

$\Upsilon(2S)$

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

$\Upsilon(2S)$ MASS

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
10023.26±0.31 OUR AVERAGE			
10023.5 ±0.5	¹ ARTAMONOV 00	MD1	$e^+e^- \rightarrow \text{hadrons}$
10023.1 ±0.4	BARBER 84	REDE	$e^+e^- \rightarrow \text{hadrons}$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
10023.6 ±0.5	^{2,3} BARU	86B REDE	$e^+e^- \rightarrow \text{hadrons}$
¹ Reanalysis of BARU 86B using new electron mass (COHEN 87).			
² Reanalysis of ARTAMONOV 84.			
³ Superseded by ARTAMONOV 00.			

$m\Upsilon(3S) - m\Upsilon(2S)$

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
331.50±0.02±0.13	LEES	11C BABR	$e^+e^- \rightarrow \pi^+\pi^-X$

$\Upsilon(2S)$ WIDTH

VALUE (keV)	DOCUMENT ID	COMMENT
31.98±2.63 OUR EVALUATION		See the Note on "Width Determinations of the Υ States"

$\Upsilon(2S)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)	Scale factor/ Confidence level
Γ_1 $\Upsilon(1S)\pi^+\pi^-$	(17.85±0.26) %	
Γ_2 $\Upsilon(1S)\pi^0\pi^0$	(8.6 ± 0.4) %	
Γ_3 $\tau^+\tau^-$	(2.00±0.21) %	
Γ_4 $\mu^+\mu^-$	(1.93±0.17) %	S=2.2
Γ_5 e^+e^-	(1.91±0.16) %	
Γ_6 $\Upsilon(1S)\pi^0$	< 4 × 10 ⁻⁵	CL=90%
Γ_7 $\Upsilon(1S)\eta$	(2.9 ± 0.4) × 10 ⁻⁴	S=2.0
Γ_8 $J/\psi(1S)$ anything	< 6 × 10 ⁻³	CL=90%
Γ_9 $J/\psi(1S)\eta_c$	< 5.4 × 10 ⁻⁶	CL=90%
Γ_{10} $J/\psi(1S)\chi_{c0}$	< 3.4 × 10 ⁻⁶	CL=90%
Γ_{11} $J/\psi(1S)\chi_{c1}$	< 1.2 × 10 ⁻⁶	CL=90%
Γ_{12} $J/\psi(1S)\chi_{c2}$	< 2.0 × 10 ⁻⁶	CL=90%
Γ_{13} $J/\psi(1S)\eta_c(2S)$	< 2.5 × 10 ⁻⁶	CL=90%
Γ_{14} $J/\psi(1S)X(3940)$	< 2.0 × 10 ⁻⁶	CL=90%
Γ_{15} $J/\psi(1S)X(4160)$	< 2.0 × 10 ⁻⁶	CL=90%
Γ_{16} χ_{c1} anything	(2.2 ± 0.5) × 10 ⁻⁴	

Γ_{17}	$\chi_{c1}(1P)^0 X_{tetra}$	$< 3.67 \times 10^{-5}$	CL=90%
Γ_{18}	χ_{c2} anything	$(2.3 \pm 0.8) \times 10^{-4}$	
Γ_{19}	$\psi(2S)\eta_c$	$< 5.1 \times 10^{-6}$	CL=90%
Γ_{20}	$\psi(2S)\chi_{c0}$	$< 4.7 \times 10^{-6}$	CL=90%
Γ_{21}	$\psi(2S)\chi_{c1}$	$< 2.5 \times 10^{-6}$	CL=90%
Γ_{22}	$\psi(2S)\chi_{c2}$	$< 1.9 \times 10^{-6}$	CL=90%
Γ_{23}	$\psi(2S)\eta_c(2S)$	$< 3.3 \times 10^{-6}$	CL=90%
Γ_{24}	$\psi(2S)X(3940)$	$< 3.9 \times 10^{-6}$	CL=90%
Γ_{25}	$\psi(2S)X(4160)$	$< 3.9 \times 10^{-6}$	CL=90%
Γ_{26}	$Z_c(3900)^+ Z_c(3900)^-$	$< 1.0 \times 10^{-6}$	CL=90%
Γ_{27}	$Z_c(4200)^+ Z_c(4200)^-$	$< 1.67 \times 10^{-5}$	CL=90%
Γ_{28}	$Z_c(3900)^\pm Z_c(4200)^\mp$	$< 7.3 \times 10^{-6}$	CL=90%
Γ_{29}	$X(4050)^+ X(4050)^-$	$< 1.35 \times 10^{-5}$	CL=90%
Γ_{30}	$X(4250)^+ X(4250)^-$	$< 2.67 \times 10^{-5}$	CL=90%
Γ_{31}	$X(4050)^\pm X(4250)^\mp$	$< 2.72 \times 10^{-5}$	CL=90%
Γ_{32}	$Z_c(4430)^+ Z_c(4430)^-$	$< 2.03 \times 10^{-5}$	CL=90%
Γ_{33}	$X(4055)^\pm X(4055)^\mp$	$< 1.11 \times 10^{-5}$	CL=90%
Γ_{34}	$X(4055)^\pm Z_c(4430)^\mp$	$< 2.11 \times 10^{-5}$	CL=90%
Γ_{35}	$\overline{2H}$ anything	$(2.78_{-0.26}^{+0.30}) \times 10^{-5}$	S=1.2
Γ_{36}	hadrons	$(94 \pm 11) \%$	
Γ_{37}	ggg	$(58.8 \pm 1.2) \%$	
Γ_{38}	γgg	$(1.87 \pm 0.28) \%$	
Γ_{39}	$\phi K^+ K^-$	$(1.6 \pm 0.4) \times 10^{-6}$	
Γ_{40}	$\omega \pi^+ \pi^-$	$< 2.58 \times 10^{-6}$	CL=90%
Γ_{41}	$K^*(892)^0 K^- \pi^+ + \text{c.c.}$	$(2.3 \pm 0.7) \times 10^{-6}$	
Γ_{42}	$\phi f_2^'(1525)$	$< 1.33 \times 10^{-6}$	CL=90%
Γ_{43}	$\omega f_2(1270)$	$< 5.7 \times 10^{-7}$	CL=90%
Γ_{44}	$\rho(770) a_2(1320)$	$< 8.8 \times 10^{-7}$	CL=90%
Γ_{45}	$K^*(892)^0 \overline{K}_2^*(1430)^0 + \text{c.c.}$	$(1.5 \pm 0.6) \times 10^{-6}$	
Γ_{46}	$K_1(1270)^\pm K^\mp$	$< 3.22 \times 10^{-6}$	CL=90%
Γ_{47}	$K_1(1400)^\pm K^\mp$	$< 8.3 \times 10^{-7}$	CL=90%
Γ_{48}	$b_1(1235)^\pm \pi^\mp$	$< 4.0 \times 10^{-7}$	CL=90%
Γ_{49}	$\rho \pi$	$< 1.16 \times 10^{-6}$	CL=90%
Γ_{50}	$\pi^+ \pi^- \pi^0$	$< 8.0 \times 10^{-7}$	CL=90%
Γ_{51}	$\omega \pi^0$	$< 1.63 \times 10^{-6}$	CL=90%
Γ_{52}	$\pi^+ \pi^- \pi^0 \pi^0$	$(1.30 \pm 0.28) \times 10^{-5}$	
Γ_{53}	$K_S^0 K^+ \pi^- + \text{c.c.}$	$(1.14 \pm 0.33) \times 10^{-6}$	
Γ_{54}	$K^*(892)^0 \overline{K}^0 + \text{c.c.}$	$< 4.22 \times 10^{-6}$	CL=90%
Γ_{55}	$K^*(892)^- K^+ + \text{c.c.}$	$< 1.45 \times 10^{-6}$	CL=90%
Γ_{56}	$f_1(1285)$ anything	$(2.2 \pm 1.6) \times 10^{-3}$	
Γ_{57}	$f_1(1285) X_{tetra}$	$< 6.47 \times 10^{-5}$	CL=90%
Γ_{58}	Sum of 100 exclusive modes	$(2.90 \pm 0.30) \times 10^{-3}$	

