The GERDA Muon Veto Cherenkov Detector

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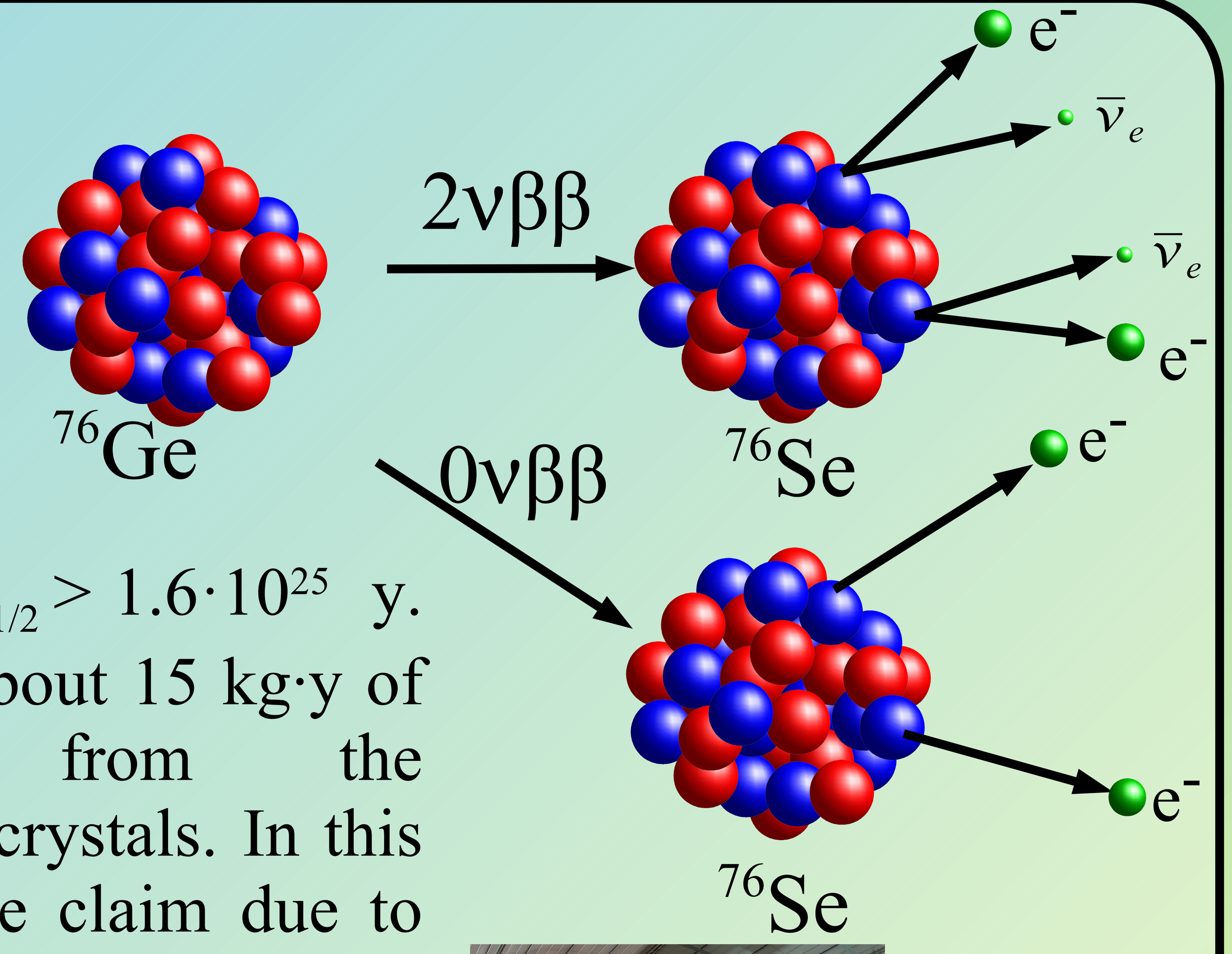
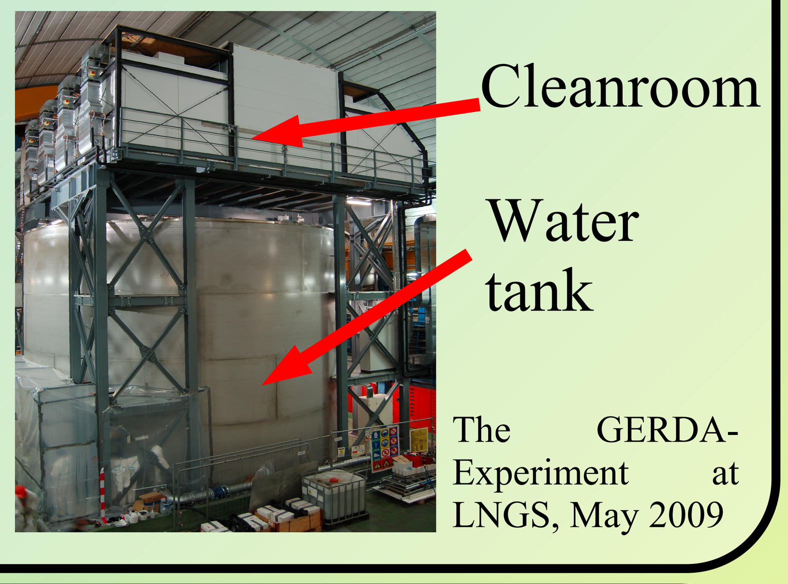
The **GER**manium **D**etector **A**rray (**GERDA**) is a new experiment to search for the neutrinoless double beta decay (**0νββ**) of ^{76}Ge. This very rare weakly interacting process is predicted to occur if the neutrino exhibits a mass and is a Majorana particle; i.e. it is its own antiparticle.
Although the 2νββ decay has been found in several nuclei, there is at this moment only a part of the Heidelberg-Moscow Collaboration claiming to have observed the neutrinoless double beta decay.

