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THE ACCURATE MEASUREMENT OF THE ENERGY DEPENDENCE OF RADIATION DAMAGE RATES IN ORGANIC MATERIALS

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In electron microscopy and radiation damage studies in organic materials it is important to be able to make an accurate assessment of the rate at which the damage processes proceed.

Approximate values for these radiation damage rates have been calculated using solid state detectors in order to measure the appropriate beam current densities (1), however the strong intensity dependence of these devices (Fig. 1) and their susceptibility to radiation damage imposes large errors when any consistency in their efficiency is assumed.

A Faraday cup has been constructed (Fig. 2) which is capable of measuring currents down to 10^{-15} amperes cm^{-2} from the final image plane of an electron microscope, with an error of less than 1%. The cup, being positioned beneath the final viewing screen is therefore capable of distinguishing local incident intensities in the object plane.

In assessing the beam current density at the specimen however, an overestimation can arise from electrons which are incident at the image plane but not derived from the associated object. This effect is most prevalent in high voltage microscopes and arises from the malalignment of lens apertures and the ability of secondary electrons, for example those created on the walls of the microscope column, to reach the final image plane. The variation of the predicted beam current density at the specimen with magnification is shown, for nominal condenser settings of the Berkeley 650kV Hitachi microscope, in Fig. 3. It is apparent that this effect is capable of introducing large errors even at relatively low magnifications. The large operating range of the Faraday cup however facilitates the measurement of beam currents at very low magnifications where this effect is minimized.

In the measurement of radiation damage rates the fading diffraction pattern technique is employed (2) and the determination of the end point can have a large degree of uncertainty associated with it, particularly at high voltages, when determined visually from the fluorescent screen. The Faraday cup can however, when measuring high beam currents, sustain a rapid response to changes in intensity. Thus, it may be utilized to monitor the decay of any Fourier component in the diffraction pattern to the intensity of the final background.

Employing these techniques therefore, the variations of the radiosensitivity of materials to sensitive parameters such as incident electron energy can be studied in a highly quantitive manner (Fig. 4).

Some conclusions based on the present work, concerning the effects of radiation damage on resolution as a function of accelerating voltage will be presented in a separate paper (3).

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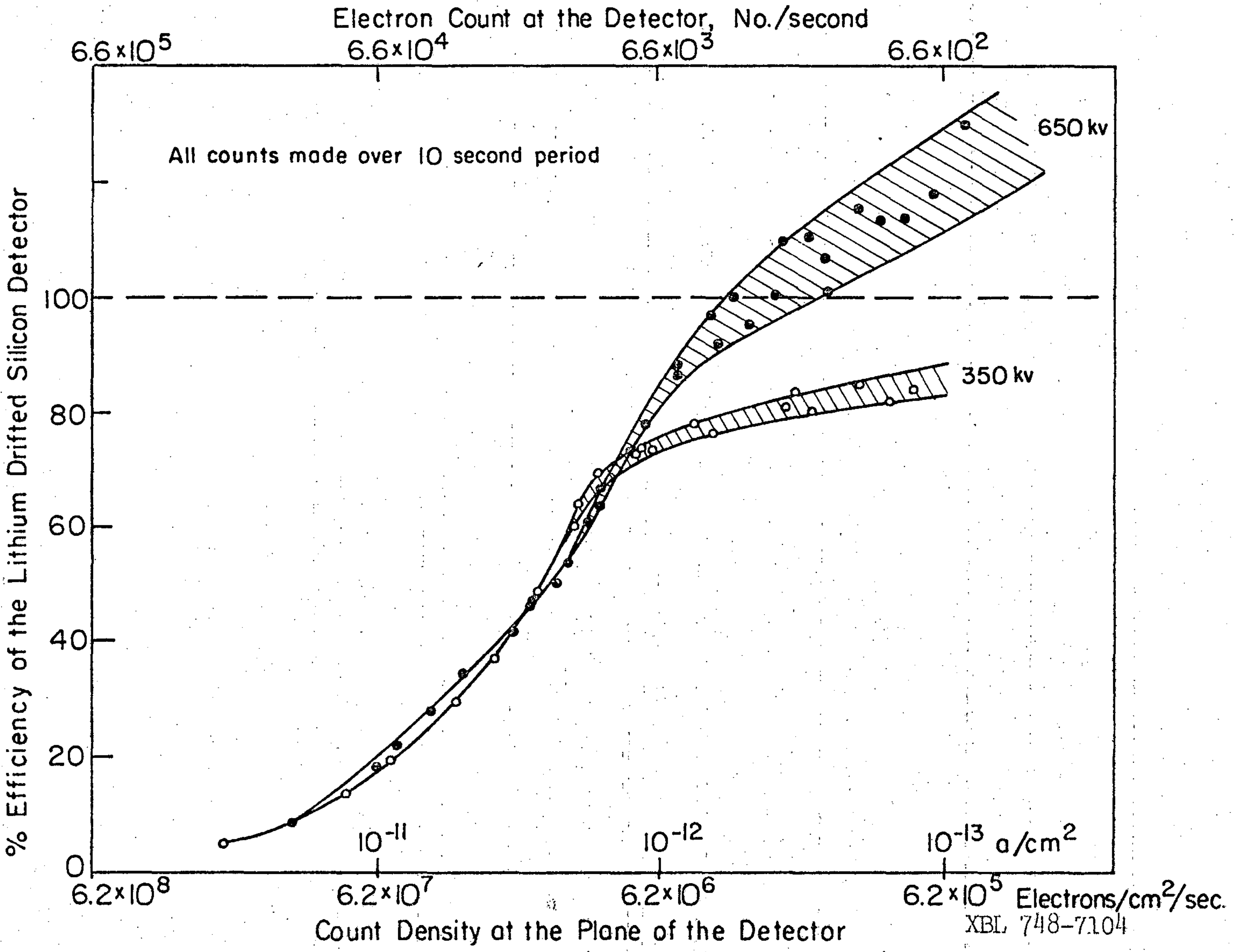