Radiative decays

Γ_{59}	$\gamma\chi_{b1}(1P)$	$(6.9 \pm 0.4) \%$		
Γ_{60}	$\gamma\chi_{b2}(1P)$	$(7.15 \pm 0.35) \%$		
Γ_{61}	$\gamma\chi_{b0}(1P)$	$(3.8 \pm 0.4) \%$		
Γ_{62}	$\gamma f_0(1710)$	< 5.9	$\times 10^{-4}$	CL=90%
Γ_{63}	$\gamma f_2'(1525)$	< 5.3	$\times 10^{-4}$	CL=90%
Γ_{64}	$\gamma f_2(1270)$	< 2.41	$\times 10^{-4}$	CL=90%
Γ_{65}	$\gamma f_J(2220)$			
Γ_{66}	$\gamma\eta_c(1S)$	< 2.7	$\times 10^{-5}$	CL=90%
Γ_{67}	$\gamma\chi_{c0}$	< 1.0	$\times 10^{-4}$	CL=90%
Γ_{68}	$\gamma\chi_{c1}$	< 3.6	$\times 10^{-6}$	CL=90%
Γ_{69}	$\gamma\chi_{c2}$	< 1.5	$\times 10^{-5}$	CL=90%
Γ_{70}	$\gamma\chi_{c1}(3872)$	< 2.1	$\times 10^{-5}$	CL=90%
Γ_{71}	$\gamma\chi_{c1}(3872), \chi_{c1} \rightarrow \pi^+\pi^-\pi^0 J/\psi$	< 2.4	$\times 10^{-6}$	CL=90%
Γ_{72}	$\gamma\chi_{c0}(3915) \rightarrow \omega J/\psi$	< 2.8	$\times 10^{-6}$	CL=90%
Γ_{73}	$\gamma\chi_{c1}(4140) \rightarrow \phi J/\psi$	< 1.2	$\times 10^{-6}$	CL=90%
Γ_{74}	$\gamma X(4350) \rightarrow \phi J/\psi$	< 1.3	$\times 10^{-6}$	CL=90%
Γ_{75}	$\gamma\eta_b(1S)$	$(5.5 \pm_{-0.9}^{+1.1}) \times 10^{-4}$		S=1.2
Γ_{76}	$\gamma\eta_b(1S) \rightarrow \gamma$ Sum of 26 exclusive modes	< 3.7	$\times 10^{-6}$	CL=90%
Γ_{77}	$\gamma X_{b\bar{b}} \rightarrow \gamma$ Sum of 26 exclusive modes	< 4.9	$\times 10^{-6}$	CL=90%
Γ_{78}	$\gamma X \rightarrow \gamma + \geq 4$ prongs	[a] < 1.95	$\times 10^{-4}$	CL=95%
Γ_{79}	$\gamma A^0 \rightarrow \gamma$ hadrons	< 8	$\times 10^{-5}$	CL=90%
Γ_{80}	$\gamma a_1^0 \rightarrow \gamma\mu^+\mu^-$	< 8.3	$\times 10^{-6}$	CL=90%

Lepton Family number (*LF*) violating modes

Γ_{81}	$e^\pm \tau^\mp$	<i>LF</i>	< 3.2	$\times 10^{-6}$	CL=90%
Γ_{82}	$\mu^\pm \tau^\mp$	<i>LF</i>	< 3.3	$\times 10^{-6}$	CL=90%

[a] $1.5 \text{ GeV} < m_X < 5.0 \text{ GeV}$

CONSTRAINED FIT INFORMATION

An overall fit to 3 branching ratios uses 13 measurements and one constraint to determine 3 parameters. The overall fit has a $\chi^2 = 11.8$ for 11 degrees of freedom.

The following *off-diagonal* array elements are the correlation coefficients $\langle \delta x_i \delta x_j \rangle / (\delta x_i \delta x_j)$, in percent, from the fit to the branching fractions, $x_i \equiv \Gamma_i / \Gamma_{\text{total}}$. The fit constrains the x_i whose labels appear in this array to sum to one.

$$x_7 \begin{array}{|c} \hline 2 \\ \hline x_1 \end{array}$$

$\Upsilon(2S) \Gamma(i)\Gamma(e^+e^-)/\Gamma(\text{total})$ **$\Gamma(\mu^+\mu^-) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_4\Gamma_5/\Gamma$**

VALUE (eV)	DOCUMENT ID	TECN	COMMENT
6.5±1.5±1.0	KOBEL	92	CBAL $e^+e^- \rightarrow \mu^+\mu^-$

 $\Gamma(\Upsilon(1S)\pi^+\pi^-) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_1\Gamma_5/\Gamma$

VALUE (eV)	EVTS	DOCUMENT ID	TECN	COMMENT
105.4±1.0±4.2	11.8k	¹ AUBERT	08BP BABR	10.58 $e^+e^- \rightarrow \gamma\pi^+\pi^-\ell^+\ell^-$

¹ Using $B(\Upsilon(1S) \rightarrow e^+e^-) = (2.38 \pm 0.11)\%$ and $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.05)\%$. **$\Gamma(\text{hadrons}) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_{36}\Gamma_5/\Gamma$**

VALUE (keV)	DOCUMENT ID	TECN	COMMENT
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0.577±0.009 OUR AVERAGE

0.581±0.004±0.009	¹ ROSNER	06	CLEO	10.0 $e^+e^- \rightarrow \text{hadrons}$
0.552±0.031±0.017	¹ BARU	96	MD1	$e^+e^- \rightarrow \text{hadrons}$
0.54 ±0.04 ±0.02	¹ JAKUBOWSKI	88	CBAL	$e^+e^- \rightarrow \text{hadrons}$
0.58 ±0.03 ±0.04	² GILES	84B	CLEO	$e^+e^- \rightarrow \text{hadrons}$
0.60 ±0.12 ±0.07	² ALBRECHT	82	DASP	$e^+e^- \rightarrow \text{hadrons}$
0.54 ±0.07 ^{+0.09} _{-0.05}	² NICZYPORUK	81C	LENA	$e^+e^- \rightarrow \text{hadrons}$
0.41 ±0.18	² BOCK	80	CNTR	$e^+e^- \rightarrow \text{hadrons}$

¹ Radiative corrections evaluated following KURAEV 85.² Radiative corrections reevaluated by BUCHMUELLER 88 following KURAEV 85. **$\Upsilon(2S)$ PARTIAL WIDTHS** **$\Gamma(e^+e^-)$ Γ_5**

VALUE (keV)	DOCUMENT ID
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0.612±0.011 OUR EVALUATION **$\Upsilon(2S)$ BRANCHING RATIOS** **$\Gamma(\Upsilon(1S)\pi^+\pi^-)/\Gamma_{\text{total}}$ Γ_1/Γ**

Abbreviation MM in the COMMENT field below stands for missing mass.

