# $\Upsilon(4S)$ or $\Upsilon(10580)$

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

## $\Upsilon(4S)$ MASS

| *VALUE* (GeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **10.5794±0.0012 OUR AVERAGE** | | | | |
| 10.5793±0.0004±0.0012 | AUBERT | 05Q | BABR | $e^+e^- \to$ hadrons |
| 10.5800±0.0035 | [1] BEBEK | 87 | CLEO | $e^+e^- \to$ hadrons |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 10.5774±0.0010 | [2] LOVELOCK | 85 | CUSB | $e^+e^- \to$ hadrons |

[1] Reanalysis of BESSON 85.
[2] No systematic error given.

## $\Upsilon(4S)$ WIDTH

| *VALUE* (MeV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **20.5±2.5 OUR AVERAGE** | | | | |
| 20.7±1.6±2.5 | AUBERT | 05Q | BABR | $e^+e^- \to$ hadrons |
| 20 ±2 ±4 | BESSON | 85 | CLEO | $e^+e^- \to$ hadrons |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 25 ±2.5 | LOVELOCK | 85 | CUSB | $e^+e^- \to$ hadrons |

## $\Upsilon(4S)$ DECAY MODES

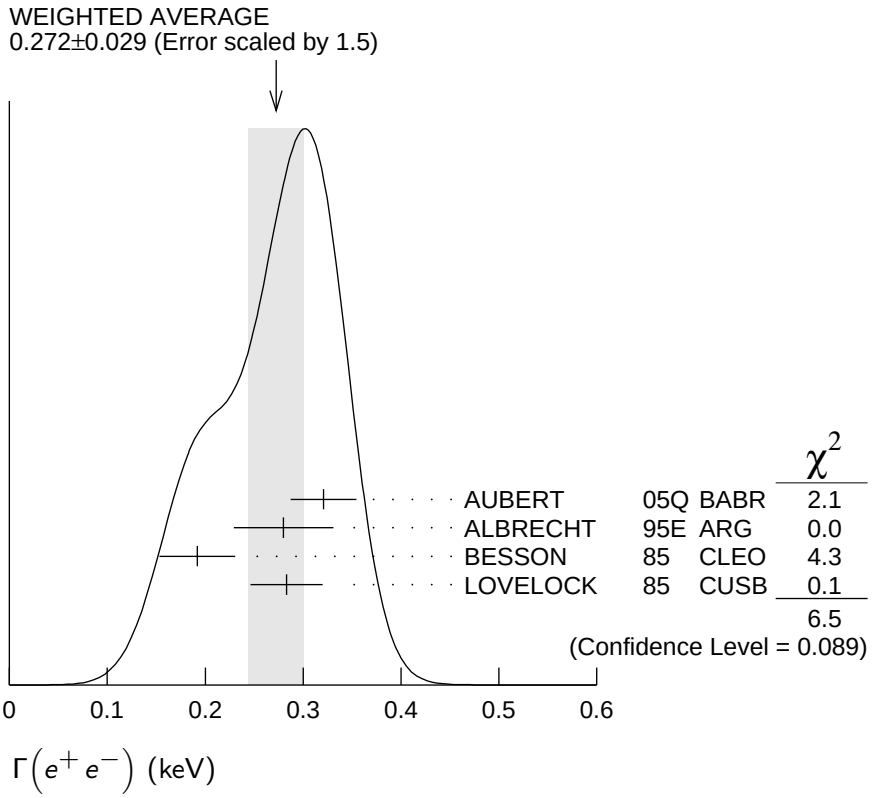
| | Mode | Fraction ($\Gamma_i/\Gamma$) | Confidence level |
|---|---|---|---|
| $\Gamma_1$ | $B\overline{B}$ | $> 96$ % | 95% |
| $\Gamma_2$ | $B^+B^-$ | (50.9 ±0.7 ) % | |
| $\Gamma_3$ | $D_s^+$ anything + c.c. | (18.2 ±3.2 ) % | |
| $\Gamma_4$ | $B^0\overline{B}^0$ | (49.1 ±0.7 ) % | |
| $\Gamma_5$ | non-$B\overline{B}$ | $< 4$ % | 95% |
| $\Gamma_6$ | $e^+e^-$ | ( 1.57±0.08) $\times 10^{-5}$ | |
| $\Gamma_7$ | $J/\psi(1S)$ anything | $< 1.9$ $\times 10^{-4}$ | 95% |
| $\Gamma_8$ | $D^{*+}$ anything + c.c. | $< 7.4$ % | 90% |
| $\Gamma_9$ | $\phi$ anything | $< 2.3$ $\times 10^{-3}$ | 90% |
| $\Gamma_{10}$ | $\Upsilon(1S)$ anything | $< 4$ $\times 10^{-3}$ | 90% |
| $\Gamma_{11}$ | $\Upsilon(1S)\pi^+\pi^-$ | $< 1.2$ $\times 10^{-4}$ | 90% |
| $\Gamma_{12}$ | $\Upsilon(2S)\pi^+\pi^-$ | $< 3.9$ $\times 10^{-4}$ | 90% |

