SCALING VIOLATION IN HADRON-NUCLEUS INTERACTION

Yu.G.Verbetski, L.P.Garsevanishvili, D.M.Kotlyarevski, N.K.Ladaria, N.G.Tatalashvili, P.V.Tsomaya, N.I.Sherer, Yu.M.Shabel'ski, G.Z.Stemanetyan

Institute of Physics, Academy of Sciences of the Georgian SSR, Tbilisi, USSR

Summary. The scaling violation within the pionization region in the energy range of 0.2 - 2.0 TeV is shown on the basis of the analysis of angular characteristics in the interactions of the cosmic radiation hadrons with the nuclei of various substances (CH_2, Al, Cu, Pb).

The investigation of multiple processes in hadron-nucleus interactions allows to obtain the information on the space-time structure of strong interactions.

It is rather paradoxical, but at present, the so called soft processes of particle generation makind the overwhelming contribution to the inelastic interaction cross-section, remain the most obscure.

The most natural method to the understanding of the structure of such interactions is the investigation of hadron--nucleus interactions at high energies using nuclei of various atomic numbers A.

The experimental data presented in this work have been obtained at Chikovani Tskhra-Tskaro Station at the height of 2500 m above the sea level by means of the instalation consisting of the magnetic spark spectrometer and the ionization calorimeter /1/.

The targets of Al, CH_2, Cu, Pb with the thickness of 0.1 λ int. were exposed. Some interesting results have been obtained in the energy region of 0.1 + 5.0 TeV using the data of several thousand of events.

Here the results of the investigation of interactions with the energy above 0.9 TeV are presented. The selected events have been generated, mainly, by primary protons which have had passed through the atmosphere without any interactions. That condition has been achieved by means of selection of showers without of other particles accompanying ($n_{acc} \leq 0.3/m^2$ /6/.

The aim of the present investigation is to reveal the dominating mechanism of the secondary particle generation. In the present paper the experimental data are analyzed with respect to the variable $\eta' = -\ln \operatorname{tg} \Theta_{pr}/2$, where Θ_{pr} is the projection of the secondary particle escape angle on the photography plane.

The experimental data have been corrected for the efficiency of secondary particle recording in wide-gap spark

chambers (depending on the track direction with respect to the electric field) and for the conversion of γ -quanta due to π^0 -meson decay /7,8/, The resolution of the apparatus does not allow us to make some definite conclusions on the particles generated within the angle interval narrower than 0.1° (i.e. at $\eta' > 6.5$). The experimental distributions given in Fig.1 take into account the corrections over the whole rapidity region excluding (0° ÷ 0.1°) where the uncertainty in the estimations may be significant.

The experimental distributions have been compared with the predictions of additive quark model /9/. According to the latter, the component interact independently with the cross-section equal to 1/3 of nucleon-nucleon one, while the generated objects do not interact within the nucleus. In addition, the comparison has been made with the active leader model, according to which the leading object interacts with nucleons, while the newly-generated particles do not interact in the nucleus: as it follows from Fig.1, a considerable discrepancy with the experimental data takes place. To achieve the agreement of theoretical predictions with the experimental data, one may: assume 1) a significant violation of scaling laws within the fragmentation region or a significant decrease of the cross-section of secondary interactions of the leading object (quarks, diquarks) with the nucleons in the nucleus; and 2) take into account the cascade of particles generated in the nucleus, which is, apparently, growing with increasing E. Table and Fig.2 present the data on the extent of the scaling violation increasing with the growth of A within the pionization region in hadron-hadron and hadron-nucleus interactions.

