Fermilab

ν_e and $\bar{\nu}_e$ Fluxes For The Single Horn System

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A Monte Carlo program was used to calculate ν_e and $\bar{\nu}_e$ fluxes for the single horn system. The sources of ν_e and $\bar{\nu}_e$ are:

$$K^+ \rightarrow \pi^o e^+ \nu_e \qquad (BR = 4.8\%)$$
$$K_L^o \rightarrow \pi^- e^+ \nu_e \qquad (19.5\%)$$
$$K_L^o \rightarrow \pi^+ e^- \bar{\nu}_e \qquad (19.5\%)$$
$$K^- \rightarrow \pi^o e^- \bar{\nu}_e \qquad (4.8\%)$$

and all the other processes were not included in the calculations. The same program was also used to calculate ν_μ and $\bar{\nu}_\mu$ fluxes from the π and K decays,

$$\left.\begin{matrix}\pi^\pm \\ K^\pm\end{matrix}\right\} \rightarrow \mu^+ + \nu_\mu \text{ and } \mu^- \bar{\nu}_\mu .$$

The single horn system was simplified in the calculations to give focussing and absorption properties as given in Table I.

Table I. Parameters of the single horn system used in the Monte Carlo calculations.

Production Angle (mrad)	ΔP_T (GeV/c)	Particle Path Lengths in the $A\ell$ Inner Conductor (cm)
0 to 1.3	0	0
1.3 to 1.8	0	53.6
1.8 to 10.0	$0.3 \times \frac{I(kA)}{140}$	6.6

Particles with production angles greater than 10 mrad were not included in the calculations. The production angular range from 1.3 mrad to 1.8 mrad corresponds to the narrow inner conductor region. The single horn was designed to give a transverse momentum deflection of 0.3 GeV/c for a charged particle at the horn excitation current of 140 kA. Neutral particles, K_L^o, are not deflected. Absorption lengths of aluminum for π^+, π^-, K^+, K^-, and

K_L^o were assumed to be 62, 59, 80, 70, and 75 cm, respectively. Table II summarizes attenuation factors used in the calculations.

Table II. Attenuation Factors

Angular Range (mrad)	π^+	π^-	K^+	K^-	K^o
0 - 1.3	1	1	1	1	1
1.3 - 1.8	0.42	0.40	0.51	0.47	0.49
1.8 - 10.0	0.90	0.89	0.92	0.91	0.92

Figures 1 and 2 show computed $\overset{(-)}{\nu}_\mu$ and $\overset{(-)}{\nu}_e$ fluxes for each individual decay process at the 15 ft. Bubble Chamber. The incident proton energy was 400 GeV for the horn current of +140 kA. The detector radius was 1.35 m. No antineutrino plug was used. Stefanski-White's parametrization[2] was used for charged pion and kaon production. The K_L^o production cross section was assumed to be the average K^+ and K^- cross sections. The present results agree reasonably well with NUADA[3] outputs except at higher energies where the present results are slightly small. It should be noted that the NUADA program calculates the neutrino flux by ray tracing at the bin center in momentum and production angle. It is not a Monte Carlo program. Therefore, the NUADA results depend somewhat on the bin size used in calculations, particularly in the forward direction where the horn has the narrow inner conductor. Figure 3 shows summed $\overset{(-)}{\nu}_\mu$ and $\overset{(-)}{\nu}_e$ fluxes.

Figures 4, 5, and 6 show $\overset{(-)}{\nu}_\mu$ at the 15' Bubble Chamber for the horn current of -140 kA, the incident proton energy of 400 GeV. No antineutrino plug was used. Figures 7, 8, and 9 show $\overset{(-)}{\nu}_\mu$ and $\overset{(-)}{\nu}_e$ fluxes at the 15' Bubble Chamber for the horn current of +80 kA, the incident proton energy of 350 GeV. No antineutrino plug was used. Figures 10, 11, and 12 show $\overset{(-)}{\nu}_\mu$ and $\overset{(-)}{\nu}_e$ fluxes at the 15' Bubble Chamber for the horn current of -80 kA, the incident proton energy of 350 GeV. The antineutrino plug which covers the production angular cone of 1.8 mrad in the forward direction was used. It was assumed that all the particles produced within this angular cone of 1.8 mrad were totally absorbed. Since the present model does not allow particles to decay before being defocussed by the horn or before reaching the antineutrino plug absorber, wrong sign background fluxes were underestimated in the present calculations.

Figures 13, 14, and 15 show $\overset{(-)}{\nu}_\mu$ and $\overset{(-)}{\nu}_e$ fluxes at Wonder Building for the horn current of +80 kA, the incident proton energy of 350 GeV. No antineutrino plug was used.

References

1. J.Grimson and S.Mori, New Single Horn System, TM-824, October 1978.
2. R.J.Stefanski and H.B.White, Jr., FN-292, 2060.000, 1976.
3. D.C.Cary and V.A.White, Fermilab Internal Report, NUADA, June 1975.

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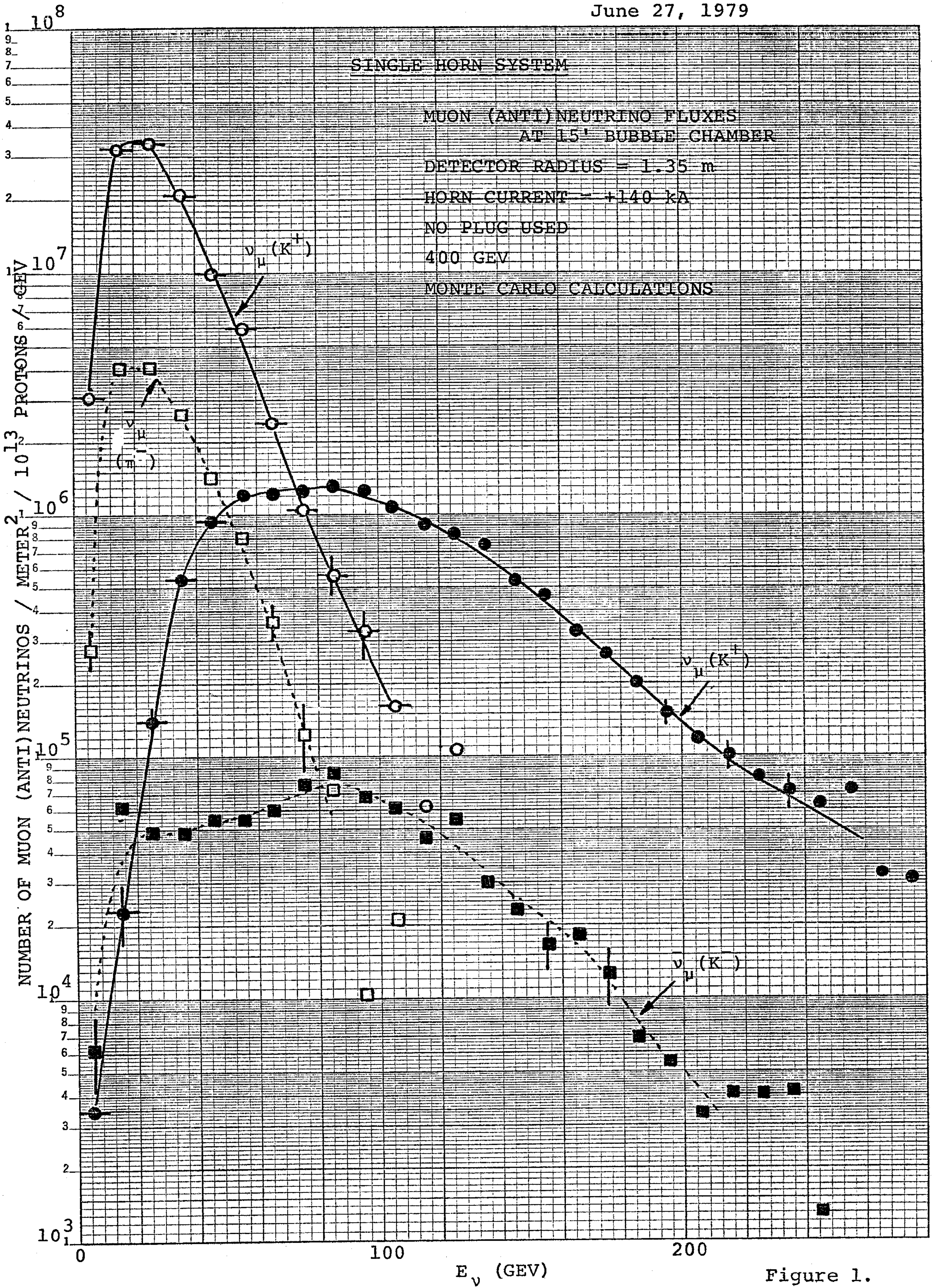

Figure 1.

