# $B_c^\pm$

$I(J^P) = 0(0^-)$
$I, J, P$ need confirmation.

Quantum numbers shown are quark-model predictions.

## $B_c^\pm$ MASS

| VALUE (GeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **6.277 ±0.006 OUR AVERAGE** | Error includes scale factor of 1.6. | | | |
| 6.2756±0.0029±0.0025 | [1] AALTONEN | 08M | CDF | $p\overline{p}$ at 1.96 TeV |
| 6.300 ±0.014 ±0.005 | [1] ABAZOV | 08T | D0 | $p\overline{p}$ at 1.96 TeV |
| 6.4 ±0.39 ±0.13 | [2] ABE | 98M | CDF | $p\overline{p}$ at 1.8 TeV |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 6.2857±0.0053±0.0012 | [1] ABULENCIA | 06C | CDF | Repl. by AALTONEN 08M |
| 6.32 ±0.06 | [3] ACKERSTAFF | 98O | OPAL | $e^+e^- \rightarrow Z$ |

[1] Measured using a fully reconstructed decay mode of $B_c \rightarrow J/\psi\pi$.

[2] ABE 98M observed $20.4^{+6.2}_{-5.5}$ events in the $B_c^+ \rightarrow J/\psi(1s)\ell\nu_\ell$ with a significance of $> 4.8$ standard deviations. The mass value is estimated from $m(J/\psi(1S)\ell)$.

[3] ACKERSTAFF 98O observed 2 candidate events in the $B_c \rightarrow J/\psi(1S)\pi^+$ channel with an estimated background of $0.63 \pm 0.20$ events.

## $B_c^\pm$ 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.

| VALUE ($10^{-12}$ s) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **0.453±0.041 OUR EVALUATION** | | | | |
| **0.45 ±0.04 OUR AVERAGE** | | | | |
| $0.448^{+0.038}_{-0.036}\pm0.032$ | [4] ABAZOV | 09H | D0 | $p\overline{p}$ at 1.96 TeV |
| $0.463^{+0.073}_{-0.065}\pm0.036$ | [5] ABULENCIA | 06O | CDF | $p\overline{p}$ at 1.96 TeV |
| $0.46^{+0.18}_{-0.16}\pm0.03$ | [5] ABE | 98M | CDF | $p\overline{p}$ 1.8 TeV |

[4] The lifetime is measured from the $J/\psi\mu$ decay vertices.

[5] The lifetime is measured from the $J/\psi e$ decay vertices.

## $B_c^+$ DECAY MODES × B($\overline{b} \rightarrow B_c$)

$B_c^-$ modes are charge conjugates of the modes below.

| Mode | Fraction ($\Gamma_i/\Gamma$) | Confidence level |
|---|---|---|

The following quantities are not pure branching ratios; rather the fraction $\Gamma_i/\Gamma \times B(\overline{b} \to B_c)$.

| | | | | |
|---|---|---|---|---|
| $\Gamma_1$ | $J/\psi(1S)\ell^+\nu_\ell$anything | $(5.2^{+2.4}_{-2.1}) \times 10^{-5}$ | | |
| $\Gamma_2$ | $J/\psi(1S)\pi^+$ | $< 8.2$ | $\times 10^{-5}$ | 90% |
| $\Gamma_3$ | $J/\psi(1S)\pi^+\pi^+\pi^-$ | $< 5.7$ | $\times 10^{-4}$ | 90% |
| $\Gamma_4$ | $J/\psi(1S)a_1(1260)$ | $< 1.2$ | $\times 10^{-3}$ | 90% |
| $\Gamma_5$ | $D^*(2010)^+\overline{D}^0$ | $< 6.2$ | $\times 10^{-3}$ | 90% |

## $B_c^+$ BRANCHING RATIOS

### $\Gamma(J/\psi(1S)\ell^+\nu_\ell\text{anything})/\Gamma_{\text{total}} \times B(\overline{b} \to B_c)$ — $\Gamma_1/\Gamma \times B$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$(5.2^{+2.4}_{-2.1}) \times 10^{-5}$** | | [6] ABE | 98M | CDF | $p\overline{p}$ 1.8 TeV |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $< 1.6 \times 10^{-4}$ | 90 | [7] ACKERSTAFF | 98O | OPAL | $e^+e^- \to Z$ |
| $< 1.9 \times 10^{-4}$ | 90 | [8] ABREU | 97E | DLPH | $e^+e^- \to Z$ |
| $< 1.2 \times 10^{-4}$ | 90 | [9] BARATE | 97H | ALEP | $e^+e^- \to Z$ |

[6] ABE 98M result is derived from the measurement of $[\sigma(B_c)\times B(B_c \to J/\psi(1S)\ell\nu_\ell)]$ / $[\sigma(B^+)\times B(B^+ \to J/\psi(1S)K^+)] = 0.132^{+0.041}_{-0.037}(\text{stat})\pm0.031(\text{sys})^{+0.032}_{-0.020}(\text{lifetime})$ by using PDG 98 values of $B(b \to B^+)$ and $B(B^+ \to J/\psi(1S)K^+)$.

[7] ACKERSTAFF 98O reports $B(Z \to B_c X)/B(Z \to q q)\times B(B_c \to J/\psi(1S)\ell\nu_\ell) < 6.95 \times 10^{-5}$ at 90%CL. We rescale to our PDG 98 values of $B(Z \to b\overline{b})$.

[8] ABREU 97E value listed is for an assumed $\tau_{B_c} = 0.4$ ps and improves to $1.6 \times 10^{-4}$ for $\tau_{B_c} = 1.4$ ps.

