

$T_{c\bar{c}1}(3900)$

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

was $Z_c(3900)$, $X(3900)$

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

Charged $T_{c\bar{c}1}(3900)^\pm$ seen as a peak in the invariant mass distribution of the $J/\psi\pi^\pm$ system by BES III (ABLIKIM 13T) in $e^+e^- \rightarrow \pi^+\pi^-J/\psi$ at c.m. energy of 4.26 GeV and by radiative return from e^+e^- collisions at \sqrt{s} from 9.46 to 10.86 GeV at Belle (LIU 13B). Partial wave analysis of ABLIKIM 17J determines $J^P = 1^+$ with more than 7σ significance. Neutral $T_{c\bar{c}1}(3900)^0$ seen in the $J/\psi\pi^0$ invariant mass distribution in $e^+e^- \rightarrow \pi^0\pi^0J/\psi$ at c.m. energies of 4.23, 4.26, and 4.36 GeV by BES III (ABLIKIM 15U) and at 4.17 GeV by XIAO 13A. Peaks in $(D\bar{D}^*)^{0,\pm}$ reported by BES III (ABLIKIM 14A, ABLIKIM 15AB) are assumed to be related.

$T_{c\bar{c}1}(3900)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
3887.1±2.6 OUR AVERAGE		Error includes scale factor of 1.7. See the ideogram below.			
3893.1±2.2± 3.0		¹ ABLIKIM	20N BES3	0	$e^+e^- \rightarrow \pi^0\pi^0J/\psi$
3902.6 ^{+5.2+ 3.3} _{-5.0- 1.4}		^{2,3} ABAZOV	19 D0	±	1.96 TeV $p\bar{p} \rightarrow J/\psi\pi^+\pi^-X$
3881.2±4.2±52.7	6k	⁴ ABLIKIM	17J BES3	±	$e^+e^- \rightarrow \pi^+\pi^-J/\psi$
3885.7 ^{+4.3} _{-5.7} ± 8.4		^{2,4} ABLIKIM	15AB BES3	0	$e^+e^- \rightarrow \pi^0(D\bar{D}^*)^0$
3881.7±1.6± 1.6	1.2k	^{2,4} ABLIKIM	15AC BES3	±	$e^+e^- \rightarrow \pi^\pm(D\bar{D}^*)^\mp$
3883.9±1.5± 4.2	1.2k	^{2,4} ABLIKIM	14A BES3	±	$e^+e^- \rightarrow \pi^\pm(D\bar{D}^*)^\mp$
3894.5±6.6± 4.5	159	² LIU	13B BELL	±	$e^+e^- \rightarrow \gamma\pi^+\pi^-J/\psi$
3886 ±4 ± 2	81	^{2,5} XIAO	13A	±	4.17 $e^+e^- \rightarrow \pi^+\pi^-J/\psi$
3904 ±9 ± 5	25	^{2,5} XIAO	13A	0	4.17 $e^+e^- \rightarrow \pi^0\pi^0J/\psi$

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

3895.0±5.2 ^{+ 4.0} _{- 2.7}	502	^{2,6} ABAZOV	18B D0	±	1.96 TeV $p\bar{p} \rightarrow J/\psi\pi^+\pi^-X$
3894.8±2.3± 3.2	356	^{2,7} ABLIKIM	15U BES3	0	$e^+e^- \rightarrow \pi^0\pi^0J/\psi$
3899.0±3.6± 4.9	307	^{2,8} ABLIKIM	13T BES3	±	$e^+e^- \rightarrow \pi^+\pi^-J/\psi$

¹ Pole mass obtained from a fit to a relativistic Breit-Wigner.

² Neglecting interference between the $T_{c\bar{c}1}(3900)$ and other processes.

³ Measured in weak decays of b -flavored hadrons (nonprompt).

