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Gas mixture quality studies for the CMS RPC detectors during LHC Run 2

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Resistive Plate Chamber (RPC) detectors are widely employed in the muon trigger systems of three experiments at the CERN Large Hadron Collider (LHC). They are operated with gas mixture recirculation systems to reduce operational costs and greenhouse gas emissions since their gas mixture is based on C2H2F4, which has a high global warning potential. It is well known that the C2H2F4 molecule can breaks under the effect of radiation and electric field. This leads to the creation of several impurities and free fluoride ions (F-), which could accumulate under gas recirculation and potentially attach to the RPC surface. For these reasons, an extensive gas analysis campaign has been performed during LHC Run 2 for the CMS RPC system to verify the gas mixture quality and possible accumulation of impurities.

During all LHC Run 2, a gas chromatograph has been used to analyze the RPC gas mixture in different points of the gas system: quality of pure C2H2F4, fresh gas from the mixer, gas at the output of the detectors and after the purifier module. Several impurities have been found and identified. Few impurities are already present in the C2H2F4 bottle, as residual of the industrial production of this refrigerant. Nevertheless, it was found out that some of these impurities as well as others, are created inside the detector gas gap due to the fragmentation of the C2H2F4 molecule under the effects of electric field and radiation.
During 2018 LHC Run several gas analysis points were added to measure the fluoride ions production in different sector of the RPC detector system. Indeed the products of the C2H2F4 fragmentation do not always recombine and F- species can stay free in the gas mixture. F- analysis were performed on the gas at the output of the detectors both for barrel and endcap regions, where radiation levels and operational conditions were different. In this way it was possible to correlate the F- production with integrated charge and gas mixture. In parallel, the RPC currents have been constantly monitored to look for possible correlations.
Fluoride measurements have also been performed at GIF++ to better understand the correlation between F- production, radiation levels and gas volume exchanges.

A comprehensive overview of the results obtained from the different types of gas analyses and possible correlation with RPC currents and LHC luminosity will be presented.

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