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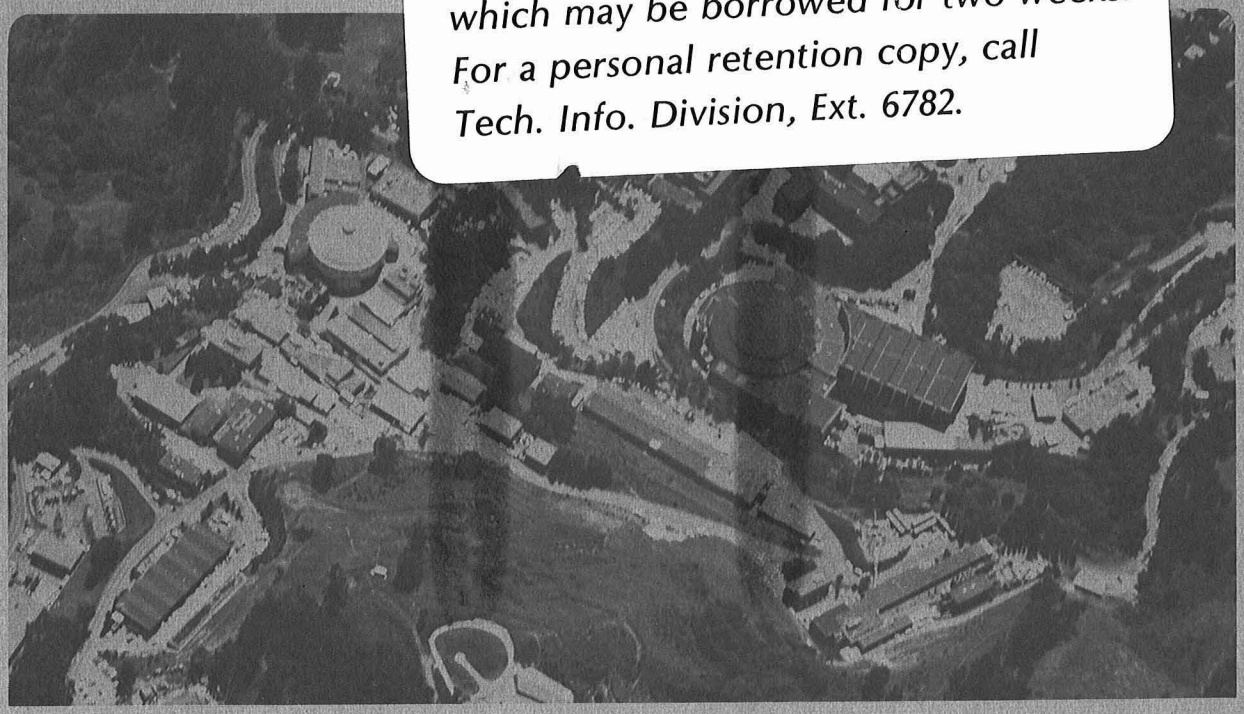

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Biomedical Applications of Digital Autoradiography with a MWPC

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Abstract

A MultiWire Proportional Chamber (MWPC) has been used as a β^- radioactivity detector in biological and medical applications. Two different kinds of experiments have been performed: 1) the study of variations in the ability of cell clones to incorporate a radioactive precursor of DNA biosynthesis (^{3}H-thymidine) and 2) the regional carbohydrate consumption in myocardial tissue by means of a deposit tracer of glucose metabolism (^{3}H-deoxyglucose).

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1. THE DETECTOR

We have constructed a specially designed MWPC with a cathode coupled delay-line read-out[1,2]. The detector is highly sensitive not only to ^{14}C β^- rays, but also to the low energy β^- rays of the cheaper ^3H-labelled compounds (E_{max} =18 keV). Statistically significant data are obtained in a few minutes in contrast to the several weeks needed for conventional autoradiography. Moreover the actual radioactivity content can be evaluated with this technique. Because of the very short range of ^3H β^- rays ($\lambda_{Ar} \simeq 1$ mm), the MWPC has an easily removable top frame that permits the introduction of the samples inside the detector as close as possible to the active volume of the chamber. Accordingly the geometrical spread-out is reduced and the resolving power is greatly improved. The main parameters and intrinsic performance of the MWPC are given in Table 1.

The resolving power of the system, i.e. the capability of identifying individual spots of β^- radioactivity, has been measured by means of a resolution phantom made up of six ^3H line sources (Fig. 1). Taking into account the finite dimensions of the sources we can set the resolving power at ~1.5 mm(FWHM). The overall detection efficiency for β^- decay is ±10% 0.4%. The sensitivity of the system, defined as the activity density which gives a count rate per unit area equal to the noise level, is $\simeq 10^{-1}$ Bq/cm^2.

