

# $\chi_{c0}(3915)$

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

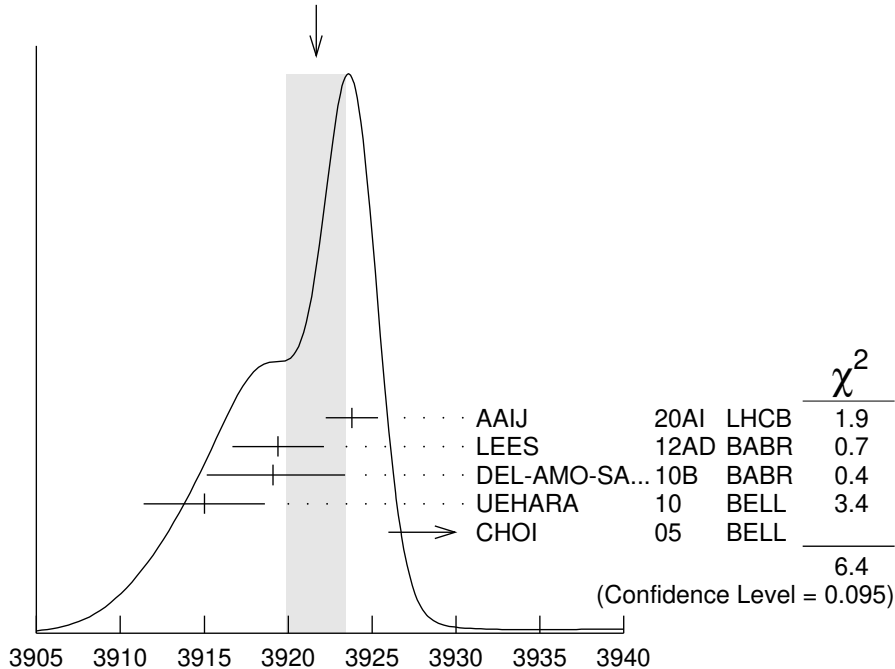
was  $X(3915)$

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
<b><math>3921.7 \pm 1.8</math></b>	<b>OUR AVERAGE</b>	Error includes scale factor of 1.5. See the ideogram below.		
$3923.8 \pm 1.5 \pm 0.4$	$1.2k$	<sup>1</sup> AAIJ	20AI LHCb	$B^+ \rightarrow D^+ D^- K^+$
$3919.4 \pm 2.2 \pm 1.6$	$59 \pm 10$	LEES	12AD BABR	$e^+ e^- \rightarrow e^+ e^- \omega J/\psi$
$3919.1^+_{-3.4} \pm 2.0$		DEL-AMO-SA...10B	BABR	$B \rightarrow \omega J/\psi K$
$3915 \pm 3 \pm 2$	$49 \pm 15$	UEHARA	10 BELL	$10.6 e^+ e^- \rightarrow e^+ e^- \omega J/\psi$
$3943 \pm 11 \pm 13$	$58 \pm 11$	<sup>2</sup> CHOI	05 BELL	$B \rightarrow \omega J/\psi K$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$3926.4 \pm 2.2 \pm 1.2$		<sup>3</sup> ABLIKIM	19V BES	$e^+ e^- \rightarrow \gamma \omega J/\psi$
$3914.6^+_{-3.4} \pm 2.0$		<sup>2</sup> AUBERT	08W BABR	Superseded by DEL-AMO-SANCHEZ 10B

WEIGHTED AVERAGE  
 $3921.7 \pm 1.8$  (Error scaled by 1.5)



<sup>1</sup> Obtained from the full amplitude analysis. Parameterized with the relativistic Breit-Wigner line shape.

<sup>2</sup>  $\omega J/\psi$  threshold enhancement fitted as an S-wave Breit-Wigner resonance.

<sup>3</sup> Could also be X(3940). Significance  $3.1\sigma$ . Fit with additional resonance at  $3963.7 \pm 5.7$  MeV, significance  $3.4\sigma$ .  $\chi_{c0}(3915)$  MASS (MeV)

### $\chi_{c0}(3915)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>18.8 ± 3.5 OUR AVERAGE</b>				
17.4 ± 5.1 ± 0.8	1.2k	<sup>1</sup> AAIJ	20AI LHCb	$B^+ \rightarrow D^+ D^- K^+$
13 ± 6 ± 3	59	LEES	12AD BABR	$e^+ e^- \rightarrow e^+ e^- \omega J/\psi$
31 $^{+10}_{-8}$ ± 5		DEL-AMO-SA..10B	BABR	$B \rightarrow \omega J/\psi K$
17 ± 10 ± 3	49	UEHARA	10 BELL	10.6 $e^+ e^- \rightarrow e^+ e^- \omega J/\psi$
87 ± 22 ± 26	58	<sup>2</sup> CHOI	05 BELL	$B \rightarrow \omega J/\psi K$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
3.8 ± 7.5 ± 2.6		<sup>3</sup> ABLIKIM	19V BES	$e^+ e^- \rightarrow \gamma \omega J/\psi$
34 $^{+12}_{-8}$ ± 5		<sup>2</sup> AUBERT	08W BABR	Superseded by DEL-AMO-SANCHEZ 10B

<sup>1</sup> Obtained from the full amplitude analysis. Parameterized with the relativistic Breit-Wigner line shape.

