

$$I^G(J^{PC}) = 1^-(0^{-+})$$

We have omitted some results that have been superseded by later experiments. The omitted results may be found in our 1988 edition *Physics Letters* **B204** 1 (1988).

### π<sup>0</sup> MASS

The value is calculated from  $m_{\pi^\pm}$  and  $(m_{\pi^\pm} - m_{\pi^0})$ . See also the notes under the  $\pi^\pm$  Mass Listings.

VALUE (MeV)                      DOCUMENT ID  
**134.9766 ± 0.0006 OUR FIT** Error includes scale factor of 1.1.

### $m_{\pi^\pm} - m_{\pi^0}$

Measurements with an error > 0.01 MeV have been omitted.

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>4.5936 ± 0.0005 OUR FIT</b>			
<b>4.5936 ± 0.0005 OUR AVERAGE</b>			
4.59364 ± 0.00048	CRAWFORD 91	CNTR	$\pi^- p \rightarrow \pi^0 n, n$ TOF
4.5930 ± 0.0013	CRAWFORD 86	CNTR	$\pi^- p \rightarrow \pi^0 n, n$ TOF
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
4.59366 ± 0.00048	CRAWFORD 88B	CNTR	See CRAWFORD 91
4.6034 ± 0.0052	VASILEVSKY 66	CNTR	
4.6056 ± 0.0055	CZIRR 63	CNTR	

### π<sup>0</sup> MEAN LIFE

Most experiments measure the  $\pi^0$  width which we convert to a lifetime. ATHERTON 85 is the only direct measurement of the  $\pi^0$  lifetime. Our average based only on indirect measurement yields  $(8.30 \pm 0.19) \times 10^{-17}$  s. The two Primakoff measurements from 1970 have been excluded from our average because they suffered model-related systematics unknown at the time. More information on the  $\pi^0$  lifetime can be found in BERNSTEIN 11.

<u>VALUE (<math>10^{-17}</math> s)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>8.52 ± 0.18 OUR AVERAGE</b>				Error includes scale factor of 1.2.
8.32 ± 0.15 ± 0.18		<sup>1</sup> LARIN 11	PRMX	Primakoff effect
8.5 ± 1.1		<sup>2</sup> BYCHKOV 09	PIBE	$\pi^+ \rightarrow e^+ \nu \gamma$ at rest
8.4 ± 0.5 ± 0.5	1182	<sup>3</sup> WILLIAMS 88	CBAL	$e^+ e^- \rightarrow e^+ e^- \pi^0$
8.97 ± 0.22 ± 0.17		ATHERTON 85	CNTR	Direct measurement
8.2 ± 0.4		<sup>4</sup> BROWMAN 74	CNTR	Primakoff effect
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
5.6 ± 0.6		BELLETTINI 70	CNTR	Primakoff effect
9 ± 0.68		KRYSHKIN 70	CNTR	Primakoff effect
7.3 ± 1.1		BELLETTINI 65B	CNTR	Primakoff effect

<sup>1</sup> LARIN 11 reported  $\Gamma(\pi^0 \rightarrow \gamma\gamma) = 7.82 \pm 0.14 \pm 0.17$  eV which we converted to mean life  $\tau = \hbar/\Gamma(\text{total})$ .

<sup>2</sup> BYCHKOV 09 obtains this using the conserved-vector-current relation between the vector form factor  $F_V$  and the  $\pi^0$  lifetime.

<sup>3</sup> WILLIAMS 88 gives  $\Gamma(\gamma\gamma) = 7.7 \pm 0.5 \pm 0.5$  eV. We give here  $\tau = \hbar/\Gamma(\text{total})$ .

<sup>4</sup> BROWMAN 74 gives a  $\pi^0$  width  $\Gamma = 8.02 \pm 0.42$  eV. The mean life is  $\hbar/\Gamma$ .

## $\pi^0$ DECAY MODES

For decay limits to particles which are not established, see the appropriate Search sections ( $A^0$  (axion) and Other Light Boson ( $X^0$ ) Searches, etc.).

