

ISTITUTO NAZIONALE DI FISICA NUCLEARE

Sezione di Torino

INFN/AE-77/7
17 Maggio 1977

L. Busso, I. V. Falomkin, V. I. Lyashenko, N. M. Kao, V. A. Panyushkin, G. Piragino, G. B. Pontecorvo, Yu. A. Shcherbakov and T. M. Troshev: STUDY OF THE CHARACTERISTICS OF THE HYDROGEN SELF-SHUNTED STREAMER CHAMBER.

L. Busso, I.V. Falomkin^(x), V.I. Lyashenko^(x), N.M. Kao^(x), V.A. Panyushkin^(x), G. Piragino, G.B. Pontecorvo^(x), Yu.A. Shcherbakov^(x) and T.M. Troshev^(x): STUDY OF THE CHARACTERISTICS OF THE HYDROGEN SELF-SHUNTED STREAMER CHAMBER.

ABSTRACT : Electron tracks have been photographed in a self-shunted hydrogen streamer chamber, with CH₄ and water vapour admixtures, in the pressure range (200 ÷ 760) torr. For a pressure higher than 600 torr, the discharge channels present the "dot" feature. This localizing effect turned out to be practically independent upon the electric field value and the admixture concentrations in the ranges studied. Also the number of discharge channels per centimetre, in this type of chamber, is practically independent upon the gas pressure, the electric field value and the admixture concentrations, in the ranges studied. The brightness of the tracks is sufficient to photograph with usual films and objectives. The memory time permits to expose this type of streamer chamber to intensive particle beams.

(x) - Joint Institute for Nuclear Research, Dubna (USSR).

1. -INTRODUCTION

In previous papers^(1, 2), pictures of relativistic particle tracks in hydrogen streamer chamber have been presented. This result has been obtained with a self-shunted streamer chamber⁽³⁾, in which the duration of the high voltage pulse, between the discharge gaps, is determined by the discharge processes within the chamber itself. With this method, it is possible to have bright tracks. The localization of the tracks is obtained by controlling the intensity of the light, along the vertical discharge channels. This is achieved by introducing suitable admixtures to the filling gas of the chamber⁽⁴⁾. To obtain localized tracks in a self-shunted streamer chamber it is necessary⁽²⁾ to add, to the hydrogen at 1 atm, about 1% of CH₄ and about 0.03% of water vapour. The small percentage of admixtures allows to use this chamber as a hydrogen target. These admixtures reduce the development velocity of the discharge in hydrogen and contribute to localize the discharge in the primitive drop zone, reducing the electron temperature and absorbing photons^(2, 4). Moreover they improve the photographic contrast between the primitive drop zone and the brush-like parts of the discharge channel.

In this paper the characteristic of this type of chamber are studied. The dependences of the track localization upon the admixture concentrations in hydrogen, upon the applied electric field value and upon the gas pressure, are reported.

2. - EXPERIMENTAL RESULTS AND DISCUSSION

The experimental apparatus and the model of streamer chamber have been described in ref. (1) and (2). Before the final filling with high purity hydrogen, the chamber was evacuated down to about 2×10^{-3} torr and washed a few times. The quantity of CH₄ and of water vapour admixtures have been varied by means of a vacuum gauge and mixed with hydrogen in the chamber.

First, the changes of the track as a function of the gas pressure have been studied. Fig. 1 shows electron tracks photographed along the electric field direction (upper view), at the pressure of 760, 600, 400 and 200 torr; with $E = 27.0 \text{ kV cm}^{-1}$, objective aperture $f/2.5$ (film GOST-2000). The gas mixture was (H₂+1% CH₄+0.025% water vapour). Fig. 2 shows the lateral view (perpendicular to the electric field direction) of electron tracks, in the same experimental conditions of Fig. 1, with objective aperture $f/0.8$. As it can be seen, the localization is worse for lower pressure; in these cases the velocity of propagation of the discharge along the discharge channels is too high, and the CH₄ and water vapour admixtures are not sufficient to produce a good track localization. At 1 atm too not all the discharge channels are dots (the "dot" is a characteristic discharge channel with a localized bright luminous region observed in its centre, the length of which along the electric field does not exceed its cross width by more than a factor of 2 or 3). The ratio $K = n_{\text{dot}}/n_{\text{tot}}$ (n_{tot} is the

