FERMILAB-CONF-81-096-E

Rockefeller University
Report No. DOE/ER/40033-10

(RU 81/A-10)
E-612 at Fermilab

MEASUREMENT OF $\gamma p \to Xp$ AT LOW t AND HIGH ENERGIES

T.J. Chapin, R.L. Cool, K. Goulianos, K.A. Jenkins, J.P. Silverman,
G.R. Snow, H. Sticker and S.N. White

The Rockefeller University, New York, NY 10021

and

Y.H. Chou

Institute of High Energy Physics
Beijing, The People's Republic of China

FERMILAB

DEC 1 1981

LIBRARY

We have studied the reaction $\gamma p \to Xp$ at high energies and low t at the tagged photon laboratory at Fermilab using our recoil detector TREAD (The Recoil Energy and Angle Detector). TREAD is a high pressure hydrogen gas time projection chamber that serves both as a target and as a detector of the recoil protons. The angle of the proton is obtained from the drift time of the ionization deposited in TREAD. The ionization drifts up to 75 cm in a high electric field (2 kV/cm) and is amplified and collected by sense wires mounted on end plates. The recoil energy is determined from the quantity of light the protons produce by stopping in scintillation counters. We present details of the apparatus as well as data on the missing mass distribution and we test factorization rules.

Contributed to the 1981 International Symposium on
Lepton and Photon Interactions at High Energies
24 - 29 August 1981, Bonn, Germany

We present preliminary results of an experiment, running at the Fermilab Tagged Photon Laboratory (TPL), which measures the diffraction dissociation of photons on hydrogen, $\gamma p \rightarrow Xp$, in the region $M_x^2 < 40$ GeV^2, momentum transfer squared $|t| < 0.1$ (GeV/c)^2 , and photon energies $70 < p_\gamma < 170$ GeV. The experiment is designed to study the known resonances, to search for new resonance structures, and to measure the low t missing mass continuum. In hadron dissociation the missing mass distribution can be understood as arising from Pomeron exchanges[1,2] in the Regge model. In particular, the hadron diffractive cross sections vary predominantly as $1/M_x^2$ and scale to the corresponding total cross sections, behaviour which is well described by the Triple Pomeron coupling. This experiment tests this behaviour for the photon, which is only partly hadronic in nature, to see whether the underlying dynamics is similar.

In this paper we only summarize the construction and performance of the apparatus; details are given in another paper[3]. The experiment uses the recoil technique to measure the missing mass from a photon-proton interaction. The recoil detector (see Fig. 1) is a unique high pressure time projection chamber (TREAD - The Recoil Energy and Angle Detector) that measures the energy and polar angle of recoil protons in the region $10 < T < 50$ MeV and $45^0 < \theta < 90^0$. The variables t and M_x^2 are determined from the measured quantities p_γ, T, and θ ,

$$t = -2M_p T \tag{1}$$

$$M_x^2 = 2p_o \sqrt{|t|} \left(\cos\theta - \sqrt{|t|}/2M_p\right) \tag{2}$$

where M_p is the mass of the proton and p_γ is the photon energy. The tagging system in the TPL provides the photon energy to 2%. The high pressure chamber is filled with hydrogen, allowing it to act as the target as well as the recoil track detector. This obviates the use of windows between the target and detector region. TREAD consists of two cylindrical drift regions arranged in tandem, each 45 cm in diameter and 75 cm long. The beam is directed along the axis of the cylinder. An electric field is established between a plate at the center of the cylinder and the end plates. Ionization electrons from recoiling protons drift along the elctric field lines to the end plates where they are detected by a set of concentric octagonal sense wires. The pulse height is also obtained, providing the energy loss of the recoil protons, dE/dx. The kinetic energy of the recoils is determined by stopping them in plastic scintillation counters located inside the pressure vessel. Typically, at 15 atmospheres with 2 kV/cm (130 kV on the HV plate) drift field and 7 kV on the 35 μm diameter sense wires, the drift velocity is 0.5 cm/μsec and the spatial resolution is 200 μm. Under these conditions, TREAD achieves a resolution of $\Delta M_x^2/M_x^2 = 0.03$ in the region $0.05 < M_x^2/s < 0.1$, limited largely by the multiple scattering of the protons in the hydrogen gas. This level of performance demands tight controls on variations in the electric field, in the pressure, in the temperature, and in contamination by oxygen and other impurities that attenuate the sense wire signal. The electric field was shaped to the necessary accuracy by a cylindrical cage made of wires that carried a graded potential from the high voltage to the ground. The temperature was maintained constant by an

