

$\Upsilon(2S)$

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

$\Upsilon(2S)$ MASS

VALUE (GeV)	DOCUMENT ID	TECN	COMMENT
10.02326 ± 0.00031 OUR AVERAGE			
10.0235 ± 0.0005	¹ ARTAMONOV 00	MD1	$e^+e^- \rightarrow$ hadrons
10.0231 ± 0.0004	BARBER	84 REDE	$e^+e^- \rightarrow$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •			
10.0236 ± 0.0005	^{2,3} BARU	86B REDE	$e^+e^- \rightarrow$ hadrons
¹ Reanalysis of BARU 86B using new electron mass (COHEN 87).			
² Reanalysis of ARTAMONOV 84.			
³ Superseded by ARTAMONOV 00.			

$\Upsilon(2S)$ WIDTH

VALUE (keV)	DOCUMENT ID
44 ± 7 OUR EVALUATION	See the Note on Width Determinations of the Υ states

$\Upsilon(2S)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)	Confidence level
$\Gamma_1 \quad \Upsilon(1S)\pi^+\pi^-$	(18.8 ± 0.6) %	
$\Gamma_2 \quad \Upsilon(1S)\pi^0\pi^0$	(9.0 ± 0.8) %	
$\Gamma_3 \quad \tau^+\tau^-$	(1.7 ± 1.6) %	
$\Gamma_4 \quad \mu^+\mu^-$	(1.31 ± 0.21) %	
$\Gamma_5 \quad e^+e^-$	(1.18 ± 0.20) %	
$\Gamma_6 \quad \Upsilon(1S)\pi^0$	< 1.1	× 10 ⁻³ 90%
$\Gamma_7 \quad \Upsilon(1S)\eta$	< 2	× 10 ⁻³ 90%
$\Gamma_8 \quad J/\psi(1S)\text{anything}$	< 6	× 10 ⁻³ 90%

Radiative decays

$\Gamma_9 \quad \gamma\chi_{b1}(1P)$	(6.8 ± 0.7) %	
$\Gamma_{10} \quad \gamma\chi_{b2}(1P)$	(7.0 ± 0.6) %	
$\Gamma_{11} \quad \gamma\chi_{b0}(1P)$	(3.8 ± 0.6) %	
$\Gamma_{12} \quad \gamma f_0(1710)$	< 5.9	× 10 ⁻⁴ 90%
$\Gamma_{13} \quad \gamma f_2'(1525)$	< 5.3	× 10 ⁻⁴ 90%
$\Gamma_{14} \quad \gamma f_2(1270)$	< 2.41	× 10 ⁻⁴ 90%
$\Gamma_{15} \quad \gamma f_J(2220)$		

$\Upsilon(2S) \Gamma(i)\Gamma(e^+e^-)/\Gamma(\text{total})$

$\Gamma(e^+e^-) \times \Gamma(\mu^+\mu^-)/\Gamma_{\text{total}}$	DOCUMENT ID	TECN	COMMENT	$\Gamma_5\Gamma_4/\Gamma$
6.5 ± 1.5 ± 1.0	KOBEL	92	CBAL $e^+e^- \rightarrow \mu^+\mu^-$	

$\Gamma(\text{hadrons}) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_0\Gamma_5/\Gamma$

<u>VALUE (keV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.553±0.023 OUR AVERAGE			
0.552±0.031±0.017	4 BARU	96 MD1	$e^+e^- \rightarrow \text{hadrons}$
0.54 ±0.04 ±0.02	4 JAKUBOWSKI	88 CBAL	$e^+e^- \rightarrow \text{hadrons}$
0.58 ±0.03 ±0.04	5 GILES	84B CLEO	$e^+e^- \rightarrow \text{hadrons}$
0.60 ±0.12 ±0.07	5 ALBRECHT	82 DASP	$e^+e^- \rightarrow \text{hadrons}$
0.54 ±0.07 ^{+0.09} _{-0.05}	5 NICZYPORUK	81c LENA	$e^+e^- \rightarrow \text{hadrons}$
0.41 ±0.18	5 BOCK	80 CNTR	$e^+e^- \rightarrow \text{hadrons}$

⁴ Radiative corrections evaluated following KURAEV 85.

⁵ Radiative corrections reevaluated by BUCHMUELLER 88 following KURAEV 85.

$\Upsilon(2S)$ PARTIAL WIDTHS

$\Gamma(e^+e^-)$ Γ_5

<u>VALUE (keV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.52 ±0.03 ±0.01	⁶ ALBRECHT	95E ARG	$e^+e^- \rightarrow \text{hadrons}$

⁶ Applying the formula of Kuraev and Fadin.

