Compact dual-parameter MCA for $\gamma - \gamma$ Coincidence Measurements

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Introduction

Gamma-Ray Coincidence measurements have immense importance in a range of isotope analysis and medical imaging methods, but these find very little representation in UG and PG laboratories for teaching purposes owing to the high costs of the equipment required.

We present the development of a dual parameter list mode 1K Multi-channel analyzer , which is capable of identifying coincident events within a 400nS window. This compact USB powered instrument has a microcontroller based design fabricated on PCB mounted in a durable aluminium enclosure measuring a mere $112 * 60 * 31 mm^3$. The inputs accept $0 - 3.3V$ shaping amplifier signals with a rise time preset to 3uS(configurable) in accordance with the output characteristics of the portable gamma ray spectrometers we have already developed and presented at DAE-2018[1]. An elementary full-spectrum gating technique for coincidence demonstration was presented at RINP2[3], and this separate dual MCA approach overcomes its severe limitations.

The MCA has two BNC sockets for input signals. Two high-bandwidth comparators linked to 12-bit threshold DACs act as discriminators for the individual inputs. These signals are interpreted by a 64MHz microcontroller , and the shaper signal heights are digitized by its built-in 12-bit DAC capable of simultaneous sampling of up to 4 input channels. The arrangement is shown in 1. Our cross-platform software written in Python, which we have licensed under open-source terms[2], is capable of plotting the list mode data as separate 1D histograms, as well as 2D surface plots for coincident events. Powerful Python modules such as Numpy, Scipy, and Pyqtgraph facilitate analysis and visualization.

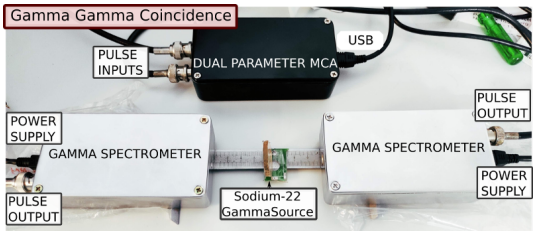

FIG. 1: Photograph showing the arrangement of two portable gamma spectrometers connected to the dual MCA for coincidence measurements. A ^{22}Na source is placed at the centre.

Results: Positron Annihilation Spectra

Gamma ray pairs from positron annihilation have well defined energy of 511keV, and relative angle of 180 degrees. A ^{22}Na point source was placed on the centre of a straight line joining two portable gamma detectors 5cms apart, and data shown in Figure 1 was acquired using the dual MCA over a period of 6 hours.

The list has 3 columns - time(15nS step size), Channel A(Pulse height of input A - 10 bit number), and Channel B(Pulse height for input B). For non-coincident events, channel information for either one of the inputs is marked as 0. This file was analyzed using Cern-Root to generate a heat map, and Pyqtgraph was used to generate a 3D surface plot

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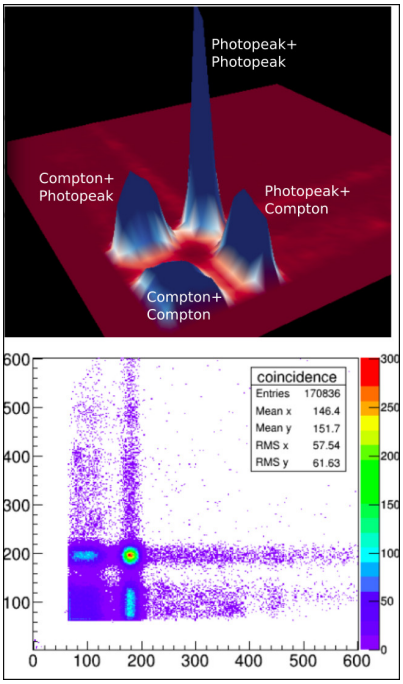

FIG. 2: 2D histogram and surface plot of gamma rays from ^{22}Na placed centrally. Events from the high energy peak at 1275keV are greatly attenuated since they don't have a companion gamma **emitted diametrically**, and can only be party to random coincidences

which is more intuitive.

For further validation, an optical spectrometer's rotational stage was used to set different angles between the spectrometers, and obtain coincidence events from a centrally placed ^{22}Na source. Data was recorded in 5 minute intervals , and the resultant angular correlation data is shown in Figure 3. The counts decrease symmetrically on either side of the 180 degree configuration, validating the performance of the MCA.

Conclusions: The modular design, and low bill of materials makes this a viable candidate for introducing concepts of gamma-gamma coincidence such as background subtraction in UG labs. This is now being extrapolated to develop particle-gamma coincidence experiments using our

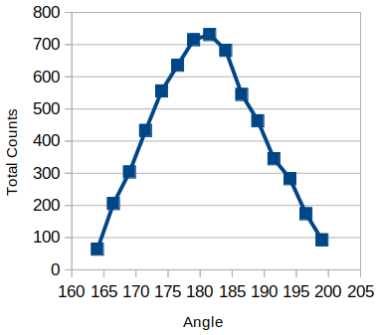

FIG. 3: Angular correlation of coincident events from positron source ^{22}Na.

indigenously developed portable alpha spectrometer[submitted to DAE2019]. We are now performing experiments to study the intensity as a function of solid angle to pinpoint the location of the source on the line connecting the two detectors. This will help in understanding principles of PET.

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[2] Analysis software Source Code. `https://github.com/csparkresearch/cnspec`

[3] Jithin BP, O.S.K.S Sastri. Gated MCA technique for demonstration of coincidence phenomena with a set of indigenously developed gamma spectrometers. `https://indico.cern.ch/event/763807/contributions/3274494/contribution.pdf`