Mode	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level
$\Gamma_1$ $2\gamma$	$(98.823 \pm 0.034) \%$	S=1.5
$\Gamma_2$ $e^+ e^- \gamma$	$(1.174 \pm 0.035) \%$	S=1.5
$\Gamma_3$ $\gamma$ positronium	$(1.82 \pm 0.29) \times 10^{-9}$	
$\Gamma_4$ $e^+ e^+ e^- e^-$	$(3.34 \pm 0.16) \times 10^{-5}$	
$\Gamma_5$ $e^+ e^-$	$(6.46 \pm 0.33) \times 10^{-8}$	
$\Gamma_6$ $4\gamma$	$< 2$	$\times 10^{-8}$ CL=90%
$\Gamma_7$ $\nu\bar{\nu}$	[a] $< 2.7$	$\times 10^{-7}$ CL=90%
$\Gamma_8$ $\nu_e \bar{\nu}_e$	$< 1.7$	$\times 10^{-6}$ CL=90%
$\Gamma_9$ $\nu_\mu \bar{\nu}_\mu$	$< 1.6$	$\times 10^{-6}$ CL=90%
$\Gamma_{10}$ $\nu_\tau \bar{\nu}_\tau$	$< 2.1$	$\times 10^{-6}$ CL=90%
$\Gamma_{11}$ $\gamma\nu\bar{\nu}$	$< 6$	$\times 10^{-4}$ CL=90%

### Charge conjugation (C) or Lepton Family number (LF) violating modes

$\Gamma_{12}$ $3\gamma$	C	$< 3.1$	$\times 10^{-8}$	CL=90%
$\Gamma_{13}$ $\mu^+ e^-$	LF	$< 3.8$	$\times 10^{-10}$	CL=90%
$\Gamma_{14}$ $\mu^- e^+$	LF	$< 3.4$	$\times 10^{-9}$	CL=90%
$\Gamma_{15}$ $\mu^+ e^- + \mu^- e^+$	LF	$< 3.6$	$\times 10^{-10}$	CL=90%

[a] Astrophysical and cosmological arguments give limits of order  $10^{-13}$ ; see the Particle Listings below.

## CONSTRAINED FIT INFORMATION

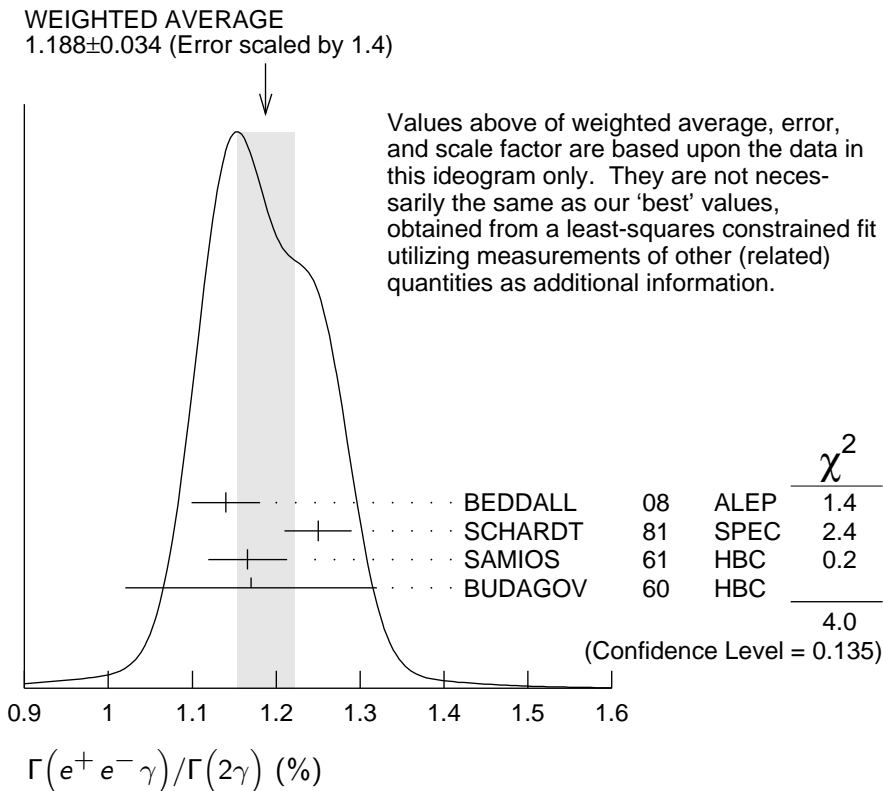
An overall fit to 2 branching ratios uses 6 measurements and one constraint to determine 3 parameters. The overall fit has a  $\chi^2 = 4.6$  for 4 degrees of freedom.

