Experiments like at the Large Hadron Collider (LHC) give the opportunity to study the structure of matter at the deepest possible level. The Higgs boson, discovered at LHC, completes the successful Standard Model of elementary particles which encodes our most fundamental knowledge of the physical world. Colliding hadrons allows for the high energy necessary in such experiments, but also complicates the interpretation of the gathered data, because hadrons are not elementary particles. If we compare the collision of elementary particles with the collision of marbles, then hadrons are full trash cans in this analogy.

Quarks are the elementary particles that hadrons consist of, and bonds confining them into hadrons are provided by gluons. When it comes to the scattering experiments, both the quarks and the gluons play an important role, and they are collectively addressed as partons. The experiments at LHC are largely of the statistical kind, and data are collected from many many hadron collisions. In only relatively few of those, for example, the Higgs boson is produced. Those are characterized by a so-called hard scattering, that is imagined to have happened between two partons of two colliding hadrons. Not every hard scattering produces a Higgs boson, but for a Higgs boson to be produced, a hard scattering must have taken place.

The mathematical theory describing the scattering of hadrons is called quantum chromodynamica (QCD). It is rather complicated and very rich, but also very successful in its task. Imagining the collision of hadrons to lead to interesting results if partons inside enter a hard scattering, like marbles inside a trash can, is heuristically straightforward, but in practice still very complicated. A meaningful interpretation of the data demands this picture to be computationally under control. It is possible by realizing that the energy involved in the hard scattering is much higher than the energy related to the structure of the hadrons, which allows a calculation related to hadron scattering to be decomposed into pieces relevant for different energy scales, which each turn out to be manageable. This computational strategy is called factorization, and its possibility is essential for the success of QCD.

Factorization prescriptions are not unique, and different approximations can be made. One choice is whether the momentum components transverse to the collision direction are taken into account. Factorization prescription that do take them into account are not very important for cases that, for example, lead to the production of the Higgs boson, but are important for cases that give the opportunity to study the hadrons themselves. One theoretical question is related to the density of partons if the amount of energy they can contribute to a hard scattering is relatively low. QCD in the linear approximation seems to predict that the density becomes arbitrary high for lower and lower energy fractions, which could lead to an inconsistency. To cure this problem the nonlinear corrections to the parton density was introduced.

Collisions for which the parton of one hadron provides much lower energy, or rather momentum, to the scattering than the other can be used to study this behavior of the density. They can be identified by the fact that the products of the scattering are all moving in the so-called forward direction along the beam of colliding hadrons. For theses asymmetric type of collisions, the factorization prescriptions taking the transverse momentum components of the low-energy parton into account, are relevant.

The objective of the proposed project is to improve the calculations that are performed with the factorization mentioned above. Factorization in general allows for the systematic increase of precision for the calculation of the hard scattering process at the price of complexity, via so-called perturbation theory. For factorizations taking the transverse momentum of a parton into account this system of improvements has, however, not hardly been worked out beyond the simplest, lowest, level. For collinear factorization, which does not take the transverse momenta of a partons into account, it has been worked out to a much higher degree. Furthermore, in order to really understand the rising the behavior of the parton density for low energy fractions, a higher than existing precision is indispensable.