Study of Multi-strip Multi-gap Resistive Plate Chamber

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Introduction: Timing Resistive Plate Chambers or the Multi-gap Resistive Plate Chambers (MRPCs) are intelligent modification over Resistive Plate Chamber (RPC) by slicing the single wide gas gap into number of thinner gaps. Due to the high granularity of MRPC detectors, its physibility in cost effective Positron Emission Tomography [1] and non-destructive security scanning using cosmic muon tomography [2] are a topic of current research. Least has been studied so far regarding the gamma and neutron response of MRPC detectors. In order to explore in this direction, prototype of Multi-strip Multi-gap Resistive Plate Chamber (MMRPC) has been built at SINP, Kolkata using local infrastructure (SINP workshop, dedicated laboratory, etc.) and major local raw materials [3,4]. The ultimate physics goal of this detector development is to study of the MRPC design of the high efficiency, high resolution neutron detector NeuLAND at the upcoming R^{3}B-FAIR facility. Response of the developed MMRPC detector for gamma and cosmic muons were studied at SINP, laboratory. Later, the MMRPC detector was taken to the electron linac ELBE at Helmholtz-Zentrum Dresden-Rossendorf, Germany to study its electron response. In this article, we would like to present - How an in-beam data of a gas detector like MMRPC can be used in exploring its working mechanism?

Experiment and Analysis: The electron energy was chosen to 29 MeV with pulse width less than 10 ps. The pulsed electron beam from the Be-window passes through air for 41 cm and then falls on the set-up. Complete description of the set-up was presented in [4]. To find the optimum operational condition of the prototype, the detector was scanned with beam focused on a single strip of MMRPC. Measurements were also performed with the beam spot focused on each of the other individual strips of MMRPC.

The measured time resolution of our developed MMRPC detector was 96.68±2.7ps with an absolute efficiency of 95.77±1.2%.

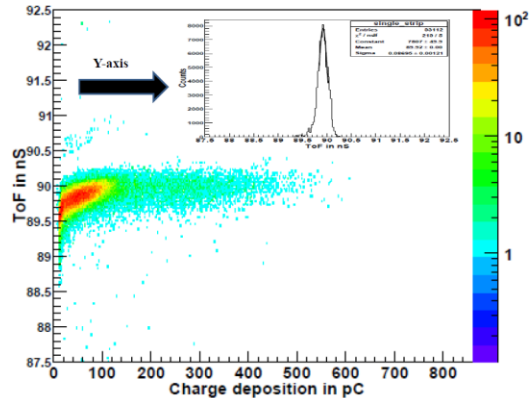

Fig. 1 Time of MMRPC (without slewing) Vs deposited charge on a strip for events hitting only one strip at a time. (insight) Time of MMRPC for events hitting only one strip.

In order to understand the operational characteristics of the MMRPC detector, time

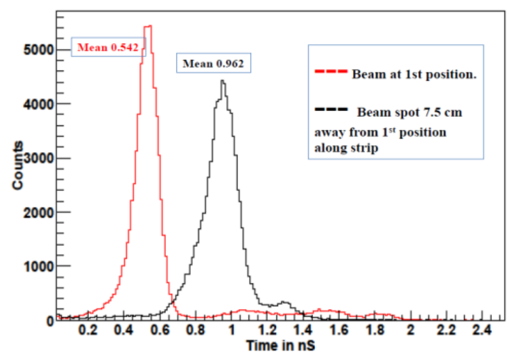

Fig. 2 Difference in time from the two TDCs at both end of a strip.

resolution and absolute efficiency of the detector were measured with consideration of events selected according to different schemes or trigger conditions. In one such scheme, events were selected for which only one strip has fired. The 2- Dimensional plot for ToF of MMRPC against deposited charge on the corresponding strip looked clean as shown in Fig. 1. Time resolution

(σ_t) corresponding to these events before

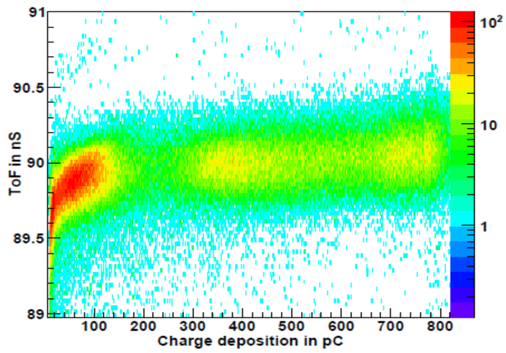

Fig. 3 ToF (without slew correction) Vs deposited charge on a single strip of MMRPC showing three patches.

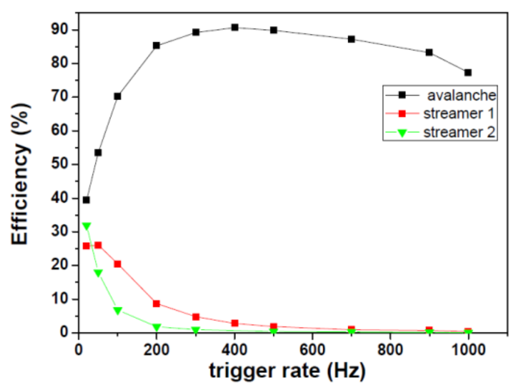

Fig. 4 Contribution of avalanche and streamers at different trigger rate for fixed bias voltage.

and after slew-correction were 129 ps and 79.6 ps, respectively. Efficiency of MMRPC measured for this event selection was 56±1.5 %. Position resolution (σ_x, σ_y) along the strip was estimated from the difference in time measurement from both end of a strip. Data was considered for which beam spot was positioned 7.5 cm and 15 cm away from the centre along the length of strip-4 (Fig. 2). The difference in time from the two TDCs at both end of a strip resulted in the signal velocity through the anode strip. Considering signal velocity and time resolution the obtained position resolution (σ_x) of MMRPC along the strip was 1.9±0.6 cm. The strip width being 2 cm, the position resolution (σ_y) across the strip is 2 cm/$\sqrt{12}$.

In the 2-Dimensional plot for ToF of MMRPC against deposited charge on a single strip three patches at lower, intermediate and higher charge deposition were observed (Fig. 3). In order to understand the causes of these patches, three different cuts were made on QDC channel corresponding to the three patches. The efficiency of the three patches at different charge deposition was also studied with the variation in trigger rate of the beam. Fig. 4 shows the contributions of the different patches at different event rate for a fixed bias voltage. It was observed that at low event rate the 2nd and 3rd patch (due to streamers) dominates over the 1st

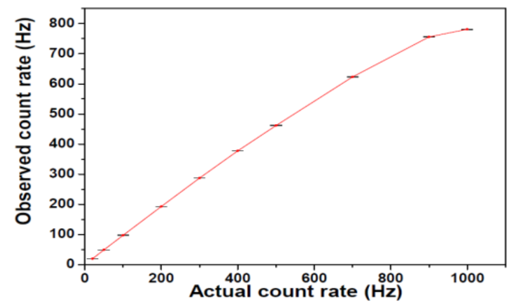

Fig. 5 Plot of observed event rate of MMRPC against actual event rate.

patch (due to avalanche mode). On the event rate streamers gradually decreases and the avalanche mode of operation dominates completely. Fig. 5 shows a plot of the observed event rate in MMRPC against the actual event rate. The maximum event rate being 1 KHz, it is not ascertained about the dead time behaviour of the MMRPC detector. No maxima was observed till an event rate of 1 KHz hence non-paralyzable model [5] was used to measure the dead time of MMRPC detector. The measured dead time was 194±46 μS.

References:

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