national accelerator laboratory

TM-299
2251.111

# THE NAL BOOSTER AS A NEUTRINO SOURCE

Y. Kang and F. A. Nezrick

April 28, 1971

Neutrino spectra have been calculated for "optimal" 8-GeV, and 10-GeV neutrino beams using the NAL booster. For comparison, neutrino spectra and event rates are presented for neutrino beams at ANL, BNL and NAL.

The NAL booster beam intensity is taken as 3.5 x $10^{12}$ protons/pulse. Assuming the worse case, the booster is available for secondary beams for 2 sec. out of every 3 sec. at 200 GeV operation, giving a minimum average beam intensity of 3.5 x $10^{13}$ protons/sec.

The parameters for the 8-GeV and 10-GeV neutrino beams are given in the accompanying table. The 8-GeV neutrino beam is composed of a 22 m long decay region of 1.7 m radius and an iron shield length of 6 m. The total beam length is 28 m. The total 10-BeV beam length is 35 m. The parameters of the ANL 12-GeV, BNL 30-GeV and NAL 200-500 GeV neutrino beams are also given on the table together with a description of their accompanying

Operated by Universities Research Association Inc. Under Contract with the United States Atomic Energy Commission

bubble chambers. The distributions of neutrino flux passing through the bubble chambers which "exist" at the various accelerators (7' at BNL, 12' at ANL, "12' at NAL" and 15' at NAL) for the different beams are presented on Fig. 1. Since the ANL and BNL accelerators will undergo substantial flux improvements during the next two years, we have presented both their present neutrino spectra (solid lines) and their expected spectra in 1973 (dashed lines) when the improvements are completed. The ANL 12-GeV neutrino beam, the BNL 30-GeV neutrino beam and the NAL 200-GeV beam already "exist". The neutrino spectra are given for perfect focusing.

The neutrino event rates expected in the hydrogen bubble chambers for the different beams (using 50% of perfect focusing) is given in the table and in parenthesis on Fig. 1. The NAL 8-GeV beam could clearly overshadow the present ANL and BNL beams below about 1.5 GeV. After the improvement programs are completed, the 8-GeV beam and the BNL beam dominate in nearly mutually exclusive energy regions below and above about 0.8 GeV. The 8-GeV beam and the ANL beam cover essentially the same energy region with the 8-GeV beam being 4 (17) times more intense than the ANL improved (present) beam. If the NAL 30" bubble chamber were used in the NAL 8-GeV beam instead of a chamber of the ANL 12' bubble chamber dimensions, then the event rate would be reduced by a factor of 100, giving about one event per hour. To take full advantage

of the NAL Booster neutrino beam flux, the detector must be able to pulse at a rate of 15 cycles per second.

A special neutrino beam could be built at BNL to cover the neutrino energy region from 0.2 GeV to 1.0 GeV. The BNL-AGS transition energy is about 8 GeV, therefore, 10 GeV is about the lowest energy proton beam that could be extracted. An optimal 10-GeV beam has the parameters given in the table. A comparison of the event rates expected in the 10-GeV BNL beam using the 7' bubble chamber and the 10-GeV NAL beam using the 12' bubble chamber is given on Fig. 2. The NAL configuration has superior event rate by a factor of 1.7. Comparing the parameters given in the table for the two beams, it is seen that at 10 GeV the BNL proton intensity is greater by 22% but their detector volume is smaller by a factor of 3, which results in their inferior event rate. In the past three years much discussion has centered around the expansion of the 7' bubble chamber. If, for example, the BNL 7' bubble chamber were expanded to a detector with a fiducial volume of 11 $m^3$ then the BNL and NAL configurations would have the same event rate at 10 GeV. It should be remembered even if the BNL and NAL event rates were the same, the NAL bubble chamber would consume ten times more film since our event rate (per picture) is ten times less.

NEUTRINO BEAM PARAMETERS

| | NAL | | | | BNL | | ANL-ZGS |
|---|---|---|---|---|---|---|---|
| Energy (GeV) | 8 | 10 | 100 | 200 | 30 | 10 | 12 |
| Beam Intensity ($\times 10^{12}$ p/sec) | | | | | | | |
| 1971 | | | | | 2.0 | 4.3 | 1.2 |
| NAL Design | 35 | 35 | 26 | 15 | | | |
| 1973 | | | | | 20 | 42.6 | 5 |
| Decay Length (m) | 22 | 27.5 | 350 | 400 | 62 | 27.5 | 33 |
| Shield Length (m) | 6 | 7.5 | 70 | 1000 | 30 | 7.5 | 9 |
| Shield Material | Iron | Iron | Iron | Earth | Iron | Iron | Iron |
| Decay Tunnel Radius (m) | 1.7 | 1.7 | 0.75 | 0.46 | 1.2 | 1.7 | 1.6 |
| Particle Prod. Model | Sanford Wang | S-W | Hagedorn Ranft | H-R | S-W | S-W | S-W |
| Detector-Bubble Chamber | 12' | 12' | 15' | 15' | 7' | 7' | 12' |
| Fid. Volume ($m^3$) | 20 | 20 | 24 | 24 | 6.5 | 6.5 | 20 |
| Event Rate on $H_2$ (events/hr) | | | | | | | |
| 1971 | | | | | 10 | 7.5 | 5 |
| NAL Design Int. | 85 | 130 | 1400 | 370 | | | |
| 1973 | | | | | 100 | 75 | 20 |
| $< E_\nu >$ (GeV) | 0.5 | 0.6 | 3. | 8. | 0.9 | 0.6 | 0.6 |

