

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 corrections between the measurements and asymmetric lifetime errors.

| VALUE (10^{-12} s) | EVTS | DOCUMENT ID | TECN | COMMENT |
|---|------|-----------------------|----------|--|
| 1.209 ± 0.049 OUR EVALUATION | | | | |
| 1.22 $^{+0.22}_{-0.18}$ ± 0.04 | | ¹ ABAZOV | 05C D0 | $p\bar{p}$ at 1.96 TeV |
| 1.16 ± 0.20 ± 0.08 | | ² ABREU | 99W DLPH | $e^+e^- \rightarrow Z$ |
| 1.19 ± 0.14 ± 0.07 | | ³ ABREU | 99W DLPH | $e^+e^- \rightarrow Z$ |
| 1.20 ± 0.08 ± 0.06 | | ⁴ BARATE | 98D ALEP | $e^+e^- \rightarrow Z$ |
| 1.10 $^{+0.19}_{-0.17}$ ± 0.09 | | ABREU | 96D DLPH | Excess $\Lambda\mu^-$ impact parameters |
| 1.16 ± 0.11 ± 0.06 | | AKERS | 96 OPAL | Excess $\Lambda\ell^-$, decay lengths and impact parameters |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● | | | | |
| 1.14 ± 0.08 ± 0.04 | | ⁵ ABREU | 99W DLPH | $e^+e^- \rightarrow Z$ |
| 1.46 $^{+0.22}_{-0.21}$ $^{+0.07}_{-0.09}$ | | ABREU | 96D DLPH | Repl. by ABREU 99W |
| 1.27 $^{+0.35}_{-0.29}$ ± 0.09 | | ABREU | 95S DLPH | Repl. by ABREU 99W |
| 1.05 $^{+0.12}_{-0.11}$ ± 0.09 | 290 | BUSKULIC | 95L ALEP | Repl. by BARATE 98D |
| 1.04 $^{+0.48}_{-0.38}$ ± 0.10 | 11 | ⁶ ABREU | 93F DLPH | Excess $\Lambda\mu^-$, decay lengths |
| 1.05 $^{+0.23}_{-0.20}$ ± 0.08 | 157 | ⁷ AKERS | 93 OPAL | Excess $\Lambda\ell^-$, decay lengths |
| 1.12 $^{+0.32}_{-0.29}$ ± 0.16 | 101 | ⁸ BUSKULIC | 92I ALEP | Excess $\Lambda\ell^-$, impact parameters |

¹ Measured mean life using fully reconstructed $\Lambda_b^0 \rightarrow J/\psi \Lambda$ decays.

² Measured using $\Lambda\ell^-$ decay length.

³ Measured using $p\ell^-$ decay length.

⁴ Measured using the excess of $\Lambda\ell^-$, lepton impact parameter.

⁵ This ABREU 99W result is the combined result of the $\Lambda\ell^-$, $p\ell^-$, and excess $\Lambda\mu^-$ impact parameter measurements.

⁶ ABREU 93F superseded by ABREU 96D.

⁷ AKERS 93 superseded by AKERS 96.

⁸ 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 $B(b \rightarrow b\text{-baryon}) = (9.9 \pm 1.7)\%$.

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 (Γ_i/Γ) |
|---|--------------------------------|
| Γ_1 $p\mu^- \bar{\nu}$ anything | $(4.9^{+2.0}_{-1.8})\%$ |
| Γ_2 $p\ell \bar{\nu}_\ell$ anything | $(4.7 \pm 1.1)\%$ |
| Γ_3 p anything | $(59 \pm 20)\%$ |
| Γ_4 $\Lambda \ell^- \bar{\nu}_\ell$ anything | $(3.2 \pm 0.6)\%$ |
| Γ_5 $\Lambda \ell^+ \nu_\ell$ anything | |
| Γ_6 Λ anything | |
| Γ_7 $\Lambda_c^+ \ell^- \bar{\nu}_\ell$ anything | |
| Γ_8 $\Lambda/\bar{\Lambda}$ anything | $(33 \pm 7)\%$ |
| Γ_9 $\Xi^- \ell^- \bar{\nu}_\ell$ anything | $(5.5 \pm 1.5) \times 10^{-3}$ |

