A new ^{76}Ge Double Beta Decay Experiment at Gran Sasso (hep-ex/0404039)

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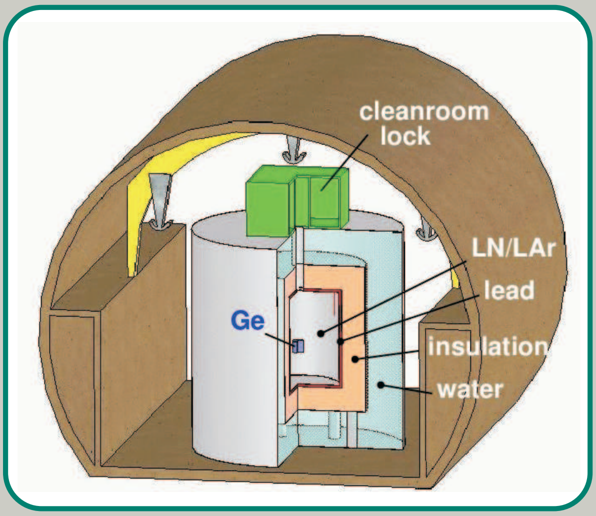
Motivation

- Experiments using ^{76}Ge as source and detector are presently most sensitive Double Beta Decay experiments.
- Part of Heidelberg-Moscow collaboration has reported 4.2-sigma evidence for neutrinoless Double Beta Decay. Corresponding Majorana neutrino mass: 0.2 eV - 0.6 eV.
- The running CUORICINO and NEMO experiments may reach 0.3 eV sensitivity region within a few years, but uncertainty with respect of matrix element remains.

A new ^{76}Ge experiment is required to confirm the current result with higher significance or to refute it.



New facility at Gran Sasso

- Current experiments limited by external background: Heidelberg-Moscow: 0.2 counts/(keV·kg·y) around 2039 keV.
- New low-level facility based on bare germanium diodes in a cryogenic liquid shield at Gran Sasso.
- Liquid nitrogen and liquid argon shield under investigation.
- Letter of Intent [Abt 04] well received by Gran Sasso sientific committee.

Goal:

Background reduction to:

- **10^{-3} cts/(keV·kg·y) for LN_2 shield**
- **10^{-4} cts/(keV·kg·y) for LAr shield**

Phase 1:

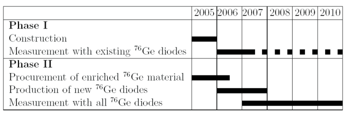
- Design and construction of tank.
- Operation of the existing ^{76}Ge detectors from Heidelberg-Moscow and IGEX experiment (about 15 kg).

Goal: Unambiguous check of current evidence with high significance.

Phase 2:

- Adding new detectors (up to 40 kg).
- Minimization of cosmic ray exposure during detector fabrication.

Goal: Operation of 100 kg·years, lifetime sensitivity >$2\cdot10^{26}$ years.

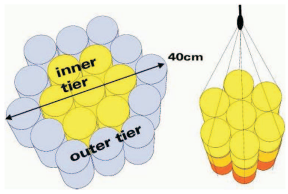


Time schedule for phase 1 and 2.

Phase 3:

- Ultimate experiment aiming to 10 meV scale needs O(1t) of enriched Ge.
- Requires world-wide collaboration.

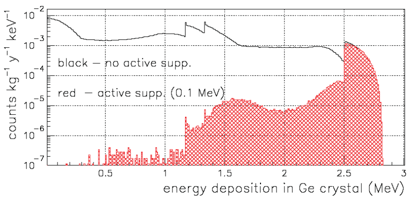
Assembly of bare Ge diodes



- Active background supression by anti-coincidence counting in neighboring diodes.

Liquid argon instrumentation

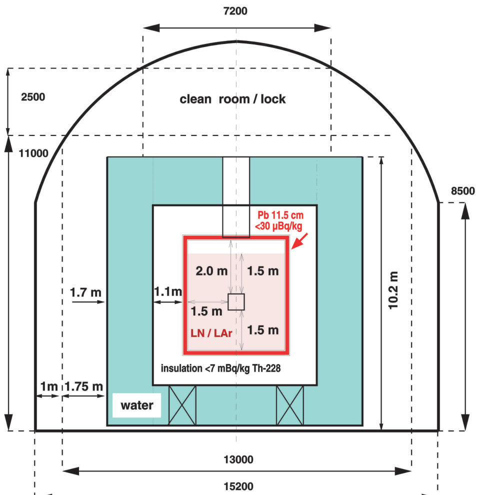
- LAr scintillation allows further suppression of background.
- see dedicated poster.



Simulated background spectrum for 0.18 µBq/kg of ^{60}Co in the diodes with and without active suppression (0.1 MeV threshold for the LAr scintillation assumed).

Tank design

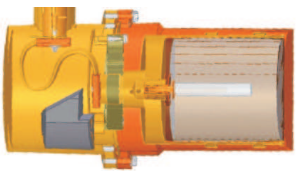
- Graded shield against external gamma rays and neutrons.
- Combination of cryogenic liquid, lead and water shield.
- Cherenkov light in water provides muon veto.

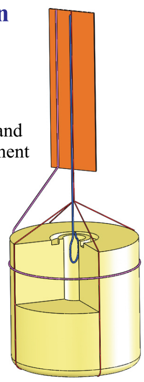


Cross section of the hall A of the Gran Sasso laboratory and a possible tank design with a conventional shield (water/lead) and a cryogenic liquid shield (LN_2/LAr). This design requires a low ^{228}Th contamination of the insulation.

Electrical contacts and suspension

- Reduction of material in direct contact to the detector with respect of mass (~1000 times less) and of surface (~200 times less).
- Conventional housing of a Ge detector (below) and a very low mass design proposed for the experiment (right side).





R&D in progress

- Suspension for relative positioning and easy access to detectors.
- Lock on top of tank to insert and withdraw detectors without contamination.
- Detector segmentation.
- Potential of pulse shape discrimination.
- Muon and neutron background.
- Purification techniques for liquid argon and liquid nitrogen.
- Material screening.
- Development of new low-level techniques for monitoring and analysis.

Conclusions

- **New facility will unambiguously confirm or refute current evidence within 1 year of measurement.**
- **Reduction of background by factor 100 to 1000 compared to current ^{76}Ge experiments.**
- **Lifetime sensitivity of $2\cdot10^{26}$ years will be reached at the end of phase 2.**

Reference

[Abt 04] I. Abt et al., *A new ^{76}Ge Double Beta Decay Experiment at LNGS*, Letter of Intent, hep-ex/0404039.