Multi-element readout of structured HPGe-detectors for high-resolution x-ray spectroscopy using CUBE-preamplifiers

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Abstract

Very recently we have shown that CUBE-preamplifiers developed by XGLab s.r.l. can be used for the read out of single elements of thick structured planar HPGe- and Si(Li)-detectors produced by SEMIKON. Depending on the size of the detector element and the shaping time an energy resolution between 344 eV ($A_{element}$ = 1 mm^2) and 407 eV ($A_{element}$ = 20 mm^2) was achieved for the 60 keV Americium-line [1]. The next step was the realization of a simultaneous multi-element readout of structured detectors using the same preamplifiers for measuring high-energy x-rays (more than 100 keV) with a comparable energy resolution as for the single-element readout. Two single-sided HPGe-detectors were used for these tests: one detector with 8 elements (3.75 mm x 10 mm each) and one detector with 32 strips (1 mm x 5 mm each).

In addition to that we equipped an existing 16-pixel HPGe-polarimeter from GSI-Darmstadt [2] with the new readout. The detector elements (7 mm x 7 mm each, arranged in a 4x4 matrix) are connected to CUBE-preamplifiers. The improved energy resolution of this detector system will allow much more precise polarization measurements of x-rays emitted from atom-ion collisions which are part of the physics program of the SPARC collaboration (Stored Particles Atomic Physics Research Collaboration) at GSI and the future FAIR accelerator facility (Facility for Antiproton and Ion Research).

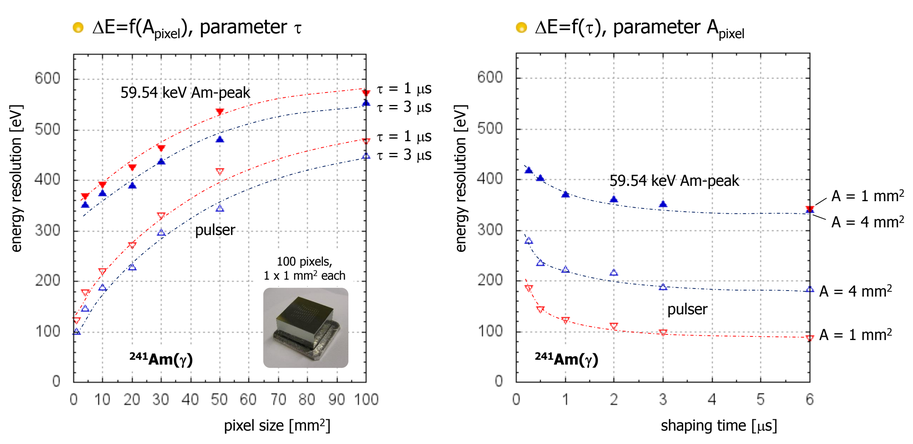
We will present the results of our laboratory tests as well as the tests of the modified detector system for GSI-Darmstadt.

Results of the single-channel readout using the CUBE-preamplifier ASIC developed by XGLab s.r.l.

At the iWoRiD conference 2013 we presented the very first results of a single-channel readout of one element of a single-sided structured HPGe-detector (with 100 pixels) using a CUBE-preamplifier [1].

The energy resolution was determined as a function of the element size - several pixels were connected by wire-bonding to realize bigger elements - and the shaping time constant τ.

A selection of these results are shown in the figures on the right side.

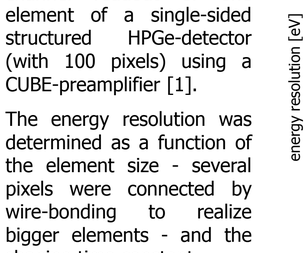


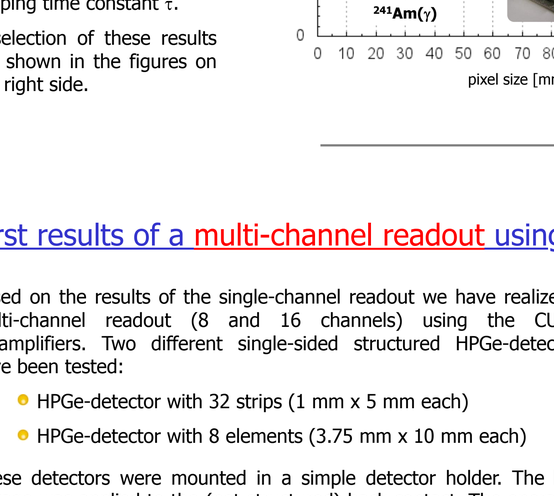
First results of a multi-channel readout using the CUBE-preamplifiers

