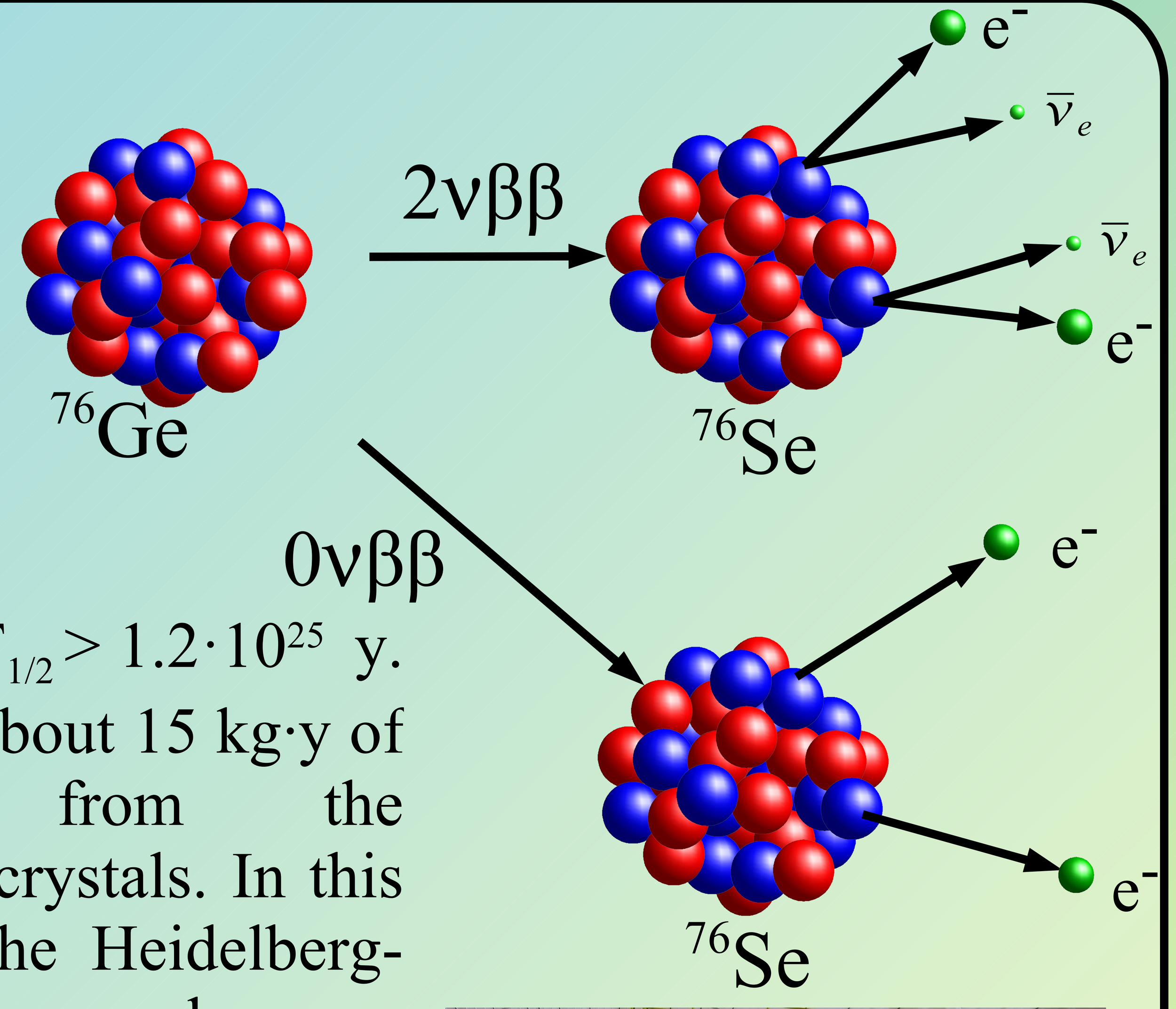
The GERDA Muon Veto Cherenkov Detector

Markus Knapp
Kepler Center for Astro and Particle Physics
University of Tübingen, Germany
NDIP 2008 – Aix les Bains

Universität Tübingen
Physikalisches Institut
Astroteilchenphysik

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, and thus annihilates during the double beta decay.

