τ – THIS IS PART 1 OF 4

To reduce the size of this section's PostScript file, we have divided it into four PostScript files. We present the following index:

PART 1

PART 2

PART 3

PART 4

τ

$J = \frac{1}{2}$

τ discovery paper was PERL 75. $e^+ e^- \rightarrow \tau^+ \tau^-$ cross-section threshold behavior and magnitude are consistent with pointlike spin-1/2 Dirac particle. BRANDELIK 78 ruled out pointlike spin-0 or spin-1 particle. FELDMAN 78 ruled out $J = 3/2$. KIRKBY 79 also ruled out J=integer, $J = 3/2$.

τ MASS

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
$1777.05^{+0.29}_{-0.26}$ OUR AVERAGE					
$1778.2 \pm 0.8 \pm 1.2$		ANASTASSOV	97	CLEO	E^{ee}_{cm}= 10.6 GeV
$1776.96^{+0.18}_{-0.21}{}^{+0.25}_{-0.17}$	65	[1] BAI	96	BES	E^{ee}_{cm}= 3.54–3.57 GeV
$1777.8 \pm 0.7 \pm 1.7$	35k	[2] BALEST	93	CLEO	E^{ee}_{cm}= 10.6 GeV
$1776.3 \pm 2.4 \pm 1.4$	11k	[3] ALBRECHT	92M	ARG	E^{ee}_{cm}= 9.4–10.6 GeV
$1783 \,^{+3}_{-4}$	692	[4] BACINO	78B	DLCO	E^{ee}_{cm}= 3.1–7.4 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$1776.9 \,^{+0.4}_{-0.5} \pm 0.2$	14	[5] BAI	92	BES	Repl. by BAI 96

[1] BAI 96 fit $\sigma(e^+ e^- \rightarrow \tau^+ \tau^-)$ at different energies near threshold.

[2] BALEST 93 fit spectra of minimum kinematically allowed τ mass in events of the type $e^+ e^- \rightarrow \tau^+ \tau^- \rightarrow (\pi^+ n\pi^0 \nu_\tau)(\pi^- m\pi^0 \nu_\tau)$ $n \leq 2$, $m \leq 2$, $1 \leq n+m \leq 3$. If $m_{\nu_\tau} \neq 0$, result increases by $(m^2_{\nu_\tau}/1100$ MeV).

[3] ALBRECHT 92M fit τ pseudomass spectrum in $\tau^- \rightarrow 2\pi^- \pi^+ \nu_\tau$ decays. Result assumes m_{ν_τ}=0.

[4] BACINO 78B value comes from $e^\pm X^\mp$ threshold. Published mass 1782 MeV increased by 1 MeV using the high precision $\psi(2S)$ mass measurement of ZHOLENTZ 80 to eliminate the absolute SPEAR energy calibration uncertainty.

[5] BAI 92 fit $\sigma(e^+ e^- \rightarrow \tau^+ \tau^-)$ near threshold using $e\mu$ events.

τ MEAN LIFE

VALUE (10^{-15} s)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
290.0± 1.2 OUR AVERAGE					
290.1± 1.5± 1.1		BARATE	97R	ALEP	1989–1994 LEP runs
291.4± 3.0		ABREU	96B	DLPH	1991–1993 LEP runs
290.1± 4.0	34k	ACCIARRI	96K	L3	1994 LEP run
289.2± 1.7± 1.2		ALEXANDER	96E	OPAL	1990–1994 LEP runs
289.0± 2.8± 4.0	57.4k	BALEST	96	CLEO	E^{ee}_{cm}= 10.6 GeV

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

291.2 ± 2.0 ± 1.2		BARATE	97I	ALEP	Repl. by BARATE 97R
297 ± 9 ± 5	1671	ABE	95Y	SLD	1992–1993 SLC runs
293 ± 9 ± 12	5743	ADRIANI	93M	L3	1991 LEP run
304 ± 14 ± 7	4100	BATTLE	92	CLEO	E^{ee}_{cm} = 10.6 GeV
309 ± 23 ± 30	2817	ADEVA	91F	L3	1990 LEP run
301 ± 29	3780	KLEINWORT	89	JADE	E^{ee}_{cm} = 35–46 GeV
288 ± 16 ± 17	807	AMIDEI	88	MRK2	E^{ee}_{cm} = 29 GeV
306 ± 20 ± 14	695	BRAUNSCH...	88C	TASS	E^{ee}_{cm} = 36 GeV
299 ± 15 ± 10	1311	ABACHI	87C	HRS	E^{ee}_{cm} = 29 GeV
295 ± 14 ± 11	5696	ALBRECHT	87P	ARG	E^{ee}_{cm} = 9.3–10.6 GeV
309 ± 17 ± 7	3788	BAND	87B	MAC	E^{ee}_{cm} = 29 GeV
325 ± 14 ± 18	8470	BEBEK	87C	CLEO	E^{ee}_{cm} = 10.5 GeV
460 ± 190	102	FELDMAN	82	MRK2	E^{ee}_{cm} = 29 GeV

τ MAGNETIC MOMENT ANOMALY

$\mu_\tau/(e\hbar/2m_\tau)-1 = (g_\tau-2)/2$

For a theoretical calculation [$(g_\tau-2)/2 = 11773(3) \times 10^{-7}$], see SAMUEL 91B.

