Atomic nuclei properties can be studied using processes producing nuclei at excitation energy which can be released as charged particles or gamma rays emission. By the measurement of emitted particles, their angle of emission and energy one can learn about such properties of nuclei as shape, deformation or life time. Depending of the reaction single nucleons or many nucleons can be excited. Excitation of many nucleons is called collective.

The goal of this project is study of collective excitations in atomic nuclei using proton induced reactions. Such excitations are giant and pygmy resonances. Giant resonances are described as neutrons against protons vibrations while pygmy are explained by the movement of the neutron excess against proton-neutron core. They will be investigated experimentally using proton inelastic scattering. The energy of the gamma rays emitted from the resonances decays and scattered proton angles and energies will be measured to obtain information on excited resonances.

As a result not known well yet the microscopic structure of giant quadrupole resonance GQR will be obtained. Study of giant resonances decay via gamma rays emission will able to determine their energy, width and strength function. The comparison with theoretical models of the experimental results of giant resonances decay to the ground state and other low lying excited states will provide information on nuclear interactions.
The studies of pygmy resonances gamma decay will bring information on their isospin character. They will deliver better understanding of their nature, not well known yet. The experimental results comparison to theoretical predictions will allow for determination of isospin nature of pygmy states.
Another aspect of nuclear structure studies is measurement of deeply bound states properties. They are important especially in astrophysics and presently very much studied in order to understand better the clusterization phenomenon. The proposed investigations concerns the measurement of gamma rays from the direct decay of deeply-bound single particle states of ^{11}B excited in proton scattering (p,2p) reaction on ^{12}C target. Additional measurement of high energy and statistical gamma rays emitted from the reaction will allow for comparison to the statistical model. As a result the properties of the 1s proton-hole state in ^{11}B will be achieved.

The subject of the project concerns nuclear physics investigations to be conducted in Cyclotron Center Bronowice (CCB) Institute of Nuclear Physics PAN (IFJ PAN) in Kraków with the use of new cyclotron built mainly for hadron therapy. It contains the foremost part of the measurements planned to be done at the beginning, accepted by International Advisory Committee (IAC). Studies are based on scattered protons and gamma rays measurements with the use of KRATTA and HECTOR arrays already installed in experimental hall in CCB. The high efficiency HECTOR array consists of 8 big BaF_2 detectors for the high energy gamma rays measurement. To increase efficiency one cluster of PARIS array will be employed. It comprises of 9 novel phoswich detectors made of two scintillators $LaBr_3$ and NaI. The use of PARIS cluster will provide simultaneously the better resolution gamma energy spectrum. The telescope detectors array KRATTA will measure scattered protons, their energy and the angle.

The experiments will be performed at new facility with the use of well-known detector arrays but adapted to work in different conditions. They will be first measurements that can serve as test for experimental methods and set-up. This experimental program will start the nuclear research at CCB.

The use of proton beam for such studies is a unique tool that will enable to obtain particular information. The measurements of the gamma-decay of giant quadrupole resonance and pygmy dipole states will allow for study in detail their microscopic structure. This subject is up to date because of the role of PDR in the process of synthesis of elements during the early stage of the Universe. The decay of deeply bound states is going to be measured at specific kinematical conditions to deduce information on nuclear wave functions in order to understand better the clusterization phenomenon. This is important for example for Hoyle state, responsible for existence in universe elements heavier than helium.