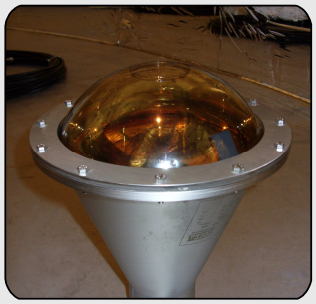
GERDA – Germanium Detector Array

searching for the

Neutrinoless Double Beta Decay

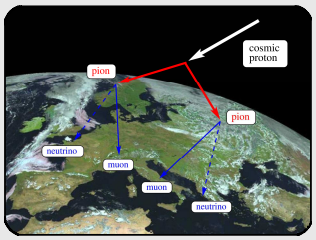


Muons (μ)

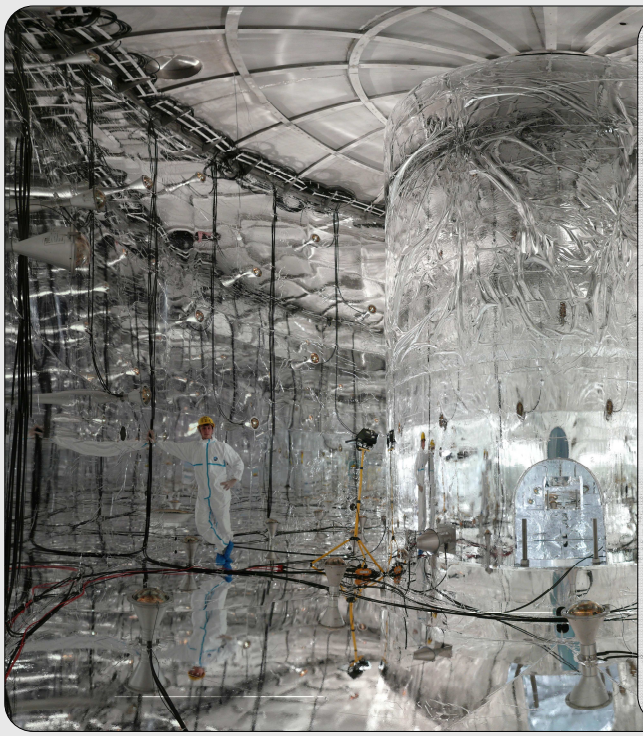
Muons are elementary particles with properties very similar to the well known electrons.

Muons have negative electric charge as well, but are about 200 times heavier than electrons. Muons with very high energies are generated by cosmic rays in the upper part of the atmosphere.

On the earth's surface, a flux of ~(100-200) muons per m^2 and per second can be observed. This is why the experiment is located underground. Most of the muons are stopped by the Gran Sasso mountains. However, some reach the detectors of GERDA in the underground laboratory. By depositing part of their energy in the germanium detectors, they can look like real neutrinoless double beta decay signals. To remove these false signals, they must be identified correctly by the light detectors.



Light detectors identify cosmic muons



GERDA requires a very low background level as the maximum expected signal rate is on the order of 10 events per year. The Gran Sasso mountain reduces the muon flux by more than a factor of 100.000. The remaining flux of 60 muons per hour hitting the experiment still exceeds the required background level.

Most muons are of extremely high energy, i.e. highly relativistic. Their velocity in water is higher than the velocity of light in water. In this case - similar to the super-sonic effect - blue light consisting of thousands of photons, is produced. This is called the Cherenkov light.

The water tank surrounding the detector cryostat is equipped with 66 light detectors. Thus, if a muon passes through the pure water, these detectors sense the Cherenkov light, and convert it into an electric signal indicating the presence of a muon.

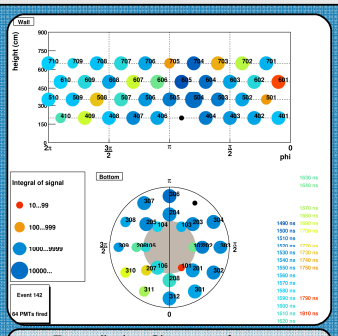
Water can easily be purified and can be handled much more comfortable than standard lead or copper shieldings. The water is sufficiently thick to shield against gamma radiation and neutrons, which are emitted by the surrounding rock.

The water tank of GERDA has a diameter of 10 m and a height of 9 m; the water level rests at 8.4 m. In total it contains 580 m^3 of purified water, which weighs 580 tons. The whole tank can be emptied in less than 2 hours without flooding the autostrada.

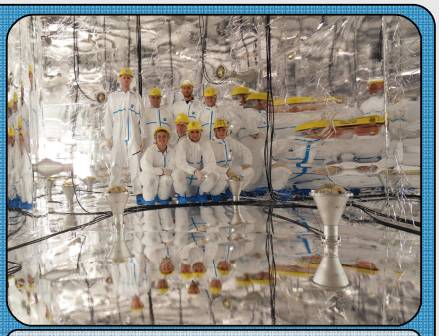
To detect the Cherenkov light 66 „photomultiplier tubes" (PMTs) are installed in the water tank. These light detectors are capable of seeing a single photon. To increase the probability for the photons to be seen by the PMTs, almost all surfaces inside the water tank are covered with a highly reflective foil. With this setup, there is a 99.5% chance to detect a traversing muon.

If a muon is identified, a signal is sent to the germanium data acquisition that a muon was present.

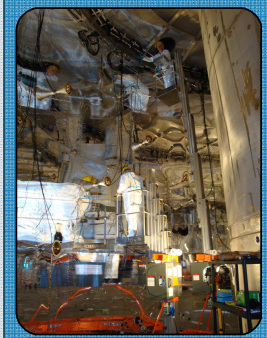
For calibration two light emitting systems are installed. Firstly, an optical fibre is mounted on each PMT which can be illuminated with light pulses from a LED. Secondly, five bulbs are hanging inside the water tank, which are able to homogenously illuminate the entire volume. With these systems it is possible to test and calibrate the response of the PMTs within a short time.



Event display: Signature of a muon



The muon veto is complete!



Mounting of the PMTs

Encapsulation procedure of the PMTs