

$$I^G(J^P) = 1^-(0^-)$$

We have omitted some results that have been superseded by later experiments.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** (1988).

### π± MASS

The most accurate charged pion mass measurements are based upon x-ray wavelength measurements for transitions in π<sup>-</sup>-mesonic atoms. The observed line is the blend of three components, corresponding to different K-shell occupancies. JECKELMANN 94 revisits the occupancy question, with the conclusion that two sets of occupancy ratios, resulting in two different pion masses (Solutions A and B), are equally probable. We choose the higher Solution B since only this solution is consistent with a positive mass-squared for the muon neutrino, given the precise muon momentum measurements now available (DAUM 91, ASSAMAGAN 94, and ASSAMAGAN 96) for the decay of pions at rest. Earlier mass determinations with pi-mesonic atoms may have used incorrect K-shell screening corrections.

Measurements with an error of > 0.005 MeV have been omitted from this Listing.

<u>VALUE (MeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>	
<b>139.57018±0.00035 OUR FIT</b>	Error includes scale factor of 1.2.				
<b>139.57018±0.00035 OUR AVERAGE</b>	Error includes scale factor of 1.2.				
139.57071±0.00053	<sup>1</sup> LENZ	98	CNTR	- pionic N2-atoms gas target	
139.56995±0.00035	<sup>2</sup> JECKELMANN 94	CNTR	-	π <sup>-</sup> atom, Soln. B	
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
139.57022±0.00014	<sup>3</sup> ASSAMAGAN 96	SPEC	+	π <sup>+</sup> → μ <sup>+</sup> ν <sub>μ</sub>	
139.56782±0.00037	<sup>4</sup> JECKELMANN 94	CNTR	-	π <sup>-</sup> atom, Soln. A	
139.56996±0.00067	<sup>5</sup> DAUM	91	SPEC	+	π <sup>+</sup> → μ <sup>+</sup> ν
139.56752±0.00037	<sup>6</sup> JECKELMANN 86B	CNTR	-	Mesonic atoms	
139.5704 ±0.0011	<sup>5</sup> ABELA	84	SPEC	+	See DAUM 91
139.5664 ±0.0009	<sup>7</sup> LU	80	CNTR	-	Mesonic atoms
139.5686 ±0.0020	CARTER	76	CNTR	-	Mesonic atoms
139.5660 ±0.0024	<sup>7,8</sup> MARUSHEN...	76	CNTR	-	Mesonic atoms

<sup>1</sup> LENZ 98 result does not suffer K-electron configuration uncertainties as does JECKELMANN 94.

<sup>2</sup> JECKELMANN 94 Solution B (dominant 2-electron K-shell occupancy), chosen for consistency with positive  $m_{\nu_{\mu}}^2$ .

<sup>3</sup> ASSAMAGAN 96 measures the μ<sup>+</sup> momentum  $p_{\mu}$  in π<sup>+</sup> → μ<sup>+</sup> ν<sub>μ</sub> decay at rest to be 29.79200 ± 0.00011 MeV/c. Combined with the μ<sup>+</sup> mass and the assumption  $m_{\nu_{\mu}} = 0$ , this gives the π<sup>+</sup> mass above; if  $m_{\nu_{\mu}} > 0$ ,  $m_{\pi^+}$  given above is a lower limit. Combined instead with  $m_{\mu}$  and (assuming CPT) the π<sup>-</sup> mass of JECKELMANN 94,  $p_{\mu}$  gives an upper limit on  $m_{\nu_{\mu}}$  (see the ν<sub>μ</sub>).

<sup>4</sup> JECKELMANN 94 Solution A (small 2-electron K-shell occupancy) in combination with either the DAUM 91 or ASSAMAGAN 94 pion decay muon momentum measurement yields a significantly negative  $m_{\nu\mu}^2$ . It is accordingly not used in our fits.

<sup>5</sup> The DAUM 91 value includes the ABELA 84 result. The value is based on a measurement of the  $\mu^+$  momentum for  $\pi^+$  decay at rest,  $p_\mu = 29.79179 \pm 0.00053$  MeV, uses  $m_\mu = 105.658389 \pm 0.000034$  MeV, and assumes that  $m_{\nu\mu} = 0$ . The last assumption means that in fact the value is a lower limit.

