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

LHCb Collaboration

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1 Introduction

We use a high statistics sample to calculate more accurately the weighting function which is given by

$$Q(\vec{p}_{D^\star}, \vec{p}_{\pi_s}) \simeq \frac{\Gamma^{\pi\pi}_{D^0}(\vec{p}_{D^\star} - \vec{p}_{\pi_s}) + \Gamma^{\pi\pi}_{\bar{D}^0}(\vec{p}_{D^\star} - \vec{p}_{\pi_s})}{\Gamma^{KK}_{D^0}(\vec{p}_{D^\star} - \vec{p}_{\pi_s}) + \Gamma^{KK}_{\bar{D}^0}(\vec{p}_{D^\star} - \vec{p}_{\pi_s})} \tag{1}$$

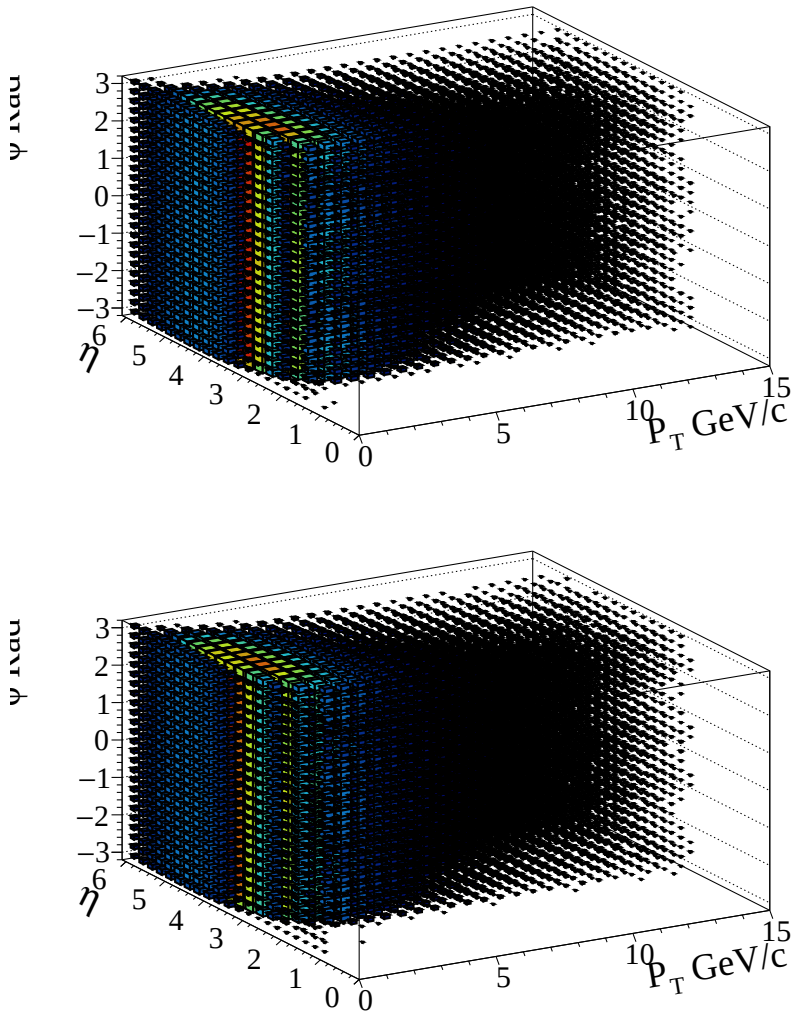

Figure 1: Normalized distributions for $D^0 \to K^-K^+$ (top) and $D^0 \to \pi^-\pi^+$ (bottom) without detection asymmetry.

Using the weighting function Eq. 1 we assign weights to the low statistics $D^0 \to K^-K^+$ sample,

thus, we equalize the kinematic distributions of D^0.

