NAL PROPOSAL No. 129

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FTS/Commercial 608 - 262-2282

AN INVESTIGATION OF THE COMPONENTS OF THE NEUTRAL BEAM PRODUCED BY HIGH ENERGY PROTONS AT NAL USING THE 30" BUBBLE CHAMBER

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April 1971

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ABSTRACT

We wish to search for new neutral particles by investigating the composition of a wide angle neutral beam produced by high energy protons on a Be target. Photons in the beam will be removed by a Pb converter. The resultant neutral beam will be incident on the 30" bubble chamber. The composition of the beam will be determined from the kinematic analysis of selected interactions in the bubble chamber, through the decays of neutral particles and through possible anomalies in the hydrogen interactions. As a byproduct we will measure the K_L° flux through the process $K_L^\circ + P \rightarrow K_S^\circ$ + all. By a slight change in the geometry we can look at a region immediately downstream of the target and measure the characteristics of neutral particles arising from the decay of hyperons and other particles produced in the Be target. We do not require any external equipment besides beam monitoring equipment. We request an initial exposure of 20,000 pictures.

One of the most exciting possibilities for discovery opened up by the high energy proton beam at NAL is the possibility of new particles production. Many experiments have already been proposed to search for new charged particles (quarks, W mesons, etc.). We wish to search for the production of new neutral particles. A new particle can be isolated in one of three ways

1. Measure the charge and mass with various spectrometers.
2. Decays into simple final states and kinematic fitting to determine the neutral particle mass.
3. Through the characteristics and kinematics of the interactions with protons.

Method 1 is clearly not useful for neutral particles. Method 2 was extraordinarily useful in establishing the low mass hyperons and K° mesons. However, for high mass objects multiparticle decay might make it difficult to separate these objects from K° or hyperon decays. Method three is perhaps the most promising provided that (a) the neutral particles interact with similar cross sections to neutrons and K° mesons, (b) the new neutral particles interact producing characteristically different final states or producing low multiplicity final states allowing a kinematic fit to deduce the neutral particle mass. For methods 2 and 3 the bubble chamber is very well suited and 3 requires a hydrogen bubble chamber. If new neutral particles are produced strongly we expect them to interact with approximately the same strength as the strong interactions. The same would be true of neutral quark like objects. The detection of new weakly interacting particles requires massive detectors unless they decay with a lifetime between 10^{-7} - 10^{-6} sec.

There is little theoretical rational for searching for new neutral particles but of course there was also no theoretical reason for searching for Λ hyperons or K° mesons or the neutron for that matter. We note that there have been from time to time some discussion of anamolies in the interaction or production of neutral particles in the cosmic radiation with nuclear emulsions which might be ascribed to new neutral particles.[1,2]

It is therefore our goal to produce a neutral beam at a relatively wide angle (30-100mr) and to expose the 30" hydrogen bubble chamber to this beam. We also wish to later search for backward neutral particle production by placing the target beyond the bubble chamber and causing the proton beam to miss the bubble chamber and strike the target and to search for the decay of neutral particles from high energy hyperon production. This may provide a source of polarized neutrons and $\bar{n}$'s from Λ and $\bar{\Lambda}$ decays.

Specifically we propose to study the neutral beam produced at relatively wide angles. If we assume that all particles are produced with a mean transverse momentum of ∿ .3 GeV/c then the particles produced in the angular range of 30-100mr will have mean momenta of 3-10 GeV/c. These particles would likely be produced in the backward cone of the pp interaction. Because of the symmetry of pp collisions any new particles that are produced in pp collisions will show up both in the forward and backward cone. It is intrinsically easier to study a relatively low energy neutral beam for several reasons

1. The interactions of the beam particles produce fewer neutrals and therefore a larger fraction of the interactions can be completely kinematically analyzed to determine the mass of the incident particle.

2. The 30" bubble chamber is well suited to the complete analysis of interactions in the multi GeV range (and not in the higher energy region).

3. Two or three body cross sections in this momentum range are still relatively large and easily analyzed kinematically.

We expect that most interactions observed in the bubble chamber will come from the K_L^o mesons and neutrons in the beam. However, only a fraction of the K_L^o interactions will be easily identified by the production of hyperons or K_S^o mesons through the processes

$$K_L^o + p \rightarrow \Lambda + \text{charged particles}$$

$$K_L^o + p \rightarrow K_S^o + \text{anything}$$

The cross section for this process in the 1-10 GeV range is presently being measured at SLAC. With a known cross section we will be able to measure the mean K_L^o flux for various production angles. A fraction of these events can be completely analyzed giving the K_L^o momentum spectrum also.

At the widest angles it should be possible to statistically separate $\bar{n}$ interactions from n and K_L^o interactions due to the large energy release in the annihilation process leading to a high multiplicity of mesons.

The detection of a new neutral particle through its interaction might be accomplished by the following type of interaction (for an X^o boson)

$$X^o + p \rightarrow \text{(slow proton)} + \text{charged mesons}$$

or for an X^o baryon

$$X^o + p \rightarrow \text{(two identified protons)} + \text{Mesons}$$

$$\rightarrow \text{(hyperons)} + \text{Mesons}$$

These interactions would be measured and a kinematic fit would be attempted assuming that no neutral particles were produced in the final state and using the direction of flight of the X°. Only events with no missing transverse momenta would be used in the subsequent analysis. The $\Sigma\vec{p}$ of the outgoing particles gives the incident momentum of the X°. The remaining unknown would be the X° mass which can be calculated under these assumptions. By this procedure we would expect to 'discover' the neutron by a peak in the calculated X° mass. For interactions with K°_S mesons or hyperons in the final state we could then 'discover' the K° meson by observing a peak in the fitted mass spectrum. In most cases a poor X^2 would be obtained for the 2c fit to the X° mass and P_{X° unless a particle of mass M_{X° actually produced the collision. Therefore only events with lowX^2 would be used to obtain an X° mass spectrum.

If the X° particle were a new massive antiparticle a large energy release would be observed and this might signature the presence of a new particle. Of course there might be other signatures like copions multiple strange particle production or high strangeness production (like Ω^- or $\bar{\Omega}^-$ production rates that are higher than expected from the measured (in the same experiment)) K°_L flux).

The main point of this proposal is to couple the visual strength of the bubble chamber to exploration of the components of the neutral beam produced by 400-500 GeV protons at wide angles. By using a relatively high intensity proton beam and a complex nuclear target our experiment will be more sensitive to weakly produced or very massive neutral particles than a conventional bubble chamber exposure where the neutral particles are directly produced in the bubble chamber.

Experimental Prodedure

Since the particle beam that enters the bubble chamber must be deflected up into the chamber it will be necessary to provide a pitching magnet for the 30" bubble chamber beam.[3,4] We propose to use this pitching magnet as a sweeping magnet, to remove most of the charged particles that would enter the bubble chamber. The fringe field of the bubble chamber magnet will also help remove charged particles. Fig. 1 shows a schematic layout of the target and the bubble chamber. The proton beam will be 'aimed' below the bubble chamber into a shield to remove the diffraction products.

