STRANGE MESONS
($S = \pm 1$, $C = B = 0$)

$K^+ = u\bar{s}$, $K^0 = d\bar{s}$, $\overline{K}^0 = \bar{d}s$, $K^- = \bar{u}s$, similarly for K^*'s

$K^\pm$

$$I(J^P) = \tfrac{1}{2}(0^-)$$

Mass $m = 493.677 \pm 0.016$ MeV [a] (S = 2.8)
Mean life $\tau = (1.2380 \pm 0.0021) \times 10^{-8}$ s (S = 1.9)
$c\tau = 3.712$ m

Slope parameter g [b]

(See Particle Listings for quadratic coefficients and alternative parametrization related to $\pi\pi$ scattering)

$K^\pm \to \pi^\pm\pi^+\pi^-$ $g = -0.21134 \pm 0.00017$
$(g_+ - g_-)\ /\ (g_+ + g_-) = (-1.5 \pm 2.2) \times 10^{-4}$
$K^\pm \to \pi^\pm\pi^0\pi^0$ $g = 0.626 \pm 0.007$
$(g_+ - g_-)\ /\ (g_+ + g_-) = (1.8 \pm 1.8) \times 10^{-4}$

$K^\pm$ decay form factors [c,d]

Assuming μ-e universality

$\lambda_+(K^+_{\mu 3}) = \lambda_+(K^+_{e3}) = (2.97 \pm 0.05) \times 10^{-2}$
$\lambda_0(K^+_{\mu 3}) = (1.95 \pm 0.12) \times 10^{-2}$

Not assuming μ-e universality

$\lambda_+(K^+_{e3}) = (2.98 \pm 0.05) \times 10^{-2}$
$\lambda_+(K^+_{\mu 3}) = (2.96 \pm 0.17) \times 10^{-2}$
$\lambda_0(K^+_{\mu 3}) = (1.96 \pm 0.13) \times 10^{-2}$

K_{e3} form factor quadratic fit

$\lambda'_+(K^\pm_{e3})$ linear coeff. $= (2.49 \pm 0.17) \times 10^{-2}$
$\lambda''_+(K^\pm_{e3})$ quadratic coeff. $= (0.19 \pm 0.09) \times 10^{-2}$

K^+_{e3} $|f_S/f_+| = (-0.3^{+0.8}_{-0.7}) \times 10^{-2}$
K^+_{e3} $|f_T/f_+| = (-1.2 \pm 2.3) \times 10^{-2}$
$K^+_{\mu 3}$ $|f_S/f_+| = (0.2 \pm 0.6) \times 10^{-2}$
$K^+_{\mu 3}$ $|f_T/f_+| = (-0.1 \pm 0.7) \times 10^{-2}$
$K^+ \to e^+\nu_e\gamma$ $|F_A + F_V| = 0.133 \pm 0.008$ (S = 1.3)
$K^+ \to \mu^+\nu_\mu\gamma$ $|F_A + F_V| = 0.165 \pm 0.013$
$K^+ \to e^+\nu_e\gamma$ $|F_A - F_V| < 0.49$
$K^+ \to \mu^+\nu_\mu\gamma$ $|F_A - F_V| = -0.24$ to 0.04, CL = 90%

Charge Radius

$\langle r \rangle = 0.560 \pm 0.031$ fm

CP violation parameters

$\Delta(K^{\pm}_{\pi e e}) = (-2.2 \pm 1.6) \times 10^{-2}$
$\Delta(K^{\pm}_{\pi \mu \mu}) = 0.010 \pm 0.023$
$\Delta(K^{\pm}_{\pi \pi \gamma}) = (0.0 \pm 1.2) \times 10^{-3}$
$A_{FB}(K^{\pm}_{\pi \mu \mu}) = \frac{\Gamma(cos(\theta_{K\mu})>0) - \Gamma(cos(\theta_{K\mu})<0)}{\Gamma(cos(\theta_{K\mu})>0) + \Gamma(cos(\theta_{K\mu})<0)} < 2.3 \times 10^{-2}$, CL = 90%

T violation parameters

$K^+ \to \pi^0 \mu^+ \nu_\mu \quad P_T = (-1.7 \pm 2.5) \times 10^{-3}$
$K^+ \to \mu^+ \nu_\mu \gamma \quad P_T = (-0.6 \pm 1.9) \times 10^{-2}$
$K^+ \to \pi^0 \mu^+ \nu_\mu \quad \mathrm{Im}(\xi) = -0.006 \pm 0.008$

K^- modes are charge conjugates of the modes below.

