ARICH performance study in the Belle II experiment

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Introduction

The Belle II experiment at the SuperKEKB asymmetric e^+e^- collider in High Energy Accelerator Research Organization (KEK, Tsukuba, Japan) is searching for CP asymmetries in different rare decays, as well as a new physics beyond the standard model, and aims to collect a high statistics data set corresponding to an integrated luminosity of 50 ab^{-1} [1].

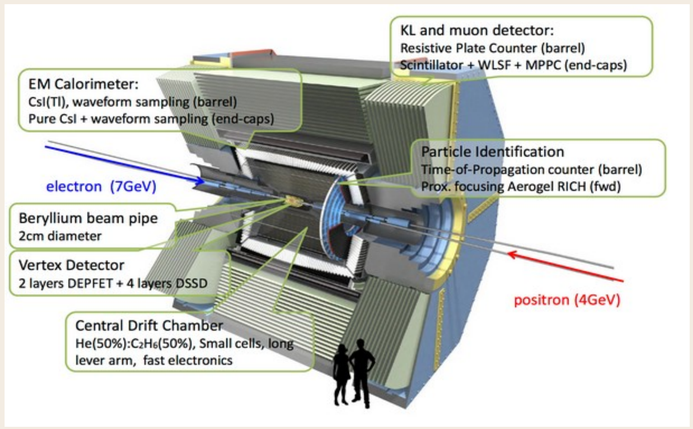

Fig.1 Schematic view of the Belle II spectrometer.

The ARICH counter is located in the forward end-cap of the Belle II spectrometer as shown in Fig. 1. This is a novel type of particle identification device that has been developed for the Belle II experiment which is capable of identifying pions and kaons with momenta up to 4 GeV/c by detecting Cherenkov photons emitted in the silica aerogel radiator.

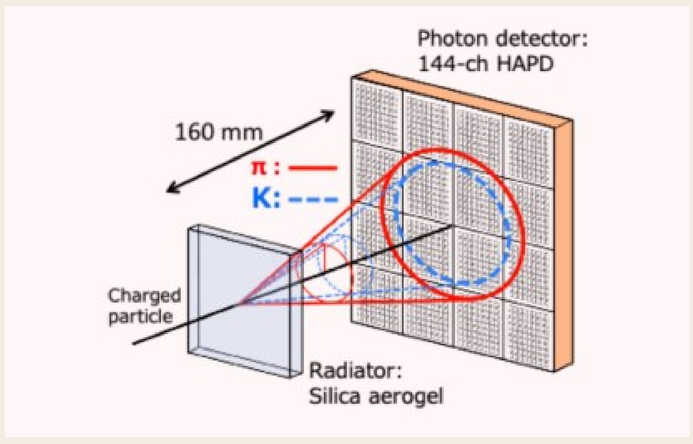

Fig. 2. The principle of the particle identification of the ARICH counter.

The principle of the particle identification in ARICH is shown in Fig. 2. ARICH uses Cherenkov photons emitted in the silica aerogel radiator when the particle velocity exceeds the speed of light in the medium. By measuring the angle of Cherenkov photons, the mass of the particle can be determined through the relation

$$\cos\theta = \frac{\sqrt{(mc/p)^2 + 1}}{n}$$

m, p – mass and momentum of a particle, n – refraction index, θ – angle of Cherenkov photons. The results are based on a data set corresponding to an integrated luminosity of 97.58 fb^{-1} recorded by the Belle II detector.
We study the ARICH performance using a clean sample of pions and kaons from the $D^{*\pm} \to D^0 (K^{\mp}\pi^{\pm}) + \pi^{\pm}$ decay.

Data selection

- pValue of the track fit pValue > 0.001
- two oppositely charge tracks
- transverse momentum of a track p_t > 0.1 [GeV/c]
- momentum of a track p > 0.5 [GeV/c]
- energy released in the decay 0.0 < Q < 0.01 [GeV]

