The DAQ and calibration system of the GERDA Muon Veto Cherenkov Detector

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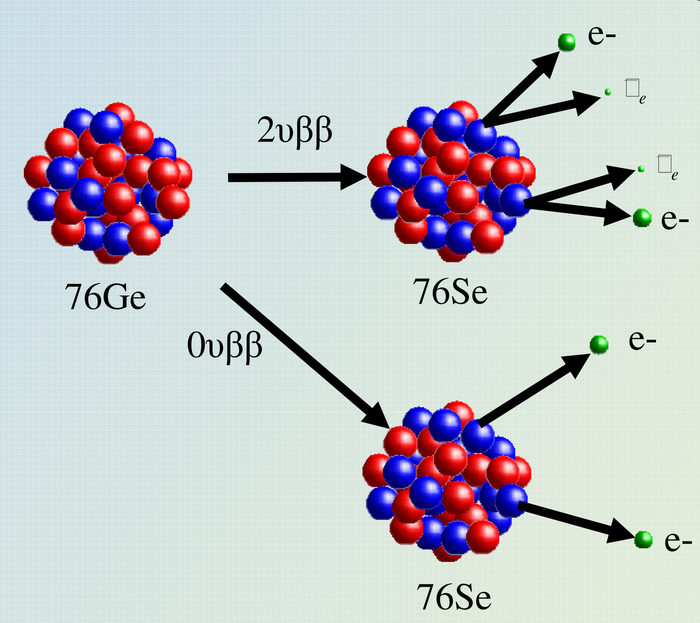
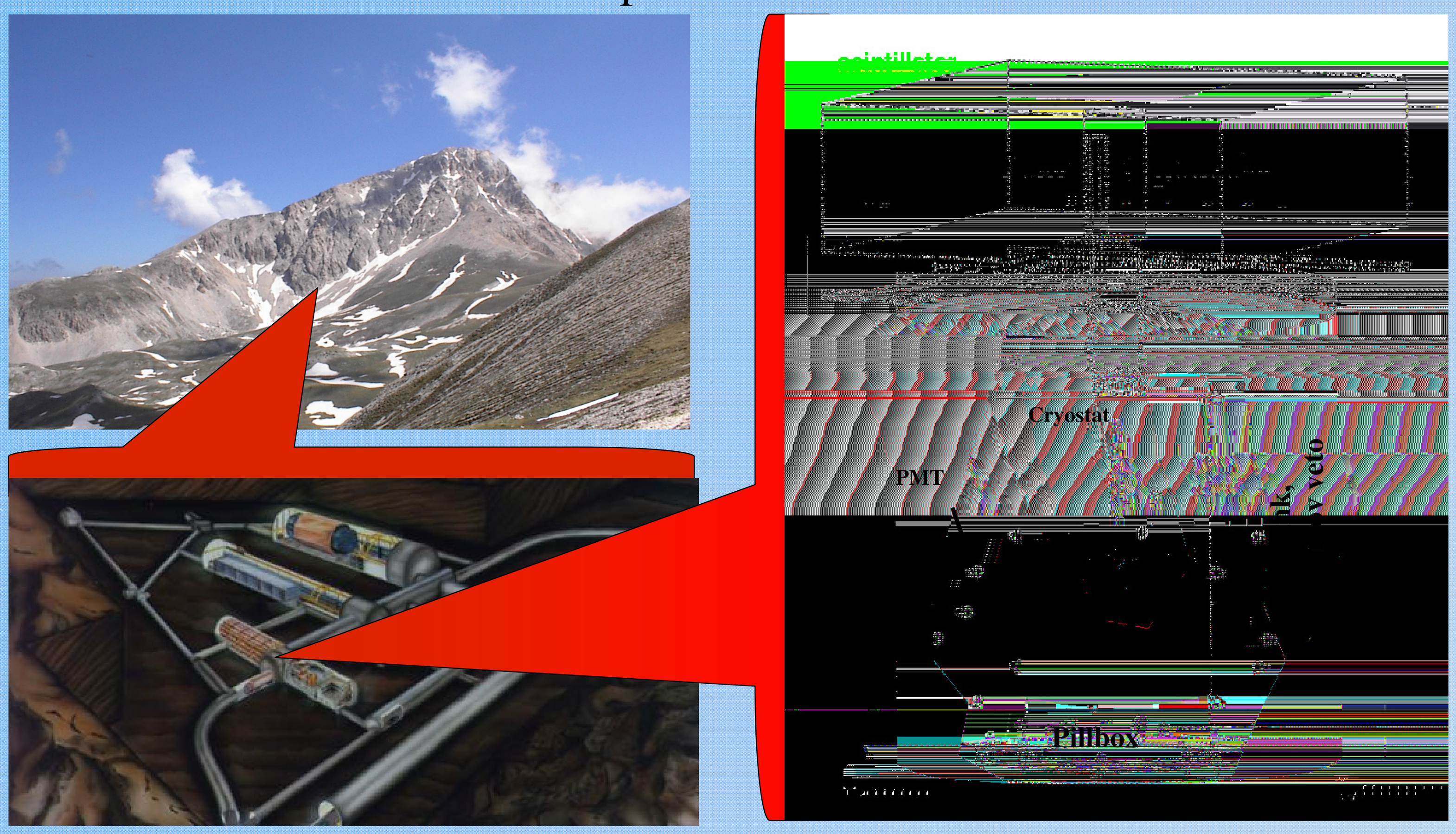
The **GER**manium **D**etector **A**rray **GERDA** is an experiment searching for the neutrinoless double beta decay (**0υββ**) of ^{76}Ge. This very rare, weakly interacting process is predicted to occur if the neutrino exhibits a mass and is a Majorana particle, i.e. the neutrino is its own antiparticle.



