TP-9 Report

Detector induced asymmetry in CP violation measurements

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Abstract

The aim of this work is to study the detector-induced asymmetry in a CP violation experimental measurement. In particular, the chosen case is the singly–Cabibbo–suppressed D^0 decay to CP final states done at LHCb. The measurement of the CP asymmetry A_{CP} is strongly affected by systematical uncertainties induced by the esperimental set up (detector shape and material). In order to control them, we studied this induced asymmetry in the Cabibbo–favoured $D^* \to D^0(\to K\pi)\pi_s$ which helps in the suppression of systematical errors. Through the study of MC data samples and real data we were able to quantify it and account for this detector effects in the evaluation of the final observable.

Contents

Introduction

The Standard Model (SM) is the most accurate model of modern particle physics, describing three out of four interactions between fundamental particles - electromagnetic, weak and strong interaction. However many questions about nature remain unanswered. One interesting example is the explanation of the matter-antimatter difference in the early universe, leading to today's abundance of normal matter and the basis of our existence. Part of this is the difference between the behavior of a particle compared to it's charge and parity mirrored partner. In the SM, the masses of charged fermions and $W^{\pm}$ and Z^0 originate from Yukawa interactions after Spontaneous Symmetry Breaking (SSB).

$$SU(3)_C \times SU(2)_W \times U(1)_Y \rightarrow SU(3)_C \times U(1)_{EM}$$

In the Lagrangian this is described by

$$-\mathcal{L}_{SM,Y} = \bar{Q}_{L_i} (Y_u)_{ij} \Phi^C U_{R_j} + \bar{Q}_{L_i} (Y_d)_{ij} \Phi D_{R_j} + \bar{L}_{L_i} (Y_e)_{ij} \Phi E_{R_j}$$

The highlighted terms $Y_{u,d,e}$ are the complex, non-diagonal 3×3 Yukawa matrices. In the quark sector the two matrices Y_u and Y_d can not be diagonal in the flavor basis. By changing to the mass basis they can be written as

$$V_{L,q} Y_q V^{\dagger}_{R,q} \text{ , with } V_{L/R,q} V^{\dagger}_{L/R,q} = \mathbb{1}$$

Applying this onto the charged weak interaction

$$\begin{aligned}\mathcal{L}_{CC} &= \bar{U}_L \overbrace{\mathbb{1}}^{V^{\dagger}_{L,u} V_{L,u}} \gamma^{\mu}(1-\gamma_5) W^{+}_{\mu} \overbrace{\mathbb{1}}^{V_{L,d} V^{\dagger}_{L,d}} D_L + h.c. \\ &= \tilde{\tilde{\bar{U}}}_L \gamma^{\mu}(1-\gamma_5) W^{+}_{\mu} \underbrace{V_{CKM}}_{V_{L,u} V^{\dagger}_{L,d}} \tilde{D}_L + h.c.\end{aligned}$$

leads to the definition of the Cabibo-Kobayashi-Maskawa matrix V_{CKM}, thanks to which flavour mixing between quarks is introduced. It is a unitary matrix which correlates the weak eigenstates to the mass eigenstates such that:

$$\begin{bmatrix} d' \\ s' \\ b' \end{bmatrix} = \begin{bmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{bmatrix} \begin{bmatrix} d \\ s \\ b \end{bmatrix}. \tag{1}$$

This means that interactions between up-like and down-like quarks holding to different families are possible and their strength is given by the coefficients of the CKM matrix, as shown in Fig.(1). This matrix can be parametrized in many ways, but the number of free parameters keep always being four. In the most common parametrization: three rotation angles (θ_{ij}) and one complex phase (δ), resulting in

$$V_{CKM} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{bmatrix} \times \begin{bmatrix} c_{13} & 0 & s_{13}e^{-i\delta} \\ 0 & 1 & 0 \\ -s_{13}e^{i\delta} & 0 & c_{13} \end{bmatrix} \times \begin{bmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{bmatrix} \tag{2}$$

where $s_{ij} = sin\theta_{ij}$ and $c_{ij} = cos\theta_{ij}$.
Because of the unitarity of V_{CKM}, the weak neutral current, defined as

$$\mathcal{L}_{CC} \propto Z_{\mu} \bar{Q} \gamma^{\mu}(v - a\gamma_5) Q$$

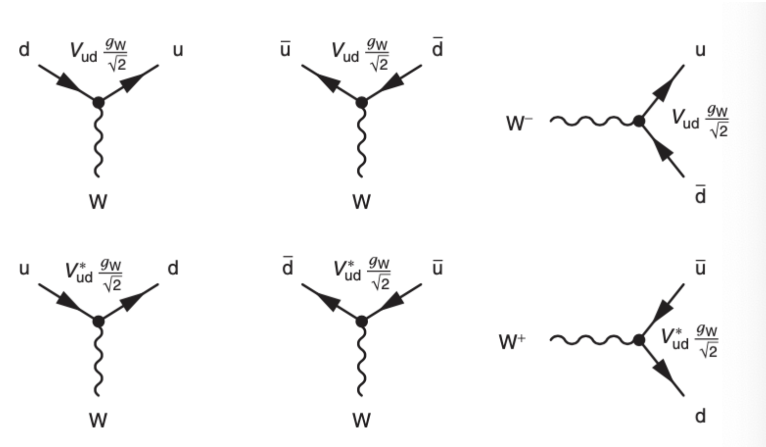


Figure 1: The charged-current weak interaction vertices involving u and d quarks.

does not allow flavour mixing within same charged quarks of different families as a tree level process. Since the type of the participating quark is the same - either $\bar{U}U$ or $\bar{D}D$ - any introduction of $V_{L/R,q}V^{\dagger}_{L/R,q}$ is canceled out. However, flavour changing neutral currents are introduced as a second order one, giving rise to the well know *flavour oscillations*. Box diagrams are introduced for the description of those interactions Fig.(2).

