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Using MCA DigiDART for neutron detection

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ABSTRACT

For making neutron detection experiences, an ORTEC DigiDART Multi Channel Analyzer (MCA) was connected to a CENTRONIC SP3 proportional counter, using an ORTEC 142PC preamplifier and a DIM-POSNAI voltage supply. Since the DigiDART MCA is designed for use with sodium iodide detectors, built-in functions that search for optimal detection parameters are not intended for use with those pulses coming from the interaction of neutrons with a proportional counter He-3 gas. The parameters needed to be reset for this new configuration with a proportional counter, in order to obtain reliable measurements. The criteria used to find new values for the parameters were counting repeatability and minimum dead time. After a series of experiments, the parameters were obtained. The response obtained with the detection system using the DigiDART was then compared to that using a Nomad Plus analog MCA, showing consistent results. Finally, the SP3 was installed on a set of Bonner spheres, exposed to AmBe source and the counts in the DigiDART were measured. After that, the response as nuclear reactions by neutron/cm2 incident from an AmBe source was calculated with MCNPX. A linear relationship was found between the calculated and the measured values.

1. INTRODUCTION

In order to achieve portability in Bonner sphere neutron spectrometry, in the past some portable MCA were used.

The ORTEC DigiDART is a portable digital processor for incoming signals from HPGe or sodium iodide detectors. The aim of this study was to obtain a set of parameters that turn it into a useful MCA for neutron counting. Now, it is intended its usefulness for processing pulses arising in a proportional counter He-3 gas connected to a preamplifier. This kind of system has its particular shape of signal, rise time, and amplitude.

2. EXPERIMENTAL SET UP

The detection probe is a CENTRONIC SP3 proportional counter filled with He-3, the counting gas, and some quench gases like CO_2. The system is completed by an ORTEC 142PC preamplifier and a DIM-POSNAI used to supply HV and preamplifier power. The Detector Interface Module (DIM) is needed because it works closely with the DigiDART that controls the high-voltage bias by software. Power supplied by the voltage range matches the requirements of the proportional counter although it is built to use with sodium iodide detectors. The signal passes through coax cables ended at BNC, SHV and proprietary design for SP3 CENTRONIC fittings. Sometimes, a PC with MAESTRO32 software was connected to control the DigiDART too.

The neutron field was supplied by a 5 Ci AmBe source placed at 2 m above ground. The detection probe was installed within an 8 inches polyethylene sphere in order to improve the counting. The center-to-center distance was 70 cm long.