10 cm

4 cm

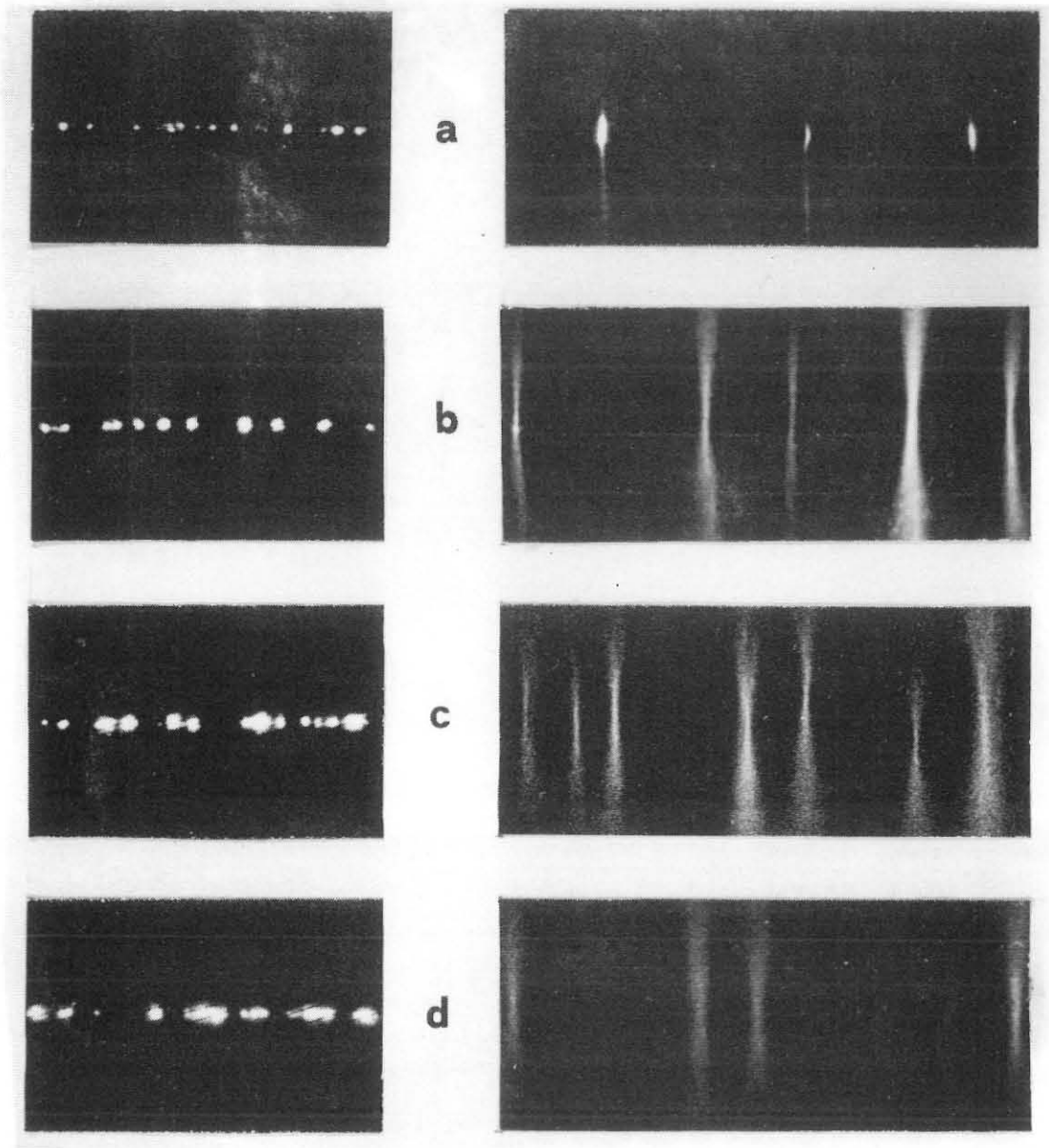


FIG. 1

FIG. 2

FIG. 1 - Electron tracks (upper view) in hydrogen self shunted streamer chamber, with admixtures of 1% of CH_4 and 0.025% of water vapour, at the pressure respectively of: a) 760 torr; b) 600 torr; c) 400 torr; d) 200 torr. $E = 27.0 \text{ kv cm}^{-1}$; lens aperture $f/2.5$. The real length of the tracks was 16 cm.

FIG. 2 - Electron tracks (lateral view) in the same cases of Fig. 1. Lens aperture $f/0.8$. The real height of the chamber was 4.5 cm.

number of discharge channels per centimetre along the tracks and n_{dot} the number of "dots" per centimetre along the tracks) and the mean length "d" of the bright region characterize the