Development and testing of Si pad array detectors for possible applications in Electromagnetic calorimeter

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Introduction

Semiconductor detectors, and in particular silicon detectors have several advantages over other types due to their better energy resolution, linear response over a broad energy range, fast timing response, flexibility of design, and tolerance to high energy doses. In these detectors, electron and hole pairs are generated when ionizing radiation passes through them, which are then gathered by applying an electric field. This process produces a signal that is proportional to the amount of energy deposited by the particle into the detector. Silicon Pad array detectors combined with a high-density absorber can be used as an Electromagnetic Calorimeter to measure the energy and shower profile of high-energy electrons or photons resulting from high-energy collisions.
An n-type silicon pad array detector is an assembly of 72 silicon detectors arranged in an array of 8 × 9. Each silicon pad has an area of 1 × 1 cm^2 with a thickness of about 325 μm. To minimize the leakage current, these detectors are fabricated with high resistivity (about 7 kΩ.cm). The fabrication is done in Bharat Electronics Limited, Bangalore in collaboration with NISER Bhubaneswar. For the readout of data from the n-type si pad array, it is glued to Printed Circuit Boards (PCBs) hosting the chip HGCROCv2 [1]. The HGCROCv2 chip handles 72 channels for processing signals which has a full analog chain consisting of low noise and high gain preamplifier and shapers. It has a 10-bit ADC which provides charge measurement over the linear range of the preamplifier.
For testing the n-type silicon pad array detector, it was irradiated with the Sr-90 source. The test setup and test results of the Si pad array detector for the Sr-90 source are discussed below.

Test Setup

The test setup consists of a Sr-90 β^- source focused on a single pad (channel 7) of the n-type silicon pad array detector

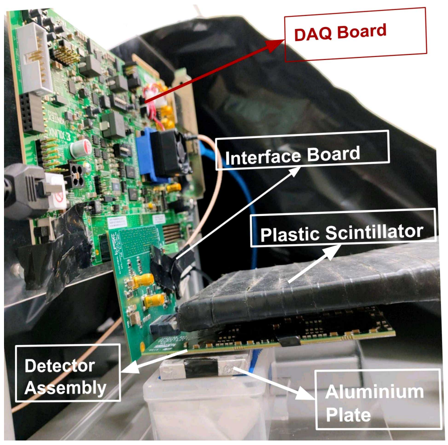

FIG. 1: The experimental setup used for testing the detector with the Sr-90 source.

using a 6 mm thick aluminum plate with a hole of 5 mm diameter as shown in FIG. 1. The silicon pad array was kept in reverse biased mode at full depletion voltage (∼50

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V). The detector is connected to the Data Acquisition Board (DAQ) called KCU105 using an interface board. A plastic scintillator is placed above the detector which is powered by a high-voltage supply that serves as a trigger source for DAQ. When an event is recorded, the scintillator triggers and an external signal is sent to the DAQ board. This trigger signal undergoes conversion by a discriminator, transforming it from the NIM (Nuclear Instrumentation Module) signal to a TTL (Transistor Transistor Logic) signal compatible with the DAQ board. Finally, the data is transferred to the computer from the DAQ board for further analysis. To reduce leakage current due to light, the entire setup was covered with a black cover.

Results and Discussion

The data from the detector was initially collected without the source to measure the background noise of the detector. Once the background measurements were obtained, data acquisition was performed using the Sr-90 β^- source. The data is structured in a ROOT file, where each entry (corresponding to each event) consists of an array of ADC values for 72 channels. These ADC values, proportional to the energy deposited by the β^- particles in the detector range from 0 to 1023 due to the 10-bit precision of the ADC. Figure 2 represents the energy deposited by the β^- particles in the detector in terms of ADC values. Additionally, the figure illustrates the background with normalized counts, observed in the absence of source. This observation confirms that the n-type silicon pad detector is fully operational and capable of measuring the energy of charged particles.

Outlook

The n-type silicon pad arrays together with the tungsten absorbers will be tested in the Proton Synchrotron facility at CERN for electron and pion beams.

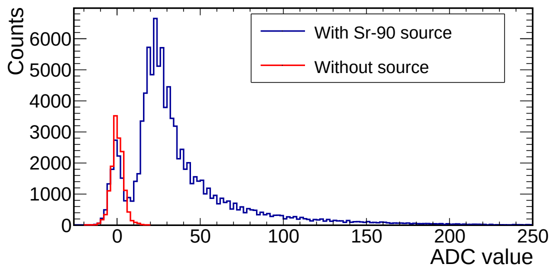

FIG. 2: (Blue) The large peak corresponds to the peak from β^- spectrum and the small peak around 0 is the background in the presence of Sr-90 source. (Red) The background distribution in the absence of the source.

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References

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