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Gas mixture quality monitoring for the RPC detectors at the LHC experiments

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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) thanks to their excellent time resolution. The LHC RPC systems are operated under gas recirculation to reduce operation cost and greenhouse gas emissions since their gas mixture is based on C2H2F4, which has a high global warning potential. Extensive gas analysis campaigns have been performed during LHC Run 2 for the CMS RPC and ALICE Muon Trigger (MTR) systems to verify the gas mixture quality and possible accumulation of impurities.

A particular attention has been addressed to the ALICE MTR system, which has been operated under gas recirculation from the end of 2015. In order to validate the system ensuring good detector operation, the gas recirculation has been increased in steps: 30%, 60% and 70%. Detector currents and gas mixture quality have been closely monitored.

A gas chromatograph and mass spectrometer (GC/MS) station has been installed to analyze the MTR gas mixture in different points of the gas system: fresh gas from the mixer, detectors output and output of the purifier module. Several impurities have been found and identified. Most of the impurities are created inside the detector gas gap due to the fragmentation of the C2H2F4 molecule under the effects of electric field and radiation. The GC/MS analyses have been regularly performed in 2016 and 2017. It has been demonstrated that impurities concentration (at the level of tens of ppm) increases with the increase of the gas recirculation fraction. GC/MS analyses have been also performed after the purifier module showing that some impurities are filtered while others not. In parallel, the RPC currents have been constantly monitored, and their trend showed no correlation with the gas recirculation fraction.

In 2017 an Ion Selective Electrode station was installed to measure the fluoride (F-) concentration in the MTR RPC gas mixture. Indeed the products of the C2H2F4 fragmentation not always recombine and F- species can stay free in the gas mixture. The analyses show that F- are present in the mixture exiting the RPCs and their concentration increases with the increase of luminosity, even if it stays at the level of ppb per day.

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.

Authors: MANDELLI, Beatrice (CERN); GUIDA, Roberto (CERN)

Co-authors: GAGLIARDI, Martino (Universita e INFN Torino (IT)); MARCHISONE, Massimiliano (Universite Claude Bernard Lyon I (FR))

Presenter: MANDELLI, Beatrice (CERN)

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