$\Upsilon(3S)$

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

$\Upsilon(3S)$ MASS

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
10355.1±0.5	[1] SHAMOV	23	RVUE	$e^+e^- \to$ hadrons
• • • We do not use the following data for averages, fits, limits, etc. • • •				
10355.2±0.5	[2,3] ARTAMONOV	00	MD1	$e^+e^- \to$ hadrons
10355.3±0.5	[4,5] BARU	86B	MD1	$e^+e^- \to$ hadrons

[1] Reanalysis of MD1 data using the electron mass from COHEN 87, the radiative corrections from KURAEV 85 and interference effects.
[2] Reanalysis of BARU 86B using new electron mass (COHEN 87).
[3] Superseded by SHAMOV 23.
[4] Reanalysis of ARTAMONOV 84.
[5] Superseded by ARTAMONOV 00.

$m_{\Upsilon(3S)} - m_{\Upsilon(2S)}$

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
331.50±0.02±0.13	LEES	11C	BABR	$e^+e^- \to \pi^+\pi^- X$

$\Upsilon(3S)$ WIDTH

VALUE (keV)	*DOCUMENT ID*
20.32±1.85 OUR EVALUATION	See the Note on "Width Determinations of the Υ States"

$\Upsilon(3S)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)	Scale factor/ Confidence level
Γ_1	$\Upsilon(2S)$ anything	(10.6 ± 0.8) %	
Γ_2	$\Upsilon(2S)\pi^+\pi^-$	(2.82 ± 0.18) %	S=1.6
Γ_3	$\Upsilon(2S)\pi^0\pi^0$	(1.85 ± 0.14) %	
Γ_4	$\Upsilon(2S)\gamma\gamma$	(5.0 ± 0.7) %	
Γ_5	$\Upsilon(2S)\pi^0$	$< 5.1 \times 10^{-4}$	CL=90%
Γ_6	$\Upsilon(1S)\pi^+\pi^-$	(4.37 ± 0.08) %	
Γ_7	$\Upsilon(1S)\pi^0\pi^0$	(2.20 ± 0.13) %	
Γ_8	$\Upsilon(1S)\eta$	$< 1 \times 10^{-4}$	CL=90%
Γ_9	$\Upsilon(1S)\pi^0$	$< 7 \times 10^{-5}$	CL=90%
Γ_{10}	$h_b(1P)\pi^0$	$< 1.2 \times 10^{-3}$	CL=90%
Γ_{11}	$h_b(1P)\pi^0 \to \gamma\eta_b(1S)\pi^0$	$(4.3 \pm 1.4) \times 10^{-4}$	
Γ_{12}	$h_b(1P)\pi^+\pi^-$	$< 1.2 \times 10^{-4}$	CL=90%
Γ_{13}	$\tau^+\tau^-$	(2.29 ± 0.30) %	
Γ_{14}	$\mu^+\mu^-$	(2.18 ± 0.21) %	S=2.1
Γ_{15}	e^+e^-	(2.18 ± 0.20) %	
Γ_{16}	hadrons	(93 ± 12) %	
Γ_{17}	ggg	(35.7 ± 2.6) %	
Γ_{18}	γgg	$(9.7 \pm 1.8) \times 10^{-3}$	
Γ_{19}	^2H anything	$(2.33 \pm 0.33) \times 10^{-5}$	

Radiative decays

Γ_{20}	$\gamma \chi_{b2}(2P)$		$(13.1 \pm 1.6)\%$	S=3.4
Γ_{21}	$\gamma \chi_{b1}(2P)$		$(12.6 \pm 1.2)\%$	S=2.4
Γ_{22}	$\gamma \chi_{b0}(2P)$		$(5.9 \pm 0.6)\%$	S=1.4
Γ_{23}	$\gamma \chi_{b2}(1P)$		$(10.0 \pm 1.0) \times 10^{-3}$	S=1.7
Γ_{24}	$\gamma \chi_{b1}(1P)$		$(9 \pm 5) \times 10^{-4}$	S=1.8
Γ_{25}	$\gamma \chi_{b0}(1P)$		$(2.7 \pm 0.4) \times 10^{-3}$	
Γ_{26}	$\gamma \eta_b(2S)$		$< 6.2 \times 10^{-4}$	CL=90%
Γ_{27}	$\gamma \eta_b(1S)$		$(5.1 \pm 0.7) \times 10^{-4}$	
Γ_{28}	$\gamma A^0 \to \gamma$ hadrons		$< 8 \times 10^{-5}$	CL=90%
Γ_{29}	$\gamma X \to \gamma + \geq 4$ prongs	[a]	$< 2.2 \times 10^{-4}$	CL=95%
Γ_{30}	$\gamma A^0 \to \gamma \mu^+ \mu^-$		$< 5.5 \times 10^{-6}$	CL=90%
Γ_{31}	$\gamma A^0 \to \gamma \tau^+ \tau^-$	[b]	$< 1.6 \times 10^{-4}$	CL=90%

Lepton Family number (*LF*) violating modes

Γ_{32}	$e^\pm \tau^\mp$	*LF*	$< 4.2 \times 10^{-6}$	CL=90%
Γ_{33}	$e^\pm \mu^\mp$	*LF*	$< 3.6 \times 10^{-7}$	CL=90%
Γ_{34}	$\mu^\pm \tau^\mp$	*LF*	$< 3.1 \times 10^{-6}$	CL=90%

[a] 1.5 GeV $< m_X <$ 5.0 GeV

[b] For $m_{\tau^+\tau^-}$ in the ranges 4.03–9.52 and 9.61–10.10 GeV.

$\Upsilon(3S)$ $\Gamma(i)\Gamma(e^+e^-)/\Gamma(\text{total})$

$\Gamma(\text{hadrons}) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ — $\Gamma_{16}\Gamma_{15}/\Gamma$

VALUE (keV)	DOCUMENT ID		TECN	COMMENT
0.414±0.007 OUR AVERAGE				
0.413±0.004±0.006	ROSNER	06	CLEO	10.4 $e^+e^- \to$ hadrons
0.45 ±0.03 ±0.03	[6] GILES	84B	CLEO	$e^+e^- \to$ hadrons

[6] Radiative corrections reevaluated by BUCHMUELLER 88 following KURAEV 85.

