Pecularities of Produced Particles in heavy-ion Collisions at CERN SPS Energy

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Introduction

Relativistic collisions offer us the only means at present to probe the high density and temperature domain in the laboratory and therefore enable us to reach a very high temperature over extended domains many times larger than the size of the single hadron. When two nuclei collide themselves with a relativistic high energy, they generally create a colour deconfined Quark-Gluon Plasma(QGP) like state of matter. Fluctuation studies in the distributions of produced particles encapsulate rich information about the dynamics of the emitting source in the late stage of a nucleus-nucleus collision where the nuclear matter is highly excited and diffused. In analyses of an azimuthal distributions of produced particles two different classes of substructures were found, which could be referred to as jet-like and ring-like structures. These structure are also familiar as tower and wall structures[1]. Here in this paper we like to investigate the ring and jet-like structure for ^{16}O-Ag/Br interactions at 60A GeV for two different types of subgroup and try to explain the probable reason behind it.

Experiment and Methodology

In this investigation, ^{16}O beam with incident momentum 60 A GeV/c was irradiated horizontally on the stacks of Ilford G5 emulsion plates at the CERN SPS. A sample of 250 Ag/Br events of 60 A GeV ^{16}O induced interactions are chosen for this analysis[2]. In this paper we have followed the method to search for a ring-like and jet-like substructure described by Adamovich *et al* [3].We have started it with a fixed number of shower track N_d. Each N_d tuple of particles are considered as a group along the η axis. This size of the group is given by, $\Delta\eta_d = |\eta_i - \eta_j|$, where η_i and η_j are the first and last particle of the group. Rapidity density(ρ_c) is defined by, $\rho_c = N_d/\Delta\eta_d$. To parameterize the azimuthal structure, two parameters are introduced namely, $S_1 = -\sum \ln(\Delta\varphi_i)$ & $s_2 = \sum (\Delta\varphi_i)^2$.Where $\Delta\varphi_i$ is the azimuthal difference between two consecutive particle in a group. Both S_1 and S_2 are small ($S_1 \rightarrow N_d \ln(N_d)$ and $S_2 \rightarrow 1/N_d$) for ring-like structures and are large ($S_1 \rightarrow \infty$ and $S_2 \rightarrow 1$)for jet-like structures. While S_1 is sensitive to small gaps, S_2 is sensitive only to large gaps. Stochastic value of the two parameter, $< S_1 >= N_d \sum_{k=1}^{N_d-1}(\frac{1}{k})$ and $< S_2 >= \frac{2}{N_d+1}$.

Results

In fig.1, we have shown the S_2 distribution for ^{16}O-Ag/Br collision at 60 A GeV for two different subgroups, N_d=15 and 20. The experimental S_2 - distributions are shown with solid lines and dotted lines for Monte-Carlo(MC) simulation in Fig.1. In case of a pure stochastic scenario S_2 - distribution would have a peak position around S_2 = 0.125 for N_d = 15 and around S_2 = 0.095 for N_d = 20.

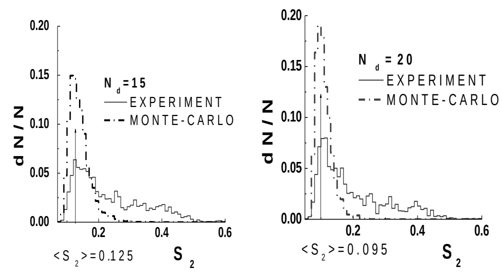

Fig.1

The existence of the ring-like substructures results to deformations and/or to appearance of additional peaks at the left part of the S_2 - distribution, where $S_2 < \langle S_2 \rangle$. One can see that our experimental distributions are shifted to the right, have a tail in the right part and are broader than the spectra calculated by the MC simulation. The experimental normalized $S_2/\langle S_2 \rangle$ distributions compared with the distributions calculated by the MC simulation are presented in the Fig.2. The model distributions were aligned according to the position of the peak with the experimental one.