The study of those processes in neutral mesons' systems has helped in the understanding

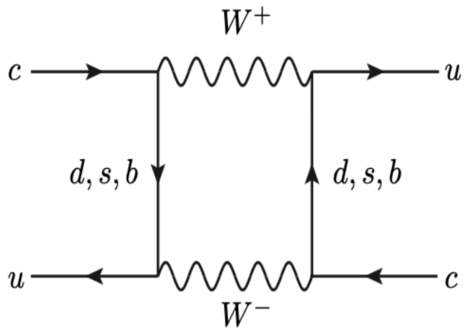


Figure 2: Flavour oscillation in a $D^0\,\bar{D}^0$ system.

of CKM matrix hence CP violation. These particles (K^0, B^0, B^0_s, D^0) are produced as flavour eigenstates either in combination with an opposite-flavoured hadron by the strong and electromagnetic interaction or as single mesons in the weak decay of heavier particles. Because of the box diagram introduced above, the wavefunction of a produced neutral meson which propagates in time is a superposition of the two flavour eigenstates

$$|\psi(t)\rangle = a(t)|M^0\rangle + b(t)|\bar{M^0}\rangle. \tag{3}$$

The consquence is that the flavour eigenstates M^0 and $\bar{M^0}$ are not anymore eigenstates of the free Hamiltonian governing their time evolution hence it would take the non-diagonal form

$$H = \begin{bmatrix} H_{11} & H_{12} \\ H_{21} & H_{22} \end{bmatrix} \tag{4}$$

The diagonalization of the Hamiltonian brings to the definition of the mass eigenstates M_1 and M_2 and, given the the non-null probability to oscillate into their antiparticles through the mixing phenomena, introduces the complex factor ξ defined as

$$\pm\xi = \sqrt{\left(\frac{M_{12}^{*} - \frac{i}{2}\Gamma_{12}^{*}}{M_{12} - \frac{i}{2}\Gamma 12}\right)} \tag{5}$$

where M_{12} and Γ_{12} are respectively the mass matrix and the decay rate given by the contribution of the box diagram introduced by the flavour mixing. This parameter quantify the CP violation in a general neutral mesons' system as it can be $\neq 1$ only if the imaginary part of the CKM, which contributes both in M_{12} and Γ_{12}, is non-null.
The key parameter for the study of the CP violation is the δ CP phase of the CKM matrix and how it was shown the mathematical treatment of the neutral mesons' oscillation gives rise to some complex factors which are strictly related to this phase and it's measurement of being different from zero is a clear hint of the existence of CP violation in nature.
There are three ways of studying CP violation in processes:

1. in *decays*:
$$\Gamma(M \to X) \neq \Gamma(\bar{M} \to \bar{X}); \tag{6}$$
2. in *mixing*
$$\Gamma(M \to \bar{M}) \neq \Gamma(\bar{M} \to M); \tag{7}$$
3. interference between mixing and decay
$$\Gamma(M \to \bar{M} \to f) \neq \Gamma(\bar{M} \to f); \tag{8}$$

Many experiments have achieved important results in this study, from CPLEAR with the $K^0\,\bar{K}^0$ system to BaBar with the $B^0\,\bar{B}^0$ one and nowadays one of the most fruitful experiment aimed to this measurement in different mesons' system is the LHCb collaboration at CERN.
The observable which is taken into account is called *asymmetry* and experimentally is based on counting the number of interesting events. Its theoretical definition takes into account the probability of happening of a certain event, which has embedded inside the parameters which gives information on the violation. Through a fit of the asymmetry calculated experimentally, the parameters would be inferred. For this reason, it is fundamental to have a good knowledge of all the sources which would influence experimentally the reconstruction and counting of the important events and the aim of this report is in particular to study the effects of the detector on the measurement of the asymmetry in a measurement performed at LHCb: the singly–Cabibbo–suppressed D^0 decay to CP final states (K^+K^- or $\pi^+\pi^-$).

1. Physical problem

The searches of CP violation in the charm sector can be made through the singly–Cabibbo–suppressed D^0 decay to CP final states, which being suppressed, requires a high level control of the systematic uncertainties, especially of the asymmetries in detecting and reconstructing particles with opposite charges [1]. The observable which needs to be measure is the CP asymmetry $A_{CP}(\bar{D}^0 \to h^+h^-)$, which experimental value is defined as:

$$A_{CP}(D^0) = \frac{N_{D^0}^{obs} - N_{\bar{D}^0}^{obs}}{N_{D^0}^{obs} + N_{\bar{D}^0}^{obs}} \tag{9}$$

where $N^{obs}_{D^0}$ is the number of D^0 mesons decaying into the selected final state ($\pi^+\pi^-$ or K^+K^-). In order to naturally suppress systematic uncertainties due to detector effects the channel $D^{*+/-} \rightarrow D^0/\bar{D}^0(\rightarrow K^{-/+}\pi^{+/-})\pi_s^{+/-}$ was studied, where π_s is the soft pion. This decay is not suppressed by Cabibbo factors and therefore has only one dominating amplitude, so that only a negligible real CP violation is expected.
This measurement was brought up by the LHCb collaboration, the detector is shown in Fig.(3). The flavour of the neutral charmed meson is inferred thought the reconstruction of the soft pion, hence for the measurement of the asymmetry the capability of recognizing the charge of π_s is extremely important and it is one of the crucial points.
The two main detector effects which need to be taken into account are:

