$\Upsilon(4S)$ 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	$e^+e^- \rightarrow$ 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±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

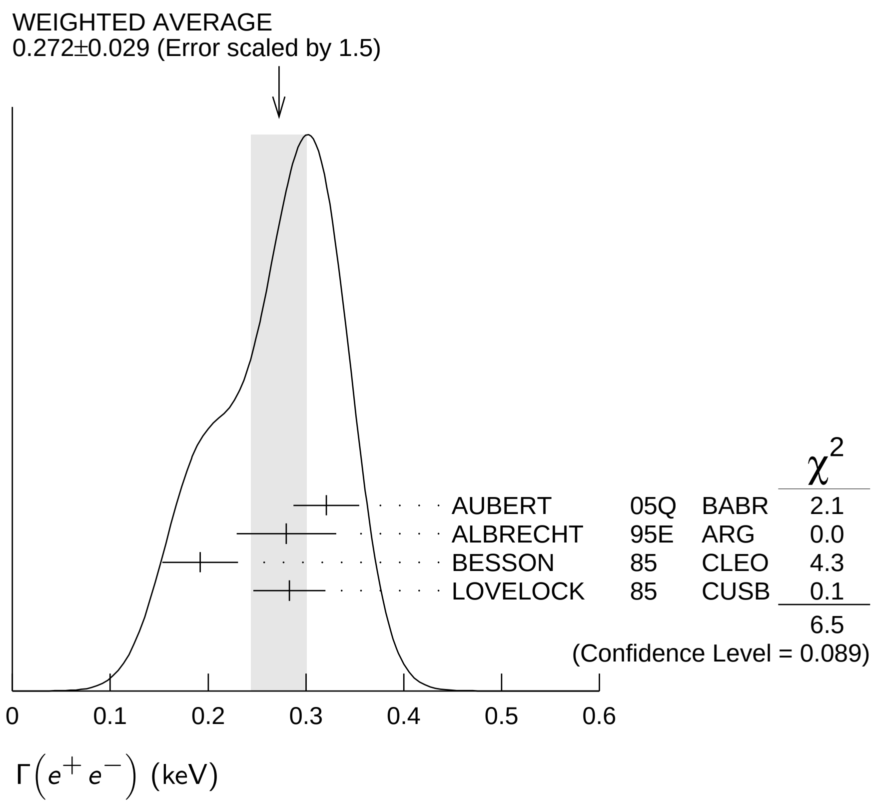
	Mode	Fraction (Γ_i/Γ)	Confidence level
Γ_1	$B\overline{B}$	> 96 %	95%
Γ_2	B^+B^-	(51.6 ±0.6) %	
Γ_3	D_s^+ anything + c.c.	(18.2 ±2.5) %	
Γ_4	$B^0\overline{B}^0$	(48.4 ±0.6) %	
Γ_5	$J/\psi K_S^0 (J/\psi, \eta_c) K_S^0$	< 4 $\times 10^{-7}$	90%
Γ_6	non-$B\overline{B}$	< 4 %	95%
Γ_7	e^+e^-	(1.57±0.08) $\times 10^{-5}$	
Γ_8	$\rho^+\rho^-$	< 5.7 $\times 10^{-6}$	90%
Γ_9	$J/\psi(1S)$ anything	< 1.9 $\times 10^{-4}$	95%
Γ_{10}	D^{*+} anything + c.c.	< 7.4 %	90%
Γ_{11}	ϕ anything	(7.1 ±0.6) %	
Γ_{12}	$\phi\eta$	< 2.5 $\times 10^{-6}$	90%
Γ_{13}	$\Upsilon(1S)$ anything	< 4 $\times 10^{-3}$	90%
Γ_{14}	$\Upsilon(1S)\pi^+\pi^-$	(8.0 ±0.7) $\times 10^{-5}$	
Γ_{15}	$\Upsilon(1S)\eta$	(1.96±0.11) $\times 10^{-4}$	
Γ_{16}	$\Upsilon(2S)\pi^+\pi^-$	(8.6 ±1.3) $\times 10^{-5}$	
Γ_{17}	$\overline{d}$ anything	< 1.3 $\times 10^{-5}$	90%

$\Upsilon(4S)$ PARTIAL WIDTHS

$\Gamma(e^+e^-)$ Γ_7

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.

