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High-Voltage studies for the new GE1/1 GEM Station in the CMS Experiment

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The contribution will concern the analysis of data provided by Gas Electron Multiplier (GEM) detectors already installed in the Compact Muon Solenoid (CMS) experiment. We will focus on the correlations among the baseline current observed in the High Voltage (HV) system, the background radiation, and the Large Hadron Collider (LHC) beam luminosity. Additionally, an update on the discharge rates observed during this year's operations will be provided.

Summary (500 words)

Part of the muon upgrade of the CMS experiment for the High-Luminosity Large Hadron Collider (HL-LHC) consists of three new GEM stations, GE1/1, GE2/1 and ME0. The purpose of these stations is to increase the redundancy of the CMS muon spectrometer in the forward endcap regions and to extend the acceptance of the detector up to a pseudo-rapidity |η|˜2.8 with the ME0 station. To achieve this result, these detectors must be able to withstand the background radiation of the installation environment, both in terms of rate capability, up to 150 kHz/cmˆ2, and radiation hardness, up to an accumulated charge of 8 C/cmˆ2. The first station, GE1/1, was installed during the Long Shutdown 2 (LS2). Since the start of Run 3 in 2022, GE1/1 has been active in CMS operations and data acquisition; this will be the focus of the contribution.

A CMS triple GEM chamber detects muons by avalanche multiplication of their primary ionization with a gain of about 10ˆ4. The multiplication is achieved in three steps by a corresponding number of GEM foils. The total high voltage required for the whole stack is about 3.5 kV. The presence of high radiation in the area where the detector operates is a challenge for the HV system, since a large charge has to be handled without reducing the effective gain of the detector. This phenomenon leads to a drop in the effective voltage applied and therefore voltage compensation must be applied to have a stable gain.

We quantify this effect by measuring the currents flowing in the HV system and comparing them with the observed particle hit rate measured in the same chamber, as a function of LHC beam luminosity. This study, based on results provided by detectors already installed in CMS, will help to develop a compensation strategy for the GE1/1 station and to support the development and to highlight the operational needs of the next two stations to be built, ME0 and GE2/1. The compensation is particularly important in ME0, where the particle flux is highest.

The second manifestation of background radiation is the observation of discharges, seen as current spikes in the HV power supply. It is observed indeed that the rate of discharges in the detectors increases with the luminosity of the LHC beam, and hence the background radiation. The discharges trigger a protective switch-off of HV for a detector, disabling its amplification and thus its ability to detect muons. The study of discharges is then important to maintain the stability of the detectors. An update on the discharge rate observed in 2024 will be given and compared with rates from previous years (e.g. 1 discharge per hour per chamber at the end of 2022).

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