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Advancing RPC Detectors with Alternative Eco-Friendly Gas Mixtures and Recuperation systems

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Resistive Plate Chamber (RPC) detectors, employed in the muon systems of CERN LHC experiments, are operated with gas mixtures containing C2H2F4 (R-134a) and SF6, both greenhouse gases (GHGs) with a high global warming potential (GWP). Among strategies developed by CERN Gas Team to reduce GHG emissions, one branch is focused on studying alternative gas mixtures and one on recuperating gases from gas mixtures used in the detectors. Firstly, R-1234ze is investigated as a potential replacement for R-134a, with additional tests exploring the necessity of a fourth gas to maintain the same working point range as R-134a based gas mixture. The performance of RPCs with R-1234ze was evaluated at different gamma rates in the presence of a muon beam at the CERN GIF++ facility by measuring efficiency, streamer probability, induced charge, cluster size, and time resolution. Secondly, adding CO2 to the standard gas mixture is studied as a mid-term solution to reduce R-134a usage and decrease CO2-equivalent emissions by 15-20%. These gas mixtures were characterized using muon beams and gamma background at the GIF++ facility, and an aging test is planned with the collaboration of EP-DT Gas team, ATLAS, and CMS RPC teams. This mid-term solution is particularly relevant to the ATLAS RPC system, as its leak rate disallows the use of a recuperation system. The third strategy involves the development of an R-134a recuperation system for the standard gas mixture, with a prototype tested in 2020-2021 and a production version under operation at CMS. This recuperation system separates and recuperates R-134a from the standard gas mixture with an efficiency of approximately 80%, allowing the recovered gas to be reused and injected into the system.

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