K^+ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Leptonic and semileptonic modes			
$e^+ \nu_e$	(1.581±0.008) × 10^{-5}		247
$\mu^+ \nu_\mu$	(63.55 ±0.11) %	S=1.2	236
$\pi^0 e^+ \nu_e$	(5.07 ±0.04) %	S=2.1	228
Called K^+_{e3}.			
$\pi^0 \mu^+ \nu_\mu$	(3.353±0.034) %	S=1.8	215
Called $K^+_{\mu 3}$.			
$\pi^0 \pi^0 e^+ \nu_e$	(2.2 ±0.4) × 10^{-5}		206
$\pi^+ \pi^- e^+ \nu_e$	(4.254±0.032) × 10^{-5}		203
$\pi^+ \pi^- \mu^+ \nu_\mu$	(1.4 ±0.9) × 10^{-5}		151
$\pi^0 \pi^0 \pi^0 e^+ \nu_e$	< 3.5 × 10^{-6}	CL=90%	135
Hadronic modes			
$\pi^+ \pi^0$	(20.66 ±0.08) %	S=1.2	205
$\pi^+ \pi^0 \pi^0$	(1.761±0.022) %	S=1.1	133
$\pi^+ \pi^+ \pi^-$	(5.59 ±0.04) %	S=1.3	125
Leptonic and semileptonic modes with photons			
$\mu^+ \nu_\mu \gamma$	[e,f] (6.2 ±0.8) × 10^{-3}		236
$\mu^+ \nu_\mu \gamma$(SD$^+$)	[c,g] (1.33 ±0.22) × 10^{-5}		–
$\mu^+ \nu_\mu \gamma$(SD$^+$INT)	[c,g] < 2.7 × 10^{-5}	CL=90%	–
$\mu^+ \nu_\mu \gamma$(SD$^-$ + SD$^-$INT)	[c,g] < 2.6 × 10^{-4}	CL=90%	–

$e^+\nu_e\gamma$			(9.4	$\pm$0.4)	$\times 10^{-6}$		247
$\pi^0 e^+\nu_e\gamma$	[e,f]		(2.56	$\pm$0.16)	$\times 10^{-4}$		228
$\pi^0 e^+\nu_e\gamma$(SD)	[c,g]	<	5.3		$\times 10^{-5}$	CL=90%	228
$\pi^0\mu^+\nu_\mu\gamma$	[e,f]		(1.25	$\pm$0.25)	$\times 10^{-5}$		215
$\pi^0\pi^0 e^+\nu_e\gamma$		<	5		$\times 10^{-6}$	CL=90%	206

Hadronic modes with photons or $\ell\overline{\ell}$ pairs

$\pi^+\pi^0\gamma$(INT)			(– 4.2	$\pm$0.9)	$\times 10^{-6}$		–
$\pi^+\pi^0\gamma$(DE)	[e,h]		(6.0	$\pm$0.4)	$\times 10^{-6}$		205
$\pi^+\pi^0\pi^0\gamma$	[e,f]		(7.6	$^{+6.0}_{-3.0}$)	$\times 10^{-6}$		133
$\pi^+\pi^+\pi^-\gamma$	[e,f]		(1.04	$\pm$0.31)	$\times 10^{-4}$		125
$\pi^+\gamma\gamma$	[e]		(1.10	$\pm$0.32)	$\times 10^{-6}$		227
$\pi^+ 3\gamma$	[e]	<	1.0		$\times 10^{-4}$	CL=90%	227
$\pi^+ e^+ e^-\gamma$			(1.19	$\pm$0.13)	$\times 10^{-8}$		227

Leptonic modes with $\ell\overline{\ell}$ pairs

$e^+\nu_e\nu\overline{\nu}$		<	6		$\times 10^{-5}$	CL=90%	247
$\mu^+\nu_\mu\nu\overline{\nu}$		<	6.0		$\times 10^{-6}$	CL=90%	236
$e^+\nu_e e^+ e^-$			(2.48	$\pm$0.20)	$\times 10^{-8}$		247
$\mu^+\nu_\mu e^+ e^-$			(7.06	$\pm$0.31)	$\times 10^{-8}$		236
$e^+\nu_e\mu^+\mu^-$			(1.7	$\pm$0.5)	$\times 10^{-8}$		223
$\mu^+\nu_\mu\mu^+\mu^-$		<	4.1		$\times 10^{-7}$	CL=90%	185

Lepton Family number (*LF*), Lepton number (*L*), $\Delta S = \Delta Q$ (*SQ*) violating modes, or $\Delta S = 1$ weak neutral current (*S1*) modes

