



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

LHCb Collaboration

Georgios Christou

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# 1 Introduction

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

$$Q(\vec{p}_{D^*}, \vec{p}_{\pi_s}) \simeq \frac{\Gamma_{D^0}^{\pi\pi}(\vec{p}_{D^*} - \vec{p}_{\pi_s}) + \Gamma_{\bar{D}^0}^{\pi\pi}(\vec{p}_{D^*} - \vec{p}_{\pi_s})}{\Gamma_{D^0}^{KK}(\vec{p}_{D^*} - \vec{p}_{\pi_s}) + \Gamma_{\bar{D}^0}^{KK}(\vec{p}_{D^*} - \vec{p}_{\pi_s})} \quad (1)$$

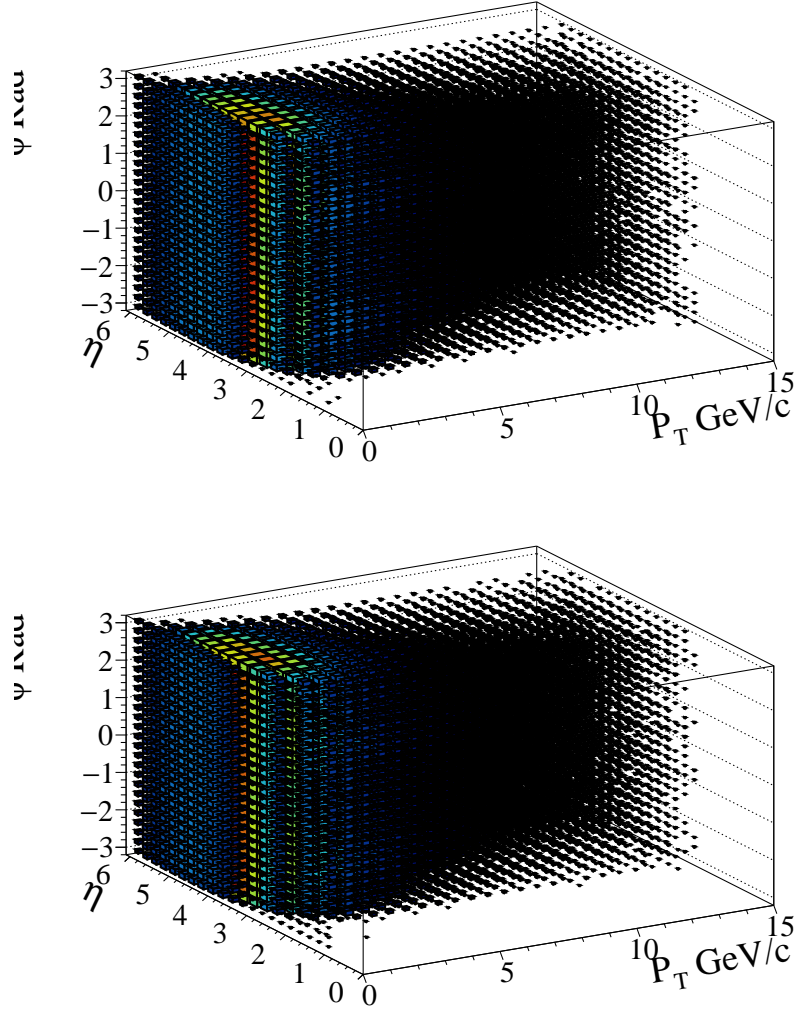


Figure 1: Normalized distributions for  $D^0 \rightarrow K^- K^+$  (top) and  $D^0 \rightarrow \pi^- \pi^+$  (bottom).

Using the weighting function Eq. 1 we assign weights to the low statistics  $D^0 \rightarrow K^- K^+$  sample, thus, we equalize the kinematic distributions of  $D^0$ .

