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Measurement of B^0, B_s^0, B^+ and Λ_b^0 production asymmetries in 7 and 8 TeV pp collisions at LHCb

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Summary. — The B^0, B_s^0, B^+ and Λ_b^0 hadron production asymmetries are measured using a data sample corresponding to an integrated luminosity of $3.0\,\text{fb}^{-1}$, collected by the LHCb experiment in proton-proton collisions at centre-of-mass energies of 7 and 8 TeV. The measurements are performed as a function of transverse momentum and rapidity of the b hadrons within the LHCb detector acceptance. The overall production asymmetries, integrated over transverse momentum and rapidity, are also determined.

1. – Introduction

The production rates of b and $\bar{b}$ quarks in pp collisions are not exptected to be equal. This phenomenon, commonly reffered to as production asymmetry, is due to the fact that $\bar{b}$ (b) quarks produced in the hard scattering might combine with the spectators quarks from the pp collision in order to form a meson (baryon), whereas the opposite is not possible. Models describing these production effects predict values of the asymmetries up to a few percent and an enchancement at high rapidities and small transverse momenta [1, 2]. The knowledge of these asymmetries plays a key role in *CP* violation measurements, since one needs to correct for production effects in order to obtain the physical asymmetries. The b hadrons production asymmetries are defined as

$$A_{\text{P}}(x) = \frac{\sigma(\overline{x}) - \sigma(x)}{\sigma(\overline{x}) + \sigma(x)}, \quad x \in \{B^0, B_s^0, B^+, \overline{\Lambda}_b^0\}, \tag{1}$$

where σ denotes the inclusive production cross-section in a certain region of phase space.

2. – Analysis

The B_s^0 and B^0 production asymmetries are measured using $B_s^0 \to D_s^-(K^+K^-\pi^-)\pi^+$ and $B^0 \to J/\psi(\mu^+\mu^-)K^{*0}(K^+\pi^-)$ decays. Two-dimensional simultaneous invariant

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mass and decay time fits in $(p_{\rm T}, y)$ bins of the B mesons are performed in order to measure the quantity

$$A(t) = A_{\rm CP}(f) + A_{\rm D}(f) + \omega(t) A_{\rm P}, \tag{2}$$

where $\omega(t) \equiv [\cos(\Delta m_{d(s)} t)]/[\cosh(\Delta\Gamma_{d(s)} t/2)]$, $A_{\rm CP}(f)$ is the physical asymmetry and $A_{\rm D}(f)$ is the detection asymmetry of the final state f. The production asymmetry is then measured as the amplitude of the oscillating term $\omega(t)$.

The B^+ production asymmetry is measured by means of $B^+ \to J/\psi(\mu^+\mu^-)K^+$ decays. Invariant mass fits in $(p_{\rm T}, y)$ bins of the B^+ meson are perfomed to measure the raw asymmetry, $A_{\rm raw}(B^+)$. $A_{\rm P}(B^+)$ can be measured as

$$A_{\rm P}(B^+) = A_{\rm raw}(B^+) - A_{\rm CP}(B^+ \to J/\psi K^+) - A_{\rm D}(K^-), \tag{3}$$

where $A_{\rm CP}(B^+ \to J/\psi K^+)$ is taken as an external input [3] and $A_{\rm D}(K^-)$ is measured by means of $D^+ \to K^-\pi^+\pi^+$ and $D^+ \to K^0_S\pi^+$ decays.

Finally, the Λ^0_b production asymmetry is obtained exploiting the fact that b and $\overline{b}$ quarks are produced in pairs through the relation

$$A_{\rm P}(\Lambda^0_b) = -\left[\frac{f_u}{f_{\Lambda^0_b}} A_{\rm P}(B^+) + \frac{f_d}{f_{\Lambda^0_b}} A_{\rm P}(B^0) + \frac{f_s}{f_{\Lambda^0_b}} A_{\rm P}(B^0_s)\right], \tag{4}$$

where f_u, f_d, f_s and $f_{\Lambda^0_b}$ are the B^+, B^0, B^0_s and Λ^0_b hadronization fractions, where the B^+_c and Ξ_b contributions have been considered as systematic uncertainties.

3. – Results and conclusions

The b hadrons production asymmetries within the LHCb acceptance are found to be

$$\begin{aligned}
A_{\rm P}(B^0)_{7\,\rm TeV} &= (+0.44 \pm 0.88 \pm 0.11)\%, & A_{\rm P}(B^0)_{8\,\rm TeV} &= (-1.40 \pm 0.55 \pm 0.10)\%,\\
A_{\rm P}(B^0_s)_{7\,\rm TeV} &= (-0.65 \pm 2.88 \pm 0.59)\%, & A_{\rm P}(B^0_s)_{8\,\rm TeV} &= (+1.98 \pm 1.90 \pm 0.59)\%,\\
A_{\rm P}(B^+)_{7\,\rm TeV} &= (-0.23 \pm 0.24 \pm 0.37)\%, & A_{\rm P}(B^+)_{8\,\rm TeV} &= (-0.74 \pm 0.15 \pm 0.32)\%,\\
A_{\rm P}(\Lambda^0_b)_{7\,\rm TeV} &= (-0.11 \pm 2.53 \pm 1.08)\%, & A_{\rm P}(\Lambda^0_b)_{8\,\rm TeV} &= (+3.44 \pm 1.61 \pm 0.76)\%,
\end{aligned}$$

where the first error is statistical and the second is systematic. All the results are found to be compatible with zero and no evidence of a dependence of the production asymmetries on the b hadrons $p_{\rm T}$ or y is observed. The production asymmetries are also measured in bins of $p_{\rm T}$ and y of the b hadrons, as reported in ref. [4].

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