For a long time, we have known that nucleons (protons and neutrons) form atomic nuclei, which serve as the basic building blocks of all the matter we encounter in our everyday lives. We also know that protons and neutrons are not elementary particles but are composed of quarks and gluons, collectively known as partons. The partonic structure of both nucleons and nuclei is dictated by the strong force, and to explore this structure, we need to use the theory of strong interactions known as quantum chromodynamics (QCD). The strong force exhibits dual characteristics: it allows quarks and gluons to move freely within nucleons (asymptotic freedom), while also strongly binding them to the nucleons at large distances (confinement). These characteristics make QCD extremely challenging, and result in a complex picture of nucleons in terms of the probabilities of finding partons with specific momentum at certain energy scales. These probabilities are referred to as parton distribution functions (PDFs).

Furthermore, the PDFs not only encode information about the structure of protons and nuclei but also play a crucial role in performing calculations for high-energy collider experiments such as the LHC in Geneva or the Electron-Ion Collider (EIC) planned in the US. This is related to the factorization property of QCD, which allows us to separate cross-sections into the high-energy part that describes interactions at the parton level, and the low-energy part that characterizes the hadron structure (in terms of PDFs). While we know how to calculate the high-energy part systematically, determining the PDFs is a more complex task. To obtain them, we need to conduct global QCD fits that combine theoretical knowledge with experimental data. Although we already possess relatively good knowledge of proton PDFs and, to a lesser extent, nuclear PDFs (which describe the partonic structure of nuclei), it is essential to improve the precision and reduce the uncertainties associated with PDFs. This need arises due to the extraordinary precision of current experiments, particularly at the LHC. Given the complexity of today's experiments, to fully utilize their results, it is crucial to achieve a comparable level of precision in theoretical calculations, and PDFs often constitute a dominant part of the current theoretical errors.

The proposed HESoPaN project aims to investigate both proton and nuclear PDFs, with a focus on the less explored nuclear distributions. The ultimate objective of the project is to perform the first simultaneous extraction of proton and nuclear PDFs, which will ensure their compatibility and allow for a unified treatment of their uncertainties. As a result, the obtained PDFs will lead to a reduction in the uncertainties of theoretical predictions, especially for processes involving both protons and nuclei, as observed in the ongoing LHC or RHIC experiments, as well as the planned EIC experiment. Since errors related to PDFs often dominate the theoretical uncertainties, this advancement will facilitate high-precision comparisons between data and theory, which are essential for exploring new physics beyond the current theory of Standard Model. Additionally, it will improve our understanding of other phenomena, e.g., shedding light on the origin of nuclear effects such as shadowing, and assisting in the determination of the properties of quark-gluon plasma.