Target and Start Detector contributions to the Vertex Resolution of the GlueX Detector

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During the GlueX Detector Review questions where raised regarding the need of a start counter. One concern was the effect that the detector material would have on the ultimate vertex resolution of the detector. In order to address these issues a small geant monte-carlo study has been carried out to study the effects of multiple scattering contributions of a liquid hydrogen target surrounded by a start counter of various thicknesses to the resolution with which we can determine the location of the reaction vertex in space.

The geometry shown in figure 1 has been used. The liquid hydrogen target is a cylinder with a radius of 3 cm and has a length of 30 cm. The start counter consists of two parts: a cylindrical part with an outer radius of 6 cm surrounding the target and a conical part at the down stream end where the outer radius of the cone is reduced from 6 cm to 1.5 cm over a distance of 6.4 cm. The scintillator thicknesses studied were 0 mm (corresponding to no detector), 2 mm and 5 mm. In addition the contribution due to the target material has also been studied . Only liquid hydrogen has been used and any other materials such as the cell walls and the vacuum vessel walls have been ignored.

4π events generated with genr8 from the reaction $\eta_1 \rightarrow a_1\pi \rightarrow \pi^+\pi^-\pi^-\pi^+$ have been analyzed. The vertex position of the events has been uniformly distributed over the target length. No transverse photon beam profile has been included. In order to simplify the reconstruction the magnetic field has been turned off.

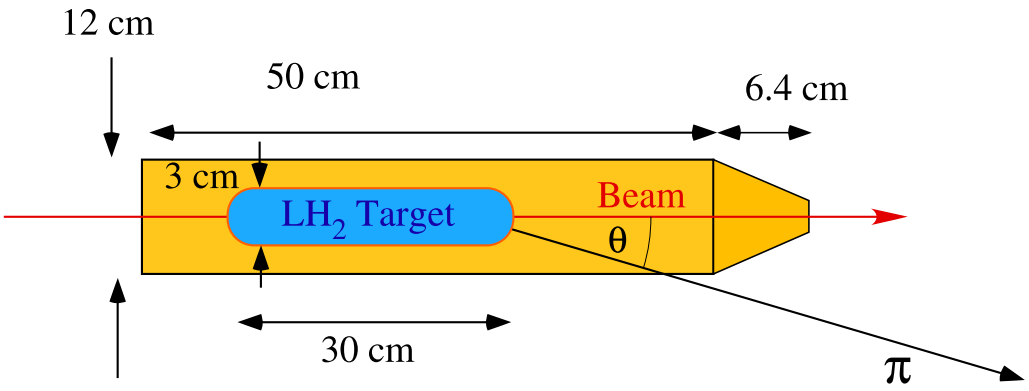

Figure 1: Detector geometry used in the study.

Since tracks that undergo multiple scattering in the surrounding material do not reconstruct to the original interaction vertex, the location has been determined by calculating the points of closest approach along the beam and along the reconstructed track. The width of the distribution of $dz = z_v^r - z_v$ where z_v^r is the reconstructed and z_v is the original vertex location, provides a measure of the vertex resolution. The dependence of the vertex resolution on the angle between the outgoing pion and the beam is shown in figure 2. From figure 2 one can observe that the longitudinal vertex resolution is dominated by contributions from the start counter material (and other materials such as vacuum chamber walls). There is virtually no difference in the vertex resolution with or without hydrogen while the resolution worsens with increasing detector thickness.

In a similar manner the transverse vertex position resolution has been determined. In this case the RMS value of the transverse distance has been determined as a function of the pion angle (see figure 3). The transverse resolution is dominated by the target material while a 5 mm scintillator would add another 20 - 35%.

The multiple scattering angle has been determined by calculating the angle between the original track at the origin and the track after the start counter. Figure 4 shows its RMS value as a function of pion angle for various detector thicknesses.

Again the target contributes typically 50% to multiple scattering. The difference between a 2 mm and a 5 mm start counter thickness contributes the rest.

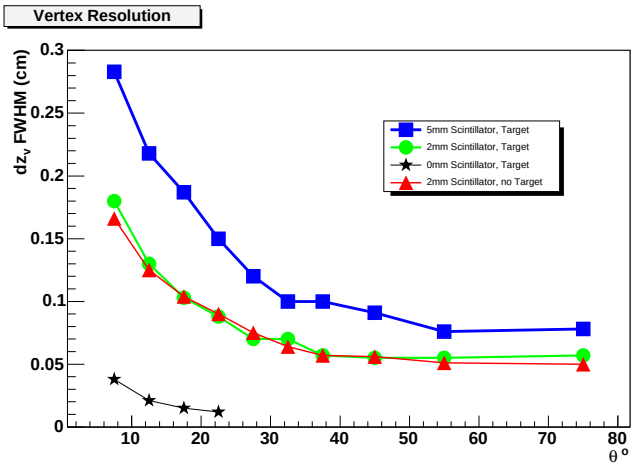

Figure 2: Width (FWHM) of the distribution of the difference between reconstructed(z_v^r) and actual vertex position (z_v).

To summarize, a start counter contributes mainly to the longitudinal vertex resolution while the target material is responsible for the largest fraction of the transverse resolution. The longitudinal resolution improves with increasing pion angle while the transverse resolution and multiple scattering deteriorate. The decrease in the amount of material in the particle's trajectory with increasing angle is compensated by the corresponding decrease of the particle's momenta

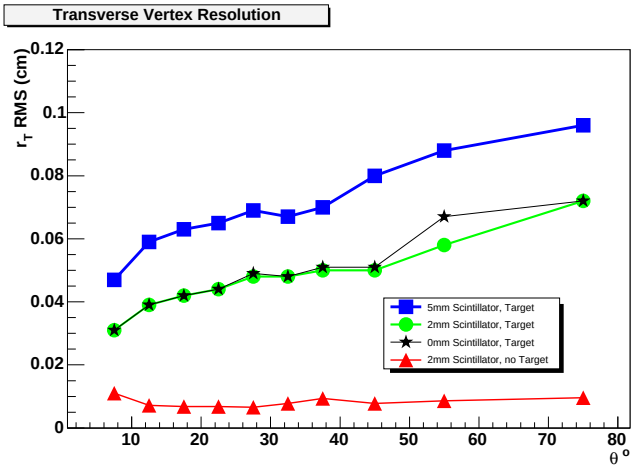

Figure 3: Transverse resolution (RMS value) of the reconstructed vertex.

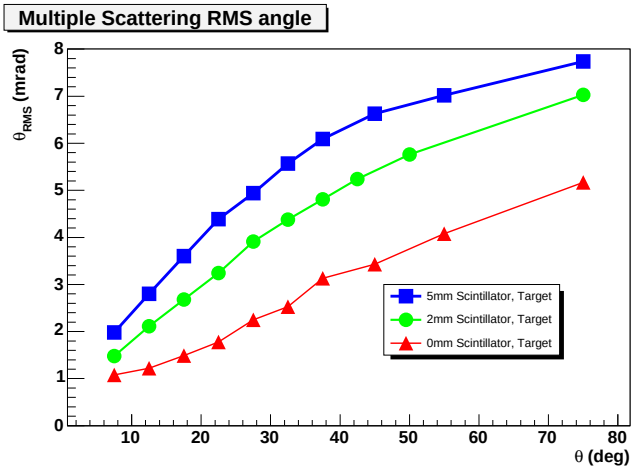

Figure 4: RMS value of the multiple scattering angles between the particle trajectory at the vertex and after passing through the target and the start counter.