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
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17.85±0.26 OUR FIT**17.92±0.26 OUR AVERAGE**

16.8 ±1.1 ±1.3	906k	¹ LEES	11C BABR	$e^+e^- \rightarrow \pi^+\pi^-X$
17.80±0.05±0.37	170k	² LEES	11L BABR	$\Upsilon(2S) \rightarrow \pi^+\pi^-\mu^+\mu^-$
18.02±0.02±0.61	851k	³ BHARI	09 CLEO	$e^+e^- \rightarrow \pi^+\pi^-MM$
17.22±0.17±0.75	11.8k	⁴ AUBERT	08BP BABR	$e^+e^- \rightarrow \gamma\pi^+\pi^-\ell^+\ell^-$
19.2 ±0.2 ±1.0	52.6k	⁵ ALEXANDER	98 CLE2	$\pi^+\pi^-\ell^+\ell^-$, $\pi^+\pi^-MM$
18.1 ±0.5 ±1.0	11.6k	ALBRECHT	87 ARG	$e^+e^- \rightarrow \pi^+\pi^-MM$
16.9 ±4.0		GELPHMAN	85 CBAL	$e^+e^- \rightarrow e^+e^-\pi^+\pi^-$
19.1 ±1.2 ±0.6		BESSION	84 CLEO	$\pi^+\pi^-MM$

18.9 ± 2.6 FONSECA 84 CUSB $e^+e^- \rightarrow \ell^+\ell^-\pi^+\pi^-$
 21 ± 7 7 NICZYPORUK 81B LENA $e^+e^- \rightarrow \ell^+\ell^-\pi^+\pi^-$

¹ LEES 11C reports $[\Gamma(\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^+\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(3S) \rightarrow \Upsilon(2S)\text{anything})] = (1.78 \pm 0.02 \pm 0.11) \times 10^{-2}$ which we divide by our best value $B(\Upsilon(3S) \rightarrow \Upsilon(2S)\text{anything}) = (10.6 \pm 0.8) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

² Using $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.05)\%$.

³ A weighted average of the inclusive and exclusive results.

⁴ Using $B(\Upsilon(2S) \rightarrow e^+e^-) = (1.91 \pm 0.16)\%$, $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.93 \pm 0.17)\%$ and, $\Gamma_{ee}(\Upsilon(2S)) = 0.612 \pm 0.011$ keV.

⁵ Using $B(\Upsilon(1S) \rightarrow e^+e^-) = (2.52 \pm 0.17)\%$ and $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.07)\%$.

$\Gamma(\Upsilon(1S)\pi^0\pi^0)/\Gamma_{\text{total}}$ Γ_2/Γ

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
8.6 ± 0.4 OUR AVERAGE				
8.43 ± 0.16 ± 0.42	38k	¹ BHARI 09	CLEO	$e^+e^- \rightarrow \pi^0\pi^0\ell^+\ell^-$
9.2 ± 0.6 ± 0.8	275	² ALEXANDER 98	CLE2	$e^+e^- \rightarrow \pi^0\pi^0\ell^+\ell^-$
9.5 ± 1.9 ± 1.9	25	ALBRECHT 87	ARG	$e^+e^- \rightarrow \pi^0\pi^0\ell^+\ell^-$
8.0 ± 1.5		GELPHMAN 85	CBAL	$e^+e^- \rightarrow \pi^0\pi^0\ell^+\ell^-$
10.3 ± 2.3		FONSECA 84	CUSB	$e^+e^- \rightarrow \pi^0\pi^0\ell^+\ell^-$

¹ Authors assume $B(\Upsilon(1S) \rightarrow e^+e^-) + B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = 4.96\%$.

² Using $B(\Upsilon(1S) \rightarrow e^+e^-) = (2.52 \pm 0.17)\%$ and $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.07)\%$.

$\Gamma(\Upsilon(1S)\pi^0\pi^0)/\Gamma(\Upsilon(1S)\pi^+\pi^-)$ Γ_2/Γ_1

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.462 ± 0.037	¹ BHARI 09	CLEO	$e^+e^- \rightarrow \Upsilon(2S)$

¹ Not independent of other values reported by BHARI 09.

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

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
2.00 ± 0.21 OUR AVERAGE				
2.00 ± 0.12 ± 0.18	22k	¹ BESSON 07	CLEO	$e^+e^- \rightarrow \Upsilon(2S) \rightarrow \tau^+\tau^-$
1.7 ± 1.5 ± 0.6		HAAS 84B	CLEO	$e^+e^- \rightarrow \tau^+\tau^-$

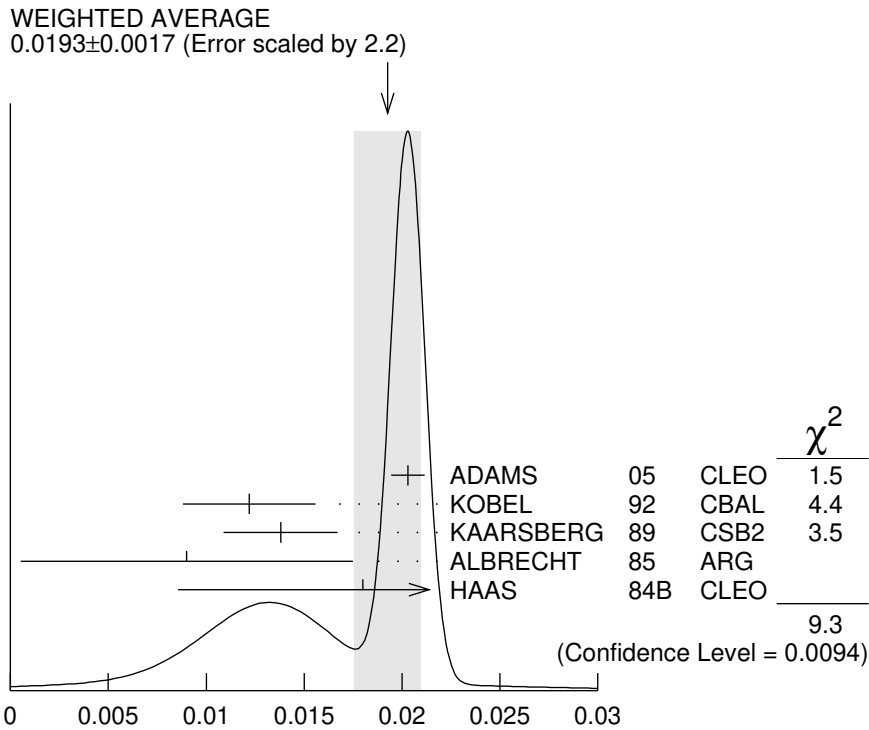
¹ BESSON 07 reports $[\Gamma(\Upsilon(2S) \rightarrow \tau^+\tau^-)/\Gamma_{\text{total}}] / [B(\Upsilon(2S) \rightarrow \mu^+\mu^-)] = 1.04 \pm 0.04 \pm 0.05$ which we multiply by our best value $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.93 \pm 0.17) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

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

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
0.0193 ± 0.0017 OUR AVERAGE					Error includes scale factor of 2.2. See the ideogram below.
0.0203 ± 0.0003 ± 0.0008		120k	ADAMS 05	CLEO	$e^+e^- \rightarrow \mu^+\mu^-$
0.0122 ± 0.0028 ± 0.0019			¹ KOBEL 92	CBAL	$e^+e^- \rightarrow \mu^+\mu^-$
0.0138 ± 0.0025 ± 0.0015			KAARSBERG 89	CSB2	$e^+e^- \rightarrow \mu^+\mu^-$
0.009 ± 0.006 ± 0.006			² ALBRECHT 85	ARG	$e^+e^- \rightarrow \mu^+\mu^-$
0.018 ± 0.008 ± 0.005			HAAS 84B	CLEO	$e^+e^- \rightarrow \mu^+\mu^-$

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

<0.038 90 NICZYPORUK 81C LENA $e^+e^- \rightarrow \mu^+\mu^-$



¹ Taking into account interference between the resonance and continuum.

