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P. del Amo Sanchez *et al.* (The BABAR Collaboration)

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Measurements of branching fractions, polarizations, and direct CP -violation asymmetries in $B^+ \rightarrow \rho^0 K^{*+}$ and $B^+ \rightarrow f_0(980) K^{*+}$ decays

P. del Amo Sanchez,¹ J. P. Lees,¹ V. Poireau,¹ E. Prencipe,¹ V. Tisserand,¹ J. Garra Tico,² E. Grauges,² M. Martinelli^{ab,3} D. A. Milanes,³ A. Palano^{ab,3} M. Pappagallo^{ab,3} G. Eigen,⁴ B. Stugu,⁴ L. Sun,⁴ D. N. Brown,⁵ L. T. Kerth,⁵ Yu. G. Kolomensky,⁵ G. Lynch,⁵ I. L. Osipenko,⁵ H. Koch,⁶ T. Schroeder,⁶ D. J. Asgeirsson,⁷ C. Hearty,⁷ T. S. Mattison,⁷ J. A. McKenna,⁷ A. Khan,⁸ V. E. Blinov,⁹ A. R. Buzykaev,⁹ V. P. Druzhinin,⁹ V. B. Golubev,⁹ E. A. Kravchenko,⁹ A. P. Onuchin,⁹ S. I. Serednyakov,⁹ Yu. I. Skovpen,⁹ E. P. Solodov,⁹ K. Yu. Todyshev,⁹ A. N. Yushkov,⁹ M. Bondioli,¹⁰ S. Curry,¹⁰ D. Kirkby,¹⁰ A. J. Lankford,¹⁰ M. Mandelkern,¹⁰ E. C. Martin,¹⁰ D. P. Stoker,¹⁰ H. Atmacan,¹¹ J. W. Gary,¹¹ F. Liu,¹¹ O. Long,¹¹ G. M. Vitug,¹¹ C. Campagnari,¹² T. M. Hong,¹² D. Kovalskyi,¹² J. D. Richman,¹² C. West,¹² A. M. Eisner,¹³ C. A. Heusch,¹³ J. Kroseberg,¹³ W. S. Lockman,¹³ A. J. Martinez,¹³ T. Schalk,¹³ B. A. Schumm,¹³ A. Seiden,¹³ L. O. Winstrom,¹³ C. H. Cheng,¹⁴ D. A. Doll,¹⁴ B. Echenard,¹⁴ D. G. Hitlin,¹⁴ P. Ongmongkolkul,¹⁴ F. C. Porter,¹⁴ A. Y. Rakitin,¹⁴ R. Andreassen,¹⁵ M. S. Dubrovin,¹⁵ G. Mancinelli,¹⁵ B. T. Meadows,¹⁵ M. D. Sokoloff,¹⁵ P. C. Bloom,¹⁶ W. T. Ford,¹⁶ A. Gaz,¹⁶ M. Nagel,¹⁶ U. Nauenberg,¹⁶ J. G. Smith,¹⁶ S. R. Wagner,¹⁶ R. Ayad,^{17,*} W. H. Toki,¹⁷ H. Jasper,¹⁸ T. M. Karbach,¹⁸ A. Petzold,¹⁸ B. Spaan,¹⁸ M. J. Kobel,¹⁹ K. R. Schubert,¹⁹ R. Schwierz,¹⁹ D. Bernard,²⁰ M. Verderi,²⁰ P. J. Clark,²¹ S. Playfer,²¹ J. E. Watson,²¹ M. Andreotti^{ab,22} D. Bettoni^{a,22} C. Bozzi^{a,22} R. Calabrese^{ab,22} A. Cecchi^{ab,22} G. Cibinetto^{ab,22} E. Fioravanti^{ab,22} P. Franchini^{ab,22} I. Garzia^{ab,22} E. Luppi^{ab,22} M. Munerato^{ab,22} M. Negrini^{ab,22} A. Petrella^{ab,22} L. Piemontese^{a,22} R. Baldini-Ferroli,²³ A. Calcaterra,²³ R. de Sangro,²³ G. Finocchiaro,²³ M. Nicolaci,²³ S. Pacetti,²³ P. Patteri,²³ I. M. Peruzzi,^{23,†} M. Piccolo,²³ M. Rama,²³ A. Zallo,²³ R. Contri^{ab,24} E. Guido^{ab,24} M. Lo Vetere^{ab,24} M. R. Monge^{ab,24} S. Passaggio^{a,24} C. Patrignani^{ab,24} E. Robutti^{a,24} S. Tosi^{ab,24} B. Bhuyan,²⁵ V. Prasad,²⁵ C. L. Lee,²⁶ M. Morii,²⁶ A. J. Edwards,²⁷ A. Adametz,²⁸ J. Marks,²⁸ U. Uwer,²⁸ F. U. Bernlochner,²⁹ M. Ebert,²⁹ H. M. Lacker,²⁹ T. Lueck,²⁹ A. Volk,²⁹ P. D. Dauncey,³⁰ M. Tibbetts,³⁰ P. K. Behera,³¹ U. Mallik,³¹ C. Chen,³² J. Cochran,³² H. B. Crawley,³² L. Dong,³² W. T. Meyer,³² S. Prell,³² E. I. Rosenberg,³² A. E. Rubin,³² A. V. Gritsan,³³ Z. J. Guo,³³ N. Arnaud,³⁴ M. Davier,³⁴ D. Derkach,³⁴ J. Firmino da Costa,³⁴ G. Grosdidier,³⁴ F. Le Diberder,³⁴ A. M. Lutz,³⁴ B. Malaescu,³⁴ A. Perez,³⁴ P. Roudeau,³⁴ M. H. Schune,³⁴ J. Serrano,³⁴ V. Sordini,^{34,‡} A. Stocchi,³⁴ L. Wang,³⁴ G. Wormser,³⁴ D. J. Lange,³⁵ D. M. Wright,³⁵ I. Bingham,³⁶ C. A. Chavez,³⁶ J. P. Coleman,³⁶ J. R. Fry,³⁶ E. Gabathuler,³⁶ R. Gamet,³⁶ D. E. Hutchcroft,³⁶ D. J. Payne,³⁶ C. Touramanis,³⁶ A. J. Bevan,³⁷ F. Di Lodovico,³⁷ R. Sacco,³⁷ M. Sigamani,³⁷ G. Cowan,³⁸ S. Paramesvaran,³⁸ A. C. Wren,³⁸ D. N. Brown,³⁹ C. L. Davis,³⁹ A. G. Denig,⁴⁰ M. Fritsch,⁴⁰ W. Gradl,⁴⁰ A. Hafner,⁴⁰ K. E. Alwyn,⁴¹ D. Bailey,⁴¹ R. J. Barlow,⁴¹ G. Jackson,⁴¹ G. D. Lafferty,⁴¹ J. Anderson,⁴² R. Cenci,⁴² A. Jawahery,⁴² D. A. Roberts,⁴² G. Simi,⁴² J. M. Tuggle,⁴² C. Dallapiccola,⁴³ E. Salvati,⁴³ R. Cowan,⁴⁴ D. Dujmic,⁴⁴ G. Sciolla,⁴⁴ M. Zhao,⁴⁴ D. Lindemann,⁴⁵ P. M. Patel,⁴⁵ S. H. Robertson,⁴⁵ M. Schram,⁴⁵ P. Biassoni^{ab,46} A. Lazzaro^{ab,46} V. Lombardo^{a,46} F. Palombo^{ab,46} S. Stracka^{ab,46} L. Cremaldi,⁴⁷ R. Godang,^{47,§} R. Kroeger,⁴⁷ P. Sonnek,⁴⁷ D. J. Summers,⁴⁷ X. Nguyen,⁴⁸ M. Simard,⁴⁸ P. Taras,⁴⁸ G. De Nardo^{ab,49} D. Monorchio^{ab,49} G. Onorato^{ab,49} C. Sciacca^{ab,49} G. Raven,⁵⁰ H. L. Snoek,⁵⁰ C. P. Jessop,⁵¹ K. J. Knoepfel,⁵¹ J. M. LoSecco,⁵¹ W. F. Wang,⁵¹ L. A. Corwin,⁵² K. Honscheid,⁵² R. Kass,⁵² J. P. Morris,⁵² N. L. Blount,⁵³ J. Brau,⁵³ R. Frey,⁵³ O. Igonkina,⁵³ J. A. Kolb,⁵³ R. Rahmat,⁵³ N. B. Sinev,⁵³ D. Strom,⁵³ J. Strube,⁵³ E. Torrence,⁵³ G. Castelli^{ab,54} E. Feltresi^{ab,54} N. Gagliardi^{ab,54} M. Margoni^{ab,54} M. Morandin^{a,54} M. Posocco^{a,54} M. Rotondo^{a,54} F. Simonetto^{ab,54} R. Stroili^{ab,54} E. Ben-Haim,⁵⁵ G. R. Bonneaud,⁵⁵ H. Briand,⁵⁵ G. Calderini,⁵⁵ J. Chauveau,⁵⁵ O. Hamon,⁵⁵ Ph. Leruste,⁵⁵ G. Marchiori,⁵⁵ J. Ocariz,⁵⁵ J. Prendki,⁵⁵ S. Sitt,⁵⁵ M. Biasini^{ab,56} E. Manoni^{ab,56} A. Rossi^{ab,56} C. Angelini^{ab,57} G. Batignani^{ab,57} S. Bettarini^{ab,57} M. Carpinelli^{ab,57,¶} G. Casarosa^{ab,57} A. Cervelli^{ab,57} F. Forti^{ab,57} M. A. Giorgi^{ab,57} A. Lusiani^{ac,57} N. Neri^{ab,57} E. Paoloni^{ab,57} G. Rizzo^{ab,57} J. J. Walsh^{a,57} D. Lopes Pegna,⁵⁸ C. Lu,⁵⁸ J. Olsen,⁵⁸ A. J. S. Smith,⁵⁸ A. V. Telnov,⁵⁸ F. Anulli^{a,59} E. Baracchini^{ab,59} G. Cavoto^{a,59} R. Faccini^{ab,59} F. Ferrarotto^{a,59} F. Ferroni^{ab,59} M. Gaspero^{ab,59} L. Li Gioi^{a,59} M. A. Mazzoni^{a,59} G. Piredda^{a,59} F. Renga^{ab,59} T. Hartmann,⁶⁰ T. Leddig,⁶⁰ H. Schröder,⁶⁰ R. Waldi,⁶⁰ T. Adye,⁶¹ B. Franek,⁶¹ E. O. Olaiya,⁶¹ F. F. Wilson,⁶¹ S. Emery,⁶² G. Hamel de Monchenault,⁶² G. Vasseur,⁶² Ch. Yèche,⁶² M. Zito,⁶² M. T. Allen,⁶³ D. Aston,⁶³ D. J. Bard,⁶³ R. Bartoldus,⁶³ J. F. Benitez,⁶³ C. Cartaro,⁶³ M. R. Convery,⁶³ J. Dorfan,⁶³ G. P. Dubois-Felsmann,⁶³ W. Dunwoodie,⁶³ R. C. Field,⁶³ M. Franco Sevilla,⁶³ B. G. Fulsom,⁶³ A. M. Gabareen,⁶³ M. T. Graham,⁶³ P. Grenier,⁶³ C. Hast,⁶³ W. R. Innes,⁶³ M. H. Kelsey,⁶³ H. Kim,⁶³ P. Kim,⁶³ M. L. Kocian,⁶³ D. W. G. S. Leith,⁶³ S. Li,⁶³ B. Lindquist,⁶³ S. Luitz,⁶³ V. Luth,⁶³ H. L. Lynch,⁶³ D. B. MacFarlane,⁶³ H. Marsiske,⁶³ D. R. Muller,⁶³ H. Neal,⁶³ S. Nelson,⁶³ C. P. O'Grady,⁶³ I. Ofte,⁶³ M. Perl,⁶³ T. Pulliam,⁶³ B. N. Ratcliff,⁶³ A. Roodman,⁶³ A. A. Salnikov,⁶³ V. Santoro,⁶³