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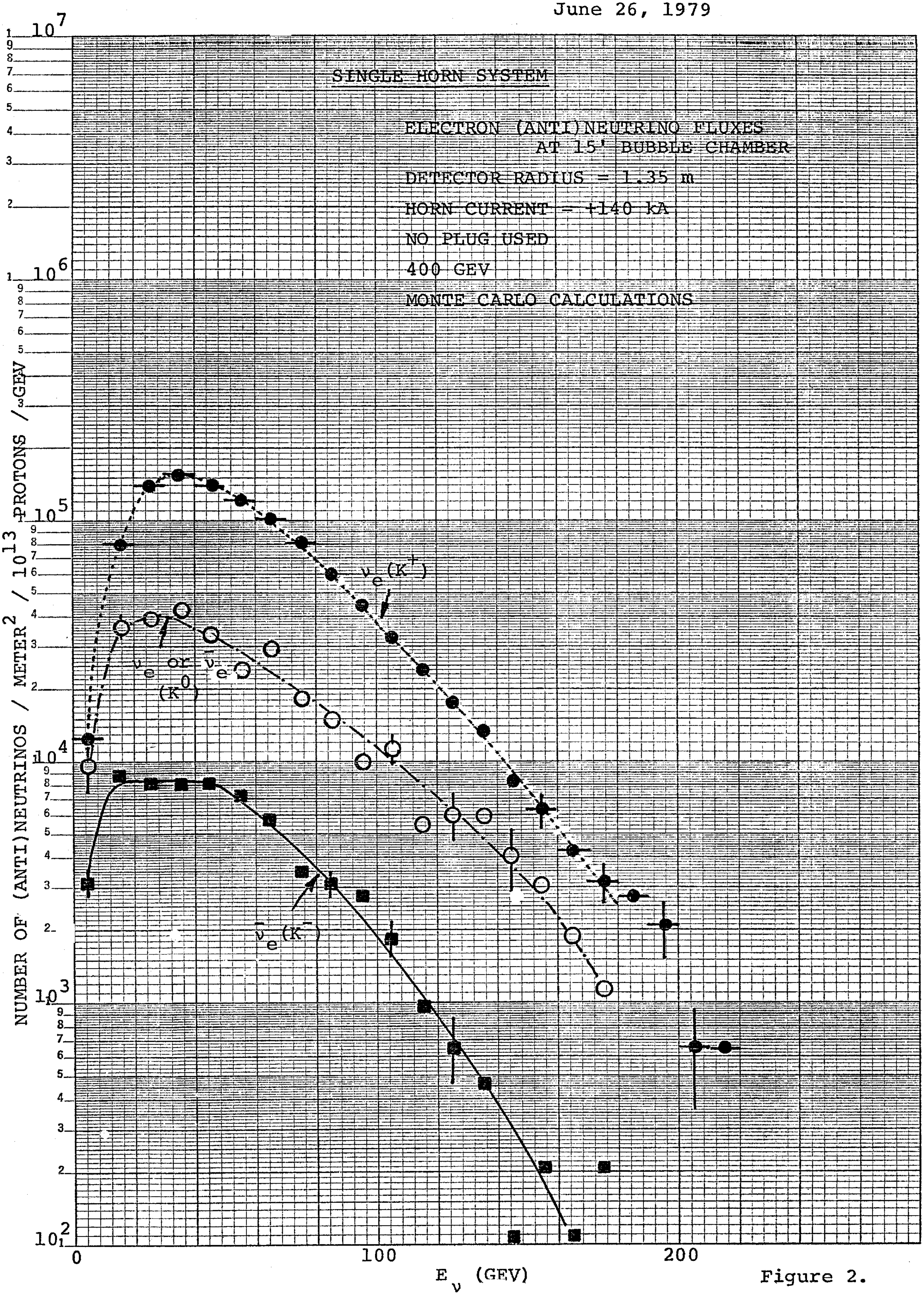

Figure 2.

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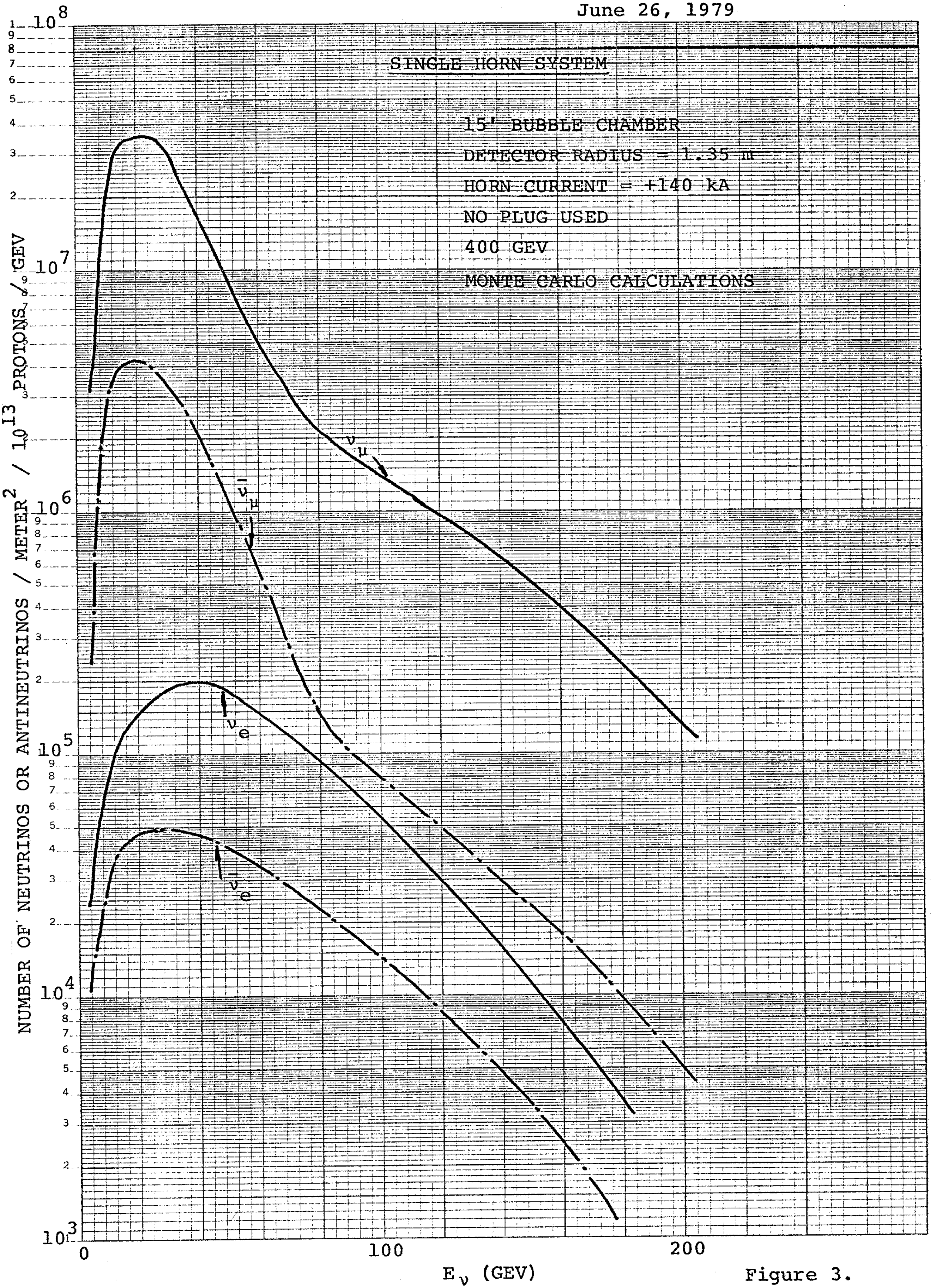

