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B LIFETIME MEASUREMENTS FROM DØ

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We present the more recent measurements of the B hadrons lifetimes and its ratios, performed using 250 pb^{-1} of the Run II data collected with DØ detector at Tevatron.

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1. Introduction

B hadrons have been under intense study last years due to its properties related to research fields like CP violation, mixing, and new physics. Even when great contributions have come from the b factories, experiments totally dedicated to the B hadron production and study, the heaviest B hadrons, like the B_s and the b baryons, are produced in high statistics only at Tevatron. The B_s lifetime has been measured only once in an fully reconstructed decay mode, and the b baryons lifetime are not known with the precision of other B hadrons like the B^+, or the B_d^0.

In this work we present the more recent B hadron lifetime measurements performed in 250 pb^{-1} of data collected with the DØ detector at Fermilab Tevatron, a $p\bar{p}$ collider at 1.96 TeV center of mass energy.

2. B hadrons lifetime measurements

The upgraded DØ detector [1] for the Run II at Tevatron, is well equipped with a silicon tracker with a pseudorapidity coverage of $|\eta| < 3$, that allows to reconstruct the decay vertexes of the B hadrons and its daughters with high precision. Vertex identification, along with triggers based in an excellent muon detector, permits an effective exploiting of the large $b\bar{b}$ cross-section at Tevatron, resulting in some of the largest B hadron yields in both exclusive and semileptonic decay modes.

2.1. *Exclusive decays channels*

In the exclusive decays reconstruction, the $J/\psi \to \mu^+\mu^-$ is an excellent background discriminator for B hadrons at the DØ detector. Easy to identify, using dimuons DØ has been able to fully reconstruct B's in several channels: $B^+ \to J/\psi K^+$,

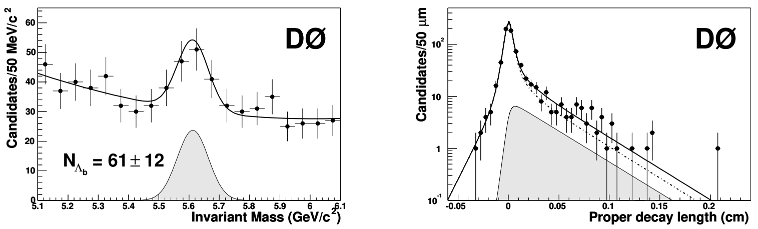
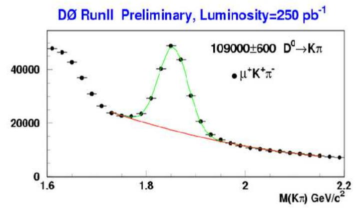


Fig. 1. Invariant mass (left) and proper decay length (right) distributions for Λ_b^0 candidate events. The points are the data, and the solid curve represents the result of the fit. Signal contribution is shown in gray. The dashed-dotted line (right) represent the background contribution.

$B_d^0 \to J/\psi K^*$, $B_d^0 \to J/\psi K_S^0$, $B_s^0 \to J/\psi\phi$, and $\Lambda_b^0 \to J/\psi\Lambda^0$. The latest lifetime measurements in DØ using these exclusive decay channels are [2,3] the B_s^0, the B_d^0 (in both modes), and the Λ_b^0 lifetime. All these measurements use the proper decay length (PDL) technique, what consist of determine the PDL $= M_B\,(\boldsymbol{L}_T \cdot \boldsymbol{p}_T(B))\,/|\boldsymbol{p}_T(B)|^2$ for each B candidate. $\boldsymbol{L}_T$ is the vector in the axial plane from the production to decay vertex of the B, $\boldsymbol{p}_T(B)$ is the transverse momentum and M_B the mass of the B, respectively. Then, a fit to the PDL distribution is performed, in what the signal contribution is modeled with a exponential decay convoluted with the detector resolution. The slope constant of the exponential decay is the lifetime of the B. Due to the similar topology, the B_s^0 and the B_d^0 (in the K^* mode) lifetime measurements were done simultaneously, with almost the same set of selection criteria, and then the ratio of these measurements, taken in account correlations, was computed. Same case for the Λ_b and the B_d^0 in the K_S^0 mode.