R. H. Schindler,⁶³ J. Schwiening,⁶³ A. Snyder,⁶³ D. Su,⁶³ M. K. Sullivan,⁶³ S. Sun,⁶³ K. Suzuki,⁶³
 J. M. Thompson,⁶³ J. Va'vra,⁶³ A. P. Wagner,⁶³ M. Weaver,⁶³ W. J. Wisniewski,⁶³ M. Wittgen,⁶³ D. H. Wright,⁶³
 H. W. Wulsin,⁶³ A. K. Yarritu,⁶³ C. C. Young,⁶³ V. Ziegler,⁶³ X. R. Chen,⁶⁴ W. Park,⁶⁴ M. V. Purohit,⁶⁴
 R. M. White,⁶⁴ J. R. Wilson,⁶⁴ A. Randle-Conde,⁶⁵ S. J. Sekula,⁶⁵ M. Bellis,⁶⁶ P. R. Burchat,⁶⁶ T. S. Miyashita,⁶⁶
 S. Ahmed,⁶⁷ M. S. Alam,⁶⁷ J. A. Ernst,⁶⁷ B. Pan,⁶⁷ M. A. Saeed,⁶⁷ S. B. Zain,⁶⁷ N. Guttman,⁶⁸ A. Soffer,⁶⁸
 P. Lund,⁶⁹ S. M. Spanier,⁶⁹ R. Eckmann,⁷⁰ J. L. Ritchie,⁷⁰ A. M. Ruland,⁷⁰ C. J. Schilling,⁷⁰ R. F. Schwitters,⁷⁰
 B. C. Wray,⁷⁰ J. M. Izen,⁷¹ X. C. Lou,⁷¹ F. Bianchi^{ab,72} D. Gamba^{ab,72} M. Pelliccioni^{ab,72} M. Bomben^{ab,73}
 L. Lanceri^{ab,73} L. Vitale^{ab,73} N. Lopez-March,⁷⁴ F. Martinez-Vidal,⁷⁴ A. Oyanguren,⁷⁴ J. Albert,⁷⁵ Sw. Banerjee,⁷⁵
 H. H. F. Choi,⁷⁵ K. Hamano,⁷⁵ G. J. King,⁷⁵ R. Kowalewski,⁷⁵ M. J. Lewczuk,⁷⁵ C. Lindsay,⁷⁵ I. M. Nugent,⁷⁵
 J. M. Roney,⁷⁵ R. J. Sobie,⁷⁵ T. J. Gershon,⁷⁶ P. F. Harrison,⁷⁶ T. E. Latham,⁷⁶ E. M. T. Puccio,⁷⁶
 H. R. Band,⁷⁷ S. Dasu,⁷⁷ K. T. Flood,⁷⁷ Y. Pan,⁷⁷ R. Prepost,⁷⁷ C. O. Vuosalo,⁷⁷ and S. L. Wu⁷⁷