$\Gamma(\Upsilon(1S)\pi^+\pi^-) \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ — $\Gamma_6\Gamma_{15}/\Gamma$

VALUE (eV)	EVTS	DOCUMENT ID		TECN	COMMENT
18.46±0.27±0.77	6.4k	[7] AUBERT	08BP	BABR	$e^+e^- \to \gamma\pi^+\pi^-\ell^+\ell^-$

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

$\Upsilon(3S)$ PARTIAL WIDTHS

$\Gamma(e^+e^-)$ — Γ_{15}

VALUE (keV)	DOCUMENT ID
0.443±0.008 OUR EVALUATION	

$\Upsilon(3S)$ BRANCHING RATIOS

$\Gamma(\Upsilon(2S)\text{anything})/\Gamma_{total}$ Γ_1/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.106 ±0.008 OUR AVERAGE					
0.1023±0.0105	4625	[8,9,10] BUTLER	94B	CLE2	$e^+e^- \to \ell^+\ell^- X$
0.111 ±0.012	4891	[9,10,11] BROCK	91	CLEO	$e^+e^- \to \pi^+\pi^- X$, $\pi^+\pi^-\ell^+\ell^-$

[8] Using B($\Upsilon(2S) \to \Upsilon(1S)\gamma\gamma$) = (0.038 ± 0.007)%, and B($\Upsilon(2S) \to \Upsilon(1S)\pi^0\pi^0$) = (1/2)B($\Upsilon(2S) \to \Upsilon(1S)\pi^+\pi^-$).

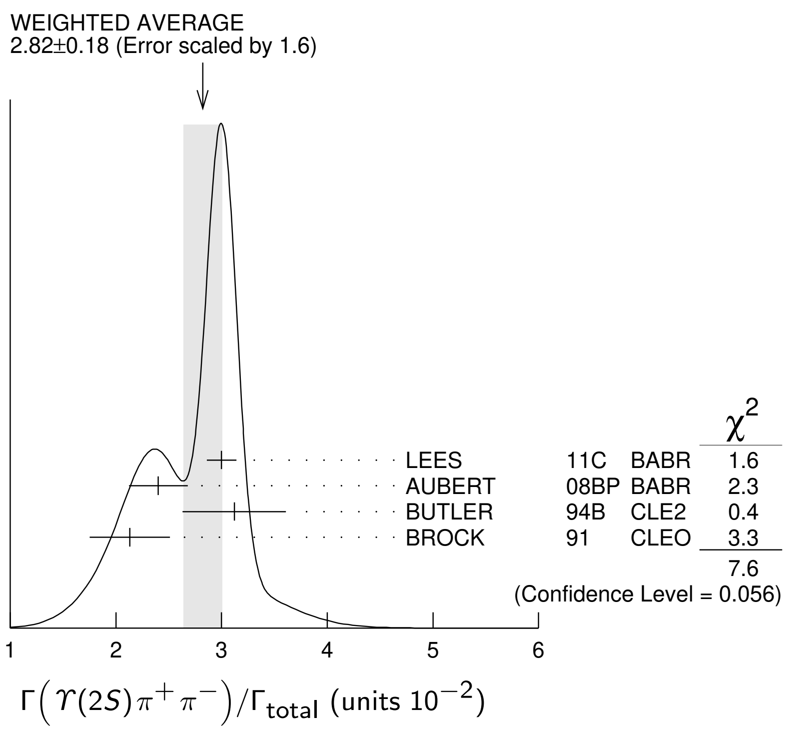
[9] Using B($\Upsilon(1S) \to \mu^+\mu^-$) = (2.48 ± 0.06)%. With the assumption of $e\mu$ universality.

[10] Using B($\Upsilon(2S) \to \Upsilon(1S)\pi^+\pi^-$) = (18.5 ± 0.8)%.

[11] Using B($\Upsilon(2S) \to \mu^+\mu^-$) = (1.31 ± 0.21)%, B($\Upsilon(2S) \to \Upsilon(1S)\gamma\gamma$)×2B($\Upsilon(1S) \to \mu^+\mu^-$) = (0.188 ± 0.035)%, and B($\Upsilon(2S) \to \Upsilon(1S)\pi^0\pi^0$)×2B($\Upsilon(1S) \to \mu^+\mu^-$) = (0.436 ± 0.056)%. With the assumption of $e\mu$ universality.

$\Gamma(\Upsilon(2S)\pi^+\pi^-)/\Gamma_{total}$ Γ_2/Γ

VALUE (units 10^{-2})	EVTS	DOCUMENT ID		TECN	COMMENT
2.82±0.18 OUR AVERAGE		Error includes scale factor of 1.6. See the ideogram below.			
3.00±0.02±0.14	543k	LEES	11C	BABR	$e^+e^- \to \pi^+\pi^- X$
2.40±0.10±0.26	800	[12] AUBERT	08BP	BABR	$e^+e^- \to \gamma\pi^+\pi^- e^+e^-$
3.12±0.49	980	[13,14] BUTLER	94B	CLE2	$e^+e^- \to \pi^+\pi^-\ell^+\ell^-$
2.13±0.38	974	[15] BROCK	91	CLEO	$e^+e^- \to \pi^+\pi^- X$, $\pi^+\pi^-\ell^+\ell^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
4.82±0.65±0.53	138	[15] WU	93	CUSB	$\Upsilon(3S) \to \pi^+\pi^-\ell^+\ell^-$
3.1 ±2.0	5	MAGERAS	82	CUSB	$\Upsilon(3S) \to \pi^+\pi^-\ell^+\ell^-$



[12] Using B($\Upsilon(1S) \to e^+e^-$) = (2.38 ± 0.11)%, B($\Upsilon(1S) \to \mu^+\mu^-$) = (2.48 ± 0.05)%, and $\Gamma_{ee}(\Upsilon(3S))$ = 0.443 ± 0.008 keV.

