Tevatron Results on b-hadron lifetimes and rare decays

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B Physics at Tevatron

Lifetime and Rare Decays

$\tau(B_s)$ in $B_s \to J/\psi\phi$, $B_s \to \mu\nu D_s X$

$\tau(\Lambda_b)$ in $\Lambda_b \to \mu\nu\Lambda_c$, $\Lambda_b \to J/\psi\ \Lambda$

$\tau(B^0)$ in $B^0 \to J/\psi\ K^0_s$, $B^0 \to J/\psi\ K^{*0}$

$\tau(B^+)$ in $B^+ \to J/\psi\ K^+$

Limit on $B_s \to \mu\mu$

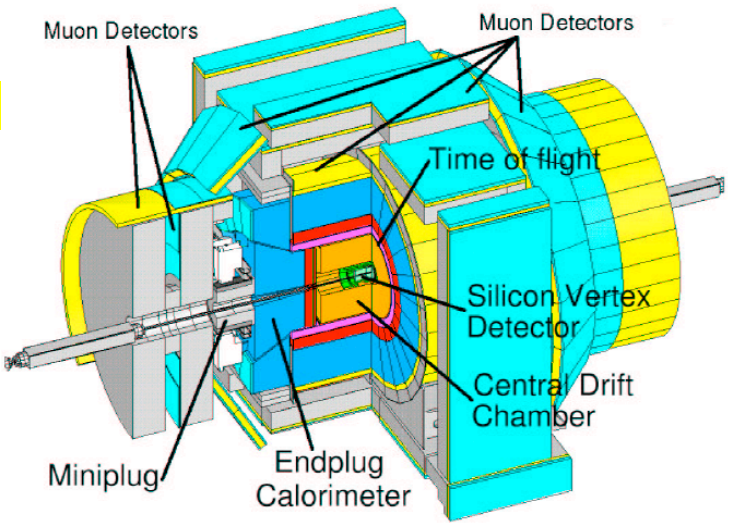
Observation of $B_s \to \psi(2S)\phi$, $B_s \to \phi\phi$

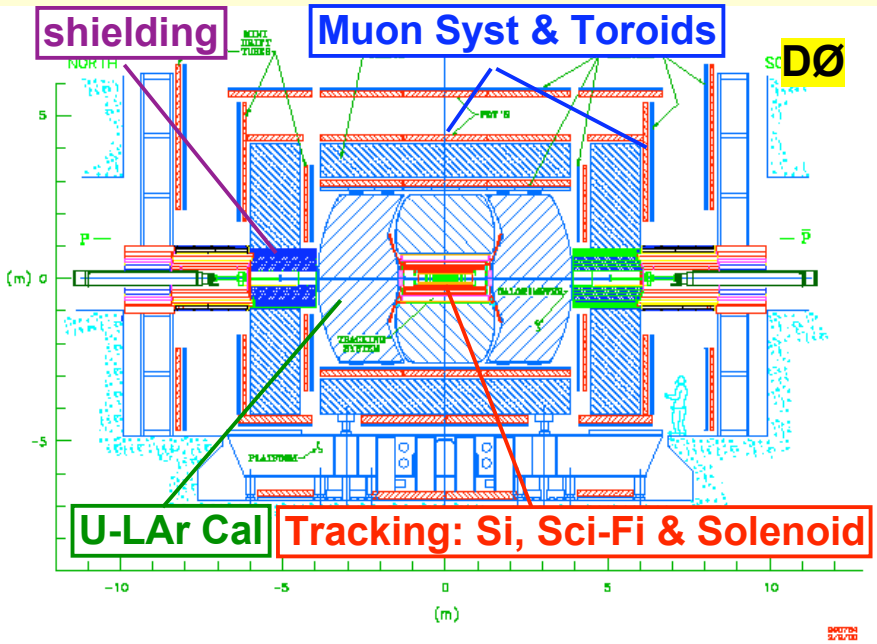
Observation of $B_s \to D_{s1}(2536)\mu\nu$

I will show the first $2fb^{-1}$ result from the Tevatron

CDF and DØ

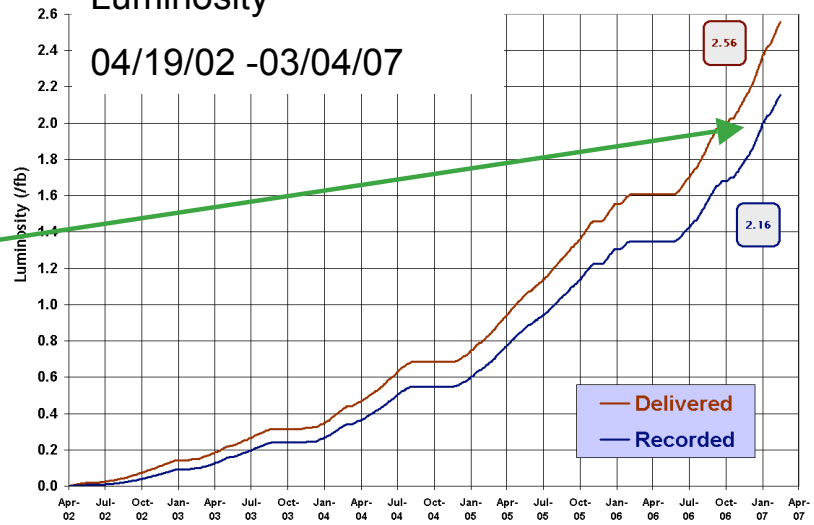
CDF





RunII Integrated Luminosity

04/19/02 -03/04/07



Data Samples

>2.5 fb^{-1} delivered

>2 fb^{-1} recorded

Results upto Jan 6, 2007

Important at the Tevatron

- **Triggering**
- **Muons**
- **Tracking/Vertexing**
- **(π / *K Separation*)**

Why Lifetimes?

- c, b Hadron masses
- c, b Hadron lifetimes
- c, b Hadron decays

} Tests of inputs to HQE, CKM → Extraction of CKM parameters

- HQE: no leading order corrections a 1/mQ

  General feature of QCD gauge structure

$$\delta\tau_{H_b} \sim O\left(\frac{\Lambda^2_{QCD}}{m_b^2}\right) + O\left(\frac{\Lambda^3_{QCD}}{m_b^3}\right) + \ldots$$

$$-\frac{1}{2}\frac{\mu_\pi^2}{m_b^2} - c_G\frac{\mu_G^2}{2m_b^2} \qquad \langle B|\bar{b}\Gamma q \cdot \bar{q}\Gamma' b|B\rangle$$

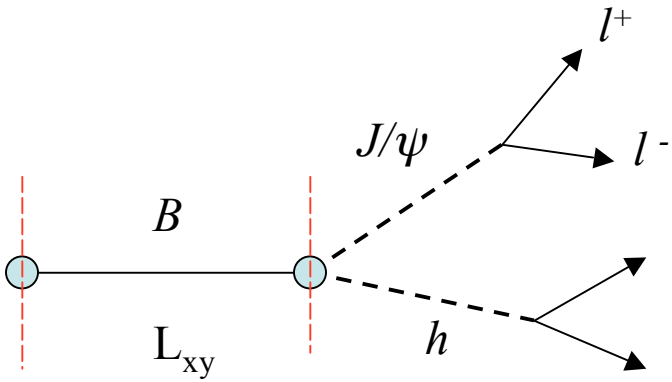
- Precise prediction possible:

$$\frac{\tau(B^+)}{\tau(B_d)} = 1.06 \pm 0.02, \quad \frac{\tau(B_s)}{\tau(B_d)} = 1.00 \pm 0.01, \quad \frac{\tau(\Lambda_b)}{\tau(B_d)} = 0.88 \pm 0.05$$