localizing effect. For different pressure values the mean length d, as a function of the electric field value E, has been measured with a microphotometer⁽⁴⁾. These measurements of light intensity distribution have been performed along different discharge channels (lateral view of the tracks) and the distribution of their widths at half height has been plotted. Fig. 3 shows different light intensity

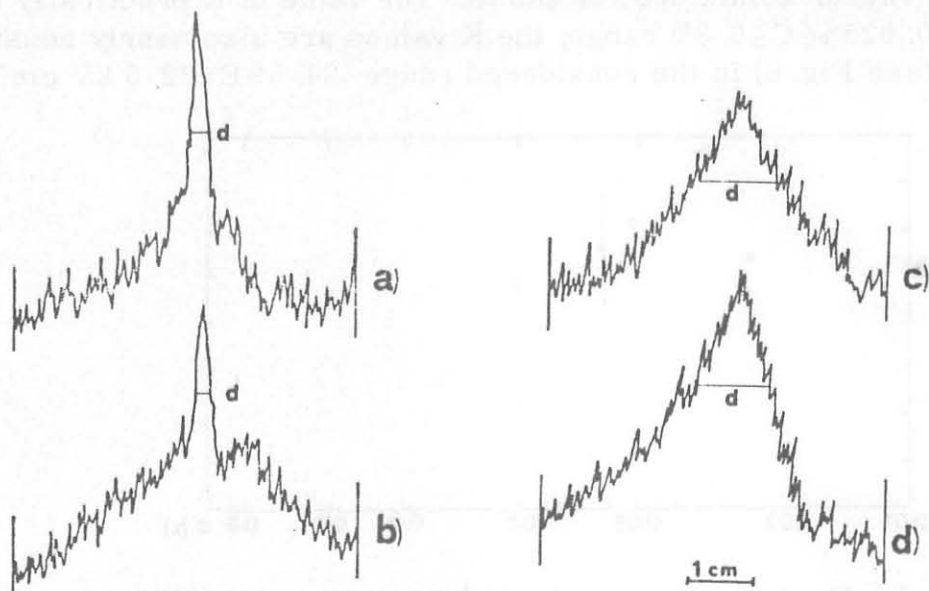


FIG. 3- Typical intensity distribution of light along discharge channels⁽⁴⁾, in the experimental condition of Fig. 1 and 2.

distributions and the corresponding values of d, for different pressure in the chamber filled with the same mixture. Fig. 4 shows the behaviour of

