A STREAMER CHAMBER FILLED WITH ^3He

Presented by Yu. A. Shcherbakov
Joint Institute for Nuclear Research
Dubna, USSR

It has previously been shown[1] that a necessary degree of localization and luminosity of tracks in a streamer chamber filled with helium may be obtained by using small admixtures of hydrocarbons in the gas and using high voltage pulses with a pulse width some hundreds of nanoseconds long.

For a number of experiments on pion scattering it is essential to have a streamer chamber filled with ^3He wherein short-range particles are detectable. The use of such a gas filling does not alter the principles of the discharge mechanism; there arises only the necessity of preventing losses of the isotope and providing the possibility of its purification for refilling the chamber. As in the case of ^4He a gas density as high as possible is desirable, therefore the chamber must be operated at elevated pressures.

The construction of the chamber was briefly described in paper[2] and has been slightly changed. The streamer chamber is 50 cm in diameter and 12-cm high. The cylinder used for the chamber is made of 1-mm thick plexiglas and is closed by an optical glass plate. A vacuum rubber seal is used. Mylar windows are used at the entrance (ϕ 80-mm) and exit (80×200 mm^2) of the beam. The windows are 0.1-mm thick.

A hodoscope of scintillation counters covering 0.12 of a 4π solid angle surrounds the streamer chamber. The trigger for the chamber is given by a pulse from the hodoscope when a scattered (elastically or inelastically) pion passes through one of the counters.

The streamer chamber was placed together with the hodoscope in a stainless steel vessel designed to hold a pressure of 8 bars. The general view of the experimental setup is shown in Fig. 1.

The system used for filling the chamber except for some changes was the same as previously described in paper.[3] The filling and purification system made it possible to add necessary amounts of α-pinene and SF_6 which is used for regulating the memory time of the chamber. The working pressure of the chamber was 4 bars. The concentration of tritium after purification of the filling gas was 10^{-15} and therefore there was practically no background from tritium decays. The chamber was kept being evacuated to a pressure of 0.1 mbar during several days before the filling. The admixture of ^4He was not greater than 0.02%. There was some amount of carbon and hydrogen nuclei (∿0.5%) in the gas due to the α-piene (up to 0.6 cm^3 of the liquid) used for the regulation of the discharge structure. During the regeneration of the gas the admixtures were frozen down in an absorbent carbon trap at the temperature of liquid nitrogen. The stainless steel vessel was filled with nitrogen, and the pressure in the outer volume of the chamber was kept equal to 10-20 mbars less than the pressure in the streamer chamber itself. In order to avoid possible losses of the ^3He an emergency system is installed allowing fast evacuation of the gas from both the inner and the outer volumes of the experimental device in case of leakages.

A twenty-stage pulse generator of the Arkadiev-Marx type was used as a source of high voltage supply to the chamber. The capacitor sections were charged to a voltage of 40 kV stabilized within 0.2%. The high voltage pulse amplitude was 500 kV, the rise-time was 25 nsec, and the pulse width was 0.5 μsec. The output capacity of the pulse generator was 320 pf. The brightness of the tracks in the chamber obtained with such characteristics of the pulse generator permitted direct photography on a film with a sensitivity $S_{0.85}$ = 800 units GOST USSR (corresponding to 1000 ASA) through an f/2.8 lens aperture. The total time delay of the high voltage pulse relative to the passing of the particles through the chamber was 1.2 μsec.

The experimental setup was used for investigation of elastic and inelastic scattering of pions on ^{3}He at an energy of 100-200 MeV. Figure 2 shows a typical event of an inelastic interaction of a pion with a nucleon of the ^{3}He nucleus. Usually the chamber was exposed without refilling for 48 hours. During such runs the brightness of the tracks and the memory time remained practically unchanged after about two hundred thousand discharges. It was noticed that due to the impulse discharge the gas temperature within the inner volume of the chamber increased. For a repetition cycle equal to 0.3 sec, the corresponding increase of pressure was 10 mbar during the time required for the exposure of one film (∿15 min). Usually a beam of pions 4 cm in diameter with an intensity of 10^4 sec^{-1} was passed through the chamber. One good event of elastic or inelastic scattering was registered per 10-15 triggers of the chamber. The repetition rate of the apparatus was limited by the photocameras and was practically 0.2 sec.