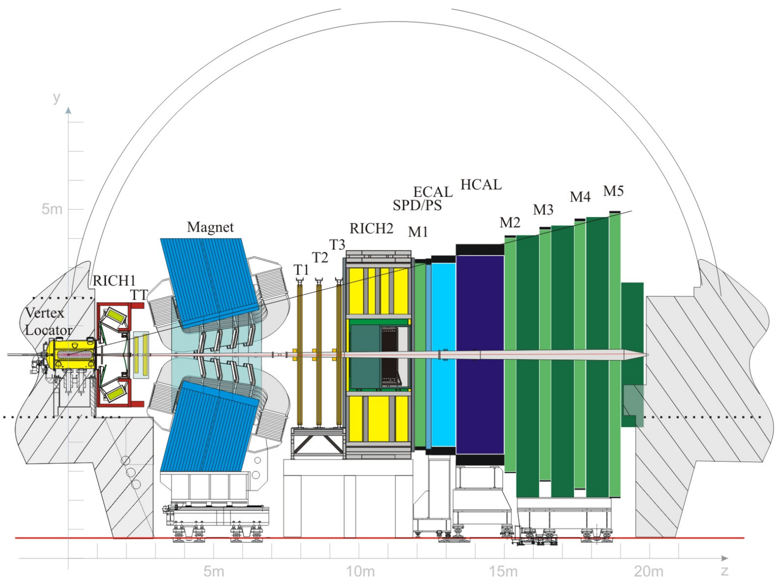


Figure 3: Experimental set up of the LHCb experiment.

1. the different *cross section* of matter and antimatter with the detector material, which gives an asymmetry in the number of K^+ and K^-;
2. the fact that the detector is not entirely symmetric, hence the number of reconstructed particles, given a magnetic field polarity, will depend on the charge of the particle. This will affect the capability of reconstruction π_s^+ and π_s^- for a given B field.

An example of this last effect is shown in Fig.(4) where the π_s^- is well reconstructed while π_s^+ is not. Hence our work is focused on the study of these detector induced asymmetries

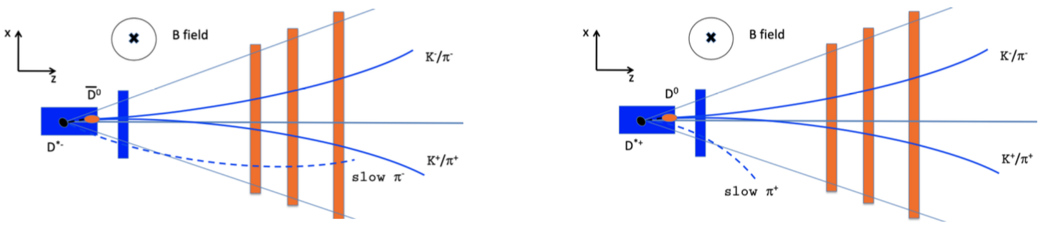


Figure 4: For a given B field, because of the asymmetry in the geometry of the detector, π_s^- is well reconstructed while π_s^+ is not.

both in a MC simulation and in a real data set from Run 2, with a final comparison. We have tried to figure out how those effects had influenced the reconstruction identifying some key kinematic and topological variables of the events which could strongly contribute to enhance the geometrical asymmetries of the experimental apparatus, as the low momentum which characterize the soft pion in Fig.(4).

2. Monte Carlo simulation

2.1. Reconstruction efficiencies

As mentioned above, the asymmetry in the geometry of the detector brings us to expect different numbers of positive and negative soft pions and the same for kaons because of the different interaction cross section. To rule out production asymmetries we looked at a MC simulation of $N = 3 \times 10^6$ D^{*+} and D^{*-} events each and how many events for each particle it was possible to reconstruct for both polarities of the field (up and down). The results are shown in Tab.(1), where D^0 and D^* are reconstructed when π_s, π and K are.

It is now evident the dominance of the positive kaons in both polarities and the unbalance

DOWN	π	K	π_s	$D^0 = \pi + K$	$D^* = \pi_s + \pi + K$
$N_{rec}\,POS$	2674000 ± 1635	2626350 ± 1620	2374360 ± 1540	2253370 ± 1501	1737460 ± 1318
$N_{rec}\,NEG$	2675660 ± 1636	2598950 ± 1612	2356980 ± 1535	2276140 ± 1508	1740180 ± 1319
UP	π	K	π_s	$D^0 = \pi + K$	$D^* = \pi_s + \pi + K$
$N_{rec}\,POS$	2669990 ± 1634	2620280 ± 1619	2352910 ± 1534	2249370 ± 1500	1720940 ± 1312
$N_{rec}\,NEG$	2670540 ± 1634	2595820 ± 1611	2371060 ± 1540	2270520 ± 1507	1749450 ± 1323

Table 1: Number of events for up and down polarities. $N_{reco}\,pos$ is the number of particle with positive charge reconstructed, while $N_{reco}\,neg$ are the ones with negative charge.

between positive and negative pions depending on the polarity. The first is expected to be the other way round, as the s quark of the negative kaon can additionally excite hyperons with the protons in the detector material leading to a higher cross section. The reason of the latter is not straightforward.

Therefore, in the down configuration the positive soft pions are reconstructed more with respect to the negative one, while in the up configuration the situation is the opposite.

It is possible to study the efficiency of reconstruction which are then useful to understand the capability of reconstructing the charmed mesons D^* and D^0. The efficiencies are reported in Tab.(2). It can be highlighted how the efficiencies of reconstruction for D^* and

DOWN	π	K	π_s	$D^0 = \pi + K$	$D^* = \pi_s + \pi + K$
ϵ *for* D^{*+}	86.70 ± 0.02	84.27 ± 0.02	76.98 ± 0.02	73.06 ± 0.03	56.33 ± 0.03
ϵ *for* D^{*-}	86.66 ± 0.02	85.07 ± 0.02	76.34 ± 0.02	73.72 ± 0.03	56.36 ± 0.02
UP	π	K	π_s	$D^0 = \pi + K$	$D^* = \pi_s + \pi + K$
ϵ *for* D^{*+}	86.66 ± 0.02	84.25 ± 0.02	76.37 ± 0.02	73.01 ± 0.03	55.86 ± 0.03
ϵ *for* D^{*-}	86.65 ± 0.02	85.02 ± 0.02	76.93 ± 0.02	73.67 ± 0.03	56.76 ± 0.03

Table 2: Efficiencies for up and down polarities. ϵ for D^{*+} is the efficiencies which contributes to the reconstruction of $D^{*+} = \pi^+ + K^- + \pi_s^+$, while ϵ for D^{*+} is the efficiencies which contributes to the reconstruction of $D^{*-} = \pi^- + K^+ + \pi_s^-$.

