

# b-baryon ADMIXTURE ( $\Lambda_b, \Xi_b, \Sigma_b, \Omega_b$ )

## b-baryon ADMIXTURE MEAN LIFE

Each measurement of the  $b$ -baryon mean life is an average over an admixture of various  $b$  baryons which decay weakly. Different techniques emphasize different admixtures of produced particles, which could result in a different  $b$ -baryon mean life. More  $b$ -baryon flavor specific channels are not included in the measurement.

“OUR EVALUATION” is an average using rescaled values of the data listed below. The average and rescaling were performed by the Heavy Flavor Averaging Group (HFAG) and are described at <http://www.slac.stanford.edu/xorg/hfag/>. The averaging/rescaling procedure takes into account correlations between the measurements and asymmetric lifetime errors.

<u>VALUE (<math>10^{-12}</math> s)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1.345 ± 0.032 OUR EVALUATION</b>				
1.401 ± 0.046 ± 0.035		1 AALTONEN	10B CDF	$\rho\bar{p}$ at 1.96 TeV
1.218 <sup>+0.130</sup> <sub>-0.115</sub> ± 0.042		2 ABAZOV	07S D0	$\rho\bar{p}$ at 1.96 TeV
1.290 <sup>+0.119</sup> <sub>-0.110</sub> ± 0.087 -0.091		3 ABAZOV	07U D0	$\rho\bar{p}$ at 1.96 TeV
1.593 <sup>+0.083</sup> <sub>-0.078</sub> ± 0.033		2 ABULENCIA	07A CDF	$\rho\bar{p}$ at 1.96 TeV
1.16 ± 0.20 ± 0.08		4 ABREU	99W DLPH	$e^+e^- \rightarrow Z$
1.19 ± 0.14 ± 0.07		5 ABREU	99W DLPH	$e^+e^- \rightarrow Z$
1.11 <sup>+0.19</sup> <sub>-0.18</sub> ± 0.05		6 ABREU	99W DLPH	$e^+e^- \rightarrow Z$
1.29 <sup>+0.24</sup> <sub>-0.22</sub> ± 0.06		6 ACKERSTAFF	98G OPAL	$e^+e^- \rightarrow Z$
1.20 ± 0.08 ± 0.06		7 BARATE	98D ALEP	$e^+e^- \rightarrow Z$
1.21 ± 0.11		6 BARATE	98D ALEP	$e^+e^- \rightarrow Z$
1.32 ± 0.15 ± 0.07		8 ABE	96M CDF	$\rho\bar{p}$ at 1.8 TeV
1.10 <sup>+0.19</sup> <sub>-0.17</sub> ± 0.09		6 ABREU	96D DLPH	$e^+e^- \rightarrow Z$
1.16 ± 0.11 ± 0.06		6 AKERS	96 OPAL	$e^+e^- \rightarrow Z$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
1.22 <sup>+0.22</sup> <sub>-0.18</sub> ± 0.04		2 ABAZOV	05C D0	Repl. by ABAZOV 07S
1.14 ± 0.08 ± 0.04		9 ABREU	99W DLPH	$e^+e^- \rightarrow Z$
1.46 <sup>+0.22</sup> <sub>-0.21</sub> ± 0.07 -0.09		ABREU	96D DLPH	Repl. by ABREU 99W
1.27 <sup>+0.35</sup> <sub>-0.29</sub> ± 0.09		ABREU	95S DLPH	Repl. by ABREU 99W
1.05 <sup>+0.12</sup> <sub>-0.11</sub> ± 0.09	290	BUSKULIC	95L ALEP	Repl. by BARATE 98D
1.04 <sup>+0.48</sup> <sub>-0.38</sub> ± 0.10	11	10 ABREU	93F DLPH	Excess $\Lambda\mu^-$ , decay lengths

1.05	$+0.23$ $-0.20$	$\pm 0.08$	157	<sup>11</sup> AKERS	93	OPAL	Excess $\Lambda\ell^-$ , decay lengths
1.12	$+0.32$ $-0.29$	$\pm 0.16$	101	<sup>12</sup> BUSKULIC	92i	ALEP	Excess $\Lambda\ell^-$ , impact parameters

<sup>1</sup> Measured mean life using fully reconstructed  $\Lambda_b^0 \rightarrow \Lambda_c^+ \pi^-$  decays.

