FNAL Experimental
Proposal 393
Spokesman: Irwin A. Pless

PROPOSAL TO STUDY THE PROPERTIES OF THE FORWARD-GOING PHOTON ENERGY IN THE TWO-CHARGED PRONG TOPOLOGY CREATED IN 150 GeV/c π^--p INTERACTIONS

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Univ. of Tenn.: W. Bugg, G. Condo, T. Handler, E. Hart
Yale Univ.: H. Kraybill, D. Ljung, T. Ludlam, H. Taft

14 May 1975

SUMMARY

We wish to study the forward electromagnetic energy associated with the two-charged prong topology in 150 GeV/c $\pi^- p$ interactions. We believe that there is evidence of a new phenomenon associated with these photons. We have tried to explain our data (E-154) on the basis of known reactions with known particles and cannot do so. We propose adding a gamma ray detector behind the last PWC plane in the FNAL 30" hybrid system. This gamma ray detector should have an energy resolution $\frac{\Delta E}{E} \leq 1\%$ and a spatial resolution of less than $\pm$ 3mm. We request 10^6 expansions in the 30" hybrid system with an incident π^- beam of 150 GeV/c. We will trigger the flash when we detect an electromagnetic energy shower greater than 20 GeV/c. We expect to take 100,000 pictures of which 9,000 will contain two-prong events and of which 3,000 will be the events of interest. This will be an increase of more than an order of magnitude over our present data and in addition will have precise information on the photon energy and distribution. This precise information on the photons should allow us to determine what is the character of the beam diffraction reaction and whether or not it represents a new phenomenon.

The purpose of this experiment is to examine the neutral energy moving in the forward direction associated with the two-charged particle topology created by $\pi^- p$ interactions at 150 GeV/c. From experiment 154 (a $\pi^- p$ exposure in the FNAL hybrid bubble chamber system) we have 376 two-prong inelastic events with an identified proton. We find these events can be classified into three distinct groups. One group is beam fragmentation, a second group is target fragmentation, and a third group is not easily categorized. These are shown in figure 1. We have in our PWC system a crude gamma ray detector. This detector consists of a two-radiation thick piece of lead followed by three PWC planes. We can count fired wires in these chambers and get a crude idea of the intensity of the electromagnetic energy impinging on the lead converter. We have arbitrarily set the scale from 0-6 where 0 indicates no fired wires and 6 indicates more than 100 fired wires. In the beam fragmented region, there is essentially always some electromagnetic energy incident on the lead converter with the vast majority of the events having intensity six. In the target fragmented region, there is almost no electromagnetic energy incident on the lead converter with the vast majority of the events having intensity zero. In the third region, half the events have an electromagnetic intensity zero and the other half have electromagnetic intensity six. This is shown in figure 2.

This in itself is interesting but not unexpected. However, when we look at the beam fragmentation events in detail, within our limited statistics (212 events), we find rather unexpected distributions.

The first unexpected distribution is that of the P_{lab} of the π^-. Although the statistics are poor, there is an accumulation of events with P_{lab} of the π^- being 110 GeV/c. There is another accumulation of 40 GeV/c and another at 10 GeV/c. This is shown in figure 3. For comparison, figure 4 shows the π^- laboratory distribution for all events. In this distribution, a high momentum peak which includes the leading particle signal (target fragmentation) is clearly visible.

A second unexpected feature is the energy distribution of the missing neutrals (beam fragments) which pass through our gamma detector. This distribution has accumulations of 140 GeV/c and 100 GeV/c. This, of course, is the reflection of the π^- distribution and conservation of energy. This distribution is shown in figure 5.

The physics questions we would like to answer are: What is the composition of the neutral energy shown in figure 5? Does the accumulation at 140 GeV/c consist of a single π^0 or several π^0's? What are the invariant mass distributions between the neutral π^0 or π^0's and the π^-?

We have investigated the possibility that the phenomena we see result from a known reaction, such as A^- production. If this were the case, given that the A^- is an I spin 1 particle and that it decays into two I spin 1 particles, we would expect to have similar behavior in the four-prong sample containing an identified proton. In particular, the events in the beam fragmentation region of the four prongs, the π^+ plays the same role as the π^- in the two-prong sample. Figure 6 shows the distribution of this π^+. As can be seen, this distribution (within the statistics) is quite different from the π^- distribution (fig. 3), particularly in the high energy region.

We believe that the above comments indicate a new phenomenon is occurring in the two-prong events and that a detailed study of this phenomenon is called for. We have tried many Monte Carlo calculations to simulate a final state that might explain our data. These include:

1) $\pi^- + p \rightarrow$ "A^-" $+ P$

$\quad\quad\hookrightarrow$ "ρ^-" $+ \pi^0$

$\quad\quad\quad\hookrightarrow \pi^- + \pi^0$

2) $\pi^- + p \rightarrow {}''A^-{}'' + p$
$\quad\quad\quad\quad\quad\quad \hookrightarrow {}''f^0{}'' + \pi^-$
$\quad\quad\quad\quad\quad\quad\quad\quad \hookrightarrow \pi^0 \pi^0$

To match the data with reaction 1), one requires "A^-" with widths less than 100 MeV, "ρ^-" with widths less than 10 MeV and angular distributions like $\cos^6\theta$. We have not found parameters that allow us to match the data with reaction 2). Hence, we believe one has to study in detail the electromagnetic energy associated with the two-prong events.

We propose to add to the proportional wire hybrid bubble chamber system a lead glass hodoscope downstream of the last proportional wire chamber that will have a resolution $\frac{\Delta E}{E} < 1\%$ and a spatial resolution less than ± 3mm. It is conceivable that the prototype device associated with E-299 (see rough draft of E-299 proposal and other plans - attached) would suffice and, hence, we might have suitable equipment for this experiment by winter 1975.

Using this equipment we would trigger the bubble chamber light flash only when there was at least 20 GeV energy detected in the downstream system. We would then scan the film for two-prong events and reconstruct all data, including photons. We should be able to reconstruct π^0 and η^0 mesons. We should also be able to distinguish up to six gamma rays (3 π^0).

We request 10^6 expansions of the 30" hybrid system with incident 150 GeV/c π^- mesons. We estimate (from our E-154 data) that we will take ~ 100,000 pictures. Of these, we estimate we will have 9,000 two prongs and, of these, we will end up with 3,000 beam fragmentation events. Since we will be measuring only two prongs, we will use a slightly higher incident flux, 10 tracks per picture, and this has been folded into the above estimates. Half of the estimated false triggers come from wall interactions and the other half from topologies greater than two prong. The data reduction part of this experiment is quite modest and we should have quick results once we have the film.

Having the gamma ray data will allow us to determine π^0 four vectors and form relevant invariant mass distributions. If there is narrow structure in this final state, we will be able to detect it. In any event, we will be able to determine the character of this final state in an exclusive manner and determine if there are any new physical phenomena involved.

The cost of the extra equipment is contained in the attachments.

FIGURE CAPTIONS

Figure 1: Scatter plot of the laboratory momentum of the π^- versus the center of mass value of the Feynman x parameter for the proton. The sample is all the inelastic two-prong (π^-, p) events. Shown are our definition of beam fragmentation and target fragmentation regions. Also indicated is the definition of Region III.

Figure 2: For each of the three regions shown in figure 1, we have estimated the electromagnetic intensity seen in the forward direction. The detecting device was two radiation lengths of lead followed by proportional wire planes. The intensity was estimated by the number of struck wires. Bin 0 implies no struck wires and bin 6 implies more than 100 fired wires. As might be expected, in the beam fragmentation region there is relatively more electromagnetic energy seen downstream than for the target fragmentation region.

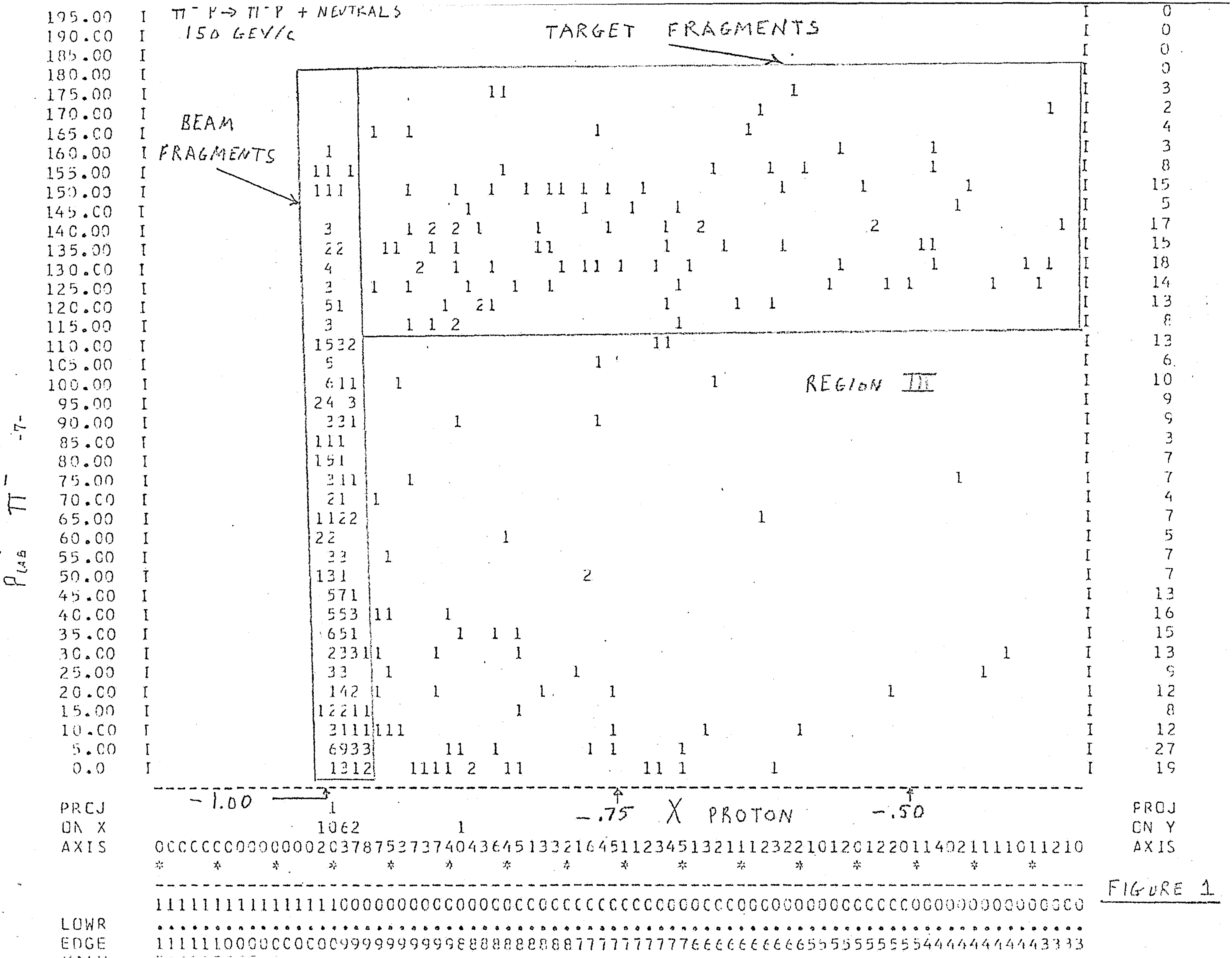
Figure 3: π^- laboratory momentum for the beam fragmentation region.

Figure 4: π^- laboratory momentum for the whole two-prong inelastic (π^-, p) sample.

Figure 5: For the beam fragmentation region we calculated the missing mass four vector. If this four vector was aimed towards our gamma ray detector, we computed the energy of the missing mass and entered it into this histogram.

Figure 6: The data for this histogram comes from the four-charged prong sample with an identified proton. We made the same cut on the proton as for the two-charged prong sample and then plotted the

laboratory momentum of the π^+. Note the events in this sample may or may not have associated missing neutrals.



π⁻ p → π⁻ p + NEUTRALS
150 GEV/c
TARGET FRAGMENTS
BEAM FRAGMENTS
REGION III
P_{LAB} π⁻
PROJ ON X AXIS
PROJ ON Y AXIS
−1.00
−.75
X PROTON
−.50
LOWR EDGE

