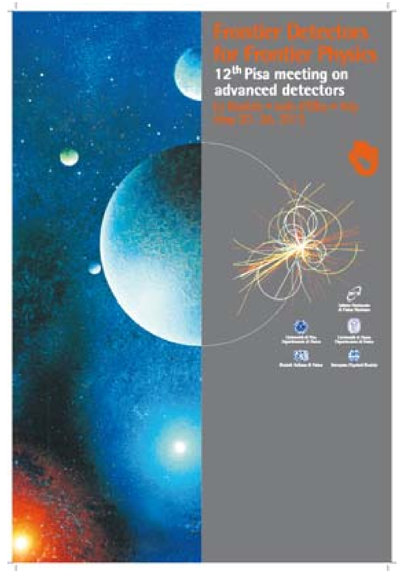
# Status Report of the GERDA Experiment Phase I

S. Riboldi on behalf of the GERDA Collaboration

(95 Physicists and 17 Institutions from Germany, Italy, Russia, Poland, Belgium, Switzerland, China)



## The GERDA Experiment

Phase I of GERDA, aimed at investigating neutrino-less double beta decay of $^{76}$Ge, is active at INFN LNGS – Italy, since November 2011.
The facility will serve 4 purposes: i) prove the Majorana nature by searching for the 0νββ of $^{76}$Ge with a sensitivity of $T_{1/2} > 10^{25}$ y; ii) probe the neutrino mass at the level of 300 meV, in a couple of years of data taking, iii) demonstrate as a pioneering low radiation level facility the background reduction by 2 order of magnitudes and iv) definitely validate the operation of non-encapsulated Germanium detectors in liquid Argon.

## Experimental Set-Up

For the first time in a physics experiment, 8 enriched bare coaxial Germanium detectors and 3 non-enriched ones are operated since months immersed in liquid Argon, acting as shield against external radiation and as cooling medium; the cryostat is surrounded by a tank containing ultra-pure water, equipped with photo multiplier tubes to veto the residual cosmic muons.

Fig. 1: The GERDA site at LNGS, showing the water tank.

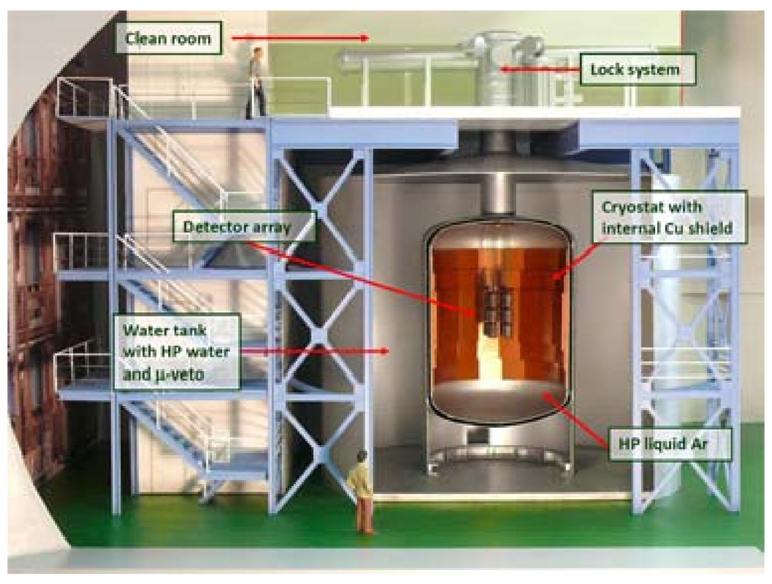



Fig. 2: Conceptual set-up of the GERDA infrastructure.

Fig. 3: The three-string arm inside the GERDA glove box, holding three Ge detectors during the set-up phase.

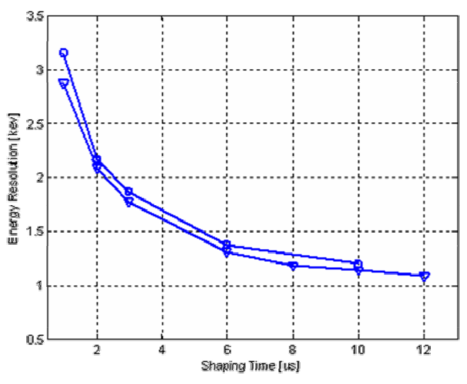
Fig. 4: Inside view of the GERDA water tank

## Germanium Front-End Electronics and DAQ system

The requirements of low radioactivity and cryogenic operation impose stringent conditions on the design and manufacturing of the charge sensitive preamplifiers.
The CC2 is a low-noise hybrid Charge Sensitive Preamplifier (CSP), based on two active components: the BF862 n-channel JFET (NXP Semiconductors) as the front-end device and a subsequent CMOS operational amplifier, the AD8651 (Analog Devices).

