BELLE2-NOTE-PL-2020-024
for ICHEP 2020
July 29, 2020

Kaon and Pion Identification Performance in Phase III data

Belle II Collaboration

Abstract

We study the performances of the charged kaon and pion identification based on 37.0 fb^{-1} Phase III data from the physics runs collected in 2019 and early 2020 and compared with Phase III Monte Carlo (MC) events. The efficiency and the mis-identification (mis-ID) rates of kaons and pions are measured using $D^{*+} \to D^0[K^-\pi^+]\pi^+$ decays for the binary particle identification criteria. The study is performed in several laboratory frame momentum, polar angle bins.

1. DEFINITIONS

Information from Belle II detector subsystems are 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 the flavour of the D^0, which is finally used to identify the kaons and pions. 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 $[0.83, 0.97]$, 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 37.0 fb^{-1} data set (34.6 fb^{-1} recorded at the $\Upsilon(4S)$ resonance and 2.4 fb^{-1} recorded at 60 MeV below the $\Upsilon(4S)$ resonance) from the Physics runs collected in 2019 and early 2020. The results are also compared with the official MC (13th campaign) generic sample which are generated using early (single-layered PXD) Phase III geometry with nominal machine background. The MC sample used here does not incorporate run-dependent random triggered background events (to account for realistic machine background) as well as actual detector conditions during the data taking.

3. BINARY LIKELIHOOD RATIOS

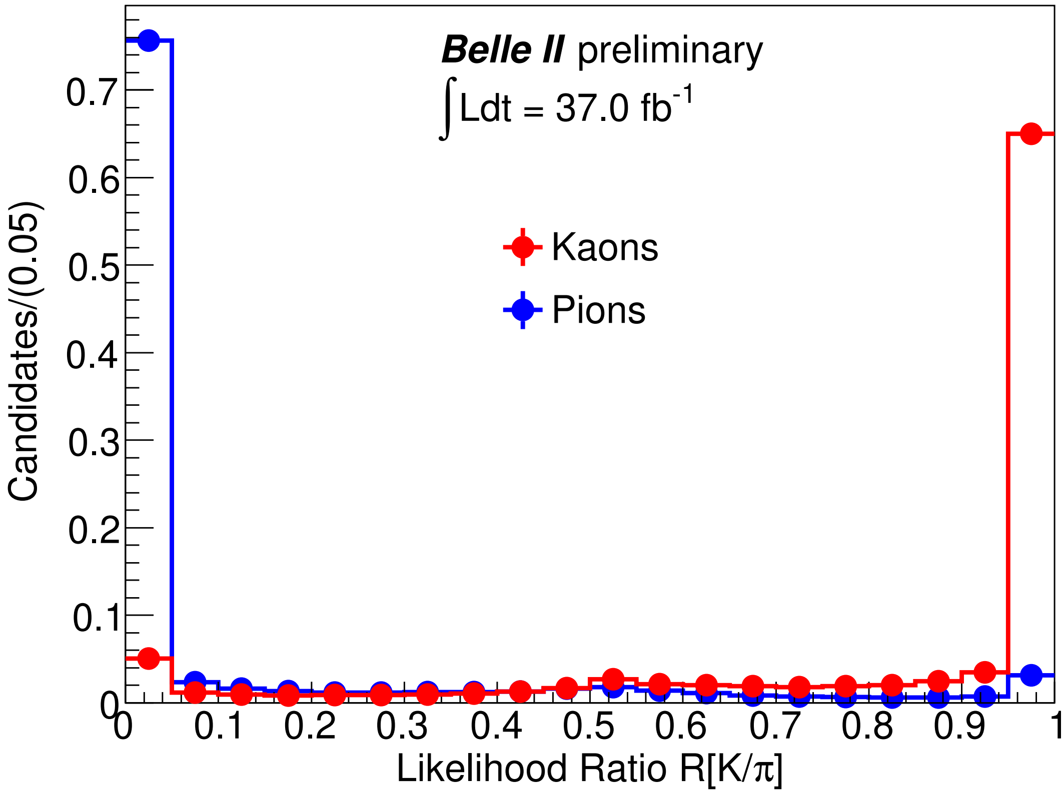

FIG. 1: The distribution for binary PID likelihood ratio ($\mathcal{R}_{K/\pi}$),obtained for signal kaons and pions using ${}_s\mathcal{P}lot$ technique in data. K and π tracks are tagged from the charge of the slow π (daughter of D^{*+}) in the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$.

