UC Berkeley

UC Berkeley Previously Published Works

Title

Measurement of CP observables for the decays B±→DCP0K*±

Permalink

https://escholarship.org/uc/item/2jc831p0

Journal

Physical Review D, 72(7)

ISSN

2470-0010

Authors

Aubert, B
Barate, R
Boutigny, D
et al.

Publication Date

2005-10-01

DOI

10.1103/physrevd.72.071103

Copyright Information

This work is made available under the terms of a Creative Commons Attribution License, availalbe at https://creativecommons.org/licenses/by/4.0/

Peer reviewed

eScholarship.org Powered by the California Digital Library
University of California

PHYSICAL REVIEW D **72,** 071103(R) (2005)

Measurement of CP observables for the decays $B^{\pm} \to D^0_{CP} K^{*\pm}$

B. Aubert,[1] R. Barate,[1] D. Boutigny,[1] F. Couderc,[1] Y. Karyotakis,[1] J. P. Lees,[1] V. Poireau,[1] V. Tisserand,[1] A. Zghiche,[1] E. Grauges,[2] A. Palano,[3] M. Pappagallo,[3] A. Pompili,[3] J. C. Chen,[4] N. D. Qi,[4] G. Rong,[4] P. Wang,[4] Y. S. Zhu,[4] G. Eigen,[5] I. Ofte,[5] B. Stugu,[5] G. S. Abrams,[6] M. Battaglia,[6] A. B. Breon,[6] D. N. Brown,[6] J. Button-Shafer,[6] R. N. Cahn,[6] E. Charles,[6] C. T. Day,[6] M. S. Gill,[6] A. V. Gritsan,[6] Y. Groysman,[6] R. G. Jacobsen,[6] R. W. Kadel,[6] J. Kadyk,[6] L. T. Kerth,[6] Yu. G. Kolomensky,[6] G. Kukartsev,[6] G. Lynch,[6] L. M. Mir,[6] P. J. Oddone,[6] T. J. Orimoto,[6] M. Pripstein,[6] N. A. Roe,[6] M. T. Ronan,[6] W. A. Wenzel,[6] M. Barrett,[7] K. E. Ford,[7] T. J. Harrison,[7] A. J. Hart,[7] C. M. Hawkes,[7] S. E. Morgan,[7] A. T. Watson,[7] M. Fritsch,[8] K. Goetzen,[8] T. Held,[8] H. Koch,[8] B. Lewandowski,[8] M. Pelizaeus,[8] K. Peters,[8] T. Schroeder,[8] M. Steinke,[8] J. T. Boyd,[9] J. P. Burke,[9] N. Chevalier,[9] W. N. Cottingham,[9] T. Cuhadar-Donszelmann,[10] B. G. Fulsom,[10] C. Hearty,[10] N. S. Knecht,[10] T. S. Mattison,[10] J. A. McKenna,[10] A. Khan,[11] P. Kyberd,[11] M. Saleem,[11] L. Teodorescu,[11] A. E. Blinov,[12] V. E. Blinov,[12] A. D. Bukin,[12] V. P. Druzhinin,[12] V. B. Golubev,[12] E. A. Kravchenko,[12] A. P. Onuchin,[12] S. I. Serednyakov,[12] Yu. I. Skovpen,[12] E. P. Solodov,[12] A. N. Yushkov,[12] D. Best,[13] M. Bondioli,[13] M. Bruinsma,[13] M. Chao,[13] S. Curry,[13] I. Eschrich,[13] D. Kirkby,[13] A. J. Lankford,[13] P. Lund,[13] M. Mandelkern,[13] R. K. Mommsen,[13] W. Roethel,[13] D. P. Stoker,[13] C. Buchanan,[14] B. L. Hartfiel,[14] A. J. R. Weinstein,[14] S. D. Foulkes,[15] J. W. Gary,[15] O. Long,[15] B. C. Shen,[15] K. Wang,[15] L. Zhang,[15] D. del Re,[16] H. K. Hadavand,[16] E. J. Hill,[16] D. B. MacFarlane,[16] H. P. Paar,[16] S. Rahatlou,[16] V. Sharma,[16] J. W. Berryhill,[17] C. Campagnari,[17] A. Cunha,[17] B. Dahmes,[17] T. M. Hong,[17] M. A. Mazur,[17] J. D. Richman,[17] W. Verkerke,[17] T. W. Beck,[18] A. M. Eisner,[18] C. J. Flacco,[18] C. A. Heusch,[18] J. Kroseberg,[18] W. S. Lockman,[18] G. Nesom,[18] T. Schalk,[18] B. A. Schumm,[18] A. Seiden,[18] P. Spradlin,[18] D. C. Williams,[18] M. G. Wilson,[18] J. Albert,[19] E. Chen,[19] G. P. Dubois-Felsmann,[19] A. Dvoretskii,[19] D. G. Hitlin,[19] I. Narsky,[19] T. Piatenko,[19] F. C. Porter,[19] A. Ryd,[19] A. Samuel,[19] R. Andreassen,[20] S. Jayatilleke,[20] G. Mancinelli,[20] B. T. Meadows,[20] M. D. Sokoloff,[20] F. Blanc,[21] P. Bloom,[21] S. Chen,[21] W. T. Ford,[21] J. F. Hirschauer,[21] A. Kreisel,[21] U. Nauenberg,[21] A. Olivas,[21] P. Rankin,[21] W. O. Ruddick,[21] J. G. Smith,[21] K. A. Ulmer,[21] S. R. Wagner,[21] J. Zhang,[21] A. Chen,[22] E. A. Eckhart,[22] A. Soffer,[22] W. H. Toki,[22] R. J. Wilson,[22] Q. Zeng,[22] D. Altenburg,[23] E. Feltresi,[23] A. Hauke,[23] B. Spaan,[23] T. Brandt,[24] J. Brose,[24] M. Dickopp,[24] V. Klose,[24] H. M. Lacker,[24] R. Nogowski,[24] S. Otto,[24] A. Petzold,[24] G. Schott,[24] J. Schubert,[24] K. R. Schubert,[24] R. Schwierz,[24] J. E. Sundermann,[24] D. Bernard,[25] G. R. Bonneaud,[25] P. Grenier,[25] S. Schrenk,[25] Ch. Thiebaux,[25] G. Vasileiadis,[25] M. Verderi,[25] D. J. Bard,[26] P. J. Clark,[26] W. Gradl,[26] F. Muheim,[26] S. Playfer,[26] Y. Xie,[26] M. Andreotti,[27] V. Azzolini,[27] D. Bettoni,[27] C. Bozzi,[27] R. Calabrese,[27] G. Cibinetto,[27] E. Luppi,[27] M. Negrini,[27] L. Piemontese,[27] F. Anulli,[28] R. Baldini-Ferroli,[28] A. Calcaterra,[28] R. de Sangro,[28] G. Finocchiaro,[28] P. Patteri,[28] I. M. Peruzzi,[28,*] M. Piccolo,[28] A. Zallo,[28] A. Buzzo,[29] R. Capra,[29] R. Contri,[29] M. Lo Vetere,[29] M. Macri,[29] M. R. Monge,[29] S. Passaggio,[29] C. Patrignani,[29] E. Robutti,[29] A. Santroni,[29] S. Tosi,[29] G. Brandenburg,[30] K. S. Chaisanguanthum,[30] M. Morii,[30] E. Won,[30] J. Wu,[30] R. S. Dubitzky,[31] U. Langenegger,[31] J. Marks,[31] S. Schenk,[31] U. Uwer,[31] W. Bhimji,[32] D. A. Bowerman,[32] P. D. Dauncey,[32] U. Egede,[32] R. L. Flack,[32] J. R. Gaillard,[32] G. W. Morton,[32] J. A. Nash,[32] M. B. Nikolich,[32] G. P. Taylor,[32] W. P. Vazquez,[32] M. J. Charles,[33] W. F. Mader,[33] U. Mallik,[33] A. K. Mohapatra,[33] J. Cochran,[34] H. B. Crawley,[34] V. Eyges,[34] W. T. Meyer,[34] S. Prell,[34] E. I. Rosenberg,[34] A. E. Rubin,[34] J. Yi,[34] N. Arnaud,[35] M. Davier,[35] X. Giroux,[35] G. Grosdidier,[35] A. Höcker,[35] F. Le Diberder,[35] V. Lepeltier,[35] A. M. Lutz,[35] A. Oyanguren,[35] T. C. Petersen,[35] M. Pierini,[35] S. Plaszczynski,[35] S. Rodier,[35] P. Roudeau,[35] M. H. Schune,[35] A. Stocchi,[35] G. Wormser,[35] C. H. Cheng,[36] D. J. Lange,[36] M. C. Simani,[36] D. M. Wright,[36] A. J. Bevan,[37] C. A. Chavez,[37] I. J. Forster,[37] J. R. Fry,[37] E. Gabathuler,[37] R. Gamet,[37] K. A. George,[37] D. E. Hutchcroft,[37] R. J. Parry,[37] D. J. Payne,[37] K. C. Schofield,[37] C. Touramanis,[37] C. M. Cormack,[38] F. Di Lodovico,[38] W. Menges,[38] R. Sacco,[38] C. L. Brown,[39] G. Cowan,[39] H. U. Flaecher,[39] M. G. Green,[39] D. A. Hopkins,[39] P. S. Jackson,[39] T. R. McMahon,[39] S. Ricciardi,[39] F. Salvatore,[39] D. Brown,[40] C. L. Davis,[40] J. Allison,[41] N. R. Barlow,[41] R. J. Barlow,[41] C. L. Edgar,[41] M. C. Hodgkinson,[41] M. P. Kelly,[41] G. D. Lafferty,[41] M. T. Naisbit,[41] J. C. Williams,[41] C. Chen,[42] W. D. Hulsbergen,[42] A. Jawahery,[42] D. Kovalskyi,[42] C. K. Lae,[42] D. A. Roberts,[42] G. Simi,[42] G. Blaylock,[43] C. Dallapiccola,[43] S. S. Hertzbach,[43] R. Kofler,[43] V. B. Koptchev,[43] X. Li,[43] T. B. Moore,[43] S. Saremi,[43] H. Staengle,[43] S. Willocq,[43] R. Cowan,[44] K. Koeneke,[44] G. Sciolla,[44] S. J. Sekula,[44] M. Spitznagel,[44] F. Taylor,[44] R. K. Yamamoto,[44] H. Kim,[45] P. M. Patel,[45] S. H. Robertson,[45] A. Lazzaro,[46] V. Lombardo,[46] F. Palombo,[46] J. M. Bauer,[47] L. Cremaldi,[47] V. Eschenburg,[47] R. Godang,[47] R. Kroeger,[47] J. Reidy,[47] D. A. Sanders,[47] D. J. Summers,[47] H. W. Zhao,[47] S. Brunet,[48] D. Côté,[48] P. Taras,[48] B. Viaud,[48] H. Nicholson,[49] N. Cavallo,[50,†] G. De Nardo,[50] F. Fabozzi,[50,†] C. Gatto,[50] L. Lista,[50] D. Monorchio,[50] P. Paolucci,[50] D. Piccolo,[50] C. Sciacca,[50] M. Baak,[51] H. Bulten,[51] G. Raven,[51] H. L. Snoek,[51] L. Wilden,[51] C. P. Jessop,[52] J. M. LoSecco,[52] T. Allmendinger,[53] G. Benelli,[53] K. K. Gan,[53] K. Honscheid,[53] D. Hufnagel,[53] P. D. Jackson,[53] H. Kagan,[53] R. Kass,[53]

