

B hadrons lifetimes in DØ

Eduard De La Cruz Burelo

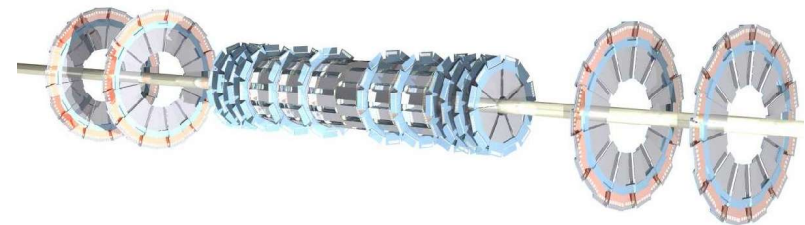


CINVESTAV
Mexico City



Outline:

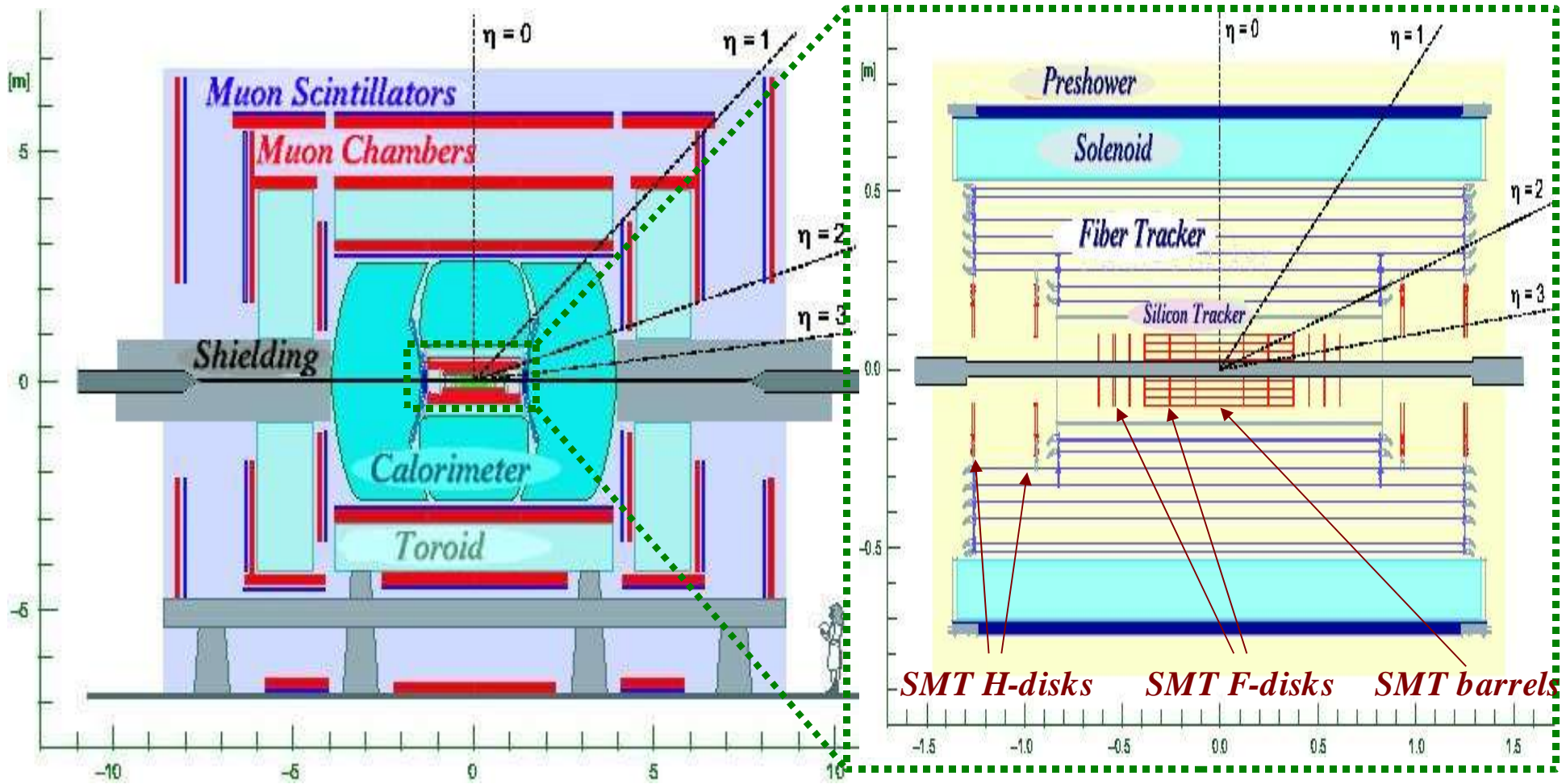
- DØ Detector
- Λ_b/B^0 and B_s/B^0 lifetime ratios in exclusive channels
- B^+/B^0 and Λ_b/B^0 lifetime ratios in semileptonic decay
- Summary results



Meeting of DPF

Riverside CA, August 26-31, 2004

DØ Detector



- ♦ Muon system with coverage $|\eta| < 2$ and good shielding

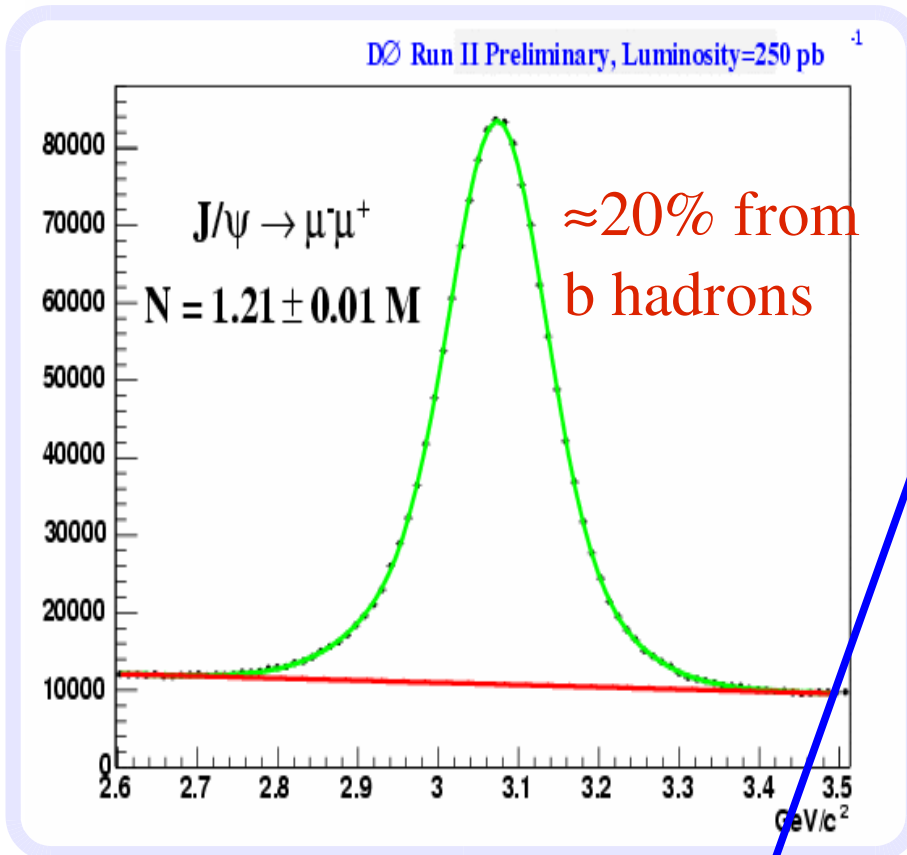
❖ Trackers

➤ Silicon Tracker: $|\eta| < 3$

➤ Fiber Tracker: $|\eta| < 2$

❖ Magnetic field 2T

Lifetime measurements from the dimuon sample:



