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CBPF - Centro Brasileiro de Pesquisas Físicas
Rio de Janeiro, RJ
BRASIL

CBPF-NF-006/83

pp PRODUCTION CROSS SECTIONS AND THE CONSTRAINT METHOD

by

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SUMMARY:

A method of constructing production cross sections that satisfy the constraints represented by the first few moments is shown to give an excellent account of the data when applied to the high energy pp production cross sections $\sigma_n(s)$ plotted as functions of n.

In a recent paper [1], we have generalized a constraint method [2] to construct production cross sections. A somewhat different generalization has also been proposed [3].

The method amounts to assuming the high energy constraints [4,5,6]

$$\begin{cases} \langle n\ (s)\rangle = \alpha\sigma_{in}(s) + \beta & \alpha,\beta = \text{const} \\ D \equiv \sqrt{\langle n^2\rangle - \langle n\rangle^2} = A\ (\langle n\rangle - 1) & A \simeq 0.56 \div 0.57 \\ \langle (n - \langle n\rangle)^3\rangle / \langle n\rangle^3 \lesssim 0.080 \pm 0.015 \equiv \gamma \end{cases} \quad (1)$$

to determine the coefficients of a second order differential equation which we consider the natural generalization of the simple constraint method originally proposed in ref. [2]. Such equation reads

$$a(x)\ \frac{d^2\sigma_n}{dx^2} + (B(x) - n)\ \frac{d\sigma_n}{dx} + C(x)\ \sigma_n = 0 \quad (2)$$

where we have used as integration variable

$$x \equiv \sigma_{in}(x) \quad (3)$$

After some algebra, it was shown in [1] that the energy dependent coefficients of eq. (2) are given by

$$\left\{\begin{array}{l} a(x) = x\dfrac{n(x)}{A^2+1}(2\gamma + A^2 - 3A^4) + \dfrac{xA^2}{A^2+1}(7A^2-2) + \\[2ex] \qquad + \dfrac{A^2 x}{n(x)(A^2+1)}(1-5A^2) + \dfrac{A^4\ x}{n^2(x)(A^2+1)} \\[2ex] B(x) = \dfrac{n(x)}{A^2+1}(1-4\gamma+2A^2+9A^4) - \dfrac{18A^4}{A^2+1} + \\[2ex] \qquad + \dfrac{A^2}{n(x)}\ \dfrac{11A^2-1}{A^2+1} - \dfrac{2A^4}{n^2(x)(A^2+1)} \\[2ex] C(x) = \dfrac{n(x)}{A^2+1}\ \dfrac{1}{x}(1+4\gamma-9A^4) + \dfrac{18A^4}{A^2+1}\ \dfrac{1}{x} - \\[2ex] \qquad - \dfrac{A^2}{n(x)}\ \dfrac{1}{x}\ \dfrac{11A^2-1}{A^2+1} + \dfrac{2A^4}{n^2(x)(A^2+1)}\ \dfrac{1}{x} \end{array}\right. \qquad (4)$$

where A and γ were defined in eq. (1) and where we have set

$$\langle n(s)\rangle \equiv n(x) \qquad (5)$$

In the limit of high energies, the asymptotic solution of the differential equation (2) be given in closed form in terms of a confluent hypergeometric equation

$$\sigma_n^{as}(s) = K\,\frac{\sigma_{in}(s)}{\langle n\rangle}\left(\frac{n}{\langle n\rangle}\right)^b e^{-dn/\langle n\rangle}\,\psi\left(a,c;\,d\frac{n}{\langle n\rangle}\right) \qquad (6)$$

where K is a normalization constant and the various parameters have, numerically, the values $11 \lesssim b \lesssim 12.4$, $7.30 \lesssim d \lesssim 7.87$, $0.78 \lesssim a \lesssim 0.82$ and $11{,}8 \lesssim c \lesssim 13{,}2$ (the uncertainty in the above parameters is a direct consequence of the uncertainty in the parameter A defined in eq. (1)).

Notice that the expression (6) satisfies KNO scaling [7] which was not the case for the solution of the original second order differential equation (2). The rapidity with which KNO scaling is approached, is briefly discussed in ref. ([1]) where it is also shown that the simpler form of ref. ([2]) obtains from eq. (6) in the limit $\frac{n}{<n>} \to \infty$.

In the present paper we give a direct comparison of the results of ref. ([1]) with the pp data for $\sigma_n(s)$ plotted vs n at fixed s (i.e. $<n>$).

Using the same normalization prescription at the maximum used in ref. ([1]), the numerical solution of equation (2) is shown in figs. (1-8) and compared with the data from the lowest to the highest energies for which they are available ([8]).

