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EXPERIMENTAL STUDY OF HIGH FLUX IN MULTIWIRE PROPORTIONAL CHAMBERS

P. Le Dû, P. Borgeaud and G. Burgun
CEN, Saclay, France

R. Hammarström, R. Lorenzi and A. Michelini
CERN, Geneva, Switzerland

ABSTRACT

We have performed measurements in order to test the behaviour of multiwire proportional chambers (MWPC) in high fluxes. We have investigated the efficiency for various fluxes as a function of six parameters:

- the high voltage
- the input threshold
- the gas mixture
- the wire spacing
- the wire diameter.

Tests were also made on the lifetime of those chambers in the highest available flux (10^5 part./mm^2/sec) for different cathode materials.

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1. FLUX MEASUREMENT

1.1 Layout

1.1.1 Mechanical characteristics of the MWPC

The chamber is a standard 10 × 10 cm^2 CERN PS beam MWPC shown in Fig. 1. The wire and HV planes are changed according to the parameters to be modified:

Chamber	Wire spacing (mm)	Ø wire (µm)	Gap (mm)	Cathode
1	1	10	5	C a) or Al b)
2	1	5	5	C
3	3	20	6	C

a) 25 µm mylar plane coated with graphite spray*).
b) 10 µm aluminium plane or 25 µm aluminized mylar.

1.1.2 Gas

The gases used were either the "magic gas" (24% isobutane, 4% methylal, 0.5% freon + argon), or the Ar-CO_2 mixture (49.5%-50% + 0.5% freon).

1.1.3 Preamplifier

The preamplifier is described elsewhere[1]. It has a low input impedance (100 Ω), and a threshold adjustable between 1 µA and 6.5 µA.

1.1.4 The amplifier and the read-out memory will be described in another report[2]. The whole system has 360 nsec time resolution for double pulses, where the second pulse is 1/10 of the amplitude of the first. The pretrigger was not used in this test.

1.1.5 The particle source

The 2.2 MeV electrons are emitted by a 50 mC ^{90}Sr collimated source. Then the maximum flux available is 10^5 part./mm^2/sec.

1.1.6 Beam intensity calibration

The beam is defined by two small scintillation counters A and B, as shown in Fig. 2. The wire plane No. 1 was used for the efficiency measurement.

The beam profile at the level of the sensitive wires was 3.3 × 3.3 mm^2. Therefore the maximum flux measured is 10^5 part./mm^2/sec.

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*) Isopropylalcohol in butylacetate.

The beam intensity at the level of wire plane 1 is measured by taking the chamber out and putting counter A at the place of the wires. In order to take into account the gas mylar window and the first cathode plane, we have placed the same amount of material in front of counter A. This number is compared to the number of coincidences in C = A × B, and is then used as the reference.

The ratio

$$K = \frac{\text{A at the place of wires 1}}{\text{(A × B) in normal operation}}$$

does not change when we vary the flux of the source.

1.2 Electronic logic

The logical design of the measurement is shown in Fig. 3. We measure

- the rate in C = A × B,
- the accidentals AC in A × (B + 500 nsec),
- the OR signal which is the coincidence between C and the 8 OR-ed wires,
- the accidentals AOR in the OR circuit.

The true efficiency is given by the ratio

$$\varepsilon = \frac{OR - AOR}{C - AC} .$$

The width of strobe in OR is adjustable by the shaper D. The width of D for full efficiency depends on the gas mixture: see later discussion.

1.3 Results

1.3.1 1 mm wire spacing measurements with 10 μm diameter wires

The measurements give the efficiency as a function of the input threshold and the high voltage. They are done for two gas mixtures:

- magic gas (Figs. 4, 5, 6, 7)
- argon-CO_2 (Figs. 8, 9).

Magic gas

Figures 4, 5, 6 give the plateau curves for different fluxes: one figure for each threshold (1 μA, 3.5 μA, and 6 μA). One feature is the existence of nice plateaux whose levels decrease as the flux increases. All curves are similar but the plateau is shifted when the threshold increases at a rate of ∿ 70 V per μA.

Figure 7 gives the same results in a way which shows that it is not worth while to lower the input threshold under a given value which depends on the high voltage.

Argon-CO_2 mixture

Figures 8 and 9 are similar to Figs. 4 and 7: they show that the plateaux occur about 1000 V higher than for magic gas, but that the maximum efficiency reached at each flux has the same value.

Figure 10 summarizes both results: all the points shown are on the different plateaux, whatever the flux, the threshold, or the gas.

1.3.2 1 mm wire spacing measurements with 5 μm diameter wires

The wire diameter does not affect the previous results, as shown in Fig. 11. Magic gas is used but we have checked that the result is the same with the argon-CO_2 mixture.

1.3.3 3 mm wire spacing measurements with 20 μm diameter wires

The results given in Fig. 12 are for magic gas only. They are qualitatively the same as for 1 mm wire spacing, but the efficiency reached on the plateau at maximum flux is lower.

Figure 13 shows the efficiency as a function of the linear density of particles per mm of wire. It can be seen that the linear density is the true important parameter, as all points, independently of the wire spacing, fall on the same line. For instance, one can reach 90% efficiency if the linear flux does not exceed 4.2×10^4 part./mm/sec. To reach with this efficiency a flux of 1.5×10^5 part. per mm/sec, it is necessary to build a chamber with 0.25 mm wire spacing. If such a spatial resolution is not required, the wires can be associated in strips, each strip (example: 4 wires = 1 mm) connected to one amplifier.

2. LIFETIME MEASUREMENT

We have performed lifetime measurements on chambers of types 1 and 2. Two gases were used: magic gas and the Ar-CO_2 mixture. Three kinds of cathode material were tested:

- aluminium foils
- aluminized mylar
- graphite deposited with a spray-on mylar*).

The results are summarized in the following table:

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*) 5 μm micrographite coated.

HV plates	Gas	Deposit HV	Plateau length for 1 μA threshold after		
			10^{11} part./cm^2	10^{12} part./cm^2	10^{13} part./cm^2
Aluminized mylar or Al foils	Magic	Yes	800 V	200 V	No plateau
	$Ar-CO_2$	Some suspect deposit	800 V		700 V
Graphited mylar	Magic	No	800 V		800 V
	$Ar-CO_2$	No	800 V		800 V

After $\sim 10^{13}$ part./cm^2 irradiation the chamber is opened:

- The aluminium or aluminized mylar foil shows a white deposit over a wide area around the beam region, both with the magic gas and the $Ar-CO_2$ mixture (Fig. 14).
- The graphite plane shows no such effect.
- The wires in the case of coated aluminium HV planes also show the white deposit, but nothing appears for the wires between the graphite planes. However, in the latter case, the wires show some local modification of the gold plating. We did not notice any carbon transportation through the chamber due to an alteration of the carbon (liant) even with gaseous methylal in the chamber (the methylal is a solvant for the carbon "liant").

3. CONCLUSION

3.1 Flux measurements

Results show the following:

1) At each flux a maximum efficiency is reached that cannot be improved either by lowering electronic threshold or highering voltages. This seems to indicate that each particle creates around the wire a dead zone in which, during a given time, there is no multiplication at all for any following particle. At high flux, the dead zones occupy a significant fraction of the wire.

2) The different gas mixtures play no role in the maximum efficiency that can be reached at each flux. This probably means that the mobility of the positive ions responsible for the space-charge effect does not vary very much from one gas to another.

