Σ^+

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

We have omitted some results that have been superseded by later experiments.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

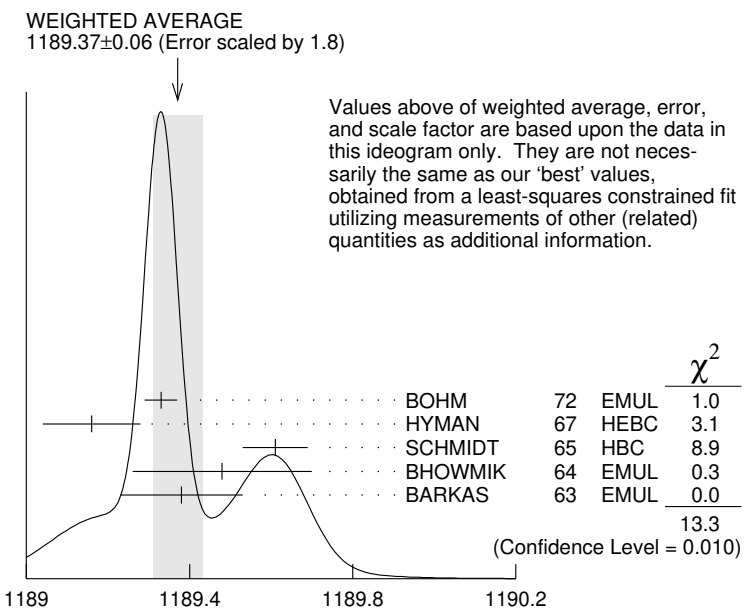
Σ^+ MASS

The fit uses Σ^+, Σ^0, 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 an error $\geq 0.1 \times 10^{-10}$ s have been omitted.

VALUE (10^{-10} s)	EVTS	DOCUMENT ID		TECN	COMMENT
0.799±0.004 OUR AVERAGE					
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
0.83 ±0.04	526	BAKKER	71	DBC	$K^- n \rightarrow \Sigma^+ \pi^- \pi^-$
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	[3] CHANG	66	HBC	
0.80 ±0.07	381	COOK	66	OSPK	
0.84 ±0.09	181	BALTAY	65	HBC	
0.76 ±0.03	900	CARAYAN...	65	HBC	
$0.749^{+0.056}_{-0.052}$	192	GRARD	62	HBC	
0.765±0.04	456	HUMPHREY	62	HBC	

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

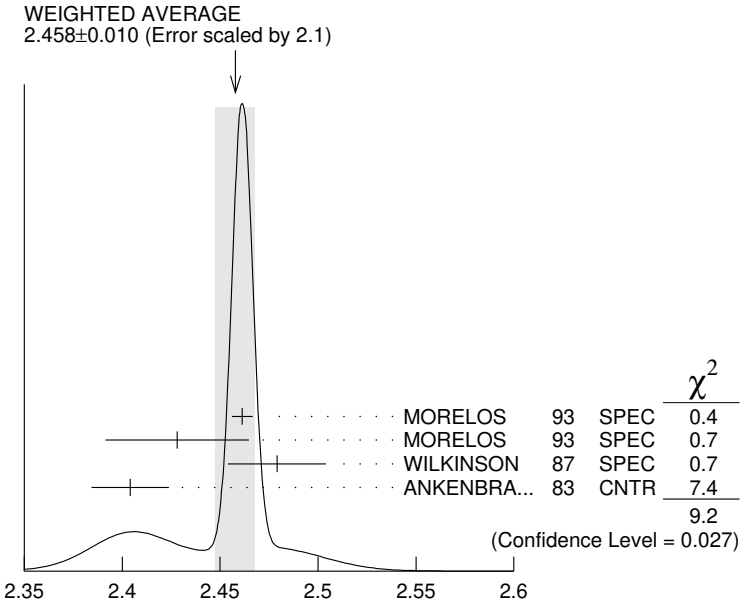
Σ^+ MAGNETIC MOMENT

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

VALUE (μ_N)	EVTS	DOCUMENT ID		TECN	COMMENT
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	pCu 800 GeV
2.428 ±0.036 ±0.007	12k	[4] MORELOS	93	SPEC	pCu 800 GeV
2.479 ±0.012 ±0.022	137k	WILKINSON	87	SPEC	pBe 400 GeV
2.4040±0.0198	44k	[5] ANKENBRA...	83	CNTR	pCu 400 GeV