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
> −0.052 and < 0.058 (CL = 95%) OUR LIMIT					
> −0.052 and < 0.058	95	ACCIARRI	98E	L3	1991–1995 LEP runs
• • • We do not use the following data for averages, fits, limits, etc. • • •					
> −0.068 and < 0.065	95	[6] ACKERSTAFF	98N	OPAL	1990–1995 LEP runs
> −0.004 and < 0.006	95	[7] ESCRIBANO	97	RVUE	$Z \to \tau^+\tau^-$ at LEP
<0.01	95	[8] ESCRIBANO	93	RVUE	$Z \to \tau^+\tau^-$ at LEP
<0.12	90	GRIFOLS	91	RVUE	$Z \to \tau\tau\gamma$ at LEP
<0.023	95	[9] SILVERMAN	83	RVUE	$e^+e^- \to \tau^+\tau^-$ at PETRA

[6] ACKERSTAFF 98N use $Z \to \tau^+\tau^-\gamma$ events. The limit applies to an average of the form factor for off-shell τ's having p^2 ranging from m^2_τ to $(M_Z-m_\tau)^2$.

[7] ESCRIBANO 97 use preliminary experimental results.

[8] ESCRIBANO 93 limit derived from $\Gamma(Z \to \tau^+\tau^-)$, and is on the absolute value of the magnetic moment anomaly.

[9] SILVERMAN 83 limit is derived from $e^+e^- \to \tau^+\tau^-$ total cross-section measurements for q^2 up to (37 GeV)^2.

τ ELECTRIC DIPOLE MOMENT (d_τ)

A nonzero value is forbidden by both T invariance and P invariance.

VALUE (10^{-16} e cm)	CL%	DOCUMENT ID		TECN	COMMENT
> −3.1 and < 3.1 (CL = 95%) OUR LIMIT					
> −3.1 and < 3.1	95	ACCIARRI	98E	L3	1991–1995 LEP runs

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

> -3.8 and < 3.6	95	[10] ACKERSTAFF	98N	OPAL	1990–1995 LEP runs
<0.11	95	[11,12] ESCRIBANO	97	RVUE	$Z \rightarrow \tau^+\tau^-$ at LEP
<0.5	95	[13] ESCRIBANO	93	RVUE	$Z \rightarrow \tau^+\tau^-$ at LEP
<7	90	GRIFOLS	91	RVUE	$Z \rightarrow \tau\tau\gamma$ at LEP
<1.6	90	DELAGUILA	90	RVUE	$e^+e^- \rightarrow \tau^+\tau^-$ E^{ee}_{cm}= 35 GeV

[10] ACKERSTAFF 98N use $Z \rightarrow \tau^+\tau^-\gamma$ events. The limit applies to an average of the form factor for off-shell τ's having p^2 ranging from m^2_τ to $(M_Z-m_\tau)^2$.

[11] ESCRIBANO 97 derive the relationship $|d_\tau| = \cot\theta_W \, |d^W_\tau|$ using effective Lagrangian methods, and use a conference result $|d^W_\tau| < 5.8 \times 10^{-18}$ $e$cm at 95% CL (L. Silvestris, ICHEP96) to obtain this result.

[12] ESCRIBANO 97 use preliminary experimental results.

[13] ESCRIBANO 93 limit derived from $\Gamma(Z \rightarrow \tau^+\tau^-)$, and is on the absolute value of the electric dipole moment.

τ WEAK DIPOLE MOMENT (d^w_τ)

A nonzero value is forbidden by *CP* invariance.

Re(d^w_τ)

VALUE (10^{-17} $e$cm)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<0.56	95	ACKERSTAFF	97L	OPAL	1991–1995 LEP runs
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<3.0	90	[14] ACCIARRI	98C	L3	1991–1995 LEP runs
<0.78	95	[15] AKERS	95F	OPAL	Repl. by ACKERSTAFF 97L
<1.5	95	[15] BUSKULIC	95C	ALEP	1990–1992 LEP runs
<7.0	95	[15] ACTON	92F	OPAL	$Z \rightarrow \tau^+\tau^-$ at LEP
<3.7	95	[15] BUSKULIC	92J	ALEP	Repl. by BUSKULIC 95C

[14] ACCIARRI 98C limit is on the absolute value of the real part of the weak dipole moment.

[15] Limit is on the absolute value of the real part of the weak dipole moment, and applies for $q^2 = m^2_Z$.

Im(d^w_τ)

VALUE (10^{-17} $e$cm)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<1.5	95	ACKERSTAFF	97L	OPAL	1991–1995 LEP runs
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<4.5	95	[16] AKERS	95F	OPAL	Repl. by ACKERSTAFF 97L

[16] Limit is on the absolute value of the imaginary part of the weak dipole moment, and applies for $q^2 = m^2_Z$.

τ WEAK ANOMALOUS MAGNETIC DIPOLE MOMENT (α^w_τ)

Re(α^w_τ)

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<4.5 × 10^{-3}	90	[17] ACCIARRI	98C	L3	1991–1995 LEP runs

[17] ACCIARRI 98C limit is on the absolute value of the real part of the weak anomalous magnetic dipole moment.

