Large-p_T π^0 Production in High-Energy πp Collisions

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It is pointed out that the recently measured difference in p_T spectrum between $\pi^{\pm}p \to \pi^0X$ and $pp \to \pi^0X$, with a large-p_T π^0, seems to be a consequence only of the smaller number of quarks per projectile in a pion beam.

In a recent experiment a Brookhaven National Laboratory–California Institute of Technology–Lawrence Berkeley Laboratory group measured the yield of large-p_T π^0's at 90° in the c.m. system from both pion-proton and proton-proton collisions at 100 and 200 GeV/c.[1] It was found that the ratio $R(\pi^+/\pi^-)$, i.e., the cross-section ratio $(\pi^+p \to \pi^0X)/(\pi^-p \to \pi^0X)$, is consistent with one for all $p_T \lesssim 4$ GeV/c, a result which is not difficult to understand within any model. On the other hand, the ratio $R(p/\pi^-)$ of $pp \to \pi^0X$ to $\pi^-p \to \pi^0X$ has some interesting features, which are claimed in Ref. 1. to be inconsistent with straightforward predictions from both the constituent interchange model (CIM)[2] and the quark fusion model.[3] It is clear, however, that the most straightforward prediction from the CIM[4] is in agreement with data at $x_T \equiv 2p_T/\sqrt{s} \gtrsim 0.3$.

The aim of this Letter is to point out that the structure of $R(p/\pi^-)$ as a function of p_T can be explained by the mere fact that the momentum *per quark* is larger in a pion beam than in a proton beam of the same momentum per projectile. The difference in quark composition between pions and protons thus seems to be of minor importance as for the production of large-p_T π^0's. This possibility was hinted at already in Ref. 1. The larger quark momentum in a beam pion is naturally taken into account in most parton models through the choice of pion and proton structure functions. My treatment will, however, be independent of the explicit forms of these structure functions.

I will not have any particular detailed parton model in mind during the following discussion but rather make some use of a simple phenomenological picture presented earlier.[5] There it was assumed that a large-p_T inclusive spectrum is built up by several components, each characterized by the number of valence partons from the initial system that are contained in the trigger hadron. From rather general assumptions about the structure of these components I obtained relations[5] between hadron ratios π^+/π^- and K^+/K^- in both pp and pN collisions. One of the phenomenological results was that "no-valence" hadrons dominate 90° pion spectra from pp collisions out to $x_T \approx 0.3$, beyond which "one-valence" hadrons take over. On intuitive grounds I therefore make the basic assumption that "two-valence" hadrons are in minority below, say, $x_T \approx 0.6$ (although this conjecture, for obvious reasons, is not tested in processes like $pp \to \pi^0X$). I regard my result below as a successful test of this crucial assumption.

Turning now to $\pi^-p \to \pi^0X$, I thus neglect quark processes giving a $\pi^0 = (\bar{q}_{\text{val}}q_{\text{val}})$ compared to $(q_{\text{val}}q_{\text{sea}})$, $(\bar{q}_{\text{sea}}q_{\text{val}})$, and $(\bar{q}_{\text{sea}}q_{\text{sea}})$. With that component "eliminated," we see that there are indeed very few differences between $\pi^-p \to \pi^0X$ and pp

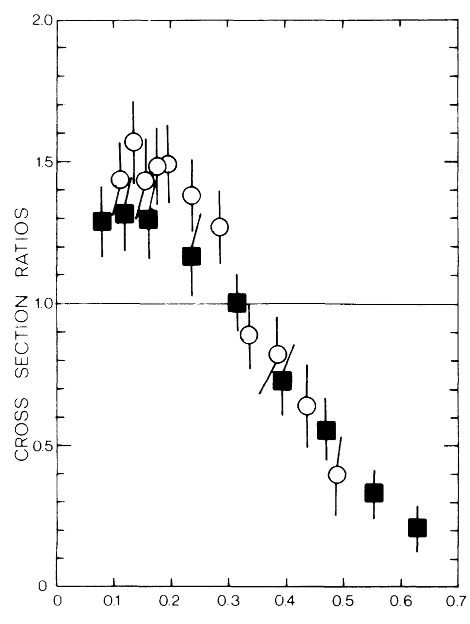

FIG. 1. A test of Eq. (2) as explained in the text. Circles show the ratio of invariant cross sections for $pp \to \pi^0X$ and $\pi^-p \to \pi^0X$ at 200 GeV/c, taken from Ref. (1). Squares show 1.5 times the ratio of $pp \to \pi X$ at 200 GeV/c and $pp \to \pi X$ at 300 GeV/c, taken from Ref. (5), where π means averaging over π^+ and π^-.

$\to \pi^0 X$, simply because the π^0 is symmetric in u, $\bar{u}$, d, and $\bar{d}$ quarks, of which also the initial systems are composed. The only differences of relevance are that there are 50% more quarks in a proton than in a pion (the same is assumed for the sea) and that the pion constituents hence get 50% more kinetic energy than the proton constituents with the same projectile momentum.

Thus I get

$$1.5\times(\pi^- p \to \pi^0 X \text{ at } 200\text{ GeV}/c) = (pp \to \pi^0 X \text{ at } 300\text{ GeV}/c). \quad (1)$$

To test this relation in the interval $0 \lesssim x_T \lesssim 0.6$, I rewrite it in the form

$$\frac{(pp \to \pi^0 X)_{200}}{(\pi^- p \to \pi^0 X)_{200}} = 1.5\,\frac{(pp \to \pi X)_{200}}{(pp \to \pi X)_{300}}, \quad (2)$$

where π in the right-hand side means averaging over π^+ and π^- production to estimate π^0 yields. I take the left-hand side directly from Ref. 1 and estimate the right-hand side from the Chicago-Princeton data[6] on proton-*tungsten* collisions. The presence of neutrons in the tungsten target should not bias this test and the A dependences in the cross sections in the right-hand side are presumably divided out.

It can be seen in Fig. 1 that Eq. (2) is remarkably successful in the full x_T range. I therefore conclude that the presence of a leading antiquark in the beam pion seems to be unimportant for π^0 production in the studied p_T interval, in contrast to the simple fact that the projectile has two valence quarks instead of three.

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Production of High-Mass Muon Pairs in Proton-Nucleus Collisions at 400 GeV

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We report results on the production of muon pairs in the mass range 2.5 to 20 GeV in 400-GeV proton-nucleus collisions. A total of 159 events are observed in the mass range 5.5 to 11 GeV with a cross section which is in agreement with the previous observation of a high-mass dielectron continuum signal in this interval. Details on the production dynamics and comparisons with parton-model predictions are presented. Within limitations of resolution and continuum uncertainty, the dimuon mass spectrum provides no evidence for fine structure above 5 GeV.

We have previously reported the observation of massive ($\gtrsim 3$ GeV) e^+e^- pairs produced in 400-GeV proton-Be collisions at Fermilab.[1,2] This Letter reports the results of an experiment we have performed to detect muon pairs over the same mass range. The conversion to muons was motivated by the higher data-taking rate made possible by filtering most hadrons. Although this comes with poorer mass resolution and different backgrounds, we have been able to increase by a factor of 5 the statistical significance of the high-mass data over that in the e^+e^- run.[1]

In order to carry out these observations, our two-arm spectrometer (shown in Fig. 1 of Ref. 1) was modified in a number of ways. Five meters of Be were added as a hadron filter just down-