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Kaon and Pion Identification Performances in Phase III data

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Abstract

We study the performances of the charged kaon and pion identification based on 2.62 fb^{-1} Phase III data from the physics runs (Experiment#7 and 8) during summer 2019 and compare with Phase III Monte Carlo events. The efficiency and the mis-ID rates of kaon and pion identification are calculated using $D^{*+} \to D^0[K^-\pi^+]\pi^+$ decays for the binary PID criteria. The study is performed in several momentum, polar angle bins.

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1. DEFINITIONS

Information from each PID system (CDC, TOP, ARICH, ECL, KLM) is analysed independently to determine a likelihood for each charged particle hypothesis. These likelihoods may then be used to construct a combined likelihood ratio. Here in the plots presented, we study the binary likelihood ratio (from all the subdetectors) defined as :

$$\mathcal{R}_{K/\pi} = \frac{\mathcal{L}_K}{\mathcal{L}_K + \mathcal{L}_\pi} \tag{1}$$

We report the PID performance of the charged kaon and pion separation using $D^{*+} \rightarrow D^0[K^-\pi^+]\pi^+$ decays (charge conjugated mode is always included). Slow pions can be used to tag D^0, which is finally used to identify the kaons and pions. So, with this information K/π PID efficiency and mis-ID rate can be studied in data. The acceptance regions of CDC, TOP and ARICH in polar angle ($\cos\theta$) are $[-0.87, 0.96]$, $[-0.48, 0.82]$, and $[0.87, 0.97]$, respectively.

The kaon identification efficiency ϵ_K (ϵ_π) is defined as:

$$\epsilon_K(\epsilon_\pi) = \frac{\text{number of kaon (pion) tracks identified as kaon (pion)}}{\text{number of kaon (pion) tracks}} \tag{2}$$

while the pion mis-identification rate (mis-ID rate) is defined as:

$$\pi \text{ mis-ID rate} = \frac{\text{number of pion tracks identified as kaon}}{\text{number of pion tracks}} \tag{3}$$

2. DATA-SET

In this study, we use the data set ($2.62\ \text{fb}^{-1}$) of `proc9` re-processing of `exp 7 runs [909 - 4120]` and `exp 8 runs [43 - 1022]` and `runs [1036 - 1554]`. The results are also compared with the official MC (12th campaign) generic sample (`mixed, charged, uubar, ddbar, ssbar, ccbar` and `taupair`) which are generated using early (single-layered PXD) Phase III geometry with nominal machine background. We call this MC sample as 'ideal MC' as this simulation does not incorporate random triggered background events (to account for realistic machine background) as well as actual detector conditions during data taking.

