BELLE2-NOTE-PL-2020-011
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Prompt measurements of time-dependent CP-violation and mixing

The Belle II Collaboration

Abstract

This document presents the approved plots corresponding to the prompt mixing and time dependent CP violation measurements using 34.6 fb^{-1} of data collected in 2019 and 2020. For more detail, see B2-NOTE-PH-2020-038 and B2-NOTE-PH-2020-027.

The fit to the $M_{\rm bc}$ and Δt distribution for $B^0 \to D^-(K^+\pi^-\pi^-)\pi^+$ candidates reconstructed in the data collected until end of May 2020 is shown in Fig. 1, 2. From this fit the following value for the mixing frequency Δm_d is found:

$$\Delta m_d = (0.531 \ \pm \ 0.046 \ (\text{stat.}) \ \pm \ 0.013 \ (\text{syst.})) \ \text{ps}^{-1},$$

which is in agreement with the world average $\Delta m_d = (0.5065 \ \pm \ 0.0019) \ \text{ps}^{-1}$. The same fit run with Δm_d fixed to the world average allows for extracting the wrong tag fraction w which is found to be $w = (20.9 \pm 2.1)\%$ in agreement with the expectation from simulated events $w = 20.0\%$.

The fit to the $M_{\rm bc}$ and Δt distribution for $B^0 \to J/\psi(e^-e^+/\mu^-\mu^+)K_S$ candidates reconstructed in the same data is shown in Fig. 3, 4. This fit is performed assuming no direct CP-violation ($A_{\rm CP}$ fixed to 0 in the fit), as well as the same reconstruciton efficiency and wrong tag fraction for B^0 and $\overline{B}^0$ tags. With these assumptions, the asymmetry is a quasi odd function of Δt, only the asymmetry of the Δt resolution function breaks its "oddness". The wrong tag fraction extracted from the mixing fit is used as an input for this fit. From the fit, the value obtained for the time-dependent CP-violation parameter $S_f \approx \sin 2\phi_1$ is

$$S_f = \ 0.55 \ \ \pm \ 0.21 \ \ (\text{stat.}) \ \pm \ 0.04 \ \ (\text{syst.}),$$

which is in agreement with the world average $S_f \approx 0.691 \pm 0.017$ and is 2.71 standard deviations away from 0 (accounting for the statistical uncertainty only).

More detail about the analysis can be found in B2-NOTE-PH-2020-038 (docs.belle2.org/record/1957). The related talk given at the Physics General Meeting on July 23$^{\rm rd}$ 2020 can also be used as a short summary (indico.belle2.org/event/2656/).

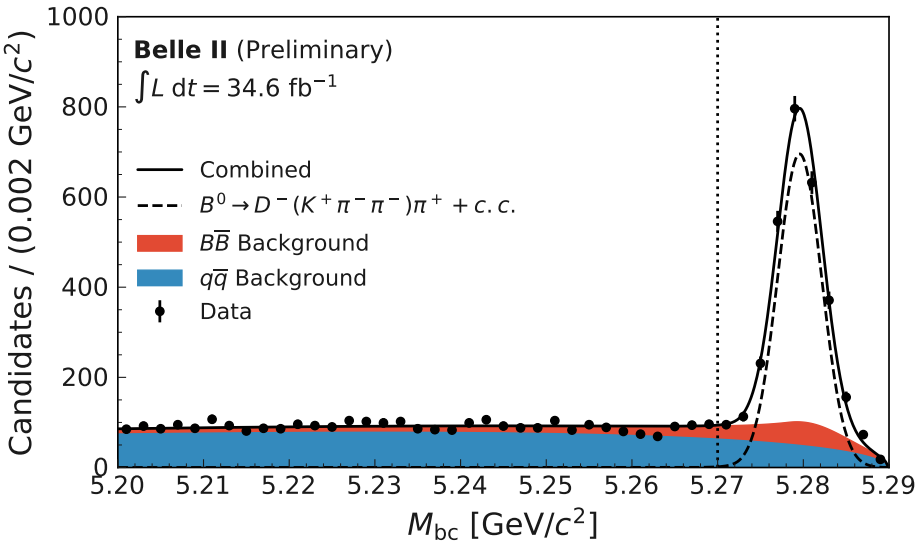

FIG. 1: Distribution of the beam-constrained mass M_{bc} for reconstructed $B^0 \to D^-\pi^+$ candidates from 34.6 fb^{-1} of data collected in 2019 and 2020 (black dots with error bars). The total fit function is shown with a solid black line. The fit contains three components. The signal is described as a Crystal Ball shape and is shown with the dashed black line. The $q\bar{q}$ background is described with an Argus shape filled in blue. The $b\bar{b}$ background is described with an Argus shape plus a Gaussian peak and is shown in red. The vertical dotted line delimits the sideband region (on the left) from the signal region (on the right) in which the events are selected for the Δt fit.