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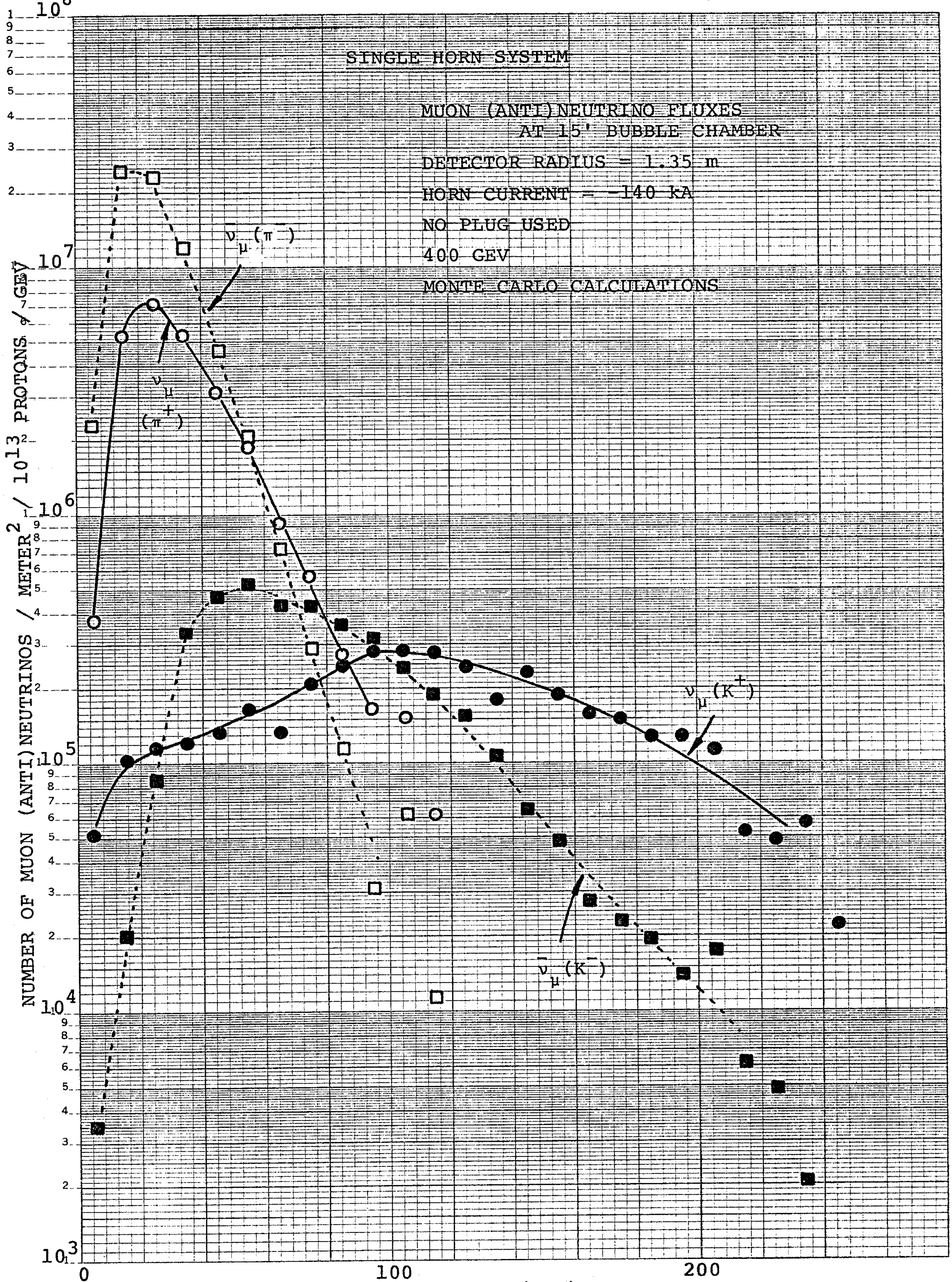

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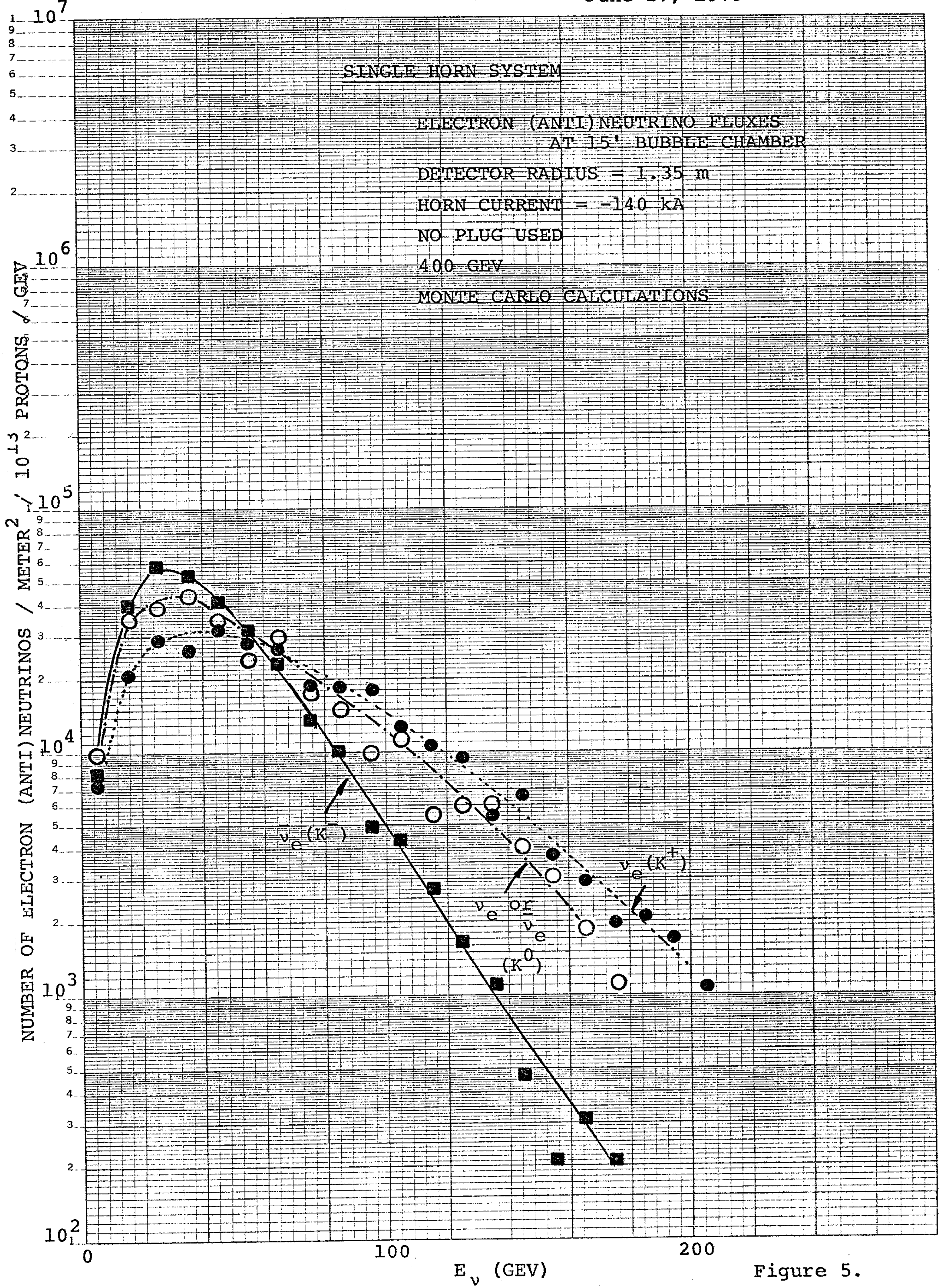