2. THE BIOLOGICAL EXPERIMENT

Most of the known DNA repair mechanism involves the unscheduled synthesis of short DNA sequences replacing the damaged regions. Consequently, repair

deficient cells (mutants) may be recognized by their inability to incorporate a radioactive precursor in DNA chains under conditions in which repair should normally occur. DNA damage is induced by UV light exposure. A differential incorporation of the labelling agent is induced with particular procedures[3] which include a bath in ^{3}H-thymidine. Repair competent cells will then incorporate radioactivity whereas repair deficient ones will stay poorly labelled. Figure 2 is a sketch of the original colonies distribution and Figure 3 shows the processed image of colonies (HeLa cells) as obtained in 20 min. of data taking with this technique. The activity of the cells is 15 Bq/clone, as measured with a liquid scintillator. The survival of the cells has been checked up to few hours of permanence in the gas atmosphere of the chamber.

3. THE MEDICAL APPLICATION

The availability of labelled deoxyglucose (DG) has recently made possible the study of carbohydrate consumption in different tissues[4]. An interesting application of our detection system concerns the reconstruction of the regional glucose uptake in myocardial tissue by means of ^{3}H-DG. A heterogeneous glucose utilization might be the consequence of differences in work and stress in different regions of the heart. Figure 4 shows an electronic autoradiograph, obtained in 20 min., of a 60 μm slice of a canine heart after an i.v. injection of 8×10^{7} Bq of ^{3}H-DG.

In conclusion, the MWPC seems to be a very useful detector for biomedical applications. Compared with the traditional autoradiography technique, it has a much higher sensitivity, especially with ^{3}H labelled compounds. Furthermore, it provides quantitative information about the two-dimensional distributions as well as the intensities of the radionuclides.

References

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Table 1

Main Parameters and Intrinsic Performance of the MWPC

ACTIVE AREA	25×25 cm^2
ANODE-CATHODE GAP	4 mm
ANODE WIRES DIAMETER	20 μm
CATHODE WIRES DIAMETER	100 μm
WIRE SPACING	2 mm
GAS FILLING	Argon/Isobutane
ENERGY RESOLUTION AT 5.9 keV	14% FWHM (Single wire)
SPATIAL RESOLUTION AT 5.9 keV	(400 ± 50) μm (FWHM)
LINEARITY	Better than 0.5%
NOISE LEVEL	10^{-4} c.p.s./mm^2

Figure Captions

1. The resolution ^{3}H phantom (TOP), and its reconstructed image (BOTTOM).
2. A sketch of the pattern of clones of ^{3}H labelled cells.
3. (a) The original image of the clones pattern; (b) after background subtraction; (c) shows the contours of the clones with a 20% threshold; (d) shows the contours of the not damaged clones, which represent the expected background activity in non repairing clones.
4. MWPC autoradiograph of a 60 μm slice of a canine heart.

