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# "LEADING CLUSTERS" IN 200 GeV/c $\pi^- p$ INCLUSIVE REACTIONS*

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## 1. INTRODUCTION

We wish to report an interesting characteristic of single-particle rapidity distributions observed in 200 GeV/c $\pi^- p$ interactions. The data are from a sample of ~16,000 events obtained with the 30" bubble chamber at Fermilab. A hybrid arrangement[1)] of upstream pwc's and downstream wide-gap chambers was used to improve the resolution for fast forward secondaries.

## 2. LEADING PARTICLE EFFECT

The cms rapidity distributions for $\pi^\pm$ produced in the reactions $\pi^- + p \rightarrow \pi^\pm +$ anything are shown in Fig. 1. Corresponding distributions for the 205 GeV/c reactions $p + p \rightarrow \pi^\pm +$ anything[2)], normalized to the $\pi^- p$ inelastic cross sections, are shown for comparison. The factorization hypothesis for target fragmentation is clearly well satisfied for both $\pi^+$ and $\pi^-$ production. The $\pi^+$ distributions for the two reactions are, in fact, in excellent agreement over the entire range of rapidity, whereas the $\pi^-$ distributions show a considerable excess in $\pi^- p$ compared to pp, production. This "leading particle effect" is not confined to the extreme forward direction but extends back into the central region, $|y| \leq 1.0$; there is, indeed, no "central region" independent of the nature of the incident particles at 200 GeV/c.

That the forward excess of $\pi^-$ is not confined to events of low multiplicity is demonstrated in Fig. 2a -- it is clearly evident even in events with multiplicity $n \geq 14$. The fast "single leading $\pi^-$" also cannot account for the effect: when we rapidity-order all secondaries in each event, and exclude the leading $\pi^-$ forward of the maximum

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rapidity gap (requiring $r_{max} \geq 1.0$) we obtain the dashed histogram of Fig. 2b. Most of the leading-particle excess remains. We next exclude from the distribution all charged secondaries in each event which are forward of the maximum rapidity gap, again requiring $r_{max} \geq 1.0$ (Fig. 3a), with the further requirement that the charged multiplicity M of this "leading cluster" be odd and that it have a total charge $Q = -1$. In this case, the distribution for the $\pi^-$ remaining is shown as the inner histogram of Fig. 2b, and we conclude that there is significant production of "leading clusters" in inclusive reactions at Fermilab energies.

## 3. "LEADING CLUSTERS"

To study systematic trends in the leading clusters, we investigate the distributions of total charge Q and cluster multiplicity M of the charged secondaries forward of $r_{max}$ in each event. In Fig. 3b, the distribution for Q shows a pronounced peak at $Q = -1$, indicating that a large fraction of the forward clusters have the same charge as the beam particle.* Fig. 3c shows that odd multiplicity predominates and that even out to high M, most of the odd-M clusters have $Q = -1$ (shaded). If the largest gaps were distributed at random one would not expect such a "picket fence" distribution. If we hand-draw a smooth background curve through the even-multiplicity values for $r_{max} \geq 1$, as indicated, the cross sections for formation of all $Q = -1$ leading clusters selected on this basis is considerable: 6.6 mb, out of a total inelastic cross section of 21 mb.

In Fig. 3d we show distributions of the leading cluster multiplicity M for different multiplicities n of charged secondaries in each event, with the requirement that $Q = -1$. For all topologies the largest M allowed has the greatest population and single forward $\pi^-$ emission has the next highest preference. All topologies are thus consistent with a "single dissociation" picture in which a large fraction of the events involve either target dissociation, with a single fast $\pi^-$ in the forward direction, or

*) In contrast to this predominance of charge transfer zero across the maximum rapidity gap, $r_{max}$, the charge transfer is zero for only 35% of all gaps.

beam dissociation into the largest number of charged secondaries allowed. This is particularly evident for the high-multiplicity events. We have made a comparison with a completely-random charge distribution model requiring only that the leading M charged particles have net charge $Q = -1$. The model calculation values are shown, dotted, in Fig. 3d. It is clear that the model does not account for the effect we see. It is also evident that the general features of these distributions are not strongly dependent (there is the expected kinematic dependence) on our choice for the minimum value of $r_{max}$ (Figs. 3b, 3d).

## 4. SUMMARY

At 200 GeV/c we find a large "leading cluster" effect that produced greater inclusive $\pi^-$ cross sections for $\pi^- p$ than for pp reactions over the entire forward cms hemisphere. These leading clusters are observed for all topologies and tend to be associated both with net cluster charge equal to the charge of the incident pion (zero charge transfer across the maximum rapidity gap) and with a maximum rapidity gap located at one end of the rapidity chain.

