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Semi-Inclusive Hadronic Interactions at High Energies

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Semi-Inclusive Hadronic Interactions at High Energies

Our group is presently involved with the data-taking and the analysis of inclusive scattering experiment E118 using the FNAL Single Arm Spectrometer (SAS).[1] In the course of this experiment we will have measured inclusive hadronic spectra with complete charged particle identification for incident $\pi^{\pm}$, $K^{\pm}$, p, and $\bar{p}$ at 100 and 175 GeV/c incident energy. The kinematic range we will have covered is approximately 0.2 to 1.0 in X and 0.3 GeV/c to 1.0 GeV/c in $p_{\perp}$ as shown by the shaded area in Fig. 1. At each of the kinematic points we also measure the associated charged multiplicity with a vertex detector consisting of proportional wire chambers, lucite radiators, and conventional hodoscopes. In addition to the fairly complete kinematic coverage of the positive X region at two incident energies, we will have large X (X > .8) data at two additional energies, 70 and 140 GeV/c. In the Appendix we exhibit some preliminary results of E118. As these results demonstrate, the combination of the SAS and our vertex detector is capable of accurately measuring particle spectra and associated multiplicities. The statistical precision of our measurements plus the ability to separate π, K, and p for the entire kinematic range extend the previous results of bubble chamber experiments, making possible more complete tests of the scaling hypothesis, predictions of associated multiplicities, and of models such as the Triple Regge Model.

The purpose of this proposal is to extend the kinematic cover-

age of E118 in two specific areas which we feel are particularly interesting. First, we would like to further investigate the anomalously large rate of π^- production around X = 0.75, which we have observed with incident positive pions and kaons (see Fig. 7). In an exchange model framework, e.g., the Triple Regge Model, this channel requires double charge exchange as shown in Fig. 2a, and therefore should be strongly suppressed for X > 0.6. Our present positive beam-negative spectrometer ("reversed polarity") data are somewhat sparse in the region 0.5 < X < 1.0, so we now propose to increase the density of these data to that of our "same polarity" data. This would include additional points below $p_\perp$ = 0.3 GeV/c, since the π^- excess seems to be increasing with decreasing $p_\perp$. Finally, we would like to supplement our 100 and 175 GeV/c data with new "reversed polarity" data at 70 and 140 GeV/c, in order to test the energy dependence of this effect.

We are investigating the possibility that the excess of negative pions with incident positive pions may be the result of the decay of rhos which are inclusively produced by pion exchange (Fig. 2b). However, this investigation will be incomplete unless our present data are extended to the X = 1 kinematic limit. We do note that inclusive ρ production at large X has been previously observed with incident negative pions in the FNAL 30" HBC [2], but with relatively low statistics. We will also study whether the π^- excess observed with incident K^+ can likewise be explained by K*(890) production via π exchange. Whatever the source of these effects, they represent a non-negligible background for the Triple-Regge analysis

of channels with charge exchange zero (e.g., $\pi^+p \rightarrow \pi^+X$) or one (e.g., $\pi^-p \rightarrow \pi^0X$). Therefore we feel that accurate "reversed polarity" measurements such as we are proposing here are essential for the analysis of E118, as well as other experiments studying inclusive processes.

Secondly we would like to extend our kinematic coverage to larger $p_\perp$ at two values of X (.6 and .9), at our original two beam energies. Because of the low cross section and the correspondingly large amount of running time required for large $p_\perp$ data we have concentrated in E118 on obtaining a wider kinematic coverage in X with a more modest range in $p_\perp$. However, we feel that the interest in large $p_\perp$ makes it essential to push the spectrometer to the limits imposed by low data rates. These limits are about 2.0 GeV/c at X = 0.9, and about 1.75 GeV/c at X = 0.6 for 175 GeV/c running. Our present data indicate that the background rates for such points are minimal. Although the statistics for the highest $p_\perp$ points will be 10% at best, they provide a long lever arm for determining the slope of the $p_\perp$ distribution and yield the associated multiplicity as well. There is evidence for a sharp increase in the associated multiplicity distribution just beyond $p_\perp$ = 1 GeV/c for pp interactions at lower energies.[3] Similarly, increases in the associated multiplicity for high $p_\perp$ particles have been observed at the ISR.[4] In the proposed experiment we will bridge the energy gap between these proton-proton data, and in addition we will be able to look for this effect with incident pions of both charges.

513

Apparatus and Run Plan

The apparatus for this experiment will be identical to our present set-up for E118 as described in the E118A proposal.[1] For that reason it would be very advantageous to carry out this experiment immediately following E118 and before any reconfiguring of SAS.

Our run plan is to take additional positive beam-negative spectrometer data at 100 and 175 GeV/c. This would include an extension of the existing data to $X = 1$ as well as an additional X sweep at low $p_\perp$. We would then repeat the entire positive-negative data grid at 70 GeV/c and 140 GeV/c. Finally at 100 and 175 GeV/c for both beam polarities we would extend our $p_\perp$ sweeps at $X = .6$ to $p_\perp = 1.75$ GeV/c and at $X = .9$ to $p_\perp = 2.0$ GeV/c.

