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Hole Fragmentation in Deep-Inelastic Processes*

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For deep-inelastic eN and νN processes we argue that there are three fragmentation regions instead of two when ω is very large.

Applications of the parton model to the problem of hadron final states in deep-inelastic electroproduction have led to the concept of parton fragmentation[1-5] and to the proposal that the ideas of short-range correlation in rapidity, successfully used in ordinary hadron-hadron collisions,[6] can be taken over directly to the deep-inelastic processes. Hence one again envisages three regions in longitudinal phase space (which we describe in terms of the rapidity variable y): a target fragmentation region (of length ~2), a photon (or W) fragmentation region (of length $\sim\ln Q^2$), and, if $\omega \gg 1$, a central region (of length $\sim\ln\omega$). This follows from rather general considerations.[7] In the parton-fragmentation picture, one concentrates on the region of leading hadrons whose longitudinal fraction $z = p_{\text{lab}}/\nu$ is, say, $\gtrsim 0.1$ (i.e., $y_{\max} - y \lesssim 2$). In that region one argues that production of hadrons of type i is proportional to the probability $f_j(\omega)$ of the incident current (virtual γ or W) having struck a parton of type j and to the probability $G_{ji}(z)$ that the parton "fragments" into hadron i plus anything:

$$\frac{dN_i}{dy} = \sum_j f_j(\omega) G_{ji}(z) . \tag{1}$$

Furthermore, it has been suggested[3] that the quantum numbers (such as Q or B) of the parton are measured by the average Q, B, etc. found in the parton fragmentation region. It is interesting to contemplate this picture in the limit of very large ω. No net charge has left the target fragmentation region (as defined above[8]), and the charge found in the parton fragmentation region must come from somewhere. A little reflection convinces one that the missing charge should be located at the lower boundary of the photon (or W) fragmentation region ($y - y_{\min} \sim \ln\omega$), which is the location in longitudinal phase space of the parton constituent of the hadron *before* it was struck by the virtual photon W. Thus the average quantum numbers Q, B, etc. of the hadrons in this hole-fragmentation region are determined by those in the parton fragmentation region and by the quantum numbers carried by the current. For example, for the process $\nu + p \to \mu^- + \text{hadrons}$ at extremely large ω, we expect the inclusive distribution function to be given schematically by Fig. 1. The charge of the incident W is distributed equally between the two fragmentation regions.[9]

The distribution function for hole fragmentation, i.e., for $zQ^2/m_p^2 \sim 1$, has the form

$$z\frac{dN_i}{dz} = \sum_j f_j(\omega) H_{ji}\left(z\frac{Q^2}{m_p^2}\right). \tag{2}$$

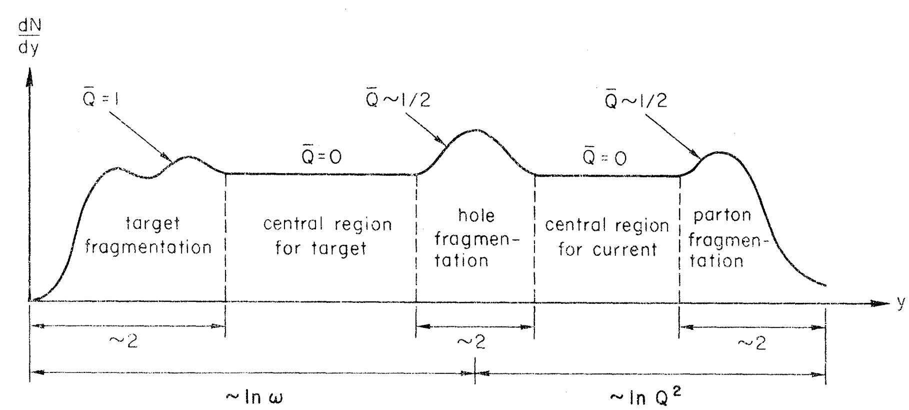

FIG. 1. Schematic hadron distribution for the process $\nu p \to \mu^- + \text{hadrons}$ at very large ω.

In the case of deep-inelastic electroproduction, the hole-fragmentation region may not be evident in the single-particle inclusive spectrum. However, there should be a strong effect in the two-particle correlation function; given positive charge in the parton-fragmentation region, the probability of finding negative charge should be maximum in the hole-fragmentation region.[10]

It may require impossibly large ω ($\gtrsim 10^3$?) to see clearly this effect. However, perhaps even at modest ω ($\gg 10$) and not-too-small Q^2 (>4 GeV^2?) it is better to think in terms of three fragmentation regions rather than two in analyzing data along the lines of the parton model.

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[8]In Ref. 5, the target-fragmentation region is defined as $y-y_{min} < \ln\omega$. In the light of Fig. 1, this is a definition complementary to the one we use.

[9]We here assume $E_\nu \to \infty$ for fixed ν and Q^2; more general kinematical configurations may be treated according to the formalism in Ref. 5.

[10]This long-range correlation effect was anticipated by Susskind; cf. Ref. 7, p. 297.