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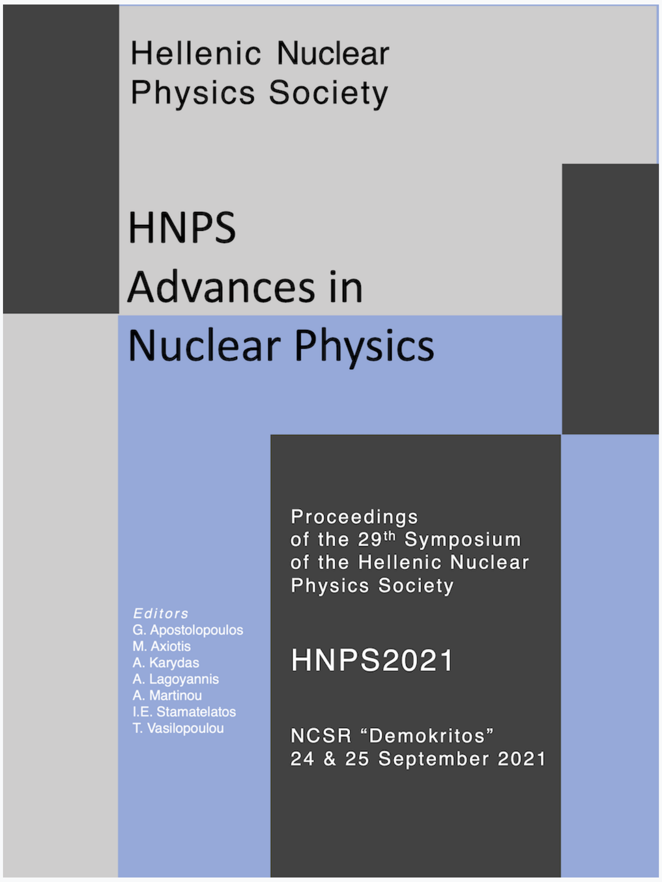

Study of digitizer properties in nuclear spectroscopy experiments

A. Liapatis, M. Axiotis

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Study of digitizer properties in nuclear spectroscopy experiments

A. Liapatis[1], M. Axiotis[2]

[1] Department of Physics, National and Technical University of Athens, Zografou Campus 15780, Athens, Greece
[2] Institute of Nuclear and Particle Physics, NCSR 'Demokritos', Aghia Paraskevi 15310, Athens, Greece

Abstract In the present work a new CAEN 725S digitizer was implemented and compared to standard analog electronics in simple detector circuits, widely used in experimental nuclear physics. The first obtained results demonstrated that low-cost digital signal processing can offer a faster, improved performance regarding dead time corrections, without any significant effect in the obtained detector resolution values.

INTRODUCTION

High speed, precise analog to digital converters are now available at a relatively low cost. This breakthrough evolution in electronics has facilitated the development of a new kind of data acquisition and pulse processing in nuclear physics experiments, for which the pre-amplifier pulse is the first and last analog signal, followed only by digitally processed waveforms. The purpose of the present work was to employ this new method using a digitizer and comparing it to standard analog circuitry. More precisely, the device we used was a CAEN 725S digitizer. The comparison was made by measuring gamma radiation from a ^{60}Co radioactive source in most cases, along with a triple alpha source made of ^{239}Pu, ^{241}Am, ^{244}Cm and a ^{137}Cs gamma emitter. We used various detectors for the comparison, such as Sodium Iodide (NaI), Silicon (SSB), HPGe and BGO. The comparison between digital and analog signal processing was based on the resolution of the recorded peaks in the experimental spectra and on the corresponding acquisition dead time. The spectrum visualization and the tuning of parameters for the digitally processed signals (pole-zero adjustment, shaping time, rise time etc.) was accomplished by the software provided by CAEN, namely MC2A Analyzer and CoMPASS. The parameter tuning was carried out by examining the waveform of the incoming signals using the software mentioned above. Before comparing the two methods, we had to find the optimal settings for the parameters, in order to obtain the best possible resolution values. The results showed that the digitizer was as accurate as the analog circuitry, as far as the detector resolution is concerned, and that it was processing the incoming signals much faster, resulting in a X times smaller dead time corrections, in certain cases.

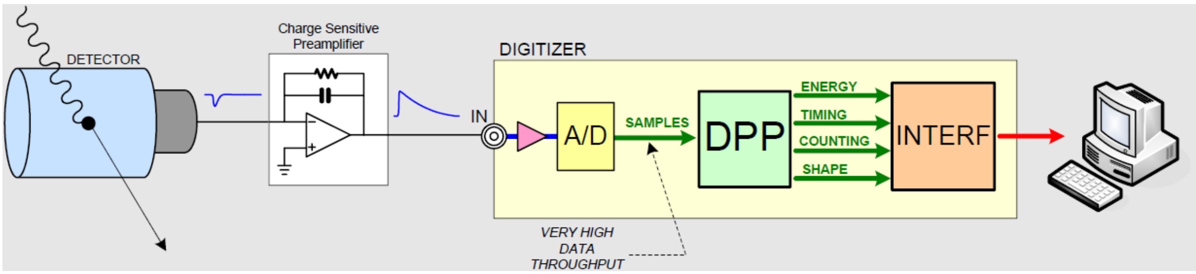

Fig. 1. *Diagram of a system that makes use of a digitizer to perform an experiment [1].*

EXPERIMENTAL SETUP

The experimental setup was simple, regardless of the detector we intended to use. The requirements to start using a digitizer are basically a connection to a power supply, a connection with the detector preamplifier and a connection with a PC by a USB cable or optical fiber. This simple setup is one of the main advantages of digital circuitry, as the only means of “communication” with the detector is through the preamplifier and everything else is processed digitally.