The following *off-diagonal* array elements are the correlation coefficients  $\langle \delta x_i \delta x_j \rangle / (\delta x_i \delta x_j)$ , in percent, from the fit to 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.

$$\begin{array}{c} x_2 \\ x_4 \end{array} \left| \begin{array}{cc} -100 & \\ 0 & -1 \end{array} \right. \begin{array}{c} \\ x_1 \\ x_2 \end{array}$$

## $\pi^0$ BRANCHING RATIOS

$\Gamma(e^+ e^- \gamma) / \Gamma(2\gamma)$						$\Gamma_2 / \Gamma_1$	
<u>VALUE (%)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>			
<b>1.188 ± 0.035 OUR FIT</b>				Error includes scale factor of 1.5.			
<b>1.188 ± 0.034 OUR AVERAGE</b>				Error includes scale factor of 1.4. See the ideogram below.			
1.140 ± 0.024 ± 0.033	12.5k	<sup>5</sup> BEDDALL	08	ALEP	$e^+ e^- \rightarrow Z \rightarrow$	hadrons	
1.25 ± 0.04		SCHARDT	81	SPEC	$\pi^- p \rightarrow n\pi^0$		
1.166 ± 0.047	3071	<sup>6</sup> SAMIOS	61	HBC	$\pi^- p \rightarrow n\pi^0$		
1.17 ± 0.15	27	BUDAGOV	60	HBC			
• • •					We do not use the following data for averages, fits, limits, etc. • • •		
1.196		JOSEPH	60	THEO	QED calculation		
					<sup>5</sup> This BEDDALL 08 value is obtained from ALEPH archived data.		
					<sup>6</sup> SAMIOS 61 value uses a Panofsky ratio = 1.62.		



### $\Gamma(\gamma\text{positronium})/\Gamma(2\gamma)$

$\Gamma_3/\Gamma_1$

VALUE (units $10^{-9}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>1.84±0.29</b>	277	AFANASYEV	90	CNTR $pC$ 70 GeV

### $\Gamma(e^+e^+e^-e^-)/\Gamma(2\gamma)$

$\Gamma_4/\Gamma_1$

VALUE (units $10^{-5}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>3.38±0.16 OUR FIT</b>				
<b>3.38±0.16 OUR AVERAGE</b>				
3.46±0.19	30.5k	<sup>7</sup> ABOUZAIID	08D	KTEV $K_L^0 \rightarrow \pi^0\pi^0\pi_{DD}^0$
3.18±0.30	146	<sup>8</sup> SAMIOS	62B	HBC

<sup>7</sup> This ABOUZAIID 08D value includes all radiative final states. The error includes both statistical and systematic errors. The correlation between the Dalitz-pair planes gives a direct measurement of the  $\pi^0$  parity. The  $\pi^0 2\gamma^*$  form factor is measured and limits are placed on a scalar contribution to the decay.

<sup>8</sup> SAMIOS 62B value uses a Panofsky ratio = 1.62.

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

$\Gamma_5/\Gamma$

Experimental results are listed; branching ratios corrected for radiative effects are given in the footnotes. BERMAN 60 found  $B(\pi^0 \rightarrow e^+e^-) \geq 4.69 \times 10^{-8}$  via an exact QED calculation.

