

# $B^\pm / B^0 / B_s^0 / b$ -baryon ADMIXTURE

## $B^\pm / B^0 / B_s^0 / b$ -baryon ADMIXTURE MEAN LIFE

Each measurement of the  $B$  mean life is an average over an admixture of various bottom mesons and baryons which decay weakly. Different techniques emphasize different admixtures of produced particles, which could result in a different  $B$  mean life.

“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, but ignores the small differences due to different techniques.

VALUE ( $10^{-12}$ s)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>1.568 ± 0.009 OUR EVALUATION</b>				
1.570 ± 0.005 ± 0.008		1 ABDALLAH	04E DLPH	$e^+ e^- \rightarrow Z$
1.533 ± 0.015 $^{+0.035}_{-0.031}$		2 ABE	98B CDF	$p\bar{p}$ at 1.8 TeV
1.549 ± 0.009 ± 0.015		3 ACCIARRI	98 L3	$e^+ e^- \rightarrow Z$
1.611 ± 0.010 ± 0.027		4 ACKERSTAFF	97F OPAL	$e^+ e^- \rightarrow Z$
1.582 ± 0.011 ± 0.027		4 ABREU	96E DLPH	$e^+ e^- \rightarrow Z$
1.533 ± 0.013 ± 0.022	19.8k	5 BUSKULIC	96F ALEP	$e^+ e^- \rightarrow Z$
1.564 ± 0.030 ± 0.036		6 ABE,K	95B SLD	$e^+ e^- \rightarrow Z$
1.542 ± 0.021 ± 0.045		7 ABREU	94L DLPH	$e^+ e^- \rightarrow Z$
1.523 ± 0.034 ± 0.038	5372	8 ACTON	93L OPAL	$e^+ e^- \rightarrow Z$
1.511 ± 0.022 ± 0.078		9 BUSKULIC	93O ALEP	$e^+ e^- \rightarrow Z$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
1.575 ± 0.010 ± 0.026		10 ABREU	96E DLPH	$e^+ e^- \rightarrow Z$
1.50 $^{+0.24}_{-0.21}$ ± 0.03		11 ABREU	94P DLPH	$e^+ e^- \rightarrow Z$
1.46 ± 0.06 ± 0.06	5344	12 ABE	93J CDF	Repl. by ABE 98B
1.23 $^{+0.14}_{-0.13}$ ± 0.15	188	13 ABREU	93D DLPH	Sup. by ABREU 94L
1.49 ± 0.11 ± 0.12	253	14 ABREU	93G DLPH	Sup. by ABREU 94L
1.51 $^{+0.16}_{-0.14}$ ± 0.11	130	15 ACTON	93C OPAL	$e^+ e^- \rightarrow Z$
1.535 ± 0.035 ± 0.028	7357	8 ADRIANI	93K L3	Repl. by ACCIARRI 98
1.28 ± 0.10		16 ABREU	92 DLPH	Sup. by ABREU 94L
1.37 ± 0.07 ± 0.06	1354	17 ACTON	92 OPAL	Sup. by ACTON 93L
1.49 ± 0.03 ± 0.06		18 BUSKULIC	92F ALEP	Sup. by BUSKULIC 96F
1.35 $^{+0.19}_{-0.17}$ ± 0.05		19 BUSKULIC	92G ALEP	$e^+ e^- \rightarrow Z$
1.32 ± 0.08 ± 0.09	1386	20 ADEVA	91H L3	Sup. by ADRIANI 93K
1.32 $^{+0.31}_{-0.25}$ ± 0.15	37	21 ALEXANDER	91G OPAL	$e^+ e^- \rightarrow Z$

1.29 ±0.06 ±0.10	2973	22	DECAMP	91C	ALEP	Sup. by BUSKULIC 92F
1.36 <sup>+0.25</sup> <sub>-0.23</sub>		23	HAGEMANN	90	JADE	$E_{cm}^{ee} = 35$ GeV
1.13 ±0.15		24	LYONS	90	RVUE	
1.35 ±0.10 ±0.24			BRAUNSCH...	89B	TASS	$E_{cm}^{ee} = 35$ GeV
0.98 ±0.12 ±0.13			ONG	89	MRK2	$E_{cm}^{ee} = 29$ GeV
1.17 <sup>+0.27</sup> <sub>-0.22</sub> <sup>+0.17</sup> <sub>-0.16</sub>			KLEM	88	DLCO	$E_{cm}^{ee} = 29$ GeV
1.29 ±0.20 ±0.21		25	ASH	87	MAC	$E_{cm}^{ee} = 29$ GeV
1.02 <sup>+0.42</sup> <sub>-0.39</sub>	301	26	BROM	87	HRS	$E_{cm}^{ee} = 29$ GeV

<sup>1</sup> Measurement performed using an inclusive reconstruction and  $B$  flavor identification technique.

<sup>2</sup> Measured using inclusive  $J/\psi(1S) \rightarrow \mu^+ \mu^-$  vertex.

<sup>3</sup> ACCIARRI 98 uses inclusively reconstructed secondary vertex and lepton impact parameter.

<sup>4</sup> ACKERSTAFF 97F uses inclusively reconstructed secondary vertices.

<sup>5</sup> BUSKULIC 96F analyzed using 3D impact parameter.

<sup>6</sup> ABE,K 95B uses an inclusive topological technique.

<sup>7</sup> ABREU 94L uses charged particle impact parameters. Their result from inclusively reconstructed secondary vertices is superseded by ABREU 96E.

<sup>8</sup> ACTON 93L and ADRIANI 93K analyzed using lepton ( $e$  and  $\mu$ ) impact parameter at  $Z$ .

<sup>9</sup> BUSKULIC 93O analyzed using dipole method.

<sup>10</sup> Combines ABREU 96E secondary vertex result with ABREU 94L impact parameter result.

<sup>11</sup> From proper time distribution of  $b \rightarrow J/\psi(1S)$  anything.

<sup>12</sup> ABE 93J analyzed using  $J/\psi(1S) \rightarrow \mu\mu$  vertices.

<sup>13</sup> ABREU 93D data analyzed using  $D/D^* \ell$  anything event vertices.

<sup>14</sup> ABREU 93G data analyzed using charged and neutral vertices.

<sup>15</sup> ACTON 93C analysed using  $D/D^* \ell$  anything event vertices.

<sup>16</sup> 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.

<sup>17</sup> ACTON 92 is combined result of muon and electron impact parameter analyses.

<sup>18</sup> BUSKULIC 92F uses the lepton impact parameter distribution for data from the 1991 run.

<sup>19</sup> 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.

<sup>20</sup> Using  $Z \rightarrow e^+ X$  or  $\mu^+ X$ , ADEVA 91H determined the average lifetime for an admixture of  $B$  hadrons from the impact parameter distribution of the lepton.

<sup>21</sup> Using  $Z \rightarrow J/\psi(1S) X$ ,  $J/\psi(1S) \rightarrow \ell^+ \ell^-$ , ALEXANDER 91G determined the average lifetime for an admixture of  $B$  hadrons from the decay point of the  $J/\psi(1S)$ .

<sup>22</sup> Using  $Z \rightarrow e X$  or  $\mu X$ , DECAMP 91C determines the average lifetime for an admixture of  $B$  hadrons from the signed impact parameter distribution of the lepton.

<sup>23</sup> HAGEMANN 90 uses electrons and muons in an impact parameter analysis.

<sup>24</sup> LYONS 90 combine the results of the  $B$  lifetime measurements 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.

<sup>25</sup> We have combined an overall scale error of 15% in quadrature with the systematic error of  $\pm 0.7$  to obtain  $\pm 2.1$  systematic error.

<sup>26</sup> Statistical and systematic errors were combined by BROM 87.

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### CHARGED $b$ -HADRON ADMIXTURE MEAN LIFE

<u>VALUE (<math>10^{-12}</math> s)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>1.72 \pm 0.08 \pm 0.06</math></b>	<sup>1</sup> ADAM	95	DLPH $e^+ e^- \rightarrow Z$

<sup>1</sup> ADAM 95 data analyzed using vertex-charge technique to tag  $b$ -hadron charge.

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### NEUTRAL $b$ -HADRON ADMIXTURE MEAN LIFE

<u>VALUE (<math>10^{-12}</math> s)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>1.58 \pm 0.11 \pm 0.09</math></b>	<sup>1</sup> ADAM	95	DLPH $e^+ e^- \rightarrow Z$

<sup>1</sup> ADAM 95 data analyzed using vertex-charge technique to tag  $b$ -hadron charge.

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### MEAN LIFE RATIO $\tau_{\text{charged } b\text{-hadron}}/\tau_{\text{neutral } b\text{-hadron}}$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>1.09^{+0.11}_{-0.10} \pm 0.08</math></b>	<sup>1</sup> ADAM	95	DLPH $e^+ e^- \rightarrow Z$

<sup>1</sup> ADAM 95 data analyzed using vertex-charge technique to tag  $b$ -hadron charge.

$$|\Delta\tau_b|/\tau_{b,\bar{b}}$$

$\tau_{b,\bar{b}}$  and  $|\Delta\tau_b|$  are the mean life average and difference between  $b$  and  $\bar{b}$  hadrons.

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>-0.001 \pm 0.012 \pm 0.008</math></b>	<sup>1</sup> ABBIENDI	99J	OPAL $e^+ e^- \rightarrow Z$

<sup>1</sup> Data analyzed using both the jet charge and the charge of secondary vertex in the opposite hemisphere.

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### $\bar{b}$ PRODUCTION FRACTIONS AND DECAY MODES

The branching fraction measurements are for an admixture of  $B$  mesons and baryons at energies above the  $\Upsilon(4S)$ . Only the highest energy results (LHC, LEP, Tevatron,  $S\bar{p}\bar{p}S$ ) are used in the branching fraction averages. In the following, we assume that the production fractions are the same at the LHC, LEP, and at the Tevatron.

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.

The modes below are listed for a  $\bar{b}$  initial state.  $b$  modes are their charge conjugates. Reactions indicate the weak decay vertex and do not include mixing.

Mode	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level
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## PRODUCTION FRACTIONS

The production fractions for weakly decaying  $b$ -hadrons at high energy have been calculated from the best values of mean lives, mixing parameters, and branching fractions in this edition by the Heavy Flavor Averaging Group (HFAG) as described in the note “ $B^0$ - $\bar{B}^0$  Mixing” in the  $B^0$  Particle Listings. The production fractions in  $b$ -hadronic  $Z$  decay or  $p\bar{p}$  collisions at the Tevatron are also listed at the end of the section. Values assume

$$\begin{aligned} B(\bar{b} \rightarrow B^+) &= B(\bar{b} \rightarrow B^0) \\ B(\bar{b} \rightarrow B^+) + B(\bar{b} \rightarrow B^0) + B(\bar{b} \rightarrow B_s^0) + B(b \rightarrow b\text{-baryon}) &= 100 \%. \end{aligned}$$

The correlation coefficients between production fractions are also reported:

$$\begin{aligned} \text{cor}(B_s^0, b\text{-baryon}) &= -0.291 \\ \text{cor}(B_s^0, B^\pm=B^0) &= -0.083 \\ \text{cor}(b\text{-baryon}, B^\pm=B^0) &= -0.929. \end{aligned}$$

The notation for production fractions varies in the literature ( $f_d$ ,  $d_{B^0}$ ,  $f(b \rightarrow \bar{B}^0)$ ,  $\text{Br}(b \rightarrow \bar{B}^0)$ ). We use our own branching fraction notation here,  $B(\bar{b} \rightarrow B^0)$ .

Note these production fractions are  $b$ -hadronization fractions, not the conventional branching fractions of  $b$ -quark to a  $B$ -hadron, which may have considerable dependence on the initial and final state kinematic and production environment.

$\Gamma_1$	$B^+$	( 40.2 $\pm$ 0.7 ) %
$\Gamma_2$	$B^0$	( 40.2 $\pm$ 0.7 ) %
$\Gamma_3$	$B_s^0$	( 10.5 $\pm$ 0.6 ) %
$\Gamma_4$	$b$ -baryon	( 9.2 $\pm$ 1.5 ) %

## DECAY MODES

### Semileptonic and leptonic modes

$\Gamma_5$	$\nu$ anything	( 23.1 $\pm$ 1.5 ) %	
$\Gamma_6$	$\ell^+ \nu_\ell$ anything	[a] ( 10.69 $\pm$ 0.22 ) %	
$\Gamma_7$	$e^+ \nu_e$ anything	( 10.86 $\pm$ 0.35 ) %	
$\Gamma_8$	$\mu^+ \nu_\mu$ anything	( 10.95 $^{+0.29}_{-0.25}$ ) %	
$\Gamma_9$	$D^- \ell^+ \nu_\ell$ anything	[a] ( 2.27 $\pm$ 0.35 ) %	S=1.7
$\Gamma_{10}$	$D^- \pi^+ \ell^+ \nu_\ell$ anything	( 4.9 $\pm$ 1.9 ) $\times 10^{-3}$	
$\Gamma_{11}$	$D^- \pi^- \ell^+ \nu_\ell$ anything	( 2.6 $\pm$ 1.6 ) $\times 10^{-3}$	
$\Gamma_{12}$	$\bar{D}^0 \ell^+ \nu_\ell$ anything	[a] ( 6.84 $\pm$ 0.35 ) %	
$\Gamma_{13}$	$\bar{D}^0 \pi^- \ell^+ \nu_\ell$ anything	( 1.07 $\pm$ 0.27 ) %	
$\Gamma_{14}$	$\bar{D}^0 \pi^+ \ell^+ \nu_\ell$ anything	( 2.3 $\pm$ 1.6 ) $\times 10^{-3}$	
$\Gamma_{15}$	$D^{*-} \ell^+ \nu_\ell$ anything	[a] ( 2.75 $\pm$ 0.19 ) %	

