

University of Nebraska - Lincoln

DigitalCommons@University of Nebraska - Lincoln

---

Gregory Snow Publications

Research Papers in Physics and Astronomy

---

10-5-2007

## Measurement of the $\Lambda_b$ Lifetime in the Exclusive Decay $\Lambda_b \rightarrow J/\psi \Lambda$

V. M. Abazov

*Joint Institute for Nuclear Research, Dubna, Russia*

Kenneth A. Bloom

*University of Nebraska - Lincoln, kbloom2@unl.edu*

Gregory R. Snow

*University of Nebraska-Lincoln, gsnow1@unl.edu*

D0 Collaboration

Follow this and additional works at: <https://digitalcommons.unl.edu/physicsnow>



Part of the [Physics Commons](#)

---

Abazov, V. M.; Bloom, Kenneth A.; Snow, Gregory R.; and Collaboration, D0, "Measurement of the  $\Lambda_b$  Lifetime in the Exclusive Decay  $\Lambda_b \rightarrow J/\psi \Lambda$ " (2007). *Gregory Snow Publications*. 10.

<https://digitalcommons.unl.edu/physicsnow/10>

This Article is brought to you for free and open access by the Research Papers in Physics and Astronomy at DigitalCommons@University of Nebraska - Lincoln. It has been accepted for inclusion in Gregory Snow Publications by an authorized administrator of DigitalCommons@University of Nebraska - Lincoln.

