

$\chi_{c1}(1P)$

$$I^G(J^{PC}) = 0^+(1^{++})$$

$\chi_{c1}(1P)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
3510.51 ± 0.12 OUR AVERAGE				
3509.4 ± 0.9		BAI	99B BES	$\psi(2S) \rightarrow \gamma X$
3510.53 ± 0.04 ± 0.12	513	ARMSTRONG	92 E760	$\bar{p}p \rightarrow e^+e^-\gamma$
3511.3 ± 0.4 ± 0.4	30	BAGLIN	86B SPEC	$\bar{p}p \rightarrow e^+e^-X$
3512.3 ± 0.3 ± 4.0		¹ GAISER	86 CBAL	$\psi(2S) \rightarrow \gamma X$
3507.4 ± 1.7	91	² LEMOIGNE	82 GOLI	190 $\pi^- \text{Be} \rightarrow \gamma 2\mu$
3510.4 ± 0.6		OREGLIA	82 CBAL	$e^+e^- \rightarrow J/\psi 2\gamma$
3510.1 ± 1.1	254	³ HIMEL	80 MRK2	$e^+e^- \rightarrow J/\psi 2\gamma$
3509 ± 11	21	BRANDELIK	79B DASP	$e^+e^- \rightarrow J/\psi 2\gamma$
3507 ± 3		³ BARTEL	78B CNTR	$e^+e^- \rightarrow J/\psi 2\gamma$
3505.0 ± 4 ± 4		^{3,4} TANENBAUM	78 MRK1	e^+e^-
3513 ± 7	367	³ BIDDICK	77 CNTR	$\psi(2S) \rightarrow \gamma X$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
3500 ± 10	40	TANENBAUM	75 MRK1	Hadrons γ

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

$\chi_{c1}(1P)$ WIDTH

VALUE (MeV)	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
0.88 ± 0.11 ± 0.08					
		513	ARMSTRONG	92 E760	$\bar{p}p \rightarrow e^+e^-\gamma$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
<1.3	95		BAGLIN	86B SPEC	$\bar{p}p \rightarrow e^+e^-X$
<3.8	90		GAISER	86 CBAL	$\psi(2S) \rightarrow \gamma X$

$\chi_{c1}(1P)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)	Scale factor
Hadronic decays		
Γ_1 $3(\pi^+\pi^-)$	$(6.3 \pm 1.4) \times 10^{-3}$	
Γ_2 $2(\pi^+\pi^-)$	$(5.6 \pm 2.6) \times 10^{-3}$	2.2
Γ_3 $\pi^+\pi^-K^+K^-$	$(4.9 \pm 1.2) \times 10^{-3}$	1.1
Γ_4 $\rho^0\pi^+\pi^-$	$(3.9 \pm 3.5) \times 10^{-3}$	
Γ_5 $K^+\bar{K}^*(892)^0\pi^- + \text{c.c.}$	$(3.2 \pm 2.1) \times 10^{-3}$	
Γ_6 $K_S^0K^+\pi^-$	$(2.5 \pm 0.8) \times 10^{-3}$	
Γ_7 $\pi^+\pi^-p\bar{p}$	$(5.4 \pm 2.1) \times 10^{-4}$	
Γ_8 $K^+K^-K^+K^-$	$(4.2 \pm 1.9) \times 10^{-4}$	
Γ_9 $p\bar{p}$	$(8.2 \pm 1.3) \times 10^{-5}$	1.2
Γ_{10} $\pi^+\pi^- + K^+K^-$	$< 2.1 \times 10^{-3}$	
Radiative decays		
Γ_{11} $\gamma J/\psi(1S)$	$(27.3 \pm 1.6) \%$	
Γ_{12} $\gamma\gamma$		

$\chi_{c1}(1P)$ PARTIAL WIDTHS

$\Gamma(p\bar{p})$					Γ_9
VALUE (eV)	EVTS	DOCUMENT ID	TECN	COMMENT	
74 ± 9 OUR AVERAGE					
76 ± 10 ± 5	513	⁵ ARMSTRONG 92	E760	$\bar{p}p \rightarrow e^+e^-\gamma$	
69 ⁺¹⁶ ₋₁₃ ± 4		⁵ BAGLIN	86B SPEC	$\bar{p}p \rightarrow e^+e^-X$	
⁵ Restated by us using $B(\chi_{c1}(1P) \rightarrow J/\psi(1S)\gamma)B(J/\psi(1S) \rightarrow e^+e^-) = 0.0171 \pm 0.0011$.					