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

[5] ANKENBRANDT 83 gives the value 2.38 ± 0.02μ_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)

$(\mu_{\Sigma^+} + \mu_{\overline{\Sigma}^-}) / |\mu|_{\text{average}}$

A test of *CPT* invariance.

VALUE	DOCUMENT ID		TECN	COMMENT
0.014±0.015	[6] MORELOS	93	SPEC	pCu 800 GeV

[6] This is our calculation from the MORELOS 93 measurements of the Σ^+ and $\overline{\Sigma}^-$ magnetic moments given above. The statistical error on $\mu_{\overline{\Sigma}^-}$ 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	$p\gamma$		$(1.23\pm0.05)\times10^{-3}$	
Γ_4	$n\pi^+\gamma$	[a]	$(4.5\pm0.5)\times10^{-4}$	
Γ_5	$\Lambda e^+\nu_e$		$(2.0\pm0.5)\times10^{-5}$	

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

Γ_6	$n e^+\nu_e$	SQ	< 5	$\times10^{-6}$	90%
Γ_7	$n\mu^+\nu_\mu$	SQ	< 3.0	$\times10^{-5}$	90%
Γ_8	$p e^+ e^-$	$S1$	< 7	$\times10^{-6}$	

[a] See the Particle 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

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

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.4836±0.0030 OUR FIT					
0.4836±0.0030 OUR AVERAGE					
0.4828±0.0036	10k	[7] 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	

[7] 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

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
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
$2.81 \pm 0.39^{+0.21}_{-0.43}$	408	HESSEY	89	CNTR	$K^- p \rightarrow \Sigma^+ \pi^-$ at rest
2.52±0.28	190	[8] 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

[8] 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.

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
0.93±0.10	180	EBENHOH	73	HBC	π^+ < 150 MeV/c
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.27±0.05	29	ANG	69B	HBC	π^+ < 110 MeV/c
~ 1.8		BAZIN	65B	HBC	π^+ < 116 MeV/c

$\Gamma(\Lambda e^+\nu_e)/\Gamma_{total}$ — Γ_5/Γ

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

EFFECTIVE DENOM.	EVTS	DOCUMENT ID		TECN	COMMENT
< 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	[9] EBENHOH	74	HBC	K^-p at rest
105000	0	[9] SECHI-ZORN	73	HBC	K^-p at rest

[9] Effective denominator calculated by us.

$\Gamma(n\mu^+\nu_\mu)/\Gamma(n\pi^+)$ — Γ_7/Γ_2

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

EFFECTIVE DENOM.	EVTS	DOCUMENT ID		TECN
< 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	[10] EISELE	69B	HBC
10150	0	[11] COURANT	64	HBC
1710	0	[11] NAUENBERG	64	HBC
120	1	GALTIERI	62	EMUL

[10] Effective denominator calculated by us.
[11] Effective denominator taken from EISELE 67.

$\Gamma(pe^+e^-)/\Gamma_{total}$ — Γ_8/Γ

VALUE (units 10^{-6})	DOCUMENT ID		TECN	COMMENT
<7	[12] ANG	69B	HBC	K^-p at rest

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

$\Gamma(\Sigma^+ \to n e^+ \nu_e)/\Gamma(\Sigma^- \to n e^- \overline{\nu}_e)$

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

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

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
<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

$\Gamma(\Sigma^+ \to n \ell^+ \nu)/\Gamma(\Sigma^- \to n \ell^- \overline{\nu})$

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

VALUE	EVTS	DOCUMENT ID		TECN
<0.043 OUR LIMIT	Our 90% CL limit, using $\left[\Gamma(n e^+ \nu_e) + \Gamma(n \mu^+ \nu_\mu)\right]/\Gamma(n \pi^+)$.			
• • • 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 $\Sigma^+ \to p \pi^0$

