$\chi_{c2}(1P)$ or $\chi_{c2}(3555)$

$I^G(J^{PC}) = 0^+(2^{++})$

Observed in the radiative decay $\psi(2S) \rightarrow \chi_{c2}(1P)\gamma$. Therefore $C = +$. The observed decay into 4π and 6π imply $G = +$, thus $I = 0$. $J = 0$ is excluded by the angular distribution in the hadronic decays. J^P abnormal excluded by $\pi^+\pi^-$ and K^+K^- decays. $J^P = 2^+$ preferred (FELDMAN 77, OREGLIA 82).

$\chi_{c2}(1P)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
3556.17± 0.13 OUR AVERAGE					
3556.15± 0.07±0.12	585	ARMSTRONG	92	SPEC	$\overline{p}p \rightarrow e^+e^-\gamma$
3556.9 ± 0.4 ±0.5	50	BAGLIN	86B	SPEC	$\overline{p}p \rightarrow e^+e^-X$
3557.8 ± 0.2 ±4		[1] GAISER	86	CBAL	$\psi(2S) \rightarrow \gamma X$
3553.4 ± 2.2	66	[2] LEMOIGNE	82	GOLI	190 GeV π^- Be $\rightarrow \gamma 2\mu$
3555.9 ± 0.7		[3] OREGLIA	82	CBAL	$e^+e^- \rightarrow J/\psi 2\gamma$
3557 ± 1.5	69	[4] HIMEL	80	MRK2	$e^+e^- \rightarrow J/\psi 2\gamma$
3551.0 ±11.0	15	BRANDELIK	79B	DASP	$e^+e^- \rightarrow J/\psi 2\gamma$
3553.0 ± 4.0		[4] BARTEL	78B	CNTR	$e^+e^- \rightarrow J/\psi 2\gamma$
3553.0 ± 4 ±4		[4,5] TANENBAUM	78	MRK1	e^+e^-
3563.0 ± 7.0	360	[4] BIDDICK	77	CNTR	$e^+e^- \rightarrow \gamma X$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
3550.0 ±10.0		TRILLING	76	MRK1	$e^+e^- \rightarrow$ hadronsγ
3543.0 ±10.0	4	WHITAKER	76	MRK1	$e^+e^- \rightarrow J/\psi 2\gamma$

[1] Using mass of $\psi(2S) = 3686.0$ MeV.
[2] $J/\psi(1S)$ mass constrained to 3097 MeV.
[3] Assuming $\psi(2S)$ mass = 3686 MeV and $J/\psi(1S)$ mass = 3097 MeV.
[4] Mass value shifted by us by amount appropriate for $\psi(2S)$ mass = 3686 MeV and $J/\psi(1S)$ mass = 3097 MeV.
[5] From a simultaneous fit to radiative and hadronic decay channels.

$\chi_{c2}(1P)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
2.00±0.18 OUR AVERAGE					
1.98±0.17±0.07	585	ARMSTRONG	92	SPEC	$\overline{p}p \rightarrow e^+e^-\gamma$
$2.6^{+1.4}_{-1.0}$	50	BAGLIN	86B	SPEC	$\overline{p}p \rightarrow e^+e^-X$
$2.8^{+2.1}_{-2.0}$		[6] GAISER	86	CBAL	$\psi(2S) \rightarrow \gamma X$

[6] Errors correspond to 90% confidence level; authors give only width range.

$\chi_{c2}(1P)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)	Confidence level
	Hadronic decays		
Γ_1	$2(\pi^+\pi^-)$	(2.2 ±0.5) %	
Γ_2	$\pi^+\pi^-K^+K^-$	(1.9 ±0.5) %	
Γ_3	$3(\pi^+\pi^-)$	(1.2 ±0.8) %	
Γ_4	$\rho^0\pi^+\pi^-$	(7 ±4) $\times 10^{-3}$	
Γ_5	$K^+\overline{K}^*(892)^0\pi^-$ + c.c.	(4.8 ±2.8) $\times 10^{-3}$	
Γ_6	$\pi^+\pi^-p\overline{p}$	(3.3 ±1.3) $\times 10^{-3}$	
Γ_7	$\pi^+\pi^-$	(1.9 ±1.0) $\times 10^{-3}$	
Γ_8	K^+K^-	(1.5 ±1.1) $\times 10^{-3}$	
Γ_9	$p\overline{p}$	(10.0 ±1.0) $\times 10^{-5}$	
Γ_{10}	$\pi^0\pi^0$	(1.10±0.28) $\times 10^{-3}$	
Γ_{11}	$\eta\eta$	(8 ±5) $\times 10^{-4}$	
Γ_{12}	$J/\psi(1S)\pi^+\pi^-\pi^0$	< 1.5 %	90%