## Measurement of the $\Lambda_b$ Lifetime in the Exclusive Decay $\Lambda_b \rightarrow J/\psi\Lambda$

V. M. Abazov,<sup>35</sup> B. Abbott,<sup>75</sup> M. Abolins,<sup>65</sup> B. S. Acharya,<sup>28</sup> M. Adams,<sup>51</sup> T. Adams,<sup>49</sup> E. Aguilo,<sup>5</sup> S. H. Ahn,<sup>30</sup> M. Ahsan,<sup>59</sup> G. D. Alexeev,<sup>35</sup> G. Alkhalaf,<sup>39</sup> A. Alton,<sup>64,\*</sup> G. Alverson,<sup>63</sup> G. A. Alves,<sup>2</sup> M. Anastasoiaie,<sup>34</sup> L. S. Ancu,<sup>34</sup> T. Andeen,<sup>53</sup> S. Anderson,<sup>45</sup> B. Andrieu,<sup>16</sup> M. S. Anzels,<sup>53</sup> Y. Arnoud,<sup>13</sup> M. Arov,<sup>60</sup> M. Arthaud,<sup>17</sup> A. Askew,<sup>49</sup> B. Åsman,<sup>40</sup> A. C. S. Assis Jesus,<sup>3</sup> O. Atramentov,<sup>49</sup> C. Autermann,<sup>20</sup> C. Avila,<sup>7</sup> C. Ay,<sup>23</sup> F. Badaud,<sup>12</sup> A. Baden,<sup>61</sup> L. Bagby,<sup>52</sup> B. Baldin,<sup>50</sup> D. V. Bandurin,<sup>59</sup> P. Banerjee,<sup>28</sup> S. Banerjee,<sup>28</sup> E. Barberis,<sup>63</sup> A.-F. Barfuss,<sup>14</sup> P. Bargassa,<sup>80</sup> P. Baringer,<sup>58</sup> J. Barreto,<sup>2</sup> J. F. Bartlett,<sup>50</sup> U. Bassler,<sup>16</sup> D. Bauer,<sup>43</sup> S. Beale,<sup>5</sup> A. Bean,<sup>58</sup> M. Begalli,<sup>3</sup> M. Begel,<sup>71</sup> C. Belanger-Champagne,<sup>40</sup> L. Bellantoni,<sup>50</sup> A. Bellavance,<sup>50</sup> J. A. Benitez,<sup>65</sup> S. B. Beri,<sup>26</sup> G. Bernardi,<sup>16</sup> R. Bernhard,<sup>22</sup> L. Berntzon,<sup>14</sup> I. Bertram,<sup>42</sup> M. Bessaçon,<sup>17</sup> R. Beuselinck,<sup>43</sup> V. A. Bezzubov,<sup>38</sup> P. C. Bhat,<sup>50</sup> V. Bhatnagar,<sup>26</sup> C. Biscarat,<sup>19</sup> G. Blazey,<sup>52</sup> F. Blekman,<sup>43</sup> S. Blessing,<sup>49</sup> D. Bloch,<sup>18</sup> K. Bloom,<sup>67</sup> A. Boehnlein,<sup>50</sup> D. Boline,<sup>62</sup> T. A. Bolton,<sup>59</sup> G. Borissov,<sup>42</sup> K. Bos,<sup>33</sup> T. Bose,<sup>77</sup> A. Brandt,<sup>78</sup> R. Brock,<sup>65</sup> G. Brooijmans,<sup>70</sup> A. Bross,<sup>50</sup> D. Brown,<sup>78</sup> N. J. Buchanan,<sup>49</sup> D. Buchholz,<sup>53</sup> M. Buehler,<sup>81</sup> V. Buescher,<sup>21</sup> S. Burdin,<sup>42,†</sup> S. Burke,<sup>45</sup> T. H. Burnett,<sup>82</sup> C. P. Buszello,<sup>43</sup> J. M. Butler,<sup>62</sup> P. Calfayan,<sup>24</sup> S. Calvet,<sup>14</sup> J. Cammin,<sup>71</sup> S. Caron,<sup>33</sup> W. Carvalho,<sup>3</sup> B. C. K. Casey,<sup>77</sup> N. M. Cason,<sup>55</sup> H. Castilla-Valdez,<sup>32</sup> S. Chakrabarti,<sup>17</sup> D. Chakraborty,<sup>52</sup> K. Chan,<sup>5</sup> K. M. Chan,<sup>55</sup> A. Chandra,<sup>48</sup> F. Charles,<sup>18</sup> E. Cheu,<sup>45</sup> F. Chevallier,<sup>13</sup> D. K. Cho,<sup>62</sup> S. Choi,<sup>31</sup> B. Choudhary,<sup>27</sup> L. Christofek,<sup>77</sup> T. Christoudias,<sup>43</sup> S. Cihangir,<sup>50</sup> D. Claes,<sup>67</sup> B. Clément,<sup>18</sup> C. Clément,<sup>40</sup> Y. Coadou,<sup>5</sup> M. Cooke,<sup>80</sup> W. E. Cooper,<sup>50</sup> M. Corcoran,<sup>80</sup> F. Couderc,<sup>17</sup> M.-C. Cousinou,<sup>14</sup> S. Crépe-Renaudin,<sup>13</sup> D. Cutts,<sup>77</sup> M. Ćwiok,<sup>29</sup> H. da Motta,<sup>2</sup> A. Das,<sup>62</sup> G. Davies,<sup>43</sup> K. De,<sup>78</sup> P. de Jong,<sup>33</sup> S. J. de Jong,<sup>34</sup> E. De La Cruz-Burelo,<sup>64</sup> C. De Oliveira Martins,<sup>3</sup> J. D. Degenhardt,<sup>64</sup> F. Déliot,<sup>17</sup> M. Demarteau,<sup>50</sup> R. Demina,<sup>71</sup> D. Denisov,<sup>50</sup> S. P. Denisov,<sup>38</sup> S. Desai,<sup>50</sup> H. T. Diehl,<sup>50</sup> M. Diesburg,<sup>50</sup> A. Dominguez,<sup>67</sup> H. Dong,<sup>72</sup> L. V. Dudko,<sup>37</sup> L. Duflot,<sup>15</sup> S. R. Dugad,<sup>28</sup> D. Duggan,<sup>49</sup> A. Duperrin,<sup>14</sup> J. Dyer,<sup>65</sup> A. Dyshkant,<sup>52</sup> M. Eads,<sup>67</sup> D. Edmunds,<sup>65</sup> J. Ellison,<sup>48</sup> V. D. Elvira,<sup>50</sup> Y. Enari,<sup>77</sup> S. Eno,<sup>61</sup> P. Ermolov,<sup>37</sup> H. Evans,<sup>54</sup> A. Evdokimov,<sup>73</sup> V. N. Evdokimov,<sup>38</sup> A. V. Ferapontov,<sup>59</sup> T. Ferbel,<sup>71</sup> F. Fiedler,<sup>24</sup> F. Filthaut,<sup>34</sup> W. Fisher,<sup>50</sup> H. E. Fisk,<sup>50</sup> M. Ford,<sup>44</sup> M. Fortner,<sup>52</sup> H. Fox,<sup>22</sup> S. Fu,<sup>50</sup> S. Fuess,<sup>50</sup> T. Gadfort,<sup>82</sup> C. F. Galea,<sup>34</sup> E. Gallas,<sup>50</sup> E. Galyaev,<sup>55</sup> C. Garcia,<sup>71</sup> A. Garcia-Bellido,<sup>82</sup> V. Gavrilov,<sup>36</sup> P. Gay,<sup>12</sup> W. Geist,<sup>18</sup> D. Gelé,<sup>18</sup> C. E. Gerber,<sup>51</sup> Y. Gershtein,<sup>49</sup> D. Gillberg,<sup>5</sup> G. Ginter,<sup>71</sup> N. Gollub,<sup>40</sup> B. Gómez,<sup>7</sup> A. Goussiou,<sup>55</sup> P. D. Grannis,<sup>72</sup> H. Greenlee,<sup>50</sup> Z. D. Greenwood,<sup>60</sup> E. M. Gregores,<sup>4</sup> G. Grenier,<sup>19</sup> Ph. Gris,<sup>12</sup> J.-F. Grivaz,<sup>15</sup> A. Grohsjean,<sup>24</sup> S. Grünendahl,<sup>50</sup> M. W. Grünwald,<sup>29</sup> F. Guo,<sup>72</sup> J. Guo,<sup>72</sup> G. Gutierrez,<sup>50</sup> P. Gutierrez,<sup>75</sup> A. Haas,<sup>70</sup> N. J. Hadley,<sup>61</sup> P. Haefner,<sup>24</sup> S. Hagopian,<sup>49</sup> J. Haley,<sup>68</sup> I. Hall,<sup>75</sup> R. E. Hall,<sup>47</sup> L. Han,<sup>6</sup> K. Hanagaki,<sup>50</sup> P. Hansson,<sup>40</sup> K. Harder,<sup>44</sup> A. Harel,<sup>71</sup> R. Harrington,<sup>63</sup> J. M. Hauptman,<sup>57</sup> R. Hauser,<sup>65</sup> J. Hays,<sup>43</sup> T. Hebbeker,<sup>20</sup> D. Hedin,<sup>52</sup> J. G. Hegeman,<sup>33</sup> J. M. Heinmiller,<sup>51</sup> A. P. Heinson,<sup>48</sup> U. Heintz,<sup>62</sup> C. Hensel,<sup>58</sup> K. Herner,<sup>72</sup> G. Hesketh,<sup>63</sup> M. D. Hildreth,<sup>55</sup> R. Hirosky,<sup>81</sup> J. D. Hobbs,<sup>72</sup> B. Hoeneisen,<sup>11</sup> H. Hoeth,<sup>25</sup> M. Hohlfield,<sup>21</sup> S. J. Hong,<sup>30</sup> R. Hooper,<sup>77</sup> S. Hossain,<sup>75</sup> P. Houben,<sup>33</sup> Y. Hu,<sup>72</sup> Z. Hubacek,<sup>9</sup> V. Hynek,<sup>8</sup> I. Iashvili,<sup>69</sup> R. Illingworth,<sup>50</sup> A. S. Ito,<sup>50</sup> S. Jabeen,<sup>62</sup> M. Jaffré,<sup>15</sup> S. Jain,<sup>75</sup> K. Jakobs,<sup>22</sup> C. Jarvis,<sup>61</sup> R. Jesik,<sup>43</sup> K. Johns,<sup>45</sup> C. Johnson,<sup>70</sup> M. Johnson,<sup>50</sup> A. Jonckheere,<sup>50</sup> P. Jonsson,<sup>43</sup> A. Juste,<sup>50</sup> D. Käfer,<sup>20</sup> S. Kahn,<sup>73</sup> E. Kajfasz,<sup>14</sup> A. M. Kalinin,<sup>35</sup> J. M. Kalk,<sup>60</sup> J. R. Kalk,<sup>65</sup> S. Kappler,<sup>20</sup> D. Karmanov,<sup>37</sup> J. Kasper,<sup>62</sup> P. Kasper,<sup>50</sup> I. Katsanos,<sup>70</sup> D. Kau,<sup>49</sup> R. Kaur,<sup>26</sup> V. Kaushik,<sup>78</sup> R. Kehoe,<sup>79</sup> S. Kermiche,<sup>14</sup> N. Khalatyan,<sup>38</sup> A. Khanov,<sup>76</sup> A. Kharchilava,<sup>69</sup> Y. M. Kharzhev,<sup>35</sup> D. Khatidze,<sup>70</sup> H. Kim,<sup>31</sup> T. J. Kim,<sup>30</sup> M. H. Kirby,<sup>34</sup> M. Kirsch,<sup>20</sup> B. Klima,<sup>50</sup> J. M. Kohli,<sup>26</sup> J.-P. Konrath,<sup>22</sup> M. Kopal,<sup>75</sup> V. M. Korabely,<sup>38</sup> B. Kothari,<sup>70</sup> A. V. Kozelov,<sup>38</sup> D. Krop,<sup>54</sup> A. Kryemadhi,<sup>81</sup> T. Kuhl,<sup>23</sup> A. Kumar,<sup>69</sup> S. Kunori,<sup>61</sup> A. Kupco,<sup>10</sup> T. Kurča,<sup>19</sup> J. Kvita,<sup>8</sup> D. Lam,<sup>55</sup> S. Lammers,<sup>70</sup> G. Landsberg,<sup>77</sup> J. Lazoflores,<sup>49</sup> P. Lebrun,<sup>19</sup> W. M. Lee,<sup>50</sup> A. Leflat,<sup>37</sup> F. Lehner,<sup>41</sup> J. Lellouch,<sup>16</sup> V. Lesne,<sup>12</sup> J. Leveque,<sup>45</sup> P. Lewis,<sup>43</sup> J. Li,<sup>78</sup> L. Li,<sup>48</sup> Q. Z. Li,<sup>50</sup> S. M. Lietti,<sup>4</sup> J. G. R. Lima,<sup>52</sup> D. Lincoln,<sup>50</sup> J. Linnemann,<sup>65</sup> V. V. Lipaev,<sup>38</sup> R. Lipton,<sup>50</sup> Y. Liu,<sup>6</sup> Z. Liu,<sup>5</sup> L. Lobo,<sup>43</sup> A. Lobodenko,<sup>39</sup> M. Lokajicek,<sup>10</sup> A. Lounis,<sup>18</sup> P. Love,<sup>42</sup> H. J. Lubatti,<sup>82</sup> A. L. Lyon,<sup>50</sup> A. K. A. Maciel,<sup>2</sup> D. Mackin,<sup>80</sup> R. J. Madaras,<sup>46</sup> P. Mättig,<sup>25</sup> C. Magass,<sup>20</sup> A. Magerkurth,<sup>64</sup> N. Makovec,<sup>15</sup> P. K. Mal,<sup>55</sup> H. B. Malbouisson,<sup>3</sup> S. Malik,<sup>67</sup> V. L. Malyshev,<sup>35</sup> H. S. Mao,<sup>50</sup> Y. Maravin,<sup>59</sup> B. Martin,<sup>13</sup> R. McCarthy,<sup>72</sup> A. Melnitchouk,<sup>66</sup> A. Mendes,<sup>14</sup> L. Mendoza,<sup>70</sup> P. G. Mercadante,<sup>4</sup> M. Merkin,<sup>37</sup> K. W. Merritt,<sup>50</sup> A. Meyer,<sup>20</sup> J. Meyer,<sup>21</sup> M. Michaut,<sup>17</sup> T. Millet,<sup>19</sup> J. Mitrevski,<sup>70</sup> J. Molina,<sup>3</sup> R. K. Mommsen,<sup>44</sup> N. K. Mondal,<sup>28</sup> R. W. Moore,<sup>5</sup> T. Moulík,<sup>58</sup> G. S. Muanza,<sup>19</sup> M. Mulders,<sup>50</sup> M. Mulhearn,<sup>70</sup> O. Mundal,<sup>21</sup> L. Mundim,<sup>3</sup> E. Nagy,<sup>14</sup> M. Naimuddin,<sup>50</sup> M. Narain,<sup>77</sup> N. A. Naumann,<sup>34</sup> H. A. Neal,<sup>64</sup> J. P. Negret,<sup>7</sup> P. Neustroev,<sup>39</sup> H. Nilsen,<sup>22</sup> C. Noeding,<sup>22</sup> A. Nomerotski,<sup>50</sup> S. F. Novaes,<sup>4</sup> T. Nunnemann,<sup>24</sup> V. O'Dell,<sup>50</sup> D. C. O'Neil,<sup>5</sup> G. Obrant,<sup>39</sup> C. Ochando,<sup>15</sup> D. Onoprienko,<sup>59</sup> N. Oshima,<sup>50</sup> J. Osta,<sup>55</sup> R. Otec,<sup>9</sup> G. J. Otero y Garzón,<sup>51</sup> M. Owen,<sup>44</sup> P. Padley,<sup>80</sup> M. Pangilinan,<sup>77</sup> N. Panikashvili,<sup>64,||</sup> N. Parashar,<sup>56</sup> S.-J. Park,<sup>71</sup> S. K. Park,<sup>30</sup> J. Parsons,<sup>70</sup> R. Partridge,<sup>77</sup> N. Parua,<sup>54</sup> A. Patwa,<sup>73</sup>

