Citation: K. Hagiwara *et al.* (Particle Data Group), Phys. Rev. D **66**, 010001 (2002) and 2003 partial update for edition 2004 (URL: http://pdg.lbl.gov)

$\chi_{c0}(1P)$

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

$\chi_{c0}(1P)$ MASS

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
3415.3± 0.4 OUR NEW AVERAGE		[3415.1 ± 0.8 MeV OUR 2002 AVERAGE]			
3415.4± 0.4±0.2	392	[3] BAGNASCO	02	E835	$\overline{p}p \to \chi_{c0} \to J/\psi\gamma$
3416.5± 3.0		EISENSTEIN	01	CLE2	$e^+e^- \to e^+e^-\chi_{c0}$
$3417.4^{+1.8}_{-1.9}\pm0.2$		[3] AMBROGIANI	99B	E835	$\overline{p}p \to e^+e^-\gamma$
3414.1± 0.6±0.8		BAI	99B	BES	$\psi(2S) \to \gamma X$
3417.8± 0.4±4		[1] GAISER	86	CBAL	$\psi(2S) \to \gamma X$
3422 ±10		[2] BARTEL	78B	CNTR	$e^+e^- \to J/\psi 2\gamma$
3416 ± 3 ±4		[2] TANENBAUM	78	MRK1	e^+e^-
3415 ± 9		[2] BIDDICK	77	CNTR	$e^+e^- \to \gamma X$

[1] Using mass of $\psi(2S) = 3686.0$ MeV.

[2] Mass value shifted by us by amount appropriate for $\psi(2S)$ mass = 3686 MeV and $J/\psi(1S)$ mass = 3097 MeV.

[3] Using mass of $\psi(2S) = 3685.96$ MeV.

$\chi_{c0}(1P)$ WIDTH

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
10.7±0.9 OUR NEW UNCHECKED FIT		[16.2 ± 2.3 MeV OUR 2002 FIT]			
10.6±1.2 OUR NEW AVERAGE Error includes scale factor of 1.2. [$14.9^{+2.6}_{-2.3}$ MeV OUR 2002 AVERAGE]					
9.8±1.0±0.1	392	BAGNASCO	02	E835	$\overline{p}p \to \chi_{c0} \to J/\psi\gamma$
$16.6^{+5.2}_{-3.7}\pm0.1$		AMBROGIANI	99B	E835	$\overline{p}p \to e^+e^-\gamma$
14.3±2.0±3.0		BAI	98I	BES	$\psi(2S) \to \gamma\pi^+\pi^-$
13.5±3.3±4.2		GAISER	86	CBAL	$\psi(2S) \to \gamma X, \gamma\pi^0\pi^0$

$\chi_{c0}(1P)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)	Scale factor/ Confidence level
	Hadronic decays		
Γ_1	$2(\pi^+\pi^-)$	(2.64±0.31) %	
Γ_2	$\pi^+\pi^-K^+K^-$	(1.8 ±0.6) %	S=1.9
Γ_3	$\rho^0\pi^+\pi^-$	(1.6 ±0.5) %	
Γ_4	$3(\pi^+\pi^-)$	(1.24±0.22) %	
Γ_5	$K^+\overline{K}^*(892)^0\pi^-$ + c.c.	(1.2 ±0.4) %	
Γ_6	K^+K^-	(5.9 ±0.9) $\times 10^{-3}$	
Γ_7	$\pi^+\pi^-$	(5.0 ±0.7) $\times 10^{-3}$	

Γ_8	$\pi^0\pi^0$	$(2.8 \pm 0.7) \times 10^{-3}$	
Γ_9	$\eta\eta$	$(2.0 \pm 1.0) \times 10^{-3}$	
Γ_{10}	$K^+K^-K^+K^-$	$(2.1 \pm 0.5) \times 10^{-3}$	
Γ_{11}	$K^0_S K^0_S$	$(2.0 \pm 0.6) \times 10^{-3}$	
Γ_{12}	$\pi^+\pi^- p\overline{p}$	$(1.8 \pm 0.9) \times 10^{-3}$	S=1.6
Γ_{13}	$\phi\phi$	$(9 \pm 5) \times 10^{-4}$	
Γ_{14}	$p\overline{p}$	$(2.4 \pm 0.4) \times 10^{-4}$	
Γ_{15}	$K^0_S K^+\pi^-$ + c.c.	$< 7.1 \times 10^{-4}$	CL=90%

Radiative decays

Γ_{16}	$\gamma J/\psi(1S)$	(1.11 ± 0.15) %	
Γ_{17}	$\gamma\gamma$	$(2.4 \pm 0.5) \times 10^{-4}$	

