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RESULTS OF TESTS ON A LARGE MULTIWIRE PROPORTIONAL CHAMBER

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1. INTRODUCTION

This work reports on measurements made with a prototype multiwire proportional chamber (MWPC)[1)] for an experiment to measure proton-proton elastic scattering at the Intersecting Storage Rings at CERN. The experimental apparatus will have a spectrometer arm along each of the two rings, situated downstream from an interaction point. Each arm consists of a septum magnet around the beam, three MWPC chambers, and a layer of scintillation counters. Two of the chambers, one before and one after the magnet, will have three planes of read-out wires, one horizontal, the other two oriented ±60° to the first. The third chamber will be placed in the middle of the magnet with two planes of vertical read-out wires.

The sensitive area of the chamber before the magnet is 680 × 390 mm^2; of the chamber in the magnet, 680 × 600 mm^2; and of the chamber after the magnet, 1980 × 810 mm^2. All the chambers have a wire spacing of 2 mm and a gap of 6 mm. These chambers, together with four other chambers used to measure the beam luminosity, give a total of about 10,000 wires.

The prototype chamber is the same size as the chambers before the magnets.

2. THE CHAMBER

The chamber consists of seven frames, each of which supports either a read-out or an HV plane. The frames are made of fibre-glass-reinforced epoxy resin (Vetronite). The frames are stacked together and sealed with O-rings. They are positioned and fixed with dowels on a stainless-steel frame, which provides rigidity. The HV planes consist of 10 μ thick aluminium foils which are glued with silver-epoxy on a double-face printed board. This printed board carried the high voltage on one side and the ground on the other. For one test a conventional wire plane was used instead of the foils. Table 1 gives the specifications of the chamber.

3. ELECTRONICS

The electronic circuit for reading out the chambers was a simple one-shot device without a pre-amplifier, similar to one proposed by Rubbia[2]. The one-shot had a threshold of 10 μA (∿ 5 mV) and delivered output pulses of a standard length. The back edge of the differentiated output pulse was reshaped and stretched to give the final signal. Hence the one-shot served simultaneously as threshold element and as delay.

Figure 1 shows the circuit diagram. The basic unit, the first one-shot, has as active part one of the four differential amplifiers of the inexpensive Motorola MC-1020-P integrated circuit. The threshold is determined by the external non-linear element, the conducting biased transistor MPS 3563. This idea of using a non-linear element in a trigger circuit has recently been suggested by Tarlé and Verweij[3]. The pulse length, which is determined by the RC constant of the feedback loop, was set to 250 nsec. The circuit did not respond to positive pulses smaller than 750 μA.

The second one-shot served to reshape the differentiated pulse and gave a standard output of 50 nsec length.

4. RESULTS

A layout for the efficiency measurements is shown in Fig. 2. The radioactive source used was ^{106}Ru (∿ 10 μCi). A coincidence between the two scintillation counters was used as monitor, and the coincidence between this and the chamber gave the efficiency.

The two parameters which we wanted to optimize for our chambers are efficiency and dark current, the counting rate without presence of a source.

4.1 Efficiency, dark current and timing

Using a magic mixture[4] with 0.4 freon, ∿ 17% isobutane, and ∿ 83% argon we obtain the efficiency curve shown in Fig. 3. The efficiency for voltages above 4.55 kV is as high as 99.4%. The counting rate due to noise in the chamber increases slowly with voltage until 250 V above the knee of the plateau, where it is 15 events/wire-sec. Above this voltage the dark current increases more rapidly.

In early tests, the singles rate due to the dark current was different across the chamber, being two orders of magnitude higher near the centre than at the edges. However, the efficiency plateaux did not differ by more than 100 V from one part of the chamber to another. The higher singles rate was correlated with sagging of the electrodes under the electrostatic forces. In fact, this effect disappeared later when more care was taken to preserve the chamber geometry under the action of electrostatic forces.

Figure 4 gives the efficiency as a function of the delay between the triggering counters and the chamber signal of the output of the electronics. For pulse widths of 10 nsec for the scintillation counters and 50 nsec for the chamber pulses, the efficiency rises from 10% to 90% varying the delay by 24 nsec.

