Precision mesurement of B_s lifetime in the channel $B_s \to \mu D_s X$

Jorge Martínez-Ortega
on behalf of the DZero collaboration

Cinvestav, IPN, México

New Perspectives, 31 May 2011

Overview

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Motivation

From Heavy Quark Expansion (**Phys. Rev. D 70**, 094031),

$$\tau_{B_s}/\tau_{B^0} = 1.00 \pm 0.01 \qquad (1)$$

In addition, τ_{B_s} is an input used to compute the CKM Unitarity Triangle (arXiv:0906.0953v2) .
In the $B^{\pm}$ and B^0 systems BaBar, Belle collaborations have reached a precision of around 1% or better

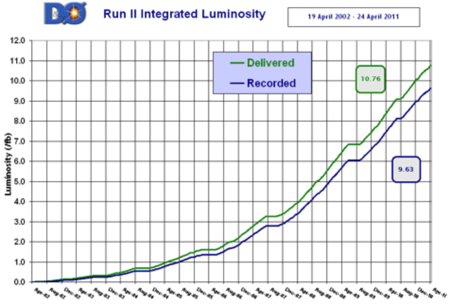
- $\tau_{B^{\pm}} = 1.635 \pm 0.011 \pm 0.011 (10^{-12}s)$, **PRD 71** 072003 and 079903, Belle Collaboration.
- $\tau_{B^0} = 1.504 \pm 0.013^{+0.018}_{-0.013} (10^{-12}s)$, **PRD 73** 012004, BaBar Collaboration.

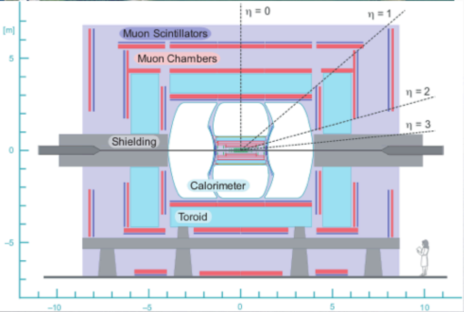
In the B_s system, DZero last measurement has 3.1% of statistical uncertainty **Phys. Rev. Lett. 97** 241801 (2006).

Tevatron and DØ

Tevatron Collider at Fermilab

- proton antiproton collisions at $\sqrt{s} = 1.96\text{TeV}$
- 10+ fb^{-1} of integrated luminosity delivered
- DØ has recorded 9.6 fb^{-1}

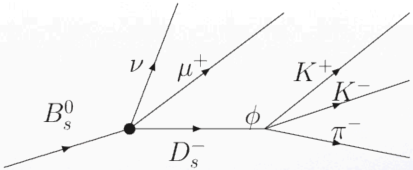




General Procedure

The decays that contribute to the channel $B_s \to D_s \mu X$ are:

- $B_s \to D_s^- \mu^+ \nu_\mu$
- $B_s \to D_s^{*-} \mu^+ \nu_\mu$
- $B_s \to D_{s0}^{*-} \mu^+ \nu_\mu$
- $B_s \to D_{s1}^{*-} \mu^+ \nu_\mu$
- $B_s \to D_s^- \tau^+ (\mu^+ \bar{\nu}_\mu \nu_\tau) \nu_\tau$



The B decays that contribute to the background are:

- $B^+ \to D_s^{(*)} D$
- $B^0 \to D_s^{(*)} D$
- $B_s \to D_s^{(*)} D$
- $B_s \to D_s^{(*)} D_s^{(*)}$

K Factor

As all these modes cannot be fully reconstructed a correction on the proper decay length has to be introduced.

$$L_{xy} = c\tau \frac{p_T}{m} \quad (2)$$

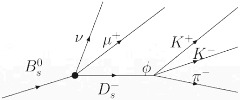
$$c\tau = K \times L_{xy} \frac{m(B_s^0)}{p_T(D_s^- \mu^+)} \quad (3)$$

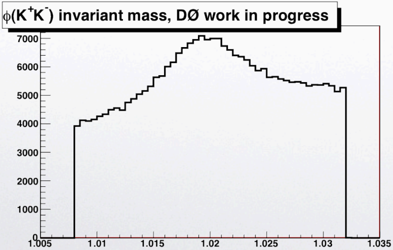
$$K = \frac{p_T(D_s^- \mu^+)}{p_T(B_s^0)} \quad (4)$$