$\pi^+\pi^+ e^-\overline{\nu}_e$	*SQ*	<	1.3		$\times 10^{-8}$	CL=90%	203
$\pi^+\pi^+\mu^-\overline{\nu}_\mu$	*SQ*	<	3.0		$\times 10^{-6}$	CL=95%	151
$\pi^+ e^+ e^-$	*S1*		(3.00	$\pm$0.09)	$\times 10^{-7}$		227
$\pi^+\mu^+\mu^-$	*S1*		(9.4	$\pm$0.6)	$\times 10^{-8}$	S=2.6	172
$\pi^+\nu\overline{\nu}$	*S1*		(1.7	$\pm$1.1)	$\times 10^{-10}$		227
$\pi^+\pi^0\nu\overline{\nu}$	*S1*	<	4.3		$\times 10^{-5}$	CL=90%	205
$\mu^-\nu e^+ e^+$	*LF*	<	2.1		$\times 10^{-8}$	CL=90%	236
$\mu^+\nu_e$	*LF*	[i] <	4		$\times 10^{-3}$	CL=90%	236
$\pi^+\mu^+ e^-$	*LF*	<	1.3		$\times 10^{-11}$	CL=90%	214
$\pi^+\mu^- e^+$	*LF*	<	5.2		$\times 10^{-10}$	CL=90%	214
$\pi^-\mu^+ e^+$	*L*	<	5.0		$\times 10^{-10}$	CL=90%	214
$\pi^- e^+ e^+$	*L*	<	6.4		$\times 10^{-10}$	CL=90%	227
$\pi^-\mu^+\mu^+$	*L*	[i] <	1.1		$\times 10^{-9}$	CL=90%	172
$\mu^+\overline{\nu}_e$	*L*	[i] <	3.3		$\times 10^{-3}$	CL=90%	236
$\pi^0 e^+\overline{\nu}_e$	*L*	<	3		$\times 10^{-3}$	CL=90%	228
$\pi^+\gamma$		[j] <	2.3		$\times 10^{-9}$	CL=90%	227

K^0

$I(J^P) = \frac{1}{2}(0^-)$

50% K_S, 50% K_L

Mass $m = 497.614 \pm 0.024$ MeV (S = 1.6)

$m_{K^0} - m_{K^\pm} = 3.937 \pm 0.028$ MeV (S = 1.8)

Mean Square Charge Radius

$\langle r^2 \rangle = -0.077 \pm 0.010$ fm^2

T-violation parameters in K^0-$\overline{K}^0$ mixing [d]

Asymmetry A_T in K^0-$\overline{K}^0$ mixing $= (6.6 \pm 1.6) \times 10^{-3}$

CPT-violation parameters [d]

Re $\delta = (2.5 \pm 2.3) \times 10^{-4}$

Im $\delta = (-1.5 \pm 1.6) \times 10^{-5}$

Re(y), K_{e3} parameter $= (0.4 \pm 2.5) \times 10^{-3}$

Re(x$_-$), K_{e3} parameter $= (-2.9 \pm 2.0) \times 10^{-3}$

$|m_{K^0} - m_{\overline{K}^0}| \,/\, m_{\text{average}} < 6 \times 10^{-19}$, CL = 90% [k]

$(\Gamma_{K^0} - \Gamma_{\overline{K}^0})/m_{\text{average}} = (8 \pm 8) \times 10^{-18}$

Tests of $\Delta S = \Delta Q$

Re(x$_+$), K_{e3} parameter $= (-0.9 \pm 3.0) \times 10^{-3}$

K^0_S

$I(J^P) = \frac{1}{2}(0^-)$

Mean life $\tau = (0.8954 \pm 0.0004) \times 10^{-10}$ s (S = 1.1) Assuming CPT

Mean life $\tau = (0.89564 \pm 0.00033) \times 10^{-10}$ s Not assuming CPT

$c\tau = 2.6844$ cm Assuming CPT

CP-violation parameters [l]