² Re-evaluated using $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = 0.026$.

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

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

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
1.04±0.04±0.05	22k	BESSION 07	CLEO	$e^+e^- \rightarrow \Upsilon(2S)$

$\Gamma(\Upsilon(1S)\pi^0)/\Gamma_{\text{total}}$ Γ_6/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

< 4 90 ¹ TAMPONI 13 BELL $e^+e^- \rightarrow \Upsilon(1S)\pi^0$
 < 18 90 ² HE 08A CLEO $e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$
 <110 90 ALEXANDER 98 CLE2 $e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$
 <800 90 LURZ 87 CBAL $e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$

¹ TAMPONI 13 reports $[\Gamma(\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^0)/\Gamma_{\text{total}}] / [B(\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^+\pi^-)]$
 < 2.3×10^{-4} which we multiply by our best value $B(\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^+\pi^-) = 17.85 \times 10^{-2}$.

² Authors assume $B(\Upsilon(1S) \rightarrow e^+e^-) + B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = 4.96\%$.

$\Gamma(\Upsilon(1S)\pi^0)/\Gamma(\Upsilon(1S)\pi^+\pi^-)$ Γ_6/Γ_1

VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	COMMENT
<2.3	90	TAMPONI 13	BELL	$e^+e^- \rightarrow \Upsilon(1S)\pi^0$

$\Gamma(\Upsilon(1S)\eta)/\Gamma_{\text{total}}$

Γ_7/Γ

VALUE (units 10^{-4}) CL% EVTS DOCUMENT ID TECN COMMENT

2.9 ± 0.4 OUR FIT Error includes scale factor of 2.0.
2.9 ± 0.4 OUR AVERAGE Error includes scale factor of 1.9. See the ideogram below.

2.39 ± 0.31 ± 0.14	112	¹ LEES	11L	BABR	$\Upsilon(2S) \rightarrow \ell^+ \ell^- \eta$
2.1 $^{+0.7}_{-0.6}$ ± 0.3	14	² HE	08A	CLEO	$e^+ e^- \rightarrow \ell^+ \ell^- \eta$

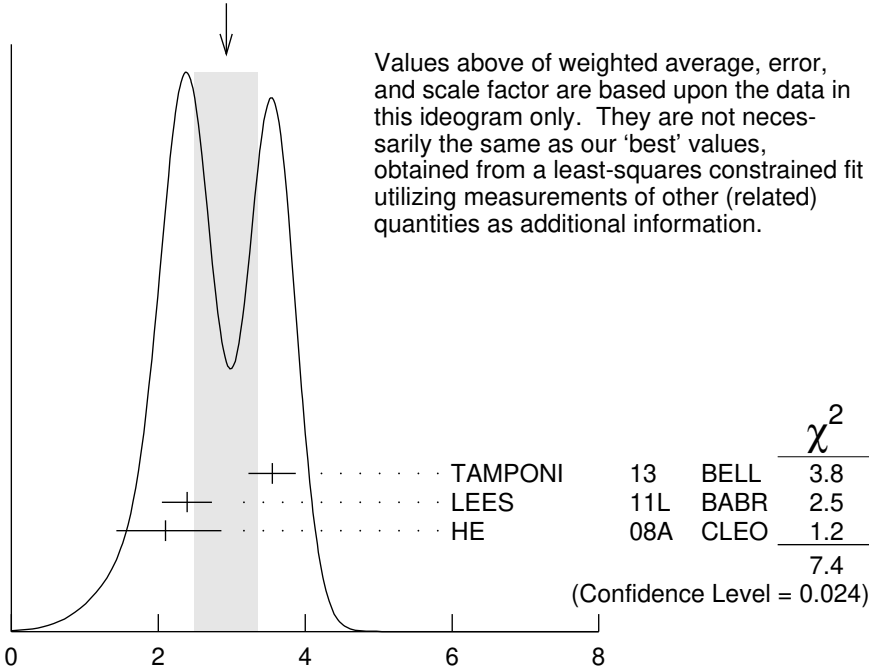
• • • We use the following data for averages but not for fits. • • •

3.55 ± 0.32 ± 0.05	241	³ TAMPONI	13	BELL	$e^+ e^- \rightarrow \Upsilon(1S)\eta$
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• • • We do not use the following data for averages, fits, limits, etc. • • •

< 9	90	^{1,4} AUBERT	08BP	BABR	$e^+ e^- \rightarrow \gamma \pi^+ \pi^- \pi^0 \ell^+ \ell^-$
< 28	90	ALEXANDER98	CLE2		$e^+ e^- \rightarrow \ell^+ \ell^- \eta$
< 50	90	ALBRECHT	87	ARG	$e^+ e^- \rightarrow \pi^+ \pi^- \ell^+ \ell^-$ MM
< 70	90	LURZ	87	CBAL	$e^+ e^- \rightarrow \ell^+ \ell^- (\gamma\gamma, 3\pi^0)$
< 100	90	BESSON	84	CLEO	$e^+ e^- \rightarrow \pi^+ \pi^- \ell^+ \ell^-$ MM
< 20	90	FONSECA	84	CUSB	$e^+ e^- \rightarrow \ell^+ \ell^- (\gamma\gamma, \pi^+ \pi^- \pi^0)$

WEIGHTED AVERAGE
 2.9 ± 0.4 (Error scaled by 1.9)



Values above of weighted average, error, and scale factor are based upon the data in this ideogram only. They are not necessarily the same as our 'best' values, obtained from a least-squares constrained fit utilizing measurements of other (related) quantities as additional information.

¹ Using $B(\Upsilon(1S) \rightarrow e^+ e^-) = (2.38 \pm 0.11)\%$ and $B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = (2.48 \pm 0.05)\%$.

² Authors assume $B(\Upsilon(1S) \rightarrow e^+ e^-) + B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = 4.96\%$.

³ TAMPONI 13 reports $[\Gamma(\Upsilon(2S) \rightarrow \Upsilon(1S)\eta)/\Gamma_{\text{total}}] / [B(\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^+\pi^-)] = (1.99 \pm 0.14 \pm 0.11) \times 10^{-3}$ which we multiply by our best value $B(\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^+\pi^-) = (17.85 \pm 0.26) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

⁴ Using $\Gamma_{ee}(\Upsilon(2S)) = 0.612 \pm 0.011$ keV.