$\chi_{c0}(1P)$ PARTIAL WIDTHS

$\chi_{c0}(1P)\ \Gamma(i)\Gamma(\gamma J/\psi(1S))/\Gamma(\text{total})$

$\Gamma(p\overline{p}) \times \Gamma(\gamma J/\psi(1S))/\Gamma_{\text{total}}$ **$\Gamma_{14}\Gamma_{16}/\Gamma$**

VALUE (eV)	EVTS	DOCUMENT ID		TECN	COMMENT
28.8± 3.3 OUR NEW UNCHECKED FIT [37 ± 10 eV OUR 2002 FIT]					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$26.6 \pm 2.6 \pm 1.4$	392	[4,5] BAGNASCO	02	E835	$\overline{p}p \to \chi_{c0} \to J/\psi\gamma$
$48.7^{+11.3}_{-8.9} \pm 2.4$		[4,5] AMBROGIANI	99B	E835	$\overline{p}p \to \gamma J/\psi$

$\Gamma(\gamma\gamma) \times \Gamma(2(\pi^+\pi^-))/\Gamma_{\text{total}}$ **$\Gamma_{17}\Gamma_1/\Gamma$**

VALUE (eV)	DOCUMENT ID		TECN	COMMENT
68±14 OUR NEW UNCHECKED FIT [74 ± 14 eV OUR 2002 FIT]				
75±13±8	EISENSTEIN	01	CLE2	$e^+e^- \to e^+e^-\chi_{c0}$

[4] Calculated by us using $B(J/\psi(1S) \to e^+e^-) = 0.0593 \pm 0.0010$.

[5] Values in $(\Gamma(p\overline{p}) \times \Gamma(\gamma J/\psi(1S))/\Gamma_{\text{total}})$ and $(\Gamma(p\overline{p}) \times \Gamma(\gamma J/\psi(1S))/\Gamma^2_{\text{total}})$ are not independent. The latter is used in the fit since it is less correlated to the total width.

$\chi_{c0}(1P)$ BRANCHING RATIOS

HADRONIC DECAYS

$\Gamma(2(\pi^+\pi^-))/\Gamma_{\text{total}}$ **Γ_1/Γ**

VALUE	DOCUMENT ID
0.0264±0.0031 OUR NEW UNCHECKED FIT [0.0244 ± 0.0033 OUR 2002 FIT]	

$\Gamma(\pi^+\pi^- K^+K^-)/\Gamma_{\text{total}}$ **Γ_2/Γ**

VALUE	DOCUMENT ID		TECN	COMMENT
0.018 ±0.006 OUR AVERAGE	Error includes scale factor of 1.9.			
$0.0147 \pm 0.0007 \pm 0.0038$	[6] BAI	99B	BES	$\psi(2S) \to \gamma\chi_{c0}$
0.030 ± 0.007	[7] TANENBAUM	78	MRK1	$\psi(2S) \to \gamma\chi_{c0}$

$\Gamma(\rho^0\pi^+\pi^-)/\Gamma_{total}$ Γ_3/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.016±0.005	[7] TANENBAUM	78	MRK1	$\psi(2S) \to \gamma\chi_{c0}$

$\Gamma(3(\pi^+\pi^-))/\Gamma_{total}$ Γ_4/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.0124±0.0022 OUR AVERAGE				
0.0117±0.0010±0.0023	[6] BAI	99B	BES	$\psi(2S) \to \gamma\chi_{c0}$
0.015 ±0.005	[7] TANENBAUM	78	MRK1	$\psi(2S) \to \gamma\chi_{c0}$

$\Gamma(K^+\overline{K}^*(892)^0\pi^- + \text{c.c.})/\Gamma_{total}$ Γ_5/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.012±0.004	[7] TANENBAUM	78	MRK1	$\psi(2S) \to \gamma\chi_{c0}$

$\Gamma(K^+K^-)/\Gamma_{total}$ Γ_6/Γ

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
5.9 ±0.9 OUR AVERAGE					
5.68±0.35±0.85	774±38	[6] BAI	98I	BES	$\psi(2S) \to \gamma\chi_{c0}$
6 ±3		[7] BRANDELIK	79B	DASP	$\psi(2S) \to \gamma\chi_{c0}$
9 ±4		[7] TANENBAUM	78	MRK1	$\psi(2S) \to \gamma\chi_{c0}$