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

$\Gamma(p\mu^- \bar{\nu} \text{ anything})/\Gamma_{\text{total}}$ **Γ_1/Γ**

| VALUE | EVTS | DOCUMENT ID | TECN | COMMENT |
|-------------------------------------|------|--------------------|----------|-------------------------|
| $0.049^{+0.019}_{-0.016} \pm 0.008$ | 125 | ⁹ ABREU | 95S DLPH | $e^+ e^- \rightarrow Z$ |

⁹ ABREU 95S reports $[B(b\text{-baryon} \rightarrow p\mu^- \bar{\nu} \text{ anything}) \times B(\bar{b} \rightarrow b\text{-baryon})] = 0.0049 \pm 0.0011^{+0.0015}_{-0.0011}$. We divide by our best value $B(\bar{b} \rightarrow b\text{-baryon}) = (10.0 \pm 1.7) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(p\ell \bar{\nu}_\ell \text{ anything})/\Gamma_{\text{total}}$ **Γ_2/Γ**

| VALUE | DOCUMENT ID | TECN | COMMENT |
|-----------------------------|----------------------|----------|-------------------------|
| $0.047 \pm 0.008 \pm 0.008$ | ¹⁰ BARATE | 98V ALEP | $e^+ e^- \rightarrow Z$ |

¹⁰ BARATE 98V reports $[B(b\text{-baryon} \rightarrow p\ell \bar{\nu}_\ell \text{ anything}) \times B(\bar{b} \rightarrow b\text{-baryon})] = (4.72 \pm 0.66 \pm 0.44) \times 10^{-3}$. We divide by our best value $B(\bar{b} \rightarrow b\text{-baryon}) = (10.0 \pm 1.7) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(\rho\ell\bar{\nu}_\ell\text{anything})/\Gamma(\rho\text{anything})$

Γ_2/Γ_3

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

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

Γ_4/Γ

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>EVS</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|---|------------|--------------------|-------------|--|
| 0.032±0.006 OUR AVERAGE | | | | |
| 0.033±0.004±0.006 | | 11 BARATE | 98D ALEP | $e^+e^- \rightarrow Z$ |
| 0.029±0.003±0.005 | | 12 AKERS | 96 OPAL | Excess of $\Lambda\ell^-$ over $\Lambda\ell^+$ |
| 0.030±0.007±0.005 | 262 | 13 ABREU | 95S DLPH | Excess of $\Lambda\ell^-$ over $\Lambda\ell^+$ |
| 0.061±0.012±0.010 | 290 | 14 BUSKULIC | 95L ALEP | Excess of $\Lambda\ell^-$ over $\Lambda\ell^+$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| seen | 157 | 15 AKERS | 93 OPAL | Excess of $\Lambda\ell^-$ over $\Lambda\ell^+$ |
| 0.070±0.021±0.012 | 101 | 16 BUSKULIC | 92I ALEP | Excess of $\Lambda\ell^-$ over $\Lambda\ell^+$ |

¹¹ BARATE 98D reports $[B(b\text{-baryon} \rightarrow \Lambda\ell^-\bar{\nu}_\ell\text{anything}) \times B(\bar{b} \rightarrow b\text{-baryon})] = 0.00326 \pm 0.00016 \pm 0.00039$. We divide by our best value $B(\bar{b} \rightarrow b\text{-baryon}) = (10.0 \pm 1.7) \times 10^{-2}$. 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.

¹² AKERS 96 reports $[B(b\text{-baryon} \rightarrow \Lambda\ell^-\bar{\nu}_\ell\text{anything}) \times B(\bar{b} \rightarrow b\text{-baryon})] = 0.00291 \pm 0.00023 \pm 0.00025$. We divide by our best value $B(\bar{b} \rightarrow b\text{-baryon}) = (10.0 \pm 1.7) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

¹³ ABREU 95S reports $[B(b\text{-baryon} \rightarrow \Lambda\ell^-\bar{\nu}_\ell\text{anything}) \times B(\bar{b} \rightarrow b\text{-baryon})] = 0.0030 \pm 0.0006 \pm 0.0004$. We divide by our best value $B(\bar{b} \rightarrow b\text{-baryon}) = (10.0 \pm 1.7) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

¹⁴ BUSKULIC 95L reports $[B(b\text{-baryon} \rightarrow \Lambda\ell^-\bar{\nu}_\ell\text{anything}) \times B(\bar{b} \rightarrow b\text{-baryon})] = 0.0061 \pm 0.0006 \pm 0.0010$. We divide by our best value $B(\bar{b} \rightarrow b\text{-baryon}) = (10.0 \pm 1.7) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

¹⁵ AKERS 93 superseded by AKERS 96.

