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A LSI/CAMAC SYSTEM FOR HEAVY ELEMENTS RESEARCH

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Abstract

We have developed a LSI-11/23 computer-driven CAMAC data acquisition system. The 64 silicon-detector system is being used to investigate the alpha and spontaneous fission activities of short-lived transactinoid isotopes by the real-time monitoring of the mother-daughter alpha decay sequence. A unique modular pulse processing electronics system was designed to simplify set up and calibration. The computer adjusts the gain of the CAMAC shaping amplifiers enabling the calibration and alignment of all 64 of the 1 k alpha spectra to within 0.5 channel in less than 10 minutes.

Introduction

The Nuclear Chemistry Heavy Elements group is searching for new neutron rich heavy nuclides with short half-lives that cannot be identified by conventional techniques. The investigation of these transactinoid isotopes with half-lives of greater than 100 ms requires a unique isotope identification method. The multiple alpha detector (MAD) system described here was developed to perform this function by the real-time monitoring of the mother-daughter alpha decay sequence. A helium gas flow is used to transport sample material from a remote target chamber and deposit it on a thin plastic foil which is positioned between two annular detectors in the MAD chamber.¹ Each incoming event is inspected to see if it falls into a preset energy window. Each valid event is then time-tagged, stored, and the interval to the next related event recorded. The sample-wheel which holds the foils is rotated by a stepping-motor to subsequent detector pairs. This complex sequence requires many counting stations. We chose 32 detector pairs initially, but the chamber design will accommodate 59 for future expansion. This paper will emphasize the unique pulse processing electronics, the need for automated set up and calibration, and the factors which led to the choice of CAMAC design.

Design Considerations

The MAD system is located at the Lawrence Berkeley Laboratory's (LBL) 88-inch cyclotron facility, where the operating environment is relatively harsh during bombardments (e.g., radio-frequency interference, poorly controlled temperature and power distribution problems). The target chamber cave where the sample is made gets highly radioactive during runs and is not always accessible. For these reasons, it was necessary to locate the MAD chamber and data acquisition electronics in two remote locations (Fig. 1). A separate isolated and filtered power distribution was installed for instrumentation, with a good one point grounding system. A relatively small, well shielded, vacuum chamber was assembled to house a positionable sample wheel and a large number of detector pairs with their associated preamplifiers. The number of counting stations requiring spectroscopy grade electronics dictated the design of a high quality, low profile plug-in preamplifier. A CAMAC design was chosen because of its standardized dataway communication and the large number of commercial high

Fig. 1. MAD System Pictorial Diagram.

density data acquisition modules available. We also recognized the need for some method of automated setup and calibration due to the difficult and time consuming job of making such a large number of manual adjustments.

System Design

The block diagram (Fig. 2) shows the complete multiple detector system. The MAD chamber (Fig. 3) is a stainless steel cylinder, 60 cm in diameter and 22 cm high, mounted on a metal stand with locking wheels. The stepping-motor sample-wheel drive is mounted just below the chamber. The chamber lid has a plexiglass window to allow viewing the detectors and sample wheel. This motor-driven lid hinges open for easy access. The Tennelec 150 mm² slimline silicon surface barrier detectors are mounted on removable plexiglass holders in two layers. Mounted in groups of 8, the upper 32 detectors attach to the lid, while the opposing 32 are mounted in the bottom of the chamber. These detectors are mounted on 6° centers to match the 1.5° increments of the stepping motor. To minimize the number of cables and keep preamp input leads short, two large, donut shaped printed circuit motherboards were designed to accept the preamplifiers. Only one calibration pulser, detector bias supply, and preamplifier power supply are used, and connect to the motherboards with a single cable. The extensive use of CAMAC modules enabled us to design a relatively low cost, high quality system having a

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Fig. 2. Block Diagram of the MAD System.

minimum number of components. Housed in just two CAMAC crates, only two crate controllers are needed to interface the LSI-11/23 microcomputer to eight modular groups. Each group consists of one in-house designed 8 channel linear shaping amplifier, an 8 channel router, and one spectroscopy ADC.

Data Acquisition

After analog pulses from the detectors are processed and digitized by the LeCroy ADCs, the crate controller flags the LSI-11/23 computer with an interrupt request. The LSI-11/23 operates as the central processor of a computer acquisition system that accumulates, sorts, displays,² and then stores the data in a list mode fashion. A serial RS232 link establishes communication to the HP85 computer-driven stepping-motor controller, which positions the sample wheel during acquisition. To obtain maximum data throughput, all coding used for acquisition, inspection, and storage was done in machine language. Acquisition time is less than 1 ms per event.

Preamplifier

A complete circuit diagram of the preamplifier is shown in Fig. 4. The small modular, plug-in preamplifier was designed for alpha spectroscopy with a linear range of 0-60 MeV, but can be easily extended to 300 MeV for fissions. The circuit is comprised of a low noise FET and a LeCroy TRA1000 monolithic amplifier configured as a charge loop with an output buffer to drive 50 ohm coax cables. The charge loop has a gain of 0.5 V/pC.

Fig. 3. The MAD Chamber.

Fig. 4a. Preamplifier.

Fig. 4b. MAD Preamplifier Circuit Diagram.

Amplifier

Since there were no commercial CAMAC amplifiers available that would meet our specialized requirements, it was decided to develop our own.³ A single width CAMAC module was designed having eight independent, digitally controlled shaping amplifier channels. A simplified schematic of one channel is shown in Fig. 5. This unit was designed with pole-zero compensation, 0.5 ms gaussian shaping and has a digitally selectable gain of zero to sixty which allows for program controlled energy calibration. The gain is controlled by a 4096 attenuator which is comprised of a 12 bit multiplying digital-to-analog converter (DAC) in the feedback loop of a wideband amplifier. Although some compromises were made to get eight amplifiers in one module, the performance met all expectations.

Fig. 5a. CAMAC Module.

Fig. 5b. Simplified CAMAC Shaping Amplifier Circuit Diagram.

*Program selected gain determining number

System Calibration

The signal from a precision tail pulser is fed to the common test input circuit of all 64 preamplifiers. A CAMAC module (Jorway DAC) provides the pulser reference voltage for energy calibration. Each automated shaping amplifier channel is then selected and gain adjusted under program control until an alignment accuracy of 0.5 channel, in the 1 k spectra, is achieved. Once calibrated, the information is stored on disk and can be checked for stability during long runs. The automatic calibration program allows fast, accurate restoration on restart or after computer crashes. All 64 channels are setup in a matter of minutes vs. hours or even days, as with previous methods.

Results

The first successful experiments were done in the fall of 1984 and, over the past several months, the system has proven to be very reliable and easy to use. The resolution of the alpha peaks is limited by the close detector geometry, but less than 30 keV FWHM resolution was attained. Because of the automated pulse processing electronics, calibration and alignment can be done rapidly. We have developed a tool that can be used to determine the decay properties of as yet undiscovered neutron rich isotopes. Figure 6 shows the results of real-time sorting of mother-daughter events from the first $^{263}\text{105}$ search.¹

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Fig. 6. Sorted Mother-Daughter Event Data.

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