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Gas mixture monitoring techniques for the LHC Detector Muon Systems

At the LHC experiments the Muon Systems are equipped with different types of gaseous detectors that will need to assure high performance (tracking, trigger, etc.) until the end of the LHC run periods (beyond 2035). One of the key parameters for good and safe long-term detector operation is the gas mixture composition and quality. Indeed a wrong gas mixture composition can decrease the detector performance or cause aging effects and irremediable damages. It is therefore a fundamental requirement to verify and monitor the detector gas mixture quality. The present contribution summarizes the different gas analysis techniques adopted at CERN for monitoring the detector gas mixture composition as well as the impact of gas quality on detector performance.

In the last years several gas monitoring techniques have been studied and developed to achieve a high-level performance and automation in the detector gas analysis. In all LHC experiments, a gas analysis module allows continuous monitoring of O2 and H2O concentrations in several zones of the gas systems for all muon detectors. Infrared-analyzers are employed to monitor well-defined gases in several gas mixtures.

More sophisticated and precise gas analyses for detectors are performed with gas chromatograph and mass spectrometer devices, which have a sensitivity at the level of ppm. These devices are usually employed to verify the correctness of the gas mixture composition, the nitrogen contamination as well as to study new impurities created under radiation. In this context, a dedicated study has been conducted on the ALICE Muon Trigger system where for the first time in an experiment, molecules fragmentation and fluorine-species caused by radiation effects have been detected and identified. Furthermore an analysis station based on a gas chromatograph has been installed in the CMS experiment and it allows analyzing automatically up to 48 gas streams coming from different detectors and several regions of the experiment subjected to different level of radiation.

In parallel to standard gas analysis techniques, a gas monitoring system based on single wire proportional counter (SWPC) has been implemented and it is nowadays in use in one experiment. Thanks to the large drift volume, the SWPC gain is very sensitive to any change of gas mixture composition, pollutants or outgassing material. SWPCs are therefore very suitable to detect and prevent possible aging contaminants in the large LHC detector systems.

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