3. BINARY LIKELIHOOD RATIOS

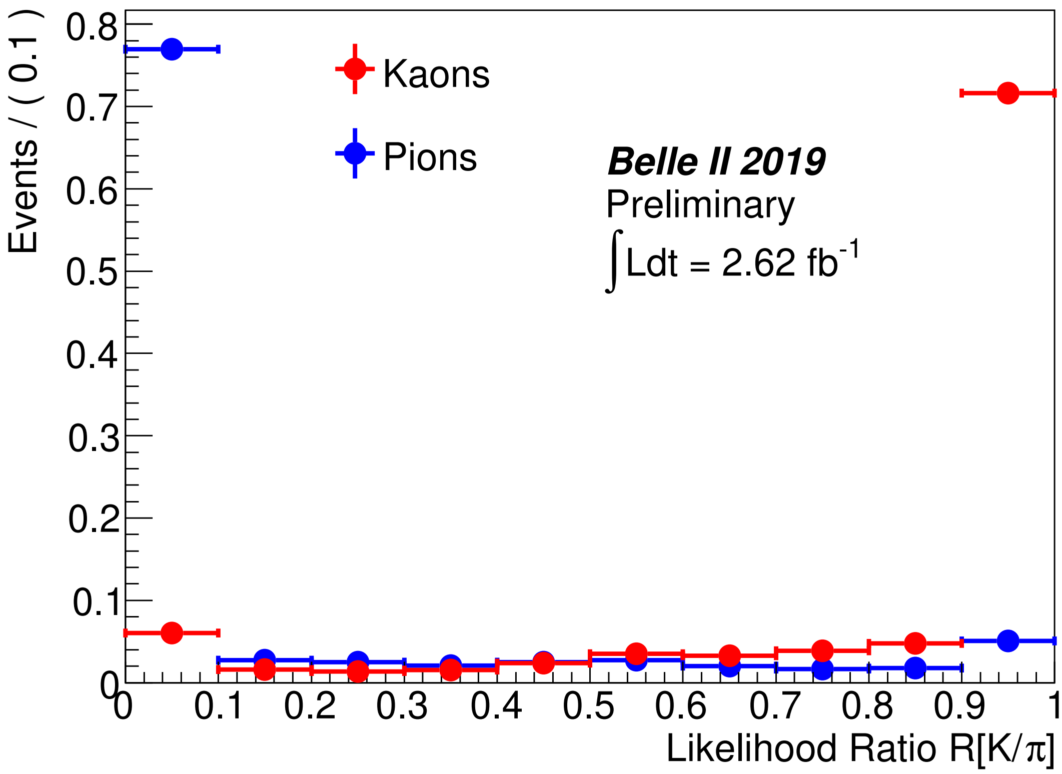

FIG. 1: $\mathcal{R}_{K/\pi}$ distribution. K and π tracks are tagged from the charge of the slow π (daughter of D^{*+}) in the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$.

4. K-EFFICIENCIES AND π-MIS-ID RATES

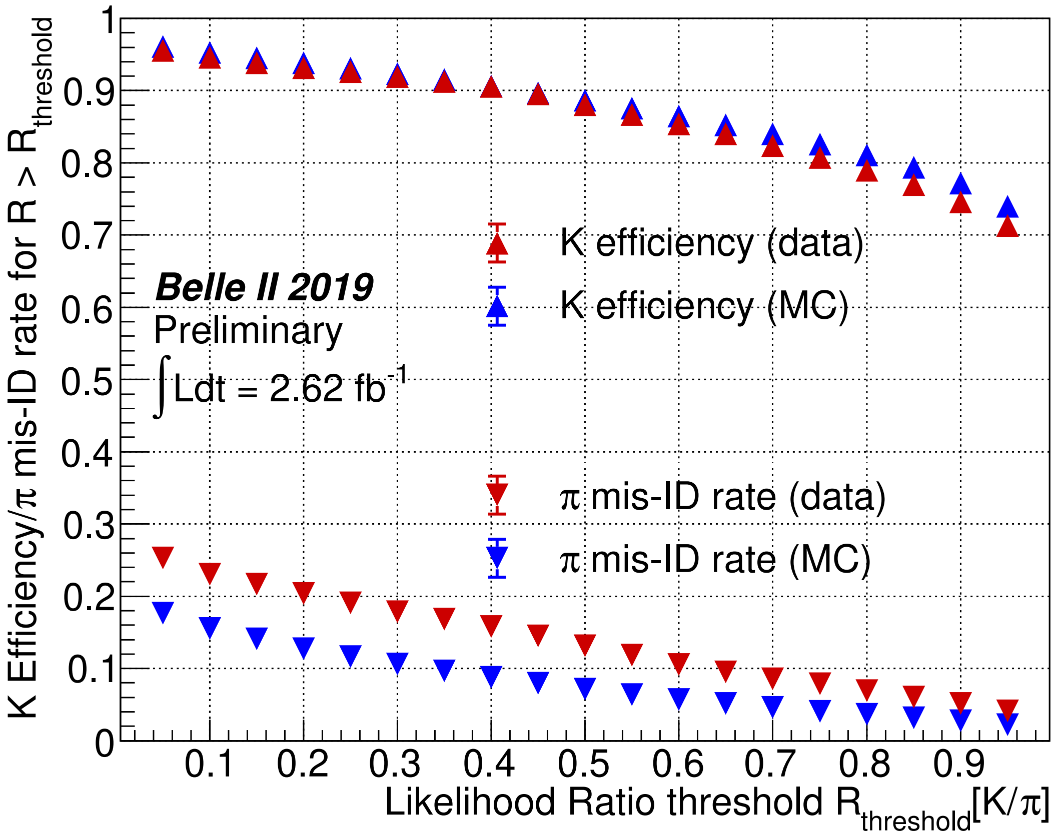

FIG. 2: K-efficiencies and π-mis-ID rates are calculated for different PID criteria using the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$.