As it can be seen, eq. (2) gives a very satisfactory account of the data showing that the parametrization resulting for $\sigma_n(s)$ is already quite well in agreement with the data if one uses the constraint method for the first three moments only.

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FIGURE CAPTIONS

Fig. 1,2 - The comparison between equation (2) and the data [8a].

Fig. 3,4 - The comparison between equation (2) and the data [8b].

Fig. 5 - The comparison between equation (2) and the data [8c].

Fig. 6 - The comparison between equation (2) and the data [8d].

Fig. 7 - The comparison between equation (2) and the data [8e].

Fig. 8 - The comparison between equation (2) and the data [8f].

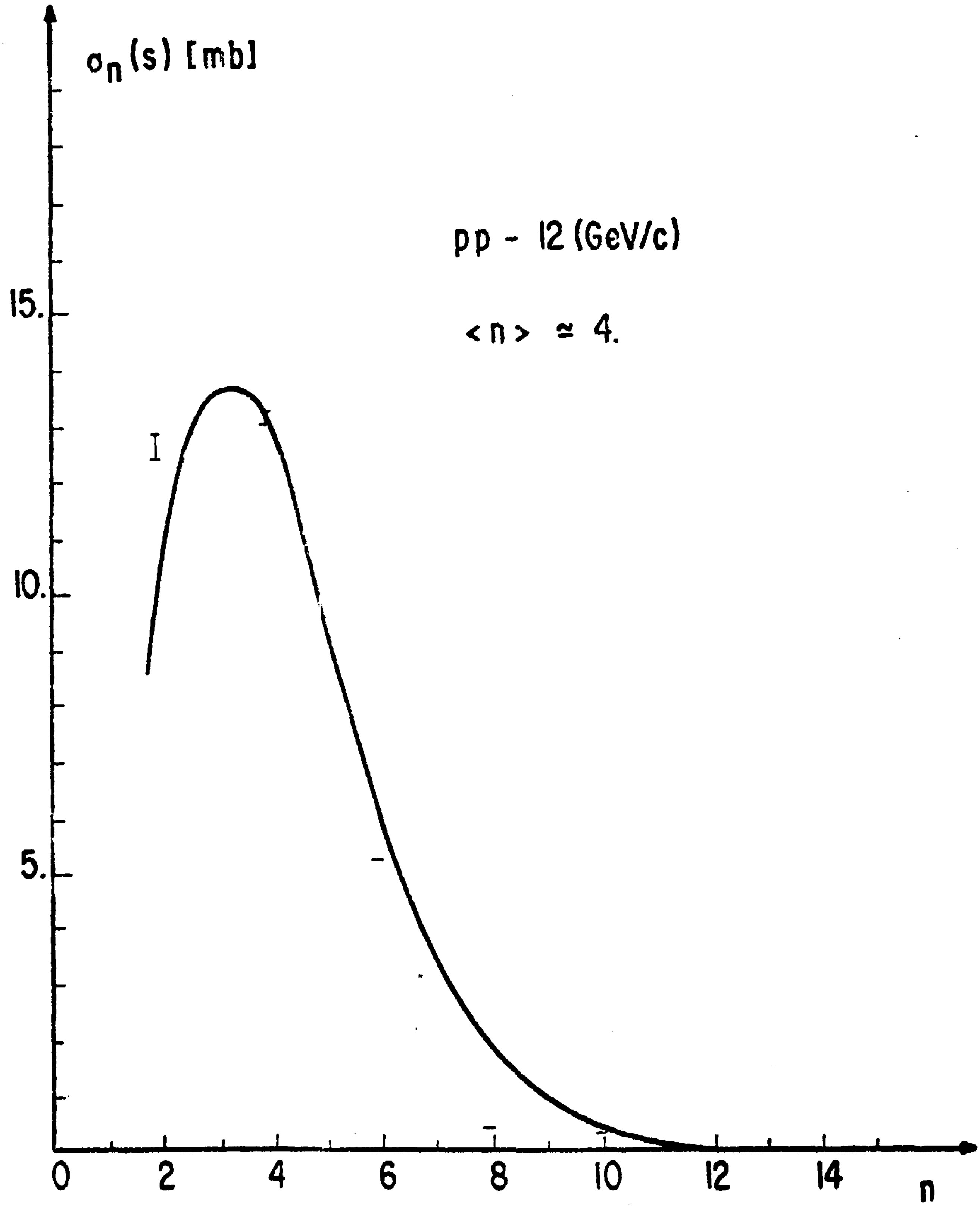
$\sigma_n(s)$ [mb]
pp - 12 (GeV/c)
$\langle n \rangle \simeq 4.$
15.
10.
5.
0
2
4
6
8
10
12
14
n

