### Im(ξ) in $K^0_{\mu 3}$ DECAY (from transverse μ pol.)

Test of $T$ reversal invariance.

| VALUE | EVTS | DOCUMENT ID | TECN | COMMENT |
|---|---|---|---|---|
| **−0.007±0.026 OUR AVERAGE** | | | | |
| 0.009±0.030 | 12M | MORSE 80 | CNTR | Polarization |
| 0.35 ±0.30 | 207k | [73] CLARK 77 | SPEC | POL, $t$=0 |
| −0.085±0.064 | 2.2M | [74] SANDWEISS 73 | CNTR | POL, $t$=0 |
| −0.02 ±0.08 | | LONGO 69 | CNTR | POL, $t$=3.3 |
| −0.2 ±0.6 | | ABRAMS 68B | OSPK | Polarization |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 0.012±0.026 | | SCHMIDT 79 | CNTR | Repl. by MORSE 80 |

[73] CLARK 77 value has additional ξ(0) dependence +0.21Re[ξ(0)].

[74] SANDWEISS 73 value corrected from value quoted in their paper due to new value of Re(ξ). See footnote 4 of SCHMIDT 79.

### $\lambda_+$ (LINEAR ENERGY DEPENDENCE OF $f_+$ IN $K^0_{\mu 3}$ DECAY)

See also the corresponding entries and notes in section "$\xi_A = f_-/f_+$" above and section "$\lambda_0$ (LINEAR ENERGY DEPENDENCE OF $f_0$ IN $K^0_{\mu 3}$ DECAY)" below. For radiative correction of $K^0_{\mu 3}$ Dalitz plot see GINSBERG 70 and BECHERRAWY 70.

| VALUE | EVTS | DOCUMENT ID | TECN | COMMENT |
|---|---|---|---|---|
| **0.034 ±0.005 OUR EVALUATION** | | From a fit discussed in note on $K_{\ell 3}$ form factors in 1982 edition, PL **111B** (April 1982). | | |
| 0.0427±0.0044 | 150k | BIRULEV 81 | SPEC | DP |
| 0.028 ±0.010 | 14k | CHO 80 | HBC | DP |
| 0.028 ±0.011 | 16k | HILL 79 | STRC | DP |
| 0.046 ±0.030 | 32k | BUCHANAN 75 | SPEC | DP |
| 0.030 ±0.003 | 1.6M | DONALDSON 74B | SPEC | DP |
| 0.085 ±0.015 | 9086 | ALBROW 72 | ASPK | DP |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | |
| 0.0337±0.0033 | 129k | DZHORD... 77 | SPEC | Repl. by BIRULEV 81 |
| 0.046 ±0.008 | 82k | ALBRECHT 74 | WIRE | Repl. by BIRULEV 81 |
| 0.11 ±0.04 | 16k | DALLY 72 | ASPK | DP |
| 0.07 ±0.02 | 16k | CHIEN 70 | ASPK | Repl. by DALLY 72 |

### $\lambda_0$ (LINEAR ENERGY DEPENDENCE OF $f_0$ IN $K^0_{\mu 3}$ DECAY)

Wherever possible, we have converted the above values of ξ(0) into values of $\lambda_0$ using the associated $\lambda_+^{\mu}$ and $d\xi(0)/d\lambda_+$.

