Ion backflow studies with a triple GEM detector*

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Time Projection Chambers (TPCs) are usually equipped with a gating structure to prevent the migration of avalanche ions created during gas amplification – traditionally realized with Multi Wire Proportional Chambers (MWPCs) – in order to maintain drift field homogeneity. This, however, limits the application of TPCs to experiments with trigger rates smaller than $\mathcal{O}(10^3\,\mathrm{Hz})$. To overcome this important limitation introduced by gating techniques, one has to find other means of ion suppression. One promising alternative is to employ a TPC with Gas Electron Multiplier (GEM) [1] instead of MWPC. A first GEM TPC prototype [2, 3] has been succesfully built and operated in FOPI at the GSI, Darmstadt.

For a GEM-TPC in a high rate environment it is mandatory to minimize the ion backflow ($\mathbb{IB}$) as a prerequisite for minimal space charge distortions that allows the maintainance of the excellent TPC performance. The GEM technology has been established in the last decade as a robust and well proven amplification technique for gaseous detectors with an excellent detector performance. The usage of GEM detectors in a high rate TPC, however, is new with regard to several aspects. Many conflicting requirements such as a low ion backflow, good point and energy resolution, low discharge probability as well as stable long term behavior have to be optimized. The challenge is not to find an optimal working point for only one of these parameters, but to define a working point that satifies all requirements within an acceptable limit. In the following only results on ion backflow will be shown. For studies concerning the discharge probability I refer to [4].

Our setup consists of a triple GEM setup. We are using 10×10 cm^2 GEM foils with a pitch of 140 μm, an outer hole diameter of 70 μm, and an inner hole diameter of 50 μm. The effective gain of the system has been kept at 2000 for all measurement. As gas we were using Ne-CO_2-N_2 in the ratio 90-10-5. Neon is advantageous over argon as it has an ion mobility that is 2.5 times higher. As the space charge density is anti-proportional to the ion drift velocity, the higher ion mobility results in a lower space charge density. Figure 1 shows the ion backflow as a function of the first transfer field E_{T1} for several values of the second transfer field E_{T2}. A clear decrease of the ion backflow as

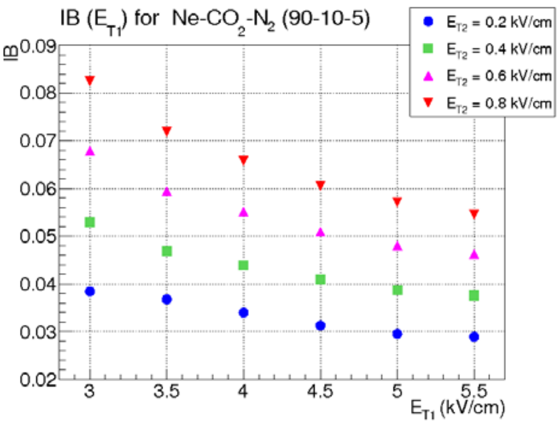

Figure 1: Ion backflow in a triple GEM detector as a function of E_{T1} for several values of E_{T2}.

a function of E_{T1} is visible due to the higher extraction of electrons out of GEM1 and higher ion blocking efficiency of GEM1 top and bottom electrode. The minimal $\mathbb{IB}$ value achieved is about 3 % for an E_{T1} of 5.5 kV/cm and an E_{T2} of 0.2 kV/cm. For a gain of about 2000 this results in a number of back-drifting electrons coming from the amplification system (ε) of about 60 per incoming ion. Present high rate experiments require a much smaller number that is in the order of $\varepsilon \sim 20$.

Future R&D activities will investigate quadruple GEM systems, which is a very promising solution including alternative GEM geometries such as large and small pitch foils. Furthermore Cobra GEMs or a combination of two GEMs and a Micromega might be an interesting options.

References

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