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**Abstract**

Micropattern Gaseous Detectors (MPGD), like Micromegas or GEM, are used or foreseen in particle physics experiments for which a very good spatial resolution is required. We have developed an experimental method to separate the contribution of the transverse diffusion and the multiplication process by varying the number of primary electrons generated by a point-like source. A pulsed nitrogen laser is focused by an optical set-up on the drift electrode which is made of a thin metal layer deposited on a quartz lamina. The number of primary electrons can be adjusted from a few to several thousands on a spot which transverse size is less than 100 $\mu$m RMS. The detector can be positioned with an accuracy of 1 $\mu$m by a motorized three dimensional system. This method was applied to a small Micromegas detector with a gain set between $10^3$ and $2.10^4$ and an injection of 60 to 2000 photoelectrons. Spatial resolutions as small as 5 $\mu$m were measured with 2000 primary electrons. An estimation of the upper limit of the relative gain variance can be obtained from the measurements.

**Keywords:** MPGD, Micromegas, UV laser, point-like electron source, spatial resolution, energy resolution.

## 1  Introduction

Micro-Pattern Gaseous Detectors (MPGD), like GEM[1] and Micromegas[2], have emerged as very promising tools for future particle physics experiments that require high counting rates, good spatial and time resolution, low $E \times B$ effect, low ion backflow and fast signal. Experimental studies using radioactive sources, like $^{55}Fe$, to characterize detector prototypes have drawbacks like the

variable event-by-event position of the interaction point in the gas and the lack of a time reference. On the other hand, particles beams composed of particles at minimum ionization produce a few tens of electrons per centimeter in the gas thus limiting spatial and energy resolution studies to a limited range of number of primary electrons.

A point-like electron source produced by focusing a laser on a thin metallic surface allows to vary the number of primary electrons in a large range (more than two orders of magnitude) and thus to work at various gains. Moreover, this method provides a time reference and the interaction point of the laser beam can be accurately known. Such a method has been successfully applied to measure the electron drift velocity in various gas mixtures [3].

In this paper, we present the method and its application to evaluate the spatial and energy resolution as a function of the number of electrons with a Micromegas detector. In section 2, the experimental set-up is described in details. Results obtained on spatial and energy resolution are presented in section 3.

## 2 Experimental set-up

The experimental set-up is shown in Fig. 1. A UV laser beam is focused on a thin metallic layer deposited on a quartz lamina. The beam intensity is tuned by means of attenuation laminae made of standard glass. The high density energies obtained allow electron production by multiphotonic process [4]. The drift electrode of the detector is composed of two parts: one is the quartz lamina, used for the photoelectron production, the other is made of a golden mylar, for gain calibration with a $^{55}Fe$ source. The laser is a 337 nm wavelength pulsed Spectra-Physics VSL337, with an output beam size of 3×7 mm, a beam divergence at full angle of 3×8 mrads and an intensity fluctuation of 4% RMS. The beam focusing is optimized by a set of five lenses mounted on a rail fixed on an optical table. The laser output beam is first collimated in a symmetrical beam by two cylindrical lenses. The beam divergence correction is optimised by two more spherical lenses. A 60 mm focal length triplet focuses the beam on the metallic deposit.

The Micromegas detector used in these measurements has an active surface of 44×44 mm$^2$. It is composed of a 3 mm drift gap and a 125 $\mu$m amplification gap, separated by a 500 lpi nickel mesh. The metallic deposit on the quartz lamina is made of a 5 $\mathring{A}$ thick Ni-Cr layer. The mesh is mounted on a kapton spacer. The anode PCB board is divided into 128 gold strips of 338 $\mu$m pitch. The detector was operated with a Ne 90% - iC$_4$H$_{10}$ 10% mixture with gains between $10^3$ and $2.10^4$.

The position and the focusing of the beam can be varied by moving the detector in the three directions of space with 1 $\mu$m precision controlled motors.

The ranges in the X (perpendicular to detector strips) and Y (parallel to the strips) directions are 250 mm, and the one in the Z direction (focusing direction) is 50 mm.

