# $\chi_{c1}(3872)$

$I^G(J^{PC}) = 0^+(1^{++})$

also known as $X(3872)$

This state shows properties different from a conventional $q\overline{q}$ state. A candidate for an exotic structure. See the review on non-$q\overline{q}$ states.

First observed by CHOI 03 in $B \to K\pi^+\pi^- J/\psi(1S)$ decays as a narrow peak in the invariant mass distribution of the $\pi^+\pi^- J/\psi(1S)$ final state. Isovector hypothesis excluded by AUBERT 05B and CHOI 11.

AAIJ 13Q perform a full five-dimensional amplitude analysis of the angular correlations between the decay products in $B^+ \to \chi_{c1}(3872)K^+$ decays, where $\chi_{c1}(3872) \to J/\psi\pi^+\pi^-$ and $J/\psi \to \mu^+\mu^-$, which unambiguously gives the $J^{PC} = 1^{++}$ assignment under the assumption that the $\pi^+\pi^-$ and $J/\psi$ are in an $S$-wave. AAIJ 15AO extend this analysis with more data to limit $D$-wave contributions to $< 4\%$ at 95% CL.

See our note on "Developments in Heavy Quarkonium Spectroscopy".

## $\chi_{c1}(3872)$ MASS FROM $J/\psi X$ MODE

| *VALUE* (MeV) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **3871.69± 0.17 OUR AVERAGE** | | | | | |
| 3871.9 ± 0.7 ±0.2 | 20 ± 5 | ABLIKIM | 14 | BES3 | $e^+e^- \to J/\psi\pi^+\pi^-\gamma$ |
| 3871.95± 0.48±0.12 | 0.6k | AAIJ | 12H | LHCB | $pp \to J/\psi\pi^+\pi^- X$ |
| 3871.85± 0.27±0.19 | ∼ 170 | [1] CHOI | 11 | BELL | $B \to K\pi^+\pi^- J/\psi$ |
| $3873 \; {}^{+\,1.8}_{-\,1.6}$ ±1.3 | 27 ± 8 | [2] DEL-AMO-SA. | 10B | BABR | $B \to \omega J/\psi K$ |
| 3871.61± 0.16±0.19 | 6k | [2,3] AALTONEN | 09AU | CDF2 | $p\overline{p} \to J/\psi\pi^+\pi^- X$ |
| 3871.4 ± 0.6 ±0.1 | 93.4 | AUBERT | 08Y | BABR | $B^+ \to K^+ J/\psi\pi^+\pi^-$ |
| 3868.7 ± 1.5 ±0.4 | 9.4 | AUBERT | 08Y | BABR | $B^0 \to K^0_S J/\psi\pi^+\pi^-$ |
| 3871.8 ± 3.1 ±3.0 | 522 | [2,4] ABAZOV | 04F | D0 | $p\overline{p} \to J/\psi\pi^+\pi^- X$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 3860.0 ±10.4 | 13.6 | [2,5] AGHASYAN | 18A | COMP | $\gamma^* N \to X\pi^\pm N'$ |
| 3868.6 ± 1.2 ±0.2 | 8 | [6] AUBERT | 06 | BABR | $B^0 \to K^0_S J/\psi\pi^+\pi^-$ |
| 3871.3 ± 0.6 ±0.1 | 61 | [6] AUBERT | 06 | BABR | $B^- \to K^- J/\psi\pi^+\pi^-$ |
| 3873.4 ± 1.4 | 25 | [7] AUBERT | 05R | BABR | $B^+ \to K^+ J/\psi\pi^+\pi^-$ |
| 3871.3 ± 0.7 ±0.4 | 730 | [2,8] ACOSTA | 04 | CDF2 | $p\overline{p} \to J/\psi\pi^+\pi^- X$ |
| 3872.0 ± 0.6 ±0.5 | 36 | [9] CHOI | 03 | BELL | $B \to K\pi^+\pi^- J/\psi$ |
| 3836 ±13 | 58 | [2,10] ANTONIAZZI | 94 | E705 | 300 $\pi^\pm$ Li → $J/\psi\pi^+\pi^- X$ |

[1] The mass difference for the $\chi_{c1}(3872)$ produced in $B^+$ and $B^0$ decays is $(-0.71 \pm 0.96 \pm 0.19)$ MeV.

