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AN INTELLIGENT MULTICHANNEL ANALYZER FOR STABILITY SUPERVISION OF PULSE HEIGHT SPECTRA

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A monitoring system for pulse height spectra has been developed. It supervises peak positions and transmits data to an on-line computer. The system can be useful both for off-line analysis and during data aquisition. The hardware is based on a Z80 microprocessor. The software is written in the programming language PEARL. Two applications are presented.

1. Introduction

Gain shifts in nuclear and particle physics experiments lead to serious problems because they degrade the quality of the data. They are the result of gain and zero changes in the detectors or the electronic components. Particularly in coincidence (low count rate) experiments they can often even adulterate the results, because in the off-line analysis the experimenter has no information to allow data correction.

In the literature many peak stabilizers have been presented. One class of these stabilizers contains regulation systems (see, e.g., refs. [1–3]). Regulation systems, however, have two disadvantages:

1) Any regulation system has time constants and when these are not adapted properly to the individual problem the whole system might start to oscillate.
2) Any malfunction in the system can destroy the data and may become a new source of error in experiments.

A second method of peak stabilizing consists of on-line spectrum stabilization by software [4–6]. This method is appropriate for high count rate experiments with data taken in the multichannel analyzer (MCA) mode.

For experiments with low count rates (some events per minute) with data acquisition in the event by event mode, however, it is not very useful, because peak shifts cannot be detected fast enough due to the fact that the event rate is not sufficient for significant tests.

In most cases, the low count rates are the consequence of a strong event filtering of the experiment electronics (e.g. in 2-arm experiments). Nevertheless, the rate of single components of these experiments often produce higher rate peaks in their free spectra with significant information about the actual gain of the component. (Otherwise test pulses of LEDs or electronic test pulses can be used to produce peaks which can provide the necessary energy information.)

For application in low count rate experiments, we built an intelligent MCA which monitors the free spectra of up to 16 components sequentially. The system recognizes peaks in the spectra and determines the actual calibration of a certain component. This information is read into the data taking computer. The on-line computer is therefore able to store the actual calibration of the experiment components for each event without being troubled by a high interrupt frequency. The calibration information is also printed out for the experimenter. These data can be used for off-line correction of the data producing the coincident spectra.

2. Design and realization

For the realization of the monitoring system presented here we have chosen a Z80 microcomputer in connection with the high level real-time programming language PEARL [7] as described in ref. [8].

The hardware components are the Z80 ECB system with a CPU, a parallel IO (64 channels), two scalers, one peak sensitive ADC, one graphics terminal, one alpha terminal, two floppy discs, a line printer and one 16 to 1 analog multiplexer as illustrated in fig. 1.

The software is built up of two components: the interactive graphic predialog and the main monitoring program.

The interactive graphic predialog consists of three tasks:

(1) MESS: This task reads out the ADC and transmits the data in a message to the task BILD.

(2) BILD: This task receives the message from MESS, interprets the data, and drives a live display of the pulse height spectra on the graphics terminal.

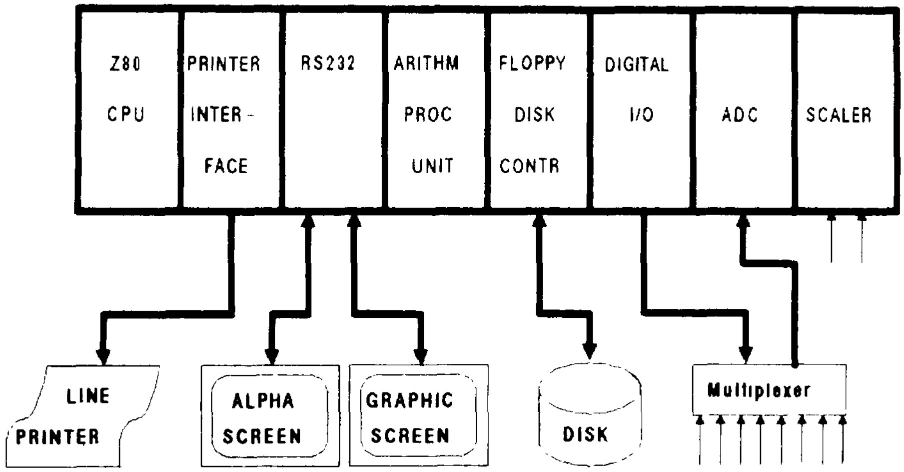

Fig. 1. Hardware components of the intelligent multichannel analyzer.

(3) INPUT: This task communicates with the user and stores the parameters for the main monitoring program on a file. The user must choose the input number of the multiplexer and wait some time for data collection. Then he can enter (with the hardware graphics cursor) the limits of the line, (displayed on the graphics terminal) of which the main program shall monitor the position. The user also enters the time intervals necessary for finding the peak position. These parameters are stored on a file on the floppy disc.

The main monitoring program consists of five tasks. Their communication is shown in fig. 2. We used the specification method published in ref. [9].

