

Efficiency Study of 1m × 1m size SFS based pickup panel

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Introduction

India-based Neutrino Observatory (INO) is proposed to build massive magnetized Iron Calorimeter i.e. ICAL with around 30, 000 number of Resistive Plate Chamber (RPC) detectors, which is an active gaseous detector in INO-ICAL. This detector is preferred due to its better time and space resolution of 1ns and 1cm, respectively. It can cover larger area due to its planar geometry and can be used for prolonged time in low cost. This particle detector consists of parallel plate electrodes of bakelite or glass with high surface resistivity of $10^{10} - 10^{20}$ ohms/cm². High resistivity of electrodes prevents the spread of collected charge and low conductivity supports the application of high voltage over the electrodes surface, which will be necessary to maintain the discharge between electrodes. It helps in electric field drop drastically in the region of discharge causing it to extinguish. A thin uniform coating of graphite paint was sprayed on glass plate whose resistivity is about 100-300 Kohms/cm². It provides uniform electric field inside the gas chamber. Mixture of gases such as Argon, Isobutane, and Freon are used inside the gas chamber. Argon acts as a target material; Isobutane helps in absorption of photons while Freon is an electronegative gas, which serves the purpose of limiting the formation secondary avalanches. When a high energetic particle enters the gas chamber, it creates an electron-ion pair that reaches the opposite polarity of electrodes. The pickup strip panels are kept above and below the glass chamber to pickup the charge, which forms the signal and later sends to electronics. The honeycomb based pickup panel is in use worldwide but it is not suitable for INO-ICAL setup.

Material Selection

The INO is an approved under ground facility/laboratory. It is planned to host huge

number of ~60,000 Pickup panels. Therefore, there are some specific requirements for pickup panels. The characteristic impedance of the pickup panels should match with the front-end electronics, which is 50 ohms. It must be flame resistant. Its efficiency should be comparable to the honeycomb based pickup panel. After all, it should be cost effective and easily available in the local market. After much effort [1], it is found that Silicon Fiber Sheet (SFS) based pickup panel fulfills the entire requirement. From the local market we procured 1m × 0.5m, size SFS. We joined two similar sheets to make 1m × 1m size sheet.



Fig. 1 (a) Silicon Fiber Sheet (SFS) of 1m × 0.5m (b) pickup panels of size 1m × 1m of SFS based.

Characteristic Study of SFS material

The characteristic impedance is measured using suitable circuit and measured impedance is found to be 50 ohms.

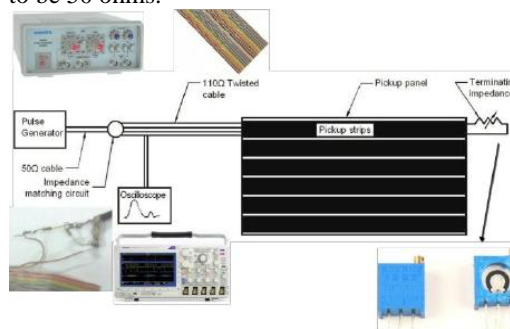


Fig. 2 Circuit diagram of the characteristic impedance measurement of the material.

To study the effect of temperature on the SFS material, specimen was kept in tubular furnace, whose temperature varied from 30°C to 900°C, and found that the material of SFS is flame resistant. Even at very high temperature i.e. ~900°C, only change in the physical property of the material is observed i.e. material changes into powdered form only. It is necessary to know the elemental composition of the SFS material. Using XRF techniques it is observed that 98% of the SFS material is made of the oxide of Silicon, Aluminum and Zirconium, which emit nonhazardous gases after burning [1, 2].

Measurement of Efficiency

Efficiency measurement of RPC detector is performed using single gas (100% Freon) with the help of two plastic scintillation detectors for trigger. Detectors, discriminator, coincidence unit etc are connected as shown in Fig. 3. When charged particle crosses the chamber, pickup panels pick up the signal. The counter-1 measure the counts attached in “AND” logic with two scintillator. The counter-2 measure the counts attached in “AND” logic with two scintillator and pickup efficiency is the measurement of ratio of (counter-2/counter-1) x100.

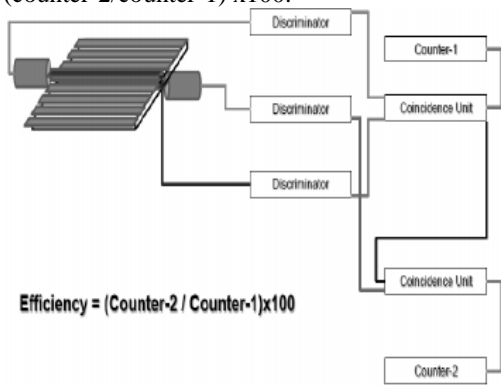


Fig. 3 Schematic Diagram of Efficiency Measurement.

Results and Conclusion

It is observed that the efficiency of both the pickup panels seem to be equally good within the experimental error, as shown in Fig. 4. Other properties such as flexibility, characteristic impedance, effects of temperature and, humidity

etc have been demonstrated [2] for the SFS based pickup panel. Obtained results are far better than the results obtained for the plastic one. The cost of the SFS based pickup panel of 1m x 1m size is roughly 5 times lower than the plastic based pickup panel. This is due to the material availability in local market and known technology of fabrication. From the above facts, it may be concluded that the Silicon Fiber Sheet (SFS) based pickup panel is most suitable for the INO-ICAL experiment compared with plastic base pickup panel, which is commonly used for the same purpose. Its characteristic impedance is about ~50ohms. No element is found which is hazardous after burning. Its efficiency is also comparable to honeycomb.

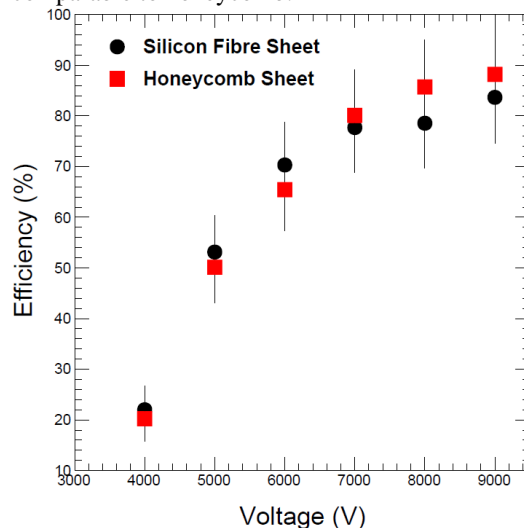


Fig. 4 Efficiency plot of RPC detector using SFS based pickup panel.

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References

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 [2] M. K. Singh et al., JINST 12, T01006 (2017).