Assuming 2.10^6 particles per pulse and one pulse every ten seconds, we estimate that this entire program will require 300 hours of data-taking time. Based on a SAS solid angle of 6μ steradians and a momentum acceptance of 6%, we will obtain better than 5% statistics at all but the largest $p_\perp$ points where we will have 10 - 20% statistics. In addition 50 hours of checkout time will be required, unless this experiment were to be contiguous with the final E118 run. Thus we are requesting a total of 350 hours of running time.

Appendix: E118 Preliminary Results

To illustrate the quality and extent of the E118 data we present here our preliminary results on a small fraction of the 100 GeV/c data. In particular, Figs. 3 and 4 show the invariant cross sections for the processes $\pi^+p \to \pi^+X$ and $pp \to pX$, first as a function of X (at $p_\perp$ = .3 GeV/c) and then as a function of $p_\perp$ (at X = .6 and .9). The statistical error bars are generally smaller than the points for these data. We estimate an additional overall systematic uncertainty of 10% at the present stage of our cross section analysis. Figs. 5 and 6 show the associated multiplicity vs. X and $p_\perp$ for the same reactions. In this case the error bars represent the estimated systematic error in correcting for multiple interactions in the target, delta rays, etc., which will be reduced by further analysis. The statistical errors are considerably smaller. Finally, Fig. 7 shows the invariant cross section vs. X at $p_\perp$ = 0.3 GeV/c for the "reversed polarity" reactions $\pi^+p \to \pi^-X$, and $K^+p \to \pi^-X$. The latter channel is a good example of the many different beam-spectrometer particle combinations made possible in E118 by the Cerenkov power of the SAS.

References

1. FNAL E118 A Proposal, Bari-Brown-FNAL-MIT Collaboration, September, 1974.

2. Fong *et al.*, Phys. Lett. 60B, 124 (1975); Winkelmann *et al.*, Phys. Lett. 56B, 101 (1975).

3. Anderson *et al.*, Phys. Rev. Lett. 34, 294 (1975); Ramanauskas *et al.*, Phys. Rev. Lett. 31, 22 (1973).

4. Della Negra *et al.*, Nucl. Phys. B104, 365 (1976); Eggert *et al.*, Nucl. Phys. B98, 73 (1975).

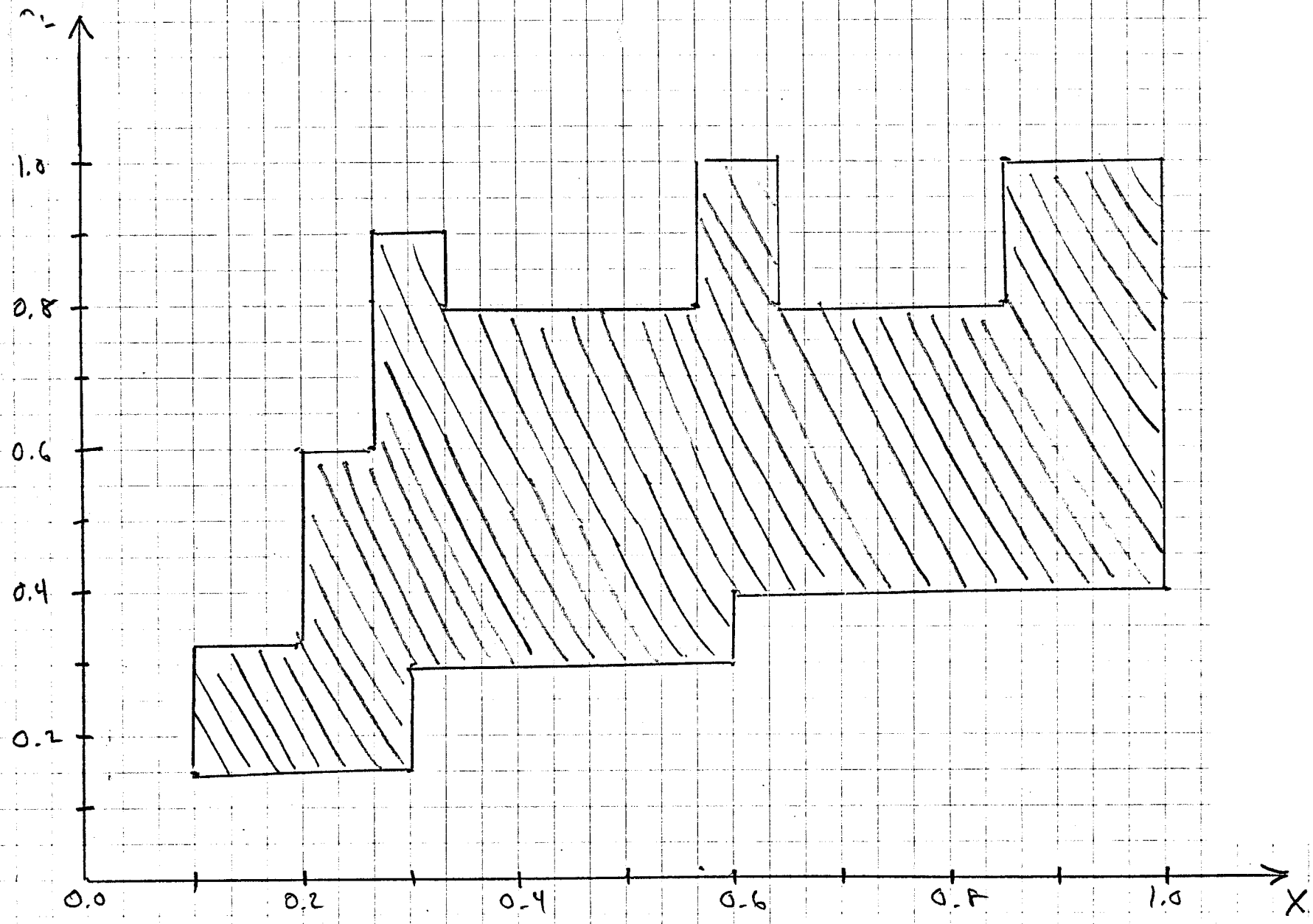


Fig. 1.