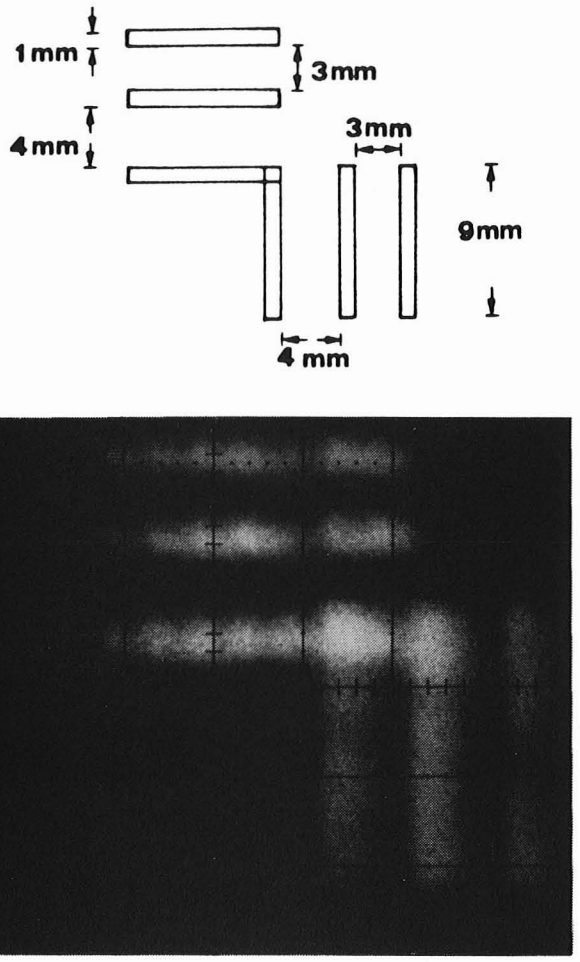

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Fig. 1

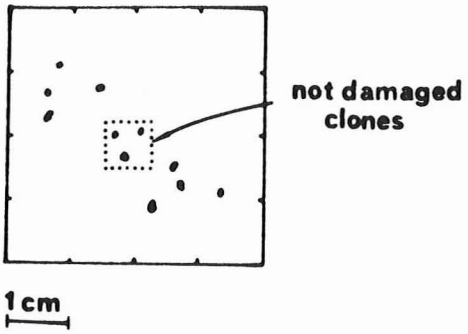
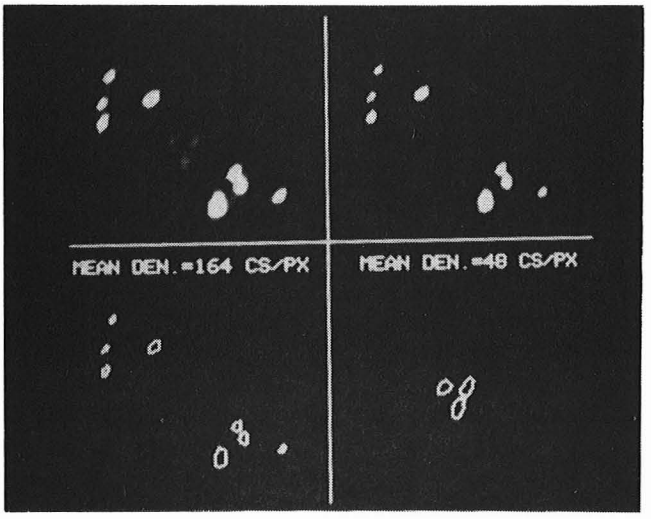


Fig. 2

a)

b)



c)

d)

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Fig. 3

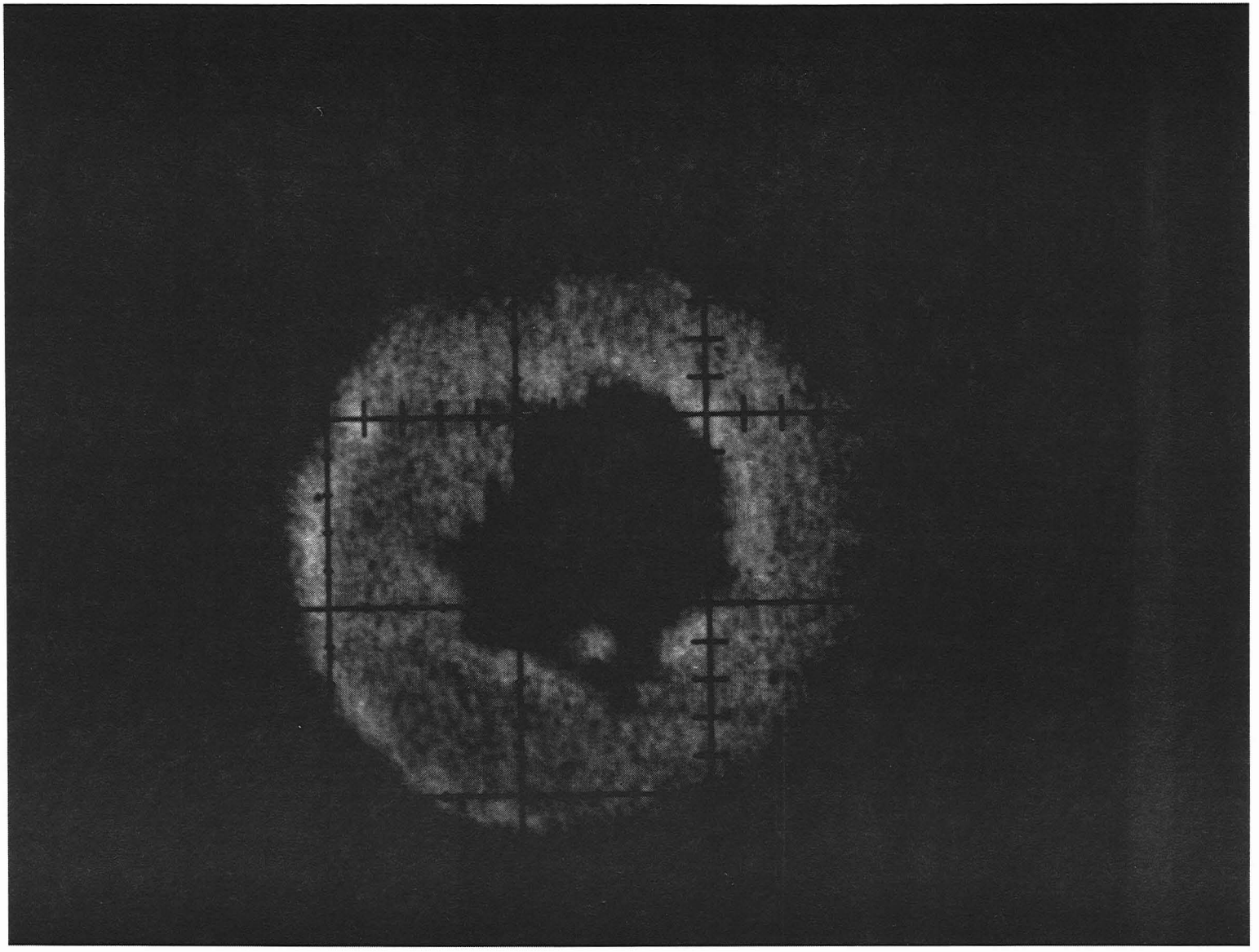

Fig. 4

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