Fermilab

TM-804
2960

500 GEV CALIBRATION BEAM USING THE N5 LINE AND THE NEW MUON LINE (N2)

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General Idea

When the NØ line is modified for 1000 GeV, it is anticipated that the N5 beam will no longer be able to use the N7 line for its source of protons. This results from the desire to use only conventional magnets in Neuhall, to make the Muhall/Neuhall split instead of the N7/NØ split, and to place additional shielding in Enclosure 100 thereby hardening the berm for 1000 GeV operation[1,2,3]. Since Neutrino experiments will require a calibration beam, a preliminary study has been made to target a small amount of beam in the N2 beamline and to transport it to the present Enclosure 1Ø9. The magnets in Enclosure 1Ø9 are positioned so that beam can be sent to either Lab E, the 15 ft. Bubble Chamber, or to Lab C through the newly constructed calibration beam between Enclosure 1Ø9 and Lab C. In going from the N2 line to Enclosure 1Ø9, the main fact to be faced is that ~ 75 mrad of horizontal bend is required, no matter what path is chosen. The major intent of this study is to investigate various beams that would yield calibration particles at a minimum of cost. Therefore, no attempt has been made to split the primary proton beam going to Muhall to obtain 0^o production. Equipment and additional enclosures necessary for splitting as well as providing a focus on the target were given up in favor of a simpler, less costly system. The beam will not have its own primary proton beam, but will take its production from a thin transmission target (few percent) placed in the beam going to Muhall. This immediately means a large spot size on the target, however, the final spot size is not crucial for the purpose of neutrino detector calibration. The beamline uses existing magnets in the N5 line and requires in addition three large aperature bends or three 6-3-120[4] magnets for 500 GeV operation.

Options

For completeness, the various options studied are shown schematically in figures 1 and 2. Beams A and C use a thin target positioned at the downstream end of Muhall and Enclosure Q3 of the Muon Beam is enlarged slightly. Beam A is directed to Enclosure 1Ø9 with no elements or enclosures between Q3 and 1Ø9. Beam C adds two enclosures for beam monitoring and momentum recombination. Beyond ~ 150 GeV/c both of these beams require a substantial addition to Enclosure Q3 to accommodate additional bending magnets. Beam D has the major bends inside Muhall so a momentum of 500 GeV/c can be achieved without increasing the cost. For this reason, most of the effort and results are given for Beam D.

Beam D has one additional enclosure between Muhall and Enclosure 1Ø9 for beam monitoring and momentum recombination.

The N2 beam is below ground and about 12 feet below the N5 beam. It is therefore natural to take vertical production off the target. Figure 3 shows the relative flux gains in choosing various production angles. The production angle is changed by moving the target position, keeping the rest of the beamline fixed in Ƶ. As the target is brought closer the production angle decreases while the solid angle increases; figure 3 shows the trade off between production and solid angle. Without using special magnets, the placement of enclosures and magnets in the proton transport to Muhall is such that the smallest obtainable production angle is ~ 1.5 mrad. An angle of ~ 4.3 mrad is a special case where no vertical bends are necessary upstream of Enclosure 1Ø9 to accomplish the 12 foot increase in elevation between the N2 and N5 beamlines.

Results

Using figure 3 as a guide, a reasonable choice of production angle is ~ 2 mard. For this angle choice, the number of secondary particles per 10^{11} interacting protons is given in figure 4. The flux was obtained using the Stefanski-White[5] pion production spectrum for 1000 GeV incident protons and the ray tracing program DECAY TURTLE[6]. A list of beamline elements and their locations are given in Table I using standard DUSAF coordinates minus 100,000. The Ƶ coordinate is the downstream end of each listed element. (The Y coordinate has not been corrected for the earth's curvature which ranges from 0 to 1 inch in the proposed beam.)

REFERENCES

1. EVANS, R. et. al., "Design Study for a High Energy Muon Beam", Fermilab Internal Report, TM-754, November 1977.

2. EVANS, R. and KIRK, T., "Transport of Tevatron Energy Primary Proton Beams to the Neutrino Area", Fermilab Internal Report, TM-796, May 26, 1978.

3. MORI, S., "Muon Shield for the Tevatron at Fermilab", Fermilab Internal Report, TM-790, May 17, 1978.

4. The required full-aperature is 3 inches horizontally by 2 inches vertically with the magnetic field across the 3 inch gap. Depending on the details of the fabrication either several could be made or if this proved to be too costly, an existing magnet, the 6-3-120 could be used.

