BABAR-CONF-02/018
SLAC-PUB-9311
July 2002

Measurement of Branching Ratios and CP Asymmetries in $B^- \to D^0_{(CP)} K^-$ Decays

The *BABAR* Collaboration

July 25, 2002

Abstract

We present preliminary results of the analysis of $B \to D^0 h$ decays, with $h = \pi, K$ and the D^0 reconstructed in the channels $K^-\pi^+$, $K^-\pi^+\pi^+\pi^-$, $K^-\pi^+\pi^0$ and in the CP eigenstate K^-K^+, using data collected by the *BABAR* detector during the years 2000-2002 at the PEP-II asymmetric-energy B Factory at SLAC. We have measured the ratio of the branching fractions

$$R \equiv \frac{\mathcal{B}(B^- \to D^0 K^-)}{\mathcal{B}(B^- \to D^0 \pi^-)} = (8.31 \pm 0.35 \pm 0.20)\%$$

and the direct CP asymmetry

$$A_{CP} \equiv \frac{\mathcal{B}(B^- \to D^0_{CP} K^-) - \mathcal{B}(B^+ \to D^0_{CP} K^+)}{\mathcal{B}(B^- \to D^0_{CP} K^-) + \mathcal{B}(B^+ \to D^0_{CP} K^+)} = 0.17 \pm 0.23\,^{+0.09}_{-0.07}\ .$$

Contributed to the 31^{st} International Conference on High Energy Physics,
7/24—7/31/2002, Amsterdam, The Netherlands

Stanford Linear Accelerator Center, Stanford University, Stanford, CA 94309

Work supported in part by Department of Energy contract DE-AC03-76SF00515.

The *BABAR* Collaboration,

B. Aubert, D. Boutigny, J.-M. Gaillard, A. Hicheur, Y. Karyotakis, J. P. Lees, P. Robbe, V. Tisserand, A. Zghiche

Laboratoire de Physique des Particules, F-74941 Annecy-le-Vieux, France

A. Palano, A. Pompili

Università di Bari, Dipartimento di Fisica and INFN, I-70126 Bari, Italy

J. C. Chen, N. D. Qi, G. Rong, P. Wang, Y. S. Zhu

Institute of High Energy Physics, Beijing 100039, China

G. Eigen, I. Ofte, B. Stugu

University of Bergen, Inst. of Physics, N-5007 Bergen, Norway

G. S. Abrams, A. W. Borgland, A. B. Breon, D. N. Brown, J. Button-Shafer, R. N. Cahn, E. Charles, M. S. Gill, A. V. Gritsan, Y. Groysman, R. G. Jacobsen, R. W. Kadel, J. Kadyk, L. T. Kerth, Yu. G. Kolomensky, J. F. Kral, C. LeClerc, M. E. Levi, G. Lynch, L. M. Mir, P. J. Oddone, T. J. Orimoto, M. Pripstein, N. A. Roe, A. Romosan, M. T. Ronan, V. G. Shelkov, A. V. Telnov, W. A. Wenzel

Lawrence Berkeley National Laboratory and University of California, Berkeley, CA 94720, USA

T. J. Harrison, C. M. Hawkes, D. J. Knowles, S. W. O'Neale, R. C. Penny, A. T. Watson, N. K. Watson

University of Birmingham, Birmingham, B15 2TT, United Kingdom

T. Deppermann, K. Goetzen, H. Koch, B. Lewandowski, K. Peters, H. Schmuecker, M. Steinke

Ruhr Universität Bochum, Institut für Experimentalphysik 1, D-44780 Bochum, Germany

N. R. Barlow, W. Bhimji, J. T. Boyd, N. Chevalier, P. J. Clark, W. N. Cottingham, C. Mackay, F. F. Wilson

University of Bristol, Bristol BS8 1TL, United Kingdom

K. Abe, C. Hearty, T. S. Mattison, J. A. McKenna, D. Thiessen

University of British Columbia, Vancouver, BC, Canada V6T 1Z1

S. Jolly, A. K. McKemey

Brunel University, Uxbridge, Middlesex UB8 3PH, United Kingdom

V. E. Blinov, A. D. Bukin, A. R. Buzykaev, V. B. Golubev, V. N. Ivanchenko, A. A. Korol, E. A. Kravchenko, A. P. Onuchin, S. I. Serednyakov, Yu. I. Skovpen, A. N. Yushkov

Budker Institute of Nuclear Physics, Novosibirsk 630090, Russia

D. Best, M. Chao, D. Kirkby, A. J. Lankford, M. Mandelkern, S. McMahon, D. P. Stoker

University of California at Irvine, Irvine, CA 92697, USA

C. Buchanan, S. Chun

University of California at Los Angeles, Los Angeles, CA 90024, USA

H. K. Hadavand, E. J. Hill, D. B. MacFarlane, H. Paar, S. Prell, Sh. Rahatlou, G. Raven, U. Schwanke, V. Sharma

University of California at San Diego, La Jolla, CA 92093, USA

J. W. Berryhill, C. Campagnari, B. Dahmes, P. A. Hart, N. Kuznetsova, S. L. Levy, O. Long, A. Lu, M. A. Mazur, J. D. Richman, W. Verkerke

University of California at Santa Barbara, Santa Barbara, CA 93106, USA

J. Beringer, A. M. Eisner, M. Grothe, C. A. Heusch, W. S. Lockman, T. Pulliam, T. Schalk, R. E. Schmitz, B. A. Schumm, A. Seiden, M. Turri, W. Walkowiak, D. C. Williams, M. G. Wilson

University of California at Santa Cruz, Institute for Particle Physics, Santa Cruz, CA 95064, USA

E. Chen, G. P. Dubois-Felsmann, A. Dvoretskii, D. G. Hitlin, F. C. Porter, A. Ryd, A. Samuel, S. Yang

California Institute of Technology, Pasadena, CA 91125, USA

S. Jayatilleke, G. Mancinelli, B. T. Meadows, M. D. Sokoloff

University of Cincinnati, Cincinnati, OH 45221, USA

T. Barillari, P. Bloom, W. T. Ford, U. Nauenberg, A. Olivas, P. Rankin, J. Roy, J. G. Smith, W. C. van Hoek, L. Zhang

University of Colorado, Boulder, CO 80309, USA

J. L. Harton, T. Hu, M. Krishnamurthy, A. Soffer, W. H. Toki, R. J. Wilson, J. Zhang

Colorado State University, Fort Collins, CO 80523, USA

D. Altenburg, T. Brandt, J. Brose, T. Colberg, M. Dickopp, R. S. Dubitzky, A. Hauke, E. Maly, R. Müller-Pfefferkorn, S. Otto, K. R. Schubert, R. Schwierz, B. Spaan, L. Wilden

Technische Universität Dresden, Institut für Kern- und Teilchenphysik, D-01062 Dresden, Germany

D. Bernard, G. R. Bonneaud, F. Brochard, J. Cohen-Tanugi, S. Ferrag, S. T'Jampens, Ch. Thiebaux, G. Vasileiadis, M. Verderi