Fig. 1

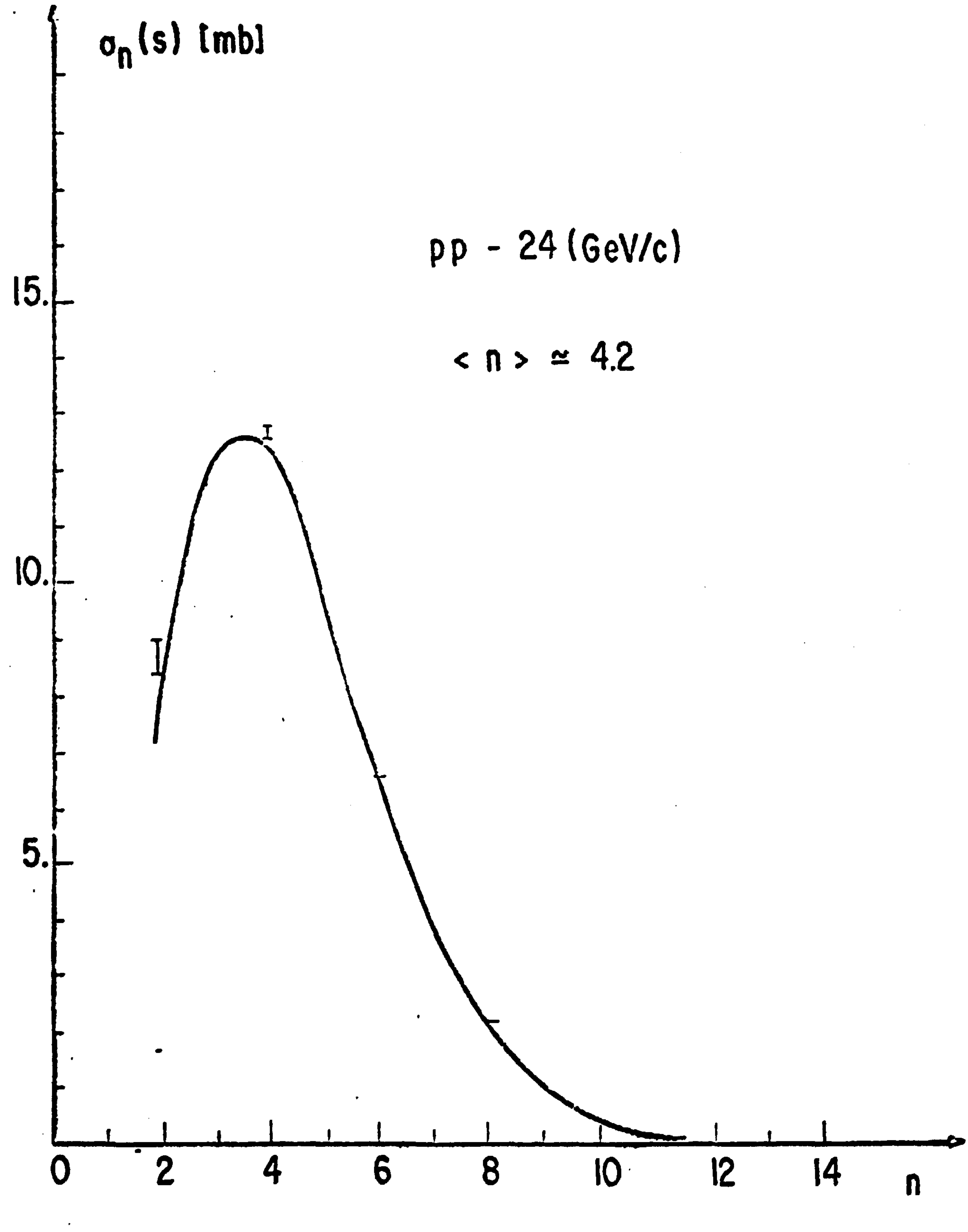

Fig. 2