[13] From the exclusive mode.

[14] Using B($\Upsilon(2S) \to \Upsilon(1S)\gamma\gamma$) = (0.038 ± 0.007)%, and B($\Upsilon(2S) \to \Upsilon(1S)\pi^0\pi^0$) = (1/2)B($\Upsilon(2S) \to \Upsilon(1S)\pi^+\pi^-$).

[15] Using B($\Upsilon(2S) \to \mu^+\mu^-$) = (1.31 ± 0.21)%, B($\Upsilon(2S) \to \Upsilon(1S)\gamma\gamma$)×2B($\Upsilon(1S) \to \mu^+\mu^-$) = (0.188 ± 0.035)%, and B($\Upsilon(2S) \to \Upsilon(1S)\pi^0\pi^0$)×2B($\Upsilon(1S) \to \mu^+\mu^-$) = (0.436 ± 0.056)%. With the assumption of $e\mu$ universality.

$\Gamma(\Upsilon(2S)\pi^0\pi^0)/\Gamma_{\text{total}}$ — Γ_3/Γ

VALUE (units 10^{-2})	EVTS	DOCUMENT ID		TECN	COMMENT
1.85±0.14 OUR AVERAGE					
1.82±0.09±0.12	4391	[16] BHARI	09	CLEO	$e^+e^- \to \pi^0\pi^0\ell^+\ell^-$
2.16±0.39		[17,18] BUTLER	94B	CLE2	$e^+e^- \to \pi^0\pi^0\ell^+\ell^-$
1.7 ±0.5 ±0.2	10	[19] HEINTZ	92	CSB2	$e^+e^- \to \pi^0\pi^0\ell^+\ell^-$

[16] Authors assume B($\Upsilon(1S) \to e^+e^-$) + B($\Upsilon(1S) \to \mu^+\mu^-$) = 4.06%.

[17] B($\Upsilon(2S) \to \mu^+\mu^-$) = (1.31 ± 0.21)% and assuming $e\mu$ universality.

[18] From the exclusive mode.

[19] B($\Upsilon(2S) \to \mu^+\mu^-$) = (1.44 ± 0.10)% and assuming $e\mu$ universality. Supersedes HEINTZ 91.

$\Gamma(\Upsilon(2S)\gamma\gamma)/\Gamma_{\text{total}}$ — Γ_4/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.0502±0.0069	[20] BUTLER	94B	CLE2	$e^+e^- \to \ell^+\ell^- 2\gamma$

[20] From the exclusive mode.

$\Gamma(\Upsilon(2S)\pi^0)/\Gamma_{\text{total}}$ — Γ_5/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<0.51	90	[21] HE	08A	CLEO	$e^+e^- \to \ell^+\ell^-\gamma\gamma$

[21] Authors assume B($\Upsilon(2S) \to e^+e^-$) + B($\Upsilon(1S) \to \mu^+\mu^-$) = 4.06%.

$\Gamma(\Upsilon(1S)\pi^+\pi^-)/\Gamma_{\text{total}}$ — Γ_6/Γ

Abbreviation MM in the *COMMENT* field below stands for missing mass.

VALUE (units 10^{-2})	EVTS	DOCUMENT ID		TECN	COMMENT
4.37±0.08 OUR AVERAGE					
4.32±0.07±0.13	90k	[22] LEES	11L	BABR	$\Upsilon(3S) \to \pi^+\pi^-\ell^+\ell^-$
4.46±0.01±0.13	190k	[23] BHARI	09	CLEO	$e^+e^- \to \pi^+\pi^-$ MM
4.17±0.06±0.19	6.4k	[24] AUBERT	08BP	BABR	10.58 $e^+e^- \to \gamma\pi^+\pi^-\ell^+\ell^-$
4.52±0.35	11830	[25] BUTLER	94B	CLE2	$e^+e^- \to \pi^+\pi^-X$, $\pi^+\pi^-\ell^+\ell^-$
4.46±0.34±0.50	451	[25] WU	93	CUSB	$\Upsilon(3S) \to \pi^+\pi^-\ell^+\ell^-$
4.46±0.30	11221	[25] BROCK	91	CLEO	$e^+e^- \to \pi^+\pi^-X$, $\pi^+\pi^-\ell^+\ell^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
4.9 ±1.0	22	GREEN	82	CLEO	$\Upsilon(3S) \to \pi^+\pi^-\ell^+\ell^-$
3.9 ±1.3	26	MAGERAS	82	CUSB	$\Upsilon(3S) \to \pi^+\pi^-\ell^+\ell^-$

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

[23] A weighted average of the inclusive and exclusive results.

[24] Using B($\Upsilon(2S) \to e^+e^-$) = (1.91 ± 0.16)%, B($\Upsilon(2S) \to \mu^+\mu^-$) = (1.93 ± 0.17)%, and $\Gamma_{ee}(\Upsilon(3S))$ = 0.443 ± 0.008 keV.

[25] Using B($\Upsilon(1S) \to \mu^+\mu^-$) = (2.48 ± 0.06)%. With the assumption of $e\mu$ universality.