4.2 Effect of freon concentrations

In Figure 5 the efficiency curves are presented for three freon concentrations. The beginning of the plateau moves to higher voltages as the freon concentration goes up. However, the efficiency drops off at 0.8% in agreement with previous results[5]. The rise of the dark current, measured as current flow through the chamber, is also displaced to higher voltages. With 0.8% freon, the rise is particularly sharp. Here, the current rises only several seconds after the voltage is increased above the critical value. A noise is audible in the chamber, coincident with this sudden rise in current. Looking at the HV electrode with an oscilloscope, we see the pulses of a discharge starting simultaneously. The transition is smoother at lower freon concentration.

By increasing the freon concentration, the voltage range for pulse efficiency and for dark current shifts towards higher voltages, but is approximately constant in length.

4.3 Type of HV electrodes

Using 50 μ wires as the HV electrodes, and a magic mixture with 0.4% freon, ∿ 17% isobutane, and ∿ 83% argon, a discharge was visible at the cathode, beginning at 4.0 kV and increasing with voltage. Furthermore, the chamber began sparking at 4.6 kV, only 300 V above the beginning of the plateau (Fig. 6a). With the aluminium foil, the field at the cathode is reduced. The plateau extends to much higher voltages and breakdown does not present any problem (Fig. 6b; the difference between supply- and chamber-voltage is due to the 5 MΩ current limiting resistor).

5. CONCLUSIONS

With a simple electronic circuit without amplifier, it is possible to get good efficiency and timing for the magic mixture. Using foils as HV electrodes, the dark current stayed at a low level and began rising only 250 V above the full efficiency level.

ACKNOWLEDGEMENTS

We would like to thank the Steinberger group, particularly Drs. K. Kleinknecht, S. Wahl, P. Sletten and D. Zanello, for useful discussions and for informing us in detail about the mechanics of their chambers. We are also grateful to Dr. G. Coignet for many fruitful conversations on the operation of multiwire proportional chambers.

Table 1

Specifications of prototype chamber

Chamber size	$508 \times 1078\ mm^2$	
Sensitive volume	$348 \times 918\ mm^2$	
Frame width	80 mm	
Gap between electrodes		6 mm
Read-out planes:	- wires	20 μ gold-plated molybdenum
	- wire tension	50 g
	- wire spacing	2 mm
	- wire inclination	$0 \pm 60°$
	- No. of wires of 0°	176
	- No. of wires of ±60°	288
HV planes with aluminium foil		
	- thickness	10 μ
HV planes with wires:	- wires	50 μ Cu-Be
	- wire spacing	1 mm
	- wire tension	110 g

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2) C. Rubbia, CEAL 1054 (1970).

3) J.C. Tarlé and H. Verweij, Nuclear Instrum. Methods 78, 93 (1970).

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5) R. Bouclier, G. Charpak, Z. Dimčovski and F. Sauli, CERN Internal Report NP 70-2, January 1970.

