TRIUMF Experiment E614
Technical Note #4

Monte Carlo Acceptance and Resolution Studies of the E614 Spectrometer

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Abstract

Several design changes have been made to the baseline E614 spectrometer which effect its acceptance and resolution. Monte Carlo studies using mono-energetic positrons have mapped out momentum and angular resolutions for two modified versions of the spectrometer and compared them to the baseline detector. The geometric acceptance for one of the modified versions was also mapped for three values of the solenoidal magnetic field.

As described in the E614 proposal [1] the spectrometer contains 52 drift chamber planes arranged symmetrically in z about a planar aluminum target. X and Y chambers share a common cathode plane and always occur in pairs. On either side of the target each of the first seven pairs is spaced 4.8 cm (common cathode to common cathode) from its nearest neighbor. The remaining six pairs are densly packed. Each chamber pair consists of two cylinders of DME gas each 0.3994 cm thick, separated by a 0.0006 cm thick aluminized mylar foil. Two more 0.0006 cm mylar foils, one upstream and one downstream, separate the DME from helium gaps between chamber pairs. Each DME plane contains 85 sense wires and 86 field wires spaced 0.2 cm from one another. The open radius, the radius inside which there is no material except gas, wires and mylar foils, is 18.0 cm. The solenoidal field in which the spectrometer operates is 2.0 T.

The baseline detector has been modified to include buffer zones between DME gas volumes and helium gaps to prevent leakage of helium into the drift chamber volume and to prevent pressure differentials between DME and helium gases from bowing the cathode planes. For each chamber pair a volume of DME gas 0.1591 cm thick was added to the upstream and downstream sides of the pair. A 0.0006 cm mylar foil was also added to upstream and downstream sides of the pair. Similar buffer zones were added to the upstream and downstream ends of the dense chamber arrays. For reference this detector will be called Mod1. The additional material in the path of the positron will broaden the resolution. Construction techniques for the prototype chambers place an upper limit on the size of the open radius of the spectrometer at 16.9 cm, instead of 18.0 cm. This reduces the number of sense and field wires in the active region from 85 and 86, respectively, to 80 and 81. The geometric acceptance will also be reduced.

Monte Carlo studies of both baseline and Mod1 spectrometers have been done using mono-energetic positrons originating from the aluminum target. The positron origins were

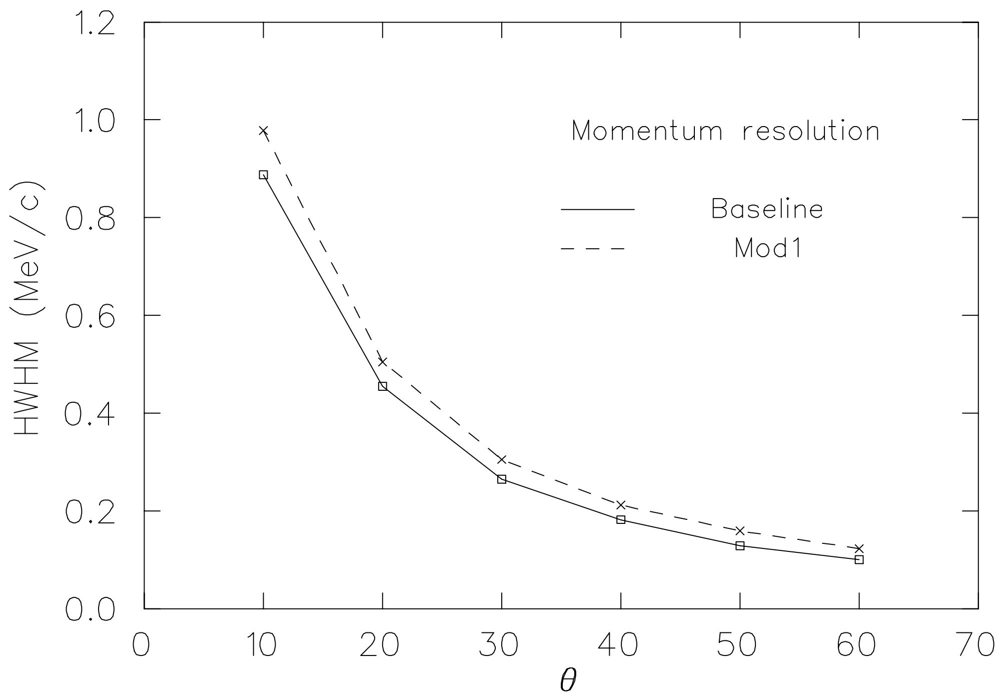

Figure 1: Momentum resolution (HWHM) vs. angle for baseline (solid curve) and Mod1 (dashed curve) spectrometers for 50 MeV/c positrons.