$\Gamma(\Upsilon(1S)\eta)/\Gamma_{\text{total}}$ (units 10^{-4})

$\Gamma(\Upsilon(1S)\eta)/\Gamma(\Upsilon(1S)\pi^+\pi^-)$ Γ_7/Γ_1

VALUE (units 10^{-3})	CL% EVTS	DOCUMENT ID	TECN	COMMENT
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1.64±0.25 OUR FIT Error includes scale factor of 2.0.**1.99±0.14±0.11** 241 TAMPONI 13 BELL $e^+e^- \rightarrow \Upsilon(1S)\eta$

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

1.35±0.17±0.08 ¹ LEES 11L BABR $\Upsilon(2S) \rightarrow (\pi^+\pi^-)(\gamma\gamma)\mu^+\mu^-$ < 5.2 90 ² AUBERT 08BP BABR $e^+e^- \rightarrow \gamma\pi^+\pi^-(\pi^0)\ell^+\ell^-$ ¹ Not independent of other values reported by LEES 11L.² Not independent of other values reported by AUBERT 08BP. $\Gamma(\Upsilon(1S)\pi^0)/\Gamma(\Upsilon(1S)\eta)$ Γ_6/Γ_7

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

<0.13 90 TAMPONI 13 BELL $e^+e^- \rightarrow \Upsilon(1S)\pi^0$ $\Gamma(J/\psi(1S) \text{ anything})/\Gamma_{\text{total}}$ Γ_8/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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<0.006 90 MASCHMANN 90 CBAL $e^+e^- \rightarrow \text{hadrons}$ $\Gamma(J/\psi(1S)\eta_c)/\Gamma_{\text{total}}$ Γ_9/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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<5.4 × 10⁻⁶ 90 YANG 14 BELL $e^+e^- \rightarrow J/\psi X$ $\Gamma(J/\psi(1S)\chi_{c0})/\Gamma_{\text{total}}$ Γ_{10}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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<3.4 × 10⁻⁶ 90 YANG 14 BELL $e^+e^- \rightarrow J/\psi X$ $\Gamma(J/\psi(1S)\chi_{c1})/\Gamma_{\text{total}}$ Γ_{11}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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<1.2 × 10⁻⁶ 90 YANG 14 BELL $e^+e^- \rightarrow J/\psi X$ $\Gamma(J/\psi(1S)\chi_{c2})/\Gamma_{\text{total}}$ Γ_{12}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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<2.0 × 10⁻⁶ 90 YANG 14 BELL $e^+e^- \rightarrow J/\psi X$ $\Gamma(J/\psi(1S)\eta_c(2S))/\Gamma_{\text{total}}$ Γ_{13}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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<2.5 × 10⁻⁶ 90 YANG 14 BELL $e^+e^- \rightarrow J/\psi X$ $\Gamma(J/\psi(1S)X(3940))/\Gamma_{\text{total}}$ Γ_{14}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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<2.0 × 10⁻⁶ 90 YANG 14 BELL $e^+e^- \rightarrow J/\psi X$ $\Gamma(J/\psi(1S)X(4160))/\Gamma_{\text{total}}$ Γ_{15}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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<2.0 × 10⁻⁶ 90 YANG 14 BELL $e^+e^- \rightarrow J/\psi X$

$\Gamma(\chi_{c1} \text{ anything})/\Gamma_{\text{total}}$ Γ_{16}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
$2.24 \pm 0.44 \pm 0.20$	376	JIA	17	BELL $\Upsilon(2S) \rightarrow \gamma J/\psi(1S)$

 $\Gamma(\chi_{c1}(1P)^0 X_{tetra})/\Gamma_{\text{total}}$ Γ_{17}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$< 36.7 \times 10^{-6}$	90	¹ JIA	17A	BELL $e^+e^- \rightarrow \text{hadrons}$

¹ For a tetraquark state X_{tetra} , with mass in the range 1.16–2.46 GeV and width in the range 0–0.3 GeV. Measured 90% CL limits as a function of X_{tetra} mass and width range from 4.4×10^{-6} to 36.7×10^{-6} .

 $\Gamma(\chi_{c2} \text{ anything})/\Gamma_{\text{total}}$ Γ_{18}/Γ

VALUE (units 10^{-4})	DOCUMENT ID	TECN	COMMENT
$2.28 \pm 0.73 \pm 0.34$	JIA	17	BELL $\Upsilon(2S) \rightarrow \gamma J/\psi(1S)$

 $\Gamma(\psi(2S)\eta_c)/\Gamma_{\text{total}}$ Γ_{19}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$< 5.1 \times 10^{-6}$	90	YANG	14	BELL $e^+e^- \rightarrow \psi(2S)X$

 $\Gamma(\psi(2S)\chi_{c0})/\Gamma_{\text{total}}$ Γ_{20}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$< 4.7 \times 10^{-6}$	90	YANG	14	BELL $e^+e^- \rightarrow \psi(2S)X$

 $\Gamma(\psi(2S)\chi_{c1})/\Gamma_{\text{total}}$ Γ_{21}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$< 2.5 \times 10^{-6}$	90	YANG	14	BELL $e^+e^- \rightarrow \psi(2S)X$

 $\Gamma(\psi(2S)\chi_{c2})/\Gamma_{\text{total}}$ Γ_{22}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$< 1.9 \times 10^{-6}$	90	YANG	14	BELL $e^+e^- \rightarrow \psi(2S)X$

 $\Gamma(\psi(2S)\eta_c(2S))/\Gamma_{\text{total}}$ Γ_{23}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$< 3.3 \times 10^{-6}$	90	YANG	14	BELL $e^+e^- \rightarrow \psi(2S)X$

 $\Gamma(\psi(2S)X(3940))/\Gamma_{\text{total}}$ Γ_{24}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$< 3.9 \times 10^{-6}$	90	YANG	14	BELL $e^+e^- \rightarrow \psi(2S)X$

 $\Gamma(\psi(2S)X(4160))/\Gamma_{\text{total}}$ Γ_{25}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$< 3.9 \times 10^{-6}$	90	YANG	14	BELL $e^+e^- \rightarrow \psi(2S)X$

 $\Gamma(Z_c(3900)^+ Z_c(3900)^-)/\Gamma_{\text{total}}$ Γ_{26}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$< 1.0 \times 10^{-6}$	90	¹ JIA	18	BELL $\Upsilon(2S) \rightarrow J/\psi \pi^\pm X$

¹ Assuming $B(Z_c(3900)^\pm \rightarrow J/\psi \pi^\pm) = 1$.

$\Gamma(Z_c(4200)^+ Z_c(4200)^-)/\Gamma_{\text{total}}$ Γ_{27}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<16.7 \times 10^{-6}$	90	¹ JIA	18	BELL $\Upsilon(1S) \rightarrow J/\psi \pi^\pm X$

¹ Assuming $B(Z_c(4200)^\pm \rightarrow J/\psi \pi^\pm) = 1$

 $\Gamma(Z_c(3900)^\pm Z_c(4200)^\mp)/\Gamma_{\text{total}}$ Γ_{28}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<7.3 \times 10^{-6}$	90	¹ JIA	18	BELL $\Upsilon(2S) \rightarrow J/\psi \pi^\pm X$

¹ Assuming $B(Z_c(4200)^\pm \rightarrow J/\psi \pi^\pm) = 1 = B(Z_c(3900)^\pm \rightarrow J/\psi \pi^\pm)$.

 $\Gamma(X(4050)^+ X(4050)^-)/\Gamma_{\text{total}}$ Γ_{29}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<13.5 \times 10^{-6}$	90	¹ JIA	18	BELL $\Upsilon(2S) \rightarrow \chi_{c1}(1P) \pi^\pm X$

¹ Assuming $B(X(4050)^\pm \rightarrow \chi_{c1}(1P) \pi^\pm)$

 $\Gamma(X(4250)^+ X(4250)^-)/\Gamma_{\text{total}}$ Γ_{30}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<26.7 \times 10^{-6}$	90	¹ JIA	18	BELL $\Upsilon(2S) \rightarrow \chi_{c1}(1P) \pi^\pm X$

¹ Assuming $B(X(4250)^\pm \rightarrow \chi_{c1}(1P) \pi^\pm) = 1$

 $\Gamma(X(4050)^\pm X(4250)^\mp)/\Gamma_{\text{total}}$ Γ_{31}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<27.2 \times 10^{-6}$	90	¹ JIA	18	BELL $\Upsilon(2S) \rightarrow \chi_{c1}(1P) \pi^\pm X$

¹ Assuming $B(X(4050)^\pm \rightarrow \chi_{c1}(1P) \pi^\pm) = 1 = B(X(4250)^\pm \rightarrow \chi_{c1}(1P) \pi^\pm)$