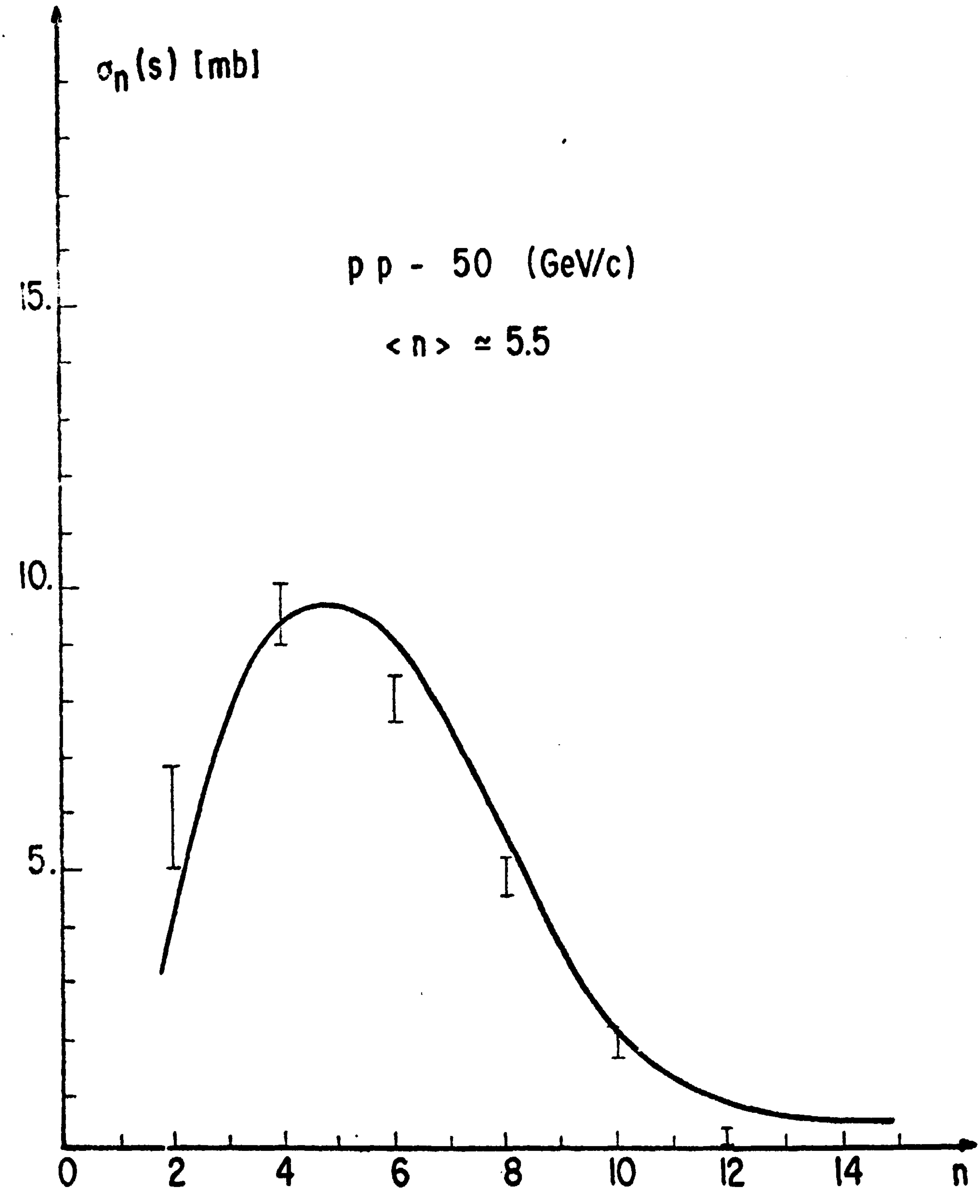

Fig. 3

