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Recent High Energy Multiplicity Distributions In The Context of the Feynman Fluid Analogy

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ABSTRACT

Recent accelerator data on multiplicity distributions is re-examined within the context of the Feynman Fluid Analogy. An interpretation of the data put forward is that the diffractive component decreases logarithmically with energy.

The recent data[1] on prong distributions at high energies (50 - 300 GeV) suggests a re-examination of results based on the Feynman Fluid Analogy. The previous[2] approach to this problem relied on cosmic ray data.[3] The available accelerator results differ with the cosmic ray ones and, presumably, are more reliable. In this note we shall present the results of such a reanalysis together with a possible hint about the energy dependence of the diffractive component of multiparticle production.

We review briefly the method used which is similar to the one of Ref. 2. The reaction studied was $p + p \rightarrow n$ negative particles ($n = 0$ includes elastic scattering) at a center of mass energy $\sqrt{s}$.

Let

$$Y = a \ln (s/s_o) \qquad (1)$$

We shall return to the choice of s_o shortly. Instead of dealing with the cross sections σ_n we study the partition function

$$Q(z, Y) = \sum z^n \sigma_n(Y)/\sigma_{total} \qquad (2)$$

and assume that at large Y it has the behavior

$$\ln Q(z, Y) = p(z)\, Y + s(z) \qquad (3)$$

For very large energies the value of s_o in (1) is irrelevant; however, for present energies it may be important. (The value assigned to a is a scale factor and for our purpose is arbitrary.) A hint as to the value of s_o may be obtained from the fluid analogy itself. The inelastic average multiplicity, $<n>$, is proportional to the length of the plateau in the one particle inclusive distribution, which in turn is the analog of the length of the fluid container, Y. Thus it isplausible that the proper extrapolation of Y to present energies is to let

$$Y = <n> \approx -2.9 + \ln s \qquad (4)$$

The analysis presented below makes this identification. Had we chosen $s_o = 1$ GeV, as was done in Ref. 2, none of our conclusions would change. With such a choice (3) is not as well satisfied as with choosing (4) and subsequently the errors on p(z) are larger.

The values of Q(z, Y) together with the best fit to (3) are shown in Fig. 1, and the pressure, p(z), is presented in Fig. 2.

One may now speculate on production mechanisms which would yield such a pressure curve. Following the discussion of Ref. 2, we would conclude that the rising part ($z \gtrsim 0.8$) of the pressure curve was due to a multiperipheral mechanism, while the relatively straight section ($0 < z \lesssim 0.8$), one could naively say, was due to a mechanism yielding

$$\sigma_n(Y) = e^{-\eta Y} d_n, \qquad (5)$$

with $\eta \sim 0.2$ and d_n independent of Y.

An energy behavior such as $s^{-0.2}$, which would be implied by a literal interpretation of Fig. 2 and Eq. (5) is somewhat unpalpable. Had η turned out to be approximately zero we could have identified (5) with the diffractive component; a decrease implied by $\eta \approx 0.2$ has no natural explanation. However, one may note that over the limited range of energies used in the present analysis (50 - 300 GeV) it is difficult to distinguish $s^{-0.2}$ from ln s.[4] Thus one may view the data as giving a hint that the diffractive component is decreasing logarithmically with energy. From a theoretical point of view, such a variation is quite acceptable. Support for this assertion could come from a similar, future, analysis of higher energy data yielding a smaller value of η.

As a consistancy check, a fit to the data, with the logarithmic energy decrease of the diffractive component, was obtained. The hypothesis employed was[5]

$$Q(z, Y) = \frac{P(z)}{\ln s} + \left(1 - \frac{P(1)}{\ln s}\right) \exp\left\{f_1(z-1) + f_2(z-1)^2/2\right\} \qquad (6)$$

where P(z) is a polynomical which was arbitrarily chosen to be of third order. The parameters obtained were

$$\begin{aligned} P(z) &= 51 + 19z + 11.5\, z^2 + 1.5\, z^3 \\ f_1 &= -2.5 + \ln s \qquad (7) \\ f_2 &= -2.35 + 0.4 \ln s \end{aligned}$$

and the results are shown in Fig. 3.[6] The success of this fit should not be taken as proof of the hypothesis on the logarithmic energy dependence of the diffractive component. The data can be well parametrized with constant diffractive contributions.[7] As mentioned above it just indicates that the logarithmic decrease is consistent with the data.