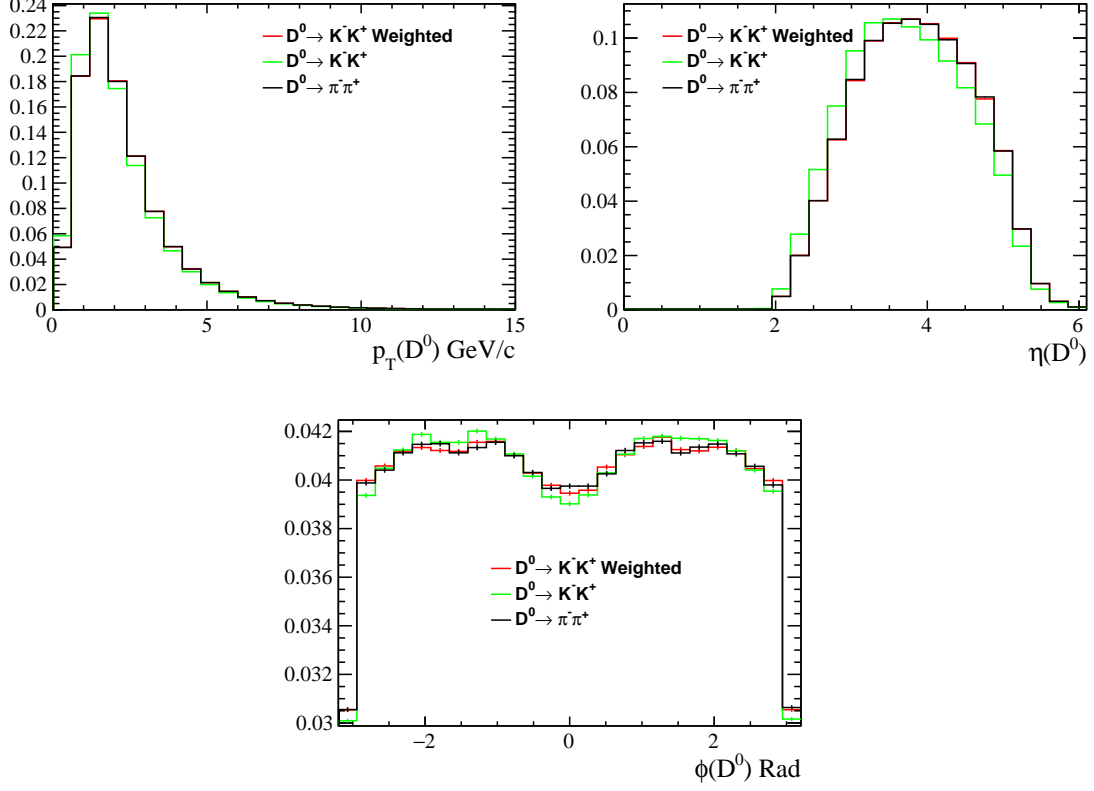


Figure 2: We present the kinematic distributions  $p_T$ ,  $\eta$  and  $\phi$  of  $D^0$  for the two decay modes, before and after weighting.

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

$$A_{\text{total}} = \frac{N^+ - N^-}{N^+ + N^-} \quad (2)$$

and the error can be estimated using the standard error propagation

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

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

	Weighted	Unweighted
$A_{\text{total}}$	$0.14994 \pm 0.00064$	$0.16268 \pm 0.00064$

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

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

$$A_{\text{total}} = 0.24571 \pm 0.00067 \quad (4)$$

Calculating the total asymmetry difference, we get

$$\Delta A_{\text{total}} = 0.09578 \pm 0.00093 \quad (5)$$

which deviates  $4.55\sigma$  from the expected value.

