Search for $B^{\pm} \to [K^{\mp}\pi^{\pm}]_D K^{\pm}$ and Upper Limit on the $b \to u$ Amplitude in $B^{\pm} \to DK^{\pm}$

B. Aubert,[1] R. Barate,[1] D. Boutigny,[1] F. Couderc,[1] J.-M. Gaillard,[1] A. Hicheur,[1] Y. Karyotakis,[1] J. P. Lees,[1] V. Tisserand,[1] A. Zghiche,[1] A. Palano,[2] A. Pompili,[2] J. C. Chen,[3] N. D. Qi,[3] G. Rong,[3] P. Wang,[3] Y. S. Zhu,[3] G. Eigen,[4] I. Ofte,[4] B. Stugu,[4] G. S. Abrams,[5] A. W. Borgland,[5] A. B. Breon,[5] D. N. Brown,[5] J. Button-Shafer,[5] R. N. Cahn,[5] E. Charles,[5] C. T. Day,[5] M. S. Gill,[5] A. V. Gritsan,[5] Y. Groysman,[5] R. G. Jacobsen,[5] R. W. Kadel,[5] J. Kadyk,[5] L. T. Kerth,[5] Yu. G. Kolomensky,[5] G. Kukartsev,[5] C. LeClerc,[5] G. Lynch,[5] A. M. Merchant,[5] L. M. Mir,[5] P. J. Oddone,[5] T. J. Orimoto,[5] M. Pripstein,[5] N. A. Roe,[5] M. T. Ronan,[5] V. G. Shelkov,[5] A. V. Telnov,[5] W. A. Wenzel,[5] K. Ford,[6] T. J. Harrison,[6] C. M. Hawkes,[6] S. E. Morgan,[6] A. T. Watson,[6] M. Fritsch,[7] K. Goetzen,[7] T. Held,[7] H. Koch,[7] B. Lewandowski,[7] M. Pelizaeus,[7] M. Steinke,[7] J. T. Boyd,[8] N. Chevalier,[8] W. N. Cottingham,[8] M. P. Kelly,[8] T. E. Latham,[8] F. F. Wilson,[8] T. Cuhadar-Donszelmann,[9] C. Hearty,[9] T. S. Mattison,[9] J. A. McKenna,[9] D. Thiessen,[9] P. Kyberd,[10] L. Teodorescu,[10] V. E. Blinov,[11] A. D. Bukin,[11] V. P. Druzhinin,[11] V. B. Golubev,[11] V. N. Ivanchenko,[11] E. A. Kravchenko,[11] A. P. Onuchin,[11] S. I. Serednyakov,[11] Yu. I. Skovpen,[11] E. P. Solodov,[11] A. N. Yushkov,[11] D. Best,[12] M. Bruinsma,[12] M. Chao,[12] I. Eschrich,[12] D. Kirkby,[12] A. J. Lankford,[12] M. Mandelkern,[12] R. K. Mommsen,[12] W. Roethel,[12] D. P. Stoker,[12] C. Buchanan,[13] B. L. Hartfiel,[13] J. W. Gary,[14] B. C. Shen,[14] K. Wang,[14] D. del Re,[15] H. K. Hadavand,[15] E. J. Hill,[15] D. B. MacFarlane,[15] H. P. Paar,[15] Sh. Rahatlou,[15] V. Sharma,[15] J. W. Berryhill,[16] C. Campagnari,[16] B. Dahmes,[16] S. L. Levy,[16] O. Long,[16] A. Lu,[16] M. A. Mazur,[16] J. D. Richman,[16] W. Verkerke,[16] T. W. Beck,[17] A. M. Eisner,[17] C. A. Heusch,[17] W. S. Lockman,[17] T. Schalk,[17] R. E. Schmitz,[17] B. A. Schumm,[17] A. Seiden,[17] P. Spradlin,[17] D. C. Williams,[17] M. G. Wilson,[17] J. Albert,[18] E. Chen,[18] G. P. Dubois-Felsmann,[18] A. Dvoretskii,[18] D. G. Hitlin,[18] I. Narsky,[18] T. Piatenko,[18] F. C. Porter,[18] A. Ryd,[18] A. Samuel,[18] S. Yang,[18] S. Jayatilleke,[19] G. Mancinelli,[19] B. T. Meadows,[19] M. D. Sokoloff,[19] T. Abe,[20] F. Blanc,[20] P. Bloom,[20] S. Chen,[20] P. J. Clark,[20] W. T. Ford,[20] U. Nauenberg,[20] A. Olivas,[20] P. Rankin,[20] J. G. Smith,[20] L. Zhang,[20] A. Chen,[21] J. L. Harton,[21] A. Soffer,[21] W. H. Toki,[21] R. J. Wilson,[21] Q. L. Zeng,[21] D. Altenburg,[22] T. Brandt,[22] J. Brose,[22] T. Colberg,[22] M. Dickopp,[22] E. Feltresi,[22] A. Hauke,[22] H. M. Lacker,[22] E. Maly,[22] R. Müller-Pfefferkorn,[22] R. Nogowski,[22] S. Otto,[22] A. Petzold,[22] J. Schubert,[22] K. R. Schubert,[22] R. Schwierz,[22] B. Spaan,[22] J. E. Sundermann,[22] D. Bernard,[23] G. R. Bonneaud,[23] F. Brochard,[23] P. Grenier,[23] S. Schrenk,[23] Ch. Thiebaux,[23] G. Vasileiadis,[23] M. Verderi,[23] D. J. Bard,[24] A. Khan,[24] D. Lavin,[24] F. Muheim,[24] S. Playfer,[24] M. Andreotti,[25] V. Azzolini,[25] D. Bettoni,[25] C. Bozzi,[25] R. Calabrese,[25] G. Cibinetto,[25] E. Luppi,[25] M. Negrini,[25] A. Sarti,[25] E. Treadwell,[26] R. Baldini-Ferroli,[27] A. Calcaterra,[27] R. de