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

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

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$K^\pm$

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

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

Slope parameter g [b]

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

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

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

Assuming μ-e universality
$\qquad \lambda_+(K^+_{\mu 3}) = \lambda_+(K^+_{e3}) = (2.96 \pm 0.06) \times 10^{-2}$
$\qquad \lambda_0(K^+_{\mu 3}) = (1.96 \pm 0.12) \times 10^{-2}$

Not assuming μ-e universality
$\qquad \lambda_+(K^+_{e3}) = (2.96 \pm 0.06) \times 10^{-2}$
$\qquad \lambda_+(K^+_{\mu 3}) = (2.96 \pm 0.17) \times 10^{-2}$
$\qquad \lambda_0(K^+_{\mu 3}) = (1.96 \pm 0.13) \times 10^{-2}$

$\qquad K_{e3}$ form factor quadratic fit
$\qquad\qquad \lambda'_+ (K^\pm_{e3})$ linear coeff. $= (2.48 \pm 0.17) \times 10^{-2}$
$\qquad\qquad \lambda''_+(K^\pm_{e3})$ quadratic coeff. $= (0.19 \pm 0.09) \times 10^{-2}$

$K^+_{e3} \quad |f_S/f_+| = (-0.3^{+0.8}_{-0.7}) \times 10^{-2}$
$K^+_{e3} \quad |f_T/f_+| = (-1.2 \pm 2.3) \times 10^{-2}$
$K^+_{\mu 3} \quad |f_S/f_+| = (0.2 \pm 0.6) \times 10^{-2}$
$K^+_{\mu 3} \quad |f_T/f_+| = (-0.1 \pm 0.7) \times 10^{-2}$
$K^+ \to e^+ \nu_e \gamma \quad |F_A + F_V| = 0.148 \pm 0.010$
$K^+ \to \mu^+ \nu_\mu \gamma \quad |F_A + F_V| = 0.165 \pm 0.013$
$K^+ \to e^+ \nu_e \gamma \quad |F_A - F_V| < 0.49$
$K^+ \to \mu^+ \nu_\mu \gamma \quad |F_A - F_V| = -0.24$ to 0.04, CL $= 90\%$

