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R&D on a new type of micropattern gaseous detector: The Fast Timing Micropattern detector

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ABSTRACT

This contribution introduces a new type of Micropattern Gaseous Detector, the Fast Timing Micropattern (FTM) detector, utilizing fully Resistive WELL structures. The structure of the prototype will be described in detail and the results of the characterization study performed with an X-ray gun will be presented, together with the first results on time resolution based on data collected with muon/pion test beams.

1. Introduction

Time resolution of classical Micropattern Gas Detectors (MPGD), like Gas Electron Multiplier (GEM) and Micromegas, is dominated by the fluctuations on the position on the first ionization cluster in the drift gap. The average time needed for the nearest ionization cluster to reach the amplification stage is indeed given by $t = d/\upsilon_d$, where d is the distance of the closest cluster to the first amplification region and follows the distribution $e^{-\lambda x}/x$, where λ is the average number of primary clusters generated by an ionizing particle inside the gas per length; υ_d is the drift velocity, that depends on the gas mixture and the applied drift field. The contribution to the time resolution of the drift velocity is $\sigma_t = (\lambda \upsilon_d)^{-1}$: with a typical drift gap of the order of 3–4 mm and with a proper choice of the gas mixture, MPGDs can reach a time resolution of the order of 5–10 ns. An improvement in the time resolution, to reach the 1 ns scale, can be obtained working on the segmentation of the drift gap: the principle is to divide a single thick drift region in many thinner drift regions, each coupled to its amplification stage. The reduction in time resolution that can be obtained is so proportional to the number of stages N_D employed: $\sigma_t = (\lambda \upsilon_d N_D)^{-1}$. The first prototype of Fast Timing Micropattern (FTM) detector exploits this principle using two 250 μm-thick drift gaps, each coupled with an amplification region composed by a fully resistive WELL. The construction of consecutive drift-amplification stages is allowed by the use of resistive layers to polarize drift and multiplication volumes. The overall structure is then transparent to the signal that can be extracted from every amplification stage.

2. The Fast Timing Micropattern detector

The structure of the first prototype of fast timing micropattern (FTM) detector is described in [1]. It is composed of two independent drift-amplification stages (Fig. 1): each amplification region is based on a pair of polyimide foils, i.e. kapton, stacked due to the electrostatic force induced by the polarization of the foils: the first foil, perforated with inverted truncated-cone-shaped holes (with top base 100 μm and bottom base 70 μm and pitch 140 μm), is a 50 μm thick polyimide foil (Apical) from KANECA, coated with diamond-like carbon (DLC) technique, to reach a specific surface resistance of up to 800 MΩ/□; the second foil is 25 μm thick XC DUPONT KAPTON, with a resistivity of 2 MΩ/□. The drift volumes are 250 μm thick, with planarity ensured by overlay pillars, 400 μm diameter and pitch of 3.3 mm. The active area of the prototype is of the order of 20 cm^2. The induced signal can be picked up from the readout electrode, but also from the drift electrode, through a capacitive coupling.

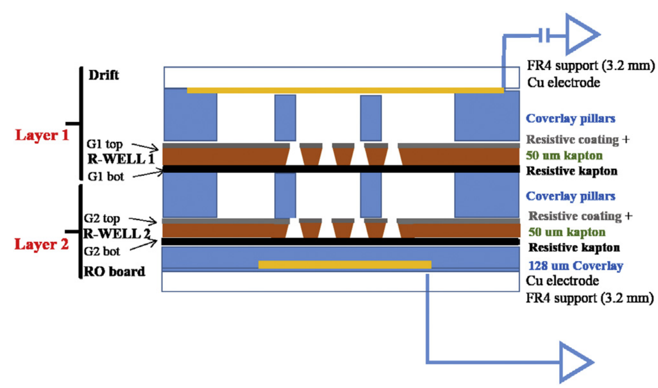

Fig. 1. Transverse view of the first prototype of FTM detector.

3. Characterization with X-rays

The first characterization of the FTM prototype was performed at CERN with a AMPTEK MINI-X X-ray tube, with Ag cathode filament (22 keV X-rays). Examples of signals picked up from the drift and readout electrodes and read out with an electronics chain composed by a preamplifier ORTEC 142PC and an amplifier ORTEC 474, are shown in Fig. 2.

The rate from both the readout and drift electrodes at different values of current from the X-Ray gun, i.e different values of incident flux up to the maximum available from the source, is shown in Fig. 3. The response of the detector, for both the electrodes, is