4. K-EFFICIENCIES AND π-MIS-ID RATES

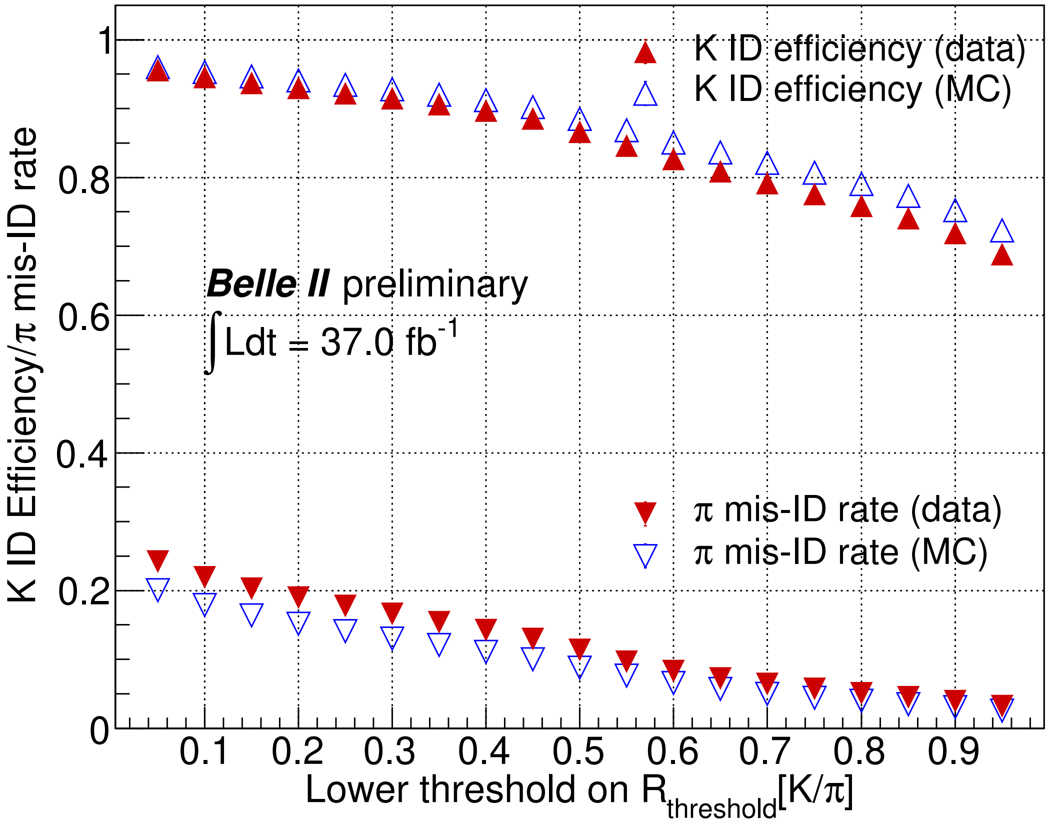

FIG. 2: K-efficiencies and π-mis-ID rates are calculated for different PID criteria using the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$.

