$\psi(2S)$

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

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

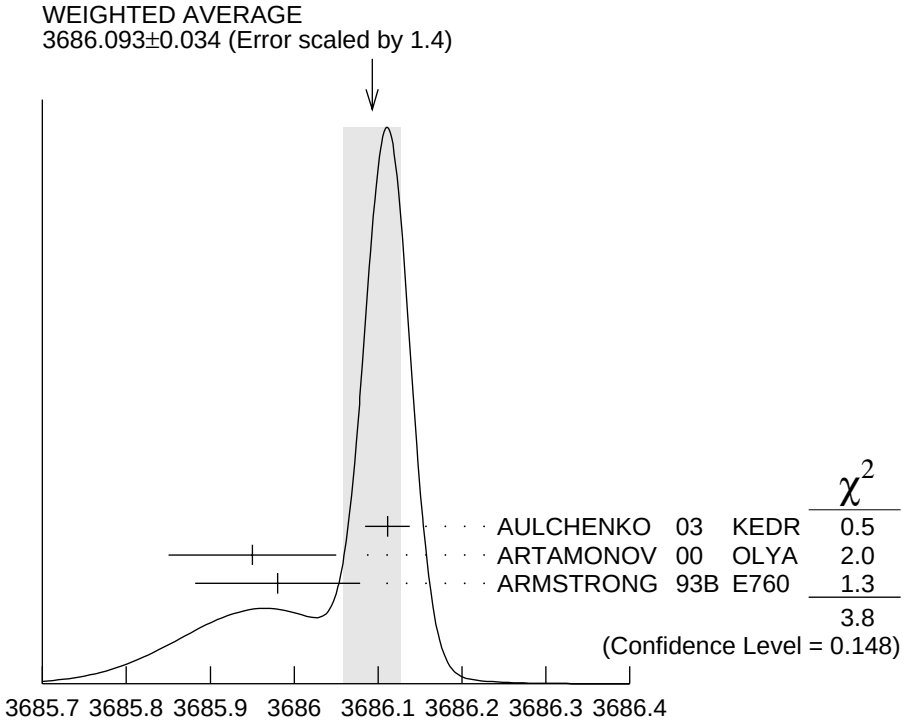
$\psi(2S)$ MASS

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
3686.093±0.034 OUR AVERAGE		Error includes scale factor of 1.4. See the ideogram below.			
3686.111±0.025±0.009		AULCHENKO	03	KEDR	$e^+e^- \to$ hadrons
3685.95 ±0.10	413	[1] ARTAMONOV	00	OLYA	$e^+e^- \to$ hadrons
3685.98 ±0.09 ±0.04		[2] 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 $\pi^\pm$, pLi $\to$ $J/\psi\pi^+\pi^-$X
3686.00 ±0.10	413	[3] ZHOLENTZ	80	OLYA	e^+e^-

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

[2] Mass central value and systematic error recalculated by us according to Eq. (16) in ARMSTRONG 93B, using the value for the $J/\psi(1S)$ mass from AULCHENKO 03.

[3] Superseded by ARTAMONOV 00.



$\psi(2S)$ mass

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

VALUE (MeV)	DOCUMENT ID		TECN	COMMENT
589.188±0.028 OUR AVERAGE				
589.194±0.027±0.011	[4] AULCHENKO	03	KEDR	$e^+e^- \rightarrow$ hadrons
589.7 ±1.2	LEMOIGNE	82	GOLI	190 π^- Be $\rightarrow$ 2μ
589.07 ±0.13	[4] 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	[5] BAI	98E	BES	e^+e^-

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

$\psi(2S)$ WIDTH

VALUE (keV)	DOCUMENT ID		TECN	COMMENT
281±17 OUR FIT				
277±22 OUR AVERAGE				
264±27	[6] BAI	02B	BES	e^+e^-
306±36±16	ARMSTRONG	93B	E760	$\overline{p}p \rightarrow e^+e^-$

[6] 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^-	(7.55±0.31) $\times 10^{-3}$	
Γ_4	$\mu^+\mu^-$	(7.3 ±0.8) $\times 10^{-3}$	
Γ_5	$\tau^+\tau^-$	(2.8 ±0.7) $\times 10^{-3}$	
	Decays into $J/\psi(1S)$ and anything		
Γ_6	$J/\psi(1S)$ anything	(57.6 ±2.0) %	
Γ_7	$J/\psi(1S)$ neutrals	(24.6 ±1.2) %	
Γ_8	$J/\psi(1S)\pi^+\pi^-$	(31.7 ±1.1) %	
Γ_9	$J/\psi(1S)\pi^0\pi^0$	(18.8 ±1.2) %	
Γ_{10}	$J/\psi(1S)\eta$	(3.16±0.22) %	
Γ_{11}	$J/\psi(1S)\pi^0$	(9.6 ±2.1) $\times 10^{-4}$	

