$\Upsilon(2S)$

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

$\Upsilon(2S)$ MASS

VALUE (GeV)	DOCUMENT ID		TECN	COMMENT
10.02326±0.00031 OUR AVERAGE				
10.0235 ±0.0005	[1] ARTAMONOV	00	MD1	$e^+e^- \to$ hadrons
10.0231 ±0.0004	BARBER	84	REDE	$e^+e^- \to$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •				
10.0236 ±0.0005	[2,3] BARU	86B	REDE	$e^+e^- \to$ 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[3] Superseded by ARTAMONOV 00.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
31.98±2.63 OUR EVALUATION	See the Note on "Width Determinations of the Υ States"

$\Upsilon(2S)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)		Scale factor/ Confidence level
Γ_1	$\Upsilon(1S)\pi^+\pi^-$	(18.8 ±0.6) %		
Γ_2	$\Upsilon(1S)\pi^0\pi^0$	(9.0 ±0.8) %		
Γ_3	$\tau^+\tau^-$	(1.7 ±1.6) %		
Γ_4	$\mu^+\mu^-$	(1.93±0.17) %		S=2.2
Γ_5	e^+e^-	(1.91±0.16) %		
Γ_6	$\Upsilon(1S)\pi^0$	< 1.1	$\times 10^{-3}$	CL=90%
Γ_7	$\Upsilon(1S)\eta$	< 2	$\times 10^{-3}$	CL=90%
Γ_8	$J/\psi(1S)$ anything	< 6	$\times 10^{-3}$	CL=90%
	Radiative decays			
Γ_9	$\gamma\chi_{b1}(1P)$	(6.9 ±0.4) %		
Γ_{10}	$\gamma\chi_{b2}(1P)$	(7.15±0.35) %		
Γ_{11}	$\gamma\chi_{b0}(1P)$	(3.8 ±0.4) %		
Γ_{12}	$\gamma f_0(1710)$	< 5.9	$\times 10^{-4}$	CL=90%
Γ_{13}	$\gamma f_2'(1525)$	< 5.3	$\times 10^{-4}$	CL=90%
Γ_{14}	$\gamma f_2(1270)$	< 2.41	$\times 10^{-4}$	CL=90%
Γ_{15}	$\gamma f_J(2220)$			
Γ_{16}	$\gamma\eta_b(1S)$	< 5.1	$\times 10^{-4}$	CL=90%

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

$\Gamma(e^+e^-) \times \Gamma(\mu^+\mu^-)/\Gamma_{total}$ $\Gamma_5\Gamma_4/\Gamma$

VALUE (eV)	DOCUMENT ID		TECN	COMMENT
6.5±1.5±1.0	KOBEL	92	CBAL	$e^+e^- \to \mu^+\mu^-$

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

VALUE (keV)	DOCUMENT ID		TECN	COMMENT
0.577±0.009 OUR AVERAGE				
0.581 ± 0.004 ± 0.009	[4] ROSNER	06	CLEO	10.0 $e^+e^- \to$ hadrons
0.552 ± 0.031 ± 0.017	[4] BARU	96	MD1	$e^+e^- \to$ hadrons
0.54 ± 0.04 ± 0.02	[4] JAKUBOWSKI	88	CBAL	$e^+e^- \to$ hadrons
0.58 ± 0.03 ± 0.04	[5] GILES	84B	CLEO	$e^+e^- \to$ hadrons
0.60 ± 0.12 ± 0.07	[5] ALBRECHT	82	DASP	$e^+e^- \to$ hadrons
0.54 ± 0.07 $^{+0.09}_{-0.05}$	[5] NICZYPORUK	81C	LENA	$e^+e^- \to$ hadrons
0.41 ± 0.18	[5] BOCK	80	CNTR	$e^+e^- \to$ 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

VALUE (keV)	DOCUMENT ID
0.612±0.011 OUR EVALUATION	

$\Upsilon(2S)$ BRANCHING RATIOS

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

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.006	90	MASCHMANN	90	CBAL	$e^+e^- \to$ hadrons

