PROCEEDINGS OF SCIENCE

Measurement of the branching fractions of B to narrow D^{**} states and other semi-leptonic b decays at the DØ experiment

Freya Blekman[∗†]
Imperial College, UK
E-mail: f.blekman@imperial.ac.uk

Using 460 pb^{-1} of integrated luminosity accumulated with the DØ detector, the product branching rates of the semileptonic decays $\bar{B} \to D_1^0(2420)\mu^-\bar{\nu}X$ and $\bar{B} \to D_2^{*0}(2460)\mu^-\bar{\nu}X$ and their ratio have been measured. This result represents a significant improvement in the knowledge of B branching rates to orbitally excited D mesons, and the first direct measurement of their ratio. Furthermore, we also present preliminary results on the observation of $B \to \mu\nu D_s^{**}$ state, where $D_s^{**} \to D^* K_S^0$ and the semi-leptonic decays of beautified baryons $\Lambda_b \to \Lambda_c \mu\nu$.

International Europhysics Conference on High Energy Physics
July 21st - 27th 2005
Lisboa, Portugal

∗Speaker.
†for the DØ Collaboration

© Copyright owned by the author(s) under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike Licence. http://pos.sissa.it/

PoS(HEP2005)234

1. Introduction

In this paper we study exited states of c quarks, which are formed in the decay of the b quark in a baryonic or mesonic system with a light quark. Because $m_c \gg \Lambda_{QCD}$ in these type of systems, the spin of the c quark decouples from the light quark spin and angular momentum of the system.

When the b quark in a B meson (or baryon) decays to a c quark, heavy quark effective theory (HQET) predicts that the light quark is not in¤uenced by the change in colour £eld. In the studies presented in this paper, only semi-leptonic b decays where a muon is produced are considered:

$$b + X \to W + c + X \to \ell\nu + c + X \tag{1.1}$$

1.1 The DØ Experiment

The DØ detector is a general-purpose particle physics detector that is situated on the Tevatron $p\bar{p}$ collider, which has an interaction energy of $\sqrt{s} = 1.96$ TeV. The detector consists of a Silicon Micro-strip Tracker and central Fibre Tracker in a magnetic £eld of 2T, a Liquid Argon calorimeter that contains both an electro-magnetic and hadronic section, and a muon system.

2. First measurement of semi-leptonic $B \to D^{**}$ branching fractions for separate states

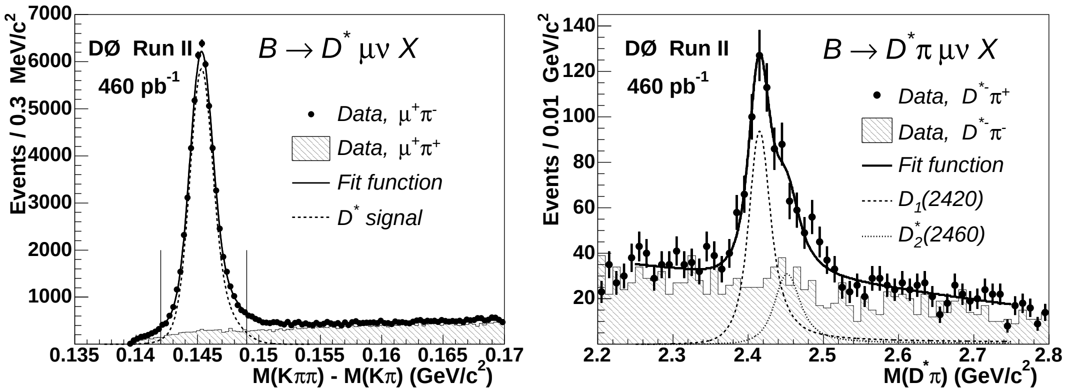

Figure 1: Left: Selection of D^* candidates as a function of the mass difference between the $K\pi\pi$ and $K\pi$ systems. Right: Reconstruction of the two narrow D^{**} states. The £t to the two resonances is used to determine the relative branching fractions.