Charge Radius

$$\langle r \rangle = 0.560 \pm 0.031 \text{ fm}$$

CP violation parameters

$$\Delta(K^{\pm}_{\pi\mu\mu}) = -0.02 \pm 0.12$$

T violation parameters

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

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				
$K^+ \rightarrow e^+ \nu_e$		(1.55 $\pm$0.07) $\times 10^{-5}$		247
$K^+ \rightarrow \mu^+ \nu_\mu$		(63.54 $\pm$0.14) %	S=1.3	236
$K^+ \rightarrow \pi^0 e^+ \nu_e$		(5.08 $\pm$0.05) %	S=2.1	228
Called K^+_{e3}.				
$K^+ \rightarrow \pi^0 \mu^+ \nu_\mu$		(3.35 $\pm$0.04) %	S=1.9	215
Called $K^+_{\mu3}$.				
$K^+ \rightarrow \pi^0 \pi^0 e^+ \nu_e$		(2.2 $\pm$0.4) $\times 10^{-5}$		206
$K^+ \rightarrow \pi^+ \pi^- e^+ \nu_e$		(4.09 $\pm$0.10) $\times 10^{-5}$		203
$K^+ \rightarrow \pi^+ \pi^- \mu^+ \nu_\mu$		(1.4 $\pm$0.9) $\times 10^{-5}$		151
$K^+ \rightarrow \pi^0 \pi^0 \pi^0 e^+ \nu_e$		< 3.5 $\times 10^{-6}$ CL=90%		135
Hadronic modes				
$K^+ \rightarrow \pi^+ \pi^0$		(20.68 $\pm$0.13) %	S=1.6	205
$K^+ \rightarrow \pi^+ \pi^0 \pi^0$		(1.761$\pm$0.022) %	S=1.1	133
$K^+ \rightarrow \pi^+ \pi^+ \pi^-$		(5.59 $\pm$0.04) %	S=1.5	125
Leptonic and semileptonic modes with photons				
$K^+ \rightarrow \mu^+ \nu_\mu \gamma$	[e,f]	(6.2 $\pm$0.8) $\times 10^{-3}$		236
$K^+ \rightarrow \mu^+ \nu_\mu \gamma (\text{SD}^+)$	[d,g]	< 3.0 $\times 10^{-5}$ CL=90%		–
$K^+ \rightarrow \mu^+ \nu_\mu \gamma (\text{SD}^+\text{INT})$	[d,g]	< 2.7 $\times 10^{-5}$ CL=90%		–
$K^+ \rightarrow \mu^+ \nu_\mu \gamma (\text{SD}^- + \text{SD}^-\text{INT})$	[d,g]	< 2.6 $\times 10^{-4}$ CL=90%		–
$K^+ \rightarrow e^+ \nu_e \gamma (\text{SD}^+)$	[d,g]	(1.52 $\pm$0.23) $\times 10^{-5}$		–
$K^+ \rightarrow e^+ \nu_e \gamma (\text{SD}^-)$	[d,g]	< 1.6 $\times 10^{-4}$ CL=90%		–
$K^+ \rightarrow \pi^0 e^+ \nu_e \gamma$	[e,f]	(2.56 $\pm$0.16) $\times 10^{-4}$		228
$K^+ \rightarrow \pi^0 e^+ \nu_e \gamma (\text{SD})$	[d,g]	< 5.3 $\times 10^{-5}$ CL=90%		228
$K^+ \rightarrow \pi^0 \mu^+ \nu_\mu \gamma$	[e,f]	(1.5 $\pm$0.4) $\times 10^{-5}$		215
$K^+ \rightarrow \pi^0 \pi^0 e^+ \nu_e \gamma$		< 5 $\times 10^{-6}$ CL=90%		206

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

$K^+ \to \pi^+\pi^0\gamma$	[e,f]	$(\ 2.75\ \pm0.15\ )\times 10^{-4}$		205
$K^+ \to \pi^+\pi^0\gamma\,(DE)$	[f,h]	$(\ 4.3\ \pm0.7\ )\times 10^{-6}$		205
$K^+ \to \pi^+\pi^0\pi^0\gamma$	[e,f]	$(\ 7.6\ {}^{+5.6}_{-3.0}\ )\times 10^{-6}$		133
$K^+ \to \pi^+\pi^+\pi^-\gamma$	[e,f]	$(\ 1.04\ \pm0.31\ )\times 10^{-4}$		125
$K^+ \to \pi^+\gamma\gamma$	[f]	$(\ 1.10\ \pm0.32\ )\times 10^{-6}$		227
$K^+ \to \pi^+ 3\gamma$	[f]	$<\ 1.0\ \times 10^{-4}$	CL=90%	227
$K^\pm \to \pi^+ e^+ e^-\gamma$		$(\ 1.19\ \pm0.13\ )\times 10^{-8}$		227

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

$K^+ \to e^+\nu_e\nu\overline{\nu}$	$<\ 6\ \times 10^{-5}$ CL=90%		247
$K^+ \to \mu^+\nu_\mu\nu\overline{\nu}$	$<\ 6.0\ \times 10^{-6}$ CL=90%		236
$K^+ \to e^+\nu_e e^+ e^-$	$(\ 2.48\ \pm0.20\ )\times 10^{-8}$		247
$K^+ \to \mu^+\nu_\mu e^+ e^-$	$(\ 7.06\ \pm0.31\ )\times 10^{-8}$		236
$K^+ \to e^+\nu_e \mu^+\mu^-$	$(\ 1.7\ \pm0.5\ )\times 10^{-8}$		223
$K^+ \to \mu^+\nu_\mu \mu^+\mu^-$	$<\ 4.1\ \times 10^{-7}$ 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

