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

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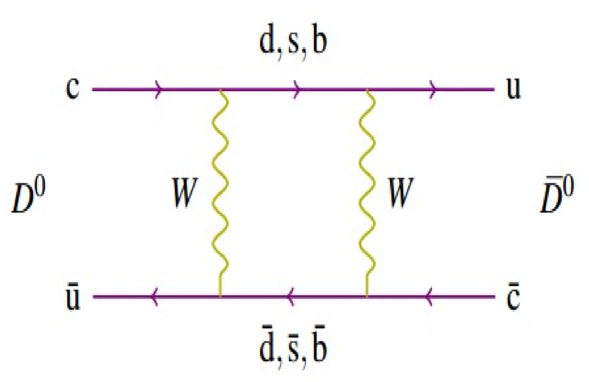
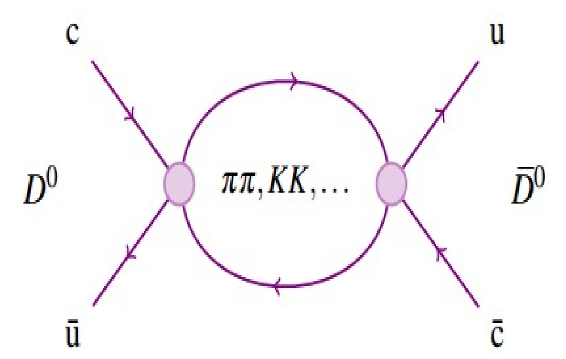
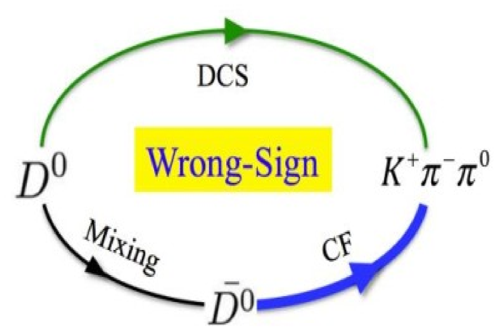
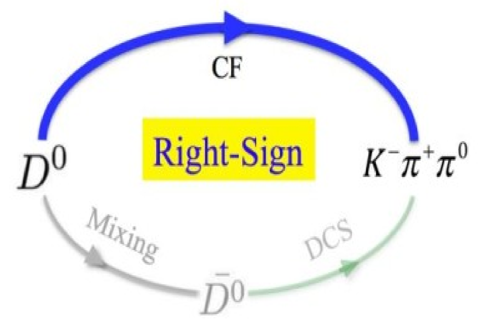
Physics Motivation

- In the standard model, mixing and CP violation in the charm sector are expected to be very small. Thus, they constitute a sensitive probe for potential new physics contributions.
- The "wrong-sign" (WS) $D^0 \longrightarrow K^+\pi^-\pi^0$ decay is one of the most promising channels at Belle II, as this can be produced through two interfering processes: a direct doubly Cabibbo-suppressed decay of the D^0 meson, or through $D^0 - \overline{D}^0$ mixing followed by a Cabibbo-favored decay of the $\overline{D}^0$ meson.
- Measuring the decay-time-dependent rate of wrong-sign decays allows us to separate the two processes and measure the mixing rate.
- The goal of this analysis is to measure the time-integrated WS-to-RS ratio of the "wrong-sign" (WS) $D^0 \longrightarrow K^+\pi^-\pi^0$ decay at Belle II.