<sup>6</sup> JECKELMANN 86B gives  $m_\pi/m_e = 273.12677(71)$ . We use  $m_e = 0.51099906(15)$  MeV from COHEN 87. The authors note that two solutions for the probability distribution of K-shell occupancy fit equally well, and use other data to choose the lower of the two possible  $\pi^\pm$  masses.

<sup>7</sup> These values are scaled with a new wavelength-energy conversion factor  $V\lambda = 1.23984244(37) \times 10^{-6}$  eV m from COHEN 87. The LU 80 screening correction relies upon a theoretical calculation of inner-shell refilling rates.

<sup>8</sup> This MARUSHENKO 76 value used at the authors' request to use the accepted set of calibration  $\gamma$  energies. Error increased from 0.0017 MeV to include QED calculation error of 0.0017 MeV (12 ppm).

### $m_{\pi^+} - m_{\mu^+}$

Measurements with an error  $> 0.05$  MeV have been omitted from this Listing.

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	CHG	COMMENT	
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
$33.91157 \pm 0.00067$		<sup>9</sup> DAUM	91	SPEC	+	$\pi^+ \rightarrow \mu^+ \nu$
$33.9111 \pm 0.0011$		ABELA	84	SPEC		See DAUM 91
$33.925 \pm 0.025$		BOOTH	70	CNTR	+	Magnetic spect.
$33.881 \pm 0.035$	145	HYMAN	67	HEBC	+	$K^-$ He

<sup>9</sup> The DAUM 91 value assumes that  $m_{\nu\mu} = 0$  and uses our  $m_\mu = 105.658389 \pm 0.000034$  MeV.

### $(m_{\pi^+} - m_{\pi^-}) / m_{\text{average}}$

A test of CPT invariance.

VALUE (units $10^{-4}$ )	DOCUMENT ID	TECN
<b><math>2 \pm 5</math></b>	AYRES	71 CNTR

### $\pi^\pm$ MEAN LIFE

Measurements with an error  $> 0.02 \times 10^{-8}$  s have been omitted.

VALUE ( $10^{-8}$ s)	DOCUMENT ID	TECN	CHG	COMMENT	
<b><math>2.6033 \pm 0.0005</math> OUR AVERAGE</b>	Error includes scale factor of 1.2.				
$2.60361 \pm 0.00052$	<sup>10</sup> KOPTEV	95	SPEC	+	Surface $\mu^+$ 's
$2.60231 \pm 0.00050 \pm 0.00084$	NUMAO	95	SPEC	+	Surface $\mu^+$ 's
$2.609 \pm 0.008$	DUNAITSEV	73	CNTR	+	
$2.602 \pm 0.004$	AYRES	71	CNTR	$\pm$	
$2.604 \pm 0.005$	NORDBERG	67	CNTR	+	
$2.602 \pm 0.004$	ECKHAUSE	65	CNTR	+	

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

2.640 ± 0.008

<sup>11</sup> KINSEY 66 CNTR +

<sup>10</sup> KOPTEV 95 combines the statistical and systematic errors; the statistical error dominates.

<sup>11</sup> Systematic errors in the calibration of this experiment are discussed by NORDBERG 67.

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

A test of *CPT* invariance.

VALUE (units 10 <sup>-4</sup> )	DOCUMENT ID	TECN
<b>5.5 ± 7.1</b>	AYRES	71 CNTR

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

-14 ± 29	PETRUKHIN	68 CNTR
40 ± 70	BARDON	66 CNTR
23 ± 40	<sup>12</sup> LOBKOWICZ	66 CNTR

<sup>12</sup> This is the most conservative value given by LOBKOWICZ 66.

### π<sup>+</sup> DECAY MODES

π<sup>-</sup> modes are charge conjugates of the modes below.