[2] Width consistent with detector resolution.

[3] A possible equal mixture of two states with a mass difference greater than 3.6 MeV/$c^2$ is excluded at 95% CL.
[4] Calculated from the corresponding $m_{\chi_{c1}(3872)} - m_{J/\psi}$ using $m_{J/\psi}$=3096.916 MeV.
[5] Could be a different state.
[6] Calculated from the corresponding $m_{\chi_{c1}(3872)} - m_{\psi(2S)}$ using $m_{\psi(2S)}$ = 3686.093 MeV. Superseded by AUBERT 08Y.
[7] Calculated from the corresponding $m_{\chi_{c1}(3872)} - m_{\psi(2S)}$ using $m_{\psi(2S)}$ = 3685.96MeV. Superseded by AUBERT 06.
[8] Superseded by AALTONEN 09AU.
[9] Superseded by CHOI 11.
[10] A lower mass value can be due to an incorrect momentum scale for soft pions.

## $\chi_{c1}(3872)$ MASS FROM $\overline{D}^{*0} D^0$ MODE

| VALUE (MeV) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $3872.9^{+0.6}_{-0.4}{}^{+0.4}_{-0.5}$ | 50 | [1,2] AUSHEV | 10 | BELL | $B \to \overline{D}^{*0} D^0 K$ |
| $3875.1^{+0.7}_{-0.5} \pm 0.5$ | 33 ± 6 | [2] AUBERT | 08B | BABR | $B \to \overline{D}^{*0} D^0 K$ |
| $3875.2 \pm 0.7^{+0.9}_{-1.8}$ | 24 ± 6 | [2,3] GOKHROO | 06 | BELL | $B \to D^0 \overline{D}^0 \pi^0 K$ |

[1] Calculated from the measured $m_{\chi_{c1}(3872)} - m_{D^{*0}} - m_{\overline{D}^0} = 1.1^{+0.6}_{-0.4}{}^{+0.1}_{-0.3}$ MeV.
[2] Experiments report $D^{*0}\overline{D}^0$ invariant mass above $D^{*0}\overline{D}^0$ threshold because $D^{*0}$ decay products are kinematically constrained to the $D^{*0}$ mass, even though the $D^{*0}$ may decay off-shell.
[3] Superseded by AUSHEV 10.

### $m_{\chi_{c1}(3872)} - m_{J/\psi}$

| VALUE (MeV) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **774.9±3.1±3.0** | 522 | ABAZOV | 04F | D0 | $p\overline{p} \to J/\psi \pi^+ \pi^- X$ |

### $m_{\chi_{c1}(3872)} - m_{\psi(2S)}$

| VALUE (MeV) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 187.4±1.4 | 25 | [1] AUBERT | 05R | BABR | $B^+ \to K^+ J/\psi \pi^+ \pi^-$ |

[1] Superseded by AUBERT 06.

## $\chi_{c1}(3872)$ WIDTH

| VALUE (MeV) | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **<1.2** | 90 | | CHOI | 11 | BELL | $B \to K \pi^+ \pi^- J/\psi$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| <2.4 | 90 | | ABLIKIM | 14 | BES3 | $e^+ e^- \to J/\psi \pi^+ \pi^- \gamma$ |
| <3.3 | 90 | | AUBERT | 08Y | BABR | $B^+ \to K^+ J/\psi \pi^+ \pi^-$ |
| <4.1 | 90 | 69 | AUBERT | 06 | BABR | $B \to K \pi^+ \pi^- J/\psi$ |
| <2.3 | 90 | 36 | [1] CHOI | 03 | BELL | $B \to K \pi^+ \pi^- J/\psi$ |

[1] Superseded by CHOI 11.

