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Helium streamer chamber with laser track registration at gas pressures of up to 5 atm*

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The paper shows that the particle track detection with a laser can be successfully performed in a helium chamber at helium pressures of up to 5 atm, if some insignificant admixtures of methane and water vapours are let into the chamber.

1. Introduction

Helium filling of a streamer chamber offers a possibility of using it effectively in those investigations where the filling gas of the chamber is not only a detecting medium but also a "thin" target [1, 2]. Note that the increase of pressure increases the interaction probabil-

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ity, thus, increasing the efficiency of chamber operation in the beams of particles from accelerators. The development of a helium streamer chabmer (HSC) of increased pressure with laser track detection is of specific interest. According to [3-8], the use of laser detection allows us to localize better the trajectories of particles, to define more accurately the location of the interaction vertex, and to carry out ionization measurements.

Unfortunately, the sensitivity of the laser detection method in a streamer chamber filled with this gas is minimal [9], due to a relatively low reflection value n - I in helium (n is the refraction index). And really, the attempts to obtain shadowgraphs of tracks with satisfactory contrast [4], while working with pure helium are still unsuccessful.

Only the introduction of methane admixtures into the chamber at the level of 1% allowed to obtain shadowgraphs of tracks of good quality at helium pressure of 1 atm [6].

The aim of the present research was to study the optimum operation conditions of a HCS with increased pressure and laser registration. Special attention has been given to obtaining good quality tracks while introducing the smallest possible admixtures with the aim of getting a practically pure helium chamber-target.

2. Apparatus

Figure 1 presents a block-diagram of the experimental apparatus used in the work. The electrons from the β-source of ^{90}Sr pass through the streamer chamber (1), and get into the scintillation counter (3) which generates the trigger signal. This signal is transmitted to the start-off electron circuit (4) from the output of which it comes to the input of the pulses voltage generator - PVG (5). The signal for starting the pulse nitrogen laser (7) is received from the second PVG cascade

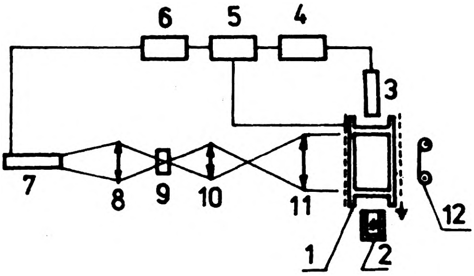

Fig. 1. The block diagram of the experimental stand (test bed). 1 - helium streamer chamber, 2 - source of electrons, 3 - scintillation counter, 4 - electronic triggering system, 5 - PVG, 6 - delay line, 7 - nitrogen pulse laser, 8 - quartz lens, 9 - cell with rhodamine 6G, 10, 11 - optical lenses, 12 - photographic film

through the delay line (6). A high voltage impulse from the PVG output is transmitted to the high voltage electrode of the streamer chamber.

The laser light pulse of wavelength $\lambda = 337.1$ nm comes into the cell filled with rhodamine 6G through a quartz lense (8). There it is transformed into an optical pulse of wavelength $\lambda = 600$ nm and is shaped into a parallel beam by means of a telescope [10, 11]. This beam of light illuminates the effective volume of the streamer chamber.

The streamer chamber is a plexiglass cylinder with the following dimensions: diameter 700 mm, height 46 mm. The edges of the cylinder are closed with glass windows (thickness 12 mm). The design of the chamber allows its operation at gas pressures of up to 5 atm. The electrons pass through the chamber via two specially made mylar windows. The electrodes are in the form of a system of parallel wires of 100 μm diameter spaced by 3 mm and positioned in the immediate vicinity of (close to) the chamber glass windows.

The high-voltage pulse generator has been assembled according to the standard scheme of Arkadyev-Marx type and consists of seven sections. The shock capacitance of the PVG is 3000 pf. The amplitude of the high voltage pulse is 120 kV. The output signal delay against the (triggering) signal from the phototube multiplier is 1 μs. The laser was started by a signal from the output of the second PVG section through the cable delay line. The delay time of the signal varied during the work from 125 ns to 3 μs. In this research a laser with a transversal discharge 1000 mm long, made in the Central Institute of Electronical Physics of the GDR Academy of Science has been used. Its parameters are presented in [6].