$K^+ \to \pi^+\pi^+ e^-\overline{\nu}_e$	SQ		$<\ 1.2\ \times 10^{-8}$ CL=90%	203
$K^+ \to \pi^+\pi^+ \mu^-\overline{\nu}_\mu$	SQ		$<\ 3.0\ \times 10^{-6}$ CL=95%	151
$K^+ \to \pi^+ e^+ e^-$	S1		$(\ 2.88\ \pm0.13\ )\times 10^{-7}$	227
$K^+ \to \pi^+ \mu^+\mu^-$	S1		$(\ 8.1\ \pm1.4\ )\times 10^{-8}$ S=2.7	172
$K^+ \to \pi^+\nu\overline{\nu}$	S1		$(\ 1.5\ {}^{+1.3}_{-0.9}\ )\times 10^{-10}$	227
$K^+ \to \pi^+\pi^0\nu\overline{\nu}$	S1		$<\ 4.3\ \times 10^{-5}$ CL=90%	205
$K^+ \to \mu^-\nu e^+ e^+$	LF		$<\ 2.0\ \times 10^{-8}$ CL=90%	236
$K^+ \to \mu^+\nu_e$	LF	[i]	$<\ 4\ \times 10^{-3}$ CL=90%	236
$K^+ \to \pi^+\mu^+ e^-$	LF		$<\ 1.3\ \times 10^{-11}$ CL=90%	214
$K^+ \to \pi^+\mu^- e^+$	LF		$<\ 5.2\ \times 10^{-10}$ CL=90%	214
$K^+ \to \pi^-\mu^+ e^+$	L		$<\ 5.0\ \times 10^{-10}$ CL=90%	214
$K^+ \to \pi^- e^+ e^+$	L		$<\ 6.4\ \times 10^{-10}$ CL=90%	227
$K^+ \to \pi^-\mu^+\mu^+$	L	[i]	$<\ 3.0\ \times 10^{-9}$ CL=90%	172
$K^+ \to \mu^+\overline{\nu}_e$	L	[i]	$<\ 3.3\ \times 10^{-3}$ CL=90%	236
$K^+ \to \pi^0 e^+\overline{\nu}_e$	L		$<\ 3\ \times 10^{-3}$ CL=90%	228
$K^+ \to \pi^+\gamma$		[j]	$<\ 2.3\ \times 10^{-9}$ CL=90%	227

K^0

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

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

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

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

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

CPT-violation parameters [c]

Re $\delta = (2.3 \pm 2.7) \times 10^{-4}$

Im $\delta = (0.4 \pm 2.1) \times 10^{-5}$

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

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

$\left| m_{K^0} - m_{\overline{K}^0} \right| / m_{\text{average}} < 8 \times 10^{-19}$, 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 $= (-0.9 \pm 3.0) \times 10^{-3}$

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

Mean life $\tau = (0.8953 \pm 0.0005) \times 10^{-10}$ s   (S = 1.1)   Assuming *CPT*

Mean life $\tau = (0.8958 \pm 0.0005) \times 10^{-10}$ s   Not assuming *CPT*

$c\tau = 2.6842$ cm   Assuming *CPT*

CP-violation parameters [l]