VALUE (units $10^{-8}$ )	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<b>6.46±0.33 OUR AVERAGE</b>					
6.44±0.25±0.22	794	<sup>9</sup> ABOUZAIID	07	KTEV	$K_L^0 \rightarrow 3\pi^0$ in flight
6.9 ±2.3 ±0.6	21	<sup>10</sup> DESHPANDE	93	SPEC	$K^+ \rightarrow \pi^+\pi^0$
7.6 $\begin{smallmatrix} +2.9 \\ -2.8 \end{smallmatrix}$ ±0.5	8	<sup>11</sup> MCFARLAND	93	SPEC	$K_L^0 \rightarrow 3\pi^0$ in flight

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

- 6.09 ± 0.40 ± 0.24    275    <sup>12</sup> ALAVI-HARATI99C    SPEC    0    Repl. by ABOUZAID 07
- <sup>9</sup> ABOUZAID 07 result is for  $m_{e^+e^-}/m_{\pi^0} > 0.95$ . With radiative corrections the result becomes  $(7.48 \pm 0.29 \pm 0.25) \times 10^{-8}$ .
- <sup>10</sup> The DESHPANDE 93 result with bremsstrahlung radiative corrections is  $(8.0 \pm 2.6 \pm 0.6) \times 10^{-8}$ .
- <sup>11</sup> The MCFARLAND 93 result is for  $B[\pi^0 \rightarrow e^+e^-, (m_{e^+e^-}/m_{\pi^0})^2 > 0.95]$ . With radiative corrections it becomes  $(8.8_{-3.2}^{+4.5} \pm 0.6) \times 10^{-8}$ .
- <sup>12</sup> ALAVI-HARATI 99C quote result for  $B[\pi^0 \rightarrow e^+e^-, (m_{e^+e^-}/m_{\pi^0})^2 > 0.95]$  to minimize radiative contributions from  $\pi^0 \rightarrow e^+e^-\gamma$ . After radiative corrections they obtain  $(7.04 \pm 0.46 \pm 0.28) \times 10^{-8}$ .

### $\Gamma(e^+e^-)/\Gamma(2\gamma)$

$\Gamma_5/\Gamma_1$

VALUE (units $10^{-7}$ )	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
<1.3	90		NIEBUHR	89	SPEC $\pi^- p \rightarrow \pi^0 n$ at rest
<5.3	90		ZEPHAT	87	SPEC $\pi^- p \rightarrow \pi^0 n$ 0.3 GeV/c
1.7 ± 0.6 ± 0.3		59	FRANK	83	SPEC $\pi^- p \rightarrow n\pi^0$
1.8 ± 0.6		58	MISCHKE	82	SPEC See FRANK 83
2.23 $_{-1.10}^{+2.40}$	90	8	FISCHER	78B	SPRK $K^+ \rightarrow \pi^+\pi^0$

### $\Gamma(4\gamma)/\Gamma_{\text{total}}$

$\Gamma_6/\Gamma$

VALUE (units $10^{-8}$ )	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
< 2	90		MCDONOUGH 88	CBOX	$\pi^- p$ at rest
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
<160	90		BOLOTOV	86C	CALO
<440	90	0	AUERBACH	80	CNTR

### $\Gamma(\nu\bar{\nu})/\Gamma_{\text{total}}$

$\Gamma_7/\Gamma$

The astrophysical and cosmological limits are many orders of magnitude lower, but we use the best laboratory limit for the Summary Tables.

