

$\Upsilon(3S)$

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

$\Upsilon(3S)$ MASS

<u>VALUE (GeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
10.3552 ± 0.0005	¹ ARTAMONOV 00	MD1	$e^+ e^- \rightarrow$ hadrons
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
10.3553 ± 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³ Superseded by ARTAMONOV 00.			

$\Upsilon(3S)$ WIDTH

<u>VALUE (keV)</u>	<u>DOCUMENT ID</u>
22.1 ± 2.7 OUR EVALUATION	See the Note on Width Determinations of the Υ states

$\Upsilon(3S)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)	Scale factor/ Confidence level
Γ_1 $\Upsilon(2S)$ anything	(10.6 ± 0.8) %	
Γ_2 $\Upsilon(2S) \pi^+ \pi^-$	(2.8 ± 0.6) %	S=2.2
Γ_3 $\Upsilon(2S) \pi^0 \pi^0$	(2.00 ± 0.32) %	
Γ_4 $\Upsilon(2S) \gamma \gamma$	(5.0 ± 0.7) %	
Γ_5 $\Upsilon(1S) \pi^+ \pi^-$	(4.48 ± 0.21) %	
Γ_6 $\Upsilon(1S) \pi^0 \pi^0$	(2.06 ± 0.28) %	
Γ_7 $\Upsilon(1S) \eta$	< 2.2 × 10 ⁻³	CL=90%
Γ_8 $\mu^+ \mu^-$	(2.18 ± 0.21) %	S=2.1
Γ_9 $e^+ e^-$	seen	

Radiative decays

Γ_{10} $\gamma \chi_{b2}(2P)$	(13.1 ± 1.6) %	S=3.4
Γ_{11} $\gamma \chi_{b1}(2P)$	(12.6 ± 1.2) %	S=2.4
Γ_{12} $\gamma \chi_{b0}(2P)$	(5.9 ± 0.6) %	S=1.4
Γ_{13} $\gamma \chi_{b0}(1P)$	(3.0 ± 1.1) × 10 ⁻³	
Γ_{14} $\gamma \eta_b(2S)$	< 6.2 × 10 ⁻⁴	CL=90%
Γ_{15} $\gamma \eta_b(1S)$	< 4.3 × 10 ⁻⁴	CL=90%

$\Upsilon(3S) \Gamma(i)\Gamma(e^+ e^-)/\Gamma(\text{total})$

$\Gamma(\text{hadrons}) \times \Gamma(e^+ e^-)/\Gamma_{\text{total}}$	$\Gamma_0 \Gamma_9/\Gamma$
<u>VALUE (keV)</u>	<u>DOCUMENT ID</u> <u>TECN</u> <u>COMMENT</u>
0.45 ± 0.03 ± 0.03	⁴ GILES 84B CLEO $e^+ e^- \rightarrow$ hadrons
⁴ Radiative corrections reevaluated by BUCHMUELLER 88 following KURAEV 85.	

$\Upsilon(3S)$ BRANCHING RATIOS

$\Gamma(\Upsilon(2S)\text{anything})/\Gamma_{\text{total}}$ Γ_1/Γ

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.106 ± 0.008 OUR AVERAGE				
0.1023 ± 0.0105	4625	5,6,7 BUTLER	94B CLE2	$e^+e^- \rightarrow \ell^+\ell^- X$
0.111 ± 0.012	4891	6,7,8 BROCK	91 CLEO	$e^+e^- \rightarrow \pi^+\pi^- X,$ $\pi^+\pi^-\ell^+\ell^-$