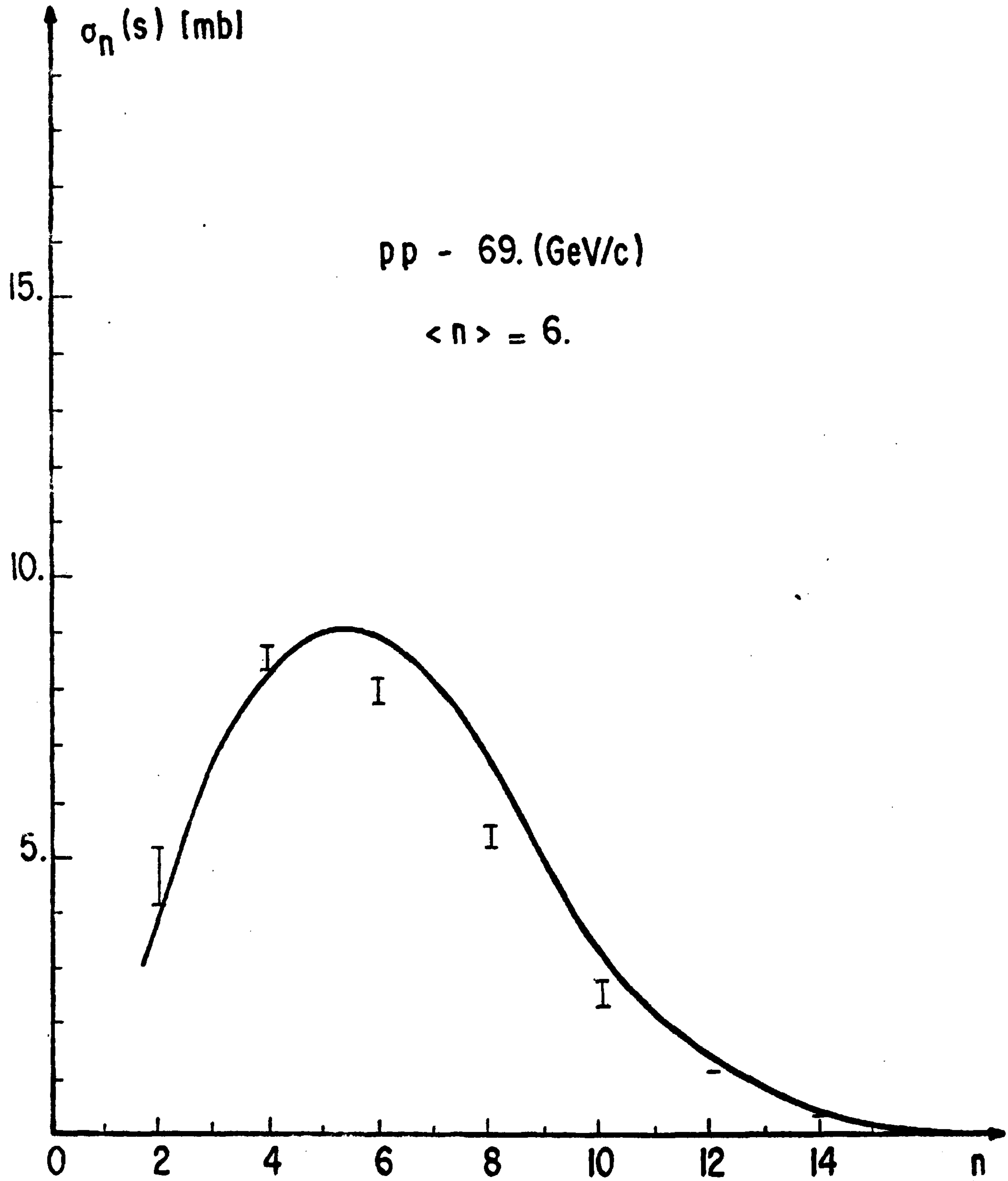

Fig. 4

