Research on interactions between nucleons is an important branch of nuclear physics. Almost all the mass of the matter which we are built of comes from the nuclei. That is one of the reasons why the understanding of the interactions between their basic constituents (protons and neutrons) is of high importance not only for the development of nuclear physics. Those interactions determine e.g. what energy is released in the decays inside of nuclear reactors and due to the synthesis reactions deep inside the stars. The proper understanding of nuclear interactions makes it possible to calculate the doses in radiotherapy, design a spallation neutron source used for material studies. It enables us to find the parameters needed for performing the transmutation of radionuclides in order to make the radioactive waste less harmful. Thus, it is worth pushing for high precision and taking all known aspects of the interaction into account, not only out of pure scientific curiosity.

The interaction between many nucleons was treated as a sum of pairwise nucleon-nucleon interactions. Alas, the calculations performed under such assumption exhibit significant discrepancies compared to numerous independent measurements. It is not just a simple failure of the theoretical description – three nucleons are a special problem of new quality. Therefore, it needs a special solution... That is the way why the concept of three-nucleon force has been introduced into the theoretical description. The force emerges only in the presence of at least three nucleons. The interaction between them is somehow more than the pairwise interactions between all the three.

The easiest way to understand the problem is to think about the way how a satellite moves around the Moon. In the Earth-Moon-satellite system one can separate the interactions between the Earth and the Moon, the Earth and the satellite, and finally the Moon and the satellite. Basing on those calculations one can find the orbit of the satellite. But this description holds true only in the case of point-like masses. The Moon is by no means a point-like particle, so e.g. its shape can change due to interactions with the Earth. A distorted Moon will interact with the satellite in a different way, than in the case when the Earth was not there.

That is, the interactions of three celestial bodies do not reduce to pairwise interactions – there is an effect in addition to them and it can be called the three-body force. In similar way, the nucleons are not elementary particles, but objects made of quarks. And although they are unimaginably small, they show their internal structure and can become excited, turning for a while into some other particles. The three-nucleon force is just due to such an excitation of one nucleon while interacting with the two others.

Deuteron breakup is reaction where the constituents of a deuteron (proton and neutron) are torn apart while hitting another nucleon (proton or neutron). The result of the reaction are three unbounded nucleons. It has been found to be the best way of testing the influence of the three-nucleon force. Along with the development of the theoretical methods more and more precise data were obtained by e.g. KVI Groningen (NL) and FZ Jülich (D). This allowed to find that the higher the beam velocity, the higher the discrepancies between experimental and theoretical data.

For the lowest energies, the experimental data are well reproduced by the theories. The exception is the so-called Star configuration, where the nucleons resulting from the breakup reaction fly apart at an angle of 120°. In this case, if a deuteron is broken up on a neutron the reaction probability is even 30% higher than the theoretical expectations, and in the case of the breakup performed on proton target the experimental results are about 15% below the theoretical values. No existing theory can account for such a difference due to the electric charge difference only. It is not known, if the anomaly dissolves with increasing energy (using faster particles), as some energies have not been measured so far.

The aim of the project is a measurement of the probability of the Star configuration production in the deuteron on proton breakup reaction with the use of the data obtained with the BINA experiment at the AGOR accelerator in Groningen (NL) and to perform new measurements with the use of Proteus C-235 accelerator placed in the Cyclotron Centre Bronowice (CCB), Cracow (PL).

It will allow for more thorough understanding of the processes and make possible to test the recent theories of nucleon interactions.