Although the 2υββ decay has been found in several nuclei, there is at this moment no proof for 0υββ decay. The best limit for the halflife is $T_{1/2} > 1.2 \cdot 10^{25}$ y. Only a part of the Heidelberg-Moscow Collaboration claims to have observed 0υββ. To improve the limit, the exposure will be increased and the background contribution must be reduced. Therefore, the experiment is well shielded inside the Gran Sasso mountain, also a muon veto is needed. The 1st phase of GERDA will measure with the existing enriched germanium detectors from the Heidelberg-Moscow and IGEX experiments. With these 15 kg, GERDA will be able to test the claim due to background reduced by a factor of 10 within one year.

Commissioning of the experiment starts in spring 2010.

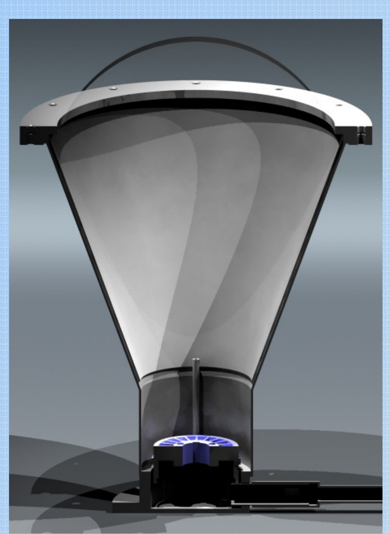


The LNGS is located below the Gran Sasso mountain region, about 150 km east of Rome. It is covered with an average of 1400 meters of rock, that provide about 3800 m.w.e. shielding.

GERDA-geometry, with final PMT distribution, used for the Monte-Carlo-simulations, implemented in the MaGe framework.

References:
1: M. Knapp, "The Gerda Muon Veto Cherenkov Detector", NIM-A 610 (2009) 280
2: J.S. Kapustinsky et al., "A fast timing light pulser for scintillation detectors", NIM-A 241 (1985) 612
3: B.K. Lubsandorzhiev et al., "Powerful nanosecond light sources based on LEDs for astroparticle physics experiments"
4: M. Knapp, "Design, Simulation und Aufbau des GERDA-Myonvetos", Doktorrabeit, 2009

The **muon veto** will consist of three independent detector systems. A layer of plastic scintillators above the penthouse will detect muons coming straight through the neck of the cryostat, while the water tank will be equipped with 4 times 10 PMTs on the wall and 20 more on the bottom [1].
It will act as an active **Cherenkov veto**. Six more PMTs just below the cryostat will complete the GERDA muon veto.
The PMTs are encapsulated in housings of stainless steel with a PET window at the front.
To protect the PMTs against the water, the contacts of the voltage divider are protected with polyurethane and silicone. Long-time tests (more than one year under water) show that the capsule is water tight.