D^0 are different: while in D^0 just the effect given by kaons is present, D^* is affected by

both of them, resulting in a worst efficiency.
Investigating the reasons and origins of the asymmetry in the number of soft pions would help in the correction and suppression of systematics which would influence A_{CP}.
One of the possible reasons could be the displacement of the vertex from zero in the simulated apparatus. The vertex coordinates (x, y, z) of D^* is not centered in (0, 0, 0) but it is displaced in the right part of the detector as shown in Fig.(5). The distributions of the

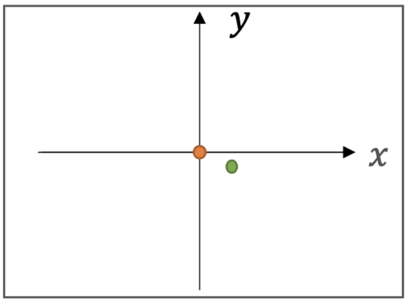


Figure 5: Where the events where produced on average in the MC which we have analyzed.

coordinates are shown in Fig(6) giving for D^{*+} :$(0.84 \pm 0.03,\ -0.18 \pm 0.03,\ -3.093 \pm 37.38)$ and similar for D^{*-} :$(0.84 \pm 0.03,\ -0.18 \pm 0.03,\ -3.078 \pm 37.38)$. The distributions are the

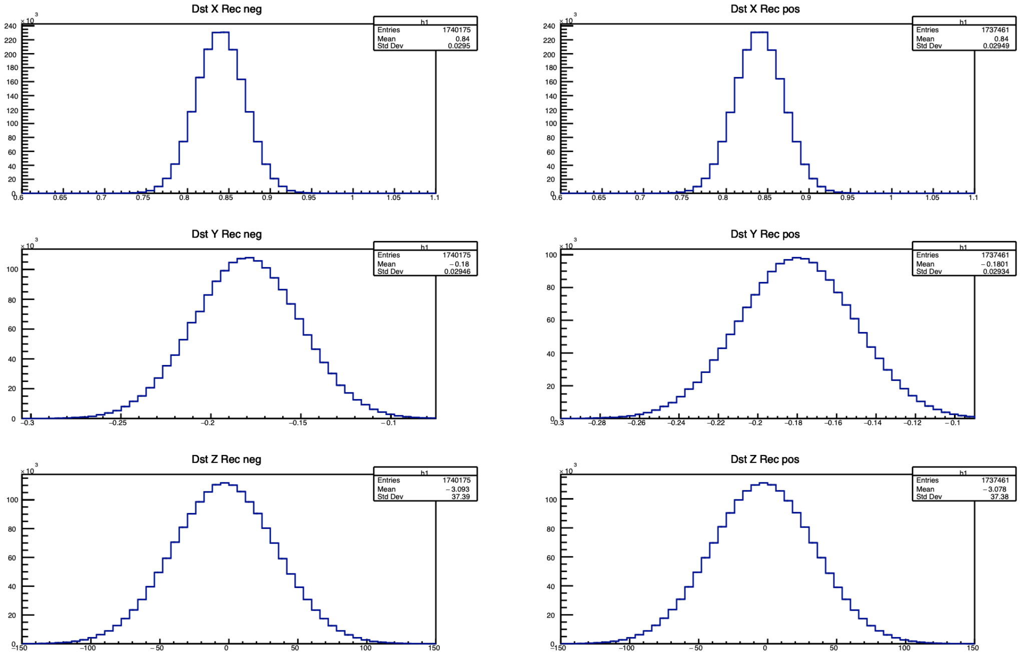


Figure 6: On the left the distribution of x, y, z coordinated of the production vertex for $D{*}{+}$, while on the right fro $D{*}{-}$.

same both for up and down polarities. Looking at the result, one should expect to have more negative soft pions in the up configuration and more positive ones in the down, as we have effectively noticed and shown above. We weren't able to investigate more on this possible cause because no MC with a vertex centered in zero could be made in a reasonable time, hence further studies are needed and in this report it would remain just an hypothesis.

In order to study this dependence, it is needed to identify the kinematic and topological variables characterizing the events which could have ranges of values in which the reconstruction is not equal for positive and negative charged particles, having fixed a polarity. We identified four of those:

- transverse momentum p_T;
- polar angle θ;
- azimuthal angle ϕ;
- pseudorapidity η.

In Fig.(7) the distribution of the four variables are shown for positive (red) and negative (blue) soft pions. In the highlighted zone it is evident how the reconstructions is not equally performed for both and it is different from up to down polarity. This behaviour would not

