$\psi(2S)$

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

See the Review on "$\psi(2S)$ and χ_c branching ratios" before the $\chi_{c0}(1P)$ Listings.

$\psi(2S)$ MASS

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
3685.96±0.09 OUR AVERAGE					
3685.95±0.10	413	[1] ARTAMONOV	00	OLYA	$e^+e^- \to$ hadrons
3686.02±0.09±0.27		ARMSTRONG	93B	E760	$\overline{p}p \to e^+e^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
3684 ±2		GRIBUSHIN	96	FMPS	515 π^- Be $\to 2\mu X$
3683 ±5	77	ANTONIAZZI	94	E705	300 $\pi^\pm$, p Li $\to$ $J/\psi\pi^+\pi^-$ X
3686.00±0.10	413	[2] ZHOLENTZ	80	OLYA	e^+e^-

[1] Reanalysis of ZHOLENTZ 80 using new electron mass (COHEN 87) and radiative corrections (KURAEV 85).
[2] Superseded by ARTAMONOV 00.

$m_{\psi(2S)} - m_{J/\psi(1S)}$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
589.07±0.13 OUR AVERAGE				
589.7 ±1.2	LEMOIGNE	82	GOLI	190 π^- Be $\to 2\mu$
589.07±0.13	[3] ZHOLENTZ	80	OLYA	e^+e^-
588.7 ±0.8	LUTH	75	MRK1	
• • • We do not use the following data for averages, fits, limits, etc. • • •				
588 ±1	[4] BAI	98E	BES	e^+e^-

[3] Redundant with data in mass above.
[4] Systematic errors not evaluated.

$\psi(2S)$ WIDTH

VALUE (keV)	*DOCUMENT ID*		*TECN*	*COMMENT*
280±17 OUR NEW UNCHECKED FIT [300 ± 25 keV OUR 2002 FIT]				
277±22 OUR NEW AVERAGE [306 ± 40 keV OUR 2002 AVERAGE]				
264±27	[5] BAI	02B	BES	e^+e^-
306±36±16	ARMSTRONG	93B	E760	$\overline{p}p \to e^+e^-$

[5] From a simultaneous fit to the hadronic and $\mu^+\mu^-$ cross section, assuming $\Gamma = \Gamma_h + \Gamma_e + \Gamma_\mu + \Gamma_\tau$ and lepton universality.

$\psi(2S)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)	Scale factor/ Confidence level
Γ_1	hadrons	(97.85 ± 0.13) %	
Γ_2	virtual $\gamma \rightarrow$ hadrons	(2.16 ± 0.35) %	S=2.1
Γ_3	$e^+ e^-$	$(7.58\pm0.29)\times10^{-3}$	
Γ_4	$\mu^+ \mu^-$	$(7.3\pm0.8)\times10^{-3}$	
Γ_5	$\tau^+ \tau^-$	$(2.8\pm0.7)\times10^{-3}$	
	Decays into $J/\psi(1S)$ and anything		
Γ_6	$J/\psi(1S)$ anything	(57.9 ± 1.9) %	
Γ_7	$J/\psi(1S)$ neutrals	(24.7 ± 1.1) %	
Γ_8	$J/\psi(1S)\pi^+\pi^-$	(31.8 ± 1.0) %	
Γ_9	$J/\psi(1S)\pi^0\pi^0$	(18.9 ± 1.1) %	
Γ_{10}	$J/\psi(1S)\eta$	(3.17 ± 0.21) %	
Γ_{11}	$J/\psi(1S)\pi^0$	$(9.6\pm2.1)\times10^{-4}$	
	Hadronic decays		
Γ_{12}	$3(\pi^+\pi^-)\pi^0$	$(3.5\pm1.6)\times10^{-3}$	
Γ_{13}	$2(\pi^+\pi^-)\pi^0$	$(3.0\pm0.8)\times10^{-3}$	
Γ_{14}	$\rho a_2(1320)$	$< 2.3\times10^{-4}$	CL=90%
Γ_{15}	$\omega\pi^+\pi^-$	$(4.8\pm0.9)\times10^{-4}$	
Γ_{16}	$b_1^\pm\pi^\mp$	$(3.2\pm0.8)\times10^{-4}$	
Γ_{17}	$\omega f_2(1270)$	$< 1.5\times10^{-4}$	CL=90%
Γ_{18}	$\pi^+\pi^- K^+ K^-$	$(1.6\pm0.4)\times10^{-3}$	
Γ_{19}	$K^*(892)\overline{K}_2^*(1430)^0$	$< 1.2\times10^{-4}$	CL=90%
Γ_{20}	$K_1(1270)^\pm K^\mp$	$(1.00\pm0.28)\times10^{-3}$	
Γ_{21}	$\pi^+\pi^- p\overline{p}$	$(8.0\pm2.0)\times10^{-4}$	
Γ_{22}	$K^+\overline{K}^*(892)^0\pi^- +$ c.c.	$(6.7\pm2.5)\times10^{-4}$	
Γ_{23}	$2(\pi^+\pi^-)$	$(4.5\pm1.0)\times10^{-4}$	
Γ_{24}	$\rho^0\pi^+\pi^-$	$(4.2\pm1.5)\times10^{-4}$	
Γ_{25}	$\omega K^+ K^-$	$(1.5\pm0.4)\times10^{-4}$	
Γ_{26}	$\omega p\overline{p}$	$(8.0\pm3.2)\times10^{-5}$	
Γ_{27}	$\overline{p}p$	$(2.07\pm0.31)\times10^{-4}$	
Γ_{28}	$\Lambda\overline{\Lambda}$	$(1.81\pm0.34)\times10^{-4}$	
Γ_{29}	$3(\pi^+\pi^-)$	$(1.5\pm1.0)\times10^{-4}$	
Γ_{30}	$\overline{p}p\pi^0$	$(1.4\pm0.5)\times10^{-4}$	
Γ_{31}	$\Delta^{++}\overline{\Delta}^{--}$	$(1.28\pm0.35)\times10^{-4}$	
Γ_{32}	$\Sigma^0\overline{\Sigma}^0$	$(1.2\pm0.6)\times10^{-4}$	
Γ_{33}	$\Sigma^{*+}\overline{\Sigma}^{*-}$	$(1.1\pm0.4)\times10^{-4}$	
Γ_{34}	$K^+ K^-$	$(1.0\pm0.7)\times10^{-4}$	
Γ_{35}	$\pi^+\pi^-\pi^0$	$(8\pm5)\times10^{-5}$	
Γ_{36}	$\rho\pi$	$< 8.3\times10^{-5}$	CL=90%
Γ_{37}	$\pi^+\pi^-$	$(8\pm5)\times10^{-5}$	

