First Tests with Digital Electronics for the RIPEN Apparatus

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INTRODUCTION

The RIPEN [1] apparatus is a neutron detector array composed of BC501 liquid scintillators specifically suited for neutron detection and time of flight measurement. It was installed at Legnaro National Laboratory in early '90s, while the last measurement campaign was performed in 2007. At the moment 24 detectors are installed and some spares are available at LNL.

The project of re-establishing the RIPEN operability is illustrated in [2], where the complete lack of readout and acquisition electronics is also underlined. The choice of testing the capabilities of digital electronics was done, while recovering or re-developing old analogue modules was considered expensive and less efficient.

In this paper we report the very first results of the tests done with V1720 (12 bit, 250 MS/s) CAEN digitizers [3].

SETUP DESCRIPTION

We tested the V1720 module in the 8 channels VME version communicating with a standard PC via a VME-USB bridge (CAEN V1718). The software used for acquisition is the default WaveDump provided by CAEN. This allows the selection of the channels to be enabled for the acquisition, a trigger threshold for every active channel, the length of the saved waveform in number of points and the percentage of pre and post trigger samples in the acquisition window. We will present the results obtained using one channel at a time with a window of about 512 ns (128 points); pre/post trigger ratio was typically around 0.3.

The V1720 allows to couple the ADCs of two consecutive channels in order to double the sampling rate, this possibility has not been tested yet but the cost/benefit ratio of this solution will be taken into account for the future selection of the proper modules for the RIPEN apparatus.

Detector number 2 of the RIPEN array was used as benchmark in the runs performed with ^{60}Co, ^{88}Y, ^{137}Cs (gamma) and AmBe (neutron) sources.

Waveforms collected in binary format were later unpacked into ROOT Trees for the following analysis.

WAVEFORMS PROCESSING

Three different kind of information are expected to be obtained processing the scintillator signals: the energy release of the impinging particle, its time of flight and the pulse shape discrimination between neutrons and gammas.

The characteristics of the BC501 pulses are well known in literature [4] and also from previous RIPEN experience, so the results obtained with the digital approach will have to be compared with existing analogue data.

Data were off-line processed using algorithms able to perform RC/CR filter and CFD emulators [5]. A proper baseline subtraction was computed from the raw data and in the same phase signals saturating the dynamic range were rejected.

Energy spectra were reconstructed by RC filtering the signal and integrating the output over a fixed range with respect to the signal maximum. The results obtained with two different gamma sources are shown in figure 1.

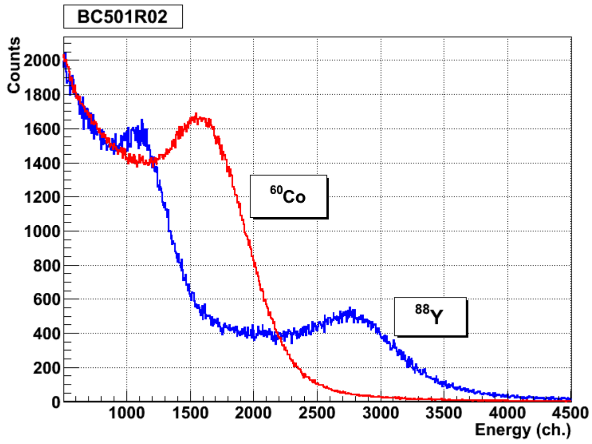

Fig. 1. ^{60}Co and ^{88}Y digitally reconstructed energy spectra.

In figure 2 the corresponding calibration is visible. It was obtained fitting the Compton energy peak on the "digital" energy spectra. The detector linearity is found and results are compatible with the analog ones (see ref. [2]).

Two different standard pulse shape methods were also tested: the zero crossing and the gate integrated method.

In the first case the pulse shape difference is enlightened by RC filtering the original waveform and looking at the time where it crosses two different thresholds, respectively on the leading edge and on the rise part of the signal. This is done using a digital CFD algorithm with cubic interpolation of the filtered form. The time difference of the two CFDs is equivalent to the zero crossing time calculated analogically by RC/CR filtering the shape.