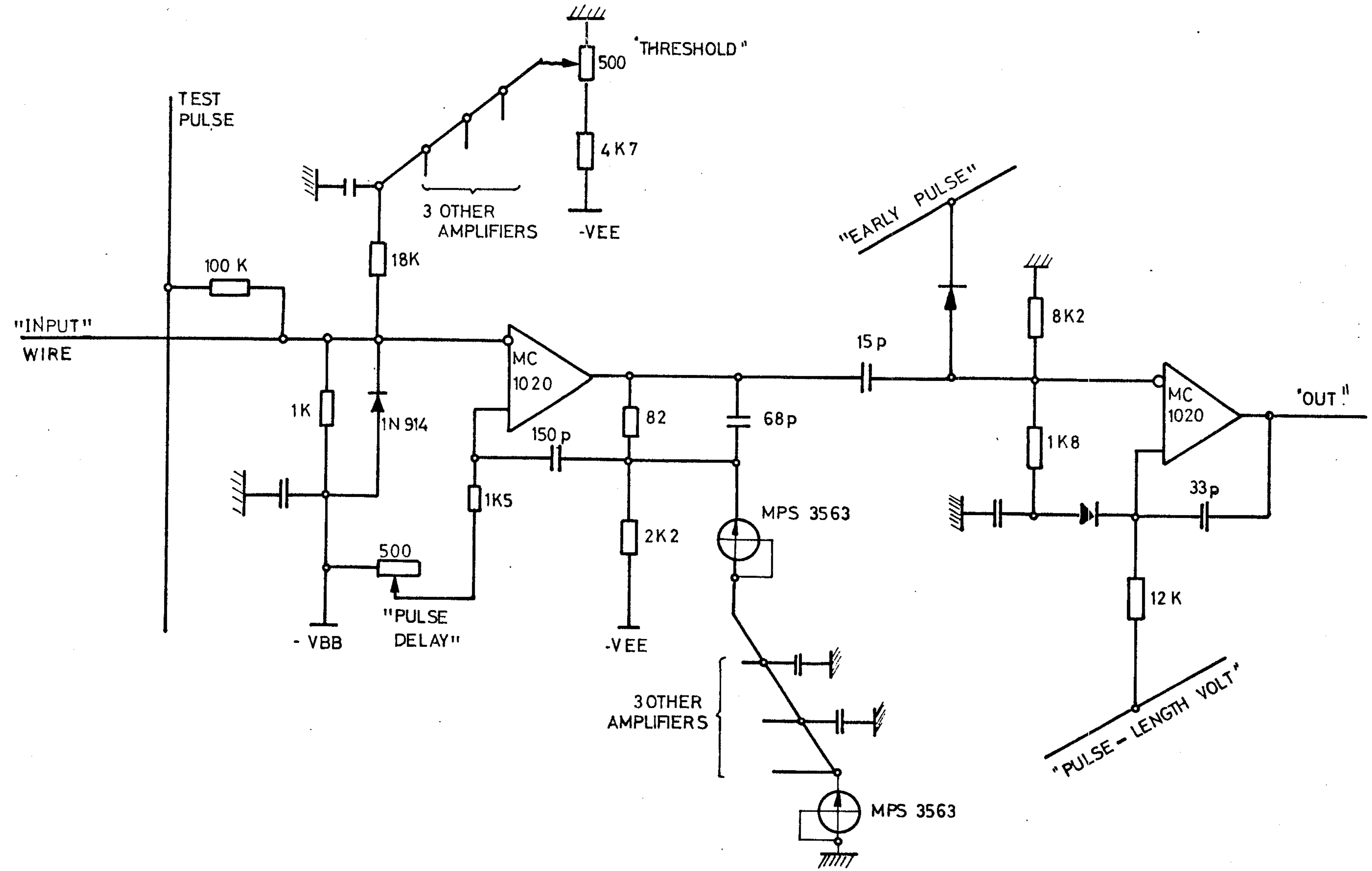

Fig. 1 Read-out electronics

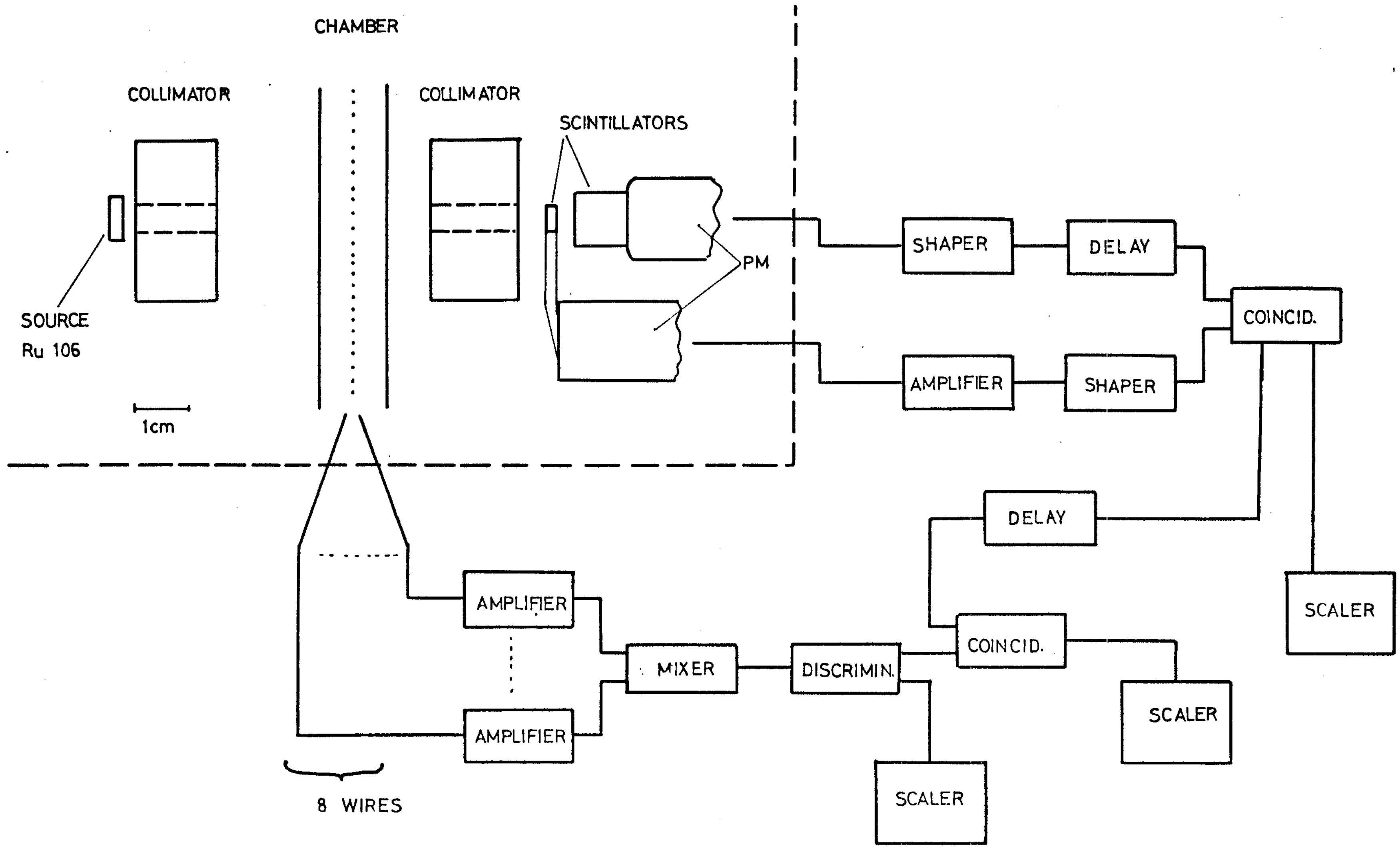