FIGURE 1

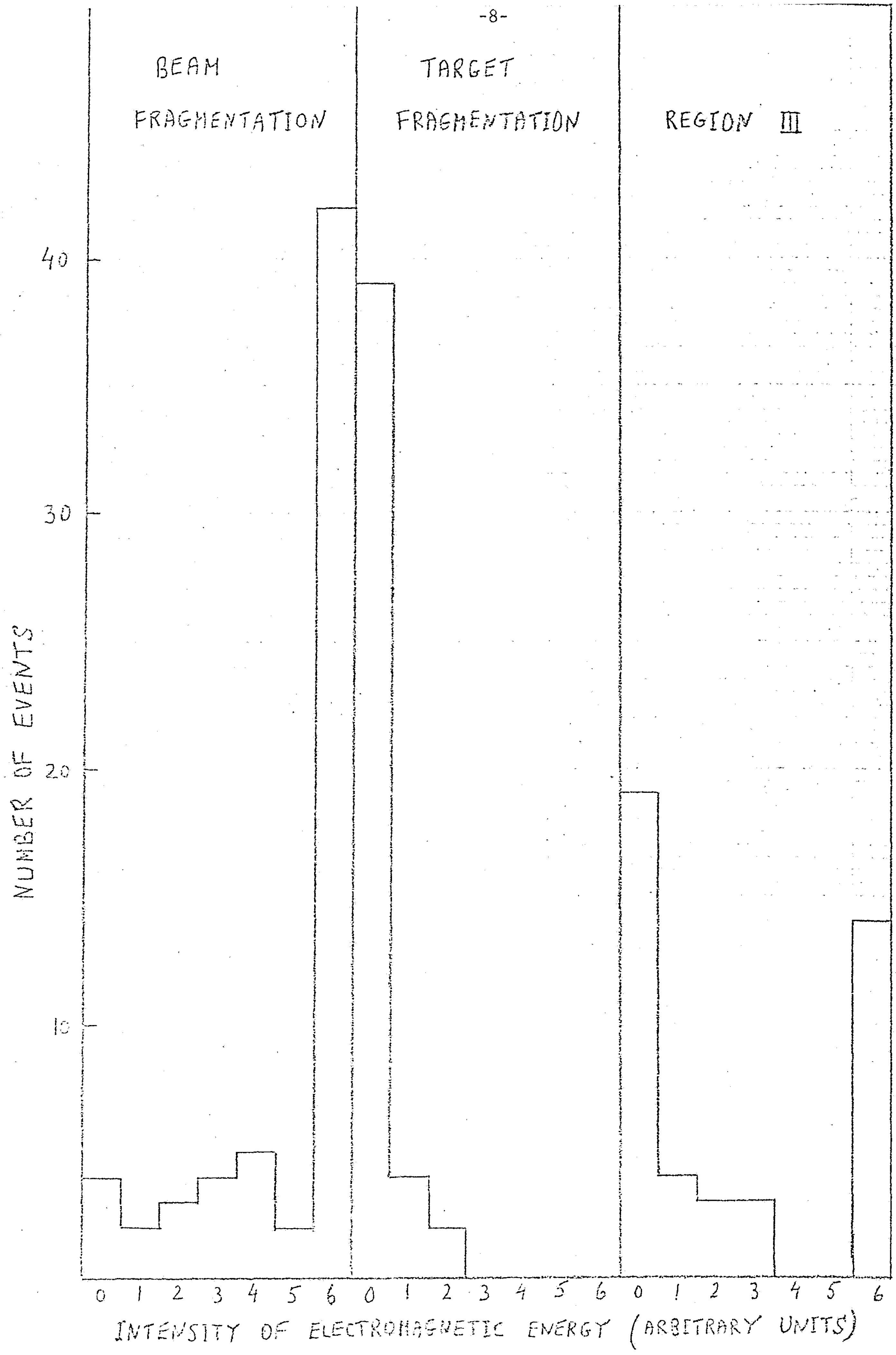
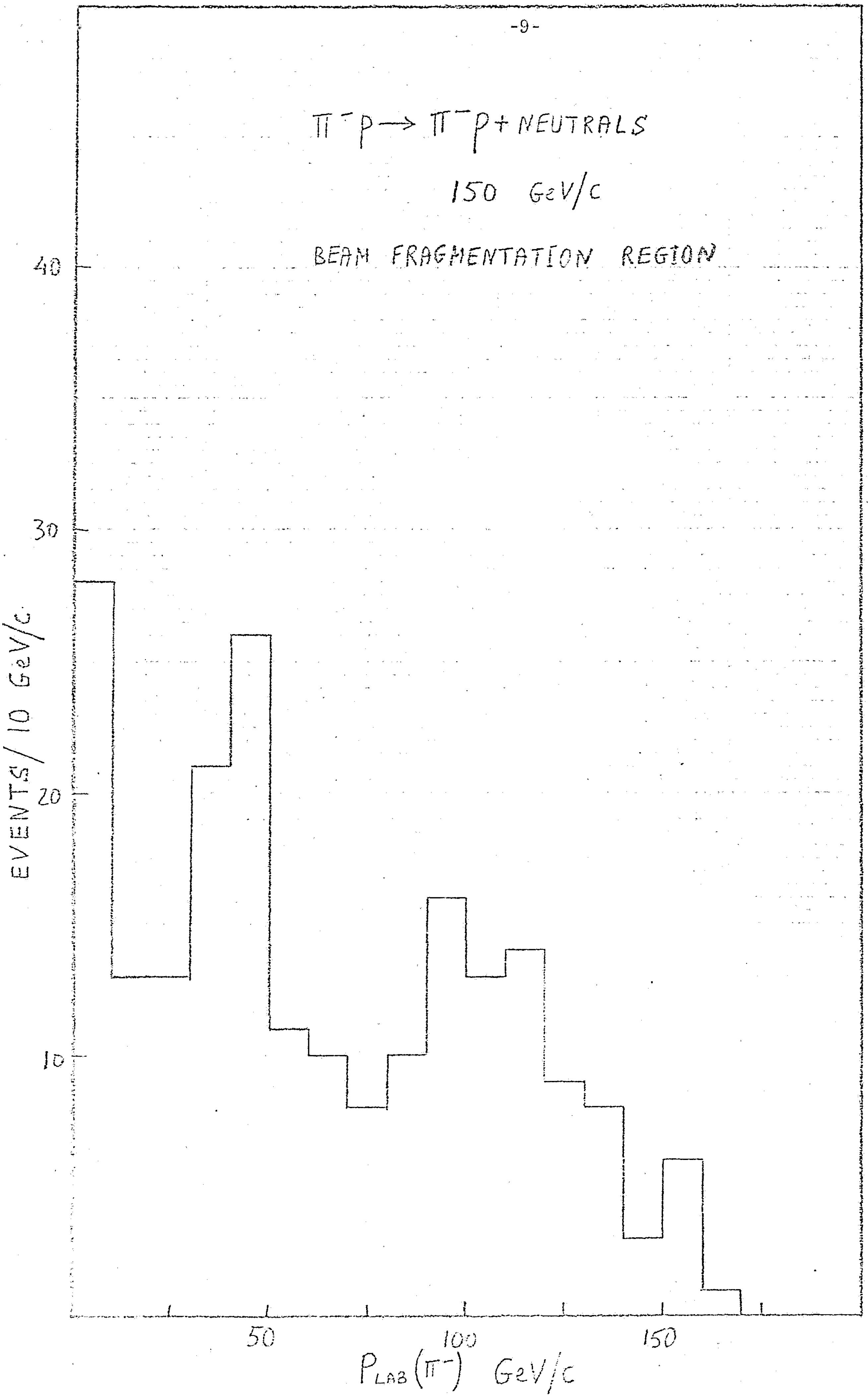
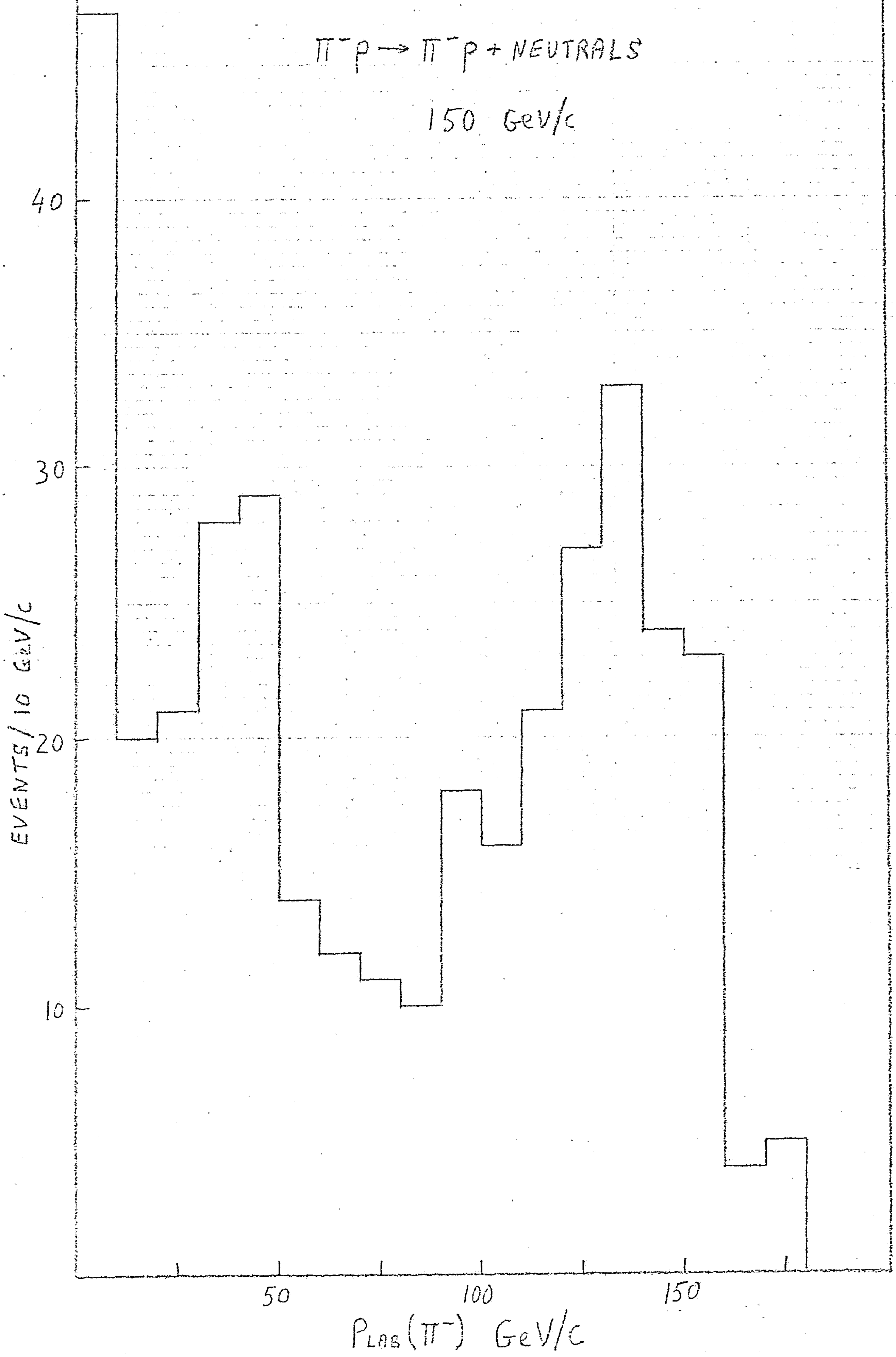

BEAM
FRAGMENTATION
TARGET
FRAGMENTATION
REGION III
NUMBER OF EVENTS
40
30
20
10
0 1 2 3 4 5 6 0 1 2 3 4 5 6 0 1 2 3 4 5 6
INTENSITY OF ELECTROMAGNETIC ENERGY (ARBITRARY UNITS)

FIGURE 2



π⁻p → π⁻p + NEUTRALS
150 GeV/c
BEAM FRAGMENTATION REGION
EVENTS/ 10 GeV/c
40
30
20
10
50
100
150
$P_{LAB}(\pi^-)$ GeV/c

FIGURE 3



π⁻p → π⁻p + NEUTRALS
150 GeV/c
40
30
20
10
EVENTS / 10 GeV/c
50
100
150
$P_{LAB}(\pi^-)$ GeV/c

FIGURE 4

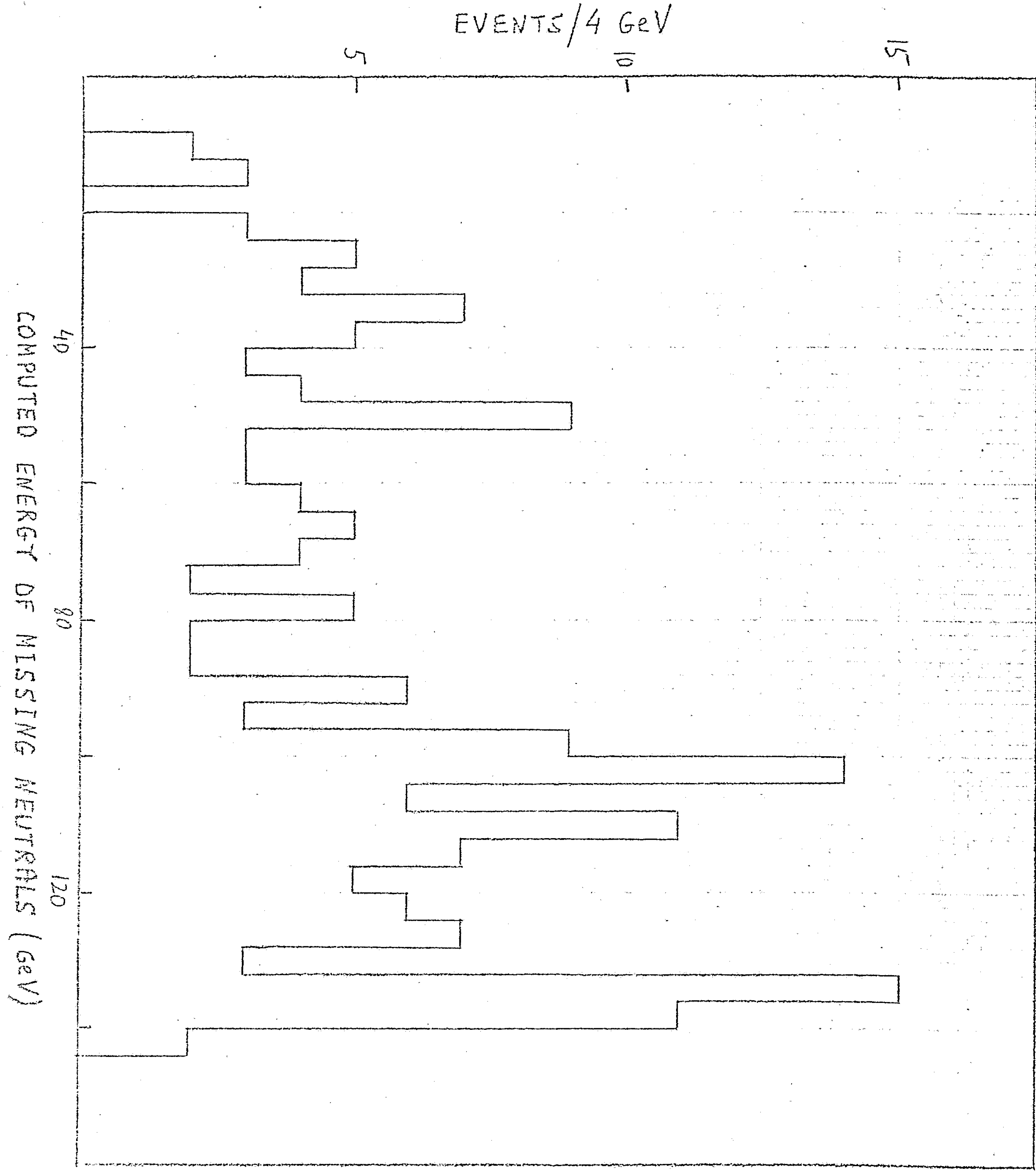
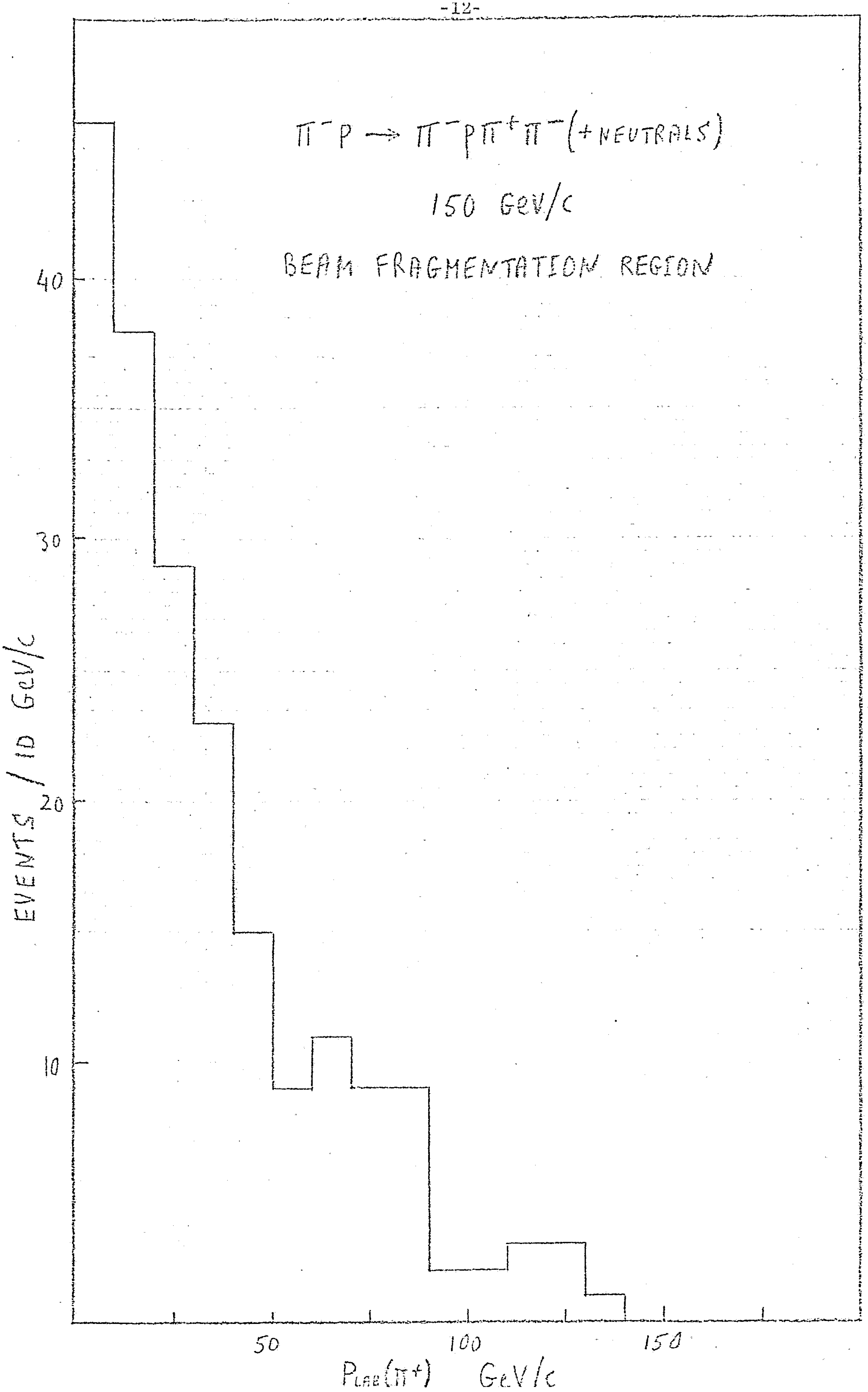