[E. Franco, V. Lubicz, F. Mescia and C. T., 2002-2003]

- Verification tests, validate of HQE

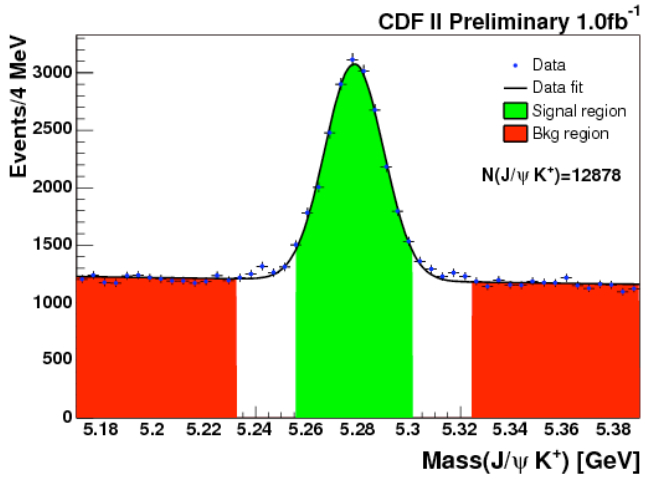
Measuring the lifetime



decay length

Proper decay time

$$ct = L^B_{xy} \cdot M_B / p_T$$

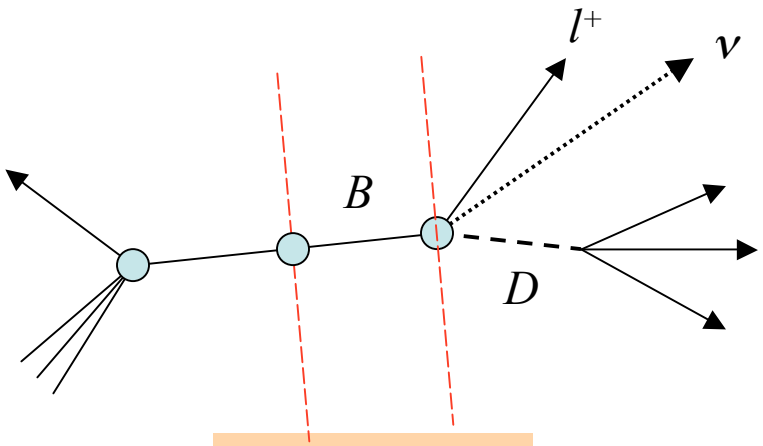


$$\mathcal{L} = \prod_{i=1}^{N} [f_{sig} \mathcal{F}^i_{sig} + (1 - f_{sig}) \mathcal{F}^i_{bck}],$$

Pros: Full reco

Cons: low stat

Measuring the lifetime

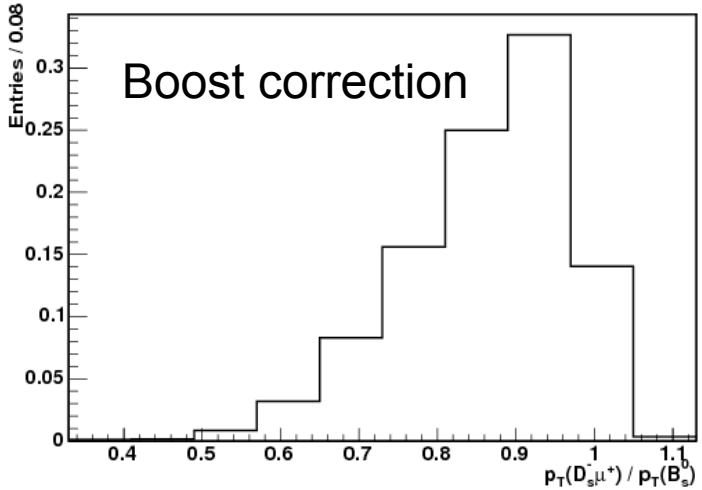


decay length

Proper decay time

$$ct = L_{xy}^{B} \cdot M_B / p_T$$

p_T approx.



$$\mathcal{L} = \prod_{i=1}^{N} [f_{sig} \mathcal{F}_{sig}^{i} + (1 - f_{sig}) \mathcal{F}_{bck}^{i}],$$

Pros: large stat

Cons: boost ambiguities,
K-factor needed

B_s Semileptonic Lifetime

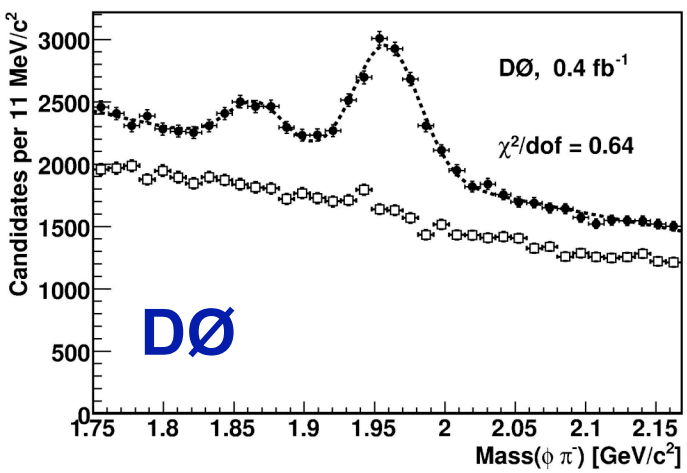
- Flavor specific; $B_s \rightarrow \mu^+$, anti-$B_s \rightarrow \mu^-$
- Fit effective lifetime distribution, τ_{fs}

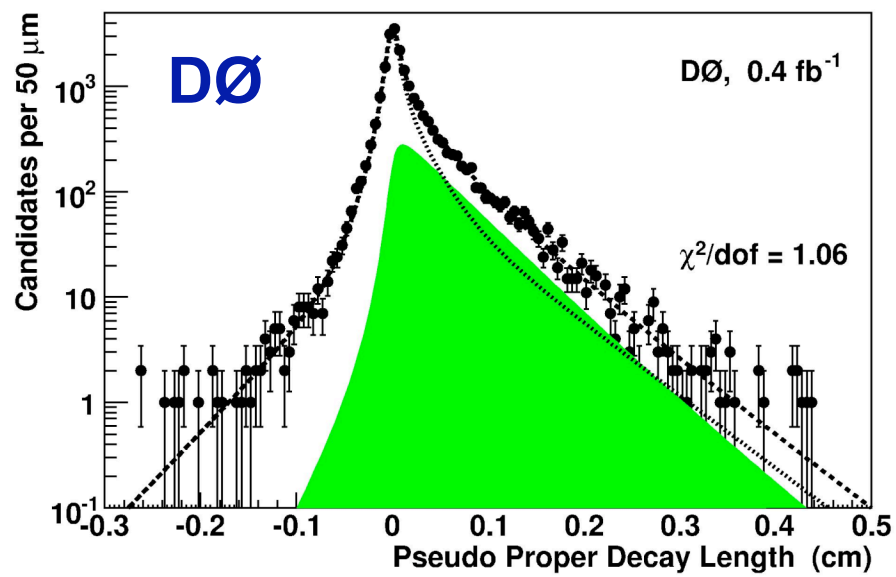
PRL 97, 241801 (2006)