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## REFERENCES


1. G. A. Smith, Particles and Fields - 1973, A.I.P. Conf. Proc. No. 14 (1974), p. 500.
2. M. Derrick, Proc. XVII Conf. on High Energy Physics at London (1974), p. I-3, and private communication.

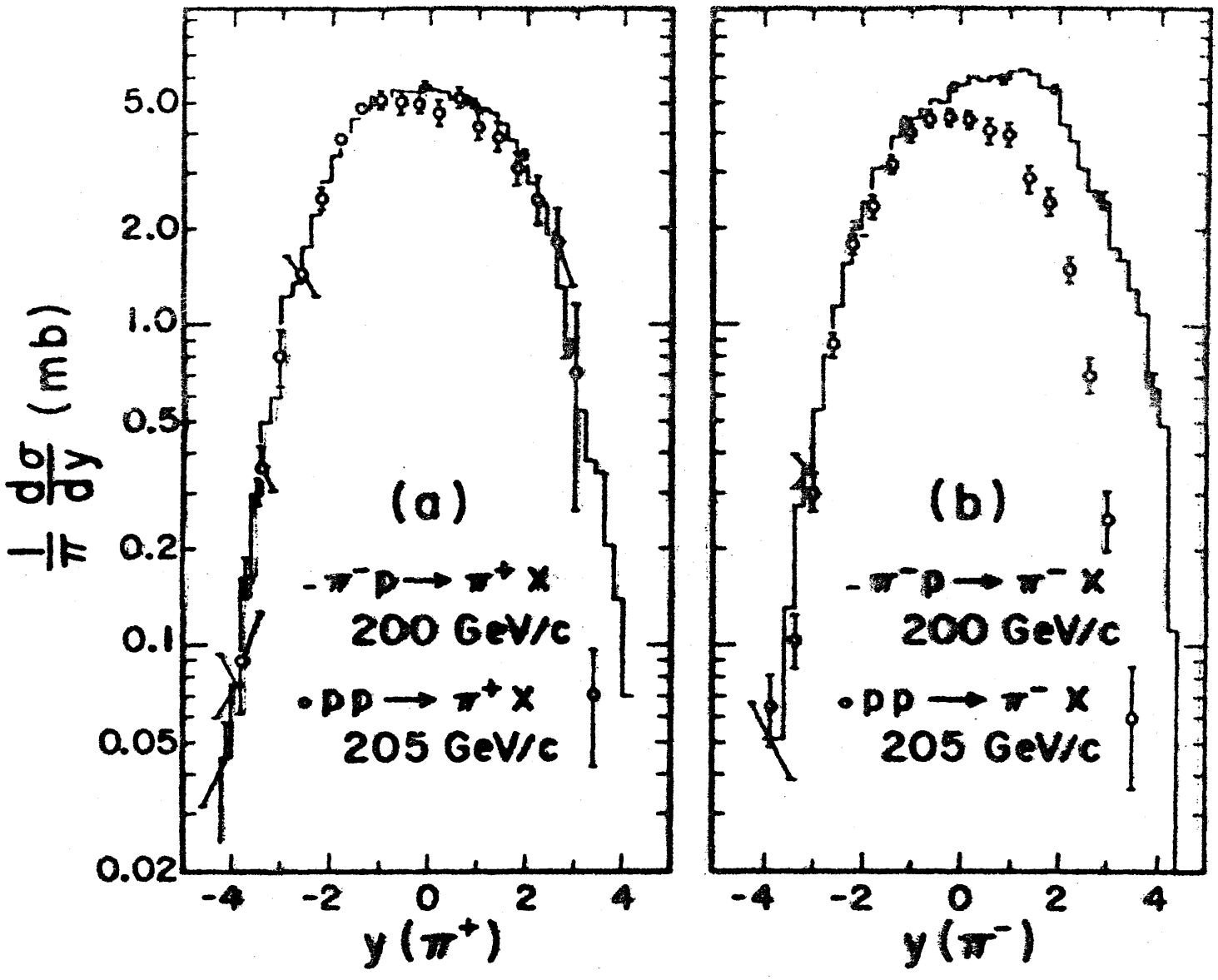


Fig. 1 Distributions of the cms rapidity for (a) $\pi^+$ and (b) $\pi^-$ produced in 200 GeV/c $\pi^- p$ inelastic inclusive reactions. Corresponding distributions for the reactions $p + p \rightarrow \pi^\pm$ + anything at 205 GeV/c, normalized to the $\pi^- p$ inelastic cross section, are shown for comparison (open circles).

