Gerda

Progress report to the LNGS scientific committee

(Short write-up)

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The format of this Gerda progress report differs from our earlier ones to facilitate both fast and in-depth reading. A *short write-up* (http://www.mpi-hd.mpg.de/GERDA/reportsLNGS/gerda-lngs-sc-oct08-shwup.pdf) summarizes the achievements during the last six months and highlights important issues. An *appendix* to the report (http://www.mpi-hd.mpg.de/GERDA/reportsLNGS/gerda-lngs-sc-oct08-appdx.pdf) provides additional technical and experimental details for follow-up reading.

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The construction of the Gerda experiment proceeded as scheduled since the last Lngs scientific committee meeting in April 2008. Important milestones, results as well as critical issues are summarized below:

Cryostat tested and cryogenic infrastructures ordered: Several acceptance tests of the cryostat were carried out after its delivery in March '08. This includes radon emanation measurements, helium leak tests and an evaporation test with liquid nitrogen. The radon emanation of the tank increased by a factor of three after completion of the copper installation. An additional cleaning is under preparation. The final documentation for the cryostat is currently checked by TÜV Nord and the formal certification of the cryostat is expected by November. The contract for the cryogenic infrastructures has been awarded to the Dutch company DeMaCo, the design finalized and the components ordered. The heater for the exhaust gas has as well been ordered following the specifications provided by Lngs.

Water tank construction completed: The water tank construction has been completed during the period April through June '08. The completed acceptance tests are a water penetration test of the bottom plate and the x-ray tests of the welds. The hydrostatic test and the fast draining test are pending as the Lngs is not yet authorized to drain the tank water into the new Lngs drainage system.

Gerda **building and general hall A infrastructures:** The Gerda building construction started after completion of the water tank construction in July and has been completed recently. The contracts for implementing the safety plants and the electrical plants, inclusive telephone, LAN and air conditioning are awarded to the companies and the installations are under preparation. The tendering process for the construction of the water pit required to release the water to the drainage system of Lngs has been started. Critical for the commissioning of Gerda is the timely completion of the design and the installation of the ventilation system by Lngs.

Clean room and lock system: The tender for the clean room has been published as scheduled, however the offers of the bidding companies were significantly above the allocated budget. In a following negotiation phase with two companies, the costs could be reduced by relaxing some uncritical specifications, and the contract is now under preparation. The construction of the clean room will start beginning of January 2009 and will be completed by the middle of March. This corresponds to a delay of two months with respect to our previous schedule.

A simplified lock system has been designed for the commissioning phase. Several strings with up to three detectors can be inserted. It consists of two linear pulleys that allow for lowering of two independent strings. The system is constructed such that one of the linear pulleys can be reconfigured to hold up to three strings, accommodating all enriched and part of the non-enriched phase I detectors. It is under construction and will be ready by the end of the year for testing. Given the new plan to start with the commissioning lock, the final lock system is not anymore time critical. Its design is currently being completed.

Muon veto system: The Gerda muon veto has taken a major step towards completion. All photomultipliers of the water Cherenkov veto system have been encapsulated and tested. The muon veto mounting procedure inclusive safety training has been completed and the equipment inclusive lifters are prepared. The work was scheduled for September and October, however, because of the missing authorization of the Lngs to drain the water of the water tank, the work had to be postponed. The Cherenkov veto system can only be mounted after the hydraulic test of the water tank has been completed. The second batch of plastic scintillators for the roof veto has been assembled. It will be delivered to Lngs this fall. Ongoing work concentrates on data acquisition and slow control.

Phase I detectors: The processing of all phase I detectors has been completed. This includes the 17.9 kg enriched detectors and the 15 kg of non-enriched detectors. All enriched and part of the non-enriched detectors were mounted in their final detector holder and their performance characterized in liquid argon. The detector mounting and handling was carried out in the radon reduced test bench under nitrogen atmosphere in the Gerda underground detector laboratory (Gdl) at Lngs. The overall exposure above ground, including transportation and processing was typically five days. Cosmogenic activation was thus negligible.

The construction of the copper cryostat of the low-background test stand LArGe has been completed. The evaporation test with liquid nitrogen (without active cooling) showed a mass loss of 1.3 kg/hour meeting the design specifications (¡ 1.6 kg/hour or 90 Watt). Components of the nitrogen supply and transfer system, the active cooling and the control system was tested successfully. The liquid argon is sub-cooled and the argon evaporation rate negligible ($<$ 0.02 kg argon per hour) at a nitrogen flow rate of 1.6 kg per hour. The photomultiplier system, the wavelength shifting reflector foils have been completed and are being assembled.

Phase II detectors: A new 18-fold segmented prototype detector was operated in liquid nitrogen for five months. The leakage current was stable at 4 pA through the full period. The measured core resolution was 4 keV (FWHM) at 1332 keV and that of the segments 4.5 to 7 keV. Single-site and multi-site events are discriminated efficiently using the event topology.

After a refurbishing the Czochralski puller set up at IKZ, Berlin crystal pulling started in April. A further upgrade with a high-purity crucible and high-purity gas system was completed recently. In total, seven test crystals have been pulled and analyzed by Hall-effect and PTIS. The impurity level are typically at $10^{13}/\mathrm{cm}^3$, yet too high for HP-Ge detector production.