Results

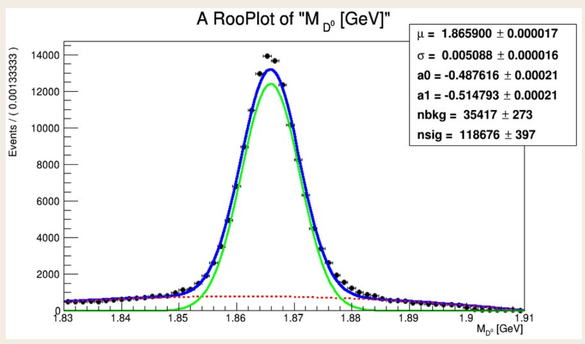

Fig 3. Invariant mass distributions of D ^{0}(left) and D (right) decay samples.*

p bins [GeV/c]	θ bins [rad]
]0.5; 1.5]	]0.30; 0.36]
]1.5; 2.3]	]0.36; 0.40]
]2.3; 3.1]	]0.40; 0.44]
]3.1; 3.9]	]0.44; 0.48]
]3.9; 5.0]	]0.48; 0.53]

Table 1. 2D (p-θ) binning for kaons and pions.

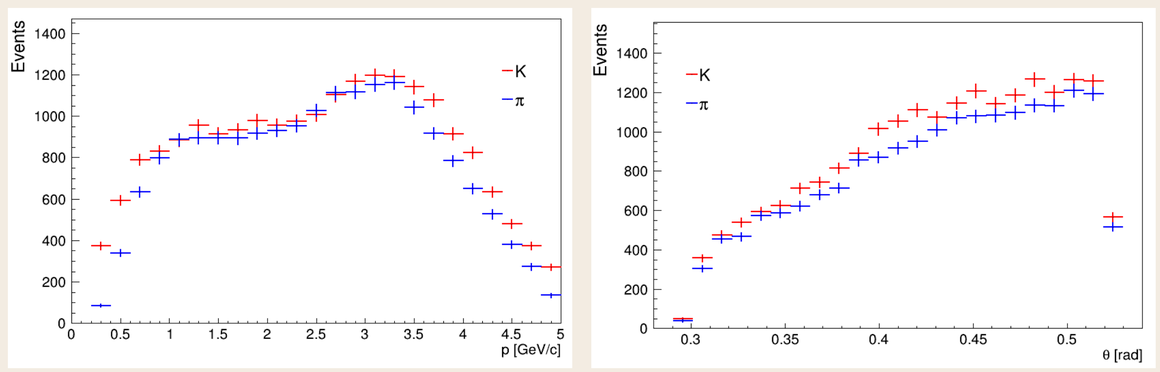

Fig.4 Momentum (left) and polar angle (right) distributions for kaons and pions from D^0 ($\bar{D}^0$) decays in ARICH acceptance.

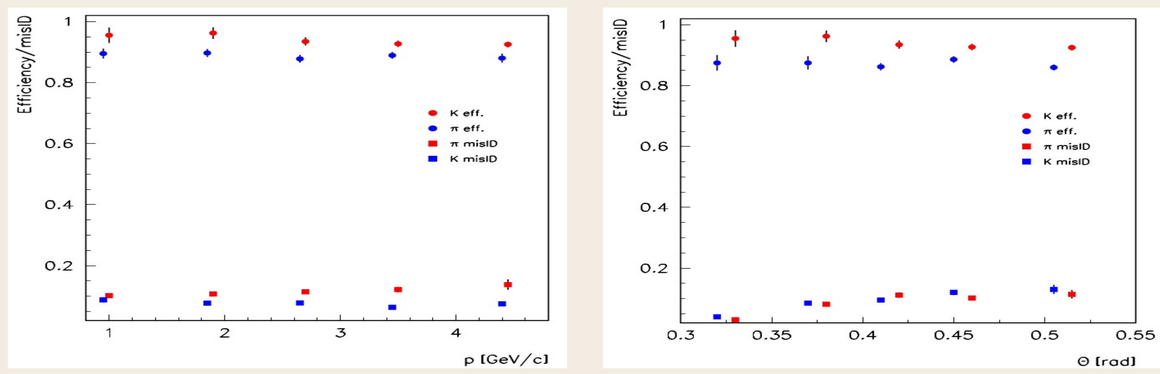

Fig 5. Efficiency and misID dependencies in 1D momentum (left) and polar angle (right) bins.

