

$\Upsilon(2S)$

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

$\Upsilon(2S)$ MASS

VALUE (GeV)	DOCUMENT ID	TECN	COMMENT
10.02330 ± 0.00031 OUR AVERAGE			
10.0236 ± 0.0005	¹ BARU	86B REDE	$e^+e^- \rightarrow$ hadrons
10.0231 ± 0.0004	BARBER	84 REDE	$e^+e^- \rightarrow$ hadrons

¹ Reanalysis of ARTAMONOV 84.

$\Upsilon(2S)$ 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
Γ_1 $\Upsilon(1S)\pi^+\pi^-$	(18.5 ± 0.8) %	
Γ_2 $\Upsilon(1S)\pi^0\pi^0$	(8.8 ± 1.1) %	
Γ_3 $\tau^+\tau^-$	(1.7 ± 1.6) %	
Γ_4 $\mu^+\mu^-$	(1.31 ± 0.21) %	
Γ_5 e^+e^-	(1.18 ± 0.20) %	
Γ_6 $\Upsilon(1S)\pi^0$	< 8	× 10 ⁻³ 90%
Γ_7 $\Upsilon(1S)\eta$	< 2	× 10 ⁻³ 90%
Γ_8 $J/\psi(1S)$ anything	< 6	× 10 ⁻³ 90%

Radiative decays

Γ_9 $\gamma\chi_{b1}(1P)$	(6.7 ± 0.9) %	
Γ_{10} $\gamma\chi_{b2}(1P)$	(6.6 ± 0.9) %	
Γ_{11} $\gamma\chi_{b0}(1P)$	(4.3 ± 1.0) %	
Γ_{12} $\gamma f_J(1710)$	< 5.9	× 10 ⁻⁴ 90%
Γ_{13} $\gamma f_2'(1525)$	< 5.3	× 10 ⁻⁴ 90%
Γ_{14} $\gamma f_2(1270)$	< 2.41	× 10 ⁻⁴ 90%
Γ_{15} $\gamma f_J(2220)$		

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

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

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

<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	² BARU	96 MD1	$e^+e^- \rightarrow \text{hadrons}$
0.54 ±0.04 ±0.02	² JAKUBOWSKI	88 CBAL	$e^+e^- \rightarrow \text{hadrons}$
0.58 ±0.03 ±0.04	³ GILES	84B CLEO	$e^+e^- \rightarrow \text{hadrons}$
0.60 ±0.12 ±0.07	³ ALBRECHT	82 DASP	$e^+e^- \rightarrow \text{hadrons}$
0.54 ±0.07 ^{+0.09} _{-0.05}	³ NICZYPORUK	81C LENA	$e^+e^- \rightarrow \text{hadrons}$
0.41 ±0.18	³ BOCK	80 CNTR	$e^+e^- \rightarrow \text{hadrons}$

² Radiative corrections evaluated following KURAEV 85.

³ Radiative corrections reevaluated by BUCHMUELLER 88 following KURAEV 85.

$\Upsilon(2S)$ PARTIAL WIDTHS

 $\Gamma(e^+e^-) \qquad \Gamma_5$

<u>VALUE (keV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.52 ±0.03 ±0.01	⁴ ALBRECHT	95E ARG	$e^+e^- \rightarrow \text{hadrons}$

⁴ Applying the formula of Kuraev and Fadin.

$\Upsilon(2S)$ BRANCHING RATIOS

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

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

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

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.185±0.008 OUR AVERAGE				
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		BESSON	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	$e^+e^- \rightarrow \ell^+\ell^-\pi^+\pi^-$

 $\Gamma(\Upsilon(1S)\pi^0\pi^0)/\Gamma_{\text{total}} \qquad \Gamma_2/\Gamma$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.088±0.011 OUR AVERAGE				
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	$e^+e^- \rightarrow \ell^+\ell^-\pi^0\pi^0$

 $\Gamma(\tau^+\tau^-)/\Gamma_{\text{total}} \qquad \Gamma_3/\Gamma$

<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		⁵ 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		⁶ 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	$e^+e^- \rightarrow \mu^+\mu^-$
⁵ Taking into account interference between the resonance and continuum.				
⁶ 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>
<0.008	90	LURZ	87 CBAL	$e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$

 $\Gamma(\Upsilon(1S)\eta)/\Gamma_{\text{total}}$ 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. ● ● ●				
<0.005	90	ALBRECHT	87 ARG	$e^+e^- \rightarrow \pi^+\pi^-\ell^+\ell^- \text{ MM}$
<0.007	90	LURZ	87 CBAL	$e^+e^- \rightarrow \ell^+\ell^-(\gamma\gamma, 3\pi^0)$
<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>
0.067±0.009 OUR AVERAGE			
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>
0.066±0.009 OUR AVERAGE			
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>
0.043±0.010 OUR AVERAGE			
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	$e^+e^- \rightarrow \gamma X$

$\Gamma(\gamma f_J(1710))/\Gamma_{\text{total}}$ Γ_{12}/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID	TECN	COMMENT
<59	90	⁷ ALBRECHT	89 ARG	$\Upsilon(2S) \rightarrow \gamma K^+ K^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 5.9	90	⁸ ALBRECHT	89 ARG	$\Upsilon(2S) \rightarrow \gamma \pi^+ \pi^-$
⁷ Re-evaluated assuming $B(f_J(1710) \rightarrow K^+ K^-) = 0.19$.				
⁸ Includes unknown branching ratio of $f_J(1710) \rightarrow \pi^+ \pi^-$.				

