

$\Upsilon(2S)$

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

$\Upsilon(2S)$ 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³ Superseded by ARTAMONOV 00.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}	$\gamma\chi_{c1}(3872) \rightarrow \pi^+\pi^- J/\psi$	< 8	$\times 10^{-7}$	CL=90%
Γ_{71}	$\gamma\chi_{c1}(3872) \rightarrow \pi^+\pi^-\pi^0 J/\psi$	< 2.4	$\times 10^{-6}$	CL=90%
Γ_{72}	$\gamma X(3915) \rightarrow \omega J/\psi$	< 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 $\langle \delta x_i \delta x_j \rangle / (\delta x_i \cdot \delta x_j)$, 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	
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	
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	
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	$e^+e^- \rightarrow \pi^+\pi^- \text{MM}$
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	$\pi^+\pi^-\ell^+\ell^-, \pi^+\pi^- \text{MM}$
18.1 ±0.5 ±1.0	11.6k	ALBRECHT	87	ARG	$e^+e^- \rightarrow \pi^+\pi^- \text{MM}$
16.9 ±4.0		GELPHMAN	85	CBAL	$e^+e^- \rightarrow e^+e^-\pi^+\pi^-$
19.1 ±1.2 ±0.6		BESSION	84	CLEO	$\pi^+\pi^- \text{MM}$
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

<u>VALUE (units 10^{-2})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • 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

<u>VALUE (units 10^{-2})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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	$e^+e^- \rightarrow \tau^+\tau^-$

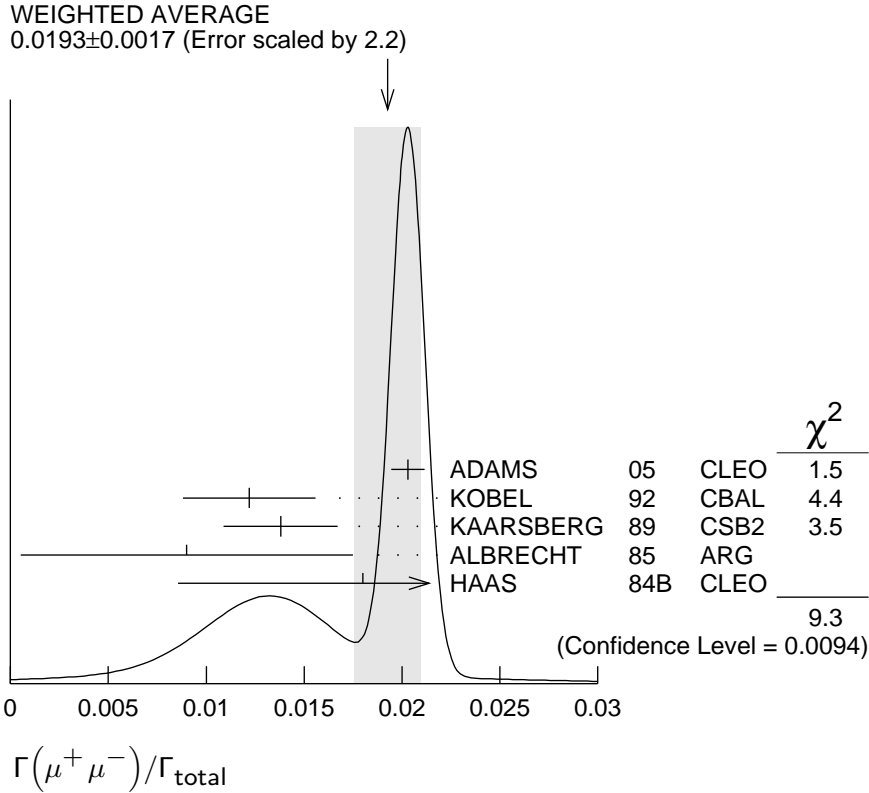
¹ BESSON 07 reports $[\Gamma(\Upsilon(2S) \rightarrow \tau^+\tau^-)/\Gamma_{\text{total}}] / [B(\Upsilon(2S) \rightarrow \mu^+\mu^-)] = 1.04 \pm 0.04 \pm 0.05$ which we multiply by our best value $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.93 \pm 0.17) \times 10^{-2}$. Our first error is their experiment's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

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

<u>VALUE</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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 $B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = 0.026$.



