

$\Upsilon(1S)$ 

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

## $\Upsilon(1S)$ MASS

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>9460.30 ± 0.26 OUR AVERAGE</b>	Error includes scale factor of 3.3.		
9460.51 ± 0.09 ± 0.05	<sup>1</sup> ARTAMONOV 00	MD1	$e^+ e^- \rightarrow$ hadrons
9459.97 ± 0.11 ± 0.07	MACKAY 84	REDE	$e^+ e^- \rightarrow$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •			
9460.60 ± 0.09 ± 0.05	<sup>2,3</sup> BARU	92B	REDE $e^+ e^- \rightarrow$ hadrons
9460.59 ± 0.12	BARU	86	REDE $e^+ e^- \rightarrow$ hadrons
9460.6 ± 0.4	<sup>3,4</sup> ARTAMONOV 84	REDE	$e^+ e^- \rightarrow$ hadrons
<sup>1</sup> Reanalysis of BARU 92B and ARTAMONOV 84 using new electron mass (COHEN 87).			
<sup>2</sup> Superseding BARU 86.			
<sup>3</sup> Superseded by ARTAMONOV 00.			
<sup>4</sup> Value includes data of ARTAMONOV 82.			

## $\Upsilon(1S)$ WIDTH

VALUE (keV)	DOCUMENT ID
<b>54.02 ± 1.25 OUR EVALUATION</b>	See the Note on "Width Determinations of the $\Upsilon$ States"

## $\Upsilon(1S)$ DECAY MODES

Mode	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level
$\Gamma_1$ $\tau^+ \tau^-$	( 2.60 ± 0.10 ) %	
$\Gamma_2$ $e^+ e^-$	( 2.38 ± 0.11 ) %	
$\Gamma_3$ $\mu^+ \mu^-$	( 2.48 ± 0.05 ) %	
<b>Hadronic decays</b>		
$\Gamma_4$ $g g g$	( 81.7 ± 0.7 ) %	
$\Gamma_5$ $\gamma g g$	( 2.2 ± 0.6 ) %	
$\Gamma_6$ $\eta'(958)$ anything	( 2.94 ± 0.24 ) %	
$\Gamma_7$ $J/\psi(1S)$ anything	( 6.5 ± 0.7 ) × 10 <sup>-4</sup>	
$\Gamma_8$ $J/\psi(1S)\eta_c$	< 2.2	× 10 <sup>-6</sup> 90%
$\Gamma_9$ $J/\psi(1S)\chi_{c0}$	< 3.4	× 10 <sup>-6</sup> 90%
$\Gamma_{10}$ $J/\psi(1S)\chi_{c1}$	( 3.9 ± 1.2 ) × 10 <sup>-6</sup>	
$\Gamma_{11}$ $J/\psi(1S)\chi_{c2}$	< 1.4	× 10 <sup>-6</sup> 90%
$\Gamma_{12}$ $J/\psi(1S)\eta_c(2S)$	< 2.2	× 10 <sup>-6</sup> 90%
$\Gamma_{13}$ $J/\psi(1S)X(3940)$	< 5.4	× 10 <sup>-6</sup> 90%
$\Gamma_{14}$ $J/\psi(1S)X(4160)$	< 5.4	× 10 <sup>-6</sup> 90%
$\Gamma_{15}$ $\chi_{c0}$ anything	< 5	× 10 <sup>-3</sup> 90%
$\Gamma_{16}$ $\chi_{c1}$ anything	( 2.3 ± 0.7 ) × 10 <sup>-4</sup>	
$\Gamma_{17}$ $\chi_{c2}$ anything	( 3.4 ± 1.0 ) × 10 <sup>-4</sup>	

$\Gamma_{18}$	$\psi(2S)$ anything	$( 2.7 \pm 0.9 ) \times 10^{-4}$	
$\Gamma_{19}$	$\psi(2S)\eta_c$	$< 3.6$	$\times 10^{-6}$ 90%
$\Gamma_{20}$	$\psi(2S)\chi_{c0}$	$< 6.5$	$\times 10^{-6}$ 90%
$\Gamma_{21}$	$\psi(2S)\chi_{c1}$	$< 4.5$	$\times 10^{-6}$ 90%
$\Gamma_{22}$	$\psi(2S)\chi_{c2}$	$< 2.1$	$\times 10^{-6}$ 90%
$\Gamma_{23}$	$\psi(2S)\eta_c(2S)$	$< 3.2$	$\times 10^{-6}$ 90%
$\Gamma_{24}$	$\psi(2S)X(3940)$	$< 2.9$	$\times 10^{-6}$ 90%
$\Gamma_{25}$	$\psi(2S)X(4160)$	$< 2.9$	$\times 10^{-6}$ 90%
$\Gamma_{26}$	$\rho\pi$	$< 3.68$	$\times 10^{-6}$ 90%
$\Gamma_{27}$	$\omega\pi^0$	$< 3.90$	$\times 10^{-6}$ 90%
$\Gamma_{28}$	$\pi^+\pi^-$	$< 5$	$\times 10^{-4}$ 90%
$\Gamma_{29}$	$K^+K^-$	$< 5$	$\times 10^{-4}$ 90%
$\Gamma_{30}$	$p\bar{p}$	$< 5$	$\times 10^{-4}$ 90%
$\Gamma_{31}$	$\pi^+\pi^-\pi^0$	$( 2.1 \pm 0.8 ) \times 10^{-6}$	
$\Gamma_{32}$	$\phi K^+K^-$	$( 2.4 \pm 0.5 ) \times 10^{-6}$	
$\Gamma_{33}$	$\omega\pi^+\pi^-$	$( 4.5 \pm 1.0 ) \times 10^{-6}$	
$\Gamma_{34}$	$K^*(892)^0 K^- \pi^+ + \text{c.c.}$	$( 4.4 \pm 0.8 ) \times 10^{-6}$	
$\Gamma_{35}$	$\phi f_2'(1525)$	$< 1.63$	$\times 10^{-6}$ 90%
$\Gamma_{36}$	$\omega f_2(1270)$	$< 1.79$	$\times 10^{-6}$ 90%
$\Gamma_{37}$	$\rho(770)a_2(1320)$	$< 2.24$	$\times 10^{-6}$ 90%
$\Gamma_{38}$	$K^*(892)^0 \bar{K}_2^*(1430)^0 + \text{c.c.}$	$( 3.0 \pm 0.8 ) \times 10^{-6}$	
$\Gamma_{39}$	$K_1(1270)^\pm K^\mp$	$< 2.41$	$\times 10^{-6}$ 90%
$\Gamma_{40}$	$K_1(1400)^\pm K^\mp$	$( 1.0 \pm 0.4 ) \times 10^{-6}$	
$\Gamma_{41}$	$b_1(1235)^\pm \pi^\mp$	$< 1.25$	$\times 10^{-6}$ 90%
$\Gamma_{42}$	$\pi^+\pi^-\pi^0\pi^0$	$( 1.28 \pm 0.30 ) \times 10^{-5}$	
$\Gamma_{43}$	$K_S^0 K^+ \pi^- + \text{c.c.}$	$( 1.6 \pm 0.4 ) \times 10^{-6}$	
$\Gamma_{44}$	$K^*(892)^0 \bar{K}^0 + \text{c.c.}$	$( 2.9 \pm 0.9 ) \times 10^{-6}$	
$\Gamma_{45}$	$K^*(892)^- K^+ + \text{c.c.}$	$< 1.11$	$\times 10^{-6}$ 90%
$\Gamma_{46}$	$D^*(2010)^\pm$ anything	$( 2.52 \pm 0.20 ) \%$	
$\Gamma_{47}$	$\bar{d}$ anything	$( 2.86 \pm 0.28 ) \times 10^{-5}$	
$\Gamma_{48}$	Sum of 100 exclusive modes	$( 1.200 \pm 0.017 ) \%$	

