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Search for $B \to J/\psi D$ Decays

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We report a search for $B \to J/\psi D$ decays, based on a sample of 124×10^6 $B\overline{B}$ events collected with the BABAR detector at the PEP-II storage ring of the Stanford Linear Accelerator Center.

No significant signal is found. We obtain upper limits on the branching fractions of 1.3×10^{-5} for $B^0 \to J/\psi \overline{D}^0$ and 1.2×10^{-4} for $B^+ \to J/\psi D^+$ at 90% confidence level.

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Measurements of the inclusive spectrum of charmonium mesons in B decays are in conflict with conventional expectations. The spectra of the momentum of the J/ψ mesons in the $\Upsilon(4S)$ rest frame observed by CLEO [1] and by BaBar [2] (Fig. 1), compared with calculations using non-relativistic QCD (NRQCD) [3], show an excess at low momentum, corresponding to a branching fraction of approximately 6×10^{-4}. Various hypotheses have been proposed to explain this low-momentum excess.

Brodsky and Navarra [4] have suggested that the decay $B \to J/\psi \Lambda \bar{p}$ [5], with the possible formation of a Λ-$\bar{p}$ bound state, could explain the CLEO result. The kinematic boundary of this structure corresponds to the case where the J/ψ recoils nearly monoenergetically in the B rest frame against a $2\,\mathrm{GeV}/c^2$ particle. The Λ-$\bar{p}$ state could be observed near or just below threshold. *BABAR* has searched for these decays and obtained an upper limit of 2.6×10^{-5} at 90% confidence level (C.L.) [6], too small to support the mechanism proposed in [4].

Decays to a J/ψ meson and a hybrid meson, i.e. a bound state of two quarks and a gluon, have been proposed [7, 8]. In this case the hybrid meson, possibly a $(s\bar{d}g)$ state, would need to have a mass of about 2 GeV/c^2.

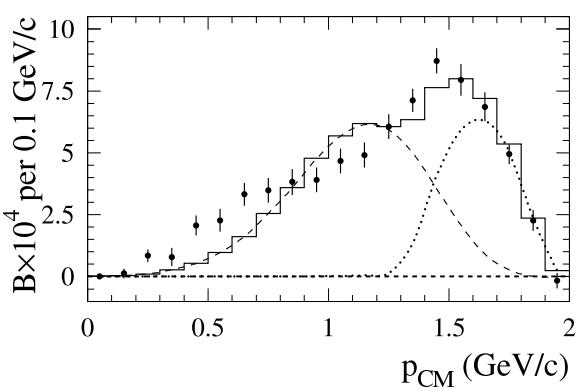

FIG. 1: Upsilon(4S) rest-frame momentum of J/ψ mesons produced in B decays, after subtracting feed-down from $\chi_{c1,2} \to J/\psi\gamma$ and $\psi(2S) \to J/\psi\pi\pi$ (points) [2]. The histogram is the sum of the color-octet component from a NRQCD calculation [3] (dashed line), which includes multibody final states, and the color-singlet $J/\psi K^{(*)}$ component (dotted line). The normalization of the curves has been constrained to fit the data.

No experimental evidence has been found to support this mechanism.

If B mesons were decaying to a narrow resonance and a J/ψ meson, the J/ψ meson would be monoenergetic in the B rest frame. Such peaks would appear smeared with an RMS of $0.12\,\mathrm{GeV}/c$ in Fig. 1, due to the motion of the B in the $\Upsilon(4S)$ rest frame.

The presence of $b\bar{u}c\bar{c}$ components (intrinsic charm) in the B-meson wave function has also been proposed. In that case the charmonium meson is obtained merely by dissociation when the b quark decays. Intrinsic charm was first introduced by Brodsky *et al.* [9] to explain an unexpectedly large cross-section for charmed-particle production in hadron collisions. Using the estimated amount of intrinsic charm in the proton as an input, Chang and Hou predict $B \to J/\psi D(\pi)$ decays with branching fractions of the order of 10^{-4} [10]. The dominant final state is expected to be $B \to J/\psi D\pi$, for which *BABAR* has reported an upper limit at 90% C.L. of 5.2×10^{-5} for $B^+ \to J/\psi D^0\pi^+$ [11]. Four-body decays such as $B \to J/\psi D\pi\pi$ should be extremely suppressed by the small phase space available near the kinematical limit. The remaining untested final state is $J/\psi D$. Calculations by Eilam *et al.* using perturbative QCD [12] predict branching fractions (BF's) for $B \to J/\psi D$ decays on the order of 10^{-8} – 10^{-7}. The observation of a signal with a BF significantly larger would suggest the presence of intrinsic charm inside the B meson.