I wish to thank Dr. H. Harari, Dr. G. Thomas and my colleagues at NAL for discussions.

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[4] In this energy region the relation $\ln s = 1.97\, s^{.185}$ is valid to $\sim 1\%$. See likewise, J. D. Jackson, Rev. Mod. Phys. 42, 12 (1970).

[5] A. Mueller, Phys. Rev. D4, 150 (1971).

[6] σ_{total} was set equal to 38.5 mb.

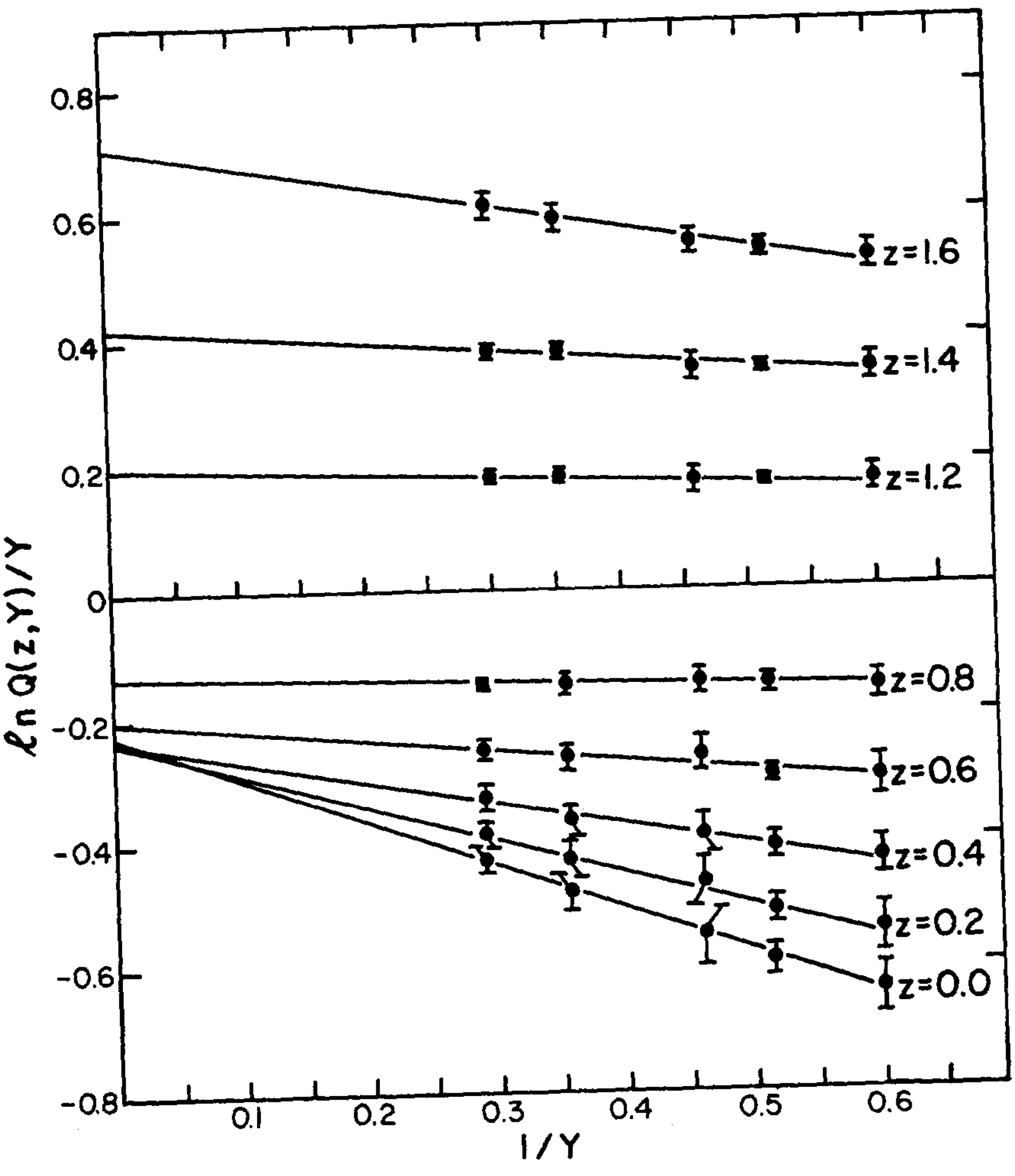
[7] W. Frazer, R. Peccei, S. Pinsky and C.-I Tan, UCSD preprint 10P10-113, 1972 (unpublished); C. Quigg and J. D. Jackson, NAL preprint, NAL-THY-93, 1972 (unpublished).

