π⁰ Analysis Update
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November 21, 2018

1 Time Coincidence

Accidental events are to be subtracted from the main coincidence window [-3,3]. Unlike DVCS analysis where an accidental π⁰ subtraction is needed, here an accidental photon subtraction is to be made. The windows selected for this subtractions contain pure randoms that are in [-11,-5], and [5,11], and combinations of [-11,-5], [5,11] and [-3,3] windows to fully subtract the accidentals. Figure 1 shows the distribution of arrival times of the two photons resulting from π⁰ decay.

Figure 1: Arrival time distribution of γ₁ and γ₂ from π⁰ → γ₁γ₂ in kinematic 48_4. The window in the center [-3,3] contains true coincidences plus accidentals.

\[ N_{acc1} = +[-11,-5]\&[5,11] \]

\[ N_{acc2} = [-11,-5]\&[-3,3]_{acc2} + [-11,-5]\&[5,11]_{acc3} \]
The subtraction of photons from the true coincidences in windows [-3,3] is done by using Equation 4.

\[ N_{acc1} + N_{acc2} = [-11, -5]_{acc1} + [-11, -5] \& [-3,3]_{acc2} + 2 \times [-11, -5] \& [5,11]_{acc3} \]  
\[ N_{\pi^0}\text{accidentals} = N_{acc1} + N_{acc2} - N_{acc3} \]  

\[ N_{acc1} \text{ selects two-photon events in the window [-11,-5]. } N_{acc2} \text{ selects events with one photon in [-3,3] and one in [-11,-5]. } N_{acc3} \text{ selects random photon events occurring in windows [-11,-5] and [5,11]. } N_{acc3} \text{ is present in the relevant windows mentioned above, hence why the factor of 2 is included in Equation 3 and is implied in Equation 4.} \]

2 \( M_x^2 \) and \( M_{\pi^0} \) Comparison

2.1 \( M_x^2 \) and \( M_{\pi^0} \) After Accidental Subtraction

Figure 2 shows the missing mass squared after accidental subtraction.

2.2 Comparison to Mongi’s analysis for kinematic 36_1

Comparing background subtraction of kinematic 36_1 with Mongi’s analysis.

3 GEANT4 Simulation vs. DVCS3 Data

Figures 6 and 7 show the \( M_x^2 \) of the Geant4 \( \pi^0 \) simulation compared with the experimental data for kinematic settings 48_1 and 48_4, before smearing.

The goal is to smear the four vector energy of both photons hitting calorimeter after the \( \pi^0 \) decay. This relationship from the Monte Carlo simulation is best demonstrated by the transformation using the smearing coefficient, \( \sigma \) and calibration coefficient, \( \mu \) also shown by Equation 5 for the "first" photon and 6 for the "second".

\[
\begin{bmatrix} q_x \\ q_y \\ q_z \\ E_1 \end{bmatrix} = \text{gaus}(\mu, \sigma) \times \begin{bmatrix} q_x \\ q_y \\ q_z \\ E_1 \end{bmatrix}
\]  
\[ q_{x2} \\ q_{y2} \\ q_{z2} \\ E_2 \]  
\[
\begin{bmatrix} q_x \\ q_y \\ q_z \\ E_1 \end{bmatrix} = \text{gaus}(\mu, \sigma) \times \begin{bmatrix} q_x \\ q_y \\ q_z \\ E_1 \end{bmatrix}
\]
Figure 2: $M_x^2$ and $M_{x\pi^0}$ before and after accidental subtraction for kinematic 48_4.

3.1 $\pi^0$ Simulation on github

Mongi’s $\pi^0$ Geant4 simulation adopted from Maxime and Rafayel\footnote{Link to "Implementation of the Hall A DVCS Calorimeter in Geant4": https://userweb.jlab.org/~rafopar/HallA/Calo/Calo_Geant4.ps} with some additional optimization has been uploaded to github. The same instructions of how to run DVCS simulation (from Bill) apply. Go to https://github.com/JeffersonLab/HallADVCS/tree/master/geant4_simulation/pi0sim to use (pull request has been made).
Figure 3: $M_x^2$ and $M_{\pi^0}$ before and after accidental subtraction for kinematic 48_4.
Figure 4: $(M_x)^2$ and $M_{\pi^0}$ shown for kinematic 36_1 (my analysis).

Figure 5: $(M_x)^2$ and $M_{\pi^0}$ shown for kinematic 36_1 (Mongi).
Figure 6: $M_\pi^2$ and $M_{\pi^0}$ of the simulation vs. experimental data for kin48.4, before smearing.
Figure 7: $M^2_{\pi}$ and $M_{\pi^0}$ the simulation vs. experimental data for kin 48_1 before smearing.