A vacuum system (Fig. 2) allowed us to fill the streamer chamber with helium, methane and water admixtures in the necessary proportions. The admixtures have been controlled by means of a vacuum-gauge. The initial vacuum was 10^{-2} Torr. In order to clean better the chamber prolonged evacuation of the chamber and its washing with helium were performed. A well cleaned streamer chamber enables us to detect the electron tracks on the shadowgrams at 0.1–1% methane admix-

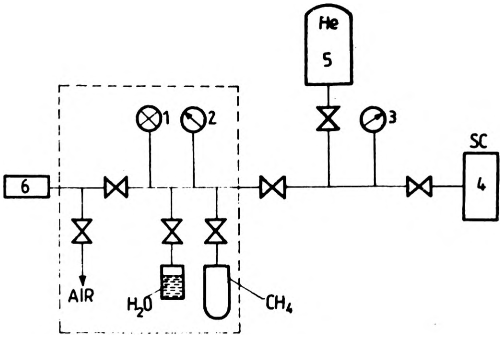

Fig. 2. Vacuum system. 1 - lamp, 2 - reference vacuum gauge (300 divisions), 3 - manometer for pressures of up to 10 atmospheres, 4 - streamer chamber, 5 - helium bottle, 6 - pump

tures. This makes a practically pure helium target out of a helium streamer chamber with a laser detection, which is important for numerous experiments studies on particle intersections with helium in a streamer chamber.

3. Experimental results

In the present research we have obtained shadowgrams of electron tracks in a HSC at helium pressure of 1 atm and methane admixtures of less than 1% with water vapour admixtures varying within 0.1–0.8%. It seems essential that for a successful detection of streamer shadowgraphs in helium the following requirements should be met:

i) All the pollutants should be well cleaned off the streamer chamber.

ii) At small methane admixtures (< 1%) water vapour should also be introduced into the chamber (some 0.1–0.8%).

Figure 3 presents the shadowgraphs of tracks obtained in helium at the pressure of 1 atm with the admixture of 0.1% methane and 0.3% of water vapour. The possibility of laser detection of tracks in the HSC was studied at 2,3,4 and 5 atmospheres. At all the pressures the electric field strength in the chamber was 20 kV/cm, being twice greater than that of the field used in [6]. The corresponding shadowgraphs for different admixtures of methane and water vapours are presented in Figs. 4–7.

The chamber operation was studied at different methane and water vapour admixtures. The minimum concentration of admixtures was 0.3–0.6% at 5 atm. As seen from Fig. 7 the tracks of satisfactory quality were obtained. From the obtained shadowgraphs the densities of streamers in electron tracks were measured depending on

Fig. 3. The shadowgrams of tracks obtained in helium at 1 atm, methane admixture 0.1%, water vapour 0.3%. The laser pulse delay 950 ns

