

$\chi_{c0}(3915)$

$$J^{PC} = 0^+(0^{++})$$

was $X(3915)$

The $\chi_{c0}(3915)$ was originally seen by BELLE in its $\omega J/\psi$ decay mode and was produced in both B decays in CHOI 05 and $\gamma\gamma$ collisions in UEHARA 10. The J^{PC} was determined to be 0^{++} by BABAR in LEES 12AD but this assignment was questioned by ZHOU 15C. In AAIJ 20AI LHCb found the $D^+ D^-$ decay mode of the $\chi_{c0}(3915)$ using B decays and determined its J^{PC} to be 0^{++} . Based on their compatible mass, width, and J^{PC} , we assume the state decaying to $\omega J/\psi$ and the state decaying to $D^+ D^-$ are both the $\chi_{c0}(3915)$. See also the $\chi_{c2}(3930)$.

$\chi_{c0}(3915)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
3922.1\pm 1.8 OUR AVERAGE		Error includes scale factor of 1.5. See the ideogram below.		
3956 \pm 5 \pm 10	360	¹ AAIJ	23AA LHCb	$B^+ \rightarrow D_s^+ D_s^- K^+$
3923.8 \pm 1.5 \pm 0.4	1.2k	² AAIJ	20AI LHCb	$B^+ \rightarrow D^+ D^- K^+$
3919.4 \pm 2.2 \pm 1.6	59 \pm 10	LEES	12AD BABR	$e^+ e^- \rightarrow e^+ e^- \omega J/\psi$
3919.1 $^{+3.8}_{-3.4}$ \pm 2.0		DEL-AMO-SA..10B	BABR	$B \rightarrow \omega J/\psi K$
3915 \pm 3 \pm 2	49 \pm 15	UEHARA	10 BELL	10.6 $e^+ e^- \rightarrow e^+ e^- \omega J/\psi$
3943 \pm 11 \pm 13	58 \pm 11	³ CHOI	05 BELL	$B \rightarrow \omega J/\psi K$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
3920.9 \pm 0.9		⁴ LI	24 RVUE	$\omega J/\psi$ invariant mass
3922.4 \pm 6.5 \pm 2.0		⁵ WANG	22A BELL	$\gamma\gamma \rightarrow \gamma\psi(2S)$
3926.4 \pm 2.2 \pm 1.2		⁶ ABLIKIM	19V BES	$e^+ e^- \rightarrow \gamma\omega J/\psi$
3914.6 $^{+3.8}_{-3.4}$ \pm 2.0		³ AUBERT	08W BABR	Superseded by DEL-AMO-SANCHEZ 10B

¹ $D_s^+ D_s^-$ near-threshold enhancement parameterized with a Flatte-like function .

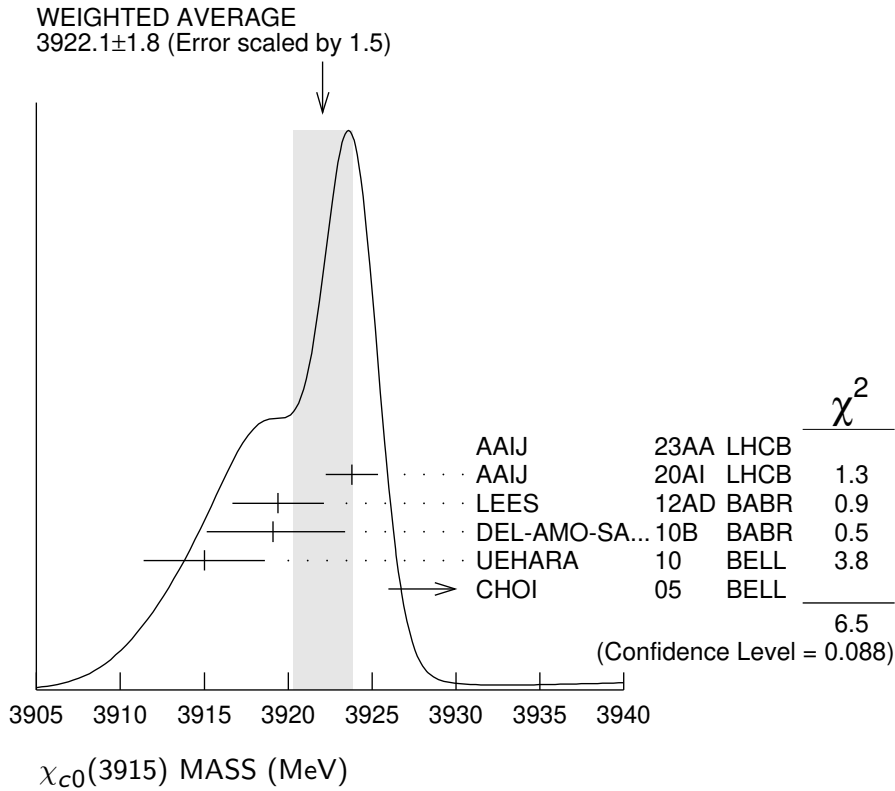
² Obtained from the full amplitude analysis. Parameterized with the relativistic Breit-Wigner line shape.