 © 2005 The American Physical Society

T. Pulliam,[53] A. M. Rahimi,[53] R. Ter-Antonyan,[53] Q. K. Wong,[53] J. Brau,[54] R. Frey,[54] O. Igonkina,[54] M. Lu,[54] C. T. Potter,[54] N. B. Sinev,[54] D. Strom,[54] J. Strube,[54] E. Torrence,[54] F. Galeazzi,[55] M. Margoni,[55] M. Morandin,[55] M. Posocco,[55] M. Rotondo,[55] F. Simonetto,[55] R. Stroili,[55] C. Voci,[55] M. Benayoun,[56] H. Briand,[56] J. Chauveau,[56] P. David,[56] L. Del Buono,[56] Ch. de la Vaissière,[56] O. Hamon,[56] M. J. J. John,[56] Ph. Leruste,[56] J. Malclès,[56] J. Ocariz,[56] L. Roos,[56] G. Therin,[56] P. K. Behera,[57] L. Gladney,[57] Q. H. Guo,[57] J. Panetta,[57] M. Biasini,[58] R. Covarelli,[58] S. Pacetti,[58] M. Pioppi,[58] C. Angelini,[59] G. Batignani,[59] S. Bettarini,[59] F. Bucci,[59] G. Calderini,[59] M. Carpinelli,[59] R. Cenci,[59] F. Forti,[59] M. A. Giorgi,[59] A. Lusiani,[59] G. Marchiori,[59] M. Morganti,[59] N. Neri,[59] E. Paoloni,[59] M. Rama,[59] G. Rizzo,[59] J. Walsh,[59] M. Haire,[60] D. Judd,[60] D. E. Wagoner,[60] J. Biesiada,[61] N. Danielson,[61] P. Elmer,[61] Y. P. Lau,[61] C. Lu,[61] J. Olsen,[61] A. J. S. Smith,[61] A. V. Telnov,[61] F. Bellini,[62] G. Cavoto,[62] A. D'Orazio,[62] E. Di Marco,[62] R. Faccini,[62] F. Ferrarotto,[62] F. Ferroni,[62] M. Gaspero,[62] L. Li Gioi,[62] M. A. Mazzoni,[62] S. Morganti,[62] G. Piredda,[62] F. Polci,[62] F. Safai Tehrani,[62] C. Voena,[62] H. Schröder,[63] G. Wagner,[63] R. Waldi,[63] T. Adye,[64] N. De Groot,[64] B. Franek,[64] G. P. Gopal,[64] E. O. Olaiya,[64] F. F. Wilson,[64] R. Aleksan,[65] S. Emery,[65] A. Gaidot,[65] S. F. Ganzhur,[65] P.-F. Giraud,[65] G. Graziani,[65] G. Hamel de Monchenault,[65] W. Kozanecki,[65] M. Legendre,[65] G. W. London,[65] B. Mayer,[65] G. Vasseur,[65] Ch. Yèche,[65] M. Zito,[65] M. V. Purohit,[66] A. W. Weidemann,[66] J. R. Wilson,[66] F. X. Yumiceva,[66] T. Abe,[67] M. T. Allen,[67] D. Aston,[67] N. van Bakel,[67] R. Bartoldus,[67] N. Berger,[67] A. M. Boyarski,[67] O. L. Buchmueller,[67] R. Claus,[67] J. P. Coleman,[67] M. R. Convery,[67] M. Cristinziani,[67] J. C. Dingfelder,[67] D. Dong,[67] J. Dorfan,[67] D. Dujmic,[67] W. Dunwoodie,[67] S. Fan,[67] R. C. Field,[67] T. Glanzman,[67] S. J. Gowdy,[67] T. Hadig,[67] V. Halyo,[67] C. Hast,[67] T. Hryn'ova,[67] W. R. Innes,[67] M. H. Kelsey,[67] P. Kim,[67] M. L. Kocian,[67] D. W. G. S. Leith,[67] J. Libby,[67] S. Luitz,[67] V. Luth,[67] H. L. Lynch,[67] H. Marsiske,[67] R. Messner,[67] D. R. Muller,[67] C. P. O'Grady,[67] V. E. Ozcan,[67] A. Perazzo,[67] M. Perl,[67] B. N. Ratcliff,[67] A. Roodman,[67] A. A. Salnikov,[67] R. H. Schindler,[67] J. Schwiening,[67] A. Snyder,[67] J. Stelzer,[67] D. Su,[67] M. K. Sullivan,[67] K. Suzuki,[67] S. Swain,[67] J. M. Thompson,[67] J. Va'vra,[67] M. Weaver,[67] W. J. Wisniewski,[67] M. Wittgen,[67] D. H. Wright,[67] A. K. Yarritu,[67] K. Yi,[67] C. C. Young,[67] P. R. Burchat,[68] A. J. Edwards,[68] S. A. Majewski,[68] B. A. Petersen,[68] C. Roat,[68] M. Ahmed,[69] S. Ahmed,[69] M. S. Alam,[69] J. A. Ernst,[69] M. A. Saeed,[69] F. R. Wappler,[69] S. B. Zain,[69] W. Bugg,[70] M. Krishnamurthy,[70] S. M. Spanier,[70] R. Eckmann,[71] J. L. Ritchie,[71] A. Satpathy,[71] R. F. Schwitters,[71] J. M. Izen,[72] I. Kitayama,[72] X. C. Lou,[72] S. Ye,[72] F. Bianchi,[73] M. Bona,[73] F. Gallo,[73] D. Gamba,[73] M. Bomben,[74] L. Bosisio,[74] C. Cartaro,[74] F. Cossutti,[74] G. Della Ricca,[74] S. Dittongo,[74] S. Grancagnolo,[74] L. Lanceri,[74] L. Vitale,[74] F. Martinez-Vidal,[75] R. S. Panvini,[76,‡] Sw. Banerjee,[77] B. Bhuyan,[77] C. M. Brown,[77] D. Fortin,[77] K. Hamano,[77] R. Kowalewski,[77] J. M. Roney,[77] R. J. Sobie,[77] J. J. Back,[78] P. F. Harrison,[78] T. E. Latham,[78] G. B. Mohanty,[78] H. R. Band,[79] X. Chen,[79] B. Cheng,[79] S. Dasu,[79] M. Datta,[79] A. M. Eichenbaum,[79] K. T. Flood,[79] M. Graham,[79] J. J. Hollar,[79] J. R. Johnson,[79] P. E. Kutter,[79] H. Li,[79] R. Liu,[79] B. Mellado,[79] A. Mihalyi,[79] Y. Pan,[79] R. Prepost,[79] P. Tan,[79] J. H. von Wimmersperg-Toeller,[79] S. L. Wu,[79] Z. Yu,[79] and H. Neal[80]

(*BABAR* Collaboration)

[1]*Laboratoire de Physique des Particules, F-74941 Annecy-le-Vieux, France*
[2]*IFAE, Universitat Autonoma de Barcelona, E-08193 Bellaterra, Barcelona, Spain*
[3]*Dipartimento di Fisica and INFN, Università di Bari, I-70126 Bari, Italy*
[4]*Institute of High Energy Physics, Beijing 100039, China*
[5]*University of Bergen, Institute of Physics, N-5007 Bergen, Norway*
[6]*Lawrence Berkeley National Laboratory, Berkeley, California 94720, USA and University of California, Berkeley, California 94720, USA*
[7]*University of Birmingham, Birmingham, B15 2TT, United Kingdom*
[8]*Ruhr Universität Bochum, Institut für Experimentalphysik 1, D-44780 Bochum, Germany*
[9]*University of Bristol, Bristol BS8 1TL, United Kingdom*
[10]*University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z1*
[11]*Brunel University, Uxbridge, Middlesex UB8 3PH, United Kingdom*
[12]*Budker Institute of Nuclear Physics, Novosibirsk 630090, Russia*
[13]*University of California at Irvine, Irvine, California 92697, USA*
[14]*University of California at Los Angeles, Los Angeles, California 90024, USA*
[15]*University of California at Riverside, Riverside, California 92521, USA*
[16]*University of California at San Diego, La Jolla, California 92093, USA*
[17]*University of California at Santa Barbara, Santa Barbara, California 93106, USA*
[18]*University of California at Santa Cruz, Institute for Particle Physics, Santa Cruz, California 95064, USA*
[19]*California Institute of Technology, Pasadena, California 91125, USA*
[20]*University of Cincinnati, Cincinnati, Ohio 45221, USA*

