Discharge probability measurement of the GEM detector for the CBM Muon Chamber

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Introduction

The Compressed Baryonic Matter (CBM) experiment at the future Facility for Antiproton and Ion Research (FAIR) in Darmstadt, Germany will use proton and heavy ion beams to study matter at extreme conditions [1, 2]. The CBM experiment at FAIR is designed to explore the QCD phase diagram in the region of high baryon densities. With CBM we will enter a new era of nuclear matter research by measuring rare diagnostic probes never observed before at FAIR energies, and thus CBM has a unique discovery potential. This will only be possible with the application of advanced instrumentation, including highly segmented and fast gaseous detectors.

Experimental details

Gas Electron multipliers (GEM) detector will be used in CBM Muon Chamber (MUCH) located downstream of the Silicon Tracking System (STS) of the CBM experiment along with other sophisticated detectors [3]. The stability of the detectors needs to be tested. In a dedicated test beam double mask triple GEM detectors of 10 cm × 10 cm area have been tested at CERN SPS/H4. The drift gap, the two transfer gaps and the induction gap were kept at 2 mm. The read-out plane consist of 256 pads of $6{\times}6$ mm^2 size. All the readout pads were routed to two connectors of 128 pins each. Even though the readout was segmented for the chamber, in this study the signals obtained from all pads were fed into a single channel charge sensitive preamplifier and analysed with PXI LabVIEW based data acquisition system [4]. During the entire beam time the detector was operated with a premixed counting gas mixture of Argon and CO_2 in 70/30 ratio. The operating potentials to the GEMs was applied by a seven-channel HVG210 power supply made by LNF-INFN [5]. This module allows for controlling the supply voltages of a triple GEM detector. The module communicates with peripherals via CAN bus. The HVG210 power supply comprises seven almost identical channels, each of them being able to produce a specified voltage level with a current reading and current limiting option. The currents of all channels were recorded and used to determine the occurrence of a discharge. In this study pion beam of $\sim$ 150 GeV/c has been used. The stability of the triple GEM detector setup in an environment of high energetic showers is studied. To this end the spark probability in a shower environment is compared to the spark probability in a pion beam.

The spark probability or the discharge probability is defined as the ratio of the total number of sparks produced in the GEM detector to the total number of particles incident on the detector [6, 7]. In this measurement, two different methods to identify the presence of a spark in the GEM-detector were used. The first one identifies a spark through the absence of a signal. The second method identifies the presence of a spark through an enhancement of operating currents. Both these methods were experimentally executed in two different ways: Absence of signal was identified through a drop in the count rate on one side and the absence of signals in the pulse height analysing

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ADC. The second method through observation of operating currents can identify a spark either through a jump in a particular current or through an internal "spark counter" of the power supply.

Results

The determined spark probability as a function of the global GEM voltage ($\Delta V_1 + \Delta V_2 + \Delta V_3$), the sum of the potential differences of every GEM in the stack, is shown in FIG. 1 (cf. [8]). The measurement was taken with different gas flow rates, 3 lt/hr and 5 lt/hr. In earlier measurements it had been observed that the gain of the detector depended upon the gas flow rate [9]. In this operational global voltage range the gain of the detector was measured to vary between 20000 and 50000. In this figure the spark probability is determined through the first method only i.e. from the drop in the GEM count rate during a spill. In this study the overall spark probability was found to be $\sim 10^{-7}$. The probable reason for this high absolute value is the operation of the GEM-detector at very high gain [10, 11]. Two different measurements i.e. a jump in the current and a drop in the counting rate yield almost identical results. During off-spill the spark probability was practically zero. The discharge probability during operation of the GEM detector in showers does not increase if compared to the operation in a pure pion beam. Thus, in such a relative measurement, relating the susceptibility to sparks in a shower environment to the spark probability in a pion beam, the overall spark probability that may depend upon the experimental particularities, is not that relevant. The showers apparently really do put some load on the GEM-detector as it is found in FLUKA simulation [12, 13]. This can be confirmed through the higher electrode currents in the stack during a shower. Yet, the spark probability is not compromised through these heavy, highly ionising showers. The value of the spark probability obtained in this beam test is a bit too high for the operation of the CBM muon chambers. As an outlook, the measurement will be repeated with 3 mm drift gap and without a current limiting protection resistor at the bottom of the GEMs in future. The effects will be studied and will be communicated at a later stage.

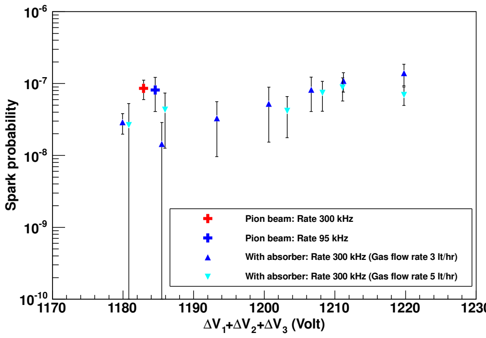

FIG. 1: Spark Probability as a function of global GEM voltage.

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