

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

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K^\pm MASS

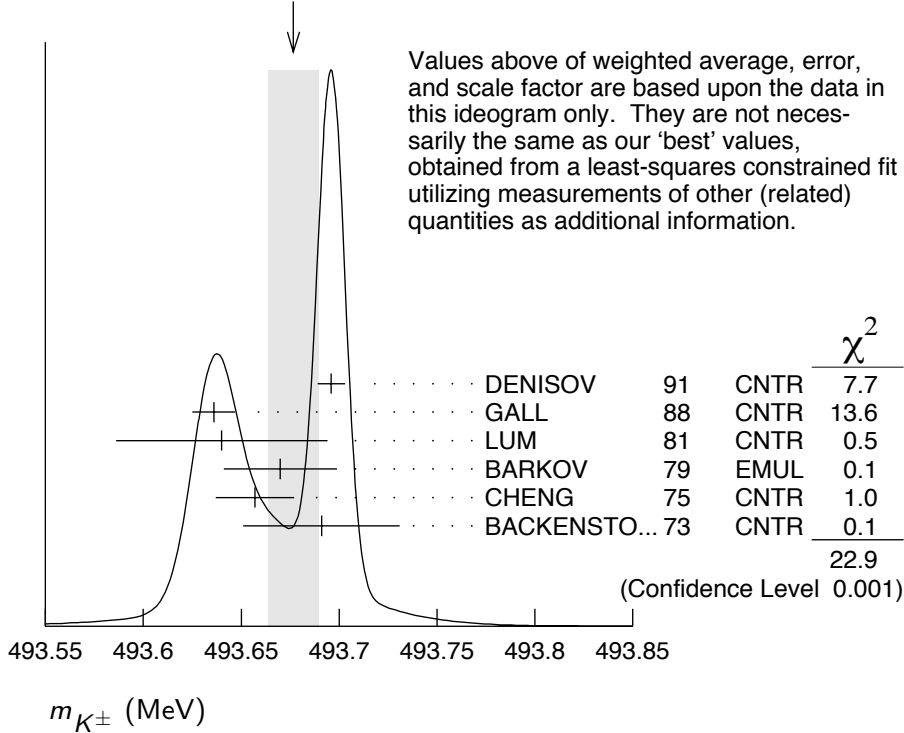
<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
493.677±0.016 OUR FIT	Error includes scale factor of 2.8.			
493.677±0.013 OUR AVERAGE	Error includes scale factor of 2.4. See the ideogram below.			
493.696±0.007	¹ DENISOV	91	CNTR –	Kaonic atoms
493.636±0.011	² GALL	88	CNTR –	Kaonic atoms
493.640±0.054	LUM	81	CNTR –	Kaonic atoms
493.670±0.029	BARKOV	79	EMUL ±	$e^+ e^- \rightarrow K^+ K^-$
493.657±0.020	² CHENG	75	CNTR –	Kaonic atoms
493.691±0.040	BACKENSTO...73	73	CNTR –	Kaonic atoms
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
493.631±0.007	GALL	88	CNTR –	K^- Pb (9→ 8)
493.675±0.026	GALL	88	CNTR –	K^- Pb (11→ 10)
493.709±0.073	GALL	88	CNTR –	K^- W (9→ 8)
493.806±0.095	GALL	88	CNTR –	K^- W (11→ 10)
493.640±0.022±0.008	³ CHENG	75	CNTR –	K^- Pb (9→ 8)
493.658±0.019±0.012	³ CHENG	75	CNTR –	K^- Pb (10→ 9)
493.638±0.035±0.016	³ CHENG	75	CNTR –	K^- Pb (11→ 10)
493.753±0.042±0.021	³ CHENG	75	CNTR –	K^- Pb (12→ 11)
493.742±0.081±0.027	³ CHENG	75	CNTR –	K^- Pb (13→ 12)

¹ Error increased from 0.0059 based on the error analysis in IVANOV 92.

² This value is the authors' combination of all of the separate transitions listed for this paper.

³ The CHENG 75 values for separate transitions were calculated from their Table 7 transition energies. The first error includes a 20% systematic error in the noncircular contaminant shift. The second error is due to a ±5 eV uncertainty in the theoretical transition energies.

WEIGHTED AVERAGE
 493.677 ± 0.013 (Error scaled by 2.4)



$m_{K^+} - m_{K^-}$

Test of *CPT*.

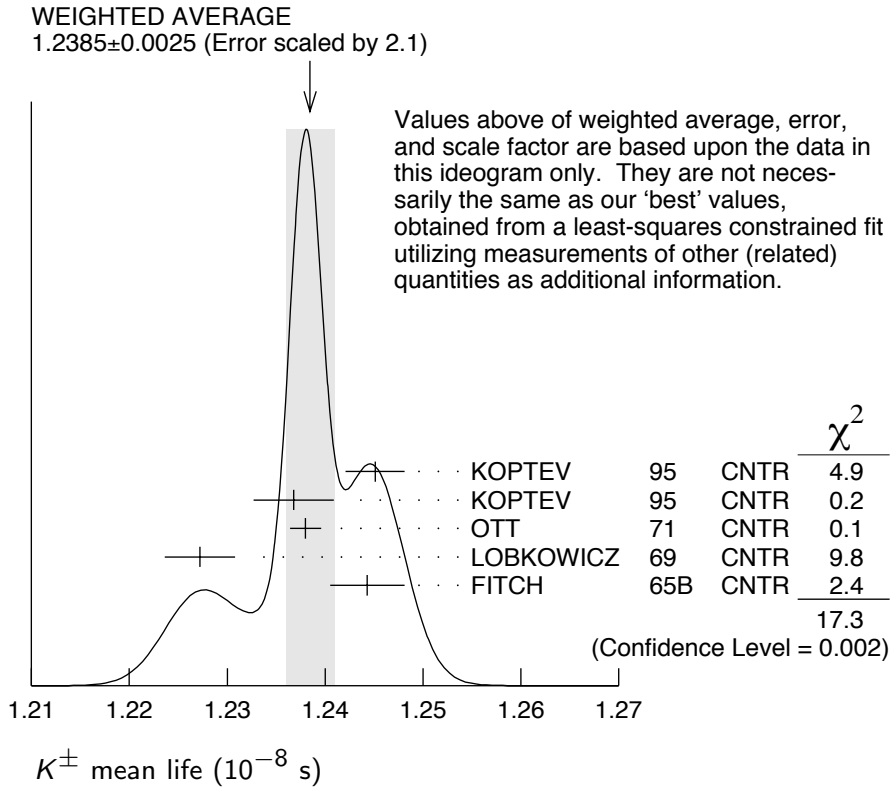
VALUE (MeV)	EVTS	DOCUMENT ID	TECN	CHG
-0.032 ± 0.090	1.5M	⁴ FORD	72	ASPK ±

⁴ FORD 72 uses $m_{\pi^+} - m_{\pi^-} = +28 \pm 70$ keV.

K^\pm MEAN LIFE

VALUE (10^{-8} s)	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
1.2385 ± 0.0024 OUR FIT					Error includes scale factor of 2.0.
1.2385 ± 0.0025 OUR AVERAGE					Error includes scale factor of 2.1. See the ideogram below.
1.2451 ± 0.0030	250k	KOPTEV	95	CNTR	<i>K</i> at rest, U target
1.2368 ± 0.0041	150k	KOPTEV	95	CNTR	<i>K</i> at rest, Cu target
1.2380 ± 0.0016	3M	OTT	71	CNTR +	<i>K</i> at rest
1.2272 ± 0.0036		LOBKOWICZ	69	CNTR +	<i>K</i> in flight
1.2443 ± 0.0038		FITCH	65B	CNTR +	<i>K</i> at rest
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
1.2415 ± 0.0024	400k	⁵ KOPTEV	95	CNTR	<i>K</i> at rest
1.221 ± 0.011		FORD	67	CNTR ±	
1.231 ± 0.011		BOYARSKI	62	CNTR +	

⁵ KOPTEV 95 report this weighted average of their U-target and Cu-target results, where they have weighted by $1/\sigma$ rather than $1/\sigma^2$.



$$(\tau_{K^+} - \tau_{K^-}) / \tau_{\text{average}}$$

This quantity is a measure of *CPT* invariance in weak interactions.

VALUE (%)	DOCUMENT ID	TECN
0.11 ± 0.09 OUR AVERAGE	Error includes scale factor of 1.2.	
0.090 ± 0.078	LOBKOWICZ 69	CNTR
0.47 ± 0.30	FORD 67	CNTR

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K^+ DECAY MODES

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

Mode	Fraction (Γ_i/Γ)	Scale factor/ Confidence level
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Leptonic and semileptonic modes

Γ_1	$e^+ \nu_e$	$(1.55 \pm 0.07) \times 10^{-5}$	
Γ_2	$\mu^+ \nu_\mu$	$(63.44 \pm 0.14) \%$	S=1.2
Γ_3	$\pi^0 e^+ \nu_e$	$(4.98 \pm 0.07) \%$	S=1.3
	Called K_{e3}^+ .		
Γ_4	$\pi^0 \mu^+ \nu_\mu$	$(3.32 \pm 0.06) \%$	S=1.2
	Called $K_{\mu 3}^+$.		
Γ_5	$\pi^0 \pi^0 e^+ \nu_e$	$(2.2 \pm 0.4) \times 10^{-5}$	
Γ_6	$\pi^+ \pi^- e^+ \nu_e$	$(4.09 \pm 0.09) \times 10^{-5}$	
Γ_7	$\pi^+ \pi^- \mu^+ \nu_\mu$	$(1.4 \pm 0.9) \times 10^{-5}$	
Γ_8	$\pi^0 \pi^0 \pi^0 e^+ \nu_e$	$< 3.5 \times 10^{-6}$	CL=90%

Hadronic modes

Γ_9	$\pi^+ \pi^0$	$(20.92 \pm 0.12) \%$	S=1.1
Γ_{10}	$\pi^+ \pi^0 \pi^0$	$(1.757 \pm 0.024) \%$	S=1.1
Γ_{11}	$\pi^+ \pi^+ \pi^-$	$(5.590 \pm 0.031) \%$	S=1.1

Leptonic and semileptonic modes with photons

Γ_{12}	$\mu^+ \nu_\mu \gamma$	$[a,b] (6.2 \pm 0.8) \times 10^{-3}$	
Γ_{13}	$\mu^+ \nu_\mu \gamma (SD^+)$	$[c] < 3.0 \times 10^{-5}$	CL=90%
Γ_{14}	$\mu^+ \nu_\mu \gamma (SD^+INT)$	$[c] < 2.7 \times 10^{-5}$	CL=90%
Γ_{15}	$\mu^+ \nu_\mu \gamma (SD^- + SD^-INT)$	$[c] < 2.6 \times 10^{-4}$	CL=90%
Γ_{16}	$e^+ \nu_e \gamma (SD^+)$	$[c] (1.52 \pm 0.23) \times 10^{-5}$	
Γ_{17}	$e^+ \nu_e \gamma (SD^-)$	$[c] < 1.6 \times 10^{-4}$	CL=90%
Γ_{18}	$\pi^0 e^+ \nu_e \gamma$	$[a,b] (2.69 \pm 0.20) \times 10^{-4}$	
Γ_{19}	$\pi^0 e^+ \nu_e \gamma (SD)$	$[c] < 5.3 \times 10^{-5}$	CL=90%
Γ_{20}	$\pi^0 \mu^+ \nu_\mu \gamma$	$[a,b] (1.5 \pm 0.4) \times 10^{-5}$	
Γ_{21}	$\pi^0 \pi^0 e^+ \nu_e \gamma$	$< 5 \times 10^{-6}$	CL=90%

Hadronic modes with photons

Γ_{22}	$\pi^+ \pi^0 \gamma$	$[a,b] (2.75 \pm 0.15) \times 10^{-4}$	
Γ_{23}	$\pi^+ \pi^0 \gamma (DE)$	$[b,d] (4.3 \pm 0.7) \times 10^{-6}$	
Γ_{24}	$\pi^+ \pi^0 \pi^0 \gamma$	$[a,b] (7.6 \pm_{-3.0}^{5.6}) \times 10^{-6}$	
Γ_{25}	$\pi^+ \pi^+ \pi^- \gamma$	$[a,b] (1.04 \pm 0.31) \times 10^{-4}$	
Γ_{26}	$\pi^+ \gamma \gamma$	$[b] (1.10 \pm 0.32) \times 10^{-6}$	
Γ_{27}	$\pi^+ 3\gamma$	$[b] < 1.0 \times 10^{-4}$	CL=90%

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

Γ_{28}	$e^+ \nu_e \nu \bar{\nu}$	$< 6 \times 10^{-5}$	CL=90%
Γ_{29}	$\mu^+ \nu_\mu \nu \bar{\nu}$	$< 6.0 \times 10^{-6}$	CL=90%
Γ_{30}	$e^+ \nu_e e^+ e^-$	$(2.48 \pm 0.20) \times 10^{-8}$	
Γ_{31}	$\mu^+ \nu_\mu e^+ e^-$	$(7.06 \pm 0.31) \times 10^{-8}$	
Γ_{32}	$e^+ \nu_e \mu^+ \mu^-$	$(1.7 \pm 0.5) \times 10^{-8}$	
Γ_{33}	$\mu^+ \nu_\mu \mu^+ \mu^-$	$< 4.1 \times 10^{-7}$	CL=90%

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

Γ_{34}	$\pi^+ \pi^+ e^- \bar{\nu}_e$	<i>SQ</i>	< 1.2	$\times 10^{-8}$	CL=90%
Γ_{35}	$\pi^+ \pi^+ \mu^- \bar{\nu}_\mu$	<i>SQ</i>	< 3.0	$\times 10^{-6}$	CL=95%
Γ_{36}	$\pi^+ e^+ e^-$	<i>SI</i>	$(2.88 \pm 0.13) \times 10^{-7}$		
Γ_{37}	$\pi^+ \mu^+ \mu^-$	<i>SI</i>	$(8.1 \pm 1.4) \times 10^{-8}$		S=2.7
Γ_{38}	$\pi^+ \nu \bar{\nu}$	<i>SI</i>	$(1.5^{+1.3}_{-0.9}) \times 10^{-10}$		
Γ_{39}	$\pi^+ \pi^0 \nu \bar{\nu}$	<i>SI</i>	< 4.3	$\times 10^{-5}$	CL=90%
Γ_{40}	$\mu^- \nu e^+ e^+$	<i>LF</i>	< 2.0	$\times 10^{-8}$	CL=90%
Γ_{41}	$\mu^+ \nu_e$	<i>LF</i>	[e] < 4	$\times 10^{-3}$	CL=90%
Γ_{42}	$\pi^+ \mu^+ e^-$	<i>LF</i>	< 1.3	$\times 10^{-11}$	CL=90%
Γ_{43}	$\pi^+ \mu^- e^+$	<i>LF</i>	< 5.2	$\times 10^{-10}$	CL=90%
Γ_{44}	$\pi^- \mu^+ e^+$	<i>L</i>	< 5.0	$\times 10^{-10}$	CL=90%
Γ_{45}	$\pi^- e^+ e^+$	<i>L</i>	< 6.4	$\times 10^{-10}$	CL=90%
Γ_{46}	$\pi^- \mu^+ \mu^+$	<i>L</i>	[e] < 3.0	$\times 10^{-9}$	CL=90%
Γ_{47}	$\mu^+ \bar{\nu}_e$	<i>L</i>	[e] < 3.3	$\times 10^{-3}$	CL=90%
Γ_{48}	$\pi^0 e^+ \bar{\nu}_e$	<i>L</i>	< 3	$\times 10^{-3}$	CL=90%
Γ_{49}	$\pi^+ \gamma$		[f] < 2.3	$\times 10^{-9}$	CL=90%

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

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

[c] Structure-dependent part.

[d] Direct-emission branching fraction.

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

[f] Violates angular-momentum conservation.

CONSTRAINED FIT INFORMATION

An overall fit to the mean life, a decay rate, and 12 branching ratios uses 26 measurements and one constraint to determine 8 parameters. The overall fit has a $\chi^2 = 30.0$ for 19 degrees of freedom.

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

x_3	-52						
x_4	-50	78					
x_5	-3	6	5				
x_9	-52	-36	-36	-2			
x_{10}	-8	-3	-3	0	-8		
x_{11}	-10	-6	-5	0	-9	4	
Γ	3	2	2	0	3	-1	-33
	x_2	x_3	x_4	x_5	x_9	x_{10}	x_{11}

Mode	Rate (10^8 s^{-1})	Scale factor
$\Gamma_2 \quad \mu^+ \nu_\mu$	0.5122 ± 0.0015	1.4
$\Gamma_3 \quad \pi^0 e^+ \nu_e$ Called K_{e3}^+	0.0402 ± 0.0006	1.3
$\Gamma_4 \quad \pi^0 \mu^+ \nu_\mu$ Called $K_{\mu 3}^+$	0.0268 ± 0.0005	1.2
$\Gamma_5 \quad \pi^0 \pi^0 e^+ \nu_e$	$(1.74 \quad \begin{smallmatrix} +0.35 \\ -0.30 \end{smallmatrix}) \times 10^{-5}$	
$\Gamma_9 \quad \pi^+ \pi^0$	0.1689 ± 0.0010	1.2
$\Gamma_{10} \quad \pi^+ \pi^0 \pi^0$	0.01419 ± 0.00020	1.1
$\Gamma_{11} \quad \pi^+ \pi^+ \pi^-$	0.04513 ± 0.00024	

K^\pm DECAY RATES

$\Gamma(\mu^+ \nu_\mu)$ Γ_2

VALUE (10^6 s^{-1}) DOCUMENT ID TECN CHG

51.22 ± 0.15 OUR FIT Error includes scale factor of 1.4.

