HEAVY FLAVOUR PRODUCTION AND SPECTROSCOPY AT LHCB

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At the Moriond QCD conference LHCb has presented results on heavy flavour production and spectroscopy. Here the latest results are discussed, which include the first observation and measurement of the branching fraction of the hadronic decay $B_c^+ \to J/\psi\pi^+\pi^-\pi^+$, the mass measurement of the excited B mesons and the mass measurement of the Ξ_b and Ω_b baryons.

1 Introduction

In the high energy pp collisions at the LHC all kind of mesons and baryons containing b- and c-quarks are produced. The production and spectroscopy of these particles is an important input for other measurements and for many theoretical calculations.

The LHCb detector is a single-arm forward spectrometer [1]. The detector is dedicated to flavour physics at the LHC and its main goal is the measurement of CP-violating observables and rare decays of heavy flavour to search for 'New Physics' beyond the Standard Model in the decays of b- and c- hadrons. In 2010 and 2011 the LHC has delivered an integrated luminosity of 1.1 fb^{-1} of data to LHCb at a center-of-mass energy of 7 TeV of which about 90% was recorded.

The open charm (D^0, D^{*+}, D^+ and D_s^+) production was measured by the LHCb collaboration using 1.4 nb^{-1} of 2010 data and is reported elsewhere [2].

The B^+ production was measured using 35 pb^{-1} of 2010 in the decay $B^\pm \to J/\psi K^\pm$ [3]. The production of other b-mesons (B_s and B_c) is determined through the fragmentation functions f_u, f_d, f_c and f_s. The measurement of f_s/f_d ratio was performed by LHCb with 2010 data [4] and it is a crucial ingredient for branching fraction measurements. Recently, the relative yield (production times branching fraction) of B_c^+ to B^+ mesons was measured [5].

The results discussed here include the first observation and the measurement of the branching fraction of the hadronic decay $B_c^+ \to J/\psi\pi^+\pi^-\pi^+$, which is discussed in Section 2, and the mass measurement of excited B mesons, generically referred to as $B_{(s)}^{**}$, which is discussed in Section 3. Finally, the measurement of the Ξ_b and Ω_b baryon masses is discussed in Section 4.

2 First observation of the hadronic decay $B_c^+ \to J/\psi\pi^+\pi^-\pi^+$

The B_c^+ meson is the lightest state composed of two heavy quarks, $\bar{b}$ and c. It was discovered by the CDF collaboration in the semileptonic decay $B_c^+ \to J/\psi l^+\nu X$ [6]. The same decay was also used for a lifetime measurement of the B_c^+ meson, which is a factor three smaller than the B^+ lifetime. Only one hadronic decay of the B_c^+ meson has been observed so far, $B_c^+ \to J/\psi\pi^+$.

Since the B_c^+ meson contains two heavy quarks, its production rate at the LHC is about three orders of magnitude smaller than for light B mesons.

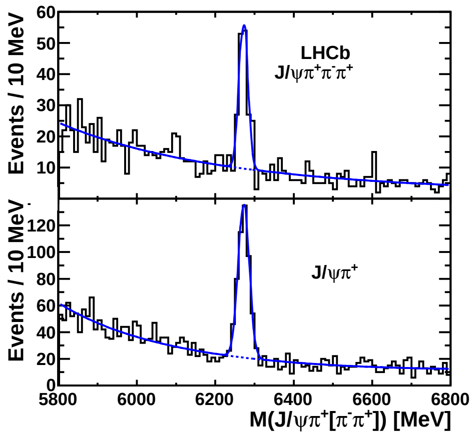

Figure 1: Invariant mass distributions of $B_c^+ \to J/\psi\pi^+\pi^-\pi^+$ and $B_c^+ \to J/\psi\pi^+$ candidates with the fit overlaid.

With an integrated luminosity of 0.8 fb^{-1} the LHCb collaboration has observed the hadronic decay $B_c^+ \to J/\psi\pi^+\pi^-\pi^+$ for the first time and measured its branching fraction relative to the branching fraction of the decay $B_c^+ \to J/\psi\pi^+$. The branching fraction for this decay is expected to be 1.5-2.3 time larger than for the decay $B_c^+ \to J/\psi\pi^+$.