CSP intrinsic best energy resolution at liquid Nitrogen temperature (with no added input capacitance) is 0.7 keV, with 2.2 eV / pF noise slope (all values are FWHM, for 12 us shaping time, in Ge detectors); the energy dynamic range is 9 MeV (for 0.3 pF feedback capacitor); it has 50 Ohms driving capability over 10 meters long coaxial cables and signal rise time less than 100 ns with terminated, long cables; measured inter-channel cross-talk is less than 0.1%, while estimated linearity is better then 1/1000; power consumption is less than 45 mW/channel.

Preamplifier signals are driven out of the cryostat by means of low-impedance coaxial cables, up to a dedicated digital acquisition system based on free running ADCs (100 MHz, 14 bit).
Dedicated signal processing techniques are finally applied to extract the information of interest (energy, time, baseline level, noise, etc.)



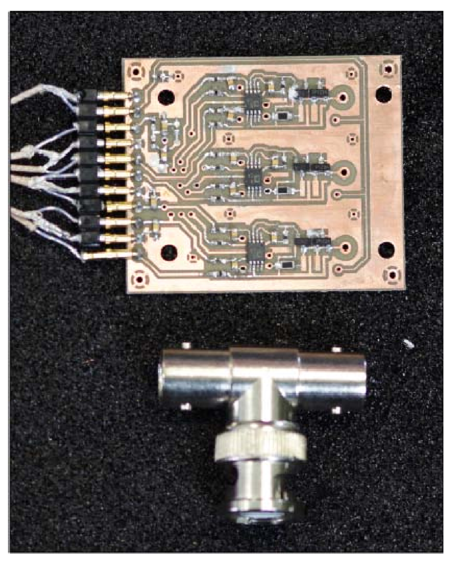



Fig. 5/6: Pulser energy resolution and picture of the CC2

## Energy Resolution during Calibration Runs (typical)

Energy is reconstructed by using digital algorithms; several options are available (based on moving window deconvolution, gaussian shaping, GAST algorithm, baseline estimation, etc.) and the results are quite in agreement with the specifications, apart from a few detectors. Because of the peculiar experimental set-up, some environmental noise contributions (conducted electrical noise, electro-magnetic fields, microphonism, etc.) still limit the theoretical energy resolution achievable with standard encapsulated Ge detectors.

## Experimental Set-Up Stability over Time

Because of the intrinsic nature of the GERDA experiment, stability of parameters such as energy resolution, peak positions of calibration sources and reference pulser, detector leakage current, etc. are extremely important.

All the 11 operated detectors, but 2, currently exhibit stable reverse currents of the order of tens of pA. From our previous experience, the 2 problematic ones suffer from surface current, that could be eliminated by reprocessing the detector groove surface.

The overall stability of the system is satisfactory, apart from a few unexpected global shifts in the peak position of the reference pulser, regarding almost all detectors and probably related to programmed black-out of mains power supply for general maintenance.