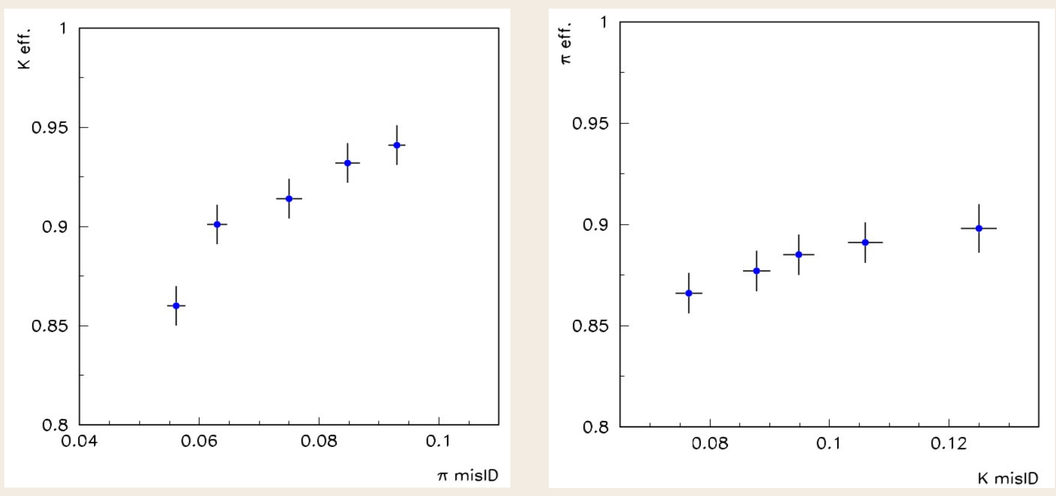

Fig 6. ROC curve for the K efficiency versus the π misidentification probability (left) and the π efficiency versus the K misidentification probability (right)

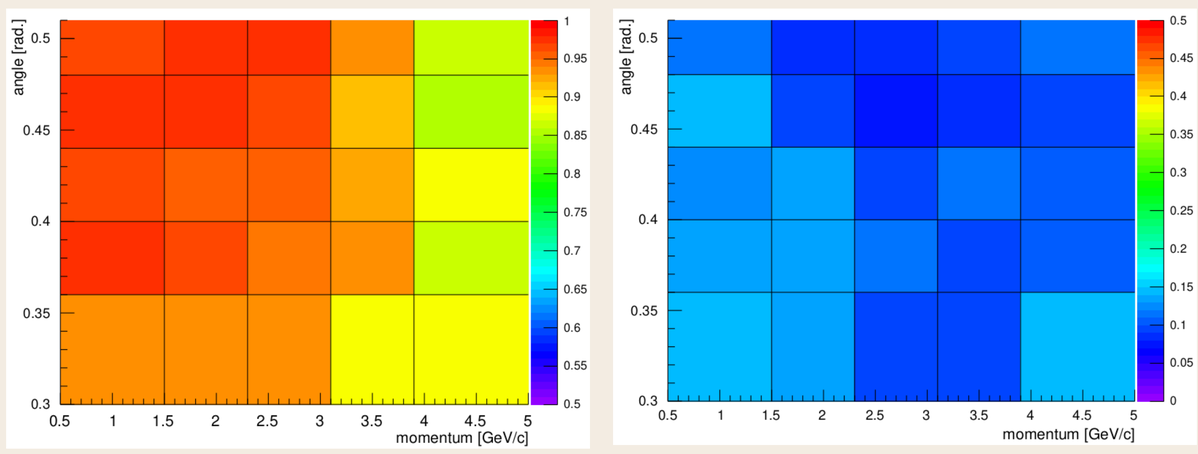

Fig 7. Kaon efficiencies (left) and pion misID's (right) in 2D (p-θ) plane.

Conclusion

The K(π) efficiency and π(K) misidentification probabilities based on pion and kaon tracks from the $D^{*+} \to D^0 \pi^+$ ($D0 \to K^- \pi^+$) decays are extracted in momentum and polar angle bins. The overall K(π) efficiency and π(K) misidentification probability are estimated to be 93.2 ± 0.59 % (88.7 ± 0.69 %) and 11.1 ± 0.38 % (7.38 ± 0.25 %), respectively.

References

M.Yonenaga et al. - "Performance evaluation of the aerogel RICH counter for the Belle II spectrometer using early beam collision data". PTEP, Volume 2020, Issue 9, September 2020, 093H01, https://doi.org/10.1093/ptep/ptaa090