Commissioning a Digital Data Acquisition System for Cosmic Muon Detection

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Cosmic-ray muons reach sea level at roughly one per square centimeter per minute, passing through most materials almost unattenuated. This makes them a steady, freely available source for testing radiation detectors. This project developed a cosmic muon detector made of layered EJ-200 plastic scintillator bars, each read out by photomultiplier tubes (PMTs) at both ends and digitized by XIA Pixie-16 modules.

Most of the work went into commissioning the data acquisition system. The main problems were a signal-polarity misconfiguration, baseline placement that limited dynamic range, and trigger thresholds set inside the noise. Correcting these gave about four times more usable dynamic range, removed signal saturation, and reduced timing failures in the constant-fraction discriminator from 48% to under 0.5%.

A custom decoder converts the list-mode data to ROOT and selects muon candidates using two coincidence requirements: both ends of a bar, and hits in two separated layers. The PMT coincidence confirms each signal is real light in the scintillator; the layer coincidence then rejects single-point gamma and neutron interactions. The timing difference between the two PMTs also gives the hit position along the bar, reaching a resolution of about 80 mm after correcting for a clock-phase bias between channels.

What survives both cuts is a clean pulse-height spectrum with the asymmetric, right-skewed shape expected of a Landau distribution, with a most-probable value reproducible to 4% between independent runs. In other words, a direct, from-scratch measurement of a real physical process, built on a DAQ chain that was debugged from the ground up.