MENU 2007
11th International Conference
on Meson-Nucleon Physics and
the Structure of the Nucleon
September10-14, 2007
IKP, Forschungzentrum Jülich, Germany

MONTE CARLO SIMULATION OF MESON-NUCLEON AND MESON-NUCLEUS INTERACTIONS AT HIGH ENERGIES

A. Galoyan[1] , *V. Uzhinsky*[2]
Joint Institute for Nuclear Research, Dubna[3]

Abstract

Simulation of meson-nucleon and meson-nucleus interactions meets various problems. The first one is a connection between the annihilation and non-annihilation channels, or vacuum and non-vacuum exchanges. The second one is the excitation of mesons. The ways to solve these problems are considered. The reggeon theory is applied for solving the first problem. The second one is solved while describing experimental data. As a result a good reproduction of experimental regularities has been reached.

1 Meson-Nucleon Interactions

The meson-nucleus interactions was left out of active theoretical discussions during last decade, though unsolved problems were left. They are annihilation of quark in mesonic interactions, cross section of mesonic diffraction dissociation, reproduction of baryon spectra, transition to the low energies where resonance production is dominated and so on. In various manner they appear in calculations. In Fig. 1 we present a description of π^+p-interactions in the frameworks of the Fritiof [1], UrQMD 1.3 [2] and QGS [3] models[4].

It is desirable for improvement of the Fritiof and QGS models to take into account resonances in the $s-$channel and yield of so-called planar diagrams. The planar diagrams are associated with processes of quark annihilation from colliding hadrons. A simulation of the $s-$channel resonance creation is rather complicated task, thus we omit this interesting question, having in mind that they are important at sufficiently low energies. At high energies the yields of the planar diagrams and pommeron exchanges have to dominate in elastic scattering amplitude according to the Regge phenomenology. They have to

[1]Laboratory of Particle Physics, JINR.
[2]Laboratory of Information Technologies, JINR.
[3]Dubna, 141980, Moscow region, Russia
[4]We use QGS model implemented in the GEANT-4 package.

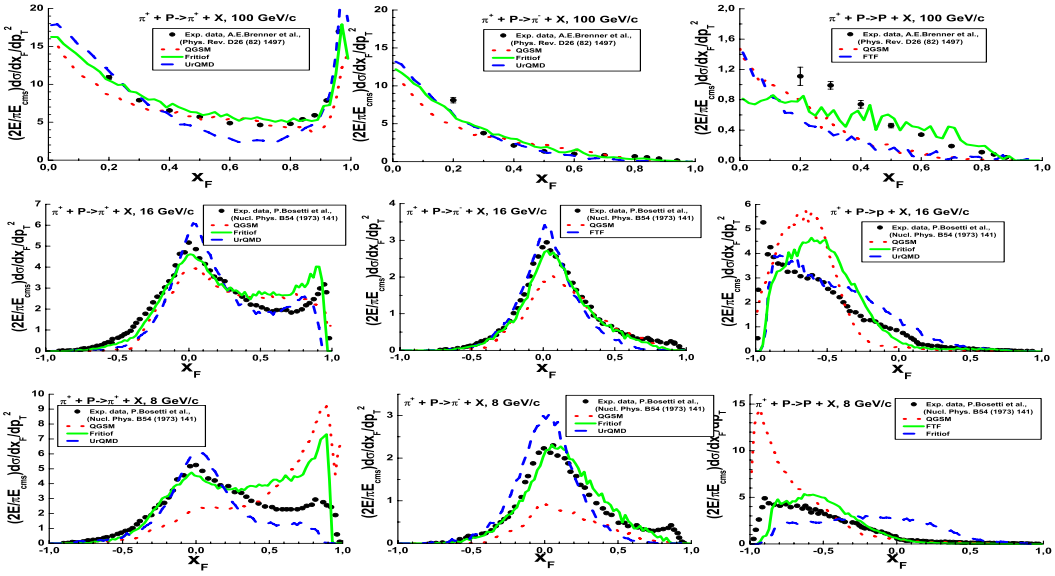

Figure 1: Spectra of π^+, π^- and protons in π^+p-interactions. Points are experimental data from Durham data base [4]. Lines are calculation results.