Fig. 2 Arrangement for efficiency measurement

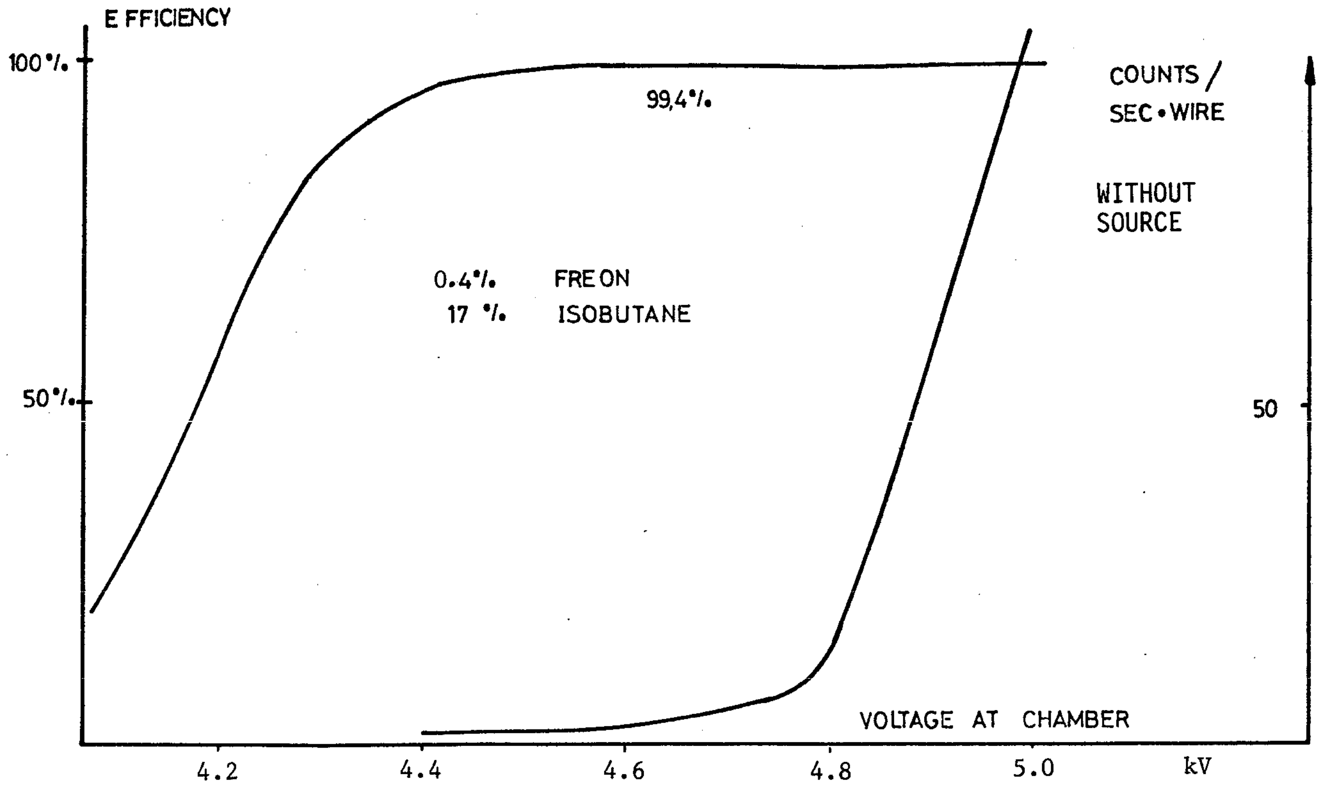