Ecole Polytechnique, LLR, F-91128 Palaiseau, France

A. Anjomshoaa, R. Bernet, A. Khan, D. Lavin, F. Muheim, S. Playfer, J. E. Swain, J. Tinslay

University of Edinburgh, Edinburgh EH9 3JZ, United Kingdom

M. Falbo

Elon University, Elon University, NC 27244-2010, USA

C. Borean, C. Bozzi, L. Piemontese, A. Sarti

Università di Ferrara, Dipartimento di Fisica and INFN, I-44100 Ferrara, Italy

E. Treadwell

Florida A&M University, Tallahassee, FL 32307, USA

F. Anulli,[1] R. Baldini-Ferroli, A. Calcaterra, R. de Sangro, D. Falciai, G. Finocchiaro, P. Patteri, I. M. Peruzzi,[1] M. Piccolo, A. Zallo

Laboratori Nazionali di Frascati dell'INFN, I-00044 Frascati, Italy

S. Bagnasco, A. Buzzo, R. Contri, G. Crosetti, M. Lo Vetere, M. Macri, M. R. Monge, S. Passaggio, F. C. Pastore, C. Patrignani, E. Robutti, A. Santroni, S. Tosi

Università di Genova, Dipartimento di Fisica and INFN, I-16146 Genova, Italy

[1] Also with Università di Perugia, I-06100 Perugia, Italy

S. Bailey, M. Morii
Harvard University, Cambridge, MA 02138, USA

R. Bartoldus, G. J. Grenier, U. Mallik
University of Iowa, Iowa City, IA 52242, USA

J. Cochran, H. B. Crawley, J. Lamsa, W. T. Meyer, E. I. Rosenberg, J. Yi
Iowa State University, Ames, IA 50011-3160, USA

M. Davier, G. Grosdidier, A. Höcker, H. M. Lacker, S. Laplace, F. Le Diberder, V. Lepeltier, A. M. Lutz, T. C. Petersen, S. Plaszczynski, M. H. Schune, L. Tantot, S. Trincaz-Duvoid, G. Wormser
Laboratoire de l'Accélérateur Linéaire, F-91898 Orsay, France

R. M. Bionta, V. Brigljević , D. J. Lange, K. van Bibber, D. M. Wright
Lawrence Livermore National Laboratory, Livermore, CA 94550, USA

A. J. Bevan, J. R. Fry, E. Gabathuler, R. Gamet, M. George, M. Kay, D. J. Payne, R. J. Sloane, C. Touramanis
University of Liverpool, Liverpool L69 3BX, United Kingdom

M. L. Aspinwall, D. A. Bowerman, P. D. Dauncey, U. Egede, I. Eschrich, G. W. Morton, J. A. Nash, P. Sanders, D. Smith, G. P. Taylor
University of London, Imperial College, London, SW7 2BW, United Kingdom

J. J. Back, G. Bellodi, P. Dixon, P. F. Harrison, R. J. L. Potter, H. W. Shorthouse, P. Strother, P. B. Vidal
Queen Mary, University of London, E1 4NS, United Kingdom

G. Cowan, H. U. Flaecher, S. George, M. G. Green, A. Kurup, C. E. Marker, T. R. McMahon, S. Ricciardi, F. Salvatore, G. Vaitsas, M. A. Winter
University of London, Royal Holloway and Bedford New College, Egham, Surrey TW20 0EX, United Kingdom

D. Brown, C. L. Davis
University of Louisville, Louisville, KY 40292, USA

J. Allison, R. J. Barlow, A. C. Forti, F. Jackson, G. D. Lafferty, A. J. Lyon, N. Savvas, J. H. Weatherall, J. C. Williams
University of Manchester, Manchester M13 9PL, United Kingdom

A. Farbin, A. Jawahery, V. Lillard, D. A. Roberts, J. R. Schieck
University of Maryland, College Park, MD 20742, USA

G. Blaylock, C. Dallapiccola, K. T. Flood, S. S. Hertzbach, R. Kofler, V. B. Koptchev, T. B. Moore, H. Staengle, S. Willocq
University of Massachusetts, Amherst, MA 01003, USA

B. Brau, R. Cowan, G. Sciolla, F. Taylor, R. K. Yamamoto
Massachusetts Institute of Technology, Laboratory for Nuclear Science, Cambridge, MA 02139, USA

M. Milek, P. M. Patel
McGill University, Montréal, QC, Canada H3A 2T8

F. Palombo

Università di Milano, Dipartimento di Fisica and INFN, I-20133 Milano, Italy

J. M. Bauer, L. Cremaldi, V. Eschenburg, R. Kroeger, J. Reidy, D. A. Sanders, D. J. Summers

University of Mississippi, University, MS 38677, USA

C. Hast, P. Taras

Université de Montréal, Laboratoire René J. A. Lévesque, Montréal, QC, Canada H3C 3J7

H. Nicholson

Mount Holyoke College, South Hadley, MA 01075, USA

C. Cartaro, N. Cavallo, G. De Nardo, F. Fabozzi, C. Gatto, L. Lista, P. Paolucci, D. Piccolo, C. Sciacca

Università di Napoli Federico II, Dipartimento di Scienze Fisiche and INFN, I-80126, Napoli, Italy

J. M. LoSecco

University of Notre Dame, Notre Dame, IN 46556, USA

J. R. G. Alsmiller, T. A. Gabriel

Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA

J. Brau, R. Frey, M. Iwasaki, C. T. Potter, N. B. Sinev, D. Strom, E. Torrence

University of Oregon, Eugene, OR 97403, USA

F. Colecchia, A. Dorigo, F. Galeazzi, M. Margoni, M. Morandin, M. Posocco, M. Rotondo, F. Simonetto, R. Stroili, C. Voci

Università di Padova, Dipartimento di Fisica and INFN, I-35131 Padova, Italy

M. Benayoun, H. Briand, J. Chauveau, P. David, Ch. de la Vaissière, L. Del Buono, O. Hamon, Ph. Leruste, J. Ocariz, M. Pivk, L. Roos, J. Stark

Universités Paris VI et VII, Lab de Physique Nucléaire H. E., F-75252 Paris, France

P. F. Manfredi, V. Re, V. Speziali

Università di Pavia, Dipartimento di Elettronica and INFN, I-27100 Pavia, Italy

L. Gladney, Q. H. Guo, J. Panetta

University of Pennsylvania, Philadelphia, PA 19104, USA

C. Angelini, G. Batignani, S. Bettarini, M. Bondioli, F. Bucci, G. Calderini, E. Campagna, M. Carpinelli, F. Forti, M. A. Giorgi, A. Lusiani, G. Marchiori, F. Martinez-Vidal, M. Morganti, N. Neri, E. Paoloni, M. Rama, G. Rizzo, F. Sandrelli, G. Triggiani, J. Walsh

Università di Pisa, Scuola Normale Superiore and INFN, I-56010 Pisa, Italy

M. Haire, D. Judd, K. Paick, L. Turnbull, D. E. Wagoner

Prairie View A&M University, Prairie View, TX 77446, USA

J. Albert, G. Cavoto,[2] N. Danielson, P. Elmer, C. Lu, V. Miftakov, J. Olsen, S. F. Schaffner, A. J. S. Smith, A. Tumanov, E. W. Varnes

