Low-gain operation of low resistivity glass Resistive Plate Chamber (RPC)

S. Chandra¹, V. K. S. Kashyap¹,∗B. Mohanty¹, and S. C. Rout¹
¹School of Physical Sciences, National Institute of Science Education and Research, HBNI, Jatni, Odisha-752050

Introduction

Future collider experiments such as Compact Muon Solenoid (CMS) and A Toroidal LHC Apparatus (ATLAS) at the High Luminosity Large Hadron Collider (HL-LHC) [1, 2], Compressed Baryonic Matter (CBM) at Facility for Antiproton and Ion Research (FAIR) [3] will have to deal with unprecedented level of particle fluxes arising from high luminosity proton/heavy ion collisions. This demands the need for high count rate capable detectors to ensure maximal collection of data.

RPCs [4] are versatile detectors used in many particle and astroparticle physics experiments mainly for the detection of particles such as muons. RPCs with bulk resistivity $\rho \sim 10^{10} \, \Omega \cdot \text{cm}$, are currently operating at rates of $\sim 1 \, \text{kHz/cm}^2$ in experiments like the CMS [5]. Experiments such as the CBM in the 3rd and 4th stations of its Muon Chamber (MuCh) subsystem would require $\sim 10 \, \text{kHz/cm}^2$ rate capability. The rate capability $R_C$ of an RPC is given by

$$R_C = \frac{V}{\rho t \langle Q \rangle},$$

where $V$ is the voltage drop across the electrodes, $t$ is the electrode thickness and $\langle Q \rangle$ is the average/mean charge produced per event. To increase the rate capability an RPC should have lower bulk resistivity, and lower mean charge production (low gain). However, they cannot be reduced to arbitrarily low values as they will lead to adverse effects such as ageing, reduced mechanical stability and reduced position resolution.

We are trying to improve the rate capability of RPCs by operating them at a lower gain using low resistivity electrodes. We present results from a low resistive glass RPC with $\rho \sim 10^{10} \, \Omega \cdot \text{cm}$ bulk resistivity. The glass has been developed by Tsinghua University, Beijing and manufactured by Bjoptics, China.

Experimental setup

The setup consists of a 32 cm x 30 cm glass RPC made of low resistivity electrodes of 2 mm thickness in coincidence with a scintillator telescope. The RPC gas gap is 2 mm thick and conductive graphite coating is applied on the electrodes with a surface resistivity of $\sim 1 \, \text{M}\Omega/\square$. Gas mixture containing r134a, $i$-butane and SF$_6$ is flown through the RPC with different concentrations with the help of a gas mixing system. A schematic of the setup is shown in figure 1.

![FIG. 1: Schematic of the RPC experimental setup.](image-url)
Results and conclusion

Various parameters of the RPC such as noise rate, mean charge and efficiency are shown in figures 2(a), 2(b) and 2(c) respectively. It can be seen from figure 2(a) that the pulses below a threshold of 100 fC are noise with very little variation as a function of voltage. With the current electronics its difficult to reduce the electronic noise levels. However, from (1) and looking at figures 2(b) and 2(c), considering \( \rho = 3 \times 10^{10} \Omega \text{cm} \) one can see that it is possible to achieve a rate capability of \( \sim 4 \text{ kHz cm}^{-2} \) (\( \langle Q \rangle \sim 400 \text{ fC} \)) with an efficiency of 55-60% and a rate capability of \( \sim 10 \text{ kHz cm}^{-2} \) (\( \langle Q \rangle \sim 150 \text{ fC} \) required) is not achievable with a 2 mm electrode currently. But an efficiency of \( \sim 40-50\% \) may be achievable with an electrode of \( \sim 1 \text{ mm} \) thickness as it relaxes the mean charge requirement \( \langle Q \rangle \sim 300 \text{ fC} \). The efficiency could be improved by using a double/multigap geometry (\( \sim 10\% \uparrow \)), reducing the electrode thickness (relaxes the mean charge requirement, \( \sim 5\% \uparrow \)) and better frontend electronics (\( \sim 5 \sim 10\% \uparrow \)). We are doing further studies in these directions.

Acknowledgments

We thank the INO-RPC group at TIFR for providing us the conductive paint and readout panels to assemble the RPC. DAE and DST, Govt. of India are acknowledged for funding. BM also acknowledges the support of J. C. Bose National Fellowship of DST.

References