$\Gamma(B^+ B^-)/\Gamma_{total}$ — Γ_2/Γ

VALUE	DOCUMENT ID
0.516±0.006 OUR EVALUATION	Assuming B($\Upsilon(4S) \to B\overline{B}$) = 1

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.182±0.021±0.014	[4] ARTUSO	05B	CLE3	$e^+ e^- \to D_X X$

[4] ARTUSO 05B reports [$\Gamma(\Upsilon(4S) \to D_s^+$ anything + c.c.$)/\Gamma_{total}$] × [B($D_s^+ \to \phi\pi^+$)] = (8.0 ± 0.2 ± 0.9) × 10^{-3}. We divide by our best value B($D_s^+ \to \phi\pi^+$) = (4.39 ± 0.34) × 10^{-2}. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(B^0 \overline{B}^0)/\Gamma_{total}$ — Γ_4/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.484±0.006 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	[5] AUBERT,B	05H	BABR	$\Upsilon(4S) \to \overline{B} B \to D^* \ell \nu_\ell$

[5] Direct measurement. This value is averaged with the value extracted from the $\Gamma(B^+ B^-)$ / $\Gamma(B^0 \overline{B}^0)$ measurements.

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

VALUE	DOCUMENT ID		TECN	COMMENT
1.065±0.026 OUR EVALUATION				
1.006±0.036±0.031	[6] AUBERT	04F	BABR	$\Upsilon(4S) \to B\overline{B} \to J/\psi K$
1.01 ±0.03 ±0.09	[6] HASTINGS	03	BELL	$\Upsilon(4S) \to B\overline{B} \to$ dileptons
1.058±0.084±0.136	[7] ATHAR	02	CLEO	$\Upsilon(4S) \to B\overline{B} \to D^* \ell \nu$
1.10 ±0.06 ±0.05	[8] AUBERT	02	BABR	$\Upsilon(4S) \to B\overline{B} \to (c\overline{c})K^*$
1.04 ±0.07 ±0.04	[9] ALEXANDER	01	CLEO	$\Upsilon(4S) \to B\overline{B} \to J/\psi K^*$

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

$\Gamma(J/\psi K_S^0 (J/\psi, \eta_c) K_S^0)/\Gamma_{total}$ — Γ_5/Γ

Forbidden by *CP* invariance.

VALUE (units 10^{-7})	CL%	DOCUMENT ID		TECN	COMMENT
<4	90	[10] TAJIMA	07A	BELL	$\Upsilon(4S) \to B^0 \overline{B}^0$

[10] $\Upsilon(4S)$ with $CP = +1$ decays to the final state with $CP = -1$.

non-$B\overline{B}$ DECAYS

$\Gamma(\text{non-}B\overline{B})/\Gamma_{total}$ — Γ_6/Γ

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

$\Gamma(e^+e^-)/\Gamma_{total}$ — Γ_7/Γ

VALUE (units 10^{-5})	DOCUMENT ID		TECN	COMMENT
1.57±0.08 OUR AVERAGE				
1.55±0.04±0.07	AUBERT	05Q	BABR	$e^+e^- \to$ hadrons
2.77±0.50±0.49	[11] ALBRECHT	95E	ARG	$e^+e^- \to$ hadrons

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

$\Gamma(\rho^+\rho^-)/\Gamma_{total}$ — Γ_8/Γ

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

$\Gamma(J/\psi(1S)$ anything$)/\Gamma_{total}$ — Γ_9/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<1.9	95	[12] 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	[12] AUBERT	01C	BABR	$e^+e^- \to J/\psi X \to \ell^+\ell^- X$

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

$\Gamma(D^{*+}$ anything + c.c.$)/\Gamma_{total}$ — Γ_{10}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.074	90	[13] ALEXANDER	90C	CLEO	e^+e^-

[13] For $x >$ 0.473.

$\Gamma(\phi$ anything$)/\Gamma_{total}$ — Γ_{11}/Γ

VALUE (units 10^{-2})	CL%	DOCUMENT ID		TECN	COMMENT
7.1 ±0.1±0.6		HUANG	07	CLEO	$\Upsilon(4S) \to \phi X$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.23	90	[14] ALEXANDER	90C	CLEO	e^+e^-

[14] For $x >$ 0.52.

