Gerda

Progress report to the LNGS scientific committee

(Short Write-up)

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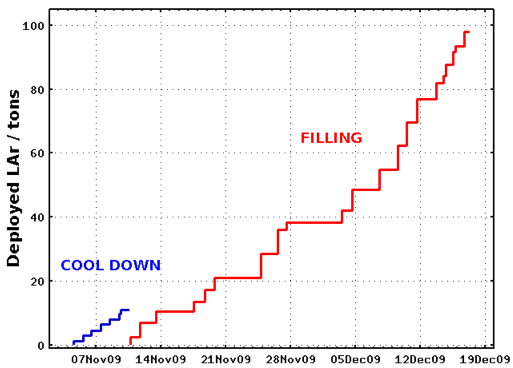
This Gerda report summarizes the progress achieved during the last six months. This *Short Write-up* is linked at:

`http://www.mpi-hd.mpg.de/GERDA/reportsLNGS/gerda-lngs-sc-apr10-shwup.pdf`.

Experimental and technical details are given in the *Appendix* which is linked at:

`http://www.mpi-hd.mpg.de/GERDA/reportsLNGS/gerda-lngs-sc-apr10-appdx.pdf`.

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



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After the filling of the cryostat with liquid argon in December 2009, the subsequent tuning of the active cooling system in January 2010, and after the arrival of the commissioning lock on March 25, the GERDA collaboration is preparing the deployment of the first detectors in the GERDA tank. The most relevant issues are summarized in this *short write-up*. Further details can be found in the *appendix*.

Cryostat filled: The cryostat was cooled down and filled in November and December 2009. This process worked very smoothly: The pressure regulation system worked very well and the exhaust gas was heated up as expected. The pressure of the insulation vacuum dropped by almost three orders of magnitude to now $2 \cdot 10^{-8}$ mbar. Afterwards the active cooling was started and we have now a stable liquid argon temperature of 88 K with practically no evaporation losses. The entire system is regulated by a PLC. Since the human machine interface is a web server the cryostat status can be easily accessed. Commissioning of all parts is practically finished. Still missing is the final integration of the water tank drainage into the PLC and the connection between the water pump and two of the former GNO pits. Since Januar 2010 continuous 24 hour safety shifts have been established. The shifters can be called in case of problems and - with the backup from experts - react to problems. The cryostat is ready for detector deployment.

Water tank drainage finalized: Several drainage tests of the partially filled water tank ($\leq$4 m) established that the foreseen passive flow regulators were unable to provide a constant and to a large extent water level independent flow rate which is needed to empty the water tank completely within the specified 2 hours. These tests revealed also that water can be drained through the new pipe below the TIR tunnel with 80 ℓ/s, a much higher flow rate than expected, without affecting the other installations in the underground laboratory. The results have been evaluated in monthly meetings between the LNGS director, SPP, Technical Division, Environmental Service and GERDA leading to the decision that in emergency the water tank can be drained at 80 ℓ/s, else the drainage rate shall be kept below 20 ℓ/s. The trigger for emergency drainage will be provided by the PLC of the cryogenic infrastructure which will also maximize the flow rate up to 80 ℓ/s by opening a butterfly valve according to the decreasing water level. Additional drainage lines will lead to two former GNO pits via the grid at up tp 16 ℓ/s and via a dedicated pump at 20 ℓ/s so that the total drainage rate approaches 116 ℓ/s which is enough to empty the water tank within 2 hours. The major hardware components for this system are available and its installation will be concluded in a few weeks.

Muon veto tested: For drainage tests, the water tank was partially filled. This opportunity was used to test the PMTs and to read out the veto detector with its final DAQ. With different light sources installed in the tank for calibration purposes we identified two broken PMTs. These will be replaced when the water tank is drained. First muon candidates have been identified with a coincidence trigger. In the next months the analysis software for muon identification will be developped and the light calibration integrated into the DAQ program. To test the long term stability of our design, a test capsule was kept in water under a pressure of 1.1 bar for 4 years. No damage to internal parts has been observed after opening the capsule showing that our design is suitable.