Mode	Fraction (Γ <sub><i>i</i></sub> /Γ)	Confidence level
Γ <sub>1</sub> μ <sup>+</sup> ν <sub>μ</sub>	[a] (99.98770 ± 0.00004) %	
Γ <sub>2</sub> μ <sup>+</sup> ν <sub>μ</sub> γ	[b] ( 2.00 ± 0.25 ) × 10 <sup>-4</sup>	
Γ <sub>3</sub> e <sup>+</sup> ν <sub>e</sub>	[a] ( 1.230 ± 0.004 ) × 10 <sup>-4</sup>	
Γ <sub>4</sub> e <sup>+</sup> ν <sub>e</sub> γ	[b] ( 1.61 ± 0.23 ) × 10 <sup>-7</sup>	
Γ <sub>5</sub> e <sup>+</sup> ν <sub>e</sub> π <sup>0</sup>	( 1.025 ± 0.034 ) × 10 <sup>-8</sup>	
Γ <sub>6</sub> e <sup>+</sup> ν <sub>e</sub> e <sup>+</sup> e <sup>-</sup>	( 3.2 ± 0.5 ) × 10 <sup>-9</sup>	
Γ <sub>7</sub> e <sup>+</sup> ν <sub>e</sub> ν <sub>ν̄</sub>	< 5	× 10 <sup>-6</sup> 90%

#### Lepton Family number (*LF*) or Lepton number (*L*) violating modes

Γ <sub>8</sub> μ <sup>+</sup> ν <sub>e</sub>	<i>L</i> [c] < 1.5	× 10 <sup>-3</sup> 90%
Γ <sub>9</sub> μ <sup>+</sup> ν <sub>e</sub>	<i>LF</i> [c] < 8.0	× 10 <sup>-3</sup> 90%
Γ <sub>10</sub> μ <sup>-</sup> e <sup>+</sup> e <sup>+</sup> ν	<i>LF</i> < 1.6	× 10 <sup>-6</sup> 90%

[a] Measurements of Γ(e<sup>+</sup>ν<sub>e</sub>)/Γ(μ<sup>+</sup>ν<sub>μ</sub>) always include decays with γ's, and measurements of Γ(e<sup>+</sup>ν<sub>e</sub>γ) and Γ(μ<sup>+</sup>ν<sub>μ</sub>γ) never include low-energy γ's. Therefore, since no clean separation is possible, we consider the modes with γ's to be subreactions of the modes without them, and let [Γ(e<sup>+</sup>ν<sub>e</sub>) + Γ(μ<sup>+</sup>ν<sub>μ</sub>)]/Γ<sub>total</sub> = 100%.

[b] See the Particle Listings below for the energy limits used in this measurement; low-energy γ's are not included.

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

## $\pi^+$ BRANCHING RATIOS

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

$\Gamma_3/\Gamma$

See note [a] in the list of  $\pi^+$  decay modes just above, and see also the next block of data.

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>DOCUMENT ID</u>
<b>1.230 ± 0.004 OUR EVALUATION</b>	

### $[\Gamma(e^+ \nu_e) + \Gamma(e^+ \nu_e \gamma)] / [\Gamma(\mu^+ \nu_\mu) + \Gamma(\mu^+ \nu_\mu \gamma)]$ $(\Gamma_3 + \Gamma_4) / (\Gamma_1 + \Gamma_2)$

See note [a] in the list of  $\pi^+$  decay modes above. See NUMAO 92 for a discussion of  $e$ - $\mu$  universality.

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1.230 ± 0.004 OUR AVERAGE</b>				

1.2346 ± 0.0035 ± 0.0036	120k	CZAPEK	93	CALO Stopping $\pi^+$
1.2265 ± 0.0034 ± 0.0044	190k	BRITTON	92	CNTR Stopping $\pi^+$
1.218 ± 0.014	32k	BRYMAN	86	CNTR Stopping $\pi^+$

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

1.273 ± 0.028	11k	<sup>13</sup> DICAPUA	64	CNTR
1.21 ± 0.07		ANDERSON	60	SPEC

<sup>13</sup>DICAPUA 64 has been updated using the current mean life.

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

$\Gamma_2/\Gamma$

Note that measurements here do not cover the full kinematic range.

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
<b>2.0 ± 0.24 ± 0.08</b>		<sup>14</sup> BRESSI	98	CALO +	Stopping $\pi^+$

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

1.24 ± 0.25	26	CASTAGNOLI	58	EMUL $KE_\mu < 3.38$ MeV
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<sup>14</sup>BRESSI 98 result is given for  $E_\gamma > 1$  MeV only. Result agrees with QED expectation,  $2.283 \times 10^{-4}$  and does not confirm discrepancy of earlier experiment CASTAGNOLI 58.