## $\chi_{c1}(3872)$ WIDTH FROM $\overline{D}^{*0} D^0$ MODE

| VALUE (MeV) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $3.9^{+2.8}_{-1.4}{}^{+0.2}_{-1.1}$ | 50 | [1] AUSHEV | 10 | BELL | $B \to \overline{D}^{*0} D^0 K$ |
| $3.0^{+1.9}_{-1.4} \pm 0.9$ | $33 \pm 6$ | AUBERT | 08B | BABR | $B \to \overline{D}^{*0} D^0 K$ |

[1] With a measured value of $B(B \to \chi_{c1}(3872) K) \times B(\chi_{c1}(3872) \to D^{*0}\overline{D}^0) = (0.80 \pm 0.20 \pm 0.10) \times 10^{-4}$, assumed to be equal for both charged and neutral modes.

## $\chi_{c1}(3872)$ DECAY MODES

| | Mode | Fraction ($\Gamma_i/\Gamma$) |
|---|---|---|
| $\Gamma_1$ | $e^+ e^-$ | |
| $\Gamma_2$ | $\pi^+\pi^- J/\psi(1S)$ | $> 3.2$ % |
| $\Gamma_3$ | $\rho^0 J/\psi(1S)$ | |
| $\Gamma_4$ | $\omega J/\psi(1S)$ | $> 2.3$ % |
| $\Gamma_5$ | $D^0\overline{D}^0\pi^0$ | >40 % |
| $\Gamma_6$ | $\overline{D}^{*0} D^0$ | >30 % |
| $\Gamma_7$ | $\gamma\gamma$ | |
| $\Gamma_8$ | $D^0\overline{D}^0$ | |
| $\Gamma_9$ | $D^+ D^-$ | |
| $\Gamma_{10}$ | $\gamma\chi_{c1}$ | |
| $\Gamma_{11}$ | $\gamma\chi_{c2}$ | |
| $\Gamma_{12}$ | $\gamma J/\psi$ | $> 7 \times 10^{-3}$ |
| $\Gamma_{13}$ | $\gamma\psi(2S)$ | $> 4$ % |
| $\Gamma_{14}$ | $\pi^+\pi^-\eta_c(1S)$ | not seen |
| $\Gamma_{15}$ | $\pi^+\pi^-\chi_{c1}$ | not seen |
| $\Gamma_{16}$ | $p\overline{p}$ | not seen |

### C-violating decays

| | | |
|---|---|---|
| $\Gamma_{17}$ | $\eta J/\psi$ | |

## $\chi_{c1}(3872)$ PARTIAL WIDTHS

### $\Gamma(e^+e^-)$ $\Gamma_1$

| VALUE (eV) | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| < 4.3 | 90 | [1] ABLIKIM | 15V | BES3 | 4.0–4.4 $e^+e^- \to \pi^+\pi^- J/\psi$ |
| <280 | 90 | [2] YUAN | 04 | RVUE | $e^+e^- \to \pi^+\pi^- J/\psi$ |

[1] ABLIKIM 15V reports this limit from the measurement of $\Gamma(\chi_{c1}(3872) \to \pi^+\pi^- J/\psi(1S)) \times \Gamma(\chi_{c1}(3872) \to e^+e^-)/\Gamma < 0.13$ eV using $\Gamma(\chi_{c1}(3872) \to \pi^+\pi^- J/\psi(1S))/\Gamma = 3\%$.

[2] Using BAI 98E data on $e^+e^- \to \pi^+\pi^-\ell^+\ell^-$. Assuming that $\Gamma(\pi^+\pi^- J/\psi)$ of $\chi_{c1}(3872)$ is the same as that of $\psi(2S)$ (85.4 keV).