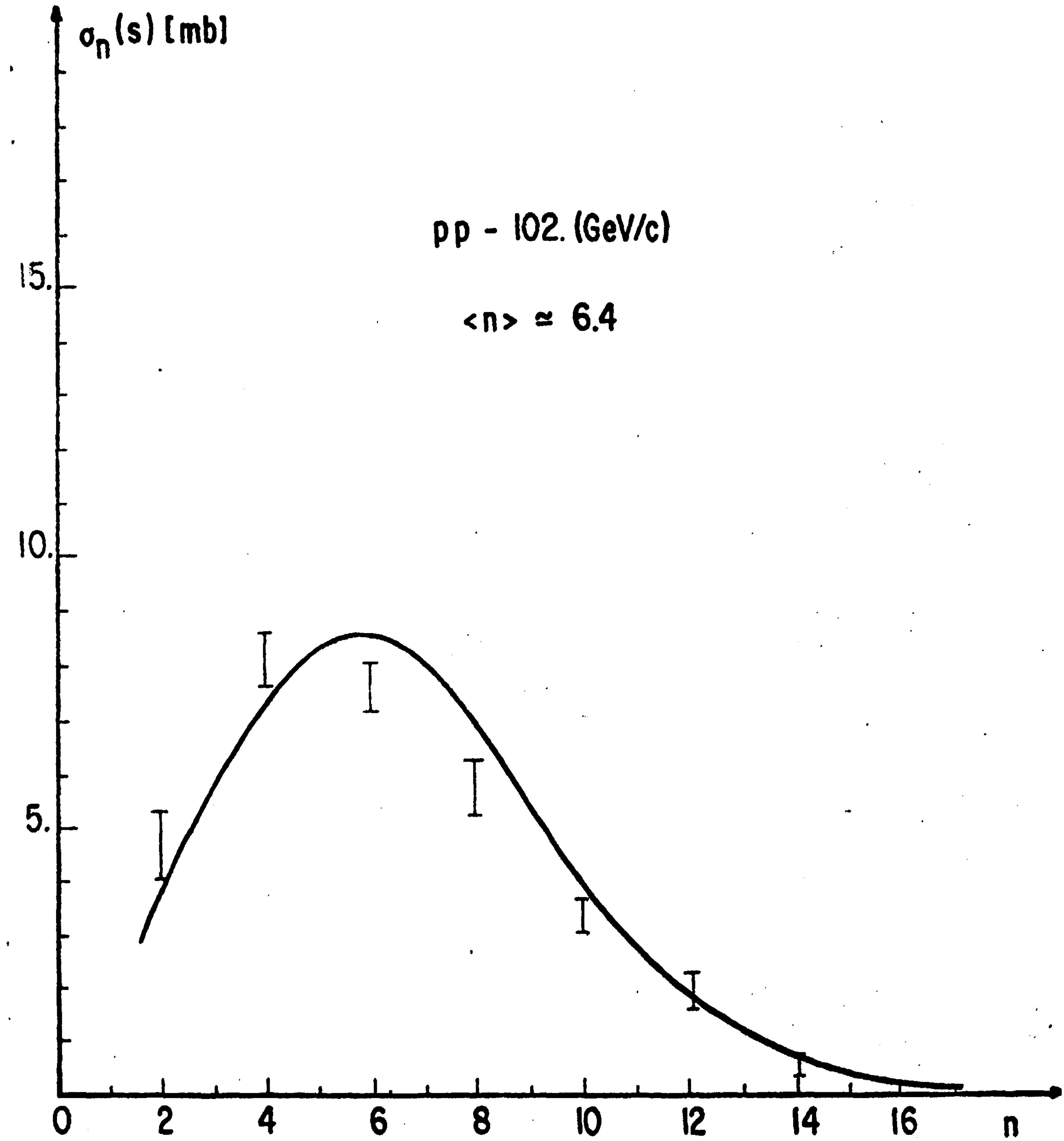

Fig. 5

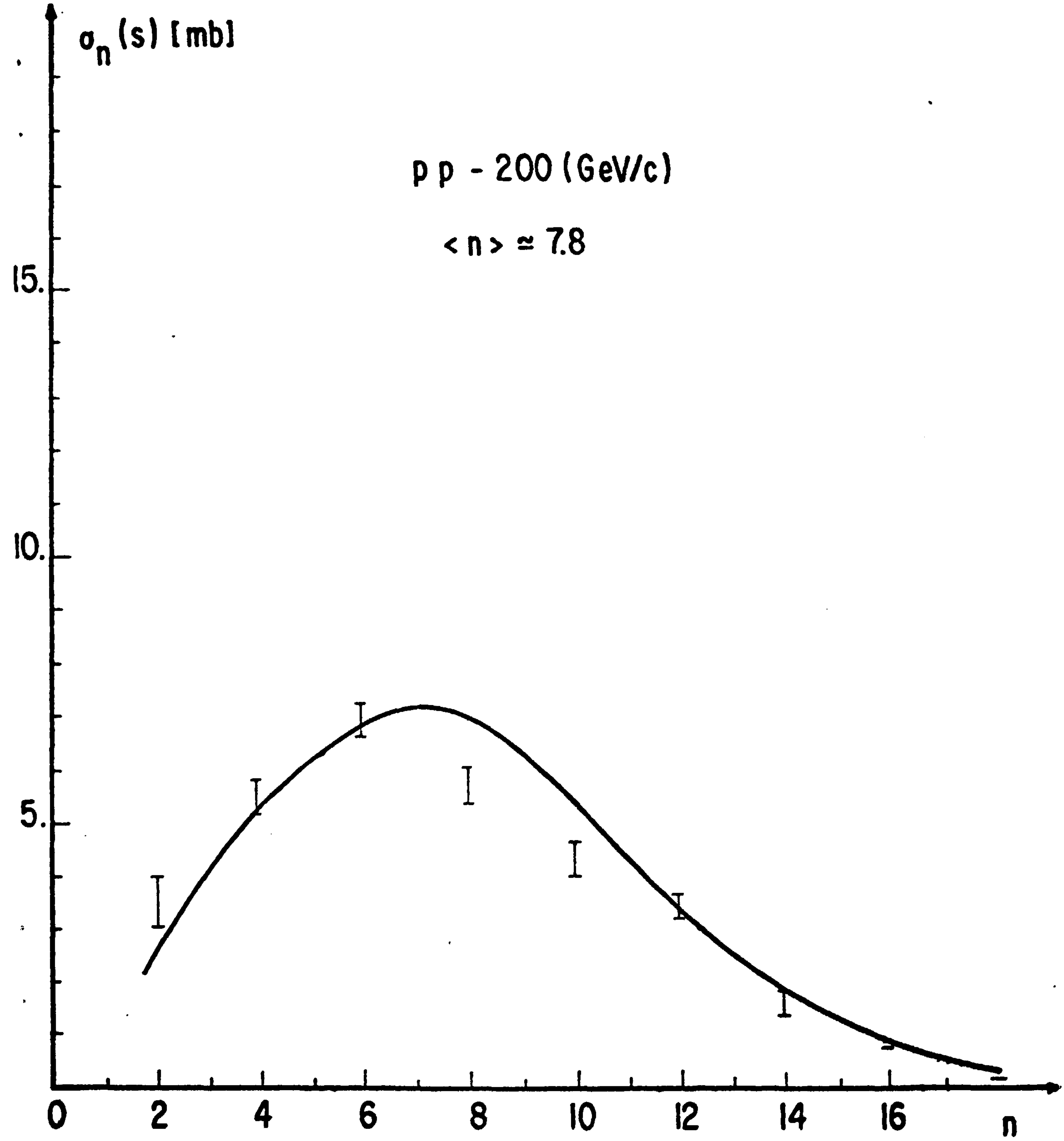

