Operation of bare HPGe detectors in LAr/LN_2 for the GERDA experiment

M Barnabé Heider [1], C Cattadori[2], O Chkvorets[1], A di Vacri[3], K Gusev[4], S Schönert[1], M Shirchenko[4]

[1]MPI für Kernphysik, Heidelberg, Germany
[2]INFN-Milano Bicocca, Milano, Italy
[3]INFN-LNGS, L'Aquila, Italy
[4]Russian Research Center Kurchatov Institute, Moscow, Russia and JINR, Dubna, Russia

E-mail: assunta.divacri@lngs.infn.it

Abstract. GERDA is designed to search for $0\nu\beta\beta$-decay of ^{76}Ge using high purity germanium detectors (HPGe), enriched ($\sim$ 85%) in ^{76}Ge, directly immersed in LAr which acts both as shield against γ radiation and as cooling medium. The cryostat is located in a stainless steel water tank providing an additional shield against external background. The GERDA experiment aims at a background (b) $\lesssim 10^{-3}$ cts/(kg·y·keV) and energy resolution (FWHM) $\leq$ 4 keV at $Q_{\beta\beta}$=2039 keV. GERDA experiment is foreseen to proceed in two phases. For Phase I, eight reprocessed enriched HPGe detectors from the past HdM [C Balysh *et al.*, *Phys. Rev. D* **66** (1997) 54] and IGEX [C E Aalseth *et al.*, *Phys. of Atomic Nuclei* **63** (2000) 1225] experiments ($\sim$ 18 kg) and six reprocessed natural HPGe detectors ($\sim$ 15 kg) from the Genius Test-Facility [H V Klapdor *et al.*, *NIM A* **481** (2002) 149] will be deployed in strings. GERDA aims at $b \lesssim 10^{-2}$ cts/(kg·keV·y). With an exposure of $\sim$ 15 kg·y of ^{76}Ge and resolution $\sim$ 3.6 keV, the sensitivity on the half-life will be $T^{0\nu}_{1/2} > 3 \cdot 10^{25}$ y (90 % C.L.) corresponding to $m_{ee} < 270$ meV [V A Rodin *et al.*, *Nucl. Phys. A* **766** (2006) 107]. In Phase II, new diodes, able to discriminate between single- and multi-site events, will be added ($\sim$ 20 kg of ^{76}Ge with intrinsic $b \sim 10^{-2}$ cts/(kg·keV·y). With an exposure of $\sim$ 120 kg·y, it is expected $T^{0\nu}_{1/2} > 1.5 \cdot 10^{26}$ y (90% C.L.) corresponding to $m_{ee} < 110$ meV [V A Rodin *et al.*, *Nucl. Phys. A* **766** (2006) 107] . Three natural p-type HPGe prototypes (different passivation layer designs) are available in the GERDA underground facility at LNGS to investigate the effect of the detector assembly (low-mass low-activity holder), of the handling procedure and of the refurbishment technology on long term stability and spectroscopy performance. The study started on prototype 1 (fully passivated on the borehole side). ^{60}Co γ-irradiation of the detector in LAr resulted in an increase of the leakage current (LC), depending on the rate of LAr ionization which however is reversible. The radiation induced LC is believed to produce pairs of Ar^+/e^- that are drifted towards the passivation layer by the diode bias electric field (E) dispersed in LAr. In fact, E, numerically calculated by the Maxwell 2D code, resulted strong enough to drift charges before recombination, in the volume surrounding the passivation layer. Charges collected and trapped at the passivation layer cause a decrease of the its resistivity, i.e. an increase of the surface LC. The increase rate depends on the charge collection rate, on the density of trapped charge and on the starting value of the passivation layer resistivity. To study this mechanism two other detector configurations were tested. They have been irradiated in LAr to investigate the influence of both geometry and extension of the passivation layer and measurements with prototype 1 have been also repeated in LN_2: prototype 2 (passivation layer only in the groove) shows a $\sim$30 times lower LC increase rate than the case of prototype 1; prototype 3 (no passivation layer) does not show any increase of LC and prototype 1 operated in LN_2 does not show any increase. The observed LC is cured by irradiation without HV, explained either by γ ionization of the passivation layer or by effect of the UV LAr scintillation light.