One of the prime goals of the Large Hadron Collider (LHC) is the study of matter properties at extreme densities and temperatures, created in nuclear collisions at highest energies. Our present theoretical knowledge of such collision distinguishes three basic phases: early, where copious emission of partons results in dense and hot initial state, intermediate, where the system expands in a collective manner (quark-gluon plasma), and the final hadronization, where particles measured in the detectors are born. From the point of view of the theory of strong interactions, most interesting are the first two phases, where the first one is also responsible for determination of the initial condition for the intermediate evolution. We do not possess full understanding and exact knowledge on the relevant dynamics, and the ultra-relativistic nuclear collisions are valuable source of information here.

Important information on the early phase may be obtained from studies of fluctuations of various physical quantities, measured in the so-called event-by-event analyses. The point is that these fluctuations are sensitive to *correlations* in the early stage. Various correlation studies have been studied for many years, starting with elementary collisions (e.g., proton-proton). Recently obtained, completely novel experimental results from the LHC open a new chapter in these investigations.

The goal of this project is a widely-designed and detailed theoretical analysis of the recently measures so-called longitudinal correlations (i.e., in the kinematic variable of rapidity), which are generated in the early phase of ultra-relativistic nuclear collisions. Such correlations carry information on the interesting early phase that we wish to extract. Moreover, recently observed phenomena, such as the event-plane angle decorrelation seen by the CMS Collaboration, or the system-independent scaling concerning the correlation function, reported by the ATLAS Collaboration, pose major theoretical challenges, whose explanation requires deeper understanding of the dynamics of the early phase.

The approach will be based on our model of fluctuating strings, which are generated in elementary collisions of nucleons or their constituents (quarks, gluons). We plan to carry out new analyses of, i.a., multiplicity correlations, forward-backward transverse-momentum fluctuations, forward-backward event-plane angle and eccentricity fluctuations. We will apply new statistical measures and advanced analytic and numerical techniques.

Our investigations will contribute to better understanding of fundamental problems of dynamics in dense and hot strongly interacting matter and the corresponding strong-interaction mechanism of particle production. We will try to answer basic questions: What is the nature of correlations in the early phase? What degrees of freedom are relevant in their formation (nucleons, quarks, gluons)? What is the mechanism of the energy deposition in the formed early system? Our predictions will be important for the interpretation of existent and new correlation data from the LHC, where they will be useful as theoretical benchmarks for experimental results.