Fig. 1. The variation of the efficiency of the lithium drifted silicon detector with dose for a defining aperture of 1.37×10^{-3} cm^2.

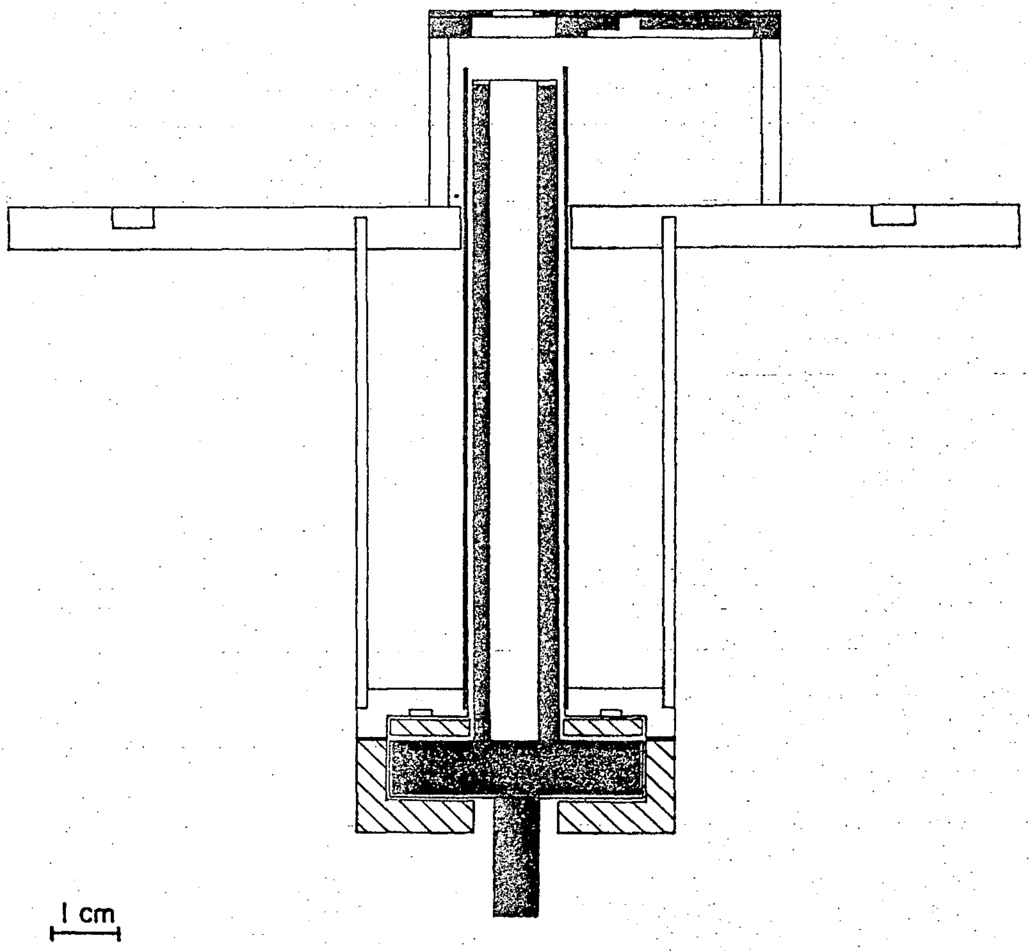

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Fig. 2. The Faraday cup.