## $\Upsilon(4S)$ PARTIAL WIDTHS

### $\Gamma(e^+e^-)$ $\Gamma_6$

| *VALUE* (keV) | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|
| **0.272±0.029 OUR AVERAGE** | Error includes scale factor of 1.5. See the ideogram below. | | | |
| 0.321±0.017±0.029 | AUBERT | 05Q | BABR | $e^+e^- \rightarrow$ hadrons |
| 0.28 ±0.05 ±0.01 | [3] ALBRECHT | 95E | ARG | $e^+e^- \rightarrow$ hadrons |
| 0.192±0.007±0.038 | BESSON | 85 | CLEO | $e^+e^- \rightarrow$ hadrons |
| 0.283±0.037 | LOVELOCK | 85 | CUSB | $e^+e^- \rightarrow$ hadrons |

[3] Using LEYAOUANC 77 parametrization of $\Gamma(s)$.




## $\Upsilon(4S)$ BRANCHING RATIOS

### $B\overline{B}$ DECAYS

The ratio of branching fraction to charged and neutral B mesons is often derived assuming isospin invariance in the decays, and relies on the knowledge of the $B^+/B^0$ lifetime ratio. "OUR EVALUATION" is obtained based on averages of rescaled data listed below. The average and rescaling were performed by the Heavy Flavor Averaging Group (HFAG) and are described at http://www.slac.stanford.edu/xorg/hfag/. The averaging/rescaling procedure takes into account the common dependence of the measurement on the value of the lifetime ratio.

## $\Gamma(B^+B^-)/\Gamma(B^0\overline{B}^0)$ $\Gamma_2/\Gamma_4$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **1.037±0.029 OUR EVALUATION** | | | | |
| 1.006±0.036±0.031 | [4] AUBERT | 04F | BABR | $\Upsilon(4S) \to B\overline{B} \to J/\psi K$ |
| 1.01 ±0.03 ±0.09 | [4] HASTINGS | 03 | BELL | $\Upsilon(4S) \to B\overline{B} \to$ dileptons |
| 1.058±0.084±0.136 | [5] ATHAR | 02 | CLEO | $\Upsilon(4S) \to B\overline{B} \to D^*\ell\nu$ |
| 1.10 ±0.06 ±0.05 | [6] AUBERT | 02 | BABR | $\Upsilon(4S) \to B\overline{B} \to (c\overline{c})K^*$ |
| 1.04 ±0.07 ±0.04 | [7] ALEXANDER | 01 | CLEO | $\Upsilon(4S) \to B\overline{B} \to J/\psi K^*$ |

[4] HASTINGS 03 and AUBERT 04F assume $\tau(B^+) / \tau(B^0) = 1.083 \pm 0.017$.
[5] ATHAR 02 assumes $\tau(B^+) / \tau(B^0) = 1.074 \pm 0.028$. Supersedes BARISH 95.
[6] AUBERT 02 assumes $\tau(B^+) / \tau(B^0) = 1.062 \pm 0.029$.
[7] ALEXANDER 01 assumes $\tau(B^+) / \tau(B^0) = 1.066 \pm 0.024$.

