# $T_{c\bar{c}1}(4430)^+$

$I^G(J^{PC}) = 1^+(1^{+-})$
$G$, $C$ need confirmation.

was $Z_c(4430)$, $X(4430)^{\pm}$

Properties incompatible with a $q\bar{q}$ structure (exotic state). See the review on non-$q\bar{q}$ states.

First seen by CHOI 08 in $B \to K\pi^+\psi(2S)$ decays, confirmed by AAIJ 14AG, and confirmed in a model-independent way by AAIJ 15BH. Also seen by CHILIKIN 14 in $B \to K^+\pi J/\psi$ decays. $J^P$ was determined by CHILIKIN 13 and AAIJ 14AG.

## $T_{c\bar{c}1}(4430)^+$ MASS

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| $4478^{+15}_{-18}$ OUR AVERAGE | | | | |
| $4475 \pm 7^{+15}_{-25}$ | [1] AAIJ | 14AG | LHCB | $\overline{B}^0 \to K^-\pi^+\psi(2S)$ |
| $4485 \pm 22^{+28}_{-11}$ | [1] CHILIKIN | 13 | BELL | $B^0 \to K^+\pi^-\psi(2S)$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $4443^{+15+19}_{-12-13}$ | [2] MIZUK | 09 | BELL | $B \to K\pi^+\psi(2S)$ |
| $4433 \pm 4 \pm 2$ | [3] CHOI | 08 | BELL | $B \to K\pi^+\psi(2S)$ |

[1] From a four-dimensional amplitude analysis.
[2] From a Dalitz plot analysis. Superseded by CHILIKIN 13.
[3] Superseded by MIZUK 09 and CHILIKIN 13.

## $T_{c\bar{c}1}(4430)^+$ WIDTH

| VALUE (MeV) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| $181 \pm 31$ OUR AVERAGE | | | | |
| $172 \pm 13^{+37}_{-34}$ | [1] AAIJ | 14AG | LHCB | $\overline{B}^0 \to K^-\pi^+\psi(2S)$ |
| $200^{+41+26}_{-46-35}$ | [1] CHILIKIN | 13 | BELL | $B^0 \to K^+\pi^-\psi(2S)$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| $107^{+86+74}_{-43-56}$ | [2] MIZUK | 09 | BELL | $B \to K\pi^+\psi(2S)$ |
| $45^{+18+30}_{-13-13}$ | [3] CHOI | 08 | BELL | $B \to K\pi^+\psi(2S)$ |

[1] From a four-dimensional amplitude analysis.
[2] From a Dalitz plot analysis. Superseded by CHILIKIN 13.
[3] Superseded by MIZUK 09 and CHILIKIN 13.

# $T_{c\overline{c}1}(4430)^+$ DECAY MODES

| | Mode | Fraction ($\Gamma_i/\Gamma$) |
|---|---|---|
| $\Gamma_1$ | $\pi^+ \psi(2S)$ | seen |
| $\Gamma_2$ | $\pi^+ J/\psi$ | seen |

# $T_{c\overline{c}1}(4430)^+$ BRANCHING RATIOS

## $\Gamma\left(\pi^+ \psi(2S)\right)/\Gamma_{\text{total}}$          $\Gamma_1/\Gamma$

| VALUE | DOCUMENT ID | TECN | COMMENT |
|---|---|---|---|
| **seen** | [1] AAIJ 14AG | LHCB | $\overline{B}^0 \to K^- \pi^+ \psi(2S)$ |
| **seen** | [2] CHILIKIN 13 | BELL | $B^0 \to K^+ \pi^- \psi(2S)$ |

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

| | | | |
|---|---|---|---|
| not seen | [3] AUBERT 09AA | BABR | $B \to K \pi^+ \psi(2S)$ |
| seen | [4] MIZUK 09 | BELL | $B \to K \pi^+ \psi(2S)$ |

[1] From a four-dimensional amplitude analysis. No product of branching fractions quoted.