[21]*University of Colorado, Boulder, Colorado 80309, USA*
[22]*Colorado State University, Fort Collins, Colorado 80523, USA*
[23]*Universität Dortmund, Institut fur Physik, D-44221 Dortmund, Germany*
[24]*Technische Universität Dresden, Institut für Kern- und Teilchenphysik, D-01062 Dresden, Germany*
[25]*Ecole Polytechnique, LLR, F-91128 Palaiseau, France*
[26]*University of Edinburgh, Edinburgh EH9 3JZ, United Kingdom*
[27]*Dipartimento di Fisica and INFN, Università di Ferrara, I-44100 Ferrara, Italy*
[28]*Laboratori Nazionali di Frascati dell'INFN, I-00044 Frascati, Italy*
[29]*Dipartimento di Fisica and INFN, Università di Genova, I-16146 Genova, Italy*
[30]*Harvard University, Cambridge, Massachusetts 02138, USA*
[31]*Universität Heidelberg, Physikalisches Institut, Philosophenweg 12, D-69120 Heidelberg, Germany*
[32]*Imperial College London, London, SW7 2AZ, United Kingdom*
[33]*University of Iowa, Iowa City, Iowa 52242, USA*
[34]*Iowa State University, Ames, Iowa 50011-3160, USA*
[35]*Laboratoire de l'Accélérateur Linéaire, F-91898 Orsay, France*
[36]*Lawrence Livermore National Laboratory, Livermore, California 94550, USA*
[37]*University of Liverpool, Liverpool L69 72E, United Kingdom*
[38]*Queen Mary, University of London, E1 4NS, United Kingdom*
[39]*University of London, Royal Holloway and Bedford New College, Egham, Surrey TW20 0EX, United Kingdom*
[40]*University of Louisville, Louisville, Kentucky 40292, USA*
[41]*University of Manchester, Manchester M13 9PL, United Kingdom*
[42]*University of Maryland, College Park, Maryland 20742, USA*
[43]*University of Massachusetts, Amherst, Massachusetts 01003, USA*
[44]*Massachusetts Institute of Technology, Laboratory for Nuclear Science, Cambridge, Massachusetts 02139, USA*
[45]*McGill University, Montréal, Quebec, Canada H3A 2T8*
[46]*Dipartimento di Fisica and INFN, Università di Milano, I-20133 Milano, Italy*
[47]*University of Mississippi, University, Mississippi 38677, USA*
[48]*Université de Montréal, Laboratoire René J. A. Lévesque, Montréal, Quebec, Canada H3C 3J7*
[49]*Mount Holyoke College, South Hadley, Massachusetts 01075, USA*
[50]*Dipartimento di Scienze Fisiche and INFN, Università di Napoli Federico II, I-80126, Napoli, Italy*
[51]*NIKHEF, National Institute for Nuclear Physics and High Energy Physics, NL-1009 DB Amsterdam, The Netherlands*
[52]*University of Notre Dame, Notre Dame, Indiana 46556, USA*
[53]*Ohio State University, Columbus, Ohio 43210, USA*
[54]*University of Oregon, Eugene, Oregon 97403, USA*
[55]*Dipartimento di Fisica and INFN, Università di Padova, I-35131 Padova, Italy*
[56]*Universités Paris VI et VII, Laboratoire de Physique Nucléaire et de Hautes Energies, F-75252 Paris, France*
[57]*University of Pennsylvania, Philadelphia, Pennsylvania 19104, USA*
[58]*Dipartimento di Fisica and INFN, Università di Perugia, I-06100 Perugia, Italy*
[59]*Dipartimento di Fisica, Università di Pisa, Scuola Normale Superiore and INFN, I-56127 Pisa, Italy*
[60]*Prairie View A&M University, Prairie View, Texas 77446, USA*
[61]*Princeton University, Princeton, New Jersey 08544, USA*
[62]*Dipartimento di Fisica and INFN, Università di Roma La Sapienza, I-00185 Roma, Italy*
[63]*Universität Rostock, D-18051 Rostock, Germany*
[64]*Rutherford Appleton Laboratory, Chilton, Didcot, Oxon, OX11 0QX, United Kingdom*
[65]*DSM/Dapnia, CEA/Saclay, F-91191 Gif-sur-Yvette, France*
[66]*University of South Carolina, Columbia, South Carolina 29208, USA*
[67]*Stanford Linear Accelerator Center, Stanford, California 94309, USA*
[68]*Stanford University, Stanford, California 94305-4060, USA*
[69]*State University of New York, Albany, New York 12222, USA*
[70]*University of Tennessee, Knoxville, Tennessee 37996, USA*
[71]*University of Texas at Austin, Austin, Texas 78712, USA*
[72]*University of Texas at Dallas, Richardson, Texas 75083, USA*
[73]*Dipartimento di Fisica Sperimentale and INFN, Università di Torino, I-10125 Torino, Italy*
[74]*Dipartimento di Fisica and INFN, Università di Trieste, I-34127 Trieste, Italy*
[75]*IFIC, Universitat de Valencia-CSIC, E-46071 Valencia, Spain*
[76]*Vanderbilt University, Nashville, Tennessee 37235, USA*

[*]Also with Dipartimento di Fisica, Università di Perugia, Perugia, Italy.
[†]Also with Università della Basilicata, Potenza, Italy.
[‡]Deceased.