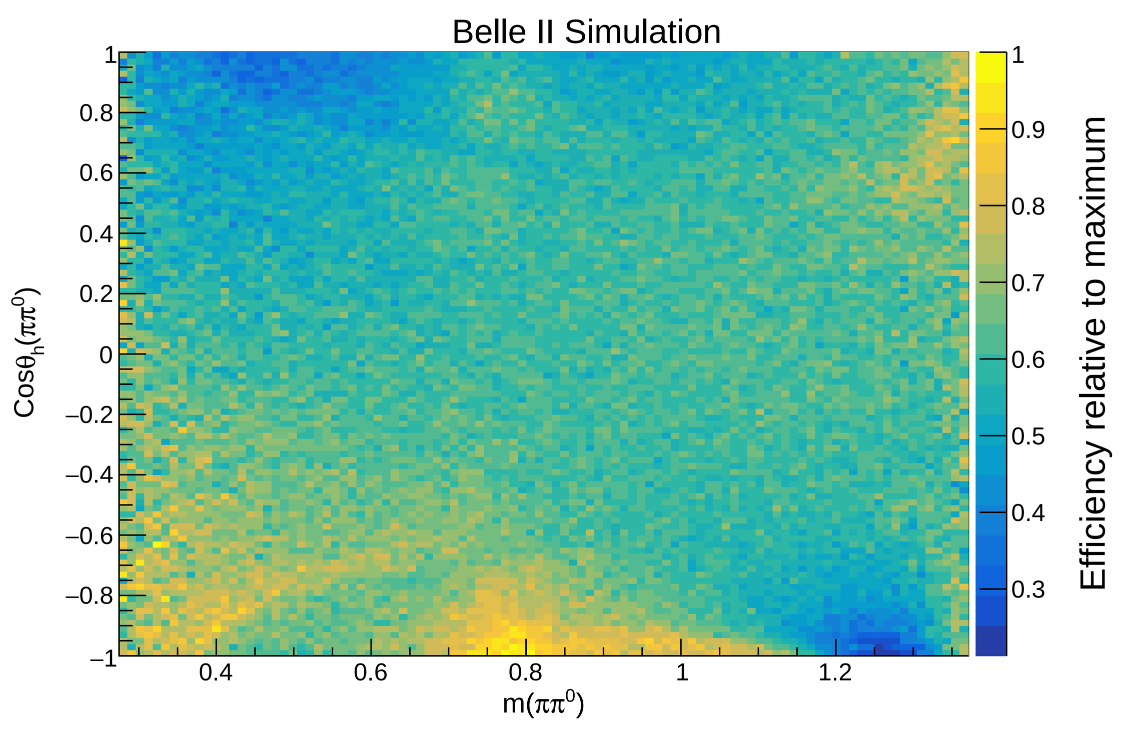






Efficiency Variation

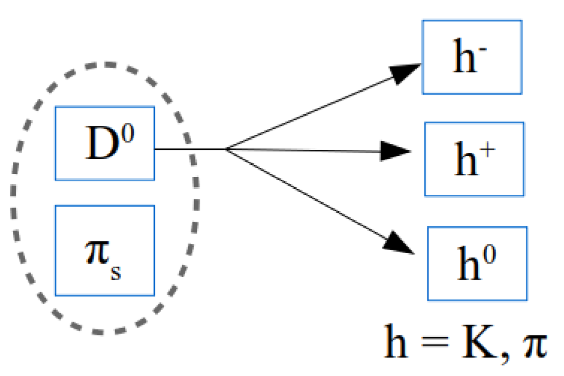
- Due to the different amplitude models for RS and WS samples, the reconstruction efficiency over the Dalitz plot is required.
- The efficiency is evaluated as a function of $m(\pi^+,\pi^0)$ invariant mass and helicity angle $\cos(\pi^+,\pi^0)$ (i.e. the angle between the π^0 and K directions in the rest frame of π^+ and π^0).
- The efficiency of the Dalitz plot can be parametrized as N_{rec}/N_{gen}.
- 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.



Fit strategy

An binned fit to $(m(K^+\pi^-\pi^0), m(D^0\pi_s))$ is performed to determine the signal yield.

The variable $m(D^0\pi_s)$:



- $m(D^0\pi_s)$ is the mass of the D^* but with no mass hypothesis on the D^0 daughters.

Summary

- Estimated the efficiency over the square Dalitz Plot.
- Efficiency corrected time-integrated WS-to-RS Ratio in the reconstruction is in agreement with the generation.

