

$\Upsilon(1S)$

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

$\Upsilon(1S)$ MASS

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
9460.30 ± 0.26 OUR AVERAGE	Error includes scale factor of 3.3.		
9460.51 ± 0.09 ± 0.05	¹ 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	^{2,3} BARU	92B	REDE $e^+ e^- \rightarrow$ hadrons
9460.59 ± 0.12	BARU	86	REDE $e^+ e^- \rightarrow$ hadrons
9460.6 ± 0.4	^{3,4} ARTAMONOV 84	REDE	$e^+ e^- \rightarrow$ hadrons
¹ Reanalysis of BARU 92B and ARTAMONOV 84 using new electron mass (COHEN 87).			
² Superseding BARU 86.			
³ Superseded by ARTAMONOV 00.			
⁴ Value includes data of ARTAMONOV 82.			

$\Upsilon(1S)$ WIDTH

<u>VALUE (keV)</u>	<u>DOCUMENT ID</u>
54.02 ± 1.25 OUR EVALUATION	See the Note on "Width Determinations of the Υ States"

$\Upsilon(1S)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)	Confidence level
Γ_1 $\tau^+ \tau^-$	(2.60 ± 0.10) %	
Γ_2 $e^+ e^-$	(2.38 ± 0.11) %	
Γ_3 $\mu^+ \mu^-$	(2.48 ± 0.05) %	
Hadronic decays		
Γ_4 $\eta'(958)$ anything	(2.94 ± 0.24) %	
Γ_5 $J/\psi(1S)$ anything	(6.5 ± 0.7) × 10 ⁻⁴	
Γ_6 χ_{c0} anything	< 5 × 10 ⁻³	90%
Γ_7 χ_{c1} anything	(2.3 ± 0.7) × 10 ⁻⁴	
Γ_8 χ_{c2} anything	(3.4 ± 1.0) × 10 ⁻⁴	
Γ_9 $\psi(2S)$ anything	(2.7 ± 0.9) × 10 ⁻⁴	
Γ_{10} $\rho\pi$	< 2 × 10 ⁻⁴	90%
Γ_{11} $\pi^+ \pi^-$	< 5 × 10 ⁻⁴	90%
Γ_{12} $K^+ K^-$	< 5 × 10 ⁻⁴	90%
Γ_{13} $\rho\bar{p}$	< 5 × 10 ⁻⁴	90%
Γ_{14} $\pi^0 \pi^+ \pi^-$	< 1.84 × 10 ⁻⁵	90%
Γ_{15} $D^*(2010)^\pm$ anything		
Γ_{16} \bar{d} anything	(2.86 ± 0.28) × 10 ⁻⁵	

