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TWO-COORDINATE MINI-DRIFT CHAMBER OPERATING IN A SELF-QUENCHING STREAMER MODE

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1. INTRODUCTION

The self-quenching streamer (SQS) mode of operation used in drift chambers [1] provides certain advantages as compared to proportional mode of operation, namely the high amplitude of anode signal enables one to substantially increase electronic registration threshold, while the independence of the signal against ionization loss in chamber offers a means for operating in a single-cluster mode being important for the determination of coordinates of inclined tracks. The SQS mode is rather stable and the anode signal height is insignificantly influenced by changes in composition of the working gas mixture. Total number of detected particles is limited by $(6-7)\cdot 10^9$ per cm of anode wire [2,3]. Local rate depends on the gas mixture and is defined by the dead region being the product of the length of a nonsensitive anode wire section by its dead time. As exemplified by the argon isobutan mixture, this region is 330 ms·cm [4] and counting rate is $3\cdot 10^3$ per cm of the anode wire length. The introduction of a delay line (DL) for determining the second coordinate (along the anode wire) due to a signal induced in cathode also limits the counting rate and the number of simultaneously registered particles. Nevertheless, in the cases with relatively small number of registered tracks the two-coordinate SQS chambers offer a means of reducing the number of detectors.

2. DESIGN OF CHAMBERS

A drift chamber with a sensitive size of $700\times 300\ mm^2$ consists of five planes (Fig.1) — that of anode, two cathode and two drift ones. The external planes are made of aluminized kapton 30 μm thick. The cathode planes are wound by a Cu—Be wire of 50 μm in diameter with a 2 mm pitch. To provide the coordinate anode wire readout, the upper cathode wires have been combined in strips (with three wires per strip). One strip end has been connected with the high voltage power supply via a 1 Mohm resistor, while another has been connected with the DL via a 220 pf capacitor. An anode plane consists of alternate potential and anode wires orthogonal to cathode ones. The winding pitch of anode and potential wires is the same and equals 8 mm. The anode and potential

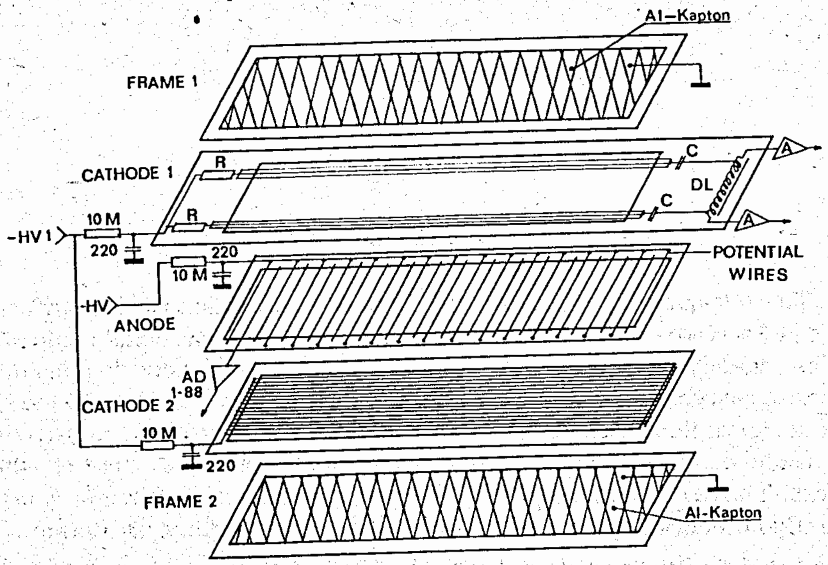

Fig.1. The general view of chambers. FRAME 1,2 — isolating frames, DL — delay line, HV1 — cathode high voltage, HV — high voltage applied at potential wires, AD — amplifier-discriminator (8 channels per plate), A — amplifiers

wires are 50 and 100 μm in diameter, respectively. The spread in thickness of fiberglass frames has amounted to less than ~ 25 μm.