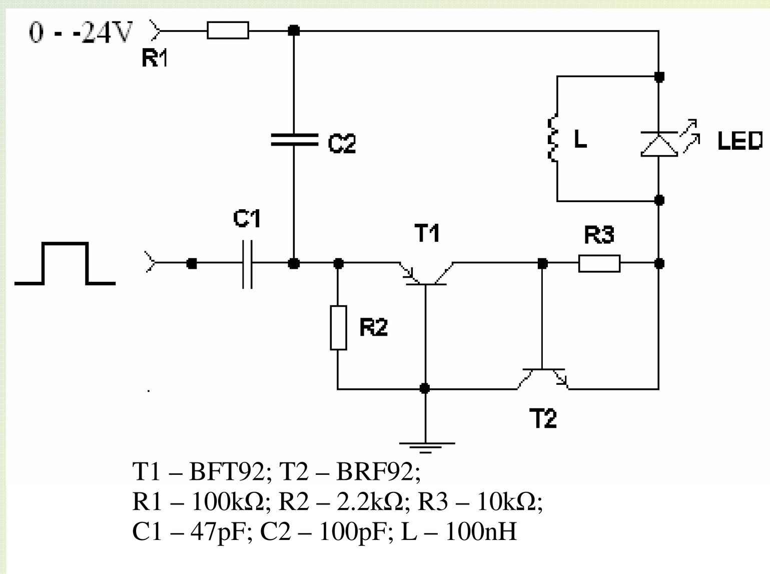
Sketch of the GERDA Photomultiplier capsule

Finished capsule with 32 m cable (RG 213 U)

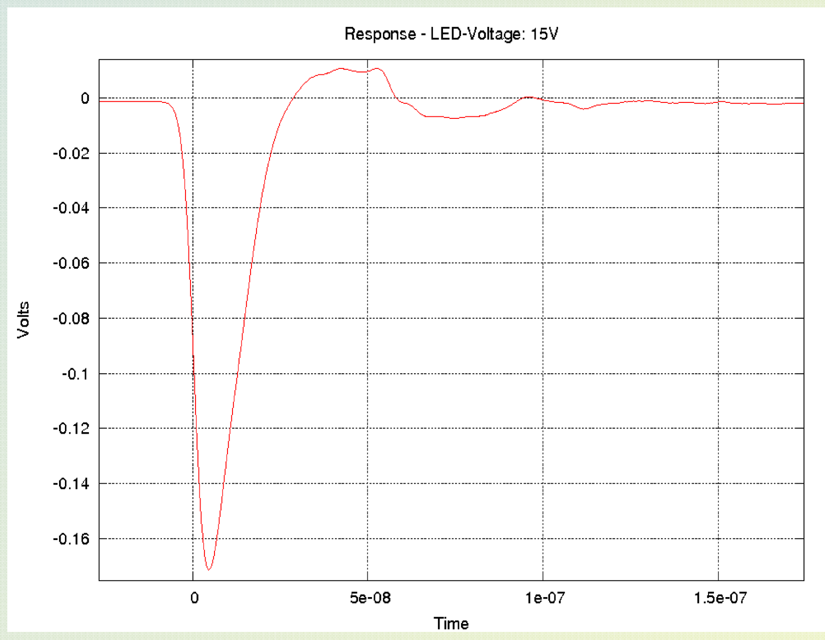
Mounted capsule on the wall of the water tank