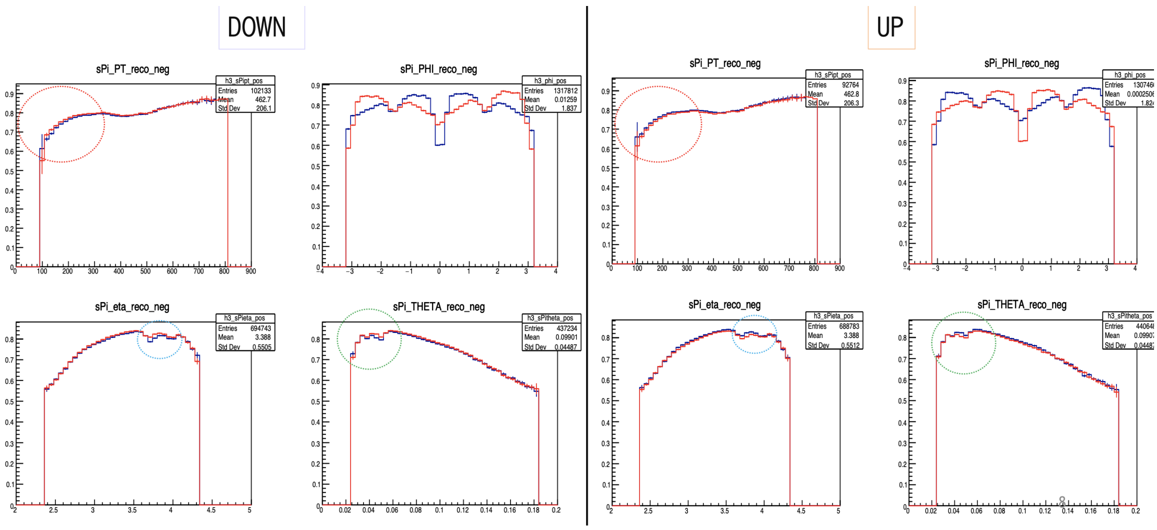


Figure 7: Distribution of the kinematic and topological variables for up (right) and down (left) field polarity. In blue the number of reconstructed negative soft pions as a function of the variable, while in red the number of the positive ones.

be expected if the experimental set up was symmetric in detecting the particle, hence it can be deduced the initial hypothesis of a geometrical irregularity.
In order to highlight this anomaly it is useful to introduce the asymmetry $A = \frac{N_{+}+N_{-}}{N_{+}+N_{-}}$ as a function of the selected kinematic and topological variables as shown in Fig.(8). It is evident from here the unbalance of reconstructed events and, as it was expected, more positive soft pions in the down polarity and more negative ones in the up.

2.2. Time integrated asymmetries

The time integrated CP-asymmetry can be calculated by Eq.(9). The truth information in the MC simulation can be used to determine the asymmetries for each final state particle. The results can be seen in Tab.3

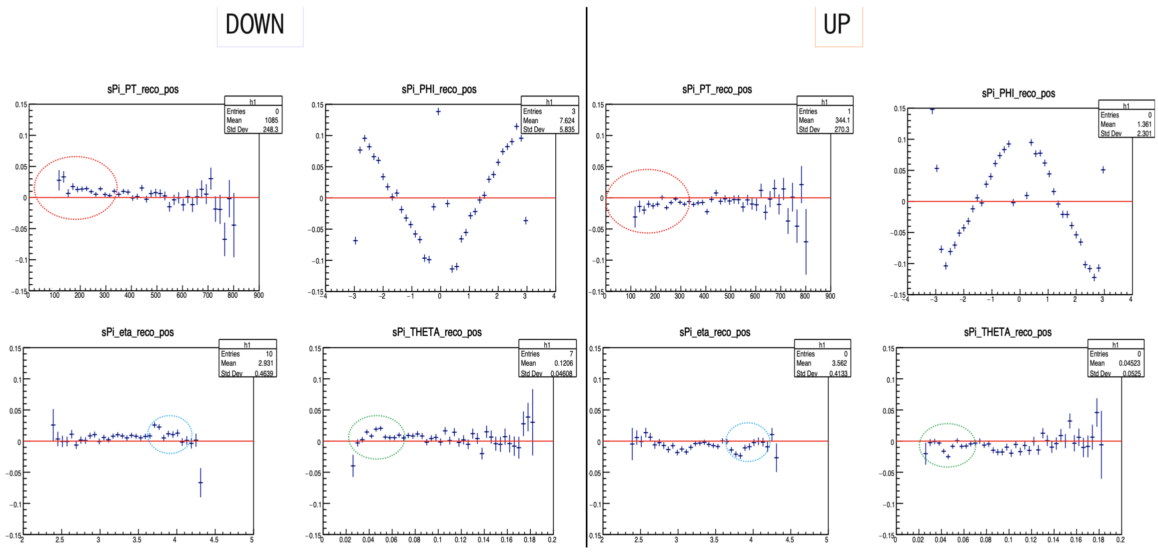


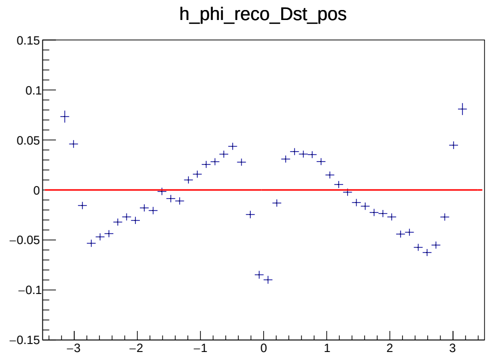
Figure 8: Asymmetries as a function of the kinematic and topological variables for up (right) and down (left) field polarity.

While the π originating from the D^0 shows an asymmetry compatible with 0, the dominant part is the K asymmetry, which is independent of the magnet polarity and only due to the aforementioned different cross sections of $|s\rangle$ and $|\bar{s}\rangle$ in matter. The low p_T pions originating directly from the D^* on the other hand show a clear dependency on the polarity.

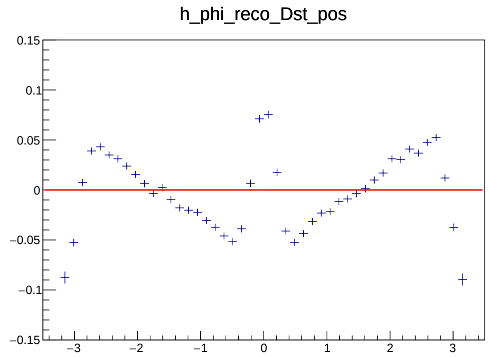
Table 3: The asymmetry $A_{CP} = \frac{N_+ - N_-}{N_+ + N_-}/10^{-3}$ for different final state and mother particles under different magnet polarities.