distributed uniformly in z throughout the target, with a gaussian distribution (σ=0.5 cm) in x and y. The initial momentum was fixed at 50 MeV/c in order to study the response near the endpoint of the Michel spectrum. The initial direction was uniform in ϕ and fixed in θ. Follwing the method described in the Appendix of the proposal [1] positrons were tracked through the first four chamber pairs only, with chamber hits taken to be the smeared intersection points of the positron track with the shared foil between X and Y chambers. The smearing was gaussian with $\sigma = 50$ μm. The reconstructed track angle and momentum were compared to the Monte Carlo values of angle and momentum at the entrance to the first chamber pair. Histograms of the difference between Monte Carlo and reconstructed values were fitted using a generalized Breit-Wigner line shape to get the HWHM of the distribution. Figure 1 shows the resulting momentum resolution as a function of positron angle θ for both baseline and Mod1 detectors.

The baseline curve agrees with an earlier study [2] using the baseline design. The larger amount of material in Mod1 causes an average 16% worsening of the momentum resolution over all angles. This contribution to the resolution is small compared, for example, to the roughly 60% effect of increasing the chamber position resolution from 50 to 100 μm.

Angular resolution for both baseline and Mod1 is shown in Figure 2. Here there is a 23% worsening of resolution going from baseline to Mod1. Again the effect of additional material in the spectrometer is small compared the 100% effect of going from 50 to 100 μm position resolution in the drift chambers.

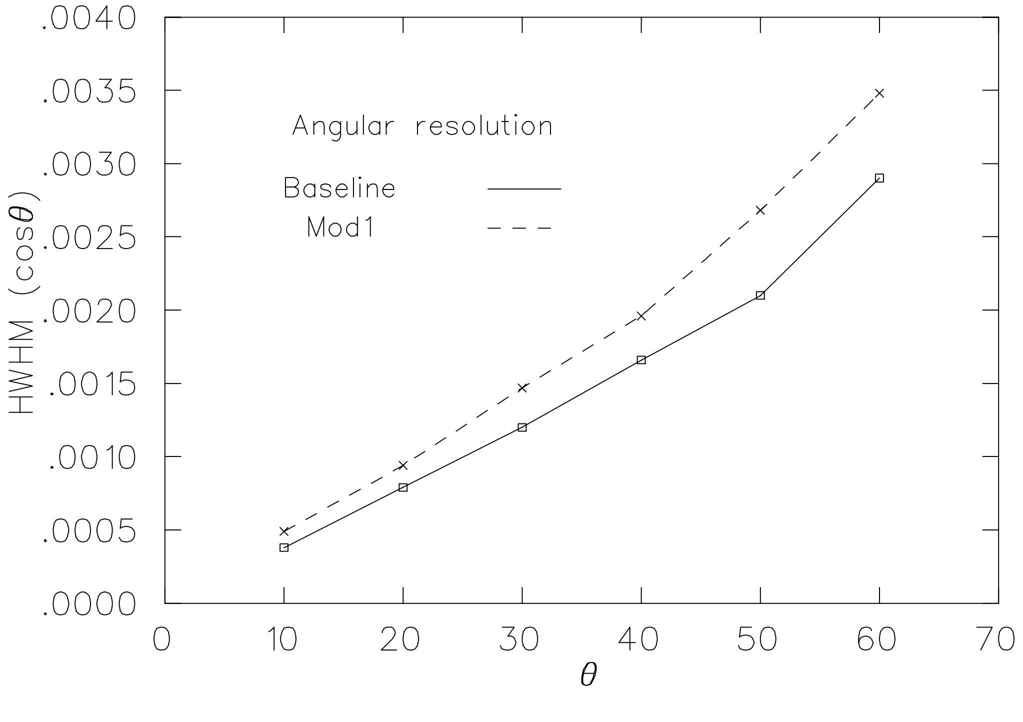

Figure 2: Angular resolution (HWHM) vs. angle for baseline (solid curve) and Mod1 (dashed curve) spectrometers for 50 MeV/c positrons.

The effect of increasing the length of the helium gaps in the Mod1 spectrometer was also studied. The Mod2 spectrometer is identical in geometry to Mod1 except that the common-cathode-to-common-cathode distance between chamber pairs was increased from 4.8 cm to 6.8 cm. The initial particle kinematics were unchanged. The intended effect of the increased distance bewteen chamber pairs was to improve the energy resolution for small angle tracks by allowing a better determination of the helix wavenumber. One drawback of this change is that the dense array of chamber pairs at either end of the spectrometer will no longer be in the region where the magnetic field is homogeneous to 1 part in 10^4. However, the first eight chamber pairs on either side, which are most important for helix reconstruction, will be in this region. Momentum and angular resolutions for both Mod1 and Mod2 spectrometers are compared in Figures 3 and 4, respectively. With longer gaps there is substantial improvement in the momentum resolution, but no appreciable deterioration in the angular resoltuion due to increased multiple scattering in the longer helium gaps.

