GERDA

Progress report to the LNGS scientific committee

(Short write-up)

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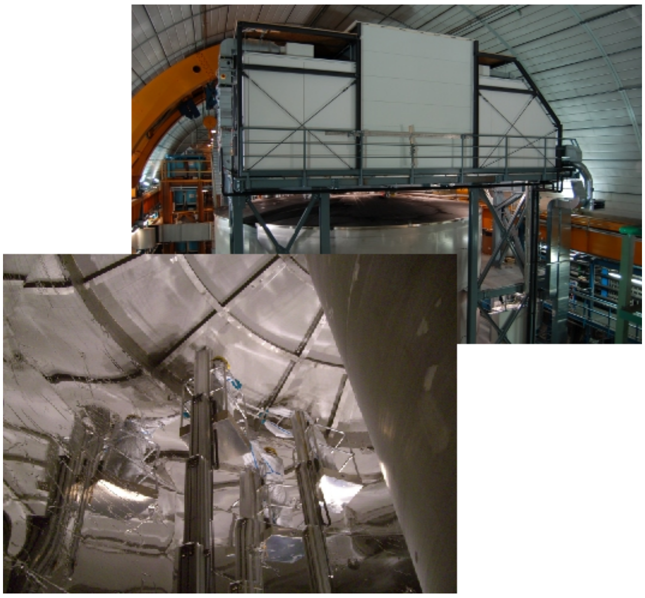
This GERDA report summarizes the progress achieved during the last six months. A *short write-up* is linked at:

http://www.mpi-hd.mpg.de/GERDA/reportsLNGS/gerda-lngs-sc-apr09-shwup.pdf.

Experimental and technical details are given in the *appendix* linked at:

http://www.mpi-hd.mpg.de/GERDA/reportsLNGS/gerda-lngs-sc-apr09-appdx.pdf.

Previous reports are available at: http://www.mpi-hd.mpg.de/GERDA/reportsLNGS.



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The construction and integration of the GERDA experiment proceeded as planned since the last LNGS scientific committee meeting in November 2008 until the earthquake of April 6. Because of this event, all on-site activities had to be suspended. They will be resumed with the re-opening of the laboratory on May 4 to external users. The most relevant issues are summarized in this *short write-up* and more details can be found in the *appendix*.

Aftermaths of April 6 earthquake: Fortunately, there were no death or serious injuries amongst the personnel at LNGS. Some GERDA colleagues, however, suffered injuries and several of them lost their homes. All installation and integration works were suspended and part of the GERDA staff, as well as personnel from external companies returned to their home places. Since April 20, the LNGS restarted operations and more detailed inspections of the underground GERDA installations are currently being carried out. So far, no damages of the GERDA installations have been reported. The GERDA collaboration plans to resume operations and to continue installations underground and above ground in the Hall di Montaggio starting from May 4.

Water tank hydrostatic test completed: The hydrostatic test of the water tank (WT) started November 24, 2008 using the water from the fire-extinguishing water supply. The radial deformations of the tank as a function of the water column height were within the specifications. The emergency drain line connecting the the tank to the drip water network below the TIR tunnel has been realized. A verification of the discharge rate of 60 l/s is yet pending. The Provincia di Teramo authorized LNGS on March 23 to drain the high purity water coming from the GERDA water tank into the LNGS drip water network for normal and in emergency operations.

Corrosion after hydrostatic test: In the course of the hydrostatic test of the water tank (WT), the cryostat was immersed in water for a period of about two months. After water drainage, both water tank and cryostat showed clear evidence for corrosion part of which being due to steel debris which had been produced by works on the GERDA platform. Other corrosion spots, however, could hardly be attributed to this origin but were caused rather by scratches, carbon steel contamination or insufficient pickling and passivation. Repair of corroded spots was done by a commercial company; in case of the cryostat the procedure included the following steps: grinding, pickling with Avesta 101, and passivation with Avesta FinishOne 630; between pickling and passivation the complete surface of the cryostat was treated with 'Remox'. After this procedure, still about 100 corrosion spots remained; they have been removed subsequently by another repair cycle carried out by us including more intense grinding. The corrosion problem created a delayed start of the muon veto installation, which is however not on the critical path to start the experiment.

Cryogenic infrastructures ready: The cryogenic infrastructure has been manufactured and delivered by the Dutch company DeMaCo. The cryogenic lines running from the LN_2 and LAr storage tanks via the valve box up to the manifold on top of the cryostat's neck have been installed in March '09. The cryogenic infrastructure will be completed by the installation of the active cooling system for LAr inside the cryostat, and the tubes leading to the safety valves and exhaust gas heater. The active cooling system has passed successful the test installation and will be inserted into the cryostat through its neck. While the manifold has been already installed by now, the installation of the active cooling system itself will be carried out after completion of the clean room on top of the water tank.

Cherenkov muon veto mounting started: The installation of the muon veto started on March 23. The water tank has been converted to a clean area and is vented with hepa-filtered air. The wave length shifting and reflective mirror foil VM2000 is glued to the outer tank wall using two personal lifters. Part of the photomultiplier tubes had been already mounted when the work was suspended by the earthquake on April 6.