Im(α^w_τ)

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<9.9 × 10^{-3}	90	[18] ACCIARRI	98C	L3	1991–1995 LEP runs

[18] ACCIARRI 98C limit is on the absolute value of the imaginary part of the weak anomalous magnetic dipole moment.

τ^- DECAY MODES

τ^+ modes are charge conjugates of the modes below. "$h^\pm$" stands for $\pi^\pm$ or $K^\pm$. "ℓ" stands for e or μ. "Neutral" means neutral hadron whose decay products include γ's and/or π^0's.

	Mode		Fraction (Γ_i/Γ)	Scale factor/ Confidence level
	Modes with one charged particle			
Γ_1	particle$^-$ ≥ 0 neutrals $\geq 0 K^0_L \nu_\tau$ ("1-prong")		(84.71 ± 0.13) %	S=1.2
Γ_2	particle$^-$ ≥ 0 neutrals $\geq 0 K^0 \nu_\tau$		(85.30 ± 0.13) %	S=1.2
Γ_3	$\mu^- \overline{\nu}_\mu \nu_\tau$	[a]	(17.37 ± 0.09) %	
Γ_4	$\mu^- \overline{\nu}_\mu \nu_\tau \gamma$	[b]	(3.0 ± 0.6) × 10^{-3}	
Γ_5	$e^- \overline{\nu}_e \nu_\tau$	[a]	(17.81 ± 0.07) %	
Γ_6	$h^- \geq 0$ neutrals $\geq 0 K^0_L \nu_\tau$		(49.52 ± 0.16) %	S=1.2
Γ_7	$h^- \geq 0 K^0_L \nu_\tau$		(12.32 ± 0.12) %	S=1.5
Γ_8	$h^- \nu_\tau$		(11.79 ± 0.12) %	S=1.5
Γ_9	$\pi^- \nu_\tau$	[a]	(11.08 ± 0.13) %	S=1.4
Γ_{10}	$K^- \nu_\tau$	[a]	(7.1 ± 0.5) × 10^{-3}	
Γ_{11}	$h^- \geq 1$ neutrals ν_τ		(36.91 ± 0.17) %	S=1.2
Γ_{12}	$h^- \pi^0 \nu_\tau$		(25.84 ± 0.14) %	S=1.1
Γ_{13}	$\pi^- \pi^0 \nu_\tau$	[a]	(25.32 ± 0.15) %	S=1.1
Γ_{14}	$\pi^- \pi^0$ non-$\rho(770) \nu_\tau$		(3.0 ± 3.2) × 10^{-3}	
Γ_{15}	$K^- \pi^0 \nu_\tau$	[a]	(5.2 ± 0.5) × 10^{-3}	
Γ_{16}	$h^- \geq 2\pi^0 \nu_\tau$		(10.79 ± 0.16) %	S=1.2
Γ_{17}	$h^- 2\pi^0 \nu_\tau$		(9.39 ± 0.14) %	S=1.2

