E1 G. Ebel et. al., Springer Tract in Modern Physics 55, Springer Verlag, Berlin 1970.

E2 L. Egart, Nuovo Cimento 39, 954, 1963.

E3 M. Elitzur and A. Pais, Rockefeller University Preprint NYO-4204-14, 1971.

E4 R.W. Ellsworth et. al., Phys. Rev. 165, 1449, 1969.

E5 T. Ericson and S.L. Glashow, Phys. Rev. 133, B130, 1964.

F1 D. Fakirov, Fac. Sci. Sofia 53, Livre 2, 1958.
Moscow University Diploma, 1958. Quoted in M3

F2 G. Feinberg, Phys. Rev. 134B, 1255, 1964.

F3 G. Feinberg, F. Gursey and A. Pais, Phys. Rev. Lett. 7, 208, 1961.

F4 G. Feinberg and A. Pais, Phys. Rev. 131, 2724, 1963.

F5 G. Feinberg and S. Weinberg, Phys. Rev. Lett. 6, 38, 1966.

F6 R.P. Feynman, Unpublished, Phys. Rev. Lett. 23, 1415, 1969, and in "High Energy Collisions" Gordon and Breach, 1969.

F7 R.P. Feynman and M. Gell-Mann, Phys. Rev. 109, 193, 1958.

F8 V. Florescu and P. Minnaert, Phys. Rev. 168, 1662, 1967.

F9 V. N. Folomeshkin, Yadernaya Fisika 12, 129, 1970 (Eng. Trans. 12, 72, 1971).

F10 C. Franzinetti, Lecture at APS Chicago Meeting 1965. CERN 66-13.

F11 H. Fritzch and M. Gell-Mann, Caltech Preprint CALT 68-297. To be published in Proc. 1971 Coral Gables Conference.

F12 A. Fujii and Y. Yamaguchi, Progr. Theoret. Phys. 33, 552, 1963.

F13 K. Fujikawa, Chicago Preprint COO-264-560. Submitted to Annals of Physics.

F14 K. Fujimura, Prog. Theoret. Phys. 38, 210, 1967.

F15 G. Furlan, N. Paver and C. Verzegnassi, Nuovo Cimento 70A, 247, 1970.

G1 J.M. Gaillard, CERN 71-772 DNPL/R9 Daresbury Weekend Study on K decays.

G2 R. Gatto, Nuovo Cimento 10, 1559, 1953
2, 670, 1955

G3 M. Gell-Mann, Phys. Rev. 111, 362, 1958.

G4 M. Gell-Mann, Phys. Rev. 125, 1067, 1962.

G5 M. Gell-Mann, Phys. Lett. 8, 214, 1964.

G6 M. Gell-Mann and A. Pais in Proc. of Intl. Conf. on High Energy Physics at Glasgow, Pergamom Press 1955.

G7 M. Gell-Mann and G. Le vy, Nuovo Cimento 16, 705, 1960.

G8 M. Gell-Mann, M. Goldberger, N. Kroll and F. E. Low, Phys. Rev. 179, 1518, 1969.

G9 S.S. Gershtein and Y.B. Zeldovich, JETP 2, 576, 1956.

G10 B.V. Geshkenbein, Phys. Lett. 16, 323, 1965.

G11 F. Gilman, SLAC-PUB 842-1970, SLAC-PUB-896-1971.

G12 M. Goldberger and S.B. Treiman, Phys. Rev. 110, 1178, 1478 1958.

G13 M. Gourdin, CERN TH 1266, 1970.

G14 M. Gourdin and A. Martin, CERN TH 261, 1962.

G15 M. Gourdin and G. Charpak in. Cargese Lectures 1962. ed. M. Levy. Benjamin 1963.

G16 M. Gourdin and P. Salin, Nuovo Cimento 27, 193, 1963.
Nuovo Cimento 27, 309, 1963.
P. Salin Nuovo Cimento 32, 521, 1964.

G17 M. Graham et. al., Univ. of Illinois, Urbana Preprint COO-1195-208, 1971.

G18 D. J. Gross and C.H. Llewellyn Smith, Nucl. Phys. B14, 337, 1969.

G19 D.J. Gross and S.B. Treiman, Princeton University Preprint, May 1971.

H1 R. Hagedorn and J. Ranft, Supp. al. Nuovo Cimento 6, 2, 169, 1968.

H2 L. Hand, P 279 in Vol 1. NAL Summer Study 1969.

H3 Harvard - Pennsylvania - Wisconsin Neutrino groups. NAL Proposal No. 1.

H4 M. Holder (Thesis) Int. Report 19 of III Phys. Inst. Technishen Hoch-Schule, Aachen 1969 ; Nuovo Cimento Lett. 3, 445, 1970.

H5 M. Holder et. al., Nuovo Cimento 57A, 338, 1968.

I1 B. L. Ioffe, L. B. Okun and A. P. Rudik, JETP 47, 1905, 1964 (Eng. trans. 20, 1281, 1965).

I2 B. L. Ioffe and E. P. Shabalin, Yadernaya Fisika 6, 828, 1967 (Eng. trans. 6, 328, 1967).

J1 R. Jackiw, Lectures delivered at 1970 Brookhaven Summer School.

J2 R. Jackiw and G. Preparata, Phys. Rev. Lett. 22, 975, 1968.

J3 C. Jarlskog, Nucl. Phys. 75, 659, 1966.

J4 C. Jarlskog, Nuovo Cimento Lett. 4, 377, 1970.

J5 K. Johnson and F. E. Low, Progr. Theoret. Phys. Supp. 37-38, 74, 1966.

J6 D. D. Jovanic and M. M. Block, p 231 in Vol 4, 1969 NAL Summer Study.

K1 P. K. Kabir and A. N. Kamal, Nuovo Cimento Lett. 1, 1, 1971.

K2 I. Y. Kabzarev and E. P. Shabalin, JETP 14, 859, 1962.

K3 G.R. Kalbfleisch, p 343 in Vol 1 1969 NAL Summer Study.

K4 G.R. Kalbfleisch, Nucl. Phys. B25, 197, 1971

K5 A. Kawakami and T. Minamikawa, Progr. Theoret. Phys. 32, 638, 1966.

K6 I. J. Ketley, Phys. Lett. 16, 340, 1965.

K7 I. J. Ketley, Nuovo Cimento 38, 302, 1965.

K8 C.W. Kim, Nuovo Cimento 37, 142, 1965.

K9 T. Kinoshita, Phys. Rev. Lett. 4, 328, 1960.

K10 J.H. Klems, R.W. Hildebrand and R. Stienig, Phys. Rev. Lett. 24, 1086, 1970.
J.W. Klems and R.W. Hildebrand, University of Chicago Preprint EF171-7, 1971.

K11 J. Konopinski and H. Mahmoud, Phys. Rev. 99, 1065, 1953.

K12 M.A. Kozhushnev and E.P. Shabalin, JETP 14, 676, 1962.

K13 W. Kummer and G. Segrè, Nucl. Phys. 64, 585, 1965.

K14 W. Kummer, Inst. for Theoret. Phys, Vienna, Preprint 1970.

K15 R.L. Kustom et. al., Phys. Rev. Lett. 22, 1014, 1969.

K16 J. Kuti and V. F. Weisskopf, Center for Theoretical Phisics (MIT) Publication 211, May 1971.

L1 P.V. Landshoff and J.C. Polkinghome, Nucl. Phys. B28, 240, 1971.

L2 T.D. Lee in CERN 1961 Seminars (CERN-61-30).

L3 T.D. Lee, Nuovo Cimento 59, 579, 1969.

L4 T.D. Lee in Proc CERN 1969 Conf. on Weak Interactions (CERN 69-7)

L5 T.D. Lee, Phys. Rev. Lett. 25, 1144, 1970.

L6 T.D. Lee, Columbia Univ. Preprint NYO-1932(2)-187, 1970 to be published in Annals of Physics.

L7 T.D. Lee, P. Markstein and C.N. Yang, Phys. Rev. Lett. 7, 429, 1961.

L8 T.D. Lee and A. Sirlin, Rev. Mod. Phys. 36, 66, 1964.

L9 T.D. Lee and C.G. Wick, Nucl. Phys. B9, 209, 1969
B10, 1, 1969
Phys. Rev. D2, 1033, 1970.

L10 T.D. Lee and C.S. Wu, Ann. Rev. of Nucl. Science 15, 381, 1966 and 16, 471, 1967.

L11 T.D. Lee and C.N. Yang, Brookhaven report BNL 443-T-91, 1957.

L12 T.D. Lee and C.N. Yang, Phys. Rev. Lett. 4, 307, 1960.

L13 T.D. Lee and C.N. Yang, Phys. Rev. 119, 1410, 1961.

L14 T.D. Lee and C.N. Yang, Phys. Rev. 126, 2239, 1962.

L15 A.D. Liberman et. al., Phys. Rev. Lett. 22, 663, 1969.

L16 H. Lipkin, Phys. Lett. 34B, 202, 1971 and "Mirror Asymmetry for Pedestrians" Weizmann Inst. Preprint 1971.

L17 C.H. Llewellyn Smith, Annals of Physics 53, 521, 1969.

L18 C.H. Llewellyn Smith, Nucl. Phys. B17, 277, 1970.

L19 C.H. Llewellyn Smith, Invited paper at Naples Conference on phenomenology CERN TH 1188, 1970.

L20 C.H. Llewellyn Smith - unpublished. SLAC-PUB 923.

L21 G.A. Lobov and E.P. Shabalin, Yadernaya Fisika 8, 971, 1968.

L22 J. Løvseth, Phys. Lett. 5, 199, 1963.

L23 J. Løvseth, Nuovo Cimento 57, 382, 1968.

L24 J. Løvseth and M. Radomski, Stanford Univ. Preprint 1971 (to be published in Phys. Rev.).

L25 G. Lüders and B. Zumino, Phys. Rev. 106, 385, 1957.

M1 P.M. Mantsch et. al., Univ. of Illinois Urbana Preprint COO-1195-210, 1971.

M2 M.A. Markov, Hyperonen und K Mesonen Berlin 1960.

M3 M.A. Markov, "The Neutrino" Nauka, Moscow 1964. (An earlier version in English is Dubna report P1269, 1963).

M4 R.E. Marshak, Riazuddin and C.P. Ryan, "Theory of Weak Interactions in Particle Physics". Wiley-Interscience 1969.

M5 R.E. Marshak, et. al., in Proc CERN 1969 Conf. on Weak Interactions. (CERN 69-7)

M6 G. Marx in Proc. of 1969 Budapest Cosmic Ray Conf.

M7 J.L. Masnou, Orsay Thesis LAL 1245, 1971.

M8 S. Mikamo et. al., Inst. for Nucl. Study; Univ. of Tokyo, report INS 160, 1970.

M9 R.N. Mohapatra et. al. Phys. Rev. Lett. 20, 19, 1968.
Phys. Rev. 171, 1502, 1968.

M10 G. Myatt and D.H. Perkins, Oxford University Preprint 1970.

M11 G. Myatt and D.H. Perkins, Phys. Lett. 34B, 542, 1971.

N1 O. Nachtmann, Nucl. Phys. B18, 112, 1970.

N2 O. Nachtmann, Nucl. Phys. B22, 385, 1970.

N3 O. Nachtmann, Orsay Preprint LPTHE 71/12.

N4 NAL Summer Studies 1968, 1969, 1970 published by National Accelerator Lab., Batavia, Illinois.

N5 Y. Nambu and M. Yoshimura, Phys. Rev. Lett. 24, 25, 1970.

N6 F.A. Nezrick, p113, NAL Summer Study Vol 2, 1969.

N7 H.T. Nieh, Phys. Rev. D1, 3161, 1970.

