Properties and decays of b hadrons at DZero

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on behalf of DZero Collaboration

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Deep-Inelastic Scattering and
Related Subjects

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Outline

1. Tevatron and DØ Experiment
2. Part I: $\tau(\Lambda_b)$ in $\Lambda_b \to J/\psi\Lambda$
3. Part II: $f(b \to \Lambda_b) \cdot \mathcal{B}\,(\Lambda_b \to J/\psi\Lambda)$
4. Part III: $\mathcal{B}(B_s \to J/\psi f_0\ , B_s \to J/\psi\phi\ )$
5. Conclusions

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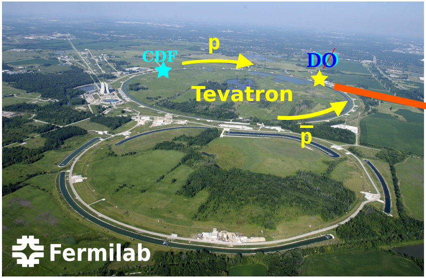
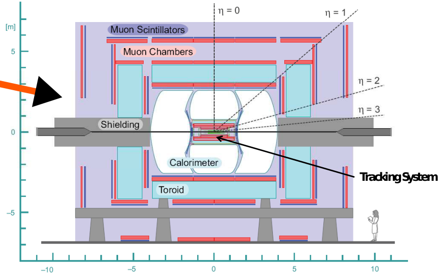
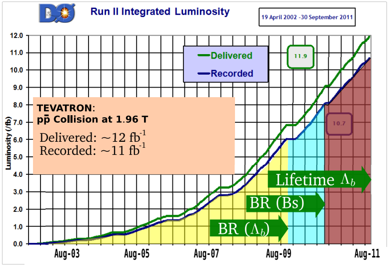
Tevatron and D0 Experiment



Experimental Setup:





B production at Tevatron

Bd, Bs, Bc, B**, Λ_b, Ξ_b, Ω_b , , , ...

Wide angle coverage:

Muon chambers; $|\eta| < 2$

Tracking volume; $|\eta| < 3$

Special B-strengths:

Muon system

Muon trigger (single and dimuon triggers)

Tracking/Vertexing

Part I

- Lifetime measurement: $\Lambda_b \rightarrow J/\psi\Lambda$

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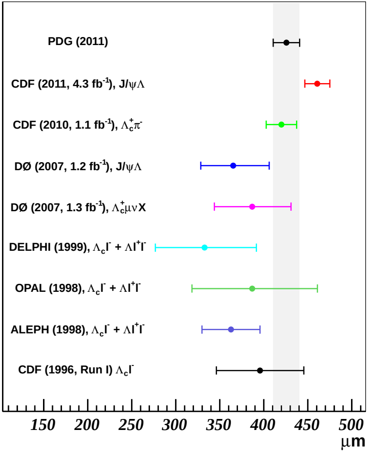
Experimental and theoretical status



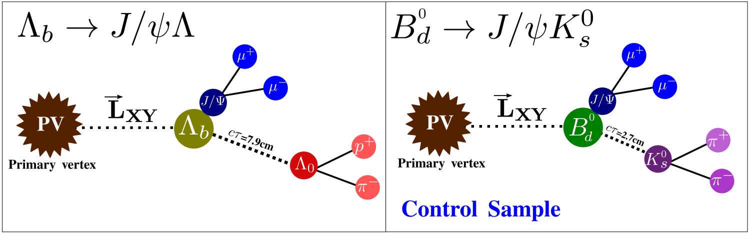
- Precise predictions of b-hadron lifetimes are difficult to calculate. Ratios are predicted with fairly high accuracy by heavy quark effective theory (HQET)
- $\frac{\tau_{\Lambda_b}}{\tau_{B_d}} = 0.88 \pm 0.05$
- $c\tau_{\Lambda_b} \approx 378 - 423\mu$m

The transverse decay length

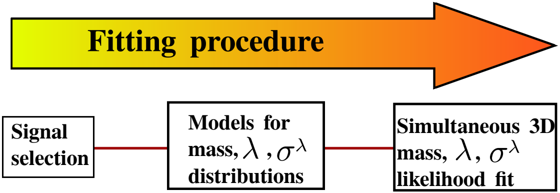
$$L_{xy} = \frac{\vec{L}_{xy} \cdot \vec{p}_T}{|p_T|}$$

The proper decay length (PDL), denoted by λ

$$\lambda = c\tau = \frac{L_{xy}}{(\beta\gamma)_{xy}} = L_{xy}\frac{M_{\Lambda_b}}{|\vec{p}_T^{\,\Lambda_b}|}$$



Lifetime measurement: $\Lambda_b \to J/\psi\Lambda$



$$\mathcal{L} = \prod_{j=1}^{N} [f_s \mathcal{F}_s(m_j, \lambda_j, \sigma_j^\lambda) + (1 - f_s)\mathcal{F}_b(m_j, \lambda_j, \sigma_j^\lambda)]$$

Signal p.d.f.

