Experimental Prospects at Hadron Colliders

$B_d$, $B_u$, $B_s$, $B_c$, and $\Lambda_b$

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Charge and Preliminaries

1. Identify channels of interest for CKM physics.

2. Identify open theoretical issues.

   A. Specifically I will address Tevatron (CDF & DØ*) prospects.

   B. Time dependent $B_s$ asymmetries can be measured only after $B_s$ mixing is observed.

   C. Modes with $\pi^0$’s, $\eta$’s, $\gamma$’s, ..., are difficult. Wide resonances ($\rho$, $\omega$, ...) suffer from large backgrounds.

   D. I will omit mixing, lifetimes, and spectroscopy.
Outline of Topics

1. Rare decays

2. $\Delta \Gamma_s / \Gamma_s$

3. $B_{u,d,s}$, $B_c$, $\Lambda_b$, … major modes

4. Charmless decays
   a. $B \rightarrow VV$ decays
   b. $\Lambda_b \rightarrow p\pi$, $pK$, $\Lambda\phi$

5. CP Asymmetries
Rare Decays

90% CL Limits

\[ \mathcal{B}(B_s \rightarrow \mu^+ \mu^-) < 3.0 \times 10^{-7} \text{(DØ)} \]
\[ \mathcal{B}(B_d \rightarrow \mu^+ \mu^-) < 1.5 \times 10^{-7} \text{(CDF)} \]

Kane, Kolda, Lennon, hep-ph/0310042:
\[ B_s \rightarrow \mu \mu \quad \text{lower bound to } \tan \beta \]
Constraints on U.T.
If $\Delta m_s$ is too large to measure, $\Delta \Gamma_s$ should be large and measurable.

\[ 0.21^{+0.33}_{-0.45} \text{(DØ)} \]
\[ 0.65^{+0.25}_{-0.33} \pm 0.01 \text{(CDF)} \]

Also measure in $B_s \rightarrow D_s^{(*)} D_s^{(*)}$ or $B_s \rightarrow K^+K^-$. 
CDF’s displaced vertex trigger (a.k.a. two-track trigger or TTT) selects fully hadronic modes otherwise inaccessible.

Briefly:

Requires 2 oppositely charged tracks each with $p_T > 2 \text{ GeV/c}$ and $d_0 > 120 \mu\text{m}$.

Two-track + lepton variation developed for continued use at $L > 10^{32} /\text{cm}^2\text{s}$.

Requirements loosened at low luminosity.
Can some baryonic decays provide constraints for CKM measurements?

\[ \frac{f_\Lambda \mathcal{B}(\Lambda_b \rightarrow \Lambda_c^+ \pi^-)}{f_{d} \mathcal{B}(B^0 \rightarrow D^+ \pi^-)} = 0.66 \pm 0.11 \pm 0.09 \pm 0.18 (BR) \]
$B^0 \rightarrow D^+ D_{s}^-$

\[
\frac{\mathcal{B}(B^0 \rightarrow D^+ D_{s}^-)}{\mathcal{B}(B^0 \rightarrow D^+ \pi^+ \pi^- \pi^-)} = 2.00 \pm 0.16 \pm 0.12 \pm 0.50 (BR)
\]
CDF has signals in $B_s \to \phi\phi$, and $B_{u,d} \to \phi K^*$

Angular analysis with new data.

$$\mathcal{B}(B_s \to \phi\phi) = (1.4 \pm 0.6 \pm 0.2 \pm 0.5(BR)) \times 10^{-5}$$
Charmless Decays

CDF Run II Preliminary

\[ L = 193 \pm 12 \text{ pb}^{-1} \]

Other modes:
\[ \Lambda_b \rightarrow \Lambda \phi \]

\[ \mathcal{B}(\Lambda_b \rightarrow p(\pi, K)) < 2.2 \times 10^{-5} (90\% CL) \]

13 May 2005

SLAC/INT QCD Workshop
B^{+} \to \phi K^{+}

\begin{align*}
    B(B^{+} \to \phi K^{+}) &= (7.6 \pm 1.3 \pm 0.6) \times 10^{-3} \\
    A_{CP} &= -0.07 \pm 0.17^{+0.03}_{-0.02}
\end{align*}
Separation by:
- kinematics
- dE/dx
- invariant mass

\(~1000 \text{ } B \rightarrow hh\)
B→hh’ Results

\[
\frac{\mathcal{B}(B_d \to \pi^+\pi^-)}{\mathcal{B}(B_d \to K^+\pi^-)} = 0.24 \pm 0.06 \pm 0.05
\]

\[
\frac{f_s \, \mathcal{B}(B_s \to K^+K^-)}{f_d \, \mathcal{B}(B_d \to K^+\pi^-)} = 0.50 \pm 0.08 \pm 0.07
\]

\[
\mathcal{B}(B_s \to K^+\pi^-) < 7.5 \times 10^{-6} (90\% CL)
\]

\[
A_{CP}(B_s \to K^+\pi^-) = -0.04 \pm 0.08 \pm 0.006
\]

B_s→KK lifetime of CP even component
What can we learn from $B_s \rightarrow hh$?

$R_d^s = \frac{B(B_s \rightarrow K^+ K^-)}{B(B_d \rightarrow \pi^+ \pi^-)}$

Example of a relation between $B_s \rightarrow KK$ and $B_d \rightarrow \pi\pi$

London and Matias, hep-ph/0404009
B_d Tagging

The question arose: can CDF measure C_{ππ} and S_{ππ}?

Results for εD^2 from Δm_d analyses:

<table>
<thead>
<tr>
<th></th>
<th>semi-leptonic</th>
<th>hadronic</th>
</tr>
</thead>
<tbody>
<tr>
<td>OST</td>
<td>1.43 ±0.09%</td>
<td>1.12 ±0.18%</td>
</tr>
<tr>
<td>OST</td>
<td>0.81 ±0.08%</td>
<td></td>
</tr>
<tr>
<td>SST</td>
<td>1.04 ±0.24%</td>
<td>1.00 ±0.35%</td>
</tr>
</tbody>
</table>

No B** explicitly used.

Can B_d tagging be improved?
Conclusions and Questions

- CDF and DØ have large b-hadron samples and are learning to extract more interesting signals.
  - CDF’s displaced vertex trigger selects modes not previously accessible.
- Lots of effort is going to Bs mixing, Bs→μμ, and ΔΓs.
- Charmless VV and hh modes are pursued.
- Can we make a list of modes that deserve serious investigation?
- Are there measurements that constrain or supplement B factory data?