- Same topology:
- Vertex of two charged tracks and one neutral
 - Four charged tracks vertex

Measure at same time

$$\Lambda_b \rightarrow J/\psi (\mu^+ \mu^-) \Lambda (p \pi)$$

$$B_d^0 \rightarrow J/\psi (\mu^+ \mu^-) K_s^0 (\pi^+ \pi^-)$$

Used to obtain: $\tau(\Lambda_b) / \tau(B_d^0)$

Measure at same time

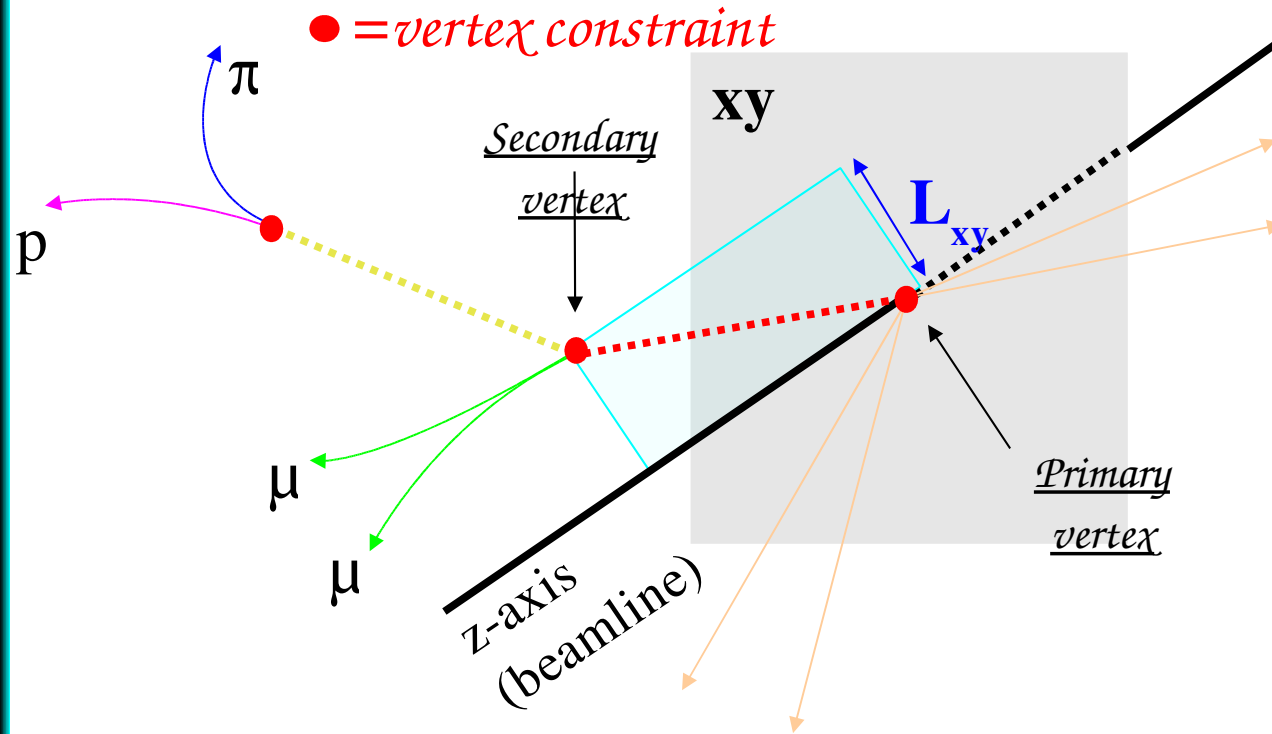
$$B_s^0 \rightarrow J/\psi (\mu^+ \mu^-) \phi (K^+ K^-)$$

$$B_d^0 \rightarrow J/\psi (\mu^+ \mu^-) K^* (K^+ \pi^-)$$

Used to obtain: $\tau(B_s^0) / \tau(B_d^0)$

Measurement technique

(The proper decay length)

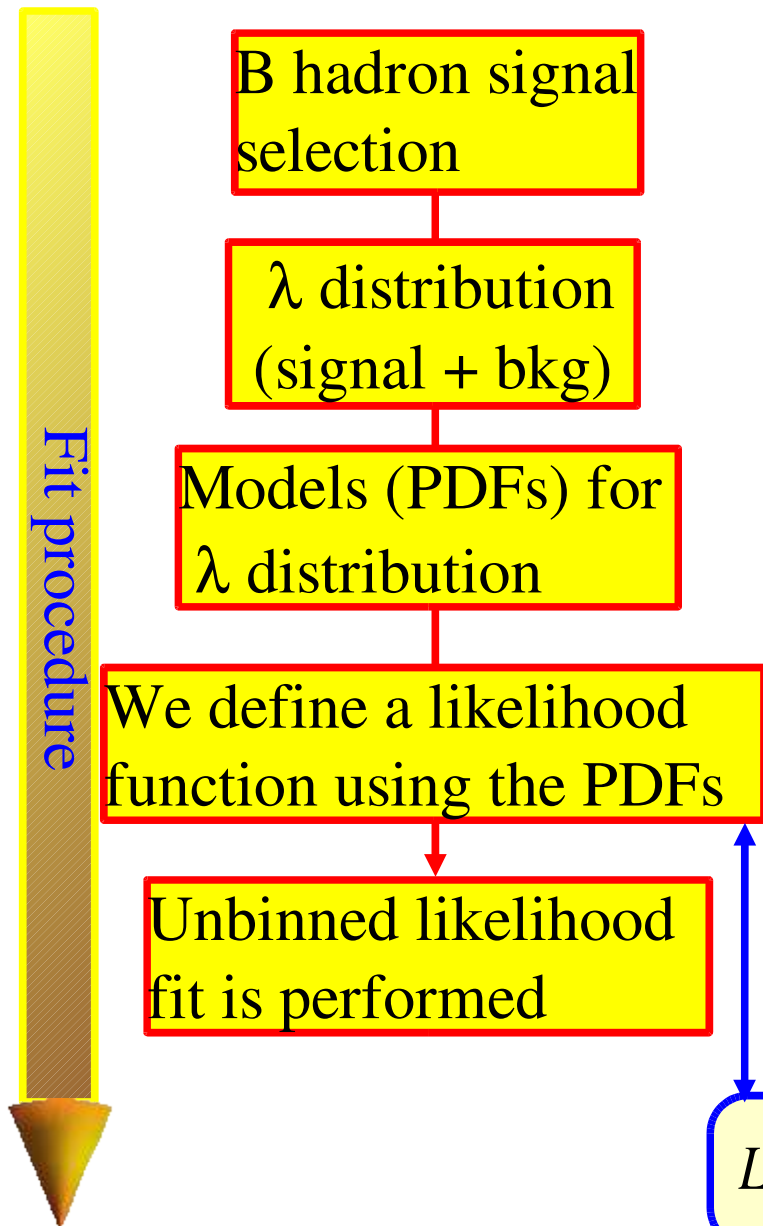


Primary vertex determine event by event, using beam spot constraint

$$\lambda = \vec{L} \cdot \hat{p}_T \frac{M}{p_T} = L_{xy} \frac{M}{p_T} = \frac{L_{xy}}{(\beta\gamma)_T}$$

