

**Observation of  $B^+ \rightarrow \rho^+ K^0$  and measurement of its branching fraction and charge asymmetry**

B. Aubert,<sup>1</sup> M. Bona,<sup>1</sup> D. Boutigny,<sup>1</sup> Y. Karyotakis,<sup>1</sup> J. P. Lees,<sup>1</sup> V. Poireau,<sup>1</sup> X. Prudent,<sup>1</sup> V. Tisserand,<sup>1</sup> A. Zghiche,<sup>1</sup> J. Garra Tico,<sup>2</sup> E. Grauges,<sup>2</sup> L. Lopez,<sup>3</sup> A. Palano,<sup>3</sup> G. Eigen,<sup>4</sup> B. Stugu,<sup>4</sup> L. Sun,<sup>4</sup> G. S. Abrams,<sup>5</sup> M. Battaglia,<sup>5</sup> D. N. Brown,<sup>5</sup> J. Button-Shafer,<sup>5</sup> R. N. Cahn,<sup>5</sup> Y. Groyzman,<sup>5</sup> R. G. Jacobsen,<sup>5</sup> J. A. Kadyk,<sup>5</sup> L. T. Kerth,<sup>5</sup> Yu. G. Kolomensky,<sup>5</sup> G. Kukartsev,<sup>5</sup> D. Lopes Pegna,<sup>5</sup> G. Lynch,<sup>5</sup> L. M. Mir,<sup>5</sup> T. J. Orimoto,<sup>5</sup> M. T. Ronan,<sup>5,\*</sup> K. Tackmann,<sup>5</sup> W. A. Wenzel,<sup>5</sup> P. del Amo Sanchez,<sup>6</sup> C. M. Hawkes,<sup>6</sup> A. T. Watson,<sup>6</sup> T. Held,<sup>7</sup> H. Koch,<sup>7</sup> B. Lewandowski,<sup>7</sup> M. Pelizaeus,<sup>7</sup> T. Schroeder,<sup>7</sup> M. Steinke,<sup>7</sup> D. Walker,<sup>8</sup> D. J. Asgeirsson,<sup>9</sup> T. Cuhadar-Donszelmann,<sup>9</sup> B. G. Fulson,<sup>9</sup> C. Hearty,<sup>9</sup> N. S. Knecht,<sup>9</sup> T. S. Mattison,<sup>9</sup> J. A. McKenna,<sup>9</sup> A. Khan,<sup>10</sup> M. Saleem,<sup>10</sup> L. Teodorescu,<sup>10</sup> V. E. Blinov,<sup>11</sup> A. D. Bukin,<sup>11</sup> V. P. Druzhinin,<sup>11</sup> V. B. Golubev,<sup>11</sup> A. P. Onuchin,<sup>11</sup> S. I. Serednyakov,<sup>11</sup> Yu. I. Skovpen,<sup>11</sup> E. P. Solodov,<sup>11</sup> K. Yu Todyshev,<sup>11</sup> M. Bondioli,<sup>12</sup> S. Curry,<sup>12</sup> I. Eschrich,<sup>12</sup> D. Kirkby,<sup>12</sup> A. J. Lankford,<sup>12</sup> P. Lund,<sup>12</sup> M. Mandelkern,<sup>12</sup> E. C. Martin,<sup>12</sup> D. P. Stoker,<sup>12</sup> S. Abachi,<sup>13</sup> C. Buchanan,<sup>13</sup> S. D. Foulkes,<sup>14</sup> J. W. Gary,<sup>14</sup> F. Liu,<sup>14</sup> O. Long,<sup>14</sup> B. C. Shen,<sup>14</sup> L. Zhang,<sup>14</sup> H. P. Paar,<sup>15</sup> S. Rahatlou,<sup>15</sup> V. Sharma,<sup>15</sup> J. W. Berryhill,<sup>16</sup> C. Campagnari,<sup>16</sup> A. Cunha,<sup>16</sup> B. Dahmes,<sup>16</sup> T. M. Hong,<sup>16</sup> D. Kovalskyi,<sup>16</sup> J. D. Richman,<sup>16</sup> T. W. Beck,<sup>17</sup> A. M. Eisner,<sup>17</sup> C. J. Flacco,<sup>17</sup> C. A. Heusch,<sup>17</sup> J. Kroseberg,<sup>17</sup> W. S. Lockman,<sup>17</sup> T. Schalk,<sup>17</sup> B. A. Schumm,<sup>17</sup> A. Seiden,<sup>17</sup> D. C. Williams,<sup>17</sup> M. G. Wilson,<sup>17</sup> L. O. Winstrom,<sup>17</sup> E. Chen,<sup>18</sup> C. H. Cheng,<sup>18</sup> F. Fang,<sup>18</sup> D. G. Hitlin,<sup>18</sup> I. Narsky,<sup>18</sup> T. Piatenko,<sup>18</sup> F. C. Porter,<sup>18</sup> G. Mancinelli,<sup>19</sup> B. T. Meadows,<sup>19</sup> K. Mishra,<sup>19</sup> M. D. Sokoloff,<sup>19</sup> F. Blanc,<sup>20</sup> P. C. Bloom,<sup>20</sup> S. Chen,<sup>20</sup> W. T. Ford,<sup>20</sup> J. F. Hirschauer,<sup>20</sup> A. Kreisel,<sup>20</sup> M. Nagel,<sup>20</sup> U. Nauenberg,<sup>20</sup> A. Olivas,<sup>20</sup> J. G. Smith,<sup>20</sup> K. A. Ulmer,<sup>20</sup> S. R. Wagner,<sup>20</sup> J. Zhang,<sup>20</sup> A. M. Gabareen,<sup>21</sup> A. Soffer,<sup>21</sup> W. H. Toki,<sup>21</sup> R. J. Wilson,<sup>21</sup> F. Winklmeier,<sup>21</sup> Q. Zeng,<sup>21</sup> D. D. Altenburg,<sup>22</sup> E. Feltresi,<sup>22</sup> A. Hauke,<sup>22</sup> H. Jasper,<sup>22</sup> J. Merkel,<sup>22</sup> A. Petzold,<sup>22</sup> B. Spaan,<sup>22</sup> K. Wacker,<sup>22</sup> T. Brandt,<sup>23</sup> V. Klose,<sup>23</sup> M. J. Kobel,<sup>23</sup> H. M. Lacker,<sup>23</sup> W. F. Mader,<sup>23</sup> R. Nogowski,<sup>23</sup> J. Schubert,<sup>23</sup> K. R. Schubert,<sup>23</sup> R. Schwierz,<sup>23</sup> J. E. Sundermann,<sup>23</sup> A. Volk,<sup>23</sup> D. Bernard,<sup>24</sup> G. R. Bonneaud,<sup>24</sup> E. Latour,<sup>24</sup> V. Lombardo,<sup>24</sup> Ch. Thiebaux,<sup>24</sup> M. Verderi,<sup>24</sup> P. J. Clark,<sup>25</sup> W. Gradl,<sup>25</sup> F. Muheim,<sup>25</sup> S. Playfer,<sup>25</sup> A. I. Robertson,<sup>25</sup> Y. Xie,<sup>25</sup> M. Andreotti,<sup>26</sup> D. Bettoni,<sup>26</sup> C. Bozzi,<sup>26</sup> R. Calabrese,<sup>26</sup> A. Cecchi,<sup>26</sup> G. Cibinetto,<sup>26</sup> P. Franchini,<sup>26</sup> E. Luppi,<sup>26</sup> M. Negrini,<sup>26</sup> A. Petrella,<sup>26</sup> L. Piemontese,<sup>26</sup> E. Prencipe,<sup>26</sup> V. Santoro,<sup>26</sup> F. Anulli,<sup>27</sup> R. Baldini-Ferrolì,<sup>27</sup> A. Calcaterra,<sup>27</sup> R. de Sangro,<sup>27</sup> G. Finocchiaro,<sup>27</sup> S. Pacetti,<sup>27</sup> P. Patteri,<sup>27</sup> I. M. Peruzzi,<sup>27,†</sup> M. Piccolo,<sup>27</sup> M. Rama,<sup>27</sup> A. Zallo,<sup>27</sup> A. Buzzo,<sup>28</sup> R. Contri,<sup>28</sup> M. Lo