

$\Upsilon(4S)$

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

also known as  $\Upsilon(10580)$ 

### $\Upsilon(4S)$ MASS

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
<b>10579.4 ± 1.2 OUR AVERAGE</b>			
10579.3 ± 0.4 ± 1.2	AUBERT	05Q	BABR $e^+e^- \rightarrow$ hadrons
10580.0 ± 3.5	<sup>1</sup> BEBEK	87	CLEO $e^+e^- \rightarrow$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •			
10577.4 ± 1.0	<sup>2</sup> LOVELOCK	85	CUSB $e^+e^- \rightarrow$ hadrons
<sup>1</sup> Reanalysis of BESSON 85.			
<sup>2</sup> No systematic error given.			

### $\Upsilon(4S)$ WIDTH

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

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

Mode	Fraction ( $\Gamma_i/\Gamma$ )	Confidence level
$\Gamma_1$ $B\bar{B}$	> 96 %	95%
$\Gamma_2$ $B^+B^-$	(51.1 $^{+0.7}_{-1.1}$ ) %	
$\Gamma_3$ $D_s^+$ anything + c.c.	(17.8 ± 2.6) %	
$\Gamma_4$ $B^0\bar{B}^0$	(48.6 ± 0.8) %	
$\Gamma_5$ $J/\psi K_S^0 + (J/\psi, \eta_c) K_S^0$	< 4 × 10 <sup>-7</sup>	90%
$\Gamma_6$ non- $B\bar{B}$	(2.64 $^{+13.00}_{-0.20}$ ) × 10 <sup>-3</sup>	
$\Gamma_7$ $e^+e^-$	(1.57 ± 0.08) × 10 <sup>-5</sup>	
$\Gamma_8$ $\rho^+\rho^-$	< 5.7 × 10 <sup>-6</sup>	90%
$\Gamma_9$ $K^*(892)^0\bar{K}^0$	< 2.0 × 10 <sup>-6</sup>	90%
$\Gamma_{10}$ $J/\psi(1S)$ anything	< 1.9 × 10 <sup>-4</sup>	95%
$\Gamma_{11}$ $D^{*+}$ anything + c.c.	< 7.4 %	90%
$\Gamma_{12}$ $\phi$ anything	(7.1 ± 0.6) %	
$\Gamma_{13}$ $\phi\eta$	< 1.8 × 10 <sup>-6</sup>	90%
$\Gamma_{14}$ $\phi\eta'$	< 4.3 × 10 <sup>-6</sup>	90%
$\Gamma_{15}$ $\rho\eta$	< 1.3 × 10 <sup>-6</sup>	90%
$\Gamma_{16}$ $\rho\eta'$	< 2.5 × 10 <sup>-6</sup>	90%

$\Gamma_{17}$	$\Upsilon(1S)$ anything	$< 4$	$\times 10^{-3}$	90%
$\Gamma_{18}$	$\Upsilon(1S)\pi^+\pi^-$	$(8.2 \pm 0.4)$	$\times 10^{-5}$	
$\Gamma_{19}$	$\Upsilon(1S)\eta$	$(1.81 \pm 0.18)$	$\times 10^{-4}$	
$\Gamma_{20}$	$\Upsilon(1S)\eta'$	$(3.4 \pm 0.9)$	$\times 10^{-5}$	
$\Gamma_{21}$	$\Upsilon(2S)\pi^+\pi^-$	$(8.2 \pm 0.8)$	$\times 10^{-5}$	
$\Gamma_{22}$	$h_b(1P)\pi^+\pi^-$	not seen		
$\Gamma_{23}$	$h_b(1P)\eta$	$(2.18 \pm 0.21)$	$\times 10^{-3}$	
$\Gamma_{24}$	$\eta_b(1S)\omega$	$< 1.8$	$\times 10^{-4}$	90%
$\Gamma_{25}$	${}^2H$ anything	$< 1.3$	$\times 10^{-5}$	90%

**Double Radiative Decays**

$\Gamma_{26}$	$\gamma\gamma \Upsilon(D) \rightarrow \gamma\gamma\eta \Upsilon(1S)$	$< 2.3$	$\times 10^{-5}$	90%
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**$\Upsilon(4S)$  PARTIAL WIDTHS**