O1 S. Okubo, Nuovo Cimento A54, 491, 1968. A57, 794, 1968.
S. Okubo, C. Ryan and R.E. Marshak; Nuovo Cimento 34, 753 and 759, 1964.

P1 H. Pagels, Phys. Lett. 34B, 299, 1971.

P2 A. Pais, Phys. Rev. Lett. 9, 117, 1962.

P3 A. Pais, Phys. Rev. D1, 1349, 1970.

P4 A. Pais in Proc. Conf. on Expectations for Particle Reactions at New Accelerators, Madison Univ. 1970 and to be published in Annals of Physics.

P5 A. Pais, Phys. Rev. Lett. 26, 51, 1971.

P6 A. Pais and S.B. Treiman, p 257 in Anniversary Vol. dedicated to N.N. Bogoliubov. Nauka, Moscow, 1969.

P7 A. Pais and S.B. Treiman, Phys. Rev. D1, 907, 1970.

P8 A. Pais and S. B. Treiman, Phys. Rev. Lett. 25, 975, 1970.

P9 R. B. Palmer, Brookhaven report BNL 1444, 1969.

P10 N.J. Papastimatiou and D.G. Sutherland, Phys. Lett. 14, 246, 1965.

P11 Particle Data Group, Phys. Lett 33B, 1, 1970.

P12 S.H. Patil and J.S. Vaishya, Nucl. Phys. 193, 338, 1970.

P13 S.V. Pepper et. al., Phys. Rev. B137, 1259, 1965.

P14 D.H. Perkins, UCRL 10022, P222, 1961.

P15 D.H. Perkins in Proc. CERN 1969 Conf. on Weak Interactions. (CERN-69-7).

P16 C.A. Piketty and L. Stodolsky, Nucl. Phys. B15, 571, 1970 and in Proc. CERN 1969 Conf. on Weak Interactions. (CERN-69-7)

P17 B. Pontecorvo, JEPT 37, 175, 1959.

R1 C.A. Ramm, Nature 227, 1323, 1970.

R2 C.A. Ramm, Nature 230, 145, 1971.

R3 J. Reiff, Nucl. Phys. B23, 387, 1970.

R4 J. Reiff, Nucl. Phys. B28, 495, 1971.

R5 F. Reines and C. L. Cowan, Phys. Rev. 92, 830, 1953.

R6 F. Reines, Ann. Rev. Nucl. Sci. 10, 1960.

R7 F. Reines and H. S. Gurr, Phys. Rev. Lett. 24, 1448, 1970. and private communication.

R8 B. Roe, p107 Vol. 2 NAL Summer Study 1969.

R9 R. Rajaraman, Phys. Rev. 178, 2211 and 2221, 1969.

S1 P. Salin, Nuovo Cimento 48A, 506, 1967.

S2 J.R. Sanford and C. L. Wang, Brookhaven report BNLJRS/CLWI and 2.

S3 M. Schwartz, Phys. Rev. Lett 4, 306, 1960.

S4 G. Segrè in Springer Tracts in Modern Physics 52, Springer Verlag, Berlin, 1970.

S5 E.P. Shabalin, JETP 16, 125, 1963.

S6 E.P. Shabalin, Yadernaya Fisika 8, 74, 1968.

S7 E.P. Shabalin, Yadernaya Fisika 9, 1050, 1968.

S8 E.P. Shabalin, "Sovremennoe Sostoyanie Teorii Slabogo Vzaimodeistviya" Inst. of Th. and Expt. Studies, Moscow report ITEP 724, 1969.

S9 E. P. Shablin, Yadernaya Fisika 13, 411, 1971.

S10 A. Sirlin, Nuovo Cimento 37, 137, 1965.

S11 J. Smith, Stonybrook - private communication; see also B44.

S12 V.V. Solov'ev and I.S. Tsukerman, JETP 42, 1252, 1962. (Eng. trans: 15, 868, 1962).

S13 H.J. Steiner, Phys. Rev. Lett. 24, 746, 1970.

S14 R.B. Strothers, Phys. Rev. Lett. 24, 538, 1970.

S15 R. Suaya, SLAC-PUB in preparation.

S16 A. Suri, Phys. Rev. Lett. 26, 208, 1971.

T1 Y. Tanikawa and S. Watanabe, Phys, Rev. 113, 1344, 1959.

T2 W.T. Toner et. al., SLAC-PUB 868, to be published in Phys. Rev. Lett.

T3 T.L. Toohig, D. Keefe and V.Z. Peterson, UCRL 16830, 1966.

T4 Y.S. Tsai and A.C. Hearn, Phys. Rev. 140B, 721, 1965.

U1 H. Uberall, Phys. Rev. 133B, 444, 1964.

V1 M. Veltman in Proc. 32 "Enrico Fermi" Summer School, Academic Press 1966.

V2 H.C. von Baeyer and Y.Y. Yam, "Comments on the possible existence of heavy lepton" College of William and Mary, Williamsburg, Preprint 1970.

V3 G. von Gehlen, Nuovo Cimento 30, 859, 1963.

W1 J.D. Walecka and P.A. Zucker, Phys. Rev. 167, 1479, 1968. P.L. Pritchett, J.D. Walecka and P.A. Zucker Phys. Rev. 184, 1825, 1969.

W2 S. Weinberg, Phys. Rev. 112, 1375, 1958.

W3 W. I. Weisberger, Phys. Rev. Lett. 14, 1047, 1965.

W4 W.I. Weisberger, Phys. Rev. 143, 1302, 1966.

W5 G. West, Stanford University Preprint 1971.

W6 G. West, Private communication and paper in preparation.

W7 D.H. Wilkinson, Phys. Lett. 31B, 447, 1970
D.H. Wilkinson and D.E. Alburger, Phys. Rev. Lett. 24, 1134, 1970.
D.H. Wilkinson and D.E. Alburger, Phys. Lett. 32B, 190, 1970.

W8 A.C.T. Wu et. al., Phys. Rev. Lett. 12, 57, 1964.
Phys. Rev. D1, 3180, 1970.

W9 H. Wachsmuth, p 159 in Vol. 2. NAL Summer Study 1969.

Y1 Y. Yamaguchi, Prog. Theoret. Phys. 6, 117, 1960.

Y2 Y. Yamaguchi, CERN yellow report 61-2, 1961.

Y3 Y. Yamaguchi, Nuovo Cimento 43A, 193, 1966.

Y4 E.C.M. Young, CERN yellow report 67-12, 1967.

Y5 York Peng Yao, Phys. Rev. 176, 1680, 1968.

Z1 P.A. Zucker, University of Oregon Preprint ITS 1085.

Z2 P. A. Zucker, Private communication.

Z3 G. Zweig, CERNTH 401, 412, 1964.

Table 1

Tests of some hypotheses about weak interactions.

Hypothesis	Best evidence from decay processes	Possible tests in neutrino reactions
$\mathscr{L}_{eff} \sim J_\lambda^+ J^\lambda$	Fits all observed decays	E_ν and ϕ dependence of cross sections (2.10)
2 component neutrino theory	Fits all observed decays	Probability of producing right- (left-) handed lepton (antilepton) $\sim m^2$ (2.12)
Conservation of lepton numbers L_e and L_μ	Fits all observed decays $\left(\frac{\Gamma(\mu^\pm \to e^\pm)}{\Gamma(\mu^\pm \to \text{all})} < 2 \times 10^{-8}\right)$	$\frac{\sigma(\nu_\mu \to e^-)}{\sigma(\nu_\mu \to \mu^-)} < 1\%$ $\frac{\sigma(\nu_\mu \to \mu^+)}{\sigma(\nu_\mu \to \mu^-)} < 4.6 \times 10^{-3}$
(The weaker hypothesis that $L_\mu + L_e$ and the sign of $(-1)^{L_e}$ are conserved $\rightarrow$ detectable $\bar{\nu}_e$ admixture from μ decay in ν beams (see p. 7)		
Absence of neutral currents	Fits all observed decays $\left(\frac{\Gamma(K_L^o \to \mu^+\mu^-)}{\Gamma(K_L^o \to \text{all})} < 1.9 \times 10^{-9}\right)$	$\frac{\sigma(\nu_\mu p \to \nu_\mu p)}{\sigma(\nu_\mu n \to \mu^- p)} < 0.12 \pm 0.06$
Universality of e and μ interactions	Fits all observed decays $\left(\frac{\Gamma(\pi^+ \to e^+\nu_e)}{\Gamma(\pi^+ \to \mu^+\nu_\mu)} = (1.00 \pm 0.03) \times \text{theory}\right)$	Comparison of $\nu_\mu(\bar{\nu}_\mu)$ with $\nu_e(\bar{\nu}_e)$ initiated reactions

Table 1 (cont'd.) - 2

$\Delta Y \leq 1$	Fits all observed decays $\left(\frac{\lvert A(\Xi^- \to n e^- \nu)\rvert}{\lvert A(\Xi^- \to \Lambda e^- \nu)\rvert} < 0.28\right)$	$\bar{\nu}_\mu n \nrightarrow \mu^+ \Xi^-$ $\nu_\mu p \nrightarrow \mu^- p K^+ K^o$ $\bar{\nu}_\mu p \to \mu^+ \Lambda (K^o + y\bar{K}^o)$ ($y=0$ if $\Delta Y \leq 1$), etc. (see Table 2)
$\Delta Y = \Delta Q$ if $\Delta Y = \pm 1$	Fits all observed decays $\left(\frac{\Gamma(K^+ \to \pi^+ \pi^+ e^- \bar{\nu}_e)}{\Gamma(K^+ \quad \pi^+ \pi^- e^+ \nu_e)} < 0.023\right.$ $\left.\frac{A(\Delta Y = -\Delta Q)}{A(\Delta Y = \Delta Q)} \lesssim 10\%$ in $K^o_{\ell 3}$ decay$\right)$	$\nu_\mu n \nrightarrow \mu^- \Sigma^+$ $\nu_\mu p \nrightarrow \mu^- \Sigma^+ \pi^+$ $\nu_\mu n \to \mu^- p (K^o + y' \bar{K}^o)$ ($y'=0$ if $\Delta Y = \Delta Q$), etc. (see Table 2)
$\Delta I = 1\ 2$ if $\Delta Y = \pm 1$	Tests in $K^o_{\ell 3}$ decay work to $\pm 10\%$	$\frac{\sigma(\bar{\nu} n \to \Sigma^- \mu^+)}{\sigma(\bar{\nu} p \to \Sigma^o \mu^+)} = 2$ and many other relations (Eqs. 2.14-2.17)
$\Delta I = 1$ if $\Delta Y = 0$	Untested	$\frac{\sigma(\nu_\mu p \to N^{*++} \mu^-)}{\sigma(\nu_\mu n \to N^{*+} \mu^-)} = 3$ and other relations (p. 39)
Charge symmetry condition for $\Delta Y = 0$ current	Lack of mirror symmetry in nuclear β decay is evidence against this (unless due to isospin violation)	Structure functions for mirror processes related by $W_i^{\nu p} = W_i^{\bar{\nu} n}$, $W_i^{\bar{\nu} p} = W_i^{\nu n}$ ($\Delta Y = 0$) $\to$ obvious relations (e.g.) between $\sigma^{\nu d}$ and $\sigma^{\bar{\nu} d}$.
Absence of second class currents ($\equiv$ charge symmetry condition if T conserved)	Lack of mirror symmetry of ft values requires 2nd class currents if CPT holds (unless due to isospin violation)	Fixes relative phases of quasielastic form factors

Table 1 (cont'd.) - 3

CVC	$g_\mu^V \simeq g_\beta^V$	Limits number of independent vector form factors. No parity violation when $\theta_{\nu\ell} = 0$
Isotriplet current	Weak magnetism predicted to ± 20% $\Gamma(\pi^+ \rightarrow \pi^0 e^+ \nu_e) = (0.95 \pm 0.07) \times$ theory	Vector form factors given by electroproduction
PCAC	Goldberger-Treiman relation works to ~ 10%	$\sigma_\nu(\theta_{\nu\ell} = 0) \propto \sigma_\pi \propto$ "$A^{2\ 3}$"
Current algebra	Adler-Weissberger relation works to ~ 5%	Adler sum rules (2.24 and 2.25) see Tables 7 and 8
T violation	$\frac{\Gamma(K_L^o \rightarrow \pi^+\pi^-)}{\Gamma(K_L^o \rightarrow all)} \sim 2 \times 10^{-3}$ $\frac{\Gamma(K_L^o \rightarrow \pi^+ \ell^- \nu)}{\Gamma(K_L^o \rightarrow \pi^- \ell^+ \bar{\nu})} \neq 1$	Transverse polarization of lepton or baryon in quasi-elastic process. Transverse polarization of lepton when hadrons unobserved.

