### B±/B⁰/Bˢ⁻/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 (HFLAV) and are described at https://hflav.web.cern.ch/. This is a weighted average of the lifetimes of the five main $b$-hadron species ($B^+, B^0, B^{0}_s$ $B^{0}_{sL}$, and $Λ_b$) that assumes the production fractions in $Z$ decays (given at the end of this section) and equal production fractions of $B^{0}_{sH}$ and $B^{0}_{sL}$ mesons.

<table>
<thead>
<tr>
<th>VALUE (10⁻¹² s)</th>
<th>EVTS</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.5668 ± 0.0028</td>
<td>OUR EVALUATION</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

- 1.570 ± 0.005 ± 0.008
- 1.533 ± 0.015 ± 0.035 ± 0.031
- 1.549 ± 0.009 ± 0.015
- 1.611 ± 0.010 ± 0.027
- 1.582 ± 0.011 ± 0.027
- 1.575 ± 0.010 ± 0.026
- 1.533 ± 0.013 ± 0.029 8k
- 1.564 ± 0.030 ± 0.036
- 1.542 ± 0.021 ± 0.045
- 1.50 +0.24 -0.21 ± 0.03
- 1.46 ± 0.06 ± 0.06 5344
- 1.23 +0.14 -0.13 ± 0.15 188
- 1.49 +0.11 ± 0.12 253
- 1.51 +0.16 -0.14 ± 0.11 130
- 1.523 ± 0.034 ± 0.03 5372
- 1.535 ± 0.035 ± 0.028 357
- 1.511 ± 0.022 ± 0.078
- 1.28 ± 0.10
- 1.37 ± 0.07 ± 0.06 1354
- 1.49 ± 0.03 ± 0.06
- 1.35 +0.19 -0.17 ± 0.05
- 1.32 ± 0.08 ± 0.09 1386
- 1.32 +0.31 -0.25 ± 0.15 37
Using HAGEMANN 90 uses electrons and muons in an impact parameter analysis.

We have combined an overall scale error of 15% in quadrature with the systematic error of ±0.7 to obtain ±2.1 systematic error.
26 Statistical and systematic errors were combined by BROM 87.

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

<table>
<thead>
<tr>
<th>VALUE ($10^{-12}$ s)</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
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<tbody>
<tr>
<td>$1.72 \pm 0.08 \pm 0.06$</td>
<td>1 ADAM 95</td>
<td>DLPH</td>
<td>$e^+ e^- \to Z$</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>VALUE ($10^{-12}$ s)</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.58 \pm 0.11 \pm 0.09$</td>
<td>1 ADAM 95</td>
<td>DLPH</td>
<td>$e^+ e^- \to Z$</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.09^{+0.11}_{-0.10} \pm 0.08$</td>
<td>1 ADAM 95</td>
<td>DLPH</td>
<td>$e^+ e^- \to Z$</td>
</tr>
</tbody>
</table>

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

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

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

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$-0.001 \pm 0.012 \pm 0.008$</td>
<td>1 ABBIENDI 99j</td>
<td>OPAL</td>
<td>$e^+ e^- \to Z$</td>
</tr>
</tbody>
</table>

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

### $\bar{b}$ PRODUCTION RATIOS 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, $S\psi S$) 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., $B \to D^{\pm}$ 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.

<table>
<thead>
<tr>
<th>Mode</th>
<th>Fraction ($\Gamma_i / \Gamma$)</th>
<th>Scale factor/Confidence level</th>
</tr>
</thead>
</table>

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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 (HFLAV) as described in the note “$B^0$-$\bar{B}^0$ Mixing” in the $B^0$ Particle Listings. We no longer provide world averages of the $b$-hadron production fractions, where results from LEP, Tevatron and LHC are averaged together; indeed the available data (from CDF and LHCb) shows that the fractions depend on the kinematics (in particular the $p_T$) of the produced $b$ hadron. Hence we would like to list the fractions in $Z$ decays instead, which are well-defined physics observables. The production fractions in $p\bar{p}$ collisions at the Tevatron are also listed at the end of the section. Values assume

$$B(B \to B^+) = B(\bar{B} \to B^0)$$

$$B(\bar{B} \to B^+) + B(B \to B^0) + B(\bar{B} \to B^0_s) + B(b \to b\text{-baryon}) = 100\%.$$ 

The correlation coefficients between production fractions are also reported:

$$\text{cor}(B^0_s, b\text{-baryon}) = 0.064$$
$$\text{cor}(B^0_s, B^\pm = B^0) = -0.633$$
$$\text{cor}(b\text{-baryon}, B^\pm = B^0) = -0.813.$$

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

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.

$$\Gamma_1 \ B^+ \ (40.8 \pm 0.7 \ %)$$
$$\Gamma_2 \ B^0 \ (40.8 \pm 0.7 \ %)$$
$$\Gamma_3 \ B^0_s \ (10.0 \pm 0.8 \ %)$$
$$\Gamma_4 \ B^+_c$$
$$\Gamma_5 \ b\text{-baryon} \ (8.4 \pm 1.1 \ %)$$

DECAY MODES

Semileptonic and leptonic modes

$$\Gamma_6 \ \nu \text{anything} \ (23.1 \pm 1.5 \ %)$$
$$\Gamma_7 \ \ell^+ \nu_\ell \text{anything} \ (10.69 \pm 0.22 \ %)$$
$$\Gamma_8 \ e^+ \nu_e \text{anything} \ (10.86 \pm 0.35 \ %)$$
$$\Gamma_9 \ \mu^+ \nu_\mu \text{anything} \ (10.95 \pm 0.29 \ %)$$
$$\Gamma_{10} \ D^- \ell^+ \nu_\ell \text{anything} \ (2.2 \pm 0.4 \ %) \ S=1.9$$
$$\Gamma_{11} \ D^- \pi^+ \ell^+ \nu_\ell \text{anything} \ (4.9 \pm 1.9 \times 10^{-3}$$
$$\Gamma_{12} \ D^- \pi^- \ell^+ \nu_\ell \text{anything} \ (2.6 \pm 1.6 \times 10^{-3}$$
$$\Gamma_{13} \ B^0 \ell^+ \nu_\ell \text{anything} \ (6.79 \pm 0.34 \ %)$$
\( \Gamma_{14} \quad D^0 \pi^- \ell^+ \nu_\ell \) anything (1.07 \( \pm \) 0.27 \%)  
\( \Gamma_{15} \quad \overline{D}^0 \pi^+ \ell^- \nu_\ell \) anything (2.3 \( \pm \) 1.6 \( \times \) 10\(^{-3}\))  
\( \Gamma_{16} \quad D^{*-} \ell^+ \nu_\ell \) anything \([a]\) (2.75 \( \pm \) 0.19 \%)  
\( \Gamma_{17} \quad D^{*-} \pi^- \ell^+ \nu_\ell \) anything (6 \( \pm \) 7 \( \times \) 10\(^{-4}\))  
\( \Gamma_{18} \quad D^{*-} \pi^- \ell^+ \nu_\ell \) anything (4.8 \( \pm \) 1.0 \( \times \) 10\(^{-3}\))  
\( \Gamma_{19} \quad \overline{D}^0_j \ell^+ \nu_\ell \) anything \( \times \) \( B(\overline{D}^0_j \rightarrow D^{*+} \pi^-) \) (2.6 \( \pm \) 0.9 \( \times \) 10\(^{-3}\))  
\( \Gamma_{20} \quad D^+_j \ell^+ \nu_\ell \) anything \( \times \) \( B(D^+_j \rightarrow D^0 \pi^-) \) (7.0 \( \pm \) 2.3 \( \times \) 10\(^{-3}\))  
\( \Gamma_{21} \quad \overline{D}^*_2(2460)^0 \ell^+ \nu_\ell \) anything \( \times \) \( B(\overline{D}^*_2(2460)^0 \rightarrow D^{*-} \pi^-) \) < 1.4 \( \times \) 10\(^{-3}\) Cl=90\%  
\( \Gamma_{22} \quad D^*_2(2460)^- \ell^+ \nu_\ell \) anything \( \times \) \( B(D^*_2(2460)^- \rightarrow D^0 \pi^-) \) (4.2 \( \pm \) 1.5 \( \times \) 10\(^{-3}\))  
\( \Gamma_{23} \quad \overline{D}^*_2(2460)^0 \ell^+ \nu_\ell \) anything \( \times \) \( B(\overline{D}^*_2(2460)^0 \rightarrow D^- \pi^+) \) (1.6 \( \pm \) 0.8 \( \times \) 10\(^{-3}\))  
\( \Gamma_{24} \quad \text{charless } \ell^\tau_\ell \) \([a]\) (1.7 \( \pm \) 0.5 \( \times \) 10\(^{-3}\))  
\( \Gamma_{25} \quad \tau^+ \nu_\tau \) anything (2.41 \( \pm \) 0.23 \%)  
\( \Gamma_{26} \quad D^{*-} \tau \nu_\tau \) anything (9 \( \pm \) 4 \( \times \) 10\(^{-3}\))  
\( \Gamma_{27} \quad \bar{\tau} \rightarrow \ell^- \nu_\ell \) anything \([a]\) (8.02 \( \pm \) 0.19 \%)  
\( \Gamma_{28} \quad c \rightarrow \ell^+ \nu_\ell \) anything (1.6 \( \pm \) 0.4 \( \times \) 10\(^{-3}\)) \%

**Charmed meson and baryon modes**

\( \Gamma_{29} \quad D^0 \) anything (58.7 \( \pm \) 2.8 \%)  
\( \Gamma_{30} \quad D^0 D^+_s \) anything \([c]\) (9.1 \( \pm \) 4.0 \( \times \) 2.8 \%)  
\( \Gamma_{31} \quad D^{+} D^+_s \) anything \([c]\) (4.0 \( \pm \) 2.3 \( \times \) 1.8 \%)  
\( \Gamma_{32} \quad \overline{D}^0 D^0 \) anything \([c]\) (5.1 \( \pm \) 2.0 \( \times \) 1.8 \%)  
\( \Gamma_{33} \quad D^0 D^+ \) anything \([c]\) (2.7 \( \pm \) 1.8 \( \times \) 1.8 \%)  
\( \Gamma_{34} \quad D^0 D^+ \) anything \([c]\) < 9 \( \times \) 10\(^{-3}\) Cl=90\%  
\( \Gamma_{35} \quad D^0 \) anything  
\( \Gamma_{36} \quad D^+ \) anything  
\( \Gamma_{37} \quad D^- \) anything (22.7 \( \pm \) 1.6 \%)  
\( \Gamma_{38} \quad D^*(2010)^+ \) anything (17.3 \( \pm \) 2.0 \%)  
\( \Gamma_{39} \quad D^+_1(2420)^0 \) anything (5.0 \( \pm \) 1.5 \%)  
\( \Gamma_{40} \quad D^*(2010)^+ D^+_s \) anything \([c]\) (3.3 \( \pm \) 1.6 \( \times \) 1.3 \%)  
\( \Gamma_{41} \quad D^0 D^*(2010)^\pm \) anything \([c]\) (3.0 \( \pm \) 1.1 \( \times \) 0.9 \%)
\[ \Gamma_{42} \] \( D^*(2010)^\pm D^\pm \) anything \[ \Gamma_{43} \] \( D^*(2010)^\pm D^*(2010)^\mp \) anything \[ \Gamma_{44} \] \( \bar{D}D \) anything \[ \Gamma_{45} \] \( D_2^*(2460)^0 \) anything \[ \Gamma_{46} \] \( D_2^- \) anything \[ \Gamma_{47} \] \( D_s^+ \) anything \[ \Gamma_{48} \] \( \Lambda_c^+ \) anything \[ \Gamma_{49} \] \( \tau^+/c \) anything