Γ_{18}	$h^- 2\pi^0 \nu_\tau (\text{ex.}K^0)$		(9.23 ± 0.14) %	S=1.2
Γ_{19}	$\pi^- 2\pi^0 \nu_\tau (\text{ex.}K^0)$	[a]	(9.15 ± 0.15) %	S=1.2
Γ_{20}	$K^- 2\pi^0 \nu_\tau (\text{ex.}K^0)$	[a]	$(8.0 \pm 2.7) \times 10^{-4}$	
Γ_{21}	$h^- \geq 3\pi^0 \nu_\tau$		(1.40 ± 0.11) %	S=1.1
Γ_{22}	$h^- 3\pi^0 \nu_\tau$		(1.23 ± 0.10) %	S=1.1
Γ_{23}	$\pi^- 3\pi^0 \nu_\tau (\text{ex.}K^0)$	[a]	(1.11 ± 0.14) %	
Γ_{24}	$K^- 3\pi^0 \nu_\tau (\text{ex.}K^0)$	[a]	$(4.3 {}^{+10.0}_{-2.9}) \times 10^{-4}$	
Γ_{25}	$h^- 4\pi^0 \nu_\tau (\text{ex.}K^0)$		$(1.7 \pm 0.6) \times 10^{-3}$	
Γ_{26}	$h^- 4\pi^0 \nu_\tau (\text{ex.}K^0,\eta)$	[a]	$(1.1 \pm 0.6) \times 10^{-3}$	
Γ_{27}	$K^- \geq 0\pi^0 \ \geq 0K^0 \ \nu_\tau$		(1.66 ± 0.10) %	
Γ_{28}	$K^- \geq 1 \ (\pi^0 \text{ or } K^0) \ \nu_\tau$		$(9.5 \pm 1.0) \times 10^{-3}$	
	Modes with K^0's			
Γ_{29}	$K^0 (\text{particles})^- \nu_\tau$		(1.66 ± 0.09) %	S=1.4
Γ_{30}	$h^- \overline{K}^0 \geq 0$ neutrals $\geq 0 K^0_L \nu_\tau$		(1.62 ± 0.09) %	S=1.4
Γ_{31}	$h^- \overline{K}^0 \nu_\tau$		$(9.9 \pm 0.8) \times 10^{-3}$	S=1.5
Γ_{32}	$\pi^- \overline{K}^0 \nu_\tau$	[a]	$(8.3 \pm 0.8) \times 10^{-3}$	S=1.4
Γ_{33}	$\pi^- \overline{K}^0$ (non-$K^*(892)^-$)ν_τ		$< 1.7 \times 10^{-3}$	CL=95%
Γ_{34}	$K^- K^0 \nu_\tau$	[a]	$(1.59 \pm 0.24) \times 10^{-3}$	
Γ_{35}	$h^- \overline{K}^0 \pi^0 \nu_\tau$		$(5.5 \pm 0.5) \times 10^{-3}$	
Γ_{36}	$\pi^- \overline{K}^0 \pi^0 \nu_\tau$	[a]	$(3.9 \pm 0.5) \times 10^{-3}$	
Γ_{37}	$\overline{K}^0 \rho^- \nu_\tau$		$(1.9 \pm 0.7) \times 10^{-3}$	
Γ_{38}	$K^- K^0 \pi^0 \nu_\tau$	[a]	$(1.51 \pm 0.29) \times 10^{-3}$	
Γ_{39}	$\pi^- \overline{K}^0 \pi^0 \pi^0 \nu_\tau$		$(6 \pm 4) \times 10^{-4}$	
Γ_{40}	$K^- K^0 \pi^0 \pi^0 \nu_\tau$		$< 3.9 \times 10^{-4}$	CL=95%
Γ_{41}	$\pi^- K^0 \overline{K}^0 \nu_\tau$	[a]	$(1.21 \pm 0.21) \times 10^{-3}$	S=1.2
Γ_{42}	$\pi^- K^0_S K^0_S \nu_\tau$		$(3.0 \pm 0.5) \times 10^{-4}$	S=1.2
Γ_{43}	$\pi^- K^0_S K^0_L \nu_\tau$		$(6.0 \pm 1.0) \times 10^{-4}$	S=1.2
Γ_{44}	$\pi^- K^0_S K^0_S \pi^0 \nu_\tau$		$< 2.0 \times 10^{-4}$	CL=95%
Γ_{45}	$\pi^- K^0_S K^0_L \pi^0 \nu_\tau$		$(3.1 \pm 1.2) \times 10^{-4}$	
Γ_{46}	$K^- K^0 \geq 0$ neutrals ν_τ		$(3.1 \pm 0.4) \times 10^{-3}$	
Γ_{47}	$K^0 h^+ h^- h^- \geq 0$ neutrals ν_τ		$< 1.7 \times 10^{-3}$	CL=95%
Γ_{48}	$K^0 h^+ h^- h^- \nu_\tau$		$(2.3 \pm 2.0) \times 10^{-4}$	
	Modes with three charged particles			
Γ_{49}	$h^- h^- h^+ \geq 0$neut. ν_τ ("3-prong")		(15.18 ± 0.13) %	S=1.2
Γ_{50}	$h^- h^- h^+ \geq 0$ neutrals ν_τ (ex. $K^0_S \rightarrow \pi^+ \pi^-$)		(14.60 ± 0.13) %	S=1.2
Γ_{51}	$\pi^- \pi^+ \pi^- \geq 0$ neutrals ν_τ		(14.60 ± 0.14) %	
Γ_{52}	$h^- h^- h^+ \nu_\tau$		(9.96 ± 0.10) %	S=1.1
Γ_{53}	$h^- h^- h^+ \nu_\tau (\text{ex.}K^0)$		(9.62 ± 0.10) %	S=1.1
Γ_{54}	$h^- h^- h^+ \nu_\tau (\text{ex.}K^0,\omega)$		(9.57 ± 0.10) %	S=1.1
Γ_{55}	$\pi^- \pi^+ \pi^- \nu_\tau$		(9.56 ± 0.11) %	S=1.1

