Development of Resistive Plate Chamber for the CBM experiment at FAIR

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The Compressed Baryonic Matter (CBM) experiment at the future Facility for Antiproton and Ion Research (FAIR) in Darmstadt, Germany, will explore the QCD phase diagram at low temperature and moderate to high baryonic density regime [1, 2]. The decay of charmonium (J/ψ), low mass vector mesons ρ^0, ω^0, Φ^0 in the muonic decay channel, *i.e.*, $\mu^+\mu^-$ will be used as a probe to get an idea about the in-medium modifications of the particles.

Given the maximum interaction rate of 10 MHz, the expected particle flux on the first two stations of CBM Muon Chamber (CBM-MuCh) will be about 1 MHz/cm^2 and 0.1 MHz/cm^2 respectively, and that on the 3^{rd} and 4^{th} stations have been estimated to be 15 kHz/cm^2 and 5.6 kHz/cm^2, respectively, for central Au–Au collisions at 8 AGeV. Triple GEM (Gas Electron Multiplier) detectors will be used in the first two stations to handle high particle rates [3, 4]. At Bose Institute a detailed R&D has been carried out on RPC detectors [5] using bakelite plates commercially available in the local market of India having moderate resistivity, for the 3^{rd} and 4^{th} stations of MuCh subsystem.

In bakelite RPC, linseed oil coating is done to get rid of surface roughness issue. The linseed oil coating also helps to reduce the noise rate of the detector, protects the electrode plate from Hydrofluoric Acid (HF) corrosive effect and it also has photon quenching properties that reduce the UV sensitivity of the electrode plates [6, 7]. In conventional bakelite RPC, the linseed oil coating is done after making the gas gap [8, 9]. A new technique is introduced for the linseed oil coating of the bakelite sheets, before making the gas gap. The advantage of this procedure is that after linseed oil coating, it can be checked visually whether the curing is properly done or if any uncured droplet of linseed oil is present.

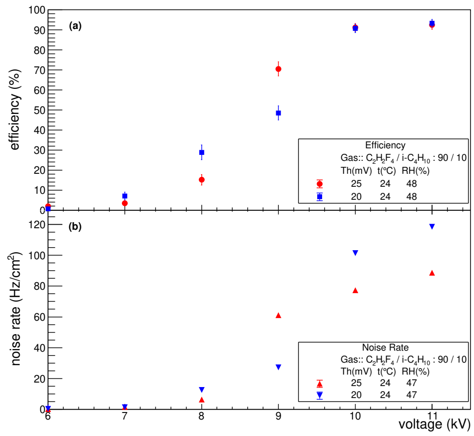

FIG. 1: (a) The efficiency (b) Noise rate as a function of voltage.

A RPC prototype made of linseed oil coated indigenous bakelite material of thickness 2 mm and having bulk resistivity $\sim 3 \times 10^{10}$ Ω cm is characterised. The chamber is tested with cosmic rays in avalanche mode using Tetrafluoroethane ($C_2H_2F_4$) and Isobutane (i-C_4H_{10}) gas mixture in 90/10 volume ratio. The leakage current through the RPC module is measured as a function of the applied high voltage (HV). The efficiency and noise rate are also studied by varying the applied HV. With the mixed gas, the module is tested with - 20 mV and - 25 mV threshold settings for the LED. An efficiency of $\sim 95 \pm 2\%$ is achieved from 10 kV onwards for both the threshold

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settings as shown in FIG 1. The maximum noise rates are found to be $\sim$ 120 Hz/cm^2 and $\sim$ 80 Hz/cm^2 for the - 20 mV and - 25 mV thresholds respectively [10].

The best time resolution 0.8 $\pm$ 0.06 ns (σ) is obtained for an applied voltage of 10.4 kV as shown in FIG 2.

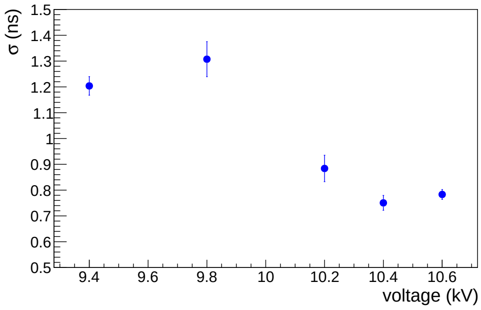

FIG. 2: Time resolution (σ) of the RPC as a function voltage.

To test the stability, the detector is operated at 10.2 kV for a period of more than three months with a mixture of $C_2H_2F_4$ and i-C_4H_{10} in the 90/10 volume ratio and also with 100% $C_2H_2F_4$. The efficiency and noise rate as function of period of operation is shown in FIG 3. It is found that for $C_2H_2F_4$ and i-C_4H_{10} mixture and 100% $C_2H_2F_4$ the average efficiencies are found to be 88 $\pm$ 6 % and 93 $\pm$ 6 % respectively whereas the average noise rates for two compositions are found to be 189 $\pm$ 131 Hz/cm^2 and 208 $\pm$ 129 Hz/cm^2.

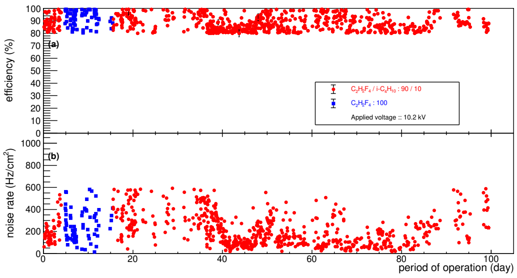

FIG. 3: (a) Efficiency and (b) noise rate as a function of period of operation for two different gas composition. For some data points the error bars are smaller than the marker size.

Variation of charge sharing between the consecutive strips is measured with the applied voltage. From 5 to 8 kV the shared charge initially increased and reached a constant ($\sim$ 30%) within the error bar. With the increasing voltage shared charge has not increased further and remained constant within a fluctuation.

The prototype detector is also tested in the high-intensity gamma-ray environment to have an idea about the behaviour in a real experiment-like scenario. This radiation tolerance test is very important, especially for high-energy heavy-ion collision experiments. A ^{137}Cs source of activity 13.6 GBq is used for this study. 662 keV photon is emitted from the source with a flux of 46 kHz/cm^2. Very high efficiency for the cosmic ray muons is also obtained in the presence of high-intensity photon background. It is observed that the efficiency decreased by only 1 % from the efficiency value without the source with a gamma ray flux of 46 kHz/cm^2.

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