$$\tau_{fs}(WA) = 1/\Gamma_{fs}$$

$$\Gamma_{fs} = \overline{\Gamma}_s - \left(\Delta\overline{\Gamma}_s\right)^2 / 2\overline{\Gamma}_s + O\left(\Delta\overline{\Gamma}_s\right)^3 / \overline{\Gamma}_s^{\,2}$$

$$\overline{\Gamma}_s = \left(\Gamma_L + \Gamma_H\right)/2$$



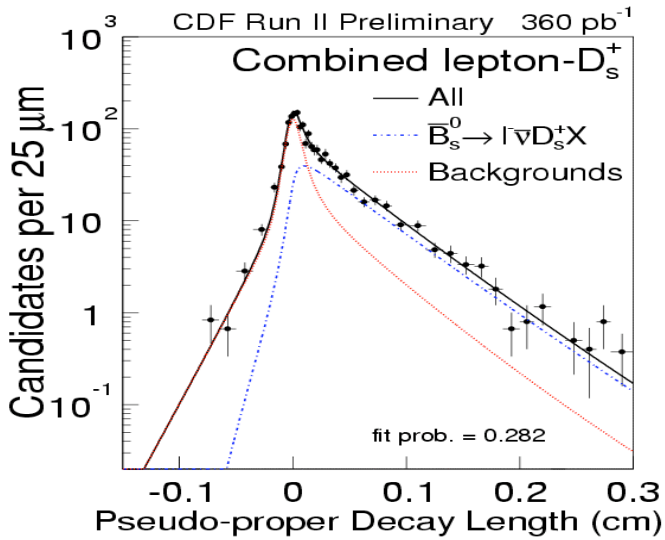


Most precise measurement

$$\tau_{fs}(B_s) = 1.398 \pm 0.044^{+0.028}_{-0.025}\, ps$$

world best!

More flavor specific B Lifetimes



Using μ and e lepton channels in the flavor specific B_s decay:

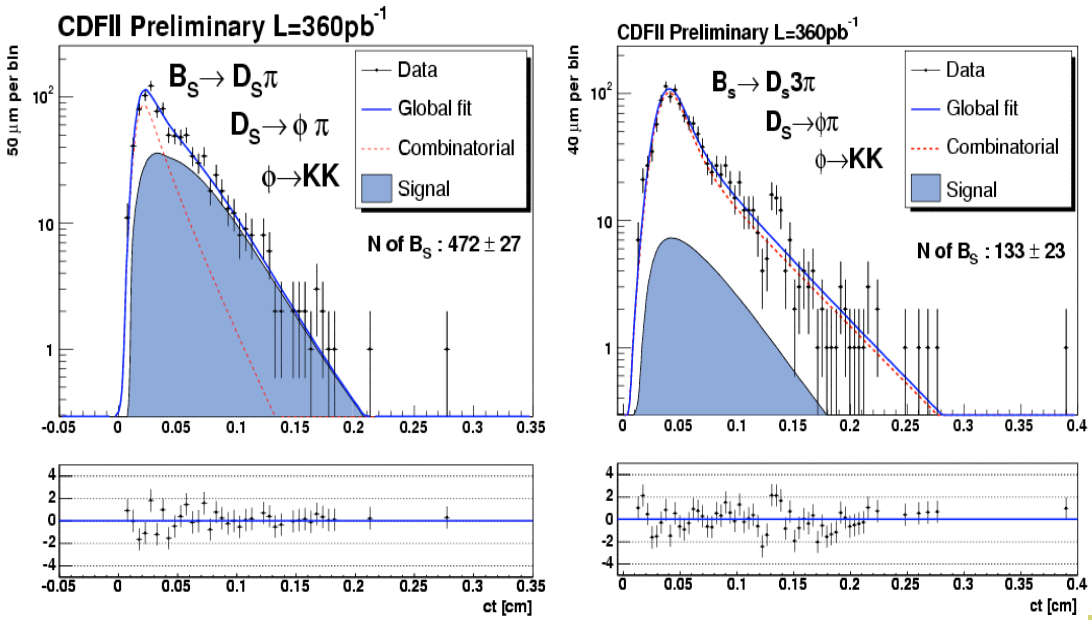
$$B_s^0 \to l^- \nu D_s^+ X$$

$$\tau(B_s) = 1.381 \pm 0.055^{+0.052}_{-0.046} \text{ ps}$$

CDF

Using a full-reconstructed decay channels

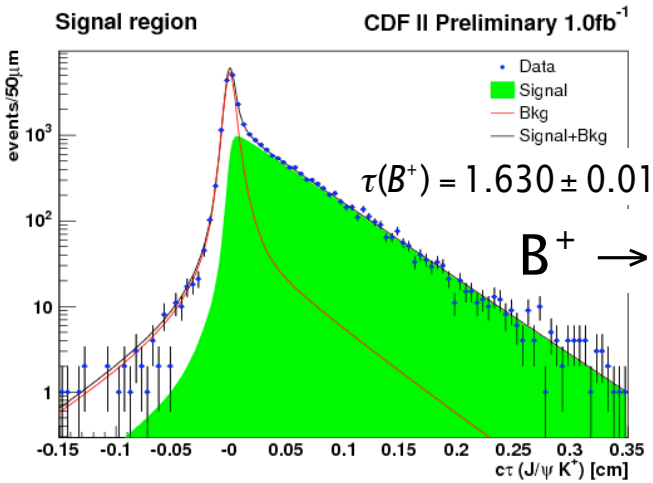
$$\tau(B_s) = 1.60 \pm 0.10 \pm 0.02 \text{ ps}$$