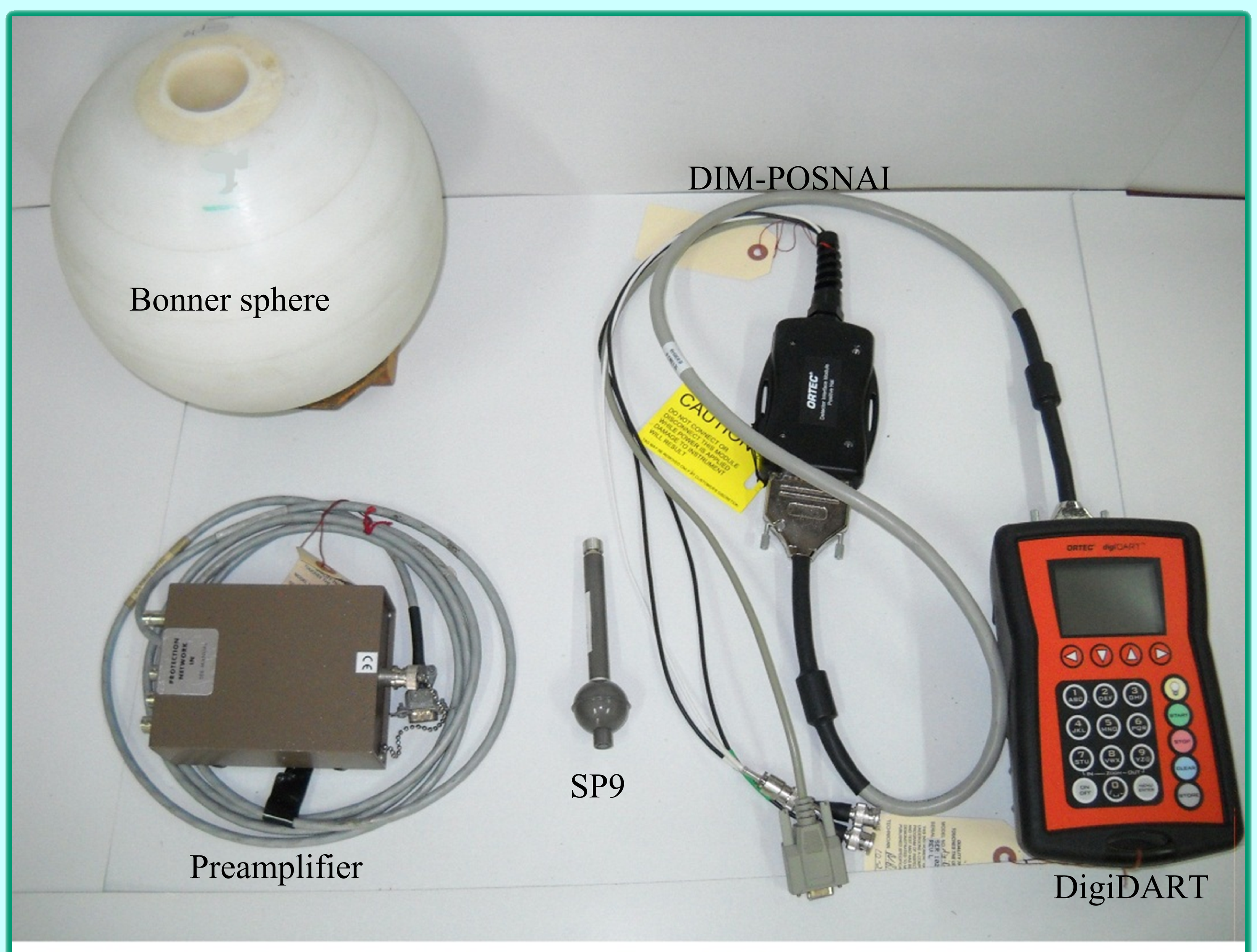

Figure 3. All elements of the neutron detector.

Figure 3 shows the complete system: the detector Centronic SP9, the multichannel DigiDART with DIM-POSNAI interface, the preamplifier PC142 and an 8" polyethylene sphere.

Search criteria for new set of parameters

Being the detection probe exposed to a same neutron field, the search criteria were:

- Minimum dead time.
- Repeatability, measured by standard deviation. Avoid a drift founded when jobs of five consecutive identical spectra were acquired (Note: a "job" is a little script that the MAESTRO32 software can run in order to make a repetitive task.)
- Maximum counting rate.
- Match with the results obtained from previous experiments with portable detectors.

3. RESULTS

Bias	800 V
Rise Time	10 µs
Flattop	0.8 µs
Flattop/ tilt	0.0000 µs
Fine gain	0.4725
Coarse gain	X4
Zero pole parameter	600

Table 1. Final parameters

The final parameters are shown in table 1.

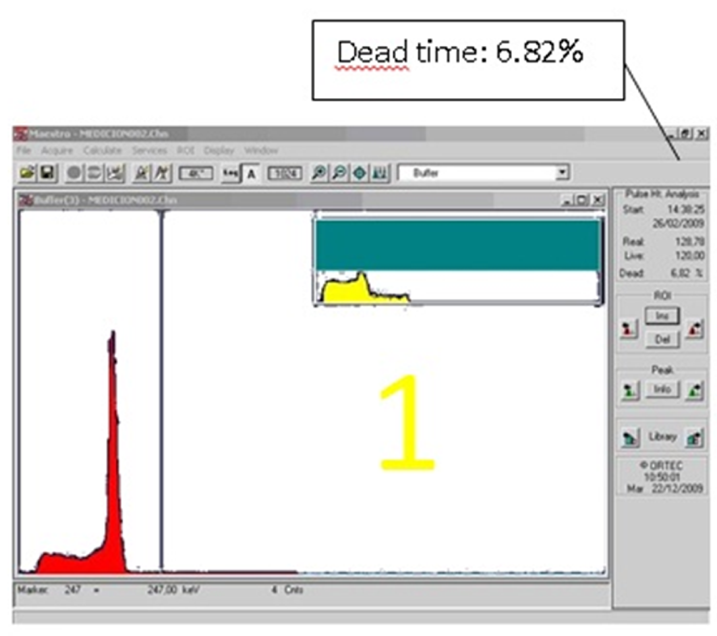

Figure 1. Default parameters.

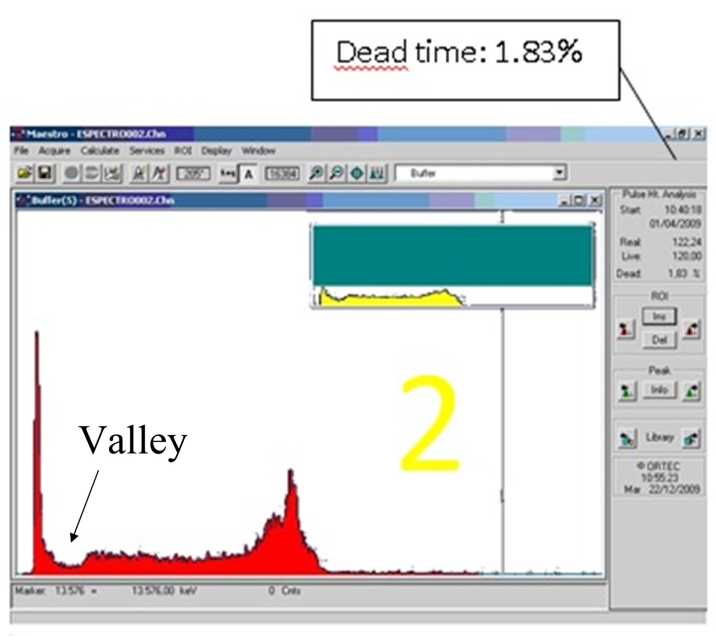

Figure 2. Optimal parameters.