Im(η_{+-0}) $= -0.002 \pm 0.009$

Im(η_{000}) $= (-0.1 \pm 1.6) \times 10^{-2}$

$|\eta_{000}| = |A(K^0_S \to 3\pi^0)/A(K^0_L \to 3\pi^0)| < 0.018$, CL = 90%

CP asymmetry A in $\pi^+\pi^- e^+ e^-$ $= (-0.4 \pm 0.8)\%$

K^0_S DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Hadronic modes				
$\pi^0\pi^0$		(30.69±0.05) %		209
$\pi^+\pi^-$		(69.20±0.05) %		206
$\pi^+\pi^-\pi^0$		(3.5 $^{+1.1}_{-0.9}$) × 10^{-7}		133
Modes with photons or $\ell\bar{\ell}$ pairs				
$\pi^+\pi^-\gamma$	[f,n]	(1.79±0.05) × 10^{-3}		206
$\pi^+\pi^-e^+e^-$		(4.79±0.15) × 10^{-5}		206
$\pi^0\gamma\gamma$	[n]	(4.9 ±1.8) × 10^{-8}		231
$\gamma\gamma$		(2.63±0.17) × 10^{-6}	S=3.0	249
Semileptonic modes				
$\pi^\pm e^\mp\nu_e$	[o]	(7.04±0.08) × 10^{-4}		229
***CP* violating (*CP*) and $\Delta S = 1$ weak neutral current (*S1*) modes**				
$3\pi^0$	*CP*	< 1.2 × 10^{-7}	CL=90%	139
$\mu^+\mu^-$	*S1*	< 9 × 10^{-9}	CL=90%	225
e^+e^-	*S1*	< 9 × 10^{-9}	CL=90%	249
$\pi^0e^+e^-$	*S1*	[n] (3.0 $^{+1.5}_{-1.2}$) × 10^{-9}		230
$\pi^0\mu^+\mu^-$	*S1*	(2.9 $^{+1.5}_{-1.2}$) × 10^{-9}		177

K^0_L

$I(J^P) = \frac{1}{2}(0^-)$

$m_{K_L} - m_{K_S}$
$= (0.5293 \pm 0.0009) \times 10^{10}\ \hbar\ \text{s}^{-1}$ (S = 1.3) Assuming *CPT*
$= (3.484 \pm 0.006) \times 10^{-12}$ MeV Assuming *CPT*
$= (0.5289 \pm 0.0010) \times 10^{10}\ \hbar\ \text{s}^{-1}$ Not assuming *CPT*

Mean life $\tau = (5.116 \pm 0.021) \times 10^{-8}$ s (S = 1.1)
$c\tau = 15.34$ m

Slope parameter *g* [b]

(See Particle Listings for quadratic coefficients)
$K^0_L \to \pi^+\pi^-\pi^0$: $g = 0.678 \pm 0.008$ (S = 1.5)

K_L decay form factors [d]

Linear parametrization assuming μ-e universality
$\lambda_+(K^0_{\mu 3}) = \lambda_+(K^0_{e3}) = (2.82 \pm 0.04) \times 10^{-2}$ (S = 1.1)
$\lambda_0(K^0_{\mu 3}) = (1.38 \pm 0.18) \times 10^{-2}$ (S = 2.2)

Quadratic parametrization assuming μ-e universality

$\lambda'_+(K^0_{\mu 3}) = \lambda'_+(K^0_{e3}) = (2.40 \pm 0.12) \times 10^{-2}$ (S = 1.2)

$\lambda''_+(K^0_{\mu 3}) = \lambda''_+(K^0_{e3}) = (0.20 \pm 0.05) \times 10^{-2}$ (S = 1.2)

$\lambda_0(K^0_{\mu 3}) = (1.16 \pm 0.09) \times 10^{-2}$ (S = 1.2)

Pole parametrization assuming μ-e universality

$M_V^\mu\ (K^0_{\mu 3}) = M_V^e\ (K^0_{e3}) = 878 \pm 6$ MeV (S = 1.1)

$M_S^\mu\ (K^0_{\mu 3}) = 1252 \pm 90$ MeV (S = 2.6)

Dispersive parametrization assuming μ-e universality

$\Lambda_+ = (0.251 \pm 0.006) \times 10^{-1}$ (S = 1.5)

$\ln(C) = (1.75 \pm 0.18) \times 10^{-1}$ (S = 2.0)

K^0_{e3} $|f_S/f_+| = (1.5^{+1.4}_{-1.6}) \times 10^{-2}$

K^0_{e3} $|f_T/f_+| = (5^{+4}_{-5}) \times 10^{-2}$

$K^0_{\mu 3}$ $|f_T/f_+| = (12 \pm 12) \times 10^{-2}$

$K_L \to \ell^+\ell^-\gamma$, $K_L \to \ell^+\ell^-\ell'^+\ell'^-$: $\alpha_{K^*} = -0.205 \pm 0.022$ (S = 1.8)

$K^0_L \to \ell^+\ell^-\gamma$, $K^0_L \to \ell^+\ell^-\ell'^+\ell'^-$: $\alpha_{DIP} = -1.69 \pm 0.08$ (S = 1.7)

$K_L \to \pi^+\pi^- e^+ e^-$: $a_1/a_2 = -0.737 \pm 0.014$ GeV^2

$K_L \to \pi^0 2\gamma$: $a_V = -0.43 \pm 0.06$ (S = 1.5)

CP-violation parameters [*l*]

$A_L = (0.332 \pm 0.006)\%$

$|\eta_{00}| = (2.220 \pm 0.011) \times 10^{-3}$ (S = 1.8)

$|\eta_{+-}| = (2.232 \pm 0.011) \times 10^{-3}$ (S = 1.8)