B Lifetimes

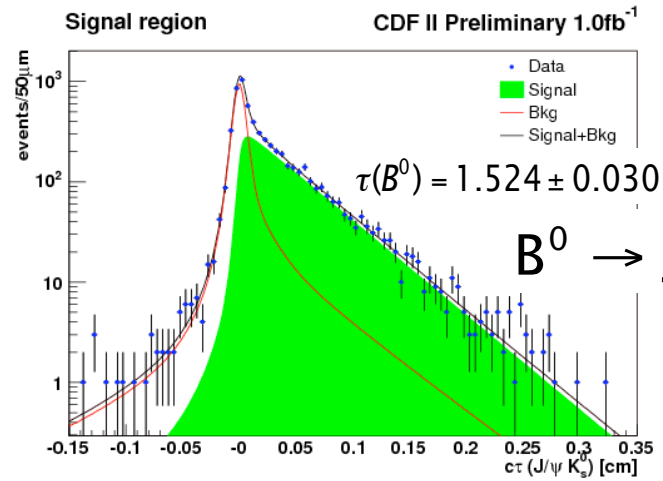
CDF

New B → J/ψ X lifetime measurements



$\tau(B^+) = 1.630 \pm 0.016 \pm 0.011\,\text{ps}$

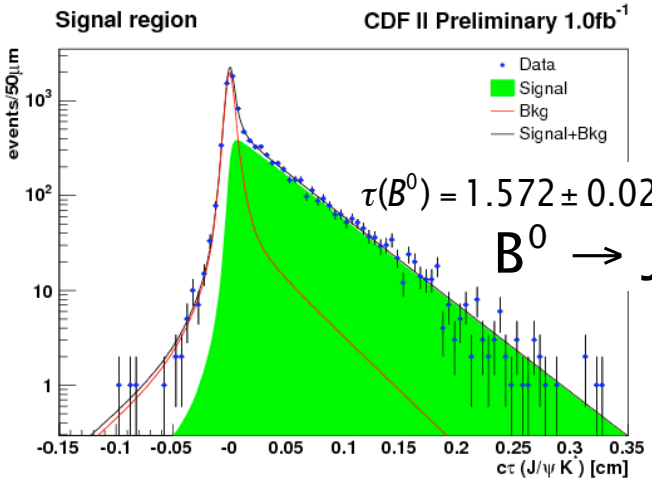
$B^+ \rightarrow J/\psi K^+$



$\tau(B^0) = 1.524 \pm 0.030 \pm 0.011\,\text{ps}$

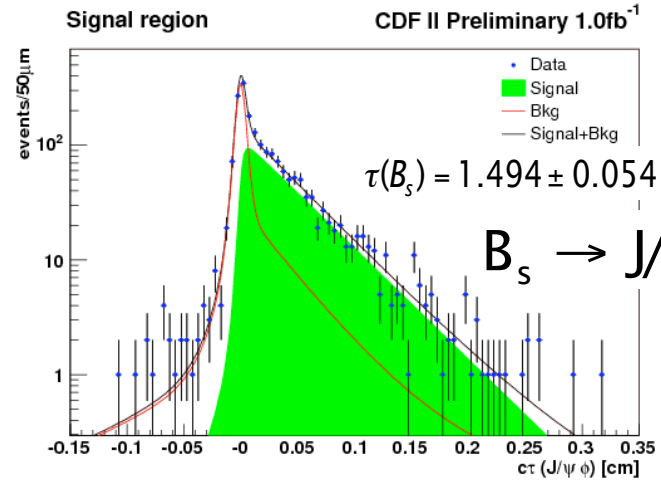
$B^0 \rightarrow J/\psi K^0_s$

uncertainties dominated by statistics, systematics < 1% level



$\tau(B^0) = 1.572 \pm 0.025 \pm 0.012\,\text{ps}$

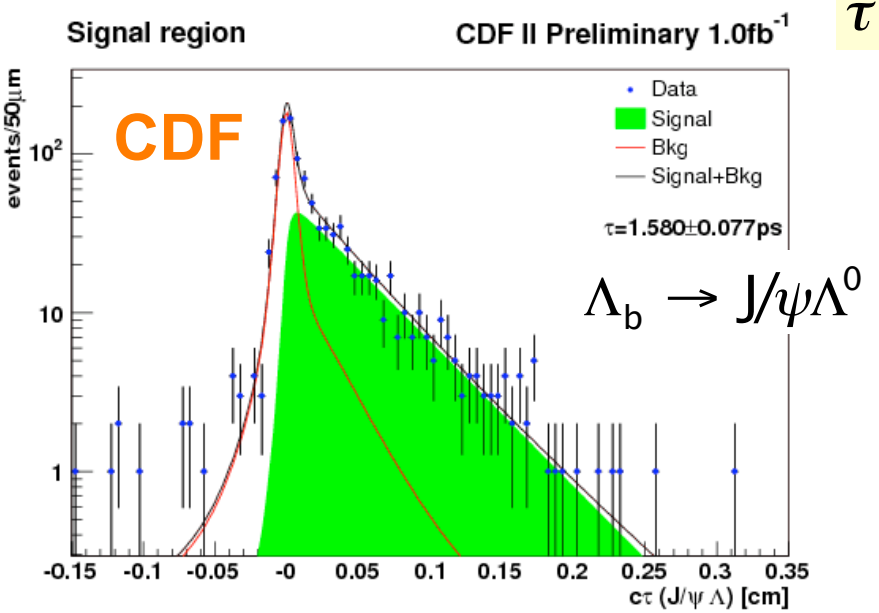
$B^0 \rightarrow J/\psi K^{0*}$



$\tau(B_s) = 1.494 \pm 0.054 \pm 0.009\,\text{ps}$

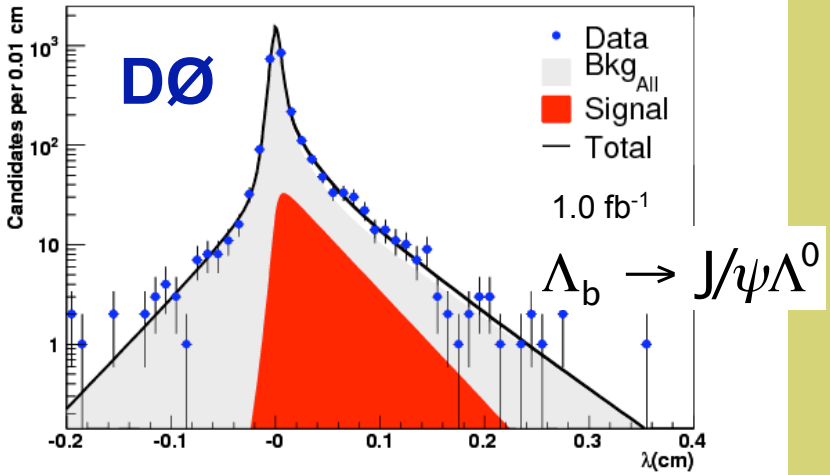
$B_s \rightarrow J/\psi\phi$

Λ_b Lifetimes

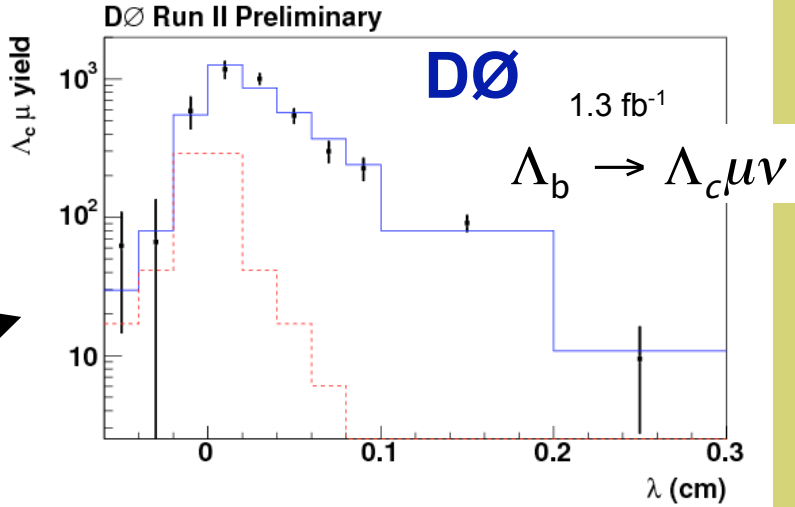


$$\tau(\Lambda_b) = 1.580 \pm 0.077 \pm 0.012 \text{ ps}$$

$$\tau(\Lambda_b) = 1.298 \pm 0.137 \pm 0.050 \text{ ps}$$