E118 Kinematic Coverage at 100 and 175 GeV/c

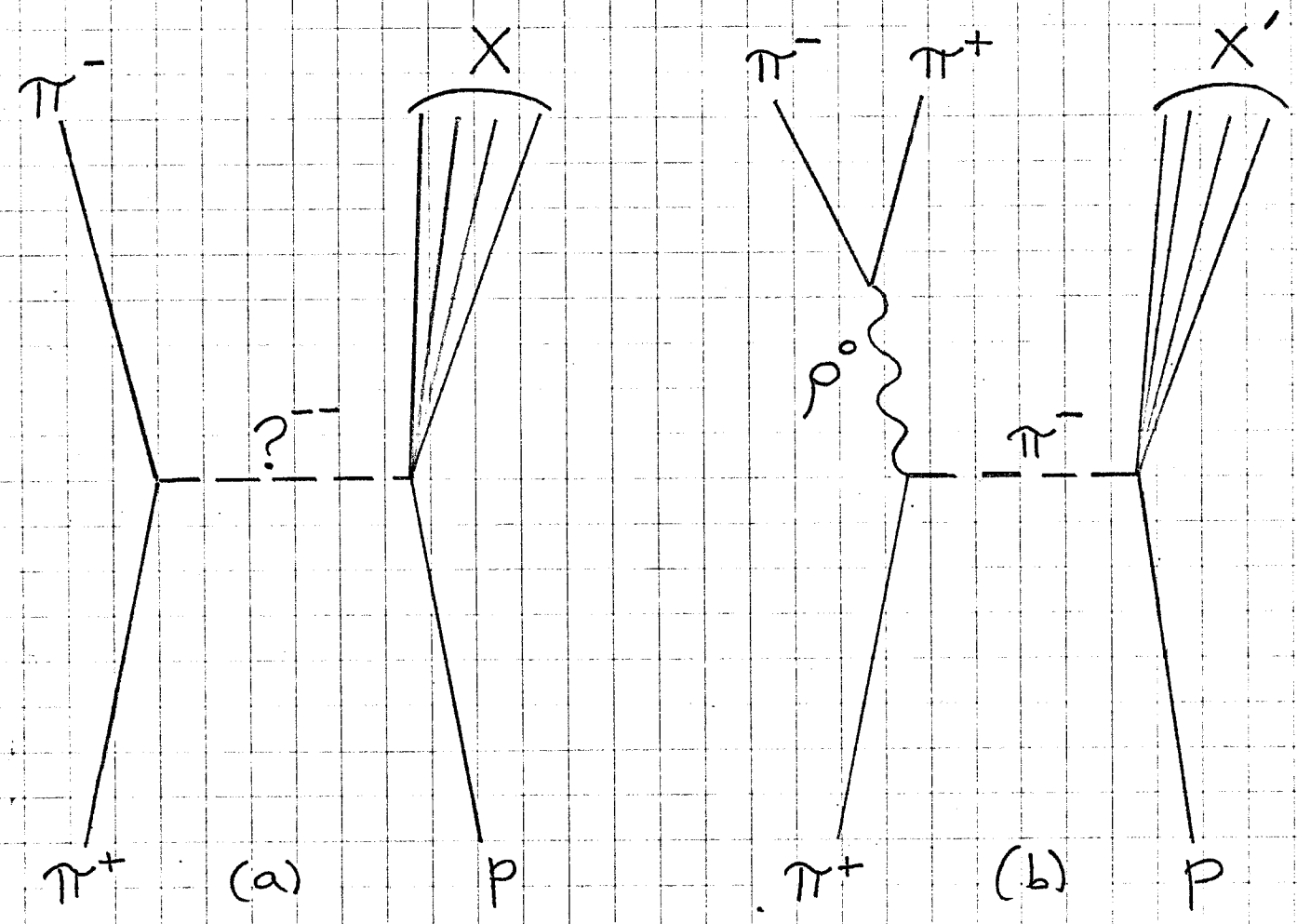
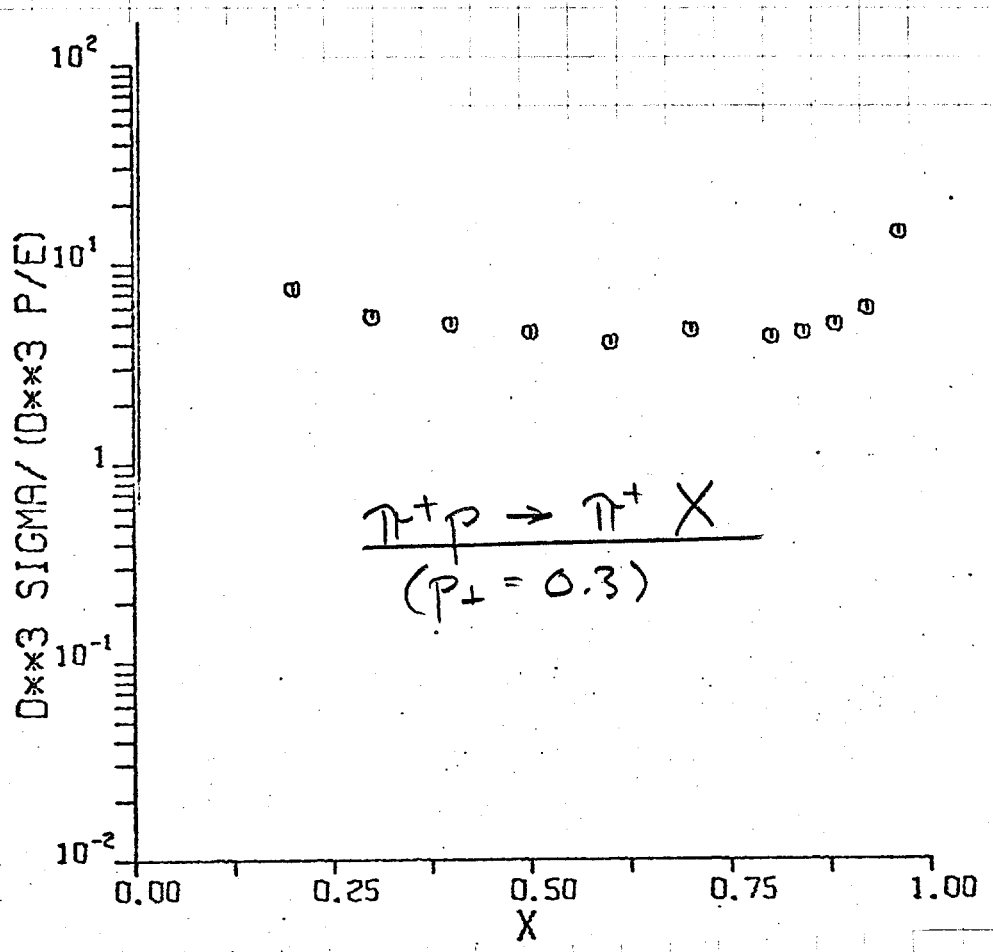