THE EXPERIMENT

At the beginning we measured the detectors’ resolution values and their dead time (in some cases) using analog circuitry. In the next stage we connected the digitizer and found the optimal parameter values for every detector (shaping time, RC-CR smoothing, DC offset etc.). The parameter tuning was carried out by examining the waveforms of the signals coming through via software. The parameters were tuned in order to achieve the best resolution value possible. For the NaI and HPGe detectors we also compared the dead time of each system for two different positions of the radioactive source, namely far from and close to the detector. Below we show a table with the optimal digitizer parameter values in order to obtain the best possible resolution results, for each detector type.

Table 1. *Optimal digitizer parameter values for each detector in order to achieve the best resolution results.*

	NaI	**HPGe**	**Si**	**BGO**
DC Offset (%)	10	90	88	8
Input Range (Volt)	2	0.5	0.5	0.5
Fine Gain	1	1	2.2	1
Decimation	1	1	1	1
Input Rise Time (us)	0.1	0.2	0.1	0.04
Trigger HoldOff (us)	0.9	0	0.3	0.4
RC-CR Smoothing	16	32	16	16
Threshold	50	50	60	400
Baseline Mean	64	16384	256	16
Rise Time (us)	0.1	1	0.3	0.5
Decay Time (us)	0.2	50	50	0.1
Flat Top (us)	0.8	1.5	1.2	0.4
Peak Delay (%)	65	20	10	45
Peak Mean	16	16	16	16
Peak HoldOff (us)	5	0.5	-	0.2
Baseline HoldOff (us)	1	1	1	1

RESULTS

According to Table 2, the detector resolution obtained with the digitizer is similar to the resolution obtained with the standard analog circuitry. Their similarity is also shown in Figure 2. The area where there really seems to be a difference is related to the dead time measurements. As it is shown, the digitizer is quicker at processing signals than analog electronics. Only the resolution measurement for the Si detector is missing, because the detector was degraded so the values wouldn’t represent its peak performance. Nevertheless, the two resolution measurements were about the same in all studied cases.

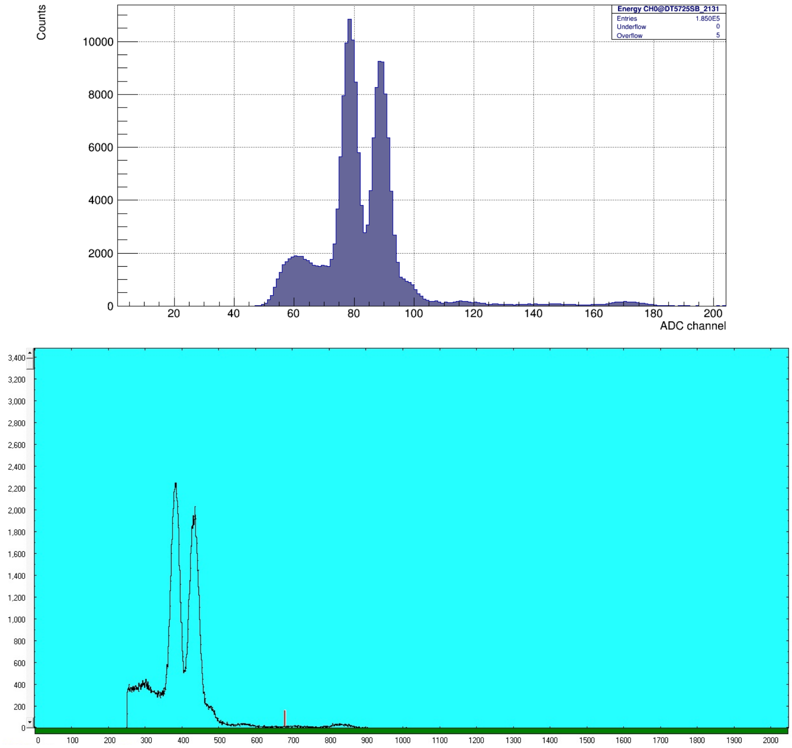

Fig. 2. *Example of the resulting histograms from the digitizer (first picture) and analog circuitry (second picture) using the NaI detector with* ^{60}Co *as a source.*

Table 2. Resolution measurements using the two different methods of signal processing for each detector.

Resolution	**NaI**	**HPGe**	**BGO**
Digitizer	5%	0.20%	15%
Analog el.	5%	0.42%	15%

Table 3. Dead time measurements using the two different methods of signal processing for each detector.

Dead Time	**NaI (far)**	**NaI (close)**	**HPGe (far)**	**HPGe (close)**
Digitizer	1%	5%	1%	1.6%
Analog el.	5%	20%	5%	5.5%

All in all, digital signal processing seems to be superior for this kind of simple experiments. The fact that this method is cheaper than the standard analog one, along with the simplicity that defines it (everything is done behind a computer) makes digital signal processing even more appealing than ever before.

FUTURE PERSPECTIVES

One way to establish this method as the default one for general signal processing is to use the digitizers in more complicated experiments. More specifically, the devices we used can support coincidences and can be used concurrently. Moreover an offline program could be made to postprocess data, as the software made by the developers is for single analysis mode and visualization purposes only.

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References

[1] CAEN MC2A User Manual Revision 10.