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NEW IMPROVEMENT IN TRACK LOCALIZATION IN SELF-SHUNTED HELIUM STREAMER CHAMBER.

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In previous papers the operating conditions of a helium-filled self-shunted streamer chamber with various admixtures have been described, and a qualitative explanation for the mechanism of the track localization was given[(1,2)]. The experimental data, together with qualitative estimations, showed a rather high sensitivity of the quality of the tracks to the concentration and the characteristics of the admixture. In the present paper a study of a self-shunted chamber, filled with helium and small admixtures of water vapour is reported. It turns out that such a mixture provides a high stability of the track quality and the repeated electrical discharges (several thousands) thorugh the chamber reduce neither the brightness nor the localization of the tracks. It turns out also that the characteri

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stics of the chamber vary little within a wide range of concentrations of the admixture. This paper includes data on the memory time of the streamer chamber. Experiments were carried out with different streamer chambers, 10 and 11.2 cm heigh. The chambers were filled, with a chosen mixture, up to 1 atm. The high voltage pulse, up to 280 kV, with a ~ 10 ns rise time and an exponential decay time of about 1.5 μs, was applied to the chamber electrodes. Tracks of electrons from a ^{90}Sr source were photographed using films with a sensitivity $S_{0.87}$ = 900 GOST units. The experimental layout and the high voltage pulse generator have been described in detail elsewhere[(3)]. Fig. 1a and 1b present pictures (lateral view) of electron tracks obtained with pure helium and with a mixture of helium and

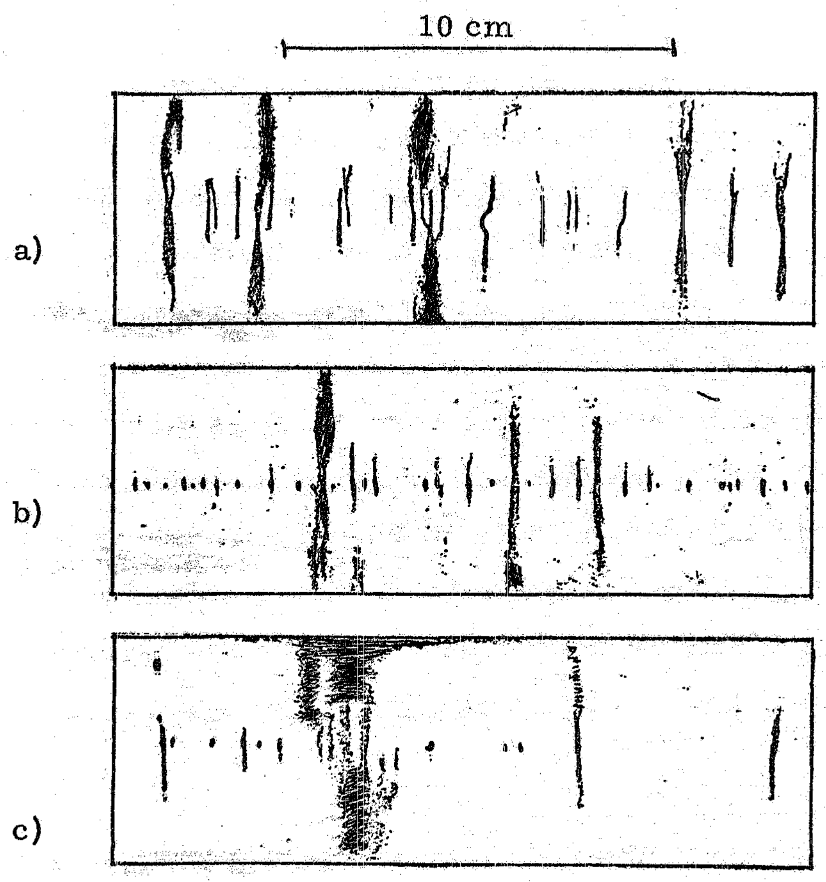

FIG. 1 - Electron tracks : a) Pure helium, hv pulse delay time τ = 0.4 μs ; b) He + 0.1% of water vapour, τ = 0.4 μs; c) He + 0.1% of water vapour + 0.5% of air, τ = 0.9 μs.