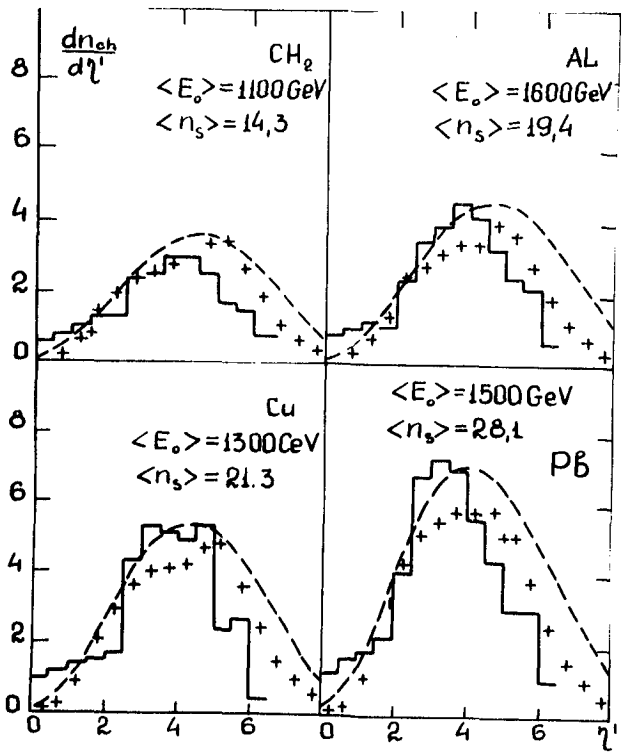

Fig.1 Inclusive distibutions over η' of secondary particles in hadron-hadron interactions. The histogram corresponds to the corrected data (see the text). Dotted line - the active leader model. Crosses-additive quark model with the shifts in distribution due to the errors in the determination of the primary particle direction, introduced by means of Monte-Carlo method.

Table

Reaction	Δn_s in the interval $\Delta\eta' = 2$ in the vicinity of $\eta' = 4$		$R = \frac{\Delta n_s(2.0)}{\Delta n_s(0.2)}$
	0.2 TeV	2.0 TeV	
pH	2.8 ± 0.1	4.0 ± 0.1	1.42 ± 0.08
pCH_2	3.9 ± 0.3	5.4 ± 0.6	1.38 ± 0.28
pH	4.2 ± 0.4	8.1 ± 1.0	1.93 ± 0.42
pC	4.0 ± 0.4	10.3 ± 1.1	2.58 ± 0.53
pPb	4.8 ± 0.5	12.1 ± 1.2	2.52 ± 0.51

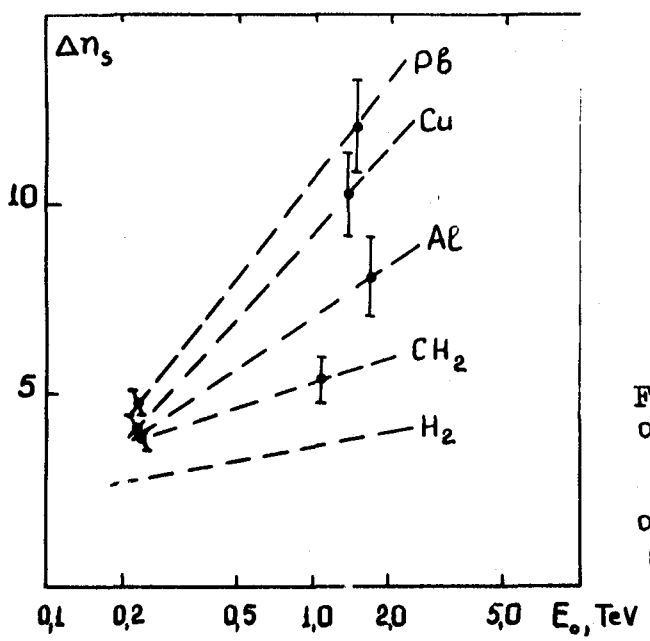

Fig.2 The multiplicity of the charged particles Δn_s within the central $\eta' = 4.0 - 1.0$ region of the distribution over η'

References

1. M.I.Atanelishvili et al., Izvestiya Akad.Nauk SSSR, 42, No.7, 1479 (1978)

2. M.I.Atanelishvili et al., Yadernaya Fizika, 24, 369 (1976)

3. O.L.Berdzenishvili et al., Bangalore, India XYIII YCRC HE 3-18 L.P., p.51 (1983)

4. M.I.Atanelishvili et al., Plovdiv XY ICRC, HE 7, p.66 (1977)

5. O.L.Berdzenishvili et al., Kioto XYI ICRC, HE 3-43, p.210 (1979)

6. O.L.Berdzenishvili et al., Kioto, XYI ICRC, HE 3-43, p.337 (1979)

7. D.M.Kotlyarevski. Pis'ma v JETF, 28, 4, 254 (1978)

8. K.G.Gulyamov et al. In: "Multiple Generation of Particles in pA-Interactions", ed. FTI of Izv.SSR, Tashkent, 78 (1976)

9. Yu.M.Shabel'ski, Proc XIII School of the LNPI, Leningrad, 90 (1978)