The current knowledge of particle physics is contained in a theory called Standard Model (SM) of particle physics. The SM encompasses our knowledge about all the fundamental forces of nature (apart from gravity). This incorporates electromagnetic and weak interactions that are unified into the electroweak force and the strong interaction described by quantum chromodynamics (QCD), which leads to the nuclear force responsible for the binding of atomic nuclei.

With the recent discovery of the Higgs boson, at the Large Hadron Collider (LHC) in Geneva Switzerland, the SM is a complete theory which provides an accurate description of the measured phenomena. However, there are important reasons (based on astrophysical observations and theoretical considerations) indicating the existence of new physics beyond the Standard Model. Theoretical models of the new physics predict the appearance of new elementary particles. We can search for these new particles using colliders – machines that accelerate particles to high velocities (energies) and collide them allowing to produce heavy particles that have never been observed before (like the Higgs boson). At 27 km in circumference, the LHC is the largest collider ever built, and it is currently used for the new physics searches.

Results from the LHC and other colliders involving hadrons (protons and nuclei) are very complex and it is not possible to interpret them without the corresponding theoretical calculations, so that the two can be directly compared. To fully exploit the high precision experimental measurements at the LHC we need similar level of precision for the theory calculations. One of the key ingredients needed to make accurate theoretical predictions are parton distribution functions (PDFs), which describe the structure of hadrons (protons or lead nuclei) in terms of the fundamental constituents of the SM (quarks and gluons). The PDFs can not be fully calculated within the QCD theory, and must be obtained from experimental data by the so called global QCD analysis. The global analysis process combines experimental measurements with theoretical predictions in order to extract the most accurate PDFs.

The main goal of this project is to use the new data from the LHC together with the most precise theoretical calculations in a global analysis to increase the precision of the currently known PDFs to a new level. The emphasis of the project is put on the lead PDFs that are much less know than their proton counterparts. This is a crucial endeavor as the PDF related errors enter basically all processes at the LHC and they often constitute the dominant part of the total uncertainties of the theory calculations. Reducing these errors will improve the predictive capabilities of the LHC which will improve our ability to make incisive measurements of fundamental parameters of the SM, as well as search for new physics which deviates from these precise predictions. It will also have important consequences for studying quark-gluon plasma produced in ultra-relativistic nucleus-nucleus collisions at the LHC and RHIC, investigating cold nuclear matter effects or studying ultra-high-energy cosmic rays. Moreover, it will result in expanding our understanding of the nucleus and proton structure in terms of quarks and gluons which by itself will contribute to broadening our understanding of nature.