In this Letter we report a search for decays $B \to J/\psi D$, with $\overline{D}^0$ decaying to $K^+\pi^-$, D^+ to $K^0_S\pi^+$, K^0_S to $\pi^+\pi^-$, and $J/\psi \to \ell^+\ell^-$, where ℓ is e or μ.

The data used in this analysis were collected with the *BABAR* detector at the PEP-II storage ring and comprise an integrated luminosity of 112 fb^{-1} taken at the $\Upsilon(4S)$ resonance. The *BABAR* detector is described in detail elsewhere [13]. A five-layer, double-sided silicon vertex tracker (SVT) surrounds the interaction point and provides precise reconstruction of track angles and B-decay vertices. A 40-layer drift chamber (DCH) provides measurements of the transverse momenta of charged particles. An internally reflecting ring-imaging Cherenkov detector (DIRC) is used for particle identification. A CsI(Tl) crystal electromagnetic calorimeter (EMC) detects photons and electrons. The calorimeter is surrounded by a solenoidal magnet providing a 1.5-T field.

The flux return is instrumented with resistive plate chambers used for muon and neutral-hadron identification.

We select multihadron events by demanding a minimum of three reconstructed charged tracks in the polar angle range $0.41 < \theta_{lab} < 2.54$ rad. A charged track must be reconstructed in the DCH, and, except for the reconstruction of $K_S^0 \to \pi^+\pi^-$, it must originate at the nominal interaction point to within 1.5 cm in the plane transverse to the beam and to within 10 cm along the beam. Events are required to have an $\Upsilon(4S)$ production point within 0.5 cm of the average position of the interaction point in the plane transverse to the beamline, and within 6 cm longitudinally. Neutral clusters are defined as electromagnetic depositions in the calorimeter in the polar angle range $0.410 < \theta_{lab} < 2.409$ rad that are not associated with charged tracks and that have an energy greater than 30 MeV and a shower shape consistent with a photon interaction. We require the total energy for charged tracks and photon candidates in the fiducial region to be greater than 4.5 GeV. To reduce continuum $e^+e^- \to q\overline{q}$ background, we require the ratio of second-to-zeroth Fox-Wolfram moments R_2 [14] of the event, calculated with both charged tracks and neutral clusters, to be less than 0.5. Charged tracks are required to be in regions of polar angle for which the particle identification (PID) efficiency is well measured. For electrons, muons, and kaons the acceptable ranges are 0.40 to 2.40, 0.30 to 2.70, and 0.45 to 2.50 rad, respectively.

We further select signal events as described in the following. Event selection is optimized by maximizing the sensitivity $s \equiv \epsilon/(a/2+\sqrt{N_B})$, where $a = 3$ is the number of standard deviations of significance desired [15]. The maximum of this ratio is independent of the unknown signal branching fraction. The signal efficiency ϵ after all selection requirements is estimated from simulated Monte Carlo (MC) samples. The number of background events N_B, scaled to the integrated luminosity of the data, is estimated using inclusive $\Upsilon(4S) \to B\overline{B}$ and $e^+e^- \to q\overline{q}$ MC samples.

We reconstruct J/ψ candidates from a pair of oppositely charged lepton candidates that form a good vertex. Muon (electron) candidates are identified with a neural-network (cut-based) selector. For $J/\psi \to e^+e^-$ decays, electron candidates are provisionally combined with nearby photon candidates in order to recover some of the energy lost through bremsstrahlung. These bremsstrahlung-photon candidates are characterized by a deposit of more that 30 MeV in the electromagnetic calorimeter and a polar angle within 35 mrad of the electron direction, as well as an azimuthal angle either within 50 mrad of the electron direction, or between the electron direction at the origin and the azimuth of the impact point in the EMC. The lepton-pair invariant mass must be in the range [3.00, 3.14] GeV/c^2 for both lepton flavors.

