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SEARCH FOR $B^+ \to K^+ \ell^+\ell^-$ AND $B^0 \to K^{*0} \ell^+\ell^-$

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Using a sample of 3.7×10^6 $\Upsilon(4S) \to B\bar{B}$ events collected with the *BABAR* detector at the PEP-II storage ring, we search for the electroweak penguin decays $B^+ \to K^+e^+e^-$, $B^+ \to K^+\mu^+\mu^-$, $B^0 \to K^{*0}$ e^+e^-, and $B^0 \to K^{*0}$ $\mu^+\mu^-$. We observe no significant signals for these modes and set preliminary 90% C.L. upper limits of

$$\begin{aligned}
\mathcal{B}(B^+ \to K^+e^+e^-) &< 12.5 \times 10^{-6},\\
\mathcal{B}(B^+ \to K^+\mu^+\mu^-) &< 8.3 \times 10^{-6},\\
\mathcal{B}(B^0 \to K^{*0}e^+e^-) &< 24.1 \times 10^{-6},\\
\mathcal{B}(B^0 \to K^{*0}\mu^+\mu^-) &< 24.5 \times 10^{-6}.
\end{aligned}$$

1. Introduction

The rare decays $B \to K\ell^+\ell^-$ and $B \to K^*\ell^+\ell^-$, where ℓ is either an electron or muon, are highly suppressed in the Standard Model and are expected to occur via electroweak penguin processes. Standard Model predictions indicate [1] that $\mathcal{B}(B \to K\ell^+\ell^-) \approx 6 \times 10^{-7}$, while $\mathcal{B}(B \to K^*\ell^+\ell^-) \approx 2 \times 10^{-6}$. These processes provide a possible window into physics beyond the Standard Model, since new, heavy particles such as those predicted by SUSY models can enter the loops in the effective flavor-changing neutral current transitions [2] $b \to s$.

Experimentally, the small expected rates make searches for these modes difficult. Searches from CDF [3] and CLEO [4] have so far yielded only upper limits.

In this paper, we report the results of a preliminary analysis to investigate the backgrounds and the ability of the *BABAR* detector [5] to reject them. We have analyzed an on-resonance data sample of 3.2 fb^{-1}, representing about a third of the current *BABAR* $\Upsilon(4S)$ integrated luminosity. The main goal of our study is to test the performance of a blind analysis in which the event selection is optimized without use of the signal or sideband regions in the data. We analyze four charged particle decay modes: $B^+ \to K^+e^+e^-$, $B^+ \to K^+\mu^+\mu^-$, $B^0 \to K^{*0}e^+e^-$, and $B^0 \to K^{*0}\mu^+\mu^-$. In each case, we include the charge conjugate mode as well.

2. Analysis Methods and Event Selection

We select event with at least 5 good quality tracks, of which two are leptons with lab frame momenta $p_e > 0.5$ GeV/c (electrons) or $p_\mu > 1.0$ GeV/c (muons). Electrons

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and positrons are also required to pass the γ conversions veto. The $B \to J/\psi\ K^{(*)}$ and $B \to \psi(2S)\ K^{(*)}$ events have the same topology as our signal processes and must be removed with great care, especially since bremsstrahlung can lower the dielectron mass with respect to the J/ψ or $\psi(2S)$ mass. We remove events with dilepton masses consistent with the J/ψ or $\psi(2S)$, and we apply a correlated cut in the ΔE vs. $M_{\ell^+\ell^-}$ plane to account for possible bremsstrahlung or track mismeasurement. The $B \to J/\psi\ K$ modes can also pass this veto if the kaon is misidentified as a lepton (most often a muon). In a similar way $B^- \to D^0\pi^-$, where $D^0 \to K^-\pi^+$, can pass our selection criteria if both of the leptons are fake. These effects can be suppressed by re-assigning the particle masses and excluding mass combinations around the J/ψ and the D^0. Continuum background is suppressed by using a four-variable Fisher discriminant. Finally, the signal region is defined as a rectangle in the plane defined by the beam-energy substituted mass of the B candidate m_{ES} and the energy difference [5] ΔE: $5.272 < m_{ES} < 5.286$ GeV/c^2 (3σ) and $-0.10 < \Delta E < 0.06$ GeV ($|\Delta E| < 0.06$ GeV) for the electron (muon) channels. For the $B^0 \to K^{*0}\ell^+\ell^-$ channels, we reconstruct the K^{*0} in the $K^+\pi^-$ final state. The kaon candidate is required to be identified as a kaon, while there are no particle identification requirements on the pion candidate. The mass of the $K^+\pi^-$ pair is required to be within 75 MeV/c^2 of the K^{*0} mass.

