Development of Resistive Plate Chambers and front-end electronics for INO-ICAL experiment

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Introduction

The India based Neutrino Observatory (INO)[1] is aimed to carry out measurements on atmospheric neutrinos and its related issues using its primary detector - the Iron Calorimeter (ICAL). In order to fulfil the physics goals, the experiment requires 29000 RPCs and associated electronics. However, before embarking this amount of RPCs and commissioning of the electronics, it is essential to perform an R&D for the optimisation of various parameters so as to have improved performance of the ICAL. In view of same, a characterization study has been conducted to find the suitable electrodes for the RPCs. Also, various RPC gas compositions have been studied to optimise RPC operation parameters like leakage current, count rate, efficiency, time resolution and charge spectra. In addition to this, an ASIC based front-end read-out, HARDROC has also been proposed, integrated and commissioned to deal with the huge number of electronic channels.

Characterization of RPC electrodes and performance study

Based on the local availability and affordability of electrodes a total of five electrode materials were chosen. The glass electrodes from following three companies namely Asahi, Saint Gobain, and Modi were procured while in bakelite, Hylam and Formica were chosen. Various characterization studies have been carried out to invigilate the electrical and surface quality aspects. The studies shows the Saint Gobain electrode best amongst all glass electrodes[2] while Formica in bakelite[3]. Various small and large size RPCS have been fabricated and tested under the muon Hodoscope. The fabricated RPCs have been tested for their performance on the basis of different parameters like leakage current, noise rate, efficiency, charge spectra and time resolution. The efficiency has been measured using a muon hodoscope, consisting of two large and one finger scintillator. The Timing and charge measurements have been performed using Time to digital (TDC) and Charge to digital (QDC) module[2]. Fig. 1 and Fig. 2 shows the efficiency and timing measurements. The timing measurements reveals that the mixture with 0.3 and 0.5% SF_6 concentration leads to best timing response while maintaining the efficiency above 90%. The charge spectra shows that the addition of SF_6 results in reduction of mean charge[4].

HARDROC testing and commissioning

The electronics of the ICAL experiment demands the instrumentation of enormous number of read out channels for its operation. However many technical challenges like low power consumption, easy accessibility and proper handling of the channels are need to be investigated for efficient data acquisition. In concern of this, a multichannel based readout namely HARDROC has been tested and commissioned. The HARDOC comprise of 64 channels and each channel is made up of charge sensitive preamplifier, fast and slow shapers, varied threshold range discriminator and a readout circuit. Various tests like

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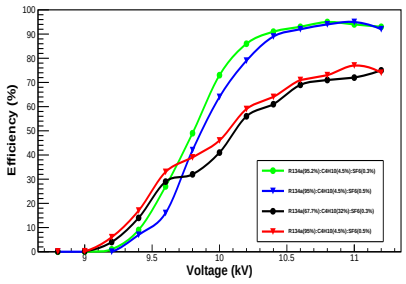

FIG. 1: Efficiency measurement of Saint Gobain and hylam RPC under 0.3 and 0.5% SF_6 concentration.

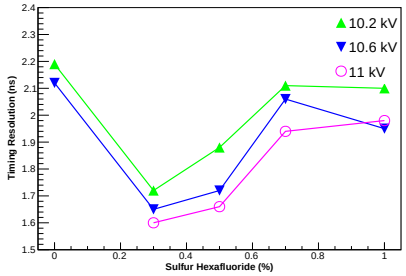

FIG. 2: Time resolution measurement of Saint Gobain RPC under SF_6 variation.

charge calibration, DAC characterization and pre amplifier gain correction have been conducted to understand the operational parameters and their impact on the readout chain. Fig. 3 and Fig. 4 shows the experimental set up used in the HARDROC testing and analog output pulse from the fast shaper. Finally the HARDROC has been integrated with fabricated RPCs and tested for their performance[5].

Conclusions

While the electrode characterization study results show that Saint Gobain is a suitable candidate, the gas mixture with 0.3 % and 0.5% SF_6 is proposed owing to excellent RPC performance as the operating gas mixture for the ICAL RPCs. The results of testing and

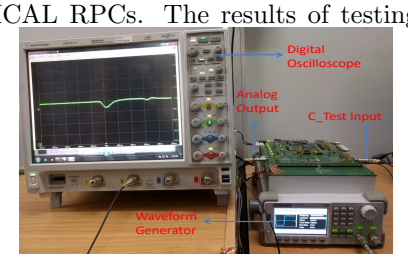

FIG. 3: The experimental setup for the charge calibration.

FIG. 4: The analog output of fast shaper.

commissioning of HARDROC based read-out, infers it to be a suitable option for the ICAL electronics.

Acknowledgments

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References

[1] The Technical Design Report of INO-ICAL Detector **2006**.
[2] D. Kaur, et al., Nucl. Instr. and Meth. A 774 (2015) 74.
[3] A. kumar, et al., 2014 JINST 9 C10042, doi:10.1088/1748-0221/C10042.
[4] A. Gaur et al., Nucl. Instrum. Methods A 877 (2018) 246.
[5] A.Phogat et al., Nucl. Instrum. Methods A 905 (2018) 193.