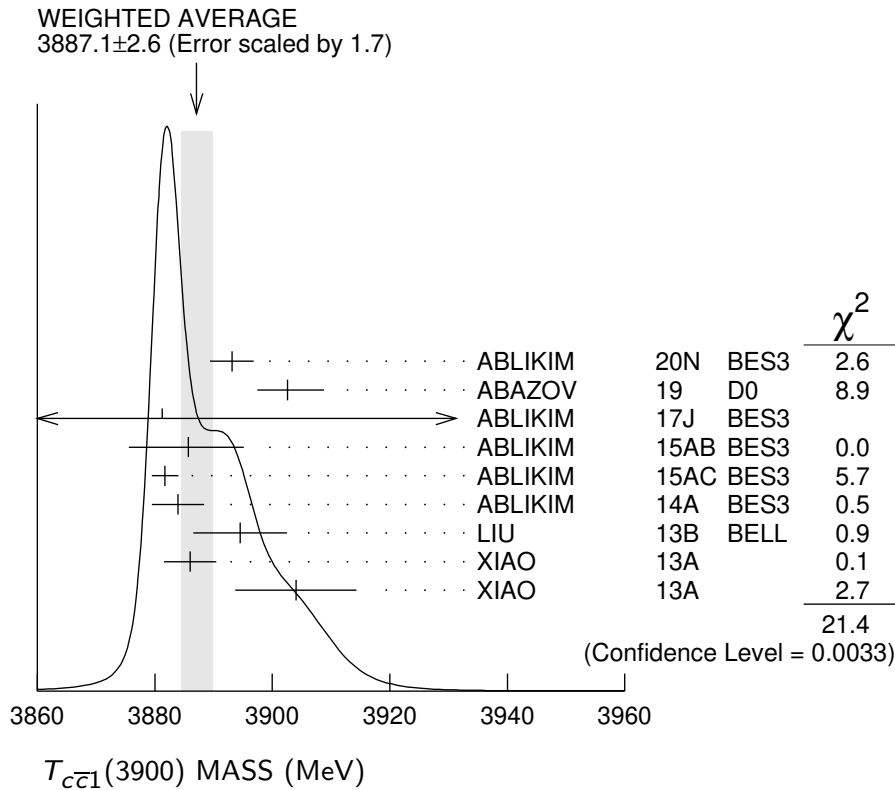
⁴ Pole mass obtained from a fit to a Flatte-like formula.

⁵ For $M^2(\pi^+\pi^-) < 0.65 \text{ GeV}^2$. Obtained by analyzing CLEO-c data but not authored by the CLEO Collaboration.

⁶ The signal of the $T_{c\bar{c}1}(3900)$ is correlated with a parent $J/\psi\pi^+\pi^-$ system in the invariant mass range 4.2–4.7 GeV. Superseded by ABAZOV 19.

⁷ Superseded by ABLIKIM 20N.

⁸ Superseded by ABLIKIM 17J.



$T_{c\bar{c}1}(3900)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
28.4± 2.6 OUR AVERAGE					
44.4± 5.2± 14.0		¹ ABLIKIM	20N BES3	0	$e^+e^- \rightarrow \pi^0\pi^0 J/\psi$
32 $\begin{smallmatrix} +28 & +26 \\ -21 & -7 \end{smallmatrix}$		^{2,3} ABAZOV	19 D0	±	1.96 TeV $p\bar{p} \rightarrow \pi^+\pi^- J/\psi X$ (non-prompt)
51.8± 4.6± 36.0	6 k	⁴ ABLIKIM	17J BES3	±	$e^+e^- \rightarrow \pi^+\pi^- J/\psi$
35 $\begin{smallmatrix} +11 \\ -12 \end{smallmatrix}$ ± 15		^{2,4} ABLIKIM	15AB BES3	0	$e^+e^- \rightarrow \pi^0(D\bar{D}^*)^0$
26.6± 2.0± 2.1	1248	^{2,4} ABLIKIM	15AC BES3	±	$e^+e^- \rightarrow \pi^\pm(D\bar{D}^*)^\mp$
24.8± 3.3± 11.0	1212	^{2,4} ABLIKIM	14A BES3	±	$e^+e^- \rightarrow \pi^\pm(D\bar{D}^*)^\mp$
63 ± 24 ± 26	159	² LIU	13B BELL	±	$e^+e^- \rightarrow \gamma\pi^+\pi^- J/\psi$
37 ± 4 ± 8	81	^{2,5} XIAO	13A	±	4.17 $e^+e^- \rightarrow \pi^+\pi^- J/\psi$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
29.6± 8.2± 8.2	356	^{2,6} ABLIKIM	15U BES3	0	$e^+e^- \rightarrow \pi^0\pi^0 J/\psi$
46 ± 10 ± 20	307	^{2,7} ABLIKIM	13T BES3	±	$e^+e^- \rightarrow \pi^+\pi^- J/\psi$

- ¹ Pole width obtained from a fit to a relativistic Breit-Wigner.
- ² Neglecting interference between the $T_{c\bar{c}1}(3900)$ and other processes.
- ³ Measured in weak decays of b -flavored hadrons (nonprompt).
- ⁴ Pole width obtained from a fit to a Flatte-like formula.
- ⁵ For $M^2(\pi^+\pi^-) < 0.65 \text{ GeV}^2$. Obtained by analyzing CLEO-c data but not authored by the CLEO Collaboration.
- ⁶ Superseded by ABLIKIM 20N.
- ⁷ Superseded by ABLIKIM 17J.