Vetere,<sup>28</sup> M. M. Macri,<sup>28</sup> M. R. Monge,<sup>28</sup> S. Passaggio,<sup>28</sup> C. Patrignani,<sup>28</sup> E. Robutti,<sup>28</sup> A. Santroni,<sup>28</sup> S. Tosi,<sup>28</sup> K. S. Chaisanguanthum,<sup>29</sup> M. Morii,<sup>29</sup> J. Wu,<sup>29</sup> R. S. Dubitzky,<sup>30</sup> J. Marks,<sup>30</sup> S. Schenk,<sup>30</sup> U. Uwer,<sup>30</sup> D. J. Bard,<sup>31</sup> P. D. Dauncey,<sup>31</sup> R. L. Flack,<sup>31</sup> J. A. Nash,<sup>31</sup> M. B. Nikolich,<sup>31</sup> W. Panduro Vazquez,<sup>31</sup> P. K. Behera,<sup>32</sup> X. Chai,<sup>32</sup> M. J. Charles,<sup>32</sup> U. Mallik,<sup>32</sup> N. T. Meyer,<sup>32</sup> V. Ziegler,<sup>32</sup> J. Cochran,<sup>33</sup> H. B. Crawley,<sup>33</sup> L. Dong,<sup>33</sup> V. Eyges,<sup>33</sup> W. T. Meyer,<sup>33</sup> S. Prell,<sup>33</sup> E. I. Rosenberg,<sup>33</sup> A. E. Rubin,<sup>33</sup> A. V. Gritsan,<sup>34</sup> Z. J. Guo,<sup>34</sup> C. K. Lae,<sup>34</sup> A. G. Denig,<sup>35</sup> M. Fritsch,<sup>35</sup> G. Schott,<sup>35</sup> N. Arnaud,<sup>36</sup> J. Béquilleux,<sup>36</sup> M. Davier,<sup>36</sup> G. Grosdidier,<sup>36</sup> A. Höcker,<sup>36</sup> V. Lepeltier,<sup>36</sup> F. Le Diberder,<sup>36</sup> A. M. Lutz,<sup>36</sup> S. Pruvot,<sup>36</sup> S. Rodier,<sup>36</sup> P. Roudeau,<sup>36</sup> M. H. Schune,<sup>36</sup> J. Serrano,<sup>36</sup> V. Sordini,<sup>36</sup> A. Stocchi,<sup>36</sup> W. F. Wang,<sup>36</sup> G. Wormser,<sup>36</sup> D. J. Lange,<sup>37</sup> D. M. Wright,<sup>37</sup> C. A. Chavez,<sup>38</sup> I. J. Forster,<sup>38</sup> J. R. Fry,<sup>38</sup> E. Gabathuler,<sup>38</sup> R. Gamet,<sup>38</sup> D. E. Hutchcroft,<sup>38</sup> D. J. Payne,<sup>38</sup> K. C. Schofield,<sup>38</sup> C. Touramanis,<sup>38</sup> A. J. Bevan,<sup>39</sup> K. A. George,<sup>39</sup> F. Di Lodovico,<sup>39</sup> W. Menges,<sup>39</sup> R. Sacco,<sup>39</sup> G. Cowan,<sup>40</sup> H. U. Flaecher,<sup>40</sup> D. A. Hopkins,<sup>40</sup> P. S. Jackson,<sup>40</sup> T. R. McMahon,<sup>40</sup> F. Salvatore,<sup>40</sup> A. C. Wren,<sup>40</sup> D. N. Brown,<sup>41</sup> C. L. Davis,<sup>41</sup> J. Allison,<sup>42</sup> N. R. Barlow,<sup>42</sup> R. J. Barlow,<sup>42</sup> Y. M. Chia,<sup>42</sup> C. L. Edgar,<sup>42</sup> G. D. Lafferty,<sup>42</sup> T. J. West,<sup>42</sup> J. I. Yi,<sup>42</sup> J. Anderson,<sup>43</sup> C. Chen,<sup>43</sup> A. Jawahery,<sup>43</sup> D. A. Roberts,<sup>43</sup> G. Simi,<sup>43</sup> J. M. Tuggle,<sup>43</sup> G. Blaylock,<sup>44</sup> C. Dallapiccola,<sup>44</sup> S. S. Hertzbach,<sup>44</sup> X. Li,<sup>44</sup> T. B. Moore,<sup>44</sup> E. Salvati,<sup>44</sup> S. Saremi,<sup>44</sup> R. Cowan,<sup>45</sup> P. H. Fisher,<sup>45</sup> G. Sciolla,<sup>45</sup> S. J. Sekula,<sup>45</sup> M. Spitznagel,<sup>45</sup> F. Taylor,<sup>45</sup> R. K. Yamamoto,<sup>45</sup> S. E. Mclachlin,<sup>46</sup> P. M. Patel,<sup>46</sup> S. H. Robertson,<sup>46</sup> A. Lazzaro,<sup>47</sup> F. Palombo,<sup>47</sup> J. M. Bauer,<sup>48</sup> L. Cremaldi,<sup>48</sup> V. Eschenburg,<sup>48</sup> R. Godang,<sup>48</sup> R. Kroeger,<sup>48</sup> D. A. Sanders,<sup>48</sup> D. J. Summers,<sup>48</sup> H. W. Zhao,<sup>48</sup> S. Brunet,<sup>49</sup> D. Côté,<sup>49</sup> M. Simard,<sup>49</sup> P. Taras,<sup>49</sup> F. B. Viaud,<sup>49</sup> H. Nicholson,<sup>50</sup> G. De Nardo,<sup>51</sup> F. Fabozzi,<sup>51,‡</sup> L. Lista,<sup>51</sup> D. Monorchio,<sup>51</sup> C. Sciacca,<sup>51</sup> M. A. Baak,<sup>52</sup> G. Raven,<sup>52</sup> H. L. Snoek,<sup>52</sup> C. P. Jessop,<sup>53</sup> J. M. LoSecco,<sup>53</sup> G. Benelli,<sup>54</sup> L. A. Corwin,<sup>54</sup> K. K. Gan,<sup>54</sup> K. Honscheid,<sup>54</sup> D. Hufnagel,<sup>54</sup> H. Kagan,<sup>54</sup> R. Kass,<sup>54</sup> J. P. Morris,<sup>54</sup> A. M. Rahimi,<sup>54</sup> J. J. Regensburger,<sup>54</sup> R. Ter-Antonyan,<sup>54</sup> Q. K. Wong,<sup>54</sup> N. L. Blount,<sup>55</sup> J. Brau,<sup>55</sup> R. Frey,<sup>55</sup> O. Igonkina,<sup>55</sup> J. A. Kolb,<sup>55</sup> M. Lu,<sup>55</sup> R. Rahmat,<sup>55</sup> N. B. Sinev,<sup>55</sup> D. Strom,<sup>55</sup> J. Strube,<sup>55</sup> E. Torrence,<sup>55</sup> N. Gagliardi,<sup>56</sup> A. Gaz,<sup>56</sup> M. Margoni,<sup>56</sup> M. Morandin,<sup>56</sup> A. Pompili,<sup>56</sup> M. Posocco,<sup>56</sup> M. Rotondo,<sup>56</sup> F. Simonetto,<sup>56</sup> R. Stroili,<sup>56</sup> C. Voci,<sup>56</sup> E. Ben-Haim,<sup>57</sup> H. Briand,<sup>57</sup> G. Calderini,<sup>57</sup> J. Chauveau,<sup>57</sup> P. David,<sup>57</sup> L. Del Buono,<sup>57</sup> Ch. de la Vaissière,<sup>57</sup> O. Hamon,<sup>57</sup> Ph. Leruste,<sup>57</sup> J. Malclès,<sup>57</sup> J. Ocariz,<sup>57</sup> A. Perez,<sup>57</sup> L. Gladney,<sup>58</sup> M. Biasini,<sup>59</sup> R. Covarelli,<sup>59</sup> E. Manoni,<sup>59</sup> C. Angelini,<sup>60</sup> G. Batignani,<sup>60</sup> S. Bettarini,<sup>60</sup> M. Carpinelli,<sup>60</sup> R. Cenci,<sup>60</sup> A. Cervelli,<sup>60</sup> F. Forti,<sup>60</sup> M. A. Giorgi,<sup>60</sup> A. Lusiani,<sup>60</sup>