Radiative decays

Γ_{17}	$\gamma\pi^+\pi^-$		$(6.3 \pm 1.8) \times 10^{-5}$	
Γ_{18}	$\gamma\pi^0\pi^0$		$(1.7 \pm 0.7) \times 10^{-5}$	
Γ_{19}	$\gamma\pi^0\eta$		$< 2.4 \times 10^{-6}$	90%
Γ_{20}	$\gamma K^+ K^-$	[a]	$(1.14 \pm 0.13) \times 10^{-5}$	
Γ_{21}	$\gamma p\bar{p}$	[b]	$< 6 \times 10^{-6}$	90%
Γ_{22}	$\gamma 2h^+ 2h^-$		$(7.0 \pm 1.5) \times 10^{-4}$	
Γ_{23}	$\gamma 3h^+ 3h^-$		$(5.4 \pm 2.0) \times 10^{-4}$	
Γ_{24}	$\gamma 4h^+ 4h^-$		$(7.4 \pm 3.5) \times 10^{-4}$	
Γ_{25}	$\gamma\pi^+\pi^- K^+ K^-$		$(2.9 \pm 0.9) \times 10^{-4}$	
Γ_{26}	$\gamma 2\pi^+ 2\pi^-$		$(2.5 \pm 0.9) \times 10^{-4}$	
Γ_{27}	$\gamma 3\pi^+ 3\pi^-$		$(2.5 \pm 1.2) \times 10^{-4}$	
Γ_{28}	$\gamma 2\pi^+ 2\pi^- K^+ K^-$		$(2.4 \pm 1.2) \times 10^{-4}$	
Γ_{29}	$\gamma\pi^+\pi^- p\bar{p}$		$(1.5 \pm 0.6) \times 10^{-4}$	
Γ_{30}	$\gamma 2\pi^+ 2\pi^- p\bar{p}$		$(4 \pm 6) \times 10^{-5}$	
Γ_{31}	$\gamma 2K^+ 2K^-$		$(2.0 \pm 2.0) \times 10^{-5}$	
Γ_{32}	$\gamma\eta'(958)$		$< 1.9 \times 10^{-6}$	90%
Γ_{33}	$\gamma\eta$		$< 1.0 \times 10^{-6}$	90%
Γ_{34}	$\gamma f_0(980)$		$< 3 \times 10^{-5}$	90%
Γ_{35}	$\gamma f_2'(1525)$		$(3.7^{+1.2}_{-1.1}) \times 10^{-5}$	
Γ_{36}	$\gamma f_2(1270)$		$(1.01 \pm 0.09) \times 10^{-4}$	
Γ_{37}	$\gamma\eta(1405)$		$< 8.2 \times 10^{-5}$	90%
Γ_{38}	$\gamma f_0(1500)$		$< 1.5 \times 10^{-5}$	90%
Γ_{39}	$\gamma f_0(1710)$		$< 2.6 \times 10^{-4}$	90%
Γ_{40}	$\gamma f_0(1710) \rightarrow \gamma K^+ K^-$		$< 7 \times 10^{-6}$	90%
Γ_{41}	$\gamma f_0(1710) \rightarrow \gamma\pi^0\pi^0$		$< 1.4 \times 10^{-6}$	90%
Γ_{42}	$\gamma f_0(1710) \rightarrow \gamma\eta\eta$		$< 1.8 \times 10^{-6}$	90%
Γ_{43}	$\gamma f_4(2050)$		$< 5.3 \times 10^{-5}$	90%
Γ_{44}	$\gamma f_0(2200) \rightarrow \gamma K^+ K^-$		$< 2 \times 10^{-4}$	90%
Γ_{45}	$\gamma f_J(2220) \rightarrow \gamma K^+ K^-$		$< 8 \times 10^{-7}$	90%
Γ_{46}	$\gamma f_J(2220) \rightarrow \gamma\pi^+\pi^-$		$< 6 \times 10^{-7}$	90%
Γ_{47}	$\gamma f_J(2220) \rightarrow \gamma p\bar{p}$		$< 1.1 \times 10^{-6}$	90%
Γ_{48}	$\gamma\eta(2225) \rightarrow \gamma\phi\phi$		$< 3 \times 10^{-3}$	90%
Γ_{49}	γX	[c]	$< 3 \times 10^{-5}$	90%
Γ_{50}	$\gamma X\bar{X}$	[d]	$< 1 \times 10^{-3}$	90%
Γ_{51}	$\gamma X \rightarrow \gamma + \geq 4$ prongs	[e]	$< 1.78 \times 10^{-4}$	95%
Γ_{52}	$\gamma a_1^0 \rightarrow \gamma\mu^+\mu^-$	[f]		
Γ_{53}	$\gamma a_1^0 \rightarrow \gamma\tau^+\tau^-$	[a]		

Lepton Flavor (LF) violating or Invisible decays

Γ_{54}	$\mu^\pm \tau^\mp$	LF	$< 6.0 \times 10^{-6}$	95%
Γ_{55}	invisible		$< 2.5 \times 10^{-3}$	90%

- [a] $2m_\tau < M(\tau^+\tau^-) < 7500$ MeV.
- [b] $2 < m_{K^+K^-} < 3$ GeV.
- [c] $X =$ pseudoscalar with $m < 7.2$ GeV
- [d] $X\bar{X} =$ vectors with $m < 3.1$ GeV
- [e] 1.5 GeV $< m_X < 5.0$ GeV
- [f] $201 < M(\mu^+\mu^-) < 3565$ MeV.

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

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

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

⁵ Radiative corrections evaluated following KURAEV 85.

⁶ Radiative corrections reevaluated by BUCHMUELLER 88 following KURAEV 85.