Pulse shape studies with a 0.8 kg p-type BEGe detector were carried out successfully. The results on the discrimination between single site events (double beta like topology) and multi site events (gamma line background topology) are very encouraging and the collaboration will go through a careful evaluation of the different discrimination techniques.

In a meeting with representative's of Canberra on October 20, the possibilities about crystal pulling from enriched germanium material was discussed.

Front end electronics for phase I: The PZ0 ASIC CMOS with discrete input J-FET and feed back components, was tested with the Sub detector test system, an encapsulated p-type detector assembly, submerged in liquid nitrogen. The achieved energy resolution was 2.3 keV (FWHM) at 1332 keV. The prototype PZ0 was subsequently tested with the phase I detector assembly in liquid argon in the Gdl an energy resolution of 3.2 keV (FWHM) at 1332 keV was achieved. The final low-background PCB, made out of Cuflon, are currently under production. Each PCB has three channels to operate one string consisting of three detectors.

DAQ and on-line software: The work on the PCI based digital data acquisition system focused on the improving of the data throughput, on the synchronization of the data provided by different acquisition cards and on the implementation of a digital trigger algorithm. After successful completion of the test of the new digital trigger, the cards will be modified accordingly. The slow control is under realization and first hardware components as VME and NIM crates, and the DAQ system are being integrated. The developed software consists of a client program for talking with the crates through CAN bus, a PostgreSQL database for data storage, an alarm system based on the ETRAX 100 LX Multi Chip Module 2 and a WEB browser for user interface.

Calibration: Monte Carlo studies to optimize the source strength, the source location and the design of the collimator are progressing. ^{60}Co and ^{228}Th gamma sources are foreseen as standard sources in Phase I. The source handling, calibration procedures and comparison of data with simulations are under preparation.

Simulations and background studies: The main focus of the Monte Carlo activities concerns a new simulation campaign using a close to final detector geometry and the latest material purity information. Further activities concerned the simulation of the pulse shape including the full signal chain from the primary energy deposition, the drift of the charge through the crystal, up to the the preamplifier and DAQ. An other study concerned the simulation the response of liquid argon scintillation light and comparison with data from a ^{148}Gd alpha source.

Material screening: The radon emanation of the cryostat was measured several times: prior the copper installation the value was (14 ± 2) mBq which would translate to a background index of 2×10^{-4} cts/(keV·kg·y) assuming homogeneous mixing and without anti-coincidence cuts. The final value after mounting was (34.4 ± 6.0) mBq, which is about a factor of two above our design specifications. Radon emanation measurements of components which are in contact with the argon volume have continued during the last six months. This includes parts from the cryogenic system, from the lock system, as well as cables.

The electrostatic radon monitor is now operational with gaseous argon up to HV of

12 kV. The collection efficiency was determined to be 20% and could be improved to 95% by using a larger silicon PIN detector and electrostatic focusing, A two month long-term measurement was carried out successfully with low radon activity. The detection limit is 200 μBq or better.

Radon deposition on surfaces of stainless steel plates, of Ge and PTFE plates from liquid nitrogen and argon were further investigated. Its dependence on the electrical field and the liquid convection are being studied.

Samples for gamma-ray screening included dust samples from Hall A, stainless steel cables for the detector strings, coaxial cables as well as PEN foil. The PEN foil which is under consideration for the production of flat cables for phase II detectors has upper limits of < 1.4 mBq/kg for ^{228}Th and < 2.0 mBq/kg for ^{226}Ra.

Coordination with Lngs: Five installation meetings between members of the Gerda collaboration and Lngs (SPP, Divisione Tecnica and directorate) took place from January through July '08. These meetings were very effective to finalize important details as the dimensioning of the heater for the Ar exhaust gas, the water tank construction, or the removal of the explosion proof door required for locating part of the cryogenic infrastructure. Given the shortage of funds at the Lngs, several infrastructure items have accumulated delays (removal of explosion door, water draining system, ventilation system) and the collaboration took over some items which originally were agreed to be covered by the laboratory. These include the water drainage pit, the electrical system and the optical fibers.

The authorization to drain water is critical to proceed with the hydrostatic test, to carry out the emergency draining test after which the mounting of the muon veto system can be carried out. The design of the ventilation system to connect the exhaust gas discharge into the Lngs system is not yet available. Both safety relevant infrastructures are critical for the timely start-up of Gerda. In summary, the installation meetings between Lngs and Gerda members are very productive to identify critical issues and address them timely. The next meeting is planned close in time with the November Lngs SC review, and we hope that the most critical items can be resolved by then.

Personnel and schedule: The collaboration strength and the number of full time equivalents (FTE's) committed to the experiment has been stable during the last year. The new group of Kai Zuber at TU Dresden has started this summer its activities and is contributing to the characterization of germanium crystals pulled at IKZ Berlin. With the decision to proceed first with a commissioning lock, the delay of the main lock does not impact the start-up of the experiment. The initial offers for the clean room, which were exceeding the allocated budget could be curbed in the following de-scoping and negotiation phase. This led however to a delay with respect to the 2007 schedule corresponding to about eight weeks. Filling and commissioning of Gerda is now projected for spring '09. External factors are becoming increasingly critical for the timely start-up of Gerda. In particular, the mentioned authorization to drain water from the water tank, which is required to proceed with the installation of the muon veto, and the design and construction of the ventilation system, are on the critical path.