5. STEFANSKI, R.J. and WHITE, H.B., "Neutrino Flux Distributions", Fermilab Internal Report, FN-292, May 10, 1976.

6. BROWN, K.L. and ISELIN, C., "DECAY TURTLE" - a computer program for simulating charged particle beam transport systems, including decay calculations, CERN Internal Report, CERN 74-2, February 5, 1974.

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ENGINEERING NOTE

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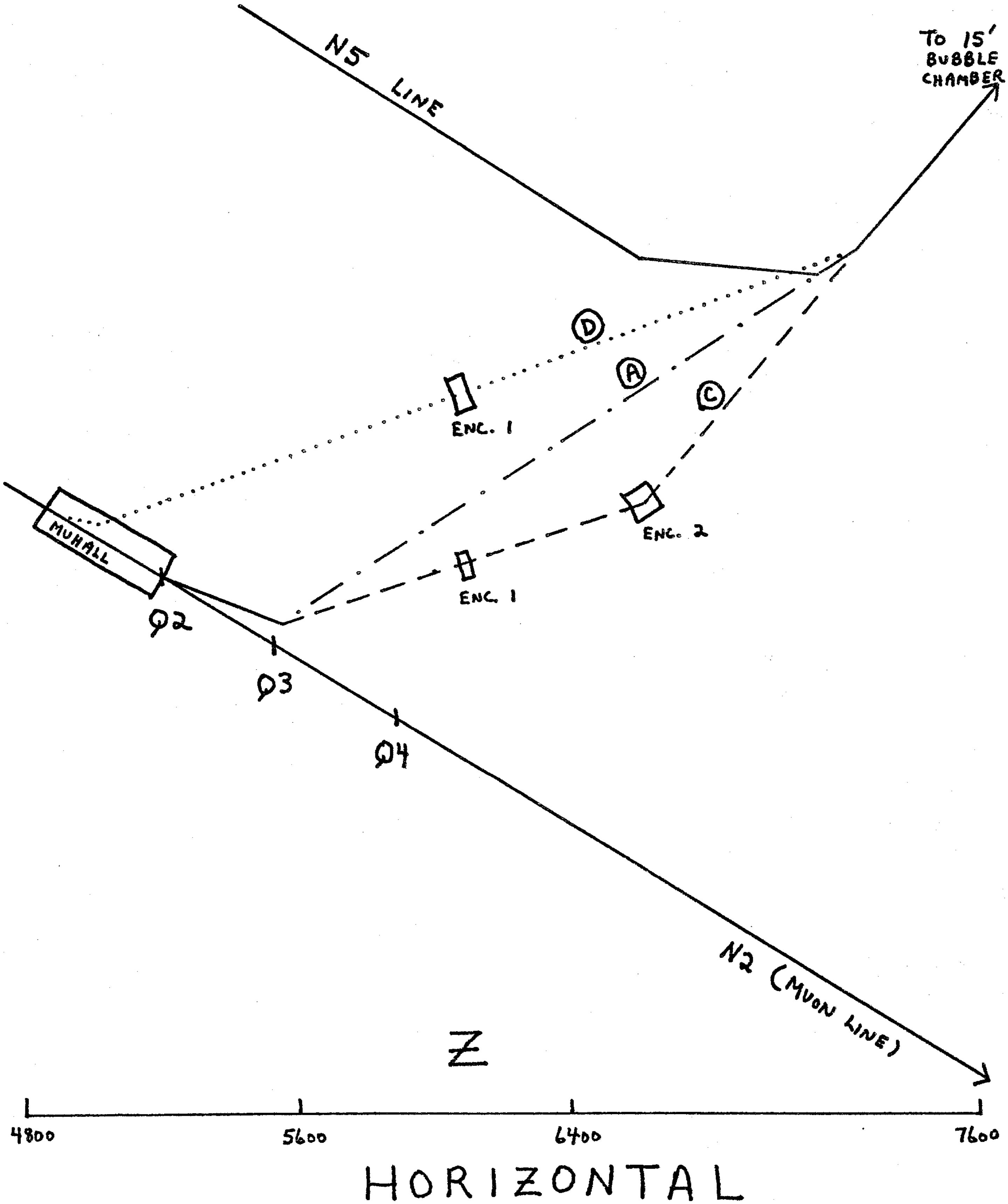
Figure 1	Page 4		