Although the 2νββ decay has often 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.



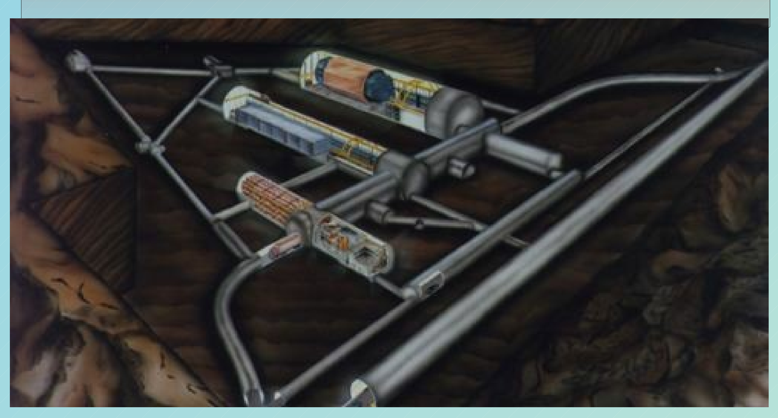
The LNGS is located below the Gran Sasso mountain region, about 150 km east of Rome. It is covered with an average of 1400 meters of rock, that provide about 3800 m.w.e. shielding.

Their best limit for the halflife is $T_{1/2} > 1.2 \cdot 10^{25}$ y.

GERDA's 1st phase will measure 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 Heidelberg-Moscow claim due to reduced background.

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. The cryostat for the germanium crystals is already installed (see right) and tested and now the water tank is constructed on site.

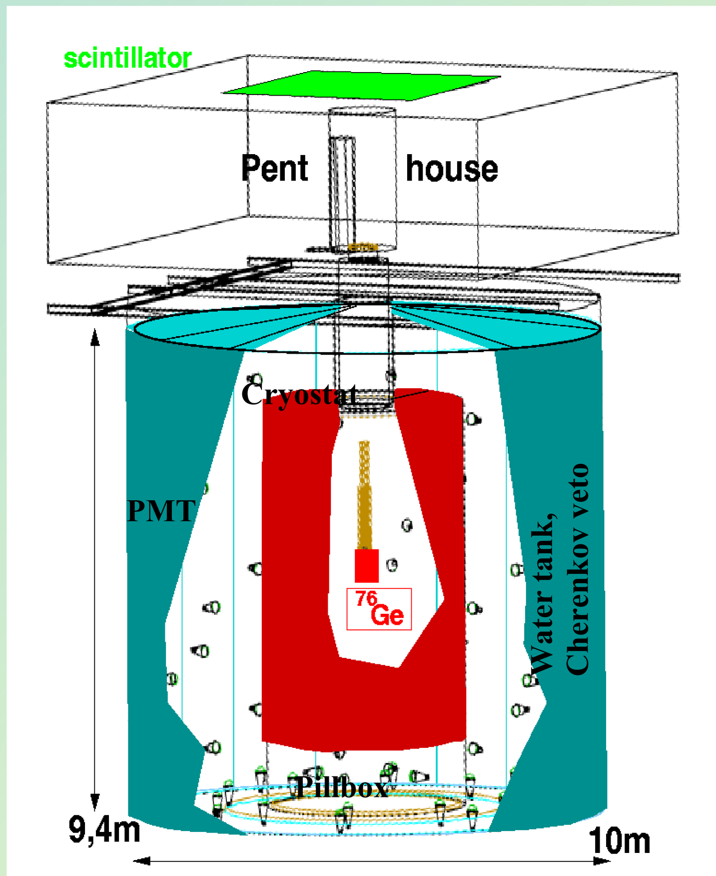


The **muon veto** will consist of three independent detector systems. A layer of plastic scintillator above the penthouse will detect muons coming straight through the neck, while the water tank will be equipped with 4 times 10 PMTs on the wall and 20 more on the bottom.

It will act as an active **Cherenkov veto**. Six more PMTs just below the cryostat (pillbox) will complete the GERDA muon veto.

The PMTs will be 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)

Long-time tests (One year under water) show that the encapsulation protects very well against water intrusion.