Hadronic decays

Γ_{12}	$3(\pi^+\pi^-)\pi^0$	$(3.5 \pm 1.6) \times 10^{-3}$	
Γ_{13}	$2(\pi^+\pi^-)\pi^0$	$(3.0 \pm 0.8) \times 10^{-3}$	
Γ_{14}	$\rho a_2(1320)$	$< 2.3 \times 10^{-4}$	CL=90%
Γ_{15}	$\omega\pi^+\pi^-$	$(4.8 \pm 0.9) \times 10^{-4}$	
Γ_{16}	$b_1^\pm\pi^\mp$	$(3.2 \pm 0.8) \times 10^{-4}$	
Γ_{17}	$\omega f_2(1270)$	$< 1.5 \times 10^{-4}$	CL=90%
Γ_{18}	$\pi^+\pi^- K^+K^-$	$(1.6 \pm 0.4) \times 10^{-3}$	
Γ_{19}	$K^*(892)\overline{K}_2^*(1430)^0$	$< 1.2 \times 10^{-4}$	CL=90%
Γ_{20}	$K_1(1270)^\pm K^\mp$	$(1.00\pm0.28) \times 10^{-3}$	
Γ_{21}	$\pi^+\pi^- p\overline{p}$	$(8.0 \pm 2.0) \times 10^{-4}$	
Γ_{22}	$K^+\overline{K}^*(892)^0\pi^- +$ c.c.	$(6.7 \pm 2.5) \times 10^{-4}$	
Γ_{23}	$2(\pi^+\pi^-)$	$(4.5 \pm 1.0) \times 10^{-4}$	
Γ_{24}	$\rho^0\pi^+\pi^-$	$(4.2 \pm 1.5) \times 10^{-4}$	
Γ_{25}	ωK^+K^-	$(1.5 \pm 0.4) \times 10^{-4}$	
Γ_{26}	$\omega p\overline{p}$	$(8.0 \pm 3.2) \times 10^{-5}$	
Γ_{27}	$\overline{p}p$	$(2.07\pm0.31) \times 10^{-4}$	
Γ_{28}	$\Lambda\overline{\Lambda}$	$(1.81\pm0.34) \times 10^{-4}$	
Γ_{29}	$3(\pi^+\pi^-)$	$(1.5 \pm 1.0) \times 10^{-4}$	
Γ_{30}	$\overline{p}p\pi^0$	$(1.4 \pm 0.5) \times 10^{-4}$	
Γ_{31}	$\Delta^{++}\overline{\Delta}^{--}$	$(1.28\pm0.35) \times 10^{-4}$	
Γ_{32}	$\Sigma^0\overline{\Sigma}^0$	$(1.2 \pm 0.6) \times 10^{-4}$	
Γ_{33}	$\Sigma^{*+}\overline{\Sigma}^{*-}$	$(1.1 \pm 0.4) \times 10^{-4}$	
Γ_{34}	K^+K^-	$(1.0 \pm 0.7) \times 10^{-4}$	
Γ_{35}	$K_S^0K_L^0$	$(5.2 \pm 0.7) \times 10^{-5}$	
Γ_{36}	$\pi^+\pi^-\pi^0$	$(8 \pm 5) \times 10^{-5}$	
Γ_{37}	$\rho\pi$	$< 8.3 \times 10^{-5}$	CL=90%
Γ_{38}	$\pi^+\pi^-$	$(8 \pm 5) \times 10^{-5}$	
Γ_{39}	$\Xi^-\overline{\Xi}^+$	$(9.4 \pm 3.1) \times 10^{-5}$	
Γ_{40}	$K_1(1400)^\pm K^\mp$	$< 3.1 \times 10^{-4}$	CL=90%
Γ_{41}	$\Xi^{*0}\overline{\Xi}^{*0}$	$< 8.1 \times 10^{-5}$	CL=90%
Γ_{42}	$\Omega^-\overline{\Omega}^+$	$< 7.3 \times 10^{-5}$	CL=90%
Γ_{43}	$K^+K^-\pi^0$	$< 2.96 \times 10^{-5}$	CL=90%
Γ_{44}	$K^+\overline{K}^*(892)^- +$ c.c.	$< 5.4 \times 10^{-5}$	CL=90%
Γ_{45}	$\phi\pi^+\pi^-$	$(1.50\pm0.28) \times 10^{-4}$	
Γ_{46}	$\phi f_0(980) \rightarrow \pi^+\pi^-$	$(6.0 \pm 2.2) \times 10^{-5}$	
Γ_{47}	ϕK^+K^-	$(6.0 \pm 2.2) \times 10^{-5}$	
Γ_{48}	$\phi p\overline{p}$	$< 2.6 \times 10^{-5}$	CL=90%
Γ_{49}	$\phi f_2'(1525)$	$< 4.5 \times 10^{-5}$	CL=90%

