

$\Upsilon(3S)$

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

$\Upsilon(3S)$ MASS

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³ Superseded by SHAMOV 23.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⁵ Superseded by ARTAMONOV 00.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

$\Upsilon(3S)$ 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 × 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 × 10 ⁻⁴	CL=90%
Γ_9 $\Upsilon(1S)\pi^0$	< 7 × 10 ⁻⁵	CL=90%
Γ_{10} $h_b(1P)\pi^0$	< 1.2 × 10 ⁻³	CL=90%
Γ_{11} $h_b(1P)\pi^0 \rightarrow \gamma\eta_b(1S)\pi^0$	(4.3 ± 1.4) × 10 ⁻⁴	
Γ_{12} $h_b(1P)\pi^+\pi^-$	< 1.2 × 10 ⁻⁴	CL=90%

Γ_{13}	$\tau^+ \tau^-$	$(2.29 \pm 0.30) \%$	
Γ_{14}	$\mu^+ \mu^-$	$(2.18 \pm 0.21) \%$	S=2.1
Γ_{15}	$e^+ e^-$	$(2.18 \pm 0.20) \%$	
Γ_{16}	hadrons	$(93 \pm 12) \%$	
Γ_{17}	$g g g$	$(35.7 \pm 2.6) \%$	
Γ_{18}	$\gamma g g$	$(9.7 \pm 1.8) \times 10^{-3}$	
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}	$\gamma A^0 \rightarrow \gamma$ hadrons	$< 8 \times 10^{-5}$	CL=90%
Γ_{29}	$\gamma X \rightarrow \gamma + \geq 4$ prongs	[a] $< 2.2 \times 10^{-4}$	CL=95%
Γ_{30}	$\gamma A^0 \rightarrow \gamma \mu^+ \mu^-$	$< 5.5 \times 10^{-6}$	CL=90%
Γ_{31}	$\gamma A^0 \rightarrow \gamma \tau^+ \tau^-$	[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] $1.5 \text{ GeV} < m_X < 5.0 \text{ GeV}$

[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 $10.4 e^+ e^- \rightarrow$ hadrons
0.45 ± 0.03 ± 0.03	⁶ GILES	84B	CLEO $e^+ e^- \rightarrow$ 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 $e^+ e^- \rightarrow \gamma \pi^+ \pi^- \ell^+ \ell^-$

⁷ Using $B(\Upsilon(1S) \rightarrow e^+ e^-) = (2.38 \pm 0.11)\%$ and $B(\Upsilon(1S) \rightarrow \mu^+ \mu^-) = (2.48 \pm 0.05)\%$.

$\Upsilon(3S)$ PARTIAL WIDTHS

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

Γ_{15}

VALUE (keV)

DOCUMENT ID

0.443 ± 0.008 OUR EVALUATION

$\Upsilon(3S)$ BRANCHING RATIOS

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

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	$e^+e^- \rightarrow \ell^+\ell^-X$
0.111 ± 0.012	4891	^{9,10,11} BROCK	91	CLEO	$e^+e^- \rightarrow \pi^+\pi^-X,$ $\pi^+\pi^-\ell^+\ell^-$

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

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

¹⁰ Using $B(\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^+\pi^-) = (18.5 \pm 0.8)\%$.

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

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

Γ_2/Γ

VALUE (units 10^{-2})

EVTS

DOCUMENT ID

TECN

COMMENT

2.82 ± 0.18 OUR AVERAGE

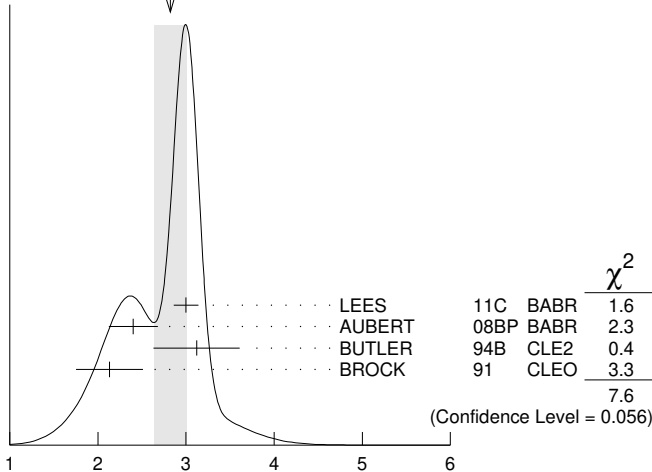
Error includes scale factor of 1.6. See the ideogram below.

