

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

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

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  $7\sigma$  significance. Neutral  $T_{c\bar{c}1}(3900)^0$  seen in the  $J/\psi\pi^0$  invariant mass distribution in  $e^+e^- \rightarrow \pi^0\pi^0 J/\psi$  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
<b>3887.1±2.6 OUR AVERAGE</b>		Error includes scale factor of 1.7. See the ideogram below.			
3893.1±2.2± 3.0		<sup>1</sup> ABLIKIM	20N BES3	0	$e^+e^- \rightarrow \pi^0\pi^0 J/\psi$
3902.6 <sup>+5.2+ 3.3</sup> <sub>-5.0- 1.4</sub>		<sup>2,3</sup> ABAZOV	19 D0	±	1.96 TeV $p\bar{p} \rightarrow J/\psi\pi^+\pi^- X$
3881.2±4.2±52.7	6k	<sup>4</sup> ABLIKIM	17J BES3	±	$e^+e^- \rightarrow \pi^+\pi^- J/\psi$
3885.7 <sup>+4.3</sup> <sub>-5.7</sub> ± 8.4		<sup>2,4</sup> ABLIKIM	15AB BES3	0	$e^+e^- \rightarrow \pi^0(D\bar{D}^*)^0$
3881.7±1.6± 1.6	1.2k	<sup>2,4</sup> ABLIKIM	15AC BES3	±	$e^+e^- \rightarrow \pi^\pm(D\bar{D}^*)^\mp$
3883.9±1.5± 4.2	1.2k	<sup>2,4</sup> ABLIKIM	14A BES3	±	$e^+e^- \rightarrow \pi^\pm(D\bar{D}^*)^\mp$
3894.5±6.6± 4.5	159	<sup>2</sup> LIU	13B BELL	±	$e^+e^- \rightarrow \gamma\pi^+\pi^- J/\psi$
3886 ±4 ± 2	81	<sup>2,5</sup> XIAO	13A	±	4.17 $e^+e^- \rightarrow \pi^+\pi^- J/\psi$
3904 ±9 ± 5	25	<sup>2,5</sup> XIAO	13A	0	4.17 $e^+e^- \rightarrow \pi^0\pi^0 J/\psi$

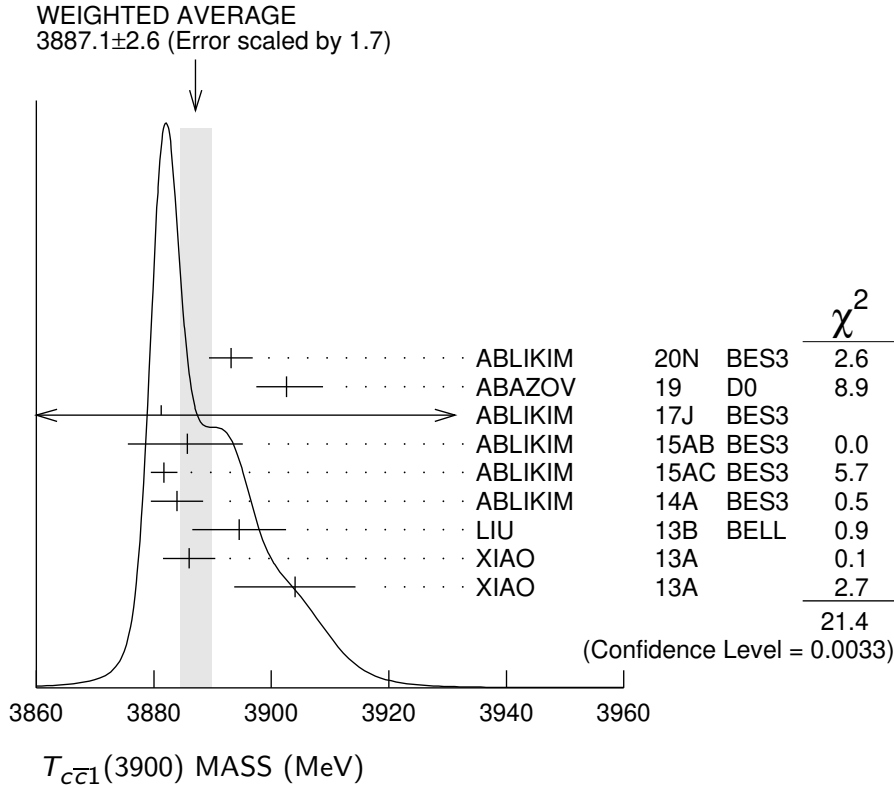
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●

