

$\Upsilon(3S)$

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

$\Upsilon(3S)$ MASS

VALUE (GeV)	DOCUMENT ID	TECN	COMMENT
10.3553 ± 0.0005	¹ BARU	86B REDE	$e^+e^- \rightarrow$ hadrons
¹ Reanalysis of ARTAMONOV 84.			

$\Upsilon(3S)$ WIDTH

VALUE (keV)	DOCUMENT ID
26.3 ± 3.5 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 $\mu^+\mu^-$	(1.81 ± 0.17) %	
Γ_9 e^+e^-	seen	
Radiative decays		
Γ_{10} $\gamma\chi_{b2}(2P)$	(11.4 ± 0.8) %	S=1.3
Γ_{11} $\gamma\chi_{b1}(2P)$	(11.3 ± 0.6) %	
Γ_{12} $\gamma\chi_{b0}(2P)$	(5.4 ± 0.6) %	S=1.1

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

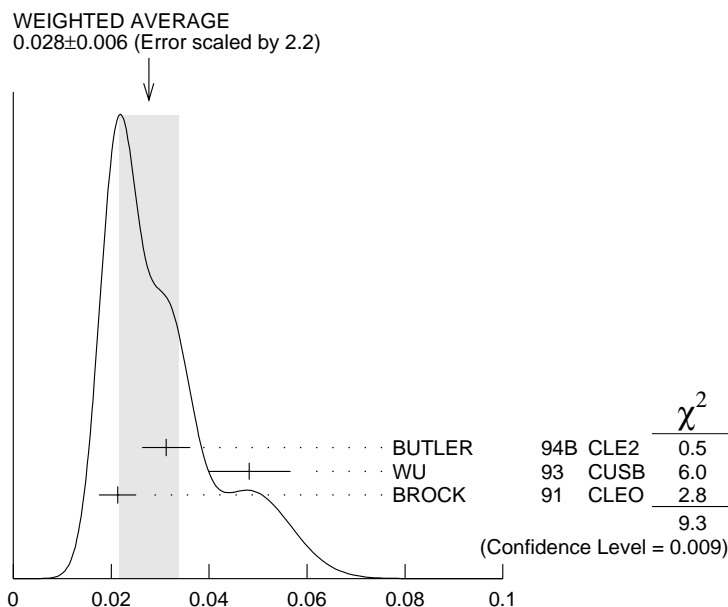
$\Gamma(\text{hadrons}) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$	DOCUMENT ID	TECN	COMMENT	$\Gamma_0\Gamma_9/\Gamma$
0.45 ± 0.03 ± 0.03	² GILES	84B CLEO	$e^+e^- \rightarrow$ hadrons	
² Radiative corrections reevaluated by BUCHMUELLER 88 following KURAEV 85.				

$\Upsilon(3S)$ BRANCHING RATIOS

$\Gamma(\Upsilon(2S)\text{anything})/\Gamma_{\text{total}}$	EVTS	DOCUMENT ID	TECN	COMMENT	Γ_1/Γ
0.106 ± 0.008 OUR AVERAGE					
0.1023 ± 0.0105	4625	^{3,4,5} BUTLER	94B CLE2	$e^+e^- \rightarrow \ell^+\ell^-X$	
0.111 ± 0.012	4891	^{4,5,6} 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	3,7 BUTLER	94B CLE2	$e^+e^- \rightarrow \pi^+\pi^-\ell^+\ell^-$
0.0482 ± 0.0065 ± 0.0053	138	6 WU	93 CUSB	$\Upsilon(3S) \rightarrow \pi^+\pi^-\ell^+\ell^-$
0.0213 ± 0.0038	974	6 BROCK	91 CLEO	$e^+e^- \rightarrow \pi^+\pi^-\ell^+\ell^-$ $\pi^+\pi^-\chi$, $\pi^+\pi^-\ell^+\ell^-$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
0.031 ± 0.020	5	MAGERAS	82 CUSB	$\Upsilon(3S) \rightarrow \pi^+\pi^-\ell^+\ell^-$


 $\Gamma(\Upsilon(2S)\pi^+\pi^-)/\Gamma_{\text{total}}$
 $\Gamma(\Upsilon(2S)\pi^0\pi^0)/\Gamma_{\text{total}}$
 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	7,8	BUTLER	94B CLE2	$e^+e^- \rightarrow \ell^+\ell^-\pi^0\pi^0$
0.017 ± 0.005 ± 0.002	10	9 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	7 BUTLER	94B CLE2	$e^+e^- \rightarrow \ell^+\ell^-2\gamma$

$\Gamma(\Upsilon(1S)\pi^+\pi^-)/\Gamma_{\text{total}} \qquad \Gamma_5/\Gamma$

<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	4 BUTLER	94B CLE2	$e^+e^- \rightarrow \pi^+\pi^-X,$ $\pi^+\pi^-\ell^+\ell^-$
0.0446 ± 0.0034 ± 0.0050	451	4 WU	93 CUSB	$\Upsilon(3S) \rightarrow \pi^+\pi^-\ell^+\ell^-$
0.0446 ± 0.0030	11221	4 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	$\Upsilon(3S) \rightarrow \pi^+\pi^-\ell^+\ell^-$