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

$\Gamma_4/\Gamma$

Note that measurements here do not cover the full kinematic range.

<u>VALUE (units <math>10^{-8}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>16.1 ± 2.3</b>		<sup>15</sup> BOLOTOV	90B SPEC	17 GeV $\pi^- \rightarrow e^- \bar{\nu}_e \gamma$

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

5.6 ± 0.7	226	<sup>16</sup> STETZ	78	SPEC $P_e > 56$ MeV/c
3.0	143	DEPOMMIER	63B CNTR	$(KE)_{e^+ \gamma} > 48$ MeV

<sup>15</sup>BOLOTOV 90B is for  $E_\gamma > 21$  MeV,  $E_e > 70 - 0.8 E_\gamma$ .

<sup>16</sup>STETZ 78 is for an  $e^- \gamma$  opening angle  $> 132^\circ$ . Obtains 3.7 when using same cutoffs as DEPOMMIER 63B.

$\Gamma(e^+ \nu_e \pi^0)/\Gamma_{\text{total}}$   $\Gamma_5/\Gamma$

<u>VALUE (units <math>10^{-8}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>	
<b>1.025 ± 0.034 OUR AVERAGE</b>						
1.026 ± 0.039	1224	<sup>17</sup> MCFARLANE	85	CNTR	+	Decay in flight
1.00 <sup>+0.08</sup> <sub>-0.10</sub>	332	DEPOMMIER	68	CNTR	+	
1.07 ± 0.21	38	<sup>18</sup> BACASTOW	65	OSPK	+	
1.10 ± 0.26		<sup>18</sup> BERTRAM	65	OSPK	+	
1.1 ± 0.2	43	<sup>18</sup> DUNAITSEV	65	CNTR	+	
0.97 ± 0.20	36	<sup>18</sup> BARTLETT	64	OSPK	+	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
1.15 ± 0.22	52	<sup>18</sup> DEPOMMIER	63	CNTR	+	See DEPOMMIER 68

<sup>17</sup> MCFARLANE 85 combines a measured rate ( $0.394 \pm 0.015$ )/s with 1982 PDG mean life.

<sup>18</sup> DEPOMMIER 68 says the result of DEPOMMIER 63 is at least 10% too large because of a systematic error in the  $\pi^0$  detection efficiency, and that this may be true of all the previous measurements (also V. Soergel, private communication, 1972).

$\Gamma(e^+ \nu_e e^+ e^-)/\Gamma(\mu^+ \nu_\mu)$   $\Gamma_6/\Gamma_1$

<u>VALUE (units <math>10^{-9}</math>)</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<b>3.2 ± 0.5 ± 0.2</b>		98	EGLI	89	SPEC	Uses $R_{PCAC} = 0.068 \pm 0.004$

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

$0.46 \pm 0.16 \pm 0.07$	7	<sup>19</sup> BARANOV	92	SPEC	Stopped $\pi^+$
< 4.8	90	KORENCHE...	76B	SPEC	
< 34	90	KORENCHE...	71	OSPK	

<sup>19</sup> This measurement by BARANOV 92 is of the structure-dependent part of the decay. The value depends on values assumed for ratios of form factors.

$\Gamma(e^+ \nu_e \nu \bar{\nu})/\Gamma_{\text{total}}$   $\Gamma_7/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	
<b>&lt; 5</b>	90	PICCIOTTO	88	SPEC

$\Gamma(\mu^+ \bar{\nu}_e)/\Gamma_{\text{total}}$   $\Gamma_8/\Gamma$

Forbidden by total lepton number conservation.

<u>VALUE (units <math>10^{-3}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<b>&lt; 1.5</b>	90	<sup>20</sup> COOPER	82	HLBC	Wideband $\nu$ beam

<sup>20</sup> COOPER 82 limit on  $\bar{\nu}_e$  observation is here interpreted as a limit on lepton number violation.