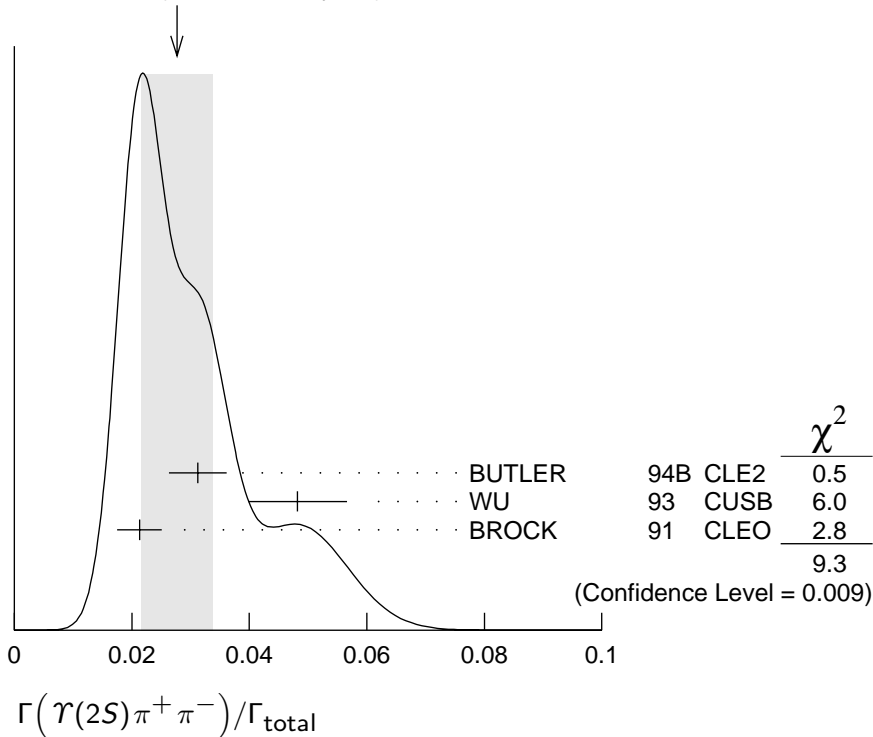
$\Gamma(\Upsilon(2S)\pi^+\pi^-)/\Gamma_{\text{total}}$ Γ_2/Γ

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.028 ± 0.006 OUR AVERAGE Error includes scale factor of 2.2. See the ideogram below.				
0.0312 ± 0.0049	980	5,9 BUTLER	94B CLE2	$e^+e^- \rightarrow \pi^+\pi^-\ell^+\ell^-$
0.0482 ± 0.0065 ± 0.0053	138	8 WU	93 CUSB	$\Upsilon(3S) \rightarrow \pi^+\pi^-\ell^+\ell^-$
0.0213 ± 0.0038	974	8 BROCK	91 CLEO	$e^+e^- \rightarrow \pi^+\pi^- X,$ $\pi^+\pi^-\ell^+\ell^-$

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

0.031 ± 0.020	5	MAGERAS	82 CUSB	$\Upsilon(3S) \rightarrow \pi^+\pi^-\ell^+\ell^-$
---------------	---	---------	---------	---

WEIGHTED AVERAGE
0.028 ± 0.006 (Error scaled by 2.2)



$\Gamma(\Upsilon(2S)\pi^0\pi^0)/\Gamma_{\text{total}}$ Γ_3/Γ

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.0200 ± 0.0032 OUR AVERAGE				
0.0216 ± 0.0039	9,10	BUTLER	94B CLE2	$e^+e^- \rightarrow \ell^+\ell^-\pi^0\pi^0$
0.017 ± 0.005 ± 0.002	10 11	HEINTZ	92 CSB2	$e^+e^- \rightarrow \ell^+\ell^-\pi^0\pi^0$

$\Gamma(\Upsilon(2S)\gamma\gamma)/\Gamma_{\text{total}}$ Γ_4/Γ

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.0502 ± 0.0069			
9	BUTLER	94B CLE2	$e^+e^- \rightarrow \ell^+\ell^-2\gamma$

