Final Report on Exchange of key technical personnel

Two main exchanges of key personnel were organized, as foreseen in the original proposal.

1) Visit of Dr. Pascovici to Padova-LNL regarding the electronics development for the GALILEO gamma-array in LNL.
Report on the test of the GALILEO Triple Cluster detector

In the period October 3 – 18, 2012 the GALILEO Triple Cluster (GTC) detector was tested with the front–end electronics.
The cryostat was mounted by the mechanical workshops of INFN Padova and Legnaro as shown in Fig. 1. We used the three dummy capsules received from the Gammapool to simulate the real load in the cryostat. Vacuum tightness could not be ensured for this test so that we used the cryostat warm, without LN_2.

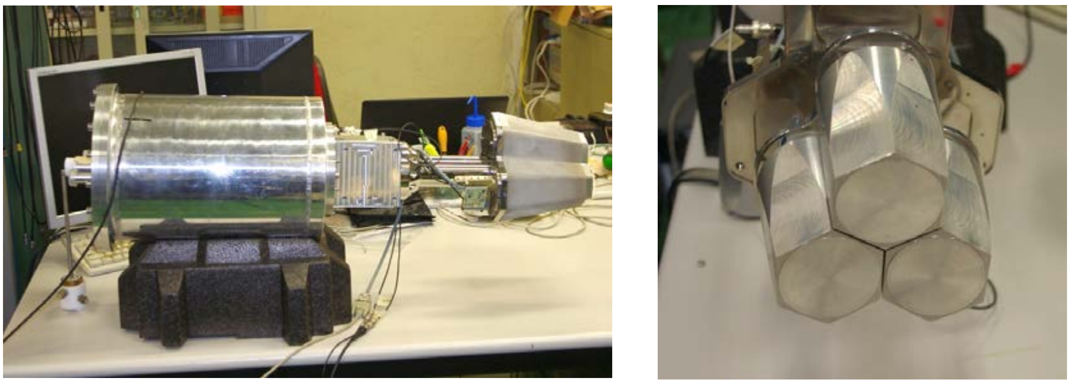


Fig. 1: The GTC cryostat fitted with the front – electronics and three dummy capsules.

The goal of the tests was to verify the mounting of all the mechanical parts and of the front–end electronics and to test the electrical quality of the cryostat with the final electronics. Mainly we were interested in finding the best solutions for grounding and shielding of the electronics and quantify the electronic noise level.
The tests were performed together with dr. G. Pascovici from IFIN-HH Bucharest who joined us for a couple of weeks within the EGAN program for exchange of experts. His expertise was very important for the proper mounting of the electronics and for the performance of qualifying tests.

The tests were performed with only one chain of electronics. The real Ge detector was simulated by a capacitor of 35 pF connected at the preamplifier input. The cold part board was recovered from one of the three EUROBALL capsules assigned to us by the Gammapool. One can see on the left–hand side of Fig. 2 the cold part mounted on one of the dummy crystals. The original EUROBALL FET was replaced with the SMD BF862 model as needed for the GTC. On the right–hand side of Fig. 2 the warm part of the preamplifier is shown; it is fixed on a PCB that is connected to a DB9 vacuum feedthrough. The solution of using a PCB for the mounting of the preamplifier is similar to what we used until now for the GASP detectors. The PCB will also hold the shutdown circuit and transmit the signals to the upper panel connectors that for the present tests were replaced with cables directly soldered on the PCB. The length of the wires inside the cold part are of about 10 cm.

Low voltage was provided to the preamplifier by the low–voltage power supply built by the electronic laboratory of INFN Padova.