$\Gamma(\Upsilon(2S)\pi^+\pi^-)/\Gamma(\Upsilon(1S)\pi^+\pi^-)$ — Γ_2/Γ_6

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$0.577\pm0.026\pm0.060$	800	[26] AUBERT	08BP	BABR	$e^+e^- \to \gamma\pi^+\pi^-\ell^+\ell^-$

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

$\Gamma(\Upsilon(1S)\pi^0\pi^0)/\Gamma_{\text{total}}$ — Γ_7/Γ

VALUE (units 10^{-2})	EVTS	DOCUMENT ID		TECN	COMMENT
2.20±0.13 OUR AVERAGE					
$2.24\pm0.09\pm0.11$	6584	[27] BHARI	09	CLEO	$e^+e^- \to \pi^0\pi^0\ell^+\ell^-$
1.99 ± 0.34	56	[28] BUTLER	94B	CLE2	$e^+e^- \to \pi^0\pi^0\ell^+\ell^-$
$2.2\ \pm0.4\ \pm0.3$	33	[29] HEINTZ	92	CSB2	$e^+e^- \to \pi^0\pi^0\ell^+\ell^-$

[27] Authors assume B($\Upsilon(1S) \to e^+e^-$) + B($\Upsilon(1S) \to \mu^+\mu^-$) = 4.96%.
[28] Using B($\Upsilon(1S) \to \mu^+\mu^-$) = (2.48 ± 0.06)% and assuming $e\mu$ universality.
[29] Using B($\Upsilon(1S) \to \mu^+\mu^-$) = (2.57 ± 0.07)% and assuming $e\mu$ universality. Supersedes HEINTZ 91.

$\Gamma(\Upsilon(1S)\pi^0\pi^0)/\Gamma(\Upsilon(1S)\pi^+\pi^-)$ — Γ_7/Γ_6

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.501 ± 0.043	[30] BHARI	09	CLEO	$e^+e^- \to \Upsilon(3S)$

[30] Not independent of other values reported by BHARI 09.

$\Gamma(\Upsilon(1S)\eta)/\Gamma_{\text{total}}$ — Γ_8/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<0.1	90	[31] LEES	11L	BABR	$\Upsilon(3S) \to (\pi^+\pi^-)(\gamma\gamma)\ell^+\ell^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.8	90	[31,32] AUBERT	08BP	BABR	$e^+e^- \to \gamma\pi^+\pi^-\pi^0\ell^+\ell^-$
<0.18	90	[33] HE	08A	CLEO	$e^+e^- \to \ell^+\ell^-\eta$
<2.2	90	BROCK	91	CLEO	$e^+e^- \to \ell^+\ell^-\eta$

[31] Using B($\Upsilon(1S) \to e^+e^-$) = (2.38 ± 0.11)%, B($\Upsilon(1S) \to \mu^+\mu^-$) = (2.48 ± 0.05)%.
[32] Using $\Gamma_{ee}(\Upsilon(3S))$ = 0.443 ± 0.008 keV.
[33] Authors assume B($\Upsilon(1S) \to e^+e^-$) + B($\Upsilon(1S) \to \mu^+\mu^-$) = 4.96%.

$\Gamma(\Upsilon(1S)\eta)/\Gamma(\Upsilon(1S)\pi^+\pi^-)$ — Γ_8/Γ_6

VALUE (units 10^{-2})	CL%	DOCUMENT ID		TECN	COMMENT
<0.23	90	[34] LEES	11L	BABR	$\Upsilon(3S) \to (\pi^+\pi^-)(\gamma\gamma)\ell^+\ell^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<1.9	90	[35] AUBERT	08BP	BABR	$e^+e^- \to \gamma\pi^+\pi^-(\pi^0)\ell^+\ell^-$

[34] Not independent of other values reported by LEES 11L.
[35] Not independent of other values reported by AUBERT 08BP.

$\Gamma(\Upsilon(1S)\pi^0)/\Gamma_{total}$ — Γ_9/Γ

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	COMMENT
<0.07	90	[36] HE	08A	CLEO	$e^+e^- \to \ell^+\ell^-\gamma\gamma$

[36] Authors assume $B(\Upsilon(1S) \to e^+e^-) + B(\Upsilon(1S) \to \mu^+\mu^-) = 4.96\%$.

$\Gamma(h_b(1P)\pi^0)/\Gamma_{total}$ — Γ_{10}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<1.2 \times 10^{-3}$	90	[37] GE	11	CLEO	$\Upsilon(3S) \to \pi^0$ anything

[37] Assuming $M(h_b(1P)) = 9900$ MeV and $\Gamma(h_b(1P)) = 0$ MeV, and allowing $B(h_b(1P) \to \gamma\eta_b(1S))$ to vary from 0–100%.

$\Gamma(h_b(1P)\pi^0 \to \gamma\eta_b(1S)\pi^0)/\Gamma_{total}$ — Γ_{11}/Γ

VALUE (units 10^{-4})	DOCUMENT ID		TECN	COMMENT
4.3±1.1±0.9	LEES	11K	BABR	$\Upsilon(3S) \to \eta_b\gamma\pi^0$

$\Gamma(h_b(1P)\pi^+\pi^-)/\Gamma_{total}$ — Γ_{12}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
< 1.2	90	[38] LEES	11C	BABR	$e^+e^- \to \pi^+\pi^- X$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<18		[38] BUTLER	94B	CLE2	$e^+e^- \to \pi^+\pi^- X$
<15		[38] BROCK	91	CLEO	$e^+e^- \to \pi^+\pi^- X$

[38] For $M(h_b(1P)) = 9900$ MeV.

$\Gamma(\tau^+\tau^-)/\Gamma_{total}$ — Γ_{13}/Γ

VALUE (units 10^{-2})	EVTS	DOCUMENT ID		TECN	COMMENT
2.29±0.21±0.22	15k	[39] BESSON	07	CLEO	$e^+e^- \to \Upsilon(3S) \to \tau^+\tau^-$