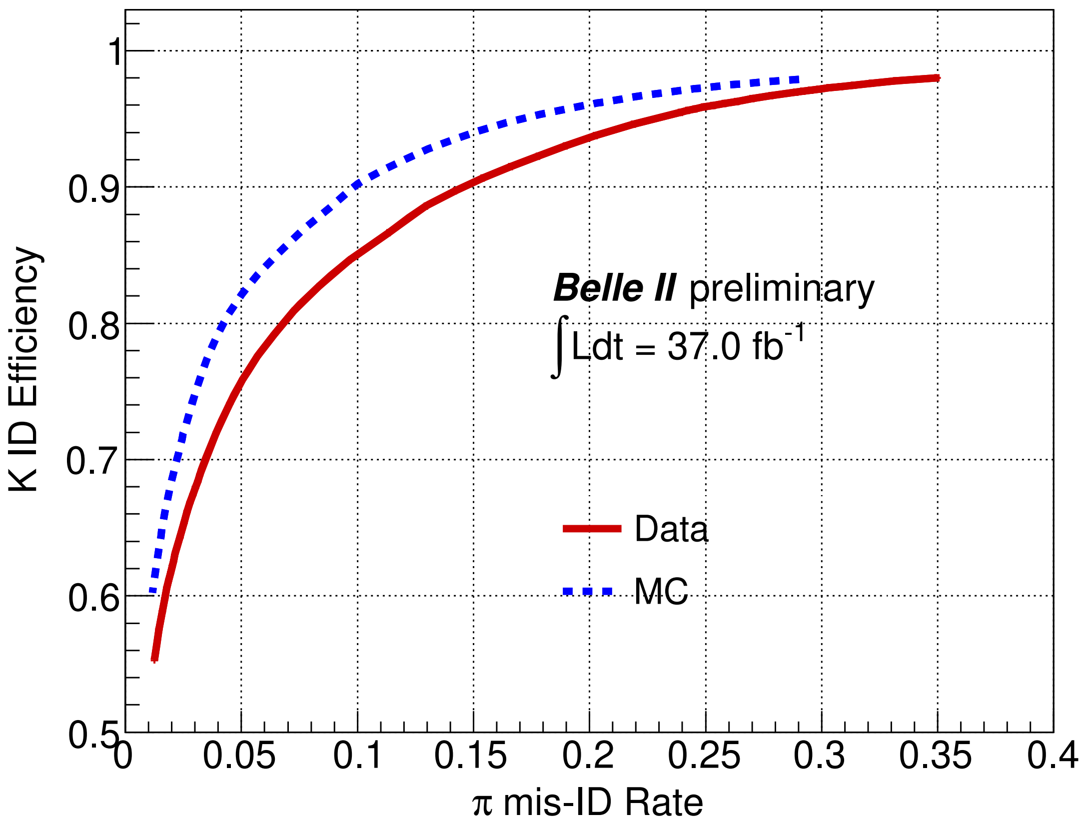

FIG. 3: K-efficiencies *vs.* π-mis-ID rates for different PID criteria using the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$.