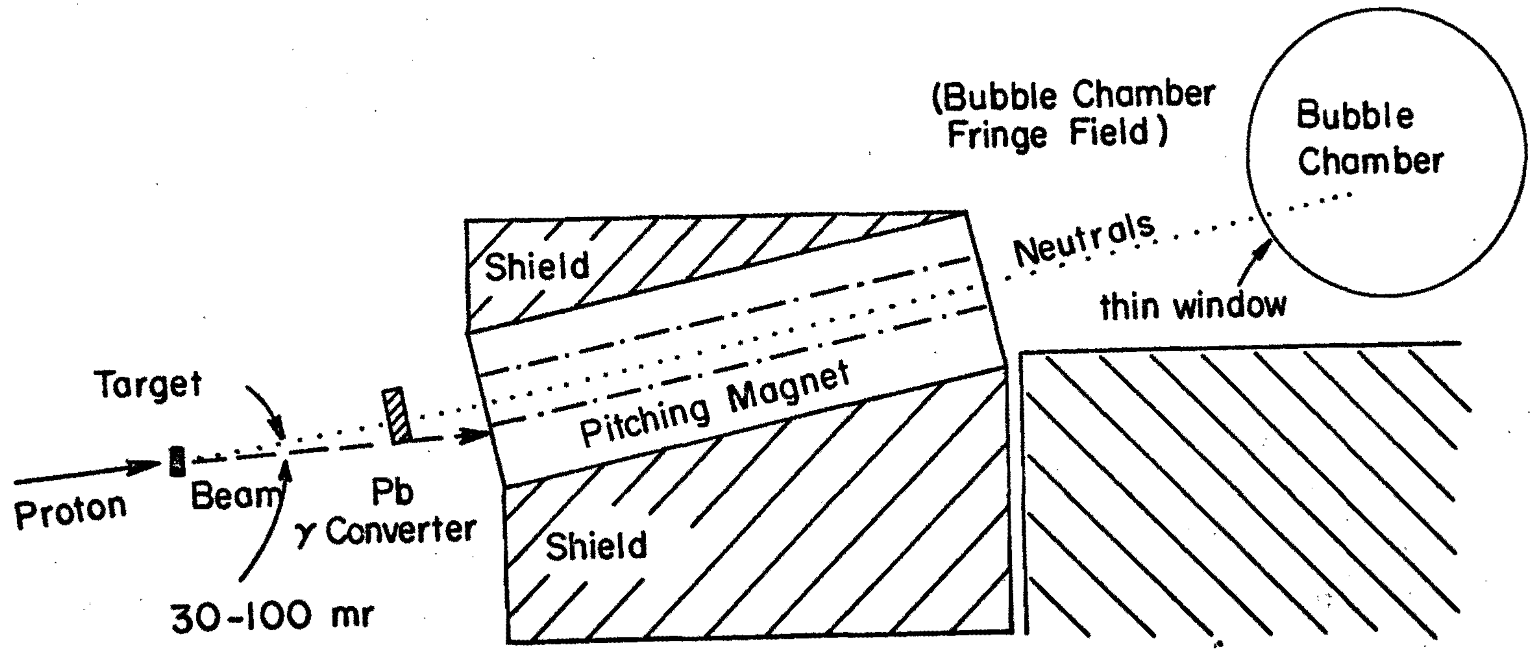
We would like a proton beam intensity of $\sim 10^4 - 10^6$/pulse hitting our target at the highest available energy. The highest beam intensity usuable in this experiment depends on the background of charged particles entering the bubble chamber. In the early stage of the experiment the beam intensity would be optimized. We request an initial shakedown run of $\sim$ 20,000 pictures, with a month interval to scan these pictures and to do the early kinematic analysis. At the end of this period we will be prepared to submit a progress report and to request the number of expansions needed to carry out a sensitive search for new neutral particles at NAL.

Personnel Working on the Experiment

We expect that one or two more Ph.D.'s will be added to the experiment and several graduate students.

References

1. B. Edwards, J. Lasty, K. Pinkau, D. H. Perkins and J. Reynolds Phil. Mag. 3, 237 (1958) See also, D. H. Perkins, Progress in Elementary Particle and Cosmic Ray Physics, Vol. V, P. 311.
2. P. H. Fowler, 'Two Anomalous Events' CERN Report 61-22, P. 125.
3. J. Lach, private communication. Also J. Lach and S. Pruss, Hadron Beams in the Neutrino Area, TM 285-2254, 1971.
4. T. Toohig, private communication.


(Bubble Chamber
Fringe Field)
Bubble
Chamber
Shield
Neutrals
thin window
Target
Pitching Magnet
Proton
Beam
Pb
γ Converter
Shield
30-100 mr

May 1971

Addendum to proposal #129

Since writing this proposal we have received a preprint from the Tata Institute indicating some evidence for a possible new high mass particle from cosmic rays data.

We quote directly from this paper

> 'These high energy large delay events have also been found to have special interaction characteristics and have been interpreted as possible evidence for the existence of heavy mass particles (mass $\sim$ 10 GeV/c^2) in air showers'

The authors of the report are S. C. Tonwar, S. Naranon and B. V. Sreekonton and the title of the report

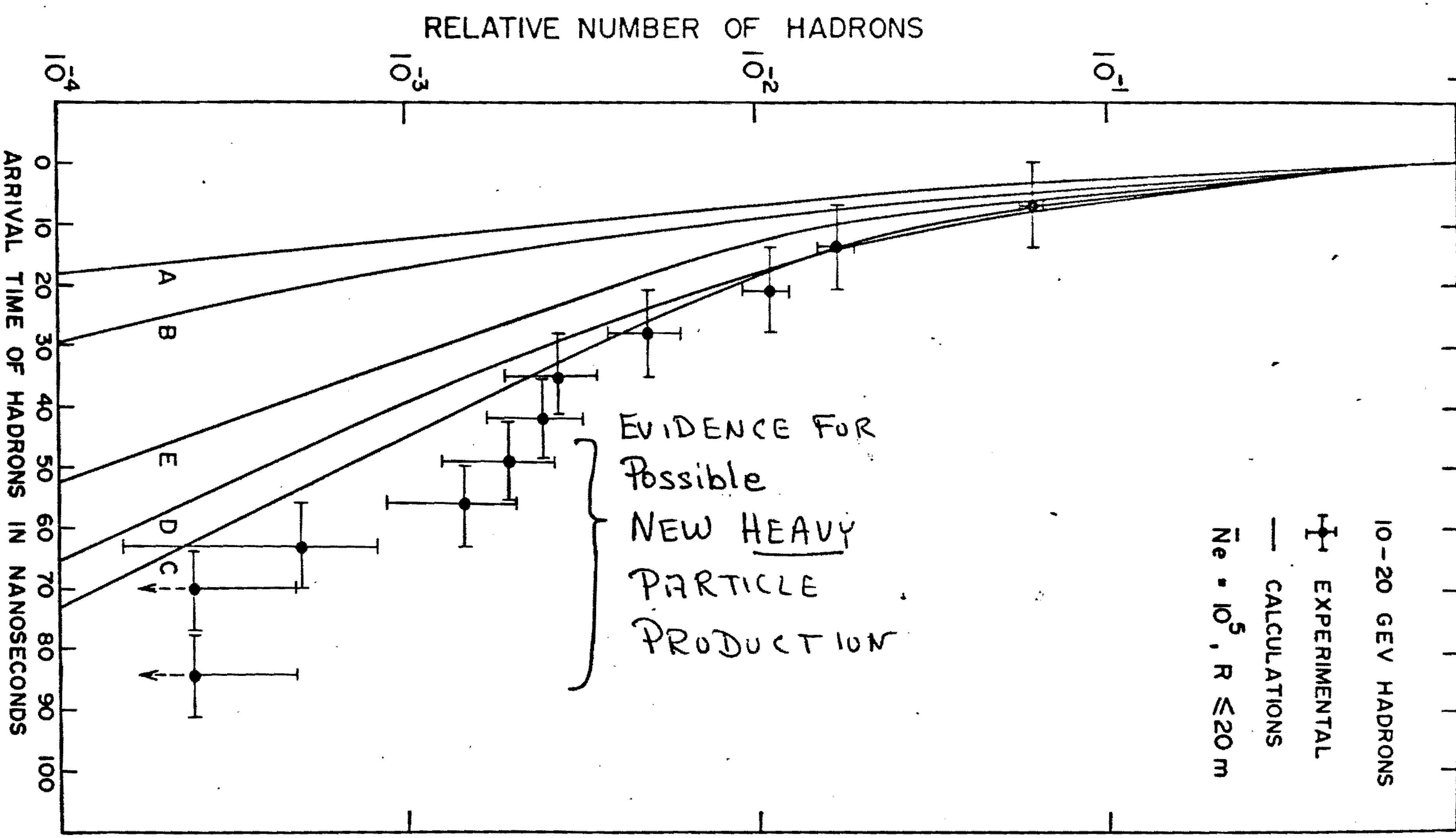
> 'Nucleon-Anti nucleon Production in High Energy ($>10^{12}$ ev) Hadrons Collisions'

We show in Fig. 1 the time delay curve between the arrival of the electronic component of the air shower and a shower hadronic component. The energy of the hadrons is measured in an ionization calorimeter. The difference between curve C and the data in this figure provides the possible evidence for new heavy particles. It is alleged that some of these long delay events have peculiar interaction characteristics. In this same report a measurement of the rate for $\bar{N}N$ production is given. It is shown that the $\bar{N}N$ production cross section rises to 14% the total pp inelastic cross section as compared to $\sim$1% at AGS energies. This increase in cross section would presumably result in a large low energy $\bar{n}$ production rate and would be observable in our experiment.

We consider this report to increase the interest in attempting the physics of proposal #129 and not necessarily as evidence of any new particles. The latter question is the purpose of this experiment.

References

1. S. C. Tonwar, S. Naranon and B. V. Sreekanton, 'Nucleon-Anti - Nucleon Production in High Energy ($>10^{12}$ ev) Hadron Collision, Tate Institute preprint EAS-1 (71).



