DATA ACQUISITION SYSTEM FOR RESISTIVE CATHODE DETECTORS

T.P. Peixoto[1], P.R. Pascholati[1], V.R. Vanin[1]
J.A.C. Gonçalves[2,3], C.C. Bueno[2,3]

[1]Instituto de Física da Universidade de São Paulo
Laboratório do Acelerador Linear – LAL
Rua do Matão Travessa R, 187
05315-970 Cidade Universitária, São Paulo, SP, Brasil

[2]Instituto de Pesquisas Energéticas e Nucleares - IPEN-CNEN/SP
Av. Lineu Prestes 2.242
05508-900 Butantã, São Paulo, SP, Brasil

[3]Departamento de Física, Pontifícia Universidade Católica de São Paulo
01303-050, São Paulo, SP, Brasil

ABSTRACT

The aim of this work is to present the development of a data acquisition system designed to aid the study of physical phenomena in metallic detectors with resistive cathode. Since the behavior of such detectors consists basically of a gain variation with time, a data acquisition and visualization program was developed that allows users to observe in real-time the temporal variation of the energy spectrum. A Linux kernel device driver responsible for I/O control and data timing was also developed for the project.

Keywords: nuclear instrumentation, data acquisition, resistive detectors

I. INTRODUCTION

Detectors with resistive electrode normally behave in a transient fashion in respect to detection efficiency or charge gain, depending mainly on the counting rate and the gas mixture used [1,2]. Therefore, it is interesting to study how this behavior takes place and to observe the data variation with time.

The motivation for the system development was to observe the spectrum obtained from any type of detector and its variation with time, and to be able to export the data as text (or binary) file to be used with an external data analysis package. Specific data analysis functions within the data acquisition program itself are being worked on.

II. THE SYSTEM

The layout of the system can be observed in Fig. 1.

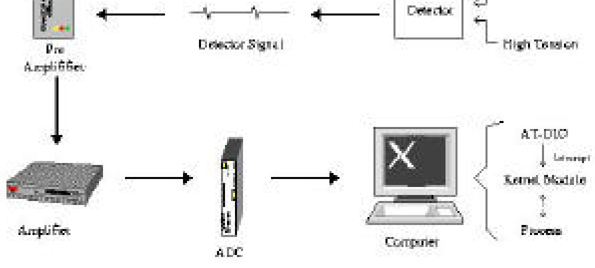

Figure 1 - System Layout

The signal from the detector goes through the pre-amplifier (Ortec 142PC) then through the amplifier (Ortec 572) following to the Analog to Digital Converter (ND582 ADC). The digital data from the ADC is retrieved with a digital IO board (ATDIO 32F - National Instruments) in a industrial microcomputer. The Kernel device driver for the IO board receives an interrupt when new data is available, retrieves it from the board, gets the time from the CPU cycle counter and stores the data in a buffer whenever acquisition is in progress, so it can be read from the acquisition program.

The microcomputer used is an industrial PC with an Intel 700MHz Pentium III CPU and 128 MB of memory, and is more than adequate for the task. The operating system used is GNU/Linux [3] and the kernel version, at the time of this writing, is 2.4.18 (with low-latency patch applied) [4].

III. THE GONK ACQUISITION PROGRAM

The acquisition program (named GONK) gets the data from the device driver and then builds and displays a two-dimensional matrix (energy vs. time histogram) representing the data. The main window can be seen in Fig. 2, and it shows, just as an illustration, an acquisition with a ^{109}Cd source and a germanium detector being gradually depolarized. The histogram at the bottom of the graph is the sum of an area in the two-dimensional display selected by the user. A selection near the beginning of the acquisition is represented by the black histogram. Another near the end of

Index

the acquisition is represented by the red histogram. The vertical scale is in seconds and the horizontal is in ADC channels.

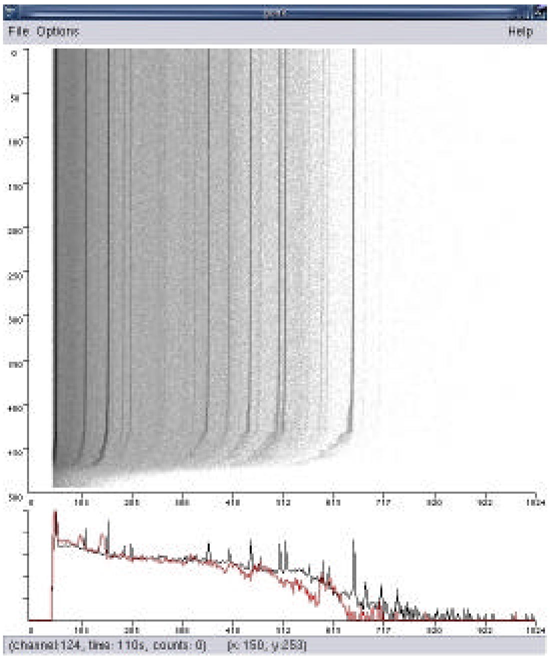

Figure 2 – Acquisition With a ^{109}Cd Source and a Germanium Detector Being Depolarized.