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

51.2 ± 0.8 FORD 67 CNTR ±

$\Gamma(\pi^+ \pi^+ \pi^-)$ Γ_{11}

VALUE (10^6 s^{-1}) EVTS DOCUMENT ID TECN CHG

4.513 ± 0.024 OUR FIT

4.511 ± 0.024 ⁶FORD 70 ASPK

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

4.529 ± 0.032 3.2M ⁶FORD 70 ASPK

4.496 ± 0.030 ⁶FORD 67 CNTR ±

⁶ First FORD 70 value is second FORD 70 combined with FORD 67.

$(\Gamma(K^+) - \Gamma(K^-)) / \Gamma(K)$

$K^\pm \rightarrow \mu^\pm \nu_\mu$ RATE DIFFERENCE/AVERAGE

Test of *CPT* conservation.

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
-0.54 ± 0.41	FORD 67	CNTR

$K^\pm \rightarrow \pi^\pm \pi^+ \pi^-$ RATE DIFFERENCE/AVERAGE

Test of *CP* conservation.

<u>VALUE (%)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
0.08 ± 0.12		⁷ FORD 70	ASP	K

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

-0.02 ± 0.16		⁸ SMITH 73	ASP	K ±
0.10 ± 0.14	3.2M	⁷ FORD 70	ASP	K
-0.50 ± 0.90		FLETCHER 67	OSP	K
-0.04 ± 0.21		⁷ FORD 67	CNTR	K

⁷ First FORD 70 value is second FORD 70 combined with FORD 67.

⁸ SMITH 73 value of $K^\pm \rightarrow \pi^\pm \pi^+ \pi^-$ rate difference is derived from SMITH 73 value of $K^\pm \rightarrow \pi^\pm 2\pi^0$ rate difference.

$K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$ RATE DIFFERENCE/AVERAGE

Test of *CP* conservation.

<u>VALUE (%)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
0.0 ± 0.6 OUR AVERAGE				
0.08 ± 0.58		SMITH 73	ASP	K ±
-1.1 ± 1.8	1802	HERZO 69	OSP	K

$K^\pm \rightarrow \pi^\pm \pi^0$ RATE DIFFERENCE/AVERAGE

Test of *CPT* conservation.

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
0.8 ± 1.2	HERZO 69	OSP

$K^\pm \rightarrow \pi^\pm \pi^0 \gamma$ RATE DIFFERENCE/AVERAGE

Test of *CP* conservation.

<u>VALUE (%)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
0.9 ± 3.3 OUR AVERAGE					
0.8 ± 5.8	2461	SMITH 76	WIRE	K ±	E_π 55–90 MeV
1.0 ± 4.0	4000	ABRAMS 73B	ASP	K ±	E_π 51–100 MeV

K^+ BRANCHING RATIOS

Leptonic and semileptonic modes

$\Gamma(e^+ \nu_e) / \Gamma(\mu^+ \nu_\mu)$

Γ_1 / Γ_2

<u>VALUE (units 10^{-5})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
2.45 ± 0.11 OUR AVERAGE				
2.51 ± 0.15	404	HEINTZE 76	SPEC	K +
2.37 ± 0.17	534	HEARD 75B	SPEC	K +
2.42 ± 0.42	112	CLARK 72	OSP	K +

$\Gamma(\mu^+ \nu_\mu)/\Gamma_{\text{total}}$ Γ_2/Γ

VALUE (units 10^{-2}) EVTS DOCUMENT ID TECN CHG COMMENT

63.44±0.14 OUR FIT Error includes scale factor of 1.2.

63.60±0.16 OUR AVERAGE

63.66±0.09±0.15 865k ⁹ AMBROSINO 06A KLOE +

63.24±0.44 62k CHIANG 72 OSPK + 1.84 GeV/c K^+

⁹Fully inclusive. Used tagged kaons from ϕ decays.

$\Gamma(\pi^0 e^+ \nu_e)/\Gamma_{\text{total}}$ Γ_3/Γ

VALUE (units 10^{-2}) EVTS DOCUMENT ID TECN CHG COMMENT

4.98±0.07 OUR FIT Error includes scale factor of 1.3.

4.86±0.10 3516 CHIANG 72 OSPK + 1.84 GeV/c K^+

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

4.7 ±0.3 429 SHAKLEE 64 HLBC +

5.0 ±0.5 ROE 61 HLBC +

$\Gamma(\pi^0 e^+ \nu_e)/\Gamma(\mu^+ \nu_\mu)$ Γ_3/Γ_2

VALUE EVTS DOCUMENT ID TECN CHG

0.0784±0.0012 OUR FIT Error includes scale factor of 1.3.

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

0.069 ±0.006 350 ZELLER 69 ASPK +

0.0775±0.0033 960 BOTTERILL 68C ASPK +

0.069 ±0.006 561 GARLAND 68 OSPK +

0.0791±0.0054 295 ¹⁰ AUERBACH 67 OSPK +

¹⁰ AUERBACH 67 changed from 0.0797 ± 0.0054 . See comment with ratio $\Gamma(\pi^0 \mu^+ \nu_\mu)/\Gamma(\mu^+ \nu_\mu)$. The value 0.0785 ± 0.0025 given in AUERBACH 67 is an average of AUERBACH 67 $\Gamma(\pi^0 e^+ \nu_e)/\Gamma(\mu^+ \nu_\mu)$ and CESTER 66 $\Gamma(\pi^0 e^+ \nu_e)/[\Gamma(\mu^+ \nu_\mu) + \Gamma(\pi^+ \pi^0)]$.

$\Gamma(\pi^0 e^+ \nu_e)/[\Gamma(\mu^+ \nu_\mu) + \Gamma(\pi^+ \pi^0)]$ $\Gamma_3/(\Gamma_2+\Gamma_9)$

VALUE (units 10^{-2}) EVTS DOCUMENT ID TECN CHG

5.90±0.09 OUR FIT Error includes scale factor of 1.3.

6.02±0.15 OUR AVERAGE

6.16±0.22 5110 ESCHSTRUTH 68 OSPK +

5.89±0.21 1679 CESTER 66 OSPK +

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

5.92±0.65 ¹¹ WEISSENBE... 76 SPEC +

¹¹ Value calculated from WEISSENBERG 76 ($\pi^0 e \nu$), ($\mu \nu$), and ($\pi \pi^0$) values to eliminate dependence on our 1974 ($\pi 2\pi^0$) and ($\pi \pi^+ \pi^-$) fractions.

$\Gamma(\pi^0 e^+ \nu_e)/[\Gamma(\pi^0 \mu^+ \nu_\mu) + \Gamma(\pi^+ \pi^0) + \Gamma(\pi^+ \pi^0 \pi^0)]$ $\Gamma_3/(\Gamma_4+\Gamma_9+\Gamma_{10})$

VALUE EVTS DOCUMENT ID TECN CHG

0.1914±0.0029 OUR FIT Error includes scale factor of 1.3.

0.1962±0.0008±0.0035 71k SHER 03 B865 +

$\Gamma(\pi^0 e^+ \nu_e)/\Gamma(\pi^+ \pi^0)$ Γ_3/Γ_9

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
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0.238±0.004 OUR FIT Error includes scale factor of 1.3.

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

0.221±0.012	786	¹² LUCAS	73B	HBC	–	Dalitz pairs only
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¹²LUCAS 73B gives $N(K_{e3}) = 786 \pm 3.1\%$, $N(2\pi) = 3564 \pm 3.1\%$. We divide.

$\Gamma(\pi^0 e^+ \nu_e)/\Gamma(\pi^+ \pi^+ \pi^-)$ Γ_3/Γ_{11}

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
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0.890±0.014 OUR FIT Error includes scale factor of 1.3.

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

0.867±0.027	2768	BARMIN	87	XEBC	+
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0.856±0.040	2827	BRAUN	75	HLBC	+
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0.850±0.019	4385	¹³ HAIDT	71	HLBC	+
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0.846±0.021	4385	¹³ EICHTEN	68	HLBC	+
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0.94 ±0.09	854	BELLOTTI	67B	HLBC	
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0.90 ±0.06	230	BORREANI	64	HBC	+
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¹³HAIDT 71 is a reanalysis of EICHTEN 68. Not included in average because of large discrepancy in $\Gamma(\pi^0 \mu^+ \nu)/\Gamma(\pi^0 e^+ \nu)$ with more precise results.

$\Gamma(\pi^0 \mu^+ \nu_\mu)/\Gamma_{\text{total}}$ Γ_4/Γ

<u>VALUE (units 10⁻²)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
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3.32±0.06 OUR FIT Error includes scale factor of 1.2.

3.33±0.16	2345	CHIANG	72	OSPK	+	1.84 GeV/c K ⁺
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• • • We do not use the following data for averages, fits, limits, etc. • • •

2.8 ±0.4		¹⁴ TAYLOR	59	EMUL	+
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¹⁴Earlier experiments not averaged.

$\Gamma(\pi^0 \mu^+ \nu_\mu)/\Gamma(\mu^+ \nu_\mu)$ Γ_4/Γ_2

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
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0.0524±0.0010 OUR FIT Error includes scale factor of 1.2.

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

0.054 ±0.009	240	ZELLER	69	ASPK	+
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0.0480±0.0037	424	¹⁵ GARLAND	68	OSPK	+
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0.0486±0.0040	307	¹⁶ AUERBACH	67	OSPK	+
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¹⁵GARLAND 68 changed from 0.055 ± 0.004 in agreement with μ -spectrum calculation of GAILLARD 70 appendix B. L.G.Pondrom, (private communication 73).

¹⁶AUERBACH 67 changed from 0.0602 ± 0.0046 by erratum which brings the μ -spectrum calculation into agreement with GAILLARD 70 appendix B.

$\Gamma(\pi^0 \mu^+ \nu_\mu)/\Gamma(\pi^0 e^+ \nu_e)$ Γ_4/Γ_3

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
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0.668±0.008 OUR FIT

0.670±0.008 OUR AVERAGE

0.671±0.007±0.008	24k	HORIE	01	SPEC	
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0.670±0.014		¹⁷ HEINTZE	77	SPEC	+
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0.667±0.017	5601	BOTTERILL	68B	ASPK	+
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• • • We do not use the following data for averages, fits, limits, etc. • • •

0.608 ± 0.014	1585	18 BRAUN	75	HLBC	+	
0.705 ± 0.063	554	19 LUCAS	73B	HBC	-	Dalitz pairs only
0.698 ± 0.025	3480	20 CHIANG	72	OSPK	+	1.84 GeV/c K^+
0.596 ± 0.025		21 HAIDT	71	HLBC	+	
0.604 ± 0.022	1398	21 EICHTEN	68	HLBC		
0.703 ± 0.056	1509	CALLAHAN	66B	HLBC		

¹⁷ HEINTZE 77 value from fit to λ_0 . Assumes μ -e universality.

¹⁸ BRAUN 75 value is from form factor fit. Assumes μ -e universality.

¹⁹ LUCAS 73B gives $N(K_{\mu 3}) = 554 \pm 7.6\%$, $N(K_{e 3}) = 786 \pm 3.1\%$. We divide.

²⁰ CHIANG 72 $\Gamma(\pi^0 \mu^+ \nu_\mu) / \Gamma(\pi^0 e^+ \nu_e)$ is statistically independent of CHIANG 72 $\Gamma(\pi^0 \mu^+ \nu_\mu) / \Gamma_{\text{total}}$ and $\Gamma(\pi^0 e^+ \nu_e) / \Gamma_{\text{total}}$.

²¹ HAIDT 71 is a reanalysis of EICHTEN 68. Not included in average because of large discrepancy with more precise results.

$[\Gamma(\pi^0 \mu^+ \nu_\mu) + \Gamma(\pi^+ \pi^0)] / \Gamma_{\text{total}}$ $(\Gamma_4 + \Gamma_9) / \Gamma$

We combine these two modes for experiments measuring them in xenon bubble chamber because of difficulties of separating them there.

<u>VALUE (units 10^{-2})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
24.24 ± 0.11 OUR FIT		Error includes scale factor of 1.1.		

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

25.4 ± 0.9	886	SHAKLEE	64	HLBC	+
23.4 ± 1.1		ROE	61	HLBC	+

$\Gamma(\pi^0 \mu^+ \nu_\mu) / \Gamma(\pi^+ \pi^+ \pi^-)$ Γ_4 / Γ_{11}

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
0.594 ± 0.011 OUR FIT		Error includes scale factor of 1.2.			

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

0.503 ± 0.019	1505	22 HAIDT	71	HLBC	+	
0.510 ± 0.017	1505	22 EICHTEN	68	HLBC	+	
0.63 ± 0.07	2845	23 BISI	65B	BC	+	HBC+HLBC

²² HAIDT 71 is a reanalysis of EICHTEN 68. Not included in average because of large discrepancy in $\Gamma(\pi^0 \mu^+ \nu) / \Gamma(\pi^0 e^+ \nu)$ with more precise results.

²³ Error enlarged for background problems. See GAILLARD 70.

$\Gamma(\pi^0 \pi^0 e^+ \nu_e) / \Gamma_{\text{total}}$ Γ_5 / Γ

<u>VALUE (units 10^{-5})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	
2.2 ± 0.4 OUR FIT					
2.54 ± 0.89	10	BARMIN	88B	HLBC	+

$\Gamma(\pi^0 \pi^0 e^+ \nu_e) / \Gamma(\pi^0 e^+ \nu_e)$ Γ_5 / Γ_3

<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
4.3^{+0.9}_{-0.7} OUR FIT				

4.1^{+1.0}_{-0.7} OUR AVERAGE

$4.2+1.0-0.9$	25	BOLOTOV	86B	CALO	-
$3.8+5.0-1.2$	2	LJUNG	73	HLBC	+

$\Gamma(\pi^+\pi^-\nu_e)/\Gamma(\pi^+\pi^+\pi^-)$

Γ_6/Γ_{11}

VALUE (units 10^{-4}) EVTS DOCUMENT ID TECN CHG

7.31±0.16 OUR AVERAGE

7.35±0.01±0.19 388k ²⁴ PISLAK 01 B865

7.21±0.32 30k ROSSELET 77 SPEC +

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

7.36±0.68 500 BOURQUIN 71 ASPK

7.0 ±0.9 106 SCHWEINB... 71 HLBC +

5.83±0.63 269 ELY 69 HLBC +

²⁴ PISLAK 01 reports $\Gamma(\pi^+\pi^-\nu_e)/\Gamma_{\text{total}} = (4.109 \pm 0.008 \pm 0.110) \times 10^{-5}$ using the PDG 00 value $\Gamma(\pi^+\pi^+\pi^-)/\Gamma_{\text{total}} = (5.59 \pm 0.05) \times 10^{-2}$. We divide by the PDG value and unfold its error from the systematic error. PISLAK 03 gives additional details on the branching ratio measurement and gives improved errors on the S-wave $\pi\text{-}\pi$ scattering length: $a_0^0 = 0.216 \pm 0.013(\text{stat.}) \pm 0.002(\text{syst.}) \pm 0.002(\text{theor.})$.

$\Gamma(\pi^+\pi^-\mu^+\nu_\mu)/\Gamma_{\text{total}}$

Γ_7/Γ

VALUE (units 10^{-5}) EVTS DOCUMENT ID TECN CHG

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

0.77^{+0.54}_{-0.50} 1 CLINE 65 FBC +

$\Gamma(\pi^+\pi^-\mu^+\nu_\mu)/\Gamma(\pi^+\pi^+\pi^-)$

Γ_7/Γ_{11}

VALUE (units 10^{-4}) EVTS DOCUMENT ID TECN CHG

2.57±1.55 7 BISI 67 DBC +

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

~ 2.5 1 GREINER 64 EMUL +

$\Gamma(\pi^0\pi^0\pi^0\nu_e)/\Gamma_{\text{total}}$

Γ_8/Γ

VALUE (units 10^{-6}) CL% EVTS DOCUMENT ID TECN CHG

<3.5 90 0 BOLOTOV 88 SPEC -

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

<9 90 0 BARMIN 92 XEBC +

————— **Hadronic modes** —————

$\Gamma(\pi^+\pi^0)/\Gamma_{\text{total}}$

Γ_9/Γ

VALUE (units 10^{-2}) EVTS DOCUMENT ID TECN CHG COMMENT

20.92±0.12 OUR FIT Error includes scale factor of 1.1.