3. REDOUT ELECTRONICS

The signals from each anode wire have been sent into the relevant amplifiers manufactured by means of surface mounting technology. a series 100 Ohm resistor and a two diode VAB 99 has been used as a protection means. Further on the signal has been fed into an IC UA 733 with ajustable amplification factor and then into a fast analog comparator AD 96 685 (t_{delay} = 2.5 ns).

The second comparator input is fed by the threshold voltage, while the required duration of the input signal (t = 300 ns) is formed via the control input. The formed signals are sent into the IC VC 10H101, the paraphase outputs of which are used to form the output signal transmitted into readout electronic via a flat cables (twisted pairs). To control the readout system one can use a test signal. This signal as well as the pickup threshold voltage are directed through the 26 pin input connector of the amplifiers. The voltage of the signal «threshold» is common to all eight amplifier's channels and all of the amplifiers mounted at a detector. The use of the 5% resistors and the modern ICs have

enabled us to get, without any additional tuning, the following spreads in 250 channels; thresholds — 10%, time alignment — < 0.2 ns.

The apmlifier-discriminator has the following parameters:

— number of channels	8
— input resistance	200 Ω
— risetime	< 5 ns
— minimum pickup threshold	5 μA
— intrinsic jitter	< 0.1 ns

(for a signal exceeding the pickup threshold by 10%).

The second coordinate has been measured with a DL possessing the following parameters: specific delay — 2 ns/mm, impedance — 310 ohm, attenuation ratio — < 25%, output signal risetime — < 50 ns. Following the amplification the signals from opposite DL ends had been fed into the constant fraction discriminators and further on into a time-to-digital converter. Within the dynamic signal range of ~ 10 the intrinsic time resolution has amounted to ~ 1,5 ns.

4. EXPERIMENTAL RESULTS

Figure 2. and 3 illustrate the computed data for the field map inside the chamber and the electron drift times for normal and inclined particle enters into the chamber. The linear part is seen to be about 3.2—3.3 mm, while the major contribution into nonlinearity is due to the regions near anode and potential wires.

The SQS mode of chamber operation has been studied for different argon-isobutane ratios in gas mixture. The anode pulse height in the initial part of the SQS mode is practically independent of gas mixture composition to amount to 200—250 μA, while the pulse risetime has been effected to 15 ns by wiring capacitance, input capacitance of the amplifier. Counting plateau have been measured with the radioactive sources Fe^{55} and Ru^{106} at different thresholds of the amplifier-discriminator (Figs.4 and 5).

In the case of Ru^{106} the coincidence circuit has been gated by a scintillation counter signal. An increase in the isobutane fraction in the gas mixture is accompanied by a significant plateau's extension, with increase in the voltages applied to both cathodes and a potential. Since the high voltage capacitors for isolating cathode strips and DL are placed outside gas volume, the probability of leakage is strongly inhanced with voltage, therefore the isobutane fraction has to be minimized. As follows from Fig.5, the transition into the SQS mode is