[9] BARATE 97H reports $B(Z \to B_c X)/B(Z \to q q)\cdot B(B_c \to J/\psi(1S)\ell\nu_\ell) < 5.2\times10^{-5}$ at 90%CL. We rescale to our PDG 96 values of $B(Z \to b\overline{b})$. A $B_c^+ \to J/\psi(1S)\mu^+\nu_\mu$ candidate event is found, compared to all the known background sources $2 \times 10^{-3}$, which gives $m_{B_c} = 5.96^{+0.25}_{-0.19}$ GeV and $\tau_{B_c} = 1.77 \pm 0.17$ ps.

### $\Gamma(J/\psi(1S)\pi^+)/\Gamma_{\text{total}} \times B(\overline{b} \to B_c)$ — $\Gamma_2/\Gamma \times B$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$<8.2 \times 10^{-5}$** | 90 | [10] BARATE | 97H | ALEP | $e^+e^- \to Z$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $<2.4 \times 10^{-4}$ | 90 | [11] ACKERSTAFF | 98O | OPAL | $e^+e^- \to Z$ |
| $<3.4 \times 10^{-4}$ | 90 | [12] ABREU | 97E | DLPH | $e^+e^- \to Z$ |
| $<2.0 \times 10^{-5}$ | 95 | [13] ABE | 96R | CDF | $p\overline{p}$ 1.8 TeV |

[10] BARATE 97H reports $B(Z \to B_c X)/B(Z \to q q)\cdot B(B_c \to J/\psi(1S)\pi) < 3.6 \times 10^{-5}$ at 90%CL. We rescale to our PDG 96 values of $B(Z \to b\overline{b})$.

[11] ACKERSTAFF 98O reports $B(Z \to B_c X)/B(Z \to q q)\times B(B_c \to J/\psi(1S)\pi^+) < 1.06 \times 10^{-4}$ at 90%CL. We rescale to our PDG 98 values of $B(Z \to b\overline{b})$.

[12] ABREU 97E value listed is for an assumed $\tau_{B_c} = 0.4$ ps and improves to $2.7 \times 10^{-4}$ for $\tau_{B_c} = 1.4$ ps.

[13] ABE 96R reports $B(b \to B_c X)/B(b \to B^+ X) \cdot B(B_c^+ \to J/\psi(1S)\pi^+)/B(B^+ \to J/\psi(1S) K^+) < 0.053$ at 95%CL for $\tau_{B_c} = 0.8$ ps. It changes from 0.15 to 0.04 for 0.17 ps$< \tau_{B_c} < 1.6$ ps. We rescale to our PDG 96 values of $B(b \to B^+) = 0.378 \pm 0.022$ and $B(B^+ \to J/\psi(1S) K^+) = 0.00101 \pm 0.00014$.

### $\Gamma(J/\psi(1S)\pi^+\pi^+\pi^-)/\Gamma_{total} \times B(\overline{b} \to B_c)$ — $\Gamma_3/\Gamma \times B$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<5.7 × 10^−4** | 90 | [14] ABREU | 97E | DLPH | $e^+ e^- \to Z$ |

[14] ABREU 97E value listed is independent of 0.4 ps$< \tau_{B_c} < 1.4$ ps.

### $\Gamma(J/\psi(1S) a_1(1260))/\Gamma_{total} \times B(\overline{b} \to B_c)$ — $\Gamma_4/\Gamma \times B$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<1.2 × 10^−3** | 90 | [15] ACKERSTAFF | 98O | OPAL | $e^+ e^- \to Z$ |

[15] ACKERSTAFF 98O reports $B(Z \to B_c X)/B(Z \to q q) \times B(B_c \to J/\psi(1S) a_1(1260)) < 5.29 \times 10^{-4}$ at 90%CL. We rescale to our PDG 98 values of $B(Z \to b\overline{b})$.

### $\Gamma(D^*(2010)^+ \overline{D}^0)/\Gamma_{total} \times B(\overline{b} \to B_c)$ — $\Gamma_5/\Gamma \times B$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<6.2 × 10^−3** | 90 | [16] BARATE | 98Q | ALEP | $e^+ e^- \to Z$ |

[16] BARATE 98Q reports $B(Z \to B_c X) \times B(B_c \to D^*(2010)^+ \overline{D}^0) < 1.9 \times 10^{-3}$ at 90%CL. We rescale to our PDG 98 values of $B(Z \to b\overline{b})$.

## $B_c^\pm$ REFERENCES


| | | | | |
|---|---|---|---|---|
| ABAZOV | 09H | PRL 102 092001 | V.M. Abazov et al. | (D0 Collab.) |
| AALTONEN | 08M | PRL 100 182002 | T. Aaltonen et al. | (CDF Collab.) |
| ABAZOV | 08T | PRL 101 012001 | V.M. Abazov et al. | (D0 Collab.) |
| ABULENCIA | 06C | PRL 96 082002 | A. Abulencia et al. | (CDF Collab.) |
| ABULENCIA | 06O | PRL 97 012002 | A. Abulencia et al. | (CDF Collab.) |
| ABE | 98M | PRL 81 2432 | F. Abe et al. | (CDF Collab.) |
| Also | | PR D58 112004 | F. Abe et al. | (CDF Collab.) |
| ACKERSTAFF | 98O | PL B420 157 | K. Ackerstaff et al. | (OPAL Collab.) |
| BARATE | 98Q | EPJ C4 387 | R. Barate et al. | (ALEPH Collab.) |
| PDG | 98 | EPJ C3 1 | C. Caso et al. | |
| ABREU | 97E | PL B398 207 | P. Abreu et al. | (DELPHI Collab.) |
| BARATE | 97H | PL B402 213 | R. Barate et al. | (ALEPH Collab.) |
| ABE | 96R | PRL 77 5176 | F. Abe et al. | (CDF Collab.) |
| PDG | 96 | PR D54 1 | R. M. Barnett et al. | |