0.1% of water vapours respectively. It must be underlined that the quality of the tracks (their brightness and localization) in a mixture of helium and water vapour is practically uninfluenced by repeated discharges through the chamber. The localization of tracks in the streamer chambers is characterized by the average lenght d of the central bright zone ("dots") of the discharge channels. The results of the measurement of d performed with a microphotometer have been described in a previous paper[1]. Fig. 2 shows the value of d plotted as a function of the concentration C of the water vapour, for

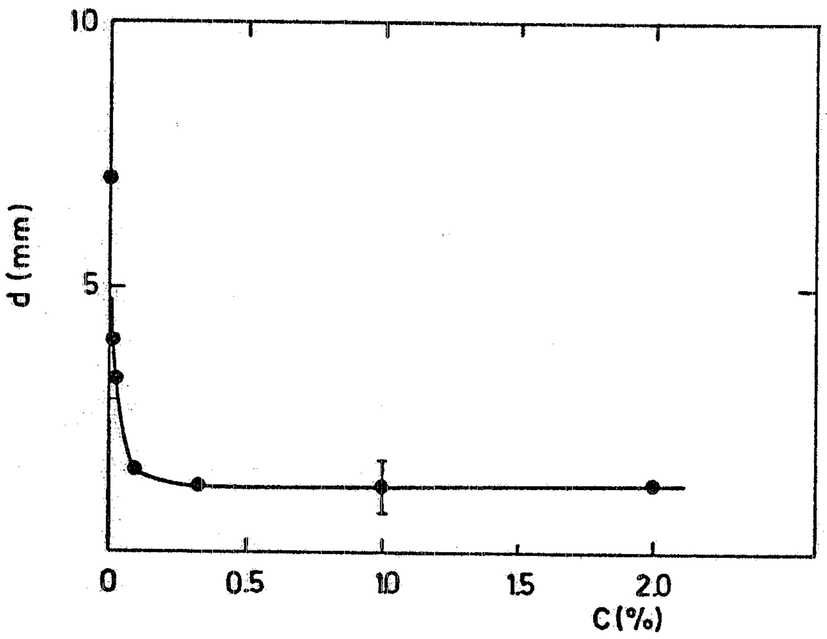

FIG. 2 - Dependence of the average lenght d of the bright central part of a discarge channel (dot) versus concentration of water vapour C (%).

an electric field gradient E = 27 kV cm^{-1}. For concentrations C > 0.1% (corresponding to a partial pressure of the water vapour higher than 0.7 torr) the d values are independent of the pressure of the admixture, and are equal to about 1.5 mm. For values of C < 0.1% the decrease of the amount of water vapour leads to an increase of the lenght d. The value of d does not depend upon the electric field gradient (within the range of the values of E investigated

(10 ÷ 25 kV cm^{-1})). The dependence of d upon E is plotted in fig. 3 for a mixture of helium and 0.1% of water vapour. An important parameter of the tracks quality is the ratio n_{dot}/n_{tot} between the

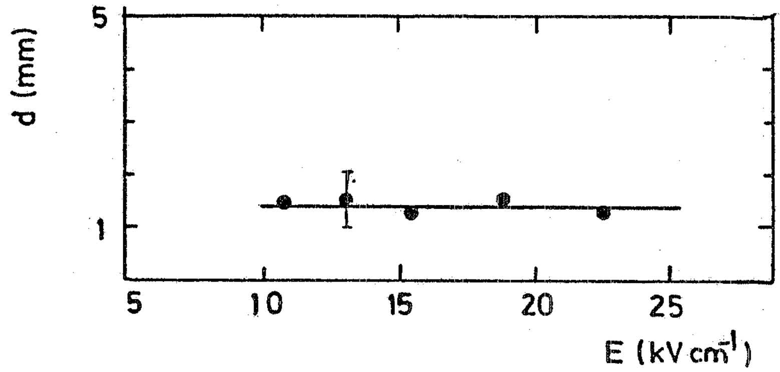

FIG. 3 - Dependence of d as a function of the electric field gradient.

number of dots per centimeter n_{dot} and the total number of discharge channels per centimeter along the track n_{tot}. The values of this ratio previously reported(1, 3) for different admixtures did not exceed 0.5; with the mixture of helium and water vapour, however, the value n_{dot}/n_{tot} = 0.8 ÷ 0.9 can be obtained. Fig. 4 presents a plot