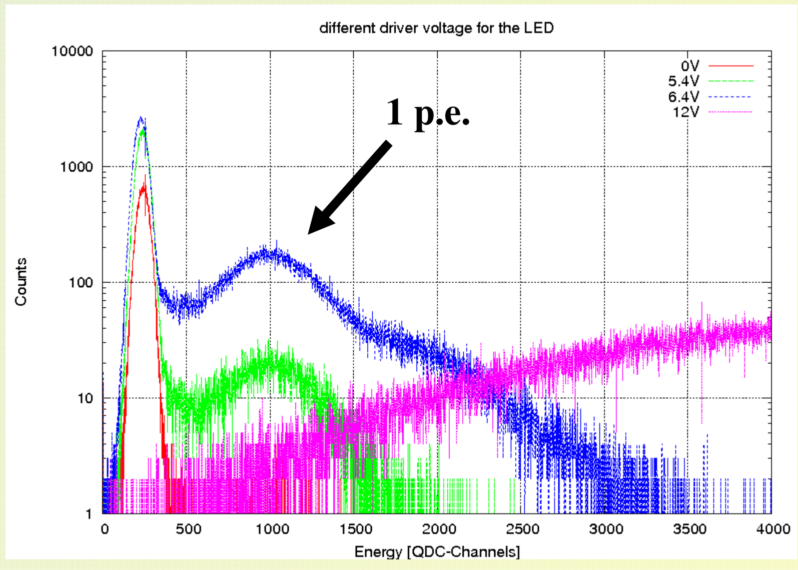
For **calibration and monitoring**, two systems will be implemented.

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. [2] (Figure on the right). 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: 1mm).



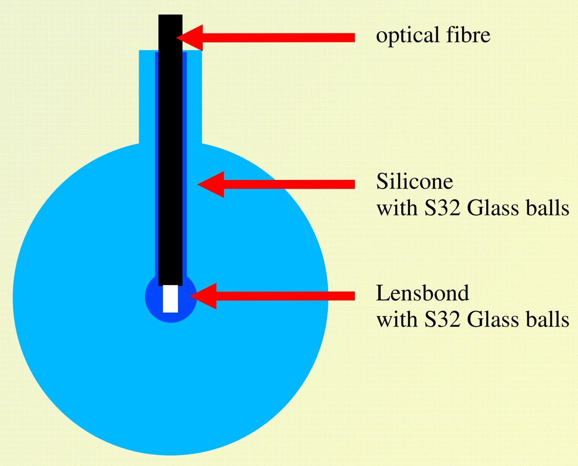
Sketch of the electronics for the LED.



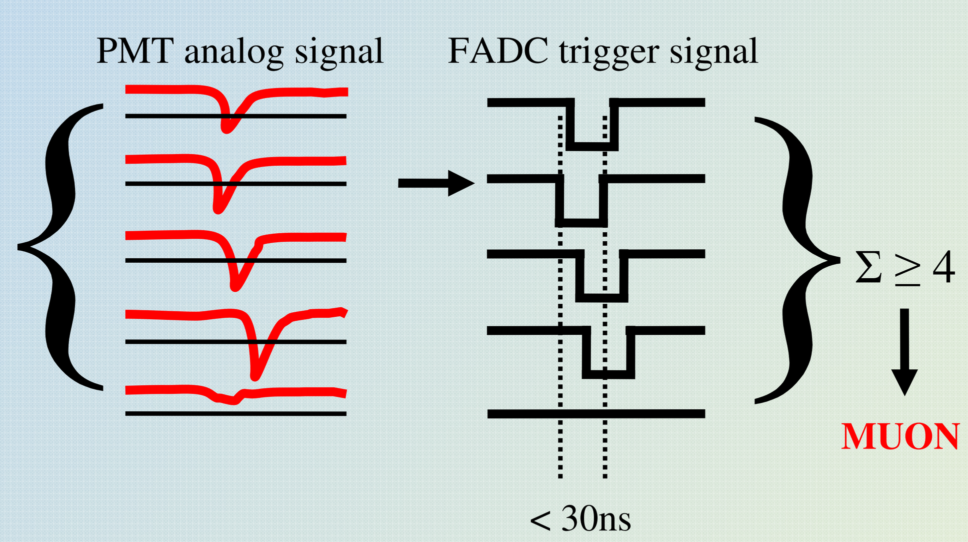


Light output of the system 1 for different supply voltages of the LED.