### Radiative decays

$\Gamma_{49}$	$\gamma\pi^+\pi^-$	$( 6.3 \pm 1.8 ) \times 10^{-5}$	
$\Gamma_{50}$	$\gamma\pi^0\pi^0$	$( 1.7 \pm 0.7 ) \times 10^{-5}$	
$\Gamma_{51}$	$\gamma\pi^0\eta$	$< 2.4$	$\times 10^{-6}$ 90%
$\Gamma_{52}$	$\gamma K^+K^-$	[a] $( 1.14 \pm 0.13 ) \times 10^{-5}$	
$\Gamma_{53}$	$\gamma p\bar{p}$	[b] $< 6$	$\times 10^{-6}$ 90%
$\Gamma_{54}$	$\gamma 2h^+ 2h^-$	$( 7.0 \pm 1.5 ) \times 10^{-4}$	
$\Gamma_{55}$	$\gamma 3h^+ 3h^-$	$( 5.4 \pm 2.0 ) \times 10^{-4}$	
$\Gamma_{56}$	$\gamma 4h^+ 4h^-$	$( 7.4 \pm 3.5 ) \times 10^{-4}$	
$\Gamma_{57}$	$\gamma\pi^+\pi^- K^+ K^-$	$( 2.9 \pm 0.9 ) \times 10^{-4}$	
$\Gamma_{58}$	$\gamma 2\pi^+ 2\pi^-$	$( 2.5 \pm 0.9 ) \times 10^{-4}$	
$\Gamma_{59}$	$\gamma 3\pi^+ 3\pi^-$	$( 2.5 \pm 1.2 ) \times 10^{-4}$	

$\Gamma_{60}$	$\gamma 2\pi^+ 2\pi^- K^+ K^-$	$( 2.4 \pm 1.2 ) \times 10^{-4}$	
$\Gamma_{61}$	$\gamma \pi^+ \pi^- p \bar{p}$	$( 1.5 \pm 0.6 ) \times 10^{-4}$	
$\Gamma_{62}$	$\gamma 2\pi^+ 2\pi^- p \bar{p}$	$( 4 \pm 6 ) \times 10^{-5}$	
$\Gamma_{63}$	$\gamma 2K^+ 2K^-$	$( 2.0 \pm 2.0 ) \times 10^{-5}$	
$\Gamma_{64}$	$\gamma \eta'(958)$	$< 1.9$	$\times 10^{-6}$ 90%
$\Gamma_{65}$	$\gamma \eta$	$< 1.0$	$\times 10^{-6}$ 90%
$\Gamma_{66}$	$\gamma f_0(980)$	$< 3$	$\times 10^{-5}$ 90%
$\Gamma_{67}$	$\gamma f_2'(1525)$	$( 3.8 \pm 0.9 ) \times 10^{-5}$	
$\Gamma_{68}$	$\gamma f_2(1270)$	$( 1.01 \pm 0.09 ) \times 10^{-4}$	
$\Gamma_{69}$	$\gamma \eta(1405)$	$< 8.2$	$\times 10^{-5}$ 90%
$\Gamma_{70}$	$\gamma f_0(1500)$	$< 1.5$	$\times 10^{-5}$ 90%
$\Gamma_{71}$	$\gamma f_0(1710)$	$< 2.6$	$\times 10^{-4}$ 90%
$\Gamma_{72}$	$\gamma f_0(1710) \rightarrow \gamma K^+ K^-$	$< 7$	$\times 10^{-6}$ 90%
$\Gamma_{73}$	$\gamma f_0(1710) \rightarrow \gamma \pi^0 \pi^0$	$< 1.4$	$\times 10^{-6}$ 90%
$\Gamma_{74}$	$\gamma f_0(1710) \rightarrow \gamma \eta \eta$	$< 1.8$	$\times 10^{-6}$ 90%
$\Gamma_{75}$	$\gamma f_4(2050)$	$< 5.3$	$\times 10^{-5}$ 90%
$\Gamma_{76}$	$\gamma f_0(2200) \rightarrow \gamma K^+ K^-$	$< 2$	$\times 10^{-4}$ 90%
$\Gamma_{77}$	$\gamma f_J(2220) \rightarrow \gamma K^+ K^-$	$< 8$	$\times 10^{-7}$ 90%
$\Gamma_{78}$	$\gamma f_J(2220) \rightarrow \gamma \pi^+ \pi^-$	$< 6$	$\times 10^{-7}$ 90%
$\Gamma_{79}$	$\gamma f_J(2220) \rightarrow \gamma p \bar{p}$	$< 1.1$	$\times 10^{-6}$ 90%
$\Gamma_{80}$	$\gamma \eta(2225) \rightarrow \gamma \phi \phi$	$< 3$	$\times 10^{-3}$ 90%
$\Gamma_{81}$	$\gamma \eta_c(1S)$	$< 5.7$	$\times 10^{-5}$ 90%
$\Gamma_{82}$	$\gamma \chi_{c0}$	$< 6.5$	$\times 10^{-4}$ 90%
$\Gamma_{83}$	$\gamma \chi_{c1}$	$< 2.3$	$\times 10^{-5}$ 90%
$\Gamma_{84}$	$\gamma \chi_{c2}$	$< 7.6$	$\times 10^{-6}$ 90%
$\Gamma_{85}$	$\gamma X(3872) \rightarrow \pi^+ \pi^- J/\psi$	$< 1.6$	$\times 10^{-6}$ 90%
$\Gamma_{86}$	$\gamma X(3872) \rightarrow \pi^+ \pi^- \pi^0 J/\psi$	$< 2.8$	$\times 10^{-6}$ 90%
$\Gamma_{87}$	$\gamma \chi_{c0}(3915) \rightarrow \omega J/\psi$	$< 3.0$	$\times 10^{-6}$ 90%
$\Gamma_{88}$	$\gamma X(4140) \rightarrow \phi J/\psi$	$< 2.2$	$\times 10^{-6}$ 90%
$\Gamma_{89}$	$\gamma X$	[c] $< 4.5$	$\times 10^{-6}$ 90%
$\Gamma_{90}$	$\gamma X \bar{X} (m_X < 3.1 \text{ GeV})$	[d] $< 1$	$\times 10^{-3}$ 90%
$\Gamma_{91}$	$\gamma X \bar{X} (m_X < 4.5 \text{ GeV})$	[e] $< 2.4$	$\times 10^{-4}$ 90%
$\Gamma_{92}$	$\gamma X \rightarrow \gamma + \geq 4 \text{ prongs}$	[f] $< 1.78$	$\times 10^{-4}$ 95%
$\Gamma_{93}$	$\gamma a_1^0 \rightarrow \gamma \mu^+ \mu^-$	[g] $< 9$	$\times 10^{-6}$ 90%
$\Gamma_{94}$	$\gamma a_1^0 \rightarrow \gamma \tau^+ \tau^-$	[a] $< 1.30$	$\times 10^{-4}$ 90%
$\Gamma_{95}$	$\gamma a_1^0 \rightarrow \gamma g g$	[h] $< 1$	% 90%
$\Gamma_{96}$	$\gamma a_1^0 \rightarrow \gamma s \bar{s}$	[h] $< 1$	$\times 10^{-3}$ 90%

**Lepton Family number (LF) violating modes**

$\Gamma_{97}$	$\mu^\pm \tau^\mp$	LF $< 6.0$	$\times 10^{-6}$ 95%
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**Other decays**

$\Gamma_{98}$	invisible	$< 3.0$	$\times 10^{-4}$ 90%
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- [a]  $2m_\tau < M(\tau^+\tau^-) < 9.2 \text{ GeV}$
- [b]  $2 \text{ GeV} < m_{K^+K^-} < 3 \text{ GeV}$
- [c]  $X = \text{scalar with } m < 8.0 \text{ GeV}$
- [d]  $X\bar{X} = \text{vectors with } m < 3.1 \text{ GeV}$
- [e]  $X \text{ and } \bar{X} = \text{zero spin with } m < 4.5 \text{ GeV}$
- [f]  $1.5 \text{ GeV} < m_\chi < 5.0 \text{ GeV}$
- [g]  $201 \text{ MeV} < M(\mu^+\mu^-) < 3565 \text{ MeV}$
- [h]  $0.5 \text{ GeV} < m_\chi < 9.0 \text{ GeV}$ , where  $m_\chi$  is the invariant mass of the hadronic final state.

### $\Upsilon(1S) \Gamma(i)\Gamma(e^+e^-)/\Gamma(\text{total})$

$\Gamma(e^+e^-) \times \Gamma(\mu^+\mu^-)/\Gamma_{\text{total}}$				$\Gamma_2\Gamma_3/\Gamma$
<u>VALUE (eV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<b>31.2±1.6±1.7</b>	KOBEL	92	CBAL	$e^+e^- \rightarrow \mu^+\mu^-$

$\Gamma(\text{hadrons}) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$				$\Gamma_0\Gamma_2/\Gamma$
<u>VALUE (keV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<b>1.240±0.016 OUR AVERAGE</b>				
1.252±0.004±0.019	<sup>5</sup> ROSNER	06	CLEO	$9.5 e^+e^- \rightarrow \text{hadrons}$
1.187±0.023±0.031	<sup>5</sup> BARU	92B	MD1	$e^+e^- \rightarrow \text{hadrons}$
1.23 ±0.02 ±0.05	<sup>5</sup> JAKUBOWSKI	88	CBAL	$e^+e^- \rightarrow \text{hadrons}$
1.37 ±0.06 ±0.09	<sup>6</sup> GILES	84B	CLEO	$e^+e^- \rightarrow \text{hadrons}$
1.23 ±0.08 ±0.04	<sup>6</sup> ALBRECHT	82	DASP	$e^+e^- \rightarrow \text{hadrons}$
1.13 ±0.07 ±0.11	<sup>6</sup> NICZYPORUK	82	LENA	$e^+e^- \rightarrow \text{hadrons}$
1.09 ±0.25	<sup>6</sup> BOCK	80	CNTR	$e^+e^- \rightarrow \text{hadrons}$
1.35 ±0.14	<sup>7</sup> BERGER	79	PLUT	$e^+e^- \rightarrow \text{hadrons}$

<sup>5</sup> Radiative corrections evaluated following KURAEV 85.