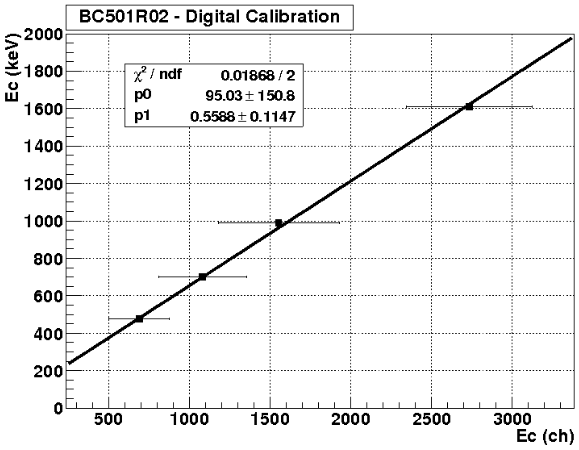

Fig. 2. Detector R02 energy calibration using ^{60}Co, ^{88}Y and ^{137}Cs γ sources.

Results obtained with AmBe neutron source are shown in figure 3; the neutron/gamma discrimination is clearly visible. More work in the parameter optimization will have to be done in order to improve the identification quality and to understand the presence of satellite peaks around channels 40 and 110.

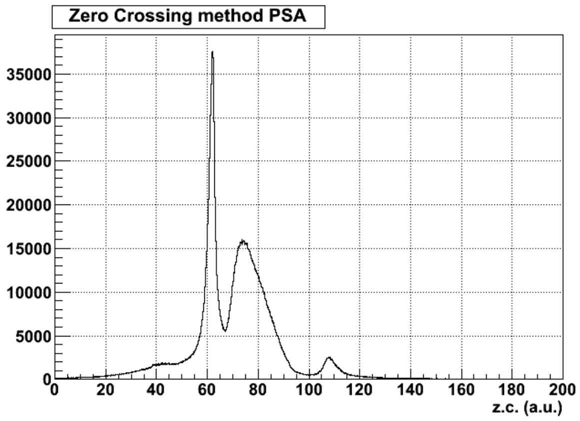

Fig. 3. Pulse shape analysis using Zero Crossing Method, left peak is corresponding to γ rays, the right one to neutrons. Structures at channel 40 and 110 have to be investigated.

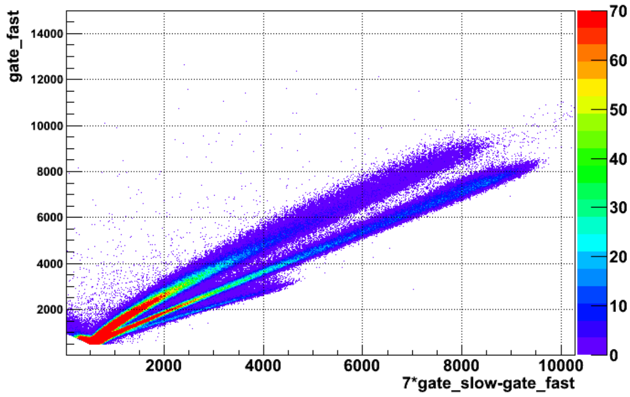

Fig. 4. Pulse shape analysis using Gate Integrated Method, neutron and gamma rays are well discriminated but the actual threshold will have to be measured.

The second method used, the gate integrated method, is based on the integration over fixed time intervals. The raw shapes are digitally RC filtered and the result is integrated in two different ranges starting from the signal minimum in the left and right directions. In figure 4 the results are shown. In the future axis calibration will need to be performed in order to measure the identification threshold and to compare quantitatively the results obtained in [2].

CONCLUSION

CAEN V1720 digitizer has been tested in order to check the compatibility of its performances to the requirements of the RIPEN apparatus. Energy spectra are well reproduced and also Pulse Shape Analysis gives good results. Figure of merit will have to be measured and optimized in order to quantify detection and discrimination thresholds. Timing performances for TOF measurements are currently under study.

[1] N. Colonna et al, Nucl. Instr. and Meth., A381 (1996) 472.
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[3] http://www.caen.it .
[4] C. Guerrero et al., Nucl. Instr. and Meth., A597 (2008) 212.
[5] L. Bardelli et al., Nucl. Instr. and Meth., A521 (2004) 480.