FIGURE CAPTIONS

1. The logarithm of the partition function and the best straight line fit to it. The data are from Ref. 1.

2. Partial pressure due to negative particles.

3. Fit to the negative prong cross sections of Ref. 1 based on Eq. (6) with the parameters given in Eq. (7).



0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0.1
0.2
0.3
0.4
0.5
0.6
1/Y
ℓn Q(z,Y)/Y
z=1.6
z=1.4
z=1.2
z=0.8
z=0.6
z=0.4
z=0.2
z=0.0

Fig. 1

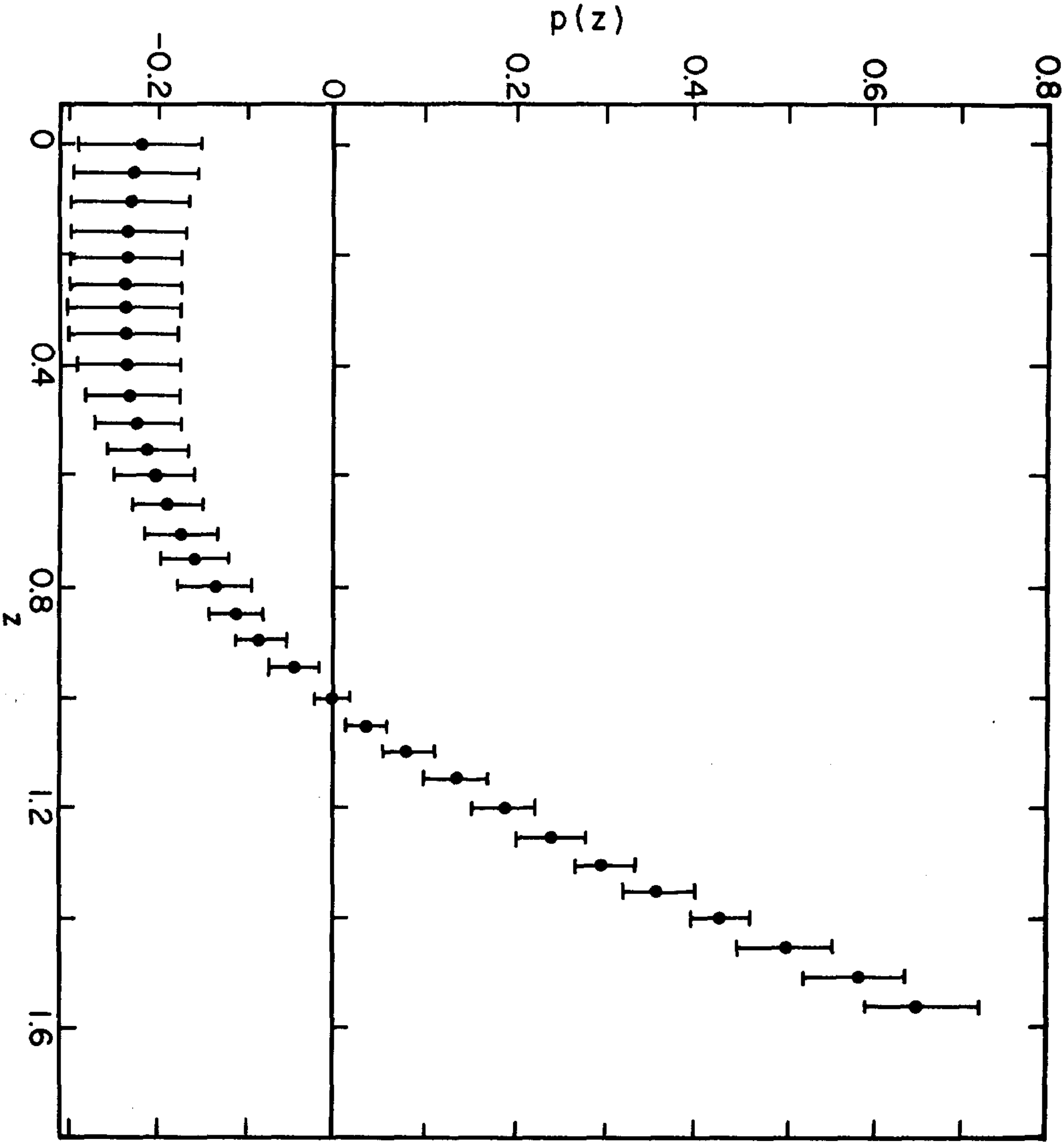


Fig. 2

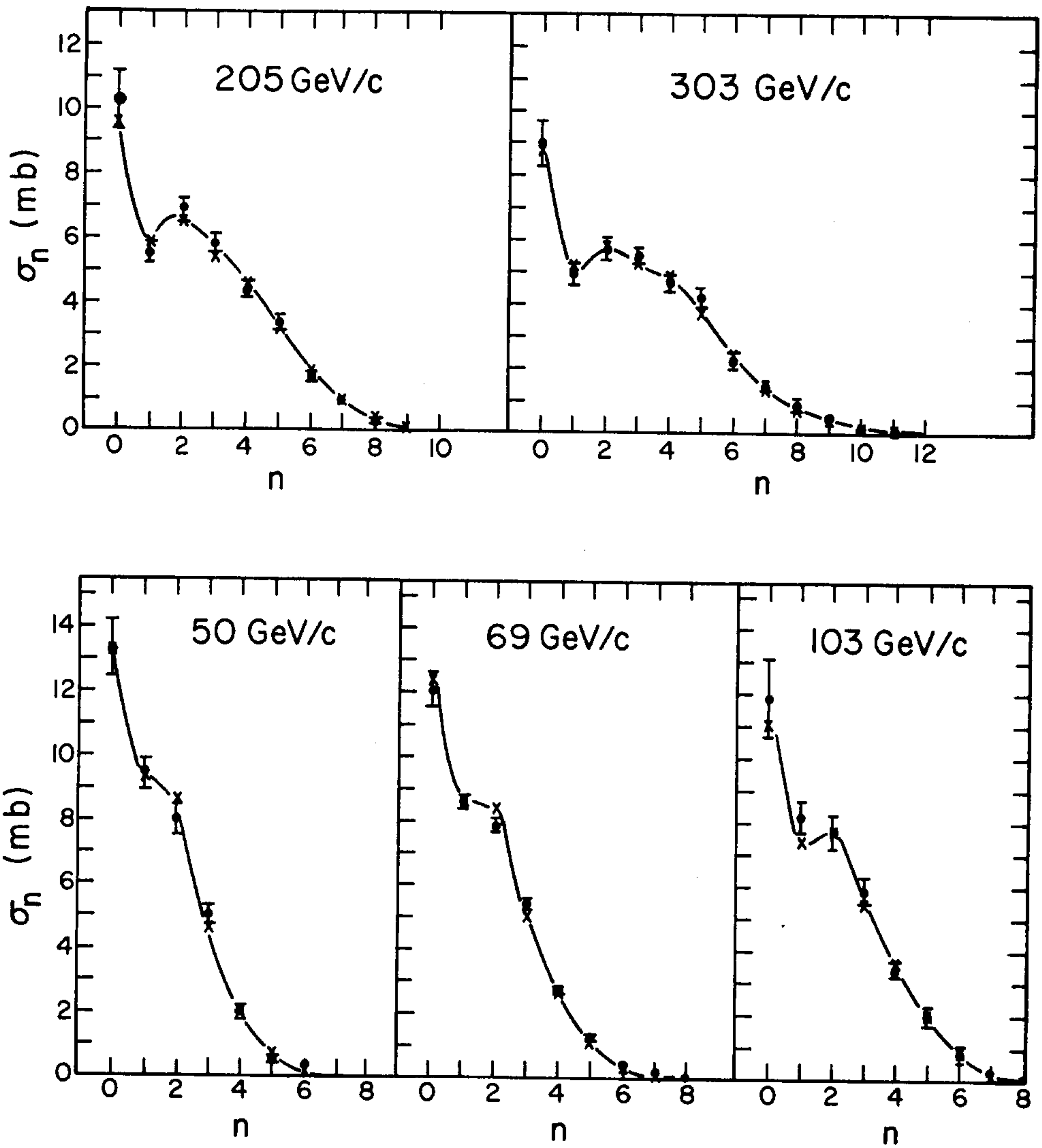


Fig. 3