Charmonium modes

\[ \Gamma_{50} \] \( J/\psi(1S) \) anything \[ \Gamma_{51} \] \( \psi(2S) \) anything \[ \Gamma_{52} \] \( \chi_{c0}(1P) \) anything \[ \Gamma_{53} \] \( \chi_{c1}(1P) \) anything \[ \Gamma_{54} \] \( \chi_{c2}(1P) \) anything \[ \Gamma_{55} \] \( \chi_c(2P) \) anything, \( \chi_c \to \phi \phi \) \[ \Gamma_{56} \] \( \eta_c(1S) \) anything \[ \Gamma_{57} \] \( \eta_c(2S) \) anything, \( \eta_c \to \phi \phi \) \[ \Gamma_{58} \] \( \chi_{c1}(3872) \) anything, \( \chi_{c1} \to \phi \phi \) \[ \Gamma_{59} \] \( X(3915) \) anything, \( X \to \phi \phi \)

\[ \Gamma_{60} \] \( \bar{s}\gamma \) \[ \Gamma_{61} \] \( \bar{s}\bar{u}\nu \) \[ \Gamma_{62} \] \( K^\pm \) anything \[ \Gamma_{63} \] \( K_S^0 \) anything

\[ \Gamma_{64} \] \( \pi^\pm \) anything \[ \Gamma_{65} \] \( \pi^0 \) anything \[ \Gamma_{66} \] \( \phi \) anything

\[ \Gamma_{67} \] \( p/\bar{p} \) anything \[ \Gamma_{68} \] \( \Lambda/\bar{\Lambda} \) anything \[ \Gamma_{69} \] \( b^- \) -baryon anything \[ \Gamma_{70} \] \( \bar{\Lambda}_b^0 \) anything \[ \Gamma_{71} \] \( \Xi_b^+ \) anything

\[ \Gamma_{72} \] charged anything \[ \Gamma_{73} \] hadron\( ^+ \) hadron\( ^- \) \[ \Gamma_{74} \] charmless

\( \text{Citation: P.A. Zyla et al. (Particle Data Group), Prog. Theor. Exp. Phys. 2020, 083C01 (2020)} \)
\[ \Delta B = 1 \text{ weak neutral current (B1) modes} \]

\[ \begin{align*}
\Gamma_{75} & : e^+ e^- \, \text{anything} \\
\Gamma_{76} & : \mu^+ \mu^- \, \text{anything} \\
\Gamma_{77} & : \nu\pi \, \text{anything}
\end{align*} \]

\[ B1 < 3.2 \times 10^{-4} \, \text{CL}=90\% \]

[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%.

\[ B^\pm/B^0/B^0_\pi/b-baryon \text{ ADMIXTURE BRANCHING RATIOS} \]

\[ \Gamma(B^+)/\Gamma \quad \Gamma_1/\Gamma \]

"OUR EVALUATION" is an average from \( Z \) decay obtained by the Heavy Flavor Averaging Group (HFLAV) as described at https://hflav.web.cern.ch/.

\begin{tabular}{lcccc}
\textbf{VALUE} & \textbf{DOCUMENT ID} & \textbf{TECN} & \textbf{COMMENT} \\
\hline
0.408 & \pm 0.007 & OUR EVALUATION & \\
0.4099 & \pm 0.0082 & \pm 0.0111 & 1 ABDALLAH 03K DLPH \( e^+ e^- \rightarrow Z \)
\end{tabular}

1 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.

\[ \Gamma(B^+)/\Gamma(B^0) \quad \Gamma_1/\Gamma_2 \]

\begin{tabular}{lcccc}
\textbf{VALUE} & \textbf{DOCUMENT ID} & \textbf{TECN} & \textbf{COMMENT} \\
\hline
1.054 & \pm 0.018 & \pm 0.062 & \pm 0.074 & AALTONEN 08N CDF \( p\bar{p} \) at 1.96 TeV
\end{tabular}

\[ \Gamma(B^0_\pi)/[\Gamma(B^+)/\Gamma(B^0)] \quad \Gamma_3/(\Gamma_1+\Gamma_2) \]

"OUR EVALUATION" is an average from \( Z \) decay obtained by the Heavy Flavor Averaging Group (HFLAV) as described at https://hflav.web.cern.ch/.

\begin{tabular}{lcccc}
\textbf{VALUE} & \textbf{DOCUMENT ID} & \textbf{TECN} & \textbf{COMMENT} \\
\hline
0.1230 & \pm 0.0115 & OUR EVALUATION & \\
0.122 & \pm 0.006 & 1 AAIJ 19AD LHCB \( pp \) at 13 TeV & \\
0.134 & \pm 0.004 & \pm 0.011 & \pm 0.010 & 2 AAIJ 12J LHCB \( pp \) at 7 TeV & \\
0.1265 & \pm 0.0085 & \pm 0.0131 & & 3 AAIJ 11F LHCB \( pp \) at 7 TeV & \\
0.128 & \pm 0.011 & \pm 0.010 & \pm 0.011 & 4 AALTONEN 08N CDF \( p\bar{p} \) at 1.96 TeV & \\
0.213 & \pm 0.068 & & & 5 AFFOLDER 00E CDF \( p\bar{p} \) at 1.8 TeV & \\
0.21 & \pm 0.036 & \pm 0.038 & \pm 0.030 & 6 ABE 99P CDF \( \bar{p}p \) at 1.8 TeV & \\
\end{tabular}

1 AAIJ 19AD measured the average value using \( b \)-hadron semileptonic decays and assuming isospin symmetry for \( b \)-hadron \( p_T \) of 4 and 25 GeV and \( \eta \) of 2 and 5.

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2 AAIJ 12J measured this value using $b$-hadron semileptonic decays and assuming isospin symmetry.

3 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.

4 AALTONEN 08N reports $\left[ \Gamma(B_s \rightarrow B^0) \right] / \left[ \Gamma(B \rightarrow B^+) + \Gamma(B \rightarrow B^0) \right] \times [B(D_s^+ \rightarrow \phi \pi^+) = (5.76 \pm 0.18^{+0.45\%}_{-0.42\%}) \times 10^{-3}$ 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.

5 AFFOLDER 00E uses several electron-charm final states in $b \rightarrow c e^- X$.

6 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 $c \rightarrow s \mu^+ X$.

\[ \frac{\Gamma'(B_s^0)}{\Gamma(B^0)} \]

\[ \frac{\Gamma_3}{\Gamma_2} \]

“OUR EVALUATION” has been provided by the Heavy Flavor Averaging Group (HFLAV, https://hflav.web.cern.ch/).

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.246±0.023</td>
<td>OUR EVALUATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.239±0.016</td>
<td>OUR AVERAGE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| 0.240±0.004±0.020   | AAD          | pp at 7 TeV |
| 0.238±0.004±0.015±0.021 | AAIJ      | pp at 7 TeV |

1 The measurement is derived from the observed $B_s^0 \rightarrow J/\psi \phi$ and $B_d^0 \rightarrow J/\psi K^*0$ yields and a recent theory prediction of $B(B_s^0 \rightarrow J/\psi \phi)/B(B_d^0 \rightarrow J/\psi K^*0)$. The second uncertainty combines in quadrature systematic and theoretical uncertainties.

2 AAIJ 13P studies also separately the $p_T(B)$ and $\eta(B)$ dependency of $\Gamma(B \rightarrow B^0_s)/\Gamma(B \rightarrow B^0)$, 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 $\langle \eta \rangle = 3.28$.

\[ \frac{\Gamma(B^+)}{[\Gamma(B^+) + \Gamma(B^0)]} \]

\[ \frac{\Gamma_4}{\Gamma_1+\Gamma_2} \]

<table>
<thead>
<tr>
<th>VALUE (units 10^{-3})</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.63±0.08±0.87</td>
<td>AAIJ</td>
<td>LHCb</td>
<td>pp at 7 TeV</td>
</tr>
<tr>
<td>3.78±0.04±0.90</td>
<td>AAIJ</td>
<td>LHCb</td>
<td>pp at 13 TeV</td>
</tr>
</tbody>
</table>

1 Measured using $B_c$ semileptonic decays.

\[ \frac{\Gamma(b\text{-baryon})}{[\Gamma(B^+) + \Gamma(B^0)]} \]

\[ \frac{\Gamma_5}{\Gamma_1+\Gamma_2} \]

“OUR EVALUATION” is an average from $Z$ decay obtained by the Heavy Flavor Averaging Group (HFLAV) as described at https://hflav.web.cern.ch/.

<table>
<thead>
<tr>
<th>VALUE</th>
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<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.103±0.015</td>
<td>OUR EVALUATION</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

| 0.259±0.018         | AAIJ        | LHCb | pp at 13 TeV  |
| 0.305±0.010±0.081   | AAIJ        | LHCb | pp at 7 TeV   |
| 0.31±0.12±0.08      | AALTONEN    | CDF  | $p\bar{p}$ at 1.8 TeV |
| 0.22±0.08±0.07      | AALTONEN    | CDF  | $p\bar{p}$ at 1.96 TeV |

Citation: P.A. Zyla et al. (Particle Data Group), Prog. Theor. Exp. Phys. 2020, 083C01 (2020)
1 AAIJ 19AD measured the average value for $\Lambda_b^0$ using semileptonic decays and assuming isospin symmetry for $b$-hadron $p_T$ of 4 and 25 GeV and $\eta$ of 2 and 5.

2 AAIJ 12J 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 $B(\Lambda_c^+ \to p K^- \pi^+)$.  

3 AALTONEN 09E errata to the measurement reported in AFFOLDER 00E using the $p_T$ spectra from fully reconstructed $B^0$ and $\Lambda_b$ decays.

4 AALTONEN 08N reports $[\Gamma(\bar{B} \to b\text{-baryon})/\Gamma(\bar{B} \to B^+ + \Gamma(\bar{B} \to B^0))] \times B(\Lambda_c^+ \to p K^- \pi^+) = (14.1 \pm 6.9^{+5.3}_{-4.4} \times 10^{-3}$ which we divide by our best value $B(\Lambda_c^+ \to p K^- \pi^+) = (6.28 \pm 0.32) \times 10^{-2}$. Our first error is their experiment’s error and our second error is the systematic error from using their best value.