Polarity	π	K	π_s	D^0	D^*
UP	-0.1 $\pm$ 0.4	4.7 $\pm$ 0.4	-3.8 $\pm$ 0.5	-4.7 $\pm$ 0.5	-8.2 $\pm$ 0.5
$DOWN$	-0.3 $\pm$ 0.4	5.2 $\pm$ 0.4	3.7 $\pm$ 0.5	-5.0 $\pm$ 0.5	-0.8 $\pm$ 0.5
$UP + DOWN$	-0.2 $\pm$ 0.3	5.0 $\pm$ 0.3	-0.1 $\pm$ 0.3	-4.8 $\pm$ 0.3	-4.5 $\pm$ 0.4

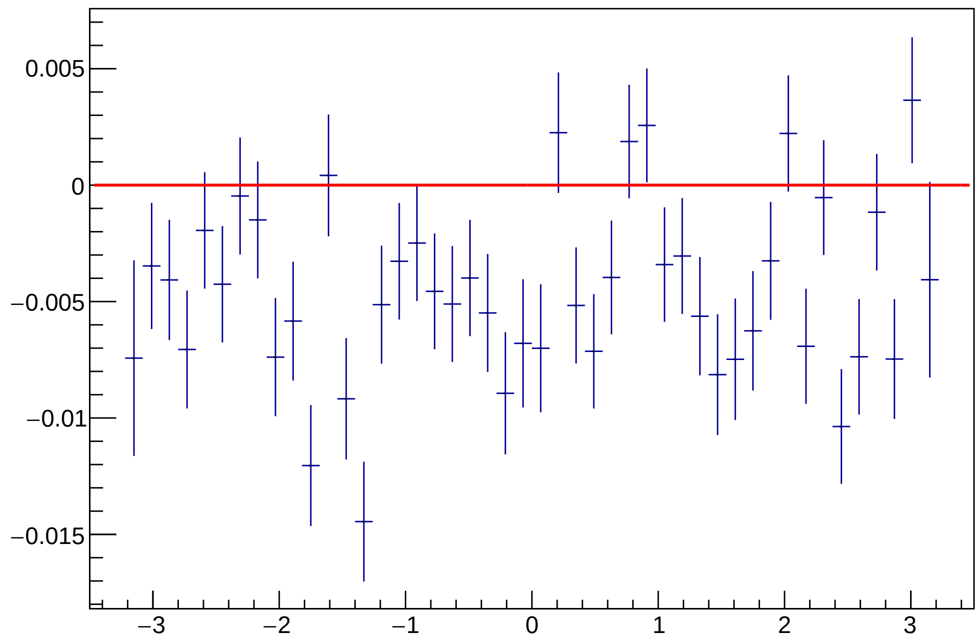
By combining the events recorded with different magnet polarities this source of detector induced asymmetry can be ruled out, like shown in Tab.3.
As already mentioned in Sec.2.1, due to the rectangular shape of the LHCb detector, the efficiency - and therefore the asymmetries - is highly dependent on the azimuthal angle ϕ. The total $A_{CP}(\phi)$ for UP, $DOWN$ and $UP + DOWN$ polarity is shown in Fig.9a - 9c.
By using a combination of different polarisations the dependency on ϕ and therefore on the detector shape can be diminished significantly, so that the resulting $A_{CP}(D^*)$ fluctuates around the total value of $(-4.5 \pm 0.4) \cdot 10^{-3}$. This value is now dominated only by the material induced K asymmetry, so the reconstruction of the π_s, which are important to tag the $D^0/\bar{D}^0$, is now independent from charge.



(a) The asymmetry A_{CP} in dependency of the azimuthal angle ϕ for magnet polarity UP.



(b) The asymmetry $A_{CP}(\phi)$ in dependency of the azimuthal angle ϕ for magnet polarity $DOWN$.



(c) The asymmetry A_{CP} in dependency of the azimuthal angle ϕ for the added samples of magnet polarity UP and $DOWN$.

3. Data analysis

For the data analysis two datasets with different magnet polarities containing $5.5 \cdot 10^6$ $D^* \rightarrow D^0\pi$ events in total are used. The DTF algorithm[2] is used to match mother particles with their decay products. For combinatorial background analysis an empirical model of the form

$$N(m_{D^*}) = (m_{D^*} - a)^b \tag{10}$$

is combined with a Breit-Wigner like signal shape as can be seen in Fig. 10.

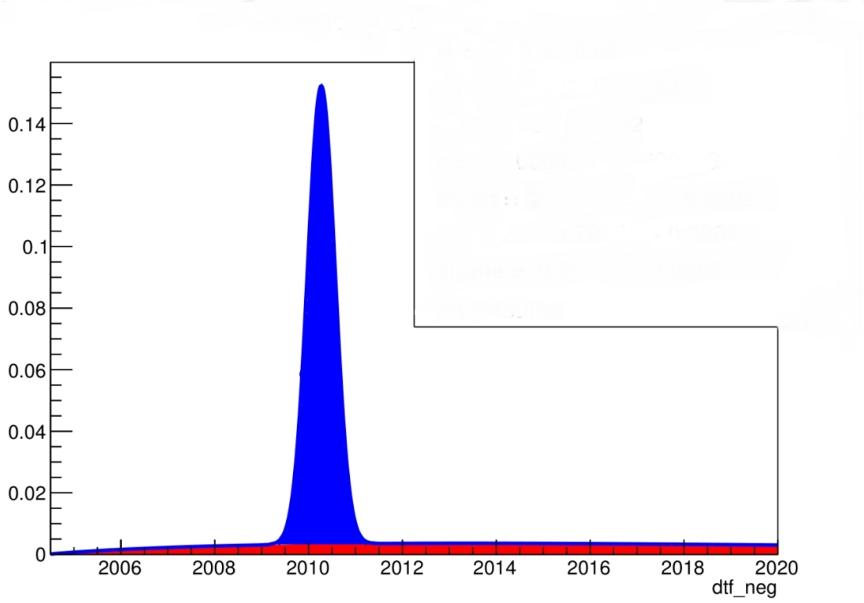


Figure 10: Shape of the model that is used to fit signal and background events in dependence of the reconstructed $m(D^*)$. For the signal(blue) a Breit-Wigner curve is used, while for the combinatorial background(red) an empirical model of the form(10) is used.

