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Efficiency study on the cross section measurement of $e^+e^- \to \pi^+\pi^-\pi^0$ through the radiative return method at Belle II

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This document presents plots of efficiency study for the cross section measurement of $e^+e^- \to \pi^+\pi^-\pi^0$. This analysis uses 190 fb^{-1} of data taken from 2018 until summer 2021. The only 10% of data is used in the plot. The Monte Carlo sample used in the plot is officially produced run-independent sample, MC14ri. Events in plots are applied a signal selection to extract $e^+e^- \to \pi^+\pi^-\pi^0\gamma$ candidates. Two tracks and three gammas are selected with particle identification, π^0 selection, a quality cut of four-vector constraint kinematic fit, and some background subtraction cuts.

Figure 1 shows the trigger efficiency with bhabha veto. The bhabha veto was not turned on during experiment experiment 7–17, from 2018 until spring 2021, and the loss of bhabha veto can be evaluated using trigger information for monitoring. This plot includes events that are triggered and events that are lost by the bhabha veto. The trigger efficiency depends on the proportion of events that are not lost by the bhabha veto, as shown in bottom plot. The remaining 89 fb^{-1} of data was collected in experiment 18, where the bhabha veto was introduced. This bhabha veto inefficiency is used to correct the data in experiment 18. The efficiency are evaluated in a data-driven way as there is a large uncertainty in a trigger simulations. Hence, the plots do not compare with MC, but they agree within the error. Signal events are triggered by ECL trigger with an efficiency of more than 99.5% using the high energy initial-state radiation photons in the final state. The effect of the bhabha-veto inefficiency uncertainty on the $\pi^+\pi^-\pi^0$ contribution to muon $g-2$ hadron vacuum polarization term is estimated to be 0.5% or less.

Figure 2 shows the signal efficney dependence on the generated Invariant mass of $\pi^+\pi^-\pi^0$ using $e^-e^- \to \pi^+\pi^-\pi^0\gamma$ MC generated by PHOKHARA. The generated event, denominator, is required to have the invariant mass of $\pi^+\pi^-\pi^0$ is more than 8 GeV and a ISR photon whose energy is more than two GeV and the polar angle is within 20 to 160 degree in the centre-of-mass frame. The red line shows the result of fitting with a quadratic function to the range of $0.75 < M(\pi^+\pi^-\pi^0) < 3.5\,\mathrm{GeV}$.

Figure 3 shows the signal efficney in dependence on the generated Invariant mass of $\pi^+\pi^-\pi^0$ using $e^-e^- \to \pi^+\pi^-\pi^0\gamma$ MC generated by PHOKHARA. For $\pi^+\pi^-\pi^0$ sample, signal and π^0-combinatorial background, Fake-π^0 $\pi^+\pi^-\pi^0$, are distinguished using MC matching. The π^0-combinatorial $\pi^+\pi^-\pi^0$ means the π^0 is reconstructed from incorrect ECL cluster.