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

$\Upsilon(1S)$ PARTIAL WIDTHS

$\Gamma(e^+e^-)$				Γ_2
VALUE (keV)	DOCUMENT ID			
1.340±0.018 OUR EVALUATION				

$\Upsilon(1S)$ BRANCHING RATIOS

$\Gamma(\tau^+\tau^-)/\Gamma_{\text{total}}$				Γ_1/Γ
VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
2.60±0.10 OUR AVERAGE				
2.53±0.13±0.05	60k	⁸ BESSON	07	CLEO $e^+e^- \rightarrow \Upsilon(1S) \rightarrow \tau^+\tau^-$
2.61±0.12 ^{+0.09} _{-0.13}	25k	CINABRO	94B	CLE2 $e^+e^- \rightarrow \tau^+\tau^-$
2.7 ±0.4 ±0.2		⁹ ALBRECHT	85C	ARG $\Upsilon(2S) \rightarrow \pi^+\pi^-\tau^+\tau^-$
3.4 ±0.4 ±0.4		GILES	83	CLEO $e^+e^- \rightarrow \tau^+\tau^-$

⁸ BESSON 07 reports $[\Gamma(\Upsilon(1S) \rightarrow \tau^+\tau^-)/\Gamma_{\text{total}}] / [B(\Upsilon(1S) \rightarrow \mu^+\mu^-)] = 1.02 \pm 0.02 \pm 0.05$. 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.

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

$\Gamma(e^+e^-)/\Gamma_{\text{total}}$			Γ_2/Γ		
<u>VALUE (units 10^{-2})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
2.38±0.11 OUR AVERAGE					
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	$e^+e^- \rightarrow e^+e^-$	

$\Gamma(\mu^+\mu^-)/\Gamma_{\text{total}}$			Γ_3/Γ		
<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
0.0248±0.0005 OUR AVERAGE					
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		¹⁰ BARU	92 MD1	$e^+e^- \rightarrow \mu^+\mu^-$	
0.0231±0.0012±0.0010		¹⁰ 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 +0.034 -0.014		BOCK	80 CNTR	$e^+e^- \rightarrow \mu^+\mu^-$	
0.022 ±0.020		BERGER	79 PLUT	$e^+e^- \rightarrow \mu^+\mu^-$	

¹⁰ Taking into account interference between the resonance and continuum.

$\Gamma(\tau^+\tau^-)/\Gamma(\mu^+\mu^-)$			Γ_1/Γ_3		
<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
1.02±0.02±0.05	60k	BESSON	07 CLEO	$e^+e^- \rightarrow \Upsilon(1S)$	

$\Gamma(\eta'(958) \text{ anything})/\Gamma_{\text{total}}$			Γ_4/Γ		
<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
0.0294±0.0024 OUR AVERAGE					
0.030 ±0.002 ±0.002		AQUINES	06A CLE3	$\Upsilon(1S) \rightarrow \eta' \text{ anything}$	
0.028 ±0.004 ±0.002		ARTUSO	03 CLE2	$\Upsilon(1S) \rightarrow \eta' \text{ anything}$	

$\Gamma(J/\psi(1S) \text{ anything})/\Gamma_{\text{total}}$			Γ_5/Γ		
<u>VALUE (units 10^{-3})</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.65±0.07 OUR AVERAGE					
0.64±0.04±0.06		730 ± 40	BRIERE	04 CLEO	$e^+e^- \rightarrow J/\psi X$
1.1 ±0.4 ±0.2			¹¹ 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	

¹¹ Using $B((J/\psi) \rightarrow \mu^+ \mu^-) = (6.9 \pm 0.9)\%$.

$\Gamma(\chi_{c0} \text{ anything})/\Gamma(J/\psi(1S) \text{ anything})$ Γ_6/Γ_5

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<7.4	90	BRIERE	04	CLEO $e^+ e^- \rightarrow J/\psi X$

$\Gamma(\chi_{c1} \text{ anything})/\Gamma(J/\psi(1S) \text{ anything})$ Γ_7/Γ_5

<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 ± 12	BRIERE	04	CLEO $e^+ e^- \rightarrow J/\psi X$

$\Gamma(\chi_{c2} \text{ anything})/\Gamma(J/\psi(1S) \text{ anything})$ Γ_8/Γ_5

<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 ± 11	BRIERE	04	CLEO $e^+ e^- \rightarrow J/\psi X$

