The Nucleus **54**, No. 1 (2017) 23-25

www.thenucleuspak.org.pk

The Nucleus

ISSN 0029-5698 (Print)

ISSN 2306-6539 (Online)

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

ARTICLE INFO

Article history :
Received : 19 November, 2016
Revised : 12 February, 2017
Accepted : 01 March, 2017

Keywords:
Multi particle production
collective phenomena
Bubble
Chamber

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, 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 to describe 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 not inclusion 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 duetron-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]. Now 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 produced. The secondary charged particles produce 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 shows the experimental results for the multiplicity distribution of the secondary charged

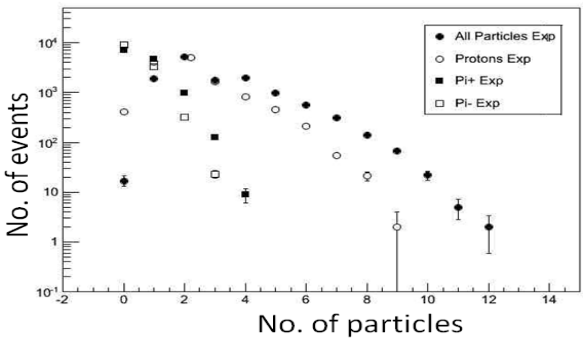

Fig. 1: The number of events as a function of the charged particles in the proton-carbon experiment

[*] Corresponding author

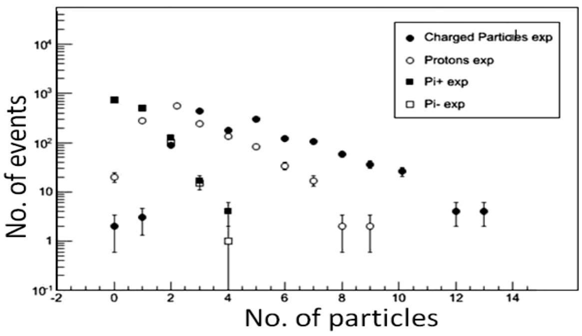

Fig. 2: The number of events as a function of the charged particles in the duetron-carbon experiment

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 the 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. May be this deviation is a reason of observed differences between all charged particles distributions in experiment and model. So we can say that in the multi particle area cascade model has problem to describe the experimental data as shown in Figs. 5 and 6. The difference might be connected with :

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

b. The model does not include collective phenomena.

One can say that with 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 is 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) increses with n_i. then in the second region it decreases and remans constant. In the third and forth region the values of the Ni decrease almost linearly but for forth region it decreses sharper then for the third region. Camparision with the cascade simulation data demonstrates that there exsists 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 gives the same result.

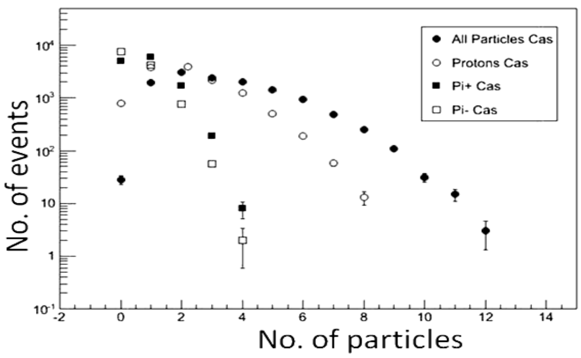

Fig. 3: The number of events as a function of the charged particles produced in proton-carbon interactions from cascade code

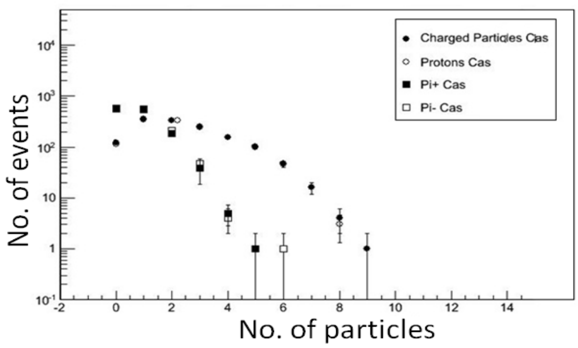

Fig. 4: The number of events as a function of the charged particles produced in duetron-carbon interactions from cascade code

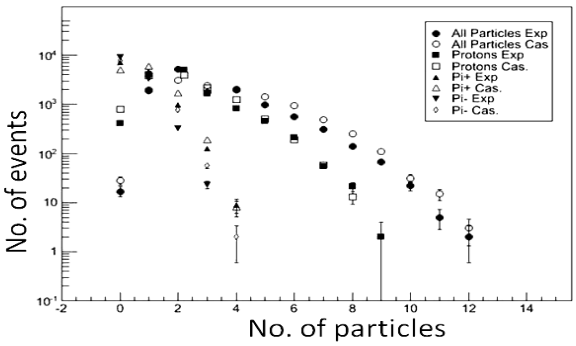

Fig. 5: The number of events as a function of the charged particles in the proton-carbon interactions from experimental and simulation data

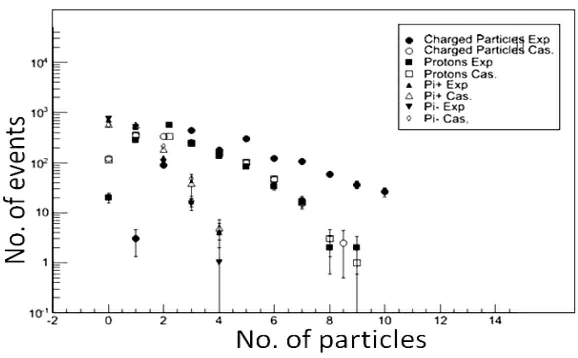

Fig. 6: The number of events as a function of the charged particles in the duetron-carbon interactions from experimental and simulation data

5. Conclusions

One can see that there are some difference 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 may be we have some processes (π- mesons) production which could not be taken into account for cascade model. As we know cascade do 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.