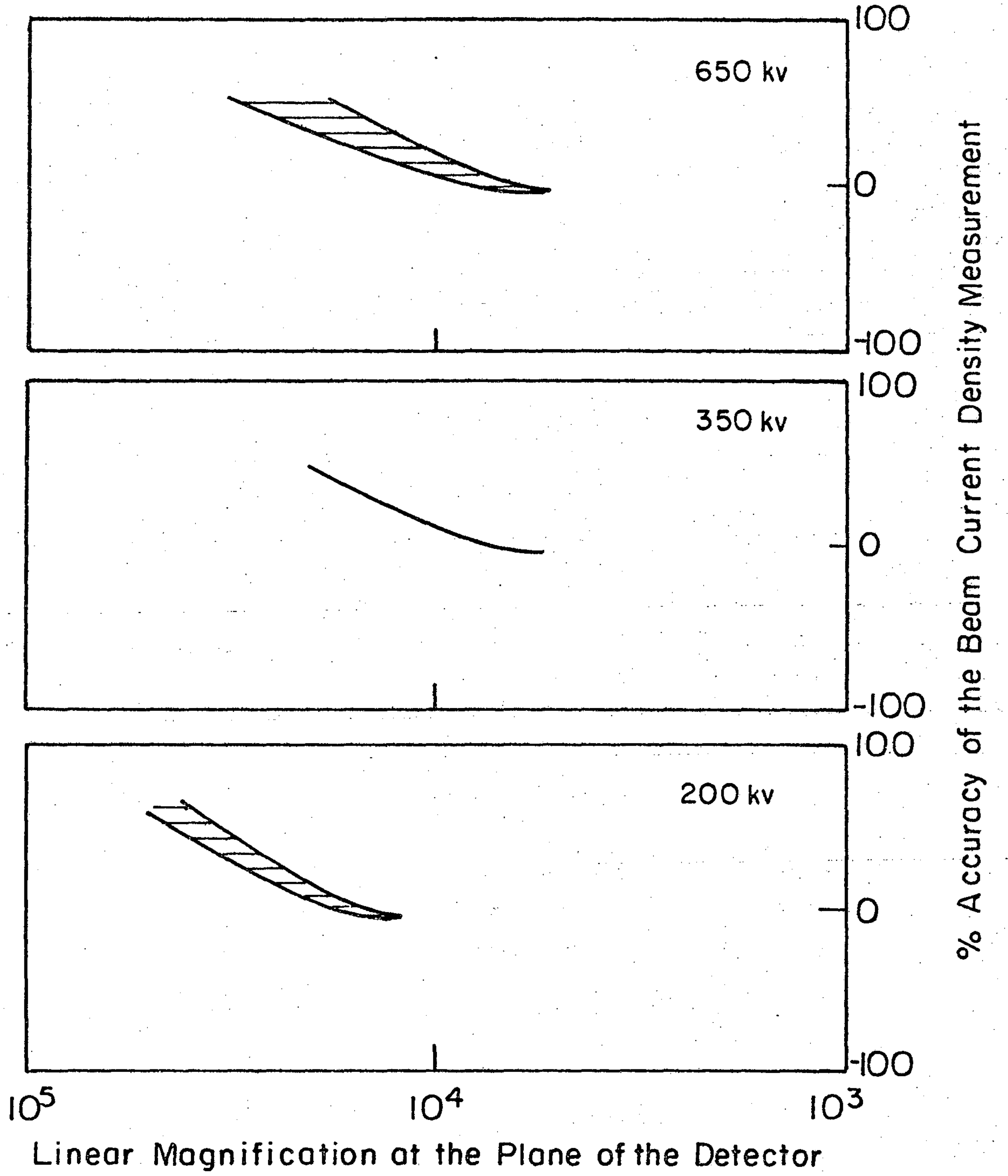

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Fig. 3. The accuracy of the beam current measurements in the 650 kV Hitachi microscope. The curve broadening represents the uncertainty in the measurements.