VALUE (units $10^{-6}$ )	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
< 0.27	90		<sup>13</sup> ARTAMONOV 05A	B949	$K^+ \rightarrow \pi^+\pi^0$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
< 0.83	90		<sup>13</sup> ATIYA	91	B787 $K^+ \rightarrow \pi^+\nu\nu'$
< 2.9 × 10 <sup>-7</sup>			<sup>14</sup> LAM	91	Cosmological limit
< 3.2 × 10 <sup>-7</sup>			<sup>15</sup> NATALE	91	SN 1987A
< 6.5	90		DORENBOS...	88	CHRM Beam dump, prompt $\nu$
<24	90	0	<sup>13</sup> HERCZEG	81	RVUE $K^+ \rightarrow \pi^+\nu\nu'$

<sup>13</sup> This limit applies to all possible  $\nu\nu'$  states as well as to other massless, weakly interacting states.

<sup>14</sup> LAM 91 considers the production of right-handed neutrinos produced from the cosmic thermal background at the temperature of about the pion mass through the reaction  $\gamma\gamma \rightarrow \pi^0 \rightarrow \nu\bar{\nu}$ .

<sup>15</sup> NATALE 91 considers the excess energy-loss rate from SN 1987A if the process  $\gamma\gamma \rightarrow \pi^0 \rightarrow \nu\bar{\nu}$  occurs, permitted if the neutrinos have a right-handed component. As pointed out in LAM 91 (and confirmed by Natale), there is a factor 4 error in the NATALE 91 published result ( $0.8 \times 10^{-7}$ ).

$\Gamma(\nu_e \bar{\nu}_e)/\Gamma_{\text{total}}$   $\Gamma_8/\Gamma$

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;1.7</b>	90	DORENBOS... 88	CHRM	Beam dump, prompt $\nu$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
<3.1	90	<sup>16</sup> HOFFMAN 88	RVUE	Beam dump, prompt $\nu$
<sup>16</sup> HOFFMAN 88 analyzes data from a 400-GeV BEBC beam-dump experiment.				

$\Gamma(\nu_\mu \bar{\nu}_\mu)/\Gamma_{\text{total}}$   $\Gamma_9/\Gamma$

VALUE (units $10^{-6}$ )	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
<b>&lt;1.6</b>	90	8.7	AUERBACH 04	LSND	800 MeV $p$ on Cu
<3.1	90		<sup>17</sup> HOFFMAN 88	RVUE	Beam dump, prompt $\nu$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
<7.8	90		DORENBOS... 88	CHRM	Beam dump, prompt $\nu$
<sup>17</sup> HOFFMAN 88 analyzes data from a 400-GeV BEBC beam-dump experiment.					

$\Gamma(\nu_\tau \bar{\nu}_\tau)/\Gamma_{\text{total}}$   $\Gamma_{10}/\Gamma$

VALUE (units $10^{-6}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;2.1</b>	90	<sup>18</sup> HOFFMAN 88	RVUE	Beam dump, prompt $\nu$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
<4.1	90	DORENBOS... 88	CHRM	Beam dump, prompt $\nu$
<sup>18</sup> HOFFMAN 88 analyzes data from a 400-GeV BEBC beam-dump experiment.				

$\Gamma(\gamma \nu \bar{\nu})/\Gamma_{\text{total}}$   $\Gamma_{11}/\Gamma$

Standard Model prediction is  $6 \times 10^{-18}$ .

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;6 × 10<sup>-4</sup></b>	90	ATIYA 92	CNTR	$K^+ \rightarrow \gamma \nu \bar{\nu} \pi^+$

$\Gamma(3\gamma)/\Gamma_{\text{total}}$   $\Gamma_{12}/\Gamma$

Forbidden by  $C$  invariance.

VALUE (units $10^{-8}$ )	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
<b>&lt; 3.1</b>	90		MCDONOUGH 88	CBOX	$\pi^- p$ at rest
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
< 38	90	0	HIGHLAND 80	CNTR	
<150	90	0	AUERBACH 78	CNTR	
<490	90	0	<sup>19</sup> DUCLOS 65	CNTR	
<490	90		<sup>19</sup> KUTIN 65	CNTR	

<sup>19</sup> These experiments give  $B(3\gamma/2\gamma) < 5.0 \times 10^{-6}$ .