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
$\mathbf{-0.980^{+0.017}_{-0.015}}$ **OUR FIT**					
$\mathbf{-0.980^{+0.017}_{-0.013}}$ **OUR AVERAGE**					
$-0.945^{+0.055}_{-0.042}$	1259	[13] LIPMAN	73	OSPK	$\pi^+ p \to \Sigma^+$
-0.940 ± 0.045	16k	BELLAMY	72	ASPK	$\pi^+ p \to \Sigma^+ K^+$
$-0.98^{+0.05}_{-0.02}$	1335	[14] HARRIS	70	OSPK	$\pi^+ p \to \Sigma^+ K^+$
-0.999 ± 0.022	32k	BANGERTER	69	HBC	$K^- p$ 0.4 GeV/c

[13] Decay protons scattered off aluminum.
[14] 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	[15] LIPMAN	73	OSPK	$\pi^+ p \rightarrow \Sigma^+ K^+$
22 ±90		[16] HARRIS	70	OSPK	$\pi^+ p \rightarrow \Sigma^+ K^+$

[15] Decay proton scattered off aluminum.
[16] 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	[17] BERLEY	70B	HBC	
143±29	560	BANGERTER	69B	HBC	$K^- p$ 0.4 GeV/c

[17] 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	[18] 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	$K^- p \rightarrow \Sigma^+ \pi^-$

[18] 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.