$\Gamma(\mu^+ \nu_e)/\Gamma_{\text{total}}$   $\Gamma_9/\Gamma$

Forbidden by lepton family number conservation.

<u>VALUE (units <math>10^{-3}</math>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<b>&lt; 8.0</b>	90	<sup>21</sup> COOPER	82	HLBC	Wideband $\nu$ beam

<sup>21</sup> COOPER 82 limit on  $\nu_e$  observation is here interpreted as a limit on lepton family number violation.

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

$\Gamma_{10}/\Gamma$

Forbidden by lepton family number conservation.

<u>VALUE (units 10<sup>-6</sup>)</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
<b>&lt;1.6</b>	90	BARANOV	91B SPEC	+
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
<7.7	90	KORENCHE...	87 SPEC	+

## $\pi^+$ — POLARIZATION OF EMITTED $\mu^+$

### $\pi^+ \rightarrow \mu^+ \nu$

Tests the Lorentz structure of leptonic charged weak interactions.

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
<(-0.9959)	90	<sup>22</sup> FETSCHER	84 RVUE	+	
-0.99 ± 0.16		<sup>23</sup> ABELA	83 SPEC	-	$\mu$ X-rays

<sup>22</sup>FETSCHER 84 uses only the measurement of CARR 83.

<sup>23</sup>Sign of measurement reversed in ABELA 83 to compare with  $\mu^+$  measurements.

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## $\pi^\pm$ FORM FACTORS

### $F_V$ , VECTOR FORM FACTOR

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.017 ± 0.008 OUR AVERAGE</b>				
0.014 ± 0.009		<sup>24</sup> BOLOTOV	90B SPEC	17 GeV $\pi^- \rightarrow e^- \bar{\nu}_e \gamma$
0.023 <sup>+0.015</sup> <sub>-0.013</sub>	98	EGLI	89 SPEC	$\pi^+ \rightarrow e^+ \nu_e e^+ e^-$

<sup>24</sup>BOLOTOV 90B only determines the absolute value.

### $F_A$ , AXIAL-VECTOR FORM FACTOR

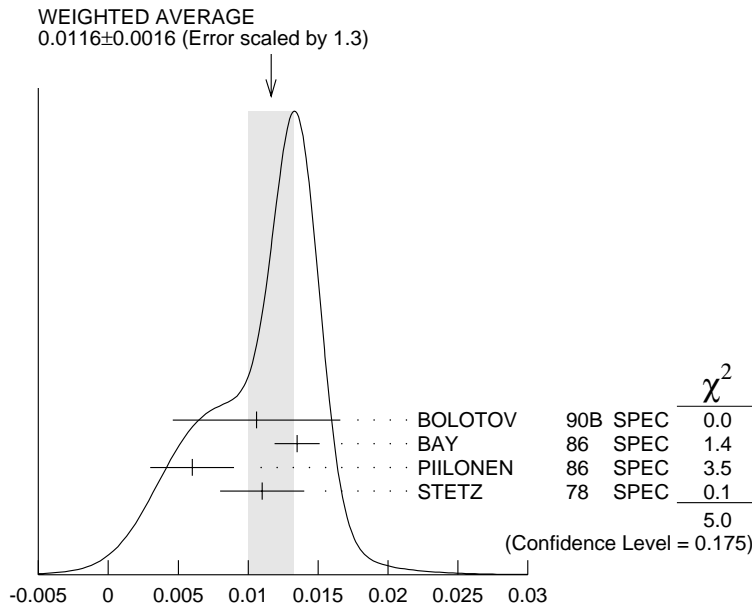
<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0116 ± 0.0016 OUR AVERAGE</b>				
Error includes scale factor of 1.3. See the ideogram below.				
0.0106 ± 0.0060		<sup>25</sup> BOLOTOV	90B SPEC	17 GeV $\pi^- \rightarrow e^- \bar{\nu}_e \gamma$
0.0135 ± 0.0016		<sup>25</sup> BAY	86 SPEC	$\pi^+ \rightarrow e^+ \nu \gamma$
0.006 ± 0.003		<sup>25</sup> PIILONEN	86 SPEC	$\pi^+ \rightarrow e^+ \nu \gamma$
0.011 ± 0.003		<sup>25,26</sup> STETZ	78 SPEC	$\pi^+ \rightarrow e^+ \nu \gamma$

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

0.021 <sup>+0.011</sup> <sub>-0.013</sub>	98	EGLI	89 SPEC	$\pi^+ \rightarrow e^+ \nu_e e^+ e^-$
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<sup>25</sup>Using the vector form factor from CVC prediction  $F_V = 0.0259 \pm 0.0005$ . Only the absolute value of  $F_A$  is determined.