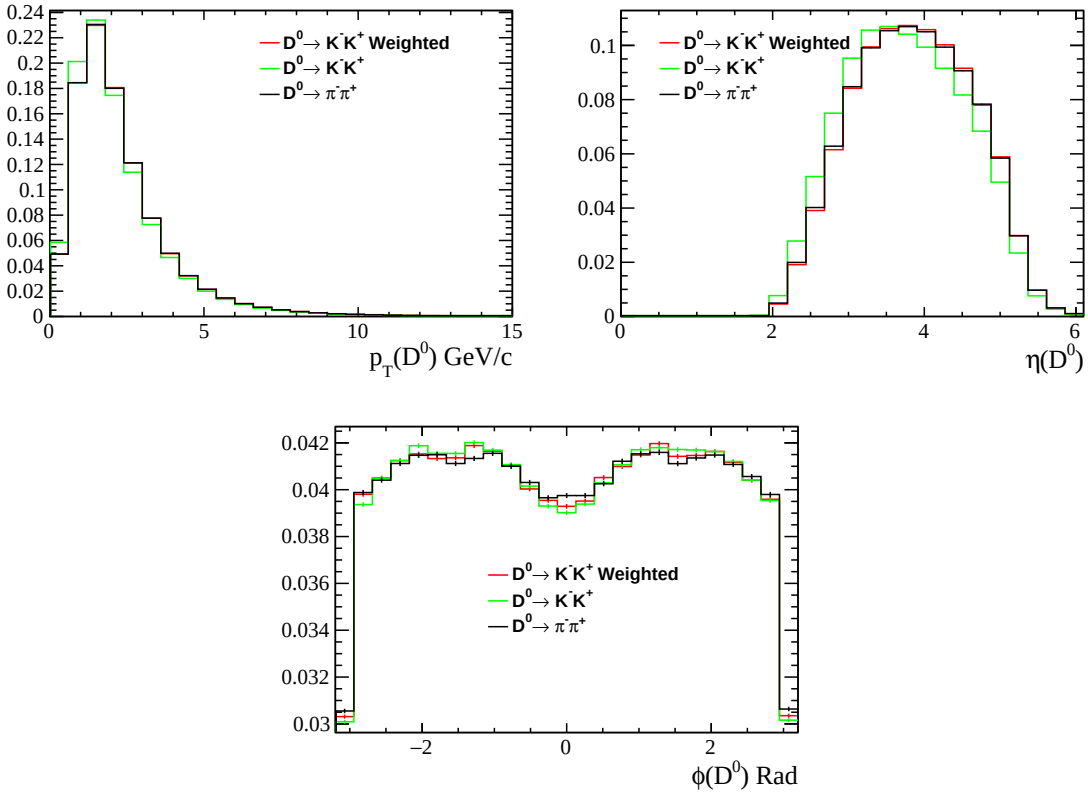

Figure 2: We present the kinematic distributions p_T, η and ϕ of D^0 for the two decay modes, before and after weighting.

We can compare how the total asymmetry is affected. The total asymmetry can be measured using

$$A_{\text{total}} = \frac{N^+ - N^-}{N^+ + N^-} \tag{2}$$

and the error can be estimated using the standard error propagation

$$\sigma A^2_{\text{total}} = \left(\frac{\partial A_{\text{total}}}{\partial N^+}\sigma N^+\right)^2 + \left(\frac{\partial A_{\text{total}}}{\partial N^-}\sigma N^-\right)^2 \tag{3}$$

For the weighted sample, $N^\pm = \sum_i w_i^\pm$ and $\sigma N^\pm = \sqrt{\sum_i (w_i^\pm)^2}$

	Asymmetry	Weighted	Unweighted
With Detection Asymmetry	A_{total}	0.14994 ± 0.00066	0.16268 ± 0.00064
Without Detection Asymmetry	A_{total}	0.14726 ± 0.00066	0.16268 ± 0.00064

Table 1: Total asymmetry for $D^0 \to K^-K^+$ sample with and without weights.

For the $D^0 \to \pi^-\pi^+$ sample the total calculated asymmetry is

$$A_{\text{total}} = 0.24571 \pm 0.00067 \tag{4}$$

The total asymmetry difference results are shown in Tab. 2

With detection asymmetry		
	Weighted	Unweighted
ΔA_{total}	-0.09578 ± 0.00094	-0.08304 ± 0.00092
Deviation (σ)	4.49	4.59
Without detection asymmetry		
	Weighted	Unweighted
ΔA_{total}	-0.09845 ± 0.00094	-0.08304 ± 0.00092
Deviation (σ)	1.64	4.59

Table 2: Total asymmetry for $D^0 \to K^-K^+$ sample with and without weights.

where the CP asymmetry for each sample is

	$D^0 \to K^-K^+$	$D^0 \to \pi^-\pi^+$
A_{CP}	0.1	0.2

Furthermore, we compare the kinematics of $D^\star$ and π_s to see whether or not the distributions are equalized after the weighting.

As we can see, the kinematics of $D^0 \to K^-K^+$ and $D^0 \to \pi^-\pi^+$ samples match after the weighting which is expected, thus we conclude that the weighting is done correctly.