*CITATION: L. Montanet et al., Physical Review D50, 1173 (1994) and 1995 off-year partial update for the 1996 edition (URL: http://pdg.lbl.gov/)

Radiative decays

Γ_{13}	$\gamma J/\psi(1S)$	(13.5 ± 1.1) %
Γ_{14}	$\gamma\gamma$	$(1.6 \pm 0.5) \times 10^{-4}$

$\chi_{c2}(1P)$ PARTIAL WIDTHS

$\Gamma(p\overline{p})$ — Γ_9

VALUE (eV)	EVTS	DOCUMENT ID	TECN	COMMENT
206±22 OUR AVERAGE				
197±18±16	585	[7] ARMSTRONG 92	SPEC	$\overline{p}p \to e^+e^-\gamma$
$252^{+55}_{-48}\pm21$		[7] BAGLIN 86B	SPEC	$\overline{p}p \to e^+e^-X$

[7] Restated by us using B($\chi_{c2}(1P) \to J/\psi(1S)\gamma$)B($J/\psi(1S) \to e^+e^-$) = 0.0085 ± 0.0007.

$\Gamma(\gamma\gamma)$ — Γ_{14}

VALUE (keV)	CL%	DOCUMENT ID	TECN	COMMENT
0.37 ±0.17 OUR AVERAGE		Error includes scale factor of 1.9.		
1.08 ±0.30 ±0.26		DOMINICK 94	CLE2	$e^+e^- \to e^+e^-\chi_{c2}$
0.321±0.078±0.054		[8] ARMSTRONG 93	SPEC	$\overline{p}p \to \gamma\gamma$
3.4 ±1.7 ±0.9		BAUER 93	TPC	$e^+e^- \to e^+e^-\chi_{c2}$
$2.9\ ^{+1.3}_{-1.0}\ \pm1.7$		BAGLIN 87B	SPEC	$\overline{p}p \to \gamma\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<4.2	95	UEHARA 91	VNS	$e^+e^- \to e^+e^-\chi_{c2}$
<1.0	95	CHEN 90B	CLEO	$e^+e^- \to e^+e^-\chi_{c2}$
<4.2	95	AIHARA 88D	TPC	$e^+e^- \to e^+e^-X$
<1.6	90	YAMADA 77	DASP	$e^+e^- \to 3\gamma$

[8] Using B($\chi_{c2}(1P) \to p\overline{p}$) = $(1.00 \pm 0.23) \times 10^{-4}$ and Γ_{total} = 2.00 ± 0.18 MeV.

$\chi_{c2}(1P)$ BRANCHING RATIOS

HADRONIC DECAYS

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

VALUE	DOCUMENT ID	TECN	COMMENT
0.022±0.005	[10] TANENBAUM 78	MRK1	$\psi(2S) \to \gamma\chi_{c2}$

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

VALUE	DOCUMENT ID	TECN	COMMENT
0.019±0.005	[10] TANENBAUM 78	MRK1	$\psi(2S) \to \gamma\chi_{c2}$

$\Gamma(3(\pi^+\pi^-))/\Gamma_{total}$ — Γ_3/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
0.012±0.008	[10] TANENBAUM 78	MRK1	$\psi(2S) \to \gamma\chi_{c2}$

$\Gamma(\rho^0\pi^+\pi^-)/\Gamma_{total}$ — Γ_4/Γ

VALUE (units 10^{-4})	DOCUMENT ID	TECN	COMMENT
68±40	[10] TANENBAUM 78	MRK1	$\psi(2S) \to \gamma\chi_{c2}$

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

VALUE (units 10^{-4})	DOCUMENT ID	TECN	COMMENT
48±28	[10] TANENBAUM 78	MRK1	$\psi(2S) \to \gamma\chi_{c2}$

$\Gamma(\pi^+\pi^-p\overline{p})/\Gamma_{total}$ — Γ_6/Γ

VALUE (units 10^{-4})	DOCUMENT ID	TECN	COMMENT
33±13	[10] TANENBAUM 78	MRK1	$\psi(2S) \to \gamma\chi_{c2}$

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

VALUE (units 10^{-3})	EVTS	DOCUMENT ID	TECN	COMMENT
1.9±1.0	4	[10] BRANDELIK 79C	DASP	$\psi(2S) \to \gamma\chi_{c2}$

$[\Gamma(\pi^+\pi^-) + \Gamma(K^+K^-)]/\Gamma_{total}$ — $(\Gamma_7+\Gamma_8)/\Gamma$

