The 2007 Europhysics Conference on High Energy Physics IOP Publishing
Journal of Physics: Conference Series **110** (2008) 022008 doi:10.1088/1742-6596/110/2/022008

DØ Results on Properties of Excited and Heavy b-hadrons

Eduard De La Cruz Burelo

Department of Physics, University of Michigan, Ann Arbor, MI 48109, USA

E-mail: eduard@fnal.gov, Eduard.Burelo@cern.ch

Abstract. We present the latest results from the DØ experiment on the properties of excited and heavy b-hadrons. DØ collaboration has measured the Λ_b lifetime in semileptonic decays as well as in a fully reconstructed decay channel. In addition, the first direct observation of the Ξ_b^- baryon is reported.

1. Introduction

An important part of the physics program of the DØ collaboration [1] is the measurement of properties of heavy hadrons. In this note we present the latest measurement of the Λ_b lifetime in the fully reconstructed decay channel $\Lambda_b \to J/\psi\Lambda$. This lifetime has caused great interest due to an earlier difference in the measured Λ_b lifetime and the prediction, and which was named as the Λ_b *lifetime puzzle* [2]. DØ collaboration has also independently measured the Λ_b lifetime in semileptonic decays [3], but is not discussed here due to the lack of space. However both measurements are consistent between the uncertainties.

In addition to the Λ_b lifetime, the first direct observation of the Ξ_b^- baryon is reported. The Ξ_b^- (dsb) is a strange b baryon made of valence quarks from all three known generations of fermions and is expected to decay through the weak interaction.

2. Λ_b lifetime

The Λ_b lifetime has been measured by the DØ collaboration in the fully reconstructed decay channel $\Lambda_b \to J/\psi\Lambda$, where the J/ψ decays to $\mu^+\mu^-$ and the Λ to $p\pi$. This lifetime measurement is based on the determination of the distance L from the decay vertex of the Λ_b to the primary interaction vertex. The proper decay length $\lambda = \vec{L} \cdot \vec{P}_T(\Lambda_b) M_{\Lambda_b}/P_T(B) = L_{xy}/(\beta\gamma)_T$ is determined on an event-per-event basis, and its distribution $F(\lambda)$ is related to the Λ_b lifetime, $\tau(\Lambda_b)$, by:

$$F(\lambda) = \int_0^\infty R(\lambda - \lambda') \frac{1}{c\tau_{\Lambda_b}} \exp\left(\frac{-\lambda'}{c\tau_{\Lambda_b}}\right) d\lambda' \qquad (1)$$

where $R(\lambda - \lambda')$ is the detector resolution.

From a data sample of integrated luminosity of 1.2 fb^{-1}, DØ reconstructed 171 $\pm$ 20 Λ_b candidates. The lifetime was extracted using an unbinned maximum likelihood fit to mass, proper decay length, and the uncertainty distribution of the proper decay length. The λ distribution for signal was modeled by $F(\lambda)$ in Eq. 1, and the background was described with

