

Development of bakelite resistive plate chamber based muon tomography system

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1. Introduction

The resistive plate chambers (RPC) are particle detectors with single gas gap separated by highly resistive electrodes. RPCs work on operational principle based on ionization of gas atoms inside the detector by through going charged particle. A mixture of suitable gas is kept inside the detector and a high, uniform electric field is maintained. The electric field is created by applying high electric voltage between two plates acting as electrodes made from highly resistive materials (10^9 - 10^{12} Ω cm). Bakelite and glass are well suited as resistive plates. RPCs have been used extensively in many experiments of high energy physics like ALICE[1]. RPCs have excellent position resolution, time resolution, high gain, and low cost. RPCs can be used in muon tomography system as they have very high efficiency in detection of muons. Multiple coulomb scattering detection of cosmic muons using two layers of detectors each consisting three RPCs is the basic principle of this imaging technique. This is an effort to develop bakelite RPC based muon tomography system and we report the fabrication steps of the detector and initial test results in this document.

2. Development of RPCs

We have developed six bakelite RPCs with dimensions 30cm x 30cm using the fabrication method described in reference [2]

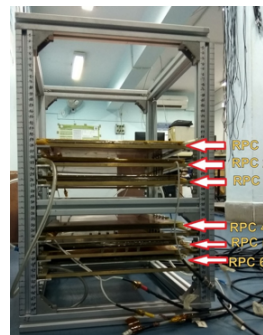


FIG. 1: Six single gap bakelite RPC based muon tomography system

3. Test results with cosmic ray muons

The gas composition for the 6 detectors was R134a : Iso-butane:SF6 :: 93.5 : 4.7:1.8 The test result with cosmic muons is discussed in the following sub-section.

A. I-V characteristics:-

Fig.2, Fig.3 and Fig.4 show the I-V characteristics of the RPCs. The breakdown voltages of RPCs are found to be in between 11.2kV and 11.4kV. From the I-V curve the bulk resistivity of the bakelite plates have been calculated and found to be in the order of 10^{11} .

B. Efficiency plot:-

The NIM logic pulse of RPC has been put in coincidence with the combination of scintillators signal using standard cosmic muon test bench setup and it formed the coincidence trigger. Ratio of coincidence trigger rates to master trigger rates gives us the efficiency

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of RPC and the threshold has been kept at around 2 mV. Fig.5, Fig.6 and Fig.7 shows the variation of the efficiency with the applied voltage. The efficiency plateau has been observed in between 11.2kV and 11.4kV and it is beyond 90%. NINO-ASIC based front end electronics were used in signal processing from the detectors.

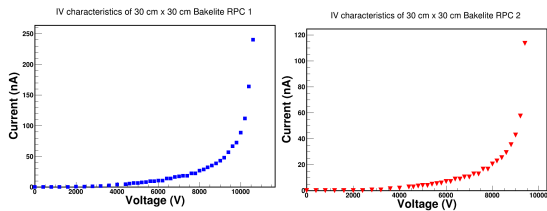


FIG. 2: IV characteristics of RPC-1 and RPC-2

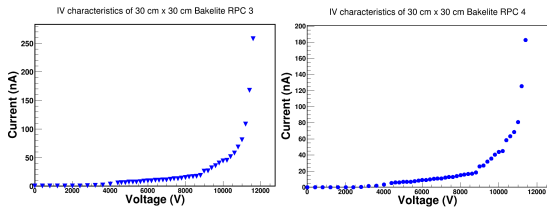


FIG. 3: IV characteristics of RPC-3 and RPC-4

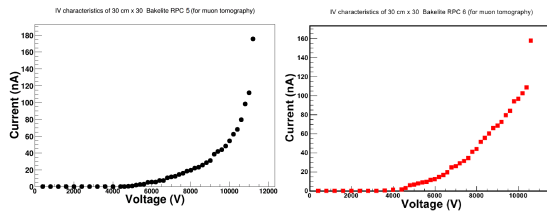


FIG. 4: IV characteristics of RPC-5 and RPC-6

3. Conclusion and outlook

Six bakelite RPCs have been successfully tested and the efficiency of them lies between 90% to 93.5%. The RPC based muon tomography system data is yet to be analyzed with position of closest approach (POCA) based al-

gorithm. A NINO-ASIC based data acquisition system is also to be established.

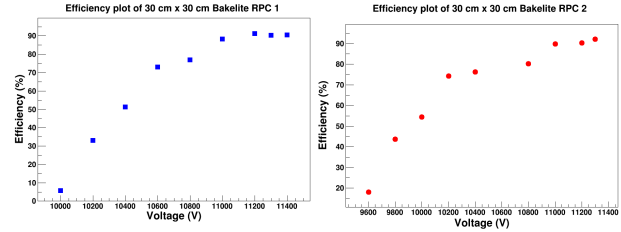


FIG. 5: Efficiency plot of RPC-1 and RPC-2

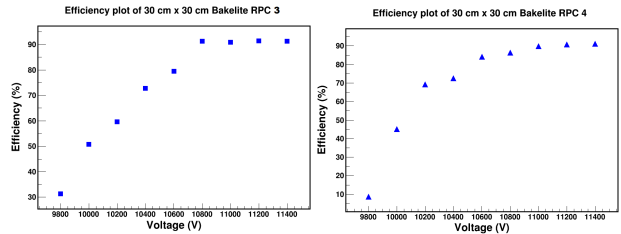


FIG. 6: Efficiency plot of RPC-3 and RPC-4

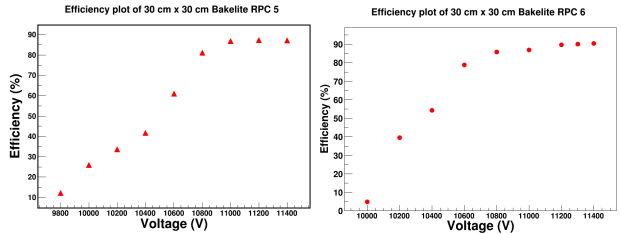


FIG. 7: Efficiency plot of RPC-5 and RPC-6

Acknowledgments

We acknowledge the work done by Mr. Ganesh Das to build the detectors.

References

- [1] <https://home.cern/about/experiments/alice>
- [2] R. Ganai et.al *Study of Performance of Bakelite Resistive Plate Chamber (RPC)*, Springer Proceedings in Physics. **174** (2016) 547.