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

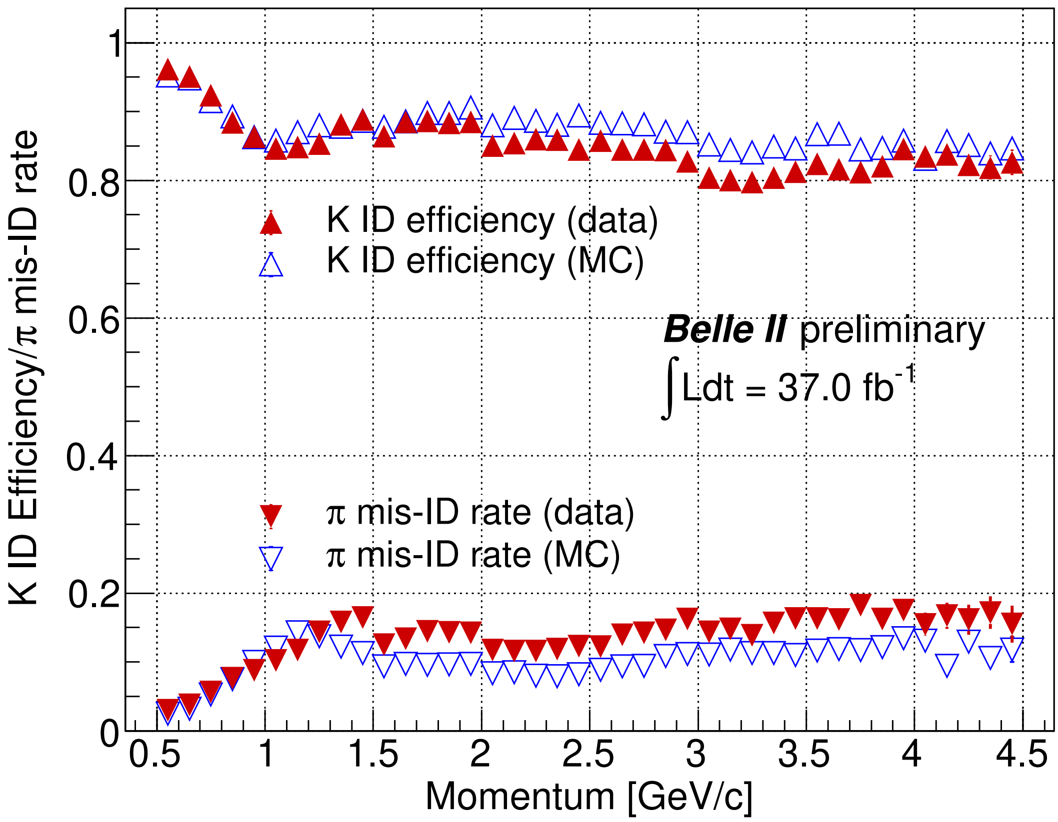

FIG. 4: Kaon efficiency and pion mis-ID rate for the PID criterion $\mathcal{R}_{K/\pi} > 0.5$ using the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$ in the bins of laboratory frame momentum of the tracks.