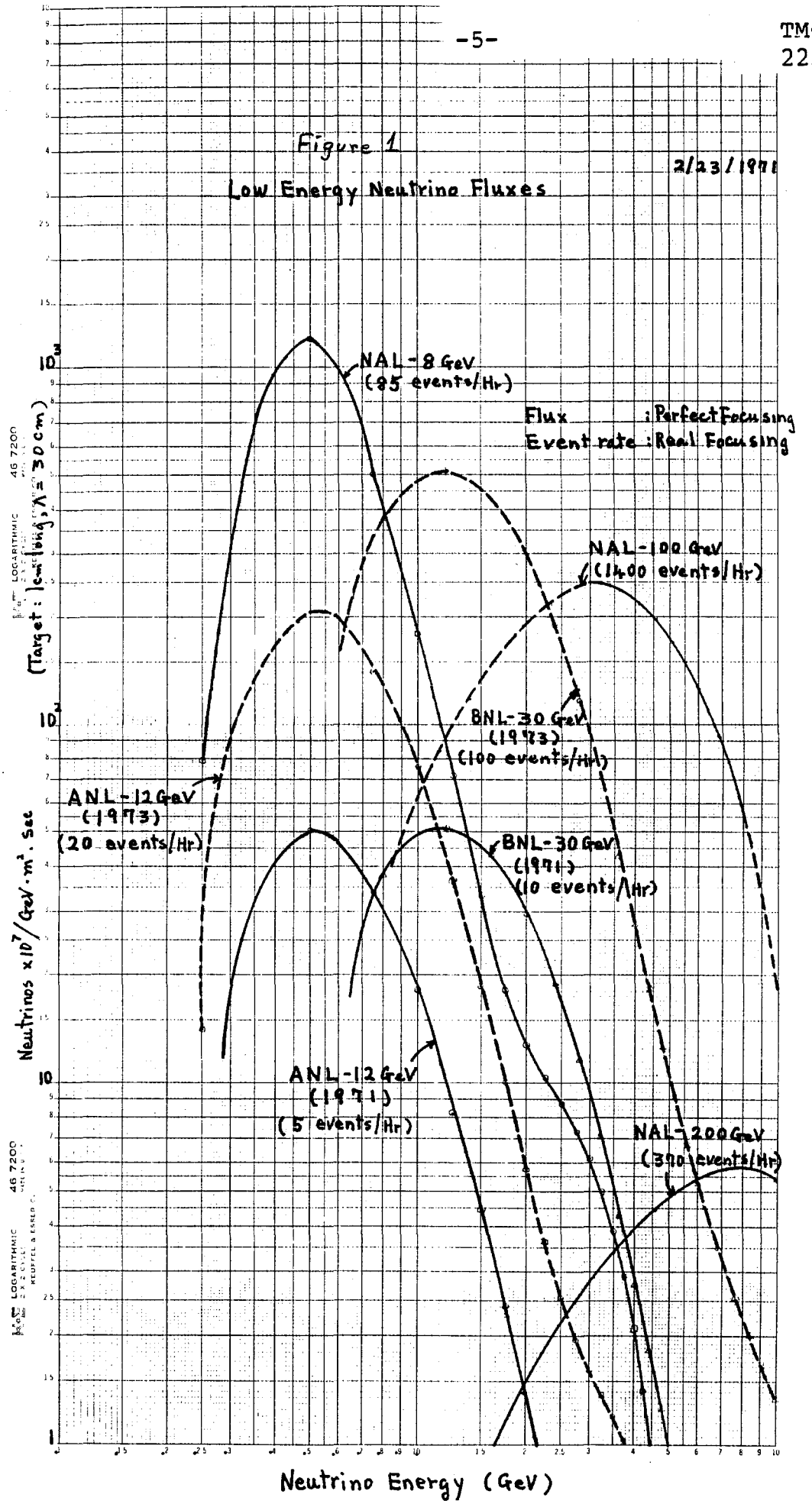
Figure 1
Low Energy Neutrino Fluxes
2/23/1971
NAL-8 GeV
(85 events/Hr)
Flux : Perfect Focusing
Event rate : Real Focusing
NAL-100 GeV
(1400 events/Hr)
BNL-30 GeV
(1973)
(100 events/Hr)
ANL-12 GeV
(1973)
(20 events/Hr)
BNL-30 GeV
(1971)
(10 events/Hr)
ANL-12 GeV
(1971)
(5 events/Hr)
NAL-200 GeV
(370 events/Hr)
Neutrinos x10^7/GeV·m^2·sec
(Target: 1cm long, λ = 30 cm)
Neutrino Energy (GeV)