Fig. 3 Efficiency and dark-current counting rate

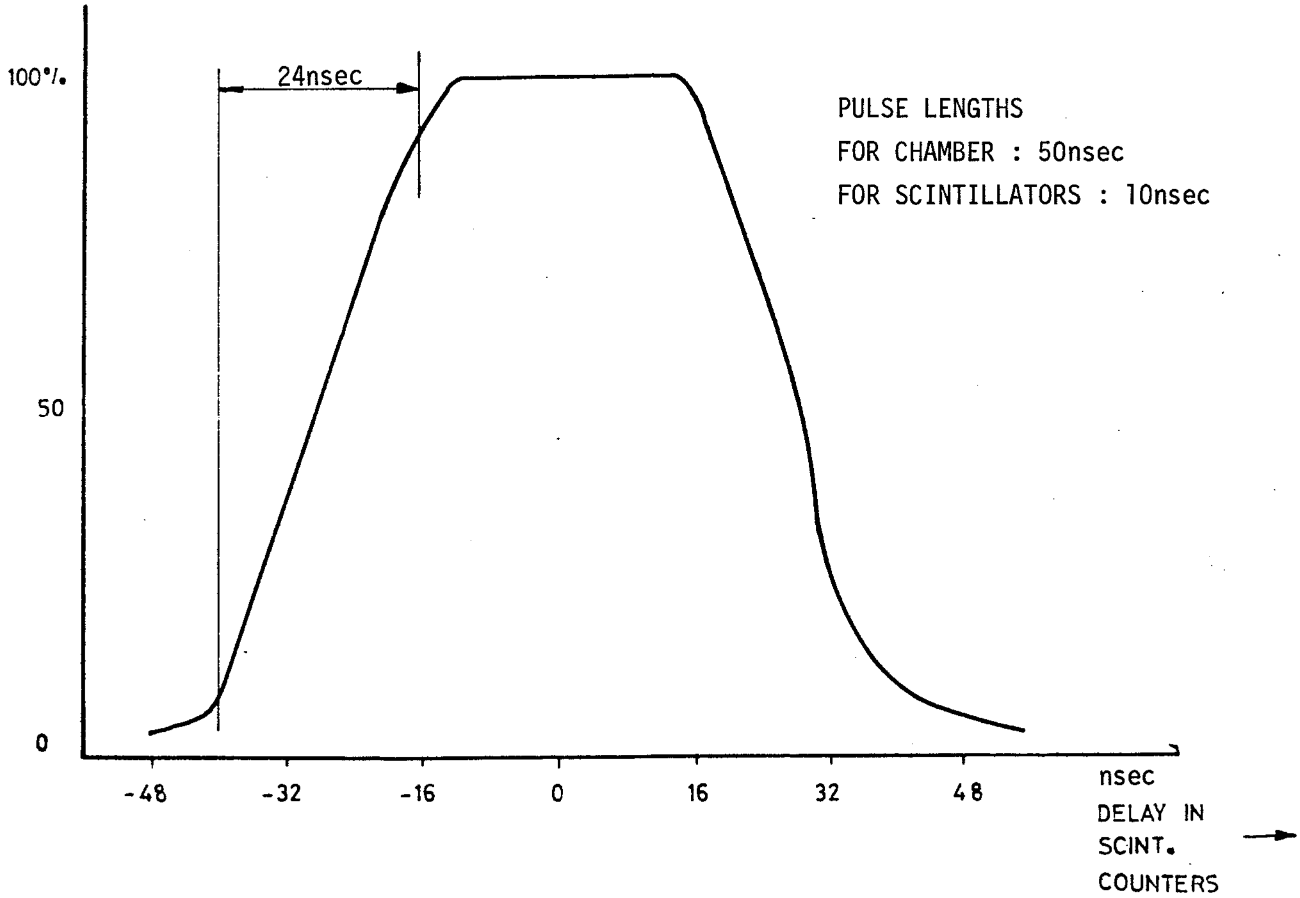

Fig. 4 Timing curve