| VALUE | $d\lambda_0/d\lambda_+$ | EVTS | DOCUMENT ID | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.025 ±0.006 OUR EVALUATION** | | | From a fit discussed in note on $K_{\ell 3}$ form factors in 1982 edition, PL **111B** (April 1982). | | |
| 0.0341±0.0067 | unknown | 150k | [75] BIRULEV 81 | SPEC | DP |
| +0.050 ±0.008 | −0.11 | 14k | CHO 80 | HBC | DP |
| +0.039 ±0.010 | −0.67 | 16k | HILL 79 | STRC | DP |
| +0.047 ±0.009 | 1.06 | 207k | [76] CLARK 77 | SPEC | POL |
| +0.025 ±0.019 | +0.5 | 32k | [77] BUCHANAN 75 | SPEC | DP |
| +0.019 ±0.004 | −0.47 | 1.6M | [78] DONALDSON 74B | SPEC | DP |
| −0.060 ±0.038 | −0.71 | 1385 | [79] PEACH 73 | HLBC | DP |
| −0.018 ±0.009 | +0.49 | 2.2M | [76] SANDWEISS 73 | CNTR | POL |
| −0.043 ±0.052 | −1.39 | 9086 | [80] ALBROW 72 | ASPK | DP |
| $-0.140\ ^{+0.043}_{-0.022}$ | +0.49 | | [76] LONGO 69 | CNTR | POL |
| +0.08 ±0.07 | −0.54 | 1371 | [76] CARPENTER 66 | OSPK | DP |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 0.041 ±0.008 | | 14k | [81] CHO 80 | HBC | BR, $\lambda_+$=0.028 |
| +0.0485±0.0076 | | 47k | DZHORD... 77 | SPEC | In BIRULEV 81 |
| +0.024 ±0.011 | | 82k | ALBRECHT 74 | WIRE | In BIRULEV 81 |
| +0.06 ±0.03 | | 6700 | [82] BRANDENB... 73 | HBC | BR, $\lambda_+$=0.019 ± 0.013 |
| −0.067 ±0.227 | unknown | 16k | [83] DALLY 72 | ASPK | DP |
| −0.333 ±0.034 | +1. | 3140 | [84] BASILE 70 | OSPK | DP |

[75] BIRULEV 81 gives $d\lambda_0/d\lambda_+ = -1.5$, giving an unreasonably narrow error ellipse which dominates all other results. We use $d\lambda_0/d\lambda_+ = 0$.

[76] $\lambda_0$ value is for $\lambda_+ = 0.03$ calculated by us from ξ(0) and $d\xi(0)/d\lambda_+$.

[77] BUCHANAN 75 value is from their appendix A and uses only $K_{\mu 3}$ data. $d\lambda_0/d\lambda_+$ was obtained by private communication, C.Buchanan, 1976.

[78] DONALDSON 74B $d\lambda_0/d\lambda_+$ obtained from figure 18.

[79] PEACH 73 assumes $\lambda_+ = 0.025$. Calculated by us from ξ(0) and $d\xi(0)/d\lambda_+$.

[80] ALBROW 72 $\lambda_0$ is calculated by us from $\xi_A$, $\lambda_+$ and $d\xi(0)/d\lambda_+$. They give $\lambda_0 = -0.043 \pm 0.039$ for $\lambda_- = 0$. We use our larger calculated error.

[81] CHO 80 BR result not independent of their Dalitz plot result.

[82] Fit for $\lambda_0$ does not include this value but instead includes the $K_{\mu 3}/K_{e3}$ result from this experiment.

[83] DALLY 72 gives $f_0 = 1.20 \pm 0.35$, $\lambda_0 = -0.080 \pm 0.272$, $\lambda_0{}' = -0.006 \pm 0.045$, but with a different definition of $\lambda_0$. Our quoted $\lambda_0$ is his $\lambda_0/f_0$. We cannot calculate true $\lambda_0$ error without his $(\lambda_0, f_0)$ correlations. See also note on DALLY 72 in section $\xi_A$.

[84] BASILE 70 $\lambda_0$ is for $\lambda_+ = 0$. Calculated by us from $\xi_A$ with $d\xi(0)/d\lambda_+ = 0$. BASILE 70 is incompatible with all other results. Authors suggest that efficiency estimates might be responsible.