3.00 ± 0.02 ± 0.14	543k	LEES	11C	BABR	$e^+e^- \rightarrow \pi^+\pi^-X$
2.40 ± 0.10 ± 0.26	800	¹² AUBERT	08BP	BABR	$e^+e^- \rightarrow \gamma\pi^+\pi^-e^+e^-$
3.12 ± 0.49	980	^{13,14} BUTLER	94B	CLE2	$e^+e^- \rightarrow \pi^+\pi^-\ell^+\ell^-$
2.13 ± 0.38	974	¹⁵ BROCK	91	CLEO	$e^+e^- \rightarrow \pi^+\pi^-X,$ $\pi^+\pi^-\ell^+\ell^-$

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

4.82 ± 0.65 ± 0.53	138	¹⁵ WU	93	CUSB	$\Upsilon(3S) \rightarrow \pi^+\pi^-\ell^+\ell^-$
3.1 ± 2.0	5	MAGERAS	82	CUSB	$\Upsilon(3S) \rightarrow \pi^+\pi^-\ell^+\ell^-$

WEIGHTED AVERAGE
2.82 ± 0.18 (Error scaled by 1.6)



$\Gamma(\Upsilon(2S)\pi^+\pi^-)/\Gamma_{\text{total}}$ (units 10^{-2})

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

¹³ From the exclusive mode.

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

¹⁵ Using $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.31 \pm 0.21)\%$, $B(\Upsilon(2S) \rightarrow \Upsilon(1S)\gamma\gamma) \times 2B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (0.188 \pm 0.035)\%$, and $B(\Upsilon(2S) \rightarrow \Upsilon(1S)\pi^0\pi^0) \times 2B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (0.436 \pm 0.056)\%$. 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 $e^+e^- \rightarrow \pi^0\pi^0\ell^+\ell^-$
2.16±0.39		^{17,18} BUTLER	94B	CLE2 $e^+e^- \rightarrow \pi^0\pi^0\ell^+\ell^-$
1.7 ±0.5 ±0.2	10	¹⁹ HEINTZ	92	CSB2 $e^+e^- \rightarrow \pi^0\pi^0\ell^+\ell^-$

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

¹⁷ $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.31 \pm 0.21)\%$ and assuming $e\mu$ universality.

¹⁸ From the exclusive mode.

¹⁹ $B(\Upsilon(2S) \rightarrow \mu^+\mu^-) = (1.44 \pm 0.10)\%$ 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 $e^+e^- \rightarrow \ell^+\ell^-2\gamma$

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 $e^+e^- \rightarrow \ell^+\ell^-\gamma\gamma$

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

$\Gamma(\Upsilon(1S)\pi^+\pi^-)/\Gamma_{\text{total}}$ 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 $\Upsilon(3S) \rightarrow \pi^+\pi^-\ell^+\ell^-$
4.46±0.01±0.13	190k	²³ BHARI	09	CLEO $e^+e^- \rightarrow \pi^+\pi^-$ MM
4.17±0.06±0.19	6.4k	²⁴ AUBERT	08BP	BABR 10.58 $e^+e^- \rightarrow \gamma\pi^+\pi^-\ell^+\ell^-$
4.52±0.35	11830	²⁵ BUTLER	94B	CLE2 $e^+e^- \rightarrow \pi^+\pi^-X$, $\pi^+\pi^-\ell^+\ell^-$
4.46±0.34±0.50	451	²⁵ WU	93	CUSB $\Upsilon(3S) \rightarrow \pi^+\pi^-\ell^+\ell^-$
4.46±0.30	11221	²⁵ BROCK	91	CLEO $e^+e^- \rightarrow \pi^+\pi^-X$, $\pi^+\pi^-\ell^+\ell^-$