$\Gamma(\pi^+\pi^-)/\Gamma_{total}$ Γ_7/Γ

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
5.0 ±0.7 OUR AVERAGE					
4.68±0.26±0.65	720±32	[6] BAI	98I	BES	$\psi(2S) \to \gamma\chi_{c0}$
7 ±3		[7] BRANDELIK	79B	DASP	$\psi(2S) \to \gamma\chi_{c0}$
8 ±3		[7] TANENBAUM	78	MRK1	$\psi(2S) \to \gamma\chi_{c0}$

$\Gamma(K^+K^-K^+K^-)/\Gamma_{total}$ Γ_{10}/Γ

VALUE (units 10^{-3})	DOCUMENT ID		TECN	COMMENT
2.14±0.26±0.40	[6] BAI	99B	BES	$\psi(2S) \to \gamma\chi_{c0}$

$\Gamma(K^0_S K^0_S)/\Gamma_{total}$ Γ_{11}/Γ

VALUE (units 10^{-3})	DOCUMENT ID		TECN	COMMENT
1.96±0.28±0.52	[6] BAI	99B	BES	$\psi(2S) \to \gamma\chi_{c0}$

$\Gamma(\pi^+\pi^- p\overline{p})/\Gamma_{total}$ Γ_{12}/Γ

VALUE (units 10^{-3})	DOCUMENT ID		TECN	COMMENT
1.8 ±0.9 OUR AVERAGE Error includes scale factor of 1.6.				
1.57±0.21±0.54	[6] BAI	99B	BES	$\psi(2S) \to \gamma\chi_{c0}$
5 ±2	[7] TANENBAUM	78	MRK1	$\psi(2S) \to \gamma\chi_{c0}$

$\Gamma(\phi\phi)/\Gamma_{total}$ Γ_{13}/Γ

VALUE (units 10^{-3})	DOCUMENT ID		TECN	COMMENT
0.92±0.34±0.38	[6] BAI	99B	BES	$\psi(2S) \to \gamma\chi_{c0}$

$\Gamma(\pi^0\pi^0)/\Gamma_{total}$ Γ_8/Γ

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
2.8 ±0.7 OUR NEW AVERAGE		[(3.1 ± 0.6) × 10^{-3} OUR 1996 AVERAGE]			
2.79±0.32±0.57	96.9± 11.1	[8] BAI	03C	BES	$\psi(2S) \to \gamma\pi^0\pi^0 \to 5\gamma$

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

3.1 ±0.4 ±0.5	[6] LEE	85	CBAL	$\psi' \to$ photons	

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

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
2.0 ±1.0 OUR NEW AVERAGE		[(2.5 ± 1.1) × 10^{-3} OUR 1996 AVERAGE]			
2.02±0.84±0.59	12.7± 5.3	[8] BAI	03C	BES	$\psi(2S) \to \gamma\eta\eta \to 5\gamma$

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

2.5 ±0.8 ±0.8	[6] LEE	85	CBAL	$\psi' \to$ photons	

$\Gamma(\eta\eta)/\Gamma(\pi^0\pi^0)$ Γ_9/Γ_8

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT

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

0.73±0.30±0.25	109.6± 12.3	BAI	03C	BES	$\psi(2S) \to 5\gamma$

$\Gamma(K^0_S K^+\pi^- + \text{c.c.})/\Gamma_{total}$ Γ_{15}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<0.71	90	[6] BAI	99B	BES	$\psi(2S) \to \gamma\chi_{c0}$

$\Gamma(p\bar{p})/\Gamma_{total}$ Γ_{14}/Γ

VALUE (units 10^{-4})	DOCUMENT ID
2.4±0.4 OUR NEW UNCHECKED FIT	[(2.2 ± 0.5) × 10^{-4} OUR 2002 FIT]

[6] Calculated using B($\psi(2S) \to \gamma\chi_{c0}(1P)$) = 0.093 ± 0.008.

[7] Calculated using B($\psi(2S) \to \gamma\chi_{c0}(1P)$) = 0.094; the errors do not contain the uncertainty in the $\psi(2S)$ decay.

[8] Derived using B($\psi(1S) \to \gamma\chi_{c0}$) = 0.087 ± 0.008 and B($\psi(2S) \to J/\psi\pi^+\pi^-$)= 0.305 ± 0.016.