The Micromegas mesh is connected to a voltage amplifier of gain 100 made with two Philips 5205A wide band amplifier integrated circuits. The anode strip readout is achieved by 3 groups of 8 consecutive strips through a daughterboard equipped with 24 amplifiers. The electronic noise is equivalent to 3 primary electrons RMS. It is negligible compared to the number of primary electrons generated in this experiment, which ranges between 60 and 2000. The signals obtained when the laser is focused on the drift electrode are typically induced on three consecutive strips, as shown in Fig. 2. The charge of each signal is measured with a CAMAC QDC. The data acquisition is triggered by the mesh signal.

## 3  Results

The laser is focused on the drift electrode in front of the middle of a strip. Its intensity is changed and the gain subsequently adjusted to have enough amplitude on each strip. From the measured strip charges, the X position is reconstructed by the center of gravity method.

Fig. 3 shows the spatial resolution as a function of $1/\sqrt{N_e}$, where $N_e$ is the number of primary electrons. For high numbers of electrons, the spatial resolution is proportionnal to $1/\sqrt{N_e}$. The origin of the fitted straight line is consistent with a zero spatial resolution for an infinite number of electrons. The slope $t$ of the straight line is interpreted as the contribution of the transverse diffusion $\sigma_d$, the source size $\sigma_s$ and gain fluctuations $f$ following: $t = \sqrt{(1+f)(\sigma_d^2 + \sigma_s^2)}$ [5]. In our experimental conditions, the transverse diffusion value, given by MAGBOLTZ [6] is 201±2 $\mu$m. A maximal value of the $f$ coefficient corresponds to the hypothesis of a perfect point-like source ($\sigma_s = 0$): $f \leq 0.2$. Similarly, the upper limit of the source size, which corresponds to the ideal case of no gain fluctuations ($f=0$) is: $\sigma_s \leq 100$ $\mu$m.

Fig. 4 presents the energy resolution measurements on the total charge induced on three adjacent strips. The energy resolution can be written as: $\sigma_E/E = \sqrt{a^2 + b^2/N_e}$. The value of $a$ (7.9 ± 0.1%) could be explained by the fluctuations of the laser intensity and the photoelectron production process. The value of $b$ (1.17±0.04) is close to 1, indicating that gain fluctuations are small.

Our experimental method provides a small dimension electron source, well localized in space. With the tested Micromegas, the gain fluctuations ($f \leq 0.2$) are much lower than those usually observed with a MWPC where $f$ is around 0.7 [5].

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## 4 Conclusions

An original test-bench using a 337 nm wavelength UV laser together with an optical focusing-system has been settled to study the performance of MPGDs. It produces electrons through multiphotonic effect, in a range of several order of magnitude by focusing the laser beam on a thin metallic layer deposited on a quartz lamina. The obtained electron source is well localized and its transverse dimension is less than 100 $\mu m$ RMS. Spatial and energy resolution studies were performed on a Micromegas type detector, at different gains and different number of primary electrons. An upper limit of 0.2 for the relative gain variance was estimated. In our experimental conditions, results show that the tested Micromegas has gain fluctuations much lower than a standard MWPC.