Radiative decays

Γ_{50}	$\gamma\chi_{c0}(1P)$	(8.6 ±0.7) %		
Γ_{51}	$\gamma\chi_{c1}(1P)$	(8.4 ±0.8) %		
Γ_{52}	$\gamma\chi_{c2}(1P)$	(6.4 ±0.6) %		
Γ_{53}	$\gamma\eta_c(1S)$	(2.8 ±0.6) $\times 10^{-3}$		
Γ_{54}	$\gamma\eta_c(2S)$			
Γ_{55}	$\gamma\pi^0$			
Γ_{56}	$\gamma\eta'(958)$	(1.5 ±0.4) $\times 10^{-4}$		
Γ_{57}	$\gamma f_2(1270)$	(2.1 ±0.4) $\times 10^{-4}$		
Γ_{58}	$\gamma f_0(1710) \rightarrow \gamma\pi\pi$	(3.0 ±1.3) $\times 10^{-5}$		
Γ_{59}	$\gamma f_0(1710) \rightarrow \gamma K\overline{K}$	(6.0 ±1.6) $\times 10^{-5}$		
Γ_{60}	$\gamma\gamma$	< 1.5	$\times 10^{-4}$	CL=90%
Γ_{61}	$\gamma\eta$	< 9	$\times 10^{-5}$	CL=90%
Γ_{62}	$\gamma\eta(1405) \rightarrow \gamma K\overline{K}\pi$	< 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 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	[8] BAI	02B	BES	e^+e^-
2.0 ±0.3	BRANDELIK	79C	DASP	e^+e^-
2.1 ±0.3	[7] LUTH	75	MRK1	e^+e^-

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

$\Gamma(\gamma\gamma)$ Γ_{60}

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

[8] 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 $\Gamma(I)/total$.

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

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^-

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

VALUE (keV)	DOCUMENT ID		TECN	COMMENT
0.67±0.05 OUR FIT				
0.68±0.09	[9] BAI	98E	BES	e^+e^-

[9] 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

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.9785±0.0013 OUR AVERAGE				
0.9779±0.0015	[10] BAI	02B	BES	e^+e^-
0.981 ±0.003	[10] LUTH	75	MRK1	e^+e^-

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.0216±0.0035 OUR AVERAGE	Error includes scale factor of 2.1.			
0.0199±0.0019	[11] BAI	02B	BES	e^+e^-
0.029 ±0.004	[11] LUTH	75	MRK1	e^+e^-

$\Gamma(e^+e^-)/\Gamma_{total}$ Γ_3/Γ

VALUE (units 10^{-4})	DOCUMENT ID		TECN	COMMENT
75.5± 3.1 OUR FIT				
• • • We do not use the following data for averages, fits, limits, etc. • • •				
88 ±13	[12] FELDMAN	77	RVUE	e^+e^-

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

VALUE (units 10^{-4})	DOCUMENT ID
73±8 OUR FIT	

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

VALUE (units 10^{-4})	DOCUMENT ID
28±7 OUR FIT	

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

VALUE	DOCUMENT ID	TECN	COMMENT
0.97±0.13 OUR FIT			
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.89±0.16	BOYARSKI 75C	MRK1	e^+e^-

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

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

[12] 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

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

VALUE	DOCUMENT ID	TECN	COMMENT
0.576±0.020 OUR 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	$e^+e^- \to \mu^+\mu^- X$