5 AFFOLDER 00E uses several electron-charm final states in $b \to c e^- X$. 

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

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
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<tbody>
<tr>
<td>0.2308 ± 0.0077</td>
<td>1,2 ACCIARRI</td>
<td>96C</td>
<td>L3</td>
</tr>
</tbody>
</table>

1 ACCIARRI 96C assumes relative $b$ semileptonic decay rates $e:\mu:\tau$ of 1:1:0.25. Based on missing-energy spectrum.

2 Assumes Standard Model value for $R_B$.

### $\Gamma(\ell^+ \nu \ell^- \text{anything})/\Gamma_{\text{total}}$ 

"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.

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
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<tbody>
<tr>
<td>0.1069 ± 0.0022</td>
<td>OUR EVALUATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1064 ± 0.0016</td>
<td>OUR AVERAGE</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 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.

2 The experimental systematic and model uncertainties are combined in quadrature.

3 ABBIENDI 00E result is determined by comparing the distribution of several kinematic variables of leptonic events in a lifetime tagged $Z \to b\bar{b}$ sample using artificial neural network techniques. The first error is statistic; the second error is the total systematic error.
We do not use the following data for averages, fits, limits, etc.

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.

ACCIARRI 96c result obtained by a fit to the single lepton spectrum.

Assumes Standard Model value for \(R_B\).

ABREU 95c give systematic errors \(\pm 0.0019\) (model) and \(0.0012\) \((R_c)\). We combine these in quadrature.

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.

ABREU 93c event count includes ee events. Combining \(ee, \mu\mu,\) and \(e\mu\) events, they obtain \(0.100 \pm 0.007 \pm 0.007\).

AKERS 93g analysis performed using single and dilepton events.

\[
\frac{\Gamma(e^+\nu_e\text{anything})/\Gamma_{\text{total}}}{\Gamma_8/\Gamma}
\]

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
<th>EVTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.1086\pm 0.0035) OUR AVERAGE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(0.1078\pm 0.0008)</td>
<td>1</td>
<td>ABBIENDI</td>
<td>00E OPAL e^+e^- (\rightarrow Z)</td>
<td>6</td>
</tr>
<tr>
<td>(0.1089\pm 0.0020)</td>
<td>2</td>
<td>ACCIARRI</td>
<td>96c L3 e^+e^- (\rightarrow Z)</td>
<td>2,3</td>
</tr>
<tr>
<td>(0.107\pm 0.015)</td>
<td>4</td>
<td>ABREU</td>
<td>93c DLPH e^+e^- (\rightarrow Z)</td>
<td>260</td>
</tr>
<tr>
<td>(0.138\pm 0.032)</td>
<td>5</td>
<td>ADEVA</td>
<td>91c L3 e^+e^- (\rightarrow Z)</td>
<td>260</td>
</tr>
</tbody>
</table>

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

\(0.086\pm 0.027\pm 0.008\) \(\pm 0.0050\) \(\pm 0.0046\) \(\pm 0.0055\)

\(0.109\pm 0.014\pm 0.013\) \(\pm 0.0055\)

\(0.111\pm 0.028\pm 0.026\) \(\pm 0.027\)

\(0.150\pm 0.011\pm 0.022\)

\(0.112\pm 0.009\pm 0.011\)

\(0.149\pm 0.022\pm 0.019\)

\(0.110\pm 0.018\pm 0.010\)

\(0.111\pm 0.034\pm 0.040\)

\(0.146\pm 0.028\)

\(0.116\pm 0.021\pm 0.017\)

1. 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.

2. ACCIARRI 96c result obtained by a fit to the single lepton spectrum.

3. Assumes Standard Model value for \(R_B\).

4. ABREU 93c event count includes ee events. Combining ee, \(\mu\mu\), and e\(\mu\) events, they obtain \(0.100 \pm 0.007 \pm 0.007\).

5. 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.

6. ABE 93e experiment also measures forward-backward asymmetries and fragmentation functions for \(b\) and \(c\).

7. AKERS 93g analysis also measures forward-backward asymmetries and fragmentation functions for \(b\) and \(c\).
We do not use the following data for averages, fits, limits, etc.

<table>
<thead>
<tr>
<th>VALUE</th>
<th>EVTS</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1096±0.0008 +0.0034 −0.0027</td>
<td>1</td>
<td>ABBIENDI 00E</td>
<td>OPAL</td>
<td>$e^+e^- \to Z$</td>
</tr>
<tr>
<td>0.1082±0.0015 +0.0059</td>
<td>2,3</td>
<td>ACIARRI 96C</td>
<td>L3</td>
<td>$e^+e^- \to Z$</td>
</tr>
<tr>
<td>0.110 ±0.012 ±0.007</td>
<td>4</td>
<td>ABREU 93C</td>
<td>DLPH</td>
<td>$e^+e^- \to Z$</td>
</tr>
<tr>
<td>0.113 ±0.012 ±0.006</td>
<td>5</td>
<td>ADEVA 91C</td>
<td>L3</td>
<td>$e^+e^- \to Z$</td>
</tr>
</tbody>
</table>

**Comment:** We do not use the following data for averages, fits, limits, etc.

<table>
<thead>
<tr>
<th>VALUE</th>
<th>EVTS</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.122 ±0.006 ±0.007</td>
<td>3</td>
<td>UENO 96</td>
<td>AMY</td>
<td>$e^+e^- \to Z$ at 57.9 GeV</td>
</tr>
<tr>
<td>0.101 +0.010 −0.009 +0.0055</td>
<td>6</td>
<td>AKERS 93B</td>
<td>OPAL</td>
<td>Repl. by ABBIENDI 00E</td>
</tr>
<tr>
<td>0.104 ±0.023 ±0.016</td>
<td>BEHREND 90D</td>
<td>CELL</td>
<td>$E^{cm}_{ee} = 43$ GeV</td>
<td></td>
</tr>
<tr>
<td>0.148 ±0.010 ±0.016</td>
<td>BEHREND 90D</td>
<td>CELL</td>
<td>$E^{cm}_{ee} = 35$ GeV</td>
<td></td>
</tr>
<tr>
<td>0.118 ±0.012 ±0.010</td>
<td>ONG 88</td>
<td>MRK2</td>
<td>$E^{cm}_{ee} = 29$ GeV</td>
<td></td>
</tr>
<tr>
<td>0.117 ±0.016 ±0.015</td>
<td>BARTEL 87</td>
<td>JADE</td>
<td>$E^{cm}_{ee} = 34.6$ GeV</td>
<td></td>
</tr>
<tr>
<td>0.114 ±0.018 ±0.025</td>
<td>BARTEL 85J</td>
<td>JADE</td>
<td>Repl. by BARTEL 87</td>
<td></td>
</tr>
<tr>
<td>0.117 ±0.028 ±0.010</td>
<td>ALTHOFF 84G</td>
<td>TASS</td>
<td>$E^{cm}_{ee} = 34.5$ GeV</td>
<td></td>
</tr>
<tr>
<td>0.105 ±0.015 ±0.013</td>
<td>ADEVA 83B</td>
<td>MRKJ</td>
<td>$E^{cm}_{ee} = 33-38.5$ GeV</td>
<td></td>
</tr>
<tr>
<td>0.155 +0.054 −0.029</td>
<td>FERNANDEZ 83D</td>
<td>MAC</td>
<td>$E^{cm}_{ee} = 29$ GeV</td>
<td></td>
</tr>
</tbody>
</table>

1. ABBIENDI 00E result is determined by comparing the distribution of several kinematic variables of leptonic events in a lifetime tagged $Z \to b\bar{b}$ sample using artificial neural network techniques. The first error is statistic; the second error is the total systematic error.
2. ACIARRI 96C result obtained by a fit to the single lepton spectrum.
3. Assumes Standard Model value for $R_B$.
4. ABREU 93C event count includes $\mu\mu$ events. Combining $ee$, $\mu\mu$, and $e\mu$ events, they obtain $0.100 \pm 0.007 \pm 0.007$.
5. ADEVA 91C measure the average $B(b \to eX)$ 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.
6. AKERS 93B analysis performed using single and dilepton events.

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.022 +0.0004 ±0.0018</td>
<td>1</td>
<td>ABREU 00R</td>
<td>DLPH</td>
</tr>
<tr>
<td>0.0272±0.0028 ±0.0018</td>
<td>2</td>
<td>AKERS 95Q</td>
<td>OPAL</td>
</tr>
</tbody>
</table>

1. ABREU 00R reports their experiment's uncertainties $0.0019 \pm 0.0016 \pm 0.0018$, 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.
2. AKERS 95Q reports $[\Gamma(D^- \ell^+ \nu_\ell \text{anything})/\Gamma_{\text{total}}] \times [B(D^+ \to K^-2\pi^+)] = (1.82 \pm 0.20 \pm 0.12) \times 10^{-3}$, which we divide by our best value $B(D^+ \to K^-2\pi^+) = (9.38 \pm 0.16) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.
\[ \Gamma(D^- \pi^+ \ell^+ \nu_\ell \text{anything})/\Gamma_{\text{total}} \]

**VALUE**

0.0049 ± 0.0018 ± 0.0007

**DOCUMENT ID**

ABREU 00R

**TECN**

DLPH

**COMMENT**

e^+ e^- \rightarrow Z

**VALUE**

0.0026 ± 0.0015 ± 0.0004

**DOCUMENT ID**

ABREU 00R

**TECN**

DLPH

**COMMENT**

e^+ e^- \rightarrow Z

**VALUE**

0.0679 ± 0.0034 OUR AVERAGE

0.0704 ± 0.0040 ± 0.0017

1 ABREU 00R reports their experiment’s uncertainties ±0.0034 ± 0.0036 ± 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.

2 AKERS 95Q reports \[ \Gamma(\bar{B} \rightarrow D^0 \ell^+ \nu_\ell \text{anything})/\Gamma_{\text{total}} \] \times \[ B(D^0 \rightarrow K^- \pi^+) \] = (2.52 ± 0.14 ± 0.17) \times 10^{-3} which we divide by our best value \( B(D^0 \rightarrow K^- \pi^+) \) = (3.950 ± 0.031) \times 10^{-2}. Our first error is their experiment’s error and our second error is the systematic error from using our best value.

**VALUE**

0.0107 ± 0.0025 ± 0.0011

**DOCUMENT ID**

ABREU 00R

**TECN**

DLPH

**COMMENT**

e^+ e^- \rightarrow Z

**VALUE**

0.0023 ± 0.0015 ± 0.0004

**DOCUMENT ID**

ABREU 00R

**TECN**

DLPH

**COMMENT**

e^+ e^- \rightarrow Z

**VALUE**

0.0275 ± 0.0019 OUR AVERAGE

0.0275 ± 0.0021 ± 0.0009

1 ABREU 00R reports their experiment’s uncertainties ±0.0017 ± 0.0013 ± 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.

