

# $\Upsilon(3S)$

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

## $\Upsilon(3S)$ MASS

VALUE (GeV)	DOCUMENT ID	TECN	COMMENT
<b>10.3552 ± 0.0005</b>	<sup>1</sup> ARTAMONOV 00	MD1	$e^+e^- \rightarrow$ hadrons
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
10.3553 ± 0.0005	<sup>2,3</sup> BARU	86B REDE	$e^+e^- \rightarrow$ hadrons
<sup>1</sup> Reanalysis of BARU 86B using new electron mass (COHEN 87).			
<sup>2</sup> Reanalysis of ARTAMONOV 84.			
<sup>3</sup> Superseded by ARTAMONOV 00.			

## $\Upsilon(3S)$ WIDTH

VALUE (keV)	DOCUMENT ID
<b>26.3 ± 3.5 OUR EVALUATION</b>	See the Note on Width Determinations of the $\Upsilon$ states

## $\Upsilon(3S)$ DECAY MODES

Mode	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level
$\Gamma_1$ $\Upsilon(2S)$ anything	(10.6 ± 0.8) %	
$\Gamma_2$ $\Upsilon(2S)\pi^+\pi^-$	(2.8 ± 0.6) %	S=2.2
$\Gamma_3$ $\Upsilon(2S)\pi^0\pi^0$	(2.00 ± 0.32) %	
$\Gamma_4$ $\Upsilon(2S)\gamma\gamma$	(5.0 ± 0.7) %	
$\Gamma_5$ $\Upsilon(1S)\pi^+\pi^-$	(4.48 ± 0.21) %	
$\Gamma_6$ $\Upsilon(1S)\pi^0\pi^0$	(2.06 ± 0.28) %	
$\Gamma_7$ $\Upsilon(1S)\eta$	< 2.2 × 10 <sup>-3</sup>	CL=90%
$\Gamma_8$ $\mu^+\mu^-$	(1.81 ± 0.17) %	
$\Gamma_9$ $e^+e^-$	seen	
<b>Radiative decays</b>		
$\Gamma_{10}$ $\gamma\chi_{b2}(2P)$	(11.4 ± 0.8) %	S=1.3
$\Gamma_{11}$ $\gamma\chi_{b1}(2P)$	(11.3 ± 0.6) %	
$\Gamma_{12}$ $\gamma\chi_{b0}(2P)$	(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	$\Gamma_0\Gamma_9/\Gamma$
<b>0.45 ± 0.03 ± 0.03</b>	<sup>4</sup> GILES	84B CLEO	$e^+e^- \rightarrow$ hadrons	
<sup>4</sup> Radiative corrections reevaluated by BUCHMUELLER 88 following KURAEV 85.				

## $\Upsilon(3S)$ BRANCHING RATIOS

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

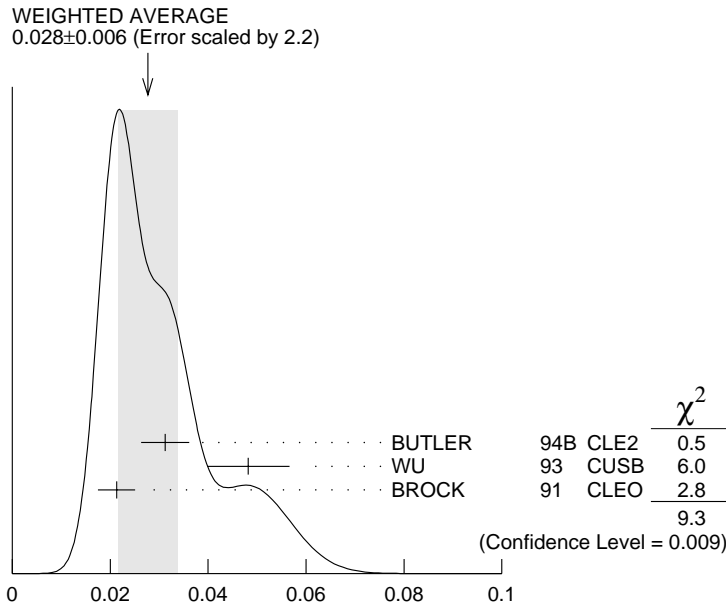
$\Gamma_1/\Gamma$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.106 ± 0.008 OUR AVERAGE</b>				
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	$e^+e^- \rightarrow \pi^+\pi^- X,$ $\pi^+\pi^-\ell^+\ell^-$

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

$\Gamma_2/\Gamma$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.028 ± 0.006 OUR AVERAGE</b>				
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	$\Upsilon(3S) \rightarrow \pi^+\pi^-\ell^+\ell^-$



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

$\Gamma(\Upsilon(2S)\pi^0\pi^0)/\Gamma_{\text{total}}$   $\Gamma_3/\Gamma$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0200±0.0032 OUR AVERAGE</b>				
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	$e^+e^- \rightarrow \ell^+\ell^-\pi^0\pi^0$

$\Gamma(\Upsilon(2S)\gamma\gamma)/\Gamma_{\text{total}}$   $\Gamma_4/\Gamma$

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

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

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0448±0.0021 OUR AVERAGE</b>				
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	$\Upsilon(3S) \rightarrow \pi^+\pi^-\ell^+\ell^-$

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

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0206±0.0028 OUR AVERAGE</b>				
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	$e^+e^- \rightarrow \ell^+\ell^-\pi^0\pi^0$

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

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

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

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

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

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.114±0.008 OUR AVERAGE</b>				
Error includes scale factor of 1.3.				
0.111±0.005±0.004	10319	13 HEINTZ	92 CSB2	$e^+e^- \rightarrow \gamma$
0.135±0.003±0.017	30741	MORRISON	91 CLE2	$e^+e^- \rightarrow \gamma X$

$\Gamma(\gamma\chi_{b1}(2P))/\Gamma_{\text{total}}$					$\Gamma_{11}/\Gamma$
<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<b>0.113±0.006 OUR AVERAGE</b>					
0.115±0.005±0.005	11147	<sup>13</sup> HEINTZ	92 CSB2	$e^+e^- \rightarrow \gamma$	
0.105 <sup>+0.003</sup> <sub>-0.002</sub> ±0.013	25759	MORRISON	91 CLE2	$e^+e^- \rightarrow \gamma X$	

$\Gamma(\gamma\chi_{b0}(2P))/\Gamma_{\text{total}}$					$\Gamma_{12}/\Gamma$
<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<b>0.054±0.006 OUR AVERAGE</b>	Error includes scale factor of 1.1.				
0.060±0.004±0.006	4959	<sup>13</sup> HEINTZ	92 CSB2	$e^+e^- \rightarrow \gamma$	
0.049 <sup>+0.003</sup> <sub>-0.004</sub> ±0.006	9903	MORRISON	91 CLE2	$e^+e^- \rightarrow \gamma X$	

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

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

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

<sup>8</sup> 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.

<sup>9</sup> From the exclusive mode.

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

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

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

<sup>13</sup> Supersedes NARAIN 91.

## $\Upsilon(3S)$ REFERENCES

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