for coincidence between chamber and scintillation counters

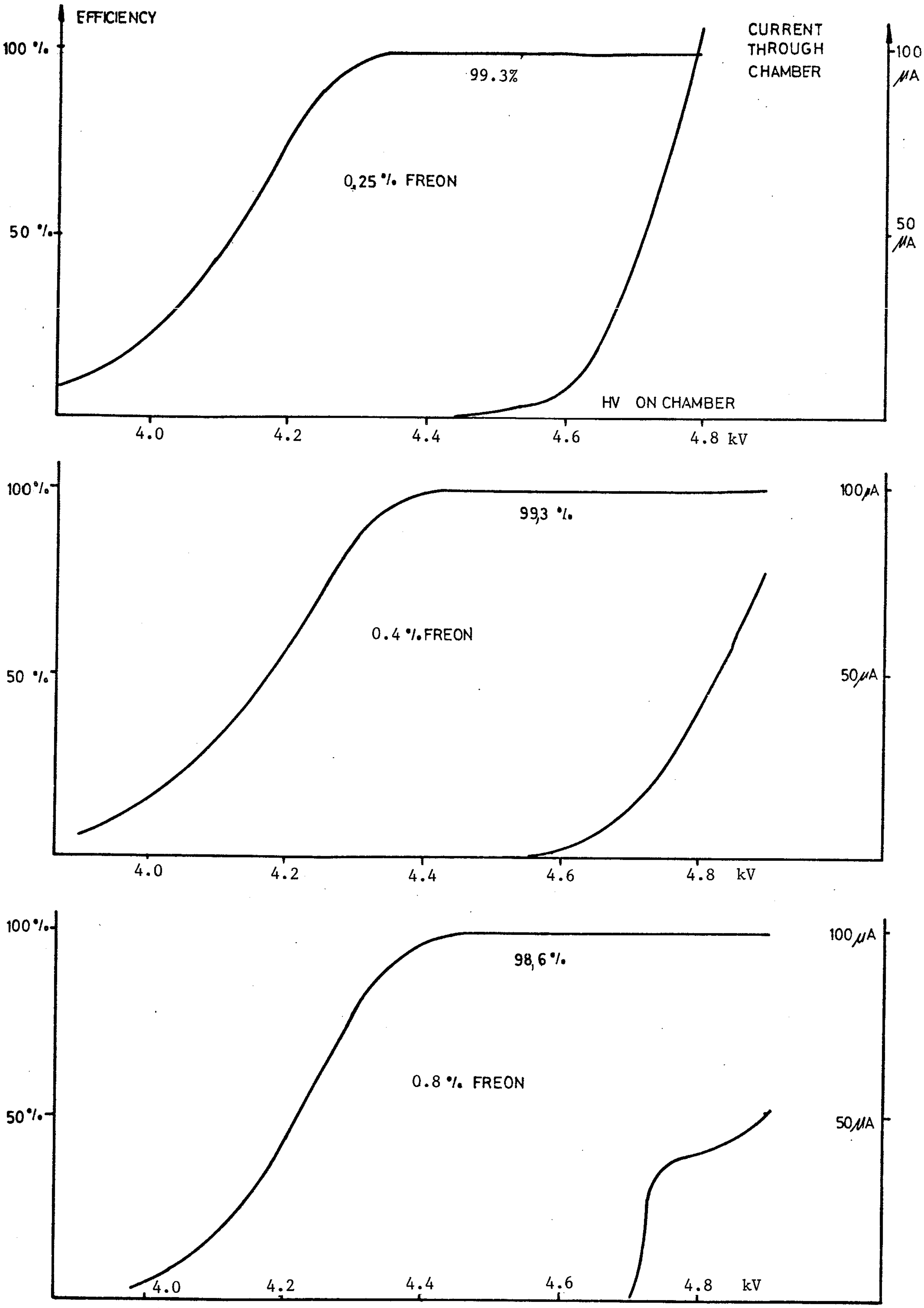