Several parameters can be configured through the configuration window (Fig. 3 and 4), such as acquisition buffer size, linear or logarithm scales, fixed or variable scale bases and the color scale. The zoom can be changed through the zoom window (Fig. 5).

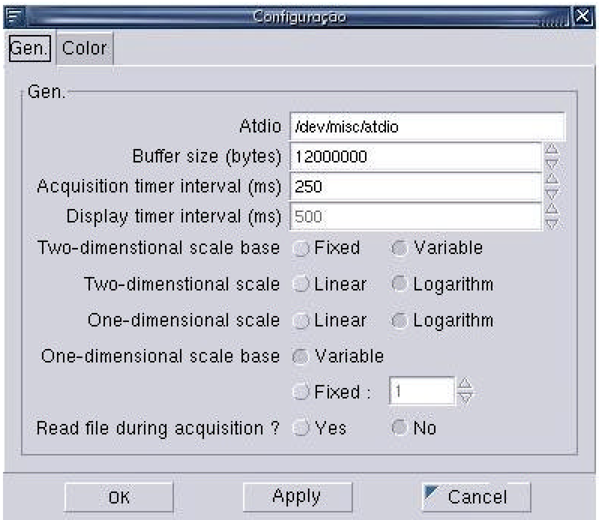

Figure 3 – General Configuration Window.

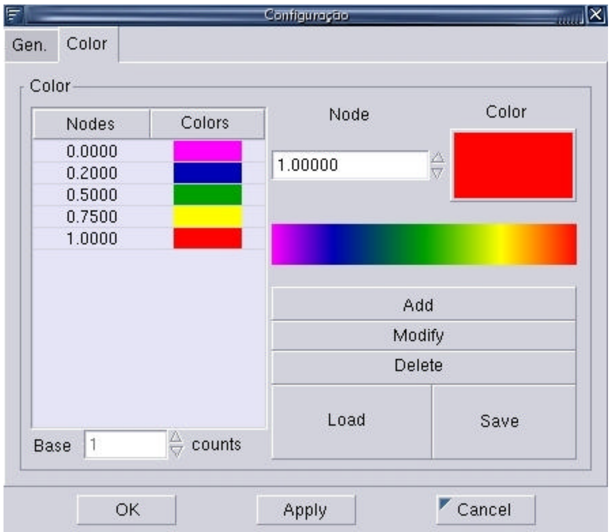

Figure 4 – Color Scale Configuration Window.

Figure 5 – Zoom Configuration Window**.**

A new acquisition can be started from the acquisition window (Fig. 6) and it can be timed or infinite. It also contains some basic statistical information such as count rate and file size.

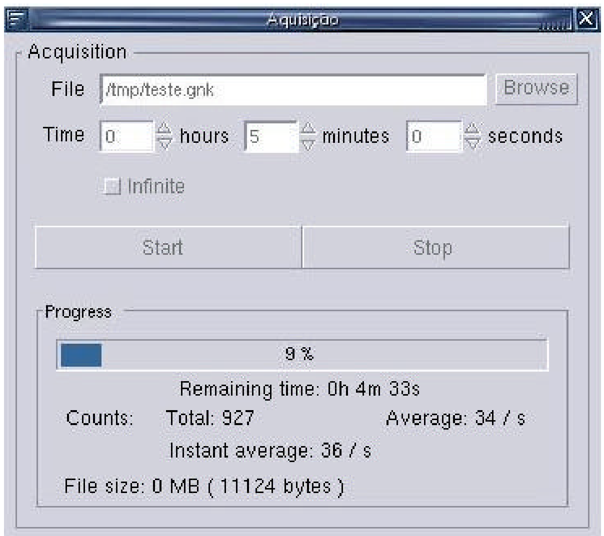

Figure 6 – Acquisition Window

The program can export both the one-dimensional and two-dimensional data as a text file. The two-dimensional data can be exported as binary file also, to save disk space.

IV. RESISISTIVE CATHODE DETECTOR DATA

To exemplify the use of the program with resistive cathode detectors, it is shown two different acquisitions (Fig. 7 and 8), one with a metallic detector and the other with a resistive detector. Both detectors are cylindric gaseous detectors, identical except for the cathode. In both acquisitions a ^{106}Cd source was used, with a 90% Ar and 10% CH_4 gas mixture.