automatically controlled heating jacket surrounding the vessel. A transducer controlling input and output solenoid valves maintained the pressure. The gas was kept at the necessary level of purity by recirculating it through a purifier consisting of catalytic converters followed by molecular sieves. Analog information, such as the drift time and pulse height in the chamber and the gain of the phototubes, was monitored with alpha sources mounted either in the chamber or on the counters.

Fig. 2 shows a scatter plot of the recoil kinetic energy against dE/dx measured by the wires. The prominant band represents the recoil protons for which the energy loss varies as 1/T. Multiplying dE/dx times T produces Fig. 3. The peak contains the recoil protons.

As a test of the performance of TREAD, and to compare with hadronic reactions, we ran with a 170 GeV/c π^- beam and collected data on the reaction $\pi^- p \rightarrow Xp$. The missing mass, calculated by Eq. (2), is shown in Figure 4. The peak is due to elastic scattering. We find that the high mass cross sections are consistent with the more precise data of experiment E-396[1)] at Fermilab in which the same recoil technique was used but the recoil angle was measured with small drift chambers rather than with a time projection chamber. Preliminary results for photon dissociation are shown in Fig. 5. The prominant peak is the ρ . If we normalize the high mass cross sections to the total cross sections of each particle, we find that up to about 15 GeV^2 the pion and the photon cross sections are the same to 10% statistical accuracy. Above 15 GeV^2 the photon cross section becomes higher than the pion cross section.

REFERENCES

1) R.L. Cool, K. Goulianos, S.L. Segler, H. Sticker and S.N. White, "Diffraction Dissociation of $\pi^{\pm}$, $K^{\pm}$ and $p^{\pm}$ at 100 and 200 GeV/c," (submitted to Phys. Rev. Letters).

2) Y. Akimov et al., Phys. Rev. Lett. 39, 1432 (1977); R.L. Anderson et al., Phys. Rev. Lett. 38, 880 (1977); D.S. Ayres et al., Phys. Rev. Lett. 37, 1724 (1976); R.D. Schamberger et al., Phys. Rev. D17, 1268 (1978); M.G. Albrow et al., Nucl. Phys. B108, 1 (1976); Y. Akimov et al., Phys. Rev. Lett. 35, 766 (1975).

3) T.J. Chapin et al., "Development and Performance of a High Pressure Hydrogen Time Projection Chamber," Rockefeller University Report No. RU81/A-9, submitted to Nuclear Instruments & Methods.

