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Measurement of the difference of time-integrated CP asymmetries in $D^0 \to K^-K^+$ and $D^0 \to \pi^-\pi^+$ decays at LHCb

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Summary. — This document reports on the measurement of the *CP* asymmetries difference, ΔA_{CP}, in $D^0 \to K^-K^+$ and $D^0 \to \pi^-\pi^+$ decays, obtained using the data collected at LHCb in 2011 and 2012, corresponding to an integrated luminosity of $3\,\text{fb}^{-1}$. The measured value of $\Delta A_{CP} \equiv A_{CP}(K^-K^+) - A_{CP}(\pi^-\pi^+)$ is $(-0.10 \pm 0.08\ (\text{stat}) \pm 0.03\ (\text{syst}))\%$. This result is the most precise measurement, obtained from a single experiment, in the search of direct *CP* violation in the D^0 meson decays.

1. – Introduction

Violation of charge-parity (*CP*) symmetry in weak decays of charmed hadrons, which is expected to be below the percent level [1-3], has never been observed. This document presents a measurement of the difference between the time-integrated *CP* asymmetries in $D^0 \to K^-K^+$ and $D^0 \to \pi^-\pi^+$ decays, performed with pp collision data corresponding to an integrated luminosity of $3\,\text{fb}^{-1}$ collected using the LHCb detector at centre-of-mass energies of 7 and 8 TeV. The inclusion of charge-conjugate decay modes is implied throughout except in the definition of asymmetries.

The time-dependent *CP* asymmetry for D^0 meson decaying to a *CP* eigenstate f is defined as

$$A_{CP}(f;t) \equiv \frac{\Gamma(D^0(t) \to f) - \Gamma(\overline{D}^0(t) \to f)}{\Gamma(D^0(t) \to f) + \Gamma(\overline{D}^0(t) \to f)}, \tag{1}$$

where Γ denotes the decay rate.

The raw asymmetry, $A_{\text{raw}}(f)$, measured for D^0 decays to a final state f is defined as

$$A_{\text{raw}}(f) \equiv \frac{N(D^{*+} \to D^0(f)\pi_s^+) - N(D^{*-} \to \overline{D}^0(f)\pi_s^-)}{N(D^{*+} \to D^0(f)\pi_s^+) + N(D^{*-} \to \overline{D}^0(f)\pi_s^-)}, \tag{2}$$

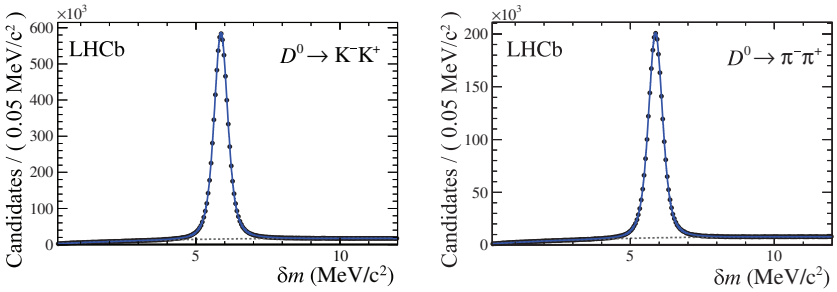

Fig. 1. – Fit to the δm spectra, for $D^0 \to K^-K^+$ (left) and $D^0 \to \pi^-\pi^+$ (right). The dashed line corresponds to the background component in the fit.

where N is the number of reconstructed signal candidates for decays in the the two channels K^-K^+ and $\pi^-\pi^+$. It can be demonstrated that the difference between the time-integrated CP asymmetries $A_{CP}(f)$ can be written, up to $\mathcal{O}(10^{-6})$, as

$$\Delta A_{CP} \equiv A_{CP}(K^-K^+) - A_{CP}(\pi^-\pi^+) = A_{\rm raw}(K^-K^+) - A_{\rm raw}(\pi^-\pi^+). \tag{3}$$

2. – Event selection and fit

The $D^0 \to \pi^-\pi^+$ and $D^0 \to K^-K^+$ candidates are required to come from the primary pp interaction vertex (PV). The flavour of the D^0 meson is identified using the charge of the soft pion π_s. Fiducial requirements are imposed to exclude kinematic regions having a large asymmetry in the soft pion reconstruction efficiency.

The data sample is split in eight independent subsamples according to the centre-of-mass energy, magnet polarity and trigger category. Signal yields and $A_{\rm raw}(K^-K^+)$ and $A_{\rm raw}(\pi^-\pi^+)$ are obtained from minimum χ^2 fits to binned δm distributions, where $\delta m \equiv m(h^+h^-\pi_s^+) - m(h^+h^-) - m(\pi_s^+)$, with $h = K, \pi$ (see fig. 1).

3. – Results

The eight independent measurements are consistent, and their weighted average is [4]

$$\Delta A_{CP} = (-0.10 \pm 0.08\ (\text{stat}) \pm 0.03\ (\text{syst}))\%. \tag{4}$$

This is the most precise measurement of a time-integrated CP asymmetry in the charm sector from a single experiment.

The combination of this result with the previous measurements of CP asymmetries in LHCb [5-7] allows to compute

$$a_{CP}^{\rm ind} = (0.058 \pm 0.044)\%, \tag{5}$$

$$\Delta a_{CP}^{\rm dir} = (-0.061 \pm 0.076)\%, \tag{6}$$

where $a_{CP}^{\rm ind}$ denotes the indirect CP asymmetry and $\Delta a_{CP}^{\rm dir}$ is the difference between the direct CP asymmetries.

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