$\Gamma(\psi(2S) \text{ anything})/\Gamma(J/\psi(1S) \text{ anything})$ Γ_9/Γ_5

<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 ± 11	BRIERE	04	CLEO $e^+ e^- \rightarrow J/\psi \pi^+ \pi^- X$

$\Gamma(\rho\pi)/\Gamma_{\text{total}}$ Γ_{10}/Γ

<u>VALUE (units 10^{-4})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 2	90	FULTON	90B	$\Upsilon(1S) \rightarrow \rho^0 \pi^0$

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

<10	90	BLINOV	90	MD1 $\Upsilon(1S) \rightarrow \rho^0 \pi^0$
<21	90	NICZYPORUK	83	LENA $\Upsilon(1S) \rightarrow \rho^0 \pi^0$

$\Gamma(\pi^+ \pi^-)/\Gamma_{\text{total}}$ Γ_{11}/Γ

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

$\Gamma(K^+ K^-)/\Gamma_{\text{total}}$ Γ_{12}/Γ

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

$\Gamma(\rho\bar{p})/\Gamma_{\text{total}}$ Γ_{13}/Γ

<u>VALUE (units 10^{-4})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<5	90	¹² BARU	96	MD1 $\Upsilon(1S) \rightarrow \rho\bar{p}$

¹² Supersedes BARU 92 in this node.

$\Gamma(\pi^0 \pi^+ \pi^-)/\Gamma_{\text{total}}$ Γ_{14}/Γ

<u>VALUE (units 10^{-5})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<1.84	90	ANASTASSOV	99	CLE2 $e^+ e^- \rightarrow \text{hadrons}$

$\Gamma(D^*(2010)^\pm \text{ anything})/\Gamma_{\text{total}}$ Γ_{15}/Γ

<u>VALUE (units 10^{-3})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<19	90	¹³ ALBRECHT	92J	ARG $e^+ e^- \rightarrow D^0 \pi^\pm X$

¹³ For $x_p > 0.2$.

$\Gamma(\bar{d} \text{ anything})/\Gamma_{\text{total}}$						Γ_{16}/Γ
<u>VALUE (units 10^{-5})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
$2.86 \pm 0.19 \pm 0.21$	455	ASNER	07	CLEO	$e^+ e^- \rightarrow \bar{d} X$	
$\Gamma(ggg, gg\gamma \rightarrow \bar{d} \text{ anything})/\Gamma(ggg, gg\gamma \rightarrow \text{anything})$						
<u>VALUE (units 10^{-5})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
$3.36 \pm 0.23 \pm 0.25$	455	ASNER	07	CLEO	$e^+ e^- \rightarrow \bar{d} X$	
$\Gamma(\gamma\pi^+\pi^-)/\Gamma_{\text{total}}$						Γ_{17}/Γ
<u>VALUE (units 10^{-5})</u>		<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
$6.3 \pm 1.2 \pm 1.3$		¹⁴ ANASTASSOV 99	CLE2	$e^+ e^- \rightarrow \text{hadrons}$		
¹⁴ For $m_{\pi\pi} > 1$ GeV.						
$\Gamma(\gamma\pi^0\pi^0)/\Gamma_{\text{total}}$						Γ_{18}/Γ
<u>VALUE (units 10^{-5})</u>		<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
$1.7 \pm 0.6 \pm 0.3$		¹⁵ ANASTASSOV 99	CLE2	$e^+ e^- \rightarrow \text{hadrons}$		
¹⁵ For $m_{\pi\pi} > 1$ GeV.						
$\Gamma(\gamma\pi^0\eta)/\Gamma_{\text{total}}$						Γ_{19}/Γ
<u>VALUE (units 10^{-6})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
< 2.4	90	¹⁶ BESSON 07A	CLEO	$e^+ e^- \rightarrow \Upsilon(1S)$		
¹⁶ BESSON 07A obtained this limit for $0.7 < m_{\pi^0\eta} < 3$ GeV.						
$\Gamma(\gamma K^+ K^-)/\Gamma_{\text{total}}$ ($2 < m_{K^+ K^-} < 3$ GeV)						Γ_{20}/Γ
<u>VALUE (units 10^{-5})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
$1.14 \pm 0.08 \pm 0.10$	90	ATHAR	06	CLE3	$\Upsilon(1S) \rightarrow \gamma K^+ K^-$	
$\Gamma(\gamma p\bar{p})/\Gamma_{\text{total}}$ ($2 < m_{p\bar{p}} < 3$ GeV)						Γ_{21}/Γ
<u>VALUE (units 10^{-5})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
< 0.6	90	ATHAR	06	CLE3	$\Upsilon(1S) \rightarrow \gamma p\bar{p}$	
$\Gamma(\gamma 2h^+ 2h^-)/\Gamma_{\text{total}}$						Γ_{22}/Γ
<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
$7.0 \pm 1.1 \pm 1.0$	80 ± 12	FULTON	90B	CLEO	$e^+ e^- \rightarrow \text{hadrons}$	
$\Gamma(\gamma 3h^+ 3h^-)/\Gamma_{\text{total}}$						Γ_{23}/Γ
<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
$5.4 \pm 1.5 \pm 1.3$	39 ± 11	FULTON	90B	CLEO	$e^+ e^- \rightarrow \text{hadrons}$	
$\Gamma(\gamma 4h^+ 4h^-)/\Gamma_{\text{total}}$						Γ_{24}/Γ
<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>		
$7.4 \pm 2.5 \pm 2.5$	36 ± 12	FULTON	90B	CLEO	$e^+ e^- \rightarrow \text{hadrons}$	