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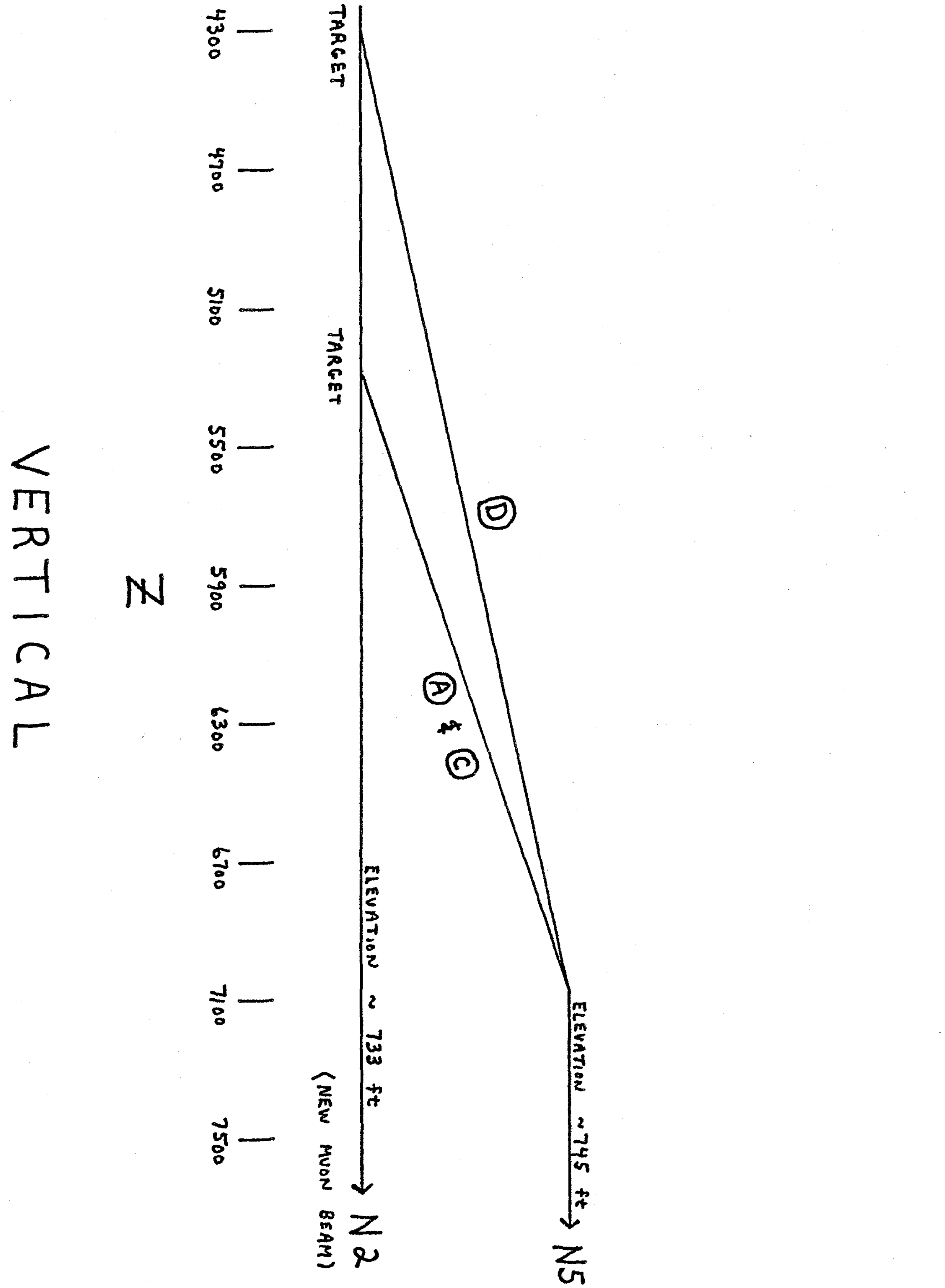