RELATIVE NUMBER OF HADRONS
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
ARRIVAL TIME OF HADRONS IN NANOSECONDS
0
10
20
30
40
50
60
70
80
90
100
A
B
E
D
C
EVIDENCE FOR Possible NEW HEAVY PARTICLE PRODUCTION
10–20 GEV HADRONS
EXPERIMENTAL
CALCULATIONS
$\bar{N}e = 10^5$, R ≤ 20 m

NAL PROPOSAL No. 129 B

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January 1972

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We propose to study the feasibility of searching for new neutral particles by investigating the composition of a wide angle neutral beam produced by high energy protons on a Be target. Photons in the beam will be removed by a Pb converter. The resultant neutral beam will be incident on the 30" bubble chamber. The composition of the beam will be determined from the kinematic analysis of selected interactions in the bubble chamber, through the decays of neutral particles and through possible anomalies in the hydrogen interactions. As a byproduct we will measure the K_L^o flux through the process $K_L^o + P \rightarrow K_S^o + \text{all}$. An initial exposure of 20,000 pictures will be needed for our purpose.

I. Introduction

One of the most exciting possibilities for discovery opened up by the high energy proton beam at NAL is the possibility of new particles production. Many experiments have already been proposed to search for new charged particles (quarks, W mesons, etc.). We wish to search for the production of new neutral particles through the characteristics and kinematics of their interactions with protons. This will be feasible provided that (a) the neutral particles interact with a cross section within a factor of 10 of the neutrons and K° cross sections, (b) the new neutral particles interact producing characteristically different final states or producing low multiplicity final states allowing a kinematic fit to deduce the neutral particle mass. The bubble chamber is very well suited for the purpose of this search. If new neutral particles are produced strongly we expect them to interact with approximately the same strength as the strong interactions. The same would be true of neutral quark like objects. The detection of new weakly interacting particles requires massive detectors unless they decay with a lifetime between 10^{-7} - 10^{-6} sec.

II. Motivation and Physics

There is little theoretical rationale for searching for new neutral particles but of course there was also no theoretical reason for searching for Λ hyperons or K° mesons or the neutron for that matter. We note that there have been from time to time discussions of anomalies in the interaction or production of neutral particles in the cosmic radiation with nuclear emulsions which might be ascribed to new neutral particles.[1,2] It is therefore our goal to produce a neutral beam at a relatively wide angle (30-100mr) and to expose the 30" hydrogen bubble chamber to this beam.

If we assume that all particles are produced with a mean transverse momentum of ∿ .3 GeV/c then the particles produced in the angular range of 30-100mr will have mean momenta of 3-10 GeV/c. These particles would likely be produced in the backward cone of the pp interaction. Because of the symmetry of pp collisions any new particles that are produced in pp collisions will show up both in the forward and backward cone. Particles may be produced in the 30-100 mr angular range with higher momenta through the decay of heavy particles. It is intrinsically easier to study a relatively low energy neutral beam for several reasons

1. The interactions of the low energy particles produce fewer neutrals and therefore a larger fraction of the interactions can be completely kinematically analyzed to determine the mass of the incident particle.
2. The 30" bubble chamber is well suited to the complete analysis of interactions in the multi GeV range (and not in the higher energy region).
3. Two or three body cross sections in this momentum range are still relatively large and easily analyzed kinematically.

The detection of a new neutral particle through its interaction might be accomplished by observing the following type of interaction (for an X° boson)

$$X^\circ + p \rightarrow \text{(slow proton)} + \text{charged mesons}$$

or for an X° baryon

$$X^\circ + p \rightarrow \text{(two identified protons)} + \text{mesons}$$
$$\rightarrow \text{(hyperons)} + \text{mesons}$$

These interactions would be measured and a kinematic fit would be attempted assuming that no neutral particles were produced in the final state and using the direction of flight of the X°. Only events with no missing transverse momenta would be used in the subsequent analysis. The vector sum of the momenta of the outgoing particles gives the incident momentum of the X°. The remaining unknown would be the X° mass which can be calculated under these assumptions. By this procedure we would expect to 'discover' the neutron by a peak in the calculated X° mass. For interactions with K_S° mesons or hyperons in the final state we could then 'discover' the K° meson by observing a peak in the fitted mass spectrum. In most cases a poor X^2 would be obtained for the 2c fit to the X° mass and P_{X° unless a particle of mass M_{X° actually produced the collision. Therefore only events with low X^2 would be used to obtain an X° mass spectrum.

If the X° particle were a new massive antiparticle a large energy release would be observed and this might signature the presence of a new particle. Of course there might be other signatures like copious multiple strange particle production or high strangeness production (like Ω^- or $\bar{\Omega}^-$ production rates that are higher than expected from the measured (in the same experiment) K_L° flux).

In part of the feasibility test we will also be able to look for the decay of deeply penetrating neutral particles. This can be done by absorbing the strongly interacting particles with three collision lengths of absorber which will be placed in the neutral particle beam.

We expect that most interactions observed in the bubble chamber will come from the K_L° mesons and neutrons in the beam. However, only a fraction of the K_L° interactions will be easily identified by the production of hyperons or K_S° mesons through the processes

$$K_L^\circ + p \rightarrow \Lambda + \text{charged particles}$$

$$K_L^\circ + p \rightarrow K_S^\circ + \text{anything}$$

The cross section for this process in the 1-10 GeV range is presently being measured at SLAC. With a known cross section we will be able to measure the mean K_L^o flux for various production angles. A fraction of these events can be completely analyzed giving the K_L^o momentum spectrum also.

The main point of this proposal is to couple the visual strength of the bubble chamber to exploration of the components of the neutral beam produced by 400-500 GeV protons at wide angles. By using a relatively high intensity proton beam and a complex nuclear target our experiment will be more sensitive to weakly produced or very massive neutral particles than a conventional bubble chamber exposure where the neutral particles are directly produced in the bubble chamber.

Experimental Procedure and Equipment

Figure 1 gives the layout for the experiment. The accelerated proton beam will be bent out of the normal beam line using the last two magnets of the normal beam (Enclosure 114) and will be directed through an evacuated beam pipe to our target. We will use the 30" bubble chamber to detect neutral particles that are produced in this target. Charged particles produced in this target will be swept away from the direction of the 30" bubble chamber by a sweeping magnet. Shielding will be provided to stop transmitted beam particles and particles scattered in directions other than that of the bubble chamber.

For a comprehensive experiment we would want to vary the target position and thereby study neutral particles produced at various angles between 30-100mr. In the feasibility test, however, we will have the target at the position necessary to study neutral particles produced between 55-65mr.

Now we will discuss some particular features of the experimental equipment. We also list the equipment needed and the estimated cost.

Beam

The last two magnets in the normal beam line will be used to direct accelerated protons into our beam pipe. These magnets in their present orientation bend particles in a horizontal plane and could be used as is if we locate our beam pipe in the horizontal plane containing the normal beam pipe. This will necessitate lowering part of the cable tray that now parallels the beam pipe in the horizontal plane.

Alternately we could rotate the last bending magnet 90° and pitch our beam over the cable tray. This would require that our target and magnet be higher off the ground and over the cable tray and it complicates the design of the table to support the target and magnet. Therefore we prefer to have our beam in the horizontal plane.

The beam pipe will be 3" I.D. aluminum pipe. It will be supported on stands similar to that which NAL uses: we will have a wooden tee which is sunk into the ground. On top of the tee will be a metal bar the height of which is adjustable. Figure 2 is a drawing of the proposed stand. We will also provide the vacuum pump for this beam pipe. A window will have to be built in the normal beam line at the position our beam exits the main beam pipe.

Beam Flux

We have used the Trilling formula to estimate the kaon and neutron production spectra where we assume that the kaon production is one tenth of the pion production. Figures 3-8 give the kaon and neutron production spectra expected from 200 GeV/c and 500 GeV/c pp collisions.

For 200 GeV/c incident protons there are 1.3 times as many kaons as neutrons produced at an angle of 60mr. For 500 GeV/c incident protons there are 2.2 times as many Kaons as neutrons at the same angle. To have a flux of 30 kaons plus neutrons per exposure, we estimate that we will need a proton beam of between 10^5 and 10^6 protons per exposure for either 200 GeV/c or 500 GeV/c pp collisions.

Collimator

We will locate a collimator between the magnet and the bubble chamber to define the size of the neutral particle beam. The aperture will be between 1 1/2" x 5" and 2 3/16" x 16" depending on how far from the magnet we decide to locate the collimator. The collimator will be made of steel and will be 2 feet long. It will rest on a small table that the University of Wisconsin has in stock.