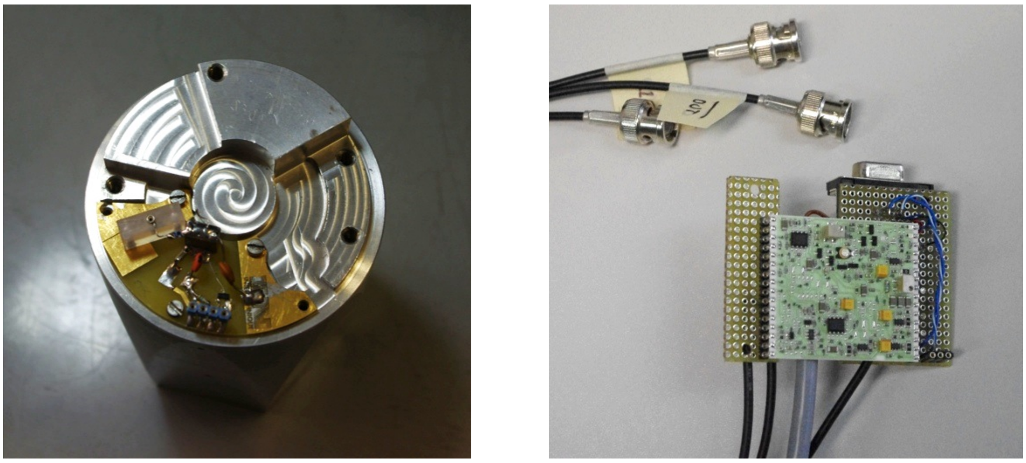


Fig. 2: The GTC cryostat fitted with the front – electronics and three dummy capsules.

A pulser signal was provided to the entrance of the preamplifier with a height corresponding to 1 MeV gamma ray equivalent energy and spectra were acquired with an ORTEC Spectroscopy Amplifier accepting differential inputs and a TRUMP PCI multichannel analyzer card.

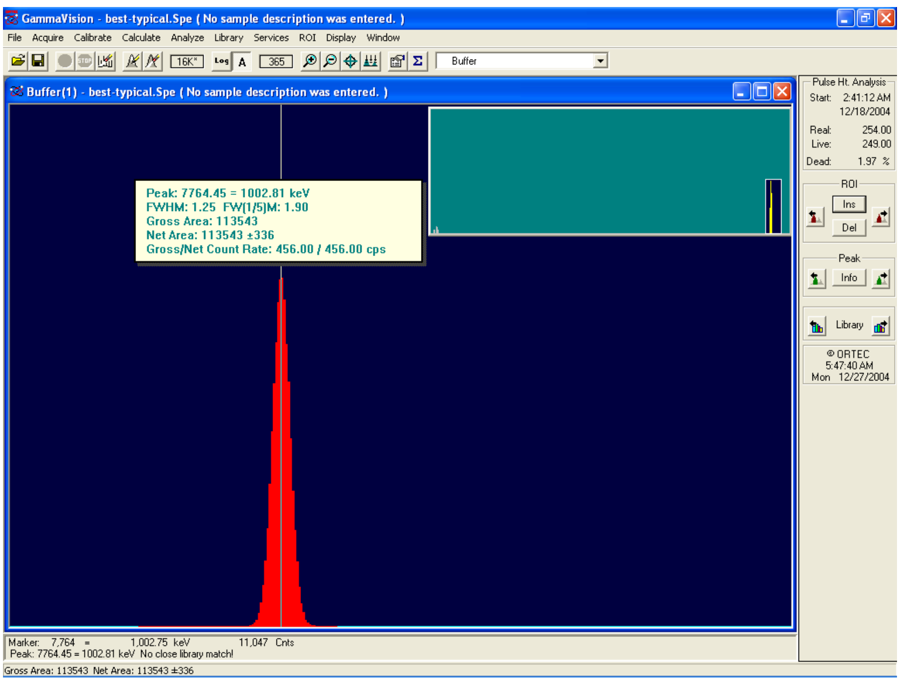


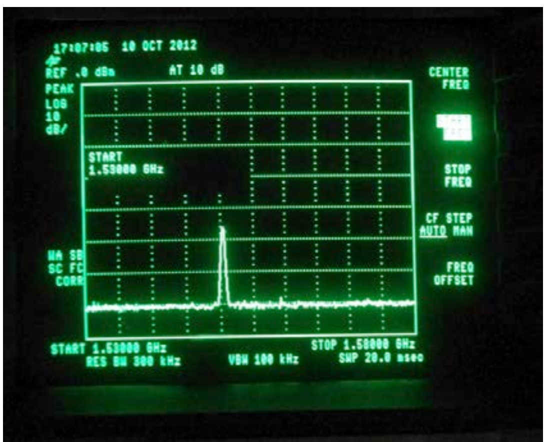
Fig. 3: Energy spectrum recorded with a pulser corresponding to a gamma–ray equivalent energy of 1 MeV.