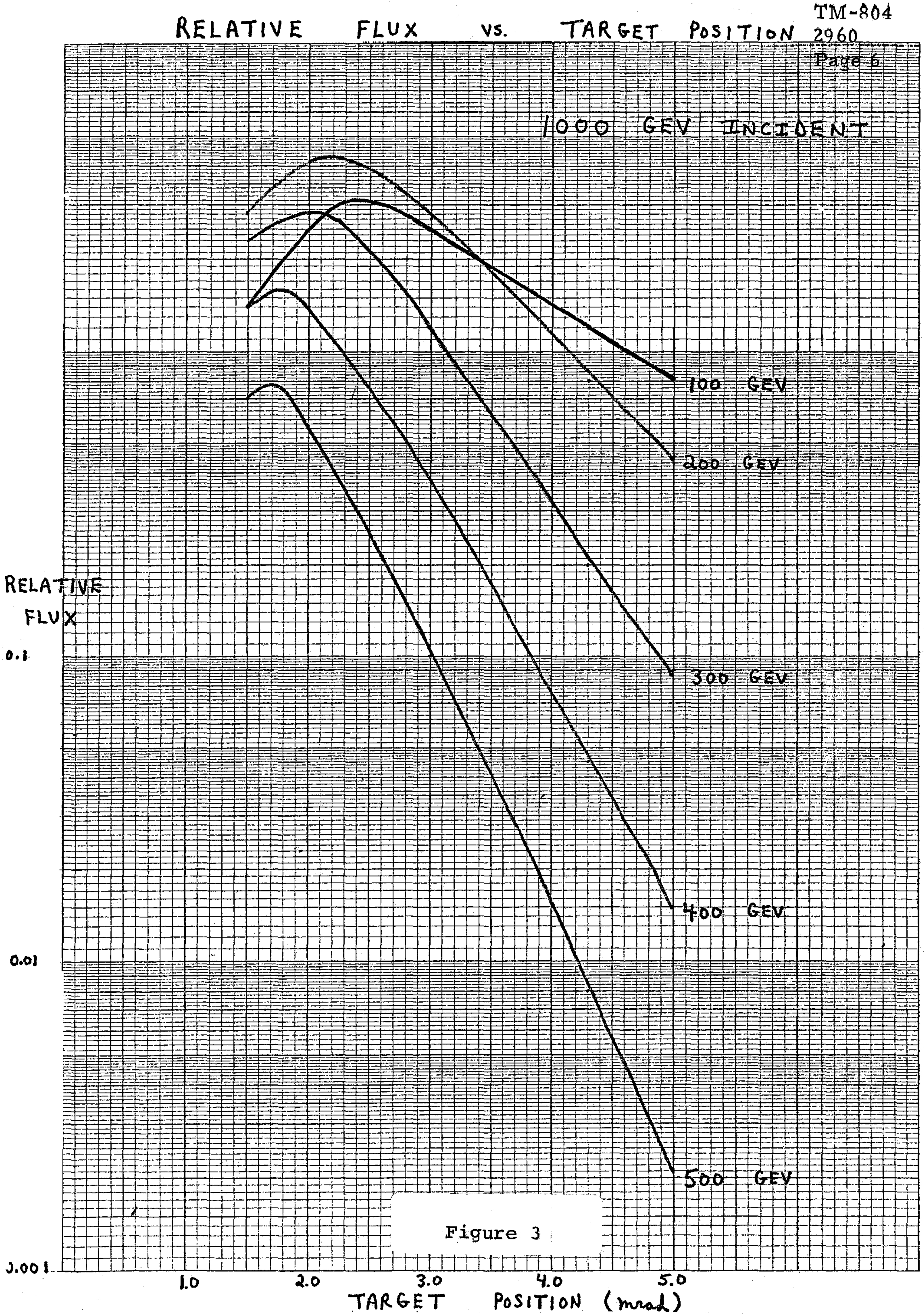
RELATIVE FLUX VS. TARGET POSITION
1000 GEV INCIDENT
RELATIVE FLUX
0.1
0.01
0.001
100 GEV
200 GEV
300 GEV
400 GEV
500 GEV
1.0
2.0
3.0
4.0
5.0
TARGET POSITION (mrad)