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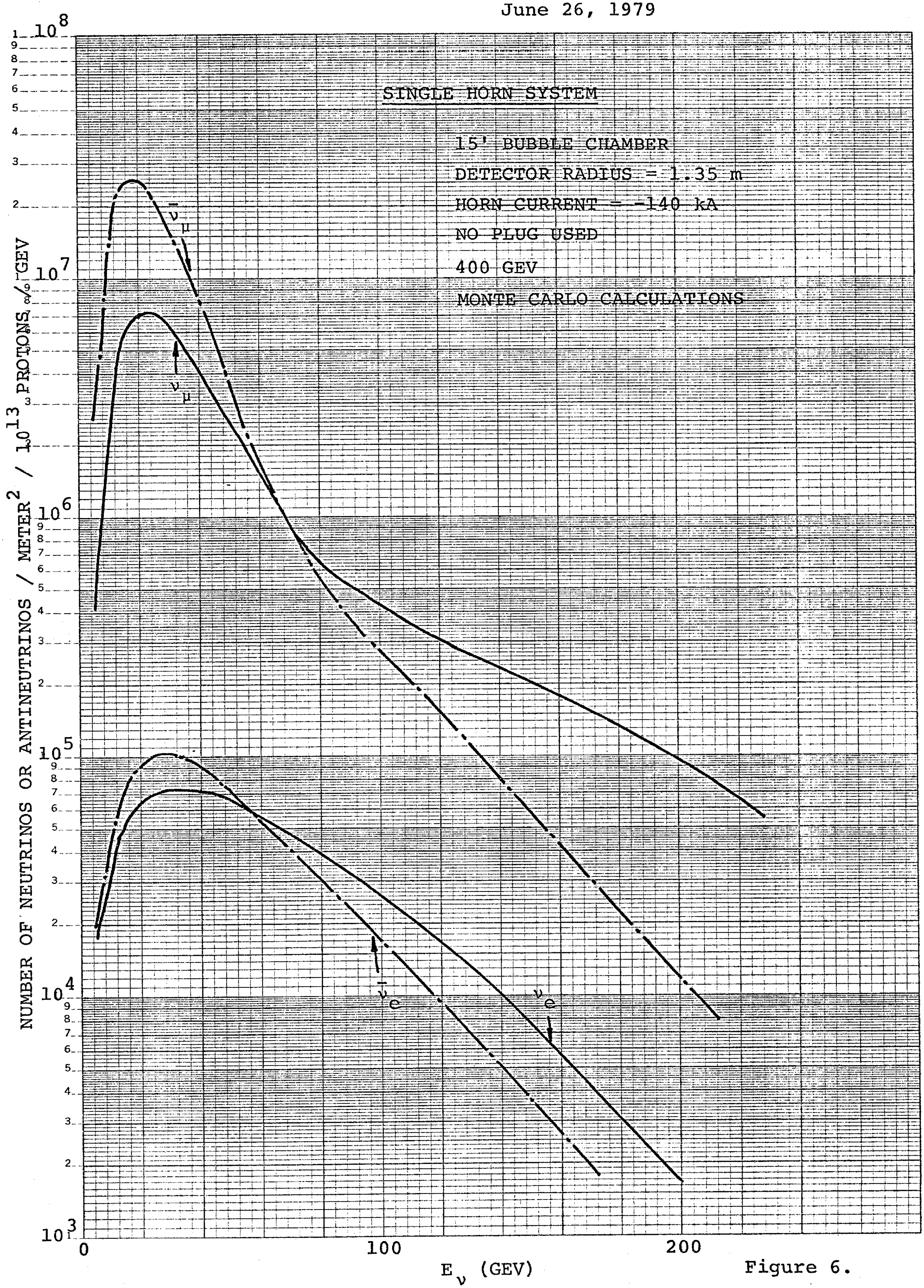
SINGLE HORN SYSTEM
15' BUBBLE CHAMBER
DETECTOR RADIUS = 1.35 m
HORN CURRENT = -140 kA
NO PLUG USED
400 GEV
MONTE CARLO CALCULATIONS
$\bar{\nu}_\mu$
ν_μ
$\bar{\nu}_e$
ν_e
NUMBER OF NEUTRINOS OR ANTINEUTRINOS / METER^2 / 10^{13} PROTONS / GEV
10^8
10^7
10^6
10^5
10^4
10^3
0
100
200
E_ν (GEV)

Figure 6.

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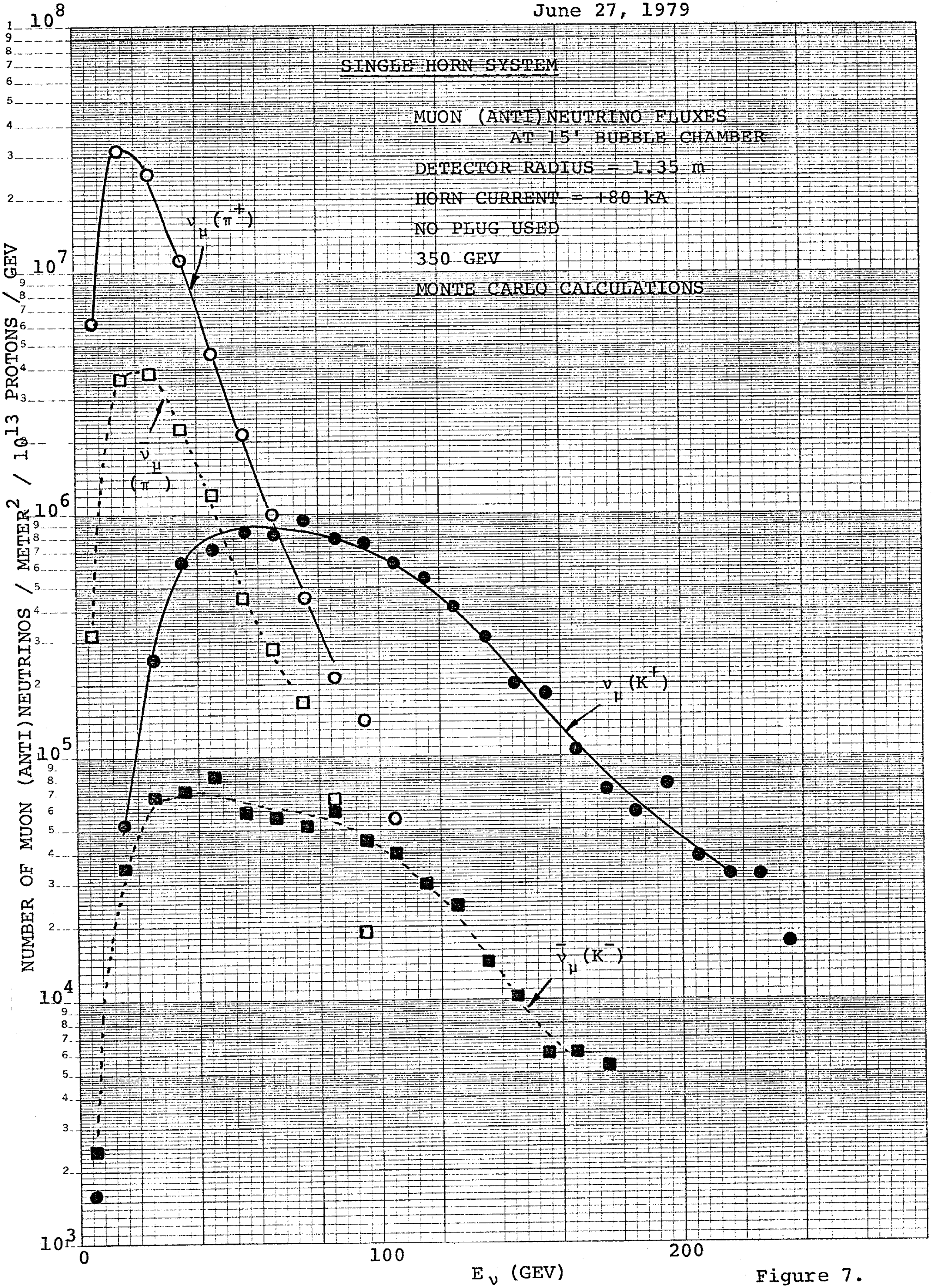

Figure 7.