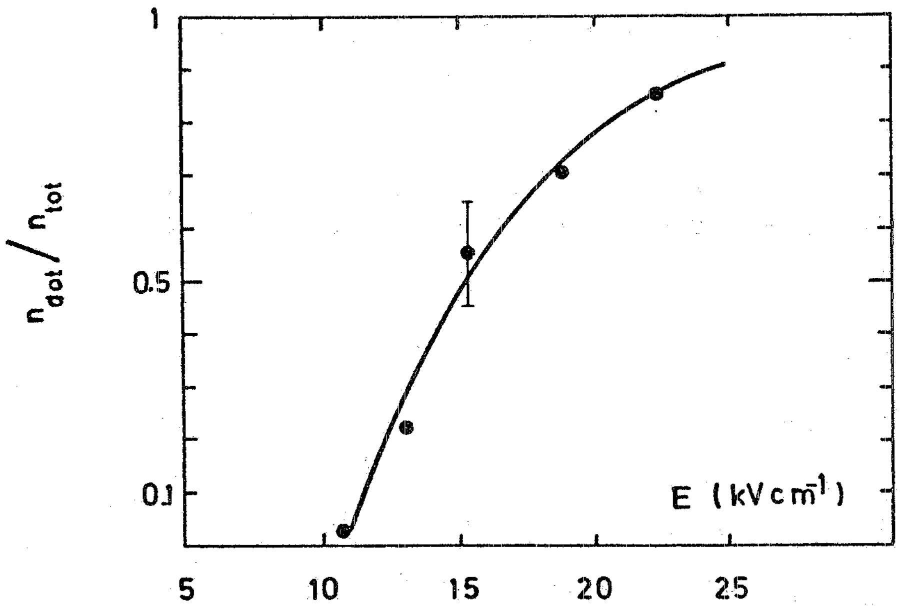

FIG. 4 - Dependence of the ratio n_{dot}/n_{tot}, between the dot number n_{tot} per centimeter and the total number discharge channels n_{tot} per centimeter, versus E.

of the ratio n_{dot}/n_{tot} as a function of the field gradient E in helium plus 0.1% of water vapour.

The memory time of the streamer chambers can be varied contaminating the filling gases with such electronegative admixtures as CCl_4 [5] and SF_6 [6], but it results unstable. It turns out, that the memory time of a chamber filled with a mixture of helium, water vapour and air does not change with time. Small amounts of air in the chamber have no effect on the tracks quality (see Fig. 1c). Fig. 5 present a plot of the number of the discarge channels per centimeter

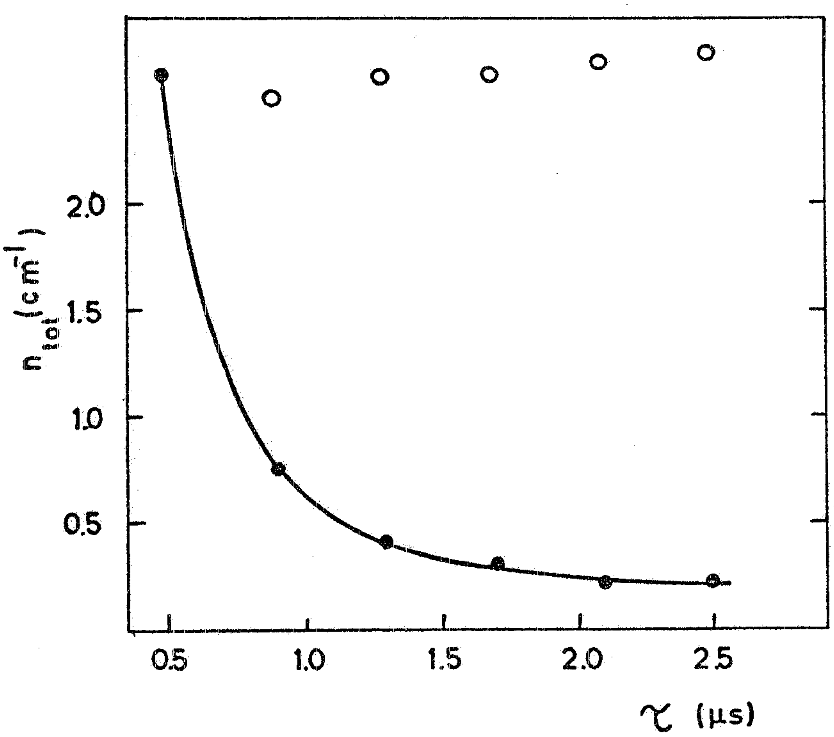

FIG. 5 - Dependence of n_{tot} upon the delay time τ of the hv pulse for a mixture of helium + 0.1% of water vapour + 0.05% of air (full points) and for a mixture of helium + 0.1% of water vapour (open circles). The time during which n_{tot} decreases by a factor of two is τ = 0.7 μs.

along a track in a mixture of helium, 0.1% of water vapour and 0.5% of air, as a function of the time delay τ of the 22.5 kV/cm hv pulse applied to the chamber electrodes.