Γ_{56}	$\pi^- \pi^+ \pi^- \nu_\tau$ (ex.K^0)		(9.52± 0.11) %	S=1.1
Γ_{57}	$\pi^- \pi^+ \pi^- \nu_\tau$ (ex.K^0,ω)	[a]	(9.23± 0.11) %	S=1.1
Γ_{58}	$h^- h^- h^+ \geq 1$ neutrals ν_τ		(5.18± 0.11) %	S=1.2
Γ_{59}	$h^- h^- h^+ \geq 1$ neutrals ν_τ (ex. $K^0_S \to \pi^+ \pi^-$)		(4.98± 0.11) %	S=1.2
Γ_{60}	$h^- h^- h^+ \pi^0 \nu_\tau$		(4.50± 0.09) %	S=1.1
Γ_{61}	$h^- h^- h^+ \pi^0 \nu_\tau$ (ex.K^0)		(4.31± 0.09) %	S=1.1
Γ_{62}	$h^- h^- h^+ \pi^0 \nu_\tau$ (ex. K^0, ω)		(2.59± 0.09) %	
Γ_{63}	$\pi^- \pi^+ \pi^- \pi^0 \nu_\tau$		(4.35± 0.10) %	
Γ_{64}	$\pi^- \pi^+ \pi^- \pi^0 \nu_\tau$ (ex.K^0)		(4.22± 0.10) %	
Γ_{65}	$\pi^- \pi^+ \pi^- \pi^0 \nu_\tau$ (ex.K^0,ω)	[a]	(2.49± 0.10) %	
Γ_{66}	$h^- (\rho\pi)^0 \nu_\tau$		(2.88± 0.35) %	
Γ_{67}	$(a_1(1260) h)^- \nu_\tau$		< 2.0 %	CL=95%
Γ_{68}	$h^- \rho \pi^0 \nu_\tau$		(1.35± 0.20) %	
Γ_{69}	$h^- \rho^+ h^- \nu_\tau$		(4.5 ± 2.2) $\times 10^{-3}$	
Γ_{70}	$h^- \rho^- h^+ \nu_\tau$		(1.17± 0.23) %	
Γ_{71}	$h^- h^- h^+ 2\pi^0 \nu_\tau$		(5.4 ± 0.4) $\times 10^{-3}$	
Γ_{72}	$h^- h^- h^+ 2\pi^0 \nu_\tau$ (ex.K^0)		(5.3 ± 0.4) $\times 10^{-3}$	
Γ_{73}	$h^- h^- h^+ 2\pi^0 \nu_\tau$ (ex.K^0,ω,η)	[a]	(1.1 ± 0.4) $\times 10^{-3}$	
Γ_{74}	$h^- h^- h^+ \geq 3\pi^0 \nu_\tau$	[a]	($1.4\ ^{+\ 0.9}_{-\ 0.7}$) $\times 10^{-3}$	S=1.5
Γ_{75}	$h^- h^- h^+ 3\pi^0 \nu_\tau$		(2.9 ± 0.8) $\times 10^{-4}$	
Γ_{76}	$K^- h^+ h^- \geq 0$ neutrals ν_τ		(5.4 ± 0.7) $\times 10^{-3}$	S=1.1
Γ_{77}	$K^- \pi^+ \pi^- \geq 0$ neutrals ν_τ		(3.1 ± 0.6) $\times 10^{-3}$	S=1.1
Γ_{78}	$K^- \pi^+ \pi^- \nu_\tau$		(2.3 ± 0.4) $\times 10^{-3}$	
Γ_{79}	$K^- \pi^+ \pi^- \nu_\tau$ (ex.K^0)	[a]	(1.8 ± 0.5) $\times 10^{-3}$	
Γ_{80}	$K^- \pi^+ \pi^- \pi^0 \nu_\tau$		(8 ± 4) $\times 10^{-4}$	
Γ_{81}	$K^- \pi^+ \pi^- \pi^0 \nu_\tau$ (ex.K^0)	[a]	($2.4\ ^{+\ 4.3}_{-\ 1.6}$) $\times 10^{-4}$	
Γ_{82}	$K^- \pi^+ K^- \geq 0$ neut. ν_τ		< 9 $\times 10^{-4}$	CL=95%
Γ_{83}	$K^- K^+ \pi^- \geq 0$ neut. ν_τ		(2.3 ± 0.4) $\times 10^{-3}$	
Γ_{84}	$K^- K^+ \pi^- \nu_\tau$	[a]	(1.61± 0.26) $\times 10^{-3}$	
Γ_{85}	$K^- K^+ \pi^- \pi^0 \nu_\tau$	[a]	(6.9 ± 3.0) $\times 10^{-4}$	
Γ_{86}	$K^- K^+ K^- \geq 0$ neut. ν_τ		< 2.1 $\times 10^{-3}$	CL=95%
Γ_{87}	$K^- K^+ K^- \nu_\tau$		< 1.9 $\times 10^{-4}$	CL=90%
Γ_{88}	$\pi^- K^+ \pi^- \geq 0$ neut. ν_τ		< 2.5 $\times 10^{-3}$	CL=95%
Γ_{89}	$e^- e^- e^+ \overline{\nu}_e \nu_\tau$		(2.8 ± 1.5) $\times 10^{-5}$	
Γ_{90}	$\mu^- e^- e^+ \overline{\nu}_\mu \nu_\tau$		< 3.6 $\times 10^{-5}$	CL=90%

Modes with five charged particles

Γ_{91}	$3h^- 2h^+ \geq 0$ neutrals ν_τ (ex. $K^0_S \to \pi^-\pi^+$) ("5-prong")		$(9.7 \pm 0.7) \times 10^{-4}$	
Γ_{92}	$3h^- 2h^+ \nu_\tau$ (ex.K^0)	[a]	$(7.5 \pm 0.7) \times 10^{-4}$	
Γ_{93}	$3h^- 2h^+ \pi^0 \nu_\tau$ (ex.K^0)	[a]	$(2.2 \pm 0.5) \times 10^{-4}$	
Γ_{94}	$3h^- 2h^+ 2\pi^0 \nu_\tau$		$< 1.1 \times 10^{-4}$	CL=90%

