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A COMPARISON OF NEUTRINO FLUXES EXPECTED AT THE HIGH ENERGY ACCELERATORS IN 1973

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The neutrino fluxes obtainable in 1973 at the high energy accelerators around the world are estimated and compared with those expected at NAL. The accelerators included in this study are those at NAL operating at 200 GeV, 100 GeV and 30 GeV, Serpukhov-70 GeV, BNL-30 GeV, CERN-25 GeV, SLAC-18 GeV and the ANL-12 GeV.

In Table I are given for each accelerator the parameters of the neutrino beam and detector used in the calculations. The primary beam intensities assumed for the accelerators in 1973 were scaled from the present intensities by considering the improvement program plans at each accelerator. The neutrino beam parameters for each accelerator were chosen to optimize the total flux at each accelerator. The muon shield thickness was chosen for each accelerator to range out the highest energy muon possible from the primary proton or electron beam.

In Figure 1 the neutrino flux distributions for perfect focusing are presented for each of the accelerators. The neutrino flux for each accelerator is averaged over a detector of 1.8 meter radius. The pion and kaon yields, momentum distributions and angular distributions used to calculate the neutrino fluxes were determined from the Hagedorn-Ranft[1] model if the primary proton energy is 70 GeV or higher, from the Sanford-Wang formula[2] if the primary proton energy is below 70 GeV and from the experimental data[3] for the SLAC electron accelerator.

In Figure 2 the total neutrino event rate expected on hydrogen at each accelerator is presented as a function of neutrino energy. The detectors assumed are the largest bubble chambers that could possibly exist at the accelerators by mid 1973. Serpukhov and CERN will probably use heavy liquid bubble chambers which operate with propane (C_3H_8). However, in the comparison in Figure 2, only the event rate on free protons is considered. The 14' bubble chamber was assumed to exist at NAL, however, the rate in the 25' bubble chamber is given for comparison. The total neutrino interaction cross-section of

$$\sigma = 0.6\ E_\nu \times 10^{-38}\ cm^2/\nu\text{-proton}$$

where E_ν is the neutrino energy in GeV was used even though this could saturate somewhere above 10 GeV neutrino energy. The neutrino event rates were calculated using the neutrino fluxes for perfect focusing, a focusing efficiency of 70% and a target efficiency of 70%. The values of the fiducial volumes of the bubble chambers and the beam intensities of the various accelerators are somewhat a matter of personal subjective judgment and will, therefore, be a point of discussion for some readers. To the first order the reader can modify any of the curves on Figure 2 by scaling linearity with the product of the primary beam intensity and the fiducial volume.

From Figure 2 we can observe that:

1. Excluding NAL, Serpukhov has a superior neutrino event rate over the other accelerators for $E_\nu \geq 3.0$ GeV.
2. The advantage in event rate of NAL over BNL with both operating at 30 GeV comes only from the relative proton intensities and relative detector volumes at the two accelerators.
3. At 4 GeV the NAL event rate in the 100 GeV beam is about eight times higher than the Serpukhov event rate.
4. The ratio of event rates in the 200 GeV beam of the 25-foot bubble chamber to the 14-foot bubble chamber is about two.
5. The ratio of event rates in the 30 GeV beam of the 25-foot bubble chamber to the 14-foot bubble chamber is about 2.

In comparing the neutrino event rates of the 25-foot and 14-foot bubble chambers it should be remembered that track sensitive internal targets would be used for many experiments[4,5]. For experiments using such internal targets, the ratio of usable events from the two bubble chambers would be substantially different[6] from what is indicated on Figure 2 because of the enhanced detection efficienty of the larger bubble chamber.

REFERENCES

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FIGURE CAPTIONS

1. Estimated neutrino fluxes at the large accelerators in 1973. The flux is calculated for perfect focusing and averaged over a 1.8 meters radius detector

2. Estimated total nuetrino event rates on hydrogen at the large accelerators in 1973 assuming the cross-section $\sigma = 0.6\ E_{\nu} \times 10^{-38} cm^2$. The neutrino fluxes were obtained from perfect focusing by using a focusing efficiency of 70% and a target efficiency of 70%.

