Project GERDA (LEGEND): searching for neutrinoless double beta decay of Ge-76

Referee report on the project

The project is oriented on participation of scientists and engineers of the DLNP (JINR Dubna) in the running GERDA and planned LEGEND experiments aimed to search for neutrinoless double beta decay ($0\nu\beta\beta$), which is fundamentally important for modern physics. Observation of $0\nu\beta\beta$-decay would prove Majorana nature of neutrino; determine neutrino's absolute mass scale and hierarchy. At the same time LNV-observation would have crucial impact on fundamental physics principles, such as CP-violation, Leptogenesys, GUTs. Therefore $0\nu\beta\beta$-decay is highly demanded and topical area of research.

The LEGEND experiment, as well as its predecessor – GERDA experiment, creatively expands the classical, canonical and leading approach to the investigation of $2\beta\beta$-decay using detectors from enriched Ge-76. Throughout the history of $2\beta\beta$-studies germanium calorimetry became a warhorse of $0\nu\beta\beta$ decay searches once it was realized that Ge-76 is both $2\beta\beta$-source and excellent material for high-resolution semiconductor detectors. Milestone experiments were the Heidelberg-Moscow (HdM) and the IGEX projects holding best world results in the fields during decades.

Moving forward, the GERDA has proposed innovative improvement in the measurement technique. Instead of a standard cryostat, germanium in a holder with minimized weight is immersed in cryostat with liquid argon, which is both a cooler and a protector (active and passive) from the background. The cryostat is submerged into large tank of water worked as passive shield and active muon veto media as well. This configuration made it possible to achieve record high background suppression down to a level of 10^{-3} cnts/keV/kg/yr in Phase II, which corresponds to background-free experiment.

Obviously, the collaboration has done a great job to achieve this result. Great efforts were made to develop the design of the project, to prepare workable germanium detectors, to test new detectors, to develop active shield. Separately it is worth to emphasize the successful fight against a serious problem - the background from Ar-42, which required special technical solutions. Finally, new background suppression techniques were proposed, such as PSD of surface events (alpha-particles). Thanks to this, the collaboration successfully confirmed the workability of the proposed design of the project and obtained the best results (limit on $0\nu\beta\beta$–decay) at the moment.

The expansion of the research mainly discussed here – the LEGEND project (a successor of GERDA and Majorana) – looks reasonable and natural, since it is going to use the best from these two successful experiments. Especially for its first phase - LEGEND-200, in which it is planned to measure 200 kg of enriched germanium in the existing GERDA detector (cryostat). The feasibility of this part of the project with minimal risks is beyond doubt. With the successful realization of the LEGEND-200, the road to a ton-scale germanium experiment will be open.

It is especially important that JINR team makes a significant contribution to the project. The JINR members made a decisive contribution to the development, testing, nad adjustment of germanium detectors, development and creation of active shields (in argon, plastic muon veto), data analysis. Finally, the Project Leader is entrusted with the important role of the technical coordinator of the GERDA project.

Summing up, one should say that, without any doubt, the project deserves maximum support with the highest priority. The goals and objectives of the project are fundamental, the results are world-class, the contribution of the JINR team is highly visible, and the budget looks reasonable.

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