Princeton University, Princeton, NJ 08544, USA

[2] Also with Università di Roma La Sapienza, Roma, Italy

F. Bellini, D. del Re, R. Faccini,[3] F. Ferrarotto, F. Ferroni, E. Leonardi, M. A. Mazzoni, S. Morganti, G. Piredda, F. Safai Tehrani, M. Serra, C. Voena

Università di Roma La Sapienza, Dipartimento di Fisica and INFN, I-00185 Roma, Italy

S. Christ, G. Wagner, R. Waldi

Universität Rostock, D-18051 Rostock, Germany

T. Adye, N. De Groot, B. Franek, N. I. Geddes, G. P. Gopal, S. M. Xella

Rutherford Appleton Laboratory, Chilton, Didcot, Oxon, OX11 0QX, United Kingdom

R. Aleksan, S. Emery, A. Gaidot, P.-F. Giraud, G. Hamel de Monchenault, W. Kozanecki, M. Langer, G. W. London, B. Mayer, G. Schott, B. Serfass, G. Vasseur, Ch. Yeche, M. Zito

DAPNIA, Commissariat à l'Energie Atomique/Saclay, F-91191 Gif-sur-Yvette, France

M. V. Purohit, A. W. Weidemann, F. X. Yumiceva

University of South Carolina, Columbia, SC 29208, USA

I. Adam, D. Aston, N. Berger, A. M. Boyarski, M. R. Convery, D. P. Coupal, D. Dong, J. Dorfan, W. Dunwoodie, R. C. Field, T. Glanzman, S. J. Gowdy, E. Grauges , T. Haas, T. Hadig, V. Halyo, T. Himel, T. Hryn'ova, M. E. Huffer, W. R. Innes, C. P. Jessop, M. H. Kelsey, P. Kim, M. L. Kocian, U. Langenegger, D. W. G. S. Leith, S. Luitz, V. Luth, H. L. Lynch, H. Marsiske, S. Menke, R. Messner, D. R. Muller, C. P. O'Grady, V. E. Ozcan, A. Perazzo, M. Perl, S. Petrak, H. Quinn, B. N. Ratcliff, S. H. Robertson, A. Roodman, A. A. Salnikov, T. Schietinger, R. H. Schindler, J. Schwiening, G. Simi, A. Snyder, A. Soha, S. M. Spanier, J. Stelzer, D. Su, M. K. Sullivan, H. A. Tanaka, J. Va'vra, S. R. Wagner, M. Weaver, A. J. R. Weinstein, W. J. Wisniewski, D. H. Wright, C. C. Young

Stanford Linear Accelerator Center, Stanford, CA 94309, USA

P. R. Burchat, C. H. Cheng, T. I. Meyer, C. Roat

Stanford University, Stanford, CA 94305-4060, USA

R. Henderson

TRIUMF, Vancouver, BC, Canada V6T 2A3

W. Bugg, H. Cohn

University of Tennessee, Knoxville, TN 37996, USA

J. M. Izen, I. Kitayama, X. C. Lou

University of Texas at Dallas, Richardson, TX 75083, USA

F. Bianchi, M. Bona, D. Gamba

Università di Torino, Dipartimento di Fisica Sperimentale and INFN, I-10125 Torino, Italy

L. Bosisio, G. Della Ricca, S. Dittongo, L. Lanceri, P. Poropat, L. Vitale, G. Vuagnin

Università di Trieste, Dipartimento di Fisica and INFN, I-34127 Trieste, Italy

R. S. Panvini

Vanderbilt University, Nashville, TN 37235, USA

[3] Also with University of California at San Diego, La Jolla, CA 92093, USA

S. W. Banerjee, C. M. Brown, D. Fortin, P. D. Jackson, R. Kowalewski, J. M. Roney

University of Victoria, Victoria, BC, Canada V8W 3P6

H. R. Band, S. Dasu, M. Datta, A. M. Eichenbaum, H. Hu, J. R. Johnson, R. Liu, F. Di Lodovico, A. Mohapatra, Y. Pan, R. Prepost, I. J. Scott, S. J. Sekula, J. H. von Wimmersperg-Toeller, J. Wu, S. L. Wu, Z. Yu

University of Wisconsin, Madison, WI 53706, USA

H. Neal

Yale University, New Haven, CT 06511, USA

1 Introduction

During the last ten years there has been growing theoretical interest in knowing the decay rates for the processes $B^- \to D^0 K^-$ [1] and $B^\pm \to D^0_{CP} K^\pm$, where D^0_{CP} indicates the *CP*-even or *CP*-odd states $(D^0 \pm \overline{D}^0)/\sqrt{2}$. These modes are key ingredients for some of the recently proposed methods for extracting the angle γ of the Cabibbo-Kobayashi-Maskawa quark mixing matrix in a theoretically clean way [1, 2].

In this paper we present an analysis of the decay $B^- \to D^0 K^-$ in which the D^0 is reconstructed in the non-*CP* eigenstates $K^-\pi^+$, $K^-\pi^+\pi^+\pi^-$, $K^-\pi^+\pi^0$, or in the *CP*-even eigenstate K^-K^+. The ratio R between the branching fractions of $B^- \to D^0 K^-$ and $B^- \to D^0 \pi^-$

$$R \equiv \frac{\mathcal{B}(B^- \to D^0 K^-)}{\mathcal{B}(B^- \to D^0 \pi^-)} \tag{1}$$

is measured, along with the ratio R_{CP} between the branching fractions of $B^\pm \to D^0_{CP} K^\pm$ and $B^\pm \to D^0_{CP} \pi^\pm$

$$R_{CP} \equiv \frac{\mathcal{B}(B^- \to D^0_{CP} K^-) + \mathcal{B}(B^+ \to D^0_{CP} K^+)}{\mathcal{B}(B^- \to D^0_{CP} \pi^-) + \mathcal{B}(B^+ \to D^0_{CP} \pi^+)}. \tag{2}$$

The yields of $B^- \to D^0_{CP} K^-$ and $B^+ \to D^0_{CP} K^+$ are separately extracted, and the *CP* asymmetry

$$A_{CP} \equiv \frac{\mathcal{B}(B^- \to D^0_{CP} K^-) - \mathcal{B}(B^+ \to D^0_{CP} K^+)}{\mathcal{B}(B^- \to D^0_{CP} K^-) + \mathcal{B}(B^+ \to D^0_{CP} K^+)} \tag{3}$$

is measured.

The $B^- \to D^0 K^-$ decay was first observed by the CLEO collaboration [3]. Using a sample of 3.1 fb^{-1} collected at the $\Upsilon(4S)$ resonance, CLEO measured $R = (5.5 \pm 1.4 \pm 0.5)\%$. Recently, based on 10.4 fb^{-1} collected at the $\Upsilon(4S)$, Belle has measured $R = (7.9 \pm 0.9 \pm 0.6)\%$ [4]. Belle also reported, using a sample of 29.1 fb^{-1}, measurements of the direct *CP* asymmetries for the *CP*-even and *CP*-odd modes, $A_{CP}(+1) = (0.29 \pm 0.26 \pm 0.05)\%$ and $A_{CP}(-1) = (-0.22 \pm 0.24 \pm 0.04)\%$ [5].