- The mass, is modeled by a Gaussian function
- The λ, is modeled with a exponential decay convoluted with the resolution function
- σ^λ, is modeled by Gaussian functions

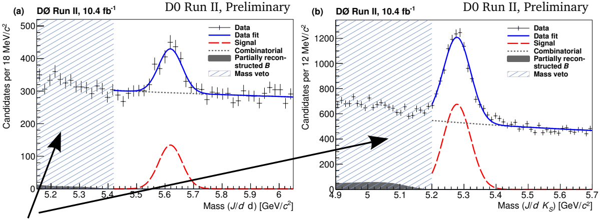
Background p.d.f.

- The mass, exponential(constant) for non-prompt (prompt) component
- The λ, exponentials and Gaussian resolution
- σ^λ, is modeled by exponential functions convoluted with a Gaussian function

Data yields

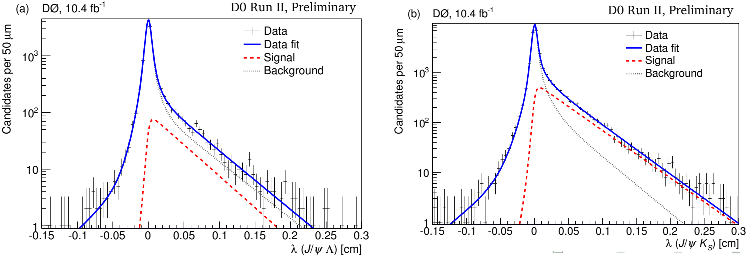
- Invariant mass distributions for Λ_b and B_d

755 ± 49 (Λ_b) and 5671 ± 126 (B_d)



regions contaminated with partially reconstructed b hadrons

- Proper decay length distributions for Λ_b and B_d



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Systematic uncertainties and the measurement of the Λ_b and B_d lifetimes

Source	Λ_b (μm)	B_d (μm)
Mass model	2.2	6.4
Proper decay length model	7.8	3.7
Proper decay length uncertainty	2.5	8.9
Partially reconstructed B decays	2.7	1.3
$B_s \rightarrow J/\psi K_s^0$	-	0.4
Aligment	5.4	5.4
Total (in quadrature)	10.4	12.9

Using the full data sample collected by the DØ Collaboration,

New DØ Result

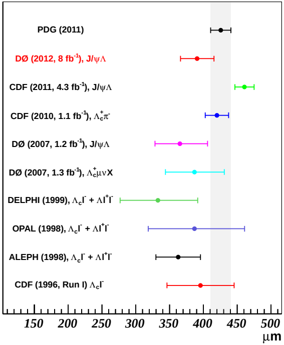
$$\tau(\Lambda_b) = 1.303^{+0.076}_{-0.074}(\text{stat}) \pm 0.035(\text{syst})$$
$$\tau(B_d) = 1.508^{+0.026}_{-0.025}(\text{stat}) \pm 0.043(\text{syst})$$

Calculating the ratio of lifetimes

$$\frac{\tau(\Lambda_b)}{\tau(B_d)} = 0.864^{+0.053}_{-0.051} \text{ (stat)} \pm 0.033 \text{ (syst)}$$

Measurement of the Λ_b and B_d lifetimes

- $\tau(\Lambda_b)$ is consistent with the world-average 1.425 ± 0.032 ps and with previous DØ measurements



- The method was thoroughly tested in $B_d \to J/\psi K_s^0$ decay:

$$\tau(B_d) = 1.508^{+0.026}_{-0.025}\ \text{(stat)} \pm 0.043\ \text{(syst)}$$

in very good agreement with the W.A., $\tau(B_d) = 1.519 \pm 0.007$ ps.