<sup>2</sup> Measured mean life using fully reconstructed  $\Lambda_b^0 \rightarrow J/\psi \Lambda$  decays.

<sup>3</sup> Measured using semileptonic decays  $\Lambda_b(0) \rightarrow \Lambda_c^+ \mu \nu X$ ,  $\Lambda_c^+ \rightarrow K_S^0 p$ .

<sup>4</sup> Measured using  $\Lambda\ell^-$  decay length.

<sup>5</sup> Measured using  $p\ell^-$  decay length.

<sup>6</sup> Measured using  $\Lambda_c \ell^-$  and  $\Lambda\ell^+ \ell^-$ .

<sup>7</sup> Measured using the excess of  $\Lambda\ell^-$ , lepton impact parameter.

<sup>8</sup> Measured using  $\Lambda_c \ell^-$ .

<sup>9</sup> This ABREU 99W result is the combined result of the  $\Lambda\ell^-$ ,  $p\ell^-$ , and excess  $\Lambda\mu^-$  impact parameter measurements.

<sup>10</sup> ABREU 93F superseded by ABREU 96D.

<sup>11</sup> AKERS 93 superseded by AKERS 96.

<sup>12</sup> BUSKULIC 92i superseded by BUSKULIC 95L.

### ***b*-baryon ADMIXTURE DECAY MODES** ( $\Lambda_b, \Xi_b, \Sigma_b, \Omega_b$ )

These branching fractions are actually an average over weakly decaying *b*-baryons weighted by their production rates in *Z* decay (or high-energy  $p\bar{p}$ ), branching ratios, and detection efficiencies. They scale with the LEP *b*-baryon production fraction  $B(b \rightarrow b\text{-baryon})$  and are evaluated for our value  $B(b \rightarrow b\text{-baryon}) = (9.2 \pm 1.8)\%$ .

The branching fractions  $B(b\text{-baryon} \rightarrow \Lambda\ell^- \bar{\nu}_\ell \text{ anything})$  and  $B(\Lambda_b^0 \rightarrow \Lambda_c^+ \ell^- \bar{\nu}_\ell \text{ anything})$  are not pure measurements because the underlying measured products of these with  $B(b \rightarrow b\text{-baryon})$  were used to determine  $B(b \rightarrow b\text{-baryon})$ , as described in the note "Production and Decay of *b*-Flavored Hadrons."

For inclusive branching fractions, *e.g.*,  $B \rightarrow D^\pm \text{ anything}$ , the values usually are multiplicities, not branching fractions. They can be greater than one.

Mode	Fraction ( $\Gamma_i/\Gamma$ )
$\Gamma_1$ $p\mu^- \bar{\nu}$ anything	$(5.8^{+2.6}_{-2.4})\%$
$\Gamma_2$ $p\ell\bar{\nu}_\ell$ anything	$(5.6 \pm 1.7)\%$
$\Gamma_3$ $p$ anything	$(69 \pm 27)\%$
$\Gamma_4$ $\Lambda\ell^- \bar{\nu}_\ell$ anything	$(3.7 \pm 1.0)\%$
$\Gamma_5$ $\Lambda\ell^+ \nu_\ell$ anything	
$\Gamma_6$ $\Lambda$ anything	
$\Gamma_7$ $\Lambda_c^+ \ell^- \bar{\nu}_\ell$ anything	
$\Gamma_8$ $\Lambda/\bar{\Lambda}$ anything	$(39 \pm 11)\%$
$\Gamma_9$ $\Xi^- \ell^- \bar{\nu}_\ell$ anything	$(6.5 \pm 2.2) \times 10^{-3}$