$\Upsilon(2S)$ BRANCHING RATIOS

$\Gamma(J/\psi(1S)\text{anything})/\Gamma_{\text{total}}$ Γ_8/Γ

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<0.006	90	MASCHMANN	90 CBAL	$e^+e^- \rightarrow \text{hadrons}$

$\Gamma(\Upsilon(1S)\pi^+\pi^-)/\Gamma_{\text{total}}$ Γ_1/Γ

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.188±0.006 OUR AVERAGE				
0.192±0.002±0.010	52.6k	⁷ ALEXANDER	98 CLE2	$\pi^+\pi^-\ell^+\ell^-$, $\pi^+\pi^-\text{MM}$
0.181±0.005±0.010	11.6k	ALBRECHT	87 ARG	$e^+e^- \rightarrow \pi^+\pi^-\text{MM}$
0.169±0.040		GELPHMAN	85 CBAL	$e^+e^- \rightarrow e^+e^-\pi^+\pi^-$
0.191±0.012±0.006		BESSION	84 CLEO	$\pi^+\pi^-\text{MM}$
0.189±0.026		FONSECA	84 CUSB	$e^+e^- \rightarrow \ell^+\ell^-\pi^+\pi^-$
0.21 ±0.07	7	NICZYPORUK	81B LENA	$e^+e^- \rightarrow \ell^+\ell^-\pi^+\pi^-$

⁷ 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</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.090±0.008 OUR AVERAGE				
0.092±0.006±0.008	275	⁸ ALEXANDER	98 CLE2	$e^+e^- \rightarrow \ell^+\ell^-\pi^0\pi^0$
0.095±0.019±0.019	25	ALBRECHT	87 ARG	$e^+e^- \rightarrow \pi^0\pi^0\ell^+\ell^-$
0.080±0.015		GELPHMAN	85 CBAL	$e^+e^- \rightarrow \ell^+\ell^-\pi^0\pi^0$
0.103±0.023		FONSECA	84 CUSB	$e^+e^- \rightarrow \ell^+\ell^-\pi^0\pi^0$

⁸ Using $B(\Upsilon(1S) \rightarrow e^+e^-) = (2.52 \pm 0.17)\%$ and $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.07)\%$.

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.017±0.015±0.006	HAAS	84B CLEO	$e^+e^- \rightarrow \tau^+\tau^-$

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

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.0131±0.0021 OUR AVERAGE				
0.0122±0.0028±0.0019		⁹ 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		¹⁰ 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	$e^+e^- \rightarrow \mu^+\mu^-$
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⁹ Taking into account interference between the resonance and continuum.

¹⁰ Re-evaluated using $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = 0.026$.

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

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<0.0011	90	ALEXANDER	98 CLE2	$e^+e^- \rightarrow l^+l^-\gamma\gamma$

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

<0.008	90	LURZ	87 CBAL	$e^+e^- \rightarrow l^+l^-\gamma\gamma$
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$\Gamma(\Upsilon(1S)\eta)/\Gamma_{\text{total}}$ Γ_7/Γ

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<0.002	90	FONSECA	84 CUSB	

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

<0.0028	90	ALEXANDER	98 CLE2	$e^+e^- \rightarrow l^+l^-\eta$
<0.005	90	ALBRECHT	87 ARG	$e^+e^- \rightarrow \pi^+\pi^-l^+l^-MM$
<0.007	90	LURZ	87 CBAL	$e^+e^- \rightarrow l^+l^-(\gamma\gamma, 3\pi^0)$
<0.010	90	BESSION	84 CLEO	

$\Gamma(\gamma\chi_{b1}(1P))/\Gamma_{\text{total}}$ Γ_9/Γ

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.068±0.007 OUR AVERAGE			
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_{10}/Γ

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.070±0.006 OUR AVERAGE			
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_{11}/Γ**

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.038±0.006 OUR AVERAGE			
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_{12}/Γ**

<u>VALUE (units 10⁻⁵)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<59	90	¹¹ ALBRECHT 89	ARG	$\Upsilon(2S) \rightarrow \gamma K^+ K^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 5.9	90	¹² ALBRECHT 89	ARG	$\Upsilon(2S) \rightarrow \gamma \pi^+ \pi^-$
¹¹ Re-evaluated assuming $B(f_0(1710) \rightarrow K^+ K^-) = 0.19$.				
¹² Includes unknown branching ratio of $f_0(1710) \rightarrow \pi^+ \pi^-$.				

$\Gamma(\gamma f'_2(1525))/\Gamma_{\text{total}}$ **Γ_{13}/Γ**

<u>VALUE (units 10⁻⁵)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<53	90	¹³ ALBRECHT 89	ARG	$\Upsilon(2S) \rightarrow \gamma K^+ K^-$
¹³ Re-evaluated assuming $B(f'_2(1525) \rightarrow K\bar{K}) = 0.71$.				

$\Gamma(\gamma f_2(1270))/\Gamma_{\text{total}}$ **Γ_{14}/Γ**

<u>VALUE (units 10⁻⁵)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<24.1	90	¹⁴ ALBRECHT 89	ARG	$\Upsilon(2S) \rightarrow \gamma \pi^+ \pi^-$
¹⁴ Using $B(f_2(1270) \rightarrow \pi\pi) = 0.84$.				

$\Gamma(\gamma f_J(2220))/\Gamma_{\text{total}}$ **Γ_{15}/Γ**

<u>VALUE (units 10⁻⁵)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<6.8	90	¹⁵ ALBRECHT 89	ARG	$\Upsilon(2S) \rightarrow \gamma K^+ K^-$
¹⁵ Includes unknown branching ratio of $f_J(2220) \rightarrow K^+ K^-$.				

$\Upsilon(2S)$ REFERENCES

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