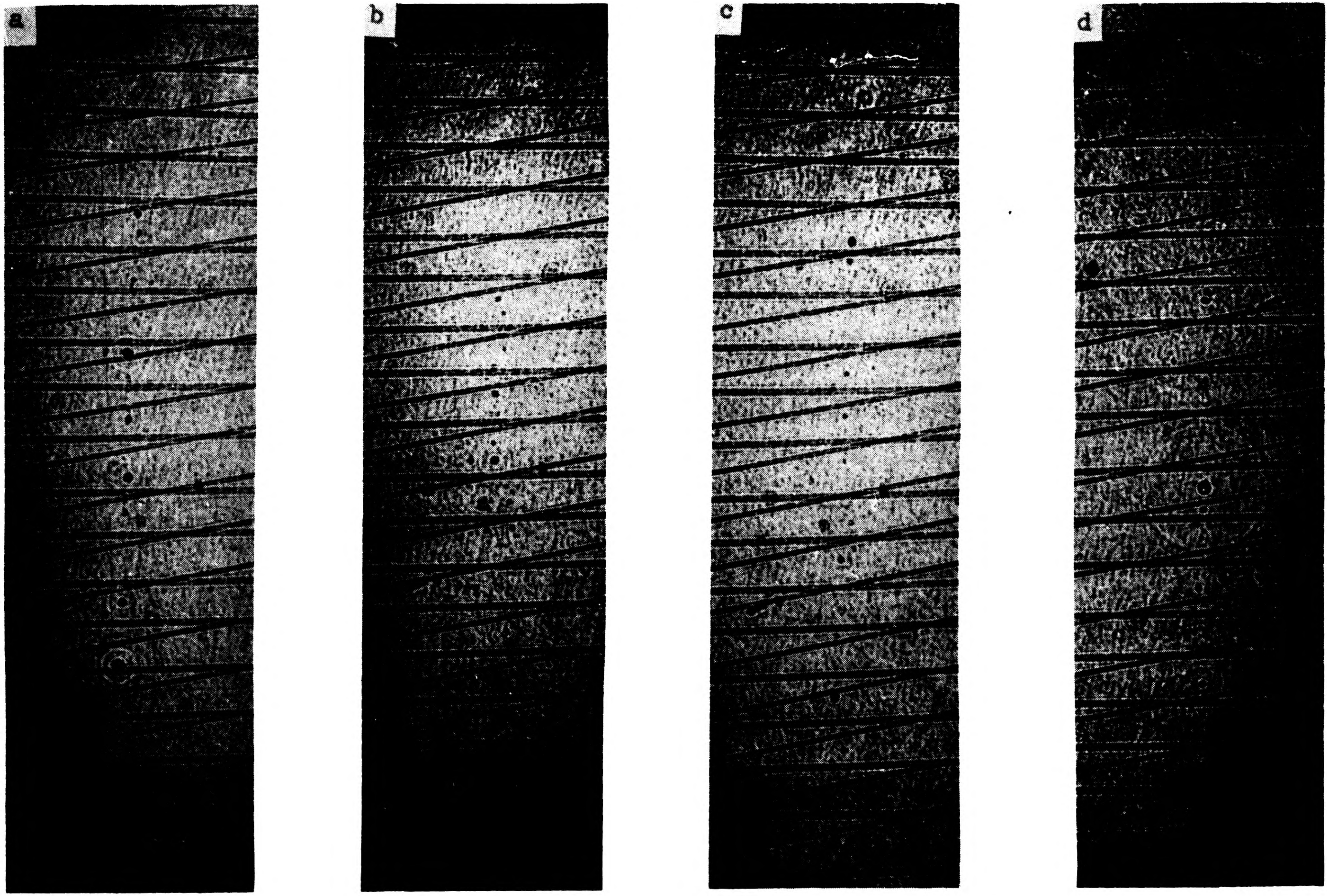

Fig. 4. The shadowgrams of tracks obtained in helium at 2 atm. a. methane admixture 3.8%, laser pulse delay 600 ns, b. methane admixture 5%, laser pulse delay 400 ns, c. methane admixture 6.5%, laser pulse delay 950 ns, d. methane admixture 10%, laser pulse delay 3 μs