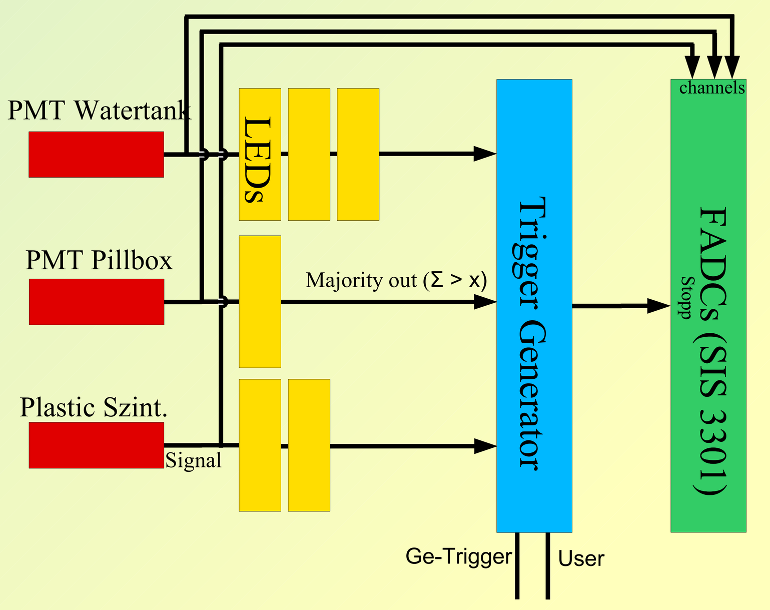
GERDA-geometry, with final PMT distribution, used for the Monte-Carlo-simulations, implemented in the MaGe framework.

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

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.

A conservative **trigger** will be a majority of 6 PMTs in the water tank or 3 PMTs in the pillbox, each with two photoelectrons produced within a time window of 40 ns. Simulations (see far right) show that this gives appropriate efficiencies.

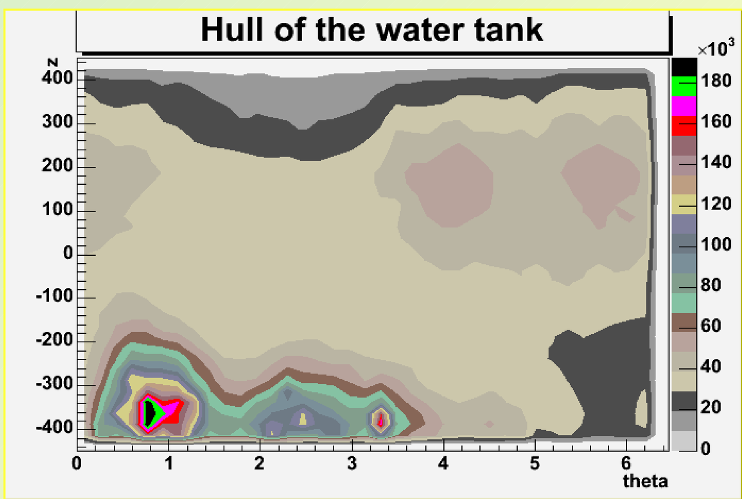
Considering the dark rate of the PMTs, this would also produce only mHz of random coincidences, and therefore be no problem.

