Top to Bottom

New Results on Top and Bottom Quark Decays

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$\boxed{\textbf{Hadronic Bottom Decays}}$

Start with

$$H = \frac{G_F}{\sqrt{2}} V_{cb} \left\{ \left[(\bar{d}u) + (\bar{s}c) \right] (\bar{c}b) \right\}$$

- Renormalise H to take into account QCD corrections

$$\begin{aligned} H_{\text{eff}} &= \frac{G_F}{\sqrt{2}} V_{cb} \Big\{ c_1(\mu) \left[(\bar{d}u) + (\bar{s}c) \right] (\bar{c}b) + \\ &\qquad c_2(\mu) \left[(\bar{c}u)(\bar{d}b) + (\bar{c}c)(\bar{c}b) \right] \Big\} \end{aligned} \tag{1}$$

- For $B \to J/\psi$ decays, employ BSW factorisation:

$$\begin{aligned} d\Gamma(B^+ \to J/\psi X) &\propto a_2(m_b)^2 |V_{cb} V_{cs}^*|^2 \\ &\qquad |\langle J/\psi | (\bar{c}c) | 0 \rangle|^2 \, |\langle X | (\bar{s}b) | B \rangle|^2 \end{aligned} \tag{2}$$

- Have to put in b quark form factors by hand

Model is fundamental enough to warrant detailed study

- CLEO/ARGUS have looked at many decays systematically
- But studies have had limitations
  - low statistics
  - only produce B° & B^+ (no B_s° or baryons)

Hadron collider experiment overcomes some limitations

- Tevatron has produced $\sim 3 \times 10^9$ $b\bar{b}$ events

$\boxed{\text{Other Features of Top Decays}}$

We have also looked for "exotic" decay modes

- $t \to Z^{\circ} q$
  - Just run out of statistics
  - Very weak limit on $\mathcal{B}(t \to Z^{\circ} q)$

Have also looked at polarisation of top decay

- May be just beyond reach statistically

Have yet to perform a complete study using all modes

- Incorporate hadronic modes
- Add in τ decay modes

Ratios of Branching Fractions

$$
\begin{aligned}
R^{K^\circ}_{K^+} = \frac{f_d}{f_u}\,\frac{\mathcal{B}(B^\circ \to J/\psi K^\circ)}{\mathcal{B}(B^+ \to J/\psi K^+)} &= 1.15 \pm 0.27 \pm 0.09, \\
R^{K^{*+}}_{K^+} = \frac{\mathcal{B}(B^+ \to J/\psi K^{*+})}{\mathcal{B}(B^+ \to J/\psi K^+)} &= 1.92 \pm 0.60 \pm 0.17, \\
R^{K^{*\circ}}_{K^+} = \frac{f_d}{f_u}\,\frac{\mathcal{B}(B^\circ \to J/\psi K^{*\circ})}{\mathcal{B}(B^+ \to J/\psi K^+)} &= 1.59 \pm 0.33 \pm 0.12, \\
R^{K^\phi}_{K^+} = \frac{f_s}{f_u}\,\frac{\mathcal{B}(B^\circ_s \to J/\psi \phi)}{\mathcal{B}(B^+ \to J/\psi K^+)} &= 0.41 \pm 0.12 \pm 0.04, \\
R^{K^{*+}}_{K^\circ} = \frac{f_u}{f_d}\,\frac{\mathcal{B}(B^+ \to J/\psi K^{*+})}{\mathcal{B}(B^\circ \to J/\psi K^\circ)} &= 1.68 \pm 0.58 \pm 0.11, \\
R^{K^{*\circ}}_{K^\circ} = \frac{\mathcal{B}(B^\circ \to J/\psi K^{*\circ})}{\mathcal{B}(B^\circ \to J/\psi K^\circ)} &= 1.39 \pm 0.36 \pm 0.10, \\
R^{K^\phi}_{K^\circ} = \frac{f_s}{f_d}\,\frac{\mathcal{B}(B^\circ_s \to J/\psi \phi)}{\mathcal{B}(B^\circ \to J/\psi K^\circ)} &= 0.35 \pm 0.12 \pm 0.03, \\
R^{K^{*\circ}}_{K^{*+}} = \frac{f_d}{f_u}\,\frac{\mathcal{B}(B^\circ \to J/\psi K^{*\circ})}{\mathcal{B}(B^+ \to J/\psi K^{*+})} &= 0.83 \pm 0.27 \pm 0.07, \\
R^{K^\phi}_{K^{*+}} = \frac{f_s}{f_u}\,\frac{\mathcal{B}(B^\circ_s \to J/\psi \phi)}{\mathcal{B}(B^+ \to J/\psi K^{*+})} &= 0.21 \pm 0.08 \pm 0.02, \\
R^{K^\phi}_{K^{*\circ}} = \frac{f_s}{f_d}\,\frac{\mathcal{B}(B^\circ_s \to J/\psi \phi)}{\mathcal{B}(B^\circ \to J/\psi K^{*\circ})} &= 0.26 \pm 0.08 \pm 0.02.
\end{aligned}
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