The calibration system of the GERDA muon veto Cherenkov detector

Florian Ritter[a,*], Bayarto Lubsandorzhiev[a,b], Kai Freund[a], Peter Grabmayr[a], Josef Jochum[a], Markus Knapp[a], Georg Meierhofer[a],
Bator Shaibonov[b]

[a] *Kepler Centre of Astro and Particle Physics, Universität Tübingen, Tübingen, Germany*
[b] *Institute for Nuclear Research of RAS, Moscow, Russia*

Abstract

The GERDA experiment searches for neutrinoless double beta decay ($0\nu\beta\beta$). To achieve a sensitivity of 10^{-3} $counts/(keV\ kg\ y)$ or better within a specific Region Of Interest (ROI), a good background identification is needed. Therefore GERDA is located in the LNGS (Laboratori Nationali del Gran Sasso) underground facility. In addition to the good rejection of cosmic muons due to the surrounding bedrocks, a dual muon veto system has to be used. For calibration and monitoring of the muon veto, two seperate systems have been developed.

Key words: GERDA, neutrinoless double beta decay, muon, Cherenkov detector, calibration

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1. Introduction

The GERmanium Detector Array GERDA searches for the neutrinoless double beta decay of ^{76}Ge [1]. This very rare, weak process is predicted to occur if the neutrino exhibits a mass and is a Majorana particle, i.e. the neutrino is its own antiparticle. A part of the Heidelberg-Moscow Collaboration claims to have observed the $0\nu\beta\beta$ decay with a halflife of $T^{0\nu}_{1/2} = 1.2^{+3.0}_{-0.5} \cdot 10^{25}$ (3σ range)[2]. To achieve the needed sensitivity, any background event must be identified. Therefore, GERDA is located at the LNGS to be well shielded against cosmic muons. Nevertheless, a muon veto is needed. The goal for Phase I of GERDA is to reach a sensitivity of 10^{-2} $counts/(keV\ kg\ y)$ or better at 2039 keV (the Q-Value of ^{76}Ge).

GERDA uses an innovative shielding design (Fig. 1). Close to the germanium detectors, only low-Z materials are used. The coryostat is surrounded by a water tank, which acts as an active Cherenkov veto. In addition, the water tank is used as neutron moderator and γ-catcher.

The muon veto will consist of three mainly independent detector systems (Fig. 1). A layer of plastic scintillators above the Cleanroom will detect muons coming straight through the neck of the cryostat. The water tank acts as an active Cherenkov veto. It is equipped with 4 times 10 photomultipliers (PMTs) with 8" diameter on the wall and 20 more on the bottom. The volume beneath the cryostat is equipped with additional 6 PMTs [3]. To protect the PMTs and the electronics against the water, they are encapsulated in housings of stainless steel with a PET window on the front.

During the life time of the experiment, the PMTs have to be monitored and calibrated. Therefore, a dedicated calibration and monitoring systems was developed.

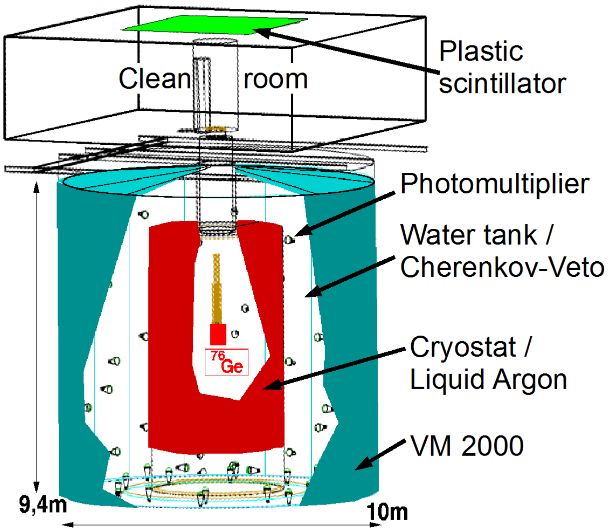

Figure 1: Schematic drawing of the GERDA muon veto. In the centre, the Cryostat with the Germanium detectors is shown. The Cryostat is surrounded by the Water tank. Above the Cleanroom, the Plastic scintillators are located [3].

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[*] Corresponding author

Email addresses: `ritter@pit.physik.uni-tuebingen.de` (Florian Ritter)

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2. Calibration and Monitoring

For calibration and monitoring, two systems of light pulsers will be implemented.