Miscellaneous other allowed modes

Γ_{95}	$(5\pi)^- \nu_\tau$		$(7.4 \pm 0.7) \times 10^{-3}$	
Γ_{96}	$4h^- 3h^+ \geq 0$ neutrals ν_τ ("7-prong")		$< 2.4 \times 10^{-6}$	CL=90%
Γ_{97}	$K^*(892)^- \geq 0(h^0 \neq K^0_S) \nu_\tau$		(1.94 ± 0.31) %	
Γ_{98}	$K^*(892)^- \geq 0$ neutrals ν_τ		(1.33 ± 0.13) %	
Γ_{99}	$K^*(892)^- \nu_\tau$		(1.28 ± 0.08) %	
Γ_{100}	$K^*(892)^0 K^- \geq 0$ neutrals ν_τ		$(3.2 \pm 1.4) \times 10^{-3}$	
Γ_{101}	$K^*(892)^0 K^- \nu_\tau$		$(2.1 \pm 0.4) \times 10^{-3}$	
Γ_{102}	$\overline{K}^*(892)^0 \pi^- \geq 0$ neutrals ν_τ		$(3.8 \pm 1.7) \times 10^{-3}$	
Γ_{103}	$\overline{K}^*(892)^0 \pi^- \nu_\tau$		$(2.2 \pm 0.5) \times 10^{-3}$	
Γ_{104}	$(\overline{K}^*(892)\pi)^- \nu_\tau \to \pi^- \overline{K}^0 \pi^0 \nu_\tau$		$(1.1 \pm 0.5) \times 10^{-3}$	
Γ_{105}	$K_1(1270)^- \nu_\tau$		$(4 \pm 4) \times 10^{-3}$	
Γ_{106}	$K_1(1400)^- \nu_\tau$		$(8 \pm 4) \times 10^{-3}$	
Γ_{107}	$K^*_2(1430)^- \nu_\tau$		$< 3 \times 10^{-3}$	CL=95%
Γ_{108}	$a_0(980)^- \geq 0$ neutrals ν_τ			
Γ_{109}	$\eta \pi^- \nu_\tau$		$< 1.4 \times 10^{-4}$	CL=95%
Γ_{110}	$\eta \pi^- \pi^0 \nu_\tau$	[a]	$(1.74 \pm 0.24) \times 10^{-3}$	
Γ_{111}	$\eta \pi^- \pi^0 \pi^0 \nu_\tau$		$(1.4 \pm 0.7) \times 10^{-4}$	
Γ_{112}	$\eta K^- \nu_\tau$		$(2.7 \pm 0.6) \times 10^{-4}$	
Γ_{113}	$\eta \pi^+ \pi^- \pi^- \geq 0$ neutrals ν_τ		$< 3 \times 10^{-3}$	CL=90%
Γ_{114}	$\eta \pi^- \pi^+ \pi^- \nu_\tau$		$(3.4 \pm 0.8) \times 10^{-4}$	
Γ_{115}	$\eta a_1(1260)^- \nu_\tau \to \eta \pi^- \rho^0 \nu_\tau$		$< 3.9 \times 10^{-4}$	CL=90%
Γ_{116}	$\eta \eta \pi^- \nu_\tau$		$< 1.1 \times 10^{-4}$	CL=95%
Γ_{117}	$\eta \eta \pi^- \pi^0 \nu_\tau$		$< 2.0 \times 10^{-4}$	CL=95%
Γ_{118}	$\eta'(958) \pi^- \nu_\tau$		$< 7.4 \times 10^{-5}$	CL=90%
Γ_{119}	$\eta'(958) \pi^- \pi^0 \nu_\tau$		$< 8.0 \times 10^{-5}$	CL=90%
Γ_{120}	$\phi \pi^- \nu_\tau$		$< 2.0 \times 10^{-4}$	CL=90%
Γ_{121}	$\phi K^- \nu_\tau$		$< 6.7 \times 10^{-5}$	CL=90%
Γ_{122}	$f_1(1285) \pi^- \nu_\tau$		$(5.8 \pm 2.3) \times 10^{-4}$	
Γ_{123}	$f_1(1285) \pi^- \nu_\tau \to \eta \pi^- \pi^+ \pi^- \nu_\tau$		$(1.9 \pm 0.7) \times 10^{-4}$	
Γ_{124}	$h^- \omega \geq 0$ neutrals ν_τ		(2.36 ± 0.08) %	
Γ_{125}	$h^- \omega \nu_\tau$	[a]	(1.93 ± 0.06) %	
Γ_{126}	$h^- \omega \pi^0 \nu_\tau$	[a]	$(4.3 \pm 0.5) \times 10^{-3}$	
Γ_{127}	$h^- \omega 2\pi^0 \nu_\tau$		$(1.9 \pm 0.8) \times 10^{-4}$	

Lepton Family number (*LF*), Lepton number (*L*), or Baryon number (*B*) violating modes (In the modes below, ℓ means a sum over *e* and μ modes)

L means lepton number violation (*e.g.* $\tau^- \to e^+\pi^-\pi^-$). Following common usage, *LF* means lepton family violation *and not* lepton number violation (*e.g.* $\tau^- \to e^-\pi^+\pi^-$). *B* means baryon number violation.