Boost in the transverse plane to the beam

Measurement technique



Lifetime models

S_{LF} : Signal lifetime PDF

- Convolution (Exponential decay, Resolution)

B_{LF} : Background lifetime PDF

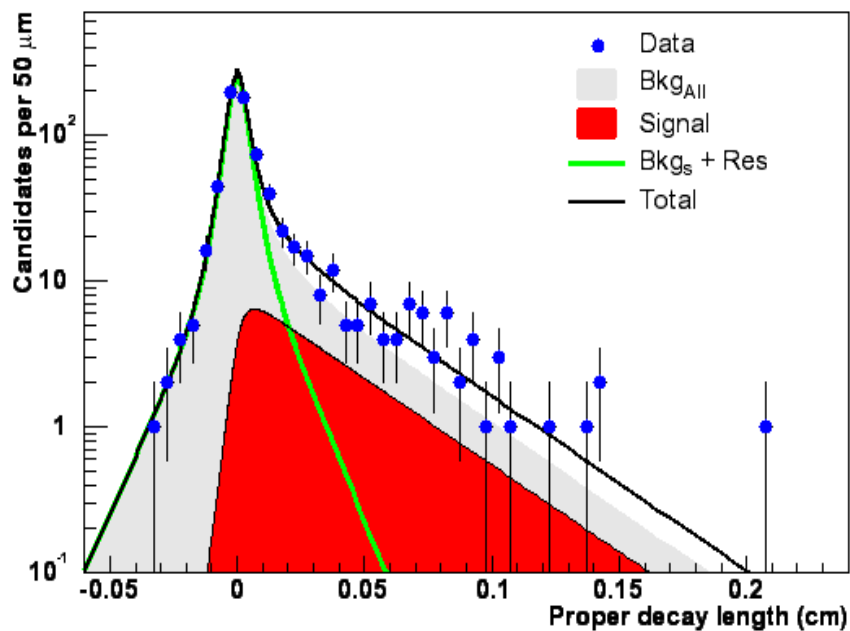
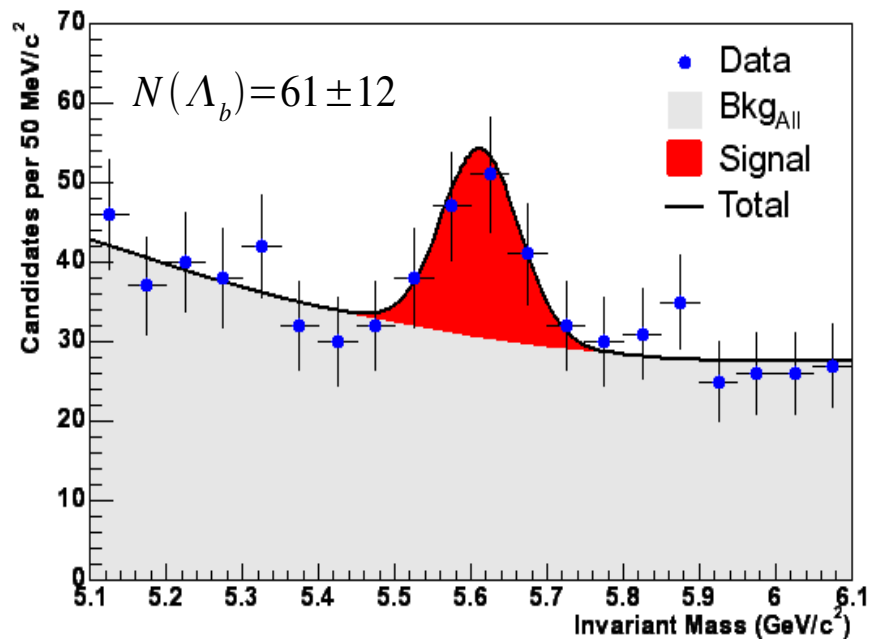
- Resolution + negative exp. decay + 2 positive exp. decays.
- Resolution:

$$Res(\lambda_j, \sigma_j) = \frac{1}{\sqrt{2\pi s \sigma_j}} e^{-\lambda_j^2 / 2(s\sigma_j)^2}$$

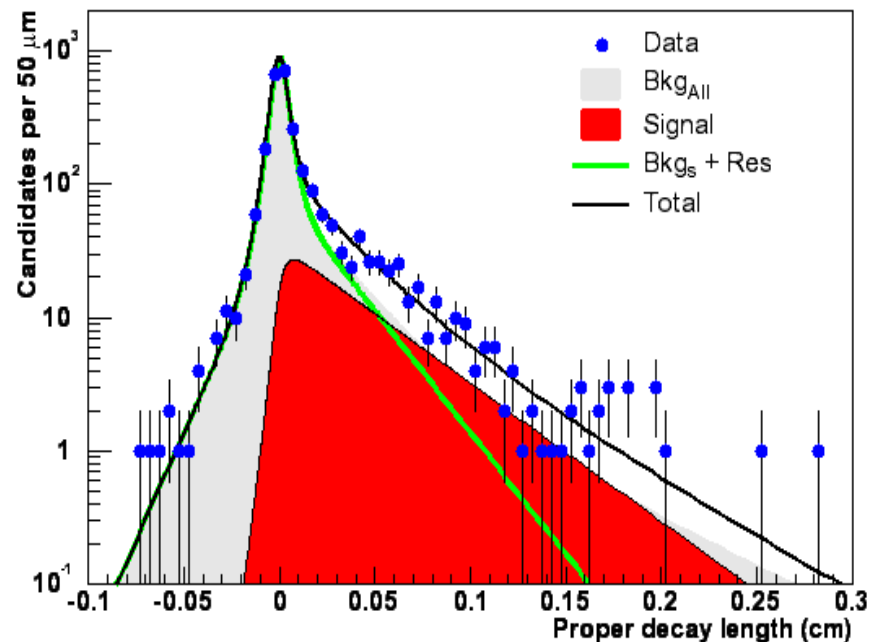
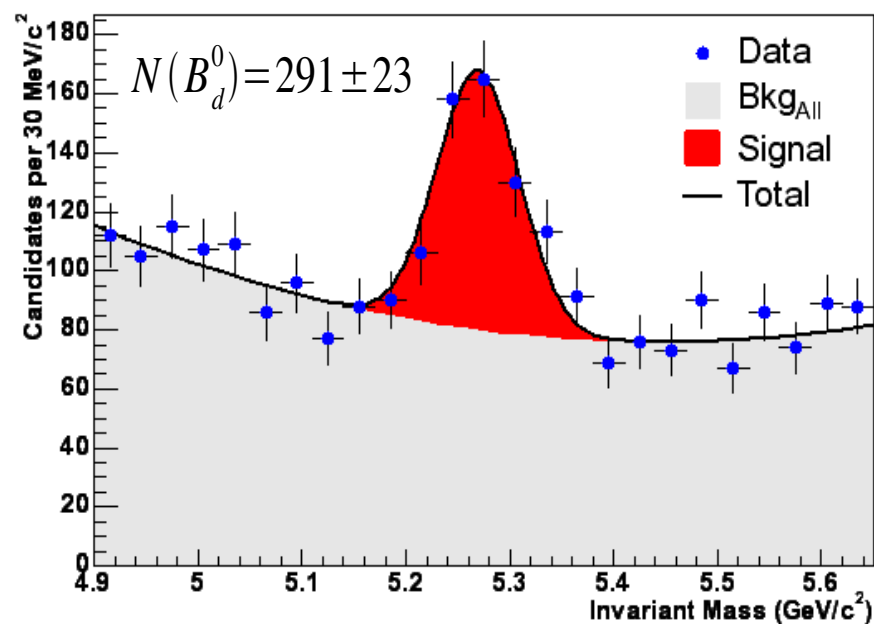
- 2Dim Likelihood:

$$L = f_s S_M(M_j) S_{LF}(\lambda_j, \sigma_j) + (1 - f_s) B_M(M_j) B_{LF}(\lambda_j, \sigma_j)$$

$$\Lambda_b \rightarrow J/\psi (\mu^+ \mu^-) \Lambda (p \pi)$$



$$B_d^0 \rightarrow J/\psi (\mu^+ \mu^-) K_S^0 (\pi^+ \pi^-)$$

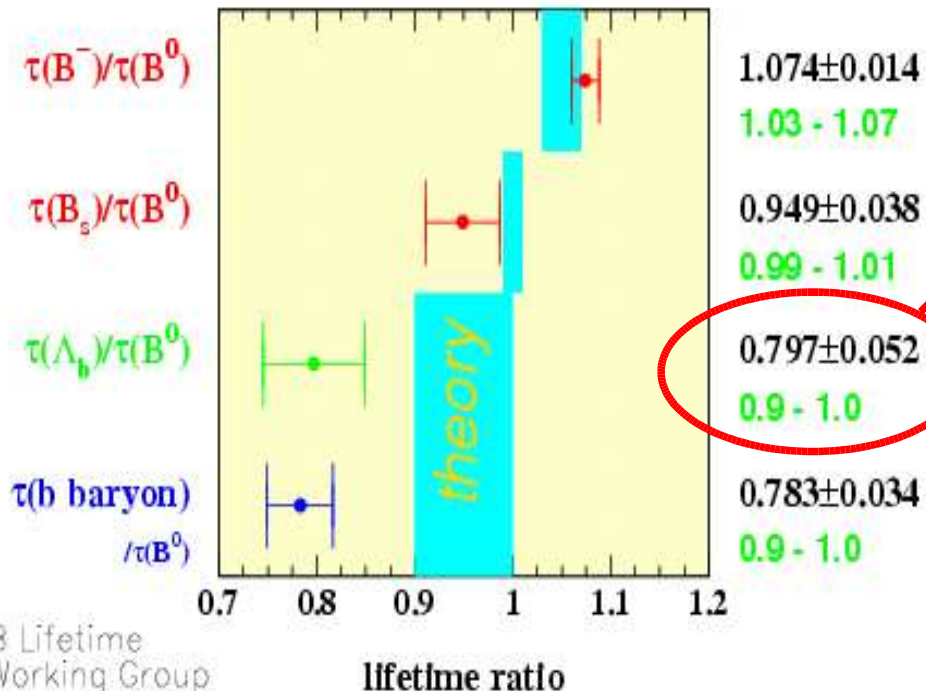


Results:

$$\tau(\Lambda_b) = 1.221 +_{-0.179}^{+0.217} (stat) \pm 0.043 (syst) ps$$

$$\tau(B_d^0) = 1.397 +_{-0.098}^{+0.107} (stat) \pm 0.031 (syst) ps$$

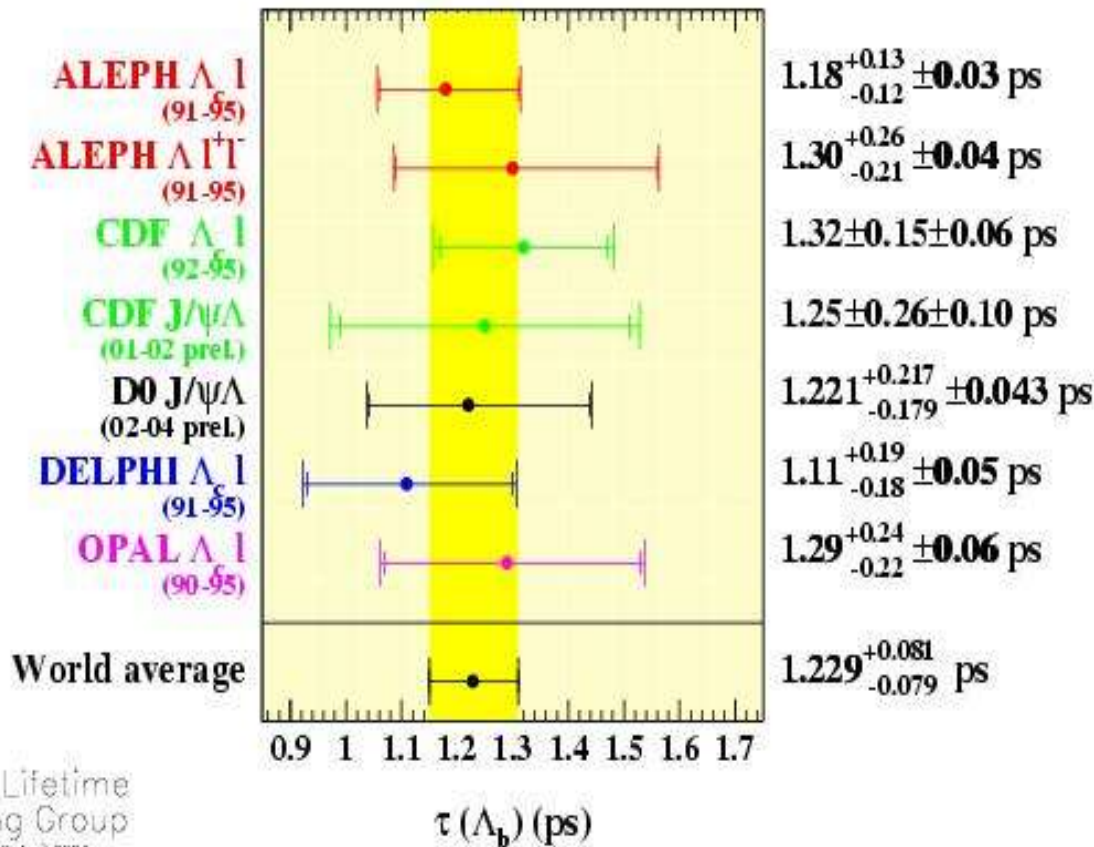
$$\frac{\tau(\Lambda_b)}{\tau(B_d^0)} = 0.874 +_{-0.142}^{+0.169} (stat) \pm 0.028 (syst)$$



