Popular science summary of the project "Delving into the Intricacies of Partonic Dynamics in the High-Energy Collider Era"

One of the most important questions in physics is the fundamental structure of matter in Nature. Since centuries researchers and thinkers posed these questions about basic building blocks of matter and their possible mutual interactions. Current understanding of elementary interactions is encompassed in the quantum theory called the Standard Model. The fundamental ingredients of matter, which are the content of this theory, have been discovered during several decades in many series of experiments and are known as quarks and leptons. According to the Standard Model the interactions between matter particles are governed by another set of particles which are force carriers. There are three forces that are described by the Standard Model: electromagnetic, weak and strong force. Each of them has corresponding elementary particles which are the force carriers. Of those three, the most powerful is the strong force, which is the force between the quarks and is also responsible for keeping together nucleons in the nuclei. The elementary, quantum carriers of the strong force are particles called gluons. The fundamental interactions between the quarks and gluons are known and are given by the theory of Quantum Chromodynamics (QCD) which is contained in the Standard Model. A pecular feature of strong interactions is that quarks and gluons are never free. They are confined in the composite particles called hadrons.

There are still many unknowns in the present understanding of the dynamics of the strong interactions. The standard methods of quantum chromodynamics, based on the smallness of the quark and gluon interactions, are not directly applicable and we have to rely on the most advanced techniques to reveal structure of hadrons.

The main objective of the proposed project is to probe the multi-dimensional structure of hadrons encoded in different type of distributions of quarks and gluons as functions of their momenta and spins. To achieve this goal we need to describe different aspects of the collective behaviour in systems of high density and very slow gluons. Also we have to understand correlations between quarks and gluons which actively participate in the scattering process which leads to final states registered in detectors. To achieve this goal, we will use advanced analytical and numerical techniques of QCD. This will permits construction of observables which can be tested experimentally at the existing colliders and future Electron Ion Collider.