Γ_{38}	$\Xi^- \overline{\Xi}^+$	(9.4 ±3.1) $\times 10^{-5}$		
Γ_{39}	$K_1(1400)^\pm K^\mp$	< 3.1	$\times 10^{-4}$	CL=90%
Γ_{40}	$\Xi^{*0} \overline{\Xi}^{*0}$	< 8.1	$\times 10^{-5}$	CL=90%
Γ_{41}	$\Omega^- \overline{\Omega}^+$	< 7.3	$\times 10^{-5}$	CL=90%
Γ_{42}	$K^+ K^- \pi^0$	< 2.96	$\times 10^{-5}$	CL=90%
Γ_{43}	$K^+ \overline{K}^*(892)^- +$ c.c.	< 5.4	$\times 10^{-5}$	CL=90%
Γ_{44}	$\phi \pi^+ \pi^-$	(1.50±0.28) $\times 10^{-4}$		
Γ_{45}	$\phi K^+ K^-$	(1.1 ±0.4) $\times 10^{-4}$		
Γ_{46}	$\phi p \overline{p}$	< 2.6	$\times 10^{-5}$	CL=90%
Γ_{47}	$\phi f_0(980)$	(1.1 ±0.4) $\times 10^{-4}$		
Γ_{48}	$\phi f_2'(1525)$	< 4.5	$\times 10^{-5}$	CL=90%

Radiative decays

Γ_{49}	$\gamma \chi_{c0}(1P)$	(8.4 ±0.7) %		
Γ_{50}	$\gamma \chi_{c1}(1P)$	(8.4 ±0.6) %		
Γ_{51}	$\gamma \chi_{c2}(1P)$	(6.4 ±0.6) %		
Γ_{52}	$\gamma \eta_c(1S)$	(2.8 ±0.6) $\times 10^{-3}$		
Γ_{53}	$\gamma \eta_c(2S)$			
Γ_{54}	$\gamma \pi^0$			
Γ_{55}	$\gamma \eta'(958)$	(1.5 ±0.4) $\times 10^{-4}$		
Γ_{56}	$\gamma f_0(1270)$	(2.1 ±0.4) $\times 10^{-4}$		
Γ_{57}	$\gamma f_0(1710) \rightarrow \gamma \pi \pi$	(3.0 ±1.3) $\times 10^{-5}$		
Γ_{58}	$\gamma f_0(1710) \rightarrow \gamma K \overline{K}$	(6.0 ±1.6) $\times 10^{-5}$		
Γ_{59}	$\gamma \gamma$	< 1.5	$\times 10^{-4}$	CL=90%
Γ_{60}	$\gamma \eta$	< 9	$\times 10^{-5}$	CL=90%
Γ_{61}	$\gamma \eta(1440) \rightarrow \gamma K \overline{K} \pi$	< 1.2	$\times 10^{-4}$	CL=90%

$\psi(2S)$ PARTIAL WIDTHS

Γ(hadrons) Γ_1

VALUE (keV)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
258±26	BAI	02B	BES	$e^+ e^-$
224±56	LUTH	75	MRK1	$e^+ e^-$

$\Gamma(e^+ e^-)$ Γ_3

VALUE (keV)	*DOCUMENT ID*		*TECN*	*COMMENT*
2.12±0.12 OUR NEW UNCHECKED FIT [2.19 ± 0.15 keV OUR 2002 FIT]				
2.14±0.21	ALEXANDER	89	RVUE	See Υ mini-review
• • • We do not use the following data for averages, fits, limits, etc. • • •				
2.44±0.21	[7] BAI	02B	BES	$e^+ e^-$
2.0 ±0.3	BRANDELIK	79C	DASP	$e^+ e^-$
2.1 ±0.3	[6] LUTH	75	MRK1	$e^+ e^-$

[6] From a simultaneous fit to $e^+ e^-$, $\mu^+ \mu^-$, and hadronic channels assuming $\Gamma(e^+ e^-) = \Gamma(\mu^+ \mu^-)$.

$\Gamma(\gamma\gamma)$ Γ_{59}

VALUE (eV)	CL%	DOCUMENT ID		TECN	COMMENT
<43	90	BRANDELIK	79C	DASP	e^+e^-

[7] From a simultaneous fit to e^+e^-, $\mu^+\mu^-$, and hadronic channel, assuming $\Gamma_e = \Gamma_\mu = \Gamma_\tau/0.38847$.