The figure 1 shows that the parameters of MCA DigiDART are far from optimal values. Neither valley or pre valley region is perceived. The last one is typically caused by gammas, thermal or electrical noise. The region that follows the valley is caused by nuclear reactions with neutrons, and also has read up to values of energies needless for the energy released by these reactions. The dead time is three times that achieved in the optimal case. If conditions are not optimal, it is not rare that things appear without justification. In Figure 2, the parameters are optimized DigiDART MCA.

Nuclear reactions rate into the detector probe was theoretically calculated using MCNPX. The comparison with the experimental results showed a constant rate. This establishes a regular relationship between the nuclear reaction rate and the counting rate.

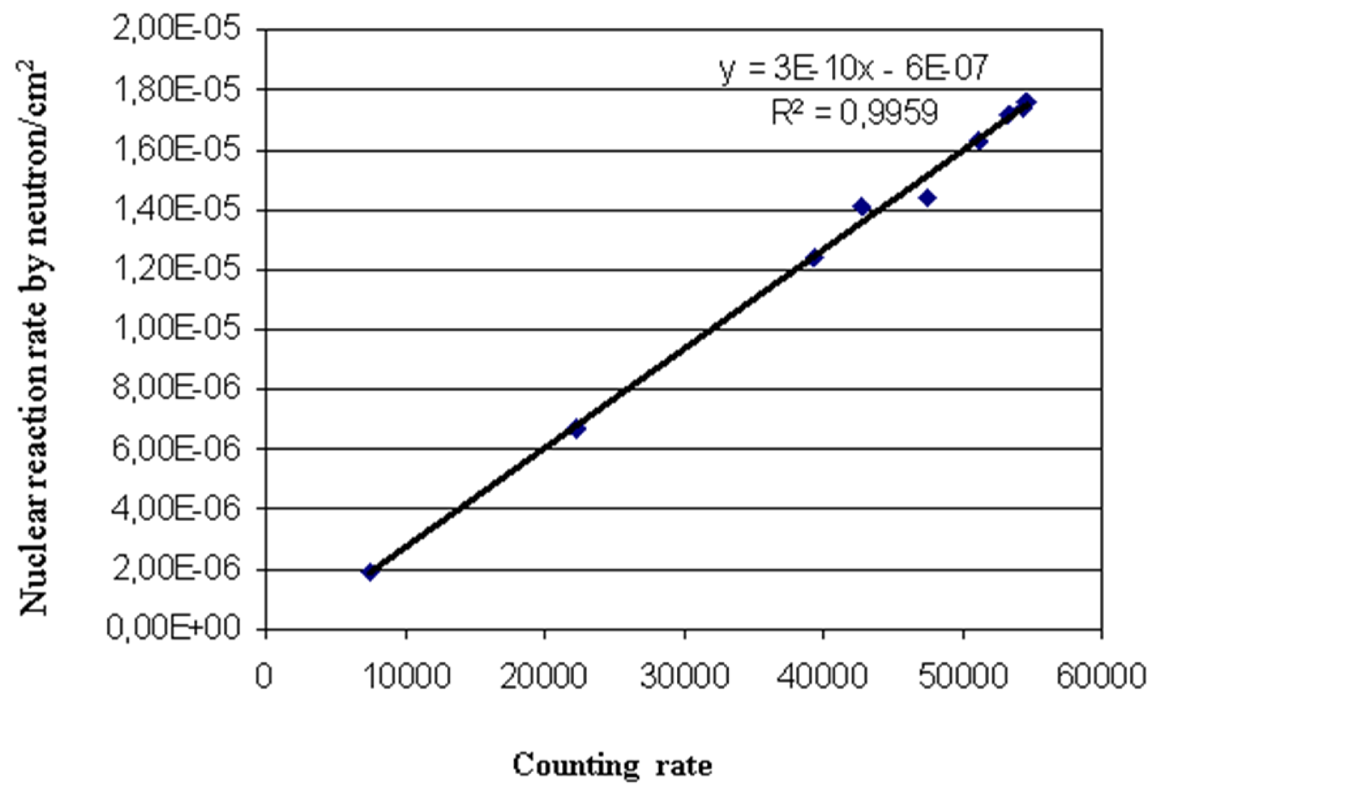

Figure 4. Nuclear reaction rate by neutron/cm^2 against counting rate. Let's see the constant relationship. A R^2=0.9959 confirms the linear relationship.

4. CONCLUSIONS

The final parameters for the DigiDART were obtained. The counting rate and the dead time were better than previous ORTEC portable MCA, Nomad Plus. Secondary goal achieved was a better resolution in energy.

Results obtained were consistent with previous results, like dependency of the counting rates with neutron nuclear reaction rates into detector probe and the neutron spectra obtained by unfolding. The experiments performed to verify measurements were acceptable.