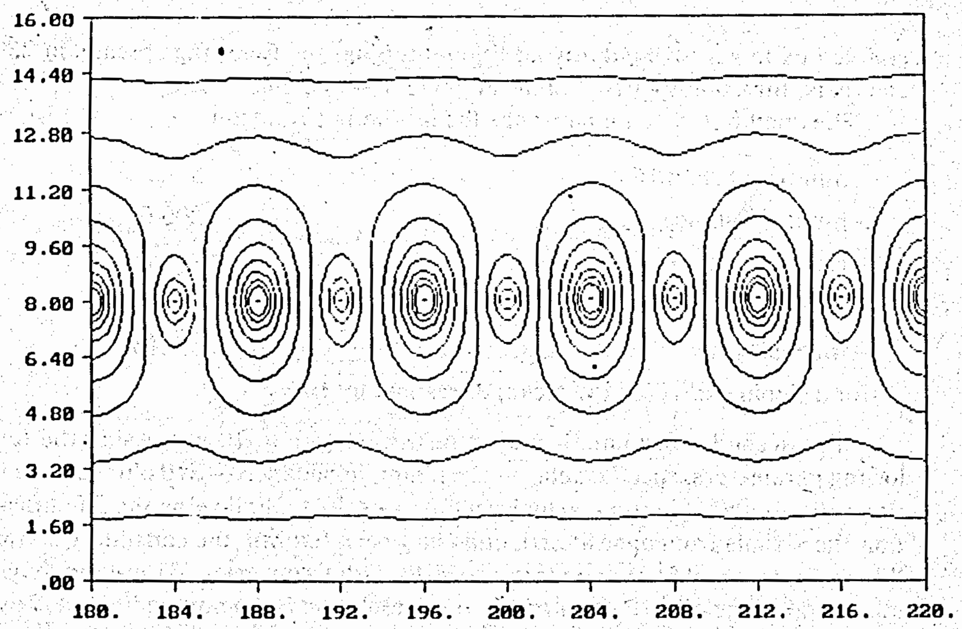

Fig.2. Calculated field maps in drift chambers. The distances along the *x*- and *y*-axes are give in mm. The potential difference between anode and potential wires is 2500 V

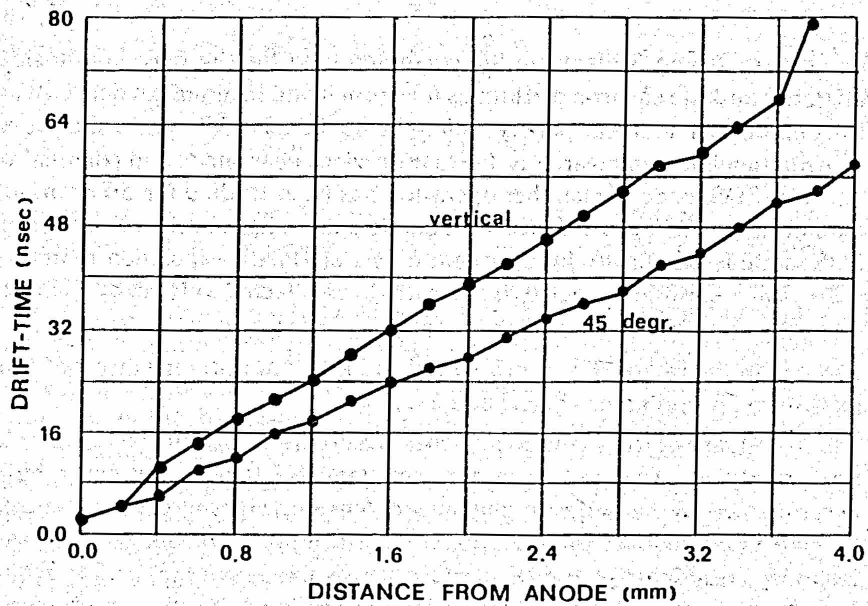

Fig.3. The calculated dependence of electron drift velocities on particle passage coordinate. The gas mixture — argone/isobutane (25/75%). The voltage on potential wire is 2500 V