<sup>26</sup>The result of STETZ 78 has a two-fold ambiguity. We take the solution compatible with later determinations.



$\pi^\pm$  axial-vector form factor

### R, SECOND AXIAL-VECTOR FORM FACTOR

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
$0.059^{+0.009}_{-0.008}$	98	EGLI	89 SPEC	$\pi^+ \rightarrow e^+ \nu_e e^+ e^-$

### $\pi^\pm$ 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** (1988).

BRESSI	98	NP B513 555	G. Bressi+	
LENZ	98	PL B416 50	S. Lenz+	
ASSAMAGAN	96	PR D53 6065	+Broennimann, Daum+	(PSI, ZURI, VILL, VIRG)
KOPTEV	95	JETPL 61 877	+Mikirtych'yants, Shcherbakov+	(PNPI)
NUMAO	95	PR D52 4855	+Macdonald, Marshall, Olin, Fujiwara	(TRIU, BRCO)
ASSAMAGAN	94	PL B335 231	+Broennimann, Daum+	(PSI, ZURI, VILL, VIRG)
JECKELMANN	94	PL B335 326	+Goudsmit, Leisi	(WABRN, VILL)
CZAPEK	93	PRL 70 17	+Federspiel, Flueckiger, Frei+	(BERN, VILL)
BARANOV	92	SJNP 55 1644	+Vanko, Glazov, Evtukhovich+	(JINR)
		Translated from YAF 55 2940.		
BRITTON	92	PRL 68 3000	+Ahmad, Bryman, Burnham+	(TRIU, CARL)
Also	94	PR D49 28	Britton, Ahmad, Bryman+	(TRIU, CARL)
NUMAO	92	MPL A7 3357		(TRIU)
BARANOV	91B	SJNP 54 790	+Kisel, Korenchenko, Kuchinskii+	(JINR)
		Translated from YAF 54 1298.		

