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Study of the Multi Particle Processes in Proton-Carbon and Deuteron-Carbon Interactions at 4.2 A GeV/c

A. Khan[1], M.K. Suleymanov[2], Z. Wazir[1*] and J. Aslam[1]

[1]*Department of Physics, Riphah International University, Islamabad, Pakistan*

[2]*Department of Physics, COMSATS Institute of Information Technology, Islamabad, Pakistan*

aasma_khan91@yahoo.com; mais_suleymanov@comsats.edu.pk; zafar_wazir@yahoo.com; jaslam_js@live.com

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ABSTRACT

In this paper, multi particle productions in hadron-nucleus and nucleus-nucleus interactions have been analyzed. The experimental data coming from 2m Propane Bubble Chamber, Joint Institute for Nuclear Research (JINR), Dubna, Russia has been used. The results have been compared with the simulated data from the Cascade Code. We could observe that the cascade code had problem in describing the experimental data for the multi particle events. One can conclude that the problem with the code could be connected due to production of Δ-resonance and exclusion of collective phenomena in the Cascade code.

1. Introduction

The investigation of particle-nucleus collisions is fundamental for understanding the nature of the interaction process and these collisions have been studied extensively [1–8]. In the study of multiparticle production, multiplicity is one of the most important parameters. This parameter may help in explaining many aspects of particle production process [9]. Keeping this fact in mind an effort is made in this direction. This will help to compare the particle production process in AA collisions and particle-nucleus collisions.

This paper presents a detailed study of compound multiplicity distribution. In this paper, the phenomenon of particle production in high energy nuclear collisions has been investigated by different types of particles.

2. Experimental Detail

We have used the experimental data of proton-carbon and deuteron-carbon interactions at 4.2 GeV/c coming from the 2m propane bubble chamber, JINR, Dubna Russia. A very detailed and descriptive analysis for these interactions have been given in papers [10-18]. The 2m propane bubble chamber is placed in a magnetic field of strength 1.5 T and irradiated with a beam of protons and deuterons separately accelerated with 4.2 A GeV/*c* at the synchrophasotron [18]. Here we will see the details of the dynamics of the hadron nuclei and nuclei nuclei interactions. There are several phenomena which may occur as the result of this interaction.

3. Model

Cascade Evaporation Model (CEM) is used for the most simple and descriptive explanation of a hadron-nuclear and nuclear-nuclear interactions**.** It is based on the simulation using Monte-Carlo techniques, which is applied to the interactions where multiplicity is to be observed. When hadrons as a projectile interacts with target carbon nuclei it is assumed [19-21] that some new particles are produce. The secondary charged particles produced in the interactions are different in every event. The basic process, assumptions, treatment and procedures of model are explained in detail in [19-21]. This model does not include the collective properties.

4. Results and Discussions

Figs. 1 and 2 show the experimental results for the multiplicity distribution of the secondary charged

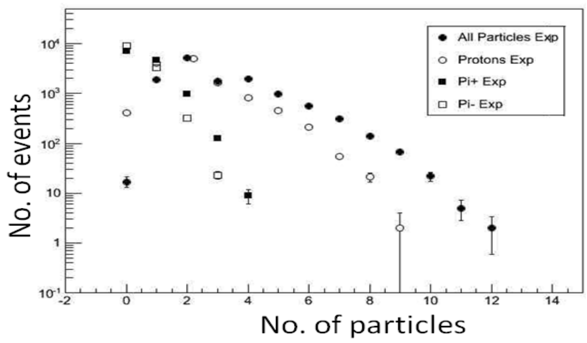

Fig. 1: The number of events as a function of charged particles in the proton-carbon experiment

[*] Corresponding author

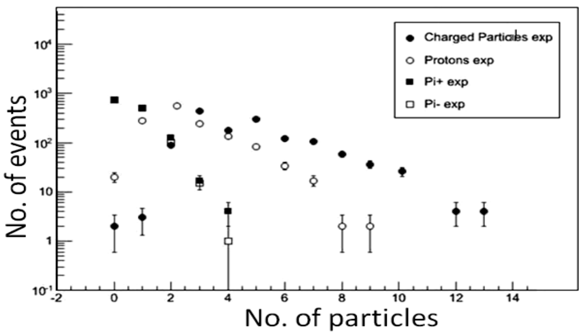

Fig. 2: The number of events as a function of the charged particles in the deuteron-carbon experiment

particles (protons, π^+ and π^- mesons) produced in $p^{12}C$ and $d^{12}C$ reactions at 4.2A GeV/c. The graphs show different regions. The first region corresponds to the values of $n_i \leq 2$; the second region is $2< n_i \leq 4$; the third region is $4 < n_i \leq 9$ and the fourth region is $9 < n_i \leq 12$.