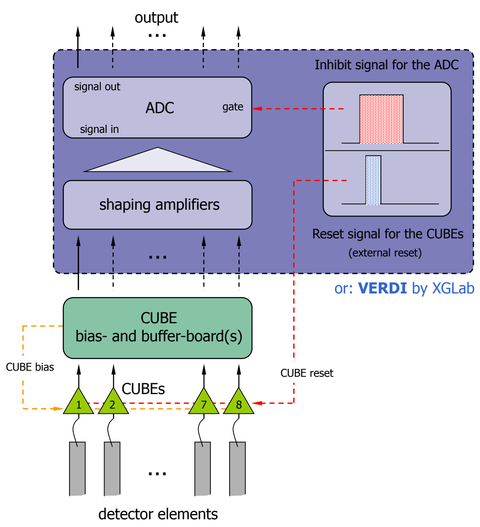
Based on the results of the single-channel readout we have realized a multi-channel readout (8 and 16 channels) using the CUBE-preamplifiers. Two different single-sided structured HPGe-detectors have been tested:

- HPGe-detector with 32 strips (1 mm x 5 mm each)
- HPGe-detector with 8 elements (3.75 mm x 10 mm each)

These detectors were mounted in a simple detector holder. The bias voltage was applied to the (not structured) back contact. The operating temperature was ~LN_2-temperature. The PCB with 8 CUBE-preamplifiers was mounted next to the detector elements and was slightly cooled (not down to LN_2-temperature).







Schematic diagram of the test setup. An external pulse is used for resetting the CUBEs. An inhibit signal, which begins before and ends after the reset pulse, stops the ADC.

For a detailed description of VERDI see also the poster:

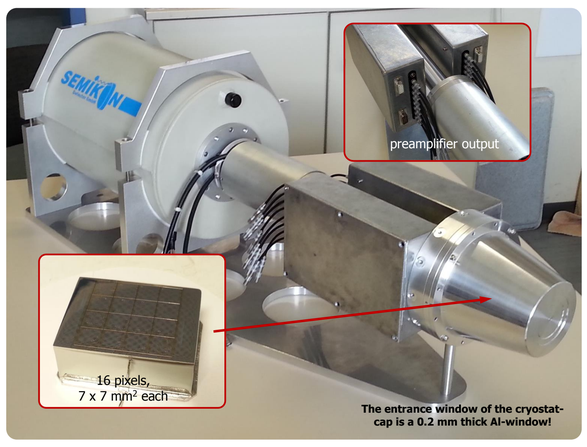
Luca Bombelli et al., "Multi-channel readout of structured detectors using CUBE preamplifiers and VERDI processing ASICs"

For each detector the 8 CUBEs [16 CUBEs for the pixel detector system] were read out with different shaping times. The results on the left side show the average of the energy resolution for the 60-keV Americium-peak.

During the tests the setup has been optimized with respect to some additional filtering of the signals, better grounding, bias-voltages of the CUBEs, … - This is for example one reason for getting better results of the 20 mm^2-elements compared to the 5 mm^2-elements of the 32-strip detector.

However, the results of the multi-element readout using CUBE-preamplifiers match well compared to the single-element readout (see above).

The very first results of a 16-pixel HPGe-detector system with CUBE-readout



I. Technical data of the HPGe-detector system

size of the crystal:	32 mm x 40 mm
detector thickness:	~11 mm
front contact:	boron-implanted (p^+-contact)
back contact:	Li-diffused (n^+-contact)
structure:	16 pixels on the front contact arranged in a 4x4 matrix
pixel size:	7 mm x 7 mm
operating temperature:	~LN_2-temperature

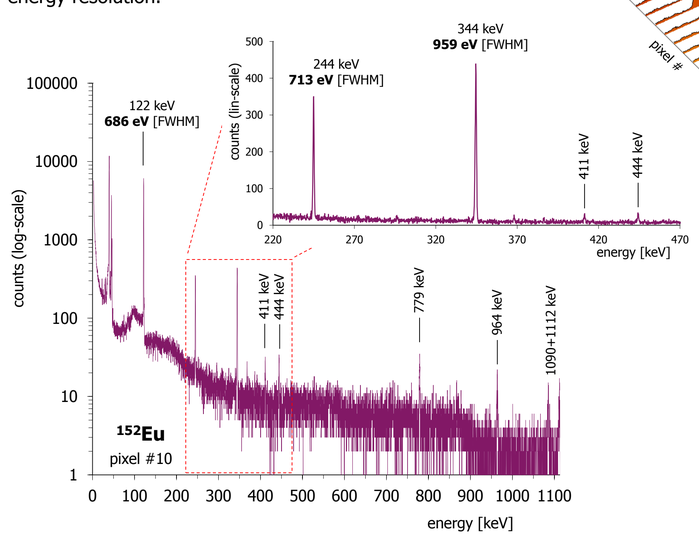
- The +HV is connected to the back contact.

