# Development of multigap RPC

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## Introduction

Resistive plate chamber (RPC) has been developed for various high energy physics and nuclear physics experiments as a low cost tracking detector for its good position and timing resolutions.

The detector presented in this article is called the Multigap Resistive Plate Chamber (MRPC) which is operated at atmospheric pressure and consists of several small gas gaps (0.2 mm to 1 mm) [1]. Small gap improves the time resolution. In MRPC the total gas volume is divided into a number of small gas gaps with equal width by inserting intermediate resistive plates (bulk resistivity $\sim 10^{11}$ - $10^{12}$ $\Omega$ cm) between the two outermost resistive plates. The high voltages (HV) are applied only to the external surfaces of each stack of plates and the intermediate plates are electrically floating, thus one can build the detector by stacking plates separated by suitable spacers. Pickup strips are located outside the stack and insulated from the high voltage electrodes. A passing charged particle creates an avalanche in the gas. Signals on the pickup electrodes are induced by the movement of charge in the gas; in case of the RPC the fast signal is generated by the fast movement of electrons towards the anode. Since the resistive plates act as dielectrics, the induced signals can be caused by the movement of charge in any of the gas gaps between the anode and the cathode pickup strips. In this way the observed induced signal on the pickup strip becomes the sum of the individual avalanche signal in any of the gaps making up the MRPC, but the time jitter in the rise time is expected to reduce due to the smaller subgap of the MRPC [2].

## Design of MRPC

One double gap module of dimension 20 cm $\times$ 30 cm with 2 mm gas gap each and one 20 cm $\times$ 20 cm module with four 0.6 mm gap have been fabricated and tested in streamer mode. Both the modules have been made with 1.6 mm thick P-120 grade bakelite sheets. Silicone coating has been applied over all the inner surfaces [3]. The fabrication procedure are same as described in Ref. [3].

## Results

In this study the efficiency, counting rate, leakage current and time resolution of both the double gap and four gap modules has been measured. The detectors have been tested in streamer mode in the same cosmic ray test bench mentioned in Ref.[3] with a gas mixture of argon, iso-butane and tetrafluroethane (R-134a) in 34:7:59 (by mass) mixing ratio [4]. The trigger is made by the coincidence signal from three scintillators (Sc I, Sc II and Sc III). The signal from the pick up strip is taken in coincidence with the trigger. Trigger signal = SC I .AND. SC II . AND. SC III. Efficiency ($\epsilon$) = (RPC count with signal in coincidence with trigger/ Trigger count). The trigger rate has been found to be 0.004 Hz/cm$^2$.

In both the RPCs the maximum leakage current has been found to be less than 400 nA (at 15 kV). The I-V curve shows two distinct slopes; at lower voltage the inverse of the slope represents the resistivity of the polycarbonate

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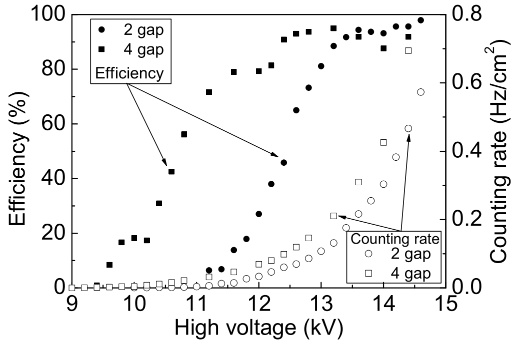


FIG. 1: The efficiency and the counting rate as a function of the high voltage for the two MRPC (one double gap and one 4-gap).

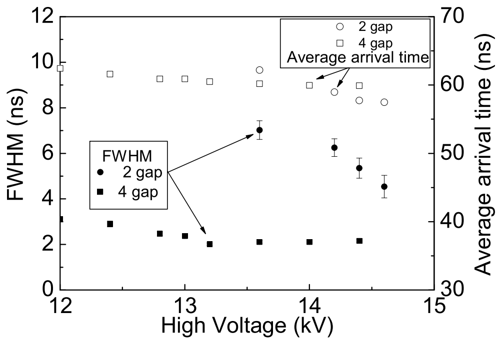


FIG. 2: The time resolution (FWHM) and the average signal arrival time as a function of the high voltage for the two MRPC (one double gap and one 4-gap).

spacer where as at higher voltage it represents the resistivity of the bakelite sheets.

FIG. 1 shows the variation of the efficiency and the counting rate with the applied HV. The efficiency increases with the increase of the applied voltage and reaches a plateau at 13.5 kV with $\epsilon$ >95% for the double gap RPC, while the efficiency plateau ($\epsilon$ >95%) is reached at 12 kV for the 4-gap RPC. The counting rate increases with the applied voltage in both the cases.

The time resolution of both the MRPC has been measured in the same process as described in the Ref.[5]. FIG. 2 shows the variation of the time resolution (FWHM) and the average signal arrival time (the time difference between the START and the STOP signal) with the applied HV. It is clear from FIG. 2 that for both the MRPC, the FWHM and the average RPC signal arrival time decreases with the increase of the HV. At 14.5 kV the time resolution has been measured to be $\sim$ 5 ns for the double gap RPC while a plateau at FWHM $\sim$ 2 ns has been observed from 13 kV to 14.5 kV for the four gap RPC.

## Conclusions and outlook

In conclusion, double gap and four gap MRPC have been fabricated and tested in streamer mode. In both the cases the efficiency plateau above 95% has been obtained. The time resolution (FWHM) is poorer ($\sim$ 5 ns) in case of double gap RPC since in that case the total gas gap is 4 mm (2mm $\times$ 2) producing a larger time fluctuation in the arrival time while in case of four gap module total gas gap is 2.4 mm (0.6 mm $\times$ 4) with small subgaps reducing the time jitter in the signal arrival time giving a better time resolution ($\sim$ 2 ns).

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## References


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