Clean room construction in final state of assembly: The steel structure, wall elements, ventilation system as well as electric installations have been completed prior to April 6. Finishing the clean room floor as well as a test run of the clean room were originally scheduled for middle of April followed by the approval and handover to the GERDA collaboration by the end of the same month. These dates are now shifted and it is planned to resume the works by the beginning of May.

GERDA **general infrastructures:** The construction of the GERDA building has been concluded and the electrical plants installed. The safety systems were close to completion prior to the suspension of the works. The supply line of de-ionized water coming from the Borexino plant to the GERDA tank as well as the water loop equipped with an Ultra-Q unit to maintain the water cleanliness have been completed. The storage tanks for LAr and LN_2 have been placed at the assigned location and connected to the cryogenic infrastructure. The work for the installation of the ducts for the ventilation system connecting GERDA to the central LNGS ventilation had started and was scheduled originally to be concluded by the end of April. The path of the ventilation had to be modified to comply with the needs of LVD leading to an increase of the budgeted costs. As a consequence the integration of the system into the LNGS supervision system for the ventilation had to be removed from the contract and must be tendered separately. The funds for this tender have not yet been allocated by LNGS.

Phase I integration test in Hall di Montaggio: The start of the integration in the LNGS Hall di Montaggio (HdM) had to be postponed and will now commence on May 4. Clearance of the HdM has been given by the LNGS directorate and SPP on April 28, and shipment of the lock and glove box system started on the same day. The commissioning lock will be integrated with a glove box system and a test cryostat with active cooling system. Everything is mounted on a platform enclosed by a clean room tent. The objective of this integration test is to operate a Phase I detector string with non-enriched detectors connected to the PZ-0 front-end electronics and read out by the Phase I data acquisition system. After completion of the argon filling and cryogenic commissioning of the GERDA cryostat, the commissioning lock and glove box will be moved into the the clean room on top of the GERDA tank.

PZ-0 front end electronics produced: The Cuflon PCBs for the 3-channel PZ0 circuits have been designed, and eleven boards produced and mounted with their components. Four of them are used for electronic and detector tests, six for the radioactivity screening, and one for mechanical tests. When the PZ-0 circuit is closed on a high impedence termination at the input stage of the receiving FADC, an energy resolution of 2.5 (2.8) keV (FWHM) at 1.275 MeV has been measured with the FE submerged in liquid nitrogen and connected to the encapsulated SUB Ge-detector, and with 2 (12) m cable length between the PZ-O and the FADC. A significant crosstalk ($\sim 8\%$) has been observed between channels of the same ASIC and PCB circuits. The causes of the problem have been identified in subsequent work at the cold test bench and actions to mitigate have been identified. One possibility is to operate the circuits at reduced bias voltage however limiting the dynamic range to about 5 MeV. Six PCBs with all SMD components mounted have been screened to evaluate their radioactivity. The overall ^{232}Th content is at a tolerable level of 220 μBq per PCB, while the ^{226}Ra content is significantly too high (6.5 mBq/PCB). The responsible components have been identified as the capacitors of type X5R and X7R used to filter on board the low voltage power supplies. Replacement capacitors with lower intrinsic activities are currently under investigation. Alternatively, separation of the FET and feedback components from the following circuit is under investigation.

Phase II detector R&D enlarged: The GERDA collaboration widened the scope of detector R&D for Phase II. In addition to segmented n-type detectors, thick-window p-type BEGe detectors with advanced pulse shape discrimination properties are considered for Phase II. A n-type 18-fold segmented HPGe detector has been operated stable for five months in liquid nitrogen. The background reduction was demonstrated to work with the similar efficiency as with the detector in the vacuum cryostat. Up to now, ten Czochralski crystals have been pulled by IKZ. An impurity level of (10^{11}–10^{12}) cm^{-3} net donor concentration was achieved which is an order of magnitude better than previous results, however still too high for high-purity germanium detectors. The Czochralski puller is being modified to further reduce the impurity level. To assess the purity of the 6N germanium produced at PPM, IKZ grew two float-zone crystals directly from the zone-refined ingots. The purity of these crystals was (10^{10}–10^{11}) cm^{-3} and in one case even reaching detector grade purity. This makes us confident that detector grade crystals can be grown directly from the PPM material without additional purification.

Based on the results of the pulse shape studies with the p-type thick-window BEGe detector, the collaboration decided to investigate further the feasibility and production yield of thick-window BEGe type detectors for Phase II. For this purpose, a full production test with depleted germanium has started in January 2009. Additional 34 kg of depleted germanium oxide has been ordered from ECP and will be delivered by April 30. The material will be subsequently reduced and purified at PPM Pure Metals and shipped to

Canberra-US for crystal pulling. From this material, several thick-window BEGe detectors will be produced for testing and for the evaluation of the expected production yield from enriched germanium material.

