Measuring the stability of GEM detectors against electrical discharges *

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The requirements of a new generation of experiments in particle and nuclear physics are driving the development of new gaseous detectors. Novel devices must handle the high luminosities planned at future hadron and electron colliders as well as meet the requirements of large experiments such as the substantial active areas to be covered by their detectors. Among the new innovative detector techniques, the Gas Electron Multiplier (GEM) [1] is foreseen to be widely used in future large-area detectors.

The key parameters for a long-term operation of such detectors in a harsh environment of high- rate experiments are: radiation hardness, ageing resistance and stability against discharges. So far, the only comprehensive discharge studies in the gas electron multiplier were reported in [2] and concern mainly Ar-based gas mixtures. We performed discharge probability studies in single, triple and quadruple GEM structures in Ne- and Ar-based gas mixtures. In this report we present the results obtained with a triple-GEM setup performed in a Ne-CO_2 (90-10) gas mixture with and without additional 5% of nitrogen.

The scheme of the experimental setup used for discharge probability studies is shown in Fig. 1. The detector housing of the setup comprises a $10\times10\,\mathrm{cm}^2$ GEM holder, a drift cathode and a readout anode.

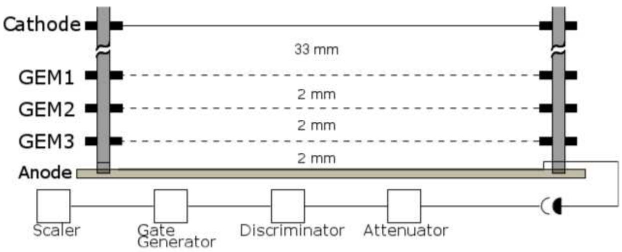

Figure 1: Experimental setup.

High voltage is applied to the GEM stack via a resistor chain which defines potential on each GEM electrode. The detector is operated with the "standard" HV settings that are commonly used with triple GEM structures, scaled in order to vary the total gain. The gain of the setup at given HV settings is determined by the usual method of recording the current at the pad plane and the rate of absorbed X-rays of known energy (an ^{55}Fe is used).

The occurrence of a spark in a GEM foil is detected according to the readout scheme presented in fig. 1. A raw signal induced on the pad plane is attenuated (1-31 dB) and then directed into the discriminator unit which filters out signals induced by alpha particles of $\mathcal{O}(100\,\mathrm{mV})$ and trigger on discharge signals of $\mathcal{O}(10\,\mathrm{V})$. Due to the fact that the raw signals are often modified by the noise (signal oscillations) a gate is created when the discriminator threshold is exceeded which is then counted by a scaler. This way, multi-counting of the same signal can be avoided.

The discharge probability is defined as the ratio of the number of detected discharges over the total number of particles irradiating the detector. For the studies presented in this report, the detector was irradiated with highly ionising, 6.4 MeV α particles emitted with a rate of $\sim$0.5 Hz from an internal, gaseous ^{222}Rn source randomly distributed within the active area of the detector.

Figure 2 shows the results of a gain scan for two different Ne-based gas mixtures. The measurements are performed at high gas gains to acquire a sufficient number of sparks with the low-rate ^{220}Rn source. Clearly, the addition of N_2 to the gas mixture has a noticeable effect on the discharge behaviour. The discharge probability observed in Ne-CO_2-N_2 (90-10-5) is one order of magnitude lower than in Ne-CO_2 (90-10). The addition of nitrogen to the Ne-CO_2 mixture alleviates the instability issue. Nitrogen provides better quenching for neon and allows for higher fields without amplification in transfer and induction gaps.

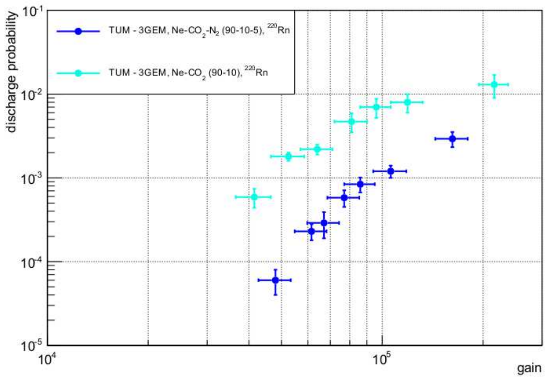

Figure 2: Discharge probability in Ne-based mixtures.

References

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