21.18±0.28 16k CHIANG 72 OSPK + 1.84 GeV/c K^+

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

21.0 ±0.6 CALLAHAN 65 HLBC See $\Gamma(\pi^+\pi^0)/\Gamma(\pi^+\pi^+\pi^-)$

$\Gamma(\pi^+\pi^0)/\Gamma(\pi^+\pi^+\pi^-)$

Γ_9/Γ_{11}

VALUE EVTS DOCUMENT ID TECN CHG

3.742±0.032 OUR FIT Error includes scale factor of 1.1.

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

3.96 ±0.15 1045 CALLAHAN 66 FBC +

$\Gamma(\pi^+\pi^0)/\Gamma(\mu^+\nu_\mu)$

Γ_9/Γ_2

VALUE EVTS DOCUMENT ID TECN CHG COMMENT

0.3297±0.0024 OUR FIT Error includes scale factor of 1.1.

0.3325±0.0032 OUR AVERAGE

0.3329±0.0047±0.0010 45k USHER 92 SPEC + $p\bar{p}$ at rest

0.3355±0.0057 25 WEISSENBE... 76 SPEC +

0.3277±0.0065 4517 26 AUERBACH 67 OSPK +

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

0.328 ±0.005 25k 25 WEISSENBE... 74 STRC +

0.305 ±0.018 1600 ZELLER 69 ASPK +

²⁵ WEISSENBERG 76 revises WEISSENBERG 74.

²⁶ AUERBACH 67 changed from 0.3253 ± 0.0065. See comment with ratio $\Gamma(\pi^0\mu^+\nu_\mu)/\Gamma(\mu^+\nu_\mu)$.

$\Gamma(\pi^+\pi^0\pi^0)/\Gamma_{\text{total}}$

Γ_{10}/Γ

VALUE (units 10⁻²) EVTS DOCUMENT ID TECN CHG COMMENT

1.757±0.024 OUR FIT Error includes scale factor of 1.1.

1.775±0.028 OUR AVERAGE Error includes scale factor of 1.2.

1.763±0.013±0.022 ALOISIO 04A KLOE ±

1.84 ±0.06 1307 CHIANG 72 OSPK + 1.84 GeV/c K^+

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

1.53 ±0.11 198 ²⁷ PANDOULAS 70 EMUL +

1.8 ±0.2 108 SHAKLEE 64 HLBC +

1.7 ±0.2 ROE 61 HLBC +

1.5 ±0.2 ²⁸ TAYLOR 59 EMUL +

²⁷ Includes events of TAYLOR 59.

²⁸ Earlier experiments not averaged.

$\Gamma(\pi^+\pi^0\pi^0)/\Gamma(\pi^+\pi^0)$

Γ_{10}/Γ_9

VALUE EVTS DOCUMENT ID TECN CHG COMMENT

0.0840±0.0013 OUR FIT Error includes scale factor of 1.1.

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

0.081 ±0.005 574 ²⁹ LUCAS 73B HBC - Dalitz pairs only

²⁹ LUCAS 73B gives $N(\pi^2\pi^0) = 574 \pm 5.9\%$, $N(2\pi) = 3564 \pm 3.1\%$. We quote $0.5N(\pi^2\pi^0)/N(2\pi)$ where 0.5 is because only Dalitz pair π^0 's were used.

$\Gamma(\pi^+\pi^0\pi^0)/\Gamma(\pi^+\pi^+\pi^-)$

Γ_{10}/Γ_{11}

VALUE EVTS DOCUMENT ID TECN CHG COMMENT

0.314±0.005 OUR FIT Error includes scale factor of 1.1.

0.303±0.009 2027 BISI 65 BC + HBC+HLBC

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

0.393±0.099 17 YOUNG 65 EMUL +

$\Gamma(\pi^+\pi^+\pi^-)/\Gamma_{\text{total}}$ **Γ_{11}/Γ**

VALUE (units 10^{-2}) EVTS DOCUMENT ID TECN CHG COMMENT

5.590±0.031 OUR FIT Error includes scale factor of 1.1.

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

5.56 ±0.20	2330	³⁰ CHIANG	72	OSPK	+	1.84 GeV/c K^+
5.34 ±0.21	693	³¹ PANDOULAS	70	EMUL	+	
5.71 ±0.15		DEMARCO	65	HBC		
6.0 ±0.4	44	YOUNG	65	EMUL	+	
5.54 ±0.12	2332	CALLAHAN	64	HLBC	+	
5.1 ±0.2	540	SHAKLEE	64	HLBC	+	
5.7 ±0.3		ROE	61	HLBC	+	

³⁰ Value is not independent of CHIANG 72 $\Gamma(\mu^+\nu_\mu)/\Gamma_{\text{total}}$, $\Gamma(\pi^+\pi^0)/\Gamma_{\text{total}}$, $\Gamma(\pi^+\pi^0\pi^0)/\Gamma_{\text{total}}$, $\Gamma(\pi^0\mu^+\nu_\mu)/\Gamma_{\text{total}}$, and $\Gamma(\pi^0e^+\nu_e)/\Gamma_{\text{total}}$.

³¹ Includes events of TAYLOR 59.

————— **Leptonic and semileptonic modes with photons** —————

$\Gamma(\mu^+\nu_\mu\gamma)/\Gamma_{\text{total}}$ **Γ_{12}/Γ**

VALUE (units 10^{-3}) EVTS DOCUMENT ID TECN CHG COMMENT

6.2±0.8 OUR AVERAGE

6.6±1.5	32,33	DEMIDOV	90	XEBC		$P(\mu) < 231.5$ MeV/c
6.0±0.9		BARMIN	88	HLBC	+	$P(\mu) < 231.5$ MeV/c

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

3.5±0.8	33,34	DEMIDOV	90	XEBC		$E(\gamma) > 20$ MeV
3.2±0.5	57	³⁵ BARMIN	88	HLBC	+	$E(\gamma) > 20$ MeV
5.4±0.3	36	AKIBA	85	SPEC		$P(\mu) < 231.5$ MeV/c

³² $P(\mu)$ cut given in DEMIDOV 90 paper, 235.1 MeV/c, is a misprint according to authors (private communication).

³³ DEMIDOV 90 quotes only inner bremsstrahlung (IB) part.

³⁴ Not independent of above DEMIDOV 90 value. Cuts differ.

³⁵ Not independent of above BARMIN 88 value. Cuts differ.

³⁶ Assumes μ -e universality and uses constraints from $K \rightarrow e\nu\gamma$.

$\Gamma(\mu^+\nu_\mu\gamma(\text{SD}^+))/\Gamma_{\text{total}}$ **Γ_{13}/Γ**

Structure-dependent part with $+\gamma$ helicity (SD^+ term). See the "Note on $\pi^\pm \rightarrow \ell^\pm\nu\gamma$ and $K^\pm \rightarrow \ell^\pm\nu\gamma$ Form Factors" in the π^\pm section of the Particle Data Listings above.

VALUE (units 10^{-5}) CL% DOCUMENT ID TECN

<3.0	90	AKIBA	85	SPEC
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$\Gamma(\mu^+\nu_\mu\gamma(\text{SD}^+\text{INT}))/\Gamma_{\text{total}}$ **Γ_{14}/Γ**

Interference term between internal Bremsstrahlung and SD^+ term. See the "Note on $\pi^\pm \rightarrow \ell^\pm\nu\gamma$ and $K^\pm \rightarrow \ell^\pm\nu\gamma$ Form Factors" in the π^\pm section of the Particle Data Listings above.

VALUE (units 10^{-5}) CL% DOCUMENT ID TECN

<2.7	90	AKIBA	85	SPEC
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$\Gamma(\mu^+ \nu_\mu \gamma(SD^- + SD^-INT))/\Gamma_{total}$ Γ_{15}/Γ

Sum of structure-dependent part with $-\gamma$ helicity (SD^- term) and interference term between internal Bremsstrahlung and SD^- term. See the “Note on $\pi^\pm \rightarrow \ell^\pm \nu \gamma$ and $K^\pm \rightarrow \ell^\pm \nu \gamma$ Form Factors” in the π^\pm section of the Particle Data Listings above.

<u>VALUE (units 10^{-4})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
<2.6	90	³⁷ AKIBA	85 SPEC

³⁷ Assumes μ - e universality and uses constraints from $K \rightarrow e \nu \gamma$.

$\Gamma(e^+ \nu_e \gamma(SD^+))/\Gamma_{total}$ Γ_{16}/Γ

Structure-dependent part with $+\gamma$ helicity (SD^+ term). See the “Note on $\pi^\pm \rightarrow \ell^\pm \nu \gamma$ and $K^\pm \rightarrow \ell^\pm \nu \gamma$ Form Factors” in the π^\pm section of the Particle Data Listings above.

<u>VALUE (units 10^{-5})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
<7.1	90	MACEK	70	OSPK +	P(e) 234–247

$\Gamma(e^+ \nu_e \gamma(SD^+))/\Gamma(e^+ \nu_e)$ Γ_{16}/Γ_1

Structure-dependent part with $+\gamma$ helicity (SD^+ term). See the “Note on $\pi^\pm \rightarrow \ell^\pm \nu \gamma$ and $K^\pm \rightarrow \ell^\pm \nu \gamma$ Form Factors” in the π^\pm section of the Particle Data Listings above.

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
$1.05^{+0.25}_{-0.30}$	56	³⁸ HEARD	75	SPEC +	P(e) 236–247

³⁸ This value is included in the first HEINTZE 79 value in the section on $\Gamma(e^+ \nu_e \gamma(SD^+))/\Gamma(\mu^+ \nu_\mu)$ above.

$\Gamma(e^+ \nu_e \gamma(SD^+))/\Gamma(\mu^+ \nu_\mu)$ Γ_{16}/Γ_2

Structure-dependent part with $+\gamma$ helicity (SD^+ term). See the “Note on $\pi^\pm \rightarrow \ell^\pm \nu \gamma$ and $K^\pm \rightarrow \ell^\pm \nu \gamma$ Form Factors” in the π^\pm section of the Particle Data Listings above.

<u>VALUE (units 10^{-5})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
2.40 ± 0.36	107	³⁹ HEINTZE	79	SPEC +

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

2.33 ± 0.42	51	³⁹ HEINTZE	79	SPEC +
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³⁹ First HEINTZE 79 result is second combined with HEARD 75 result from section $\Gamma(e^+ \nu_e \gamma(SD^+))/\Gamma(e^+ \nu_e)$ below.

$\Gamma(e^+ \nu_e \gamma(SD^-))/\Gamma_{total}$ Γ_{17}/Γ

Structure-dependent part with $-\gamma$ helicity (SD^- term). See the “Note on $\pi^\pm \rightarrow \ell^\pm \nu \gamma$ and $K^\pm \rightarrow \ell^\pm \nu \gamma$ Form Factors” in the π^\pm section of the Particle Data Listings above.

<u>VALUE (units 10^{-4})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
<1.6	90	⁴⁰ HEINTZE	79	SPEC +

⁴⁰ Implies (axial vector/vector) amplitude ratio outside range from -1.8 to -0.54 .

$\Gamma(\pi^0 e^+ \nu_e \gamma) / \Gamma(\pi^0 e^+ \nu_e)$

Γ_{18} / Γ_3

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
0.54 ± 0.04		OUR AVERAGE Error includes scale factor of 1.1.			
0.46 ± 0.08	82	⁴¹ BARMIN	91	XEBC	$E(\gamma) > 10$ MeV, $0.6 <$ $\cos\theta_{e\gamma} <$ 0.9
0.56 ± 0.04	192	⁴² BOLOTOV	86B	CALO -	$E(\gamma) > 10$ MeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1.51 ± 0.25	82	⁴¹ BARMIN	91	XEBC	$E(\gamma) > 10$ MeV, $\cos\theta_{e\gamma} <$ 0.98
0.48 ± 0.20	16	⁴³ LJUNG	73	HLBC +	$E(\gamma) > 30$ MeV
$0.22^{+0.15}_{-0.10}$		⁴³ LJUNG	73	HLBC +	$E(\gamma) > 30$ MeV
0.76 ± 0.28	13	⁴⁴ ROMANO	71	HLBC	$E(\gamma) > 10$ MeV
0.53 ± 0.22		⁴⁴ ROMANO	71	HLBC +	$E(\gamma) > 30$ MeV

⁴¹ BARMIN 91 quotes branching ratio $\Gamma(K \rightarrow e\pi^0\nu\gamma) / \Gamma_{\text{all}}$. The measured normalization is $[\Gamma(K \rightarrow e\pi^0\nu) + \Gamma(K \rightarrow \pi^+\pi^+\pi^-)]$. For comparison with other experiments we used $\Gamma(K \rightarrow e\pi^0\nu) / \Gamma_{\text{all}} = 0.0482$ to calculate the values quoted here.

⁴² $\cos\theta(e\gamma)$ between 0.6 and 0.9.

⁴³ First LJUNG 73 value is for $\cos\theta(e\gamma) < 0.9$, second value is for $\cos\theta(e\gamma)$ between 0.6 and 0.9 for comparison with ROMANO 71.

⁴⁴ Both ROMANO 71 values are for $\cos\theta(e\gamma)$ between 0.6 and 0.9. Second value is for comparison with second LJUNG 73 value. We use lowest $E(\gamma)$ cut for Summary Table value. See ROMANO 71 for E_γ dependence.

$\Gamma(\pi^0 e^+ \nu_e \gamma(\text{SD})) / \Gamma_{\text{total}}$

Γ_{19} / Γ

Structure-dependent part.

VALUE (units 10^{-5})	CL%	DOCUMENT ID	TECN	CHG
<5.3	90	BOLOTOV	86B	CALO -

$\Gamma(\pi^0 \mu^+ \nu_\mu \gamma) / \Gamma_{\text{total}}$

Γ_{20} / Γ

VALUE (units 10^{-5})	CL%	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
$1.46 \pm 0.22 \pm 0.32$		153	⁴⁵ TCHIKILEV	07	ISTR -	$30 < E_\gamma < 60$ MeV

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

$2.4 \pm 0.5 \pm 0.6$	125	SHIMIZU	06	K470 +	$E_\gamma > 30$ MeV; $\Theta_{\mu\gamma} > 20^\circ$
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<6.1	90	0	LJUNG	73	HLBC +	$E(\gamma) > 30$ MeV
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⁴⁵ Obtained from measuring $B(K_{\mu 3\gamma}) / B(K_{\mu 3})$ and using PDG 02 value $B(K_{\mu 3}) = 3.37\%$. $B(K_{\mu 3\gamma}) = (8.82 \pm 0.94 \pm 0.86) \times 10^{-5}$ is obtained for $5 \text{ MeV} < E_\gamma < 30 \text{ MeV}$.

$\Gamma(\pi^0 \pi^0 e^+ \nu_e \gamma) / \Gamma_{\text{total}}$

Γ_{21} / Γ

VALUE (units 10^{-6})	CL%	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<5	90	0	BARMIN	92	XEBC +	$E_\gamma > 10$ MeV

————— **Hadronic modes with photons** —————

$\Gamma(\pi^+\pi^0\gamma)/\Gamma_{\text{total}}$ **Γ_{22}/Γ**

<u>VALUE (units 10^{-4})</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
2.75±0.15 OUR AVERAGE						
2.71±0.45		140	BOLOTOV	87	WIRE	− $T\pi^-$ 55–90 MeV
2.87±0.32		2461	SMITH	76	WIRE	± $T\pi^\pm$ 55–90 MeV
2.71±0.19		2100	ABRAMS	72	ASPK	± $T\pi^\pm$ 55–90 MeV
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
1.5 $^{+1.1}_{-0.6}$			⁴⁶ LJUNG	73	HLBC	+ $T\pi^+$ 55–80 MeV
2.6 $^{+1.5}_{-1.1}$			⁴⁶ LJUNG	73	HLBC	+ $T\pi^+$ 55–90 MeV
6.8 $^{+3.7}_{-2.1}$		17	⁴⁶ LJUNG	73	HLBC	+ $T\pi^+$ 55–102 MeV
2.4 ±0.8		24	EDWARDS	72	OSPK	$T\pi^+$ 58–90 MeV
<1.0		0	⁴⁷ MALTSEV	70	HLBC	+ $T\pi^+$ <55 MeV
<1.9	90	0	EMMERSON	69	OSPK	$T\pi^+$ 55–80 MeV
2.2 ±0.7		18	CLINE	64	FBC	+ $T\pi^+$ 55–80 MeV

⁴⁶ The LJUNG 73 values are not independent.

⁴⁷ MALTSEV 70 selects low π^+ energy to enhance direct emission contribution.

$\Gamma(\pi^+\pi^0\gamma(\text{DE}))/\Gamma_{\text{total}}$ **Γ_{23}/Γ**

Direct emission (DE) part of $\Gamma(\pi^+\pi^0\gamma)/\Gamma_{\text{total}}$, assuming that interference (INT) component is zero.