Source	Bd (um)	Ab (um)	lifetime ratio
Alignment	5.4	5.4	0.002
Model for resolution	2.7	6.7	0.010
Decays convoluted	0.5	2.7	0.005
Short-lived decays	3.1	0.5	0.008
Long-lived component	0.1	1.5	0.003
Model for signal mass	0	0.2	0.000
Model for background mass	6.2	2.5	0.007
Contamination	0.8	8.8	0.023
Total	9.2	12.9	0.028

B Lifetime Working Group
CKM WKS February 2002

Λ_b lifetime

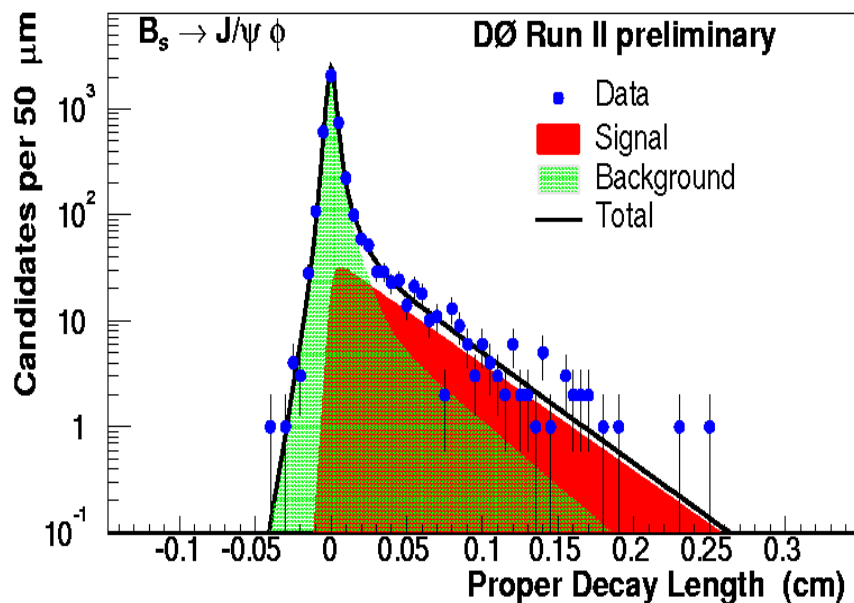
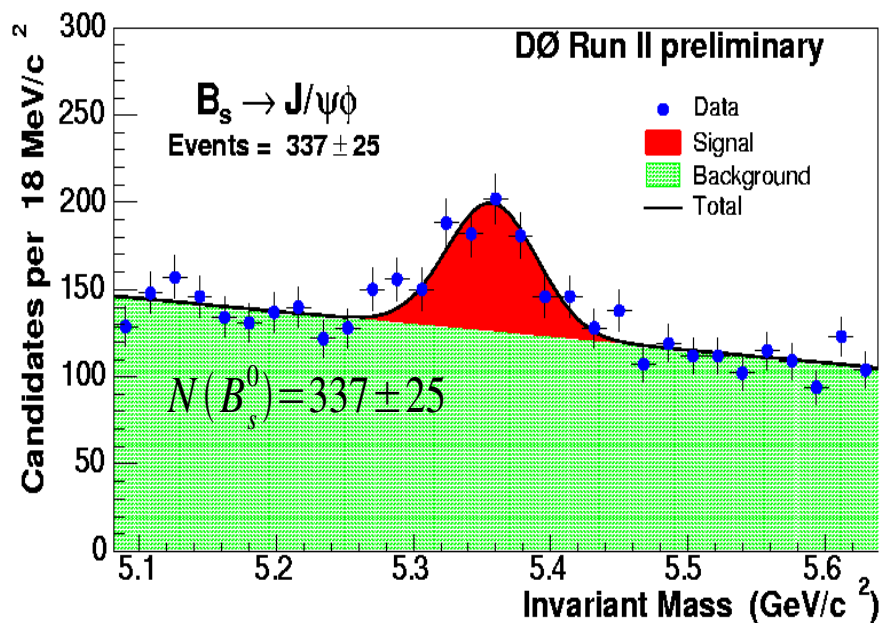


← New $D0$ result
 (Average not updated,
 plot not official or
 approved by HFAG)

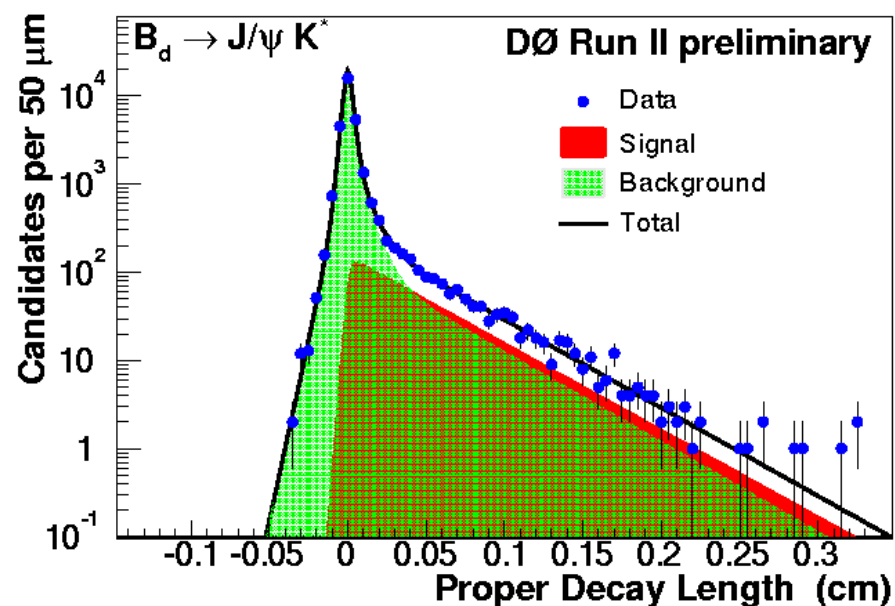
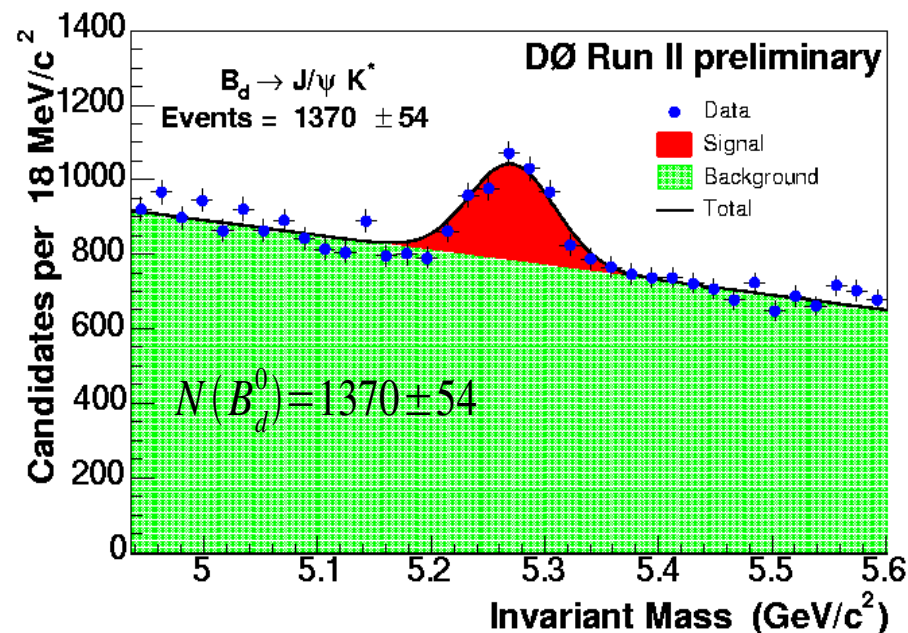
LEP B Lifetime
 Working Group
 Privately Add. CD, April 2004