Sangro,[27] G. Finocchiaro,[27] P. Patteri,[27] M. Piccolo,[27] A. Zallo,[27] A. Buzzo,[28] R. Capra,[28] R. Contri,[28] G. Crosetti,[28] M. Lo Vetere,[28] M. Macri,[28] M. R. Monge,[28] S. Passaggio,[28] C. Patrignani,[28] E. Robutti,[28] A. Santroni,[28] S. Tosi,[28] S. Bailey,[29] G. Brandenburg,[29] M. Morii,[29] E. Won,[29] R. S. Dubitzky,[30] U. Langenegger,[30] W. Bhimji,[31] D. A. Bowerman,[31] P. D. Dauncey,[31] U. Egede,[31] J. R. Gaillard,[31] G. W. Morton,[31] J. A. Nash,[31] G. P. Taylor,[31] G. J. Grenier,[32] U. Mallik,[32] J. Cochran,[33] H. B. Crawley,[33] J. Lamsa,[33] W. T. Meyer,[33] S. Prell,[33] E. I. Rosenberg,[33] J. Yi,[33] M. Davier,[34] G. Grosdidier,[34] A. Höcker,[34] S. Laplace,[34] F. Le Diberder,[34] V. Lepeltier,[34] A. M. Lutz,[34] T. C. Petersen,[34] S. Plaszczynski,[34] M. H. Schune,[34] L. Tantot,[34] G. Wormser,[34] C. H. Cheng,[35] D. J. Lange,[35] M. C. Simani,[35] D. M. Wright,[35] A. J. Bevan,[36] J. P. Coleman,[36] J. R. Fry,[36] E. Gabathuler,[36] R. Gamet,[36] R. J. Parry,[36] D. J. Payne,[36] R. J. Sloane,[36] C. Touramanis,[36] J. J. Back,[37] P. F. Harrison,[37] G. B. Mohanty,[37] C. L. Brown,[38] G. Cowan,[38] R. L. Flack,[38] H. U. Flaecher,[38] M. G. Green,[38] C. E. Marker,[38] T. R. McMahon,[38] S. Ricciardi,[38] F. Salvatore,[38] G. Vaitsas,[38] M. A. Winter,[38] D. Brown,[39] C. L. Davis,[39] J. Allison,[40] N. R. Barlow,[40] R. J. Barlow,[40] P. A. Hart,[40] M. C. Hodgkinson,[40] G. D. Lafferty,[40] A. J. Lyon,[40] J. C. Williams,[40] A. Farbin,[41] W. D. Hulsbergen,[41] A. Jawahery,[41] D. Kovalskyi,[41] C. K. Lae,[41] V. Lillard,[41] D. A. Roberts,[41] G. Blaylock,[42] C. Dallapiccola,[42] K. T. Flood,[42] S. S. Hertzbach,[42] R. Kofler,[42] V. B. Koptchev,[42] T. B. Moore,[42] S. Saremi,[42] H. Staengle,[42] S. Willocq,[42] R. Cowan,[43] G. Sciolla,[43] F. Taylor,[43] R. K. Yamamoto,[43] D. J. J. Mangeol,[44] P. M. Patel,[44] S. H. Robertson,[44] A. Lazzaro,[45] F. Palombo,[45] J. M. Bauer,[46] L. Cremaldi,[46] V. Eschenburg,[46] R. Godang,[46] R. Kroeger,[46] J. Reidy,[46] D. A. Sanders,[46] D. J. Summers,[46] H. W. Zhao,[46] S. Brunet,[47] D. Côté,[47] P. Taras,[47] H. Nicholson,[48] N. Cavallo,[49] F. Fabozzi,[49,*] C. Gatto,[49] L. Lista,[49] D. Monorchio,[49] P. Paolucci,[49] D. Piccolo,[49] C. Sciacca,[49] M. Baak,[50] H. Bulten,[50] G. Raven,[50] L. Wilden,[50] C. P. Jessop,[51] J. M. LoSecco,[51] T. A. Gabriel,[52] T. Allmendinger,[53] B. Brau,[53] K. K. Gan,[53] K. Honscheid,[53] D. Hufnagel,[53] H. Kagan,[53] R. Kass,[53] T. Pulliam,[53] A. M. Rahimi,[53] R. Ter-Antonyan,[53] Q. K. Wong,[53] J. Brau,[54] R. Frey,[54] O. Igonkina,[54] C. T. Potter,[54] N. B. Sinev,[54] D. Strom,[54] E. Torrence,[54] F. Colecchia,[55] A. Dorigo,[55] F. Galeazzi,[55] M. Margoni,[55] M. Morandin,[55] M. Posocco,[55] M. Rotondo,[55] F. Simonetto,[55] R. Stroili,[55] G. Tiozzo,[55]