Table 2

Reactions allowed by charge conservation but forbidden by the $\Delta Y = 0, \pm 1$ rule and the $\Delta Y = \Delta Q$ rule for $\Delta Y = 1$ transitions.

Each box represents a reaction. The boxes representing reactions with the same initial state are grouped into rectangles, the initial state being inscribed in the upper right hand corner. The final state consists of the appropriate lepton and a baryon and a meson chosen from the corresponding position in the left hand column and the top row respectively. (The column headed vac. represents reactions with a single baryon in the final state).

X — indicates that the reaction has $\Delta Y \geqslant 2$

0 — indicates that the reaction has $\Delta Y = 1$ and $\Delta Y \neq \Delta Q$

The same results obtain, of course, if the pseudoscalar mesons are everywhere replaced by the corresponding vector mesons.

Table 2

	π^-	K^-	K°	$\pi^\circ \eta^\circ$	Vac	$\bar{K}^\circ$	K^+	π^+
Ω^-			×	×	×	($\bar{\nu}n$) ×	×	($\bar{\nu}p$) ×
Ξ^- Ξ^{*-}				×	×	×		×
Y^{*-} Σ^-						×		
N^{*-}			○				○	
Ξ° Ξ^{*-}	×	($\bar{\nu}n$) ×		×	×	($\bar{\nu}p$) ×	○	(νn) ×
$\Sigma^\circ, \Lambda^\circ$ $Y^{*\circ}$		×				×		○
$N^{*\circ}$ n			○					
Y^{*+} Σ^+		($\bar{\nu}p$) ×		○	○	(νn) ×		(νp) ○
N^{*+} p						○		
N^{*++}		(νn) ○				(νp) ○		

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Table 3

Characteristics of Dimuon Events.[H3] $p_{\perp\pm}$ is the component of the $\mu^{\pm}$ momentum $p^{\pm}$ perpendicular to the direction of the incident ν_{μ}. $p_{\perp\pm} = p_{\pm} \sin \theta_{\mu^{\pm}}$ (the $p_{\perp}$ given for the trilepton process disagrees with that obtained by other authors — see the text).

Process	$p_{\perp+}$	$p_{\perp-}$	θ_{μ^+}	θ_{μ^-}	p_{μ^+}	p_{μ^-}	Remarks
Trilepton (coherent)	0-50 MeV	0-50 MeV	Small	Small	Small	$\sim E_{\nu}$	$p_{\perp\pm}$, $\theta_{\mu^{\pm}}$ are multiple scattering limited
W production (incoherent)	$\simeq M_W/2$	0-100 MeV/c	Large	Small	$> \frac{1}{2} M_W$	Moderate	
Background from single π production	300	~ 500		Medium	Small	$> \frac{1}{2} E_{\nu}$	
Background from multiple π production	~ 300	~ 500	Small	Small to Large	Small	$> \frac{1}{2} E_{\nu}$	

Table 4

Errors expected from a ν experiment at ANL with 10^{18} incident protons[D3]. Dipole formulae were assumed for F_A, F_V^1 and F_V^2 parametrized by M_A, M_V and WM respectively. ξ is the strength of the weak magnetism term F_V^2, as in the text.

Table 4

	NEUTRINO			ANTINEUTRINO		
Unknowns	Flux Unknown	Flux 10%	Flux Exact	Flux Unknown	Flux 10%	Flux Exact
M_A	78	51	35	85	83	82
M_A	293	221	198	97	84	82
M_V	881	553	477	182	117	105
M_A	748	494	416	158	108	100
ξ	5.2	3.3	2.7	1.0	0.6	0.6
M_A	389	302	246	219	184	179
M_V	892	580	487	293	258	248
WM	140	115	100	200	177	172
M_A	922	726	694	237	188	182
M_V	999	583	489	387	300	281
ξ	6.3	4.0	3.5	2.9	2.2	2.1
WM	149	135	130	264	247	245

Table 5

Isobar coupling constants for $\nu n \rightarrow \mu^- N^{*+}$ in various models - adopted from B20. The static model results are essentially the same as Berman and Veltmans'. The multipole content of these form factors may be obtained using the formulae in Adler's [A6] Appendix 5.

	Berman and Veltman	Salin	Bijtebier	Adler**
C_3^V	2.0*	2.0	2.0	1.85
C_4^V	0	0	0	-0.89
C_5^V	0	0	0	0
C_A^3	0	0	0	0
C_A^4	0	2.7	2.9 to 3.6	-0.35
C_A^5	-1.2	0***	-1.2	-1.2

* Corrected (see p. 90).

** Approximate equivalent values deduced by Bijtebier.

*** This model violates PCAC which gives $C_A^5 \simeq -1.2$.

Table 6

t channel quantum numbers for weak and electromagnetic structure functions.[P1]

Structure Functions	$(-1)^J P$	$(-1)^J C$	I^G	Regge Trajectory
$W_{1,2}^{\gamma p} + W_{1,2}^{\gamma n}$	+	+	0^+	P, f_0, f'
$W_{1,2}^{\gamma p} - W_{1,2}^{\gamma n}$	+	+	1^-	A_2^0
$W_{1,2}^{\nu p} + W_{1,2}^{\bar{\nu} p}$	+	+	0^+	P, f_0, f'
$W_{1,2}^{\nu p} - W_{1,2}^{\bar{\nu} p}$	+	+	1^+	ρ
$W_3^{\nu p} + W_3^{\bar{\nu} p}$	+	+	0^-	ϕ, ω
$W_3^{\nu p} - W_3^{\nu n}$	-	-	1^-	A_1

Table 7

Quark model sum rules for $\Delta Y=0$ reactions in the scaling region (assuming scale invariance).

Sum rules from commutators of currents	Comments
$\int \frac{d\omega}{\omega} (F_2^{\nu n} - F_2^{\nu p}) = 2$	The Adler sum rule.[A5] True in all reputable models.
$\int \frac{d\omega}{\omega^2} (F_1^{\nu n} - F_1^{\nu n}) = 1$	Bjorken's "backward" sum rule.[B22] True in all models in which the elementary fields have spin 1/2.
$-\int \frac{d\omega}{\omega^2} (F_3^{\nu p} + F_3^{\nu n}) = 6$	Peculiar to the quark model.[G18] (R.H.S.=2 in Sakata and Fermi-Yang models.)
Sum rules from commutators of currents and their time derivations in models with renormalizable interactions	
$2 F_1^{\gamma,\nu,\bar{\nu}} = \omega F_2^{\gamma,\nu,\bar{\nu}}$	Callan-Cross relation.[C6, G18] Depends on the elementary fields having spin 1/2.
$F_5^{\nu,\bar{\nu}} = 2 F_1^{\nu,\bar{\nu}}$ $F_4^{\nu,\bar{\nu}} = 0$	— follows from $2F_1 = \omega F_2$ and kinematical inequalities. asymptotic chiral symmetry.[L20]
$12(F_1^{\gamma p} - F_1^{\gamma n}) = F_3^{\nu p} - F_3^{\nu n}$	Peculiar to the quark model.[L18, L20] (12 → 4 in Sakata or Fermi-Yang models.)
$F_1^{\nu p} + F_1^{\nu n} \leq \frac{18}{5} (F_1^{\gamma p} + F_1^{\gamma n})$	Peculiar to the quark model.[L18, L20] (→ equality with $\frac{18}{5} \rightarrow 2$ in Sakata or Fermi-Yang model.)

Table 8

Quark model sum rules for $\Delta Y=1$ reactions in the scaling region (assuming scale invariance).

Sum rules from commutators of currents

$$\int \frac{d\omega}{\omega}\,(f_2^{\bar{\nu}} - f_2^{\nu}) = \langle 3Y + 2I_3 \rangle \qquad \text{(A5)}$$

$$2\int \frac{d\omega}{\omega^2}\,(f_1^{\bar{\nu}} - f_1^{\nu}) = \langle 3Y + 2I_3 \rangle \qquad \text{(B22)}$$

$$-\int \frac{d\omega}{\omega^2}\,(f_3^{\bar{\nu}} + f_3^{\nu}) = \langle 4B - Y + 2I_3 \rangle \qquad \text{(G18)}$$

Sum rules from commutators of currents and their time derivatives in models with renormalizable interactions

$$2f_1^{\nu,\bar{\nu}} = \omega f_2^{\nu,\bar{\nu}} = f_5^{\nu,\bar{\nu}} \qquad \text{(G18, L20)}$$

$$f_4^{\nu,\bar{\nu}} = 0 \qquad \text{(L20)}$$

with

$$U_p = \frac{F_1^{\nu n}}{2} - \frac{F_3^{\nu n}}{4}, \qquad U_n = \frac{F_1^{\nu p}}{2} - \frac{F_3^{\nu p}}{4}$$

$$U_{\bar{n}} = \frac{F_1^{\nu n}}{2} + \frac{F_3^{\nu n}}{4}, \qquad U_{\bar{p}} = \frac{F_1^{\nu p}}{2} + \frac{F_3^{\nu p}}{4}$$

$$U_\lambda + U_{\bar{\lambda}} = 9\,(F_1^{\gamma p} + F_1^{\gamma n}) - \frac{5}{2}\,(F_1^{\nu n} + F_1^{\nu p})$$

$$U_\lambda - U_{\bar{\lambda}} = f_1^{\nu p} - f_1^{\bar{\nu} p} + \frac{F_1^{\nu n} - F_1^{\nu p}}{2} - \frac{F_3^{\nu n} + F_3^{\nu p}}{4}$$

the f_i are given by (L19, L20)

$$f_1^{\nu p} = U_\lambda + U_{\bar{p}}, \quad f_3^{\nu p} = 2\,(U_{\bar{p}} - U_\lambda) \quad f_1^{\bar{\nu} p} = U_p + U_{\bar{\lambda}}, \quad f_3^{\bar{\nu} p} = 2\,(U_{\bar{\lambda}} - U_p)$$

$$f_1^{\nu n} = U_\lambda + U_{\bar{n}}, \quad f_3^{\nu n} = 2\,(U_{\bar{n}} - U_\lambda) \quad f_1^{\bar{\nu} n} = U_n + U_{\bar{\lambda}}, \quad f_3^{\bar{\nu} n} = 2\,(U_{\bar{\lambda}} - U_n)$$

i.e., the f_i are determined by the F_i and (e.g.) $f_i^{\nu p}$-$f_i^{\bar{\nu} p}$ (in the parton model the U_i are the distribution functions for the quarks).