Im(η_{+-0}) $= -0.002 \pm 0.009$

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

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

CP asymmetry A in $\pi^+ \pi^- e^+ e^- = (-1 \pm 4)\%$

K^0_S DECAY MODES		Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
Hadronic modes				
$\pi^0\pi^0$		(30.69 ± 0.05) %		209
$\pi^+\pi^-$		(69.20 ± 0.05) %		206
$\pi^+\pi^-\pi^0$		$(\ 3.5\ ^{+1.1}_{-0.9}\ )\times 10^{-7}$		133
Modes with photons or $\ell\bar{\ell}$ pairs				
$\pi^+\pi^-\gamma$	[e,m]	$(\ 1.79\pm0.05)\times 10^{-3}$		206
$\pi^+\pi^-e^+e^-$		$(\ 4.69\pm0.30)\times 10^{-5}$		206
$\pi^0\gamma\gamma$	[m]	$(\ 4.9\ \pm1.8\ )\times 10^{-8}$		231
$\gamma\gamma$		$(\ 2.71\pm0.06)\times 10^{-6}$		249
Semileptonic modes				
$\pi^\pm e^\mp \nu_e$	[n]	$(\ 7.04\pm0.08)\times 10^{-4}$		229
CP violating (CP) and $\Delta S = 1$ weak neutral current ($S1$) modes				
$3\pi^0$	CP	$<\ 1.2\ \times 10^{-7}$	90%	139
$\mu^+\mu^-$	$S1$	$<\ 3.2\ \times 10^{-7}$	90%	225
e^+e^-	$S1$	$<\ 1.4\ \times 10^{-7}$	90%	249
$\pi^0 e^+e^-$	$S1$ [m]	$(\ 3.0\ ^{+1.5}_{-1.2}\ )\times 10^{-9}$		230
$\pi^0\mu^+\mu^-$	$S1$	$(\ 2.9\ ^{+1.5}_{-1.2}\ )\times 10^{-9}$		177

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

$m_{K_L} - m_{K_S}$
$= (0.5292 \pm 0.0009) \times 10^{10}\ \hbar\ \text{s}^{-1}$ (S = 1.2)   Assuming CPT
$= (3.483 \pm 0.006) \times 10^{-12}$ MeV   Assuming CPT
$= (0.5290 \pm 0.0015) \times 10^{10}\ \hbar\ \text{s}^{-1}$ (S = 1.1)   Not assuming CPT
    Mean life $\tau = (5.116 \pm 0.020) \times 10^{-8}$ s
        $c\tau = 15.34$ 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 [c]

    Linear parametrization assuming μ-e universality
        $\lambda_+(K^0_{\mu3}) = \lambda_+(K^0_{e3}) = (2.82 \pm 0.04) \times 10^{-2}$ (S = 1.1)
        $\lambda_0(K^0_{\mu3}) = (1.38 \pm 0.18) \times 10^{-2}$ (S = 2.2)

Quadratic parametrization assuming μ-e universality

$$\lambda'_+(K^0_{\mu 3}) = \lambda'_+(K^0_{e3}) = (2.40 \pm 0.12) \times 10^{-2} \quad (S = 1.2)$$
$$\lambda''_+(K^0_{\mu 3}) = \lambda''_+(K^0_{e3}) = (0.20 \pm 0.05) \times 10^{-2} \quad (S = 1.2)$$
$$\lambda_0(K^0_{\mu 3}) = (1.16 \pm 0.09) \times 10^{-2} \quad (S = 1.2)$$

Pole parametrization assuming μ-e universality

$$M^\mu_V(K^0_{\mu 3}) = M^e_V(K^0_{e3}) = 878 \pm 6 \text{ MeV} \quad (S = 1.1)$$
$$M^\mu_S(K^0_{\mu 3}) = 1252 \pm 90 \text{ MeV} \quad (S = 2.6)$$

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

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

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

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

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

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

$K_L \to \pi^0 2\gamma$: $a_V = -0.54 \pm 0.12$ $(S = 2.8)$

CP-violation parameters [l]

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

$\left| \eta_{00} \right| = (2.222 \pm 0.012) \times 10^{-3}$ $(S = 1.7)$

$\left| \eta_{+-} \right| = (2.233 \pm 0.012) \times 10^{-3}$ $(S = 1.7)$

$\left| \epsilon \right| = (2.229 \pm 0.012) \times 10^{-3}$ $(S = 1.7)$

$\left| \eta_{00}/\eta_{+-} \right| = 0.9951 \pm 0.0008$ [o] $(S = 1.6)$

$\text{Re}(\epsilon'/\epsilon) = (1.65 \pm 0.26) \times 10^{-3}$ [o] $(S = 1.6)$

Assuming *CPT*

$$\phi_{+-} = (43.51 \pm 0.05)^\circ \quad (S = 1.1)$$
$$\phi_{00} = (43.52 \pm 0.05)^\circ \quad (S = 1.1)$$
$$\phi_\epsilon = \phi_{SW} = (43.51 \pm 0.05)^\circ \quad (S = 1.1)$$