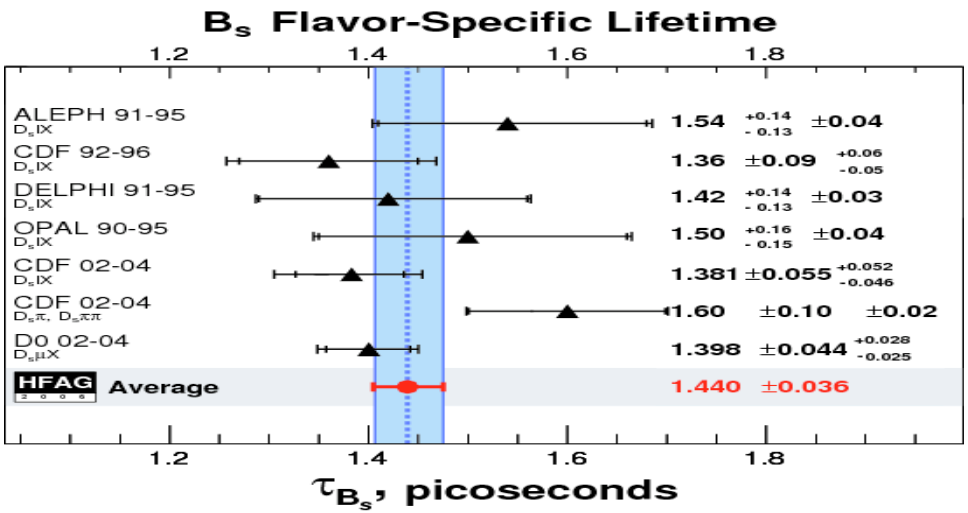
$$\tau(\Lambda_b) = 1.28^{+0.12}_{-0.11} \pm 0.09 \text{ ps}$$

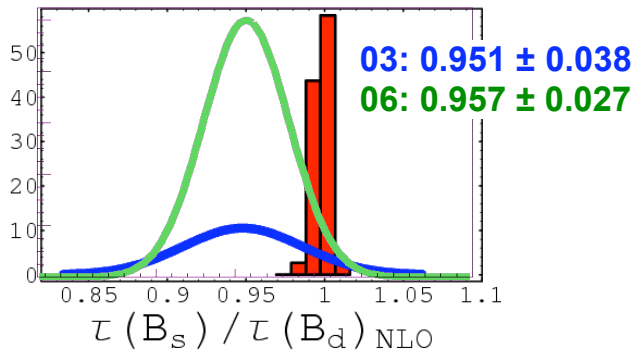


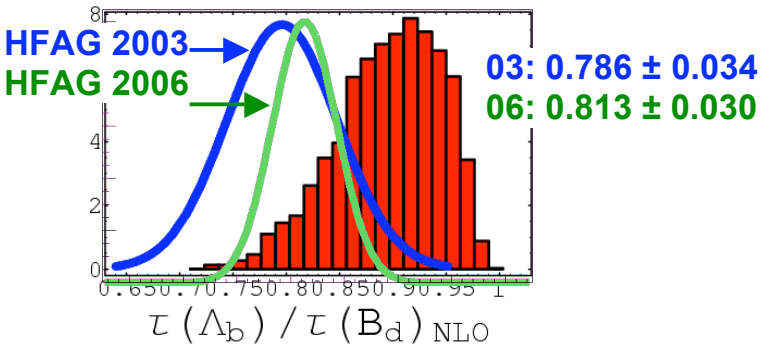
Due to the large background the #signal-event/cτ bin is used

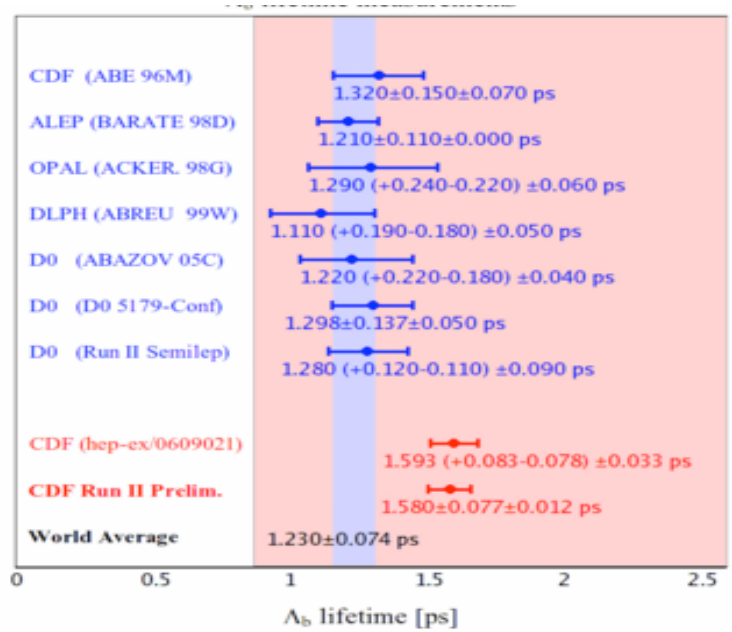
B Lifetimes summary

Significant improvement over the last years





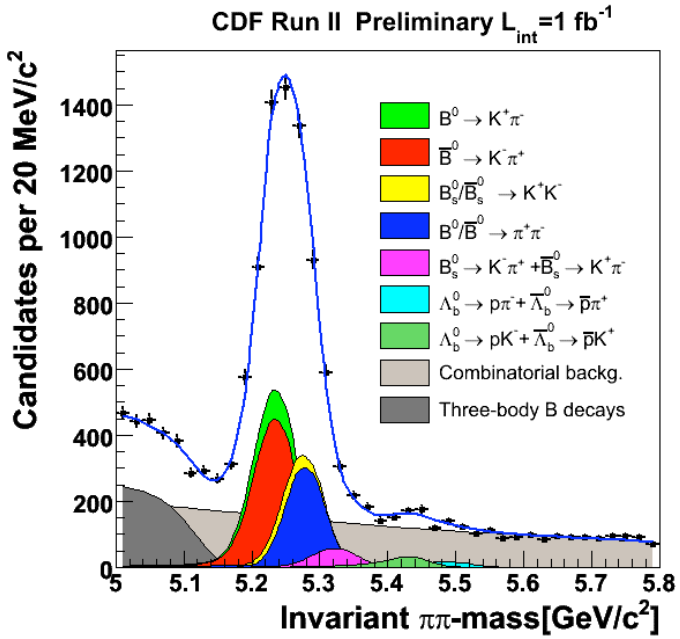




C.Tarantino, hep-ex/0310241 and hep-ex/0702235

Rare Hadronic B.R.s

1) CDF: $B_s / B^0 \to h^+ h'^-$
   - test of SU(3)
   - CP Asymmetries (γ)

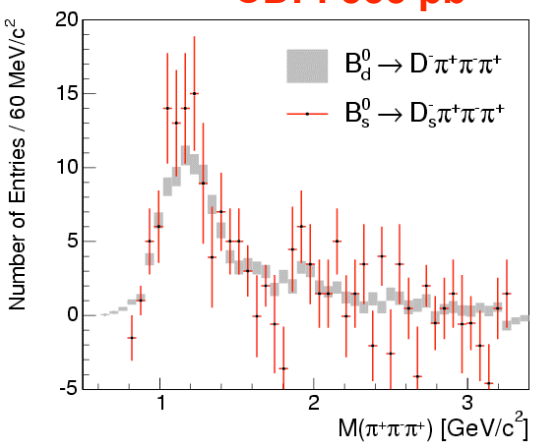


Fit for comp.
- M (h^+h^-)
- dE / dx
- $P(h^+)$, $P(h^-)$

CDF

2) CDF: $B_s \to D_s^- \pi^+$ & $D_s^- 3\pi^\pm$
   - test of SU(3)

CDF: 355 pb^{-1}



Decay Modes
- $D_s^-(\phi\pi^-)\ \pi^+$
- $D_s^-(\phi\pi^-, K^{*0}K^-, \pi^-\pi^-\pi^+)\ \pi^+\ \pi^+\ \pi^-$