<u>VALUE (units 10^{-6})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
4.3±0.7 OUR AVERAGE					
3.8±0.8±0.7	10k	ALIEV	06	K470	+ $T\pi^+$ 55–90 MeV
3.7±3.9±1.0	930	UVAROV	06	ISTR	− $T\pi^-$ 55–90 MeV
4.7±0.8±0.3	20k	⁴⁸ ADLER	00C	B787	+ $T\pi^+$ 55–90 MeV

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

3.2±1.3±1.0	4k	ALIEV	03	K470	+ $T\pi^+$ 55–90 MeV
6.1±2.5±1.9	4k	ALIEV	03	K470	+ $T\pi^+$ full range
20.5±4.6 $^{+3.9}_{-2.3}$		BOLOTOV	87	WIRE	− $T\pi^-$ 55–90 MeV
15.6±3.5±5.0		ABRAMS	72	ASPK	± $T\pi^\pm$ 55–90 MeV

⁴⁸ ADLER 00C measures the INT component to be $(-0.4 \pm 1.6)\%$ of the inner bremsstrahlung (IB) component.

$\Gamma(\pi^+\pi^0\pi^0\gamma)/\Gamma(\pi^+\pi^0\pi^0)$ **Γ_{24}/Γ_{10}**

<u>VALUE (units 10^{-4})</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
4.3 $^{+3.2}_{-1.7}$	BOLOTOV	85	SPEC	− $E(\gamma) > 10$ MeV

$\Gamma(\pi^+\pi^+\pi^-\gamma)/\Gamma_{\text{total}}$ **Γ_{25}/Γ**

<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
1.04±0.31 OUR AVERAGE					
1.10±0.48	7	BARMIN	89	XEBC	$E(\gamma) > 5$ MeV
1.0 ±0.4		STAMER	65	EMUL	+ $E(\gamma) > 11$ MeV

$\Gamma(\pi^+\gamma\gamma)/\Gamma_{\text{total}}$

Γ_{26}/Γ

VALUE (units 10^{-7})	CL%	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
11±3 ±1		31	⁴⁹ KITCHING	97	B787	
●●● We do not use the following data for averages, fits, limits, etc. ●●●						
< 0.083	90		⁵⁰ ARTAMONOV	05	B949	+ $P_\pi > 213$ MeV/c
< 10	90	0	ATIYA	90B	B787	T_π 117–127 MeV
< 84	90	0	ASANO	82	CNTR	+ T_π 117–127 MeV
−420 ± 520		0	ABRAMS	77	SPEC	+ $T_\pi < 92$ MeV
< 350	90	0	LJUNG	73	HLBC	+ 6–102, 114–127 MeV
< 500	90	0	KLEMS	71	OSPK	+ $T_\pi < 117$ MeV
−100 ± 600			CHEN	68	OSPK	+ T_π 60–90 MeV

⁴⁹KITCHING 97 is extrapolated from their model-independent branching fraction $(6.0 \pm 1.5 \pm 0.7) \times 10^{-7}$ for $100 \text{ MeV}/c < P_{\pi^+} < 180 \text{ MeV}/c$ using Chiral Perturbation Theory.

⁵⁰ARTAMONOV 05 limit assumes ChPT with $\hat{c}=1.8$ with unitarity corrections. With $\hat{c}=1.6$ and no unitarity corrections they obtain $< 2.3 \times 10^{-8}$ at 90% CL. This partial branching ratio is predicted to be 6.10×10^{-9} and 0.49×10^{-9} for the cases with and without unitarity correction.

$\Gamma(\pi^+3\gamma)/\Gamma_{\text{total}}$

Γ_{27}/Γ

Values given here assume a phase space pion energy spectrum.

VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	CHG	COMMENT
<1.0	90	ASANO	82	CNTR	+ $T(\pi)$ 117–127 MeV
●●● We do not use the following data for averages, fits, limits, etc. ●●●					
<3.0	90	KLEMS	71	OSPK	+ $T(\pi) > 117$ MeV

———— Leptonic modes with $\ell\bar{\ell}$ pairs ————

$\Gamma(e^+\nu_e\nu\bar{\nu})/\Gamma(e^+\nu_e)$

Γ_{28}/Γ_1

VALUE	CL%	EVTS	DOCUMENT ID	TECN	CHG	
<3.8	90	0	HEINTZE	79	SPEC	+

$\Gamma(\mu^+\nu_\mu\nu\bar{\nu})/\Gamma_{\text{total}}$

Γ_{29}/Γ

VALUE (units 10^{-6})	CL%	EVTS	DOCUMENT ID	TECN	CHG	
<6.0	90	0	⁵¹ PANG	73	CNTR	+

⁵¹PANG 73 assumes μ spectrum from ν - ν interaction of BARDIN 70.

$\Gamma(e^+\nu_e e^+ e^-)/\Gamma_{\text{total}}$

Γ_{30}/Γ

VALUE (units 10^{-8})	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
2.48± 0.14±0.14	410	POBLAGUEV	02	B865	+ $m_{ee} > 150$ MeV
●●● We do not use the following data for averages, fits, limits, etc. ●●●					
20 ±20	4	DIAMANT-...	76	SPEC	+ $m_{e^+e^-} > 140$ MeV

$\Gamma(\mu^+\nu_\mu e^+ e^-)/\Gamma_{\text{total}}$

Γ_{31}/Γ

VALUE (units 10^{-8})	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
7.06± 0.16±0.26	2.7k	POBLAGUEV	02	B865	+ $m_{ee} > 145$ MeV
●●● We do not use the following data for averages, fits, limits, etc. ●●●					
100 ±30	14	DIAMANT-...	76	SPEC	+ $m_{e^+e^-} > 140$ MeV

$\Gamma(e^+ \nu_e \mu^+ \mu^-) / \Gamma_{\text{total}}$ Γ_{32} / Γ

VALUE (units 10^{-8})	CL%	DOCUMENT ID	TECN
1.72 ± 0.45		MA	06 B865

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

<50	90	ADLER	98 B787
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$\Gamma(\mu^+ \nu_\mu \mu^+ \mu^-) / \Gamma_{\text{total}}$ Γ_{33} / Γ

VALUE (units 10^{-7})	CL%	DOCUMENT ID	TECN	CHG
<4.1	90	ATIYA	89 B787	+

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

$\Gamma(\pi^+ \pi^+ e^- \bar{\nu}_e) / \Gamma_{\text{total}}$ Γ_{34} / Γ
 Test of $\Delta S = \Delta Q$ rule.

VALUE (units 10^{-7})	CL%	EVTS	DOCUMENT ID	TECN	CHG
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• • • We do not use the following data for averages, fits, limits, etc. • • •

< 9.0	95	0	SCHWEINB...	71 HLBC	+
< 6.9	95	0	ELY	69 HLBC	+
<20.	95		BIRGE	65 FBC	+

$\Gamma(\pi^+ \pi^+ e^- \bar{\nu}_e) / \Gamma(\pi^+ \pi^- e^+ \nu_e)$ Γ_{34} / Γ_6
 Test of $\Delta S = \Delta Q$ rule.

VALUE (units 10^{-4})	CL%	EVTS	DOCUMENT ID	TECN
< 3	90	3	⁵² BLOCH	76 SPEC

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

<130.	95	0	BOURQUIN	71 ASPK
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⁵²BLOCH 76 quotes 3.6×10^{-4} at CL = 95%, we convert.

$\Gamma(\pi^+ \pi^+ \mu^- \bar{\nu}_\mu) / \Gamma_{\text{total}}$ Γ_{35} / Γ
 Test of $\Delta S = \Delta Q$ rule.

VALUE (units 10^{-6})	CL%	EVTS	DOCUMENT ID	TECN	CHG
<3.0	95	0	BIRGE	65 FBC	+

$\Gamma(\pi^+ e^+ e^-) / \Gamma_{\text{total}}$ Γ_{36} / Γ
 Test for $\Delta S = 1$ weak neutral current. Allowed by combined first-order weak and electromagnetic interactions.

VALUE (units 10^{-7})	EVTS	DOCUMENT ID	TECN	CHG
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2.88 ± 0.13 OUR AVERAGE

2.94 ± 0.05 ± 0.14	10300	⁵³ APPEL	99	SPEC	+
2.75 ± 0.23 ± 0.13	500	⁵⁴ ALLIEGRO	92	SPEC	+
2.7 ± 0.5	41	⁵⁵ BLOCH	75	SPEC	+

⁵³APPEL 99 establishes vector nature of this decay and determines form factor $f(Z) = f_0(1 + \delta Z)$, $Z = M_{e^+e^-}^2 / m_K^2$, $\delta = 2.14 \pm 0.13 \pm 0.15$.

⁵⁴ALLIEGRO 92 assumes a vector interaction with a form factor given by $\lambda = 0.105 \pm 0.035 \pm 0.015$ and a correlation coefficient of -0.82 .

⁵⁵BLOCH 75 assumes a vector interaction.

$\Gamma(\pi^+ \mu^+ \mu^-)/\Gamma_{\text{total}}$ **Γ_{37}/Γ**

Test for $\Delta S = 1$ weak neutral current. Allowed by higher-order electroweak interactions.

VALUE (units 10^{-8}) CL% EVTS DOCUMENT ID TECN CHG
8.1 ±1.4 OUR AVERAGE Error includes scale factor of 2.7. See the ideogram below.

9.8 ±1.0 ±0.5	110	56	PARK	02	HYCP	±
9.22±0.60±0.49	402	57	MA	00	B865	+
5.0 ±0.4 ±0.9	207	58	ADLER	97C	B787	+

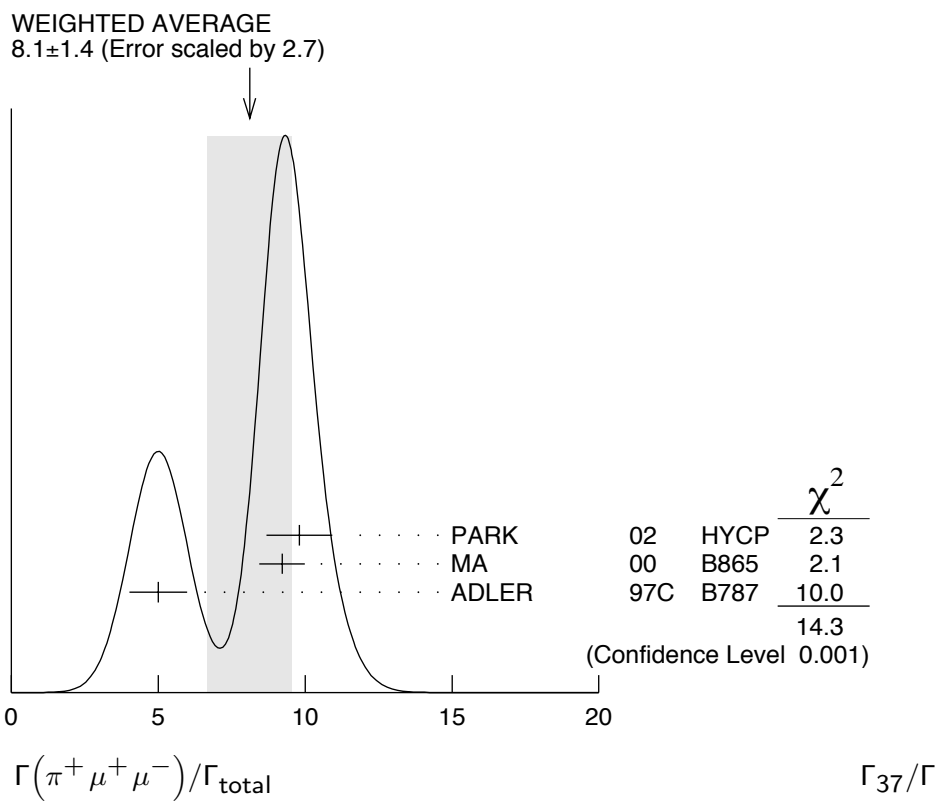
• • • We do not use the following data for averages, fits, limits, etc. • • •

9.7 ±1.2 ±0.4	65		PARK	02	HYCP	+
10.0 ±1.9 ±0.7	35		PARK	02	HYCP	-
<23	90		ATIYA	89	B787	+

⁵⁶ PARK 02 “±” result comes from combining $K^+ \rightarrow \pi^+ \mu^+ \mu^-$ and $K^- \rightarrow \pi^- \mu^+ \mu^-$, assuming CP is conserved.

⁵⁷ MA 00 establishes vector nature of this decay and determines form factor $f(Z) = f_0(1+\delta Z)$, $Z = M_{\mu\mu}^2/m_K^2$, $\delta = 2.45^{+1.30}_{-0.95}$.

⁵⁸ ADLER 97C gives systematic error 0.7×10^{-8} and theoretical uncertainty 0.6×10^{-8} , which we combine in quadrature to obtain our second error.



$\Gamma(\pi^+ \nu \bar{\nu})/\Gamma_{\text{total}}$ **Γ_{38}/Γ**

Test for $\Delta S = 1$ weak neutral current. Allowed by higher-order electroweak interactions. Branching ratio values are extrapolated from the momentum or energy regions shown in the comments assuming Standard Model phase space except for those labeled “Scalar” or “Tensor” to indicate the assumed non-Standard-Model interaction.

<u>VALUE (units 10^{-9})</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>	
$0.147^{+0.130}_{-0.089}$		3	⁵⁹ ANISIMOVSK...04	B949	+	$211 < P_{\pi} < 229$ MeV/c	
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●							
< 2.2	90		⁶⁰ ADLER	04	B787	+	$140 < P_{\pi} < 195$ MeV/c
$0.157^{+0.175}_{-0.082}$		2	ADLER	02	B787		$P_{\pi} > 211$ MeV/c
< 4.2	90	1	ADLER	02C	B787		$140 < P_{\pi} < 195$ MeV/c
< 4.7	90		ADLER	02C	B787		Scalar
< 2.5	90		ADLER	02C	B787		Tensor
$0.15^{+0.34}_{-0.12}$		1	ADLER	00	B787		In ADLER 02
$0.42^{+0.97}_{-0.35}$		1	ADLER	97	B787		
< 2.4	90		ADLER	96	B787		
< 7.5	90		ATIYA	93	B787	+	$T(\pi)$ 115–127 MeV
< 5.2	90		⁶¹ ATIYA	93	B787	+	
< 17	90	0	ATIYA	93B	B787	+	$T(\pi)$ 60–100 MeV
< 34	90		ATIYA	90	B787	+	
< 140	90		ASANO	81B	CNTR	+	$T(\pi)$ 116–127 MeV

⁵⁹ Value obtained combining the previous E787 result ADLER 02 with 2 evts and the present E949 with 1 evt. The additional event has a signal-to-background ratio 0.9.

⁶⁰ Value obtained combining the previous result ADLER 02C with 1 event and the present result with 0 events to obtain an expected background 1.22 ± 0.24 evts and 1 evt observed.

⁶¹ Combining ATIYA 93 and ATIYA 93B results. Superseded by ADLER 96.

$\Gamma(\pi^+ \pi^0 \nu \bar{\nu})/\Gamma_{\text{total}}$ **Γ_{39}/Γ**
 Test for $\Delta S = 1$ weak neutral current. Allowed by higher-order electroweak interactions.

<u>VALUE (units 10^{-5})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
< 4.3	90	⁶² ADLER	01 SPEC

⁶² Search region defined by $90 \text{ MeV}/c < P_{\pi^+} < 188 \text{ MeV}/c$ and $135 \text{ MeV} < E_{\pi^0} < 180 \text{ MeV}$.

$\Gamma(\mu^- \nu_e^+ e^+)/\Gamma(\pi^+ \pi^- e^+ \nu_e)$ **Γ_{40}/Γ_6**
 Test of lepton family number conservation.

<u>VALUE (units 10^{-3})</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
< 0.5	90	0	⁶³ DIAMANT-...	76	SPEC +

⁶³ DIAMANT-BERGER 76 quotes this result times our 1975 $\pi^+ \pi^- e \nu$ BR ratio.

$\Gamma(\mu^+ \nu_e)/\Gamma_{\text{total}}$ **Γ_{41}/Γ**
 Forbidden by lepton family number conservation.

<u>VALUE</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>	
< 0.004	90	0	⁶⁴ LYONS	81	HLBC	0	200 GeV K^+ narrow band ν beam

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

< 0.012	90		⁶⁴ COOPER	82	HLBC		Wideband ν beam
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⁶⁴ COOPER 82 and LYONS 81 limits on ν_e observation are here interpreted as limits on lepton family number violation in the absence of mixing.

$\Gamma(\pi^+ \mu^+ e^-)/\Gamma_{\text{total}}$ Γ_{42}/Γ

Test of lepton family number conservation.

<u>VALUE (units 10^{-10})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
<0.13	90	⁶⁵ SHER	05	RVUE +
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.21	90	SHER	05	B865 +
<0.39	90	APPEL	00	B865 +
<2.1	90	LEE	90	SPEC +

⁶⁵ This result combines SHER 05 1998 data, APPEL 00 1996 data, and data from BERGMAN 97 and PISLAK 97 theses, all from BNL-E865, with LEE 90 BNL-E777 data.

