Testing of the NSC Electronics Module with the GSI Clover Detector

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*This report refers to the testing of the NSC (**N**uclear **S**cience **C**entre, New Delhi) Electronics Module for Clover Ge-detectors performed at the RISING (**R**are **I**sotope **S**pectroscopic **IN**vestigation at **G**SI)) group in GSI. The aim of this investigation is to compare its performance with that of a conventional electronics apparatus.*

1 Introduction

This paper examines the results of the tests performed on the NSC Electronics Module for Clover Ge-detectors. These investigations were performed at GSI and their goal is to compare the behaviour of the NSC Module with that of a conventional electronic module.

In the following sections, information regarding the setting, the electronics and the perfomance characteristics for both NSC Module and conventional electronics (energy and time resolutions) is to be found.

2 Materials and Methods

The detector used was the EURISYS MESURES 4 fold segmented Super Clover detector N° 101 of the VEGA-array (**V**ersatile and **E**fficient **GA**mma Detector). The first Clover Detector was developed in France by EURISYS MESURES in the frame of the EUROGAM collaboration. It consists of four coaxial N-type Germanium detectors, arranged in a four leaf clover shape. Each Germanium crystal has a length of 140 mm and a square front face with two flat parts at 90° along the whole length and two tapered parts at an angle of 15°. Its output signals' characteristic values are presented in Table 1. The detector was delivered to the GSI (**G**esellschaft für **S**chwer**i**onenforschung, Darmstadt) laboratory in April 1997 [1].

The NSC Module aims to replace the various electronics modules necessary to operate a Clover Detector in a double width NIM mode. This is achieved by placing all the necessary components into one single module capable of handling four channels, i.e., 4 TFA (**T**ime **F**ilter **A**mplifier), 4 CFD (**C**onstant **F**raction **D**iscriminator), 4 main amplifiers (with 3 μs shaping constant), 4 gate generators and a coincidence unit [2]. The NSC Module arrived at GSI in 2005.

Tab. 1: *Properties of the signals from the Clover Detector.*

Detector Contact	Rise Time ns	Fall Time μs	Undershoot %
Black	120 ± 60	80 ± 10	2 ± 1
Blue	120 ± 60	80 ± 10	3 ± 1.5
Green	130 ± 70	80 ± 10	1.5 ± 0.5
Red	120 ± 60	80 ± 15	2 ± 1

The results for the Clover detector read out were obtained with the four channels of the NSC Module and with the conventional electronics channel.

Each channel has to be connected to one of the four detector contacts. Table 2 shows the correspondence between the detector's centre contacts (black, blue, green and red) and the electronics channels (both from the NSC Module and the conventional electronics).

The ^{60}Co γ-source (which has two well known transitions at 1173 and 1333 keV [3]) was attached to a plastic detector and placed before the front face of the crystals (at a 15-25 cm distance). The plastic detector served as a trigger for the electronics, as it has a very good time resolution ($\sim$1 ns), although a very poor energy resolution.

^{60}Co β^--decays into ^{60}Ni through a cascade of two E2 transitions:

$$4^+ \xrightarrow{1173\text{ keV}} 2^+ \xrightarrow{1333\text{ keV}} 0^+$$

This process results in two almost simultaneous γ-rays being emitted, since the 4^+ and the 2^+ states are very short-lived ($\tau \lesssim 1$ ps). When one of the γ-rays hits the plastic detector and another one hits one of the Ge-detectors, the electronics are triggered (using the AND unit and TRIGGER 2, as in Figure 1). A delayed Ge-detector signal is then used as a stop.

Several different sets of measurements were taken, both by varying the threshold value and the CFD delay for the Ge-detectors. The threshold values used were the normal one (cutting just the noise) and the maximum one (cutting the Compton edge and leaving only the two photo-peaks).

LEA software was used to acquire the spectra and to analyse them.

Tab. 2: *Correspondence between electronic channels, detector contacts and TDC and ADC inputs.*

Electr. Channel	Detector Contact	ADC Input	TDC Input
NSC A	Black	ENERGY1	TIME1
NSC B	Blue	ENERGY2	TIME2
NSC C	Green	ENERGY3	TIME3
NSC D	Red	ENERGY4	TIME4
conv.	Black[a]	ENERGY5	TIME5

[a] In some parts of the experiment, the conventional electronics channel was connected to different detector contacts. In those cases, this is clearly stated.