3) The only parameters which can be played with in order to improve the performances are the wire spacing and, to a lesser extent, the gap width.

3.2 Lifetime measurements

The graphite HV plane seems to be a real improvement for the lifetime and seems to be usable indefinitely. It is not the same for the wires. As the Ar-CO_2 mixture brings no improvement to the lifetime problem, the magic gas seems to be better suited for gas amplification reasons and HV behaviour.

* * *

REFERENCES

1) R. Hammarström, Multiwire proportional chamber preamplifier for high counting rates, CERN NP Internal Report 75-6 (1975).

2) R. Hammarström, Multiwire proportional chamber amplifier for high counting rates (to be published).

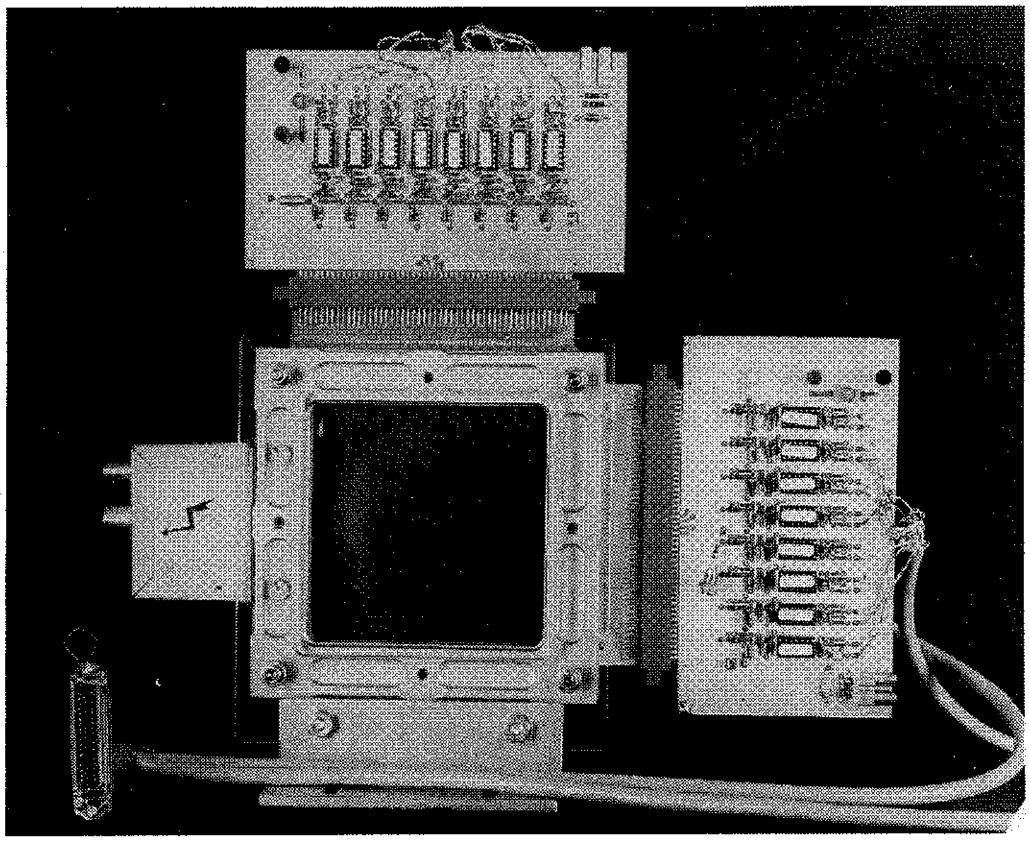

Fig. 1 View of MWPC and preamplifiers.

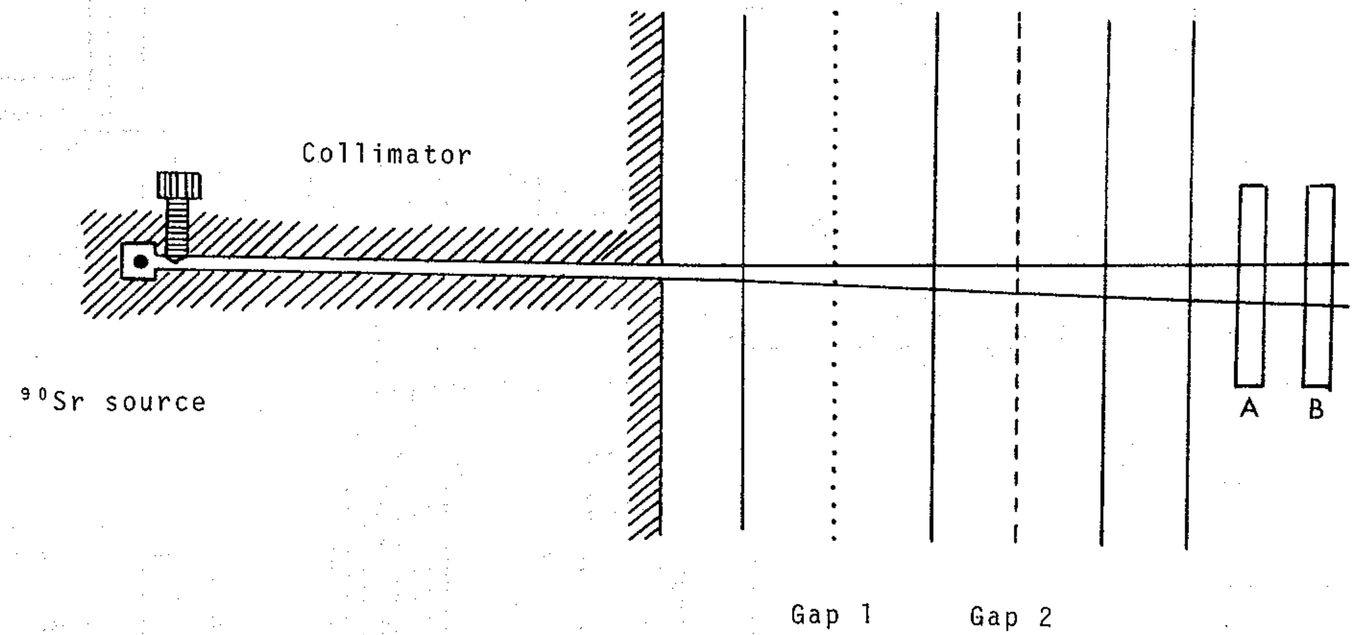

Fig. 2 Experimental layout.