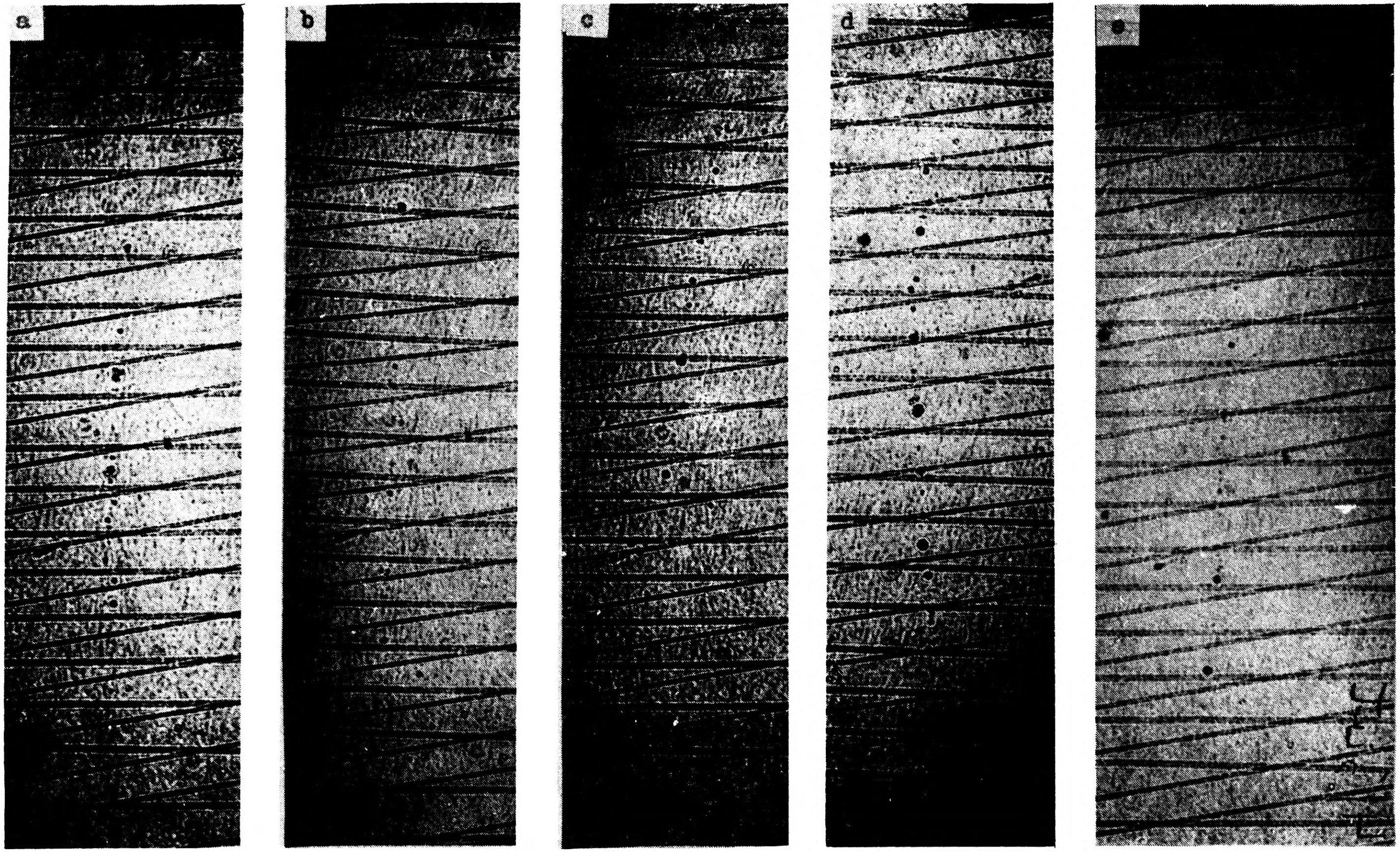

Fig. 5. The shadowgrams of tracks obtained in helium at 3 atm. a. methane admixture 1.9%, laser pulse delay 600 ns, b. methane admixture 1.25%, laser pulse delay 950 ns, c. methane admixture 2.5%, laser pulse delay 1725 ns, d. methane admixture 5%, laser pulse delay 3 µs, e. methane admixture 0.25% CH_4, laser pulse delay 950 ns