Also shown in the same figures are the resolutions for the Mod1 detector in which five chamber pairs instead of four were used in the helix reconstruction. This method was intended to improve the resolution without lengthening the spectrometer by including a longer segment of the positron track in the fit. This method did improve the momentum resolution over the 4-chamber-pair fit but not by as much as lengthening the helium gaps. The angular resolution however was worse than either Mod1 or Mod2 in which the 4-chamber-pair fit was used. Although the track length included in the Mod1, 5-pair fit was nearly equal

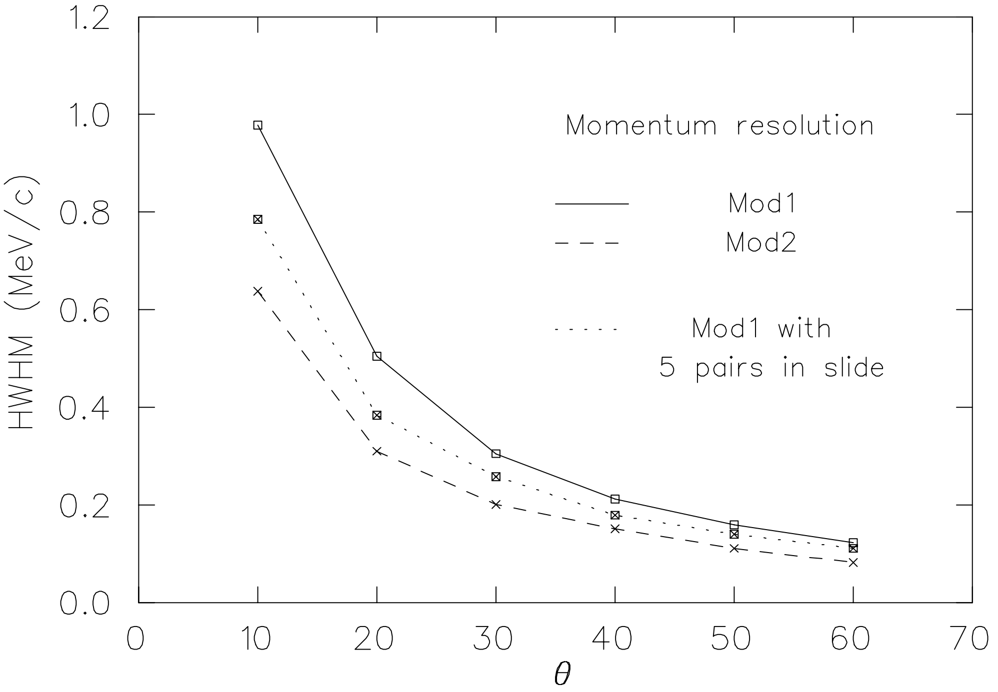

Figure 3: Momentum resolution (HWHM) vs. angle for Mod1 (solid curve) and Mod2 (dashed curve) spectrometers for 50 MeV/c positrons. The result of the 5-pair fitting method using Mod1 is shown by the dotted curve.