2 The *BABAR* detector and dataset

The data used in this analysis were collected with the *BABAR* detector at the PEP-II storage ring during the years 2000-2002. The sample corresponds to an integrated luminosity of about 75 fb^{-1} accumulated at the $\Upsilon(4S)$ resonance ("on-resonance") and about 10 fb^{-1} accumulated at a center-of-mass (CM) energy about 40 MeV below the $\Upsilon(4S)$ resonance ("off-resonance"). Data taken below the $\Upsilon(4S)$ are used for continuum background studies. The on-resonance sample corresponds to $(81.1 \pm 0.9) \times 10^6$ $B\overline{B}$ pairs. The results regarding the non-*CP* modes are based on a subsample of data collected in the years 2000-2001; this corresponds to an integrated luminosity of about 56 fb^{-1} accumulated at the $\Upsilon(4S)$ resonance, which in turn corresponds to $(61.2 \pm 0.7) \times 10^6$ $B\overline{B}$ pairs.

PEP-II is an e^+e^- storage ring operated with asymmetric beam energies, producing a boosted $(\beta\gamma = 0.55)$ $\Upsilon(4S)$ along the collision axis. *BABAR* is a solenoidal detector optimized for the asymmetric beam configuration at PEP-II and is described in detail in Ref. [6]. Charged particle (track) momenta are measured in a tracking system consisting of a 5-layer, double-sided, silicon

[1] Charge conjugation is implied here and throughout this paper unless explicitly stated.

vertex tracker (SVT) and a 40-layer drift chamber (DCH) filled with a gas mixture of helium and isobutane, both operating within a 1.5 T superconducting solenoidal magnet. Photon candidates are selected as local maxima of deposited energy in an electromagnetic calorimeter (EMC) consisting of 6580 CsI(Tl) crystals arranged in barrel and forward endcap subdetectors. Particle identification is performed by combining information from ionization measurements (dE/dx) in the SVT and DCH, and the Cherenkov angle θ_C measured by a detector of internally reflected Cherenkov light (DIRC). The DIRC system is a unique type of Cherenkov detector that relies on total internal reflection within the radiating volumes (quartz bars) to deliver the Cherenkov light outside the tracking and magnetic volumes, where the Cherenkov ring is imaged by an array of ∼11000 photomultiplier tubes.

3 Event selection

We reconstruct B mesons decaying to a D^0 meson and a charged prompt track h, where h is a pion or a kaon. D^0 meson candidates are reconstructed in four decay modes: $D^0 \to K^-\pi^+$, $D^0 \to K^-\pi^+\pi^+\pi^-$, $D^0 \to K^-\pi^+\pi^0$ and $D^0 \to K^-K^+$. The decay $B^- \to D^0\pi^-$ is used to evaluate detector resolutions, systematic uncertainties and to normalize branching fractions.

All charged tracks are reconstructed in the drift chamber and/or the vertex detector, and their parameters determined with the pion mass hypothesis. In order to reduce the combinatorial background, only charged tracks with momentum greater than 150 MeV/c are used in the reconstruction of $D^0 \to K^-\pi^+\pi^+\pi^-$ and $D^0 \to K^-\pi^+\pi^0$; the prompt track h is required to have momentum greater than 1.4 GeV/c. Particle ID information from the drift chamber (dE/dx) and, when available, from the DIRC is required to be consistent with the kaon hypothesis for the K meson candidate from the D^0. In order for the prompt track h to be identified as a pion or a kaon we require that its Cherenkov angle be reconstructed in the DIRC with at least five photons. We reject candidate tracks whose Cherenkov angle is within 3 standard deviations (σ, where σ means the experimental resolution) from the expected angle for the proton hypothesis, and candidate tracks that are identified as electrons by the DCH and the EMC.

Candidate π^0 mesons are reconstructed from a combination of two photon candidates. Photon candidates are selected as showers in the EMC that have the expected lateral shape, are not matched with any charged track, and have a minimum energy of 70 MeV. The $\gamma\gamma$ invariant mass is required to be in the range 124–144 MeV/c^2, and the total energy of the γ pair must exceed 200 MeV. The $\pi^0 \to \gamma\gamma$ candidates are then kinematically fit with their mass constrained to the nominal π^0 mass [7].

The invariant mass of $D^0 \to K^-\pi^+$, $D^0 \to K^-\pi^+\pi^+\pi^-$ and $D^0 \to K^-K^+$ candidates is required to be within 3 σ of the mean mass value. As the combinatorial background of the $D^0 \to K^-\pi^+\pi^0$ decays is larger due to the presence of a neutral pion, a 2-σ cut on the invariant mass is applied for this mode. D^0 candidates are then kinematically fit with their mass constrained to the nominal D^0 mass [7], in order to improve momentum determination.

We reconstruct B meson candidates by combining a D^0 candidate with a track h. For the non-CP modes, the charge of the bachelor track h must match that of the kaon from the D^0 meson decay. We exploit our knowledge of the initial state momentum and energy to select B meson candidates by defining two largely uncorrelated variables. The first is the *beam-energy substituted mass* $m_{\rm ES} = \sqrt{E_{\rm b}^2 - \mathbf{p}_B^2}$, where $E_{\rm b} = (s/2 + \mathbf{p}_i \cdot \mathbf{p}_B)/E_i$, $\sqrt{s}$ and E_i are the total energies of the e^+e^- system in the CM and lab frames, respectively, and $\mathbf{p}_i$ and $\mathbf{p}_B$ are the momentum vectors in the lab frame of the e^+e^- system and the B candidate, respectively. The second is the *energy* *difference* ΔE, which is defined as the difference between the energy of the B candidate and half the energy of the e^+e^- system, computed in the CM system. The $m_{\rm ES}$ resolution is dominated by the beam energy spread, while for ΔE the main contribution comes from the measurement of particle energies in the detector.

The $m_{\rm ES}$ distribution for $B^- \to D^0 h^-$ signals does not depend on whether the prompt track h is a pion or a kaon, nor, to first order, on the D^0 momentum resolution. This has been checked both for signal Monte Carlo and for data. The $m_{\rm ES}$ resolution for the $B^- \to D^0 h^-$ channels is found to be $2.6\,{\rm MeV}/c^2$, regardless of the D^0 decay mode.

In contrast, the ΔE distributions depend on the nature of the bachelor track h and on the resolution for the D^0 meson momentum. We evaluate ΔE with the kaon mass hypothesis (and denote it by ΔE_K to avoid confusion) in such a way that the distributions are centered near 0 for $B^- \to D^0 K^-$ events and shifted by approximately 42 MeV for $B^- \to D^0 \pi^-$ events. The ΔE_K resolution is typically 17 MeV for all D^0 decay modes.

B candidates are selected in the range $5.2 < m_{\rm ES} < 5.3\,{\rm GeV}/c^2$ and $-0.100 < \Delta E < 0.130$ GeV. For events with multiple B candidates, the best candidate is chosen based on the values of the D^0 invariant mass and $m_{\rm ES}$.

