The goal of this project is to perform an analysis of Bose-Einstein correlations (BEC) for pairs of identical pions from proton-lead collisions in the LHCb experiment at the LHC (Large Hadron Collider) accelerator. By studying this kind of correlations, one can obtain information on a shape and size of particles source, which is created in collisions of high-energy particles. When particles (e.g. protons) collide, new particles are created – those can be of any kind, if only energy of the collision is sufficient. It's not possible to directly observe processes taking place inside the source – one can only see 'ready' particles, emitted from this region (hadrons). The Bose-Einstein correlations manifest themselves by an increased probability of production of identical particles (bosons) with similar momenta. By measuring such correlations, one can obtain a correlation radius, which is related to the size of the source at the moment when particles are emitted. It was observed that the size of the source depends on a number of factors, such as the mass of produced hadrons or the total number of charged particles created in a collision. There are also studies that aim to check how the size of the source changes with different colliding particles and energies. Some of the theoretical models give prediction that the source size should increase if heavier particles are collided. Others state that the size of the source should by universal for different kinds of collisions. Results obtained during this project will allow to test and develop those theoretical models.

Performing this analysis requires to prepare a dedicated software environment. It's not a typical scientific problem tackled at the LHCb experiment, therefore a lot of tools will be created completely from scratch. Next step is to prepare a data sample from proton-lead collisions recorded by the LHCb experiment in 2013. Data collected at the LHC accelerator are stored in a dedicated computing grid WLCG (Worldwide LHC Computing Grid). It's currently the biggest grid of this kind in the world and gives access to the LHC data to scientists worldwide. The sample collected by the LHCb experiment in proton-lead collision in 2013 alone is more than 150 terabytes of data. The next step will be to prepare a simulated sample, corresponding to that of data. Then it will be necessary to choose from a large number of events only those that are interesting from the point of view of this analysis. This will be mainly focused on selecting particles that had high quality of reconstruction in the detector, as well as removing those which are not pions. For such selected samples, a correlation function will be constructed, from which correlation radius will be extracted and compared to results of other experiments.

The main reason for choosing to study the Bose-Einstein correlations in proton-lead collisions is the possibility to make this measurement in a unique 'forward' direction by the LHCb experiment – which means particles that travel at small angles with respect to the initial beam of colliding particles. The LHCb detector is special among other experiments at the LHC, because it's shaped as a single-arm 'sleeve', starting at the particles collision point and stretching along the beam axis. It's most distinctive feature is a very precise reconstruction of particles tracks and the exact point where collision took place (primary vertex). It is also very efficient in identifying the kind of registered particles. Results obtained for proton-lead collisions in the forward region will be the first of this type in the world. It will allow for comparison with other experiments, which will help to determine how the correlations depend on the direction (angle with respect to the beam axis) of registered particles.