Figure 3

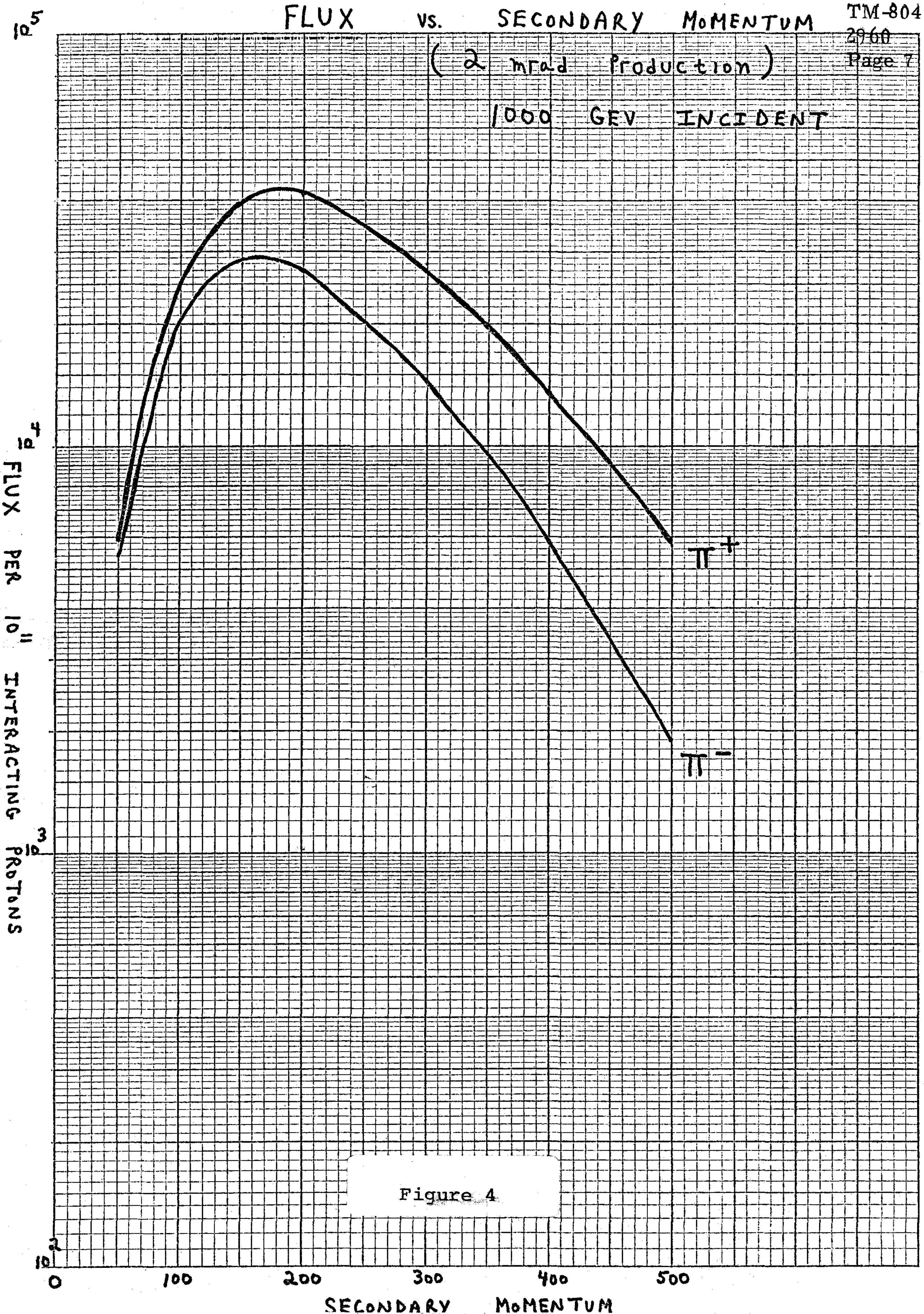
FLUX VS. SECONDARY MOMENTUM
(2 mrad Production)
1000 GEV INCIDENT
10^5
10^4
10^3
10^2
FLUX PER 10^{11} INTERACTING PROTONS
0
100
200
300
400
500
SECONDARY MOMENTUM
π^+
π^-

Figure 4

TABLE I

(DOWNSTREAM COORDIANTES OF THE ELEMENTS)

X	Y	Z	KG/IN OR KG	ELEMENT
-51.26	733.00	4022.00		TARGET
-65.15	733.93	4486.79	3.38958	QUAD(3Q84)
-68.14	734.13	4586.75	-2.78468	QUAD(3Q84)
-77.07	734.73	4885.61	-2.08602	QUAD(3Q84)
-77.65	734.77	4907.10	16.28770	H BEND (B2)
-78.10	734.81	4928.60	16.28770	H BEND (B2)
-78.43	734.86	4950.10	16.28770	H BEND (B2)
-78.63	734.90	4971.60	16.28770	H BEND (B2)
-78.68	734.92	4980.10	2.28692	QUAD(3Q84)
-78.75	734.96	5001.60	16.28770	H BEND (B2)
-78.69	735.00	5023.10	16.28770	H BEND (B1)
-78.51	735.05	5044.59	16.28770	H BEND (B1)
-78.19	735.09	5066.09	16.28770	H BEND (B1)
-77.98	735.13	5078.09	16.02403	V BEND(SEE REF 4)
-62.64	739.39	5942.28	1.20579	QUAD(3Q84)
-42.42	744.98	7080.75	13.47162	V BEND(SEE REF 4)
-42.21	745.00	7092.75	13.47162	V BEND(SEE REF. 4)
-42.06	745.00	7101.25	-3.43681	QUAD(3Q84)
-41.62	745.00	7122.74	15.38216	H BEND (B2)
-40.40	745.00	7174.73	3.53456	QUAD(3Q84)
-39.36	745.00	7217.22	15.38216	H BEND (B1)
-38.68	745.00	7238.70	15.38216	H BEND (B1)
-37.86	745.00	7260.69	15.38216	H BEND (B1)
-36.94	745.00	7282.17	15.38216	H BEND (B1)
-0.67	745.00	8072.00		15 FT B.C.