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Kaon and Pion Identification Performances in Phase III data for TOP detector

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Abstract

We study the performances of the charged kaon and pion identification based on 2.64 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 fake rates of kaon and pion identification are calculated using $D^{*+} \to D^0[K^-\pi^+]\pi^+$ decays for the TOP only binary PID criteria. The study is performed in several momentum, polar angle bins and TOP slot bins.

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1. DEFINITIONS

Information from each PID system 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 TOP detector specific binary likelihood ratio 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 fake rate can be studied in data.

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 (fake rate) is defined as:

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

2. DATA-SET

In this study, we use the data set (2.64 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. TOP ONLY BINARY LIKELIHOOD RATIOS

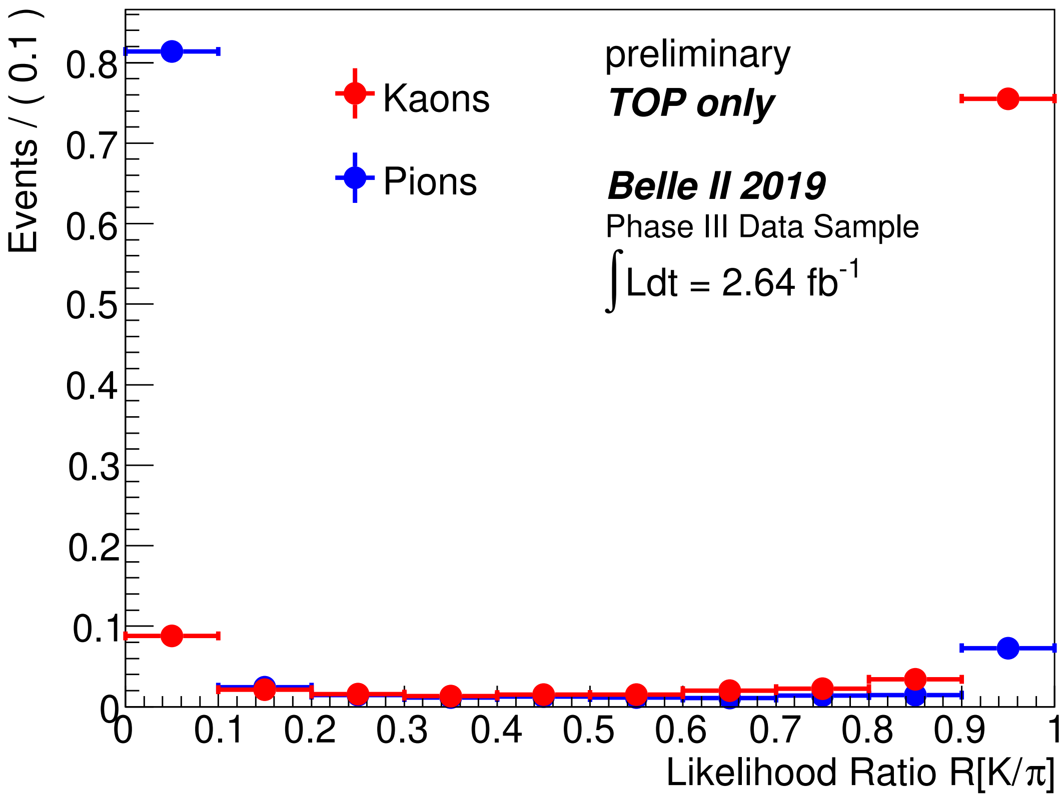

FIG. 1: $\mathcal{R}_{K/\pi}$ distribution from TOP only information. K and π tracks are tagged from the charge of the slow π (daughter of D^{*+}) in the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$.

