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Environment-friendly gas mixtures for Resistive Plate Chambers: an experimental and simulation study

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Resistive Plate Chambers (RPC) have shown stable operation at the Large Hadron Collider and satisfactory efficiency for the entire Run 1 (2010–2013) and Run 2 (2015–2018) with $C_2H_2F_4$-based gas mixtures and the addition of SF_6 and i-C_4H_{10}. However, $C_2H_2F_4$ and SF_6 are greenhouse gases with a high Global Warming Potential (GWP): in particular, $C_2H_2F_4$ is already phasing out of production, due to the recent European Union (EU) regulations, and its cost is progressively increasing. In parallel, CERN has elaborated a number of strategies to reduce as much as possible the greenhouse gas emissions or, at least, optimize their use in the LHC experiments. For these reasons, finding gas mixtures with a low GWP has become extremely important.

This study is focused on the characterization of innovative gas mixtures with tetrafluoropropene $C_3H_2F_4$ (HFO1234ze), a hydrofluoroolefin with very low GWP. The lack of knowledge on fundamental parameters of $C_3H_2F_4$, e.g. its electron collision cross sections, makes implementation of this gas in simulations rather difficult. A dedicated experimental set-up with a small-size (50×50 cm^2, 2 mm thick) RPC was built in order to carry out direct measurements with several $C_3H_2F_4$-based gas mixtures and the addition of various gases to optimize the performance in terms of efficiency, streamer probability and cluster size. In parallel, simulation studies were carried out using an iterative method to unfold the electron swarm parameters of $C_3H_2F_4$ and obtain its electron collision cross sections.

Promising gas mixtures with low environmental impact will be presented, along with a systematic study of the behaviour of $C_3H_2F_4$-based gas mixtures performed by varying separately the fraction of each gas in the mixture. Preliminary results regarding the simulation of RPC efficiency with $C_3H_2F_4$-based gas mixtures will also be discussed.

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