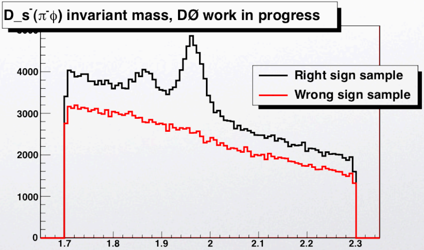
We use Monte Carlo events to obtain the K factor distribution for each channel in our signal and B mesons background.

Selection and Reconstruction

- $\mu^{\pm}$ with $p_T > 1.5$ GeV/c and $p_{tot} > 3$ GeV/c
- K^+K^- with $p_T > 0.7$ GeV/c each,
  invariant mass $\in (1.08, 1.32)$ GeV/c^2
- $\pi^{\mp}$ with $p_T > 0.7$ GeV/c,
  $\phi\pi$ invariant mass $\in (1.6, 2.3)$ GeV/c^2
- $D_s^{\pm}\mu^{\mp}$ invariant mass $\in (2.5, 5, 5)$ GeV/c^2







Likelihood

Our Likelihood is given by

$$\mathcal{L} = \mathcal{C}_{signal} \prod_{i \in \mathbf{SS}} [f_{signal} \mathcal{F}^{i}_{signal} + (1 - f_{signal}) \mathcal{F}^{i}_{bkg}] \prod_{j \in \mathbf{BS}} \mathcal{F}^{j}_{bkg}, \quad (5)$$

- **SS**: Signal sample, $M(D_s) - 2\sigma < M(\phi\pi) < M(D_s) + 2\sigma$.
- **BS**: Background sample, sidebands and wrong sign combination, $\mu^{\pm}\pi^{\pm}$. Helps to model the combinatorial background.
- f_{signal}: signal fraction, obtained from a fit on the D_s mass distribution.
- $\mathcal{C}_{signal}$ Gaussian constraint on the signal fraction.

Signal Likelihood

The probability for the signal is given by:

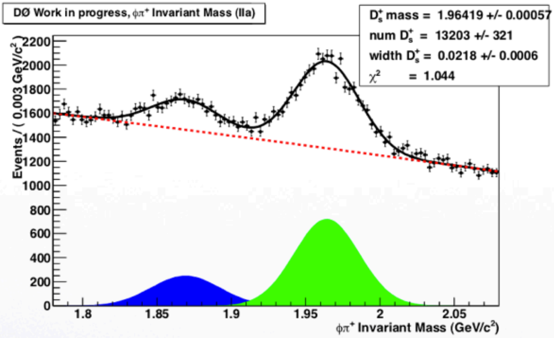
$$\mathcal{F}^i_{signal} = \quad f_{\bar{c}c} F^i_{\bar{c}c} + \\ (1 - f_{\bar{c}c}) \quad \Big[f_{B_s \to D_s D} \mathcal{E}^i_{B_s \to D_s D} + f_{B_s \to D_s^* D_s^*} \mathcal{E}^i_{B_s \to D_s^* D_s^*} + \\ f_{B_0 \to D_s D} \mathcal{E}^i_{B_0 \to D_s D} + f_{B^+ \to D_s D} \mathcal{E}^i_{B^+ \to D_s D} + \\ (1 - f_{B_s \to D_s D} - f_{B_s \to D_s^* D_s^*} - f_{B_0 \to D_s D} - f_{B^+ \to D_s D}) \mathcal{E}^i_{B_s \to D_s \mu X} \Big], \tag{6}$$

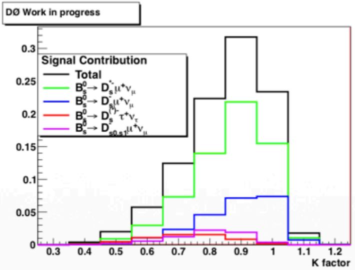
- f_{decay}: fraction of events for each decay in the D_s peak.