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

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

<sup>7</sup> Superseded by ABLIKIM 20N.

<sup>8</sup> Superseded by ABLIKIM 17J.



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

VALUE (MeV)	EVTs	DOCUMENT ID	TECN	CHG	COMMENT
<b>28.4± 2.6 OUR AVERAGE</b>					
44.4± 5.2±14.0		<sup>1</sup> ABLIKIM	20N BES3	0	$e^+e^- \rightarrow \pi^0\pi^0 J/\psi$
32 $^{+28}_{-21}$ $^{+26}_{-7}$		<sup>2,3</sup> 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	<sup>4</sup> ABLIKIM	17J BES3	±	$e^+e^- \rightarrow \pi^+\pi^- J/\psi$
35 $^{+11}_{-12}$ ±15		<sup>2,4</sup> ABLIKIM	15AB BES3	0	$e^+e^- \rightarrow \pi^0(D\bar{D}^*)^0$
26.6± 2.0± 2.1	1248	<sup>2,4</sup> ABLIKIM	15AC BES3	±	$e^+e^- \rightarrow \pi^\pm(D\bar{D}^*)^\mp$
24.8± 3.3±11.0	1212	<sup>2,4</sup> ABLIKIM	14A BES3	±	$e^+e^- \rightarrow \pi^\pm(D\bar{D}^*)^\mp$
63 ±24 ±26	159	<sup>2</sup> LIU	13B BELL	±	$e^+e^- \rightarrow \gamma\pi^+\pi^- J/\psi$
37 ± 4 ± 8	81	<sup>2,5</sup> 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	<sup>2,6</sup> ABLIKIM	15U BES3	0	$e^+e^- \rightarrow \pi^0\pi^0 J/\psi$
46 ±10 ±20	307	<sup>2,7</sup> ABLIKIM	13T BES3	±	$e^+e^- \rightarrow \pi^+\pi^- J/\psi$

<sup>1</sup> Pole width obtained from a fit to a relativistic Breit-Wigner.

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

<sup>3</sup> Measured in weak decays of  $b$ -flavored hadrons (nonprompt).

<sup>4</sup> Pole width obtained from a fit to a Flatte-like formula.

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

<sup>6</sup> Superseded by ABLIKIM 20N.

<sup>7</sup> Superseded by ABLIKIM 17J.

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

	Mode	Fraction ( $\Gamma_i/\Gamma$ )
$\Gamma_1$	$J/\psi\pi$	seen
$\Gamma_2$	$h_c\pi^\pm$	not seen
$\Gamma_3$	$\eta_c\pi^+\pi^-$	not seen
$\Gamma_4$	$\eta_c(1S)\rho(770)^\pm$	seen
$\Gamma_5$	$(D\bar{D}^*)^\pm$	seen
$\Gamma_6$	$D^0 D^{*-} + \text{c.c.}$	seen
$\Gamma_7$	$D^- D^{*0} + \text{c.c.}$	seen
$\Gamma_8$	$\omega\pi^\pm$	not seen
$\Gamma_9$	$J/\psi\eta$	not seen
$\Gamma_{10}$	$D^+ D^{*-} + \text{c.c.}$	seen
$\Gamma_{11}$	$D^0 \bar{D}^{*0} + \text{c.c.}$	seen

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

$\Gamma(J/\psi\pi)/\Gamma_{\text{total}}$						$\Gamma_1/\Gamma$
VALUE	EVTS	DOCUMENT ID	TECN	CHG	COMMENT	
seen		ABLIKIM	20N	BES3	0	$e^+e^- \rightarrow \pi^0\pi^0 J/\psi$
seen		<sup>1</sup> ABAZOV	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		<sup>2</sup> 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	<sup>3</sup> XIAO	13A		0	$4.17 e^+e^- \rightarrow \pi^0\pi^0 J/\psi$

<sup>1</sup> But not seen in the "prompt" sample (no b-hadron enhancement).