 $\Gamma(Z_c(4430)^+ Z_c(4430)^-)/\Gamma_{\text{total}}$ Γ_{32}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<20.3 \times 10^{-6}$	90	¹ JIA	18	BELL $\Upsilon(2S) \rightarrow \psi(2S) \pi^\pm X$

¹ Assuming $B(Z_c(4430)^\pm \rightarrow \psi(2P) \pi^\pm) = 1$

 $\Gamma(X(4055)^\pm X(4055)^\mp)/\Gamma_{\text{total}}$ Γ_{33}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<11.1 \times 10^{-6}$	90	¹ JIA	18	BELL $\Upsilon(2S) \rightarrow \psi(2S) \pi^\pm X$

¹ Assuming $B(X(4055)^\pm \rightarrow \psi(2S) \pi^\pm) = 1$

 $\Gamma(X(4055)^\pm Z_c(4430)^\mp)/\Gamma_{\text{total}}$ Γ_{34}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<21.1 \times 10^{-6}$	90	¹ JIA	18	BELL $\Upsilon(2S) \rightarrow \psi(2S) \pi^\pm X$

¹ Assuming $B(X(4055)^\pm \rightarrow \psi(2S) \pi^\pm) = 1 = B(Z_c(4430)^\pm \rightarrow \psi(2S) \pi^\pm)$

 $\Gamma(\overline{2H} \text{ anything})/\Gamma_{\text{total}}$ Γ_{35}/Γ

VALUE (units 10^{-5})	EVTS	DOCUMENT ID	TECN	COMMENT
$2.78^{+0.30}_{-0.26}$ OUR AVERAGE				Error includes scale factor of 1.2.

2.64 ± 0.11 ^{+0.26}/_{-0.21} LEES 14G BABR $e^+ e^- \rightarrow \overline{2H} X$

3.37 ± 0.50 ± 0.25 58 ASNER 07 CLEO $e^+ e^- \rightarrow \overline{2H} X$

$\Gamma(g g g)/\Gamma_{\text{total}}$ Γ_{37}/Γ

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
58.8±1.2	6M	¹ BESSON	06A CLEO	$\Upsilon(2S) \rightarrow \text{hadrons}$

¹ Calculated using the value $\Gamma(\gamma g g)/\Gamma(g g g) = (3.18 \pm 0.04 \pm 0.22 \pm 0.41)\%$ from BESSON 06A and PDG 08 values of $B(\pi^+ \pi^- \Upsilon(1S)) = (18.1 \pm 0.4)\%$, $B(\pi^0 \pi^0 \Upsilon(1S)) = (8.6 \pm 0.4)\%$, $B(\mu^+ \mu^-) = (1.93 \pm 0.17)\%$, and $R_{\text{hadrons}} = 3.51$. The statistical error is negligible and the systematic error is partially correlated with that of $\Gamma(\gamma g g)/\Gamma_{\text{total}}$ measurement of BESSON 06A.

$\Gamma(\gamma g g)/\Gamma(g g g)$ Γ_{38}/Γ_{37}

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
3.18±0.04±0.47	6M	BESSON	06A CLEO	$\Upsilon(2S) \rightarrow (\gamma +) \text{hadrons}$

$\Gamma(\phi K^+ K^-)/\Gamma_{\text{total}}$ Γ_{39}/Γ

VALUE (units 10^{-6})	EVTS	DOCUMENT ID	TECN	COMMENT
1.58±0.33±0.18	58	SHEN	12A BELL	$\Upsilon(1S) \rightarrow 2(K^+ K^-)$

$\Gamma(\omega \pi^+ \pi^-)/\Gamma_{\text{total}}$ Γ_{40}/Γ

VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT
<2.58	90	SHEN	12A BELL	$\Upsilon(1S) \rightarrow 2(\pi^+ \pi^-) \pi^0$

$\Gamma(K^*(892)^0 K^- \pi^+ + \text{c.c.})/\Gamma_{\text{total}}$ Γ_{41}/Γ

VALUE (units 10^{-6})	EVTS	DOCUMENT ID	TECN	COMMENT
2.32±0.40±0.54	135	SHEN	12A BELL	$\Upsilon(1S) \rightarrow K^+ K^- \pi^+ \pi^-$

$\Gamma(\phi f'_2(1525))/\Gamma_{\text{total}}$ Γ_{42}/Γ

VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT
<1.33	90	SHEN	12A BELL	$\Upsilon(1S) \rightarrow 2(K^+ K^-)$

$\Gamma(\omega f_2(1270))/\Gamma_{\text{total}}$ Γ_{43}/Γ

VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT
<0.57	90	SHEN	12A BELL	$\Upsilon(1S) \rightarrow 2(\pi^+ \pi^-) \pi^0$

$\Gamma(\rho(770) a_2(1320))/\Gamma_{\text{total}}$ Γ_{44}/Γ

VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT
<0.88	90	SHEN	12A BELL	$\Upsilon(1S) \rightarrow 2(\pi^+ \pi^-) \pi^0$

$\Gamma(K^*(892)^0 \bar{K}_2^*(1430)^0 + \text{c.c.})/\Gamma_{\text{total}}$ Γ_{45}/Γ

VALUE (units 10^{-6})	EVTS	DOCUMENT ID	TECN	COMMENT
1.53±0.52±0.19	32	SHEN	12A BELL	$\Upsilon(1S) \rightarrow K^+ K^- \pi^+ \pi^-$

$\Gamma(K_1(1270)^\pm K^\mp)/\Gamma_{\text{total}}$ Γ_{46}/Γ

VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT
<3.22	90	SHEN	12A BELL	$\Upsilon(1S) \rightarrow K^+ K^- \pi^+ \pi^-$

$\Gamma(K_1(1400)^\pm K^\mp)/\Gamma_{\text{total}}$ Γ_{47}/Γ

VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT
<0.83	90	SHEN	12A BELL	$\Upsilon(1S) \rightarrow K^+ K^- \pi^+ \pi^-$