Table 9

Theoretical total cross sections for W production (B43) for M_W=10 GeV in units of 10^{-38} cm^2. $\sigma(p)$, $\sigma(n)$ denote the cross section for scattering off protons and neutrons with a dipole form factor. $\sigma'(p)$ and $\sigma'(n)$ denote the corresponding cross sections with the exclusion principle and Fermi motion included. σ_{inel} denotes the "inelastic" cross section. $\sigma_c(Ne)/10$, $\sigma_c(Fe)/26$, and $\sigma_c(U)/92$ denote the coherent cross sections per proton from neon, iron, and uranium nuclei with Fermi form factors. The total cross section can be calculated by combining these numbers according to Eq. 3.134. Similar tables are given in B43 for M_W=5 GeV and M_W=15 GeV.

κ	-1	0	+1	-1	0	+1
		E_1 = 100 GeV			E_1 = 200 GeV	
$\sigma(p)$	0.0923	0.0991	0.107	4.37	4.76	5.26
$\sigma(n)$	0.0405	0.0436	0.0471	1.41	1.55	1.74
$\sigma'(p)$	0.175	0.188	0.204	4.85	5.28	5.86
$\sigma'(n)$	0.0790	0.0790	0.0858	1.50	1.66	1.87
σ_{inel}	0.0387	0.0445	0.0514	2.29	2.68	3.25
$\sigma_c(Ne)/10$				7.41×10^{-3}	7.67×10^{-3}	7.97×10^{-3}
$\sigma_c(Fe)/26$				6.64×10^{-3}	6.90×10^{-3}	7.21×10^{-3}
$\sigma_c(U)/92$				3.15×10^{-3}	3.25×10^{-3}	3.36×10^{-3}
		E_1 = 400 GeV			E_1 = 1000 GeV	
$\sigma(p)$	21.8	23.9	27.3	74.0	81.4	96.4
$\sigma(n)$	4.38	4.94	5.88	8.45	9.44	12.1
$\sigma'(p)$	18.7	20.6	23.7	50.0	55.4	67.3
$\sigma'(n)$	3.90	4.42	5.30	7.05	7.89	10.3
σ_{inel}	13.5	16.0	20.2	50.6	59.0	79.6
$\sigma_c(Ne)/10$	1.61	1.67	1.73	75.8	80.5	86.8
$\sigma_c(Fe)/26$	0.664	0.690	0.721	103	109	116
$\sigma_c(U)/92$	0.528	0.548	0.572	75.0	78.5	82.3

Table 10

Yield of events in 10^6 pictures

Assume: 10^6 pictures at 2×10^{13} protons/pulse

500 BeV protons

Horn focusing

$\frac{\bar{\nu} \text{ flux}}{\nu \text{ flux}} = \frac{1}{3}$

Reaction	15 m^3 H_2	15 m^3 D_2	10 m^3 Ne
Total	0.5×10^6	1.0×10^6	6×10^6
$\nu n \rightarrow \mu^- p$	-	1.4×10^4	1×10^5
$\nu p \rightarrow \mu^- p \pi^+$	1.8×10^4	1.8×10^4	1.2×10^5
$\nu n \rightarrow \mu^- n \pi^+$	-	4.8×10^3	3.2×10^5
$\bar{\nu} p \rightarrow \mu^+ \Lambda^o$	200	200	1300
$\bar{\nu} p \rightarrow \mu^+ \Sigma^o$	70	70	400
$\bar{\nu} n - \mu^+ \Sigma^-$	-	130	800

Table 11

W and four-fermion search in neon

Assume: 10^6 pictures at 2×10^{13} protons/pulse

500 BeV protons

Horn focusing

Reaction	Events in 10 m^3 Ne
ν_μ Ne $\rightarrow$ Ne $\mu^- e^+ \nu_e$	100
ν_μ Ne $\rightarrow$ Ne $\mu^- \mu^+ \nu_\mu$	50
ν Ne $\rightarrow \mu^- W^+$	
Mw = 5	2.5×10^5
8	2.5×10^4
10	5.5×10^3
12	1.2×10^3
14	250
16	50

Table 12

Cross sections used in compiling Tables 10 and 11.

Reaction	σ in cm^2	
Total	$0.8\ E_\nu \times 10^{-38}$	
$\nu n \rightarrow \mu^- p$	0.7×10^{-38}	
$\nu n \rightarrow \mu^- p \pi^o$	0.24×10^{-38}	Adler $\times$ 2 because of CERN experiments
$\nu n \rightarrow \mu^- n \pi^+$	0.32×10^{-38}	
$\nu p \rightarrow \mu^- p \pi^+$	0.88×10^{-38}	
$\bar{\nu} p \rightarrow \mu^+ \Lambda^o$	3×10^{-40}	Cabbibo and Chilton corrected by Cabbibo (depends on M_A)
$\bar{\nu} p \rightarrow \mu^+ \Sigma^o$	1×10^{-40}	
$\bar{\nu} n \rightarrow \mu^+ \Sigma^-$	2×10^{-40}	
$\nu Ne \rightarrow Ne \mu^- e^+ \nu$	$10^{-42} - 10^{-40}$	Coherent on Neon
$\nu Ne \rightarrow Ne \mu^- \mu^+ \nu$	$10^{-42} - 10^{-40}$	
$\nu p \rightarrow \mu^- p W^+$	$10^{-42} - 10^{-36}$	depending on M_W and E_ν

Figure Captions

1. Approximate neutrino event rates as a function of time (taken from P15 and updated slightly). In the interests of clarity the expected results of improvements planned for Brookhaven (→ 100/hour) and Argonne (→ 20/hour) in 1973 have not been included. Although it will use an iron target (so that the scale of this figure does not really apply) we have included the event rate expected in the first experiments planned for NAL for comparison (in this experiment it is planned to introduce the liquid H_2 store as a target at some stage; this should yield $\sim \frac{1}{2}$ events/hour).
2. Production of neutrino beams at proton accelerators (schematic!).
3. Neutrino fluxes obtainable at various accelerators in 1973.[C10] (Perfect focusing assumed. Hagedorn-Ranft[H1] predictions used for π/K yields for $E_p > 70$ GeV; Sanford-Wang[S2] used for $E_p < 70$ GeV. Experimental data used for SLAC. The number of interacting protons corresponds to 10^5 incident protons on the target assumed. The flux was averaged over a detector with radius 1.8 m.)
4. Predicted neutrino spectra for a variety of incident energies at NAL.[C10] (Assuming 450 m decay length, 1000 m. shielding, 1.35 m radius detector, Hagedorn-Ranft production model[H1] and perfect focusing.)
5. $\nu/\bar{\nu}$ spectra for a possible NAL beam operating at 200 GeV primary proton energy.[K3] (Assuming 600 m. decay length, 300 m. shielding and 2.5 m. target — m.f.p. = 0.9 m.)
6. ν_e flux from $K^+_{\ell 3}$ and μ^+ decay expected in the NAL ν_μ beam shown in figure 5.[K3]

7. Spectra in the NAL "monoenergetic" beam — schematic (θ is the angle the neutrino makes with the primary π/K beam).

8. The coherent cross section to order $G^2\alpha^2$ with a target nucleus A = 56 [C28] for

a) $\nu_\mu Z \rightarrow \mu^- e^+ \nu_e Z$

b) $\nu_\mu Z \rightarrow \mu^- \mu^+ \nu_\mu Z$

c) $\nu_e Z \rightarrow e^- e^+ \nu_\mu Z$

full lines — exact (numerical) calculation

dashed lines — asymptotic formulae (see text)

$\sigma_0 = G^2\alpha^2 Z^2 m_\mu^2 = 3.03 \times 10^{-44} Z^2 cm^2.$

(the dipole form factor given in the text was used).

9. Numerical results to order $G^2\alpha^2$ for the coherent process $\nu_\mu Z \rightarrow \mu^- e^+ \nu_e Z$ for various nuclei. [C28]

full lines — nuclear form factor in text

dashed lines — $F(q^2) = \exp(q^2 R_0^2/10)$.

σ_0 as in figure 8. (Similar curves are given in C28 for $\nu_\mu Z \rightarrow \mu^- \mu^+ \nu_\mu Z$ — see also figure 8.)

10. Cross sections for the quasielastic process in the conventional theory with m = 0 and dipole forms

$$\frac{F(0)}{\left(1 - \frac{q^2}{0.73 \text{ GeV}^2}\right)^2}$$

for the form factors F_A and $F_V^{1,2}$ [L12] (the dotted line is the limit for σ_ν and $\sigma_{\bar{\nu}}$ as $E \rightarrow \infty$).

11. Differential cross section for the quasielastic process; as in figure 10 with $0.73 \text{ GeV}^2 \rightarrow 0.71 \text{ GeV}^2$. [D3]

12. Contributions of the structure functions "A", "B" and "C" to the differential cross section for the quasielastic process (P9 quoted in D3) where

$\sigma = [\text{"A"} + \text{"B"}(s-u) + \text{"C"}(s-u)^2] / E^2.$

13. Simulated experiment at the AGS (Brookhaven)(P9 quoted in D3). The model input is the same as in figures 11 and 12.

14. Average transverse polarizations in quasielastic neutrino scattering as a function of the neutrino energy.[D4]

a) Bound of $0(\alpha)$ contribution of the elastic intermediate state.

b) Bound of $0(\alpha)$ contribution of the inelastic intermediate states.

c) Predictions of Cabibbo's theory of T violation (see text for a discussion of the form factors used).

labels: p polarization of proton in $\nu n \rightarrow \mu^- p$

n polarization of neutron in $\bar{\nu} p \rightarrow \mu^+ n$

μ polarization of muon in $\bar{\nu} p \rightarrow \mu^+ n$.

15. Exclusion factors defined in text for C^{12}.[B11]

16. Exclusion factors defined in text for Fe^{56}.[B11]

17. Ratio of deuteron to neutron cross sections in the quasielastic process for $E_\nu >> 1$ obtained using a Hulthen wave function in the closure approximation.[B33]

18. Results of the Argonne experiment for quasielastic events on an iron target.[K15] The upper and lower solid curves are the experimenters theoretical results for a free neutron and for the Fermi gas model. The three dashed curves were obtained[B11] from the free neutron curve using 1) symmetric Fermi gas; 2) asymmetric Fermi gas; 3) shell model ($\bar{\sigma}$ = cross section per neutron).

19. Same experiment and solid curves as figure 18. 3) is as in figure 18. 4) is curve 3) increased by 30% (the experimenters regard their absolute flux as uncertain to this degree).

20. Results of the CERN spark chamber experiment[H5] for events with $E_\nu > 1.4$ GeV and $\cos\theta_{\nu\mu} > 0.8$:

——— inelastic + elastic (M_A = 0.84 GeV)

- - - - inelastic + elastic (M_A = 0.5 GeV)

-·-·-· inelastic contamination.

21. Results of the CERN bubble chamber experiment for the elastic cross section[B45] as a function of the visible energy (E_{vis}).

22. Q^2 distribution of quasielastic events in the CERN bubble chamber experiment[B45]

● experimental values.

○ π^0 contribution

——— theoretical curve for M_A = 0.7 GeV.

23. Total cross section for $\bar{\nu} p \rightarrow \Lambda \mu^+$ as a function of the antineutrino energy in the Cabibbo theory. The same q^2 dependence was taken for all form factors.[W9]

24. Total cross section for $\bar{\nu} n \rightarrow \Sigma^- \mu^+$ (otherwise as for figure 23).[W9]

25. Polarizations in $|\Delta Y| = 1$ antineutrino reactions at E_ν = 0.5 GeV (in a double-pole approximation with six form factors) and a comparison $\Delta Y = 0$ curve[M4]

1. $\bar{\nu} p \rightarrow \mu^+ n$
2. $\bar{\nu} p \rightarrow \mu^+ \Lambda$
3. $\bar{\nu} p \rightarrow \mu^+ \Sigma^0$
4. $\bar{\nu} n \rightarrow \mu^+ \Sigma^-$

(This figure and figure 26 are reproduced by permission of John Wiley and Sons, Inc.)