(The BABAR Collaboration)

¹Laboratoire d'Annecy-le-Vieux de Physique des Particules (LAPP),
 Université de Savoie, CNRS/IN2P3, F-74941 Annecy-Le-Vieux, France

²Universitat de Barcelona, Facultat de Física, Departament ECM, E-08028 Barcelona, Spain

³INFN Sezione di Bari^a; Dipartimento di Fisica, Università di Bari^b, I-70126 Bari, Italy

⁴University of Bergen, Institute of Physics, N-5007 Bergen, Norway

⁵Lawrence Berkeley National Laboratory and University of California, Berkeley, California 94720, USA

⁶Ruhr Universität Bochum, Institut für Experimentalphysik 1, D-44780 Bochum, Germany

⁷University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z1

⁸Brunel University, Uxbridge, Middlesex UB8 3PH, United Kingdom

⁹Budker Institute of Nuclear Physics, Novosibirsk 630090, Russia

¹⁰University of California at Irvine, Irvine, California 92697, USA

¹¹University of California at Riverside, Riverside, California 92521, USA

¹²University of California at Santa Barbara, Santa Barbara, California 93106, USA

¹³University of California at Santa Cruz, Institute for Particle Physics, Santa Cruz, California 95064, USA

¹⁴California Institute of Technology, Pasadena, California 91125, USA

¹⁵University of Cincinnati, Cincinnati, Ohio 45221, USA

¹⁶University of Colorado, Boulder, Colorado 80309, USA

¹⁷Colorado State University, Fort Collins, Colorado 80523, USA

¹⁸Technische Universität Dortmund, Fakultät Physik, D-44221 Dortmund, Germany

¹⁹Technische Universität Dresden, Institut für Kern- und Teilchenphysik, D-01062 Dresden, Germany

²⁰Laboratoire Leprince-Ringuet, CNRS/IN2P3, Ecole Polytechnique, F-91128 Palaiseau, France

²¹University of Edinburgh, Edinburgh EH9 3JZ, United Kingdom

²²INFN Sezione di Ferrara^a; Dipartimento di Fisica, Università di Ferrara^b, I-44100 Ferrara, Italy

²³INFN Laboratori Nazionali di Frascati, I-00044 Frascati, Italy

²⁴INFN Sezione di Genova^a; Dipartimento di Fisica, Università di Genova^b, I-16146 Genova, Italy

²⁵Indian Institute of Technology Guwahati, Guwahati, Assam, 781 039, India

²⁶Harvard University, Cambridge, Massachusetts 02138, USA

²⁷Harvey Mudd College, Claremont, California 91711

²⁸Universität Heidelberg, Physikalisches Institut, Philosophenweg 12, D-69120 Heidelberg, Germany

²⁹Humboldt-Universität zu Berlin, Institut für Physik, Newtonstr. 15, D-12489 Berlin, Germany

³⁰Imperial College London, London, SW7 2AZ, United Kingdom

³¹University of Iowa, Iowa City, Iowa 52242, USA

³²Iowa State University, Ames, Iowa 50011-3160, USA

³³Johns Hopkins University, Baltimore, Maryland 21218, USA

³⁴Laboratoire de l'Accélérateur Linéaire, IN2P3/CNRS et Université Paris-Sud 11,

Centre Scientifique d'Orsay, B. P. 34, F-91898 Orsay Cedex, France

³⁵Lawrence Livermore National Laboratory, Livermore, California 94550, USA

³⁶University of Liverpool, Liverpool L69 7ZE, United Kingdom

³⁷Queen Mary, University of London, London, E1 4NS, United Kingdom

³⁸University of London, Royal Holloway and Bedford New College, Egham, Surrey TW20 0EX, United Kingdom

³⁹University of Louisville, Louisville, Kentucky 40292, USA

⁴⁰Johannes Gutenberg-Universität Mainz, Institut für Kernphysik, D-55099 Mainz, Germany

⁴¹University of Manchester, Manchester M13 9PL, United Kingdom

⁴²University of Maryland, College Park, Maryland 20742, USA

⁴³University of Massachusetts, Amherst, Massachusetts 01003, USA

⁴⁴Massachusetts Institute of Technology, Laboratory for Nuclear Science, Cambridge, Massachusetts 02139, USA

⁴⁵McGill University, Montréal, Québec, Canada H3A 2T8

⁴⁶INFN Sezione di Milano^a; Dipartimento di Fisica, Università di Milano^b, I-20133 Milano, Italy