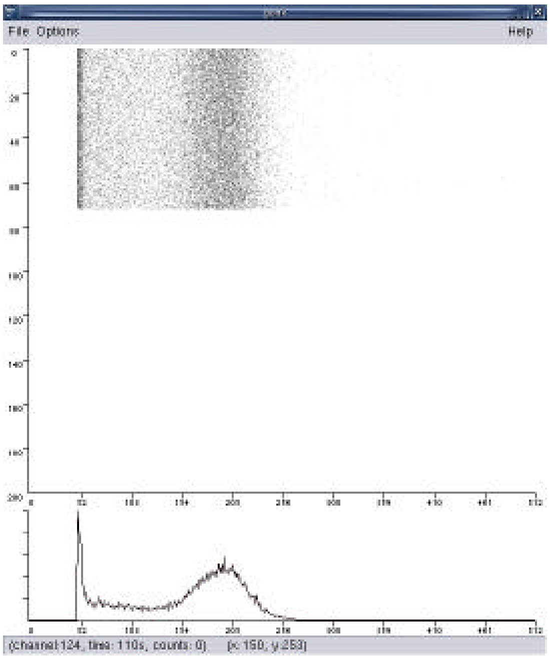

Figure 7 – Acquisition with a ^{106}Cd Source and a Metallic Detector.

The effect of the resistive cathode can be seen very clearly in Fig. 8. A theoretical model for this behavior was developed by Fraga et al [1], and it implies that the detector gain decays according to the following expression:

$$y = A_1 + e^{a_1 t} + A_2 + e^{a_2 t} + C \qquad (1)$$

where A_1, A_2, α_1, α_2 and C are constants.

Just as a simple test of that model, the acquisition data for the resistive detector in Fig. 8 was partitioned in 1.7 seconds pieces, and for each piece the peak centroid was determined by fitting a Gaussian function. The function of equation (1) was fitted to the resulting data (Fig. 9). The value of the χ^2 for the fit was 1.31, which is reasonable, since the expected value for data which agrees with the model is around 1.

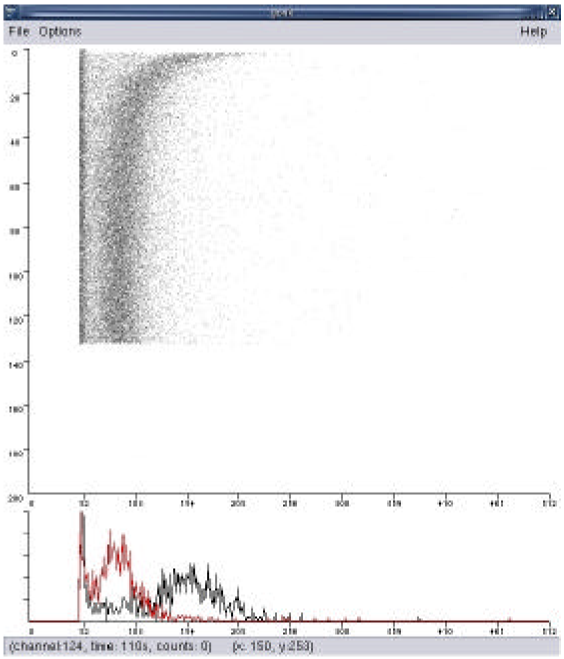

Figure 8 – Acquisition with a ^{106}Cd Source and a Resistive Detector.

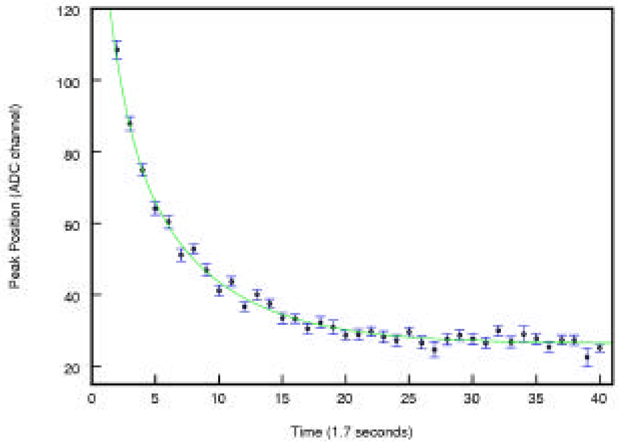

Figure 9 - Variation in Time of The Peak Position With a 106Cd Source For Each 1.7s ``Channel" of The Two-Dimensional Spectrum. The Function Fitted is Eq. (1).

V. CONCLUSION

From the obtained data, it can be concluded that the developed system behaves well for the type of experiments for which it was developed. It was shown that it is possible to determine the detector gain variation with time using the system, and that the model by Fraga et al. [1] can be used as a good starting point to study the behavior of this type of detector.

REFERENCES

[1] Fraga, M. M. et al., **Influence of Resistive Electrodes on Detector Performance**, Scientifica Acta, Quaderni del Dottorato, Volume XIII, Ano XIII, Numero 2, IV International Workshop on Resistive Plate Chambers and Related Detectors, Napoli, 1998.

[2] Fraga, M. M. et al, **Transient Behaviour and Rate Effects in Resistive Detectors**, Nucl Instr Meth in Phys Res, vol. 263, p.485,1998.

[3] **The GNU/Linux operating System**,
http://www.gnu.org , http://www.linux.org

[4] **Linux scheduling latency**,
http://www.zip.com.au/~ akpm/linux/schedlat.html