[2] From a four-dimensional amplitude analysis. Measured a product of branching fractions $\mathrm{B}(B^0 \to T_{c\overline{c}1}(4430)^- K^+) \times \mathrm{B}(T_{c\overline{c}1}(4430)^- \to \psi(2S)\pi^-) = (6.0^{+1.7+2.5}_{-2.0-1.4}) \times 10^{-5}$.

[3] AUBERT 09AA quotes $\mathrm{B}(B^+ \to \overline{K}^0 T_{c\overline{c}1}(4430)^+) \times \mathrm{B}(T_{c\overline{c}1}(4430)^+ \to \pi^+ \psi(2S)) < 4.7 \times 10^{-5}$ and $\mathrm{B}(\overline{B}^0 \to K^- T_{c\overline{c}1}(4430)^+) \times \mathrm{B}(T_{c\overline{c}1}(4430)^+ \to \pi^+ \psi(2S)) < 3.1 \times 10^{-5}$ at 95% CL.

[4] Measured a product of branching fractions $\mathrm{B}(\overline{B}^0 \to K^- T_{c\overline{c}1}(4430)^+) \times \mathrm{B}(T_{c\overline{c}1}(4430)^+ \to \pi^+ \psi(2S)) = (3.2^{+1.8+5.3}_{-0.9-1.6}) \times 10^{-5}$. Superseded by CHILIKIN 13.

## $\Gamma\left(\pi^+ J/\psi\right)/\Gamma_{\text{total}}$          $\Gamma_2/\Gamma$

| VALUE | DOCUMENT ID | TECN | COMMENT |
|---|---|---|---|
| **seen** | [1,2] CHILIKIN 14 | BELL | $\overline{B}^0 \to K^- \pi^+ J/\psi$ |

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

| | | | |
|---|---|---|---|
| not seen | [3] AUBERT 09AA | BABR | $B \to K \pi^+ J/\psi$ |

[1] CHILIKIN 14 reports $\mathrm{B}(\overline{B}^0 \to T_{c\overline{c}1}(4430)^+ K^-) \times \mathrm{B}(T_{c\overline{c}1}(4430)^+ \to J/\psi \pi^+) = (5.4^{+4.0+1.1}_{-1.0-0.9}) \times 10^{-6}$.

[2] A broad enhancement seen by AAIJ 19R in the decays $B^0 \to J/\psi \pi^+ K^-$ at 4600 MeV can be due to an interplay of $T_{c\overline{c}1}(4430)$, $T_{c\overline{c}1}(4200)$ and the fitting polynomials.

[3] AUBERT 09AA quotes $\mathrm{B}(B^+ \to \overline{K}^0 T_{c\overline{c}1}(4430)^+) \times \mathrm{B}(T_{c\overline{c}1}(4430)^+ \to \pi^+ J/\psi) < 1.5 \times 10^{-5}$ and $\mathrm{B}(\overline{B}^0 \to K^- T_{c\overline{c}1}(4430)^+) \times \mathrm{B}(T_{c\overline{c}1}(4430)^+ \to \pi^+ J/\psi) < 0.4 \times 10^{-5}$ at 95% CL.

# $T_{c\overline{c}1}(4430)^+$ REFERENCES

| AAIJ | 19R | PRL 122 152002 | R. Aaij *et al.* | (LHCb Collab.) |
| AAIJ | 15BH | PR D92 112009 | R. Aaij *et al.* | (LHCb Collab.) |
| AAIJ | 14AG | PRL 112 222002 | R. Aaij *et al.* | (LHCb Collab.) JP |
| CHILIKIN | 14 | PR D90 112009 | K. Chilikin *et al.* | (BELLE Collab.) |
| CHILIKIN | 13 | PR D88 074026 | K. Chilikin *et al.* | (BELLE Collab.) JP |
| AUBERT | 09AA | PR D79 112001 | B. Aubert *et al.* | (BABAR Collab.) |
| MIZUK | 09 | PR D80 031104 | R. Mizuk *et al.* | (BELLE Collab.) |
| CHOI | 08 | PRL 100 142001 | S.-K. Choi *et al.* | (BELLE Collab.) |