EVENTS/4 GeV
5
10
15
40
80
120
COMPUTED ENERGY OF MISSING NEUTRALS (GeV)

FIGURE 5



$\pi^- p \rightarrow \pi^- p \pi^+ \pi^-$ (+NEUTRALS)
150 GeV/c
BEAM FRAGMENTATION REGION
40
30
20
10
EVENTS / 10 GeV/c
50
100
150
$P_{LAB}(\pi^+)$ GeV/c

FIGURE 6

Proposed
Draft Agreement

This is an agreement between Fermilab and Professor I. A. Pless of M. I. T. representing the experimenters of Experiment No. 299. This document contains enumeration of the major items needed for the proper execution of Experiment No. 299 as expressed in the proposal for the experiment and subsequent correspondence. This agreement covers Phases I and II of the experiment and is outlined in Appendix I.

A. Personnel

1. The experimenters committed to this experiment are:

D. G. Fong, A. M. Shapiro, M. Widgoff, Brown University; G. Ascoli, B. Eisenstein, U. Kruse, L. Peek, T. Roberts, R. Sard, L. Seward, A. M. Snyder, J. Tortora, University of Illinois; R. A. Burnstein, C. Fu, D. V. Petersen, M. Robertson, H. A. Rubin, Illinois Institute of Technology; E. D. Alyea, C. Ellis, W. Farmer, K. F. Galloway, H. J. Martin, R. A. Mercer, M. Morrison, J. E. Mott, Indiana University; C.-Y. Chien, A. Pevsner, V. Sreedhar, R. A. Zdanis, Johns Hopkins University; J. Grunhaus, E. Hafen, R. Hulsizer, U. Karshon, V. Kistiakowsky, P. Marcato, A. Napier, I. A. Pless, P. Trepagnier, B. Wadsworth, J. Wolfson, R. K. Yamamoto, Massachusetts Institute of Technology; E. B. Brucker, E. L. Koller, R. J. Plano, S. Taylor, T. L. Watts, Rutgers University/Stevens Institute; J. Barwick, H. Brashear, W. Bugg, H. Cohn, G. Condo, T. Handler, E. Hart, B. Meadows, University of Tennessee/Oak Ridge; D. Bogert, M. Johnson, H. Kraybill, T. Ludlam, P. Martin, H. Taft, Yale University/Fermilab.

2. In addition, the university groups expect to involve three other physicists, six engineers, three draftsmen, and twelve technicians during various phases of the experiment. In addition, the universities will supply at least two full-time people stationed at Fermilab during the testing and installation period of the drift chambers and gamma ray detectors at Fermilab.
3. R. K. Yamamoto was chosen to be Project Manager to direct all aspects of the design, construction, installation, testing, and initial operation of the drift chamber and gamma ray detector.
4. The scientific spokesman for this experiment is I. A. Pless.
5. The presently assigned Fermilab physicist is L. Voyvodic.

B. Equipment and Beam:

1. The instrumentation and experiment will be done using the N3 beam to the 30-inch hybrid bubble chamber facility located in the neutrino area.
2. The beam will be equipped with appropriate quadrapoles, bending magnets, collimators, and with additional instrumentation as described herein.
3. Fermilab will provide:
    a. The secondary beam, hybrid bubble chamber and beam enclosures
    b. Instrumentation for tuning and controlling the beam, including Čerenkov counters
    c. Data tagging computer
    d. Space in bubble chamber high bay area for downstream detecting equipment

e. Standard electronics; CAMAC crate and modules $ 32,000

f. Cables from bubble chamber high bay area to Laboratory A $ 5,000

g. Lead glass and photo tubes 48 pieces (existing) Value ($50,000)

New Equipment	$ 37,000
Existing value	($50,000)

4. The experiments will provide:

a. Drift chamber with 1.2 meter diameter active area and read out system $ 40,000

b. Lead glass gamma ray detector with .75 meter x .75 meter active area and read out system $ 80,000

New Equipment	$ 120,000

5. Operating costs:

a. Rigging $ 5,000

b. Film (1.2 x 10^6 pictures)

c. Bubble chamber operation

d. Computer time (PDP-10 + CDC 6600)

C. Funding:

1. Fermilab funds are available in FY 76 for the items in Category B3.

2. Each university will approach its funding agency (ERDA, NSF) for an incremental increase of at least $10,000. This will provide a base of $90,000 or greater to fund this experiment.

R. K. Yamamoto was chosen to be the treasurer to monitor the university funds. (ORNL will provide $30,000 to augment the university funds which will be spent mainly on item B. 4a. M. I. T. will try to furnish $60,000 which will be spent mainly for item B. 4b)

D. Special Considerations:

1. It is recognized that the experiment is in two phases. The two phases of this experiment are based on Dr. Goldwasser's letter of November 22, 1974, Ref. 299. It is understood that Phase II is contingent on major completion of Phase I and on the approval of a new physics proposal by Fermilab.

   a. Phase I 600 x 10^3 pictures: approved.

      i. 500 x 10^3 pictures with a mixture of π^+ and p at 150 GeV/c

      ii. 100 x 10^3 pictures of π^- at 150 GeV/c

   b. Phase II 600 x 10^3 pictures:

      i. 400 x 10^3 pictures with a mixture of π^+ and p at 150 GeV/c

      ii. 200 x 10^3 pcitures of π^- at 150 GeV/c

2. Beam characteristics

   a. Each picture shall contain between 6 and 10 tracks.

   b. Beam should have a π^+ filter to optimize π^+/p ratio.

   c. For the π^+ and p exposure the π^+/p ratio shall be more than 1/3. This can be obtained by controlling the bubble chamber flash lamps by means of a suitable monitoring system.

   d. The beam spill to the bubble chamber should be 100 microseconds or longer.

3. Testing time

   a. Experimenters estimate that the installation of the gamma ray detector and drift chamber will take one month. In site testing of the system will require two months. A beam spill of 100 microseconds or longer is required.

   b. A short test run with 5,000 correlated bubble chamber pictures will be required to fully certify the installation.

E. Experimental Planning Milestones (tentative)

1.	Construction of prototype drift chamber	1 May 1975
2.	Construction of prototype lead glass hodoscope	1 June 1975
3.	Beam testing of prototype system	1 Sept. 1975
4.	Construction of drift chamber	1 Dec. 1975
5.	Construction of gamma ray detector	1 Jan. 1976
6.	Installation of equipment	1 March 1976
7.	Test of equipment	1 April 1976
8.	Data collection	1 July 1977

Appendix

In Phase I of this experiment the experimenters will receive and start to analyze the 600×10^3 pictures approved by Fermilab. These pictures will be divided between a π^+/p exposure and π^- exposure at 150 GeV/c. Phase II of this proposal anticipates an additional 600×10^3 pictures at 150 GeV/c, also divided between π^+/p and π^- incident particles. Phase II is based on Dr. Goldwasser's letter of November 22, 1974, Ref. 299. As stated in the body of this agreement, it is understood that the receipt of the pictures requested in Phase II is contingent on a major completion of the already approved Phase I and on the approval of the physics by Fermilab.

As part of the ongoing program to improve the Fermilab 30-inch hybrid bubble chamber system, the experimenters will design, construct, and bring into operation a large drift chamber and a gamma ray detector. These two devices will increase the acceptance of the hybrid system for charged particles and give information on the direction and energy of gamma rays. The experimenters will furnish the equipment described in the body of this document and when the devices are installed, documented, and operational, they will be turned over to Fermilab to be operated as a general facility.

190.096.32

<u>Exploratory discussion for setting up a beam line test for the 299 lead glass hodoscope</u>

The following is a suggested outline for determining the important energy and special characteristics of the lead glass hodoscope suggested for the 299 gamma ray detector. This outline is meant to be a reference point of discussion and not a firm commitment on any party.

1. Beam line - Fermilab
   a) Flux density of e^- up to 100 cts/mm^2 in a "few hours" at most.
   b) $\frac{\Delta p}{p} \sim 0.3\%$
   c) $25 < p < 200$ GeV/c
   d) PDP-11 computer plus scope
   e) NIM LOGIC - borrowed
   f) beam counters
2. Remote CAMAC System - Fermilab
   a) CAMAC CRATE
   b) serial crate controller system
   c) parallel to serial converter
   d) 12 channel A to D converter (borrowed or bought)
3. 5 element x, 5 element y 2 dimensional lead glass hodoscope - Fermilab
   a) glass and photo tubes
   b) box
   c) movable carriage
   d) calibration tubes and pulser
   e) cross slide
4. Calibration system and data - PHSC
   a) similar to that described in FGD and PHSC - Fermilab agreement
   b) provide phototube + source + neutral density filter and mount.
   c) use Fermilab neon tube and pulser
5. Binary glass system - Fermilab
   a) glass 12" x 12" by $\frac{1}{4}$", $\frac{1}{2}$", 1", 1"
   b) mount for above

6. Hole counter system - PHSC

   a) two counters

      i) 1" diameter
      ii) $1\frac{1}{2}$" diameter with 3.6 mm diameter hole in center

   b) photo tubes - 56 AVP

   c) bases - 5 nanosecond pulse

   d) two-dimensional cross slides with 4" travel

7. Software - PHSC

   a) data gathering

   b) histograms

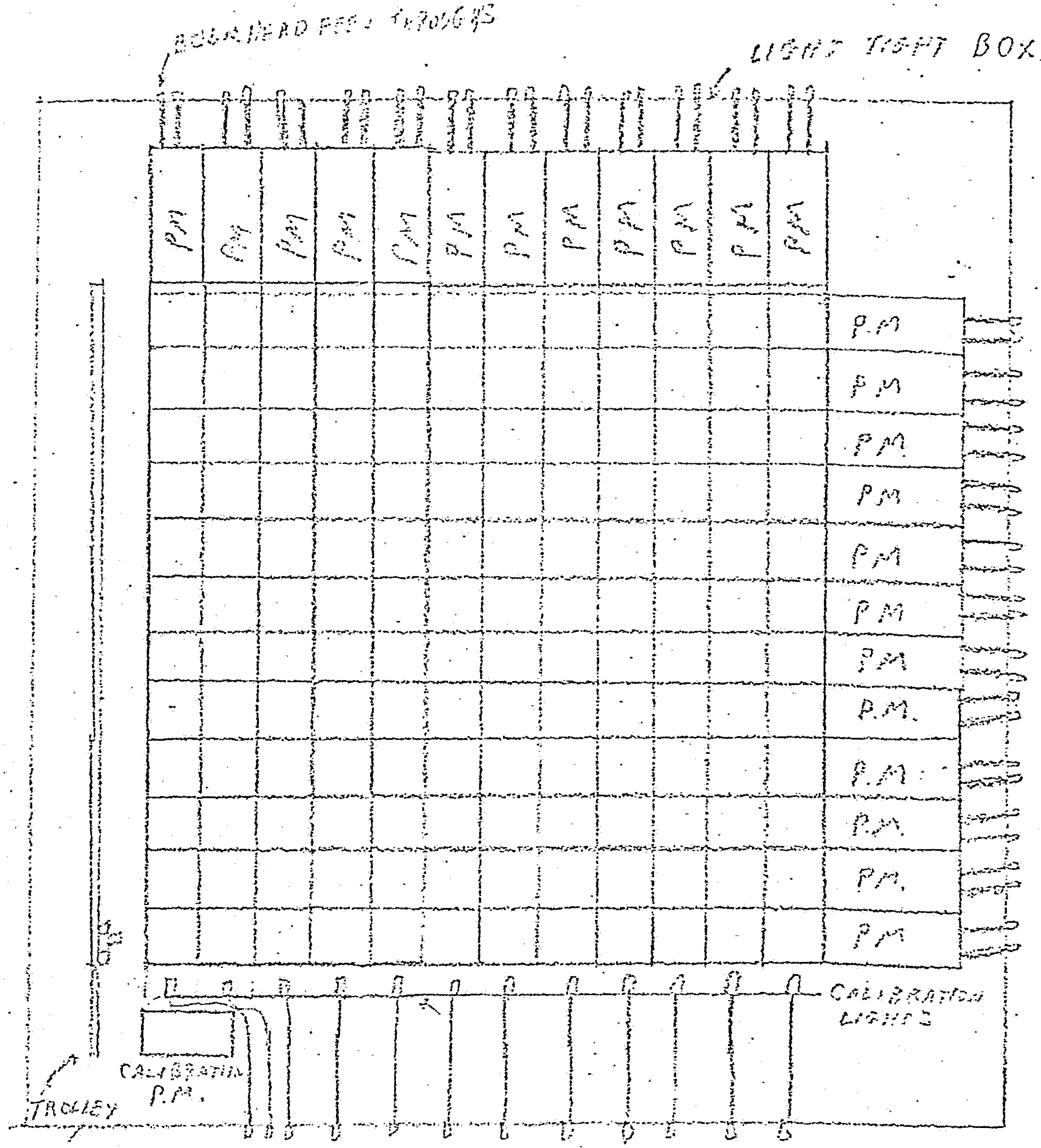
8. Off-line computer time - Fermilab-PHSC

As noted above, the outline is not meant to be an agreement but rather the basis for discussion so that an agreement can be reached. The enclosed sketch is just a rough idea of how the test might go.

