On Very High Multiplicity Distributions

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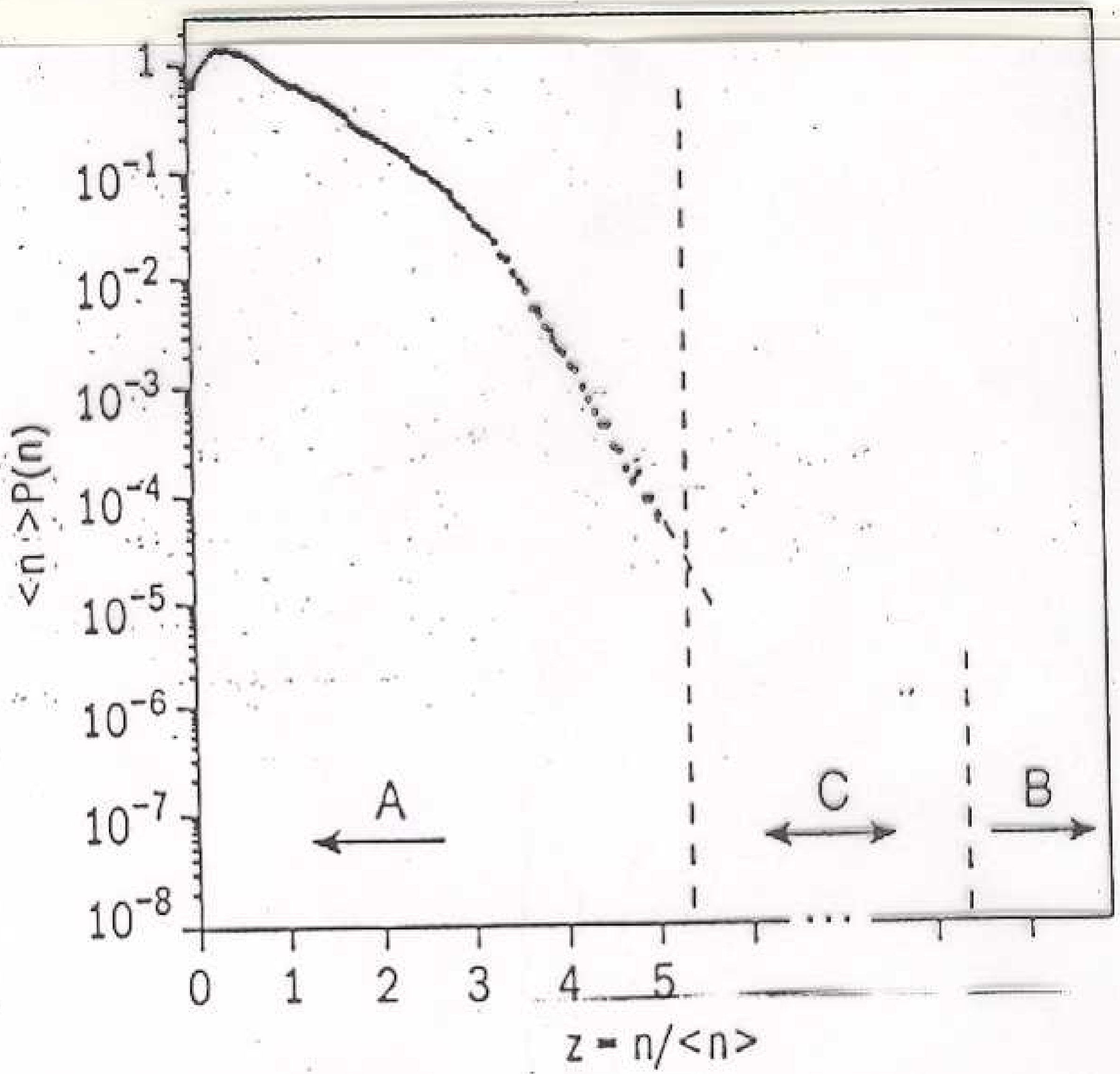
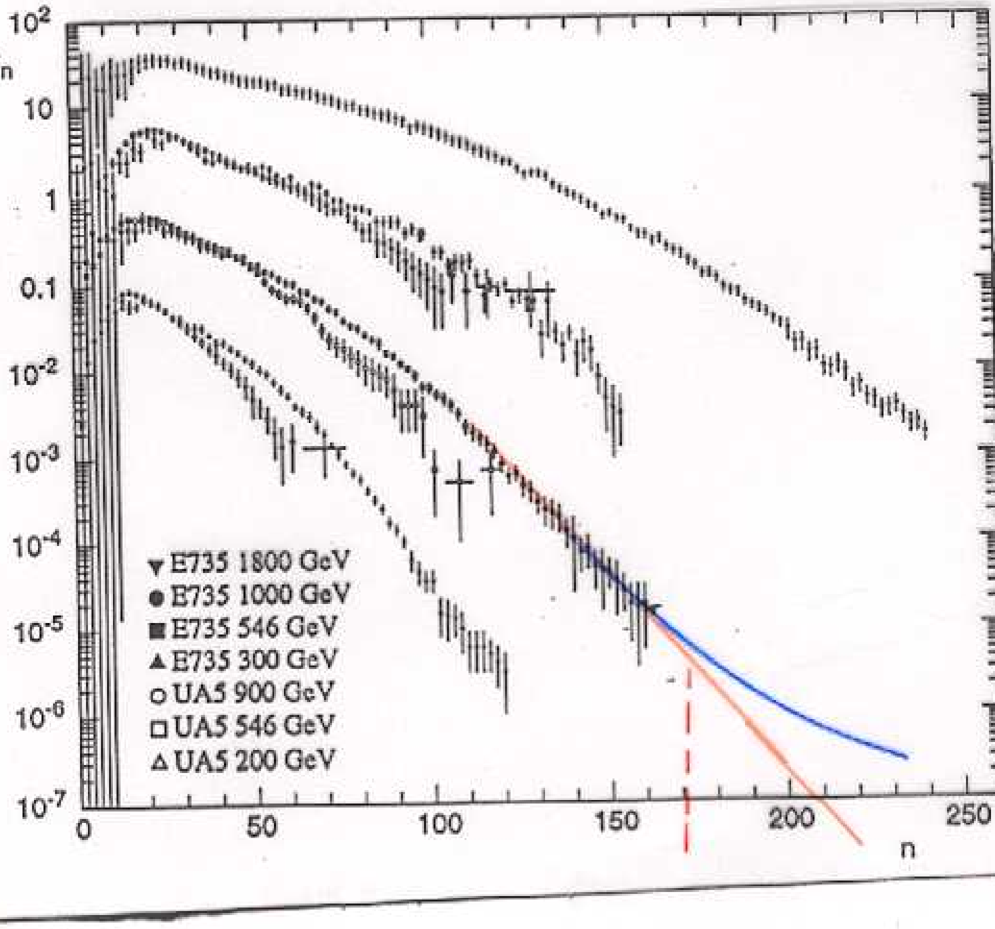