## $\Gamma(B^+B^-)/\Gamma_{total}$ $\Gamma_2/\Gamma$

| VALUE | DOCUMENT ID |
|---|---|
| **0.509±0.007 OUR EVALUATION** | Assuming B($\Upsilon(4S) \to B\overline{B}$) = 1 |

## $\Gamma(D_s^+ \text{anything} + \text{c.c.})/\Gamma_{total}$ $\Gamma_3/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **0.182±0.021±0.024** | [9] ARTUSO | 05B | CLE3 | $e^+e^- \to D_X X$ |

## $\Gamma(B^0\overline{B}^0)/\Gamma_{total}$ $\Gamma_4/\Gamma$

| VALUE | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **0.491±0.007 OUR EVALUATION** | Assuming B($\Upsilon(4S) \to B\overline{B}$) = 1 | | | |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 0.487±0.010±0.008 | [8] AUBERT,B | 05H | BABR | $\Upsilon(4S) \to \overline{B}B \to D^*\ell\nu_\ell$ |

[8] Direct measurement. This value is averaged with the value extracted from the $\Gamma(B^+B^-)$ / $\Gamma(B^0\overline{B}^0)$ measurements.
[9] ARTUSO 05B reports [B($\Upsilon(4S) \to D_s^+$ anything + c.c.) × B($D_s^+ \to \phi\pi^+$)] = 0.0080 ± 0.0002 ± 0.0009. We divide by our best value B($D_s^+ \to \phi\pi^+$) = (4.4 ± 0.6) × $10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

## non-$B\overline{B}$ DECAYS

## $\Gamma(e^+e^-)/\Gamma_{total}$ $\Gamma_6/\Gamma$

| VALUE (units $10^{-5}$) | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|
| **1.57±0.08 OUR AVERAGE** | | | | |
| 1.55±0.04±0.07 | AUBERT | 05Q | BABR | $e^+e^- \to$ hadrons |
| 2.77±0.50±0.49 | [10] ALBRECHT | 95E | ARG | $e^+e^- \to$ hadrons |

[10] Using LEYAOUANC 77 parametrization of $\Gamma(s)$.

## $\Gamma(D^{*+} \text{anything} + \text{c.c.})/\Gamma_{total}$ $\Gamma_8/\Gamma$

| VALUE | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<0.074** | 90 | [11] ALEXANDER | 90C | CLEO | $e^+e^-$ |

[11] For $x > 0.473$.

### $\Gamma(\phi\text{anything})/\Gamma_{\text{total}}$ $\Gamma_9/\Gamma$

| *VALUE* | *CL%* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **<0.0023** | 90 | [12] ALEXANDER | 90C | CLEO | $e^+e^-$ |

[12] For $x > 0.52$.

### $\Gamma(J/\psi(1S)\text{anything})/\Gamma_{\text{total}}$ $\Gamma_7/\Gamma$

| *VALUE* (units $10^{-4}$) | *CL%* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **<1.9** | 95 | [13] ABE | 02D | BELL | $e^+e^- \to J/\psi X \to \ell^+\ell^- X$ |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <4.7 | 90 | [13] AUBERT | 01C | BABR | $e^+e^- \to J/\psi X \to \ell^+\ell^- X$ |

[13] Uses $B(J/\psi \to e^+e^-) = 0.0593 \pm 0.0010$ and $B(J/\psi \to \mu^+\mu^-) = 0.0588 \pm 0.0010$.

