Factorial correlator in ^{28}Si-Ag/Br collision at 14.5A GeV/c

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Introduction

The scaled factorial moment (SFM) and its scaling behaviour with diminishing phase space interval size (known as 'intermittency'), primarily deals with short range correlation as it is related to the local properties of the density fluctuation [1]. On the other hand, the factorial correlator (FC) is more fundamental in nature, as it is capable of characterizing the bin to bin long range correlation generated by intermittent type fluctuating patterns [2]. Both SFM and FC are actually integrals of the same underlying conventional correlation function(s) differing only in respect of their domains of integration, and both are sensitive to the projection (i.e., dimensional reduction) effects. To understand the dynamics of multiparticle production in high-energy interactions, it's therefore, more than prudent that an SFM analysis together with the corresponding FC analysis for a wide range of data should be made available. While a large number of experimental results on intermittency have been published, not so many on FCs are available in literature [3]. Complimentary to our intermittency related observation (to be) presented in this symposium, we in this contribution report an FC study on the same set of nuclear emulsion data on shower tracks emanating from ^{28}Si-Ag/Br interaction at 14.5A GeV/c.

Methodology

The pseudorapidity $\eta = -\ln\tan\frac{\theta}{2}$ of a particle is used as the basic phase space variable. But to ensure translational invariance, the underlying density function has been converted to that of a cumulant variable X_η. The FCs defined for each pair of nonoverlapping bins (jj') are averaged over all possible combinations of jj's separated by a fixed distance D in an event: $\tilde{F}_{p,q} = \left\langle n_j^{[p]}\, n_{j'}^{[q]} \right\rangle / \tilde{F}_p\tilde{F}_q$, where $n_j^{[q]} = n_j(n_j-1)\ldots(n_j-q+1)$, $\tilde{F}_q = \left\langle n_j^{[q]} \right\rangle$ and $n_j(n_{j'})$ is the number of particles in the $j(j')$th bin. $\tilde{F}_{pq}$ $(p \neq q)$ are not symmetric in p and q, but can easily be done so, $\langle F_{p,q}\rangle = (\tilde{F}_{p,q} + \tilde{F}_{q,p})/2$. According to a random cascading (α-model) model $\langle F_{p,q}\rangle$ depends only on the correlation length D but not on the interval width δX_η, and they follow an approximate scaling law, $\langle F_{p,q}\rangle \propto D^{-\phi_{p,q}}$.

TABLE I: Exponent values $\phi_{p,q}$ for different combinations of p and q for the experimental data.

(p,q)	$\phi_{p,q}$	R^2
(1,1)	0.0108±0.0016	0.9586
(2,1)	0.0243±0.0036	0.9579
(3,1)	0.0449±0.0093	0.9228
(2,2)	0.0567±0.0128	0.9115
(3,2)	0.0886±0.0170	0.9332
(3,3)	0.2027±0.0250	0.9793

Results

The FCs are calculated both for the experimental data as well as for the events simulated by the FRITIOF code [4], and they are graphically plotted in Fig.1. For the experiment for each combination of p and q, a rapidly growing correlation is observed at the beginning, which gets saturated at $-\ln D \approx 1.5$, that corresponds to a correlation length $D = 0.223$. On the other hand, the FRITIOF sample does not show any such variation. The exponents $\phi_{p,q}$ have been evaluated from the linear fit in the region $D \leq 0.16$. Table I shows such values of $\phi_{p,q}$ for the experimental data only, along with the Pearson's coefficients (R^2) indicating

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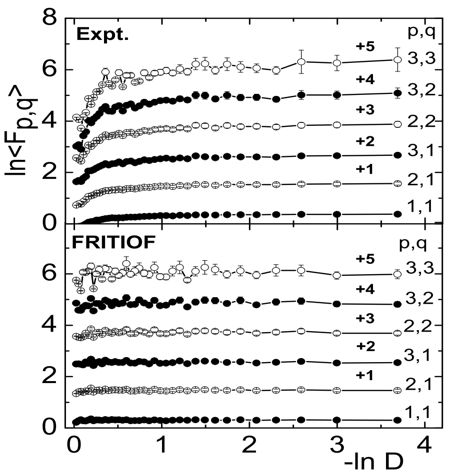

FIG. 1: FCs of different orders plotted against correlation length.

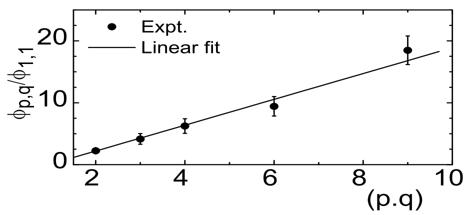

FIG. 2: Variation of $\phi_{p,q}/\phi_{1,1}$ with $(p.q)$

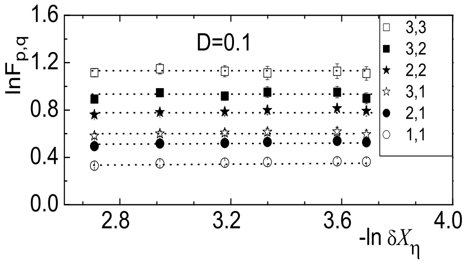

FIG. 3: $\langle F_{p,q}\rangle$ as a function of δX_η for fixed D.

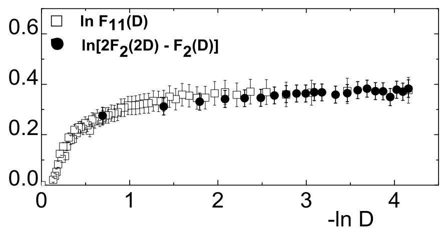

FIG. 4: $\ln F_{11}$ and $\ln[F_2(2D) - F_2(D)]$ plotted against $-\ln D$.

the goodness of fit. We did the same exercise for the FRITIOF simulated events also but obtained negligibly small values of $\phi_{p,q}$ those are not quoted here. In Fig.2 we have verified the α-model prediction for the exponents $\phi_{p,q}$ under a log-normal approximation, $\phi_{p,q} = \phi_{p+q} - \phi_p - \phi_q = (p.q)\ \phi_{1,1}$. As expected and as shown in this diagram within error bars $\phi_{p,q}$ linearly rise with $(p.q)$, confirming validity of the α-model. Another prediction of the α-model is that, for a fixed correlation length the correlators should not depend on the phase space interval width. Fig.3 shows the variation of $\ln\langle F_{p,q}\rangle$ with $-\ln\delta X_\eta$ for a fixed value $D = 0.1$. The dotted lines in this figure are all horizontal lines fitted to the data, which once again shows an agreement with the α-model prediction. Finally, we have tested the dimension independent scaling relation [5] for intermittent-like fluctuations: $F_{11}(D) \equiv 2F_2(2D) - F_2(D)$. Fig.4 shows the validity of this scaling relation where both hand sides have been plotted against D.

Conclusion

The above analysis shows that correlations among particles produced in ^{28}Si-Ag/Br interaction at 14.5A GeV/c, and belonging to different bins arising out of intermittent type fluctuations are present. The relevant scaling relation and sum rule as predicted in the framework of the α-model have also been confirmed. Our experimental results could not be reproduced by the FRITIOF code.

References

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