## $\chi_{c1}(3872)$ Γ(i)Γ($e^+e^-$)/Γ(total)

### $\Gamma(\pi^+\pi^- J/\psi(1S)) \times \Gamma(e^+e^-)/\Gamma_{total}$ $\Gamma_2\Gamma_1/\Gamma$

| VALUE (eV) | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **< 0.13** | 90 | ABLIKIM | 15V | BES3 | 4.0–4.4 $e^+e^- \to \pi^+\pi^- J/\psi$ |

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

| | | | | | |
|---|---|---|---|---|---|
| < 6.2 | 90 | [1,2] AUBERT | 05D | BABR | 10.6 $e^+e^- \to K^+K^-\pi^+\pi^-\gamma$ |
| < 8.3 | 90 | [2] DOBBS | 05 | CLE3 | $e^+e^- \to \pi^+\pi^- J/\psi$ |
| <10 | 90 | [3] YUAN | 04 | RVUE | $e^+e^- \to \pi^+\pi^- J/\psi$ |

[1] Using B($\chi_{c1}(3872) \to J/\psi\pi^+\pi^-$) · B($J/\psi \to \mu^+\mu^-$) · Γ($\chi_{c1}(3872) \to e^+e^-$) < 0.37 eV from AUBERT 05D and B($J/\psi \to \mu^+\mu^-$) = 0.0588 ± 0.0010 from the PDG 04.

[2] Assuming $\chi_{c1}(3872)$ has $J^{PC} = 1^{--}$.

[3] Using BAI 98E data on $e^+e^- \to \pi^+\pi^-\ell^+\ell^-$. From theoretical calculation of the production cross section and using B($J/\psi \to \mu^+\mu^-$) = (5.88 ± 0.10)%.

## $\chi_{c1}(3872)$ Γ(i)Γ($\gamma\gamma$)/Γ(total)

### $\Gamma(\pi^+\pi^- J/\psi(1S)) \times \Gamma(\gamma\gamma)/\Gamma_{total}$ $\Gamma_2\Gamma_7/\Gamma$

| VALUE (eV) | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|

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

| | | | | | |
|---|---|---|---|---|---|
| <12.9 | 90 | [1] DOBBS | 05 | CLE3 | $e^+e^- \to \pi^+\pi^- J/\psi\gamma$ |

[1] Assuming $\chi_{c1}(3872)$ has positive $C$ parity and spin 0.

### $\Gamma(\omega J/\psi(1S)) \times \Gamma(\gamma\gamma)/\Gamma_{total}$ $\Gamma_4\Gamma_7/\Gamma$

| VALUE (eV) | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|

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

| | | | | | |
|---|---|---|---|---|---|
| <1.7 | 90 | [1] LEES | 12AD | BABR | $e^+e^- \to e^+e^-\omega J/\psi$ |

[1] Assuming $\chi_{c1}(3872)$ has spin 2.

### $\Gamma(\pi^+\pi^-\eta_c(1S)) \times \Gamma(\gamma\gamma)/\Gamma_{total}$ $\Gamma_{14}\Gamma_7/\Gamma$

| VALUE (eV) | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<11.1** | 90 | LEES | 12AE | BABR | $e^+e^- \to e^+e^-\pi^+\pi^-\eta_c$ |

## $\chi_{c1}(3872)$ BRANCHING RATIOS

### $\Gamma(\pi^+\pi^- J/\psi(1S))/\Gamma_{total}$ $\Gamma_2/\Gamma$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **>0.032** | 93 ± 17 | [1] AUBERT | 08Y | BABR | $B \to \chi_{c1}(3872)K$ |

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

| | | | | | |
|---|---|---|---|---|---|
| seen | 151 | [2] BALA | 15 | BELL | $B \to \chi_{c1}(3872)K\pi$ |
| >0.05 | 30 | [3] AUBERT | 05R | BABR | $B^+ \to K^+\pi^+\pi^- J/\psi$ |
| >0.05 | 36 ± 7 | [4] CHOI | 03 | BELL | $B^+ \to K^+\pi^+\pi^- J/\psi$ |

[1] AUBERT 08Y reports [$\Gamma(\chi_{c1}(3872) \to \pi^+\pi^- J/\psi(1S))/\Gamma_{total}$] × [B($B^+ \to \chi_{c1}(3872)K^+$)] = $(8.4 \pm 1.5 \pm 0.7) \times 10^{-6}$ which we divide by our best value B($B^+ \to \chi_{c1}(3872)K^+$) < $2.6 \times 10^{-4}$.

