Fast Timing MPGD for PET-TOF and Future Colliders applications

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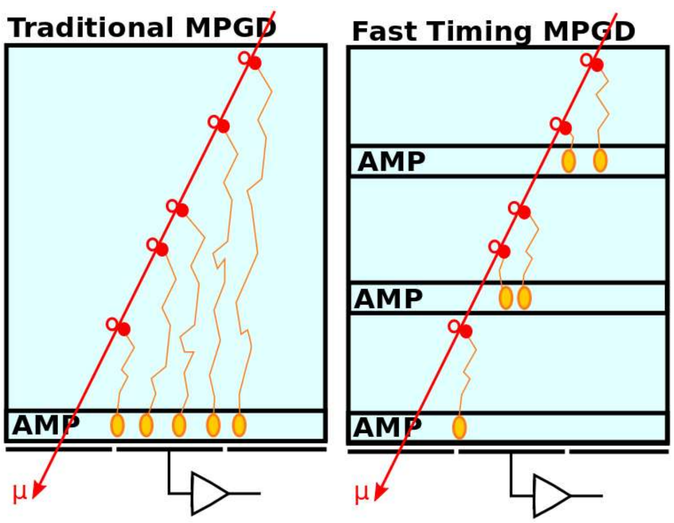
Introduction

The development of a new detector, combining high time resolution with high spatial resolution and rate capability, exploiting the advantages of a reasonable energy resolution, will mskr large TOF-PET systems afordable. The increase of contrast with TOF-PET will result in shorter scanning times and better diagnosis. The development of fast timing detectors will be critical for correct vertex assigment in calorimetry and muon tracking systems at future colliders.

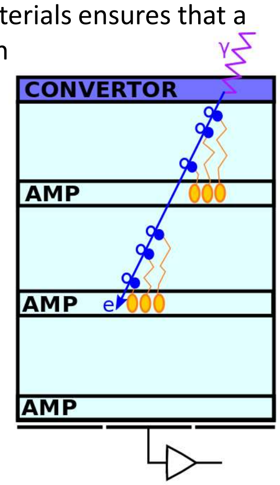
The Idea/Concept

In the past 20 years the development of micro-structure technology led to the birth of the Micro-Pattern Gaseous Detectors (MPGDs), which have high rate capability (> 50 MHz/cm^2), excellent spatial resultion (< 50 um) with time resolution of 5-15 ns for minimum ionising particles. We propose here a new MPGD detector, the Fast Timing MPGD (FTM) that would combine both high spatial resolution (100 um), high rate capability (100 MHz/cm^2) with high timing resolution (100 ps). This detector will be equipped with a suited photon convertor, optimized for 511 keV photons.



Fast Timing MPGD for Minimum Ionising Particles

MPGDs consist typically of a drift region (creation of electron-ion pairs) and a gain region (multiply drifted electrons to an observable signal). The MPGD time resolution is driven by fluctuations in the distance of the closest electron-ion pair to the amplification structure. The FTM principle is to divide the unique drift region in many thinner drift regions, each coupled with an amplification stage. This will reduce the distance fluctuations between the closest electron and the amplification stage, resulting in a faster detector. Constructing such a detector using only resistive materials ensures that a signal in any intermediate amplification layer is induced in the readout strips.



Fast Timing MPGD for 511 keV photons from PET

Introducing thin layers of soda-lime glass inside the detector will enhance the photon detection efficiency. 511 keV photons from PET will mainly interact through Compton scattering, resulting in an electron with energy between 200-400 keV that will ionize the gas. Low energy electrons will have smaller range and will travel less layers, on the other hand they create more electron-ion clusters along their track. Preliminar simulations have shown that for 200-400 keV electrons we can obtain 500ps time resolution, independent of electron energy, with a 4 layer detector.

Potential Impact

There is a need for detectors with high spatial and time resolution that can handle high rates and are cost-effective for instrumenting large areas. Applications are foreseen in TOF-PET, where the field of fiew can be increased drastically and where fast timing results in higher contrast images, and in dose monitoring for hadron therapy. Experiments at future colliders will have to instrument large muon detection systems, with high spatial resolution detectors. Detectors with a fast timing signal will enable unambiguous vertex identification. These detectors will be suited for muon tracking and calorimetry. Further applications are foreseen in non-destructive testing of buildings and large structures.