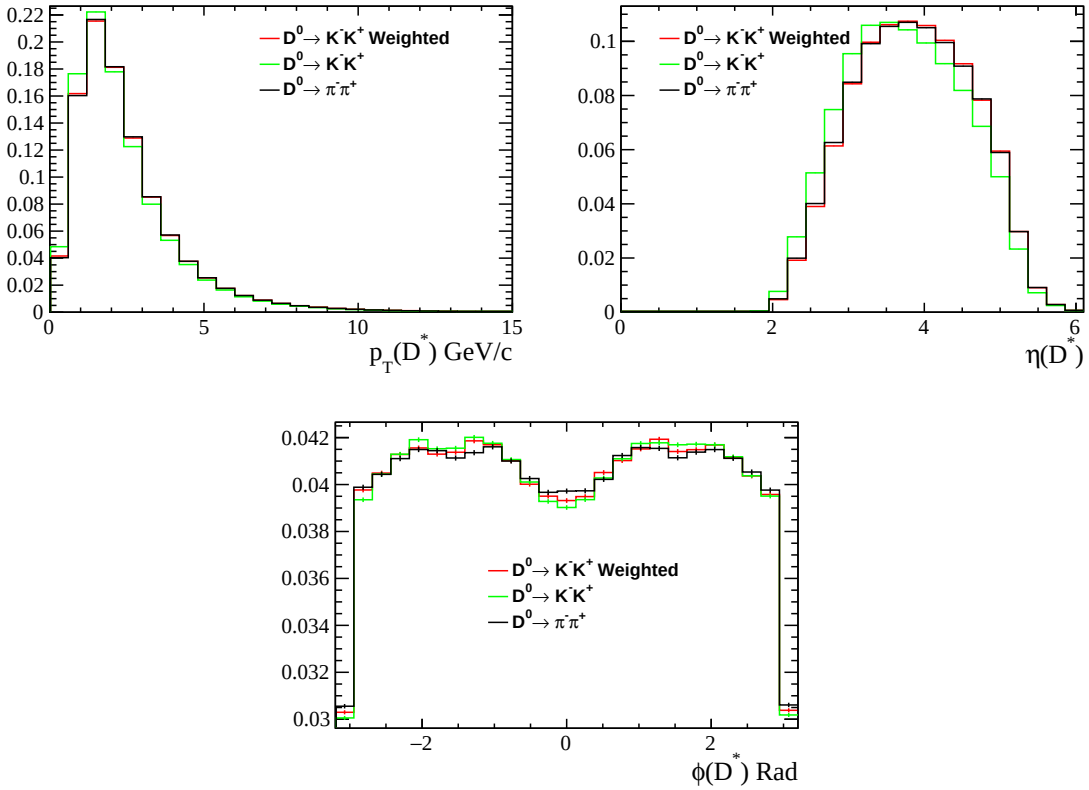

Figure 3: We present the kinematic distributions p_T, η and ϕ of $D^\star$ for the two decay modes, before and after weighting.

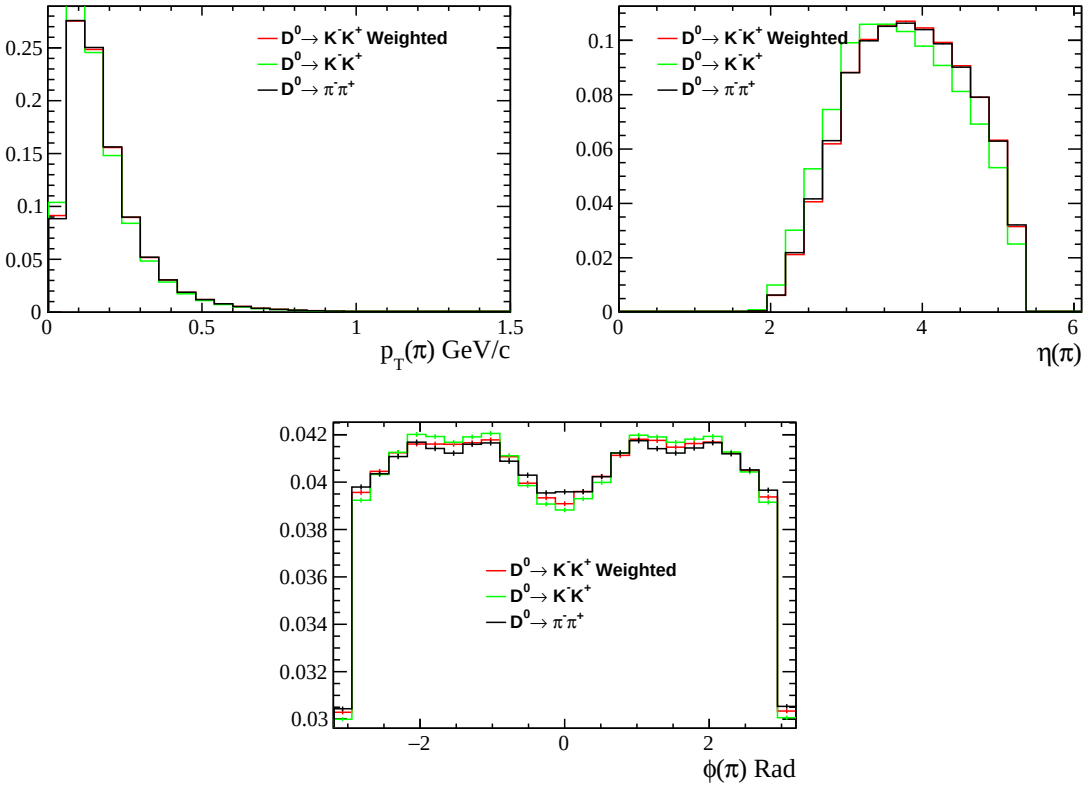

Figure 4: We present the kinematic distributions p_T, η and ϕ of π_s for the two decay modes, before and after weighting.