$|\epsilon| = (2.228 \pm 0.011) \times 10^{-3}$ (S = 1.8)

$|\eta_{00}/\eta_{+-}| = 0.9950 \pm 0.0007$ [*p*] (S = 1.6)

$\mathrm{Re}(\epsilon'/\epsilon) = (1.66 \pm 0.23) \times 10^{-3}$ [*p*] (S = 1.6)

Assuming *CPT*

$\phi_{+-} = (43.51 \pm 0.05)^\circ$ (S = 1.2)

$\phi_{00} = (43.52 \pm 0.05)^\circ$ (S = 1.3)

$\phi_\epsilon = \phi_{SW} = (43.52 \pm 0.05)^\circ$ (S = 1.2)

$\mathrm{Im}(\epsilon'/\epsilon) = -(\phi_{00} - \phi_{+-})/3 = (-0.002 \pm 0.005)^\circ$ (S = 1.7)

Not assuming *CPT*

$\phi_{+-} = (43.4 \pm 0.5)^\circ$ (S = 1.2)

$\phi_{00} = (43.7 \pm 0.6)^\circ$ (S = 1.2)

$\phi_\epsilon = (43.5 \pm 0.5)^\circ$ (S = 1.3)

CP asymmetry *A* in $K_L^0 \to \pi^+\pi^- e^+ e^- = (13.7 \pm 1.5)\%$

β_{CP} from $K_L^0 \to e^+e^-e^+e^- = -0.19 \pm 0.07$

γ_{CP} from $K_L^0 \to e^+e^-e^+e^- = 0.01 \pm 0.11$ (S = 1.6)

j for $K_L^0 \to \pi^+\pi^-\pi^0 = 0.0012 \pm 0.0008$

f for $K_L^0 \to \pi^+\pi^-\pi^0 = 0.004 \pm 0.006$

$|\eta_{+-\gamma}| = (2.35 \pm 0.07) \times 10^{-3}$

$\phi_{+-\gamma} = (44 \pm 4)^\circ$

$|\epsilon'_{+-\gamma}|/\epsilon < 0.3$, CL = 90%

$|g_{E1}|$ for $K_L^0 \to \pi^+\pi^-\gamma < 0.21$, CL = 90%

T-violation parameters

Im(ξ) in $K^0_{\mu 3} = -0.007 \pm 0.026$

CPT invariance tests

$\phi_{00} - \phi_{+-} = (0.34 \pm 0.32)^\circ$

Re($\frac{2}{3}\eta_{+-} + \frac{1}{3}\eta_{00}) - \frac{A_L}{2} = (-3 \pm 35) \times 10^{-6}$

$\Delta S = -\Delta Q$ in $K^0_{\ell 3}$ decay

Re $x = -0.002 \pm 0.006$

Im $x = 0.0012 \pm 0.0021$

K^0_L DECAY MODES			Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Semileptonic modes					
$\pi^\pm e^\mp \nu_e$ Called K^0_{e3}.		[o]	(40.55 ±0.11) %	S=1.7	229
$\pi^\pm \mu^\mp \nu_\mu$ Called $K^0_{\mu 3}$.		[o]	(27.04 ±0.07) %	S=1.1	216
$(\pi\mu\text{atom})\nu$			(1.05 ±0.11) × 10^{-7}		188
$\pi^0\pi^\pm e^\mp \nu$		[o]	(5.20 ±0.11) × 10^{-5}		207
$\pi^\pm e^\mp \nu e^+ e^-$		[o]	(1.26 ±0.04) × 10^{-5}		229
Hadronic modes, including Charge conjugation×Parity Violating (*CPV*) modes					
$3\pi^0$			(19.52 ±0.12) %	S=1.6	139
$\pi^+\pi^-\pi^0$			(12.54 ±0.05) %		133
$\pi^+\pi^-$	*CPV*	[q]	(1.967±0.010) × 10^{-3}	S=1.5	206
$\pi^0\pi^0$	*CPV*		(8.64 ±0.06) × 10^{-4}	S=1.8	209
Semileptonic modes with photons					
$\pi^\pm e^\mp \nu_e \gamma$		[f,o,r]	(3.79 ±0.06) × 10^{-3}		229
$\pi^\pm \mu^\mp \nu_\mu \gamma$			(5.65 ±0.23) × 10^{-4}		216
Hadronic modes with photons or $\ell\bar{\ell}$ pairs					
$\pi^0\pi^0\gamma$			< 2.43 × 10^{-7}	CL=90%	209
$\pi^+\pi^-\gamma$		[f,r]	(4.15 ±0.15) × 10^{-5}	S=2.8	206
$\pi^+\pi^-\gamma$(DE)			(2.84 ±0.11) × 10^{-5}	S=2.0	206
$\pi^0 2\gamma$		[r]	(1.273±0.033) × 10^{-6}		231
$\pi^0\gamma e^+ e^-$			(1.62 ±0.17) × 10^{-8}		230
Other modes with photons or $\ell\bar{\ell}$ pairs					
2γ			(5.47 ±0.04) × 10^{-4}	S=1.1	249
3γ			< 7.4 × 10^{-8}	CL=90%	249
$e^+ e^-\gamma$			(9.4 ±0.4) × 10^{-6}	S=2.0	249
$\mu^+\mu^-\gamma$			(3.59 ±0.11) × 10^{-7}	S=1.3	225
$e^+ e^-\gamma\gamma$		[r]	(5.95 ±0.33) × 10^{-7}		249
$\mu^+\mu^-\gamma\gamma$		[r]	(1.0 $^{+0.8}_{-0.6}$) × 10^{-8}		225
Charge conjugation × Parity (*CP*) or Lepton Family number (*LF*) violating modes, or $\Delta S = 1$ weak neutral current (*S1*) modes					
$\mu^+\mu^-$	*S1*		(6.84 ±0.11) × 10^{-9}		225
$e^+ e^-$	*S1*		(9 $^{+6}_{-4}$) × 10^{-12}		249
$\pi^+\pi^- e^+ e^-$	*S1*	[r]	(3.11 ±0.19) × 10^{-7}		206
$\pi^0\pi^0 e^+ e^-$	*S1*		< 6.6 × 10^{-9}	CL=90%	209
$\pi^0\pi^0\mu^+\mu^-$	*S1*		< 9.2 × 10^{-11}	CL=90%	57
$\mu^+\mu^- e^+ e^-$	*S1*		(2.69 ±0.27) × 10^{-9}		225