We form K_S^0 candidates from oppositely charged tracks originating from a common vertex and having an invariant mass in the range [487, 510] MeV/c^2. The K_S^0 flight length must be greater than 1 mm, and its direction in the plane perpendicular to the beam line must be within 0.2 rad of the K_S^0 momentum vector. All charged tracks are taken as pion candidates, and kaon candidates are identified with a likelihood selector based on Cherenkov-angle measurements from the DIRC and specific ionization in the SVT and in the DCH. Candidates for D mesons are formed from $K\pi$ combinations; a requirement on the $K\pi$ invariant mass $m_{K\pi}$ is applied during the optimization of the selection. The analysis is then performed in a larger window $1.80 < m_{K\pi} < 1.92$ GeV/c^2. The high statistics decays $B \to J/\psi\ K^*$ with the same $J/\psi K\pi$ final state are used as a control sample to evaluate the possible differences between data and MC. These are selected with requirements similar to those of the signal, except for an $m_{K\pi}$ range of [0.79, 0.99] GeV/c^2. The J/ψ and K_S^0 candidates are constrained to their nominal masses [16] to improve the resolution of the measurement of the four-momentum of their parent-B candidate.

Candidate B mesons are formed from J/ψ and D candidates. Two kinematic variables are used to further remove incorrectly reconstructed B candidates. The first is the difference $\Delta E \equiv E_B^* - E_{beam}^*$ between the B-candidate energy and the beam energy in the $\Upsilon(4S)$ rest frame. In the absence of experimental effects, correctly reconstructed signal candidates have $\Delta E = 0$. The ΔE resolution is 7.5 MeV. For the signal region, ΔE is required to be in the range $[-15, +12]$ MeV. The second variable is the energy-substituted mass $m_{\rm ES} \equiv (E_{beam}^{*2} - p_B^{*2})^{1/2}$, where p_B^* is the momentum of the B candidate in the $\Upsilon(4S)$ rest frame. The energy substituted mass $m_{\rm ES}$ peaks at the nominal B mass of 5.279 GeV/c^2 for the signal. Its typical resolution is 2.5 MeV/c^2. A requirement of $5.274 < m_{\rm ES} < 5.284$ GeV/c^2 was obtained in the optimization of the signal selection. The analysis is then performed in the window $5.2 < m_{\rm ES} < 5.3$ GeV/c^2. If more than one B candidate is found in an event, the one having the smallest $|\Delta E|$ is retained.

Non-D $B \to J/\psi K\pi$ decays that have $m_{\rm ES}$, ΔE, and $m_{\ell^+\ell^-}$ distributions similar to those of the signal are found to be the dominant contribution to the remaining background after selection cuts are applied. Signal events can be separated from non-D events by their peaking at the D invariant mass in the $m_{K\pi}$ spectrum. In MC samples, this spectrum shows a small but significant number of true D mesons: a D meson from the decay of one B was combined with a J/ψ meson from the decay of the other B. We subtract this combinatorial background using the $m_{\rm ES}$ distribution: the $m_{K\pi}$ distribution of the events in the sideband ($5.21 < m_{\rm ES} < 5.27$ GeV/c^2) is subtracted from the distribution of the events in the signal region, with a scaling factor R that is the ratio of the combinatorial background in the signal region and in the sideband. The value of R is obtained from the integrals of the AR-

GUS shape [17] in fits of the $m_{\rm ES}$ distribution with a Gaussian function for the signal and an ARGUS shape for the combinatorial background (Fig. 2). The $m_{\rm ES}$ signal window for the data is shifted by $+0.6$ MeV/c^2 with respect to MC after such a shift is observed on the J/ψ K^* control sample. We obtain $R = 0.093 \pm 0.011$ and $R = 0.131 \pm 0.038$ for $J/\psi\,\overline{D}^0$ and $J/\psi\,D^+$, respectively.