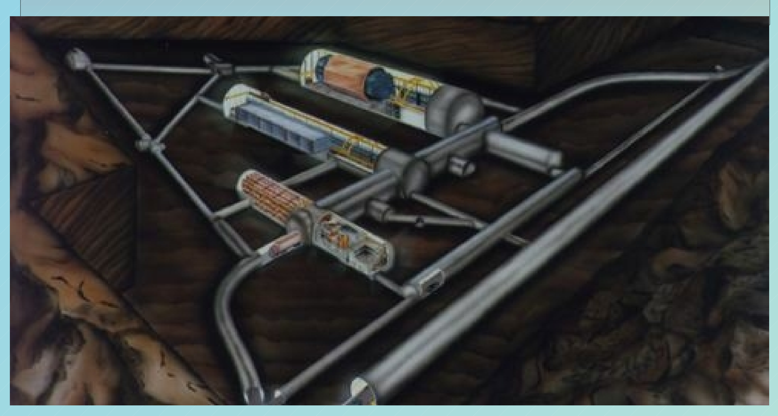


The LNGS is located below the Gran Sasso mountain region, about 150 km east of Rome. It is covered with an average of 1400 meters of rock, that provide about 3800 m.w.e. shielding.

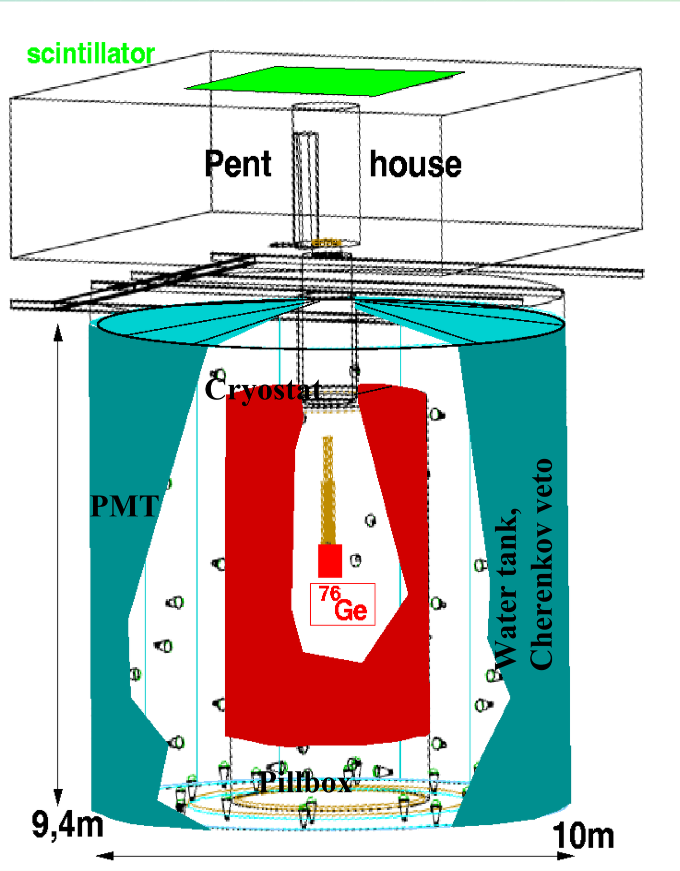
The best limit for the halflife is $T_{1/2} > 1.6 \cdot 10^{25}$ y.
GERDA's 1st phase will expose about 15 kg·y of enriched germanium detectors from the Heidelberg-Moscow and IGEX crystals. In this phase, we will be able to test the claim due to reduced background by a factor 10.
In a 2nd phase about 100 kg·y of data will be accumulated, leading to $T_{1/2} > 2 \cdot 10^{26}$ y.
At the moment the experiment is build up at the LNGS. Water tank, cryostat and cleanroom are installed (see right) and tested and now the muon veto is constructed on site.