Target - γ converter

The target will be a 1" wide, 3" high and 12" long piece of beryllium. The γ-converter will be a 2.5 cm thick sheet of lead (3 Rad. length).

Magnet

The magnet will be an NAL bending magnet, type 5-1.5-240. We will need a 10 kilogauss field to bend 30 GeV/c particles away from the bubble chamber which should be more than adequate.

To achieve a 10 kilogauss field requires a current of 2500 amps and dissipates a power of 38 kilowatts. We will provide the power supply and cooling for the magnet. A. J. Holland & Son, Inc. power supply capable of supplying 3000 amp at 18 volts D. C. from a 440V, 60 cps input is being investigated for use as the power supply. The cooling will be provided by a water pump with a coil tubing heat exchanger.

Shielding

We will want to use NAL steel plates for shielding. The position of the shielding is shown in figure 10. We will want to use the pieces of NAL steel that are described below.

a)	3 pieces	10' long × 12" wide × 10" thick	$\sim$ 2.1 tons each
b)	8 pieces	3' long × 2.5' wide × 8" thick	$\sim$ 1.3 tons each
c)	1 piece	8' long × 4' wide × 1" thick	$\sim$ .8 tons each

The shielding will be held to the height of the target on a metal table.

Table

The target will be 50" from the center of the normal beam line and will be at the height of the normal beam, approximately 5' above the ground (this is if we have a horizontal beam). It will be 81' from the bubble chamber.

The magnet will be 46" from the center of the target and will also be at the height of the normal beam pipe. We will also have steel shielding around the magnet and target. All of this - the target, magnet, and shielding - will rest on a table. The combined weight of the magnet and shielding is approximately 31 tons.

Figure 9 gives the preliminary design of a table to hold 31 tons to the height of 5'. H beams will be welded into a long skinny A-frame with a short cross bar. This A-frame will rest on concrete shielding blocks. Steel pieces will be put between the A-frame and the concrete to adjust the height of the A-frame.

The arrangement of the target, magnet and shielding is illustrated in figure 10.

Beam Monitor

We will monitor the beam position at our target with a telescope of two scintillation counters. In addition we will use a scintillation counter near the bubble chamber to help align the target and the magnet.

Housing

The target and magnet will be covered with a crude wooden shed. The power supply and counter electronics will also have to be housed, possibly in a rented van.

List of Equipment

	Furnished by U. of W.	Furnished by NAL
Beam		
Pipe	$600	
Stands to hold pipe	$500	
Vacuum pump	in stock at U. of W.	
Misc.	$100	
Window in Normal Beam Line		NAL
Magnet Power Supply	$3,000	
Magnet Cooling System		
Water Pump, up to 200 PSI, 10 gal/min	$120	
Radiator	$200-400	
Fan	$100	
Misc.	$100	
Magnet (NAL 5-1.5-240)		NAL
Table		
Concrete Shielding Blocks		NAL
Steel H-Beams	$400	
Additional Steel Spacers	$200	
Beam Monitor		
Scintillation Counter and Electronics	$7,000	
Bubble Chamber Film		NAL

Housing		
Wooden Shed Magnet Housing	$100	
Van to House Electronics, Rental	$800	
Shielding		NAL
Crane to Stack Table, Shielding, Magnet		NAL
Collimator	$900	
Total	$14,320	

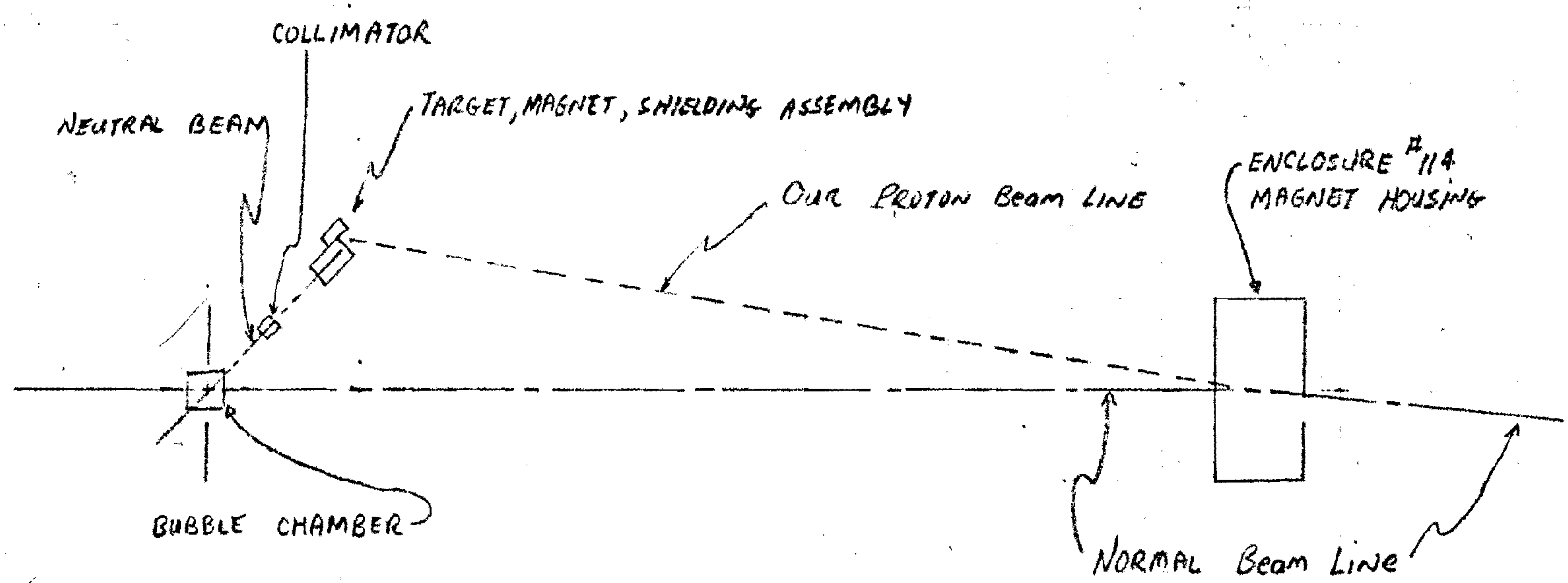
References

1. B. Edwards, J. Lasty, K. Pinkau, D. H. Perkins and J. Reynolds Phil. Mag. 3, 237 (1958). See also, D. H. Perkins, Progress in Elementary Particle and Cosmic Ray Physics, Vol. V, p. 311.

2. P. H. Fowler, 'Two Anomalous Events' CERN Report 61-22, p. 125.

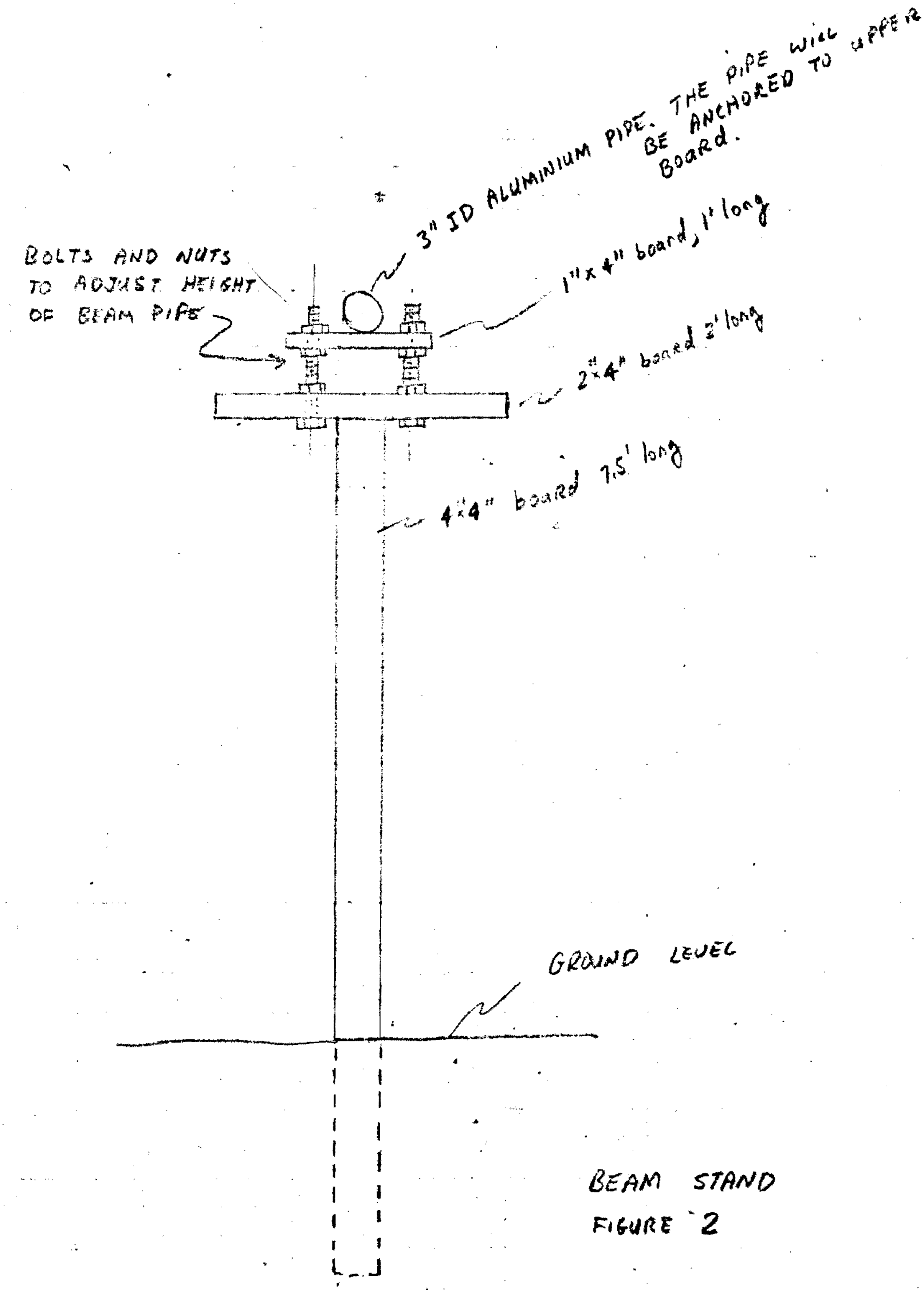
3. J. Lach and S. Pruss, Hadron Beams in the Neutrino Area, TM 285-2254, 1971; J. Lach and S. Pruss, Instrumentation of the Hadron Beams in the Neutrino Area, TM 295-2254, 1971.