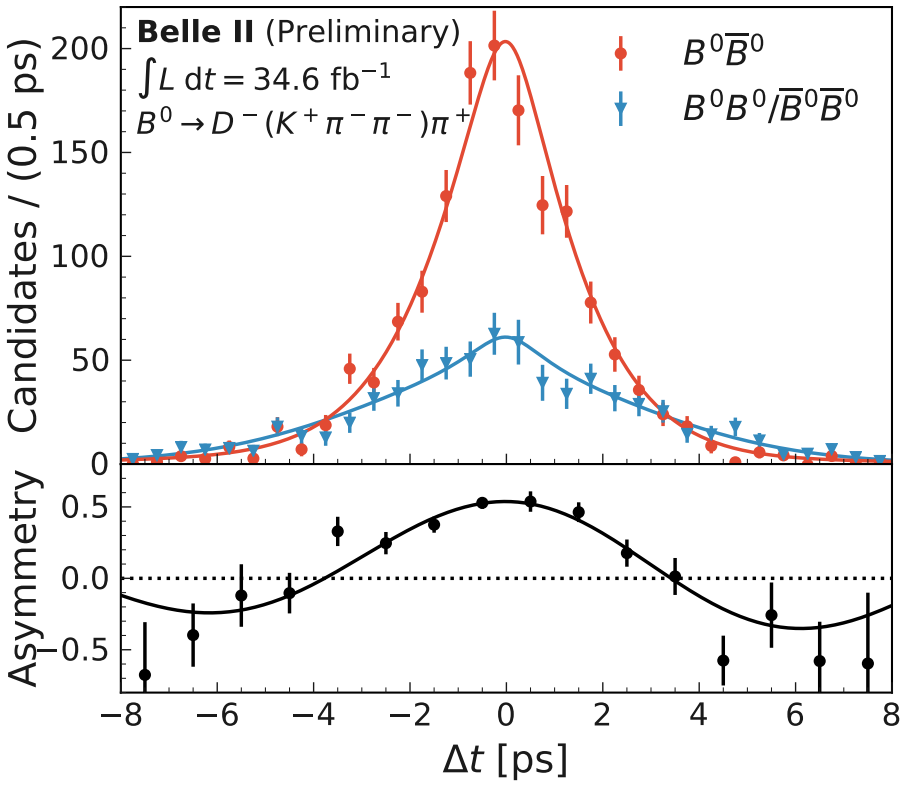

FIG. 2: Top: Δt distribution for reconstructed $B^0 \to D^-\pi^+$ candidates. The red circles (blue triangles) with error bars show events in which the tag and signal B^0 have opposite flavours (the same flavour). The background expectation, the shape of which is extracted from simulated events and the yield of which is obtained from the $M_{\rm bc}$ fit, is subtracted to show only the signal distribution. The solid line shows the signal Δt distributions obtained from a fit to the events shown with the corresponding colour. Bottom: asymmetry between the number of events with opposite flavour and same flavour, *i.e.* $\frac{N(B^0\overline{B}^0)-N(B^0B^0/\overline{B}^0\overline{B}^0)}{N(B^0\overline{B}^0)+N(B^0B^0/\overline{B}^0\overline{B}^0)}$. The fitted asymmetry obtained from the fit shapes is superimposed and shown with a solid black line.