[2] BALA 15 reports $B(\chi_{c1}(3872) \to \pi^+\pi^- J/\psi) \times B(B^0 \to \chi_{c1}(3872) K^+\pi^-) = (7.9 \pm 1.3 \pm 0.4) \times 10^{-6}$ and $B(\chi_{c1}(3872) \to \pi^+\pi^- J/\psi) \times B(B^+ \to \chi_{c1}(3872) K^0\pi^+) = (10.6 \pm 3.0 \pm 0.9) \times 10^{-6}$.

[3] Superseded by AUBERT 08Y. AUBERT 05R reports $[\Gamma(\chi_{c1}(3872) \to \pi^+\pi^- J/\psi(1S))/\Gamma_{total}] \times [B(B^+ \to \chi_{c1}(3872) K^+)] = (1.28 \pm 0.41) \times 10^{-5}$ which we divide by our best value $B(B^+ \to \chi_{c1}(3872) K^+) < 2.6 \times 10^{-4}$.

[4] CHOI 03 reports $[\Gamma(\chi_{c1}(3872) \to \pi^+\pi^- J/\psi(1S))/\Gamma_{total}] \times [B(B^+ \to \chi_{c1}(3872) K^+)] / [B(B^+ \to \psi(2S) K^+)] / [B(\psi(2S) \to J/\psi(1S)\pi^+\pi^-)] = 0.063 \pm 0.012 \pm 0.007$ which we multiply or divide by our best values $B(B^+ \to \chi_{c1}(3872) K^+) < 2.6 \times 10^{-4}$, $B(B^+ \to \psi(2S) K^+) = (6.21 \pm 0.22) \times 10^{-4}$, $B(\psi(2S) \to J/\psi(1S)\pi^+\pi^-) = (34.68 \pm 0.30) \times 10^{-2}$.

## $\Gamma(\omega J/\psi(1S))/\Gamma_{total}$ $\Gamma_4/\Gamma$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **>0.023** | $21 \pm 7$ | [1] DEL-AMO-SA..10B | | BABR | $B^+ \to \omega J/\psi K^+$ |

[1] DEL-AMO-SANCHEZ 10B reports $[\Gamma(\chi_{c1}(3872) \to \omega J/\psi(1S))/\Gamma_{total}] \times [B(B^+ \to \chi_{c1}(3872) K^+)] = (6 \pm 2 \pm 1) \times 10^{-6}$ which we divide by our best value $B(B^+ \to \chi_{c1}(3872) K^+) < 2.6 \times 10^{-4}$. DEL-AMO-SANCHEZ 10B also reports $B(B^0 \to \chi_{c1}(3872) K^0) \times B(\chi_{c1}(3872) \to J/\psi\omega) = (6 \pm 3 \pm 1) \times 10^{-6}$.

## $\Gamma(\omega J/\psi(1S))/\Gamma(\pi^+\pi^- J/\psi(1S))$ $\Gamma_4/\Gamma_2$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **0.8±0.3** | [1] DEL-AMO-SA..10B | | BABR | $B \to \omega J/\psi K$ |

[1] Statistical and systematic errors added in quadrature. Uses the values of $B(B \to \chi_{c1}(3872) K) \times B(\chi_{c1}(3872) \to J/\psi\pi^+\pi^-)$ reported in AUBERT 08Y, taking into account the common systematics.

