Study of Surface Resistivity of Resistive Plate Chamber Detectors

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Introduction

Glass Resistive Plate Chamber (RPC) detector has a long history dating back to 1970s [1]. For large area coverage, RPC detector array is a key component of muon detection and tracking. RPCs find use as the active elements in the tracking (iron) calorimeter which can simultaneously measure the energy as well as the direction of the charged particle. RPC detector is preferred over scintillation detector because of important reasons such as high position resolution and detection efficiency [2, 3], has large area but at minimal material cost [4], easy to assemble and possesses simple read-out electronics and exhibits better time resolution (than scintillators) along with long-term stability [4].

There are initially two types of RPCs in use, i.e. glass and Bakelite electrode RPCs. The glass RPCs have been proposed as the active element in the iron calorimeter detector for the India-based Neutrino Observatory (INO).

The RPC detector described here is dc operated particle detector whose sensitive element is a 2mm thick layer of suitable mixture of gases, under uniform steady electric field generated by two parallel electrode plates of float glass with a volume resistivity of $10^{12}\Omega$-cm. Charged particle passes through the gas layer, an electric discharge is suddenly initiated by the liberated electrons. This discharge may be quenched by the following mechanisms: a) Prompt switching-off of the field around the discharge point, due to the large electrode resistivity, b) UV photon absorption by the quencher preventing secondary discharges from gas photo ionization, and c) Capture of outer electrons of the discharge due to the gas with high electron affinity, which reduces the size of the discharge and possibly its transversal dimensions. The duration of the discharge is of the order of ns. The relaxation time of the resistive electrode plate is $\tau \sim 2s$. The large difference between these two characteristic times ensures that during the discharge the electrode plates behave like insulators, so that only a limited area of ~0.1cm^2 around the discharge point remains inactive for the dead time of the detector. Graphite painted high-voltage electrodes of surface resistivity 100-300k$\Omega/\square$, transparent to the electrical pulse originated in the gas; allow a capacitive readout through external pick up electrodes, which are copper strips, about 2.5cm wide, facing the glass electrode.

Fabrication of 50cm × 50cm RPC

Various stages involved in the fabrication of RPC are as follows:

Glass cutting and Cleaning: The float glasses each of 2mm thick procured by local vendors are cut by diamond cutter to the desired size. The glasses are thoroughly cleaned with alcohol followed by distilled water. After that the edge spacers and corner spacers which are connected to the gas nozzle are also cleaned with alcohol. The glass edges are taped over with masking tape with 2cm being masked on each side so as to prevent the conductive coating to be painted right up to the edge of the glass plate and leakage of high voltage does not take place through the edge spacers.

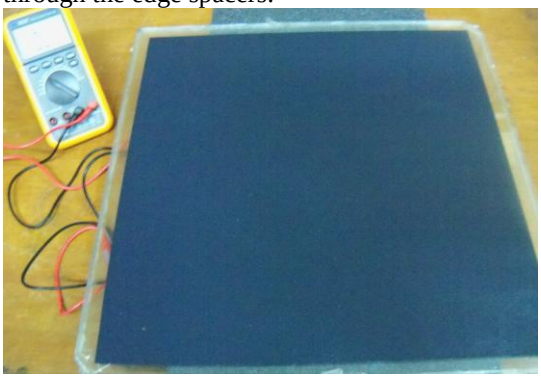

FIG. 1: A complete resistive plate chamber of 50×50cm^2.

Conductive Coating: Conductivity of the glass is increased by coating one side of it with a mixture of dry colloidal graphite and industrial lacquer in a ratio of 1:8 using a spray gun. We procured a liter of such graphite paint from TIFR, Mumbai. Surface of glass plate is coated in a clean and dry environment and temperature was

in between 30-35^{0}C. Once the surface is coated the masking tape is removed and the resistivity of both surfaces is measured using a resistance measurement jig of copper. The thickness of the coating is almost uniform and in between 10-30μm. This layer serves two purposes as it is conductive enough to act as anode/cathode and it is resistive enough to prevent itself from conducting away signal to the pickup strips so as to minimize the lateral spread.