Acknowledgement

We thank Riphah Academy of Research and Education (RARE) for their financial support.

References

[1] M.C. Abreu et al., (NA50 Collaboration) "Anomalous suppression in Pb-Pb interactions at 158 GeV/*c* per nucleon", Phys. Lett. B., vol. 410, nos. 2-4, pp 337-343, 1997.

[2] Fu-Hu Liu, N.N. Abd Allah, D.H. Zhang and M.Y. Duan, "Particle multiplicity distributions in silicon-emulsion collisions at 4.5 AGeV/c, "Phys. Rev. C, vol. 67, no. 4, pp. 047603, 2003.

[3] Z.V. Anzon, I.Y. Chasnikov, A.S. Gaitinov, et al. "A study of inelastic pion-nucleus interactions at 200 GeV/c in an emulsion", Nucl. Phys. B., vol. 129, no. 2, pp. 205–234, 1977.

[4] I. Otterlund, E. Stenlund, B. Andersson et al., "Nuclear interactions of 400 GeV protons in emulsion", Nuclear Physics B, vol. 142, no. 4, pp. 445–462, 1978.

[5] M. El-Nadi, O. E. Badawy, M. K. Hegab et al., "Inelastic interactions of 340 GeV/c - with emulsion nuclei", Physical Review D, vol. 27, no. 1, pp. 12–18, 1983.

[6] R.K. Shivpuri and A. Kotha, "Multiplicity, rapidity and rapidity correlations in 800 GeV proton-nucleus interactions", Physical Review D, vol. 35, no. 11, pp. 3508–3511, 1987.

[7] A. Tufail, S. Ahmad, A. R. Khan, M. Zafar, and M. Shafi, "Nuclear interactions of 340 GeV pions in emulsion, "Physical Review D, vol. 42, no. 7, pp. 2187–2193, 1990.

[8] A. Tufail, S. Ahmad, and M. Zafar, "Features of forward-backward multiplicity correlations in hadronic collisions", Canadian J. of Phys., vol. 74, no. 3-4, pp. 141–144, 1996.

[9] A. Jurak and A. Linscheid, "Some characteristics of compound shower and grey tracks multiplicity distributions produced in proton emulsion interactions", Acta Physica Polonica B, vol. 8, pp. 875–886, 1977.

[10] M.K Suleimanov, O.B Abdinov, A.M Bagirov, A.I. Anoshin, J. Bogdanowicz and A.A Kuznetsov, "Single particle correlations in events with total disintegration of nuclei", Phys. Rev. C, vol. 58, no. 1, pp. 351-355, 1998.

[11] H Satz, "The onset of deconfinement in nuclear collisions", Nucl. Phys. A, vol. 661, no. 1-4, pp. 104-118, 1999.

[12] A.J. Santiago, K.C. Chung, "Energy spectra of nuclear fragmentation in the percolation description", J. Phys. G: Nucl. Part. Phys., vol. 16, pp. 1483-1492, 1990.

[13] A. Dąbrowska, R. Hołyński, A. Jurak, A. Olszewski, M. Szarska, A. Trzupek, B. Wilczyńska, H. Wilczyński, W. Wolter, B. Wosiek, K. Woźniak, M. L. Cherry, W. V. Jones, K. Sengupta, J. P. Wefel, P. S. Freier, and C. J. Waddington, "Particle production in interactions of 200 GeV/nucleon oxygen and sulfur nuclei in nuclear emulsion", Phys. Rev. D, vol. 47, no. 5, pp. 1751-1761, 1993).

[14] J Desbois, "Heavy ion collisions and the site-bond percolation" Nucl. Phys. A, vol. 466, nos. 3-4, pp. 724-748, 1987.

[15] D. Sarunyagate, Lasers, 2nd Ed., New York: McGraw-Hill, 1996.

[16] H.W. Bertini, T.A. Gabriel and R.T. Santoro, "Predicted proton spectrum at forward angles for 29.4 GeV nitrogen on carbon", Phys. Rev. C ,vol. 9, pp 522-526, 1974.

[17] H. W.Bertini, R.T. Santoro and O.W. Hermann. "Calculated nucleon spectra at several angles from 192,500,700 and 900 MeV carbon on Iron", Phys. Rev. C, vol. 14, pp. 590, 1976.

[18] J.P. Bondorf, H.T. Feldeier, S. Garpman, E.C. Halbert, "Classical microscopic description of U+U collisions", Phys. Lett. B, vol 65, pp 217-220, 1976.

[19] J.P. Bondorf, "Classical microscopic calculation of fast heavy ion collisions", Zeit. Phys. A, vol. 279, pp. 385-394,1976.

[20] V.D. Toneev and K K Gudima, "Particle emission in light and heavy ion reactions", Nucl. Phys. A, vol. 40, pp 173-189, 1983.

[21] A. Boudard, J. Cugnon, S. Leray and C. Volant. "Intranuclear cascade model for a comprehensive description of spallation reaction data", Phys. Rev. C, vol. 66, pp. 044615, 2002.