$\psi(2S)$ $\Gamma(i)\Gamma(e^+e^-)/\Gamma(total)$

This combination of a partial width with the partial width into e^+e^- and with the total width is obtained from the integrated cross section into channel$_i$ in the e^+e^- annihilation. We list only data that have not been used to determine the partial width $\Gamma(i)$ or the branching ratio $\Gamma(i)$/total.

$\Gamma(\text{hadrons}) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_1\Gamma_3/\Gamma$

VALUE (keV)	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
2.2±0.4	ABRAMS	75	MRK1	e^+e^-

$\Gamma(e^+e^-) \times \Gamma(J/\psi(1S)\pi^+\pi^-)/\Gamma_{\text{total}}$ $\Gamma_3\Gamma_8/\Gamma$

VALUE (keV)	DOCUMENT ID		TECN	COMMENT
0.67±0.05 OUR NEW UNCHECKED FIT	[0.67 ± 0.06 keV OUR 2002 FIT]			
0.68±0.09	[8] BAI	98E	BES	e^+e^-

[8] The value of $\Gamma(e^+e^-)$ quoted in BAI 98E is derived using $B(\psi(2S) \to J/\psi(1S)\pi^+\pi^-) = (32.4 \pm 2.6) \times 10^{-2}$ and $B(J/\psi(1S) \to \ell^+\ell^-) = 0.1203 \pm 0.0038$. Recalculated by us using $B(J/\psi(1S) \to \ell^+\ell^-) = 0.1181 \pm 0.0020$.

$\psi(2S)$ BRANCHING RATIOS

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.9785±0.0013 OUR NEW AVERAGE	[0.9810 ± 0.0030 OUR 2002 AVERAGE]			
0.9779±0.0015	[9] BAI	02B	BES	e^+e^-
0.981 ±0.003	[9] LUTH	75	MRK1	e^+e^-

$\Gamma(\text{virtual}\,\gamma \to \text{hadrons})/\Gamma_{\text{total}}$ Γ_2/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.0216±0.0035 OUR NEW AVERAGE	Error includes scale factor of 2.1. [0.029 ± 0.004 OUR 2002 AVERAGE]			
0.0199±0.0019	[10] BAI	02B	BES	e^+e^-
0.029 ±0.004	[10] LUTH	75	MRK1	e^+e^-

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

VALUE (units 10^{-4})	DOCUMENT ID		TECN	COMMENT
75.8± 2.9 OUR NEW UNCHECKED FIT	[(73 ± 4) × 10^{-4} OUR 2002 FIT]			
• • • We do not use the following data for averages, fits, limits, etc. • • •				
88 ±13	[11] FELDMAN	77	RVUE	e^+e^-

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

VALUE (units 10^{-4})	*DOCUMENT ID*
73±8 OUR NEW UNCHECKED FIT	[$(70 \pm 9) \times 10^{-4}$ OUR 2002 FIT]

$\Gamma(\tau^+\tau^-)/\Gamma_{total}$ Γ_5/Γ

VALUE (units 10^{-4})	*DOCUMENT ID*
28±7 OUR NEW UNCHECKED FIT	[$(27 \pm 7) \times 10^{-3}$ OUR 2002 FIT]

$\Gamma(\mu^+\mu^-)/\Gamma(e^+e^-)$ Γ_4/Γ_3

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.97±0.12 OUR NEW UNCHECKED FIT	[0.97 ± 0.14 OUR 2002 FIT]		
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.89±0.16	BOYARSKI	75C MRK1	e^+e^-

[9] Includes cascade decay into $J/\psi(1S)$.

[10] Included in $\Gamma(\text{hadrons})/\Gamma_{total}$.

[11] From an overall fit assuming equal partial widths for e^+e^- and $\mu^+\mu^-$. For a measurement of the ratio see the entry $\Gamma(\mu^+\mu^-)/\Gamma(e^+e^-)$ below. Includes LUTH 75, HILGER 75, BURMESTER 77.

DECAYS INTO $J/\psi(1S)$ AND ANYTHING

$\Gamma(J/\psi(1S)\text{anything})/\Gamma_{total}$ Γ_6/Γ

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.579±0.019 OUR NEW UNCHECKED FIT	[0.557 ± 0.026 OUR 2002 FIT]		
0.55 ±0.07 OUR AVERAGE			
0.51 ±0.12	BRANDELIK	79C DASP	$e^+e^- \to \mu^+\mu^-X$
0.57 ±0.08	ABRAMS	75B MRK1	$e^+e^- \to \mu^+\mu^-X$

$\Gamma(J/\psi(1S)\text{neutrals})/\Gamma_{total}$ Γ_7/Γ

VALUE	*DOCUMENT ID*
0.247±0.011 OUR NEW UNCHECKED FIT	[0.239 ± 0.012 OUR 2002 FIT]

