

**$Z_c(3900)$** 

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

was  $X(3900)$ 

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

Charged  $Z_c(3900)$  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  $Z_c(3900)$  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.

### $Z_c(3900)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<b>3887.2±2.3 OUR AVERAGE</b>		Error includes scale factor of 1.6. See the ideogram below.			
3895.0±5.2 <sup>+4.0</sup> <sub>-2.7</sub>	502	<sup>1</sup> ABAZOV	18B D0		1.96 TeV $p\bar{p} \rightarrow J/\psi\pi^+\pi^-X$
3885.7 <sup>+4.3</sup> <sub>-5.7</sub> ± 8.4		<sup>2</sup> ABLIKIM	15AB BES3	0	$e^+e^- \rightarrow \pi^0(D\bar{D}^*)^0$
3881.7±1.6 ± 1.6	1.2k	<sup>2</sup> ABLIKIM	15AC BES3	±	$e^+e^- \rightarrow \pi^\pm(D\bar{D}^*)^\mp$
3894.8±2.3 ± 3.2	356	<sup>2</sup> ABLIKIM	15U BES3	0	$e^+e^- \rightarrow \pi^0\pi^0J/\psi$
3883.9±1.5 ± 4.2	1.2k	<sup>2</sup> ABLIKIM	14A BES3	±	$e^+e^- \rightarrow \pi^\pm(D\bar{D}^*)^\mp$
3899.0±3.6 ± 4.9	307	<sup>2</sup> ABLIKIM	13T BES3	±	$e^+e^- \rightarrow \pi^+\pi^-J/\psi$
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>2,3</sup> XIAO	13A	±	4.17 $e^+e^- \rightarrow \pi^+\pi^-J/\psi$
3904 ±9 ± 5	25	<sup>2,3</sup> 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. • • •

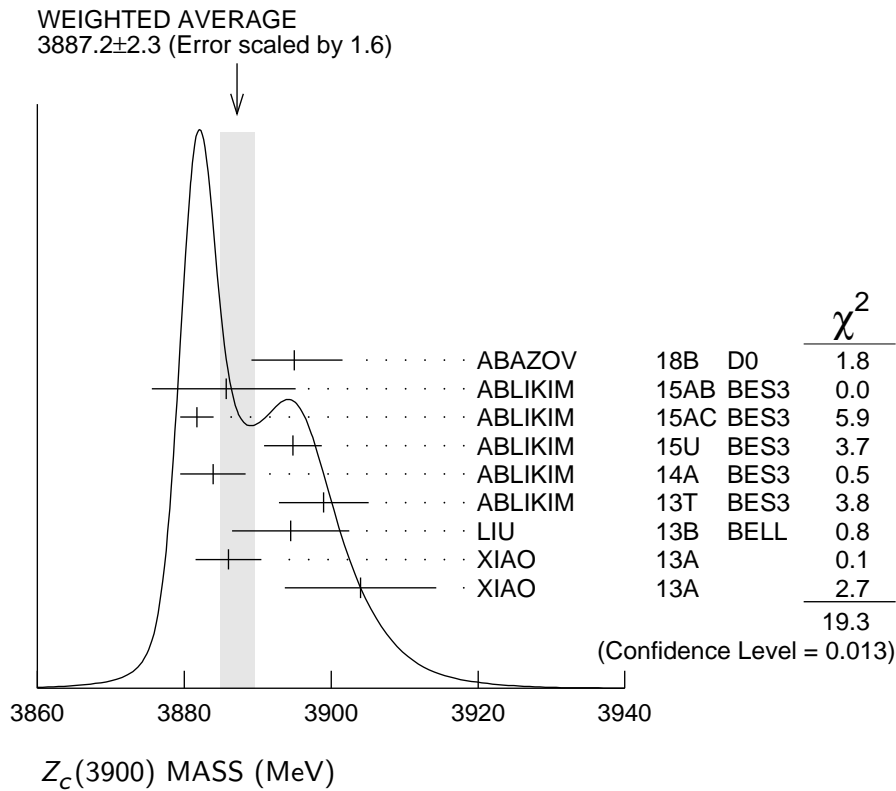
3881.2±4.2±52.7 6k <sup>4</sup> ABLIKIM 17J BES3 ±  $e^+e^- \rightarrow \pi^+\pi^-J/\psi$

<sup>1</sup> The signal of the  $Z_c(3900)$  is correlated with a parent  $J/\psi\pi^+\pi^-$  system in the invariant mass range 4.2–4.7 GeV.