Fig. 2

Diagrams for $\pi^+ p \to \pi^- X$

Fig 3 – Preliminary E118 Data
100 GeV/c



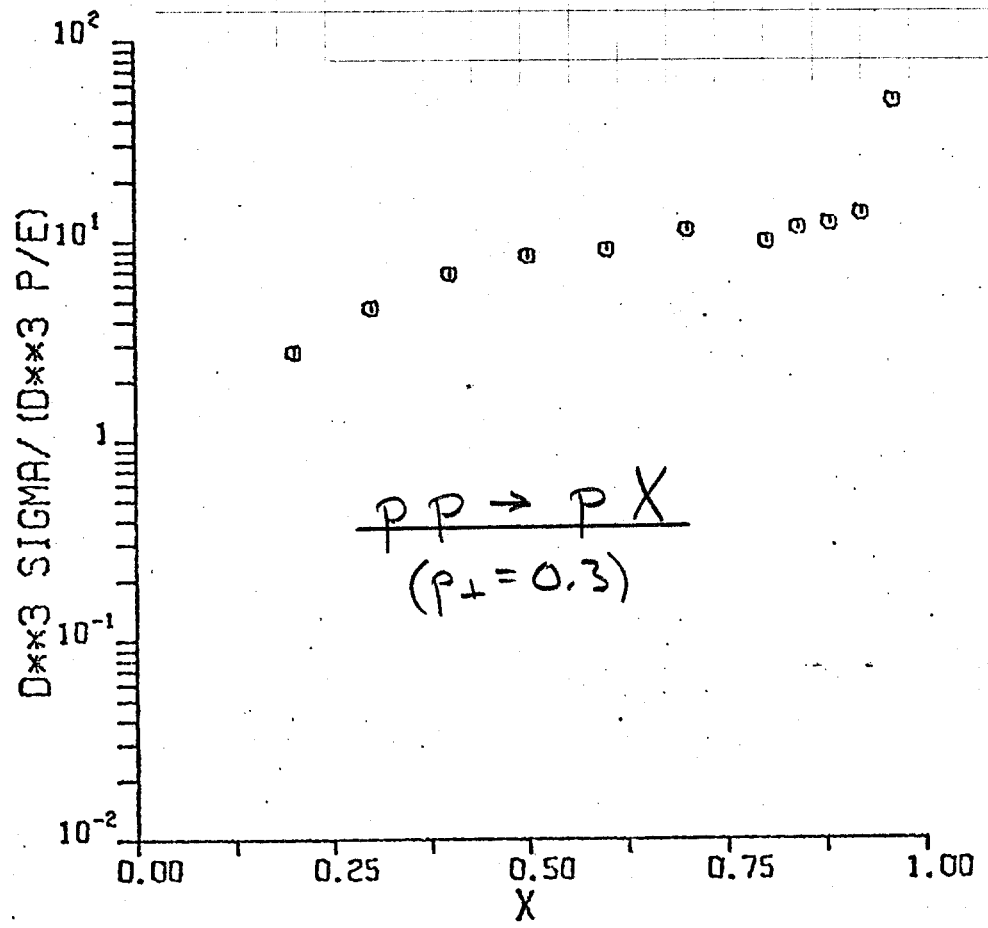