 0031-9007/04/93(13)/131804(7)$22.50

C. Voci,[55] M. Benayoun,[56] H. Briand,[56] J. Chauveau,[56] P. David,[56] Ch. de la Vaissière,[56] L. Del Buono,[56] O. Hamon,[56] M. J. J. John,[56] Ph. Leruste,[56] J. Ocariz,[56] M. Pivk,[56] L. Roos,[56] S. T'Jampens,[56] G. Therin,[56] P. F. Manfredi,[57] V. Re,[57] P. K. Behera,[58] L. Gladney,[58] Q. H. Guo,[58] J. Panetta,[58] F. Anulli,[27,59] M. Biasini,[59] I. M. Peruzzi,[27,59] M. Pioppi,[59] C. Angelini,[60] G. Batignani,[60] S. Bettarini,[60] M. Bondioli,[60] F. Bucci,[60] G. Calderini,[60] M. Carpinelli,[60] V. Del Gamba,[60] F. Forti,[60] M. A. Giorgi,[60] A. Lusiani,[60] G. Marchiori,[60] F. Martinez-Vidal,[60,†] M. Morganti,[60] N. Neri,[60] E. Paoloni,[60] M. Rama,[60] G. Rizzo,[60] F. Sandrelli,[60] J. Walsh,[60] M. Haire,[61] D. Judd,[61] K. Paick,[61] D. E. Wagoner,[61] N. Danielson,[62] P. Elmer,[62] C. Lu,[62] V. Miftakov,[62] J. Olsen,[62] A. J. S. Smith,[62] F. Bellini,[63] G. Cavoto,[62,63] R. Faccini,[63] F. Ferrarotto,[63] F. Ferroni,[63] M. Gaspero,[63] L. Li Gioi,[63] M. A. Mazzoni,[63] S. Morganti,[63] M. Pierini,[63] G. Piredda,[63] F. Safai Tehrani,[63] C. Voena,[63] S. Christ,[64] G. Wagner,[64] R. Waldi,[64] T. Adye,[65] N. De Groot,[65] B. Franek,[65] N. I. Geddes,[65] G. P. Gopal,[65] E. O. Olaiya,[65] R. Aleksan,[66] S. Emery,[66] A. Gaidot,[66] S. F. Ganzhur,[66] P.-F. Giraud,[66] G. Hamel de Monchenault,[66] W. Kozanecki,[66] M. Langer,[66] M. Legendre,[66] G. W. London,[66] B. Mayer,[66] G. Schott,[66] G. Vasseur,[66] Ch. Yèche,[66] M. Zito,[66] M. V. Purohit,[67] A. W. Weidemann,[67] F. X. Yumiceva,[67] D. Aston,[68] R. Bartoldus,[68] N. Berger,[68] A. M. Boyarski,[68] O. L. Buchmueller,[68] M. R. Convery,[68] M. Cristinziani,[68] G. De Nardo,[68] D. Dong,[68] J. Dorfan,[68] D. Dujmic,[68] W. Dunwoodie,[68] E. E. Elsen,[68] S. Fan,[68] R. C. Field,[68] T. Glanzman,[68] S. J. Gowdy,[68] T. Hadig,[68] V. Halyo,[68] T. Hryn'ova,[68] W. R. Innes,[68] M. H. Kelsey,[68] P. Kim,[68] M. L. Kocian,[68] D. W. G. S. Leith,[68] J. Libby,[68] S. Luitz,[68] V. Luth,[68] H. L. Lynch,[68] H. Marsiske,[68] R. Messner,[68] D. R. Muller,[68] C. P. O'Grady,[68] V. E. Ozcan,[68] A. Perazzo,[68] M. Perl,[68] S. Petrak,[68] B. N. Ratcliff,[68] A. Roodman,[68] A. A. Salnikov,[68] R. H. Schindler,[68] J. Schwiening,[68] G. Simi,[68] A. Snyder,[68] A. Soha,[68] J. Stelzer,[68] D. Su,[68] M. K. Sullivan,[68] J. Va'vra,[68] S. R. Wagner,[68] M. Weaver,[68] A. J. R. Weinstein,[68] W. J. Wisniewski,[68] M. Wittgen,[68] D. H. Wright,[68] A. K. Yarritu,[68] C. C. Young,[68] P. R. Burchat,[69] A. J. Edwards,[69] T. I. Meyer,[69] B. A. Petersen,[69] C. Roat,[69] S. Ahmed,[70] M. S. Alam,[70] J. A. Ernst,[70] M. A. Saeed,[70] M. Saleem,[70] F. R. Wappler,[70] W. Bugg,[71] M. Krishnamurthy,[71] S. M. Spanier,[71] R. Eckmann,[72] H. Kim,[72] J. L. Ritchie,[72] A. Satpathy,[72] R. F. Schwitters,[72] J. M. Izen,[73] I. Kitayama,[73] X. C. Lou,[73] S. Ye,[73] F. Bianchi,[74] M. Bona,[74] F. Gallo,[74] D. Gamba,[74] C. Borean,[75] L. Bosisio,[75] C. Cartaro,[75] F. Cossutti,[75] G. Della Ricca,[75] S. Dittongo,[75] S. Grancagnolo,[75] L. Lanceri,[75] P. Poropat,[75,‡] L. Vitale,[75] G. Vuagnin,[75] R. S. Panvini,[76] Sw. Banerjee,[77] C. M. Brown,[77] D. Fortin,[77] P. D. Jackson,[77] R. Kowalewski,[77] J. M. Roney,[77] H. R. Band,[78] S. Dasu,[78] M. Datta,[78] A. M. Eichenbaum,[78] J. J. Hollar,[78] J. R. Johnson,[78] P. E. Kutter,[78] H. Li,[78] R. Liu,[78] F. Di Lodovico,[78] A. Mihalyi,[78] A. K. Mohapatra,[78] Y. Pan,[78] R. Prepost,[78] S. J. Sekula,[78] P. Tan,[78] J. H. von Wimmersperg-Toeller,[78] J. Wu,[78] S. L. Wu,[78] Z. Yu,[78] and H. Neal[79]

(*BABAR* Collaboration)

[1]*Laboratoire de Physique des Particules, F-74941 Annecy-le-Vieux, France*
[2]*Università di Bari, Dipartimento di Fisica and INFN, I-70126 Bari, Italy*
[3]*Institute of High Energy Physics, Beijing 100039, China*
[4]*University of Bergen, Institute of Physics, N-5007 Bergen, Norway*
[5]*Lawrence Berkeley National Laboratory and University of California, Berkeley, California 94720, USA*
[6]*University of Birmingham, Birmingham, B15 2TT, United Kingdom*
[7]*Ruhr Universität Bochum, Institut für Experimentalphysik 1, D-44780 Bochum, Germany*
[8]*University of Bristol, Bristol BS8 1TL, United Kingdom*
[9]*University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z1*
[10]*Brunel University, Uxbridge, Middlesex UB8 3PH, United Kingdom*
[11]*Budker Institute of Nuclear Physics, Novosibirsk 630090, Russia*
[12]*University of California at Irvine, Irvine, California 92697, USA*
[13]*University of California at Los Angeles, Los Angeles, California 90024, USA*
[14]*University of California at Riverside, Riverside, California 92521, USA*
[15]*University of California at San Diego, La Jolla, California 92093, USA*
[16]*University of California at Santa Barbara, Santa Barbara, California 93106, USA*
[17]*University of California at Santa Cruz, Institute for Particle Physics, Santa Cruz, California 95064, USA*
[18]*California Institute of Technology, Pasadena, California 91125, USA*
[19]*University of Cincinnati, Cincinnati, Ohio 45221, USA*
[20]*University of Colorado, Boulder, Colorado 80309, USA*
[21]*Colorado State University, Fort Collins, Colorado 80523, USA*
[22]*Technische Universität Dresden, Institut für Kern- und Teilchenphysik, D-01062 Dresden, Germany*
[23]*Ecole Polytechnique, LLR, F-91128 Palaiseau, France*
[24]*University of Edinburgh, Edinburgh EH9 3JZ, United Kingdom*
[25]*Università di Ferrara, Dipartimento di Fisica and INFN, I-44100 Ferrara, Italy*