⁴⁷University of Mississippi, University, Mississippi 38677, USA

- ⁴⁸Université de Montréal, Physique des Particules, Montréal, Québec, Canada H3C 3J7
⁴⁹INFN Sezione di Napoli^a; Dipartimento di Scienze Fisiche,
 Università di Napoli Federico II^b, I-80126 Napoli, Italy
⁵⁰NIKHEF, National Institute for Nuclear Physics and High Energy Physics, NL-1009 DB Amsterdam, The Netherlands
⁵¹University of Notre Dame, Notre Dame, Indiana 46556, USA
⁵²Ohio State University, Columbus, Ohio 43210, USA
⁵³University of Oregon, Eugene, Oregon 97403, USA
⁵⁴INFN Sezione di Padova^a; Dipartimento di Fisica, Università di Padova^b, I-35131 Padova, Italy
⁵⁵Laboratoire de Physique Nucléaire et de Hautes Energies,
 IN2P3/CNRS, Université Pierre et Marie Curie-Paris6,
 Université Denis Diderot-Paris7, F-75252 Paris, France
⁵⁶INFN Sezione di Perugia^a; Dipartimento di Fisica, Università di Perugia^b, I-06100 Perugia, Italy
⁵⁷INFN Sezione di Pisa^a; Dipartimento di Fisica,
 Università di Pisa^b; Scuola Normale Superiore di Pisa^c, I-56127 Pisa, Italy
⁵⁸Princeton University, Princeton, New Jersey 08544, USA
⁵⁹INFN Sezione di Roma^a; Dipartimento di Fisica,
 Università di Roma La Sapienza^b, I-00185 Roma, Italy
⁶⁰Universität Rostock, D-18051 Rostock, Germany
⁶¹Rutherford Appleton Laboratory, Chilton, Didcot, Oxon, OX11 0QX, United Kingdom
⁶²CEA, Irfu, SPP, Centre de Saclay, F-91191 Gif-sur-Yvette, France
⁶³SLAC National Accelerator Laboratory, Stanford, California 94309 USA
⁶⁴University of South Carolina, Columbia, South Carolina 29208, USA
⁶⁵Southern Methodist University, Dallas, Texas 75275, USA
⁶⁶Stanford University, Stanford, California 94305-4060, USA
⁶⁷State University of New York, Albany, New York 12222, USA
⁶⁸Tel Aviv University, School of Physics and Astronomy, Tel Aviv, 69978, Israel
⁶⁹University of Tennessee, Knoxville, Tennessee 37996, USA
⁷⁰University of Texas at Austin, Austin, Texas 78712, USA
⁷¹University of Texas at Dallas, Richardson, Texas 75083, USA
⁷²INFN Sezione di Torino^a; Dipartimento di Fisica Sperimentale, Università di Torino^b, I-10125 Torino, Italy
⁷³INFN Sezione di Trieste^a; Dipartimento di Fisica, Università di Trieste^b, I-34127 Trieste, Italy
⁷⁴IFIC, Universitat de Valencia-CSIC, E-46071 Valencia, Spain
⁷⁵University of Victoria, Victoria, British Columbia, Canada V8W 3P6
⁷⁶Department of Physics, University of Warwick, Coventry CV4 7AL, United Kingdom
⁷⁷University of Wisconsin, Madison, Wisconsin 53706, USA

We present measurements of the branching fractions, longitudinal polarization, and direct CP -violation asymmetries for the decays $B^+ \rightarrow \rho^0 K^{*+}$ and $B^+ \rightarrow f_0(980)K^{*+}$ with a sample of $(467 \pm 5) \times 10^6 B\bar{B}$ pairs collected with the BABAR detector at the PEP-II asymmetric-energy e^+e^- collider at the SLAC National Accelerator Laboratory. We observe $B^+ \rightarrow \rho^0 K^{*+}$ with a significance of 5.3σ and measure the branching fraction $\mathcal{B}(B^+ \rightarrow \rho^0 K^{*+}) = (4.6 \pm 1.0 \pm 0.4) \times 10^{-6}$, the longitudinal polarization $f_L = 0.78 \pm 0.12 \pm 0.03$, and the CP -violation asymmetry $\mathcal{A}_{CP} = 0.31 \pm 0.13 \pm 0.03$. We observe $B^+ \rightarrow f_0(980)K^{*+}$ and measure the branching fraction $\mathcal{B}(B^+ \rightarrow f_0(980)K^{*+}) \times \mathcal{B}(f_0(980) \rightarrow \pi^+\pi^-) = (4.2 \pm 0.6 \pm 0.3) \times 10^{-6}$ and the CP -violation asymmetry $\mathcal{A}_{CP} = -0.15 \pm 0.12 \pm 0.03$. The first uncertainty quoted is statistical and the second is systematic.

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The study of the branching fractions and angular distributions of B meson decays to hadronic final states without a charm quark probes the dynamics of both the weak and strong interactions. It also plays an important

role in understanding CP violation in the quark sector, constraining the Cabibbo-Kobayashi-Maskawa (CKM) matrix parameters [1] and searching for evidence for physics beyond the standard model [2, 3].

The charmless decays $B \rightarrow \rho K^*$ proceed through penguin loops and tree processes ($B^+ \rightarrow \rho^+ K^{*0}$ is a pure penguin process) to two vector particles (VV). QCD factorization models predict a large longitudinal polarization fraction f_L (of order $(1 - 4m_V^2/m_B^2) \sim 0.9$) for VV decays [4]. However, measurements of penguin-dominated VV decays give f_L as low as ~ 0.5 [5]. Several attempts to understand the values of f_L within or beyond the standard model have been made [6].

For the $B^+ \rightarrow \rho^0 K^{*+}$ branching fraction, Beneke,

*Now at Temple University, Philadelphia, Pennsylvania 19122, USA

†Also with Università di Perugia, Dipartimento di Fisica, Perugia, Italy

‡Also with Università di Roma La Sapienza, I-00185 Roma, Italy

§Now at University of South Alabama, Mobile, Alabama 36688, USA

¶Also with Università di Sassari, Sassari, Italy

Rohrer and Yang [2] predict the CP -averaged branching fraction to be $(4.5_{-1.3-1.4}^{+1.5+3.0}) \times 10^{-6}$, while Cheng and Yang [3] quote $(5.5_{-0.5-2.5}^{+0.6+1.3}) \times 10^{-6}$, both based on QCD factorization. The 90% confidence level (C.L.) upper limit $B^+ \rightarrow \rho^0 K^{*+}$ branching fraction has been measured to be $< 6.1 \times 10^{-6}$ [7].

We report measurements of branching fractions, longitudinal polarizations, and direct CP -violating asymmetries for the decay modes $B^+ \rightarrow \rho^0 K^{*+}$ and $B^+ \rightarrow f_0(980) K^{*+}$ where ρ^0 and K^{*+} refer to the $\rho^0(770)$ and $K^{*+}(892)$ resonances, respectively. The analysis is based on a data sample of $(467 \pm 5) \times 10^6 B\bar{B}$ pairs, equivalent to an integrated luminosity of 426 fb^{-1} , collected with the BABAR detector at the PEP-II asymmetric-energy e^+e^- collider operated at the SLAC National Accelerator Laboratory. The e^+e^- center-of-mass (c.m.) energy is $\sqrt{s} = 10.58 \text{ GeV}$, corresponding to the $\Upsilon(4S)$ resonance mass (on-resonance data). In addition, 44.4 fb^{-1} of data collected 40 MeV below the $\Upsilon(4S)$ resonance (off-resonance data) are used for background studies. We assume equal production rates of B^+B^- and $B^0\bar{B}^0$ mesons and charge-conjugate modes are implied throughout [8]. The BABAR detector is described in detail in Ref. [9].