$\Gamma(\phi\eta)/\Gamma_{total}$ — Γ_{12}/Γ

VALUE (units 10^{-6})	CL%	DOCUMENT ID		TECN	COMMENT
<2.5	90	AUBERT,BE	06F	BABR	$e^+e^- \to \phi\eta$

$\Gamma(\Upsilon(1S)$ anything$)/\Gamma_{total}$ — Γ_{13}/Γ

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

$\Gamma(\Upsilon(1S)\pi^+\pi^-)/\Gamma_{total}$ — Γ_{14}/Γ

VALUE (units 10^{-5})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
8.00±0.64±0.27		430	[15] AUBERT	08BP	BABR	$\Upsilon(4S) \to \pi^+\pi^-\ell^+\ell^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
17.8 ±4.0 ±0.3			[16,17] SOKOLOV	07	BELL	$e^+e^- \to \pi^+\pi^-\mu^+\mu^-$
9.0 ±1.5 ±0.2		167 ± 19	[18] AUBERT	06R	BABR	$e^+e^- \to \pi^+\pi^-\mu^+\mu^-$
<12	90		GLENN	99	CLE2	e^+e^-

[15] Using B($\Upsilon(1S) \rightarrow e^+ e^-$) = (2.38 ± 0.11)% and B($\Upsilon(1S) \rightarrow \mu^+ \mu^-$) = (2.48 ± 0.05)%.

[16] SOKOLOV 07 reports [$\Gamma(\Upsilon(4S) \rightarrow \Upsilon(1S)\pi^+\pi^-)/\Gamma_{total}$] × [B($\Upsilon(1S) \rightarrow \mu^+\mu^-$)] = (4.42 ± 0.81 ± 0.56) × 10^{-6}. We divide by our best value B($\Upsilon(1S) \rightarrow \mu^+\mu^-$) = (2.48 ± 0.05) × 10^{-2}. Our first error is their experiment's error and our second error is the systematic error from using our best value.

[17] According to the authors, systematic errors were underestimated.

[18] Superseded by AUBERT 08BP. AUBERT 06R reports [$\Gamma(\Upsilon(4S) \rightarrow \Upsilon(1S)\pi^+\pi^-)/\Gamma_{total}$] × [B($\Upsilon(1S) \rightarrow \mu^+\mu^-$)] = (2.23 ± 0.25 ± 0.27) × 10^{-6}. We divide by our best value B($\Upsilon(1S) \rightarrow \mu^+\mu^-$) = (2.48 ± 0.05) × 10^{-2}. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(\Upsilon(1S)\eta)/\Gamma_{total}$ — Γ_{15}/Γ

VALUE (units 10^{-4})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
1.96±0.06±0.09	56	[19] AUBERT	08BP	BABR	$\Upsilon(4S) \rightarrow \pi^+\pi^-\pi^0\ell^+\ell^-$

[19] Using B($\Upsilon(1S) \rightarrow e^+ e^-$) = (2.38 ± 0.11)% and B($\Upsilon(1S) \rightarrow \mu^+ \mu^-$) = (2.48 ± 0.05)%.

$\Gamma(\Upsilon(1S)\eta)/\Gamma(\Upsilon(1S)\pi^+\pi^-)$ — Γ_{15}/Γ_{14}

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	[20] AUBERT	08BP	BABR	$\Upsilon(4S) \rightarrow \pi^+\pi^-(\pi^0)\ell^+\ell^-$

[20] Not independent of other values reported by AUBERT 08BP.

$\Gamma(\Upsilon(2S)\pi^+\pi^-)/\Gamma_{total}$ — Γ_{16}/Γ

VALUE (units 10^{-4})	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.86±0.11±0.07		220	[21] AUBERT	08BP	BABR	$\Upsilon(4S) \rightarrow \pi^+\pi^-\ell^+\ell^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
0.88±0.17±0.08		97 ± 15	[22] AUBERT	06R	BABR	$e^+e^- \rightarrow \pi^+\pi^-\mu^+\mu^-$
<3.9	90		GLENN	99	CLE2	e^+e^-

[21] Using B($\Upsilon(2S) \rightarrow e^+ e^-$) = (1.91 ± 0.16)% and B($\Upsilon(2S) \rightarrow \mu^+ \mu^-$) = (1.93 ± 0.17)%.

[22] Superseded by AUBERT 08BP. AUBERT 06R reports [$\Gamma(\Upsilon(4S) \rightarrow \Upsilon(2S)\pi^+\pi^-)/\Gamma_{total}$] × [B($\Upsilon(2S) \rightarrow \mu^+\mu^-$)] = (1.69 ± 0.26 ± 0.20) × 10^{-6}. We divide by our best value B($\Upsilon(2S) \rightarrow \mu^+\mu^-$) = (1.93 ± 0.17) × 10^{-2}. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(\Upsilon(2S)\pi^+\pi^-)/\Gamma(\Upsilon(1S)\pi^+\pi^-)$ — Γ_{16}/Γ_{14}

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1.16±0.16±0.14	220	[23] AUBERT	08BP	BABR	$\Upsilon(4S) \rightarrow \pi^+\pi^-\ell^+\ell^-$

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

$\Gamma(\overline{d}\text{ anything})/\Gamma_{total}$ Γ_{17}/Γ

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

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