3. Physics results

Figure 1 shows a large ΔE vs. m_{ES} region (the "grand sideband") and a small box indicating the signal region for each of the four modes. Table 1 lists the signal efficiencies, total yield, the expected background, and the 90% C.L. upper limits on the branching fractions. The signal efficiencies were determined from the signal Monte Carlo events. The efficiencies include the branching fractions for the K^{*0} modes. Note that even though we carry through a background estimation procedure using the sidebands in data, we are setting an upper limit assuming that each event in the signal region is potentially due to the signal process. The table also lists the total systematic error. The dominant systematic uncertainty is on the tracking efficiency (2.5% per track).

Table 1. Signal efficiencies, systematic uncertainties (combining the uncertainties on the signal efficiencies and on the number of produced Υ(4S) mesons), the number of observed events, the number of estimated background events, and upper limits on the branching fractions. In computing the upper limits we have assumed $\mathcal{B}(K^{*0} \to K^+\pi^-) = 2/3$.

Mode	Efficiency (%)	Total systematic uncertainty (%)	Observed events	Bkgd. estimated from data	$\mathcal{B}/10^{-6}$ (90% C.L.)
$B^+ \to K^+e^+e^-$	13.1	11.7	2	0.20	< 12.5
$B^+ \to K^+\mu^+\mu^-$	8.6	12.3	0	0.25	< 8.3
$B^0 \to K^{*0}e^+e^-$	7.7	14.2	1	0.50	< 24.1
$B^0 \to K^{*0}\mu^+\mu^-$	4.5	14.8	0	0.33	< 24.5

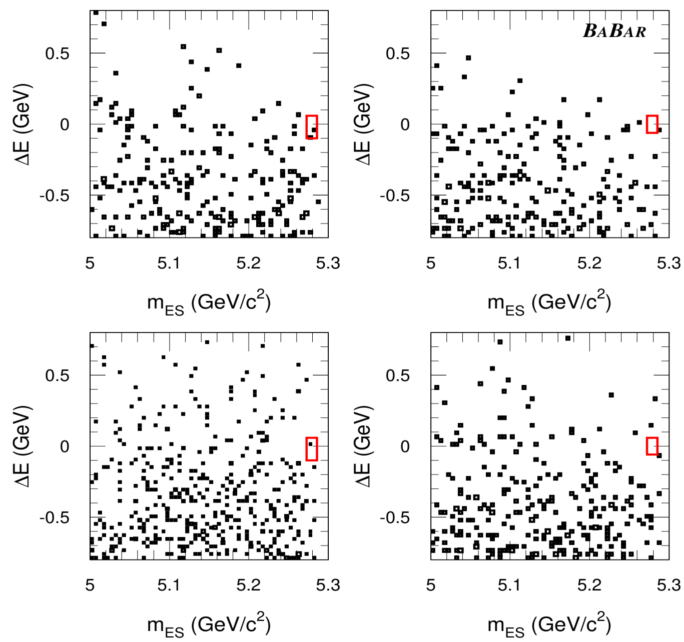

Fig. 1. ΔE vs. m_{ES} (grand sideband) for data: (a) $B^+ \to K^+e^+e^-$, (b) $B^+ \to K^+\mu^+\mu^-$, (c) $B^0 \to K^{*0}e^+e^-$, and (d) $B^0 \to K^{*0}\mu^+\mu^-$. The smaller boxes show the signal region.

4. Conclusion

We have searched for rare B decays $B \to K^{(*)}\ \ell^+\ell^-$ in a sample of $3.7 \times 10^6\ B\bar{B}$ events. We find no observable signal for any of the four modes considered, and set preliminary 90% C.L. upper limits on the branching fractions:

$$\begin{aligned}
\mathcal{B}(B^+ \to K^+e^+e^-) &< 12.5 \times 10^{-6}, \\
\mathcal{B}(B^+ \to K^+\mu^+\mu^-) &< 8.3 \times 10^{-6}, \\
\mathcal{B}(B^0 \to K^{*0}e^+e^-) &< 24.1 \times 10^{-6}, \\
\mathcal{B}(B^0 \to K^{*0}\mu^+\mu^-) &< 24.5 \times 10^{-6}.
\end{aligned}$$

The limits for the $B^+ \to K^+\ell^+\ell^-$ modes are comparable to those set by other experiments, while those for $B^0 \to K^{*0}\ell^+\ell^-$ are less sensitive with this data sample. We plan to analyze substantially more data in the near future.

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