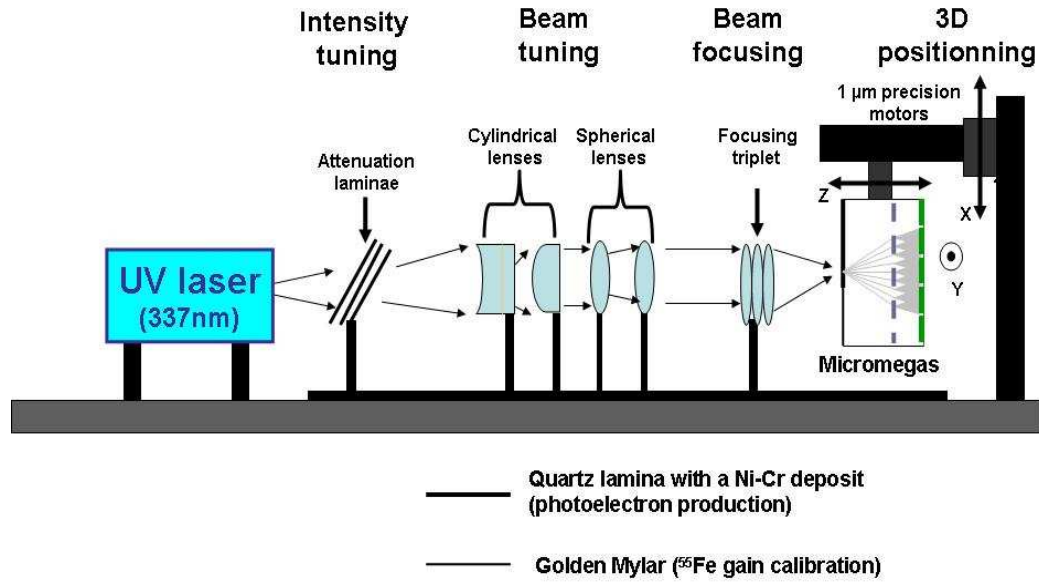## 5 Acknowledgements

# 6   Figures


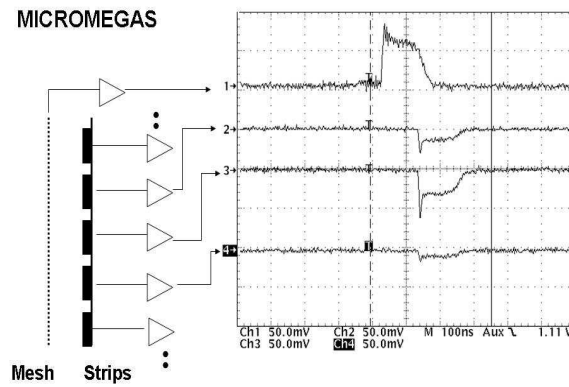
Fig. 1. Experimental set-up.



Fig. 2. Mesh and strips signals. The mesh voltage is 440 V and the primary signal comprises around 1000 electrons. The delay between the strips signals and the mesh signal is due to different cable lengthes.
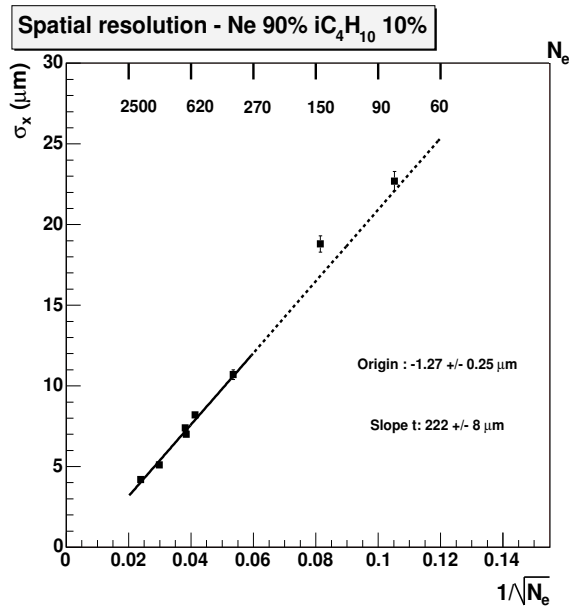
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Fig. 3. Spatial resolution as a function of $1/\sqrt{N_e}$. The continuous line shows the result of a linear fit performed for a number of electrons greater than 300. The dotted line is an extrapolation of the fit for a low number of primary electrons.
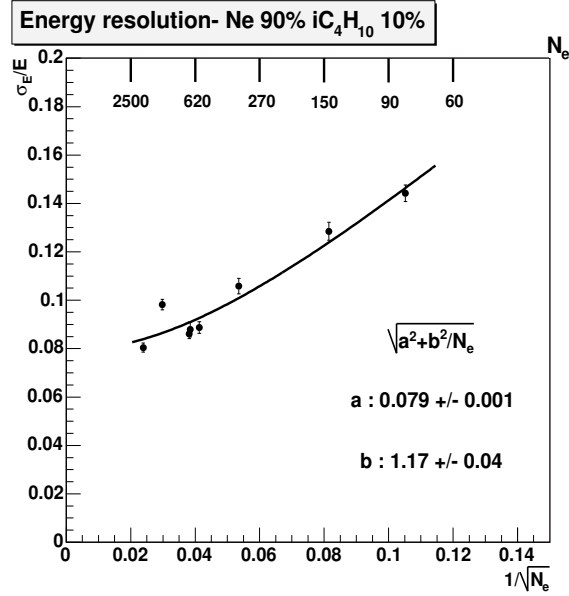


Fig. 4. Energy resolution as a function of $1/\sqrt{N_e}$ measured from the total charge induced on the strips. The continuous line shows a quadratic fit (see text for details).

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