

$$I(J^P) = 1(\frac{1}{2}^+) \text{ Status: } ****$$

We have omitted some results that have been superseded by later experiments. See our earlier editions.

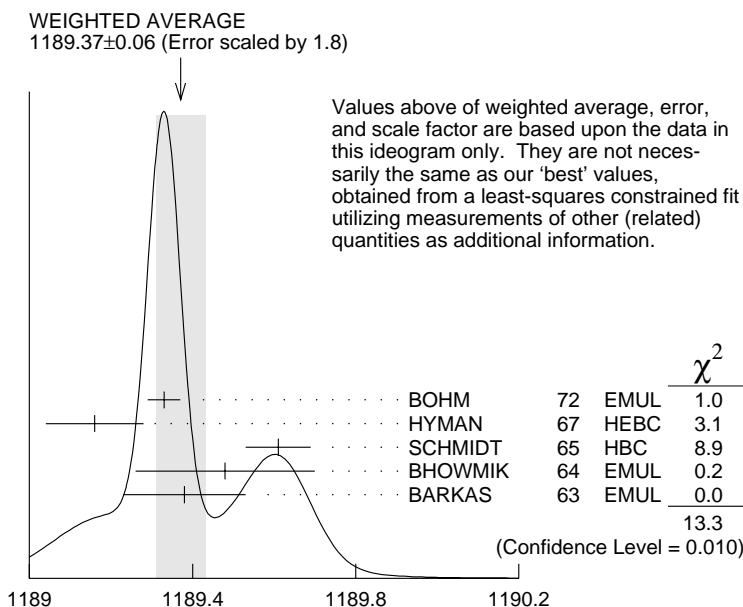
Σ⁺ MASS

The fit uses Σ⁺, Σ⁰, Σ⁻, and Λ mass and mass-difference measurements.

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
1189.37±0.07 OUR FIT				Error includes scale factor of 2.2.
1189.37±0.06 OUR AVERAGE				Error includes scale factor of 1.8. See the ideogram below.
1189.33±0.04	607	¹ BOHM	72 EMUL	
1189.16±0.12		HYMAN	67 HEBC	
1189.61±0.08	4205	SCHMIDT	65 HBC	See note with Λ mass
1189.48±0.22	58	² BHOWMIK	64 EMUL	
1189.38±0.15	144	² BARKAS	63 EMUL	

¹ BOHM 72 is updated with our 1973 K^- , π^- , and π^0 masses (Reviews of Modern Physics **45** No. 2 Pt. II (1973)).

² These masses have been raised 30 keV to take into account a 46 keV increase in the proton mass and a 21 keV decrease in the π^0 mass (note added 1967 edition, Reviews of Modern Physics **39** 1 (1967)).



Σ⁺ mass (MeV)

Σ^+ MEAN LIFE

Measurements with fewer than 1000 events have been omitted.

<u>VALUE (10^{-10} s)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.8018 ± 0.0026 OUR AVERAGE				
0.8038 ± 0.0040 ± 0.0014		BARBOSA	00 E761	hyperons, 375 GeV
0.8043 ± 0.0080 ± 0.0014		³ BARBOSA	00 E761	hyperons, 375 GeV
0.798 ± 0.005	30k	MARRAFFINO	80 HBC	$K^- p$ 0.42–0.5 GeV/c
0.807 ± 0.013	5719	CONFORTO	76 HBC	$K^- p$ 1–1.4 GeV/c
0.795 ± 0.010	20k	EISELE	70 HBC	$K^- p$ at rest
0.803 ± 0.008	10664	BARLOUTAUD	69 HBC	$K^- p$ 0.4–1.2 GeV/c
0.83 ± 0.032	1300	⁴ CHANG	66 HBC	

³This is a measurement of the $\bar{\Sigma}^-$ lifetime. Here we assume *CPT* invariance; see below for the fractional $\Sigma^+ - \bar{\Sigma}^-$ lifetime difference obtained by BARBOSA 00.

⁴We have increased the CHANG 66 error of 0.018; see our 1970 edition, Reviews of Modern Physics **42** No. 1 (1970).

$$(\tau_{\Sigma^+} - \tau_{\bar{\Sigma}^-}) / \tau_{\Sigma^+}$$

A test of *CPT* invariance.

