ITS A GIRL!

8lb. 15oz. June 27, 2AM.

\[ \eta \rightarrow D^{+} \pi^{-} \]
\[ X^{s_p n} \leftrightarrow B^{s_p n} \]
\[ X^f/j, \ell \rightarrow B \]

- Lifetimes and Mixing
- Flavor Physics at DØ
- Motivation

Brendan Casey, Brown University

Lifetimes and Mixing at DØ
\[ i^i i + \left| s^t \Lambda / p^t \Lambda \right| \Rightarrow B^8 \text{ mixing} \]

\text{frontier}

Usually involving the nature of particles inaccessible at the energy

Every flavor mixing measurement has lead to a major discovery.

\[ \text{neutrinos have mass} \quad \Leftrightarrow \quad \nu - \bar{\nu} \text{ mixing} \]

\[ \text{Top has CP\-violating} \quad \Leftrightarrow \quad W^\nu < \nu \text{ mixing} \]

\[ \text{Top is heavy!} \quad \Leftrightarrow \quad B^p - B^\bar{p} \text{ mixing} \]

\[ \text{existence of a third generation!} \quad \Leftrightarrow \quad CP\text{\-violating} \]

\[ \text{What we\,ve learned from mixing:\} \]

Why Study Mixing?
\[ \forall \] mixing discovery

Look for \( r(\text{even}) \neq r(\text{odd}) \)

and underlying physics.

Key link between experiment
non perturbative QCD...

quark-hadron duality, spectator models,

\[ \Rightarrow 1 + \text{Higher order corrections to } \text{OPE} \]

\[ \Rightarrow \sum_{p} c_{p} \]

Why Study Lifetimes?
Ideal samples for mixing and lifetime studies

$$X \rightarrow n + \eta + \pi^-$$

Semi-leptonic decays and $q, c \rightarrow \eta + \pi^- X$

- Single and dimuon triggers
- Tracking and vertexing
- Muon spectrometer

Focus on the strengths

\[ D \] Flavor Physics Program

Brendan Casey

BRACH, June 26, 2004
preshower (SciFi)
silicon
solenoid

Layer 0

\[ r = 16.4 \text{ mm} \]

Adding new solenoid

27 T field

plus 16 disks

4 silicon barrels

scintillating fibers

0.52 m

double layers
Scintillators for trigger; scintillator timing: cosmic/beam veto

trigger/scintillators

trigger/scintillators

Three layers of proportional tubes + toroids: stand alone muon tracking

$Z = |\mu|$

Coverage to

DO Muon Spectrometer
add processes and increase rate to tape
partially move offline reconstruction $\leftarrow \text{L3}
$hardware upgrades at L1, L2

As $I$ increases:

(lead means not used yet)

<table>
<thead>
<tr>
<th>Invariant mass</th>
<th>Impact parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>$z$ primary vertex</td>
<td>$z$ primary vertex</td>
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<tr>
<td>$z$ vertex</td>
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</tr>
<tr>
<td>Central track finding</td>
<td>Impact parameter</td>
</tr>
<tr>
<td>Track matching</td>
<td>Fast trackfinding</td>
</tr>
<tr>
<td>Muon hits</td>
<td>Muon trackfinding</td>
</tr>
<tr>
<td>Muon scintillators</td>
<td>Muon scintillators</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level 3</th>
<th>Level 2</th>
<th>Level 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 3, flexible software based trigger</td>
<td>Level 1, 2 dominated by muon info</td>
<td></td>
</tr>
</tbody>
</table>

Muon Triggering and Readout
$(\phi^0, \phi^+)$ pair: $\phi^0, \phi^+ \rightarrow n, n$

Other can be a calorimeter.

At least one $n$ in $n$ event.

$X \phi / f \leftarrow B$
Need to add semi-leptonic to make an

\[ \frac{B^p}{V^q} \]

Expect ~ 20% error on \( \frac{V^q}{B^p} \)

\[ P \]

\[ Q \]

\[ R \]

\[ S \]

\[ T \]

\[ U \]

\[ V \]

\[ W \]

\[ X \]

\[ Y \]

\[ Z \]

\[ a \]

\[ b \]

\[ c \]

\[ d \]

\[ e \]

\[ f \]

\[ g \]

\[ h \]

\[ i \]

\[ j \]

\[ k \]

\[ l \]

\[ m \]

\[ n \]

\[ o \]

\[ p \]

\[ q \]

\[ r \]

\[ s \]

\[ t \]

\[ u \]

\[ v \]

\[ w \]

\[ x \]

\[ y \]

\[ z \]

\[ \phi \]

\[ \eta \]

\[ \chi \]

\[ \delta \]

\[ \epsilon \]

\[ \zeta \]

\[ \eta \]

\[ \theta \]

\[ \iota \]

\[ \kappa \]

\[ \lambda \]

\[ \mu \]

\[ \nu \]

\[ \xi \]

\[ \omicron \]

\[ \pi \]

\[ \rho \]

\[ \sigma \]

\[ \tau \]

\[ \upsilon \]

\[ \phi \]

\[ \chi \]

\[ \psi \]

\[ \omega \]

\[ \theta \]

\[ \vartheta \]

\[ \varepsilon \]

\[ \zeta \]

\[ \eta \]

\[ \kappa \]

\[ \lambda \]

\[ \mu \]

\[ \nu \]

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\[ \omicron \]