Γ_{128}	$e^-\gamma$	*LF*	$<$ 2.7	$\times 10^{-6}$	CL=90%
Γ_{129}	$\mu^-\gamma$	*LF*	$<$ 3.0	$\times 10^{-6}$	CL=90%
Γ_{130}	$e^-\pi^0$	*LF*	$<$ 3.7	$\times 10^{-6}$	CL=90%
Γ_{131}	$\mu^-\pi^0$	*LF*	$<$ 4.0	$\times 10^{-6}$	CL=90%
Γ_{132}	e^-K^0	*LF*	$<$ 1.3	$\times 10^{-3}$	CL=90%
Γ_{133}	μ^-K^0	*LF*	$<$ 1.0	$\times 10^{-3}$	CL=90%
Γ_{134}	$e^-\eta$	*LF*	$<$ 8.2	$\times 10^{-6}$	CL=90%
Γ_{135}	$\mu^-\eta$	*LF*	$<$ 9.6	$\times 10^{-6}$	CL=90%
Γ_{136}	$e^-\rho^0$	*LF*	$<$ 2.0	$\times 10^{-6}$	CL=90%
Γ_{137}	$\mu^-\rho^0$	*LF*	$<$ 6.3	$\times 10^{-6}$	CL=90%
Γ_{138}	$e^-K^*(892)^0$	*LF*	$<$ 5.1	$\times 10^{-6}$	CL=90%
Γ_{139}	$\mu^-K^*(892)^0$	*LF*	$<$ 7.5	$\times 10^{-6}$	CL=90%
Γ_{140}	$e^-\overline{K}^*(892)^0$	*LF*	$<$ 7.4	$\times 10^{-6}$	CL=90%
Γ_{141}	$\mu^-\overline{K}^*(892)^0$	*LF*	$<$ 7.5	$\times 10^{-6}$	CL=90%
Γ_{142}	$e^-\phi$	*LF*	$<$ 6.9	$\times 10^{-6}$	CL=90%
Γ_{143}	$\mu^-\phi$	*LF*	$<$ 7.0	$\times 10^{-6}$	CL=90%
Γ_{144}	$\pi^-\gamma$	*L*	$<$ 2.8	$\times 10^{-4}$	CL=90%
Γ_{145}	$\pi^-\pi^0$	*L*	$<$ 3.7	$\times 10^{-4}$	CL=90%
Γ_{146}	$e^-e^+e^-$	*LF*	$<$ 2.9	$\times 10^{-6}$	CL=90%
Γ_{147}	$e^-\mu^+\mu^-$	*LF*	$<$ 1.8	$\times 10^{-6}$	CL=90%
Γ_{148}	$e^+\mu^-\mu^-$	*LF*	$<$ 1.5	$\times 10^{-6}$	CL=90%
Γ_{149}	$\mu^-e^+e^-$	*LF*	$<$ 1.7	$\times 10^{-6}$	CL=90%
Γ_{150}	$\mu^+e^-e^-$	*LF*	$<$ 1.5	$\times 10^{-6}$	CL=90%
Γ_{151}	$\mu^-\mu^+\mu^-$	*LF*	$<$ 1.9	$\times 10^{-6}$	CL=90%
Γ_{152}	$e^-\pi^+\pi^-$	*LF*	$<$ 2.2	$\times 10^{-6}$	CL=90%
Γ_{153}	$e^+\pi^-\pi^-$	*L*	$<$ 1.9	$\times 10^{-6}$	CL=90%
Γ_{154}	$\mu^-\pi^+\pi^-$	*LF*	$<$ 8.2	$\times 10^{-6}$	CL=90%
Γ_{155}	$\mu^+\pi^-\pi^-$	*L*	$<$ 3.4	$\times 10^{-6}$	CL=90%
Γ_{156}	$e^-\pi^+K^-$	*LF*	$<$ 6.4	$\times 10^{-6}$	CL=90%
Γ_{157}	$e^-\pi^-K^+$	*LF*	$<$ 3.8	$\times 10^{-6}$	CL=90%
Γ_{158}	$e^+\pi^-K^-$	*L*	$<$ 2.1	$\times 10^{-6}$	CL=90%
Γ_{159}	$e^-K^+K^-$	*LF*	$<$ 6.0	$\times 10^{-6}$	CL=90%
Γ_{160}	$e^+K^-K^-$	*L*	$<$ 3.8	$\times 10^{-6}$	CL=90%
Γ_{161}	$\mu^-\pi^+K^-$	*LF*	$<$ 7.5	$\times 10^{-6}$	CL=90%
Γ_{162}	$\mu^-\pi^-K^+$	*LF*	$<$ 7.4	$\times 10^{-6}$	CL=90%
Γ_{163}	$\mu^+\pi^-K^-$	*L*	$<$ 7.0	$\times 10^{-6}$	CL=90%

Γ_{164}	$\mu^- K^+ K^-$	*LF*	$<$	1.5	$\times 10^{-5}$	CL=90%
Γ_{165}	$\mu^+ K^- K^-$	*L*	$<$	6.0	$\times 10^{-6}$	CL=90%
Γ_{166}	$e^- \pi^0 \pi^0$	*LF*	$<$	6.5	$\times 10^{-6}$	CL=90%
Γ_{167}	$\mu^- \pi^0 \pi^0$	*LF*	$<$	1.4	$\times 10^{-5}$	CL=90%
Γ_{168}	$e^- \eta \eta$	*LF*	$<$	3.5	$\times 10^{-5}$	CL=90%
Γ_{169}	$\mu^- \eta \eta$	*LF*	$<$	6.0	$\times 10^{-5}$	CL=90%
Γ_{170}	$e^- \pi^0 \eta$	*LF*	$<$	2.4	$\times 10^{-5}$	CL=90%
Γ_{171}	$\mu^- \pi^0 \eta$	*LF*	$<$	2.2	$\times 10^{-5}$	CL=90%
Γ_{172}	$\overline{p} \gamma$	*L,B*	$<$	2.9	$\times 10^{-4}$	CL=90%
Γ_{173}	$\overline{p} \pi^0$	*L,B*	$<$	6.6	$\times 10^{-4}$	CL=90%
Γ_{174}	$\overline{p} \eta$	*L,B*	$<$	1.30	$\times 10^{-3}$	CL=90%
Γ_{175}	e^- light boson	*LF*	$<$	2.7	$\times 10^{-3}$	CL=95%
Γ_{176}	μ^- light boson	*LF*	$<$	5	$\times 10^{-3}$	CL=95%