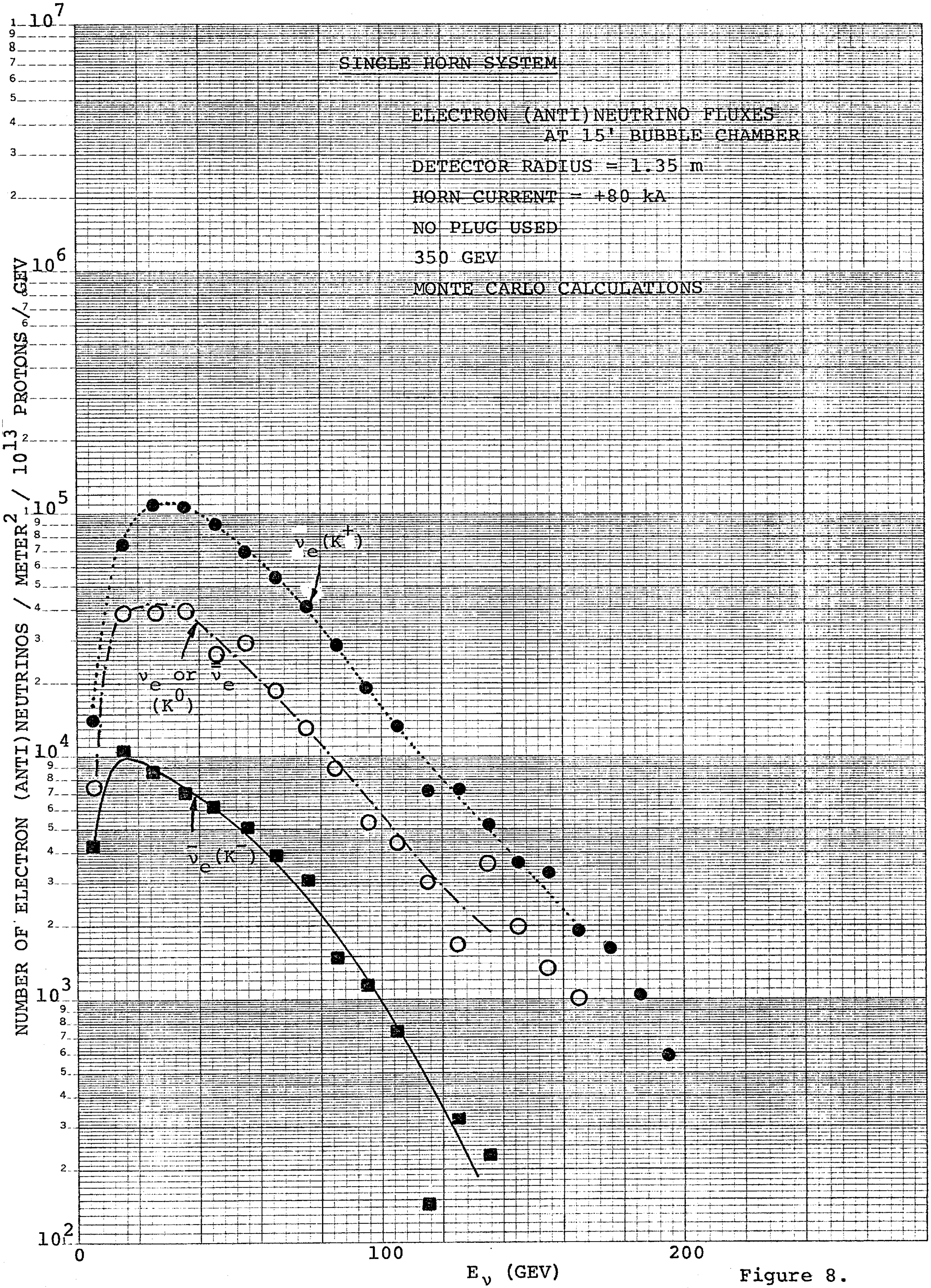
SINGLE HORN SYSTEM
ELECTRON (ANTI)NEUTRINO FLUXES AT 15' BUBBLE CHAMBER
DETECTOR RADIUS = 1.35 m
HORN CURRENT = +80 kA
NO PLUG USED
350 GEV
MONTE CARLO CALCULATIONS
$\nu_e(K^+)$
ν_e or $\bar{\nu}_e$ (K^0)
$\bar{\nu}_e(K^-)$
NUMBER OF ELECTRON (ANTI)NEUTRINOS / METER^2 / 10^{13} PROTONS / GEV
E_ν (GEV)
10^2
10^3
10^4
10^5
10^6
10^7
0
100
200

Figure 8.

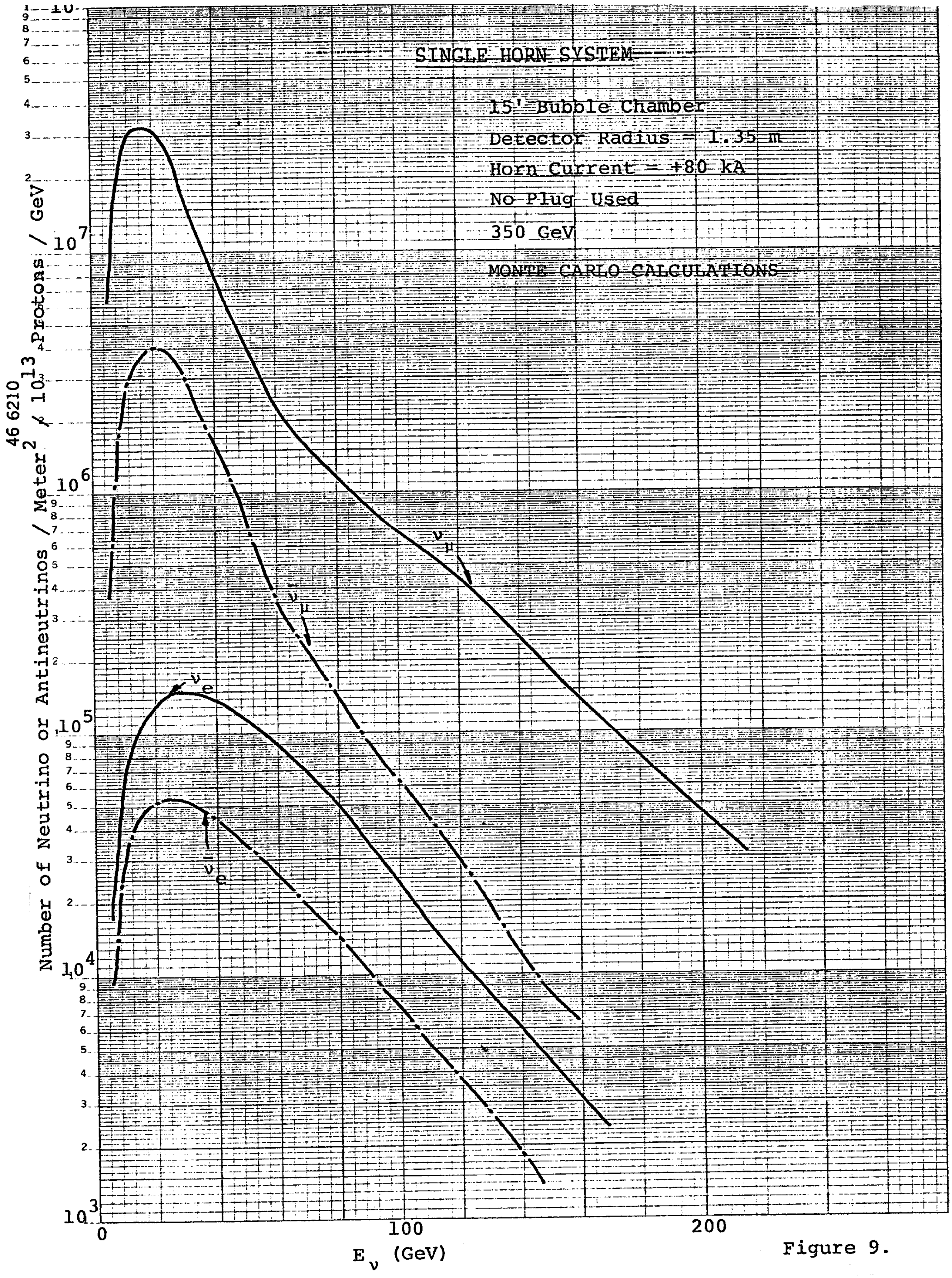
SINGLE HORN SYSTEM
15' Bubble Chamber
Detector Radius = 1.35 m
Horn Current = +80 kA
No Plug Used
350 GeV
MONTE CARLO CALCULATIONS
Number of Neutrino or Antineutrinos / Meter^2 / 10^{13} Protons / GeV
E_ν (GeV)
ν_μ
$\bar{\nu}_\mu$
ν_e
$\bar{\nu}_e$
46 6210

Figure 9.

