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Search for the Rare Hadronic Decay $B \to p\bar{p}$

CLEO Collaboration

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Abstract

We have searched for the rare hadronic decay $B \to p\bar{p}$. We see no evidence for any signal, and find an upper limit branching fraction of 1.1 $\times 10^{-5}$.

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I. INTRODUCTION

CLEO has previously reported a few measurements of and a large number of upper limits for charmless B decays into mesons. The simplest, and easiest to measure, rare baryonic decay is $B \to p\bar{p}$. It is the $b \to u$ analog of the $b \to c$ decay $B \to \Lambda_c \bar{p}$. Thus, a naive prediction is that $\mathrm{Br}(B \to p\bar{p})/\mathrm{Br}(B \to \Lambda_c\bar{p}) \approx |V_{ub}/V_{cb}|^2$ (neglecting a phase space factor of 1.25) . CLEO has an upper limit measurement of 2.1×10^{-4} [1] for the branching fraction for $B \to \Lambda_c\bar{p}$. Thus, for $p\bar{p}$, we would expect a branching fraction of at most 2×10^{-6}.

II. DATA SAMPLE AND EVENT SELECTION

The data used in this analysis were selected from hadronic events produced in e^+e^- annihilations at the Cornell Electron Storage Ring (CESR). The data sample consists of an integrated luminosity of 2.85 fb^{-1} collected on the $\Upsilon(4s)$ resonance and 1.42 fb^{-1} at a center-of-mass energy just below the threshold for producing $B\bar{B}$ mesons (referred to as continuum data).The on-resonance data corresponds to 3.05×10^6 B^0's (including $\bar{B}^0$) in our sample.

Standard CLEO rare hadronic cuts have been applied [2] including a Fisher Discriminant cut. Since the kinematics for the $p\bar{p}$ decay are identical to the $K\pi/\pi\pi$ decays, the same Fisher Discriminant is used.

Protons from the $p\bar{p}$ decay of the B meson have a central momentum of 2.47 GeV/c. Accepted events are required to have two oppositely charged tracks with momenta within the range 2.5± 0.5 GeV/c. The beam constrained mass, M_B, must be within ± 5 Mev of the B mass and ΔE must be within the range 0± 50 Mev(2σ), where $M_B = \sqrt{E_{beam} - \sum_i \mathbf{p}_i^2}$ and $\Delta E = E_1 + E_2 - E_{beam}$.

A pion misidentified as a proton has an energy 166 Mev less than a real proton, while, for a misidentified Kaon, the energy difference is 121 Mev. Thus, with an energy resolution of 25 Mev, there can be no contamination from $\pi\pi$ or $K\pi$ decays of the B.

Protons are identified by the use of both dE/dx and time-of-flight. For dE/dx , the πp separation is 1.8 sigma while,unfortunately, the Kp separation is zero near 2.5 Gev/c. On the other hand,the time-of-flight Kp separation is 1.0 sigma and the πp separation is 1.4 sigma. The information from both devices was combined to obtain a particle ID probability.

A. $p\bar{p}$ selection

In order to best identify the event, a two-particle probability was calculated for the candidate tracks (e.g. Prob(pp) is the probability that both tracks are protons, Prob($p\pi$) is the probability that the first track is a proton and the second is a pion, etc.). Since continuum events constitute the only background, there are nine possible combinations of π, K and p. Identification is made using a likelihood ratio, L(xy)= Prob(xy)/Prsum, where Prsum is the sum of all nine two-particle probabilities. Prsum is required to be greater than 0.01.

We expect the largest background to be due to a real proton and a pion. Thus we require that L(pp) > L($p\pi$) and L(pp) > L(πp). In addition, it is required that L(pp) $\geq$ 0.19. This was determined by optimizing $signal/\sqrt{background}$ where the signal was obtained from $p\bar{p}$

Monte Carlo [3] and the background from continuum data with the event-shape cuts relaxed. The L(pp) cut has an efficiency for signal of 0.77 while rejecting 70% of the background.