$\chi_{c1}(1P)$ BRANCHING RATIOS

HADRONIC DECAYS

$\Gamma(3(\pi^+\pi^-))/\Gamma_{\text{total}}$				Γ_1/Γ
VALUE (units 10^{-3})		DOCUMENT ID	TECN	COMMENT
6.3 ± 1.4 OUR AVERAGE				
5.8 ± 0.7 ± 1.2		⁶ BAI	99B BES	$\psi(2S) \rightarrow \gamma\chi_{c1}$
22 ± 8		⁷ TANENBAUM	78 MRK1	$\psi(2S) \rightarrow \gamma\chi_{c1}$
$\Gamma(2(\pi^+\pi^-))/\Gamma_{\text{total}}$				Γ_2/Γ
VALUE (units 10^{-3})		DOCUMENT ID	TECN	COMMENT
5.6 ± 2.6 OUR AVERAGE Error includes scale factor of 2.2.				
4.9 ± 0.4 ± 1.2		⁶ BAI	99B BES	$\psi(2S) \rightarrow \gamma\chi_{c1}$
16 ± 5		⁷ TANENBAUM	78 MRK1	$\psi(2S) \rightarrow \gamma\chi_{c1}$

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

VALUE (units 10^{-4})	DOCUMENT ID	TECN	COMMENT
49 ± 12 OUR AVERAGE	Error includes scale factor of 1.1.		
45 ± 4 ± 11	⁶ BAI	99B BES	$\psi(2S) \rightarrow \gamma \chi_{c1}$
90 ± 40	⁷ TANENBAUM	78 MRK1	$\psi(2S) \rightarrow \gamma \chi_{c1}$

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

VALUE (units 10^{-4})	DOCUMENT ID	TECN	COMMENT
39 ± 35	⁷ TANENBAUM	78 MRK1	$\psi(2S) \rightarrow \gamma \chi_{c1}$

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

VALUE (units 10^{-4})	DOCUMENT ID	TECN	COMMENT
32 ± 21	⁷ TANENBAUM	78 MRK1	$\psi(2S) \rightarrow \gamma \chi_{c1}$

$\Gamma(K_S^0 K^+ \pi^-)/\Gamma_{\text{total}}$ Γ_6/Γ

VALUE (units 10^{-3})	DOCUMENT ID	TECN	COMMENT
2.46 ± 0.44 ± 0.65	⁶ BAI	99B BES	$\psi(2S) \rightarrow \gamma \chi_{c1}$

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

VALUE (units 10^{-4})	DOCUMENT ID	TECN	COMMENT
5.4 ± 2.1 OUR AVERAGE			
4.9 ± 1.3 ± 1.7	⁶ BAI	99B BES	$\psi(2S) \rightarrow \gamma \chi_{c1}$
14 ± 9	⁷ TANENBAUM	78 MRK1	$\psi(2S) \rightarrow \gamma \chi_{c1}$

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

VALUE (units 10^{-3})	DOCUMENT ID	TECN	COMMENT
0.42 ± 0.15 ± 0.12	⁶ BAI	99B BES	$\psi(2S) \rightarrow \gamma \chi_{c1}$

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

VALUE (units 10^{-4})	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
0.82 ± 0.13 OUR AVERAGE	Error includes scale factor of 1.2.				
0.42 ± 0.22 ± 0.28		4.2 ± 2.2	⁶ BAI	98I BES	$\psi(2S) \rightarrow \gamma \chi_{c1}$
0.86 ± 0.12		513	⁸ ARMSTRONG	92 E760	$\bar{p}p \rightarrow e^+ e^- \gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
> 0.54	95		BAGLIN	86B SPEC	$\bar{p}p \rightarrow e^+ e^- X$
< 12.0	90		⁷ BRANDELIK	79B DASP	$\psi(2S) \rightarrow \gamma \chi_{c1}$

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

VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	COMMENT
< 21		⁷ FELDMAN	77 MRK1	$\psi(2S) \rightarrow \gamma \chi_{c1}$

- • • We do not use the following data for averages, fits, limits, etc. • • •
- < 38 90 ⁷ BRANDELIK 79B DASP $\psi(2S) \rightarrow \gamma \chi_{c1}$
- ⁶ Using $B(\psi(2S) \rightarrow \gamma \chi_{c1}(1P)) = 0.087 \pm 0.008$.
- ⁷ Estimated using $B(\psi(2S) \rightarrow \gamma \chi_{c1}(1P)) = 0.087$. The errors do not contain the uncertainty in the $\psi(2S)$ decay.
- ⁸ Restated by us using $B(\chi_{c1}(1P) \rightarrow J/\psi(1S)\gamma)B(J/\psi(1S) \rightarrow e^+ e^-) = 0.0171 \pm 0.0011$.