G. Marchiori,<sup>60</sup> M. A. Mazur,<sup>60</sup> M. Morganti,<sup>60</sup> N. Neri,<sup>60</sup> E. Paoloni,<sup>60</sup> G. Rizzo,<sup>60</sup> J. J. Walsh,<sup>60</sup> M. Haire,<sup>61</sup> J. Biesiada,<sup>62</sup> P. Elmer,<sup>62</sup> Y. P. Lau,<sup>62</sup> C. Lu,<sup>62</sup> J. Olsen,<sup>62</sup> A. J. S. Smith,<sup>62</sup> A. V. Telnov,<sup>62</sup> E. Baracchini,<sup>63</sup> F. Bellini,<sup>63</sup> G. Cavoto,<sup>63</sup> A. D’Orazio,<sup>63</sup> D. del Re,<sup>63</sup> E. Di Marco,<sup>63</sup> R. Faccini,<sup>63</sup> F. Ferrarotto,<sup>63</sup> F. Ferroni,<sup>63</sup> M. Gaspero,<sup>63</sup> P. D. Jackson,<sup>63</sup> L. Li Gioi,<sup>63</sup> M. A. Mazzoni,<sup>63</sup> S. Morganti,<sup>63</sup> G. Piredda,<sup>63</sup> F. Polci,<sup>63</sup> F. Renga,<sup>63</sup> C. Voena,<sup>63</sup> M. Ebert,<sup>64</sup> H. Schröder,<sup>64</sup> R. Waldi,<sup>64</sup> T. Adye,<sup>65</sup> G. Castelli,<sup>65</sup> B. Franek,<sup>65</sup> E. O. Olaiya,<sup>65</sup> S. Ricciardi,<sup>65</sup> W. Roethel,<sup>65</sup> F. F. Wilson,<sup>65</sup> R. Aleksan,<sup>66</sup> S. Emery,<sup>66</sup> M. Escalier,<sup>66</sup> A. Gaidot,<sup>66</sup> S. F. Ganzhur,<sup>66</sup> G. Hamel de Monchenault,<sup>66</sup> W. Kozanecki,<sup>66</sup> M. Legendre,<sup>66</sup> G. Vasseur,<sup>66</sup> Ch. Yèche,<sup>66</sup> M. Zito,<sup>66</sup> X. R. Chen,<sup>67</sup> H. Liu,<sup>67</sup> W. Park,<sup>67</sup> M. V. Purohit,<sup>67</sup> J. R. Wilson,<sup>67</sup> M. T. Allen,<sup>68</sup> D. Aston,<sup>68</sup> R. Bartoldus,<sup>68</sup> P. Bechtle,<sup>68</sup> N. Berger,<sup>68</sup> R. Claus,<sup>68</sup> J. P. Coleman,<sup>68</sup> M. R. Convery,<sup>68</sup> J. C. Dingfelder,<sup>68</sup> J. Dorfan,<sup>68</sup> G. P. Dubois-Felsmann,<sup>68</sup> D. Dujmic,<sup>68</sup> W. Dunwoodie,<sup>68</sup> R. C. Field,<sup>68</sup> T. Glanzman,<sup>68</sup> S. J. Gowdy,<sup>68</sup> M. T. Graham,<sup>68</sup> P. Grenier,<sup>68</sup> C. Hast,<sup>68</sup> T. Hryn’ova,<sup>68</sup> W. R. Innes,<sup>68</sup> J. Kaminski,<sup>68</sup> M. H. Kelsey,<sup>68</sup> H. Kim,<sup>68</sup> P. Kim,<sup>68</sup> M. L. Kocian,<sup>68</sup> D. W. G. S. Leith,<sup>68</sup> S. Li,<sup>68</sup> S. Luitz,<sup>68</sup> V. Luth,<sup>68</sup> H. L. Lynch,<sup>68</sup> D. B. MacFarlane,<sup>68</sup> H. Marsiske,<sup>68</sup> R. Messner,<sup>68</sup> D. R. Muller,<sup>68</sup> C. P. O’Grady,<sup>68</sup> I. Ofte,<sup>68</sup> A. Perazzo,<sup>68</sup> M. Perl,<sup>68</sup> T. Pulliam,<sup>68</sup> B. N. Ratcliff,<sup>68</sup> A. Roodman,<sup>68</sup> A. A. Salnikov,<sup>68</sup> R. H. Schindler,<sup>68</sup> J. Schwiening,<sup>68</sup> A. Snyder,<sup>68</sup> J. Stelzer,<sup>68</sup> D. Su,<sup>68</sup> M. K. Sullivan,<sup>68</sup> K. Suzuki,<sup>68</sup> S. K. Swain,<sup>68</sup> J. M. Thompson,<sup>68</sup> J. Va’vra,<sup>68</sup> N. van Bakel,<sup>68</sup> A. P. Wagner,<sup>68</sup> M. Weaver,<sup>68</sup> W. J. Wisniewski,<sup>68</sup> M. Wittgen,<sup>68</sup> D. H. Wright,<sup>68</sup> A. K. Yarritu,<sup>68</sup> K. Yi,<sup>68</sup> C. C. Young,<sup>68</sup> P. R. Burchat,<sup>69</sup> A. J. Edwards,<sup>69</sup> S. A. Majewski,<sup>69</sup> B. A. Petersen,<sup>69</sup> L. Wilden,<sup>69</sup> S. Ahmed,<sup>70</sup> M. S. Alam,<sup>70</sup> R. Bula,<sup>70</sup> J. A. Ernst,<sup>70</sup> V. Jain,<sup>70</sup> B. Pan,<sup>70</sup> M. A. Saeed,<sup>70</sup> F. R. Wappler,<sup>70</sup> S. B. Zain,<sup>70</sup> W. Bugg,<sup>71</sup> M. Krishnamurthy,<sup>71</sup> S. M. Spanier,<sup>71</sup> R. Eckmann,<sup>72</sup> J. L. Ritchie,<sup>72</sup> A. M. Ruland,<sup>72</sup> C. J. Schilling,<sup>72</sup> R. F. Schwitters,<sup>72</sup> J. M. Izen,<sup>73</sup> X. C. Lou,<sup>73</sup> S. Ye,<sup>73</sup> F. Bianchi,<sup>74</sup> F. Gallo,<sup>74</sup> D. Gamba,<sup>74</sup> M. Pelliccioni,<sup>74</sup> M. Bomben,<sup>75</sup> L. Bosisio,<sup>75</sup> C. Cartaro,<sup>75</sup> F. Cossutti,<sup>75</sup> G. Della Ricca,<sup>75</sup> L. Lanceri,<sup>75</sup> L. Vitale,<sup>75</sup> V. Azzolini,<sup>76</sup> N. Lopez-March,<sup>76</sup> F. Martinez-Vidal,<sup>76</sup> D. A. Milanes,<sup>76</sup> A. Oyanguren,<sup>76</sup> J. Albert,<sup>77</sup> Sw. Banerjee,<sup>77</sup> B. Bhuyan,<sup>77</sup> K. Hamano,<sup>77</sup> R. Kowalewski,<sup>77</sup> I. M. Nugent,<sup>77</sup> J. M. Roney,<sup>77</sup> R. J. Sobie,<sup>77</sup> J. J. Back,<sup>78</sup> P. F. Harrison,<sup>78</sup> T. E. Latham,<sup>78</sup> G. B. Mohanty,<sup>78</sup> M. Pappagallo,<sup>78,§</sup> H. R. Band,<sup>79</sup> X. Chen,<sup>79</sup> S. Dasu,<sup>79</sup> K. T. Flood,<sup>79</sup> J. J. Hollar,<sup>79</sup> P. E. Kutter,<sup>79</sup> Y. Pan,<sup>79</sup> M. Pierini,<sup>79</sup> R. Prepost,<sup>79</sup> S. L. Wu,<sup>79</sup> Z. Yu,<sup>79</sup> and H. Neal<sup>80</sup>