$\Gamma(\mu^+ e^-)/\Gamma_{\text{total}}$   $\Gamma_{13}/\Gamma$

Forbidden by lepton family number conservation.

VALUE (units $10^{-9}$ )	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
<b>&lt; 0.38</b>	90	0	APPEL 00	SPEC	$K^+ \rightarrow \pi^+ \mu^+ e^-$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
<16	90		LEE 90	SPEC	$K^+ \rightarrow \pi^+ \mu^+ e^-$
<78	90		CAMPAGNARI 88	SPEC	See LEE 90

$\Gamma(\mu^- e^+)/\Gamma_{\text{total}}$   $\Gamma_{14}/\Gamma$

Forbidden by lepton family number conservation.

VALUE (units $10^{-9}$ )	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
<b>&lt;3.4</b>	90	0	APPEL	00B B865	$K^+ \rightarrow \pi^+ e^+ \mu^-$

$[\Gamma(\mu^+ e^-) + \Gamma(\mu^- e^+)]/\Gamma_{\text{total}}$   $\Gamma_{15}/\Gamma$

Forbidden by lepton family number conservation.

VALUE (units $10^{-9}$ )	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt; 0.36</b>	90	ABOUZAID	08C KTEV	$K_L^0 \rightarrow 2\pi^0 \mu^\pm e^\mp$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
< 17.2	90	KROLAK	94 E799	In $K_L^0 \rightarrow 3\pi^0$
<140		HERCZEG	84 RVUE	$K^+ \rightarrow \pi^+ \mu e$
< 2 $\times 10^{-6}$		HERCZEG	84 THEO	$\mu^- \rightarrow e^-$ conversion
< 70	90	BRYMAN	82 RVUE	$K^+ \rightarrow \pi^+ \mu e$

**$\pi^0$  ELECTROMAGNETIC FORM FACTOR**

The amplitude for the process  $\pi^0 \rightarrow e^+ e^- \gamma$  contains a form factor  $F(x)$  at the  $\pi^0 \gamma \gamma$  vertex, where  $x = [m_{e^+ e^-}/m_{\pi^0}]^2$ . The parameter  $a$  in the linear expansion  $F(x) = 1 + ax$  is listed below.

All the measurements except that of BEHREND 91 are in the time-like region of momentum transfer.

**LINEAR COEFFICIENT OF  $\pi^0$  ELECTROMAGNETIC FORM FACTOR**

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.032 ±0.004 OUR AVERAGE</b>				
+0.026 ±0.024 ±0.048	7548	FARZANPAY	92 SPEC	$\pi^- p \rightarrow \pi^0 n$ at rest
+0.025 ±0.014 ±0.026	54k	MEIJERDREES92B	SPEC	$\pi^- p \rightarrow \pi^0 n$ at rest
+0.0326 ±0.0026 ±0.0026	127	<sup>20</sup> BEHREND	91 CELL	$e^+ e^- \rightarrow e^+ e^- \pi^0$
-0.11 ±0.03 ±0.08	32k	FONVIEILLE	89 SPEC	Radiation corr.
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.12 $\begin{smallmatrix} +0.05 \\ -0.04 \end{smallmatrix}$		<sup>21</sup> TUPPER	83 THEO	FISCHER 78 data
+0.10 ±0.03	31k	<sup>22</sup> FISCHER	78 SPEC	Radiation corr.
+0.01 ±0.11	2200	DEVONS	69 OSPK	No radiation corr.
-0.15 ±0.10	7676	KOBRAK	61 HBC	No radiation corr.
-0.24 ±0.16	3071	SAMIOS	61 HBC	No radiation corr.

<sup>20</sup> BEHREND 91 estimates that their systematic error is of the same order of magnitude as their statistical error, and so we have included a systematic error of this magnitude. The value of  $a$  is obtained by extrapolation from the region of large space-like momentum transfer assuming vector dominance.

<sup>21</sup> TUPPER 83 is a theoretical analysis of FISCHER 78 including 2-photon exchange in the corrections.