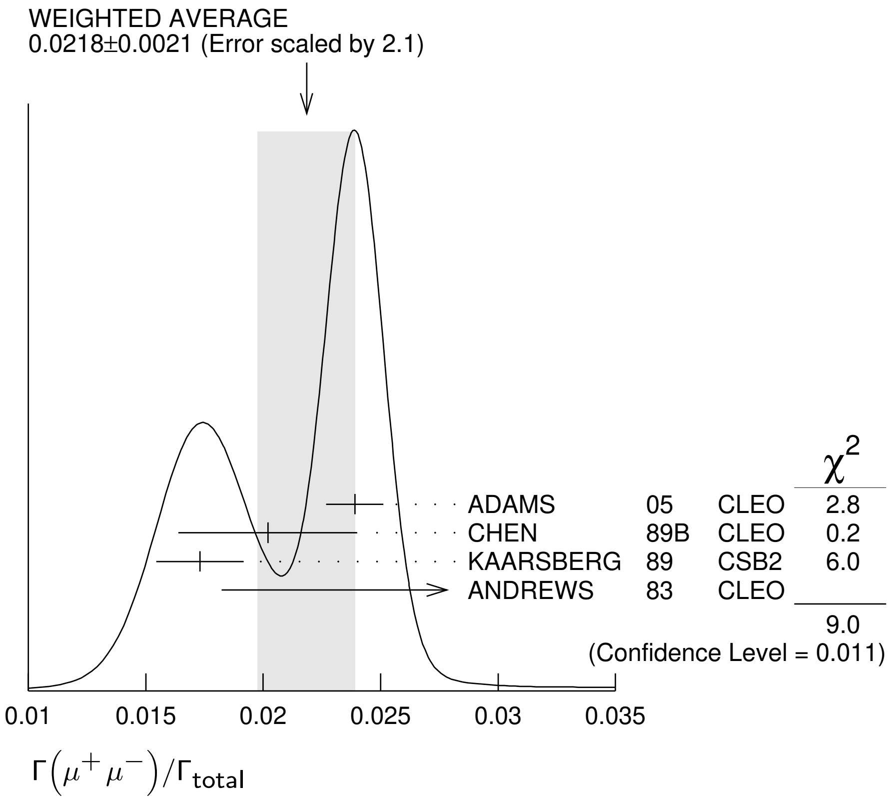
[39] BESSON 07 reports $[\Gamma(\Upsilon(3S) \to \tau^+\tau^-)/\Gamma_{total}] / [B(\Upsilon(3S) \to \mu^+\mu^-)] = 1.05 \pm 0.08 \pm 0.05$ which we multiply by our best value $B(\Upsilon(3S) \to \mu^+\mu^-) = (2.18 \pm 0.21) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(\tau^+\tau^-)/\Gamma(\mu^+\mu^-)$ — Γ_{13}/Γ_{14}

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.968±0.016 OUR AVERAGE					
0.966±0.008±0.014	2.2M	LEES	20E	BABR	$e^+e^- \to \Upsilon(3S)$
1.05 ±0.08 ±0.05	15k	BESSON	07	CLEO	$e^+e^- \to \Upsilon(3S)$

$\Gamma(\mu^+\mu^-)/\Gamma_{total}$ — Γ_{14}/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.0218±0.0021 OUR AVERAGE Error includes scale factor of 2.1. See the ideogram below.					
0.0239±0.0007±0.0010	81k	ADAMS	05	CLEO	$e^+e^- \to \mu^+\mu^-$
0.0202±0.0019±0.0033		CHEN	89B	CLEO	$e^+e^- \to \mu^+\mu^-$
0.0173±0.0015±0.0011		KAARSBERG	89	CSB2	$e^+e^- \to \mu^+\mu^-$
0.033 ±0.013 ±0.007	1096	ANDREWS	83	CLEO	$e^+e^- \to \mu^+\mu^-$



$\Gamma(ggg)/\Gamma_{\text{total}}$ $\qquad\qquad$ Γ_{17}/Γ

VALUE (units 10^{-2})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
35.7±2.6	3M	[40] BESSON	06A	CLEO	$\Upsilon(3S) \to$ hadrons

[40] Calculated using BESSON 06A value of $\Gamma(\gamma gg)/\Gamma(ggg) = (2.72 \pm 0.06 \pm 0.32 \pm 0.37)\%$ and the PDG 08 values of B($\Upsilon(2S)$ + anything) = $(10.6 \pm 0.8)\%$, B($\pi^+\pi^-\Upsilon(1S)$) = $(4.40 \pm 0.10)\%$, B($\pi^0\pi^0\Upsilon(1S)$) = $(2.20 \pm 0.13)\%$, B($\gamma\chi_{b2}(2P)$) = $(13.1 \pm 1.6)\%$, B($\gamma\chi_{b1}(2P)$) = $(12.6 \pm 1.2)\%$, B($\gamma\chi_{b0}(2P)$) = $(5.9 \pm 0.6)\%$, B($\gamma\chi_{b0}(1P)$) = $(0.30 \pm 0.11)\%$,B($\mu^+\mu^-$) = $(2.18 \pm 0.21)\%$, and $R_{\text{hadrons}} = 3.51$. The statistical error is negligible and the systematic error is partially correlated with $\Gamma(\gamma gg)/\Gamma_{\text{total}}$ BESSON 06A value.

$\Gamma(\gamma gg)/\Gamma_{\text{total}}$ $\qquad\qquad$ Γ_{18}/Γ

VALUE (units 10^{-2})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.97±0.18	60k	[41] BESSON	06A	CLEO	$\Upsilon(3S) \to \gamma +$ hadrons

[41] Calculated using BESSON 06A values of $\Gamma(\gamma gg)/\Gamma(ggg) = (2.72 \pm 0.06 \pm 0.32 \pm 0.37)\%$ and $\Gamma(ggg)/\Gamma_{\text{total}}$. The statistical error is negligible and the systematic error is partially correlated with $\Gamma(ggg)/\Gamma_{\text{total}}$ BESSON 06A value.