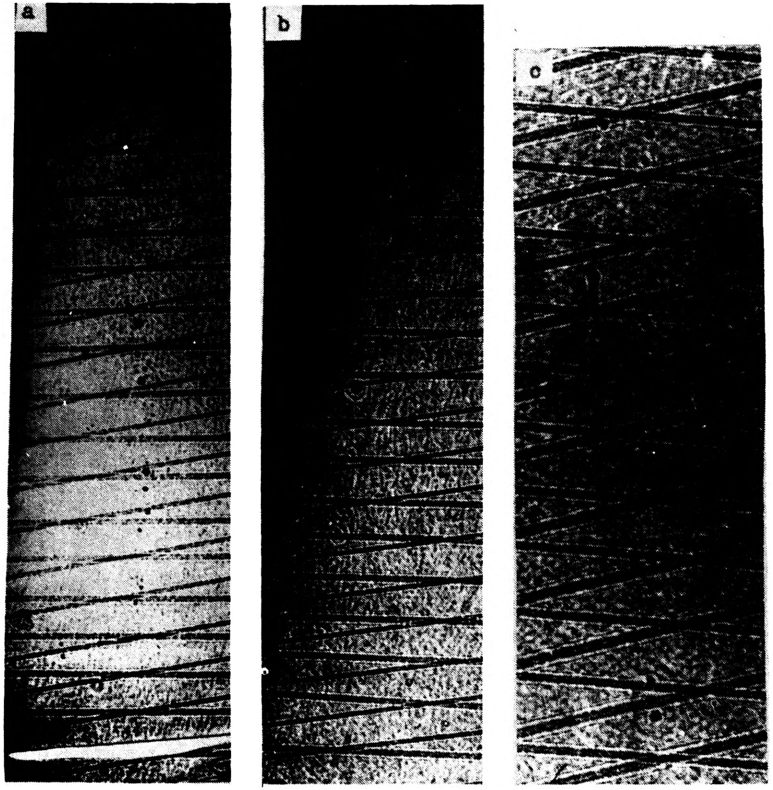

Fig. 6. Shadowgrams of tracks obtained in helium at 4 atm. a. methane admixture 5%, laser pulse delay 950 ns, b. methane admixture 0.95%, laser pulse delay 600 ns, c. methane admixture 0.6%, laser pulse delay 1700 ns

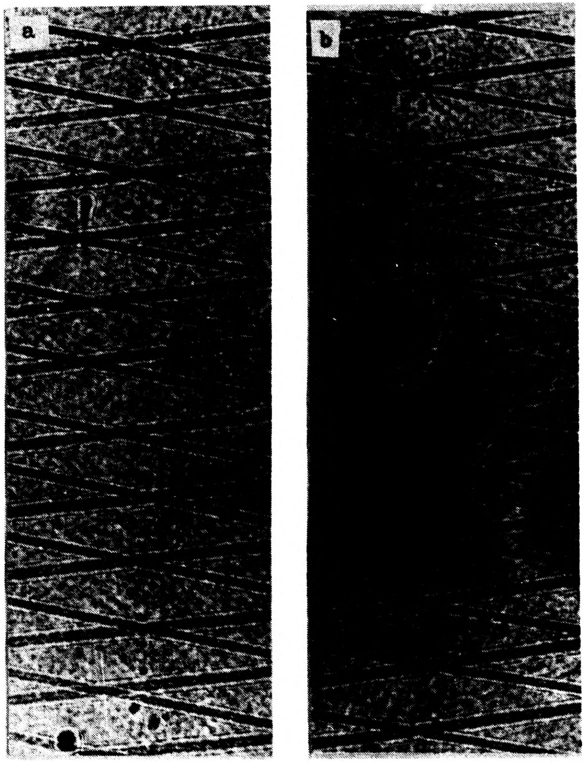

Fig. 7. The shadowgrams of tracks obtained in helium at 5 atm. a. methane admixture 0.6%, laser pulse delay 2 μs, b. methane admixture 0.6%, laser pulse delay 1.7 μs

the chamber pressure and laser pulse delay. The results are given in Table and in Fig. 8.

Figure 8 shows that the streamer density increases with the delay (up to 1–2 µs) and remains practically constant at higher values. Analogous effects were observed in [10] for a streamer chamber filled with a mixture of 70% He and 30% CH_4. This effect may be due to the following reasons:

When the chamber is operating in the self shunting mode the electric field energy is distributed non-uniformly among the streamers. This is caused, evidently, by a fluctuation of the initial number of electrons in the cascades from which the streamers originate and can bring about a time spread in the streamer development.

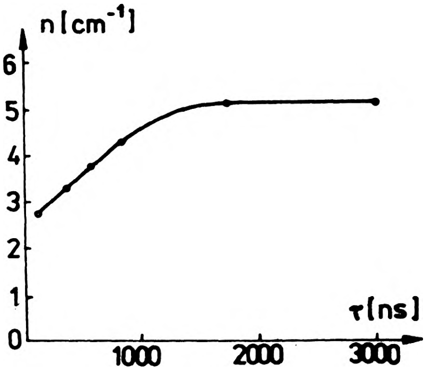

Fig. 8. The streamer density as a function of laser pulse delay at 2 atm and 5% methane admixture

