HORIZON 2020 RESEARCH AND INNOVATION FRAMEWORK PROGRAMME OF THE EUROPEAN ATOMIC ENERGY COMMUNITY

HORIZON 2020

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Comments:After a delay due to the stop of activities during the COVID pandemic, the work has restarted and the milestone is today reached.

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Subtask 1.2.2 - M.8 Report: Completion of the commissioning of the HPGe equipped with newly developed electronics at CERN

This activity has been performed by CERN together with U. Manch, NTUA, UOI, IFIN-HH.

The project is to develop a HPGe detector with customized electronics with the goal of performing (n,n’) and (n,xn) cross-section measurements at the n_TOF facility at CERN. A particularity of the n_TOF facility is the high instantaneous neutron flux that comes at the draw back of an intense so-called gamma-flash that the detection system needs to be able to handle whilst preserving the high spectroscopic energy resolution crucial to such experiments. For this purpose, custom electronics have been developed and the commissioning of the detector has been achieved in several steps as described below:

1. Characterization of the detector carried out in Fall2019/Winter2020:
    1.1. Implementation of the detailed detector geometry in GEANT4 to model the efficiency crucial for the application of corrections in future measurements.
    1.2. The detector has been characterized with radioactive sources, e.g. ^{152}Eu, in our laboratory.
    1.3. An excellent agreement between the experimentally obtained and simulated response for various geometrical distances between source and detector was achieved as shown in Figure 1.

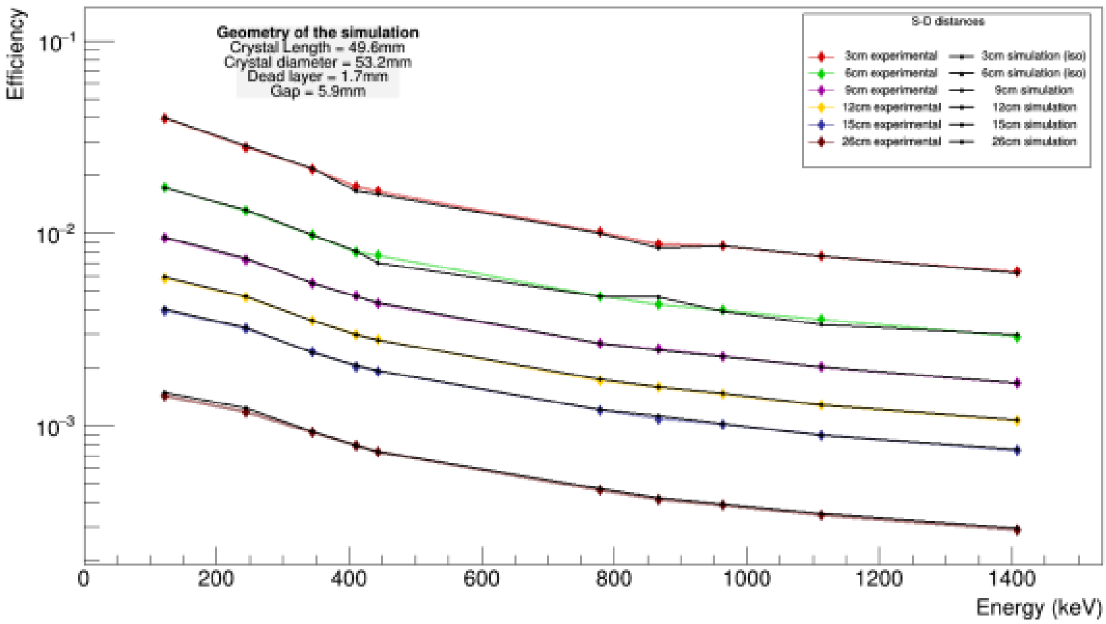

Figure 1: Simulated and measured efficiency of the prototype HPGe detector for ^{152}Eu g-rays source. The agreement is very good over the wide gamma lines range..

2. Modification of the prototype:
    2.1. Initially the detector was cooled with liquid Nitrogen (LN2) which required a daily refilling process as there are no fixed installations for a LN2 line into the experimental area. Additionally, there are safety concerns as the experimental area is a rather small room and a potential LN2 leak would pose a safety risk. In order to avoid those two

limitations and to reduce the support material required close to the detector (dewar) the decision was taken to switch to electrical cooling.