$\Gamma_{16}$	$D^{*-} \pi^- \ell^+ \nu_\ell$ anything	( 6 ± 7 ) × 10 <sup>-4</sup>	
$\Gamma_{17}$	$D^{*-} \pi^+ \ell^+ \nu_\ell$ anything	( 4.8 ± 1.0 ) × 10 <sup>-3</sup>	
$\Gamma_{18}$	$\bar{D}_j^0 \ell^+ \nu_\ell$ anything × B( $\bar{D}_j^0 \rightarrow D^{*+} \pi^-$ )	[a,b] ( 2.6 ± 0.9 ) × 10 <sup>-3</sup>	
$\Gamma_{19}$	$D_j^- \ell^+ \nu_\ell$ anything × B( $D_j^- \rightarrow D^0 \pi^-$ )	[a,b] ( 7.0 ± 2.3 ) × 10 <sup>-3</sup>	
$\Gamma_{20}$	$\bar{D}_2^*(2460)^0 \ell^+ \nu_\ell$ anything × B( $\bar{D}_2^*(2460)^0 \rightarrow$ $D^{*-} \pi^+$ )	< 1.4 × 10 <sup>-3</sup>	CL=90%
$\Gamma_{21}$	$D_2^*(2460)^- \ell^+ \nu_\ell$ anything × B( $D_2^*(2460)^- \rightarrow$ $D^0 \pi^-$ )	( 4.2 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ $\begin{smallmatrix} 1.5 \\ 1.8 \end{smallmatrix}$ ) × 10 <sup>-3</sup>	
$\Gamma_{22}$	$\bar{D}_2^*(2460)^0 \ell^+ \nu_\ell$ anything × B( $\bar{D}_2^*(2460)^0 \rightarrow$ $D^- \pi^+$ )	( 1.6 ± 0.8 ) × 10 <sup>-3</sup>	
$\Gamma_{23}$	charmless $\ell \bar{\nu}_\ell$	[a] ( 1.7 ± 0.5 ) × 10 <sup>-3</sup>	
$\Gamma_{24}$	$\tau^+ \nu_\tau$ anything	( 2.41 ± 0.23 ) %	
$\Gamma_{25}$	$D^{*-} \tau \nu_\tau$ anything	( 9 ± 4 ) × 10 <sup>-3</sup>	
$\Gamma_{26}$	$\bar{c} \rightarrow \ell^- \bar{\nu}_\ell$ anything	[a] ( 8.02 ± 0.19 ) %	
$\Gamma_{27}$	$c \rightarrow \ell^+ \nu$ anything	( 1.6 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ $\begin{smallmatrix} 0.4 \\ 0.5 \end{smallmatrix}$ ) %	

### Charmed meson and baryon modes

$\Gamma_{28}$	$\bar{D}^0$ anything	( 59.8 ± 2.9 ) %	
$\Gamma_{29}$	$D^0 D_s^\pm$ anything	[c] ( 9.1 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ $\begin{smallmatrix} 4.0 \\ 2.8 \end{smallmatrix}$ ) %	
$\Gamma_{30}$	$D^\mp D_s^\pm$ anything	[c] ( 4.0 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ $\begin{smallmatrix} 2.3 \\ 1.8 \end{smallmatrix}$ ) %	
$\Gamma_{31}$	$\bar{D}^0 D^0$ anything	[c] ( 5.1 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ $\begin{smallmatrix} 2.0 \\ 1.8 \end{smallmatrix}$ ) %	
$\Gamma_{32}$	$D^0 D^\pm$ anything	[c] ( 2.7 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ $\begin{smallmatrix} 1.8 \\ 1.6 \end{smallmatrix}$ ) %	
$\Gamma_{33}$	$D^\pm D^\mp$ anything	[c] < 9 × 10 <sup>-3</sup>	CL=90%
$\Gamma_{34}$	$D^0$ anything		
$\Gamma_{35}$	$D^+$ anything		
$\Gamma_{36}$	$D^-$ anything	( 23.3 ± 1.7 ) %	
$\Gamma_{37}$	$D^*(2010)^+$ anything	( 17.3 ± 2.0 ) %	
$\Gamma_{38}$	$D_1(2420)^0$ anything	( 5.0 ± 1.5 ) %	
$\Gamma_{39}$	$D^*(2010)^\mp D_s^\pm$ anything	[c] ( 3.3 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ $\begin{smallmatrix} 1.6 \\ 1.3 \end{smallmatrix}$ ) %	
$\Gamma_{40}$	$D^0 D^*(2010)^\pm$ anything	[c] ( 3.0 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ $\begin{smallmatrix} 1.1 \\ 0.9 \end{smallmatrix}$ ) %	
$\Gamma_{41}$	$D^*(2010)^\pm D^\mp$ anything	[c] ( 2.5 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ $\begin{smallmatrix} 1.2 \\ 1.0 \end{smallmatrix}$ ) %	
$\Gamma_{42}$	$D^*(2010)^\pm D^*(2010)^\mp$ anything	[c] ( 1.2 ± 0.4 ) %	

$\Gamma_{43}$	$\bar{D}D$ anything	( 10 $\begin{smallmatrix} +11 \\ -10 \end{smallmatrix}$ ) %
$\Gamma_{44}$	$D_2^*(2460)^0$ anything	( 4.7 $\pm$ 2.7 ) %
$\Gamma_{45}$	$D_s^-$ anything	( 14.7 $\pm$ 2.1 ) %
$\Gamma_{46}$	$D_s^+$ anything	( 10.1 $\pm$ 3.1 ) %
$\Gamma_{47}$	$\Lambda_c^+$ anything	( 9.7 $\pm$ 2.9 ) %
$\Gamma_{48}$	$\bar{c}/c$ anything	[d] (116.2 $\pm$ 3.2 ) %

### Charmonium modes

$\Gamma_{49}$	$J/\psi(1S)$ anything	( 1.16 $\pm$ 0.10 ) %
$\Gamma_{50}$	$\psi(2S)$ anything	( 2.83 $\pm$ 0.29 ) $\times 10^{-3}$
$\Gamma_{51}$	$\chi_{c1}(1P)$ anything	( 1.4 $\pm$ 0.4 ) %

### K or K\* modes

$\Gamma_{52}$	$\bar{s}\gamma$	( 3.1 $\pm$ 1.1 ) $\times 10^{-4}$
$\Gamma_{53}$	$\bar{s}\bar{\nu}\nu$	<i>B1</i> < 6.4 $\times 10^{-4}$ CL=90%
$\Gamma_{54}$	$K^\pm$ anything	( 74 $\pm$ 6 ) %
$\Gamma_{55}$	$K_S^0$ anything	( 29.0 $\pm$ 2.9 ) %

### Pion modes

$\Gamma_{56}$	$\pi^\pm$ anything	(397 $\pm$ 21 ) %
$\Gamma_{57}$	$\pi^0$ anything	[d] (278 $\pm$ 60 ) %
$\Gamma_{58}$	$\phi$ anything	( 2.82 $\pm$ 0.23 ) %

### Baryon modes

$\Gamma_{59}$	$p/\bar{p}$ anything	( 13.1 $\pm$ 1.1 ) %
$\Gamma_{60}$	$\Lambda/\bar{\Lambda}$ anything	( 5.9 $\pm$ 0.6 ) %
$\Gamma_{61}$	$b$ -baryon anything	( 10.2 $\pm$ 2.8 ) %

### Other modes

$\Gamma_{62}$	charged anything	[d] (497 $\pm$ 7 ) %
$\Gamma_{63}$	hadron <sup>+</sup> hadron <sup>-</sup>	( 1.7 $\begin{smallmatrix} + \\ - \end{smallmatrix}$ $\begin{smallmatrix} 1.0 \\ 0.7 \end{smallmatrix}$ ) $\times 10^{-5}$
$\Gamma_{64}$	charmless	( 7 $\pm$ 21 ) $\times 10^{-3}$

### $\Delta B = 1$ weak neutral current (*B1*) modes

$\Gamma_{65}$	$e^+e^-$ anything	<i>B1</i>
$\Gamma_{66}$	$\mu^+\mu^-$ anything	<i>B1</i> < 3.2 $\times 10^{-4}$ CL=90%
$\Gamma_{67}$	$\nu\bar{\nu}$ anything	<i>B1</i>

[a] An  $\ell$  indicates an  $e$  or a  $\mu$  mode, not a sum over these modes.

[b]  $D_j$  represents an unresolved mixture of pseudoscalar and tensor  $D^{**}$  ( $P$ -wave) states.

[c] The value is for the sum of the charge states or particle/antiparticle states indicated.

[d] Inclusive branching fractions have a multiplicity definition and can be greater than 100%.

## $B^\pm/B^0/B_s^0/b$ -baryon ADMIXTURE BRANCHING RATIOS

$\Gamma(B^+)/\Gamma_{\text{total}}$   $\Gamma_1/\Gamma$

“OUR EVALUATION” is an average using rescaled values of the data listed below and from the best values of mean lives, mixing parameters, and branching fractions in this edition by the Heavy Flavor Averaging Group (HFAG) as described at <http://www.slac.stanford.edu/xorg/hfag/>.

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.402 ± 0.007 OUR EVALUATION</b>			
<b>0.4099 ± 0.0082 ± 0.0111</b>	<sup>1</sup> ABDALLAH	03K DLPH	$e^+ e^- \rightarrow Z$

<sup>1</sup> The analysis is based on a neural network, to estimate the charge of the weakly-decaying  $b$  hadron by distinguishing its decay products from particles produced at the primary vertex.

$\Gamma(B^+)/\Gamma(B^0)$   $\Gamma_1/\Gamma_2$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1.054 ± 0.018 <sup>+0.062</sup><sub>-0.074</sub></b>	AALTONEN	08N CDF	$\rho\bar{p}$ at 1.96 TeV

$\Gamma(B_s^0)/[\Gamma(B^+) + \Gamma(B^0)]$   $\Gamma_3/(\Gamma_1 + \Gamma_2)$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.131 ± 0.008 OUR EVALUATION</b>			
<b>0.134 ± 0.008 OUR AVERAGE</b>			
0.134 ± 0.004 <sup>+0.011</sup> <sub>-0.010</sub>	<sup>1</sup> AAIJ	12J LHCB	$pp$ at 7 TeV
0.1265 ± 0.0085 ± 0.0131	<sup>2</sup> AAIJ	11F LHCB	$pp$ at 7 TeV
0.128 <sup>+0.011</sup> <sub>-0.010</sub> ± 0.011	<sup>3</sup> AALTONEN	08N CDF	$\rho\bar{p}$ at 1.96 TeV
0.213 ± 0.068	<sup>4</sup> AFFOLDER	00E CDF	$\rho\bar{p}$ at 1.8 TeV
0.21 ± 0.036 <sup>+0.038</sup> <sub>-0.030</sub>	<sup>5</sup> ABE	99P CDF	$\bar{p}p$ at 1.8 TeV

<sup>1</sup> Measured using  $b$ -hadron semileptonic decays and assuming isospin symmetry.

<sup>2</sup> AAIJ 11F measured  $f_s/f_d = 0.253 \pm 0.017 \pm 0.017 \pm 0.020$ , where the errors are statistical, systematic, and theoretical. We divide their value by 2. Our second error combines systematic and theoretical uncertainties.

<sup>3</sup> AALTONEN 08N reports  $[\Gamma(\bar{b} \rightarrow B_s^0)/[\Gamma(\bar{b} \rightarrow B^+) + \Gamma(\bar{b} \rightarrow B^0)]] \times [B(D_s^+ \rightarrow \phi\pi^+)] = (5.76 \pm 0.18 <sup>+0.45</sup><sub>-0.42</sub>) \times 10^{-3}$  which we divide by our best value  $B(D_s^+ \rightarrow \phi\pi^+) = (4.5 \pm 0.4) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>4</sup> AFFOLDER 00E uses several electron-charm final states in  $b \rightarrow c e^- X$ .

<sup>5</sup> ABE 99P uses the numbers of  $K^*(892)^0$ ,  $K^*(892)^+$ , and  $\phi(1020)$  events produced in association with the double semileptonic decays  $b \rightarrow c \mu^- X$  with  $c \rightarrow s \mu^+ X$ .

$\Gamma(B_s^0)/\Gamma(B^0)$   $\Gamma_3/\Gamma_2$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.261 ± 0.015 OUR EVALUATION</b>			
<b>0.238 ± 0.004 ± 0.015 ± 0.021</b>	<sup>1</sup> AAIJ	13P LHCB	$pp$ at 7 TeV

<sup>1</sup> AAIJ 13P studies also separately the  $p_T(B)$  and  $\eta(B)$  dependency of  $\Gamma(\bar{b} \rightarrow B_s^0)/\Gamma(\bar{b} \rightarrow B^0)$ , finding  $f_s/f_d(p_T) = (0.256 \pm 0.020) + (-2.0 \pm 0.6) 10^{-3} / \text{GeV}/c (p_T - \langle p_T \rangle)$  and  $f_s/f_d(\eta) = (0.256 \pm 0.020) + (0.005 \pm 0.006) (\eta - \langle \eta \rangle)$ , where  $\langle p_T \rangle = 10.4 \text{ GeV}/c$  and  $\langle \eta \rangle = 3.28$ .

$\Gamma(b\text{-baryon})/[\Gamma(B^+) + \Gamma(B^0)]$   $\Gamma_4/(\Gamma_1+\Gamma_2)$

VALUE DOCUMENT ID TECN COMMENT

**0.114±0.021 OUR EVALUATION**

**0.30 ±0.06 OUR AVERAGE**

0.305±0.010±0.081	<sup>1</sup> AAIJ	12J	LHCB	$p\bar{p}$ at 7 TeV
0.31 ±0.11 $\begin{smallmatrix} +0.12 \\ -0.08 \end{smallmatrix}$	<sup>2</sup> AALTONEN	09E	CDF	$p\bar{p}$ at 1.8 TeV
0.28 $\begin{smallmatrix} +0.11 \\ -0.09 \end{smallmatrix}$ ±0.07	<sup>3</sup> AALTONEN	08N	CDF	$p\bar{p}$ at 1.96 TeV

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

0.118±0.042	<sup>4</sup> AFFOLDER	00E	CDF	$p\bar{p}$ at 1.8 TeV
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<sup>1</sup> Measured the ratio to be  $(0.404 \pm 0.017 \pm 0.027 \pm 0.105) \times [1 - (0.031 \pm 0.004 \pm 0.003) \times P_T]$  using  $b$ -hadron semileptonic decays where the  $P_T$  is the momentum of charmed hadron-muon pair in GeV/c. We quote their weighted average value where the second error combines systematic and the error on  $B(\Lambda_c^+ \rightarrow pK^- \pi^+)$ .