Not assuming *CPT*

$$\phi_{+-} = (43.4 \pm 0.7)^\circ \quad (S = 1.3)$$

$$\phi_{00} = (43.7 \pm 0.8)^\circ \quad (S = 1.2)$$

$$\phi_{\epsilon} = (43.5 \pm 0.7)^\circ \quad (S = 1.3)$$

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 $K_L^0 \to e^+ e^- e^+ e^- = 0.01 \pm 0.11 \quad (S = 1.6)$

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

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

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

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

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

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

T-violation parameters

$\text{Im}(\xi)$ in $K_{\mu 3}^0 = -0.007 \pm 0.026$

CPT invariance tests

$$\phi_{00} - \phi_{+-} = (0.2 \pm 0.4)^\circ$$

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

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

$\text{Re } x = -0.002 \pm 0.006$

$\text{Im } x = 0.0012 \pm 0.0021$

K^0_L DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	p (MeV/c)
Semileptonic modes				
$\pi^\pm e^\mp \nu_e$	[n]	$(40.55 \pm 0.12)\%$	S=1.8	229
Called K^0_{e3}.				
$\pi^\pm \mu^\mp \nu_\mu$	[n]	$(27.04 \pm 0.07)\%$	S=1.1	216
Called $K^0_{\mu3}$.				
$(\pi\mu\text{atom})\nu$		$(1.05 \pm 0.11)\times 10^{-7}$		188
$\pi^0\pi^\pm e^\mp \nu$	[n]	$(5.20 \pm 0.11)\times 10^{-5}$		207
$\pi^\pm e^\mp \nu e^+ e^-$	[n]	$(1.28 \pm 0.04)\times 10^{-5}$		229
Hadronic modes, including Charge conjugation×Parity Violating (*CPV*) modes				
$3\pi^0$		$(19.52 \pm 0.12)\%$	S=1.7	139
$\pi^+\pi^-\pi^0$		$(12.54 \pm 0.05)\%$		133
$\pi^+\pi^-$	*CPV* [p]	$(1.966\pm 0.010)\times 10^{-3}$	S=1.6	206
$\pi^0\pi^0$	*CPV*	$(8.65 \pm 0.06)\times 10^{-4}$	S=1.8	209
Semileptonic modes with photons				
$\pi^\pm e^\mp \nu_e\gamma$	[e,n,q]	$(3.80 \pm 0.08)\times 10^{-3}$		229
$\pi^\pm \mu^\mp \nu_\mu\gamma$		$(5.65 \pm 0.23)\times 10^{-4}$		216
Hadronic modes with photons or $\ell\bar{\ell}$ pairs				
$\pi^0\pi^0\gamma$		$< 5.6 \times 10^{-6}$	CL=90%	209
$\pi^+\pi^-\gamma$	[e,q]	$(4.15 \pm 0.15)\times 10^{-5}$	S=2.8	206
$\pi^+\pi^-\gamma$(DE)		$(2.84 \pm 0.11)\times 10^{-5}$	S=2.0	206
$\pi^0 2\gamma$	[q]	$(1.32 \pm 0.14)\times 10^{-6}$	S=3.6	231
$\pi^0\gamma e^+ e^-$		$(1.62 \pm 0.17)\times 10^{-8}$		230
Other modes with photons or $\ell\bar{\ell}$ pairs				
2γ		$(5.47 \pm 0.04)\times 10^{-4}$	S=1.2	249
3γ		$< 2.4 \times 10^{-7}$	CL=90%	249
$e^+ e^-\gamma$		$(9.50 \pm 0.35)\times 10^{-6}$	S=1.7	249
$\mu^+\mu^-\gamma$		$(3.59 \pm 0.11)\times 10^{-7}$	S=1.3	225
$e^+ e^-\gamma\gamma$	[q]	$(5.95 \pm 0.33)\times 10^{-7}$		249
$\mu^+\mu^-\gamma\gamma$	[q]	$(1.0 \;^{+0.8}_{-0.6})\times 10^{-8}$		225
Charge conjugation × Parity (*CP*) or Lepton Family number (*LF*) violating modes, or $\Delta S = 1$ weak neutral current (*S1*) modes				
$\mu^+\mu^-$	*S1*	$(6.84 \pm 0.11)\times 10^{-9}$		225
$e^+ e^-$	*S1*	$(9 \;^{+6}_{-4})\times 10^{-12}$		249
$\pi^+\pi^- e^+ e^-$	*S1* [q]	$(3.11 \pm 0.19)\times 10^{-7}$		206
$\pi^0\pi^0 e^+ e^-$	*S1*	$< 6.6 \times 10^{-9}$	CL=90%	209
$\mu^+\mu^- e^+ e^-$	*S1*	$(2.69 \pm 0.27)\times 10^{-9}$		225
$e^+ e^- e^+ e^-$	*S1*	$(3.56 \pm 0.21)\times 10^{-8}$		249