<sup>2</sup> Neglecting interference between the  $Z_c(3900)$  and non-resonant continuum.

<sup>3</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>4</sup> Pole mass obtained from a fit to a Flatte-like formula.



### $Z_c(3900)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<b>28.2± 2.6 OUR AVERAGE</b>					
51.8± 4.6± 36.0	6 k	<sup>1</sup> ABLIKIM 17J	BES3	±	$e^+ e^- \rightarrow \pi^+ \pi^- J/\psi$
35 <sup>+11</sup> <sub>-12</sub> ± 15		<sup>2</sup> ABLIKIM 15AB	BES3	0	$e^+ e^- \rightarrow \pi^0 (D\bar{D}^*)^0$
26.6± 2.0± 2.1	1248	<sup>2</sup> ABLIKIM 15AC	BES3	±	$e^+ e^- \rightarrow \pi^\pm (D\bar{D}^*)^\mp$
29.6± 8.2± 8.2	356	<sup>2</sup> ABLIKIM 15U	BES3	0	$e^+ e^- \rightarrow \pi^0 \pi^0 J/\psi$
24.8± 3.3± 11.0	1212	<sup>2</sup> ABLIKIM 14A	BES3	±	$e^+ e^- \rightarrow \pi^\pm (D\bar{D}^*)^\mp$
46 ± 10 ± 20	307	<sup>2</sup> ABLIKIM 13T	BES3	±	$e^+ e^- \rightarrow \pi^+ \pi^- J/\psi$
63 ± 24 ± 26	159	<sup>2</sup> LIU 13B	BELL	±	$e^+ e^- \rightarrow \gamma \pi^+ \pi^- J/\psi$
37 ± 4 ± 8	81	<sup>2,3</sup> XIAO 13A		±	$4.17 e^+ e^- \rightarrow \pi^+ \pi^- J/\psi$

<sup>1</sup> Pole width obtained from a fit to a Flatte-like formula.

<sup>2</sup> Neglecting interference between the  $Z_c(3900)$  and non-resonant continuum.

<sup>3</sup> For  $M^2(\pi^+ \pi^-) < 0.65 \text{ GeV}^2$ . Obtained by analyzing CLEO-c data but not authored by the CLEO Collaboration.

### $Z_c(3900)$ 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

$\Gamma_4$	$(D\bar{D}^*)^\pm$	seen
$\Gamma_5$	$D^0 D^{*-} + \text{c.c.}$	seen
$\Gamma_6$	$D^- D^{*0} + \text{c.c.}$	seen
$\Gamma_7$	$\omega\pi^\pm$	not seen
$\Gamma_8$	$J/\psi\eta$	not seen
$\Gamma_9$	$D^+ D^{*-} + \text{c.c.}$	seen
$\Gamma_{10}$	$D^0 \bar{D}^{*0} + \text{c.c.}$	seen

## $Z_c(3900)$ BRANCHING RATIOS

$\Gamma(J/\psi\pi)/\Gamma_{\text{total}}$						$\Gamma_1/\Gamma$	
VALUE	CL%	EVTS	DOCUMENT ID	TECN	CHG	COMMENT	
seen		356	ABLIKIM	15U	BES3	0	$e^+e^- \rightarrow \pi^0\pi^0 J/\psi$
<b>seen</b>		307	ABLIKIM	13T	BES3	$\pm$	$e^+e^- \rightarrow \pi^+\pi^- J/\psi$
seen		25	<sup>1</sup> XIAO	13A		0	$4.17 e^+e^- \rightarrow \pi^0\pi^0 J/\psi$

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not seen 90 <sup>2</sup>ADOLPH 15D COMP  $\pm$   $\gamma N \rightarrow J/\psi\pi^\pm N$

<sup>1</sup> Obtained by analyzing CLEO-c data but not authored by the CLEO Collaboration.

<sup>2</sup> ADOLPH 15D measure  $B(Z_c(3900)^\pm \rightarrow J/\psi\pi^\pm) \sigma(\gamma N \rightarrow Z_c(3900)^\pm N) / \sigma(\gamma N \rightarrow J/\psi N) < 3.7 \times 10^{-3}$  at 90% CL.

$\Gamma(h_c\pi^\pm)/\Gamma_{\text{total}}$						$\Gamma_2/\Gamma$
VALUE	DOCUMENT ID	TECN	CHG	COMMENT		
<b>not seen</b>	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		
<b>not seen</b>	<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.