<sup>2</sup> Errata to the measurement reported in AFFOLDER 00E using the  $p_T$  spectra from fully reconstructed  $B^0$  and  $\Lambda_b$  decays.

<sup>3</sup> AALTONEN 08N reports  $[\Gamma(\bar{b} \rightarrow b\text{-baryon})/[\Gamma(\bar{b} \rightarrow B^+) + \Gamma(\bar{b} \rightarrow B^0)]] \times [B(\Lambda_c^+ \rightarrow pK^- \pi^+)] = (14.1 \pm 0.6_{-4.4}^{+5.3}) \times 10^{-3}$  which we divide by our best value  $B(\Lambda_c^+ \rightarrow pK^- \pi^+) = (5.0 \pm 1.3) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>4</sup> AFFOLDER 00E uses several electron-charm final states in  $b \rightarrow ce^- X$ .

$\Gamma(\nu\text{ anything})/\Gamma_{\text{total}}$   $\Gamma_5/\Gamma$

VALUE DOCUMENT ID TECN COMMENT

<b>0.2308±0.0077±0.0124</b>	<sup>1,2</sup> ACCIARRI	96C	L3	$e^+e^- \rightarrow Z$
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<sup>1</sup> ACCIARRI 96C assumes relative  $b$  semileptonic decay rates  $e:\mu:\tau$  of 1:1:0.25. Based on missing-energy spectrum.

<sup>2</sup> Assumes Standard Model value for  $R_B$ .

$\Gamma(\ell^+ \nu_\ell \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_6/\Gamma$

"OUR EVALUATION" is an average of the data listed below, excluding all asymmetry measurements, performed by the LEP Electroweak Working Group as described in the "Note on the Z boson" in the Z Particle Listings.

VALUE DOCUMENT ID TECN COMMENT

**0.1069±0.0022 OUR EVALUATION**

**0.1064±0.0016 OUR AVERAGE**

0.1070±0.0010±0.0035	<sup>1</sup> HEISTER	02G	ALEP	$e^+e^- \rightarrow Z$
0.1070±0.0008 $\begin{smallmatrix} +0.0037 \\ -0.0049 \end{smallmatrix}$	<sup>2</sup> ABREU	01L	DLPH	$e^+e^- \rightarrow Z$
0.1083±0.0010 $\begin{smallmatrix} +0.0028 \\ -0.0024 \end{smallmatrix}$	<sup>3</sup> ABBIENDI	00E	OPAL	$e^+e^- \rightarrow Z$
0.1016±0.0013±0.0030	<sup>4</sup> ACCIARRI	00	L3	$e^+e^- \rightarrow Z$
0.1085±0.0012±0.0047	<sup>5,6</sup> ACCIARRI	96C	L3	$e^+e^- \rightarrow Z$

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

0.1106±0.0039±0.0022	<sup>7</sup> ABREU	95D	DLPH	$e^+e^- \rightarrow Z$
0.114 ±0.003 ±0.004	<sup>8</sup> BUSKULIC	94G	ALEP	$e^+e^- \rightarrow Z$
0.100 ±0.007 ±0.007	<sup>9</sup> ABREU	93C	DLPH	$e^+e^- \rightarrow Z$
0.105 ±0.006 ±0.005	<sup>10</sup> AKERS	93B	OPAL	Repl. by ABBI- ENDI 00E



- <sup>1</sup> Uses the combination of lepton transverse momentum spectrum and the correlation between the charge of the lepton and opposite jet charge. The first error is statistic and the second error is the total systematic error including the modeling.
- <sup>2</sup> The experimental systematic and model uncertainties are combined in quadrature.
- <sup>3</sup> ABBIENDI 00E result is determined by comparing the distribution of several kinematic variables of leptonic events in a lifetime tagged  $Z \rightarrow b\bar{b}$  sample using artificial neural network techniques. The first error is statistic; the second error is the total systematic error.
- <sup>4</sup> ACCIARRI 00 result obtained from a combined fit of  $R_b = \Gamma(Z \rightarrow b\bar{b})/\Gamma(Z \rightarrow \text{hadrons})$  and  $B(b \rightarrow \ell\nu X)$ , using double-tagging method.
- <sup>5</sup> ACCIARRI 96C result obtained by a fit to the single lepton spectrum.
- <sup>6</sup> Assumes Standard Model value for  $R_B$ .
- <sup>7</sup> ABREU 95D give systematic errors  $\pm 0.0019$  (model) and  $0.0012$  ( $R_C$ ). We combine these in quadrature.
- <sup>8</sup> BUSKULIC 94G uses  $e$  and  $\mu$  events. This value is from a global fit to the lepton  $p$  and  $p_T$  (relative to jet) spectra which also determines the  $b$  and  $c$  production fractions, the fragmentation functions, and the forward-backward asymmetries. This branching ratio depends primarily on the ratio of dileptons to single leptons at high  $p_T$ , but the lower  $p_T$  portion of the lepton spectrum is included in the global fit to reduce the model dependence. The model dependence is  $\pm 0.0026$  and is included in the systematic error.
- <sup>9</sup> ABREU 93C event count includes  $ee$  events. Combining  $ee$ ,  $\mu\mu$ , and  $e\mu$  events, they obtain  $0.100 \pm 0.007 \pm 0.007$ .
- <sup>10</sup> AKERS 93B analysis performed using single and dilepton events.

$\Gamma(e^+ \nu_e \text{ anything})/\Gamma_{\text{total}}$					$\Gamma_7/\Gamma$
VALUE	EVTS	DOCUMENT ID	TECN	COMMENT	
<b>0.1086 ± 0.0035 OUR AVERAGE</b>					
$0.1078 \pm 0.0008$ $+0.0050$ $-0.0046$		<sup>1</sup> ABBIENDI	00E OPAL	$e^+ e^- \rightarrow Z$	
$0.1089 \pm 0.0020 \pm 0.0051$		<sup>2,3</sup> ACCIARRI	96C L3	$e^+ e^- \rightarrow Z$	
$0.107 \pm 0.015 \pm 0.007$	260	<sup>4</sup> ABREU	93C DLPH	$e^+ e^- \rightarrow Z$	
$0.138 \pm 0.032 \pm 0.008$		<sup>5</sup> ADEVA	91C L3	$e^+ e^- \rightarrow Z$	
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
$0.086 \pm 0.027 \pm 0.008$		<sup>6</sup> ABE	93E VNS	$E_{\text{cm}}^{ee} = 58 \text{ GeV}$	
$0.109$ $+0.014$ $-0.013$	$\pm 0.0055$	2719	<sup>7</sup> AKERS	93B OPAL	Repl. by ABBI- ENDI 00E
$0.111 \pm 0.028 \pm 0.026$		BEHREND	90D CELL	$E_{\text{cm}}^{ee} = 43 \text{ GeV}$	
$0.150 \pm 0.011 \pm 0.022$		BEHREND	90D CELL	$E_{\text{cm}}^{ee} = 35 \text{ GeV}$	
$0.112 \pm 0.009 \pm 0.011$		ONG	88 MRK2	$E_{\text{cm}}^{ee} = 29 \text{ GeV}$	
$0.149$ $+0.022$ $-0.019$		PAL	86 DLCO	$E_{\text{cm}}^{ee} = 29 \text{ GeV}$	
$0.110 \pm 0.018 \pm 0.010$		AIHARA	85 TPC	$E_{\text{cm}}^{ee} = 29 \text{ GeV}$	
$0.111 \pm 0.034 \pm 0.040$		ALTHOFF	84J TASS	$E_{\text{cm}}^{ee} = 34.6 \text{ GeV}$	
$0.146 \pm 0.028$		KOOP	84 DLCO	Repl. by PAL 86	
$0.116 \pm 0.021 \pm 0.017$		NELSON	83 MRK2	$E_{\text{cm}}^{ee} = 29 \text{ GeV}$	

- <sup>1</sup> ABBIENDI 00E result is determined by comparing the distribution of several kinematic variables of leptonic events in a lifetime tagged  $Z \rightarrow b\bar{b}$  sample using artificial neural network techniques. The first error is statistic; the second error is the total systematic error.
- <sup>2</sup> ACCIARRI 96C result obtained by a fit to the single lepton spectrum.
- <sup>3</sup> Assumes Standard Model value for  $R_B$ .
- <sup>4</sup> ABREU 93C event count includes  $ee$  events. Combining  $ee$ ,  $\mu\mu$ , and  $e\mu$  events, they obtain  $0.100 \pm 0.007 \pm 0.007$ .

<sup>5</sup> ADEVA 91C measure the average  $B(b \rightarrow eX)$  branching ratio using single and double tagged  $b$  enhanced  $Z$  events. Combining  $e$  and  $\mu$  results, they obtain  $0.113 \pm 0.010 \pm 0.006$ . Constraining the initial number of  $b$  quarks by the Standard Model prediction ( $378 \pm 3$  MeV) for the decay of the  $Z$  into  $b\bar{b}$ , the electron result gives  $0.112 \pm 0.004 \pm 0.008$ . They obtain  $0.119 \pm 0.003 \pm 0.006$  when  $e$  and  $\mu$  results are combined. Used to measure the  $b\bar{b}$  width itself, this electron result gives  $370 \pm 12 \pm 24$  MeV and combined with the muon result gives  $385 \pm 7 \pm 22$  MeV.

<sup>6</sup> ABE 93E experiment also measures forward-backward asymmetries and fragmentation functions for  $b$  and  $c$ .

<sup>7</sup> AKERS 93B analysis performed using single and dilepton events.

$\Gamma(\mu^+ \nu_\mu \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_8/\Gamma$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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**0.1095<sup>+0.0029</sup><sub>-0.0025</sub> OUR AVERAGE**

0.1096 ± 0.0008 <sup>+0.0034</sup> <sub>-0.0027</sub>		<sup>1</sup> ABBIENDI	00E OPAL	$e^+ e^- \rightarrow Z$
0.1082 ± 0.0015 ± 0.0059		<sup>2,3</sup> ACCIARRI	96C L3	$e^+ e^- \rightarrow Z$
0.110 ± 0.012 ± 0.007	656	<sup>4</sup> ABREU	93C DLPH	$e^+ e^- \rightarrow Z$
0.113 ± 0.012 ± 0.006		<sup>5</sup> ADEVA	91C L3	$e^+ e^- \rightarrow Z$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
0.122 ± 0.006 ± 0.007		<sup>3</sup> UENO	96 AMY	$e^+ e^-$ at 57.9 GeV
0.101 <sup>+0.010</sup> <sub>-0.009</sub> ± 0.0055	4248	<sup>6</sup> AKERS	93B OPAL	Repl. by ABBI- ENDI 00E
0.104 ± 0.023 ± 0.016		BEHREND	90D CELL	$E_{\text{cm}}^{ee} = 43$ GeV
0.148 ± 0.010 ± 0.016		BEHREND	90D CELL	$E_{\text{cm}}^{ee} = 35$ GeV
0.118 ± 0.012 ± 0.010		ONG	88 MRK2	$E_{\text{cm}}^{ee} = 29$ GeV
0.117 ± 0.016 ± 0.015		BARTEL	87 JADE	$E_{\text{cm}}^{ee} = 34.6$ GeV
0.114 ± 0.018 ± 0.025		BARTEL	85J JADE	Repl. by BARTEL 87
0.117 ± 0.028 ± 0.010		ALTHOFF	84G TASS	$E_{\text{cm}}^{ee} = 34.5$ GeV
0.105 ± 0.015 ± 0.013		ADEVA	83B MRKJ	$E_{\text{cm}}^{ee} = 33\text{--}38.5$ GeV
0.155 <sup>+0.054</sup> <sub>-0.029</sub>		FERNANDEZ	83D MAC	$E_{\text{cm}}^{ee} = 29$ GeV

<sup>1</sup> ABBIENDI 00E result is determined by comparing the distribution of several kinematic variables of leptonic events in a lifetime tagged  $Z \rightarrow b\bar{b}$  sample using artificial neural network techniques. The first error is statistic; the second error is the total systematic error.

<sup>2</sup> ACCIARRI 96C result obtained by a fit to the single lepton spectrum.

<sup>3</sup> Assumes Standard Model value for  $R_B$ .

<sup>4</sup> ABREU 93C event count includes  $\mu\mu$  events. Combining  $ee$ ,  $\mu\mu$ , and  $e\mu$  events, they obtain  $0.100 \pm 0.007 \pm 0.007$ .

<sup>5</sup> ADEVA 91C measure the average  $B(b \rightarrow eX)$  branching ratio using single and double tagged  $b$  enhanced  $Z$  events. Combining  $e$  and  $\mu$  results, they obtain  $0.113 \pm 0.010 \pm 0.006$ . Constraining the initial number of  $b$  quarks by the Standard Model prediction ( $378 \pm 3$  MeV) for the decay of the  $Z$  into  $b\bar{b}$ , the muon result gives  $0.123 \pm 0.003 \pm 0.006$ . They obtain  $0.119 \pm 0.003 \pm 0.006$  when  $e$  and  $\mu$  results are combined. Used to measure the  $b\bar{b}$  width itself, this muon result gives  $394 \pm 9 \pm 22$  MeV and combined with the electron result gives  $385 \pm 7 \pm 22$  MeV.

<sup>6</sup> AKERS 93B analysis performed using single and dilepton events.