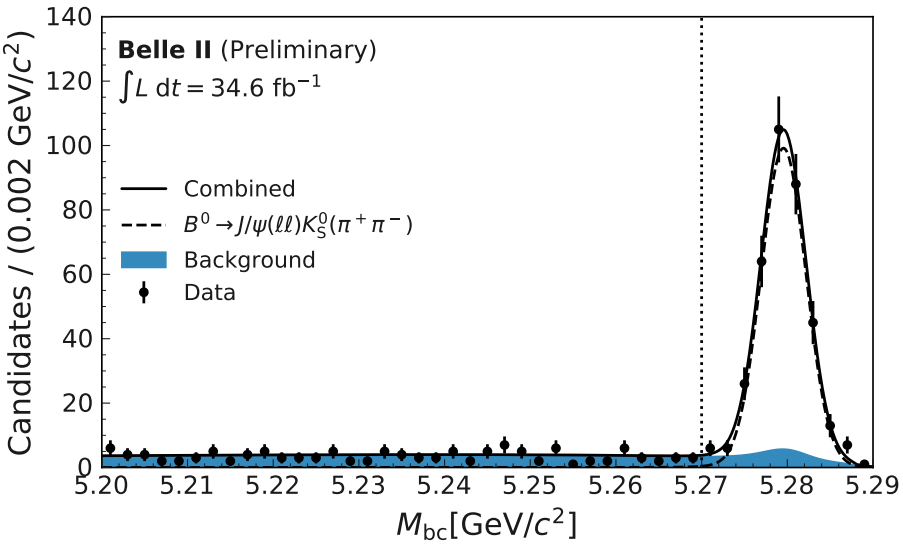

FIG. 3: Distribution of the beam-constrained mass M_{bc} for reconstructed $B^0 \to J/\psi(\mu^+\mu^-)K_S(\pi^+\pi^-)$ and $B^0 \to J/\psi(e^+e^-)K_S(\pi^+\pi^-)$ candidates in 34.6 fb^{-1} of data collected in 2019 and 2020 (black dots with error bars). The total fit function is shown with a solid black line. The fit contains two components. The signal is described as a Crystal Ball shape and is shown with the dashed black line. The background ($q\bar{q} + b\bar{b}$) is described with an Argus shape plus a Gaussian peak and is shown with a filled blue shape. The vertical dotted line delimits the sideband region (on the left) from the signal region (on the right) in which the events are selected for the Δt fit.

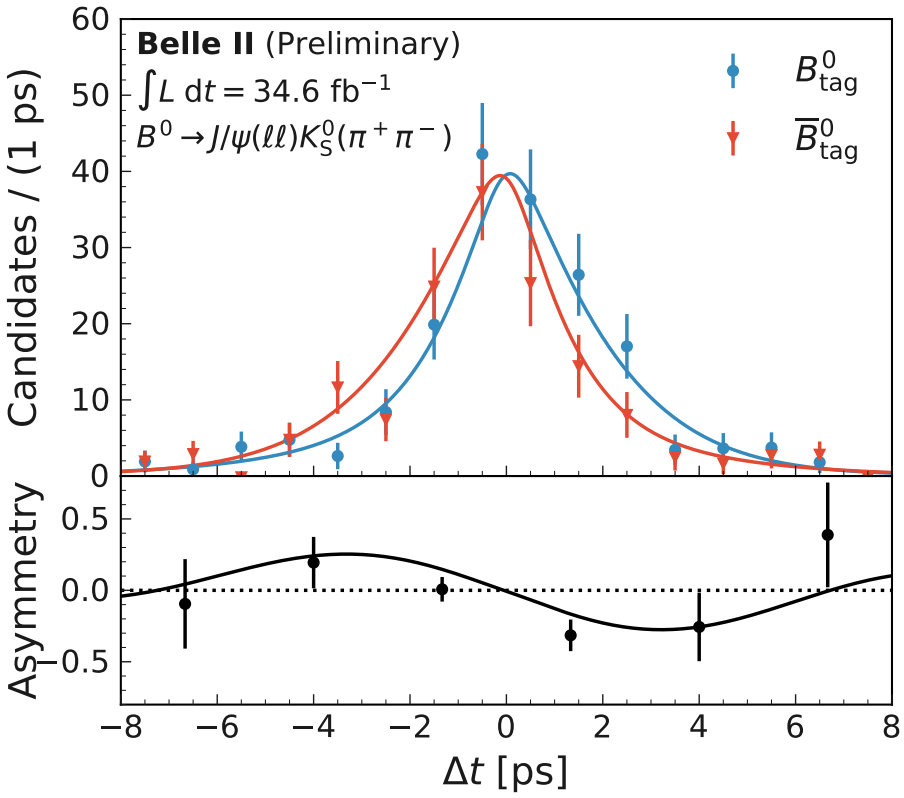

FIG. 4: Top: Δt distribution for reconstructed $B^0 \to J/\psi(\mu^+\mu^-)K_S(\pi^+\pi^-)$ and $B^0 \to J/\psi(e^+e^-)K_S(\pi^+\pi^-)$candidates. The blue circles (red triangles) with error bars show events in which the signal candidate is accompanied by a B^0 ($\overline{B}^0$) tag. The background expectation, the shape of which is extracted from simulated events and the yield of which is obtained from the M_{bc} fit, is subtracted to show only the signal distribution. The solid lines show the signal Δt distributions obtained from a fit to the events shown with the corresponding colour. Bottom: asymmetry between the number of events with B^0 tag and $\overline{B}^0$ tag. *i.e.* $\frac{N(\overline{B}^0_{\mathrm{tag}})-N(B^0_{\mathrm{tag}})}{N(\overline{B}^0_{\mathrm{tag}})+N(B^0_{\mathrm{tag}})}$. The fitted asymmetry obtained from the fit shapes is superimposed and shown with a solid black line.