[26]Florida A&M University, Tallahassee, Florida 32307, USA
[27]Laboratori Nazionali di Frascati dell'INFN, I-00044 Frascati, Italy
[28]Università di Genova, Dipartimento di Fisica and INFN, I-16146 Genova, Italy
[29]Harvard University, Cambridge, Massachusetts 02138, USA
[30]Universität Heidelberg, Physikalisches Institut, Philosophenweg 12, D-69120 Heidelberg, Germany
[31]Imperial College London, London, SW7 2AZ, United Kingdom
[32]University of Iowa, Iowa City, Iowa 52242, USA
[33]Iowa State University, Ames, Iowa 50011-3160, USA
[34]Laboratoire de l'Accélérateur Linéaire, F-91898 Orsay, France
[35]Lawrence Livermore National Laboratory, Livermore, California 94550, USA
[36]University of Liverpool, Liverpool L69 72E, United Kingdom
[37]Queen Mary, University of London, E1 4NS, United Kingdom
[38]University of London, Royal Holloway and Bedford New College, Egham, Surrey TW20 0EX, United Kingdom
[39]University of Louisville, Louisville, Kentucky 40292, USA
[40]University of Manchester, Manchester M13 9PL, United Kingdom
[41]University of Maryland, College Park, Maryland 20742, USA
[42]University of Massachusetts, Amherst, Massachusetts 01003, USA
[43]Massachusetts Institute of Technology, Laboratory for Nuclear Science, Cambridge, Massachusetts 02139, USA
[44]McGill University, Montréal, Quebec, Canada H3A 2T8
[45]Università di Milano, Dipartimento di Fisica and INFN, I-20133 Milano, Italy
[46]University of Mississippi, University, Mississippi 38677, USA
[47]Université de Montréal, Laboratoire René J. A. Lévesque, Montréal, Quebec, Canada H3C 3J7
[48]Mount Holyoke College, South Hadley, Massachusetts 01075, USA
[49]Università di Napoli Federico II, Dipartimento di Scienze Fisiche and INFN, I-80126, Napoli, Italy
[50]NIKHEF, National Institute for Nuclear Physics and High Energy Physics, NL-1009 DB Amsterdam, The Netherlands
[51]University of Notre Dame, Notre Dame, Indiana 46556, USA
[52]Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, USA
[53]The Ohio State University, Columbus, Ohio 43210, USA
[54]University of Oregon, Eugene, Oregon 97403, USA
[55]Università di Padova, Dipartimento di Fisica and INFN, I-35131 Padova, Italy
[56]Universités Paris VI et VII, Lab de Physique Nucléaire H. E., F-75252 Paris, France
[57]Università di Pavia, Dipartimento di Elettronica and INFN, I-27100 Pavia, Italy
[58]University of Pennsylvania, Philadelphia, Pennsylvania 19104, USA
[59]Università di Perugia, Dipartimento di Fisica and INFN, I-06100 Perugia, Italy
[60]Università di Pisa, Dipartimento di Fisica, Scuola Normale Superiore and INFN, I-56127 Pisa, Italy
[61]Prairie View A&M University, Prairie View, Texas 77446, USA
[62]Princeton University, Princeton, New Jersey 08544, USA
[63]Università di Roma La Sapienza, Dipartimento di Fisica and INFN, I-00185 Roma, Italy
[64]Universität Rostock, D-18051 Rostock, Germany
[65]Rutherford Appleton Laboratory, Chilton, Didcot, Oxon, OX11 0QX, United Kingdom
[66]DSM/Dapnia, CEA/Saclay, F-91191 Gif-sur-Yvette, France
[67]University of South Carolina, Columbia, South Carolina 29208, USA
[68]Stanford Linear Accelerator Center, Stanford, California 94309, USA
[69]Stanford University, Stanford, California 94305-4060, USA
[70]State University of New York, Albany, New York 12222, USA
[71]University of Tennessee, Knoxville, Tennessee 37996, USA
[72]University of Texas at Austin, Austin, Texas 78712, USA
[73]University of Texas at Dallas, Richardson, Texas 75083, USA
[74]Università di Torino, Dipartimento di Fisica Sperimentale and INFN, I-10125 Torino, Italy
[75]Università di Trieste, Dipartimento di Fisica and INFN, I-34127 Trieste, Italy
[76]Vanderbilt University, Nashville, Tennessee 37235, USA
[77]University of Victoria, Victoria, British Columbia, Canada V8W 3P6
[78]University of Wisconsin, Madison, Wisconsin 53706, USA
[79]Yale University, New Haven, Connecticut 06511, USA

(Received 12 February 2004; published 23 September 2004)

We search for $B^{\pm} \to [K^{\mp}\pi^{\pm}]_D K^{\pm}$ decays, where $[K^{\mp}\pi^{\pm}]_D$ indicates that the $K^{\mp}\pi^{\pm}$ pair originates from the decay of a D^0 or $\overline{D}^0$. Results are based on 120×10^6 $\Upsilon(4S) \to B\overline{B}$ decays collected with the *BABAR* detector at SLAC. We set an upper limit on the ratio $\mathcal{R}_{K\pi} \equiv \frac{[\Gamma(B^+ \to [K^-\pi^+]_D K^+) + \Gamma(B^- \to [K^+\pi^-]_D K^-)]}{[\Gamma(B^+ \to [K^+\pi^-]_D K^+) + \Gamma(B^- \to [K^-\pi^+]_D K^-)]} < 0.026$ (90% C.L.). This constrains the amplitude ratio $r_B \equiv |A(B^- \to \overline{D}^0 K^-)/A(B^- \to D^0 K^-)| < 0.22$ (90% C.L.), consistent with expectations. The small value of r_B favored by our analysis suggests that the determination of the Cabibbo-Kobayashi-Maskawa phase γ from $B \to DK$ will be difficult.

DOI: 10.1103/PhysRevLett.93.131804 PACS numbers: 13.25.Hw, 12.15.Hh

Following the discovery of CP violation in B-meson decays and the measurement of the angle β of the unitarity triangle [1] associated with the Cabibbo-Kobayashi-Maskawa (CKM) quark mixing matrix, focus has turned towards the measurements of the other angles α and γ. The angle γ is $\arg(-V_{ub}^* V_{ud}/V_{cb}^* V_{cd})$, where V_{ij} are CKM matrix elements; in the Wolfenstein convention [2], $\gamma = \arg(V_{ub}^*)$.