## $\Gamma(D^0\overline{D}{}^0\pi^0)/\Gamma_{total}$ $\Gamma_5/\Gamma$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **>0.4** | $17 \pm 5$ | [1] GOKHROO | 06 | BELL | $B^+ \to D^0\overline{D}{}^0\pi^0 K^+$ |

[1] GOKHROO 06 reports $[\Gamma(\chi_{c1}(3872) \to D^0\overline{D}{}^0\pi^0)/\Gamma_{total}] \times [B(B^+ \to \chi_{c1}(3872) K^+)] = (1.02 \pm 0.31^{+0.21}_{-0.29}) \times 10^{-4}$ which we divide by our best value $B(B^+ \to \chi_{c1}(3872) K^+) < 2.6 \times 10^{-4}$.

## $\Gamma(D^0\overline{D}{}^0\pi^0)/\Gamma(\pi^+\pi^- J/\psi(1S))$ $\Gamma_5/\Gamma_2$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **seen** | [1] GOKHROO | 06 | BELL | $B \to D^0\overline{D}{}^0\pi^0 K$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| seen | AUSHEV | 10 | BELL | $B \to D^0\overline{D}{}^0\pi^0 K$ |

[1] May not necessarily be the same state as that observed in the $J/\psi\pi^+\pi^-$ mode. Supersedes CHISTOV 04.

## $\Gamma(\overline{D}^{*0} D^0)/\Gamma_{\text{total}}$ $\Gamma_6/\Gamma$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **>0.30** | $41^{+9}_{-8}$ | [1] AUSHEV | 10 | BELL | $B^+ \to D^{*0}\overline{D}^0 K^+$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| >0.6 | 27 ± 6 | [2] AUBERT | 08B | BABR | $B^+ \to \overline{D}^{*0} D^0 K^+$ |

[1] AUSHEV 10 reports $[\Gamma(\chi_{c1}(3872) \to \overline{D}^{*0} D^0)/\Gamma_{\text{total}}] \times [\text{B}(B^+ \to \chi_{c1}(3872) K^+)] = (0.77 \pm 0.16 \pm 0.10) \times 10^{-4}$ which we divide by our best value $\text{B}(B^+ \to \chi_{c1}(3872) K^+) < 2.6 \times 10^{-4}$.

[2] AUBERT 08B reports $[\Gamma(\chi_{c1}(3872) \to \overline{D}^{*0} D^0)/\Gamma_{\text{total}}] \times [\text{B}(B^+ \to \chi_{c1}(3872) K^+)] = (1.67 \pm 0.36 \pm 0.47) \times 10^{-4}$ which we divide by our best value $\text{B}(B^+ \to \chi_{c1}(3872) K^+) < 2.6 \times 10^{-4}$.

## $\Gamma(D^0\overline{D}^0)/\Gamma(\pi^+\pi^- J/\psi(1S))$ $\Gamma_8/\Gamma_2$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| not seen | CHISTOV | 04 | BELL | $B \to K D^0 \overline{D}^0$ |

## $\Gamma(D^+ D^-)/\Gamma(\pi^+\pi^- J/\psi(1S))$ $\Gamma_9/\Gamma_2$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| not seen | CHISTOV | 04 | BELL | $B \to K D^+ D^-$ |

## $\Gamma(\gamma\chi_{c1})/\Gamma(\pi^+\pi^- J/\psi(1S))$ $\Gamma_{10}/\Gamma_2$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| not seen | | [1] BHARDWAJ | 13 | BELL | $B^+ \to \chi_{c1}\gamma K^+$ |
| **<0.89** | 90 | CHOI | 03 | BELL | $B \to K\pi^+\pi^- J/\psi$ |

[1] Reported $\text{B}(B^\pm \to \chi_{c1}(3872) K^\pm) \times \text{B}(\chi_{c1}(3872) \to \gamma\chi_{c1}) < 1.9 \times 10^{-6}$ at 90% CL.

## $\Gamma(\gamma\chi_{c2})/\Gamma(\pi^+\pi^- J/\psi(1S))$ $\Gamma_{11}/\Gamma_2$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **not seen** | [1] BHARDWAJ | 13 | BELL | $B^\pm \to \chi_{c2}\gamma K^+$ |

[1] Reported $\text{B}(B^\pm \to \chi_{c1}(3872) K^\pm) \times \text{B}(\chi_{c1}(3872) \to \gamma\chi_{c2}) < 6.7 \times 10^{-6}$ at 90% CL.

