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Numerical Studies on Time Resolution of Micro-Pattern Gaseous Detectors

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Owing to the use of typical manufacturing techniques for microelectronics, the new genre of Micro-Pattern Gaseous Detectors (MPGDs) with high granularity and very small distances between the electrodes can offer high spatial and time resolutions and good counting rate capability. The requirement of fast collection of data in various applications of the MPGDs has necessitated a thorough optimization of their time resolution through the modification of their design parameters and choice of gas mixture. In this context, the study of the time resolution of these detectors and their dependence on various parameters turns out to be an interesting aspect of MPGD development for many of the current and future applications. For this purpose, an attempt has been made to establish an algorithm for estimating the time resolution of an MPGD. In the present work, a numerical simulation of the time resolution of a few MPGDs, computed following the said algorithm, is reported.

The time resolution of a detector can be defined as the precision with which the detector can distinguish between two overlapping events in terms of time. The time resolution depends on the transit of the electrons from their generation point to the collecting electrode. The spread on the duration of transit leads to a finite time resolution of the detector. The two factors that contribute to the spread are the statistics and distribution of the primary electrons and their diffusion in the gas medium. The resolution has been estimated numerically on the basis of these two aspects while ignoring the electron multiplication. A threshold limit of detecting the signal has been considered which is related to the gain variance of a detector. The cosmic muons at different inclination angles have been used as the event generator.

In this work, a comprehensive study on the dependence of time resolution on detector design parameters and field configuration, has been made for a few MPGDs. In addition, the effect of variation in the relative proportions of gas components in the gas mixture has been investigated. Two examples of these results are presented in figures 1 and 2 as calculated for a bulk Micromegas and a triple-GEM, respectively.

Several measurements on the time resolution of triple-GEM based prototype for muon endcap upgrade of CMS are available from the CMS GEM collaboration [1]. The simulated results have been compared with these references and the agreement with the experiment is very encouraging.

The present work aims to accomplish a comprehensive characterization of the time resolution of the MPGDs on the basis of numerical as well as experimental measurements. In addition to further improvement in the numerical work, development of a test bench for studying the MPGDs individually for their characteristic time resolution and its dependence on the design parameters and gas compositions has been planned.

[1] CMS Technical Design Report For The Muon Endcap GEM Upgrade

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