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AN ELELECTRONIC DELAY FOR PERTURBED GAMA-GAMA ANGULAR CORRELATION SPECTROMETER

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ABSTRACT

Nuclear techniques are very useful in condensed matter physics and materials science specially to study electronic properties of chemical compounds in a microscopic scale, like magnetism, defects in semiconductors, spin transition in metallic oxides, etc. Among the wide variety of nuclear techniques used to study materials, the perturbed gamma-gamma angular correlation (PAC) technique has been used with success to study several different type of materials mainly because it is based on hyperfine interactions, which are interactions between the nuclear moments an the electronic charges in the neighborhood of probe nuclei. Probe nuclei for PAC measurements must decay in a gama-gama cascade through an intermediate level with half-life in the scale of nanoseconds. A typical result from a PAC measurement is a time spectrum formed by coincidences of fast pulses corresponding to each gamma from the cascade. A PAC spectrometer typically has the slow-fast configuration, where the coincidence between pulses in both, slow (proportional to gamma energy) and fast path, are necessary to assure that the fast signal comes from the selected gamma energy. In order to measure this slow-fast coincidence it is necessary to apply a delay to the fast pulse in relation to the slow pulse. Long special coaxial cables are often used as this delay, typically of hundreds of nanoseconds. However, those cables degrade and attenuate the fast signal, require large physical area in laboratory, and are expensive. As an alternative, it could be used a specific electronic module to act as a time delay in the pulse, eliminating all those inconveniences. However, this system introduces another problem: the dead time of electronic delay unit. The main objective of the present work is to use an improved methodology with few electronic delay units, designed and assembled in our laboratory, connected in cascade in order to substitute for the cable delay. The results showed that four units in cascade are enough to reduce the dead time and achieve the same performance of cable delays.

1. INTRODUCTION

We intend to substitute the of coaxial cable system delay of fast pulse Fig. 1. It was developed an electronic system to delay the referring fast pulse to the time fond of fótons. An improvement in the efficiency of the electronic system with the use of two on electronic modules in series with half of the total delay in each one was verified, when compared with an only module with the same total delay. From this result we start to develop in a new electronic module consisting of two independent circuits of delay with intention to substitute the system of handles with the same efficiency.

The Module of Double Electronic Delay Fig.2 entirely was developed and mounted in the laboratory of electronics of the Centro do Reator de Pesquisa (CRPq). It was developed and confectioned the circuit plate printed matter beyond the purchase of the diverse electronic components. The structural part for the new module was used to advantage of the simple module (with only one circuit of delay) which was using.

Figure 1. System of delay with coaxial cables for the fast pulse, with four bobbins of 600m (a bobbin for each detector of the spectrometer).

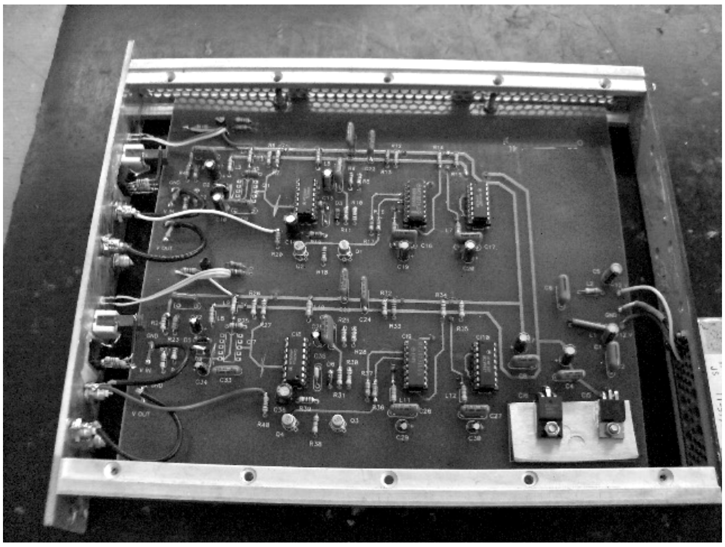

Figure 2. Double Electronic module for the delay of the fast pulse.