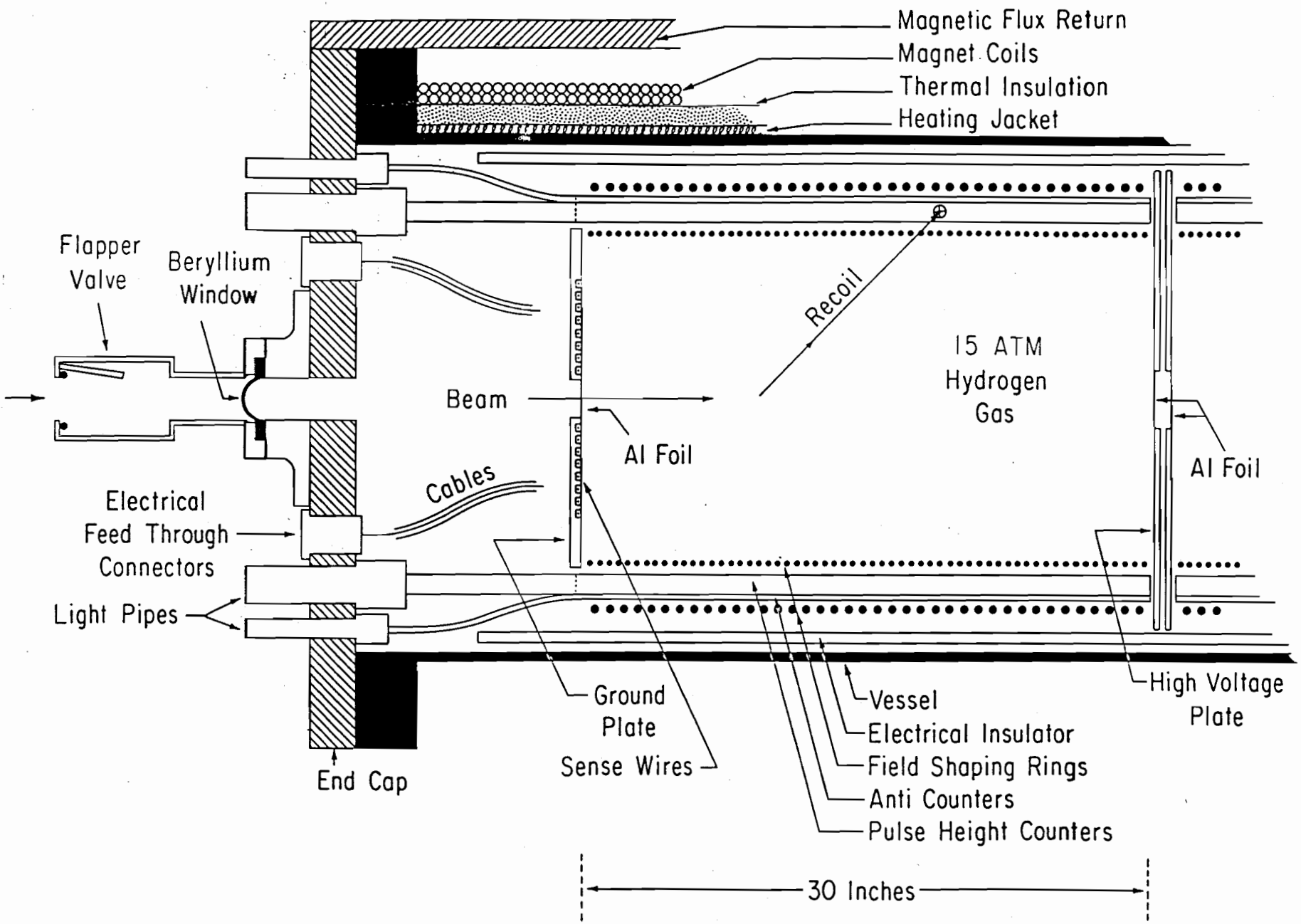
Magnetic Flux Return
Magnet Coils
Thermal Insulation
Heating Jacket
Flapper Valve
Beryllium Window
Recoil
15 ATM Hydrogen Gas
Beam
Al Foil
Al Foil
Cables
Electrical Feed Through Connectors
Light Pipes
Ground Plate
Sense Wires
Vessel
Electrical Insulator
Field Shaping Rings
Anti Counters
Pulse Height Counters
High Voltage Plate
End Cap
30 Inches

