SMALL AIR SHOWERS AND COLLIDER PHYSICS

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1. Introduction

At energies lower than 2.10^5 GeV (in Lab. system), we have now more accurate information on nucleon-nucleon collision ($\bar{p}$-p collider (1)) and on primary composition (JACEE data (2)). The behaviour of those both basic elements in cosmic ray phenomenology from ISR energy suggests some tendencies for reasonable extrapolation in the next decade 2.10^5 - 2.10^6 GeV (paper HE 4.1-10).

Small showers in altitude, recorded in the decade 2.10^4-2.10^5 GeV offers a good tool to testify the validity of all the Monte-Carlo simulation analysis and appreciate how nucleon-air collision are different from nucleon-nucleon collisions.

2. Multicluster phenomenological model and nucleon-nucleus collision

The width and the height of the rapidity plateau are together assumed to rise with Ln s, in agreement with a total multiplicity proportional to $\ln^2$ s, taken as $n_s = 0.127 \text{ Ln}^2 s + 0.584 \text{ Ln } s + 0.57$. The proportion of secondary neutral is rising slightly more rapidly, on the opposite of other works assuming $n_\gamma = n_s$, following the numerical values quoted from UA5 and UA1 (1) (HE 5.1-5). For each individual collision we assume a uniform distribution of clusters, choosen randomly on the length of the available rapidity plateau. The short range clustering effect is obtained by the production in large number of small masses resonances decaying in $\pi^+\pi^-$, $\pi^+\pi^o$,... (K=2). We assumed a Gaussian distribution for the rapidity of the individual secondaries around the rapidity of corresponding cluster in center of mass system. The width of this normal distribution has been parametrized between ISR and collider energy, and the model gives a very good fit to the pseudo-rapidity distributions at E_{cm} = 53 and 540 GeV.

Strong KNO violation is taken into account, in the sense shown in HE 5.1-5, with a better accuracy, treating the fluctuations of multiplicity like Erlang processes :

$$\Psi(z) \sim \frac{z^{\alpha-1}}{\Gamma(z)} e^{-\alpha z}$$

describing correctly the situation in all the dynamical range if $\alpha = 100 \, aE^{-a}$ where a = 0.1042 (E in GeV in laboratory system). The values $\alpha = 6$ describes the low energy part, near Slattery behaviour and the very high energy corresponds to $\alpha = 2$, considered as an asymptotic KNO function in the "bremstrahlung analogy" approach to multiproduction.

For each individual collision the central density of rapidity ρ_o is estimated by counting the secondaries contained in 2/3 of the plateau length and the average $\langle p_t \rangle$ is correlated with ρ_o(3)

according to

$$< p_t > = \frac{C}{[-e^z E_i(-z)]^\gamma}$$

($C = 0.38$ GeV/c, $\gamma = \frac{1}{8}$ at 155 TeV and here $z = \frac{\pi}{4}[n/\bar{n}(s)]^2$), the the invariant cross section being parametrized by the same formula for π's and K's in function of the transverse mass $m_T = \sqrt{m^2+p_t^2}$.

We observed that the model described up to here reproduced also the decrease of inelasticity by 30% between ISR and $\bar{p}$-p collider, after summation of the energies $E_i = m_T \cosh y_i$ carried by individual secondaries (E_i, y_i in Lab. system) (4).

The model is extended to hadron-air collision by introducing the number of participating nucleons $< \nu > = A$ ($\sigma_{in}^{pp}/\sigma_{in}^{pA} = 1.325 + 0.0543$ Ln E established from hadron-nucleus data (5) (6) with $R_A = < n(pA)>/< n(pp)> \sim \frac{1}{2}(< \nu > + 1)$. Considering rapidity distribution normalized by rapidity distributions of p-p interactions of the same energy, we describe the rate

$$R(y) = \frac{(dn/dy)_{p-Air}}{(dn/dy)_{p-p}} \sim my + m_o$$

on plateau basis ($m_o = \rho_A/\rho_o$) and finally generate directly the clusters from the corresponding "inclined plateau" ; the value R(y) obtained by the adapted Monte-Carlo procedure for all secondaries is shown on fig. 1 for 3000 p-air collisions with $E = 10^6$ GeV.

For hadron-nucleus collision we adopt $< p_t >_{p-A} = < p_t >_{p-p}$ as predicted by dual parton model (7) and fluctuations of multiplicity similar to p-p collisions. We refer hereafter this model as MPM (multicluster phenomenological model).