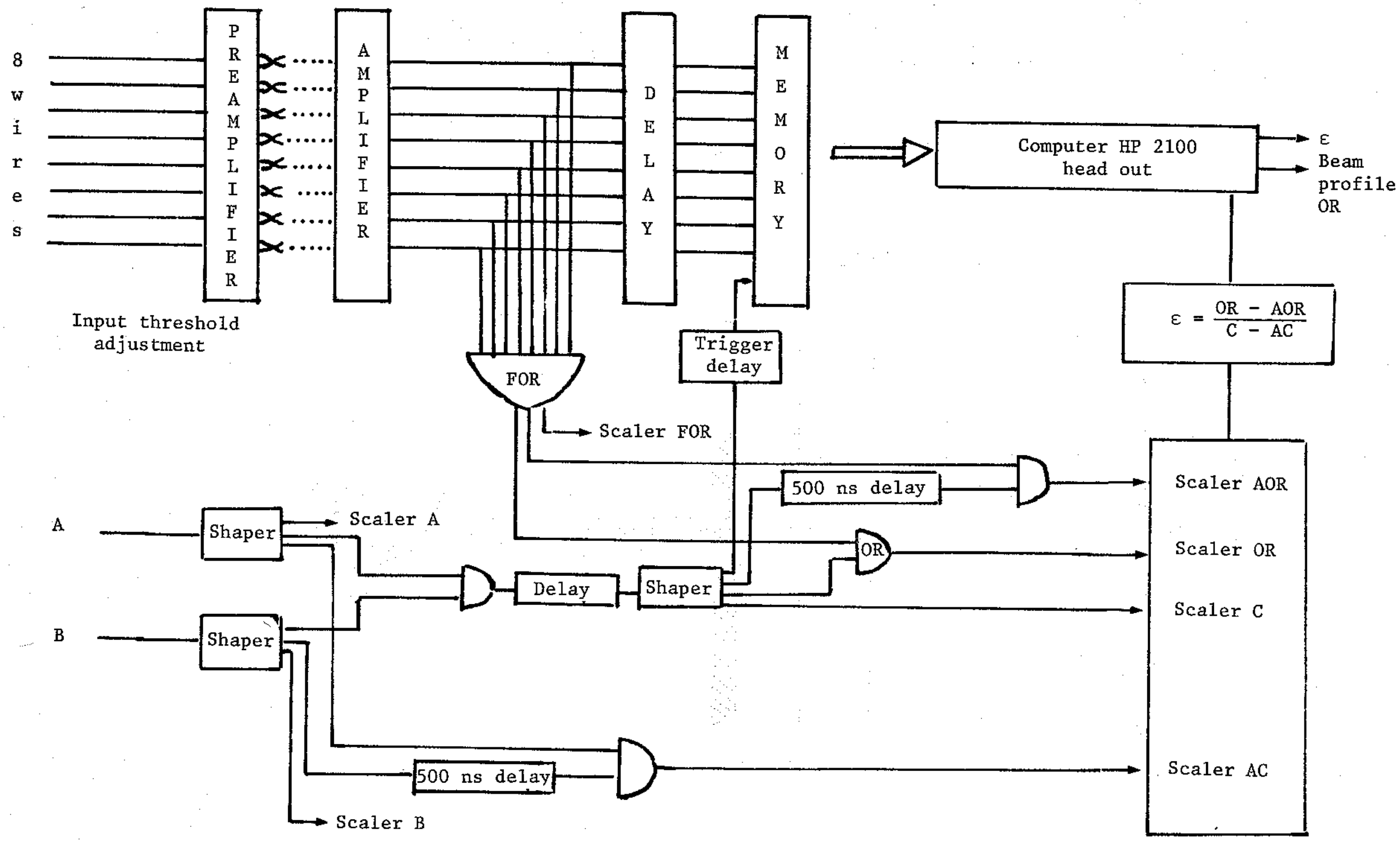

Fig. 3 Schema of the electronic.

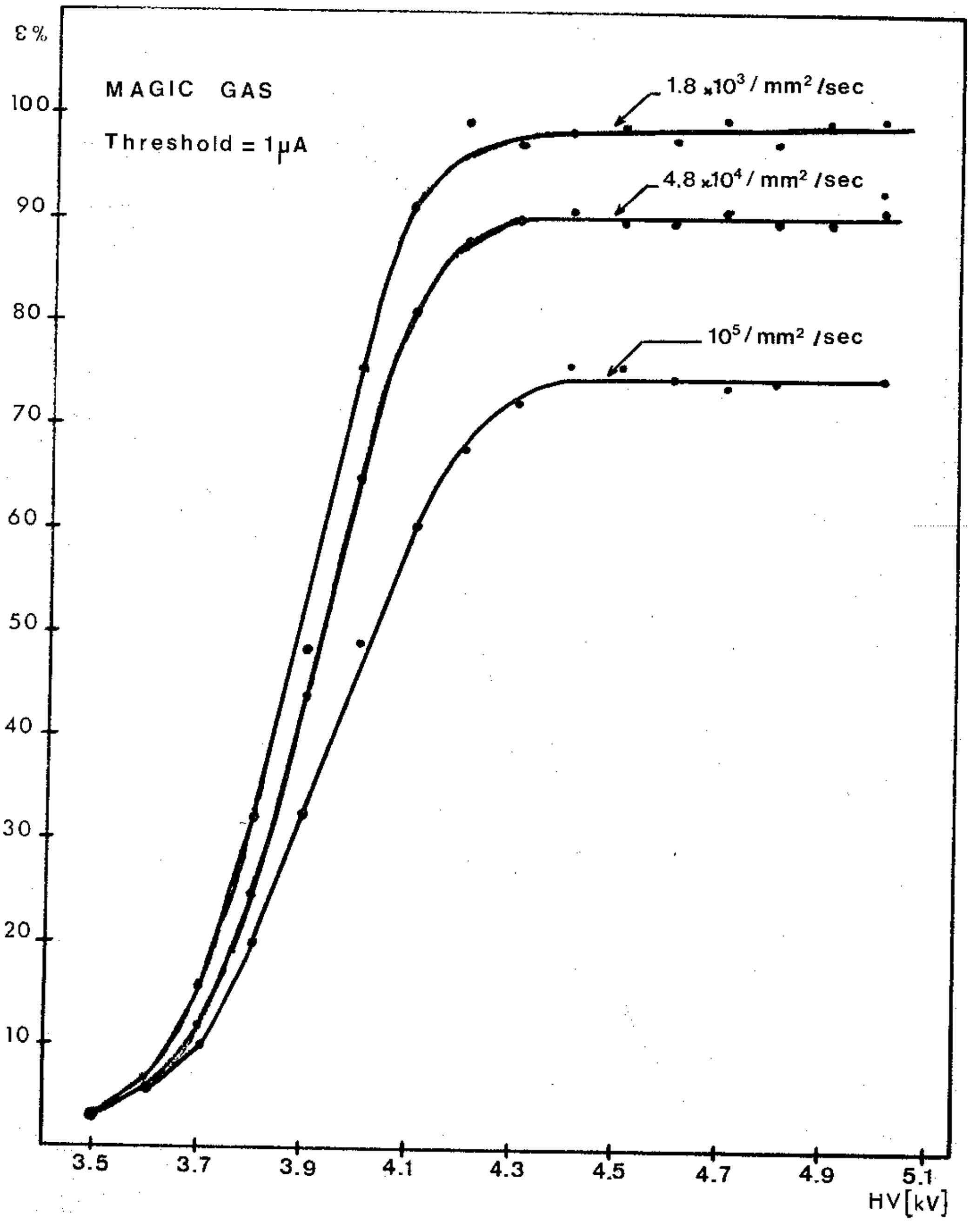

Fig. 4 Efficiency versus H.V. for different fluxes and different thresholds (Magic gas).