G. Pawloski,<sup>80</sup> P. M. Perea,<sup>48</sup> K. Peters,<sup>44</sup> Y. Peters,<sup>25</sup> P. Pétrouff,<sup>15</sup> M. Petteni,<sup>43</sup> R. Piegaia,<sup>1</sup> J. Piper,<sup>65</sup> M.-A. Pleier,<sup>21</sup> P. L. M. Podesta-Lerma,<sup>32,‡</sup> V. M. Podstavkov,<sup>50</sup> Y. Pogorelov,<sup>55</sup> M.-E. Pol,<sup>2</sup> A. Pompoš,<sup>75</sup> B. G. Pope,<sup>65</sup> A. V. Popov,<sup>38</sup> C. Potter,<sup>5</sup> W. L. Prado da Silva,<sup>3</sup> H. B. Prosper,<sup>49</sup> S. Protopopescu,<sup>73</sup> J. Qian,<sup>64</sup> A. Quadt,<sup>21</sup> B. Quinn,<sup>66</sup> A. Rakitine,<sup>42</sup> M. S. Rangel,<sup>2</sup> K. J. Rani,<sup>28</sup> K. Ranjan,<sup>27</sup> P. N. Ratoff,<sup>42</sup> P. Renkel,<sup>79</sup> S. Reucroft,<sup>63</sup> P. Rich,<sup>44</sup> M. Rijssenbeek,<sup>72</sup> I. Ripp-Baudot,<sup>18</sup> F. Rizatdinova,<sup>76</sup> S. Robinson,<sup>43</sup> R. F. Rodrigues,<sup>3</sup> C. Royon,<sup>17</sup> P. Rubinov,<sup>50</sup> R. Ruchti,<sup>55</sup> G. Safronov,<sup>36</sup> G. Sajot,<sup>13</sup> A. Sánchez-Hernández,<sup>32</sup> M. P. Sanders,<sup>16</sup> A. Santoro,<sup>3</sup> G. Savage,<sup>50</sup> L. Sawyer,<sup>60</sup> T. Scanlon,<sup>43</sup> D. Schaile,<sup>24</sup> R. D. Schamberger,<sup>72</sup> Y. Scheglov,<sup>39</sup> H. Schellman,<sup>53</sup> P. Schieferdecker,<sup>24</sup> T. Schliephake,<sup>25</sup> C. Schmitt,<sup>25</sup> C. Schwanenberger,<sup>44</sup> A. Schwartzman,<sup>68</sup> R. Schwienhorst,<sup>65</sup> J. Sekaric,<sup>49</sup> S. Sengupta,<sup>49</sup> H. Severini,<sup>75</sup> E. Shabalina,<sup>51</sup> M. Shamim,<sup>59</sup> V. Shary,<sup>17</sup> A. A. Shchukin,<sup>38</sup> R. K. Shivpuri,<sup>27</sup> D. Shpakov,<sup>50</sup> V. Siccaldi,<sup>18</sup> V. Simak,<sup>9</sup> V. Sirotenko,<sup>50</sup> P. Skubic,<sup>75</sup> P. Slattery,<sup>71</sup> D. Smirnov,<sup>55</sup> R. P. Smith,<sup>50</sup> G. R. Snow,<sup>67</sup> J. Snow,<sup>74</sup> S. Snyder,<sup>73</sup> S. Söldner-Rembold,<sup>44</sup> L. Sonnenschein,<sup>16</sup> A. Sopczak,<sup>42</sup> M. Sosebee,<sup>78</sup> K. Soustruznik,<sup>8</sup> M. Souza,<sup>2</sup> B. Spurlock,<sup>78</sup> J. Stark,<sup>13</sup> J. Steele,<sup>60</sup> V. Stolin,<sup>36</sup> A. Stone,<sup>51</sup> D. A. Stoyanova,<sup>38</sup> J. Strandberg,<sup>64</sup> S. Strandberg,<sup>40</sup> M. A. Strang,<sup>69</sup> M. Strauss,<sup>75</sup> R. Ströhmer,<sup>24</sup> D. Strom,<sup>53</sup> M. Strovink,<sup>46</sup> L. Stutte,<sup>50</sup> S. Sumowidagdo,<sup>49</sup> P. Svoisky,<sup>55</sup> A. Sznajder,<sup>3</sup> M. Talby,<sup>14</sup> P. Tamburello,<sup>45</sup> A. Tanasijczuk,<sup>1</sup> W. Taylor,<sup>5</sup> P. Telford,<sup>44</sup> J. Temple,<sup>45</sup> B. Tiller,<sup>24</sup> F. Tissandier,<sup>12</sup> M. Titov,<sup>17</sup> V. V. Tokmenin,<sup>35</sup> M. Tomoto,<sup>50</sup> T. Toole,<sup>61</sup> I. Torchiani,<sup>22</sup> T. Trefzger,<sup>23</sup> D. Tsybychev,<sup>72</sup> B. Tuchming,<sup>17</sup> C. Tully,<sup>68</sup> P. M. Tuts,<sup>70</sup> R. Unalan,<sup>65</sup> L. Uvarov,<sup>39</sup> S. Uvarov,<sup>39</sup> S. Uzunyan,<sup>52</sup> B. Vachon,<sup>5</sup> P. J. van den Berg,<sup>33</sup> B. van Eijk,<sup>35</sup> R. Van Kooten,<sup>54</sup> W. M. van Leeuwen,<sup>33</sup> N. Varelas,<sup>51</sup> E. W. Varnes,<sup>45</sup> A. Vartapetian,<sup>78</sup> I. A. Vasilyev,<sup>38</sup> M. Vaupel,<sup>25</sup> P. Verdier,<sup>19</sup> L. S. Vertogradov,<sup>35</sup> M. Verzocchi,<sup>50</sup> F. Villeneuve-Seguiet,<sup>43</sup> P. Vint,<sup>43</sup> E. Von Toerne,<sup>59</sup> M. Voutilainen,<sup>67,§</sup> M. Vreeswijk,<sup>33</sup> R. Wagner,<sup>68</sup> H. D. Wahl,<sup>49</sup> L. Wang,<sup>61</sup> M. H. L. S Wang,<sup>50</sup> J. Warchol,<sup>55</sup> G. Watts,<sup>82</sup> M. Wayne,<sup>55</sup> G. Weber,<sup>23</sup> M. Weber,<sup>50</sup> H. Weerts,<sup>65</sup> A. Wenger,<sup>22,¶</sup> N. Wermes,<sup>21</sup> M. Wetstein,<sup>61</sup> A. White,<sup>78</sup> D. Wicke,<sup>25</sup> G. W. Wilson,<sup>58</sup> S. J. Wimpenny,<sup>48</sup> M. Wobisch,<sup>60</sup> D. R. Wood,<sup>63</sup> T. R. Wyatt,<sup>44</sup> Y. Xie,<sup>77</sup> S. Yacoub,<sup>53</sup> R. Yamada,<sup>50</sup> M. Yan,<sup>61</sup> T. Yasuda,<sup>50</sup> Y. A. Yatsunenko,<sup>35</sup> K. Yip,<sup>73</sup> H. D. Yoo,<sup>77</sup> S. W. Youn,<sup>53</sup> C. Yu,<sup>13</sup> J. Yu,<sup>78</sup> A. Yurkewicz,<sup>72</sup> A. Zatserklyaniy,<sup>52</sup> C. Zeitnitz,<sup>25</sup> D. Zhang,<sup>50</sup> T. Zhao,<sup>82</sup> B. Zhou,<sup>64</sup> J. Zhu,<sup>72</sup> M. Zielinski,<sup>71</sup> D. Zieminska,<sup>54</sup> A. Zieminski,<sup>54</sup> L. Zivkovic,<sup>70</sup> V. Zutshi,<sup>52</sup> and E. G. Zverev<sup>37</sup>

