseudorapidity ($\eta = -\ln(\tan(\theta/2))$) of the track, where θ is the angle of the track with respect to the incoming beam. For reference, $\eta = 1, 2, 3, 4$ correspond to $\theta = 40, 15, 6, 2$ degrees.

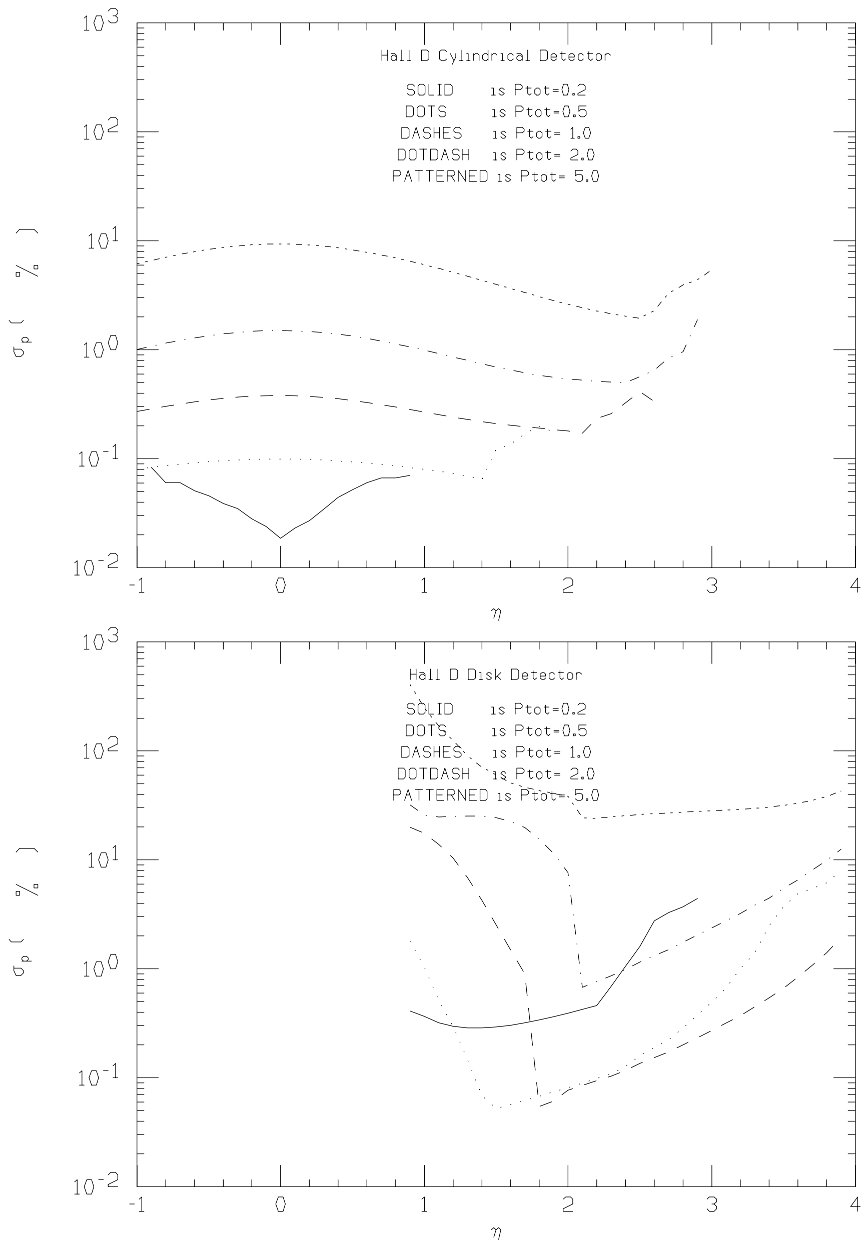

Figure 1 Momentum resolution as a function of pseudorapidity. The two plots correspond to the ideal cylindrical and ideal planar detector described in the text.

The plots show that the momenta are well measured in the ideal cylindrical detector out to $\eta \sim 2$. This is where the track exits the detector before reaching the maximum radius. Although the uncertainty begins to rise after that, the main effect is the rapid loss of tracking layers crossed as the polar angle decreases. Very rapidly, we reach a point where there aren't enough layers crossed for the track to be found at all. A similar effect is seen with the disk geometry, although here the decrease in layers crossed occurs at smaller η (larger polar angles). From these two plots, we conclude that the cylindrical portion of any real detector should cover the angles down to 10-25 degrees with the limit probably being determined by the difficulties in building a long cylindrical detector. This result shouldn't be too surprising, since the cylindrical detector geometry is better matched to a solenoidal field.