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

4.9 ±1.0	22	GREEN	82	CLEO $\Upsilon(3S) \rightarrow \pi^+\pi^-\ell^+\ell^-$
3.9 ±1.3	26	MAGERAS	82	CUSB $\Upsilon(3S) \rightarrow \pi^+\pi^-\ell^+\ell^-$

²² Using $B(\Upsilon(1S) \rightarrow e^+e^-) = (2.38 \pm 0.11)\%$ and $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.05)\%$.

²³ A weighted average of the inclusive and exclusive results.

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

²⁵ Using $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.06)\%$. 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
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• • • We do not use the following data for averages, fits, limits, etc. • • •

$0.577 \pm 0.026 \pm 0.060$ 800 ²⁶ AUBERT 08BP BABR $e^+e^- \rightarrow \gamma\pi^+\pi^-\ell^+\ell^-$

²⁶ 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.

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

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
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2.20 ± 0.13 OUR AVERAGE

$2.24 \pm 0.09 \pm 0.11$ 6584 27 BHARI 09 CLEO $e^+e^- \rightarrow \pi^0\pi^0\ell^+\ell^-$

1.99 ± 0.34 56 28 BUTLER 94B CLE2 $e^+e^- \rightarrow \pi^0\pi^0\ell^+\ell^-$

$2.2 \pm 0.4 \pm 0.3$ 33 29 HEINTZ 92 CSB2 $e^+e^- \rightarrow \pi^0\pi^0\ell^+\ell^-$

²⁷ Authors assume $B(\Upsilon(1S) \rightarrow e^+e^-) + B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = 4.96\%$.

²⁸ Using $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.06)\%$ and assuming $e\mu$ universality.

²⁹ Using $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.57 \pm 0.07)\%$ 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
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• • • We do not use the following data for averages, fits, limits, etc. • • •

0.501 ± 0.043 ³⁰ BHARI 09 CLEO $e^+e^- \rightarrow \Upsilon(3S)$

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
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<0.1 90 ³¹ LEES 11L BABR $\Upsilon(3S) \rightarrow (\pi^+\pi^-)(\gamma\gamma)\ell^+\ell^-$

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

<0.8 90 ^{31,32} AUBERT 08BP BABR $e^+e^- \rightarrow \gamma\pi^+\pi^-\pi^0\ell^+\ell^-$

<0.18 90 ³³ HE 08A CLEO $e^+e^- \rightarrow \ell^+\ell^-\eta$

<2.2 90 BROCK 91 CLEO $e^+e^- \rightarrow \ell^+\ell^-\eta$

³¹ Using $B(\Upsilon(1S) \rightarrow e^+e^-) = (2.38 \pm 0.11)\%$, $B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.05)\%$.

³² Using $\Gamma_{ee}(\Upsilon(3S)) = 0.443 \pm 0.008$ keV.

³³ Authors assume $B(\Upsilon(1S) \rightarrow e^+e^-) + B(\Upsilon(1S) \rightarrow \mu^+\mu^-) = 4.96\%$.

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

VALUE (units 10^{-2})	CL%	DOCUMENT ID	TECN	COMMENT
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<0.23 90 ³⁴ LEES 11L BABR $\Upsilon(3S) \rightarrow (\pi^+\pi^-)(\gamma\gamma)\ell^+\ell^-$

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

<1.9 90 ³⁵ AUBERT 08BP BABR $e^+e^- \rightarrow \gamma\pi^+\pi^-(\pi^0)\ell^+\ell^-$

³⁴ Not independent of other values reported by LEES 11L.

³⁵ Not independent of other values reported by AUBERT 08BP.