Best Λ_b lifetime measurement in a fully reconstructed channel

$$B_s^0 \rightarrow J/\psi (\mu^+ \mu^-) \phi (K^+ K^-)$$



$$B_d^0 \rightarrow J/\psi (\mu^+ \mu^-) K^* (K^+ \pi^-)$$



Results:

$$\tau(B_s^0) = 1.444 +_{-0.090}^{+0.098} (stat) \pm 0.020 (syst) ps$$

$$\tau(B_d^0) = 1.473 +_{-0.050}^{+0.052} (stat) \pm 0.023 (syst) ps$$

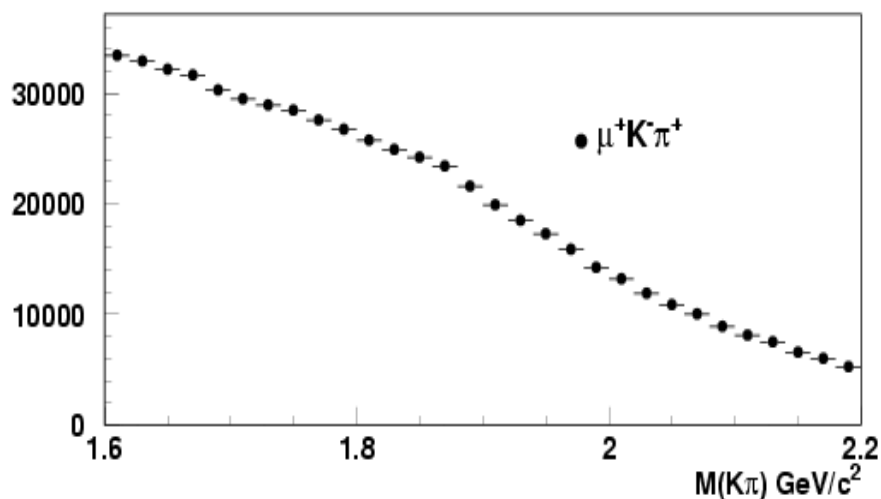
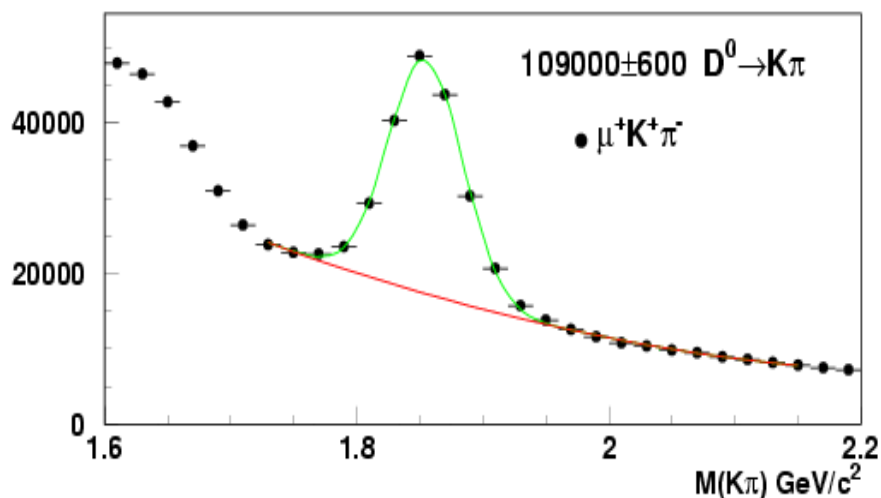
$$\frac{\tau(B_s^0)}{\tau(B_d^0)} = 0.980 +_{-0.070}^{+0.075} (stat) \pm 0.003 (syst)$$

The B_s^0 lifetime is the best measurement from a single experiment

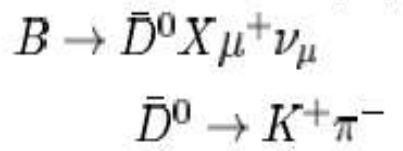
Source	Bs (um)	Bd (um)	lifetime ratio
Alignment	2	2	0.000
J/ ψ vertex	3	4	0.002
Resolution Model	3	3	0.000
Background	4	5	0.003
Total	6	7	0.003

Lifetime measurements from the single muon sample:

DØ RunII Preliminary, Luminosity=250 pb⁻¹



- Direct measurement of the B^+ to B^0_d lifetime ratio
- Direct measurement of the Λ_b to B^0_d lifetime ratio (in progress)



~ 400 events/pb⁻¹

Lifetime ratio of B^+ to B^0_d

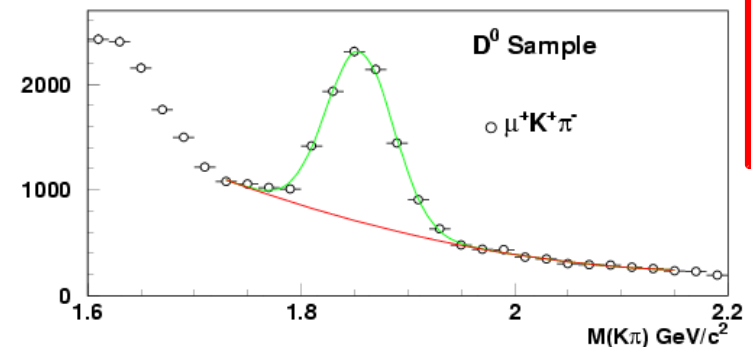
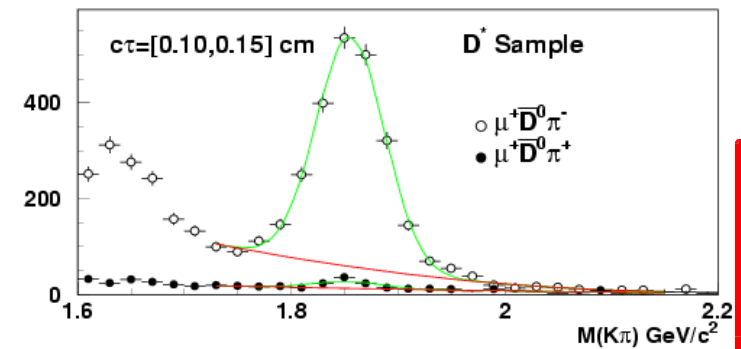
- Direct lifetime ratio measurement via counting of events in bins of visible proper decay length (VPDL)

$$x^M = \frac{L_T}{P_T^{\mu D^0}} \cdot M_B$$

L_T is defined as the distance in the axial plane between the PV and the μD^0 vertex

