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NUCLEAR EFFECTS IN INCLUSIVE PRODUCTION AT LARGE p_T

T. FERBEL*
University of Rochester
Rochester, NY 14627, USA

ABSTRACT

The original discovery of an anomalous nuclear enhancement in particle production at large transverse momenta by Cronin and collaborators [1] generated great interest in the nature of the propagation of hadrons and partons through nuclear matter. Here we present preliminary results from E706 on the nuclear dependence of inclusive π^0, η, ω and γ production in π^- interactions with Be and Cu nuclei at 500 GeV/c, and compare these results to previous measurements and to expectations from phenomenology.

Production of particles at large transverse momenta (p_T) in hadronic collisions reflects the presence of point-like constituents, their fundamental interactions, and their fragmentation. For the case of nuclear targets, the yields can, in addition, shed light on any rescattering of hadrons or partons, and the time development of these states. Previous data on inclusive pion production in nuclei [1, 2] indicated that, although below p_T values of $\sim$ 1 GeV/c there is much absorption and the A-dependence of the cross section can be approximated by $A^{2/3}$, beyond this region of small p_T point-like interactions start to dominate. The produced partons can rescatter one or more times, leading to a dependence of e cross section that is related to the number of such rescatters:

$$Ed\sigma/d^3p = a\cdot A + b\cdot A\cdot A^{1/3} + c\cdot A\cdot A^{1/3}\cdot A^{1/3} + \ldots \quad (1)$$

The above series is usually approximated by A^α, where a, b, c, and α are taken as constants. Clearly, in the regime of large p_T, α should exceed unity. However, from recent arguments based on perturbative QCD, the value of α at very large p_T is expected to decrease (towards unity), and then increase again at sufficiently large p_T near the edge of phase space [3]. In general, because of color factors, the cross section for rescattering of gluons is expected to be larger than for rescattering of quarks, and therefore particle production in nuclei at large p_T should be particularly sensitive to contributions from gluons [4, 5]. The cross section for inclusive production of hadrons or of jets at large p_T would consequently be expected to be strongly influenced by the rescattering of the constituents, while that for inclusive production of photons should display a weaker dependence on A, with α closer to unity. Additional nuclear enhancements (or depletions) can also be expected from any A-dependence of the parton densities [6].

The data to be presented are from a preliminary comparison of π^- collisions with Be and Cu targets, obtained in the second run of E706. Our previous measurements using π^- and p beams [7] have poorer statistics, but are completely consistent with these latest results. Figure 1 displays the p_T dependence of α for π^0 production, for rapidities (y) integrated between -0.7 and $+0.7$. Superimposed are similar measurements of α for the average of π^+ and π^- production from previous experiments [1, 2]. Our high-statistics data support the turn-over in the value of α that can be discerned in the proton-nucleus data of Antreasyan et al [1]. As can be seen in Fig. 2, for our range of p_T, there is essentially no change in α with rapidity. Within statistical uncertainty, the α-dependence of η and ω production is consistent with that for π^0 production. These results are shown in Fig. 3 for data integrated over rapidity ($|y| < 0.7$). Finally, in Fig. 4, we display the variation of α with p_T for "candidate direct-photons". These are events from which we have excluded photons from π^0 and η decays observed in the inclusive two-photon mass spectrum, but have not corrected the data for any remnant background. In fact, below p_T values of $\sim$4 GeV/c, the data in Fig. 4 are still largely dominated by π^0s, where one of the decay photons escaped detection. However, at higher p_T there is a large admixture of true direct photons [7]. The p_T dependence of α in Fig. 4 is similar to that found for π^0 production, except that α is somewhat larger for $p_T < 4$ GeV/c, and decreases more (approaches closer to unity) at larger p_T than for the case of the π^0 data in Fig. 1. (At the present stage of our analysis, we can only speculate that the small discrepancy observed in α, of ~ 0.01, between the data in Figs. 1 and 4 for $p_T < 4$ GeV/c, reflects our current systematic uncertainties.)

To conclude, previous measurements of inclusive pion production in π^- and proton collisions with nuclei indicate that α increases with p_T, crossing unity near 2 GeV/c [1, 2]. Subsequently, α levels off near a value of 1.1, and decreases somewhat at larger p_T. Our own results confirm these trends, which are also qualitatively consistent with expectations from phenomenology [3, 5].

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In the kinematic limits of our data, the nuclear dependence of η production is the same as of π^0 production, and, for both mesons, there is essentially no dependence of α on rapidity. At largest p_T, the value of α for direct-photon production appears to be somewhat smaller than for π^0s. This may reflect the absence of a large enhancement in the gluon distribution in nuclei for x-values above 0.3 [6]. However, because of the variety of effects that can affect the value α, further analysis will be required before reaching any such conclusion.

