Accurate understanding of the dynamics of nuclear collisions at highest available energies is one of the main challenges of present-day strong-interaction physics, as it deals with matter under as extreme conditions as in the early Universe, where the Quark-Gluon Plasma (QGP) was formed. The principal purpose of the project is the modeling of multiparticle production processes in relativistic ion collisions at energies available at accelerators and beyond, in cosmic ray physics experiments. The developed models will incorporate numerous effects, phenomenologically crucial for understanding the physics of relativistic nuclear collisions and will be used in analyses of results of the ongoing and future experiments.

Fluctuations of physical observables in collisions of relativistic ions have become in recent years one of the main topics of interest, as they can provide some important signals for the formation of QGP. The proper implementation of mechanism of fluctuations of the effective energy available in collision or fluctuations of nucleon-nucleon cross section in the models of multiparticle production processes will allow to test its influence on various, up to now not evaluated, important and experimentally observed effects of collisions (for instance, the initial shape fluctuations, multiplicity fluctuations, various correlation effects). Such studies, done with use of tools that contain a new possible sources of fluctuations are expected to provide very valuable new information in the question of the onset of deconfinement where quarks and gluons start to move freely, forming QGP.

The discovery of cosmic rays (CR) more than 100 years ago allowed us to deal with particles which are produced in the collisions at energies being far beyond the possibilities even of the modern accelerators. The proper modeling of the multiparticle production processes at these energies can provide answers for the questions like: what is the composition of the primary cosmic ray flux? or where is the origin of the ultra-high-energy cosmic rays? In the proposed project there will be an attempt of bringing of a new light for these questions by construction of model of multiparticle production processes which describes the surprisingly broad multiplicity distribution of muon bundles registered by accelerator experiments in their runs dedicated to CR physics.

Finally, we plan to carefully check the influence of symmetry constraints and conservation principles on the fluctuation measures in the analyzed tasks. We focus, in particular, on the energy conservation. It causes, during the production of entropy in the sources, a global constraints for the number of finally produced particles and most of all for the widths of the multiplicity distributions. It should be noticed that inadequate implementation of conservation principles, e.g. energy, momentum or electrical charge, especially during the modeling of particle production mechanisms in Monte Carlo generators, may induce many of artificial correlations in the studied systems, which can substantially influence the obtained results.