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
(-6 ± 12) × 10⁻⁴	BARBOSA	00 E761	hyperons, 375 GeV

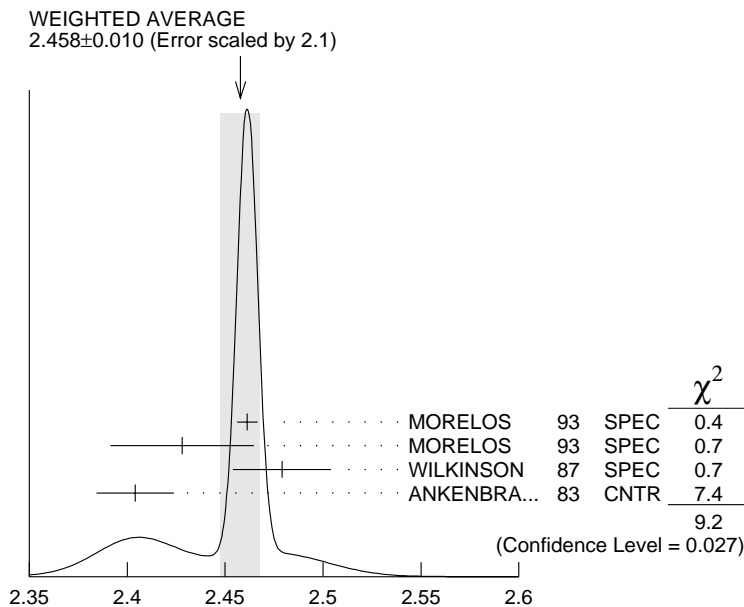
Σ^+ MAGNETIC MOMENT

See the “Note on Baryon Magnetic Moments” in the Λ Listings. Measurements with an error $\geq 0.1 \mu_N$ have been omitted.

<u>VALUE (μ_N)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
2.458 ± 0.010 OUR AVERAGE Error includes scale factor of 2.1. See the ideogram below.				
2.4613 ± 0.0034 ± 0.0040	250k	MORELOS	93 SPEC	p Cu 800 GeV
2.428 ± 0.036 ± 0.007	12k	⁵ MORELOS	93 SPEC	p Cu 800 GeV
2.479 ± 0.012 ± 0.022	137k	WILKINSON	87 SPEC	p Be 400 GeV
2.4040 ± 0.0198	44k	⁶ ANKENBRA...	83 CNTR	p Cu 400 GeV

⁵We assume *CPT* invariance: this is (minus) the $\bar{\Sigma}^-$ magnetic moment as measured by MORELOS 93. See below for the moment difference testing *CPT*.

⁶ANKENBRANDT 83 gives the value $2.38 \pm 0.02 \mu_N$. MORELOS 93 uses the same hyperon magnet and channel and claims to determine the field integral better, leading to the revised value given here.



Σ^+ magnetic moment (μ_N)

$$(\mu_{\Sigma^+} + \mu_{\Sigma^-}) / \mu_{\Sigma^+}$$

A test of *CPT* invariance.

VALUE	DOCUMENT ID	TECN	COMMENT
0.014±0.015	⁷ MORELOS	93 SPEC	p Cu 800 GeV

⁷This is our calculation from the MORELOS 93 measurements of the Σ^+ and Σ^- magnetic moments given above. The statistical error on μ_{Σ^-} dominates the error here.

Σ^+ DECAY MODES

Mode	Fraction (Γ_i/Γ)	Confidence level
Γ_1 $p\pi^0$	(51.57±0.30) %	
Γ_2 $n\pi^+$	(48.31±0.30) %	
Γ_3 $p\gamma$	(1.23±0.05) × 10 ⁻³	
Γ_4 $n\pi^+\gamma$	[a] (4.5 ±0.5) × 10 ⁻⁴	
Γ_5 $\Lambda e^+\nu_e$	(2.0 ±0.5) × 10 ⁻⁵	

$\Delta S = \Delta Q$ (SQ) violating modes or $\Delta S = 1$ weak neutral current (S1) modes

Γ_6 $ne^+\nu_e$	SQ	< 5	× 10 ⁻⁶	90%
Γ_7 $n\mu^+\nu_\mu$	SQ	< 3.0	× 10 ⁻⁵	90%
Γ_8 pe^+e^-	S1	< 7	× 10 ⁻⁶	

[a] See the Listings below for the pion momentum range used in this measurement.