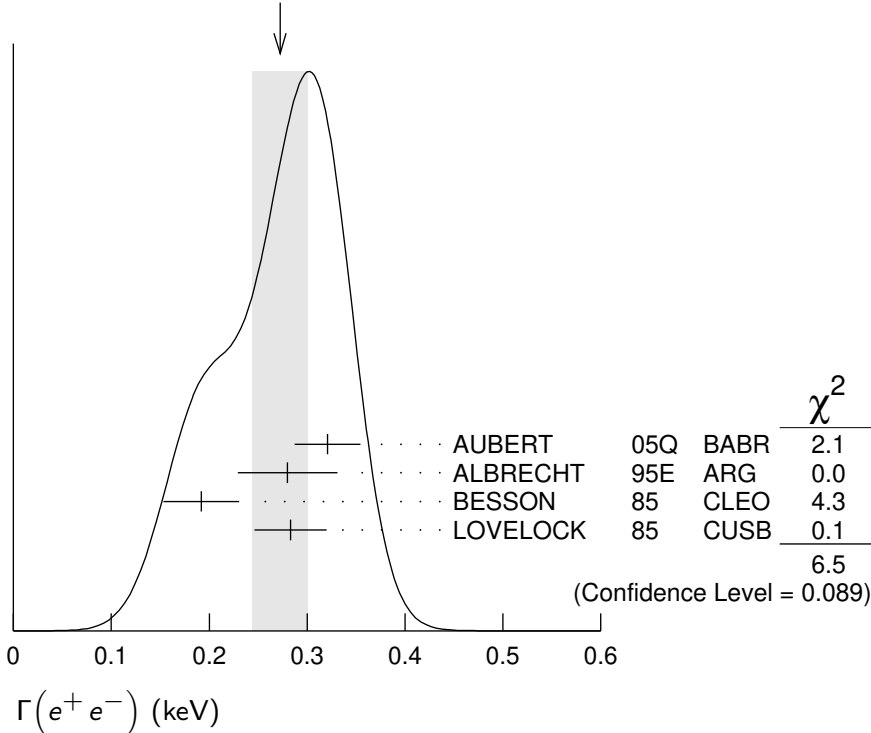
**$\Gamma(e^+e^-)$**

**$\Gamma_7$**

<u>VALUE (keV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>0.272 \pm 0.029</math> OUR AVERAGE</b>	Error includes scale factor of 1.5. See the ideogram below.		
$0.321 \pm 0.017 \pm 0.029$	AUBERT	05Q	BABR $e^+e^- \rightarrow$ hadrons
$0.28 \pm 0.05 \pm 0.01$	<sup>1</sup> ALBRECHT	95E	ARG $e^+e^- \rightarrow$ hadrons
$0.192 \pm 0.007 \pm 0.038$	BESSION	85	CLEO $e^+e^- \rightarrow$ hadrons
$0.283 \pm 0.037$	LOVELOCK	85	CUSB $e^+e^- \rightarrow$ hadrons

<sup>1</sup>Using LEYAOUANC 77 parametrization of  $\Gamma(s)$ .

WEIGHTED AVERAGE  
 $0.272 \pm 0.029$  (Error scaled by 1.5)



**$\Upsilon(4S)$  BRANCHING RATIOS** **$B\bar{B}$  DECAYS** **$\Gamma(B^+ B^-)/\Gamma_{\text{total}}$**  **$\Gamma_2/\Gamma$** 

VALUE	DOCUMENT ID	TECN
$0.5113^{+0.0073}_{-0.0108}$	<sup>1</sup> BANERJEE 26	RVUE

<sup>1</sup> The quantities  $\Gamma(B^+ B^-)/\Gamma_{\text{total}}$ ,  $\Gamma(B^0 \bar{B}^0)/\Gamma_{\text{total}}$ ,  $\Gamma(B^+ B^-)/\Gamma(B^0 \bar{B}^0)$  and  $\Gamma(\text{non-}B\bar{B})/\Gamma_{\text{total}}$  produced by the Heavy Flavor Averaging Group (HFLAV) are correlated.