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

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

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

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

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

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

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

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

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

VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	COMMENT
< 1.2	90	³⁸ LEES	11C	BABR $e^+e^- \rightarrow \pi^+\pi^-X$

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

<18 ³⁸ BUTLER 94B CLE2 $e^+e^- \rightarrow \pi^+\pi^-X$

<15 ³⁸ BROCK 91 CLEO $e^+e^- \rightarrow \pi^+\pi^-X$

³⁸ For $M(h_b(1P)) = 9900$ MeV.

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

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

³⁹ BESSON 07 reports $[\Gamma(\Upsilon(3S) \rightarrow \tau^+\tau^-)/\Gamma_{\text{total}}] / [B(\Upsilon(3S) \rightarrow \mu^+\mu^-)] = 1.05 \pm 0.08 \pm 0.05$ which we multiply by our best value $B(\Upsilon(3S) \rightarrow \mu^+\mu^-) = (2.18 \pm 0.21) \times 10^{-2}$. 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}

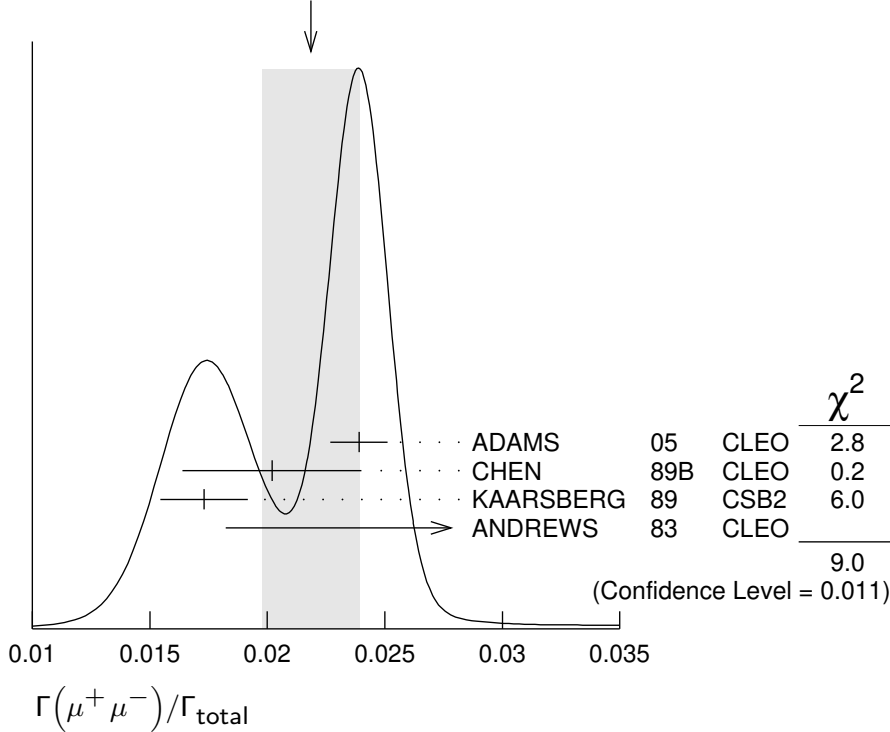
VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.968 ± 0.016 OUR AVERAGE				
$0.966 \pm 0.008 \pm 0.014$	2.2M	LEES	20E	BABR $e^+e^- \rightarrow \Upsilon(3S)$
$1.05 \pm 0.08 \pm 0.05$	15k	BESSON	07	CLEO $e^+e^- \rightarrow \Upsilon(3S)$

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

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 $e^+ e^- \rightarrow \mu^+ \mu^-$
0.0202 ± 0.0019 ± 0.0033		CHEN	89B	CLEO $e^+ e^- \rightarrow \mu^+ \mu^-$
0.0173 ± 0.0015 ± 0.0011		KAARSBERG	89	CSB2 $e^+ e^- \rightarrow \mu^+ \mu^-$
0.033 ± 0.013 ± 0.007	1096	ANDREWS	83	CLEO $e^+ e^- \rightarrow \mu^+ \mu^-$

WEIGHTED AVERAGE
0.0218 ± 0.0021 (Error scaled by 2.1)