Part II

- Measururementof $f(b \to \Lambda_b) \cdot \mathcal{B}(\Lambda_b \to J/\psi \Lambda)$

How to get the $f(b \to \Lambda_b) \cdot \mathcal{B}\left(\Lambda_b \to J/\psi\Lambda\right)$?

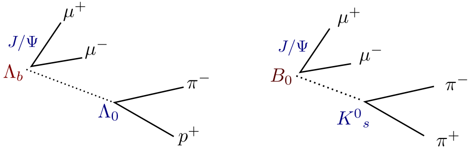
We can compute the σ_{rel}:

$$\sigma_{rel} \equiv \frac{f(b \to \Lambda_b) \cdot \mathcal{B}(\Lambda_b \to J/\psi\Lambda)}{f(b \to B^0) \cdot \mathcal{B}(B^0 \to J/\psi K_s^0)} = \epsilon \cdot \frac{N_{\Lambda_b \to J/\psi\Lambda}}{N_{B^0 \to J/\psi K_S^0}} \cdot \frac{\mathcal{B}(K_s^0 \to \pi^+\pi^-)}{\mathcal{B}(\Lambda \to p\pi^-)}$$

where ϵ is the ratio of reconstruction efficiencies $\frac{\epsilon_{B^0 \to J/\psi K_S^0}}{\epsilon_{\Lambda_b \to J/\psi\Lambda}}$, obtained from Monte Carlo.

Samples:

- Two samples to analyse: $\Lambda_b \to J/\psi\Lambda$ & $B_d \to J/\psi K_s^0$ (normalization channel)



- How to get the signal?
  1. Dimuons + 2 tracks + Quality Cuts
  2. + Optimized Cuts

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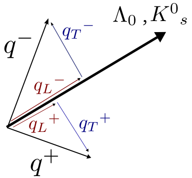
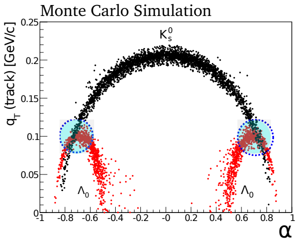
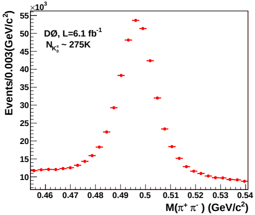
Dimuons + 2 tracks + Quality Cuts

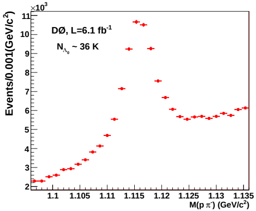
- Two Muons
  - Quality cuts
  - $p_T(\mu) > 2$ GeV$/c$;
  - $|\eta(\mu)| < 2$;
- Two oppositely-charged tracks
- $p_T(\Lambda_b, B_0) > 5$ GeV$/c$
- $p_T(J/\psi) > 3$ GeV$/c$
- The *Armenteros–Podolanski* technique is used to check if we have removed background coming from the misidentified Λ and K^0_S .

$$\alpha = \frac{{q^+}_L - {q^-}_L}{{q^+}_L + {q^-}_L}$$







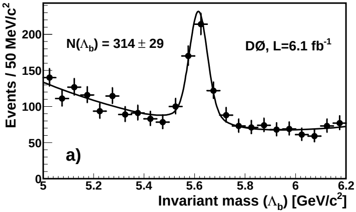


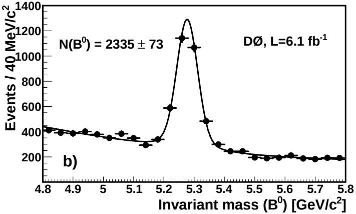
+ Optimized Cuts

$$S = \frac{N_s}{\sqrt{N_s + N_b}}$$

Decay	Parameter	Cut Value
$\Lambda_b \to J/\psi\Lambda$	$c\tau/\sigma_{c\tau}$ (Λ)	> 4
	Length Decay XY (Λ)	> 0.8
	P_T (Λ)	> 1.6
	$c\tau/\sigma_{c\tau}$ (Λ_b)	> 2
$B_d \to J/\psi K_s^0$	$c\tau/\sigma_{c\tau}$ (K_S^0)	> 9
	Length Decay XY (K_S^0)	> 0.4
	P_T (K_S^0)	> 1
	$c\tau/\sigma_{c\tau}$ (B_d)	> 3

- In case of multiple candidates in a event, we keep the Λ_b (B_d) candidate per event with best vertex χ^2