Fig 4 — Preliminary E118 Data 5/3
100 GeV/c

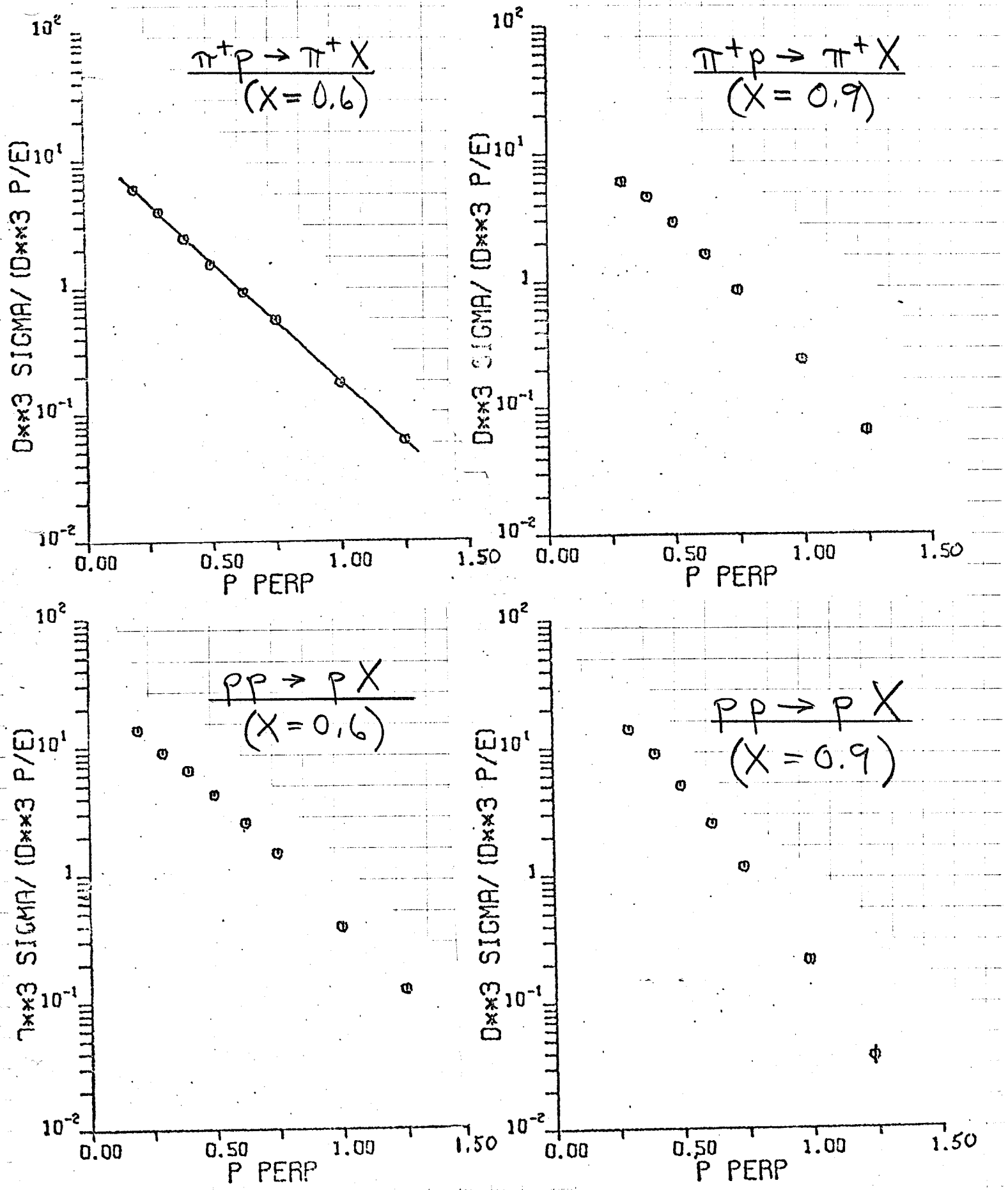
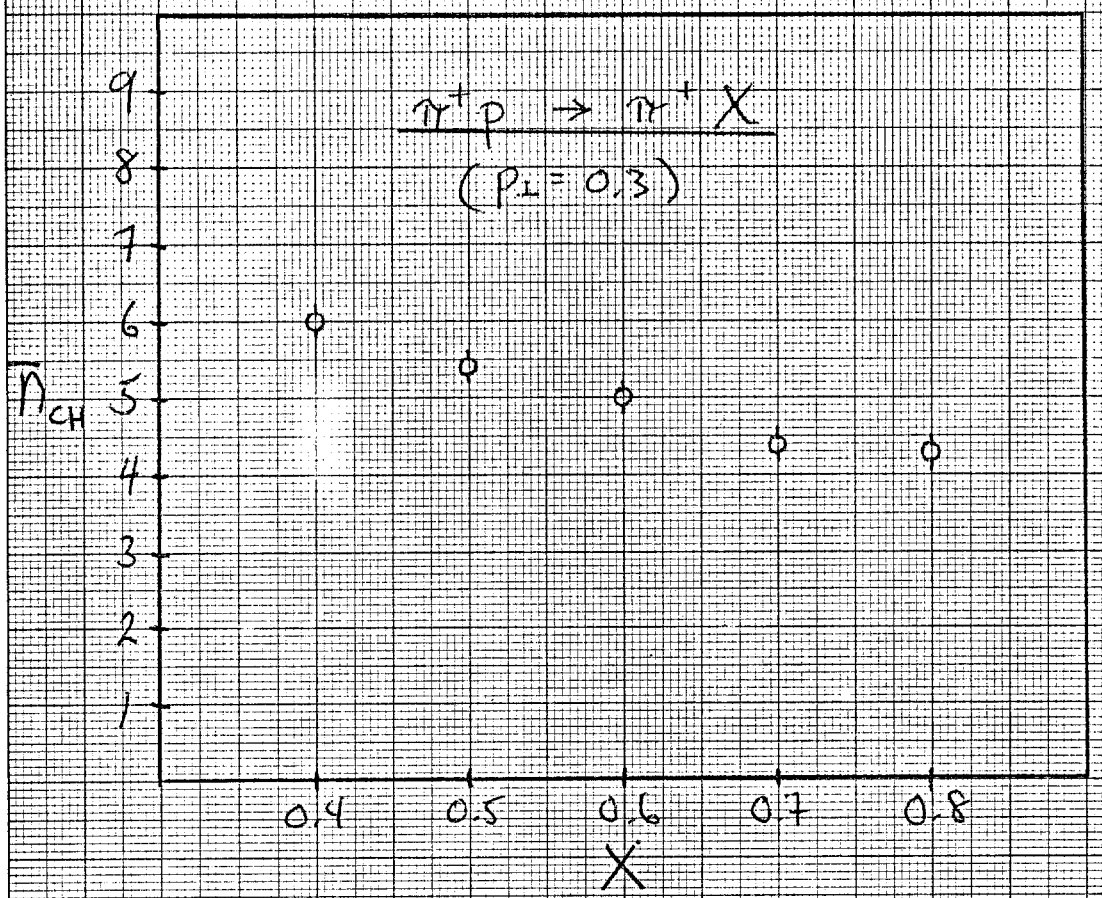


