Azimuthal structure of particle emission in ^{28}Si-Ag(Br) interaction at 14.5A GeV

P. Mali[1],* A. Mukhopadhyay[1], and G. Singh[2]
[1] *Department of Physics, University of North Bengal, Siliguri - 734013, INDIA and*
[2] *Department of Computer and Information Science, SUNY at Fredonia, NY- 14063, USA*

Rapidly fluctuating particle densities in the final state are typical to any high energy interaction. The issue has so far been thoroughly examined through different experimental and phenomenological techniques [1]. It is speculated that the Cherenkov gluon emssion is one of the probable reasons of observing large particle densities within a narrow phase space region [2]. An alternative explanation is the Mach shock wave formation in the nuclear medium. Both mechanisms can possibly lead to a ring and/or a jet like azimuthal (φ) substructures in the particle distribution.

Here we study sych unusual azimuthal substructures, if there is any, in the distribution secondary charged hadrons emerging from the ^{28}Si-Ag(Br) interactions at 14.5 GeV per nucleon. The nuclear emulsion technique is utilized to collect the experimental data, which contains 152 events with a minimum shower track multiplicity of 50. The Ulta-relativistic Quantum Molecular Dynamics (UrQMD) code [3] is used to simulate the statistical background.

The presence of ring/jet like substructures can be studied in terms of a set of parameters namely, (i) the cluster size $\Delta\eta = \eta_{\max} - \eta_{\min}$, (ii) the cluster density $\rho = n_d/\Delta\eta$ and (iii) the cluster mean $\eta_m = \sum_{i=1}^{n_d} \eta_i/n_d$. Here η is the pseudorapidity of a particle, while $\eta_{\min}(\eta_{\max})$ is the minimum(maximum) value of η within the cluster. Two other parameters namely, (i) $S_1 = -\sum_{i=1}^{n_d} \ln(\Delta\varphi_i)$ and (ii) $S_2 = \sum_{i=1}^{n_d} (\Delta\varphi_i)^2$ are introduced that can distinguish between ring and jet like structures. All variables / parameters are calculated for every possible subgroups having a fixed multiplicity n_d. The S-parameters along with ρ would indicate whether the substructures are ring like or jet like; on the other hand, $\Delta\eta$ and η_m are used to characterize the clusters. In case of a pure stochastic emission the average values of the S-parameters can be evaluated analytically. These are $\langle S_1\rangle = n_d \sum_{k=1}^{n_d-1} \frac{1}{k}$ and $\langle S_2\rangle = \frac{2}{n_d+1}$ [4]. An S-parameter distribution normalized by the corresponding stochastic value would have its peak around $S/\langle S\rangle \approx 1$. Presence of ring like structures would result in an excess count in the experiment over the model prediction towards the left of the mean, whereas, an opposite effect would be observed if the jet like structures dominate.

In this analysis the fixed cluster multiplicity is $n_d = 15$. The S-parameters normalized by the respective stochastic values are plotted in FIG.1. The UrQMD model predictions of these parameters and the difference between the experimental and the model prediction are also shown in the same diagram. The experimental distributions have small excesses over the UrQMD for $S/\langle S\rangle > 1$ (shown by the shaded area), which is statistically not very significant. The average behaviour of the S-parameters are also studied and are plotted against $\Delta\eta$ in FIG.2. It can be observed that the first two experimental points are significantly above whereas the other experimental values are consistently above the stochastic line as well as the UrQMD prediction. The observation indicates the presence of strong short range correlation in the data. To get an idea about the cluster size, we have plotted the $\Delta\eta$ distribution in FIG.3. Separate plots have been made for (a) the ring like region and (b) the jet like region. In both diagrams experimental excesses are found in the $\Delta\eta < 0.5$ region. This implies that a large number of jets

*Electronic address: `provashmali@gmail.com`

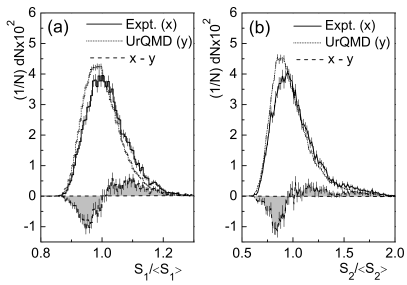

FIG. 1: The S-parameter distributions normalized by its stochastic values for $n_d = 15$.

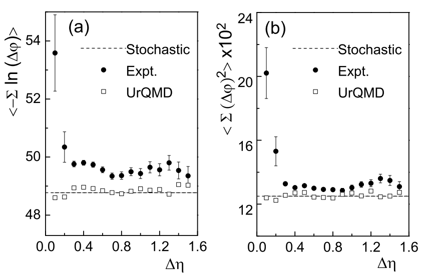

FIG. 2: The average behaviour of the S-parameters; $n_d = 15$.

of small size are present in the experimental data. In FIG.4 the η_m distribution is shown with the same convention as FIG.3. In FIG. 4(b) a significant experimental excess over the UrQMD is noticeable for $\eta_m > 1$.

From the above analysis one can conclude that the azimuthal structure of the shower

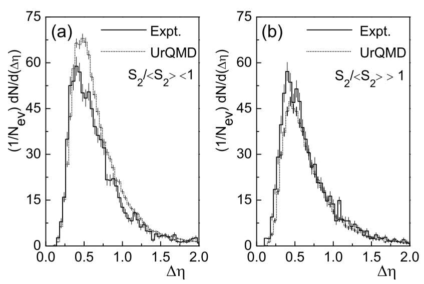

FIG. 3: The cluster size distributions for two different regions; $n_d = 15$.

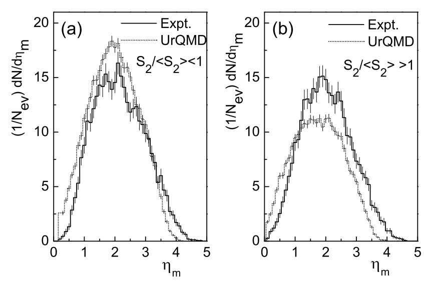

FIG. 4: The cluster mean pseudorapidity distributions for two different regions; $n_d = 15$.

tracks coming out of ^{28}Si-Ag(Br) events are mostly jet like having maximum jet width $\Delta\eta = 0.5$ and the corresponding mean pseudorapidity value $\eta_m > 1$. More detail analysis and model calculations are required to determine the nuclear refractive index and/or elastic wave velocity in the nuclear medium, which are so helpful to find out an appropriate nuclear eaquation of state.

Acknowledgments

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