- How well are hadronic interactions modeled in the Monte Carlo.

- How well are the dimensions of the detector known.

A number of potentially troublesome systematic errors cancel out if the measurement of the $K^+ \to \pi^+\gamma\gamma$ is normalized to $K_{\mu 2}$ . Most important are the systematic errors due to the kaon beam, how it enters and is recorded by the detector. Also, the systematic errors of whatever acceptance measurements are common to both the $K_{\mu 2}$ and $\pi\gamma\gamma$ decay channels will cancel. This can be seen in the equation used to calculate an upper limit UL.

$$\mathrm{UL} = \frac{2.3}{N_{Kt_{Live}}\ f_s\ A_{\pi\gamma\gamma(1)}} \tag{3.16}$$

$$f_s = \frac{N_{K_{\mu 2}}\ PS_{K_{\mu 2}(1)}}{N_{Kt_{Live}}\ A_{K_{\mu 2}}\ BR_{K_{\mu 2}}} \tag{3.17}$$

Substituting $f_s$ into the equation for UL:

$$\mathrm{UL} = \frac{2.3\ BR_{K_{\mu 2}}}{N_{K_{\mu 2}}} \frac{PS_{\pi\gamma\gamma(1)}\ (N_{Kt_{Live}\ K_{\mu 2}})\ A_{K_{\mu 2}}}{PS_{K_{\mu 2}(1)}\ (N_{Kt_{Live}\ \pi\gamma\gamma(1)})\ A_{\pi\gamma\gamma(1)}} \tag{3.18}$$

The above equation isolates the systematics errors to ones which are unique in the $K_{\mu 2}$ and $\pi\gamma\gamma$ acceptances. Of these acceptance differences, the ones that cause the most concern are those in the range cut of the $\pi\gamma\gamma(1)$ trigger, and in the photon hextant veto. In the case of the range cut, the parameter that can affect the acceptance most severely is the range stack counter thickness. In the case of the hextant veto, variations in the energy threshold could affect the acceptance. These two sources of systematic error are investigated.

### 3.10.1 Range Stack Counter Thickness

The range stack counter thickness was designed to be 3/4" thick. This translates to 1.905 cm. Since the $\pi^+$ is forced to go through many range stack counters in order to fire the $\pi\gamma\gamma(1)$ trigger, a small uncertainty in the the range stack counter thickness is amplified by the number of range stack counters the meson must traverse. Also, since the range stack counters are fabricated from the same mold, the error in the thickness of the counter tends to be common to each counter. Compounding this problem is the fact that the $\pi\gamma\gamma(1)$ trigger is very restrictive kinematically, in that the

