Measurement of the CKM angle ϕ_3 using $B \to DK$ at Belle II

M. Kumar[1*], K. Lalwani[1], K. Trabelsi[2], K. Prasanth[3] (On behalf of the Belle II Collaboration)
Malaviya National Institute of Technology Jaipur, INDIA[1],
High Energy Accelerator Research Organization (KEK), Tsukuba, JAPAN[2],
Tata Institute of Fundamental Research, Mumbai, INDIA[3]

Abstract We present the preliminary Monte Carlo (MC) study of the $B^{\pm} \to D^0(K_S^0\pi^+\pi^-)K^{\pm}$ to extract ϕ_3 at the Belle II along. We discuss here the improvement in ϕ_3 measurement one may expect at Belle II with 50 ab^{-1}. We also present preliminary reconstruction of the K_S^0 and $D^0 \to K_S^0\pi^+\pi^-$ using the Phase II data and compared with MC.

1 Introduction

The CKM angle ϕ_3 is one of the least well constrained parameters of the Unitarity Triangle [1, 2]. The precise measurement of ϕ_3 is highly desirable to scrutinise the consistency of the Standard Model and to detect presence of new physics. The measurement that currently dominates sensitivity to ϕ_3 uses $B^{\pm} \to DK^{\pm}$ decays with the neutral D mesons decaying to different final states such as KK, $K\pi$, $K_S^0\pi^+\pi^-$ etc. As the sensitivity of ϕ_3 comes from the interference of $b \to c\bar{u}s$ and $b \to u\bar{c}s$,

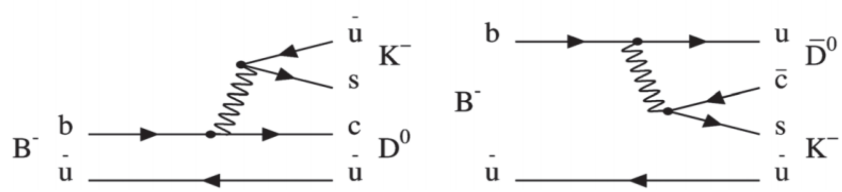

Fig. 1: Feynman diagram for $B^- \to D^0K^-$ (left) and $B^- \to \overline{D}^0K^-$ (right) [3].

therefore, measurement of ϕ_3 is performed by exploiting the difference between $K_S^0\pi^+\pi^-$ Dalitz plots for D mesons from B^+ and B^- decay. The measurement of

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* e-mail: 2016rpy9052@mnit.ac.in

ϕ_3 from $B^\pm \to D^0 K^\pm$ and $B^\pm \to \overline{D}^0 K^\pm$ decays is theoretically clean as they occur at the tree level (Fig. 1). Various methods [4, 5] for extracting ϕ_3 have been proposed, from which the Dalitz plot analysis method [6] is one of the novel methods to measure the ϕ_3. There have been many efforts by BaBar, Belle and LHCb collaborations to measure this angle but due to the small data samples so far produced, ϕ_3 is poorly determined. Therefore, an independent measurement with high statis-

Sr. No.	Experiment	Measurement of ϕ_3
1	Belle	$\left(73^{+13}_{-15}\right)^\circ$ [7]
2	BaBar	$\left(69^{+17}_{-16}\right)^\circ$ [8]
3	LHCb	$\left(74^{+5.0}_{-5.8}\right)^\circ$ [9]

Table 1: Previous results for the measurement of ϕ_3.

tics is required to measure ϕ_3, as the measurement is dominated by the statistical uncertainty. In this work, we present the preliminary MC study of $B^\pm \to D^0 K^\pm$ to extract ϕ_3 using the 50 ab^{-1} data to be accumulated by the Belle II detector. The Belle II [10] experiment at the SuperKEKB asymmetric e^+e^- collider [11], will accumulate the collision data at an unprecedented instantaneous luminosity of 8 $\times$ 10^{35} cm^{-2}s^{-1}, which is 40 times larger than preceding experiment, Belle. Fig. 2 shows how the expected uncertainty on ϕ_3 scale with luminosity based on toy Monte Carlo studies. It shows that the expected uncertainty with an integrated 50 ab^{-1} is approximately 3°. In addition, Belle II will also have a better particle iden-

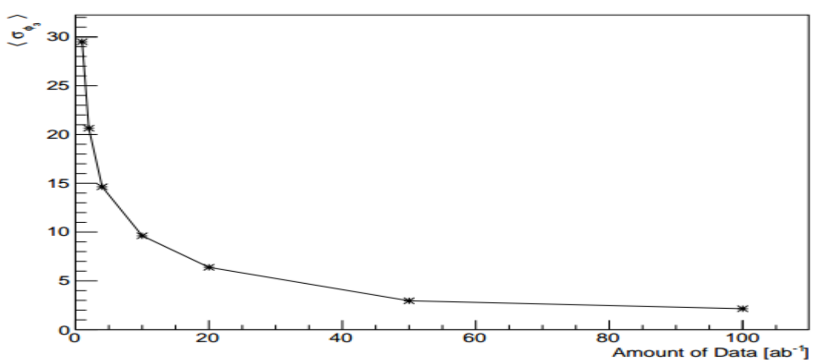

Fig. 2: The distribution shows the expected uncertanity versus luminosity on ϕ_3 [12].