[77]*University of Victoria, Victoria, British Columbia, Canada V8W 3P6*
[78]*Department of Physics, University of Warwick, Coventry CV4 7AL, United Kingdom*
[79]*University of Wisconsin, Madison, Wisconsin 53706, USA*
[80]*Yale University, New Haven, Connecticut 06511, USA*
(Received 4 July 2005; published 19 October 2005)

Using a sample of 232×10^6 $\Upsilon(4S) \to B\overline{B}$ events collected with the *BABAR* detector at the PEP-II *B* Factory in 1999–2004, we study $B^- \to D^0 K^*(892)^-$ decays where $K^{*-} \to K^0_S \pi^-$ and $D^0 \to K^-\pi^+$, $K^-\pi^+\pi^0$, $K^-\pi^+\pi^+\pi^-$ (non-*CP* final states); K^+K^-, $\pi^+\pi^-$ (*CP*+ eigenstates); $K^0_S\pi^0$, $K^0_S\phi$, and $K^0_S\omega$ (*CP*− eigenstates). We measure four observables that are sensitive to the angle γ of the CKM unitarity triangle; the partial-rate charge asymmetries $\mathcal{A}_{CP\pm}$ and the ratios of the *B*-decay branching fraction in $CP\pm$ and non-*CP* decays $\mathcal{R}_{CP\pm}$: $\mathcal{A}_{CP+} = -0.08 \pm 0.19(\text{stat}) \pm 0.08(\text{syst})$, $\mathcal{A}_{CP-} = -0.26 \pm 0.40(\text{stat}) \pm 0.12(\text{syst})$, $\mathcal{R}_{CP+} = 1.96 \pm 0.40(\text{stat}) \pm 0.11(\text{syst})$, and $\mathcal{R}_{CP-} = 0.65 \pm 0.26(\text{stat}) \pm 0.08(\text{syst})$.

DOI: 10.1103/PhysRevD.72.071103 PACS numbers: 13.25.Hw, 11.30.Er, 12.15.Hh

The measurement of *CP* violation in *B*-meson decays offers a means to over-constrain the unitarity triangle. A theoretically clean determination of the angle $\gamma = \arg(-V_{ud}V^*_{ub}/V_{cd}V^*_{cb})$ is provided by the $B^- \to D^{(*)0}K^{(*)-}$ decay channels in which the favored $b \to c\bar{u}s$ and suppressed $b \to u\bar{c}s$ tree amplitudes interfere [1,2]. Results on the $B^- \to D^{(*)0}K^-$ decays have been published by the *BABAR* [3–5] and BELLE [6,7] collaborations. In this paper, we present a study based on the interference between $B^- \to D^0 K^*(892)^-$ and $B^- \to \overline{D}^0 K^{*-}$ when both D^0 and $\overline{D}^0$ decay to the same *CP* eigenstate (D^0_{CP}). Reference to a charge conjugate mode is implied throughout this paper unless otherwise stated.

We follow [2,8] and define:

$$\mathcal{R}_{CP\pm} = 2\frac{\Gamma(B^- \to D^0_{CP\pm}K^{*-}) + \Gamma(B^+ \to D^0_{CP\pm}K^{*+})}{\Gamma(B^- \to D^0 K^{*-}) + \Gamma(B^+ \to D^0 K^{*+})},$$

$$\mathcal{A}_{CP\pm} = \frac{\Gamma(B^- \to D^0_{CP\pm}K^{*-}) - \Gamma(B^+ \to D^0_{CP\pm}K^{*+})}{\Gamma(B^- \to D^0_{CP\pm}K^{*-}) + \Gamma(B^+ \to D^0_{CP\pm}K^{*+})}.$$

Both $\mathcal{A}_{CP}$ and $\mathcal{R}_{CP}$ carry *CP*-violating information. Neglecting D^0-$\overline{D}^0$ mixing, they can be expressed as follows:

$$\mathcal{R}_{CP\pm} = 1 \pm 2r_B \cos\delta\cos\gamma + r_B^2, \quad (1)$$

$$\mathcal{A}_{CP\pm} = \frac{\pm 2r_B \sin\delta \sin\gamma}{\mathcal{R}_{CP\pm}}, \quad (2)$$

where δ is the *CP*-conserving strong phase difference between the $B^- \to \overline{D}^0 K^{*-}$ (suppressed) and $B^- \to D^0 K^{*-}$ (favored) amplitudes, $r_B \simeq 0.1$–0.3 [8] is the magnitude of their ratio, and γ is the *CP*-violating weak phase difference. A value close to 60° is favored for γ when one combines all measurements related to the unitarity triangle [9]. It is useful to introduce also new variables,

$$x^\pm \equiv r_B \cos(\delta \pm \gamma), \quad (3)$$

which are better behaved (more Gaussian) in the region where r_B is small.

To search for $B^- \to D^0_{CP}K^{*-}$ decays we use data collected with the *BABAR* detector [10] at the PEP-II storage ring. The sample corresponds to an integrated luminosity of 211 fb^{-1} at the $\Upsilon(4S)$ resonance (232×10^6 $B\overline{B}$ pairs) and 20.4 fb^{-1} at an energy 40 MeV below the peak.

To reconstruct $B^- \to D^0 K^{*-}$ decays, we select K^{*-} candidates in the $K^{*-} \to K^0_S\pi^-$, $K^0_S \to \pi^+\pi^-$ mode and D^0 candidates in eight decay channels, $D^0 \to K^-\pi^+$, $K^-\pi^+\pi^0$, $K^-\pi^+\pi^+\pi^-$ (non-*CP* final states); K^+K^-, $\pi^+\pi^-$ (*CP*+ eigenstates); and $K^0_S\pi^0$, $K^0_S\phi$, $K^0_S\omega$ (*CP*− eigenstates). We optimize our event selection to minimize the statistical error on the signal yield, determined for each channel using simulated signal and background events. Particle identification is required for all charged particles except for the pions from K^0_S decays.

K^0_S candidates are formed from oppositely charged tracks assumed to be pions with a reconstructed invariant mass within 13 MeV/c^2 (4 standard deviations) from the known K^0_S mass [11], $m_{K^0_S}$. All K^0_S candidates are refitted so that their invariant mass equals $m_{K^0_S}$ (mass constraint). For those retained to build a D^0_{CP-} candidate the tracks are also constrained to emerge from a single vertex (vertex constraint). For those retained to build a K^{*-} we further require their flight direction and length be consistent with a K^0_S coming from the interaction point. The K^0_S candidate flight path and momentum must make an acute angle and the flight length in the plane transverse to the beam direction must exceed its uncertainty by 3 standard deviations. K^{*-} candidates are formed from a K^0_S and a charged particle with a vertex constraint. We select K^{*-} candidates which have an invariant mass within 75 MeV/c^2 of the known value [11]. Finally, since the K^{*-} in $B^- \to D^0 K^{*-}$ is polarized, we require $|\cos\theta_H| \geq 0.35$, where θ_H is the angle in the K^{*-} rest frame between the daughter pion and the parent *B* momentum. The helicity distribution discriminates well between a *B*-meson decay and an event from the $e^+e^- \to q\overline{q}$ ($q \in \{u, d, s, c\}$) continuum, since the former is distributed as $\cos^2\theta_H$ and the latter is flat.