2 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 ± 0.47 ± 0.56) \times 10^{-4}) and uses \( B(D^{*+} \rightarrow D^0 \pi^+) = 0.681 ± 0.013 \) and \( B(D^0 \rightarrow K^- \pi^+) = 0.0401 ± 0.0014 \) 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.

**VALUE**

0.0006 ± 0.0007 ± 0.0002

**DOCUMENT ID**

ABREU 00R

**TECN**

DLPH

**COMMENT**

e^+ e^- \rightarrow Z

**VALUE**

0.0048 ± 0.0009 ± 0.0005

**DOCUMENT ID**

ABREU 00R

**TECN**

DLPH

**COMMENT**

e^+ e^- \rightarrow Z
\[ \Gamma(D^0 J \ell^+ \nu_e \text{ anything} \times B(D^0 J \rightarrow D^{**} \pi^-))/\Gamma_{\text{total}} \]

\[ D^0 J \] represents an unresolved mixture of pseudoscalar and tensor \( D^{**} \) (\( P \)-wave) states.

\[ \Gamma(D^- J \ell^+ \nu_e \text{ anything} \times B(D^- J \rightarrow D^0 \pi^-))/\Gamma_{\text{total}} \]

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

\[ \Gamma(D^0_2(2460)^0 \ell^+ \nu_e \text{ anything} \times B(D^0_2(2460)^0 \rightarrow D^{*-} \pi^+))/\Gamma_{\text{total}} \]

\[ \Gamma(D^0_2(2460)^- \ell^+ \nu_e \text{ anything} \times B(D^0_2(2460)^- \rightarrow D^0 \pi^-))/\Gamma_{\text{total}} \]

\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

"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.

\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

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\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

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\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

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\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

\[ \Gamma(\text{charmless } \ell \nu e)/\Gamma_{\text{total}} \]

\[ \Gamma(\text{charmless } \ell \nu e)/\Γ
### \( \Gamma(\tau^+ \nu_\tau \text{ anything}) / \Gamma_{\text{total}} \)\( \quad \Gamma_{25}/\Gamma \)

<table>
<thead>
<tr>
<th>\text{VALUE (units (10^{-2})) EVTS}</th>
<th>\text{DOCUMENT ID}</th>
<th>\text{TECN}</th>
<th>\text{COMMENT}</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.41 ± 0.23 OUR AVERAGE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.78 ± 0.18 ± 0.51</td>
<td>1 ABBIENDI 01Q</td>
<td>OPAL</td>
<td>( e^+ e^- \rightarrow Z )</td>
</tr>
<tr>
<td>2.43 ± 0.20 ± 0.25</td>
<td>2 BARATE 01E</td>
<td>ALEP</td>
<td>( e^+ e^- \rightarrow Z )</td>
</tr>
<tr>
<td>2.19 ± 0.24 ± 0.39</td>
<td>3 ABREU 00C</td>
<td>DLPH</td>
<td>( e^+ e^- \rightarrow Z )</td>
</tr>
<tr>
<td>1.7 ± 0.5 ± 1.1</td>
<td>4,5 ACCIARRI 96C</td>
<td>L3</td>
<td>( e^+ e^- \rightarrow Z )</td>
</tr>
<tr>
<td>2.4 ± 0.7 ± 0.8</td>
<td>6 ACCIARRI 94C</td>
<td>L3</td>
<td>( e^+ e^- \rightarrow Z )</td>
</tr>
</tbody>
</table>

- We do not use the following data for averages, fits, limits, etc. • • •
- 1 ABBIENDI 01Q uses a missing energy technique.
- 2 The energy-flow and \( b \)-tagging algorithms were used.
- 3 Uses the missing energy in \( Z \rightarrow b \bar{b} \) decays without identifying leptons.
- 4 ACCIARRI 96C result obtained from missing energy spectrum.
- 5 Assumes Standard Model value for \( R_B \).
- 6 This is a direct result using tagged \( b \bar{b} \) events at the \( Z \), but species are not separated.
- 7 BUSKULIC 95 uses missing-energy technique.

\[
\Gamma(D^+ \rightarrow \tau^+ \nu_\tau \text{ anything}) / \Gamma_{\text{total}}
\]

<table>
<thead>
<tr>
<th>\text{VALUE} ((0.88 \pm 0.31 \pm 0.28) \times 10^{-2})</th>
<th>\text{DOCUMENT ID}</th>
<th>\text{TECN}</th>
<th>\text{COMMENT}</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 BARATE 01E</td>
<td>ALEP</td>
<td>( e^+ e^- \rightarrow Z )</td>
<td></td>
</tr>
</tbody>
</table>

- The energy-flow and \( b \)-tagging algorithms were used.

### \( \Gamma(b \rightarrow \ell^- \bar{\nu}_\ell \text{ anything}) / \Gamma_{\text{total}} \)\( \quad \Gamma_{27}/\Gamma \)

**“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.

<table>
<thead>
<tr>
<th>\text{VALUE} ((0.0802 \pm 0.0019) \text{ OUR EVALUATION}) ((0.0817 \pm 0.0020) \text{ OUR AVERAGE})</th>
<th>\text{DOCUMENT ID}</th>
<th>\text{TECN}</th>
<th>\text{COMMENT}</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0818 ± 0.0015 ± 0.0024 ± 0.0026</td>
<td>1 HEISTER 02G</td>
<td>ALEP</td>
<td>( e^+ e^- \rightarrow Z )</td>
</tr>
<tr>
<td>0.0798 ± 0.0022 ± 0.0025 ± 0.0029</td>
<td>2 ABREU 01L</td>
<td>DLPH</td>
<td>( e^+ e^- \rightarrow Z )</td>
</tr>
<tr>
<td>0.0840 ± 0.0016 ± 0.0039 ± 0.0036</td>
<td>3 ABBIENDI 00E</td>
<td>OPAL</td>
<td>( e^+ e^- \rightarrow Z )</td>
</tr>
</tbody>
</table>

- We do not use the following data for averages, fits, limits, etc. • • •
- 1 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.
- 2 The experimental systematic and model uncertainties are combined in quadrature.
- 3 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.
The systematic error includes the uncertainties due to the charm branching ratios.

1 The experimental systematic and model uncertainties are combined in quadrature.

\[ \frac{\Gamma(c \rightarrow \ell^+ \nu \text{anything})}{\Gamma_{\text{total}}} \quad \Gamma_{\text{28}}/\Gamma \]

\begin{tabular}{lcc}
\hline
\textbf{VALUE} & \textbf{DOCUMENT ID} & \textbf{TECN} & \textbf{COMMENT} \\
\hline
\end{tabular}

0.0161 ± 0.0020 +0.0034 -0.0047 & 1 ABREU 01l DLPH & e^+ e^- → Z & \\

\[ \Gamma(D^0 \text{anything})/\Gamma_{\text{total}} \quad \Gamma_{\text{29}}/\Gamma \]

\begin{tabular}{lcc}
\hline
\textbf{VALUE} & \textbf{DOCUMENT ID} & \textbf{TECN} & \textbf{COMMENT} \\
\hline
\end{tabular}

0.587 ± 0.028 ± 0.005 & 1 BUSKULIC 96Y ALEP & e^+ e^- → Z & \\

\[ \Gamma(D_s^\pm \text{anything})/\Gamma_{\text{total}} \quad \Gamma_{\text{30}}/\Gamma \]

\begin{tabular}{lcc}
\hline
\textbf{VALUE} & \textbf{DOCUMENT ID} & \textbf{TECN} & \textbf{COMMENT} \\
\hline
\end{tabular}

0.091 +0.020 +0.034 -0.018 -0.022 & 1 BARATE 98Q ALEP & e^+ e^- → Z & \\

\[ \Gamma(D^\mp D_s^\pm \text{anything})/\Gamma_{\text{total}} \quad \Gamma_{\text{31}}/\Gamma \]

\begin{tabular}{lcc}
\hline
\textbf{VALUE} & \textbf{DOCUMENT ID} & \textbf{TECN} & \textbf{COMMENT} \\
\hline
\end{tabular}

0.040 +0.017 +0.016 -0.014 -0.011 & 1 BARATE 98Q ALEP & e^+ e^- → Z & \\

\[ \frac{[\Gamma(D^0 D_s^\pm \text{anything}) + \Gamma(D^\mp D_s^\pm \text{anything})]}{\Gamma_{\text{total}}} \quad (\Gamma_{\text{30}} + \Gamma_{\text{31}})/\Gamma \]

\begin{tabular}{lcc}
\hline
\textbf{VALUE} & \textbf{DOCUMENT ID} & \textbf{TECN} & \textbf{COMMENT} \\
\hline
\end{tabular}

0.131 +0.026 +0.048 -0.022 -0.031 & 1 BARATE 98Q ALEP & e^+ e^- → Z & \\

\[ \Gamma(D^0 D^0 \text{anything})/\Gamma_{\text{total}} \quad \Gamma_{\text{32}}/\Gamma \]

\begin{tabular}{lcc}
\hline
\textbf{VALUE} & \textbf{DOCUMENT ID} & \textbf{TECN} & \textbf{COMMENT} \\
\hline
\end{tabular}

0.051 +0.016 +0.012 -0.014 -0.011 & 1 BARATE 98Q ALEP & e^+ e^- → Z & \\

\[ \Gamma(D^0 D^\pm \text{anything})/\Gamma_{\text{total}} \quad \Gamma_{\text{33}}/\Gamma \]

\begin{tabular}{lcc}
\hline
\textbf{VALUE} & \textbf{DOCUMENT ID} & \textbf{TECN} & \textbf{COMMENT} \\
\hline
\end{tabular}

0.027 +0.015 +0.010 -0.013 -0.009 & 1 BARATE 98Q ALEP & e^+ e^- → Z & \\

1 The systematic error includes the uncertainties due to the charm branching ratios.
\[
\frac{\Gamma(D_0^0 D_0^0 \text{anything}) + \Gamma(D_0^0 D_\pm \text{anything})}{\Gamma_{\text{total}}} \quad \frac{\Gamma_3^2 + \Gamma_3^3}{\Gamma}
\]

\[
\begin{array}{c|c|c|c|c}
\text{VALUE} & \text{DOCUMENT ID} & \text{TECN} & \text{COMMENT} \\
\hline
0.078^{+0.020+0.018}_{-0.018-0.016} & 1 & \text{BARATE} & 98Q & \text{ALEP} & e^+ e^- \rightarrow Z \\
\hline
\end{array}
\]

The systematic error includes the uncertainties due to the charm branching ratios.