[*a*] Basis mode for the τ.

[*b*] See the Particle Listings below for the energy limits used in this measurement.

CONSTRAINED FIT INFORMATION

An overall fit to 65 branching ratios uses 141 measurements and one constraint to determine 29 parameters. The overall fit has a $\chi^2 = 94.2$ for 113 degrees of freedom.

The following *off-diagonal* array elements are the correlation coefficients $\left\langle\delta x_i \delta x_j\right\rangle/(\delta x_i \cdot \delta x_j)$, in percent, from the fit to the branching fractions, $x_i \equiv \Gamma_i/\Gamma_{total}$. The fit constrains the x_i whose labels appear in this array to sum to one.

	x_3	x_5	x_9	x_{10}	x_{13}	x_{15}	x_{19}	x_{20}	x_{23}	x_{24}
x_5	11									
x_9	−11	−10								
x_{10}	0	0	−34							
x_{13}	−15	−13	−17	3						
x_{15}	0	0	2	−7	−37					
x_{19}	−16	−14	−15	1	−24	1				
x_{20}	0	0	1	−3	1	−4	−18			
x_{23}	−7	−6	−13	14	−14	17	−14	8		
x_{24}	0	0	7	−19	9	−23	2	−11	−72	
x_{26}	−5	−4	−5	0	−7	0	−9	0	−4	0
x_{32}	−2	−2	−24	0	−3	0	−12	0	−2	1
x_{34}	0	0	−4	−3	1	−3	−2	−2	7	−9
x_{36}	−2	−2	−1	1	−4	1	−3	1	−8	3
x_{38}	−1	−1	1	−3	0	−4	−1	−2	6	−11
x_{41}	−1	−1	−3	0	−2	0	−2	0	−1	0
x_{57}	−7	−6	−4	0	−10	0	−9	0	−4	0
x_{65}	−3	−3	−4	0	−5	0	−5	0	−1	−1
x_{73}	−1	−1	−2	0	−2	0	−2	0	−1	0
x_{74}	−6	−5	−7	0	−9	0	−9	0	−4	0
x_{79}	0	0	1	0	0	1	0	0	−1	2
x_{81}	0	0	0	1	0	1	0	0	−1	3
x_{84}	0	0	0	0	0	0	0	0	0	0
x_{85}	0	0	0	0	0	0	0	0	0	0
x_{92}	0	0	−1	0	−1	0	−1	0	0	0
x_{93}	0	0	0	0	0	0	0	0	0	0
x_{110}	−1	−1	−1	0	−1	0	−1	0	−1	0
x_{125}	−2	−2	−3	0	−3	0	−4	0	−1	0
x_{126}	−2	−2	−3	0	−3	0	−4	0	−2	0

	x_{26}	x_{32}	x_{34}	x_{36}	x_{38}	x_{41}	x_{57}	x_{65}	x_{73}	x_{74}
x_{32}	−1									
x_{34}	0	−10								
x_{36}	−1	−8	−1							
x_{38}	0	−3	−2	−29						
x_{41}	−1	−4	−1	−2	−1					
x_{57}	−3	−17	4	0	0	0				
x_{65}	−2	1	0	−10	7	0	−10			
x_{73}	1	0	0	0	0	0	−1	−2		
x_{74}	−3	0	0	0	0	−1	−13	−15	−3	
x_{79}	0	2	−18	0	0	0	−40	3	0	0
x_{81}	0	1	1	7	−23	0	3	−41	0	0
x_{84}	0	0	0	0	0	0	−23	3	0	0
x_{85}	0	0	0	0	0	0	2	−30	0	0
x_{92}	0	0	0	0	0	0	0	0	0	0
x_{93}	0	0	0	0	0	0	0	0	0	0
x_{110}	−14	0	0	0	0	0	−1	0	−14	−1
x_{125}	−1	0	0	−4	−1	0	−6	−28	−1	−8
x_{126}	−1	0	0	0	0	0	−1	−4	−42	−4

	x_{79}	x_{81}	x_{84}	x_{85}	x_{92}	x_{93}	x_{110}	x_{125}
x_{81}	−8							
x_{84}	0	0						
x_{85}	0	0	−9					
x_{92}	0	0	0	0				
x_{93}	0	0	0	0	−24			
x_{110}	0	0	0	0	0	0		
x_{125}	0	0	0	0	0	0	0	
x_{126}	0	0	0	0	0	0	0	−1