<sup>22</sup> The FISCHER 78 error is statistical only. The result without radiation corrections is  $+0.05 \pm 0.03$ .

$\pi^0$  REFERENCES

We have omitted some papers that have been superseded by later experiments. The omitted papers may be found in our 1988 edition *Physics Letters* **B204** 1 (1988).

BERNSTEIN	11	arXiv:1112.4809	A.M. Bernstein, B.R. Hostein	(MIT, MASA)
LARIN	11	PRL 106 162303	I. Larin <i>et al.</i>	(PrimEx Collab.)
BYCHKOV	09	PRL 103 051802	M. Bychkov <i>et al.</i>	(PSI PIBETA Collab.)
ABOUZAID	08C	PRL 100 131803	E. Abouzaid <i>et al.</i>	(FNAL KTeV Collab.)
ABOUZAID	08D	PRL 100 182001	E. Abouzaid <i>et al.</i>	(FNAL KTeV Collab.)
BEDDALL	08	EPJ C54 365	A. Beddall, A. Beddall	(UGAZ)
ABOUZAID	07	PR D75 012004	E. Abouzaid <i>et al.</i>	(KTeV Collab.)
ARTAMONOV	05A	PR D72 091102R	A.V. Artamonov <i>et al.</i>	(BNL E949 Collab.)
AUERBACH	04	PRL 92 091801	L.B. Auerbach <i>et al.</i>	(LSND 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.)
ALAVI-HARATI	99C	PRL 83 922	A. Alavi-Harati <i>et al.</i>	(FNAL KTeV Collab.)
KROLAK	94	PL B320 407	P. Krolak <i>et al.</i>	(EFI, UCLA, COLO, ELMT+)
DESHPANDE	93	PRL 71 27	A. Deshpande <i>et al.</i>	(BNL E851 Collab.)
MCFARLAND	93	PRL 71 31	K.S. McFarland <i>et al.</i>	(EFI, UCLA, COLO+)
ATIYA	92	PRL 69 733	M.S. Atiya <i>et al.</i>	(BNL, LANL, PRIN+)
FARZANPAY	92	PL B278 413	F. Farzanpay <i>et al.</i>	(ORST, TRIU, BRCO+)
MEIJERDREES	92B	PR D45 1439	R. Meijer Drees <i>et al.</i>	(PSI SINDRUM-I Collab.)
ATIYA	91	PRL 66 2189	M.S. Atiya <i>et al.</i>	(BNL, LANL, PRIN+)
BEHREND	91	ZPHY C49 401	H.J. Behrend <i>et al.</i>	(CELLO Collab.)
CRAWFORD	91	PR D43 46	J.F. Crawford <i>et al.</i>	(VILL, UVA)
LAM	91	PR D44 3345	W.P. Lam, K.W. Ng	(AST)
NATALE	91	PL B258 227	A.A. Natale	(SPIFT)
AFANASYEV	90	PL B236 116	L.G. Afanasyev <i>et al.</i>	(JINR, MOSU, SERP)
Also		SJNP 51 664	L.G. Afanasyev <i>et al.</i>	(JINR)
		Translated from YAF 51 1040.		
LEE	90	PRL 64 165	A.M. Lee <i>et al.</i>	(BNL, FNAL, VILL, WASH+)
FONVIEILLE	89	PL B233 65	H. Fonvieille <i>et al.</i>	(CLER, LYON, SACL)
NIEBUHR	89	PR D40 2796	C. Niebuhr <i>et al.</i>	(SINDRUM Collab.)
CAMPAGNARI	88	PRL 61 2062	C. Campagnari <i>et al.</i>	(BNL, FNAL, PSI+)
CRAWFORD	88B	PL B213 391	J.F. Crawford <i>et al.</i>	(PSI, UVA)
