Event-by-event fluctuations in collective quantities

V. Koch, H.-G. Ritter, and S.A. Voloshin

We discuss fluctuations in quantities defined on a group of particles. Examples of such quantities are mean transverse momentum, flow vectors, etc. The fluctuations itself consist of two parts, statistical and non-statistical (dynamical). The first is due to finite number of particles used to define the observable. It can be calculated from inclusive spectra treating the production of all particles as totally independent. The non-statistical fluctuations, especially their event-by-event part, contain important information on the dynamics of the collision and are the subject of our study.

The main result of our investigation is the development of methods for the experimental evaluation of the non-statistical fluctuations, so-called full event and subevent methods. We also discuss the interrelation of the fluctuations in dependent quantities, such as mean p_t and effective slope. Our conclusion about the possibility of measuring the heat capacity of the system as proposed in [1] are rather pessimistic: having access to only two degrees of freedom (two components of the transverse momentum) the heat capacity cannot be measured.

We find the subevent method, in which one correlates the quantities defined on two subgroups of particles, most useful for practical applications. Using a toy model we generate 4000 events each of 1000 particles thermally distributed with the temperature fluctuating event by event in accordance to $\langle T \rangle = 0.1$ GeV, and $\sigma^2_{T,dynam} = 0.208 \cdot 10^{-5}$ GeV^2. Fig.1 shows the inclusive particle distributions; it looks like as perfectly thermal. The result of an application of the subevent method to this case is shown in Fig.2. The method very clearly indicates the non-zero dynamical fluctuations in the sample $\sigma^2_{T,dynam} = 0.205 \pm 0.011 \cdot 10^{-5}$ GeV^2 which is in a very good agreement with the input value.

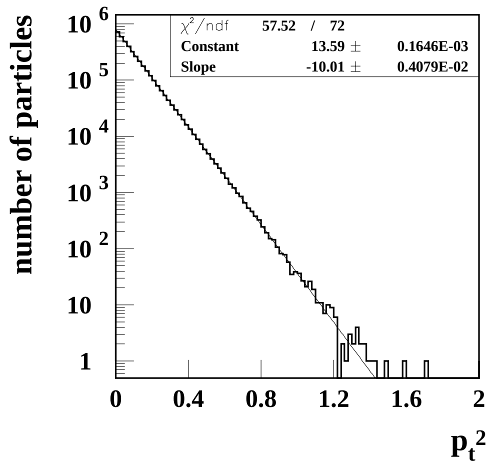

Figure 1: Inclusive distribution in p_t^2.

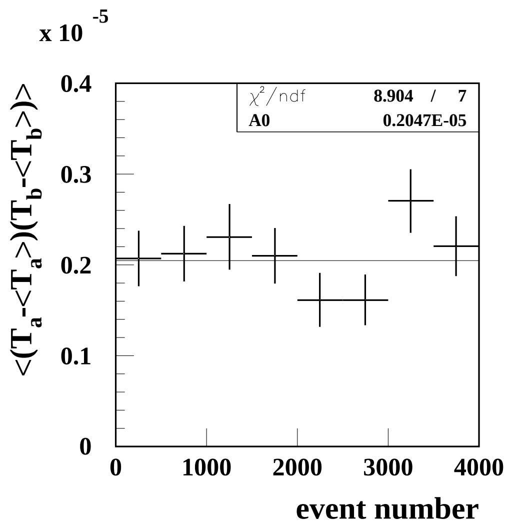

Figure 2: Dynamical fluctuations in temperature.

References

[1] L. Stodolsky, Phys. Rev. Lett., 75 (1995) 1044; E.V. Shuryak, Phys. Lett., B423(1998) 9.