

Problem with past $K_{\pi 2\gamma}$ background assessment

Next page shows the UMC charged pion kinetic energy spectrum from $K_{\pi 2\gamma}$ decay in Jean Roy and Bipul Bhuyan's theses.

Jean Roy claimed to use a matrix element with internal bremsstrahlung (I_B) and direct emission (DE) components (and interference).

Bipul claimed to use a matrix element with IB only. Wang Zhe has been using a similar spectrum for his recent studies.

My conclusion is that Bipul used the DE matrix element only. Based on a quick reading of Jean's thesis, I conclude that Bipul underestimated the $K_{\pi 2\gamma}$ background, but the estimate is off by less than a factor of 2. If his $K_{\pi 2\gamma}$ background estimate were doubled ($2 \times (0.006 \pm 0.002)$), it is still not significant compared to $K_{\pi 2}$ -scatters (0.39 ± 0.15). Rates are for 1997 2/3 sample from Table 3.30 of the thesis.

I advised Wang Zhe to use the IB (or IB + DE) matrix element.

In order to normalize the number of $K_{\pi 2\gamma}$ events to the number of $K_{\pi 2}$ peak events, it is necessary to know the branching ratio for each decay. The branching ratio for $K_{\pi 2\gamma}$ is a function of the region of phase space considered. In fact, most of the $K_{\pi 2\gamma}$ branching fraction for very low photon energy is included in the $K_{\pi 2}$ branching fraction. Experimental measurements of the $K_{\pi 2\gamma}$ branching ratio have been made using the region of π^+ kinetic energy between 55 and 90 MeV [64, 65], significantly below the $K_{\pi 2}$ peak energy of 108.5 MeV. Figure 4.71 shows the π^+ energy spectrum for 10^5 decays generated with a Monte Carlo program. The correct matrix element, including a direct emission contribution, was used to weigh the events generated. A cutoff on the π^+ kinetic energy was placed at 106 MeV. The ratio of the integral of the spectrum in figure 4.71 for the ranges 55–90 MeV and 0–106 MeV gave the correction factor for the effective $K_{\pi 2\gamma}$ branching ratio for the full energy range up to the cutoff :

$$\text{BR}(K_{\pi 2\gamma}) = \frac{\int_0^{106} dN}{\int_{55}^{90} dN} \times (2.93 \pm 0.16) \times 10^{-4} = (1.11 \pm 0.06) \times 10^{-3} \quad (4.58)$$

where the sum of the accepted values for the inner bremsstrahlung and the direct emission parts of the branching ratio in the energy region 55–90 MeV has been used [17].

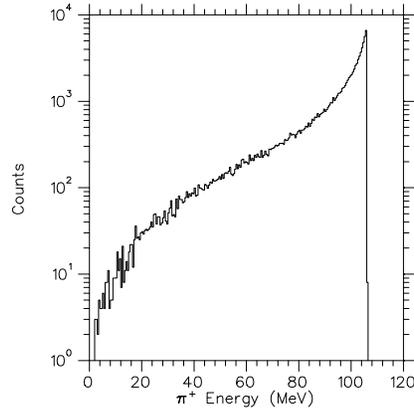


Figure 4.71: Kinetic energy spectrum of π^+ from $K_{\pi 2\gamma}$ decays simulated by Monte Carlo. A total of 10^5 decays were generated.

$K_{\pi 2}$ and $K_{\pi 2\gamma}$ events were generated with the Monte Carlo program. The photon veto

Jean's thesis

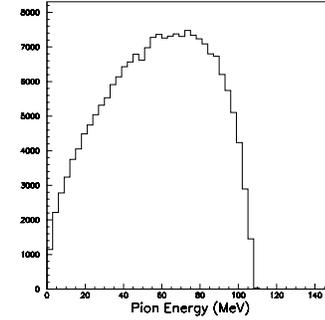


Figure 3.9: Pion energy spectrum from $K_{\pi 2\gamma}$ decay simulated by Monte Carlo.

3.5.3 Radiative $K_{\pi 2}$ Background

The background due to radiative $K_{\pi 2}$ ($K^+ \rightarrow \pi^+ \pi^0 \gamma$) decay is expected to be small as compared to the $K_{\pi 2}$ -scatter background in the PNN2 analysis because of the presence of the extra photon and the small branching ratio. For the $K^+ \rightarrow \pi^+ \pi^0 \gamma$ decay, the γ can be emitted by a direct emission (DE) process with a branching ratio of $(4.7 \pm 0.9) \times 10^{-6}$. However, the dominant source of γ emission is due to inner bremsstrahlung (IB) with a branching ratio of $(2.75 \pm 0.15) \times 10^{-4}$ in the π^+ kinematic region of 55 MeV to 90 MeV. Since it is difficult to separate this background sample from the $K_{\pi 2}$ -scatter background sample, both Monte Carlo and data were used to measure this background. This method consisted of determining the expected number of $K_{\pi 2\gamma}$ events in the $K^+ \rightarrow \pi^+ \nu \bar{\nu}$ kinematic search region as a function of the number of $K_{\pi 2}$ peak events observed outside the search region. In order to normalize the number of $K_{\pi 2\gamma}$ events to the number of $K_{\pi 2}$ peak events, it is necessary to know the branching ratio for each decay. The branching ratio for $K_{\pi 2\gamma}$ is a function of phase space and for very low energy photons, the $K_{\pi 2\gamma}$ branching ratio is included in the $K_{\pi 2}$ branching ratio.

To study the radiative $K_{\pi 2}$ background, about 10^5 Monte Carlo events were generated for this decay without taking into account the direct emission process. Figure 3.9 shows the pion energy distribution from the $K_{\pi 2\gamma}$ decay. The ratio of the integral of the pion energy spectrum in Figure 3.9 for the ranges 55 - 90 MeV and 0 - 106 MeV gives the correction factor for the effective $K_{\pi 2\gamma}$ branching ratio for the full pion energy spectrum. This effective $K_{\pi 2\gamma}$ branching ratio for the full pion energy spectrum can be calculated as:

Bipul's thesis