First cable arm of commissioning lock installed on glove box: Several mechanical improvements of the commissioning lock system were implemented. They included a mechanical stabilization of the linear pulley guide system, a friction clutch limiting the force on the steel rope, the installation of a meter drive measuring the real position of the string, the installation of inductive sensors that serve as end switches as well as an additional camera that monitors the horizontal arm. After extensive testing, the lock arrived at LNGS on 25 March. It has been installed on the glove box and the vacuum and gas system is currently being mounted. The lock system is expected to be ready for first detector deployment tests by the end of April.

Non-enriched detectors ready for deployment: The non-enriched low-background detectors GTF32 (mass: 2321 g), GTF45 (2334 g) and GTF112 (2967 g) have been mounted in their low-mass holders and tested in liquid argon in Test Bench-1 in the GERDA underground Detector Laboratory (GDL). With the front-end electronics of this setup (60 cm cable between detector and FET operated in cold argon gas; FET separated from discrete preamplifier), the achieved energy resolutions are 2.5 keV full width at half maximum (FWHM) at 1.3 MeV for GTF32, 2.6 keV for GTF45 and 2.5 keV for GTF112. All leakage currents were stable at a few tens of pA and the detector assemblies are ready for deployment in the GERDA cryostat.

Front-end electronics available: Three 3-channel PCBs with PZ0 ASICs are currently available for Phase I and additional 8 PCBs are in production. These PCBs now meet the radioactivity requirements, i.e. the background contribution should be below 10^{-3} cts/(keV·kg·y) for the design distance to the diodes. A new ASIC called PZ1 has been produced and is under test now. This version is able to drive 10 m long 50 Ω cables.

All other hardware needed for detector operation like low voltage and high voltage power supplies, HV filters and a pulser are available.

As an alternative, some charge sensitive amplifiers based on commercial components have been tested. One option is promising. It meets our requirements in terms of noise and is able to drive long 50 Ω cables. It is less sensitive to power supply variations and needs therefore possibly fewer blocking capacitors - the main source of radioactivity on our PCB. A smaller PCB with fewer components is currently under production to test this amplifier.

DAQ installed in Hall A: The data acquisition systems for the germanium detectors and the muon veto have been installed in March in Hall A. The system for the germanium detectors has been debugged during the last months to ensure a reliable readout via PCI bus. The readout rate is 132 MB/s. The event rate is however limited by writing to disk (60 MB/s) to about 2 kHz for 10 channels. A digital filter generating a trigger for each channel is now integrated into the hardware as well as a monitor of the baseline. The muon veto system has two trigger modes. Either a germanium trigger starts the readout of the digitized PMT signals in a 40 μs window or a coincidence between of several PMT signals above threshold is considered a muon candidate. A first commissioning was performed with a partially filled water tank. The integration of a light calibration system and the analysis software is ongoing.

The slow control database for collecting information from the various systems is running and recording data from the cryostat and the clean room since months. Other components will be integrated as soon as they become available. An alarm generation and distribution system is developed and needs to be commissioned.

Additional low-neutron flux ^{228}Th calibration sources available: The neutron rates for the ^{228}Th custom source of 15 kBq was measured to be (2.9±0.07) × 10^{-2} n/s. Subsequently, it has been sent for a precise calibration of its activity to IRMM in Geel. Two new ^{228}Th custom sources have been produced: one of ∼30 kBq at PSI, and one of ∼40 kBq at Mainz. These sources have been sent for encapsulation to Eckert&Ziegler, Braunschweig, and will arrive at IRMM for a precise calibration by the end of April 2010. After the calibration procedure, the sources will be sent to LNGS where the neutron fluxes will be measured.