DORENBOS...	88	ZPHY C40 497	J. Dorenbosch <i>et al.</i>	(CHARM Collab.)
HOFFMAN	88	PL B208 149	C.M. Hoffman	(LANL)
MCDONOUGH	88	PR D38 2121	J.M. McDonough <i>et al.</i>	(TEMP, LANL, CHIC)
PDG	88	PL B204 1	G.P. Yost <i>et al.</i>	(LBL+)
WILLIAMS	88	PR D38 1365	D.A. Williams <i>et al.</i>	(Crystal Ball Collab.)
ZEPHAT	87	JPG 13 1375	A.G. Zephat <i>et al.</i>	(OMICRON Collab.)
BOLOTOV	86C	JETPL 43 520	V.N. Bolotov <i>et al.</i>	(INRM)
		Translated from ZETFP 43 405.		
CRAWFORD	86	PRL 56 1043	J.F. Crawford <i>et al.</i>	(SIN, UVA)
ATHERTON	85	PL 158B 81	H.W. Atherton <i>et al.</i>	(CERN, ISU, LUND+)
HERCZEG	84	PR D29 1954	P. Herczeg, C.M. Hoffman	(LANL)
FRANK	83	PR D28 423	J.S. Frank <i>et al.</i>	(LANL, ARZS)
TUPPER	83	PR D28 2905	G.B. Tupper, T.R. Grose, M.A. Samuel	(OKSU)
BRYMAN	82	PR D26 2538	D.A. Bryman	(TRIU)
MISCHKE	82	PRL 48 1153	R.E. Mischke <i>et al.</i>	(LANL, ARZS)
HERCZEG	81	PL 100B 347	P. Herczeg, C.M. Hoffman	(LANL)
SCHARDT	81	PR D23 639	M.A. Schardt <i>et al.</i>	(ARZS, LANL)
AUERBACH	80	PL 90B 317	L.B. Auerbach <i>et al.</i>	(TEMP, LASL)
HIGHLAND	80	PRL 44 628	V.L. Highland <i>et al.</i>	(TEMP, LASL)
AUERBACH	78	PRL 41 275	L.B. Auerbach <i>et al.</i>	(TEMP, LASL)
FISCHER	78	PL 73B 359	J. Fischer <i>et al.</i>	(GEVA, SACL)
FISCHER	78B	PL 73B 364	J. Fischer <i>et al.</i>	(GEVA, SACL)
BROWMAN	74	PRL 33 1400	A. Browman <i>et al.</i>	(CORN, BING)
BELLETTINI	70	NC 66A 243	G. Bellettini <i>et al.</i>	(PISA, BONN)
KRYSHKIN	70	JETP 30 1037	V.I. Kryshkin, A.G. Sterligov, Y.P. Usov	(TMSK)
		Translated from ZETF 57 1917.		
DEVONS	69	PR 184 1356	S. Devons <i>et al.</i>	(COLU, ROMA)
VASILEVSKY	66	PL 23 281	I.M. Vasilevsky <i>et al.</i>	(JINR)
BELLETTINI	65B	NC 40A 1139	G. Bellettini <i>et al.</i>	(PISA, FIRZ)
DUCLOS	65	PL 19 253	J. Duclos <i>et al.</i>	(CERN, HEID)
KUTIN	65	JETPL 2 243	V.M. Kutjin, V.I. Petrukhin, Y.D. Prokoshkin	(JINR)
		Translated from ZETFP 2 387.		



CZIRR	63	PR 130 341	J.B. Czirr	(LRL)
SAMIOS	62B	PR 126 1844	N.P. Samios <i>et al.</i>	(COLU, BNL)
KOBRAK	61	NC 20 1115	H. Kobrak	(EFI)
SAMIOS	61	PR 121 275	N.P. Samios	(COLU, BNL)
BERMAN	60	NC XVIII 1192	S. Berman, D. Geffen	
BUDAGOV	60	JETP 11 755	Y.A. Budagov <i>et al.</i>	(JINR)
		Translated from ZETF 38 1047.		
JOSEPH	60	NC 16 997	D.W. Joseph	(EFI)

---