Several proposed methods for measuring γ exploit the interference between $B^- \to D^0 K^-$ and $B^- \to \overline{D}^0 K^-$ (Fig. 1) which occurs when the D^0 and the $\overline{D}^0$ decay to common final states, as first suggested in Ref. [3].

Following the proposal in Ref. [4], we search for $B^- \to \tilde{D}^0 K^-$ followed by $\tilde{D}^0 \to K^+\pi^-\rho$, as well as the charge conjugate sequence, where the symbol $\tilde{D}^0$ indicates either a D^0 or a $\overline{D}^0$. Here the favored B decay followed by the doubly CKM-suppressed D decay interferes with the suppressed B decay followed by the CKM-favored D decay. We use the notation $B^- \to [h_1^+ h_2^-]_D h_3^-$ (with each $h_i = \pi$ or K) for the decay chain $B^- \to \tilde{D}^0 h_3^-$, $\tilde{D}^0 \to h_1^+ h_2^-$. We also refer to h_3 as the bachelor π or K. Then, ignoring D mixing,

$$\mathcal{R}^{\pm}_{K\pi} \equiv \frac{\Gamma([K^{\mp}\pi^{\pm}]_D K^{\pm})}{\Gamma([K^{\pm}\pi^{\mp}]_D K^{\pm})} = r_B^2 + r_D^2 + 2 r_B r_D \cos(\pm\gamma + \delta),$$

where

$$r_B \equiv \left| \frac{A(B^- \to \overline{D}^0 K^-)}{A(B^- \to D^0 K^-)} \right|, \qquad \delta \equiv \delta_B + \delta_D,$$

$$r_D \equiv \left| \frac{A(D^0 \to K^+\pi^-)}{A(D^0 \to K^-\pi^+)} \right| = 0.060 \pm 0.003$$

[5], and δ_B and δ_D are strong phase differences between the two B and D decay amplitudes, respectively. The expression for $\mathcal{R}^{\pm}_{K\pi}$ neglects the tiny contribution to the $[K^{\pm}\pi^{\mp}]_D K^{\pm}$ mode from the color-suppressed B decay followed by the doubly CKM-suppressed D decay.

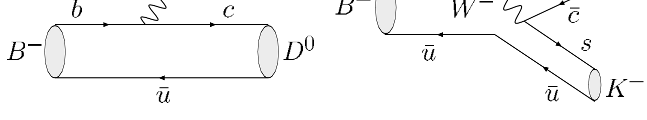

FIG. 1. Feynman diagrams for $B^- \to D^0 K^-$ and $\overline{D}^0 K^-$. The latter is CKM and color suppressed with respect to the former.

Since r_B is expected to be of the same order as r_D, CP violation could manifest itself as a large difference between $\mathcal{R}^{+}_{K\pi}$ and $\mathcal{R}^{-}_{K\pi}$. Measurements of $\mathcal{R}^{\pm}_{K\pi}$ are not sufficient to extract γ, since these two quantities are functions of three unknowns: γ, r_B, and δ. However, they can be combined with measurements for other $\tilde{D}^0$ modes to extract γ in a theoretically clean way [4].

The value of r_B determines, in part, the level of interference between the diagrams of Fig. 1. In most techniques for measuring γ, high values of r_B lead to better sensitivity. Since $\mathcal{R}^{\pm}_{K\pi}$ depend quadratically on r_B, measurements of $\mathcal{R}^{\pm}_{K\pi}$ can constrain r_B. In the standard model, $r_B = |V_{ub}V_{cs}^*/V_{cb}V_{us}^*| F_{cs} \approx 0.4 F_{cs}$, and $F_{cs} < 1$ accounts for the additional suppression, beyond that due to CKM factors, of $B^- \to \overline{D}^0 K^-$ relative to $B^- \to D^0 K^-$. Naively, $F_{cs} = \frac{1}{3}$, which is the probability for the color of the quarks from the virtual W in $B^- \to \overline{D}^0 K^-$ to match that of the other two quarks; see Fig. 1. Early estimates gave $F_{cs} \approx 0.22$ [6], leading to $r_B \approx 0.09$; however, recent measurements [7] of color-suppressed $b \to c$ decays [$B \to D^{(*)} h^0$; $h^0 = \pi^0, \rho^0, \omega, \eta, \eta'$] suggest that F_{cs}, and therefore r_B, could be larger, e.g., $r_B \approx 0.2$ [8]. A study by the Belle Collaboration of $B^{\pm} \to \tilde{D}^0 K^{\pm}$, $\tilde{D}^0 \to K_S \pi^+\pi^-$, favors a large value of r_B: $r_B = 0.26^{+0.11}_{-0.15}$ [9].

Our results are based on 120×10^6 $\Upsilon(4S) \to B\overline{B}$ decays, corresponding to an integrated luminosity of 109 fb^{-1}, collected between 1999 and 2003 with the *BABAR* detector [10] at the PEP-II B Factory at SLAC. A 12 fb^{-1} off-resonance data sample, with a c.m. energy 40 MeV below the $\Upsilon(4S)$ resonance, is used to study continuum events, $e^+e^- \to q\bar{q}$ ($q = u, d, s$, or c).

The event selection was developed from studies of simulated $B\overline{B}$ and continuum events, and off-resonance data. A large on-resonance data sample of $B^- \to D^0\pi^-$, $D^0 \to K^-\pi^+$ events was used to validate several aspects of the simulation and analysis procedure. We refer to this mode and its charge conjugate as $B \to D\pi$.

Kaon and pion candidates in $B^{\pm} \to [K\pi]_D K^{\pm}$ must satisfy K or π identification criteria that are typically 90% efficient, depending on momentum and polar angle. Misidentification rates are at the few percent level. The invariant mass of the $K\pi$ pair must be within 18.8 MeV (2.5σ) of the mean reconstructed D^0 mass. The remaining background from other $B^{\pm} \to [h_1 h_2]_D h_3^{\pm}$ modes is eliminated by removing events where any $h_i^+ h_j^-$ pair, with any particle-type assignment except for the signal hypothesis for the $h_1 h_2$ pair, is consistent with $\tilde{D}^0$ decay. We also reject B candidates where the $\tilde{D}^0$ paired with a π^0 or $\pi^{\pm}$ in the event is consistent with $D^* \to D\pi$ decay.

