Characteristics and Performance Studies of Glass Resistive Plate Chambers

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Introduction

In the proposed Indian-based Neutrino Observatory (INO), the Resistive Plate Chambers (RPCs) have been chosen as the prime active detector for the detection of muons (produced through the interaction of neutrinos) in an Iron Calorimeter (ICAL) [1]. INO is being planned to determine the neutrino oscillation parameters precisely in the 3-flavor mixing scenario using atmospheric neutrinos. For effective separation of upcoming and downgoing neutrinos and background rejection, ICAL requires highly efficient and sensitive detectors with 2 ns time resolution. During the last few years significant work on the prototype graphite coated glass based RPCs has been carried out at SINP/VECC/TIFR for INO-ICAL Experiment. Glass and Bakelite RPC detectors of various sizes from $10cm \times 10cm$ to $1m \times 1m$ have been fabricated, characterized and optimized for efficiency and time resolution, and are reported earlier [2].

Resistive Plate Chambers are Parallel Plate gaseous detectors built using electrodes of high volume resistivity of the order of $10^{10} - 10^{12}$ ohm-cm[3]. The charged particles leave a trail of free charge carriers (primary ionisation) in the gas which trigger avalanches of charge carriers in the electric field. At a certain size the avalanches transform into streamers, where photons produced by recombination process, contribute to the spread of free charge carriers. RPCs are rugged and find extensive use in High energy physics (HEP) and Astroparticle physics experiments [4]. The main features of these counters are the very large signal output and pulse height, reduced cost per unit area and good time resolution (around 1ns). However, a relatively low production cost and a simple structure are the most attractive features of the RPC, as many modern detector systems require the coverage of large areas. Electrodes chosen for the RPCs should have smoothness of surfaces to avoid localization of excess charges, surface treatment to reduce the surface resistivity or providing alternate leakage path for post-streamer recovery adopted in the major high energy physics experiments. The new developments have extended the range of HEP applications and promise new applications in medical imaging[5]. Operating the RPCs in avalanche mode of operation, the field has enjoyed progress in recent years[6]. The original RPCs were single-gap counters operated in streamer mode. Soon the double-gap structure was introduced to improve the detection efficiency along with the avalanche mode of operation [7], which extends its counting-rate capabilities. In the current analysis, single gap (gas gap 2 mm) Glass RPCs modules of size $1m \times 1m$ have been fabricated, characterized and optimized for efficiency and noise rate. The design, construction and the test results (using cosmic-ray muons telescope) of a prototype RPC real-sized AB11, whose bulk resistivity is about $10^{10}\Omega$cm, have been done. The current studies deals with the development of instruments and methods for the measurement of efficiency, Noise rate, of glass RPCs.The results indicate definite correlation of the detector efficiency for the atmospheric muons and the RPC noise rates with applied bias voltage.

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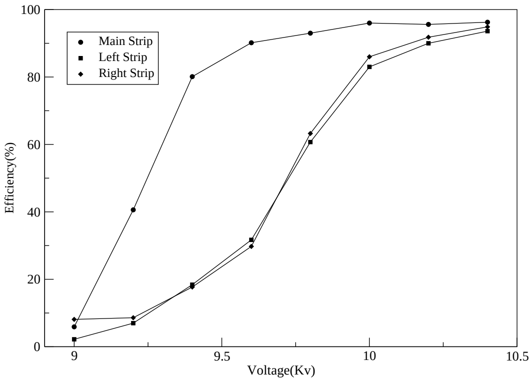

FIG. 1: Variation of Efficiency with Voltage (Kv)for the avalanche operated chamber

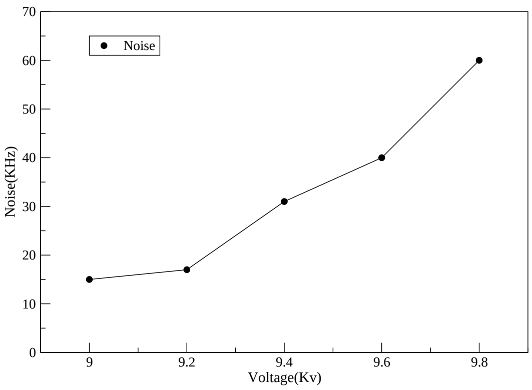

FIG. 2: Variation of Noise rate with Voltage(Kv) for same mode of operation

Results

We have successfully built and characterised the glass RPCs of $1m \times 1m$ in area that will be used for the INO-ICAL experiment. We have calculated efficiency of one of the twelve RPCs at different values of the high voltage (AB11) Stack in TIFR. Normally the RPCs are operated at a high voltage starting from 9.8KV. It is observed that the efficiency values are almost constant for voltages higher than 9.8 KV but falls sharply with decreasing voltage below it[Fig1].The horizontal part of the plot in the high voltage region is known as plateau region of operation of the RPC. Calculation of noise rate[Fig2] also shows desired behaviour. As the voltage increases even low energy particles are able to produce signal above threshold leading to the increase in noise. Noise serves as the long term stability test of the RPC.

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