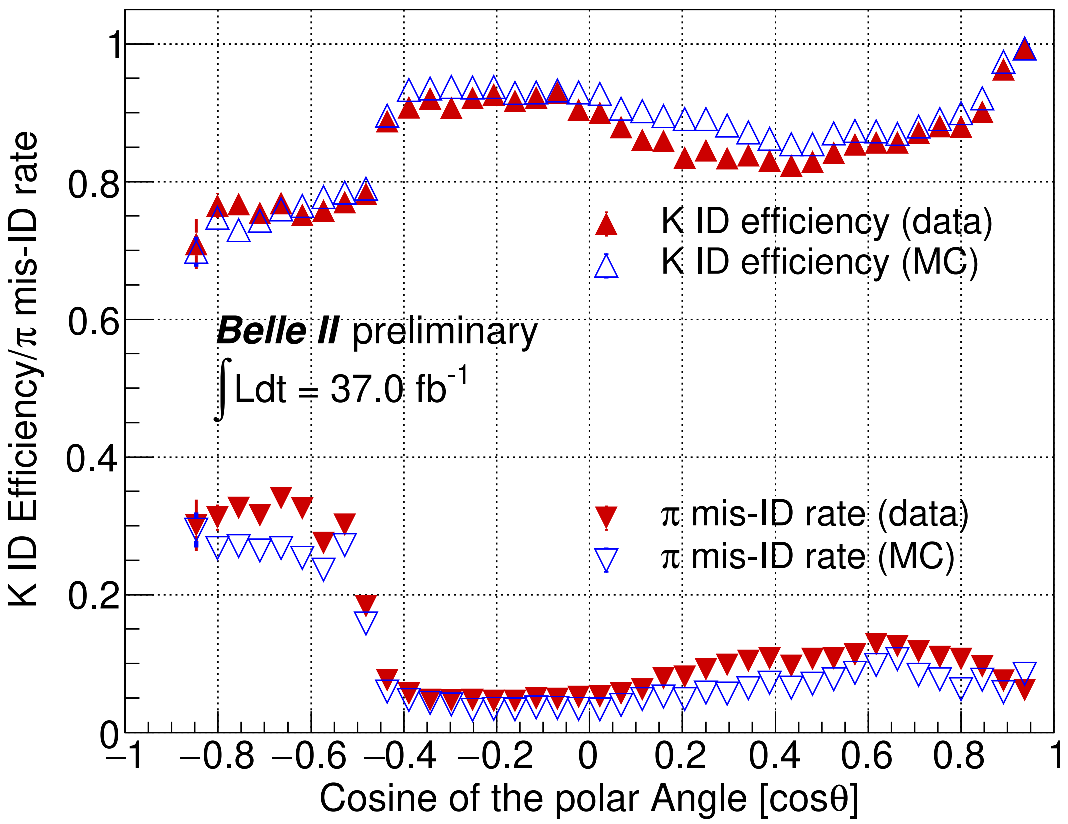

FIG. 5: Kaon efficiency and pion mis-ID rate for the PID criterion $\mathcal{R}_{K/\pi} > 0.5$ using the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$ in the bins of polar angle (laboratory frame) of the tracks. Note that the acceptance regions of CDC, TOP and ARICH in polar angle ($\cos\theta$) are $[-0.87, 0.96]$, $[-0.48, 0.82]$, and $[0.83, 0.97]$, respectively.

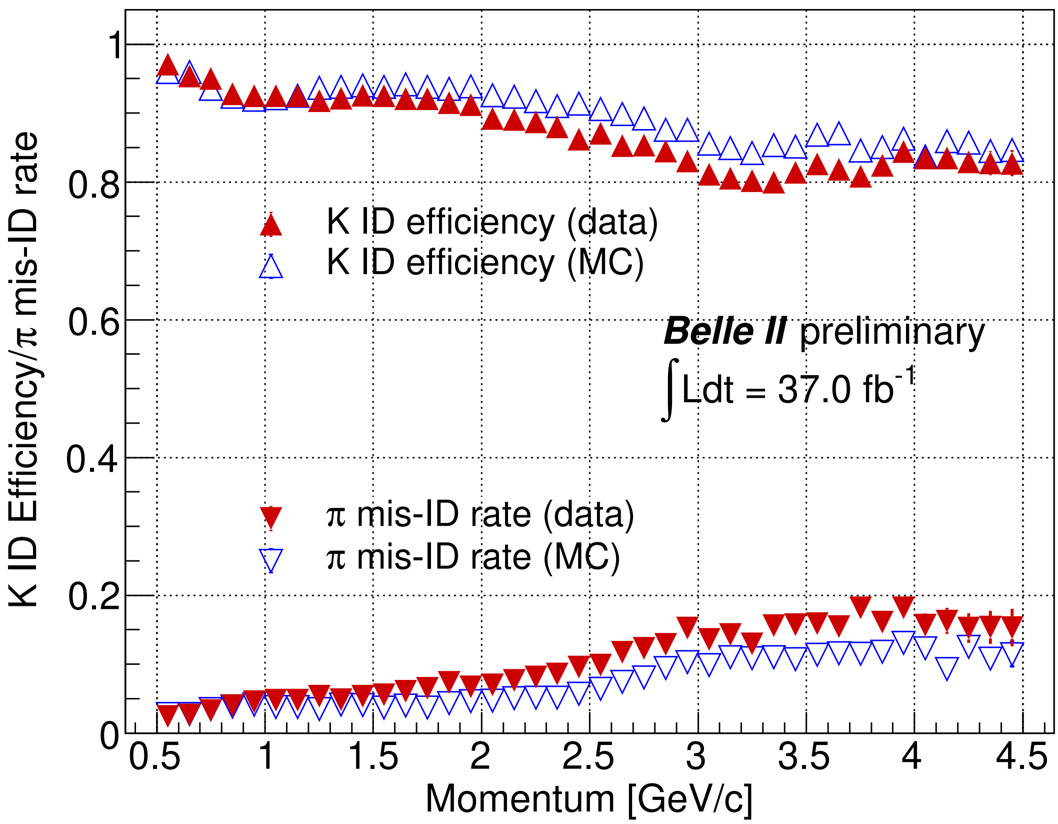

FIG. 6: Kaon efficiency and pion mis-ID rate for the PID criterion $\mathcal{R}_{K/\pi} > 0.5$ using the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$ in bins of laboratory momentum for tracks, which produce atleast one hit in either the ARICH or TOP detector.