 $\Gamma(\Upsilon(1S)\pi^0\pi^0)/\Gamma_{\text{total}} \qquad \Gamma_6/\Gamma$

<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	4 BUTLER	94B CLE2	$e^+e^- \rightarrow \ell^+\ell^-\pi^0\pi^0$
0.022 ± 0.004 ± 0.003	33	10 HEINTZ	92 CSB2	$e^+e^- \rightarrow \ell^+\ell^-\pi^0\pi^0$

 $\Gamma(\Upsilon(1S)\eta)/\Gamma_{\text{total}} \qquad \Gamma_7/\Gamma$

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

 $\Gamma(\mu^+\mu^-)/\Gamma_{\text{total}} \qquad \Gamma_8/\Gamma$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.0181 ± 0.0017 OUR AVERAGE				
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	$e^+e^- \rightarrow \mu^+\mu^-$

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

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.114 ± 0.008 OUR AVERAGE	Error includes scale factor of 1.3.			
0.111 ± 0.005 ± 0.004	10319	11 HEINTZ	92 CSB2	$e^+e^- \rightarrow \gamma$
0.135 ± 0.003 ± 0.017	30741	MORRISON	91 CLE2	$e^+e^- \rightarrow \gamma X$

 $\Gamma(\gamma\chi_{b1}(2P))/\Gamma_{\text{total}} \qquad \Gamma_{11}/\Gamma$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.113 ± 0.006 OUR AVERAGE				
0.115 ± 0.005 ± 0.005	11147	11 HEINTZ	92 CSB2	$e^+e^- \rightarrow \gamma$
0.105 ^{+0.003} _{-0.002} ± 0.013	25759	MORRISON	91 CLE2	$e^+e^- \rightarrow \gamma X$

$\Gamma(\gamma\chi_{b0}(2P))/\Gamma_{\text{total}}$					Γ_{12}/Γ
<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
0.054 ± 0.006 OUR AVERAGE	Error includes scale factor of 1.1.				
0.060 ± 0.004 ± 0.006	4959	¹¹ HEINTZ	92 CSB2	$e^+e^- \rightarrow \gamma$	
0.049 ^{+0.003} _{-0.004} ± 0.006	9903	MORRISON	91 CLE2	$e^+e^- \rightarrow \gamma X$	
³ Using $B(\Upsilon(2S) \rightarrow \Upsilon(1S)\gamma\gamma) = (0.038 \pm 0.007)\%$, and $B(\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^0\pi^0) = (1/2)B(\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^+\pi^-)$.					
⁴ Using $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.06)\%$. With the assumption of $e\mu$ universality.					
⁵ Using $B(\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^+\pi^-) = (18.5 \pm 0.8)\%$.					
⁶ 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.					
⁷ From the exclusive mode.					
⁸ $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.31 \pm 0.21)\%$ and assuming $e\mu$ universality.					
⁹ $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.44 \pm 0.10)\%$ and assuming $e\mu$ universality. Supersedes HEINTZ 91.					
¹⁰ Using $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.57 \pm 0.07)\%$ and assuming $e\mu$ universality. Supersedes HEINTZ 91.					
¹¹ Supersedes NARAIN 91.					

$\Upsilon(3S)$ REFERENCES

BUTLER	94B	PR D49 40	+Fu, Kalbfleisch, Lambrecht+	(CLEO Collab.)
WU	93	PL B301 307	+Franzini, Kanekal+	(CUSB Collab.)
HEINTZ	92	PR D46 1928	+Lee, Franzini+	(CUSB II Collab.)
BROCK	91	PR D43 1448	+Ferguson+	(CLEO Collab.)
HEINTZ	91	PRL 66 1563	+Kaarsberg+	(CUSB Collab.)
MORRISON	91	PRL 67 1696	+Schmidt+	(CLEO Collab.)
NARAIN	91	PRL 66 3113	+Loveloock+	(CUSB Collab.)
CHEN	89B	PR D39 3528	+Mcllwain, Miller+	(CLEO 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				
BARU	86B	ZPHY C32 622	+Blinov, Bondar, Bukin+	(NOVO)
KURAEV	85	SJNP 41 466	+Fadin	(NOVO)
Translated from YAF 41 733.				
ARTAMONOV	84	PL 137B 272	+Baru, Blinov, Bondar+	(NOVO)
GILES	84B	PR D29 1285	+Hassard, Hempstead, Kinoshita+	(CLEO Collab.)
ANDREWS	83	PRL 50 807	+Avery, Berkelman, Cassel+	(CLEO Collab.)
GREEN	82	PRL 49 617	+Sannes, Skubic, Snyder+	(CLEO Collab.)
MAGERAS	82	PL 118B 453	+Herb, Imlay+	(COLU, CORN, LSU, MPIM, STON)

OTHER RELATED PAPERS

ALEXANDER	89	NP B320 45	+Bonvicini, Drell, Frey, Luth	(LBL, MICH, SLAC)
ARTAMONOV	84	PL 137B 272	+Baru, Blinov, Bondar+	(NOVO)
GILES	84B	PR D29 1285	+Hassard, Hempstead, Kinoshita+	(CLEO Collab.)
HAN	82	PRL 49 1612	+Horstkotte, Imlay+	(CUSB Collab.)
PETERSON	82	PL 114B 277	+Giannini, Lee-Franzini+	(CUSB Collab.)
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)