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INCLUSIVE π^+ ELECTROPRODUCTION AND THE HYPOTHESIS OF LIMITING FRAGMENTATION*

S. Rai Choudhury**
International Centre for Theoretical Physics, Trieste, Italy.

ABSTRACT

The data on the inclusive electroproduction of π^+ is shown to be consistent with factorization and limiting fragmentation.

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**On leave from University of Delhi, India. Address from Sept. 1972:
Department of Physics, University of Michigan, Ann Arbor, Mich., USA.

During the past year or so, attempts have been made towards finding a systematic pattern amongst the observed one-particle inclusive cross-sections[1)-8)]. The starting-point of all these papers is the work of Mueller[9)], who relates the inclusive cross-section for the process $a + b \to e$ + anything to the discontinuity of the three-particle forward amplitude $a + b + \bar{c} \to a + b + \bar{c}$, continued analytically to an unphysical point. In the fragmentation domain the $(b\bar{c})$ system has an invariant mass which stays finite and small as the energy goes to infinity; one can then write an expansion of the cross-section in terms of Regge exchanges dominated at high energies by the P, followed by the four leading meson trajectories, which, at this stage of experimental accuracy, are all taken to have $\alpha(0) = 1/2$. A reasonable amount of success has been achieved along these lines. Very recently, a Cornell group[10)] has presented data on the inclusive process $e + p \to e + \pi^+$ + anything, and this note is devoted to relating these measurements, via factorization, to other hadronic inclusive cross-sections.

In an earlier paper[11)], we had given the general formalism for the inclusive electroproduction process, and it was pointed out that tests of factorization and exchange degeneracy would be much easier if c is a π^- rather than a π^+. However, π^+ inclusive hadronic cross-sections, in the proton fragmentation region, seem to exhibit a particularly weak energy dependence. This can be seen from the fact that the reduced distribution function for the following reactions in the region $x = (p_{\parallel}/p_{max})_{c.m.}$ between 0 and -0.15, are almost overlapping: $p + p \to \pi^+$ + anything at energies between 12 GeV and ISR energies[12)]; $\pi^+ p \to \pi^+ x$ at 3.7 and 7.0 GeV/c,[13)] and at 8 and 16 GeV/c;[14)] $K^- p \to \pi^+$ + anything at 10 GeV/c;[15)] $K + p \to \pi^+$ + anything at 12 GeV/c;[16)] $\pi^- p \to \pi^+ x$ at 16[17)] and 25[18)] GeV/c. Since the limiting behaviour sets in at a relatively early energy in a variety of reactions rather than one particular one, we are forced to conclude that the vector and tensor trajectories have very weak coupling to the composite $(\pi^- p)$ system. The experimentally observed inclusive electroproduction of π^+ at a c.m. energy of 3 GeV is therefore expected to exhibit this limiting behaviour. We therefore compute the invariant structure function for inclusive π^+ electroproduction:

$$F(x) = \int \frac{1}{\sigma_T} \frac{E_{\pi^+}}{\pi} \frac{d^2\sigma}{dp_{\parallel} dp_{\perp}^2} \, dp_{\perp}^2$$

where σ_T is the virtual photon total cross-section. $E_{\pi^+}\left(d^2\sigma/dp_{\parallel}^2\, dp_{\perp}^2\right)$ is the invariant cross-section and $x = (p_{\parallel}/p_{max})_{c.m.}$. The results are shown in Table I with the results for $\pi^+p \to \pi^+x$ at the corresponding x-values. The error bars in either of the entries are of the order of 10 – 15% and the two entries are in reasonable agreement with each other. It seems, then, that π^+ electroproduction data is consistent with the hypothesis of limiting fragmentation and factorization.

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TABLE I

	$-0.15 < x < -0.10$			$-0.10 < x < -0.05$		
	$Q^2 = 0.3$	$Q^2 = 0.6$	$Q^2 = 1.2$	$Q^2 = 0.3$	$Q^2 = 0.6$	$Q^2 = 1.2$
γ(virtual) + p $\longrightarrow \pi^+ x$	0.13	0.11	0.13	0.12	0.12	0.12
$\pi^+ p \rightarrow \pi^+ x$ at 3.7 GeV/c	0.13			0.13		

Table showing the values of the structure function F(x) for electroproduction of π^+ and for $\pi^+ p \rightarrow \pi^+ x$. Q^2 is in $(GeV)^2$.