Surface resistance measurement: The contour plots are obtained for four glass plates and all of them having fairly uniform surface resistance are selected for the construction of the two RPC detectors. The surface resistance is found to be fairly constant and is about 100-200kΩ/□ as shown in Figures 2 & 3. We observe variation in surface resistance near the edges due to non-uniform coating of graphite.

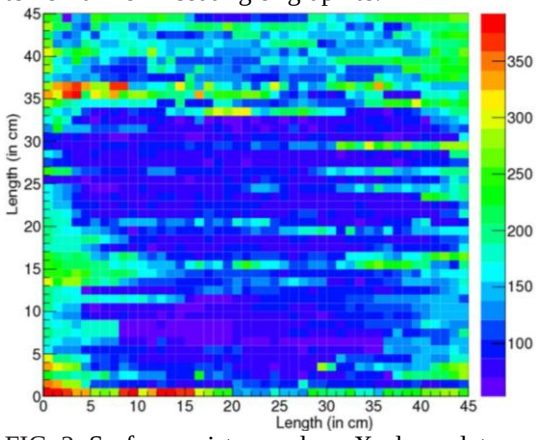

FIG. 2: Surface resistance along X-plane plate.

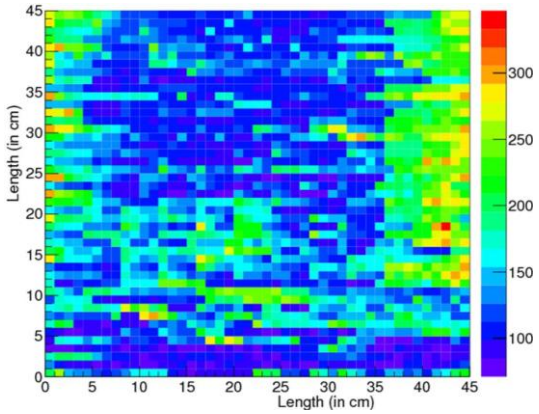

FIG. 3: Surface resistance along Y-plane plate.

Variation of Surface Resistance with Time

Variation in surface resistance with time has been observed after drying the paint coating on float glass. All four coated glass plates show almost similar behaviour of surface resistance variation. It shows rapid fall in surface resistance within few days and after that becomes constant at around 150KΩ/□ as shown in Figure 4.

Gluing of Glass

A mixture of 1:10 of hardener (Hardener 758) and glue (Dobeckot 520 F) of Elantas Beck India Ltd. is used to fix the edges, spacer and gas nozzles. To put a uniform weight throughout the 50cm^2 area similar frame placed on top of the whole set up and a weight of 2kg placed. The set up is left for whole day to fix the chamber. The straight edge-spacers are also designed such that the glass sits neatly within. There is a 1mm gap where the glue can be poured. The spacer, button and nozzles are procured from TIFR, Mumbai. The gas gap between glass plates in the chamber is 2mm. The corner spacers (gas nozzles) contain the gas inlet/outlet pipes. The glue is poured in the required gap and heavy weight is placed along the 4 sides to put the pressure and whole setup is left for one day, on the next day the same procedure is followed for the other side of the RPC.

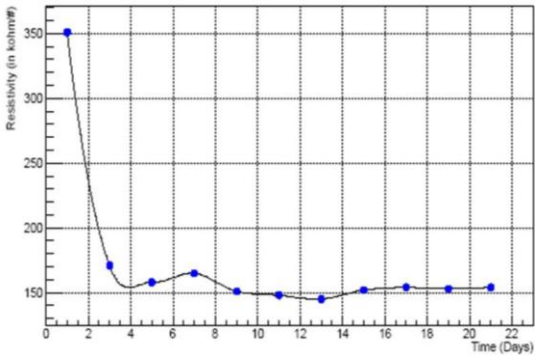

FIG. 4: Variation of surface resistance with time.

Observation shows that surface resistance is constant with time and there is variation in surface resistance near the edges due to non-uniform coating of graphite.

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References

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