tification with the Central Drift Chamber (CDC), Time of Propagation (TOP) and the Aerogel Ring Imaging Cherenkov Counter (ARICH), which is functioning in different momentum ranges [10]. Due to larger acceptance of the detector, an improved reconstruction efficiency of K_S^0 is anticipated. Recently, Belle II successfully completed its Phase II and collected 478 pb^{-1}. Here, Phase II data is incorporating single ladder per layer of the vertex detector and all other subdetectors. However, when the poster was shown, available data was 250 pb^{-1}. Therefore, the plots here are with 250 pb^{-1}.

2 Preliminary results from Phase II data

The analysis begins with the reconstruction of K_S^0 from the two charged tracks of π^+ and π^-. The invariant mass of K_S^0 is shown in Fig. 3 (left) with MC samples

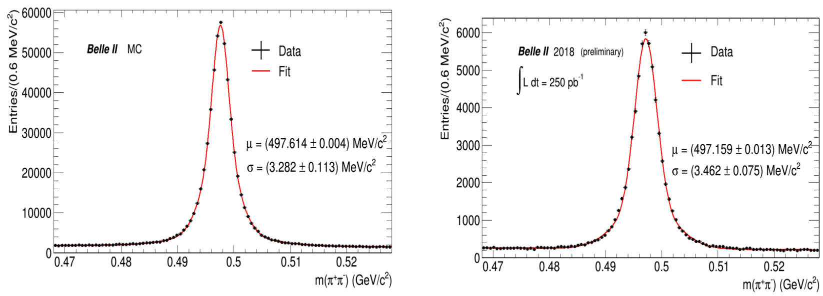

Fig. 3: Invariant mass of K_S^0 with MC (left) and data (right).

collected at integrated luminosity 1 fb^{-1} and with Phase II data shown in Fig. 3 (right). Here, black points are data and red line is fitting. As can be seen from the

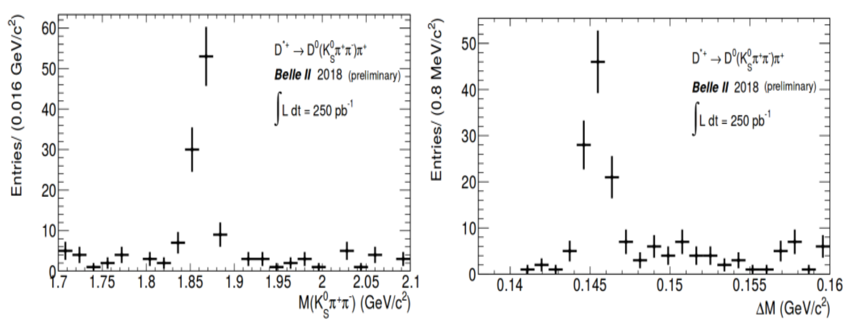

Fig. 4: Invariant mass (left) and ΔM (right) for D^* tagged mode $D^0 \to K_S^0\pi^+\pi^-$ shown with Phase II data.

figure, the invariant mass resolution shows the good aggrement between data and

MC. Further, the D^0 is reconstructed from one K_S^0 and two charged tracks of π^+ and π^- followed by the inclusive decay of $D^{*\pm} \to D^0(K_S^0\pi^+\pi^-)\pi^\pm$. Invariant mass of D^0 is shown in Fig. 4 (left) and ΔM is shown in Fig. 4 (right). Here, ΔM is the mass difference between the $D^{*\pm}$ and D candidates. The reconstruction of B meson is in progress by using the two important variables, energy difference, $\Delta E = \sum E_i - E_{beam}$ and the beam constrained mass, $M_{bc} = \sqrt{(E_{beam})^2 - \sum(\overrightarrow{p_i})^2}$, where E_{beam} is the center-of-mass (CM) beam energy, E_i and p_i are the CM energies and momenta of B candidates decay product.

3 Summary

The large statistics with Belle II at SuperKEKB will provide a substantial improvement in the precision of ϕ_3 with the full 50 ab^{-1} data sample. Extrapolated results are expected to provide a more precise measurement of the CKM angle ϕ_3 at integrated luminosity 50 ab^{-1}. Invariant masses of K_S^0 and D^0 are reconstructed and compared with MC and Phase II data. The reconstruction of B meson is in progress.

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