$\Gamma(D^- \ell^+ \nu_\ell \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_9/\Gamma$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0227 ± 0.0035 OUR AVERAGE</b>	Error includes scale factor of 1.7.		
0.0272 ± 0.0028 ± 0.0018	<sup>1</sup> ABREU	00R	DLPH $e^+ e^- \rightarrow Z$
0.0199 ± 0.0026 ± 0.0004	<sup>2</sup> AKERS	95Q	OPAL $e^+ e^- \rightarrow Z$

<sup>1</sup> ABREU 00R reports their experiment's uncertainties  $\pm 0.0019 \pm 0.0016 \pm 0.0018$ , where the first error is statistical, the second is systematic, and the third is the uncertainty due to the  $D$  branching fraction. We combine first two in quadrature.

<sup>2</sup> AKERS 95Q reports  $[\Gamma(\bar{b} \rightarrow D^- \ell^+ \nu_\ell \text{ anything})/\Gamma_{\text{total}}] \times [B(D^+ \rightarrow K^- 2\pi^+)] = (1.82 \pm 0.20 \pm 0.12) \times 10^{-3}$  which we divide by our best value  $B(D^+ \rightarrow K^- 2\pi^+) = (9.13 \pm 0.19) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(D^- \pi^+ \ell^+ \nu_\ell \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{10}/\Gamma$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0049 ± 0.0018 ± 0.0007</b>	ABREU	00R	DLPH $e^+ e^- \rightarrow Z$

$\Gamma(D^- \pi^- \ell^+ \nu_\ell \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{11}/\Gamma$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0026 ± 0.0015 ± 0.0004</b>	ABREU	00R	DLPH $e^+ e^- \rightarrow Z$

$\Gamma(\bar{D}^0 \ell^+ \nu_\ell \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{12}/\Gamma$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0684 ± 0.0035 OUR AVERAGE</b>			
0.0704 ± 0.0040 ± 0.0017	<sup>1</sup> ABREU	00R	DLPH $e^+ e^- \rightarrow Z$
0.065 ± 0.006 ± 0.001	<sup>2</sup> AKERS	95Q	OPAL $e^+ e^- \rightarrow Z$

<sup>1</sup> ABREU 00R reports their experiment's uncertainties  $\pm 0.0034 \pm 0.0036 \pm 0.0017$ , where the first error is statistical, the second is systematic, and the third is the uncertainty due to the  $D$  branching fraction. We combine first two in quadrature.

<sup>2</sup> AKERS 95Q reports  $[\Gamma(\bar{b} \rightarrow \bar{D}^0 \ell^+ \nu_\ell \text{ anything})/\Gamma_{\text{total}}] \times [B(D^0 \rightarrow K^- \pi^+)] = (2.52 \pm 0.14 \pm 0.17) \times 10^{-3}$  which we divide by our best value  $B(D^0 \rightarrow K^- \pi^+) = (3.88 \pm 0.05) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(\bar{D}^0 \pi^- \ell^+ \nu_\ell \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{13}/\Gamma$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0107 ± 0.0025 ± 0.0011</b>	ABREU	00R	DLPH $e^+ e^- \rightarrow Z$

$\Gamma(\bar{D}^0 \pi^+ \ell^+ \nu_\ell \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{14}/\Gamma$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0023 ± 0.0015 ± 0.0004</b>	ABREU	00R	DLPH $e^+ e^- \rightarrow Z$

$\Gamma(D^{*-} \ell^+ \nu_\ell \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{15}/\Gamma$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0275 ± 0.0019 OUR AVERAGE</b>			
0.0275 ± 0.0021 ± 0.0009	<sup>1</sup> ABREU	00R	DLPH $e^+ e^- \rightarrow Z$
0.0276 ± 0.0027 ± 0.0011	<sup>2</sup> AKERS	95Q	OPAL $e^+ e^- \rightarrow Z$

<sup>1</sup> ABREU 00R reports their experiment's uncertainties  $\pm 0.0017 \pm 0.0013 \pm 0.0009$ , where the first error is statistical, the second is systematic, and the third is the uncertainty due to the  $D$  branching fraction. We combine first two in quadrature.

<sup>2</sup> AKERS 95Q reports  $[B(\bar{b} \rightarrow D^* \ell^+ \nu_\ell X) \times B(D^{*+} \rightarrow D^0 \pi^+) \times B(D^0 \rightarrow K^- \pi^+)] = ((7.53 \pm 0.47 \pm 0.56) \times 10^{-4})$  and uses  $B(D^{*+} \rightarrow D^0 \pi^+) = 0.681 \pm 0.013$  and  $B(D^0 \rightarrow K^- \pi^+) = 0.0401 \pm 0.0014$  to obtain the above result. The first error is the experiments error and the second error is the systematic error from the  $D^{*+}$  and  $D^0$  branching ratios.

$\Gamma(D^{*-} \pi^- \ell^+ \nu_\ell \text{anything})/\Gamma_{\text{total}}$				$\Gamma_{16}/\Gamma$
VALUE	DOCUMENT ID	TECN	COMMENT	
<b>0.0006 ± 0.0007 ± 0.0002</b>	ABREU	00R	DLPH	$e^+ e^- \rightarrow Z$

$\Gamma(D^{*-} \pi^+ \ell^+ \nu_\ell \text{anything})/\Gamma_{\text{total}}$				$\Gamma_{17}/\Gamma$
VALUE	DOCUMENT ID	TECN	COMMENT	
<b>0.0048 ± 0.0009 ± 0.0005</b>	ABREU	00R	DLPH	$e^+ e^- \rightarrow Z$

$\Gamma(\bar{D}_j^0 \ell^+ \nu_\ell \text{anything} \times B(\bar{D}_j^0 \rightarrow D^{*+} \pi^-))/\Gamma_{\text{total}}$				$\Gamma_{18}/\Gamma$
VALUE (units $10^{-3}$ )	DOCUMENT ID	TECN	COMMENT	
<b>2.64 ± 0.79 ± 0.39</b>	ABBIENDI	03M	OPAL	$e^+ e^- \rightarrow Z$

$D_j$  represents an unresolved mixture of pseudoscalar and tensor  $D^{**}$  ( $P$ -wave) states.

VALUE (units $10^{-3}$ )	DOCUMENT ID	TECN	COMMENT	
<b>6.1 ± 1.3 ± 1.3</b>	AKERS	95Q	OPAL	Repl. by ABBI- ENDI 03M

$\Gamma(D_j^- \ell^+ \nu_\ell \text{anything} \times B(D_j^- \rightarrow D^0 \pi^-))/\Gamma_{\text{total}}$				$\Gamma_{19}/\Gamma$
VALUE (units $10^{-3}$ )	DOCUMENT ID	TECN	COMMENT	
<b>7.0 ± 1.9<sup>+1.2</sup><sub>-1.3</sub></b>	AKERS	95Q	OPAL	$e^+ e^- \rightarrow Z$

$D_j$  represents an unresolved mixture of pseudoscalar and tensor  $D^{**}$  ( $P$ -wave) states.

$\Gamma(\bar{D}_2^*(2460)^0 \ell^+ \nu_\ell \text{anything} \times B(\bar{D}_2^*(2460)^0 \rightarrow D^{*-} \pi^+))/\Gamma_{\text{total}}$				$\Gamma_{20}/\Gamma$
VALUE (units $10^{-3}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;1.4</b>	90	ABBIENDI	03M	OPAL $e^+ e^- \rightarrow Z$

$\Gamma(D_2^*(2460)^- \ell^+ \nu_\ell \text{anything} \times B(D_2^*(2460)^- \rightarrow D^0 \pi^-))/\Gamma_{\text{total}}$				$\Gamma_{21}/\Gamma$
VALUE (units $10^{-3}$ )	DOCUMENT ID	TECN	COMMENT	
<b>4.2 ± 1.3<sup>+0.7</sup><sub>-1.2</sub></b>	AKERS	95Q	OPAL	$e^+ e^- \rightarrow Z$

$\Gamma(\bar{D}_2^*(2460)^0 \ell^+ \nu_\ell \text{anything} \times B(\bar{D}_2^*(2460)^0 \rightarrow D^- \pi^+))/\Gamma_{\text{total}}$				$\Gamma_{22}/\Gamma$
VALUE (units $10^{-3}$ )	DOCUMENT ID	TECN	COMMENT	
<b>1.6 ± 0.7 ± 0.3</b>	AKERS	95Q	OPAL	$e^+ e^- \rightarrow Z$

$\Gamma(\text{charmless } \ell\bar{\nu}_\ell)/\Gamma_{\text{total}}$

$\Gamma_{23}/\Gamma$

“OUR EVALUATION” is an average of the data listed below performed by the LEP Heavy Flavour Steering Group. The averaging procedure takes into account correlations between the measurements.

VALUE	DOCUMENT ID	TECN	COMMENT
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**0.00171 ± 0.00052 OUR EVALUATION**

**0.0017 ± 0.0004 OUR AVERAGE**

$0.00163 \pm 0.00053^{+0.00055}_{-0.00062}$	1 ABBIENDI	01R	OPAL	$e^+e^- \rightarrow Z$
$0.00157 \pm 0.00035 \pm 0.00055$	2 ABREU	00D	DLPH	$e^+e^- \rightarrow Z$
$0.00173 \pm 0.00055 \pm 0.00055$	3 BARATE	99G	ALEP	$e^+e^- \rightarrow Z$
$0.0033 \pm 0.0010 \pm 0.0017$	4 ACCIARRI	98K	L3	$e^+e^- \rightarrow Z$

<sup>1</sup> Obtained from the best fit of the MC simulated events to the data based on the  $b \rightarrow X_u \ell \nu$  neutral network output distributions.

<sup>2</sup> ABREU 00D result obtained from a fit to the numbers of decays in  $b \rightarrow u$  enriched and depleted samples and their lepton spectra, and assuming  $|V_{cb}| = 0.0384 \pm 0.0033$  and  $\tau_b = 1.564 \pm 0.014$  ps.

<sup>3</sup> Uses lifetime tagged  $b\bar{b}$  sample.

<sup>4</sup> ACCIARRI 98K assumes  $R_b = 0.2174 \pm 0.0009$  at  $Z$  decay.

$\Gamma(\tau^+ \nu_\tau \text{ anything})/\Gamma_{\text{total}}$

$\Gamma_{24}/\Gamma$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
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**2.41 ± 0.23 OUR AVERAGE**

$2.78 \pm 0.18 \pm 0.51$		1 ABBIENDI	01Q	OPAL $e^+e^- \rightarrow Z$
$2.43 \pm 0.20 \pm 0.25$		2 BARATE	01E	ALEP $e^+e^- \rightarrow Z$
$2.19 \pm 0.24 \pm 0.39$		3 ABREU	00C	DLPH $e^+e^- \rightarrow Z$
$1.7 \pm 0.5 \pm 1.1$		4,5 ACCIARRI	96C	L3 $e^+e^- \rightarrow Z$
$2.4 \pm 0.7 \pm 0.8$	1032	6 ACCIARRI	94C	L3 $e^+e^- \rightarrow Z$

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

$2.75 \pm 0.30 \pm 0.37$	405	7 BUSKULIC	95	ALEP Repl. by BARATE 01E
$4.08 \pm 0.76 \pm 0.62$		BUSKULIC	93B	ALEP Repl. by BUSKULIC 95

<sup>1</sup> ABBIENDI 01Q uses a missing energy technique.

<sup>2</sup> The energy-flow and  $b$ -tagging algorithms were used.

<sup>3</sup> Uses the missing energy in  $Z \rightarrow b\bar{b}$  decays without identifying leptons.

<sup>4</sup> ACCIARRI 96C result obtained from missing energy spectrum.

<sup>5</sup> Assumes Standard Model value for  $R_B$ .

<sup>6</sup> This is a direct result using tagged  $b\bar{b}$  events at the  $Z$ , but species are not separated.

<sup>7</sup> BUSKULIC 95 uses missing-energy technique.

$\Gamma(D^{*-} \tau \nu_\tau \text{ anything})/\Gamma_{\text{total}}$

$\Gamma_{25}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
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<b><math>(0.88 \pm 0.31 \pm 0.28) \times 10^{-2}</math></b>	1 BARATE	01E	ALEP $e^+e^- \rightarrow Z$
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<sup>1</sup> The energy-flow and  $b$ -tagging algorithms were used.

$\Gamma(\bar{b} \rightarrow \bar{c} \rightarrow \ell^- \bar{\nu}_\ell \text{anything})/\Gamma_{\text{total}}$   $\Gamma_{26}/\Gamma$

“OUR EVALUATION” is an average of the data listed below, excluding all asymmetry measurements, performed by the LEP Electroweak Working Group as described in the “Note on the Z boson” in the Z Particle Listings.

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0802 ± 0.0019 OUR EVALUATION</b>			
<b>0.0817 ± 0.0020 OUR AVERAGE</b>			
$0.0818 \pm 0.0015^{+0.0024}_{-0.0026}$	<sup>1</sup> HEISTER	02G ALEP	$e^+ e^- \rightarrow Z$
$0.0798 \pm 0.0022^{+0.0025}_{-0.0029}$	<sup>2</sup> ABREU	01L DLPH	$e^+ e^- \rightarrow Z$
$0.0840 \pm 0.0016^{+0.0039}_{-0.0036}$	<sup>3</sup> ABBIENDI	00E OPAL	$e^+ e^- \rightarrow Z$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$0.0770 \pm 0.0097 \pm 0.0046$	<sup>4</sup> ABREU	95D DLPH	$e^+ e^- \rightarrow Z$
$0.082 \pm 0.003 \pm 0.012$	<sup>5</sup> BUSKULIC	94G ALEP	$e^+ e^- \rightarrow Z$
$0.077 \pm 0.004 \pm 0.007$	<sup>6</sup> AKERS	93B OPAL	Repl. by ABBI- ENDI 00E

<sup>1</sup> Uses the combination of lepton transverse momentum spectrum and the correlation between the charge of the lepton and opposite jet charge. The first error is statistic and the second error is the total systematic error including the modeling.