(1) FLOPLES: this task reads the parameters stored on floppy disc by the predialog and transmits these parameters to INPUT. Afterwards, it initalizes and starts the rest of the system.

(2) INPUT: Via this task the user can choose the cut on the monitored peak and adapt the collection time for each multiplexer input to actual rates in the experiment. These parameters are transmitted in a message to MANAG.

(3) MANAG: This task receives the messages from INPUT, switches the multiplexer inputs, and activates the task MESS. After the collection time it receives the data taken by MESS in a message and terminates it.

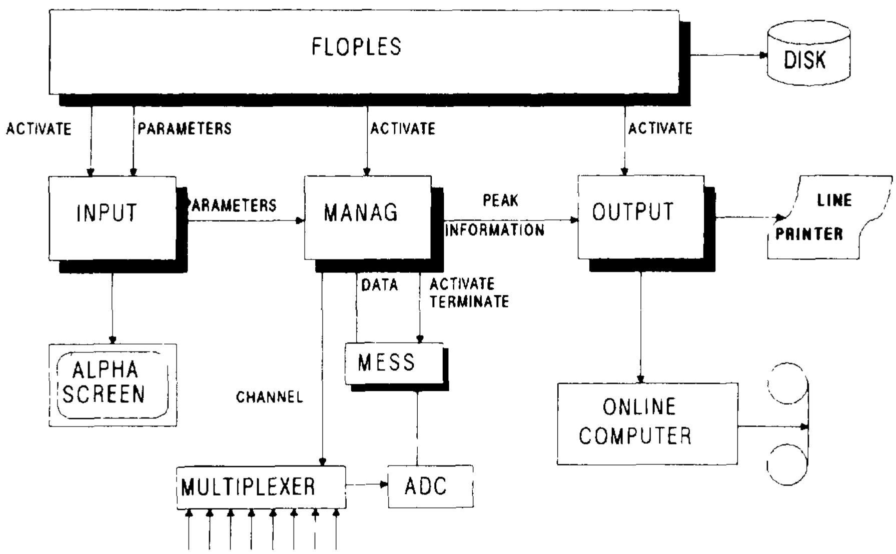

Fig. 2. Communication diagram of the tasks in the intelligent multichannel analyzer

Then it calls the subroutine calculating the peak shift. Especially in this task, the advantage of the use of a high level language for this problem is obvious: It is easy to adapt this subroutine to the problem with low effort. Any of the methods presented in the literature [10–12] can easily be implemented at this point. The information of the peak shift is now transmitted in a message to OUTPUT.

(4) MESS: This task reads the ADC and transmits the data to MANAG.

(5) OUTPUT: This task receives the message with peak shift information from MANAG and sends the data to the data taking computer, which can write this information on magnetic tape together with the experimental data. The use of PEARL allows a simple adaptation to any interface of the on-line computer. For example, it has been implemented with a parallel CAMAC input register and a PDP11/40 in one experiment, and with DAC–ADC coupling to a Nuclear Data ND4420 system in another application. Furthermore this information is printed (on a line printer), so that the experimenter can check the faultless working of the different components of his experiment.

3. Two examples of application

In order to demonstrate the benefits of this monitoring system, we will describe its application in two different types of experiments.

3.1. Monitoring of NaI detectors in a (π, $\pi'\gamma$) coincidence experiment

In a (π, $\pi'\gamma$) experiment at SIN [13] the pulse height spectra of six NaI detectors operating in coincidence with a pion spectrometer were taken. The data rate in the NaI counters was some 10 kHz. The coincidence rate was some counts per minute. For stability supervision we pulsed LED signals into the photomultipliers at 100 Hz. The monitoring system collected the LED pulses and transmitted the peak information to the data taking computer. The pulse height data of every coincident event, together with the peak position of the LED, were archived on magnetic tape. This configuration is illustrated in fig. 3.

In this experiment peak monitoring was essential for the calibration of the spectra. Fig. 4a shows the shape of a pure spectrum of 4.4 MeV photons in our 5 inch × 5 inch NaI detectors when no peak shifts occur. The presence of the 4.4 MeV photopeak and the "single escape" peak at 3.9 MeV allows calibration of the spectrum. Fig. 4b shows a coincident NaI spectrum of 4.4 MeV photons taken in 6 h. The intelligent MCA detected gain shifts of a few percent. Due to these shifts the ratio of the peak intensities is not the same as in the pure spectrum and on the high energy side of the photopeak a shoulder appears. This spectrum is difficult to calibrate. With the help of supervisory data on the magnetic tape, the data can be corrected event by event