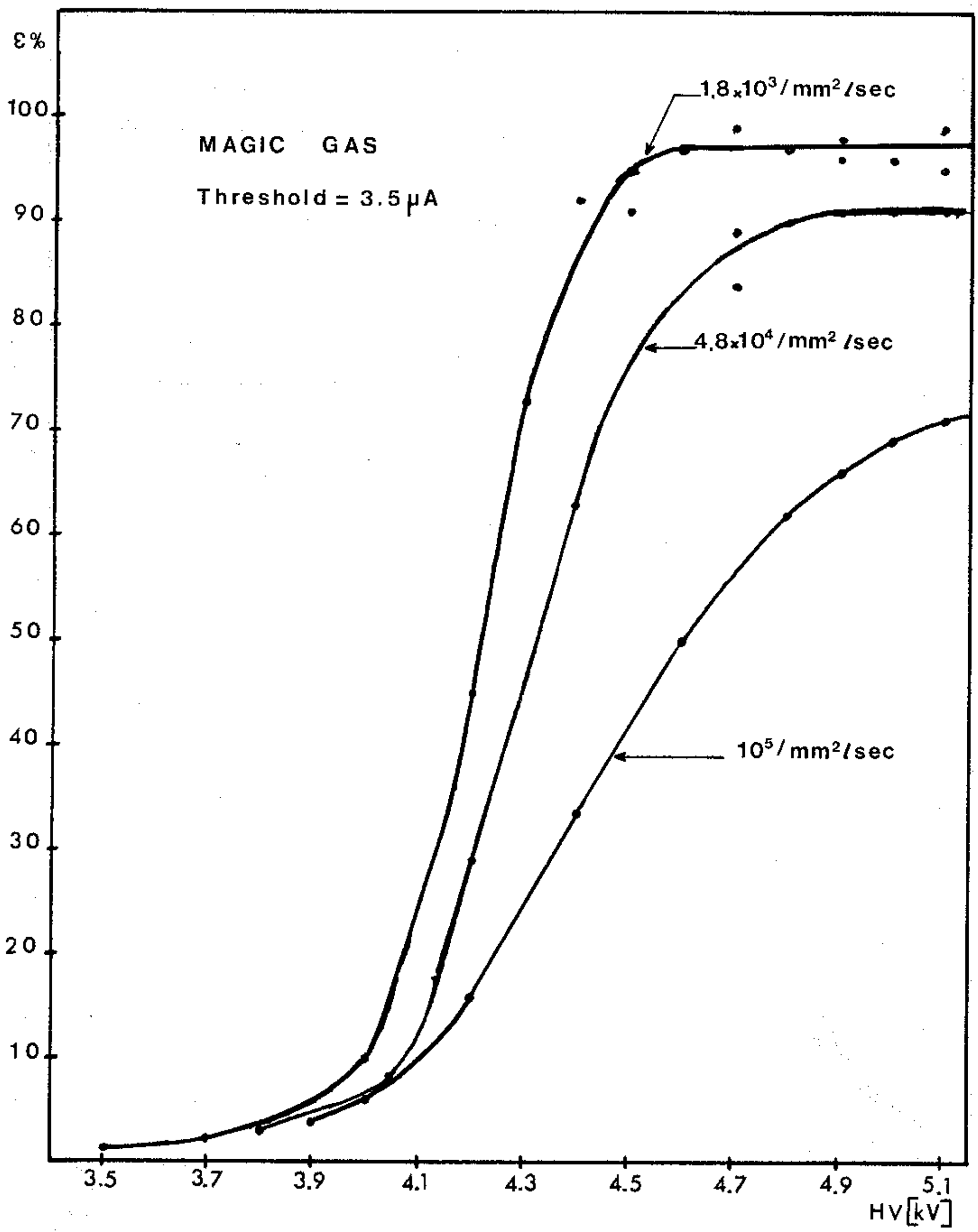

Fig. 5 Efficiency versus H.V. for different fluxes and different thresholds (Magic gas).

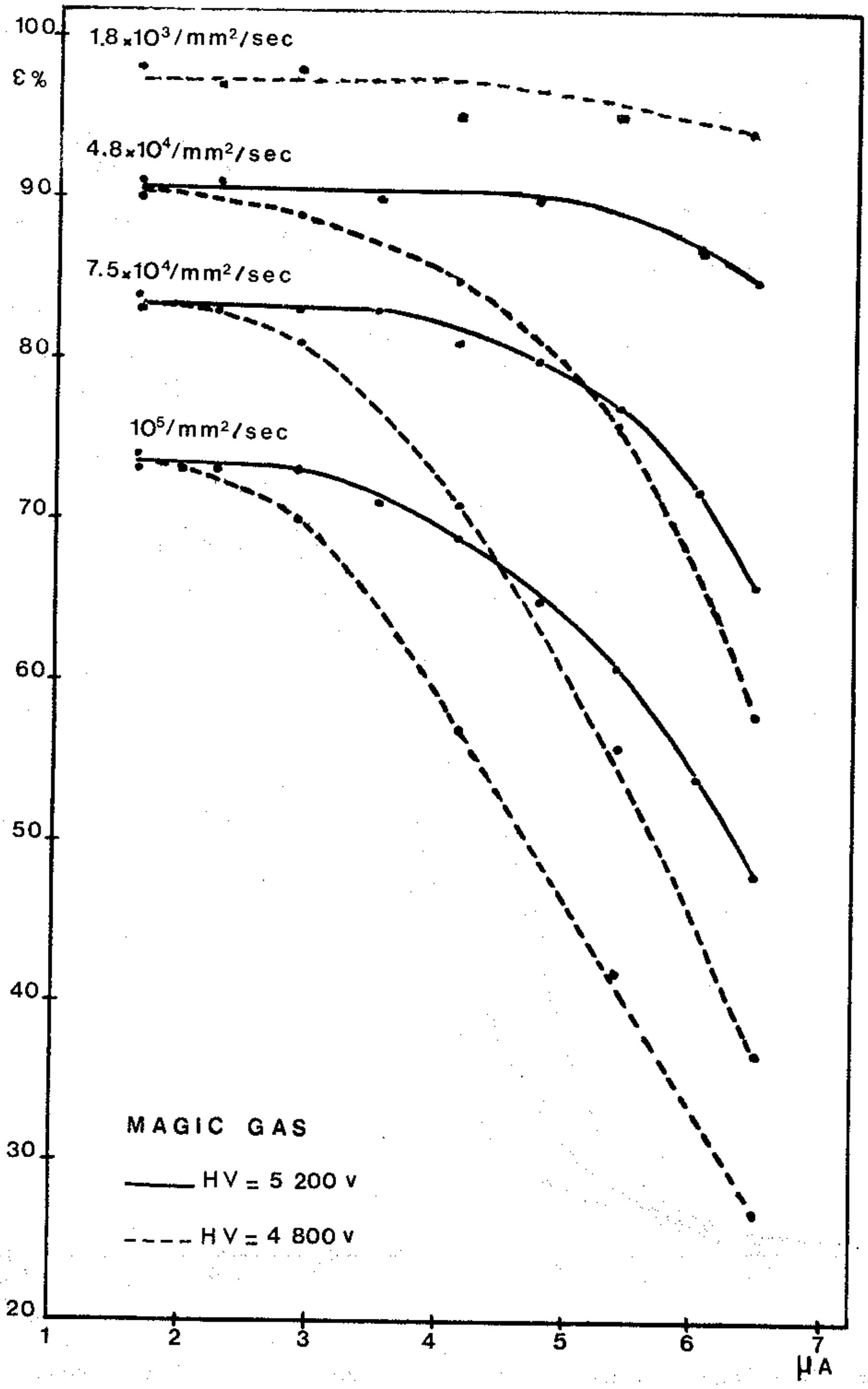

Fig. 7 Efficiency versus threshold for different fluxes (Magic gas).