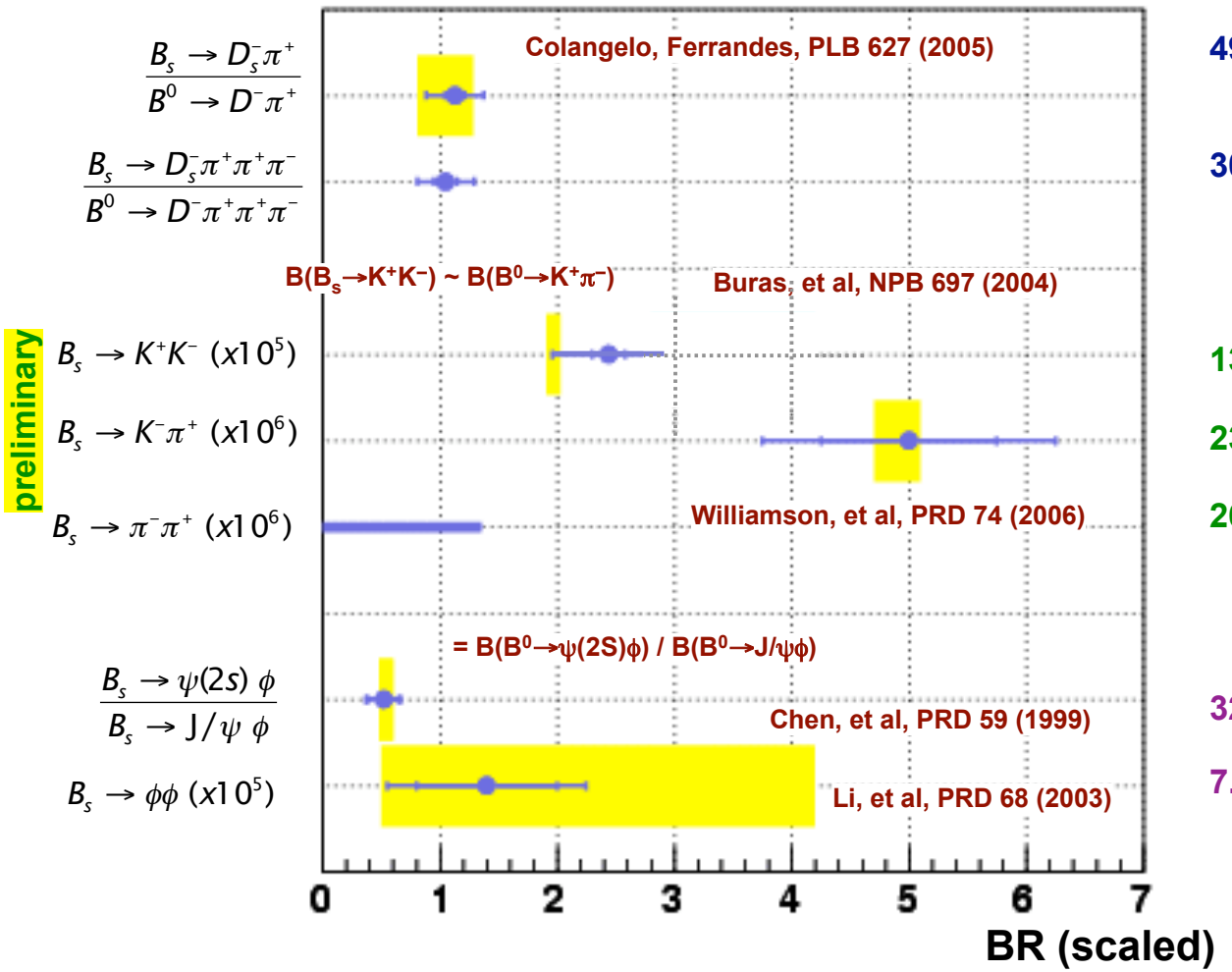
3) CDF: $B_s \to \psi(2S)\ \phi$
   - comp to $B^{+,0} \to \psi(2S)\ K^{+,*0}$
   - CP-even vs -odd (c.f. $B_s \to J/\psi\ \phi$)

4) CDF: $B_s \to \phi\ \phi$
   - CP-even vs -odd (c.f. $B_s \to J/\psi\ \phi$)

Hadronic BR Results

CDF

CDF Branching Ratio Results



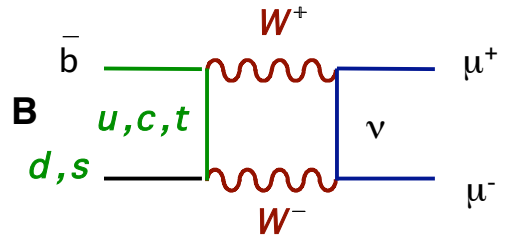
	N(signal)	Result	Sigf
$\frac{B_s \to D_s^- \pi^+}{B^0 \to D^- \pi^+}$	494±28	1.13 ± 0.08 ± 0.23	
$\frac{B_s \to D_s^- \pi^+ \pi^+ \pi^-}{B^0 \to D^- \pi^+ \pi^+ \pi^-}$	309±26	1.05 ± 0.10 ± 0.22	
$B_s \to K^+K^-$ $(x10^5)$	1307±64	2.44 ± 0.14 ± 0.46	
$B_s \to K^-\pi^+$ $(x10^6)$	230±38	5.00 ± 0.75 ± 1.00	
$B_s \to \pi^-\pi^+$ $(x10^6)$	26±21	< 1.36 @ 90% CL	
$\frac{B_s \to \psi(2s)\,\phi}{B_s \to J/\psi\,\phi}$	32.5±6.5	0.52 ± 0.13 ± 0.07	6.4σ
$B_s \to \phi\phi$ $(x10^5)$	7.3±2.9	1.4 ± 0.6 ± 0.6	4.7σ

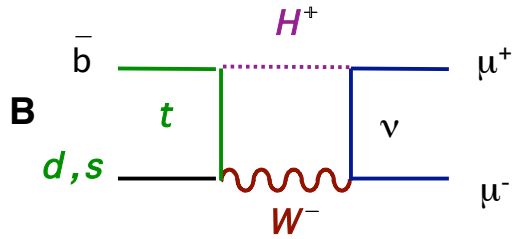
Leptonic B_s Decays and FCNCs

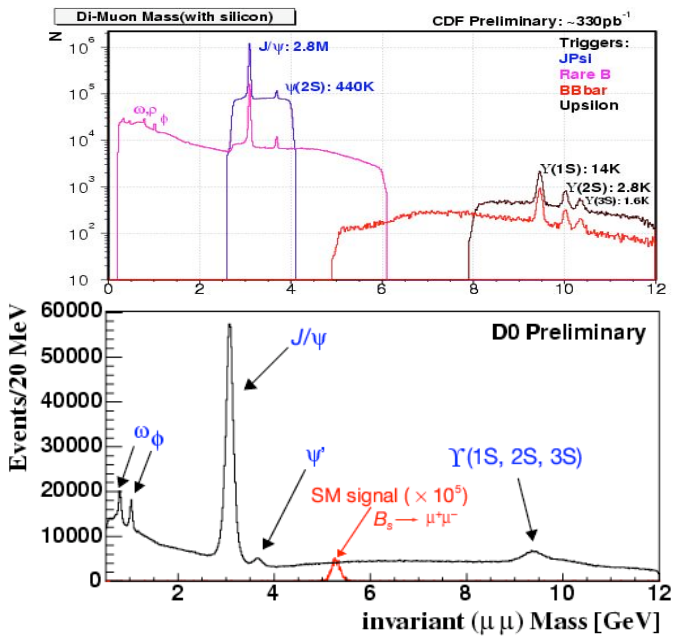
$B \rightarrow \mu^+\mu^-$ Predictions

- $BR(B_s) = (3.4 \pm 0.5) \times 10^{-9}$
- $BR(B^0) \downarrow |V_{td} / V_{ts}|^2 \sim 0.04$