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

VALUE	DOCUMENT ID	TECN	COMMENT
$0.178 \pm 0.021 \pm 0.016$	<sup>1</sup> ARTUSO 05B	CLE3	$e^+ e^- \rightarrow D_s X$

<sup>1</sup> ARTUSO 05B reports  $[\Gamma(\Upsilon(4S) \rightarrow D_s^+ \text{ anything} + \text{c.c.})/\Gamma_{\text{total}}] \times [B(D_s^+ \rightarrow \phi \pi^+)] = (8.0 \pm 0.2 \pm 0.9) \times 10^{-3}$  which we divide by our best (shown rounded) value  $B(D_s^+ \rightarrow \phi \pi^+) = (4.5 \pm 0.4) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best (shown rounded) value.

 **$\Gamma(B^0 \bar{B}^0)/\Gamma_{\text{total}}$**  **$\Gamma_4/\Gamma$** 

VALUE	DOCUMENT ID	TECN	COMMENT
$0.4861^{+0.0074}_{-0.0080}$	<sup>1</sup> BANERJEE 26	RVUE	

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

$0.487 \pm 0.010 \pm 0.008$  <sup>2</sup> AUBERT,B 05H BABR  $\Upsilon(4S) \rightarrow \bar{B} B \rightarrow D^* \ell \nu_\ell$

<sup>1</sup> The quantities  $\Gamma(B^+ B^-)/\Gamma_{\text{total}}$ ,  $\Gamma(B^0 \bar{B}^0)/\Gamma_{\text{total}}$ ,  $\Gamma(B^+ B^-)/\Gamma(B^0 \bar{B}^0)$  and  $\Gamma(\text{non-}B\bar{B})/\Gamma_{\text{total}}$  produced by the Heavy Flavor Averaging Group (HFLAV) are correlated.

<sup>2</sup> Direct measurement. This value is averaged with the value extracted from the  $\Gamma(B^+ B^-) / \Gamma(B^0 \bar{B}^0)$  measurements.

 **$\Gamma(B^+ B^-)/\Gamma(B^0 \bar{B}^0)$**  **$\Gamma_2/\Gamma_4$** 

VALUE	DOCUMENT ID	TECN	COMMENT
$1.052 \pm 0.031$	<sup>1</sup> BANERJEE 26	RVUE	

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

$1.065 \pm 0.012 \pm 0.051$	<sup>2</sup> CHOUDHURY 23	BELL	$\Upsilon(4S) \rightarrow B\bar{B} \rightarrow J/\psi K$
$1.006 \pm 0.036 \pm 0.031$	<sup>3</sup> AUBERT 04F	BABR	$\Upsilon(4S) \rightarrow B\bar{B} \rightarrow J/\psi K$
$1.01 \pm 0.03 \pm 0.09$	<sup>3</sup> HASTINGS 03	BELL	$\Upsilon(4S) \rightarrow B\bar{B} \rightarrow \text{dileptons}$
$1.058 \pm 0.084 \pm 0.136$	<sup>4</sup> ATHAR 02	CLEO	$\Upsilon(4S) \rightarrow B\bar{B} \rightarrow D^* \ell \nu$
$1.10 \pm 0.06 \pm 0.05$	<sup>5</sup> AUBERT 02	BABR	$\Upsilon(4S) \rightarrow B\bar{B} \rightarrow (c\bar{c})K^*$
$1.04 \pm 0.07 \pm 0.04$	<sup>6</sup> ALEXANDER 01	CLEO	$\Upsilon(4S) \rightarrow B\bar{B} \rightarrow J/\psi K^*$

<sup>1</sup> The quantities  $\Gamma(B^+ B^-)/\Gamma_{\text{total}}$ ,  $\Gamma(B^0 \bar{B}^0)/\Gamma_{\text{total}}$ ,  $\Gamma(B^+ B^-)/\Gamma(B^0 \bar{B}^0)$  and  $\Gamma(\text{non-}B\bar{B})/\Gamma_{\text{total}}$  produced by the Heavy Flavor Averaging Group (HFLAV) are correlated.