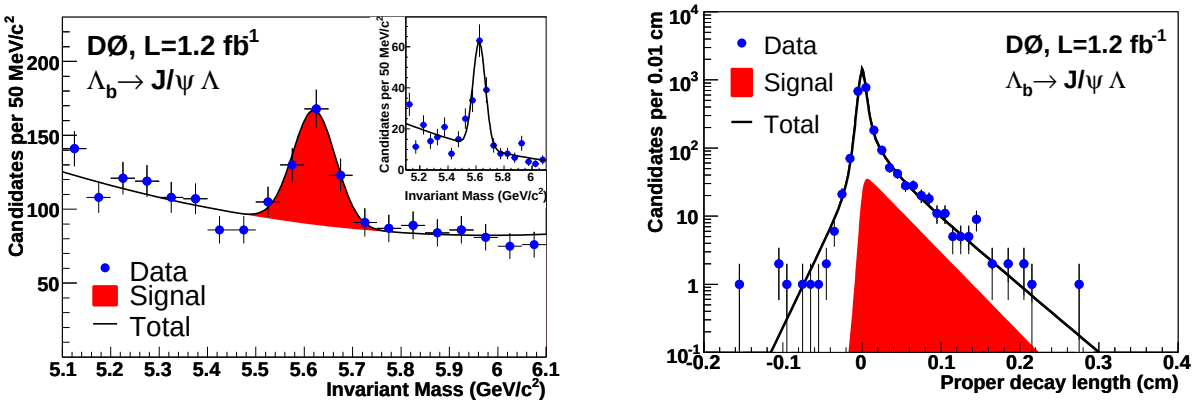

Figure 1. Invariant mass(left) and proper decay length (right) distributions for Λ_b candidates, with the fit results superimposed. The inserts show the Λ_b mass distribution after requiring $\lambda/\sigma > 5$.

a negative and two positive exponential decays accounting for mis-measured decay vertices and background from other heavy-flavor decays. The mass distribution was modeled as the sum of a Gaussian signal and linear background. Figure 2 shows the Λ_b mass and proper decay length distributions with the projection of the fit result superimposed. The Λ_b lifetime was found to be [4]:

$$\tau(\Lambda_b) = 1.218^{+0.130}_{-0.115}\ (\text{stat}) \pm 0.042\ (\text{syst})\ \text{ps}, \tag{2}$$

As a control measurement, DØ determined in the same data sample the B^0 lifetime, in the decay channel $B^0 \to J/\psi K^0_S$, to be:

$$\tau(B^0) = 1.501^{+0.078}_{-0.074}\ (\text{stat}) \pm 0.050\ (\text{syst})\ \text{ps}. \tag{3}$$

These measurements can be combined to determine the ratio of lifetimes:

$$\frac{\tau(\Lambda_b)}{\tau(B^0)} = 0.811^{+0.096}_{-0.087}\ (\text{stat}) \pm 0.034\ (\text{syst}), \tag{4}$$

The Λ_b lifetime measurement is consistent with the world average [5], and the ratio of Λ_b to B^0 lifetimes is consistent with the most recent theoretical predictions [6].

3. Ξ_b^- Observation

In the Standard Model the Ξ_b^0 and the Ξ_b^- [1] form an isodoublet (u s b, d s b) pair. Both of these states are expected to have $J^P = 1/2^+$ although I, J or P have yet to be measured. Evidence for the Ξ_b^- has been inferred from an excess of same sign $\Xi^\pm\ell^\pm$ events in jets which are interpreted as $\Xi_b^- \to \Xi^-\ell^-\bar{\nu}_\ell X$ [7]. From this decay mode, the average lifetime of the Ξ_b^- is measured to be $1.42^{+0.28}_{-0.24}$ ps. These semileptonic decays of the Ξ_b^- did not allow for a mass measurement. However, using the fully reconstructed decay $\Xi_b^- \to J/\psi\Xi^-$, DØ collaboration has measured for first time the mass of the Ξ_b^- along with its production fraction relative to $\Lambda_b \to J/\psi\Lambda$ [8].

