FNAL Experimental

Proposal No. 464

Spokesman: F. Grard

A proposal to study diffractive processes in K^+p interactions at 150 GeV/c

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ABSTRACT

We propose an investigation of diffractive processes in K^+p interactions at 150 GeV/c. For this purpose we require a sample of 10000 K^+p interactions in the FNAL 30" bubble chamber using the Proportional Wire Hybrid System (PWHS).

INTRODUCTION

As a continuation of the systematic study of K^+p interactions which has been performed by our group during many years, we propose an exposure of the FNAL 30" bubble chamber Proportional Wire Hybrid System to an enriched K^+ beam at a momentum close to 150 GeV/c[1]. The number of pictures required depends on the percentage of K^+ in the beam and should be choosen to provide about 10000 K^+p interactions, corresponding to a statistics of ∿ 0.5 event/μb[2].

A determination of topological cross sections and related quantities may be obtained from raw scanning data. Furthermore several interesting features of the proposed experiment have been described in another proposal[3]. We would like to insist here on some special aspects of the diffractive processes which in a first stage will be our main subject of interest in this experiment. We expect indeed diffractive events to be dominant among 4C fits and to account for a sizable fraction of the inclusive reactions

$$K^+p \rightarrow p\ X \qquad (1)$$

and

$$K^+p \rightarrow K^+X \qquad (2)$$

With our present knowledge of K^+p interactions at 32 GeV/c[4] – the highest momentum available outside FNAL – we feel that even a small sample of K^+p events in an entirely new energy region will contribute significantly to our understanding of the diffractive interaction mechanism. Furthermore, since the total K^+p cross section starts to rise around 25 GeV/c, we may expect that some features already observed at Serpukhov energies will appear more clearly at 150 GeV/c where the distinction between diffractive and non-diffractive events is much easier.

FOUR-CONSTRAINT REACTIONS

4-C fits to inelastic reactions are expected only in the lowest topologies, namely 4 and 6 prongs. With the requested statistics we expect to obtain a significant number of fits to the following reactions:

$$K^+p \rightarrow K^+p\pi^+\pi^- \qquad (3)$$

$$K^+p \rightarrow K^+pK^+K^- \qquad (4)$$

$$K^+p \rightarrow K^+p(2\pi^+)(2\pi^-) \qquad (5)$$

$$K^+p \rightarrow K^+p\ K^+\pi^+K^-\pi^- \qquad (6)$$

a) The energy dependence of reaction (3) has been found to follow a $p^{-0.71}$ law for incident momenta between 5 and 16 GeV/c[5]. However the cross section at 32 GeV/c[6] is significantly higher than the extrapolated value (630 ± 40 μb instead of ∿480 μb). This behaviour is clearly due to the fact that the reaction is entirely dominated by diffractive processes at 32 GeV/c while at lower energies competing mechanisms contribute. At 150 GeV/c we may thus expect a cross section of the order of 500 μb, much closer to the value obtained at 32 GeV/c than to the value extrapolated from the 5-16 GeV/c data (∿140 μb)(fig.1).
At 32 GeV/c it can be seen on the scatter plot of $M(K\pi\pi)$ vs. $M(p\pi\pi)$ that respectively ∿ 50 % and ∿ 35 % of the events of this reaction correspond to the beam and the target fragmentation (fig.2). The events corresponding to the beam fragmentation may be mostly assigned to the channels

$$K^+p \rightarrow pQ \qquad (\sim 2/3) \qquad (7)$$

and $$K^+p \rightarrow pL \qquad (\sim 1/3) \qquad (8)$$

We expect similar proportions to hold at 150 GeV/c. A determination of the cross sections of these various channels will certainly contribute to a better understanding of their nature.

b) Reaction (4) is dominated by the production of a low mass KKK system and its cross section is almost constant from 8 to 32 GeV/c[7] (∿35 μb). If this behaviour persists up to 150 GeV/c the number of events is expected to be small but would enable us to determine the total cross section with an accuracy of ∿ 25 %.

c) The cross section of reaction (5) decreases from ∿250 μb at 8.25 GeV/c to (160 ± 20) μb at 32 GeV/c. Assuming a power law decrease the total cross section should be of the order of 100 μb at 150 GeV/c. It is however likely that a change in the energy dependence-similar to the one observed in reaction (3) - will occur and that the cross section will fall somewhere between 100 and 160 μb. The sample will contain some single diffraction (i.e. fragmentation of the beam or the target into 5 particles) as well as double diffraction. A comparison between the number of double diffractive and simple diffractive events in reactions (3)(4)(5) will provide a simple test of factorization.

d) Very little is known about reaction (6) which has practically never been analyzed at lower energies. Preliminary data at 32 GeV/c suggest that its cross section could be as high as 50 μb (i.e.>1/4 of that of reaction (5)). At 150 GeV/c we may hope to obtain an estimate of the total cross section of this reaction if the kinematical ambiguities with reaction (5) are not to severe or if the final state kaons can be unambiguously identified by the PWHS.

