Simulations of Multiple Scattering in the TWIST detector

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Introduction

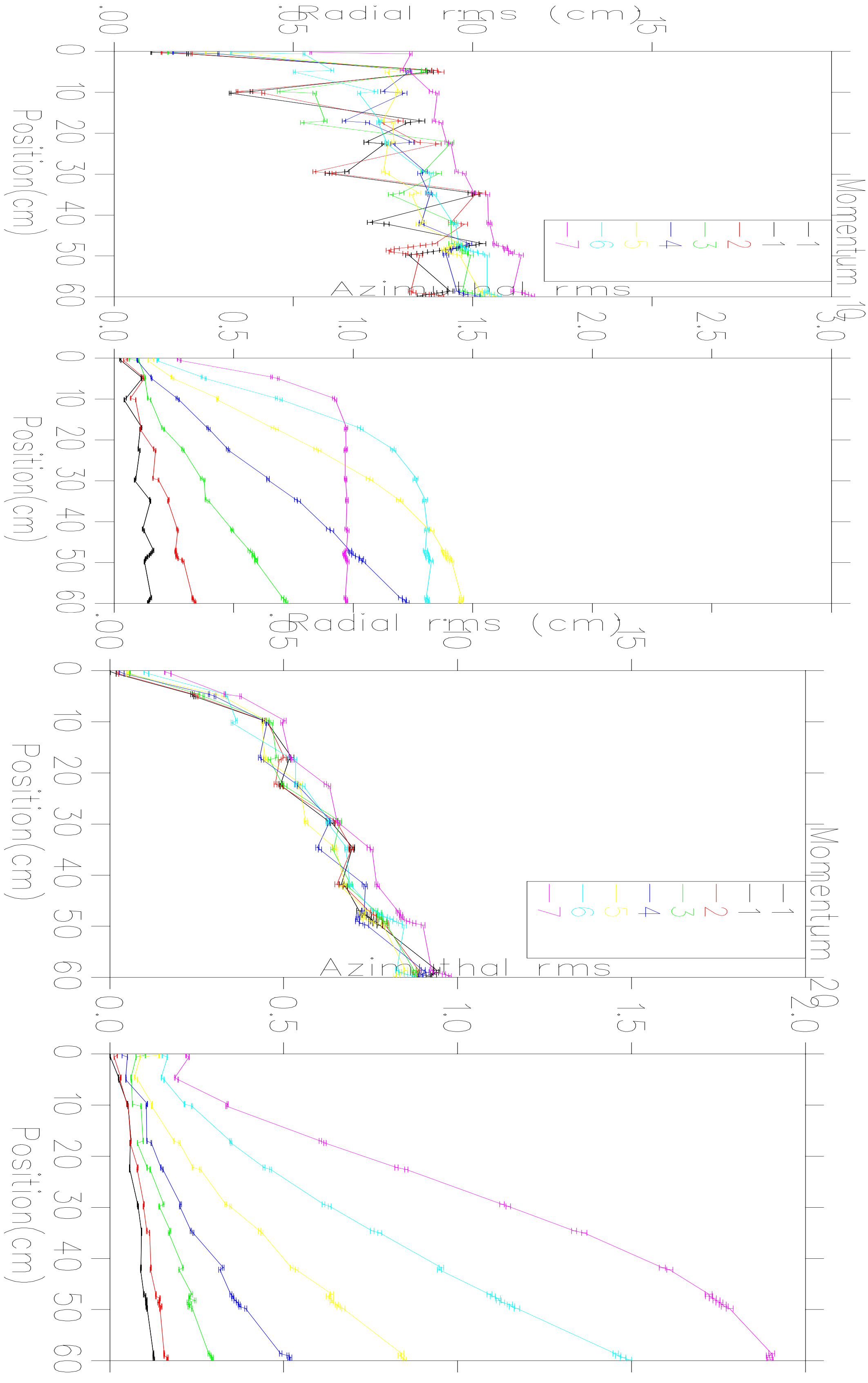
The core of this report is a series of plots of multiple scattering distributions simulated for the TWIST spectrometer . These have been produced by analyzing simulation runs with positrons generated just outside the target foil for a range of discrete angles and momenta in a 2 T field. Space points from the simulated trajectory were sampled at the position of each detector plane, and compared with the ideal helical trajectory . RMS deviations of these distributions as well as gaussian fits were examined in the radial and azimuthal directions. In order to characterize these distributions in the plane normal to the trajectory I reduced the width in the detector azimuthal plane according to the pitch angle of the helix.