<sup>2</sup> The experimental systematic and model uncertainties are combined in quadrature.

<sup>3</sup> ABBIENDI 00E result is determined by comparing the distribution of several kinematic variables of leptonic events in a lifetime tagged  $Z \rightarrow b\bar{b}$  sample using artificial neural network techniques. The first error is statistic; the second error is the total systematic error.

<sup>4</sup> ABREU 95D give systematic errors  $\pm 0.0033$  (model) and  $0.0032$  ( $R_c$ ). We combine these in quadrature. This result is from the same global fit as their  $\Gamma(\bar{b} \rightarrow \ell^+ \nu_\ell X)$  data.

<sup>5</sup> BUSKULIC 94G uses  $e$  and  $\mu$  events. This value is from the same global fit as their  $\Gamma(\bar{b} \rightarrow \ell^+ \nu_\ell \text{anything})/\Gamma_{\text{total}}$  data.

<sup>6</sup> AKERS 93B analysis performed using single and dilepton events.

$\Gamma(c \rightarrow \ell^+ \nu \text{anything})/\Gamma_{\text{total}}$   $\Gamma_{27}/\Gamma$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$0.0161 \pm 0.0020^{+0.0034}_{-0.0047}$	<sup>1</sup> ABREU	01L DLPH	$e^+ e^- \rightarrow Z$

<sup>1</sup> The experimental systematic and model uncertainties are combined in quadrature.

$\Gamma(\bar{D}^0 \text{anything})/\Gamma_{\text{total}}$   $\Gamma_{28}/\Gamma$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$0.598 \pm 0.028 \pm 0.007$	<sup>1</sup> BUSKULIC	96Y ALEP	$e^+ e^- \rightarrow Z$

<sup>1</sup> BUSKULIC 96Y reports  $0.605 \pm 0.024 \pm 0.016$  from a measurement of  $[\Gamma(\bar{b} \rightarrow \bar{D}^0 \text{anything})/\Gamma_{\text{total}}] \times [B(D^0 \rightarrow K^- \pi^+)]$  assuming  $B(D^0 \rightarrow K^- \pi^+) = 0.0383$ , which we rescale to our best value  $B(D^0 \rightarrow K^- \pi^+) = (3.88 \pm 0.05) \times 10^{-2}$ . Our first error is their experiment’s error and our second error is the systematic error from using our best value.

$\Gamma(D^0 D_s^\pm \text{anything})/\Gamma_{\text{total}}$   $\Gamma_{29}/\Gamma$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$0.091^{+0.020+0.034}_{-0.018-0.022}$	<sup>1</sup> BARATE	98Q ALEP	$e^+ e^- \rightarrow Z$

<sup>1</sup> The systematic error includes the uncertainties due to the charm branching ratios.

$\Gamma(D^\mp D_s^\pm \text{ anything})/\Gamma_{\text{total}}$				$\Gamma_{30}/\Gamma$
VALUE	DOCUMENT ID	TECN	COMMENT	
$0.040^{+0.017+0.016}_{-0.014-0.011}$	<sup>1</sup> BARATE	98Q	ALEP	$e^+ e^- \rightarrow Z$

<sup>1</sup> The systematic error includes the uncertainties due to the charm branching ratios.

$[\Gamma(D^0 D_s^\pm \text{ anything}) + \Gamma(D^\mp D_s^\pm \text{ anything})]/\Gamma_{\text{total}}$				$(\Gamma_{29} + \Gamma_{30})/\Gamma$
VALUE	DOCUMENT ID	TECN	COMMENT	
$0.131^{+0.026+0.048}_{-0.022-0.031}$	<sup>1</sup> BARATE	98Q	ALEP	$e^+ e^- \rightarrow Z$

<sup>1</sup> The systematic error includes the uncertainties due to the charm branching ratios.

$\Gamma(\bar{D}^0 D^0 \text{ anything})/\Gamma_{\text{total}}$				$\Gamma_{31}/\Gamma$
VALUE	DOCUMENT ID	TECN	COMMENT	
$0.051^{+0.016+0.012}_{-0.014-0.011}$	<sup>1</sup> BARATE	98Q	ALEP	$e^+ e^- \rightarrow Z$

<sup>1</sup> The systematic error includes the uncertainties due to the charm branching ratios.

$\Gamma(D^0 D^\pm \text{ anything})/\Gamma_{\text{total}}$				$\Gamma_{32}/\Gamma$
VALUE	DOCUMENT ID	TECN	COMMENT	
$0.027^{+0.015+0.010}_{-0.013-0.009}$	<sup>1</sup> BARATE	98Q	ALEP	$e^+ e^- \rightarrow Z$

<sup>1</sup> The systematic error includes the uncertainties due to the charm branching ratios.

$[\Gamma(\bar{D}^0 D^0 \text{ anything}) + \Gamma(D^0 D^\pm \text{ anything})]/\Gamma_{\text{total}}$				$(\Gamma_{31} + \Gamma_{32})/\Gamma$
VALUE	DOCUMENT ID	TECN	COMMENT	
$0.078^{+0.020+0.018}_{-0.018-0.016}$	<sup>1</sup> BARATE	98Q	ALEP	$e^+ e^- \rightarrow Z$

<sup>1</sup> The systematic error includes the uncertainties due to the charm branching ratios.

$\Gamma(D^\pm D^\mp \text{ anything})/\Gamma_{\text{total}}$	CL%	DOCUMENT ID	TECN	COMMENT	$\Gamma_{33}/\Gamma$
$<0.009$	90	BARATE	98Q	ALEP	$e^+ e^- \rightarrow Z$

$[\Gamma(D^0 \text{ anything}) + \Gamma(D^+ \text{ anything})]/\Gamma_{\text{total}}$				$(\Gamma_{34} + \Gamma_{35})/\Gamma$
VALUE	DOCUMENT ID	TECN	COMMENT	
$0.093 \pm 0.017 \pm 0.014$	<sup>1</sup> ABDALLAH	03E	DLPH	$e^+ e^- \rightarrow Z$

<sup>1</sup> The second error is the total of systematic uncertainties including the branching fractions used in the measurement.

$\Gamma(D^- \text{ anything})/\Gamma_{\text{total}}$				$\Gamma_{36}/\Gamma$
VALUE	DOCUMENT ID	TECN	COMMENT	
$0.233 \pm 0.016 \pm 0.005$	<sup>1</sup> BUSKULIC	96Y	ALEP	$e^+ e^- \rightarrow Z$

<sup>1</sup> BUSKULIC 96Y reports  $0.234 \pm 0.013 \pm 0.010$  from a measurement of  $[\Gamma(\bar{b} \rightarrow D^- \text{ anything})/\Gamma_{\text{total}}] \times [B(D^+ \rightarrow K^- 2\pi^+)]$  assuming  $B(D^+ \rightarrow K^- 2\pi^+) = 0.091$ , which we rescale to our best value  $B(D^+ \rightarrow K^- 2\pi^+) = (9.13 \pm 0.19) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(D^*(2010)^+ \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{37}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
$0.173 \pm 0.016 \pm 0.012$	<sup>1</sup> ACKERSTAFF 98E	OPAL	$e^+ e^- \rightarrow Z$

<sup>1</sup> Uses lepton tags to select  $Z \rightarrow b\bar{b}$  events.

$\Gamma(D_1(2420)^0 \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{38}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
$0.050 \pm 0.014 \pm 0.006$	<sup>1</sup> ACKERSTAFF 97W	OPAL	$e^+ e^- \rightarrow Z$

<sup>1</sup> ACKERSTAFF 97W assumes  $B(D_2^*(2460)^0 \rightarrow D^{*+} \pi^-) = 0.21 \pm 0.04$  and  $\Gamma_{b\bar{b}}/\Gamma_{\text{hadrons}} = 0.216$  at  $Z$  decay.

$\Gamma(D^*(2010)^{\mp} D_s^{\pm} \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{39}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
$0.033^{+0.010+0.012}_{-0.009-0.009}$	<sup>1</sup> BARATE	98Q ALEP	$e^+ e^- \rightarrow Z$

<sup>1</sup> The systematic error includes the uncertainties due to the charm branching ratios.

$\Gamma(D^0 D^*(2010)^{\pm} \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{40}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
$0.030^{+0.009+0.007}_{-0.008-0.005}$	<sup>1</sup> BARATE	98Q ALEP	$e^+ e^- \rightarrow Z$

<sup>1</sup> The systematic error includes the uncertainties due to the charm branching ratios.

$\Gamma(D^*(2010)^{\pm} D^{\mp} \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{41}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
$0.025^{+0.010+0.006}_{-0.009-0.005}$	<sup>1</sup> BARATE	98Q ALEP	$e^+ e^- \rightarrow Z$

<sup>1</sup> The systematic error includes the uncertainties due to the charm branching ratios.

$\Gamma(D^*(2010)^{\pm} D^*(2010)^{\mp} \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{42}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
$0.012^{+0.004}_{-0.003} \pm 0.002$	<sup>1</sup> BARATE	98Q ALEP	$e^+ e^- \rightarrow Z$

<sup>1</sup> The systematic error includes the uncertainties due to the charm branching ratios.

$\Gamma(\bar{D} D \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{43}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
$0.10 \pm 0.032^{+0.107}_{-0.095}$	<sup>1</sup> ABBIENDI	04i OPAL	$e^+ e^- \rightarrow Z$

<sup>1</sup> Measurement performed using an inclusive identification of  $B$  mesons and the  $D$  candidates.

$\Gamma(D_2^*(2460)^0 \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{44}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
$0.047 \pm 0.024 \pm 0.013$	<sup>1</sup> ACKERSTAFF 97W	OPAL	$e^+ e^- \rightarrow Z$

<sup>1</sup> ACKERSTAFF 97W assumes  $B(D_2^*(2460)^0 \rightarrow D^{*+} \pi^-) = 0.21 \pm 0.04$  and  $\Gamma_{b\bar{b}}/\Gamma_{\text{hadrons}} = 0.216$  at  $Z$  decay.



$\Gamma(D_s^- \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{45}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
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<b>0.147 ± 0.017 ± 0.013</b>	<sup>1</sup> BUSKULIC	96Y ALEP	$e^+e^- \rightarrow Z$
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<sup>1</sup> BUSKULIC 96Y reports  $0.183 \pm 0.019 \pm 0.009$  from a measurement of  $[\Gamma(\bar{b} \rightarrow D_s^- \text{ anything})/\Gamma_{\text{total}}] \times [B(D_s^+ \rightarrow \phi\pi^+)]$  assuming  $B(D_s^+ \rightarrow \phi\pi^+) = 0.036$ , which we rescale to our best value  $B(D_s^+ \rightarrow \phi\pi^+) = (4.5 \pm 0.4) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(D_s^+ \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{46}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
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<b>0.101 ± 0.010 ± 0.029</b>	<sup>1</sup> ABDALLAH	03E DLPH	$e^+e^- \rightarrow Z$
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<sup>1</sup> The second error is the total of systematic uncertainties including the branching fractions used in the measurement.

$\Gamma(b \rightarrow \Lambda_c^+ \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{47}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
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<b>0.097 ± 0.013 ± 0.025</b>	<sup>1</sup> BUSKULIC	96Y ALEP	$e^+e^- \rightarrow Z$
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<sup>1</sup> BUSKULIC 96Y reports  $0.110 \pm 0.014 \pm 0.006$  from a measurement of  $[\Gamma(b \rightarrow \Lambda_c^+ \text{ anything})/\Gamma_{\text{total}}] \times [B(\Lambda_c^+ \rightarrow pK^-\pi^+)]$  assuming  $B(\Lambda_c^+ \rightarrow pK^-\pi^+) = 0.044$ , which we rescale to our best value  $B(\Lambda_c^+ \rightarrow pK^-\pi^+) = (5.0 \pm 1.3) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(\bar{c}/c \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{48}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
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**1.162 ± 0.032 OUR AVERAGE**

1.12 <sup>+0.11</sup> <sub>-0.10</sub>	<sup>1</sup> ABBIENDI	04I OPAL	$e^+e^- \rightarrow Z$
1.166 ± 0.031 ± 0.080	<sup>2</sup> ABREU	00 DLPH	$e^+e^- \rightarrow Z$
1.147 ± 0.041	<sup>3</sup> ABREU	98D DLPH	$e^+e^- \rightarrow Z$
1.230 ± 0.036 ± 0.065	<sup>4</sup> BUSKULIC	96Y ALEP	$e^+e^- \rightarrow Z$

<sup>1</sup> Measurement performed using an inclusive identification of  $B$  mesons and the  $D$  candidates.

<sup>2</sup> Evaluated via summation of exclusive and inclusive channels.

<sup>3</sup> ABREU 98D results are extracted from a fit to the  $b$ -tagging probability distribution based on the impact parameter.

<sup>4</sup> BUSKULIC 96Y assumes PDG 96 production fractions for  $B^0$ ,  $B^+$ ,  $B_s^-$ ,  $b$  baryons, and PDG 96 branching ratios for charm decays. This is sum of their inclusive  $\bar{D}^0$ ,  $D^-$ ,  $\bar{D}_s$ , and  $\Lambda_c$  branching ratios, corrected to include inclusive  $\Xi_c$  and charmonium.

$\Gamma(J/\psi(1S) \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{49}/\Gamma$

VALUE (units $10^{-2}$ )	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
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**1.16 ± 0.10 OUR AVERAGE**

1.12 ± 0.12 ± 0.10			<sup>1</sup> ABREU	94P DLPH	$e^+e^- \rightarrow Z$
1.16 ± 0.16 ± 0.14	121		<sup>2</sup> ADRIANI	93J L3	$e^+e^- \rightarrow Z$
1.21 ± 0.13 ± 0.08			BUSKULIC	92G ALEP	$e^+e^- \rightarrow Z$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1.3 ± 0.2 ± 0.2			<sup>3</sup> ADRIANI	92 L3	$e^+e^- \rightarrow Z$
< 4.9	90		MATTEUZZI	83 MRK2	$E_{\text{cm}}^{ee} = 29 \text{ GeV}$

<sup>1</sup> ABREU 94P is an inclusive measurement from  $b$  decays at the  $Z$ . Uses  $J/\psi(1S) \rightarrow e^+e^-$  and  $\mu^+\mu^-$  channels. Assumes  $\Gamma(Z \rightarrow b\bar{b})/\Gamma_{\text{hadron}}=0.22$ .