$\Gamma(g g g)/\Gamma_{\text{total}}$

Γ_{17}/Γ

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

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

$\Gamma(\gamma g g)/\Gamma_{\text{total}}$

Γ_{18}/Γ

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

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

$\Gamma(\gamma g g)/\Gamma(g g g)$

Γ_{18}/Γ_{17}

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

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

Γ_{19}/Γ

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

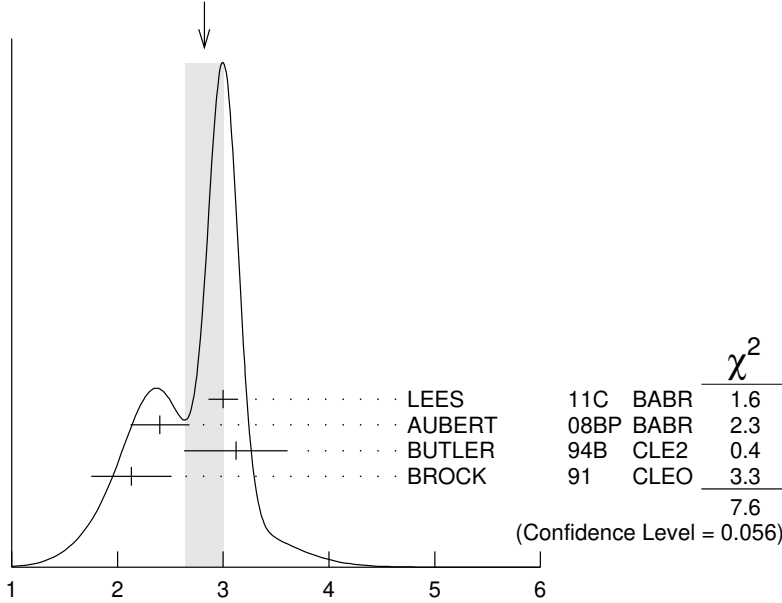
$\Gamma(\gamma \chi_{b2}(2P))/\Gamma_{\text{total}}$

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 ± 0.0017 ± 0.0073	568k	ARTUSO	05	CLEO $e^+ e^- \rightarrow \gamma X$
0.111 ± 0.005 ± 0.004	10319	⁴² HEINTZ	92	CSB2 $e^+ e^- \rightarrow \gamma X$
0.135 ± 0.003 ± 0.017	30741	MORRISON	91	CLE2 $e^+ e^- \rightarrow \gamma X$

⁴² Supersedes NARAIN 91.

WEIGHTED AVERAGE
2.82 ± 0.18 (Error scaled by 1.6)



$\Gamma(\Upsilon(2S) \pi^+ \pi^-)/\Gamma_{\text{total}}$ (units 10^{-2})

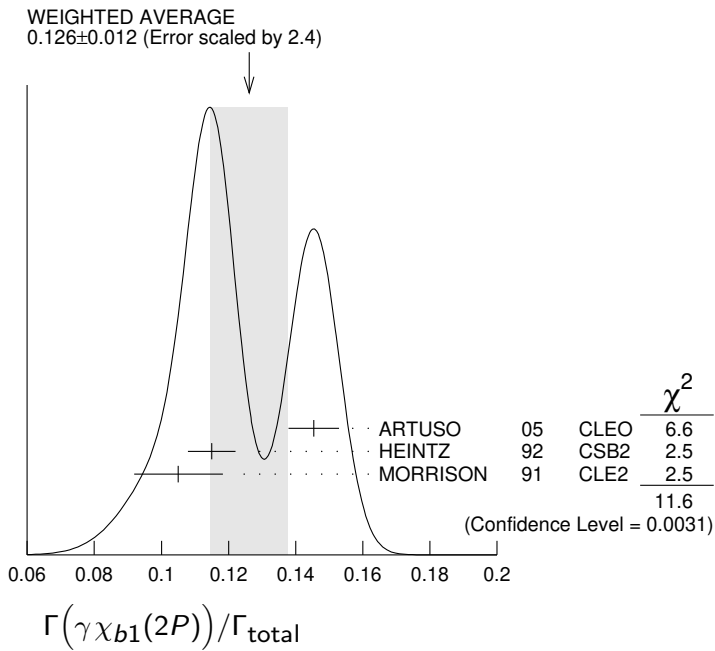
M048R5.plot0.48in0.33in2.70in2.70in1.00 $\Gamma(\gamma \chi_{b2}(2P))/\Gamma_{\text{total}}$