Some decay modes of the D^0 contain a π^0. We combine pairs of photons to form a π^0 candidate with a total energy

greater than 200 MeV and an invariant mass between 115 and 150 MeV/c^2. A mass-constrained fit is applied to the selected π^0 candidates. Composite particles included in the $CP-$ modes are vertex constrained. Candidate ϕ (ω) mesons are constructed from K^+K^- ($\pi^+\pi^-\pi^0$) particle combinations with the invariant mass required to be within 12 (20) MeV/c^2 or 2 standard deviations of the known values [11]. Two further requirements are made on the ω candidates. The magnitude of the cosine of the helicity angle between the D^0 momentum in the rest frame of the ω and the normal to the plane containing all three decay pions must be greater than 0.25. The Dalitz angle [12], defined as the angle between the momentum of one daughter pion in the ω rest frame and the direction of one of the other two pions in the rest frame of the two pions, must have a cosine with a magnitude less than 0.9.

Except for the $K^0_S\pi^0$ final state, all D^0 candidates are mass and vertex constrained. We select D^0 candidates with an invariant mass differing from the known mass [11] by less than 12 MeV/c^2 for all channels except $K^0_S\pi^0$ (30 MeV/c^2) and $K^0_S\omega$ (20 MeV/c^2). These limits are about twice the corresponding rms mass resolutions.

To suppress the background due to $e^+e^- \to q\overline{q}$ reactions, we require $|\cos\theta_B| \leq 0.9$, where θ_B is defined as the angle between the B candidate momentum in the $\Upsilon(4S)$ rest frame and the beam axis. In $q\overline{q}$ background events the $\cos\theta_B$ distribution is uniform, while for B mesons it follows a $\sin^2\theta_B$ distribution. We also use global event shape variables to distinguish between $q\overline{q}$ continuum events, which have a two-jet-like topology in the $\Upsilon(4S)$ rest frame, and $B\overline{B}$ events, which are more spherical. We require $|\cos\theta_T| \leq 0.9$ where θ_T is the angle between the thrust axes of the B candidate and that of the rest of the event. We construct a linear discriminant [13] from $\cos\theta_T$ and Legendre monomials [14] describing the energy flow in the rest of the event.

We identify B candidates using two nearly independent kinematic variables: the beam-energy-substituted mass $m_{\rm ES} \equiv \sqrt{(s/2 + \mathbf{p_0}\cdot\mathbf{p_B})^2/E_0^2 - p_B^2}$ and the energy difference $\Delta E = E_B^* - \sqrt{s}/2$, where E and p are energy and momentum, the subscripts 0 and B refer to the e^+e^--beam system and the B candidate respectively; s is the square of the center-of-mass (CM) energy and the asterisk labels the CM frame. For signal modes, the $m_{\rm ES}$ distributions are all described by the same Gaussian function $\mathcal{G}$ centered at the B mass with a 2.6 MeV/c^2 resolution (for $D^0 \to K^0_S\pi^0$ the peak is slightly wider, 2.7 MeV/c^2). The ΔE distributions are centered on zero for signal with a resolution of 11 to 13 MeV for all channels except $K^0_S\pi^0$ for which the resolution is asymmetric and about 30 MeV. We define a signal region through the requirement $|\Delta E| < 50$ (25) MeV for $K^0_S\pi^0$ (all other modes).

A background for $B^- \to D^0(\pi^+\pi^-)K^{*-}(K^0_S\pi^-)$ is the decay $B^- \to D^0(K^0_S\pi^+\pi^-)\pi^-$ which contains the same final state as the signal but has a branching fraction 600 times larger. We therefore explicitly veto any selected B candidate containing a $K^0_S\pi^+\pi^-$ combination within 25 MeV/c^2 of the D^0 mass. No background remains.

In those events where we find more than one acceptable B candidate (less than 25% of selected events depending on the D^0 mode), we choose that with the smallest χ^2 formed from the differences of the measured and true D^0 and K^{*-} masses scaled by the mass spread which includes the resolution and, for the K^{*-}, the natural width. Simulations show that no bias is introduced by this choice and the correct candidate is picked at least 82% of the time.

According to simulation of signal events, the total reconstruction efficiencies are 13.1% and 14.2% for the $CP+$ modes $D^0 \to K^+K^-$ and $\pi^+\pi^-$; 5.5%, 10.0%, and 2.4% for the $CP-$ modes $D^0 \to K^0_S\pi^0$, $K^0_S\phi$, and $K^0_S\omega$; 13.3%, 4.3%, and 8.2% for the non-CP modes $D^0 \to K^-\pi^+$, $K^-\pi^+\pi^0$, and $K^-\pi^+\pi^+\pi^-$.

To study $B\overline{B}$ backgrounds we look in sideband regions away from the signal region in ΔE and m_{D^0}. We define a ΔE sideband in the interval $-100 \leq \Delta E \leq -60$ and $60 \leq \Delta E \leq 200$ MeV for all modes except $D^0 \to K^0_S\pi^0$ for which the inside limit is ± 95 rather than 60 MeV. The sideband region in m_{D^0} is defined by requiring that this quantity differs from the D^0 mass peak by more than 4 standard deviations. It provides sensitivity to doubly-peaking background sources which mimic signal both in ΔE and $m_{\rm ES}$. This pollution comes from either charmed or charmless B-meson decays that do not contain a true D^0. As many of the possible contributions to this background are not well known, we attempt to measure its size by including the m_{D^0} sideband in the fit described below.

An unbinned extended maximum likelihood fit to $m_{\rm ES}$ distributions in the range $5.2 \leq m_{\rm ES} \leq 5.3$ GeV/c^2 is used to determine yields and CP-violating quantities $\mathcal{A}_{CP}$ and $\mathcal{R}_{CP}$. We use the same Gaussian function $\mathcal{G}$ to describe the signal shape for all modes considered. The combinatorial background in the $m_{\rm ES}$ distribution is modeled with a threshold function [15] $\mathcal{A}$. Its shape is governed by one parameter ξ that is left free in the fit. We fit simultaneously $m_{\rm ES}$ distributions of nine samples: the non-CP, $CP+$, and $CP-$ samples for (i) the signal region, (ii) the m_{D^0} sideband, and (iii) the ΔE sideband. We fit three probability density functions (PDF) weighted by the unknown event yields. For the ΔE sideband, we use $\mathcal{A}$. For the m_{D^0} sideband (sb) we use $a_{\rm sb}\cdot\mathcal{A} + b_{\rm sb}\cdot\mathcal{G}$, where $\mathcal{G}$ accounts for the doubly-peaking B decays. For the signal region PDF, we use $a\cdot\mathcal{A} + b\cdot\mathcal{G} + c\cdot\mathcal{G}$, where $b = N_{\rm peak}$ is scaled from $b_{\rm sb}$ according to the ratio of the m_{D^0} signal window to sideband widths and c is the number of $B^\pm \to D^0K^{*\pm}$ signal events. The non-CP mode sample, with relatively high statistics, helps constrain the PDF shapes for the low statistics CP mode distributions. The ΔE sideband sample helps define the $\mathcal{A}$ background shape.

