B-Decays at CLEO:
un-charmed hadronic — rare and not-so-rare

R.D. Ehrlich, Cornell University
(for the CLEO Collaboration)
rde4@cornell.edu
Outline of the Talk

• Brief introduction to detector, data sets.

• Update on 2-body charmless B-decay results.

Reference: hep-ex/0302026

• Inclusive production of $\bar{D}^0$ in charmless B-decay

CESR: a symmetric $e^+e^-$ collider on the Cornell campus. Soon to become CESR-c

Cleo III: the penultimate version of the CLEO detector. 4-layer SVX, RICH PID, CsI(Tl), 1.5 T field, low-Z gas ... CLEO II lacked RICH and silicon. A well-understood detector, with good resolution for charged and neutral particles.

- 15.3 fb$^{-1}$ at Y(4S) in CLEOII/CLEO III data set.

- 6.6 fb$^{-1}$ taken 60MeV below Y(4S) for understanding of continuum backgrounds.
• Good momentum resolution for charged B-decay products
  ~0.5% or 12.5 MeV/c at p=2.5 GeV/c

• Likewise for photons/\(\pi^0\)
  ~2% or 40 MeV/c at p=2.5 GeV/c, \(\pi^0\) mass ~7MeV

• Combined PID performance of RICH and dE/dX at 2.5 GeV/c

<table>
<thead>
<tr>
<th>PID eff.</th>
<th>PID fake-rate</th>
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<th>P/P eff.</th>
<th>P/P fake-rate</th>
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<tbody>
<tr>
<td>90%</td>
<td>8%</td>
<td>90%</td>
<td>11%</td>
<td>72%/76%</td>
<td>1%</td>
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PID calibrated on \(\pi^0\)’s and K’’s
From tagged D*
Two-body charmless decays of $B$ mesons

Updated CLEOIII/CLEOII results for 13 two-body modes.

• Penguin, tree, baryonic, and “exotic”: all $O(10^{-5})$ or less.

• Need continuum rejection/understanding and efficient PID: small systematic errors make CLEO competitive.

Method: cut loosely on $M_B$, harder on $\cos q_{sph}$. Do PID. Form likelihood from $M_B$, $\Delta E$, $F$, $\cos q_{B}$ PDF’s.

Each mode gets signal, background, and “crossfeed” components.

Fit via unbinned max. likelihood.

$M_B = (E_b^2 - (p_i)^2)^{1/2}$, $\Delta E = E - E_b$

$q_{sph}$ = angle between candidate axis and sphericity axis of event

$q_B$ = angle between cand. direction and beam

$F$ = Fisher discriminant: direction of candidate, energy flows about 2-body axis, $q_B$, shape info
• 6 B.R.’s (>3$\sigma$) significance) & 7 U.L.’s

• $\mathcal{B}^{+}\mathcal{B}^{-}$ U.L. at<10$^{-6}$

• good agreement with CLEO*, Babar, and Belle, (as of Spring 2003).

First error statistical, second systematic, dominantly #BB and efficiencies uncertainties.
Implications

• No sign of annihilation channels or new physics (no $K\bar{K}$)

• Neubert, *et al.*, say: world averages imply that $\theta$ is likely greater than 90°. (use SU(3) and ratio of B.R.’s)

\[ \text{Purple zone preferred by } \begin{array}{c} \theta \\ \text{contours. Conflict??} \end{array} \]

* See hep-ph/0207327
In 1998 CLEO observed “copious” inclusive production of high-\(p\) \(\pi^\prime\)’s in B-decay (B.R. \(\sim 6 \times 10^{-4}\)), as well as exclusive a large \(\pi^\prime\)K rate. Babar and Belle have since confirmed that result.

Theorists have searched for explanations: enhanced gluonic coupling to \(\pi^\prime\) via the anomaly, intrinsic cc; etc. See Fritzsch and Zhou, hep-ph/0301038, and Eeg et al., hep-ph/0304274 for recent efforts.

CLEO has now redone its earlier CLEO II analysis for the entire \(9.1\, \text{fb}^{-1}\) (on 4S) and \(4.4\, \text{fb}^{-1}\) (off) CLEO II + CLEO II.V data sample.
Features of Analysis

- Better statistics and use of techniques from b→ s studies.

Steps (a bit complicated):
1) Find $q'$ in $q' \rightarrow \ell^+\ell^-$, $q' \rightarrow \ell\nu$ signal: $2.0 < P_{q'} < 2.7$ GeV/c
   save continuum bkgd. from ctrl. region, $1.6 < P_{q'} < 1.9$ GeV/c

2) Perform “pseudo-reconstruction” of B mass using $q'$ a K, and up to 4 $q$’s, one of which may be neutral.

3) Collect shape variables, $E$, $M_b$, presence of leptons....

4) Construct a neural net (trained on MC) to tell signal from continuum, use weights to optimize total error.

5) Subtract scaled continuum yields, fit for yields

6) Use Monte Carlo for charm contribution, scaled to agree in control region, $1.6 < P_{q'} < 1.9$ GeV/c. ISGW2 assigned 50% systematic uncertainty at D**.
Yields, ON and OFF Y(4S)

Yield in the "signal region"

2.0 < P < 2.7 GeV/c
- Region above 2.5 GeV corresponds to "control" region dominated by charm

- signal at 0.5 GeV, ~1.4 GeV, ~2.2 GeV

- no $K^*(890)$
After all that, we find 61.2±13.9 (stat.) weights for the inclusive non-charmed yield in the range 2.0 GeV/c <P< 2.7 GeV/c.

This corresponds to a final B.R.:

$$[4.6±1.1\text{(stat.)}±0.4\text{(sys.)}±0.5\text{(bkgd.)}] \times 10^{-4}$$

Consistent with earlier result. Study of detection efficiencies says that we have measured B.R. (B→KSX) + 0.79 • B.R. (B→KS′Xu,d)

What’s the status of explanations??
Still no firm explanation for high $\bar{\psi}'$ rate.

- CLEO, in hep-ex/0211029 and in M. Artuso, et al., Phys. Rev. Letters 87, 141801 (2001), finds no support for a slowly falling $\bar{\psi}'g^*g$ coupling. Few high-$P \bar{\psi}'$ in $Y(1S)$ decay!

Intrinsic $c\bar{c}$ within $\bar{\psi}'$ predicts $B\to \bar{\psi}'K^*$ rate $\sim 0.5 \times \bar{\psi}'K$ rate—larger than observed by CLEO or Babar.

Perhaps, it will all be made clear at this conference!