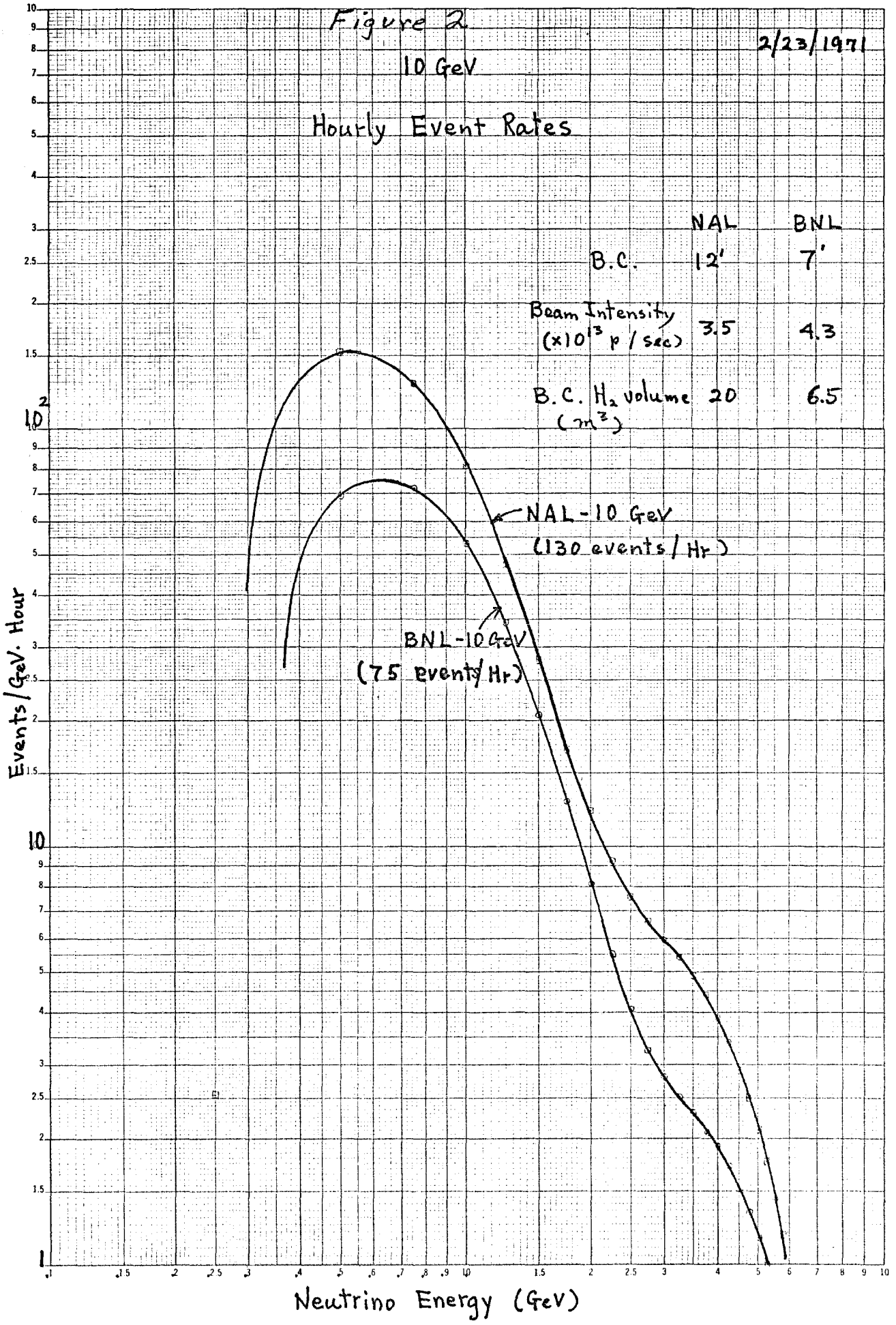
Figure 2
2/23/1971
10 GeV
Hourly Event Rates
NAL
BNL
B.C.
12'
7'
Beam Intensity
(x10^13 p / sec)
3.5
4.3
B.C. H2 volume
(m^3)
20
6.5
NAL-10 GeV
(130 events / Hr)
BNL-10 GeV
(75 events/Hr)
Events / GeV. Hour
Neutrino Energy (GeV)