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Towards Sustainable RPC Detectors: Exploring CO2-Based Gas Mixtures for CERN LHC Experiments

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Resistive Plate Chamber detectors at the CERN LHC experiments use a Freon-based gas mixture containing R-134a and SF6, high global warming potential greenhouse gases. To minimise greenhouse gas emissions and expenses and optimise RPC performance, it is crucial to research new environmentally friendly gas mixtures. Thus, according to CERN's environmental strategies and European regulations, this study aims to understand the properties of adding CO2 to the standard gas mixtures as a medium-term solution to reduce greenhouse gas emissions. The gas mixtures tested were chosen to be compatible with the current CERN RPC systems. Detector performance, operational costs, and emissions are key characteristics considered in this research, focused on the potential use of CO2-based gas mixtures in the ATLAS RPC system during LHC Run 3.
This research is conducted at the CERN Gamma Irradiation Facility, where a 12 TBq 137Cs source and a muon beam allow emulating the background radiation experienced in the LHC experiment. The setup consists of five, 2 mm single-gap HPL RPCs located on three different positions, placed respectively outside the irradiation bunker, at 5m and 12m from the gamma source.

The detectors inside the bunker are continuously irradiated for long-term performance studies, aiming to reach the integrated charge expected for ATLAS RPC detectors in LHC Run 3 and for the future High Luminosity LHC phase. Monitoring is performed with various metrics: gas analysis, oxygen, humidity, dose, environmental parameters, and flow measurements to ensure the correct operation of the gas system. Throughout the study, three test beam periods are used to evaluate the muon performance parameters for the targeted gas mixtures: efficiency, current, streamer probability, mean prompt charge, cluster size, and time resolution.
Preliminary results using 30% CO2 will be presented, showing performances closely aligned with the Standard Gas Mixture. In addition to long-term studies, muon beam performance with higher amounts of CO2 in the mixture, aimed at further reducing the consumption of R-134a, will be presented. Furthermore, an investigation into SF6 reduction is conducted to further decrease the mixture's GWP.

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