This new equipment they have 2 identical and independent electronic circuits of delay, each one with an entrance and two exits. It allows to vary the band of delay in each one of the circuits through micron keys adapted in the part frontal of the module, being able to be used with different configurations of delay Fig. 3.

Figure 3. Module of Double Electronic Delay (front).

2. EXPERIMENTAL

With the available resources, we obtain to construct 4 electronic modules that had been adjusted and tested. The first tests had been carried through using a generator of pulses mark ORTEC model 416, and an oscilloscope Tektronics model TDS 220, where we can verify the quality of the signal and the variation of the delay time. With the new modules we can make tests important and to verify if it is possible to substitute the conventional system with handles for the system with electronic delay.

The delay system using cables does not have dead time, that is, none another pulse is rejected during delay and thus we can take it as the reference. With the new modules we can make a delay equivalent to the cable, however varying the number of circuits hardwired in series, and thus we will be able to determine how many cascades will be necessary to arrive the same rate of counting of the cable what it would be the ideal. For this test we only γ use the system of electronic delay in the detector, being used as start (for γ1) and the system with handle in too much detectors B, C and D as stop (for γ 2). We use the detectors A1 (start) and B2 (stop) in 90º, A1 (start) and C2 (stop) in 180º and A1 (start) and D2 (stop) in 90º, schematized in Fig. 4.

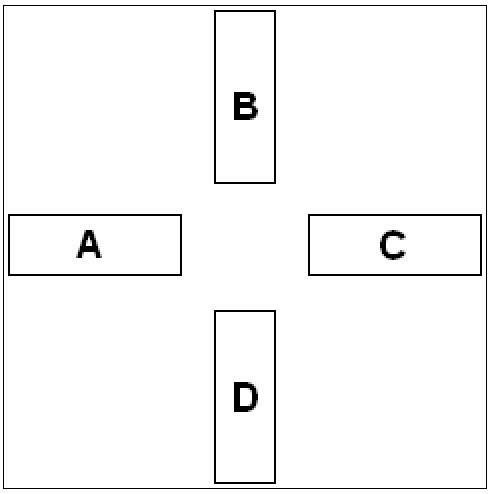

Figure 4. Scheme of the disposal of the detectors.

They had been made measured of behind coincidences for gama-gama using a source of ^{181}Hf (in form of Metallic Háfnium), that γ_2 (482kV) in γ_1 (133kV) and γ ^{181}Te decays for β^- emission, where we use fótons cascade [1]. First the system of coaxial cables for the delay of 2,7μs was made and gets the maximum counting for the acquisition of data only using used sample getting the spectra presented in Fig. 5.

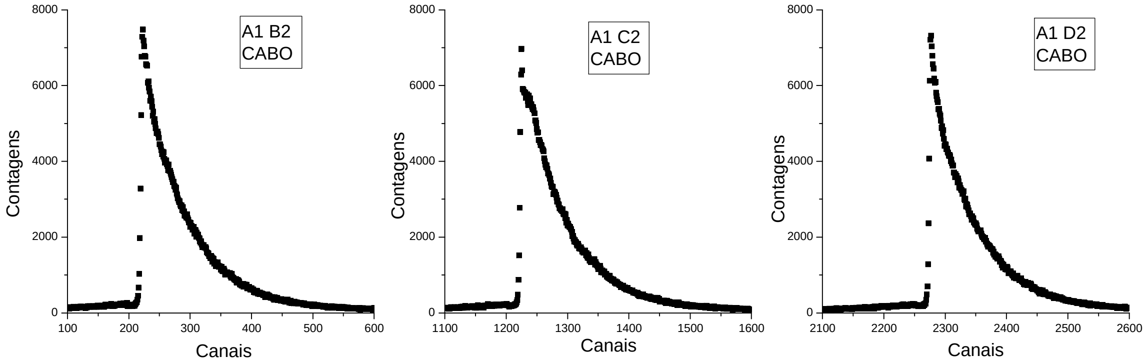

Figure 5. Spectra using the system of delay with handles in A1 (start) and with system of delay with handles B2, C2 and D2 (stop).