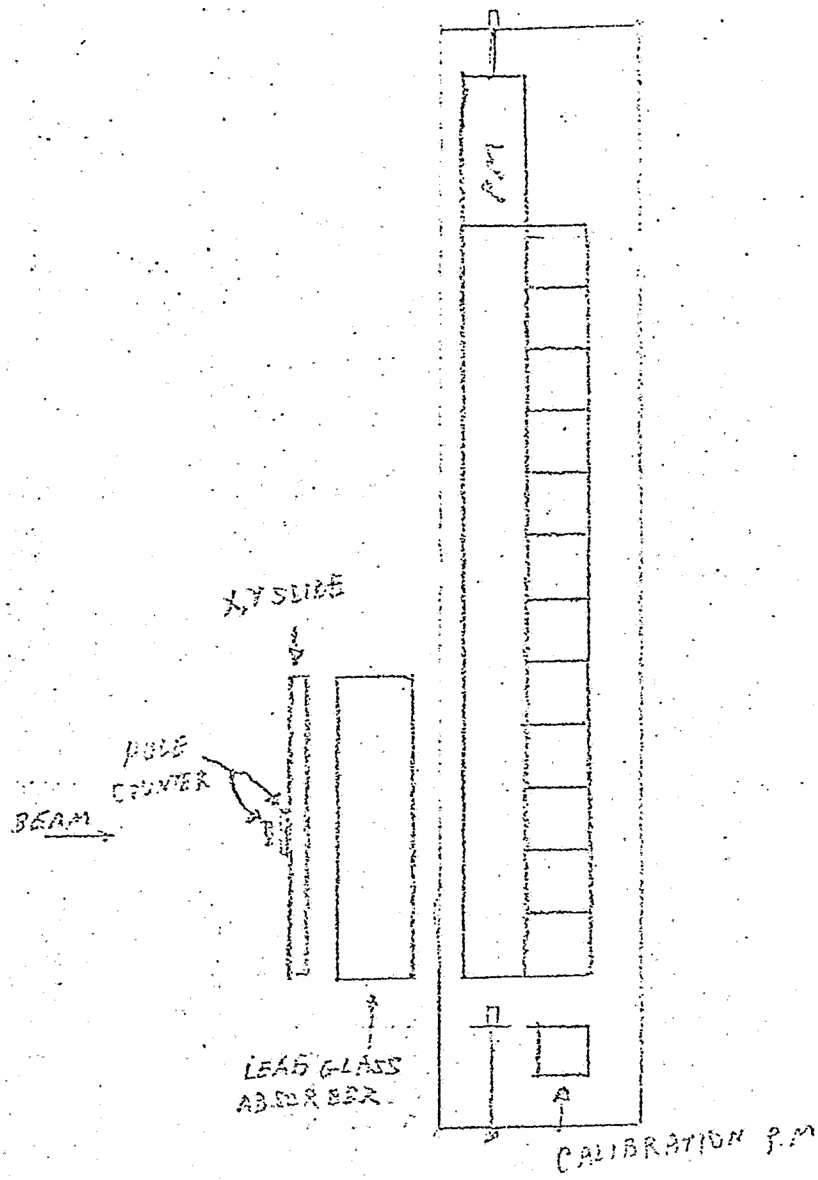
M. Johnson
I. A. Pless

11 February 1975

CHKD. BY............DATE................ APPARATUS. JOB NO.................
SCALE



FRONT VIEW



SIDE VIEW

NOTES

1. COMPLETE ASSEMBLY MOUNTED ON A PORTA TABLE

2. LEAD GLASS ABSORBER AND HOLE COUNTER IS MOUNTED ON A FRAME SO THAT IT CAN BE POSITIONED ANYWHERE IN FRONT OF THE LEAD GLASS ARRAY

3. FOR THE TEST, ANY 5 HORIZONTAL AND ANY 5 VERTICAL TUBES AND CALIBRATION LIGHTS WILL BE POWERED

4. LIGHT TIGHT CAN SHOULD HAVE BOTH FRONT AND BACK COVERS EASILY DEMOUNTABLE

5. COMPLETE UNIT SHOULD BE ON A FRAME WHICH IS RIGID AND STRONG ENOUGH SO THAT IT CAN BE PICKED UP BY A CRANE

1 90.096.32

Outline for the Joint Construction between the European FGD Collaboration and the American PHSC-Fermilab of a Forward Gamma Detector

The following outline is the result of discussions between Gigi Ventura and Irwin Pless. These discussions followed presentations to the whole PHSC-Fermilab and a subgroup of the PHSC-Fermilab.

The purpose of this outline is to delineate construction ideas and preliminary responsibilities for accomplishing two objectives. The first objective is a preliminary study of the critical parameters of the system. This will involve a test period in the Fermilab beams with a prototype representing a minimal configuration. The second is the construction, installation, and operation of a full-size Forward Gamma Detector in the Fermilab 30" Hybrid Bubble Chamber System, to be used for physics experiments. It is anticipated that the equipment will remain at Fermilab through 1 January 1977.

I. Preliminary Test

A. Size:

1. Full-size along beam direction

2. One quarter area perpendicular to beam direction

B. Components:

1. 4 block 15 x 15 x 60 cm^3

a. Responsibility

i. FGD

2. 30 x 30 cm^2 two coordinate scintillation hodoscope

a. Responsibility

i. FGD

3. 31.5 x 31.5 cm^2 two coordinate lead glass hodoscope

a. Responsibility

i. PHSC-Fermilab

I. B. 4. 30 x 30 cm^2 three coordinate PWC hodoscope

a. Responsibility

i. PHSC-Fermilab

5. 64 Channel ADC - 10 bit

a. Responsibility

i. FDG - borrowed

ii. PHSC-Fermilab - borrowed

6. NIM Logic

a. Responsibility

i. PHSC-Fermilab

7. Calibration phototubes - 2 each

a. Responsibility

i. FGD

8. Movable Carriage

a. Responsibility

i. PHSC-Fermilab

II. Operational Hardware

A. Size:

1. 30 radiation lengths along beam direction

2. 60 x 60 cm^2 perpendicular to beam direction

B. Components

1. Lead glass counter

ī. 16 blocks 15 x 15 x 60 cm^3

a. Responsibility

i. FGD

ii. PHSC-Fermilab

$\bar{2}$. Calibration tube and two-dimensional remote control [1]

a. Responsibility

i. FGD

ii. PHSC-Fermilab

$\bar{3}$. Nitrogen box

a. Responsibility

i. PHSC-Fermilab

2. Vertex hodoscope

$\bar{1}$. 60 x 60 cm^2 three coordinate scintillation hodoscope

a. Responsibility

i. FGD

b. Calibration tube and remote control system [1]

a. Responsibility

i. FGD

$\bar{2}$. Nitrogen box

a. Responsibility

i. FGD

3. Lead glass hodoscope

$\bar{1}$. 62.5 x 62.5 cm^2 two coordinate lead glass hodoscope

a. Responsibility

i. PHSC-Fermilab

$\bar{2}$. Calibration tube and one-dimensional remote control [4]

a. Responsibility

i. FGD

ii. PHSC-Fermilab

$\bar{3}$. Nitrogen box

a. Responsibility

i. PHSC-Fermilab

4. Drift chamber

   1. 120 x 120 cm^2 drift chamber

      a. Responsibility

         i. PHSC-Fermilab

5. Mechanical mount

   1. Two-dimensional remote control mechanical mount for items 1, 2, 3, 4, and 5.

      a. Responsibility

         i. PHSC-Fermilab

6. Calibration device [6 each]

   1. Tubes - nuclear services - ADC - Self Trigger - LED

      a. Responsibility

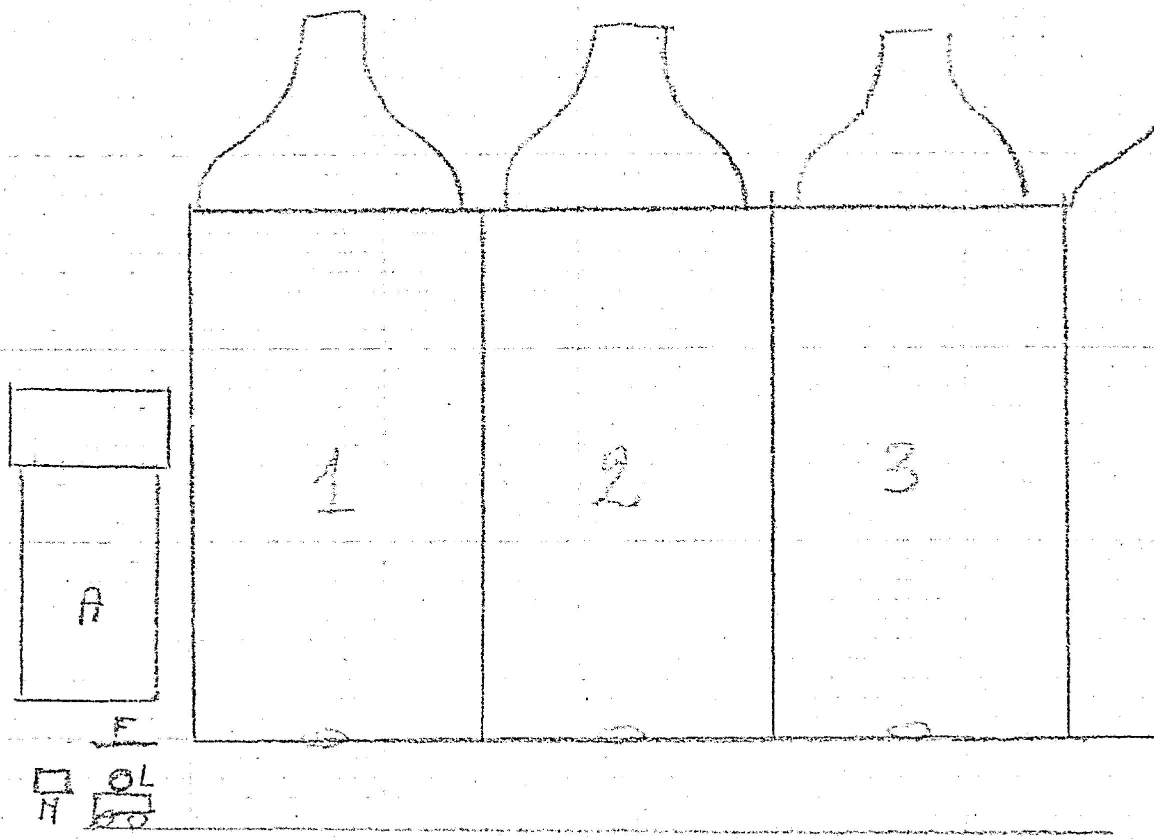
         i. FGD

This document just records, as mentioned above, informal discussions between Drs. Ventura and Pless. This document is not meant to be a binding commitment but, rather, a basis for discussion before any final commitments are made. In particular, the attached rough sketch is only that; much effort must be expended before these crude ideas become a working scheme.

G. Ventura

I. Pless

30 January, 1975



A is a reference PM, whose gain is kept constant by monitoring the light pulses from the NaI (Am 241 doped) source N. The LED L can be moved, by computer control, over the central region of the faces of lead glass blocks 1, 2, 3, etc. to control the stability of their gains, and over A to check for shifts in the light output of L itself. Since for the lead glass counters a pulse intensity is needed equivalent to the light from a shower of several tens GeV, while the pulses from N correspond to or ~ 1 GeV shower, an attenuating filter F is set between L and the photocathode of A, so as to roughly equalize its outputs for L and N.