2.2. *Semileptonic channels*

In the semileptonic modes, DØ has measured with a novel technique the lifetime ratio $\tau(B^+)/\tau(B_d^0)$. B mesons are identified via their decays [4] $B \to \mu^+\nu\bar{D}^0X$, and are classified into a "D^{*-}" sample, containing all events with reconstructed $D^{*-} \to \bar{D}^0\pi^-$ decays, and a "$\bar{D}^0$" sample, containing all remaining events. Both simulation and available experimental results show that the D^{*-} sample is dominated by $B_d^0 \to \mu^+\nu D^{*-}X$ decays, while the $\bar{D}^0$ sample is dominated by $B^+ \to \mu^+\nu\bar{D}^0X$ decays. Since the final (semileptonic) state has missing particles, the PDL is not determined. Instead, the measured visible proper decay length (VPDL) is computed as $VPDL = M_B\left(\boldsymbol{L}_T \cdot \boldsymbol{p}_T(\mu^+\bar{D}^0)\right)/|\boldsymbol{p}_T(\mu^+\bar{D}^0)|^2$, where $\boldsymbol{p}_T(\mu^+\bar{D}^0)$ is the transverse momentum of the $\mu^+\bar{D}^0$ system. The VPDL distribution is divided in 8 intervals (same for both samples). The ratio r_i of B_d^0 to B^+ candidates is extracted from a fit to the mass distributions of both samples on those intervals. Then $\chi^2(\varepsilon,k) = \sum_i (r_i - r_i^e(\varepsilon,k))^2/\sigma^2(r_i)$, where $r_i^e(\varepsilon,k)$ is the expected ratio and ε a reconstruction efficiency, is minimized to find $k = \tau(B^+)/\tau(B_d^0) - 1$.



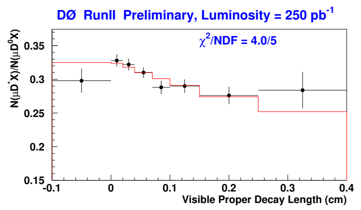


Fig. 2. Left: Invariant mass of the $K\pi$ system. Right: Points with the error bars show the ratio of the number of events in the $\mu^+ D^{*-}$ and $\mu^+ \bar{D}^0$ samples as a function of the VPDL. The result of the minimization fit is shown as a histogram.

3. Results

Lifetime measurements and ratios are summarize in Table 1. The B_s^0 lifetime measurement is the most precise single measurement of this quantity from any experiment, the Λ_b lifetime measurement was done for one of the first times in an exclusive decay channel, and the ratio $\tau(B^+)/\tau(B_d^0)$ is one of the best single measurements of the world (at the time that this work was being written, this measurement was updated [5] to 440 pb^{-1} of data, and the result is currently the most precise measurement). These new measurements agree with theoretical predictions and the world averages.

Table 1. B hadron lifetime measurements from the DØ collaboration.

Decay channel	Measurement
$B_d^0 \to J/\psi K_S^0$	$\tau(B_d^0) = 1.397^{+0.107}_{-0.098}(\text{stat}) \pm 0.031(\text{syst})$ ps
$B_d^0 \to J/\psi K^*$	$\tau(B_d^0) = 1.473^{+0.052}_{-0.050}(\text{stat}) \pm 0.023(\text{syst})$ ps
$B_s^0 \to J/\psi \phi$	$\tau(B_s^0) = 1.444^{+0.098}_{-0.090}(\text{stat}) \pm 0.020(\text{syst})$ ps
$\Lambda_b \to J/\psi \Lambda$	$\tau(\Lambda_b) = 1.221^{+0.217}_{-0.179}(\text{stat}) \pm 0.043(\text{syst})$ ps
$\frac{B_s^0 \to J/\psi \phi}{B_d^0 \to J/\psi K^*}$	$\tau(B_s^0)/\tau(B_d^0) = 0.980^{+0.075}_{-0.070}(\text{stat}) \pm 0.003(\text{syst})$
$\frac{\Lambda_b \to J/\psi \Lambda}{B_d^0 \to J/\psi K_S^0}$	$\tau(\Lambda_b)/\tau(B_d^0) = 0.874^{+0.169}_{-0.142}(\text{stat}) \pm 0.028(\text{syst})$
Semileptonic	$\tau(B^+)/\tau(B_d^0) = 1.093 \pm 0.021(\text{stat}) \pm 0.022(\text{syst})$

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3. V. M. Abazov et al, hep-ex/0409043; FERMILAB-Pub-04-225-E.
4. Charged conjugate states are implied in this analysis.
5. V. M. Abazov et. al., hep-ex/0410052; FERMILAB-Pub-04/284-E.