Time resolution measurement of silicone coated bakelite Resistive Plate Chamber

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Introduction

The proposed India-based Neutrino Observatory (INO) [1] is being planned with an aim to determine precisely the oscillation parameters using atmospheric neutrinos. In INO, the Resistive Plate Chambers (RPC) [2] have been chosen as the active detector for the detection of muons (produced through the interaction of neutrinos) in a 50 kton Iron Calorimeter (ICAL). One requirement for the RPC for INO is to have a time resolution ~ 2 ns to discriminate the tracks of the up coming and down going neutrinos. During the last few years R&D on the RPC with bakelite paper laminates commercially available in India is going on at SINP/VECC. The work was initiated by the use of 2 mm thick matt finished P-120 grade bakelite for fabricating the RPC modules of dimension 30 cm $\times$ 30 cm. The application of a thin coating of silicone fluid (chemical formula : $[R_2SiO]_n$, where R = organic groups such as methyl, ethyl, or phenyl) [coefficient of viscosity = 5.5 Pa.s at 23°C, manufactured by Metroark Limited, Kolkata, India] on the inner surface was found to give satisfactory and stable performance (efficiency $> 90\%$, counting rate ~ 0.1 Hz/cm^2) for a period of > 130 days when operated in the streamer mode (gas mixture: argon, tetrafluroethane (R-134a) and isobutane in 34:59:7 mixing ratio) [3, 4]. The bulk resistivity (ρ) of this particular grade of bakelite is quite high ($\sim 10^{11}$ - 10^{12} Ω cm). Such high resistive electrodes are being explored since the plan is to operate these detectors in low-rate cosmic/neutrino experiments. The results of the long term test and some other aspects such as crosstalk, dependency on threshold value, the effect of external humidity etc. of these silicone coated RPC have been reported earlier [4, 5]. In this article we present the time resolution measurement of such single gap (2 mm) silicone coated RPC.

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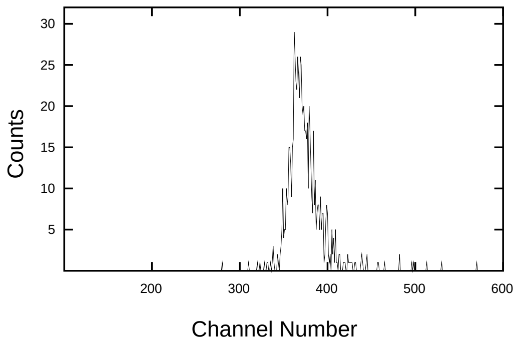

FIG. 1: The distribution of the time difference (TDC channel) between the RPC and the master trigger.

Method of calculation and results

The time resolution of the RPC was measured in the same cosmic ray test bench described in Ref.[4] using a common start in Phillips Scientific 7186 TDC. The cosmic ray telescope was constructed using three scintillators, two placed above the RPC and one below. The individual time resolution of each RPC was estimated by the following procedure. The coincidence between the signals obtained from the scintillator I, the finger scin-

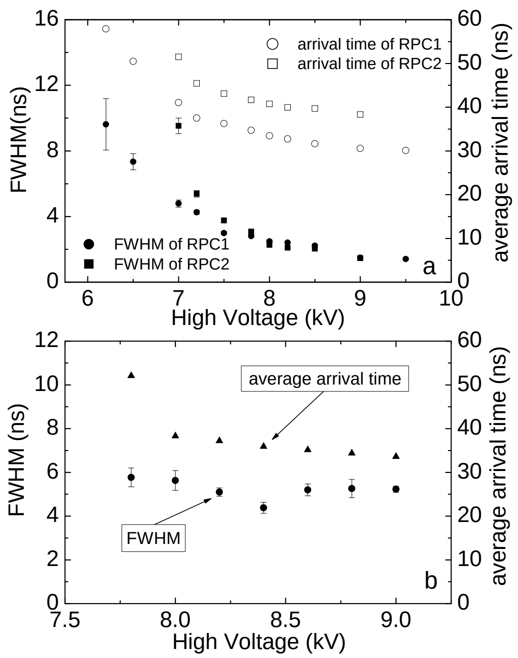

FIG. 2: (a) The time resolution (FWHM) and the average signal arrival time with respect to the master trigger as a function of HV for two silicone coated RPC. (b) The time resolution (FWHM) and the average signal arrival time as a function of HV for a 1m × 1m RPC.

tillator(III) which was placed above the RPC plane and the scintillator II which was placed below, was taken as the START signal (master trigger) for TDC. The STOP signal was taken from a single RPC strip. The distribution of the time difference between the master trigger and the signal from one RPC strip is shown in FIG. 1. The channel calibration was taken as 0.1 ns/channel. The Full Width at Half Maximum (FWHM) and the corresponding standard deviation (σ_{ij}), where the indices (i and j) refer to the three scintillators and one RPC strip, were obtained by fitting the time distributions with a Gaussian curve. The individual standard deviations σ_i, σ_j of the scintillators and the RPC were subsequently obtained by solving the equations: ${\sigma_{ij}}^2 = {\sigma_i}^2 + {\sigma_j}^2$. The corresponding FWHMs were calculated from the σ-values [6].

The average signal arrival time and the time resolution (FWHM) as a function of the applied high voltage (HV) of two small (30 cm × 30 cm) silicone coated RPCs are shown in FIG. 2 (a). The time resolution for both the modules improves with the increase of HV which is common to any gas filled detector. At the plateau region the time resolution has been found to be ∼ 2 ns.

The time resolution between two RPCs was also measured keeping one RPC at constant voltage (8 kV) varying the voltage of the other RPC. In this case, the average time resolution is found to be ∼ 3 ns in the plateau region.

The FWHM of a 1m × 1m RPC is found to be ∼ 5 ns at the plateau [shown in FIG. 2 (b)].

Conclusions and outlook

In conclusion, a systematic study on the timing properties of silicone coated single gap RPCs made from P-120 grade of bakelite, commercially available in India has been performed. The measured time resolution (FWHM) of those RPCs have been found to be ∼ 2 ns which is comparable to any single gap glass or linseed oil treated bakelite RPC.

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