FNAL Experimental
Proposal 393 (revised)
Spokesman: Irwin A. Pless

HIGH STATISTICS STUDY OF π^0 PRODUCTION IN 150 GeV/c π^--p INTERACTIONS

Brown University: M. Heller, A. Janos, A. M. Shapiro, M. Widgoff
Illinois Institute of Technology: R. A. Burnstein, C. Fu, M. Nazaretz, H. A. Rubin
University of Illinois: J. W. Cooper, R. Plumer, R. D. Sard, J. Tortora
Indiana University: E. D. Alyea, Jr.
Johns Hopkins University: L. Bachman, C. -Y. Chien, P. Lucas, L. Madansky, A. Pevsner, R. A. Zdanis
Massachusetts Institute of Technology: J. E. Brau, J. Grunhaus, E. S. Hafen, R. I. Hulsizer, U. Karshon, V. Kistiakowsky, P. A. Miller, A. Napier, I. A. Pless, J. Wolfson, R. K. Yamamoto
University of Padova/University of Rome: S. Centro, G. Ciapetti, M. De Giorgi, D. Pascoli, L. Ventura, D. Zanello
Rutgers University/Stevens Institute/SUNY, Albany: E. B. Brucker, P. F. Jacques, M. D. Jones, E. L. Koller, T. C. Ou, R. J. Plano, P. Stamer, C. Sun, S. Taylor, T. L. Watts
University of Tennessee/Oak Ridge National Laboratory: J. Barwick, W. Bugg, H. O. Cohn, G. Condo, T. Handler, E. Hart, R. D. McCulloch
Yale University/Fermilab: D. Bogert, M. Johnson, H. Kraybill, D. Ljung, T. Ludlam, H. Taft

20 January 1976 (Revised)

SUMMARY

We propose a high statistics study of two, four, six, and eight charged particle final state channels in which a single forward going π^0 is also produced in 150 GeV/c $\pi^- p$ interactions. We will also perform high statistics studies of the four, six, and eight charged particle channels without neutrals and inclusive studies of π^0 production as a function of rapidity. We will also study the forward going electromagnetic energy associated with the two-charged prong topology in 150 GeV/c $\pi^- p$ interactions. We believe that there is evidence of a new phenomenon associated with these photons based on previous data (E-154) which cannot be explained on the basis of known reactions with known particles. We propose adding a gamma ray detector behind the last PWC plane in the Fermilab 30" hybrid system. This gamma ray detector should have an energy resolution $\frac{\Delta E}{E} \leqslant 1\%$ and a spatial resolution of less than $\pm$ 3mm. We request 10^6 frames taken in the 30" hybrid system with an incident π^- beam of 150 GeV/c. In this exposure there will be $\sim$ 9000 two prong events with electromagnetic energy greater than 20 GeV of which 3000 will be the events associated with the new phenomenon. The precise information on the photons should allow us to determine what is the character of the beam diffraction reaction and whether or not it represents a new phenomenon. This part of the experiment will be performed first and a quick answer should be possible.

Introduction

The purposes of this experiment are twofold: 1) a high statistics study of π^0 production and 2) a study of the forward going neutral energy associated with the two charged particle topology, both in $\pi^- p$ interactions at 150 GeV/c. We propose a change in the experiment discussed in the original version of this proposal (submitted 14 May 1975), replacing operation with a triggered bubble chamber light flash to untriggered operation in which the events of interest are selected in off-line analysis of the forward going neutrals. We still request 10^6 expansions of the 30-inch hybrid system but now replace our original estimate of $\sim 10^5$ pictures with a request for 10^6 pictures. A scan for tagged two charged-particle events would be done first and permit an expeditious elucidation of the second topic listed above.

High Statistics Study

Based on our previous experience in experiment 154 ($\pi^- p$ at 147 GeV/c), we believe that it is possible to use a slightly higher incident flux and therefore request 10^6 pictures with ten tracks per picture of $\pi^- p$ interactions at 150 GeV/c. Table I gives an estimate of the number of events we expect for the various topologies based on our E-154 results. It is seen that this experiment also would permit high statistics studies of the channels in which no neutral particles were produced for the four, six, and eight charged prong topologies.

The primary purpose of this proposed experiment is a study of channels in which one or more π^0's is produced. In order to accomplish this we propose to add to the proportional wire hybrid bubble chamber system a lead glass hodoscope downstream of the last proportional wire chamber that will have a resolution $\frac{\Delta E}{E} \sim 1\%$ and a spatial resolution less than $\pm$ 3mm. It is expected that the prototype device associated with E-299 (see E-299 agreement and other plans - attached) will suffice and, hence, that we will have suitable equipment for this experiment as soon as the test run with E-299 is completed (spring 1976). We should be able to reconstruct π^0 and η^0 mesons and should be able to distinguish up to six gamma rays ($3\pi^0$). Thus, we would be able to perform a study of the two, four, six, and eight charged prong topologies where one π^0 is observed allowing four constraint (4C) fits. These are channels of which there have not been previous studies. This experiment together with E-154 also would permit high statistics studies of the four, six, and eight charged prong topologies with no neutral particles and comparison with the corresponding channels with π^0 mesons should prove extremely fruitful. For example, our E-154 study of the four charged-particle 4C sample has shown that more than 92% of the cross section is due to beam and target diffraction dissociation. $\rho^0\pi^-$ events make an important contribution to the beam dissociation cross section in the A_1 and A_2 mass region and there is some evidence for a contribution from $f^0\pi^-$. Higher statistics should permit a resolution of the latter question as well as yielding a better understanding of the three-pion system in all invariant mass regions. It would obviously be of great interest to obtain results for the four charged prong, one π^0 channel at a similar level of statistics.

This experiment will also permit an inclusive study of π^0 production as a function of rapidity. Such a study is extremely important in order to verify the previous evidence for the existence of clusters and to determine whether they consist mainly of two pions ("ρ" like) or three pions ("ω" like). Light would also be shed on the question of transverse momentum conservation along the rapidity axis. In particular, the question of local transverse momentum conservation could be answered, whereas with charged-particle rapidity studies only, this is virtually impossible.

Two Charged Prong Events with Forward π^0 Mesons

Another facet of this experiment is the examination of the forward going neutral energy associated with the production of two charged particles. From experiment 154 we have 376 two-prong inelastic events with an identified proton which we find can be classified into three distinct groups. One group is beam fragmentation, and a second, target fragmentation. The third group is not easily categorized and consists of events shown in figure 1. We had in our PWC system for E-154 a crude gamma ray detector consisting of a two-radiation thick piece of lead followed by three PWC planes. By counting the number of wires that fired in these chambers, we can get a crude idea of the intensity of the electromagnetic energy incident on the lead converter. We have arbitrarily defined a scale ranging from 0-6 where 0 indicates no fired wires and 6 indicates more than 100 fired wires. In the beam fragmentation region, there is essentially always some electromagnetic energy incident on the lead converter with the vast majority of the events having intensity six. In the target fragmentation region, there is almost no electromagnetic energy incident on the lead converter with the vast majority of the events having intensity zero. In the third region, half the events have an electromagnetic intensity zero and the other half have electromagnetic intensity six. This is shown in figure 2.

This in itself is interesting but not unexpected. However, when we look at the beam fragmentation events in detail, within our limited statistics (212 events), we find rather unexpected distributions. The first is that for the P_{lab} of the π^-. Although the statistics are poor, there is an accumulation of events with P_{lab} of the π^- at 110 GeV/c. There is another accumulation at 40 GeV/c and another at 10 GeV/c. This is shown in figure 3. For comparison, figure 4 shows the π^- laboratory distribution for all events. In this distribution, a high momentum peak which includes the leading particle signal (target fragmentation) is clearly visible.

A second unexpected feature is the energy distribution of the missing neutrals (beam fragments) which pass through our gamma detector. This distribution has accumulations at 140 GeV/c and 100 GeV/c. This, of course, is the reflection of the π^- distribution and conservation of energy. This distribution is shown in figure 5.

The physics questions we would like to answer are: What is the composition of the neutral energy shown in figure 5? Does the accumulation at 140 GeV/c consist of a single π^0 or several π^0's? What are the invariant mass distributions between the neutral π^0 or π^0's and the π^-?

We have investigated the possibility that the phenomena we see result from a known reaction, such as A^- production. If this were the case, given that the A^- is an I spin 1 particle and that it decays into two I spin 1 particles, we would expect to have similar behavior in the four-prong sample containing an identified proton. In particular, the events in the beam fragmentation region of the four prongs, the π^+ plays the same role as the π^- in the two-prong sample. Figure 6 shows the distribution of this π^+. As can be seen, this distribution (within the statistics) is quite different from the π^- distribution (fig. 3), particularly in the high energy region.

We believe that the above comments indicate a new phenomenon is occurring in the two-prong events and that a detailed study of this phenomenon is called for. We have tried many Monte Carlo calculations to simulate a final state that might explain our data. These include:

1) $\pi^- + p \rightarrow$ "A^-" $+ P$

$\qquad\qquad\quad \hookrightarrow$ "ρ^-" $+ \pi^0$

$\qquad\qquad\qquad \hookrightarrow \pi^- + \pi^0$

2) $\pi^- + p \rightarrow$ "A^-" $+ p$

"f^0" $+ \pi^-$

$\pi^0 \pi^0$

To match the data with reaction 1), one requires "A^-" with widths less than 100 MeV, "ρ^-" with widths less than 10 MeV and angular distributions like $\cos^6\theta$. We have not found parameters that allow us to match the data with reaction 2). Hence, we believe one has to study in detail the electromagnetic energy associated with the two-prong events.

We would use the information from the photon detector to identify those frames in which there was an event with at least 20 GeV of photon energy. These frames would be scanned for two prongs, and we estimate that we will find 9000 two prongs for an exposure of 10^6 frames at ten tracks per frame. Approximately one third of these will be beam fragmentation events. Hence, the data reduction part of this experiment is quite modest and since the scan of preselected frames for two prongs would have the first priority, we should be able to perform this part of the experiment in a short time.

The gamma ray data will allow us to determine π^0 four vectors and form relevant invariant mass distributions. If there is narrow structure in this final state, we will be able to detect it. In any event, we will be able to determine the character of this final state in an exclusive manner and determine if there are any new physical phenomena involved.

Scope of the Experiment

This experiment will be accomplished by use of the Fermilab 30-inch bubble chamber hybrid system with the addition of a gamma ray detector behind the last PWC plane. A total of 10^6 pictures of $\pi^- p$ interactions at 150 GeV/c is requested. The film will first be scanned for two-prong events associated with at least 20 GeV of forward going electromagnetic energy and the measurement and analysis of the ~9000 events expected could be completed quickly. Then the film will be scanned for all events associated with forward going electromagnetic energy and for all four, six, and eight-prong events. This scanning and the measurement of the events will be carried out by the groups forming the Proportional Hybrid System Consortium (PHSC). If necessary, the number of groups involved in the experiment could be expanded to permit a more rapid reduction of the data.

Table I

Number of Events for 10^6 Pictures with Ten Incident π^- Mesons Per Picture for $\pi^- p$ Interactions at 150 GeV/c

Number of Charged Particles	Number of Events
2	55,000
elastic	35,000
inelastic	20,000
4	46,000
4C	6,300
6	52,000
4C	1,600
8	49,000
$\geq$ 10	75,000
All events	280,000 (11.6 events/μb)

FIGURE CAPTIONS

Figure 1: Scatter plot of the laboratory momentum of the π^- versus the center of mass value of the Feynman x parameter for the proton. The sample is all the inelastic two-prong (π^-, p) events. Shown are our definition of beam fragmentation and target fragmentation regions. Also indicated is the definition of Region III.

Figure 2: For each of the three regions shown in figure 1, we have estimated the electromagnetic intensity seen in the forward direction. The detecting device was two radiation lengths of lead followed by proportional wire planes. The intensity was estimated by the number of struck wires. Bin 0 implies no struck wires and bin 6 implies more than 100 fired wires. As might be expected, in the beam fragmentation region there is relatively more electromagnetic energy seen downstream than for the target fragmentation region.

Figure 3: π^- laboratory momentum for the beam fragmentation region.

Figure 4: π^- laboratory momentum for the whole two-prong inelastic (π^-, p) sample.

Figure 5: For the beam fragmentation region we calculated the missing mass four vector. If this four vector was aimed towards our gamma ray detector, we computed the energy of the missing mass and entered it into this histogram.

Figure 6: The data for this histogram comes from the four-charged prong sample with an identified proton. We made the same cut on the proton as for the two-charged prong sample and then plotted the laboratory momentum of the π^+. Note the events in this sample may or may not have associated missing neutrals.

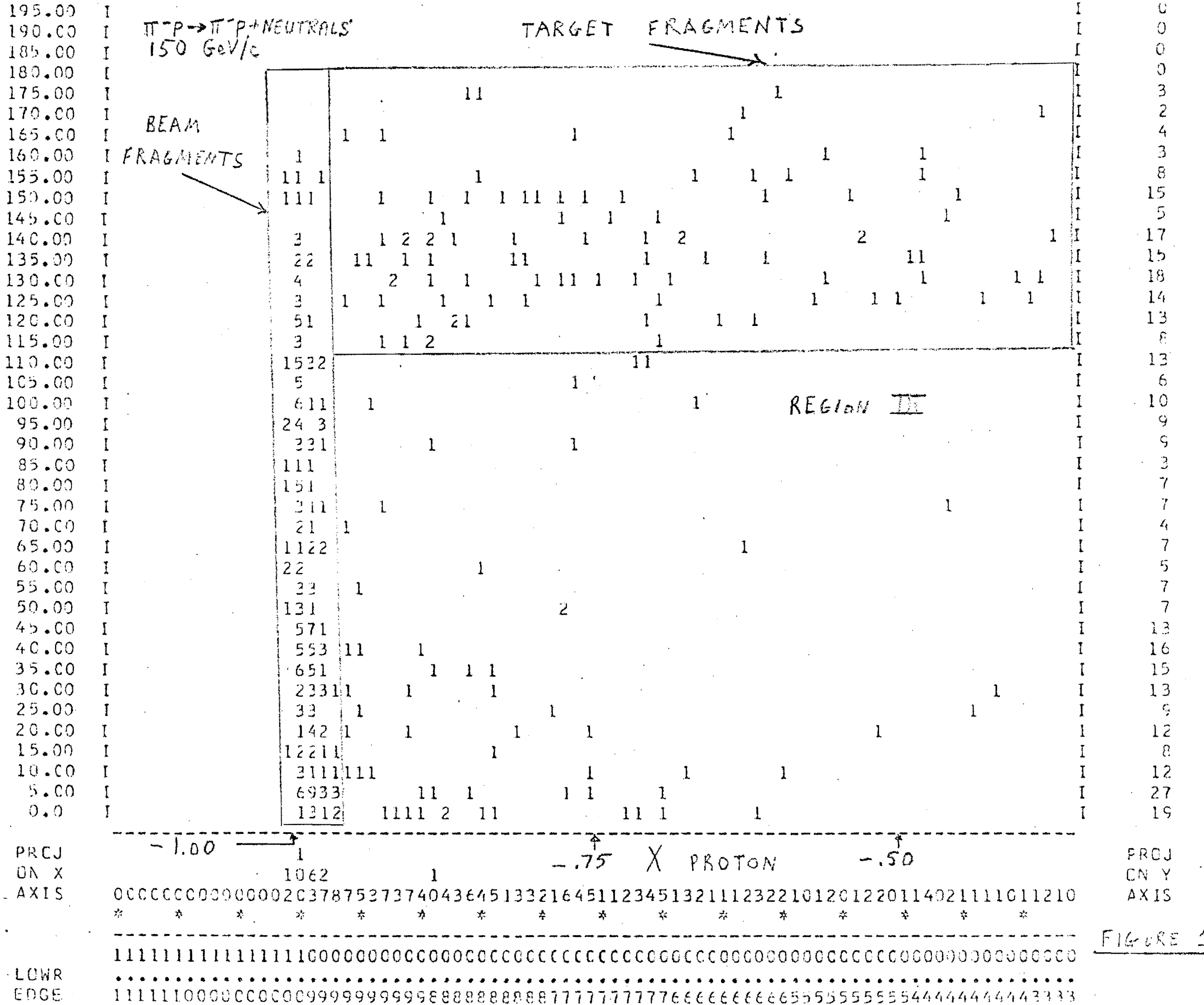

π⁻p → π⁻p + NEUTRALS
150 GeV/c
TARGET FRAGMENTS
BEAM FRAGMENTS
REGION III
P LAB
-1.00
-.75
X PROTON
-.50
PROJ ON X AXIS
PROJ ON Y AXIS
LOWR EDGE

