Drift chamber for the registration of strongly ionizing particles

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We investigate a drift chamber filled with the mixture He^4+CO_2 or He^4+CH_4, intended for the registration of strongly ionizing particles. The chamber has high coordinate and time resolution ($\sigma_k \lesssim 0.2$ mm, $\Delta t \approx 80$ nsec). The electron drift velocities were measured for the mixtures $He^4+(5, 10, 20, 30)\%$ CH_4 and $He^4+(5, 10, 20, 30)\%$ CO_2. It is shown that if the chamber is filled with He^4+CH_4 the registration efficiency is ~ 100% over the entire width of the drift gap.

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INTRODUCTION

Until recently, all investigations with drift chambers operating in the counting regime were carried out with the chambers filled with argon with various additives (CO_2, CH_4, isobutane, etc.).[1,2] In the investigation of photoproduction and electroproduction on nuclei, it may become necessary to register heavy strongly-ionizing particles (α particles, deuterons, etc.) against a large background of electrons and photons (10^6/sec).

It was shown in[3] that a proportional chamber filled with a mixture $He^4+(1-2)\%$ CH_4 has high registration efficiency for strongly-ionizing particles (α particles) and has an amplitude ratio α/β 30(β electrons).

The purpose of the present study was to investigate the possibility of using a drift chamber filled with the mixture He^4+CO_2 or He^4+CH_4 for the registration of strongly-ionizing particles, to determine the temporal and coordinate resolutions of this chamber, and to investigate the amplitude ratio α/β.

MEASUREMENT PROCEDURE

A beam of α particles from a Pu^{239} source was shaped by two slit collimators (1×15 mm) mounted on two sides of the drift chamber, and was registered in a CsI(T1) crystal. By moving the α source it was possible to vary the distance from the particle beam to the anode. The working mixture was drawn through the volume containing the α source, the collimators, and the chamber. We registered and analyzed only those events in which coincidence occurred between the signals of the drift chamber and the photomultiplier. The established threshold made it possible to discriminate reliably the α-particle signals from the noise.

RESULTS

We investigated various concentrations of He^4+CH_4 and He^4+CO_2. The choice of helium as the main component of the mixture was dictated by the fact that in many problems it is possible to use the chamber gas as a target.[4] Figure 1 shows the dependence of the electron drift velocity on the concentrations of the CO_2 and CH_4. With increasing CH_4 concentration, the drift velocity increases, a fact not observed for CO_2.

The electron drift velocity remained practically constant in the He^4+CH_4 mixture when the working voltage of the chamber (U_k) was varied in the range 200–400 V. This means that in this region there is no need for high stabilization of the working voltage of the chamber.

The temporal distribution of the signals from the α particles, at distances 5 mm and 20 mm from the

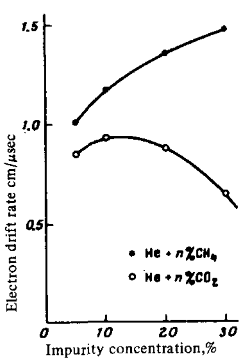

FIG. 1. Dependence of the electron drift velocity on the CO_2 and CH_4 concentration.

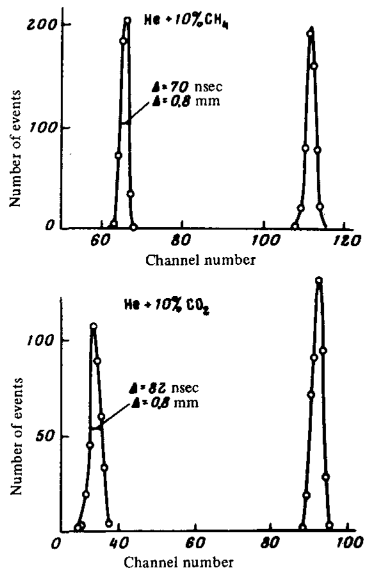

FIG. 2. Temporal distribution of the α-particle signal from the drift chamber: a) $He^4+10\%$ CH_4, b) $He^4+10\%$ CO_2. The distance between spectra is 15 mm.

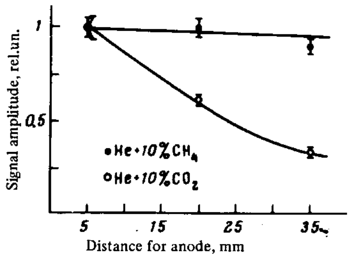

FIG. 3. Dependence of the amplitude of the drift-chamber signal on the distance to the signal filament for the mixtures $He^4 + 10\% CH_4$ and $He^4 + 10\% CO_2$.

anode, are shown in Figs. 2(a,b) for the mixtures $He^4 + 10\% CH_4$ and $He^4 + 10\% CO_2$. The width at half-height is 70 nsec for the $He^4 + 10\% CH_4$ mixture and 82 nsec for the $He^4 + 10\% CO_2$ mixture.

The corresponding coordinate resolution is ~0.8 mm (width at half height). Allowance for the width of the beam yields $\sigma_k \lesssim 0.2$ mm for the proper resolution of the chamber.

The high coordinate resolution is determined by the fact that in the case of strong ionization, ~10^3—10^4 ions/cm (α particles), the leading front is always formed by the electrons that reach the anode along the shortest path from the point of passage of the particle. For comparison of the coordinate resolutions for electrons and α particles, the drift chamber was filled with a mixture $10\% Ar + 10\% CH_4 + 80\% He^4$. It turned out that the resolution for the α particles was twice as good as for electrons under the same conditions.

Coordinate resolution does not change when the CO_2 and CH_4 concentration changes.

For the investigated concentrations, the amplitude ratio $\overline{\alpha}/\beta_{max}$ amounts to ~20. This ensures 100% efficiency of the registration of the α particles with complete suppression of the electron background.

In the registration of strongly-ionized particles by drift chambers with large spacings between the signal wires, it is necessary to use mixtures that ensure homogeneity of the efficiency over the entire sensitive gap.

The measured dependences of the signal amplitudes on the distance to the signal filament is shown in Fig. 3. The small decrease in the amplitudes for the mixture $He^4 + 10\% CH_4$ is due to the presence of impurities in the helium and to the inhomogeneity of the electric field of the drift chamber.

In the case of CO_2, the probability of electron trapping in the collisions is 10^{-4}, which leads in the case of ~10^{-4} collisions on the drift path to a noticeable decrease of the signal amplitude (Fig. 3). It is possible that the decrease of the observed value is enhanced by the presence of electronegative impurities and by the fact that we used CO_2 used in the food industry.

CONCLUSIONS

We investigated a drift chamber filled with $He^4 + CO_2$ or $He^4 + CH_4$. The chamber has high coordinate and temporal resolution, has ~100% efficiency of registration of strongly-ionizing particles with complete suppression of the electron and photon background. Electron drift velocities were measured for the mixtures $He^4 + (5,10,20,30)\% CH_4$ and $He^4 + (5,10,20,30)\% CO_2$. The drift velocity of the investigated concentrations depends little on the working voltage of the chamber. We investigated the dependence of the amplitudes of the drift chamber on the point of passage of the α particles. In the case of $He^4 + CH_4$, it is possible to obtain uniform efficiency over the entire area at a distance 8—10 cm between the signal wires of the drift chamber.

In conclusion, the authors consider it their pleasant duty to thank V.M. Kharitonov for useful discussions and for interest in the work.

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