(D0 Collaboration)

<sup>1</sup>Universidad de Buenos Aires, Buenos Aires, Argentina<sup>2</sup>LAFEX, Centro Brasileiro de Pesquisas Físicas, Rio de Janeiro, Brazil<sup>3</sup>Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil<sup>4</sup>Instituto de Física Teórica, Universidade Estadual Paulista, São Paulo, Brazil<sup>5</sup>University of Alberta, Edmonton, Alberta, Canada,

Simon Fraser University, Burnaby, British Columbia, Canada,

York University, Toronto, Ontario, Canada,

and McGill University, Montreal, Quebec, Canada

<sup>6</sup>University of Science and Technology of China, Hefei, People's Republic of China<sup>7</sup>Universidad de los Andes, Bogotá, Colombia<sup>8</sup>Center for Particle Physics, Charles University, Prague, Czech Republic<sup>9</sup>Czech Technical University, Prague, Czech Republic<sup>10</sup>Center for Particle Physics, Institute of Physics, Academy of Sciences of the Czech Republic, Prague, Czech Republic<sup>11</sup>Universidad San Francisco de Quito, Quito, Ecuador<sup>12</sup>Laboratoire de Physique Corpusculaire, IN2P3-CNRS, Université Blaise Pascal, Clermont-Ferrand, France<sup>13</sup>Laboratoire de Physique Subatomique et de Cosmologie, IN2P3-CNRS, Université de Grenoble 1, Grenoble, France<sup>14</sup>CPPM, IN2P3-CNRS, Université de la Méditerranée, Marseille, France<sup>15</sup>Laboratoire de l'Accélérateur Linéaire, IN2P3-CNRS et Université Paris-Sud, Orsay, France<sup>16</sup>LPNHE, IN2P3-CNRS, Universités Paris VI and VII, Paris, France<sup>17</sup>DAPNIA/Service de Physique des Particules, CEA, Saclay, France<sup>18</sup>IPHC, Université Louis Pasteur et Université de Haute Alsace, CNRS, IN2P3, Strasbourg, France<sup>19</sup>IPNL, Université Lyon 1, CNRS/IN2P3, Villeurbanne, France and Université de Lyon, Lyon, France<sup>20</sup>III. Physikalisches Institut A, RWTH Aachen, Aachen, Germany<sup>21</sup>Physikalisches Institut, Universität Bonn, Bonn, Germany<sup>22</sup>Physikalisches Institut, Universität Freiburg, Freiburg, Germany<sup>23</sup>Institut für Physik, Universität Mainz, Mainz, Germany<sup>24</sup>Ludwig-Maximilians-Universität München, München, Germany<sup>25</sup>Fachbereich Physik, University of Wuppertal, Wuppertal, Germany<sup>26</sup>Panjab University, Chandigarh, India