$\Gamma(\pi^+ \mu^- e^+)/\Gamma_{\text{total}}$ Γ_{43}/Γ

Test of lepton family number conservation.

<u>VALUE (units 10^{-10})</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
< 5.2	90	0	APPEL	00B	B865 +
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<70	90	0	⁶⁶ DIAMANT-...	76	SPEC +

⁶⁶ Measurement actually applies to the sum of the $\pi^+ \mu^- e^+$ and $\pi^- \mu^+ e^+$ modes.

$\Gamma(\pi^- \mu^+ e^+)/\Gamma_{\text{total}}$ Γ_{44}/Γ

Test of total lepton number conservation.

<u>VALUE (units 10^{-10})</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
< 5.0	90	0	APPEL	00B	B865 +
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<70	90	0	⁶⁷ DIAMANT-...	76	SPEC +

⁶⁷ Measurement actually applies to the sum of the $\pi^+ \mu^- e^+$ and $\pi^- \mu^+ e^+$ modes.

$\Gamma(\pi^- e^+ e^+)/\Gamma_{\text{total}}$ Γ_{45}/Γ

Test of total lepton number conservation.

<u>VALUE</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
< 6.4×10^{-10}	90	0	APPEL	00B	B865 +
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 9.2×10^{-9}	90	0	DIAMANT-...	76	SPEC +
< 1.5×10^{-5}			CHANG	68	HBC -

$\Gamma(\pi^- \mu^+ \mu^+)/\Gamma_{\text{total}}$ Γ_{46}/Γ

Forbidden by total lepton number conservation.

<u>VALUE</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
< 3.0×10^{-9}	90	0	APPEL	00B	B865 +
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 1.5×10^{-4}	90		⁶⁸ LITTENBERG	92	HBC

⁶⁸ LITTENBERG 92 is from retroactive data analysis of CHANG 68 bubble chamber data.

$\Gamma(\mu^+\bar{\nu}_e)/\Gamma_{\text{total}}$ Γ_{47}/Γ

Forbidden by total lepton number conservation.

VALUE (units 10^{-3})	CL%	DOCUMENT ID	TECN	COMMENT
<3.3	90	⁶⁹ COOPER	82 HLBC	Wideband ν beam

⁶⁹ COOPER 82 limit on $\bar{\nu}_e$ observation is here interpreted as a limit on lepton number violation in the absence of mixing.

$\Gamma(\pi^0 e^+\bar{\nu}_e)/\Gamma_{\text{total}}$ Γ_{48}/Γ

Forbidden by total lepton number conservation.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.003	90	⁷⁰ COOPER	82 HLBC	Wideband ν beam

⁷⁰ COOPER 82 limit on $\bar{\nu}_e$ observation is here interpreted as a limit on lepton number violation in the absence of mixing.

$\Gamma(\pi^+\gamma)/\Gamma_{\text{total}}$ Γ_{49}/Γ

Violates angular momentum conservation and gauge invariance. Current interest in this decay is as a search for non-commutative space-time effects as discussed in ARTAMONOV 05 and for exotic physics such as a vacuum expectation value of a new vector field, non-local Superstring effects, or departures from Lorentz invariance, as discussed in ADLER 02B.

VALUE (units 10^{-9})	CL%	DOCUMENT ID	TECN	CHG
< 2.3	90	ARTAMONOV 05	B949	+
< 360	90	ADLER 02B	B787	+
<1400	90	ASANO 82	CNTR	+
<4000	90	⁷¹ KLEMS 71	OSPK	+

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

⁷¹ Test of model of Selleri, Nuovo Cimento **60A** 291 (1969).

K^+ LONGITUDINAL POLARIZATION OF EMITTED μ^+

VALUE	CL%	DOCUMENT ID	TECN	CHG	COMMENT
<-0.990	90	⁷² AOKI 94	SPEC	+	
<-0.990	90	IMAZATO 92	SPEC	+	Repl. by AOKI 94
-0.970 ± 0.047		⁷³ YAMANAKA 86	SPEC	+	
-1.0 ± 0.1		⁷³ CUTTS 69	SPRK	+	
-0.96 ± 0.12		⁷³ COOMBES 57	CNTR	+	

⁷² AOKI 94 measures $\xi P_\mu = -0.9996 \pm 0.0030 \pm 0.0048$. The above limit is obtained by summing the statistical and systematic errors in quadrature, normalizing to the physically significant region ($|\xi P_\mu| < 1$) and assuming that $\xi=1$, its maximum value.

⁷³ Assumes $\xi=1$.

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ENERGY DEPENDENCE OF K^\pm DALITZ PLOT

$$|\text{matrix element}|^2 = 1 + gu + hu^2 + kv^2$$

where $u = (s_3 - s_0) / m_\pi^2$ and $v = (s_2 - s_1) / m_\pi^2$

LINEAR COEFFICIENT g_+ FOR $K^+ \rightarrow \pi^+ \pi^+ \pi^-$

Some experiments use Dalitz variables x and y . In the comments we give $a_y =$ coefficient of y term. See note above on "Dalitz Plot Parameters for $K \rightarrow 3\pi$ Decays." For discussion of the conversion of a_y to g , see the earlier version of the same note in the *Review* published in Physics Letters **111B** 70 (1982).

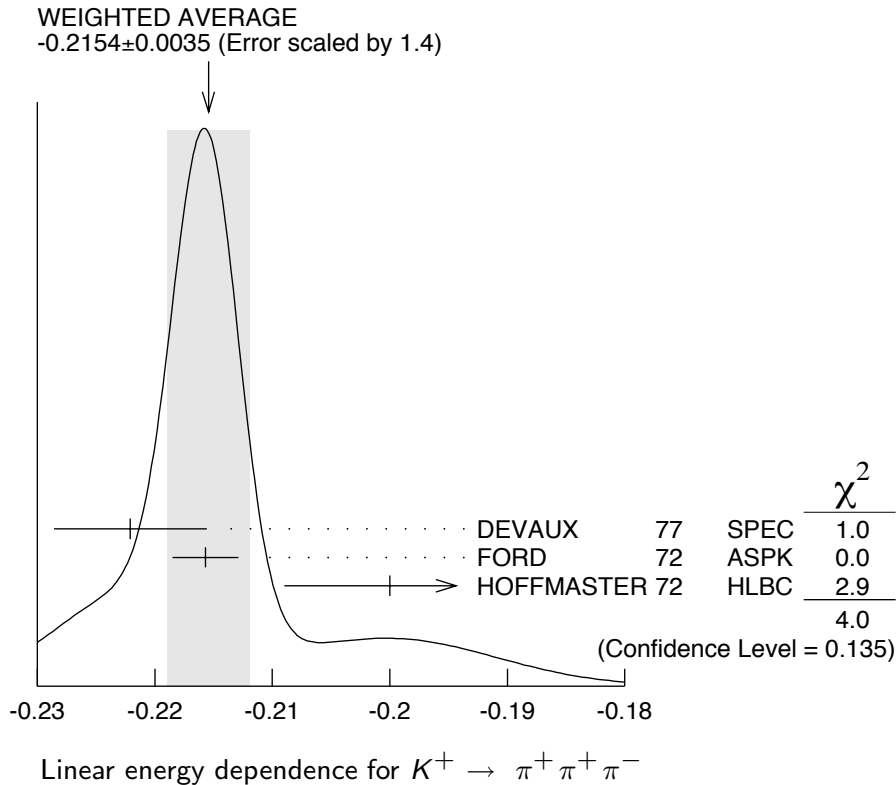
VALUE	EVTs	DOCUMENT ID	TECN	CHG	COMMENT
-0.2154 ± 0.0035 OUR AVERAGE					Error includes scale factor of 1.4. See the ideogram below.
-0.2221 ± 0.0065	225k	DEVAUX	77	SPEC	+ $a_y = .2814 \pm .0082$
-0.2157 ± 0.0028	750k	FORD	72	ASPK	+ $a_y = .2734 \pm .0035$
-0.200 ± 0.009	39819	⁷⁴ HOFFMASTER	72	HLBC	+
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
-0.196 ± 0.012	17898	⁷⁵ GRAUMAN	70	HLBC	+ $a_y = 0.228 \pm 0.030$
-0.218 ± 0.016	9994	⁷⁶ BUTLER	68	HBC	+ $a_y = 0.277 \pm 0.020$
-0.22 ± 0.024	5428	^{76,77} ZINCHENKO	67	HBC	+ $a_y = 0.28 \pm 0.03$

⁷⁴HOFFMASTER 72 includes GRAUMAN 70 data.

⁷⁵Emulsion data added — all events included by HOFFMASTER 72.

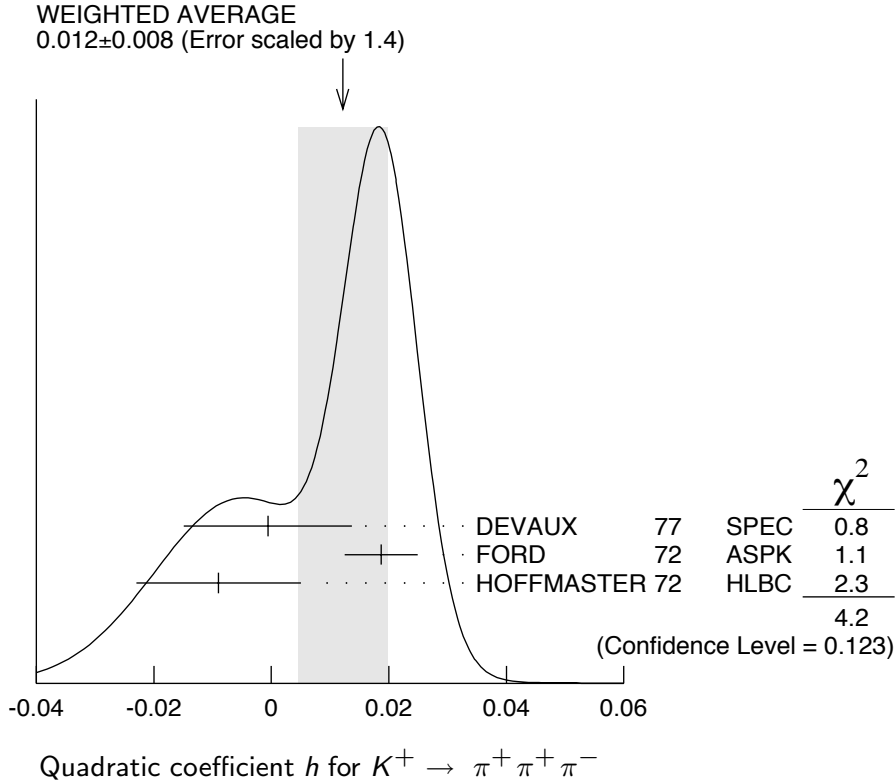
⁷⁶Experiments with large errors not included in average.

⁷⁷Also includes DBC events.



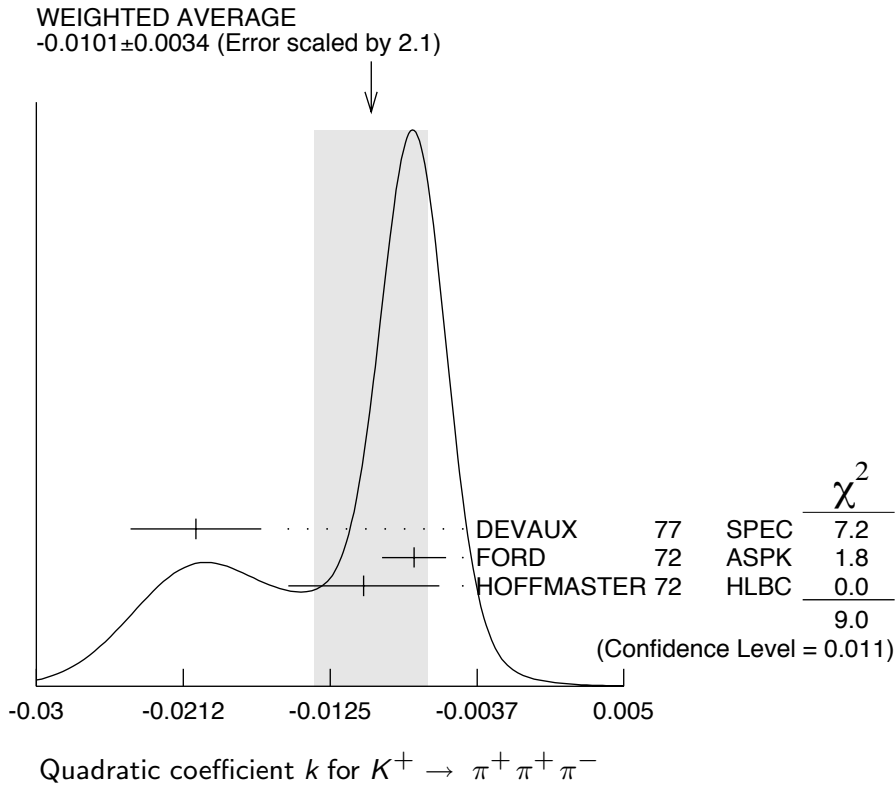
QUADRATIC COEFFICIENT h FOR $K^+ \rightarrow \pi^+ \pi^+ \pi^-$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
0.012 ± 0.008	OUR AVERAGE	Error includes scale factor of 1.4. See the ideogram below.		
-0.0006 ± 0.0143	225k	DEVAUX	77	SPEC +
0.0187 ± 0.0062	750k	FORD	72	ASPK +
-0.009 ± 0.014	39819	HOFFMASTER72	HLBC	+



QUADRATIC COEFFICIENT k FOR $K^+ \rightarrow \pi^+ \pi^+ \pi^-$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
-0.0101 ± 0.0034	OUR AVERAGE	Error includes scale factor of 2.1. See the ideogram below.		
-0.0205 ± 0.0039	225k	DEVAUX	77	SPEC +
-0.0075 ± 0.0019	750k	FORD	72	ASPK +
-0.0105 ± 0.0045	39819	HOFFMASTER72	HLBC	+



LINEAR COEFFICIENT g_- FOR $K^- \rightarrow \pi^- \pi^- \pi^+$

Some experiments use Dalitz variables x and y . In the comments we give $a_y =$ coefficient of y term. See note above on “Dalitz Plot Parameters for $K \rightarrow 3\pi$ Decays.” For discussion of the conversion of a_y to g , see the earlier version of the same note in the *Review* published in *Physics Letters* **111B** 70 (1982).

VALUE	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
-0.217 ± 0.007	OUR AVERAGE	Error includes scale factor of 2.5.			
-0.2186 ± 0.0028	750k	FORD	72	ASPK	— $a_y = 0.2770 \pm 0.0035$
-0.193 ± 0.010	50919	MAST	69	HBC	— $a_y = 0.244 \pm 0.013$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
-0.199 ± 0.008	81k	⁷⁸ LUCAS	73	HBC	— $a_y = 0.252 \pm 0.011$
-0.190 ± 0.023	5778	^{79,80} MOSCOSO	68	HBC	— $a_y = 0.242 \pm 0.029$
-0.220 ± 0.035	1347	⁸¹ FERRO-LUZZI	61	HBC	— $a_y = 0.28 \pm 0.045$

⁷⁸ Quadratic dependence is required by K_L^0 experiments. For comparison we average only those K^\pm experiments which quote quadratic fit values.

⁷⁹ Experiments with large errors not included in average.

⁸⁰ Also includes DBC events.

⁸¹ No radiative corrections included.

QUADRATIC COEFFICIENT h FOR $K^- \rightarrow \pi^- \pi^- \pi^+$

VALUE	EVTS	DOCUMENT ID	TECN	CHG
0.010 ± 0.006	OUR AVERAGE			
0.0125 ± 0.0062	750k	FORD	72	ASPK —
-0.001 ± 0.012	50919	MAST	69	HBC —

QUADRATIC COEFFICIENT k FOR $K^- \rightarrow \pi^- \pi^- \pi^+$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
-0.0084 ± 0.0019 OUR AVERAGE				
-0.0083 ± 0.0019	750k	FORD	72	ASPK -
-0.014 ± 0.012	50919	MAST	69	HBC -

$(g_+ - g_-) / (g_+ + g_-)$ FOR $K^\pm \rightarrow \pi^\pm \pi^+ \pi^-$

A nonzero value for this quantity indicates CP violation.

<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
1.5 ± 2.9 OUR AVERAGE			
1.7 ± 2.1 ± 2.0	1.7G	⁸² BATLEY	06 NA48
-7.0 ± 53	3.2M	FORD	70 ASPK

⁸² This measurement neglects any possible charge asymmetry in higher order slope parameters h or k .

LINEAR COEFFICIENT g FOR $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$

Unless otherwise stated, all experiments include terms quadratic in $(s_3 - s_0) / m_{\pi^+}^2$. See note above on "Dalitz Plot Parameters for $K \rightarrow 3\pi$ Decays."

See BATUSOV 98 for a discussion of the discrepancy between their result and others, especially BOLOTOV 86. At this time we have no way to resolve the discrepancy so we depend on the large scale factor as a warning.