II. ^{152}Eu-spectrum of one pixel

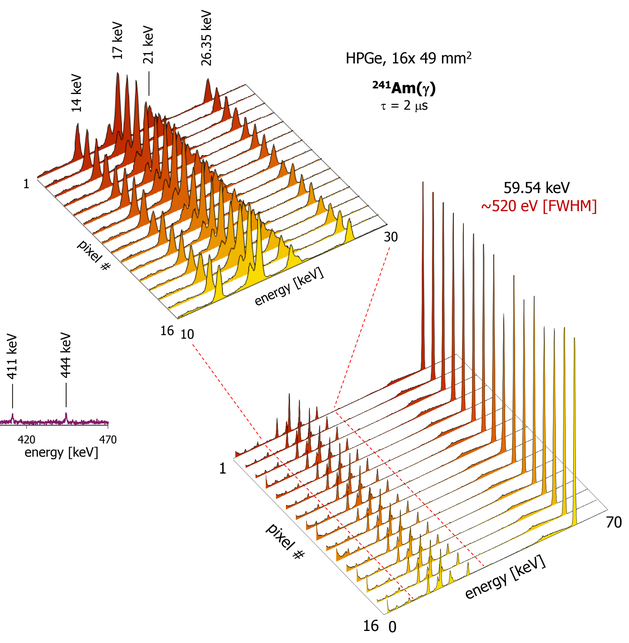
As an example for a measurement of photons in the energy range up to several hundred keV the HPGe-pixel detector system was tested with a ^{152}Europium-source.

The figures show a spectrum recorded with one pixel with a shaping time τ **= 0.5 µs**.

Even the high energy peaks of the Europium-source are clearly detected with a very good energy resolution.



III. ^{241}Am(γ)-spectra of the 16 pixels

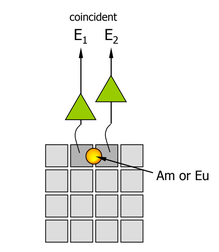


III. Coincident measurements of neighbouring pixels

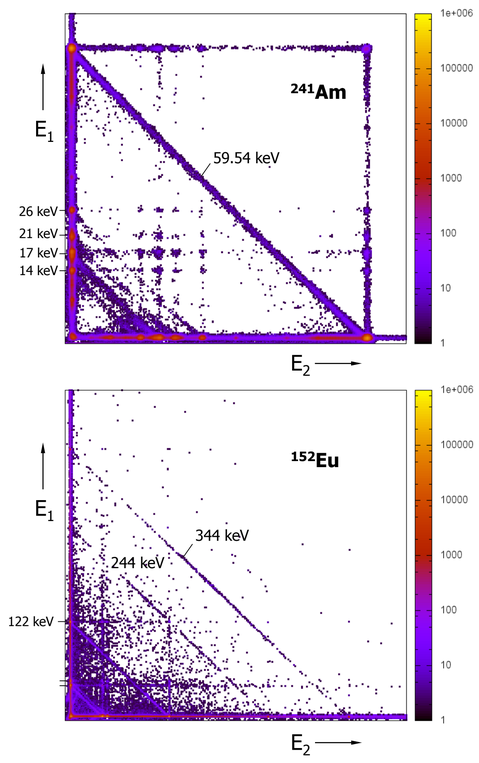
The 16 pixels (more precise: the output of the 16 CUBE-preamplifiers) were connected to standard NIM/VME readout electronics (discrete shaping amplifier, 16-channel ADC,…). All events were stored in list-mode data-format for offline-analysis of charge-sharing effects between neighbouring pixels.

The spectra of two neighbouring pixels are plotted in a 2D-diagram. The output E_1 and E_2 of the two pixels are plotted on the x- and y-axis. The shared events are plotted in the xy-plane.

The sum of the shared energy forms straight lines between the peak-energies, which means that there is no charge loss and crosstalk.



All 16 pixels are connected to a CUBE-preamplifier, but only two are shown in the figure!



Summary and outlook

- We have demonstrated that a high-resolution multi-element readout of HPGe-detectors with segmentation on one side is possible by using CUBE-preamplifiers.
- The achieved energy resolution of ~500 eV @ 60 keV is close to that we have achieved earlier with a single-channel readout using CUBE.
- There is obviously no indication of crosstalk and charge loss between neighbouring elements.

References

[1] T. Krings, D. Protić, C. Roß, L. Bombelli, R. Alberti and T. Frizzi , "High-resolution Spectroscopy with Multi-element HPGe- and Si(Li)-Detectors and CUBE-preamplifiers", 15th iWoRiD conference, Paris, June 2013, http://dx.doi.org/10.1088/1748-0221/9/05/C05050.

[2] S. Tashenov et al., "First Measurements of the Linear Polarization of Radiative Electron Capture Transitions", Phys. Rev. Lett. **97**, 223202 (2006).

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