## **$b$ -baryon ADMIXTURE ( $\Lambda_b, \Xi_b, \Sigma_b, \Omega_b$ ) BRANCHING RATIOS**

### $\Gamma(\rho\mu^-\bar{\nu}\text{anything})/\Gamma_{\text{total}}$ $\Gamma_1/\Gamma$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>0.058^{+0.022}_{-0.018} \pm 0.015</math></b>	125	<sup>13</sup> ABREU	95S DLPH	$e^+e^- \rightarrow Z$

<sup>13</sup> ABREU 95S reports  $[\Gamma(b\text{-baryon} \rightarrow \rho\mu^-\bar{\nu}\text{anything})/\Gamma_{\text{total}}] \times [B(\bar{b} \rightarrow b\text{-baryon})] = 0.0049 \pm 0.0011^{+0.0015}_{-0.0011}$  which we divide by our best value  $B(\bar{b} \rightarrow b\text{-baryon}) = (8.5 \pm 2.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

### $\Gamma(\rho\ell\bar{\nu}_\ell\text{anything})/\Gamma_{\text{total}}$ $\Gamma_2/\Gamma$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>0.056 \pm 0.009 \pm 0.014</math></b>	<sup>14</sup> BARATE	98V ALEP	$e^+e^- \rightarrow Z$

<sup>14</sup> BARATE 98V reports  $[\Gamma(b\text{-baryon} \rightarrow \rho\ell\bar{\nu}_\ell\text{anything})/\Gamma_{\text{total}}] \times [B(\bar{b} \rightarrow b\text{-baryon})] = (4.72 \pm 0.66 \pm 0.44) \times 10^{-3}$  which we divide by our best value  $B(\bar{b} \rightarrow b\text{-baryon}) = (8.5 \pm 2.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

### $\Gamma(\rho\ell\bar{\nu}_\ell\text{anything})/\Gamma(p\text{anything})$ $\Gamma_2/\Gamma_3$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>0.080 \pm 0.012 \pm 0.014</math></b>	BARATE	98V ALEP	$e^+e^- \rightarrow Z$

### $\Gamma(\Lambda\ell^-\bar{\nu}_\ell\text{anything})/\Gamma_{\text{total}}$ $\Gamma_4/\Gamma$

The values and averages in this section serve only to show what values result if one assumes our  $B(b \rightarrow b\text{-baryon})$ . They cannot be thought of as measurements since the underlying product branching fractions were also used to determine  $B(b \rightarrow b\text{-baryon})$  as described in the note on "Production and Decay of  $b$ -Flavored Hadrons."

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>0.037 \pm 0.010</math> OUR AVERAGE</b>				

$0.038 \pm 0.005 \pm 0.010$		<sup>15</sup> BARATE	98D ALEP	$e^+e^- \rightarrow Z$
$0.034 \pm 0.004 \pm 0.009$		<sup>16</sup> AKERS	96 OPAL	Excess of $\Lambda\ell^-$ over $\Lambda\ell^+$
$0.035 \pm 0.008 \pm 0.009$	262	<sup>17</sup> ABREU	95S DLPH	Excess of $\Lambda\ell^-$ over $\Lambda\ell^+$
$0.072 \pm 0.014 \pm 0.019$	290	<sup>18</sup> BUSKULIC	95L ALEP	Excess of $\Lambda\ell^-$ over $\Lambda\ell^+$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
seen	157	<sup>19</sup> AKERS	93 OPAL	Excess of $\Lambda\ell^-$ over $\Lambda\ell^+$
$0.082 \pm 0.024 \pm 0.021$	101	<sup>20</sup> BUSKULIC	92I ALEP	Excess of $\Lambda\ell^-$ over $\Lambda\ell^+$

<sup>15</sup> BARATE 98D reports  $[\Gamma(b\text{-baryon} \rightarrow \Lambda\ell^-\bar{\nu}_\ell\text{anything})/\Gamma_{\text{total}}] \times [B(\bar{b} \rightarrow b\text{-baryon})] = 0.00326 \pm 0.00016 \pm 0.00039$  which we divide by our best value  $B(\bar{b} \rightarrow b\text{-baryon}) = (8.5 \pm 2.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value. Measured using the excess of  $\Lambda\ell^-$ , lepton impact parameter.