$\Gamma(J/\psi(1S)\pi^+\pi^-)/\Gamma_{total}$ Γ_8/Γ

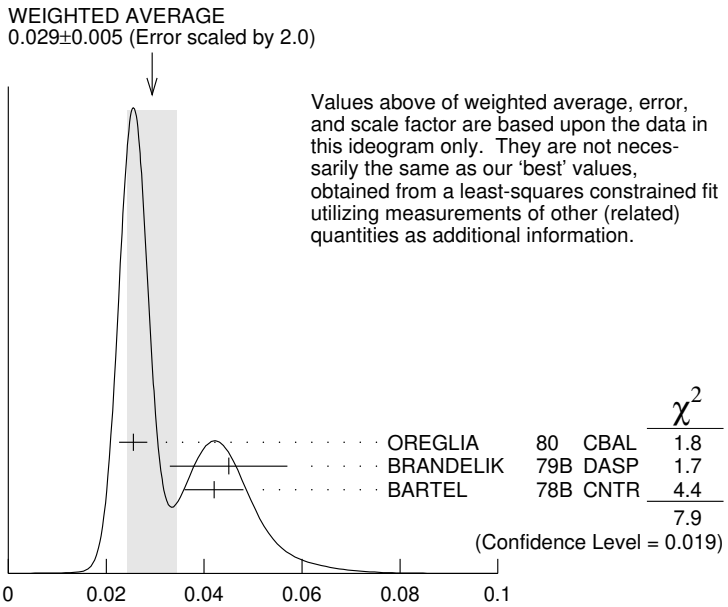
VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.318±0.010 OUR NEW UNCHECKED FIT	[0.305 ± 0.016 OUR 2002 FIT]		
0.323±0.013 OUR NEW AVERAGE	[0.32 ± 0.04 OUR 2002 AVERAGE]		
0.323±0.014	BAI	02B BES	e^+e^-
0.32 ±0.04	ABRAMS	75B MRK1	$e^+e^- \to J/\psi\pi^+\pi^-$

$\Gamma(J/\psi(1S)\pi^0\pi^0)/\Gamma_{total}$ Γ_9/Γ

VALUE	*DOCUMENT ID*
0.189±0.011 OUR NEW UNCHECKED FIT	[0.182 ± 0.012 OUR 2002 FIT]

$\Gamma(J/\psi(1S)\eta)/\Gamma_{total}$ Γ_{10}/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.0317±0.0021 OUR NEW UNCHECKED FIT [0.0313 ± 0.0021 OUR 2002 FIT]					
0.029 ±0.005 OUR AVERAGE Error includes scale factor of 2.0. See the ideogram below.					
0.0255±0.0029	386	[12] OREGLIA	80	CBAL	$e^+e^- \to J/\psi 2\gamma$
0.045 ±0.012	17	[13] BRANDELIK	79B	DASP	$e^+e^- \to J/\psi 2\gamma$
0.042 ±0.006	164	[13] BARTEL	78B	CNTR	e^+e^-
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.043 ±0.008	44	TANENBAUM	76	MRK1	e^+e^-



$\Gamma\left(J/\psi(1S)\eta\right)/\Gamma_{total}$

$\Gamma(J/\psi(1S)\pi^0)/\Gamma_{total}$ Γ_{11}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
9.6±2.1 OUR AVERAGE					
14 ±6	7	HIMEL	80	MRK2	e^+e^-
9 ±2 ±1	23	[12] OREGLIA	80	CBAL	$\psi(2S) \to J/\psi 2\gamma$

$\Gamma(J/\psi(1S)\text{neutrals})/\Gamma(J/\psi(1S)\pi^+\pi^-)$ Γ_7/Γ_8

VALUE	DOCUMENT ID		TECN	COMMENT
0.776±0.032 OUR NEW UNCHECKED FIT [0.784 ± 0.035 OUR 2002 FIT]				
0.73 ±0.09	TANENBAUM	76	MRK1	e^+e^-

$\Gamma(J/\psi(1S)\pi^+\pi^-)/\Gamma(J/\psi(1S)\text{anything})$ Γ_8/Γ_6

VALUE	DOCUMENT ID	TECN	COMMENT
0.550±0.011 OUR NEW UNCHECKED FIT	[0.547 ± 0.011 OUR 2002 FIT]		
0.496±0.037	ARMSTRONG 97	E760	$\overline{p}p \rightarrow \psi(2S)$

$\Gamma(J/\psi(1S)\pi^0\pi^0)/\Gamma(J/\psi(1S)\text{anything})$ Γ_9/Γ_6

VALUE	DOCUMENT ID	TECN	COMMENT
0.327±0.012 OUR NEW UNCHECKED FIT	[0.326 ± 0.012 OUR 2002 FIT]		
0.327±0.014 OUR AVERAGE			
0.328±0.013±0.008	AMBROGIANI 00A	E835	$p\overline{p} \rightarrow \psi(2S)$
0.323±0.033	ARMSTRONG 97	E760	$\overline{p}p \rightarrow \psi(2S)$

$\Gamma(J/\psi(1S)\pi^0\pi^0)/\Gamma(J/\psi(1S)\pi^+\pi^-)$ Γ_9/Γ_8

VALUE	DOCUMENT ID	TECN	COMMENT
0.59±0.05 OUR NEW UNCHECKED FIT	[0.60 ± 0.06 OUR 2002 FIT]		
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.53±0.06	TANENBAUM 76	MRK1	e^+e^-
0.64±0.15	[14] HILGER 75	SPEC	e^+e^-

$\Gamma(J/\psi(1S)\eta)/\Gamma(J/\psi(1S)\text{anything})$ Γ_{10}/Γ_6

VALUE	DOCUMENT ID	TECN	COMMENT
0.055±0.004 OUR NEW UNCHECKED FIT	[0.056 ± 0.004 OUR 2002 FIT]		
0.069±0.008 OUR AVERAGE			
0.072±0.009	AMBROGIANI 00A	E835	$p\overline{p} \rightarrow \psi(2S)$
0.061±0.015	ARMSTRONG 97	E760	$\overline{p}p \rightarrow \psi(2S)$

$\Gamma(J/\psi(1S)\eta)/\Gamma(J/\psi(1S)\pi^+\pi^-)$ Γ_{10}/Γ_8

VALUE	DOCUMENT ID	TECN	COMMENT
0.100±0.008 OUR NEW UNCHECKED FIT	[0.103 ± 0.010 OUR 2002 FIT]		
0.091±0.021	[15] HIMEL 80	MRK2	$e^+e^- \rightarrow \psi(2S)X$