4. TOP ONLY K-EFFICIENCIES AND π-FAKE RATES

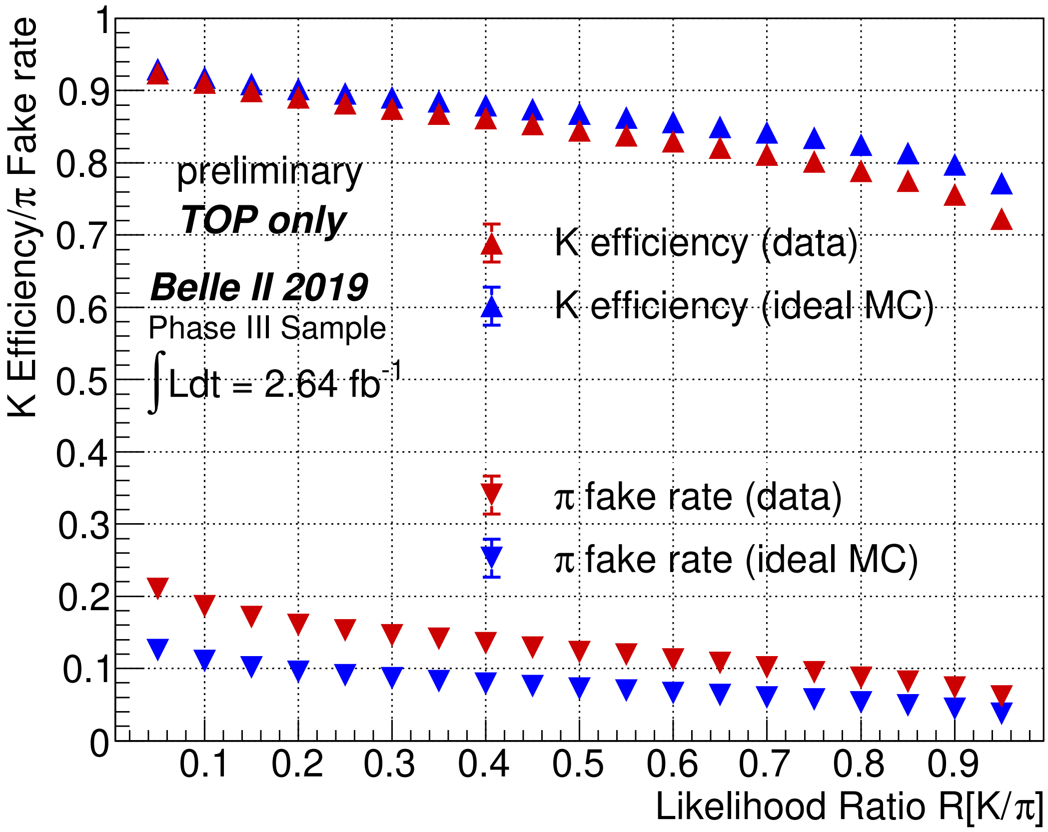

FIG. 2: TOP only K-efficiencies and π-fake rates are calculated for different PID criteria using the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$.

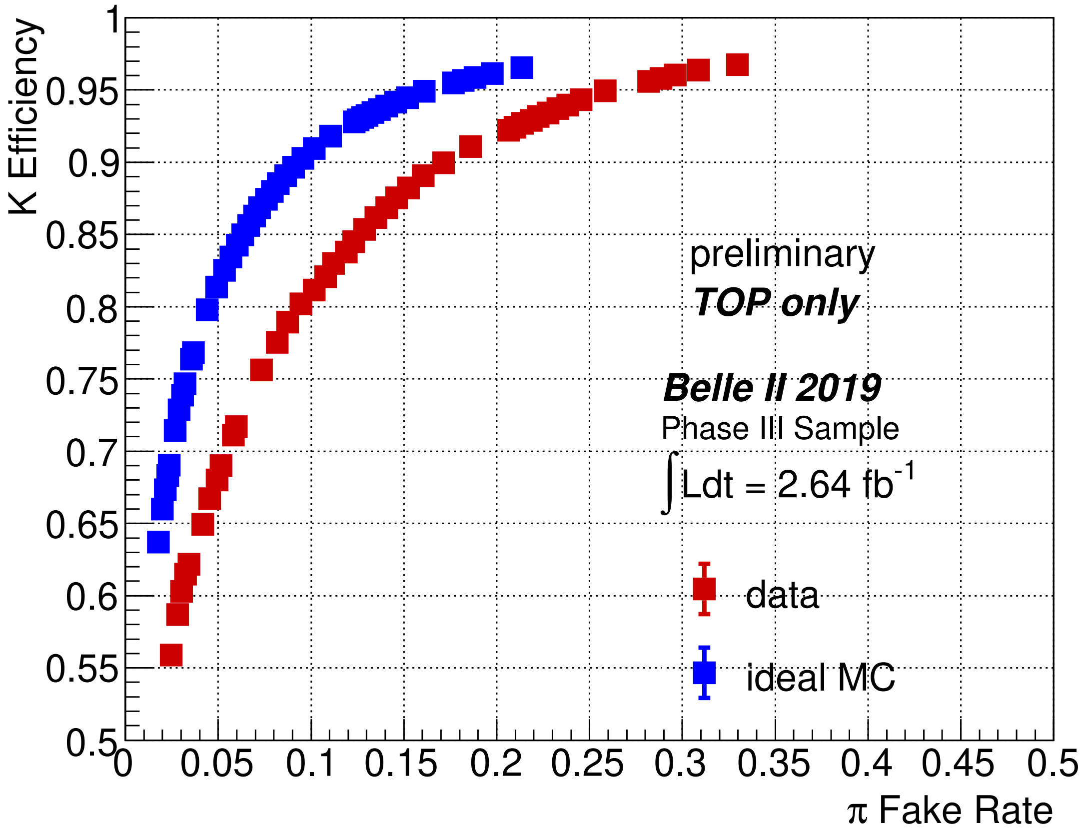

FIG. 3: TOP only K-efficiencies *vs.* π-fake rates for different PID criteria using the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$.

