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Measurement of $\bar{B}^0$-B^0 and $\bar{B}^0_s$-B^0_s production asymmetries in 7 TeV *pp* collisions

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Summary. — The measurements of the $\bar{B}^0$-B^0 and $\bar{B}^0_s$-B^0_s production asymmetries, $A_{\rm P}(B^0)$ and $A_{\rm P}(B^0_s)$ performed by LHCb, using *pp* collisions data at the centre-of-mass energy of 7 TeV, corresponding to an integrated luminosity of $1\,{\rm fb}^{-1}$, are reported. Integrating over $p_{\rm T}$ and η, in the ranges $4 < p_{\rm T} < 30\,{\rm GeV}/c$ and $2.5 < \eta < 4.5$, the production asymmetries are found to be $A_{\rm P}(B^0) = -0.35 \pm 0.76\,({\rm stat}) \pm 0.28\,({\rm syst})\%$ and $A_{\rm P}(B^0_s) = 1.09 \pm 2.61\,({\rm stat}) \pm 0.61\,({\rm syst})\%$.

PACS `11.30.Er` – Charge conjugation, parity, time reversal, and other discrete symmetries.
PACS `13.25.Hw` – Decays of bottom mesons.

1. – Introduction

The production rates of b and $\bar{b}$ hadrons in pp collisions at the LHC are not expected to be strictly identical. This phenomenon, commonly referred to as production asymmetry, is naively related to the fact that the $\bar{b}$ quark produced in the hard scattering might combine with a u or d valence quark from the colliding protons, whereas the same cannot happen for a b quark. Therefore one can expect a slight excess in the production of B^+ and B^0 mesons over B^- and $\bar{B}^0$ mesons, giving rise to an asymmetry which must be compensated by an opposite asymmetry in the production of the other b meson and baryon species. It is also conjectured that such production asymmetries are more enhanced at forward rapidities and small transverse momenta, as the phase space of the $b\bar{b}$ quark pair is close to that of the proton valence quarks. However, there are also other effects that might contribute at large transverse momenta [1-3].

The production asymmetry is also one of the key ingredients to perform measurements of CP violation in b hadron decays at the LHC, since the physical CP asymmetry must be disentangled from other spurious sources. The production asymmetries for B^0 and

B_s^0 mesons are defined as

$$A_{\rm P}\left(B^0_{(s)}\right) = \frac{\sigma\left(\bar{B}^0_{(s)}\right) - \sigma\left(B^0_{(s)}\right)}{\sigma\left(\bar{B}^0_{(s)}\right) + \sigma\left(B^0_{(s)}\right)},$$

where σ denotes the production cross-section. LHCb has already performed measurements of $D^+ - D^-$ and $D_s^+ - D_s^-$ production asymmetries [4, 5].

In these proceedings we report the measurements of $A_{\rm P}\left(B^0\right)$ and $A_{\rm P}\left(B_s^0\right)$ by means of a time-dependent analysis of the $B^0 \rightarrow J/\psi(\mu^+\mu^-)K^{*0}(K^+\pi^-)$, $B^0 \rightarrow D^-(K^+\pi^-\pi^-)\pi^+$ and $B_s^0 \rightarrow D_s^-(K^+K^-\pi^-)\pi^+$ decay rates, performed by LHCb using $1\,{\rm fb}^{-1}$ of integrated luminosity [6]. The inclusion of charge-conjugate decay modes is implied throughout. The measurements are performed as a function of transverse momentum ($p_{\rm T}$) and pseudorapidity (η) of the $B^0_{(s)}$ meson within the LHCb acceptance and then integrated over the ranges $4 < p_{\rm T} < 30\,{\rm GeV}/C$ and $2.5 < \eta < 4.5$.

2. – Production asymmetries determination

The time-dependent decay rate of a flavour-specific $B \rightarrow f$ final state of a neutral B meson and its CP conjugate $\bar{B} \rightarrow \bar{f}$ is given by

$$\Gamma\left(t, \psi\right) \sim \left(1 - \psi A_{CP}\right)\left(1 - \psi A_f\right) e^{-\Gamma t}\left[\Lambda_+ \cosh\left(\frac{\Delta\Gamma t}{2}\right) + \psi\Lambda_- \cos\left(\Delta m t\right)\right],$$

where ψ is the tag of the final state, which assumes the values $\psi = 1$ if the final state is f and $\psi = -1$ if the final state is the *CP* conjugate $\bar{f}$, the symbol $A_{\rm P}$ denotes the production asymmetry of the given $B^0_{(s)}$ meson, A_f is detection asymmetry of the final state, and $A_{\rm CP}$ is the direct *CP* asymmetry. The terms Λ_+ and Λ_- are defined as

$$\Lambda_\pm = \left(1 - A_{\rm P}\right)\left|\frac{q}{p}\right|^{1-\psi} \pm \left(1 + A_{\rm P}\right)\left|\frac{q}{p}\right|^{-1-\psi}.$$