The data coming from cascade code are drawn in Figs. 3 and 4 for $p^{12}C$ and $d^{12}C$ interactions at 4.2 A GeV/c. Cascade gives systematically greater values for Ni than observed in the experiment. One can see that the model can completely describe the proton distribution. The comparison of the cascade simulation data with experimental ones for mesons demonstrates some differences. This deviation may be a reason for observed differences between all charged particles distributions between experiment and model. So we can say that in the multi particle area cascade model has problem to describing the experimental data as shown in Figs. 5 and 6. The difference might be connected with :

a. The model uses increased values for cross section of Δ-resonance production.

b. The model does not include collective phenomena.

One can say that increasing the number of particles (n_i), there are 4 regions observed for the behaviour of the distribution of all produced particles: the first region coresponds to the values of $n_i \leq 2$; the second region is $2 < n_i \leq 4$; the third region is $4< ni \leq 9$; the fourth region is $9< ni\leq 12$. In the first region the values of events (N_i) increases with n_i. then in the second region it decreases and remains constant. In the third and fourth region the values of Ni decrease almost linearly but for fourth region it decreases more sharply than in the third region. Camparision with the cascade simulation data demonstrates that there exsist some differences only in the third region. No considerable deviation is observed in case of multiplicity of protons as the experimental data and cascade simulation give the same result.

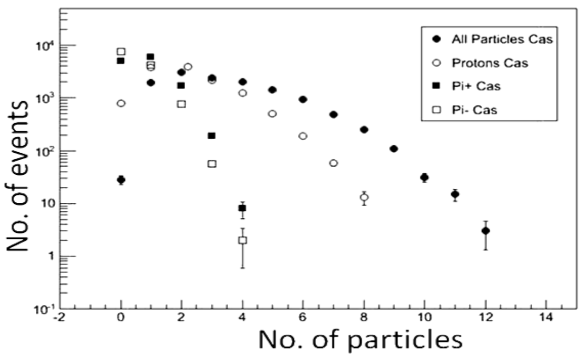

Fig. 3: The number of events as a function of charged particles produced in proton-carbon interactions from cascade code

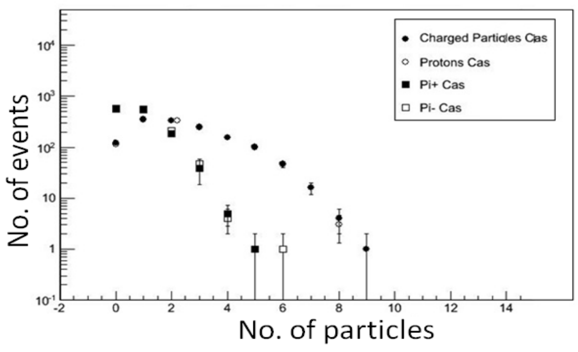

Fig. 4: The number of events as a function of charged particles produced in deuteron-carbon interactions from cascade code

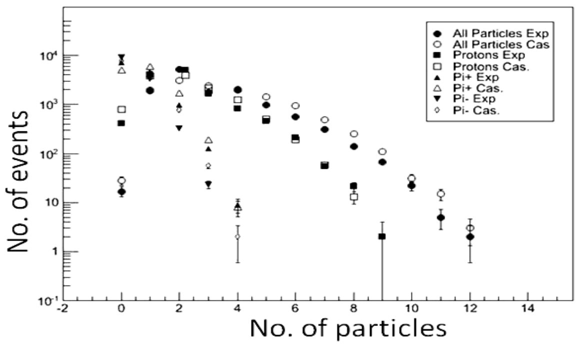

Fig. 5: The number of events as a function of charged particles in the proton-carbon interactions from experimental and simulation data

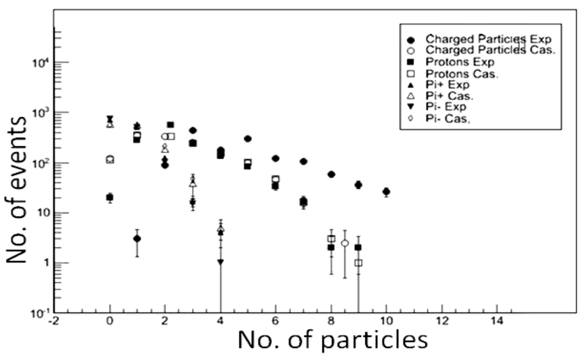

Fig. 6: The number of events as a function of charged particles in the duetron-carbon interactions from experimental and simulation data

5. Conclusions

One can see that there are some differences in the multiplicity of π^+ and π^- mesons between the experimental data and data coming from the cascade simulation. The results demonstrate that the observed deviation for the multiplicity of charged particles in the multi particles area is mainly connected with the production of π^+ and π^- mesons. So we can suppose that we have some processes (π- mesons) production which were not taken into account in cascade model. As we know the cascade model does not take into account collective particle production and also may be it is a result of Δ resonance because as we know the last decays to proton and pion.

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