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
0.626 ± 0.007 OUR AVERAGE					
0.6259 ± 0.0043 ± 0.0093	493k	AKOPDZHAN..05B	TNF	±	
0.627 ± 0.004 ± 0.010	252k	^{83,84} AJINENKO	03B	ISTR	-
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
0.736 ± 0.014 ± 0.012	33k	BATUSOV	98	SPEC	+
0.582 ± 0.021	43k	BOLOTOV	86	CALO	-
0.670 ± 0.054	3263	BRAUN	76B	HLBC	+
0.630 ± 0.038	5635	SHEAFF	75	HLBC	+
0.510 ± 0.060	27k	SMITH	75	WIRE	+
0.67 ± 0.06	1365	AUBERT	72	HLBC	+
0.544 ± 0.048	4048	DAVISON	69	HLBC	+

⁸³ Measured using in-flight decays of the 25 GeV negative secondary beam.

⁸⁴ They form new world averages $g_- = (0.617 \pm 0.018)$ and $g_+ = (0.684 \pm 0.033)$ which give $\Delta g_{\pi^0} = 0.051 \pm 0.028$.

QUADRATIC COEFFICIENT h FOR $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
0.052 ± 0.008 OUR AVERAGE					
0.0551 ± 0.0044 ± 0.0086	493k	AKOPDZHAN..05B	TNF	±	
0.046 ± 0.004 ± 0.012	252k	⁸⁵ AJINENKO	03B	ISTR	-
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
0.128 ± 0.015 ± 0.024	33k	BATUSOV	98	SPEC	+
0.037 ± 0.024	43k	BOLOTOV	86	CALO	-
0.152 ± 0.082	3263	BRAUN	76B	HLBC	+
0.041 ± 0.030	5635	SHEAFF	75	HLBC	+
0.009 ± 0.040	27k	SMITH	75	WIRE	+
-0.01 ± 0.08	1365	AUBERT	72	HLBC	+
0.026 ± 0.050	4048	DAVISON	69	HLBC	+

⁸⁵ Measured using in-flight decays of the 25 GeV negative secondary beam.

QUADRATIC COEFFICIENT k FOR $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
0.0054 ± 0.0035 OUR AVERAGE				
Error includes scale factor of 2.5.				
0.0082 ± 0.0011 ± 0.0014	493k	AKOPDZHAN..05B	TNF	±
0.001 ± 0.001 ± 0.002	252k	⁸⁶ AJINENKO	03B ISTR	–

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

0.0197 ± 0.0045 ± 0.0029	33k	BATUSOV	98 SPEC	+
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⁸⁶ Measured using in-flight decays of the 25 GeV negative secondary beam.

$(g_+ - g_-) / (g_+ + g_-)$ FOR $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$

A nonzero value for this quantity indicates CP violation.

<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
1.8 ± 2.5 OUR AVERAGE			
1.8 ± 2.2 ± 1.3	47M	⁸⁷ BATLEY	06A NA48
2 ± 18 ± 5	619k	⁸⁸ AKOPDZHAN..05	TNF

⁸⁷ Linear and quadratic slopes from PDG 04 used.

⁸⁸ Asymmetry obtained assuming that $g_+ + g_- = 2 \times 0.652$ (PDG 02) and that asymmetries in h and k are zero.

ALTERNATIVE PARAMETERIZATION OF $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$ DALITZ PLOT

The following functional form for the matrix element suggested by $\pi\pi$ rescattering in $K^+ \rightarrow \pi^+ \pi^+ \pi^- \rightarrow \pi^+ \pi^0 \pi^0$ is used for this fit (CABIBBO 04A, CABIBBO 05): Matrix element = $M_0 + M_1$ where $M_0 = 1 + (1/2)g_0 u + (1/2)h' u^2$ with $u = (s_3 - s_0)/(m_{\pi^+})^2$ and where M_1 takes into account the non-analytic piece due to $\pi\pi$ rescattering amplitudes a_0 and a_2 ; The parameters g_0 and h' are related to the parameters g and h of the matrix element squared given in the previous section by the approximations $g_0 \sim g^{PDG}$ and $h' \sim h^{PDG} - (g/2)^2$.

LINEAR COEFFICIENT g_0 FOR $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
0.645 ± 0.004 ± 0.009	23M	⁸⁹ BATLEY	06B NA48	±

⁸⁹ This fit is obtained with the CABIBBO 05 matrix element in the $2\pi^0$ invariant mass squared range $0.074 \text{ GeV}^2 < m_{2\pi^0}^2 < 0.097 \text{ GeV}^2$, assuming $k = 0$ (no term proportional to $(s_2 - s_1)^2$) and excluding the kinematic region around the cusp ($m_{2\pi^0}^2 = (2m_{\pi^+})^2 \pm 0.000525 \text{ GeV}^2$). Also $\pi-\pi$ phase shifts a_0 and a_2 are measured: $(a_0 - a_2)m_{\pi^+} = 0.268 \pm 0.010 \pm 0.004 \pm 0.013(\text{external})$ and $a_2 m_{\pi^+} = -0.041 \pm 0.022 \pm 0.014$.

QUADRATIC COEFFICIENT h' FOR $K^\pm \rightarrow \pi^\pm \pi^0 \pi^0$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
-0.047 ± 0.012 ± 0.011	23M	⁹⁰ BATLEY	06B NA48	±

⁹⁰This fit is obtained with the CABIBBO 05 matrix element in the $2\pi^0$ invariant mass squared range $0.074 \text{ GeV}^2 < m_{2\pi^0}^2 < 0.097 \text{ GeV}^2$, assuming $k = 0$ (no term proportional to $(s_2 - s_1)^2$) and excluding the kinematic region around the cusp ($m_{2\pi^0}^2 = (2m_{\pi^+})^2 \pm 0.000525 \text{ GeV}^2$). Also $\pi - \pi$ phase shifts a_0 and a_2 are measured: $(a_0 - a_2)m_{\pi^+} = 0.268 \pm 0.010 \pm 0.004 \pm 0.013(\text{external})$ and $a_2 m_{\pi^+} = -0.041 \pm 0.022 \pm 0.014$.

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K_{e3}^{\pm} FORM FACTORS

In the form factor comments, the following symbols are used.

f_+ and f_- are form factors for the vector matrix element.

f_S and f_T refer to the scalar and tensor term.

$$f_0 = f_+ + f_- t / (m_{K^+}^2 - m_{\pi^0}^2).$$

t = momentum transfer to the π .

λ_+ and λ_0 are the linear expansion coefficients of f_+ and f_0 :

$$f_+(t) = f_+(0) (1 + \lambda_+ t / m_{\pi^+}^2)$$

For quadratic expansion

$$f_+(t) = f_+(0) (1 + \lambda'_+ t / m_{\pi^+}^2 + \frac{\lambda''_+}{2} t^2 / m_{\pi^+}^4)$$

as used by KTeV. If there is a non-vanishing quadratic term, then λ_+ represents an average slope, which is then different from λ'_+ .

NA48 and ISTRA quadratic expansion coefficients are converted with

$$\lambda'_+{}^{PDG} = \lambda_+{}^{NA48} \text{ and } \lambda''_+{}^{PDG} = 2 \lambda'_+{}^{NA48}$$

$$\lambda'_+{}^{PDG} = \left(\frac{m_{\pi^+}}{m_{\pi^0}}\right)^2 \lambda_+{}^{ISTRA} \text{ and}$$

$$\lambda''_+{}^{PDG} = 2 \left(\frac{m_{\pi^+}}{m_{\pi^0}}\right)^4 \lambda'_+{}^{ISTRA}$$

ISTRA linear expansion coefficients are converted with

$$\lambda_+{}^{PDG} = \left(\frac{m_{\pi^+}}{m_{\pi^0}}\right)^2 \lambda_+{}^{ISTRA} \text{ and } \lambda_0{}^{PDG} = \left(\frac{m_{\pi^+}}{m_{\pi^0}}\right)^2 \lambda_0{}^{ISTRA}$$

The pole parametrization is

$$f_+(t) = f_+(0) \left(\frac{M_V^2}{M_V^2 - t}\right)$$

$$f_0(t) = f_0(0) \left(\frac{M_S^2}{M_S^2 - t}\right)$$

where M_V and M_S are the vector and scalar pole masses.

The following abbreviations are used:

DP = Dalitz plot analysis.

PI = π spectrum analysis.

MU = μ spectrum analysis.

POL = μ polarization analysis.

BR = $K_{\mu 3}^{\pm} / K_{e 3}^{\pm}$ branching ratio analysis.

E = positron or electron spectrum analysis.

RC = radiative corrections.

λ_+ (LINEAR ENERGY DEPENDENCE OF f_+ IN K_{e3}^\pm DECAY)

These results are for a linear expansion only. See the next section for fits including a quadratic term. For radiative correction of the K_{e3}^\pm Dalitz plot, see GINSBERG 67, BECHERRAWY 70, CIRIGLIANO 02, CIRIGLIANO 04, and ANDRE 04. Results labeled OUR FIT are discussed in the review “ $K_{\ell 3}^\pm$ and $K_{\ell 3}^0$ Form Factors” above. For earlier, lower statistics results, see the 2004 edition of this review, Physics Letters **B592** 1 (2004).

<u>VALUE (units 10^{-2})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>	
2.96 ± 0.05 OUR FIT	Assuming μ -e universality					
2.96 ± 0.06 OUR AVERAGE						
2.966 ± 0.050 ± 0.034	919k	⁹¹ YUSHCHENKO04B	ISTR	–	DP	
2.78 ± 0.26 ± 0.30	41k	SHIMIZU	00	SPEC	+	DP
2.84 ± 0.27 ± 0.20	32k	⁹² AKIMENKO	91	SPEC		PI, no RC
2.9 ± 0.4	62k	⁹³ BOLOTOV	88	SPEC		PI, no RC
• • • We do not use the following data for averages, fits, limits, etc. • • •						
3.06 ± 0.09 ± 0.06	550k	^{91,94} AJINENKO	03C	ISTR	–	DP
2.93 ± 0.15 ± 0.2	130k	⁹⁴ AJINENKO	02	SPEC		DP

⁹¹ Rescaled to agree with our conventions as noted above.

⁹² AKIMENKO 91 state that radiative corrections would raise λ_+ by 0.0013.

⁹³ BOLOTOV 88 state radiative corrections of GINSBERG 67 would raise λ_+ by 0.002.

⁹⁴ Superseded by YUSHCHENKO 04B.

λ_+ (LINEAR ENERGY DEPENDENCE OF f_+ IN $K_{\mu 3}^\pm$ DECAY)

Results labeled OUR FIT are discussed in the review “ $K_{\ell 3}^\pm$ and $K_{\ell 3}^0$ Form Factors” above. For earlier, lower statistics results, see the 2004 edition of this review, Physics Letters **B592** 1 (2004).

<u>VALUE (units 10^{-2})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>	
2.96 ± 0.05 OUR FIT	Assuming μ -e universality					
2.96 ± 0.17 OUR FIT	Not assuming μ -e universality					
2.96 ± 0.14 ± 0.10	540k	⁹⁵ YUSHCHENKO04	ISTR	–	DP	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
3.21 ± 0.45	112k	⁹⁶ AJINENKO	03	ISTR	–	DP
⁹⁵ Rescaled to agree with our conventions as noted above.						
⁹⁶ Superseded by YUSHCHENKO 04.						

λ_0 (LINEAR ENERGY DEPENDENCE OF f_0 IN $K_{\mu 3}^\pm$ DECAY)

Results labeled OUR FIT are discussed in the review “ $K_{\ell 3}^\pm$ and $K_{\ell 3}^0$ Form Factors” above. For earlier, lower statistics results, see the 2004 edition of this review, Physics Letters **B592** 1 (2004).

<u>VALUE (units 10^{-2})</u>	<u>$d\lambda_0/d\lambda_+$</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
1.96 ± 0.12 OUR FIT	Assuming μ -e universality. Correlation is $d\lambda_0/d\lambda_+ = -0.35$.					
1.96 ± 0.13 OUR FIT	Not assuming μ -e universality. Correlation is $d\lambda_0/d\lambda_+ = -0.35$.					
+1.96 ± 0.12 ± 0.06	–0.348	540k	⁹⁷ YUSHCHENKO04	ISTR	–	DP

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

+2.09±0.45	-0.46	112k	⁹⁸ AJINENKO	03	ISTR	-	DP
+1.9 ±0.64		24k	⁹⁹ HORIE	01	SPEC	+	BR
+1.9 ±1.0	+0.03	55k	¹⁰⁰ HEINTZE	77	SPEC	+	BR

⁹⁷ Rescaled to agree with our conventions as noted above.

⁹⁸ Superseded by YUSHCHENKO 04.

⁹⁹ HORIE 01 assumes μ - e universality in $K_{\ell 3}^+$ decay and uses SHIMIZU 00 value $\lambda=0.0278 \pm 0.0040$ from K_{e3}^+ decay.

¹⁰⁰ HEINTZE 77 uses $\lambda_+ = 0.029 \pm 0.003$. $d\lambda_0/d\lambda_+$ estimated by us.

λ'_+ (LINEAR K_{e3}^{\pm} FORM FACTOR FROM QUADRATIC FIT)

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
2.485±0.163±0.034	919k ^{101,102}	YUSHCHENKO04B	ISTR	-	DP

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

3.07 ±0.21	550k ^{101,103}	AJINENKO	03C	ISTR	-	DP
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¹⁰¹ Rescaled to agree with our conventions as noted above.

¹⁰² YUSHCHENKO 04B λ'_+ and λ''_+ are strongly correlated with coefficient $\rho(\lambda'_+, \lambda''_+) = -0.95$.

¹⁰³ Superseded by YUSHCHENKO 04B.

λ''_+ (QUADRATIC K_{e3}^{\pm} FORM FACTOR)

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
0.192±0.062±0.071	919k ^{104,105}	YUSHCHENKO04B	ISTR	-	DP

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

-0.5 ±0.7 ±1.5	550k ^{104,106}	AJINENKO	03C	ISTR	-	DP
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¹⁰⁴ Rescaled to agree with our conventions as noted above.

¹⁰⁵ YUSHCHENKO 04B λ'_+ and λ''_+ are strongly correlated with coefficient $\rho(\lambda'_+, \lambda''_+) = -0.95$.

¹⁰⁶ Superseded by YUSHCHENKO 04B.

$|f_S/f_+|$ FOR K_{e3}^{\pm} DECAY

Ratio of scalar to f_+ couplings.

VALUE (units 10^{-2})	CL%	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
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- **0.3 \pm 0.8 \pm 0.7** OUR AVERAGE

- 0.37 \pm 0.66 \pm 0.56 ±0.41	919k	YUSHCHENKO04B	ISTR	-		$\lambda'_+, \lambda''_+, f_S$ fit
0.2 ± 2.6 ±1.4	41k	SHIMIZU	00	SPEC	+	λ_+, f_S, f_T fit

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

0.2 \pm 2.0 \pm 2.2 ±0.3	550k	¹⁰⁷ AJINENKO	03C	ISTR	-	λ_+, f_S, f_T fit
- 1.9 \pm 2.5 \pm 1.6	130k	¹⁰⁷ AJINENKO	02	SPEC		λ_+, f_S fit
7.0 ± 1.6 ±1.6	32k	AKIMENKO	91	SPEC		$\lambda_+, f_S, f_T, \phi$ fit
0 ±10	2827	¹⁰⁸ BRAUN	75	HLBC	+	
< 13	90	4017 CHIANG	72	OSPK	+	

14	$\begin{matrix} + 3 \\ - 4 \end{matrix}$	2707	¹⁰⁸ STEINER	71	HLBC	+	$\lambda_+, f_S, f_T,$ ϕ fit
< 23		90	BOTTERILL	68C	ASPK		
< 18		90	BELLOTTI	67B	HLBC		
< 30		95	KALMUS	67	HLBC	+	

¹⁰⁷ Superseded by YUSHCHENKO 04B.

¹⁰⁸ Statistical errors only.

$|f_T/f_+|$ FOR K_{e3}^\pm DECAY

Ratio of tensor to f_+ couplings.