Paper [11] shows that the degree of contrast of streamer shadowgrams is defined to a great extent by the value of energy produced (released). At small laser pulse delays, the dimensions of streamer shadowgrams are significantly less than at large ones. Under these conditions the pictures of streamers with the minimum energy release are not contrast enough to be observed in the shadowgraphs, though at large delays they can manifest themselves as well. This can also be due to the fluctuations of time necessary to establish equilibrium temperature inside the streamer channel, i.e., during the energy transfer from the electron gas heated in the discharge to the gas heavy components. This is consistent with the fact that in case when the laser beam delay is less than some minimum value the shadowgrams of streamers are not observed at all [6,9], i.e., they cannot manifest themselves. While discussing the effect of admixtures on the improvement of the sensitivity of laser detection method for the HSC account should be taken of the relationship of this phenomenon and the localizing effect of gas admixtures, which was studied earlier [12, 13]. The introduction of admixtures such as methane and water decreases the photoionization in the chamber volume. As a result the streamers in helium be-

Table

P [atm]	CH_4 [%]	τ[ns]	n [cm^{-1}]
2	0.2	950	4.07
2	0.5	950	3.29
2	2.5	950	3.61
2	5.0	125	2.80
2	5.0	400	3.26
2	5.0	600	3.79
2	5.0	950	4.33
2	5.0	1725	5.15
2	5.0	3000	5.25
2	10.0	950	3.33
3	0.25	950	3.33
3	0.4	2820	1.78
3	2.5	400	1.96
3	2.5	600	3.55
3	2.5	950	4.70
3	2.5	1725	4.28
3	5.0	950	4.89
4	0.6	1750	3.81
4	0.6	2675	4.88
4	0.8	725	5.00
4	0.9	600	3.45
4	1.2	400	2.33
4	2.5	950	4.38
5	0.3	725	3.54
5	0.4	2150	3.36
5	0.5	2150	4.35
5	0.6	2150	3.76

come less diffused, their transversal cross-section decreases and, correspondingly, their energy release increases. As has been mentioned above, this improves the contrast of shadow pictures of the separate streamers.

4. Conclusions

The present paper shows that laser track of charged particles in the HSC can be successfully detected at helium pressures of up to 5 atm, in the case when some insignificant admixtures of methane and water vapour have been introduced into the chamber.

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References

[1] FALOMKIN I.V. et al., Nuc. Instr. und Meth. 53 (1967), 226.

[2] SHCHERBAKOV Yu. A., et al., Novo Cim. 31A (1976), 249, 262.

[3] KULYUKIN M.H. et al., Proc. Int. Conf. Instr. for High Energy Phys., Frascati 1973, p. 235.

[4] KOZLOV V.S. et al., Nuc. Instr. und Meth. 140 (1977), 125.

[5] KALIMOV A.G. et al., Zh. Exper. Teor. Fiz. Letters 30 (1979),460.

[6] UHLMAN P., et al., Preprint 13-81-323, JINR, Dubna 1981.

[7] KALIMOV A.G., et al., Nuc. Instr. und Meth. 185 (1981), 81.

[8] BUDZIAK A. et al., Preprint 1-80-299, JINR, Dubna 1980.

[9] STABNIKOV M.V., TOMBAK M.A., Preprint No. 497, Leningrad Institute of Nuclear Physics, Leningrad 1979.

[10] KALIMOV A.G. et al., Zh. Exper. Teor. Fiz. Letters 3 (1957),1057.

[11] TOMBAK M.A., Preprint No. 499, Leningrad Institute of Nuclear Physics, Leningrad 1979.

[12] PONTECORVO D.B., Doctor's Thesis, JINR, 1-9849, Dubna 1976.
[13] BUSSO L., et al., Zh. Exper. Teor. Fiz. 70 (1976), 785.

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ГЕЛИЕВАЯ СТРИМЕРНАЯ КАМЕРА ПРИ ДАВЛЕНИИ ГАЗА ДО 5 АТМ С ЛАЗЕРНОЙ РЕГИСТРАЦИЕЙ СЛЕДОВ

В работе показано, что лазерная регистрация следов заряженных частиц в гелиевой стримерной камере может успешно выполняться при давлениях гелия до 5 атм., при условии введения в камеру незначительных примесей метана и паров воды.