Discharge probability studies with GEM detectors *

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GEM (Gas Electron Multiplier) [1] foils are commonly known structures used as proportional counters, which permits to obtain high gains at very high radiation rates. However, highly ionizing particles, which may be produced during heavy ion collisions, may trigger an electrical breakdown which may result in damage of the foils or readout electronics. The key parameter for a long-term operation of the GEM-based detectors for high-intensity beams is the stability against electrical discharges. We have successfully started a dedicated discharge probability studies with multi GEM structures in various gas mixtures to find operational conditions for these type of detectors.

The scheme of experimental setup used for discharge probability studies is shown in Fig. 1. The detector housing contains a GEM stack positioned between a drift cathode and a read-out anode. It is equipped with HV feedthroughs for up to 4 GEM foils. The cathode is made out of a PCB covered with copper layer on one side, where the high potential is applied. Charged particles traversing active area of the detector are ionising gas creating electron-ion pairs. Electrons from the primary ionisation are drifting towards the GEM stack, where the charge amplification occurs. High voltage is applied to the GEM stack via a resistor chain which specifies potential differences across each GEM foil and the values of transfer (E_{T1}, E_{T2}) and induction (E_{IND}) fields. After the amplification process a signal is induced on a single-pad anode plate and then can be processed in different ways, indicated by different readout branches in Fig. 1. Branch a) is for energy spectra and rate measurements. The information about the rate of the primary ionisation together with measurement of the current induced at the anode (branch b) is used to calculate the effective gain of the detector. Branch c) processes raw signals induced on the readout anode and is used to determine number of discharges which occur during the detector operation. The principle of operation is based on fact that signals induced by sparks are by orders of magnitude higher than signals induced by the primary ionisation.

The discharge probability is defined as a ratio of number of detected discharges over the total number of particles irradiating the detector. For our studies the detector is irradiated with highly ionising, 5.59 MeV α particles emitted with a rate of ~0.5 Hz from gaseous ^{222}Rn source randomly distributed within active area of the detector.

So far, the only comprehensive discharge studies in the

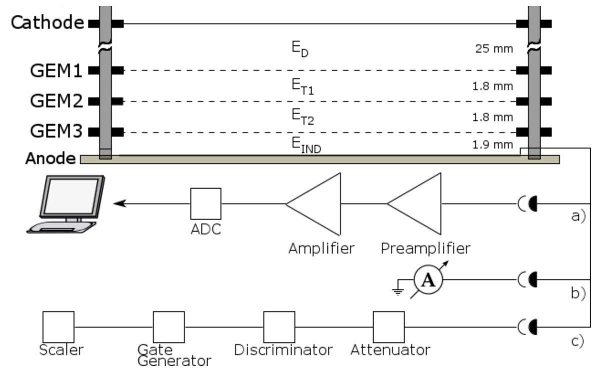

Figure 1: Experimental setup.

Gas Electron Multiplier were reported in [2] and concerns mainly Ar-based gas mixtures. With our setup we performed a set of measurements in a quencher-rich mixture Ar-CO_2 (70-30). Preliminary results are shown in Fig. 2 for a triple GEM irradiated, at high gains of $\mathcal{O}(10^4\text{-}10^5)$, and compared with data from [2] obtained with the same gas mixture under similar conditions. Our results are in good agreement with the published data.

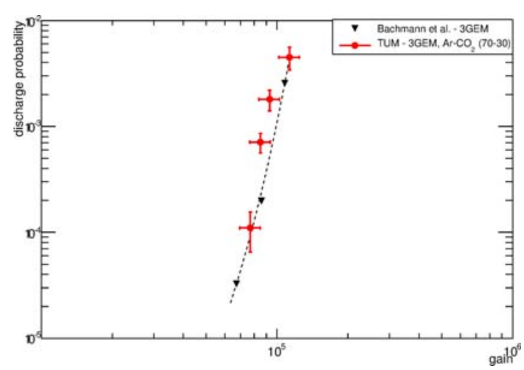

Figure 2: Discharge probability in Ar-CO_2 (70-30).

After the successful commissioning of the setup we are planning a long campaign of discharge probability studies involving measurements in various gas mixtures, employing multi-GEM structures (triple, quadruple), using standard as well as exotic GEM geometries.

References

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