Table of Figures



GENERAL EXPERIMENTAL LAYOUT

FIGURE 1



BEAM STAND

FIGURE 2

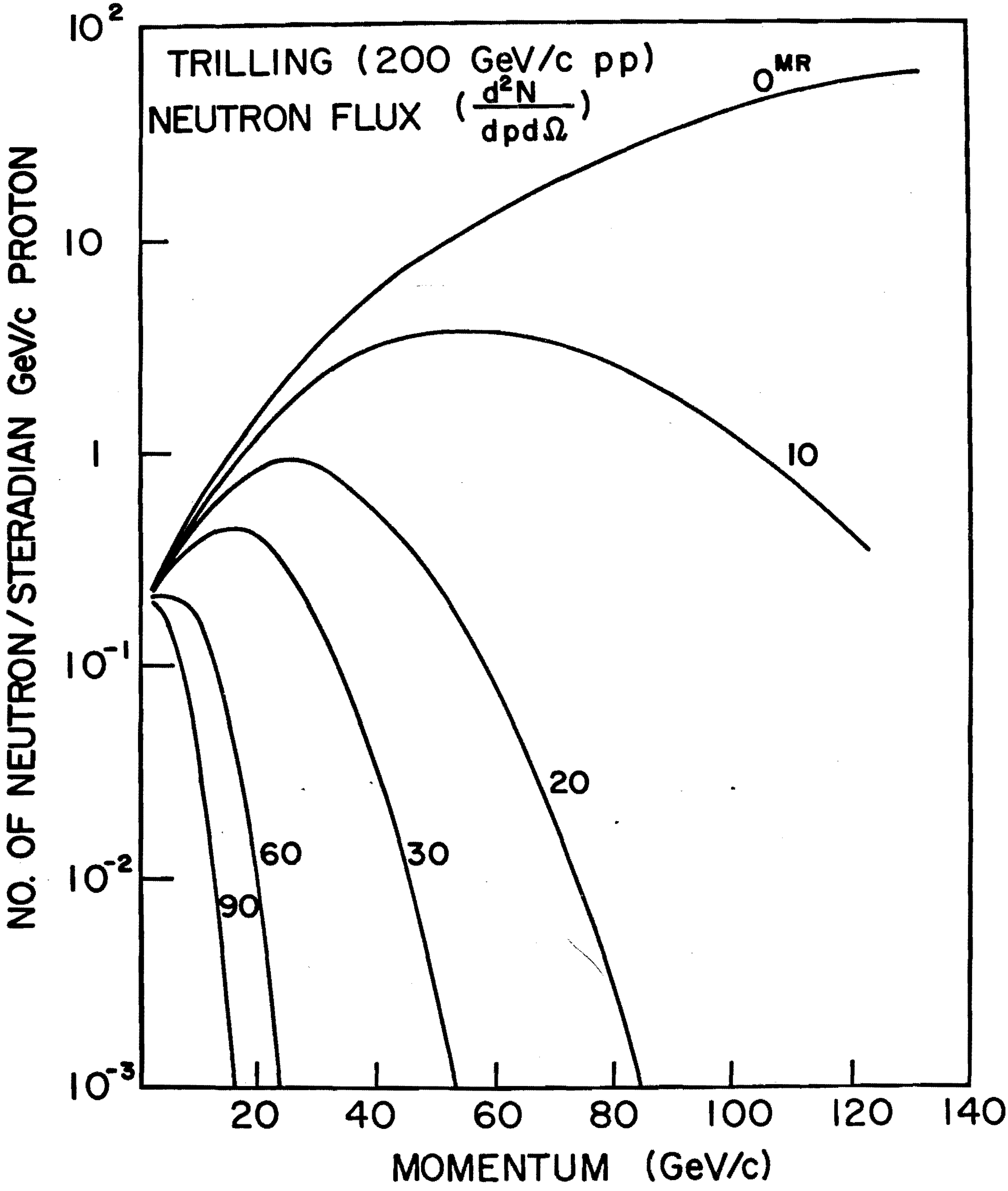
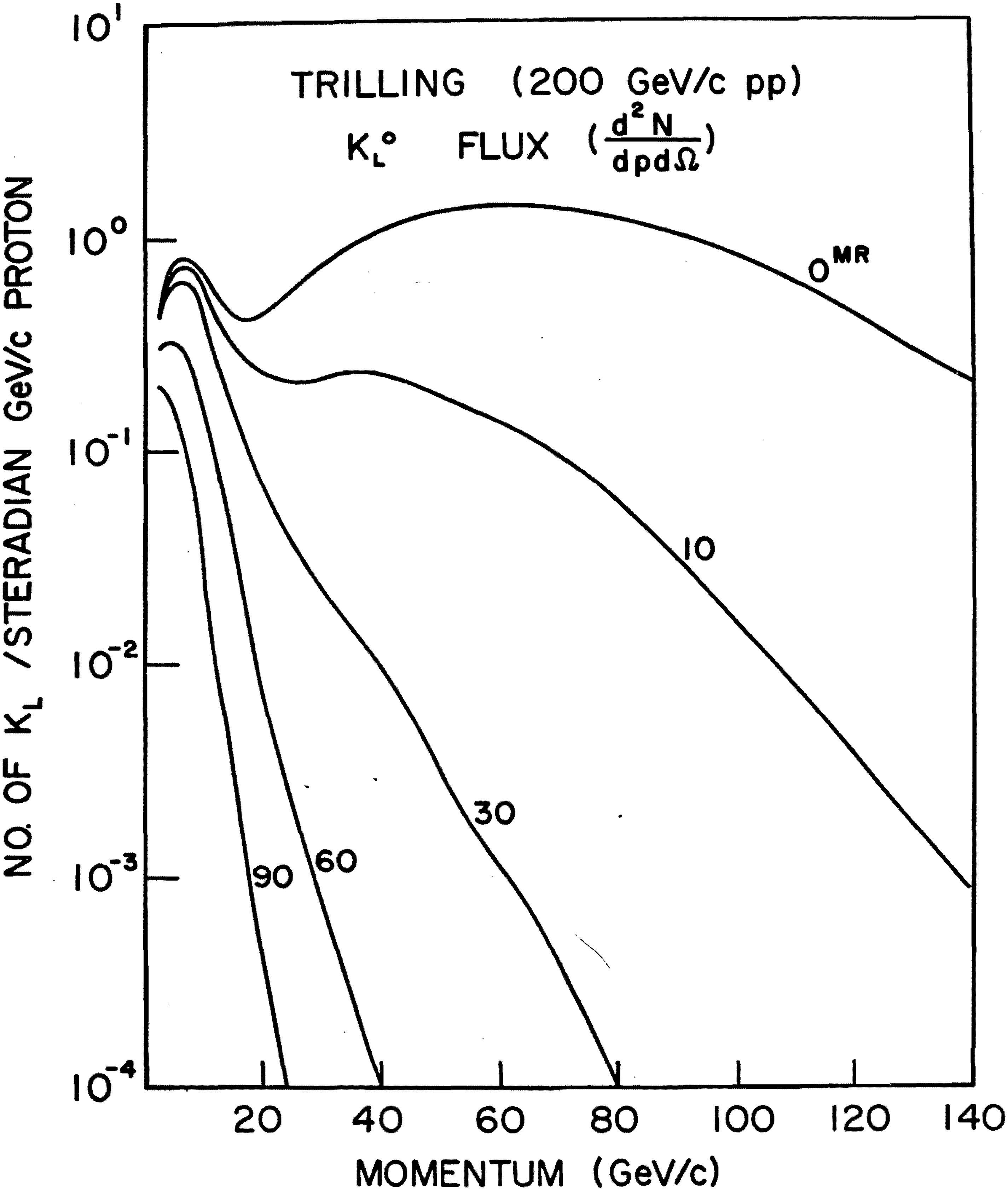

