Investigation of the bb-decay processes of Se-82 with SuperNEMO detector (JINR participation)
Project extension for the period 2019-2021
Referee report on project

The SuperNEMO project is aimed to search for neutrinoless double-beta decay ($0\nu\beta\beta$), which is a process of fundamental importance for modern particle physics. Interest in this scientific direction has received a fresh impetus after the discovery of neutrino oscillations in a series of experiments with solar, atmospheric reactor and accelerator neutrinos which convincingly proved non zero mass of neutrino. The main motivation to search for $0\nu\beta\beta$-decay is the fact that neutrinos are massive particles, in contrast to the prediction of the Standard Model (SM), and, what is even more important, almost all theories beyond the SM predict them to be Majorana particles. Observation of $0\nu\beta\beta$-decay would allow testing neutrino nature, absolute mass scale and hierarchy. But an observation of Lepton Number Violation itself would be far more fundamental than mere measurement of neutrino properties, as it would crucially impact the most fundamental principles of physics: CP violation, Leptogenesys, GUTs. For this reason a huge amount of experimental and theoretical activity is pursued in order to predict and to detect the $0\nu\beta\beta$-process.

The SuperNEMO Demonstrator, which is the first module of the SuperNEMO experiment, is located in Modane underground laboratory (France) and search for neutrinoless double beta decay ($0\nu\beta\beta$) of ^{82}Se in order to unveil the nature of the neutrino. This project is devoted to the preparation of a new generation SuperNEMO experiment for the investigation of $0\nu\beta\beta$ and $2\nu\beta\beta$ decays in a 100 kg sample of enriched Se-82 by a tracker-calorimetric detection technique successfully proven in the NEMO-3 experiment. As the first stage, the SuperNEMO Demonstrator was created, which should demonstrate the performance of the advanced, in comparison with NEMO-3, tracker-calorimetric technique, the ability to achieve the required low background and, correspondingly, the desired sensitivity, and prove the possibility of mass production of low-background photomultipliers and plastic scintillators. The SuperNEMO Demonstrator module should reach the sensitivity to the half-life $T(0\nu)_{1/2} > 5.9 \times 10^{24}$ years after 2.5 years of measurement.

In the first sections of the project, the state of the art in $0\nu\beta\beta$ searches was presented with special emphasis on large scale running experiments with different isotopes - ^{136}Xe, ^{76}Ge. ^{130}Te and ^{82}Se. The overview includes the list of the main double beta-decay experiments such as EXO, KamLAND-Zen, GERDA, MAJORANA, LEGEND and CUORE. Similarly to SuperNEMO all these experiments are aimed to reach the sensitivity to the effective Majorana mass in the region $\langle m_\nu \rangle \sim 30 - 100$ meV. In case of a positive signal, an observation with several isotopes is needed for convincing evidence. The results would imply that neutrino follow an inverted hierarchy mass scheme and allow to directly measure the neutrino mass scale. Even a missing observation of $0\nu\beta\beta$ on all the isotopes under investigation would play an important role and the results would have to be combined with those coming from future neutrino oscillation experiments (reactors and long baseline). In the general part of the project, the demonstrator's design and its basic parameters were presented, including detailed description of the construction, radiopurity requirements and sensitivity, particle identification, background origins and multivariate analysis. In comparison with the other existing projects of the next generation