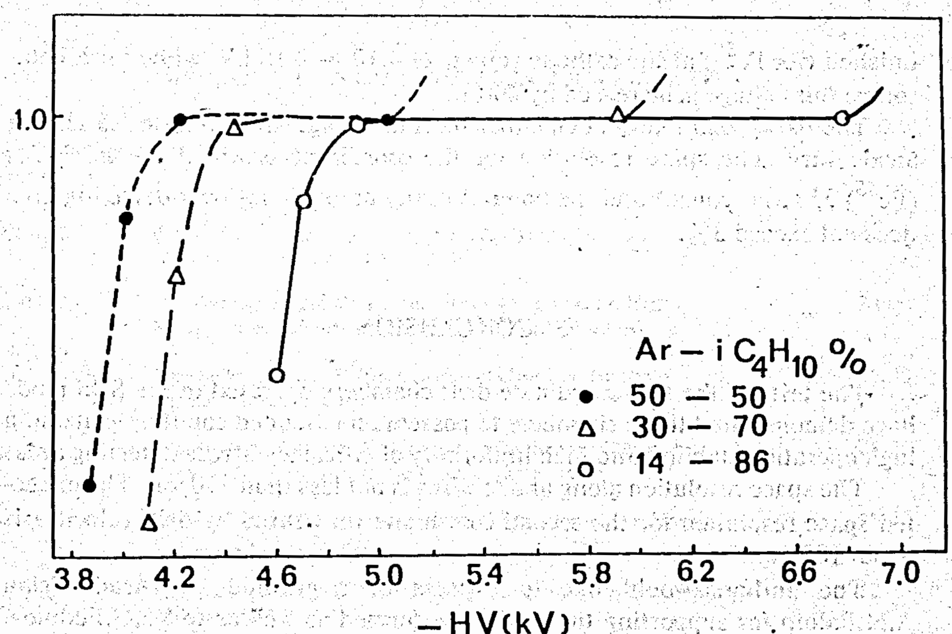

Fig.4. Counting plateau of chambers for different argon/isobutan ratios in gas mixtures. The threshold of amplifiers-discriminators is 100 μm

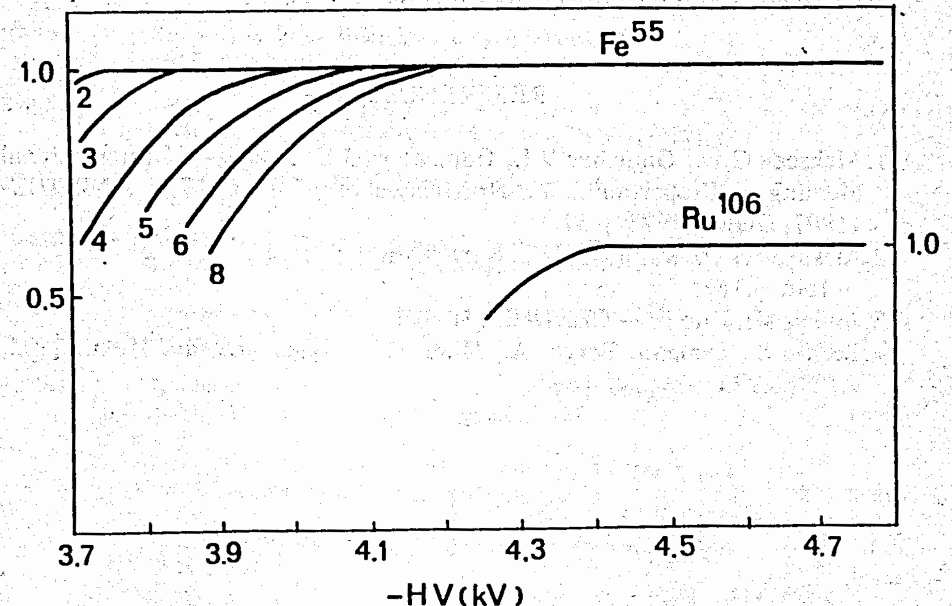

Fig.5. Counting characteristics of chambers for different thresholds of an amplifier-discriminator. Curve 1 — for Fe^{55}, curve 2 — for Ru^{106}. The thresholds of discriminators from 0 to 8 correspond to the range 0—300 mkA (step 40 μA)

finished (for Fe^{55}) at the cathode voltage of 4.10 — 4.15 kV, while for a beta-source this voltage is increased by 300 V.

The background level of chamber has on average amounted to 1.5 Hz per anode wire. The space resolution for the coordinate provided by the DL is (Fe^{55}) 250 μm (r.m.s.) and the nonuniformity of efficiency over detecting area does not exceed 3%.

5. CONCLUSION

The tests of the two-coordinate drift chambers operated in the SQS mode have demonstrated these chambers to possess an extended counting plateau, a high operation stability and high uniformity of efficiency across detecting area.

The space resolution along anode wires is not less than 250 μm. The expected space resolution for the second coordinate (measured by drift velocity) is about 100 μm.

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