Tab. 3: *Calibration of the ADC and of the TDC for the various channels.*

Electronics Channel	ADC keV/channel	TDC ns/channel
NSC A	1.44	0.24
NSC B	1.53	0.25
NSC C	1.16	0.26
NSC D	1.56	0.24
conv.	0.54	0.28

3 Results and Discussion

3.1 Resolution

3.1.1 Energy Resolution

The energy resolution was measured with an ADC (**A**nalog to **D**igital **C**onverter). Its calibration was done by adjusting Gaussian curves to the two photo-peaks of ^{60}Co and taking the distance between their mean values (given in ADC channels) as 160 keV (Table 3).

The results obtained for the energy resolution can be found in Table 4. It can be observed that there are no major variations for the two different threshold values.

The poor results of the NSC module in comparison with the conventional electronics are probably due to the impossibility of adjusting its pole zero. The output signal should be a Gaussian curve, but an under- or an over-shoot often occurs. In these cases, one must use the pole zero adjustment to shape the signal. In the present experiment, however, turning the adjustment screws on the front panel of the NSC module did not result in any changes in the observed signal.

3.1.2 Time Resolution

The time resolution was measured using first a TDC (**T**ime to **D**igital **C**onverter) and later a TAC (**T**ime to **A**mplifier **C**onverter).

Both the TDC (Table 3) and the TAC were calibrated using a pulse generator. The distance between the mean values of two peaks that are 24 ns appart was taken as a reference.

In Table 5 are the results for the TDC. The data for the maximum threshold value was not collected simultaneously, but for one NSC Mod-

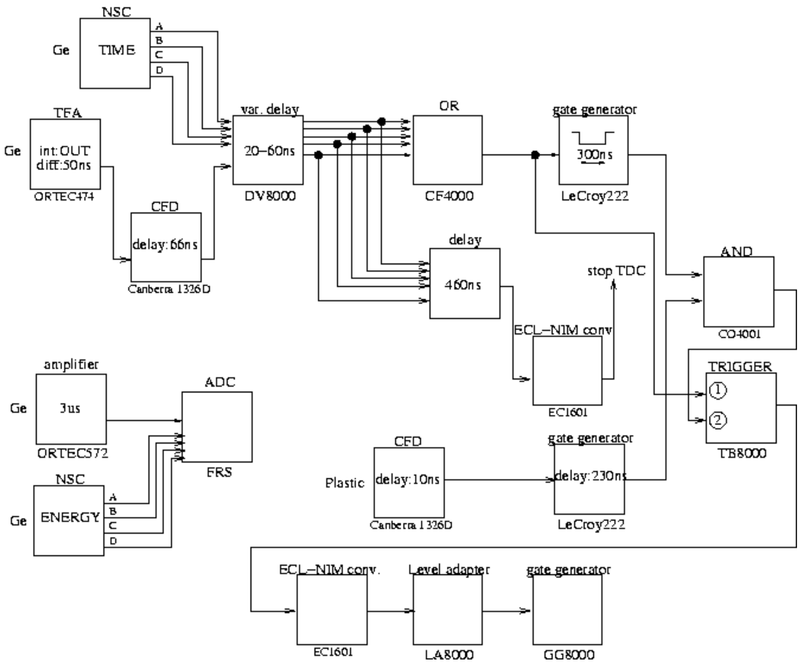

Fig. 1: *Electronics block diagram.*

Tab. 4: *Energy resolution for both photo-peaks of ^{60}Co with normal and maximum threshold values.*

Channel	FWMH (keV)			
	Normal Thr.		Maximum Thr.	
	1173 keV	1333 keV	1173 keV	1333 keV
ENERGY1	4.9	4.9	4.5	4.6
ENERGY2	4.5	4.8	4.6	4.6
ENERGY3	3.8	4.0	3.9	4.0
ENERGY4	4.4	4.7	4.6	4.6
ENERGY5	3.0	3.0	3.0	3.1

ule channel at a time. The conventional electronics channel was connected to the same detector contact as the NSC Module channel for every measurement.

The conventional electronics channel presents a rather worse resolution for both cases. Concerning the normal threshold value, the possibility that the CFD of the Ge-detectors has a smaller ideal delay was investigated and the results can be found in Table 6. For a 32 ns delay the resolution of the conventional electronics is similar to that of the NSC module. For 20 ns it worsens again.

For the maximum threshold value another problem arises: the CFD starts working in a LE (**L**eading **E**dge) mode, which deteriorates the quality of the spectra. When the TDC delay is increased, the spectra deteriorates even further.

The results for the TAC are very similar, and therefore not interesting.