VALUE (units 10^{-4})	DOCUMENT ID	TECN	COMMENT
24±10	[10] TANENBAUM 78	MRK1	$\psi(2S) \to \gamma\chi_{c2}$

$\Gamma(K^+K^-)/\Gamma_{total}$ — Γ_8/Γ

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
1.5±1.1	2	[10] BRANDELIK	79C	DASP	$\psi(2S) \to \gamma\chi_{c2}$

$\Gamma(p\overline{p})/\Gamma_{total}$ — Γ_9/Γ

VALUE (units 10^{-4})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
1.00±0.10 OUR AVERAGE						
1.00±0.11		585	[9] ARMSTRONG	92	SPEC	$\overline{p}p \to e^+e^-\gamma$
$0.97^{+0.44}_{-0.28}\pm0.08$			BAGLIN	86B	SPEC	$\overline{p}p \to e^+e^-X$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<9.5	90		[10] BRANDELIK	79B	DASP	$\psi(2S) \to \gamma\chi_{c2}$

[9] Restated by us using $B(\chi_{c2}(1P) \to J/\psi(1S)\gamma)B(J/\psi(1S) \to e^+e^-) = 0.0085 \pm 0.0007$.

$\Gamma_i\Gamma_f/\Gamma^2_{total}$ in $p\overline{p} \to \chi_{c2}(1P) \to \gamma\gamma$ — $\Gamma_9\Gamma_{14}/\Gamma^2$

VALUE (units 10^{-7})	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.160±0.039±0.016		ARMSTRONG	93	SPEC	$\overline{p}p \to \gamma\gamma$
$0.99\ ^{+0.46}_{-0.35}$	6	[11] BAGLIN	87B	SPEC	$\overline{p}p \to \gamma\gamma$

$\Gamma(\pi^0\pi^0)/\Gamma_{total}$ — Γ_{10}/Γ

VALUE (units 10^{-3})	DOCUMENT ID		TECN	COMMENT
1.1 ±0.2 ±0.2	[12] LEE	85	CBAL	$\psi' \to$ photons

$\Gamma(\eta\eta)/\Gamma_{total}$ — Γ_{11}/Γ

VALUE (units 10^{-4})	DOCUMENT ID		TECN	COMMENT
7.9±4.1±2.4	[12] LEE	85	CBAL	$\psi' \to$ photons

$\Gamma(J/\psi(1S)\pi^+\pi^-\pi^0)/\Gamma_{total}$ — Γ_{12}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.015	90	BARATE	81	SPEC	190 GeV π^- Be $\to 2\pi 2\mu$

[10] Estimated using $B(\psi(2S) \to \gamma\chi_{c2}(1P)) = 0.078$; the errors do not contain the uncertainty in the $\psi(2S)$ decay.
[11] Assuming isotropic $\chi_{c2}(1P) \to \gamma\gamma$ distribution.
[12] LEE 85 result is calculated using $B(\psi(2S) \to \gamma\chi_{c2}(1P)) = 0.078 \pm 0.008$.

RADIATIVE DECAYS

$\Gamma(\gamma J/\psi(1S))/\Gamma_{total}$ — Γ_{13}/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.135±0.011 OUR AVERAGE					
0.124±0.015		GAISER	86	CBAL	$\psi(2S) \to \gamma X$
0.162±0.028	479	[13] OREGLIA	82	CBAL	$\psi(2S) \to \gamma\chi_{c2}$
0.14 ±0.04		[13] HIMEL	80	MRK2	$\psi(2S) \to \gamma\chi_{c2}$
0.18 ±0.05		[13] BRANDELIK	79B	DASP	$\psi(2S) \to \gamma\chi_{c2}$
0.13 ±0.03		[13] BARTEL	78B	CNTR	$\psi(2S) \to \gamma\chi_{c2}$
$0.11\ ^{+0.13}_{-0.07}$		[13] SPITZER	78	PLUT	$\psi(2S) \to \gamma\chi_{c2}$
0.13 ±0.08		[13] TANENBAUM	78	MRK1	$\psi(2S) \to \gamma\chi_{c2}$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.28 ±0.13		[13] BIDDICK	77	CNTR	$\psi(2S) \to \gamma X$

[13] Estimated using $B(\psi(2S) \to \gamma\chi_{c2}(1P)) = 0.078$; the errors do not contain the uncertainty in the $\psi(2S)$ decay.