<sup>2</sup> 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.

<sup>3</sup> Obtained by analyzing CLEO-c data but not authored by the CLEO Collaboration.

$\Gamma(h_c\pi^\pm)/\Gamma_{\text{total}}$						$\Gamma_2/\Gamma$
VALUE		DOCUMENT ID	TECN	CHG	COMMENT	
not seen		ABLIKIM	13X	BES3	$\pm$	$e^+e^- \rightarrow h_c\pi^+\pi^-$

$\Gamma(\eta_c\pi^+\pi^-)/\Gamma_{\text{total}}$						$\Gamma_3/\Gamma$
VALUE		DOCUMENT ID	TECN	CHG	COMMENT	
not seen		<sup>1</sup> VINOKUROVA 15	BELL	0	$B^+ \rightarrow K^+\eta_c\pi^+\pi^-$	

<sup>1</sup> 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.

$\Gamma(\eta_c(1S)\rho(770)^\pm)/\Gamma(J/\psi\pi)$   $\Gamma_4/\Gamma_1$ 

VALUE	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<b>2.3±0.8</b>	332	<sup>1</sup> ABLIKIM	19BC BES3		$e^+e^- \rightarrow \pi^+\pi^-\pi^0\eta_c(1S)$

<sup>1</sup> 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.

 $\Gamma((D\bar{D}^*)^\pm)/\Gamma(J/\psi\pi)$   $\Gamma_5/\Gamma_1$ 

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
<b>6.2±1.1±2.7</b>	<sup>1</sup> ABLIKIM	14A BES3	±	$e^+e^- \rightarrow \pi^\pm(D\bar{D}^*)^\mp$

<sup>1</sup> Assuming the same origin of the  $(D\bar{D}^*)^\pm$  and  $\pi^\pm J/\psi$  decay modes.

 $\Gamma(D^0 D^{*-} + \text{c.c.})/\Gamma_{\text{total}}$   $\Gamma_6/\Gamma$ 

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

 $\Gamma(D^- D^{*0} + \text{c.c.})/\Gamma_{\text{total}}$   $\Gamma_7/\Gamma$ 

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

 $\Gamma(\omega\pi^\pm)/\Gamma_{\text{total}}$   $\Gamma_8/\Gamma$ 

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

 $\Gamma(J/\psi\eta)/\Gamma_{\text{total}}$   $\Gamma_9/\Gamma$ 

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

 $\Gamma(J/\psi\eta)/\Gamma(J/\psi\pi)$   $\Gamma_9/\Gamma_1$ 

VALUE	CL%	DOCUMENT ID	TECN	CHG	COMMENT
<0.15	90	ABLIKIM	15Q BES3	0	4.226 $e^+e^- \rightarrow J/\psi\eta\pi^0$

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<0.65	90	ABLIKIM	15Q BES3	0	4.257 $e^+e^- \rightarrow J/\psi\eta\pi^0$
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 $\Gamma(D^+ D^{*-} + \text{c.c.})/\Gamma_{\text{total}}$   $\Gamma_{10}/\Gamma$ 

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

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

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

 $\Gamma(D^+ D^{*-} + \text{c.c.})/\Gamma(D^0\bar{D}^{*0} + \text{c.c.})$   $\Gamma_{10}/\Gamma_{11}$ 

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
<b>0.96±0.18±0.12</b>	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 (errat.)	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)

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