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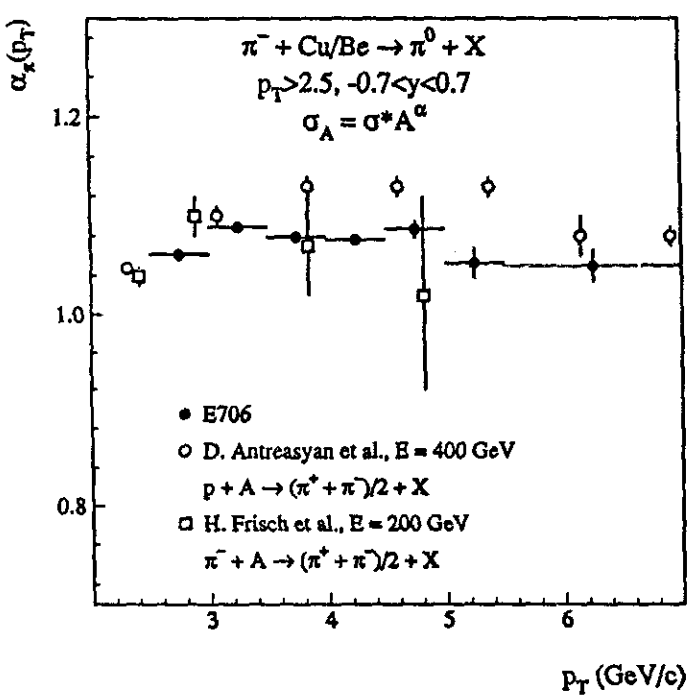

Figure 1: The dependence of α on p_T for π^0 production in π^-Cu and π^-Be collisions at 500 GeV.

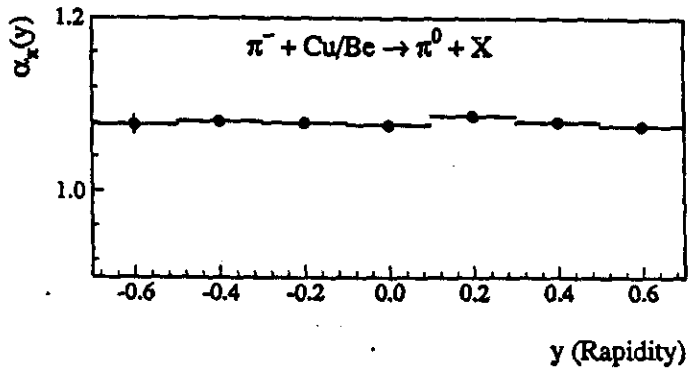

Figure 2: The dependence of α on rapidity for π^0 production in π^-Be and π^-Cu collisions at 500 GeV for $2.5 < p_T < 7.0$ GeV/c.

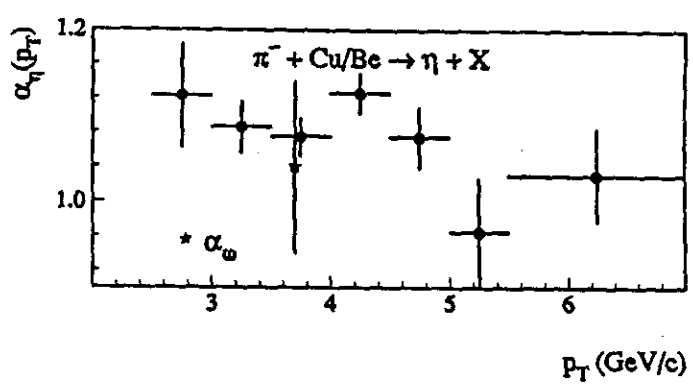

Figure 3: The p_T dependence of α for η production in π^-Be and π^-Cu interactions at 500 GeV. (The data point for ω production is also shown in the figure.)

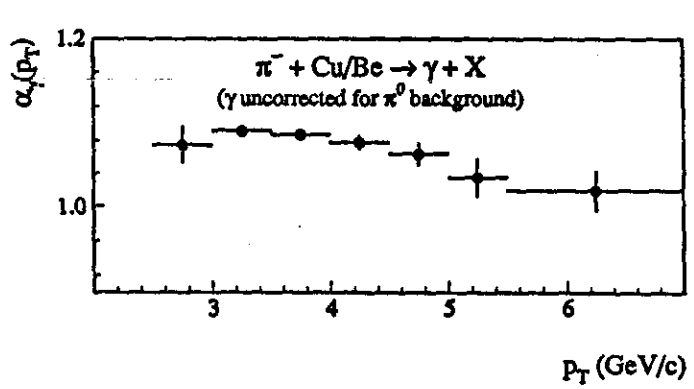

Figure 4: The p_T dependence of α for "direct-photon candidates" in π^-Be and π^-Cu collisions at 500 GeV. (Not corrected for remnant π^0 background.)