Two-body Charmless Hadronic B decays: $B \to K^0 h$, $B \to h^+ \pi^0$

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BaBar collaboration

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and INFN (Rome)

Flavour Physics Session
APS
05-01-2001
The measurements of charmless hadronic BR

• **Charmless two body B decays:**
  
  \[
  B \rightarrow h^- h^+ \\
  B \rightarrow K_s h^{(+,0)} \\
  \begin{aligned}
  B &\rightarrow h^+ \pi^0 \\
  \end{aligned}
  \}

  at least one neutral particle

• The measurement of these branching ratios could help in extraction of parameters of the Standard Model

• Small BR → high statistic is needed
  → BaBar recorded \(~23\) million of B’s
The measurements of charmless hadronic BR

Discriminant variables:

\begin{align*}
\text{Sphericity, } R2 \\
\text{Fisher discriminant}
\end{align*}
\begin{align*}
\text{High momentum} \\
M_{ES} &= \sqrt{\frac{1}{2} \frac{s + p_0 \cdot p_B}{E_0^2 - p_B^2}} \\
\Delta E &= E_B^* - \sqrt{s}/2
\end{align*}
\begin{align*}
\theta \text{ Cherenkov} \\
\Rightarrow \text{ Unbinned Maximum Likelihood}
\end{align*}
Detected Internally Reflected Cherenkov light.

- 144 fused silica bars (1.7 cm thick)
- 11000 PMTs
- 10 mrad single photon resolution
Reconstruction of $K_s$

- $K_s$ reconstructed only in $\pi^+\pi^-$ channel ($\text{BF} \sim 68\%$)
- Basically two cuts:
  
  1. $K_s$ mass
     \[ |m_{K_s} - m_{PDG}| < 11.2 \text{ MeV} \quad (\rightarrow 3.5 \sigma) \]
  
  2. Decay time significance
     \[ \frac{\tau_{K_s}}{\sigma_{\tau_{K_s}}} > 5 \]

\[ \text{BABAR} \]

histo = bkg
dots = $K_s$ signal
Reconstruction of $\pi^0$

- Cuts on: $\gamma$ energy (>30 MeV)
- lateral momentum (shower shape)
- $\pi^0$ energy (>1.0 GeV)
- $\pi^0$ mass $\sigma(M \pi^0)$ ~ 8.5 MeV, 3$\sigma$ cut
  $\rightarrow$ 110 $< M(\gamma \gamma) <$ 160 MeV/$c^2$
- $\cos \theta^*(\gamma)$ (<0.95)
$M_{ES}$ and $\Delta E$ parametrization

- $M_{ES}$:
  - Signal from $B \to D\pi$ ($B \to D\rho$)
  - Bkg $\Rightarrow$ argus
  - (from $\Delta E$ sidebands)

- $\Delta E$:
  - Different value for $Kh$ and $\pi h$
  - MC $\to$ data resol. rescaled using $B \to D\pi$ ($B \to D\rho$)

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• **Fisher:**

  signal from MC

  background $M_{ES}$ sidebands

  control sample used

  $B \rightarrow D\pi$ ($B \rightarrow D\rho$)
• \( \theta \) Cherenkov: 
parametrization of \( \theta c \) vs momentum from 
\( D^* \to D\pi \) (ccbar events) 

satellite peak due to misID 

included in the PDF
# Systematics

<table>
<thead>
<tr>
<th></th>
<th>$B \to K_s \pi^+$</th>
<th>$B \to K_s \pi^0$</th>
<th>$B \to K^+ \pi^0$</th>
<th>$B \to \pi^+ \pi^0$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PDF parametriz</strong></td>
<td>+7.9%</td>
<td>+10.2%</td>
<td>+7.4%</td>
<td>+14.5%</td>
</tr>
<tr>
<td></td>
<td>-10.1%</td>
<td>-11.2%</td>
<td>-9.5%</td>
<td>-14.3%</td>
</tr>
<tr>
<td><strong>$K_s, \pi^0$ reco, tracking</strong></td>
<td>±3.8%</td>
<td>±6.4%</td>
<td>±5.1%</td>
<td>±5.1%</td>
</tr>
<tr>
<td><strong>B counting</strong></td>
<td>±1.6%</td>
<td>±1.6%</td>
<td>±1.6%</td>
<td>±1.6%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>+8.9%</td>
<td>+12.2%</td>
<td>+9.1%</td>
<td>+15.5%</td>
</tr>
<tr>
<td></td>
<td>-10.9%</td>
<td>-13.0%</td>
<td>-10.6%</td>
<td>-15.3%</td>
</tr>
</tbody>
</table>
## Results ($B \rightarrow K^0h^{(+,0)}$)

<table>
<thead>
<tr>
<th>Mode</th>
<th>$N_S$</th>
<th>Stat. Sig. ($\sigma$)</th>
<th>$\mathcal{B} \times 10^{-6}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$K^0\pi^+$</td>
<td>$59_{-10}^{+11}$</td>
<td>9.8</td>
<td>$18.2_{-3.0}^{+3.3+1.6}$</td>
</tr>
<tr>
<td>$K^0K^+$</td>
<td>$0(&lt;8)$</td>
<td>0</td>
<td>$&lt;2.6$</td>
</tr>
<tr>
<td>$K^0\pi^0$</td>
<td>$17.9_{-5.8}^{+6.8}$</td>
<td>4.5</td>
<td>$8.2_{-2.7}^{+3.1+1.1}$</td>
</tr>
</tbody>
</table>

**$M_{ES}$**

- $K^0\pi^+$
- $K^0\pi^0$

**$\Delta E$**

- $K^0\pi^+$
- $K^0\pi^0$
Results ($B \to h^+ \pi^0$)

Upper limit $B(10^{-6}) < 9.0$

<table>
<thead>
<tr>
<th>Mode</th>
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<th>Stat. Sig. ($\sigma$)</th>
<th>$B(10^{-6})$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi^0 \pi^+$</td>
<td>$37^{+15}_{-13}$</td>
<td>3.4</td>
<td>$5.1^{+2.0}_{-1.8} \pm 0.8$</td>
</tr>
<tr>
<td>$\pi^0 K^+$</td>
<td>$75^{+14}_{-13}$</td>
<td>8.0</td>
<td>$10.8^{+2.1+1.0}_{-1.9-1.2}$</td>
</tr>
</tbody>
</table>

$M_{ES}$

$\Delta E$

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Measurement of Asymmetries

• The measurement of the asymmetries corresponds to the measurement of the direct CP violation

• the result for $h^+h^0$ channels are:

\[ B \rightarrow K_s\pi^+ : \quad A_{K_S\pi^+} = -0.21 \pm 0.18 \pm 0.03 \]

\[ B \rightarrow K^+\pi^0 : \quad A_{K^+\pi^0} = 0.00 \pm 0.18 \pm 0.04 \]

• systematic uncertainty comes from

1) asymmetry in tracking (eval. from $\tau$ decays)
2) asymmetry in PID (detector effect)

this is evaluated by using $D^0 \rightarrow K\pi$

3) PDF variation
Future

• The measures of BR and asymmetries are still statistically limited

• BaBar will take an equivalent amount of data by the summer

• In the near future we will be able to measure the time dependent asymmetry (for $\pi\pi \Rightarrow \sin 2\alpha$)