TABLE I

Neutrino Beam Parameters

	NAL			Serpukhov	BNL	CERN	SLAC	ZGS
Energy (GeV)	200	100	30	70	30	25	18	12
Beam Intensity at Present (10^{12} protons/sec.)	-	-	-	0.2	1.5	0.7	10^{14} e⁻/sec.	1.3
Beam Intensity in 1973 (10^{12} protons/sec.)	15	26	44	10	20	6	10^{14} e⁻/sec.	10
Decay Distance (m)	600	350	62	150	62	72	70	33
Shielding Length (m)	150	70	30	50	30	23	20	9
Tunnel Radius (m)	0.75	0.75	1.20	1.0	1.20	1.8	1.8	1.6
Recess (m)	22.5	22.5	5.4	5.0	5.4	1.5	1.5	4.2
Particle Production Model	Hagedorn-Ranft		Sanford-Wang	Hagedorn-Ranft	Sanford-Wang	Sanford-Wang	Experimental data	Sanford-Wang
Maximum Angle acceptance by focusing element	3.4°	6.9°	17.2°	11.5°	17.2°	20°	20°	30°
Accepted pion multiplicity	1.8	1.7	1.2	1.8	1.2	0.92		0.54
Accepted Kaon multiplicity	0.37	0.27	0.14	0.24	0.14	0.10		0.051
Bubble chamber	25'	14'		SKAT (heavy liquid)	14'	Gargamelle heavy liquid	12'	12'
Radius (m)	1.8	1.4		0.6	1.4	0.9	1.5	1.5
Visible Volume (m^3)	70	24		4	24	10	20	20
Length	7	4		4	4	3.9	2.8	2.8

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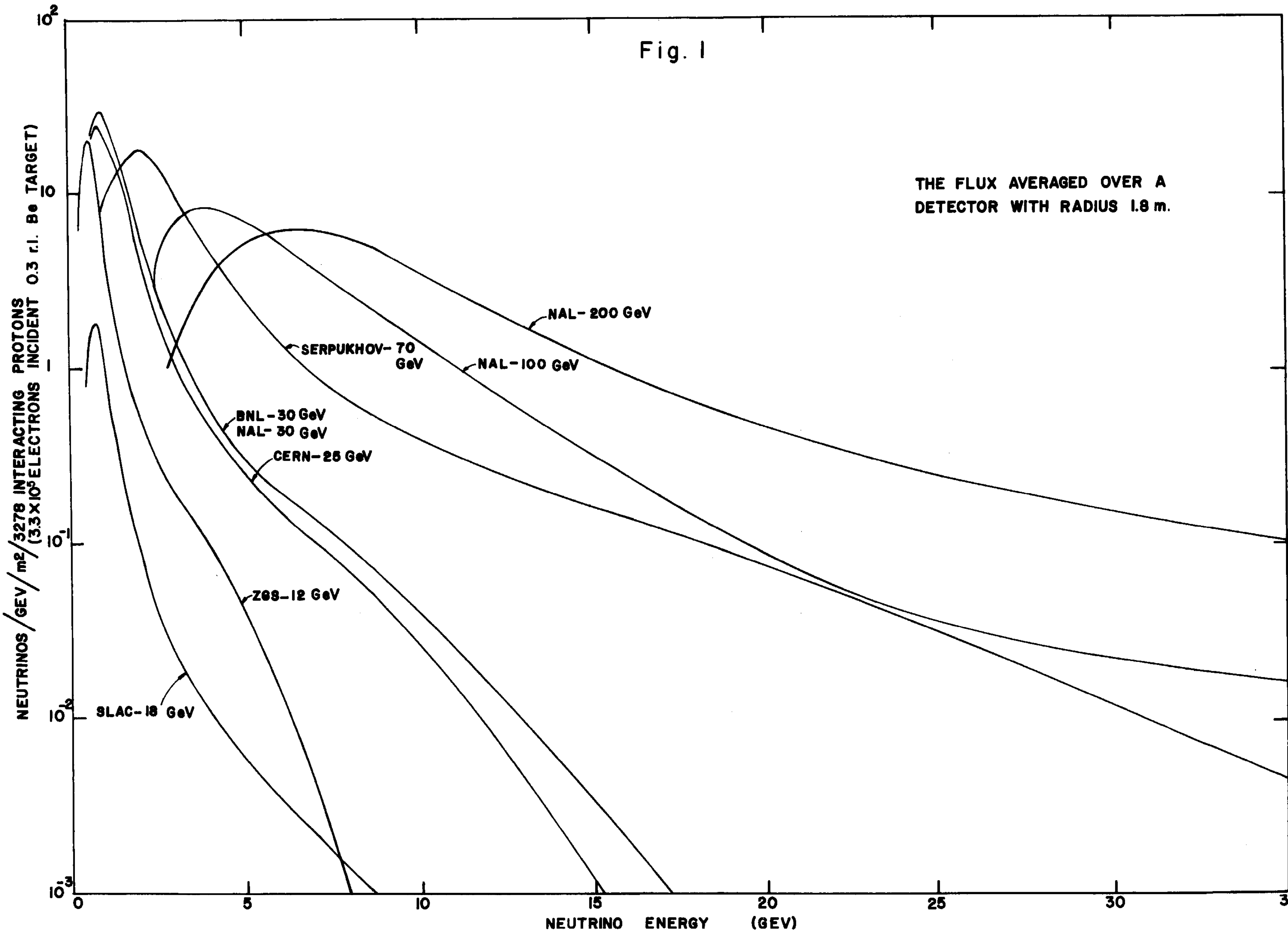