$\Gamma(\Upsilon(1S)\pi^+\pi^-)/\Gamma_{\text{total}}$ Γ_5/Γ

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.0448 ± 0.0021 OUR AVERAGE				
0.0452 ± 0.0035	11830	6 BUTLER	94B CLE2	$e^+e^- \rightarrow \pi^+\pi^-X,$ $\pi^+\pi^-\ell^+\ell^-$
0.0446 ± 0.0034 ± 0.0050	451	6 WU	93 CUSB	$\Upsilon(3S) \rightarrow \pi^+\pi^-\ell^+\ell^-$
0.0446 ± 0.0030	11221	6 BROCK	91 CLEO	$e^+e^- \rightarrow \pi^+\pi^-X,$ $\pi^+\pi^-\ell^+\ell^-$

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

0.049 ± 0.010	22	GREEN	82 CLEO	$\Upsilon(3S) \rightarrow \pi^+\pi^-\ell^+\ell^-$
0.039 ± 0.013	26	MAGERAS	82 CUSB	$\Upsilon(3S) \rightarrow \pi^+\pi^-\ell^+\ell^-$

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

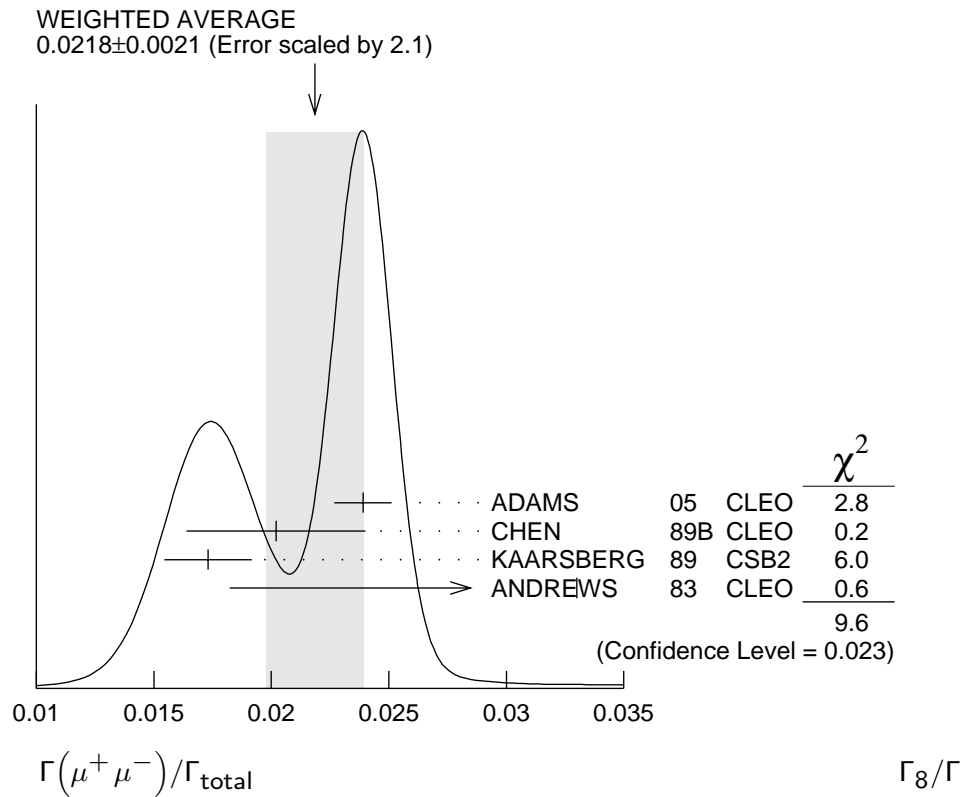
<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.0206 ± 0.0028 OUR AVERAGE				
0.0199 ± 0.0034	56	6 BUTLER	94B CLE2	$e^+e^- \rightarrow \ell^+\ell^-\pi^0\pi^0$
0.022 ± 0.004 ± 0.003	33	12 HEINTZ	92 CSB2	$e^+e^- \rightarrow \ell^+\ell^-\pi^0\pi^0$

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

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<0.0022				
	90	BROCK	91 CLEO	$e^+e^- \rightarrow \pi^+\pi^-\pi^0\ell^+\ell^-$