Following these figures is a technical expanation of how they were obtained and some of the implicit assumptions. Finally there is some discussion of the implications of these findings.

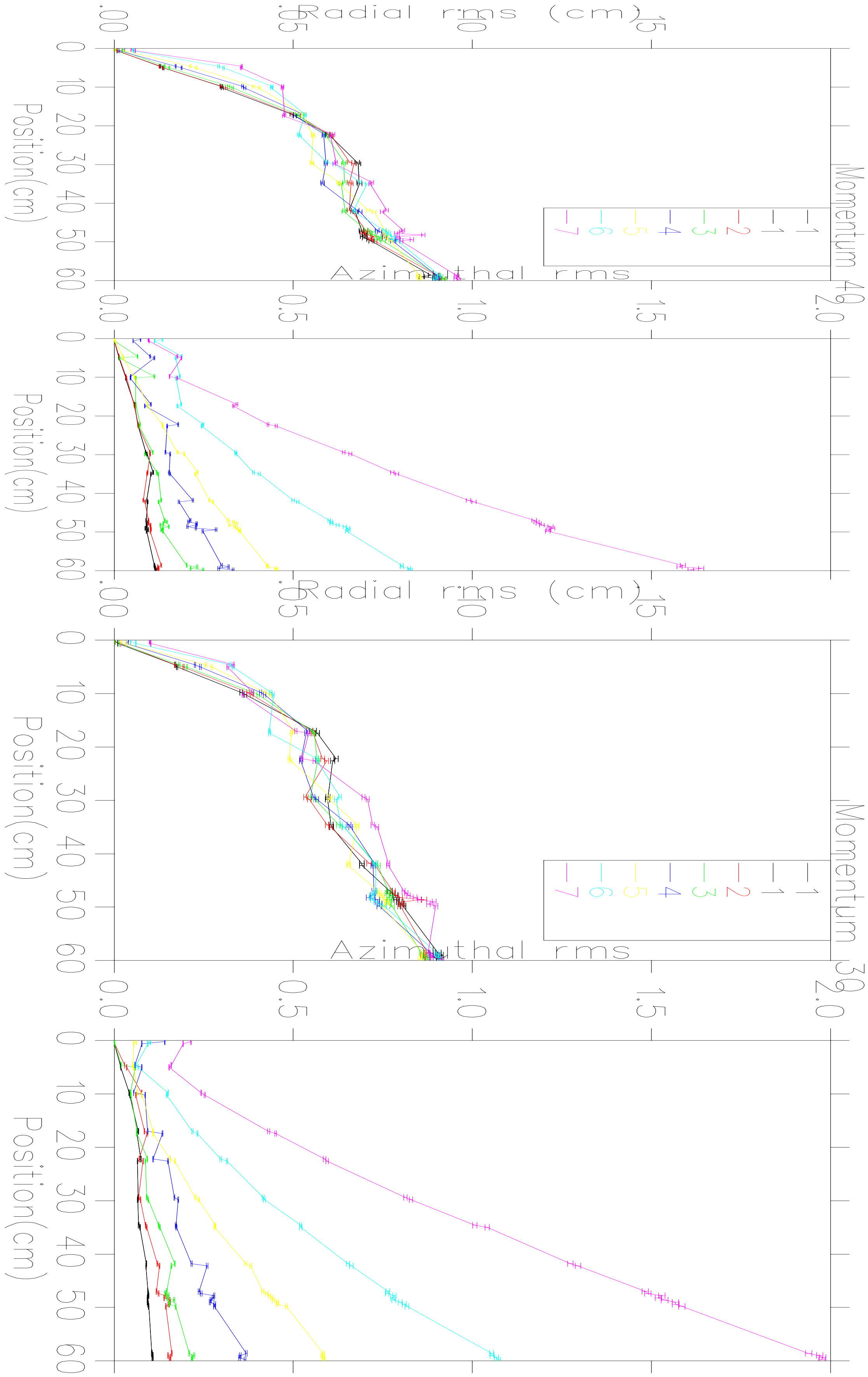
Simulation Results

These curves plot the simulated rms distributions for angles of 10° to 70° (curves 1-7) and momenta of 10 MeV/c to 60 MeV/c. There are several striking features:

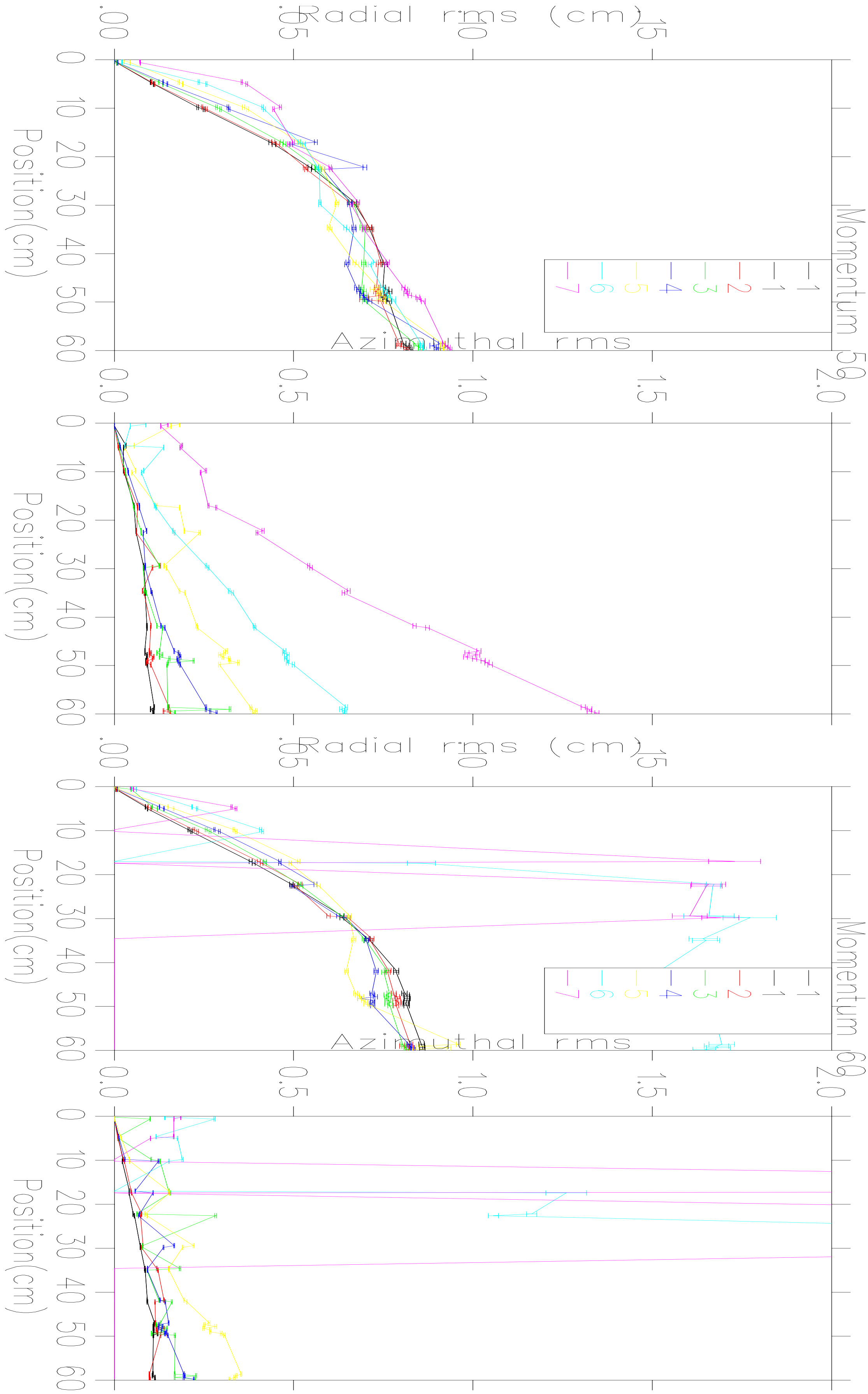
1. ***The radial distributions are rather narrow and grow slowly with z. Values are comparable to the expected drift time resolution. There seems little dependence on pitch angle. Some structure can be seen.***
2. ***The azimuthal widths vary strongly with pitch angle starting at values comparable to the drift time resolution for θ = 10° to values 20 x higher at 70°. The z dependence becomes quite strong.***
3. ***The azimuthal widths show a clear variation with positron momentum. At low momentum and large angles they are dominated by the helix radius. The narrow distributions for some 60 MeV high angle points correspond to trajectories that exit the detector volume.***
4. ***I have included some simulations where the positrons multiple scatter in the target first, and then continue through the chambers. Here we see minima when the helix has gone through a full rotation.***
5. ***Values of gaussian fits to the distributions are 10-20% narrower than the rms widths. They sample a fraction of the distribution depending on the histogram definition. Fits for the >.5mm broad distributions are not reliable. It is not clear that they are anyway a better measure than rms, as the distributions have long small tails.***
6. ***The mean values of the radial distributions (not shown) get systematically smaller with increasing z, as expected from the energy loss. The mean values of the azimuthal distributions fluctuate about 0 with z, and the fluctuations are small compared to the distribution widths.***