RADIATIVE DECAYS

$\Gamma(\gamma J/\psi(1S))/\Gamma_{total}$ Γ_{16}/Γ

VALUE (units 10^{-4})	DOCUMENT ID
111±15 OUR NEW UNCHECKED FIT	[(102 ± 17) × 10^{-4} OUR 2002 FIT]

$\Gamma(\gamma\gamma)/\Gamma_{total}$ Γ_{17}/Γ

VALUE (units 10^{-4})	DOCUMENT ID
2.4±0.5 OUR NEW UNCHECKED FIT	[(1.9 ± 0.4) × 10^{-4} OUR 2002 FIT]

$\Gamma(\gamma\gamma)/\Gamma(\gamma J/\psi(1S))$ Γ_{17}/Γ_{16}

VALUE (units 10^{-2})	DOCUMENT ID		TECN	COMMENT
2.2 ±0.6 OUR NEW UNCHECKED FIT	[(1.8 ± 0.6) × 10^{-2} OUR 2002 FIT]			
1.45±0.74	[9] AMBROGIANI	00B	E835	$\overline{p}p \to \chi_{c2} \to \gamma\gamma$, $\gamma J/\psi$

$\Gamma(p\overline{p}) \times \Gamma(\gamma J/\psi(1S))/\Gamma^2_{\text{total}}$ $\Gamma_{14}\Gamma_{16}/\Gamma^2$

VALUE (units 10^{-7})	EVTS	DOCUMENT ID		TECN	COMMENT
27.0±2.1 OUR FIT					
27.5±2.1 OUR AVERAGE					
27.2±1.9±1.3	392	[9,10] BAGNASCO	02	E835	$\overline{p}p \to \chi_{c0} \to J/\psi\gamma$
$29.3^{+5.7}_{-4.7}$±1.5	89	[9,10] AMBROGIANI	99B		$\overline{p}p \to \chi_{c0} \to J/\psi\gamma$

[9] Calculated by us using $B(J/\psi(1S) \to e^+e^-) = 0.0593 \pm 0.0010$.
[10] Values in $(\Gamma(p\overline{p}) \times \Gamma(\gamma J/\psi(1S))/\Gamma_{\text{total}})$ and $(\Gamma(p\overline{p}) \times \Gamma(\gamma J/\psi(1S))/\Gamma^2_{\text{total}})$ are not independent. The latter is used in the fit since it is less correlated to the total width.

$\chi_{c0}(1P)$ CROSS-PARTICLE BRANCHING RATIOS

$B(\chi_{c0}(1P) \to p\overline{p}) \times \dfrac{\Gamma(\psi(2S) \to \gamma\chi_{c0}(1P))}{\Gamma(\psi(2S) \to J/\psi(1S)\pi^+\pi^-)}$

VALUE (units 10^{-5})	DOCUMENT ID		TECN	COMMENT
6.4±1.2 OUR NEW UNCHECKED FIT	[(6.4 ± 1.6) × 10^{-5} OUR 2002 FIT]			
4.6±1.9	[11] BAI	98I	BES	$\psi(2S) \to \gamma\chi_{c0} \to \gamma\overline{p}p$

$B(\chi_{c0}(1P) \to \gamma J/\psi(1S)) \times B(\psi(2S) \to \gamma\chi_{c0}(1P))$

VALUE (units 10^{-2})	DOCUMENT ID		TECN	COMMENT
0.094±0.014 OUR NEW UNCHECKED FIT	[(0.089 ± 0.015) × 10^{-2} OUR 2002 FIT]			
0.073±0.018 OUR AVERAGE				
0.069±0.018	[12] OREGLIA	82	CBAL	$\psi(2S) \to \gamma\chi_{c0}$
0.4 ±0.3	[13] BRANDELIK	79B	DASP	$\psi(2S) \to \gamma\chi_{c0}$
0.16 ±0.11	[13] BARTEL	78B	CNTR	$\psi(2S) \to \gamma\chi_{c0}$
3.3 ±1.7	[14] BIDDICK	77	CNTR	$e^+e^- \to \gamma X$

$B(\chi_{c0}(1P) \to \gamma\gamma) \times B(\psi(2S) \to \gamma\chi_{c0}(1P))$

VALUE (units 10^{-5})	DOCUMENT ID		TECN	COMMENT
2.0±0.5 OUR NEW UNCHECKED FIT	[(1.6 ± 0.4) × 10^{-5} OUR 2002 FIT]			
3.7±1.8±1.0	LEE	85	CBAL	$\psi(2S) \to \gamma\chi_{c0}$

$$B(\chi_{c0}(1P) \to 2(\pi^+\pi^-)) \times \frac{\Gamma(\psi(2S) \to \gamma\chi_{c0}(1P))}{\Gamma(\psi(2S) \to J/\psi(1S)\pi^+\pi^-)}$$