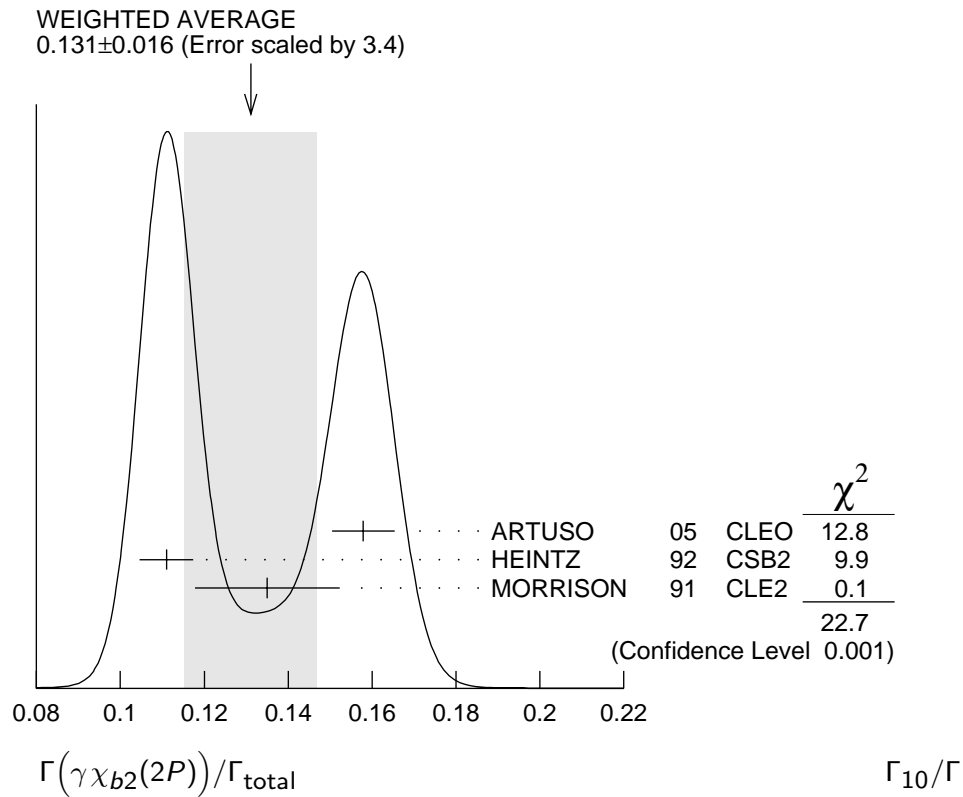
$\Gamma(\mu^+\mu^-)/\Gamma_{\text{total}}$ Γ_8/Γ

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.0218 ± 0.0021 OUR AVERAGE Error includes scale factor of 2.1. See the ideogram below.				
0.0239 ± 0.0007 ± 0.0010	81k	ADAMS	05 CLEO	$e^+e^- \rightarrow \mu^+\mu^-$
0.0202 ± 0.0019 ± 0.0033		CHEN	89B CLEO	$e^+e^- \rightarrow \mu^+\mu^-$
0.0173 ± 0.0015 ± 0.0011		KAARSBERG	89 CSB2	$e^+e^- \rightarrow \mu^+\mu^-$
0.033 ± 0.013 ± 0.007	1096	ANDREWS	83 CLEO	$e^+e^- \rightarrow \mu^+\mu^-$