Production asymmetries are determined by means of a simultaneous fit to the invariant mass and decay time. In oder to investigate whether the production asymmetry has a dependence on the kinematics of the B mesons, the events are splitted in bins of $p_{\rm T}$ and η, performing fits for each bin. $A_{\rm P}$ are then measured in each bin by integrating over the LHCb acceptance in the range $4 < p_{\rm T} < 30\,{\rm GeV}/c$ and $2.5 < \eta < 4.5$. Bin-by-bin results are reported in the paper [6].

2·1. *Systematic uncertainties.* – Several sources of systematic uncertainty that may affect the determination of the production asymmetries are considered. For the invariant mass model the inaccuracies in the shapes of all components (signals, combinatorial and partially reconstructed backgrounds) are investigated. For the decay time model, systematic effects related to the decay time resolution and acceptance are studied. The effects of the external inputs used in the fits and the parametrization of the background are also considered.

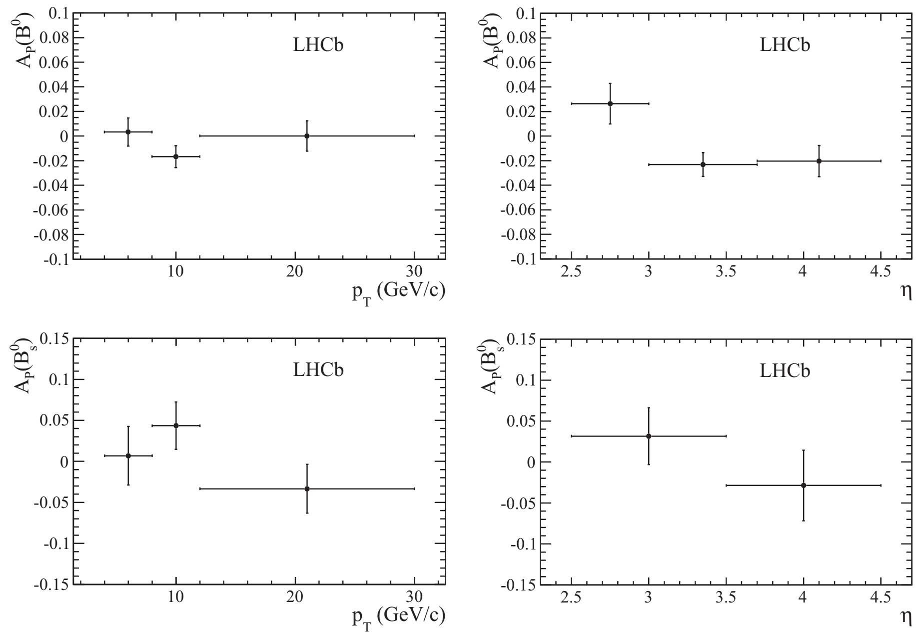

Fig. 1. – Dependence of $A_{\mathrm{P}}(B^0)$ on p_T (top left) and η (top right). Dependence of $A_{\mathrm{P}}(B^0_s)$ on p_T (bottom left) and η (bottom right).

3. – Results and conclusion

The production asymmetries of B^0 and B^0_s mesons in pp collisions at $\sqrt{s} = 7\,\mathrm{TeV}$, using a data sample corresponding to an integrated luminosity of $1\,\mathrm{fb}^{-1}$ are measured. The measurements are performed in bins of p_T and η and the dependencies of $A_{\mathrm{P}}(B^0)$ and $A_{\mathrm{P}}(B^0_s)$ on p_T and η are shown in fig. 1. No clear evidence of dependences on the values of p_{T} and η has been observed.

The overall production asymmetries, integrated in the ranges $4 < p_{\mathrm{T}} < 30\,\mathrm{GeV}/c$ and $2.5 < \eta < 4.5$, are determined to be

$$A_{\mathrm{P}}(B^0) = (-0.35 \pm 0.76\,(\mathrm{stat}) \pm 0.28\,(\mathrm{syst}))\%,$$

$$A_{\mathrm{P}}(Bs^0) = (1.09 \pm 2.61\,(\mathrm{stat}) \pm 0.61\,(\mathrm{syst}))\%.$$

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