be reflected in inelastic processes. The yields of the planar diagrams are not positive defined. This introduces some difficulties in creation of Monte Carlo algorithms. For the Monte Carlo simulation of the meson-nucleon interactions it is desirable to represent total cross section as sum of positive defined terms, $\sigma^{tot}_{MN} = \sigma^{el} + \sigma^{dif}_M + \sigma^{dif}_N + \sigma_{2str} + \sigma_{ann}$. Here σ^{el} is elastic cross section, σ^{dif}_M is cross section of projectile meson dissociation, σ^{dif}_N – cross section of target nucleon dissociation, σ_{ann} is unknown annihilation cross section. In π^+p-interactions it is possible $\overline{d}d$ annihilation. One can expect that the annihilation cross section is proportional to an annihilation probability, w_{ann}. In π^-p-interactions it is possible $\overline{u}u$ annihilation, and the annihilation cross section has to be proportional to $2w_{ann}$, because there is a possibility to annihilate with different u-quarks of a proton. Thus,

$$\sigma^{tot}_{\pi^+p} = \sigma^{el} + \sigma^{dif}_M + \sigma^{dif}_N + \sigma_{2str} + \acute{a} * w_{ann}. \quad (1)$$

$$\sigma^{tot}_{\pi^-p} = \sigma^{el} + \sigma^{dif}_M + \sigma^{dif}_N + \sigma_{2str} + 2 * \acute{a} * w_{ann}.$$

and $c * w_{ann} = \sigma^{tot}_{\pi^-p} - \sigma^{tot}_{\pi^+p}$.

According to our estimations, the annihilation cross sections are not large in π^+p-interactions (10, 9 and 5% at 8, 16 and 100 GeV/c, correspondingly), and can not have a strong influence on calculation results. The main problem in the calculations is connected with 2-string interactions. In Fig. 2 we show yields of the processes in the π^+-meson spectra at 8 and 16 GeV/c calculated

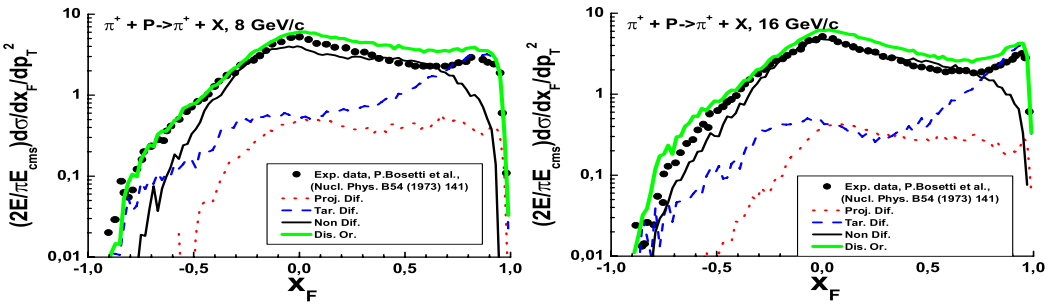

Figure 2: Spectra of π^+ in π^+p-interactions. Points are experimental data. Lines are calculation results.

in the Fritiof model. The dotted curves give the yields of projectile meson diffraction dissociation. The dashed lines are contributions of the target dissociation. The thin solid ones are the yields of 2-string processes. As seen, the 2-string processes are responsible for disagreement of the calculations and the experimental data in the region of $x_F \sim 0.3$–1. It is too difficult to change the calculation results varying model parameters.

After many attempts to improve the results, we accept a hypothesis on string disorientation in the collision process. Usually it is assumed that strings are fragmented along the collision axis. At low energies due to residual interactions a change of the axis can happen. Assuming complete disorientation, randomly rotating events, we obtain promising results presented by thick solid curves in Fig.2. We believe that a good description of experimental data and understanding of the meson-nucleon interaction can be reached on the direction.