<sup>2</sup> ADRIANI 93J is an inclusive measurement from  $b$  decays at the  $Z$ . Uses  $J/\psi(1S) \rightarrow \mu^+\mu^-$  and  $J/\psi(1S) \rightarrow e^+e^-$  channels.

<sup>3</sup> ADRIANI 92 measurement is an inclusive result for  $B(Z \rightarrow J/\psi(1S)X) = (4.1 \pm 0.7 \pm 0.3) \times 10^{-3}$  which is used to extract the  $b$ -hadron contribution to  $J/\psi(1S)$  production.

**$\Gamma(\psi(2S)\text{anything})/\Gamma_{\text{total}}$**   **$\Gamma_{50}/\Gamma$**   
VALUE DOCUMENT ID TECN COMMENT

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

0.0048 ± 0.0022 ± 0.0010 <sup>1</sup> ABREU 94P DLPH  $e^+e^- \rightarrow Z$

<sup>1</sup> ABREU 94P is an inclusive measurement from  $b$  decays at the  $Z$ . Uses  $\psi(2S) \rightarrow J/\psi(1S)\pi^+\pi^-$ ,  $J/\psi(1S) \rightarrow \mu^+\mu^-$  channels. Assumes  $\Gamma(Z \rightarrow b\bar{b})/\Gamma_{\text{hadron}}=0.22$ .

**$\Gamma(\psi(2S)\text{anything})/\Gamma(J/\psi(1S)\text{anything})$**   **$\Gamma_{50}/\Gamma_{49}$**   
VALUE DOCUMENT ID TECN COMMENT

**0.243 ± 0.014 OUR AVERAGE**

0.239 ± 0.015 ± 0.005 <sup>1,2</sup> AAIJ 12BD LHCb  $pp$  at 7 TeV

0.260 ± 0.015 ± 0.029 <sup>3,4</sup> CHATRCHYAN 12AK CMS  $pp$  at 7 TeV

<sup>1</sup> AAIJ 12BD reports  $0.235 \pm 0.005 \pm 0.015$  from a measurement of  $[\Gamma(\bar{b} \rightarrow \psi(2S)\text{anything})/\Gamma(\bar{b} \rightarrow J/\psi(1S)\text{anything})] \times [B(J/\psi(1S) \rightarrow \mu^+\mu^-)] / [B(\psi(2S) \rightarrow e^+e^-)]$  assuming  $B(J/\psi(1S) \rightarrow \mu^+\mu^-) = (5.93 \pm 0.06) \times 10^{-2}$ ,  $B(\psi(2S) \rightarrow e^+e^-) = (7.72 \pm 0.17) \times 10^{-3}$ , which we rescale to our best values  $B(J/\psi(1S) \rightarrow \mu^+\mu^-) = (5.961 \pm 0.033) \times 10^{-2}$ ,  $B(\psi(2S) \rightarrow e^+e^-) = (7.89 \pm 0.17) \times 10^{-3}$ . Our first error is their experiment's error and our second error is the systematic error from using our best values.

<sup>2</sup> Assumes lepton universality imposing  $B(\psi(2S) \rightarrow \mu^+\mu^-) = B(\psi(2S) \rightarrow e^+e^-)$ .

<sup>3</sup> CHATRCHYAN 12AK really reports  $\Gamma_{50}/\Gamma = (3.08 \pm 0.12 \pm 0.13 \pm 0.42) \times 10^{-3}$  assuming PDG 10 value of  $\Gamma_{49}/\Gamma = (1.16 \pm 0.10) \times 10^{-2}$  which we present as a ratio of  $\Gamma_{50}/\Gamma_{49} = (26.5 \pm 1.0 \pm 1.1 \pm 2.8) \times 10^{-2}$ .

<sup>4</sup> CHATRCHYAN 12AK reports  $(26.5 \pm 1.0 \pm 1.1 \pm 2.8) \times 10^{-2}$  from a measurement of  $[\Gamma(\bar{b} \rightarrow \psi(2S)\text{anything})/\Gamma(\bar{b} \rightarrow J/\psi(1S)\text{anything})] \times [B(\psi(2S) \rightarrow \mu^+\mu^-)] / [B(J/\psi(1S) \rightarrow \mu^+\mu^-)]$  assuming  $B(\psi(2S) \rightarrow \mu^+\mu^-) = (7.7 \pm 0.8) \times 10^{-3}$ ,  $B(J/\psi(1S) \rightarrow \mu^+\mu^-) = (5.93 \pm 0.06) \times 10^{-2}$ , which we rescale to our best values  $B(\psi(2S) \rightarrow \mu^+\mu^-) = (7.9 \pm 0.9) \times 10^{-3}$ ,  $B(J/\psi(1S) \rightarrow \mu^+\mu^-) = (5.961 \pm 0.033) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best values.

**$\Gamma(\chi_{c1}(1P)\text{anything})/\Gamma_{\text{total}}$**   **$\Gamma_{51}/\Gamma$**   
VALUE EVTS DOCUMENT ID TECN COMMENT

**0.014 ± 0.004 OUR AVERAGE**

0.0113  $^{+0.0058}_{-0.0050}$  ± 0.0004 <sup>1</sup> ABREU 94P DLPH  $e^+e^- \rightarrow Z$

0.019 ± 0.007 ± 0.001 19 <sup>2</sup> ADRIANI 93J L3  $e^+e^- \rightarrow Z$

<sup>1</sup> ABREU 94P reports  $0.014 \pm 0.006^{+0.004}_{-0.002}$  from a measurement of  $[\Gamma(\bar{b} \rightarrow \chi_{c1}(1P)\text{anything})/\Gamma_{\text{total}}] \times [B(\chi_{c1}(1P) \rightarrow \gamma J/\psi(1S))]$  assuming  $B(\chi_{c1}(1P) \rightarrow \gamma J/\psi(1S)) = 0.273 \pm 0.016$ , which we rescale to our best value  $B(\chi_{c1}(1P) \rightarrow \gamma J/\psi(1S)) = (33.9 \pm 1.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value. Assumes no  $\chi_{c2}(1P)$  and  $\Gamma(Z \rightarrow b\bar{b})/\Gamma_{\text{hadron}}=0.22$ .

<sup>2</sup> ADRIANI 93J reports  $0.024 \pm 0.009 \pm 0.002$  from a measurement of  $[\Gamma(\bar{b} \rightarrow \chi_{c1}(1P)\text{anything})/\Gamma_{\text{total}}] \times [B(\chi_{c1}(1P) \rightarrow \gamma J/\psi(1S))]$  assuming  $B(\chi_{c1}(1P) \rightarrow \gamma J/\psi(1S)) = 0.273 \pm 0.016$ , which we rescale to our best value  $B(\chi_{c1}(1P) \rightarrow \gamma J/\psi(1S)) = (33.9 \pm 1.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

### $\Gamma(\chi_{c1}(1P)\text{anything})/\Gamma(J/\psi(1S)\text{anything})$

$\Gamma_{51}/\Gamma_{49}$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

$1.92 \pm 0.82$	121	<sup>1</sup> ADRIANI	93J L3	$e^+e^- \rightarrow Z$
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<sup>1</sup> ADRIANI 93J is a ratio of inclusive measurements from  $b$  decays at the  $Z$  using only the  $J/\psi(1S) \rightarrow \mu^+\mu^-$  channel since some systematics cancel.

### $\Gamma(\bar{3}\gamma)/\Gamma_{\text{total}}$

$\Gamma_{52}/\Gamma$

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
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<b><math>3.11 \pm 0.80 \pm 0.72</math></b>		<sup>1</sup> BARATE	98i ALEP	$e^+e^- \rightarrow Z$
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• • • We do not use the following data for averages, fits, limits, etc. • • •

$< 5.4$	90	<sup>2</sup> ADAM	96D DLPH	$e^+e^- \rightarrow Z$
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$< 12$	90	<sup>3</sup> ADRIANI	93L L3	$e^+e^- \rightarrow Z$
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<sup>1</sup> BARATE 98i uses lifetime tagged  $Z \rightarrow b\bar{b}$  sample.

<sup>2</sup> ADAM 96D assumes  $f_{B^0} = f_{B^-} = 0.39$  and  $f_{B_s} = 0.12$ .

<sup>3</sup> ADRIANI 93L result is for  $\bar{b} \rightarrow \bar{3}\gamma$  is performed inclusively.

### $\Gamma(\bar{3}\nu\nu)/\Gamma_{\text{total}}$

$\Gamma_{53}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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<b><math>&lt; 6.4 \times 10^{-4}</math></b>	90	<sup>1</sup> BARATE	01E ALEP	$e^+e^- \rightarrow Z$
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<sup>1</sup> The energy-flow and  $b$ -tagging algorithms were used.

### $\Gamma(K^\pm\text{anything})/\Gamma_{\text{total}}$

$\Gamma_{54}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
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**$0.74 \pm 0.06$  OUR AVERAGE**

$0.72 \pm 0.02 \pm 0.06$	BARATE	98V ALEP	$e^+e^- \rightarrow Z$
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$0.88 \pm 0.05 \pm 0.18$	ABREU	95C DLPH	$e^+e^- \rightarrow Z$
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### $\Gamma(K_S^0\text{anything})/\Gamma_{\text{total}}$

$\Gamma_{55}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
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<b><math>0.290 \pm 0.011 \pm 0.027</math></b>	ABREU	95C DLPH	$e^+e^- \rightarrow Z$
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### $\Gamma(\pi^\pm\text{anything})/\Gamma_{\text{total}}$

$\Gamma_{56}/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
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<b><math>3.97 \pm 0.02 \pm 0.21</math></b>	BARATE	98V ALEP	$e^+e^- \rightarrow Z$
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**$\Gamma(\pi^0 \text{ anything})/\Gamma_{\text{total}}$**   **$\Gamma_{57}/\Gamma$**

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>2.78 \pm 0.15 \pm 0.60</math></b>	<sup>1</sup> ADAM	96	DLPH $e^+ e^- \rightarrow Z$

<sup>1</sup> ADAM 96 measurement obtained from a fit to the rapidity distribution of  $\pi^{0's}$  in  $Z \rightarrow b\bar{b}$  events.

**$\Gamma(\phi \text{ anything})/\Gamma_{\text{total}}$**   **$\Gamma_{58}/\Gamma$**

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>0.0282 \pm 0.0013 \pm 0.0019</math></b>	ABBIENDI	00Z	OPAL $e^+ e^- \rightarrow Z$

**$\Gamma(\rho/\bar{\rho} \text{ anything})/\Gamma_{\text{total}}$**   **$\Gamma_{59}/\Gamma$**

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>0.131 \pm 0.011</math> OUR AVERAGE</b>			
$0.131 \pm 0.004 \pm 0.011$	BARATE	98V	ALEP $e^+ e^- \rightarrow Z$
$0.141 \pm 0.018 \pm 0.056$	ABREU	95C	DLPH $e^+ e^- \rightarrow Z$

**$\Gamma(\Lambda/\bar{\Lambda} \text{ anything})/\Gamma_{\text{total}}$**   **$\Gamma_{60}/\Gamma$**

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>0.059 \pm 0.006</math> OUR AVERAGE</b>			
$0.0587 \pm 0.0046 \pm 0.0048$	ACKERSTAFF	97N	OPAL $e^+ e^- \rightarrow Z$
$0.059 \pm 0.007 \pm 0.009$	ABREU	95C	DLPH $e^+ e^- \rightarrow Z$

**$\Gamma(b\text{-baryon anything})/\Gamma_{\text{total}}$**   **$\Gamma_{61}/\Gamma$**

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>0.102 \pm 0.007 \pm 0.027</math></b>	<sup>1</sup> BARATE	98V	ALEP $e^+ e^- \rightarrow Z$

<sup>1</sup> BARATE 98V assumes  $B(B_s \rightarrow pX) = 8 \pm 4\%$  and  $B(b\text{-baryon} \rightarrow pX) = 58 \pm 6\%$ .

**$\Gamma(\text{charged anything})/\Gamma_{\text{total}}$**   **$\Gamma_{62}/\Gamma$**

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>4.97 \pm 0.03 \pm 0.06</math></b>	<sup>1</sup> ABREU	98H	DLPH $e^+ e^- \rightarrow Z$

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

$5.84 \pm 0.04 \pm 0.38$	ABREU	95C	DLPH Repl. by ABREU 98H
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<sup>1</sup> ABREU 98H measurement excludes the contribution from  $K^0$  and  $\Lambda$  decay.

**$\Gamma(\text{hadron}^+ \text{ hadron}^-)/\Gamma_{\text{total}}$**   **$\Gamma_{63}/\Gamma$**

<u>VALUE (units <math>10^{-5}</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>1.7^{+1.0}_{-0.7} \pm 0.2</math></b>	<sup>1,2</sup> BUSKULIC	96V	ALEP $e^+ e^- \rightarrow Z$

<sup>1</sup> BUSKULIC 96V assumes PDG 96 production fractions for  $B^0$ ,  $B^+$ ,  $B_s$ ,  $b$  baryons.

<sup>2</sup> Average branching fraction of weakly decaying  $B$  hadrons into two long-lived charged hadrons, weighted by their production cross section and lifetimes.

**$\Gamma(\text{charmless})/\Gamma_{\text{total}}$**   **$\Gamma_{64}/\Gamma$**

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>0.007 \pm 0.021</math></b>	<sup>1</sup> ABREU	98D	DLPH $e^+ e^- \rightarrow Z$

<sup>1</sup> ABREU 98D results are extracted from a fit to the  $b$ -tagging probability distribution based on the impact parameter. The expected hidden charm contribution of  $0.026 \pm 0.004$  has been subtracted.