Low-background test stand LArGe commissioned: The GERDA low-background test stand LArGe, located in the GDL, has been filled in February. The argon is sub-cooled to -187 ^{o}C with a liquid nitrogen flow into the heat exchanger of 2.05 m^3 (STP) per hour and the pressure is adjusted to about 960 mbarg by fine tuning of the active cooling. No argon is lost by evaporation under this operational conditions. Limited by the argon purity employed, the measured scintillation triplet life time is 820 ± 40 nsec. Though the photo electron yield is reduced with respect to expectations, it is sufficient for operating it as an active veto with a threshold of a few tens of keV energy deposition in the liquid argon. The lock has been mounted and the system is being prepared for the deployment of the first germanium detector.

Chemical reduction and zone refinement of enriched germanium material ongoing: After the terms of the contract were agreed we started the reduction and zone refinement of the enriched germanium at PPM Pure Metals, in Langelsheim. The 53.3 kg of enriched GeO_2 purchased from ECP in 2006 was stored underground at the SCK CEN Mol (HADES) underground laboratory in Belgium until now. On the 8th of March 2010 the boxes with the enriched GeO_2 were transported from HADES to the Rammelsberg mining museum in Goslar. To minimize the exposure to cosmic rays during the production the material is stored in an unused shaft of the old Rammelsberg mine. Only the material that is being processed is taken out each time before the production starts and taken back underground when it is over. At the moment of writing already 32.9 kg oxide was reduced to metallic germanium. The zone-refinement procedure starts each time when enough material is available to fill the boats. So far 7.7 kg of 6N material was produced but the production rate will increase as more metal is available. The mean exposure after the first five reduction runs and of two zone-refinement runs is about 97.8 hours, slightly more than four days. This includes the transport time of 6 hours from HADES. The exposure is expected to increase as more zone-refinement runs will be necessary to achieve our goal of 90% yield of 6N material. This is a small fraction of the total processing time of two months assumed for all steps from reduction to completed detector fabrication. The zone-refinement is expected to end around 30th of April or soon after.

First two BEGe detectors from depleted germanium operational: Four ingots with a total mass of 17.7 kg were pulled from depleted germanium with the impurity levels according to specifications. Four of possible 16 detectors will be produced from this material. The first two slices were successfully transformed into detectors and mounted into standard cryostats. After passing the acceptance tests at the manufacturer, the two detectors have arrived at LNGS on March 29. Measurements with a ^{60}Co source showed at 1.3 MeV an energy resolution of 1.62 keV and 1.67 keV FWHM, respectively. First results on the pulse shape analysis based on the A/E ratio method are available for a bevel-shape BEGe detector (P8190DD): Fixing the acceptance of the double escape peak to $90 \pm 1\,\%$, the full energy peaks at 1621 keV and 2615 keV have survival probabilities of $11.3 \pm 0.6\,\%$ and $8.83 \pm 0.07\,\%$, respectively, the single escape peak of $5.8 \pm 0.4\,\%$, and the Compton continuum at $Q_{\beta\beta}$ of $39.8 \pm 0.3\,\%$. Within errors, the results are identical to those obtained with the cylindrical BEGe detectors of 80 mm and 70 mm diameter, and corroborate the simplicity and robustness of the detectors and of the analysis method.

Detector deployment plan: After completion of the installations of the commissioning lock in the clean room and the deployment of a mock-up detector for mechanical and electronic tests, a single non-enriched detector ('prototype detector') will be deployed in the liquid argon tank. The purpose is to test and debug the spectroscopic performance of the full system, similar as done in the hall di montaggio integration test. Subsequently, a string with three non-enriched GTF-detectors, or alternatively with two non-enriched GTF- plus one enriched detectors, will be mounted in one string and deployed. It will be operated for about two months in the GERDA cryostat in order to measure the background of the full detector assembly in the GERDA setup. Subsequently, it is planned to start the deployment of the enriched phase I detectors.