$\Gamma(\gamma\gamma)/\Gamma_{total}$ — Γ_{14}/Γ

VALUE (units 10^{-4})	DOCUMENT ID		TECN	COMMENT
1.60±0.39±0.23	[14] ARMSTRONG	93	SPEC	$\overline{p}p \to \gamma\gamma$

[14] Using $B(\chi_{c2}(1P) \to p\overline{p}) = (1.00 \pm 0.23) \times 10^{-4}$.

$\chi_{c2}(1P)$ REFERENCES

DOMINICK	94	PR D50 4265	+Sanghera+	(CLEO Collab.)
ARMSTRONG	93	PRL 70 2988	+Bettoni, Bharadwaj+	(FNAL E760 Collab.)
BAUER	93	PL B302 345	+Belcinski+	(TPC Collab.)
ARMSTRONG	92	NP B373 35	+Bettoni+	(FNAL, FERR, GENO, UCI, NWES+)
Also	92B	PRL 68 1468	Armstrong, Bettoni+	(FNAL, FERR, GENO, UCI, NWES+)
UEHARA	91	PL B266 188	+Abe+	(VENUS Collab.)
CHEN	90B	PL B243 169	+McIlwain+	(CLEO Collab.)
AIHARA	88D	PRL 60 2355	+Alston-Garnjost+	(TPC Collab.)
BAGLIN	87B	PL B187 191	+Baird, Bassompierre, Borreani+	(R704 Collab.)
BAGLIN	86B	PL B172 455		(LAPP, CERN, GENO, LYON, OSLO, ROMA+)
GAISER	86	PR D34 711	+Bloom, Bulos, Godfrey+	(Crystal Ball Collab.)
LEE	85	SLAC 282		(SLAC)
LEMOIGNE	82	PL 113B 509	+Barate, Astbury+	(SACL, LOIC, SHMP, IND)
OREGLIA	82	PR D25 2259	+Partridge+	(SLAC, CIT, HARV, PRIN, STAN)
Also	82B	Private Comm.	Oreglia	(EFI)
BARATE	81	PR D24 2994	+Astbury+	(SACL, LOIC, SHMP, CERN, IND)
HIMEL	80	PRL 44 920	+Abrams, Alam, Blocker+	(LBL, SLAC)
Also	82	Private Comm.	Trilling	(LBL, UCB)
BRANDELIK	79B	NP B160 426	+Cords+	(DASP Collab.)
BRANDELIK	79C	ZPHY C1 233	+Cords+	(DASP Collab.)
BARTEL	78B	PL 79B 492	+Dittmann, Duinker, Olsson, O'Neill+	(DESY, HEIDP)
SPITZER	78	Kyoto Sum. Inst. 47		(HAMB)
TANENBAUM	78	PR D17 1731	+Alam, Boyarski+	(SLAC, LBL)
Also	82	Private Comm.	Trilling	(LBL, UCB)
BIDDICK	77	PRL 38 1324	+Burnett+	(UCSD, UMD, PAVI, PRIN, SLAC, STAN)
FELDMAN	77	PRPL 33C 285	+Perl	(LBL, SLAC)
YAMADA	77	Hamburg Conf. 69		(DASP Collab.)
TRILLING	76	Stanford Symp. 437		(LBL)
WHITAKER	76	PRL 37 1596	+Tanenbaum, Abrams, Alam+	(SLAC, LBL)

OTHER RELATED PAPERS

BARATE	83	PL 121B 449	+Bareyre, Bonamy+	(SACL, LOIC, SHMP, IND)
FELDMAN	75B	PRL 35 821	+Jean-Marie, Sadoulet, Vannucci+	(LBL, SLAC)
Also	75C	PRL 35 1189	Feldman	
Erratum.				
TANENBAUM	75	PRL 35 1323	+Whitaker, Abrams+	(LBL, SLAC)

$\eta_c(2S)$ or $\eta_c(3590)$

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

OMITTED FROM SUMMARY TABLE

Our latest mini-review on this particle can be found in the 1984 edition. Needs confirmation.

$\eta_c(2S)$ MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
3594.0±5.0	[1] EDWARDS	82C	CBAL	$e^+e^- \to \gamma X$

[1] Assuming mass of $\psi(2S)$ = 3686 MeV.

$\eta_c(2S)$ WIDTH

VALUE (MeV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<8.0	95	EDWARDS	82C	CBAL	$e^+e^- \to \gamma X$

$\eta_c(2S)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	hadrons	seen
Γ_2	$\gamma\gamma$	

$\eta_c(2S)$ BRANCHING RATIOS

$\Gamma(\text{hadrons})/\Gamma_{\text{total}}$ $\quad$ **Γ_1/Γ**

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
seen	EDWARDS	82C	CBAL	$e^+e^- \to \gamma X$