Study of a new kinematic weighting algorithm for the measurement of CP asymmetries in charm decays

LHCb Collaboration

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Abstract

We investigate the asymmetries that occur in charm decays at the LHCb, specifically we study $D^{\star +} \to D^0\pi^+$ and $\bar{D}^{\star -} \to D^0\pi^-$ where $D^0 \to K^-K^+$ or $D^0 \to \pi^-\pi^+$. We study the effect of CP and detection asymmetries on MC samples generated via RapidSim and implement a new kinematic weighting function which allows us to keep events that are otherwise discarded from LHCb data, since they are associated with large detection asymetries.

1 Introduction

We investigate charm decays and specifically the $D^\star$ meson. By studying the differences between $D^{\star+}$ and $D^{\star-}$ decays shown in Fig. 1 we can estimate the CP asymmetry in charm decays.

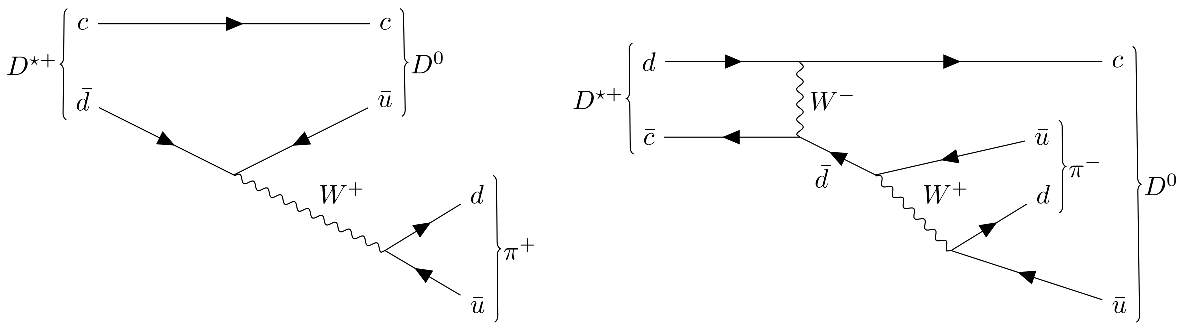

Figure 1: Feynman diagram showing $D^{\star\pm} \to D^0\pi^\pm$ decays.

The total asymmetry one observes at an experiment is a combination of multiple asymmetries. Namely, the total asymmetry consists of a *CP asymmetry* and a *detection asymmetry*. The former is associated with the difference between matter and anti-matter, while the latter is associated with the differences while detecting the soft pion (π_s) that is produced during the decay.

The total asymmetry can be estimated using

$$A_{\text{total}} = \frac{A_{CP} + A_{\mathrm{D}}}{1 + A_C A_{\mathrm{D}}} \tag{1}$$

where A_{CP} and A_{D} are the CP and *integrated detection asymmetries*. The latter can be calculated through

$$A_{\mathrm{D}} = \frac{\int \mathrm{d}\vec{p} N(\vec{p}) A_{\mathrm{D}}(\vec{p})}{\int dd\vec{p} N(\vec{p})} \tag{2}$$

At the LHCb one observes large pion detection asymmetries that are associated with specific kinematic regions, which so far have been discarded, thus reducing the statistics. We can, however, introduce a *weighting function* that allows us to keep events associated with large asymmetries. Such a weighting function can be expressed as the following ratio

$$Q(\vec{p}_{D^\star}, \vec{p}_{\pi_s}) \simeq \frac{\Gamma^{\pi\pi}_{D^0}(\vec{p}_{D^\star} - \vec{p}_{\pi_s}) + \Gamma^{\pi\pi}_{\bar{D}^0}(\vec{p}_{D^\star} - \vec{p}_{\pi_s})}{\Gamma^{KK}_{D^0}(\vec{p}_{D^\star} - \vec{p}_{\pi_s}) + \Gamma^{KK}_{\bar{D}^0}(\vec{p}_{D^\star} - \vec{p}_{\pi_s})} \tag{3}$$

where $\Gamma^{\pi\pi/KK}_{D^0/\bar{D}^0}$ are the normalized distributions of D^0 candidates. Unfortunately in Run-2 such candidates were discarded, thus, we do not have a large enough sample to accurately calculate the weighting function, thus we resort to Monte Carlo simulations.

2 Analysis

2.1 RapidSim

References

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