The $B^+ \rightarrow \rho^0 K^{*+}$ and $B^+ \rightarrow f_0(980) K^{*+}$ candidates are reconstructed through the decays of ρ^0 or $f_0(980) \rightarrow \pi^+\pi^-$, $K^{*+} \rightarrow K_s^0\pi^+$ or $K^{*+} \rightarrow K^+\pi^0$, with $K_s^0 \rightarrow \pi^+\pi^-$ and $\pi^0 \rightarrow \gamma\gamma$. The differential decay rate for $B^+ \rightarrow \rho^0 K^{*+}$, after integrating over the angle between the decay planes of the vector mesons, for which the acceptance is nearly uniform, is proportional to

$$\frac{1 - f_L}{4} \sin^2 \theta_{K^{*+}} \sin^2 \theta_{\rho^0} + f_L \cos^2 \theta_{K^{*+}} \cos^2 \theta_{\rho^0}, \quad (1)$$

where $\theta_{K^{*+}}$ (θ_{ρ^0}) is the helicity angle of the K^{*+} (ρ^0), defined as the angle between the daughter K (π^+) momentum and the direction opposite to the B meson momentum in the K^{*+} (ρ^0) rest frame [10]. The direct CP -violating asymmetry \mathcal{A}_{CP} is defined as $\mathcal{A}_{CP} = (\Gamma^- - \Gamma^+)/(\Gamma^- + \Gamma^+)$, where $\Gamma^\pm = \Gamma(B^\pm \rightarrow f^\pm)$ is the decay width for a given charged final state f^\pm .

We apply the same selection criteria for ρ^0 and $f_0(980)$ candidates. The charged particles from the K^{*+} and ρ^0 decays are required to have a transverse momentum relative to the beam axis greater than $0.05 \text{ GeV}/c$. The particles are identified as either charged pions or kaons by measurement of the energy loss in the tracking detectors, the number of photons recorded by the ring-imaging Cherenkov detector and the corresponding Cherenkov angle. These measurements are combined with information from the electromagnetic calorimeter and the instrumented magnetic-flux return detector, where appropriate, to reject electrons, muons, and protons.

The K_s^0 candidates are required to have a mass within $0.01 \text{ GeV}/c^2$ of the nominal K_s^0 mass [8], a decay vertex separated from the B meson decay vertex by at least 20 times the uncertainty in the measurement of the separation of the vertex positions, a flight distance in the direction transverse to the beam axis of at least 0.3 cm ,

and the cosine of the angle between the line joining the B and K_s^0 decay vertices and the K_s^0 momentum greater than 0.999 .

In the laboratory frame, the energy of each photon from the π^0 candidate must be greater than 0.03 GeV , the π^0 energy must exceed 0.25 GeV , and the reconstructed π^0 invariant mass is required to be in the range $0.12 \leq m_{\gamma\gamma} \leq 0.15 \text{ GeV}/c^2$. After selection, the π^0 candidate's mass is constrained to its nominal value [8].

We require the invariant mass of the K^{*+} and ρ^0 candidates to satisfy $0.792 < m_{K\pi} < 0.992 \text{ GeV}/c^2$ and $0.52 < m_{\pi^+\pi^-} < 1.05 \text{ GeV}/c^2$, respectively. A B meson candidate is formed from the K^{*+} and ρ^0 candidates, with the condition that the K^{*+} and ρ^0 candidates originate from the interaction region and the χ^2 of the B meson vertex fit is less than 100. We require that there is at least one additional charged track in the event and create a vertex for a second B meson from all remaining charged tracks and neutral clusters that are consistent with originating from the interaction region.

The B meson candidates are characterized kinematically by the energy difference $\Delta E = E_B^* - \sqrt{s}/2$ and the beam energy-substituted mass $m_{\text{ES}} = [(s/2 + \mathbf{p} \cdot \mathbf{p}_B)^2/E^2 - \mathbf{p}_B^2]^{1/2}$, where (E, \mathbf{p}) and (E_B, \mathbf{p}_B) are the four-momenta of the $\Upsilon(4S)$ and B meson candidate in the laboratory frame, respectively, and the asterisk denotes the c.m. frame. The event sample is taken from the region $|\Delta E| < 0.10 \text{ GeV}$ and $5.255 \leq m_{\text{ES}} \leq 5.289 \text{ GeV}/c^2$. The extended m_{ES} range ensures the shape of the background distribution is properly modeled. Sideband events, outside the region $|\Delta E| \leq 0.07 \text{ GeV}$ and $5.270 \leq m_{\text{ES}} \leq 5.289 \text{ GeV}/c^2$, are used to characterize the background and cross-check the Monte Carlo (MC) background simulations [11].

We suppress the background from B mesons decaying to charm by forming the invariant mass m_D from combinations of two or three out of the four daughter particles' four-momenta. The event is rejected if $1.835 < m_D < 1.895 \text{ GeV}/c^2$ and the charge and particle type of the tracks are consistent with a known decay from a D meson [8]. Finally, to reduce the background and to avoid the region where the reconstruction efficiency falls off rapidly for low momentum tracks, we require the cosines of the helicity angles of the K^{*+} and ρ^0 candidates to satisfy $\cos \theta_{K^{*+}} \leq 0.92$ and $|\cos \theta_{\rho^0}| \leq 0.95$, respectively.

To reject the background consisting of light-quark $q\bar{q}$ ($q = u, d, s, c$) continuum events, we require $|\cos \theta_T| < 0.85$, where θ_T is the angle, in the c.m. frame, between the thrust axis of the B meson and that formed from the other tracks and neutral clusters in the event. Signal events have an approximately uniform distribution in $|\cos \theta_T|$, while $q\bar{q}$ continuum events peak at 1.