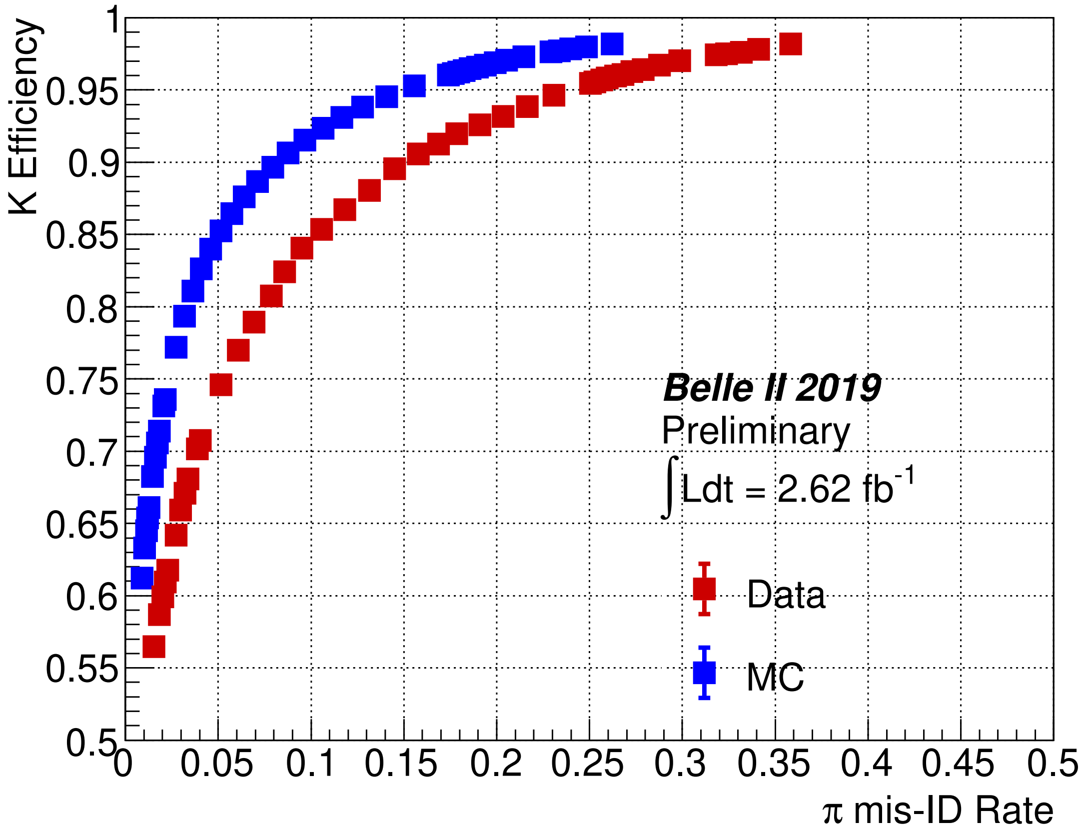

FIG. 3: K-efficiencies *vs.* π-mis-ID rates for different PID criteria using the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$.

