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Aging and outgassing studies for GEM detectors in the LHC high-rate environment

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Gaseous detectors potentially show degradation of their performances with time, mostly due to the deposition of polymers created in the plasmas surrounding the amplification region. This "classical aging"depends on many and various parameters such as the flux of particles, charge density in the amplification structure, gas composition with possible pollutants, gas flow rate as well as the physical and chemical properties of the plasma and the geometry of the detector itself. For these reasons it is not possible to produce reliable models simulating the aging process. The accelerated aging under laboratory conditions, i.e. realistic conditions of operation and assuming large safety factors, is thus the most appropriate way to measure the longevity of gaseous detectors. To test the latest generation of GEM prototypes, using the final materials, the final geometry and a gas mixture of Ar/CO2/CF4 (45:15:40%), was kept under heavy radiation for 12 months at CERN's Gamma Irradiation Facility (GIF) to accumulate a total charge of 11 mC/cm2. This dose corresponds to the duration of a Slice Test, in which GEM detectors installed in the CMS experiment will be operational. No aging effects were observed and the chamber is now under test at the new irradiation facility GIF++ to extend the total accumulated dose and reproduce 20 years of real operation in CMS including a second CF4-free gas mixture of Ar/CO2 (70:30%). To complement the classical aging tests each type of detector material is tested for its outgassing behaviour to identify the materials that can possibly release pollutants in the gas mixture and trigger polymerization processes in the GEM layers. Each material was separately flushed with a gas mixture of Ar/CO2/CF4 (45:15:40%) sent to Single Wire Proportional Counters (SWPCs). The SWPCs are preferred to identify outgassing since the full detection process is based on the integrity of microscopic wire that establishes the amplification electric field and collects the readout signal. Even a small amount of polluting species may affect the gas properties or produce polymer deposits on the anode wire and cause fast and significant damages to the chambers. Many different materials were tested, some identified as not useable and thus replaced with an alternative. Once all the materials are tested and approved, the CMS GEM Collaboration will propose a set of recommendations to assemble and operate MPGDs for high rate experiments.

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