fcnc

$e^+ e^- e^+ e^-$	*S1*		(3.56 ±0.21) × 10^{-8}			249
$\pi^0 \mu^+ \mu^-$	*CP,S1*	[s]	< 3.8	× 10^{-10}	CL=90%	177
$\pi^0 e^+ e^-$	*CP,S1*	[s]	< 2.8	× 10^{-10}	CL=90%	230
$\pi^0 \nu\overline{\nu}$	*CP,S1*	[t]	< 2.6	× 10^{-8}	CL=90%	231
$\pi^0 \pi^0 \nu\overline{\nu}$	*S1*		< 8.1	× 10^{-7}	CL=90%	209
$e^\pm \mu^\mp$	*LF*	[o]	< 4.7	× 10^{-12}	CL=90%	238
$e^\pm e^\pm \mu^\mp \mu^\mp$	*LF*	[o]	< 4.12	× 10^{-11}	CL=90%	225
$\pi^0 \mu^\pm e^\mp$	*LF*	[o]	< 7.6	× 10^{-11}	CL=90%	217
$\pi^0 \pi^0 \mu^\pm e^\mp$	*LF*		< 1.7	× 10^{-10}	CL=90%	159

$K^*(892)$

$I(J^P) = \frac{1}{2}(1^-)$

$K^*(892)^\pm$ hadroproduced mass $m = 891.66 \pm 0.26$ MeV
$K^*(892)^\pm$ in τ decays mass $m = 895.5 \pm 0.8$ MeV
$K^*(892)^0$ mass $m = 895.81 \pm 0.19$ MeV (S = 1.4)
$K^*(892)^\pm$ hadroproduced full width $\Gamma = 50.8 \pm 0.9$ MeV
$K^*(892)^\pm$ in τ decays full width $\Gamma = 46.2 \pm 1.3$ MeV
$K^*(892)^0$ full width $\Gamma = 47.4 \pm 0.6$ MeV (S = 2.2)

$K^*(892)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K\pi$	~ 100 %		289
$K^0\gamma$	(2.46±0.21) × 10^{-3}		307
$K^\pm\gamma$	(9.9 ±0.9) × 10^{-4}		309
$K\pi\pi$	< 7 × 10^{-4}	95%	223

$K_1(1270)$

$I(J^P) = \frac{1}{2}(1^+)$

Mass $m = 1272 \pm 7$ MeV [u]
Full width $\Gamma = 90 \pm 20$ MeV [u]

$K_1(1270)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\rho$	(42 ±6) %	46
$K_0^*(1430)\pi$	(28 ±4) %	†
$K^*(892)\pi$	(16 ±5) %	302
$K\omega$	(11.0±2.0) %	†
$K f_0(1370)$	(3.0±2.0) %	†
γK^0	seen	539

$K_1(1400)$ $I(J^P) = \frac{1}{2}(1^+)$

Mass $m = 1403 \pm 7$ MeV
Full width $\Gamma = 174 \pm 13$ MeV (S = 1.6)