$\Gamma(\gamma \chi_{b1}(2P))/\Gamma_{\text{total}}$

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 ± 0.0018 ± 0.0073	537k	ARTUSO	05	CLEO $e^+ e^- \rightarrow \gamma X$
0.115 ± 0.005 ± 0.005	11147	⁴³ HEINTZ	92	CSB2 $e^+ e^- \rightarrow \gamma X$
0.105 ^{+0.003} _{-0.002} ± 0.013	25759	MORRISON	91	CLE2 $e^+ e^- \rightarrow \gamma X$

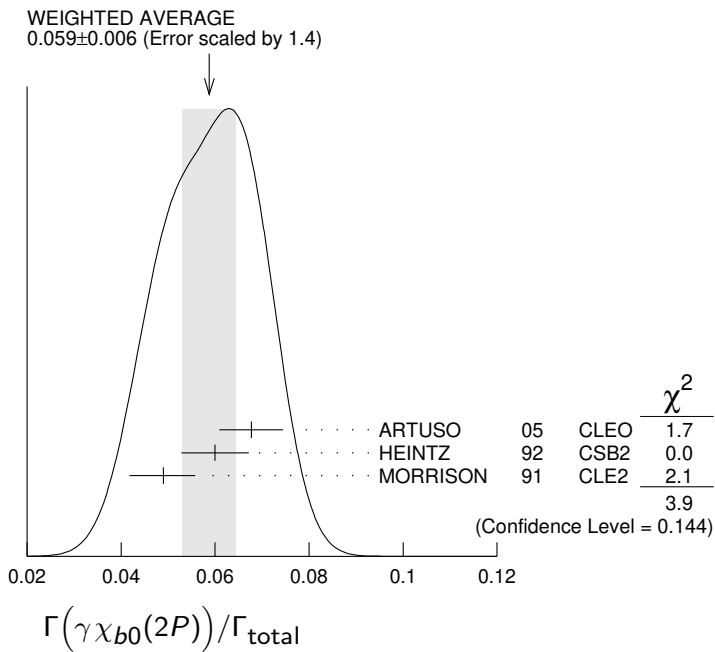
⁴³ Supersedes NARAIN 91.



$\Gamma(\gamma\chi_{b0}(2P))/\Gamma_{\text{total}}$ **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 ± 0.0020 ± 0.0065	225k	ARTUSO	05 CLEO	$e^+e^- \rightarrow \gamma X$
0.060 ± 0.004 ± 0.006	4959	⁴⁴ HEINTZ	92 CSB2	$e^+e^- \rightarrow \gamma X$
0.049 ^{+0.003} / _{-0.004} ± 0.006	9903	MORRISON	91 CLE2	$e^+e^- \rightarrow \gamma X$

⁴⁴Supersedes NARAIN 91.



$\Gamma(\gamma\chi_{b2}(1P))/\Gamma_{\text{total}}$ 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±1.3±0.4		126	^{45,46} KORNICER	11	CLEO $e^+e^- \rightarrow \gamma\gamma\ell^+\ell^-$
10.5±0.3 ^{+0.7} _{-0.6}		9.7k	LEES	11J	BABR $\Upsilon(3S) \rightarrow X\gamma$

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

<19 seen	90		⁴⁷ ASNER	08A	CLEO $\Upsilon(3S) \rightarrow \gamma + \text{hadrons}$
			⁴⁸ HEINTZ	92	CSB2 $e^+e^- \rightarrow \gamma\gamma\ell^+\ell^-$

⁴⁵ Assuming $B(\Upsilon(1S) \rightarrow \ell^+\ell^-) = (2.48 \pm 0.05)\%$.

