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In the project we intend to provide new information in two sectors in which there is a good chance for finding new physics phenomena. These are the interactions in extremely hot and dense nuclear matter and the neutrino interactions. The first goal is to find the conditions and signatures of forming new form of matter - quark-gluon plasma. We believe that such form of matter existed in the very first moments after the Big Bang. Therefore the study of the transition from the quark-gluon matter to the matter composed of strongly interacting particles - hadrons is of fundamental importance for understanding of formation of our Universe and for cosmology. We would like to form in laboratory for a very short moment the conditions similar to that in the early Universe. We will collide the relativistic nuclei from SPS accelerator at CERN with different nuclei and measure the different reaction products at different angles and momenta in the NA61/SHINE system with very high precision.

The same experimental set-up will be used to achieve the next goal of our project: getting information about the multiplicity, momenta and emission angles of the neutrinos "parents" in the big "long baseline" neutrino experiments. In such experiments working and planned in Fermilab and in Japan, the large neutrino detectors are placed underground at the large distance from the neutrino sources - mesons produced in proton-nucleus interactions. Neutrinos are elusive particles, they interact very weekly. Neutrino masses are tiny compared to the mass of other fundamental particles. They oscillates - changes their flavour as they propagate. To study such oscillation effect the good knowledge of the flux of the primary neutrinos is needed. Only a small fraction of the neutrinos leave behind any sign of their passage. Therefore the good knowledge of their parents together with simulation of such parents decays can improve substantially the precision of the neutrino beam flux knowledge. The parameters of the neutrino oscillation process have been measured giving the neutrino mass squares differences and mixing parameters. The new challenging goal is a measurements of the neutrino mass hierarchy and the degree of violation of fundamental symmetries in the neutrino sector : the CP violation parameter. It would help to understand one of the biggest puzzle in physics : why there is no matter and antimatter symmetry in our Universe. The sensitivity of the future neutrino experiments largely depends on the decreasing of systematic errors. One of the main source of such error is the imprecise knowledge of the neutrino flux. It is challenging to get the absolute values of cross sections for the meson production for different angles and momenta with required precision. However our team has got experience performing with success similar measurements for T2K neutrino experiment in Japan.

Among 30 institutions participating in NA61/SHINE there are seven Polish groups. The experimental groups from Polish research institutions, present since beginning of NA61/SHINE, play a leading role in the collaboration.