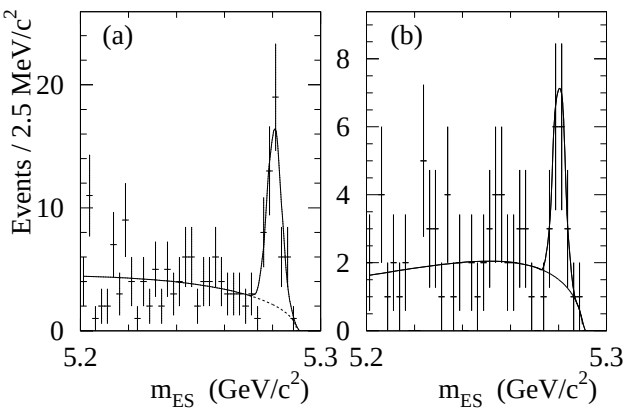

FIG. 2: Distribution of $m_{\rm ES}$ for data events with $m_{K\pi}$ in the range [1.8, 1.92] GeV/c^2. (a): $J/\psi\,\overline{D}^0$, (b): $J/\psi\,D^+$. The fits are described in the text. The peaks at the nominal B mass are due to non-D events.

The combinatorial-background-subtracted $m_{K\pi}$ distributions (Fig. 3) are fitted with the combination of a linear background (two free parameters) and a Gaussian signal in which the number of signal events S is a free parameter. The central value and the resolution of the D peak

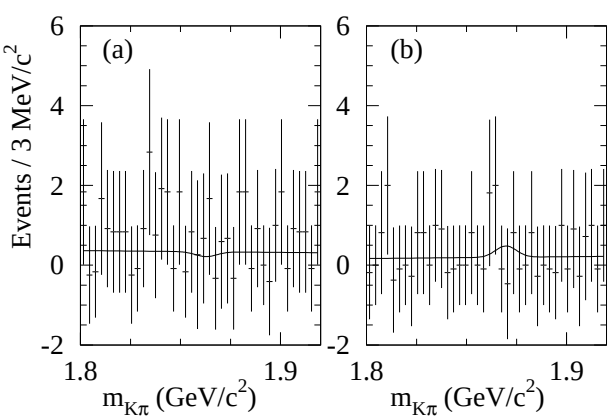

FIG. 3: Background-subtracted $m_{K\pi}$ distributions. ((a): $J/\psi\,\overline{D}^0$, (b): $J/\psi\,D^+$) The fits are described in the text.

are fixed in the fit. The resolution measured on the signal MC sample is used. The agreement of data and MC samples has been studied with a D-meson control sample obtained with the same selection as for the D candidates of the $J/\psi\,D$ events. The resolutions are found to be similar in the data and in the MC samples, and a shift of $-0.6 \pm 0.2\,{\rm MeV}/c^2$ of the central value is observed and accounted for.

No significant signal for $B \to J/\psi\,D$ is observed. The numbers of events obtained are $-0.6 \pm 1.2 \pm 0.2$ ($J/\psi\,\overline{D}^0$) and $1.2 \pm 1.9 \pm 0.2$ ($J/\psi\,D^+$), where the first uncertainty is statistical, and the second one is the systematic contribution due to the uncertainties in the scaling factor for background subtraction, and of the D mass and mass resolution used in the fit. The branching fractions are:

$$\mathcal{B} = \frac{S}{N_{evt} \times \epsilon \times b}, \qquad (1)$$

where S is the number of signal events obtained from the fit, $N_{evt} = 124 \times 10^6$ is the number of $B\overline{B}$ events in the data sample, and b is the product of the branching fractions of the secondary decays (Table I).

TABLE I: Number of signal events, efficiency, secondary branching fraction, measured branching fraction ($\mathcal{B}$) and upper limit (UL) at 90% C.L.

