Measurements of Electron Drift Velocity in Isobutane using the Pulsed Townsend Technique

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Abstract. In the present work we report on the preliminary results related to the dependence of the electron drift velocity for isobutane as function of the reduced electric field E/N in the range of 190 Td up to 211 Td. The employed method is based on the Pulsed Townsend technique. In our configuration the anode is of a high resistivity (2.10^{10} □ .m) glass, while the cathode is made of aluminum. In order to validate the technique, the initial measurements were carried out for nitrogen, which is a gas widely studied.

Keywords: Electron drift velocity, nitrogen, isobutane.
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INTRODUCTION

The knowledge of electron transport parameters in a gas is essential for validating collision cross sections and determining the average fractional energy loss. The electron drift velocity is an important swarm parameter used to characterize the conductivity of a gas weakly ionized. In gaseous detectors where temporal information is critical, as in drift chambers and timing resistive plate chambers (RPC), this parameter contributes to determining the quantities involved.

The development of detectors operating at high rate with stability has motivated studies about filling gases with complex structure, as isobutane. This gas is often used in RPCs due to its excellent timing properties [1]. However, few data are available in literature, mainly for high electric fields.

There are different techniques for determining electron drift velocity in a gas and the obtained values depend on the employed experiment [2]. In this work, the method used is based on the Pulsed Townsend technique, which consists of extracting electrons from a metallic cathode by the incidence of a nitrogen laser beam. These electrons are accelerated toward the anode and this movement is responsible for the

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generation of a fast electric signal. Therefore, the drift velocity can be determined by the ratio between the electrodes distance and the electron transit time.

EXPERIMENTAL SETUP

The measurements were carried out with a parallel plate configuration at gas flow regime and atmospheric pressure. The electrodes are enclosed in a stainless steel chamber (Fig.1). The cathode is made of an aluminium plate (40 mm diameter) and the anode is made of glass (3.5 mm thick and 32.5x32.5 mm² area) with high resistivity (2.10^{10} Ω.m). In order to vary the electrodes distance, the cathode is fixed to a linear positioner (L2241-2 HUNTINGTON®) with 2 μm precision.

The primary electrons are liberated from the cathode by the incidence of a nitrogen laser beam (MNL200-LD LTB®) with 700 ps pulse duration, 337.1 nm wavelength and low divergence. In order to accelerate the electrons toward the anode, the glass is polarized in its back by a metallic plate using a 225-30 BERTAN® high voltage supply.

Since the temporal information of the induced signal is important, the amplifier circuit had to hold special features in order to preserve the signal shape. On that account, the amplifier, specially developed and built at the Laboratório de Instrumentação e Física Experimental de Partículas / Portugal [3], is based on BGM1013 integrated circuit of PHILIPS®.

After being amplified, the signals are digitalized and stored in a digital oscilloscope Wavepro 7000 (LECROY®), with 10GS/s sampling rate and 1GHz bandwidth. Once the drift distance and the transit time are known, the drift velocity (W) can be determined for a particular reduced electric field value, E/N (where N is the gas density).

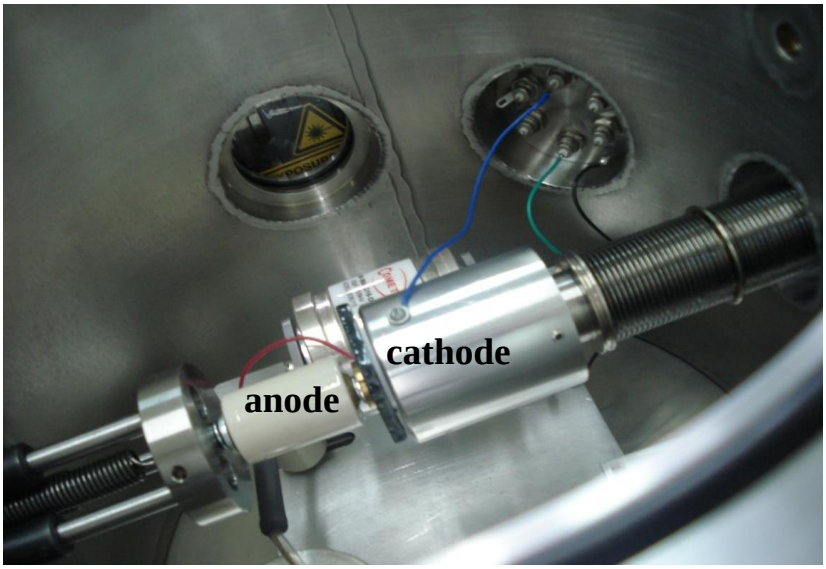

FIGURE 1. Stainless steel chamber.

RESULTS

The measures were initially carried out for nitrogen and later extended to isobutane. In the Fig.2 electric signals obtained for electrodes gaps of 1.50 mm and 1.25 mm in nitrogen are presented. The signal amplitudes are proportional to the gap due to the number of electrons created per path unit.

The electron drift velocity was studied as function of the reduced electric field. Thus, the results obtained were compared with that from Y. Nakamura [5], W. Roznerski and K. Leja [6], H. Hasegawa *et al.* [7] and P. Fonte *et al.* [8], who use different experimental methods (Fig.3). The values determined with Magboltz 2 – version 8.6, which solves numerically the Boltzmann transport equation, are also presented in Fig.3.