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

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.188±0.006 OUR AVERAGE					
0.192 ± 0.002 ± 0.010	52.6k	[6] ALEXANDER	98	CLE2	$\pi^+\pi^-\ell^+\ell^-$, $\pi^+\pi^-$ MM
0.181 ± 0.005 ± 0.010	11.6k	ALBRECHT	87	ARG	$e^+e^- \to \pi^+\pi^-$ MM
0.169 ± 0.040		GELPHMAN	85	CBAL	$e^+e^- \to e^+e^-\pi^+\pi^-$
0.191 ± 0.012 ± 0.006		BESSON	84	CLEO	$\pi^+\pi^-$ MM
0.189 ± 0.026		FONSECA	84	CUSB	$e^+e^- \to \ell^+\ell^-\pi^+\pi^-$
0.21 ± 0.07	7	NICZYPORUK	81B	LENA	$e^+e^- \to \ell^+\ell^-\pi^+\pi^-$

[6] Using B($\Upsilon(1S) \to e^+e^-$) = (2.52 ± 0.17)% and B($\Upsilon(1S) \to \mu^+\mu^-$) = (2.48 ± 0.07)%.

$\Gamma(\Upsilon(1S)\pi^0\pi^0)/\Gamma_{total}$ Γ_2/Γ

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

[7] Using B($\Upsilon(1S) \to e^+e^-$) = (2.52 ± 0.17)% and B($\Upsilon(1S) \to \mu^+\mu^-$) = (2.48 ± 0.07)%.

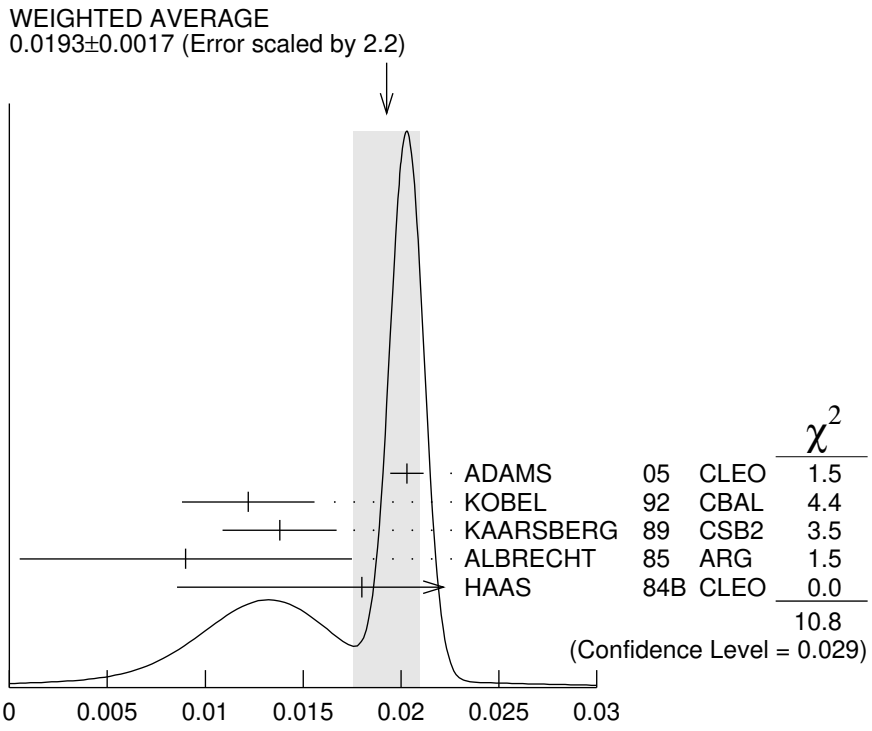
$\Gamma(\tau^+\tau^-)/\Gamma_{total}$ Γ_3/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.017±0.015±0.006	HAAS	84B	CLEO	$e^+e^- \to \tau^+\tau^-$

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

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
0.0193±0.0017 OUR AVERAGE Error includes scale factor of 2.2. See the ideogram below.						
0.0203±0.0003±0.0008		120k	ADAMS	05	CLEO	$e^+e^- \to \mu^+\mu^-$
0.0122±0.0028±0.0019			[8] KOBEL	92	CBAL	$e^+e^- \to \mu^+\mu^-$
0.0138±0.0025±0.0015			KAARSBERG	89	CSB2	$e^+e^- \to \mu^+\mu^-$
0.009 ±0.006 ±0.006			[9] ALBRECHT	85	ARG	$e^+e^- \to \mu^+\mu^-$
0.018 ±0.008 ±0.005			HAAS	84B	CLEO	$e^+e^- \to \mu^+\mu^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<0.038	90		NICZYPORUK	81C	LENA	$e^+e^- \to \mu^+\mu^-$

[8] Taking into account interference between the resonance and continuum.
[9] Re-evaluated using B($\Upsilon(1S) \to \mu^+\mu^-$) = 0.026.