\[
\frac{\Gamma(D_\pm \text{anything})}{\Gamma_{\text{total}}} \quad \Gamma_3^4/\Gamma
\]

\[
\begin{array}{c|c|c|c|c}
\text{VALUE} & \text{CL} & \text{CL} & \text{DOCUMENT ID} & \text{TECN} & \text{COMMENT} \\
\hline
<0.009 & 90 & & & & \\
\hline
\end{array}
\]

\[
\frac{\Gamma(D^0 \text{anything}) + \Gamma(D^+ \text{anything})}{\Gamma_{\text{total}}} \quad \Gamma_3^5 + \Gamma_3^6/\Gamma
\]

\[
\begin{array}{c|c|c|c|c}
\text{VALUE} & \text{DOCUMENT ID} & \text{TECN} & \text{COMMENT} \\
\hline
0.093^{+0.017+0.014}_{-0.014-0.014} & 1 & \text{ABDALLAH} & 03E & \text{DLPH} & e^+ e^- \rightarrow Z \\
\hline
\end{array}
\]

The second error is the total of systematic uncertainties including the branching fractions used in the measurement.

\[
\frac{\Gamma(D^- \text{anything})}{\Gamma_{\text{total}}} \quad \Gamma_3^7/\Gamma
\]

\[
\begin{array}{c|c|c|c|c}
\text{VALUE} & \text{DOCUMENT ID} & \text{TECN} & \text{COMMENT} \\
\hline
0.227^{+0.016+0.004}_{-0.004-0.004} & 1 & \text{BUSKULIC} & 96Y & \text{ALEP} & e^+ e^- \rightarrow Z \\
\hline
\end{array}
\]

1BUSKULIC 96Y reports 0.234 ± 0.013 ± 0.010 from a measurement of \([\Gamma(b \rightarrow D^- \text{anything})/\Gamma_{\text{total}}] \times [B(D^+ \rightarrow K^- 2\pi^+)]\) assuming \(B(D^+ \rightarrow K^- 2\pi^+) = 0.091\), which we rescale to our best value \(B(D^+ \rightarrow K^- 2\pi^+) = (9.38 ± 0.16) \times 10^{-2}\). Our first error is their experiment’s error and our second error is the systematic error from using our best value.

\[
\frac{\Gamma(D^* (2010)^+ \text{anything})}{\Gamma_{\text{total}}} \quad \Gamma_3^8/\Gamma
\]

\[
\begin{array}{c|c|c|c|c}
\text{VALUE} & \text{DOCUMENT ID} & \text{TECN} & \text{COMMENT} \\
\hline
0.173^{+0.016+0.012}_{-0.012-0.012} & 1 & \text{ACKERSTAFF} & 98E & \text{OPAL} & e^+ e^- \rightarrow Z \\
\hline
\end{array}
\]

1Uses lepton tags to select \(Z \rightarrow b \bar{b}\) events.

\[
\frac{\Gamma(D_1 (2420)^0 \text{anything})}{\Gamma_{\text{total}}} \quad \Gamma_3^9/\Gamma
\]

\[
\begin{array}{c|c|c|c|c}
\text{VALUE} & \text{DOCUMENT ID} & \text{TECN} & \text{COMMENT} \\
\hline
0.050^{+0.014+0.006}_{-0.006-0.006} & 1 & \text{ACKERSTAFF} & 97W & \text{OPAL} & e^+ e^- \rightarrow Z \\
\hline
\end{array}
\]

1ACKERSTAFF 97W assumes \(B(D_{2}^{*}(2460)^0 \rightarrow D_+^{\mp} \pi^-) = 0.21 \pm 0.04\) and \(\Gamma_{b \bar{b}}/\Gamma_{\text{hadrons}} = 0.216\) at \(Z\) decay.

\[
\frac{\Gamma(D^* (2010)^+ D_\pm \text{anything})}{\Gamma_{\text{total}}} \quad \Gamma_4^0/\Gamma
\]

\[
\begin{array}{c|c|c|c|c}
\text{VALUE} & \text{DOCUMENT ID} & \text{TECN} & \text{COMMENT} \\
\hline
0.033^{+0.010+0.012}_{-0.009-0.009} & 1 & \text{BARATE} & 98Q & \text{ALEP} & e^+ e^- \rightarrow Z \\
\hline
\end{array}
\]

1The systematic error includes the uncertainties due to the charm branching ratios.

\[
\frac{\Gamma(D^0 D^* (2010)^{\pm} \text{anything})}{\Gamma_{\text{total}}} \quad \Gamma_4^1/\Gamma
\]

\[
\begin{array}{c|c|c|c|c}
\text{VALUE} & \text{DOCUMENT ID} & \text{TECN} & \text{COMMENT} \\
\hline
0.030^{+0.009+0.007}_{-0.008-0.005} & 1 & \text{BARATE} & 98Q & \text{ALEP} & e^+ e^- \rightarrow Z \\
\hline
\end{array}
\]

1The systematic error includes the uncertainties due to the charm branching ratios.
<table>
<thead>
<tr>
<th>( \Gamma(D^*(2010)^\pm D^{\mp} \text{anything})/\Gamma_{\text{total}} )</th>
<th>Document ID</th>
<th>TECN</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.025^{+0.010+0.006}_{-0.009-0.005})</td>
<td>1 BARATE 98Q ALEP</td>
<td>(e^+ e^- \rightarrow Z)</td>
<td>(1) The systematic error includes the uncertainties due to the charm branching ratios.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( \Gamma(D^<em>(2010)^\pm D^</em>(2010)^\mp \text{anything})/\Gamma_{\text{total}} )</th>
<th>Document ID</th>
<th>TECN</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.012^{+0.004}_{-0.003} \pm 0.002)</td>
<td>1 BARATE 98Q ALEP</td>
<td>(e^+ e^- \rightarrow Z)</td>
<td>(1) The systematic error includes the uncertainties due to the charm branching ratios.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( \Gamma(D D \text{anything})/\Gamma_{\text{total}} )</th>
<th>Document ID</th>
<th>TECN</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.10\pm 0.032^{+0.107}_{-0.095})</td>
<td>1 ABBIENDI 04I OPAL</td>
<td>(e^+ e^- \rightarrow Z)</td>
<td>(1) Measurement performed using an inclusive identification of (B) mesons and the (D) candidates.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( \Gamma(D_2^*(2460)^0 \text{anything})/\Gamma_{\text{total}} )</th>
<th>Document ID</th>
<th>TECN</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.047\pm 0.024\pm 0.013)</td>
<td>1 ACKERSTAFF 97W OPAL</td>
<td>(e^+ e^- \rightarrow Z)</td>
<td>(1) ACKERSTAFF 97W assumes (B(D_2^<em>(2460)^0 \rightarrow D^</em> \pi^-) = 0.21 \pm 0.04) and (\Gamma_{bK^}\Gamma_{\text{hadrons}} = 0.216) at (Z) decay.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( \Gamma(D_s^- \text{anything})/\Gamma_{\text{total}} )</th>
<th>Document ID</th>
<th>TECN</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.147\pm 0.017\pm 0.013)</td>
<td>1 BUSKULIC 96Y ALEP</td>
<td>(e^+ e^- \rightarrow Z)</td>
<td>(1) BUSKULIC 96Y reports (0.183 \pm 0.019 \pm 0.009) from a measurement of ([\Gamma(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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( \Gamma(D_s^+ \text{anything})/\Gamma_{\text{total}} )</th>
<th>Document ID</th>
<th>TECN</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.101\pm 0.010\pm 0.029)</td>
<td>1 ABDALLAH 03E DLPH</td>
<td>(e^+ e^- \rightarrow Z)</td>
<td>(1) The second error is the total of systematic uncertainties including the branching fractions used in the measurement.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>( \Gamma(b \rightarrow \Lambda_c^+ \text{anything})/\Gamma_{\text{total}} )</th>
<th>Document ID</th>
<th>TECN</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.077\pm 0.011\pm 0.004)</td>
<td>1 BUSKULIC 96Y ALEP</td>
<td>(e^+ e^- \rightarrow Z)</td>
<td>(1) 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 p K^- \pi^+)] ) assuming (B(\Lambda_c^+ \rightarrow p K^- \pi^+) = 0.044), which we rescale to our best value (B(\Lambda_c^+ \rightarrow p K^- \pi^+) = (6.28 \pm 0.32) \times 10^{-2}). Our first error is their experiment’s error and our second error is the systematic error from using our best value.</td>
</tr>
</tbody>
</table>
### $\Gamma(\tau/c \text{ anything})/\Gamma_{\text{total}}$

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.162 ± 0.032 OUR AVERAGE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.12 ± 0.11</td>
<td>1</td>
<td>ABBIENDI 04i</td>
<td>OPAL</td>
</tr>
<tr>
<td>1.166 ± 0.031 ± 0.080</td>
<td>2</td>
<td>ABREU 00</td>
<td>DLPH</td>
</tr>
<tr>
<td>1.147 ± 0.041</td>
<td>3</td>
<td>ABREU 98d</td>
<td>DLPH</td>
</tr>
<tr>
<td>1.230 ± 0.036 ± 0.065</td>
<td>4</td>
<td>BUSKULIC 96Y</td>
<td>ALEP</td>
</tr>
</tbody>
</table>

1. Measurement performed using an inclusive identification of $B$ mesons and the $D$ candidates.
2. Evaluated via summation of exclusive and inclusive channels.
3. ABREU 98d results are extracted from a fit to the $b$-tagging probability distribution based on the impact parameter.
4. 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 $D^0$, $D^-$, $D_s^-$, and $\Lambda_c$ branching ratios, corrected to include inclusive $\Xi_c$ and charmonium.

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

<table>
<thead>
<tr>
<th>VALUE (units 10^{-2})</th>
<th>CL% EVS</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.16 ± 0.10 OUR AVERAGE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.12 ± 0.12 ± 0.10</td>
<td>1</td>
<td>ABREU 94p</td>
<td>DLPH</td>
<td>$e^+ e^- \rightarrow Z$</td>
</tr>
<tr>
<td>1.16 ± 0.16 ± 0.14</td>
<td>2</td>
<td>ADRIANI 93j</td>
<td>L3</td>
<td>$e^+ e^- \rightarrow Z$</td>
</tr>
<tr>
<td>1.21 ± 0.13 ± 0.08</td>
<td>BUSKULIC 92g</td>
<td>ALEP</td>
<td>$e^+ e^- \rightarrow Z$</td>
<td></td>
</tr>
</tbody>
</table>

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

| 1.3 ± 0.2 ± 0.2 | 3 | ADRIANI 92 | L3 | $e^+ e^- \rightarrow Z$ |
| <4.9 | 90 | MATTEUZZI 83 | MRK2 | $E_{\text{CM}}^{\text{e+e-}} = 29$ GeV |

1. ABREU 94p is an inclusive measurement from $b$ decays at the $Z$. Uses $J/\psi(1S) \rightarrow e^+ e^-$ and $\mu^+ \mu^-$ channels. Assumes $\Gamma(Z \rightarrow b\overline{b})/\Gamma_{\text{hadron}}=0.22$.
2. 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.
3. 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.