¹⁶ BUSKULIC 92I reports $[B(b\text{-baryon} \rightarrow \Lambda\ell^-\bar{\nu}_\ell\text{anything}) \times B(\bar{b} \rightarrow b\text{-baryon})] = 0.0070 \pm 0.0010 \pm 0.0018$. We divide by our best value $B(\bar{b} \rightarrow b\text{-baryon}) = (10.0 \pm 1.7) \times 10^{-2}$. 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.

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

Γ_5/Γ_6

| <u>VALUE</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|--------------------------|--------------------|-------------|------------------------|
| 0.080±0.012±0.008 | 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 ABBIENDI 99L |
|-------------------|------------|----------|-----------------------|

$\Gamma(\Lambda/\bar{\Lambda}\text{anything})/\Gamma_{\text{total}}$ **Γ_8/Γ**

| <u>VALUE</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|--|--------------------|-------------|------------------------|
| 0.33±0.07 OUR AVERAGE | | | |
| 0.35±0.05±0.06 | 17 ABBIENDI | 99L OPAL | $e^+e^- \rightarrow Z$ |
| 0.22 ^{+0.12} _{-0.08} ±0.04 | 18 ABREU | 95C DLPH | $e^+e^- \rightarrow Z$ |

• • • We do not use the following data for averages, fits, limits, etc. • • •

- 0.39±0.06±0.07 19 ACKERSTAFF 97N OPAL Repl. by ABBIENDI 99L
- 17 ABBIENDI 99L reports $[B(b\text{-baryon} \rightarrow \Lambda/\bar{\Lambda}\text{anything}) \times B(\bar{b} \rightarrow b\text{-baryon})] = 0.035 \pm 0.0032 \pm 0.0035$. We divide by our best value $B(\bar{b} \rightarrow b\text{-baryon}) = (10.0 \pm 1.7) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.
- 18 ABREU 95C reports $0.28^{+0.17}_{-0.12}$ for $B(\bar{b} \rightarrow b\text{-baryon}) = 0.08 \pm 0.02$. We rescale to our best value $B(\bar{b} \rightarrow b\text{-baryon}) = (10.0 \pm 1.7) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.
- 19 ACKERSTAFF 97N reports $[B(b\text{-baryon} \rightarrow \Lambda/\bar{\Lambda}\text{anything}) \times B(\bar{b} \rightarrow b\text{-baryon})] = 0.0393 \pm 0.0046 \pm 0.0037$. We divide by our best value $B(\bar{b} \rightarrow b\text{-baryon}) = (10.0 \pm 1.7) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(\Xi^- \ell^- \bar{\nu}_\ell \text{anything})/\Gamma_{\text{total}}$ **Γ_9/Γ**

| <u>VALUE</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u> |
|----------------------------------|--------------------|-------------|---|
| 0.0055±0.0015 OUR AVERAGE | | | |
| 0.0054±0.0014±0.0009 | 20 BUSKULIC | 96T ALEP | Excess $\Xi^- \ell^-$ over $\Xi^- \ell^+$ |
| 0.0059±0.0023±0.0010 | 21 ABREU | 95V DLPH | Excess $\Xi^- \ell^-$ over $\Xi^- \ell^+$ |

- 20 BUSKULIC 96T reports $[B(b\text{-baryon} \rightarrow \Xi^- \ell^- \bar{\nu}_\ell \text{anything}) \times B(\bar{b} \rightarrow b\text{-baryon})] = 0.00054 \pm 0.00011 \pm 0.00008$. We divide by our best value $B(\bar{b} \rightarrow b\text{-baryon}) = (10.0 \pm 1.7) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.
- 21 ABREU 95V reports $[B(b\text{-baryon} \rightarrow \Xi^- \ell^- \bar{\nu}_\ell \text{anything}) \times B(\bar{b} \rightarrow b\text{-baryon})] = 0.00059 \pm 0.00021 \pm 0.0001$. We divide by our best value $B(\bar{b} \rightarrow b\text{-baryon}) = (10.0 \pm 1.7) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

| | | | |
|------------|-------------------|-----------------------------|------------------|
| 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.) |
| 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.) |
| 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.) |