2 Meson-Nucleus Interactions

At high energies, the effects considered above are not essential in meson-nucleus interactions, and one can expect a good agreement of the model predictions with experimental data. In Fig. 3 we present such comparison. Points are experimental data [5], solid lines are the Fritiof model calculations, and dotted ones are predictions of the QGS-G model. We have not obtained the UrQMD model results, because the code falls into an infinite loops. We are searching for bugs. As seen, the Fritiof model results are close to the data at large rapidities. In the target fragmentation region, the model underestimates the data due to an absence of formation time and secondary particle interactions in nuclei. All of them are taken into account in the QGS-G model. Thus, good results have been reached. At the same time,

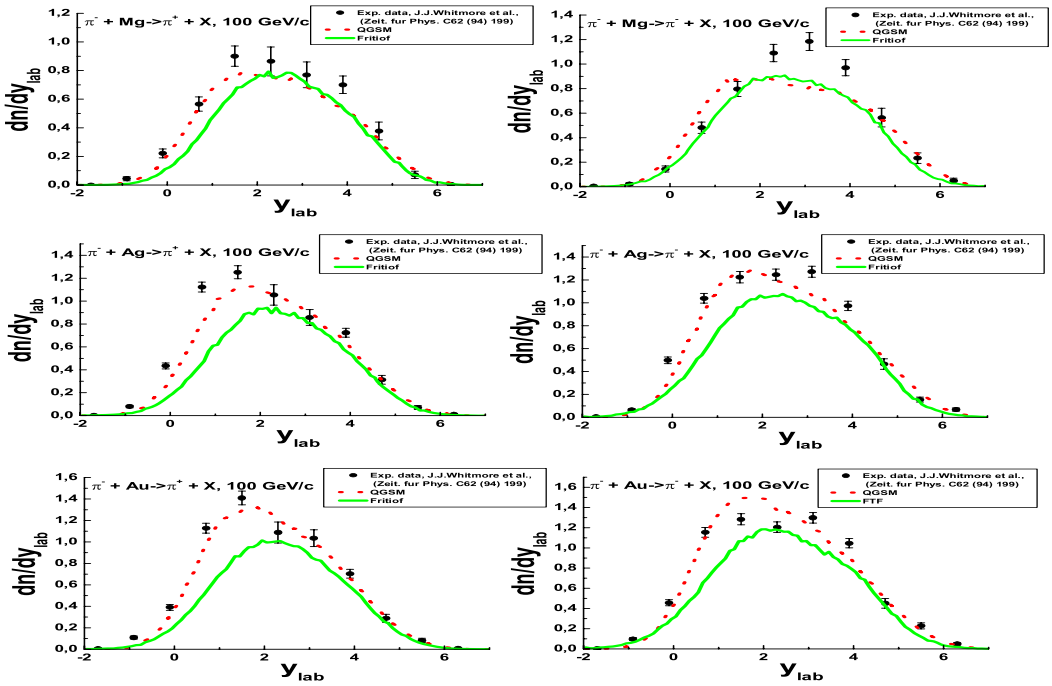

Figure 3: Spectra of π^+ and π^- in $\pi^- A$-interactions at 100 GeV/c. Points are experimental data. Lines are calculation results.

as it was shown before, the model works badly for the meson-nucleon interactions. So, a problem of consistence description of the meson-nucleon and meson-nucleus interactions is left.

References

[1] B. Andersson *et al. Nucl. Phys.* **B281**, 289 (1987); B. Nilsson-Almquist and E. Stenlund, *Comp. Phys. Commun.* **43**, 387 (1987).

[2] S. A. Bass *et al. Prog. Part. Nucl. Phys.* **41**, 225 (1998); M. Bleicher *et al. J. Phys.* **G25**, 1859 (1999).

[3] A. B. Kaidalov and K. A. Ter-Martirosian, *Phys. Lett.* **B117**, 247 (1982); A. B. Kaidalov, *Phys. Lett.* **B116**, 459 (1982); A. Capella, U. Sukhatme, C-I Tan, J. Tran Thanh Van, *Phys. Rept.* **236**, 225 (1994).

[4] http://durpdg.dur.ac.uk/HEPDATA/HEPDATA.html

[5] J. J. Whitmore *et al. Zeit. fur Phys.* **C62**, 199 (1994).