After these requirements, backgrounds are mostly from continuum, mainly $e^+e^- \to c\bar{c}$, with $\bar{c} \to \overline{D}^0 \to K^+\pi^-$ and $c \to D \to K^-$. These are reduced with a neural network based on nine quantities that distinguish continuum and $B\overline{B}$ events: (i) A Fisher discriminant based on the quantities $L_0 = \sum_i p_i$ and $L_2 = \sum_i p_i \cos^2\theta_i$ calculated in the c.m. frame. Here, p_i is the momentum and θ_i is the angle with respect to the thrust axis of the B candidate of tracks and clusters not used to reconstruct the B. (ii) $|\cos\theta_T|$, where θ_T is the angle in the c.m. frame between the thrust axes of the B and the detected remainder of the event. (iii) $\cos\theta_B$, where θ_B is the polar angle of the B in the c.m. frame. (iv) $\cos\theta_D^K$ where θ_D^K is the decay angle in $\tilde{D}^0 \to K\pi$, i.e., the angle between the direction of the K and the line of flight of the $\tilde{D}^0$ in the $\tilde{D}^0$ rest frame. (v) $\cos\theta_B^D$, where θ_B^D is the decay angle in $B \to \tilde{D}^0 K$. (vi) The difference ΔQ between the sum of the charges of tracks in the $\tilde{D}^0$ hemisphere and the sum of the charges of the tracks in the opposite hemisphere excluding the tracks used in the reconstructed B. For signal, $\langle \Delta Q \rangle = 0$, while for the $c\bar{c}$ background $\langle \Delta Q \rangle \approx \frac{7}{3} \times Q_B$, where Q_B is the B candidate charge. The ΔQ rms is 2.4. (vii) $Q_B \cdot Q_K$, where Q_K is the sum of the charges of all kaons not in the reconstructed B. Many signal events have $Q_B \cdot Q_K \leq -1$, while most continuum events have no kaons outside of the reconstructed B, and hence $Q_K = 0$. (viii) The distance of the closest approach between the bachelor track and the trajectory of the $\tilde{D}^0$. This is consistent with zero for signal events, but can be larger in $c\bar{c}$ events. (ix) The existence of a lepton (e or μ) and the invariant mass ($m_{K\ell}$) of the lepton and the bachelor K. Continuum events have fewer leptons than signal events. Moreover, most leptons in $c\bar{c}$ events are from $D \to K\ell\nu$, where K is the bachelor kaon, so that $m_{K\ell} < m_D$.

The neural net is trained with simulated continuum and signal events. We find agreement between the distributions of all nine variables in simulation and in control samples of off-resonance data and of $B \to D\pi$. The neural net requirement is 66% efficient for signal, and rejects 96% of the continuum background. An additional requirement, $\cos\theta_D^K > -0.75$, rejects 50% of the remaining $B\overline{B}$ backgrounds and is 93% efficient for signal.

A B candidate is characterized by the energy-substituted mass $m_{\rm ES} \equiv \sqrt{(\frac{s}{2} + \vec{p}_0 \cdot \vec{p}_B)^2/E_0^2 - p_B^2}$ and the energy difference $\Delta E \equiv E_B^* - \frac{1}{2}\sqrt{s}$, where E and p are energy and momentum, the asterisk denotes the c.m. frame, the subscripts 0 and B refer to the $\Upsilon(4S)$ and B candidates, respectively, and s is the square of the c.m. energy. For signal events $m_{\rm ES} = m_B$ within the resolution of about 2.5 MeV, where m_B is the known B mass.

We require ΔE to be within 47.8 MeV (2.5σ) of the mean value of -4.1 MeV found in the $B \to D\pi$ control sample. The yield of signal events is extracted from a fit to the $m_{\rm ES}$ distribution of events satisfying all of the requirements discussed above.

Our selection includes contributions from backgrounds with $m_{\rm ES}$ distributions peaked near m_B (peaking backgrounds). We distinguish those with a real $\tilde{D}^0 \to K^\mp\pi^\pm$ and those without, e.g., $B^- \to h^+h^-h^-$. The latter are estimated from events with $K^\mp\pi^\pm$ mass in a sideband of the $\tilde{D}^0$. The former are from $B^- \to D^0\pi^-$, followed by the CKM-suppressed decay $D^0 \to K^+\pi^-$, with the bachelor π misidentified as a K. These are estimated as $N_{\rm peak}^D = r_D^2 N_{D\pi}$, where $N_{D\pi}$ is the number of observed $B \to D\pi$ events with the π misidentified as a K. The technique used to measure $N_{D\pi}$ is described below. Studies of simulated $B\overline{B}$ events indicate that other peaking background contributions are negligible.

Because of the small number of events, we combine the B^+ and B^- samples. We define the quantity

$$\mathcal{R}_{K\pi} \equiv \frac{\Gamma(B^- \to [K^+\pi^-]_D K^-) + \Gamma(B^+ \to [K^-\pi^+]_D K^+)}{\Gamma(B^- \to [K^-\pi^+]_D K^-) + \Gamma(B^+ \to [K^+\pi^-]_D K^+)},$$

$$\mathcal{R}_{K\pi} = \frac{\mathcal{R}_{K\pi}^+ + \mathcal{R}_{K\pi}^-}{2} = r_B^2 + r_D^2 + 2r_B r_D \cos\gamma \cos\delta,$$

assuming no CP violation in $[K^\mp\pi^\pm]_D K^\mp$.

We determine $\mathcal{R}_{K\pi} = cN_{\rm sig}/N_{DK}$, where $N_{\rm sig}$ is the number of $B^\pm \to [K^\mp\pi^\pm]_D K^\pm$ signal events and N_{DK} is the number of $B^\pm \to [K^\pm\pi^\mp]_D K^\pm$ events, a mode that we denote by $B \to DK$. Most systematic uncertainties cancel in the ratio. The factor $c = 0.93 \pm 0.04$, determined from simulation, accounts for a difference in the event selection efficiency between the signal mode and $B \to DK$. This difference is mostly due to a correlation between the efficiencies of the $\cos\theta_D^K$ requirement and the $\tilde{D}^0$ veto constructed using the bachelor track and the oppositely charged track in the $[K\pi]$ pair. This correlation depends on the relative sign of the kaon and the bachelor track, and is different in the two modes.