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

VALUE (units 10^{-5})	CL%	DOCUMENT ID	TECN	COMMENT
<53	90	⁹ ALBRECHT	89 ARG	$\Upsilon(2S) \rightarrow \gamma K^+ K^-$
⁹ Re-evaluated assuming $B(f'_2(1525) \rightarrow K \bar{K}) = 0.71$.				

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

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

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

VALUE (units 10^{-5})	CL%	DOCUMENT ID	TECN	COMMENT
<6.8	90	¹¹ ALBRECHT	89 ARG	$\Upsilon(2S) \rightarrow \gamma K^+ K^-$
¹¹ Includes unknown branching ratio of $f_J(2220) \rightarrow K^+ K^-$.				

$\Upsilon(2S)$ REFERENCES

BARU	96	PRPL 267 71	+Blinov, Blinov, Bondar+	(NOVO)
ALBRECHT	95E	ZPHY C65 619	+Hamacher+	(ARGUS Collab.)
KOBEL	92	ZPHY C53 193	+Antreasyan, Bartels, Besset+	(Crystal Ball Collab.)
MASCHMANN	90	ZPHY C46 555	+Antreasyan, Bartels, Besset+	(Crystal Ball Collab.)
ALBRECHT	89	ZPHY C42 349	+Boeckmann, Glaeser, Harder+	(ARGUS Collab.)
KAARSBERG	89	PRL 62 2077	+Heintz+	(CUSB Collab.)
BUCHMUEL...	88	HE $e^+ e^-$ Physics 412	Buchmueller, Cooper	(HANN, DESY, MIT)
Editors: A. Ali and P. Soeding, World Scientific, Singapore				
JAKUBOWSKI	88	ZPHY C40 49	+Antreasyan, Bartels+	(Crystal Ball Collab.) IGJPC
ALBRECHT	87	ZPHY C35 283	+Binder, Boeckmann, Glaeser+	(ARGUS Collab.)
LURZ	87	ZPHY C36 383	+Antreasyan, Besset+	(Crystal Ball Collab.)
BARU	86B	ZPHY C32 622	+Blinov, Bondar, Bukin+	(NOVO)
ALBRECHT	85	ZPHY C28 45	+Dreschell, Heller+	(ARGUS Collab.)
ALBRECHT	85E	PL 160B 331	+Drescher, Heller+	(ARGUS Collab.)
GELPHMAN	85	PR D11 2893	+Lurz, Antreasyan+	(Crystal Ball Collab.)
KURAEV	85	SJNP 41 466	+Fadin	(NOVO)
Translated from YAF 41 733.				
NERNST	85	PRL 54 2195	+Antreasyan, Aschman+	(Crystal Ball Collab.)
ARTAMONOV	84	PL 137B 272	+Baru, Blinov, Bondar+	(NOVO)
BARBER	84	PL 135B 498	+	(DESY, ARGUS Collab., Crystal Ball Collab.)
BESSON	84	PR D30 1433	+Green, Hicks, Namjoshi, Sannes+	(CLEO Collab.)
FONSECA	84	NP B242 31	+Mageras, Son, Dietl, Eigen+	(CUSB Collab.)
GILES	84B	PR D29 1285	+Hassard, Hempstead, Kinoshita+	(CLEO Collab.)
HAAS	84	PRL 52 799	+Jensen, Kagan, Kass, Behrends+	(CLEO Collab.)
HAAS	84B	PR D30 1996	+Jensen, Kagan, Kass, Behrends+	(CLEO Collab.)
KLOPFEN...	83	PRL 51 160	Klopfenstein, Horstkotte+	(CUSB Collab.)
ALBRECHT	82	PL 116B 383	+Hofmann+	(DESY, DORT, HEIDH, LUND, ITEP)
NICZYPORUK	81B	PL 100B 95	+Chen, Folger, Lurz+	(LENA Collab.)
NICZYPORUK	81C	PL 99B 169	+Chen, Vogel, Wegener+	(LENA Collab.)
BOCK	80	ZPHY C6 125	+Blancar, Blum+	(HEIDP, MPIM, DESY, HAMB)

————— **OTHER RELATED PAPERS** —————

ALEXANDER	89	NP B320 45	+Bonvicini, Drell, Frey, Luth	(LBL, MICH, SLAC)
WALK	86	PR D34 2611	+Zschorsch+	(Crystal Ball Collab.)
ALBRECHT	84	PL 134B 137	+Drescher, Heller+	(ARGUS Collab.)
ARTAMONOV	84	PL 137B 272	+Baru, Blinov, Bondar+	(NOVO)
ANDREWS	83	PRL 50 807	+Avery, Berkelman, Cassel+	(CLEO Collab.)
GREEN	82	PRL 49 617	+Sannes, Skubic, Snyder+	(CLEO Collab.)
BLENLEIN	78	PL 78B 360	+Glawe, Bock, Blana+	(DESY, HAMB, HEIDP, MPIM)
DARDEN	78	PL 76B 246	+Hofmann, Schubert+	(DESY, DORT, HEIDH, LUND)
KAPLAN	78	PRL 40 435	+Appel, Herb, Hom+	(STON, FNAL, COLU)
YOH	78	PRL 41 684	+Herb, Hom, Lederman+	(COLU, FNAL, STON)
COBB	77	PL 72B 273	+Iwata, Fabjan+	(BNL, CERN, SYRA, YALE)
HERB	77	PRL 39 252	+Hom, Lederman, Appel, Ito+	(COLU, FNAL, STON)
INNES	77	PRL 39 1240	+Appel, Brown, Herb, Hom+	(COLU, FNAL, STON)