INCLUSIVE REACTIONS

a) Reaction (1) is quite suitable for a bubble chamber experiment since most of the final state protons are easily identified by their bubble density. At 32 GeV/c about one inelastic event out of three contains a low momentum proton[8] (P<1.2 GeV/c). These protons are found almost exclusively in the lowest topologies (i.e. 2-4-6 prongs).

For 2 and 4-prong events the distribution of the missing mass to the proton shows a clear enhancement near its lower edge corresponding to the fragmentation of the beam particle (fig.3). The size of this enhancement (∿ 1 mb at 32 GeV/c), its position and the topologies in which it occurs will be compared with the existing data at lower energies and with those obtained in similar reactions induced by different beam particles. The results may be easily obtained since only the position of the vertex and the momentum and the emission angles of the proton are needed.

b) On the other hand reaction (2) is not analysable in a bare bubble chamber experiment since the fast forward kaons cannot be properly identified. Recent results of a counter experiment at 10 and 14 GeV/c(have shown that the momentum transfer distribution strongly depends on the missing mass recoiling against the kaon. The slope is much higher than for elastic scattering when the missing mass is near its minimum value, falls to 3-4 GeV^{-2} for $M_X \approx 1.8$ GeV and remains constant for higher values of the missing mass. This phenomenon is practically independ nt of the incident energy between 10 and 14 GeV but it should be checked over a much broader range.

BEAM AND CHAMBER REQUIREMENTS

To obtain the physical results presented in the previous sections an unambiguous identification of the incident kaons is required. The total number of incoming tracks should not exceed 5 per picture to avoid difficulties at the scanning and measurement stages. The momentum of the fast outgoing particles should be measured by external detectors with an accuracy of a few percent to obtain meaningful 4C fits and to reduce the kinematical ambiguities to an acceptable level.

Identification of the fast outgoing kaons is obviously needed for the analysis of reaction (2). If not available it will still be possible - and meaningful - to analyze all the other reactions, knowing that at least a fraction of the outgoing kaons will be identified by the kinematical constraints.

EXPERIMENTAL EQUIPMENT AND MANPOWER

The group submitting this proposal has a long experience in bubble chamber physics and, more specifically, in the analysis of K^+p interactions. The analysis of a 32 GeV/c experiment with a statistics of ∿10 events/μb is presently underway. Our automatic measuring device (SWEEPNIK) will be fully available for the proposed experiment and the requested sample could be completely measured in ∿ 6 months. The laboratory is linked to a CDC6600 and the physicists involved in the experiment are familiar with the CERN geometry and kinematics programs. They are ready to collaborate with any other group interested in the same experiment.

REFERENCES

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"Enriched particle beams for the bubble chambers at the Fermi Accelerator Laboratory" (June 1974).

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"Total cross sections of $\pi^{\pm}$, $K^{\pm}$, p and $\overline{p}$ on protons and deuterons between 23 and 280 GeV/c". (Submitted to Phys. Letters)

3. FNAL experimental proposal 375: "Studies of K^{+}-meson collisions with protons at an incident momentum close to 150 GeV/c"

4. See for instance: "P.V. CHLIAPNIKOV. "New results on $K^{+}p$ and $K^{-}p$ reactions at Serpukhov" (Invited talk at the International Conference on High Energy Physics - Palermo, June 1975).

5. G. CIAPETTI et al. - Nucl. Phys. B64 (73)58

6. France - Soviet-Union and CERN -Soviet-Union collaborations:
"$K^{+}p$ elastic scattering and cross sections for 4C-fit channels at 32 GeV/c" (presented at the Palermo Conference, June 1975).

7. J.N. CARNEY et al. - Physics Letters 55B (1975) 117

8. France-Soviet-Union and CERN - Soviet-Union collaborations:
"Study of the inclusive reaction $K^{+}p \rightarrow pX$ at 32 GeV/c" (presented at the Palermo conference, June 1975).