Reconstruction of $D^0 \longrightarrow K^+\pi^-\pi^0$

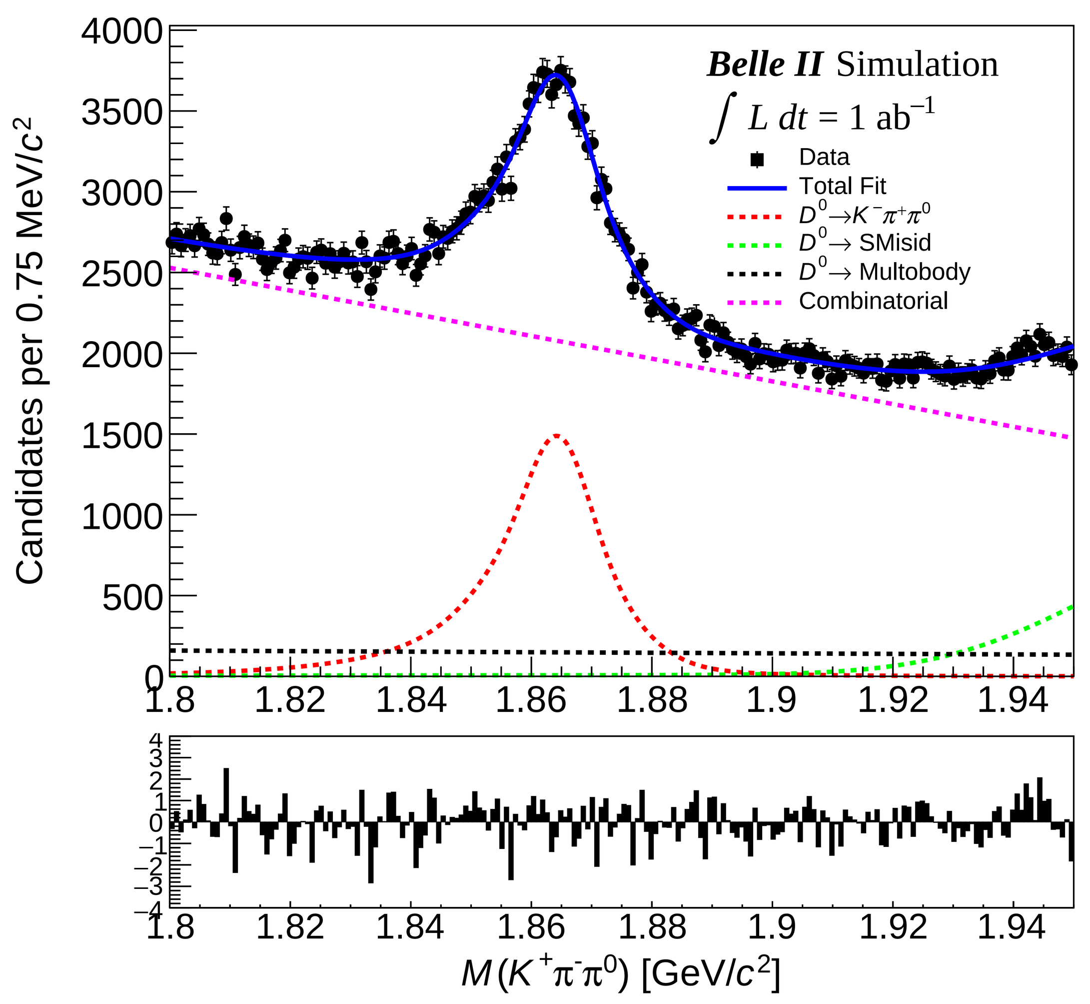
Dataset and Selection Criteria:

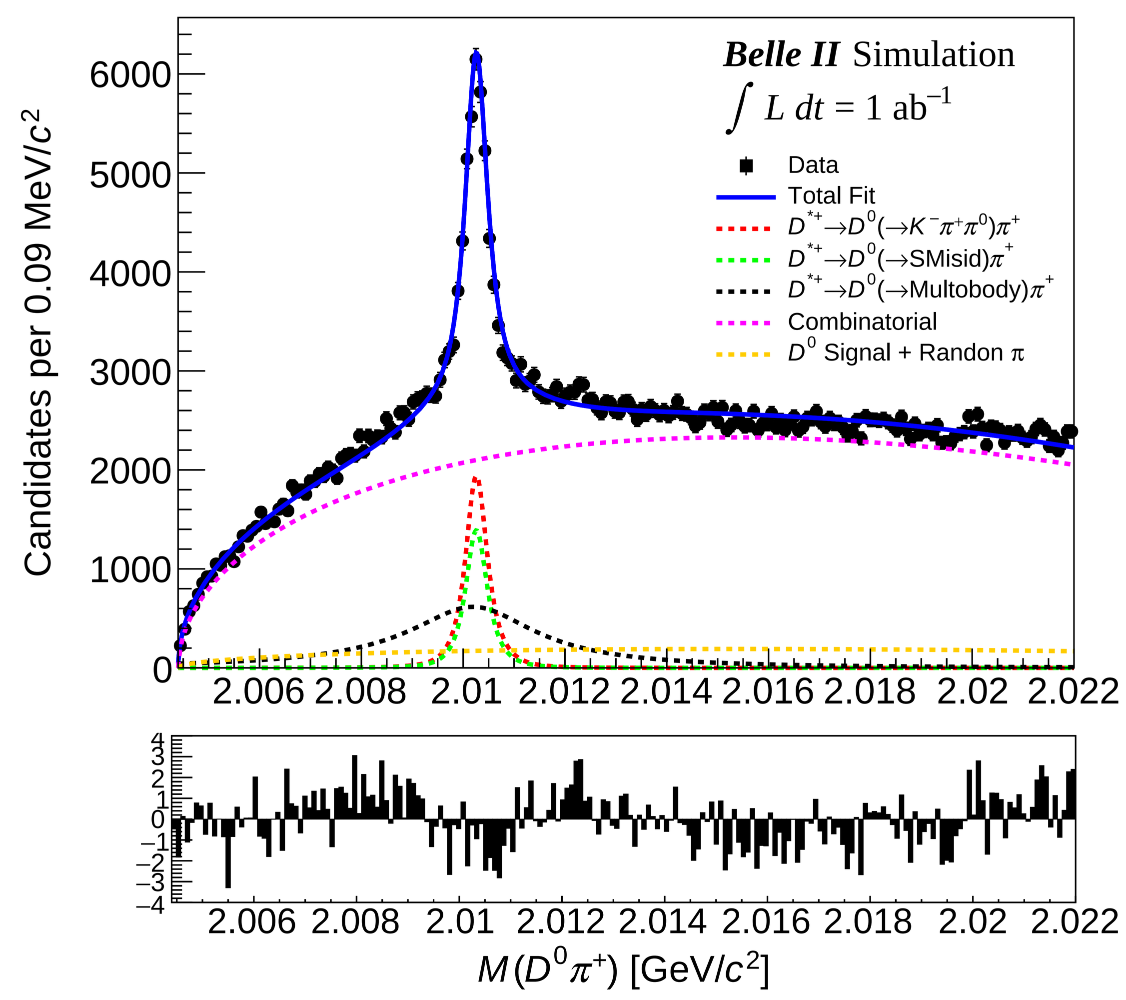
- Monte Carlo (MC) Simulation: 1 ab^{-1}.
- Candidate $D^0 \longrightarrow K^+\pi^-\pi^0$ are formed using charged kaon, and pion has at least one hit in Silicon Vertex Detector (SVD) and at least 20 hits in Central Drift Chamber (CDC), combined with $\pi^0 \longrightarrow \gamma\gamma$, satisfying the range [0.12, 0.145] GeV/c^2.
- The D^0 thus reconstructed is combined with low momentum pions, have at least one hit in CDC to form $D^{*+} \longrightarrow D^0\pi^+$ decay.
- Center of mass momentum of $D^{*+} > 2.5 GeV/c$ to remove D from B decays.

Results

- Identified all the background components of $D^0 \longrightarrow K^+\pi^-\pi^0$ decay to separate from signal.
- The Probability Density Function (PDF) for every component corresponding to $m(D^0\pi_s)$ and $m(K^+\pi^-\pi^0)$ shown with different colors.
- Used a 2D fit PDF that is the product of the corresponding $m(D^0\pi_s)$ and $m(K^+\pi^-\pi^0)$ PDFs to determine signal yield.
- All fit parameters are fixed to the values obtained from separate fits to all components.

Components	$m(D^0\pi_s)$	$m(K^+\pi^-\pi^0)$
$D^{*+} \longrightarrow D^0(\longrightarrow K^+\pi^-\pi^0)\pi_s$	Johnson + Double gaussian	Johnson + Double gaussian
$D^{*+} \longrightarrow D^0(\longrightarrow SMisID)\pi_s$	same as signal	Double Gaussian
$D^{*+} \longrightarrow D^0(\longrightarrow multibody)\pi_s$	Johnson	1^{st} order Chebyshev
D^0 signal + random pion	$(x-x_0)^{1/2} + \alpha(x-x_0)^{3/2} + \beta(x-x_0)^{5/2}$	same as signal
Combinatorial	same as D^0 signal + random pion	1^{st} order Chebyshev





- Signal Yield for WS $D^0 \longrightarrow K^+\pi^-\pi^0 = 14322 \pm 262$.
- Signal Yield for RS $D^0 \longrightarrow K^-\pi^+\pi^0 = 6713521 \pm 4030$.
- Reconstructed time-integrated WS-to-RS ratio $(2.13 \pm 0.04) \times 10^{-3}$ is consistent with the value used in generation 2.12×10^{-3}.