5. K-EFFICIENCY AND π-MIS-ID RATE IN MOMENTUM/POLAR ANGLE BINS

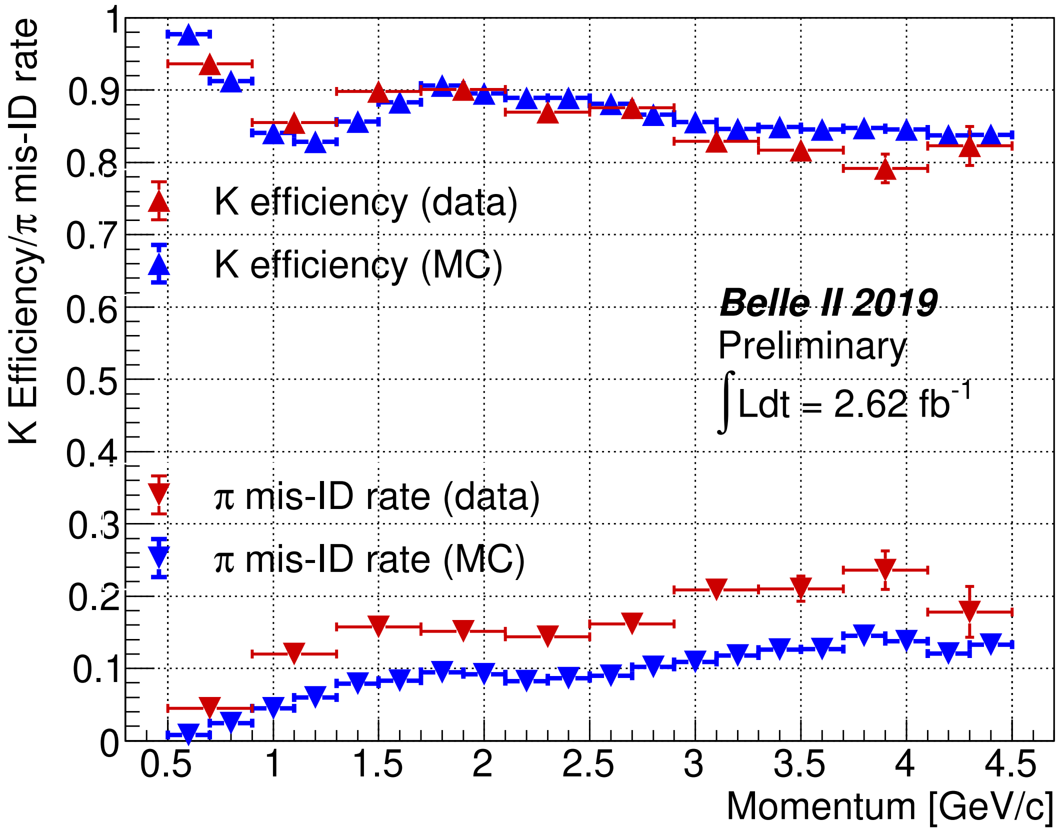

FIG. 4: Kaon efficiency and pion mis-ID rate for the PID criterion $\mathcal{R}_{K/\pi} > 0.5$ using the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$ in the bins of laboratory frame momentum of the tracks.