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

VALUE	DOCUMENT ID
0.246±0.012 OUR FIT	

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

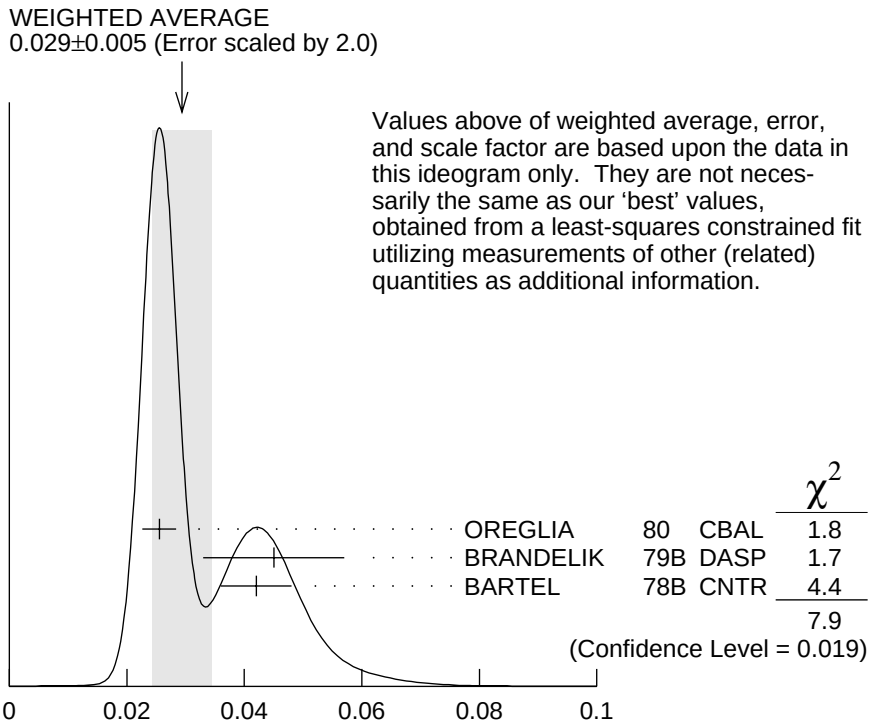
VALUE	DOCUMENT ID	TECN	COMMENT
0.317±0.011 OUR FIT			
0.323±0.013 OUR AVERAGE			
0.323±0.014	BAI 02B	BES	e^+e^-
0.32 ±0.04	ABRAMS 75B	MRK1	$e^+e^- \to J/\psi\pi^+\pi^-$

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

VALUE	DOCUMENT ID
0.188±0.012 OUR FIT	

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

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.0316±0.0022 OUR FIT				
0.029 ±0.005 OUR AVERAGE Error includes scale factor of 2.0. See the ideogram below.				
0.0255±0.0029	386	[13] OREGLIA 80	CBAL	$e^+e^- \to J/\psi 2\gamma$
0.045 ±0.012	17	[14] BRANDELIK 79B	DASP	$e^+e^- \to J/\psi 2\gamma$
0.042 ±0.006	164	[14] 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^-



$\Gamma(J/\psi(1S)\pi^0)/\Gamma_{total}$ 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	[13] OREGLIA	80	CBAL	$\psi(2S) \rightarrow J/\psi 2\gamma$

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

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.777±0.032 OUR 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*
0.549±0.011 OUR 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 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 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	[15] 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 FIT				
0.069±0.008 OUR AVERAGE				
0.072±0.009	AMBROGIANI	00A	E835	$p\overline{p} \to \psi(2S)$
0.061±0.015	ARMSTRONG	97	E760	$\overline{p}p \to \psi(2S)$

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.100±0.008 OUR FIT				
0.091±0.021	[16] HIMEL	80	MRK2	$e^+e^- \to \psi(2S)X$

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.0131±0.0010 OUR FIT				
0.0131±0.0006 OUR AVERAGE Error includes scale factor of 1.8.				
0.0128±0.0003±0.0002	[17] AMBROGIANI	00A	E835	$p\overline{p} \to \psi(2S)$
0.0144±0.0008±0.0002	[17] ARMSTRONG	97	E760	$\overline{p}p \to \psi(2S)$

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.0238±0.0017 OUR FIT				
0.0252±0.0028±0.0011	[17] 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 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±0.0030 OUR FIT				
0.0224±0.0029 OUR AVERAGE				
0.0216±0.0026±0.0014	[18] AUBERT	02B	BABR	e^+e^-
0.0327±0.0077±0.0072	[18] GRIBUSHIN	96	FMPS	515 π^- Be $\to 2\mu X$