FIGURE 1

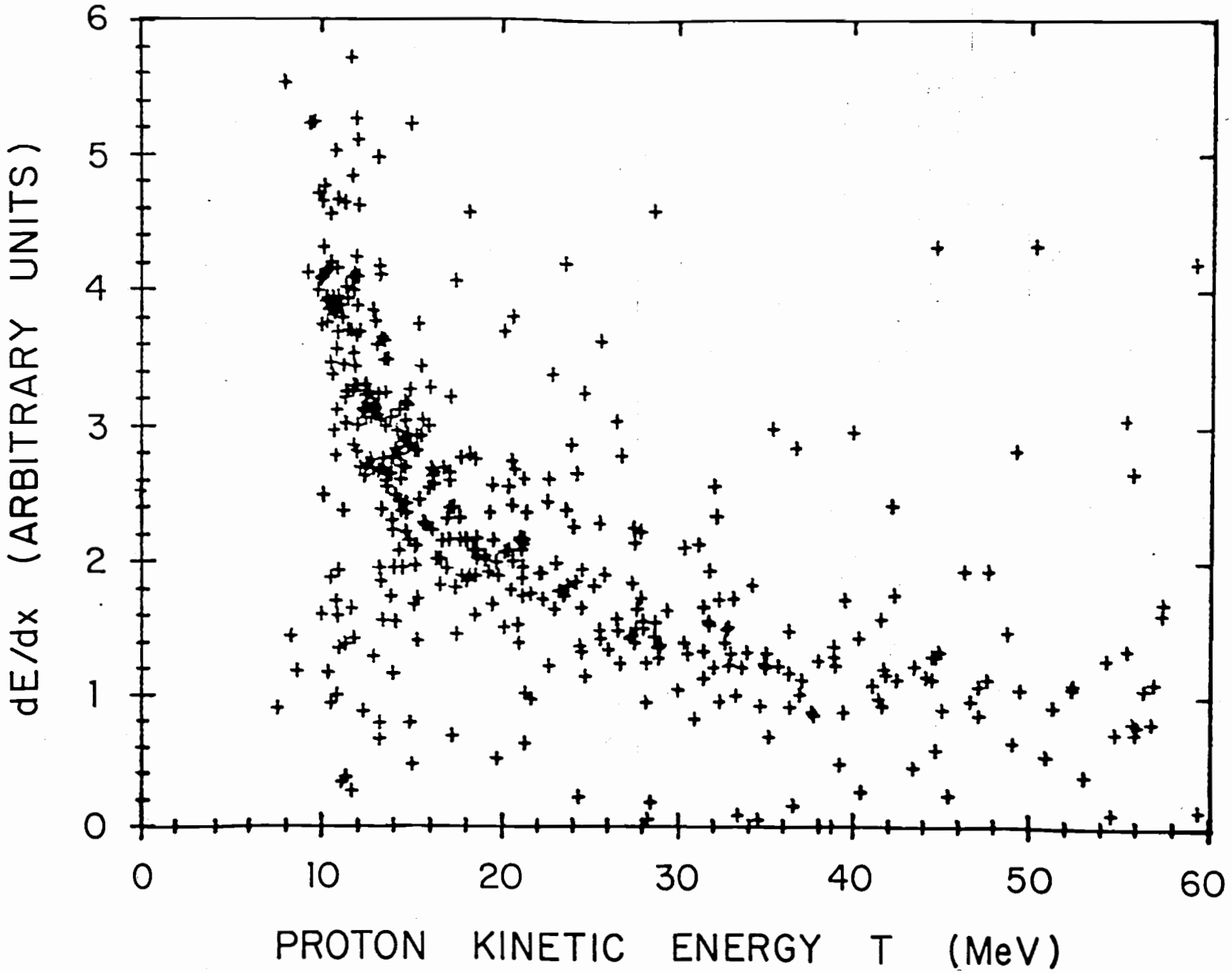
dE/dx (ARBITRARY UNITS)
0
1
2
3
4
5
6
0
10
20
30
40
50
60
PROTON KINETIC ENERGY T (MeV)