The value of $\mathcal{R}_{K\pi}$ is obtained from a simultaneous unbinned maximum likelihood fit to four $m_{\rm ES}$ and three ΔE distributions. These distributions are used to extract the parameters needed to calculate $\mathcal{R}_{K\pi}$ (e.g., $N_{\rm sig}$) or to constrain the shapes of other distributions. The likelihood is expressed directly in terms of $\mathcal{R}_{K\pi}$.

The $m_{\rm ES}$ distribution for signal candidates is fit to the sum of a threshold background function and a Gaussian centered at m_B. The number of events in the Gaussian is $N_{\rm sig} + N_{\rm peak}^D + N_{\rm peak}^{hhh}$, where $N_{\rm peak}^D$ and $N_{\rm peak}^{hhh}$ are the number of peaking background events with and without a real $\tilde{D}^0$, respectively. The Gaussian parameters are constrained by the fit to the $m_{\rm ES}$ distribution of $B \to DK$ events. The shape of the threshold function is constrained by fitting the $m_{\rm ES}$ distribution of candidates in a sideband of ΔE ($-125 < \Delta E < 200$ MeV, excluding the signal region). The $m_{\rm ES}$ distribution for events passing all signal requirements, but with $K^\mp\pi^\pm$ mass in the sideband of the $\tilde{D}^0$ is fit in the same manner. We estimate $N_{\rm peak}^{hhh}$ from the Gaussian yield of this last fit, accounting for the different sizes of the signal and sideband $\tilde{D}^0$ mass ranges. The $m_{\rm ES}$

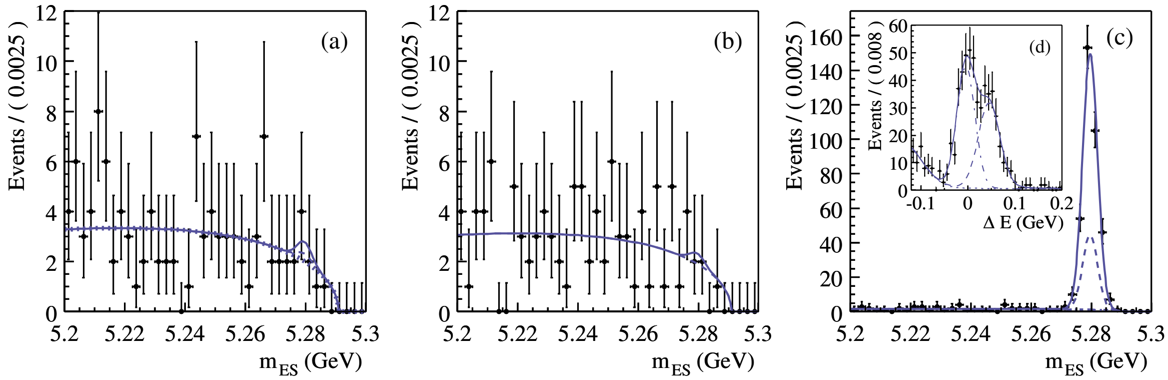

FIG. 2 (color online). m_{ES} distributions for (a) signal ($[K^{\mp}\pi^{\pm}]_D K^{\pm}$) candidates, (b) candidates from the $\tilde{D}^0$ sideband, and (c) $B \to DK$ candidates. The $\tilde{D}^0$ sideband selection uses a $K^{\mp}\pi^{\pm}$ invariant mass range 2.72 times larger than the signal selection. (d) ΔE distribution for $B \to DK$ candidates; the peak centered at ≈ 0.05 GeV is from $B \to D\pi$. The superimposed curves are described in the text. In (c), the dashed Gaussian centered at m_B represents the $B \to D\pi$ contribution estimated from (d).

distributions for signal and $\tilde{D}^0$ sideband candidates are shown in Figs. 2(a) and 2(b).

The m_{ES} distribution for $B \to DK$ candidates with $|\Delta E + 4.1\text{ MeV}| < 47.8$ MeV [see Fig. 2(c)] is also fit to a Gaussian and a threshold function. The number of events in the Gaussian is $N_{DK} + N_{D\pi}$, where, as previously defined, N_{DK} is the number of $B \to DK$ events and $N_{D\pi}$ is the number of $B \to D\pi$ events with the bachelor π misidentified as a K. The ratio $N_{DK}/N_{D\pi}$ is obtained by fitting the ΔE distribution for $B \to DK$ candidate events with $m_{ES} > 5.27$ GeV [see Fig. 2(d)]. This is modeled as the sum of a combinatoric background function, a double Gaussian for the $B \to D\pi$ background, and a Gaussian for the $B \to DK$ signal. The parameters of the Gaussians in the ΔE fit are constrained from fits to the ΔE distributions of well-identified $B \to D\pi$ events with the bachelor π assumed to be a π or a K.

We find $\mathcal{R}_{K\pi} = (4 \pm 12) \times 10^{-3}$, consistent with zero. The number of signal, normalization, and peaking background events are $N_{\rm sig} = 1.1 \pm 3.0$, $N_{DK} = 261 \pm 22$, $N^D_{\rm peak} = r_D^2 N_{D\pi} = 0.38 \pm 0.07$, and $N^{hhh}_{\rm peak} = 0.4 \pm 1.1$. The uncertainties are mostly statistical. From this likelihood, we set a Bayesian limit $\mathcal{R}_{K\pi} < 0.026$ at the 90% confidence level (C.L.), assuming a constant prior probability for $\mathcal{R}_{K\pi} > 0$ (see Fig. 3).

In Fig. 4 we show the dependence of $\mathcal{R}_{K\pi}$ on r_B, together with our limit. This is shown allowing a $\pm 1\sigma$ variation on r_D, for the full range 0°–180° for γ and δ, as well as with the restriction $48° < \gamma < 73°$ suggested by global CKM fits [11]. The least restrictive limit on r_B is computed assuming maximal destructive interference: $\gamma = 0°, \delta = 180°$ or $\gamma = 180°, \delta = 0°$. This limit is $r_B < 0.22$ at 90% C.L.