$\Gamma(\gamma \chi_{b2}(2P)) / \Gamma_{\text{total}}$ Γ_{10} / Γ

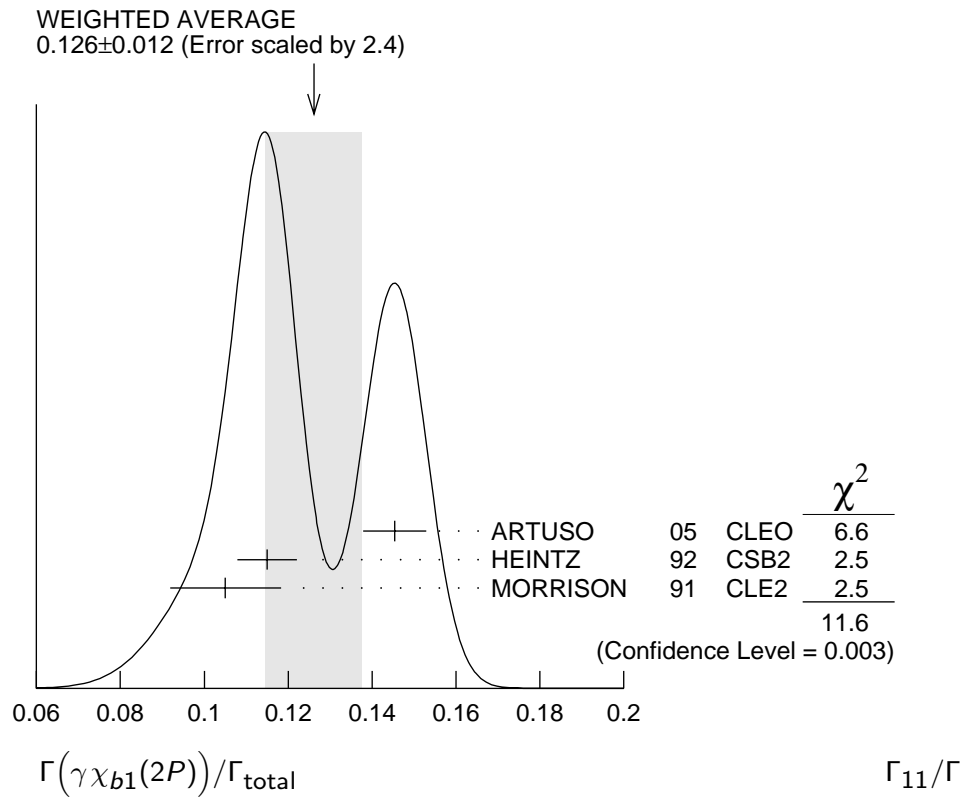
<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.131 ± 0.016 OUR AVERAGE				Error includes scale factor of 3.4. See the ideogram below.
0.1579 ± 0.0017 ± 0.0073	568k	ARTUSO	05 CLEO	$e^+ e^- \rightarrow \gamma X$
0.111 ± 0.005 ± 0.004	10319	¹³ HEINTZ	92 CSB2	$e^+ e^- \rightarrow \gamma X$
0.135 ± 0.003 ± 0.017	30741	MORRISON	91 CLE2	$e^+ e^- \rightarrow \gamma X$



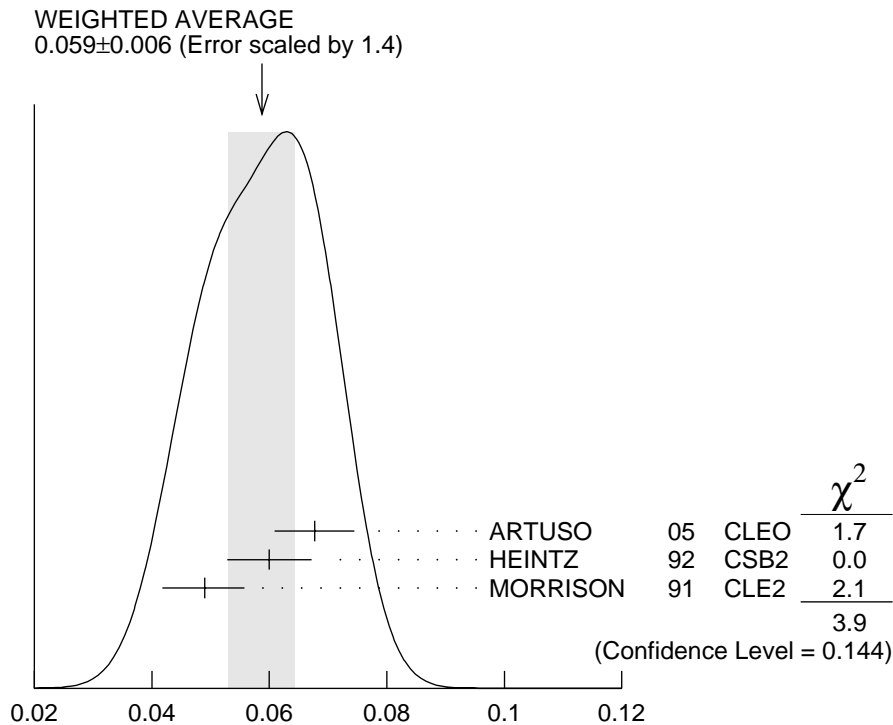
$\Gamma(\gamma\chi_{b1}(2P))/\Gamma_{\text{total}}$