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\[ \nu \]

\[ \xi \]

\[ \omicron \]

\[ \pi \]

\[ \rho \]

\[ \sigma \]

\[ \tau \]
Interesting numbers with $2 \times 3 \times 5$ more data

Limits on $\sqrt{s}$ coming soon

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

$N = 1857 \pm 72$

$B = 28 - N = 1857$

Do Run II preliminary. Luminosity $\approx 225$ pb$^{-1}$

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

$N = 403 \pm 28$

$\phi + J/\psi \rightarrow B^0

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

$N = 28 - N = 28$

$\phi + J/\psi \rightarrow B^0

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

$N = 403 \pm 28$
Lifetime analysis performed with

\[ \phi \phi \rightarrow \phi \phi \]

\[ \phi \phi / J \]

\[ \delta K \phi / J \]

\[ \phi / J \]

\[ \phi + K \phi / J \]

Inclusive B Lifetime

\[ 1.56 \pm 0.08^{+0.20}_{-0.13} \pm 0.01^{+0.02}_{-0.01} \text{ ps} \]

\[ 1.51 \pm 0.08 \text{ ps} \]

\[ 1.49 \pm 0.09 \text{ ps} \]

\[ 1.19^{+0.16}_{-0.19} \text{ ps} \]

\[ 1.65 \pm 0.08^{+0.20}_{-0.13} \pm 0.01^{+0.02}_{-0.01} \text{ ps} \]

\[ 1.56 \pm 0.08^{+0.20}_{-0.13} \pm 0.01^{+0.02}_{-0.01} \text{ ps} \]

Update coming soon based on

\[ 250 \text{ pb}^{-1} \]

\[ 120 \text{ pb}^{-1} \]

Events/12.5 \mu m

Data

Sideband

B Signal

B Signal + background

Inclusive B Lifetime

\[ 468 \pm 37 \pm 4 \text{ (stat) + 29} \pm 37 \pm 4 \text{ (syst) } \]

Run II Preliminary
combining \( D_0 \) sample extracted by \( D \) to the lifetime ratio:

\[ \frac{N(D^+) - N(D^-)}{N(D^+) + N(D^-)} \]

and vertex significance cuts on impacts parameter cuts on tracks.

Muon charge provides kaon ID

\[ \text{in the } \pi \text{ jet} \]

Search for \( D_0 \)

\[ (n\pi)d, n \leq 3 \text{ GeV}^2 < 2 \text{ GeV} \]

Reconstruction: \( \eta \) \( X \) \( D_0 \) \( \rightarrow \) \( B \)
Sample Composition

Can eventually improve on all numbers

plus isospin

using PDG BP's
function \( Z(\mathcal{X}) \)

use MC for boost correction

\[ \eta_{\text{prior}} D_0 \left( \frac{m_{\text{Jpsi}}}{p_T} \right) \]

boost back using \( D_0 \)

vertex in transverse plane \( T_{xy} \)

reconstruct \( \eta' \) vertex and \( D_0 \)

Proper Time Reconstruction
\[
(D_\nu)^{\nu_\nu} \neq \mathcal{C} (\nu_\nu) = \mathcal{C} \times (0(D_0))^\nu_\nu
\]

not used in yield extraction, vertex, or boost correction

slow not only used to de- 

\[
(pB)^+/(pB)^-(pB)^0
\]

resolution

boost correction

sample composition

Expected value based on:

perform \( \chi^2 \) fit to ratio of yields

extract yield from \( m(\nu_\nu) \) spectra

group data in \( \nu_\nu \) bins

to two samples

instead of simultaneous fit.

Lifetime Ratio Extraction
(D) not included in W.A.

\[ \frac{(B^-)}{(B^0)} (p_B) \]

**Lifetime Ratio**

DO Preliminary, Luminosity = 250 pb^{-1}

\[ \chi^2/\text{NDF} = 4.0/5 \]

\[ \frac{1.073 \pm 0.022}{1.10 \pm 0.025} \]

**Using**

\[ (p_B) = 1.674 \pm 0.018 \text{ ps} \]

**New**

1.093 \pm 0.021 \pm 0.022
Mixing Program
Lots of room for improvements, more tags, smart comb.

$\phi$ + $J/\psi$ + with muon tags

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

Flavor Tagging

Jet Time dependence

Reconstruction

Measurement mixing
Mixing Measurement

The diagram shows a process involving flavor tagging, mixing, and measurement. The text reads:

still good for systematic studies,

\[ B^s \]

\[ \frac{N_{\text{mixed}}(\text{unmixed})}{N_{\text{mixed}}(\text{unmixed})} \]

can not bin for final measurement,

\( \leftrightarrow \)

bin data and fit asymmetry

\[ B^p \]

build on success of \( \tau \) ratio measurement
time dependence flavor tagging mixing measurement

$$\text{Asymmetry} = \frac{N_{\text{osc}} - N_{\text{non-osc}}}{N_{\text{osc}} + N_{\text{non-osc}}}$$

Muon tagged $$D^*$$ sample:
$B_s$ Mixing

- $\mu^{-} \phi \pi^{+}$
- $B \rightarrow \mu^{-} \phi \pi^{+} X$
- $9481 \pm 253$ $D_s$
- in $\phi \pi$ channel alone

Adding:
- $K^* K$, $K_SK$...

Plus:
- better tagging
- better resolution
- better simulation

$\ldots$

silicon $dE/dx$

LØ

Brendan Casey

BEACH, June 28, 2004
Conclusions
$4.8 \times 10^{31}$ cm$^{-2}$

Achieved: $4.8 \times 10^{31}$ cm$^{-2}$

Expected: $1.5 \times 3 \times 10^{32}$ cm$^{-2}$
Sample Composition