3. Comparison with Tian-Shan and KGF data (8,9)

Mixed component is taken as energy constant with 39.5% nucleons, 28.7% α, 13.5% CNO, 11.5% LH, 6.9% iron groups, with $\gamma = 2.7$ (2). The situation is shown in fig. 2 for MPM and nucleons, as well as for MPM and mixed. (The extension to nucleus-nucleus collision and the introduction of secondary η-mesons are discussed in HE 4.1-10), and also in fig. 3 for 220 GeV muons recorded in KGF (for nucleons primary only). The hadron behaviour versus size is shown on fig. 4 for $E_H > 0.6$ TeV and $E_H \geqslant 1$ TeV at Tian Shan level.

4. Conclusion

The multicluster phenomenological model, adapted to p-air collision is in surprising good agreement with EAS data at energy smaller than 2.10^5 GeV ; this agreement is obtained without an increase of primary mass or multiplicity, even for higher energy muons in KGF (220 GeV) and high energy hadrons (0.6 to 1 TeV), suggesting agreement non only in central region, but in all the dynamical rapidity range.

5. Aknowledgements J.N.C. is indebted to Professor B. Degrange for drawing his attention on multicluster models.

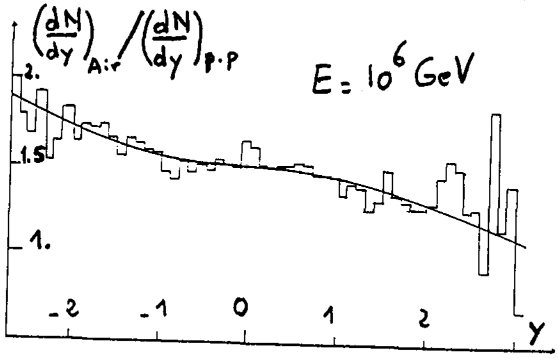

Fig. 1

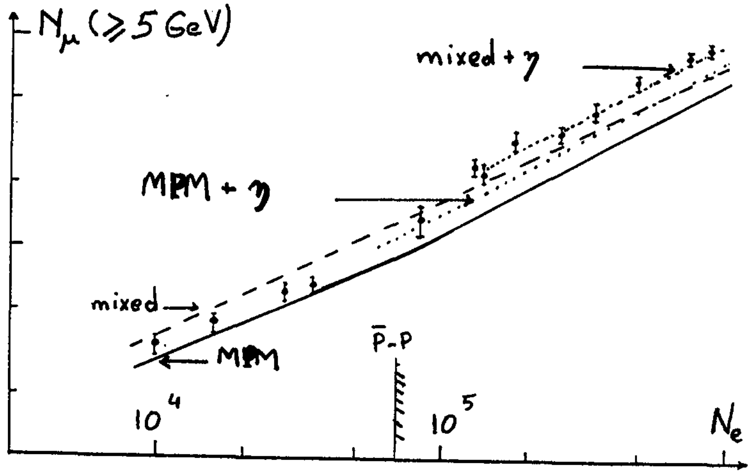

Fig. 2

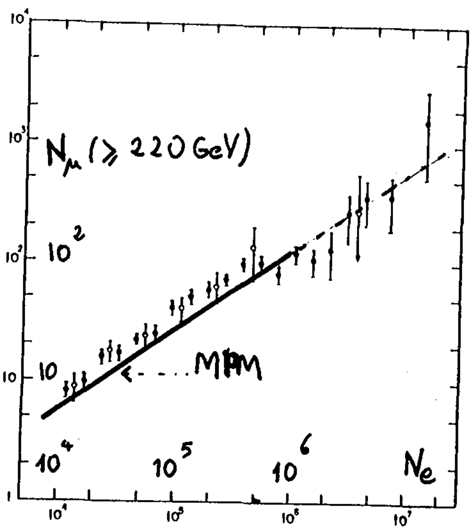

Fig. 3

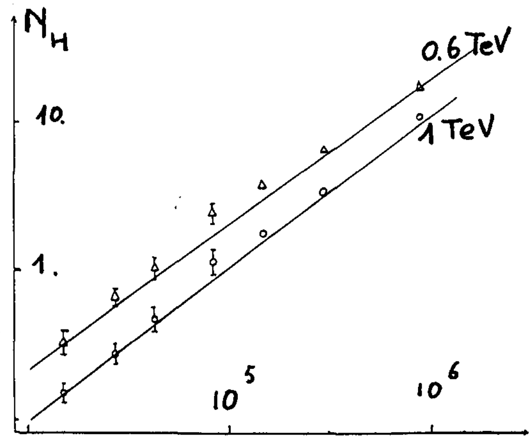

Fig. 4

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