More than 200 thousand pictures were obtained during the exposure of the chamber filled with ^{3}He and about 1 million pictures were taken with ^{4}He.

The previously observed dependence of the track structure upon the ionization density[4] remains the same for many prong events, and this is very essential for the identification of the events.

Figure 3 shows a typical five prong event of an interaction of a pion with the ^{4}He nucleus. This star was taken from a group of events being analyzed in the search for double charge exchange processes of the pions.

In particle beams with fluxes of 10^4 sec^{-1} or more the statistics of events can be obtained with a greater rate with a helium streamer chamber than with a liquid helium bubble chamber of the same dimensions. The possibility of selecting certain processes and observing tracks of short range recoil nuclei is also an important advantage of the streamer chamber. This possibility of observing tracks of recoil nuclei is useful for the selection of elastic scattering events, and of coherent production processes, and widens the range of applications of such chambers in experiments at both intermediate and high energies.

References

[1] I. V. Falomkin, M. M. Kulyukin, G. Pontecorvo, and Yu. A. Shcherbakov, Nucl. Instr. and Methods 53, 266 (1967).

[2] I. V. Falomkin, M. M. Kulyukin, V. I. Lyashenko, G. Pontecorvo, A. G. Petrov, and Yu. A. Shcherbakov, Symposium on Filmless Spark Chambers and Streamer Chambers, Dubna, 1969, 13-4527.

[3] G. M. Aleksandrov, O. A. Zaimidoroga, M. M. Kulyukin, V. P. Peshkov, R. M. Sulyaev, A. I. Filippov, V. M. Tsupko, and Yu. A. Shcherbakov, PTE 1, 69 (1964) (in Russian).

[4] I. V. Falomkin, D. M. Khazins, M. M. Kulyukin, G. Pontecorvo, and Yu. A. Shcherbakov, Proceedings of the International Conference on Instrumentation in High Energy Physics, Stanford, 1966.

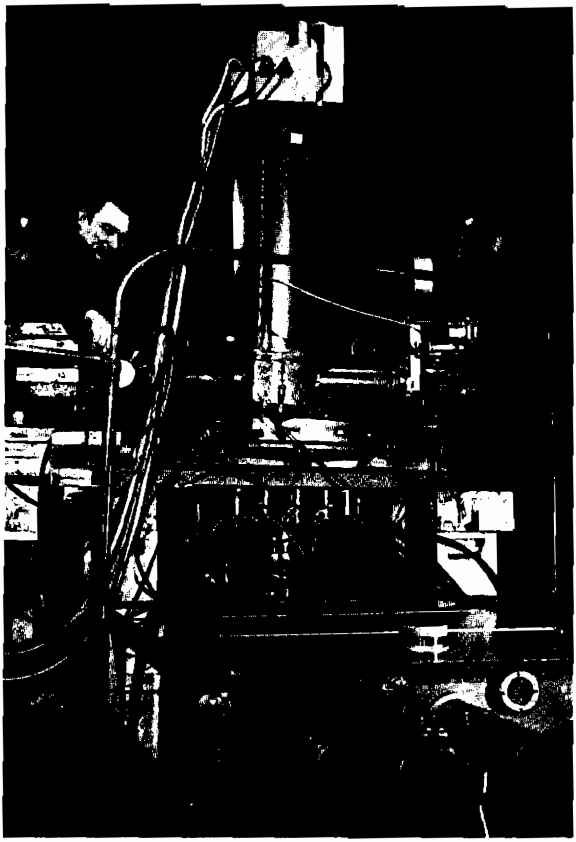

Fig. 1. General view of experimental setup.