**$\Gamma(\mu^+ \mu^- \text{ anything})/\Gamma_{\text{total}}$**   **$\Gamma_{66}/\Gamma$**

Test for  $\Delta B = 1$  weak neutral current.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b><math>&lt;3.2 \times 10^{-4}</math></b>	90	ABBOTT 98B	D0	$p\bar{p}$ 1.8 TeV
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$<5.0 \times 10^{-5}$	90	<sup>1</sup> ALBAJAR 91C	UA1	$E_{\text{cm}}^{p\bar{p}} = 630$ GeV
$<0.02$	95	ALTHOFF 84G	TASS	$E_{\text{cm}}^{e^+e^-} = 34.5$ GeV
$<0.007$	95	ADEVA 83	MRKJ	$E_{\text{cm}}^{e^+e^-} = 30\text{--}38$ GeV
$<0.007$	95	BARTEL 83B	JADE	$E_{\text{cm}}^{e^+e^-} = 33\text{--}37$ GeV

<sup>1</sup> Both ABBOTT 98B and GLENN 98 claim that the efficiency quoted in ALBAJAR 91C was overestimated by a large factor.

**$[\Gamma(e^+ e^- \text{ anything}) + \Gamma(\mu^+ \mu^- \text{ anything})]/\Gamma_{\text{total}}$**   **$(\Gamma_{65} + \Gamma_{66})/\Gamma$**

Test for  $\Delta B = 1$  weak neutral current.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$<0.008$	90	MATTEUZZI 83	MRK2	$E_{\text{cm}}^{e^+e^-} = 29$ GeV

**$\Gamma(\nu\bar{\nu} \text{ anything})/\Gamma_{\text{total}}$**   **$\Gamma_{67}/\Gamma$**

VALUE	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
$<3.9 \times 10^{-4}$	<sup>1</sup> GROSSMAN 96	RVUE	$e^+ e^- \rightarrow Z$

<sup>1</sup> GROSSMAN 96 limit is derived from the ALEPH BUSKULIC 95 limit  $B(B^+ \rightarrow \tau^+ \nu_\tau) < 1.8 \times 10^{-3}$  at CL=90% using conservative simplifying assumptions.

### $\chi_b$ AT HIGH ENERGY

For a discussion of  $B\text{--}\bar{B}$  mixing, see the note on " $B^0\text{--}\bar{B}^0$  Mixing" in the  $B^0$  Particle Listings.

$\chi_b$  is the average  $B\text{--}\bar{B}$  mixing parameter at high-energy  $\chi_b = f'_d \chi_d + f'_s \chi_s$  where  $f'_d$  and  $f'_s$  are the fractions of  $B^0$  and  $B_s^0$  hadrons in an unbiased sample of semileptonic  $b$ -hadron decays.

"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.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>0.1284 \pm 0.0069</math> OUR EVALUATION</b>				
<b><math>0.129 \pm 0.004</math> OUR AVERAGE</b>				
$0.132 \pm 0.001 \pm 0.024$		<sup>1</sup> ABAZOV 06S	D0	$p\bar{p}$ at 1.96 TeV
$0.152 \pm 0.007 \pm 0.011$		<sup>2</sup> ACOSTA 04A	CDF	$p\bar{p}$ at 1.8 TeV
$0.1312 \pm 0.0049 \pm 0.0042$		<sup>3</sup> ABBIENDI 03P	OPAL	$e^+ e^- \rightarrow Z$
$0.127 \pm 0.013 \pm 0.006$		<sup>4</sup> ABREU 01L	DLPH	$e^+ e^- \rightarrow Z$
$0.1192 \pm 0.0068 \pm 0.0051$		<sup>5</sup> ACCIARRI 99D	L3	$e^+ e^- \rightarrow Z$

0.121 ±0.016 ±0.006		<sup>6</sup> ABREU	94J	DLPH	$e^+e^- \rightarrow Z$
0.114 ±0.014 ±0.008		<sup>7</sup> BUSKULIC	94G	ALEP	$e^+e^- \rightarrow Z$
0.129 ±0.022		<sup>8</sup> BUSKULIC	92B	ALEP	$e^+e^- \rightarrow Z$
0.176 ±0.031 ±0.032	1112	<sup>9</sup> ABE	91G	CDF	$p\bar{p}$ 1.8 TeV
0.148 ±0.029 ±0.017		<sup>10</sup> ALBAJAR	91D	UA1	$p\bar{p}$ 630 GeV
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
0.131 ±0.020 ±0.016		<sup>11</sup> ABE	97I	CDF	Repl. by ACOSTA 04A
0.1107 ±0.0062 ±0.0055		<sup>12</sup> ALEXANDER	96	OPAL	Rep. by ABBI-ENDI 03P
0.136 ±0.037 ±0.040		<sup>13</sup> UENO	96	AMY	$e^+e^-$ at 57.9 GeV
0.144 ±0.014 $\begin{smallmatrix} +0.017 \\ -0.011 \end{smallmatrix}$		<sup>14</sup> ABREU	94F	DLPH	Sup. by ABREU 94J
0.131 ±0.014		<sup>15</sup> ABREU	94J	DLPH	$e^+e^- \rightarrow Z$
0.123 ±0.012 ±0.008		ACCIARRI	94D	L3	Repl. by ACCIARRI 99D
0.157 ±0.020 ±0.032		<sup>16</sup> ALBAJAR	94	UA1	$\sqrt{s} = 630$ GeV
0.121 $\begin{smallmatrix} +0.044 \\ -0.040 \end{smallmatrix}$ ±0.017	1665	<sup>17</sup> ABREU	93C	DLPH	Sup. by ABREU 94J
0.143 $\begin{smallmatrix} +0.022 \\ -0.021 \end{smallmatrix}$ ±0.007		<sup>18</sup> AKERS	93B	OPAL	Sup. by ALEXANDER 96
0.145 $\begin{smallmatrix} +0.041 \\ -0.035 \end{smallmatrix}$ ±0.018		<sup>19</sup> ACTON	92C	OPAL	$e^+e^- \rightarrow Z$
0.121 ±0.017 ±0.006		<sup>20</sup> ADEVA	92C	L3	Sup. by ACCIARRI 94D
0.132 ±0.22 $\begin{smallmatrix} +0.015 \\ -0.012 \end{smallmatrix}$	823	<sup>21</sup> DECAMP	91	ALEP	$e^+e^- \rightarrow Z$
0.178 $\begin{smallmatrix} +0.049 \\ -0.040 \end{smallmatrix}$ ±0.020		<sup>22</sup> ADEVA	90P	L3	$e^+e^- \rightarrow Z$
0.17 $\begin{smallmatrix} +0.15 \\ -0.08 \end{smallmatrix}$		<sup>23,24</sup> WEIR	90	MRK2	$e^+e^-$ 29 GeV
0.21 $\begin{smallmatrix} +0.29 \\ -0.15 \end{smallmatrix}$		<sup>23</sup> BAND	88	MAC	$E_{cm}^{ee} = 29$ GeV
>0.02 at 90% CL		<sup>23</sup> BAND	88	MAC	$E_{cm}^{ee} = 29$ GeV
0.121 ±0.047		<sup>23,25</sup> ALBAJAR	87C	UA1	Repl. by ALBAJAR 91D
<0.12 at 90% CL		<sup>23,26</sup> SCHAAD	85	MRK2	$E_{cm}^{ee} = 29$ GeV

<sup>1</sup> Uses the dimuon charge asymmetry. Averaged over the mix of  $b$ -flavored hadrons.

<sup>2</sup> Measurement performed using events containing a dimuon or an  $e/\mu$  pair.

<sup>3</sup> The average  $B$  mixing parameter is determined simultaneously with  $b$  and  $c$  forward-backward asymmetries in the fit.

<sup>4</sup> The experimental systematic and model uncertainties are combined in quadrature.

<sup>5</sup> ACCIARRI 99D uses maximum-likelihood fits to extract  $\chi_b$  as well as the  $A_{FB}^b$  in  $Z \rightarrow b\bar{b}$  events containing prompt leptons.

<sup>6</sup> This ABREU 94J result is from 5182  $\ell\ell$  and 279  $\Lambda\ell$  events. The systematic error includes 0.004 for model dependence.

<sup>7</sup> BUSKULIC 94G data analyzed using  $ee$ ,  $e\mu$ , and  $\mu\mu$  events.

<sup>8</sup> BUSKULIC 92B uses a jet charge technique combined with electrons and muons.

<sup>9</sup> ABE 91G measurement of  $\chi$  is done with  $e\mu$  and  $ee$  events.

<sup>10</sup> ALBAJAR 91D measurement of  $\chi$  is done with dimuons.

<sup>11</sup> Uses di-muon events.

<sup>12</sup> ALEXANDER 96 uses a maximum likelihood fit to simultaneously extract  $\chi$  as well as the forward-backward asymmetries in  $e^+e^- \rightarrow Z \rightarrow b\bar{b}$  and  $c\bar{c}$ .

<sup>13</sup> UENO 96 extracted  $\chi$  from the energy dependence of the forward-backward asymmetry.

- <sup>14</sup> ABREU 94F uses the average electric charge sum of the jets recoiling against a  $b$ -quark jet tagged by a high  $p_T$  muon. The result is for  $\bar{\chi} = f_d \chi_d + 0.9 f_s \chi_s$ .
- <sup>15</sup> This ABREU 94J result combines  $\ell\ell$ ,  $\Lambda\ell$ , and jet-charge  $\ell$  (ABREU 94F) analyses. It is for  $\bar{\chi} = f_d \chi_d + 0.96 f_s \chi_s$ .
- <sup>16</sup> ALBAJAR 94 uses dimuon events. Not independent of ALBAJAR 91D.
- <sup>17</sup> ABREU 93C data analyzed using  $ee$ ,  $e\mu$ , and  $\mu\mu$  events.
- <sup>18</sup> AKERS 93B analysis performed using dilepton events.
- <sup>19</sup> ACTON 92C uses electrons and muons. Superseded by AKERS 93B.
- <sup>20</sup> ADEVA 92C uses electrons and muons.
- <sup>21</sup> DECAMP 91 done with opposite and like-sign dileptons. Superseded by BUSKULIC 92B.
- <sup>22</sup> ADEVA 90P measurement uses  $ee$ ,  $\mu\mu$ , and  $e\mu$  events from 118k events at the  $Z$ . Superseded by ADEVA 92C.
- <sup>23</sup> These experiments are not in the average because the combination of  $B_s$  and  $B_d$  mesons which they see could differ from those at higher energy.
- <sup>24</sup> The WEIR 90 measurement supersedes the limit obtained in SCHAAD 85. The 90% CL are 0.06 and 0.38.
- <sup>25</sup> ALBAJAR 87C measured  $\chi = (\bar{B}^0 \rightarrow B^0 \rightarrow \mu^+ X)$  divided by the average production weighted semileptonic branching fraction for  $B$  hadrons at 546 and 630 GeV.
- <sup>26</sup> Limit is average probability for hadron containing  $B$  quark to produce a positive lepton.

### CP VIOLATION PARAMETERS in semileptonic $b$ -hadron decays.

#### $\text{Re}(\epsilon_b) / (1 + |\epsilon_b|^2)$

CP impurity in semileptonic  $b$ -hadron decays.

VALUE (units $10^{-3}$ )	DOCUMENT ID	TECN	COMMENT
<b><math>1.24 \pm 0.38 \pm 0.18</math></b>	<sup>1</sup> ABAZOV 14	D0	$\rho\bar{p}$ at 1.96 TeV
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$-1.97 \pm 0.43 \pm 0.23$	<sup>2</sup> ABAZOV 11U	D0	Repl. by ABAZOV 14
$-2.39 \pm 0.63 \pm 0.37$	<sup>3</sup> ABAZOV 10H	D0	Repl. by ABAZOV 11U

<sup>1</sup> ABAZOV 14 reports a measurement of like-sign dimuon charge asymmetry of  $A_{SL}^b = (-4.96 \pm 1.53 \pm 0.72) \times 10^{-3}$  in semileptonic  $b$ -hadron decays.

<sup>2</sup> ABAZOV 11U reports a measurement of like-sign dimuon charge asymmetry of  $A_{SL}^b = (-7.87 \pm 1.72 \pm 0.93) \times 10^{-3}$  in semileptonic  $b$ -hadron decays.

<sup>3</sup> ABAZOV 10H reports a measurement of like-sign dimuon charge asymmetry of  $A_{SL}^b = (-9.57 \pm 2.51 \pm 1.46) \times 10^{-3}$  in semileptonic  $b$ -hadron decays. Using the measured production ratio of  $B_d^0$  and  $B_s^0$ , and the asymmetry of  $B_d^0$   $A_{SL}^d = (-4.7 \pm 4.6) \times 10^{-3}$  measured from  $B$ -factories, they obtain the asymmetry for  $B_s^0$  as  $A_{SL}^s = (-14.6 \pm 7.5) \times 10^{-3}$ .

### B-HADRON PRODUCTION FRACTIONS IN HADRONIC Z DECAY

The production fractions of  $b$ -hadrons in hadronic  $Z$  decays have been calculated using the best values of mean lives, mixing parameters and branching fractions in this edition by the Heavy Flavor Averaging Group (HFAG) (see <http://www.slac.stanford.edu/xorg/hfag/>).