26. Polarizations as in figure 25 except E_ν = 5 GeV.[M4]

27. Berman-Veltman angles (defined in the N* rest frame).

28. Total pion production cross section in Adler's model with W < 1.39 BeV, by a neutrino incident on a target consisting of $\frac{1}{2}p + \frac{1}{2}n$. Curve (a) — Born approximation plus resonant multipoles; curve (b) — full model, including

dispersion integral corrections to the small partial waves; curve (c) — full model, multiplied by the electroproduction experiment/theory ratio $R(k^2)$. The values of M_A^2 are in $(\mathrm{BeV})^2$.[A6]

29. Total pion production cross section in Adler's model with $W \leq 1.39$ GeV by antineutrinos incident on CF_3Br. The values of M_A^2 are in GeV^2. Theoretical curves calculated from the Born approximation plus resonant multipole model.[A6] Experimental points from Y4. The same experiment gave a neutrino cross section compatible with Adler's model with M_A^2 in the range 0.71 to 2 GeV^2 ($\sigma \sim (0.6 \pm 0.2) \times 10^{-38} \mathrm{cm}^2$/nucleon — see reference Y4 or Adler's figure 25. In a later experiment on C_3H_8 [B46] the events originating on free protons were selected; this (presumably) more reliable procedure gave a much larger result — see figure 35).

30. $\frac{d\sigma}{dQ^2}$ for single pion production in Adler's model[A6] using the Born approximation plus resonant multipoles all multiplied by the experiment/theory ratio for electroproduction. The theoretical curves are normalized to the number of events. (The data is from the CERN CF_3Br experiment — see the discussion in the previous figure caption.)

31. Differential cross section for $\nu n \rightarrow N^{*+}\mu^-$ for each form factor taken one at a time as $F_i = \frac{1}{(1-q^2/b^2)^n}$ with $b = 850$ MeV.[A12] Dashed curves — $n = 1$; solid curves — $n = 2$. The form factors are those defined by Albright and Liu [A12] (see the appendix).

32. Total cross sections corresponding to figure 31.[A12]

33. q^2 and $M^2(\pi p)$ distributions for $(\mu^-\pi^+p)$ events with $E_{vis} > 1$ GeV originating on free protons in the CERN C_3H_8 experiment.[B46]

34. Distributions in the Berman and Veltman angles (figure 27) for events with

$1.3 < M^2(\pi p) < 1.9$ GeV^2 and $\sin^2 \frac{\alpha}{2} < 0.1$ (same experiment as figure 33).[B46]

35. Cross section for $\nu p \rightarrow \mu^- \pi^+ p$ (same experiment as figures 33 and 34[B46]). The errors shown are purely statistical. Systematic errors are ± 20%.

36. The $Q^2 - \nu$ plane for neutrino scattering.

    I. Elastic scattering: $Q^2 = 2\nu$

    II. Threshold for π production: $Q^2 = 2\nu - 2Mm_\pi - M_\pi^2$

    III. Line of fixed missing mass M*: $Q^2 = 2\nu + M^2 - M^{*2}$.

37. Total neutrino-nucleon cross section as a function of neutrino energy E. The freon cross sections have been multiplied by 1.35 to normalize them to the propane cross sections for $E_\nu > 2$ GeV. The errors shown are statistical only.[B47]

38. Plot of $\bar{Q}^2$ versus the neutrino energy.[M10, M11]

39. Form of the distributions in $y = \nu/ME$ for three ranges of neutrino energy. The dotted lines in the first and last bin indicate the raw data before making small corrections for the exclusion principle in elastic events and for the E dependent coefficient in Eq. (3.67) so that (3.74) applies[M10, M11]. (The labels $F_1 = F_3 = 0$, etc. really mean that the integrals over these quantities are equal, weighted as in (3.74)).

40. Fits to the ratios A and B (Eq. 3.118) for all the data with $E > 1$ GeV.[M11] The broad hatched area is the physical region allowed by the positivity conditions (3.77). The ellipse is the likelyhood contour corresponding to one standard deviation from the best fit. A and B together determine $r = (\sigma^{\nu n} + \sigma^{\nu p})/(\sigma^{\bar{\nu} p} + \sigma^{\bar{\nu} p})$ and lines of constant r are shown (see the text for a discussion of the significance of these results).

41. Fraction F of "clean" events with an identified proton (momentum

$\lesssim$ 0.8 GeV/c) plotted against q^2.[M10] "Clean" events have net secondary charge Q = 0 or + 1 and do not contain more than one identified nucleon (indicating that the nucleus did not necessarily break up).

42. Average pion multiplicity in "clean" events (see caption to figure 41) plotted against $\log \nu$.[M10] The authors of the paper from which this figure is taken[M10] caution that because of uncertainties due to the fact that the target is a nucleus (so that, e.g., the selection of "clean" events biases against large multiplicity) it is only possible to conclude that $\bar{n}$ increases slowly with ν. In spite of this we give this figure because it shows the only data now available.

43. The forward neutrino cross section averaged over free neutrons and protons. (a) The inelastic cross section according to Adler's theorem using $\sigma_\pi = 35$ mb for missing mass $W > 2.13\ M_p$ and a resonance formula for $W < 2.13\ M_p$. (b) The contribution to the inelastic cross section from $W < 2.13\ M_p$. (c) The elastic cross section.[B10]

44. The differential cross section for the forward process in the resonance region for a neutrino energy $4M_p$ (upper curve) and the result (lower curve) of multiplying by the square of the modulus of the shadow factor, the potential V being computed in a modified forward scattering approximation. W is the invariant mass of the final hadron system.[B10]

45. The inelastic differential cross section $d\sigma/d\cos\theta$ in our model averaged over free neutrons and protons and over the CERN neutrino spectrum. The muon energy was required to be > 1.2 GeV. The longitudinal contribution (which is liable to shadowing) and the transverse contribution (which is not) are shown separately. The horizontal scale is related to $\cos\theta$ by $\cos\theta = 1.0 - 0.00095\,x$.[B10]

46. Cross sections for $\nu N \to \mu^- W^+ N$ with N = proton/neutron, $M_W = 7$ GeV, K = 0, ± 1 and dipole form factors.[B43]

47. "Elastic" cross section ($\nu p \to \mu^- W^+ p$), as in figure 46 with K = 0, and "inelastic" cross section ($\nu p \to \mu^- W^+ + \ldots$).[B43]

48. Incoherent total cross sections for W production off protons and neutrons without allowing for the Pauli principle or the Fermi motion (i. e., the free nucleon cross section σ (p) of table 9 is plotted; we refer to the table for an illustration of the influence of nuclear effects which would not change the qualitative features of this figure) and the coherent cross section per nucleon in typical cases. $M_W = 8$ GeV, K = 0.[B43]

49. Plot of the fraction of μ^-'s with energy greater than a specific E_{μ^-} in $\nu p \to \mu^- W^+ p$. Solid curves: $M_W = 5$ GeV. Dashed curves: $M_W = 10$ GeV (K = 0 in both cases).[B44]

50. The angular distribution of the μ^- with respect to the neutrino direction in $\nu p \to \mu^- W^+ p$ (K = 0).[B44]

51. Plot of $\sigma_\nu = \sigma_{inel.}(x, y) + \sigma_W$ against x and E_ν for $M_W = 7$ GeV. The cross sections are for Pb^{208}.[C23]

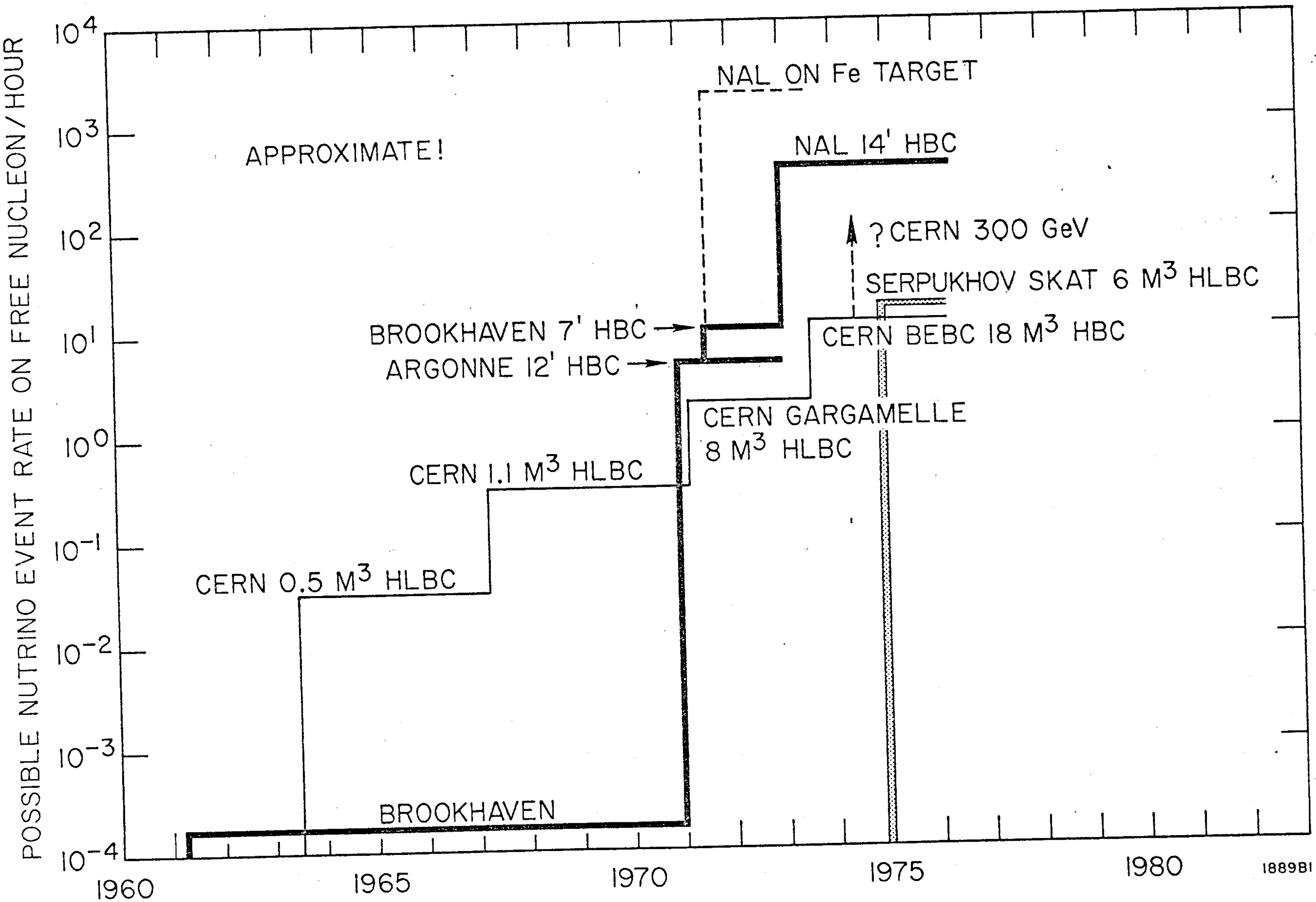
52. Scatter plot of $M_{\mu p}$ versus $\cos\theta_{\mu\nu}$: × freon (1963-1964); propane (1967); the continuous curve is the expected elastic distribution.[B45]

