

Brief Reports

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Contribution of diffraction dissociation to the A dependence of inclusive pion-fragmentation data

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Analysis of data on the coherent production of $\pi^+\pi^+\pi^-$ in π^+ -nucleus collisions shows that it is the diffraction-dissociation channels which are largely responsible for the enhancement seen in the A dependence of inclusive pion production at $x_{\text{Feynman}} \approx 0.7$. In the A^α parametrizations, coherent contributions may effect the value of α up to 15%, due to their different target dependence. After removal of the contribution to the data of these channels, the A dependence of the invariant cross sections exhibits the same universality as seen in incident-proton data. The significance of these results is discussed.

In a Fermilab single-arm-spectrometer experiment, projectile fragmentation was studied in 100-GeV hadron-proton and hadron-nucleus collisions.¹ In order to understand the influence of the target on the fragmentation process, the measured inclusive differential cross sections $E d\sigma/d^3p$, for processes of the type

$$h + A \rightarrow h' + X$$

at small values of transverse momentum ($p_T = 300$ MeV/ c) and various values of Feynman x were analyzed in terms of the empirical form

$$E \frac{d\sigma}{d^3p} = \sigma_0 A^\alpha \quad (1)$$

The results indicate that for incident protons, α is a universal, weakly decreasing function of x , independent of the outgoing particle or incident energy. The incident-pion results are very similar except for a trivial increase in the value of α arising from the difference in the A dependence of π - A and p - A reaction cross sections and a curious enhancement around $x \approx 0.7$. Thus, with the exception of this enhancement, the A dependence exhibits a remarkable simplicity and an unexpected similarity between pion- and proton-induced reactions, which impose a strong set of constraints on the possible mechanisms of particle production.

In an attempt to gain further insight into these results we have investigated the effects of coherent contributions to inclusive cross sections on nuclear-dependence parametrizations. We expect the strongest such contribution at large x values to come from coherent diffraction of the beam into a low-mass system. Since the A dependencies of such coherent processes do not follow simple A^α form, they may

significantly affect the determination of α .

The dominant pion-diffraction-dissociation mode $\pi \rightarrow \pi\pi\pi$ has been extensively studied at Fermilab by the Rochester-Fermilab-Minnesota collaboration² using a high-resolution magnetic spectrometer. We have analyzed their 200-GeV data for the reaction

$$\pi^+ A \rightarrow \pi^+ \pi^+ \pi^- A$$

taken with C, Cu, and Pb targets, to measure the contribution of the coherent process

$$(A) \quad \pi^+ A \rightarrow \pi^+ \pi^+ \pi^- A \rightarrow \pi^{+(-)} X$$

to the inclusive cross section for

$$(B) \quad \pi^+ A \rightarrow \pi^{+(-)} X$$

To be specific, using the data-handling procedures described in Ref. 2, we have extracted from the raw data $\pi^+\pi^+\pi^-$ events which have an effective mass $M_{3\pi}$ in the range 0.6–2.0 GeV/ c^2 , and which have a four-momentum transfer $t < 0.1$ (GeV/ c)². These cuts include almost 100% of the coherently produced $\pi^+\pi^+\pi^-$ system on all three targets. From this sample we selected events which have a π^+ or π^- with a transverse momentum in the range 200–450 MeV/ c with respect to the beam direction. These events were then used to obtain the cross section for reaction (A),

$$\left(E \frac{d\sigma}{d^3p} \right)_{3\pi \rightarrow \pi^{+(-)},}$$

as a function of x and for an average p_T of 300 MeV/ c .

In calculating $(E d\sigma/d^3p)_{3\pi \rightarrow \pi^{+(-)}}$, corrections were ap-

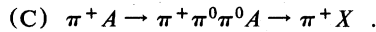
plied for target-empty background, a small ($\sim 5\%$) incoherent contribution, and detector efficiency. The latter were calculated for each x bin using the Monte Carlo technique described in Ref. 2.

Our results are shown in Figs. 1 and 2, where they are compared with the total inclusive cross sections [i.e., reaction (B)], as measured by Barton *et al.*¹ As can be seen from these figures, the coherent part plays a very important role in the inclusive process, contributing up to 25% of the cross section at large x . These results emphasize the importance of subtracting contributions from coherent channels when interpreting data on the A dependence of projectile fragmentation.

We now use these results to estimate how the observed A dependence of the cross sections for reaction (B) would be modified if all coherent contributions were removed.

The only significant contribution to $\pi^+ \rightarrow \pi^-$ from coherent processes is via reaction (A). Contributions from channels such as the coherent production of 5π are considerably smaller. Thus the difference between the cross sections for (B) and (A) should correspond to the incoherent part of the $\pi^+ \rightarrow \pi^-$ process. We have fitted this difference to Eq. (1), and obtain values of α as shown in Fig. 3.

