

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

We have omitted some results that have been superseded by later experiments.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 13.

<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.

$x_2$	-100	
$x_4$	0	-1
	$x_1$	$x_2$

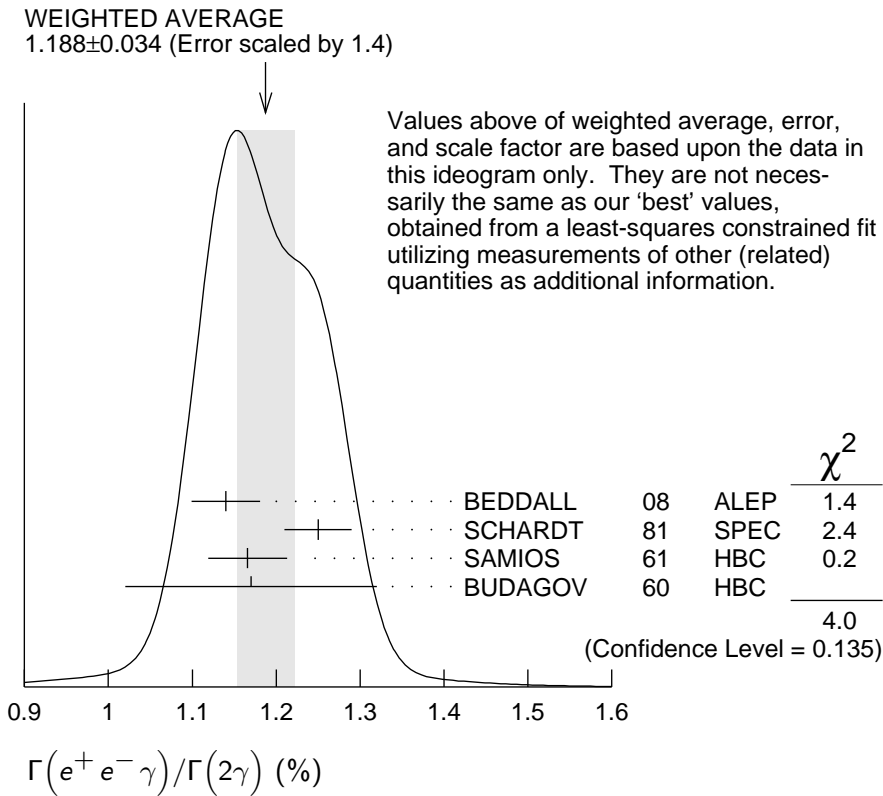
## $\pi^0$ BRANCHING RATIOS

$\Gamma(e^+ e^- \gamma) / \Gamma(2\gamma)$   $\Gamma_2 / \Gamma_1$

VALUE (%)	EVTS	DOCUMENT ID	TECN	COMMENT
<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 $^{+2.9}_{-2.8}$ ± 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 ABOUZAIID 07
<sup>9</sup> ABOUZAIID 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 $(8.8 ^{+4.5}_{-3.2} ± 0.6) \times 10^{-8}$ .					
<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 $^{+2.40}_{-1.10}$	90	8	FISCHER 78B	SPRK	$K^+ \rightarrow \pi^+\pi^0$

**$\Gamma(4\gamma)/\Gamma_{\text{total}}$**   **$\Gamma_6/\Gamma$**

<u>VALUE (units <math>10^{-8}</math>)</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt; 2</b>	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.

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt; 0.27</b>	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	$K^+ \rightarrow \pi^+ \nu \nu'$
< $2.9 \times 10^{-7}$			<sup>14</sup> LAM 91		Cosmological limit
< $3.2 \times 10^{-7}$			<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 ( $0.8 \times 10^{-7}$ ).

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

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<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.					

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

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<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 $\text{In } K_L^0 \rightarrow 3\pi^0$
<140		HERCZEG	84	RVUE $K^+ \rightarrow \pi^+ \mu e$
< 2 × 10 <sup>-6</sup>		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</b>	<b>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 +0.05 -0.04		<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 13	RMP 85 49	A. M. Bernstein, B. R. Holstein	(AMHT, MIT)
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 091102	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	JP G13 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)