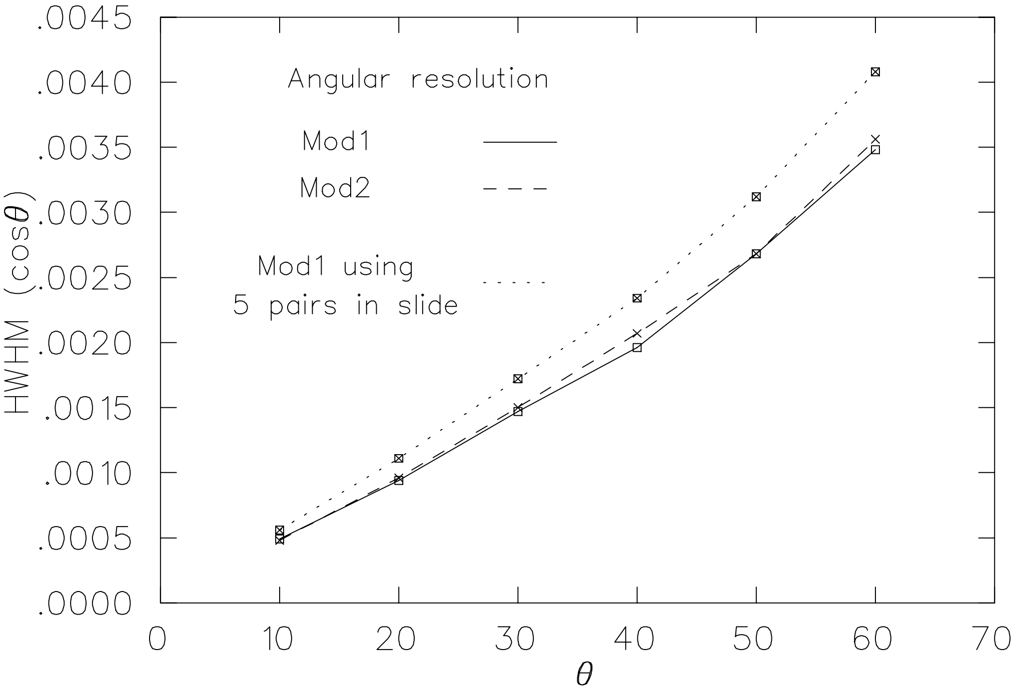

Figure 4: Angular resolution (HWHM) vs. angle for Mod1 (solid curve) and Mod2 (dashed curve) spectrometers for 50 MeV/c positrons. The result of the 5-pair fitting method using Mod1 is shown by the dotted curve.

to that in the Mod2, 4-pair fit, the increased amount of material in the former case causes the resolution to be worse.

Acceptance studies were also performed on the Mod1 spectrometer for three values of the solenoidal magnetic field. In this case the positron origins and direction distributions were the same as above, but the positron momentum was fixed at 52.85 MeV/c. The acceptance was defined as the number of positrons which reach the eighth x-y chamber pair of the spectrometer, divided by the total number of Monte Carlo events thrown from the aluminum target. Any positron which touches the glass frames, spacers or G10 rings before reaching the eighth pair is rejected. At the baseline field of 2.0 T, the acceptance is 100% and uniform up to positron angles of 60^o where it begins a sharp drop-off. This is caused mainly by positrons hitting the G10 rings which support the mylar foils on either side of the DME drift regions. Also, if the beam spot size on the aluminum target were to increase, this drop-off would begin to cut into the acceptance at an even smaller angle. It has been noted [3] that the proposed magnet will be able to deliver up 2.28 T within the accepted current range. At that field the acceptance remains uniform out to 70^o and does not fall off as quickly as in the 2.0 T case. This would provide a safety margin which may be useful should the beam spot be larger than expected.

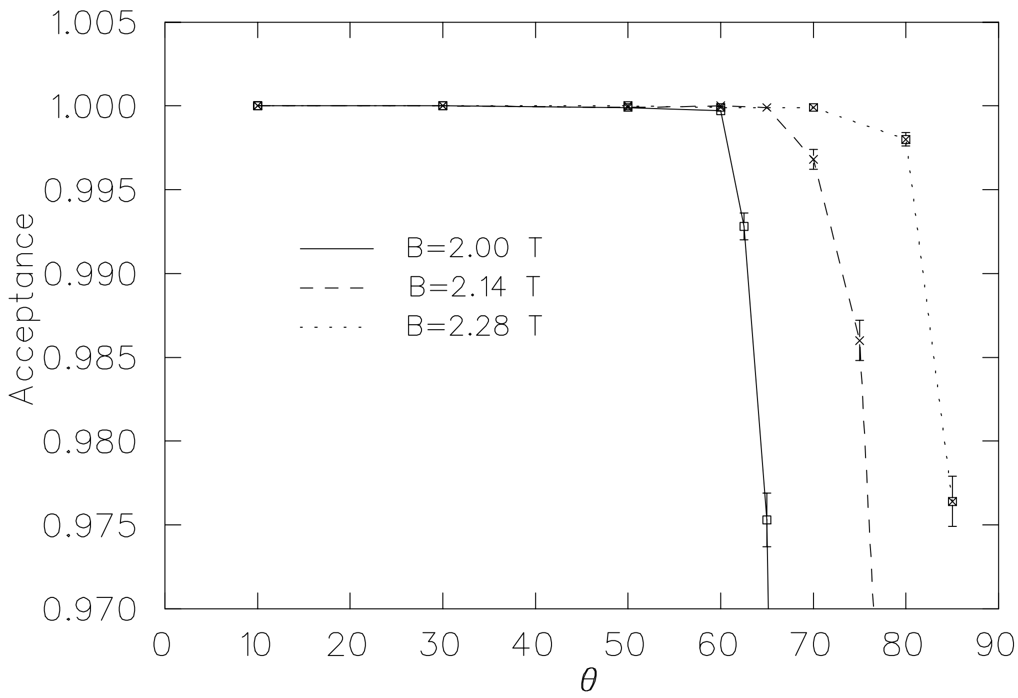

Figure 5: Geometric acceptance of spectrometer vs. angle at 3 values of solenoidal field.

References

[1] E614 collaboration Major Installation Grant proposal (1996).

[2] Y. Lachin in Major Installation Grant proposal (1996).

[3] D. Lobb, presentation at E614 collaboration meeting Jan. 1996.