<sup>6</sup> Radiative corrections reevaluated by BUCHMUELLER 88 following KURAEV 85.

<sup>7</sup> Radiative corrections reevaluated by ALEXANDER 89 using  $B(\mu\mu) = 0.026$ .

### $\Upsilon(1S)$ PARTIAL WIDTHS

$\Gamma(e^+e^-)$				$\Gamma_2$
<u>VALUE (keV)</u>	<u>DOCUMENT ID</u>			
<b>1.340±0.018 OUR EVALUATION</b>				

### $\Upsilon(1S)$ BRANCHING RATIOS

$\Gamma(\tau^+\tau^-)/\Gamma_{\text{total}}$				$\Gamma_1/\Gamma$
<u>VALUE (units <math>10^{-2}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>2.60±0.10 OUR AVERAGE</b>				
2.53±0.13±0.05	60k	<sup>8</sup> BESSON	07	CLEO $e^+e^- \rightarrow \Upsilon(1S) \rightarrow \tau^+\tau^-$
2.61±0.12 <sup>+0.09</sup> <sub>-0.13</sub>	25k	CINABRO	94B	CLE2 $e^+e^- \rightarrow \tau^+\tau^-$
2.7 ±0.4 ±0.2		<sup>9</sup> ALBRECHT	85C	ARG $\Upsilon(2S) \rightarrow \pi^+\pi^-\tau^+\tau^-$
3.4 ±0.4 ±0.4		GILES	83	CLEO $e^+e^- \rightarrow \tau^+\tau^-$

<sup>8</sup> BESSON 07 reports  $[\Gamma(\Upsilon(1S) \rightarrow \tau^+ \tau^-) / \Gamma_{\text{total}}] / [B(\Upsilon(1S) \rightarrow \mu^+ \mu^-)] = 1.02 \pm 0.02 \pm 0.05$  which we multiply by our best value  $B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = (2.48 \pm 0.05) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value.

<sup>9</sup> Using  $B(\Upsilon(1S) \rightarrow ee) = B(\Upsilon(1S) \rightarrow \mu\mu) = 0.0256$ ; not used for width evaluations.

$\Gamma(e^+ e^-) / \Gamma_{\text{total}}$					$\Gamma_2 / \Gamma$
<u>VALUE (units <math>10^{-2}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<b>2.38 ± 0.11 OUR AVERAGE</b>					
2.29 ± 0.08 ± 0.11		ALEXANDER	98 CLE2	$\Upsilon(2S) \rightarrow \pi^+ \pi^- e^+ e^-$	
2.42 ± 0.14 ± 0.14	307	ALBRECHT	87 ARG	$\Upsilon(2S) \rightarrow \pi^+ \pi^- e^+ e^-$	
2.8 ± 0.3 ± 0.2	826	BESSON	84 CLEO	$\Upsilon(2S) \rightarrow \pi^+ \pi^- e^+ e^-$	
5.1 ± 3.0		BERGER	80C PLUT	$e^+ e^- \rightarrow e^+ e^-$	

$\Gamma(\mu^+ \mu^-) / \Gamma_{\text{total}}$					$\Gamma_3 / \Gamma$
<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<b>0.0248 ± 0.0005 OUR AVERAGE</b>					
0.0249 ± 0.0002 ± 0.0007	345k	ADAMS	05 CLEO	$e^+ e^- \rightarrow \mu^+ \mu^-$	
0.0249 ± 0.0008 ± 0.0013		ALEXANDER	98 CLE2	$\Upsilon(2S) \rightarrow$ $\pi^+ \pi^- \mu^+ \mu^-$	
0.0212 ± 0.0020 ± 0.0010		<sup>10</sup> BARU	92 MD1	$e^+ e^- \rightarrow \mu^+ \mu^-$	
0.0231 ± 0.0012 ± 0.0010		<sup>10</sup> KOBEL	92 CBAL	$e^+ e^- \rightarrow \mu^+ \mu^-$	
0.0252 ± 0.0007 ± 0.0007		CHEN	89B CLEO	$e^+ e^- \rightarrow \mu^+ \mu^-$	
0.0261 ± 0.0009 ± 0.0011		KAARSBERG	89 CSB2	$e^+ e^- \rightarrow \mu^+ \mu^-$	
0.0230 ± 0.0025 ± 0.0013	86	ALBRECHT	87 ARG	$\Upsilon(2S) \rightarrow$ $\pi^+ \pi^- \mu^+ \mu^-$	
0.029 ± 0.003 ± 0.002	864	BESSON	84 CLEO	$\Upsilon(2S) \rightarrow$ $\pi^+ \pi^- \mu^+ \mu^-$	
0.027 ± 0.003 ± 0.003		ANDREWS	83 CLEO	$e^+ e^- \rightarrow \mu^+ \mu^-$	
0.032 ± 0.013 ± 0.003		ALBRECHT	82 DASP	$e^+ e^- \rightarrow \mu^+ \mu^-$	
0.038 ± 0.015 ± 0.002		NICZYPORUK	82 LENA	$e^+ e^- \rightarrow \mu^+ \mu^-$	
0.014 <sup>+0.034</sup> <sub>-0.014</sub>		BOCK	80 CNTR	$e^+ e^- \rightarrow \mu^+ \mu^-$	
0.022 ± 0.020		BERGER	79 PLUT	$e^+ e^- \rightarrow \mu^+ \mu^-$	

<sup>10</sup> Taking into account interference between the resonance and continuum.

$\Gamma(\tau^+ \tau^-) / \Gamma(\mu^+ \mu^-)$					$\Gamma_1 / \Gamma_3$
<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<b>1.008 ± 0.023 OUR AVERAGE</b>					
1.005 ± 0.013 ± 0.022	0.7M	<sup>11</sup> DEL-AMO-SA..10C	BABR	$\Upsilon(3S) \rightarrow \pi^+ \pi^- \Upsilon(1S)$	
1.02 ± 0.02 ± 0.05	60k	BESSON	07 CLEO	$e^+ e^- \rightarrow \Upsilon(1S)$	

<sup>11</sup> Allows any number of extra photons with total energy < 500 MeV.

$\Gamma(g g g) / \Gamma_{\text{total}}$					$\Gamma_4 / \Gamma$
<u>VALUE (units <math>10^{-2}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<b>81.7 ± 0.7</b>	20M	<sup>12</sup> BESSON	06A CLEO	$\Upsilon(1S) \rightarrow \text{hadrons}$	

<sup>12</sup> Calculated using the value  $\Gamma(\gamma g g) / \Gamma(g g g) = (2.70 \pm 0.01 \pm 0.13 \pm 0.24)\%$  from BESSON 06A and PDG 08 values of  $B(\mu^+ \mu^-) = (2.48 \pm 0.05)\%$  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.

$\Gamma(\gamma g g)/\Gamma_{\text{total}}$   $\Gamma_5/\Gamma$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>2.20 ± 0.60</b>	400k	<sup>13</sup> BESSON	06A CLEO	$\Upsilon(1S) \rightarrow \gamma + \text{hadrons}$

<sup>13</sup> Calculated using BESSON 06A values of  $\Gamma(\gamma g g)/\Gamma(g g g) = (2.70 \pm 0.01 \pm 0.13 \pm 0.24)\%$  and  $\Gamma(g g g)/\Gamma_{\text{total}}$ . The statistical error is negligible and the systematic error is partially correlated with that of  $\Gamma(g g g)/\Gamma_{\text{total}}$  measurement of BESSON 06A.

