Scaled factorial cumulant moment analysis in hadron-nucleus interactions

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Scaled factorial moment techniques have been widely used for several years in investigating fluctuation phenomena in high-energy multiparticle production. Any factorial moment of a given order contains information about all lower orders of multiparticle correlations and in fact is found to be dominated by two particle correlations. A method is needed which removes lower order correlations to explicitly focus on the correlations of a given order. To extract the genuine multiparticle correlations, the factorial cumulant moments are designed.

The factorial cumulants are constructed from the q - particle cumulant correlation functions which vanish whenever one of their arguments becomes independent of the others, so that they measure the genuine correlations. The scaled factorial moment (F_q) of order q can be defined as [1]

$$F_q = \frac{1}{M}\sum_{m=1}^{M} \frac{< n_m(n_m-1).....(n_m-q+1) >}{< n_m >^q}$$

The phase space range is divided into M bins of equal width, n_m is the number of particles in the m th bin in a single event The factorial cumulants are computed [2] by subtracting the influence of all lower order moments from a given factorial moment. Let a one dimensional region of phase space to be partitioned in to M bins and let n_m is the multiplicity in the mth bin. The q th order scaled factorial cumulant moments are given by

$$K_q = \frac{1}{M}\sum_{m=1}^{M} \frac{f_q^{(m)}}{\langle n_m \rangle^q}$$

where $f_q^{(m)}$ is the q th order factorial cumulant moment for bin m, and represent genuine q - particle correlations. The second order normalised factorial cumulant moment can be given by

$$K_2 = \frac{1}{M}\sum_{m=1}^{M} \frac{f_2^{(m)}}{< n_m >^2}$$

The second order scaled factorial cumulant moment is related to the second order scaled factorial moment by $F_2 = 1 + K_2$.

Scaled factorial cumulate moments provide a sensitive method for investigating correlations of various orders, because they remove the influence of lower order correlations which would otherwise mask the behaviour of the correlations of a given order. The factorial cumulants remove the influence of the statistical component of the correlations in the same way as the factorial moments.

By construction, the factorial cumulant moments are a direct method for investigating independent correlations of a specific order. They have the added benefit that for a Poisson distribution of particles the factorial cumulant of all orders except the first are identically equal to zero. Thus they automatically remove any contribution due to Poissonian fluctuations, and any deviation from zero for a given cumulants indicates the presence of non-statistical correlations of that order.

In order to reduce the effect of non-flat average distribution, the cumulative variables X_η is used instead of η [3]. The new "cumulative" variable X_z is related to the original single- particle density distribution $\rho(z)$ as, $X_z = \int_{z_{min}}^{z} \rho(z')\partial z' / \int_{z_{min}}^{z_{max}} \rho(z')\partial z'$, where z_{min} and z_{max} are the two extreme points of the distribution. After the transformation, the phase space region $X(\eta)$ becomes [0-1].

Here genuine two particle correlation among the pions in the multiparticle production of $\pi^- - AgBr$ interactions at 350 AGeV and at 200 AGeV is analysed in terms of the normalized cumulant moments. We have calculated the second order normalized cumulant moment K_2 for the considered bin interval M = 2 to 20 for η phase space. The values of K_2 are significantly different from zero indicating the presence of genuine two particle dynamical correlations. The variation of normalized cumulant moment K_2 with the number of bins is shown in the figure for the two interactions. The errors shown in the figures are purely statistical. The normalized cumulant moment is found to increase with the increase of number of bins, i.e., with the decrease in the bin size. It signifies that pion- pion correlation increases with decreasing bin size. From the figure it is observed that the values of K_2 for π^-- AgBr interaction at 350 AGeV are higher than 200 AGeV interaction. Thus it may be concluded that values of normalized cumulant moment increases with the increase of projectile energy signifying that two particle genuine correlation increases with the increase of projectile energy.

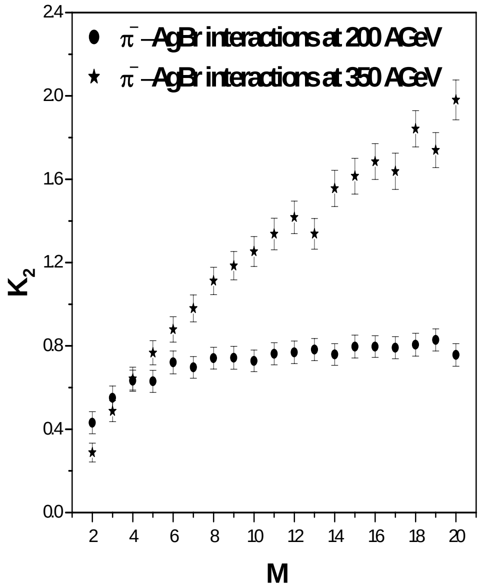

Fig: plot of M vs. K_2

References

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