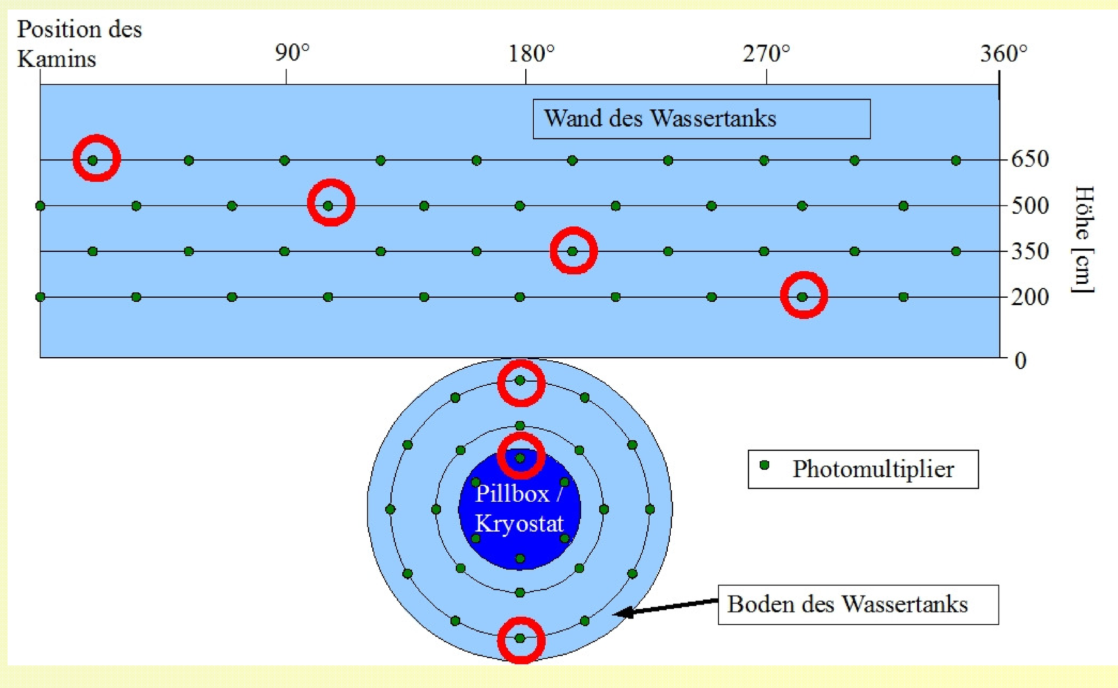
The **second monitor system** will use **diffuser balls** in the tank to illuminate it for geometry dependent calibration. Four of them will be located in the water tank, while one will be located in the volume under the cryostat. These balls are glass bulbs (diameter ~ 50 mm) filled with silicone (Wacker SilGel 612 A&B) mixed with S32 5 microns glass bubbles (3M). The light source itself consists of a high power blue LED and a special electronic driver based on three consecutively switched avalanche transistors [3]. It provides 10^{12} photons per pulse and is not adjustable.
The width of the light pulse is 10ns.
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 ball.



Sketch and Picture of one diffuser ball



The **DAQ** for the Water Cherenkov system consists of a VME crate equipped with 10 FADCs (SIS 3301). Each FADC is fed with the signals of one PMT of each ring on the wall and two of the bottom PMTs. The 6 PMTs of the volume beneath the cryostat ("Pillbox") are distributed on different FADCs. The trigger threshold for each PMT is set to single photo electrons. The triggers on one FADC are combined with logic "OR".
Signals are recorded as "muon", if 4 FADCs trigger within 30ns.
Simulations show an efficiency of > 99 % for this configuration.
The expected muon rate is ~100 mHz with a random coincidence rate of ~100 μHz.



Example for the configuration of one FADC

The water tank is fully equipped. The electronics will be installed within the next weeks and first signals from the PMT in the water tank will be seen.