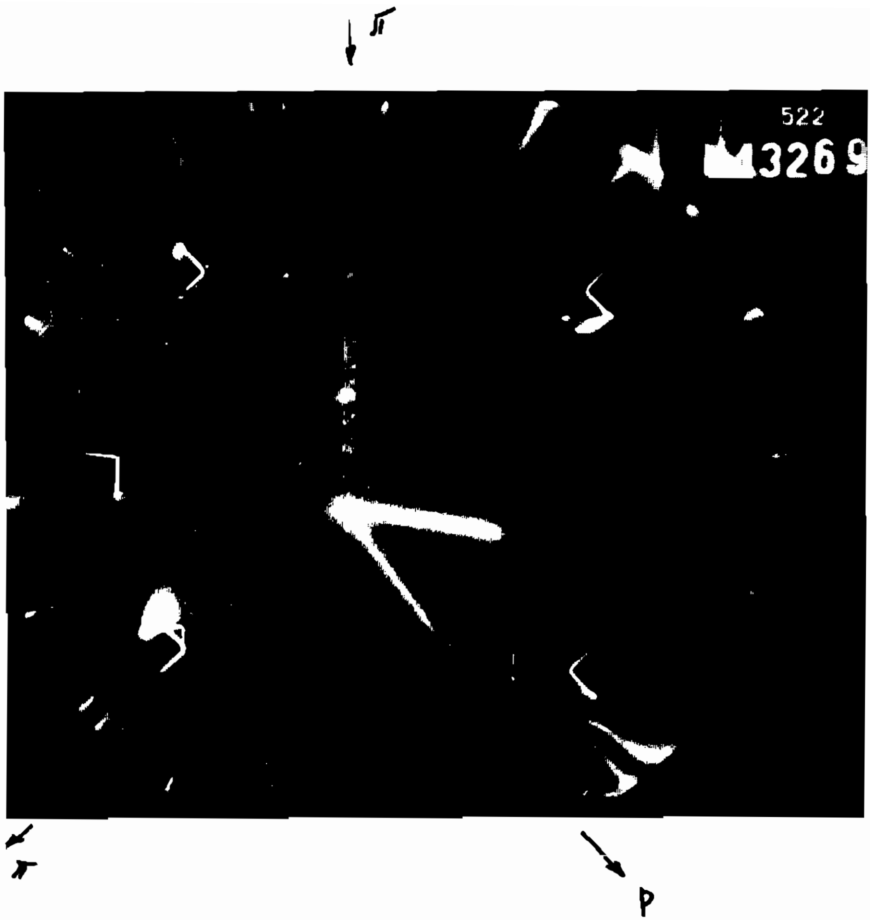

Fig. 2. Picture of an inelastic $\pi-{}^{3}He$ scattering event at 100 MeV, $\pi^{-} + {}^{3}He \rightarrow \pi^{-} + p + d$.

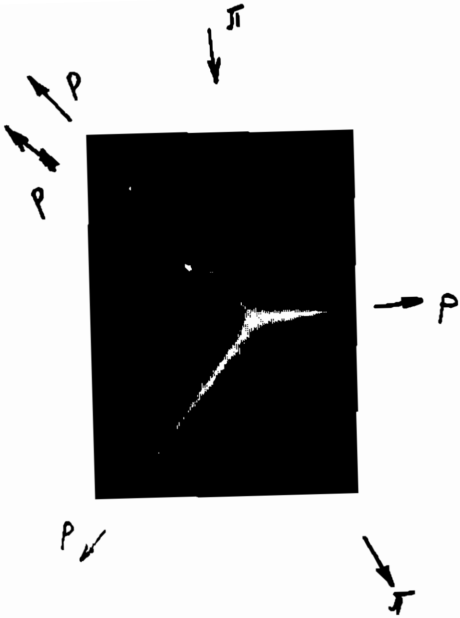

Fig. 3. Five prong event of π-^{4}He interaction, $\pi^+ + {}^4He \rightarrow \pi^- + 4p$.