The signal region is defined by $2008.5\,\text{MeV} \leq m_{D^*} \leq 2012.5\,\text{MeV}$, while events out of this range are used as a control region for background estimation. For better asymmetry reconstruction, D^{*+} and D^{*-} events are analysed and fitted separately.
The best fit parameters are determined in a multivariate simultaneous analysis using the `RooMinuit` minimizer class[3]. The resulting models for D^{*+} and D^{*-} events with different magnet polarization can be seen in Fig.11. Furthermore, the background and signal distributions are unfolded using the `RooStats::sPlot` class[4], where the signal is used to calculate the asymmetries

$$A_{CP,UP} = (-21.0059 \pm 0.0001) \cdot 10^{-3},$$
$$A_{CP,DOWN} = (-1.22236 \pm 0.00008) \cdot 10^{-3}.$$

To reduce the polarity dependent π_s asymmetry the data sample with UP and DOWN polarity are combined. Since the latter contains significantly more events it is weighted for this process to not induce an artificial asymmetry.
The asymmetry in dependency of ϕ can be used as a control variable to see, if this source of A_{CP} is canceled out and can be seen in Fig12a - 12c. Like in the MC samples the clear

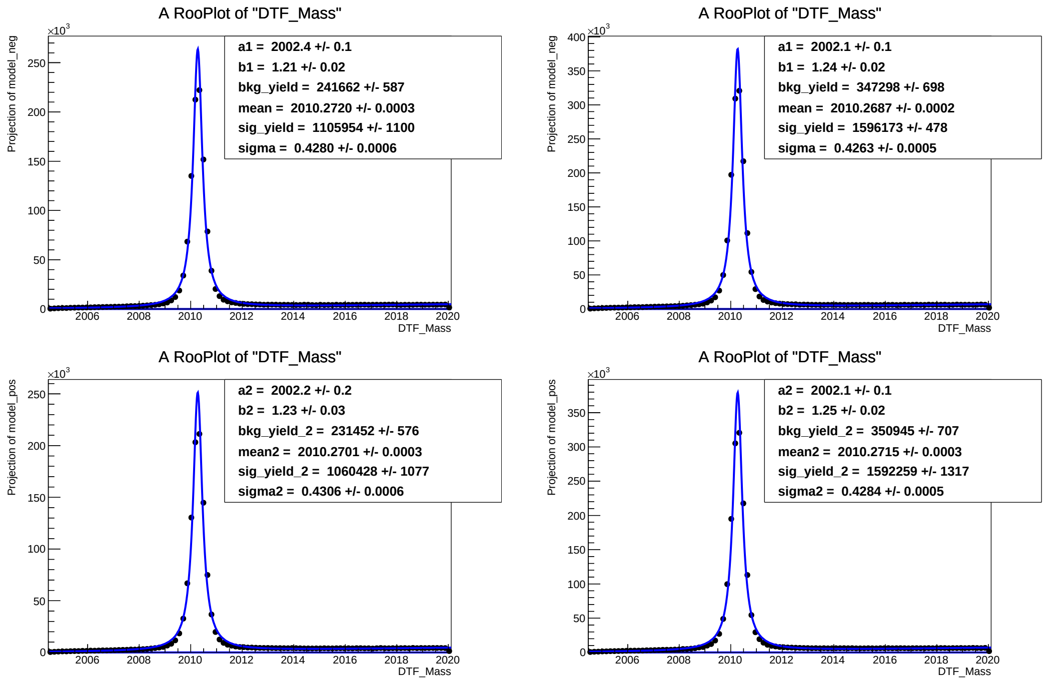


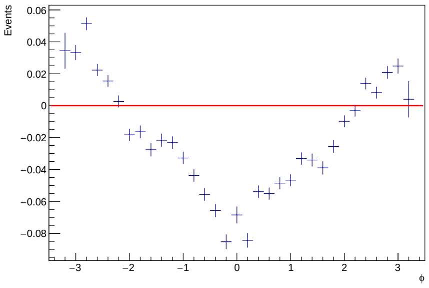
Figure 11: The best fit for reconstructed D^{*+} and D^{*-} in magnet polarities UP (left) and DOWN(right).

dependence on ϕ - and therefore on the detector shape - is eliminated by using data from both polarities, resulting in a combined

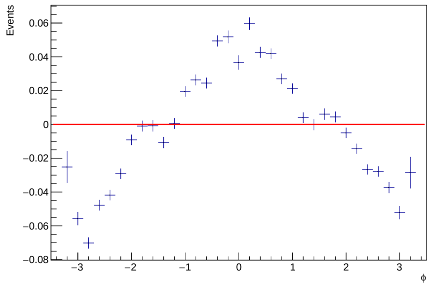
$$A_{CP,U+D} = (-10.9024 \pm 0.0001) \cdot 10^{-3}.$$

Similar to the MC samples this enhances the value of A_{CP} by a factor of two. Still the asymmetry from $K^{\pm}$ reconstruction seems to be dominating independent from the polarity. Also the fact that A_{CP} is two times larger in the real data than in the MC simulation indicates that either the background is not correctly understood or the detector response might be overestimated in simulation.