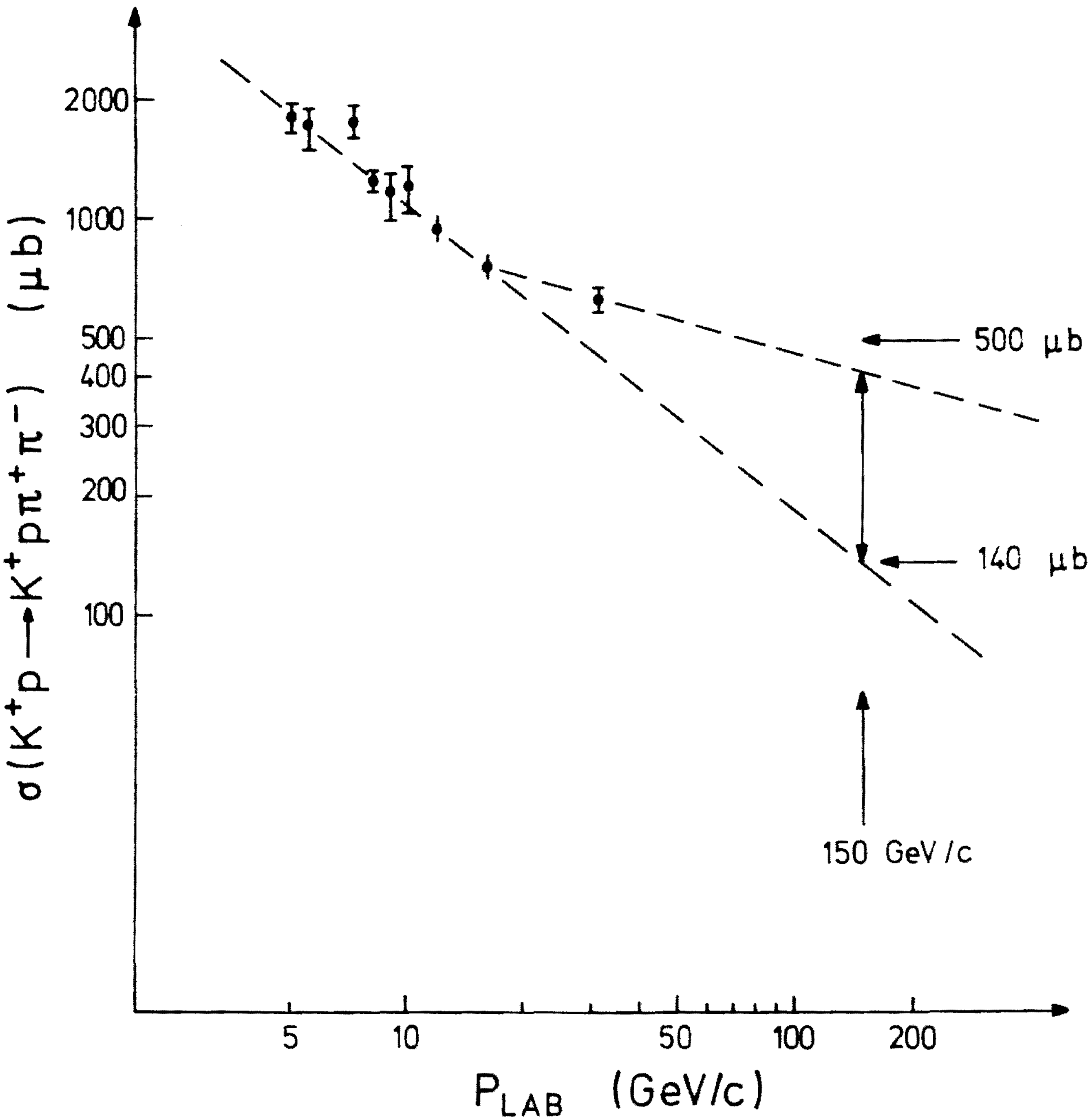
9. R.K. CARNEGIE et al.: "Comparison of K^{+} and K^{-} inclusive scattering (SLAC-PUB-1610, July 1975).

FIGURE CAPTIONS

Fig.1. Variation of the total cross section of the reaction $K^+p \rightarrow K^+p\pi^+\pi^-$ vs. the incident momentum. The data points are taken from ref.5-6.