TRILLING (200 GeV/c pp)
NEUTRON FLUX $\left(\frac{d^2N}{dp\,d\Omega}\right)$
0^{MR}
10
20
30
60
90
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
20
40
60
80
100
120
140
NO. OF NEUTRON/STERADIAN GeV/c PROTON
MOMENTUM (GeV/c)

fig. 3



TRILLING (200 GeV/c pp)
K_L^o FLUX $\left(\frac{d^2N}{dp\,d\Omega}\right)$
NO. OF K_L /STERADIAN GeV/c PROTON
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0 MR
10
30
60
90
20
40
60
80
100
120
140
MOMENTUM (GeV/c)

fig. 4

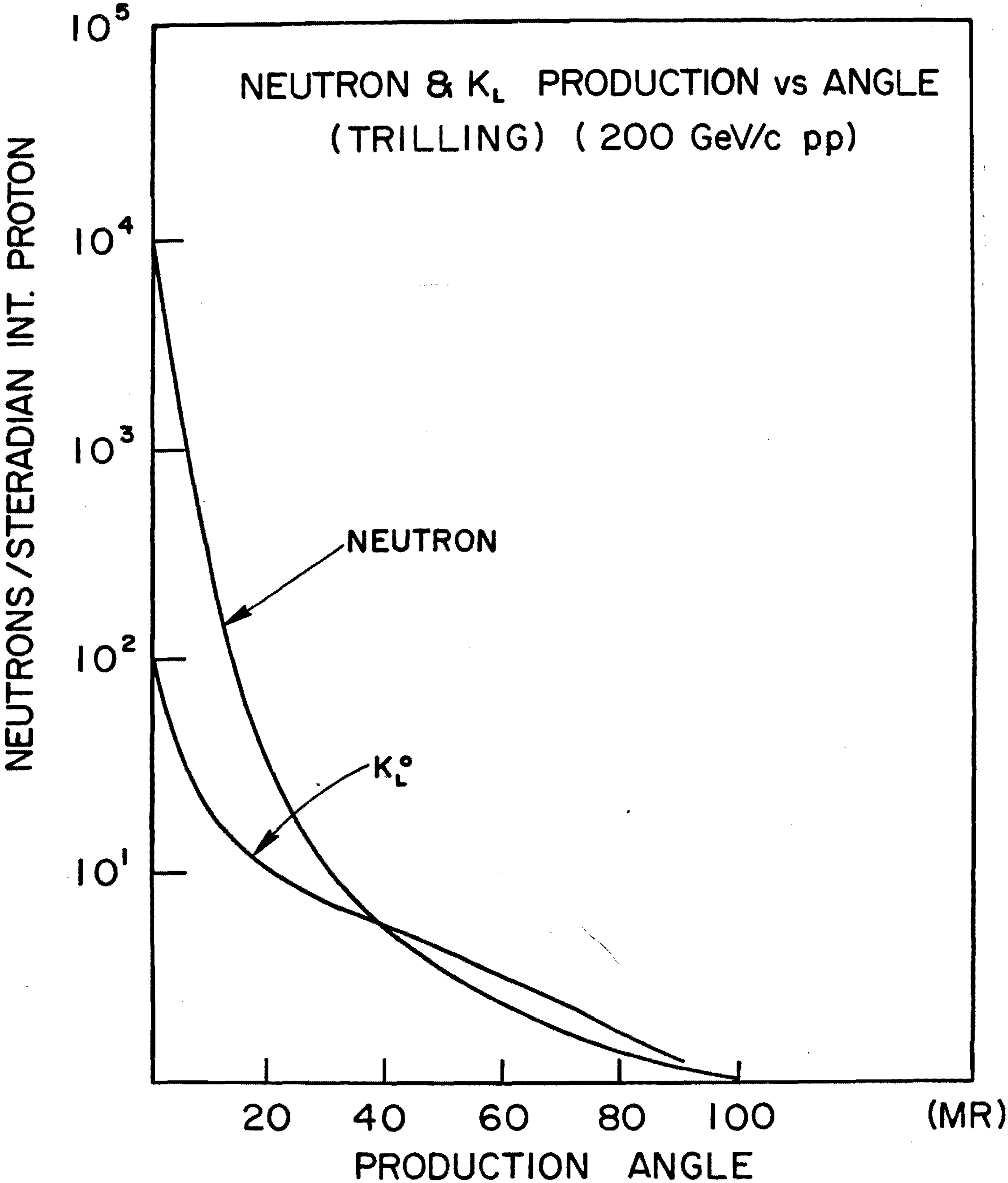

NEUTRON & K_L PRODUCTION vs ANGLE
(TRILLING) (200 GeV/c pp)
NEUTRONS/STERADIAN INT. PROTON
10^5
10^4
10^3
10^2
10^1
NEUTRON
K_L^o
20
40
60
80
100
(MR)
PRODUCTION ANGLE