$K_1(1400)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K^*(892)\pi$	(94 ±6) %	402
$K\rho$	(3.0±3.0) %	293
$K f_0(1370)$	(2.0±2.0) %	†
$K\omega$	(1.0±1.0) %	284
$K_0^*(1430)\pi$	not seen	†
γK^0	seen	613

$K^*(1410)$ $I(J^P) = \frac{1}{2}(1^-)$

Mass $m = 1414 \pm 15$ MeV (S = 1.3)
Full width $\Gamma = 232 \pm 21$ MeV (S = 1.1)

$K^*(1410)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K^*(892)\pi$	> 40 %	95%	410
$K\pi$	(6.6±1.3) %		612
$K\rho$	< 7 %	95%	305
γK^0	seen		619

$K_0^*(1430)$ [v] $I(J^P) = \frac{1}{2}(0^+)$

Mass $m = 1425 \pm 50$ MeV
Full width $\Gamma = 270 \pm 80$ MeV

$K_0^*(1430)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi$	(93±10) %	619

$K_2^*(1430)$ $I(J^P) = \frac{1}{2}(2^+)$

$K_2^*(1430)^\pm$ mass $m = 1425.6 \pm 1.5$ MeV (S = 1.1)
$K_2^*(1430)^0$ mass $m = 1432.4 \pm 1.3$ MeV
$K_2^*(1430)^\pm$ full width $\Gamma = 98.5 \pm 2.7$ MeV (S = 1.1)
$K_2^*(1430)^0$ full width $\Gamma = 109 \pm 5$ MeV (S = 1.9)

$K_2^*(1430)$ DECAY MODES	Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
$K\pi$	(49.9±1.2) %		619
$K^*(892)\pi$	(24.7±1.5) %		419
$K^*(892)\pi\pi$	(13.4±2.2) %		372
$K\rho$	(8.7±0.8) %	S=1.2	318
$K\omega$	(2.9±0.8) %		311
$K^+\gamma$	(2.4±0.5) $\times 10^{-3}$	S=1.1	627
$K\eta$	($1.5^{+3.4}_{-1.0}$) $\times 10^{-3}$	S=1.3	486
$K\omega\pi$	$<$ 7.2 $\times 10^{-4}$	CL=95%	100
$K^0\gamma$	$<$ 9 $\times 10^{-4}$	CL=90%	626

$K^*(1680)$

$I(J^P) = \frac{1}{2}(1^-)$

Mass $m = 1717 \pm 27$ MeV (S = 1.4)
Full width $\Gamma = 322 \pm 110$ MeV (S = 4.2)

$K^*(1680)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi$	(38.7±2.5) %	781
$K\rho$	($31.4^{+5.0}_{-2.1}$) %	571
$K^*(892)\pi$	($29.9^{+2.2}_{-5.0}$) %	618

$K_2(1770)$ [x]

$I(J^P) = \frac{1}{2}(2^-)$

Mass $m = 1773 \pm 8$ MeV
Full width $\Gamma = 186 \pm 14$ MeV

$K_2(1770)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi\pi$		794
$K_2^*(1430)\pi$	dominant	288
$K^*(892)\pi$	seen	654
$Kf_2(1270)$	seen	55
$K\phi$	seen	441
$K\omega$	seen	607

$K_3^*(1780)$

$I(J^P) = \frac{1}{2}(3^-)$

Mass $m = 1776 \pm 7$ MeV (S = 1.1)
Full width $\Gamma = 159 \pm 21$ MeV (S = 1.3)

$K_3^*(1780)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K\rho$	(31 ± 9) %		613
$K^*(892)\pi$	(20 ± 5) %		656
$K\pi$	(18.8± 1.0) %		813
$K\eta$	(30 ±13) %		719
$K_2^*(1430)\pi$	< 16 %	95%	291

$K_2(1820)$ [y]

$I(J^P) = \frac{1}{2}(2^-)$

Mass $m = 1816 \pm 13$ MeV
Full width $\Gamma = 276 \pm 35$ MeV

$K_2(1820)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K_2^*(1430)\pi$	seen	327
$K^*(892)\pi$	seen	681
$Kf_2(1270)$	seen	186
$K\omega$	seen	638

$K_4^*(2045)$

$I(J^P) = \frac{1}{2}(4^+)$

Mass $m = 2045 \pm 9$ MeV (S = 1.1)
Full width $\Gamma = 198 \pm 30$ MeV

$K_4^*(2045)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi$	(9.9±1.2) %	958
$K^*(892)\pi\pi$	(9 ±5) %	802
$K^*(892)\pi\pi\pi$	(7 ±5) %	768
$\rho K\pi$	(5.7±3.2) %	741
$\omega K\pi$	(5.0±3.0) %	738
$\phi K\pi$	(2.8±1.4) %	594
$\phi K^*(892)$	(1.4±0.7) %	363

NOTES

[*a*] See the note in the $K^\pm$ Particle Listings.