## $\Gamma(\gamma J/\psi)/\Gamma_{\text{total}}$ $\Gamma_{12}/\Gamma$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **>7 × 10⁻³** | | [1] BHARDWAJ | 11 | BELL | $B^\pm \to \gamma J/\psi K^\pm$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| >0.011 | 20 | [2] AUBERT | 09B | BABR | $B^+ \to \gamma J/\psi K^+$ |
| >0.013 | 19 | [3] AUBERT,BE | 06M | BABR | $B^+ \to \gamma J/\psi K^+$ |

[1] BHARDWAJ 11 reports $[\Gamma(\chi_{c1}(3872) \to \gamma J/\psi)/\Gamma_{\text{total}}] \times [\text{B}(B^+ \to \chi_{c1}(3872) K^+)] = (1.78^{+0.48}_{-0.44} \pm 0.12) \times 10^{-6}$ which we divide by our best value $\text{B}(B^+ \to \chi_{c1}(3872) K^+) < 2.6 \times 10^{-4}$.

[2] AUBERT 09B reports $[\Gamma(\chi_{c1}(3872) \to \gamma J/\psi)/\Gamma_{\text{total}}] \times [\text{B}(B^+ \to \chi_{c1}(3872) K^+)] = (2.8 \pm 0.8 \pm 0.1) \times 10^{-6}$ which we divide by our best value $\text{B}(B^+ \to \chi_{c1}(3872) K^+) < 2.6 \times 10^{-4}$.

[3] Superseded by AUBERT 09B. AUBERT,BE 06M reports $[\Gamma(\chi_{c1}(3872) \to \gamma J/\psi)/\Gamma_{\text{total}}] \times [\text{B}(B^+ \to \chi_{c1}(3872) K^+)] = (3.3 \pm 1.0 \pm 0.3) \times 10^{-6}$ which we divide by our best value $\text{B}(B^+ \to \chi_{c1}(3872) K^+) < 2.6 \times 10^{-4}$.

## $\Gamma(\gamma\psi(2S))/\Gamma_{\text{total}}$ $\Gamma_{13}/\Gamma$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| seen | $36 \pm 9$ | [1] AAIJ | 14AH | LHCB | $B^+ \to \gamma\psi(2S) K^+$ |
| **>0.04** | $25 \pm 7$ | [2] AUBERT | 09B | BABR | $B^+ \to \gamma\psi(2S) K^+$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| not seen | | [3] BHARDWAJ | 11 | BELL | $B^+ \to \gamma\psi(2S) K^+$ |

[1] From $36.4 \pm 9.0$ events of $\chi_{c1}(3872) \to J/\psi\gamma$ decays with a statistical significance of $4.4\sigma$.

[2] AUBERT 09B reports $[\Gamma(\chi_{c1}(3872) \to \gamma\psi(2S))/\Gamma_{\text{total}}] \times [\text{B}(B^+ \to \chi_{c1}(3872) K^+)] = (9.5 \pm 2.7 \pm 0.6) \times 10^{-6}$ which we divide by our best value $\text{B}(B^+ \to \chi_{c1}(3872) K^+) < 2.6 \times 10^{-4}$.

[3] BHARDWAJ 11 reports $\text{B}(B^+ \to K^+ \chi_{c1}(3872)) \times \text{B}(\chi_{c1} \to \gamma\psi(2S)) < 3.45 \times 10^{-6}$ at 90% CL.