<sup>2</sup> CHOUDHURY 23 includes uncertainty due to the isospin symmetry assumption in  $B \rightarrow J/\psi K$  decays.

<sup>3</sup> HASTINGS 03 and AUBERT 04F assume  $\tau(B^+) / \tau(B^0) = 1.083 \pm 0.017$ .

<sup>4</sup> ATHAR 02 assumes  $\tau(B^+) / \tau(B^0) = 1.074 \pm 0.028$ . Supersedes BARISH 95.

<sup>5</sup> AUBERT 02 assumes  $\tau(B^+) / \tau(B^0) = 1.062 \pm 0.029$ .

<sup>6</sup> ALEXANDER 01 assumes  $\tau(B^+) / \tau(B^0) = 1.066 \pm 0.024$ .

$[\Gamma(J/\psi K_S^0) + \Gamma((J/\psi, \eta_c) K_S^0)]/\Gamma_{\text{total}}$   $\Gamma_5/\Gamma$

Forbidden by  $CP$  invariance.

VALUE (units $10^{-7}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<4	90	<sup>1</sup> TAJIMA	07A	BELL $\gamma(4S) \rightarrow B^0 \bar{B}^0$
<sup>1</sup> $\gamma(4S)$ with $CP = +1$ decays to the final state with $CP = -1$ .				

————— non- $B\bar{B}$  DECAYS —————

$\Gamma(\text{non-}B\bar{B})/\Gamma_{\text{total}}$   $\Gamma_6/\Gamma$

VALUE (units $10^{-2}$ )	CL%	DOCUMENT ID	TECN	COMMENT
$0.26^{+1.25}_{-0.02}$		<sup>1</sup> BANERJEE	26	RVUE

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

<4	95	BARISH	96B	CLEO $e^+e^-$
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<sup>1</sup> The quantities  $\Gamma(B^+B^-)/\Gamma_{\text{total}}$ ,  $\Gamma(B^0\bar{B}^0)/\Gamma_{\text{total}}$ ,  $\Gamma(B^+B^-)/\Gamma(B^0\bar{B}^0)$  and  $\Gamma(\text{non-}B\bar{B})/\Gamma_{\text{total}}$  produced by the Heavy Flavor Averaging Group (HFLAV) are correlated.

$\Gamma(e^+e^-)/\Gamma_{\text{total}}$   $\Gamma_7/\Gamma$

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b><math>1.57 \pm 0.08</math> OUR AVERAGE</b>				
$1.55 \pm 0.04 \pm 0.07$		AUBERT	05Q	BABR $e^+e^- \rightarrow \text{hadrons}$
$2.77 \pm 0.50 \pm 0.49$		<sup>1</sup> ALBRECHT	95E	ARG $e^+e^- \rightarrow \text{hadrons}$

<sup>1</sup> Using LEYAOUANC 77 parametrization of  $\Gamma(s)$ .

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

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
< $5.7 \times 10^{-6}$	90	AUBERT	08BO	BABR $e^+e^- \rightarrow \pi^+\pi^-2\pi^0$

$\Gamma(K^*(892)^0\bar{K}^0)/\Gamma_{\text{total}}$   $\Gamma_9/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
< $2.0 \times 10^{-6}$	90	SHEN	13A	BELL $e^+e^- \rightarrow K^*(892)^0\bar{K}^0$

$\Gamma(J/\psi(1S) \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{10}/\Gamma$

VALUE (units $10^{-4}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<1.9	95	<sup>1</sup> ABE	02D	BELL $e^+e^- \rightarrow J/\psi X \rightarrow \ell^+\ell^-X$

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

<4.7	90	<sup>1</sup> AUBERT	01C	BABR $e^+e^- \rightarrow J/\psi X \rightarrow \ell^+\ell^-X$
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<sup>1</sup> Uses  $B(J/\psi \rightarrow e^+e^-) = 0.0593 \pm 0.0010$  and  $B(J/\psi \rightarrow \mu^+\mu^-) = 0.0588 \pm 0.0010$ .