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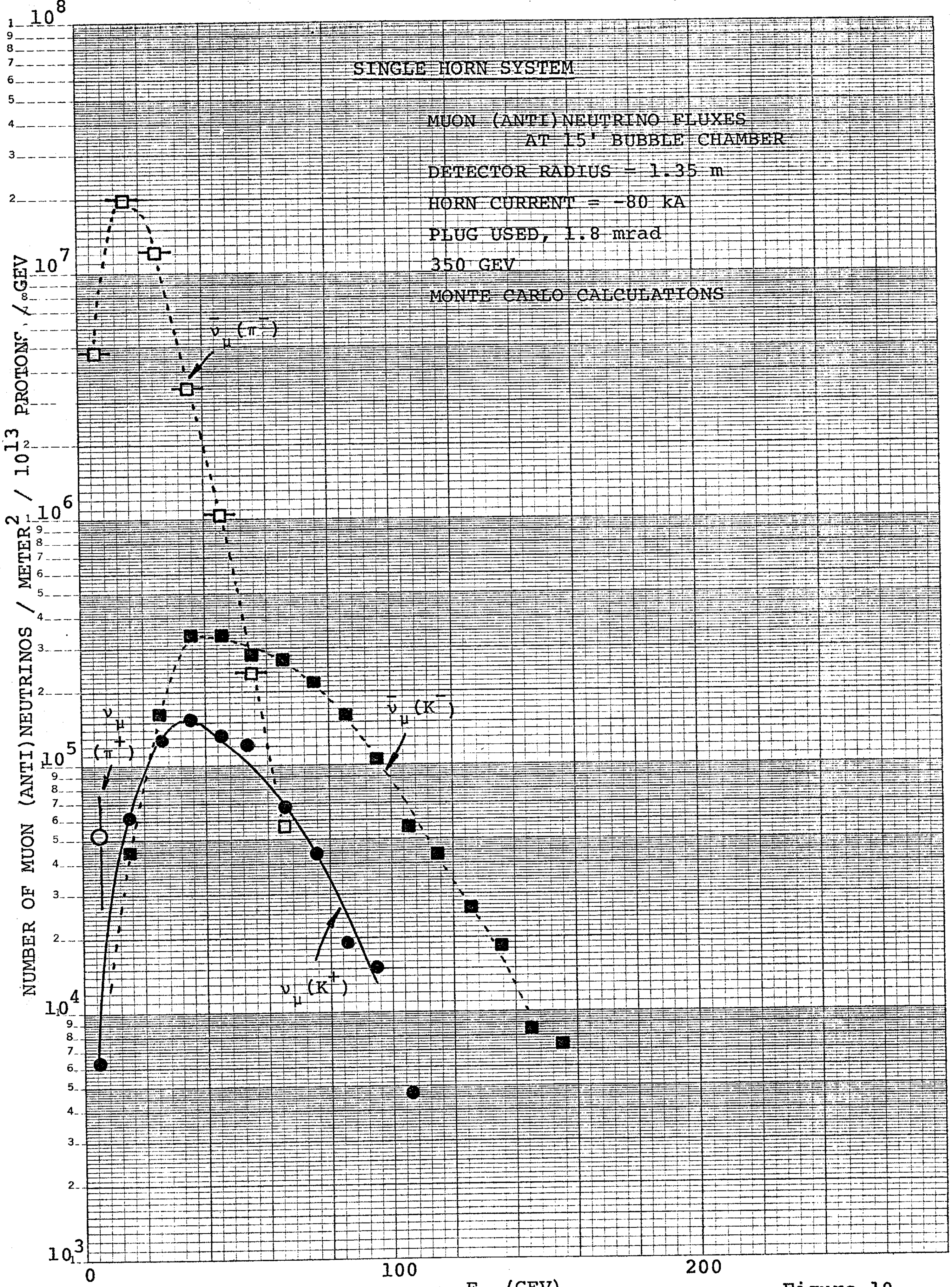

Figure 10.

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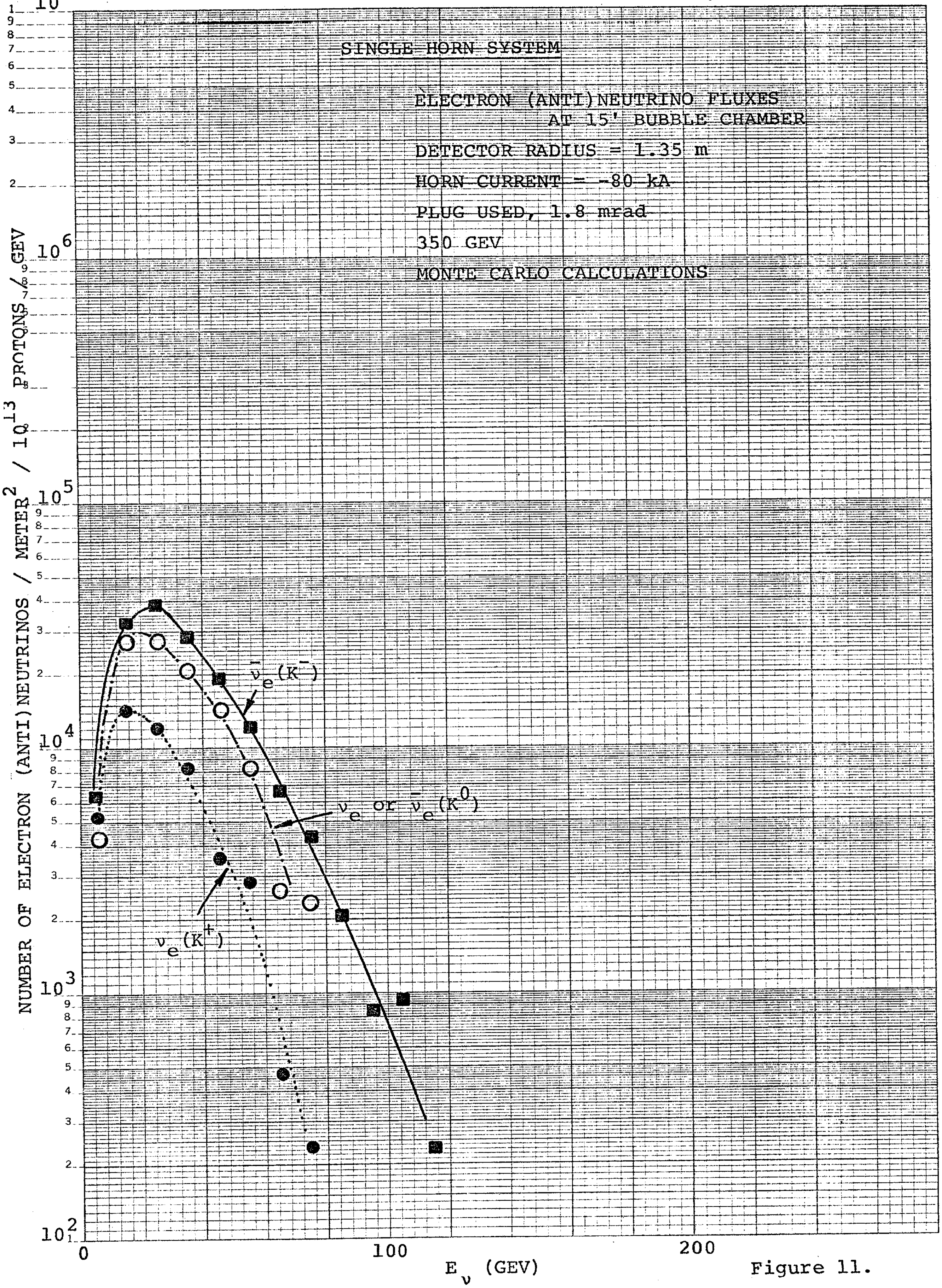