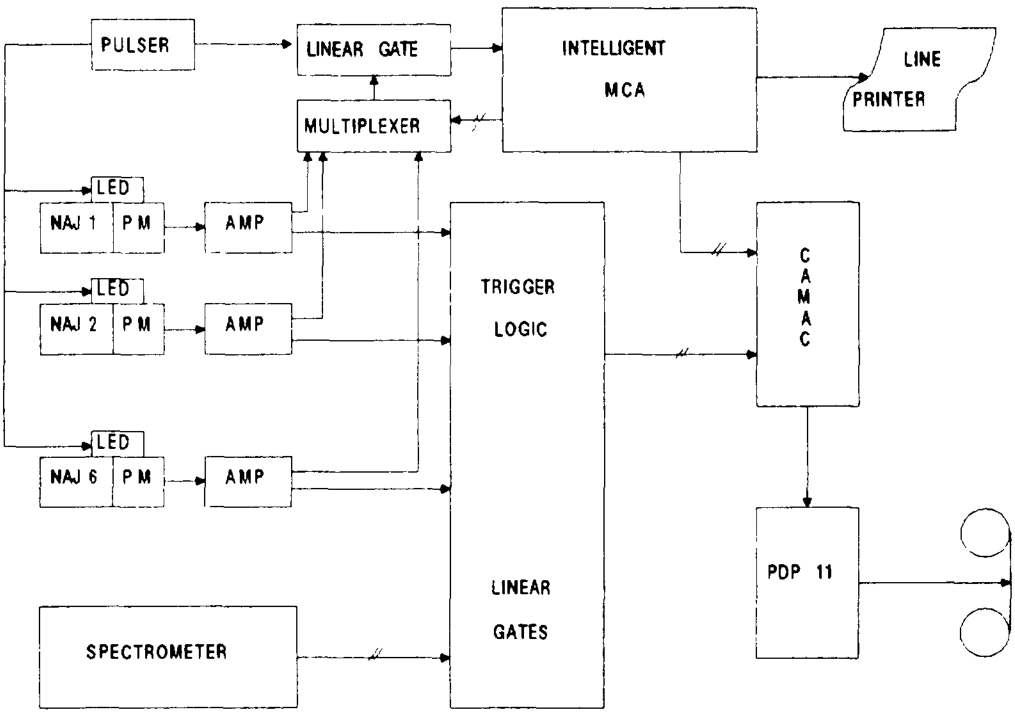

Fig. 3. Electronic setup of a (π, $\pi'\gamma$) experiment using the intelligent multichannel analyzer.

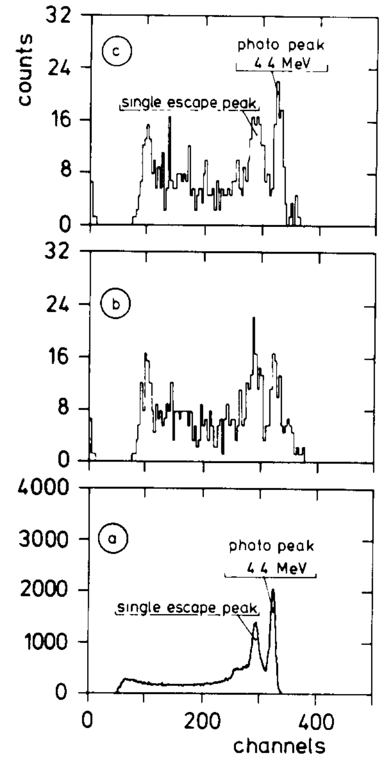

Fig. 4. (a) Spectrum of 4.4 MeV photons taken in some minutes with a 5 inch × 5 inch NaI detector. (b) NaI spectrum of 4.4 MeV photons taken in coincidence with a spectrometer in 6 h. (c) Data of (b) corrected with the help of the information of the intelligent multichannel analyzer.

using routines such as published in refs. [5,6,14]. The corrected spectrum is presented in fig. 4c. It shows the same form as the "free" spectrum and therefore it is possible to calibrate it with the help of the 4.4 MeV photopeak and the 3.9 MeV "single escape" peak. Proper calibration allows a reproducible setting of the integration limits.

3.2. Monitoring stability of TPC spectra in a (^{6}Li, ^{6}Li′n) experiment

In an experiment at the Karlsruhe cyclotron [15] inelastically scattered ^{6}Li particles were measured in coincidence with the time of flight of neutrons of decaying nuclear states. Our MCA system monitored the pulse height spectra of both the solid state detectors used for the registration of the scattered ^{6}Li particles and also the spectra of the time-to-pulse-height converters which measured the time of flight of the neutrons (frequency of some kHz). The peak shift information was printed on the line printer and an indication of shifts too large to be accetable was transmitted to a data acquisition ADC (interrupt frequency: some Hz).

The system has worked without problems in many experiments. Use of a high level programming language allows a quick adaptation to any problem. (Program adapting time: 1–2 days) In the off-line analysis it was possible to evaluate data which were nearly useless without the quantitative peak shift information acquired during the data run. All observed peak shifts could be corrected to allow accurate spectral analysis. Thus the experimenters could be sure that the quality of the evaluated data was not injured by gain shifts. The intelligent MCA has proved to be a useful tool for experiments where a high gain stability is essential.

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