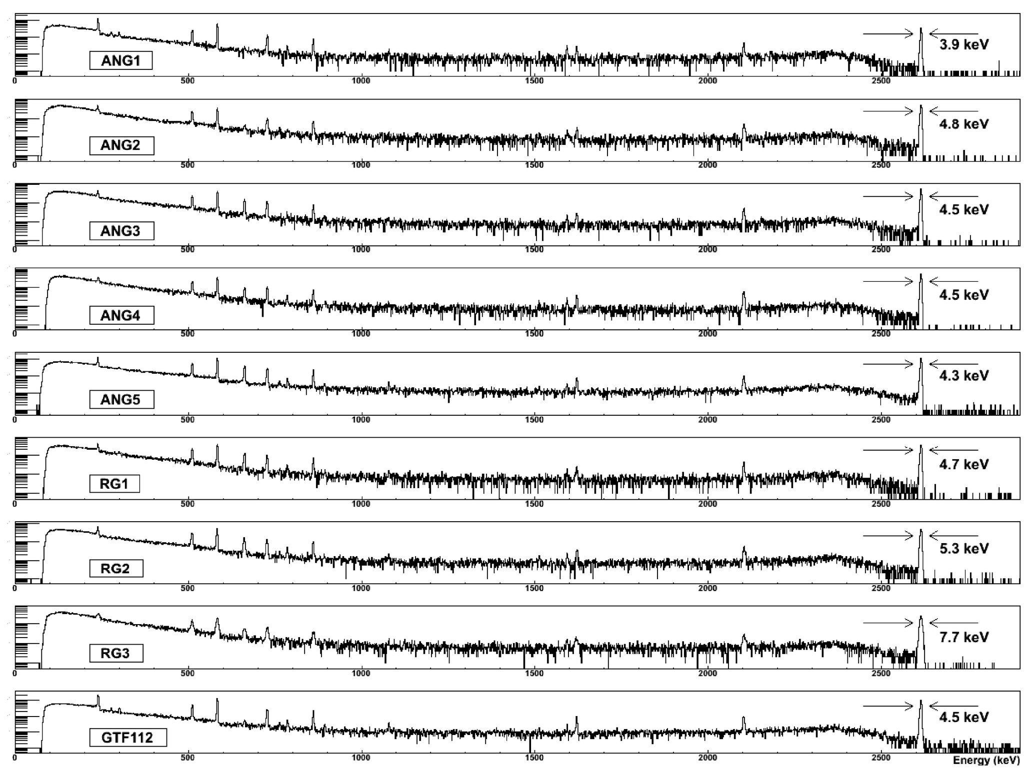



Fig. 9: Typical energy spectra of calibration runs for 9 GERDA Ge detectors (8 enriched). The energy resolution at 2.6 MeV is comprised between 3.9 keV and 7.7 keV FWHM, with an average value of 5 keV.

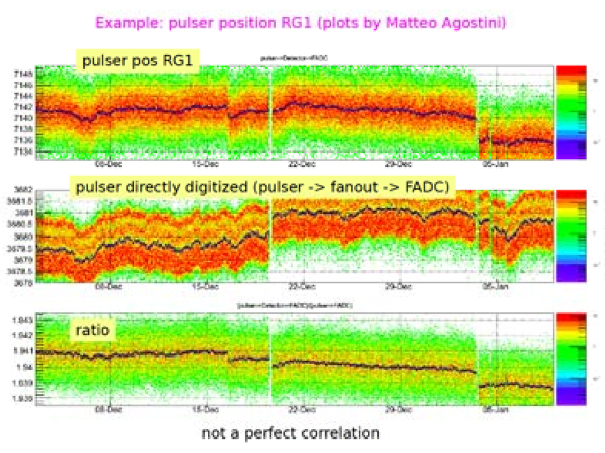



Fig. 7a: Pulser energy peak for RG1 detector and pulser amplitude as directly estimated by the FADC, versus time.

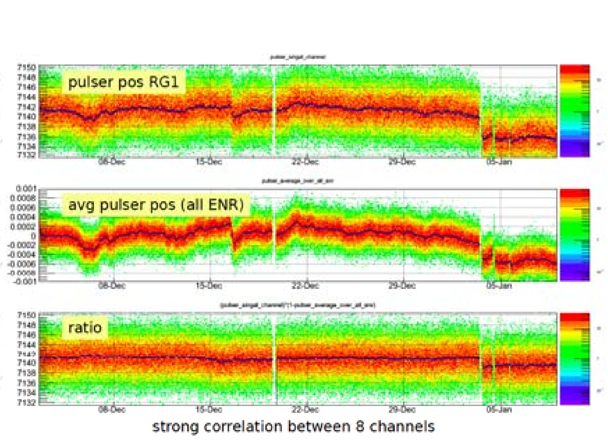



Fig. 7b: Pulser energy peak for RG1 detector and average amplitude of pulser energy peak for all detectors, versus time.

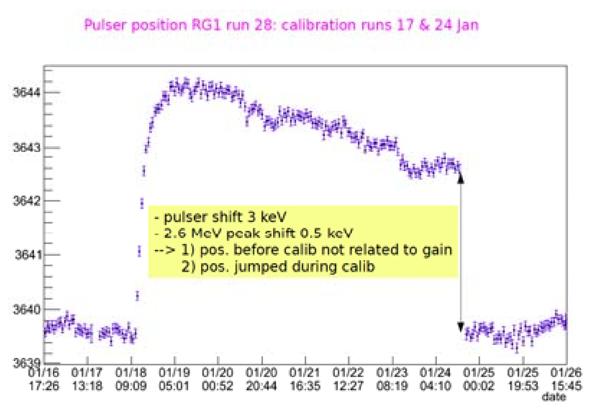



Fig. 8: Pulser energy peak position for RG1 detector, showing changes of the order of 1/1000 before and after a calibration run.

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