One of the most interesting scientific problems is understanding of the formation and evolution of the Universe. It is widely expected that shortly after the Big Bang, the entire Universe was filled with a hot and dense medium composed of very basic components of matter including quarks and gluons whose interactions are described by Quantum Chromo-dynamics (QCD). According to the QCD theory, quark and gluons (called partons), trapped in bound states and forming hadronic matter, are released at extremely high densities and can move on their own, creating the quark-gluon plasma (QGP) phase. Nowadays, scientists can “recreate” conditions of the early Universe in the laboratory producing QGP at a small scale in heavy-ion collisions in powerful accelerators. To this end, the ultra-relativistic nuclei of gold, lead and other atoms are collided at Relativistic Heavy Ion Collider (RHIC, in operation since 2000) located at Brookhaven National Laboratory in the US and at the Large Hadron Collider (LHC, in operation since 2010) at CERN in Switzerland. At the LHC, collision energies are much greater than at RHIC, by an order of magnitude, allowing to study the QGP properties at larger densities and temperatures. The results from RHIC and LHC detectors clearly reveal the presence of the QGP phase and its unexpected properties. In particular, the heavy-ion collisions results show that the QGP behaves like a perfect fluid with very small viscosity.

One of the most important tasks of the LHC programme is the measurement of jets in heavy-ion collisions. Jets originate from high transverse momentum, short-range partonic scatterings which occur early in nuclear collisions. The hard scattered partons propagate through the dense QGP medium before they fragment into a collimated spray of elementary particles, called jets. In the dense and opaque QGP medium the scattered partons experience energy losses, e.g. through an induced gluon radiation, which in turn lead to a suppression of jet production, an effect called also jet quenching. The partonic energy loss is expected to depend on the traversed path length in the QGP medium. This sensitivity leaves its footprint on the measured jet suppression pattern, which allows to obtain a “tomographic” view of the QGP droplet. At the extremely high collision energies available at the LHC, a copious production of high-energy jets is observed. The jet suppression in head-on heavy nuclear collisions was first measured by the ATLAS experiment. The jet measurements based on high statistics data collected in later LHC runs have significantly improved our knowledge of the jet-quenching phenomenon.

The aim of the project is to measure the suppression of jets originating from heavy-flavour quarks in Pb+Pb collisions with the ATLAS experiment. The project will be performed by scientists from the Institute of Nuclear Physics PAS from Kraków. ATLAS is a general-purpose detector, which obtained substantial samples of lead-lead (Pb+Pb) and proton-lead (p+Pb) collisions, which are used by investigators of the project for comprehensive study of hard processes. Quarks and gluons are expected to interact and thus lose energy while traversing the QGP differently. Jets initiated by light quarks and gluons are however very hard to distinguish based on the signals they leave in the detector. The heavy-flavour quarks, i.e. charm and bottom quarks produced in the early stage of the collision, will form long lived particles which produce characteristic displaced vertices when they decay. This unique feature makes them a useful tool for identification of the type of parton that initiated the jet. Measuring how different types of jets are modified in QGP will help to understand its properties. The measurements of the jet suppression for jets originating from light and heavy quarks will be compared to theoretical models aiming to provide a detailed description of the underlying jet physics in ultra-relativistic heavy-ion collisions and will lead to better understanding of QGP properties.