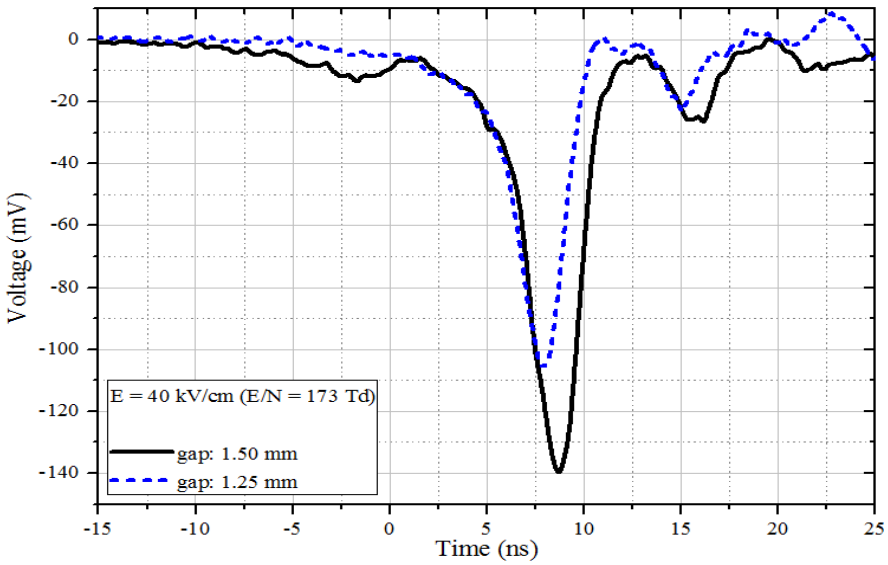

FIGURE 2. Comparison of electric signals for different gaps in nitrogen.

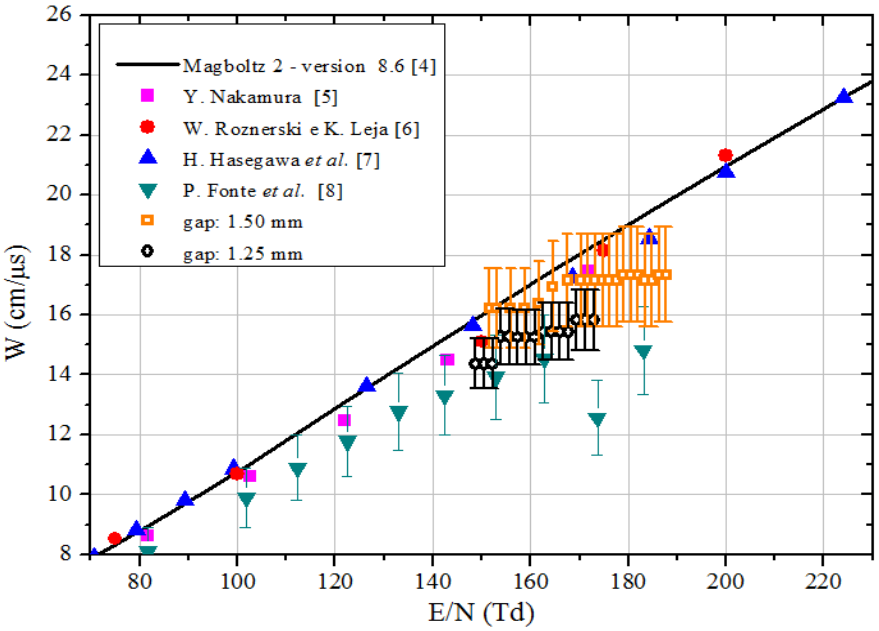

FIGURE 3. Electron drift velocity as function of the reduced electric field for nitrogen.

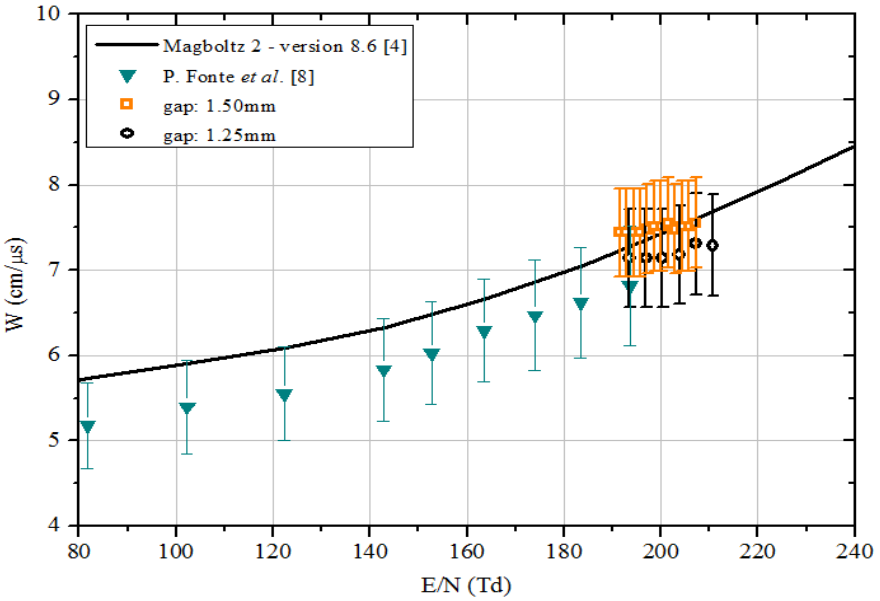

FIGURE 4. Drift velocity as function of the reduced electric field for isobutane.

Since the measurements with nitrogen showed a good agreement with the published data, the technique was extended to isobutane. The results are presented in Fig.4 along with earlier data obtained by the group.

CONCLUSIONS

For the E/N range under study, the results for nitrogen demonstrated good agreement with the literature data and with Magboltz 2 – version 8.6 values, which allowed employing the technique for isobutane safely. The obtained results of electron drift velocity in isobutane also agree with data earlier obtained by the research group. Although the satisfactory behavior, the experimental setup will be modified in order to achieve higher electric fields.

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