$T_{c\bar{c}1}(3900)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)
Γ_1 $J/\psi\pi$	seen
Γ_2 $h_c\pi^\pm$	not seen
Γ_3 $\eta_c\pi^+\pi^-$	not seen
Γ_4 $\eta_c(1S)\rho(770)^\pm$	seen
Γ_5 $(D\bar{D}^*)^\pm$	seen
Γ_6 $D^0 D^{*-} + \text{c.c.}$	seen
Γ_7 $D^- D^{*0} + \text{c.c.}$	seen
Γ_8 $\omega\pi^\pm$	not seen
Γ_9 $J/\psi\eta$	not seen
Γ_{10} $D^+ D^{*-} + \text{c.c.}$	seen
Γ_{11} $D^0 \bar{D}^{*0} + \text{c.c.}$	seen

$T_{c\bar{c}1}(3900)$ BRANCHING RATIOS

$\Gamma(J/\psi\pi)/\Gamma_{\text{total}}$							Γ_1/Γ
VALUE	EVTS	DOCUMENT ID	TECN	CHG	COMMENT		
seen		ABLIKIM	20N	BES3	0	$e^+e^- \rightarrow \pi^0\pi^0 J/\psi$	
seen		¹ ABZOV	19	D0	\pm	$1.96 \text{ TeV } p\bar{p} \rightarrow \pi^+\pi^- J/\psi X$ (prompt)	
seen		ABLIKIM	17J	BES3	\pm	$e^+e^- \rightarrow \pi^+\pi^- J/\psi$	
seen	356	ABLIKIM	15U	BES3	0	$e^+e^- \rightarrow \pi^0\pi^0 J/\psi$	
not seen		² ADOLPH	15D	COMP	\pm	$\gamma N \rightarrow J/\psi\pi^\pm N$	
seen	307	ABLIKIM	13T	BES3	\pm	$e^+e^- \rightarrow \pi^+\pi^- J/\psi$	
seen	25	³ XIAO	13A		0	$4.17 e^+e^- \rightarrow \pi^0\pi^0 J/\psi$	

- ¹ But not seen in the "prompt" sample (no b -hadron enhancement).
- ² ADOLPH 15D measure $B(T_{c\bar{c}1}(3900)^\pm \rightarrow J/\psi\pi^\pm) \sigma(\gamma N \rightarrow T_{c\bar{c}1}(3900)^\pm N)/\sigma(\gamma N \rightarrow J/\psi N) < 3.7 \times 10^{-3}$ at 90% CL.
- ³ Obtained by analyzing CLEO-c data but not authored by the CLEO Collaboration.

$\Gamma(h_c\pi^\pm)/\Gamma_{\text{total}}$							Γ_2/Γ
VALUE		DOCUMENT ID	TECN	CHG	COMMENT		
not seen		ABLIKIM	13X	BES3	\pm	$e^+e^- \rightarrow h_c\pi^+\pi^-$	

$\Gamma(\eta_c \pi^+ \pi^-)/\Gamma_{\text{total}}$ Γ_3/Γ

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
not seen	¹ VINOKUROVA 15	BELL	0	$B^+ \rightarrow K^+ \eta_c \pi^+ \pi^-$
¹ VINOKUROVA 15 reports $B(B^+ \rightarrow K^+ Z_c(3900)^0) \times B(X \rightarrow \eta_c \pi^+ \pi^-) < 4.7 \times 10^{-5}$ at 90% CL.				

$\Gamma(\eta_c(1S)\rho(770)^\pm)/\Gamma(J/\psi\pi)$ Γ_4/Γ_1

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
2.3±0.8	332	¹ ABLIKIM	19BC BES3	$e^+ e^- \rightarrow \pi^+ \pi^- \pi^0 \eta_c(1S)$
¹ Using $e^+ e^- \rightarrow \pi^\mp(T_{c\bar{c}1}(3900)^\pm \rightarrow J/\psi \pi^\pm)$ cross section at 4.23 and 4.26 GeV from ABLIKIM 17J.				

$\Gamma((D\bar{D}^*)^\pm)/\Gamma(J/\psi\pi)$ Γ_5/Γ_1

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
6.2±1.1±2.7	¹ ABLIKIM	14A BES3	±	$e^+ e^- \rightarrow \pi^\pm (D\bar{D}^*)^\mp$
¹ Assuming the same origin of the $(D\bar{D}^*)^\pm$ and $\pi^\pm J/\psi$ decay modes.				