- $BR \propto \tan^6 \beta$ in MSSM
  $\propto \tan^4 \beta$ in 2HDM







Meeting the Experimental Challenges

- Cut around J/ψ and ψ'
- Discrim against other di-sources
  - Isolation
  - Decay Length Significance
  - Angle b/w decay length and momentum vectors
- Normalize to known decays
  - $B^+ \rightarrow J/\psi\ K^+$

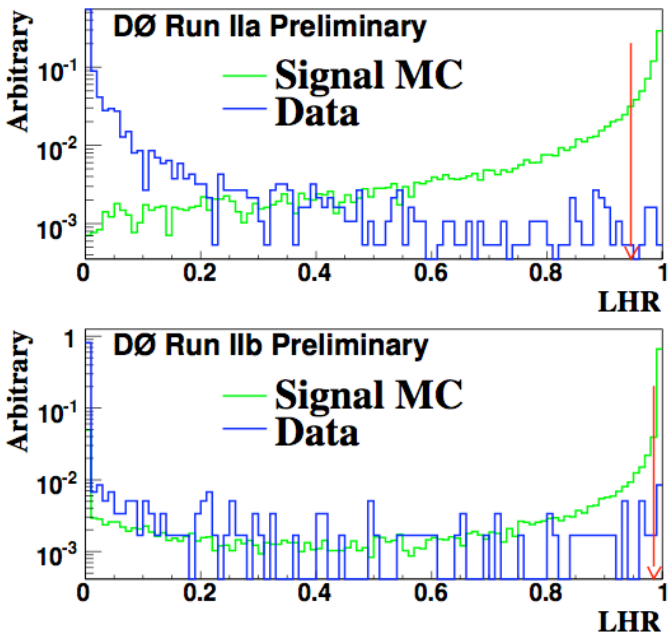
Preliminary FCNC Results

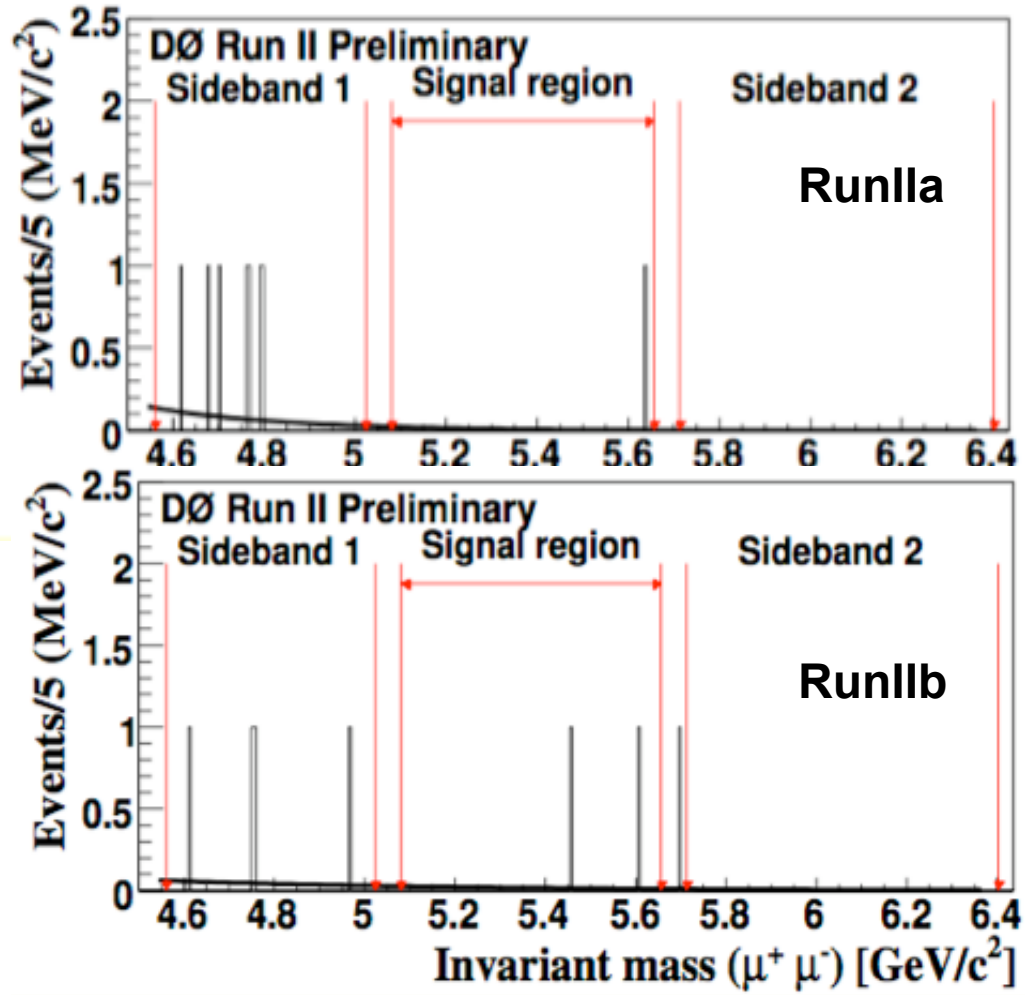
DØ new result on B → $\mu^+ \mu^-$ using 2fb^{-1} of data

Using a revisited selection method based on a likelihood ratio

$$LHR = \frac{\prod_{i=1}^{6} S_i(x)}{\prod^{6} S_i(x) + \prod^{6} B_i(x)}$$

DØ



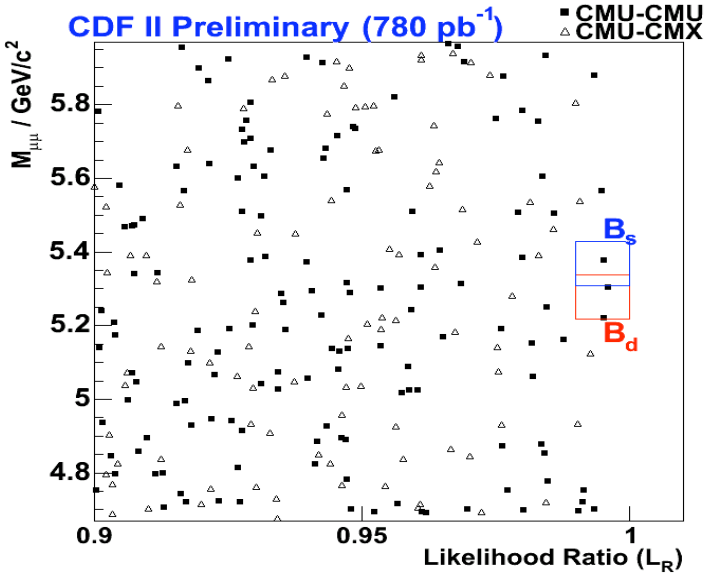


90%CL 7.5 x 10^{-8} (DØ combined)