³ $\omega J/\psi$ threshold enhancement fitted as an S-wave Breit-Wigner resonance.

⁴ From a simultaneous χ^2 fit to the distributions of the $\omega J/\psi$ invariant mass measured by BaBar and Belle in the processes $\gamma\gamma \rightarrow \omega J/\psi$ and $B \rightarrow \omega J/\psi K$. LHCb results also taken into account as an additional constraint in the χ^2 calculation.

⁵ Not distinguished from the $\chi_{c2}(3930)$.

⁶ Could also be $X(3940)$. Significance 3.1σ . Fit with additional resonance at 3963.7 ± 5.7 MeV, significance 3.4σ .



$\chi_{c0}(3915)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
20 ± 4	OUR AVERAGE	Error includes scale factor of 1.1.		
$43 \pm 13 \pm 8$	360	¹ AAIJ	23AA LHCb	$B^+ \rightarrow D_s^+ D_s^- K^+$
$17.4 \pm 5.1 \pm 0.8$	1.2k	² AAIJ	20AI LHCb	$B^+ \rightarrow D^+ D^- K^+$
$13 \pm 6 \pm 3$	59	LEES	12AD BABR	$e^+ e^- \rightarrow e^+ e^- \omega J/\psi$
$31 \begin{smallmatrix} +10 \\ -8 \end{smallmatrix} \pm 5$		DEL-AMO-SA..10B	BABR	$B \rightarrow \omega J/\psi K$
$17 \pm 10 \pm 3$	49	UEHARA	10 BELL	$10.6 e^+ e^- \rightarrow e^+ e^- \omega J/\psi$
$87 \pm 22 \pm 26$	58	³ CHOI	05 BELL	$B \rightarrow \omega J/\psi K$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
18.2 ± 2.4		⁴ LI	24 RVUE	$\omega J/\psi$ invariant mass
$22 \pm 17 \pm 4$		⁵ WANG	22A BELL	$\gamma\gamma \rightarrow \gamma\psi(2S)$
$3.8 \pm 7.5 \pm 2.6$		⁶ ABLIKIM	19V BES	$e^+ e^- \rightarrow \gamma\omega J/\psi$
$34 \begin{smallmatrix} +12 \\ -8 \end{smallmatrix} \pm 5$		³ AUBERT	08W BABR	Superseded by DEL-AMO-SANCHEZ 10B

- ¹ $D_s^+ D_s^-$ near-threshold enhancement parameterized with a Flatté-like function .
- ² Obtained from the full amplitude analysis. Parameterized with the relativistic Breit-Wigner line shape.
- ³ $\omega J/\psi$ threshold enhancement fitted as an S-wave Breit-Wigner resonance.
- ⁴ From a simultaneous χ^2 fit to the distributions of the $\omega J/\psi$ invariant mass measured by BaBar and Belle in the processes $\gamma\gamma \rightarrow \omega J/\psi$ and $B \rightarrow \omega J/\psi K$. LHCb results also taken into account as an additional constraint in the χ^2 calculation.
- ⁵ Not distinguished from the $\chi_{c2}(3930)$.