VALUE (units 10^{-2})	CL%	EVTS	DOCUMENT ID	TECN	CHG	COMMENT	
= 1.2 ± 2.3 OUR AVERAGE							
– 1.2 ± 2.1 ± 1.1		919k	YUSHCHENKO04B	ISTR	–	$\lambda'_+, \lambda''_+,$ f_T fit	
1 ± 14 ± 9		41k	SHIMIZU	00	SPEC	+	λ_+, f_S, f_T fit

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

2.1 $\begin{matrix} + \\ - \end{matrix}$ $\begin{matrix} 6.4 \\ 7.5 \end{matrix}$ ± 2.6		550k	¹⁰⁹ AJINENKO	03C	ISTR	–	λ_+, f_S, f_T fit
– 4.5 $\begin{matrix} + \\ - \end{matrix}$ $\begin{matrix} 6.0 \\ 5.7 \end{matrix}$		130k	¹⁰⁹ AJINENKO	02	SPEC		λ_+, f_T fit
53 $\begin{matrix} + \\ - \end{matrix}$ $\begin{matrix} 9 \\ 10 \end{matrix}$ ± 10		32k	AKIMENKO	91	SPEC		$\lambda_+, f_S, f_T,$ ϕ fit
7 ± 37		2827	¹¹⁰ BRAUN	75	HLBC	+	
< 75.	90	4017	CHIANG	72	OSPK	+	
24 $\begin{matrix} + 16 \\ - 14 \end{matrix}$		2707	¹¹⁰ STEINER	71	HLBC	+	$\lambda_+, f_S, f_T,$ ϕ fit
< 58.	90		BOTTERILL	68C	ASPK		
< 58.	90		BELLOTTI	67B	HLBC		
< 110.	95		KALMUS	67	HLBC	+	

¹⁰⁹ Superseded by YUSHCHENKO 04B.

¹¹⁰ Statistical errors only.

f_S/f_+ FOR $K_{\mu 3}^\pm$ DECAY

Ratio of scalar to f_+ couplings.

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
0.17 ± 0.14 ± 0.54	540k	¹¹¹ YUSHCHENKO04	ISTR	–	DP

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

0.4 ± 0.5 ± 0.5	112k	¹¹² AJINENKO	03	ISTR	–	DP
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¹¹¹ The second error is the theoretical error from the uncertainty in the chiral perturbation theory prediction for λ_0 , ±0.0053, combined in quadrature with the systematic error ±0.0009.

¹¹² The second error is the theoretical error from the uncertainty in the chiral perturbation theory prediction for λ_0 . Superseded by YUSHCHENKO 04.

f_T/f_+ FOR $K_{\mu 3}^{\pm}$ DECAY

Ratio of tensor to f_+ couplings.

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
$-0.07 \pm 0.71 \pm 0.20$	540k	YUSHCHENKO04	ISTR	-	DP
$-2.1 \pm 2.8 \pm 1.4$	112k	¹¹³ AJINENKO	03	ISTR	- DP
2 ± 12	1585	BRAUN	75	HLBC	

¹¹³The second error is the theoretical error from the uncertainty in the chiral perturbation theory prediction for λ_0 . Superseded by YUSHCHENKO 04.

DECAY FORM FACTORS FOR $K^{\pm} \rightarrow \pi^+ \pi^- e^{\pm} \nu_e$

Given in PISLAK 01, ROSSELET 77, BEIER 73, and BASILE 71C.

DECAY FORM FACTOR FOR $K^{\pm} \rightarrow \pi^0 \pi^0 e^{\pm} \nu$

Given in BOLOTOV 86B, BARMIN 88B, and SHIMIZU 04.

$K^{\pm} \rightarrow \ell^{\pm} \nu \gamma$ FORM FACTORS

For definitions of the axial-vector F_A and vector F_V form factor, see the "Note on $\pi^{\pm} \rightarrow \ell^{\pm} \nu \gamma$ and $K^{\pm} \rightarrow \ell^{\pm} \nu \gamma$ Form Factors" in the π^{\pm} section. In the kaon literature, often different definitions $a_K = F_A/m_K$ and $v_K = F_V/m_K$ are used.

$F_A + F_V$, SUM OF AXIAL-VECTOR AND VECTOR FORM FACTOR FOR $K \rightarrow e \nu_e \gamma$

VALUE	EVTS	DOCUMENT ID	TECN
0.148 ± 0.010 OUR AVERAGE			
0.147 ± 0.011	51	¹¹⁴ HEINTZE	79 SPEC
$0.150^{+0.018}_{-0.023}$	56	¹¹⁵ HEARD	75 SPEC

¹¹⁴HEINTZE 79 quotes absolute value of $|F_A + F_V| \sin\theta_c$. We use $\sin\theta_c = V_{us} = 0.2205$.

¹¹⁵HEARD 75 quotes absolute value of $|F_A + F_V| \sin\theta_c$. We use $\sin\theta_c = V_{us} = 0.2205$.

$F_A + F_V$, SUM OF AXIAL-VECTOR AND VECTOR FORM FACTOR FOR $K \rightarrow \mu \nu_{\mu} \gamma$

VALUE	CL%	EVTS	DOCUMENT ID	TECN	CHG
$0.165 \pm 0.007 \pm 0.011$		2588	¹¹⁶ ADLER	00B B787	+
-1.2 to 1.1	90		DEMIDOV	90	XEBC
< 0.23	90		¹¹⁶ AKIBA	85	SPEC

¹¹⁶Quotes absolute value. Sign not determined.

$F_A - F_V$, DIFFERENCE OF AXIAL-VECTOR AND VECTOR FORM FACTOR FOR $K \rightarrow e \nu_e \gamma$

VALUE	EVTS	DOCUMENT ID	TECN
< 0.49	90	¹¹⁷ HEINTZE	79 SPEC

¹¹⁷HEINTZE 79 quotes $|F_A - F_V| < \sqrt{11} |F_A + F_V|$.

$F_A - F_V$, DIFFERENCE OF AXIAL-VECTOR AND VECTOR FORM FACTOR FOR $K \rightarrow \mu\nu\mu\gamma$

<u>VALUE</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
-0.24 to 0.04	90	2588	ADLER	00B B787	+
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
-2.2 to 0.6	90		DEMIDOV	90 XEBC	
-2.5 to 0.3	90		AKIBA	85 SPEC	

K^\pm CHARGE RADIUS

<u>VALUE (fm)</u>	<u>DOCUMENT ID</u>	<u>COMMENT</u>
0.560±0.031 OUR AVERAGE		
0.580±0.040	AMENDOLIA 86B	$K e \rightarrow K e$
0.530±0.050	DALLY 80	$K e \rightarrow K e$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●		
0.620±0.037	BLATNIK 79	VMD + dispersion relations

CP VIOLATION TESTS IN K^+ AND K^- DECAYS

$$\Delta(K_{\pi\mu\mu}^\pm) = \frac{\Gamma(K_{\pi\mu\mu}^+) - \Gamma(K_{\pi\mu\mu}^-)}{\Gamma(K_{\pi\mu\mu}^+) + \Gamma(K_{\pi\mu\mu}^-)}$$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
-0.02±0.11±0.04	PARK	02 HYCP

T VIOLATION TESTS IN K^+ AND K^- DECAYS

P_T in $K^+ \rightarrow \pi^0 \mu^+ \nu_\mu$

T-violating muon polarization. Sensitive to new sources of CP violation beyond the Standard Model.

<u>VALUE (units 10^{-3})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
-1.7±2.3±1.1		¹¹⁸ ABE	04F K246	+

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

-4.2±4.9±0.9	3.9M	ABE	99S K246	+
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¹¹⁸ Includes three sets of data: 96-97 (ABE 99S), 98, and 99-00 totaling about three times the ABE 99S data sample. Corresponds to $P_T < 5.0 \times 10^{-3}$ at 90% CL.

P_T in $K^+ \rightarrow \mu^+ \nu_\mu \gamma$

T-violating muon polarization. Sensitive to new sources of CP violation beyond the Standard Model.

<u>VALUE (units 10^{-2})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
-0.64±1.85±0.10	114k	¹¹⁹ ANISIMOVSK..03	K246	+

¹¹⁹ Muons stopped and polarization measured from decay to positrons.

Im(ξ) in $K^+ \rightarrow \pi^0 \mu^+ \nu_\mu$ DECAY (from transverse μ pol.)

Test of T reversal invariance.

VALUE	EVT5	DOCUMENT ID	TECN	CHG	COMMENT
-0.006 ± 0.008 OUR AVERAGE					
-0.0053 ± 0.0071 ± 0.0036	120	ABE	04F K246	+	
-0.016 ± 0.025	20M	CAMPBELL	81 CNTR	+	Pol.
• • • We do not use the following data for averages, fits, limits, etc. • • •					
-0.013 ± 0.016 ± 0.003	3.9M	ABE	99S CNTR	+	$p_T K^+$ at rest
120 Includes three sets of data: 96-97 (ABE 99S), 98, and 99-00 totaling about three times the ABE 99S data sample. Corresponds to Im(ξ) < 0.016 at 90% CL.					

K^\pm REFERENCES

TCHIKILEV	07	PAN 70 29	O.G. Tchikilev <i>et al.</i>	(ISTRA+ Collab.)
ALIEV	06	EPJ C46 61	M.A. Aliev <i>et al.</i>	(KEK E470 Collab.)
AMBROSINO	06A	PL B632 76	F. Ambrosino <i>et al.</i>	(KLOE Collab.)
BATLEY	06	PL B634 474	J.R. Batley <i>et al.</i>	(CERN NA48/2 Collab.)
BATLEY	06A	PL B638 22	J.R. Batley <i>et al.</i>	(CERN NA48/2 Collab.)
Also		PL B640 297 (Erratum)	J.R. Batley <i>et al.</i>	(CERN NA48/2 Collab.)
BATLEY	06B	PL B633 173	J.R. Batley <i>et al.</i>	(CERN NA48/2 Collab.)
MA	06	PR D73 037101	H. Ma <i>et al.</i>	(BNL E865 Collab.)
SHIMIZU	06	PL B633 190	S. Shimizu <i>et al.</i>	(KEK E470 Collab.)
UVAROV	06	PAN 69 26	V.A. Uvarov <i>et al.</i>	(ISTRA+ Collab.)
AKOPDZHAN...	05	EPJ C40 343	G.A. Akopdzhanov <i>et al.</i>	(IHEP)
Also		PAN 68 948	G.A. Akopdzhanov <i>et al.</i>	(IHEP)
		Translated from YAF 68 986.		
AKOPDZHAN...	05B	JETPL 82 675	G.A. Akopdzhanov <i>et al.</i>	(IHEP)
		Translated from ZETFP 82 771.		
ARTAMONOV	05	PL B623 192	A.V. Artamonov <i>et al.</i>	(BNL E949 Collab.)
CABIBBO	05	JHEP 0503 021	N. Cabibbo, G. Isidori	(CERN, ROMA1, FRAS)
SHER	05	PR D72 012005	A. Sher <i>et al.</i>	(BNL E865 Collab.)
ABE	04F	PRL 93 131601	M. Abe <i>et al.</i>	(KEK E246 Collab.)
Also		PR D73 072005	M. Abe <i>et al.</i>	(KEK E246 Collab.)
ADLER	04	PR D70 037102	S. Adler <i>et al.</i>	(BNL E787 Collab.)
ALOISIO	04A	PL B597 139	A. Aloisio <i>et al.</i>	(KLOE Collab.)
ANDRE	04	hep-ph/0406006	T. Andre	(EFI)
ANISIMOVSK...	04	PRL 93 031801	V.V. Anisimovskiy <i>et al.</i>	(BNL E949 Collab.)
CABIBBO	04A	PRL 93 121801	N. Cabibbo	(CERN, ROMA1)
CIRIGLIANO	04	EPJ C35 53	V. Cirigliano, H. Neufeld, H. Pichl	(CIT, VALE+)
PDG	04	PL B592 1	S. Eidelman <i>et al.</i>	
SHIMIZU	04	PR D70 037101	S. Shimizu <i>et al.</i>	(KEK E470 Collab.)
YUSHCHENKO	04	PL B581 31	O.P. Yushchenko <i>et al.</i>	(INRM, INRM)
YUSHCHENKO	04B	PL B589 111	O.P. Yushchenko <i>et al.</i>	(INRM)
AJINENKO	03	PAN 66 105	I.V. Ajinenko <i>et al.</i>	(IHEP, INRM)
		Translated from YAF 66 107.		
AJINENKO	03B	PL B567 159	I.V. Ajinenko <i>et al.</i>	(IHEP, INRM)
AJINENKO	03C	PL B574 14	I.V. Ajinenko <i>et al.</i>	(IHEP, INRM)
ALIEV	03	PL B554 7	M.A. Aliev <i>et al.</i>	(KEK E470 Collab.)
ANISIMOVSK...	03	PL B562 166	V.V. Anisimovskiy <i>et al.</i>	
PISLAK	03	PR D67 072004	S. Pislak <i>et al.</i>	(BNL E865 Collab.)
SHER	03	PRL 91 261802	A. Sher <i>et al.</i>	(BNL E865 Collab.)
ADLER	02	PRL 88 041803	S. Adler <i>et al.</i>	(BNL E787 Collab.)
ADLER	02B	PR D65 052009	S. Adler <i>et al.</i>	(BNL E787 Collab.)
ADLER	02C	PL B537 211	S. Adler <i>et al.</i>	(BNL E787 Collab.)
AJINENKO	02	PAN 65 2064	I.V. Ajinenko <i>et al.</i>	(IHEP, INRM)
		Translated from YAF 65 2125.		
CIRIGLIANO	02	EPJ C23 121	V. Cirigliano <i>et al.</i>	(VIEN, VALE, MARS)
PARK	02	PRL 88 111801	H.K. Park <i>et al.</i>	(FNAL HyperCP Collab.)
PDG	02	PR D66 010001	K. Hagiwara <i>et al.</i>	
POBLAGUEV	02	PRL 89 061803	A.A. Poblaguev <i>et al.</i>	(BNL 865 Collab.)
ADLER	01	PR D63 032004	S. Adler <i>et al.</i>	(BNL E787 Collab.)
HORIE	01	PL B513 311	K. Horie <i>et al.</i>	(KEK E426 Collab.)
PISLAK	01	PRL 87 221801	S. Pislak <i>et al.</i>	(BNL E865 Collab.)
Also		PR D67 072004	S. Pislak <i>et al.</i>	(BNL E865 Collab.)
ADLER	00	PRL 84 3768	S. Adler <i>et al.</i>	(BNL E787 Collab.)
ADLER	00B	PRL 85 2256	S. Adler <i>et al.</i>	(BNL E787 Collab.)
ADLER	00C	PRL 85 4856	S. Adler <i>et al.</i>	(BNL E787 Collab.)