DAUM	91	PL B265 425	+Frosch, Herter, Janousch, Kettle	(VILL)
BOLOTOV	90B	PL B243 308	+Gninenko, Djilkibaev, Isakov+	(INRM)
EGLI	89	PL B222 533	+Engfer, Grab, Hermes, Kraus+	(SINDRUM Collab.)
Also	86	PL B175 97	Egli, Engfer, Grab, Hermes+	(AACH3, ETH, SIN, ZURI)
PDG	88	PL B204	Yost, Barnett+	(LBL+)
PICCIOTTO	88	PR D37 1131	+Ahmad, Britton, Bryman, Clifford+	(TRIU, CNRC)
COHEN	87	RMP 59 1121	+Taylor	(RISC, NBS)
KORENCHE...	87	SJNP 46 192	Korenchenko, Kostin, Mzhaviya+	(JINR)
		Translated from YAF 46 313.		
BAY	86	PL B174 445	+Ruegger, Gabioud, Joseph, Loude+	(LAUS, ZURI)
BRYMAN	86	PR D33 1211	+Dubois, Macdonald, Numao+	(TRIU, CNRC)
Also	83	PRL 50 7	Bryman, Dubois, Numao, Olaniya+	(TRIU, CNRC)
JECKELMANN	86B	NP A457 709	+Beer, Chambrier, Elsenhans+	(ETH, FRIB)
Also	86	PRL 56 1444	Jeckelmann, Nakada, Beer+	(ETH, FRIB)
PIILONEN	86	PRL 57 1402	+Bolton, Cooper, Frank+	(LANL, TEMP, CHIC)
MCFARLANE	85	PR D32 547	+Auerbach, Gaille+	(TEMP, LANL)
ABELA	84	PL 146B 431	+Daum, Eaton, Frosch, Jost, Kettle+	(SIN)
Also	78	PL 74B 126	Daum, Eaton, Frosch, Hirschmann+	(SIN)
Also	79	PR D20 2692	Daum, Eaton, Frosch, Hirschmann+	(SIN)
FETSCHER	84	PL 140B 117		(ETH)
ABELA	83	NP A395 413	+Backenstoss, Kunold, Simons+	(BASL, KARLK, KARLE)
CARR	83	PRL 51 627	+Gidal, Gobbi, Jodidio, Oram+	(LBL, NWES, TRIU)
COOPER	82	PL 112B 97	+Guy, Michette, Tyndel, Venus	(RL)
LU	80	PRL 45 1066	+Delker, Dugan, Wu, Caffrey+	(YALE, COLU, JHU)
STETZ	78	NP B138 285	+Carroll, Ortendahl, Perez-Mendez+	(LBL, UCLA)
CARTER	76	PRL 37 1380	+Dixit, Sundaresan+	(CARL, CNRC, CHIC, CIT)
KORENCHE...	76B	JETP 44 35	Korenchenko, Kostin, Micelmacher+	(JINR)
		Translated from ZETF 71 69.		
MARUSHEN...	76	JETPL 23 72	Marushenko, Mezentsev, Petrunin+	(PNPI)
		Translated from ZETFP 23 80.		
Also	76	Private Comm.	Shafer	(FNAL)
Also	78	Private Comm.	Smirnov	(PNPI)
DUNAITSEV	73	SJNP 16 292	+Prokoshkin, Razuvaev+	(SERP)
		Translated from YAF 16 524.		
AYRES	71	PR D3 1051	+Cormack, Greenberg, Kenney+	(LRL, UCSB)
Also	67	PR 157 1288	Ayres, Caldwell, Greenberg, Kenney, Kurz+	(LRL)
Also	68	PRL 21 261	Ayres, Cormack, Greenberg+	(LRL, UCSB)
Also	69	Thesis UCRL 18369	Ayres	(LRL)
Also	69	PRL 23 1267	Greenberg, Ayres, Cormack+	(LRL, UCSB)
KORENCHE...	71	SJNP 13 189	Korenchenko, Kostin, Micelmacher+	(JINR)
		Translated from YAF 13 339.		
BOOTH	70	PL 32B 723	+Johnson, Williams, Wormald	(LIVP)
DEPOMMIER	68	NP B4 189	+Duclos, Heintze, Kleinknecht+	(CERN)
PETRUKHIN	68	JINR P1 3862	+Rykalin, Khazins, Cisek	(JINR)
HYMAN	67	PL 25B 376	+Loken, Pewitt, McKenzie+	(ANL, CMU, NWES)
NORDBERG	67	PL 24B 594	+Lobkowicz, Burman	(ROCH)
BARDON	66	PRL 16 775	+Dore, Dorfan, Krieger+	(COLU)
KINSEY	66	PR 144 1132	+Lobkowicz, Nordberg	(ROCH)
LOBKOWICZ	66	PRL 17 548	+Melissinos, Nagashima+	(ROCH, BNL)
BACASTOW	65	PR 139B 407	+Ghesquiere, Wiegand, Larsen	(LRL, SLAC)
BERTRAM	65	PR 139B 617	+Meyer, Carrigan+	(MICH, CMU)
DUNAITSEV	65	JETP 20 58	+Petrukhin, Prokoshkin+	(JINR)
		Translated from ZETF 47 84.		
ECKHAUSE	65	PL 19 348	+Harris, Shuler+	(WILL)
BARTLETT	64	PR 136B 1452	+Devons, Meyer, Rosen	(COLU)
DICAPUA	64	PR 133B 1333	+Garland, Pondrom, Strelzoff	(COLU)
Also	86	Private Comm.	Pondrom	(WISC)
DEPOMMIER	63	PL 5 61	+Heintze, Rubbia, Soergel	(CERN)
DEPOMMIER	63B	PL 7 285	+Heintze, Rubbia, Soergel	(CERN)
ANDERSON	60	PR 119 2050	+Fujii, Miller+	(EFI)
CASTAGNOLI	58	PR 112 1779	+Muchnik	(ROMA)