- Semi-leptonic decays:
 - $B \rightarrow \mu^+ \nu D^* (2010) X$, dominated by B^0_d decays (86%)
 - $B \rightarrow \mu^+ \nu D^0 X$, dominated by B^+ decays (82%)

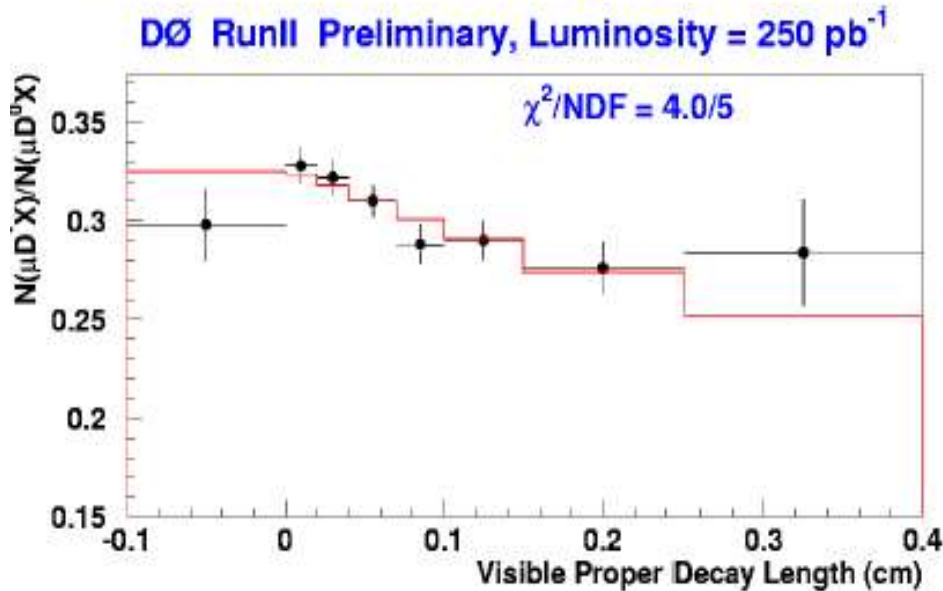
DØ RunII Preliminary, Luminosity=250 pb⁻¹



Example (bin)

Lifetime ratio of B^+ to B^0_d

Use binned χ^2 fit of event ratios to determine $\tau(B^+)/\tau(B^0)$



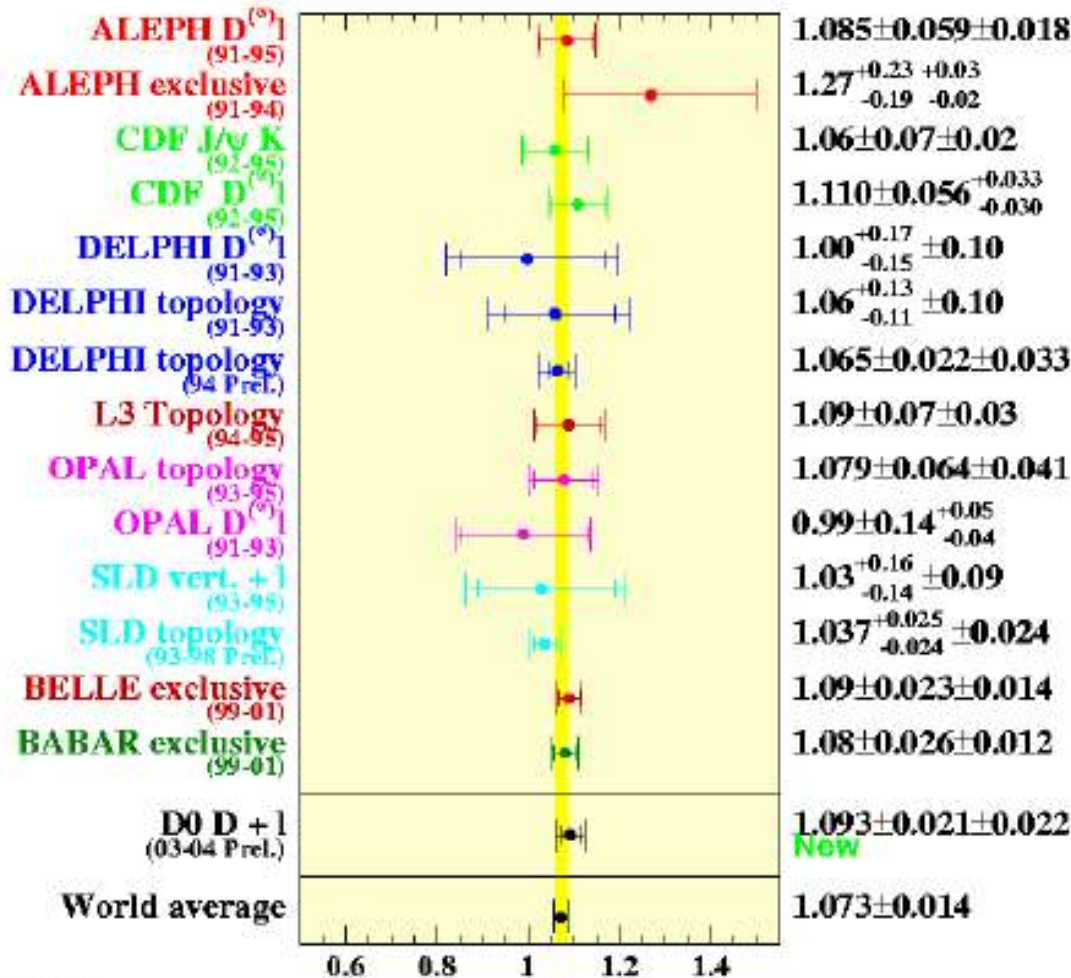
Main systematic errors:

Source	Δk
$Br(B^+ \rightarrow D^{*-} \pi^+ \mu \nu X)$	0.0053
Resolution description	0.0042
Difference in resolution D^+, D^0	0.0041
$Eff(D^+)/Eff(D^0) \neq const$	0.0132
Efficiency of different B decays	0.0086
Energy scale of B -hadron	0.0072
Fitting of N^+, N^0	0.0060

Preliminary result:

$$\tau(B^+)/\tau(B^0) = 1.093 \pm 0.021 \text{ (stat)} \pm 0.022 \text{ (syst)}$$

Lifetime ratio of B^+ to B^0_d



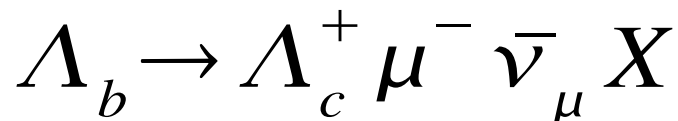
← **New D^0 result**
 (average not updated, plot not official or approved by HFAG)

