

**$\Upsilon(4S)$** 

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

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%
$\Gamma_2$ $B^+B^-$	(51.4 ± 0.6) %	
$\Gamma_3$ $D_s^+$ anything + c.c.	(17.8 ± 2.6) %	
$\Gamma_4$ $B^0\bar{B}^0$	(48.6 ± 0.6) %	
$\Gamma_5$ $J/\psi K_S^0 + (J/\psi, \eta_c) K_S^0$	< 4 × 10 <sup>-7</sup>	90%
$\Gamma_6$ non- $B\bar{B}$	< 4 %	95%
$\Gamma_7$ $e^+e^-$	(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%

$\Gamma_{16}$	$\rho\eta'$	$< 2.5$	$\times 10^{-6}$	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**

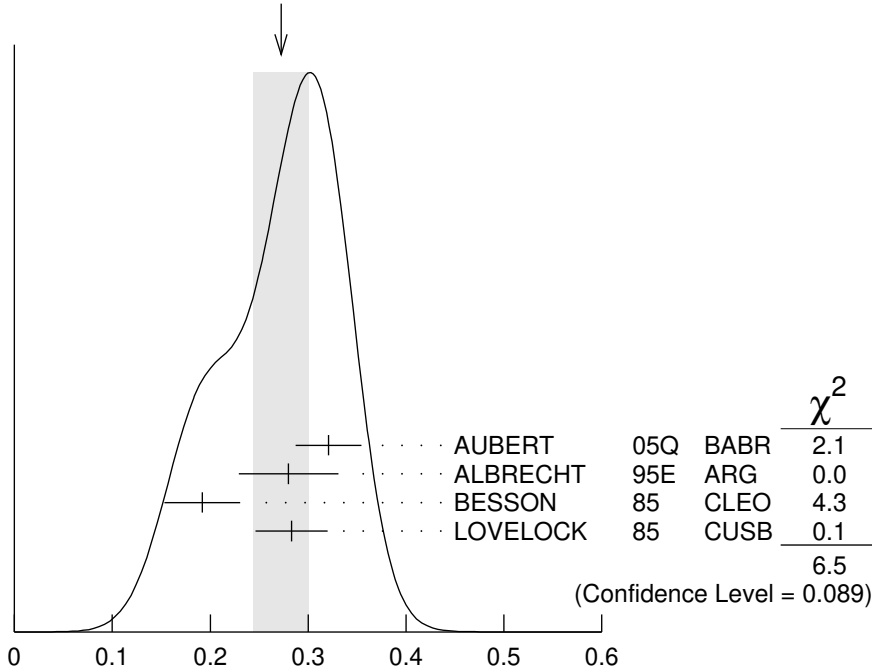
$\Gamma_{26}$	$\gamma\gamma \Upsilon(D) \rightarrow \gamma\gamma\eta \Upsilon(1S)$	$< 2.3$	$\times 10^{-5}$	90%
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**$\Upsilon(4S)$  PARTIAL WIDTHS**

$\Gamma(e^+e^-)$   $\Gamma_7$

<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
$0.192 \pm 0.007 \pm 0.038$	BESSON	85	CLEO $e^+e^- \rightarrow$ hadrons
$0.283 \pm 0.037$	LOVELOCK	85	CUSB $e^+e^- \rightarrow$ hadrons

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



<sup>1</sup> Using LEYAOUANC 77 parametrization of  $\Gamma(s)$ .  
 $\Gamma(e^+e^-)$  (keV)

**$\Upsilon(4S)$  BRANCHING RATIOS** **$B\bar{B}$  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 (HFLAV) and are described at <https://hflav.web.cern.ch/>. The averaging/rescaling procedure takes into account the common dependence of the measurement on the value of the lifetime ratio.

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

VALUE	DOCUMENT ID
<b>0.514 ± 0.006 OUR EVALUATION</b>	Assuming $B(\Upsilon(4S) \rightarrow B\bar{B}) = 1$

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

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.178 ± 0.021 ± 0.016</b>	<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 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 value.

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

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.486 ± 0.006 OUR EVALUATION</b>	Assuming $B(\Upsilon(4S) \rightarrow B\bar{B}) = 1$		

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

0.487 ± 0.010 ± 0.008	<sup>1</sup> AUBERT,B	05H	BABR $\Upsilon(4S) \rightarrow \bar{B}B \rightarrow D^* \ell \nu_\ell$
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<sup>1</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
<b>1.058 ± 0.024 OUR EVALUATION</b>			

