The scientific purpose of the project is a far-reaching and detailed analysis of longitudinal correlations created in the early phase of ultra-relativistic nuclear collisions. Recent correlation measurements at the Large Hadron Collider revived intense activity in this field, comprising fundamental problems of particle production via chromodynamic mechanisms. Long-range correlations in rapidity carry information on the earliest stage of the collision, hence their relevance. In nucleus-nucleus or proton-nucleus reactions, where the initial density is very high, we do not yet possess complete understanding allowing for exact modeling of the process. 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.

We are planning to carry out new, not done up-to-now, theoretical analyses devoted to the longitudinal correlations, using the approach based on fluctuating strings generated in elementary collisions of nucleons or their constituents. The prime question is *In relativistic heavy-ion collisions, where do fluctuations come from?* In the independent-source model explored here, there are two main components: the event-by-event fluctuations of the number of sources in the two colliding nuclei, and the genuine dynamical correlations from the particle production mechanism. The first major objective of the project is the separation of the dynamical correlations from trivial fluctuations in the number of sources.

The second main objective is the *determination of the relevant degrees of freedom*. There are indications that the so-called wounded quark model works in a more natural way than the popular wounded nucleon model. We plan to explore this basic question of the nature of relevant degrees of freedom in the early phase with the help of the recent correlation data from the LHC, applying a novel analysis based on the fluctuating-source model. The third major goal concerns the modeling of the *production mechanism from sources*. Our hope is that a joint consideration of various correlation observables, with the help of novel methods, will allow to put relevant constraints on the elementary production of particles in the early phase. The planned investigations are also directly related to such fundamental issues as the extraction of the transport coefficients of the quark-gluon plasma, or problems related to the spatial anisotropy of the system. More generally, it is also important for the still not fully understood isotropization and the early-thermalization puzzles.

The work plan of the project contains the following tasks: Analysis of multiplicity correlations with higher-order cumulants, analysis of the forward-backward transverse-momentum correlations, analysis of forward-backward correlations of event-plane angles and eccentricity magnitudes in the initial state, formulation of the fluctuating source model in the fragmentation region, and analysis of longitudinal correlations in asymmetric nuclear collisions.

Our methodology is based on both analytic calculations in sufficiently simple models, as well as on numerical simulations to be carried out in more involved variants of the models. The methods can be grouped as follows: analytic models, numerical simulations, higher cumulants, multi-bin measures, Principal Component Analysis, elimination of short-distance components, symmetry constraints, and role of hydrodynamics.

All tasks of the project consist of new, hitherto not carried out, theoretical analyses. While carrying out our investigations, we will be responsive to upcoming experimental results, which undoubtedly will become available in the near future.

Through realization of the described tasks, our investigations will contribute to better understanding of fundamental questions concerning the dynamics of hot and dense strongly interacting matter. Our new predictions will be relevant for interpretation of the experimental results. The answer to the question of the proper degrees of freedom in the early phase, or confirmation of the approach with independent fluctuating strings will have, in our view, important conceptual significance for basic understanding of ultra-relativistic heavy-ion collisions.