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

• • • 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 $[\Gamma(\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^0) / \Gamma_{\text{total}}] / [B(\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^+ \pi^-)] < 2.3 \times 10^{-4}$ 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	$e^+ e^- \rightarrow \Upsilon(1S)\eta$
--------------------	-----	----------------------	----	------	--

• • • 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	$e^+ e^- \rightarrow \ell^+ \ell^- (\gamma\gamma, \pi^+ \pi^- \pi^0)$

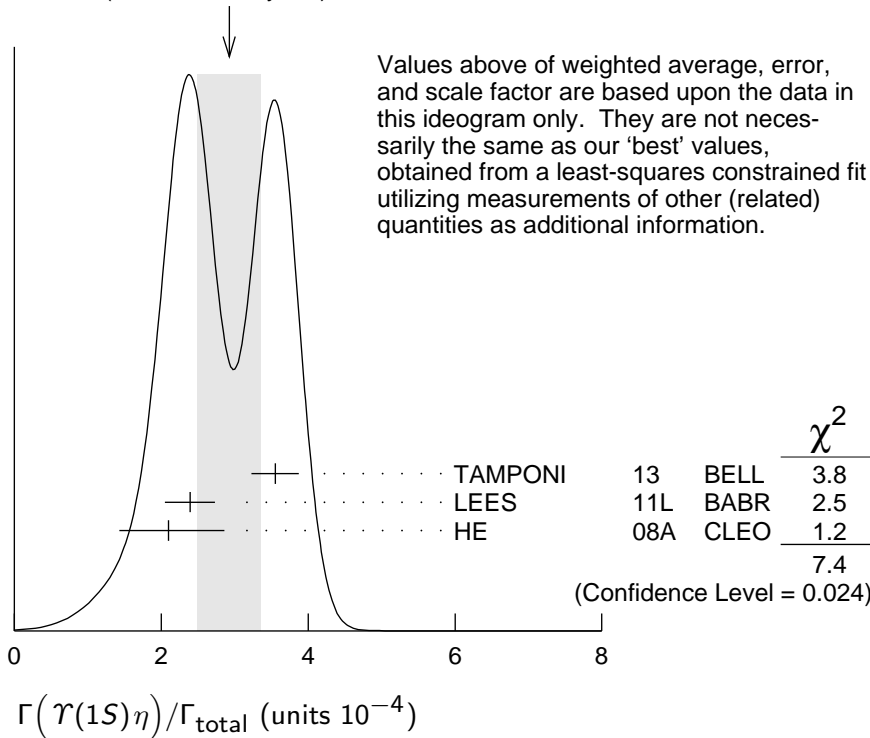
¹ Using $B(\Upsilon(1S) \rightarrow e^+ e^-) = (2.38 \pm 0.11)\%$ and $B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = (2.48 \pm 0.05)\%$.

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.

WEIGHTED AVERAGE
 2.9±0.4 (Error scaled by 1.9)



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

VALUE (units 10^{-3})	CL% EVTS	DOCUMENT ID	TECN	COMMENT
--------------------------	----------	-------------	------	---------

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
-------	-----	-------------	------	---------

• • • 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
-------	-----	-------------	------	---------

<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
-------	-----	-------------	------	---------

<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
-------	-----	-------------	------	---------

<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
-------	-----	-------------	------	---------

<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
-------	-----	-------------	------	---------

<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
-------	-----	-------------	------	---------

<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
-------	-----	-------------	------	---------

<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
-------	-----	-------------	------	---------

<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.
$2.64 \pm 0.11^{+0.26}_{-0.21}$		LEES	14G BABR	$e^+ e^- \rightarrow \overline{2H} \chi$
$3.37 \pm 0.50 \pm 0.25$	58	ASNER	07 CLEO	$e^+ e^- \rightarrow \overline{2H} \chi$

$\Gamma(g g g)/\Gamma_{\text{total}}$ 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
$3.18 \pm 0.04 \pm 0.47$	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
$1.58 \pm 0.33 \pm 0.18$	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
$2.32 \pm 0.40 \pm 0.54$	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

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

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

<u>VALUE (units 10^{-6})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 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

<u>VALUE (units 10^{-6})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 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

<u>VALUE (units 10^{-6})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 0.40	90	SHEN	12A	BELL $\Upsilon(1S) \rightarrow 2(\pi^+ \pi^-) \pi^0$

$\Gamma(\rho\pi)/\Gamma_{\text{total}}$ Γ_{49}/Γ

<u>VALUE (units 10^{-6})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 1.16	90	SHEN	13	BELL $\Upsilon(2S) \rightarrow \pi^+ \pi^- \pi^0$

$\Gamma(\pi^+ \pi^- \pi^0)/\Gamma_{\text{total}}$ Γ_{50}/Γ

<u>VALUE (units 10^{-6})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 0.80	90	SHEN	13	BELL $\Upsilon(2S) \rightarrow \pi^+ \pi^- \pi^0$

$\Gamma(\omega\pi^0)/\Gamma_{\text{total}}$ Γ_{51}/Γ

<u>VALUE (units 10^{-6})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 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

<u>VALUE (units 10^{-6})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$13.0 \pm 1.9 \pm 2.1$	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

<u>VALUE (units 10^{-6})</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$1.14 \pm 0.30 \pm 0.13$	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