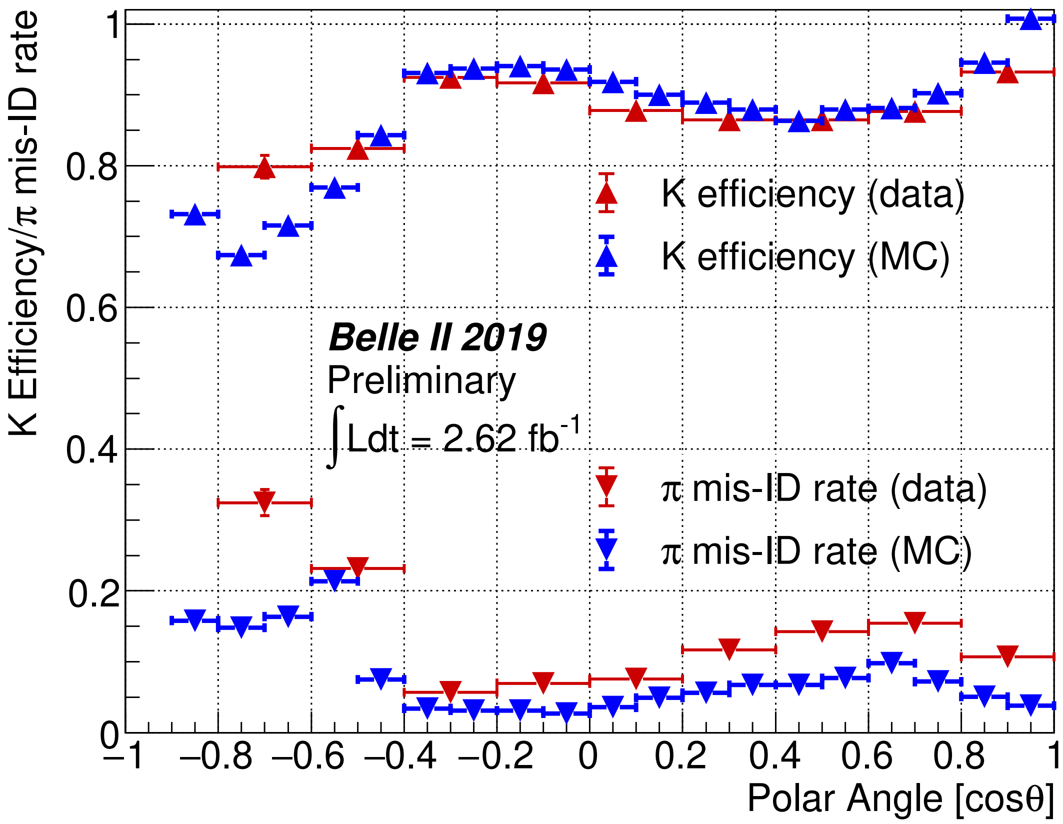

FIG. 5: Kaon efficiency and pion mis-ID rate for the PID criterion $\mathcal{R}_{K/\pi} > 0.5$ using the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$ in the bins of polar angle (laboratory frame) of the tracks. Note that the acceptance regions of CDC, TOP and ARICH in polar angle ($\cos\theta$) are $[-0.87, 0.96]$, $[-0.48, 0.82]$, and $[0.87, 0.97]$, respectively.