<sup>2</sup>  $\omega J/\psi$  threshold enhancement fitted as an S-wave Breit-Wigner resonance.

<sup>3</sup> Could also be X(3940). Significance  $3.1\sigma$ . Fit with additional resonance at  $3963.7 \pm 5.7$  MeV, significance  $3.4\sigma$ .

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

Mode	Fraction ( $\Gamma_i/\Gamma$ )
$\Gamma_1$ $\omega J/\psi$	seen
$\Gamma_2$ $\overline{D}^{*0} D^0$	not seen
$\Gamma_3$ $D^+ D^-$	seen
$\Gamma_4$ $\pi^+ \pi^- \eta_c(1S)$	not seen
$\Gamma_5$ $\eta_c \eta$	not seen
$\Gamma_6$ $\eta_c \pi^0$	not seen
$\Gamma_7$ $K \overline{K}$	not seen
$\Gamma_8$ $\gamma \gamma$	seen
$\Gamma_9$ $\pi^0 \chi_{c1}$	not seen

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

VALUE (eV)	EVTS	DOCUMENT ID	TECN	COMMENT	$\Gamma_1 \Gamma_8 / \Gamma$
<b><math>\Gamma(\omega J/\psi) \times \Gamma(\gamma\gamma) / \Gamma_{\text{total}}</math></b>					
<b>54 ± 9 OUR AVERAGE</b>					
52 ± 10 ± 3	59 ± 10	<sup>1</sup> LEES	12AD BABR	$e^+ e^- \rightarrow e^+ e^- \omega J/\psi$	
61 ± 17 ± 8	49 ± 15	<sup>1</sup> 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	<sup>2</sup> UEHARA	10 BELL	10.6 $e^+ e^- \rightarrow e^+ e^- \omega J/\psi$	

<sup>1</sup> For  $J^P = 0^+$ .

<sup>2</sup> For  $J^P = 2^+$ , helicity-2.

$\Gamma(\pi^+\pi^-\eta_c(1S)) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$   $\Gamma_4\Gamma_8/\Gamma$ 

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

 $\Gamma(K\bar{K}) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$   $\Gamma_7\Gamma_8/\Gamma$ 

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

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

<sup>1</sup> 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  $B(B^0 \rightarrow \chi_{c0}(3915) K^0) \times B(\chi_{c0}(3915) \rightarrow J/\psi\omega)$   
 $= (2.1 \pm 0.9 \pm 0.3) \times 10^{-5}$ .

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

 $\Gamma(\omega J/\psi)/\Gamma(\bar{D}^{*0} D^0)$   $\Gamma_1/\Gamma_2$ 

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

<sup>1</sup> 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  $B(B \rightarrow \chi_{c0}(3915) K) \times B(\chi_{c0}(3915) \rightarrow \omega J/\psi) = (0.51 \pm 0.11) \times 10^{-4}$ .

 $\Gamma(D^+ D^-)/\Gamma_{\text{total}}$   $\Gamma_3/\Gamma$ 

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

 $\Gamma(\eta_c \eta)/\Gamma_{\text{total}}$   $\Gamma_5/\Gamma$ 

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

<sup>1</sup> 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.

 $\Gamma(\eta_c \pi^0)/\Gamma_{\text{total}}$   $\Gamma_6/\Gamma$ 

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

<sup>1</sup> 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.

 $\Gamma(\gamma\gamma)/\Gamma_{\text{total}}$   $\Gamma_8/\Gamma$ 

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 $e^+e^- \rightarrow e^+e^-\omega J/\psi$

$\Gamma(\pi^0 \chi_{c1})/\Gamma_{\text{total}}$					$\Gamma_g/\Gamma$
<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<b>not seen</b>	$42 \pm 14$	<sup>1</sup> BHARDWAJ	19	BELL	$B^\pm \rightarrow \chi_{c1} \pi^0 K^\pm$
<sup>1</sup> 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

AAIJ	20AI	PR D102 112003	R. Aaij <i>et al.</i>	(LHCb Collab.) JPC
ABLIKIM	19V	PRL 122 232002	M. Ablikim <i>et al.</i>	(BESIII Collab.)
BHARDWAJ	19	PR D99 111101	V. Bhardwaj <i>et al.</i>	(BELLE 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.)
ZHOU	15C	PRL 115 022001	Z.-Y. Zhou, Z. Xiao, H.-Q. Zhou	(BEIJT, NANJ)
UEHARA	13	PTEP 2013 123C01	S. Uehara <i>et al.</i>	(BELLE Collab.)
LEES	12AD	PR D86 072002	J.P. Lees <i>et al.</i>	(BABAR Collab.)
LEES	12AE	PR D86 092005	J.P. Lees <i>et al.</i>	(BABAR Collab.)
AUSHEV	10	PR D81 031103	T. Aushev <i>et al.</i>	(BELLE Collab.)
DEL-AMO-SA...	10B	PR D82 011101	P. del Amo Sanchez <i>et al.</i>	(BABAR Collab.)
UEHARA	10	PRL 104 092001	S. Uehara <i>et al.</i>	(BELLE Collab.)
AUBERT	08W	PRL 101 082001	B. Aubert <i>et al.</i>	(BABAR Collab.)
CHOI	05	PRL 94 182002	S.-K. Choi <i>et al.</i>	(BELLE Collab.)