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# AN ESTIMATE OF THE MASS OF THE 'SLOW BODIES' EMITTED IN p-NUCLEUS INTERACTIONS AT 200 AND 300 GeV

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SUMMARY

Angular and multiplicity correlations in proton-nucleus interactions in emulsion are interpreted within the framework of the Energy Flux Cascade model. The average mass of the 'slow bodies' or novae emitted in the backward hemisphere is $\sim$ 3.5 GeV/$c^2$ at both energies. This result is in reasonable agreement with previous work on two-particle correlations.

The purpose of this letter is to analyse, within the framework of the Energy Flux Cascade (EFC) model [1], the results obtained from nuclear emulsion stacks exposed to the 200 GeV and 300 GeV proton beams at the Fermi National Accelerator Laboratory. It was pointed out previously [1,2] that such an analysis may shed light on the space-time structure of multi-hadron-producing p-p collisions in their early stages.

The method of analysis is outlined below. The details of exposure, scanning and preliminary analysis of data were presented in previous papers [3,4]. The results discussed here refer to a sample of 2136 events at 200 GeV and 887 events at 300 GeV.

As has been suspected for a long time and recently shown by Babecki et al [5] and by Andersson and Otterlund [6], the number $N_h$ of heavily ionizing prongs often associated with the star size (accompanying multi-hadron production in nuclei) acts as a convenient monitor for the effective number of nucleons $\nu$ involved in the production process. Consequently, we divided the data into different classes of $N_h$, the classes being $N_h$ = 0-3, 4-5, 6-8, 9-11, 12-14, 15-18, 19-22, 23-26, and $\geq$ 27 at 200 GeV and $N_h$ = 0, 1, 2-3, 4-5, 6-11, 12-18, and $\geq$ 19 at 300 GeV. The difference in the class groups is due mainly to the smaller sample of events used at 300 GeV.

For each event we recorded the number $n_s$ of fast ($\beta \geq 0.7$) charged particles and their angles of emission with respect to the primary direction. We now define for each event the quantity, $\eta$, that we shall call the 'reduced' pseudo-rapidity

$$\eta = \frac{1}{\langle n_{ch} \rangle} \sum_{i=1}^{n_s} u_i$$

where $u_i = - \log \operatorname{tg} \theta_i$ is the pseudo-rapidity of the ith particle and $\langle n_{ch} \rangle$ is the average number of charged particles in the final state of p-p collisions at the same energy.

If we assume that the shower multiplicity $n_s$ is an uncorrelated sum of the type

$$n_s = n_{ch} + \sum_{i=1}^{\nu-1} k_i$$

where each $k_j$ is the contribution from a 'slow body'('slice' [1]) resulting from each collision, then we expect a linear relationship between the mean value of $\eta$ at a given value of $N_h$ and the relative multiplicity $R = \langle n_s \rangle / \langle n_{ch} \rangle$ at the same $N_h$. Thus we can express the 'reduced' pseudo-rapidity as a sum of two terms

$$\langle \eta \rangle = a + b\ (R - 1)$$

where a is the pseudo-rapidity of a p-p collision at the same energy and b is the pseudo-rapidity of the particles emitted by the 'slow bodies'.

The results of the analysis, presented in figure 1, may be represented by the following relations:

$$\langle \eta \rangle = (-1.198 \pm 0.022) - (0.416 \pm 0.035)\ (R - 1) \text{ at } 200 \text{ GeV}$$

$$\langle \eta \rangle = (-1.371 \pm 0.052) - (0.535 \pm 0.047)\ (R - 1) \text{ at } 300 \text{ GeV}$$

The estimated value of a is in excellent agreement with the mean value of the pseudo-rapidity in p-p collisions [7]. If $u_i$ were true rapidities, one would expect that

$$a = a_o = -\log \gamma_c \doteq \begin{matrix} -1.01 \text{ at } 200 \text{ GeV} \\ -1.10 \text{ at } 300 \text{ GeV} \end{matrix}$$

But in fact, $u_i$ are pseudo-rapidities and differ from the true rapidities by a constant amount essentially independent of energy [8].

The value of b is of direct relevance to the model predictions concerning the identity of the 'slow bodies'. In the EFC model b corresponds to the mean pseudo-rapidity of the 'slow bodies' at an energy $E_2 = E^{1/3}$, where E is the incident proton total energy. Therefore, for each collision, one has associated with the target particles an average total energy (in the lab. system) of $E_2$ = 5.85 GeV, at 200 GeV, and $E_2$ = 6.7 GeV at 300 GeV. If we assume that $b_o$ differs from b by the same amount as $a_o$ differs from a [9], the corresponding values are $b_o$ = -0.23 at 200 GeV and $b_o$ = - 0.27 at 300 GeV.

From the $b_o$ values we estimate the mass of the 'slow bodies' or novae to be ∿ 3.5 GeV/$c^2$ at both energies.