Fig 5 - Preliminary E118 Data

100 GeV/c



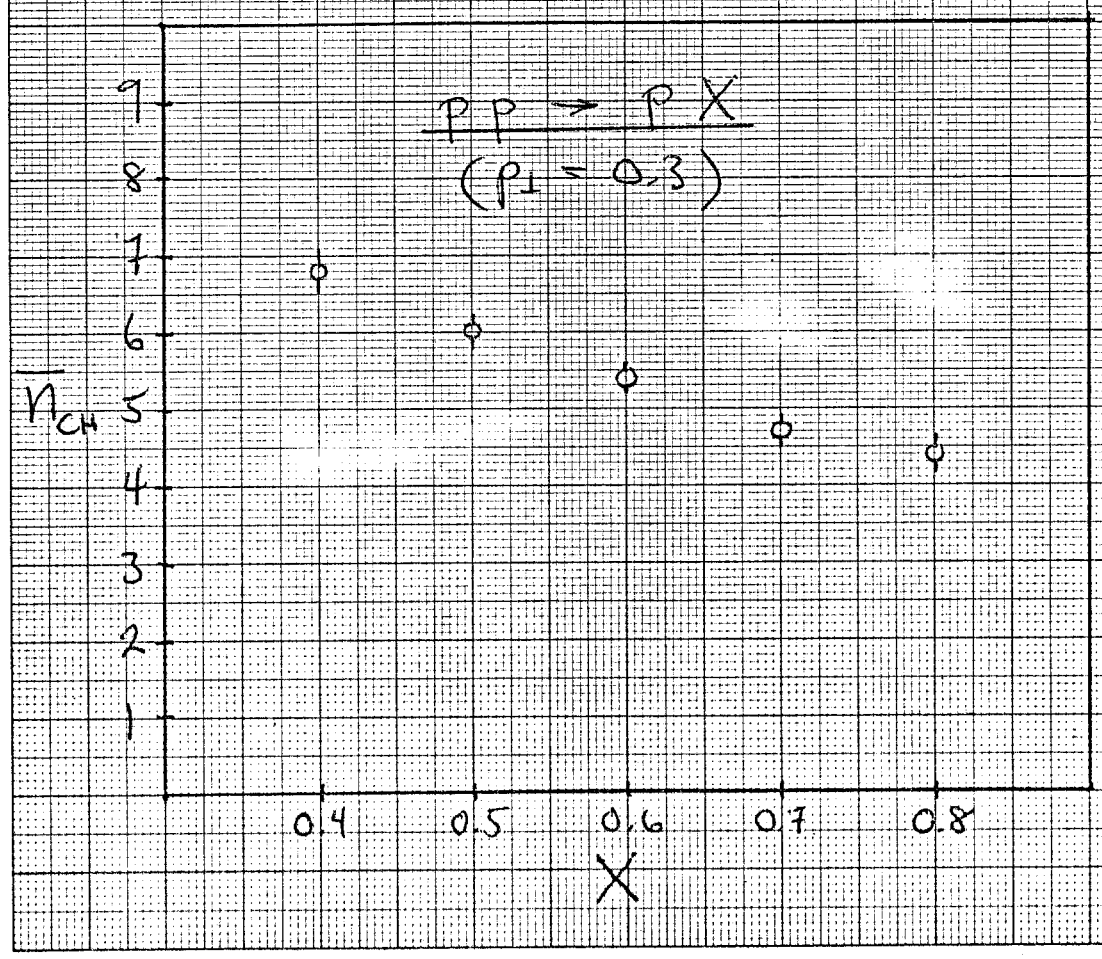


