Test and characterization of p-type silicon detector for high energy physics experiment

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(Dated:)

Introduction

Silicon detectors are nowadays very common sensors of choice in high energy physics experiments. P-type silicon detector being a radiation hard technology, is of great attraction for high energy experiments with very high particle fluence. Being a first time effort in India, we, a joint collaborative effort between VECC-BARC-BEL, have started R&D for p-type silicon detector array with design, process optimization, fabrication and testing. As the very first step of fabrication, we have produced a number of 1 cm^2 p-type test detectors. Detector level tests like IV, CV, noise response, response to cosmic, response to radioactive source etc. have been considered as basic test and check for detector quality.

Experimental Setup

The available 25 single p-type detectors were arranged in a 5x5 matrix. These detectors were fabricated on 300 μm thick, high resistivity p-type silicon wafers. The detectors were attached and wire bonded on a customized PCB. The experimental setup consists of the sensor array, 2 trigger scintillators, data acquisition systems and relevant front end and back end electronics. The data was recorded in the coincidence mode for all occasions, like for noise, cosmics and with radioactive source. The detector array and the experimental setup is shown in Figure 1. For the very first measurements, detector's response to noise, comics and electron from Sr^{90} radioactive source have been analyzed.

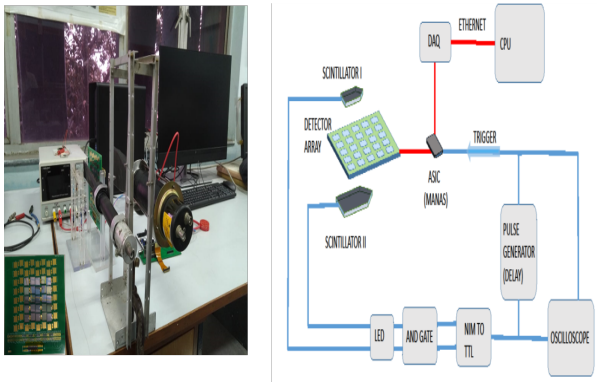

FIG. 1: The experimental setup is shown(left) along with the detector array(bottom left corner). The schematic representation of the setup is shown in the right side.

Response to Noise

The response to noise of the each individual detector in the array, at a bias voltage of 60 V have been studied. As shown in Figure 2, pedestal (noise) mean and sigma for all channels are plotted. The pedestal has been recorded at various times and for different voltages to check its stability. The noise response for a particular pad has been fitted with a gaussian and analyzed in details, which has later on been used for signal extraction.

Response to β (Sr^{90})

Standard Sr^{90} radioactive source has been used to check the detector response to electron and its capability to differentiate electron signal from noise. This study has been done scanning various elements of the sensor array. Since the electron from Sr^{90} source has

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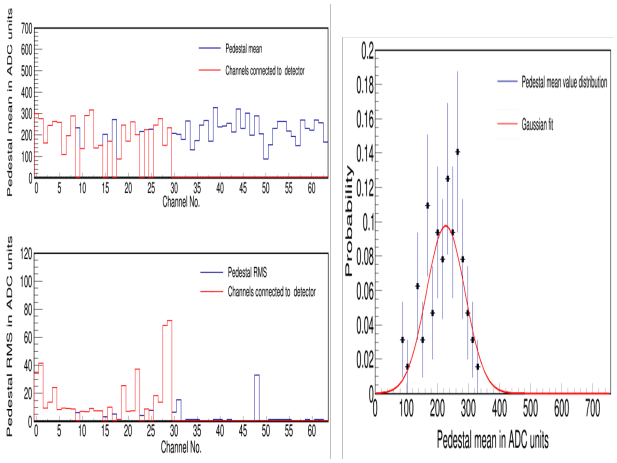

FIG. 2: The pedestal mean value (top left) and the pedestal sigma(bottom left) are plotted for all channels. It can be seen that some of the detector pads are very noisy. The observed distribution of pedestal mean for the detector pads is also plotted(right) side.

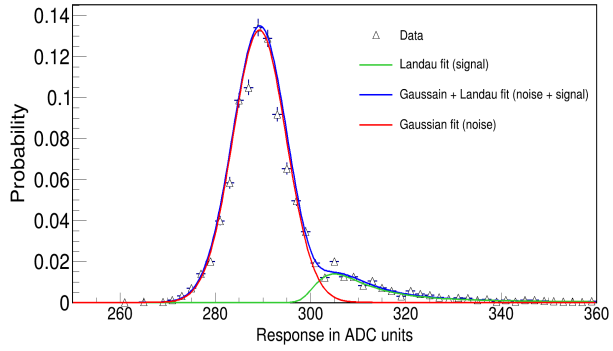

FIG. 3: The data taken with source is plotted. The presence of a landau distribution along with the Gaussian noise can be seen.

a maximum energy of ∼2.28 MeV and there is no absorber, we do not expect it to produce an electromagnetic shower and give a minimum ionizing particle like signal. The energy deposition in this case is better understood with a landau fit. The signals from the detector pads were analyzed to identify the electron signal by combined fit of gaussian+landau with the gaussian parameters extracted from noise only fit.

A clear existence of a landau distribution along with the noise peaks has been observed, as can shown in Figure 3. It is important to mention that there is scope of improvement of these detectors to make a clear separation of the noise and signal peak. Effort has been made towards these improvements. The details of tests and results like IV, CV, response to noise, signal and their uniformity checks over all pads will be presented. The scope of improvement will also be discussed in the presentation.

Acknowledgement

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References

[1] Sourav Mukhopadhyay, Sanjib Muhuri, *et al.*, Proceedings of the DAE Symp. on Nucl. Phys. 67 (2023)