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

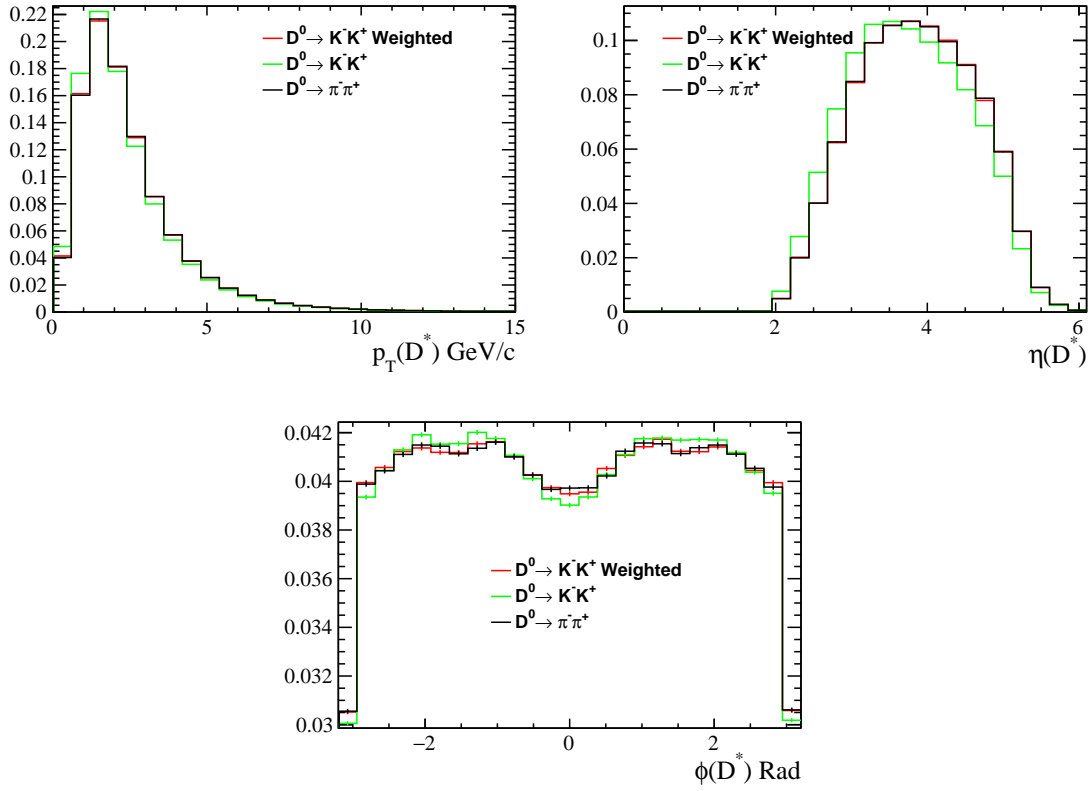


Figure 3: We present the kinematic distributions  $p_T$ ,  $\eta$  and  $\phi$  of  $D^*$  for the two decay modes, before and after weighting.

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

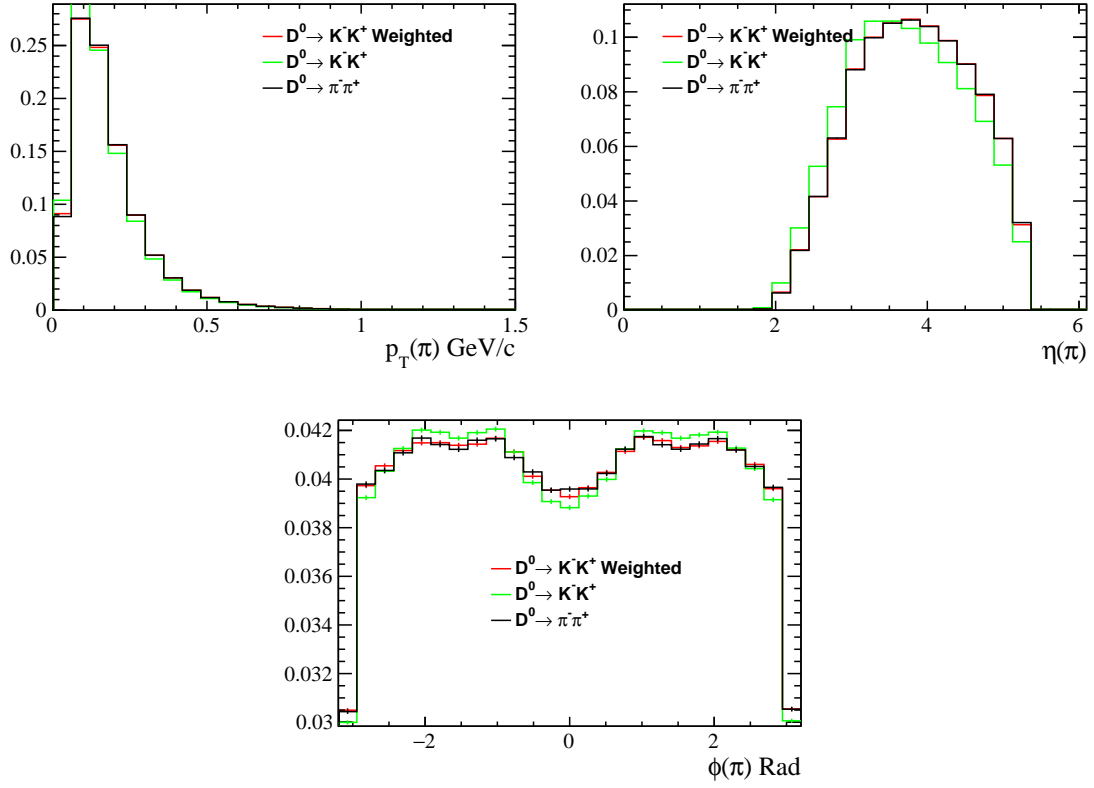


Figure 4: We present the kinematic distributions  $p_T$ ,  $\eta$  and  $\phi$  of  $\pi_s$  for the two decay modes, before and after weighting.