Since the values of ξ obtained for each data sample were found to be consistent with each other, albeit with large

statistical uncertainties, we have constrained ξ to have the same value for all data samples in the fit. The simulation shows that the use of the same Gaussian parameters for all signal modes introduces only negligible systematic corrections. We assume that the B decays found in the m_{D^0} sideband have the same final states as the signal and we fit the same Gaussian to the doubly-peaking B background.

The doubly-peaking B background is assumed to not violate CP and is therefore split equally between the B^- and B^+ subsamples. This assumption is considered further when we discuss the systematic uncertainties. The fit results are shown graphically in Fig. 1 and numerically in Table I.

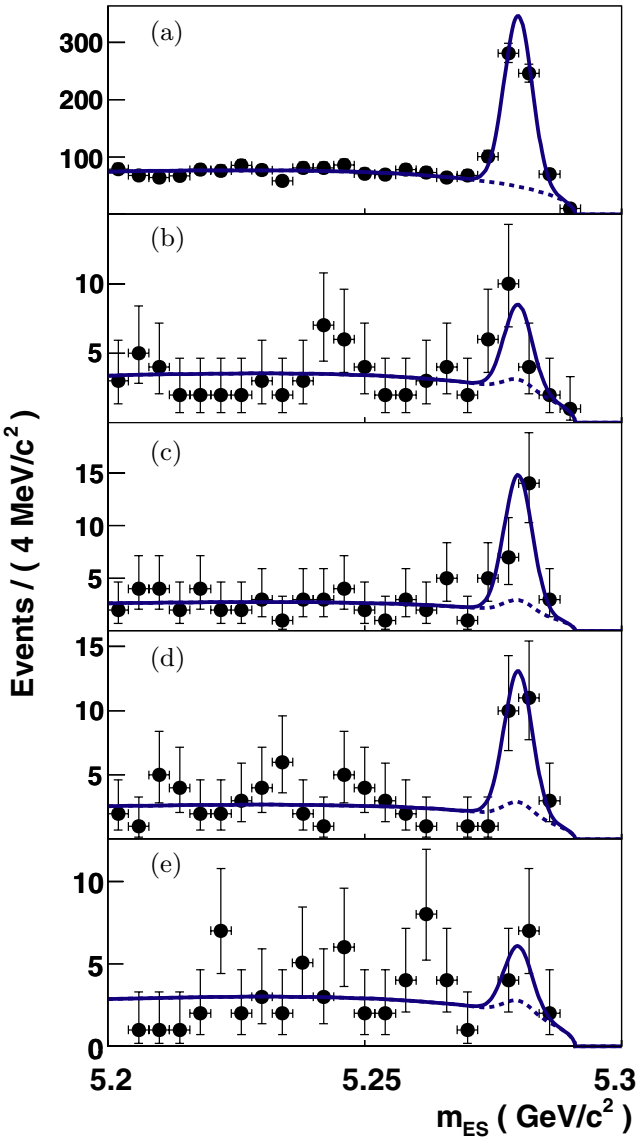

FIG. 1 (color online). Distributions of $m_{\rm ES}$ in the signal region for the non-CP modes in $B^\pm$ decays (a), the $CP+$ modes in B^+ (b) and B^- (c) decays, and the $CP-$ modes in B^+ (d) and B^- (e) decays. The dashed curve indicates the contribution from the doubly-peaking B background estimated from a simultaneous fit to the D^0 sideband (not shown).

TABLE I. Results from the fits. For each D^0 mode class, we give the event yield, the peaking background contribution $N_{\rm peak}$, $\mathcal{A}_{CP}$, and $\mathcal{R}_{CP}$. The uncertainties are statistical only.

	Yield	$N_{\rm peak}$	$\mathcal{A}_{CP}$	$\mathcal{R}_{CP}$
non-CP	489 ± 27	20.1 ± 5.6		
$CP+$	37.6 ± 7.4	4.1 ± 1.3	-0.08 ± 0.19	1.96 ± 0.40
$CP-$	14.8 ± 5.9	3.0 ± 2.3	-0.24 ± 0.35	0.73 ± 0.29

The statistical significance of the $CP+$ and $CP-$ yields are 6.8 and 2.7 standard deviations, respectively. The yields for each individual mode are 23.1 ± 5.1 (K^+K^-), 17.4 ± 5.0 ($\pi^+\pi^-$), 10.9 ± 4.1 ($K^0_S\pi^0$), 3.1 ± 3.2 ($K^0_S\phi$), and 3.8 ± 2.7 ($K^0_S\omega$).

Although most systematic errors cancel for $\mathcal{A}_{CP}$, an asymmetry inherent to the detector or data processing may exist. After performing the analysis on a high statistics $B^- \to D^0\pi^-$ sample (not applying the K^{*-}selection), the final sample shows an asymmetry of -0.019 ± 0.008. We assign a systematic uncertainty of ± 0.027. The second substantial systematic effect is a possible CP asymmetry in the peaking background. Although there is no physics reason that requires the peaking background to be asymmetric, it cannot be excluded. We note that if there were an asymmetry $\mathcal{A}_{\rm peak}$, a systematic error on $\mathcal{A}_{CP}$ would be given by $\mathcal{A}_{\rm peak} \times \frac{b}{c}$, where b is the contribution of the peaking background and c the signal yield. Assuming conservatively $|\mathcal{A}_{\rm peak}| \leq 0.5$, we obtain systematic errors of ± 0.06 and ± 0.10 on $\mathcal{A}_{CP+}$ and $\mathcal{A}_{CP-}$, respectively.