$\Gamma(b_1(1235)^\pm \pi^\mp)/\Gamma_{\text{total}}$			Γ_{48}/Γ		
VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT	
<0.40	90	SHEN	12A	BELL	$\Upsilon(1S) \rightarrow 2(\pi^+ \pi^-) \pi^0$
$\Gamma(\rho\pi)/\Gamma_{\text{total}}$			Γ_{49}/Γ		
VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT	
<1.16	90	SHEN	13	BELL	$\Upsilon(2S) \rightarrow \pi^+ \pi^- \pi^0$
$\Gamma(\pi^+ \pi^- \pi^0)/\Gamma_{\text{total}}$			Γ_{50}/Γ		
VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT	
<0.80	90	SHEN	13	BELL	$\Upsilon(2S) \rightarrow \pi^+ \pi^- \pi^0$
$\Gamma(\omega\pi^0)/\Gamma_{\text{total}}$			Γ_{51}/Γ		
VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT	
<1.63	90	SHEN	13	BELL	$\Upsilon(2S) \rightarrow \pi^+ \pi^- \pi^0 \pi^0$
$\Gamma(\pi^+ \pi^- \pi^0 \pi^0)/\Gamma_{\text{total}}$			Γ_{52}/Γ		
VALUE (units 10^{-6})	EVTS	DOCUMENT ID	TECN	COMMENT	
$13.0 \pm 1.9 \pm 2.1$	261 ± 37	SHEN	13	BELL	$\Upsilon(2S) \rightarrow \pi^+ \pi^- \pi^0 \pi^0$
$\Gamma(K_S^0 K^+ \pi^- + \text{c.c.})/\Gamma_{\text{total}}$			Γ_{53}/Γ		
VALUE (units 10^{-6})	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
$1.14 \pm 0.30 \pm 0.13$	40 ± 10	SHEN	13	BELL	$\Upsilon(2S) \rightarrow K_S^0 K^- \pi^+$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<3.2	90	¹ DOBBS	12A		$\Upsilon(2S) \rightarrow K_S^0 K^- \pi^+$
¹ Obtained by analyzing CLEO III data but not authored by the CLEO Collaboration.					
$\Gamma(K^*(892)^0 \bar{K}^0 + \text{c.c.})/\Gamma_{\text{total}}$			Γ_{54}/Γ		
VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT	
<4.22	90	SHEN	13	BELL	$\Upsilon(2S) \rightarrow K_S^0 K^- \pi^+$
$\Gamma(K^*(892)^- K^+ + \text{c.c.})/\Gamma_{\text{total}}$			Γ_{55}/Γ		
VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT	
<1.45	90	SHEN	13	BELL	$\Upsilon(2S) \rightarrow K_S^0 K^- \pi^+$
$\Gamma(f_1(1285) \text{ anything})/\Gamma_{\text{total}}$			Γ_{56}/Γ		
VALUE (units 10^{-3})	EVTS	DOCUMENT ID	TECN	COMMENT	
$2.20 \pm 1.50 \pm 0.63$	2.9k	JIA	17A	BELL	$e^+ e^- \rightarrow \text{hadrons}$
$\Gamma(f_1(1285) X_{\text{tetra}})/\Gamma_{\text{total}}$			Γ_{57}/Γ		
VALUE	CL%	DOCUMENT ID	TECN	COMMENT	
< 64.7×10^{-6}	90	¹ JIA	17A	BELL	$e^+ e^- \rightarrow \text{hadrons}$
¹ For a tetraquark state X_{tetra} , with mass in the range 1.16–2.46 GeV and width in the range 0–0.3 GeV. Measured 90% CL limits as a function of X_{tetra} mass and width range from 7.8×10^{-6} to 64.7×10^{-6} .					

$\Gamma(\text{Sum of 100 exclusive modes})/\Gamma_{\text{total}}$ Γ_{58}/Γ

<u>VALUE (units 10^{-2})</u>		<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.29 ± 0.03	1,2	DOBBS 12A		$\Upsilon(2S) \rightarrow \text{hadrons}$

¹ DOBBS 12A presents individual exclusive branching fractions or upper limits for 100 modes of four to ten pions, kaons, or protons.

² Obtained by analyzing CLEO III data but not authored by the CLEO Collaboration.

 $\Gamma(\gamma\chi_{b1}(1P))/\Gamma_{\text{total}}$ Γ_{59}/Γ

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.069 ± 0.004 OUR AVERAGE				
0.0693 ± 0.0012 ± 0.0041	407k	ARTUSO	05	CLEO $e^+e^- \rightarrow \gamma X$
0.069 ± 0.005 ± 0.009		EDWARDS	99	CLE2 $\Upsilon(2S) \rightarrow \gamma\chi(1P)$
0.091 ± 0.018 ± 0.022		ALBRECHT	85E	ARG $e^+e^- \rightarrow \gamma \text{conv. } X$
0.065 ± 0.007 ± 0.012		NERNST	85	CBAL $e^+e^- \rightarrow \gamma X$
0.080 ± 0.017 ± 0.016		HAAS	84	CLEO $e^+e^- \rightarrow \gamma \text{conv. } X$
0.059 ± 0.014		KLOPFEN...	83	CUSB $e^+e^- \rightarrow \gamma X$

 $\Gamma(\gamma\chi_{b2}(1P))/\Gamma_{\text{total}}$ Γ_{60}/Γ

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.0715 ± 0.0035 OUR AVERAGE				
0.0724 ± 0.0011 ± 0.0040	410k	ARTUSO	05	CLEO $e^+e^- \rightarrow \gamma X$
0.074 ± 0.005 ± 0.008		EDWARDS	99	CLE2 $\Upsilon(2S) \rightarrow \gamma\chi(1P)$
0.098 ± 0.021 ± 0.024		ALBRECHT	85E	ARG $e^+e^- \rightarrow \gamma \text{conv. } X$
0.058 ± 0.007 ± 0.010		NERNST	85	CBAL $e^+e^- \rightarrow \gamma X$
0.102 ± 0.018 ± 0.021		HAAS	84	CLEO $e^+e^- \rightarrow \gamma \text{conv. } X$
0.061 ± 0.014		KLOPFEN...	83	CUSB $e^+e^- \rightarrow \gamma X$

 $\Gamma(\gamma\chi_{b0}(1P))/\Gamma_{\text{total}}$ Γ_{61}/Γ

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.038 ± 0.004 OUR AVERAGE				
0.0375 ± 0.0012 ± 0.0047	198k	ARTUSO	05	CLEO $e^+e^- \rightarrow \gamma X$
0.034 ± 0.005 ± 0.006		EDWARDS	99	CLE2 $\Upsilon(2S) \rightarrow \gamma\chi(1P)$
0.064 ± 0.014 ± 0.016		ALBRECHT	85E	ARG $e^+e^- \rightarrow \gamma \text{conv. } X$
0.036 ± 0.008 ± 0.009		NERNST	85	CBAL $e^+e^- \rightarrow \gamma X$
0.044 ± 0.023 ± 0.009		HAAS	84	CLEO $e^+e^- \rightarrow \gamma \text{conv. } X$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.035 ± 0.014		KLOPFEN...	83	CUSB $e^+e^- \rightarrow \gamma X$

 $\Gamma(\gamma f_0(1710))/\Gamma_{\text{total}}$ Γ_{62}/Γ

<u>VALUE (units 10^{-5})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 59	90	¹ ALBRECHT 89	ARG	$\Upsilon(2S) \rightarrow \gamma K^+ K^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 5.9	90	² ALBRECHT 89	ARG	$\Upsilon(2S) \rightarrow \gamma \pi^+ \pi^-$

¹ Re-evaluated assuming $B(f_0(1710) \rightarrow K^+ K^-) = 0.19$.

² Includes unknown branching ratio of $f_0(1710) \rightarrow \pi^+ \pi^-$.

 $\Gamma(\gamma f'_2(1525))/\Gamma_{\text{total}}$ Γ_{63}/Γ

<u>VALUE (units 10^{-5})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 53	90	¹ ALBRECHT 89	ARG	$\Upsilon(2S) \rightarrow \gamma K^+ K^-$

¹ Re-evaluated assuming $B(f'_2(1525) \rightarrow K \bar{K}) = 0.71$.