The GERDA-Experiment at LNGS, May 2009

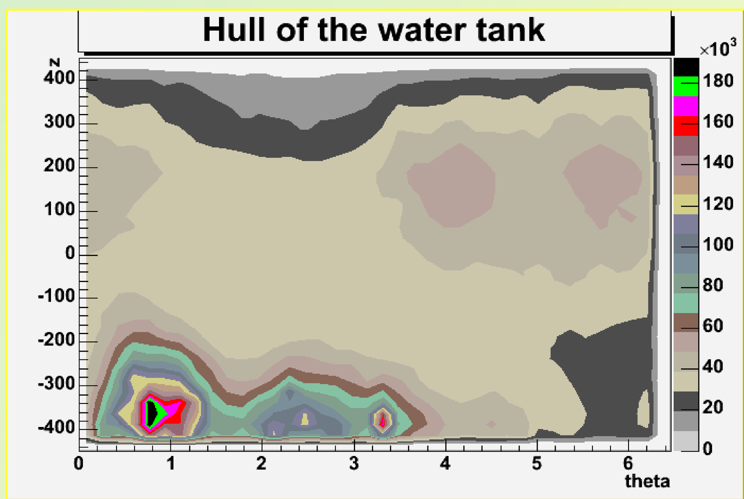


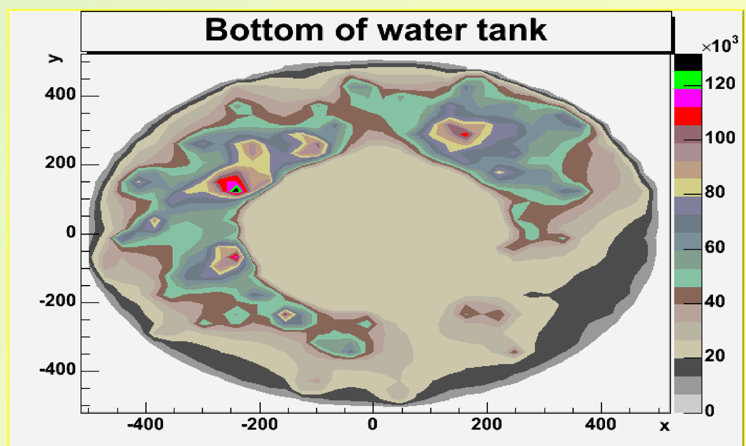
The **muon veto** will consist of three independent detector systems. A layer of plastic scintillator above the experiment will detect muons coming straight through the neck, while the water tank will be equipped with 40 PMTs on the wall and 20 more on the bottom.
To increase the efficiency of the muon veto, the surface of the water tank was covered with **VM2000**, a highly reflecting and wave-length shifting foil from 3M.
It will act as an active **Cherenkov veto**. Six more PMTs just below the cryostat (pillbox) will complete the GERDA muon veto.
The DAQ will use **SIS3301** FlashADCs from Struck systems. The trigger will require four PMTs in four different FADCs, or one of the plastic veto FADCs to fire.
For **calibration**, two systems will be implemented. The first feeds LED light pulses to each individual PMT, while the second one will use diffusor balls in the tank to illuminate it for geometry dependent calibration.

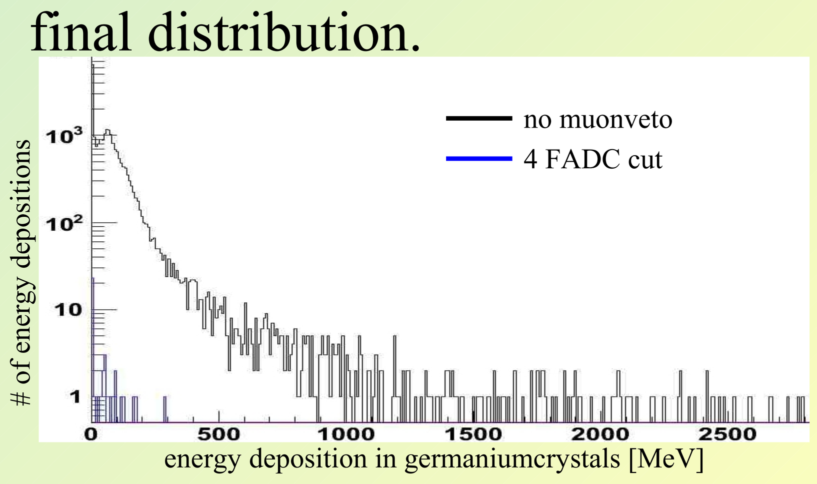


GERDA-geometry, with final PMT distribution, used for the Monte-Carlo-simulations, implemented in the MaGe framework.

To optimize the efficiency of the muon veto, extensive **simulations** have been performed. In a first step a spectrum of dangerous muons (i.e. energy deposition around $Q_{\beta\beta}$=2039 keV) was created.
For these muons, Cherenkov photon intensity maps for several surfaces, e.g. the hull of the water tank, have been simulated (shown on the right) to find a first hint for the final distribution. Thereafter simulations of different positions and numbers of PMTs lead to the final distribution.







Simulated energy deposition in germaniumcrystals without muon veto compared to a cut of 4 FADCs.

