$B \rightarrow K \nu \bar{\nu}$

Shohei NISHIDA & Nobu KATAYAMA

KEK (Belle)

Jan 21, 2004
Super B Factory Workshop in Hawaii
$B \rightarrow K \nu \bar{\nu}$

$B^+ \rightarrow K^+ \nu \bar{\nu}$ MC study

Assumption
- $50 \text{ ab}^{-1}$.
- full reconstruction is perfect.
- full reconstruction efficiency is $0.2\%$.
- the detector performance is the same as present Belle detector.

MC study
- Geant simulation.
- Only one charged track.
- Kaon identification to the track.
- Selection to $E$ (ECL energy of unmatched clusters) and $p^*$ (CM momenta of the only track)
$B \to K\nu\bar{\nu}$

$p^*$ distribution for signals and typical background.

(a) $B^- \to K^-\nu\nu$

(b) $B^- \to \tau^-\nu$

(c) $B^- \to D^0\ell^-\nu$

(d) $B^- \to D^0\rho^-$

(e) $B^- \to D^0\pi^-$

(f) $B^- \to \rho^+\pi^0$

- Phase space is assumed for $B \to K\nu\bar{\nu}$. 

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If we apply similar selection criteria as present analysis....

- no PID
- $p^* > 0.7$ GeV/$c^2$

Obviously, we need tighter selection criteria.
$B \to K\nu\bar{\nu}$

Our optimized selection criteria:

- Tight KID
- $2.0 \text{ GeV}/c^2 < p^* < 2.7 \text{ GeV}$

\begin{align*}
B \to K\nu\bar{\nu} & \quad 43.0 \pm 1.1 \\
B \text{ decays (}b \to u\text{)} & \quad 21.6 \pm 3.3 \\
\text{rare } B \text{ decays} & \quad 7.8 \pm 0.8 \\
B \to \tau\nu & \quad 4.3 \pm 1.2 \\
\text{significance} & \quad 5.1\sigma
\end{align*}

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Background Breakdown

<table>
<thead>
<tr>
<th>Mode</th>
<th>$E &lt; 1.0$</th>
<th>$E &lt; 1.0$ with KID</th>
<th>$E &lt; 0.5$ with KID</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B^- \rightarrow D^{*0} \mu^- \bar{\nu}$</td>
<td>$265.7 \pm 11.7$</td>
<td>$8.2 \pm 2.1$</td>
<td>$2.1 \pm 1.0$</td>
</tr>
<tr>
<td>$B^- \rightarrow D^0 \pi^-$</td>
<td>$199.0 \pm 10.1$</td>
<td>$7.7 \pm 2.0$</td>
<td>$3.1 \pm 1.3$</td>
</tr>
<tr>
<td>$B^- \rightarrow D^{*0} e^- \bar{\nu}$</td>
<td>$181.1 \pm 9.6$</td>
<td>$8.7 \pm 2.1$</td>
<td>$2.1 \pm 1.0$</td>
</tr>
<tr>
<td>$B^- \rightarrow D^0 \mu^- \bar{\nu}$</td>
<td>$131.3 \pm 8.2$</td>
<td>$25.1 \pm 3.6$</td>
<td>$5.1 \pm 1.6$</td>
</tr>
<tr>
<td>$B^- \rightarrow D^{*0} \pi^-$</td>
<td>$110.3 \pm 7.5$</td>
<td>$3.6 \pm 1.4$</td>
<td>$0.0 \pm 0.0$</td>
</tr>
<tr>
<td>$B^- \rightarrow D^0 \rho^-$</td>
<td>$95.9 \pm 7.0$</td>
<td>$6.2 \pm 1.8$</td>
<td>$1.0 \pm 0.7$</td>
</tr>
<tr>
<td>$B^- \rightarrow D^0 e^- \bar{\nu}$</td>
<td>$85.7 \pm 6.6$</td>
<td>$19.5 \pm 3.2$</td>
<td>$4.1 \pm 1.5$</td>
</tr>
<tr>
<td>$B^- \rightarrow D^{*0} \rho^-$</td>
<td>$43.6 \pm 4.7$</td>
<td>$3.6 \pm 1.4$</td>
<td>$0.5 \pm 0.5$</td>
</tr>
<tr>
<td>$B^- \rightarrow D^0 K^-$</td>
<td>$13.3 \pm 2.6$</td>
<td>$8.7 \pm 2.1$</td>
<td>$2.1 \pm 1.0$</td>
</tr>
<tr>
<td>$B^- \rightarrow D^{*0} K^-$</td>
<td>$5.6 \pm 1.7$</td>
<td>$4.6 \pm 1.5$</td>
<td>$0.5 \pm 0.5$</td>
</tr>
<tr>
<td>Other $b \rightarrow c$ decays</td>
<td>$29.8 \pm 3.9$</td>
<td>$3.1 \pm 1.3$</td>
<td>$1.0 \pm 0.7$</td>
</tr>
<tr>
<td>$b \rightarrow c$ decays total</td>
<td>$1161.4 \pm 24.4$</td>
<td>$99.0 \pm 7.1$</td>
<td>$21.5 \pm 3.3$</td>
</tr>
</tbody>
</table>
$B \to K\nu\bar{\nu}$