CONSTRAINED FIT INFORMATION

An overall fit to 2 branching ratios uses 14 measurements and one constraint to determine 3 parameters. The overall fit has a $\chi^2 = 7.7$ for 12 degrees of freedom.

The following *off-diagonal* array elements are the correlation coefficients $\langle \delta x_i \delta x_j \rangle / (\delta x_i \cdot \delta x_j)$, 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_3	12	-14
	x_1	x_2

Σ^+ BRANCHING RATIOS

$\Gamma(n\pi^+) / \Gamma(N\pi)$ $\Gamma_2 / (\Gamma_1 + \Gamma_2)$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.4836 ± 0.0030 OUR FIT				
0.4836 ± 0.0030 OUR AVERAGE				
0.4828 ± 0.0036	10k	⁸ MARRAFFINO 80	HBC	$K^- p$ 0.42–0.5 GeV/c
0.488 ± 0.008	1861	NOWAK 78	HBC	
0.484 ± 0.015	537	TOVEE 71	EMUL	
0.488 ± 0.010	1331	BARLOUTAUD 69	HBC	$K^- p$ 0.4–1.2 GeV/c
0.46 ± 0.02	534	CHANG 66	HBC	
0.490 ± 0.024	308	HUMPHREY 62	HBC	

⁸ MARRAFFINO 80 actually gives $\Gamma(p\pi^0) / \Gamma(\text{total}) = 0.5172 \pm 0.0036$.

$\Gamma(p\gamma) / \Gamma(p\pi^0)$ Γ_3 / Γ_1

<u>VALUE (units 10^{-3})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
2.38 ± 0.10 OUR FIT				
2.38 ± 0.10 OUR AVERAGE				
2.32 ± 0.11 ± 0.10	32k	TIMM 95	E761	Σ^+ 375 GeV
2.81 ± 0.39 ^{+0.21} / _{-0.43}	408	HESSEY 89	CNTR	$K^- p \rightarrow \Sigma^+ \pi^-$ at rest
2.52 ± 0.28	190	⁹ KOBAYASHI 87	CNTR	$\pi^+ p \rightarrow \Sigma^+ K^+$
2.46 ^{+0.30} / _{-0.35}	155	BIAGI 85	CNTR	CERN hyperon beam
2.11 ± 0.38	46	MANZ 80	HBC	$K^- p \rightarrow \Sigma^+ \pi^-$
2.1 ± 0.3	45	ANG 69B	HBC	$K^- p$ at rest
2.76 ± 0.51	31	GERSHWIN 69B	HBC	$K^- p \rightarrow \Sigma^+ \pi^-$
3.7 ± 0.8	24	BAZIN 65	HBC	$K^- p$ at rest

⁹ KOBAYASHI 87 actually gives $\Gamma(p\gamma) / \Gamma(\text{total}) = (1.30 \pm 0.15) \times 10^{-3}$.

$\Gamma(n\pi^+\gamma)/\Gamma(n\pi^+)$

Γ_4/Γ_2

The π^+ momentum cuts differ, so we do not average the results but simply use the latest value in the Summary Table.

<u>VALUE (units 10^{-3})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
0.93±0.10	180	EBENHOH	73 HBC	$\pi^+ < 150$ MeV/c

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

0.27±0.05	29	ANG	69B HBC	$\pi^+ < 110$ MeV/c
~ 1.8		BAZIN	65B HBC	$\pi^+ < 116$ MeV/c

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

Γ_5/Γ

<u>VALUE (units 10^{-5})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
2.0±0.5 OUR AVERAGE				

1.6±0.7	5	BALTAY	69 HBC	$K^- p$ at rest
2.9±1.0	10	EISELE	69 HBC	$K^- p$ at rest
2.0±0.8	6	BARASH	67 HBC	$K^- p$ at rest

$\Gamma(ne^+\nu_e)/\Gamma(n\pi^+)$

Γ_6/Γ_2

Test of $\Delta S = \Delta Q$ rule. Experiments with an effective denominator less than 100,000 have been omitted.

<u>EFFECTIVE DENOM.</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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< 1.1 × 10⁻⁵ OUR LIMIT Our 90% CL limit = (2.3 events)/(effective denominator sum). [Number of events increased to 2.3 for a 90% confidence level.]

111000	0	¹⁰ EBENHOH	74 HBC	$K^- p$ at rest
105000	0	¹⁰ SECHI-ZORN	73 HBC	$K^- p$ at rest

¹⁰ Effective denominator calculated by us.

