

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

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

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

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

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>4478<sup>+15</sup><sub>-18</sub> OUR AVERAGE</b>			
4475 ± 7 <sup>+15</sup> <sub>-25</sub>	<sup>1</sup> AAIJ	14AG LHCB	$B^0 \rightarrow K^+\pi^-\psi(2S)$
4485 ± 22 <sup>+28</sup> <sub>-11</sub>	<sup>1</sup> CHILIKIN	13 BELL	$B^0 \rightarrow K^+\pi^-\psi(2S)$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
4443 <sup>+15+19</sup> <sub>-12-13</sub>	<sup>2</sup> MIZUK	09 BELL	$B \rightarrow K\pi^+\psi(2S)$
4433 ± 4 ± 2	<sup>3</sup> CHOI	08 BELL	$B \rightarrow K\pi^+\psi(2S)$

<sup>1</sup> From a four-dimensional amplitude analysis.

<sup>2</sup> From a Dalitz plot analysis. Superseded by CHILIKIN 13.

<sup>3</sup> Superseded by MIZUK 09 and CHILIKIN 13.

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

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>181 ± 31 OUR AVERAGE</b>			
172 ± 13 <sup>+37</sup> <sub>-34</sub>	<sup>1</sup> AAIJ	14AG LHCB	$B^0 \rightarrow K^+\pi^-\psi(2S)$
200 <sup>+41+26</sup> <sub>-46-35</sub>	<sup>1</sup> CHILIKIN	13 BELL	$B^0 \rightarrow K^+\pi^-\psi(2S)$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
107 <sup>+86+74</sup> <sub>-43-56</sub>	<sup>2</sup> MIZUK	09 BELL	$B \rightarrow K\pi^+\psi(2S)$
45 <sup>+18+30</sup> <sub>-13-13</sub>	<sup>3</sup> CHOI	08 BELL	$B \rightarrow K\pi^+\psi(2S)$

<sup>1</sup> From a four-dimensional amplitude analysis.

<sup>2</sup> From a Dalitz plot analysis. Superseded by CHILIKIN 13.

<sup>3</sup> Superseded by MIZUK 09 and CHILIKIN 13.

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

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

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

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

VALUE	DOCUMENT ID	TECN	COMMENT
<b>seen</b>	<sup>1</sup> AAIJ	14AG LHCb	$B^0 \rightarrow K^+ \pi^- \psi(2S)$
<b>seen</b>	<sup>2</sup> CHILIKIN	13 BELL	$B^0 \rightarrow K^+ \pi^- \psi(2S)$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
not seen	<sup>3</sup> AUBERT	09AA BABR	$B \rightarrow K \pi^+ \psi(2S)$
seen	<sup>4</sup> MIZUK	09 BELL	$B \rightarrow K \pi^+ \psi(2S)$

- <sup>1</sup> From a four-dimensional amplitude analysis. No product of branching fractions quoted.
- <sup>2</sup> From a four-dimensional amplitude analysis. Measured a product of branching fractions  $B(B^0 \rightarrow T_{c\bar{c}1}(4430)^- K^+) \times B(T_{c\bar{c}1}(4430)^- \rightarrow \psi(2S) \pi^-) = (6.0_{-2.0}^{+1.7+2.5}) \times 10^{-5}$ .
- <sup>3</sup> AUBERT 09AA quotes  $B(B^+ \rightarrow \bar{K}^0 T_{c\bar{c}1}(4430)^+) \times B(T_{c\bar{c}1}(4430)^+ \rightarrow \pi^+ \psi(2S)) < 4.7 \times 10^{-5}$  and  $B(\bar{B}^0 \rightarrow K^- T_{c\bar{c}1}(4430)^+) \times B(T_{c\bar{c}1}(4430)^+ \rightarrow \pi^+ \psi(2S)) < 3.1 \times 10^{-5}$  at 95% CL.
- <sup>4</sup> Measured a product of branching fractions  $B(\bar{B}^0 \rightarrow K^- T_{c\bar{c}1}(4430)^+) \times B(T_{c\bar{c}1}(4430)^+ \rightarrow \pi^+ \psi(2S)) = (3.2_{-0.9-1.6}^{+1.8+5.3}) \times 10^{-5}$ . Superseded by CHILIKIN 13.

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

VALUE	DOCUMENT ID	TECN	COMMENT
<b>seen</b>	<sup>1,2</sup> CHILIKIN	14 BELL	$\bar{B}^0 \rightarrow K^- \pi^+ J/\psi$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
not seen	<sup>3</sup> AUBERT	09AA BABR	$B \rightarrow K \pi^+ J/\psi$

- <sup>1</sup> CHILIKIN 14 reports  $B(\bar{B}^0 \rightarrow T_{c\bar{c}1}(4430)^+ K^-) \times B(T_{c\bar{c}1}(4430)^+ \rightarrow J/\psi \pi^+) = (5.4_{-1.0-0.9}^{+4.0+1.1}) \times 10^{-6}$ .
- <sup>2</sup> A broad enhancement seen by AAIJ 19R in the decays  $B^0 \rightarrow J/\psi \pi^+ K^-$  at 4600 MeV can be due to an interplay of  $T_{c\bar{c}1}(4430)$ ,  $T_{c\bar{c}1}(4200)$  and the fitting polynomials.
- <sup>3</sup> AUBERT 09AA quotes  $B(B^+ \rightarrow \bar{K}^0 T_{c\bar{c}1}(4430)^+) \times B(T_{c\bar{c}1}(4430)^+ \rightarrow \pi^+ J/\psi) < 1.5 \times 10^{-5}$  and  $B(\bar{B}^0 \rightarrow K^- T_{c\bar{c}1}(4430)^+) \times B(T_{c\bar{c}1}(4430)^+ \rightarrow \pi^+ J/\psi) < 0.4 \times 10^{-5}$  at 95% CL.

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

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