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# Development and Testing of RPC Module Developed in the Mini Array Laboratory, Gauhati University

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**Abstract**

A Resistive Plate Chamber (RPC) module of size 15cm×15cm has been developed and its performance tested in a cosmic ray setup. Performances have been tested using three different gas compositions using P-10 and Freon-134A at different bias voltages. A characteristic plateau region has been obtained for efficiency when measured with varying applied bias voltage. The maximum efficiency is obtained 92% and the performance is found to be stable.

**Key Word:** RPC, Efficiency, Gas ratio.

## Introduction

Resistive plate counter is a gas filled particle detector operating in the proportional counter region, mainly in two modes streamer and avalanche mode. This detector has found wide applications in cosmic rays and accelerator based experiments due to low cost and fast timing properties [1, 2]. Resistive plate counter (RPC)is made from phenolic sheet as the resistive plate and tested for different gas mixtures in evaluating its performance using cosmic ray muons. The RPC has been operated in streamer mode with a gas mixture of P-10 and Freon (Freon-134A) of varying gas compositions. This module of RPC has been designed and fabricated in the mini-array laboratory, Physics Department, GU.

### Experimental setup

A block diagram of an RPC is shown in fig.1. The present RPC is made of two parallel phenolic sheets of thickness 1.5mm each and gas gap of 1mm. The dimension of the RPC is 15 × 15 $cm^2$. A glass sheet (window glass) of same size is placed over the Bakelite sheet to provide the required electrical isolation when the copper side

anode is connected to HV bias. Signal pick up strips are placed over the glass sheet. The width of the pick up strip is 3cm with a separation of 2cm between the strips.

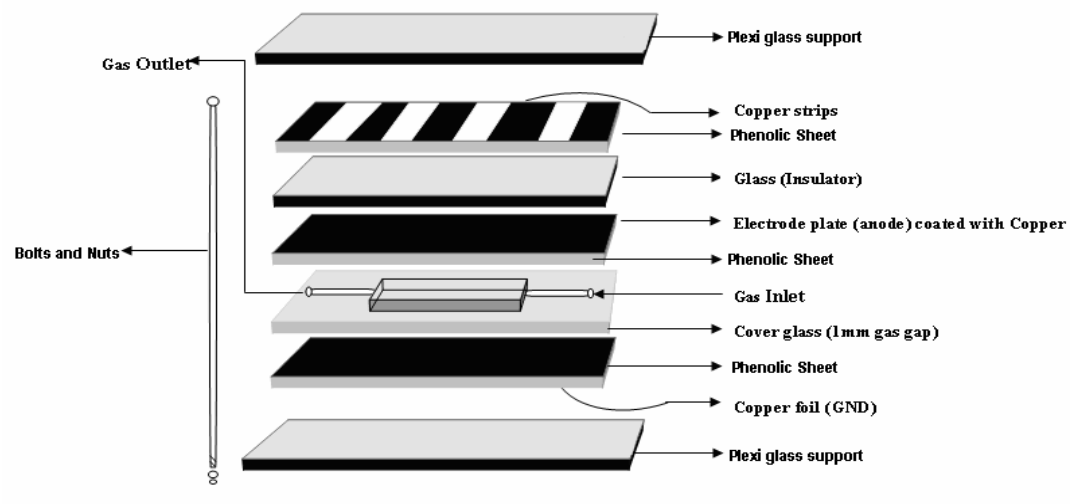


**Figure 1:** Resistive Plate Counter.

Fig.2. shows schematic representation of the experimental setup and fig.3. shows a photograph of the same setup in the miniarray laboratory. RPC module is sandwiched between two scintillation detectors (SC1 and SC2, scintillator size 50× 50cm$^2$ and thickness 5cm ). To obtain the RPC efficiency in a region within one pickup strip, the trigger setup is further zoomed into a region of Finger scintillator (SCF) of dimension 5cm ×5cm and placed above the pickup strip. A cosmic ray muon passing through each of these detectors produces a pulse signal. The trigger signal is obtained as SC1 AND SC2 AND SCF. We therefore obtain the efficiency in a region of 3cm ×15cm within a pickup strip. Final count is obtained by coincidence between RPC counts with the trigger count. Therefore, efficiency is obtained from the following formula.

$$\text{Efficiency (\%)} = \frac{RPC\ count\ with\ the\ signal\ in\ coincidence\ with\ trigger}{Trigger\ count} \times 100$$

The high voltage to the scintillation detectors SC1 & SC2 is supplied from standard HV power supply (ECIL, HV 4800D) HV, for SCF supplied from NIM BIN (ECIL HV 216A) and the RPC is biased by another HV power supply [3] designed in the mini array laboratory. Counting is made by timer counter (ECIL-5104).