<sup>16</sup> AKERS 96 reports  $[\Gamma(b\text{-baryon} \rightarrow \Lambda\ell^-\bar{\nu}_\ell\text{anything})/\Gamma_{\text{total}}] \times [B(\bar{b} \rightarrow b\text{-baryon})] = 0.00291 \pm 0.00023 \pm 0.00025$  which we divide by our best value  $B(\bar{b} \rightarrow b\text{-baryon}) = (8.5 \pm 2.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>17</sup> ABREU 95S reports  $[\Gamma(b\text{-baryon} \rightarrow \Lambda \ell^- \bar{\nu}_\ell \text{ anything})/\Gamma_{\text{total}}] \times [B(\bar{b} \rightarrow b\text{-baryon})] = 0.0030 \pm 0.0006 \pm 0.0004$  which we divide by our best value  $B(\bar{b} \rightarrow b\text{-baryon}) = (8.5 \pm 2.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>18</sup> BUSKULIC 95L reports  $[\Gamma(b\text{-baryon} \rightarrow \Lambda \ell^- \bar{\nu}_\ell \text{ anything})/\Gamma_{\text{total}}] \times [B(\bar{b} \rightarrow b\text{-baryon})] = 0.0061 \pm 0.0006 \pm 0.0010$  which we divide by our best value  $B(\bar{b} \rightarrow b\text{-baryon}) = (8.5 \pm 2.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>19</sup> AKERS 93 superseded by AKERS 96.

<sup>20</sup> BUSKULIC 92I reports  $[\Gamma(b\text{-baryon} \rightarrow \Lambda \ell^- \bar{\nu}_\ell \text{ anything})/\Gamma_{\text{total}}] \times [B(\bar{b} \rightarrow b\text{-baryon})] = 0.0070 \pm 0.0010 \pm 0.0018$  which we divide by our best value  $B(\bar{b} \rightarrow b\text{-baryon}) = (8.5 \pm 2.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value. Superseded by BUSKULIC 95L.

### $\Gamma(\Lambda \ell^+ \nu_\ell \text{ anything})/\Gamma(\Lambda \text{ anything})$ $\Gamma_5/\Gamma_6$

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.080 ± 0.012 ± 0.008</b>	ABBIENDI	99L	OPAL $e^+ e^- \rightarrow Z$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.070 ± 0.012 ± 0.007	ACKERSTAFF	97N	OPAL Repl. by ABBI- ENDI 99L

### $\Gamma(\Lambda/\bar{\Lambda} \text{ anything})/\Gamma_{\text{total}}$ $\Gamma_8/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.39 ± 0.11 OUR AVERAGE</b>			
0.41 ± 0.06 ± 0.11	<sup>21</sup> ABBIENDI	99L	OPAL $e^+ e^- \rightarrow Z$
0.26 <sup>+0.15</sup> <sub>-0.09</sub> ± 0.07	<sup>22</sup> ABREU	95C	DLPH $e^+ e^- \rightarrow Z$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.46 ± 0.07 ± 0.12	<sup>23</sup> ACKERSTAFF	97N	OPAL Repl. by ABBI- ENDI 99L

<sup>21</sup> ABBIENDI 99L reports  $[\Gamma(b\text{-baryon} \rightarrow \Lambda/\bar{\Lambda} \text{ anything})/\Gamma_{\text{total}}] \times [B(\bar{b} \rightarrow b\text{-baryon})] = 0.035 \pm 0.0032 \pm 0.0035$  which we divide by our best value  $B(\bar{b} \rightarrow b\text{-baryon}) = (8.5 \pm 2.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>22</sup> ABREU 95C reports 0.28<sup>+0.17</sup><sub>-0.12</sub> from a measurement of  $[\Gamma(b\text{-baryon} \rightarrow \Lambda/\bar{\Lambda} \text{ anything})/\Gamma_{\text{total}}] \times [B(\bar{b} \rightarrow b\text{-baryon})]$  assuming  $B(\bar{b} \rightarrow b\text{-baryon}) = 0.08 \pm 0.02$ , which we rescale to our best value  $B(\bar{b} \rightarrow b\text{-baryon}) = (8.5 \pm 2.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>23</sup> ACKERSTAFF 97N reports  $[\Gamma(b\text{-baryon} \rightarrow \Lambda/\bar{\Lambda} \text{ anything})/\Gamma_{\text{total}}] \times [B(\bar{b} \rightarrow b\text{-baryon})] = 0.0393 \pm 0.0046 \pm 0.0037$  which we divide by our best value  $B(\bar{b} \rightarrow b\text{-baryon}) = (8.5 \pm 2.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