⁴⁶ KORNICER 11 reports $[\Gamma(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(1P))/\Gamma_{\text{total}}] \times [B(\chi_{b2}(1P) \rightarrow \gamma\Upsilon(1S))]$
 $= (1.435 \pm 0.162 \pm 0.169) \times 10^{-3}$ which we divide by our best value $B(\chi_{b2}(1P) \rightarrow \gamma\Upsilon(1S)) = (18.0 \pm 1.0) \times 10^{-2}$. 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 $[\Gamma(\Upsilon(3S) \rightarrow \gamma\chi_{b2}(1P))/\Gamma_{\text{total}}] / [B(\Upsilon(2S) \rightarrow \gamma\chi_{b2}(1P))]$
 $< 27.1 \times 10^{-2}$ which we multiply by our best value $B(\Upsilon(2S) \rightarrow \gamma\chi_{b2}(1P)) = 7.15 \times 10^{-2}$.

⁴⁸ HEINTZ 92, while unable to distinguish between different J states, measures $\sum_J B(\Upsilon(3S) \rightarrow \gamma\chi_{bJ}) \times B(\chi_{bJ} \rightarrow \gamma\Upsilon(1S)) = (1.7 \pm 0.4 \pm 0.6) \times 10^{-3}$ 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 $\Upsilon(1S) \rightarrow \ell^+\ell^-$.

$\Gamma(\gamma\chi_{b1}(1P))/\Gamma_{\text{total}}$ 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±0.4±0.1		50	^{49,50} KORNICER	11	CLEO $e^+e^- \rightarrow \gamma\gamma\ell^+\ell^-$
0.5±0.3 ^{+0.2} _{-0.1}			LEES	11J	BABR $\Upsilon(3S) \rightarrow X\gamma$

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

<1.7 seen	90		⁵¹ ASNER	08A	CLEO $\Upsilon(3S) \rightarrow \gamma + \text{hadrons}$
			⁵² HEINTZ	92	CSB2 $e^+e^- \rightarrow \gamma\gamma\ell^+\ell^-$

⁴⁹ Assuming $B(\Upsilon(1S) \rightarrow \ell^+\ell^-) = (2.48 \pm 0.05)\%$.

⁵⁰ KORNICER 11 reports $[\Gamma(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(1P))/\Gamma_{\text{total}}] \times [B(\chi_{b1}(1P) \rightarrow \gamma\Upsilon(1S))]$
 $= (5.38 \pm 1.20 \pm 0.95) \times 10^{-4}$ which we divide by our best value $B(\chi_{b1}(1P) \rightarrow \gamma\Upsilon(1S)) = (35.2 \pm 2.0) \times 10^{-2}$. 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 $[\Gamma(\Upsilon(3S) \rightarrow \gamma\chi_{b1}(1P))/\Gamma_{\text{total}}] / [B(\Upsilon(2S) \rightarrow \gamma\chi_{b1}(1P))]$
 $< 2.5 \times 10^{-2}$ which we multiply by our best value $B(\Upsilon(2S) \rightarrow \gamma\chi_{b1}(1P)) = 6.9 \times 10^{-2}$.

⁵² HEINTZ 92, while unable to distinguish between different J states, measures $\sum_J B(\Upsilon(3S) \rightarrow \gamma\chi_{bJ}) \times B(\chi_{bJ} \rightarrow \gamma\Upsilon(1S)) = (1.7 \pm 0.4 \pm 0.6) \times 10^{-3}$ 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 $\Upsilon(1S) \rightarrow \ell^+\ell^-$.

