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Fast Timing Micro-Pattern Gaseous Detector for PET-TOF and Future Colliders applications

Today, the newly developed micro-structure technology opens the possibility to realize a new generation of gaseous detectors. Research focused in particular on the radiation induced processes leading to discharge breakdown, and led to the development of a family of more resistant devices with similar performance named Micro-Pattern Gas Detectors (MPGDs). The main features of the MPGDs are: flexible geometry; high rate capability (> 50MHz/cm^2); excellent spatial resolution (down to 50um); good time resolution (down to 3ns); reduced radiation length. Recently a detector layout has been proposed that would combine both the high spatial resolution (100um) and high rate capability (100MHz/cm^2) of the current state-of-the-art MPGDs with a high time resolution of 100ps. This contribution introduces a new type of MPGD, namely the Fast Timing MPGD (FTM) detector.

The Fast Timing MPGD can potentially reach sub-millimeter spatial resolution and 100 ps time resolution. Such a detector, able to measure photons with excellent time and spatial resolution, will allow the development of an affordable TOF-PET scanner with improved image contrast. This fast timing MPGD will enable at the same time muon tracking, under high radiation, allowing identification of the originating collision vertex at High Energy Physics (HEP) experiments for future colliders. These techniques will be highly recommended to trigger and reconstruct multi-muon signatures as predicted by many extensions of the Standard Model, while distinguishing this signature from background due to muons originating from neighbouring collisions.

The Fast Timing MPGD consists of a stack of several coupled layers where drift and multiplication stages alternate in the structure, yielding a significant improvement in timing properties due to competing ionization processes in the different drift regions. Three FTM prototypes have been developed so far. The first one consisting of two amplification stages made of 50um thick kapton foil, covered on both sides with resistive material. The second one, also with two amplification stages, has a resistive Micromegas-like structure, with multiplication developing in a region delimited by a resistive mesh. The third one consisting of four multiplication stages made of 200um thick PCB covered with resistive material. The structure of these prototypes will be described in detail and the results of the characterization study performed with an X-Ray generator with two different gas mixtures will be presented. First results on rate capability and time resolution based on data collected with cosmic rays and muon/pion test beams will also be presented.

Summary

The design and development of a new detector, combining high time resolution with high spatial resolution, while exploiting the advantages of a reasonable energy resolution will be a boost for the design of affordable TOF-PET systems. The use of a gas detector to instrument on the one hand large areas in a cost-effective way, and with very good spatial resolution, and on the other hand obtaining a very fast signal will be a leap forward in the development of TOF-PET devices, which are also under study to use as dose monitoring in hadron therapy. The increase in image contrast obtained with these detectors will allow for shorter scanning times (lowering the risk for the patient) and better diagnosis of the disease. On the other hand this project will also develop a gas detector with high spatial and time resolution, being cost-effective to instrument large detectors foreseen for future colliders. The development of fast timing is critical to allow for unambiguous assignment of muon tracks to the right collision vertex, amongst hundred of pile-up collisions. This will allow for LHC-like particle reconstruction and identification at much higher background levels. The studies made in this project will pave the way for the development of a new generation of fast front-end electronics for these gaseous detectors.

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