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Measurement of Time-integrated WS-to-RS ratio of the "Wrong-Sign" $D^0 \longrightarrow K^+\pi^-\pi^0$ decay at Belle II

Chanchal Sharma[1*] and Kavita Lalwani[1]
(for the Belle II Collaboration)
[1] *Malaviya National Institute of Technology Jaipur, Jaipur 302017, India*

Introduction

The mixing and CP violation in the charm sector is projected to be very small in the standard model, and thus, they constitute a sensitive probe for potential new physics contributions [1]. One of the most promising channels at Belle II [2] is the "Wrong-Sign" (WS) decay $D^0 \rightarrow K^+\pi^-\pi^0$, which can be produced by two interfering processes namely direct doubly Cabibbo-suppressed decay of the D^0 meson, or through D^0-$\bar{D^0}$ mixing followed by a Cabibbo-favored decay of the $\bar{D^0}$ meson. The WS decay $D^{*+} \rightarrow D^0\pi^+$ where $D^0 \rightarrow K^+\pi^-\pi^0$ is one of the best channels to study charm mixing and search for the CP violation in D^0-$\bar{D^0}$ oscillations. Measuring the time-dependent decay rate of wrong-sign decays allows us to separate the two processes and measure the mixing rate. The goal of this analysis to measure the time-integrated WS-to-RS ratio of the "wrong-sign" $D^0 \rightarrow K^+\pi^-\pi^0$ decay in the simulation at the integrated luminosity of 1ab $^{-1}$ for the Belle II experiment. The Belle II [2] is the upgraded experimental facility at SuperKEKB [3], KEK, Japan.

Dataset and Selection Criteria

The WS signal decay $D^{*+} \rightarrow D^0(\rightarrow K^+\pi^-\pi^0)\pi^+$ are reconstructed alongside with the corresponding "Right-Sign" (RS) decay $D^{*+} \rightarrow D^0(\rightarrow K^-\pi^+\pi^0)\pi^+$, which is used as control channel in the simulation at the integrated luminosity of 1 ab^{-1} at Belle II. The same criteria used to reconstruct the WS decays are also used for the RS decays. The candidates $D^0 \rightarrow K^\pm\pi^\mp\pi^0$ are reconstructed from charged kaon, and pion having at least one hit in Silicon Vertex Detector (SVD) [2] and 20 hits in Central Drift Chamber (CDC) [2], combined with $\pi^0 \rightarrow \gamma\gamma$, satisfying the range [0.12, 0.145] GeV/c^2. The D^0 is thus reconstructed by combining with low momentum pions, which has at least one hit in CDC to form $D^{*+} \rightarrow D^0\pi^+$ decay. The criteria on the center of mass momentum of D^{*+} is applied to be greater than 2.5 GeV/c to remove the background contribution coming from D^0 meson from B decays.

Physics Analysis of $D^{*+} \rightarrow D^0(\rightarrow K^\pm\pi^\mp\pi^0)\pi^+$

Due to the different amplitude models for RS and WS samples, the reconstruction efficiency over the Dalitz plot [5] is required. In this analysis, we have used a 60×10^{-3} PhaSe SPace (PHSP) simulation sample, which comprises both D^{*+} and D^{*-} mesons in the generation. The efficiency is then evaluated as a function of two variables, namely invariant mass of m(π,π^0) and helicity angle cosθ (π,π^0) (angle between the π^0 and K directions in the rest frame of π and π^0). The efficiency of the Dalitz plot can be parametrized as N_{rec}/N_{gen} as shown in figure 1, where N_{rec} and N_{gen} are the reconstructed candidates over the Dalitz plot and generated candidates. To correct the efficiency variation over this plane, we reweighted the generic MC events with 1/efficiency, where the efficiency is the relative efficiency over this plane.

The background components are identified for $D^0 \rightarrow K^\pm\pi^\mp\pi^0$ candidates, and a two-

*Electronic address: 2018RPY9026@mnit.ac.in

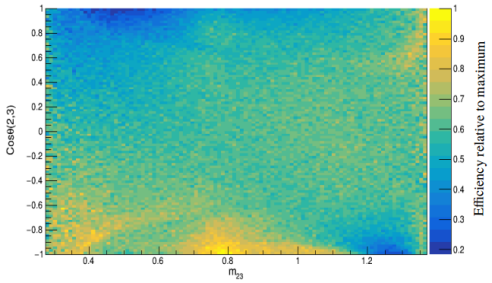

FIG. 1: Efficiency across the Dalitz plot evaluated as a function of m(π,π^0) invariant mass and helicity angle cosθ (π,π^0).

dimensional binned fit ($m(D^0)$, $m(D^0\pi^+)$) is performed to determine the signal yield, where $m(D^0\pi^+)$ is the mass of the D^* but with no mass hypothesis on the D^0 daughters. The Probability Density Function (PDF) for signal component corresponding to $m(D^0)$ and $m(D^0\pi^+)$ are Double Gaussian and Johnson [4]. All fit parameters are fixed to the values obtained from separate fits to all signal and background components. The efficiency corrected fit results of $m(D^0)$ and $m(D^0\pi^+)$ distribution for WS sample are reported in figure 2.

Results

We have rediscovered the wrong-sign $D^0 \to K^+\pi^-\pi^0$ decay in simulation. The observed yield of WS and RS Sample are N($D^0 \to K^+\pi^-\pi^0$) = 14322 ± 262 and N($D^0 \to K^-\pi^+\pi^0$) = 6713521 ± 4030, where the uncertainties are only statistical. The ratios of WS to RS yields are measured to be,

$$\frac{N(D^0 \to K^+\pi^-\pi^0)}{N(D^0 \to K^-\pi^+\pi^0)} = (2.13 \pm 0.04) \times 10^{-3}, \quad (1)$$

The results agree with the ratio in simulation 2.12×10^{-3}.

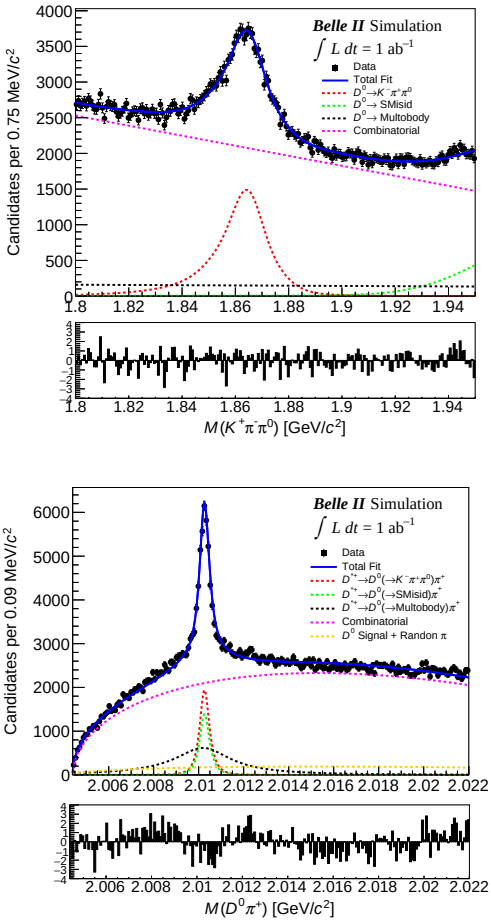

FIG. 2: Distribution of $m(D^0)$ (upper) and $m(D^0\pi^+)$ (lower) for WS $D^0 \to K^+\pi^-\pi^0$ candidates reconstructed in simulation, with fit projections overlaid.

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