The D^{**} is an excited, bound state of a c and light quark. Conservation of parity and angular momentum thus leads to two classes of D^{**} bound states: Narrow states , where the light quark spin and angular momentum are in the same direction; and broader resonances , where the spin and angular momentum of the light quark point in opposite direction. In this paper we will only consider D^{**} states of the £rst category; two states labelled D_1 and D_2^*.

In quantitative HQET predictions, the free $b \to c$ decay has to be corrected to the order $1/m_c$. One of the properties that is sensitive to these mass corrections is the ratio between the branching fractions of the B to the two narrow D^{**} states:

$$R = \frac{Br(B \to D_2^* \ell \bar{\nu}_\ell)}{Br(B \to D_1 \ell \bar{\nu}_\ell)}. \tag{2.1}$$

PoS(HEP2005)234

$R = 1.6$ in the mass limit of $m_c \to \infty$. Different HQET models in predict R as low as 0.4, but in general the quantity is considered to be relatively model-independent.

2.1 Selection of the D^{**} candidates

To measure R, we use the DØ dataset up to 2004, which is equivalent to approximately 460 pb^{-1}. B jet reconstruction and other selection methods are described in detail here[3]. We use the decay chain $D^{**} \to D^*\pi \to D^0\pi\pi \to K\pi\pi\pi$. The D^* candidates are shown in Figure 1 (left). After rejection of $B \to DD$ and $g \to c\bar{c}$ backgrounds, we are left with 31k D^* candidates. Adding a $\pi^\pm$ to the D^* leads to the mass spectrum shown in Figure 1 (right). The £t includes two Breit-Wigner functions for the two resonances and a second order polynomial function for the background. The background is examined for a possible wide resonance by comparing to the wrong sign background. Unlike other experiments [2], DØ does not observe a wide resonance.

When the known branching fraction of $B \to D^{*-}\mu^+\bar{\nu}_\mu X$ is used for normalisation, the following branching fractions are observed:

$$Br(\bar{b} \to B) \cdot Br(B \to \bar{D}_2^{*0}\mu^+\bar{\nu}_\mu X) \cdot Br(\bar{D}_2^{*0}\pi) = (0.035 \pm 0.007(\text{stat}) \pm 0.008(\text{syst}))\% \qquad (2.2)$$

and

$$Br(\bar{b} \to B) \cdot Br(B \to \bar{D}_1^0\mu^+\bar{\nu}_\mu X) \cdot Br(\bar{D}_1^0\pi) = (0.087 \pm 0.007(\text{stat}) \pm 0.014(\text{syst}))\%, \qquad (2.3)$$

This leads to a branching fraction ratio of

$$\frac{Br(B \to \bar{D}_1^0\mu^+\bar{\nu}_\mu X) \cdot Br(\bar{D}_1^0\pi)}{Br(B \to \bar{D}_2^{*0}\mu^+\bar{\nu}_\mu X) \cdot Br(\bar{D}_2^{*0}\pi)} = 0.39 \pm 0.09(\text{stat}) \pm 0.12(\text{syst}). \qquad (2.4)$$

This information can be used to extract R [3]:

$$R = 1.31 \pm 0.29(\text{stat}) \pm 0.47(\text{syst}), \qquad (2.5)$$

where the dominant systematic uncertainties include the uncertainty on $Br(B \to D^{*-})$, the mass resolution, the width of the two D^{**} states, £t errors, D^0 selection, possible wide resonances and the difference between Monte Carlo simulation and data.

