# $\Upsilon(3S)$

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

## $\Upsilon(3S)$ MASS

| *VALUE* (GeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **10.3552±0.0005** | [1] ARTAMONOV | 00 | MD1 | $e^+e^- \to$ hadrons |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 10.3553±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[3] Superseded by ARTAMONOV 00.

## $\Upsilon(3S)$ WIDTH

| *VALUE* (keV) | *DOCUMENT ID* |
|---|---|
| **26.3±3.4 OUR EVALUATION** | 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) % | |
| $\Gamma_7$ | $\Upsilon(1S)\eta$ | $< 2.2 \times 10^{-3}$ | CL=90% |
| $\Gamma_8$ | $\mu^+\mu^-$ | ( 1.81±0.17) % | |
| $\Gamma_9$ | $e^+e^-$ | seen | |
| | **Radiative decays** | | |
| $\Gamma_{10}$ | $\gamma\chi_{b2}(2P)$ | (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 |

## $\Upsilon(3S)$ $\Gamma(i)\Gamma(e^+e^-)/\Gamma(total)$

**$\Gamma(hadrons) \times \Gamma(e^+e^-)/\Gamma_{total}$** **$\Gamma_0\Gamma_9/\Gamma$**

| *VALUE* (keV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **0.45±0.03±0.03** | [4] GILES | 84B | CLEO | $e^+e^- \to$ hadrons |

[4] Radiative corrections reevaluated by BUCHMUELLER 88 following KURAEV 85.

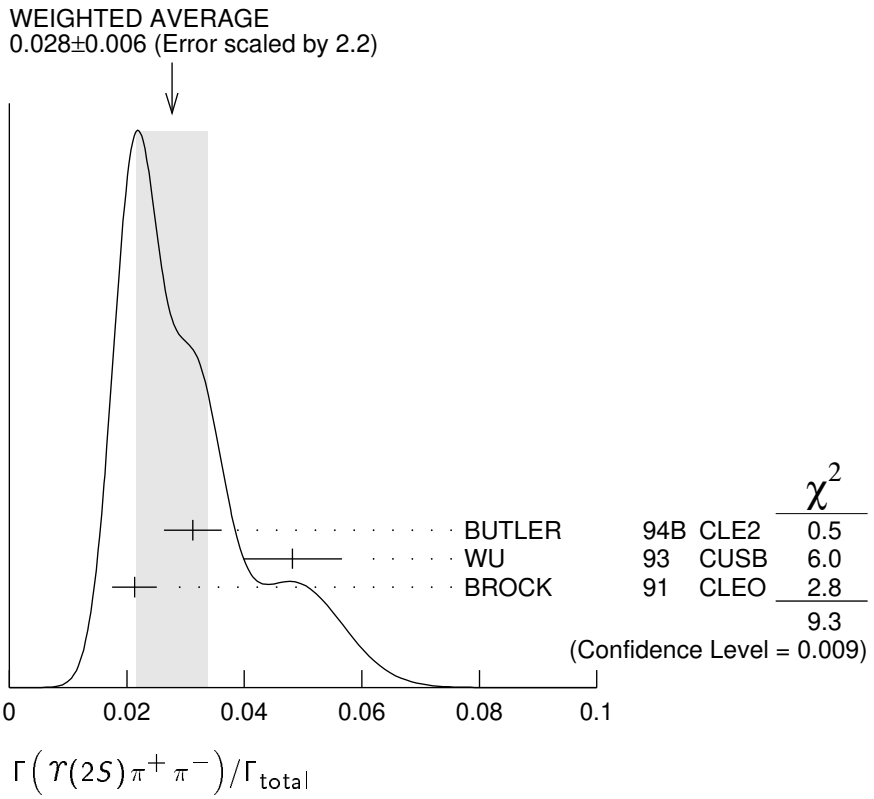
## $\Upsilon(3S)$ BRANCHING RATIOS

### $\Gamma(\Upsilon(2S)\text{anything})/\Gamma_{\text{total}}$ $\Gamma_1/\Gamma$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.106 ±0.008 OUR AVERAGE** | | | | | |
| 0.1023±0.0105 | 4625 | [5,6,7] BUTLER | 94B | CLE2 | $e^+e^- \to \ell^+\ell^- X$ |
| 0.111 ±0.012 | 4891 | [6,7,8] BROCK | 91 | CLEO | $e^+e^- \to \pi^+\pi^- X$, $\pi^+\pi^-\ell^+\ell^-$ |

### $\Gamma(\Upsilon(2S)\pi^+\pi^-)/\Gamma_{\text{total}}$ $\Gamma_2/\Gamma$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **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 | $e^+e^- \to \pi^+\pi^-\ell^+\ell^-$ |
| 0.0482±0.0065±0.0053 | 138 | [8] WU | 93 | CUSB | $\Upsilon(3S) \to \pi^+\pi^-\ell^+\ell^-$ |
| 0.0213±0.0038 | 974 | [8] BROCK | 91 | CLEO | $e^+e^- \to \pi^+\pi^- X$, $\pi^+\pi^-\ell^+\ell^-$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 0.031 ±0.020 | 5 | MAGERAS | 82 | CUSB | $\Upsilon(3S) \to \pi^+\pi^-\ell^+\ell^-$ |