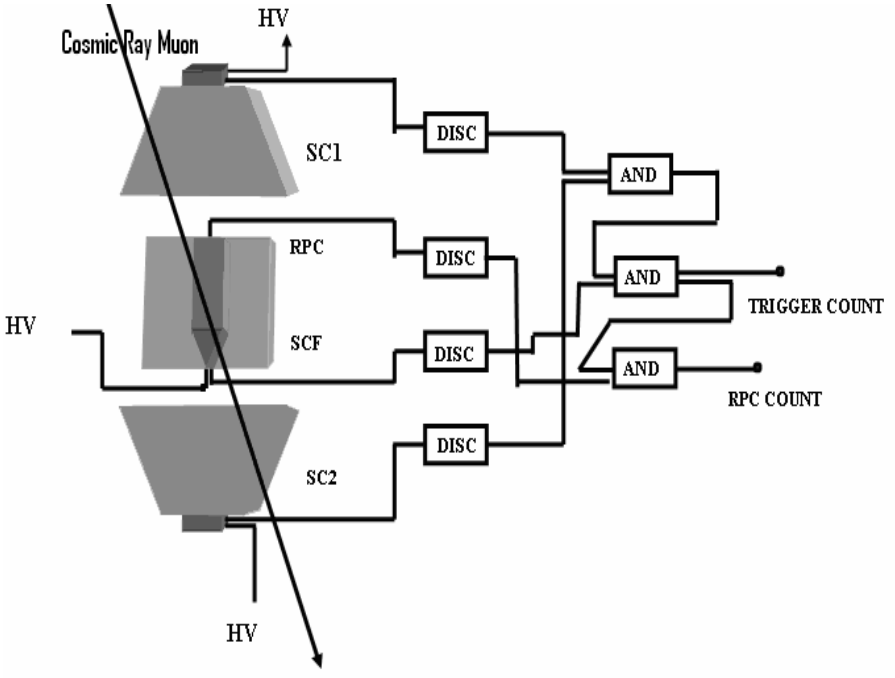


**Figure 2:** Schematic representation of the Cosmic ray setup.

**Figure 3:** Photo view Experimental setup for efficiency test for RPC.

**Electronics setup**

The signals generated by cosmic ray muons from all the scintillators and RPC strips have been brought into high speed discriminator [4] circuit designed in the laboratory. COINCIDENCE LOGIC UNIT (fig.4.) used for efficiency measurement is also designed in the laboratory. Coincidence pulse from the discriminated output of the two large scintillators and the smallest scintillator are put to QUAD. This triple coincidence part of the circuit has been used as a trigger. This trigger output is coincided with the RPC signal by the fourth channel of the same coincidence logic unit. Three fold coincidence output count rate are taken by the counter timer (ECIL-5104) and four fold coincidence counts are taken by Computer through GPIB (IEEE-488) interface bus.

High voltage of 1400 volt is supplied to the PMTs attached to SC1 and SC2 (BICRON) respectively and 1700 volt to the PMT( 9807B02) attached to the finger scintillator (SCF). The noise in the signals from the detectors can be eliminated by keeping the discriminator threshold at 47mV for all the detectors. The pulses from the RPC are monitored by DSO (Model, Tektronix-TDS 520A). The rise time of the RPC pulse was 3.2 ns and width 30nS.