3. Evidence of semi-leptonic $B_s \to D_s^{**}$

In an analysis very similar to the aforementioned D^{**} measurement, the DØ Collaboration has examined the $B_s \to D_S^{**}\mu\nu$ spectrum. In this case, D_{S1} candidates are extracted from the D^*K_S spectrum. The addition of a charged π to the D^*K_S candidates yields the D_S^{**}. Figure 2 (left) shows the invariant mass spectrum. A resonance peak containing 18 ± 5.5 candidates is attributed to the presence of D_S^{**} in the sample. The signi£cance of this result was examined using two different methods, where in both cases the resonance was more than 3σ con£dence level above background. For this analysis, the systematic uncertainties are currently under study, and the D_S^{**} sample will be used to measure its production and properties [4].

PoS(HEP2005)234

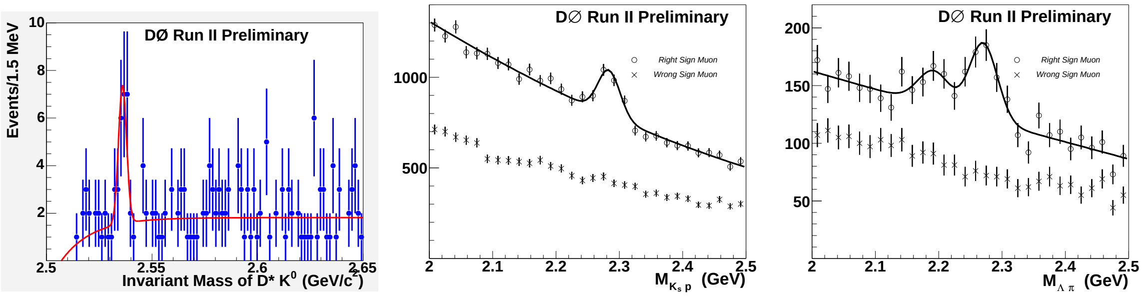

Figure 2: Left: The invariant mass spectrum of $D^{*}K_S^0$ in semi-leptonic B decays. The peak is attributed to the D_S^{**}. Center: The plot shows the Λ_c resonance as observed in $\Lambda_c \rightarrow K_S^0 p$ decays in semi-leptonic B events. Right: A similar invariant mass plot for the $\Lambda_c \rightarrow \lambda\pi$ mode, where a possible Σ resonance can be seen around $M_{\Lambda\pi} = 2.2$ GeV/c^2

4. Observation of semi-leptonic $\Lambda_b \rightarrow \Lambda_c$ decays

It is also possible to reconstruct the Λ_b, a *udb* baryon, in semi-leptonic events. The method is to look for $\Lambda_b \rightarrow \Lambda_c \mu \nu$ events where Λ_c decays to either $K_S p$ or $\Lambda\pi$. Figure 2 shows that in both decay channels there is evidence of the Λ_c resonance. In the $\Lambda\pi$ spectrum (Figure 2 right) an additional resonance, attributed to Σ baryons, can be observed. The isolated samples will be used for a Λ_b lifetime measurement [4]

5. Conclusion

For the £rst time, the narrow D^{**} meson branching fractions have been separately measured in semi-leptonic events. The ratio between the semi-leptonic branching fractions of the two modes is

$$R = 1.31 \pm 0.29(\text{stat}) \pm 0.47(\text{syst}) \tag{5.1}$$

The DØ Collaboration also observes the D_S^{**} resonance and the measurement of its properties is in progress. It is also possible to reconstruct the Λ_b^0 in semi-leptonic decays, and the reconstructed candidates will be used in a Λ_b lifetime measurement.

References

[1] V.M. Abazov *et al.*, DØ Collaboration, Submitted to Nucl. Instr. and Methods, hep-physics/0507191

[2] K. Abe *et al.*,, Belle Collaboration, Phys.Rev.D 69, 112002 (2004)

[3] V.M. Abazov *et al.*, DØ Collaboration, Submitted to Phys.Rev.Lett,hep-ex/0507046

[4] The DØ Collaboration's Results page (for *b*-physics), http://www-d0.fnal.gov/Run2Physics/WWW/results/b.htm

PoS(HEP2005)234