Fig 6 – Preliminary E118 Data

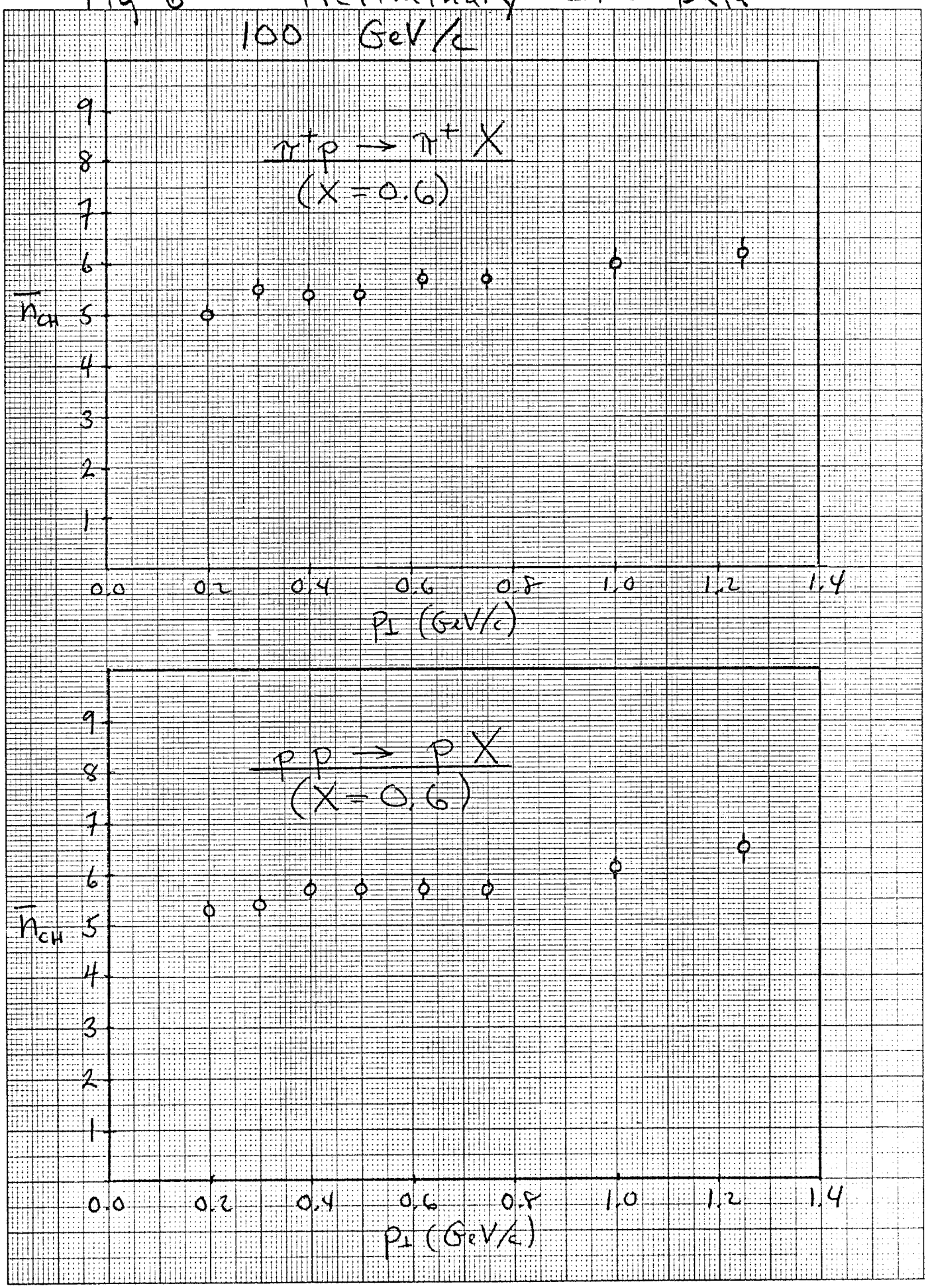
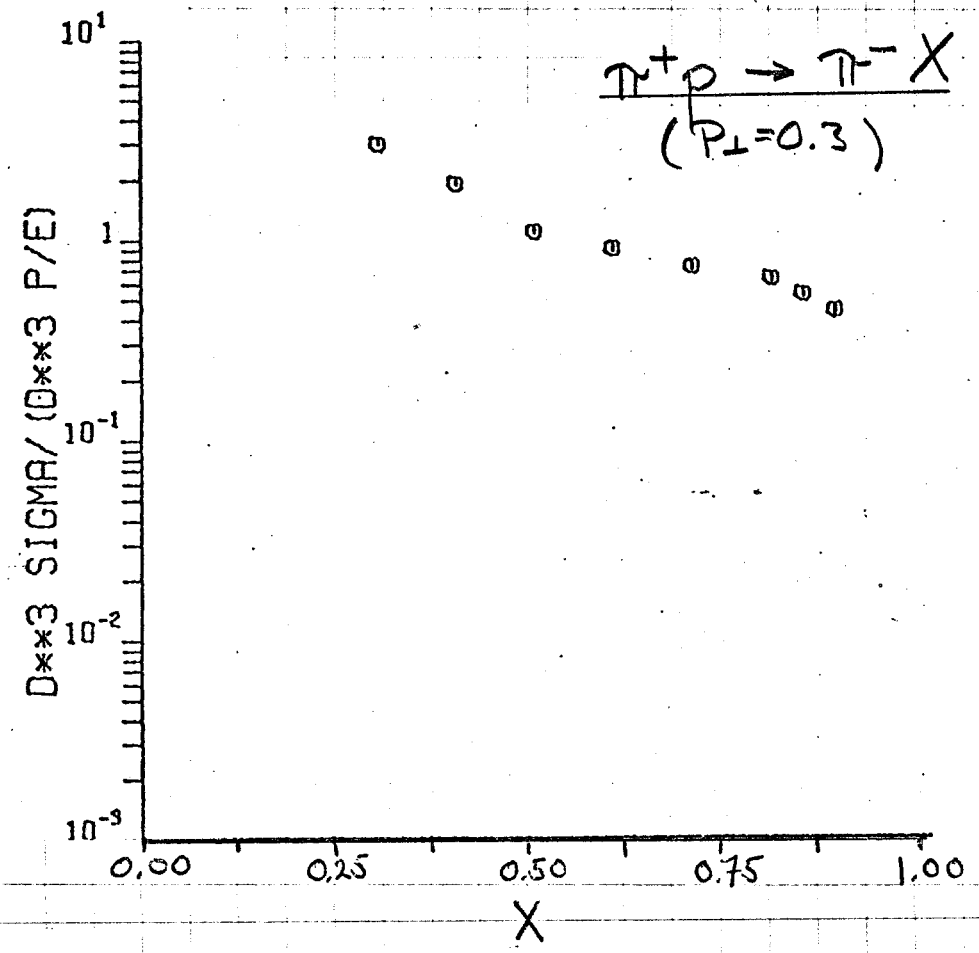