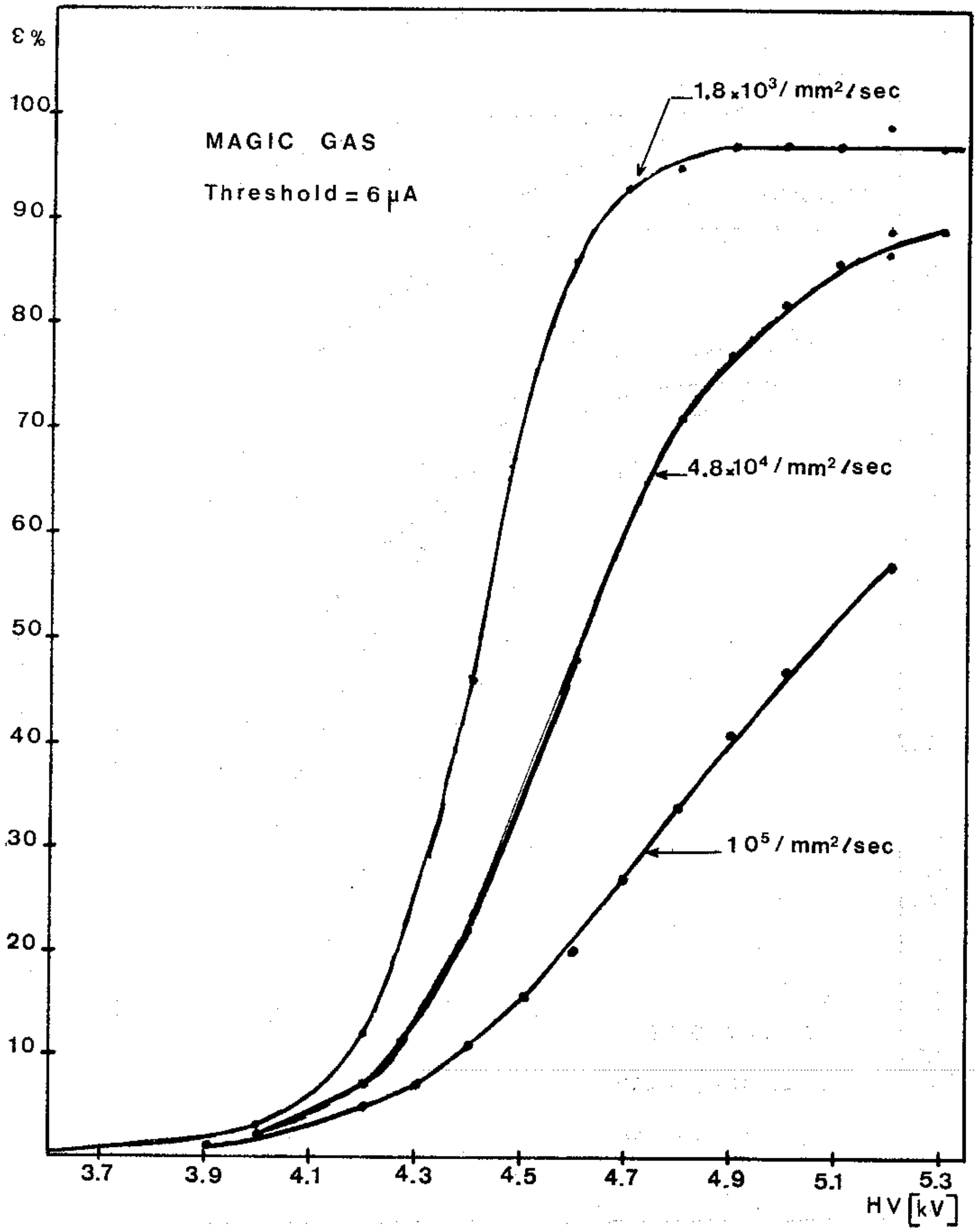

Fig. 6 Efficiency versus H.V. for different fluxes and different thresholds (Magic gas).

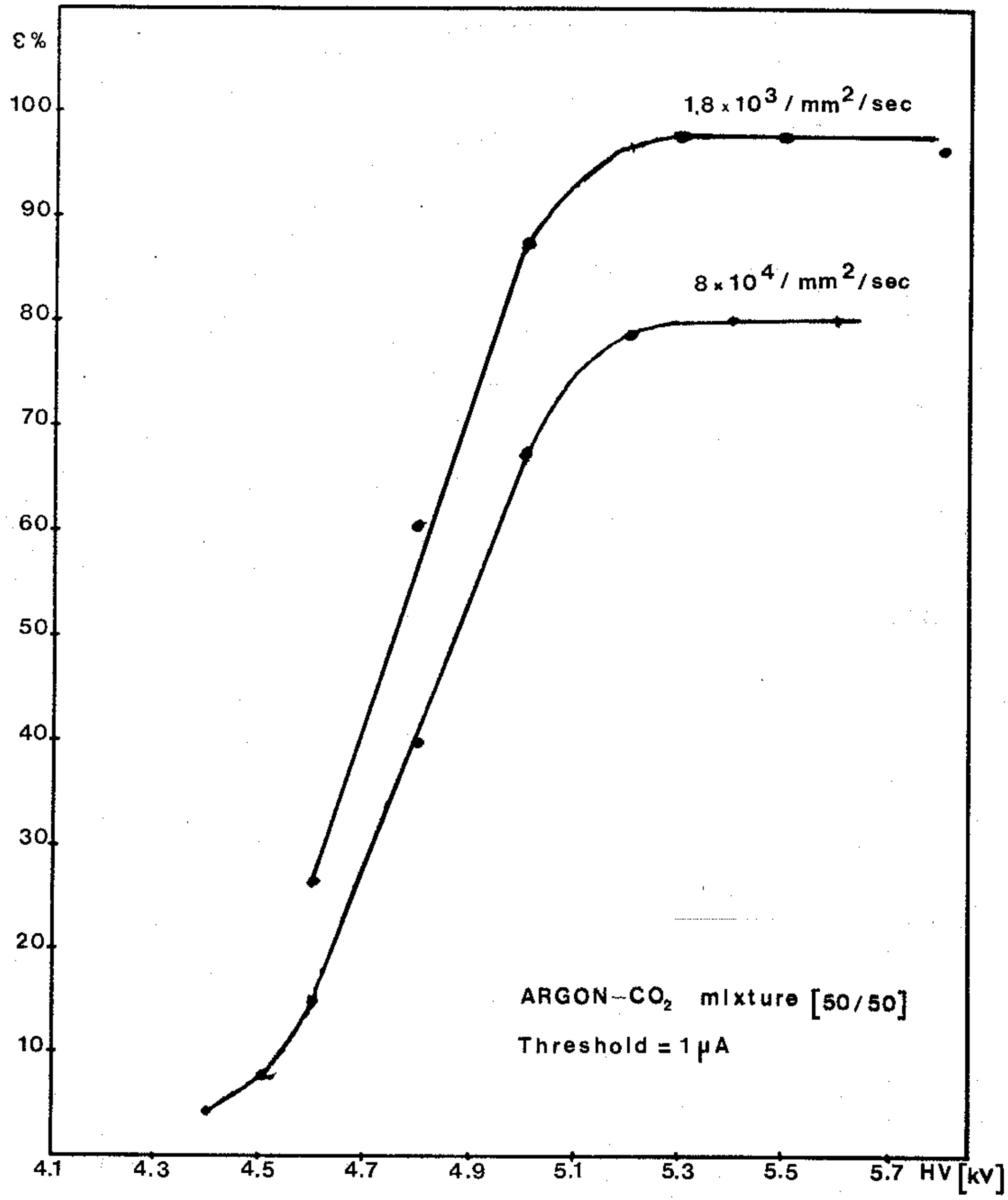

Fig. 8 Efficiency versus H.V. for different fluxes (Argon - CO_2 mixture).