The invariant mass distribution of $B_c^+ \to J/\psi\pi^+(\pi^-\pi^+)$ candidates is shown in Fig. 1.

The ratio of branching fractions is found to be [7]

$$\frac{B(B_c^+ \to J/\psi\pi^+\pi^-\pi^+)}{B(B_c^+ \to J/\psi\pi^+)} = 2.41 \pm 0.30 \pm 0.33,$$

where the first uncertainty is statistical and the second is systematic. The main sources of systematic uncertainty are the tracking efficiency, trigger, kaon veto and B_c^+ lifetime.

3 Measurement of the mass of the excited $B_{(s)}^{**}$ mesons

The properties of excited B mesons are predicted by the Heavy Quark Effective Theory (HQET). There are four excited B mesons with orbital angular momentum $L = 1$. These excited states are generically labelled as $B_{(s)}^{**}$, whereas the individual particles follow the PDG notation $B_{(s)J}^{(*)}$.

LHCb performed the search for $B_{(s)}^{**}$ states in the B^+K^-, $B^+\pi^-$ and $B^0\pi^+$ invariant mass distributions. Fig. 2 shows the invariant mass distributions relative to the threshold (Q value) of B^+K^-, $B^+\pi^-$ and $B^0\pi^+$ combinations with the fit overlaid. The peaks correspond to different $B_{(s)}^{**}$ states. The $B_{(s)1}$ and $B_{(s)2}^*$ resonances are observed with a significance greater than 5σ for all decays except for the $B_2^{*+} \to B^0\pi^+$ decay, which has a significance of more than 3σ. The decay $B_1^+ \to B^{*0}\pi^+$ is observed for the first time.

The masses measured for these six excited B mesons are [8]

$$M_{B_{s1}^0} = (5828.99 \pm 0.08 \pm 0.13 \pm 0.45)\ \mathrm{MeV}/c^2 \qquad M_{B_{s2}^0} = (5839.67 \pm 0.13 \pm 0.17 \pm 0.29)\ \mathrm{MeV}/c^2$$
$$M_{B_1^0} = (5724.1 \pm 1.7 \pm 2.0 \pm 0.5)\ \mathrm{MeV}/c^2 \qquad M_{B_2^{*0}} = (5738.6 \pm 1.2 \pm 1.2 \pm 0.3)\ \mathrm{MeV}/c^2$$
$$M_{B_1^+} = (5726.3 \pm 1.9 \pm 3.0 \pm 0.5)\ \mathrm{MeV}/c^2 \qquad M_{B_2^{*+}} = (5739.0 \pm 3.3 \pm 1.6 \pm 0.3)\ \mathrm{MeV}/c^2$$

where the first uncertainty is statistical, the second is systematic and the third is the B mass uncertainty from PDG. The masses of B_1^+ and B_2^{*+} are measured for the first time.