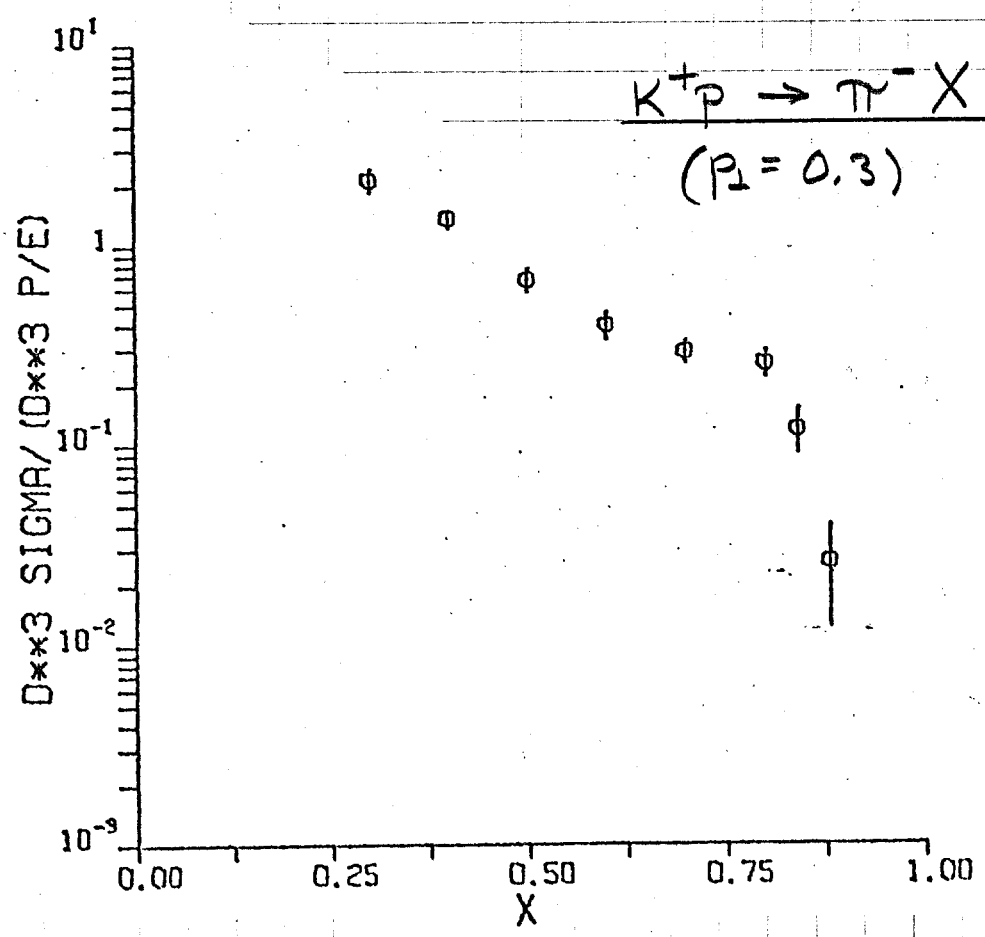



Fig 7 - Preliminary E118 Data
100 GeV/c