B Lifetime Working Group (mod. RvK)
 March 2004

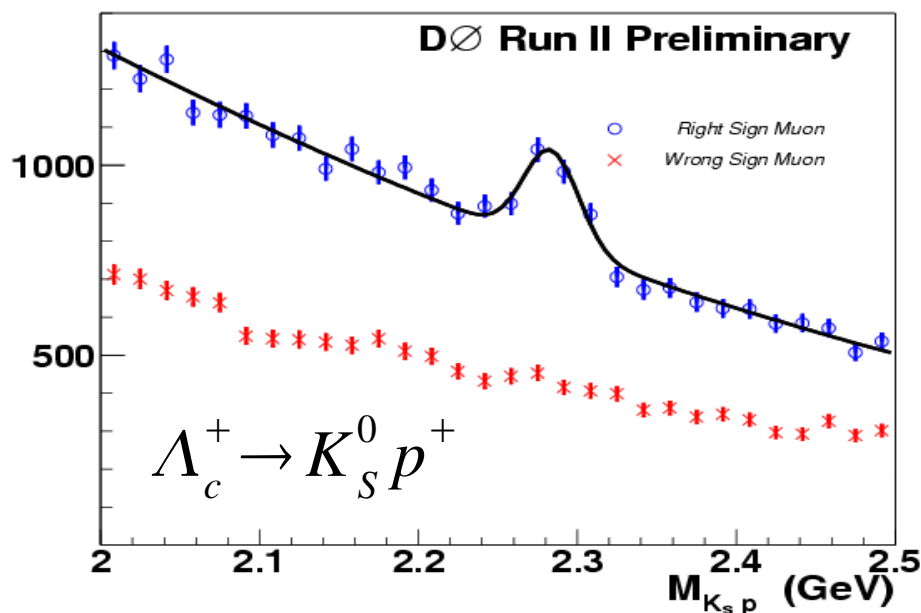
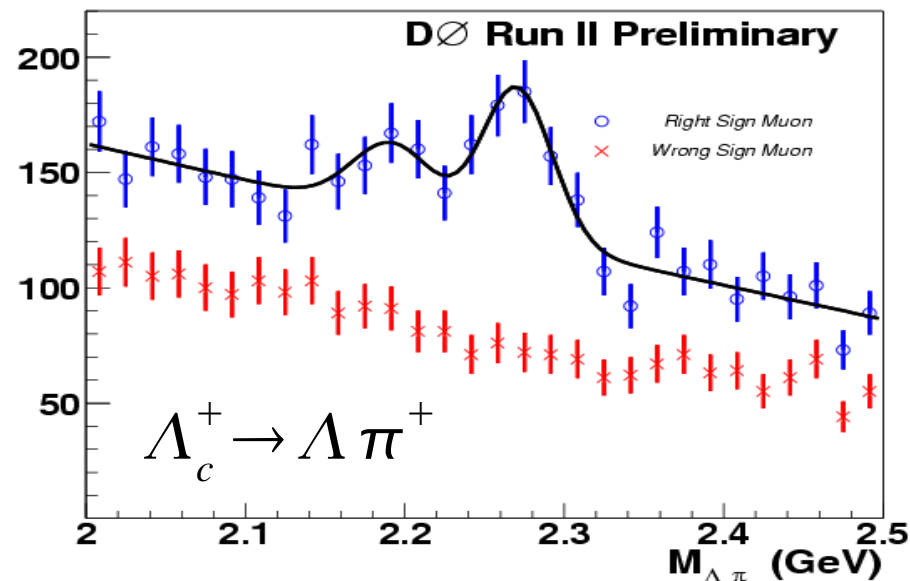
$\tau(B^+)/\tau(B^0_d)$

Towards lifetime ratio of Λ_b to B^0

- Searching for Λ_b in:



- More statistics than in exclusive channels
- Measurement by using same technique as used for the $\tau(B^+)/\tau(B^0)$ lifetime ratio.
- B^0 sample already selected in the $\tau(B^+)/\tau(B^0)$ ratio measurement.



Summary

Exclusive channels

$$\tau(B_d^0 \rightarrow J/\psi K_s^0) = 1.397 +_{-0.098}^{+0.107} (stat) \pm 0.031 (syst) ps$$

$$\tau(B_d^0 \rightarrow J/\psi K^*) = 1.473 +_{-0.050}^{+0.052} (stat) \pm 0.023 (syst) ps$$

$$\tau(B_s^0 \rightarrow J/\psi \phi) = 1.444 +_{-0.090}^{+0.098} (stat) \pm 0.020 (syst) ps$$

$$\tau(\Lambda_b \rightarrow J/\psi \Lambda) = 1.221 +_{-0.179}^{+0.217} (stat) \pm 0.043 (syst) ps$$

$$\frac{\tau(B_s^0 \rightarrow J/\psi \phi)}{\tau(B_d^0 \rightarrow J/\psi K^*)} = 0.980 +_{-0.070}^{+0.075} (stat) \pm 0.003 (syst)$$

$$\frac{\tau(\Lambda_b \rightarrow J/\psi \Lambda)}{\tau(B_d^0 \rightarrow J/\psi K_s^0)} = 0.874 +_{-0.142}^{+0.169} (stat) \pm 0.028 (syst)$$

Semileptonic:

$$\frac{\tau(B^+)}{\tau(B_d^0)} = 1.093 \pm 0.021 (stat) \pm 0.022 (syst)$$

Backup slides

Data selection

J/ψ cuts

- J/ψ mass [2.8,3.35] GeV
- Smt hits in muon >0
- Distance from PV to J/ψ vertex <10 cm
- At least one PV reconstructed
- Track measurements downstream (<1) to the vertex and misses upstream (<5)
- Probability (J/ψ) vertex $P(\chi) > 1\%$

$\Lambda^0(K^0s)$ cuts

- Mass windows [1.1100,1.1285] GeV/c, ([0.460,0.525])
- 2 opposite charged tracks that make a vertex
- SMT hits > 0 for each track

$\Lambda_b(B_d)$ cuts

- Mass window [5.1, 6.1] GeV, ([4.9,5.7])
- $\sigma(c\tau) < 100 \mu\text{m}$

Optimization Cuts

- $p(\Lambda_b)(B_d) > 5.0 \text{ GeV}/c$
- $\Lambda_b(B_d) \chi^2 \text{ vertex} < 25$
- Distance (x-y) from the J/ψ vertex to the Λ^0 vertex > 0.3 cm
- if $|\eta(\mu)| < 1$, $pT(\mu) > 2.5 \text{ GeV}/c$
- $pT(\Lambda^0)(K^0_s) > 2.4 (1.8) \text{ GeV}/c$

Final Cut

- If we have >1 candidate per event after all the previous cuts, then we take the one with the highest $\Lambda_b P(\chi^2)$ on the vertex

Systematic uncertainties

- For this analysis we considered the following sources of uncertainties:
 - SMT alignment, important in the vertex reconstruction
 - Resolution model
 - Models used for describing lifetime distributions
 - Models used for describing the mass distribution
 - Contamination due to a cross feed between the B^0 and the Λ_b
 - Difference in the lifetime distribution for the high and low mass background
 - We tested our fitting code against any possible bias

Cross-checks

- Also, as part of the analysis we made a lot of consistency checks. Some of them are:
 - Performing the fit procedure in full reconstructed MC
 - Using different fit methods besides the 2D fit
 - 1D fixed background
 - 1D simultaneous fit to background and signal
 - Using J/psi vertex instead of b hadron vertex
 - Varying mass windows used in the fit
 - Split the sample in detector and kinematic regions
 - Split the sample randomly

All cross checks were consistent with the central results