B HADRON MEAN LIFE

These measurements of the B mean life are averages over bottom particles produced, weighted by their semileptonic branching ratios, unless otherwise stated. Only the measurements at high energy are averaged since it is expected that the admixtures of B hadrons from Z decay and 1.8 TeV $p\overline{p}$ collisions should should not differ significantly.

VALUE (10^{-12} s)	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
1.537±0.021 OUR AVERAGE					
1.582±0.012±0.032			ABREU 94C	DLPH	$e^+e^- \to Z$
1.46 ±0.06 ±0.06		5344	[7] ABE 93J	CDF	$p\overline{p}$ at 1.8 TeV
$1.51\ ^{+0.16}_{-0.14}$ ±0.11		130	[8] ACTON 93C	OPAL	$e^+e^- \to Z$
1.523±0.034±0.038		5372	[9] ACTON 93L	OPAL	$e^+e^- \to Z$
1.535±0.035±0.028		7357	[9] ADRIANI 93K	L3	$e^+e^- \to Z$
1.50 ±0.020±0.050			[10] BUSKULIC 93O	ALEP	$e^+e^- \to Z$
$1.35\ ^{+0.19}_{-0.17}$ ±0.005			[11] BUSKULIC 92G	ALEP	$e^+e^- \to Z$
$1.32\ ^{+0.31}_{-0.25}$ ±0.15		37	[12] ALEXANDER 91G	OPAL	$e^+e^- \to Z$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$1.23\ ^{+0.14}_{-0.13}$ ±0.15		188	[13] ABREU 93D	DLPH	Sup. by ABREU 94C
1.49 ±0.11 ±0.12		253	[14] ABREU 93G	DLPH	Sup. by ABREU 94C
1.28 ±0.10			[15] ABREU 92	DLPH	Sup. by ABREU 94C
1.37 ±0.07 ±0.06		1354	[16] ACTON 92	OPAL	Sup. by ACTON 93L
1.49 ±0.03 ±0.06			[17] BUSKULIC 92F	ALEP	Sup. by BUSKULIC 93O
1.32 ±0.08 ±0.09		1386	[18] ADEVA 91H	L3	Sup. by ADRIANI 93K
1.29 ±0.06 ±0.10		2973	[19] DECAMP 91C	ALEP	Sup. by BUSKULIC 92F
$1.36\ ^{+0.25}_{-0.23}$			[20] HAGEMANN 90	JADE	$E^{ee}_{\rm cm}$= 35 GeV
1.13 ±0.15			[21] LYONS 90	RVUE	
1.35 ±0.10 ±0.24			BRAUNSCH... 89B	TASS	$E^{ee}_{\rm cm}$= 35 GeV
0.98 ±0.12 ±0.13			ONG 89	MRK2	$E^{ee}_{\rm cm}$= 29 GeV
$1.17\ ^{+0.27}_{-0.22}\ ^{+0.17}_{-0.16}$			KLEM 88	DLCO	$E^{ee}_{\rm cm}$= 29 GeV
1.29 ±0.20 ±0.21			[22] ASH 87	MAC	$E^{ee}_{\rm cm}$= 29 GeV
$1.02\ ^{+0.42}_{-0.39}$		301	[23] BROM 87	HRS	$E^{ee}_{\rm cm}$= 29 GeV
$1.8\ ^{+0.5}_{-0.4}$ ±0.4		25	BARTEL 86B	JADE	$E^{ee}_{\rm cm}$= 35 GeV
$1.83\ ^{+0.38}_{-0.37}\ ^{+0.37}_{-0.34}$			ALTHOFF 84H	TASS	$E^{ee}_{\rm cm}$= 30–46.8 GeV
$1.16\ ^{+0.37}_{-0.34}$ ±0.23		46	KLEM 84	DLCO	Repl. by KLEM 88
1.8 ±0.6 ±0.4			FERNANDEZ 83B	MAC	$E^{ee}_{\rm cm}$= 29 GeV
$1.20\ ^{+0.45}_{-0.36}$ ±0.30			LOCKYER 83	MRK2	Repl. by ONG 89
<1.4	95		BARTEL 82C	JADE	e^+e^-, average $E_{\rm cm}$= 34 GeV

[7] ABE 93J analyzed using $J/\psi(1S) \to \mu\mu$ vertices.

[8] ACTON 93C analysed using $D/D^*\ell$anything event vertices.

[9] ACTON 93L and ADRIANI 93K analyzed using lepton (e and m) impact parameter at Z.

[10] BUSKULIC 93O analyzed using dipole method plus lepton (e and μ) impact parameter at Z.