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

VALUE (units 10^{-3})	DOCUMENT ID		TECN	COMMENT
8.7 ±2.2 OUR FIT				
8.73±1.39±1.57	BAI	02	BES	e^+e^-

[13] Recalculated by us using B($J/\psi(1S) \to \ell^+\ell^-$) = 0.1181 ± 0.0020.
[14] Recalculated by us using B($J/\psi(1S) \to \mu^+\mu^-$) = 0.0588 ± 0.0010.
[15] Ignoring the $J/\psi(1S)\eta$ and $J/\psi(1S)\gamma\gamma$ decays.
[16] The value for B($\psi(2S) \to J/\psi(1s)\eta$) reported in HIMEL 80 is derived using B(ψ(2S)) → $J/\psi(1S)\pi^+\pi^-$) = (33 ± 3))% and B($J/\psi(1S) \to \ell^+\ell^-$) = 0.138 ± 0.018. Calculated by us using B($J/\psi(1S) \to \ell^+\ell^-$) = (0.1181 ± 0.0020).
[17] Using B($J/\psi(1S) \to e^+e^-$) = 0.0593 ± 0.0010.
[18] Using B($J/\psi(1S) \to \mu^+\mu^-$) = 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	$e^+e^- \to$ 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	[19] BAI	03B	BES	$\psi(2S) \to 2(\pi^+\pi^-)\pi^0$

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

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
3.2±0.6±0.5	61 ± 11	[19,20] BAI	03B	BES	$\psi(2S) \to 2(\pi^+\pi^-)\pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
5.2±0.8±1.0		[20] 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	90	[19] BAI	03B	BES	$\psi(2S) \to 2(\pi^+\pi^-)\pi^0$
• • • 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	[21] 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	[22] BAI	99C	BES	e^+e^-

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

VALUE (units 10^{-4})	DOCUMENT ID		TECN	COMMENT
8 ±2	[21] TANENBAUM	78	MRK1	e^+e^-

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

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

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

VALUE (units 10^{-4})	EVTS		DOCUMENT ID		TECN	COMMENT
1.5±0.3±0.2	23.0± 5.2	[19]	BAI	03B	BES	$\psi(2S) \to K^+K^-\pi^+\pi^-\pi^0$

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

VALUE (units 10^{-4})	EVTS		DOCUMENT ID		TECN	COMMENT
0.8 ±0.3 ±0.1	14.9± 0.1	[19]	BAI	03B	BES	$\psi(2S) \to p\overline{p}\pi^+\pi^-\pi^0$

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

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

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

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

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

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

$\Gamma(\overline{p}p)/\Gamma_{\text{total}}$ 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	[23]	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^-

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

VALUE (units 10^{-4})	CL%	EVTS		DOCUMENT ID		TECN	COMMENT
1.81±0.20±0.27		80	[23]	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^-

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

VALUE (units 10^{-4})	DOCUMENT ID		TECN	COMMENT
1.5±1.0	[21] TANENBAUM	78	MRK1	e^+e^-

$\Gamma(\overline{p}p\pi^0)/\Gamma_{\text{total}}$ 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^-

$\Gamma(K^0_S K^0_L)/\Gamma_{total}$ Γ_{35}/Γ

VALUE (units 10^{-5})	EVTS	DOCUMENT ID		TECN	COMMENT
5.24±0.47±0.48	156±14	[24] BAI	04B	BES2	$\psi(2S) \to K^0_S K^0_L \to \pi^+\pi^- X$

$\Gamma(\pi^+\pi^-)/\Gamma_{total}$ Γ_{38}/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_{36}/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±1.0±3.4	157	[23] 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±4±4	8	[23] 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±3±3	14	[23] BAI	01	BES	$e^+e^- \to \psi(2S)$

$\Gamma(K_1(1400)^\pm K^\mp)/\Gamma_{total}$ Γ_{40}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<3.1	90	[25] BAI	99C	BES	e^+e^-

$\Gamma(\Xi^-\overline{\Xi}^+)/\Gamma_{total}$ Γ_{39}/Γ

VALUE (units 10^{-5})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
9.4±2.7±1.5	12		[23] 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_{41}/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID		TECN	COMMENT
<8.1	90	[23] BAI	01	BES	$e^+e^- \to \psi(2S)$

$\Gamma(\Omega^-\overline{\Omega}^+)/\Gamma_{\text{total}}$ Γ_{42}/Γ

VALUE (units 10^{-5})	CL%		DOCUMENT ID		TECN	COMMENT
<7.3	90	[23]	BAI	01	BES	$e^+e^- \to \psi(2S)$