[*b*] The definition of the slope parameter g of the $K \to 3\pi$ Dalitz plot is as follows (see also "Note on Dalitz Plot Parameters for $K \to 3\pi$ Decays" in the $K^\pm$ Particle Listings):

$$|M|^2 = 1 + g(s_3 - s_0)/m^2_{\pi^+} + \cdots .$$

[*c*] See the "Note on $\pi^\pm \to \ell^\pm \nu\gamma$ and $K^\pm \to \ell^\pm \nu\gamma$ Form Factors" in the $\pi^\pm$ Particle Listings for definitions and details.

[*d*] For more details and definitions of parameters see the Particle Listings.

[*e*] See the $K^\pm$ Particle Listings for the energy limits used in this measurement.

[*f*] Most of this radiative mode, the low-momentum γ part, is also included in the parent mode listed without γ's.

[*g*] Structure-dependent part.

[*h*] Direct-emission branching fraction.

[*i*] Derived from an analysis of neutrino-oscillation experiments.

[*j*] Violates angular-momentum conservation.

[*k*] Derived from measured values of ϕ_{+-}, ϕ_{00}, $|\eta|$, $|m_{K^0_L} - m_{K^0_S}|$, and $\tau_{K^0_S}$, as described in the introduction to "Tests of Conservation Laws."

[*l*] The *CP*-violation parameters are defined as follows (see also "Note on *CP* Violation in $K_S \to 3\pi$" and "Note on *CP* Violation in K^0_L Decay" in the Particle Listings):

$$\eta_{+-} = |\eta_{+-}|e^{i\phi_{+-}} = \frac{A(K^0_L \to \pi^+\pi^-)}{A(K^0_S \to \pi^+\pi^-)} = \epsilon + \epsilon'$$

$$\eta_{00} = |\eta_{00}|e^{i\phi_{00}} = \frac{A(K^0_L \to \pi^0\pi^0)}{A(K^0_S \to \pi^0\pi^0)} = \epsilon - 2\epsilon'$$

$$\delta = \frac{\Gamma(K^0_L \to \pi^-\ell^+\nu) - \Gamma(K^0_L \to \pi^+\ell^-\nu)}{\Gamma(K^0_L \to \pi^-\ell^+\nu) + \Gamma(K^0_L \to \pi^+\ell^-\nu)} ,$$

$$\mathrm{Im}(\eta_{+-0})^2 = \frac{\Gamma(K^0_S \to \pi^+\pi^-\pi^0)^{CP \text{ viol.}}}{\Gamma(K^0_L \to \pi^+\pi^-\pi^0)} ,$$

$$\mathrm{Im}(\eta_{000})^2 = \frac{\Gamma(K^0_S \to \pi^0\pi^0\pi^0)}{\Gamma(K^0_L \to \pi^0\pi^0\pi^0)} .$$

where for the last two relations *CPT* is assumed valid, *i.e.*, $\mathrm{Re}(\eta_{+-0}) \simeq 0$ and $\mathrm{Re}(\eta_{000}) \simeq 0$.

[*n*] See the K^0_S Particle Listings for the energy limits used in this measurement.

[*o*] The value is for the sum of the charge states or particle/antiparticle states indicated.

[*p*] $\mathrm{Re}(\epsilon'/\epsilon) = \epsilon'/\epsilon$ to a very good approximation provided the phases satisfy *CPT* invariance.

[*q*] This mode includes gammas from inner bremsstrahlung but not the direct emission mode $K^0_L \to \pi^+\pi^-\gamma$(DE).

[*r*] See the K^0_L Particle Listings for the energy limits used in this measurement.

[*s*] Allowed by higher-order electroweak interactions.

[*t*] Violates *CP* in leading order. Test of direct *CP* violation since the indirect *CP*-violating and *CP*-conserving contributions are expected to be suppressed.

[*u*] This is only an educated guess; the error given is larger than the error on the average of the published values. See the Particle Listings for details.

[*v*] See the "Note on $f_0(1370)$" in the $f_0(1370)$ Particle Listings and in the 1994 edition.

[*x*] See the note in the $L(1770)$ Particle Listings in Reviews of Modern Physics **56** S1 (1984), p. S200. See also the "Note on $K_2(1770)$ and the $K_2(1820)$" in the $K_2(1770)$ Particle Listings .

[*y*] See the "Note on $K_2(1770)$ and the $K_2(1820)$" in the $K_2(1770)$ Particle Listings .