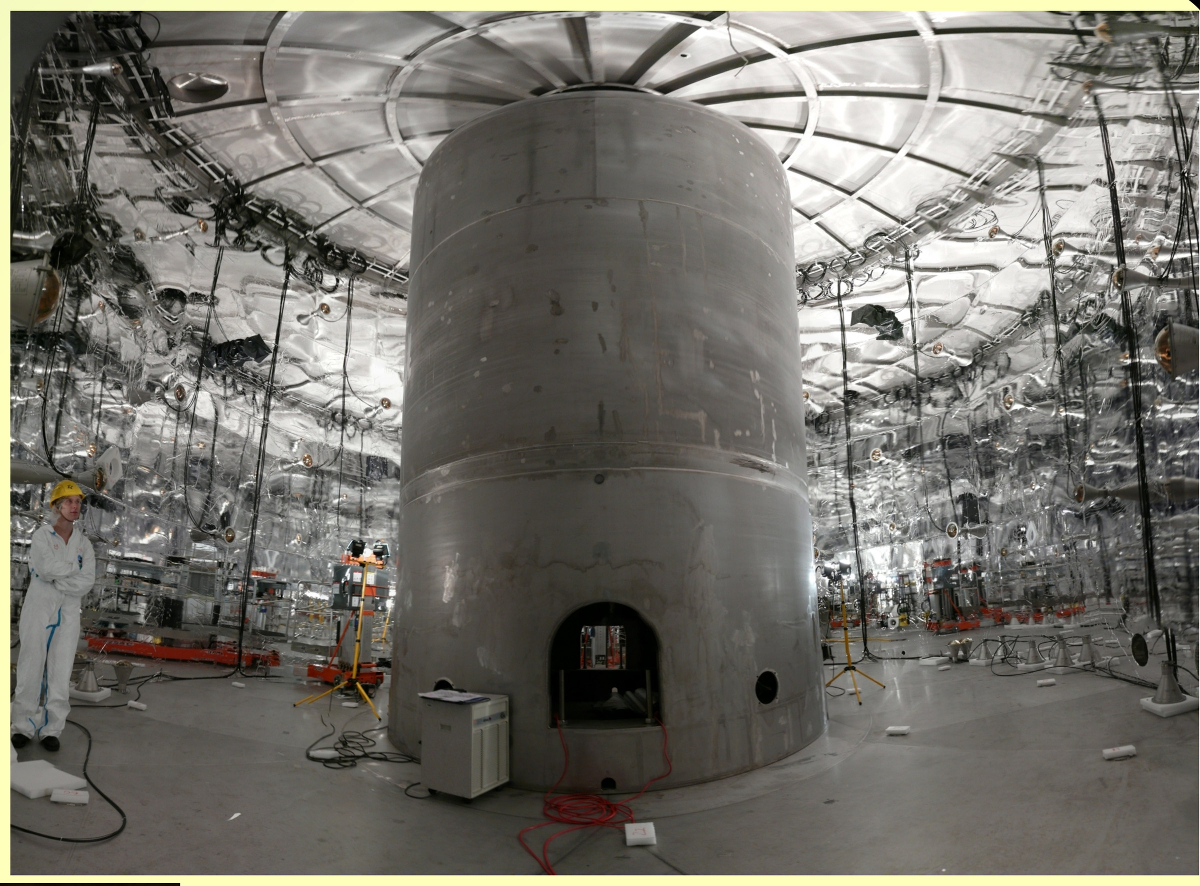
Recent simulations show, that an **efficiency** of more than 99 % can easily be achieved, reducing the muon induced background to a level of 10^{-5} events/(keV·kg·y).
A spectrum of the energy deposition in the germanium crystals is shown on the left.

The PMTs were encapsulated in housings of stainless steel with a PET window on the front. To protect the **photomultipliers** against the water, especially the sealing of the encapsulation was optimized. Several steps beginning with a shrinking hose followed by a block of polyurethane, that protects the voltage divider and finally a layer of silicone shield the contacts of the PMT. (see below)
At first, the water tank wall had to be covered with **VM2000**. For this, two mobile hoisting platforms were used. (see right)

Left: Sketch of the GERDA Photomultiplier encapsulation
Right: Finished encapsulation with 35 m cable (RG 213 U)

The **photomultipliers** on the wall were mounted, using the same platforms. The PMTs are fixed with two studs welded to the wall of the tank. Their cables are led upwards and over a cable tray through a chimney in the ceiling of the tank.

After that, the **optical fibres** of the 1st calibration system and the PMTs on the bottom were installed.
At the moment, all photomultipliers in the water tank are installed.
The VM2000 covering the wall of the tank is also mounted.



In **August 2009** the pillbox will be finished and the bottom of the watertank covered with foil. Additionally the 2nd calibration system will be installed.
For further information see:
M. Knapp et al., The Gerda muon veto Cherenkov detector, NIM A, in press