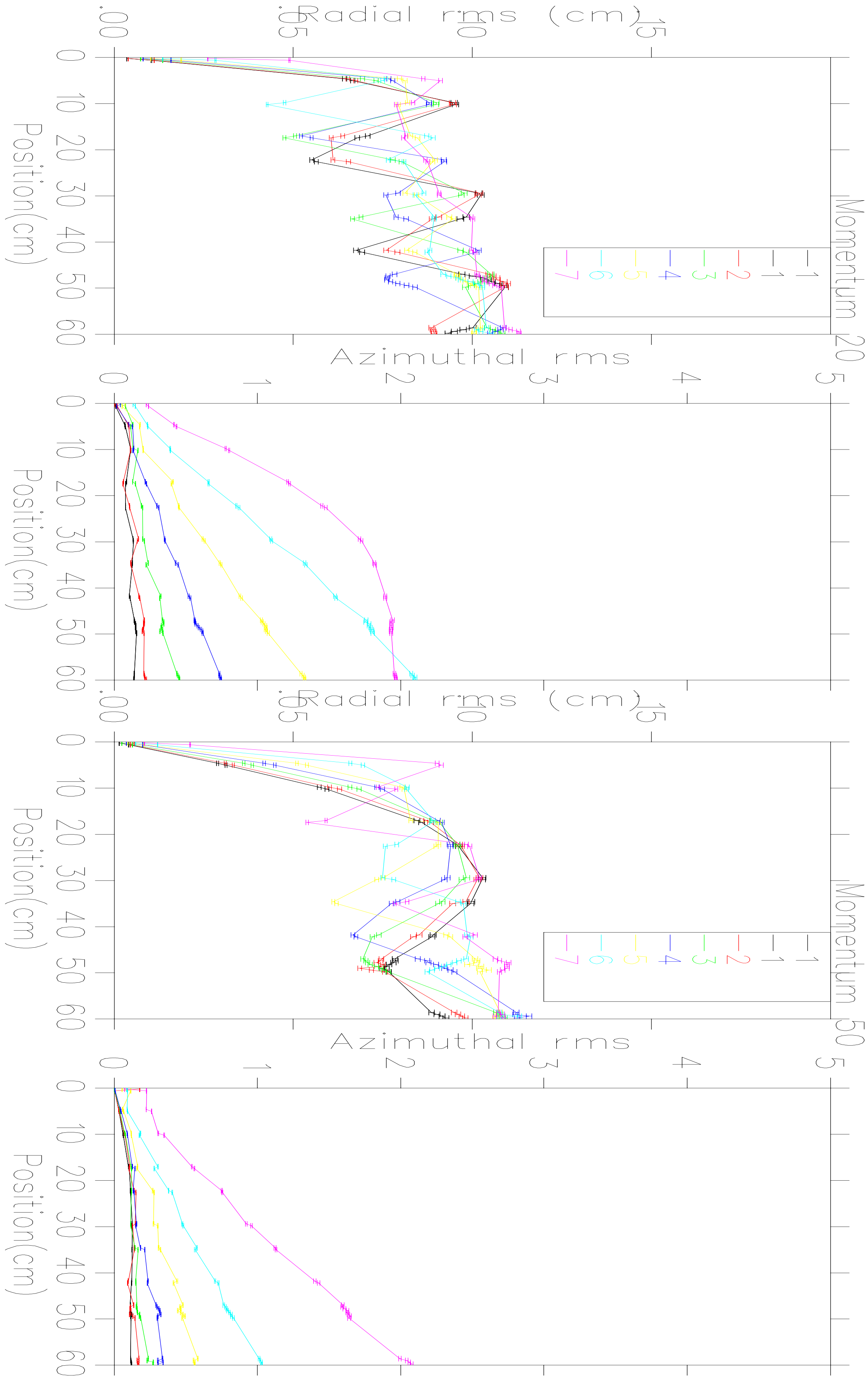
Figures 1,2: 10 MeV/c and 20 MeV/c Positrons starting after the target. Curves 1-7 are for angles of 10° - 70°.