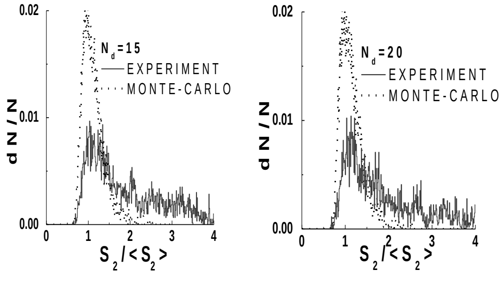

Fig.2

The MC are used neither the ring-like nor the jet-like effects, only for the statistical background.

We have plotted the $\Delta\eta$ distributions for the experimental [16]O-Ag/Br data with that of the data generated by the MC simulation for N_d=15 and 20 in fig.3. There are two types of graph for each N_d. One is $S_2/\langle S_2\rangle$ <1 and another is $S_2/\langle S_2\rangle$ >1. Former is for searching the ring-like and later is for jet-like substructures. In former case we can see that there are some clusters of experimental surpluses over the model distributions and the said fact is more prominent for N_d=20 compared to N_d=15. This is the signature of ring-like substructure. Whereas the clustering also observed in case of S_2 /$\langle S_2\rangle$ >1 and this observation emphasizes on the fact of jet-like effect.

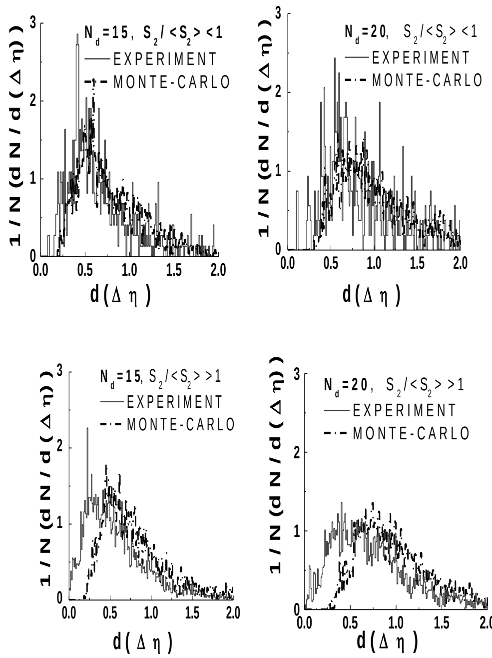

Fig.3

In fig.4 we have shown the $\langle -\sum \ln(\Delta\varphi_i)\rangle$ vs $\Delta\eta$ distribution for two types of subgroup and we find that distribution of the data obtained from the MC simulation lie more or less along the stochastic expectation line indicated by the dotted line, in all the cases. Experimental data points have a weak tendency to be above the stochastic average line. The above fact corresponds directly to the jet-like structure i.e jettyness is present.

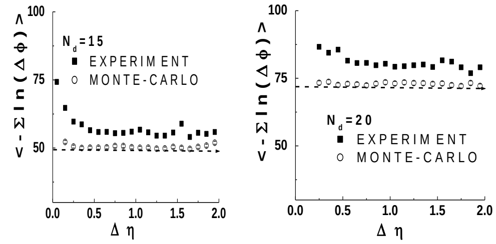

Fig.4

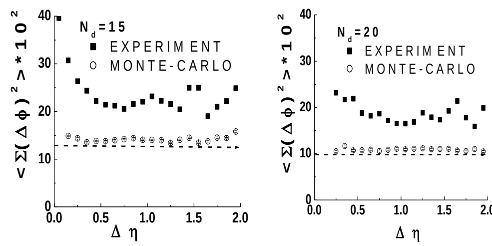

Fig. 5

In fig.5 we have plotted the $\langle\sum (\Delta\varphi_i)^2\rangle$ vs $\Delta\eta$ distribution for experimental as well as model based data. Here also the experimental data points have a strong tendency to be above the MC distribution. Once again presence of jet-like structure is reestablished.

Conclusions

We have investigated the azimuthal substructure of particles produced in [16]O induced collisions with Ag/Br nuclei in an emulsion detector at 60 A GeV/c within dense and dilute groups along the rapidity axis. Non-statistical ring-like and jet-like substructures have been found and results are in an agreement with I. M. Dremin idea[4].

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