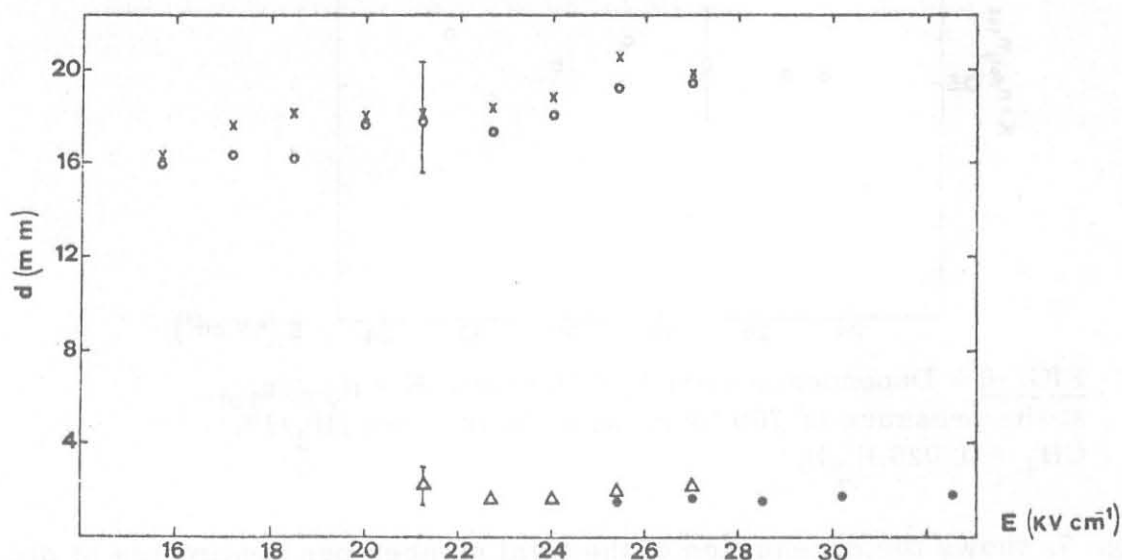


FIG. 4- Dependence upon E of the mean length d, of the bright luminous region of the discharge channel, for the mixture ($\text{H}_2 + 1\% \text{CH}_4 + 0.025\% \text{H}_2\text{O}$) at different pressure: ●-760 torr; Δ-600 torr; x-400 torr; ○-200 torr.

4.

$d(\text{mm})$ as a function of $E (\text{kV cm}^{-1})$, for different values of the pressure. As it can be seen, at higher pressure ($600 \div 760$ torr) the localization is good ($d \approx 2$ mm), while at lower pressures ($200 \div 400$ torr) the localization is worse ($d \approx 15 \div 20$ mm). The dots appear only at high pressure (≈ 600 torr), like a condensation effect; it is evident that for these pressure values there are qualitative changes in the discharge propagation mechanism.

In Fig. 5 the dependence of the ratio $K = n_{\text{dot}}/n_{\text{tot}}$, upon the concentration $C (\%)$ of water vapour admixture, is shown. The value of K practically does not change in the $0.025\% \leq C \leq 0.3\%$ range; the K values are also nearly constant vs. electric field (see Fig. 6) in the considered range ($24.5 \leq E \leq 32.5 \text{ kV cm}^{-1}$).

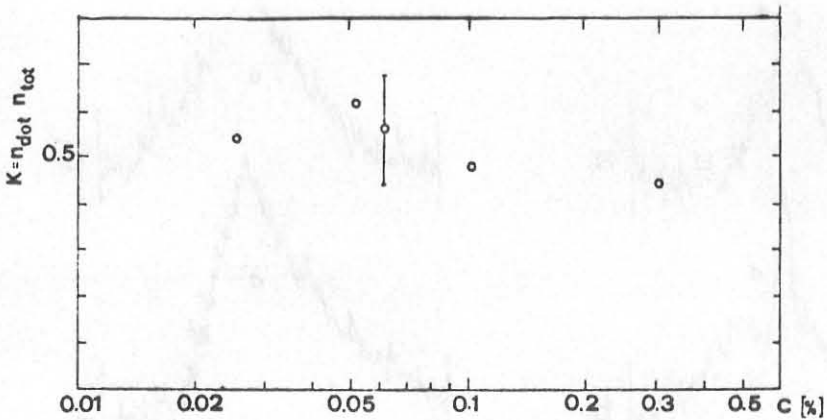


FIG. 5 - Dependence upon the water vapour concentration $C (\%)$ of the ratio $K = n_{\text{dot}}/n_{\text{tot}}$ (see text), at 760 torr, with $E = 32.5 \text{ kV cm}^{-1}$ and 1% of CH_4 admixture.