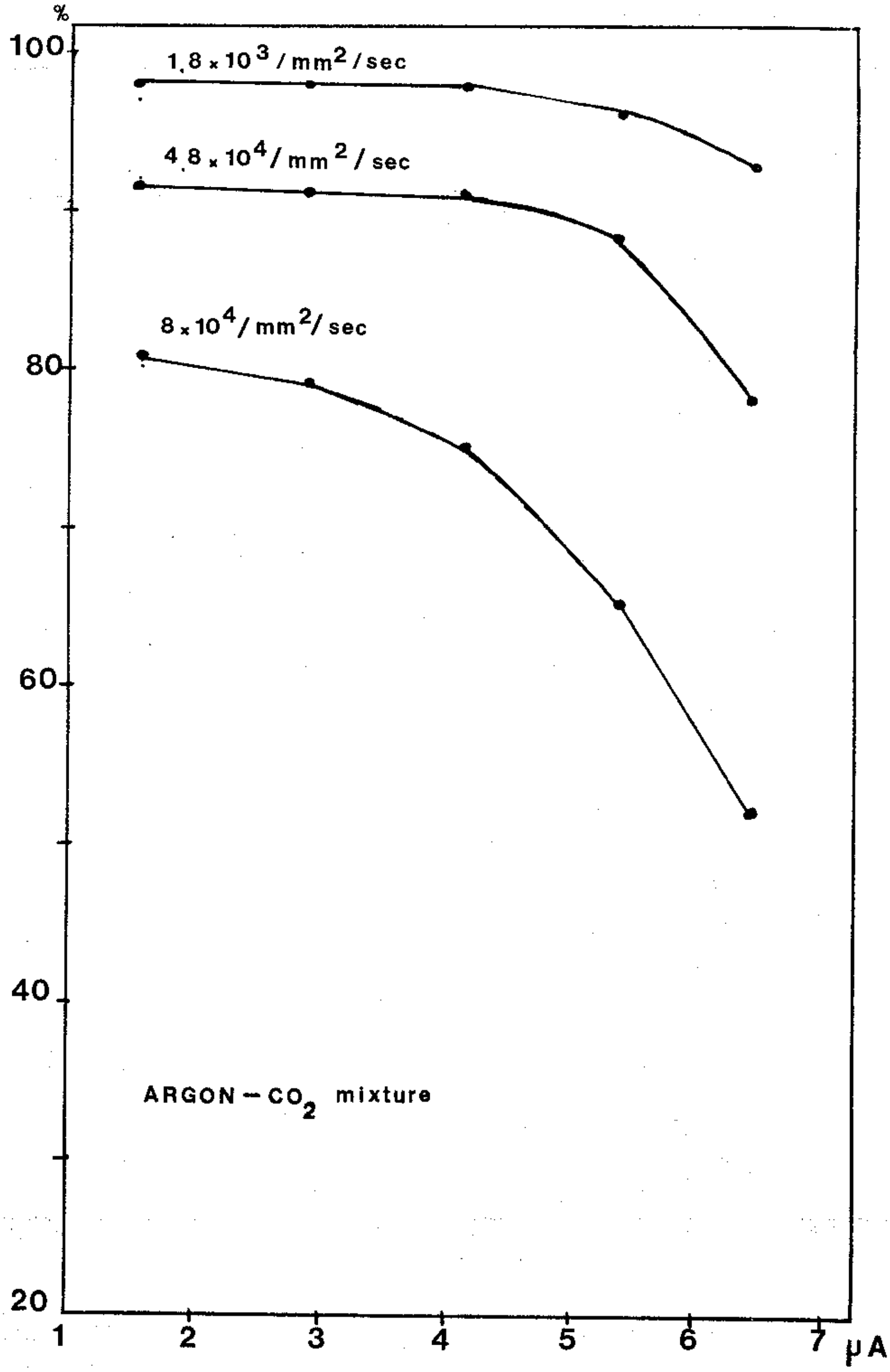

Fig. 9 Efficiency versus threshold for different fluxes (Argon - CO_2 mixture).