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

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

$\Gamma(\gamma 2\pi^+ 2\pi^-)/\Gamma_{\text{total}}$ Γ_{26}/Γ

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

$\Gamma(\gamma 3\pi^+ 3\pi^-)/\Gamma_{\text{total}}$ Γ_{27}/Γ

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

$\Gamma(\gamma 2\pi^+ 2\pi^- K^+ K^-)/\Gamma_{\text{total}}$ Γ_{28}/Γ

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

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

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

$\Gamma(\gamma 2\pi^+ 2\pi^- p\bar{p})/\Gamma_{\text{total}}$ Γ_{30}/Γ

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

$\Gamma(\gamma 2K^+ 2K^-)/\Gamma_{\text{total}}$ Γ_{31}/Γ

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

$\Gamma(\gamma\eta'(958))/\Gamma_{\text{total}}$ Γ_{32}/Γ

<u>VALUE (units 10^{-6})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 1.9	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	$\Upsilon(1S) \rightarrow \gamma\eta' \rightarrow \gamma\eta\pi^+\pi^-$

$\Gamma(\gamma\eta)/\Gamma_{\text{total}}$ Γ_{33}/Γ

<u>VALUE (units 10^{-6})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 1.0	90	ATHAR 07A	CLEO	$\Upsilon(1S) \rightarrow \gamma\eta \rightarrow \gamma\gamma\gamma, \gamma\pi^+\pi^-\pi^0, \gamma 3\pi^0$
••• We do not use the following data for averages, fits, limits, etc. •••				
<21	90	MASEK 02	CLEO	$\Upsilon(1S) \rightarrow \gamma\eta$

$\Gamma(\gamma f_0(980))/\Gamma_{\text{total}}$ Γ_{34}/Γ

<u>VALUE (units 10^{-5})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 3	90	¹⁷ ATHAR 06	CLE3	$\Upsilon(1S) \rightarrow \gamma\pi^+\pi^-$

¹⁷ Assuming $B(f_0(980) \rightarrow \pi\pi) = 1$.

$\Gamma(\gamma f'_2(1525))/\Gamma_{\text{total}}$ **Γ_{35}/Γ**

<u>VALUE (units 10^{-5})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$3.7^{+0.9}_{-0.7} \pm 0.8$		ATHAR	06	CLE3 $\Upsilon(1S) \rightarrow \gamma K^+ K^-$

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

<14	90	¹⁸ FULTON	90B	CLEO $\Upsilon(1S) \rightarrow \gamma K^+ K^-$
<19.4	90	¹⁸ ALBRECHT	89	ARG $\Upsilon(1S) \rightarrow \gamma K^+ K^-$

¹⁸ Assuming $B(f'_2(1525) \rightarrow K\bar{K}) = 0.71$.