Γ_{11}/Γ

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.126 ± 0.012 OUR AVERAGE				Error includes scale factor of 2.4. See the ideogram below.
$0.1454 \pm 0.0018 \pm 0.0073$	537k	ARTUSO	05 CLEO	$e^+e^- \rightarrow \gamma X$
$0.115 \pm 0.005 \pm 0.005$	11147	¹³ HEINTZ	92 CSB2	$e^+e^- \rightarrow \gamma X$
$0.105 \begin{smallmatrix} +0.003 \\ -0.002 \end{smallmatrix} \pm 0.013$	25759	MORRISON	91 CLE2	$e^+e^- \rightarrow \gamma X$



$\Gamma(\gamma\chi_{b0}(2P))/\Gamma_{\text{total}}$						Γ_{12}/Γ
VALUE	EVTS	DOCUMENT ID	TECN	COMMENT		
0.059 ± 0.006 OUR AVERAGE		Error includes scale factor of 1.4. See the ideogram below.				
0.0677 ± 0.0020 ± 0.0065	225k	ARTUSO	05 CLEO	$e^+e^- \rightarrow \gamma X$		
0.060 ± 0.004 ± 0.006	4959	¹³ HEINTZ	92 CSB2	$e^+e^- \rightarrow \gamma X$		
0.049 ^{+0.003} / _{-0.004} ± 0.006	9903	MORRISON	91 CLE2	$e^+e^- \rightarrow \gamma X$		



$\Gamma(\gamma\chi_{b0}(2P))/\Gamma_{\text{total}}$ Γ_{12}/Γ

$\Gamma(\gamma\chi_{b0}(1P))/\Gamma_{\text{total}}$ Γ_{13}/Γ

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
$0.30 \pm 0.04 \pm 0.10$	8.7k	ARTUSO	05	CLEO $e^+e^- \rightarrow \gamma X$

$\Gamma(\gamma\eta_b(2S))/\Gamma_{\text{total}}$ Γ_{14}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	COMMENT
<6.2	90	ARTUSO	05	CLEO $e^+e^- \rightarrow \gamma X$

$\Gamma(\gamma\eta_b(1S))/\Gamma_{\text{total}}$ Γ_{15}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	COMMENT
<4.3	90	ARTUSO	05	CLEO $e^+e^- \rightarrow \gamma X$

⁵ Using $B(\Upsilon(2S) \rightarrow \Upsilon(1S)\gamma\gamma) = (0.038 \pm 0.007)\%$, and $B(\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^0\pi^0) = (1/2)B(\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^+\pi^-)$.

⁶ Using $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.06)\%$. With the assumption of $e\mu$ universality.

⁷ Using $B(\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^+\pi^-) = (18.5 \pm 0.8)\%$.

⁸ Using $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.31 \pm 0.21)\%$, $B(\Upsilon(2S) \rightarrow \Upsilon(1S)\gamma\gamma) \times 2B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (0.188 \pm 0.035)\%$, and $B(\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^0\pi^0) \times 2B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (0.436 \pm 0.056)\%$. With the assumption of $e\mu$ universality.