FIGURE 2

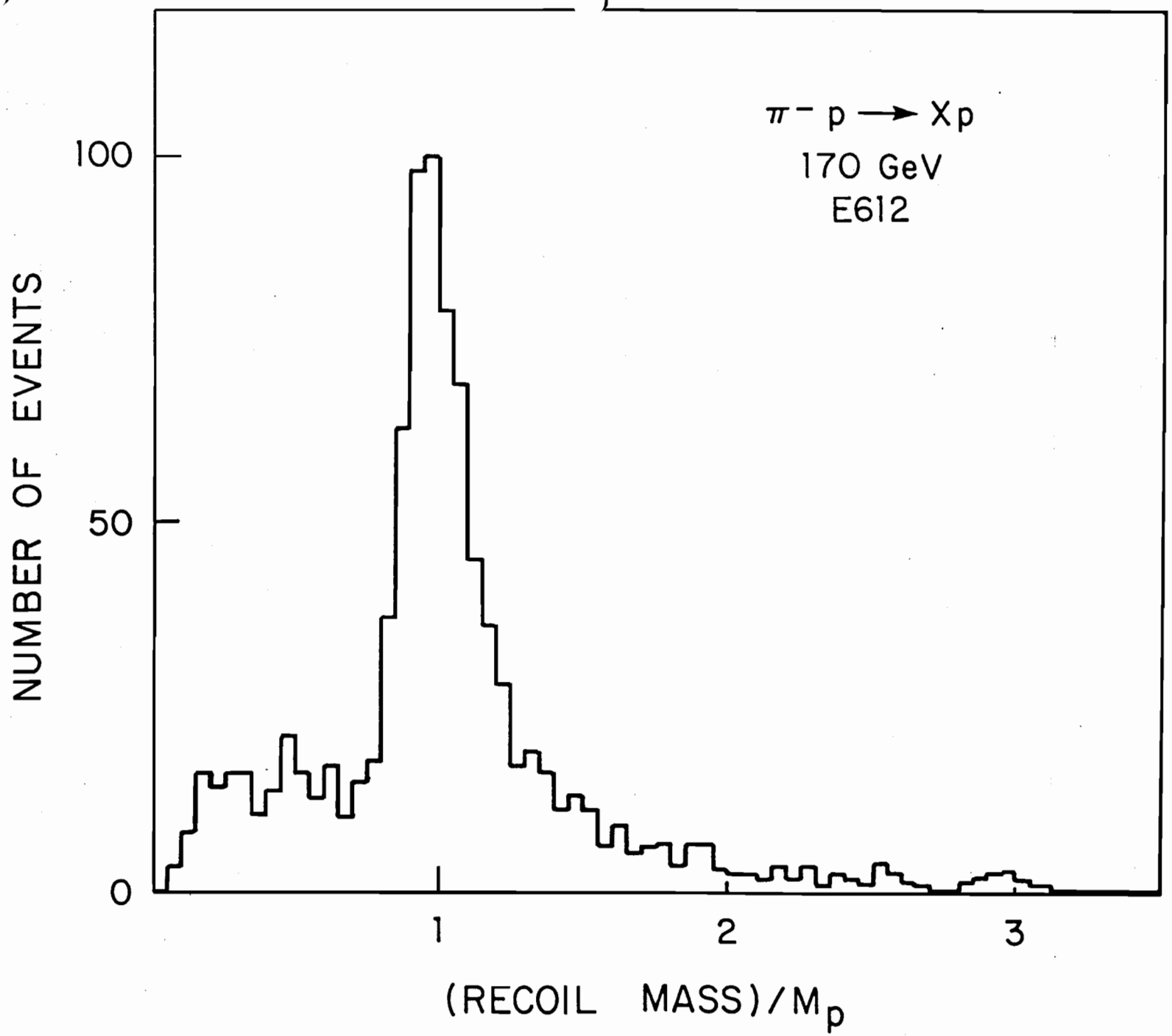
$\pi^- p \rightarrow Xp$
170 GeV
E612
NUMBER OF EVENTS
100
50
0
1
2
3
(RECOIL MASS)/M_p