fig. 5

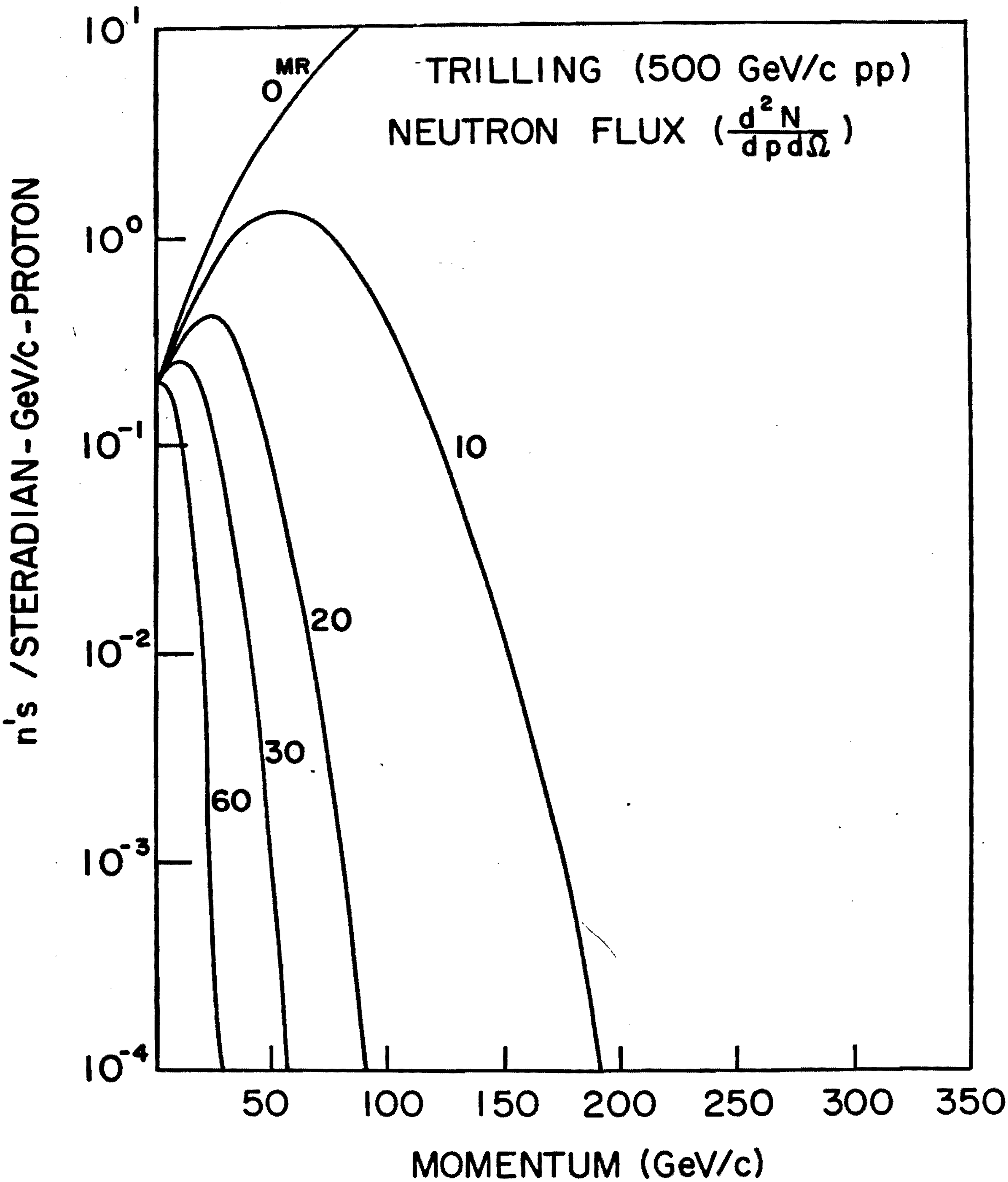
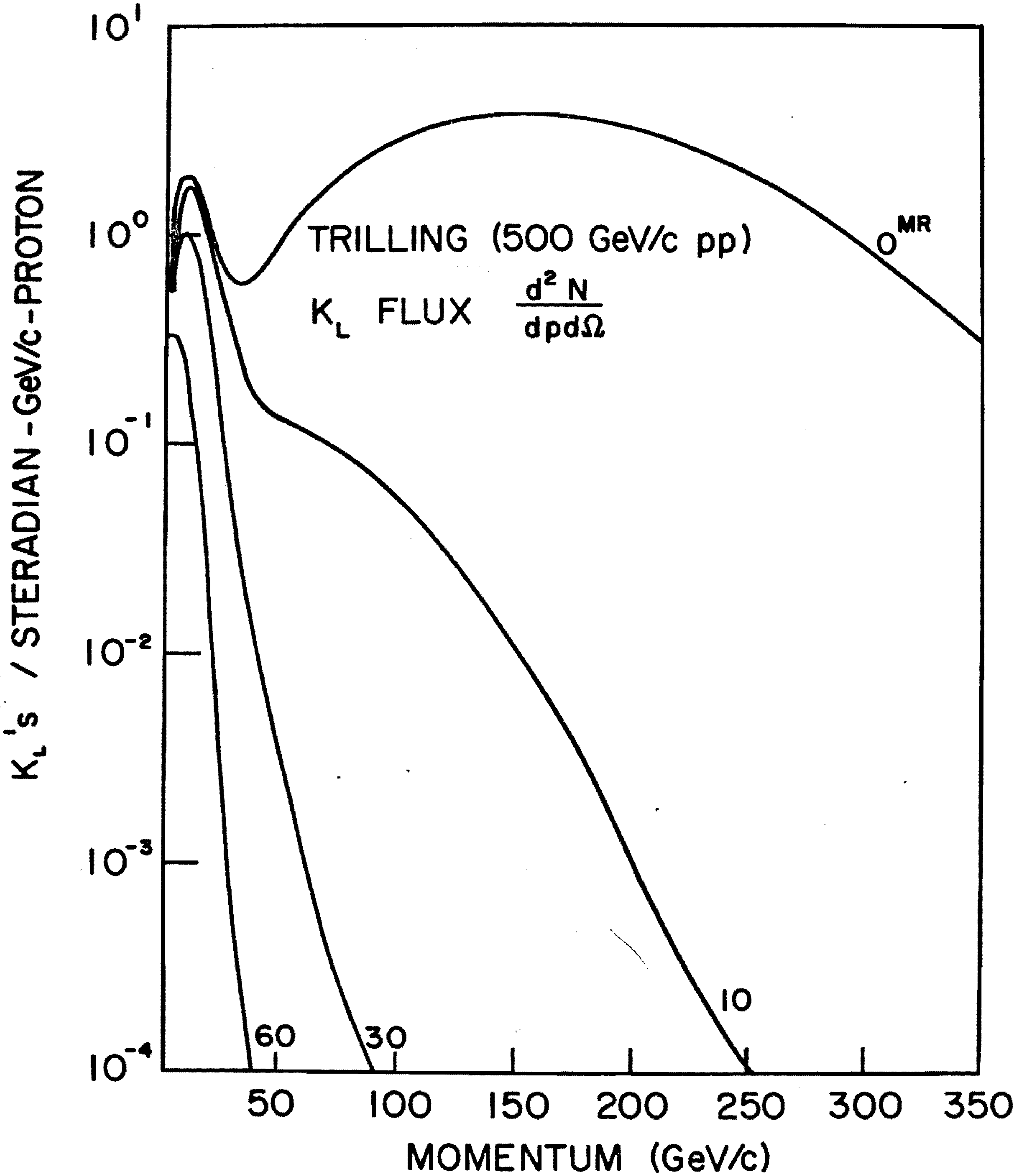

TRILLING (500 GeV/c pp)
NEUTRON FLUX ($\frac{d^2N}{dp\,d\Omega}$)
0^MR
10
20
30
60
n's /STERADIAN-GeV/c-PROTON
10^1
10^0
10^-1
10^-2
10^-3
10^-4
50
100
150
200
250
300
350
MOMENTUM (GeV/c)

fig. 6



TRILLING (500 GeV/c pp)
K_L FLUX $\frac{d^2N}{dp\,d\Omega}$
K_L's / STERADIAN - GeV/c - PROTON
MOMENTUM (GeV/c)
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
50
100
150
200
250
300
350
0^{MR}
10
30
60

