Characterization of Prototype Oil-free Bakelite RPC for High Rate Experiments

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1. Introduction

RPCs [1] are gaseous detectors and their principle of operation is based on the detection of the gas ionization produced by charged particles when passing through the detector, under a strong uniform electric field produced between two highly resistive electrodes (10^9-10^{12} Ωcm) e.g. glass, bakelite. RPCs have been used as muon trigger system in several high rate ($\sim$ 10 kHz/cm^2) experiments of high energy physics like CMS, ATLAS, ALICE in LHC due to its excellent timing capability, high gain, simple design, low cost, moderate spatial resolution and ability to scale to large areas.VECC is currently involved in R&D to make a oilfree single gap bakelite RPC which can withstand such a high particle rate ($\sim$ 10 kHz/cm^2) for the CBM experiment. For this purpose, we are reporting on a prototype oil-free RPC (30 cm× 30cm) in avalanche mode. This mode increases the rate capability as reduction of the charge produced in the gas gap in avanche mode improves the rate capability.

2. Developement and Characterization of prototype bakelite RPC

We have fabricated the single gap bakelite oilfree prototype RPC using standard method as explained in [2]. The measured bulk resistivity of the bakelite sample was $\sim 9\times10^{11}\Omega$-cm whereas the surface resistivity was $\sim 3\times10^{12}\Omega/\Box$ [2]. The pick-up panels, which were used to read out the signal from the RPC are made of $\sim$(30 cm × 30 cm × 0.15 cm) FR4 sheet sandwiched between $\sim$(30 cm × 30 cm × 0.0035 cm) copper sheets. The area of each copper strip is $\sim$(30 cm × 2.3 cm) with a separation of 2 mm between two adjacent strips. The effective strip area considered to tap the signal from the detector for efficiency and noise rate measurement is $\sim$(30 cm × 4.6 cm) obtained by adding signals from two adjacent strips.

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3. Cosmic ray test results

The RPC was tested in avalanche mode with cosmic rays in standard cosmic ray set up with the help of three scintillators - one finger and two paddle scintillators. The paddle scintillators are of dimension $\sim$ 20 cm × 8.5 cm and the finger is of dimension $\sim$ 7 cm × 1.5 cm. The overlap area between the scintillators was used to obtain the cosmic ray detection efficiency. The master trigger was generated from the scintillators. The gas composition used is Freon(R134a) : Iso-butane : SF6 :: 94.1 : 5.2 : 0.7. CAEN N979 fast amplifier has been used to amplify the RPC signals. The various test results have been discussed in the following sub-sections.

A. I-V characteristics

Fig. 1 shows the I-V characteristics of the RPC. Two distinct slopes can be seen in the I-V characteristics with a breakdown voltage $\sim$ 11000 V.

B. Efficiency and noise rate test

The signal obtained from the two adjacent pick up strips was put in coincidence with the master trigger from scintillators and it was referred as coincidence trigger. The efficiency of the RPC was calculated as the ratio between the coincidence trigger rates and the master trigger rates. Fig. 2 shows the measured efficiency of the RPC as a function of applied high voltage at different thresholds. An efficieny plateau was obtained for the RPC beyond 12500 V for various threshold values.

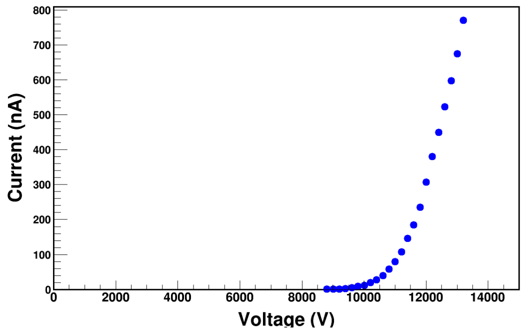

FIG. 1: I-V characteristic of the developed prototype bakelite RPC.

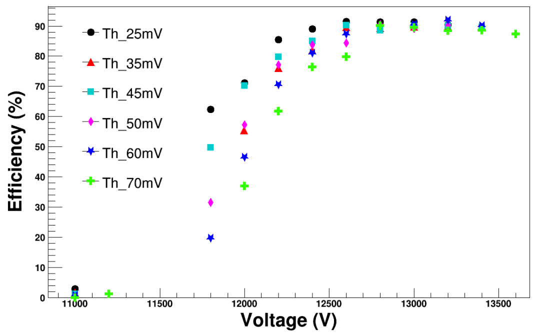

FIG. 2: The efficiency as a function of high voltage for the prototype bakelite RPC with various discriminator threshold values.

The efficiency value at the plateau is ∼ 90%. During this test, noise rate of the RPC was calculated at multiple thresholds. The noise rate variation as a function of applied voltage at multiple thresholds is shown in the Fig. 3. It was found that the noise rate is ∼ 8 Hz/cm^2 at 13200 V at minimum threshold (25 mV) whereas noise rate is ∼ 3.5 Hz/cm^2 at 13600 V at maximum threshold value (70 mV).

4. Conclusions and outlook

The prototype bakelite RPC has shown promising results during the initial tests in avanche mode. The efficiency of the detector was measured to be ∼ 90% at various thresholds. The effect of thresholds on the efficiency and noise rate has been established. As a part of the performance study of RPC on rate operation we need to measure

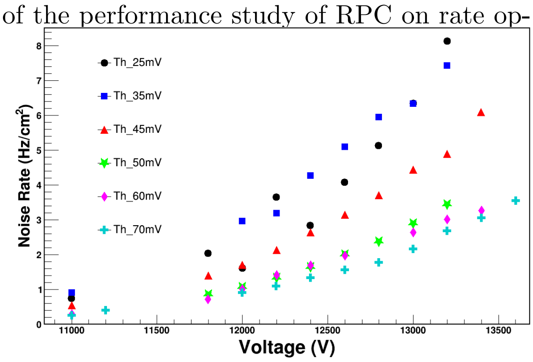

FIG. 3: The noise rate as a function of applied high voltage for the RPC at multiple thresholds.

1. the charge spectra of the detector,
2. the time resolution of the RPC,
3. the rate handling capability of RPC,
4. long term performances of the detector, like efficiency, noise rate, time resolution, rate handling capability,

As this is our first step towards developing oil-free single gap bakelite resistive plate chamber for high rate experiments, several prototypes with different resistivity of the electrodes have to be developed and tested.

5. Acknowledgement

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