4 Background rejection

The physics backgrounds for the considered modes originate both from the continuum production of light quarks, $e^+e^- \to q\overline{q}$ ($q = u, d, s, c$), and from $B\overline{B}$ events. In the center-of-mass frame, the continuum background typically exhibits a two-jet structure; in contrast, the low momentum of the B meson in the decay $\Upsilon(4S) \to B\overline{B}$ leads to a more spherically symmetric event. We exploit this topology difference between signal and continuum background by making use of two event-shape quantities.

The first variable is the normalized second Fox-Wolfram moment [8], $R_2 \equiv \frac{H_2}{H_0}$, where H_l is the l–order Fox-Wolfram moment. R_2 is required to be less than 0.5 for all the selected events.

The second quantity is the angle θ_T between the thrust axes, evaluated in the center-of-mass frame, of the B candidate and the remaining charged and neutral particles in the event. The absolute value of the cosine of this angle is strongly peaked near 1 for continuum events and is approximately uniform for $B\overline{B}$ events. $|\cos\theta_T|$ is required to be less than 0.9 for the $D^0 \to K^-\pi^+$ mode, and this value is tightened to 0.7 for $D^0 \to K^-\pi^+\pi^+\pi^-$ and $D^0 \to K^-\pi^+\pi^0$ modes, which suffer from larger combinatorial background.

For the $D^0 \to K^-K^+$ mode an additional quantity, the D^0 rest frame decay angle θ_{KK}, is used in conjunction with $|\cos\theta_T|$. The angle θ_{KK} is defined as the angle between the direction of the D^0 calculated in the rest frame of the B and the direction of one of the decay products of the D^0 calculated in the rest frame of the D^0. The distribution of $\cos\theta_{KK}$ is flat for signal and peaked at ± 1 for fake D^0 background. $|\cos\theta_T|$ and $\cos\theta_{KK}$ are uncorrelated for signal but *not* for continuum background. This correlation is exploited to make a more efficient cut in the $\cos\theta_T - \cos\theta_{KK}$ plane.

The main contributions from $B\overline{B}$ background come from the processes $B^- \to D^{*0} h^-$ ($h = \pi, K$), $B^- \to D^0 \rho^-$ and from mis-reconstructed $B^- \to D^0 h^-$ decays. Background from the charmless three-body process $B^- \to K^-K^+K^-$ is potentially the most critical for the $B^- \to D^0 K^-$, $D^0 \to K^-K^+$ decay, because it consists of three kaons coming from a B meson and hence is characterized by the same ΔE and $m_{\rm ES}$ distribution as the signal. Results from recent studies [9] of the resonant composition of such a decay have been used to estimate this non-negligible background.

The total number of B candidates and the final selection efficiency ε for each mode are summarized in Table 1. The small differences between $B^- \to D^0\pi^-$ and $B^- \to D^0K^-$ efficiences arise both from reconstruction (kaons have lower dE/dx than pions and hence fewer hits associated to the track) and from candidate selection (the rejection of electrons and protons has different efficiencies for kaons and pions).

Table 1: Number of candidates selected for the maximum-likelihood fit and final selection efficiencies. The selection efficiency has been evaluated on simulated events.

D^0 decay mode	events selected	$\varepsilon(B^- \to D^0\pi^-)$	$\varepsilon(B^- \to D^0K^-)$	$\int \mathcal{L}\,dt$ (fb^{-1})
$K^-\pi^+$	12606	$(43.65 \pm 0.12)\%$	$(42.17 \pm 0.31)\%$	56.0
$K^-\pi^+\pi^+\pi^-$	9782	$(14.53 \pm 0.17)\%$	$(13.55 \pm 0.22)\%$	56.0
$K^-\pi^+\pi^0$	8177	$(8.04 \pm 0.11)\%$	$(8.12 \pm 0.18)\%$	56.0
K^-K^+	2389	$(34.5 \pm 0.2)\%$	$(33.7 \pm 0.3)\%$	74.8

5 Signal extraction

For each D^0 decay mode an extended unbinned maximum-likelihood fit to the selected data events determines the signal and background yields n_i ($i = 1$ to M, where M is the total number of signal and background species). We consider two kinds of signal events, $B^- \to D^0\pi^-$ and $B^- \to D^0K^-$, and four kinds of background events: candidates selected either from continuum or from $B\overline{B}$ events, in which the prompt track h is either a pion or a kaon. In the case of $B^- \to D^0h^-$, $D^0 \to K^-K^+$ events, the fit is also performed on the B^+ and B^- subsamples separately.

The input variables to the fit are $m_{\rm ES}$, ΔE_K, and a particle identification probability for the bachelor track h based on the Cherenkov angle θ_C, the momentum p at the DIRC and the polar angle θ of the track. The extended likelihood function $\mathcal{L}$ is defined as

$$\mathcal{L} = \exp\left(-\sum_{i=1}^{M} n_i\right) \prod_{j=1}^{N}\left[\sum_{i=1}^{M} n_i \mathcal{P}_i\left(\vec{x}_j; \vec{\alpha}_i\right)\right]. \tag{4}$$

The exponential factor in the likelihood accounts for Poisson fluctuations in the total number of observed events N. The M functions $\mathcal{P}_i(\vec{x}_j; \vec{\alpha}_i)$ are the probability density functions (PDFs) for the variables $\vec{x}_j$, given the set of parameters $\vec{\alpha}_i$. They are evaluated as a product $\mathcal{P}_i = \mathcal{P}_i(\Delta E_K, m_{\rm ES}) \times \mathcal{P}_i(\text{DIRC})$, since $m_{\rm ES}$ and ΔE_K are not correlated with the Cherenkov angle of the prompt track.

The correlation between $m_{\rm ES}$ and ΔE_K can be neglected for signal events and for the combinatorial background from the continuum: $\mathcal{P}_i(\Delta E_K, m_{\rm ES}) = \mathcal{P}_i(\Delta E_K) \times \mathcal{P}_i(m_{\rm ES})$. However it cannot be neglected for the $B\overline{B}$ background component, for which we use a two-dimensional PDF determined from simulated events through a method based on the *Kernel Estimation* [10] technique.

The parameters for the ΔE_K and $m_{\rm ES}$ distributions for continuum background are determined from off-resonance data. The background shape in ΔE_K is parameterized as a linear polynomial, while the $m_{\rm ES}$ shape is parameterized by an ARGUS threshold function [11] $f(m_{\rm ES}) \propto m_{\rm ES}\sqrt{1-x^2}\exp[-\xi(1-x^2)]$, where $x = m_{\rm ES}/m_0$ and m_0 is the average CM beam energy.

The $m_{\rm ES}$ PDF for signal events is determined from a pure sample of $B^- \to D^0\pi^-$, $D^0 \to K^-\pi^+$ decays selected from on-resonance data by applying the standard selection plus a 3 σ cut on ΔE_π. $B\overline{B}$ background is negligible in this channel; therefore the $m_{\rm ES}$ distribution is fit by a Gaussian signal over a background described by an ARGUS function. The resulting Gaussian shape is used to parameterize the $m_{\rm ES}$ PDF for the $B^- \to D^0 h^-$ signals.

