NOTES

[a] 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.

[b] Measurements of \( \Gamma(e^+\nu_e)/\Gamma(\mu^+\nu_\mu) \) always include decays with \( \gamma \)'s, and measurements of \( \Gamma(e^+\nu_e\gamma) \) and \( \Gamma(\mu^+\nu_\mu\gamma) \) never include low-energy \( \gamma \)'s. Therefore, since no clean separation is possible, we consider the modes with \( \gamma \)'s to be subreactions of the modes without them, and let \( \left[ \Gamma(e^+\nu_e) + \Gamma(\mu^+\nu_\mu) \right]/\Gamma_{\text{total}} = 100\% \).

[c] See the \( \pi^\pm \) Particle Listings for the energy limits used in this measurement; low-energy \( \gamma \)'s are not included.

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

[e] Astrophysical and cosmological arguments give limits of order \( 10^{-13} \); see the \( \pi^0 \) Particle Listings.

[f] See the “Note on the Decay Width \( \Gamma(\eta \to \gamma\gamma) \)” in our 1994 edition, Phys. Rev. D50, 1 August 1994, Part I, p. 1451.

[g] C parity forbids this to occur as a single-photon process.

[h] See the “Note on scalar mesons” in the \( f_0(1370) \) Particle Listings. The interpretation of this entry as a particle is controversial.

[i] See the “Note on \( \rho(770) \)” in the \( \rho(770) \) Particle Listings.

[j] The \( e^+e^- \) branching fraction is from \( e^+e^- \to \pi^+\pi^- \) experiments only. The \( \omega\rho \) interference is then due to \( \omega\rho \) mixing only, and is expected to be small. If \( e\mu \) universality holds, \( \Gamma(\rho^0 \to \mu^+\mu^-) = \Gamma(\rho^0 \to e^+e^-) \times 0.99785 \).

[k] See the “Note on scalar mesons” in the \( f_0(1370) \) Particle Listings.

[l] See the “Note on \( a_1(1260) \)” in the \( a_1(1260) \) Particle Listings.

[m] 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.

[n] See the “Note on the \( f_1(1420) \)” in the \( \eta(1440) \) Particle Listings.

[o] See also the \( \omega(1650) \) Particle Listings.

[p] See the “Note on the \( \eta(1440) \)” in the \( \eta(1440) \) Particle Listings.

[q] See the “Note on the \( \rho(1450) \) and the \( \rho(1700) \)” in the \( \rho(1700) \) Particle Listings.

[r] See the “Note on non-quark-antiquark mesons” in the Particle Listings (see the index for the page number).

[s] See also the \( \omega(1420) \) Particle Listings.

[t] See the “Note on \( f_0(1710) \)” in the \( f_0(1710) \) Particle Listings.

[u] See the note in the \( K^\pm \) Particle Listings.
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):

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

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

Most of this radiative mode, the low-momentum $\gamma$ part, is also included in the parent mode listed without $\gamma$'s.

See the $K^{\pm}$ Particle Listings for the energy limits used in this measurement.

Structure-dependent part.

Direct-emission branching fraction.

Violates angular-momentum conservation.

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

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):

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

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

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

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

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

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

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

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

$\text{Re}(\epsilon'/\epsilon) = \epsilon'/\epsilon$ to a very good approximation provided the phases satisfy $CPT$ invariance.
[hh] See the $K^0_L$ Particle Listings for the energy limits used in this measurement.

[ii] Allowed by higher-order electroweak interactions.

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

[kk] See the “Note on $f_0(1370)$” in the $f_0(1370)$ Particle Listings and in the 1994 edition.

[ll] See the note in the $L(1770)$ Particle Listings in Reviews of Modern Physics 56, No. 2 Pt. II (1984), p. S200. See also the “Note on $K_2(1770)$ and the $K_2(1820)$” in the $K_2(1770)$ Particle Listings.

[mm] See the “Note on $K_2(1770)$ and the $K_2(1820)$” in the $K_2(1770)$ Particle Listings.