$\Gamma(\gamma f_2(1270))/\Gamma_{\text{total}}$ Γ_{64}/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID	TECN	COMMENT
<24.1	90	¹ ALBRECHT 89	ARG	$\Upsilon(2S) \rightarrow \gamma \pi^+ \pi^-$

¹ Using $B(f_2(1270) \rightarrow \pi \pi) = 0.84$. $\Gamma(\gamma f_J(2220))/\Gamma_{\text{total}}$ Γ_{65}/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID	TECN	COMMENT
<6.8	90	¹ ALBRECHT 89	ARG	$\Upsilon(2S) \rightarrow \gamma K^+ K^-$

¹ Includes unknown branching ratio of $f_J(2220) \rightarrow K^+ K^-$. $\Gamma(\gamma \eta_c(1S))/\Gamma_{\text{total}}$ Γ_{66}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<2.7 $\times 10^{-5}$	90	WANG 11B	BELL	$\Upsilon(2S) \rightarrow \gamma X$

 $\Gamma(\gamma \chi_{c0})/\Gamma_{\text{total}}$ Γ_{67}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<1.0 $\times 10^{-4}$	90	WANG 11B	BELL	$\Upsilon(2S) \rightarrow \gamma X$

 $\Gamma(\gamma \chi_{c1})/\Gamma_{\text{total}}$ Γ_{68}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<3.6 $\times 10^{-6}$	90	WANG 11B	BELL	$\Upsilon(2S) \rightarrow \gamma X$

 $\Gamma(\gamma \chi_{c2})/\Gamma_{\text{total}}$ Γ_{69}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<1.5 $\times 10^{-5}$	90	WANG 11B	BELL	$\Upsilon(2S) \rightarrow \gamma X$

 $\Gamma(\gamma \chi_{c1}(3872))/\Gamma_{\text{total}}$ Γ_{70}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<2.1 $\times 10^{-5}$	90	¹ WANG 11B	BELL	$\Upsilon(2S) \rightarrow \gamma X$

¹ WANG 11B reports $[\Gamma(\Upsilon(2S) \rightarrow \gamma \chi_{c1}(3872))/\Gamma_{\text{total}}] \times [B(\chi_{c1}(3872) \rightarrow \pi^+ \pi^- J/\psi(1S))] < 0.8 \times 10^{-6}$ which we divide by our best value $B(\chi_{c1}(3872) \rightarrow \pi^+ \pi^- J/\psi(1S)) = 3.8 \times 10^{-2}$. $\Gamma(\gamma \chi_{c1}(3872), \chi_{c1} \rightarrow \pi^+ \pi^- \pi^0 J/\psi)/\Gamma_{\text{total}}$ Γ_{71}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<2.4 $\times 10^{-6}$	90	WANG 11B	BELL	$\Upsilon(2S) \rightarrow \gamma X$

 $\Gamma(\gamma \chi_{c0}(3915) \rightarrow \omega J/\psi)/\Gamma_{\text{total}}$ Γ_{72}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<2.8 $\times 10^{-6}$	90	WANG 11B	BELL	$\Upsilon(2S) \rightarrow \gamma X$

 $\Gamma(\gamma \chi_{c1}(4140) \rightarrow \phi J/\psi)/\Gamma_{\text{total}}$ Γ_{73}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<1.2 $\times 10^{-6}$	90	WANG 11B	BELL	$\Upsilon(2S) \rightarrow \gamma X$

$\Gamma(\gamma X(4350) \rightarrow \phi J/\psi)/\Gamma_{\text{total}}$ Γ_{74}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<1.3 \times 10^{-6}$	90	WANG	11B	BELL $\Upsilon(2S) \rightarrow \gamma X$

$\Gamma(\gamma \eta_b(1S))/\Gamma_{\text{total}}$ Γ_{75}/Γ

VALUE (units 10^{-4})	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
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$5.5^{+1.1}_{-0.9}$ OUR AVERAGE Error includes scale factor of 1.2.

$6.1^{+0.6+0.9}_{-0.7-0.6}$ 29k FULSOM 18 BELL $\Upsilon(2S) \rightarrow \gamma X$

$3.9 \pm 1.1^{+1.1}_{-0.9}$ $13 \pm 5k$ ¹ AUBERT 09AQ BABR $\Upsilon(2S) \rightarrow \gamma X$

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

<21 90 LEES 11J BABR $\Upsilon(2S) \rightarrow X\gamma$

<8.4 90 ¹ BONVICINI 10 CLEO $\Upsilon(2S) \rightarrow \gamma X$

<5.1 90 ² ARTUSO 05 CLEO $e^+e^- \rightarrow \gamma X$

¹ Assuming $\Gamma_{\eta_b(1S)} = 10$ MeV.

² Superseded by BONVICINI 10.

$\Gamma(\gamma \eta_b(1S) \rightarrow \gamma \text{Sum of 26 exclusive modes})/\Gamma_{\text{total}}$ Γ_{76}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<3.7 \times 10^{-6}$	90	SANDILYA	13	BELL $\Upsilon(2S) \rightarrow \gamma$ hadrons

$\Gamma(\gamma X_{b\bar{b}} \rightarrow \gamma \text{Sum of 26 exclusive modes})/\Gamma_{\text{total}}$ Γ_{77}/Γ

VALUE (units 10^{-6})	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
<4.9	90		SANDILYA	13	BELL $\Upsilon(2S) \rightarrow \gamma$ hadrons

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

$46.2^{+29.7}_{-14.2} \pm 10.6$ 10 ¹ DOBBS 12 $\Upsilon(2S) \rightarrow \gamma$ hadrons

¹ Obtained by analyzing CLEO III data but not authored by the CLEO Collaboration.

$\Gamma(\gamma X \rightarrow \gamma + \geq 4 \text{ prongs})/\Gamma_{\text{total}}$ Γ_{78}/Γ
($1.5 \text{ GeV} < m_X < 5.0 \text{ GeV}$)

VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	COMMENT
<1.95	95	ROSNER	07A	CLEO $e^+e^- \rightarrow \gamma X$

$\Gamma(\gamma A^0 \rightarrow \gamma \text{hadrons})/\Gamma_{\text{total}}$ Γ_{79}/Γ
($0.3 \text{ GeV} < m_{A^0} < 7 \text{ GeV}$)

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<8 \times 10^{-5}$	90	¹ LEES	11H	BABR $\Upsilon(2S) \rightarrow \gamma$ hadrons

¹ For a narrow scalar or pseudoscalar A^0 , excluding known resonances, with mass in the range 0.3–7 GeV. Measured 90% CL limits as a function of m_{A^0} range from 1×10^{-6} to 8×10^{-5} .

$\Gamma(\gamma a_1^0 \rightarrow \gamma \mu^+ \mu^-)/\Gamma_{\text{total}}$ Γ_{80}/Γ

VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT
<8.3	90	¹ AUBERT	09Z	BABR $e^+e^- \rightarrow \gamma a_1^0 \rightarrow \gamma \mu^+ \mu^-$

¹ For a narrow scalar or pseudoscalar a_1^0 with mass in the range 212–9300 MeV, excluding J/ψ and $\psi(2S)$. Measured 90% CL limits as a function of $m_{a_1^0}$ range from $0.26\text{--}8.3 \times 10^{-6}$.

LEPTON FAMILY NUMBER (LF) VIOLATING MODES

$\Gamma(e^\pm \tau^\mp)/\Gamma_{\text{total}}$					Γ_{81}/Γ
VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT	
<3.2	90	LEES	10B	BABR $e^+e^- \rightarrow e^\pm \tau^\mp$	
$\Gamma(\mu^\pm \tau^\mp)/\Gamma_{\text{total}}$					Γ_{82}/Γ
VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT	
< 3.3	90	LEES	10B	BABR $e^+e^- \rightarrow \mu^\pm \tau^\mp$	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<14.4	95	LOVE	08A	CLEO $e^+e^- \rightarrow \mu^\pm \tau^\mp$	

$\Upsilon(2S)$ Cross-Particle Branching Ratios

$B(\Upsilon(2S) \rightarrow \pi^+ \pi^-) \times B(\Upsilon(3S) \rightarrow \Upsilon(2S) X)$				
VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
1.78±0.02±0.11	906k	LEES	11C	BABR $e^+e^- \rightarrow \pi^+ \pi^- X$

$\Upsilon(2S)$ REFERENCES

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ROSNER	07A	PR D76 117102	J.L. Rosner <i>et al.</i>	(CLEO Collab.)
BESSON	06A	PR D74 012003	D. Besson <i>et al.</i>	(CLEO Collab.)
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