FIGURE 3

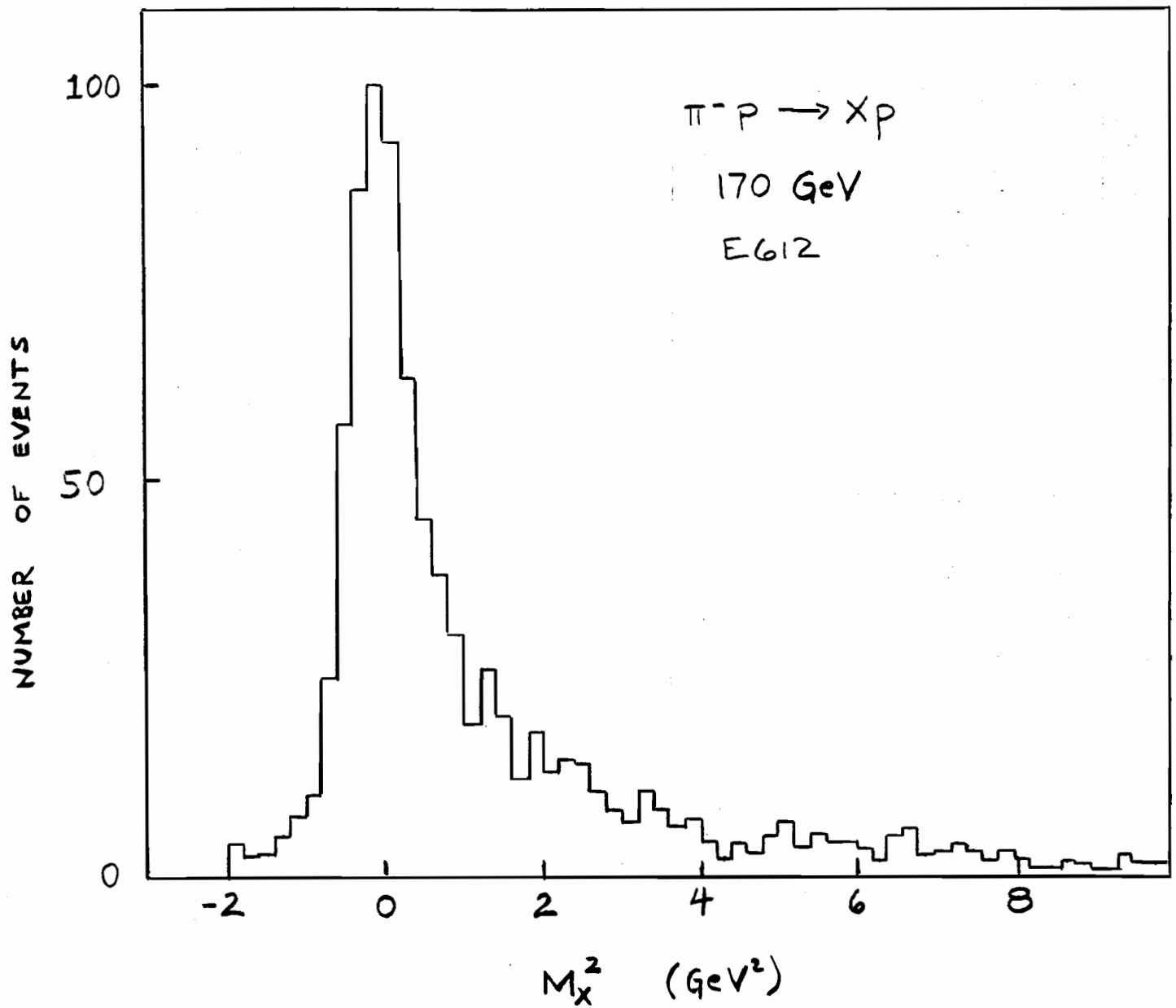
$\pi^- p \longrightarrow Xp$
170 GeV
E612
NUMBER OF EVENTS
100
50
0
-2
0
2
4
6
8
M_X^2 (GeV^2)

