Jet-structure in ^{16}O-Ag/Br interaction at 200A GeV/c

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Rapidly fluctuating density of final state particles (hadrons) is typical to high-energy interactions. One hypothesis behind this phenomenon is the emission of conical gluonic radiation as and when a partonic jet travels through the hadronic/nuclear medium, which is similar to the emission of Cérenkov radiation. An alternative conjecture is that, it is due to the formation of a Mach shock wave traveling through a similar medium [1]. In either case the emission pattern will be characterized by a conical structure defined through an angle α as, $\cos\alpha = c_{med}/v = c/(\mu v)$. Here c is the velocity of gluons (sound wave) in vacuum (air), and depending on the case as it may be, c_{med} is the velocity of gluons (shock wave), v is the velocity of the partonic jet that triggers the Cérenkov gluon (shock wave) emission, and μ is the refractive index, all values pertaining to the medium concerned. Under favourable circumstances the conical structure so formed may withstand the impact of collision and retain its original structure. If the triggering parton direction is same as that of the incident beam and if the number of jet emitting gluons is large, then one may observe ring-like structures that are clustered within narrow pseudorapidity (η) but distributed uniformly over the entire azimuth (φ). On the other hand, if such gluon number is small then several jets each restricted to narrow (η, φ) intervals will be formed. Such azimuthal structures were first studied in a cosmic ray experiment [2] and subsequently in some other accelerator based experiments [3].

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Consider a fixed number (n) of particles in an event that has total multiplicity n_s. Each n-tuple of particles is arranged consecutively along the η-axis, and the subgroup is characterized by a mean $\eta_m = \sum_{i=1}^{n} \eta_i/n$, a size $\Delta\eta = \eta_{n+i-1} - \eta_i$ $(i = 1, \cdots, n_s)$, and a density $\rho = n/\Delta\eta$. The azimuthal structure of any such subgroup is then parametrized by $S_1 = \sum_i^n - \ln(\Delta\varphi_i)$ and $S_2 = \sum_i^n (\Delta\varphi_i)^2$, where $\Delta\varphi_i$ is the φ-difference of two neighbouring particles normalised by a complete revolution (2π). For a perfect ring-like structure, both S_1 and S_2 are small ($S_1 \to n \ln n$ and $S_2 \to 1/n$), and they are large ($S_1 \to \infty$ and $S_2 \to 1$) for a perfect jet-like structure. The stochastic expectation values of these parameters are, $\langle S_1 \rangle = n \sum_{i=1}^{n-1} 1/k$ and $\langle S_2 \rangle = 2/(n+1)$. The S-parameters would be distributed around these values. Presence of jet-like structure may result in bulging and small local peaks in the distributions to the right side, whereas ring-like structures would do the same to the left of the mean. Often trivial statistical noise is combined with dynamical effect(s) and it is not always an easy task to separate out one from the other. One way to do so is to replace the basic phase space variables by randomly generated numbers and distribute them according to the particle multiplicity. The generated data set can then serve the purpose of a statistical background. For a sample of 280 ^{16}O-Ag/Br emulsion events at 200A GeV/c that has $\langle n_s \rangle = 119.26 \pm 3.59$, we have chosen $n = 15$. The stochastic expectation values are $\langle S_1 \rangle \approx 48.8$ and $\langle S_2 \rangle = 0.125$. S_1 and S_2 each normalised by the respective stochastic expectation value are distributed in Fig.1 As expected and as can be seen from these diagrams, the random number

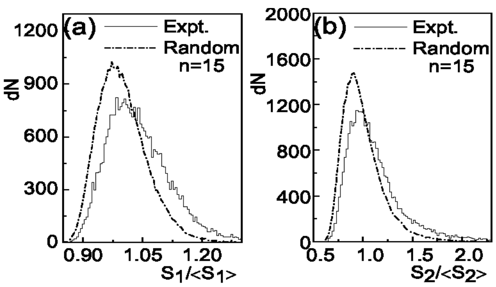

FIG. 1: (a) S_1 and (b) S_2 distribution.

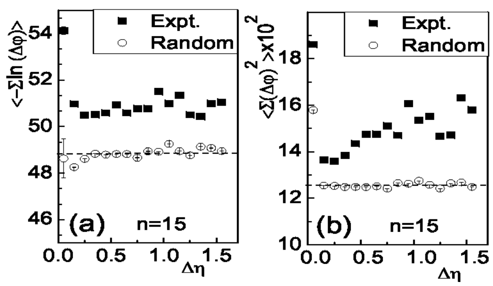

FIG. 2: Average S_1 and S_2 against $\Delta\eta$. The dotted lines represent stochastic expectation.

generated distributions are peaked around $S_i/\langle S_i\rangle = 1$. Each distribution is left skewed, and the asymmetry is more pronounced in the experiment which is also significantly shifted towards right with respect to the generated distribution. One can also find small bulging in the right hand side of the peaks. Thus large S_i values signifying jet-like structures, cannot be generated as abundantly by a random number based independent emission model as it can be in the experiment. In Fig.2 the averages $\langle\sum -\ln(\Delta\varphi_i)\rangle$ and $\langle\sum(\Delta\varphi_i)^2\rangle$ are plotted against $\Delta\eta$. Corresponding stochastic expectation lines and random number generated values are also included in the diagrams. While the random number generated values fall along the respective stochastic expectation line, the experimental values are consistently above both of them. Once again the inadequacy of independent emission to replicate the experimental data can be seen. The location of jet/ring-like structures can be investigated by studying the η_m distribution. There can be three categories: (i) $S_2/\langle S_2\rangle < 0.95$ - where ring-like effects dominate, (ii) $0.95 \le S_2/\langle S_2\rangle \le 1.1$ - statistical background, and (iii) $S_2/\langle S_2\rangle > 1.1$

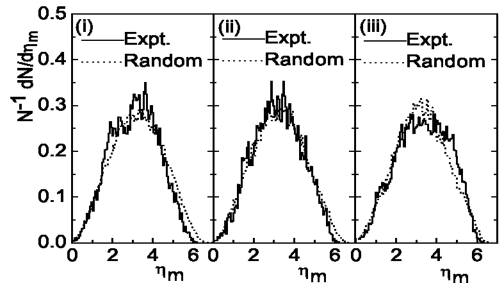

FIG. 3: η_m distributions: (i) $S_2/\langle S_2\rangle < 0.95$,(ii) $0.95 < S_2/\langle S_2\rangle < 1.1$ and (iii) $S_2/\langle S_2\rangle > 1.1$.

- jet structures dominate. In Fig.3 the η_m distributions have been graphically plotted. Each distribution is more or less symmetric about a central value. There are always small experimental excesses over the random number generated values, which for category (i) are present mainly near the central region and left to it, for category (ii) in the form of two narrow structures in the central region, and for category (iii) continuously extending over a region of ~ 1 unit of η in the right hand side of the central maxima.

The present analysis of a sample of ^{16}O-Ag/Br events at 200A GeV/c shows presence of jet-like structures in the angular emission of produced charged particles that cannot be reproduced by stochastic/independent emission model. An wavelet analysis, which at present is underway for the same data, is expected to reveal a greater detail of fluctuating density.

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