<n>P(n)
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
0
1
2
3
4
5
z = n/<n>
A
C
B

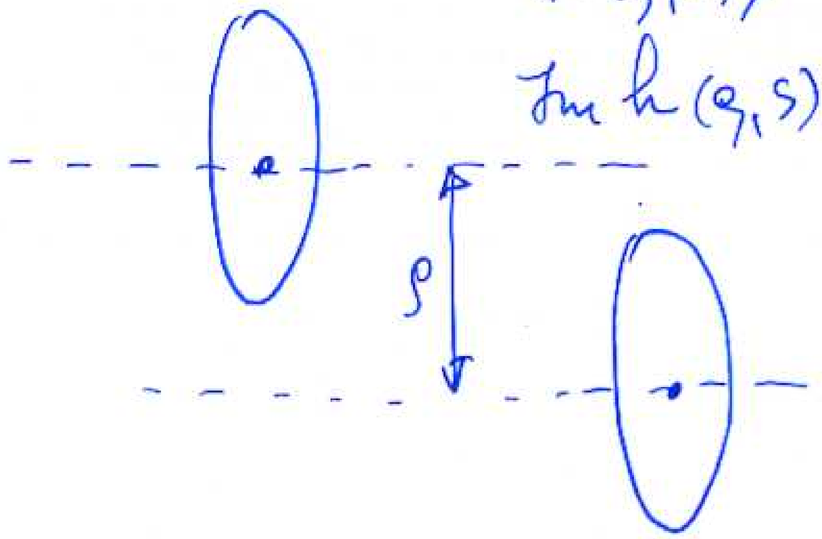


P_n
10^2
10
1
0.1
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
0
50
100
150
200
250
n
▼E735 1800 GeV
● E735 1000 GeV
■ E735 546 GeV
▲E735 300 GeV
○ UA5 900 GeV
□ UA5 546 GeV
△ UA5 200 GeV

geometrical approach:

$$\langle n(\rho,s)\rangle = N(s)\, G(\rho,s)$$

$$\mathrm{Im}\, h(\rho,s) = |h(s,\rho)|^2 + G(\rho,s)$$



Barshay, Semenov, ...

In Kiev (80-ies): Aliev, Chikovani, L.J., Struminsky

Reviewed in: A.N. Vall, L.J., and B.V. Struminsky, Sov. J. of Particles and Nuclei $\underline{19}$ (1988) 77.

Derivation of the inelastic overlap function $G_{in}(\rho,s)$ from the elastic scattering amplitude $T(s,t)$

$$T(s,t) = \frac{i\sigma_0}{16\pi\alpha' b} \sum_{i=1}^{2} c_i \exp\left(-\rho^2/4R^2(s)\right)$$

$c_1 = 1$; $c_2 = \lambda b - 1 = -\varepsilon$; $R_1^2 = \alpha'\left(b + L - \frac{i\pi}{2}\right)$; $R_2^2 = \alpha'\left(L - \frac{i\pi}{2}\right)$.