$\Gamma(\rho\pi)/\Gamma_{\text{total}}$ Γ_{37}/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		[26] ABRAMS	75	MRK1	e^+e^-

$\Gamma(K^+K^-\pi^0)/\Gamma_{\text{total}}$ Γ_{43}/Γ

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

$\Gamma(K^+\overline{K}^*(892)^- + \text{c.c.})/\Gamma_{\text{total}}$ Γ_{44}/Γ

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

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

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

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

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
1.5 ±0.2 ±0.2	51.5± 8.3	[19] BAI	03B	BES	$\psi(2S) \to K^+K^-\pi^+\pi^-$

$\Gamma(\phi f_0(980) \to \pi^+\pi^-)/\Gamma_{\text{total}}$ Γ_{46}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
0.6 ±0.2 ±0.1	18.4± 6.4	[19] BAI	03B	BES	$\psi(2S) \to K^+K^-\pi^+\pi^-$

$\Gamma(\phi K^+K^-)/\Gamma_{\text{total}}$ Γ_{47}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
0.6 ±0.2 ±0.1	16.1± 5.0	[19] BAI	03B	BES	$\psi(2S) \to 2(K^+K^-)$

$\Gamma(\phi p\overline{p})/\Gamma_{\text{total}}$ Γ_{48}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<0.26	90	[19] BAI	03B	BES	$\psi(2S) \to K^+K^-p\overline{p}$

$\Gamma(\phi f_2'(1525))/\Gamma_{total}$ Γ_{49}/Γ

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

[19] Normalized to B($\psi(2S) \to J/\psi\pi^+\pi^-$) = 0.305 ± 0.016.
[20] Assuming B($b_1 \to \omega\pi$)=1.
[21] Assuming entirely strong decay.
[22] Assuming B($K_1(1270) \to K\rho$)=0.42 ± 0.06
[23] Estimated using B($\psi(2S) \to J/\psi\pi^+\pi^-$)= 0.310 ± 0.028.
[24] Using B($K_S^0 \to \pi^+\pi^-$) = 0.6860 ± 0.0027.
[25] Assuming B($K_1(1400) \to K^*\pi$)=0.94 ± 0.06
[26] Final state $\rho^0\pi^0$.

RADIATIVE DECAYS

$\Gamma(\gamma\chi_{c0}(1P))/\Gamma_{total}$ Γ_{50}/Γ

VALUE (units 10^{-2})	DOCUMENT ID		TECN	COMMENT
8.6±0.7 OUR FIT				
9.3±0.8 OUR AVERAGE				
9.9±0.5±0.8	[27] GAISER	86	CBAL	$e^+e^- \to \gamma X$
7.2±2.3	[27] BIDDICK	77	CNTR	$e^+e^- \to \gamma X$
7.5±2.6	[27] WHITAKER	76	MRK1	e^+e^-

$\Gamma(\gamma\chi_{c1}(1P))/\Gamma_{total}$ Γ_{51}/Γ

VALUE (units 10^{-2})	DOCUMENT ID		TECN	COMMENT
8.4±0.8 OUR FIT				
8.7±0.8 OUR AVERAGE				
9.0±0.5±0.7	[28] GAISER	86	CBAL	$e^+e^- \to \gamma X$
7.1±1.9	[29] BIDDICK	77	CNTR	$e^+e^- \to \gamma X$

$\Gamma(\gamma\chi_{c2}(1P))/\Gamma_{total}$ Γ_{52}/Γ

VALUE (units 10^{-2})	DOCUMENT ID		TECN	COMMENT
6.4±0.6 OUR FIT				
7.8±0.8 OUR AVERAGE				
8.0±0.5±0.7	[30] GAISER	86	CBAL	$e^+e^- \to \gamma X$
7.0±2.0	[29] BIDDICK	77	CNTR	$e^+e^- \to \gamma X$

$\Gamma(\gamma\eta_c(1S))/\Gamma_{total}$ Γ_{53}/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_{54}/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_{55}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 54	95	[31] LIBERMAN	75	SPEC	e^+e^-
<100	90	WIIK	75	DASP	e^+e^-

$\Gamma(\gamma\eta'(958))/\Gamma_{total}$ Γ_{56}/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		[32] BRAUNSCH...	77	DASP	e^+e^-
<11	90		[33] BARTEL	76	CNTR	e^+e^-