[1] Charge conjugation is always assumed for this state

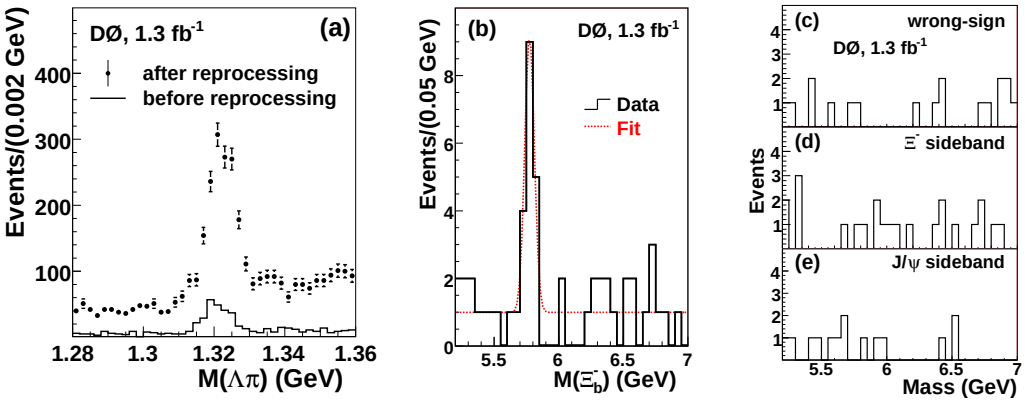

Figure 2. (a) Invariant mass distributions of the $\Lambda\pi^-$ pair before and after data reprocessing. The reprocessing significantly increases the Ξ^- yield. (b) The $M(\Xi_b^-)$ distribution of the Ξ_b^- candidates after all selection criteria. The dotted curve is an unbinned likelihood fit to the model of a constant background plus a Gaussian signal. The $(\mu^+\mu^-)\Lambda\pi$ mass distributions for (c) the wrong-sign background, (d) the Ξ^- sideband, and (e) the J/ψ sideband events. The mass $M(J/\psi\,\Lambda\pi) - M(\mu^+\mu^-) + M_{\rm PDG}(J/\psi)$ is plotted for (c) and (d) while the mass $M(\mu^+\mu^-\Xi^-) - M(\Lambda\pi^-) + M_{\rm PDG}(\Xi^-)$ is plotted for (e).

The DØ collaboration searched for decays of $\Xi_b^- \to J/\psi\,\Xi^-$ with $J/\psi \to \mu^+\mu^-$, $\Xi^- \to \Lambda\pi^- \to p\pi^-\pi^-$ in a data set of integrated luminosity of 1.3 fb^{-1} collected between 2002-2006 by using the DØ detector, and reprocessed with an extended setup of the DØ tracking algorithm to increase the efficiency of reconstructing the decay products of long lived particles such as K_s, Λ and Ξ^-. DØ collaboration observed 15.2 ± 4.4 Ξ_b^- events and measured the Ξ_b^- mass to be $5.774 \pm 0.011\,(\text{stat.}) \pm 0.015\,(\text{syst.})$ GeV. DØ also determined its $\sigma \times \mathcal{B}$ relative to that of the Λ_b to be $0.28 \pm 0.09\,(\text{stat.})^{+0.09}_{-0.08}\,(\text{syst.})$. The statistical significance of the signal was found to be 5.5σ.

4. Summary

DØ collaboration continues making contributions to heavy hadron physics with precise lifetime measurements and with the observation of new heavy baryons such as the Ξ_b^-. With the increase of statistics, more excited b hadron states will be observed and other precision measurements will follow.

[1] D0 Collaboration, V.M. Abazov *et al.*, Nucl. Instrum. Methods A **565**, 463 (2006).
[2] F. Gabbiani *et al.* Phys. Rev. Lett. **D** 68, (2003) 114006-1-4.
[3] D0 Collaboration, V.M. Abazov *et al.*, hep-ex/0706.2358; to appear in Phys. Rev. Lett.
[4] D0 Collaboration, V.M. Abazov *et al.*, arXiv:hep-ex/0704.3909; to appear in Phys. Rev. Lett.
[5] W. M. Yao *et al.*, J. Phys. G **33**, 1 (2006).
[6] C. Tarantino, Nucl. Phys. B **156**, (Proc. Suppl.), 33 (2006).
[7] J. Abdallah *et al.* (DELPHI Collaboration), Eur. Phys. J. **C44**, 299 (2005); D. Buskulic *et al.* (ALEPH Collaboration), Phys. Lett. B **384**, 449 (1996).
[8] DØ collaboration, V.M. Abazov et. al, Phys. Rev. Lett. 99 , 1052001 (2007).