$\Gamma(D^{*+} \text{ anything} + \text{c.c.})/\Gamma_{\text{total}}$   $\Gamma_{11}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.074	90	<sup>1</sup> ALEXANDER	90C	CLEO $e^+e^-$

<sup>1</sup> For  $x > 0.473$ .

$\Gamma(\phi \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{12}/\Gamma$

VALUE (units $10^{-2}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b><math>7.1 \pm 0.1 \pm 0.6</math></b>		HUANG	07	CLEO $\gamma(4S) \rightarrow \phi X$

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

<0.23                      90            <sup>1</sup> ALEXANDER 90C CLEO  $e^+e^-$

<sup>1</sup> For  $x > 0.52$ .

**$\Gamma(\phi\eta)/\Gamma_{\text{total}}$**   **$\Gamma_{13}/\Gamma$**

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;1.8</b>	90	<sup>1</sup> BELOUS 09	BELL	$e^+e^- \rightarrow \phi\eta$

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

<2.5                      90            AUBERT,BE 06F BABR  $e^+e^- \rightarrow \phi\eta$

<sup>1</sup> Using all intermedite branching fraction values from PDG 08.

**$\Gamma(\phi\eta')/\Gamma_{\text{total}}$**   **$\Gamma_{14}/\Gamma$**

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;4.3</b>	90	<sup>1</sup> BELOUS 09	BELL	$e^+e^- \rightarrow \phi\eta'$

<sup>1</sup> Using all intermedite branching fraction values from PDG 08.

**$\Gamma(\rho\eta)/\Gamma_{\text{total}}$**   **$\Gamma_{15}/\Gamma$**

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;1.3</b>	90	<sup>1</sup> BELOUS 09	BELL	$e^+e^- \rightarrow \rho\eta$

<sup>1</sup> Using all intermedite branching fraction values from PDG 08.

**$\Gamma(\rho\eta')/\Gamma_{\text{total}}$**   **$\Gamma_{16}/\Gamma$**

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;2.5</b>	90	<sup>1</sup> BELOUS 09	BELL	$e^+e^- \rightarrow \rho\eta'$

<sup>1</sup> Using all intermedite branching fraction values from PDG 08.

**$\Gamma(\Upsilon(1S) \text{ anything})/\Gamma_{\text{total}}$**   **$\Gamma_{17}/\Gamma$**

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;0.004</b>	90	ALEXANDER 90C	CLEO	$e^+e^-$

**$\Gamma(\Upsilon(1S)\pi^+\pi^-)/\Gamma_{\text{total}}$**   **$\Gamma_{18}/\Gamma$**

<u>VALUE (units <math>10^{-5}</math>)</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>8.2 ± 0.4 OUR AVERAGE</b>					
8.2 ± 0.5 ± 0.4		515	GUIDO 17	BELL	$\Upsilon(4S) \rightarrow \pi^+\pi^-\mu^+\mu^-$
8.5 ± 1.3 ± 0.1	113 ± 16		<sup>1</sup> SOKOLOV 09	BELL	$e^+e^- \rightarrow \pi^+\pi^-\mu^+\mu^-$
8.00 ± 0.64 ± 0.27		430	<sup>2</sup> AUBERT 08BP	BABR	$\Upsilon(4S) \rightarrow \pi^+\pi^-\ell^+\ell^-$

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

17.8 ± 4.0 ± 0.3                      <sup>3,4</sup> SOKOLOV 07    BELL     $e^+e^- \rightarrow \pi^+\pi^-\mu^+\mu^-$

9.0 ± 1.5 ± 0.2                      167 ± 19    <sup>5</sup> AUBERT 06R    BABR     $e^+e^- \rightarrow \pi^+\pi^-\mu^+\mu^-$

<12                      90            GLENN 99    CLE2     $e^+e^-$

<sup>1</sup> SOKOLOV 09 reports  $[\Gamma(\Upsilon(4S) \rightarrow \Upsilon(1S)\pi^+\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(1S) \rightarrow \mu^+\mu^-)] = (0.211 \pm 0.030 \pm 0.014) \times 10^{-5}$  which we divide by our best (shown rounded) value  $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.04) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best (shown rounded) value.