The influence of water vapour on the discharge in a self-shunted helium streamer chamber can be qualitatively explained as follows. The probability of electron attachment[7] and also of formation of complex ions[8] in the helium-water mixture is high. The rate constant, in triple collisions, of complex ions in a mixture of helium and water vapour[8] is $k \approx 10^{-27}\ cm^6\ s^{-1}$. This fact means that, for a water vapour concentration of about 1%, the characteristic formation time for complex ions is $t \simeq (k\, n_w\, n_{He})^{-1} \simeq 10^{-9}$ s, where n_w and n_{He} are the densities of water molecules and of helium atoms respectively. Therefore the ionization of an atom or molecule in the gas mixture with a high probability leads to the formation of a complex ion. Then the discharge current in a streamer chamber flows in a mixture of helium atoms, water molecules and of complex ions. The dimensions[9] of the complex ions, and hence the probability of collisions of electrons with these ions, is independent of the density of the water molecules. It is also necessary to consider that the electron attachment reduces the Townsend ionization coefficient. Therefore the water wapour is more effective than hydrocarbons in reducing the mean electron energy in the discharge in helium[1, 2, 3] and leads to the very good photographic contrast between the region of the neck and the brushes of the discarge channel (Fig. 1b). We have used the water-helium mixture to photograph $\pi^{\pm}$ tracks in a magnetic field, with the experimental apparatus described in ref (2), at the Frascati Laboratory. Fig. 6 shows a track of a 30 MeV positive pion in a 5 kG magnetic field, obtained using $E = 17.5$ kV cm^{-1}, an aperture f/4 and film Ilford HP4. As it can be seen the track is well localized and does not present luminous brushes along the direction of the electric field, as in the case of hydrocarbon-helium mixture (see for example Fig. 1 and 9 of ref (2)).

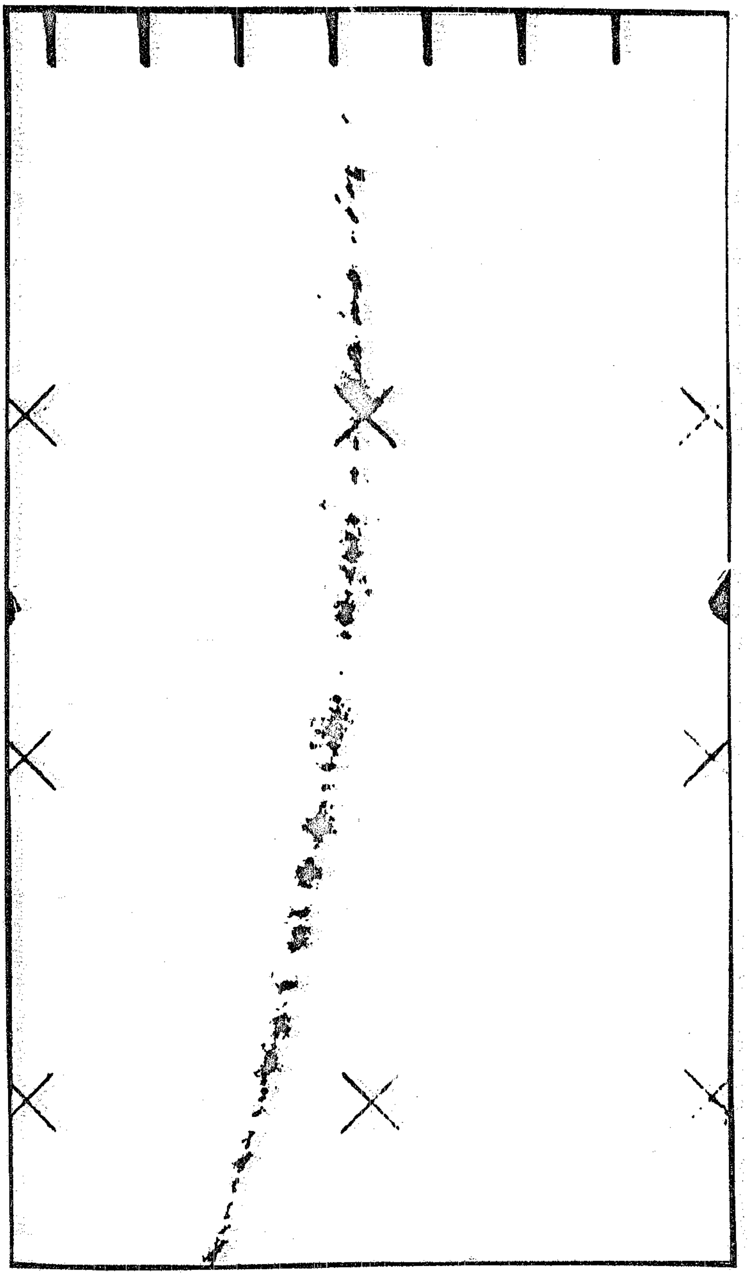

FIG. 6 - Pion track in a self-shunted streamer chamber[2], filled at 1 atm with water-helium mixture. The fiducial marks represent a square of 19.5 cm of side.

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