$\pi^0 \mu^+ \mu^-$	$CP,S1$	$[r]$	$<$	3.8	$\times 10^{-10}$ CL=90%	177
$\pi^0 e^+ e^-$	$CP,S1$	$[r]$	$<$	2.8	$\times 10^{-10}$ CL=90%	230
$\pi^0 \nu \overline{\nu}$	$CP,S1$	$[s]$	$<$	2.1	$\times 10^{-7}$ CL=90%	231
$\pi^0 \pi^0 \nu \overline{\nu}$	$S1$		$<$	4.7	$\times 10^{-5}$ CL=90%	209
$e^\pm \mu^\mp$	LF	$[n]$	$<$	4.7	$\times 10^{-12}$ CL=90%	238
$e^\pm e^\pm \mu^\mp \mu^\mp$	LF	$[n]$	$<$	4.12	$\times 10^{-11}$ CL=90%	225
$\pi^0 \mu^\pm e^\mp$	LF	$[n]$	$<$	6.2	$\times 10^{-9}$ CL=90%	217

$K^*(892)$ $\qquad\qquad I(J^P) = \frac{1}{2}(1^-)$

$K^*(892)^\pm$ mass $m = 891.66 \pm 0.26$ MeV
Mass $m = 895.5 \pm 0.8$ MeV
$K^*(892)^0$ mass $m = 896.00 \pm 0.25$ MeV   (S = 1.4)
$K^*(892)^\pm$ full width $\Gamma = 50.8 \pm 0.9$ MeV
Full width $\Gamma = 46.2 \pm 1.3$
$K^*(892)^0$ full width $\Gamma = 50.3 \pm 0.6$ MeV   (S = 1.1)

$K^*(892)$ DECAY MODES	Fraction (Γ_i/Γ)	Confidence level	p (MeV/c)
$K\pi$	$\sim$ 100 %		289
$K^0 \gamma$	$(2.31 \pm 0.20) \times 10^{-3}$		307
$K^\pm \gamma$	$(9.9 \pm 0.9) \times 10^{-4}$		309
$K\pi\pi$	$< 7 \times 10^{-4}$	95%	223

$K_1(1270)$ $\qquad\qquad I(J^P) = \frac{1}{2}(1^+)$

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

$K_1(1270)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\rho$	(42 ± 6) %	45
$K_0^*(1430)\pi$	(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