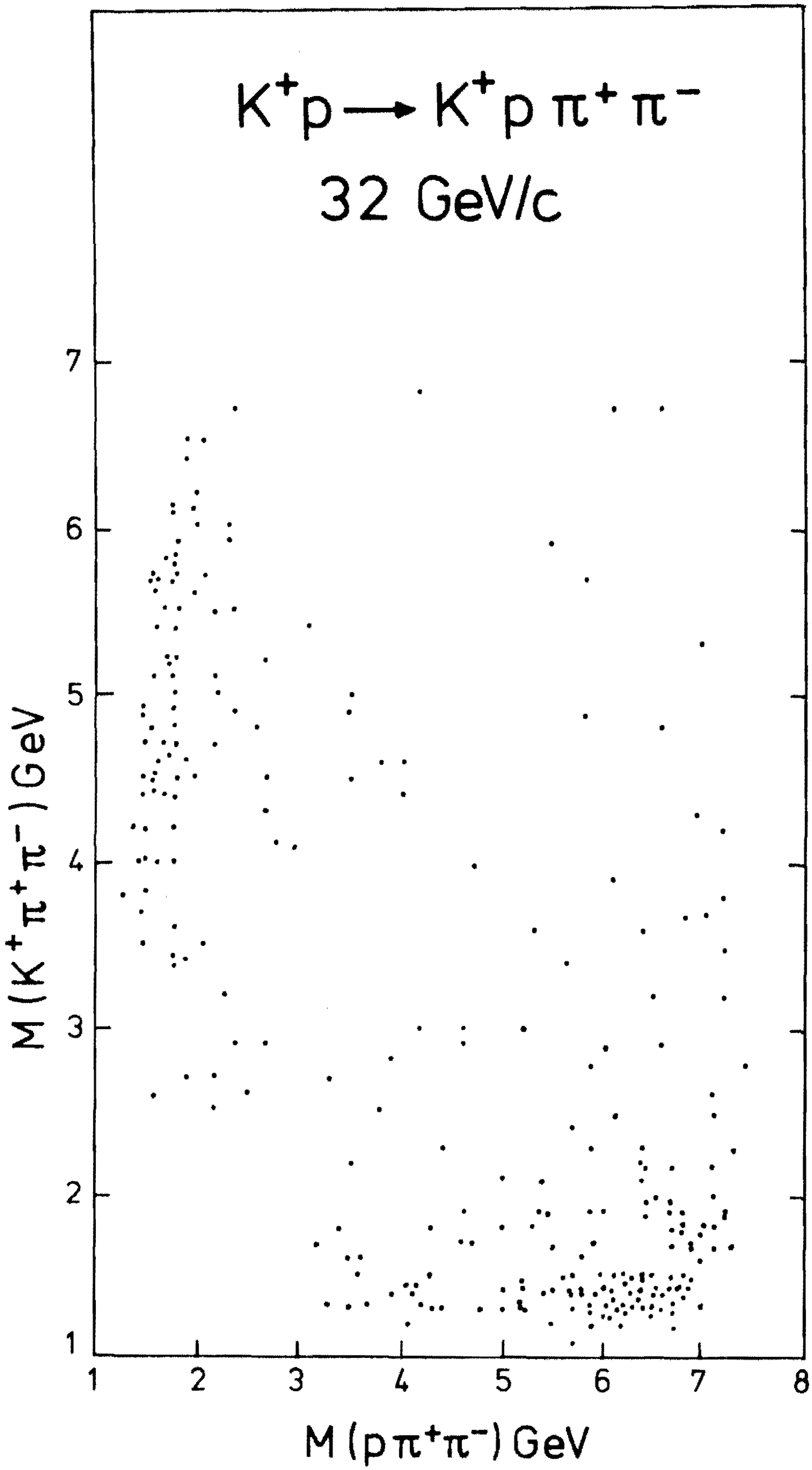
Fig.2. Scatter diagram $M(K\pi\pi)$vs.$M(P\pi\pi)$ for the reaction $K^+p \rightarrow K^+p\pi^+\pi^-$ at 32 GeV/c (from ref.6)

Fig.3. Missing mass squared to the proton for the reaction $K^+p \rightarrow pX$ at 32 GeV/c. Only events with P_{Lab}(proton) <1.2 GeV/c are included (from ref.8.)