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

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

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.0011	90	ALEXANDER	98	CLE2	$e^+e^- \to \ell^+\ell^-\gamma\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.008	90	LURZ	87	CBAL	$e^+e^- \to \ell^+\ell^-\gamma\gamma$

$\Gamma(\Upsilon(1S)\eta)/\Gamma_{total}$ Γ_7/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.002	90	FONSECA	84	CUSB	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.0028	90	ALEXANDER	98	CLE2	$e^+e^- \to \ell^+\ell^-\eta$
<0.005	90	ALBRECHT	87	ARG	$e^+e^- \to \pi^+\pi^-\ell^+\ell^-$ MM
<0.007	90	LURZ	87	CBAL	$e^+e^- \to \ell^+\ell^-(\gamma\gamma, 3\pi^0)$
<0.010	90	BESSON	84	CLEO	

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

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.069 ±0.004 OUR AVERAGE					
0.0693±0.0012±0.0041	407k	ARTUSO	05	CLEO	$e^+e^- \to \gamma X$
0.069 ±0.005 ±0.009		EDWARDS	99	CLE2	$\Upsilon(2S) \to \gamma\chi(1P)$
0.091 ±0.018 ±0.022		ALBRECHT	85E	ARG	$e^+e^- \to \gamma$ conv. X
0.065 ±0.007 ±0.012		NERNST	85	CBAL	$e^+e^- \to \gamma X$
0.080 ±0.017 ±0.016		HAAS	84	CLEO	$e^+e^- \to \gamma$ conv. X
0.059 ±0.014		KLOPFEN...	83	CUSB	$e^+e^- \to \gamma X$

$\Gamma(\gamma\chi_{b2}(1P))/\Gamma_{total}$ Γ_{10}/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.0715±0.0035 OUR AVERAGE					
0.0724±0.0011±0.0040	410k	ARTUSO	05	CLEO	$e^+e^- \to \gamma X$
0.074 ±0.005 ±0.008		EDWARDS	99	CLE2	$\Upsilon(2S) \to \gamma\chi(1P)$
0.098 ±0.021 ±0.024		ALBRECHT	85E	ARG	$e^+e^- \to \gamma$ conv. X
0.058 ±0.007 ±0.010		NERNST	85	CBAL	$e^+e^- \to \gamma X$
0.102 ±0.018 ±0.021		HAAS	84	CLEO	$e^+e^- \to \gamma$ conv. X
0.061 ±0.014		KLOPFEN...	83	CUSB	$e^+e^- \to \gamma X$

$\Gamma(\gamma\chi_{b0}(1P))/\Gamma_{total}$ Γ_{11}/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.038 ±0.004 OUR AVERAGE					
0.0375±0.0012±0.0047	198k	ARTUSO	05	CLEO	$e^+e^- \to \gamma X$
0.034 ±0.005 ±0.006		EDWARDS	99	CLE2	$\Upsilon(2S) \to \gamma\chi(1P)$
0.064 ±0.014 ±0.016		ALBRECHT	85E	ARG	$e^+e^- \to \gamma$ conv. X
0.036 ±0.008 ±0.009		NERNST	85	CBAL	$e^+e^- \to \gamma X$
0.044 ±0.023 ±0.009		HAAS	84	CLEO	$e^+e^- \to \gamma$ conv. X
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.035 ±0.014		KLOPFEN...	83	CUSB	$e^+e^- \to \gamma X$

$\Gamma(\gamma f_0(1710))/\Gamma_{total}$ Γ_{12}/Γ

VALUE (units 10^{-5})	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<59	90	[10] ALBRECHT	89	ARG	$\Upsilon(2S) \to \gamma K^+ K^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 5.9	90	[11] ALBRECHT	89	ARG	$\Upsilon(2S) \to \gamma \pi^+ \pi^-$

[10] Re-evaluated assuming $B(f_0(1710) \to K^+ K^-) = 0.19$.

[11] Includes unknown branching ratio of $f_0(1710) \to \pi^+ \pi^-$.

$\Gamma(\gamma f_2'(1525))/\Gamma_{total}$ Γ_{13}/Γ

VALUE (units 10^{-5})	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<53	90	[12] ALBRECHT	89	ARG	$\Upsilon(2S) \to \gamma K^+ K^-$

[12] Re-evaluated assuming $B(f_2'(1525) \to K\overline{K}) = 0.71$.