New calibration task group formed: To concentrate the activities related to the Gerda calibration system, a new task group (TG-12), lead by Laura Baudis, was formed in February 2009. Some of the immediate responsibilities are Monte Carlo simulations of the required source types, strengths and collimators, of the induced gamma and neutron backgrounds, as well as the fabrication and test of custom made, low neutron emission sources and collimators. Near-future responsibilities are the long-term maintenance of the calibration system and stability monitoring of calibration parameters.

Network, DAQ electronics and on-line software available: The network structure for the Gerda building in Hall A has been defined and the hardware is ready for deployment. Two separate logical networks are visible: the DAQ/Slow Control network, where mission critical machines are connected, and a network branch for user laptops and computers temporarily connected to the LAN. Various centralized services like NIS, DNS, DHCP, and Web servers are available. It will be possible to access the Web servers of specific components from the outside network, only by authorized experts, for hardware monitoring and parameter setting purposes.

The data acquisition for the phase II germanium detector readout is based on Struck SIS3301 flash ADCs. The FADCs and the trigger controller for this system are available. In the next months, VME based fan-out modules for the clock distribution will be acquired and the firmware for the trigger controller will be developed. This controller is identical to the one which will be used for the muon detector readout since the latter is using the same FADCs for readout.

New Monte Carlo simulation campaign started: The Monte Carlo campaign-2 (MCC2) aims at the production of a realistic energy spectrum of the Gerda experiment for the full energy range based on the measured impurity concentrations of the different detector components. Using the Geant4-based MaGe framework, one energy spectrum for each elementary contribution is simulated. The final expected spectrum in Gerda is obtained after rescaling the elementary spectra with respect to a set of physics parameters (e.g. specific activities, half-lives, etc.), and summation of the different components.

Dedicated MaGe-based simulations were run to evaluate the impact of the ^{222}Rn emanation from the cryostat, which was measured to be about 30 mBq. Previous simulations were run with the assumption that the activity of ^{222}Rn and daughters (specifically, ^{214}Bi) is uniformly distributed in the full liquid argon (LAr) volume. With this assumption, the background index at $Q_{\beta\beta}$ turns out to be about $4{\cdot}10^{-4}$ cts/(keV·kg·y) for the Phase I array, which is reduced only by 15% using the anti-coincidence cut. A result of the same order is obtained also for the Phase II array. It has been realized that the assumption of uniform radon distribution in LAr is too optimistic, since convection is expected to transport radon from the cryostat walls to the vicinity of the crystal array. Monte Carlo simulations were re-run considering more realistic assumptions for the radon distribution in LAr, resulting in a background rate of $2{\cdot}10^{-3}$ cts/(keV·kg·y) (Phase I array, no cuts) for 30 mBq emanation rate. The collaboration is investigating the possibility to install a shroud around the crystal array which would prevent ^{222}Rn from approaching close to the detectors. The design of such a shroud is well underway, and a decision on its installation will be taken soon. Based on a simplified convection model and on MC simulations, a shroud reduces the ^{222}Rn background by one order of magnitude. Other MC activities included the efficiency of the Cherenkov muon veto up to the trigger level, and the simulation of pulse shapes from Ge detectors.

Material screening and radon monitoring: Radon emanation measurements have have been performed for various components including different welding samples, components used in the cryostat and lock system, the liquid argon supply line, and the cryostat shutter valve. The long-term measurements with the electrostatic radon monitor were continued successfully. A collection efficiency of 95% (76%) was achieved for ^{218}Po from argon (nitrogen) gas at 8 kV (40 kV). The transport of the radon monitor to LNGS was planned for May, however will be delayed because of the earthquake. Gamma ray screening of samples continued at LNGS, MPIK, Geel and Baksan. A large fraction of the screening measurements was dedicated to the study of front end electronic components. Activation measurements of copper and stainless steel materials of the GERDA cryostat were performed by exposing them to cosmic rays at Gran Sasso and Heidelberg. In addition, dedicated measurements with a DT-generator providing mono-energetic 14 MeV neutrons are being carried out to investigate neutron induced reactions. First results of the cross section measurement of cold neutron capture on ^{76}Ge have been published.

Schedule and impact of earthquake: The planning prior to the earthquake of April 6 was to complete the clean room by the end of April, followed by the installation of the cryogenic cooling system inside the cryostat in May, and the commissioning of the the PLC and argon filling in June. The completion of the installation of the ventilation system by LNGS was scheduled for April. In parallel, the integration of the Phase I detector string were intended to be carried out in the Hall di Montaggio starting in April. Following the closure of the LNGS subsequent to the earthquake April 6, the directorate announced the restart of normal operations at LNGS external laboratories for May 4. Since all GERDA installation works had been suspended on April 6, we have accumulated so far a delay with respect to our previous planning of at least one month. Additional delays depend how fast the services and operations at LNGS will start, and on the availability of the external companies to resume construction work. The GERDA collaboration plans to restart the on-site work on May 4 with the integration efforts in the Hall di Montaggio and with the installation of the Cherenkov muon veto inside the water tank in Hall A.