$\Gamma(\gamma f_2(1270))/\Gamma_{\text{total}}$ **Γ_{36}/Γ**

<u>VALUE (units 10^{-5})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
10.1 ± 0.9 OUR AVERAGE				

$10.5 \pm 1.6^{+1.9}_{-1.8}$		¹⁹ BESSON	07A	CLE3 $\Upsilon(1S) \rightarrow \gamma \pi^0 \pi^0$
$10.2 \pm 0.8 \pm 0.7$		ATHAR	06	CLE3 $\Upsilon(1S) \rightarrow \gamma \pi^+ \pi^-$
$8.1 \pm 2.3^{+2.9}_{-2.7}$		²⁰ ANASTASSOV	99	CLE2 $e^+ e^- \rightarrow \text{hadrons}$

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

<21	90	²⁰ FULTON	90B	CLEO $\Upsilon(1S) \rightarrow \gamma \pi^+ \pi^-$
<13	90	²⁰ ALBRECHT	89	ARG $\Upsilon(1S) \rightarrow \gamma \pi^+ \pi^-$
<81	90	SCHMITT	88	CBAL $\Upsilon(1S) \rightarrow \gamma X$

¹⁹ Using $B(f_2(1270) \rightarrow \pi^0 \pi^0) = B(f_2(1270) \rightarrow \pi\pi)/3$ and $B(f_2(1270) \rightarrow \pi\pi) = (0.845^{+0.025}_{-0.012})\%$.

²⁰ Using $B(f_2(1270) \rightarrow \pi\pi) = 0.84$.

$\Gamma(\gamma \eta(1405))/\Gamma_{\text{total}}$ **Γ_{37}/Γ**

<u>VALUE (units 10^{-5})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<8.2	90	²¹ FULTON	90B	CLEO $\Upsilon(1S) \rightarrow \gamma K^\pm \pi^\mp K_S^0$

²¹ Includes unknown branching ratio of $\eta(1405) \rightarrow K^\pm \pi^\mp K_S^0$.

$\Gamma(\gamma f_0(1500))/\Gamma_{\text{total}}$ **Γ_{38}/Γ**

<u>VALUE (units 10^{-5})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<1.5	90	²² 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	²³ BESSON	07A	CLEO $e^+ e^- \rightarrow \Upsilon(1S) \rightarrow \gamma \eta \eta$
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²² Using $B(f_0(1500) \rightarrow \pi^0 \pi^0) = B(f_0(1500) \rightarrow \pi\pi)/3$ and $B(f_0(1500) \rightarrow \pi\pi) = (0.349 \pm 0.023)\%$.

²³ Calculated by us using $B(f_0(1500) \rightarrow \eta\eta) = (5.1 \pm 0.9)\%$.

$\Gamma(\gamma f_0(1710))/\Gamma_{\text{total}}$ **Γ_{39}/Γ**

<u>VALUE (units 10^{-4})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
< 2.6	90	²⁴ ALBRECHT	89	ARG $\Upsilon(1S) \rightarrow \gamma K^+ K^-$

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

< 6.3	90	²⁴ FULTON	90B	CLEO $\Upsilon(1S) \rightarrow \gamma K^+ K^-$
<19	90	²⁴ FULTON	90B	CLEO $\Upsilon(1S) \rightarrow \gamma K_S^0 K_S^0$
< 8	90	²⁵ ALBRECHT	89	ARG $\Upsilon(1S) \rightarrow \gamma \pi^+ \pi^-$
<24	90	²⁶ SCHMITT	88	CBAL $\Upsilon(1S) \rightarrow \gamma X$

²⁴ Assuming $B(f_0(1710) \rightarrow K\bar{K}) = 0.38$.

²⁵ Assuming $B(f_0(1710) \rightarrow \pi\pi) = 0.04$.

²⁶ Assuming $B(f_0(1710) \rightarrow \eta\eta) = 0.18$.

$\Gamma(\gamma f_0(1710) \rightarrow \gamma K^+ K^-)/\Gamma_{\text{total}}$ Γ_{40}/Γ

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

$\Gamma(\gamma f_0(1710) \rightarrow \gamma \pi^0 \pi^0)/\Gamma_{\text{total}}$ Γ_{41}/Γ

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

$\Gamma(\gamma f_0(1710) \rightarrow \gamma \eta \eta)/\Gamma_{\text{total}}$ Γ_{42}/Γ

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

$\Gamma(\gamma f_4(2050))/\Gamma_{\text{total}}$ Γ_{43}/Γ

<u>VALUE (units 10^{-5})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<5.3	90	²⁷ ATHAR 06	CLE3	$\Upsilon(1S) \rightarrow \gamma \pi^+ \pi^-$

²⁷ Assuming $B(f_4(2050) \rightarrow \pi\pi) = 0.17$.