$\Gamma(e^+e^-)/\Gamma(J/\psi(1S)\text{anything})$ Γ_3/Γ_6

VALUE	DOCUMENT ID	TECN	COMMENT
0.0131±0.0010 OUR NEW UNCHECKED FIT	[0.01308 ± 0.00032 OUR 2002 FIT]		
0.0131±0.0006 OUR AVERAGE	Error includes scale factor of 1.8.		
0.0128±0.0003±0.0002	[16] AMBROGIANI 00A	E835	$p\overline{p} \rightarrow \psi(2S)$
0.0144±0.0008±0.0002	[16] ARMSTRONG 97	E760	$\overline{p}p \rightarrow \psi(2S)$

$\Gamma(e^+e^-)/\Gamma(J/\psi(1S)\pi^+\pi^-)$ Γ_3/Γ_8

VALUE	DOCUMENT ID	TECN	COMMENT
0.0238±0.0015 OUR NEW UNCHECKED FIT	[0.0239 ± 0.0024 OUR 2002 FIT]		
0.0252±0.0028±0.0011	[16] AUBERT 02B	BABR	e^+e^-

$\Gamma(\mu^+\mu^-)/\Gamma(J/\psi(1S)\text{anything})$ Γ_4/Γ_6

VALUE	DOCUMENT ID	TECN	COMMENT
0.0127±0.0033 OUR NEW UNCHECKED FIT	[0.0126 ± 0.0014 OUR 2002 FIT]		
0.014 ±0.003	HILGER 75	SPEC	e^+e^-

$\Gamma(\mu^+\mu^-)/\Gamma(J/\psi(1S)\pi^+\pi^-)$ Γ_4/Γ_8

VALUE	DOCUMENT ID		TECN	COMMENT
0.0231±0.0029 OUR NEW UNCHECKED FIT [0.0231 ± 0.0035 OUR 2002 FIT]				
0.0224±0.0029 OUR AVERAGE				
0.0216±0.0026±0.0014	[17] AUBERT	02B	BABR	e^+e^-
0.0327±0.0077±0.0072	[17] GRIBUSHIN	96	FMPS	515 π^- Be → $2\mu X$

$\Gamma(\tau^+\tau^-)/\Gamma(J/\psi(1S)\pi^+\pi^-)$ Γ_5/Γ_8

VALUE (units 10^{-3})	DOCUMENT ID		TECN	COMMENT
8.7 ±2.2 OUR NEW UNCHECKED FIT [(8.7 ± 2.3) × 10^{-3} OUR 2002 FIT]				
8.73±1.39±1.57	BAI	02	BES	e^+e^-

[12] Recalculated by us using B($J/\psi(1S)$ → $\ell^+\ell^-$) = 0.1181 ± 0.0020.
[13] Recalculated by us using B($J/\psi(1S)$ → $\mu^+\mu^-$) = 0.0588 ± 0.0010.
[14] Ignoring the $J/\psi(1S)\eta$ and $J/\psi(1S)\gamma\gamma$ decays.
[15] The value for B($\psi(2S)$ → $J/\psi(1s)\eta$) reported in HIMEL 80 is derived using B($\psi(2S)$) → $J/\psi(1S)\pi^+\pi^-$) = (33 ± 3))% and B($J/\psi(1S)$ → $\ell^+\ell^-$) = 0.138 ± 0.018. Calculated by us using B($J/\psi(1S)$ → $\ell^+\ell^-$) = (0.1181 ± 0.0020).
[16] Using B($J/\psi(1S)$ → e^+e^-) = 0.0593 ± 0.0010.
[17] Using B($J/\psi(1S)$ → $\mu^+\mu^-$) = 0.0588 ± 0.0010.

HADRONIC DECAYS

$\Gamma(3(\pi^+\pi^-)\pi^0)/\Gamma_{total}$ Γ_{12}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
35±16	6	FRANKLIN	83	MRK2	e^+e^- → hadrons

$\Gamma(2(\pi^+\pi^-)\pi^0)/\Gamma_{total}$ Γ_{13}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
30±8	42	FRANKLIN	83	MRK2	e^+e^-

$\Gamma(\omega\pi^+\pi^-)/\Gamma_{total}$ Γ_{15}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
4.8±0.6±0.7	100± 22	[18] BAI	03B	BES	$\psi(2S)$ → $2(\pi^+\pi^-)\pi^0$

$\Gamma(b_1^\pm\pi^\mp)/\Gamma_{total}$ Γ_{16}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
3.2±0.8 OUR NEW AVERAGE [(5.2 ± 1.3) × 10^{-4} OUR 2002 AVERAGE]					
3.2±0.6±0.5	61 ± 11	[18,19] BAI	03B	BES	$\psi(2S)$ → $2(\pi^+\pi^-)\pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
5.2±0.8±1.0		[19] BAI	99C	BES	Repl. by BAI 03B

$\Gamma(\omega f_2(1270))/\Gamma_{total}$ Γ_{17}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<1.5 (CL = 90%) [<1.7 × 10^{-4} (CL = 90%) OUR 2002 BEST LIMIT]					
<1.5	90	[18] BAI	03B	BES	$\psi(2S)$ → $2(\pi^+\pi^-)\pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<1.7	90	BAI	98J	BES	Repl. by BAI 03B