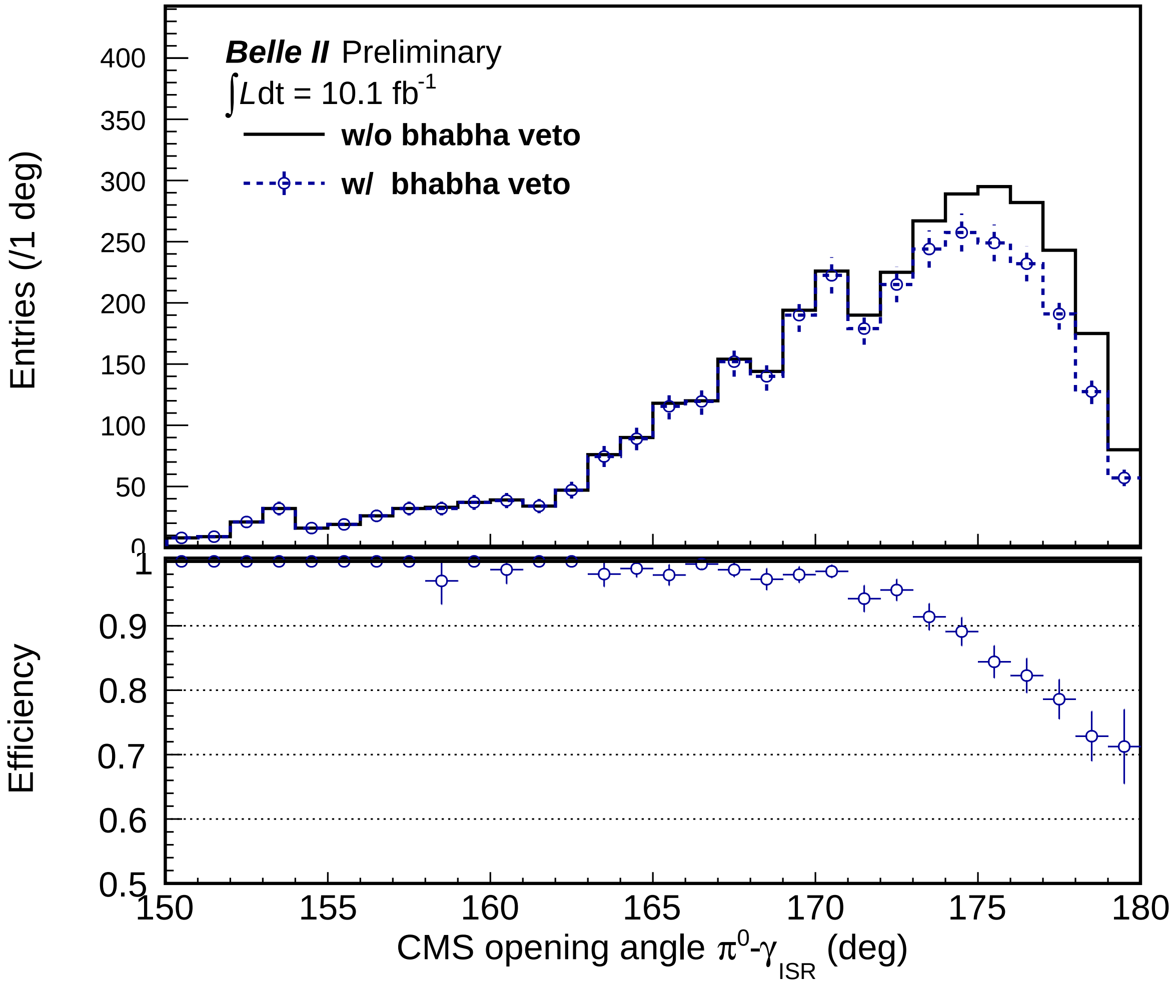

FIG. 1. Trigger efficiency in dependence on the opening angle of π^0 and ISR photon in the CM frame. The solid line shows the number of signal events passing the selection. The circle with error bar shows the events when bhabha veto is turned on. The top plot shows the distribution of observed events, and the bottom plot shows the efficiency after introducing the bhabha veto.