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<tr>
<th>Mode</th>
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<th>$E &lt; 1.0$ with KID</th>
<th>$E &lt; 0.5$ with KID</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B^- \to K^{*-} \pi^- \pi^+$</td>
<td>28.0 ± 1.5</td>
<td>0.8 ± 0.2</td>
<td>0.2 ± 0.1</td>
</tr>
<tr>
<td>$B^- \to \pi^- \bar{K}^0$</td>
<td>22.8 ± 1.3</td>
<td>0.5 ± 0.2</td>
<td>0.0 ± 0.0</td>
</tr>
<tr>
<td>$B^- \to \rho^+ \pi^0$</td>
<td>21.1 ± 1.3</td>
<td>0.4 ± 0.2</td>
<td>0.0 ± 0.0</td>
</tr>
<tr>
<td>$B^- \to K^- f_2'(1525)$</td>
<td>19.1 ± 1.2</td>
<td>12.5 ± 1.0</td>
<td>1.1 ± 0.3</td>
</tr>
<tr>
<td>$B^- \to K^- \pi^0$</td>
<td>18.5 ± 1.2</td>
<td>12.7 ± 1.0</td>
<td>3.3 ± 0.5</td>
</tr>
<tr>
<td>$B^- \to K^{*-} \rho^0$</td>
<td>13.6 ± 1.0</td>
<td>0.2 ± 0.1</td>
<td>0.1 ± 0.1</td>
</tr>
<tr>
<td>$B^- \to K^{*-} f_2(1270)$</td>
<td>10.9 ± 0.9</td>
<td>0.4 ± 0.2</td>
<td>0.0 ± 0.0</td>
</tr>
<tr>
<td>$B^- \to K^{*-} f_2'(1525)$</td>
<td>10.7 ± 0.9</td>
<td>8.2 ± 0.8</td>
<td>1.3 ± 0.3</td>
</tr>
<tr>
<td>$B^- \to \pi^- \pi^0$</td>
<td>9.3 ± 0.8</td>
<td>0.4 ± 0.2</td>
<td>0.2 ± 0.1</td>
</tr>
<tr>
<td>Other rare $B$ decays</td>
<td>16.7 ± 1.1</td>
<td>3.2 ± 0.5</td>
<td>0.2 ± 0.1</td>
</tr>
<tr>
<td>Rare $B$ decays total</td>
<td>215.6 ± 4.1</td>
<td>51.6 ± 2.0</td>
<td>7.8 ± 0.8</td>
</tr>
<tr>
<td>Total</td>
<td>1377.0 ± 24.7</td>
<td>150.6 ± 7.3</td>
<td>29.3 ± 3.4</td>
</tr>
</tbody>
</table>
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Future studies

- Full reconstruction.
  - Hadronic modes only / With semi-leptonic modes?
  - Background from full reconstruction.
  - ...
- Solid angle coverage / $K_L$ reconstruction.
- $B^0 \rightarrow K_S \nu \bar{\nu}, B \rightarrow K^* \nu \bar{\nu}$
- ....