Quantum Chromodynamics (QCD), the theory of strong interaction, is a cornerstone of the Standard Model of modern particle physics. It explains all strongly interacting matter in terms of point-like quarks interacting by exchanging gauge bosons, known as gluons. This strongly interacting matter is responsible for 99% of the visible mass in the Universe. Over the past several decades, a rich picture has come to light, with several overarching questions remaining: what is the nature of quark and gluon confinement? how does the spin of the nucleon emerge from parton dynamics? how do quarks and gluons convert (hadronize) into final-state particles? how can we describe the multidimensional landscape of nucleons and nuclei in terms of partons (quarks and gluons)? what is the nature of the initial state in nuclear collisions? does the gluon distribution saturate? does the colour glass condensate exist? what is the nature of diffractive exchange? can we confirm the scalar glueball, i.e. a hypothetical particle built only from gluons? Some of these questions have been and continue to be addressed by the current RHIC and LHC p+p, p+A and A+A programmes and hopefully will ultimately become understood in full detail at the future Electron-Ion Collider.

Within this project, we plan to perform pioneering measurements that can only be performed with the STAR detector thanks to its unique ability to tag the intact, diffractively scattered beam protons and intermediate energy range available at the RHIC accelerator. RHIC is one of two currently operating circular accelerators of protons and heavy ions and the only one where it can collide with polarized (longitudinally or transversely) proton beams. STAR experiment, which began taking data in 2001, is expected to continue taking new data till autumn 2025, and they will be analysed for several subsequent years. One of the most significant achievements of the RHIC experiments is the first observation of a new state of matter, the so-called quark-gluon plasma (QGP), in heavy-ion collisions. Examination of the phase diagram of QCD, the initial state and the nature of the hadronization process in heavy-ion collisions are still the main objectives of the physics programme of the STAR experiment. In parallel, studies of diffractive processes and so-called Ultra-Peripheral Collisions (UPC) of heavy ions are ongoing. These last two broad subjects are the ones which we plan to investigate in our project. The diffractive interactions are supposed to proceed via the exchange of the so-called Pomeron, a particle-like object dominated by gluons. We plan to study the production of particles containing strange valence quarks, i.e., the quark flavour that only exists in the sea inside the proton. In UPC, the heavy ions collide with an impact parameter greater than the sum of their radii so that the strong interactions, leading to the creation of QGP, are suppressed, and the interaction is dominated by an exchange of Pomerons and/or photons. These measurements will be an important step towards our complete understanding of the strong interaction and quantum chromodynamic description of nucleon and nuclei structure. It should be stressed that several of the studies proposed in the project will add to the understanding of long-range QCD interactions, i.e. non-perturbative QCD regime, where calculations are difficult, phenomenological in nature and must be guided by experiment.

In addition, we plan to make significant contributions to the ePIC detector design and studies of possible measurements at the future Electron-Ion Collider. One of the most important parameters of every accelerator is its luminosity. We participate in developing detectors that will provide very accurate luminosity values based on the Bremsstrahlung process. We also work on the feasibility of measuring the exclusive tau lepton pairs production in two-photon collisions as a tool to measure precisely the anomalous magnetic moment of the tau lepton and to discover possible signals of physics beyond the Standard Model.