$\Gamma(\gamma g g)/\Gamma(g g g)$   $\Gamma_5/\Gamma_4$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>2.70 ± 0.01 ± 0.27</b>	20M	BESSON	06A CLEO	$\Upsilon(1S) \rightarrow (\gamma +) \text{hadrons}$

$\Gamma(\eta'(958) \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_6/\Gamma$

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.0294 ± 0.0024 OUR AVERAGE</b>			
0.030 ± 0.002 ± 0.002	AQUINES	06A CLE3	$\Upsilon(1S) \rightarrow \eta' \text{ anything}$
0.028 ± 0.004 ± 0.002	ARTUSO	03 CLE2	$\Upsilon(1S) \rightarrow \eta' \text{ anything}$

$\Gamma(J/\psi(1S) \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_7/\Gamma$

VALUE (units $10^{-3}$ )	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.65 ± 0.07 OUR AVERAGE</b>					
0.64 ± 0.04 ± 0.06		730 ± 40	BRIERE	04 CLEO	$e^+e^- \rightarrow J/\psi X$
1.1 ± 0.4 ± 0.2			<sup>14</sup> FULTON	89 CLEO	$e^+e^- \rightarrow \mu^+\mu^- X$

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

<0.68	90	ALBRECHT	92J ARG	$e^+e^- \rightarrow e^+e^- X, \mu^+\mu^- X$
<1.7	90	MASCHMANN	90 CBAL	$e^+e^- \rightarrow \text{hadrons}$
<20	90	NICZYPORUK	83 LENA	

<sup>14</sup> Using  $B((J/\psi) \rightarrow \mu^+\mu^-) = (6.9 \pm 0.9)\%$ .

$\Gamma(J/\psi(1S)\eta_c)/\Gamma_{\text{total}}$   $\Gamma_8/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;2.2 × 10<sup>-6</sup></b>	90	YANG	14 BELL	$e^+e^- \rightarrow J/\psi X$

$\Gamma(J/\psi(1S)\chi_{c0})/\Gamma_{\text{total}}$   $\Gamma_9/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;3.4 × 10<sup>-6</sup></b>	90	YANG	14 BELL	$e^+e^- \rightarrow J/\psi X$

$\Gamma(J/\psi(1S)\chi_{c1})/\Gamma_{\text{total}}$   $\Gamma_{10}/\Gamma$

VALUE (units $10^{-6}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>3.90 ± 1.21 ± 0.23</b>	20	YANG	14 BELL	$e^+e^- \rightarrow J/\psi X$

$\Gamma(J/\psi(1S)\chi_{c2})/\Gamma_{\text{total}}$   $\Gamma_{11}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;1.4 × 10<sup>-6</sup></b>	90	YANG	14 BELL	$e^+e^- \rightarrow J/\psi X$

$\Gamma(J/\psi(1S)\eta_c(2S))/\Gamma_{\text{total}}$   $\Gamma_{12}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;2.2 × 10<sup>-6</sup></b>	90	YANG	14 BELL	$e^+e^- \rightarrow J/\psi X$

$\Gamma(J/\psi(1S)X(3940))/\Gamma_{\text{total}}$					$\Gamma_{13}/\Gamma$
<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
$<5.4 \times 10^{-6}$	90	YANG 14	BELL	$e^+e^- \rightarrow J/\psi X$	
$\Gamma(J/\psi(1S)X(4160))/\Gamma_{\text{total}}$					$\Gamma_{14}/\Gamma$
<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
$<5.4 \times 10^{-6}$	90	YANG 14	BELL	$e^+e^- \rightarrow J/\psi X$	
$\Gamma(\chi_{c0} \text{ anything})/\Gamma(J/\psi(1S) \text{ anything})$					$\Gamma_{15}/\Gamma_7$
<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
$<7.4$	90	BRIERE 04	CLEO	$e^+e^- \rightarrow J/\psi X$	
$\Gamma(\chi_{c1} \text{ anything})/\Gamma(J/\psi(1S) \text{ anything})$					$\Gamma_{16}/\Gamma_7$
<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
$0.35 \pm 0.08 \pm 0.06$	$52 \pm 12$	BRIERE 04	CLEO	$e^+e^- \rightarrow J/\psi X$	
$\Gamma(\chi_{c2} \text{ anything})/\Gamma(J/\psi(1S) \text{ anything})$					$\Gamma_{17}/\Gamma_7$
<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
$0.52 \pm 0.12 \pm 0.09$	$47 \pm 11$	BRIERE 04	CLEO	$e^+e^- \rightarrow J/\psi X$	
$\Gamma(\psi(2S) \text{ anything})/\Gamma(J/\psi(1S) \text{ anything})$					$\Gamma_{18}/\Gamma_7$
<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
$0.41 \pm 0.11 \pm 0.08$	$42 \pm 11$	BRIERE 04	CLEO	$e^+e^- \rightarrow J/\psi \pi^+ \pi^- X$	
$\Gamma(\psi(2S)\eta_c)/\Gamma_{\text{total}}$					$\Gamma_{19}/\Gamma$
<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
$<3.6 \times 10^{-6}$	90	YANG 14	BELL	$e^+e^- \rightarrow \psi(2S)X$	
$\Gamma(\psi(2S)\chi_{c0})/\Gamma_{\text{total}}$					$\Gamma_{20}/\Gamma$
<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
$<6.5 \times 10^{-6}$	90	YANG 14	BELL	$e^+e^- \rightarrow \psi(2S)X$	
$\Gamma(\psi(2S)\chi_{c1})/\Gamma_{\text{total}}$					$\Gamma_{21}/\Gamma$
<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
$<4.5 \times 10^{-6}$	90	YANG 14	BELL	$e^+e^- \rightarrow \psi(2S)X$	
$\Gamma(\psi(2S)\chi_{c2})/\Gamma_{\text{total}}$					$\Gamma_{22}/\Gamma$
<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
$<2.1 \times 10^{-6}$	90	YANG 14	BELL	$e^+e^- \rightarrow \psi(2S)X$	
$\Gamma(\psi(2S)\eta_c(2S))/\Gamma_{\text{total}}$					$\Gamma_{23}/\Gamma$
<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
$<3.2 \times 10^{-6}$	90	YANG 14	BELL	$e^+e^- \rightarrow \psi(2S)X$	
$\Gamma(\psi(2S)X(3940))/\Gamma_{\text{total}}$					$\Gamma_{24}/\Gamma$
<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
$<2.9 \times 10^{-6}$	90	YANG 14	BELL	$e^+e^- \rightarrow \psi(2S)X$	

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

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$<2.9 \times 10^{-6}$	90	YANG	14	BELL $e^+e^- \rightarrow \psi(2S)X$

$\Gamma(\rho\pi)/\Gamma_{\text{total}}$   $\Gamma_{26}/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;3.68</b>	90	SHEN	13	BELL $\Upsilon(1S) \rightarrow \pi^+\pi^-\pi^0$

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

$<1 \times 10^3$	90	BLINOV	90	MD1 $\Upsilon(1S) \rightarrow \rho^0\pi^0$
$<2 \times 10^2$	90	FULTON	90B	$\Upsilon(1S) \rightarrow \rho^0\pi^0$
$<2.1 \times 10^3$	90	NICZYPORUK	83	LENA $\Upsilon(1S) \rightarrow \rho^0\pi^0$

$\Gamma(\omega\pi^0)/\Gamma_{\text{total}}$   $\Gamma_{27}/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;3.90</b>	90	SHEN	13	BELL $\Upsilon(1S) \rightarrow \pi^+\pi^-\pi^0\pi^0$

$\Gamma(\pi^+\pi^-)/\Gamma_{\text{total}}$   $\Gamma_{28}/\Gamma$

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;5</b>	90	BARU	92	MD1 $\Upsilon(1S) \rightarrow \pi^+\pi^-$

$\Gamma(K^+K^-)/\Gamma_{\text{total}}$   $\Gamma_{29}/\Gamma$

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;5</b>	90	BARU	92	MD1 $\Upsilon(1S) \rightarrow K^+K^-$

$\Gamma(\rho\bar{p})/\Gamma_{\text{total}}$   $\Gamma_{30}/\Gamma$

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;5</b>	90	<sup>15</sup> BARU	96	MD1 $\Upsilon(1S) \rightarrow \rho\bar{p}$

<sup>15</sup>Supersedes BARU 92 in this node.