53. Ideograms, histograms, and least squares fitted means for the $M_{\mu\pi}$ distribution for events giving one possible single muon-pion combination in the 1967 neutrino experiment. a. Total distribution for 217 ν events and 12 $\bar{\nu}$ events, the latter also shown separately (34 ν events are off scale). The inset shows the mass distribution of the seven Λ^0 obtained in the experiment. b. Distribution for 106 ν events and 6 $\bar{\nu}$ events remaining after selecting out

events with 1.125 < M^* < 1.350 GeV (21 ν events are off scale). c. Ideograms of all ν events and all $\bar{\nu}$ events in the region of $M_{\mu\pi}$ = 0.425 GeV. The weighted means and their standard errors are shown for all the largest groups of three or more consecutive values of $M_{\mu\pi}$ with a confidence level ≥ 50%. The two groups indicated are: WM (17ν) = 0.423 ± 0.002 GeV; WM(4$\bar{\nu}$) = 0.424 ± 0.003 GeV.[Rl]

54. Anti-neutrino cross section ratios for Y_1^* compared to N^* production.[W9] Here

$$R_1 = \frac{\sigma(\bar{\nu}_\mu + N \rightarrow Y_1^{*-} + \mu^+)}{\sigma(\bar{\nu}_\mu + N \rightarrow N^{*-} + \mu^+)} \text{ and } R_2 = \frac{\sigma(\bar{\nu}_\mu + p \rightarrow Y_1^{*o} + \mu^+)}{\sigma(\bar{\nu}_\mu + p \rightarrow N^{*o} + \mu^+)} .$$



POSSIBLE NUTRINO EVENT RATE ON FREE NUCLEON / HOUR
10^4
10^3
10^2
10^1
10^0
10^-1
10^-2
10^-3
10^-4
APPROXIMATE!
NAL ON Fe TARGET
NAL 14' HBC
? CERN 300 GeV
SERPUKHOV SKAT 6 M3 HLBC
BROOKHAVEN 7' HBC
CERN BEBC 18 M3 HBC
ARGONNE 12' HBC
CERN GARGAMELLE
8 M3 HLBC
CERN 1.1 M3 HLBC
CERN 0.5 M3 HLBC
BROOKHAVEN
1960
1965
1970
1975
1980
1889B1

Fig. 1

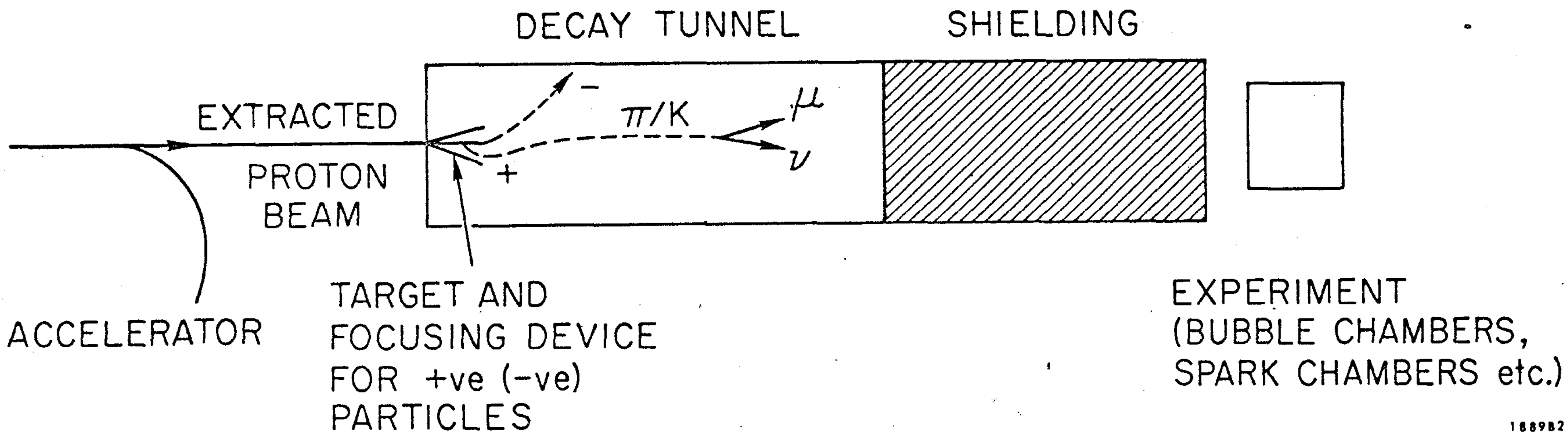
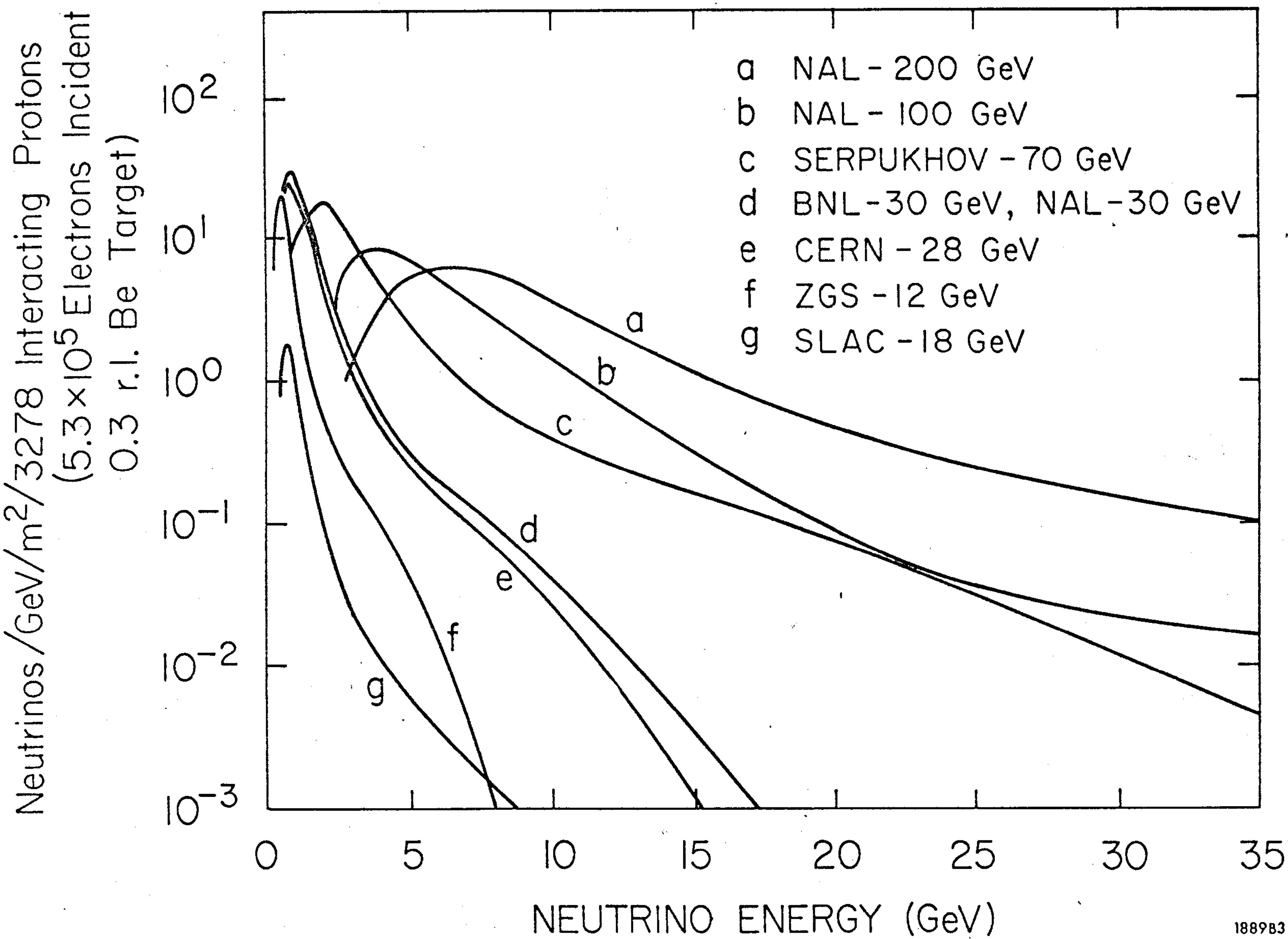

DECAY TUNNEL
SHIELDING
EXTRACTED
PROTON
BEAM
π/K
μ
ν
-
+
ACCELERATOR
TARGET AND
FOCUSING DEVICE
FOR +ve (-ve)
PARTICLES
EXPERIMENT
(BUBBLE CHAMBERS,
SPARK CHAMBERS etc.)
188982

Fig. 2



Neutrinos /GeV/m²/3278 Interacting Protons
(5.3×10⁵ Electrons Incident
0.3 r.l. Be Target)
10²
10¹
10⁰
10⁻¹
10⁻²
10⁻³
0
5
10
15
20
25
30
35
NEUTRINO ENERGY (GeV)
a NAL - 200 GeV
b NAL - 100 GeV
c SERPUKHOV - 70 GeV
d BNL-30 GeV, NAL-30 GeV
e CERN - 28 GeV
f ZGS - 12 GeV
g SLAC - 18 GeV
a
b
c
d
e
f
g
1889B3

