Neutron detection with boron-coated GEM detector using ^{252}Cf source

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Introduction

Gas Electron Multiplier (GEM) belongs to the family of micro-pattern gaseous detectors, primarily used to detect and track charge particles. These can also be used for neutron detection by using a suitable converter material. Owing to rising demand and high cost of ^{3}**He**, its availability in neutron dosimeters has become a major issue. Alternative technologies for neutron detection are hence being looked into. At the same time, it is essential to develop high-rate detectors that can fully exploit the increase of neutron flux in the upcoming spallation neutron sources. One of the technologies fulfilling these requirements is the Gas Electron multiplier (GEM), since it can combine high rate capability (MHz/cm^2), large coverage area ($\sim 1m^2$) and sub-mm spatial resolution. These detectors can also be used for the thermal neutron scattering experiments.

We report here the fabrication and testing of a position-sensitive GEM based neutron detector having Boron coated converter cathode. The detector was tested with ^{252}**Cf** neutron source at various operating conditions.

Boron as a neutron converter

Neutrons are converted into ion fragments by boron-10 via a nuclear capture reaction with the two branches: First branch of reaction have branching ratio of 94% [1].

$$^{10}\mathbf{B} + n \longrightarrow {}^{7}\mathbf{Li}(0.84MeV) + \alpha(1.475MeV) + \gamma(0.48MeV)$$
$$\longrightarrow {}^{7}\mathbf{Li}(1.013MeV) + \alpha(1.776MeV)$$

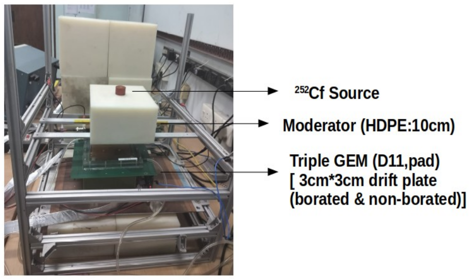

FIG. 1: Experiment setup with neutron source on Boratd-GEM detector

Fabrication at VECC and Experimental setup

A triple GEM detector having 10 cm x 10 cm active area was built at VECC. Boron-10 coating on the copper-coated drift PCB of the GEM chamber was carried out by Doctor's blade method, at VECC. A pre-mixed Ar/CO2 gas mixture in the ratio (70/30) was used for the test. The signal was readout via MuCh XYTER-based electronics[2] and an AFCK based CBM DAQ were selected for data acquisition. Borated and non-borated drift cathodes each of 3 cm x 3 cm was used in the detector for the experiment. ^{252}**Cf** neutron source was placed on a 10 cm block of High density polyethylene (HDPE), as shown in Fig. 1. The HDPE moderates the high energy neutrons to lower energies, where the reaction cross-sections are higher. Fig. 2 shows the incident neutron energy spectra for the case with and without moderator, as studied in GEANT4 simulations. Data were taken for a range of detector voltages.The detector was operated at low gain, since for gain < 100, it tends to become insensitive to γ-rays, as the

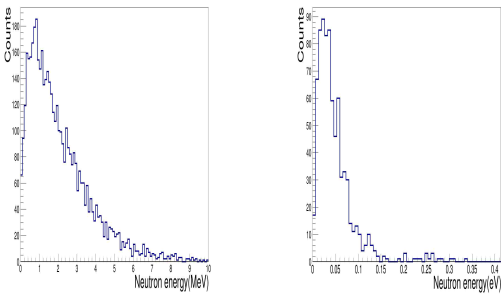

FIG. 2: Neutron energy without HDPE(left) and with HDPE of 10 cm(right) using simulation

other byproducts of neutron conversion reaction deposits a much higher energy in gas with respect to γ in the active medium of detector. In our case, γ-rays induced signals fall below the threshold (6 fC) set for electronic noise rejection.

Experiment Results

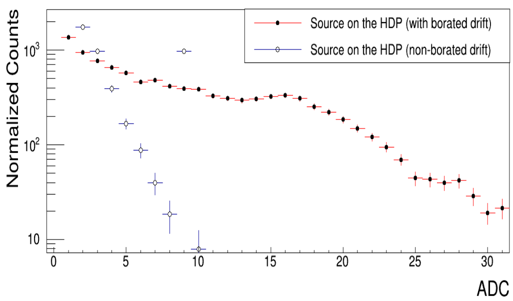

FIG. 3: Comparison of ADC spectra of neutron source for borated and non-borated drift regions

Fig. 3 shows the ADC comparison spectra for for the borated and the non-borated drift regions at the bias voltage 3400V, for borated drift region, signals are due to the charge deposition by α or $^{7}\mathbf{Li}$ charge particles which are on the higher side of ADCs.

Fig. 4 shows Digis per Time Slice(TS) for borated and non-borated drift regions. Each fired pad in the detector represents one Digi. Fig. 5, shows the XY position of hits in the detector, for borated and non-borated regions.

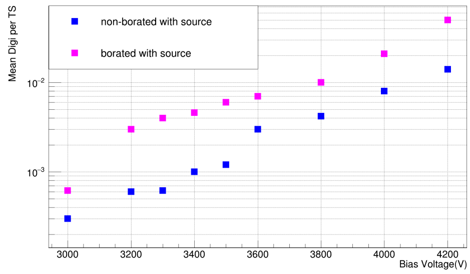

FIG. 4: Digi per TS vs Bias voltage plot for borated drift and non-borated drift region

Large numbers of hits are seen in the borated region (right) while almost no significant hits on the left, as expected. Based on the number of hits at 3400 V, acquired in the active area and considering other geometrical parameters a neutron detection efficiency of 1% was estimated. The setup has been modelled in GEANT4 and further studies are in progress.

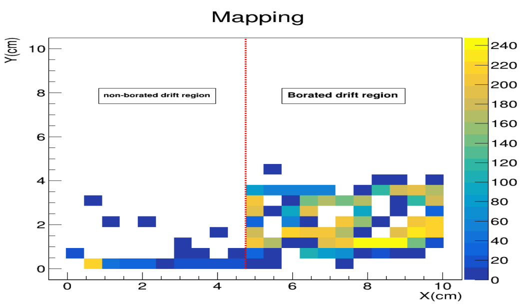

FIG. 5: XY distribution for non-borated drift(left bottom quadrant) & borated drift(right bottom quadrant) for 3400V with ADC > 1

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