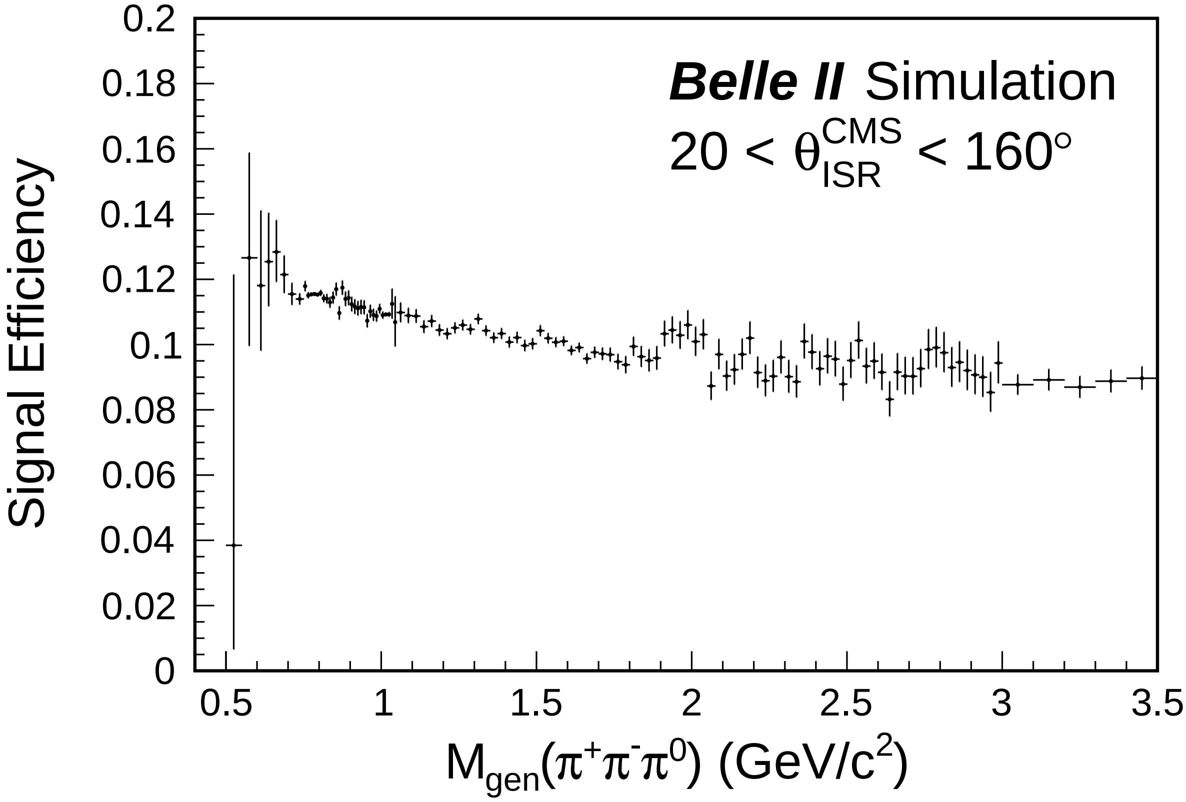

FIG. 2. Detection efficiency in dependence on the generated invariant mass of $\pi^+\pi^-\pi^0$ using $e^-e^- \to \pi^+\pi^-\pi^0\gamma$ MC.

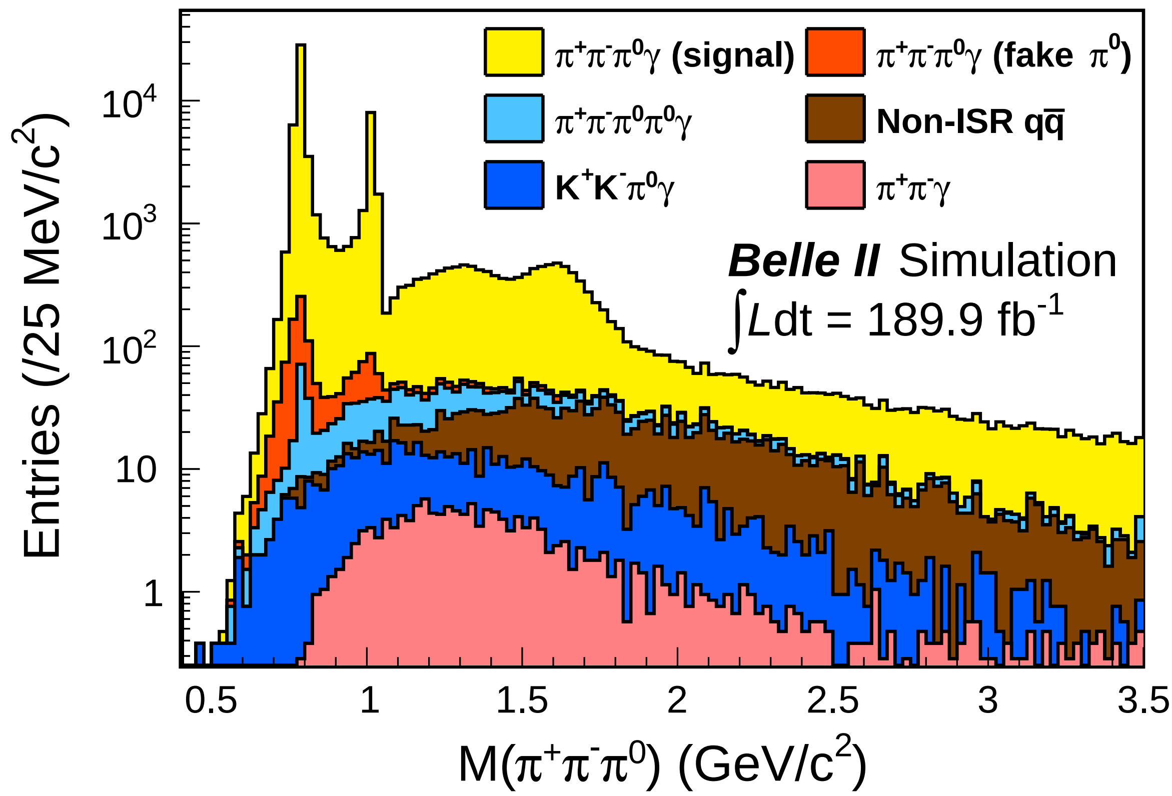

FIG. 3. Expected number of events in dependence on the invariant mass of $\pi^+\pi^-\pi^0$ after event selection. The statistics is scaled to be 189.88 fb^{-1}. The colored stack histogram shows the background components. The trigger efficiency is not taken into account.