<u>VALUE (units 10^{-6})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 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

<u>VALUE (units 10^{-6})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 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 ± 1.50 ± 0.63	2.9k	JIA	17A	BELL $e^+e^- \rightarrow$ hadrons

$\Gamma(f_1(1285)X_{tetra})/\Gamma_{\text{total}}$ Γ_{57}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<64.7 × 10⁻⁶	90	¹ JIA	17A	BELL $e^+e^- \rightarrow$ 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

VALUE (units 10^{-2})	DOCUMENT ID	COMMENT
0.29 ± 0.03	^{1,2} DOBBS	12A $\Upsilon(2S) \rightarrow$ 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

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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

VALUE (units 10^{-5})	CL%	DOCUMENT ID	TECN	COMMENT
<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

VALUE (units 10^{-5})	CL%	DOCUMENT ID	TECN	COMMENT
<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
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<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 × 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 × 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 × 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 × 10⁻⁵	90	WANG 11B	BELL	$\Upsilon(2S) \rightarrow \gamma X$

 $\Gamma(\gamma \chi_{c1}(3872) \rightarrow \pi^+ \pi^- J/\psi)/\Gamma_{\text{total}}$ Γ_{70}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.8 × 10⁻⁶	90	WANG 11B	BELL	$\Upsilon(2S) \rightarrow \gamma X$

$\Gamma(\gamma\chi_{c1}(3872) \rightarrow \pi^+\pi^-\pi^0 J/\psi)/\Gamma_{\text{total}}$ Γ_{71}/Γ

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

$\Gamma(\gamma X(3915) \rightarrow \omega J/\psi)/\Gamma_{\text{total}}$ 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
--------------------------	-----	------	-------------	------	---------

$5.5^{+1.1}_{-0.9}$ OUR AVERAGE Error includes scale factor of 1.2.

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

$3.9 \pm 1.1^{+1.1}_{-0.9}$ $13 \pm 5k$ ¹AUBERT 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 ¹BONVICINI 10 CLEO $\Upsilon(2S) \rightarrow \gamma X$

< 5.1 90 ²ARTUSO 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 ¹DOBBS 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 GeV < m_{A^0} < 7 GeV)

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

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 – 8.3×10^{-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
$1.78 \pm 0.02 \pm 0.11$	906k	LEES	11C BABR	$e^+ e^- \rightarrow \pi^+ \pi^- X$

$\Upsilon(2S)$ REFERENCES

FULSOM	18	PRL 121 232001	B.G. Fulsom <i>et al.</i>	(BELLE Collab.)
JIA	18	PR D97 112004	S. Jia <i>et al.</i>	(BELLE Collab.)
JIA	17	PR D95 012001	S. Jia <i>et al.</i>	(BELLE Collab.)
JIA	17A	PR D96 112002	S. Jia <i>et al.</i>	(BELLE Collab.)
LEES	14G	PR D89 111102	J.P. Lees <i>et al.</i>	(BABAR Collab.)
YANG	14	PR D90 112008	S.D. Yang <i>et al.</i>	(BELLE Collab.)
SANDILYA	13	PRL 111 112001	S. Sandilya <i>et al.</i>	(BELLE Collab.)
SHEN	13	PR D88 011102	C.P. Shen <i>et al.</i>	(BELLE Collab.)
TAMPONI	13	PR D87 011104	U. Tamponi <i>et al.</i>	(BELLE Collab.)
DOBBS	12	PRL 109 082001	S. Dobbs <i>et al.</i>	
DOBBS	12A	PR D86 052003	S. Dobbs <i>et al.</i>	
SHEN	12A	PR D86 031102	C.P. Shen <i>et al.</i>	(BELLE Collab.)
LEES	11C	PR D84 011104	J.P. Lees <i>et al.</i>	(BABAR Collab.)
LEES	11H	PRL 107 221803	J.P. Lees <i>et al.</i>	(BABAR Collab.)
LEES	11J	PR D84 072002	J.P. Lees <i>et al.</i>	(BABAR Collab.)
LEES	11L	PR D84 092003	J.P. Lees <i>et al.</i>	(BABAR Collab.)