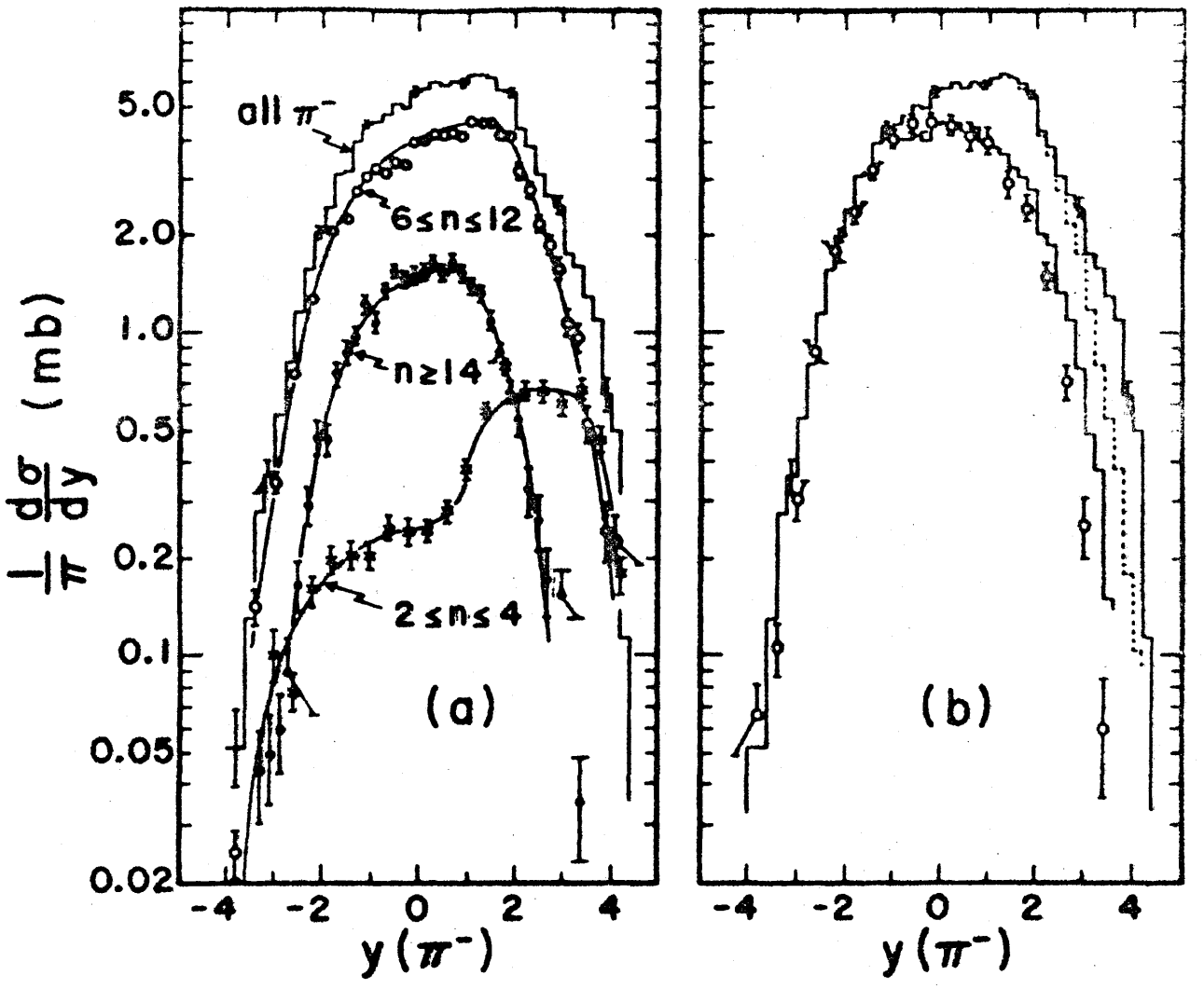


Fig. 2 a) Rapidity distributions (cms) by multiplicity for $\pi^-$ produced in 200 GeV/c $\pi^-p$ interactions, for (outer histogram) all $\pi^-$, for (x) $2 \le n \le 4$, for (o) $6 \le n \le 12$, and for (•) $n \ge 14$.

b) Rapidity distribution for (outer histogram) all $\pi^-$, for (dashed histogram) $\pi^-$ remaining when "single leading $\pi^-$" are excluded, and for (inner histogram) $\pi^-$ remaining when "leading clusters" are removed. Data for 205 GeV/c pp interactions, normalized to the $\pi^-p$ inelastic cross section, are shown for comparison (open circles).