⁶ Could also be $X(3940)$. Significance 3.1σ . Fit with additional resonance at 3963.7 ± 5.7 MeV, significance 3.4σ .

$\chi_{c0}(3915)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)
$\Gamma_1 \quad \omega J/\psi$	seen
$\Gamma_2 \quad \bar{D}^{*0} D^0$	not seen
$\Gamma_3 \quad D^+ D^-$	seen
$\Gamma_4 \quad D_s^+ D_s^-$	seen
$\Gamma_5 \quad \pi^+ \pi^- \eta_c(1S)$	not seen
$\Gamma_6 \quad \eta_c \eta$	not seen
$\Gamma_7 \quad \eta_c \pi^0$	not seen
$\Gamma_8 \quad K \bar{K}$	not seen
$\Gamma_9 \quad \gamma\gamma$	seen
$\Gamma_{10} \quad \gamma\psi(2S)$	not seen
$\Gamma_{11} \quad \pi^0 \chi_{c1}$	not seen

$\chi_{c0}(3915) \Gamma(i)\Gamma(\gamma\gamma)/\Gamma(\text{total})$

$\Gamma(\omega J/\psi) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ $\Gamma_1\Gamma_9/\Gamma$

VALUE (eV)	EVTS	DOCUMENT ID	TECN	COMMENT
54 ± 9 OUR AVERAGE				
52 ± 10 ± 3	59 ± 10	¹ LEES	12AD BABR	$e^+ e^- \rightarrow e^+ e^- \omega J/\psi$
61 ± 17 ± 8	49 ± 15	¹ UEHARA	10 BELL	10.6 $e^+ e^- \rightarrow e^+ e^- \omega J/\psi$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
18 ± 5 ± 2	49 ± 15	² UEHARA	10 BELL	10.6 $e^+ e^- \rightarrow e^+ e^- \omega J/\psi$
¹ For $J^P = 0^+$.				
² For $J^P = 2^+$, helicity-2.				

$\Gamma(\gamma\psi(2S)) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ $\Gamma_{10}\Gamma_9/\Gamma$

VALUE (eV)	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
9.8 ± 3.6 ± 1.3	¹ WANG	22A BELL	$\gamma\gamma \rightarrow \gamma\psi(2S)$
¹ Not distinguished from the $\chi_{c2}(3930)$.			

$\Gamma(\pi^+ \pi^- \eta_c(1S)) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ $\Gamma_5\Gamma_9/\Gamma$

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
<16	90	LEES	12AE BABR	$e^+ e^- \rightarrow e^+ e^- \pi^+ \pi^- \eta_c$

$\Gamma(K \bar{K}) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ $\Gamma_8\Gamma_9/\Gamma$

VALUE (eV)	CL%	DOCUMENT ID	TECN	COMMENT
<1.96	90	UEHARA	13 BELL	$\gamma\gamma \rightarrow K_S^0 K_S^0$

$\chi_{c0}(3915)$ BRANCHING RATIOS

$\Gamma(\omega J/\psi)/\Gamma_{\text{total}}$ Γ_1/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
seen		¹ DEL-AMO-SA..10B	BABR	$B \rightarrow \omega J/\psi K$
seen		² CHOI 05	BELL	$B \rightarrow \omega J/\psi K$

¹ DEL-AMO-SANCHEZ 10B reports $B(B^\pm \rightarrow \chi_{c0}(3915) K^\pm) \times B(\chi_{c0}(3915) \rightarrow J/\psi \omega) = (3.0^{+0.7+0.5}_{-0.6-0.3}) \times 10^{-5}$ and $B(B^0 \rightarrow \chi_{c0}(3915) K^0) \times B(\chi_{c0}(3915) \rightarrow J/\psi \omega) = (2.1 \pm 0.9 \pm 0.3) \times 10^{-5}$.