5. TOP ONLY K-EFFICIENCY AND π-FAKE RATE IN MOMENTUM/POLAR ANGLE BINS

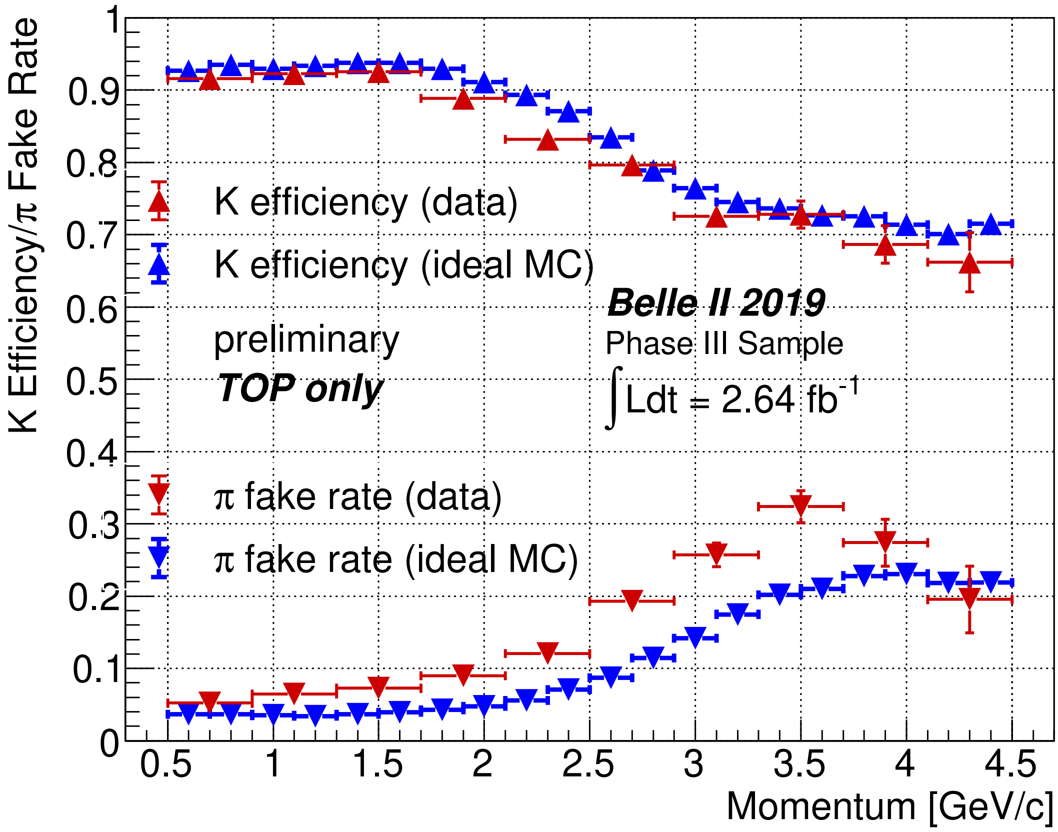

FIG. 4: Kaon efficiency and pion fake rate for the TOP only PID criterion $\mathcal{R}_{K/\pi} > 0.5$ using the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$ in the bins of laboratory frame momentum of the tracks.