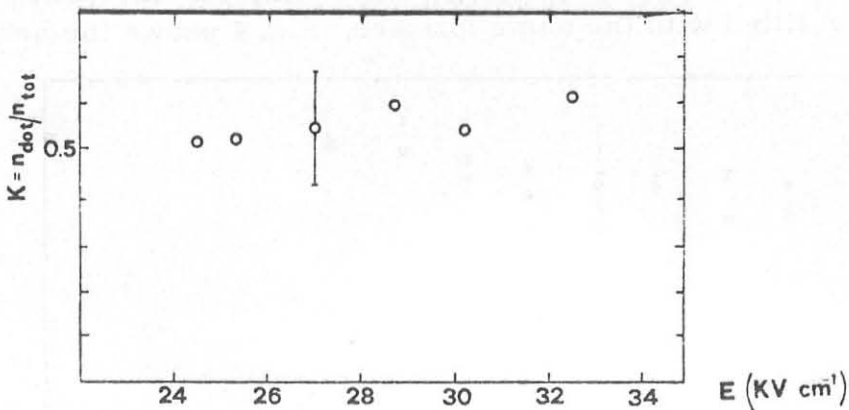


FIG. 6 - Dependence upon E of the ratio $K = n_{\text{dot}}/n_{\text{tot}}$, at the pressure of 760 torr, with the mixture ($\text{H}_2 + 1\% \text{ CH}_4 + 0.025 \text{ H}_2\text{O}$).

Fig. 7. shows the dependence of the total number per centimetre of discharge channels (n_{tot} is the total number of photographed discharge channels for a fixed electric field value with an objective aperture $f/2.5$), upon the

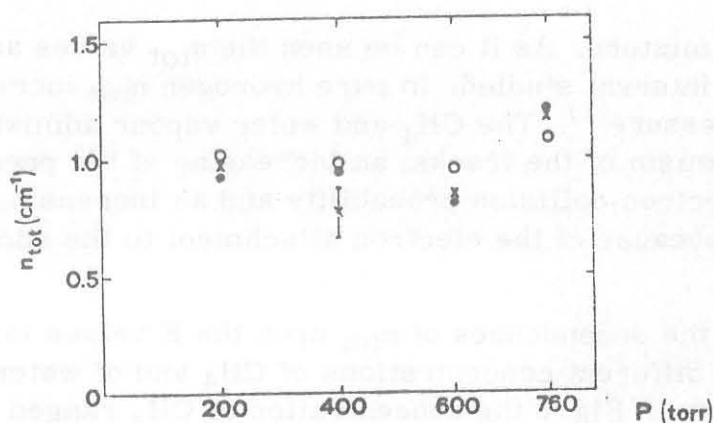


FIG. 7 - Dependence upon the pressure of the total number per centimetre n_{tot} of photographable discharge channels, for different E values. o- 32.3 kV cm^{-1} ; x- 27.0 kV cm^{-1} , mixture ($\text{H}_2 + 1\% \text{ CH}_4 + 0.025\% \text{ H}_2\text{O}$).