III. RESULTS

After applying all the cuts outlined above, we find one event in the signal region. Figure 1 shows all the events in the M_B-ΔE grand sideband region. As for measured backgrounds, there are no events in the signal region for continuum runs and the grand sideband region for the on-resonance runs indicate that there are less than 0.5 events expected in the signal region. To quote a conservative upper limit, we take the background to be zero.

The efficiency, using a $p\bar{p}$ Monte Carlo, is 0.142±0.005. Following our usual procedure, we reduce this by one sigma. In addition, we also reduce the efficiency by its 20% systematic error.

With one signal event and no background, the 90% confidence level upper limit is 3.9 events. The resulting upper limit on the branching fraction for $B \to p\bar{p}$ is 1.1 $\times 10^{-5}$. This is almost a factor of 2 smaller than the ALEPH limit of 2×10^{-5} [4].

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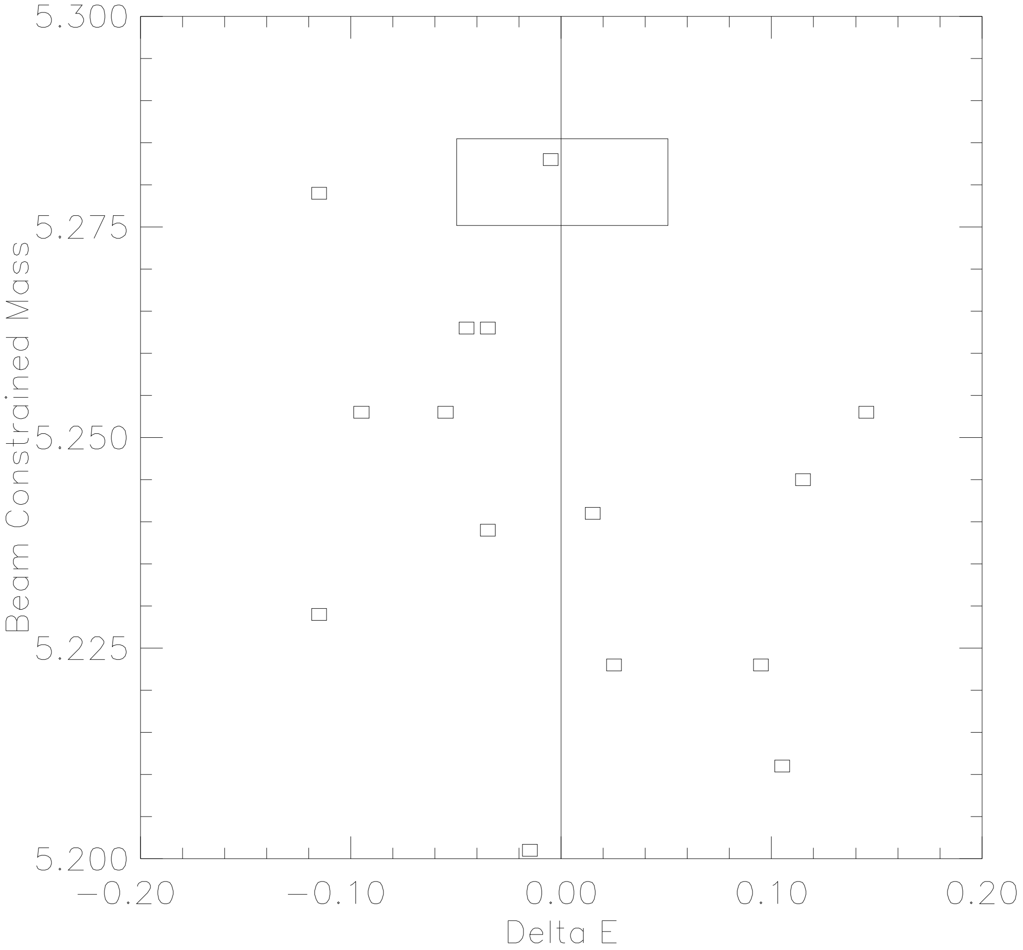

FIG. 1. Beam constained mass vs. ΔE for accepted events

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