Figures 3,4: 30 MeV/c and 40 MeV/c Positrons starting after the target.



Figures 5,6: 50 MeV/c and 60 MeV/c Positrons starting after the target.



Figures 7,8:20 MeV/c and 50 MeV/c Positrons passing through the target.

Technical Issues

The studies used a version of GEANT from Feb 3, 2003 before the recent changes to clustering were done. Those developments are not relevant to this work. The GEANT geometry was modified to remove wires, so the distributions shown contain no wire hits.The calculations used PHYS = 0, MULS=2, ELOSS=2, AUTO=0, ERAN 0.00001 0 .1 196 and other standard FFCARD values. The generator was

PGUN 2 -1

0. 0. 0.05 0. 0. 0. 0.00001 0.00001 0. momentum 1.0

0. 0. 0. 0. 0. 0. 0.00001 0.00001 0. 30. 1.0

CONE 1 -1

angle 0.

2. 1.

Mofia routines in scatter_weights_mod calculate the distributions and output them to a text file. Physica macros read these files and produce the plots. The results are stored in a big physica matrix, which could be used to investigate interpolation approximations.

Discussion

These systematics provide a validation of the methodology used in first guess to depend mainly on the circle fit to associate hits with tracks. The phase fit used to determine the pitch angle is much more sensitive to the multiple scattering and a chisquare cut on this fit could easily introduce momentum and energy dependent inefficiencies. These would occur in both data and simulation, and would therefore be corrected to the limit of the accuracy of the multiple scattering simulation.

In the determination of the track angle the hits on the first planes contain the most information. However they are widely spaced and can therfore suffer from winding ambiguities. By the time the track has reached the dense stack the winding may have changed for high angle tracks. The target PC information may be the most valuable for determining angles even with their limited resolution.

The multiple scattering uncertainties presented to the fitter will be a combination of the radial and azimuthal values. For large angles this may even change between U-V pairs. It is questionable whether a few kinks in the tracker will be sufficient to model these distributions. Likely we will need a kink/plane. This has a clear possibliity to produce an azimuthal dependence to our results.

It is not clear to me whether there is a need for a numerical interpolation scheme to use these results, or whether scattering in the target PC's should be ignored in this calculation.