- <sup>27</sup>Delhi University, Delhi, India  
<sup>28</sup>Tata Institute of Fundamental Research, Mumbai, India  
<sup>29</sup>University College Dublin, Dublin, Ireland  
<sup>30</sup>Korea Detector Laboratory, Korea University, Seoul, Korea  
<sup>31</sup>SungKyunKwan University, Suwon, Korea  
<sup>32</sup>CINVESTAV, Mexico City, Mexico  
<sup>33</sup>FOM-Institute NIKHEF and University of Amsterdam/NIKHEF, Amsterdam, The Netherlands  
<sup>34</sup>Radboud University Nijmegen/NIKHEF, Nijmegen, The Netherlands  
<sup>35</sup>Joint Institute for Nuclear Research, Dubna, Russia  
<sup>36</sup>Institute for Theoretical and Experimental Physics, Moscow, Russia  
<sup>37</sup>Moscow State University, Moscow, Russia  
<sup>38</sup>Institute for High Energy Physics, Protvino, Russia  
<sup>39</sup>Petersburg Nuclear Physics Institute, St. Petersburg, Russia  
<sup>40</sup>Lund University, Lund, Sweden, Royal Institute of Technology and Stockholm University, Stockholm, Sweden, and Uppsala University, Uppsala, Sweden  
<sup>41</sup>Physik Institut der Universität Zürich, Zürich, Switzerland  
<sup>42</sup>Lancaster University, Lancaster, United Kingdom  
<sup>43</sup>Imperial College, London, United Kingdom  
<sup>44</sup>University of Manchester, Manchester, United Kingdom  
<sup>45</sup>University of Arizona, Tucson, Arizona 85721, USA  
<sup>46</sup>Lawrence Berkeley National Laboratory and University of California, Berkeley, California 94720, USA  
<sup>47</sup>California State University, Fresno, California 93740, USA  
<sup>48</sup>University of California, Riverside, California 92521, USA  
<sup>49</sup>Florida State University, Tallahassee, Florida 32306, USA  
<sup>50</sup>Fermi National Accelerator Laboratory, Batavia, Illinois 60510, USA  
<sup>51</sup>University of Illinois at Chicago, Chicago, Illinois 60607, USA  
<sup>52</sup>Northern Illinois University, DeKalb, Illinois 60115, USA  
<sup>53</sup>Northwestern University, Evanston, Illinois 60208, USA  
<sup>54</sup>Indiana University, Bloomington, Indiana 47405, USA  
<sup>55</sup>University of Notre Dame, Notre Dame, Indiana 46556, USA  
<sup>56</sup>Purdue University Calumet, Hammond, Indiana 46323, USA  
<sup>57</sup>Iowa State University, Ames, Iowa 50011, USA  
<sup>58</sup>University of Kansas, Lawrence, Kansas 66045, USA  
<sup>59</sup>Kansas State University, Manhattan, Kansas 66506, USA  
<sup>60</sup>Louisiana Tech University, Ruston, Louisiana 71272, USA  
<sup>61</sup>University of Maryland, College Park, Maryland 20742, USA  
<sup>62</sup>Boston University, Boston, Massachusetts 02215, USA  
<sup>63</sup>Northeastern University, Boston, Massachusetts 02115, USA  
<sup>64</sup>University of Michigan, Ann Arbor, Michigan 48109, USA  
<sup>65</sup>Michigan State University, East Lansing, Michigan 48824, USA  
<sup>66</sup>University of Mississippi, University, Mississippi 38677, USA  
<sup>67</sup>University of Nebraska, Lincoln, Nebraska 68588, USA  
<sup>68</sup>Princeton University, Princeton, New Jersey 08544, USA  
<sup>69</sup>State University of New York, Buffalo, New York 14260, USA  
<sup>70</sup>Columbia University, New York, New York 10027, USA  
<sup>71</sup>University of Rochester, Rochester, New York 14627, USA  
<sup>72</sup>State University of New York, Stony Brook, New York 11794, USA  
<sup>73</sup>Brookhaven National Laboratory, Upton, New York 11973, USA  
<sup>74</sup>Langston University, Langston, Oklahoma 73050, USA  
<sup>75</sup>University of Oklahoma, Norman, Oklahoma 73019, USA  
<sup>76</sup>Oklahoma State University, Stillwater, Oklahoma 74078, USA  
<sup>77</sup>Brown University, Providence, Rhode Island 02912, USA  
<sup>78</sup>University of Texas, Arlington, Texas 76019, USA  
<sup>79</sup>Southern Methodist University, Dallas, Texas 75275, USA  
<sup>80</sup>Rice University, Houston, Texas 77005, USA  
<sup>81</sup>University of Virginia, Charlottesville, Virginia 22901, USA  
<sup>82</sup>University of Washington, Seattle, Washington 98195, USA

(Received 1 May 2007; published 1 October 2007)

We have measured the  $\Lambda_b$  lifetime using the exclusive decay  $\Lambda_b \rightarrow J/\psi\Lambda$ , based on  $1.2 \text{ fb}^{-1}$  of data collected with the D0 detector during 2002–2006. From 171 reconstructed  $\Lambda_b$  decays, where the  $J/\psi$  and

$\Lambda$  are identified via the decays  $J/\psi \rightarrow \mu^+ \mu^-$  and  $\Lambda \rightarrow p \pi$ , we measured the  $\Lambda_b$  lifetime to be  $\tau(\Lambda_b) = 1.218_{-0.115}^{+0.130}(\text{stat}) \pm 0.042(\text{syst})$  ps. We also measured the  $B^0$  lifetime in the decay  $B^0 \rightarrow J/\psi(\mu^+ \mu^-) K_S^0(\pi^+ \pi^-)$  to be  $\tau(B^0) = 1.501_{-0.074}^{+0.078}(\text{stat}) \pm 0.050(\text{syst})$  ps, yielding a lifetime ratio of  $\tau(\Lambda_b)/\tau(B^0) = 0.811_{-0.087}^{+0.096}(\text{stat}) \pm 0.034(\text{syst})$ .

DOI: 10.1103/PhysRevLett.99.142001

PACS numbers: 14.20.Mr, 13.25.Hw, 13.30.Eg, 14.40.Nd

Lifetime measurements of  $b$  hadrons provide important information on the interactions between heavy and light quarks. At leading order in heavy quark effective theory (HQET) [1], light quarks are considered spectators and all  $b$  hadrons have the same lifetime. Differences arise at higher orders when corrections from interactions are taken into account. For HQET calculations of order  $1/m_b^2$ , where  $m_b$  is the mass of the  $b$  quark, the agreement between the predicted lifetimes and the experimental results is excellent for  $B$  mesons [2]. However, in the  $b$  baryon sector, the world average of measurements of  $\tau(\Lambda_b)/\tau(B^0) = 0.844 \pm 0.043$  [3] is smaller than the prediction of the ratio at this order. Recently, there have been significant improvements in theoretical calculations of  $\tau(\Lambda_b)/\tau(B^0)$ . Next-to-leading order effects in QCD [4], corrections at  $\mathcal{O}(1/m_b^4)$  in HQET [5], and lattice QCD studies [6], have led to an improved theoretical prediction,  $\tau(\Lambda_b)/\tau(B^0) = 0.88 \pm 0.05$  [7]. This value agrees with previous experiments to within the current theoretical and experimental uncertainties. However, a recent precise measurement [8] reports a value of the  $\Lambda_b$  lifetime consistent with  $B$  meson lifetimes, and the ratio  $\tau(\Lambda_b)/\tau(B^0)$  consistent with unity. Additional precise measurements of the  $\Lambda_b$  lifetime and  $\tau(\Lambda_b)/\tau(B^0)$  ratio may help settle this question.

In this Letter, we report measurements of the  $\Lambda_b$  lifetime using the exclusive decay  $\Lambda_b \rightarrow J/\psi + \Lambda$ , and its ratio to the  $B^0$  lifetime using the  $B^0 \rightarrow J/\psi + K_S^0$  decay channel. This  $B^0$  decay channel is chosen because of its similar topology to the  $\Lambda_b$  decay. The  $J/\psi$  is reconstructed from the  $\mu^+ \mu^-$  decay mode, the  $\Lambda$  from  $p \pi^-$ , and the  $K_S^0$  from  $\pi^+ \pi^-$ . Throughout this Letter, the appearance of a specific charge state also implies its charge conjugate. The data used in this analysis were collected during 2002–2006 with the D0 detector in run II of the Tevatron Collider at a center-of-mass energy of 1.96 TeV, and correspond to an integrated luminosity of  $1.2 \text{ fb}^{-1}$ .

The D0 detector is described in detail elsewhere [9]. The detector components most relevant to this analysis are the central tracking and the muon systems. The former consists of a silicon microstrip tracker (SMT) and a central scintillating fiber tracker (CFT) surrounded by a 2 T superconducting solenoidal magnet. The SMT has a design optimized for tracking and vertexing for pseudorapidity of  $|\eta| < 3$  [10]. For charged particles, the resolution on the distance of closest approach as provided by the tracking system is approximately  $50 \mu\text{m}$  for tracks with  $p_T \approx 1 \text{ GeV}/c$ , where  $p_T$  is the component of the momentum perpendicular to the beam axis. It improves asymptotically to  $15 \mu\text{m}$  for tracks with  $p_T > 10 \text{ GeV}/c$ . Preshower

detectors and electromagnetic and hadronic calorimeters surround the tracker. The muon system is located beyond the calorimeter, and consists of multilayer drift chambers and scintillation counters inside 1.8 T toroidal magnets, and two similar layers outside the toroids. Muon identification for  $|\eta| < 1$  relies on 10 cm wide drift tubes, while 1 cm mini-drift tubes are used for  $1 < |\eta| < 2$ .

