Charged Particle Identification with the TOP detector at Belle II

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Abstract

The Belle II detector is located at the SuperKEKB energy-asymmetric e^+-e^- collider and has acquired the world's highest instantaneous luminosity this year. Charged particle identification (PID) in Belle II is provided by the TOP (Time Of Propagation) counters in the barrel region. We report the overall and TOP-focused PID performance in recently recorded 208 fb^{-1} data with the decay $D^{*+} \to D^0[K^-\pi^+]\pi^+$ as a control sample.

1 Introduction

An effective charged particle identification (PID) [1] system is essential for any successful High Energy Physics Experiment. PID plays a vital role in isolating the hadronic final states and reducing backgrounds. In B-factories [1], PID is particularly very important in enabling flavour-tagging techniques in B-mesons. The Belle II [1] detector, located at the interaction region of $e^+ - e^-$ SuperKEKB [1] collider offers a unique PID system. The Time-of-Propagation (TOP) [2] counters provides PID in the barrel region of the Belle II detector.

2 Discussion

When a charged track exceeds the speed of light in a dielectric medium, it emits Cherenkov light at a specific angle. These photons undergo total internal reflection in a quartz radiator and are recorded at the MCPPMT [1] plane. Analyzing the position of the photon hits and time of propagation provides the information about the Cherenkov angle. The TOP detector combines this time-of-flight data with the Cherenkov angle information to determine the PID of the charged track.

To determine the likelihood of each charged particle hypothesis, the information obtained from each sub-detector is independently analyzed. For this purpose, the

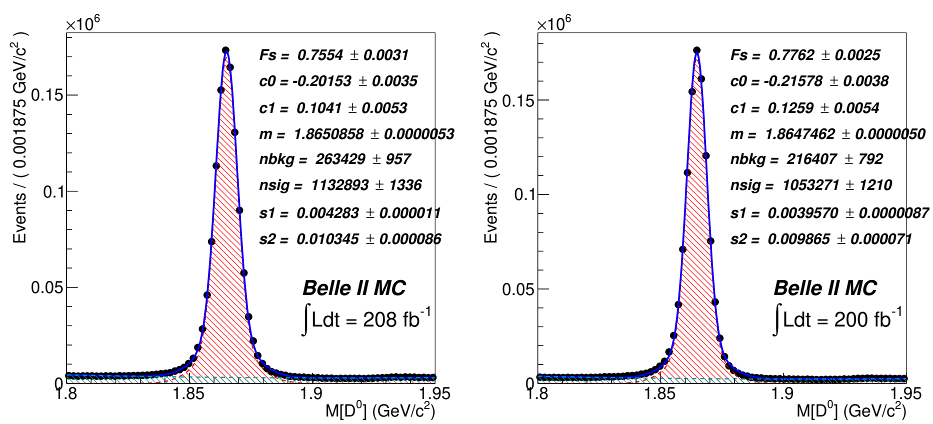

Figure 1: $M[D^0]$ fit distribution of data (left) and MC (right).

decay $D^{*+} \to D^0(\to K^-\pi^+)\pi^+$ is utilized as an ideal control sample. To obtain the number of K and π tracks, a one dimensional unbinned maximum likelihood fit is performed on the mass of D^0 as shown in Figure 1.

The K-efficiency and mis-identification rate are investigated for the PID criterion $\mathcal{R}_{K/\pi} > 0.5$ [2], and the analysis is conducted in momentum and polar angle bins for both data and Monte Carlo (MC) samples, specifically using the TOP likelihood, as shown in Figure 2. This study is based on the analysis of recently reprocessed Belle II data, totaling 208 fb^{-1}.

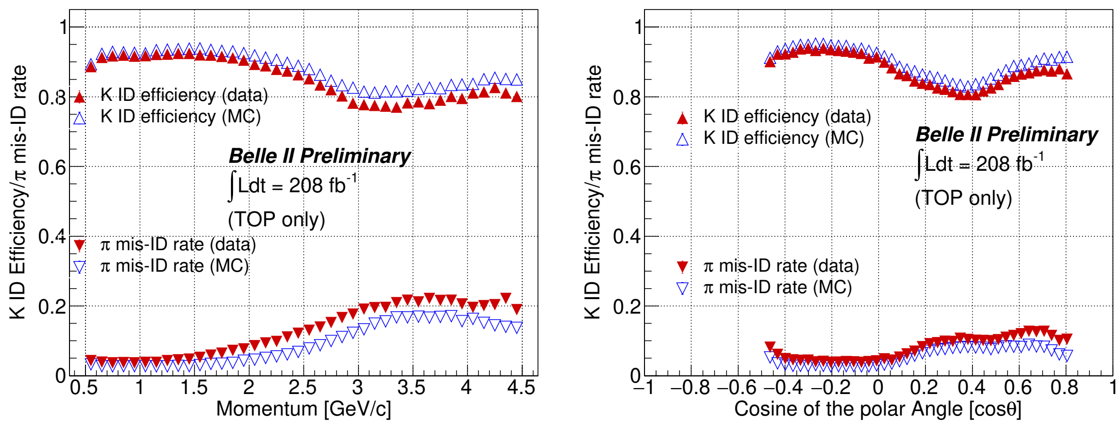

Figure 2: K-identification and π mis-identification rate as a function of lab-momenta and polar angle for the requirement $\mathcal{R}_{K/\pi} > 0.5$ [2] with TOP likelihood only.

3 Conclusion

PID is crucial for most of the analyses in Belle II. In order to achieve physics goals at Belle II, an efficient K/π separation is needed for the momentum range up to 4 GeV/c. In the current data-set the K-identification efficiency (π-mis-identification rates) in data is about 87.3% (7.8%) and in MC is about 88.7% (7.8%) respectively by using the information from all sub-detectors. For the TOP only case K-identification efficiency (π-mis-identification rates) is 87% (8.4%) in data and 88.9% (6.0%) in MC. Ongoing studies aim to further enhance the PID performance and gain insights into the remaining data-MC discrepancies.

References

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