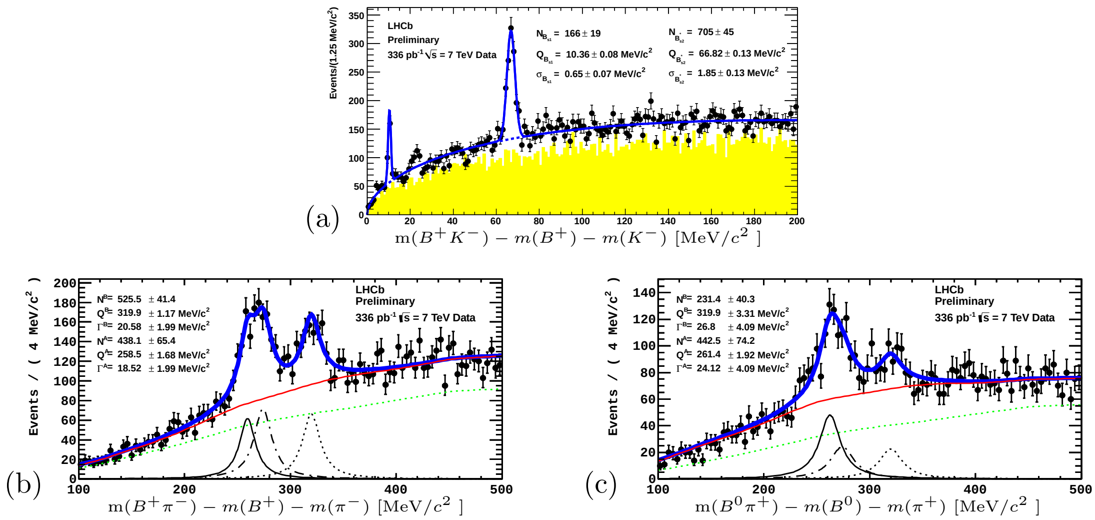

Figure 2: Fits to the Q distributions of the (a) B^+K^-, (b) $B^+\pi^-$ and (c) $B^0\pi^+$ final states. The full histogram (a) shows the distribution of wrong sign combinations.

4 Mass measurement of b-baryons, Ξ_b and Ω_b

The quark model predicts fifteen different ground states of b-baryons. There are seven ground states with $J^P = \frac{1}{2}^+$, containing one b quark and two light quarks (u, d or s). These states are the Λ_b^0 singlet, the Σ_b triplet, the Ξ_b doublet and the Ω_b singlet. Except for the Σ_b^0 baryon, all these states have already been observed and their masses have been measured. On the other hand, the quantum numbers and other properties for all these states have not yet been determined experimentally.

LHCb can improve the understanding of the baryon properties, such as masses and lifetimes, and their production. LHCb has performed the measurement of masses of two b-baryons: $\Xi_b(bsd)$ and $\Omega_b(bss)$. The mass of the Ω_b baryon was measured by CDF[9] and D0[10], showing a discrepancy of 6σ. The Ξ_b baryon has also been observed by Tevatron[11] and there is good agreement between the mass measurements.

The analysis done by LHCb is based on data corresponding to an integrated luminosity of 0.62 fb^{-1} recorded with the LHCb detector in the first half of 2011. Fig. 3 shows the invariant mass distributions of the Ξ_b and Ω_b candidates.

The measured masses of the Ξ_b and Ω_b baryons[12] are shown in Table 1 and are compared with the CDF and D0 results. The first uncertainty is statistical and the second is systematic.

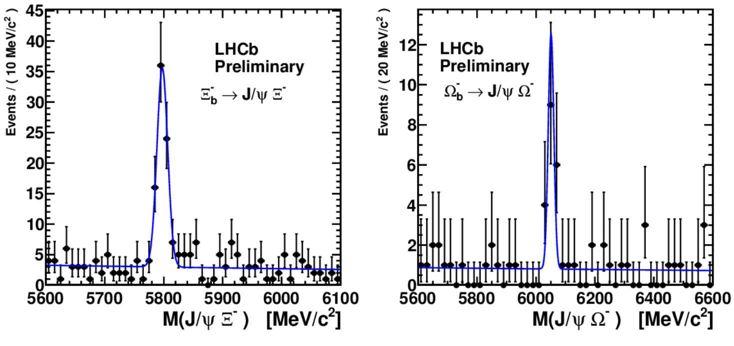

Figure 3: Invariant mass distribution of Ξ_b and Ω_b with the fit projections overlaid.

Table 1: LHCb results compared with results from CDF and D0.

	M(Ξ_b) [MeV/c^2]	M(Ω_b) [MeV/c^2]
LHCb	$5796.5 \pm 1.2 \pm 1.2$	$6050.3 \pm 4.5 \pm 2.2$
D0	$5774 \quad \pm 19$	$6165 \quad \pm 16$
CDF	5790.9 ± 2.7	6054.4 ± 6.9

The systematic uncertainty is dominated by the momentum scale uncertainty.

The Ξ_b result is compatible with CDF and D0, while the Ω_b result is in good agreement with the CDF measurement but not with the D0 measurement.

5 Summary

Heavy flavour production and spectroscopy is a wide topic in LHCb. The recent results presented at the Moriond QCD conference include the first observation and the measurement of the branching fraction of the hadronic decay $B_c^+ \to J/\psi\pi^+\pi^-\pi^+$, the mass measurement of the excited B mesons and the mass measurement of the Ξ_b and Ω_b baryons.

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