### $\Gamma(\Upsilon(1S)\text{anything})/\Gamma_{\text{total}}$ $\Gamma_{10}/\Gamma$

| *VALUE* | *CL%* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **<0.004** | 90 | ALEXANDER | 90C | CLEO | $e^+e^-$ |

### $\Gamma(\Upsilon(1S)\pi^+\pi^-)/\Gamma_{\text{total}}$ $\Gamma_{11}/\Gamma$

| *VALUE* (units $10^{-4}$) | *CL%* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **<1.2** | 90 | GLENN | 99 | CLE2 | $e^+e^-$ |

### $\Gamma(\Upsilon(2S)\pi^+\pi^-)/\Gamma_{\text{total}}$ $\Gamma_{12}/\Gamma$

| *VALUE* (units $10^{-4}$) | *CL%* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **<3.9** | 90 | GLENN | 99 | CLE2 | $e^+e^-$ |

### $\Gamma(\text{non-}B\overline{B})/\Gamma_{\text{total}}$ $\Gamma_5/\Gamma$

| *VALUE* | *CL%* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **<0.04** | 95 | BARISH | 96B | CLEO | $e^+e^-$ |

## $\Upsilon(4S)$ REFERENCES


| | | | | |
|---|---|---|---|---|
| ARTUSO | 05B | PRL 95 261801 | M. Artuso *et al.* | (CLEO Collab.) |
| AUBERT | 05Q | PR D72 032005 | B. Aubert *et al.* | (BABAR Collab.) |
| AUBERT,B | 05H | PRL 95 042001 | B. Aubert *et al.* | (BABAR Collab.) |
| AUBERT | 04F | PR D69 071101 | B.Aubert *et al.* | |
| HASTINGS | 03 | PR D67 052004 | N.C. Hastings *et al.* | (BELLE Collab.) |
| ABE | 02D | PRL 88 052001 | K. Abe *et al.* | (BELLE Collab.) |
| ATHAR | 02 | PR D66 052003 | S.B. Athar *et al.* | (CLEO Collab.) |
| AUBERT | 02 | PR D65 032001 | B. Aubert *et al.* | (BaBar Collab.) |
| ALEXANDER | 01 | PRL 86 2737 | J.P. Alexander *et al.* | (CLEO Collab.) |
| AUBERT | 01C | PRL 87 162002 | B. Aubert *et al.* | (BaBar Collab.) |
| GLENN | 99 | PR D59 052003 | S. Glenn *et al.* | |
| BARISH | 96B | PRL 76 1570 | B.C. Barish *et al.* | (CLEO Collab.) |
| ALBRECHT | 95E | ZPHY C65 619 | H. Albrecht *et al.* | (ARGUS Collab.) |
| BARISH | 95 | PR D51 1014 | B.C. Barish *et al.* | (CLEO Collab.) |
| ALEXANDER | 90C | PRL 64 2226 | J. Alexander *et al.* | (CLEO Collab.) |
| BEBEK | 87 | PR D36 1289 | C. Bebek *et al.* | (CLEO Collab.) |
| BESSON | 85 | PRL 54 381 | D. Besson *et al.* | (CLEO Collab.) |
| LOVELOCK | 85 | PRL 54 377 | D.M.J. Lovelock *et al.* | (CUSB Collab.) |
| LEYAOUANC | 77 | PL B71 397 | A. Le Yaouanc *et al.* | (ORSAY) |

## OTHER RELATED PAPERS


| | | | | |
|---|---|---|---|---|
| VOLOSHIN | 05A | PAN 68 771<br>Translated from YAF 68 804. | M.B. Voloshin | |
| ABE | 01J | PR D64 072001 | K. Abe *et al.* | (BELLE Collab.) |
| HENDERSON | 92 | PR D45 2212 | S. Henderson *et al.* | (CLEO Collab.) |
| ANDREWS | 80B | PRL 45 219 | D. Andrews *et al.* | (CLEO Collab.) |
| FINOCCHI... | 80 | PRL 45 222 | G. Finocchiaro *et al.* | (CUSB Collab.) |