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

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.0200±0.0032 OUR AVERAGE** | | | | | |
| 0.0216±0.0039 | | [9,10] BUTLER | 94B | CLE2 | $e^+e^- \to \ell^+\ell^-\pi^0\pi^0$ |
| 0.017 ±0.005 ±0.002 | 10 | [11] HEINTZ | 92 | CSB2 | $e^+e^- \to \ell^+\ell^-\pi^0\pi^0$ |

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

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **0.0502±0.0069** | [9] BUTLER | 94B | CLE2 | $e^+e^- \to \ell^+\ell^- 2\gamma$ |

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

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.0448±0.0021 OUR AVERAGE** | | | | | |
| 0.0452±0.0035 | 11830 | [6] BUTLER | 94B | CLE2 | $e^+e^- \to \pi^+\pi^-$ X, $\pi^+\pi^-\ell^+\ell^-$ |
| 0.0446±0.0034±0.0050 | 451 | [6] WU | 93 | CUSB | $\Upsilon(3S) \to \pi^+\pi^-\ell^+\ell^-$ |
| 0.0446±0.0030 | 11221 | [6] BROCK | 91 | CLEO | $e^+e^- \to \pi^+\pi^-$ 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 | $\Upsilon(3S) \to \pi^+\pi^-\ell^+\ell^-$ |
| 0.039 ±0.013 | 26 | MAGERAS | 82 | CUSB | $\Upsilon(3S) \to \pi^+\pi^-\ell^+\ell^-$ |

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

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.0206±0.0028 OUR AVERAGE** | | | | | |
| 0.0199±0.0034 | 56 | [6] BUTLER | 94B | CLE2 | $e^+e^- \to \ell^+\ell^-\pi^0\pi^0$ |
| 0.022 ±0.004 ±0.003 | 33 | [12] HEINTZ | 92 | CSB2 | $e^+e^- \to \ell^+\ell^-\pi^0\pi^0$ |

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

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<0.0022** | 90 | BROCK | 91 | CLEO | $e^+e^- \to \pi^+\pi^-\pi^0\ell^+\ell^-$ |

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

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.0181±0.0017 OUR AVERAGE** | | | | | |
| 0.0202±0.0019±0.0033 | | CHEN | 89B | CLEO | $e^+e^- \to \mu^+\mu^-$ |
| 0.0173±0.0015±0.0011 | | KAARSBERG | 89 | CSB2 | $e^+e^- \to \mu^+\mu^-$ |
| 0.033 ±0.013 ±0.007 | 1096 | ANDREWS | 83 | CLEO | $e^+e^- \to \mu^+\mu^-$ |

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

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.114±0.008 OUR AVERAGE** | Error includes scale factor of 1.3. | | | | |
| 0.111±0.005±0.004 | 10319 | [13] HEINTZ | 92 | CSB2 | $e^+e^- \to \gamma$ X |
| 0.135±0.003±0.017 | 30741 | MORRISON | 91 | CLE2 | $e^+e^- \to \gamma$ X |

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

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.113±0.006 OUR AVERAGE** | | | | | |
| $0.115\pm0.005\pm0.005$ | 11147 | [13] HEINTZ | 92 | CSB2 | $e^+e^-\to\gamma X$ |
| $0.105^{+0.003}_{-0.002}\pm0.013$ | 25759 | MORRISON | 91 | CLE2 | $e^+e^-\to\gamma X$ |

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

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.054±0.006 OUR AVERAGE** | Error includes scale factor of 1.1. | | | | |
| $0.060\pm0.004\pm0.006$ | 4959 | [13] HEINTZ | 92 | CSB2 | $e^+e^-\to\gamma X$ |
| $0.049^{+0.003}_{-0.004}\pm0.006$ | 9903 | MORRISON | 91 | CLE2 | $e^+e^-\to\gamma X$ |

[5] Using $B(\Upsilon(2S)\to\Upsilon(1S)\gamma\gamma)=(0.038\pm0.007)\%$, and $B(\Upsilon(2S)\to\Upsilon(1S)\pi^0\pi^0)=(1/2)B(\Upsilon(2S)\to\Upsilon(1S)\pi^+\pi^-)$.

[6] Using $B(\Upsilon(1S)\to\mu^+\mu^-)=(2.48\pm0.06)\%$. With the assumption of $e\mu$ universality.

[7] Using $B(\Upsilon(2S)\to\Upsilon(1S)\pi^+\pi^-)=(18.5\pm0.8)\%$.

[8] Using $B(\Upsilon(2S)\to\mu^+\mu^-)=(1.31\pm0.21)\%$, $B(\Upsilon(2S)\to\Upsilon(1S)\gamma\gamma)\times2B(\Upsilon(1S)\to\mu^+\mu^-)=(0.188\pm0.035)\%$, and $B(\Upsilon(2S)\to\Upsilon(1S)\pi^0\pi^0)\times2B(\Upsilon(1S)\to\mu^+\mu^-)=(0.436\pm0.056)\%$. With the assumption of $e\mu$ universality.

[9] From the exclusive mode.

[10] $B(\Upsilon(2S)\to\mu^+\mu^-)=(1.31\pm0.21)\%$ and assuming $e\mu$ universality.

[11] $B(\Upsilon(2S)\to\mu^+\mu^-)=(1.44\pm0.10)\%$ and assuming $e\mu$ universality. Supersedes HEINTZ 91.

[12] Using $B(\Upsilon(1S)\to\mu^+\mu^-)=(2.57\pm0.07)\%$ and assuming $e\mu$ universality. Supersedes HEINTZ 91.

[13] Supersedes NARAIN 91.

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