² CHOI 05 reports $B(B \rightarrow \chi_{c0}(3915) K) \times B(\chi_{c0}(3915) \rightarrow J/\psi \omega) = (7.1 \pm 1.3 \pm 3.1) \times 10^{-5}$.

$\Gamma(\omega J/\psi)/\Gamma(\bar{D}^{*0} D^0)$ Γ_1/Γ_2

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
>0.71	90	¹ AUSHEV 10	BELL	$B \rightarrow \bar{D}^{*0} D^0 K$

¹ By combining the upper limit $B(B \rightarrow \chi_{c0}(3915) K) \times B(\chi_{c0}(3915) \rightarrow D^{*0} \bar{D}^0) < 0.67 \times 10^{-4}$ from AUSHEV 10 with the average of CHOI 05 and AUBERT 08w measurements $B(B \rightarrow \chi_{c0}(3915) K) \times B(\chi_{c0}(3915) \rightarrow \omega J/\psi) = (0.51 \pm 0.11) \times 10^{-4}$.

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

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
seen		AAIJ 20AI	LHCB	$B^+ \rightarrow D^+ D^- K^+$

$\Gamma(D^+ D^-)/\Gamma(D_s^+ D_s^-)$ Γ_3/Γ_4

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
0.29 ± 0.09 ± 0.10 ± 0.08		¹ AAIJ 23AA	LHCB	$B^+ \rightarrow D_s^+ D_s^- K^+$

¹ Assuming that AAIJ 20AI reporting on $B^+ \rightarrow D^+ D^- K^+$ also refers to $\chi_{c0}(3915)$. The last uncertainty is due to the values of $B(D^+ \rightarrow K^- \pi^+ \pi^+)$ and $B(D_s^+ \rightarrow K^- K^+ \pi^+)$ from PDG 22.

$\Gamma(\eta_c \eta)/\Gamma_{\text{total}}$ Γ_6/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
not seen	90	¹ VINOKUROVA 15	BELL	$B^+ \rightarrow K^+ \eta_c \eta$

¹ VINOKUROVA 15 reports $B(B^+ \rightarrow K^+ \chi_{c0}(3915)) \times B(\chi_{c0}(3915) \rightarrow \eta_c \eta) < 4.7 \times 10^{-5}$ at 90% CL.

$\Gamma(\eta_c \pi^0)/\Gamma_{\text{total}}$ Γ_7/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
not seen	90	¹ VINOKUROVA 15	BELL	$B^+ \rightarrow K^+ \eta_c \pi^0$

¹ VINOKUROVA 15 reports $B(B^+ \rightarrow K^+ \chi_{c0}(3915)^0) \times B(\chi_{c0}(3915) \rightarrow \eta_c \pi^0) < 1.7 \times 10^{-5}$ at 90% CL.

$\Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ Γ_9/Γ

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
seen	59 ± 10	LEES	12AD BABR	$e^+ e^- \rightarrow e^+ e^- \omega J/\psi$
seen		UEHARA 10	BELL	10.6 $e^+ e^- \rightarrow e^+ e^- \omega J/\psi$

$\Gamma(\pi^0 \chi_{c1})/\Gamma_{\text{total}}$					Γ_{11}/Γ
<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
not seen	42 ± 14	¹ BHARDWAJ	19	BELL	$B^\pm \rightarrow \chi_{c1} \pi^0 K^\pm$
¹ BHARDWAJ 19 reports $B(B^+ \rightarrow K^+ \chi_{c0}(3915)) \times B(\chi_{c0}(3915) \rightarrow \chi_{c1} \pi^0) < 3.8 \times 10^{-5}$ at 90% CL. A signal significance 2.3 standard deviations.					

$\chi_{c0}(3915)$ REFERENCES

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Also		JHEP 1702 088 (errat.)	A. Vinokurava <i>et al.</i>	(BELLE Collab.)
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UEHARA	10	PRL 104 092001	S. Uehara <i>et al.</i>	(BELLE Collab.)
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