(BABAR Collaboration)

<sup>1</sup>Laboratoire de Physique des Particules, IN2P3/CNRS et Université de Savoie, F-74941 Annecy-Le-Vieux, France

<sup>2</sup>Universitat de Barcelona, Facultat de Física, Departament ECM, E-08028 Barcelona, Spain

<sup>3</sup>Università di Bari, Dipartimento di Fisica and INFN, I-70126 Bari, Italy

<sup>4</sup>University of Bergen, Institute of Physics, N-5007 Bergen, Norway

<sup>5</sup>Lawrence Berkeley National Laboratory and University of California, Berkeley, California 94720, USA

<sup>6</sup>University of Birmingham, Birmingham, B15 2TT, United Kingdom

<sup>7</sup>Ruhr Universität Bochum, Institut für Experimentalphysik 1, D-44780 Bochum, Germany

<sup>8</sup>University of Bristol, Bristol BS8 1TL, United Kingdom

<sup>9</sup>University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z1

<sup>10</sup>Brunel University, Uxbridge, Middlesex UB8 3PH, United Kingdom

<sup>11</sup>Budker Institute of Nuclear Physics, Novosibirsk 630090, Russia

<sup>12</sup>University of California at Irvine, Irvine, California 92697, USA

<sup>13</sup>University of California at Los Angeles, Los Angeles, California 90024, USA

<sup>14</sup>University of California at Riverside, Riverside, California 92521, USA

<sup>15</sup>University of California at San Diego, La Jolla, California 92093, USA

<sup>16</sup>University of California at Santa Barbara, Santa Barbara, California 93106, USA

<sup>17</sup>University of California at Santa Cruz, Institute for Particle Physics, Santa Cruz, California 95064, USA

<sup>18</sup>California Institute of Technology, Pasadena, California 91125, USA

<sup>19</sup>University of Cincinnati, Cincinnati, Ohio 45221, USA

<sup>20</sup>University of Colorado, Boulder, Colorado 80309, USA

<sup>21</sup>Colorado State University, Fort Collins, Colorado 80523, USA

<sup>22</sup>Universität Dortmund, Institut für Physik, D-44221 Dortmund, Germany

<sup>23</sup>Technische Universität Dresden, Institut für Kern- und Teilchenphysik, D-01062 Dresden, Germany

<sup>24</sup>Laboratoire Leprince-Ringuet, CNRS/IN2P3, Ecole Polytechnique, F-91128 Palaiseau, France

<sup>25</sup>University of Edinburgh, Edinburgh EH9 3JZ, United Kingdom

<sup>26</sup>Università di Ferrara, Dipartimento di Fisica and INFN, I-44100 Ferrara, Italy

<sup>27</sup>Laboratori Nazionali di Frascati dell’INFN, I-00044 Frascati, Italy

<sup>28</sup>Università di Genova, Dipartimento di Fisica and INFN, I-16146 Genova, Italy

<sup>29</sup>Harvard University, Cambridge, Massachusetts 02138, USA

<sup>30</sup>Universität Heidelberg, Physikalisches Institut, Philosophenweg 12, D-69120 Heidelberg, Germany

- <sup>31</sup>Imperial College London, London, SW7 2AZ, United Kingdom  
<sup>32</sup>University of Iowa, Iowa City, Iowa 52242, USA  
<sup>33</sup>Iowa State University, Ames, Iowa 50011-3160, USA  
<sup>34</sup>Johns Hopkins University, Baltimore, Maryland 21218, USA  
<sup>35</sup>Universität Karlsruhe, Institut für Experimentelle Kernphysik, D-76021 Karlsruhe, Germany  
<sup>36</sup>Laboratoire de l'Accélérateur Linéaire, IN2P3/CNRS et Université Paris-Sud 11, Centre Scientifique d'Orsay, B. P. 34, F-91898 ORSAY Cedex, France  
<sup>37</sup>Lawrence Livermore National Laboratory, Livermore, California 94550, USA  
<sup>38</sup>University of Liverpool, Liverpool L69 7ZE, United Kingdom  
<sup>39</sup>Queen Mary, University of London, E1 4NS, United Kingdom  
<sup>40</sup>University of London, Royal Holloway and Bedford New College, Egham, Surrey TW20 0EX, United Kingdom  
<sup>41</sup>University of Louisville, Louisville, Kentucky 40292, USA  
<sup>42</sup>University of Manchester, Manchester M13 9PL, United Kingdom  
<sup>43</sup>University of Maryland, College Park, Maryland 20742, USA  
<sup>44</sup>University of Massachusetts, Amherst, Massachusetts 01003, USA  
<sup>45</sup>Massachusetts Institute of Technology, Laboratory for Nuclear Science, Cambridge, Massachusetts 02139, USA  
<sup>46</sup>McGill University, Montréal, Québec, Canada H3A 2T8  
<sup>47</sup>Università di Milano, Dipartimento di Fisica and INFN, I-20133 Milano, Italy  
<sup>48</sup>University of Mississippi, University, Mississippi 38677, USA  
<sup>49</sup>Université de Montréal, Physique des Particules, Montréal, Québec, Canada H3C 3J7  
<sup>50</sup>Mount Holyoke College, South Hadley, Massachusetts 01075, USA  
<sup>51</sup>Università di Napoli Federico II, Dipartimento di Scienze Fisiche and INFN, I-80126, Napoli, Italy  
<sup>52</sup>NIKHEF, National Institute for Nuclear Physics and High Energy Physics, NL-1009 DB Amsterdam, The Netherlands  
<sup>53</sup>University of Notre Dame, Notre Dame, Indiana 46556, USA  
<sup>54</sup>Ohio State University, Columbus, Ohio 43210, USA  
<sup>55</sup>University of Oregon, Eugene, Oregon 97403, USA  
<sup>56</sup>Università di Padova, Dipartimento di Fisica and INFN, I-35131 Padova, Italy  
<sup>57</sup>Laboratoire de Physique Nucléaire et de Hautes Energies, IN2P3/CNRS, Université Pierre et Marie Curie-Paris6, Université Denis Diderot-Paris7, F-75252 Paris, France  
<sup>58</sup>University of Pennsylvania, Philadelphia, Pennsylvania 19104, USA  
<sup>59</sup>Università di Perugia, Dipartimento di Fisica and INFN, I-06100 Perugia, Italy  
<sup>60</sup>Università di Pisa, Dipartimento di Fisica, Scuola Normale Superiore and INFN, I-56127 Pisa, Italy  
<sup>61</sup>Prairie View A&M University, Prairie View, Texas 77446, USA  
<sup>62</sup>Princeton University, Princeton, New Jersey 08544, USA  
<sup>63</sup>Università di Roma La Sapienza, Dipartimento di Fisica and INFN, I-00185 Roma, Italy  
<sup>64</sup>Universität Rostock, D-18051 Rostock, Germany  
<sup>65</sup>Rutherford Appleton Laboratory, Chilton, Didcot, Oxon, OX11 0QX, United Kingdom  
<sup>66</sup>DSM/Dapnia, CEA/Saclay, F-91191 Gif-sur-Yvette, France  
<sup>67</sup>University of South Carolina, Columbia, South Carolina 29208, USA  
<sup>68</sup>Stanford Linear Accelerator Center, Stanford, California 94309, USA  
<sup>69</sup>Stanford University, Stanford, California 94305-4060, USA  
<sup>70</sup>State University of New York, Albany, New York 12222, USA  
<sup>71</sup>University of Tennessee, Knoxville, Tennessee 37996, USA  
<sup>72</sup>University of Texas at Austin, Austin, Texas 78712, USA  
<sup>73</sup>University of Texas at Dallas, Richardson, Texas 75083, USA  
<sup>74</sup>Università di Torino, Dipartimento di Fisica Sperimentale and INFN, I-10125 Torino, Italy  
<sup>75</sup>Università di Trieste, Dipartimento di Fisica and INFN, I-34127 Trieste, Italy  
<sup>76</sup>IFIC, Universitat de Valencia-CSIC, E-46071 Valencia, Spain  
<sup>77</sup>University of Victoria, Victoria, British Columbia, Canada V8W 3P6  
<sup>78</sup>Department of Physics, University of Warwick, Coventry CV4 7AL, United Kingdom  
<sup>79</sup>University of Wisconsin, Madison, Wisconsin 53706, USA  
<sup>80</sup>Yale University, New Haven, Connecticut 06511, USA  
(Received 26 February 2007; published 9 July 2007)

