Time integrated ratio of wrong-sign to right-sign $D^0 \to K\pi$ decays in 2010 data at LHCb

Martin Bessner for the LHCb collaboration

1 Introduction

The LHCb experiment [1] is a single-arm forward spectrometer well suited to study the forward production of heavy quarks (c, b) at the LHC.

Mixing in the D meson system is well established [2] [3] and the combination of several measurements [4] yields a significance for D^0 mixing of 10 σ, but none of the existing single measurements exceeds 5 σ significance. The time dependent analysis of *wrong-sign* $D^0 \to K^+\pi^-$ decays provides good sensitivity for mixing.

In 2010, LHCb recorded a data sample corresponding to an integrated luminosity of $\mathcal{L} = (36.4 \pm 3.6)\,\mathrm{pb}^{-1}$. These data are not sufficient to perform a time dependent measurement. However, the extraction of the time integrated ratio of wrong-sign to right-sign $D^0 \to K\pi$ decays is feasible and presented here.

2 Selection

For the measurement, D^0 mesons from the reconstructed decay $D^{*+} \to D^0\pi^+_{\mathrm{tag}}$ are used[1], where the charge of the π_{tag} allows to determine the production flavor of the D^0-meson. For the $D^0 \to K\pi$ decays, the charge of the K classifies the decay mode as right-sign (RS) $D^0 \to K^-\pi^+$ or as wrong-sign (WS) $D^0 \to K^+\pi^-$ decay. The wrong-sign decays include contributions from DCS decays and from mixing.

The data selection is based on vertex and track properties, on particle identification in the RICH detectors, and on kinematics. WS and RS events are kinematically identical. Therefore, their background shapes are similar. The main background contribution arises from adding an unrelated pion to a correct D^0 candidate to form a fake D^* (random tag pion (π_{tag}) background). In total, $28.7 \cdot 10^4$ RS and $3.5 \cdot 10^4$ WS $D^0 \to K\pi$ decay candidates are observed.

For the determination of the signal yields, extended unbinned maximum likelihood fits within the RooFit toolkit [5] of the two dimensional event distribution in the plane $(m(D^*) - m(D^0), m(D^0))$ are used.

[1]Unless otherwise stated, charge conjugate decay modes are implied throughout.

3 Results

3.1 Ratio of wrong-sign to right-sign decays

The signal yields from the fits are taken to compute the ratio of WS to RS decays, $R_{\text{meas}} = N_{\text{WS}}/N_{\text{RS}} = (0.442 \pm 0.033)\%$. The error is statistical only.

In the ratio, asymmetries of the production rate and detection and trigger efficiencies cancel to first order and can be neglected. The relative amount of charm from B decays is assumed to be the same in WS and RS decays and cancels in the ratio.

For systematic uncertainties, contributions due to the fit model and the choice of the signal range in $m(D^*) - m(D^0)$ are considered and account for a combined uncertainty of $\delta R_{\text{sys.}} = 0.042\%$. The uncertainty from double particle misidentification is negligible compared to the other systematic uncertainties.

3.2 Correction to the wrong-sign to right-sign ratio

Due to mixing the ratio of WS to RS decays depends on the D^0 decay time. Therefore, a decay time acceptance function $\epsilon(t)$ changes the time integrated value of the WS to RS ratio. In order to determine the true ratio a correction factor has to be applied.

The decay time acceptance is determined from data. The mixing parameters needed to calculate the correction factor are taken from HFAG [2]. The correction factor is calculated to be $c_{\text{acc}} = 0.926$ and varies with the mixing parameters. Its uncertainty is neglected since this is an uncertainty on a correction of 7.4 %.

	WS/RS of $D \to K\pi$ decays (%)
R_{meas}	0.442 ± 0.033 (stat.) ± 0.042 (sys.)
R_{corr}	0.409 ± 0.031 (stat.) ± 0.039 (sys.)
R(PDG)	0.380 ± 0.018

Table 1: Measured and decay time acceptance corrected ratio of WS to RS $D^0 \to K\pi$ decays. The last line gives the world average. [3]

4 Summary

The acceptance corrected value (R_{corr}) agrees very well with the world average as shown in Table 1. This demonstrates that the signal composition in data is well understood and that this analysis is a first step towards a time dependent analysis which will allow to extract the mixing parameters R_{D}, x'^2, y'. Due to improvements of the trigger settings, the systematic error is expected to reduce significantly with 2011 data. [6]

References

[1] The LHCb collaboration, Journal of Instrumentation (JINST) **3**, S08005 (2008).

[2] http://www.slac.stanford.edu/xorg/hfag/charm/index.html;
D. Asner *et al.* (Heavy Flavor Averaging Group), [arXiv:1010.1589v2].

[3] K. Nakamura *et al.* (Particle Data Group), J. Phys. G **37**, 075021 (2010).

[4] B. Aubert et al. (BABAR Collab.), Phys. Rev. Lett. **98**, 211802 (2007);
T. Aaltonen et al. (CDF Collab.), Phys. Rev. Lett. **100**, 121802 (2008);
M. Staric et al. (Belle Collab.), Phys. Rev. Lett. **98**, 211803 (2007).

[5] W. Verkerke and D.P. Kirkby, [arXiv:physics/0306116].

[6] [LHCb Collaboration], LHCb-CONF-2011-029