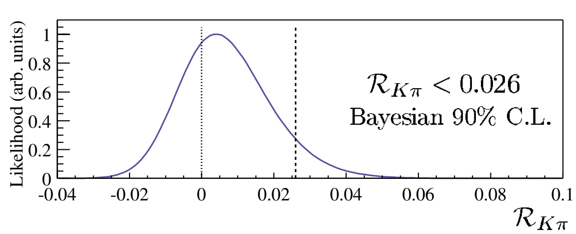

FIG. 3 (color online). Likelihood as a function of $\mathcal{R}_{K\pi}$. The integral for $0 < \mathcal{R}_{K\pi} < 0.026$ is 90% of the integral for $\mathcal{R}_{K\pi} > 0$.

In summary, we find no evidence for $B^{\pm} \to [K^{\mp}\pi^{\pm}]_D K^{\pm}$. We set a 90% C.L. limit on the ratio $\mathcal{R}_{K\pi}$ of rates for this mode and the favored mode $B^{\pm} \to [K^{\pm}\pi^{\mp}]_D K^{\pm}$. Our limit is $\mathcal{R}_{K\pi} < 0.026$ at 90% C.L. With the most conservative assumption on the values of γ and of the strong phases in the B and D decays, this results in a limit on the ratio of the magnitudes of the $B^- \to \overline{D}^0 K^-$ and $B^- \to D^0 K^-$ amplitudes $r_B < 0.22$ at 90% C.L. Our analysis suggests that r_B is smaller than the value reported by the Belle Collaboration, $r_B = 0.26^{+0.11}_{-0.15}$ [9], but given the uncertainties the two results are not in disagreement. A small value of r_B will make it diffi-

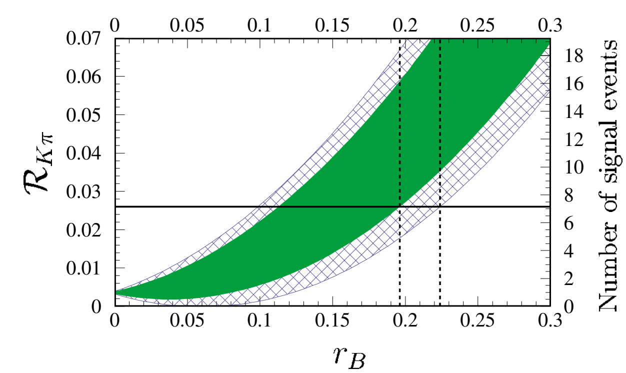

FIG. 4 (color online). Expectations for $\mathcal{R}_{K\pi}$ and $N_{\rm sig}$ vs r_B. Shaded area: allowed region for any value of δ, with a $\pm 1\sigma$ variation on r_D, and $48° < \gamma < 73°$. Hatched area: additional allowed region with no constraint on γ. The horizontal line represents the 90% C.L. limit $\mathcal{R}_{K\pi} < 0.026$. The dashed lines are drawn at $r_B = 0.196$ and $r_B = 0.224$. They represent the 90% C.L. upper limits on r_B with and without the constraint on γ.

cult to measure γ with other methods [3,12] based on $B \to \tilde{D}K$.

We are grateful for the excellent luminosity and machine conditions provided by our PEP-II colleagues, and for the substantial dedicated effort from the computing organizations that support *BABAR*. The collaborating institutions thank SLAC for its support and kind hospitality. This work is supported by DOE and NSF (USA), NSERC (Canada), IHEP (China), CEA and CNRS-IN2P3 (France), BMBF and DFG (Germany), INFN (Italy), FOM (The Netherlands), NFR (Norway), MIST (Russia), and PPARC (United Kingdom). Individuals have received support from the A. P. Sloan Foundation, Research Corporation, and Alexander von Humboldt Foundation.

*Also with Università della Basilicata, Potenza, Italy.
†Also with IFIC, Instituto de Física Corpuscular, CSIC-Universidad de Valencia, Valencia, Spain.
‡Deceased.

[1] *BABAR* Collaboration, B. Aubert *et al.*, Phys. Rev. Lett. **89**, 201802 (2002); Belle Collaboration, K. Abe *et al.*, Phys. Rev. D **66**, 071102 (2002).
[2] L. Wolfenstein, Phys. Rev. Lett. **51**, 1945 (1983).
[3] M. Gronau and D. Wyler, Phys. Lett. B **265**, 172 (1991); M. Gronau and D. London, Phys. Lett. B **253**, 483 (1991).
[4] D. Atwood, I. Dunietz, and A. Soni, Phys. Rev. Lett. **78**, 3257 (1997); Phys. Rev. D **63**, 036005 (2001).
[5] *BABAR* Collaboration, B. Aubert *et al.*, Phys. Rev. Lett. **91**, 171801 (2003).
[6] See, for example, M. Neubert and B. Stech, in *Heavy Flavors, 2nd Edition*, edited by A. J. Buras and M. Lindner (World Scientific, Singapore, 1997).
[7] CLEO Collaboration, T. E. Coan *et al.*, Phys. Rev. Lett. **88**, 062001 (2001); Belle Collaboration, K. Abe *et al.*, Phys. Rev. Lett. **88**, 052002 (2002); A. Satpathy *et al.*, Phys. Lett. B **553**, 159 (2003); *BABAR* Collaboration, B. Aubert *et al.*, Phys. Rev. D **69**, 032004 (2004).
[8] M. Gronau, Phys. Lett. B **557**, 198 (2003).
[9] Belle Collaboration, K. Abe *et al.*, hep-ex/0406067.
[10] *BABAR* Collaboration, B. Aubert *et al.*, Nucl. Instrum. Methods Phys. Res., Sect. A **479**, 1 (2002).
[11] A. Höcker, H. Lacker, S. Laplace, and F. Le Diberder, Eur. Phys. J. C **21**, 225 (2001); updated results can be found in http://ckmfitter.in2p3.fr.
[12] A. Giri, Yu. Grossman, A. Soffer, and J. Zupan, Phys. Rev. D **68**, 054018 (2003); Yu. Grossman, Z. Ligeti, and A. Soffer, Phys. Rev. D **67**, 071301 (2003).