$\Gamma(\gamma f_0(2200) \rightarrow \gamma K^+ K^-)/\Gamma_{\text{total}}$ Γ_{44}/Γ

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

$\Gamma(\gamma f_J(2220) \rightarrow \gamma K^+ K^-)/\Gamma_{\text{total}}$ Γ_{45}/Γ

<u>VALUE (units 10^{-7})</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	$\Upsilon(1S) \rightarrow \gamma K^+ K^-$

$\Gamma(\gamma f_J(2220) \rightarrow \gamma \pi^+ \pi^-)/\Gamma_{\text{total}}$ Γ_{46}/Γ

<u>VALUE (units 10^{-7})</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	$\Upsilon(1S) \rightarrow \gamma \pi^+ \pi^-$
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$\Gamma(\gamma f_J(2220) \rightarrow \gamma p \bar{p})/\Gamma_{\text{total}}$ Γ_{47}/Γ

<u>VALUE (units 10^{-7})</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	$\Upsilon(1S) \rightarrow \gamma p \bar{p}$
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$\Gamma(\gamma\eta(2225) \rightarrow \gamma\phi\phi)/\Gamma_{\text{total}}$ Γ_{48}/Γ

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

$\Gamma(\gamma X)/\Gamma_{\text{total}}$ Γ_{49}/Γ

(X = pseudoscalar with $m < 7.2$ GeV)

VALUE (units 10^{-5})	CL%	DOCUMENT ID	TECN	COMMENT
<3	90	28 BALEST	95 CLEO	$e^+ e^- \rightarrow \gamma + X$

²⁸ For a noninteracting pseudoscalar X with mass < 7.2 GeV.

$\Gamma(\gamma X\bar{X})/\Gamma_{\text{total}}$ Γ_{50}/Γ

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

VALUE (units 10^{-3})	CL%	DOCUMENT ID	TECN	COMMENT
<1	90	29 BALEST	95 CLEO	$e^+ e^- \rightarrow \gamma + X\bar{X}$

²⁹ For a noninteracting vector X with mass < 3.1 GeV.

$\Gamma(\gamma X \rightarrow \gamma + \geq 4 \text{ prongs})/\Gamma_{\text{total}}$ Γ_{51}/Γ

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

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

$\Gamma(\gamma a_1^0 \rightarrow \gamma \mu^+ \mu^-)/\Gamma_{\text{total}}$ Γ_{52}/Γ

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

VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT
< ~ 3	90	30 LOVE	08 CLEO	$e^+ e^- \rightarrow \gamma a_1^0 \rightarrow \gamma \mu^+ \mu^-$

³⁰ For narrow scalar or pseudoscalar a_1^0 with $201 < M(\mu^+ \mu^-) < 3565$ MeV, excluding J/ψ . Range of actual limits is $1-9 \times 10^{-6}$.

$\Gamma(\gamma a_1^0 \rightarrow \gamma \tau^+ \tau^-)/\Gamma_{\text{total}}$ Γ_{53}/Γ

($2m_\tau < M(\tau^+ \tau^-) < 7500$ MeV)

VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT
< ~ 20	90	31 LOVE	08 CLEO	$e^+ e^- \rightarrow \gamma a_1^0 \rightarrow \gamma \tau^+ \tau^-$

³¹ For narrow scalar or pseudoscalar a_1^0 with $2m_\tau < M(\tau^+ \tau^-) < 7500$ MeV. Range of actual limits is $1-5 \times 10^{-5}$.

$\Gamma(\mu^\pm \tau^\mp)/\Gamma_{\text{total}}$ Γ_{54}/Γ

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

$\Gamma(\text{invisible})/\Gamma_{\text{total}}$ Γ_{55}/Γ

VALUE (units 10^{-2})	CL%	DOCUMENT ID	TECN	COMMENT
<0.25	90	TAJIMA	07 BELL	$\Upsilon(3S) \rightarrow \pi^+ \pi^- \Upsilon(1S)$

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

<0.39	90	RUBIN	07 CLEO	$\Upsilon(2S) \rightarrow \pi^+ \pi^- \Upsilon(1S)$
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