The parameterization of the ΔE_K distribution for $B^- \to D^0 K^-$events is deduced from that of ΔE_π for $B^- \to D^0\pi^-$ events in the data. The ΔE_π distribution for a pure sample of $B^- \to D^0\pi^-$decays, selected by applying the standard selection plus a 3 σ cut on $m_{\rm ES}$ and the requirement that the bachelor track h not be consistent with the kaon hypothesis, is fit by a Gaussian signal over a linear background. The resulting Gaussian shape is used to parameterize the ΔE_K PDF for the $B^- \to D^0 K^-$ signal. We also use the ΔE_π resolution together with the known momentum spectrum of the bachelor track in the laboratory frame to generate a "translated" ΔE_K distribution for $B^- \to D^0\pi^-$ events: for each generated value of ΔE_π and p, we calculate the energy shift according to $\Delta E_{\rm shift} \equiv \Delta E_K - \Delta E_\pi = \gamma\left(\sqrt{m_K^2 + \vec{p}^{\,2}} - \sqrt{m_\pi^2 + \vec{p}^{\,2}}\right)$, where γ is the Lorentz boost of the center-of-mass frame. The resulting ΔE_K distribution is empirically parameterized by the sum of two Gaussians.

The θ_C PDFs are derived from kaon and pion tracks in the momentum range of interest from a sample of $D^{*+} \to D^0\pi^+$ ($D^0 \to K^-\pi^+$) decays. Since the θ_C resolution depends in principle uniquely on the number of found photons, and the number of expected photons depends on both the track polar angle and momentum, we use this sample to parameterize the θ_C resolution as a function of track polar angle and momentum extrapolated to the DIRC.

The results of the fit are summarized in Table 2 and the ΔE_K distributions are shown in Fig. 1 for all the D^0 modes. The projection of the likelihood fit is overlaid on the distributions. The individual contributions of each of the signals and the total background are shown.

In order to increase the relative fraction of signal $B^- \to D^0 K^-$ events for illustration only, candidates are selected with the further requirements that the prompt track be identified as a kaon and $|m_{\rm ES} - \langle m_{\rm ES}\rangle| < 3\sigma$. The ΔE_K distributions of the selected candidates are shown in Figure 2 for all modes. The peak around zero from $B^- \to D^0 K^-$ candidates is visible, but the efficiency for the signal is decreased by 13% with respect to the standard selection outlined in Secs. 3 and 4.

Table 2: Results from the maximum-likelihood fit. For the $D^0 \to K^-K^+$mode we quote the results for the fits performed on the whole sample and on the B^+ and B^- subsamples.

D^0 decay mode	$N(B^- \to D^0\pi^-)$	$N(B^- \to D^0 K^-)$	$\int \mathcal{L}\,dt$ (fb^{-1})
$K^-\pi^+$	4440 ± 69	360 ± 21	56.0
$K^-\pi^+\pi^+\pi^-$	2914 ± 56	242 ± 18	56.0
$K^-\pi^+\pi^0$	2650 ± 56	208 ± 18	56.0
K^-K^+	508 ± 24	37 ± 8	74.8
K^-K^+ $[B^+]$	254 ± 17	15 ± 6	74.8
K^-K^+ $[B^-]$	254 ± 17	22 ± 6	74.8

6 Systematic studies

Systematic uncertainties on the ratio R and on the CP asymmetry A_{CP} arise primarily from uncertainties on n_i due to imperfect knowledge of the PDF shapes. In this section we describe how the different contributions to these uncertainties have been evaluated; the results are summarized in Tables 3 and 4.

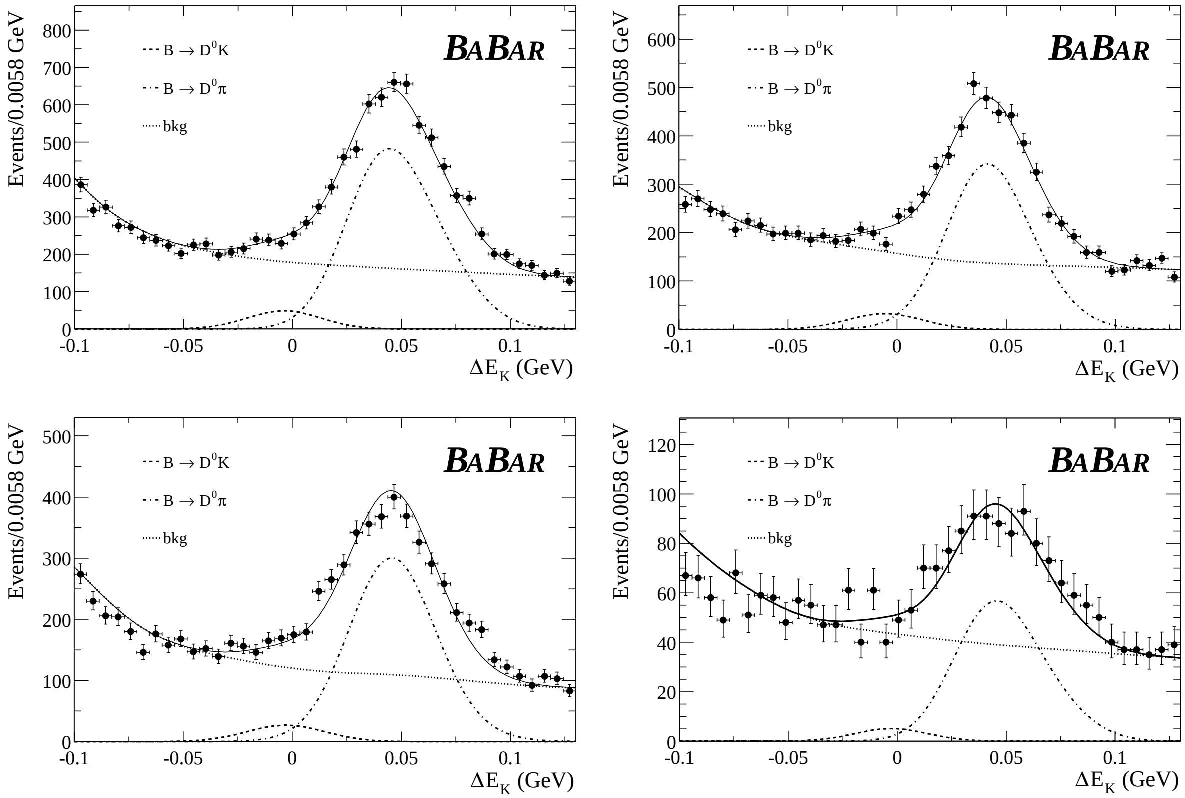

Figure 1: ΔE_K distribution of the $B^- \rightarrow D^0 h^-$ candidates selected in the data sample. As described in the text, tracks h consistent with the electron or proton hypothesis have been explicitly removed. Top left: $D^0 \rightarrow K^-\pi^+$; top right: $D^0 \rightarrow K^-\pi^+\pi^+\pi^-$; bottom left: $D^0 \rightarrow K^-\pi^+\pi^0$; bottom right: $D^0 \rightarrow K^-K^+$. The solid curve represents the projection on the ΔE_K axis of the resulting fit probability density function, scaled by the number of candidates in the sample. The contribution from the two signals and from the total background is also shown.