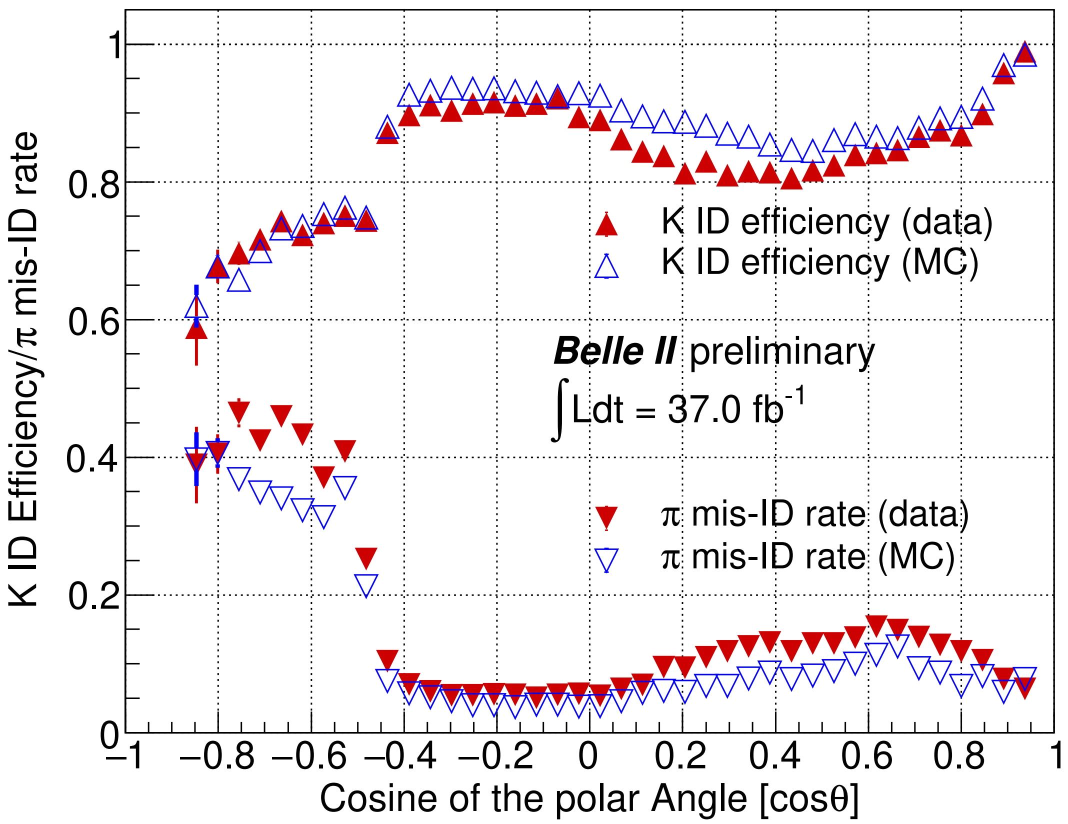

FIG. 7: Kaon efficiency and pion mis-ID rate for the PID criterion $\mathcal{R}_{K/\pi} > 0.5$ using the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$ in the bins of polar angle (laboratory frame) of the tracks which have laboratory frame momentum greater than 1 GeV/c. Note that the acceptance regions of CDC, TOP and ARICH in polar angle ($\cos\theta$) are $[-0.87, 0.96]$, $[-0.48, 0.82]$, and $[0.83, 0.97]$, respectively.