Search for new gas mixture for Resistive Plate Chamber

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1.Introduction

Resistive plate chambers(RPC) [1] are particle detectors which have a single gas gap between two electrodes made from highly resistive materials (10^9 - 10^{12} Ωcm) like glass and bakelite. When a charged particle passes through gas volume confined by the detector, it causes ionization in the gas in presence of a high uniform electric field created by applying high electrical voltage on the mentioned highly resistive electrodes.
RPCs have some advantageous features like easy to construct, low cost, good rate handling capacity($\sim$1kHz/cm^2)[2] and good time resolution($\sim$1nS)[3]. Due to these features, they have been used in many high energy physics experiments like ALICE[4], CMS[5], etc. in LHC.
RPCs work on the principle of ionization of gas ,for this reason the gas mixture plays a role of great importance in the working of the detector. Generally mixture of freon, isobutene and SF6 are used as suitable gas mixture in case of RPCs all over the world. It is decided by EU (European Union)[6] and EPA (Environmental Protection agency) of USA[7] ,that use of freon(134a) will be banned in new systems completely in near future, as release of freon in the atmosphere possesses threat of global warming. Hence it is crucial to find a new composition of gas mixture for RPCs which will function desirably in the experiments and currently at VECC we are trying to find such new suitable gas mixture which is reported in detail in the following section.

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2. Testing of RPC using argon and CO_2 gas mixture with cosmic rays

The RPC detector we have used has two 3mm thick bakelite electrodes of dimension 30cm x 30cm. The gas gap between them is 2mm, having 5 button spacers glued inside to separate the electrodes from each other. Two gas nozzles were attached with the detector for the gas mixture to enter and to exit[8].

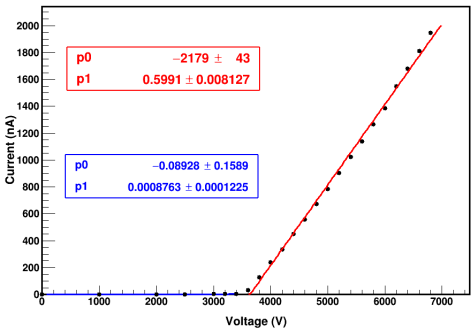

FIG. 1: I-V characteristics of Bakelite RPC with Ar:CO_2 :: 90:10.

Insted of the conventional mixture we have tested the oil free Bakelite RPC with two different composition of argon and CO_2. Generally this mixture is used in case of other gaseous detector like GEMs but not in RPCs. We have used two gas cylinders with precisely mixed argon and CO_2. The ratios were Ar:Co_2 :: 90:10 and Ar:CO_2 :: 80:20.

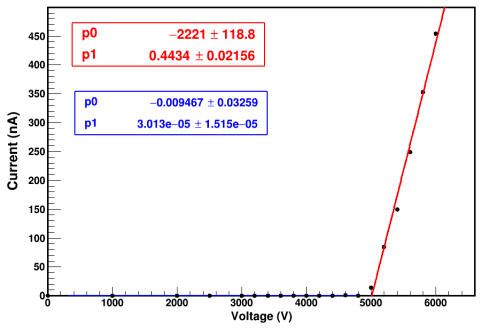

FIG. 2: I-V characteristics of Bakelite RPC with Ar:CO_2 :: 80:20.

The test results are discussed in the following section.

A. I-V characteristics:-

In Fig.1 and Fig.2 the I-V characteristics of the RPC tested with gas mixture of two different ratios, that are Ar:CO_2 :: 90:10 and Ar:CO_2 :: 80:20 respectively are shown. Two distinct slopes are observed in each of the graphs, that can be seen in blue and red coloured line in the graphs. The breakdown voltages are found to be at ∼3600V and ∼5000V for Fig.1 and Fig.2. It is observed that the breakdown voltage with gas mixture having 90% Ar is at ∼3000V which is lower than ∼5000V, found in csae of the gas mixture containing 80% Ar. This was expected as Argon has low ionization potential and the proportion of Ar was higher in the first gas mixture(Ar:CO_2 :: 90:10). From the I-V characteristics curves the bakelite plate resistivity was calculated to be 7.393×10^8 Ωcm and 2.195×10^9 Ωcm for Ar:CO_2 :: 90:10 and Ar:CO_2 :: 80:20 gas mixtures respectively.

3. Conclusion and outlook

From the two graphs it is seen that the gas mixture of Argon:CO_2 :: 90:10 and Argon:CO2 :: 80:20 have shown promising result. But further testing and characterization is required for this purpose, which will be carried out by us. The following performance study we need to measure:
1. Charge spectra of the RPC.
2. Rate handling capability of the detector.
3. Long term performance of the detector to observe any aging effect of the RPC due to the exposure of new gas mixture.

This is our first step towards the search of an alternative gas mixture for RPC operation, many other different gas mixtures will be tested using RPCs until a comparable or better alternative of the existing gas mixture is found.

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References

[1] R. Santonico, R. Cardarelli, *Development of Resistive Plate Counters*, *Nucl. Instr. and Meth.* **187** (1981) 377.
[2] https://indico.gsi.de/event/6250/contribution/5/material/poster/0.pdf
[3] https://arxiv.org/pdf/1410.5532.pdf
[4] https://home.cern/about/experiments/alice
[5] https://home.cern/about/experiments/cms
[6] https://ec.europa.eu/clima/policies/f-gas/legislation_en
[7] https://www.epa.gov/sites/production/files/2016-09/documents/snap_status_change_rule_2_2060_as80.pdf
[8] R. Ganai *Study of Performance of Bakelite Resistive Plate Chamber (RPC)*, *Springer Proceedings in Physics.*. **174** (2006) 547.