After the application of the selection criteria, the average number of $\rho^0 K^{*+}$ candidates per event with $K^{*+} \rightarrow K_s^0\pi^+$ in signal MC simulations is 1.14 (1.03) for fully longitudinally (transversely) polarized decays. The candidate with the smallest fitted decay vertex χ^2 is cho-

sen. Up to 2.1% (1.0%) of longitudinally (transversely) polarized MC signal events are misreconstructed, with one or more tracks originating from the other B meson in the event. For $\rho^0 K^{*+}$ with $K^{*+} \rightarrow K^+ \pi^0$, the average number of candidates per event is 1.20 (1.08) and the fraction of misreconstructed candidates is 5.9% (2.7%) for fully longitudinally (transversely) polarized decays. For $f_0(980) K^{*+}$, the number of candidates per event and the fraction of misreconstructed events are 1.02 (1.06) and 9.1% (13.8%) for decays with $K^{*+} \rightarrow K_s^0 \pi^+$ ($K^{*+} \rightarrow K^+ \pi^0$). The ρ^0 and K^{*+} masses and widths in the MC simulation are taken from Ref. [8] and we use the measured $f_0(980)$ lineshape from Ref. [12].

A neural net discriminant is used to provide additional separation between signal and $q\bar{q}$ continuum. It is constructed from six variables calculated in the c.m. frame: the polar angles of the B meson momentum vector and the B meson thrust axis with respect to the beam axis, the angle between the B meson thrust axis and the thrust axis of the rest of the event, the ratio of the second- and zeroth-order momentum-weighted polynomial moments of the energy flow around the B meson thrust axis [13], the flavor of the other B meson as reported by a multivariate tagging algorithm [14], and the boost-corrected proper-time difference between the decays of the two B mesons divided by its variance. The discriminant is trained using MC for the signal, and $q\bar{q}$ continuum MC and off-resonance data for the background.

We define an extended likelihood function to be used in an unbinned maximum likelihood (ML) fit as

$$\mathcal{L} = \frac{1}{N!} \exp \left(- \sum_j n_j \right) \prod_{i=1}^N \left[\sum_j n_j \mathcal{P}_j(\vec{x}_i; \vec{\alpha}_j) \right], \quad (2)$$

where the likelihood \mathcal{L}_i for each event candidate i is the sum of $n_j \mathcal{P}_j(\vec{x}_i; \vec{\alpha}_j)$ over hypotheses j : two signal modes $\rho^0 K^{*+}$ and $f_0(980) K^{*+}$ (including misreconstructed signal candidates); $q\bar{q}$ continuum background; and nine $B\bar{B}$ backgrounds as discussed below. $\mathcal{P}_j(\vec{x}_i; \vec{\alpha}_j)$ is the product of the probability density functions (PDFs) for hypothesis j evaluated for the i -th event's measured variables \vec{x}_i . The number of events for hypothesis j is denoted by n_j and N is the total number of events in the sample. The quantities $\vec{\alpha}_j$ represent parameters to describe the expected distributions of the measured variables for each hypothesis j . Each discriminating variable \vec{x}_i in the likelihood function is modeled with a PDF, where the parameters $\vec{\alpha}_j$ are extracted from MC simulation, off-resonance data, or $(m_{\text{ES}}, \Delta E)$ sideband data. The seven variables \vec{x}_i used in the fit are m_{ES} , ΔE , the neural net output, $m_{\pi^+\pi^-}$, $m_{K\pi}$, the absolute cosine of the helicity angle of the $\rho^0/f_0(980)$ candidate and the cosine of the helicity of the K^{*+} candidate. Since most of the linear correlations among the fit variable distributions are found to be about 1%, with a maximum of 11%, we take each \mathcal{P}_j to be the product of the PDFs for the separate variables.

The decays $B^+ \rightarrow \bar{D}^0(\rightarrow K_s^0 \pi^+ \pi^-) \pi^+$ and $B^+ \rightarrow \bar{D}^0(\rightarrow K^+ \pi^0 \pi^-) \pi^+$ have large branching fractions and a similar topology to the decays under consideration. They are used as calibration channels. We apply the same selection criteria as described above except that the neural net is trained on the MC simulated data for the calibration channel under consideration; the ΔE range is reduced to $|\Delta E| < 0.08 \text{ GeV}$; the $m_{K\pi}$ and $m_{\pi^+\pi^-}$ mass criteria are replaced with a mass range $1.8445 < m_{\bar{D}^0} < 1.8845 \text{ GeV}/c^2$; and no D meson veto is applied. We use the selected data to verify that the ML fit is performing correctly and that the MC is simulating the neural net, ΔE and m_{ES} distributions.

Backgrounds from $B\bar{B}$ decays involving charmed mesons are effectively suppressed by applying the veto on the D meson mass described above. The $B\bar{B}$ backgrounds that remain after the event selection criteria have been applied are identified and modeled using MC simulation. We categorize the $B\bar{B}$ backgrounds in the ML fit into nine main groups. Two groups represent decays where either a K^{*+} or a $\rho^0/f_0(980)$ is falsely reconstructed. Four groups represent nonresonant final states $\pi^+\pi^- K^{*+}$, $\rho^0 (K\pi)^+$, $\pi^+\pi^- (K\pi)^+$, and $f_0(980) (K\pi)^+$, where $(K\pi)^+$ stands for $K_s^0 \pi^+$ or $K^+ \pi^0$. The decays $B^0 \rightarrow \eta' K_s^0$ and $B^+ \rightarrow \eta' K^+$ peak at high $\cos \theta_{K^{*+}}$ and are assigned their own category. We allow for decays from higher mass $K_0^*(1430)$ states. All remaining $B\bar{B}$ background decays that are not accounted for by the above groups are assigned to a dominant remainder group.

The invariant mass distributions in the ML fit are modeled with relativistic Breit–Wigner functions for the K^{*+} and $f_0(980)$, together with a polynomial of order up to four for the smoothly varying distribution of misreconstructed candidates. Following Ref. [15], a modified relativistic Breit–Wigner function is used for the ρ^0 meson. The $K_0^*(1430)$ is modeled with the LASS parametrization, which consists of the $K_0^*(1430)$ resonance together with an effective-range nonresonant component [16]. For the signal, the distributions of the cosine of the helicity angles are described by Eq. 1 multiplied by a polynomial acceptance function that corrects for changes in efficiency as a function of helicity angle. The correction also accounts for the reduction in efficiency at helicity near 0.78 introduced indirectly by the criteria used to veto D mesons. For backgrounds, the cosine of the helicity angle distribution is modeled with a polynomial. The neural net distributions are modeled using either an empirical nonparametric function [17] or a histogram. For m_{ES} , an asymmetric Gaussian is used for the signal; the function $x\sqrt{1-x^2} \exp[-\xi(1-x^2)]$ with $x = m_{\text{ES}}/E_B^*$ and ξ a free parameter [18] is used for $q\bar{q}$ continuum and $B\bar{B}$ backgrounds; and a combination of an asymmetric Gaussian with a polynomial is used for all other hypotheses. For ΔE , two Gaussians are used for signal and polynomials for all other hypotheses.