FIGURE 4

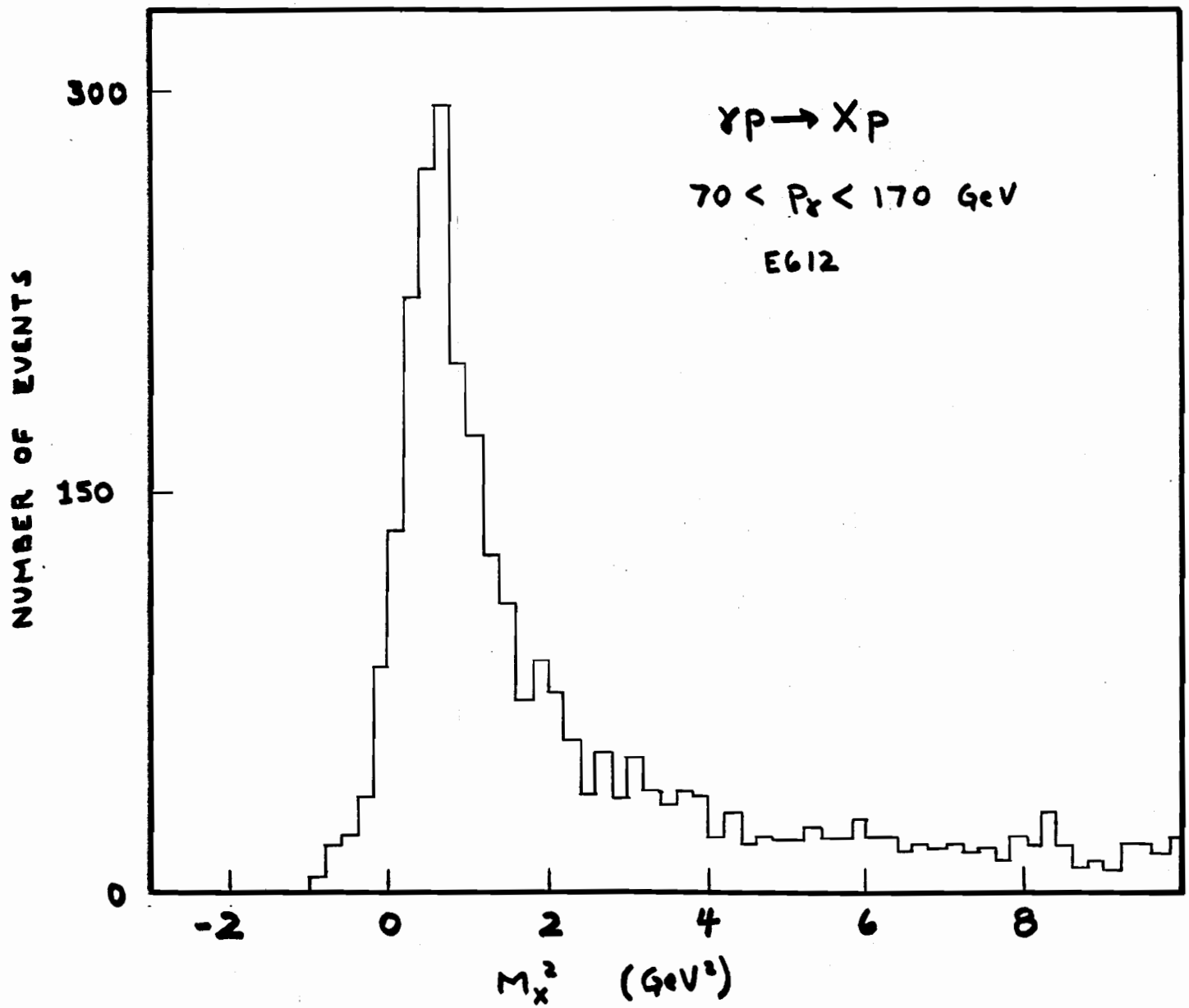
γp → Xp
70 < Pγ < 170 GeV
E612
NUMBER OF EVENTS
300
150
0
-2
0
2
4
6
8
Mx² (GeV²)

FIGURE 5