$$\mathcal{E}^j_{decay}(\lambda_j, \sigma(\lambda_j), s) = \int dK \mathcal{H}_{decay}(K) \left[\frac{K}{c\tau(B_{decay})} e^{-K\lambda_j / c\tau(B_{decay})} \otimes \mathcal{R}(\lambda_j, \sigma(\lambda_j), s) \right] \tag{7}$$

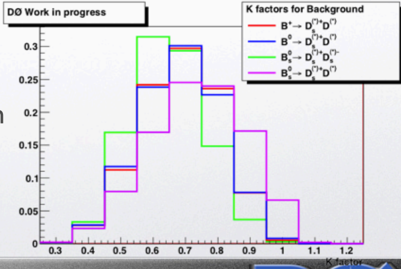
- $\mathcal{R}(\lambda_j, \sigma(\lambda_j), s)$: resolution

Signal Sample and K factors

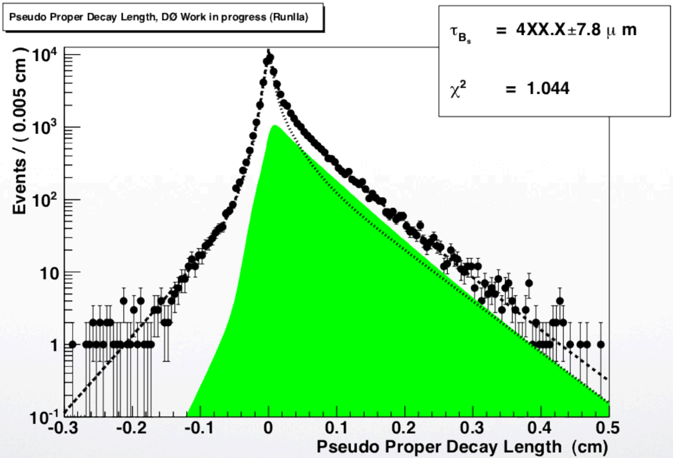




- $\sim 25\%$ of SS comes from D_s
- K factors and fractions obtained from MC



Lifetime Fit (RunIIa)



The expected statistical uncertainty with the complete sample is around $5\ \mu\mathrm{m}$ with a similar systematic uncertainty.

Summary

- The plan is to use $8.9\ fb^{-1}$
- All MC generated
- K factors computed
- Fractions computed
- To be ready in a few weeks, for the summer conferences

Thank you for attending

Back Up

Contribution	Branchig ratio	Contribution	Mean	R.M.S
$B_s^0 \to D_s^- \mu^+ \bar{\nu_\mu}$	$2.10 \pm 0.64\%$	$24.08 \pm 7.34\%$	0.8823	0.1109
$B_s^0 \to D_s^{*-} \mu^+ \bar{\nu_\mu}$	$5.60 \pm 1.70\%$	$64.22 \pm 19.50\%$	0.8590	0.1021
$B_s^0 \to D_{s0}^{*-} \mu^+ \bar{\nu_\mu}$	$0.20 \pm 0.06\%$	$2.29 \pm 0.69\%$	0.8254	0.0986
$B_s^0 \to D_{s1}^{*-} \mu^+ \bar{\nu_\mu}$	$0.37 \pm 0.11\%$	$3.36 \pm 1.26\%$	0.8147	0.0900
$B_s^0 \to D_s^{(*)-} \tau^+ \bar{\nu}_\tau$	$0.51 \pm 0.15\%$	$5.85 \pm 1.72\%$	0.7703	0.0948
All	8.72%	100%	0.8628	0.1053

Contribution	Branching Fraction	$f_{D_s} D$	$\langle K \rangle$	RMS (K)
$B_d^0 \to D_s^- D^{(*)} X$	$10.5 \pm 2.6\%$	3.7%	0.7607	0.0918
$B^- \to D_s^- D^{(*)} X$	$10.5 \pm 2.6\%$	3.7%	0.7599	0.0843
$B_s^0 \to D_s^{*-} D_s^+$	$10^{+9}_{-7}\%$	3.5%	0.8155	0.1093
$B_s^0 \to D_s^{*-} D^{(*)}$	$15.4 \pm 3.9\%$	0.4%	0.7623	0.0885