## $\Gamma(\gamma\psi(2S))/\Gamma(\gamma J/\psi)$ $\Gamma_{13}/\Gamma_{12}$

| VALUE | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **2.6 ±0.6 OUR AVERAGE** | | | | | | |
| $2.46 \pm 0.64 \pm 0.29$ | | $36 \pm 9$ | [1] AAIJ | 14AH | LHCB | $B^+ \to \gamma\psi(2S) K^+$ |
| $3.4 \pm 1.4$ | | | AUBERT | 09B | BABR | $B^+ \to \gamma c\overline{c} K'$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| $<2.1$ | 90 | | BHARDWAJ | 11 | BELL | $B^+ \to \gamma\psi(2S) K^+$ |

[1] From $36.4 \pm 9.0$ events of $\chi_{c1}(3872) \to J/\psi\gamma$ decays with a statistical significance of $4.4\sigma$.

## $\Gamma(\pi^+\pi^-\chi_{c1})/\Gamma_{\text{total}}$ $\Gamma_{15}/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **not seen** | [1] BHARDWAJ | 16 | BELL | $B^+ \to \pi^+\pi^-\chi_{c1} K^+$ |

[1] BHARDWAJ 16 quotes $\text{B}(B^+ \to \chi_{c1}(3872) K^+) \cdot \text{B}(\chi_{c1}(3872) \to \pi^+\pi^-\chi_{c1}) < 1.5 \times 10^{-6}$ at 90% CL.

## $\Gamma(p\overline{p})/\Gamma_{\text{total}}$ $\Gamma_{16}/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **not seen** | [1] AAIJ | 17AD | LHCB | $pp \to B^+ X \to p\overline{p} K^+ X$ |

[1] AAIJ 17AD reports $\text{B}(B^+ \to \chi_{c1}(3872) K^+ \to p\overline{p} K^+)/\text{B}(B^+ \to J/\psi K^+ \to p\overline{p} K^+) < 2.0\ (2.5) \times 10^{-3}$ at 90% (95%) CL.

## $\Gamma(p\overline{p})/\Gamma(\pi^+\pi^- J/\psi(1S))$ $\Gamma_{16}/\Gamma_2$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$<2.0 \times 10^{-3}$** | 95 | [1] AAIJ | 13S | LHCB | $B^+ \to p\overline{p} K^+$ |

[1] AAIJ 13S reports $[\Gamma(\chi_{c1}(3872) \to p\overline{p})/\Gamma(\chi_{c1}(3872) \to \pi^+\pi^- J/\psi(1S))] \times [\text{B}(B^+ \to \chi_{c1}(3872) K^+,\ \chi_{c1} \to J/\psi\pi^+\pi^-)] < 1.7 \times 10^{-8}$ which we divide by our best value $\text{B}(B^+ \to \chi_{c1}(3872) K^+,\ \chi_{c1} \to J/\psi\pi^+\pi^-) = 8.6 \times 10^{-6}$.

## *C*-violating decays

### $\Gamma(\eta J/\psi)/\Gamma(\pi^+\pi^- J/\psi(1S))$ $\Gamma_{17}/\Gamma_2$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<0.4** | 90 | [1,2] IWASHITA | 14 | BELL | $B \to K\eta J/\psi$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <0.6 | 90 | AUBERT | 04Y | BABR | $B \to K\eta J/\psi$ |

[1] IWASHITA 14 reports $[\Gamma(\chi_{c1}(3872) \to \eta J/\psi)/\Gamma(\chi_{c1}(3872) \to \pi^+\pi^- J/\psi(1S))] \times [B(B^+ \to \chi_{c1}(3872)K^+,\ \chi_{c1} \to J/\psi\pi^+\pi^-)] < 3.8 \times 10^{-6}$ which we divide by our best value $B(B^+ \to \chi_{c1}(3872)K^+,\ \chi_{c1} \to J/\psi\pi^+\pi^-) = 8.6 \times 10^{-6}$.

[2] IWASHITA 14 also scans the $\eta J/\psi$ mass range 3.8–4.75 GeV and sets upper limits for $B(B^\pm \to \chi_{c1}(3872)K^\pm) \times B(\chi_{c1}(3872) \to \eta J/\psi)$ in 5 MeV intervals.

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