[11] BUSKULIC 92G use $J/\psi(1S)$ tags to measure the average b lifetime. This is comparable to other methods only if the $J/\psi(1S)$ branching fractions of the different b-flavored hadrons are in the same ratio.

[12] Using $Z \to J/\psi(1S)$X, $J/\psi(1S) \to \ell^+\ell^-$, ALEXANDER 91G determined the average lifetime for an admixture of B hadrons from the decay point of the $J/\psi(1S)$.

[13] ABREU 93D data analyzed using $D/D^*\ell$anything event vertices.

[14] ABREU 93G data analyzed using charged and neutral vertices.

[15] ABREU 92 is combined result of muon and hadron impact parameter analyses. Hadron tracks gave $(12.7 \pm 0.4 \pm 1.2) \times 10^{-13}$ s for an admixture of B species weighted by production fraction and mean charge multiplicity, while muon tracks gave $(13.0 \pm 1.0 \pm 0.8) \times 10^{-13}$ s for an admixture weighted by production fraction and semileptonic branching fraction.

[16] ACTON 92 is combined result of muon and electron impact parameter analyses.

[17] BUSKULIC 92F uses the lepton impact parameter distribution for data from the 1991 run.

[18] Using $Z \to e^+$X or μ^+X, ADEVA 91H determined the average lifetime for an admixture of B hadrons from the impact parameter distribution of the lepton.

[19] Using $Z \to e$X or μX, DECAMP 91C determines the average lifetime for an admixture of B hadrons from the signed impact parameter distribution of the lepton.

[20] HAGEMANN 90 uses electrons and muons in an impact parameter analysis.

[21] LYONS 90 combine the results of the B lifetime measuresments of ONG 89, BRAUNSCHWEIG 89B, KLEM 88, and ASH 87, and JADE data by private communication. They use statistical techniques which include variation of the error with the mean life, and possible correlations between the systematic errors. This result is not independent of the measured results used in our average.

[22] We have combined an overall scale error of 15% in quadrature with the systematic error of ±0.7 to obtain ±2.1 systematic error.

[23] Statistical and systematic errors were combined by BROM 87.

B^+ DECAY MODES

B^- modes are charge conjugates of the modes below.

Only data from $\Upsilon(4S)$ decays are used for branching fractions, with rare exceptions. The branching fractions listed below assume a 50:50 $B^0\overline{B}^0$:B^+B^- production ratio at the $\Upsilon(4S)$. We have attempted to bring older measurements up to date by rescaling their assumed $\Upsilon(4S)$ production ratio to 50:50 and their assumed D, D_s, D^*, and ψ branching ratios to current values whenever this would effect our averages and best limits significantly.

Indentation is used to indicate a subchannel of a previous reaction. All resonant subchannels have been corrected for resonance branching fractions to the final state so the sum of the subchannel branching fractions can exceed that of the final state.