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

VALUE (units 10^{-5})	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<24.1	90	[13] ALBRECHT	89	ARG	$\Upsilon(2S) \to \gamma \pi^+ \pi^-$

[13] Using $B(f_2(1270) \to \pi\pi) = 0.84$.

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

VALUE (units 10^{-5})	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<6.8	90	[14] ALBRECHT	89	ARG	$\Upsilon(2S) \to \gamma K^+ K^-$

[14] Includes unknown branching ratio of $f_J(2220) \to K^+ K^-$.

$\Gamma(\gamma \eta_b(1S))/\Gamma_{total}$ Γ_{16}/Γ

VALUE (units 10^{-4})	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<5.1	90	ARTUSO	05	CLEO	$e^+ e^- \to \gamma X$

$\Upsilon(2S)$ REFERENCES

ROSNER	06	PRL 96 092003	J.L. Rosner *et al.*	(CLEO Collab.)
ADAMS	05	PRL 94 012001	G.S. Adams *et al.*	(CLEO Collab.)
ARTUSO	05	PRL 94 032001	M. Artuso *et al.*	(CLEO Collab.)
ARTAMONOV	00	PL B474 427	A.S. Artamonov *et al.*	
EDWARDS	99	PR D59 032003	K.W. Edwards *et al.*	(CLEO Collab.)
ALEXANDER	98	PR D58 052004	J.P. Alexander *et al.*	(CLEO Collab.)
BARU	96	PRPL 267 71	S.E. Baru *et al.*	(NOVO)
KOBEL	92	ZPHY C53 193	M. Kobel *et al.*	(Crystal Ball Collab.)
MASCHMANN	90	ZPHY C46 555	W.S. Maschmann *et al.*	(Crystal Ball Collab.)
ALBRECHT	89	ZPHY C42 349	H. Albrecht *et al.*	(ARGUS Collab.)
KAARSBERG	89	PRL 62 2077	T.M. Kaarsberg *et al.*	(CUSB Collab.)
BUCHMUEL...	88	HE $e^+ e^-$ Physics 412 Editors: A. Ali and P. Soeding, World Scientific, Singapore	W. Buchmueller, S. Cooper	(HANN, DESY, MIT)
JAKUBOWSKI	88	ZPHY C40 49	Z. Jakubowski *et al.*	(Crystal Ball Collab.) IGJPC
ALBRECHT	87	ZPHY C35 283	H. Albrecht *et al.*	(ARGUS Collab.)
COHEN	87	RMP 59 1121	E.R. Cohen, B.N. Taylor	(RISC, NBS)
LURZ	87	ZPHY C36 383	B. Lurz *et al.*	(Crystal Ball Collab.)
BARU	86B	ZPHY C32 622	S.E. Baru *et al.*	(NOVO)
ALBRECHT	85	ZPHY C28 45	H. Albrecht *et al.*	(ARGUS Collab.)
ALBRECHT	85E	PL 160B 331	H. Albrecht *et al.*	(ARGUS Collab.)
GELPHMAN	85	PR D11 2893	D. Gelphman *et al.*	(Crystal Ball Collab.)
KURAEV	85	SJNP 41 466 Translated from YAF 41 733.	E.A. Kuraev, V.S. Fadin	(NOVO)

NERNST	85	PRL 54 2195	R. Nernst *et al.*	(Crystal Ball Collab.)
ARTAMONOV	84	PL 137B 272	A.S. Artamonov *et al.*	(NOVO)
BARBER	84	PL 135B 498	D.P. Barber *et al.*	
BESSON	84	PR D30 1433	D. Besson *et al.*	(CLEO Collab.)
FONSECA	84	NP B242 31	V. Fonseca *et al.*	(CUSB Collab.)
GILES	84B	PR D29 1285	R. Giles *et al.*	(CLEO Collab.)
HAAS	84	PRL 52 799	J. Haas *et al.*	(CLEO Collab.)
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KLOPFEN...	83	PRL 51 160	C. Klopfenstein *et al.*	(CUSB Collab.)
ALBRECHT	82	PL 116B 383	H. Albrecht *et al.*	(DESY, DORT, HEIDH+)
NICZYPORUK	81B	PL 100B 95	B. Niczyporuk *et al.*	(LENA Collab.)
NICZYPORUK	81C	PL 99B 169	B. Niczyporuk *et al.*	(LENA Collab.)
BOCK	80	ZPHY C6 125	P. Bock *et al.*	(HEIDP, MPIM, DESY, HAMB)

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