2.2. The supplier offered to add a low gain pre-amplifier free of charge. The decision was to accept this free offer with the intention to extend the capabilities to measure higher energies and thus expand the potential physics cases this detector could be used for.

2.3. Recharacterization with radioactive sources in the laboratory showed no significant difference with respect to efficiency or energy resolution. Figure 2 shows the comparison of the energy resolution of the signals from the original (high-gain) pre-amplifier before and after modifications. The low-gain pre-amplifier that was added did not perform as nice as expected with respect to resolution but also some issues with the electronic baseline were detected. It seemed to have no effect on the original high-gain pre-amplifier in the laboratory.

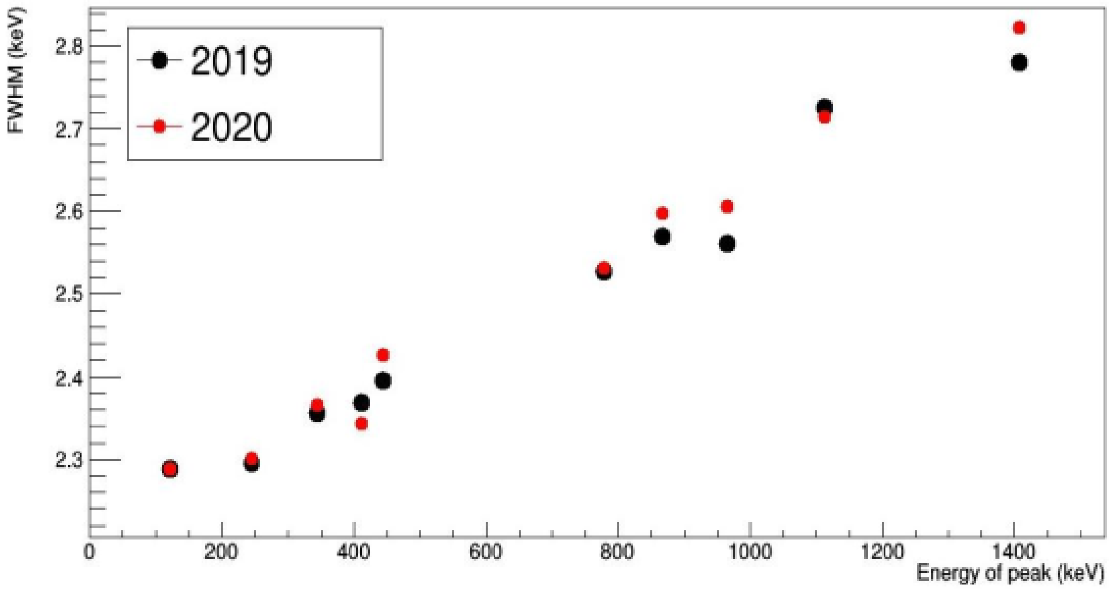

Figure 2: Measured energy resolution (FWHM) before and after the major change concerning the cooling of the device. The results show the same good performances of the HPGe detector.

3. Testing the detector in realistic conditions in the n_TOF Experimental Area 1 (EAR1):

3.1. The delays of the restart of the CERN accelerator complex and the implications on the rest of the physics programme of the n_TOF facility allowed the first test with beam only at the end of 2021.

3.2. During this test the gamma-flash gating did not behave as expected, rendering the goal of measuring (n,n’) cross-sections impossible. The behaviour of the detector is shown by the black line in Figure 3. Several tests were carried out in the period of April-August 2022 in the laboratory but this effect was not reproducible.

3.3. After extensive tests in the laboratory and on-beam, the problem was identified. With the help of the manufacturer, it could then be swiftly fixed by disconnecting the low gain pre-amplifier. The effect of disconnecting the low-gain pre-amplifier is shown by the red curve in Figure 3, which shows the detector response to a dedicated proton bunch.