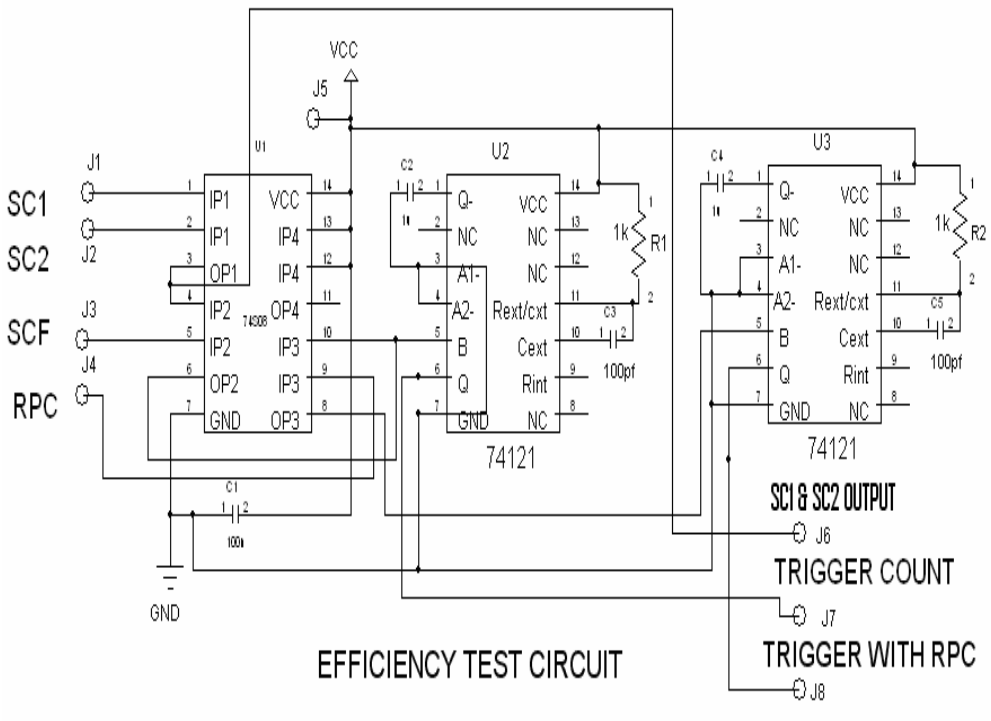


**Figure 4:** Efficiency test circuit Schematic.

**Different gas mixtures for RPC testing:**

We test the RPC using mixture of two different gases i.e. P-10(90% Ar and 10% $CH_4$) & Freon-134A with three different gas ratios. P-10 gas provides efficient gas

amplification and Freon-134A is used as “quench gas” to control charge and physical size of the streamers. Three different gas mixture ratios (50:50, 40:60, 30:70) of P-10 and Freon are tested for efficiency.

## Experimental Result

The efficiency was measured at different values of HV ranging from 3.6kV to 5.4kV. The counting time is taken for 3.15hrs. Fig. 5 & 6 and 7 shows the variation of efficiency with applied high voltage for the three gas mixtures mentioned above. Measured efficiency is found to increase with the HV applied. The maximum HV (5kV) corresponds to efficiency of 88% for gas mixture ratio (50:50) and 92% for both (40:60) and (30:70). This variation of efficiency with Freon percentage is shown in fig.8.