FIGURE 1

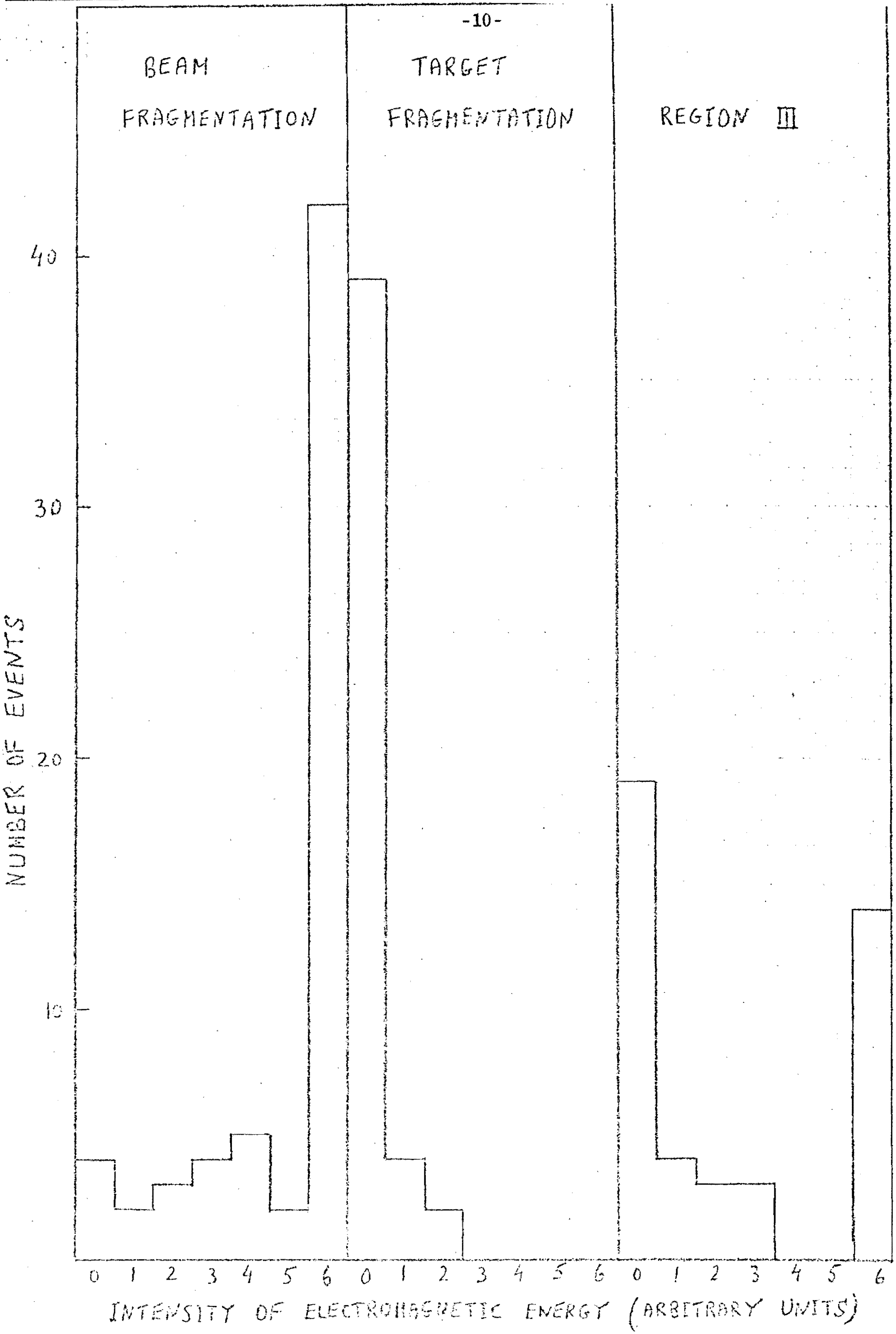
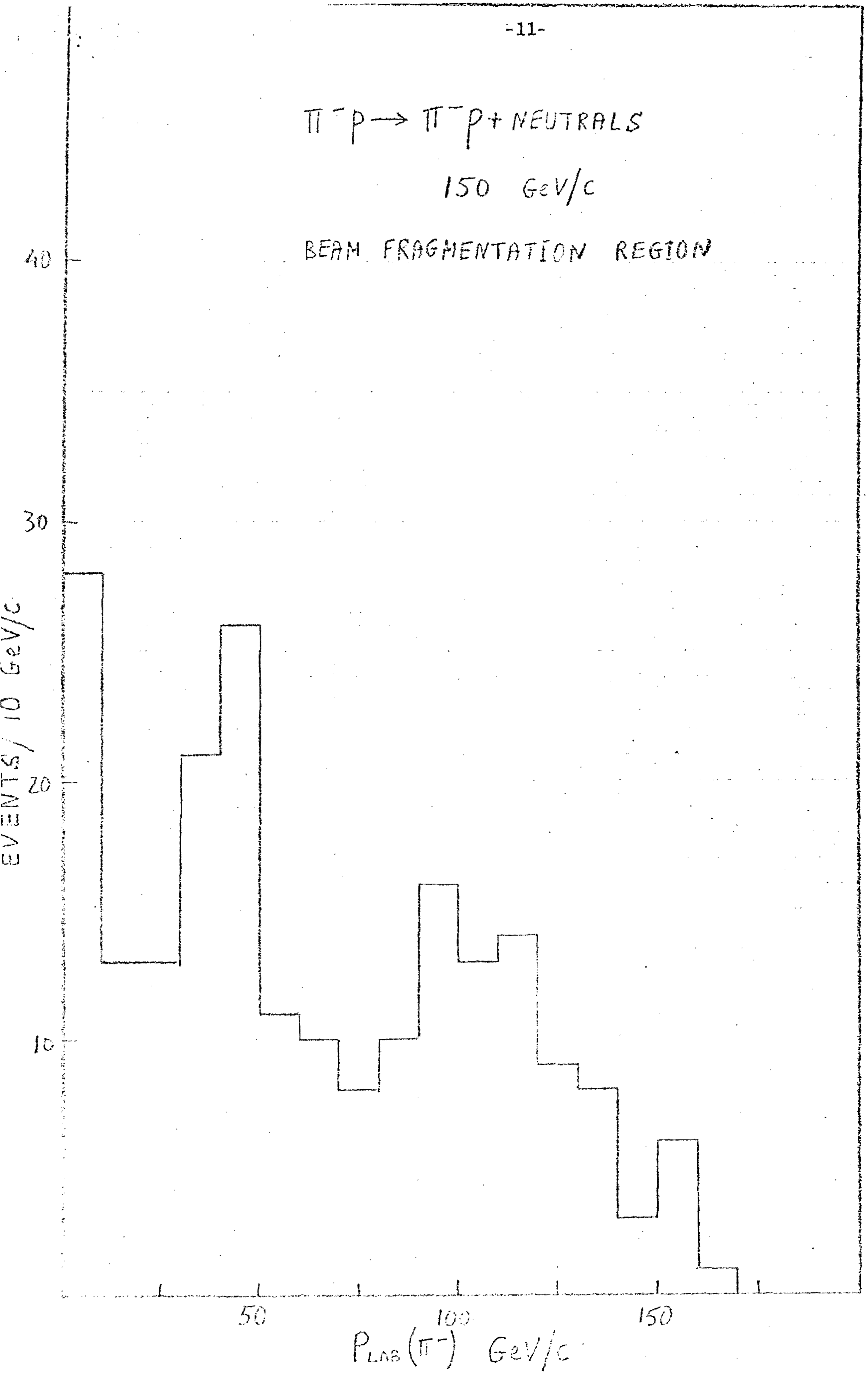
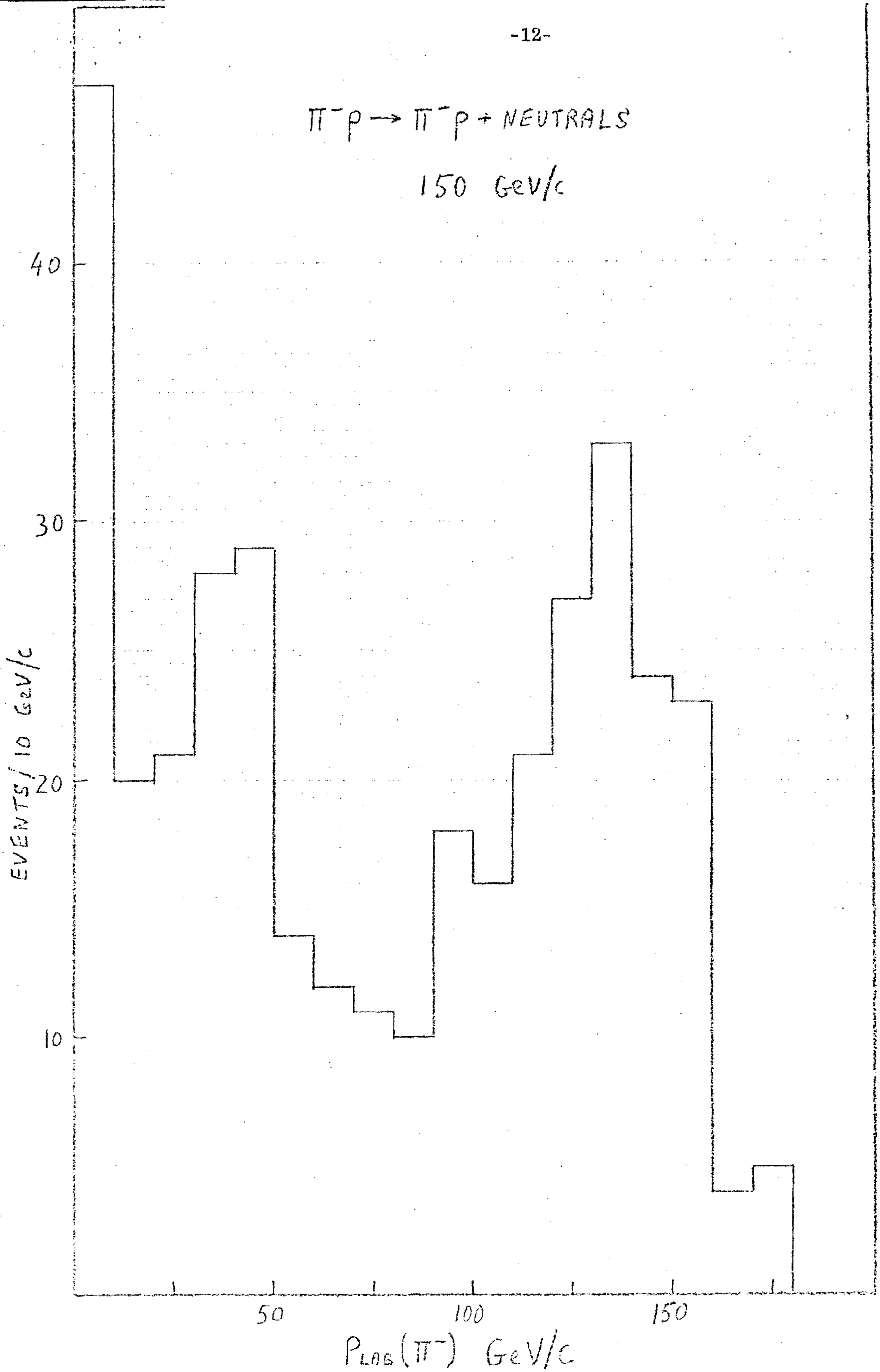

BEAM FRAGMENTATION
TARGET FRAGMENTATION
REGION III
40
30
20
10
NUMBER OF EVENTS
0 1 2 3 4 5 6 0 1 2 3 4 5 6 0 1 2 3 4 5 6
INTENSITY OF ELECTROMAGNETIC ENERGY (ARBITRARY UNITS)

FIGURE .