$\Gamma(\gamma f_2(1270))/\Gamma_{total}$ Γ_{57}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
$2.12\pm0.19\pm0.32$		[34,35] 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	[34] BAI	03C	BES	$\psi(2S) \to \gamma\pi^+\pi^-$
$2.90\pm1.08\pm1.07$	29.9 ± 11.1	[34] BAI	03C	BES	$\psi(2S) \to \gamma\pi^0\pi^0$

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

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
$0.301\pm0.041\pm0.124$	35.6 ± 4.8	[34] BAI	03C	BES	$\psi(2S) \to \gamma\pi^+\pi^-$

$\Gamma(\gamma f_0(1710) \to \gamma K\overline{K})/\Gamma_{total}$ Γ_{59}/Γ

VALUE (units 10^{-4})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
$0.604\pm0.090\pm0.132$		39.6 ± 5.9	[34,36] BAI	03C	BES	$\psi(2S) \to \gamma K^+K^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<1.56	90	6.8 ± 3.1	[34,36] BAI	03C	BES	$\psi(2S) \to \gamma K^0_S K^0_S$

$\Gamma(\gamma\eta)/\Gamma_{total}$ Γ_{61}/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	$e^+e^- \to 3\gamma$

$\Gamma(\gamma\eta(1405) \to \gamma K\overline{K}\pi)/\Gamma_{total}$ Γ_{62}/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<0.12	90	[37] SCHARRE	80	MRK1	e^+e^-

[27] Angular distribution $(1+\cos^2\theta)$ assumed.
[28] Angular distribution $(1-0.189\ \cos^2\theta)$ assumed.
[29] Valid for isotropic distribution of the photon.
[30] Angular distribution $(1-0.052\ \cos^2\theta)$ assumed.
[31] Restated by us using $B(\psi(2S) \to \mu^+\mu^-) = 0.0077$.
[32] Restated by us using total decay width 228 keV.
[33] The value is normalized to the branching ratio for $\Gamma(J/\psi(1S)\eta)/\Gamma_{total}$.
[34] Normalized to $B(\psi(2S) \to J/\psi\pi^+\pi^-) = 0.305 \pm 0.016$.
[35] Combining the results from $\pi^+\pi^-$ and $\pi^0\pi^0$ decay modes.
[36] Includes unknown branching fractions to K^+K^- or $K^0_SK^0_S$. We have multiplied the K^+K^- result by a factor of 2 and the $K^0_SK^0_S$ result by a factor of 4 to obtain the $K\overline{K}$ result.
[37] Includes unknown branching fraction $\eta(1405) \to K\overline{K}\pi$.

$\psi(2S)$ 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.

$\psi(2S)$ REFERENCES

BAI	04B	PRL 92 052001	J.Z. Bai *et al.*	(BES2 Collab.)
AULCHENKO	03	PL B573 63	V.M. Aulchenko *et al.*	(KEDR Collab.)
BAI	03B	PR D67 052002	J.Z. Bai *et al.*	(BES Collab.)
BAI	03C	PR D67 032004	J.Z. Bai *et al.*	(BES Collab.)
AUBERT	02B	PR D65 031101R	B. Aubert *et al.*	(BaBar Collab.)
BAI	02	PR D65 052004	J.Z. Bai *et al.*	(BES Collab.)
BAI	02B	PL B550 24	J.Z. Bai *et al.*	(BES Collab.)
BAI	01	PR D63 032002	J.Z. Bai *et al.*	(BES Collab.)
AMBROGIANI	00A	PR D62 032004	M. Ambrogiani *et al.*	(FNAL E835 Collab.)
ARTAMONOV	00	PL B474 427	A.S. Artamonov *et al.*	
BAI	99C	PRL 83 1918	J.Z. Bai *et al.*	(BES Collab.)
BAI	98E	PR D57 3854	J.Z. Bai *et al.*	(BES Collab.)
BAI	98F	PR D58 097101	J.Z. Bai *et al.*	(BES Collab.)
BAI	98J	PRL 81 5080	J.Z. Bai *et al.*	(BES Collab.)
ARMSTRONG	97	PR D55 1153	T.A. Armstrong *et al.*	(E760 Collab.)
GRIBUSHIN	96	PR D53 4723	A. Gribushin *et al.*	(E672 Collab., E706 Collab.)
ANTONIAZZI	94	PR D50 4258	L. Antoniazzi *et al.*	(E705 Collab.)
ARMSTRONG	93B	PR D47 772	T.A. Armstrong *et al.*	(FNAL E760 Collab.)
ALEXANDER	89	NP B320 45	J.P. Alexander *et al.*	(LBL, MICH, SLAC)
COHEN	87	RMP 59 1121	E.R. Cohen, B.N. Taylor	(RISC, NBS)
GAISER	86	PR D34 711	J. Gaiser *et al.*	(Crystal Ball Collab.)
KURAEV	85	SJNP 41 466	E.A. Kuraev, V.S. Fadin	(NOVO)
		Translated from YAF 41 733.		
FRANKLIN	83	PRL 51 963	M.E.B. Franklin *et al.*	(LBL, SLAC)
EDWARDS	82C	PRL 48 70	C. Edwards *et al.*	(CIT, HARV, PRIN+)
LEMOIGNE	82	PL 113B 509	Y. Lemoigne *et al.*	(SACL, LOIC, SHMP+)
HIMEL	80	PRL 44 920	T. Himel *et al.*	(LBL, SLAC)
OREGLIA	80	PRL 45 959	M.J. Oreglia *et al.*	(SLAC, CIT, HARV+)
SCHARRE	80	PL 97B 329	D.L. Scharre *et al.*	(SLAC, LBL)
ZHOLENTZ	80	PL 96B 214	A.A. Zholents *et al.*	(NOVO)
Also	81	SJNP 34 814	A.A. Zholents *et al.*	(NOVO)
		Translated from YAF 34 1471.		