We present the first observation of the decay  $B^+ \rightarrow \rho^+ K^0$ , using a data sample of  $348 \text{ fb}^{-1}$  collected at the  $Y(4S)$  resonance with the BABAR detector. The branching fraction and charge asymmetry are

\*Deceased

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

‡Also with Università della Basilicata, Potenza, Italy.

§Also with IPPP, Physics Department, Durham University, Durham DH1 3LE, United Kingdom.

measured to be  $(8.0_{-1.3}^{+1.4} \pm 0.6) \times 10^{-6}$  and  $(-12.2 \pm 16.6 \pm 2.0)\%$ , respectively, where the first uncertainty is statistical and the second is systematic. The charge asymmetry is defined by  $\mathcal{A}_{\text{ch}} = (\Gamma_{B^-} - \Gamma_{B^+})/(\Gamma_{B^-} + \Gamma_{B^+})$  with  $\Gamma_{B^\pm}$  the  $B^\pm$  decay rate. The significance of the observed branching fraction, including systematic uncertainties, is 7.9 standard deviations.

DOI: [10.1103/PhysRevD.76.011103](https://doi.org/10.1103/PhysRevD.76.011103)

PACS numbers: 13.25.Hw, 11.30.Er, 12.15.Hh

In the standard model (SM) of particle physics, the weak-current couplings of quarks are described by elements of the Cabibbo-Kobayashi-Maskawa (CKM) matrix [1]. Charmless decays of  $B$  mesons provide important information about these couplings. These decays, which have branching fractions of the order of  $10^{-6}$ , are generally expected to occur via  $b \rightarrow s$  or  $b \rightarrow d$  virtual loop (“penguin”) amplitudes, tree-level  $b \rightarrow u$  decays, or a combination of the two. Phenomenological fits to the branching fractions and charge asymmetries of charmless  $B$  decays can be used to understand the relative importance of tree and penguin amplitudes and to extract measurements of the CKM phase angles.

We present the first observation of the charmless  $b \rightarrow s$  process  $B^+ \rightarrow \rho^+ K^0$ . Throughout this paper, the charge conjugate channel is implied unless otherwise stated. We measure the branching fraction and charge asymmetry. The latter is defined as  $\mathcal{A}_{\text{ch}} = (\Gamma_{B^-} - \Gamma_{B^+})/(\Gamma_{B^-} + \Gamma_{B^+})$  with  $\Gamma_{B^\pm}$  the  $B^\pm$  decay rate. A nonzero value of  $\mathcal{A}_{\text{ch}}$  implies violation of  $CP$  symmetry. Data were collected with the *BABAR* detector at the PEP-II asymmetric  $e^+e^-$  collider at the Stanford Linear Accelerator Center. The data used in the analysis are based on a sample with an integrated luminosity of  $348 \text{ fb}^{-1}$ , corresponding to  $383 \pm 4$  million  $B\bar{B}$  pairs recorded at the  $Y(4S)$  resonance [center-of-mass energy (CM)  $\sqrt{s} = 10.58 \text{ GeV}$ ].

The  $B^+ \rightarrow \rho^+ K^0$  decay is expected to be a pure penguin decay [2], making it particularly helpful to separate the contributions of tree and penguin amplitudes in other channels. Phenomenological studies [2–4] of charmless, strangeness changing ( $|\Delta S| = 1$ )  $B \rightarrow VP$  decays, with  $V$  a vector and  $P$  a pseudoscalar meson, assume that the penguin amplitudes  $p'_V$  and  $p'_P$  are related by  $p'_V = -p'_P$ , where  $p'_V$  ( $p'_P$ ) is the amplitude for the spectator quark to appear in the  $V$  ( $P$ ) meson. Measurement of the  $B^+ \rightarrow \rho^+ K^0$  branching fraction can provide a direct test of this assumption [5]. Exploiting  $U$ -spin symmetry, Soni and Suprun [6] recently introduced a technique to determine the CKM phase angle  $\gamma$  with precision comparable to the best current measurements, using charmless  $B^\pm \rightarrow M^\pm M^0$  decays, where  $M^\pm$  and  $M^0$  are charged and neutral mesons. Of the eight  $M^\pm M^0$  channels necessary to apply this technique to  $B^\pm \rightarrow V^\pm P^0$  decays, experimental results exist for all but two channels:  $B^+ \rightarrow \rho^+ K^0$ , the topic of this study, and  $K^{*+} \bar{K}^0$ .

Theoretical predictions of the branching fraction for  $B^+ \rightarrow \rho^+ K^0$ , based on QCD factorization [7,8], heavy quark effective theory [9], and flavor  $SU(3)$  symmetry [2,10], vary from  $10^{-5}$  to  $10^{-6}$ . The only current experi-

mental result is  $\mathcal{B}(B^+ \rightarrow \rho^+ K^0) < 4.8 \times 10^{-5}$  at 90% confidence level (CL) [11]. The charge asymmetry for this decay is expected to be zero. Any significant deviation from this expectation could provide evidence for the creation of non-SM particles produced in the loops.

The *BABAR* detector is described elsewhere [12]. In brief, charged particle tracks are detected and their momenta measured by a combination of a five-layer double-sided silicon microstrip detector (SVT) and a 40-layer drift chamber (DCH), both operating in the 1.5 T magnetic field of a superconducting solenoid. Tracks are identified as charged kaons or pions using specific energy loss measurements in the SVT and DCH as well as radiation angles measured in a ring imaging Cherenkov detector. Photons are reconstructed from energy clusters deposited in a CsI(Tl) electromagnetic calorimeter.

Monte Carlo (MC) events are used to determine signal and background characteristics, optimize selection criteria, and evaluate efficiencies. Samples of  $e^+e^- \rightarrow Y(4S) \rightarrow B^0\bar{B}^0$  and  $B^+B^-$  events, generated by the EVTGEN [13] event generator, are passed through the GEANT-based [14] *BABAR* detector simulation. The number of MC events corresponds to about 3 times the integrated luminosity of the data. We follow a blind procedure in which the optimization and systematic study of selection criteria, and tests of the fitting procedure, described below, are completed before the data are examined in the region where the signal is expected.