Fig. 6

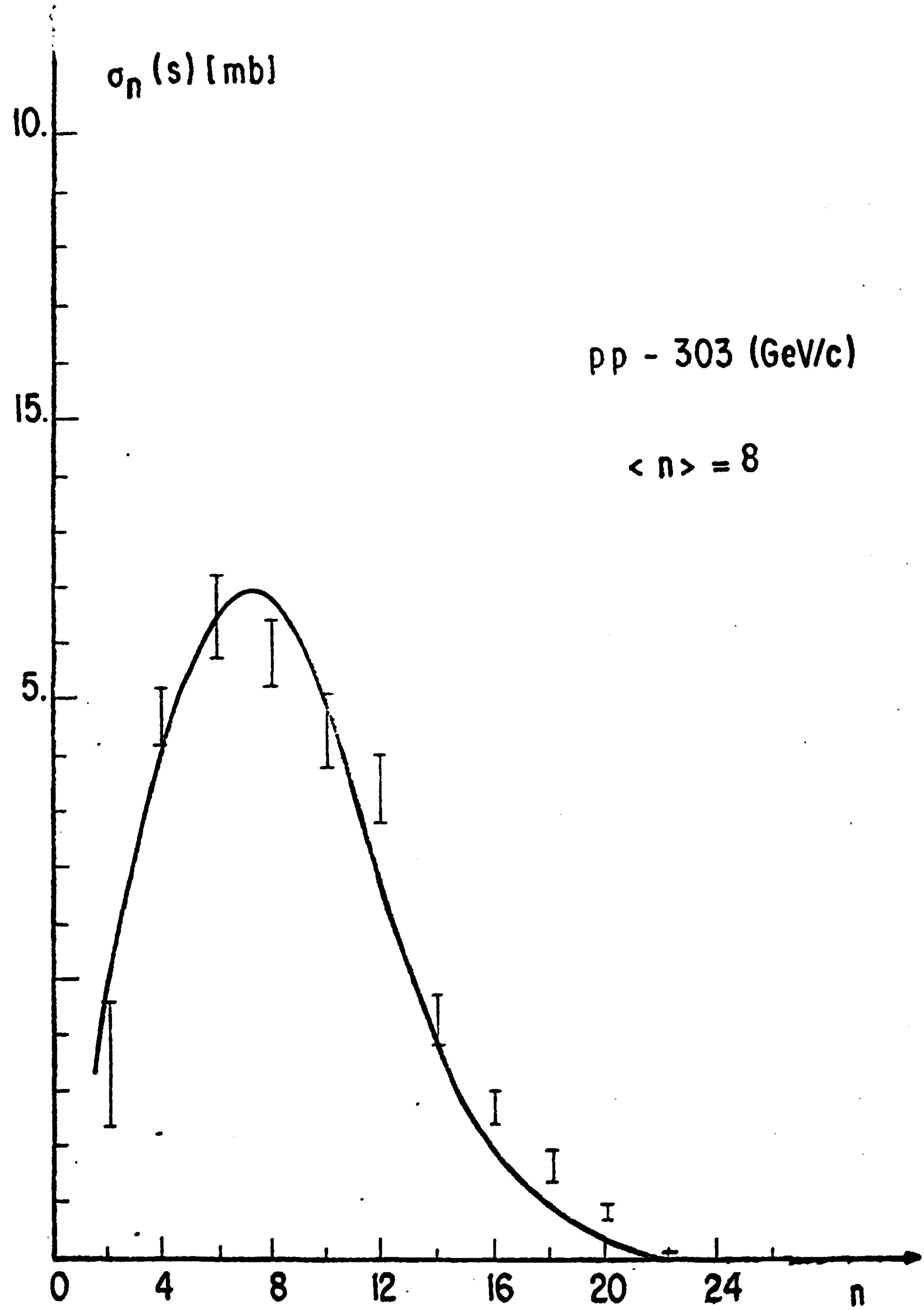