<sup>2</sup> Using  $B(\Upsilon(1S) \rightarrow e^+e^-) = (2.38 \pm 0.11)\%$  and  $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.05)\%$ .

<sup>3</sup>SOKOLOV 07 reports  $[\Gamma(\Upsilon(4S) \rightarrow \Upsilon(1S)\pi^+\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(1S) \rightarrow \mu^+\mu^-)] = (4.42 \pm 0.81 \pm 0.56) \times 10^{-6}$  which we divide by our best (shown rounded) value  $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.04) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best (shown rounded) value.

<sup>4</sup>According to the authors, systematic errors were underestimated.

<sup>5</sup>Superseded by AUBERT 08BP. AUBERT 06R reports  $[\Gamma(\Upsilon(4S) \rightarrow \Upsilon(1S)\pi^+\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(1S) \rightarrow \mu^+\mu^-)] = (2.23 \pm 0.25 \pm 0.27) \times 10^{-6}$  which we divide by our best (shown rounded) value  $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.04) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best (shown rounded) value.

### $\Gamma(\Upsilon(1S)\eta)/\Gamma_{\text{total}}$ $\Gamma_{19}/\Gamma$

VALUE (units $10^{-4}$ )	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
<b>1.81±0.18 OUR AVERAGE</b>					
1.70±0.23±0.08		49	GUIDO	17	BELL $\Upsilon(4S) \rightarrow \pi^+\pi^-\pi^0\mu^+\mu^-$
1.96±0.26±0.09		56	<sup>1</sup> AUBERT	08BP	BABR $\Upsilon(4S) \rightarrow \pi^+\pi^-\pi^0\ell^+\ell^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<2.7		90	<sup>2</sup> TAMPONI	15	BELL $e^+e^- \rightarrow \gamma\eta + \text{hadrons}$
<sup>1</sup> Using $B(\Upsilon(1S) \rightarrow e^+e^-) = (2.38 \pm 0.11)\%$ and $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.05)\%$ .					
<sup>2</sup> Using $B(\eta \rightarrow 2\gamma) = (39.41 \pm 0.20)\%$ .					

### $\Gamma(\Upsilon(1S)\eta')/\Gamma_{\text{total}}$ $\Gamma_{20}/\Gamma$

VALUE (units $10^{-5}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>3.43±0.88±0.21</b>	27	GUIDO	18	BELL $\Upsilon(4S) \rightarrow (\rho^0\gamma, \pi^+\pi^-\eta)\mu^+\mu^-$

### $\Gamma(\Upsilon(1S)\eta)/\Gamma(\Upsilon(1S)\pi^+\pi^-)$ $\Gamma_{19}/\Gamma_{18}$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
2.41±0.40±0.12	56	<sup>1</sup> AUBERT	08BP	BABR $\Upsilon(4S) \rightarrow \pi^+\pi^-(\pi^0)\ell^+\ell^-$
<sup>1</sup> Not independent of other values reported by AUBERT 08BP.				

### $\Gamma(\Upsilon(2S)\pi^+\pi^-)/\Gamma_{\text{total}}$ $\Gamma_{21}/\Gamma$

VALUE (units $10^{-5}$ )	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
<b>8.2±0.8 OUR AVERAGE</b>					
7.9±1.0±0.4		181	GUIDO	17	BELL $\Upsilon(4S) \rightarrow \pi^+\pi^-\mu^+\mu^-$
8.6±1.1±0.7		220	<sup>1</sup> AUBERT	08BP	BABR $\Upsilon(4S) \rightarrow \pi^+\pi^-\ell^+\ell^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
8.8±1.7±0.8		97 ± 15	<sup>2</sup> AUBERT	06R	BABR $e^+e^- \rightarrow \pi^+\pi^-\mu^+\mu^-$
<3.9		90	GLENN	99	CLE2 $e^+e^-$
<sup>1</sup> Using $B(\Upsilon(2S) \rightarrow e^+e^-) = (1.91 \pm 0.16)\%$ and $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.93 \pm 0.17)\%$ .					
<sup>2</sup> Superseded by AUBERT 08BP. AUBERT 06R reports $[\Gamma(\Upsilon(4S) \rightarrow \Upsilon(2S)\pi^+\pi^-)/\Gamma_{\text{total}}] \times [B(\Upsilon(2S) \rightarrow \mu^+\mu^-)] = (1.69 \pm 0.26 \pm 0.20) \times 10^{-6}$ which we divide by our best (shown rounded) value $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.93 \pm 0.17) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best (shown rounded) value.					