### $\Gamma(\psi(2S)\text{ anything})/\Gamma_{\text{total}}$

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0048 ± 0.0022 ± 0.0010</td>
<td>1</td>
<td>ABREU 94p</td>
<td>DLPH</td>
</tr>
</tbody>
</table>

1. ABREU 94p is an inclusive measurement from $b$ decays at the $Z$. Uses $\psi(2S) \rightarrow J/\psi(1S) \mu^+ \mu^-$ and $J/\psi(1S) \rightarrow \mu^+ \mu^-$ channels. Assumes $\Gamma(Z \rightarrow b\overline{b})/\Gamma_{\text{hadron}}=0.22$.

### $\Gamma(\psi(2S)/\Gamma(J/\psi(1S)\text{ anything})$

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.245 ± 0.013</td>
<td>1, 2</td>
<td>AAJ 12BD LHCb</td>
<td>pp at 7 TeV</td>
</tr>
<tr>
<td>0.257 ± 0.015 ± 0.019</td>
<td>3, 4</td>
<td>CHATRCHYAN 12AK CMS</td>
<td>pp at 7 TeV</td>
</tr>
</tbody>
</table>

1. AAJ 12BD reports 0.235 ± 0.005 ± 0.015 from a measurement of $[\Gamma(\Gamma(\psi(2S) \rightarrow \psi(2S) \text{ anything})/\Gamma(\psi(2S) \rightarrow J/\psi(1S) \text{ anything})] \times [B(J/\psi(1S) \rightarrow \mu^+ \mu^-)] / [B(\psi(2S) \rightarrow e^+ e^-)]$ 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 $B(J/\psi(1S) \rightarrow \mu^+ \mu^-)$.
\( \Gamma = (5.961 \pm 0.033) \times 10^{-2} \). \( B(\psi(2S) \to e^+e^-) = (7.93 \pm 0.17) \times 10^{-3} \). Our first error is their experiment’s error and our second error is the systematic error from using our best values.

2 Assumes lepton universality imposing \( B(\psi(2S) \to \mu^+\mu^-) = B(\psi(2S) \to e^+e^-) \).

3 CHATRCHYAN 12AK really reports \( \Gamma_{51}/\Gamma = (3.08 \pm 0.12 \pm 0.13 \pm 0.42) \times 10^{-3} \) assuming PDG 10 value of \( \Gamma_{50}/\Gamma = (1.16 \pm 0.10) \times 10^{-2} \) which we present as a ratio of \( \Gamma_{51}/\Gamma_{50} = (26.5 \pm 1.0 \pm 1.1 \pm 2.8) \times 10^{-2} \).

4 CHATRCHYAN 12AK reports \( (26.5 \pm 1.0 \pm 1.1 \pm 2.8) \times 10^{-2} \) from a measurement of \( [\Gamma(\bar{b} \to \psi(2S) \text{ anything})/\Gamma(\bar{b} \to J/\psi(1S) \text{ anything})] \times [B(\psi(2S) \to \mu^+\mu^-)] / [B(J/\psi(1S) \to \mu^+\mu^-)] \) assuming \( B(\psi(2S) \to \mu^+\mu^-) = (7.7 \pm 0.8) \times 10^{-3}, B(J/\psi(1S) \to \mu^+\mu^-) = (5.93 \pm 0.06) \times 10^{-2} \), which we rescale to our best values \( B(\psi(2S) \to \mu^+\mu^-) = (8.0 \pm 0.6) \times 10^{-3}, B(J/\psi(1S) \to \mu^+\mu^-) = (5.961 \pm 0.033) \times 10^{-2} \). Our first error is their experiment’s error and our second error is the systematic error from using our best values.

\[ \Gamma(\chi_{c0}(1P) \text{ anything})/\Gamma(\eta_c(1S) \text{ anything}) \]

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 0.33 \pm 0.06 \pm 0.05 )</td>
<td>AAII 17BB</td>
<td>LHCB</td>
<td>( pp ) at 7, 8 TeV</td>
</tr>
</tbody>
</table>

AAII 17BB reports \( [\Gamma(\bar{b} \to \chi_{c0}(1P) \text{ anything})/\Gamma(\bar{b} \to \eta_c(1S) \text{ anything})] / [B(\eta_c(1S) \to \phi \phi)] \times [B(\chi_{c0}(1P) \to \phi \phi)] = 0.147 \pm 0.023 \pm 0.011 \) which we multiply or divide by our best values \( B(\eta_c(1S) \to \phi \phi) = (1.77 \pm 0.19) \times 10^{-3}, B(\chi_{c0}(1P) \to \phi \phi) = (8.0 \pm 0.7) \times 10^{-4} \). Our first error is their experiment’s error and our second error is the systematic error from using our best values.

\[ \Gamma(\chi_{c1}(1P) \text{ anything})/\Gamma_{\text{total}} \]

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 0.014 \pm 0.004 ) OUR AVERAGE</td>
<td>1 ABREU 94P</td>
<td>DLP</td>
<td>( e^+e^- \to Z )</td>
</tr>
<tr>
<td>( 0.019 \pm 0.007 \pm 0.001 )</td>
<td>2 ADRIANI 93J</td>
<td>L3</td>
<td>( e^+e^- \to Z )</td>
</tr>
</tbody>
</table>

1 ABREU 94P reports \( 0.014 \pm 0.006^{+0.004}_{-0.002} \) from a measurement of \( [\Gamma(\bar{b} \to \chi_{c1}(1P) \text{ anything})/\Gamma_{\text{total}}] \times [B(\chi_{c1}(1P) \to \gamma J/\psi(1S))] \) assuming \( B(\chi_{c1}(1P) \to \gamma J/\psi(1S)) = 0.273 \pm 0.016 \), which we rescale to our best value \( B(\chi_{c1}(1P) \to \gamma J/\psi(1S)) = (34.3 \pm 1.0) \times 10^{-2} \). 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 \( \Gamma(Z \to b\bar{b})/\Gamma_{\text{hadron}}=0.22 \).

2 ADRIANI 93J reports \( 0.024 \pm 0.009 \pm 0.002 \) from a measurement of \( [\Gamma(\bar{b} \to \chi_{c1}(1P) \text{ anything})/\Gamma_{\text{total}}] \times [B(\chi_{c1}(1P) \to \gamma J/\psi(1S))] \) assuming \( B(\chi_{c1}(1P) \to \gamma J/\psi(1S)) = 0.273 \pm 0.016 \), which we rescale to our best value \( B(\chi_{c1}(1P) \to \gamma J/\psi(1S)) = (34.3 \pm 1.0) \times 10^{-2} \). Our first error is their experiment’s error and our second error is the systematic error from using our best value.

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

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \cdot \cdot \cdot ) We do not use the following data for averages, fits, limits, etc. ( \cdot \cdot \cdot )</td>
<td>1 ADRIANI 93J</td>
<td>L3</td>
<td>( e^+e^- \to Z )</td>
</tr>
</tbody>
</table>

1 ADRIANI 93J is a ratio of inclusive measurements from \( b \) decays at the \( Z \) using only the \( J/\psi(1S) \to \mu^+\mu^- \) channel since some systematics cancel.
\[
\Gamma(\chi_{c1}(1P)\text{anything})/\Gamma(\chi_{c0}(1P)\text{anything}) \quad \Gamma_{53}/\Gamma_{52}
\]

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.96 ± 0.21 ± 0.15</td>
<td>AAIJ</td>
<td>17BB LHCb</td>
<td>pp at 7, 8 TeV</td>
</tr>
</tbody>
</table>

1 AAIJ 17BB reports \( \Gamma(\bar{b} \rightarrow \chi_{c1}(1P)\text{anything})/\Gamma(\bar{b} \rightarrow \chi_{c0}(1P)\text{anything}) \) / \( [B(\chi_{c1}(1P) \rightarrow \phi \phi)] \times [B(\chi_{c2}(1P) \rightarrow \phi \phi)] = 0.50 ± 0.11 ± 0.01 \) which we multiply or divide by our best values \( B(\chi_{c0}(1P) \rightarrow \phi \phi) = (8.0 ± 0.7) \times 10^{-4} \), \( B(\chi_{c1}(1P) \rightarrow \phi \phi) = (4.2 ± 0.5) \times 10^{-4} \). Our first error is their experiment’s error and our second error is the systematic error from using our best values.

\[
\Gamma(\chi_{c2}(1P)\text{anything})/\Gamma(\chi_{c0}(1P)\text{anything}) \quad \Gamma_{54}/\Gamma_{52}
\]

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.42 ± 0.08 ± 0.05</td>
<td>AAIJ</td>
<td>17BB LHCb</td>
<td>pp at 7, 8 TeV</td>
</tr>
</tbody>
</table>

1 AAIJ 17BB reports \( \Gamma(\bar{b} \rightarrow \chi_{c2}(1P)\text{anything})/\Gamma(\bar{b} \rightarrow \chi_{c0}(1P)\text{anything}) \) / \( [B(\chi_{c1}(1P) \rightarrow \phi \phi)] \times [B(\chi_{c2}(1P) \rightarrow \phi \phi)] = 0.56 ± 0.10 ± 0.01 \) which we multiply or divide by our best values \( B(\chi_{c0}(1P) \rightarrow \phi \phi) = (8.0 ± 0.7) \times 10^{-4} \), \( B(\chi_{c1}(1P) \rightarrow \phi \phi) = (4.2 ± 0.5) \times 10^{-4} \). Our first error is their experiment’s error and our second error is the systematic error from using our best values.

\[
\Gamma(\chi_{c2}(1P)\text{anything})/\Gamma(\eta_{c}(1S)\text{anything}) \quad \Gamma_{54}/\Gamma_{56}
\]

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.135 ± 0.023 ± 0.018</td>
<td>AAIJ</td>
<td>17BB LHCb</td>
<td>pp at 7, 8 TeV</td>
</tr>
</tbody>
</table>

1 AAIJ 17BB reports \( \Gamma(\bar{b} \rightarrow \chi_{c2}(1P)\text{anything})/\Gamma(\bar{b} \rightarrow \chi_{c0}(1P)\text{anything}) \) / \( [B(\chi_{c1}(1P) \rightarrow \phi \phi)] \times [B(\chi_{c2}(1P) \rightarrow \phi \phi)] = 0.081 ± 0.013 ± 0.005 \) which we multiply or divide by our best values \( B(\eta_{c}(1S) \rightarrow \phi \phi) = (1.77 ± 0.19) \times 10^{-3} \), \( B(\chi_{c2}(1P) \rightarrow \phi \phi) = (1.06 ± 0.09) \times 10^{-3} \). Our first error is their experiment’s error and our second error is the systematic error from using our best values.

