

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

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

$\Upsilon(4S)$ MASS

VALUE (GeV)	DOCUMENT ID	TECN	COMMENT
10.5794 ± 0.0012 OUR AVERAGE			
$10.5793 \pm 0.0004 \pm 0.0012$	AUBERT	05Q BABR	$e^+e^- \rightarrow$ hadrons
10.5800 ± 0.0035	¹ BEBEK	87 CLEO	$e^+e^- \rightarrow$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •			
10.5774 ± 0.0010	² LOVELOCK	85 CUSB	$e^+e^- \rightarrow$ 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			
$20.7 \pm 1.6 \pm 2.5$	AUBERT	05Q BABR	$e^+e^- \rightarrow$ hadrons
$20 \pm 2 \pm 4$	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 (Γ_i/Γ)	Confidence level
Γ_1	$B\bar{B}$	> 96 %	95%
Γ_2	B^+B^-	(50.6 ± 0.8) %	
Γ_3	D_s^+ anything + c.c.	(18.2 ± 3.2) %	
Γ_4	$B^0\bar{B}^0$	(49.4 ± 0.8) %	
Γ_5	non- $B\bar{B}$	< 4 %	95%
Γ_6	e^+e^-	$(1.57 \pm 0.08) \times 10^{-5}$	
Γ_7	$J/\psi(1S)$ anything	$< 1.9 \times 10^{-4}$	95%
Γ_8	D^{*+} anything + c.c.	< 7.4 %	90%
Γ_9	ϕ anything	$< 2.3 \times 10^{-3}$	90%
Γ_{10}	$\Upsilon(1S)$ anything	$< 4 \times 10^{-3}$	90%
Γ_{11}	$\Upsilon(1S)\pi^+\pi^-$	$< 1.2 \times 10^{-4}$	90%
Γ_{12}	$\Upsilon(2S)\pi^+\pi^-$	$< 3.9 \times 10^{-4}$	90%

$\Upsilon(4S)$ PARTIAL WIDTHS

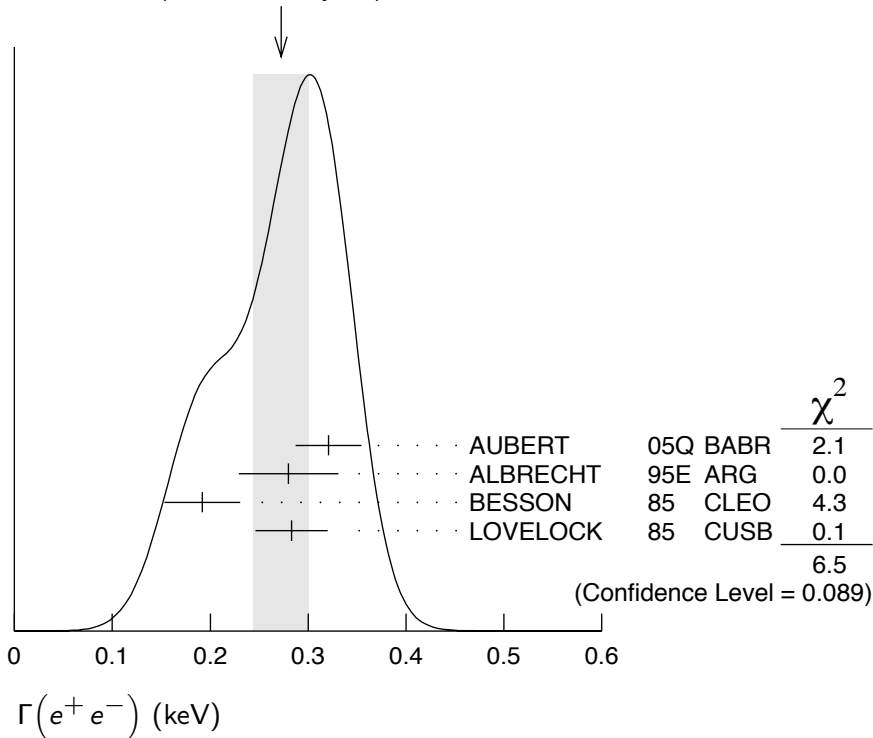
$\Gamma(e^+e^-)$

Γ_6

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

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

WEIGHTED AVERAGE
 0.272 ± 0.029 (Error scaled by 1.5)



$\Upsilon(4S)$ 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 (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.