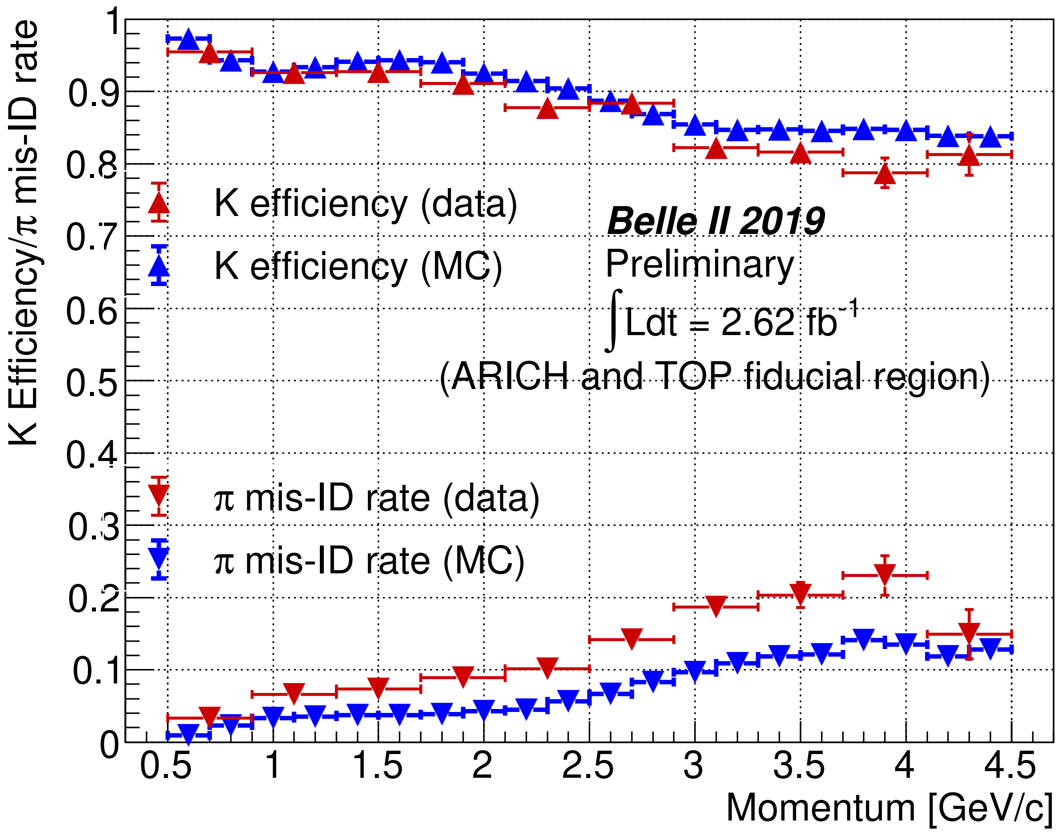

FIG. 6: Kaon efficiency and pion mis-ID rate for the PID criterion $\mathcal{R}_{K/\pi} > 0.5$ using the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$ in the bins of laboratory frame momentum of the tracks which produces atleast produce hit in ARICH or TOP detector.

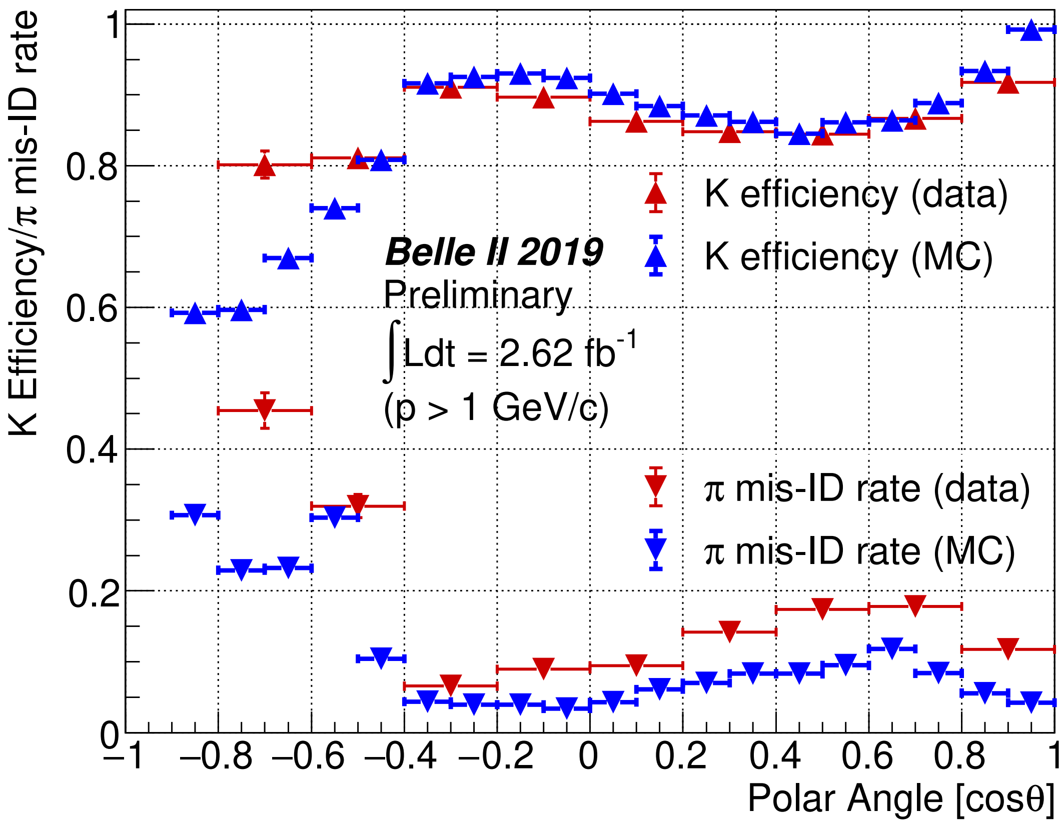

FIG. 7: Kaon efficiency and pion mis-ID rate for the PID criterion $\mathcal{R}_{K/\pi} > 0.5$ using the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$ in the bins of polar angle (laboratory frame) of the tracks which have laboratory frame momentum greater than 1 GeV/c. Note that the acceptance regions of CDC, TOP and ARICH in polar angle ($\cos\theta$) are $[-0.87, 0.96]$, $[-0.48, 0.82]$, and $[0.87, 0.97]$, respectively.