COMMENT ON THE SHAPES OF MULTIPLICITY DISTRIBUTIONS IN pp COLLISIONS*

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We discuss the shapes of multiplicity spectra observed in inelastic pp collisions at high energies. It is found that a recent observation, which claims that the negative-particle multiplicity is consistent with a Poisson distribution for high multiplicities, is not valid at the highest Fermilab energies.

Results from a recent experiment examining inelastic π^+p and pp collisions at 100 GeV/c [1] have been used to show that the multiplicity spectrum for large values of prong number (n) follows a Poisson distribution in negative prong number $\left(n_- = \frac{n-2}{2}\right)$. This result is certainly unexpected because it is believed that inelastic production data exhibit substantial clustering, or correlation, among produced particles [2]. If this result were true for all energies in the 100–400 GeV/c Fermilab-momentum range, it would imply that the observed correlations arose entirely from the diffractive component present in the low multiplicities. The fact that the Mueller moment $f_2^- = \langle n_-(n_- - 1)\rangle - \langle n_-\rangle^2$ grows with increasing energy would be understandable in terms of the presence of an uncorrelated "central-production" component at high n_- and a diffractive component at low n_- values, each of which displays a different dependence of the inelastic multiplicity on incident momentum.

In this note we re-examine the degree to which a Poisson distribution in n_- is consistent with inelastic production data in pp collisions. In particular, we ask the question whether the multiplicity spectrum for data which do not contain large diffractive contributions, namely $n_- \geqslant 3$, are in agreement with a Poisson shape.

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Figure 1 displays pp data between 12.9 GeV/c and 400 GeV/c [3] in terms of the dependence of log $(n_-!\,\sigma_{n_-})$ on n_- [4]. (σ_{n_-} is the cross section for the n_- multiplicity class.) If a Poisson distribution were to fit the data we would observe, at fixed energy, a linear variation of $\log(n_-!\sigma_{n_-})$ with n_-; the slope of this variation would be $\log\langle n^c_-\rangle$, where $\langle n^c_-\rangle$ would correspond to an average negative-particle multiplicity of the "central" component of the inelastic cross section. Table I lists the parameters for linear and for quadratic fits of $\log(n_-!\sigma_{n_-})$ as a function of n_- in the 100 GeV/c — 400 GeV/c momentum range. (The

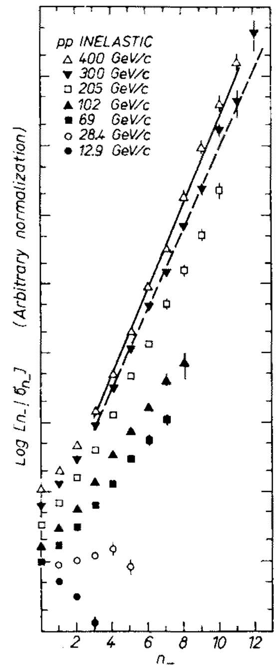

Fig. 1. The dependence of log $(n_-!\,\sigma_{n_-})$ on n_- for inelastic pp collisions between 12.9 GeV/c and 400 GeV/c. Where no error bars are given the errors are smaller than the size of the data points

TABLE I

Dependence of log $(n_-!\,\sigma_{n_-})$ on n_-

Beam momentum	Linear fit $(A+Bn_-)$[b]		χ^2 [a]	Quadratic fit $(A+Bn_-+Cn_-^2)$[b]			χ^2 [a]
	A	B		A	B	C	
102 GeV/c	5.9±0.1	0.85±0.03	0.8	5.4±0.4	1.1±0.2	−0.025±0.018	0.4
205 GeV/c	4.7±0.1	1.20±0.01	1.0	4.9±0.2	1.1±0.1	0.006±0.006	1.0
300 GeV/c	5.1±0.1	1.33±0.01	4.5	5.6±0.2	1.1±0.1	0.018±0.005	2.7
400 GeV/c	5.2±0.1	1.41±0.01	5.7	6.1±0.2	1.1±0.1	0.032±0.006	1.5

[a] This is the value of χ^2 per degree of freedom. There are typically eight data points per energy.
[b] The overall normalization is arbitrary.

linear fits at 300 GeV/c and 400 GeV/c are shown in the figure.) Linear fits are acceptable for the 100 GeV/c and 200 GeV/c data. However, the coefficients of the quadratic term between 100 GeV/c and 400 GeV/c appear to change smoothly through zero near $\sim$150 GeV/c, indicating that the acceptable linear fits in the 100 GeV/c and 200 GeV/c data are transitory and accidental. The 300 GeV/c and 400 GeV/c spectra for $n_- \geqslant 3$ are broader than Poisson, and consequently imply the presence of correlated emission of particles (i.e., $f_2^- \neq 0$) for inelastic production in the central regime.

I wish to thank P. Slattery for comments on this work.

REFERENCES

[1] J. Erwin et al., *Phys. Rev. Lett.* **32**, 254 (1974).

[2] See, for example, the recent review by J. Ranft, *Proc. V Int. Symp. on Many Particle Hadrodynamics*, Eisenach–Leipzig (1974).

[3] The data at 12.9 GeV/c and 28.4 GeV/c are from the thesis of D. Smith, *UCRL* 20632–71 (unpublished). The 69 GeV/c, 102 GeV/c, 205 GeV/c, 300 GeV/c, 400 GeV/c data are, respectively, from: V. Ammosov et al., *Phys. Lett.* **42B**, 519 (1972); C. Bromberg et al., *Phys. Rev. Lett.* **31**, 1563 (1973); S. Barish et al., *ANL/HEP* 7361 (1974); A. Firestone et al., *NAL preprint* (1974); and C. Bromberg et al. loc. cit., updated using latest, as yet unpublished, multiplicity data at 400 GeV/c (Michigan-Rochester Group).

[4] Here we proceed as in reference 1. For a discussion of previous data and theoretical justification see W. Frazer, *Ann. N. Y. Acad. Sci.* **229**, 193 (1974).