Tab. 5: *Time resolution. For the maximum threshold value the convencional electronics channel (TIME5) was connected for every measurement to the same detector contact as the NSC Module channel.*

Channel	FWMH (ns)		
	Normal Thr.	Maximum Thr.	
		NSC	conv.
TIME1	11.4	6.7	12.1
TIME2	8.3	5.6	14.2
TIME3	10.2	5.2	13.1
TIME4	10.9	6.2	8.9
TIME5	15.1	-	-

Tab. 6: *Time resolution from the conventional eletronics channel using different CFD delays and detector contacts.*

Detector	CFD delay (ns)		
Contact	20	32	66
Black	-	7.0	15.1
Blue	-	7.0	-
Green	-	9.8	-
Red	13.2	10.1	13.3

3.2 Spectra

3.2.1 Energy Spectra

Figures 2 and 3 are examples of some of the energy spectra collected with the conventional electronics. The spectra from the NSC module look essentialy the same.

As desired, with the maximum threshold value (Figure 3) the Compton edge is no longer present, but the two photo-peaks can still very clearly be seen.

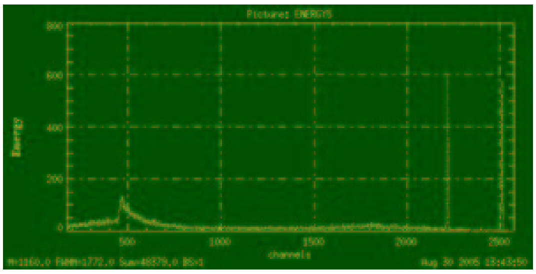

Fig. 2: *Energy spectrum from the conventional electronics channel with normal threshold.*

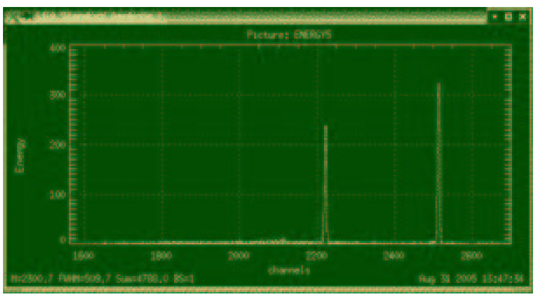

Fig. 3: *Energy spectrum from the conventional electronics channel with maximum threshold.*

3.2.2 Time Spectra

Figures 4, 5 and 6 are examples of the time spectra collected.

Figure 4 refers to the conventional electronics.

In Figure 5 one can see unexpected smaller peaks in the NSC module normal threshold spectrum, which desappear in Figure 6 with the setting of the maximum threshold. The tests are not conclusive enough to establish a reason for this behaviour.

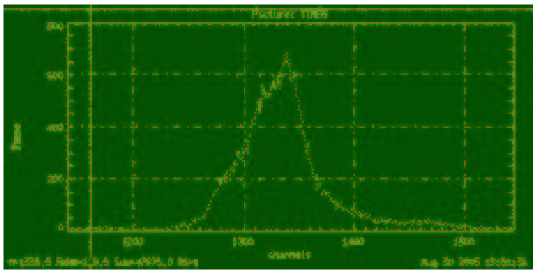

Fig. 4: *Time spectrum from the conventional electronics channel with normal threshold and a TDC 64 ns delay.*

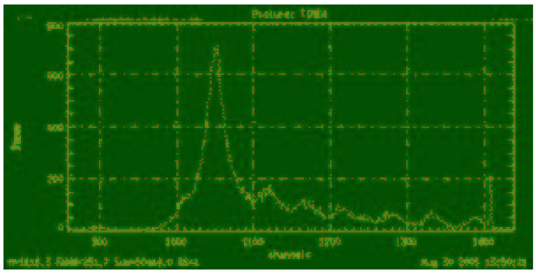

Fig. 5: *Time spectrum from the NDC module channel D with normal threshold.*

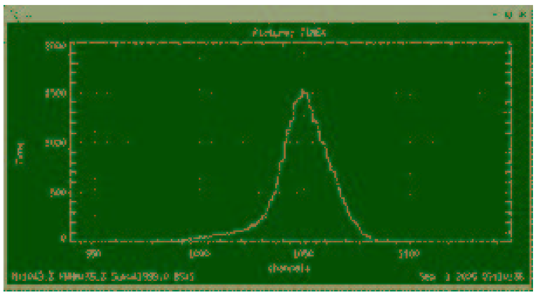

Fig. 6: *Time spectrum from the NDC module channel D with maximum threshold.*

References

[1] Y. Kopach and H.-J. Wollersheim, *Testing of the GSI Clover Detector under Experi-*

mental Conditions, Gesellschaft für Schwerionenforschung, Darmstadt (March 2000).

[2] S. Venkataramanan et al., *Technical Report on Clover Electronics Module*, Nuclear Science Centre, New Delhi (2003).

[3] S. Eidelman et al., *Particle Physics Booklet*, Particle Data Group (July 2004).