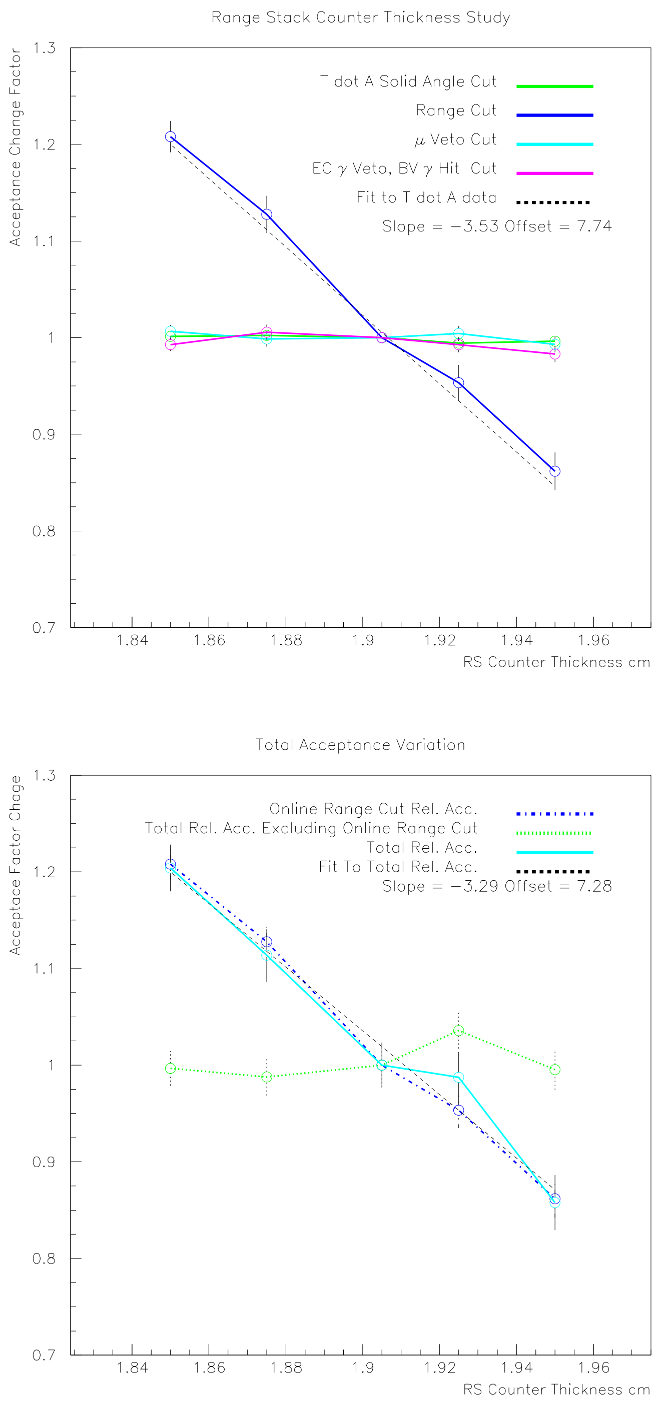


Figure 3.23: Range Stack Counter Thickness Acceptance Study.

$\pi^+$ meson must stop close to the edge of the target and have a small dip angle in order for it to reach the stopping layers of the this trigger. A small change in the range that the pion must traverse will greatly affect is chances of making the trigger. Therefore a study was undertaken to examine the variation in the $\pi\gamma\gamma(1)$ trigger acceptance as a function of the range stack counter thickness. The results, plotted in Figure 3.23,[15] show that an uncertainly in the range stack counter thickness of 2.3% (1.905 cm $\rightarrow$ 1.950 cm) causes a variation in the acceptance of 14%. There is evidence from studies comparing the stopping distribution of pions and muons from UMC $K_{\pi 2}$ and $K_{\mu 2}$ decays with those of data, that a range stack counter thickness of 1.950 cm may be favored. Therefore a systematic error of 14% will be assigned to the online range cut.

### 3.10.2 Hextant Veto Energy Threshold

There are two aspects of the hextant veto which may significantly affect the acceptance. First of all, the acceptance was measured using $K_{\pi 2}$ decays. One needs to know whether the photons emanating from the $K_{\pi 2}$ decay are similar enough to those emanating from a $\pi\gamma\gamma$ decay that one can use the former to measure the photon hextant veto acceptance. The second question is how well the energy threshold of the hextant veto is known. Unlike the end cap veto energy threshold which is readily measured in data, the current analysis software makes measuring the hextant veto energy threshold very difficult. The best one can do from the data is to count how many orthogonally selected $K_{\pi 2}$ events pass the hextant veto cut and postulate that the difference in acceptance between the $K_{\pi 2}$ and $\pi\gamma\gamma$ decays is negligible.

To check this assumption, UMC samples of $K_{\pi 2}$ and $\pi\gamma\gamma$ decays were generated. The energy threshold for the hextant photon veto was set to 10 MeV in both UMC jobs. The $K_{\pi 2}$ UMC job gave a photon veto acceptance of .349 $\pm$ .006. This is to be compared to the $\pi\gamma\gamma$ UMC job which reported an acceptance of .334 $\pm$ .003. The fractional difference between the two is 4%. One can then assume a 4% systematic error due to the fact that the hextant veto acceptance was measured with $K_{\pi 2}$ decays rather than $\pi\gamma\gamma$ decays.

Next, the variation in the total acceptance as a function of the hextant

[15] The top graph plots the acceptance as a function of range stack counter thickness for the individual components of the $\pi\gamma\gamma(1)$ trigger. The bottom graph plots the the range acceptance, which is affected the most by the range stack counter thickness, the total $\pi\gamma\gamma$ acceptance excluding the range cut and the combination of the two.