In the $\pi^+ \rightarrow \pi^+$ data, in addition to a contribution from (A), one expects a significant coherent contribution from



We are not aware of any direct data on this channel. However, based on the fact that both (A) and (C) are dominated by a $\rho\pi$ intermediate state, one expects the π^+ cross

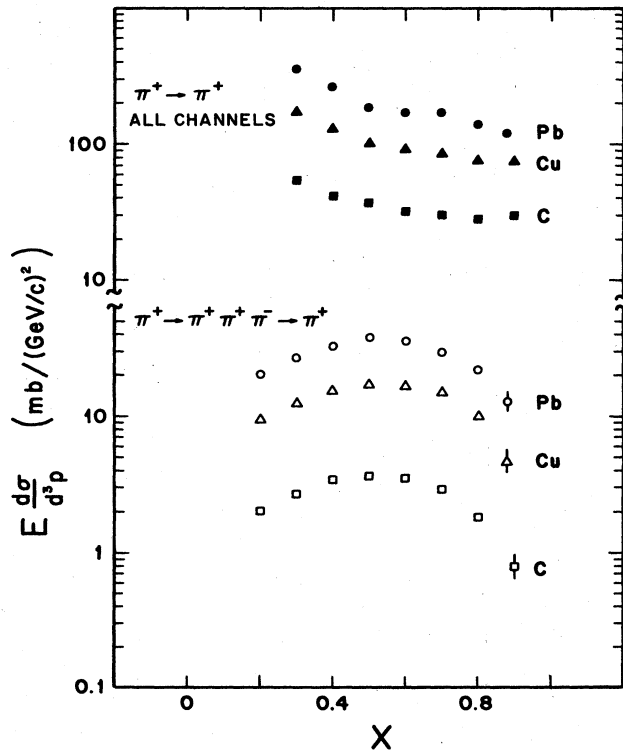


FIG. 1. The invariant differential cross section $E d\sigma/d^3p$ as a function of x , at $p_T=300$ MeV/c; for π^+ production through reactions (A) and (B), see text.

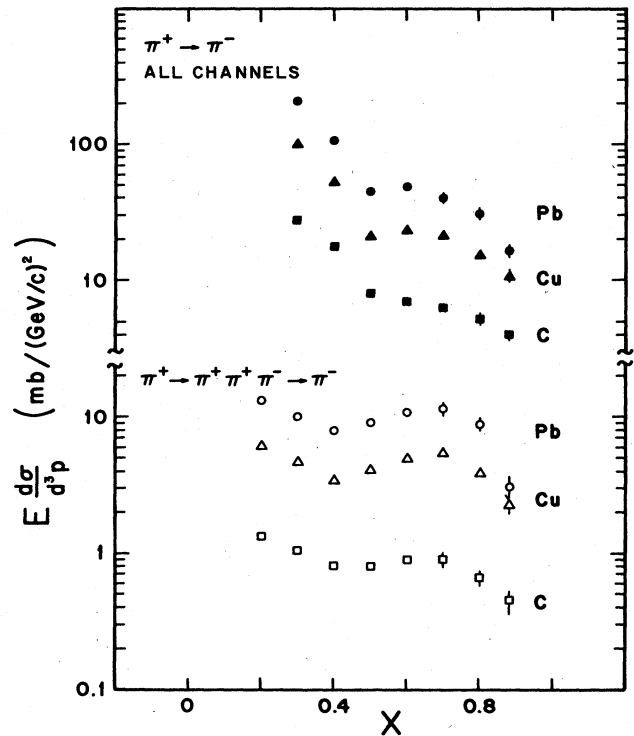


FIG. 2. The invariant differential cross section $E d\sigma/d^3p$ as a function of x , at $p_T=300$ MeV/c; for π^- production through reactions (A) and (B), see text.