$\Gamma(\pi^+\pi^-\pi^0)/\Gamma_{\text{total}}$   $\Gamma_{31}/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>2.14 \pm 0.72 \pm 0.34</math></b>		$26 \pm 9$	SHEN	13	BELL $\Upsilon(1S) \rightarrow \pi^+\pi^-\pi^0$

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

$<18.4$	90	ANASTASSOV	99	CLE2 $e^+e^- \rightarrow \text{hadrons}$
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$\Gamma(\phi K^+K^-)/\Gamma_{\text{total}}$   $\Gamma_{32}/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>2.36 \pm 0.37 \pm 0.29</math></b>	56	SHEN	12A	BELL $\Upsilon(1S) \rightarrow 2(K^+K^-)$

$\Gamma(\omega\pi^+\pi^-)/\Gamma_{\text{total}}$   $\Gamma_{33}/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>4.46 \pm 0.67 \pm 0.72</math></b>	64	SHEN	12A	BELL $\Upsilon(1S) \rightarrow 2(\pi^+\pi^-)\pi^0$

$\Gamma(K^*(892)^0 K^- \pi^+ + \text{c.c.})/\Gamma_{\text{total}}$   $\Gamma_{34}/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>4.42 \pm 0.50 \pm 0.58</math></b>	173	SHEN	12A	BELL $\Upsilon(1S) \rightarrow K^+K^-\pi^+\pi^-$



$\Gamma(\phi f'_2(1525))/\Gamma_{\text{total}}$   $\Gamma_{35}/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;1.63</b>	90	SHEN	12A	BELL $\gamma(1S) \rightarrow 2(K^+ K^-)$

$\Gamma(\omega f_2(1270))/\Gamma_{\text{total}}$   $\Gamma_{36}/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;1.79</b>	90	SHEN	12A	BELL $\gamma(1S) \rightarrow 2(\pi^+ \pi^-) \pi^0$

$\Gamma(\rho(770) a_2(1320))/\Gamma_{\text{total}}$   $\Gamma_{37}/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;2.24</b>	90	SHEN	12A	BELL $\gamma(1S) \rightarrow 2(\pi^+ \pi^-) \pi^0$

$\Gamma(K^*(892)^0 \bar{K}_2^*(1430)^0 + \text{c.c.})/\Gamma_{\text{total}}$   $\Gamma_{38}/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>3.02 \pm 0.68 \pm 0.34</math></b>	42	SHEN	12A	BELL $\gamma(1S) \rightarrow K^+ K^- \pi^+ \pi^-$

$\Gamma(K_1(1270)^\pm K^\mp)/\Gamma_{\text{total}}$   $\Gamma_{39}/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;2.41</b>	90	SHEN	12A	BELL $\gamma(1S) \rightarrow K^+ K^- \pi^+ \pi^-$

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

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>1.02 \pm 0.35 \pm 0.22</math></b>	24	SHEN	12A	BELL $\gamma(1S) \rightarrow K^+ K^- \pi^+ \pi^-$

$\Gamma(b_1(1235)^\pm \pi^\mp)/\Gamma_{\text{total}}$   $\Gamma_{41}/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;1.25</b>	90	SHEN	12A	BELL $\gamma(1S) \rightarrow 2(\pi^+ \pi^-) \pi^0$

$\Gamma(\pi^+ \pi^- \pi^0 \pi^0)/\Gamma_{\text{total}}$   $\Gamma_{42}/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>12.8 \pm 2.0 \pm 2.3</math></b>	$143 \pm 22$	SHEN	13	BELL $\gamma(1S) \rightarrow \pi^+ \pi^- \pi^0 \pi^0$

$\Gamma(K_S^0 K^+ \pi^- + \text{c.c.})/\Gamma_{\text{total}}$   $\Gamma_{43}/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>1.59 \pm 0.33 \pm 0.18</math></b>	$37 \pm 8$	SHEN	13	BELL $\gamma(1S) \rightarrow K_S^0 K^- \pi^+$	

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

<b>&lt;3.4</b>	90	<sup>16</sup> DOBBS	12A	$\gamma(1S) \rightarrow K_S^0 K^- \pi^+$
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<sup>16</sup> Obtained by analyzing CLEO III data but not authored by the CLEO Collaboration.

$\Gamma(K^*(892)^0 \bar{K}^0 + \text{c.c.})/\Gamma_{\text{total}}$   $\Gamma_{44}/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>2.92 \pm 0.85 \pm 0.37</math></b>	$16 \pm 5$	SHEN	13	BELL $\gamma(1S) \rightarrow K_S^0 K^- \pi^+$

$\Gamma(K^*(892)^- K^+ + \text{c.c.})/\Gamma_{\text{total}}$   $\Gamma_{45}/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;1.11</b>	90	SHEN	13	BELL $\gamma(1S) \rightarrow K_S^0 K^- \pi^+$

$\Gamma(D^*(2010)^\pm \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{46}/\Gamma$

VALUE (units $10^{-3}$ )	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
<b>25.2±1.3±1.5</b>		≈ 2k	<sup>17</sup> AUBERT	10C BABR	$\Upsilon(2S) \rightarrow \pi^+ \pi^- \Upsilon(1S)$

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

<19	90		<sup>18</sup> ALBRECHT	92J ARG	$e^+ e^- \rightarrow D^0 \pi^\pm X$
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<sup>17</sup> For  $x_p > 0.1$ .

<sup>18</sup> For  $x_p > 0.2$ .

$\Gamma(\bar{d} \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{47}/\Gamma$

VALUE (units $10^{-5}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>2.86±0.19±0.21</b>	455	ASNER	07 CLEO	$e^+ e^- \rightarrow \bar{d} X$

$\Gamma(\text{Sum of 100 exclusive modes})/\Gamma_{\text{total}}$   $\Gamma_{48}/\Gamma$

VALUE (units $10^{-2}$ )	DOCUMENT ID	COMMENT
<b>1.200±0.017</b>	<sup>19,20</sup> DOBBS	12A $\Upsilon(1S) \rightarrow \text{hadrons}$

<sup>19</sup> DOBBS 12A presents individual exclusive branching fractions or upper limits for 100 modes of four to ten pions, kaons, or protons.

<sup>20</sup> Obtained by analyzing CLEO III data but not authored by the CLEO Collaboration.

$\Gamma(ggg, \gamma gg \rightarrow \bar{d} \text{ anything})/\Gamma(ggg, \gamma gg \rightarrow \text{anything})$

VALUE (units $10^{-5}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>3.36±0.23±0.25</b>	455	ASNER	07 CLEO	$e^+ e^- \rightarrow \bar{d} X$

$\Gamma(\gamma \pi^+ \pi^-)/\Gamma_{\text{total}}$   $\Gamma_{49}/\Gamma$

VALUE (units $10^{-5}$ )	DOCUMENT ID	TECN	COMMENT
<b>6.3±1.2±1.3</b>	<sup>21</sup> ANASTASSOV	99 CLE2	$e^+ e^- \rightarrow \text{hadrons}$

<sup>21</sup> For  $m_{\pi\pi} > 1$  GeV.

$\Gamma(\gamma \pi^0 \pi^0)/\Gamma_{\text{total}}$   $\Gamma_{50}/\Gamma$

VALUE (units $10^{-5}$ )	DOCUMENT ID	TECN	COMMENT
<b>1.7±0.6±0.3</b>	<sup>22</sup> ANASTASSOV	99 CLE2	$e^+ e^- \rightarrow \text{hadrons}$

<sup>22</sup> For  $m_{\pi\pi} > 1$  GeV.

$\Gamma(\gamma \pi^0 \eta)/\Gamma_{\text{total}}$   $\Gamma_{51}/\Gamma$

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;2.4</b>	90	<sup>23</sup> BESSON	07A CLEO	$e^+ e^- \rightarrow \Upsilon(1S)$

<sup>23</sup> BESSON 07A obtained this limit for  $0.7 < m_{\pi^0 \eta} < 3$  GeV.

