Germanium Detector Teststands for the GERDA Experiment

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Neutrinoless double beta decay and the GERDA experiment

Neutrinoless double beta decay ($0\nu\beta\beta$) can occur as an extremely rare second order weak process if neutrinos are Majorana particles. The half-life of the process is a function of the neutrino masses, their mixing angles and CP-phases. An observational proof of the process would not only reveal the nature of neutrinos but would also give information about the absolute scale of neutrino masses.

The GERManium Detector Array, GERDA, is a new experiment that will search for neutrinoless double beta decay of the germanium isotope $^{76}$Ge. Its main design feature is to submerge and operate high purity germanium detectors, enriched in $^{76}$Ge to a level of 86%, directly in a cryogenic liquid (nitrogen or argon). The latter serves as coolant and shield from external radiation simultaneously. The cryostat is placed inside a buffer of ultra-pure water which serves as additional shielding and will be instrumented as Cherenkov detector in order to veto cosmic muons. With this setup a background index better than $10^{-4}$ counts/(kg·keV·y) is expected.

The GERDA experiment will be installed in the Hall A of the INFN Gran Sasso National Laboratory, LNGS, in Italy.

Prototype detector characterization

In a second phase of GERDA segmented germanium detectors will be installed. The segmentation scheme foresees a 6-fold segmentation in the azimuthal angle $\varphi$ and a 3-fold segmentation in the height $z$. A prototype detector is currently under investigation at the MPI Munich.

The GERDA Phase II prototype detector under study is a high purity n-type germanium crystal with a true coaxial geometry. It is 70 mm high and has an outer diameter of 75 mm. The inner diameter is 10 mm. It was placed inside a two-walled aluminum cryostat with a total thickness of 6 mm. A copper cooling finger is used as thermal link between the detector and a volume of liquid nitrogen. The operation voltage of the detector is $\pm 3,000$ V. The detector signals are read-out using charge sensitive PSC-B5 pre-amplifiers. The pre-amplified signals are digitized using a data acquisition system based on 5 14-bit ADC PIXIE-4 modules at a rate of 75 MHz. In this configuration the energy resolution of the core is approximately 2.6 keV (at 1.3 MeV), the energy resolution of the segments varies between 2.4 keV and 4.7 keV with an average energy resolution of 3.3 keV.

Background suppression

The largest background contribution is expected to come from events with photons in the final state. An identification of those events is therefore crucial for the understanding and suppression of the background.

Monte Carlo simulation and Data to Monte Carlo comparison

A GEANT4 based Monte Carlo simulation was performed using the MaGe code which is developed by the Majorana and GERDA collaborations. It includes all necessary physics processes and allows for a flexible design of geometries. After the inclusion of crystal axis and the measured anisotropies of charge carriers the achieved level of agreement was improved and is of the order of 10%.