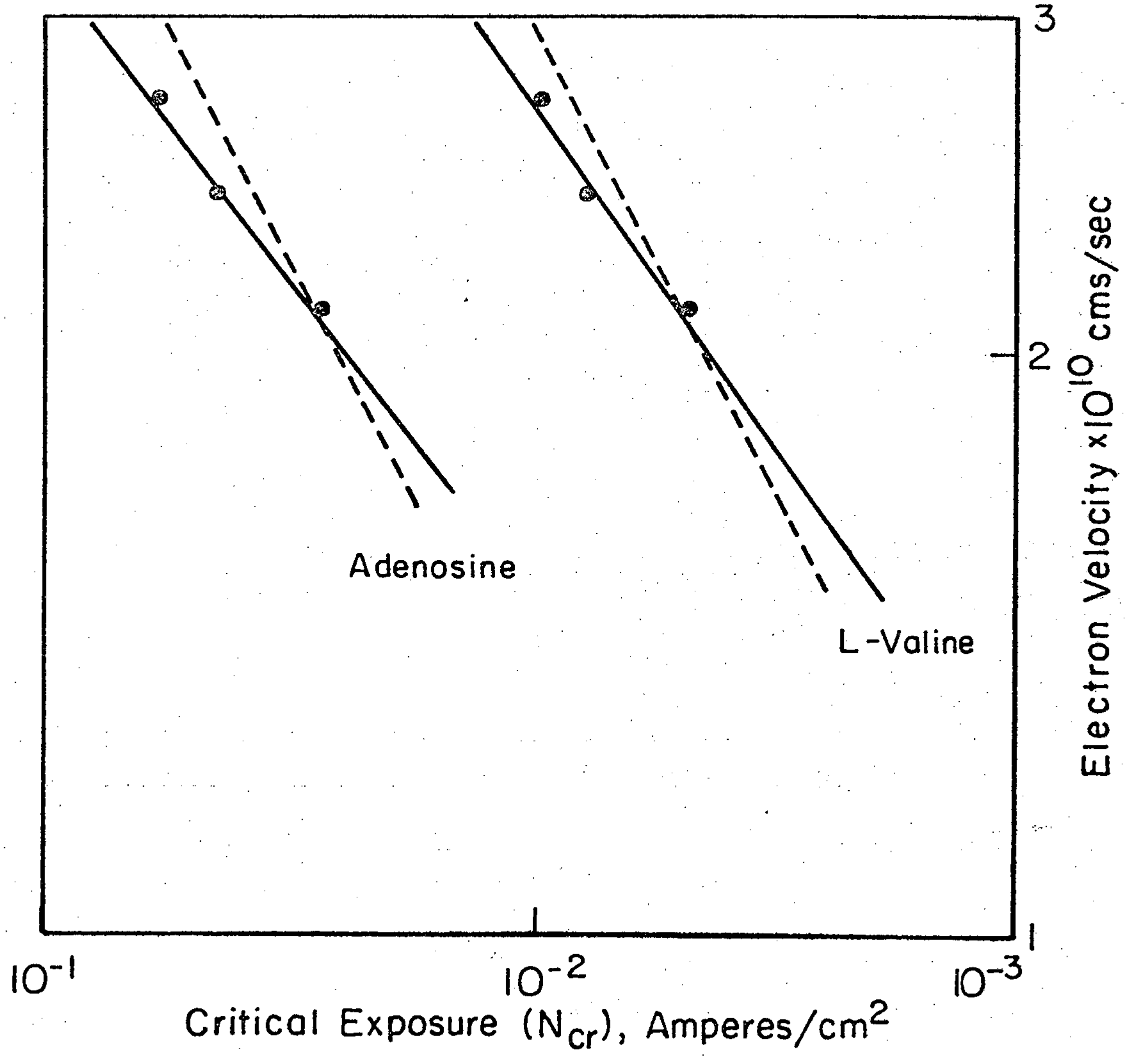

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Fig. 4. The variation of critical exposure of adenosine and l-value with the velocity of the irradiating electrons. The broken line indicates the behavior consistent with v^2.

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