Fig. 7

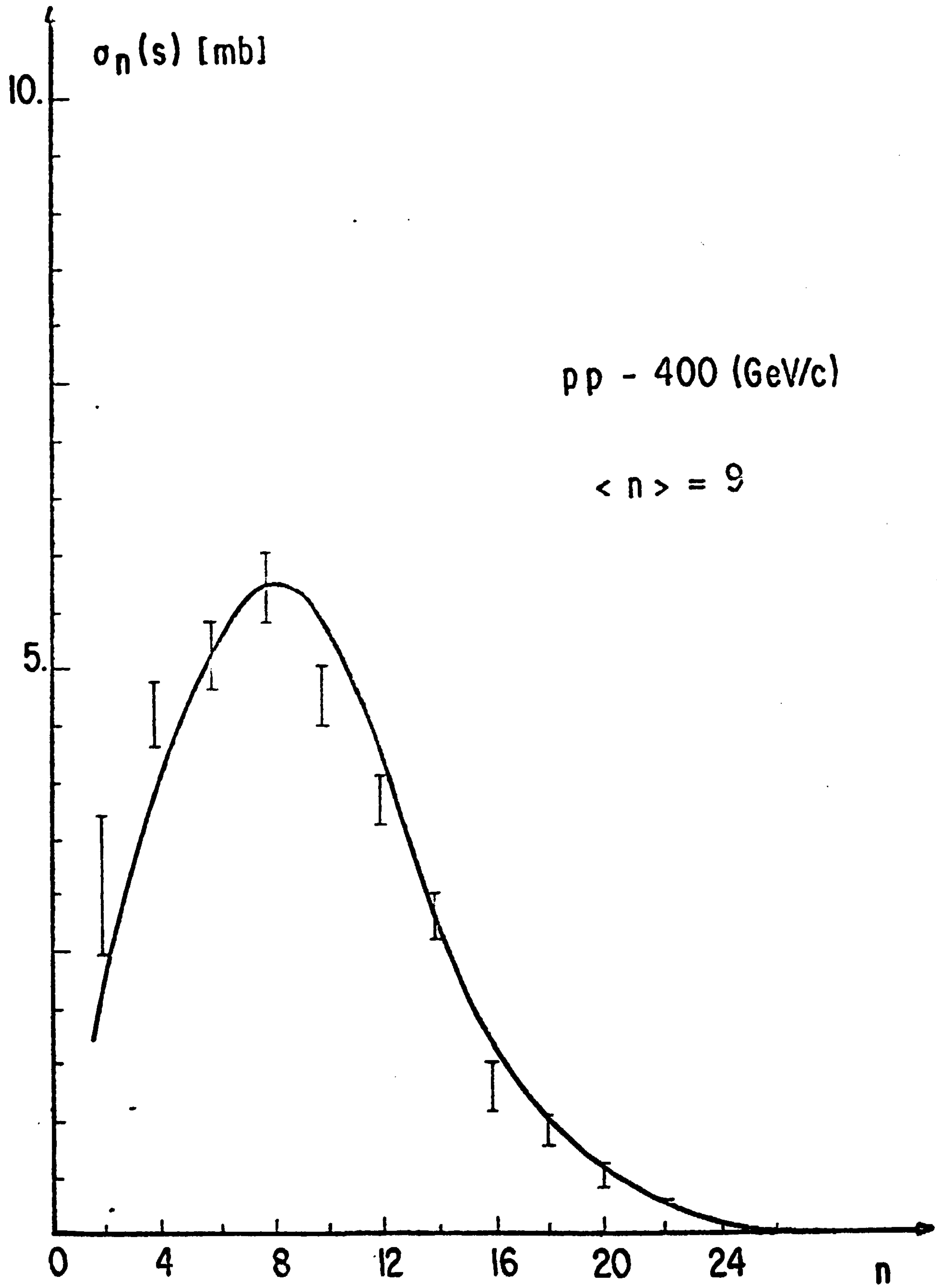

Fig. 8