$\pi^- p \to \pi^- p$ + NEUTRALS
150 GeV/c
BEAM FRAGMENTATION REGION
40
30
20
10
EVENTS / 10 GeV/c
50
100
150
$P_{LAB}(\pi^-)$ GeV/c

FIGURE 3



$\pi^- p \to \pi^- p$ + NEUTRALS
150 GeV/c
40
30
20
10
EVENTS/10 GeV/c
50
100
150
$P_{LAB}(\pi^-)$ GeV/c

FIGURE 4

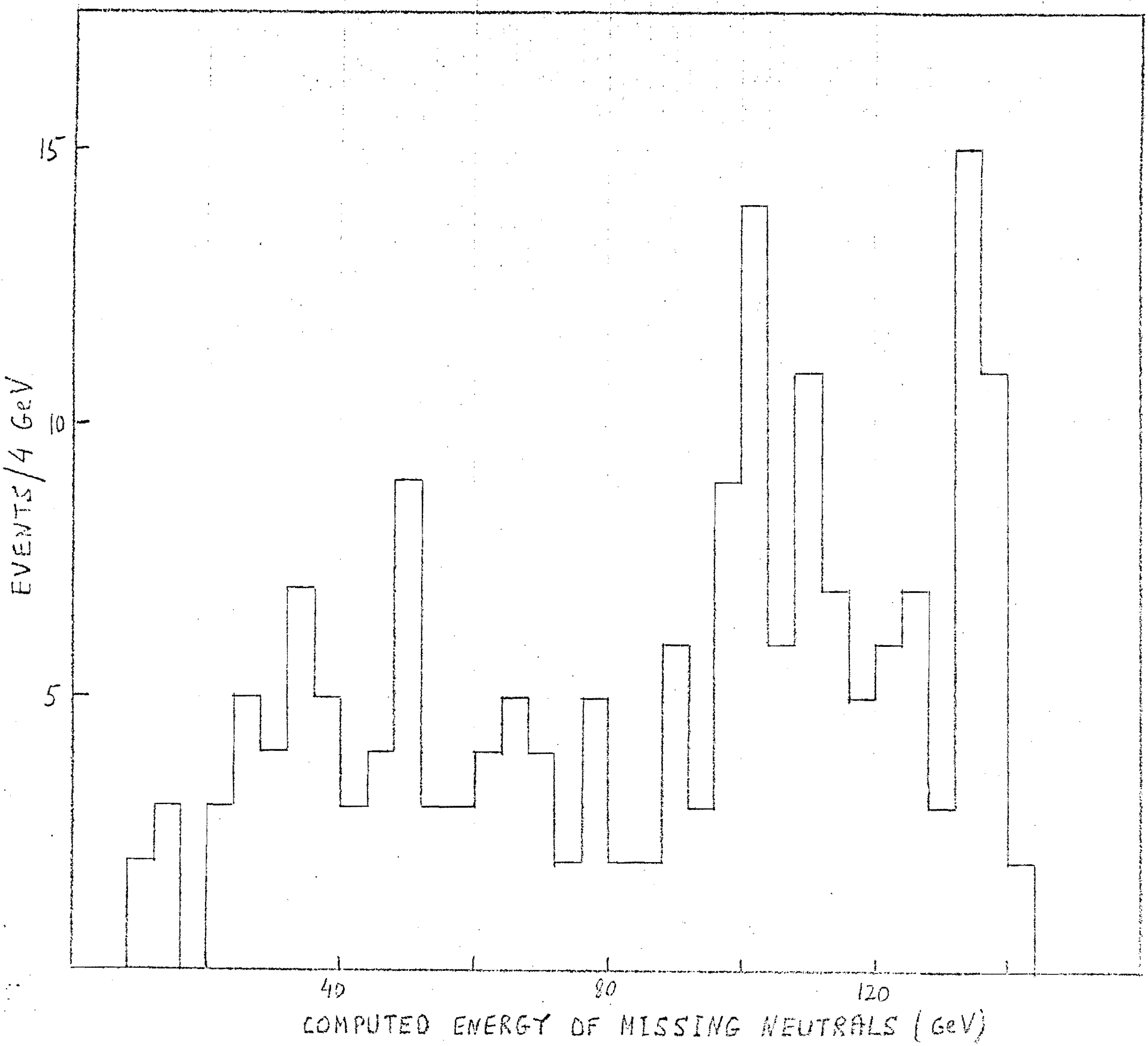
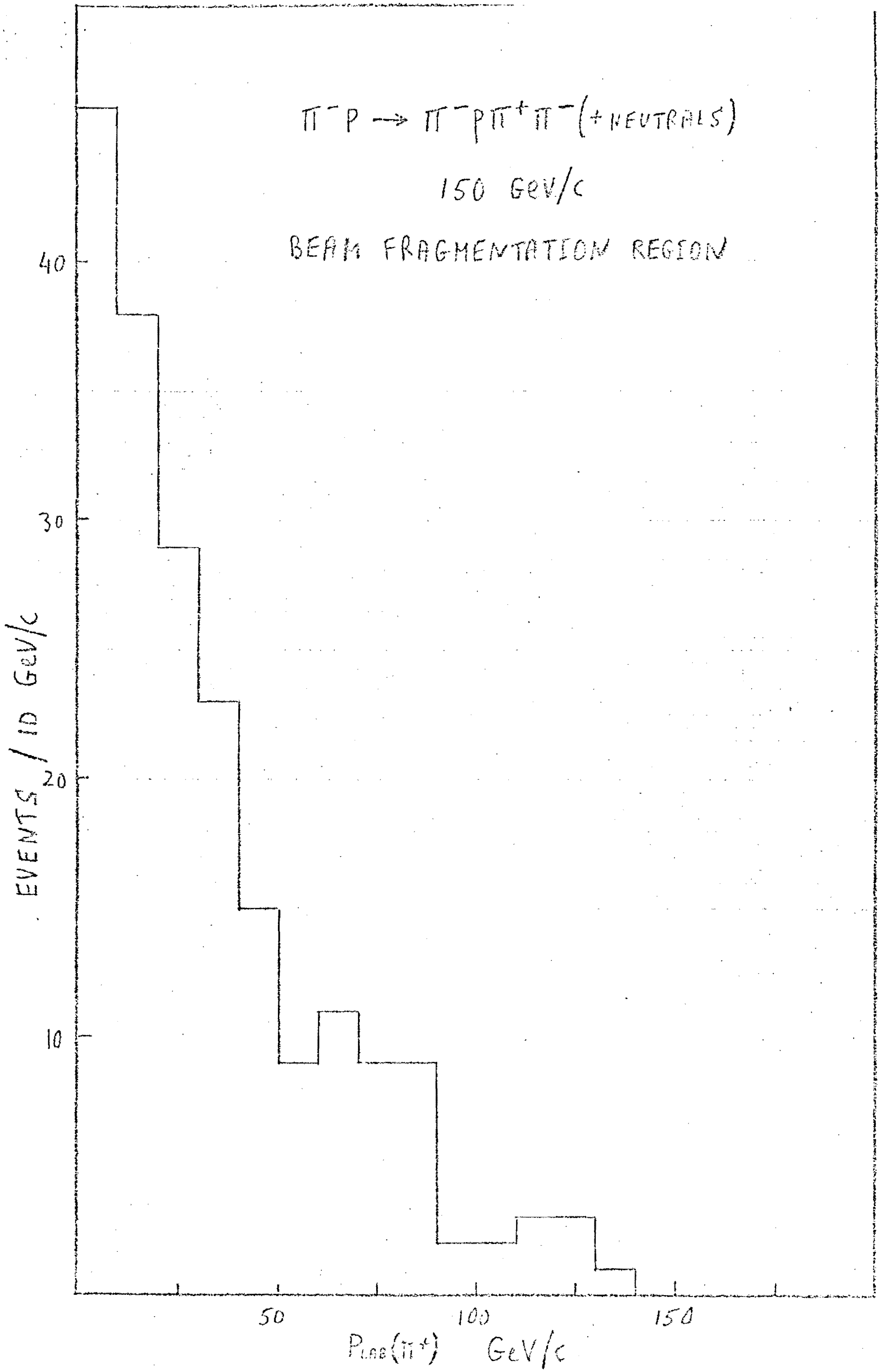

15
10
5
EVENTS/4 GeV
40
80
120
COMPUTED ENERGY OF MISSING NEUTRALS (GeV)

FIGURE 5



$\pi^- p \rightarrow \pi^- p \pi^+ \pi^-$ (+NEUTRALS)
150 GeV/c
BEAM FRAGMENTATION REGION
40
30
20
10
EVENTS / 10 GeV/c
50
100
150
$P_{LAB}(\pi^+)$ GeV/c

FIGURE

Agreement

This is an Agreement between Fermi National Accelerator Laboratory and the experimenters of Proposal No. 299. This document contains an enumeration of the major items needed for the proper execution of Experiment No. 299 as expressed in the proposal for the experiment and subsequent correspondence. A one page summary describing the current research objectives of this experiment as expressed by the experimenters is given in Appendix I.

A. Personnel

1. The experimenters committed to this experiment are: D.G. Fong, M. Heller, A. Janos, A.M. Shapiro, M. Widgoff, Brown University; J.W. Cooper, R. Plumer, R.D. Sard, A.E. Snyder, J. Tortora, University of Illinois; R.A. Burnstein, C. Fu, H.A. Rubin, Illinois Institute of Technology; E.D. Alyea, Indiana University; L. Bachman, C.-Y. Chien, P. Lucas, L. Madansky, A. Pevsner, R.A. Zdanis, Johns Hopkins University; J.E. Brau, J. Grunhaus, E.S. Hafen, R.I. Hulsizer, U. Karshon, V. Kistiakowsky, P.A. Miller, A. Napier, I.A. Pless, P.C. Trepagnier, J. Wolfson, R.K. Yamamoto, Massachusetts Institute of Technology; S. Centro, G. Ciapetti, M. De Giorgi, D. Pascoli, L. Ventura, D. Zanello, Padova/Rome; E.B. Brucker, P.F. Jacques, M.D. Jones, E.L. Koller, T.C. Ou, R.J. Plano, C. Sun, S. Taylor, T.L. Watts, Rutgers University/Stevens Institute/SUNY, Albany; J. Barwick, W. Bugg, H. Cohn, G. Condo, T. Handler, E. Hart, R.D. McCulloch, University of Tennessee/Oak Ridge; D. Bogert, M. Johnson, H. Kraybill, D. Ljung, T. Ludlam, H. Taft, Yale University/Fermilab.

2. In addition, the university groups expect to involve three other physicists, six engineers, three draftsmen, and twelve technicians during various phases of the experiment. In addition, the universities will supply at least two full-time people stationed at Fermilab during the testing and installation period of the drift chambers and gamma ray detectors at Fermilab.

3. R.K. Yamamoto was chosen to be Project Manager to direct all aspects of the design, construction, installation, testing, and initial operation of the drift chamber and gamma ray detector.

4. The scientific spokesman for this Experiment is I.A. Pless.

5. The presently assigned Fermilab liaison physicist is L. Voyvodic

B. Equipment and Beam:

1. The instrumentation and experiment will be done using the N3 beam to the 30-inch hybrid bubble chamber facility located in the neutrino area.

2. The beam will be equipped with appropriate quadrupoles, bending magnets, collimators, and with additional instrumentation as described herein.

3. Fermilab will provide:

a. The secondary beam and beam enclosures	----
b. Instrumentation for tuning and controlling the beam, including Čerenkov counters	(30.0K)
c. The 30-inch Fermilab bubble chamber with manpower for bubble chamber operation and beam line technicians. It is understood that the experimenters will assist in these efforts.	----

d. The film and film processing will be provided by Fermilab. Test strip developing facilities will be available for use during the exposure.	
e. Proportional wire planes with 2" radius active area	$(14.6K)
f. Upstream system and interfaces	(23.3K)
g. Cables, power supplies, etc.	(13.0K)
h. Proportional wire planes with 6" radius active area for downstream system	(19.4K)
i. Downstream systems and interfaces	(10.0K)
j. Cables and power supplies for downstream system	(15.0K)
k. Enclosure for detectors	(2.0K)
l. Data tagging computer - existing PDP-11	(80.0K)
m. The experimenters request the use of an existing computer in Lab A for debugging equipment. Cables and serial read-out equipment must be installed to Enclosure 114.	6.0K
n. Space in bubble chamber high bay area for downstream detecting equipment	-
o. Standard PREP electronics, CAMAC crate and modules (see Appendix II)	78.7K
PREP equipment presently assigned to E154	(1.3K)
p. Cables from bubble chamber high bay area to Laboratory A	(5.0K)
q. Lead glass photo tubes - 48 pieces (existing)	(15.0K)
r. Rigging	5.0K
s. Fast turn around CDC 6600 time (50 hours)	-
New Costs	$ 89.7K
Existing Value	$(228.6K)
Total	$ 318.3K

4. The University experimenters and Oak Ridge National Laboratory will provide:

   a. Drift chamber with 1.2 meter diameter active area and read out system — 40.0K

   b. Lead glass gamma ray detector with .75 meter x .75 meter active area and read out system — 80.0K

   Total New Equipment — $120.0

5. The Fermilab Physics Department will provide:

   a. Computing time on IBM 370/195 (10 hours) — 3.5

   b. Three (3) scanner/measurer-months on Film Analysis Facility with PDP-10. To be decided later. — ---- ----

   c. Funds towards item 4. above — 5.0K

   Total Cost — 8.5K

C. Funding

1. Fermilab funds are available in FY 76 and FY77 for items in Category B3. The Fermilab Neutrino Department budget codes for this experiment are ENU (operating) and EAH (equipment).

2. The budget codes of the university experimenters at Fermilab are ___ (operating) and ___ (equipment). The budget codes for the Fermilab experimenters through the Physics Department are ___ (operating) and ___ (equipment).

3. Each university will approach its funding agency (ERDA, NSF) for an incremental increase of at least $10K. This will provide a base of $90K or greater to fund this experiment. R.K. Yamamoto was chosen to be the treasurer to monitor the university funds. (ORNL will provide $30K to augment the university funds which will be spent mainly on item B. 4a).

D. Special Considerations:

1. It is recognized that the physics under investigation in Experiment #299 has been expressed in two phases. It is understood that Phase II of this investigation is contingent on completion of Phase I and on the approval of a separate proposal by Fermilab.

   a. Phase I - 600 x 10^3 pictures: (approved)

      i. 500 x 10^3 pictures with a mixture of π^+ and p. at 150 GeV/c (158 x 10^3 pictures already have been taken as of the signing of this document)

      ii. 100 x 10^3 pictures of π^- at 150 GeV/c

   b. Phase II - 600 x 10^3 pictures: (requiring a new proposal)

      1. 400 x 10^3 pictures with a mixture of π^+ and p at 150 GeV/c

      ii. 200 x 10^3 pictures of π^- at 150 GeV/c

2. As part of the ongoing program to improve the Fermilab 30-inch hybrid bubble chamber system, the experimenters will design, construct and bring into operation a large drift chamber and a gamma ray detector. These two devices will increase the acceptance of the hybrid system for charged particles and give information on the direction and energy of gamma rays. The experimenters will furnish the equipment described in the body of this document and when the devices are installed, documented and operational, they will be turned over to Fermilab to be operated as a part of the Fermilab bubble chamber spectrometer system.