The second acquisition of data was carried through using the electronic system of delay with an only double module with the two circuits of delay adjusted in 1,35μs getting the spectrum presented in series totalizing 2,7μs Fig. 6. The third acquisition of data was carried through using the electronic system of delay using two double modules. The two circuits of delay of the first each and a module as circuit also adjuste module had been adjusted in 0,9μs in series totalizing 2,7μs getting the spectrum shown in Fig. 7.

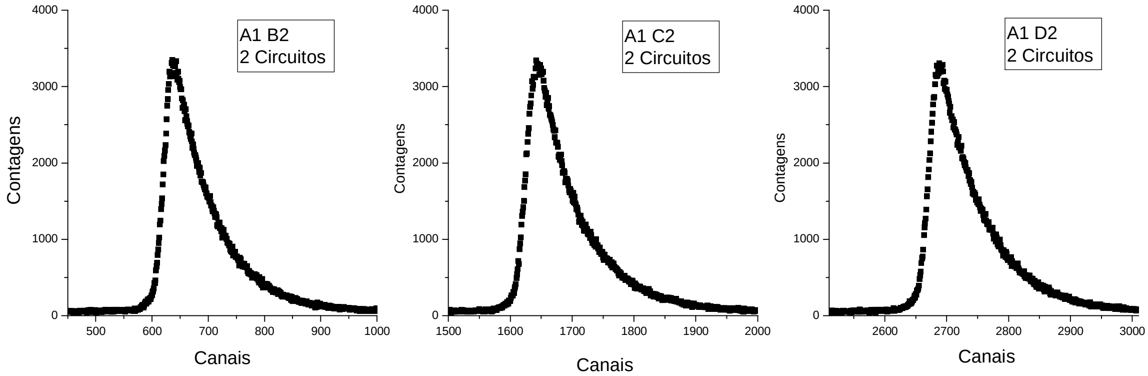

Figure 6. Spectrum with 2 electronic circuits of delay in A1 (start) and with system of delay with handles in B2, C2 and D2 (stop).

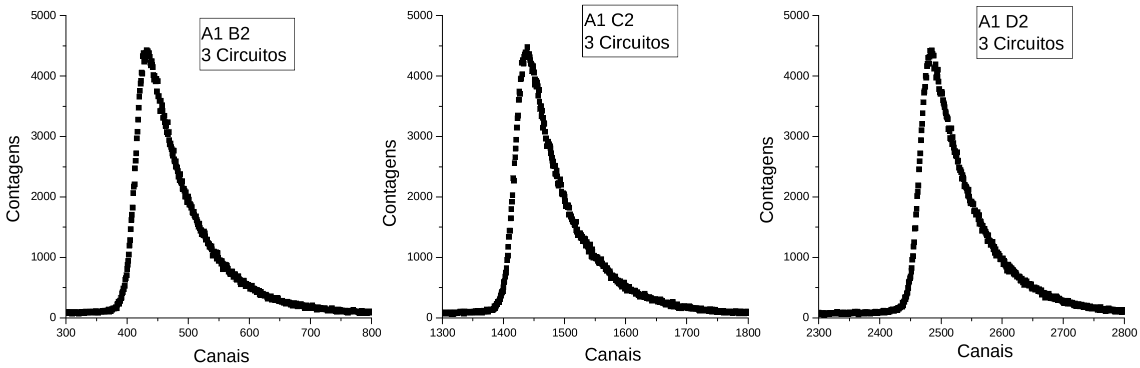

Figure 7. Spectrum with 3 electronic circuits of delay in A1 (start) and with system of delay with handles in B2, C2 and D2 (stop).

The last acquisition of data was carried through using the electronic system of delay with two double modules, with all four circuits of delay adjusted in 0,675μs getting on in series totalizing 2,7μs the spectra presented in Fig. 8.