[nn] This result applies to $Z^0 \rightarrow c\bar{c}$ decays only. Here $\ell^+$ is an average (not a sum) of $e^+$ and $\mu^+$ decays.

[oo] This is a weighted average of $D^\pm$ (44%) and $D^0$ (56%) branching fractions. See “$D^+$ and $D^0 \rightarrow (\eta$ anything) / (total $D^+$ and $D^0$)” under “$D^+$ Branching Ratios” in the Particle Listings.

[pp] This value averages the $e^+$ and $\mu^+$ branching fractions, after making a small phase-space adjustment to the $\mu^+$ fraction to be able to use it as an $e^+$ fraction; hence our $\ell^+$ here is really an $e^+$.

[qq] An $\ell$ indicates an $e$ or a $\mu$ mode, not a sum over these modes.

[rr] The branching fraction for this mode may differ from the sum of the submodes that contribute to it, due to interference effects. See the relevant papers in the Particle Listings.

[ss] The two experiments measuring this fraction are in serious disagreement. See the Particle Listings.

[tt] This value includes only $\pi^+\pi^-$ decays of the intermediate resonance, because branching fractions of this resonance are not known.

[uu] This mode is not a useful test for a $\Delta C=1$ weak neutral current because both quarks must change flavor in this decay.

[vv] This $D^0_1-D^0_2$ limit is inferred from the $D^0-\bar{D}^0$ mixing ratio $\Gamma(K^+\pi^- (\text{via}\ \bar{D}^0)) / \Gamma(K^-\pi^+)$ near the end of the $D^0$ Listings.

[ww] The exclusive $e^+$ modes $K^-e^+\nu_e$, $K^-\pi^0e^+\nu_e$, $K^-\pi^0 e^+\nu_e$, and $\pi^-e^+\nu_e$ are constrained to equal this (well-measured) inclusive fraction.

[xx] The experiments on the division of this charge mode amongst its submodes disagree, and the submode branching fractions here add up to considerably more than the charged-mode fraction.

[yy] However, these upper limits are in serious disagreement with values obtained in another experiment.
[zz] For now, we average together measurements of the $Xe^+\nu_e$ and $X\mu^+\nu_\mu$ branching fractions. This is the average, not the sum.

[aaa] This branching fraction includes all the decay modes of the final-state resonance.

[bbb] This value includes only $K^+K^-$ decays of the intermediate resonance, because branching fractions of this resonance are not known.

[ccc] $B^0$ and $B^0_s$ contributions not separated. Limit is on weighted average of the two decay rates.

[ddd] These values are model dependent. See 'Note on Semileptonic Decays' in the $B^+$ Particle Listings.

[eee] $D^{**}$ stands for the sum of the $D(1\,^1S_0)$, $D(1\,^3P_0)$, $D(1\,^3P_1)$, $D(1\,^3P_2)$, $D(2\,^1S_0)$, and $D(2\,^1S_1)$ resonances.

[fff] $D^{(*)}\bar{D}^{(*)}$ stands for the sum of $D^*\bar{D}^*$, $D^*\bar{D}$, $D\bar{D}^*$, and $D\bar{D}$.

[ggg] Inclusive branching fractions have a multiplicity definition and can be greater than 100%.

[hhh] $D_j$ represents an unresolved mixture of pseudoscalar and tensor $D^{**}$ ($P$-wave) states.

[iii] Not a pure measurement. See note at head of $B^0_s$ Decay Modes.

[ijj] Includes $p\bar{p}\pi^+\pi^-\gamma$ and excludes $p\bar{p}\eta$, $p\bar{p}\omega$, $p\bar{p}\eta'$. 

[kkk] $J^{PC}$ known by production in $e^+e^-$ via single photon annihilation. $IG$ is not known; interpretation of this state as a single resonance is unclear because of the expectation of substantial threshold effects in this energy region.

[lll] Spectroscopic labeling for these states is theoretical, pending experimental information.