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

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)
$K^*(892)\pi$	$(94 \pm 6)\%$	402
$K\rho$	$(3.0\pm3.0)\%$	292
$K f_0(1370)$	$(2.0\pm2.0)\%$	†
$K\omega$	$(1.0\pm1.0)\%$	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)
$K^*(892)\pi$	$> 40 \quad \%$	95%	410
$K\pi$	$(6.6\pm1.3)\%$		612
$K\rho$	$< 7 \quad \%$	95%	305
γK^0	seen		619

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

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)
$K\pi$	$(93\pm10)\%$	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
$K^+\gamma$	$(2.4\pm0.5)\times10^{-3}$	S=1.1	627
$K\eta$	$(1.5^{+3.4}_{-1.0})\times10^{-3}$	S=1.3	486
$K\omega\pi$	$<7.2\times10^{-4}$	CL=95%	100
$K^0\gamma$	$<9\times10^{-4}$	CL=90%	626

$K^*(1680)$ $\qquad I(J^P) = \frac{1}{2}(1^-)$

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

$K^*(1680)$ DECAY MODES	Fraction (Γ_i/Γ)	p (MeV/c)
$K\pi$	(38.7 ± 2.5) %	781
$K\rho$	$(31.4^{+4.7}_{-2.1})$ %	570
$K^*(892)\pi$	$(29.9^{+2.2}_{-4.7})$ %	618

$K_2(1770)$ [v] $\qquad I(J^P) = \frac{1}{2}(2^-)$

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
$\quad K_2^*(1430)\pi$	dominant	288
$\quad K^*(892)\pi$	seen	654
$\quad K f_2(1270)$	seen	55
$K\phi$	seen	441
$K\omega$	seen	607

$K_3^*(1780)$ $\qquad I(J^P) = \frac{1}{2}(3^-)$

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

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

$K_2(1820)$ [w] $I(J^P) = \frac{1}{2}(2^-)$

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
$K f_2(1270)$	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)
$K\pi$	$(9.9 \pm 1.2)\%$	958
$K^*(892)\pi\pi$	$(9 \pm 5)\%$	802
$K^*(892)\pi\pi\pi$	$(7 \pm 5)\%$	768
$\rho K\pi$	$(5.7 \pm 3.2)\%$	741
$\omega K\pi$	$(5.0 \pm 3.0)\%$	738
$\phi K\pi$	$(2.8 \pm 1.4)\%$	594
$\phi K^*(892)$	$(1.4 \pm 0.7)\%$	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):
$$\left|M\right|^2 = 1 + g(s_3 - s_0)/m_{\pi^+}^2 + \cdots .$$

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

[d] 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.

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

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

[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}, $\left|\eta\right|$, $\left|m_{K_L^0} - m_{K_S^0}\right|$, and $\tau_{K_S^0}$, 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_L^0 Decay" in the Particle Listings):
$$\eta_{+-} = \left|\eta_{+-}\right| e^{i\phi_{+-}} = \frac{A(K_L^0 \to \pi^+ \pi^-)}{A(K_S^0 \to \pi^+ \pi^-)} = \epsilon + \epsilon'$$

$$\eta_{00} = \left|\eta_{00}\right| e^{i\phi_{00}} = \frac{A(K_L^0 \to \pi^0 \pi^0)}{A(K_S^0 \to \pi^0 \pi^0)} = \epsilon - 2\epsilon'$$

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

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

$$\mathrm{Im}(\eta_{000})^2 = \frac{\Gamma(K_S^0 \to \pi^0 \pi^0 \pi^0)}{\Gamma(K_L^0 \to \pi^0 \pi^0 \pi^0)} .$$

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

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

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

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

[p] This mode includes gammas from inner bremsstrahlung but not the direct emission mode $K^0_L \rightarrow \pi^+\pi^-\gamma(\text{DE})$.

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

[r] Allowed by higher-order electroweak interactions.

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

[t] 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.

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

[v] 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 .

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