Fig. 5 Efficiency and current in the chamber with 17% isobutane

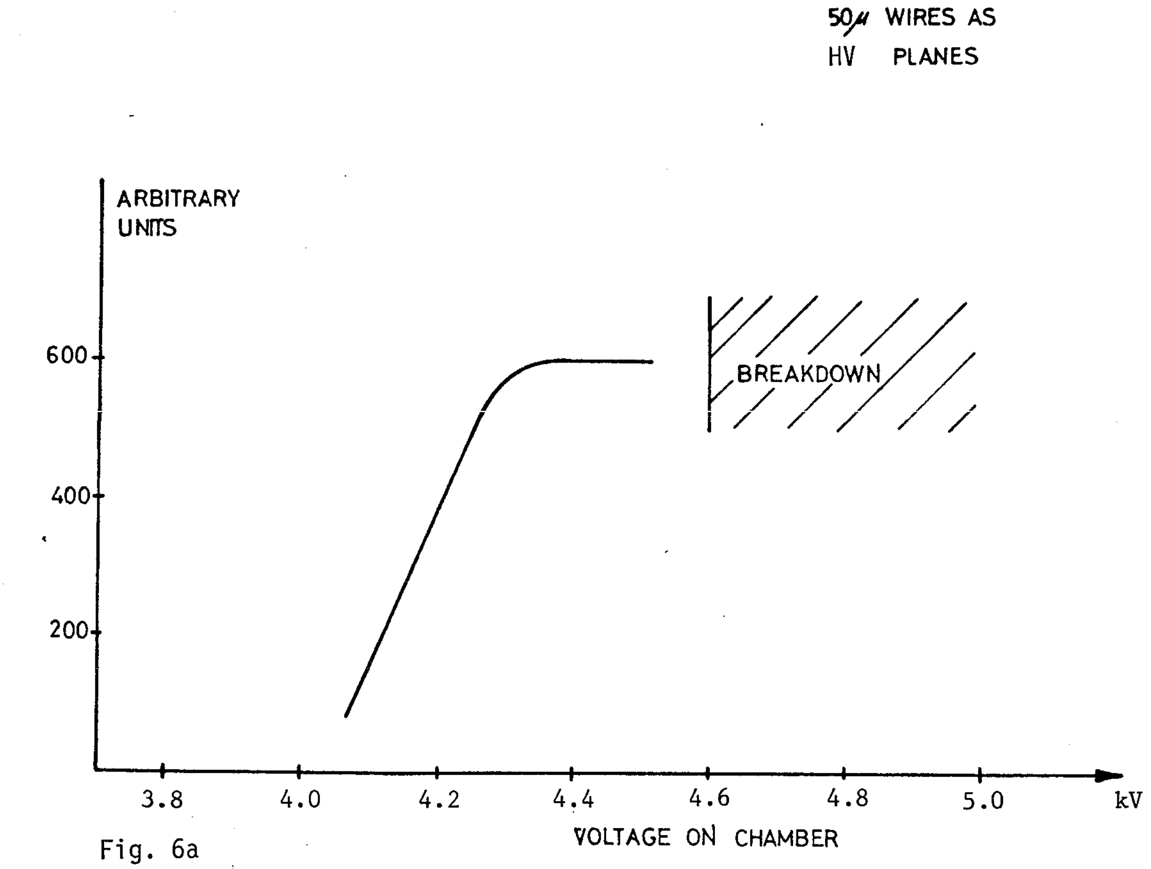