$\Gamma(\pi^+\pi^- K^+ K^-)/\Gamma_{total}$ Γ_{18}/Γ

VALUE (units 10^{-4})		DOCUMENT ID		TECN	COMMENT
16±4	[20]	TANENBAUM	78	MRK1	e^+e^-

$\Gamma(K_1(1270)^{\pm} K^{\mp})/\Gamma_{total}$ Γ_{20}/Γ

VALUE (units 10^{-4})		DOCUMENT ID		TECN	COMMENT
10.0±1.8±2.1	[21]	BAI	99C	BES	e^+e^-

$\Gamma(\pi^+\pi^- p\overline{p})/\Gamma_{total}$ Γ_{21}/Γ

VALUE (units 10^{-4})		DOCUMENT ID		TECN	COMMENT
8 ±2	[20]	TANENBAUM	78	MRK1	e^+e^-

$\Gamma(K^+\overline{K}^*(892)^0\pi^- + \text{c.c.})/\Gamma_{total}$ Γ_{22}/Γ

VALUE (units 10^{-4})	DOCUMENT ID		TECN	COMMENT
6.7±2.5	TANENBAUM	78	MRK1	e^+e^-

$\Gamma(\omega K^+ K^-)/\Gamma_{total}$ Γ_{25}/Γ

VALUE (units 10^{-4})	EVTS		DOCUMENT ID		TECN	COMMENT
1.5±0.3±0.2	23.0± 5.2	[18]	BAI	03B	BES	$\psi(2S) \to K^+K^-\pi^+\pi^-\pi^0$

$\Gamma(\omega p\overline{p})/\Gamma_{total}$ Γ_{26}/Γ

VALUE (units 10^{-4})	EVTS		DOCUMENT ID		TECN	COMMENT
0.8 ±0.3 ±0.1	14.0± 0.1	[18]	BAI	03B	BES	$\psi(2S) \to p\overline{p}\pi^+\pi^-\pi^0$

$\Gamma(2(\pi^+\pi^-))/\Gamma_{total}$ Γ_{23}/Γ

VALUE (units 10^{-4})	DOCUMENT ID		TECN	COMMENT
4.5±1.0	TANENBAUM	78	MRK1	e^+e^-

$\Gamma(\rho^0\pi^+\pi^-)/\Gamma_{total}$ Γ_{24}/Γ

VALUE (units 10^{-4})	DOCUMENT ID		TECN	COMMENT
4.2±1.5	TANENBAUM	78	MRK1	e^+e^-

$\Gamma(\rho a_2(1320))/\Gamma_{total}$ Γ_{14}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<2.3	90	BAI	98J	BES	e^+e^-

$\Gamma(\overline{p}p)/\Gamma_{total}$ Γ_{27}/Γ

VALUE (units 10^{-4})	EVTS		DOCUMENT ID		TECN	COMMENT
2.07±0.31 OUR AVERAGE						
2.16±0.15±0.36	201	[22]	BAI	01	BES	$e^+e^- \to \psi(2S)$
1.4 ±0.8	4		BRANDELIK	79C	DASP	e^+e^-
2.3 ±0.7			FELDMAN	77	MRK1	e^+e^-

$\Gamma(\Lambda\overline{\Lambda})/\Gamma_{total}$ Γ_{28}/Γ

VALUE (units 10^{-4})	CL%	EVTS		DOCUMENT ID		TECN	COMMENT
$1.81\pm0.20\pm0.27$		80	[22]	BAI	01	BES	$e^+e^- \to \psi(2S)$
• • • We do not use the following data for averages, fits, limits, etc. • • •							
<4	90			FELDMAN	77	MRK1	e^+e^-

$\Gamma(3(\pi^+\pi^-))/\Gamma_{total}$ Γ_{29}/Γ

VALUE (units 10^{-4})		DOCUMENT ID		TECN	COMMENT
1.5 ± 1.0	[20]	TANENBAUM	78	MRK1	e^+e^-

$\Gamma(\overline{p}p\pi^0)/\Gamma_{total}$ Γ_{30}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
1.4 ± 0.5	9	FRANKLIN	83	MRK2	e^+e^-

$\Gamma(K^+K^-)/\Gamma_{total}$ Γ_{34}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
1.0 ± 0.7		BRANDELIK	79C	DASP	e^+e^-
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.5	90	FELDMAN	77	MRK1	e^+e^-

$\Gamma(\pi^+\pi^-)/\Gamma_{total}$ Γ_{37}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
0.8 ± 0.5		BRANDELIK	79C	DASP	e^+e^-
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.5	90	FELDMAN	77	MRK1	e^+e^-

$\Gamma(\pi^+\pi^-\pi^0)/\Gamma_{total}$ Γ_{35}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
0.85 ± 0.46	4	FRANKLIN	83	MRK2	$e^+e^- \to$ hadrons

$\Gamma(\Delta^{++}\overline{\Delta}^{--})/\Gamma_{total}$ Γ_{31}/Γ

VALUE (units 10^{-5})	EVTS	DOCUMENT ID		TECN	COMMENT
$12.8\pm1.0\pm3.4$	157	[22] BAI	01	BES	$e^+e^- \to \psi(2S)$

$\Gamma(\Sigma^0\overline{\Sigma}^0)/\Gamma_{total}$ Γ_{32}/Γ

VALUE (units 10^{-5})	EVTS	DOCUMENT ID		TECN	COMMENT
$12\pm4\pm4$	8	[22] BAI	01	BES	$e^+e^- \to \psi(2S)$

$\Gamma(\Sigma^{*+}\overline{\Sigma}^{*-})/\Gamma_{total}$ Γ_{33}/Γ

VALUE (units 10^{-5})	EVTS	DOCUMENT ID		TECN	COMMENT
$11\pm3\pm3$	14	[22] BAI	01	BES	$e^+e^- \to \psi(2S)$