$\Gamma(\Upsilon(2S)\pi^+\pi^-)/\Gamma(\Upsilon(1S)\pi^+\pi^-)$   $\Gamma_{21}/\Gamma_{18}$ 

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

1.16±0.16±0.14      220      <sup>1</sup> AUBERT      08BP BABR       $\Upsilon(4S) \rightarrow \pi^+\pi^-\ell^+\ell^-$ 

<sup>1</sup> Using  $B(\Upsilon(1S) \rightarrow e^+e^-) = (2.38 \pm 0.11)\%$ ,  $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.05)\%$ ,  
 $B(\Upsilon(2S) \rightarrow e^+e^-) = (1.91 \pm 0.16)\%$ , and  $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.93 \pm 0.17)\%$ .  
 Not independent of other values reported by AUBERT 08BP.

 $\Gamma(h_b(1P)\pi^+\pi^-)/\Gamma_{\text{total}}$   $\Gamma_{22}/\Gamma$ 

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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not seen       $(35^{+32}_{-26})k$       <sup>1</sup> ADACHI      12 BELL      10.58  $e^+e^- \rightarrow h_b(1P)\pi^+\pi^-$ 

<sup>1</sup> From the upper limit on the ratio of  $\sigma(e^+e^- \rightarrow h_b(1P)\pi^+\pi^-)$  at the  $\Upsilon(4S)$  to that at the  $\Upsilon(5S)$  of 0.27.

 $\Gamma(h_b(1P)\eta)/\Gamma_{\text{total}}$   $\Gamma_{23}/\Gamma$ 

VALUE (units $10^{-3}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
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2.18±0.11±0.18      112k      <sup>1</sup> TAMPONI      15 BELL       $e^+e^- \rightarrow h_b(1P)\eta$ 

<sup>1</sup> Using  $B(\eta \rightarrow 2\gamma) = (39.41 \pm 0.20)\%$ .

 $\Gamma(\eta_b(1S)\omega)/\Gamma_{\text{total}}$   $\Gamma_{24}/\Gamma$ 

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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<1.8 × 10<sup>-4</sup>      90      OSKIN      20 BELL       $e^+e^- \rightarrow \omega X$  $\Gamma(\eta_b(1S)\omega)/\Gamma(h_b(1P)\eta)$   $\Gamma_{24}/\Gamma_{23}$ 

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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<8.4 × 10<sup>-2</sup>      90      <sup>1</sup> OSKIN      20 BELL       $e^+e^- \rightarrow \omega X$ 

<sup>1</sup> Using  $B(\Upsilon(4S) \rightarrow h_b(1P)\eta) = (2.18 \pm 0.11 \pm 0.18) \times 10^{-3}$  from TAMPONI 15.

 $\Gamma(\overline{2H} \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{25}/\Gamma$ 

VALUE (units $10^{-5}$ )	CL%	DOCUMENT ID	TECN	COMMENT
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<1.3      90      ASNER      07 CLEO       $e^+e^- \rightarrow \overline{d}X$ 

## ———— Double Radiative Decays ————

 $\Gamma(\gamma\gamma \Upsilon(D) \rightarrow \gamma\gamma\eta \Upsilon(1S))/\Gamma_{\text{total}}$   $\Gamma_{26}/\Gamma$ 

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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<2.3 × 10<sup>-5</sup>      90      GUIDO      17 BELL       $\Upsilon(4S) \rightarrow \gamma\gamma\pi^+\pi^-\pi^0\mu^+\mu^-$  $\Upsilon(4S)$  REFERENCES