The primary vertex of the  $p\bar{p}$  interaction is determined for each event using the average position of the beam-collision in the plane perpendicular to the beam as a constraint. The precision of the primary vertex reconstruction is on average  $20 \mu\text{m}$  in the plane perpendicular to the beam and about  $40 \mu\text{m}$  along the direction of the beam.

We base our data selection on reconstructed charged tracks and identified muons. Although we do not require any specific trigger, most of the selected events satisfy dimuon or muon triggers. To avoid a trigger bias in the lifetime measurement, we reject events that depend on impact parameter based triggers. We start the  $\Lambda_b$  and  $B^0$  reconstruction by searching for events with  $J/\psi$  mesons. We then search in these events for  $\Lambda$  and  $K_S^0$  particles. To reconstruct  $J/\psi \rightarrow \mu^+ \mu^-$  candidates, we select events with at least two muons of opposite charge reconstructed in the tracker and the muon system. The track of each muon candidate must either match hits in the muon system, or have calorimeter energies consistent with a minimum-ionizing particle along the direction of hits extrapolated from the tracking layers. For at least one of the muons, we require hits in all three layers of the muon detector. Both muons are required to have  $p_T > 2.5 \text{ GeV}/c$  if they are in the region  $|\eta| < 1$ . The muon tracks are constrained to originate from a common vertex with a  $\chi^2$  probability greater than 1%, and each  $J/\psi$  candidate is required to have a mass in the range  $2.80\text{--}3.35 \text{ GeV}/c^2$ . The  $\Lambda \rightarrow p \pi^-$  decays are reconstructed from two tracks of opposite charge constrained to a common vertex with a  $\chi^2$  probability greater than 1%. Each  $\Lambda$  candidate is required to have a mass in the range  $1.100\text{--}1.128 \text{ GeV}/c^2$ . The proton mass is assigned to the track of higher  $p_T$ , as observed in Monte Carlo studies. To suppress contamination from cascade decays of more massive baryons such as  $\Sigma^0 \rightarrow \Lambda \gamma$  or  $\Xi^0 \rightarrow \Lambda \pi^0$ , we require the cosine of the angle between the  $p_T$  vector of the  $\Lambda$  and the vector in the perpendicular plane from the  $J/\psi$  vertex to the  $\Lambda$  decay vertex to be larger than 0.9999. For  $\Lambda$ 's that decay from  $\Lambda_b$  the cosine of this angle is very close to 1. The  $K_S^0 \rightarrow \pi^+ \pi^-$  selection follows the same criteria, except that for the  $K_S^0$ , the mass window is  $0.460\text{--}0.525 \text{ GeV}/c^2$ , and pion mass assignments are used.



We reconstruct the  $\Lambda_b$  and  $B^0$  by performing a constrained fit to a common vertex for either the  $\Lambda$  or  $K_S^0$  and the two muon tracks, with the latter constrained to the  $J/\psi$  mass of  $3.097 \text{ GeV}/c^2$  [3]. Because of their long decay lengths, a significant fraction of  $\Lambda$  and  $K_S^0$  particles will decay outside the SMT. There is therefore no requirement of SMT hits on the tracks from  $\Lambda$  and  $K_S^0$  decays. To reconstruct the  $\Lambda_b$  ( $B^0$ ), we first find the  $\Lambda$  ( $K_S^0$ ) decay vertex, and then extrapolate the momentum vector of the ensuing particle and form a vertex together with the two muon tracks belonging to the  $J/\psi$ . If more than one candidate is found in the event, the candidate with the best  $\chi^2$  probability is selected as the  $\Lambda_b$  ( $B^0$ ) candidate. The mass is required to be within the range  $5.1\text{--}6.1 \text{ GeV}/c^2$  for  $\Lambda_b$  candidates and within  $4.9\text{--}5.7 \text{ GeV}/c^2$  for  $B^0$  candidates. For the choice of the final selection criteria, we optimize  $S/\sqrt{S+B}$ , where  $S$  and  $B$  are the number of signal ( $\Lambda_b$ ) and background candidates, respectively, by using Monte Carlo estimates for  $S$  and data for  $B$ . For the Monte Carlo, we use PYTHIA [11] and EVTGEN [12] to produce and decay particles, respectively, and GEANT3 [13] to simulate detector effects. As a result of this optimization, the  $p_T$  of the  $\Lambda$  ( $K_S^0$ ) is required to be greater than  $2.4(1.8) \text{ GeV}/c$ , and the total momentum for both  $\Lambda_b$  and  $B^0$  is required to be greater than  $5 \text{ GeV}/c$ . Finally, any candidate which has been identified as a  $\Lambda_b$  is removed from the  $B^0$  sample.

We determine the decay time of a  $\Lambda_b$  or  $B^0$  by measuring the distance traveled by the  $b$  hadron candidate in a plane transverse to the beam direction, and then applying a correction for the Lorentz boost. We define the transverse decay length as  $L_{xy} = \mathbf{L}_{xy} \cdot \mathbf{p}_T / p_T$ , where  $\mathbf{L}_{xy}$  is the vector that points from the primary vertex to the  $b$  hadron decay vertex and  $\mathbf{p}_T$  is the transverse momentum vector of the  $b$  hadron. The event-by-event value of the proper transverse decay length,  $\lambda$ , for the  $b$  hadron candidate is given by

$$\lambda = \frac{L_{xy}}{(\beta\gamma)_T^B} = L_{xy} \frac{cM_B}{p_T}, \quad (1)$$

where  $(\beta\gamma)_T^B$  and  $M_B$  are the transverse boost and the mass of the  $b$  hadron. In our measurement, the value of  $M_B$  in Eq. (1) is set to the Particle Data Group (PDG) mass value of  $\Lambda_b$  or  $B^0$  [3]. We require the uncertainty on  $\lambda$  to be less than  $500 \mu\text{m}$ .

We perform a simultaneous unbinned maximum likelihood fit to the mass and proper decay length distributions. The likelihood function  $\mathcal{L}$  is defined by

$$L = \frac{(n_s + n_b)^n}{n!} \exp(-n_s - N_b) \times \prod_{j=1}^n \left[ \frac{n_s}{n_s + n_b} \mathcal{F}_{\text{sig}}^j + \frac{n_b}{n_s + n_b} \mathcal{F}_{\text{bkg}}^j \right], \quad (2)$$

where  $n_s$  and  $n_b$  are the expected number of signal and

background events in the sample, respectively.  $N$  is the total number of events.  $\mathcal{F}_{\text{sig}}^j$  ( $\mathcal{F}_{\text{bkg}}^j$ ) is the product of three probability density functions that model the mass, proper decay length, and uncertainty on proper decay length distributions for the signal (background). We divide the background into two categories, prompt and nonprompt. The prompt background is primarily due to direct production of  $J/\psi$ 's which are then randomly combined with a  $\Lambda$  or  $K_S^0$  candidate in the event. The nonprompt background is mainly produced by the combination of  $J/\psi$  mesons from  $b$  hadron decays with  $\Lambda$  or  $K_S^0$  candidates present in the event.