Results & Systematic uncertainties

From Monte Carlo

$$\epsilon = \frac{\epsilon_{B^0 \to J/\psi K^0_S}}{\epsilon_{\Lambda_b \to J/\psi \Lambda}} = 2.37 \pm 0.05\ (stat.)$$

The sources of systematic uncertainties are:

Test	Systematic uncertainty (%)
Fit Model	5.5
Signal Decay Model for B_0	2.0
Background from B_d and Λ_b	2.3
Λ_b Polarization ($P_b \alpha_b = +1$)	7.2
Total (in quadrature)	9.6

$$\sigma_{rel} = \frac{f(b \to \Lambda_b) \cdot \mathcal{B}(\Lambda_b \to J/\psi\Lambda)}{f(b \to B^0) \cdot \mathcal{B}(B^0 \to J/\psi K^0_s)} = 0.345 \pm 0.034\ \text{(stat.)} \pm 0.033\ \text{(syst.)} \pm 0.003\ \text{(PDG)}$$

New DØ Result

$$f(b \to \Lambda_b) \cdot \mathcal{B}(\Lambda_b \to J/\psi\Lambda) = (6.01 \pm 0.60\ \text{(stat.)} \pm 0.58\ \text{(syst.)} \pm 0.28\ \text{(PDG)}) \times 10^{-5}$$

The current world average for this product from the PDG is $(4.7 \pm 2.3) \times 10^{-5}$.
This result represents a reduction by a factor of ~ 3 of the uncertainty with respect to the W.A.

Estimation of $\mathcal{B}\left(\Lambda_b \to J/\psi\Lambda\right)$

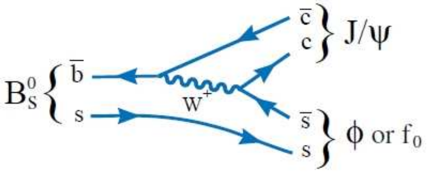
- We need an external measurement of $f(b \to \Lambda_b)$. We are not aware of any direct measurement of this quantity
- Making some assumptions
  - $f(b \to b_{baryon}) \approx f(b \to \Lambda_b) + f(b \to \Xi_b^-) + f(b \to \Xi_b^0)$
  - $f(b \to \Xi_b^-) \approx f(b \to \Xi_b^0)$
  - $\frac{f(b \to B_s)}{f(b \to B^0)} \approx \frac{f(b \to \Xi_b^-)}{f(b \to \Lambda_b)}$
- Then $\mathcal{B}(\Lambda_b \to J/\psi\Lambda) \approx (11.08 \pm 3.31) \times 10^{-4}$
- Same to the W.A. would lead to $\mathcal{B}(\Lambda_b \to J/\psi\Lambda) \approx (8.67 \pm 4.84) \times 10^{-4}$

Part III

- Measurement of the branching fraction $\mathcal{B}(B_s \to J/\psi f_0 \,, B_s \to J/\psi \phi \,)$

Motivation

- B_s mesons are important particles created at high rates in hadron collisions
- Many of the decays of B_s mesons are important because they allow the study of possible asymmetries in the phenomenology of these particles
- Same tree diagram as $B_s \to J/\psi\phi$
- Sensitive to $\Delta\Gamma_s$ and ϕ_s



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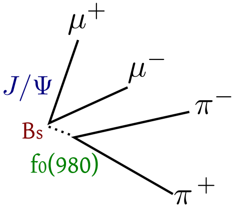
Event Selection

- We require two reconstructed muons of opposite charge.
- Form J/Ψ candidates
- Form $f_0(980)$ (ϕ) candiates from opposite charged tracks assuming the tracks are pions (kaons).
- Form B_s candidates from J/Ψ and $f_0(980)$ (ϕ) candidates.
  - Make cuts in the kinematic and the mass windows:
    - Pion (Kaon) leading $P_T > 1.4GeV$
    - B_s $P_T > 5GeV$,
    - $f_0(980)$ $P_T > 1.6GeV$
    - $0.91GeV < M_{\pi^+\pi^-} < 1.05GeV$ (When J/Ψ $f_0(980)$)
    - $1.01GeV < M_{K^+K^-} < 1.03GeV$ (When J/Ψ ϕ)