BANERJEE	26	PR D113 012008	Sw. Banerjee <i>et al.</i>	(HFLAV Collab.)
CHOUDHURY	23	PR D107 L031102	S. Choudhury <i>et al.</i>	(BELLE Collab.)
OSKIN	20	PR D102 092011	P. Oskin <i>et al.</i>	(BELLE Collab.)
GUIDO	18	PRL 121 062001	E. Guido <i>et al.</i>	(BELLE Collab.)
GUIDO	17	PR D96 052005	E. Guido <i>et al.</i>	(BELLE Collab.)
TAMPONI	15	PRL 115 142001	U. Tamponi <i>et al.</i>	(BELLE Collab.)
SHEN	13A	PR D88 052019	C.P. Shen <i>et al.</i>	(BELLE Collab.)
ADACHI	12	PRL 108 032001	I. Adachi <i>et al.</i>	(BELLE Collab.)
BELOUS	09	PL B681 400	K. Belous <i>et al.</i>	(BELLE Collab.)
SOKOLOV	09	PR D79 051103	A. Sokolov <i>et al.</i>	(BELLE Collab.)
AUBERT	08BO	PR D78 071103	B. Aubert <i>et al.</i>	(BABAR Collab.)

AUBERT	08BP	PR D78 112002	B. Aubert <i>et al.</i>	(BABAR Collab.)
PDG	08	PL B667 1	C. Amsler <i>et al.</i>	(PDG Collab.)
ASNER	07	PR D75 012009	D.M. Asner <i>et al.</i>	(CLEO Collab.)
HUANG	07	PR D75 012002	G.S. Huang <i>et al.</i>	(CLEO Collab.)
SOKOLOV	07	PR D75 071103	A. Sokolov <i>et al.</i>	(BELLE Collab.)
TAJIMA	07A	PRL 99 211601	O. Tajima <i>et al.</i>	(BELLE Collab.)
AUBERT	06R	PRL 96 232001	B. Aubert <i>et al.</i>	(BABAR Collab.)
AUBERT,BE	06F	PR D74 111103	B. Aubert <i>et al.</i>	(BABAR Collab.)
ARTUSO	05B	PRL 95 261801	M. Artuso <i>et al.</i>	(CLEO Collab.)
AUBERT	05Q	PR D72 032005	B. Aubert <i>et al.</i>	(BABAR Collab.)
AUBERT,B	05H	PRL 95 042001	B. Aubert <i>et al.</i>	(BABAR Collab.)
AUBERT	04F	PR D69 071101	B. Aubert <i>et al.</i>	(BABAR Collab.)
HASTINGS	03	PR D67 052004	N.C. Hastings <i>et al.</i>	(BELLE Collab.)
ABE	02D	PRL 88 052001	K. Abe <i>et al.</i>	(BELLE Collab.)
ATHAR	02	PR D66 052003	S.B. Athar <i>et al.</i>	(CLEO Collab.)
AUBERT	02	PR D65 032001	B. Aubert <i>et al.</i>	(BABAR Collab.)
ALEXANDER	01	PRL 86 2737	J.P. Alexander <i>et al.</i>	(CLEO Collab.)
AUBERT	01C	PRL 87 162002	B. Aubert <i>et al.</i>	(BABAR Collab.)
GLENN	99	PR D59 052003	S. Glenn <i>et al.</i>	(CLEO Collab.)
BARISH	96B	PRL 76 1570	B.C. Barish <i>et al.</i>	(CLEO Collab.)
ALBRECHT	95E	ZPHY C65 619	H. Albrecht <i>et al.</i>	(ARGUS Collab.)
BARISH	95	PR D51 1014	B.C. Barish <i>et al.</i>	(CLEO Collab.)
ALEXANDER	90C	PRL 64 2226	J. Alexander <i>et al.</i>	(CLEO Collab.)
BEBEK	87	PR D36 1289	C. Bebek <i>et al.</i>	(CLEO Collab.)
BESSON	85	PRL 54 381	D. Besson <i>et al.</i>	(CLEO Collab.)
LOVELOCK	85	PRL 54 377	D.M.J. Lovelock <i>et al.</i>	(CUSB Collab.)
LEYAOUANC	77	PL B71 397	A. Le Yaouanc <i>et al.</i>	(ORSAY)

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