### $\Gamma(\Xi^- \ell^- \bar{\nu}_\ell \text{ anything})/\Gamma_{\text{total}}$ $\Gamma_9/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.0065 ± 0.0022 OUR AVERAGE</b>			
0.0064 ± 0.0016 ± 0.0016	<sup>24</sup> BUSKULIC	96T	ALEP Excess $\Xi^- \ell^-$ over $\Xi^- \ell^+$
0.0069 ± 0.0027 ± 0.0018	<sup>25</sup> ABREU	95V	DLPH Excess $\Xi^- \ell^-$ over $\Xi^- \ell^+$

- <sup>24</sup> BUSKULIC 96T reports  $[\Gamma(b\text{-baryon} \rightarrow \Xi^- \ell^- \bar{\nu}_\ell \text{ anything})/\Gamma_{\text{total}}] \times [B(\bar{b} \rightarrow b\text{-baryon})] = 0.00054 \pm 0.00011 \pm 0.00008$  which we divide by our best value  $B(\bar{b} \rightarrow b\text{-baryon}) = (8.5 \pm 2.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.
- <sup>25</sup> ABREU 95V reports  $[\Gamma(b\text{-baryon} \rightarrow \Xi^- \ell^- \bar{\nu}_\ell \text{ anything})/\Gamma_{\text{total}}] \times [B(\bar{b} \rightarrow b\text{-baryon})] = 0.00059 \pm 0.00021 \pm 0.0001$  which we divide by our best value  $B(\bar{b} \rightarrow b\text{-baryon}) = (8.5 \pm 2.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

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### **$b$ -baryon ADMIXTURE ( $\Lambda_b, \Xi_b, \Sigma_b, \Omega_b$ ) REFERENCES**

AALTONEN	10B	PRL 104 102002	T. Aaltonen <i>et al.</i>	(CDF Collab.)
ABAZOV	07S	PRL 99 142001	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABAZOV	07U	PRL 99 182001	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABULENCIA	07A	PRL 98 122001	A. Abulencia <i>et al.</i>	(FNAL CDF Collab.)
ABAZOV	05C	PRL 94 102001	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABBIENDI	99L	EPJ C9 1	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABREU	99W	EPJ C10 185	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ACKERSTAFF	98G	PL B426 161	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)
BARATE	98D	EPJ C2 197	R. Barate <i>et al.</i>	(ALEPH Collab.)
BARATE	98V	EPJ C5 205	R. Barate <i>et al.</i>	(ALEPH Collab.)
ACKERSTAFF	97N	ZPHY C74 423	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)
ABE	96M	PRL 77 1439	F. Abe <i>et al.</i>	(CDF Collab.)
ABREU	96D	ZPHY C71 199	P. Abreu <i>et al.</i>	(DELPHI Collab.)
AKERS	96	ZPHY C69 195	R. Akers <i>et al.</i>	(OPAL Collab.)
BUSKULIC	96T	PL B384 449	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
ABREU	95C	PL B347 447	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	95S	ZPHY C68 375	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	95V	ZPHY C68 541	P. Abreu <i>et al.</i>	(DELPHI Collab.)
BUSKULIC	95L	PL B357 685	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
ABREU	93F	PL B311 379	P. Abreu <i>et al.</i>	(DELPHI Collab.)
AKERS	93	PL B316 435	R. Akers <i>et al.</i>	(OPAL Collab.)
BUSKULIC	92I	PL B297 449	D. Buskulic <i>et al.</i>	(ALEPH Collab.)

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