BRANDELIK	79B	NP B160 426	R. Brandelik *et al.*	(DASP Collab.)
BRANDELIK	79C	ZPHY C1 233	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)
BIDDICK	77	PRL 38 1324	C.J. Biddick *et al.*	(UCSD, UMD, PAVI+)
BRAUNSCH...	77	PL 67B 249	W. Braunschweig *et al.*	(DASP Collab.)
BURMESTER	77	PL 66B 395	J. Burmester *et al.*	(DESY, HAMB, SIEG+)
FELDMAN	77	PRPL 33C 285	G.J. Feldman, M.L. Perl	(LBL, SLAC)
YAMADA	77	Hamburg Conf. 69	S. Yamada	(DASP Collab.)
BARTEL	76	PL 64B 483	W. Bartel *et al.*	(DESY, HEIDP)
TANENBAUM	76	PRL 36 402	W.M. Tanenbaum *et al.*	(SLAC, LBL) IG
WHITAKER	76	PRL 37 1596	J.S. Whitaker *et al.*	(SLAC, LBL)
ABRAMS	75	Stanford Symp. 25	G.S. Abrams	(LBL)
ABRAMS	75B	PRL 34 1181	G.S. Abrams *et al.*	(LBL, SLAC)
BOYARSKI	75C	Palermo Conf. 54	A.M. Boyarski *et al.*	(SLAC, LBL)
HILGER	75	PRL 35 625	E. Hilger *et al.*	(STAN, PENN)
LIBERMAN	75	Stanford Symp. 55	A.D. Liberman	(STAN)
LUTH	75	PRL 35 1124	V. Luth *et al.*	(SLAC, LBL) JPC
WIIK	75	Stanford Symp. 69	B.H. Wiik	(DESY)

OTHER RELATED PAPERS

CHEN	98	PRL 80 5060	Y.Q. Chen, E. Braaten	
SUZUKI	98	PR D57 5717	M. Suzuki	
BARATE	83	PL 121B 449	R. Barate *et al.*	(SACL, LOIC, SHMP, IND)
AUBERT	75B	PRL 33 1624	J.J. Aubert *et al.*	(MIT, BNL)
BRAUNSCH...	75B	PL 57B 407	W. Braunschweig *et al.*	(DASP Collab.)
CAMERINI	75	PRL 35 483	U. Camerini *et al.*	(WISC, SLAC)
FELDMAN	75B	PRL 35 821	G.J. Feldman *et al.*	(LBL, SLAC)
GRECO	75	PL 56B 367	M. Greco, G. Pancheri-Srivastava, Y. Srivastava	
JACKSON	75	NIM 128 13	J.D. Jackson, D.L. Scharre	(LBL)
SIMPSON	75	PRL 35 699	J.W. Simpson *et al.*	(STAN, PENN)
ABRAMS	74	PRL 33 1453	G.S. Abrams *et al.*	(LBL, SLAC)