Atomic nucleus, consisting of densely packed protons and neutrons, is a system in which three fundamental interactions: strong, electromagnetic and weak, can be studied. Despite a great amount of experimental data on the structure and characteristics of atomic nucleus collected so far, theoretical description which would explain all the observed phenomena is still incomplete. It is due to a very high complexity demonstrated by the nucleus, being a system of many strongly interacting nucleons obeying Pauli exclusion principle and very complicated characteristics of the nucleon-nucleon interaction. As a consequence, progress in theory must be supported by experimental studies, which leads to a strong connection between theory and experiment in nuclear physics. New theoretical concepts set the line of the measurements which would be the most effective in verification of a particular model. And vice versa, experiment can inspire theory to gain better parameters values in its models. The presented project will belong to the latter class of research activity: new experimental data that are planned to be obtained, will allow to test various theoretical approaches.

The purpose of this project is to investigate the nuclear structure of the light isotopes. In particular, the studies will focus on the states located in ^{13}C isotope at 21.47 MeV and ^{14}N at 20.1 MeV excitation energy. These states belong to the category of nuclear excitations called “stretched” resonances – single-particle excitations for which the excited particle and the residual hole couple to the maximal possible spin value (J_{max}). It happens when both the particle and the hole occupy the highest angular-momentum orbitals in their respective shells. The configurational purity of such states is assured because other one-particle one-hole configurations having the same angular momentum and parity quantum numbers lie much higher in excitation energy. This feature makes them ones of the simplest known nuclear excitations which should provide the most clean information on the properties of atomic nucleus.

The second part of the project will aim at the search for a narrow resonance in ^{11}B just above the proton separation energy, whose existence was predicted by theoretical studies in the Shell Model Embedded in the Continuum. If such near-proton-threshold state in ^{11}B exists, a very rare process of the beta-delayed proton decay of the halo nucleus ^{11}Be could be explained. Also the results of measurements performed recently at CERN (Switzerland) and TRIUMF (Canada) suggested the presence of such state in ^{11}B, but the final conclusion was that no direct experimental evidence could be obtained so far. In this project, it is proposed to perform an independent search for this near-threshold state in ^{11}B, by using its gamma decay as a direct probe.

The main part of the project will have experimental character and the experiments will be performed at Cyclotron Centre Bronowice in Kraków (Poland). The access to the nuclei of interest will be possible with use of the inelastic scattering of protons. The ^{11}B, ^{13}C and ^{14}N nuclei will be studied by using the combined measurements of emitted γ rays and light particles. This method will provide full identification of the reaction channels and the decay path, thus allowing to reduce the background in the final γ spectra and helping to achieve better precision of the results.

The undertaken experimental way must include developing the probes with high selectivity. Therefore, one of the important parts of the project will be the construction of the detection system consisted of four double-sided silicon strip modules and their electronic read-out line. This system would be put together with the existing at CCB apparatus. This way improved detection system will allow for measurements of the light charged particles from the decay of the investigated isotopes and taking a more complete picture of the reaction of interest.

The final step would be to compare the new experimental results with the predictions of the modern theoretical models currently used for describing the nuclear properties and phenomena, in particular, Gamow Shell Model.