1.006 ± 0.036 ± 0.031	<sup>1</sup> AUBERT	04F	BABR $\Upsilon(4S) \rightarrow B\bar{B} \rightarrow J/\psi K$
1.01 ± 0.03 ± 0.09	<sup>1</sup> HASTINGS	03	BELL $\Upsilon(4S) \rightarrow B\bar{B} \rightarrow \text{dileptons}$
1.058 ± 0.084 ± 0.136	<sup>2</sup> ATHAR	02	CLEO $\Upsilon(4S) \rightarrow B\bar{B} \rightarrow D^* \ell \nu$
1.10 ± 0.06 ± 0.05	<sup>3</sup> AUBERT	02	BABR $\Upsilon(4S) \rightarrow B\bar{B} \rightarrow (c\bar{c})K^*$
1.04 ± 0.07 ± 0.04	<sup>4</sup> ALEXANDER	01	CLEO $\Upsilon(4S) \rightarrow B\bar{B} \rightarrow J/\psi K^*$

<sup>1</sup> HASTINGS 03 and AUBERT 04F assume  $\tau(B^+) / \tau(B^0) = 1.083 \pm 0.017$ .

<sup>2</sup> ATHAR 02 assumes  $\tau(B^+) / \tau(B^0) = 1.074 \pm 0.028$ . Supersedes BARISH 95.

<sup>3</sup> AUBERT 02 assumes  $\tau(B^+) / \tau(B^0) = 1.062 \pm 0.029$ .

<sup>4</sup> ALEXANDER 01 assumes  $\tau(B^+) / \tau(B^0) = 1.066 \pm 0.024$ .

$$\frac{\Gamma(J/\psi K_S^0) + \Gamma((J/\psi, \eta_c) K_S^0)}{\Gamma_{\text{total}}} \quad \Gamma_5/\Gamma$$
Forbidden by  $CP$  invariance.

VALUE (units $10^{-7}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<4	90	<sup>1</sup> TAJIMA	07A	BELL $\Upsilon(4S) \rightarrow B^0 \bar{B}^0$

<sup>1</sup>  $\Upsilon(4S)$  with  $CP = +1$  decays to the final state with  $CP = -1$ .

————— non- $B\bar{B}$  DECAYS —————

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

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

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

VALUE (units $10^{-5}$ )	DOCUMENT ID	TECN	COMMENT
<b>1.57 ± 0.08 OUR AVERAGE</b>			

1.55 ± 0.04 ± 0.07

AUBERT 05Q BABR  $e^+ e^- \rightarrow$  hadrons

2.77 ± 0.50 ± 0.49

<sup>1</sup> ALBRECHT 95E ARG  $e^+ e^- \rightarrow$  hadrons<sup>1</sup> Using LEYAOUANC 77 parametrization of  $\Gamma(s)$ .
$$\frac{\Gamma(\rho^+ \rho^-)}{\Gamma_{\text{total}}} \quad \Gamma_8/\Gamma$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<5.7 × 10 <sup>-6</sup>	90	AUBERT	08BO	BABR $e^+ e^- \rightarrow \pi^+ \pi^- 2\pi^0$

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

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

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

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  $e^+ e^- \rightarrow J/\psi X \rightarrow \ell^+ \ell^- X$ <sup>1</sup> Uses  $B(J/\psi \rightarrow e^+ e^-) = 0.0593 \pm 0.0010$  and  $B(J/\psi \rightarrow \mu^+ \mu^-) = 0.0588 \pm 0.0010$ .
$$\frac{\Gamma(D^{*+} \text{ anything} + \text{c.c.})}{\Gamma_{\text{total}}} \quad \Gamma_{11}/\Gamma$$

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

<sup>1</sup> For  $x > 0.473$ .
$$\frac{\Gamma(\phi \text{ anything})}{\Gamma_{\text{total}}} \quad \Gamma_{12}/\Gamma$$

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

• • • 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  $x > 0.52$ .

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

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<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. $\Gamma(\phi\eta')/\Gamma_{\text{total}}$   $\Gamma_{14}/\Gamma$ 

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<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. $\Gamma(\rho\eta)/\Gamma_{\text{total}}$   $\Gamma_{15}/\Gamma$ 

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<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. $\Gamma(\rho\eta')/\Gamma_{\text{total}}$   $\Gamma_{16}/\Gamma$ 

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<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. $\Gamma(\Upsilon(1S) \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_{17}/\Gamma$ 

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

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

VALUE (units $10^{-5}$ )	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
<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 ± 0.2	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 value  $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.05) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best 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 value  $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.05) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best 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 value  $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.05) \times 10^{-2}$ . Our first error is their experiment's error and our second error is the systematic error from using our best 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
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 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 value.					

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

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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
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
$2.18 \pm 0.11 \pm 0.18$	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
$<1.8 \times 10^{-4}$	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
$<8.4 \times 10^{-2}$	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
$<1.3$	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
$<2.3 \times 10^{-5}$	90	GUIDO	17 BELL	$\Upsilon(4S) \rightarrow \gamma\gamma\pi^+\pi^-\pi^0\mu^+\mu^-$

**$\Upsilon(4S)$  REFERENCES**

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>	
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>	
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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