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CP Violation measurement in the decay $B^0 \to D^+D^-$ at the LHCb experiment

N. Belloli([1])([2]) on behalf of the LHCb Collaboration

([1]) *Università degli Studi di Milano Bicocca - Milano, Italy*
([2]) *INFN, Sezione di Milano Bicocca - Milano, Italy*

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Summary. — We report on a study for the measurement of the CP parameters S and C in the decay channel $B^0 \to D^+D^-$. The data sample considered for this analysis corresponds to the 3 fb^{-1} collected by the LHCb experiment at 7 (8) TeV during 2011 (2012). An unbinned, time-dependent maximum likelihood fit on tagged events, shows that LHCb sensitivity on CP parameters is competitive with what obtained from previous experiments.

The LHCb experiment is dedicated to the study of B mesons and to the search for indirect evidences of physics beyond the Standard Model. In this framework the time evolution of B mesons can be parametrized as

$$(1) \quad \left|B^0(t)\right\rangle = g_+(t)\left|B^0\right\rangle + \frac{q}{p}g_-(t)\left|\bar{B}^0\right\rangle, \quad \left|\bar{B}^0(t)\right\rangle = g_+(t)\left|\bar{B}^0\right\rangle + \frac{p}{q}g_-(t)\left|B^0\right\rangle,$$

where $g_\pm(t) = \frac{1}{2}(e^{-im_Ht-\frac{1}{2}\Gamma_Ht} \pm e^{-im_Lt-\frac{1}{2}\Gamma_Lt})$, L and H are the light and heavy mass eigenstates respectively. In the $B^0 \to D^+D^-$ channel the decay amplitude receives contributions both from tree and penguin diagrams, and CP violation is caused by the interference between decay with or without mixing. The time dependent CP asymmetry is related to CP violation parameters, namely $C_{D^+D^-}$ and $S_{D^+D^-}$, according to the relation

$$(2) \qquad A_{CP}(t) = -C_{D^+D^-}\cos(\Delta mt) + S_{D^+D^-}\sin(\Delta mt),$$

where $\Delta m = m_H - m_L$ is the mass differences between the two eigenstates. Using a time measurement it is possible to extract the value for $S_{D^+D^-} = \sin(2\beta_{\text{eff}})$, a quantity directly related with CKM matrix elements. This analysis aims to provide a contribution to CP parameters measurement in addition to the ones performed by Babar [1] and Belle [2]. From a theoretical point of view it is interesting because the measurement of $\sin(2\beta_{\text{eff}})$ can be related to the penguin contribution in the ϕ_s measurement in $B_s^0 \to D_sD_s$.

The data sample used in this analysis corresponds to an integrated luminosity of $3\,\text{fb}^{-1}$, for data collected in p-p collision at the center-of-mass energies 7 (8) TeV during 2011 (2012). D mesons are reconstructed in the final states $D \to K\pi\pi/KK\pi$. A mass fit is used to separate signal events from background ones, mainly due to combinatorial and $B^0 \to D_s^+ D^-$ events.

Flavour tagging is calibrated using a control channel, namely $B^0 \to D_s^+ D^-$. In this channel D mesons are reconstructed through the decays $D(D_s) \to K\pi\pi(KK\pi)$. For the first time a combination of Opposite Side, Same Side π and Same Side p taggers, recently finalized by the Collaboration is used. This combination provided a tagging power higher than in all previous CP time-dependent analysis.

In order to obtain a measurement for the CP parameters, a fit on decay time is performed. The probability density function used for this fit includes a per-event time resolution function, whose parameters are fixed from simulated events; it also includes an acceptance function described by cubic splines. The analysis is still blind at this stage; the sensitivity to CP parameters is expected to be competitive with the ones obtained by previous experiments and close to the current world average ($S^{HFAG}_{D^+D^-} = -0.98 \pm 0.17$ and $C^{HFAG}_{D^+D^-} = -0.31 \pm 0.14$) [3].

REFERENCES

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