WANG	11B	PR D84 071107	X.L. Wang <i>et al.</i>	(BELLE Collab.)
BONVICINI	10	PR D81 031104	G. Bonvicini <i>et al.</i>	(CLEO Collab.)
LEES	10B	PRL 104 151802	J.P. Lees <i>et al.</i>	(BABAR Collab.)
AUBERT	09AQ	PRL 103 161801	B. Aubert <i>et al.</i>	(BABAR Collab.)
AUBERT	09Z	PRL 103 081803	B. Aubert <i>et al.</i>	(BABAR Collab.)
BHARI	09	PR D79 011103	S.R. Bhari <i>et al.</i>	(CLEO Collab.)
AUBERT	08BP	PR D78 112002	B. Aubert <i>et al.</i>	(BABAR Collab.)
HE	08A	PRL 101 192001	Q. He <i>et al.</i>	(CLEO Collab.)
LOVE	08A	PRL 101 201601	W. Love <i>et al.</i>	(CLEO Collab.)
PDG	08	PL B667 1	C. Amsler <i>et al.</i>	(PDG Collab.)
ASNER	07	PR D75 012009	D.M. Asner <i>et al.</i>	(CLEO Collab.)
BESSON	07	PRL 98 052002	D. Besson <i>et al.</i>	(CLEO Collab.)
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.)
ROSNER	06	PRL 96 092003	J.L. Rosner <i>et al.</i>	(CLEO Collab.)
ADAMS	05	PRL 94 012001	G.S. Adams <i>et al.</i>	(CLEO Collab.)
ARTUSO	05	PRL 94 032001	M. Artuso <i>et al.</i>	(CLEO Collab.)
ARTAMONOV	00	PL B474 427	A.S. Artamonov <i>et al.</i>	
EDWARDS	99	PR D59 032003	K.W. Edwards <i>et al.</i>	(CLEO Collab.)
ALEXANDER	98	PR D58 052004	J.P. Alexander <i>et al.</i>	(CLEO Collab.)
BARU	96	PRPL 267 71	S.E. Baru <i>et al.</i>	(NOVO)
KOBEL	92	ZPHY C53 193	M. Kobel <i>et al.</i>	(Crystal Ball Collab.)
MASCHMANN	90	ZPHY C46 555	W.S. Maschmann <i>et al.</i>	(Crystal Ball Collab.)
ALBRECHT	89	ZPHY C42 349	H. Albrecht <i>et al.</i>	(ARGUS Collab.)
KAARSBERG	89	PRL 62 2077	T.M. Kaarsberg <i>et al.</i>	(CUSB Collab.)
BUCHMUEL...	88	HE e^+e^- Physics 412	W. Buchmueller, S. Cooper	(HANN, DESY, MIT)
Editors: A. Ali and P. Soeding, World Scientific, Singapore				
JAKUBOWSKI	88	ZPHY C40 49	Z. Jakubowski <i>et al.</i>	(Crystal Ball Collab.) IGJPC
ALBRECHT	87	ZPHY C35 283	H. Albrecht <i>et al.</i>	(ARGUS Collab.)
COHEN	87	RMP 59 1121	E.R. Cohen, B.N. Taylor	(RISC, NBS)
LURZ	87	ZPHY C36 383	B. Lurz <i>et al.</i>	(Crystal Ball Collab.)
BARU	86B	ZPHY C32 622 (erratum)	S.E. Baru <i>et al.</i>	(NOVO)
ALBRECHT	85	ZPHY C28 45	H. Albrecht <i>et al.</i>	(ARGUS Collab.)
ALBRECHT	85E	PL 160B 331	H. Albrecht <i>et al.</i>	(ARGUS Collab.)
GELPHMAN	85	PR D32 2893	D. Gelpman <i>et al.</i>	(Crystal Ball Collab.)
KURAEV	85	SJNP 41 466	E.A. Kuraev, V.S. Fadin	(NOVO)
Translated from YAF 41 733.				
NERNST	85	PRL 54 2195	R. Nernst <i>et al.</i>	(Crystal Ball Collab.)
ARTAMONOV	84	PL 137B 272	A.S. Artamonov <i>et al.</i>	(NOVO)
BARBER	84	PL 135B 498	D.P. Barber <i>et al.</i>	(DESY, ARGUS Collab.+)
BESSON	84	PR D30 1433	D. Besson <i>et al.</i>	(CLEO Collab.)
FONSECA	84	NP B242 31	V. Fonseca <i>et al.</i>	(CUSB Collab.)
GILES	84B	PR D29 1285	R. Giles <i>et al.</i>	(CLEO Collab.)
HAAS	84	PRL 52 799	J. Haas <i>et al.</i>	(CLEO Collab.)
HAAS	84B	PR D30 1996	J. Haas <i>et al.</i>	(CLEO Collab.)
KLOPFEN...	83	PRL 51 160	C. Klopfenstein <i>et al.</i>	(CUSB Collab.)
ALBRECHT	82	PL 116B 383	H. Albrecht <i>et al.</i>	(DESY, DORT, HEIDH+)
NICZYPORUK	81B	PL 100B 95	B. Niczyporuk <i>et al.</i>	(LENA Collab.)
NICZYPORUK	81C	PL 99B 169	B. Niczyporuk <i>et al.</i>	(LENA Collab.)
BOCK	80	ZPHY C6 125	P. Bock <i>et al.</i>	(HEIDP, MPIM, DESY, HAMB)