APPEL	00	PRL 85 2450	R. Appel <i>et al.</i>	(BNL 865 Collab.)
Also		Thesis, Yale Univ.	D.R. Bergman	
Also		Thesis, Univ. Zurich	S. Pislak	
APPEL	00B	PRL 85 2877	R. Appel <i>et al.</i>	(BNL 865 Collab.)
MA	00	PRL 84 2580	H. Ma <i>et al.</i>	(BNL 865 Collab.)
PDG	00	EPJ C15 1	D.E. Groom <i>et al.</i>	
SHIMIZU	00	PL B495 33	S. Shimizu <i>et al.</i>	(KEK E246 Collab.)
ABE	99S	PRL 83 4253	M. Abe <i>et al.</i>	(KEK E246 Collab.)
APPEL	99	PRL 83 4482	R. Appel <i>et al.</i>	(BNL 865 Collab.)
ADLER	98	PR D58 012003	S. Adler <i>et al.</i>	(BNL E787 Collab.)
BATUSOV	98	NP B516 3	V.Y. Batusov <i>et al.</i>	
ADLER	97	PRL 79 2204	S. Adler <i>et al.</i>	(BNL E787 Collab.)
ADLER	97C	PRL 79 4756	S. Adler <i>et al.</i>	(BNL E787 Collab.)
BERGMAN	97	Thesis, Yale Univ.	D.R. Bergman	
KITCHING	97	PRL 79 4079	P. Kitching <i>et al.</i>	(BNL E787 Collab.)
PISLAK	97	Thesis, Univ. Zurich	S. Pislak	
ADLER	96	PRL 76 1421	S. Adler <i>et al.</i>	(BNL E787 Collab.)
KOPTEV	95	JETPL 61 877	V.P. Koptev <i>et al.</i>	(PNPI)
		Translated from ZETFP 61 865.		
AOKI	94	PR D50 69	M. Aoki <i>et al.</i>	(INUS, KEK, TOKMS)
ATIYA	93	PRL 70 2521	M.S. Atiya <i>et al.</i>	(BNL E787 Collab.)
Also		PRL 71 305 (erratum)	M.S. Atiya <i>et al.</i>	(BNL E787 Collab.)
ATIYA	93B	PR D48 R1	M.S. Atiya <i>et al.</i>	(BNL E787 Collab.)
ALLIEGRO	92	PRL 68 278	C. Alliegro <i>et al.</i>	(BNL, FNAL, PSI+)
BARMIN	92	SJNP 55 547	V.V. Barmin <i>et al.</i>	(ITEP)
		Translated from YAF 55 976.		
IMAZATO	92	PRL 69 877	J. Imazato <i>et al.</i>	(KEK, INUS, TOKY+)
IVANOV	92	THESIS	Yu.M. Ivanov	(PNPI)
LITTENBERG	92	PRL 68 443	L.S. Littenberg, R.E. Shrock	(BNL, STON)
USHER	92	PR D45 3961	T. Usher <i>et al.</i>	(UCI)
AKIMENKO	91	PL B259 225	S.A. Akimenko <i>et al.</i>	(SERP, JINR, TBIL+)
BARMIN	91	SJNP 53 606	V.V. Barmin <i>et al.</i>	(ITEP)
		Translated from YAF 53 981.		
DENISOV	91	JETPL 54 558	A.S. Denisov <i>et al.</i>	(PNPI)
		Translated from ZETFP 54 557.		
Also		THESIS	Yu.M. Ivanov	(PNPI)
ATIYA	90	PRL 64 21	M.S. Atiya <i>et al.</i>	(BNL E787 Collab.)
ATIYA	90B	PRL 65 1188	M.S. Atiya <i>et al.</i>	(BNL E787 Collab.)
DEMIDOV	90	SJNP 52 1006	V.S. Demidov <i>et al.</i>	(ITEP)
		Translated from YAF 52 1595.		
LEE	90	PRL 64 165	A.M. Lee <i>et al.</i>	(BNL, FNAL, VILL, WASH+)
ATIYA	89	PRL 63 2177	M.S. Atiya <i>et al.</i>	(BNL E787 Collab.)
BARMIN	89	SJNP 50 421	V.V. Barmin <i>et al.</i>	(ITEP)
		Translated from YAF 50 679.		
BARMIN	88	SJNP 47 643	V.V. Barmin <i>et al.</i>	(ITEP)
		Translated from YAF 47 1011.		
BARMIN	88B	SJNP 48 1032	V.V. Barmin <i>et al.</i>	(ITEP)
		Translated from YAF 48 1719.		
BOLOTOV	88	JETPL 47 7	V.N. Bolotov <i>et al.</i>	(ASCI)
		Translated from ZETFP 47 8.		
GALL	88	PRL 60 186	K.P. Gall <i>et al.</i>	(BOST, MIT, WILL, CIT+)
BARMIN	87	SJNP 45 62	V.V. Barmin <i>et al.</i>	(ITEP)
		Translated from YAF 45 97.		
BOLOTOV	87	SJNP 45 1023	V.N. Bolotov <i>et al.</i>	(INRM)
		Translated from YAF 45 1652.		
AMENDOLIA	86B	PL B178 435	S.R. Amendolia <i>et al.</i>	(CERN NA7 Collab.)
BOLOTOV	86	SJNP 44 73	V.N. Bolotov <i>et al.</i>	(INRM)
		Translated from YAF 44 117.		
BOLOTOV	86B	SJNP 44 68	V.N. Bolotov <i>et al.</i>	(INRM)
		Translated from YAF 44 108.		
YAMANAKA	86	PR D34 85	T. Yamanaka <i>et al.</i>	(KEK, TOKY)
Also		PRL 52 329	R.S. Hayano <i>et al.</i>	(TOKY, KEK)
AKIBA	85	PR D32 2911	Y. Akiba <i>et al.</i>	(TOKY, TINT, TSUK, KEK)
BOLOTOV	85	JETPL 42 481	V.N. Bolotov <i>et al.</i>	(INRM)
		Translated from ZETFP 42 390.		
ASANO	82	PL 113B 195	Y. Asano <i>et al.</i>	(KEK, TOKY, INUS, OSAK)
COOPER	82	PL 112B 97	A.M. Cooper <i>et al.</i>	(RL)
PDG	82B	PL 111B 70	M. Roos <i>et al.</i>	(HELS, CIT, CERN)
ASANO	81B	PL 107B 159	Y. Asano <i>et al.</i>	(KEK, TOKY, INUS, OSAK)
CAMPBELL	81	PRL 47 1032	M.K. Campbell <i>et al.</i>	(YALE, BNL)
Also		PR D27 1056	S.R. Blatt <i>et al.</i>	(YALE, BNL)
LUM	81	PR D23 2522	G.K. Lum <i>et al.</i>	(LBL, NBS+)
LYONS	81	ZPHY C10 215	L. Lyons, C. Albajar, G. Myatt	(OXF)
DALLY	80	PRL 45 232	E.B. Dally <i>et al.</i>	(UCLA+)

BARKOV	79	NP B148 53	L.M. Barkov <i>et al.</i>	(NOVO, KIAE)
BLATNIK	79	LNC 24 39	S. Blatnik, J. Stahov, C.B. Lang	(TUZL, GRAZ)
HEINTZE	79	NP B149 365	J. Heintze <i>et al.</i>	(HEIDP, CERN)
ABRAMS	77	PR D15 22	R.J. Abrams <i>et al.</i>	(BNL)
DEVAUX	77	NP B126 11	B. Devaux <i>et al.</i>	(SACL, GEVA)
HEINTZE	77	PL 70B 482	J. Heintze <i>et al.</i>	(HEIDP, CERN)
ROSSELET	77	PR D15 574	L. Rosselet <i>et al.</i>	(GEVA, SACL)
BLOCH	76	PL 60B 393	P. Bloch <i>et al.</i>	(GEVA, SACL)
BRAUN	76B	LNC 17 521	H.M. Braun <i>et al.</i>	(AACH3, BARI, BELG+)
DIAMANT-...	76	PL 62B 485	A.M. Diamant-Berger <i>et al.</i>	(SACL, GEVA)
HEINTZE	76	PL 60B 302	J. Heintze <i>et al.</i>	(HEIDP)
SMITH	76	NP B109 173	K.M. Smith <i>et al.</i>	(GLAS, LIVP, OXF+)
WEISSENBE...	76	NP B115 55	A.O. Weissenberg <i>et al.</i>	(ITEP, LEBD)
BLOCH	75	PL 56B 201	P. Bloch <i>et al.</i>	(SACL, GEVA)
BRAUN	75	NP B89 210	H.M. Braun <i>et al.</i>	(AACH3, BARI, BRUX+)
CHENG	75	NP A254 381	S.C. Cheng <i>et al.</i>	(COLU, YALE)
HEARD	75	PL 55B 324	K.S. Heard <i>et al.</i>	(CERN, HEIDH)
HEARD	75B	PL 55B 327	K.S. Heard <i>et al.</i>	(CERN, HEIDH)
SHEAFF	75	PR D12 2570	M. Sheaff	(WISC)
SMITH	75	NP B91 45	K.M. Smith <i>et al.</i>	(GLAS, LIVP, OXF+)
WEISSENBE...	74	PL 48B 474	A.O. Weissenberg <i>et al.</i>	(ITEP, LEBD)
ABRAMS	73B	PRL 30 500	R.J. Abrams <i>et al.</i>	(BNL)
BACKENSTO...	73	PL 43B 431	G. Backenstoss <i>et al.</i>	(CERN, KARLK, KARLE+)
BEIER	73	PRL 30 399	E.W. Beier <i>et al.</i>	(PENN)
LJUNG	73	PR D8 1307	D. Ljung, D. Cline	(WISC)
Also		PRL 28 523	D. Ljung	(WISC)
Also		PRL 28 1287	D. Cline, D. Ljung	(WISC)
Also		PRL 23 326	U. Camerini <i>et al.</i>	(WISC)
LUCAS	73	PR D8 719	P.W. Lucas, H.D. Taft, W.J. Willis	(YALE)
LUCAS	73B	PR D8 727	P.W. Lucas, H.D. Taft, W.J. Willis	(YALE)
PANG	73	PR D8 1989	C.Y. Pang <i>et al.</i>	(EFI, ARIZ, LBL)
Also		PL 40B 699	G.D. Cable <i>et al.</i>	(EFI, LBL)
SMITH	73	NP B60 411	K.M. Smith <i>et al.</i>	(GLAS, LIVP, OXF+)
ABRAMS	72	PRL 29 1118	R.J. Abrams <i>et al.</i>	(BNL)
AUBERT	72	NC 12A 509	B. Aubert <i>et al.</i>	(ORSAY, BRUX, EPOL)
CHIANG	72	PR D6 1254	I.H. Chiang <i>et al.</i>	(ROCH, WISC)
CLARK	72	PRL 29 1274	A.R. Clark <i>et al.</i>	(LBL)
EDWARDS	72	PR D5 2720	R.T. Edwards <i>et al.</i>	(ILL)
FORD	72	PL 38B 335	W.T. Ford <i>et al.</i>	(PRIN)
HOFFMASTER	72	NP B36 1	S. Hoffmaster <i>et al.</i>	(STEV, SETO, LEHI)
BASILE	71C	PL 36B 619	P. Basile <i>et al.</i>	(SACL, GEVA)
BOURQUIN	71	PL 36B 615	M.H. Bourquin <i>et al.</i>	(GEVA, SACL)
HAIDT	71	PR D3 10	D. Haidt	(AACH, BARI, CERN, EPOL, NIJM+)
Also		PL 29B 691	D. Haidt <i>et al.</i>	(AACH, BARI, CERN, EPOL+)
KLEMS	71	PR D4 66	J.H. Klems, R.H. Hildebrand, R. Stiening	(CHIC+)
Also		PRL 24 1086	J.H. Klems, R.H. Hildebrand, R. Stiening	(LRL+)
Also		PRL 25 473	J.H. Klems, R.H. Hildebrand, R. Stiening	(LRL+)
OTT	71	PR D3 52	R.J. Ott, T.W. Pritchard	(LOQM)
ROMANO	71	PL 36B 525	F. Romano <i>et al.</i>	(BARI, CERN, ORSAY)
SCHWEINB...	71	PL 36B 246	W. Schweinberger	(AACH, BELG, CERN, NIJM+)
STEINER	71	PL 36B 521	H.J. Steiner	(AACH, BARI, CERN, EPOL, ORSAY+)
BARDIN	70	PL 32B 121	D.Y. Bardin, S.N. Bilenky, B.M. Pontecorvo	(JINR)
BECHERRAWY	70	PR D1 1452	T. Becherrawy	(ROCH)
FORD	70	PRL 25 1370	W.T. Ford <i>et al.</i>	(PRIN)
GAILLARD	70	CERN 70-14	J.M. Gaillard, L.M. Chounet	(CERN, ORSAY)
GRAUMAN	70	PR D1 1277	J. Grauman <i>et al.</i>	(STEV, SETO, LEHI)
Also		PRL 23 737	J.U. Grauman <i>et al.</i>	(STEV, SETO, LEHI)
MACEK	70	PR D1 1249	R.J. Macek <i>et al.</i>	(PENN)
MALTSEV	70	SJNP 10 678	E.I. Maltsev <i>et al.</i>	(JINR)
PANDOULAS	70	PR D2 1205	D. Pandoulas <i>et al.</i>	(STEV, SETO)
CUTTS	69	PR 184 1380	D. Cutts <i>et al.</i>	(LRL, MIT)
Also		PRL 20 955	D. Cutts <i>et al.</i>	(LRL, MIT)
DAVISON	69	PR 180 1333	D.C. Davison <i>et al.</i>	(UCR)
ELY	69	PR 180 1319	R.P.J. Ely <i>et al.</i>	(LOUC, WISC, LRL)
EMMERSON	69	PRL 23 393	J.M.L. Emmerson, T.W. Quirk	(OXF)
HERZO	69	PR 186 1403	D. Herzo <i>et al.</i>	(ILL)
LOBKOWICZ	69	PR 185 1676	F. Lobkowicz <i>et al.</i>	(ROCH, BNL)
Also		PRL 17 548	F. Lobkowicz <i>et al.</i>	(ROCH, BNL)
MAST	69	PR 183 1200	T.S. Mast <i>et al.</i>	(LRL)
SELLERI	69	NC 60A 291	F. Selleri	

ZELLER	69	PR 182 1420	M.E. Zeller <i>et al.</i>	(UCLA, LRL)
BOTTERILL	68B	PRL 21 766	D.R. Botterill <i>et al.</i>	(OXF)
BOTTERILL	68C	PR 174 1661	D.R. Botterill <i>et al.</i>	(OXF)
BUTLER	68	UCRL 18420	W.D. Butler <i>et al.</i>	(LRL)
CHANG	68	PRL 20 510	C.Y. Chang <i>et al.</i>	(UMD, RUTG)
CHEN	68	PRL 20 73	M. Chen <i>et al.</i>	(LRL, MIT)
EICHTEN	68	PL 27B 586	T. Eichten	(AACH, BARI, CERN, EPOL, ORSAY+)
ESCHSTRUTH	68	PR 165 1487	P.T. Eschstruth <i>et al.</i>	(PRIN, PENN)
GARLAND	68	PR 167 1225	R. Garland <i>et al.</i>	(COLU, RUTG, WISC)
MOSCOSO	68	Thesis	L. Moscoso	(ORSAY)
AUERBACH	67	PR 155 1505	L.B. Auerbach <i>et al.</i>	(PENN, PRIN)
		Also	L.B. Auerbach	
		Erratum.		
BELLOTTI	67B	NC 52A 1287	E. Bellotti, E. Fiorini, A. Pullia	(MILA)
		Also	E. Bellotti <i>et al.</i>	(MILA)
BISI	67	PL 25B 572	V. Bisi <i>et al.</i>	(TORI)
FLETCHER	67	PRL 19 98	C.R. Fletcher <i>et al.</i>	(ILL)
FORD	67	PRL 18 1214	W.T. Ford <i>et al.</i>	(PRIN)
GINSBERG	67	PR 162 1570	E.S. Ginsberg	(MASB)
KALMUS	67	PR 159 1187	G.E. Kalmus, A. Kernan	(LRL)
ZINCHENKO	67	Thesis Rutgers	A.I. Zinchenko	(RUTG)
CALLAHAN	66	NC 44A 90	A.C. Callahan	(WISC)
CALLAHAN	66B	PR 150 1153	A.C. Callahan <i>et al.</i>	(WISC, LRL, UCR+)
CESTER	66	PL 21 343	R. Cester <i>et al.</i>	(PPA)
		See footnote 1 in AUERBACH 67.		
		Also	L.B. Auerbach <i>et al.</i>	(PENN, PRIN)
BIRGE	65	PR 139B 1600	R.W. Birge <i>et al.</i>	(LRL, WISC)
BISI	65	NC 35 768	V. Bisi <i>et al.</i>	(TORI)
BISI	65B	PR 139B 1068	V. Bisi <i>et al.</i>	(TORI)
CALLAHAN	65	PRL 15 129	A. Callahan, D. Cline	(WISC)
CLINE	65	PL 15 293	D. Cline, W.F. Fry	(WISC)
DEMARCO	65	PR 140B 1430	A. de Marco, C. Grosso, G. Rinaudo	(TORI, CERN)
FITCH	65B	PR 140B 1088	V.L. Fitch, C.A. Quarles, H.C. Wilkins	(PRIN+)
STAMER	65	PR 138B 440	P. Stamer <i>et al.</i>	(STEV)
YOUNG	65	Thesis UCRL 16362	P.S. Young	(LRL)
		Also	P.S. Young, W.Z. Osborne, W.H. Barkas	(LRL)
BORREANI	64	PL 12 123	G. Borreani, G. Rinaudo, A.E. Werbrouck	(TORI)
CALLAHAN	64	PR 136B 1463	A. Callahan, R. March, R. Stark	(WISC)
CLINE	64	PRL 13 101	D. Cline, W.F. Fry	(WISC)
GREINER	64	PRL 13 284	D.E. Greiner, W.Z. Osborne, W.H. Barkas	(LRL)
SHAKLEE	64	PR 136B 1423	F.S. Shaklee <i>et al.</i>	(MICH)
BOYARSKI	62	PR 128 2398	A.M. Boyarski <i>et al.</i>	(MIT)
FERRO-LUZZI	61	NC 22 1087	M. Ferro-Luzzi <i>et al.</i>	(LRL)
ROE	61	PRL 7 346	B.P. Roe <i>et al.</i>	(MICH, LRL)
TAYLOR	59	PR 114 359	S. Taylor <i>et al.</i>	(COLU)
COOMBES	57	PR 108 1348	C.A. Coombes <i>et al.</i>	(LBL)

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BRYMAN	89	IJMP A4 79	D.A. Bryman	(TRIU)
		"Rare Kaon Decays"		
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FEARING	70	PR D2 542	H.W. Fearing, E. Fischbach, J. Smith	(STON, BOHR)
HAIDT	69B	PL 29B 696	D. Haidt <i>et al.</i>	(AACH, BARI, CERN, EPOL+)
CRONIN	68B	Vienna Conf. 241	J.W. Cronin	(PRIN)
		Rapporteur talk.		
WILLIS	67	Heidelberg Conf. 273	W.J. Willis	(YALE)
		Rapporteur talk.		
CABIBBO	66	Berkeley Conf. 33	N. Cabibbo	(CERN)
ADAIR	64	PL 12 67	R.K. Adair, L.B. Leipuner	(YALE, BNL)
CABIBBO	64	PL 9 352	N. Cabibbo, A. Maksymowicz	(CERN)
		Also	N. Cabibbo, A. Maksymowicz	(CERN)
		Also	N. Cabibbo, A. Maksymowicz	(CERN)

BIRGE	63	PRL 11 35	R.W. Birge <i>et al.</i>	(LRL, WISC, BARI)
BLOCK	62B	CERN Conf. 371	M.M. Block, L. Lendinara, L. Monari	(NWES, BGNA)
BRENE	61	NP 22 553	N. Brene, L. Egardt, B. Qvist	(NORD)