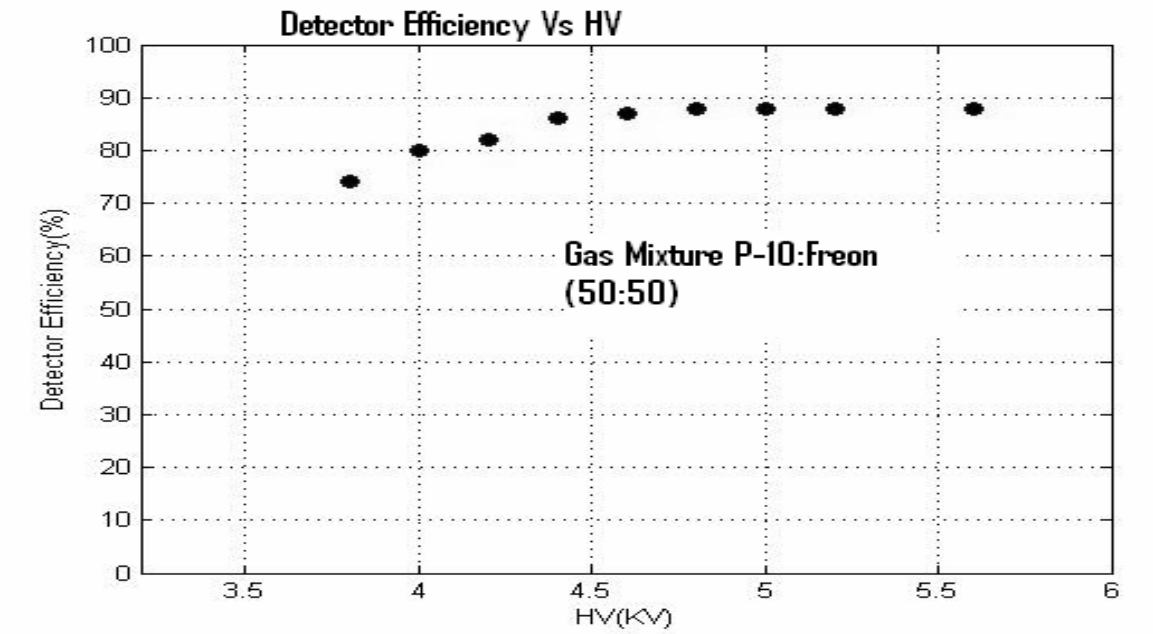


**Figure 5:** Detector efficiency vs HV (RPC material Phenolic, Gas gap=1mm), Efficiency 88% at 5kV.

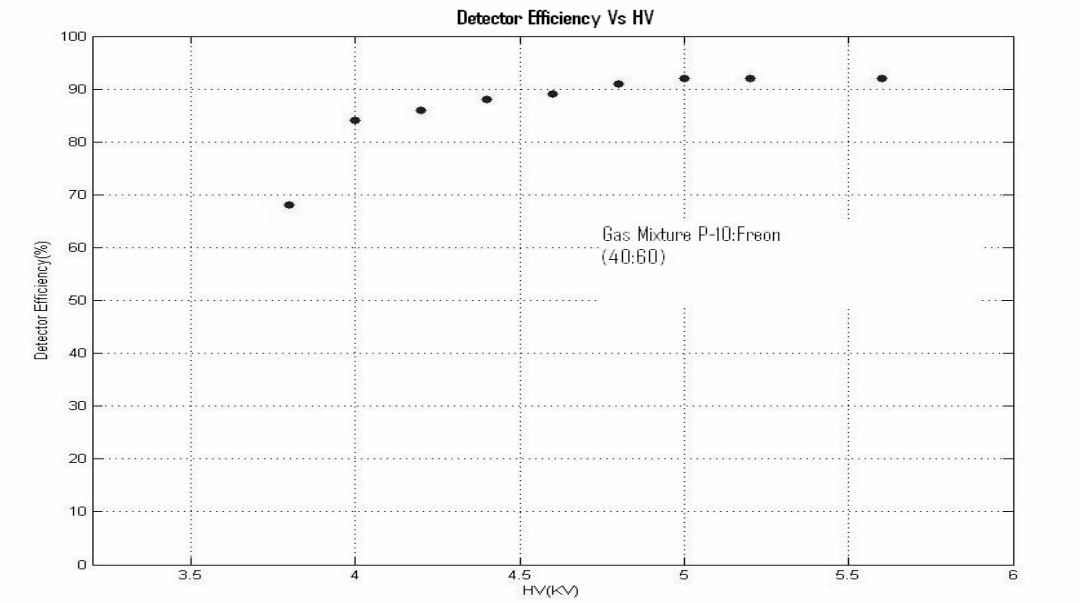


**Figure 6:** Detector efficiency vs HV (RPC material Phenolic, Gas gap=1mm) , Efficiency 92% at 5kV.

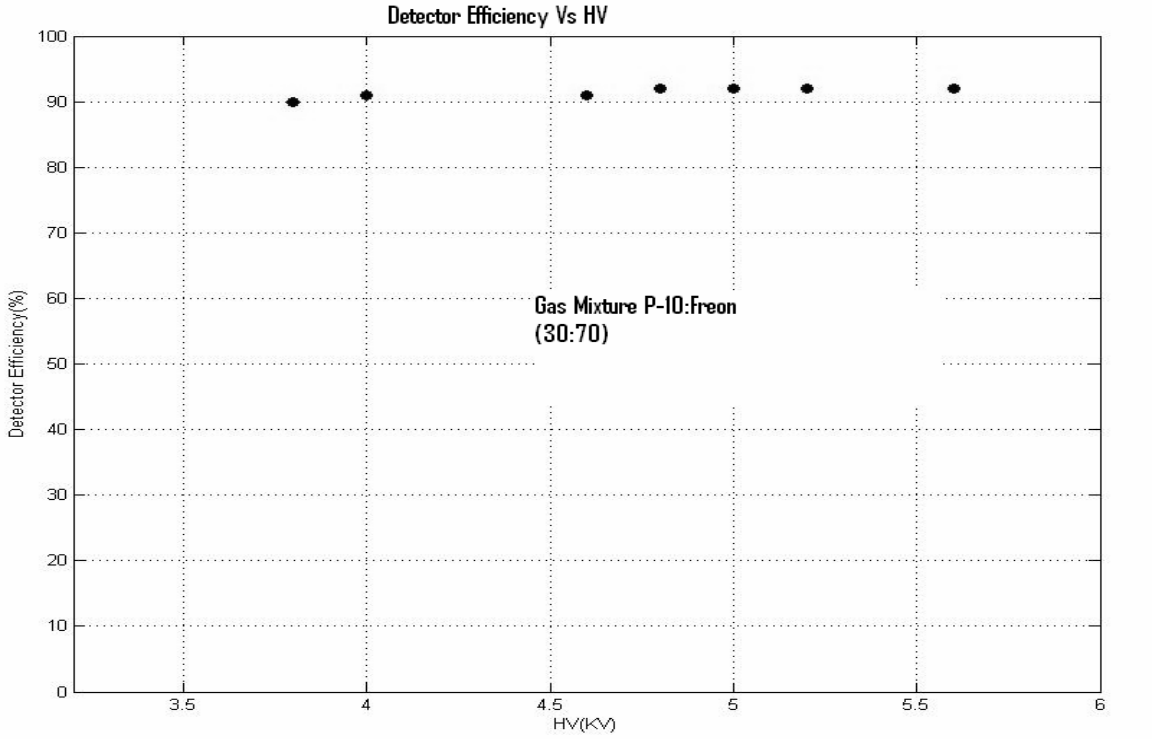


**Figure 7:** Detector efficiency vs HV (RPC material Phenolic, Gas gap=1mm) Efficiency 92% at 5kV.

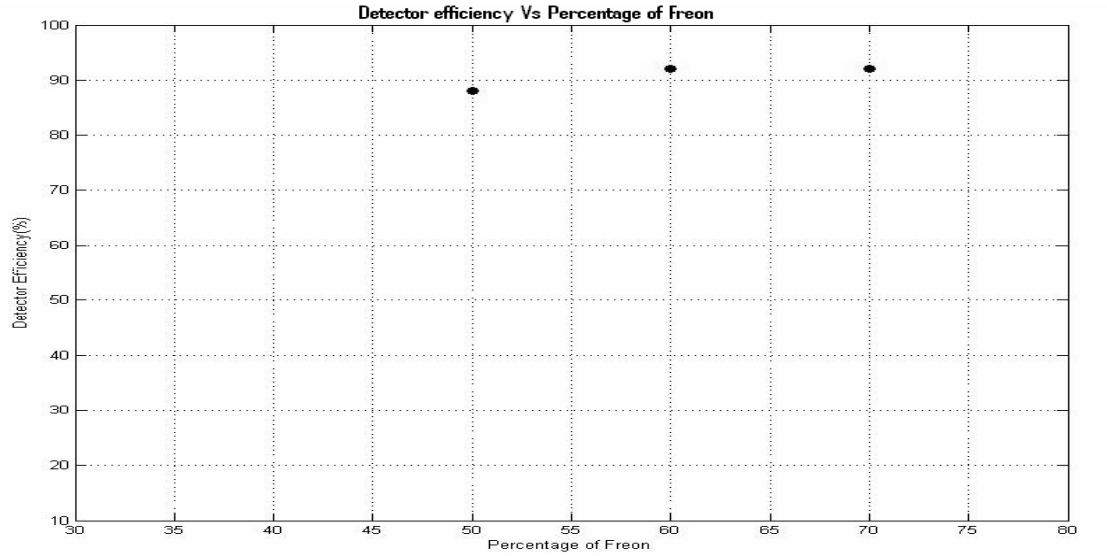


**Figure 8:** Detector efficiency Vs percentage of Freon.

## Discussion and conclusion:

A prototype RPC (15cm ×15cm) has been successfully designed and tested continuously for several hours. The required electronics for the experiment as also designed and tested.

The maximum efficiency obtained is 92% at 5kV which is somewhat lower than that was obtained in other experiments done elsewhere [6] [7]. However the efficiency may be improved with higher bias voltages for which a new HV power supply has been fabricated and being tested.

It is also found from fig.8., that efficiency does not increase beyond 60% Freon mixture. Hence optimum value of the gas mixture ratio giving highest efficiency is (40:60).

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