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

VALUE (units 10^{-2})	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
0.27±0.04 OUR AVERAGE					
0.27±0.04±0.02		2.3k	LEES	11J	BABR $\Upsilon(3S) \rightarrow X\gamma$
0.30±0.04±0.10		8.7k	ARTUSO	05	CLEO $e^+e^- \rightarrow \gamma X$

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

<0.8 90 ⁵³ ASNER 08A CLEO $\Upsilon(3S) \rightarrow \gamma + \text{hadrons}$
⁵³ ASNER 08A reports $[\Gamma(\Upsilon(3S) \rightarrow \gamma\chi_{b0}(1P))/\Gamma_{\text{total}}] / [B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P))]$
 < 21.9×10^{-2} which we multiply by our best value $B(\Upsilon(2S) \rightarrow \gamma\chi_{b0}(1P)) = 3.8 \times 10^{-2}$.

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

VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	COMMENT
< 6.2	90	ARTUSO	05	CLEO $e^+e^- \rightarrow \gamma X$

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

<19 90 LEES 11J BABR $\Upsilon(3S) \rightarrow X\gamma$

$\Gamma(\gamma\eta_b(1S))/\Gamma_{\text{total}}$ 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 $\Upsilon(3S) \rightarrow \gamma X$
4.8±0.5±0.6		19±3k	⁵⁴ AUBERT	09AQ	BABR $\Upsilon(3S) \rightarrow \gamma X$

5.1±0.7 OUR AVERAGE

7.1±1.8±1.3 2.3±0.5k ⁵⁴ BONVICINI 10 CLEO $\Upsilon(3S) \rightarrow \gamma X$

4.8±0.5±0.6 19±3k ⁵⁴ AUBERT 09AQ BABR $\Upsilon(3S) \rightarrow \gamma X$

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

<8.5 90 LEES 11J BABR $\Upsilon(3S) \rightarrow X\gamma$

4.8±0.5±1.2 19±3k ^{54,55} AUBERT 08V BABR $\Upsilon(3S) \rightarrow \gamma X$

<4.3 90 ⁵⁶ ARTUSO 05 CLEO $e^+e^- \rightarrow \gamma X$

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

⁵⁵ Systematic error re-evaluated by AUBERT 09AQ.

⁵⁶ Superseded by BONVICINI 10.

$\Gamma(\gamma A^0 \rightarrow \gamma \text{hadrons})/\Gamma_{\text{total}}$ 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 $\Upsilon(3S) \rightarrow \gamma \text{hadrons}$

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} .

$\Gamma(\gamma X \rightarrow \gamma + \geq 4 \text{ prongs})/\Gamma_{\text{total}}$ 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 $e^+e^- \rightarrow \gamma X$

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

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

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 × 10⁻⁶.

$\Gamma(\gamma A^0 \rightarrow \gamma \tau^+ \tau^-)/\Gamma_{\text{total}}$					Γ_{31}/Γ
VALUE	CL%	DOCUMENT ID	TECN	COMMENT	
$<1.6 \times 10^{-4}$	90	⁵⁹ AUBERT	09P BABR	$e^+ e^- \rightarrow \gamma A^0 \rightarrow \gamma \tau^+ \tau^-$	
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 $1.5\text{--}16 \times 10^{-5}$.					

LEPTON FAMILY NUMBER (LF) VIOLATING MODES

$\Gamma(e^\pm \tau^\mp)/\Gamma_{\text{total}}$					Γ_{32}/Γ
VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT	
<4.2	90	LEES	10B BABR	$e^+ e^- \rightarrow e^\pm \tau^\mp$	

$\Gamma(e^\pm \mu^\mp)/\Gamma_{\text{total}}$					Γ_{33}/Γ
VALUE	CL%	DOCUMENT ID	TECN	COMMENT	
$<3.6 \times 10^{-7}$	90	LEES	22A BABR	$e^+ e^- \rightarrow e^\pm \mu^\mp$	

$\Gamma(\mu^\pm \tau^\mp)/\Gamma_{\text{total}}$					Γ_{34}/Γ
VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT	
< 3.1	90	LEES	10B BABR	$e^+ e^- \rightarrow \mu^\pm \tau^\mp$	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<20.3	95	LOVE	08A CLEO	$e^+ e^- \rightarrow \mu^\pm \tau^\mp$	

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