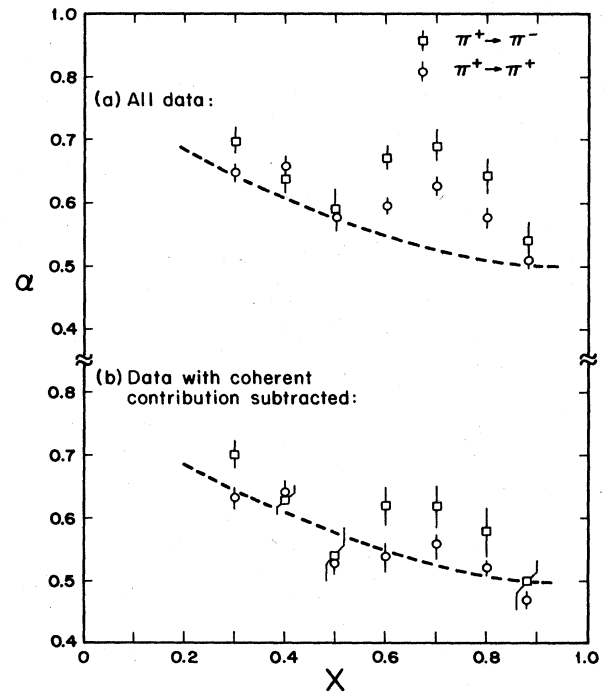


FIG. 3. The variation of the parameter α with x as determined (a) from the inclusive data, and (b) from the inclusive data after subtraction of the contributions from the 3π coherent channels. The curve is a fit to incident proton data raised by 0.045 to take into account the difference in the A dependence of $\pi-A$ and $p-A$ reaction cross sections. It is taken from Ref. 1.

section from (C) to be very similar to the π^- cross section from (A). Using this assumption and the data in Figs. 1 and 2, we have calculated the incoherent contribution and therefore obtained α as a function of x for $\pi^+ \rightarrow \pi^+$. These results are also shown in Fig. 3.

As can be seen in Fig. 3, the subtraction of the contribution from the 3π coherent channel removes a large fraction of the enhancement in α around $x=0.7$. The remaining excess, in particular in the $\pi^+ \rightarrow \pi^-$ data, is most likely due to a contribution from other less important coherent channels.

In Ref. 1, it was concluded that at high energies the A dependence of the inclusive production of particles by incident protons was independent of, or only weakly dependent on, the nature of the outgoing-particle type. From the results shown in Fig. 3 we conclude that, after subtracting the coherent contributions and taking into account the difference in the A dependence of π - A and p - A reaction cross sections, the A dependence of the inclusive production of particles is also independent of, or only weakly dependent on, the nature of the incident-particle type. As discussed in Ref. 1, it is difficult to reconcile the outgoing-particle independence with models of production. The observed incident-particle independence puts an even stronger constraint on such models.

Recently, Abreu *et al.*³ have compared the A dependence of the inclusive production of baryons and antibaryons by pions at a somewhat lower energy of 30 GeV. Their results are shown in Fig. 4; here they are also compared with our pion-production data. Comparing these data it is tempting to speculate that at least at lower energies baryon fragments from the nuclear target extend up to a surprisingly large value of $x_{\text{Feynman}} (\geq 0.6)$ (Ref. 4), while projectile frag-

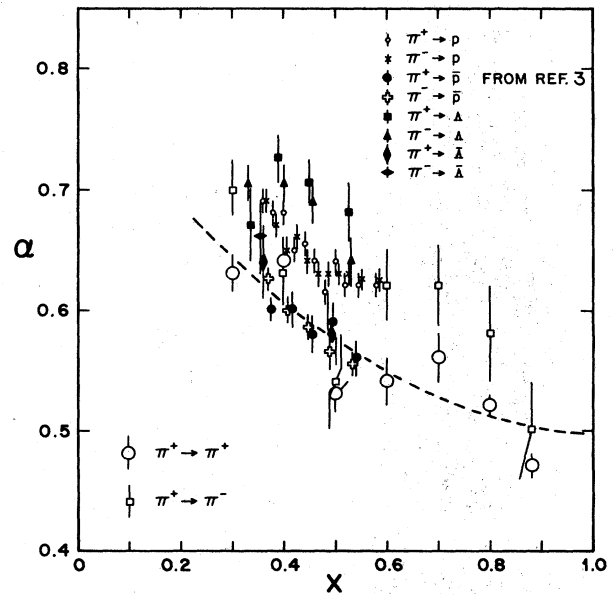


FIG. 4. The variation of the parameter α with x for various particles produced by pions. The curve is the same fit to incident-proton data as shown in Fig. 3.

ments exhibit the same universality as seen at higher energies.

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¹D. S. Barton *et al.*, Phys. Rev. D **27**, 2580 (1983).

²M. Zielinski *et al.*, Z. Phys. C **16**, 197 (1983); J. Jensen *et al.*, Phys. Rev. D **27**, 26 (1983).

³M. C. Abreu *et al.*, paper submitted to the International Europhysics Conference on High Energy Physics, Brighton, 1983 (unpublished).

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⁴In hadron-nucleus collisions the ratio of positive to negative relativistic particles increases with A [see, e.g., W. M. Yeager *et al.*, Phys. Rev. D **16**, 1294 (1977); D. H. Brick *et al.*, Nucl. Phys. **B201**, 189 (1982)]. The fact that in π -nucleus fragmentation data α for produced baryons is greater than for antibaryons may be a reflection of the same phenomenon.