$\Gamma(\gamma K^+ K^-)/\Gamma_{\text{total}}$   $\Gamma_{52}/\Gamma$

( $2 < m_{K^+ K^-} < 3$  GeV)

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>1.14±0.08±0.10</b>	90	ATHAR	06 CLE3	$\Upsilon(1S) \rightarrow \gamma K^+ K^-$

$\Gamma(\gamma\rho\bar{\rho})/\Gamma_{\text{total}}$   $\Gamma_{53}/\Gamma$   
 ( $2 < m_{\rho\bar{\rho}} < 3 \text{ GeV}$ )

<u>VALUE (units <math>10^{-5}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;0.6</b>	90	ATHAR	06 CLE3	$\Upsilon(1S) \rightarrow \gamma\rho\bar{\rho}$

$\Gamma(\gamma 2h^+ 2h^-)/\Gamma_{\text{total}}$   $\Gamma_{54}/\Gamma$

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>7.0 \pm 1.1 \pm 1.0</math></b>	$80 \pm 12$	FULTON	90B CLEO	$e^+e^- \rightarrow \text{hadrons}$

$\Gamma(\gamma 3h^+ 3h^-)/\Gamma_{\text{total}}$   $\Gamma_{55}/\Gamma$

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>5.4 \pm 1.5 \pm 1.3</math></b>	$39 \pm 11$	FULTON	90B CLEO	$e^+e^- \rightarrow \text{hadrons}$

$\Gamma(\gamma 4h^+ 4h^-)/\Gamma_{\text{total}}$   $\Gamma_{56}/\Gamma$

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>7.4 \pm 2.5 \pm 2.5</math></b>	$36 \pm 12$	FULTON	90B CLEO	$e^+e^- \rightarrow \text{hadrons}$

$\Gamma(\gamma\pi^+\pi^-K^+K^-)/\Gamma_{\text{total}}$   $\Gamma_{57}/\Gamma$

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>2.9 \pm 0.7 \pm 0.6</math></b>	$29 \pm 8$	FULTON	90B CLEO	$e^+e^- \rightarrow \text{hadrons}$

$\Gamma(\gamma 2\pi^+ 2\pi^-)/\Gamma_{\text{total}}$   $\Gamma_{58}/\Gamma$

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>2.5 \pm 0.7 \pm 0.5</math></b>	$26 \pm 7$	FULTON	90B CLEO	$e^+e^- \rightarrow \text{hadrons}$

$\Gamma(\gamma 3\pi^+ 3\pi^-)/\Gamma_{\text{total}}$   $\Gamma_{59}/\Gamma$

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>2.5 \pm 0.9 \pm 0.8</math></b>	$17 \pm 5$	FULTON	90B CLEO	$e^+e^- \rightarrow \text{hadrons}$

$\Gamma(\gamma 2\pi^+ 2\pi^- K^+ K^-)/\Gamma_{\text{total}}$   $\Gamma_{60}/\Gamma$

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>2.4 \pm 0.9 \pm 0.8</math></b>	$18 \pm 7$	FULTON	90B CLEO	$e^+e^- \rightarrow \text{hadrons}$

$\Gamma(\gamma\pi^+\pi^-\rho\bar{\rho})/\Gamma_{\text{total}}$   $\Gamma_{61}/\Gamma$

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>1.5 \pm 0.5 \pm 0.3</math></b>	$22 \pm 6$	FULTON	90B CLEO	$e^+e^- \rightarrow \text{hadrons}$

$\Gamma(\gamma 2\pi^+ 2\pi^- \rho\bar{\rho})/\Gamma_{\text{total}}$   $\Gamma_{62}/\Gamma$

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>0.4 \pm 0.4 \pm 0.4</math></b>	$7 \pm 6$	FULTON	90B CLEO	$e^+e^- \rightarrow \text{hadrons}$

$\Gamma(\gamma 2K^+ 2K^-)/\Gamma_{\text{total}}$   $\Gamma_{63}/\Gamma$

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>0.2 \pm 0.2</math></b>	$2 \pm 2$	FULTON	90B CLEO	$e^+e^- \rightarrow \text{hadrons}$

**$\Gamma(\gamma\eta'(958))/\Gamma_{\text{total}}$**   **$\Gamma_{64}/\Gamma$**

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt; 1.9</b>	90	ATHAR 07A	CLEO	$\Upsilon(1S) \rightarrow \gamma\eta' \rightarrow \gamma\pi^+\pi^-\eta, \gamma\rho$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<16	90	RICHICHI 01B	CLE2	$\Upsilon(1S) \rightarrow \gamma\eta' \rightarrow \gamma\eta\pi^+\pi^-$

**$\Gamma(\gamma\eta)/\Gamma_{\text{total}}$**   **$\Gamma_{65}/\Gamma$**

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt; 1.0</b>	90	ATHAR 07A	CLEO	$\Upsilon(1S) \rightarrow \gamma\eta \rightarrow \gamma\gamma\gamma, \gamma\pi^+\pi^-\pi^0, \gamma3\pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<21	90	MASEK 02	CLEO	$\Upsilon(1S) \rightarrow \gamma\eta$

**$\Gamma(\gamma f_0(980))/\Gamma_{\text{total}}$**   **$\Gamma_{66}/\Gamma$**

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;3</b>	90	<sup>24</sup> ATHAR 06	CLE3	$\Upsilon(1S) \rightarrow \gamma\pi^+\pi^-$
<sup>24</sup> Assuming $B(f_0(980) \rightarrow \pi\pi) = 1$ .				

**$\Gamma(\gamma f'_2(1525))/\Gamma_{\text{total}}$**   **$\Gamma_{67}/\Gamma$**

VALUE (units $10^{-5}$ )	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
<b>3.8±0.9 OUR AVERAGE</b>					
4.0±1.4±0.1		17 ± 5	<sup>25</sup> BESSON	11	CLEO $\Upsilon(1S) \rightarrow K_S^0 K_S^0$
3.7 <sup>+0.9</sup> <sub>-0.7</sub> ±0.8			ATHAR	06	CLE3 $\Upsilon(1S) \rightarrow \gamma K^+ K^-$

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

<14	90	<sup>26</sup> FULTON	90B	CLEO	$\Upsilon(1S) \rightarrow \gamma K^+ K^-$
<19.4	90	<sup>26</sup> ALBRECHT	89	ARG	$\Upsilon(1S) \rightarrow \gamma K^+ K^-$

<sup>25</sup> BESSON 11 reports  $(4.0 \pm 1.3 \pm 0.6) \times 10^{-5}$  from a measurement of  $[\Gamma(\Upsilon(1S) \rightarrow \gamma f'_2(1525))/\Gamma_{\text{total}}] \times [B(f'_2(1525) \rightarrow K\bar{K})]$  assuming  $B(f'_2(1525) \rightarrow K\bar{K}) = (88.8 \pm 3.1) \times 10^{-2}$ , which we rescale to our best value  $B(f'_2(1525) \rightarrow K\bar{K}) = (88.7 \pm 2.2) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best value. The result also assumes  $B(K_S^0 \rightarrow \pi^+\pi^-) = (69.20 \pm 0.05)\%$  and  $B(f'_2(1525) \rightarrow K\bar{K}) = 4 B(f'_2(1525) \rightarrow K_S^0 K_S^0)$ .

<sup>26</sup> Assuming  $B(f'_2(1525) \rightarrow K\bar{K}) = 0.71$ .

**$\Gamma(\gamma f_2(1270))/\Gamma_{\text{total}}$**   **$\Gamma_{68}/\Gamma$**

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>10.1±0.9 OUR AVERAGE</b>				
10.5±1.6 <sup>+1.9</sup> <sub>-1.8</sub>		<sup>27</sup> BESSON	07A	CLE3 $\Upsilon(1S) \rightarrow \gamma\pi^0\pi^0$
10.2±0.8±0.7		ATHAR	06	CLE3 $\Upsilon(1S) \rightarrow \gamma\pi^+\pi^-$
8.1±2.3 <sup>+2.9</sup> <sub>-2.7</sub>		<sup>28</sup> ANASTASSOV	99	CLE2 $e^+e^- \rightarrow \text{hadrons}$

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

<21	90	<sup>28</sup> FULTON	90B	CLEO	$\Upsilon(1S) \rightarrow \gamma\pi^+\pi^-$
<13	90	<sup>28</sup> ALBRECHT	89	ARG	$\Upsilon(1S) \rightarrow \gamma\pi^+\pi^-$
<81	90	SCHMITT	88	CBAL	$\Upsilon(1S) \rightarrow \gamma X$

<sup>27</sup> Using  $B(f_2(1270) \rightarrow \pi^0 \pi^0) = B(f_2(1270) \rightarrow \pi \pi)/3$  and  $B(f_2(1270) \rightarrow \pi \pi) = (0.845^{+0.025}_{-0.012})\%$ .

<sup>28</sup> Using  $B(f_2(1270) \rightarrow \pi \pi) = 0.84$ .

**$\Gamma(\gamma\eta(1405))/\Gamma_{\text{total}}$   $\Gamma_{69}/\Gamma$**

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;8.2</b>	90	<sup>29</sup> FULTON	90B CLEO	$\Upsilon(1S) \rightarrow \gamma K^\pm \pi^\mp K_S^0$

<sup>29</sup> Includes unknown branching ratio of  $\eta(1405) \rightarrow K^\pm \pi^\mp K_S^0$ .

