# 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 $<m_\nu> \sim 30 - 100$ 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

0νββ experiments its necessary to say that the advantage of SuperNEMO is the ability to identify both emitted electrons, which is not possible for pure calorimeters.

The SuperNEMO Demonstrator is currently in the last stage of its installation phase which will be completed in the first months of 2018. After 2.5 years of data taking, the sensitivity goal of the detector will be reached if the required background levels of internal and external contaminations will be achieved. To enhance the sensitivity and partially explore the inverted region of the effective Majorana neutrino mass (between 40 and 110 meV), the requirement on the 0νββ half-life is at the level of $T(0\nu)_{1/2} > 10^{26}$ yr. With 20 detector modules based on the design of the Demonstrator and hosting 5 kg of $^{82}Se$ each, SuperNEMO will be able to fulfill this requirement after an exposure of 500 kg·yr.

The JINR group had played a crucial role in the development of the NEMO-3: construction of the calorimeter, its calibration, passive shielding, development of software, data taking and analysis. The group has accumulated huge experience, which the group continues to deliver for the SuperNEMO Demonstrator project focusing on the same areas. There is no doubt that the impact and contribution of JINR group is valuable and important for the SuperNEMO collaboration. That's why the participation of JINR group in this field leading project should be considered as a highest priority issue.

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