The recorded peak shows an energy resolution of about 1.25 keV (see Fig. 3) corresponding to electronic noise, grounding and shielding. The characteristics of the GALILEO preamplifier are summarized in Table 1. The intrinsic noise of the preamplifier (FWHM) at 0 pF detector capacity and the FET at 150 K is of 0.6 keV. This noise has a slope of 8 eV/pF. Since we used a capacity of 35 pF to simulate the detector, the FWHM corresponding to the intrinsic preamplifier noise is of about 0.9 keV. A deterioration of the FWHM of about 0.3 keV is expected due to the operation of the FET at room temperature. The excellent value of 1.25 keV shows the good quality of the wiring, of the grounding and shielding of the capsules and front–end electronics in our cryostat.

Table 1: Main characteristics of the GALILEO preamplifier (A.Pullia, G.Pascovici, C.A.Ur, submitted to IEEE Nuclear Science Symposium 2012).

Property	Value	Tolerance
Conversion gain	100 mV / MeV (terminated)	±10 mV
Noise	0.6 keV FWHM (C_d=0 pF @ 150K)	
Noise slope	8 eV / pF	±2 eV
Rise time	~13 ns (0 pF)	±2 ns
Rise-time slope	~0.2 ns / pF	
Decay time	50 μs	±2 μs
Integral non linearity	< 0.025% (dyn.~3.5V)	
Output polarity	Differential, Z_o=100Ω	
Fast reset speed	10 MeV/μs	
Inhibit output	LVDS or CMOS	
Power supply	± 6.5 V, ± 12.5 V	±0.5V
Power consumption FET	< 20 mW	
Power consumption (except diff. buffer)	< 350 mW	
Supplementary power at very high counting rates	~230 mW	
Mechanical dimension	1.6 x 1.8 inch	

We used an analog spectrum analyzer from HP to measure the frequency composition of the noise.



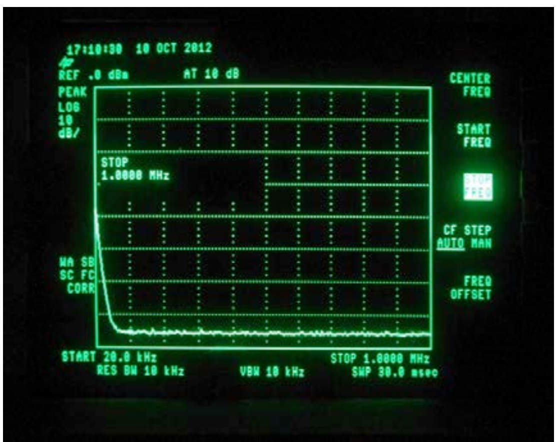


Fig. 4: Frequency spectra recorded with an HP spectrum analyzer connectred at the output of the preamplifier.

The main component observed in the frequency spectrum located at ~1.55 GHz corresponds to the resonant cavity (the vessel of the dewar) eigenfrequency (see Fig. 4). Another screenshot in the range from 20 kHz to 1 MHz shows no evident peaks in the region of interest for spectroscopic analysis.

Signals were also digitized and recorded with a CAEN N1728A module running at 100 MS/s and 14 bit accepting differential signals at input. Fig. 5 shows 50 microsec. of signal (20 microsec. of baseline before the signal).