For the signal, the mass distribution is modeled by a Gaussian function, and the  $\lambda$  distribution is parametrized by an exponential decay convoluted with the resolution function

$$G(\lambda_j, \sigma_j) = \frac{1}{\sqrt{2\pi}s\sigma_j} \exp\left[\frac{-\lambda_j^2}{2(s\sigma_j)^2}\right], \quad (3)$$

where  $\lambda_j$  and  $\sigma_j$  represent  $\lambda$  and its uncertainty, respectively, for a given decay  $j$ , and  $s$  is a common scale parameter introduced in the fit to account for a possible misestimate of  $\sigma_j$ . The convolution is defined by

$$S_\lambda(\lambda_j, \sigma_j) = \frac{1}{\lambda_B} \int_0^\infty G(x - \lambda_j, \sigma_j) \exp\left(\frac{-x}{\lambda_B}\right) dx, \quad (4)$$

where  $\lambda_B = c\tau_B$ , and  $\tau_B$  is the lifetime of the  $\Lambda_b$  ( $B^0$ ). The distribution of the uncertainty of  $\lambda$  is modeled by an exponential function convoluted by a Gaussian.

For the background, the mass distribution of the prompt component is assumed to follow a flat distribution as observed in data when a cut of  $\lambda > 100 \mu\text{m}$  is applied. The nonprompt component is modeled with a second-order polynomial function. The  $\lambda$  distribution is parametrized by the resolution function for the prompt component, and by the sum of negative and positive exponential functions for the nonprompt component. A positive and a negative exponential function model the combinatorial background, and an exponential function accounts for long-lived heavy flavor decays. The distribution of the uncertainty of  $\lambda$  is modeled by two exponential functions convoluted by a Gaussian.

We minimize  $-2 \ln \mathcal{L}$  to extract  $c\tau(\Lambda_b) = 365.1_{-34.7}^{+39.1} \mu\text{m}$  and  $c\tau(B^0) = 450.0_{-22.1}^{+23.5} \mu\text{m}$ . From the fits, we obtain  $s = 1.41 \pm 0.05$  for the  $\Lambda_b$  and  $s = 1.41 \pm 0.03$  for the  $B^0$ . The numbers of signal decays are  $171 \pm 20$   $\Lambda_b$  and  $717 \pm 38$   $B^0$ . Figures 1 and 2 show the mass and  $\lambda$  distributions for the  $\Lambda_b$  and  $B^0$  candidates. Fit results are superimposed.

Table I summarizes the systematic uncertainties in our measurements. The contribution from possible misalignment of the SMT detector was estimated to be  $5.4 \mu\text{m}$  [14]. We estimate the systematic uncertainty due to the models for the  $\lambda$  and mass distributions by varying the

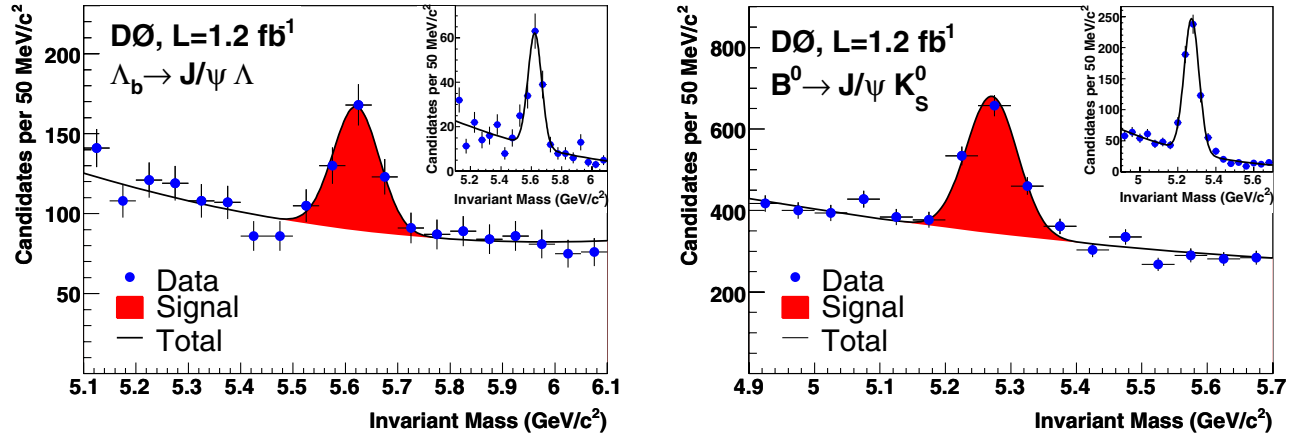


FIG. 1 (color online). Invariant mass distribution for  $\Lambda_b$  (left) and  $B^0$  (right) candidates, with the fit results superimposed. The inserts show the mass distributions after requiring  $\lambda/\sigma > 5$ .

parametrizations of the different components: (i) the resolution function is modeled by two Gaussian functions instead of one, (ii) the exponential functions in the non-prompt background are replaced by exponentials convoluted with the resolution function, (iii) a uniform background is added to account for outlier events (this has only a negligible effect), (iv) the positive and negative exponentials describing the combinatorial nonprompt background are assumed to be symmetric, and (v) for the mass distribution of the nonprompt background, a linear function is used instead of the nominal quadratic form. To take into account correlations between the effects of the different models, a fit that combines all different model changes is performed. We quote the difference between the result of this fit and the nominal fit as the systematic uncertainty.

The lifetime of the background events under the  $\Lambda_b(B^0)$  signal is mostly modeled by events in the low and high mass sideband regions with respect to the peak. To estimate the effect of any difference between the lifetime distribu-

tions of these two regions, we perform separate fits to the  $\Lambda_b(B^0)$  mass regions of 5.1–5.8 and 5.4–6.1  $\text{GeV}/c^2$  (4.9–5.45 and 5.1–5.7  $\text{GeV}/c^2$ ), where the contributions from high and low mass background events are reduced, respectively. The largest difference between these fits and the nominal fit is quoted as the systematic uncertainty due to this source.

We also study the contamination of the  $\Lambda_b$  sample by  $B^0$  events that pass the  $\Lambda_b$  selection. From Monte Carlo studies, we estimate that 6.5% of  $B^0$  events pass the  $\Lambda_b$  selection criteria. However, the invariant mass of  $B^0$  events which contaminate the  $\Lambda_b$  sample is distributed almost uniformly across the entire  $\Lambda_b$  mass range, and their proper decay lengths therefore tend to be incorporated in the long-lived component of the background. To estimate the effect due to this contamination, we remove from the  $\Lambda_b$  sample any event which also passes the  $B^0$  selection criteria, and we perform a fit to the remaining events. The difference between this and the nominal fit is quoted as the systematic uncertainty due to the contamination. For the  $B^0$ , we do not

