Factorial correlators study for Ring-like and Jet-like events at CERN SPS energy

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Introduction

The large density fluctuation in small rapidity intervals is an interesting topic in high energy collision now a days[1]. A large number of analyses have been done in terms of fractal moments [2] but we do not know the actual origin of such fluctuations. In this context, "factorial correlators"(FC) which have also been introduced by Bialas and Peschenski [3] is an important addition, since it can provide extra information about the bin-bin correlation. It not only measures non statistical local density fluctuation, but also gives information about the correlation between these local density fluctuation in phase space.

In case of ultra-relativistic heavy-ion collisions, two different classes of substructures are found from an analysis of azimuthal distribution of pions which are referred as ring-like and jet-like structures[4]. Ring-like structures are occurring where many pions are produced in narrow regions along the rapidity axis, which are at the same time diluted over whole azimuth. On the other hand, the jet-like structures consist of cases where particles are focused in both dimensions. In this paper we have performed an in depth study of correlators, introduced by Bialas and Peschanski, to extract the information about bin-bin correlations into two subgroups of particles – ring-like and jet-like events for pions multiplicity emitted from ^{32}S-Ag/Br interactions at 200A GeV and compared with the results of full data sets [5].

Experiment and Methodology

In this investigation, ^{32}S beam with incident momentum 200 AGeV/c was irradiated horizontally on the stacks of Ilford G5 emulsion plates at the CERN SPS. A sample of 140 Ag/Br events of 200 A GeV ^{32}S induced interactions are chosen for this analysis. In this paper we have followed the method to search for a ring-like and jet-like substructure described by Adamovich *et al* [4]. 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.

To separate the ring-like and jet-like events we used S_2 distribution. The distribution of $S_2/\langle S_2 \rangle$ for ^{32}S – AgBr interactions at 200 A GeV shows a peak at 0.60. We consider ring-like structured events having $S_2/\langle S_2 \rangle$ in the range 0.3–0.7[6].

Result and Discussions:

For the present investigation we have subdivided the total azimuthal angle space($\Delta\varphi = 360^o$) in to 9,18,27,36 bins of width 40^o, 20^o, 13.3^o & 10^o respectively. Factorial correlator has been studied for the order (1,1) ,(2,1), (3,1), (2,2), (3,2), (3,3) for ring-like and jet-like events respectively and we have followed the method prescribed in [3]. The plot of $\ln C_{pq}$ vs $-\ln D$ for the bin width $\delta\Phi = 20^o$ and 13.3^o have been plotted for jet-like and ring-like events which are shown in fig.1 and fig.2 respectively.

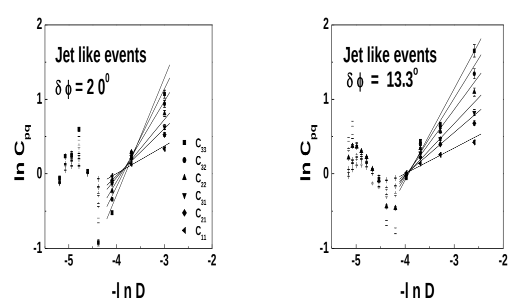

Fig.1

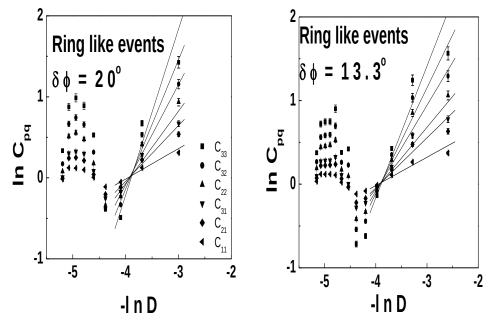

Fig.2

These figures clearly support that the power law behavior is maintained for small D≤80° but not in the full D region. The exponents are extracted from the linear fits in the region 10≤D≤40, 13.3≤D≤54, 20≤D≤60, 40≤D≤80 for bin widths 10°,13.3°,20°,40° respectively. In table.1 and table.2 we have tabulated the exponents for jet like and ring like events respectively.

Table.1 Slopes of the best fits in $\ln C_{pq}$ vs $-\ln D$ graph for Jet like events in the above said regions.

Order	δΦ=13.3°	δΦ=20°
11	0.344±0.011	0.369±0.012
21	0.566±0.017	0.631±0.019
31	0.699±0.020	0.780±0.023
22	0.892±0.026	1.077±0.032
32	1.064±0.030	1.311±0.039
33	1.227±0.034	1.570±0.050

It is found from the table that as the bin size increases the slope value also increases. It also increases with the increase of the order of the correlator for a particular bin width. We have also studied the variation of Φ_{pq} with pxq for the above said bin widths and we observed that as bin size increases the slope of the curves increases more or less in all the cases for a particular order and the same property observed when bin size fixed and order increases.

Table.2 Slopes of the best fits in $\ln C_{pq}$ vs $-\ln D$ graph for Ring like events in the above said regions.

Order	δΦ=13.3°	δΦ=20°
11	0.339±0.009	0.376±0.011
21	0.599±0.016	0.688±0.020
31	0.739±0.019	0.893±0.026
22	1.028±0.028	1.240±0.037
32	1.265±0.034	1.595±0.048
33	1.578±0.042	2.047±0.062

Another notable thing we observed that for both type of events, for each bin width, the slope value increases linearly with pxq . the fact is consistent with lognormal approximation. To verify the bin width (δΦ) independent of the correlators for fixed separation D as predicted by the α model, we have plotted $\ln C_{pq}$ against $-\ln D$ for D=120° for jet and ring-like events(fig.3).

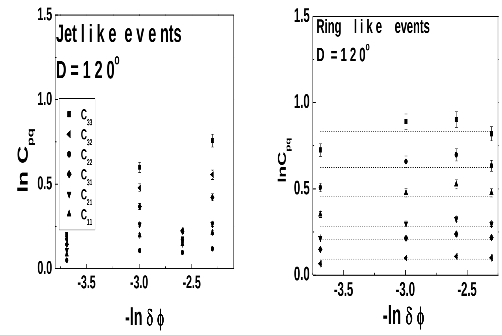

Fig.3

The following conclusions can be drawn from the above observations which are given below - The correlated moments (C_{pq}) for the ring and jet-like events follow a power law behavior within a restricted D region where D≤80° indicating self-similar behavior. It is further interesting to note that the strength of the non-statistical fluctuations is less for jet-like events than those of ring-like events. More or less bin size independence is reproduced for ring-like events and roughly matches with the jet-like events support the α model of intermittency.

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