In the case of the $m_{\rm ES}$ and ΔE_K PDFs for the different signal and continuum background contributions, we vary the PDF parameters — which have been determined through a fit to ΔE_K and $m_{\rm ES}$ distributions in data or Monte Carlo events — by one statistical error.

The systematic uncertainty from the $B\overline{B}$ background must be treated as a special case, because the parameterization is performed through the *Kernel Estimation* and not through an analytical function. To study the systematic uncertainty associated with the uncertainty on the shape of the $B\overline{B}$ background we generate 500 different samples of $B\overline{B}$ events and for each one the corresponding PDF is used in the maximum-likelihood fit. The width of the distribution of the difference between the new yields and the original yields is used as an estimate of the systematic uncertainty. Uncertainties arising from the imperfect knowledge on the branching fractions of the different channels that contribute to the $B\overline{B}$ background are also taken into account (this is important for the $D^0 \rightarrow K^-K^+$ mode, where one of the main sources of uncertainty is the expected number of $B \rightarrow KKK$ background events).

The parameterization of the particle identification PDF is performed by fitting with a Gaussian

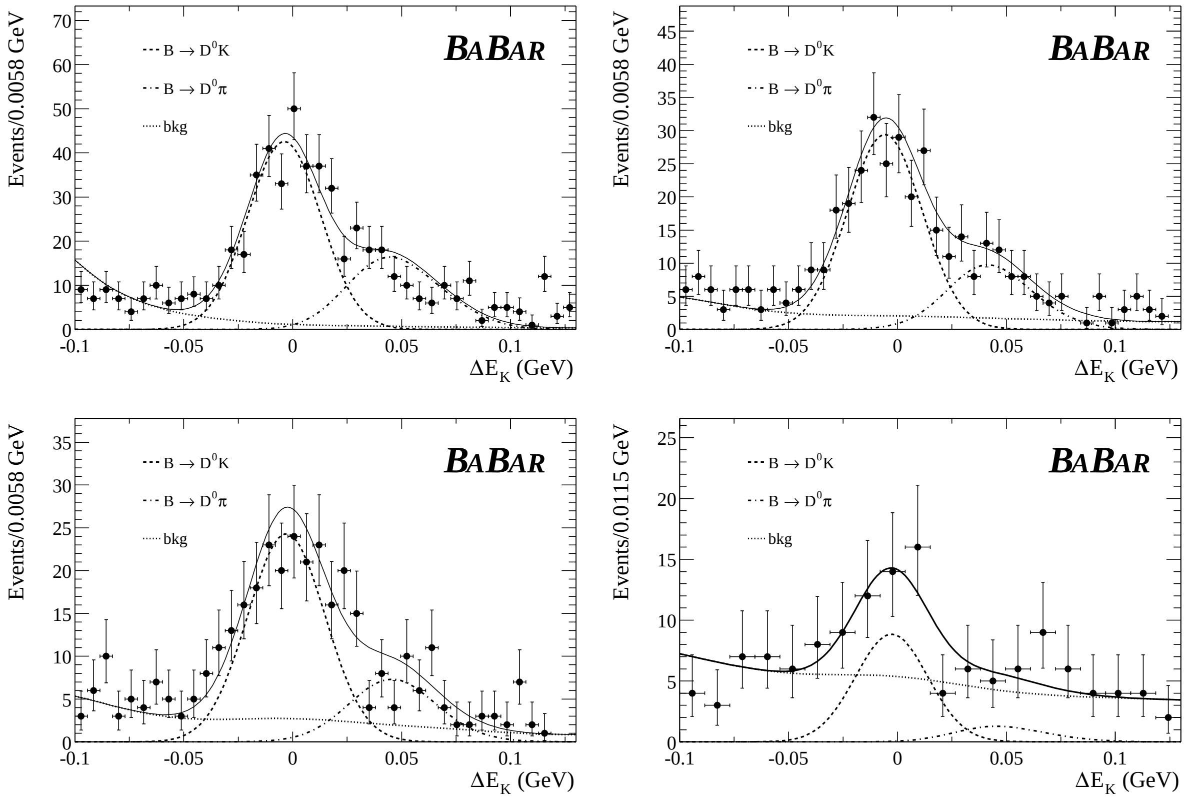

Figure 2: ΔE_K distribution of the $B^- \to D^0 h^-$ candidates selected in the data sample by requiring that the prompt track h be identified as a kaon and $|m_{\rm ES} - \langle m_{\rm ES}\rangle| < 3\sigma$. Top left: $D^0 \to K^-\pi^+$; top right: $D^0 \to K^-\pi^+\pi^+\pi^-$; bottom left: $D^0 \to K^-\pi^+\pi^0$; bottom right: $D^0 \to K^-K^+$. The peak around zero from $B^- \to D^0 K^-$ candidates is visible.

function the background-subtracted distribution of the difference between the reconstructed and expected Cherenkov angle of the charged tracks from D^0 decays in the $D^{*+} \to D^0\pi^+$ ($D^0 \to K^-\pi^+$) control sample, in bins of momentum and polar angle. Therefore, the significant parameters for each momentum-polar angle bin are the mean and the width of the fitted Gaussian. We estimate the systematic error associated with the particle identification PDF by varying by one statistical error the Gaussian parameters of each bin, while all the others are kept fixed at their central value.

The various sources of systematic errors are assumed to be uncorrelated. The total systematic error is obtained by summing in quadrature the individual contributions.

Systematic uncertainties on the charge asymmetries are added in quadrature with the limit on intrinsic charge bias in the detector (0.05), measured on data for the processes $B^- \to D^0\pi^-$ [$D^0 \to K^-\pi^+$], $B^- \to D^0K^-$ [$D^0 \to K^-\pi^+$] and $B^- \to D^0\pi^-$ [$D^0 \to K^-K^+$], where the *CP* asymmetry is expected to be zero.

7 Results

Table 3: Systematic uncertainties on the ratio R of the branching fractions of $B^- \to D^0 K^-$ and $B^- \to D^0 \pi^-$.

Parameter	Uncertainty on R (%)
$\Delta E_K (B^- \to D^0 h^-)$	± 0.13
$m_{\rm ES} (B^- \to D^0 h^-)$	± 0.01
$q\overline{q}$ background ΔE_K	± 0.01
$q\overline{q}$ background $m_{\rm ES}$	± 0.01
$B\overline{B}$ background ΔE_K *vs* $m_{\rm ES}$	± 0.04
Particle identification	± 0.16
Background composition	± 0.03
Total	± 0.20

Table 4: Systematic uncertainties on the *CP* asymmetry in the decay $B^- \to D^0 K^-$, with $D^0 \to K^- K^+$.