$\Gamma(K_1(1400)^{\pm}K^{\mp})/\Gamma_{total}$ Γ_{39}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<3.1	90	[23] BAI	99C	BES	e^+e^-

$\Gamma(\Xi^-\overline{\Xi}^+)/\Gamma_{total}$ — Γ_{38}/Γ

VALUE (units 10^{-5})	CL%	EVTS		DOCUMENT ID		TECN	COMMENT
$9.4\pm2.7\pm1.5$		12	[22]	BAI	01	BES	$e^+e^-\to\ \psi(2S)$
• • • We do not use the following data for averages, fits, limits, etc. • • •							
<20	90			FELDMAN	77	MRK1	e^+e^-

$\Gamma(\Xi^{*0}\overline{\Xi}^{*0})/\Gamma_{total}$ — Γ_{40}/Γ

VALUE (units 10^{-5})	CL%		DOCUMENT ID		TECN	COMMENT
<8.1	90	[22]	BAI	01	BES	$e^+e^-\to\ \psi(2S)$

$\Gamma(\Omega^-\overline{\Omega}^+)/\Gamma_{total}$ — Γ_{41}/Γ

VALUE (units 10^{-5})	CL%		DOCUMENT ID		TECN	COMMENT
<7.3	90	[22]	BAI	01	BES	$e^+e^-\to\ \psi(2S)$

$\Gamma(\rho\pi)/\Gamma_{total}$ — Γ_{36}/Γ

VALUE (units 10^{-4})	CL%	EVTS		DOCUMENT ID		TECN	COMMENT
<0.83	90	1		FRANKLIN	83	MRK2	e^+e^-
• • • We do not use the following data for averages, fits, limits, etc. • • •							
<10	90			BARTEL	76	CNTR	e^+e^-
<10	90		[24]	ABRAMS	75	MRK1	e^+e^-

$\Gamma(K^+K^-\pi^0)/\Gamma_{total}$ — Γ_{42}/Γ

VALUE (units 10^{-5})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
<2.96	90	1	FRANKLIN	83	MRK2	$e^+e^-\to$ hadrons

$\Gamma(K^+\overline{K}^*(892)^- + \text{c.c.})/\Gamma_{total}$ — Γ_{43}/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID		TECN	COMMENT
<5.4	90	FRANKLIN	83	MRK2	$e^+e^-\to$ hadrons

$\Gamma(K^*(892)\overline{K}_2^*(1430)^0)/\Gamma_{total}$ — Γ_{19}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<1.2	90	BAI	98J	BES	e^+e^-

$\Gamma(\phi\pi^+\pi^-)/\Gamma_{total}$ — Γ_{44}/Γ

VALUE (units 10^{-4})	EVTS		DOCUMENT ID		TECN	COMMENT
$1.5\ \pm0.2\ \pm0.2$	51.5 ± 8.3	[18]	BAI	03B	BES	$\psi(2S)\to K^+K^-\pi^+\pi^-$

$\Gamma(\phi K^+K^-)/\Gamma_{total}$ — Γ_{45}/Γ

VALUE (units 10^{-4})	EVTS		DOCUMENT ID		TECN	COMMENT
$1.1\pm0.4\pm0.1$	16.1 ± 5.0	[18]	BAI	03B	BES	$\psi(2S)\to\ 2(K^+K^-)$

$\Gamma(\phi p\overline{p})/\Gamma_{total}$ — Γ_{46}/Γ

VALUE (units 10^{-4})	CL%		DOCUMENT ID		TECN	COMMENT
<0.26	90	[18]	BAI	03B	BES	$\psi(2S)\to\ K^+K^-p\overline{p}$

$\Gamma(\phi f_0(980))/\Gamma_{total}$ Γ_{47}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
$1.1\pm0.4\pm0.1$	18.4 ± 6.4	[18] BAI	03B	BES	$\psi(2S) \to K^+K^-\pi^+\pi^-$

$\Gamma(\phi f_2'(1525))/\Gamma_{total}$ Γ_{48}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<0.45	90	BAI	98J	BES	$e^+e^- \to 2(K^+K^-)$

[18] Normalized to B($\psi(2S) \to J/\psi\pi^+\pi^-$) = 0.305 ± 0.016.
[19] Assuming B($b_1 \to \omega\pi$)=1.
[20] Assuming entirely strong decay.
[21] Assuming B($K_1(1270) \to K\rho$)=0.42 ± 0.06
[22] Estimated using B($\psi(2S) \to J/\psi\pi^+\pi^-$)= 0.310 ± 0.028.
[23] Assuming B($K_1(1400) \to K^*\pi$)=0.94 ± 0.06
[24] Final state $\rho^0\pi^0$.

RADIATIVE DECAYS

$\Gamma(\gamma\chi_{c0}(1P))/\Gamma_{total}$ Γ_{49}/Γ

VALUE (units 10^{-2})	DOCUMENT ID		TECN	COMMENT
8.4 ± 0.7 OUR NEW UNCHECKED FIT [$(8.7 \pm 0.8)\times10^{-2}$ OUR 2002 FIT]				
9.3 ± 0.8 OUR AVERAGE				
$9.9\pm0.5\pm0.8$	[25] GAISER	86	CBAL	$e^+e^- \to \gamma X$
7.2 ± 2.3	[25] BIDDICK	77	CNTR	$e^+e^- \to \gamma X$
7.5 ± 2.6	[25] WHITAKER	76	MRK1	e^+e^-