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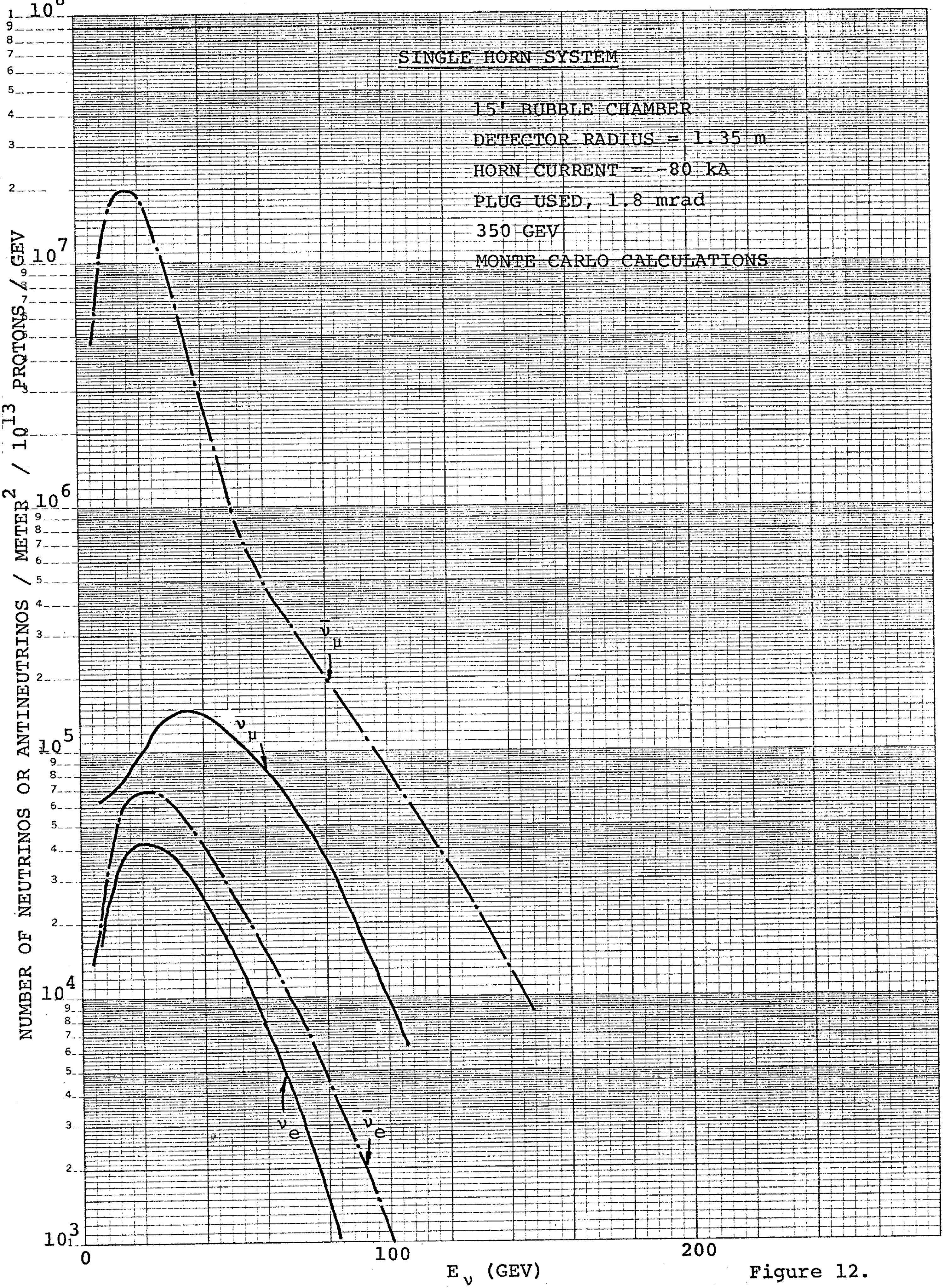

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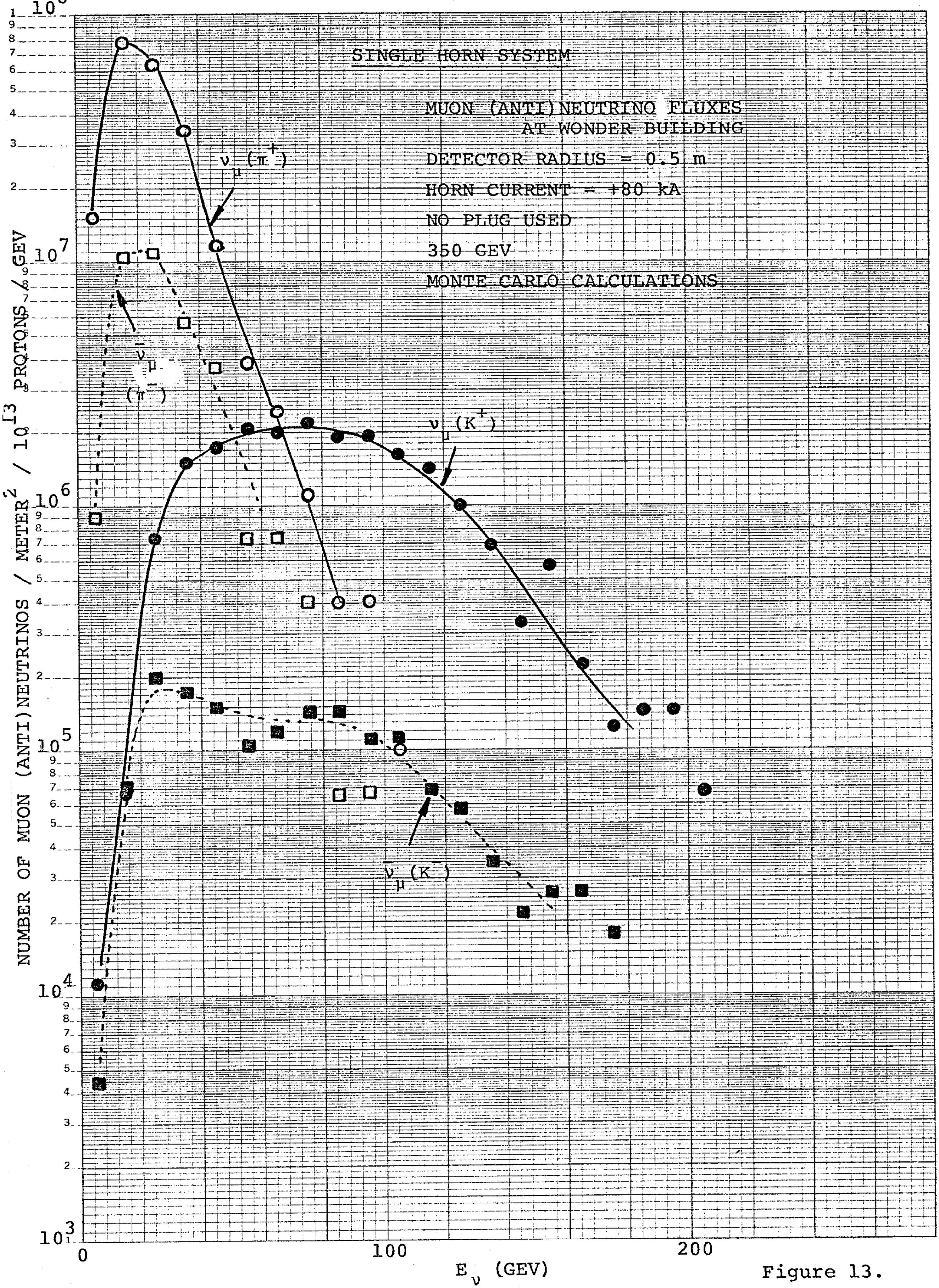
SINGLE HORN SYSTEM
MUON (ANTI)NEUTRINO FLUXES AT WONDER BUILDING
DETECTOR RADIUS = 0.5 m
HORN CURRENT = +80 kA
NO PLUG USED
350 GEV
MONTE CARLO CALCULATIONS
$\nu_\mu(\pi^+)$
$\bar{\nu}_\mu(\pi^-)$
$\nu_\mu(K^+)$
$\bar{\nu}_\mu(K^-)$
NUMBER OF MUON (ANTI)NEUTRINOS / METER^2 / 10^{13} PROTONS / GEV
E_ν (GEV)
10^3
10^4
10^5
10^6
10^7
10^8
0
100
200

Figure 13.