Parameter	Uncertainty on A_{CP} (%)
$\Delta E_K (B^- \to D^0 h^-)$	$^{+0.5}_{-0.0}$
$m_{\rm ES} (B^- \to D^0 h^-)$	$^{+0.5}_{-0.1}$
$q\overline{q}$ background ΔE_K	$^{+0.3}_{-0.0}$
$q\overline{q}$ background $m_{\rm ES}$	$^{+0.1}_{-0.7}$
$B\overline{B}$ background ΔE_K *vs* $m_{\rm ES}$	± 0.3
Particle identification	$^{+4.1}_{-0.9}$
Background composition	$^{+6.2}_{-4.4}$
Detector charge asymmetry	± 5.0
Total	$^{+9.0}_{-6.8}$

7.1 Measurement of the ratio $\mathcal{B}(B^- \to D^0 K^-)/\mathcal{B}(B^- \to D^0 \pi^-)$

The ratio of the branching fractions of the decays $B^- \to D^0 \pi^-$ and $B^- \to D^0 K^-$ is calculated separately for the three non-*CP* D^0 decay channels and for the $D^0 \to K^- K^+$ mode. The ratio is computed from the number of $B^- \to D^0 K^-$ and $B^- \to D^0 \pi^-$ mesons estimated with the maximum-likelihood fit and listed in Table 2. The resulting ratios are scaled by a correction factor that account for small differences in the efficiency between $B^- \to D^0 K^-$ and $B^- \to D^0 \pi^-$ selection, estimated with signal Monte Carlo samples. The results for the ratio of the branching fraction of the decay $B^- \to D^0 \pi^-$ and $B^- \to D^0 K^-$ with D^0 decaying to the non-*CP* modes, measured with 56.0 fb^{-1}, are listed in Table 5; they represent three independent measurements of the same quantity, and they are statistically consistent. The weighted mean of the three measurements gives the result for the non-*CP* modes:

$$R = (8.31 \pm 0.35 \pm 0.20)\% \ . \tag{5}$$

The resulting ratio of the branching fractions of the $D^0 \to K^-K^+$ mode, measured with 74.8 fb^{-1}, is also reported in Table 5 and is found to be:

$$R_{CP} = (7.4 \pm 1.7 \pm 0.6)\% \ . \tag{6}$$

In the evaluation of the statistical error on R the correlation between the numbers of $B^- \to D^0K^-$ and $B^- \to D^0\pi^-$ events obtained from the fit has been taken into account.

Table 5: Measured ratio $\mathcal{B}(B^- \to D^0K^-)/\mathcal{B}(B^- \to D^0\pi^-)$ for different D^0 decay modes.

$B^- \to D^0h^-$ decay mode	**ratio**	$\int \mathcal{L}\,dt$ (fb^{-1})
$D^0 \to K^-\pi^+$	$(8.4 \pm 0.5 \pm 0.2)\,\%$	56.0
$D^0 \to K^-\pi^+\pi^+\pi^-$	$(8.7 \pm 0.7 \pm 0.2)\,\%$	56.0
$D^0 \to K^-\pi^+\pi^0$	$(7.7 \pm 0.7 \pm 0.3)\,\%$	56.0
weighted mean	$(8.31 \pm 0.35 \pm 0.20)\,\%$	56.0
$D^0 \to K^-K^+$	$(7.4 \pm 1.7 \pm 0.6)\,\%$	74.8

7.2 Measurement of the direct *CP* asymmetry

The direct *CP* asymmetry for the $B^- \to D^0K^-$, $D^0 \to K^-K^+$ decay is calculated from the measured yields of positive and negative decays reported in Table 2. The resulting asymmetry, measured with 74.8 fb^{-1}, is

$$A_{CP} = 0.17 \pm 0.23\,^{+0.09}_{-0.07} \ . \tag{7}$$

We checked for detector charge bias by measuring the asymmetries for the processes $B^- \to D^0\pi^-$ $[D^0 \to K^-\pi^+]$, $B^- \to D^0K^-$ $[D^0 \to K^-\pi^+]$ and $B^- \to D^0\pi^-$ $[D^0 \to K^-K^+]$, where the *CP* asymmetry is expected to be zero. The measured values, $(-2.4 \pm 1.3)\%$, $(-0.6 \pm 5.0)\%$ and $(0.0 \pm 4.7)\%$, are consistent with zero.

8 Summary

The $B^- \to D^0K^-$ decays with D^0 selected in the channels $D^0 \to K^-\pi^+$, $D^0 \to K^-\pi^+\pi^+\pi^-$, $D^0 \to K^-\pi^+\pi^0$ have been reconstructed on a data sample of 56.0 fb^{-1}. The ratio R of the branching fractions $\mathcal{B}(B^- \to D^0K^-)$ and $\mathcal{B}(B^- \to D^0\pi^-)$ has been measured to be

$$R \equiv \frac{\mathcal{B}(B^- \to D^0K^-)}{\mathcal{B}(B^- \to D^0\pi^-)} = (8.31 \pm 0.35 \pm 0.20)\% \ .$$

The $B^- \to D^0K^-$ decays with D^0 decaying to the *CP*-even eigenstate $D^0 \to K^-K^+$ have been reconstructed on a data sample of 74.8 fb^{-1}. The yield has been measured separately for positive and negative B mesons. The total yield is

$$N_\pm \equiv N_{B^\pm \to D^0_{CP}K^\pm} = 36.8 \pm 8.4 \pm 4.0 \ .$$

The ratio R_{CP} of the branching fractions $\mathcal{B}(B^{\pm} \to D^0_{CP}K^{\pm})$ and $\mathcal{B}(B^{\pm} \to D^0_{CP}\pi^{\pm})$ has been measured:

$$R_{CP} \equiv \frac{\mathcal{B}(B^- \to D^0_{CP}K^-) + \mathcal{B}(B^+ \to D^0_{CP}K^+)}{\mathcal{B}(B^- \to D^0_{CP}\pi^-) + \mathcal{B}(B^+ \to D^0_{CP}\pi^+)} = (7.4 \pm 1.7 \pm 0.6)\% \; .$$

The direct CP asymmetry has been measured:

$$A_{CP} \equiv \frac{\mathcal{B}(B^- \to D^0_{CP}K^-) - \mathcal{B}(B^+ \to D^0_{CP}K^+)}{\mathcal{B}(B^- \to D^0_{CP}K^-) + \mathcal{B}(B^+ \to D^0_{CP}K^+)} = 0.17 \pm 0.23\,^{+0.09}_{-0.07} \; .$$

9 Acknowledgments

We are grateful for the extraordinary contributions of our PEP-II colleagues in achieving the excellent luminosity and machine conditions that have made this work possible. The success of this project also relies critically on the expertise and dedication of the computing organizations that support *BABAR*. The collaborating institutions wish to thank SLAC for its support and the kind hospitality extended to them. This work is supported by the US Department of Energy and National Science Foundation, the Natural Sciences and Engineering Research Council (Canada), Institute of High Energy Physics (China), the Commissariat à l'Energie Atomique and Institut National de Physique Nucléaire et de Physique des Particules (France), the Bundesministerium für Bildung und Forschung and Deutsche Forschungsgemeinschaft (Germany), the Istituto Nazionale di Fisica Nucleare (Italy), the Research Council of Norway, the Ministry of Science and Technology of the Russian Federation, and the Particle Physics and Astronomy Research Council (United Kingdom). Individuals have received support from the A. P. Sloan Foundation, the Research Corporation, and the Alexander von Humboldt Foundation.

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