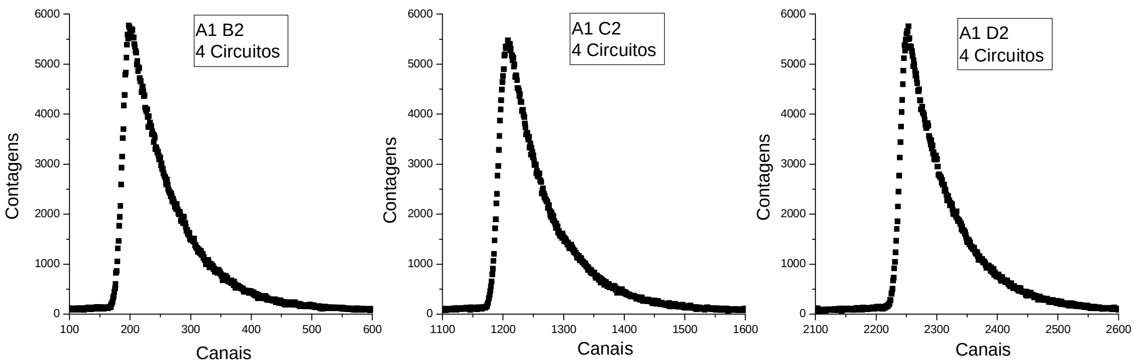

Figure 8. Spectra with 4 electronic circuits of delay in A1(start) and with system of delay with handles in B2, C2 and D2(stop).

The acquisition of the countings was carried through in the interval time of 3600s for each configuration, therefore the Half-Life of ^{181}Hf was not necessary to make a correction of the variation of the activity of the sample in relation to the time therefore is of 42.4 days [1]. The liquid countings after subtraction of accidental countings for the diverse configurations are shown in Table 1 for each spectrum. Some measures for each configuration had been carried through and the results represent the measures of the countings. The results show clearly that 4 on circuits of delay in series are necessary (2 modules), for terms the same efficiency of the cable. Even though resulted with only three circuits the radioactive source (^{181}Hf) used in this experiment can be considered excellent therefore was sufficiently high, compared the samples that are measured in the existing spectrometer already in the Laboratório de Interações Hiperfinas (LIH).

Table 1. Results of the liquid countings using the system of delay with diverse configurations of circuits and handles.

	Counting - A1 B2	Counting - A1 C2	Counting - A1 D2	Counting - Average	% *
2 circuits	320944	316917	314520	317460	0.63
3 circuits	440604	434639	431658	435634	0.86
4 circuits	514913	489990	495532	500145	0.99
Cable	525592	503784	486551	505309	1.00

* Reason of the average counting using the diverse configurations of delay for the average counting using handle

3. CONCLUSIONS

The gotten results had confirmed the expectations in developing a system that can substitute the system of conventional delay that uses coaxial handles, and this fact is entertainer, therefore a system as this would be innovative and reduce the final cost of the equipment. We conclude that we need four circuits of delay (two modules) to make a delay with efficiency equivalent to the handle. The cost of two double modules is about 30% of the value of 600m of coaxial handle necessary to make the delay, also as the handle attenuates the signal still needs a fast amplifying module that also has high cost.

However, although the good results with regarding to the countings using the electronic modules, the resolution in time of the system inferior when are compared with the system with handles, had the sensitivity of the system of electronic delay. This can be seen clearly when we compare the specta of figure 5 (system with handle), with the spectra of figures 6, 7 and 8 (systems with electronic delay). This instability is decurrent of the high sensitivity of the electronic components the variations of temperature of the same environment and the oscillations of the proper system.

We start to substitute some components for equivalents with bigger precision and to make tests to improve this aspect with the objective to arrive at a good resolution. Also we are studying the possibility to construct an only module of delay with four independent circuits to make the delay. They still lack tests with radioactive source of ^{111}In that it has stocking-life of 2,8 days that very is used in measures of PAC. We will give to continuity in the project making the final tests in the new experimental apparatus with samples whose properties are known of literature and simultaneously trying to make improvements in the new modules thus concluding the project with the reached initial goal.

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REFERENCES

1. E. Browne; J.Dairiki; R. Doebler; “Table of Isotopes”, Lawrence Berkeley Laboratory, USA, 1978.