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

Γ_7/Γ_2

Test of $\Delta S = \Delta Q$ rule.

<u>EFFECTIVE DENOM.</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
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< 6.2 × 10⁻⁵ OUR LIMIT Our 90% CL limit = (6.7 events)/(effective denominator sum). [Number of events increased to 6.7 for a 90% confidence level.]

33800	0	BAGGETT	69B HBC
62000	2	¹¹ EISELE	69B HBC
10150	0	¹² COURANT	64 HBC
1710	0	¹² NAUENBERG	64 HBC
120	1	GALTIERI	62 EMUL

¹¹ Effective denominator calculated by us.

¹² Effective denominator taken from EISELE 67.

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

Γ_8/Γ

<u>VALUE (units 10^{-6})</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<7	¹³ ANG	69B HBC	$K^- p$ at rest

¹³ ANG 69B found three pe^+e^- events in agreement with $\gamma \rightarrow e^+e^-$ conversion from $\Sigma^+ \rightarrow p\gamma$. The limit given here is for neutral currents.

$\Gamma(\Sigma^+ \rightarrow ne^+\nu_e)/\Gamma(\Sigma^- \rightarrow ne^-\bar{\nu}_e)$

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
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<0.009 OUR LIMIT Our 90% CL limit, using $\Gamma(ne^+\nu_e)/\Gamma(n\pi^+)$ above.

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

<0.019	90	0	EBENHOH	74 HBC	$K^- p$ at rest
<0.018	90	0	SECHI-ZORN	73 HBC	$K^- p$ at rest
<0.12	95	0	COLE	71 HBC	$K^- p$ at rest
<0.03	90	0	EISELE	69B HBC	See EBENHOH 74

$\Gamma(\Sigma^+ \rightarrow n\mu^+\nu_\mu)/\Gamma(\Sigma^- \rightarrow n\mu^-\bar{\nu}_\mu)$

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
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<0.12 OUR LIMIT Our 90% CL limit, using $\Gamma(n\mu^+\nu_\mu)/\Gamma(n\pi^+)$ above.

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

$0.06^{+0.045}_{-0.03}$		2	EISELE	69B HBC	$K^- p$ at rest
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$\Gamma(\Sigma^+ \rightarrow n\ell^+\nu)/\Gamma(\Sigma^- \rightarrow n\ell^-\bar{\nu})$

Test of $\Delta S = \Delta Q$ rule.

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
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<0.043 OUR LIMIT Our 90% CL limit, using $[\Gamma(ne^+\nu_e) + \Gamma(n\mu^+\nu_\mu)]/\Gamma(n\pi^+)$.

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

<0.08		1	NORTON	69 HBC	
<0.034		0	BAGGETT	67 HBC	

Σ^+ DECAY PARAMETERS

See the "Note on Baryon Decay Parameters" in the neutron Listings. A few early results have been omitted.

α_0 FOR $\Sigma^+ \rightarrow p\pi^0$

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
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$-0.980^{+0.017}_{-0.015}$ OUR FIT

$-0.980^{+0.017}_{-0.013}$ OUR AVERAGE

$-0.945^{+0.055}_{-0.042}$		1259	¹⁴ LIPMAN	73 OSPK	$\pi^+ p \rightarrow \Sigma^+$
-0.940 ± 0.045		16k	BELLAMY	72 ASPK	$\pi^+ p \rightarrow \Sigma^+ K^+$
$-0.98^{+0.05}_{-0.02}$		1335	¹⁵ HARRIS	70 OSPK	$\pi^+ p \rightarrow \Sigma^+ K^+$
-0.999 ± 0.022		32k	BANGERTER	69 HBC	$K^- p$ 0.4 GeV/c

¹⁴ Decay protons scattered off aluminum.

¹⁵ Decay protons scattered off carbon.