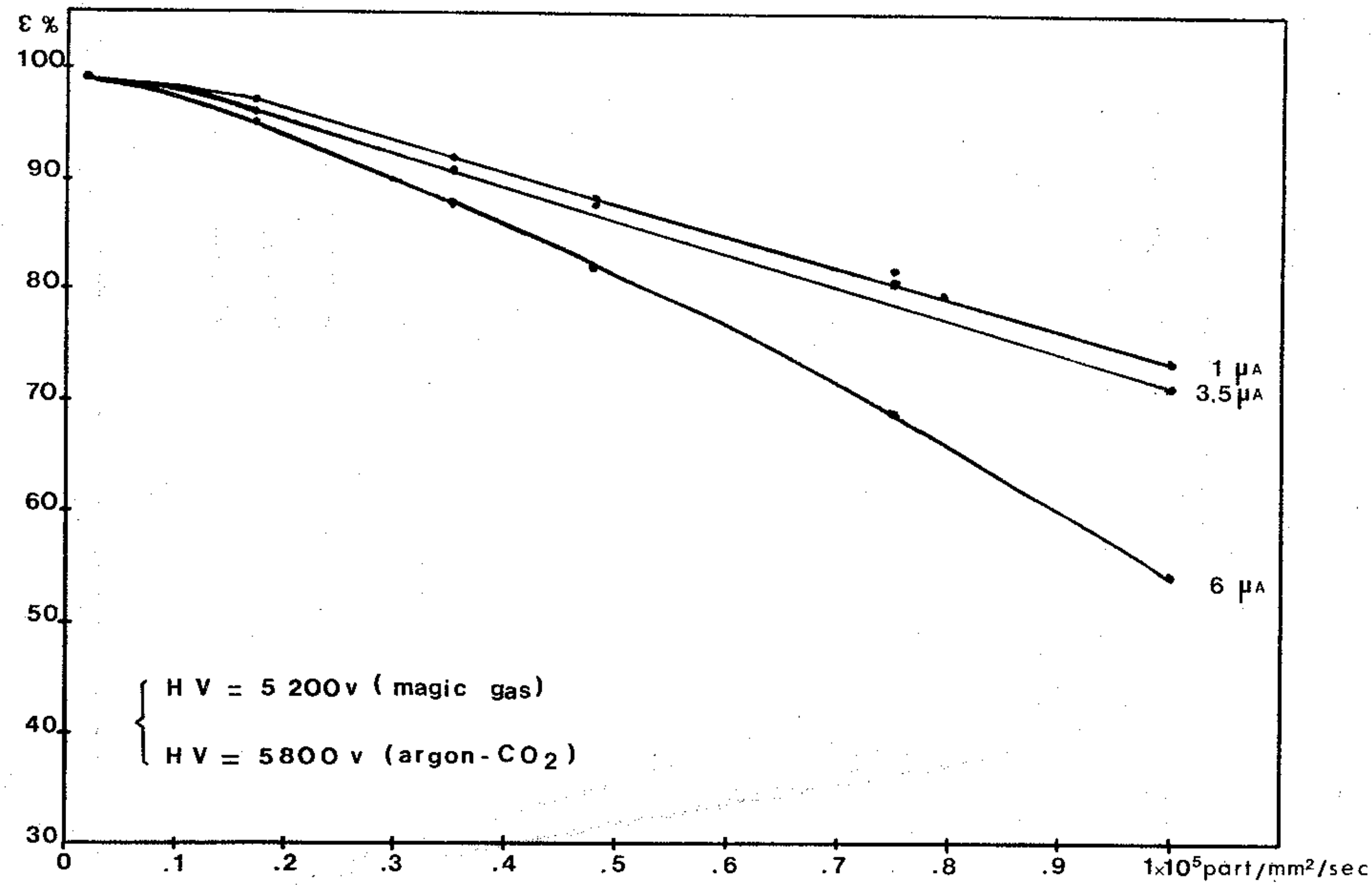

Fig. 10 Efficiency versus fluxes for different thresholds.

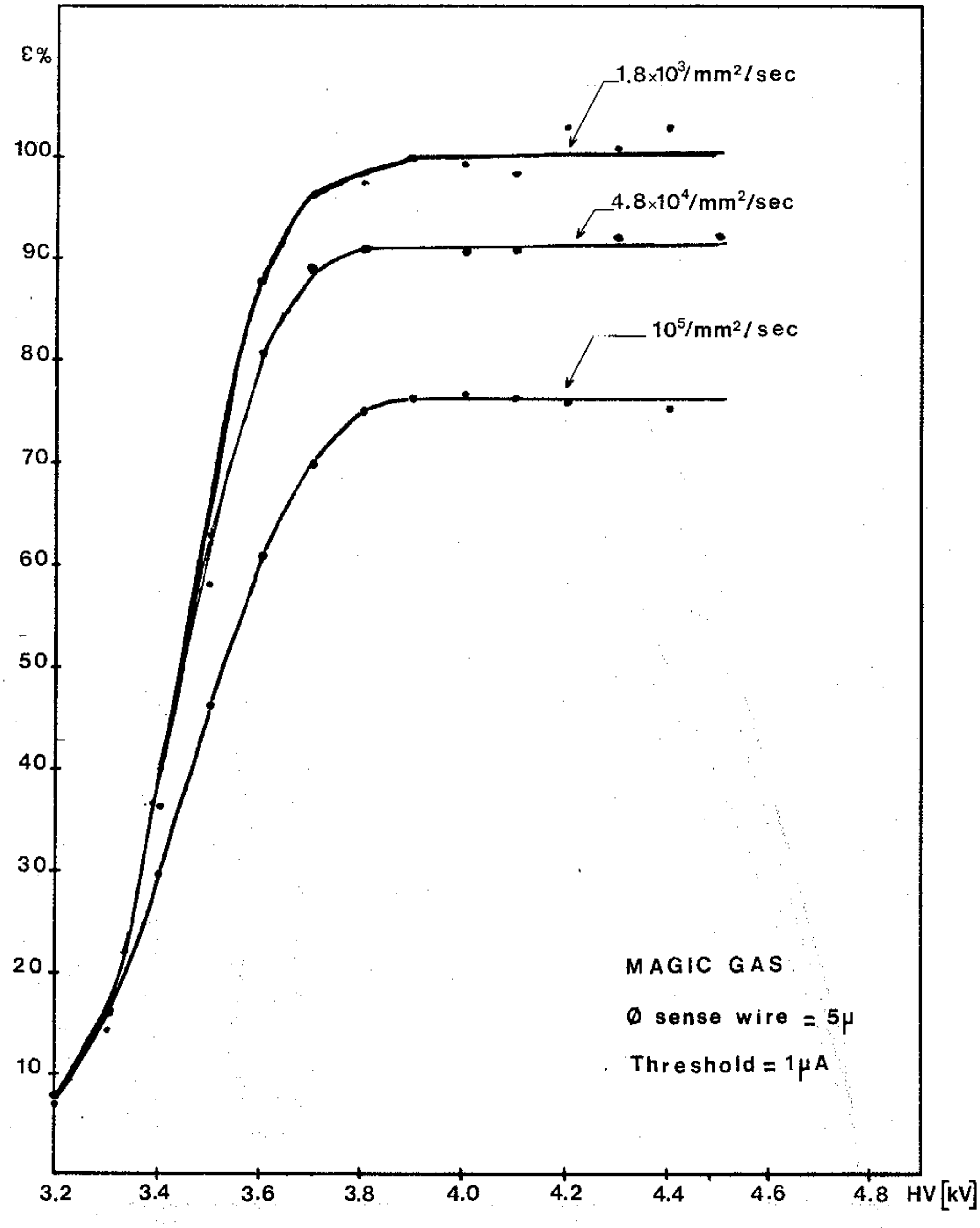

Fig. 11 Efficiency versus H.V. for different fluxes with 5 μm sense wire.