⁹ From the exclusive mode.

¹⁰ $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.31 \pm 0.21)\%$ and assuming $e\mu$ universality.

¹¹ $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.44 \pm 0.10)\%$ and assuming $e\mu$ universality. Supersedes HEINTZ 91.

¹² Using $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.57 \pm 0.07)\%$ and assuming $e\mu$ universality. Supersedes HEINTZ 91.

¹³ Supersedes NARAIN 91.

$\tau(3S)$ REFERENCES

ADAMS	05	PRL 94 012001	G.S. Adams <i>et al.</i>	(CLEO Collab.)
ARTUSO	05	PRL 94 032001	M. Artuso <i>et al.</i>	(CLEO Collab.)
ARTAMONOV	00	PL B474 427	A.S. Artamonov <i>et al.</i>	
BUTLER	94B	PR D49 40	F. Butler <i>et al.</i>	(CLEO Collab.)
WU	93	PL B301 307	Q.W. Wu <i>et al.</i>	(CUSB Collab.)
HEINTZ	92	PR D46 1928	U. Heintz <i>et al.</i>	(CUSB II Collab.)
BROCK	91	PR D43 1448	I.C. Brock <i>et al.</i>	(CLEO Collab.)
HEINTZ	91	PRL 66 1563	U. Heintz <i>et al.</i>	(CUSB Collab.)
MORRISON	91	PRL 67 1696	R.J. Morrison <i>et al.</i>	(CLEO Collab.)
NARAIN	91	PRL 66 3113	M. Narain <i>et al.</i>	(CUSB Collab.)
CHEN	89B	PR D39 3528	W.Y. Chen <i>et al.</i>	(CLEO Collab.)
KAARSBERG	89	PRL 62 2077	T.M. Kaarsberg <i>et al.</i>	(CUSB Collab.)
BUCHMUEL...	88	HE e^+e^- Physics 412	W. Buchmueller, S. Cooper	(HANN, DESY, MIT)
Editors: A. Ali and P. Soeding, World Scientific, Singapore				
COHEN	87	RMP 59 1121	E.R. Cohen, B.N. Taylor	(RISC, NBS)
BARU	86B	ZPHY C32 622	S.E. Baru <i>et al.</i>	(NOVO)
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)
GILES	84B	PR D29 1285	R. Giles <i>et al.</i>	(CLEO Collab.)
ANDREWS	83	PRL 50 807	D.E. Andrews <i>et al.</i>	(CLEO Collab.)
GREEN	82	PRL 49 617	J. Green <i>et al.</i>	(CLEO Collab.)
MAGERAS	82	PL 118B 453	G. Mageras <i>et al.</i>	(COLU, CORN, LSU+)

OTHER RELATED PAPERS

ROSNER	03	PR D67 097504	J.L. Rosner	
ALEXANDER	89	NP B320 45	J.P. Alexander <i>et al.</i>	(LBL, MICH, SLAC)
ARTAMONOV	84	PL 137B 272	A.S. Artamonov <i>et al.</i>	(NOVO)
GILES	84B	PR D29 1285	R. Giles <i>et al.</i>	(CLEO Collab.)
HAN	82	PRL 49 1612	K. Han <i>et al.</i>	(CUSB Collab.)
PETERSON	82	PL 114B 277	D. Peterson <i>et al.</i>	(CUSB Collab.)
KAPLAN	78	PRL 40 435	D.M. Kaplan <i>et al.</i>	(STON, FNAL, COLU)
YOH	78	PRL 41 684	J.K. Yoh <i>et al.</i>	(COLU, FNAL, STON)
COBB	77	PL 72B 273	J.H. Cobb <i>et al.</i>	(BNL, CERN, SYRA, YALE)
HERB	77	PRL 39 252	S.W. Herb <i>et al.</i>	(COLU, FNAL, STON)
INNES	77	PRL 39 1240	W.R. Innes <i>et al.</i>	(COLU, FNAL, STON)