We simultaneously fit for the branching fractions \mathcal{B} , \mathcal{A}_{CP} , and f_L (for $B^+ \rightarrow \rho^0 K^{*+}$ only). We allow the

yields for all hypotheses to float except for ρ^0 ($K\pi$) $^+$ and $f_0(980)$ ($K\pi$) $^+$ which are fixed to their predicted MC yields, assuming a branching fraction of 1×10^{-6} . The predicted yields for the fixed modes are less than one event. The PDF parameters ξ for m_{ES} , the slope of the ΔE distribution, and the polynomial coefficients and normalizations describing the mass and helicity angle distributions are allowed to vary for the $q\bar{q}$ continuum and $B\bar{B}$ remainder groups. We validate the fitting procedure and obtain the sizes of potential biases on the fit results by applying the fit to ensembles of simulated experiments using the extracted fitted yields from data. The observed fit biases in the MC samples are subtracted from the fitted yields measured in the data.

The results of the ML fits are summarized in Table I, where we assume a branching fraction of 100% for $f_0(980) \rightarrow \pi^+ \pi^-$. For decays with $K^{*+} \rightarrow K_S^0 \pi^+$ ($K^{*+} \rightarrow K^+ \pi^0$), the event sample is 7444 (12867), with 5959 ± 96 (10727 ± 122) fitted $q\bar{q}$ continuum events and 1266 ± 81 (1451 ± 129) events in the $B\bar{B}$ background remainder group. The signal significance S is defined as $S = \sqrt{2\Delta \ln \mathcal{L}}$, where $\Delta \ln \mathcal{L}$ is the change in log-likelihood from the maximum value to the value when the number of signal events is set to zero, corrected for systematic errors by convolving the likelihood function with a Gaussian distribution with a variance equal to the total systematic error defined below. The linear correlation coefficient between the $\rho^0 K^{*+}$ and $f_0(980) K^{*+}$ branching fractions is 0.25.

Figs. 1 and 2 show the projections of the fits onto m_{ES} , ΔE , the masses, and the cosines of the helicity angles for decays with $K^{*+} \rightarrow K_S^0 \pi^+$ and $K^{*+} \rightarrow K^+ \pi^0$, respectively. The candidates in the figures are subject to a requirement on the probability ratio $\mathcal{P}_{\text{sig}}/(\mathcal{P}_{\text{sig}} + \mathcal{P}_{\text{bkg}}) > 0.9$, where \mathcal{P}_{sig} and \mathcal{P}_{bkg} are the signal and total background probabilities, respectively, computed without the use of the variable plotted.

The systematic errors on the yields and branching fractions arise from the PDFs, fit biases, $f_0(980)$ parameters, interference, $B\bar{B}$ background yields, and efficiencies. The PDF uncertainties are calculated by varying the PDF parameters that are held fixed in the original fit by their errors, taking into account correlations. The uncertainty from the fit bias includes its statistical uncertainty from the simulated experiments and half of the correction itself, added in quadrature. We allow for uncertainties in the $f_0(980)$ lineshape by performing a separate fit with the $f_0(980)$ mean and width as additional free parameters. The effect of possible interference between the $f_0(980)$ and ρ^0 is estimated by adding the $f_0(980)$ and ρ^0 amplitudes together with a varying phase difference and using half the maximum change in the yield as an uncertainty. We test for the presence of a scalar $f_0(600)$ (or σ) by adding it to our model, using the mass and width reported in Ref. [19]. The contribution of the $B\bar{B}$ backgrounds to the error is calculated by performing an ensemble of fits to the data where backgrounds are either removed from the fit (for those categories with a fitted

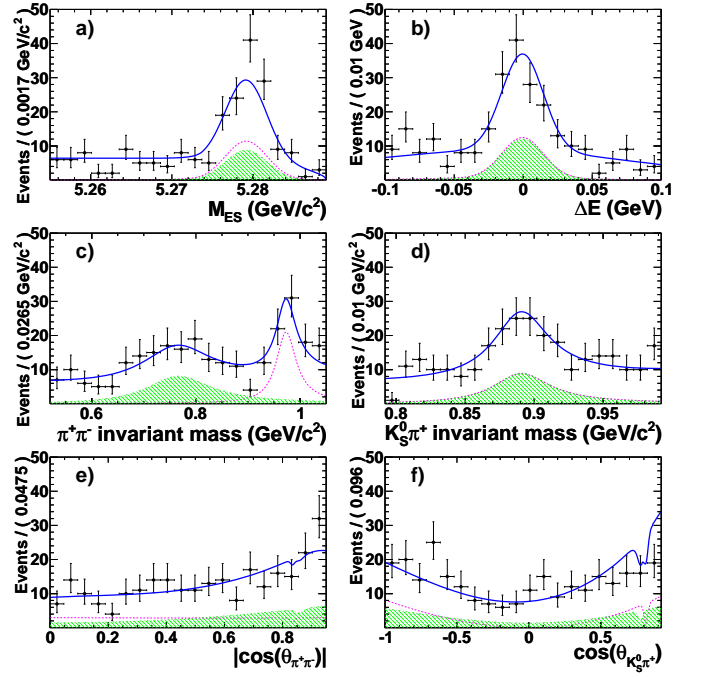


FIG. 1: Projections of the multidimensional fit onto (a) m_{ES} , (b) ΔE , (c) $\pi^+ \pi^-$ mass, (d) $K_S^0 \pi^+$ mass, (e) $|\cos \theta_{\pi^+ \pi^-}|$, and (f) $\cos \theta_{K_S^0 \pi^+}$ for modes with $K^{*+} \rightarrow K_S^0 \pi^+$. The points with error bars show the data; the solid line shows signal-plus-background; the green hatched area is the $\rho^0 K^{*+}$ signal; and the red dashed line is the $f_0(980) K^{*+}$ signal.