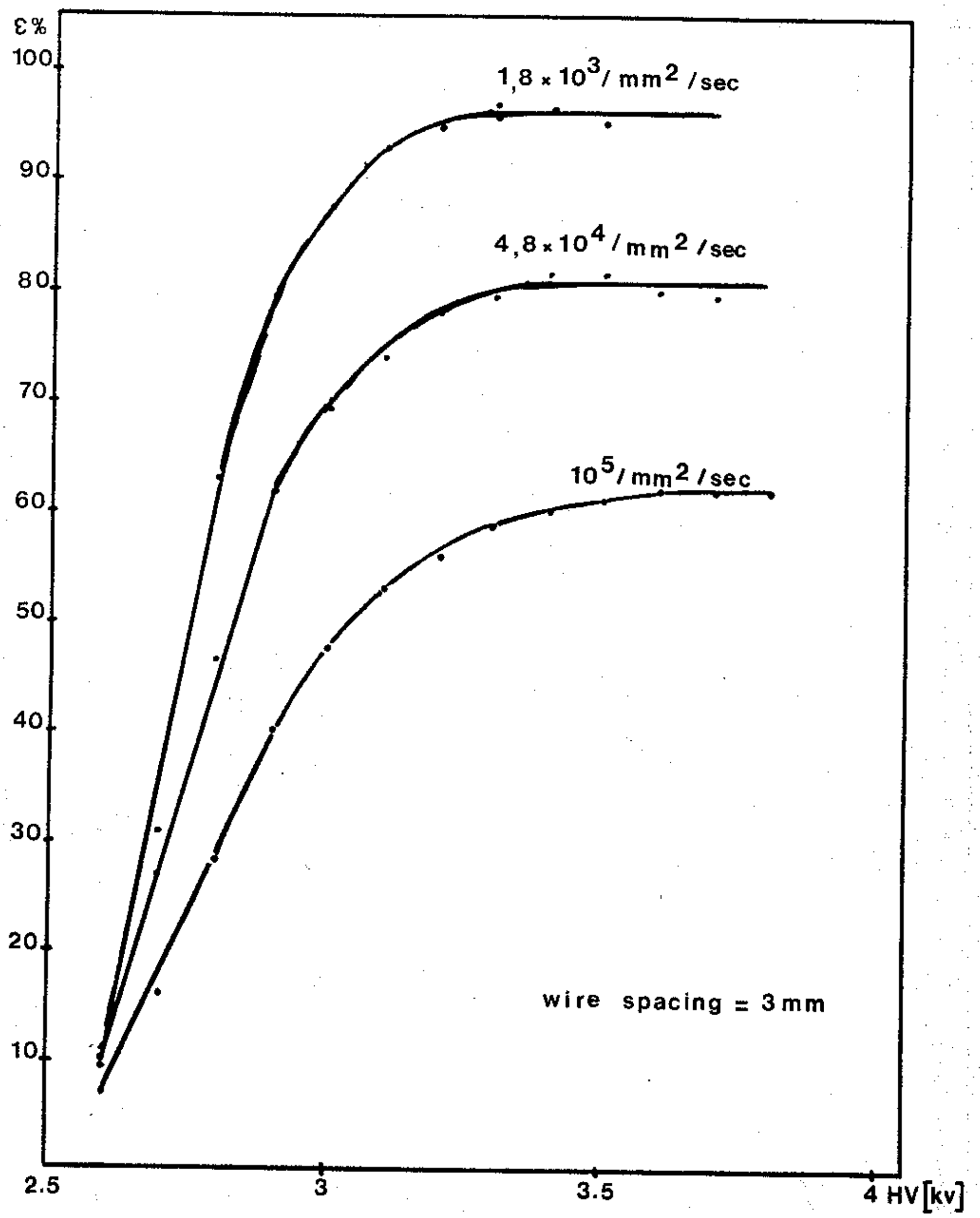

Fig. 12 Efficiency versus H.V. for different fluxes with 3 mm wire spacing.

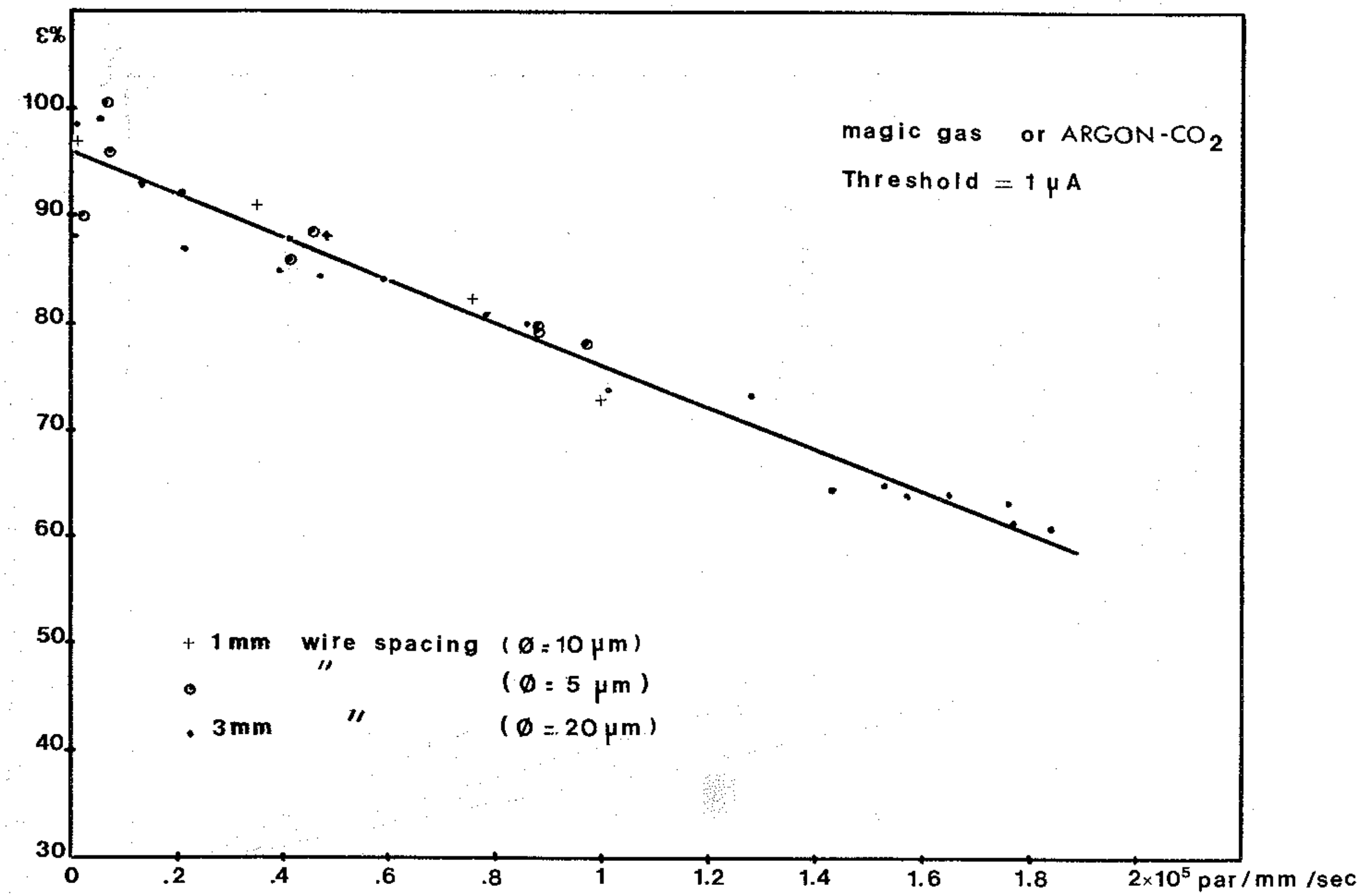

Fig. 13 Efficiency for different fluxes.

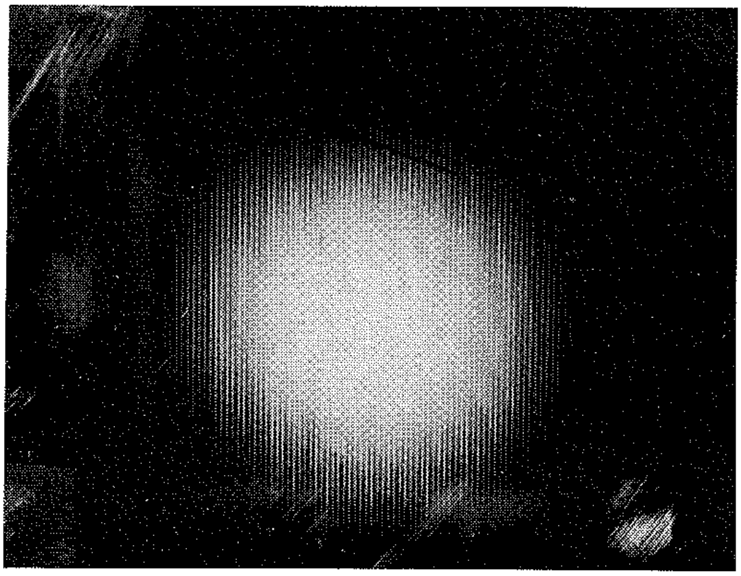

Fig. 14 Aluminium cathode white deposit. Photography after 10^{13} part./cm^2.