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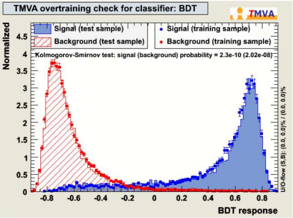
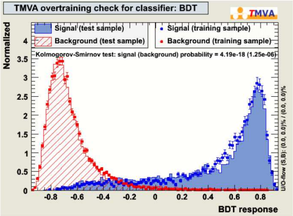
BDT used to suppress background:

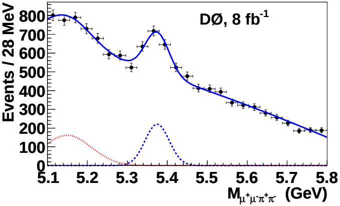
- Prompt $p\bar{p} \rightarrow J/\Psi X$

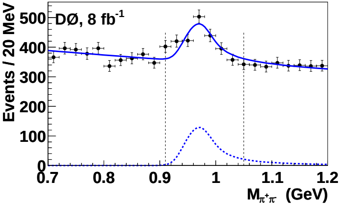


- b-inclusive $b\bar{b} \rightarrow J/\Psi X$

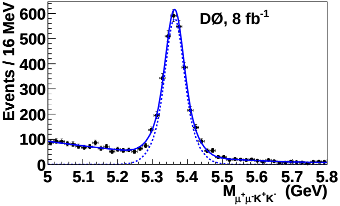


- $\mu^+\mu^-\pi^+\pi^-$ and $\pi^+\pi^-$ mass distribution





- $\mu^+\mu^-K^+K^-$ mass distribution



Efficiencies and uncertainties

- Generated MC samples for both $J/\psi f_0$ and $J/\psi \phi$
- $\epsilon = \frac{\epsilon_{reco}^{B_s \to J/\psi \phi}}{\epsilon_{reco}^{B_s \to J/\psi f_0(980)}} = 1.20 \pm 0.04$

Uncertainties in the ratio of branching fraction are:

Source	Uncertainty (%)
Statistical	14.9
Systematic from fitting	15.0
Systematic from different MC samples	8.58

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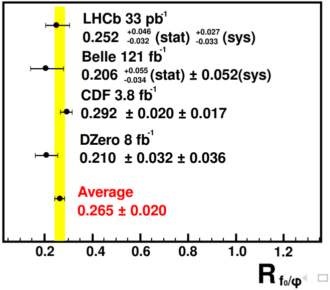
Ratio of Branching fractions

$$R = \frac{\mathcal{B}(B_s \to J/\psi f_0(980); f_0(980) \to \pi^+\pi^-)}{\mathcal{B}(B_s \to J/\psi\phi; \phi \to K^+K^-)}$$

$$= \frac{N_{B_s \to J/\psi f_0(980)}}{N_{B_s \to J/\psi\phi}} \times \frac{\epsilon_{reco}^{B_s \to J/\psi\phi}}{\epsilon_{reco}^{B_s \to J/\psi f_0(980)}}$$

New D0 Result

$$R = 0.210 \pm 0.032(stat) \pm 0.036(syst)$$



Conclusions

Three new measurements

Conclusions

- Using the full DØ dataset we have measured the Λ_b lifetime in the exclusive decay $J/\Psi\Lambda$. We found:

$$\tau(\Lambda_b) = 1.303^{+0.076}_{-0.074}\ \text{(stat)} \pm 0.035\ \text{(syst)}$$

  consistent with the previous DØ measurements and the W.A., 1.425 ± 0.032 ps

- A new measurement of $f(b \to \Lambda_b) \cdot \mathcal{B}(\Lambda_b \to J/\psi\Lambda)$ has been performed and it is found to be:

$$f(b \to \Lambda_b) \cdot \mathcal{B}(\Lambda_b \to J/\psi\Lambda) = (6.0 \pm 0.6\ \text{(stat.)} \pm 0.6\ \text{(syst.)} \pm 0.3\text{(PDG)}) \times 10^{-5}$$

- A new measurement of $\mathcal{B}(B_s \to J/\psi f_0\ , B_s \to J/\psi\phi\ )$

$$\frac{\mathcal{B}(B_s \to J/\psi f_0(980); f_0(980) \to \pi^+\pi^-)}{\mathcal{B}(B_s \to J/\psi\phi; \phi \to K^+K^-\ )} = 0.210 \pm 0.032\ \text{(stat)} \pm 0.036\ \text{(syst.)}$$

- More results comming .....

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