$L \equiv \ln \frac{s}{s_0}$; $\sigma_t(s) = \sigma_0(1 + \lambda L)$

By a Fourier-Bessel transformation one gets

$$u(\rho,s) = \frac{i\sigma_0}{16\pi\alpha' b} \sum_{i=1}^{2} c_i \exp\left(-\rho^2/4R_i^2(s)\right)$$

Unitarization a la' Serpukhov
(see S. Troshin's contribution at this Conf.)

$$h(\rho,s) = \frac{u(\rho,s)}{1 - iu(\rho,s)}.$$

By keeping terms up to $\frac{1}{L}$, one gets $h(x,s) = i g_0 e^{-x}(1 + \varkappa x)$

$$G_{in}(\rho,s) = \frac{\operatorname{Im} u(\rho,s)}{1 + \operatorname{Im} u + |u|^2},$$

$$g_0 = \frac{\sigma_0 \lambda}{16\pi\alpha'}$$

$$\frac{\sigma_{el}}{\sigma_t} = 1 - \frac{g_0}{(1+g_0)\ln(1+g_0)}$$

Further unitarity corrections (final state interaction):

$$G_{in}(\rho,s) = |S(\rho,s)|^{\alpha}\,\tilde{G}^{\alpha}(\rho,s), \qquad 0 \le \alpha \le 1$$

thus, $\langle n(\rho,s)\rangle = N(s)\,\tilde{G}_{in}(\rho,s)$.

Multiplicity moments are:

$$\langle n^K(s)\rangle = \frac{N^K(s)\int G_{in}(\rho,s)\left(G^{\alpha}_{in}(\rho,s)\right)^K d^2\rho}{\int G_{in}(\rho,s)\,d^2\rho} =$$

$$= \frac{N^K(s)(1+g)}{g}\int_0^g \frac{dx}{(1+x)^2}\left(\left(\frac{1+x}{1-x}\right)^{\alpha}\frac{x}{(1+x)^2}\right)^2$$

Mean multiplicity:

$$\langle n(s)\rangle = \frac{N(s)(1+g)}{g}\int_0^g \frac{x\,dx}{(1+x)^4}\left(\frac{1+x}{1-x}\right)^{\alpha} = \frac{N(s)}{a}$$

Multiplicity distributions:

$$P(n) = \frac{1+g}{g}\int_0^g \frac{dx}{(1+x)^2}\,\delta\!\left(n - N\left(\frac{1+x}{1-x}\right)^{\alpha}\frac{x}{(1+x)^2}\right) \quad \text{or}$$

$$\psi(z) = \langle n\rangle P(n) = \frac{1+g}{g}\,\frac{x(1-x)}{z(1+x)\left[(1-x)^2+2\alpha x\right]}, \qquad z \equiv \frac{n}{\langle n\rangle}$$

From $\delta(\ldots)=1$, one gets

$$n = N\left(\frac{1+x}{1-x}\right)^{\alpha}\frac{x}{(1+x)^2} \quad \text{where}$$

$$Z = \frac{a x}{(1+x)^{2-\alpha}(1-x)^{\alpha}}$$

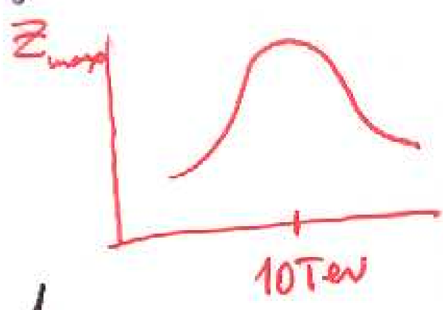
This equation can be solved explicitly for $\alpha = 0, 1$, otherwise — numerically. Having solved this equation, one can calculate $\psi(Z)$.

$Z(s)$ has a maximum, corresponding to $x = g$ (x varies between 0 and g)

$$Z_{max} = \frac{a g}{(1+g)^{2-\alpha}\,|(1-g)|^{\alpha}},$$

and it is a constant if g is energy-independent.

This is not the case:



$\frac{\sigma_{el}}{\sigma_t}$	0.174	0.225	
g	0.489	0.702	≈ 1
$\sqrt{s}$	53 GeV	900 GeV	10 TeV
Z	increase		$\longrightarrow$ decrease

1) Conclusions &2) Prospect

1. A turning point (change of regime) is expected near $Z_{max}(s)$. This point moves outwards towards the LHC energy, whereafter it is expected to move back. The phenomenon is expected to occur and be related to the change from the shadowing to antishadowing regime (transition of the black disc limit)

2) Calculate the local slope of $P(n)$ or $\psi(z)$

$$B = \frac{d}{dn} \ln P(n) \quad \text{or} \quad \frac{d}{dz} \ln \psi(z)$$