Fig. 3

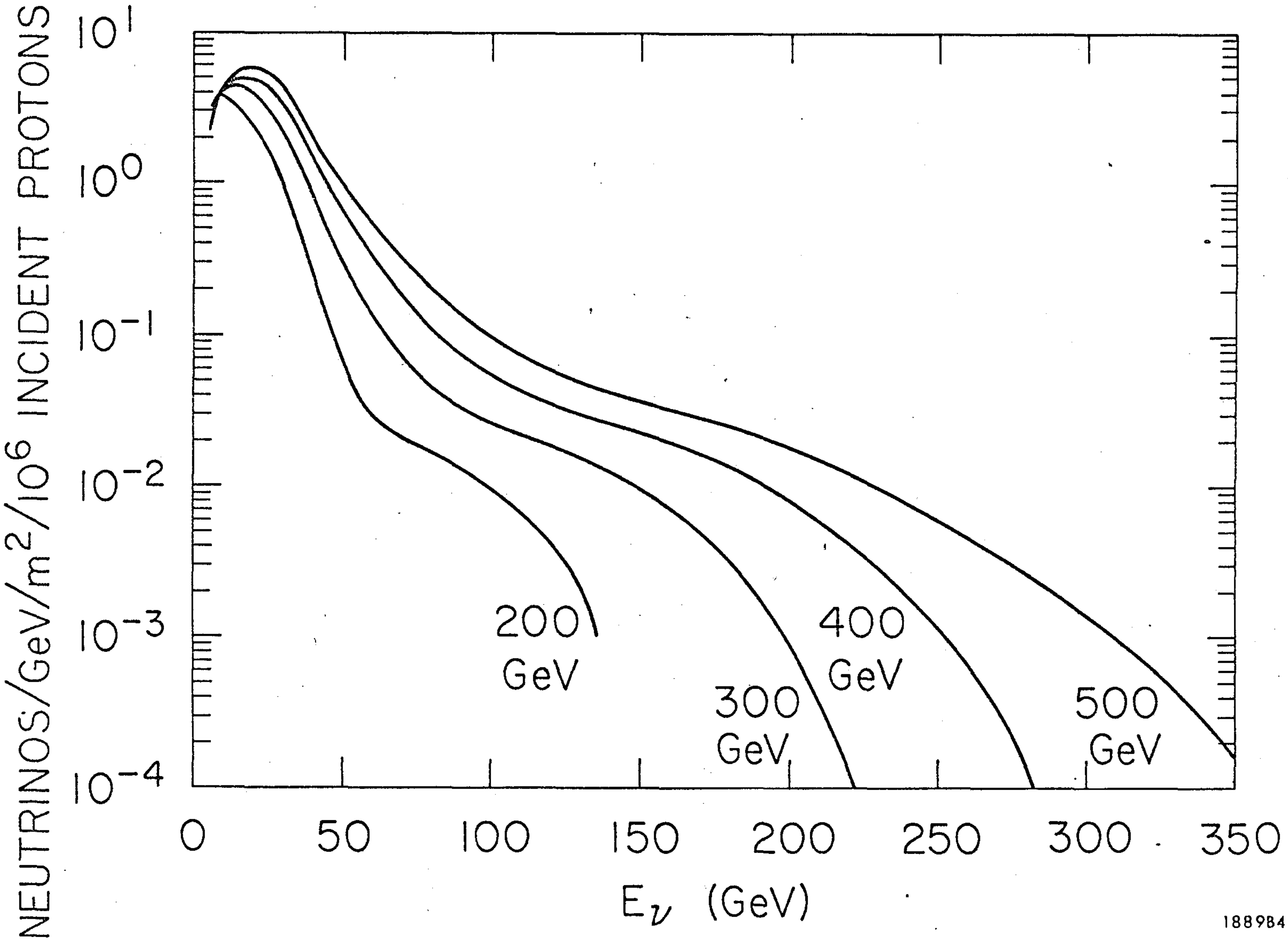
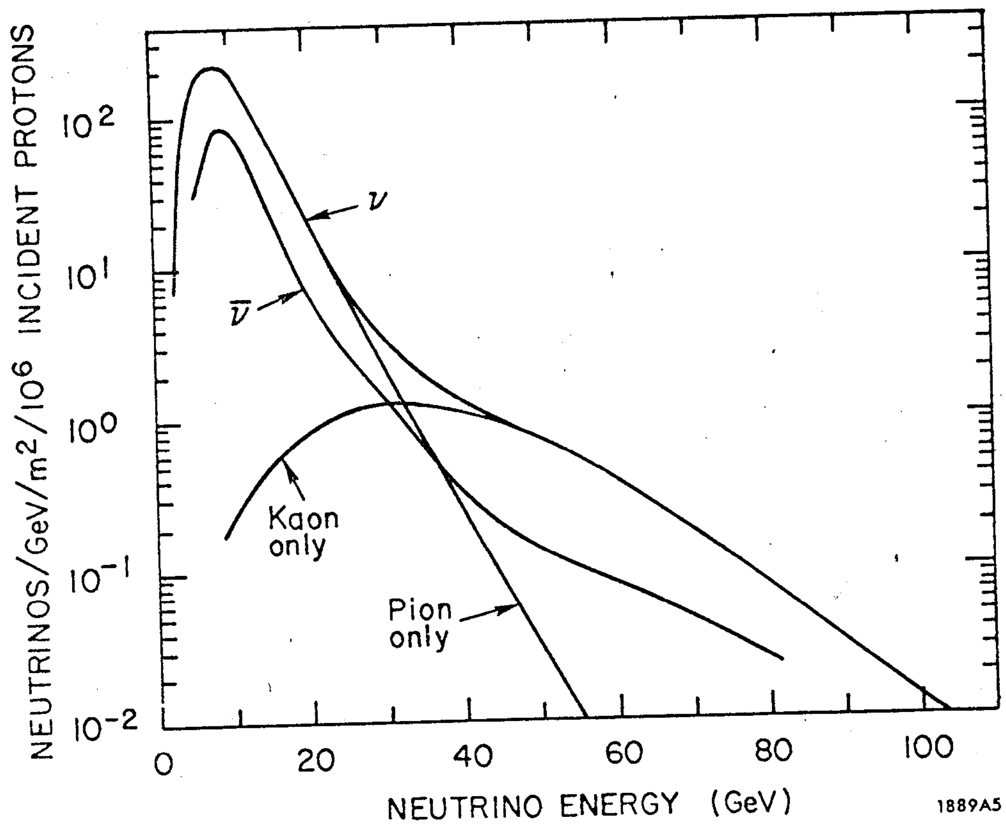
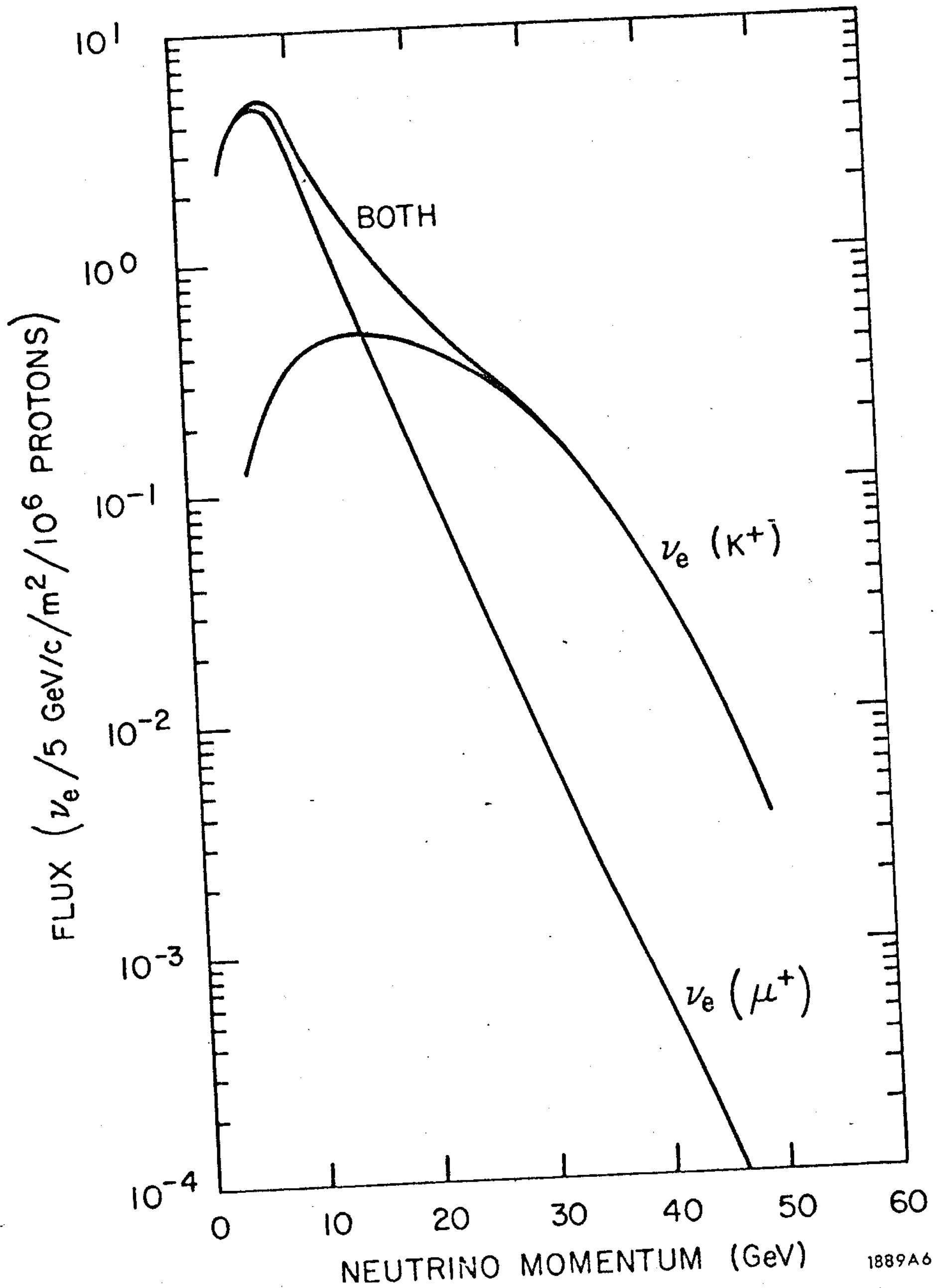

NEUTRINOS/GeV/m²/10⁶ INCIDENT PROTONS
10¹
10⁰
10⁻¹
10⁻²
10⁻³
10⁻⁴
0
50
100
150
200
250
300
350
E_ν (GeV)
200 GeV
300 GeV
400 GeV
500 GeV
1889B4

Fig. 4



NEUTRINOS/GeV/m²/10⁶ INCIDENT PROTONS
10²
10¹
10⁰
10⁻¹
10⁻²
0
20
40
60
80
100
NEUTRINO ENERGY (GeV)
ν
ν̄
Kaon
only
Pion
only
1889A5

Fig. 5



10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
FLUX $(\nu_e/5\ GeV/c/m^2/10^6\ PROTONS)$
BOTH
$\nu_e\ (K^+)$
$\nu_e\ (\mu^+)$
0
10
20
30
40
50
60
NEUTRINO MOMENTUM (GeV)
1889A6