The values reported below assume:

$$f(\bar{b} \rightarrow B^+) = f(\bar{b} \rightarrow B^0)$$

$$f(\bar{b} \rightarrow B^+) + f(\bar{b} \rightarrow B^0) + f(\bar{b} \rightarrow B_s^0) + f(b \rightarrow b\text{-baryon}) = 1$$

The values are:

$$f(\bar{b} \rightarrow B^+) = f(\bar{b} \rightarrow B^0) = 0.404 \pm 0.009$$

$$f(\bar{b} \rightarrow B_s^0) = 0.103 \pm 0.009$$

$$f(b \rightarrow b\text{-baryon}) = 0.089 \pm 0.015$$

and their correlation coefficients are:

$$\text{cor}(B_s^0, b\text{-baryon}) = +0.052$$

$$\text{cor}(B_s^0, B^+ = B^0) = -0.534$$

$$\text{cor}(b\text{-baryon}, B^+ = B^0) = -0.872$$

as obtained using a time-integrated mixing parameter  $\bar{\chi} = 0.1259 \pm 0.0042$  given by a fit to heavy quark quantities with asymmetries removed (see the note "The Z boson").

## B-HADRON PRODUCTION FRACTIONS IN $p\bar{p}$ COLLISIONS AT Tevatron

The production fractions for  $b$ -hadrons in  $p\bar{p}$  collisions at the Tevatron have been calculated from the best values of mean lifetimes, mixing parameters, and branching fractions in this edition by the Heavy Flavor Averaging Group (HFAG) (see <http://www.slac.stanford.edu/xorg/hfag/>).

The values reported below assume:

$$f(\bar{b} \rightarrow B^+) = f(\bar{b} \rightarrow B^0)$$

$$f(\bar{b} \rightarrow B^+) + f(\bar{b} \rightarrow B^0) + f(\bar{b} \rightarrow B_s^0) + f(b \rightarrow b\text{-baryon}) = 1$$

The values are:

$$f(\bar{b} \rightarrow B^+) = f(\bar{b} \rightarrow B^0) = 0.339 \pm 0.031$$

$$f(\bar{b} \rightarrow B_s^0) = 0.111 \pm 0.014$$

$$f(b \rightarrow b\text{-baryon}) = 0.212 \pm 0.069$$

and their correlation coefficients are:

$$\text{cor}(B_s^0, b\text{-baryon}) = -0.581$$

$$\text{cor}(B_s^0, B^+ = B^0) = +0.425$$

$$\text{cor}(b\text{-baryon}, B^+ = B^0) = -0.984$$

as obtained with the Tevatron average of time-integrated mixing parameter  $\bar{\chi} = 0.147 \pm 0.011$ .

## $B^\pm/B^0/B_s^0/b\text{-baryon}$ ADMIXTURE REFERENCES

ABAZOV	14	PR D89 012002	V.M. Abazov <i>et al.</i>	(D0 Collab.)
AAIJ	13P	JHEP 1304 001	R. Aaij <i>et al.</i>	(LHCb Collab.)
AAIJ	12BD	EPJ C72 2100	R. Aaij <i>et al.</i>	(LHCb Collab.)
AAIJ	12J	PR D85 032008	R. Aaij <i>et al.</i>	(LHCb Collab.)
CHATRCHYAN	12AK	JHEP 1202 011	S. Chatrchyan <i>et al.</i>	(CMS Collab.)
AAIJ	11F	PRL 107 211801	R. Aaij <i>et al.</i>	(LHCb Collab.)
ABAZOV	11U	PR D84 052007	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABAZOV	10H	PR D82 032001	V.M. Abazov <i>et al.</i>	(D0 Collab.)
Also		PRL 105 081801	V.M. Abazov <i>et al.</i>	(D0 Collab.)
PDG	10	JP G37 075021	K. Nakamura <i>et al.</i>	(PDG Collab.)
AALTONEN	09E	PR D79 032001	T. Aaltonen <i>et al.</i>	(CDF Collab.)
AALTONEN	08N	PR D77 072003	T. Aaltonen <i>et al.</i>	(CDF Collab.)
ABAZOV	06S	PR D74 092001	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABBIENDI	04I	EPJ C35 149	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABDALLAH	04E	EPJ C33 307	J. Abdallah <i>et al.</i>	(DELPHI Collab.)
ACOSTA	04A	PR D69 012002	D. Acosta <i>et al.</i>	(CDF Collab.)
ABBIENDI	03M	EPJ C30 467	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABBIENDI	03P	PL B577 18	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABDALLAH	03E	PL B561 26	J. Abdallah <i>et al.</i>	(DELPHI Collab.)
ABDALLAH	03K	PL B576 29	J. Abdallah <i>et al.</i>	(DELPHI Collab.)
HEISTER	02G	EPJ C22 613	A. Heister <i>et al.</i>	(ALEPH Collab.)



ABBIENDI	01Q	PL B520 1	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABBIENDI	01R	EPJ C21 399	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABREU	01L	EPJ C20 455	P. Abreu <i>et al.</i>	(DELPHI Collab.)
BARATE	01E	EPJ C19 213	R. Barate <i>et al.</i>	(ALEPH Collab.)
ABBIENDI	00E	EPJ C13 225	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABBIENDI	00Z	PL B492 13	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABREU	00	EPJ C12 225	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	00C	PL B496 43	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	00D	PL B478 14	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	00R	PL B475 407	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ACCIARRI	00	EPJ C13 47	M. Acciarri <i>et al.</i>	(L3 Collab.)
AFFOLDER	00E	PRL 84 1663	T. Affolder <i>et al.</i>	(CDF Collab.)
ABBIENDI	99J	EPJ C12 609	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABE	99P	PR D60 092005	F. Abe <i>et al.</i>	(CDF Collab.)
ACCIARRI	99D	PL B448 152	M. Acciarri <i>et al.</i>	(L3 Collab.)
BARATE	99G	EPJ C6 555	R. Barate <i>et al.</i>	(ALEPH Collab.)
ABBOTT	98B	PL B423 419	B. Abbott <i>et al.</i>	(D0 Collab.)
ABE	98B	PR D57 5382	F. Abe <i>et al.</i>	(CDF Collab.)
ABREU	98D	PL B426 193	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	98H	PL B425 399	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ACCIARRI	98	PL B416 220	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	98K	PL B436 174	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACKERSTAFF	98E	EPJ C1 439	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)
BARATE	98I	PL B429 169	R. Barate <i>et al.</i>	(ALEPH Collab.)
BARATE	98Q	EPJ C4 387	R. Barate <i>et al.</i>	(ALEPH Collab.)
BARATE	98V	EPJ C5 205	R. Barate <i>et al.</i>	(ALEPH Collab.)
GLENN	98	PRL 80 2289	S. Glenn <i>et al.</i>	(CLEO Collab.)
ABE	97I	PR D55 2546	F. Abe <i>et al.</i>	(CDF Collab.)
ACKERSTAFF	97F	ZPHY C73 397	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)
ACKERSTAFF	97N	ZPHY C74 423	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)
ACKERSTAFF	97W	ZPHY C76 425	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)
ABREU	96E	PL B377 195	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ACCIARRI	96C	ZPHY C71 379	M. Acciarri <i>et al.</i>	(L3 Collab.)
ADAM	96	ZPHY C69 561	W. Adam <i>et al.</i>	(DELPHI Collab.)
ADAM	96D	ZPHY C72 207	W. Adam <i>et al.</i>	(DELPHI Collab.)
ALEXANDER	96	ZPHY C70 357	G. Alexander <i>et al.</i>	(OPAL Collab.)
BUSKULIC	96F	PL B369 151	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
BUSKULIC	96V	PL B384 471	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
BUSKULIC	96Y	PL B388 648	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
GROSSMAN	96	NP B465 369	Y. Grossman, Z. Ligeti, E. Nardi	(REHO, CIT)
Also		NP B480 753 (erratum)	Y. Grossman, Z. Ligeti, E. Nardi	
PDG	96	PR D54 1	R. M. Barnett <i>et al.</i>	(PDG Collab.)
UENO	96	PL B381 365	K. Ueno <i>et al.</i>	(AMY Collab.)
ABE,K	95B	PRL 75 3624	K. Abe <i>et al.</i>	(SLD Collab.)
ABREU	95C	PL B347 447	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	95D	ZPHY C66 323	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ADAM	95	ZPHY C68 363	W. Adam <i>et al.</i>	(DELPHI Collab.)
AKERS	95Q	ZPHY C67 57	R. Akers <i>et al.</i>	(OPAL Collab.)
BUSKULIC	95	PL B343 444	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
ABREU	94F	PL B322 459	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	94J	PL B332 488	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	94L	ZPHY C63 3	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	94P	PL B341 109	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ACCIARRI	94C	PL B332 201	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	94D	PL B335 542	M. Acciarri <i>et al.</i>	(L3 Collab.)
ALBAJAR	94	ZPHY C61 41	C. Albajar <i>et al.</i>	(UA1 Collab.)
BUSKULIC	94G	ZPHY C62 179	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
ABE	93E	PL B313 288	K. Abe <i>et al.</i>	(VENUS Collab.)
ABE	93J	PRL 71 3421	F. Abe <i>et al.</i>	(CDF Collab.)
ABREU	93C	PL B301 145	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	93D	ZPHY C57 181	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	93G	PL B312 253	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ACTON	93C	PL B307 247	P.D. Acton <i>et al.</i>	(OPAL Collab.)
ACTON	93L	ZPHY C60 217	P.D. Acton <i>et al.</i>	(OPAL Collab.)
ADRIANI	93J	PL B317 467	O. Adriani <i>et al.</i>	(L3 Collab.)
ADRIANI	93K	PL B317 474	O. Adriani <i>et al.</i>	(L3 Collab.)
ADRIANI	93L	PL B317 637	O. Adriani <i>et al.</i>	(L3 Collab.)
AKERS	93B	ZPHY C60 199	R. Akers <i>et al.</i>	(OPAL Collab.)
BUSKULIC	93B	PL B298 479	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
BUSKULIC	93O	PL B314 459	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
ABREU	92	ZPHY C53 567	P. Abreu <i>et al.</i>	(DELPHI Collab.)

ACTON	92	PL B274 513	D.P. Acton <i>et al.</i>	(OPAL Collab.)
ACTON	92C	PL B276 379	D.P. Acton <i>et al.</i>	(OPAL Collab.)
ADEVA	92C	PL B288 395	B. Adeva <i>et al.</i>	(L3 Collab.)
ADRIANI	92	PL B288 412	O. Adriani <i>et al.</i>	(L3 Collab.)
BUSKULIC	92B	PL B284 177	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
BUSKULIC	92F	PL B295 174	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
BUSKULIC	92G	PL B295 396	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
ABE	91G	PRL 67 3351	F. Abe <i>et al.</i>	(CDF Collab.)
ADEVA	91C	PL B261 177	B. Adeva <i>et al.</i>	(L3 Collab.)
ADEVA	91H	PL B270 111	B. Adeva <i>et al.</i>	(L3 Collab.)
ALBAJAR	91C	PL B262 163	C. Albajar <i>et al.</i>	(UA1 Collab.)
ALBAJAR	91D	PL B262 171	C. Albajar <i>et al.</i>	(UA1 Collab.)
ALEXANDER	91G	PL B266 485	G. Alexander <i>et al.</i>	(OPAL Collab.)
DECAMP	91	PL B258 236	D. Decamp <i>et al.</i>	(ALEPH Collab.)
DECAMP	91C	PL B257 492	D. Decamp <i>et al.</i>	(ALEPH Collab.)
ADEVA	90P	PL B252 703	B. Adeva <i>et al.</i>	(L3 Collab.)
BEHREND	90D	ZPHY C47 333	H.J. Behrend <i>et al.</i>	(CELLO Collab.)
HAGEMANN	90	ZPHY C48 401	J. Hagemann <i>et al.</i>	(JADE Collab.)
LYONS	90	PR D41 982	L. Lyons, A.J. Martin, D.H. Saxon	(OXF, BRIS+)
WEIR	90	PL B240 289	A.J. Weir <i>et al.</i>	(Mark II Collab.)
BRAUNSCHW...	89B	ZPHY C44 1	R. Braunschweig <i>et al.</i>	(TASSO Collab.)
ONG	89	PRL 62 1236	R.A. Ong <i>et al.</i>	(Mark II Collab.)
BAND	88	PL B200 221	H.R. Band <i>et al.</i>	(MAC Collab.)
KLEM	88	PR D37 41	D.E. Klem <i>et al.</i>	(DELCO Collab.)
ONG	88	PRL 60 2587	R.A. Ong <i>et al.</i>	(Mark II Collab.)
ALBAJAR	87C	PL B186 247	C. Albajar <i>et al.</i>	(UA1 Collab.)
ASH	87	PRL 58 640	W.W. Ash <i>et al.</i>	(MAC Collab.)
BARTEL	87	ZPHY C33 339	W. Bartel <i>et al.</i>	(JADE Collab.)
BROM	87	PL B195 301	J.M. Brom <i>et al.</i>	(HRS Collab.)
PAL	86	PR D33 2708	T. Pal <i>et al.</i>	(DELCO Collab.)
AIHARA	85	ZPHY C27 39	H. Aihara <i>et al.</i>	(TPC Collab.)
BARTEL	85J	PL 163B 277	W. Bartel <i>et al.</i>	(JADE Collab.)
SCHAAD	85	PL 160B 188	T. Schaad <i>et al.</i>	(Mark II Collab.)
ALTHOFF	84G	ZPHY C22 219	M. Althoff <i>et al.</i>	(TASSO Collab.)
ALTHOFF	84J	PL 146B 443	M. Althoff <i>et al.</i>	(TASSO Collab.)
KOOP	84	PRL 52 970	D.E. Koop <i>et al.</i>	(DELCO Collab.)
ADEVA	83	PRL 50 799	B. Adeva <i>et al.</i>	(Mark-J Collab.)
ADEVA	83B	PRL 51 443	B. Adeva <i>et al.</i>	(Mark-J Collab.)
BARTEL	83B	PL 132B 241	W. Bartel <i>et al.</i>	(JADE Collab.)
FERNANDEZ	83D	PRL 50 2054	E. Fernandez <i>et al.</i>	(MAC Collab.)
MATTEUZZI	83	PL 129B 141	C. Matteuzzi <i>et al.</i>	(Mark II Collab.)
NELSON	83	PRL 50 1542	M.E. Nelson <i>et al.</i>	(Mark II Collab.)