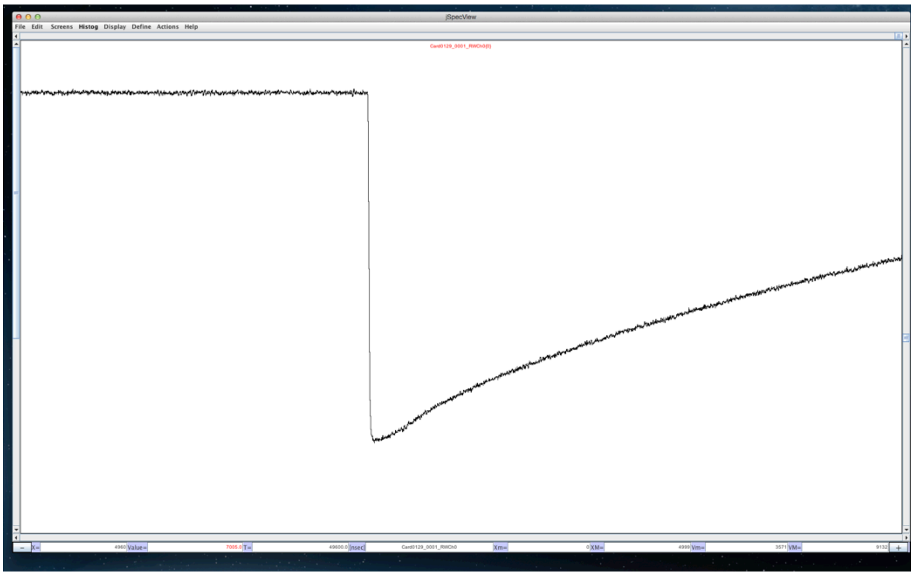


Fig. 5: Digital sampling of the pulser signal at 100 MS/s and 14 bit. The full length of the trace is 50 microsec.

By applying a mowing window deconvolution analysis to these signals we reconstructed the energy spectrum of the pulser shown in Fig. 6. The obtained resolution is about 1.21 keV similar to the one measured with the analog acquisition system.

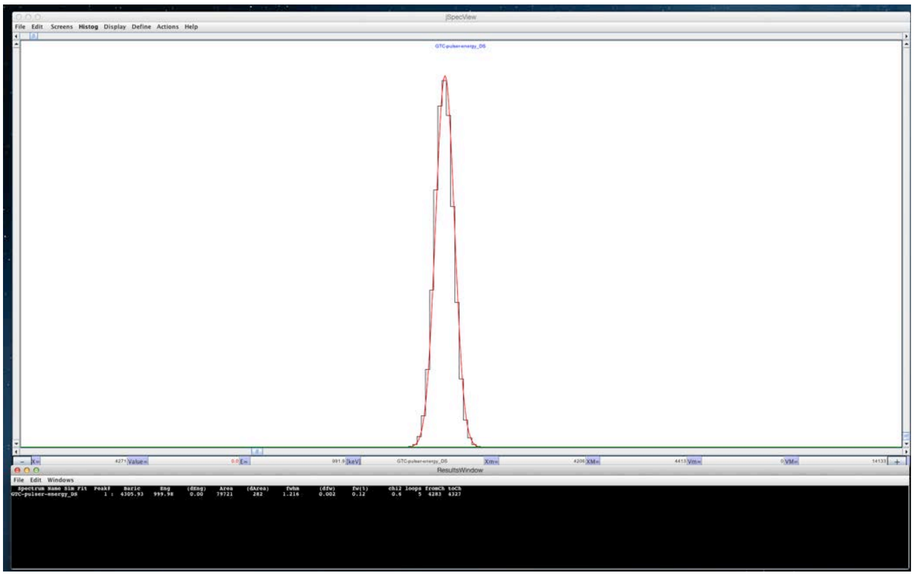


Fig. 6: Pulser peak obtained from the digital data by applying the MWD algorithm.

For the future we plan to build new cold part boards in order to improve the capacitive coupling to the capsules and to add new features such as the measurement of the electronics temperature with a PT100. The HV filter is under development at Padova with the aim to build one fitting in the space available behind the warm part of the preamplifier.

The next test should be performed with the front–end electronics mounted for all three capsules to investigate possible cross talk between the channels.

Vacuum tightness is the main issue under test at the moment in the mechanical workshop of Legnaro. Preliminary tests gave us some hints on possible solutions and they are verified. Once solved the problem, the electronics tests will be repeated with the cryostat filled with LN_2 to see the influence on the noise characteristics.

The design and building of the mechanical structure and cryogenic distribution lines have required more resources than foreseen before and we accumulated some more delay as compared to the July planning for assembling the triple clusters.
Most of the mechanical parts of the cryostats were declared as final and we started their production. The parts critical for the vacuum tightness and thermal isolation will be finalized in a few weeks and they will be ordered at the beginning of the next year. Taking into account the time needed for the production of the mechanical parts of the cryostat and of the front–end electronics, the time needed for mounting the cryostats and test them we plan to start in April and mount the clusters at a rate of one per month.

Commissioning runs for the data acquisition system and the coupling with different complementary detectors will be performed with the GASP detectors during the next semester at LNL.

2) A second exchanged of personnel was done in 2013, when Mariam Kebbiri and Bart Bruyneel spent 1 week training stay at the IKP in Cologne.
They were trained in the AGATA clusters technique and testing. In particular, they mounted 3 AGATA Ge crystals into a cryostat and installed some electronics cards. They then performed some electronics test and also carried out some vacuum tightness tests.