It should be pointed out that this result is in reasonable agreement with our recent work [10] on two-particle correlation where a maximum of the correlation function R was observed in p-nucleus collisions in nuclear emulsion at 300 GeV. If we associate the rapidity corresponding to the maximum of R with the mean rapidity of the 'slow bodies', a value of 2 to 3 GeV/$c^2$ is obtained for their masses.

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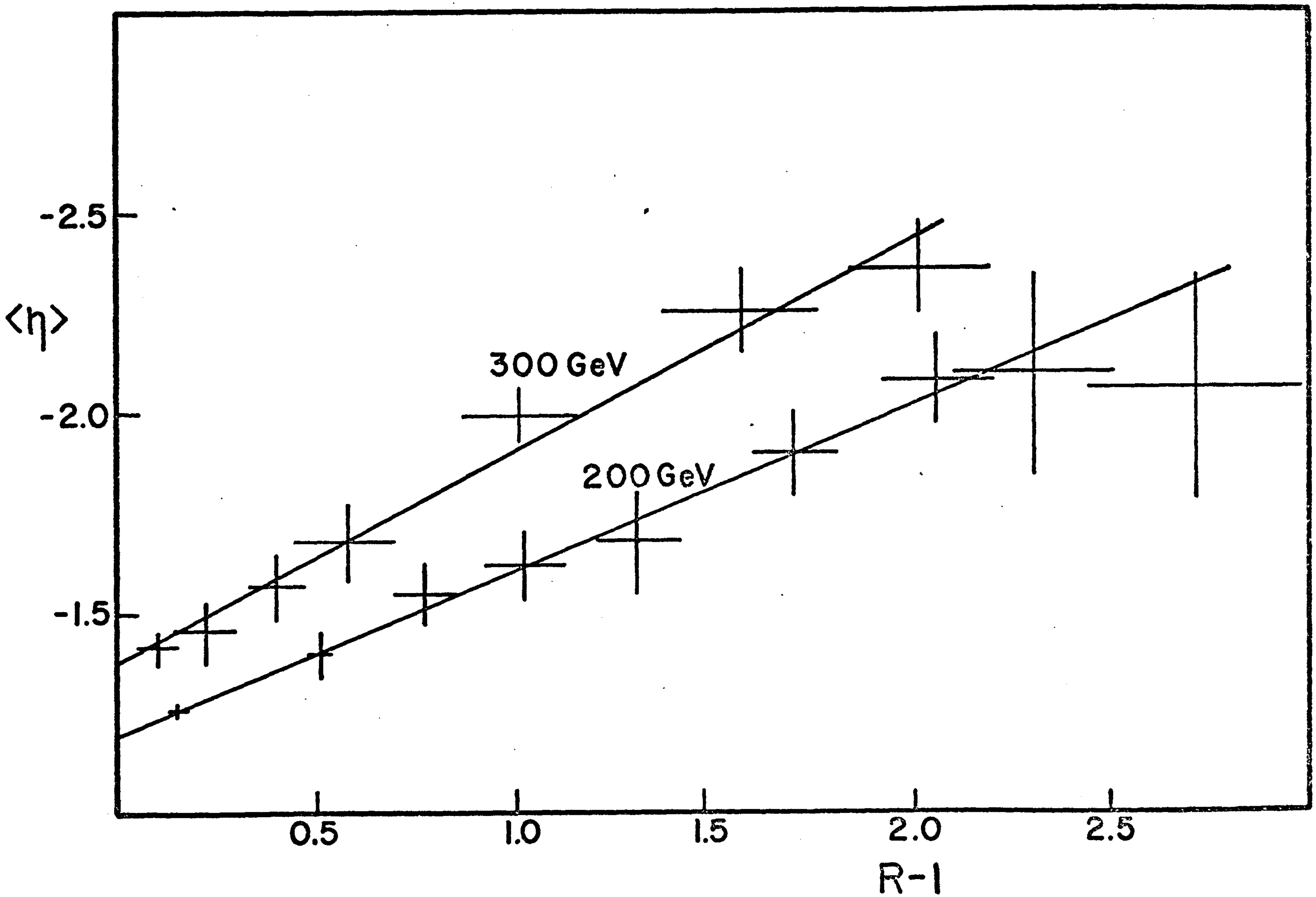
LEGEND FOR FIGURE I

The average value of the 'reduced' pseudo-rapidity $\eta = \frac{1}{\langle n_{ch} \rangle} \sum_{i=1}^{n_s} u_i$ (where $u_i = -\log tg\, \theta_i$) is plotted versus the relative multiplicity R minus 1 for different $N_h$ groups of events. The straight lines correspond to the least-square fit to the experimental data.


⟨η⟩
-2.5
-2.0
-1.5
300 GeV
200 GeV
0.5
1.0
1.5
2.0
2.5
R-1