$\Gamma(\gamma gg)/\Gamma(ggg)$ $\qquad\qquad$ Γ_{18}/Γ_{17}

VALUE (units 10^{-2})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
2.72±0.06±0.49	3M	BESSON	06A	CLEO	$\Upsilon(3S) \to (\gamma +)$ hadrons

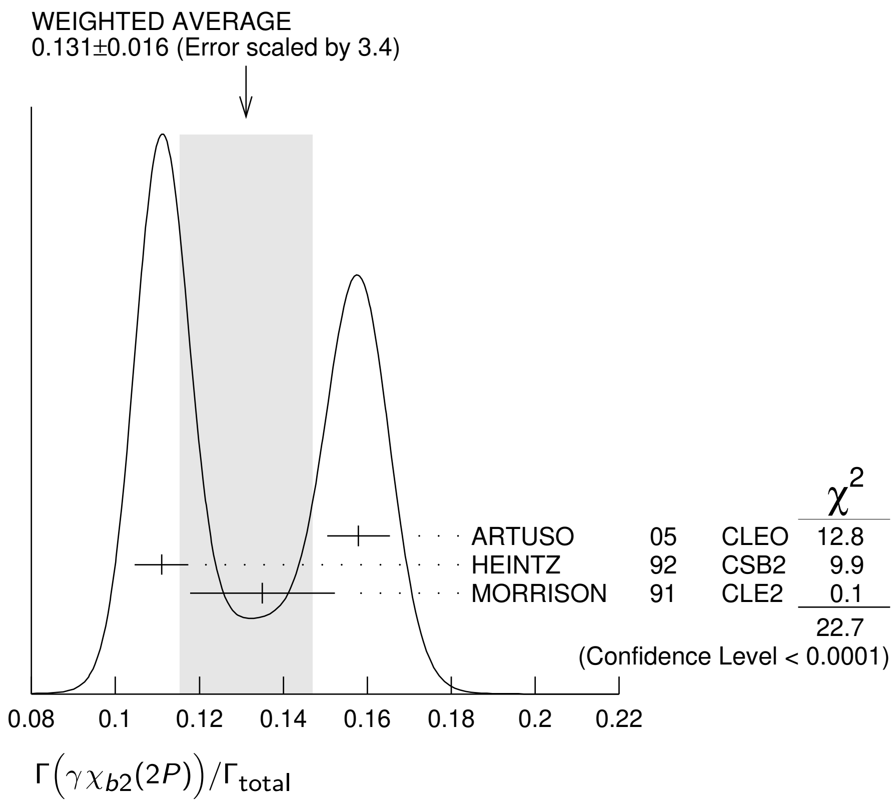
$\Gamma(\overline{^2H}$ anything$)/\Gamma_{total}$ — Γ_{19}/Γ

VALUE (units 10^{-5})	DOCUMENT ID		TECN	COMMENT
$2.33 \pm 0.15 ^{+0.31}_{-0.28}$	LEES	14G	BABR	$e^+ e^- \to \overline{^2H}\ X$

$\Gamma(\gamma\chi_{b2}(2P))/\Gamma_{total}$ — Γ_{20}/Γ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.131 ± 0.016 OUR AVERAGE Error includes scale factor of 3.4. See the ideogram below.					
$0.1579 \pm 0.0017 \pm 0.0073$	568k	ARTUSO	05	CLEO	$e^+ e^- \to \gamma X$
$0.111 \pm 0.005 \pm 0.004$	10319	[42] HEINTZ	92	CSB2	$e^+ e^- \to \gamma X$
$0.135 \pm 0.003 \pm 0.017$	30741	MORRISON	91	CLE2	$e^+ e^- \to \gamma X$

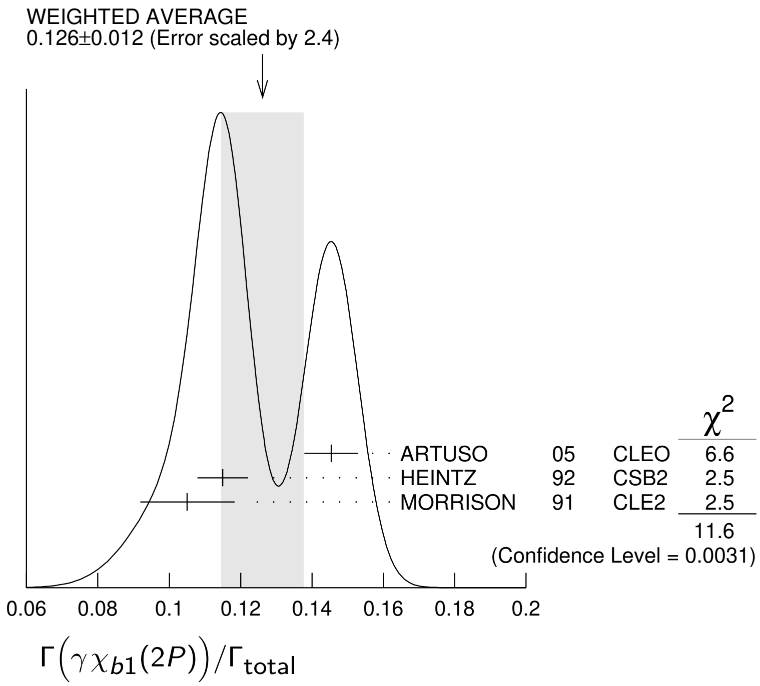
[42] Supersedes NARAIN 91.



