COMPARISON OF MULTIPLICITY DISTRIBUTION DATA FOR π^-d REACTIONS WITH PREDICTIONS OF THE SIMPLE NON-INTERACTING FIREBALL MODEL

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It is shown that the simple non-interacting fireball model reproduces the charged particles multiplicity distribution for π^-d collisions as well as more sophisticated models based on the reggeon calculus do. Much better statistical data for the highest multiplicity channels in both π^-d and π^-N scattering would be necessary to resolve the present ambiguity.

There exists a conviction that high energy hadron-nucleus interactions may explain many interesting problems concerning the structure of matter. Many models are created for describing processes occurring in these collisions. It seems that reactions with a deuteron as a target may give good test for these models, because the analysis and interpretation of the experimental data are relatively easy in this instance.

For scattering on nuclei an especially important question is: — what part of the process is due to multiple scattering. Comparison of experimental data with theoretical predictions for this part of the cross-section which corresponds to double scattering on a deuteron is one of the crucial tests which allow one to accept or reject a proposed description of the process. It is accepted [1] that the ratio

$$\alpha_N = \sigma_N(\text{“hp”})/\sigma_N(\text{hp}), \tag{1}$$

where σ_N(“hp”) is the effective topological cross-section for hadron-proton collisions in hadron-deuteron scattering — it contains events with an even number of charged particles (incident hadron is charged), corrected for unseen spectators and σ_N(hp) is the topological cross-section for a hadron-proton interactions with a free proton as a target, is a good measure of the double scattering contribution to hadron-deuteron collision.

Baker et al. [1] have proposed a model of scattering on a deuteron, further quoted BLRW, in which a hadron with momentum p decays into two components with momenta

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$p_1 = p_2 = p/2$. Double collisions are realized by scattering one of the components on the proton and the other on the neutron. It is the simplest model resulting from the conventional picture of the space-time development of hadronic interactions obtained from reggeon calculus. It was shown in the same paper that the dependence of α_N on the multiplicity obtained from this model is in agreement with experimental data. One can use a similar method to evaluate α_N for another, much older model of scattering on nuclei: the so-called non-interacting fireballs model — NFB [2]. In this model the incident hadron is scattered by several nucleons and non-interacting intermediate states (fireballs), decaying outside the nucleus, are produced in each collision. The projectile loses energy on each collision and it is reasonable (i.e. it is in agreement with experiment) to accept that the mean value of the inelasticity coefficient for internal hadron-nucleon interactions: $\bar{k} = 0.5$ [3]. It means that one can assume that energy is lost in the same ratio in each internal collision, i.e. if the incident hadron has energy E in the first interaction it will have energy $\bar{k}E$ in the second, $\bar{k}^2E$ in the third etc.

As was shown in Ref. [1]

$$\alpha_N = C + \sigma_N(2)/\sigma(\text{hp}), \tag{2}$$

where $C = [\sigma(\text{``hp''}) - \sigma(2)]/\sigma(\text{hp})$ is a constant independent of multiplicity N, $\sigma(\text{hp})$ is the total inelastic cross-section for the hadron-proton interaction and $\sigma_N(2)$ is the topological cross-section for double scattering. $\sigma(2)$ is the total cross-section for double scattering given by

$$\sigma(2) = 2\delta\sigma, \tag{3}$$

where $\delta\sigma = \sigma_T(\text{hp}) + \sigma_T(\text{hn}) - \sigma_T(\text{hd})$ is the cross-section defect. In Ref. [1] formula (3) was deduced from the reggeon calculus. It follows also, however, for the simple Glauber model supplemented by probabilistic arguments.

A multiplicity distribution $\sigma_N(2)$ must be calculated from a model. The method proposed in Ref. [1] for computation of multiplicity distribution in double scattering $\varrho_N(2) = \sigma_N(2)/\sigma(2)$ can be used for the NFB model, too. The distribution for double scattering composed of single interactions with momenta p_1 and p_2 can be described as a convolution

$$\varrho_N(2) = \sum_{i/2}^{N} \varrho_i(p_1)\varrho_{N-i}(p_2), \tag{4}$$

where the distributions $\varrho_i(p_k)$ are taken from scattering on nucleons.

Calculations are made for the π^-d process at three values of beam momentum: 21 GeV/c, 205 GeV/c, 360 GeV/c for multiplicity $N > 3$. For the BLRW model at $p = 205$ GeV/c the distributions averaged over π^-p and π^+p with $p_1 = p_2 = p/2$ are used for the convolution. At other beam momenta we must convolute the π^-p distribution with itself, because only these data are available at the relevant values of beam energy. Since at 100 GeV/c the two distributions are similar, this is unlikely to introduce a significant error. For the NFB model $p_1 = p$, $p_2 = p/2$ and distributions for π^-p reaction are convoluted with themselves for our calculations [4]. The cross-section defect $\delta\sigma$ is obtained from the total cross-sections given in Refs [4b, 5] and they are presented below:[1]

$$p = 21 \text{ GeV}/c \text{ — } 2\delta\sigma = 2.12 \pm 0.25 \text{ mb},$$

$$p = 205 \text{ GeV}/c \text{ — } 2\delta\sigma = 3.62 \pm 0.25 \text{ mb},$$

$$p = 360 \text{ GeV}/c \text{ — } 2\delta\sigma = 3.77 \pm 0.35 \text{ mb}.$$

Experimental data for π^-p interaction at 180 GeV/c are not available, thus we use data for this reaction at 205 GeV/c as an approximation.

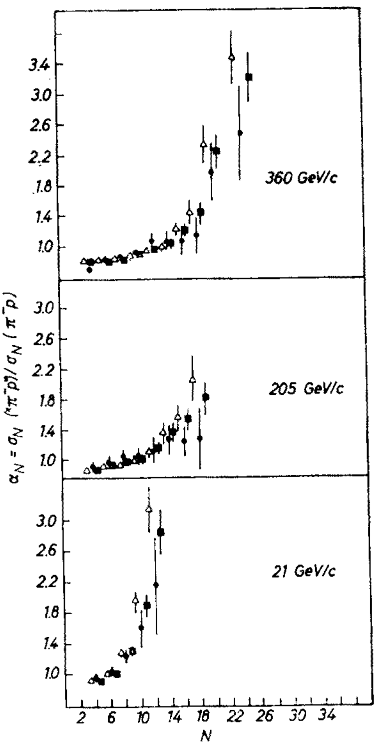

Fig. 1. Comparison of experimental values of $\alpha_N = \sigma_N(\text{"hp"})/\sigma_N(\text{hp})$ with predictions of the NFB and BLRW models for π^-d interactions. ● — experiment, △ — NFB, ■ — BLRW

The results obtained are presented in Fig. 1. Experimental values of α_N are taken from multiplicity distributions given in Refs [6–8]. It is visible that the NFB model describes the N-dependence of α_N as well as the BLRW model. It has been checked that the statistical difference between these two theoretical predictions is not significant. One can observe that divergencies increase at higher multiplicity. Thus this is the region in which the problem — which model is better — could be in the future resolved. This agrees with the fact

[1] For p = 360 GeV/c approximation is made. It was assumed that $\sigma_T(\pi^-n) = \sigma_T(\pi^+p)$.

that multiple scattering is important in processes with large numbers of produced particles. The decision will be possible only when much better statistics for high multiplicity data will be available both for π^-d and π^-N interactions. At present, the experimental errors are too large to give significant preference to one of the two models.

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