fig. 7

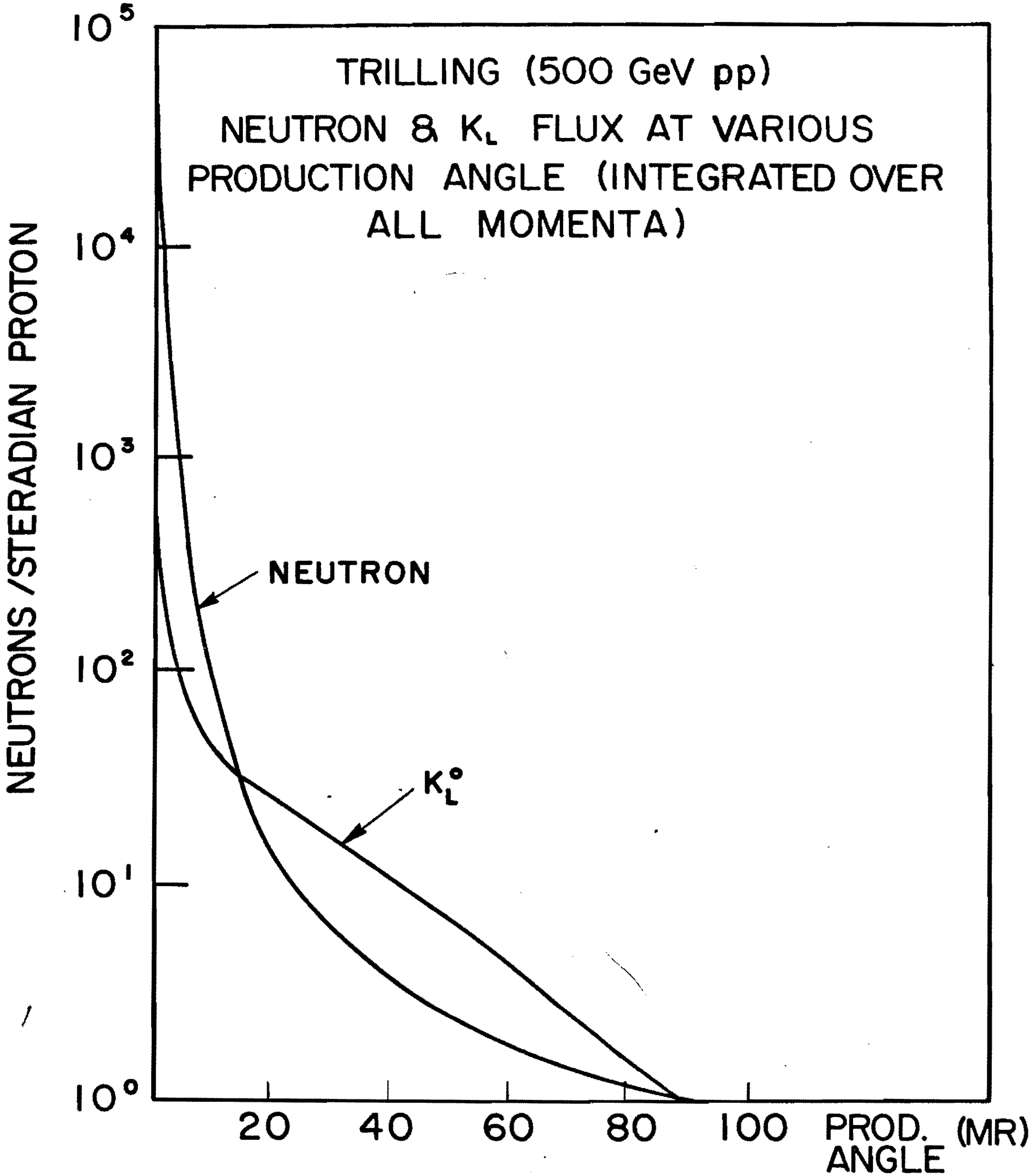

TRILLING (500 GeV pp)
NEUTRON & K_L FLUX AT VARIOUS PRODUCTION ANGLE (INTEGRATED OVER ALL MOMENTA)
NEUTRONS /STERADIAN PROTON
10^5
10^4
10^3
10^2
10^1
10^0
NEUTRON
K_L^0
20
40
60
80
100
PROD. ANGLE (MR)

fig. 8

PROPOSED TABLE TO HOLD
TARGET, MAGNET, AND SHIELDING

THE SHIELDING WILL REST ON THE A-FRAME
THE MAGNET WILL SIT ON THE SHIELDING
BLOCKS AND WOODED SUPPORTS.

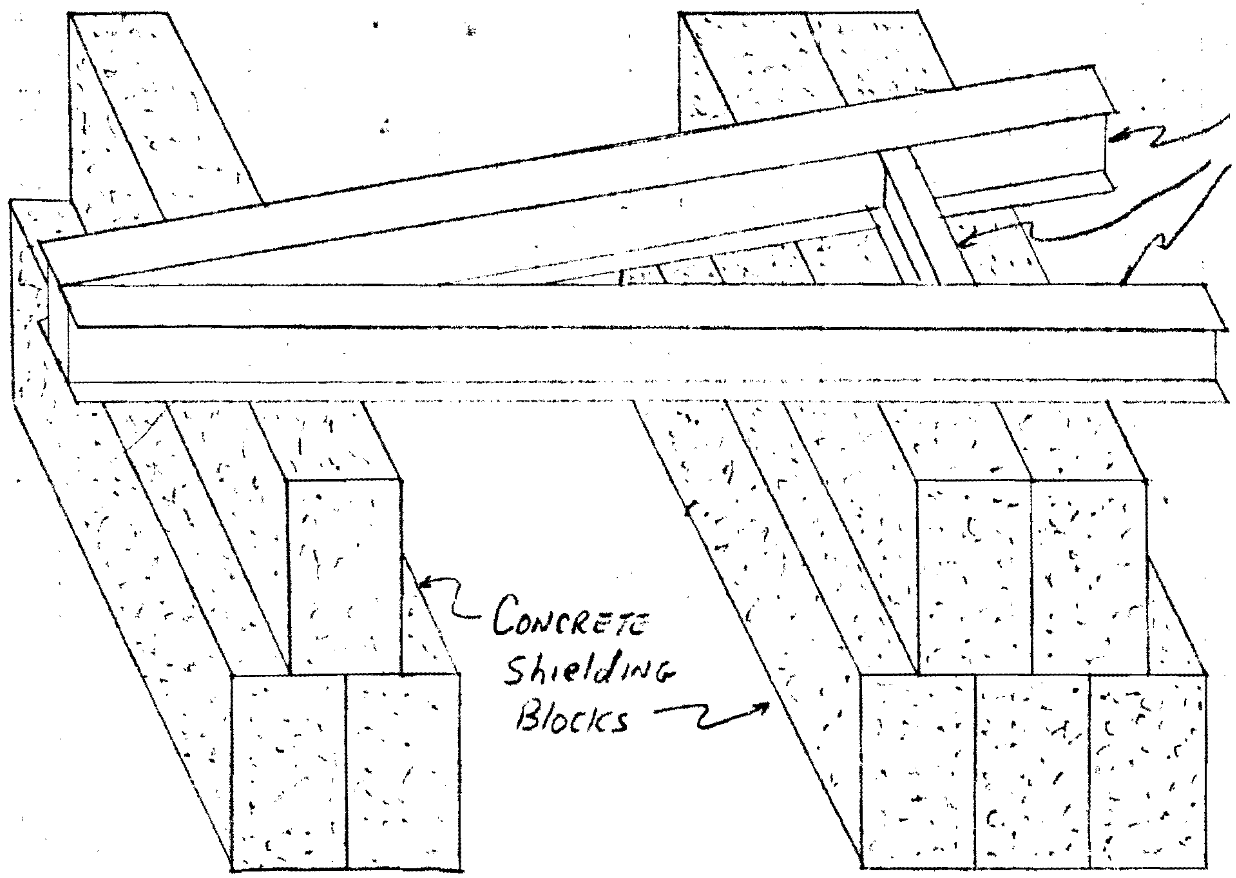


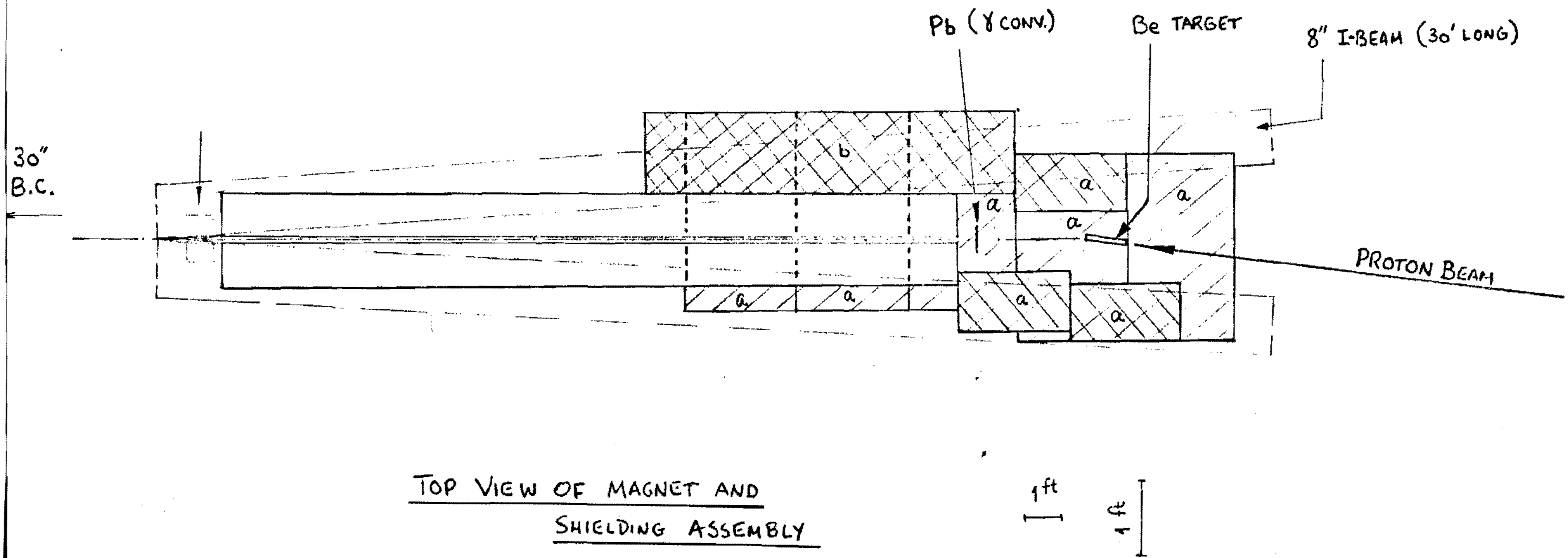
FIGURE 9.

a) Steel pieces 8" by 3' by 2.5', 8 such pieces shown

b) Steel piece 10" by 12" by 10', 3 such pieces, one on top of the other.

In addition to the pieces shown there will be two above the target. These pieces are ① 8"× 3'× 2.5'

② 8'× 4'× 1"



TOP VIEW OF MAGNET AND SHIELDING ASSEMBLY

FIGURE 10