ϕ_0 ANGLE FOR $\Sigma^+ \rightarrow p\pi^0$ ($\tan \phi_0 = \beta/\gamma$)

VALUE (°)	EVTS	DOCUMENT ID	TECN	COMMENT
36 ± 34 OUR AVERAGE				
38.1 ^{+35.7} _{-37.1}	1259	¹⁶ LIPMAN	73 OSPK	$\pi^+ p \rightarrow \Sigma^+ K^+$
22 ± 90		¹⁷ HARRIS	70 OSPK	$\pi^+ p \rightarrow \Sigma^+ K^+$

¹⁶ Decay proton scattered off aluminum.¹⁷ Decay protons scattered off carbon. **α_+ / α_0**

Older results have been omitted.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
-0.069 ± 0.013 OUR FIT				
-0.073 ± 0.021	23k	MARRAFFINO 80	HBC	$K^- p$ 0.42–0.5 GeV/c

 α_+ FOR $\Sigma^+ \rightarrow n\pi^+$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.068 ± 0.013 OUR FIT				
0.066 ± 0.016 OUR AVERAGE				
0.037 ± 0.049	4101	BERLEY	70B HBC	
0.069 ± 0.017	35k	BANGERTER 69	HBC	$K^- p$ 0.4 GeV/c

 ϕ_+ ANGLE FOR $\Sigma^+ \rightarrow n\pi^+$ ($\tan \phi_+ = \beta/\gamma$)

VALUE (°)	EVTS	DOCUMENT ID	TECN	COMMENT
167 ± 20 OUR AVERAGE				Error includes scale factor of 1.1.
184 ± 24	1054	¹⁸ BERLEY	70B HBC	
143 ± 29	560	BANGERTER 69B	HBC	$K^- p$ 0.4 GeV/c

¹⁸ Changed from 176 to 184° to agree with our sign convention. **α_γ FOR $\Sigma^+ \rightarrow p\gamma$**

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
-0.76 ± 0.08 OUR AVERAGE				
-0.720 ± 0.086 ± 0.045	35k	¹⁹ FOUCHER	92 SPEC	Σ^+ 375 GeV
-0.86 ± 0.13 ± 0.04	190	KOBAYASHI	87 CNTR	$\pi^+ p \rightarrow \Sigma^+ K^+$
-0.53 ^{+0.38} _{-0.36}	46	MANZ	80 HBC	$K^- p \rightarrow \Sigma^+ \pi^-$
-1.03 ^{+0.52} _{-0.42}	61	GERSHWIN	69B HBC	$K^- p \rightarrow \Sigma^+ \pi^-$

¹⁹ See TIMM 95 for a detailed description of the analysis. **Σ^+ REFERENCES**

We have omitted some papers that have been superseded by later experiments. See our earlier editions.

BARBOSA	00	PR D61 031101R	R.F. Barbosa <i>et al.</i>	(FNAL E761 Collab.)
TIMM	95	PR D51 4638	S. Timm <i>et al.</i>	(FNAL E761 Collab.)
MORELOS	93	PRL 71 3417	A. Morelos <i>et al.</i>	(FNAL E761 Collab.)
FOUCHER	92	PRL 68 3004	M. Foucher <i>et al.</i>	(FNAL E761 Collab.)
HESSEY	89	ZPHY C42 175	N.P. Hessey <i>et al.</i>	(BNL-811 Collab.)
KOBAYASHI	87	PRL 59 868	M. Kobayashi <i>et al.</i>	(KYOT)
WILKINSON	87	PRL 58 855	C.A. Wilkinson <i>et al.</i>	(WISC, MICH, RUTG+)
BIAGI	85	ZPHY C28 495	S.F. Biagi <i>et al.</i>	(CERN WA62 Collab.)
ANKENBRA...	83	PRL 51 863	C.M. Ankenbrandt <i>et al.</i>	(FNAL, IOWA, ISU+)
MANZ	80	PL 96B 217	A. Manz <i>et al.</i>	(MPIM, VAND)