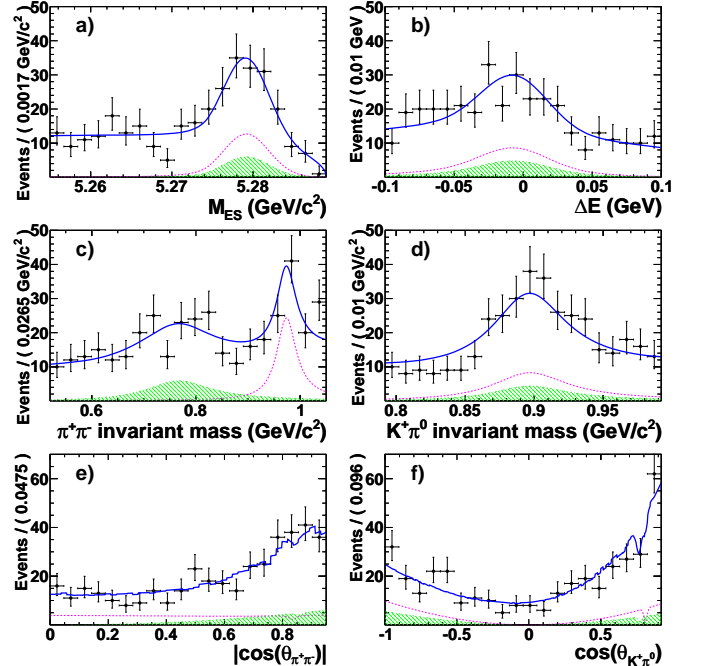


FIG. 2: Projections of the multidimensional fit onto (a) m_{ES} , (b) ΔE , (c) $\pi^+ \pi^-$ mass, (d) $K^+ \pi^0$ mass, (e) $|\cos \theta_{\pi^+ \pi^-}|$, and (f) $\cos \theta_{K^+ \pi^0}$ for modes with $K^{*+} \rightarrow K^+ \pi^0$. The same projection criteria and legend are used as in Fig. 1.

number of events consistent with zero), allowed to float

TABLE I: Results for the measured B decays: signal yield Y (corrected for fit bias) and its statistical uncertainty, reconstruction efficiency (%), daughter branching fraction product $\Pi\mathcal{B}_i$ (%) [8], significance S (with statistical and systematic uncertainties included), branching fraction \mathcal{B} , 90% C.L. upper limit (for modes with $S < 6\sigma$), longitudinal polarization f_L and CP -violating asymmetry \mathcal{A}_{CP} .

Mode	Y	$\epsilon(\%)$	$\Pi\mathcal{B}_i(\%)$	$S(\sigma)$	$\mathcal{B} (\times 10^{-6})$	UL ($\times 10^{-6}$)	f_L	\mathcal{A}_{CP}
$B^+ \rightarrow \rho^0 K^{*+}$				5.3	$4.6 \pm 1.0 \pm 0.4$	6.0	$0.78 \pm 0.12 \pm 0.03$	$0.31 \pm 0.13 \pm 0.03$
$K^{*+} \rightarrow K_S^0 \pi^+$	85 ± 24	17.1	23.1	4.1	$4.6 \pm 1.2 \pm 0.5$	6.4	$0.74 \pm 0.13 \pm 0.03$	$0.25 \pm 0.14 \pm 0.03$
$K^{*+} \rightarrow K^+ \pi^0$	67 ± 31	9.9	33.3	3.3	$4.4 \pm 2.0 \pm 0.5$	7.1	$0.94 \pm 0.27 \pm 0.03$	$0.59 \pm 0.31 \pm 0.03$
$B^+ \rightarrow f_0(980) K^{*+}$				9.0	$4.2 \pm 0.6 \pm 0.3$	-	-	$-0.15 \pm 0.12 \pm 0.03$
$K^{*+} \rightarrow K_S^0 \pi^+$	69 ± 14	17.9	23.1	6.0	$3.6 \pm 0.7 \pm 0.3$	-	-	$-0.34 \pm 0.16 \pm 0.03$
$K^{*+} \rightarrow K^+ \pi^0$	91 ± 20	11.3	33.3	6.8	$5.2 \pm 1.0 \pm 0.3$	-	-	$0.14 \pm 0.12 \pm 0.03$

(for the fixed backgrounds) or fixed to the expected number of events calculated from MC. The error is calculated as half the difference between the default fit and the maximum deviation seen in the ensemble of fits. Finally, the uncertainty on the longitudinal polarization affects the calculated yield efficiency. All these errors are additive in nature and affect the significance of the branching fraction results. We assume the sources of the uncertainties that contribute to the additive errors are uncorrelated when combined to form the overall branching fractions. The PDF parameter uncertainty contributes up to 0.4 signal events to the systematic error and the fit bias between 2.4 and 0.8 events, depending on the signal mode. We see no evidence for the $f_0(600)$ state. The $f_0(980)$ lineshape and interference account for up to 0.8 and 2.0 events, respectively. The overall systematic error is dominated by the uncertainty in the $B\bar{B}$ backgrounds and, for $\rho^0 K^{*+}$, the systematic error on f_L . The total additive systematic error on the $B^+ \rightarrow \rho^0 K^{*+}$ signal yield is 9.4 and 6.7 events for $K^{*+} \rightarrow K_S^0 \pi^+$ and $K^{*+} \rightarrow K^+ \pi^0$, respectively, and for $B^+ \rightarrow f_0(980) K^{*+}$ it is 4.4 and 1.3 events, respectively.

Multiplicative uncertainties include reconstruction efficiency uncertainties from tracking (0.8% per track added linearly), charged particle identification (1.1% per track added linearly), π^0 identification (3.0%), K_S^0 identification (1.0%), track multiplicity (1.0%), the number of $B\bar{B}$ pairs (1.1%), and MC signal statistics (0.2%). The total multiplicative branching fraction systematic error is 4.5% and 5.3% for decays with $K^{*+} \rightarrow K_S^0 \pi^+$ and $K^{*+} \rightarrow K^+ \pi^0$, respectively. The multiplicative uncer-

tainties for both sub-modes are correlated. The majority of the systematic uncertainties on f_L and \mathcal{A}_{CP} cancel and the error is dominated by the uncertainty on the PDF parameters (0.02). The uncertainty due to the dependence of the reconstruction efficiency on the charge of the kaon is estimated from MC to be 0.005. The total systematic is calculated to be ± 0.03 for all modes.

In summary, we observe $B^+ \rightarrow \rho^0 K^{*+}$ with a significance of 5.3σ . We measure the branching fraction $\mathcal{B}(B^+ \rightarrow \rho^0 K^{*+}) = (4.6 \pm 1.0 \pm 0.4) \times 10^{-6}$, the longitudinal polarization $f_L = 0.78 \pm 0.12 \pm 0.03$, and the CP -violating asymmetry $\mathcal{A}_{CP} = 0.31 \pm 0.13 \pm 0.03$. We observe $B^+ \rightarrow f_0(980) K^{*+}$ and measure the branching fraction $\mathcal{B}(B^+ \rightarrow f_0(980) K^{*+}) \times \mathcal{B}(f_0(980) \rightarrow \pi^+ \pi^-) = (4.2 \pm 0.6 \pm 0.3) \times 10^{-6}$ and the CP -violating asymmetry $\mathcal{A}_{CP} = -0.15 \pm 0.12 \pm 0.03$. The $B^+ \rightarrow \rho^0 K^{*+}$ branching fraction is compatible with theoretical predictions [2, 3].

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