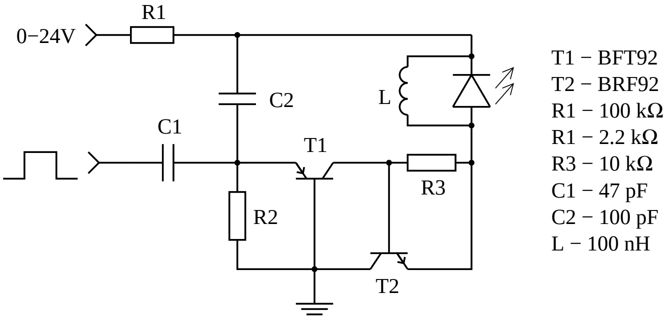

Figure 2: Schematic of the electronics for the LED. The voltage is adjusted via a VME DAC module PAS 9817/AO.

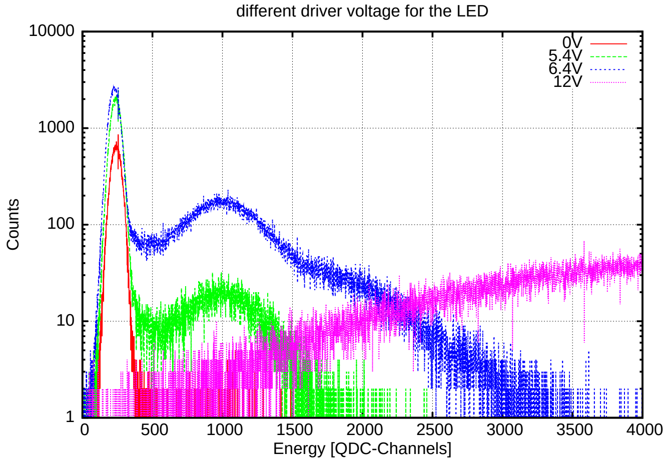

Figure 3: Response of one PMT for different supply voltages of the LED.

2.1. *First system*

The first system uses a single fast ultra bright blue LED. An electronic driver for the source is a modified version of a driver first proposed by J. Kapustinsky et al.[4] (Fig. 2). The light output of this source is adjustable in the range of $0 - 10^9$ Photons per pulse in the range of $3 - 10$ ns. Thus, the response of the PMTs is easily monitored. The light pulses are fed to each individual PMT via optical fibres (PMMA, core diameter: 1 mm). Figure 3 shows the different response of one PMT by different supply voltages of the LED. The red curve shows the response of the PMT when the LED is switched off. Driving the LED with 5.4 V, the single photoelectron peak arises. With 6.4 V (resp. 12 V), double (multiple) photoelectron peaks show up.

2.2. *Second system*

The second system will use diffuser balls in the tank to illuminate it for geometry dependent calibration. Four of these diffuser balls will be located in the water tank, while one ball will be in the volume below the cryostat. The light source itself consists of a high power blue LED and a special electronic driver based in three consecutively switched avalanche transistors [5]. It provides 10^{12} photons per pulse and is not adjustable. The width of the light pulse is 10 ns. The light is fed to each diffuser ball with optical fibres. The diffuser balls are glass bulbs with a diameter of around 50 mm (Fig. 4). The inner volume is filled with silicone SilGel 612 A&B(Wacker) mixed with S32 5 microns glass bubbles (3M). In the centre of the volume, a small glass bulb is located. The optical fibre is fed to this innermost volume, and here, the volume is filled with a mixture of Lensbond (Summers Optical) and S32 glass bubbles.

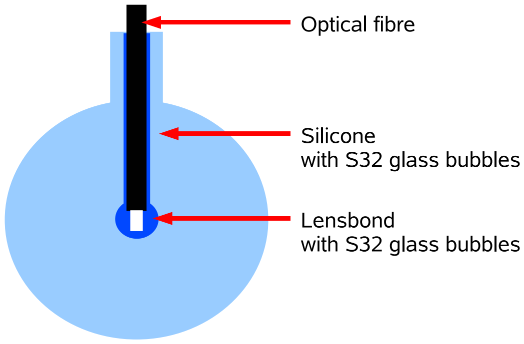

Figure 4: Sketch of a diffuser ball.

The use of these diffuser balls will provide not only geometric dependent responses of the PMTs, but also a timing information due to the different distance of the PMTs to the diffuser balls.

3. Conclusion

Two calibration and monitoring systems for the Gerda muon veto were developed. First results look promising. A first test of the systems will be made as soon as the water tank is filled.

Acknowledgments

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