Fig. 6a

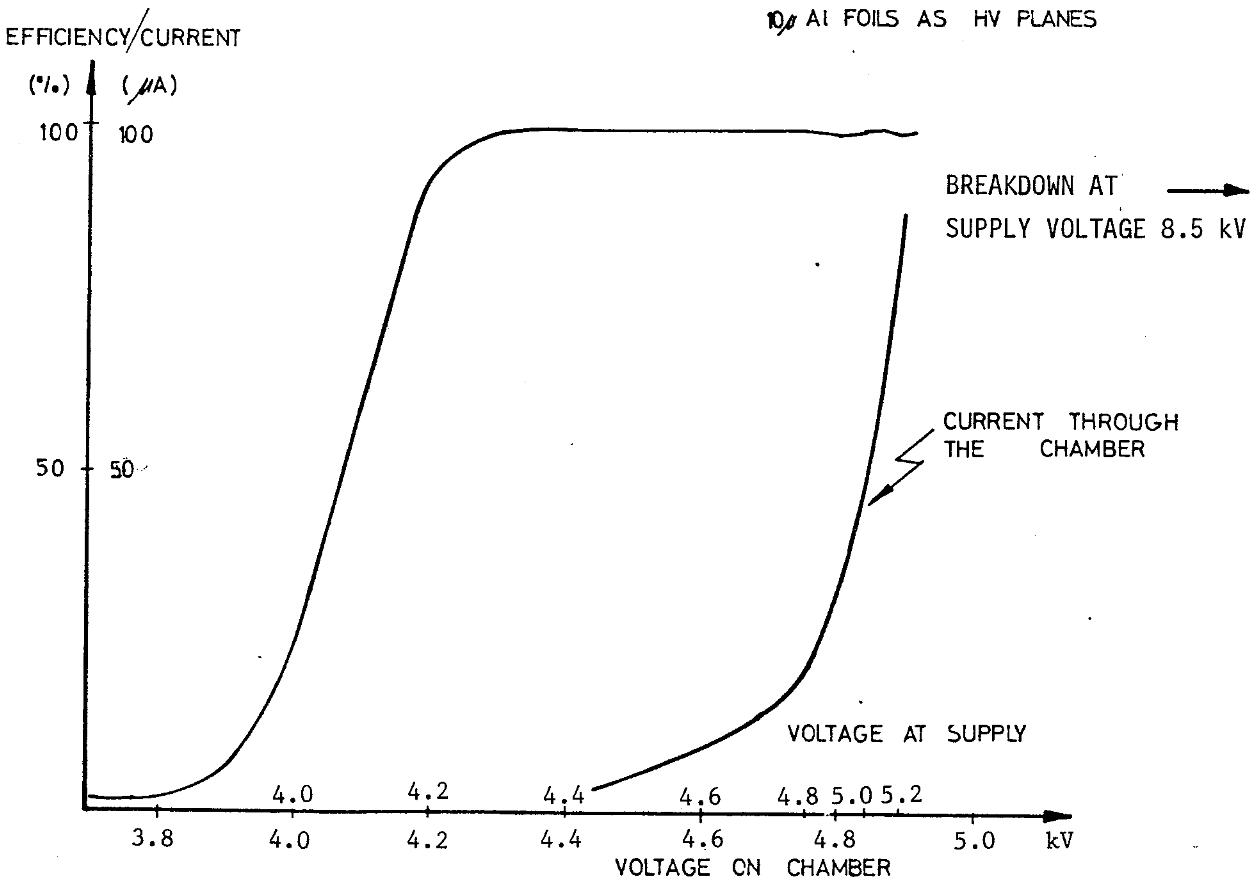

Fig. 6b Comparison of HV planes with wires and Al foils