Since $\mathcal{R}_{CP}$ is a ratio of rates of processes with different final states of the D^0, we must consider the uncertainties affecting the selection algorithms for the different D channels. This results in small correction factors which account for the difference between the actual detector response and the simulation model. The main effects stem from the approximate modeling of the tracking efficiency (1.2% per track), the K^0_S reconstruction efficiency for $CP-$ modes of the D^0 (2.0% per K^0_S), the π^0 reconstruction efficiency for the $K^0_S\pi^0$ channel (3%) and the efficiency and misidentification probabilities from the particle identification (2% per track). A substantial effect is the uncertainty on the measured branching fractions [11]. Altogether, we obtain systematic uncertainties equal to ± 0.11 and ± 0.055 for $\mathcal{R}_{CP+}$ and $\mathcal{R}_{CP-}$, respectively.

Another systematic correction is applied to the $CP-$ measurements which arises from a possible $CP+$ background for the $K^0_S\phi$ and $K^0_S\omega$ channels. In this case, the observed quantities, $\mathcal{A}^{\rm obs}_{CP-}$ and $\mathcal{R}^{\rm obs}_{CP-}$ are corrected:

$$\mathcal{A}_{CP-} = (1+\epsilon)\mathcal{A}^{\rm obs}_{CP-} - \epsilon\mathcal{A}_{CP+};$$

$$\mathcal{R}_{CP-} = \frac{\mathcal{R}^{\rm obs}_{CP-}}{(1+\epsilon)},$$

where ϵ is the ratio of $CP+$ background to $CP-$ signal. There is little information on this $CP+$ background. An investigation in *BABAR* of the $D^0 \to K^-K^+K^0_S$ Dalitz plot indicates that the dominant background for $D^0 \to K^0_S\phi$ comes from the decay $a_0(980) \to K^+K^-$, at the level of $(25 \pm 1)\%$ the size of the ϕK^0_S signal. We have no information for the ωK^0_S channel and assume $(30 \pm 30)\%$. Adding the most frequent $K^0_S\pi^0$ mode which does not suffer such a $CP+$ pollution, we estimate $\epsilon = (13 \pm 7)\%$. The systematic error associated with this correction is ± 0.01 and ± 0.04 for $\mathcal{A}_{CP-}$ and $\mathcal{R}_{CP-}$, respectively.

To account for the nonresonant $K^0_S\pi^-$ pairs under the K^{*-}, we vary by 2π all the strong phases in a conservative model which incorporates S-wave $K\pi$ pairs in both $b \to c\bar{u}s$ and $b \to u\bar{c}s$ amplitudes. This background induces systematic variations of ± 0.051 for $\mathcal{A}_{CP\pm}$ and ± 0.035 for $\mathcal{R}_{CP\pm}$. We add the systematic uncertainties in quadrature and quote the final results:

$$\mathcal{A}_{CP+} = -0.08 \pm 0.19(\text{stat}) \pm 0.08(\text{syst}),$$

$$\mathcal{A}_{CP-} = -0.26 \pm 0.40(\text{stat}) \pm 0.12(\text{syst}),$$

$$\mathcal{R}_{CP+} = 1.96 \pm 0.40(\text{stat}) \pm 0.11(\text{syst}),$$

$$\mathcal{R}_{CP-} = 0.65 \pm 0.26(\text{stat}) \pm 0.08(\text{syst}).$$

These results also can be expressed in terms of $x^\pm$ defined in Equation (3):

$$x^+ = 0.32 \pm 0.18(\text{stat}) \pm 0.07(\text{syst}),$$

$$x^- = 0.33 \pm 0.16(\text{stat}) \pm 0.06(\text{syst}),$$

where the $CP+$ pollution systematic effects increase x^+ and x^- by 0.022 ± 0.012 and 0.019 ± 0.010, respectively. From Eq. (1) we find $r_B^2 = 0.30 \pm 0.25$.

In summary, we have studied the decays of charged B mesons to a $K^*(892)^-$ and a D^0, where the latter is seen in final states of even and odd CP. We express the results with $\mathcal{R}_{CP}$, $\mathcal{A}_{CP}$, and $x^\pm$. These quantities can be combined with other $D^{(*)}K^{(*)}$ measurements to estimate r_B more precisely and improve our understanding of the angle γ.

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 wish to 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 CONACyT (Mexico), A. P. Sloan Foundation, Research Corporation, and Alexander von Humboldt Foundation.

[1] M. Gronau and D. London, Phys. Lett. B **253**, 483 (1991); M. Gronau and D. Wyler, Phys. Lett. B **265**, 172 (1991); A. B. Carter and A. I. Sanda, Phys. Rev. D **23**, 1567 (1981); I. I. Bigi and A. I. Sanda, Phys. Lett. B **211**, 213 (1988); D. Atwood, I. Dunietz, and A. Soni, Phys. Rev. Lett. **78**, 3257 (1997); A. Giri, Y. Grossman, A. Soffer, and J. Zupan, Phys. Rev. D **68**, 054018 (2003).

[2] M. Gronau, Phys. Rev. D **58**, 037301 (1998).

[3] B. Aubert *et al.* (*BABAR* Collaboration), Phys. Rev. Lett. **92**, 202 002 (2004).

[4] B. Aubert *et al.* (*BABAR* Collaboration), Phys. Rev. Lett. **93**, 131 804 (2004).

[5] B. Aubert *et al.* (*BABAR* Collaboration), Phys. Rev. D **71**, 031102 (2005).

[6] S. K. Swain *et al.*, (Belle Collaboration), Phys. Rev. D **68**, 051101 (2003).

[7] A. Poluektov *et al.* (Belle Collaboration), Phys. Rev. D **70**, 072003 (2004).

[8] M. Gronau, Phys. Lett. B **557**, 198 (2003).

[9] J. Charles *et al.* (CKMfitter Group), Eur. Phys. J. C **41**, 1 (2005).

[10] B. Aubert *et al.* (*BABAR* Collaboration), Nucl. Instrum. Methods Phys. Res., Sect. A **479**, 1 (2002).

[11] S. Eidelman *et al.* (Particle Data Group), Phys. Lett. B **592**, 1 (2004).

[12] B. Aubert *et al.* (*BABAR* Collaboration), Phys. Rev. D **69**, 032004 (2004).

[13] R. A. Fisher, Annals of Eugenics **7**, 179 (1936).

[14] B. Aubert *et al.* (*BABAR* Collaboration), Phys. Rev. Lett. **89**, 281 802 (2002).

[15] The function is $\mathcal{A}(m_{ES}) \propto m_{ES}\sqrt{1-x^2}\exp[-\xi(1-x^2)]$, where $x = 2m_{ES}/\sqrt{s}$ and ξ is a fit parameter; H. Albrecht *et al.* (ARGUS Collaboration), Phys. Lett. B **185**, 218 (1987); **241**, 278 (1990).