$\Gamma(D^0 D^{*-} + \text{c.c.})/\Gamma_{\text{total}}$ Γ_6/Γ

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
seen	ABLIKIM	15AC BES3	±	$e^+ e^- \rightarrow \pi^+ D^0 D^{*-} + \text{c.c.}$
seen	ABLIKIM	14A BES3	±	$e^+ e^- \rightarrow \pi^+ D^0 D^{*-} + \text{c.c.}$

$\Gamma(D^- D^{*0} + \text{c.c.})/\Gamma_{\text{total}}$ Γ_7/Γ

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
seen	ABLIKIM	15AC BES3	±	$e^+ e^- \rightarrow \pi^+ D^- D^{*0} + \text{c.c.}$
seen	ABLIKIM	14A BES3	±	$e^+ e^- \rightarrow \pi^+ D^- D^{*0} + \text{c.c.}$

$\Gamma(\omega \pi^\pm)/\Gamma_{\text{total}}$ Γ_8/Γ

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
not seen	ABLIKIM	15R BES3	±	$e^+ e^- \rightarrow \omega \pi^+ \pi^-$

$\Gamma(J/\psi\eta)/\Gamma_{\text{total}}$ Γ_9/Γ

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
not seen	ABLIKIM	15Q BES3	0	4.0–4.6 $e^+ e^- \rightarrow J/\psi \eta \pi^0$

$\Gamma(J/\psi\eta)/\Gamma(J/\psi\pi)$ Γ_9/Γ_1

VALUE	CL%	DOCUMENT ID	TECN	CHG	COMMENT
<0.15	90	ABLIKIM	15Q BES3	0	4.226 $e^+ e^- \rightarrow J/\psi \eta \pi^0$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
<0.65	90	ABLIKIM	15Q BES3	0	4.257 $e^+ e^- \rightarrow J/\psi \eta \pi^0$

$\Gamma(D^+ D^{*-} + \text{c.c.})/\Gamma_{\text{total}}$ Γ_{10}/Γ

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
seen	ABLIKIM	15AB BES3	0	$e^+ e^- \rightarrow \pi^0 (D\bar{D}^*)^0$

$\Gamma(D^0 \bar{D}^{*0} + \text{c.c.})/\Gamma_{\text{total}}$ Γ_{11}/Γ

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
seen	ABLIKIM	15AB BES3	0	$e^+ e^- \rightarrow \pi^0 (D\bar{D}^*)^0$

$\Gamma(D^+ D^{*-} + c.c.) / \Gamma(D^0 \bar{D}^{*0} + c.c.)$	$\Gamma_{10} / \Gamma_{11}$
<u>VALUE</u>	<u>DOCUMENT ID</u> <u>TECN</u> <u>CHG</u> <u>COMMENT</u>
0.96 ± 0.18 ± 0.12	ABLIKIM 15AB BES3 0 $e^+ e^- \rightarrow \pi^0 (D \bar{D}^*)^0$

$T_{c\bar{c}1}(3900)$ REFERENCES

ABLIKIM	20N	PR D102 012009	M. Ablikim <i>et al.</i>	(BESIII Collab.) JP
ABAZOV	19	PR D100 012005	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABLIKIM	19BC	PR D100 111102	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABAZOV	18B	PR D98 052010	V.M. Abazov <i>et al.</i>	(D0 Collab.)
ABLIKIM	17J	PRL 119 072001	M. Ablikim <i>et al.</i>	(BESIII Collab.) JP
ABLIKIM	15AB	PRL 115 222002	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM	15AC	PR D92 092006	M. Ablikim <i>et al.</i>	(BESIII Collab.) JP
ABLIKIM	15Q	PR D92 012008	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM	15R	PR D92 032009	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM	15U	PRL 115 112003	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ADOLPH	15D	PL B742 330	C. Adolph <i>et al.</i>	(COMPASS Collab.)
VINOKUROVA	15	JHEP 1506 132	A. Vinokurova <i>et al.</i>	(BELLE Collab.)
Also		JHEP 1702 088 (errata.)	A. Vinokurava <i>et al.</i>	(BELLE Collab.)
ABLIKIM	14A	PRL 112 022001	M. Ablikim <i>et al.</i>	(BESIII Collab.) JP
ABLIKIM	13T	PRL 110 252001	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ABLIKIM	13X	PRL 111 242001	M. Ablikim <i>et al.</i>	(BESIII Collab.)
LIU	13B	PRL 110 252002	Z.Q. Liu <i>et al.</i>	(BELLE Collab.)
XIAO	13A	PL B727 366	T. Xiao <i>et al.</i>	(NWES)