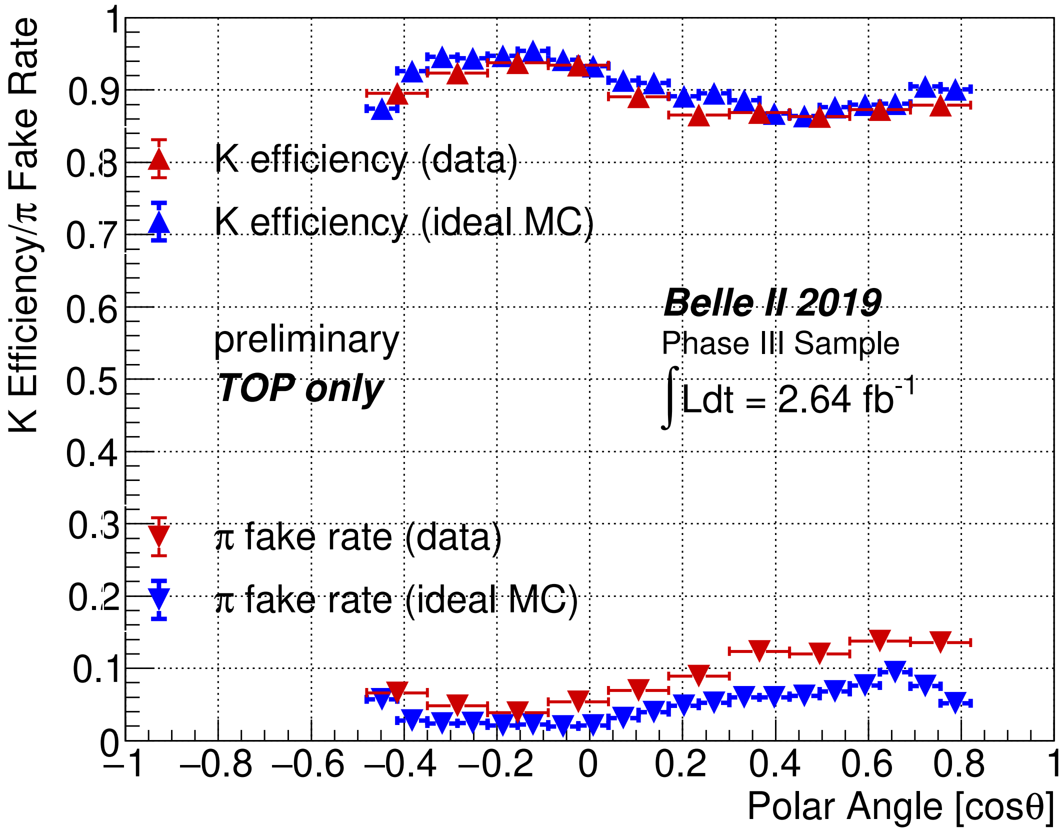

FIG. 5: Kaon efficiency and pion fake rate for the TOP only PID criterion $\mathcal{R}_{K/\pi} > 0.5$ using the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$ in the bins of polar angle (laboratory frame) of the tracks.

6. TOP ONLY K-EFFICIENCY AND π-FAKE RATE IN DIFFERENT SLOTS

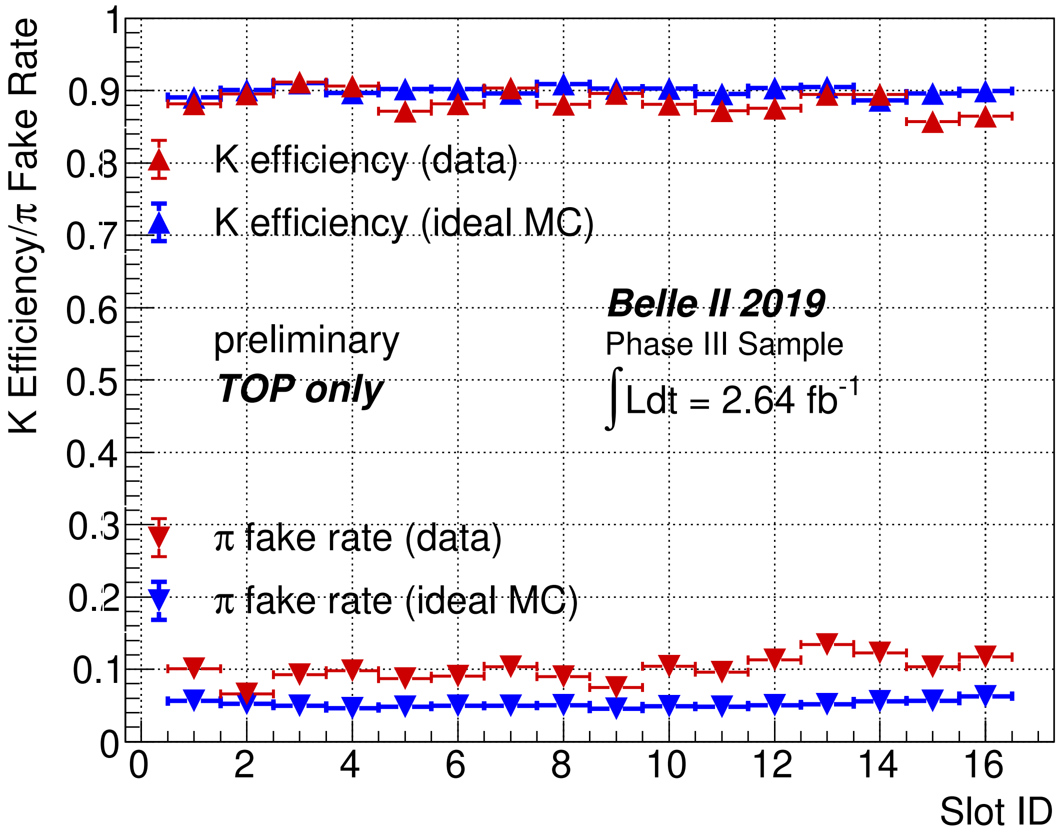

FIG. 6: Kaon efficiency and pion fake rate for the TOP only PID criterion $\mathcal{R}_{K/\pi} > 0.5$ using the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$ in the 16 TOP slots (arXiv:1011.0352).