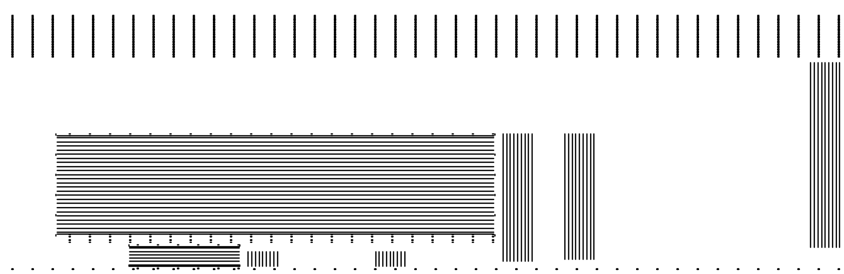

Figure 2 A schematic drawing of the tracking system. The solenoid is indicated by the vertical bars at the top of the figure, while the beam line is indicated by the dots at the bottom. The three-dimensional detector would be the volume defined by rotating this figure through 360 degrees about the beam line.

This leads me to an initial suggestion for the tracking system of a Hall D stage I detector. It consists of a main cylindrical system covering the region from $-65 < z < 175$ cm and $15 < r < 60$ cm. The main system is assumed have a measurement resolution of 200 μm, with half the layers having a 6 degree stereo angle and cathode strips providing 500 μm z measurements. At smaller radii another cylindrical chamber covers large angles, while small angles are covered by 5 sets of planar drift chambers providing u,v, and w views. A sketch of the system showing a cut-away above the beamline is

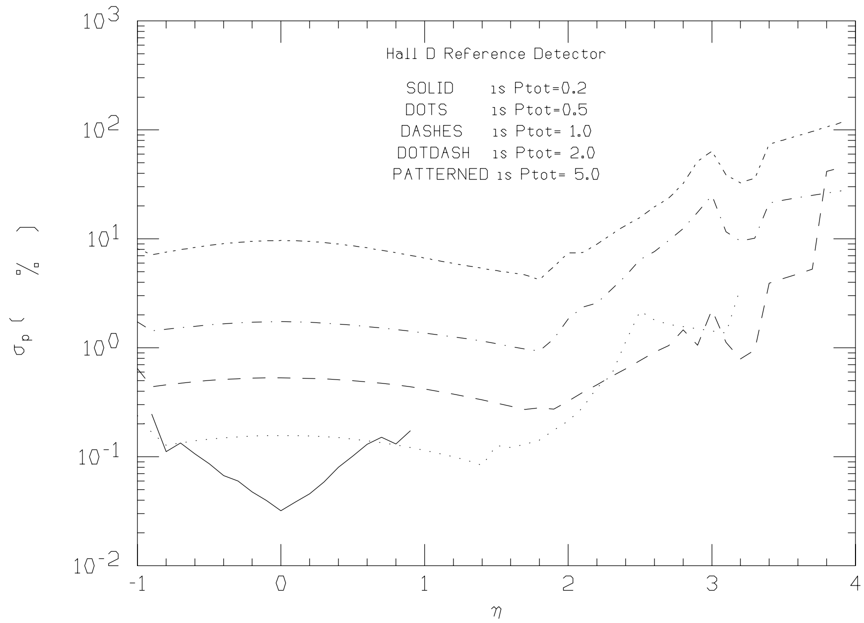

Figure 3 The relative momentum resolution as a function of pseudo-rapidity for the tracking system described in the text and figure 3.

shown in Figure 2. A plot of the results from is shown in Figure 3.

For this calculation, I have also tried to include some indication of the material in the support structure of the beam and detector, although it is probably not yet complete. This results in somewhat worse resolution at higher angles and significantly worse resolution at smaller angles. This may suggest modifications to this design. many alternative ideas can now be examined and compared.

References

[1] A. Dzerba and other contributions to these proceedeings.

[2] W. Innes, BABAR Note 390, (1998).

[3] P. Billoir, *NIM* **225** 352 (1984).

[4] C. Meyer, private communication.