\[
\Gamma(\chi_{c}(2P)\text{anything}, \chi_{c} \rightarrow \phi \phi)/\Gamma_{\text{total}} \quad \Gamma_{55}/\Gamma
\]

<table>
<thead>
<tr>
<th>VALUE</th>
<th>CL%</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;2.8 × 10^{-7}</td>
<td>95</td>
<td>AAIJ</td>
<td>17BB LHCb</td>
<td>pp at 7, 8 TeV</td>
</tr>
</tbody>
</table>

\[
\Gamma(\eta_{c}(2S)\text{anything}, \eta_{c} \rightarrow \phi \phi)/\Gamma(\eta_{c}(1S)\text{anything}) \quad \Gamma_{57}/\Gamma_{56}
\]

<table>
<thead>
<tr>
<th>VALUE (units 10^{-5})</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1 ± 2.1 ± 0.8</td>
<td>AAIJ</td>
<td>17BB LHCb</td>
<td>pp at 7, 8 TeV</td>
</tr>
</tbody>
</table>

1 AAIJ 17BB reports \( \Gamma(\bar{b} \rightarrow \eta_{c}(2S)\text{anything}, \eta_{c} \rightarrow \phi \phi)/\Gamma(\bar{b} \rightarrow \eta_{c}(1S)\text{anything}) \) / \( [B(\eta_{c}(1S) \rightarrow \phi \phi)] = 0.040 ± 0.011 ± 0.004 \) which we multiply by our best value \( B(\eta_{c}(1S) \rightarrow \phi \phi) = (1.77 ± 0.19) \times 10^{-3} \). Our first error is their experiment’s error and our second error is the systematic error from using our best value.
\[ \Gamma(\chi_{c1}(3872) \text{anything}, \chi_{c1} \rightarrow \phi \phi) / \Gamma_{\text{total}} \]

<table>
<thead>
<tr>
<th>Value</th>
<th>CL%</th>
</tr>
</thead>
<tbody>
<tr>
<td>( &lt; 4.5 \times 10^{-7} )</td>
<td>95</td>
</tr>
</tbody>
</table>

**Comment:**

pp at 7, 8 TeV

\[ \Gamma(\chi(3915) \text{anything}, X \rightarrow \phi \phi) / \Gamma_{\text{total}} \]

<table>
<thead>
<tr>
<th>Value</th>
<th>CL%</th>
</tr>
</thead>
<tbody>
<tr>
<td>( &lt; 3.1 \times 10^{-7} )</td>
<td>95</td>
</tr>
</tbody>
</table>

**Comment:**

pp at 7, 8 TeV

\[ \Gamma(\pi \gamma) / \Gamma_{\text{total}} \]

<table>
<thead>
<tr>
<th>Value (units ( 10^{-4} ))</th>
<th>CL%</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 3.11 \pm 0.80 \pm 0.72 )</td>
<td></td>
<td>1 BARATE</td>
<td>98i</td>
<td>ALEP</td>
</tr>
</tbody>
</table>

- We do not use the following data for averages, fits, limits, etc. 
- BARATE 98i uses lifetime tagged \( Z \rightarrow b \bar{b} \) sample.
- ADAM 96D assumes \( f_{B^0} = f_{B^-} = 0.39 \) and \( f_{B^+} = 0.12 \).
- ADRIANI 93L result is for \( b \rightarrow \pi \gamma \) is performed inclusively.

\[ \Gamma(\pi \nu \nu) / \Gamma_{\text{total}} \]

<table>
<thead>
<tr>
<th>Value</th>
<th>CL%</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( &lt; 6.4 \times 10^{-4} )</td>
<td>90</td>
<td>1 BARATE</td>
<td>01E</td>
<td>ALEP</td>
</tr>
</tbody>
</table>

1 The energy-flow and \( b \)-tagging algorithms were used.

\[ \Gamma(K^{\pm} \text{anything}) / \Gamma_{\text{total}} \]

<table>
<thead>
<tr>
<th>Value</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 0.74 \pm 0.06 ) OUR AVERAGE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( 0.72 \pm 0.02 \pm 0.06 )</td>
<td>BARATE</td>
<td>98v</td>
<td>ALEP</td>
</tr>
<tr>
<td>( 0.88 \pm 0.05 \pm 0.18 )</td>
<td>ABREU</td>
<td>95c</td>
<td>DLPH</td>
</tr>
</tbody>
</table>

\[ \Gamma(K_S^{0} \text{anything}) / \Gamma_{\text{total}} \]

<table>
<thead>
<tr>
<th>Value</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 0.290 \pm 0.011 \pm 0.027 )</td>
<td>ABREU</td>
<td>95c</td>
<td>DLPH</td>
</tr>
</tbody>
</table>

\[ \Gamma(\pi^{\pm} \text{anything}) / \Gamma_{\text{total}} \]

<table>
<thead>
<tr>
<th>Value</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 3.97 \pm 0.02 \pm 0.21 )</td>
<td>BARATE</td>
<td>98v</td>
<td>ALEP</td>
</tr>
</tbody>
</table>

\[ \Gamma(\pi^0 \text{anything}) / \Gamma_{\text{total}} \]

<table>
<thead>
<tr>
<th>Value</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 2.78 \pm 0.15 \pm 0.60 )</td>
<td>1 ADAM</td>
<td>96</td>
<td>DLPH</td>
</tr>
</tbody>
</table>

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

\[ \Gamma(\phi \text{anything}) / \Gamma_{\text{total}} \]

<table>
<thead>
<tr>
<th>Value</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 0.0282 \pm 0.0013 \pm 0.0019 )</td>
<td>ABBIENDI</td>
<td>00Z</td>
<td>OPAL</td>
</tr>
</tbody>
</table>
### Averages, Fits, Limits, etc.

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

### Average Branching Fraction of Weakly Decaying Hadrons

- **\( \Gamma(\rho/\pi \text{anything})/\Gamma_{\text{total}} \)\(^{\Gamma_{67}}\)**
  - **VALUE**
    - 0.131 ± 0.011 **OUR AVERAGE**
  - **DOCUMENT ID**
    - BARATE 98V ALEP
  - **TECN**
    - e\(^+\) e\(^-\) \(\rightarrow\) Z
  - **COMMENT**

- **\( \Gamma(\Lambda/\Xi \text{anything})/\Gamma_{\text{total}} \)\(^{\Gamma_{68}}\)**
  - **VALUE**
    - 0.059 ± 0.006 **OUR AVERAGE**
  - **DOCUMENT ID**
    - ACKERSTAFF 97N OPAL
  - **TECN**
    - e\(^+\) e\(^-\) \(\rightarrow\) Z
  - **COMMENT**

- **\( \Gamma(b\text{-baryon anything})/\Gamma_{\text{total}} \)\(^{\Gamma_{69}}\)**
  - **VALUE**
    - 0.102 ± 0.007 ± 0.027
  - **DOCUMENT ID**
    - BARATE 98V ALEP
  - **TECN**
    - e\(^+\) e\(^-\) \(\rightarrow\) Z
  - **COMMENT**

- **\( \Gamma(\Xi^+_b \text{anything})/\Gamma(\Xi^0_b \text{anything}) \)\(^{\Gamma_{71}}\)**
  - **VALUE (units 10\(^{-2}\))**
    - 7.3 ± 1.7 **OUR AVERAGE**
  - **DOCUMENT ID**
    - AAIIJ 19AB LHC
  - **TECN**
    - pp at 7 and 8 TeV

### Charged Hadrons

- **\( \Gamma(\text{charged anything})/\Gamma_{\text{total}} \)\(^{\Gamma_{72}}\)**
  - **VALUE**
    - 4.97 ± 0.03 ± 0.06
  - **DOCUMENT ID**
    - ABREU 98H DLPH
  - **TECN**
    - e\(^+\) e\(^-\) \(\rightarrow\) Z

- **\( \Gamma(\text{hadron}^+ \text{hadron}^-)/\Gamma_{\text{total}} \)\(^{\Gamma_{73}}\)**
  - **VALUE (units 10\(^{-5}\))**
    - 1.7 ± 1.0 ± 0.2
  - **DOCUMENT ID**
    - BUSKULIC 96V ALEP
  - **TECN**
    - e\(^+\) e\(^-\) \(\rightarrow\) Z

### Charmless Hadrons

- **\( \Gamma(\text{charmless})/\Gamma_{\text{total}} \)\(^{\Gamma_{74}}\)**
  - **VALUE**
    - 0.007 ± 0.021
  - **DOCUMENT ID**
    - ABREU 98D DLPH
  - **TECN**
    - e\(^+\) e\(^-\) \(\rightarrow\) Z

---

**Citation:** P.A. Zyla et al. (Particle Data Group), Prog. Theor. Exp. Phys. **2020**, 083C01 (2020)

**HTTP://PDG.LBL.GOV**

Page 22    Created: 6/1/2020 08:33
$\Gamma(\mu^+\mu^-\text{anything})/\Gamma_{\text{total}}$
Test for $\Delta B = 1$ weak neutral current.

<table>
<thead>
<tr>
<th>VALUE</th>
<th>CL%</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$&lt;3.2 \times 10^{-4}$</td>
<td>90</td>
<td>ABBOTT 98B</td>
<td>D0</td>
<td>$p\bar{p}$ 1.8 TeV</td>
</tr>
<tr>
<td>$&lt;5.0 \times 10^{-5}$</td>
<td>90</td>
<td>ALBAJAR 91c</td>
<td>UA1</td>
<td>$E_{cm}^{\Pi_b} = 630$ GeV</td>
</tr>
<tr>
<td>$&lt;0.02$</td>
<td>95</td>
<td>ALTHOFF 84G</td>
<td>TASS</td>
<td>$E_{cm}^{ee} = 34.5$ GeV</td>
</tr>
<tr>
<td>$&lt;0.007$</td>
<td>95</td>
<td>ADEVA 83</td>
<td>MRKJ</td>
<td>$E_{cm}^{\pi\pi} = 30$–38 GeV</td>
</tr>
<tr>
<td>$&lt;0.007$</td>
<td>95</td>
<td>BARTEL 83B</td>
<td>JADE</td>
<td>$E_{cm}^{\pi\pi} = 33$–37 GeV</td>
</tr>
</tbody>
</table>

1 Both ABBOTT 98B and GLENN 98 claim that the efficiency quoted in ALBAJAR 91c was overestimated by a large factor.

$\left[\Gamma(e^+e^-\text{anything}) + \Gamma(\mu^+\mu^-\text{anything})\right]/\Gamma_{\text{total}}$  
($\Gamma_{75} + \Gamma_{76}$)/$\Gamma$
Test for $\Delta B = 1$ weak neutral current.