$\Gamma(\gamma\chi_{c1}(1P))/\Gamma_{total}$ Γ_{50}/Γ

VALUE (units 10^{-2})	DOCUMENT ID		TECN	COMMENT
8.4 ± 0.6 OUR NEW UNCHECKED FIT [$(8.4 \pm 0.7)\times10^{-2}$ OUR 2002 FIT]				
8.7 ± 0.8 OUR AVERAGE				
$9.0\pm0.5\pm0.7$	[26] GAISER	86	CBAL	$e^+e^- \to \gamma X$
7.1 ± 1.9	[27] BIDDICK	77	CNTR	$e^+e^- \to \gamma X$

$\Gamma(\gamma\chi_{c2}(1P))/\Gamma_{total}$ Γ_{51}/Γ

VALUE (units 10^{-2})	DOCUMENT ID		TECN	COMMENT
6.4 ± 0.6 OUR NEW UNCHECKED FIT [$(6.8 \pm 0.6)\times10^{-2}$ OUR 2002 FIT]				
7.8 ± 0.8 OUR AVERAGE				
$8.0\pm0.5\pm0.7$	[28] GAISER	86	CBAL	$e^+e^- \to \gamma X$
7.0 ± 2.0	[27] BIDDICK	77	CNTR	$e^+e^- \to \gamma X$

$\Gamma(\gamma\eta_c(1S))/\Gamma_{total}$ Γ_{52}/Γ

VALUE (units 10^{-2})	DOCUMENT ID		TECN	COMMENT
0.28 ± 0.06	GAISER	86	CBAL	$e^+e^- \to \gamma X$

$\Gamma(\gamma\eta_c(2S))/\Gamma_{total}$ Γ_{53}/Γ

VALUE (units 10^{-2})	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.2 to 1.3	95	EDWARDS	82C	CBAL	$e^+e^- \to \gamma X$

$\Gamma(\gamma\pi^0)/\Gamma_{total}$ Γ_{54}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 54	95	[29] LIBERMAN	75	SPEC	e^+e^-
<100	90	WIIK	75	DASP	e^+e^-

$\Gamma(\gamma\eta'(958))/\Gamma_{total}$ Γ_{55}/Γ

VALUE (units 10^{-4})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
$1.54\pm0.31\pm0.20$		~ 43	BAI	98F	BES	$\psi(2S)\to\pi^+\pi^-2\gamma$, $\pi^+\pi^-3\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<60	90		[30] BRAUNSCH...	77	DASP	e^+e^-
<11	90		[31] BARTEL	76	CNTR	e^+e^-

$\Gamma(\gamma f_0(1270))/\Gamma_{total}$ Γ_{56}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
$2.12\pm0.19\pm0.32$		[32,33] BAI	03C	BES	$\psi(2S)\to\gamma\pi\pi$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$2.08\pm0.19\pm0.33$	200.6 ± 18.8	[32] BAI	03C	BES	$\psi(2S)\to\gamma\pi^+\pi^-$
$2.90\pm1.08\pm1.07$	29.9 ± 11.1	[32] BAI	03C	BES	$\psi(2S)\to\gamma\pi^0\pi^0$

$\Gamma(\gamma f_0(1710)\to\gamma\pi\pi)/\Gamma_{total}$ Γ_{57}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
$0.301\pm0.041\pm0.124$	35.6 ± 4.8	[32] BAI	03C	BES	$\psi(2S)\to\gamma\pi^+\pi^-$

$\Gamma(\gamma f_0(1710)\to\gamma K\overline{K})/\Gamma_{total}$ Γ_{58}/Γ

VALUE (units 10^{-4})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
$0.604\pm0.090\pm0.132$		39.6 ± 5.4	[32,34] BAI	03C	BES	$\psi(2S)\to\gamma K^+K^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<1.56	90		[18,34] BAI	03C	BES	$\psi(2S)\to\gamma K^0_S K^0_S$

$\Gamma(\gamma\eta)/\Gamma_{total}$ Γ_{60}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<0.9	90	BAI	98F	BES	$\psi(2S)\to\pi^+\pi^-3\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<2	90	YAMADA	77	DASP	$e^+e^-\to 3\gamma$

$\Gamma(\gamma\eta(1440) \to \gamma K\overline{K}\pi)/\Gamma_{\text{total}}$ Γ_{61}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<0.12	90	[35] SCHARRE	80	MRK1	e^+e^-

[25] Angular distribution $(1+\cos^2\theta)$ assumed.
[26] Angular distribution $(1-0.189\ \cos^2\theta)$ assumed.
[27] Valid for isotropic distribution of the photon.
[28] Angular distribution $(1-0.052\ \cos^2\theta)$ assumed.
[29] Restated by us using $B(\psi(2S) \to \mu^+\mu^-) = 0.0077$.
[30] Restated by us using total decay width 228 keV.
[31] The value is normalized to the branching ratio for $\Gamma(J/\psi(1S)\eta)/\Gamma_{\text{total}}$.
[32] Normalized to $B(\psi(2S) \to J/\psi\pi^+\pi^-) = 0.305 \pm 0.016$.
[33] Combining the results from $\pi^+\pi^-$ and $\pi^0\pi^0$ decay modes.
[34] Includes unknown branching fractions to K^+K^- or $K^0_S K^0_S$. We have multiplied the K^+K^- result by a factor of 2 and the $K^0_S K^0_S$ result by a factor of 4 to obtain the $K\overline{K}$ result.
[35] Includes unknown branching fraction $\eta(1440) \to K\overline{K}\pi$.

$\psi(2S)$ CROSS-PARTICLE BRANCHING RATIOS

For measurements involving $B(\psi(2S) \to \gamma\chi_{cJ}(1P))\times B(\chi_{cJ}(1P) \to X)$ see the corresponding entries in the $\chi_{cJ}(1P)$ sections.

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