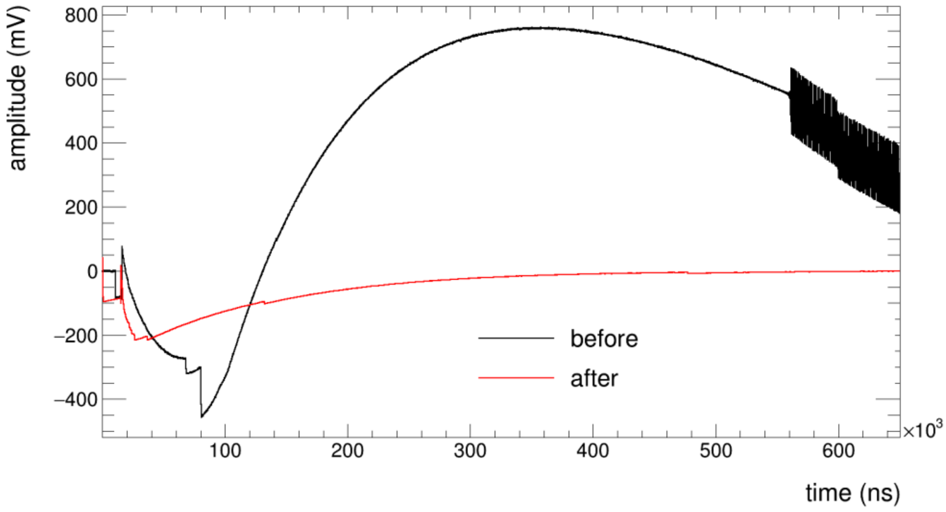

Figure 3: Detector response to a dedicated bunch (800e10 protons) before and after disconnecting the low gain pre-amplifier. It is clear that there is an issue when the low gain pre-amplifier is connected shown by the high amplitude slow oscillation over the whole plot and the rapid oscillations at approximately 600e3 ns. The structure below and around 10e3 is the gate switching on-off.

3.4. The detector is now fully functional and in working conditions – see Figure 4, where an example of the detector response in the neutron energy region of interest for (n,n') reactions is shown.

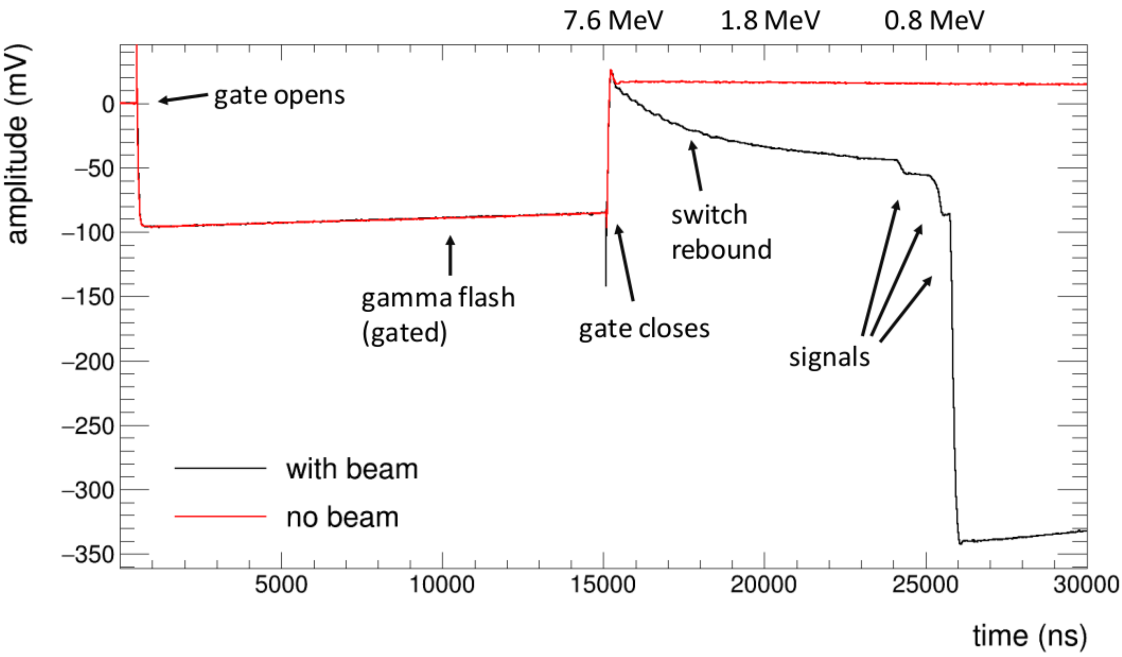

Figure 4: Example of the detector response to a dedicated bunch (800e10 protons) and a calibration trigger. The gate is applied from 1-15 us and the gamma-flash is at approximately 10 us (not visible because gated). Signals in the detector are visible after a few microseconds. Corresponding neutron energies are indicated in the plot.

This concludes the commissioning of the detector and therefore the completion of the milestone