Characteristic Study of Plastic Sheet based RPC Detector

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Introduction

The Resistive Plate Chamber (RPC) was introduced in 1981 by R. Santonico and R. Cardarelli. It is a gaseous particle tracking detector utilizing a constant and uniform electric field produced in between two parallel plate electrodes, which is made of a material with high bulk resistivity. Usually glass or Bakelite materials are used as electrodes. Due to larger area coverage requirement and brittle in nature, glass seems to be not suitable. Now the acrylic material sheets are used as electrodes, which is easily foldable and unbreakable as well as light in weight that may allow use in the development of cheap and robust medical imaging devices. The surface resistivity of acrylic sheet is in between 10^{10}–10^{12}ohm/cm^2. High resistivity of electrodes prevent the spread of collected charge and low conductivity support the application of high voltage over electrodes surface which will be necessary to maintain the discharge between electrodes. A thin uniform coating of graphite paint was sprayed over the sheet upper surface, which makes the resistivity of about 100-300 K-Ohm. It provides uniform electric field inside the gas chamber. Mixture of gases such as Argon, Isobutene and Freon are used inside the gas chamber. Argon acts as a target material. Polyatomic gases such as Isobutene are used in absorption of photon. These photons are capable of creating cascade avalanche. These gases act as quencher by absorbing the photons while Freon is an electronegative gas like R134a which limit the formation of secondary avalanches. These gases trap the unbound energetic electrons from the gas before they can initiate new avalanches. These gases Freon: Isobutene: Argon is mixed in the ratio of 62:8:30 by volume wise. When high energy particles enter the gas chamber, it creates an electron-ion pair that reaches the opposite polarity of electrodes. The pick-up strip panels are kept above and below the gas chamber to pick-up the charger, which forms the signal and transferred to the electronics.

V-I Characteristic of RPC

At lower applied voltages, the primary ionizations in the gas gap do not lead to the development of avalanches. Therefore, the gas gap offers infinite resistance. At higher voltage ionization volume almost seizes to offer any value of resistance. Figure 1 show the plot between voltage vs current using single gas Freon R134a.

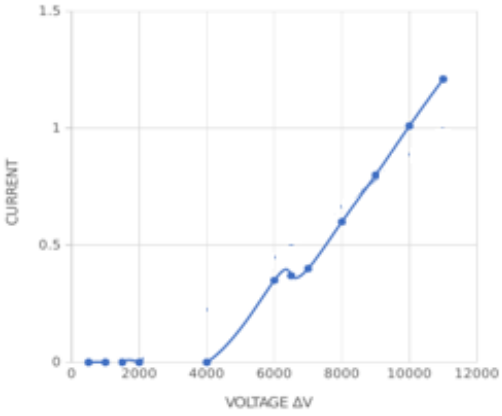

Fig. 1: V-I Characteristic of RPC detector. On y-axis current is in microampere and on x-axis potential difference is in volts.

Efficiency measurement & distribution

We fabricated a 420mm · 420mm · 20mm size (graphite coated area) acrylic based RPC detector in which total 5 buttons are placed around center out of which 4 are placed in square shape and one is placed at the center . Figure 2 shows the experimental setup that used for the efficiency measurement of the newly developed plastic based RPC detector.

Efficiency measurement of RPC detector is performed by using only Freon R134a gas. Two

pick-up panels of breadth 28mm and length 420mm and two plastic scintillation detectors were used for measurement of efficiency of the whole graphite coated surface of RPC gas detector. Figure 3 shows the raw signal from pickup panel of acrylic based RPC detector. The RPC detector was operated at 7000 volts, which is a fast signal. The room temperature and relative humidity were 250c and 70%, respectively during the period of data taking.

Fig.2: Experimental setup of RPC detector for efficiency measurement.

Two pick-up panels were kept perpendicular to each other on both side of the RPC detector and two plastic scintillation detectors above and below the RPC detector were also placed to take counts of cosmic rays. When high energy cosmic rays passes through the gas chamber and the plastic scintillators he electric signal produced through it, pickup panels pick up the signal and scintillation signal also validate. The counter-1 measure the coincident counts attached in with two scintillators. The counter-2 measure the counts attached in "AND" logic with counter-1 and two pickup panels. Efficiency is the measurement of ratio of (counter-2/counter-1)· 100. Measurement of efficiency at every area of 28mm · 28mm is done by placing the whole set-up i.e. a pair of pickup panel and plastic scintillation detector, above and below the resistive plate chamber. Figure 4 shows the contour plot of RPC detector efficiency. Whole RPC gas chamber is divided into 225 (15 x 15) small area of 28mm X 28mm size.

Results and Conclusions

It is observed from the efficiency plot of RPC gas chamber is that the maximum achieved efficiency is about 80% at 7000 voltage in the middle part of the chamber while at the boundary it is less about 20%. There are much scopes of improvement in this detector and various parameters must be optimized.

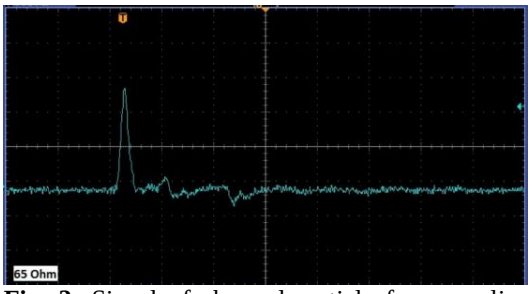

Fig. 3: Signal of charged particle from acrylic Sheet RPC.

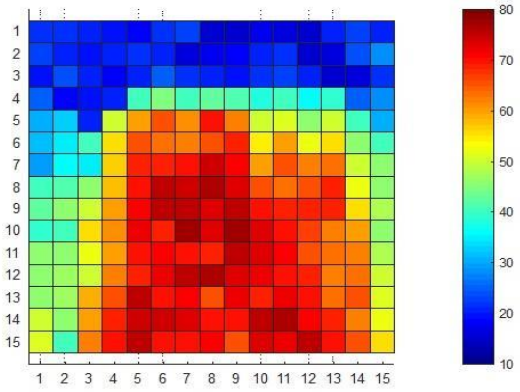

Fig. 4: Contour plot of efficiency distribution of RPC detector.

Acknowledgment

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References

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