Preliminary FCNC Results 2

CDF

$B \rightarrow \mu^+ \mu^-$ Results



Summary

Exp	Mode	Lumi [fb^{-1}]	Evts	Bgrd Pred	BR Limit (95% CL)
DØ	$B_s \rightarrow \mu^+ \mu^-$	2	3	2.3 ± 0.5	< 0.93 x 10^{-7}
CDF	$B_s \rightarrow \mu^+ \mu^-$	0.78	1	1.27 ± 0.37	< 1.0 x 10^{-7}
	$B_d \rightarrow \mu^+ \mu^-$	0.78	2	2.45 ± 0.40	< 0.3 x 10^{-7}

$$\frac{Br(B_s)\,\text{limit}}{Br(B_s)\,\text{SM}} \approx 20 \qquad \frac{Br(B_d)\,\text{limit}}{Br(B_d)\,\text{SM}} \approx 300$$

Summary and Prospects

Lifetimes

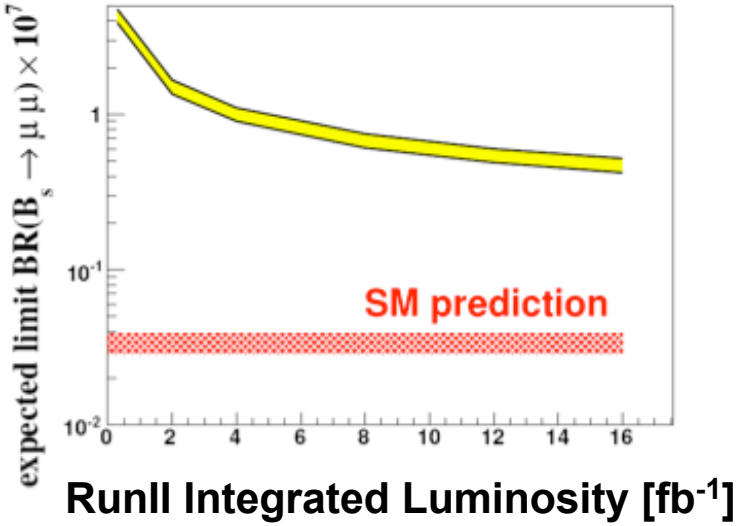
- Very significat improvement over the last year
- Getting best measurements on B_s and Λ_b (had and SL)
- B^+ and B^0 competitive to B-factories

Hadronic rare decays

- Important test for SU(3)

Leptonic rare decays

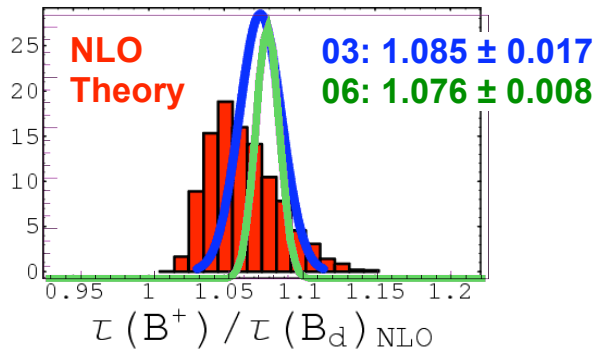
- New $2fb^{-1}$ result from DØ
- A factor of ~20 of SM $\mu^+\mu^-$ prediction
  - DØ: improving analysis techniques and accessing data as available



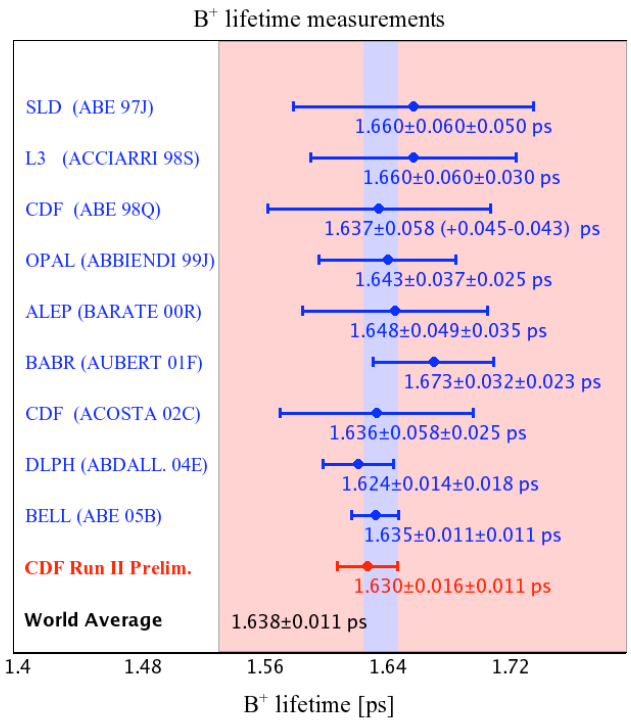
Backup

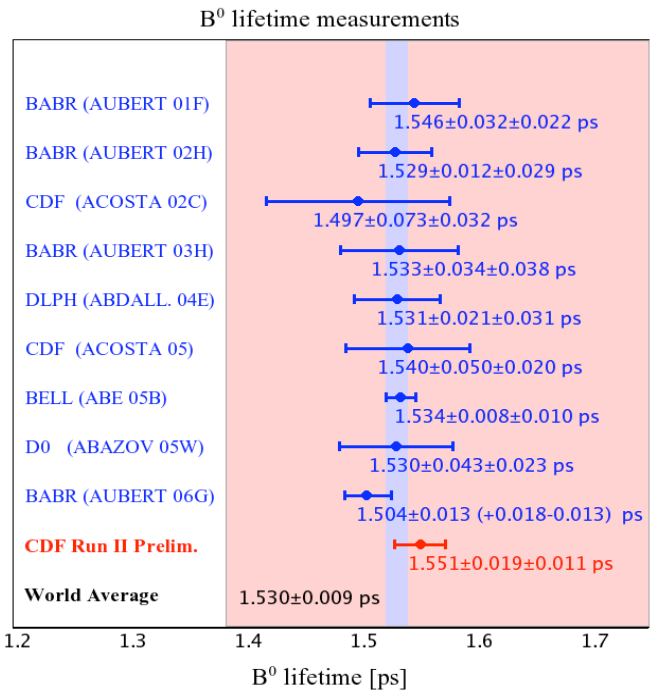
B Lifetimes summary

C.Tarantino, hep-ex/0310241 and hep-ex/0702235



At the same level as b-factories





Preliminary FCNC Results

DØ new result on $B \rightarrow \mu^+ \mu^-$ using $2fb^{-1}$ of data

	RunIIa	RunIIb
$\frac{\epsilon^{B^+}_{\mu\mu K}}{\epsilon^{B_s}_{\mu\mu}}$	$0.173 \pm 0.005 \pm 0.009$	$0.136 \pm 0.003 \pm 0.019$
N_{B^+}	$1781 \pm 54 \pm 20$	$440 \pm 25 \pm 5$
N_{back}	0.8 ± 0.2	1.5 ± 0.5
N_{obs}	1	2
limit 90% C.L.	7.9×10^{-8}	3.0×10^{-7}
limit 90% C.L.	7.5×10^{-8} (DØ combined)	
limit 95% C.L.	9.5×10^{-8}	3.9×10^{-7}
limit 95% C.L.	9.3×10^{-8} (DØ combined)	