Fig. 1

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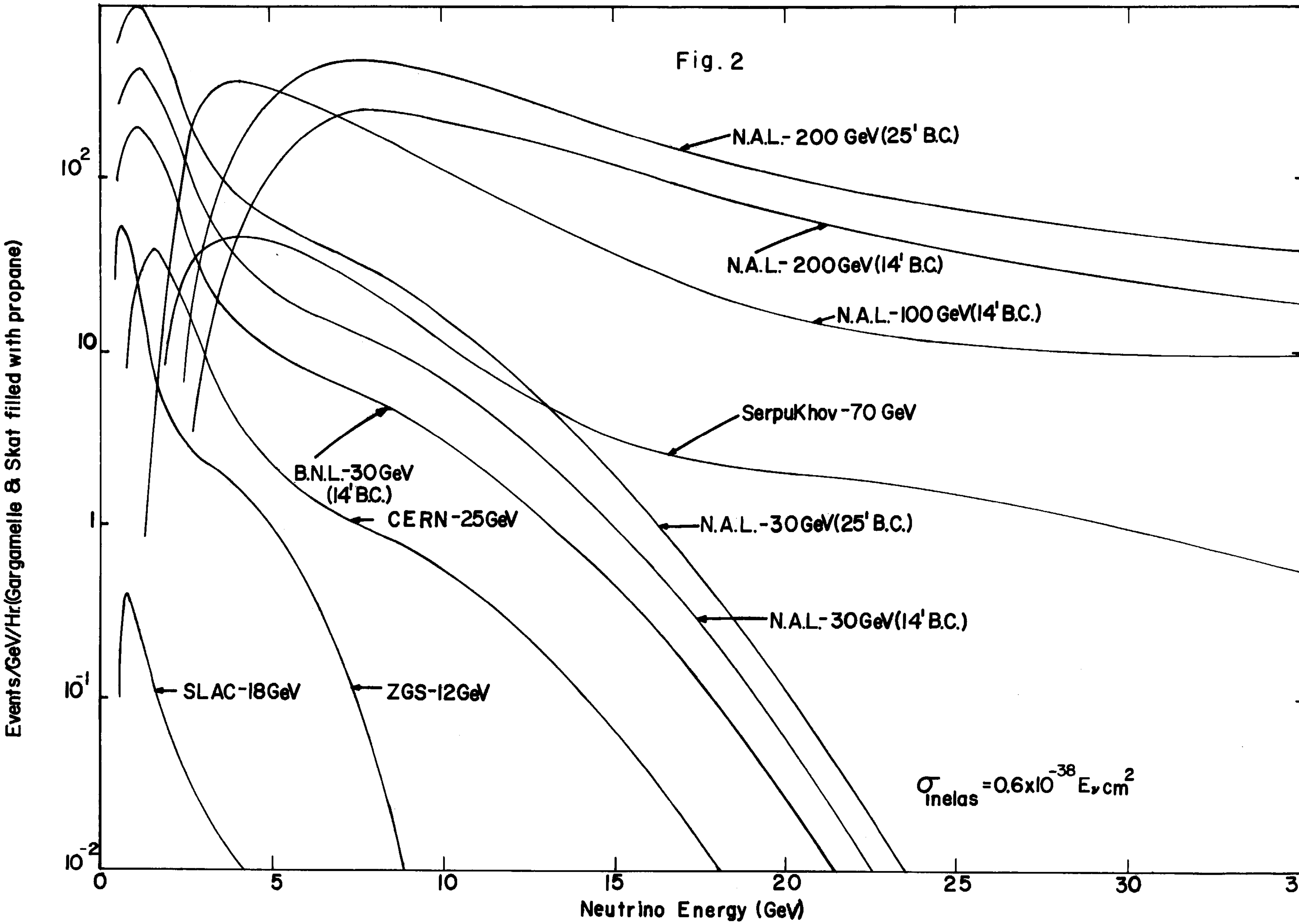
Fig. 2
N.A.L.- 200 GeV(25' B.C.)
N.A.L.- 200GeV(14' B.C.)
N.A.L.-100 GeV(14' B.C.)
Serpukhov -70 GeV
B.N.L.-30GeV
(14' B.C.)
CERN -25GeV
N.A.L.-30GeV(25' B.C.)
N.A.L.-30GeV(14' B.C.)
SLAC-18GeV
ZGS-12GeV
$\sigma_{inelas} = 0.6 \times 10^{-38} E_\nu cm^2$
Events/GeV/Hr.(Gargamelle & Skat filled with propane)
Neutrino Energy (GeV)
10^2
10
1
10^{-1}
10^{-2}
0
5
10
15
20
25
30
35