A  $B$  meson candidate is kinematically characterized by the beam-energy substituted mass  $m_{\text{ES}} \equiv \sqrt{s/4 - (p_B^*)^2}$  and the energy difference  $\Delta E \equiv E_B^* - \sqrt{s}/2$ , where  $E_B^*$  and  $p_B^*$  are the CM energy and 3-momentum of the  $B$  candidate, respectively. Signal events peak at the nominal  $B$  mass for  $m_{\text{ES}}$  and at zero for  $\Delta E$ .

We reconstruct  $B^+ \rightarrow \rho^+ K^0$  candidates through the decays  $K^0 \rightarrow K_S^0 \rightarrow \pi^+\pi^-$  and  $\rho^+ \rightarrow \pi^+\pi^0$ , with  $\pi^0 \rightarrow \gamma\gamma$ . The  $\gamma$  energy in the laboratory frame is required to exceed 30 MeV. The  $\pi^0$  candidates are required to have a mass in the interval  $[0.115, 0.150] \text{ GeV}/c^2$  and a laboratory energy larger than 0.2 GeV. The  $\pi^0$  mass resolution is about 6 MeV/ $c^2$ . To improve the resolution of  $m_{\text{ES}}$  and  $\Delta E$ , the  $\pi^0$  candidate’s mass is constrained to its nominal value. The  $\pi^0$  candidate is combined with an identified charged pion to form a  $\rho^+$  candidate, which is required to have a mass  $m_{\pi^+\pi^0}$  in the interval  $[0.5, 1.0] \text{ GeV}/c^2$ . The helicity angle  $\theta_\rho$ , defined as the angle in the  $\rho^+$  rest frame between the direction of the boost from the  $B^+$  rest frame and the 3-momentum of the  $\pi^+$  from the  $\rho^+$  decay, is

required to satisfy  $|\cos\theta_\rho| < 0.9$ , since misreconstructed  $\pi^0$  mesons are concentrated near  $|\cos(\theta_\rho)| \approx 1$ . We form  $K_S^0$  candidates by combining all oppositely charged pairs of tracks, by fitting the two tracks to a common vertex, and by requiring the mass to lie in the interval  $[0.490, 0.506]$  GeV/ $c^2$  assuming the two tracks to be pions. The  $K_S^0$  mass resolution is about 3 MeV/ $c^2$ . The angle  $\alpha$  between the  $K_S^0$  flight direction and its momentum vector is required to satisfy  $\cos\alpha > 0.995$ , where the flight direction is the direction between the primary and secondary vertices. The  $K_S^0$  candidate is combined with the  $\rho^+$  candidate to form a  $B^+$  candidate with a vertex constrained to the beam spot. The  $K_S^0$  decay length significance, defined as the ratio of the distance between the  $K_S^0$  and  $B^+$  decay vertices and the uncertainty on that quantity, is required to be larger than 5. The  $\chi^2$  probabilities of the fitted  $K_S^0$  and  $B^+$  vertices are each required to exceed 0.5%.  $B^+$  candidates are required to satisfy  $5.25 < m_{\text{ES}} < 5.29$  GeV/ $c^2$  and  $|\Delta E| < 0.20$  GeV. The typical resolution for  $m_{\text{ES}}$  ( $\Delta E$ ) is approximately 3.0 MeV/ $c^2$  (30 MeV). We find that 9.8% of the events contain two or more  $B^+ \rightarrow \rho^+ K^0$  candidates. These are mostly events with more than one reconstructed  $\pi^0$ . For these events, the candidate with the largest  $B$  vertex fit probability is retained.

Backgrounds arise primarily from random combinations of tracks and clusters in  $e^+e^- \rightarrow q\bar{q}$  ( $q = u, d, s, c$ ) continuum events. To suppress these events, we follow a procedure similar to that described in Ref. [15]. We use the angle  $\theta_T$  between the thrust axis of the  $B$  candidate's decay products and the thrust axis determined using the remaining charged tracks and neutral clusters in the event, evaluated in the CM frame. The distribution of  $|\cos\theta_T|$  is nearly uniform for the almost-isotropic  $B\bar{B}$  events and sharply peaked near 1 for the jetlike continuum events. We require  $|\cos\theta_T| < 0.9$ . Additional use of the event topology is made by employing a Fisher discriminant  $\mathcal{F}$ , constructed from the angles with respect to the beam axis of the  $B$  momentum and the  $B$  thrust axis, and the energy flow around the  $B$  thrust axis [15].

Potential backgrounds from  $B^+B^-$  and  $B^0\bar{B}^0$  events arise from  $\bar{B} \rightarrow \bar{D}\pi$ ,  $K^*(892)\pi$  and  $K_0^*(1430)\pi$  decays that have the same  $\pi^+\pi^0 K_S^0$  final state and similar peaking structure in  $m_{\text{ES}}$  and  $\Delta E$  as the signal events. The selection requirement applied to  $m_{\pi^+\pi^0}$ , given above, rejects most of these backgrounds. To further reduce the  $B\bar{B}$  background, we apply a  $D^0$  veto ( $1.78 \leq m_{K_S^0\pi^0} \leq 1.94$ ) GeV/ $c^2$ , a  $D^+$  veto ( $1.83 \leq m_{K_S^0\pi^+} \leq 1.91$ ) GeV/ $c^2$ , a  $K^{*0}$  veto ( $0.8 \leq m_{K_S^0\pi^0} \leq 1.0$ ) GeV/ $c^2$ , a  $K^{*+}$  veto ( $0.8 \leq m_{K_S^0\pi^+} \leq 1.0$ ) GeV/ $c^2$ , a  $K^{*0}(1430)$  veto ( $1.3 \leq m_{K_S^0\pi^0} \leq 1.6$ ) GeV/ $c^2$ , and a  $K^{*+}(1430)$  veto ( $1.3 \leq m_{K_S^0\pi^+} \leq 1.6$ ) GeV/ $c^2$ , where a veto indicates that an event is rejected if the two-particle invariant mass lies in the specified mass window. These veto criteria are determined as follows: 4 standard deviations of the experimen-

tal resolution around the mass peaks for  $D^+$  and  $D^0$ , and 2 (1) resonance widths [16] around the mass peak for  $K^{*0}$  [ $K^{*+}(1430)$ ]. The decay  $B^+ \rightarrow K_S^0\pi^+$  ( $B^0 \rightarrow K_S^0\pi^0$ ) can contribute to the background when the decay products are combined with a low momentum  $\pi^0$  ( $\pi^+$ ). We therefore require the  $K_S^0\pi^0$  and  $K_S^0\pi^+$  invariant masses to be less than 5.2 GeV/ $c^2$ .

These criteria reject more than 99% of the  $B\bar{B}$  background channels discussed above and about 30% of the signal. The remaining  $B\bar{B}$  background is combinatoric and does not peak in  $\Delta E$  and  $m_{\text{ES}}$ .

From MC simulation, the signal efficiency is determined to be  $(14.78 \pm 0.10)\%$  where the uncertainty is statistical. This efficiency has been corrected to account for small differences in neutral particle reconstruction efficiencies between the data and MC, and for differences in the identification efficiency of the  $\pi^+$  used to reconstruct the  $\rho^+$ . As an example, the latter correction is determined using a  $D^{*+} \rightarrow D^0\pi^+$  data control sample with  $D^0 \rightarrow K^-\pi^+$ . The efficiency corrections are 97% for the  $\pi^0$  reconstruction and greater than 99% for the  $K_S^0$  reconstruction and  $\pi^+$  identification.