TIMM	95	PR D51 4638	+Albuquerque, Bondar+	(FNAL E761 Collab.)
MORELOS	93	PRL 71 3417	+Albuquerque, Bondar, Carrigan+	(FNAL E761 Collab.)
FOUCHER	92	PRL 68 3004	+Albuquerque, Bondar+	(FNAL E761 Collab.)
HESSEY	89	ZPHY C42 175	+Booth, Fickinger, Gall+	(BNL-811 Collab.)
KOBAYASHI	87	PRL 59 868	+Haba, Homma, Kawai, Miyake+	(KYOT)
WILKINSON	87	PRL 58 855	+Handler+	(WISC, MICH, RUTG, MINN)
BIAGI	85	ZPHY C28 495	+Bourquin+	(CERN WA62 Collab.)
ANKENBRA...	83	PRL 51 863	Ankenbrandt, Berge+	(FNAL, IOWA, ISU, YALE)
MANZ	80	PL 96B 217	+Reucroft, Settles, Wolf+	(MPIM, VAND)
MARRAFFINO	80	PR D21 2501	+Reucroft, Roos, Waters+	(VAND, MPIM)
NOWAK	78	NP B139 61	+Armstrong, Davis+	(LOUC, BELG, DURH, WARS)
CONFORTO	76	NP B105 189	+Gopal, Kalmus, Litchfield, Ross+	(RHEL, LOIC)
EBENHOH	74	ZPHY 266 367	+Eisele, Engelmann, Filthuth, Hepp+	(HEIDT)
EBENHOH	73	ZPHY 264 413	+Eisele, Filthuth, Hepp, Leitner, Thouw+	(HEIDT)
LIPMAN	73	PL 43B 89	+Uto, Walker, Montgomery+	(RHEL, SUSS, LOWC)
PDG	73	RMP 45 No. 2 Pt. II	Lasinski, Barbaro-Galtieri, Kelly+	(LBL, BRAN, CERN+)
SECHI-ZORN	73	PR D8 12	+Snow	(UMD)
BELLAMY	72	PL 39B 299	+Anderson, Crawford+	(LOWC, RHEL, SUSS)
BOHM	72	NP B48 1	+	(BERL, KIDR, BRUX, IASD, DUUC, LOUC+)
Also	73	IIHE-73.2 Nov	Bohm	(BERL, KIDR, BRUX, IASD, DUUC, LOUC+)
BAKKER	71	LNC 1 37	+Hoogland, Kluyver, Massard+	(SABRE Collab.)
COLE	71	PR D4 631	+Lee-Franzini, Loveless, Baltay+	(STON, COLU)
TOVEE	71	NP B33 493	+	(LOUC, KIDR, BERL, BRUX, DUUC, WARS)
BERLEY	70B	PR D1 2015	+Yamin, Hertzbach, Kofler+	(BNL, MASA, YALE)
EISELE	70	ZPHY 238 372	+Filthuth, Hepp, Presser, Zech	(HEID)
HARRIS	70	PRL 24 165	+Overseth, Pondrom, Dettmann	(MICH, WISC)
PDG	70	RMP 42 No. 1	Barbaro-Galtieri, Derenzo, Price+	(LRL, BRAN, CERN+)
ANG	69B	ZPHY 228 151	+Ebenhoh, Eisele, Engelmann, Filthuth+	(HEID)
BAGGETT	69B	Thesis MDDP-TR-973		(UMD)
BALTAY	69	PRL 22 615	+Franzini, Newman, Norton+	(COLU, STON)
BANGERTER	69	Thesis UCRL 19244		(LRL)
BANGERTER	69B	PR 187 1821	+Alston-Garnjost, Galtieri, Gershwin+	(LRL)
BARLOUTAUD	69	NP B14 153	+DeBellefon, Granet+	(SACL, CERN, HEID)
EISELE	69	ZPHY 221 1	+Engelmann, Filthuth, Fohlisch, Hepp+	(HEID)
Also	64	PRL 13 291	Willis, Courant+	(BNL, CERN, HEID, UMD)
EISELE	69B	ZPHY 221 401	+Engelmann, Filthuth, Fohlisch, Hepp+	(HEID)
GERSHWIN	69B	PR 188 2077	+Alston-Garnjost, Bangerter+	(LRL)
Also	69	Thesis UCRL 19246	Gershwin	(LRL)
NORTON	69	Thesis Nevis 175		(COLU)
BAGGETT	67	PRL 19 1458	+Day, Glasser, Kehoe, Knop+	(UMD)
Also	68	Vienna Abs. 374	Baggett, Kehoe	(UMD)
Also	68B	Private Comm.	Baggett	(UMD)
BARASH	67	PRL 19 181	+Day, Glasser, Kehoe, Knop+	(UMD)
EISELE	67	ZPHY 205 409	+Engelmann, Filthuth, Folish, Hepp+	(HEID)
HYMAN	67	PL 25B 376	+Loken, Pewitt, McKenzie+	(ANL, CMU, NWES)
PDG	67	RMP 39 1	Rosenfeld, Barbaro-Galtieri, Podolsky+	(LRL, CERN, YALE)
CHANG	66	PR 151 1081		(COLU)
Also	65	Thesis Nevis 145	Chang	(COLU)
COOK	66	PRL 17 223	+Ewart, Masek, Orr, Platner	(WASH)
BALTAY	65	PR 140B 1027	+Sandweiss, Culwick, Kopp+	(YALE, BNL)
BAZIN	65	PRL 14 154	+Blumenfeld, Nauenberg+	(PRIN, COLU)
BAZIN	65B	PR 140B 1358	+Plano, Schmidt+	(PRIN, RUTG, COLU)
CARAYAN...	65	PR 138B 433	Carayannopoulos, Tautfest, Willmann	(PURD)
SCHMIDT	65	PR 140B 1328		(COLU)
BHOWMIK	64	NP 53 22	+Jain, Mathur, Lakshmi	(DELH)
COURANT	64	PR 136B 1791	+Filthuth+	(CERN, HEID, UMD, NRL, BNL)
NAUENBERG	64	PRL 12 679	+Marateck+	(COLU, RUTG, PRIN)
BARKAS	63	PRL 11 26	+Dyer, Heckman	(LRL)
Also	61	Thesis UCRL 9450	Dyer	(LRL)
GALTIERI	62	PRL 9 26	+Barkas, Heckman, Patrick, Smith	(LRL)
GRARD	62	PR 127 607	+Smith	(LRL)
HUMPHREY	62	PR 127 1305	+Ross	(LRL)