Development and characterization of glass Multigap Resistive Plate Chambers

Moon Moon Devi,* N. K. Mondal, B. Satyanarayana, and R. R. Shinde
Tata Institute of Fundamental Research, Mumbai-400005, INDIA

Introduction

The Multigap RPCs (MRPC) [1, 2] are gas ionization detectors with multiple sub gaps, made of highly resistive electrodes (Glass in our case). The high voltage (HV) is applied to at the outer surfaces of outermost resistive plates only, while the interior plates are electrically floating. The presence of multiple gas gaps requires a higher voltage across them compared to the single gap structure. A charged particle passing through the gas gaps creates simultaneous avalanches in each of the individual gas gaps. The movement of ions and electrons in the gas gaps induce signals at the pickup electrodes. The fast signals in case of MRPC are produced by the flow of electrons towards the anode. Avalanches in any of the sub-gaps induce the signals on these electrodes and the resultant signal is a summation from all the gas gaps. Copper pickup strips placed outside the cathode and anode collect the signal, with a reduced time jitter, through induction.

MRPC detectors are being developed and studied in order to find potential applications in the future upgrades of the Iron Calorimeter (ICAL) detector which is being built by the India-based neutrino observatory (INO), as well as in other societal applications such as medical imaging. Six-gap MRPCs (each sub gap being $\sim$ 250m) have been fabricated and tested in avalanche mode, with the gas mixture being optimized to R134a(95.2%), C_4H_{10}(4.5%), SF_6(0.3%)). Here we present the method of fabrication, and preliminary characterisation including efficiency, counting rate, leakage current and time resolution.

*Electronic address: moonmoon4u@tifr.res.in

Fabrication of glass MRPC

We have fabricated six gap MRPCs of dimension 27cm×27cm×0.758cm. Glasses of 2mm thickness coated with a conductive layer using NEROLAC paint are used for the outer electrodes. The surface resistances of the conductive coat are in the range (0.5-1)M$\Omega/\Box$. The inner glass plates are of thickness 0.410 mm. Two sided non conducting adhesive tapes are used to make small circular spacers of diameter 4mm. Fig. 1 shows a schematic of the configuration. The pickup panel consists of honeycomb panels with copper strips of width 3cm. Some blockers were put in appropriate places to ensure a proper gas flow thorugh the sub gaps. The MRPCs were sealed by gluing side spacers between the outermost electrodes.

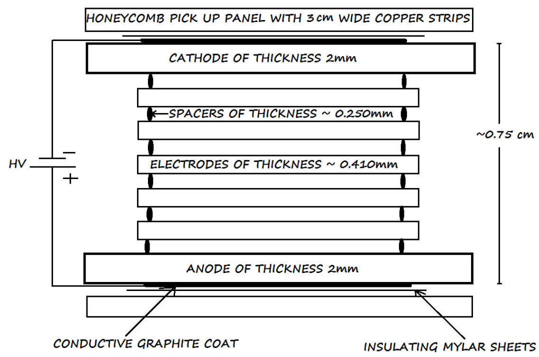

FIG. 1: A schematic diagram of the six gap MRPC configuration.

Characterization of glass MRPC

Set up: The MRPCs are being tested in avalanche mode. Three scintillator paddles of width 2cm in coincidence mode has been used for the trigger. The signals from the pick up strips are amplified with NINO ASIC and then taken with coincidence with the trigger. Pictures of the setup are shown in Fig. 2

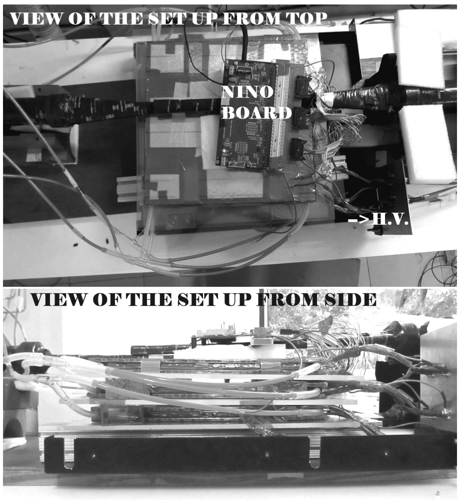

FIG. 2: The set up. (top) View from top, (bottom) Side view.

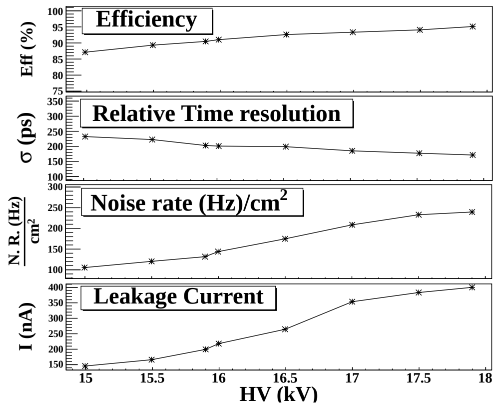

FIG. 3: Plots showing the performance of the MRPC.

Each channel in the NINO [3] ASIC chip takes the differential signal from the pick-up strips as input, and amplifies them in a four stage cascade amplifier. Threshold to the discriminator stage of the chip was optimized to 157mV after studying counting rates of the detector at various values.

DAQ: We have used a CAMAC based DAQ system for the MRPC detector test set up.

Characterization: After studying the MRPC characteristics at various concentrations of the components of the gas mixture, it was optimized to R134a(91.06%), C_4H_{10}(4.94%), SF_6(4%)). The efficiency, time resolution, leakage current and noise rate of the MRPCs have been studied.

Fig. 3 shows various performance of an MRPC at different applied high voltages. The maximum leakage current is found to be $\sim$ 400 nA. The efficiency increased with HV and at 17.9KV the MRPC obtained $\sim$ 95% efficiency. The counting rate at the same HV was found to be about 240 Hz/cm2. The relative time resolution (with respect to another MRPC) is obtained to be $\sim$ 170 ps at 17.9 kV.

Remarks

The design and fabrication procedure of 6-gap MRPCs has been optimized and are now being successfully operated. The gas mixture was optimized to R134a(91.06%), C_4H_{10}(4.94%), SF_6(4%). The characteristics like efficiency, time resolutions etc. were studied at different operating voltages. The relative time resolution between two MRPCs is obtained to be $\sim$ 170 ps and work is in progress to improve the time resolution further by correcting for the time distributions from electronic jitter and other sources. A 4-layered MRPC stack is now fully operational and we now using the stack for applications. It is now being tested as trigger to characterize the single gap RPCs. We are planning to explore other applications as well. We plan to modify the design of the MRPC (from single cell to double cell structure) to try to improve the timing. In addition, we plan to fabricate and study larger MRPCs (of about 50 cm X 50 cm in dimensions).

Acknowledgments

We would like to thank P. Verma, S. R. Joshi, Mandar Saraf, Darshana Gonji, Santosh Chavan and Vishal Asgolkar for their help during the course of this work.

References

[1] M. C. S. Williams [ALICE Collaboration], Nucl. Instrum. Meth. A 478 (2002).
[2] A. N. Akindinov et al. [Alice Collaboration], Nucl. Instrum. Meth. A 533 (2004).
[3] F. Anghinolfi et al., Nucl. Instrum. Meth. A 533 (2004).