The number of signal events (the signal yield) and charge asymmetry are determined from an extended unbinned maximum likelihood (ML) fit with the following variables:  $m_{\text{ES}}$ ,  $\Delta E$ ,  $\mathcal{F}$ ,  $m_{\pi^+\pi^0}$ ,  $\cos\theta_\rho$ , and the  $B$  flight time significance, with the latter variable defined as the proper time difference  $\Delta t$  between the produced  $B$  and  $\bar{B}$  candidates divided by its uncertainty  $\sigma_{\Delta t}$  [17]. The  $\bar{B}$  vertex is determined by fitting all tracks except the daughters of the signal  $B$  candidate to a common vertex, employing constraints from the beam spot. The likelihood function has the form

$$\mathcal{L} = \frac{1}{N!} \exp\left(-\sum_{j=1}^3 n_j\right) \prod_{i=1}^N \left[ \sum_{j=1}^3 n_j \mathcal{P}_j(\mathbf{x}_i) \right], \quad (1)$$

where  $N$  is the total number of input events,  $n_j$  is the fitted yield of component  $j$  (signal, continuum, and  $B\bar{B}$  background), and  $\mathcal{P}_j(\mathbf{x}_i)$  is the corresponding overall probability density function (PDF), given by

$$\begin{aligned} \mathcal{P}_j &= \mathcal{P}_j(m_{\text{ES}}) \mathcal{P}_j(\Delta E) \mathcal{P}_j(\mathcal{F}) \mathcal{P}_j(m_{\pi^+\pi^0}) \\ &\times \mathcal{P}_j(\cos\theta_\rho) \mathcal{P}_j(\Delta t/\sigma_{\Delta t}). \end{aligned} \quad (2)$$

The signal and  $B\bar{B}$  background PDFs are determined from MC simulation. The continuum background PDF is obtained from sideband data ( $0.1 < |\Delta E| < 0.2$  GeV for  $m_{\text{ES}}$  and  $5.25 < m_{\text{ES}} < 5.27$  GeV/ $c^2$  for other variables). For  $m_{\text{ES}}$ , the PDFs of the signal and continuum are parameterized by a Crystal Ball [18] and an ARGUS function [19], respectively. A relativistic Breit-Wigner function with a  $p$ -wave Blatt-Weisskopf form factor [20] is used to model the signal  $m_{\pi^+\pi^0}$  distribution. For the background components, the  $\pi^+\pi^0$  mass is modeled by a combination of a polynomial and the signal function. Slowly varying distri-

butions ( $\Delta E$  for the continuum background, and  $\cos\theta_\rho$ ) are modeled by polynomials. The remaining variables are parametrized with either a Gaussian, the sum of two or three Gaussians, or an asymmetric Gaussian. Dips occur near  $|\cos\theta_\rho| = 0.81$  because of the resonance vetoes. We describe these dips by two Gaussian shapes. We use a large data control sample of  $B^+ \rightarrow \bar{D}^0 \pi^+$  ( $\bar{D}^0 \rightarrow K_S^0 \pi^0$ ) events to verify the simulated resolutions and peak positions of the  $m_{ES}$ ,  $\Delta E$ ,  $\mathcal{F}$ , and  $\Delta t/\sigma_{\Delta t}$  signal PDFs.

Equation (2) is based on the assumption that the variables in the PDFs are uncorrelated. To evaluate possible bias in the signal yield that might arise from residual correlations, we construct an ensemble of 600 simulated experiments. Each experiment contains the expected number of signal, continuum, and  $B\bar{B}$  background events. The continuum events are randomly drawn from the PDFs while the signal and  $B\bar{B}$  background events are randomly drawn from the MC samples. The bias is defined as the difference between the mean signal yield, determined from fits to the simulated experiments, and the number of signal events included in the samples. The bias in the signal yield is determined to be  $4.8 \pm 1.2$  events, where the uncertainty is statistical.

Table I lists the results of the fit to the data. The fit yields a simultaneous determination of the fraction  $f_+$  ( $f_-$ ) of  $B^+$  ( $B^-$ ) events relative to the total number of signal events, with the constraint  $f_+ + f_- = 1$ . The charge asymmetry is determined from  $\mathcal{A}_{\text{ch}} = 2f_- - 1$ . The statistical uncertainty of the signal yield is given by the change in the central value when the quantity  $-2\ln\mathcal{L}$  increases by one unit from its minimum value. The statistical significance is given by the square root of the difference between the value of  $-2\ln\mathcal{L}$  for zero signal events and the value at its minimum. The corresponding significance including systematic uncertainties (discussed below) is determined by convolution of the likelihood function with a Gaussian distribution whose standard deviation equals the total systematic uncertainty. Figure 1 shows projections of the fitted variables. To enhance the visibility of the signal, events are

TABLE I. Summary of results. The uncertainties on the event yields, fit bias, and efficiencies are statistical only.

Parameter	Value
Events in fit	41 150
Signal yield (events)	$158_{-26}^{+27}$
Continuum background yield (events)	$40\,321_{-211}^{+210}$
$B\bar{B}$ background yield (events)	$673_{-70}^{+71}$
Fit bias (events)	$4.8 \pm 1.2$
Detection efficiency (%)	$14.78 \pm 0.10$
Daughter branching fractions $\prod \mathcal{B}_i$ (%)	$34.18 \pm 0.03$
Statistical significance ( $\sigma$ )	8.2
Significance with systematics ( $\sigma$ )	7.9
Branching fraction $\mathcal{B}$ ( $\times 10^{-6}$ )	$8.0_{-1.3}^{+1.4} \pm 0.6$
Charge asymmetry $\mathcal{A}_{\text{ch}}$ (%)	$-12.2 \pm 16.6 \pm 2.0$

required to satisfy  $\mathcal{L}_i(S)/[\mathcal{L}_i(S) + \mathcal{L}_i(B)] > 0.9$  (this retains 70.0%, 1.4%, and 14.5% of the signal, continuum, and  $B\bar{B}$  background events, respectively), where  $\mathcal{L}_i(S)$  is the likelihood function for signal events excluding the PDF of the plotted variable  $i$  and  $\mathcal{L}_i(B)$  is the corresponding sum for all background components.

We calculate the branching fraction by subtracting the fit bias from the measured signal yield and dividing the result by the overall efficiency and the number of produced  $B\bar{B}$  pairs  $N_{B\bar{B}}$ . The overall efficiency is the product of the detection efficiency and the daughter branching fractions [16] (see Table I). We assume equal decay rates of the  $\Upsilon(4S)$  to  $B^+B^-$  and  $B^0\bar{B}^0$ . The branching fraction and charge asymmetry are determined to be  $(8.0_{-1.3}^{+1.4} \pm 0.6) \times 10^{-6}$  and  $(-12.2 \pm 16.6 \pm 2.0)\%$ , respectively, where the first uncertainty is statistical and the second is systematic. We determine  $-0.40 < \mathcal{A}_{\text{ch}} < 0.15$  at 90% CL, including systematic uncertainties.

The principal sources of systematic uncertainty are as follows. The uncertainty in the  $\pi^0$  reconstruction efficiency is 3%. The uncertainty related to the signal PDFs, assessed by varying the fitted PDF parameters within their uncertainties as determined from the  $B^+ \rightarrow \bar{D}^0 \pi^+$  data control sample, is 3.2 events. An uncertainty in the fit bias (2.7 events) is defined by the quadratic sum of half the bias itself and the statistical uncertainty of the bias. To evaluate the effect of a possible nonresonant component, we generate a Monte Carlo sample using a 3-body Dalitz amplitude event generator for  $B^+ \rightarrow \pi^+ \pi^0 K_S^0$ , including the  $\bar{K}^*(892)$ ,  $\bar{K}_0^*(1430)$ ,  $\rho$  resonances and a nonresonant amplitude. Reperforming the ML fit with signal PDFs determined from this sample results in a 3.5% increase in the signal yield, which we take to be the systematic uncertainty. Variations of all resonance vetoes yield an uncertainty of 3.1%. When the requirement on  $\cos\theta_\rho$  is varied, the results change by 2.0%. Other principal sources of uncertainty are those from the track reconstruction efficiency (1.6%), the  $B\bar{B}$  background PDFs (2.0 events),  $N_{B\bar{B}}$  (1.1%), and variation of the selection criteria on  $|\cos\theta_T|$  (1.0%). We add all terms in quadrature to obtain the total systematic uncertainty.