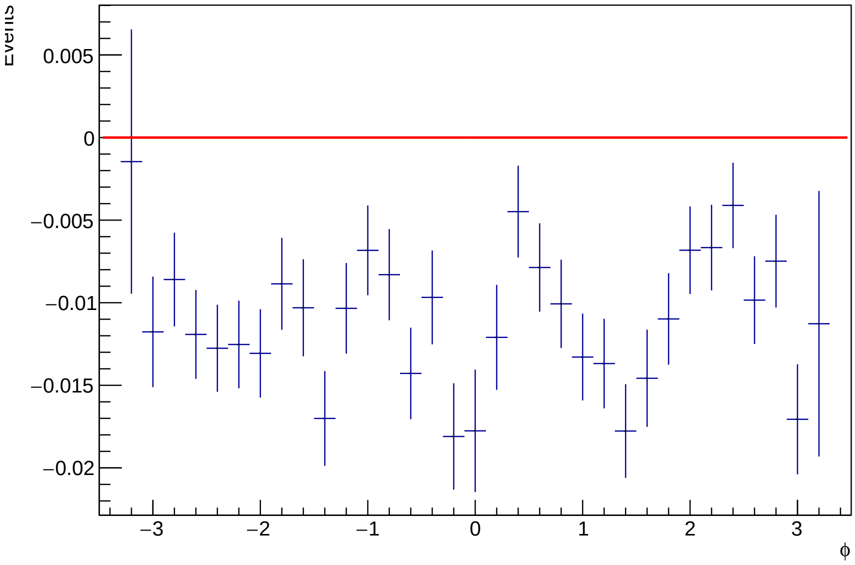
To see if the real data matches the prediction of the MC sample, the distribution of p_T of the reconstructed D^* is shown in Fig.13. It can be seen that in the MC distribution particles with low transverse momentum seem to be shifted to higher p_T, which again could hint that the loss in the detector is underestimated.



(a) The asymmetry A_{CP} in dependency of the azimuthal angle ϕ for magnet polarity UP.



(b) The asymmetry $A_{CP}(\phi)$ in dependency of the azimuthal angle ϕ for magnet polarity DOWN.



(c) The asymmetry A_{CP} in dependency of the azimuthal angle ϕ for the combined magnet polarities UP and DOWN.

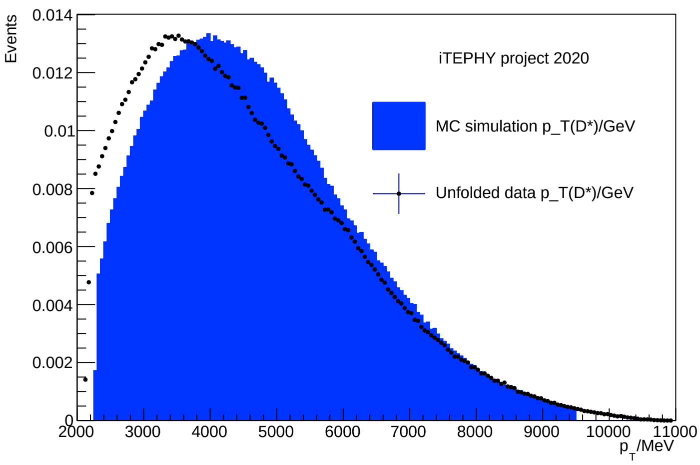


Figure 13: The transversal momentum distribution of LHCb data normalized to the total number of events is compared to that of a MC simulation.

4. Conclusion

The Kobayashi-Maskawa mechanism introduced CP violation in the Standard Model of particle physics. To correctly measure and understand these CP violating phases, in this project it is studied how the design of the LHCb detector contributes as a systematic uncertainty to the asymmetries.
Next to a possible difference in production of particles and their CP transformed counterparts from the accelerator, the dominant sources of detector induced asymmetry are on the one hand a not completely symmetric detector shape and shifted decay vertices due to boosted mother particles and on the other hand different cross section of decay products in the detector material.
In this project we looked at the contributions from both these systematics and how to work around them at the LHCb detector.
Due to its rectangular forward shape and dipole magnet for a given polarisation the track of especially less energetic particles like the soft π's produced in the Cabibbo allowed $D^{*\pm} \to D^0/\bar{D}^0\pi_s^\pm$ decay can be bent, so that some do not even reach the detector, while π_s with opposite charge are perfectly bent into the detector. The resulting charge dependent asymmetry can be diminished by recording and combining events with inverted magnet polarities. From the analysis of Monte Carlo simulated truth information it can be seen that the asymmetries under different polarities cancel each other out leading to $A_{CP}(D^*) = (-4.5 \pm 0.4) \cdot 10^{-3}$. As a control variable $A_{CP}(\phi)$ is used to show that the dependency on the detector shape is indeed lifted. The same procedure is applied onto data samples from the LHCb detector after unfolding signal and combinatorial background leading to a value of $A_{CP} = (-10.9024 \pm 0.0001) \cdot 10^{-3}$.
Since they contain a $|s\rangle$ or respectively $|\bar{s}\rangle$ differently charged kaons also have different cross section in the detector material, e.g. a K^- can also excite hyperons in the detector material and therefore has a higher cross section than a K^+. It is interesting though that the K^+ is better reconstructed than K^-, so the overall efficiency difference is determined from Monte Carlo to be $\Delta\varepsilon = \varepsilon_{K^+} - \varepsilon_{K^-} \approx 0.8\%$ leading to an asymmetry in kaon reconstruction of $A_{CP}(K) = (5.0 \pm 0.3) \cdot 10^{-3}$, which dominates the asymmetry of the whole process.
For the measurement of ΔA_{CP} by the LHCb Collaboration in 2019, which was the first measurement to discover CP violation in the charm sector, the channels $D^0 \to K^+ K^-$ and $D^0 \to \pi^+ \pi^-$ were used. The difference of the A_{CP} values of these channels was calculated, to diminish detector induced asymmetry that is equal in both channels. This led to $\Delta A_{CP} = (-15.4 \pm 2.9) \cdot 10^{-4}$[5].
Another possibility to reduce the bias from material induced CP asymmetry could be to weight those events with a reconstructed K^- with the ratio $\frac{\varepsilon_{K^+}}{\varepsilon_{K^-}}$ determined by simulations to account for different reconstruction efficiencies. Applying this onto the data set used in this analysis reduces the value of the measured asymmetry by more than 40% to $A_{CP} = (-6.27188 \pm 0.0006) \cdot 10^{-3}$.
Since this channel is expected to have negligible CP violation this is still a large number, so further studies have to be made to understand the underlying processes in the detector correctly. Also the Monte Carlo simulation does not seem to match the real data even when assuming that additional background processes have to be taken into account. A shift towards higher can be seen in the MC, which could hint that the loss in the detector is underestimated.

References

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