MARRAFFINO	80	PR D21 2501	J. Marraffino <i>et al.</i>	(VAND, MPIM)
NOWAK	78	NP B139 61	R.J. Nowak <i>et al.</i>	(LOUC, BELG, DURH+)
CONFORTO	76	NP B105 189	B. Conforto <i>et al.</i>	(RHEL, LOIC)
EBENHOH	74	ZPHY 266 367	H. Ebenhoh <i>et al.</i>	(HEIDT)
EBENHOH	73	ZPHY 264 413	W. Ebenhoh <i>et al.</i>	(HEIDT)
LIPMAN	73	PL 43B 89	N.H. Lipman <i>et al.</i>	(RHEL, SUSS, LOWC)
PDG	73	RMP 45 No. 2 Pt. II	T.A. Lasinski <i>et al.</i>	(LBL, BRAN, CERN+)
SECHI-ZORN	73	PR D8 12	B. Sechi-Zorn, G.A. Snow	(UMD)
BELLAMY	72	PL 39B 299	E.H. Bellamy <i>et al.</i>	(LOWC, RHEL, SUSS)
BOHM	72	NP B48 1	G. Bohm <i>et al.</i>	(BERL, KIDR, BRUX, IASD+)
Also	73	IIHE-73.2 Nov	G. Bohm	(BERL, KIDR, BRUX, IASD, DUUC+)
COLE	71	PR D4 631	J. Cole <i>et al.</i>	(STON, COLU)
TOVEE	71	NP B33 493	D.N. Tovee <i>et al.</i>	(LOUC, KIDR, BERL+)
BERLEY	70B	PR D1 2015	D. Berley <i>et al.</i>	(BNL, MASA, YALE)
EISELE	70	ZPHY 238 372	F. Eisele <i>et al.</i>	(HEID)
HARRIS	70	PRL 24 165	F. Harris <i>et al.</i>	(MICH, WISC)
PDG	70	RMP 42 No. 1	A. Barbaro-Galtieri <i>et al.</i>	(LRL, BRAN+)
ANG	69B	ZPHY 228 151	G. Ang <i>et al.</i>	(HEID)
BAGGETT	69B	Thesis MDDP-TR-973	N.V. Baggett	(UMD)
BALTAY	69	PRL 22 615	C. Baltay <i>et al.</i>	(COLU, STON)
BANGERTER	69	Thesis UCRL 19244	R.O. Bangerter	(LRL)
BANGERTER	69B	PR 187 1821	R.O. Bangerter <i>et al.</i>	(LRL)
BARLOUTAUD	69	NP B14 153	R. Barloutaud <i>et al.</i>	(SACL, CERN, HEID)
EISELE	69	ZPHY 221 1	F. Eisele <i>et al.</i>	(HEID)
Also	64	PRL 13 291	W. Willis <i>et al.</i>	(BNL, CERN, HEID, UMD)
EISELE	69B	ZPHY 221 401	F. Eisele <i>et al.</i>	(HEID)
GERSHWIN	69B	PR 188 2077	L.K. Gershwin <i>et al.</i>	(LRL)
Also	69	Thesis UCRL 19246	L.K. Gershwin	(LRL)
NORTON	69	Thesis Nevis 175	H. Norton	(COLU)
BAGGETT	67	PRL 19 1458	N. Baggett <i>et al.</i>	(UMD)
Also	68	Vienna Abs. 374	N.V. Baggett, B. Kehoe	(UMD)
Also	68B	Private Comm.	N.V. Baggett	(UMD)
BARASH	67	PRL 19 181	N. Barash <i>et al.</i>	(UMD)
EISELE	67	ZPHY 205 409	F. Eisele <i>et al.</i>	(HEID)
HYMAN	67	PL 25B 376	L.G. Hyman <i>et al.</i>	(ANL, CMU, NWES)
PDG	67	RMP 39 1	A.H. Rosenfeld <i>et al.</i>	(LRL, CERN, YALE)
CHANG	66	PR 151 1081	C.Y. Chang	(COLU)
Also	65	Thesis Nevis 145	C.Y. Chang	(COLU)
BAZIN	65	PRL 14 154	M. Bazin <i>et al.</i>	(PRIN, COLU)
BAZIN	65B	PR 140B 1358	M. Bazin <i>et al.</i>	(PRIN, RUTG, COLU)
SCHMIDT	65	PR 140B 1328	P. Schmidt	(COLU)
BHOWMIK	64	NP 53 22	B. Bhowmik <i>et al.</i>	(DELH)
COURANT	64	PR 136B 1791	H. Courant <i>et al.</i>	(CERN, HEID, UMD+)
NAUENBERG	64	PRL 12 679	U. Nauenberg <i>et al.</i>	(COLU, RUTG, PRIN)
BARKAS	63	PRL 11 26	W.H. Barkas, J.N. Dyer, H.H. Heckman	(LRL)
Also	61	Thesis UCRL 9450	J.N. Dyer	(LRL)
GALTIERI	62	PRL 9 26	A. Barbaro-Galtieri <i>et al.</i>	(LRL)
HUMPHREY	62	PR 127 1305	W.E. Humphrey, R.R. Ross	(LRL)