	S	ϵ (%)	b (10^{-3})	$\mathcal{B}$ (10^{-5})	UL (10^{-5})
$J/\psi\ \overline{D}^0$	-0.6 ± 1.2	23.3 ± 0.3	4.49	-0.46 ± 0.93	1.3
$J/\psi\ D^+$	1.2 ± 1.9	22.6 ± 0.2	1.15	3.7 ± 5.9	12.3

Additional contributions to the systematic uncertainty of the branching fraction are described in the following. The relative uncertainty in the number of $B\overline{B}$ events is 1.1%. The secondary branching fractions and their uncertainties are taken from PDG [16]. Other estimated uncertainties are from tracking efficiency (1.3% per track added linearly), K^0_S reconstruction (2.5%), PID efficiency (3.0%) and the statistical uncertainty in the selection efficiency. The uncertainty in the selection efficiency due to the uncertainty of the MC/data difference of the central value and of the width of the peaks in $m_{\ell^+\ell^-}$, $m_{\rm ES}$, and ΔE is estimated from the J/ψ K^* control sample. A summary of the multiplicative contributions to the systematics can be found in Table II. The ratio of B^0 to B^+ production in $\Upsilon(4S)$ decays is assumed to be unity. The related uncertainty is small and is neglected here.

We obtain upper limits for the branching fractions at 90% C.L. of 1.3×10^{-5} for $B^0 \to J/\psi\ \overline{D}^0$ and 1.2×10^{-4} for $B^+ \to J/\psi\ D^+$, using a Bayesian method with uniform prior for positive BF values. These results are significantly lower than the predictions of Ref. [10]. Together with the small upper limits on the branching fraction for decays $B \to J/\psi\,D\pi$ [11], we conclude that intrinsic charm as the explanation of the low momentum J/ψ excess in B decays is not supported.

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TABLE II: Summary of the contributions to the relative systematic uncertainty (%).

	$J/\psi\,\overline{D}^0$ $(K^+\ \pi^-)$	$J/\psi\,D^+$ $(K^0_S\ \pi^+)$
B counting	1.1	1.1
Secondary BF's	2.7	6.8
Tracking	5.2	3.9
K^0_S	–	2.5
PID	3.0	3.0
MC statistics	1.5	1.0
Sample selection	1.0	0.8
Total	6.9	8.9

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[1] R. Balest *et al.* [CLEO Collaboration], Phys. Rev. D **52**, 2661 (1995); S. Chen *et al.*, Phys. Rev. D **63**, 031102 (2001).
[2] B. Aubert *et al.* [BABAR Collaboration], Phys. Rev. D **67**, 032002 (2003).
[3] M. Beneke, G. A. Schuler and S. Wolf, Phys. Rev. D **62**, 034004 (2000).
[4] S. J. Brodsky and F. S. Navarra, Phys. Lett. B **411** (1997) 152.
[5] Charge-conjugate modes are included implicitly throughout this paper.
[6] B. Aubert *et al.* [BABAR Collaboration], Phys. Rev. Lett. **90**, 231801 (2003).
[7] C.T.H Davies and S.H.H Tye, Phys.Lett. **B154** 332 (1985).
[8] C. K. Chua, W. S. Hou and G. G. Wong, Phys. Rev. D **68**, 054012 (2003).
[9] S. J. Brodsky, P. Hoyer, C. Peterson and N. Sakai, Phys. Lett. B **93** (1980) 451.
[10] C. H. Chang and W. S. Hou, Phys. Rev. D **64** (2001) 071501.
[11] B. Aubert *et al.* [BABAR Collaboration], hep-ex/0406022.
[12] G. Eilam, M. Ladisa and Y. D. Yang, Phys. Rev. D **65** (2002) 037504.
[13] B. Aubert *et al.* [BABAR Collaboration], Nucl. Instrum. Meth. A **479**, 1 (2002).
[14] G. C. Fox and S. Wolfram, Phys. Rev. Lett. **41**, 1581 (1978).
[15] G. Punzi, eConf **C030908** (2003) MODT002 [arXiv:physics/0308063].
[16] Particle Data Group, S. Eidelman *et al.*, Phys. Lett. B **592**, 1 (2004).
[17] H. Albrecht *et al.*, [ARGUS Collaboration], Z. Phys. C **48**, 543 (1990).