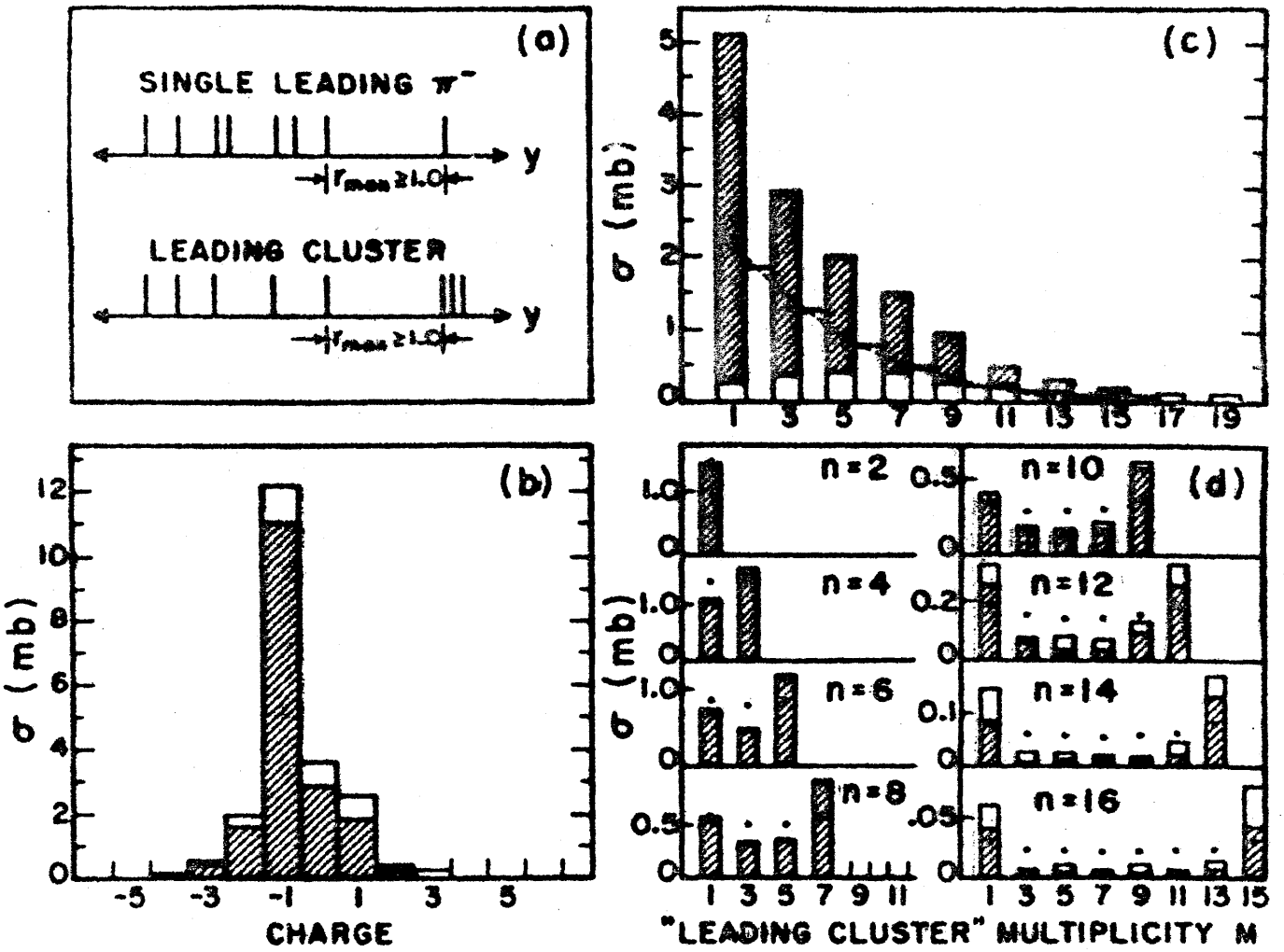


Fig. 3

a) Diagrams illustrating rapidity ordering with (above) selection of "single leading $\pi^-$" and (below) selection of "leading clusters".

b) Distribution of total charge Q of all charged secondaries which are forward of the maximum rapidity gap for $r_{max} \geq 0$ (unshaded) and $r_{max} \geq 1$ (shaded).

c) Distribution of multiplicity M of charged particles for the same events, $r_{max} \geq 1$. The shaded portion corresponds to Q = -1. The dashed "background" curve is hand-drawn through the even-multiplicity values.

d) Distribution of Q = -1 leading-cluster multiplicity M by over-all event multiplicity n. (Note changes of scale.) The unshaded portion corresponds to $r_{max} \geq 0$ and the shaded to $r_{max} \geq 1$. Results of a model calculation with completely random charge distribution, requiring only that the leading M charged particles have net charge Q = -1, are shown dotted.