$\Gamma((D\bar{D}^*)^\pm)/\Gamma(J/\psi\pi)$						$\Gamma_4/\Gamma_1$
VALUE	DOCUMENT ID	TECN	CHG	COMMENT		
<b>6.2<math>\pm</math>1.1<math>\pm</math>2.7</b>	<sup>1</sup> ABLIKIM	14A	BES3	$\pm$	$e^+e^- \rightarrow \pi^\pm (D\bar{D}^*)^\mp$	

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

$\Gamma(D^0 D^{*-} + \text{c.c.})/\Gamma_{\text{total}}$						$\Gamma_5/\Gamma$
VALUE	DOCUMENT ID	TECN	CHG	COMMENT		
<b>seen</b>	ABLIKIM	15AC	BES3	$\pm$	$e^+e^- \rightarrow \pi^+ D^0 D^{*-} + \text{c.c.}$	
<b>seen</b>	ABLIKIM	14A	BES3	$\pm$	$e^+e^- \rightarrow \pi^+ D^0 D^{*-} + \text{c.c.}$	

$\Gamma(D^- D^{*0} + \text{c.c.})/\Gamma_{\text{total}}$						$\Gamma_6/\Gamma$
VALUE	DOCUMENT ID	TECN	CHG	COMMENT		
<b>seen</b>	ABLIKIM	15AC	BES3	$\pm$	$e^+e^- \rightarrow \pi^+ D^- D^{*0} + \text{c.c.}$	
<b>seen</b>	ABLIKIM	14A	BES3	$\pm$	$e^+e^- \rightarrow \pi^+ D^- D^{*0} + \text{c.c.}$	

$\Gamma(\omega\pi^\pm)/\Gamma_{\text{total}}$						$\Gamma_7/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>		
<b>not seen</b>	ABLIKIM	15R	BES3	$\pm$	$e^+e^- \rightarrow \omega\pi^+\pi^-$	

$\Gamma(J/\psi\eta)/\Gamma_{\text{total}}$						$\Gamma_8/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>		
<b>not seen</b>	ABLIKIM	15Q	BES3	0	4.0–4.6 $e^+e^- \rightarrow J/\psi\eta\pi^0$	

$\Gamma(J/\psi\eta)/\Gamma(J/\psi\pi)$						$\Gamma_8/\Gamma_1$
<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>	
<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 $e^+e^- \rightarrow J/\psi\eta\pi^0$

$\Gamma(D^+D^{*-} + \text{c.c.})/\Gamma_{\text{total}}$						$\Gamma_9/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>		
<b>seen</b>	ABLIKIM	15AB	BES3	0	$e^+e^- \rightarrow \pi^0(D\bar{D}^*)^0$	

$\Gamma(D^0\bar{D}^{*0} + \text{c.c.})/\Gamma_{\text{total}}$						$\Gamma_{10}/\Gamma$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>		
<b>seen</b>	ABLIKIM	15AB	BES3	0	$e^+e^- \rightarrow \pi^0(D\bar{D}^*)^0$	

$\Gamma(D^+D^{*-} + \text{c.c.})/\Gamma(D^0\bar{D}^{*0} + \text{c.c.})$						$\Gamma_9/\Gamma_{10}$
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>		
<b>0.96 ± 0.18 ± 0.12</b>	ABLIKIM	15AB	BES3	0	$e^+e^- \rightarrow \pi^0(D\bar{D}^*)^0$	

### Z<sub>c</sub>(3900) REFERENCES

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>	(BES III Collab.)
ABLIKIM	15AB	PRL 115 222002	M. Ablikim <i>et al.</i>	(BES III Collab.)
ABLIKIM	15AC	PR D92 092006	M. Ablikim <i>et al.</i>	(BES III Collab.) JP
ABLIKIM	15Q	PR D92 012008	M. Ablikim <i>et al.</i>	(BES III Collab.)
ABLIKIM	15R	PR D92 032009	M. Ablikim <i>et al.</i>	(BES III Collab.)
ABLIKIM	15U	PRL 115 112003	M. Ablikim <i>et al.</i>	(BES III 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. Vinokurova <i>et al.</i>	(BELLE Collab.)
ABLIKIM	14A	PRL 112 022001	M. Ablikim <i>et al.</i>	(BES III Collab.) JP
ABLIKIM	13T	PRL 110 252001	M. Ablikim <i>et al.</i>	(BES III Collab.)
ABLIKIM	13X	PRL 111 242001	M. Ablikim <i>et al.</i>	(BES III 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)