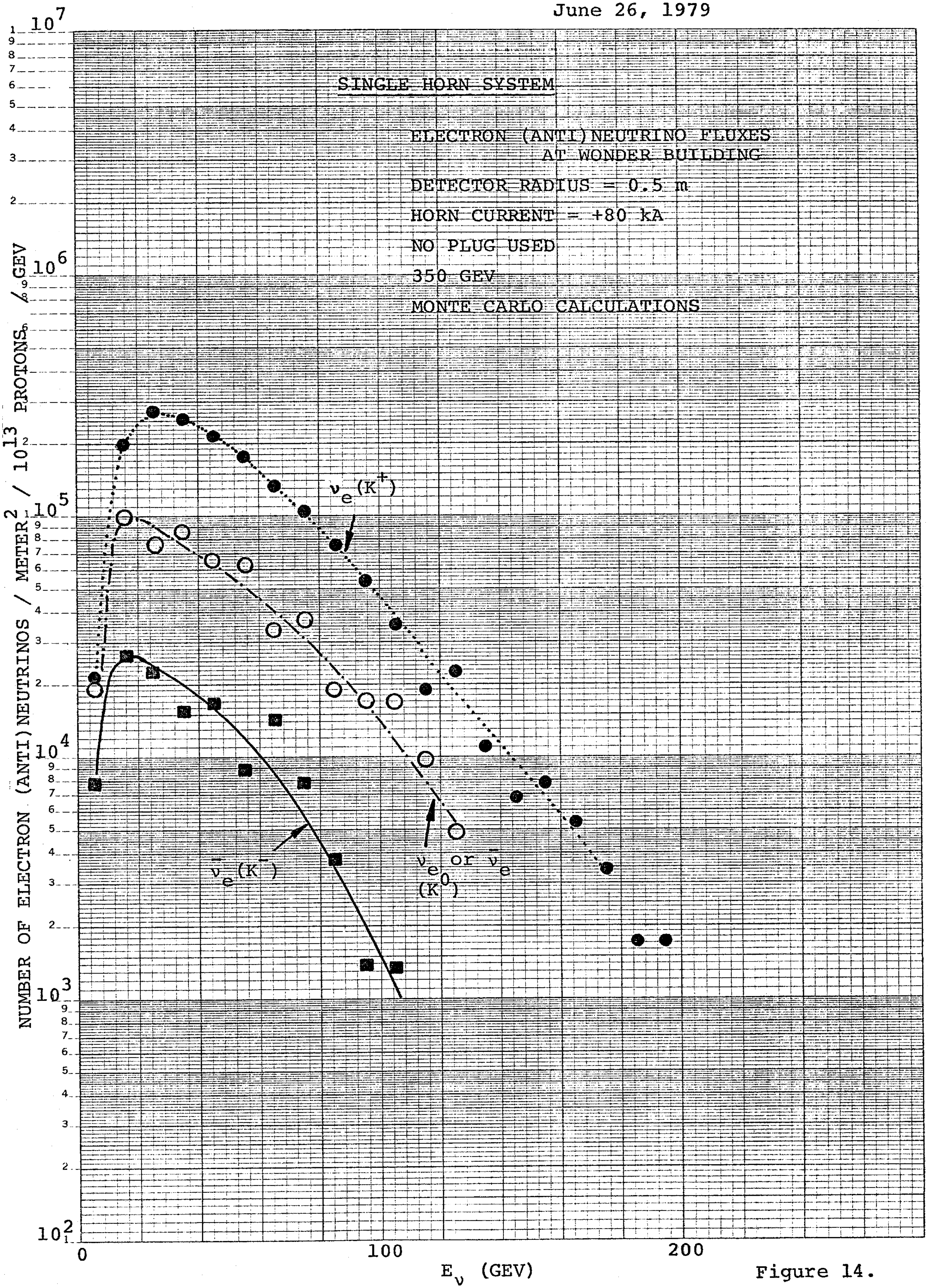
SINGLE HORN SYSTEM
ELECTRON (ANTI)NEUTRINO FLUXES AT WONDER BUILDING
DETECTOR RADIUS = 0.5 m
HORN CURRENT = +80 kA
NO PLUG USED
350 GEV
MONTE CARLO CALCULATIONS
$\nu_e(K^+)$
ν_e or $\bar{\nu}_e$ (K^0)
$\bar{\nu}_e(K^-)$
NUMBER OF ELECTRON (ANTI)NEUTRINOS / METER^2 / 10^{13} PROTONS / GEV
E_ν (GEV)
10^7
10^6
10^5
10^4
10^3
10^2
0
100
200

Figure 14.

June 26, 1979

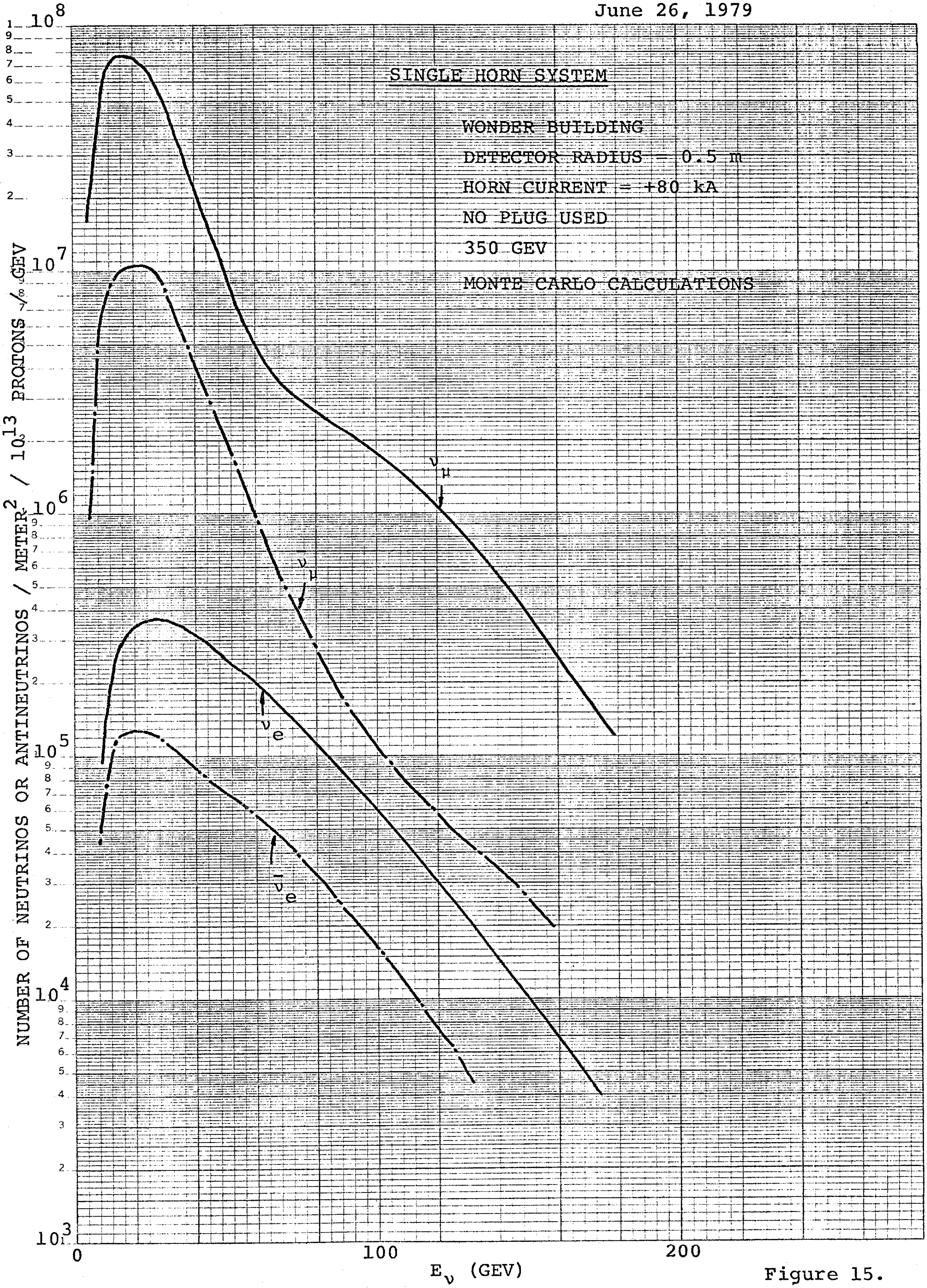

Figure 15.