$\Gamma(\gamma\chi_{b1}(2P))/\Gamma_{total}$ — Γ_{21}/Γ

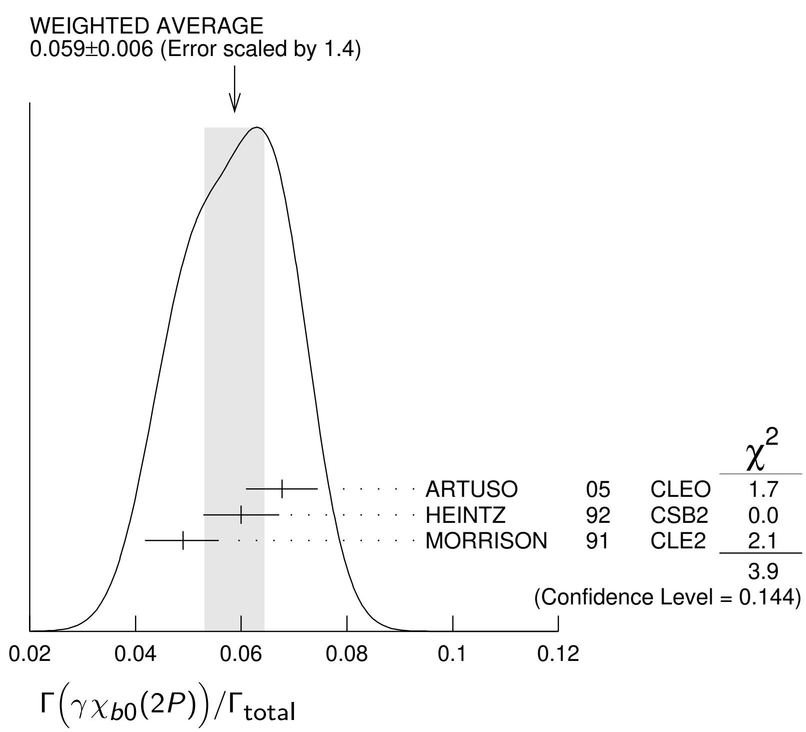
VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.126 ± 0.012 OUR AVERAGE Error includes scale factor of 2.4. See the ideogram below.					
$0.1454 \pm 0.0018 \pm 0.0073$	537k	ARTUSO	05	CLEO	$e^+ e^- \to \gamma X$
$0.115 \pm 0.005 \pm 0.005$	11147	[43] HEINTZ	92	CSB2	$e^+ e^- \to \gamma X$
$0.105 ^{+0.003}_{-0.002} \pm 0.013$	25759	MORRISON	91	CLE2	$e^+ e^- \to \gamma X$

[43] Supersedes NARAIN 91.



$\Gamma\big(\gamma\chi_{b0}(2P)\big)/\Gamma_{\text{total}}$ Γ_{22}/Γ

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.059 ±0.006 OUR AVERAGE Error includes scale factor of 1.4. See the ideogram below.				
$0.0677\pm0.0020\pm0.0065$	225k	ARTUSO 05	CLEO	$e^+e^- \to \gamma X$
$0.060\ \pm0.004\ \pm0.006$	4959	[44] HEINTZ 92	CSB2	$e^+e^- \to \gamma X$
$0.049\ ^{+0.003}_{-0.004}\ \pm0.006$	9903	MORRISON 91	CLE2	$e^+e^- \to \gamma X$



[44] Supersedes NARAIN 91.

$\Gamma(\gamma\chi_{b2}(1P))/\Gamma_{total}$ — Γ_{23}/Γ

VALUE (units 10^{-3})	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
10.0±1.0 OUR AVERAGE			Error includes scale factor of 1.7.			
$8.0\pm1.3\pm0.4$		126	[45,46] KORNICER	11	CLEO	$e^+e^- \to \gamma\gamma\ell^+\ell^-$
$10.5\pm0.3^{+0.7}_{-0.6}$		9.7k	LEES	11J	BABR	$\Upsilon(3S) \to X\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<19	90		[47] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma +$ hadrons
seen			[48] HEINTZ	92	CSB2	$e^+e^- \to \gamma\gamma\ell^+\ell^-$

[45] Assuming B($\Upsilon(1S) \to \ell^+\ell^-$) = (2.48 ± 0.05)%.

[46] KORNICER 11 reports $[\Gamma(\Upsilon(3S) \to \gamma\chi_{b2}(1P))/\Gamma_{total}] \times [B(\chi_{b2}(1P) \to \gamma\Upsilon(1S))] = (1.435 \pm 0.162 \pm 0.169) \times 10^{-3}$ which we divide by our best value $B(\chi_{b2}(1P) \to \gamma\Upsilon(1S)) = (18.0 \pm 1.0) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

[47] ASNER 08A reports $[\Gamma(\Upsilon(3S) \to \gamma\chi_{b2}(1P))/\Gamma_{total}] / [B(\Upsilon(2S) \to \gamma\chi_{b2}(1P))] < 27.1 \times 10^{-2}$ which we multiply by our best value $B(\Upsilon(2S) \to \gamma\chi_{b2}(1P)) = 7.15 \times 10^{-2}$.

[48] HEINTZ 92, while unable to distinguish between different J states, measures $\sum_J B(\Upsilon(3S) \to \gamma\chi_{bJ}) \times B(\chi_{bJ} \to \gamma\Upsilon(1S)) = (1.7 \pm 0.4 \pm 0.6) \times 10^{-3}$ for J = 0,1,2 using inclusive $\Upsilon(1S)$ decays and $(1.2^{+0.4}_{-0.3} \pm 0.09) \times 10^{-3}$ for J = 1,2 using $\Upsilon(1S) \to \ell^+\ell^-$.

$\Gamma(\gamma\chi_{b1}(1P))/\Gamma_{total}$ — Γ_{24}/Γ

VALUE (units 10^{-3})	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.9±0.5 OUR AVERAGE			Error includes scale factor of 1.8.			
$1.5\pm0.4\pm0.1$		50	[49,50] KORNICER	11	CLEO	$e^+e^- \to \gamma\gamma\ell^+\ell^-$
$0.5\pm0.3^{+0.2}_{-0.1}$			LEES	11J	BABR	$\Upsilon(3S) \to X\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<1.7	90		[51] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma +$ hadrons
seen			[52] HEINTZ	92	CSB2	$e^+e^- \to \gamma\gamma\ell^+\ell^-$

[49] Assuming B($\Upsilon(1S) \to \ell^+\ell^-$) = (2.48 ± 0.05)%.

[50] KORNICER 11 reports $[\Gamma(\Upsilon(3S) \to \gamma\chi_{b1}(1P))/\Gamma_{total}] \times [B(\chi_{b1}(1P) \to \gamma\Upsilon(1S))] = (5.38 \pm 1.20 \pm 0.95) \times 10^{-4}$ which we divide by our best value $B(\chi_{b1}(1P) \to \gamma\Upsilon(1S)) = (35.2 \pm 2.0) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

[51] ASNER 08A reports $[\Gamma(\Upsilon(3S) \to \gamma\chi_{b1}(1P))/\Gamma_{total}] / [B(\Upsilon(2S) \to \gamma\chi_{b1}(1P))] < 2.5 \times 10^{-2}$ which we multiply by our best value $B(\Upsilon(2S) \to \gamma\chi_{b1}(1P)) = 6.9 \times 10^{-2}$.