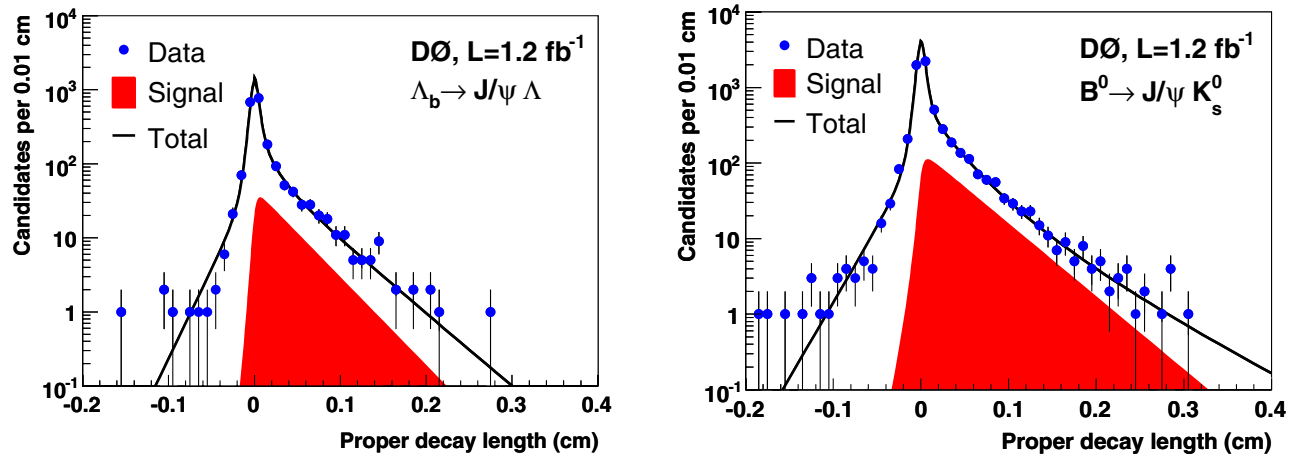


FIG. 2 (color online). Proper decay length distribution for  $\Lambda_b$  (left) and  $B^0$  (right) candidates, with the fit results superimposed. The shaded region represents the signal.

TABLE I. Summary of systematic uncertainties in the measurement of  $c\tau$  for  $\Lambda_b$  and  $B^0$  and their ratio. The total uncertainties are determined by combining individual uncertainties in quadrature.

Source	$\Lambda_b$ ( $\mu\text{m}$ )	$B^0$ ( $\mu\text{m}$ )	Ratio
Alignment	5.4	5.4	0.002
Distribution models	6.6	2.8	0.020
Long-lived components	6.0	13.6	0.022
Contamination	7.2	...	0.016
Total	12.7	14.9	0.034

consider this source of systematic uncertainty since any event identified as  $\Lambda_b$  is removed from the  $B^0$  sample.

We perform several cross-checks of the lifetime measurements. The  $J/\psi$  vertex is used instead of the  $b$  hadron vertex, the mass windows are varied, the reconstructed  $b$  hadron mass is used instead of the PDG [3] value, and the sample is split into different pseudorapidity regions and different regions of azimuth. All results obtained with these variations are consistent with our measurement. We also cross-check the fitting procedure and selection criteria by measuring the  $\Lambda_b$  lifetime in Monte Carlo events. The lifetime obtained was consistent with the input value.

The results of our measurement of the  $\Lambda_b$  and  $B^0$  lifetimes are summarized as

$$\begin{aligned} c\tau(\Lambda_b) &= 365.1_{-34.7}^{+39.1}(\text{stat}) \pm 12.7(\text{syst}) \mu\text{m}, \\ c\tau(B^0) &= 450.0_{-22.1}^{+23.5}(\text{stat}) \pm 14.9(\text{syst}) \mu\text{m}, \end{aligned} \quad (5)$$

from which we have

$$\begin{aligned} \tau(\Lambda_b) &= 1.218_{-0.115}^{+0.130}(\text{stat}) \pm 0.042(\text{syst}) \text{ ps}, \\ \tau(B^0) &= 1.501_{-0.074}^{+0.078}(\text{stat}) \pm 0.050(\text{syst}) \text{ ps}. \end{aligned} \quad (6)$$

These can be combined to determine the ratio of lifetimes

$$\frac{\tau(\Lambda_b)}{\tau(B^0)} = 0.811_{-0.087}^{+0.096}(\text{stat}) \pm 0.034(\text{syst}), \quad (7)$$

where we determine the systematic uncertainty on the ratio by calculating the ratio for each systematic source and quoting the deviation in the ratio as the systematic uncertainty due to that source. We combine all systematics in quadrature as shown in Table I. The main contribution to the systematic uncertainty of the lifetime ratio is due to the long-lived component of the  $B^0$  sample. This is expected since the  $B^0$  is more likely than the  $\Lambda_b$  to be contaminated by misreconstructed  $B$  mesons due to its lower mass. The ratio of lifetimes, using the world average  $B^0$  lifetime  $\tau(B^0) = 1.527 \pm 0.008$  ps [3], is

$$\frac{\tau(\Lambda_b)}{\tau(B^0)} = 0.797_{-0.080}^{+0.089}. \quad (8)$$

In conclusion, we have measured the  $\Lambda_b$  lifetime in the fully reconstructed exclusive decay channel  $J/\psi\Lambda$ . The measurement is consistent with the world average [3], and the ratio of  $\Lambda_b$  to  $B^0$  lifetimes is consistent with the most recent theoretical predictions [7].

We thank the staffs at Fermilab and collaborating institutions, and acknowledge support from the DOE and NSF (USA); CEA and CNRS/IN2P3 (France); FASI, Rosatom and RFBR (Russia); CAPES, CNPq, FAPERJ, FAPESP and FUNDUNESP (Brazil); DAE and DST (India); Colciencias (Colombia); CONACyT (Mexico); KRF and KOSEF (Korea); CONICET and UBACyT (Argentina); FOM (The Netherlands); Science and Technology Facilities Council (United Kingdom); MSMT and GACR (Czech Republic); CRC Program, CFI, NSERC and WestGrid Project (Canada); BMBF and DFG (Germany); SFI (Ireland); The Swedish Research Council (Sweden); CAS and CNSF (China); Alexander von Humboldt Foundation; and the Marie Curie Program.

\*Visitor from Augustana College, Sioux Falls, SD, USA.

†Visitor from The University of Liverpool, Liverpool, United Kingdom.

‡Visitor from ICN-UNAM, Mexico City, Mexico.

§Visitor from Helsinki Institute of Physics, Helsinki, Finland.

||Visitor from Technion – Israel Institute of Technology, Haifa, Israel.

¶Visitor from Universität Zürich, Zürich, Switzerland.

- [1] I. I. Y. Bigi *et al.*, Phys. Lett. B **293**, 430 (1992).
- [2] M. Neubert and C. T. Sachrajda, Nucl. Phys. B **483**, 339 (1997).
- [3] W. M. Yao *et al.*, J. Phys. G **33**, 1 (2006).
- [4] E. Franco *et al.*, Nucl. Phys. **B633**, 212 (2002).
- [5] F. Gabbiani, A. I. Onishchenko, and A. A. Petrov, Phys. Rev. D **68**, 114006 (2003).
- [6] M. Di Pierro *et al.*, Phys. Lett. B **468**, 143 (1999).
- [7] C. Tarantino, Nucl. Phys. B, Proc. Suppl. **156**, 33 (2006).
- [8] A. Abulencia *et al.*, Phys. Rev. Lett. **98**, 122001 (2007).
- [9] V. Abazov *et al.*, Nucl. Instrum. Methods Phys. Res., Sect. A **565**, 463 (2006).
- [10]  $\eta = -\ln[\tan(\theta/2)]$ , where  $\theta$  is the polar angle with respect to the beam line.
- [11] T. Sjöstrand *et al.*, Comput. Phys. Commun. **135**, 238 (2001).
- [12] D. J. Lange, Nucl. Instrum. Methods Phys. Res., Sect. A **462**, 152 (2001).
- [13] R. Brun and F. Carminati, CERN Program Library Long Writup No. W5013, 1993 (unpublished).
- [14] V. Abazov *et al.*, Phys. Rev. Lett. **94**, 102001 (2005).