In summary, we present the first observation of the pure penguin  $b \rightarrow s$  decay process  $B^+ \rightarrow \rho^+ K^0$ . The significance of the measured branching fraction is 7.9 standard deviations. Using the assumption  $p'_V = -p'_p$  [5], the  $B^+ \rightarrow \rho^+ K^0$  branching fraction is predicted to lie between about 9 and  $13 \times 10^{-6}$ , consistent with our measurement within the uncertainties. The measured charge asymmetry is consistent with the SM expectation of zero.

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

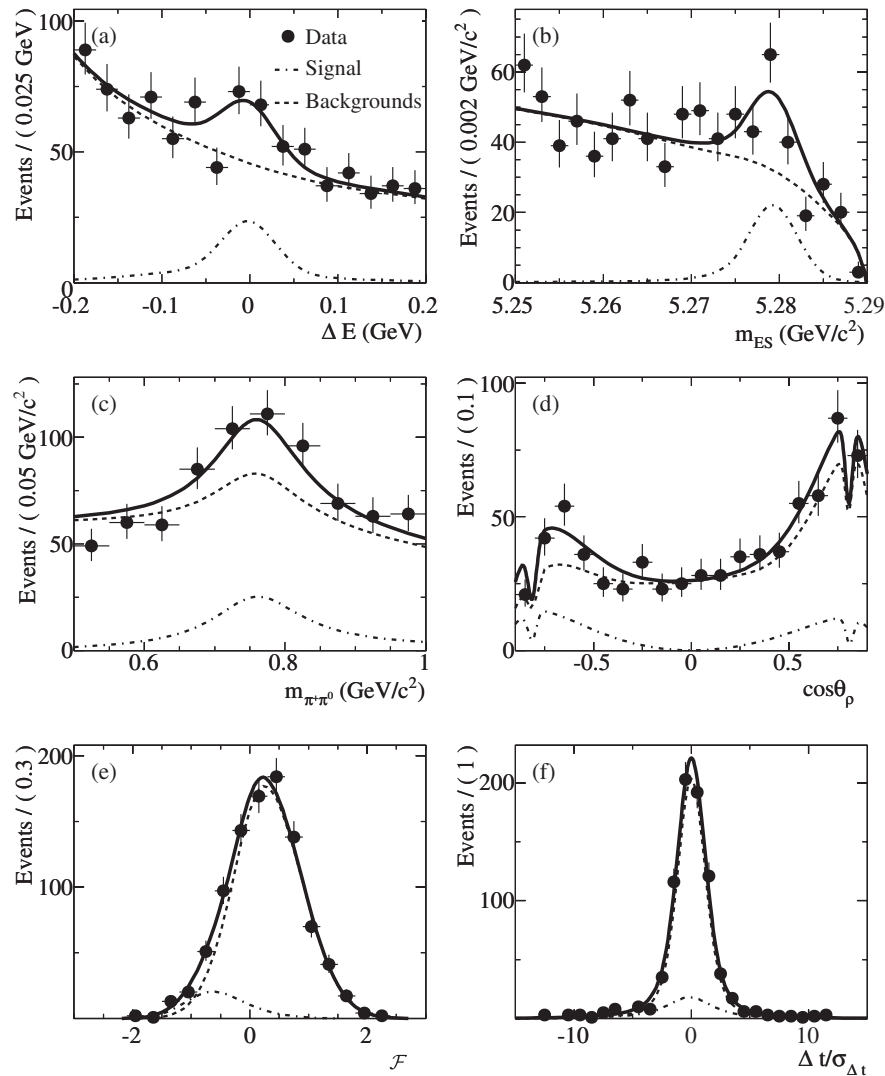


FIG. 1. Distributions of (a)  $\Delta E$ , (b)  $m_{ES}$ , (c)  $m_{\pi^+\pi^0}$ , (d)  $\cos\theta_\rho$ , (e)  $\mathcal{F}$ , and (f)  $\Delta t/\sigma_{\Delta t}$ . To improve visibility, a selection requirement on the likelihood ratio that retains 70.0% of the signal events has been applied. The points with uncertainties are the data. The curves are projections of the ML fit. The dashed curves show the sum of the continuum and  $B\bar{B}$  background components. The dot-dashed curves show the signal component. The solid curves show the sum of the signal and background components.

(Canada), CEA and CNRS-IN2P3 (France), BMBF and DFG (Germany), INFN (Italy), FOM (The Netherlands), NFR (Norway), MIST (Russia), MEC (Spain), and PPARC

(United Kingdom). Individuals have received support from the Marie Curie EIF (European Union) and the A. P. Sloan Foundation.

- 
- [1] N. Cabibbo, Phys. Rev. Lett. **10**, 531 (1963); M. Kobayashi and T. Maskawa, Prog. Theor. Phys. **49**, 652 (1973).  
 [2] C. W. Chiang *et al.*, Phys. Rev. D **69**, 034001 (2004).  
 [3] M. Gronau and J.L. Rosner, Phys. Rev. D **61**, 073008 (2000).  
 [4] C. W. Chiang and J.L. Rosner, Phys. Rev. D **65**, 074035 (2002).  
 [5] H. J. Lipkin, Phys. Rev. Lett. **46**, 1307 (1981); Phys. Lett. B **254**, 247 (1991).  
 [6] A. Soni and D. A. Suprun, Phys. Lett. B **635**, 330 (2006).  
 [7] M. Beneke and M. Neubert, Nucl. Phys. **B675**, 333 (2003).  
 [8] D. S. Du *et al.*, Phys. Rev. D **65**, 094025 (2002).  
 [9] C. Isola *et al.*, Phys. Rev. D **68**, 114001 (2003).  
 [10] M. Gronau and J.L. Rosner, Phys. Rev. D **72**, 094031 (2005).

B. AUBERT *et al.*

PHYSICAL REVIEW D **76**, 011103(R) (2007)

- [11] D. M. Asner *et al.* (CLEO Collaboration), *Phys. Rev. D* **53**, 1039 (1996).
- [12] B. Aubert *et al.* (BABAR Collaboration), *Nucl. Instrum. Methods Phys. Res., Sect. A* **479**, 1 (2002).
- [13] D. Lange, *Nucl. Instrum. Methods Phys. Res., Sect. A* **462**, 152 (2001).
- [14] S. Agostinelli *et al.*, *Nucl. Instrum. Methods Phys. Res., Sect. A* **506**, 250 (2003).
- [15] B. Aubert *et al.* (BABAR Collaboration), *Phys. Rev. D* **70**, 032006 (2004).
- [16] W. M. Yao *et al.* (Particle Data Group), *J. Phys. G* **33**, 1 (2006).
- [17] B. Aubert *et al.* (BABAR Collaboration), *Phys. Rev. D* **66**, 032003 (2002).
- [18] M. J. Oreglia, Ph.D. thesis [SLAC Report No. SLAC-236, 1980], Appendix D; J. E. Gaiser, Ph.D. thesis [SLAC Report No. SLAC-255, 1982], Appendix F; T. Skwarnicki, Ph.D. thesis [DESY Report No. DESY F31-86-02, 1986], Appendix E.
- [19] H. Albrecht *et al.* (ARGUS Collaboration), *Phys. Lett. B* **241**, 278 (1990).
- [20] J. Blatt and V. Weisskopf, *Theoretical Nuclear Physics* (John Wiley & Sons, New York, 1952), p. 361.