**$\Gamma(\gamma f_0(1500))/\Gamma_{\text{total}}$   $\Gamma_{70}/\Gamma$**

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;1.5</b>	90	<sup>30</sup> BESSON	07A CLEO	$e^+ e^- \rightarrow \Upsilon(1S) \rightarrow \gamma \pi^0 \pi^0$

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

<6.1 90 <sup>31</sup> BESSON 07A CLEO  $e^+ e^- \rightarrow \Upsilon(1S) \rightarrow \gamma \eta \eta$

<sup>30</sup> Using  $B(f_0(1500) \rightarrow \pi^0 \pi^0) = B(f_0(1500) \rightarrow \pi \pi)/3$  and  $B(f_0(1500) \rightarrow \pi \pi) = (0.349 \pm 0.023)\%$ .

<sup>31</sup> Calculated by us using  $B(f_0(1500) \rightarrow \eta \eta) = (5.1 \pm 0.9)\%$ .

**$\Gamma(\gamma f_0(1710))/\Gamma_{\text{total}}$   $\Gamma_{71}/\Gamma$**

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt; 2.6</b>	90	<sup>32</sup> ALBRECHT	89 ARG	$\Upsilon(1S) \rightarrow \gamma K^+ K^-$

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

< 6.3 90 <sup>32</sup> FULTON 90B CLEO  $\Upsilon(1S) \rightarrow \gamma K^+ K^-$

<19 90 <sup>32</sup> FULTON 90B CLEO  $\Upsilon(1S) \rightarrow \gamma K_S^0 K_S^0$

< 8 90 <sup>33</sup> ALBRECHT 89 ARG  $\Upsilon(1S) \rightarrow \gamma \pi^+ \pi^-$

<24 90 <sup>34</sup> SCHMITT 88 CBAL  $\Upsilon(1S) \rightarrow \gamma X$

<sup>32</sup> Assuming  $B(f_0(1710) \rightarrow K \bar{K}) = 0.38$ .

<sup>33</sup> Assuming  $B(f_0(1710) \rightarrow \pi \pi) = 0.04$ .

<sup>34</sup> Assuming  $B(f_0(1710) \rightarrow \eta \eta) = 0.18$ .

**$\Gamma(\gamma f_0(1710) \rightarrow \gamma K^+ K^-)/\Gamma_{\text{total}}$   $\Gamma_{72}/\Gamma$**

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;0.7</b>	90	ATHAR	06 CLEO	$e^+ e^- \rightarrow \Upsilon(1S) \rightarrow \gamma K^+ K^-$

**$\Gamma(\gamma f_0(1710) \rightarrow \gamma \pi^0 \pi^0)/\Gamma_{\text{total}}$   $\Gamma_{73}/\Gamma$**

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;1.4</b>	90	BESSON	07A CLEO	$e^+ e^- \rightarrow \Upsilon(1S) \rightarrow \gamma \pi^0 \pi^0$

**$\Gamma(\gamma f_0(1710) \rightarrow \gamma \eta \eta)/\Gamma_{\text{total}}$   $\Gamma_{74}/\Gamma$**

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;1.8</b>	90	BESSON	07A CLEO	$e^+ e^- \rightarrow \Upsilon(1S) \rightarrow \gamma \eta \eta$

**$\Gamma(\gamma f_4(2050))/\Gamma_{\text{total}}$   $\Gamma_{75}/\Gamma$**

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;5.3</b>	90	<sup>35</sup> ATHAR	06 CLE3	$\Upsilon(1S) \rightarrow \gamma \pi^+ \pi^-$

<sup>35</sup> Assuming  $B(f_4(2050) \rightarrow \pi \pi) = 0.17$ .

$\Gamma(\gamma f_0(2200) \rightarrow \gamma K^+ K^-) / \Gamma_{\text{total}}$   $\Gamma_{76} / \Gamma$

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<0.0002	90	BARU	89 MD1	$\Upsilon(1S) \rightarrow \gamma K^+ K^-$

$\Gamma(\gamma f_J(2220) \rightarrow \gamma K^+ K^-) / \Gamma_{\text{total}}$   $\Gamma_{77} / \Gamma$

<u>VALUE (units <math>10^{-7}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 8	90	ATHAR	06 CLE3	$\Upsilon(1S) \rightarrow \gamma K^+ K^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 160	90	MASEK	02 CLEO	$\Upsilon(1S) \rightarrow \gamma K^+ K^-$
< 150	90	FULTON	90B CLEO	$\Upsilon(1S) \rightarrow \gamma K^+ K^-$
< 290	90	ALBRECHT	89 ARG	$\Upsilon(1S) \rightarrow \gamma K^+ K^-$
<2000	90	BARU	89 MD1	$\Upsilon(1S) \rightarrow \gamma K^+ K^-$

$\Gamma(\gamma f_J(2220) \rightarrow \gamma \pi^+ \pi^-) / \Gamma_{\text{total}}$   $\Gamma_{78} / \Gamma$

<u>VALUE (units <math>10^{-7}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 6	90	ATHAR	06 CLE3	$\Upsilon(1S) \rightarrow \gamma \pi^+ \pi^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<120	90	MASEK	02 CLEO	$\Upsilon(1S) \rightarrow \gamma \pi^+ \pi^-$

$\Gamma(\gamma f_J(2220) \rightarrow \gamma p \bar{p}) / \Gamma_{\text{total}}$   $\Gamma_{79} / \Gamma$

<u>VALUE (units <math>10^{-7}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 11	90	ATHAR	06 CLE3	$\Upsilon(1S) \rightarrow \gamma p \bar{p}$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<160	90	MASEK	02 CLEO	$\Upsilon(1S) \rightarrow \gamma p \bar{p}$

$\Gamma(\gamma \eta(2225) \rightarrow \gamma \phi \phi) / \Gamma_{\text{total}}$   $\Gamma_{80} / \Gamma$

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<0.003	90	BARU	89 MD1	$\Upsilon(1S) \rightarrow \gamma K^+ K^- K^+ K^-$

$\Gamma(\gamma \eta_c(1S)) / \Gamma_{\text{total}}$   $\Gamma_{81} / \Gamma$

<u>VALUE (units <math>10^{-5}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<5.7	90	SHEN	10A BELL	$\Upsilon(1S) \rightarrow \gamma X$

$\Gamma(\gamma \chi_{c0}) / \Gamma_{\text{total}}$   $\Gamma_{82} / \Gamma$

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<6.5	90	SHEN	10A BELL	$\Upsilon(1S) \rightarrow \gamma X$

$\Gamma(\gamma \chi_{c1}) / \Gamma_{\text{total}}$   $\Gamma_{83} / \Gamma$

<u>VALUE (units <math>10^{-5}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<2.3	90	SHEN	10A BELL	$\Upsilon(1S) \rightarrow \gamma X$

$\Gamma(\gamma \chi_{c2}) / \Gamma_{\text{total}}$   $\Gamma_{84} / \Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<7.6	90	SHEN	10A BELL	$\Upsilon(1S) \rightarrow \gamma X$

$\Gamma(\gamma X(3872) \rightarrow \pi^+ \pi^- J/\psi) / \Gamma_{\text{total}}$   $\Gamma_{85} / \Gamma$

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<1.6	90	SHEN 10A	BELL	$\Upsilon(1S) \rightarrow \gamma X$

$\Gamma(\gamma X(3872) \rightarrow \pi^+ \pi^- \pi^0 J/\psi) / \Gamma_{\text{total}}$   $\Gamma_{86} / \Gamma$

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<2.8	90	SHEN 10A	BELL	$\Upsilon(1S) \rightarrow \gamma X$

$\Gamma(\gamma \chi_{c0}(3915) \rightarrow \omega J/\psi) / \Gamma_{\text{total}}$   $\Gamma_{87} / \Gamma$

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<3.0	90	SHEN 10A	BELL	$\Upsilon(1S) \rightarrow \gamma X$

$\Gamma(\gamma X(4140) \rightarrow \phi J/\psi) / \Gamma_{\text{total}}$   $\Gamma_{88} / \Gamma$

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<2.2	90	SHEN 10A	BELL	$\Upsilon(1S) \rightarrow \gamma X$

$\Gamma(\gamma X) / \Gamma_{\text{total}}$   $\Gamma_{89} / \Gamma$

( $X = \text{scalar with } m < 8.0 \text{ GeV}$ )

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
< 4.5	90	<sup>36</sup> DEL-AMO-SA..11J	BABR	$e^+ e^- \rightarrow \gamma + X$

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

<30	90	<sup>37</sup> BALEST 95	CLEO	$e^+ e^- \rightarrow \gamma + X$
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<sup>36</sup> For a noninteracting scalar  $X$  with mass  $m < 8.0 \text{ GeV}$ .

<sup>37</sup> For a noninteracting pseudoscalar  $X$  with mass  $< 7.2 \text{ GeV}$ .