<table>
<thead>
<tr>
<th>VALUE</th>
<th>CL%</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$&lt;0.008$</td>
<td>90</td>
<td>MATTEUZZI 83</td>
<td>MRK2</td>
<td>$E_{cm}^{\pi\pi} = 29$ GeV</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>VALUE</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$&lt;3.9 \times 10^{-4}$</td>
<td>1 GROSSMAN 96</td>
<td>RVUE</td>
<td>$e^+\nu\rightarrow Z$</td>
</tr>
</tbody>
</table>
1 GROSSMAN 96 limit is derived from the ALEPH BUSKULIC 95 limit $B(B^+ \rightarrow \tau^+\nu_\tau)$

$\chi_b$ AT HIGH ENERGY

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

$\chi_b$ is the average $B^0$-$\bar{B}^0$ 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 $\bar{B}^0$ 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 https://hfag.web.cern.ch/.

The averaging/rescaling procedure takes into account correlations between the measurements.

<table>
<thead>
<tr>
<th>VALUE</th>
<th>EVTS</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.1284 \pm 0.0069$ OUR EVALUATION</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$0.129 \pm 0.004$ OUR AVERAGE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$0.132 \pm 0.001 \pm 0.024$</td>
<td>1 ABAZOV 06S</td>
<td>D0</td>
<td>$p\bar{p}$ at 1.96 TeV</td>
<td></td>
</tr>
<tr>
<td>$0.152 \pm 0.007 \pm 0.011$</td>
<td>2 ACOSTA 04A</td>
<td>CDF</td>
<td>$p\bar{p}$ at 1.8 TeV</td>
<td></td>
</tr>
<tr>
<td>$0.1312 \pm 0.0049 \pm 0.0042$</td>
<td>3 ABBIENDI 03P</td>
<td>OPAL</td>
<td>$e^+e^- \rightarrow Z$</td>
<td></td>
</tr>
<tr>
<td>$0.127 \pm 0.013 \pm 0.006$</td>
<td>4 ABREU 01L</td>
<td>DLPH</td>
<td>$e^+e^- \rightarrow Z$</td>
<td></td>
</tr>
<tr>
<td>$0.1192 \pm 0.0068 \pm 0.0051$</td>
<td>5 ACCIARRI 99D</td>
<td>L3</td>
<td>$e^+e^- \rightarrow Z$</td>
<td></td>
</tr>
</tbody>
</table>
We do not use the following data for averages, fits, limits, etc. • • •

0.121 ± 0.016 ± 0.006
0.114 ± 0.014 ± 0.008
0.129 ± 0.022
0.176 ± 0.031 ± 0.032
0.148 ± 0.029 ± 0.017

0.131 ± 0.020 ± 0.016
0.1107 ± 0.0062 ± 0.0055
0.136 ± 0.037 ± 0.040
0.144 ± 0.014 -0.017 -0.011
0.131 ± 0.014
0.123 ± 0.012 ± 0.008
0.157 ± 0.020 ± 0.032
0.121 ± 0.044 0.040 ± 0.017 1665
0.143 +0.022 -0.021 ± 0.007
0.145 +0.041 -0.035 ± 0.018
0.121 ± 0.017 ± 0.006
0.132 ± 0.22 ± 0.015 ± 0.012 823
0.178 +0.049 -0.040 ± 0.020
0.17 +0.15 -0.08
0.21 +0.29 -0.15
>0.02 at 90% CL
0.121 ± 0.047

<0.12 at 90% CL

1Uses the dimuon charge asymmetry. Averaged over the mix of b-flavored hadrons.
2Measurement performed using events containing a dimuon or an e/μ pair.
3The average B mixing parameter is determined simultaneously with b and c forward-backward asymmetries in the fit.
4The experimental systematic and model uncertainties are combined in quadrature.
5ACCIARRI 99D uses maximum-likelihood fits to extract χ_b as well as the A_FB^b in Z → b̅b events containing prompt leptons.
6This ABREU 94J result is from 5182 ℓℓ and 279 Aℓ events. The systematic error includes 0.004 for model dependence.
7BUSKULIC 94G data analyzed using ee, eμ, and μμ events.
8BUSKULIC 92B uses a jet charge technique combined with electrons and muons.
9ABE 91G measurement of χ is done with eμ and ee events.
10ALBAJAR 91D measurement of χ is done with dimuons.
11Uses di-muon events.
12ALEXANDER 96 uses a maximum likelihood fit to simultaneously extract χ as well as the forward-backward asymmetries in e^+ e^- → Z → b̅b and c̅c.
13UENO 96 extracted χ from the energy dependence of the forward-backward asymmetry.
14 ABREU 94f uses the average electric charge sum of the jets recoiling against a $b$-quark jet tagged by a high $\mathcal{P}_T$ muon. The result is for $\chi = f_d \chi_d + 0.9 f_s \chi_s$.

15 This ABREU 94( result combines $\ell \ell$, $\Lambda\ell$, and jet-charge $\ell$ (ABREU 94f) analyses. It is for $\chi = f_d \chi_d + 0.96 f_s \chi_s$.

16 ALBAJAR 94 uses dimuon events. Not independent of ALBAJAR 91D.

17 ABREU 93c data analyzed using $ee$, $e\mu$, and $\mu\mu$ events.

18 AKERS 93b analysis performed using dilepton events.

19 ACTON 92c uses electrons and muons. Superseded by AKERS 93b.

20 ADEVA 92c uses electrons and muons.

21 DECAMP 91 done with opposite and like-sign dileptons. Superseded by BUSKULIC 92b.

22 ADEVA 90p measurement uses $ee$, $\mu\mu$, and $e\mu$ events from 118k events at the $Z$. Superseded by ADEVA 92c.

23 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.

24 The WEIR 90 measurement supersedes the limit obtained in SCHAAD 85. The 90% CL are 0.06 and 0.38.

25 ALBAJAR 87c measured $\chi = (B^0 \rightarrow B^0 \rightarrow \mu^+ \chi)$ divided by the average production weighted semileptonic branching fraction for $B$ hadrons at 546 and 630 GeV.

26 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.

<table>
<thead>
<tr>
<th>VALUE (units $10^{-3}$)</th>
<th>DOCUMENT ID</th>
<th>TECN</th>
<th>COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$-6.2 \pm 5.2 \pm 4.7$</td>
<td>1 AABOUD 17e</td>
<td>ATLS</td>
<td>$pp$ at 8 TeV</td>
</tr>
<tr>
<td>$-1.24 \pm 0.38 \pm 0.18$</td>
<td>2 ABAZOV 14</td>
<td>D0</td>
<td>$p\mathcal{P}$ at 1.96 TeV</td>
</tr>
<tr>
<td>$-1.97 \pm 0.43 \pm 0.23$</td>
<td>3 ABAZOV 11u</td>
<td>D0</td>
<td>Repl. by ABAZOV 14</td>
</tr>
<tr>
<td>$-2.39 \pm 0.63 \pm 0.37$</td>
<td>4 ABAZOV 10h</td>
<td>D0</td>
<td>Repl. by ABAZOV 11u</td>
</tr>
</tbody>
</table>

1 AABOUD 17e reports a measurement of charge asymmetry of $A_{SL}^b = (-25 \pm 21 \pm 19) \times 10^{-3}$ in lepton + jets $t\mathcal{P}$ events in which a $b$-hadron decays semileptonically to a soft muon.

2 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.

3 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.

4 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 $B^0_d$ and $B^0_s$, and the asymmetry of $B^0_d A_{SL}^d = (-4.7 \pm 4.6) \times 10^{-3}$ measured from $B$-factories, they obtain the asymmetry for $B^0_s$ as $A_{SL}^s = (-14.6 \pm 7.5) \times 10^{-3}$. 

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HTTP://PDG.LBL.GOV
\textbf{B-HADRON PRODUCTION FRACTIONS IN }\bar{p}p\textbf{ COLLISIONS AT Tevatron}

The production fractions for \( b \)-hadrons in \( \bar{p}p \) 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 (HFLAV) (see https://hflav.web.cern.ch/).

The values reported below assume:

\[
\begin{align*}
 f(\bar{B} \to \bar{B}^+) &= f(\bar{B} \to \bar{B}^0) \\
 f(\bar{B} \to \bar{B}^+) + f(\bar{B} \to \bar{B}^0) &= f(\bar{B} \to \bar{B}^0_s) + f(b \to b\text{-}baryon) = 1 \\
\end{align*}
\]

The values are:

\[
\begin{align*}
 f(\bar{B} \to \bar{B}^+) &= f(\bar{B} \to \bar{B}^0) = 0.344 \pm 0.021 \\
 f(\bar{B} \to \bar{B}^0_s) &= 0.115 \pm 0.013 \\
 f(b \to b\text{-}baryon) &= 0.198 \pm 0.046 \\
 f(\bar{B} \to \bar{B}^0_s) / f(\bar{B} \to \bar{B}^0) &= 0.334 \pm 0.041 \\
\end{align*}
\]

and their correlation coefficients are:

\[
\begin{align*}
 \text{cor}(\bar{B}^0_s, b\text{-}baryon) &= -0.429 \\
 \text{cor}(\bar{B}^0_s, \bar{B}^+ = B^0) &= +0.159 \\
 \text{cor}(b\text{-}baryon, \bar{B}^+ = B^0) &= -0.960 \\
\end{align*}
\]

as obtained with the Tevatron average of time-integrated mixing parameter \( \chi = 0.147 \pm 0.011 \).

\section*{PRODUCTION ASYMMETRIES}

\[
A^{b\bar{B}}_{C} = \frac{[N(\Delta y > 0) - N(\Delta y < 0)]}{[N(\Delta y > 0) + N(\Delta y < 0)]} \text{ with } \Delta y = |y_b| - |y_{\bar{B}}|
\]

where \( y_b, \bar{B} \) is rapidity of \( b \) or \( \bar{B} \) quarks.

\begin{table}
\centering
\begin{tabular}{l|c|c|c}
\hline
VALUE (units \( 10^{-2} \)) & DOCUMENT ID & TECN & COMMENT \\
\hline
Average is meaningless. & & & \\
0.4 \pm 0.4 \pm 0.3 & 1 & AAIJ & 14AS LHCb \( pp \) at 7 TeV \\
2.0 \pm 0.9 \pm 0.6 & 2 & AAIJ & 14AS LHCb \( pp \) at 7 TeV \\
1.6 \pm 1.7 \pm 0.6 & 3 & AAIJ & 14AS LHCb \( pp \) at 7 TeV \\
\hline
\end{tabular}
\end{table}

1 Measured for \( 40 < M(b\bar{B}) < 75 \text{ GeV/c}^2 \).

2 Measured for \( 75 < M(b\bar{B}) < 105 \text{ GeV/c}^2 \).

3 Measured for \( M(b\bar{B}) > 105 \text{ GeV/c}^2 \).

\section*{\( B^\pm /B^0 /B^0_s /b\text{-}baryon ADMIXTURE REFERENCES}

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Citation: P.A. Zyla et al. (Particle Data Group), Prog. Theor. Exp. Phys. \textbf{2020}, 083C01 (2020)
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