Fig. 6

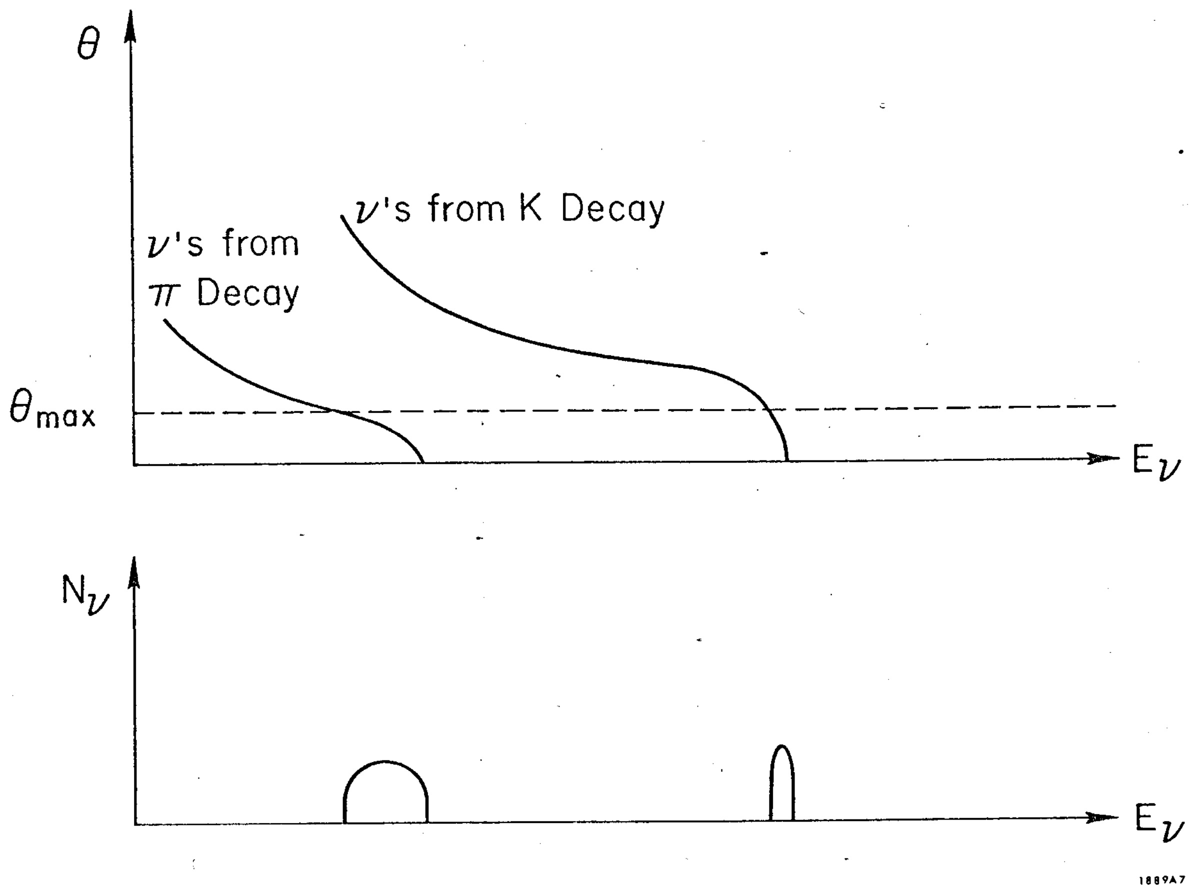


Fig. 7

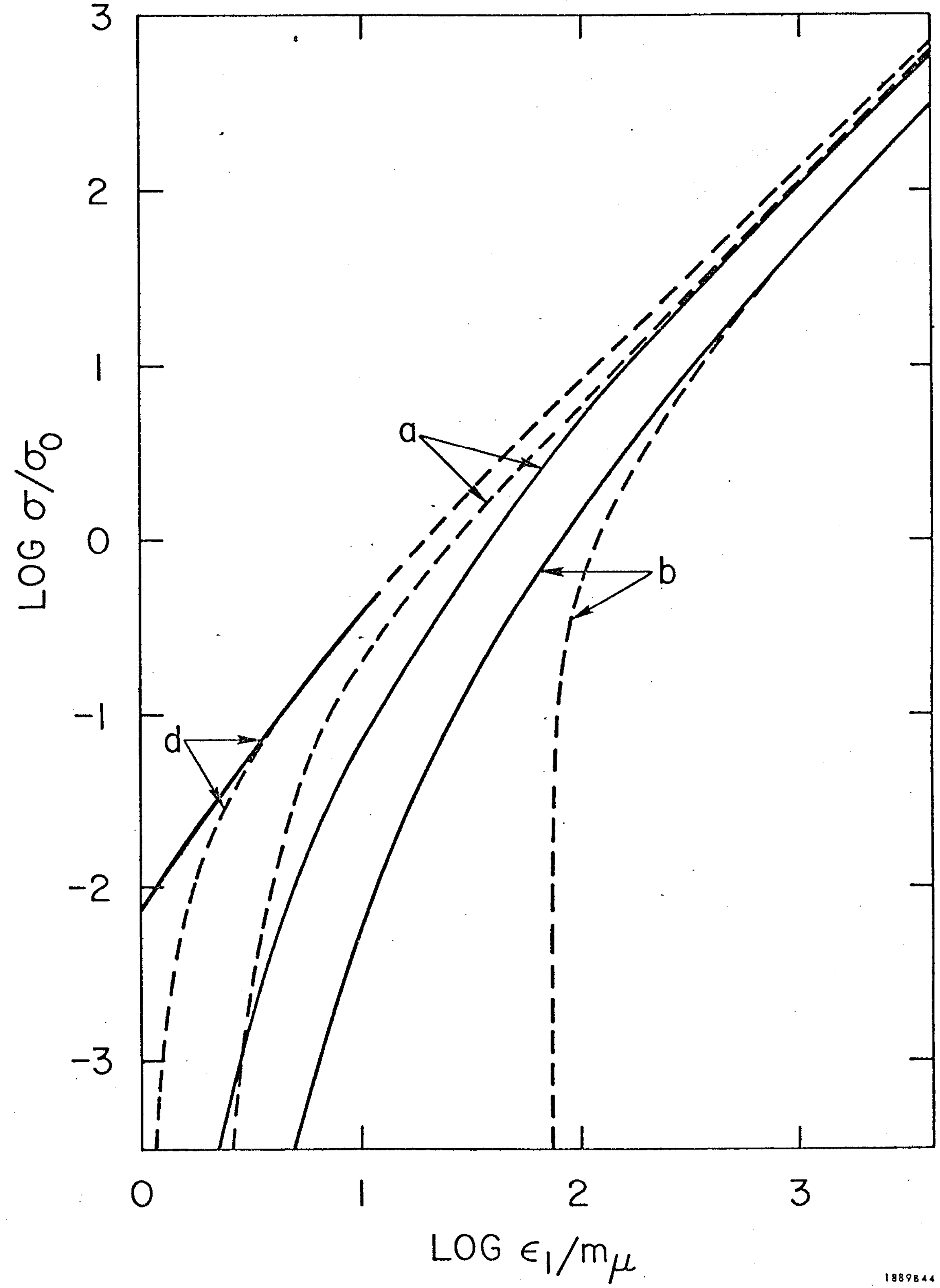
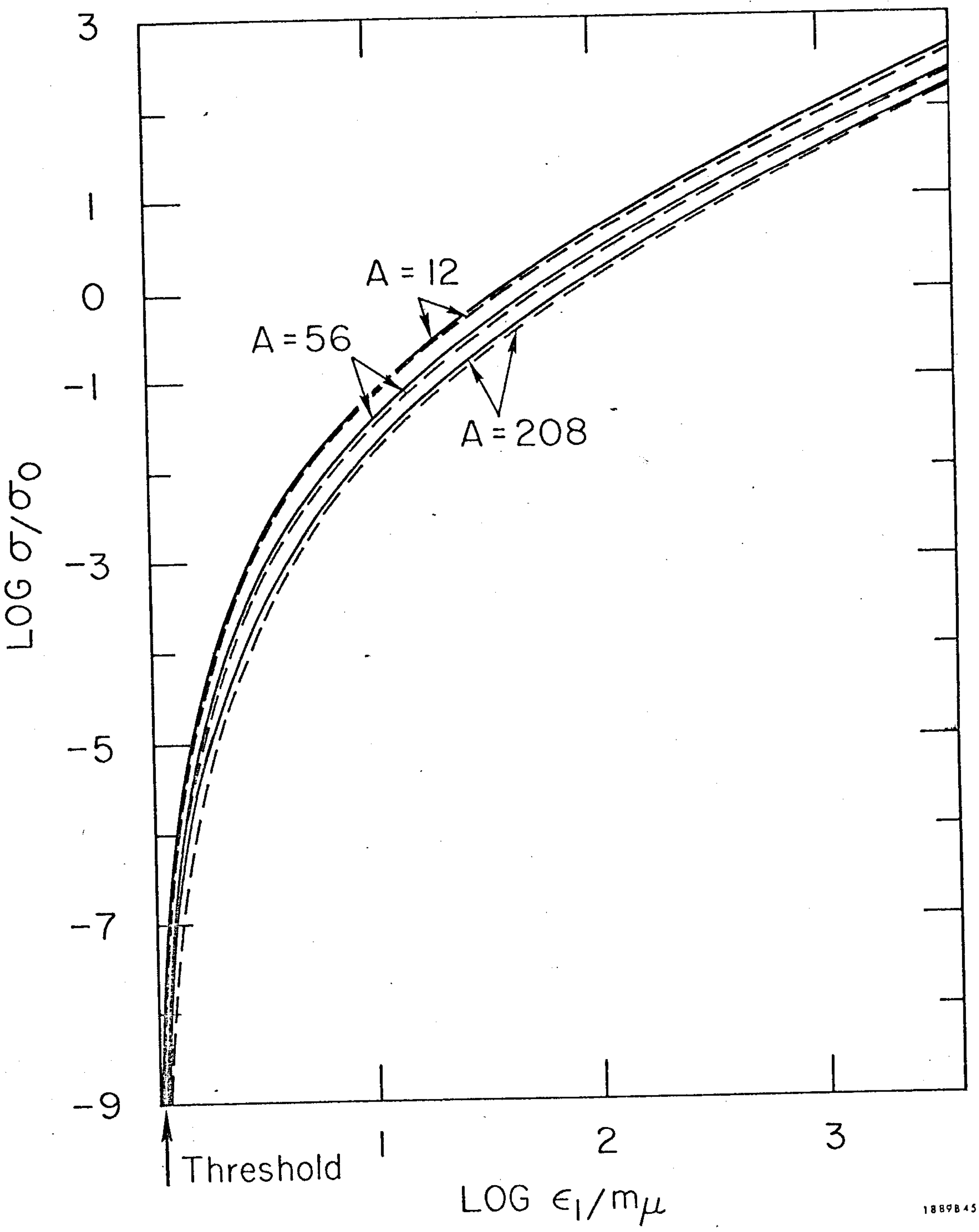


Fig. 8



3
1
0
-1
-3
-5
-7
-9
A = 12
A = 56
A = 208
LOG σ/σ0
Threshold
1
2
3
LOG ε1/mμ
1889B45

Fig. 9

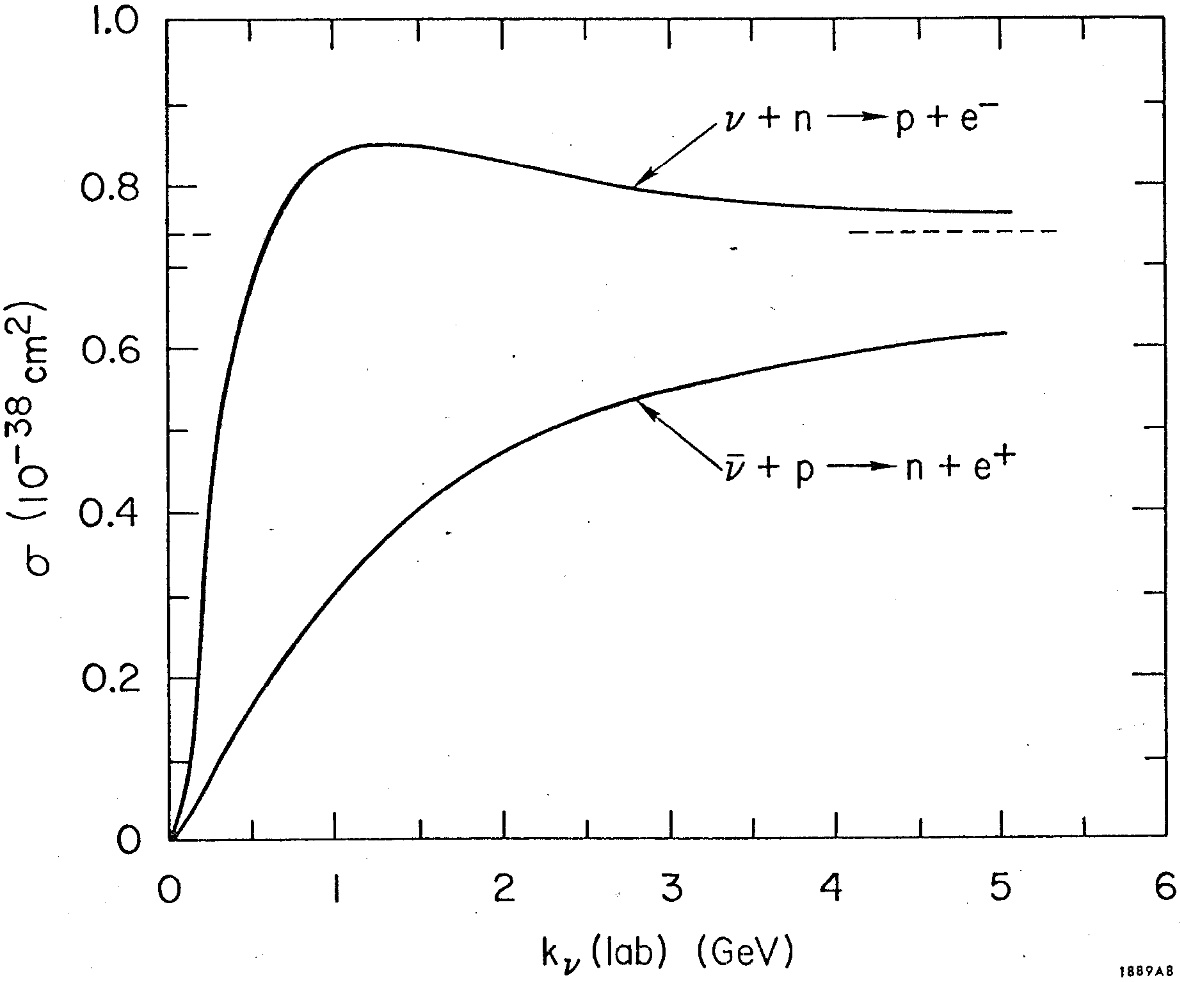


Fig. 10