	Mode	Fraction (Γ_i/Γ)	Scale factor/ Confidence level
	Semileptonic modes		
Γ_1	$B^+ \to \overline{D}^0\ell^+\nu$	[a] (1.6 ± 0.7) %	
Γ_2	$B^+ \to \overline{D}^*(2007)^0\ell^+\nu$	[a] (6.6 ± 2.2) %	
Γ_3	$B^+ \to \pi^0 e^+\nu_e$	< 2.2 × 10^{-3}	CL=90%
Γ_4	$B^+ \to \omega\ell^+\nu_\ell$	[a] < 2.1 × 10^{-4}	CL=90%
Γ_5	$B^+ \to \omega\mu^+\nu_\mu$	seen	
Γ_6	$B^+ \to \rho^0\ell^+\nu_\ell$	[a] < 2.1 × 10^{-4}	CL=90%
	***D*, *D**, or *D$_s$* modes**		
Γ_7	$B^+ \to \overline{D}^0\pi^+$	(5.3 ± 0.5) × 10^{-3}	
Γ_8	$B^+ \to \overline{D}^0\rho^+$	(1.34± 0.18) %	
Γ_9	$B^+ \to \overline{D}^0\pi^+\pi^+\pi^-$	(1.1 ± 0.4) %	
Γ_{10}	$B^+ \to \overline{D}^0\pi^+\pi^+\pi^-$ nonresonant	(5 ± 4) × 10^{-3}	
Γ_{11}	$B^+ \to \overline{D}^0\pi^+\rho^0$	(4.2 ± 3.0) × 10^{-3}	
Γ_{12}	$B^+ \to \overline{D}^0 a_1(1260)^+$	(5 ± 4) × 10^{-3}	
Γ_{13}	$B^+ \to D^*(2010)^-\pi^+\pi^+$	(2.1 ± 0.6) × 10^{-3}	
Γ_{14}	$B^+ \to D^-\pi^+\pi^+$	< 1.4 × 10^{-3}	CL=90%
Γ_{15}	$B^+ \to \overline{D}^*(2007)^0\pi^+$	(5.2 ± 0.8) × 10^{-3}	
Γ_{16}	$B^+ \to \overline{D}^*(2007)^0\rho^+$	(1.55± 0.31) %	
Γ_{17}	$B^+ \to \overline{D}^*(2007)^0\pi^+\pi^+\pi^-$	(9.4 ± 2.6) × 10^{-3}	
Γ_{18}	$B^+ \to D^*(2010)^-\pi^+\pi^+\pi^0$	(1.5 ± 0.7) %	
Γ_{19}	$B^+ \to D^*(2010)^-\pi^+\pi^+\pi^+\pi^-$	< 1 %	CL=90%
Γ_{20}	$B^+ \to \overline{D}^*_1(2420)^0\pi^+$	(1.1 ± 0.5) × 10^{-3}	
Γ_{21}	$B^+ \to \overline{D}^*_1(2420)^0\rho^+$	< 1.4 × 10^{-3}	CL=90%
Γ_{22}	$B^+ \to \overline{D}^*_2(2460)^0\pi^+$	< 1.3 × 10^{-3}	CL=90%
Γ_{23}	$B^+ \to \overline{D}^*_2(2460)^0\rho^+$	< 4.7 × 10^{-3}	CL=90%
Γ_{24}	$B^+ \to \overline{D}^0 D^+_s$	(1.7 ± 0.6) %	
Γ_{25}	$B^+ \to \overline{D}^0 D^{*+}_s$	(1.2 ± 1.0) %	
Γ_{26}	$B^+ \to \overline{D}^*(2007)^0 D^+_s$	(1.0 ± 0.7) %	
Γ_{27}	$B^+ \to \overline{D}^*(2007)^0 D^{*+}_s$	(2.4 ± 1.3) %	
Γ_{28}	$B^+ \to D^+_s\pi^0$	< 2.1 × 10^{-4}	CL=90%
Γ_{29}	$B^+ \to D^{*+}_s\pi^0$	< 3.4 × 10^{-4}	CL=90%
Γ_{30}	$B^+ \to D^+_s\eta$	< 5 × 10^{-4}	CL=90%
Γ_{31}	$B^+ \to D^{*+}_s\eta$	< 8 × 10^{-4}	CL=90%
Γ_{32}	$B^+ \to D^+_s\rho^0$	< 4 × 10^{-4}	CL=90%
Γ_{33}	$B^+ \to D^{*+}_s\rho^0$	< 5 × 10^{-4}	CL=90%
Γ_{34}	$B^+ \to D^+_s\omega$	< 5 × 10^{-4}	CL=90%
Γ_{35}	$B^+ \to D^{*+}_s\omega$	< 7 × 10^{-4}	CL=90%
Γ_{36}	$B^+ \to D^+_s a_1(1260)^0$	< 2.3 × 10^{-3}	CL=90%
Γ_{37}	$B^+ \to D^{*+}_s a_1(1260)^0$	< 1.7 × 10^{-3}	CL=90%
Γ_{38}	$B^+ \to D^+_s\phi$	< 3.3 × 10^{-4}	CL=90%
Γ_{39}	$B^+ \to D^{*+}_s\phi$	< 4 × 10^{-4}	CL=90%
Γ_{40}	$B^+ \to D^+_s\overline{K}^0$	< 1.1 × 10^{-3}	CL=90%
Γ_{41}	$B^+ \to D^{*+}_s\overline{K}^0$	< 1.2 × 10^{-3}	CL=90%
Γ_{42}	$B^+ \to D^+_s\overline{K}^*(892)^0$	< 5 × 10^{-4}	CL=90%
Γ_{43}	$B^+ \to D^{*+}_s\overline{K}^*(892)^0$	< 5 × 10^{-4}	CL=90%
Γ_{44}	$B^+ \to D^-_s\pi^+K^+$	< 9 × 10^{-4}	CL=90%
Γ_{45}	$B^+ \to D^{*-}_s\pi^+K^+$	< 1.2 × 10^{-3}	CL=90%
Γ_{46}	$B^+ \to D^-_s\pi^+K^*(892)^+$	< 7 × 10^{-3}	CL=90%
Γ_{47}	$B^+ \to D^{*-}_s\pi^+K^*(892)^+$	< 9 × 10^{-3}	CL=90%