3. Beam characteristics and bubble chamber operation.

a. Beam will use the available filter to optimize the π^+/p ratio. This will nominally be 1/3 or greater.

b. The nominal beam spill to the bubble chamber should be 100 microseconds or longer.

c. The experimenters will be provided with 35 mm film. The bubble chamber will be operated in a multi-pulse mode during each accelerator cycle.

d. The 30-inch magnet will be operated at approximately 25

e. The film is the property of the Fermi National Accelerator Laboratory and is on loan to the experimenters for an eighteen (18) month period starting with the date of exposure. Following this period the film is to be returned to Fermilab for possible reassignment to other approved research groups unless an extension of the loan has been arranged.

f. The picture count is to be determined by the frame counter. Reasonable care will be taken by the beam line technicians and bubble chamber crews to provide quality pictures.

4. Testing time

a. Experimenters estimate that the installation of the gamma ray detector and drift chamber will take one month. On site testing of the system will require two months. A beam spill of 100 microseconds or longer is required. Beam will be available on a parasitic basis only.

b. A short test run with 5,000 correlated bubble chamber pictures will be required to fully certify the installation.

5. The experimenters will provide all programs, magnetic tapes and consumable items for the on-line computer system.

6. Six (6) copies of all publications or preprints for work done at Fermilab will be sent by the Scientific Spokesman for this experiment to the Director of Fermilab.

E. Experimental Planning Milestones (tentative)

	Relative Time	Estimated Date
1. Construction of prototype lead glass hodoscope	t_o-10 mos.	1 Sept, 197!
2. Beam testing of prototype lead glass system (requiring about 1 week of prime running in N3 hadron beam at 50 GeV)	t_o-9 mos.	1 Oct, 1975
3. Construction of prototype drift chamber	t_o-7 mos.	1 Dec, 1975
4. Test prototype drift chamber (requiring parasitic use of N3 hadron beam)	t_o-6 mos.	1 Jan, 1976
5. Construction of drift chambers	t_o-4 mos.	1 Mar, 1976
6. Construction of gamma ray detector	t_o-4 mos.	1 Mar, 1976
7. Installation of equipment	t_o-3 mos.	1 Apr, 1976

8.	Test of equipment	t_o-2 mos.	1 May, 19
9.	Data collection	t_o	1 July, 1
10.	Completion of experiment	t_o+6 mos.	1 Jan, 19

This Agreement is mutually acceptable to both the experimenters and Fermilab. Circumstances and needs will change as the experimental program develops. This Agreement will be amended when necessary.

James R. Sanford 9/29/75

James R. Sanford (Date)
Fermi National Accelerator Laboratory

Irwin A. Pless 10/10/75

I. A. Pless (Date)
Massachusetts Institute of Technology

Appendix I

Current One-Page Summary of Physics Objectives and Experimental Techniques for Experiment 299

Precision Study of High Energy Collisions Induced by Incident 150 GeV/c Pions and Protons

The experiment will be performed using the Fermilab Proportional Wire Hybrid 30" Bubble Chamber System. A total of 600,000 pictures will be taken of which 500,000 will be with π^+ and protons on hydrogen at 150 GeV/c, and 100,000 with π^- on hydrogen, also at 150 GeV/c.

The objective of the experiment is the study of the following topics:

1) Charged particle multiplicity moments
2) Production spectra for charged and neutral particles
3) Leading particle and diffraction phenomena
4) Correlating in momentum and rapidly among the produced particles
5) Factorization of production amplitudes with respect to the quantum numbers of the incident particle.

In addition, we expect to make a preliminary study of $K^{\pm}p$ and $\bar{p}p$ interactions.

Appendix II

New PREP Equipment for Experiment #299

PREP REQUEST FILE/ SORT BY AFFILIATION

AFFILIATION E299

TYPE CODE	QTY	MFGR	MODEL #	DESCRIPTION	UNIT COST	TOTAL COST
AA	2	ORTEC	401A	NIM BIN	182	364
AB	2	BL PACK	1011	NIM BIN PWR SUPPLY	362	724
AD	5	LECROY	621AL	QUAD DISCRIMINATOR	795	3975
AE	3	LECROY	364AL	4-FOLD LOGIC UNIT	675	2025
AF	2	LECROY	429	LOGIC FAN-IN/FANOUT	545	1090
CA	13	STD ENGR	LCS	CAMAC CRATE	695	9035
CB	13	STD ENGR	1410	CAMAC PWR SUPPLY	850	11050
CG	10	LECROY	2249	CAMAC ADC	2000	20000
CI	13	JORWAY	70A	CRATE CONTROLLER	855	11115
CI	3	GEC-ELL	CBF6501	CAMAC B-H EXTENDER	1000	3000
CJ	3	STD ENGR	MM816C	CAMAC MEMORY CORE	2795	8385
FB	5	POW DES	1570	H V POWER SUPPLY	595	2975
FD	5	FERMILAB	FS-7092	HV DISTRIBUTION BOX	1000	5000

TOTAL QUANTITY IS 79 ITEMS AT A TOTAL COST OF $ 78738

TOTALS:

ALL ITEMS	$ 78738	ALL DELIV ITEMS	$ 0
ALL 'A' ITEMS	$ 7975	ALL OWED ITEMS	$ 78738

Exploratory discussion for setting up a beam line test for the 299 lead glass hodoscope

The following is a suggested outline for determining the important energy and special characteristics of the lead glass hodoscope suggested for the 299 gamma ray detector. This outline is meant to be a reference point of discussion and not a firm commitment on any party.

1. Beam line - Fermilab

   a) Flux density of e^- up to 100 cts/mm^2 in a "few hours" at most.

   b) $\frac{\Delta p}{p} \sim 0.3\%$

   c) $25 < p < 200$ GeV/c

   d) PDP-11 computer plus scope

   e) NIM LOGIC - borrowed

   f) beam counters

2. Remote CAMAC System - Fermilab

   a) CAMAC CRATE

   b) serial crate controller system

   c) parallel to serial converter

   d) 12 channel A to D converter (borrowed or bought)

3. 5 element x, 5 element y 2 dimensional lead glass hodoscope - Fermilab

   a) glass and photo tubes

   b) box

   c) movable carriage

   d) calibration tubes and pulser

   e) cross slide

4. Calibration system and data - PHSC

   a) similar to that described in FGD and PHSC - Fermilab agreement

   b) provide phototube + source + neutral density filter and mount.

   c) use Fermilab neon tube and pulser

5. Binary glass system - Fermilab

   a) glass 12" x 12" by $\frac{1}{2}$", $\frac{1}{2}$", 1", 1"

   b) mount for above

6. Hole counter system - PHSC

   a) two counters

      i) 1" diameter
      ii) $1\frac{1}{2}$" diameter with 3.6 mm diameter hole in center

   b) photo tubes - 56 AVP

   c) bases - 5 nanosecond pulse

   d) two-dimensional cross slides with 4" travel

7. Software - PHSC

   a) data gathering

   b) histograms

8. Off-line computer time - Fermilab-PHSC

As noted above, the outline is not meant to be an agreement but rather the basis for discussion so that an agreement can be reached. The enclosed sketch is just a rough idea of how the test might go.

M. Johnson
I. A. Pless

11 February 1975

Outline for the Joint Construction between the European FGD Collaboration and the American PHSC-Fermilab of a Forward Gamma Detector

The following outline is the result of discussions between Gigi Ventura and Irwin Pless. These discussions followed presentations to the whole PHSC-Fermilab and a subgroup of the PHSC-Fermilab.

The purpose of this outline is to delineate construction ideas and preliminary responsibilities for accomplishing two objectives. The first objective is a preliminary study of the critical parameters of the system. This will involve a test period in the Fermilab beams with a prototype representing a minimal configuration. The second is the construction, installation, and operation of a full-size Forward Gamma Detector in the Fermilab 30" Hybrid Bubble Chamber System, to be used for physics experiments. It is anticipated that the equipment will remain at Fermilab through 1 January 1977.

I. Preliminary Test

A. Size:

1. Full-size along beam direction

2. One quarter area perpendicular to beam direction

B. Components:

1. 4 block 15 x 15 x 60 cm^3

a. Responsibility

i. FGD

2. 30 x 30 cm^2 two coordinate scintillation hodoscope

a. Responsibility

i. FGD

3. 31.5 x 31.5 cm^2 two coordinate lead glass hodoscope

a. Responsibility

i. PHSC-Fermilab

I. B. 4. 30 x 30 cm^2 three coordinate PWC hodoscope

a. Responsibility

i. PHSC-Fermilab

5. 64 Channel ADC - 10 bit

a. Responsibility

i. FDG - borrowed

ii. PHSC-Fermilab - borrowed

6. NIM Logic

a. Responsibility

i. PHSC-Fermilab

7. Calibration phototubes - 2 each

a. Responsibility

i. FGD

8. Movable Carriage

a. Responsibility

i. PHSC-Fermilab

II. Operational Hardware

A. Size:

1. 30 radiation lengths along beam direction

2. 60 x 60 cm^2 perpendicular to beam direction

B. Components

1. Lead glass counter

i. 16 blocks 15 x 15 x 60 cm^3

a. Responsibility

i. FGD

ii. PHSC-Fermilab

$\bar{2}$. Calibration tube and two-dimensional remote control [1]

a. Responsibility

i. FGD

ii. PHSC-Fermilab

$\bar{3}$. Nitrogen box

a. Responsibility

i. PHSC-Fermilab

2. Vertex hodoscope

$\bar{1}$. 60 x 60 cm^2 three coordinate scintillation hodoscope

a. Responsibility

i. FGD

b. Calibration tube and remote control system [1]

a. Responsibility

i. FGD

$\bar{2}$. Nitrogen box

a. Responsibility

i. FGD

3. Lead glass hodoscope

$\bar{1}$. 62.5 x 62.5 cm^2 two coordinate lead glass hodoscope

a. Responsibility

i. PHSC-Fermilab

$\bar{2}$. Calibration tube and one-dimensional remote control [4]

a. Responsibility

i. FGD

ii. PHSC-Fermilab

$\bar{3}$. Nitrogen box

a. Responsibility

i. PHSC-Fermilab

4. Drift chamber

1. 120 x 120 cm^2 drift chamber

a. Responsibility

i. PHSC-Fermilab

5. Mechanical mount

1. Two-dimensional remote control mechanical mount for items 1, 2, 3, 4, and 5.

a. Responsibility

i. PHSC-Fermilab

6. Calibration device [6 each]

1. Tubes - nuclear services - ADC - Self Trigger - LED

a. Responsibility

i. FGD

This document just records, as mentioned above, informal discussions between Drs. Ventura and Pless. This document is not meant to be a binding commitment but,rather, a basis for discussion before any final commitments are made. In particular, the attached rough sketch is only that; much effort must be expended before these crude ideas become a working scheme.

G. Ventura

I. Pless

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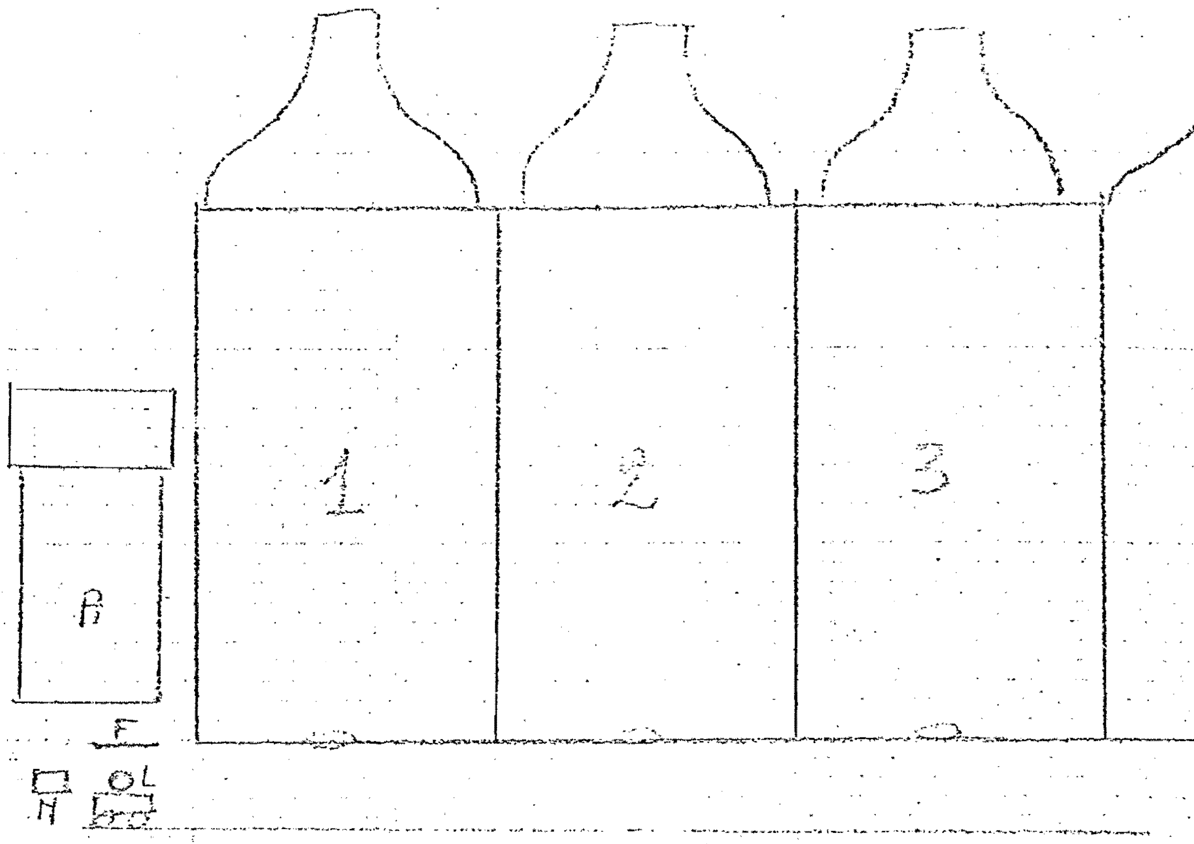

A is a reference PM, whose gain is kept constant by monitoring the light pulses from the NaI (Am 241 doped) source N. The LED L can be moved, by computer control, over the central region of the faces of lead glass blocks 1, 2, 3, etc. to control the stability of their gains, and over A to check for shifts in the light output of L itself. Since for the lead glass counters a pulse intensity is needed equivalent to the light from a shower of several tens GeV, while the pulses from N correspond to or ~ 1 GeV shower, an attenuating filter F is set between L and the photocathode of A, so as to roughly equalize its outputs for L and N.