σ(K+p → K+pπ+π−) (μb)
2000
1000
500
400
300
200
100
500 μb
140 μb
150 GeV/c
5
10
50
100
200
PLAB (GeV/c)

Fig. 1



$K^+p \rightarrow K^+p\,\pi^+\pi^-$
32 GeV/c
$M(K^+\pi^+\pi^-)$ GeV
$M(p\pi^+\pi^-)$ GeV
1
2
3
4
5
6
7
8

Fig. 2

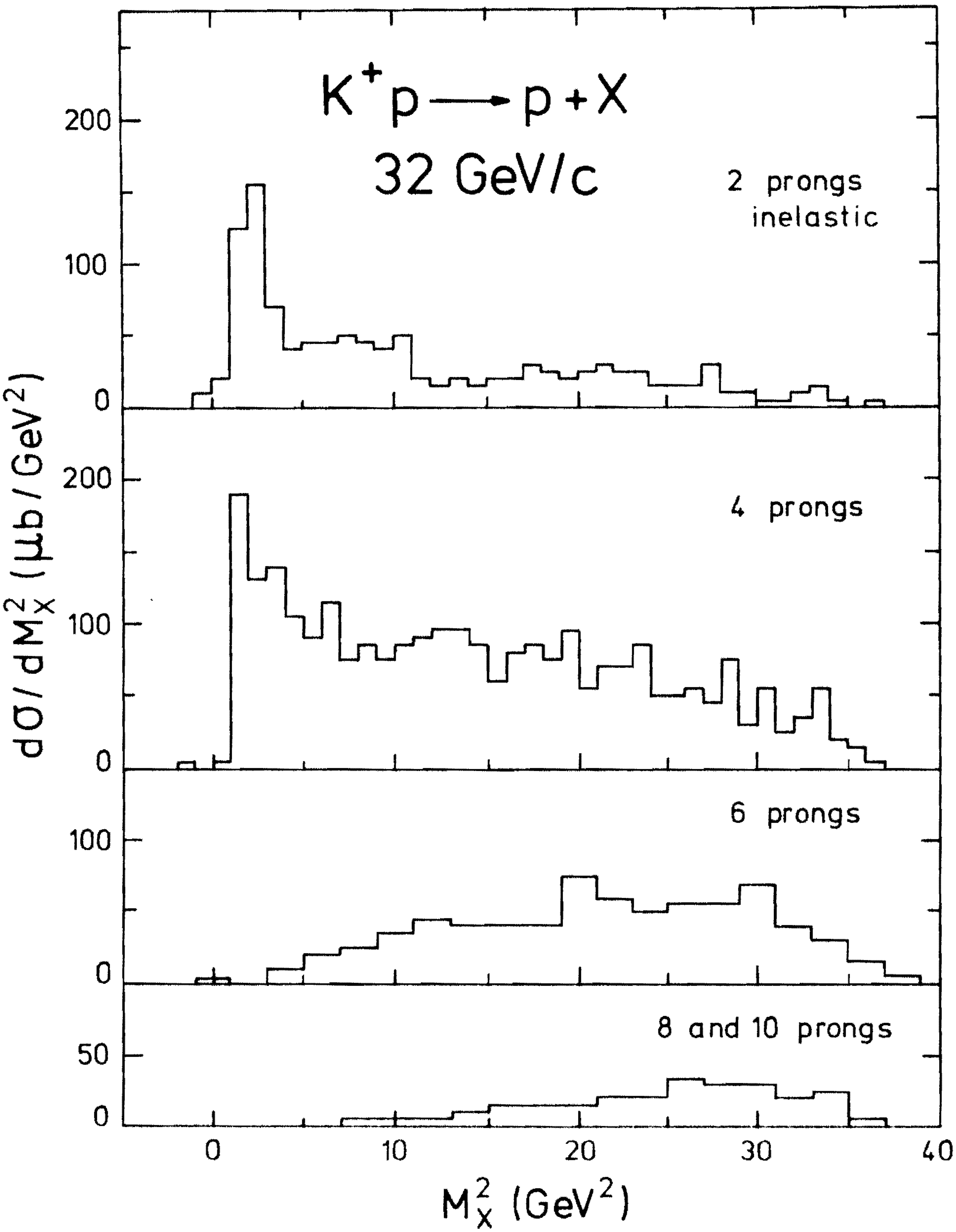

K+p → p + X
32 GeV/c
2 prongs inelastic
4 prongs
6 prongs
8 and 10 prongs
dσ / dM_X^2 (μb / GeV^2)
M_X^2 (GeV^2)
200
100
0
200
100
0
100
0
50
0
0
10
20
30
40

Fig. 3