VALUE (units 10^{-3})	*DOCUMENT ID*		*TECN*	*COMMENT*
7.0±0.8 OUR NEW UNCHECKED FIT	[(7.0 ± 1.0) × 10^{-3} OUR 2002 FIT]			
6.9±2.4 OUR AVERAGE	Error includes scale factor of 3.8.			
4.4±0.1±0.9	[15] BAI	99B	BES	$\psi(2S) \to \gamma\chi_{c0}$
9.3±0.9	[16] TANENBAUM	78	MRK1	$\psi(2S) \to \gamma\chi_{c0}$

[11] Calculated by us. The value for $B(\chi_{c0} \to p\overline{p})$ reported in BAI 98I is derived using $B(\psi(2S) \to \gamma\chi_{c0}) = (9.3 \pm 0.8)\%$ and $B(\psi(2S) \to J/\psi(1S)\pi^+\pi^-) = (32.4 \pm 2.6)\%$ [BAI 98D].

[12] Recalculated by us using $B(J/\psi(1S) \to \ell^+\ell^-) = 0.1181 \pm 0.0020$.

[13] Recalculated by us using $B(J/\psi(1S) \to \mu^+\mu^-) = 0.0588 \pm 0.0010$.

[14] Assumes isotropic gamma distribution.

[15] Calculated by us. The value for $B(\chi_{c0} \to 2\pi^+2\pi^-)$ reported in BAI 99B is derived using $B(\psi(2S) \to \gamma\chi_{c0}) = (9.3 \pm 0.8)\%$ and $B(\psi(2S) \to J/\psi(1S)\pi^+\pi^-) = (32.4 \pm 2.6)\%$ [BAI 98D].

[16] The value $B(\psi(1S) \to \gamma\chi_{c0}) \times B(\chi_{c0} \to 2\pi^+2\pi^-)$ reported in TANENBAUM 78 is derived using $B(\psi(2S) \to J/\psi(1S)\pi^+\pi^-) \times B(J/\psi(1S) \to \ell^+\ell^-) = (4.6 \pm 0.7)\%$. Calculated by us using $B(J/\psi(1S) \to \ell^+\ell^-) = 0.1181 \pm 0.0020$.

$\chi_{c0}(1P)$ REFERENCES

BAI	03C	PR D67 032004	J.Z. Bai *et al.*	(BES Collab.)
BAGNASCO	02	PL B533 237	S. Bagnasco *et al.*	(FNAL E835 Collab.)
EISENSTEIN	01	PRL 87 061801	B.I. Eisenstein *et al.*	(CLEO Collab.)
AMBROGIANI	00B	PR D62 052002	M. Ambrogiani *et al.*	(FNAL E835 Collab.)
AMBROGIANI	99B	PRL 83 2902	M. Ambrogiani *et al.*	(FNAL E835 Collab.)
BAI	99B	PR D60 072001	J.Z. Bai *et al.*	(BES Collab.)
BAI	98D	PR D58 092006	J.Z. Bai *et al.*	(BES Collab.)
BAI	98I	PRL 81 3091	J.Z. Bai *et al.*	(BES Collab.)
GAISER	86	PR D34 711	J. Gaiser *et al.*	(Crystal Ball Collab.)
LEE	85	SLAC 282	R.A. Lee	(SLAC)
OREGLIA	82	PR D25 2259	M.J. Oreglia *et al.*	(SLAC, CIT, HARV+)
BRANDELIK	79B	NP B160 426	R. Brandelik *et al.*	(DASP Collab.)
BARTEL	78B	PL 79B 492	W. Bartel *et al.*	(DESY, HEIDP)
TANENBAUM	78	PR D17 1731	W.M. Tanenbaum *et al.*	(SLAC, LBL)
Also	82	Private Comm.	G. Trilling	(LBL, UCB)
BIDDICK	77	PRL 38 1324	C.J. Biddick *et al.*	(UCSD, UMD, PAVI+)

OTHER RELATED PAPERS

BARBERIS	00G	PL B485 357	D. Barberis *et al.*	(Omega Expt.)
ACCIARRI	99T	PL B461 155	M. Acciarri *et al.*	(L3 Collab.)
CHEN	90B	PL B243 169	W.Y. Chen *et al.*	(CLEO Collab.)
AIHARA	88D	PRL 60 2355	H. Aihara *et al.*	(TPC Collab.)
FELDMAN	75B	PRL 35 821	G.J. Feldman *et al.*	(LBL, SLAC)
Also	75C	PRL 35 1189	G.J. Feldman	
Erratum.				
TANENBAUM	75	PRL 35 1323	W.M. Tanenbaum *et al.*	(LBL, SLAC)