$\Gamma(B^+ B^-)/\Gamma(B^0 \bar{B}^0)$ Γ_2/Γ_4

VALUE	DOCUMENT ID	TECN	COMMENT
1.026 ± 0.032 OUR EVALUATION			
1.006 ± 0.036 ± 0.031	⁴ AUBERT	04F BABR	$\Upsilon(4S) \rightarrow B\bar{B} \rightarrow J/\psi K$
1.01 ± 0.03 ± 0.09	⁴ HASTINGS	03 BELL	$\Upsilon(4S) \rightarrow B\bar{B} \rightarrow \text{dileptons}$
1.058 ± 0.084 ± 0.136	⁵ ATHAR	02 CLEO	$\Upsilon(4S) \rightarrow B\bar{B} \rightarrow D^* \ell \nu$
1.10 ± 0.06 ± 0.05	⁶ AUBERT	02 BABR	$\Upsilon(4S) \rightarrow B\bar{B} \rightarrow (c\bar{c}) K^*$
1.04 ± 0.07 ± 0.04	⁷ ALEXANDER	01 CLEO	$\Upsilon(4S) \rightarrow B\bar{B} \rightarrow J/\psi K^*$

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 $\tau(B^+)/\tau(B^0) = 1.066 \pm 0.024$. $\Gamma(B^+ B^-)/\Gamma_{\text{total}}$ Γ_2/Γ

VALUE	DOCUMENT ID
0.506 ± 0.008 OUR EVALUATION	Assuming $B(\Upsilon(4S) \rightarrow B\bar{B}) = 1$

 $\Gamma(D_s^+ \text{ anything} + \text{c.c.})/\Gamma_{\text{total}}$ Γ_3/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
0.182 ± 0.021 ± 0.024	⁹ ARTUSO	05B CLE3	$e^+ e^- \rightarrow D_s^+ X$

 $\Gamma(B^0 \bar{B}^0)/\Gamma_{\text{total}}$ Γ_4/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
0.494 ± 0.008 OUR EVALUATION	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	⁸ AUBERT, B	05H BABR	$\Upsilon(4S) \rightarrow \bar{B} B \rightarrow D^* \ell \nu_\ell$
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⁸ Direct measurement. This value is averaged with the value extracted from the $\Gamma(B^+ B^-)/\Gamma(B^0 \bar{B}^0)$ measurements.⁹ ARTUSO 05B reports $[B(\Upsilon(4S) \rightarrow D_s^+ \text{ anything} + \text{c.c.}) \times B(D_s^+ \rightarrow \phi \pi^+)] = 0.0080 \pm 0.0002 \pm 0.0009$. We divide by our best value $B(D_s^+ \rightarrow \phi \pi^+) = (4.4 \pm 0.6) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.**non- $B\bar{B}$ DECAYS** $\Gamma(e^+ e^-)/\Gamma_{\text{total}}$ Γ_6/Γ

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

¹⁰ Using LEYAOUANC 77 parametrization of $\Gamma(s)$. $\Gamma(D^{*+} \text{ anything} + \text{c.c.})/\Gamma_{\text{total}}$ Γ_8/Γ

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

¹¹ For $x > 0.473$.

$\Gamma(\phi \text{ anything})/\Gamma_{\text{total}}$ Γ_9/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.0023	90	¹² ALEXANDER	90C CLEO	e^+e^-

¹² For $x > 0.52$. $\Gamma(J/\psi(1S) \text{ anything})/\Gamma_{\text{total}}$ Γ_7/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	COMMENT
<1.9	95	¹³ 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	¹³ AUBERT	01C BABR	$e^+e^- \rightarrow J/\psi X \rightarrow \ell^+ \ell^- X$
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¹³ Uses $B(J/\psi \rightarrow e^+e^-) = 0.0593 \pm 0.0010$ and $B(J/\psi \rightarrow \mu^+\mu^-) = 0.0588 \pm 0.0010$. $\Gamma(\Upsilon(1S) \text{ anything})/\Gamma_{\text{total}}$ Γ_{10}/Γ

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

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

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

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

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

 $\Gamma(\text{non-}B\bar{B})/\Gamma_{\text{total}}$ Γ_5/Γ

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

 $\Upsilon(4S)$ REFERENCES

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.)
BESSION	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)

OTHER RELATED PAPERS

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