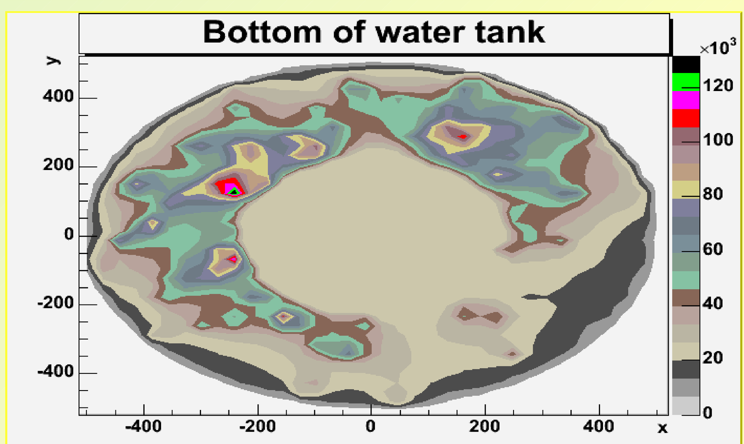


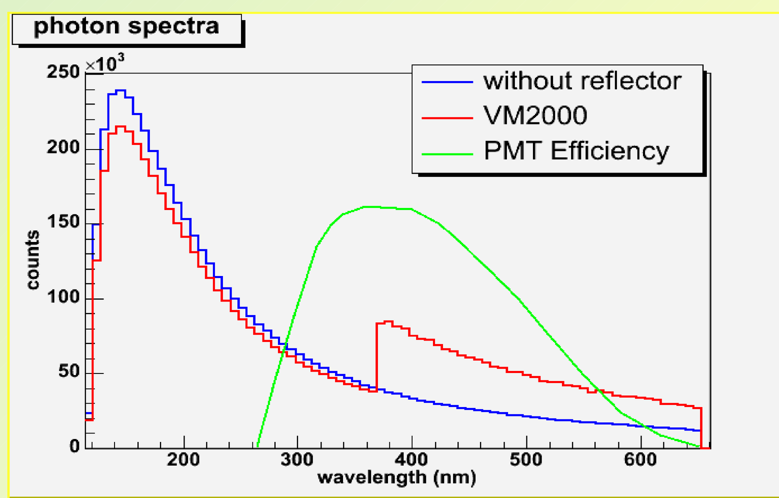
Sketch of the Muon Veto Trigger System, using a photomultiplier majority as trigger.

To optimize the efficiency of the muon veto, extensive **simulations** have been performed. In a first step a spectrum of dangerous muons (i.e. 2 MeV energy deposition) was created.

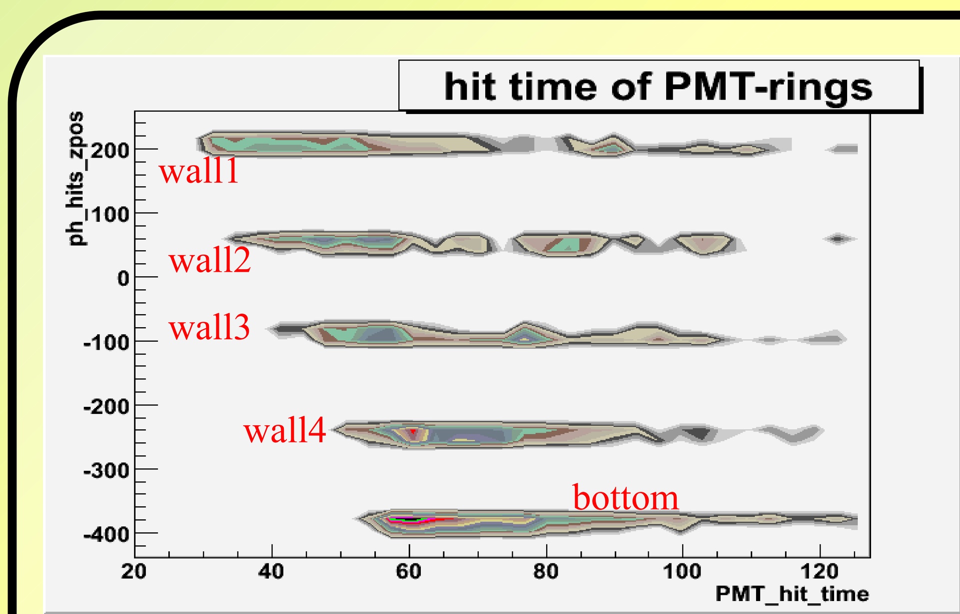
For these muons, photon intensity maps for several surfaces, e.g. the hull of the water tank, have been simulated (shown on the right) to find a first hint for the final distribution. Thereafter simulations of different positions and numbers of Photomultipliers lead to the final distribution shown on the left.







Another simulation was used to examine the effect of the reflector foil **VM2000** attached to most surfaces in the water tank. It has a high reflectivity and acts as a wavelength shifter (shown on the left). Both properties double the amount of detectable photons.



For the final distribution **efficiency** studies were accomplished, which showed that more than 98% of dangerous muons (muons with energy depostion around the 2 MeV of the neutrinoless double beta decay) will be detected.

According to the latest simulations, most of the Cherenkov photons (around 80%) will be detected within a time window of around 40 ns (see right). This allows to trigger on the photomultiplier signals directly (shown left).