$\Gamma(\gamma X \bar{X} (m_X < 3.1 \text{ GeV})) / \Gamma_{\text{total}}$   $\Gamma_{90} / \Gamma$

( $X \bar{X} = \text{vectors with } m < 3.1 \text{ GeV}$ )

VALUE (units $10^{-3}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<1	90	<sup>38</sup> BALEST 95	CLEO	$e^+ e^- \rightarrow \gamma + X \bar{X}$

<sup>38</sup> For a noninteracting vector  $X$  with mass  $< 3.1 \text{ GeV}$ .

$\Gamma(\gamma X \bar{X} (m_X < 4.5 \text{ GeV})) / \Gamma_{\text{total}}$   $\Gamma_{91} / \Gamma$

$X$  and  $\bar{X} = \text{zero spin with } m < 4.5 \text{ GeV}$

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<24	90	<sup>39</sup> DEL-AMO-SA..11J	BABR	$e^+ e^- \rightarrow \gamma + X \bar{X}$

<sup>39</sup> For a noninteracting scalar  $X$  with mass  $m < 4.5 \text{ GeV}$ .

$\Gamma(\gamma X \rightarrow \gamma + \geq 4 \text{ prongs}) / \Gamma_{\text{total}}$   $\Gamma_{92} / \Gamma$

( $1.5 \text{ GeV} < m_X < 5.0 \text{ GeV}$ )

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<1.78	95	ROSNER 07A	CLEO	$e^+ e^- \rightarrow \gamma X$

$\Gamma(\gamma a_1^0 \rightarrow \gamma \mu^+ \mu^-) / \Gamma_{\text{total}}$   $\Gamma_{93} / \Gamma$

( $201 < M(\mu^+ \mu^-) < 3565$  MeV)

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<9	90	40 LOVE	08	CLEO $e^+ e^- \rightarrow \gamma a_1^0 \rightarrow \gamma \mu^+ \mu^-$

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

<9.7	90	41 LEES	13C	BABR $e^+ e^- \rightarrow \gamma a_1^0 \rightarrow \gamma \mu^+ \mu^-$
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<sup>40</sup> For a narrow scalar or pseudoscalar  $a_1^0$  with  $201 < M(\mu^+ \mu^-) < 3565$  MeV, excluding  $J/\psi$ . Measured 90% CL limits as a function of  $M(\mu^+ \mu^-)$  range from  $1-9 \times 10^{-6}$ .

<sup>41</sup> For a narrow scalar or pseudoscalar  $a_1^0$  with mass in the range 212–9200 MeV, excluding  $J/\psi$  and  $\psi(2S)$ . Measured 90% CL limits as a function of  $m_{a_1^0}$  range from  $0.28-9.7 \times 10^{-6}$ .

$\Gamma(\gamma a_1^0 \rightarrow \gamma \tau^+ \tau^-) / \Gamma_{\text{total}}$   $\Gamma_{94} / \Gamma$

( $2m_\tau < M(\tau^+ \tau^-) < 9.2$  GeV)

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<130	90	42 LEES	13R	BABR $\Upsilon(2S) \rightarrow \gamma \tau^+ \tau^- \pi^+ \pi^-$

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

< 50	90	43 LOVE	08	CLEO $e^+ e^- \rightarrow \gamma a_1^0 \rightarrow \gamma \tau^+ \tau^-$
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<sup>42</sup> For a narrow scalar  $a_1^0$  with  $2m_\tau < M(a_1^0) < 9.2$  GeV, which result in a 90% CL upper limits of  $0.9 \times 10^{-5}$  at  $M(a_1^0) = 2m_\tau$ ,  $\approx 1.5 \times 10^{-5}$  at  $M(a_1^0) = 7.5$  GeV, and  $13 \times 10^{-5}$  at  $M(a_1^0) = 9.2$  GeV.

<sup>43</sup> For a narrow scalar or pseudoscalar  $a_1^0$  with  $2m_\tau < M(a_1^0) < 7.5$  GeV, which result in a 90% CL limits ranging from  $1 \times 10^{-5}$  at  $M(a_1^0) = 2m_\tau$  to  $5 \times 10^{-5}$  at  $M(a_1^0) = 7.5$  GeV.

$\Gamma(\gamma a_1^0 \rightarrow \gamma g g) / \Gamma_{\text{total}}$   $\Gamma_{95} / \Gamma$

( $0.5 \text{ GeV} < m < 9.0 \text{ GeV}$ )

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
< $1 \times 10^{-2}$	90	44 LEES	13L	BABR $\Upsilon(1S) \rightarrow \gamma X$

<sup>44</sup> For a narrow,  $CP$ -odd pseudoscalar  $a_1^0$  searched for in 26 hadronic decay modes with invariant mass  $0.5 \text{ GeV} < m_X < 9.0 \text{ GeV}$ . Measured 90% CL limit as a function of  $m_X$  range from  $10^{-6}$  to  $10^{-2}$ .

$\Gamma(\gamma a_1^0 \rightarrow \gamma s \bar{s}) / \Gamma_{\text{total}}$   $\Gamma_{96} / \Gamma$

( $0.5 \text{ GeV} < m < 9.0 \text{ GeV}$ )

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
< $1 \times 10^{-3}$	90	45 LEES	13L	BABR $\Upsilon(1S) \rightarrow \gamma X$

<sup>45</sup> For a narrow,  $CP$ -odd pseudoscalar  $a_1^0$  searched for in 14 hadronic decay modes with invariant mass  $1.5 \text{ GeV} < m_X < 9.0 \text{ GeV}$ . Measured 90% CL limit as a function of  $m_X$  range from  $10^{-5}$  to  $10^{-3}$ .

———— LEPTON FAMILY NUMBER (LF) VIOLATING MODES ————

$\Gamma(\mu^\pm \tau^\mp) / \Gamma_{\text{total}}$   $\Gamma_{97} / \Gamma$

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<6.0	95	LOVE	08A	CLEO $e^+ e^- \rightarrow \mu^\pm \tau^\mp$



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**OTHER DECAYS**


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$\Gamma(\text{invisible})/\Gamma_{\text{total}}$					$\Gamma_{98}/\Gamma$
VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT	
< 3.0	90	AUBERT	09AX BABR	$\Upsilon(3S) \rightarrow \pi^+ \pi^- \Upsilon(1S)$	
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
<39	90	RUBIN	07 CLEO	$\Upsilon(2S) \rightarrow \pi^+ \pi^- \Upsilon(1S)$	
<25	90	TAJIMA	07 BELL	$\Upsilon(3S) \rightarrow \pi^+ \pi^- \Upsilon(1S)$	

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SCHMITT	88	ZPHY C40 199	P. Schmitt <i>et al.</i>	(Crystal Ball Collab.)
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)
BARU	86	ZPHY C30 551	S.E. Baru <i>et al.</i>	(NOVO)
ALBRECHT	85C	PL 154B 452	H. Albrecht <i>et al.</i>	(ARGUS Collab.)
KURAEV	85	SJNP 41 466	E.A. Kuraev, V.S. Fadin	(NOVO)
		Translated from YAF 41 733.		
ARTAMONOV	84	PL 137B 272	A.S. Artamonov <i>et al.</i>	(NOVO)
BESSON	84	PR D30 1433	D. Besson <i>et al.</i>	(CLEO Collab.)
GILES	84B	PR D29 1285	R. Giles <i>et al.</i>	(CLEO Collab.)
MACKAY	84	PR D29 2483	W.W. MacKay <i>et al.</i>	(CUSB Collab.)
ANDREWS	83	PRL 50 807	D.E. Andrews <i>et al.</i>	(CLEO Collab.)
GILES	83	PRL 50 877	R. Giles <i>et al.</i>	(HARV, OSU, ROCH, RUTG+)
NICZYPORUK	83	ZPHY C17 197	B. Niczyporuk <i>et al.</i>	(LENA Collab.)
ALBRECHT	82	PL 116B 383	H. Albrecht <i>et al.</i>	(DESY, DORT, HEIDH+)
ARTAMONOV	82	PL 118B 225	A.S. Artamonov <i>et al.</i>	(NOVO)
NICZYPORUK	82	ZPHY C15 299	B. Niczyporuk <i>et al.</i>	(LENA Collab.)
BERGER	80C	PL 93B 497	C. Berger <i>et al.</i>	(PLUTO Collab.)
BOCK	80	ZPHY C6 125	P. Bock <i>et al.</i>	(HEIDP, MPIM, DESY, HAMB)
BERGER	79	ZPHY C1 343	C. Berger <i>et al.</i>	(PLUTO Collab.)

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