

$Z_c(3900)$

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

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 7σ 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
3887.1±2.6 OUR AVERAGE		Error includes scale factor of 1.7. See the ideogram below.			
3893.1±2.2± 3.0	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 $Z_c(3900)$ and other processes.

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

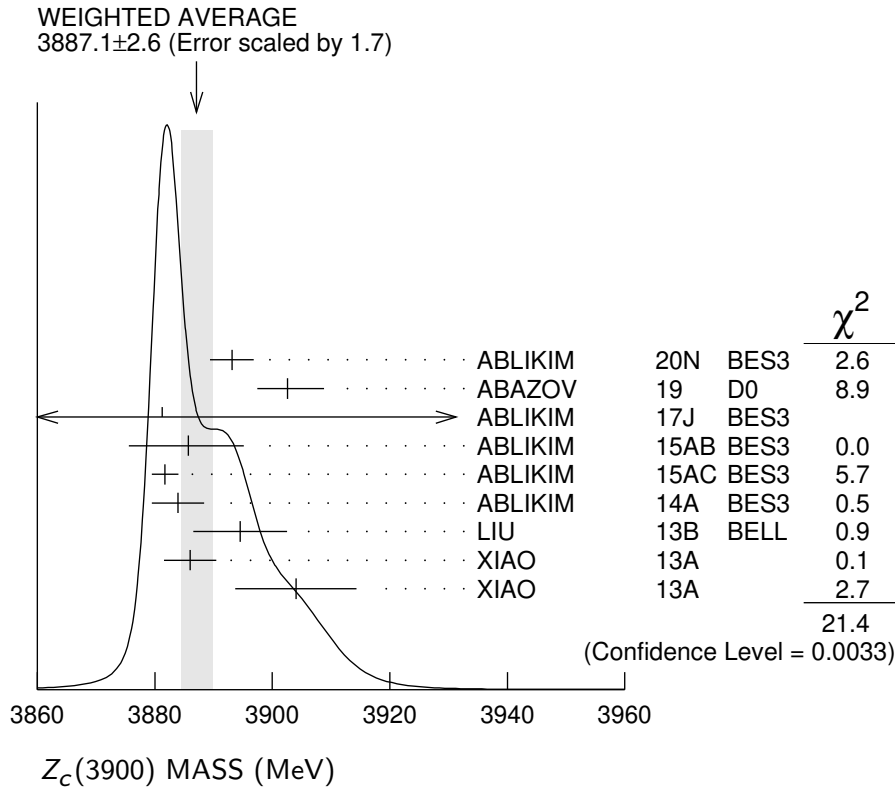
⁴ Pole mass obtained from a fit to a Flatte-like formula.

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 $Z_c(3900)$ 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.



$Z_c(3900)$ 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 $\begin{smallmatrix} +11 & \pm 15 \\ -12 & \end{smallmatrix}$		^{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 $e^+e^- \rightarrow \pi^+\pi^- J/\psi$

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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 $Z_c(3900)$ 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.

$Z_c(3900)$ 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	$\eta_c(1S)\rho(770)^\pm$	
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

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

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.

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

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
6.2±1.1±2.7	¹ ABLIKIM	14A	BES3	± e ⁺ e ⁻ → π [±] (D \bar{D}^*) [∓]

¹ Assuming the same origin of the (D \bar{D}^*)[±] and π[±]J/ψ decay modes.

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

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
seen	ABLIKIM	15AC	BES3	± e ⁺ e ⁻ → π ⁺ D ⁰ D ^{*-} + c.c.
seen	ABLIKIM	14A	BES3	± e ⁺ e ⁻ → π ⁺ D ⁰ D ^{*-} + c.c.

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

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
seen	ABLIKIM	15AC	BES3	± e ⁺ e ⁻ → π ⁺ D ⁻ D ^{*0} + c.c.
seen	ABLIKIM	14A	BES3	± e ⁺ e ⁻ → π ⁺ D ⁻ D ^{*0} + c.c.

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

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
not seen	ABLIKIM	15R	BES3	± e ⁺ e ⁻ → ωπ ⁺ π ⁻

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

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
not seen	ABLIKIM	15Q	BES3	0 4.0–4.6 e ⁺ e ⁻ → J/ψηπ 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 ⁻ → J/ψηπ ⁰

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<0.65	90	ABLIKIM	15Q	BES3	0 4.257 e ⁺ e ⁻ → J/ψηπ ⁰
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$\Gamma(\eta_c(1S)\rho(770)^\pm)/\Gamma(J/\psi\pi)$ Γ_4/Γ_1

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
2.3±0.8	332	¹ ABLIKIM	19BC	BES3 e ⁺ e ⁻ → π ⁺ π ⁻ π ⁰ η _c (1S)

¹ Using e⁺e⁻ → π[∓](Z_c(3900)[±] → J/ψπ[±]) cross section at 4.23 and 4.26 GeV from ABLIKIM 17J.

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

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
seen	ABLIKIM	15AB	BES3	0 e ⁺ e ⁻ → π ⁰ (D \bar{D}^*) ⁰

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

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
seen	ABLIKIM	15AB	BES3	0 e ⁺ e ⁻ → π ⁰ (D \bar{D}^*) ⁰

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

VALUE	DOCUMENT ID	TECN	CHG	COMMENT
0.96±0.18±0.12	ABLIKIM	15AB	BES3	0 e ⁺ e ⁻ → π ⁰ (D \bar{D}^*) ⁰

Z_c(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)