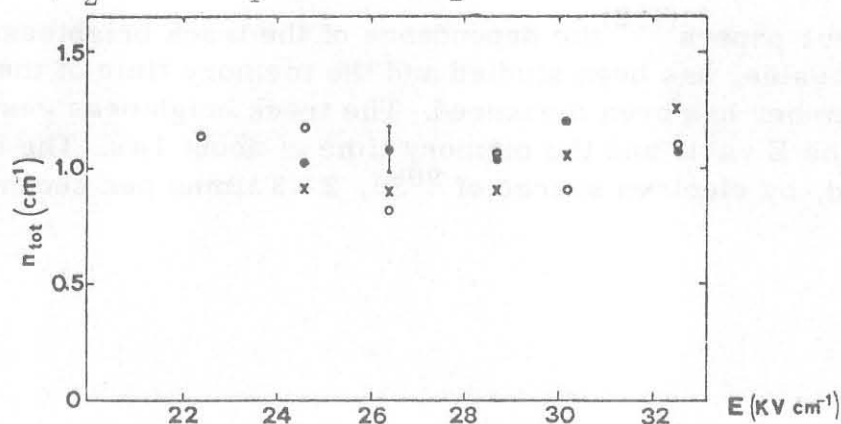


FIG. 8 - Dependence upon E of n_{tot} , for different concentration C (%) of CH_4 , at the pressure of 760 torr and with 0.025% of H_2O . ● - 5% CH_4 ; x - 1% CH_4 , O - 0.2% CH_4 .

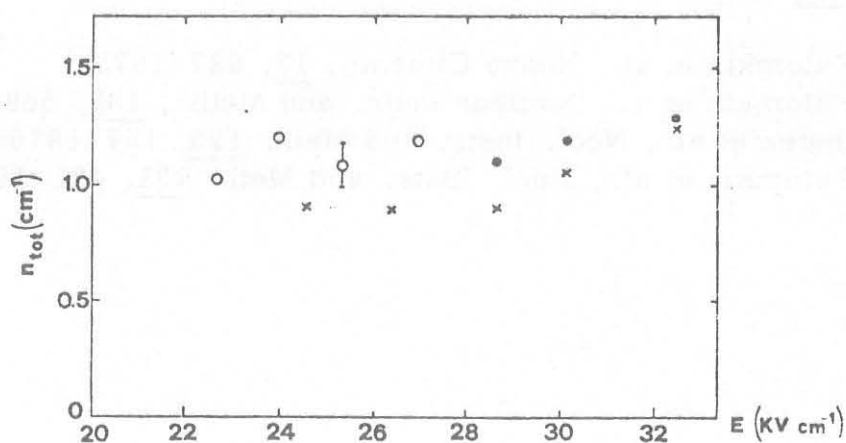


FIG. 9 - Dependence upon E of n_{tot} , for different concentrations C (%) of water vapour, at the pressure of 760 torr with 1% of CH_4 . o - 0.300% H_2O ; x - 0.050% H_2O ; O - 0.025% H_2O .

pressure of the gas mixture. As it can be seen the n_{tot} values are about constant in the E value interval studied. In pure hydrogen n_{tot} increases with the increasing of the pressure⁽¹⁾. The CH₄ and water vapour admixtures change the formation mechanism of the tracks: an increasing of the pressure gives an increasing of the electron collision probability and an increasing of the neutralization of the ions because of the electron attachment to the admixtures, added to the hydrogen.

In Fig. 8 and 9 the dependences of n_{tot} upon the E values in the (23 ÷ 33) kV cm⁻¹ range, for different concentrations of CH₄ and of water vapour, respectively, are shown. In Fig. 8 the concentration of CH₄ ranged in the 0 ÷ 5.0)% interval, with 0.025% of water vapour, and in Fig. 9 the concentration of water vapour ranged in the (0.025 ÷ 0.300)% interval with 1% of CH₄. In both cases the n_{tot} values results nearly constant in the E values range considered.

In previous papers^(1, 2) the dependence of the track brightness upon the electric field value, has been studied and the memory time of the hydrogen streamer chamber has been measured. The track brightness resulted proportional to the E value and the memory time of about 1 μs. The chamber was triggered, by electron source of ⁹⁰Sr, 2 ÷ 3 times per second.

REFERENCES

- (1) - I. V. Falomkin et al., Nuovo Cimento, 13, 427 (1975).
- (2) - I. V. Falomkin et al., Nuclear Instr. and Meth. , 137, 589 (1976).
- (3) - F. Balestra et al. , Nucl. Instr. and Meth. 125, 157 (1975).
- (4) - I. V. Falomkin et al. , Nucl. Instr. and Meth. 131, 431 (1976).