RADIATIVE DECAYS

 $\Gamma(\gamma J/\psi(1S))/\Gamma_{\text{total}}$ Γ_{11}/Γ

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.273±0.016 OUR AVERAGE				
0.284±0.021		GAISER	86 CBAL	$\psi(2S) \rightarrow \gamma X$
0.274±0.046	943	⁹ OREGLIA	82 CBAL	$\psi(2S) \rightarrow \gamma \chi_{c1}$
0.28 ±0.07		⁹ HIMEL	80 MRK2	$\psi(2S) \rightarrow \gamma \chi_{c1}$
0.19 ±0.05		⁹ BRANDELIK	79B DASP	$\psi(2S) \rightarrow \gamma \chi_{c1}$
0.29 ±0.05		⁹ BARTEL	78B CNTR	$\psi(2S) \rightarrow \gamma \chi_{c1}$
0.28 ±0.09		⁹ TANENBAUM	78 MRK1	$\psi(2S) \rightarrow \gamma \chi_{c1}$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
0.57 ±0.17		⁹ BIDDICK	77 CNTR	$\psi(2S) \rightarrow \gamma X$

 $\Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ Γ_{12}/Γ

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
<0.0015	90	⁹ YAMADA	77 DASP	$e^+ e^- \rightarrow 3\gamma$
⁹ Estimated using $B(\psi(2S) \rightarrow \gamma \chi_{c1}(1P)) = 0.087$. The errors do not contain the uncertainty in the $\psi(2S)$ decay.				

 $\chi_{c1}(1P)$ REFERENCES

BAI	99B	PR D60 072001	J.Z. Bai <i>et al.</i>	(BES Collab.)
BAI	98I	PRL 81 3091	J.Z. Bai <i>et al.</i>	(BES Collab.)
ARMSTRONG	92	NP B373 35	T.A. Armstrong <i>et al.</i>	(FNAL, FERR, GENO+)
Also	92B	PRL 68 1468	T.A. Armstrong <i>et al.</i>	(FNAL, FERR, GENO+)
BAGLIN	86B	PL B172 455	C. Baglin	(LAPP, CERN, GENO, LYON, OSLO+)
GAISER	86	PR D34 711	J. Gaiser <i>et al.</i>	(Crystal Ball Collab.)
LEMOIGNE	82	PL 113B 509	Y. Lemoigne <i>et al.</i>	(SACL, LOIC, SHMP+)
OREGLIA	82	PR D25 2259	M.J. Oreglia <i>et al.</i>	(SLAC, CIT, HARV+)
Also	82B	Private Comm.	M.J. Oreglia	(EFI)
HIMEL	80	PRL 44 920	T. Himel <i>et al.</i>	(LBL, SLAC)
Also	82	Private Comm.	G. Trilling	(LBL, UCB)
BRANDELIK	79B	NP B160 426	R. Brandelik <i>et al.</i>	(DASP Collab.)
BARTEL	78B	PL 79B 492	W. Bartel <i>et al.</i>	(DESY, HEIDP)
TANENBAUM	78	PR D17 1731	W.M. Tanenbaum <i>et al.</i>	(SLAC, LBL)
Also	82	Private Comm.	G. Trilling	(LBL, UCB)
BIDDICK	77	PRL 38 1324	C.J. Biddick <i>et al.</i>	(UCSD, UMD, PAVI+)
FELDMAN	77	PRPL 33C 285	G.J. Feldman, M.L. Perl	(LBL, SLAC)
YAMADA	77	Hamburg Conf. 69	S. Yamada	(DASP Collab.)
TANENBAUM	75	PRL 35 1323	W.M. Tanenbaum <i>et al.</i>	(LBL, SLAC)

OTHER RELATED PAPERS

BARATE	83	PL 121B 449	R. Barate <i>et al.</i>	(SACL, LOIC, SHMP, IND)
BRAUNSCH...	75B	PL 57B 407	W. Braunschweig <i>et al.</i>	(DASP Collab.)
SIMPSON	75	PRL 35 699	J.W. Simpson <i>et al.</i>	(STAN, PENN)