### $|f_S/f_+|$ FOR $K^0_{e3}$ DECAY

Ratio of scalar to $f_+$ couplings.

| VALUE | CL% | EVTS | DOCUMENT ID | TECN | COMMENT |
|---|---|---|---|---|---|
| **<0.04** | 68 | 25k | BLUMENTHAL 75 | SPEC | |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <0.095 | 95 | 18k | HILL 78 | STRC | |
| <0.07 | 68 | 48k | BIRULEV 76 | SPEC | See also BIRULEV 81 |
| <0.19 | 95 | 5600 | ALBROW 73 | ASPK | |
| <0.15 | 68 | | KULYUKINA 67 | CC | |

### $|f_T/f_+|$ FOR $K^0_{e3}$ DECAY

Ratio of tensor to $f_+$ couplings.

| VALUE | CL% | EVTS | DOCUMENT ID | TECN | COMMENT |
|---|---|---|---|---|---|
| **<0.23** | 68 | 25k | BLUMENTHAL 75 | SPEC | |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| <0.40 | 95 | 18k | HILL 78 | STRC | |
| <0.34 | 68 | 48k | BIRULEV 76 | SPEC | See also BIRULEV 81 |
| <1.0 | 95 | 5600 | ALBROW 73 | ASPK | |
| <1.0 | 68 | | KULYUKINA 67 | CC | |

### $|f_T/f_+|$ FOR $K^0_{\mu 3}$ DECAY

Ratio of tensor to $f_+$ couplings.

| VALUE | DOCUMENT ID | TECN |
|---|---|---|
| **0.12±0.12** | BIRULEV 81 | SPEC |

### $\alpha_{K^*}$ DECAY FORM FACTOR FOR $K_L \to e^+ e^- \gamma$

$\alpha_{K^*}$ is the constant in the model of BERGSTROM 83 which measures the relative strength of the vector-vector transition $K_L \to K^* \gamma$ with $K^* \to \rho, \omega, \phi \to \gamma^*$ and the pseudoscalar-pseudoscalar transition $K_L \to \pi, \eta, \eta' \to \gamma\gamma^*$.

| VALUE | DOCUMENT ID | TECN |
|---|---|---|
| **−0.28 ±0.08 OUR AVERAGE** | | |
| −0.28 ±0.13 | BARR 90B | NA31 |
| $-0.280\ ^{+0.099}_{-0.090}$ | OHL 90B | B845 |

### DECAY FORM FACTORS FOR $K^0_L \to \pi^{\pm}\pi^0 e^{\mp}\nu_e$

Given in MAKOFF 93.

## NOTE ON $CP$ VIOLATION IN $K^0_L$ DECAY

(by L. Wolfenstein, Carnegie-Mellon University and T. Trippe, LBL)

### Experimentally Measured Parameters

$CP$ violation has been observed in the semi-leptonic decays $K^0_L \to \pi^{\mp}\ell^{\pm}\nu$ and in the nonleptonic decay $K^0_L \to 2\pi$. The experimental numbers that have been measured are [1]

$$\delta = \frac{\Gamma(K^0_L \to \pi^-\ell^+\nu) - \Gamma(K^0_L \to \pi^+\ell^-\nu)}{\Gamma(K^0_L \to \pi^-\ell^+\nu) + \Gamma(K^0_L \to \pi^+\ell^-\nu)} \tag{1a}$$

$$\eta_{+-} = A(K^0_L \to \pi^+\pi^-)/A(K^0_S \to \pi^+\pi^-)$$

$$= |\eta_{+-}|\ e^{i\phi_{+-}} \tag{1b}$$

$$\eta_{00} = A(K^0_L \to \pi^0\pi^0)/A(K^0_S \to \pi^0\pi^0)$$

$$= |\eta_{00}|\ e^{i\phi_{00}}\ . \tag{1c}$$

Thus there are five real numbers, three magnitudes, and two phases. We list $\delta(\mu)$ for $K^0_L \to \pi\mu\nu$ and $\delta(e)$ for $K^0_L \to \pi e\nu$ separately and a weighted average $\delta$. Experimentally for the $K^0_L \to \pi^0\pi^0$ decay the quantities directly measured (and also of greatest theoretical interest) are $|\eta_{00}/\eta_{+-}|$ and $\phi_{00} - \phi_{+-}$.

### Analysis Based on $CPT$ Invariance [2]

$CP$ violation can occur either in the $K^0 - \overline{K}^0$ mixing or in the decay amplitudes. Assuming $CPT$ invariance, the $CP$