[52] HEINTZ 92, while unable to distinguish between different J states, measures $\sum_J B(\Upsilon(3S) \to \gamma\chi_{bJ}) \times B(\chi_{bJ} \to \gamma\Upsilon(1S)) = (1.7 \pm 0.4 \pm 0.6) \times 10^{-3}$ for J = 0,1,2 using inclusive $\Upsilon(1S)$ decays and $(1.2^{+0.4}_{-0.3} \pm 0.09) \times 10^{-3}$ for J = 1,2 using $\Upsilon(1S) \to \ell^+\ell^-$.

$\Gamma(\gamma\chi_{b0}(1P))/\Gamma_{total}$ — Γ_{25}/Γ

VALUE (units 10^{-2})	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.27±0.04 OUR AVERAGE						
$0.27\pm0.04\pm0.02$		2.3k	LEES	11J	BABR	$\Upsilon(3S) \to X\gamma$
$0.30\pm0.04\pm0.10$		8.7k	ARTUSO	05	CLEO	$e^+e^- \to \gamma X$

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

<0.8	90	[53] ASNER	08A	CLEO	$\Upsilon(3S) \to \gamma +$ hadrons

[53] ASNER 08A reports $[\Gamma(\Upsilon(3S) \to \gamma\chi_{b0}(1P))/\Gamma_{total}] / [B(\Upsilon(2S) \to \gamma\chi_{b0}(1P))] < 21.9 \times 10^{-2}$ which we multiply by our best value $B(\Upsilon(2S) \to \gamma\chi_{b0}(1P)) = 3.8 \times 10^{-2}$.

$\Gamma(\gamma\eta_b(2S))/\Gamma_{total}$ Γ_{26}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
< 6.2	90	ARTUSO	05	CLEO	$e^+e^- \to \gamma X$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<19	90	LEES	11J	BABR	$\Upsilon(3S) \to X\gamma$

$\Gamma(\gamma\eta_b(1S))/\Gamma_{total}$ Γ_{27}/Γ

VALUE (units 10^{-4})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
5.1±0.7 OUR AVERAGE						
7.1±1.8±1.3		2.3 ± 0.5k	[54] BONVICINI	10	CLEO	$\Upsilon(3S) \to \gamma X$
4.8±0.5±0.6		19 ± 3k	[54] AUBERT	09AQ	BABR	$\Upsilon(3S) \to \gamma X$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<8.5	90		LEES	11J	BABR	$\Upsilon(3S) \to X\gamma$
4.8±0.5±1.2		19 ± 3k	[54,55] AUBERT	08V	BABR	$\Upsilon(3S) \to \gamma X$
<4.3	90		[56] ARTUSO	05	CLEO	$e^+e^- \to \gamma X$

[54] Assuming $\Gamma_{\eta_b(1S)} = 10$ MeV.

[55] Systematic error re-evaluated by AUBERT 09AQ.

[56] Superseded by BONVICINI 10.

$\Gamma(\gamma A^0 \to \gamma\,\text{hadrons})/\Gamma_{total}$ Γ_{28}/Γ

(0.3 GeV < m_{A^0} < 7 GeV)

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<8 × 10⁻⁵	90	[57] LEES	11H	BABR	$\Upsilon(3S) \to \gamma$ hadrons

[57] For a narrow scalar or pseudoscalar, A^0, excluding known resonances, with mass in the range 0.3–7 GeV. Measured 90% CL limits as a function of m_{A^0} range from 1×10^{-6} to 8×10^{-5}.

$\Gamma(\gamma X \to \gamma + \geq 4\,\text{prongs})/\Gamma_{total}$ Γ_{29}/Γ

(1.5 GeV < m_X < 5.0 GeV)

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<2.2	95	ROSNER	07A	CLEO	$e^+e^- \to \gamma X$

$\Gamma(\gamma A^0 \to \gamma\mu^+\mu^-)/\Gamma_{total}$ Γ_{30}/Γ

VALUE (units 10^{-6})	CL%	DOCUMENT ID		TECN	COMMENT
<5.5	90	[58] AUBERT	09Z	BABR	$e^+e^- \to \gamma A^0 \to \gamma\mu^+\mu^-$

[58] For a narrow scalar or pseudoscalar, A^0, with mass in the range 212–9300 MeV, excluding J/ψ and $\psi(2S)$. Measured 90% CL limits as a function of m_{A^0} range from $0.27–5.5 \times 10^{-6}$.

$\Gamma(\gamma A^0 \to \gamma\tau^+\tau^-)/\Gamma_{total}$ Γ_{31}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<1.6 × 10⁻⁴	90	[59] AUBERT	09P	BABR	$e^+e^- \to \gamma A^0 \to \gamma\tau^+\tau^-$

[59] For a narrow scalar or pseudoscalar, A^0, with M($\tau^+\tau^-$) in the ranges 4.03–9.52 and 9.61–10.10 GeV. Measured 90% CL limits as a function of M($\tau^+\tau^-$) range from 1.5–16 $\times 10^{-5}$.

LEPTON FAMILY NUMBER (*LF*) VIOLATING MODES

$\Gamma(e^\pm\tau^\mp)/\Gamma_{total}$ Γ_{32}/Γ

VALUE (units 10^{-6})	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<4.2	90	LEES	10B	BABR	$e^+e^- \to e^\pm\tau^\mp$

$\Gamma(e^\pm\mu^\mp)/\Gamma_{total}$ Γ_{33}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<3.6 × 10⁻⁷	90	LEES	22A	BABR	$e^+e^- \to e^\pm\mu^\mp$

$\Gamma(\mu^\pm\tau^\mp)/\Gamma_{total}$ Γ_{34}/Γ

VALUE (units 10^{-6})	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
< 3.1	90	LEES	10B	BABR	$e^+e^- \to \mu^\pm\tau^\mp$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<20.3	95	LOVE	08A	CLEO	$e^+e^- \to \mu^\pm\tau^\mp$

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