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OBSERVATIONS ON THE RESPONSE OF A LITHIUM-DRIFTED DETECTOR TO PROTONS

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ABSTRACT

The response of a lithium-drifted solid state detector has been measured for protons and found to be linear up to the highest energy observed, 13.2 Mev. The resolution observed for these protons is 0.81% with a bias of 500 volts and 0.65% with a bias of 250 volts.

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This report describes some observations on the response of a lithium-drifted[1] silicon p-n junction diode to protons of various energies up to 13.2 Mev. The unit in question was made available to us through the courtesy of J. H. Elliott of the Lawrence Radiation Laboratory in Berkeley. The wafer is square, about 300 mils on a side, and is about 100 mils thick. In use, a 1/8-inch collimator is set before the detector to define the central portion of the active area.

The experimental procedure has been described in some detail previously.[2] Briefly, the detector is mounted in a charged-particle scattering chamber in such a way as to observe protons elastically and inelastically scattered from a thin (1 mg/cm^2) mylar foil. The bombarding energy is determined by measuring the range of the protons in aluminum. With the application of the range-energy relations, the precision of the energy measurement is expected to be 0.5%. We find, for the beam energy at the center of the scatterer, 13.2 Mev. The energy of the various proton groups observed was determined from the kinematics of scattering from H^1 and the several levels of C^{12} and O^{16}.

A charge preamplifier is operated in the scattering chamber. The rest of the electronics includes a good linear amplifier and a 256-channel analyzer. The block diagram appears in Fig. 1. The linearity of the system was checked by feeding a tail-pulser signal through an attenuator into the amplifier input. Figure 2 shows that the departure from a linear response never exceeded 0.5 channels over the entire 256-channel range.

PROTON RESPONSE

With 500-volts bias on the detector, a typical pulse-height spectrum observed in the multichannel analyzer appears in Fig. 3. The origin of the several groups is identified in the figure.

Observations of this type at a number of scattering angles yield the information necessary to construct the response curve of Fig. 4. This curve is seen to be perfectly linear up to the highest energy observed; furthermore, the pulse height spectrum of the highest energy groups show no sign of deterioration as observed[2] when the particle range was commensurate with the depletion layer thickness. It has been estimated[3] that this particular detector is capable of yielding a linear response for protons up to 18 Mev.

The triangle represents α-particle data from a Cm^{242} source. That it lands on the same straight line as for protons indicates that the detector response is a function only of the energy deposited, and that there is no appreciable dead-layer at the detector surface.

The response of the detector to 13-Mev protons and 6.11-Mev α-particles was measured as a function of bias voltage. Figure 5 shows that above 250 volts bias the line joining the two data points passes through the origin — as one would expect if the response remained linear. Below 250 volts, however, a straight line joining the two points misses the origin, indicating that the response to α-particles is less than it should be due either to the existence of a dead-layer between the surface and the depletion layer, or to a loss of collection efficiency of electron-hole pairs.

The resolution of the detector for 13-Mev protons and 6.11-Mev α-particles was found to be:

	500-v bias	250-v bias
6.11-Mev alphas	1.2% (73 kev)	--
13.2-Mev protons	0.81% (105 kev)	0.65% (84 kev)

REFERENCES

[1] E. M. Pell, J. Appl. Phys. 31, 291 (1960).

J. H. Elliott, Lawrence Radiation Laboratory, Berkeley, California, UCRL-9538 (Feb. 1961).

[2] J. Benveniste, R. Booth, and A. C. Mitchell, Lawrence Radiation Laboratory, Livermore, California, UCRL-6200 (Nov. 1960).

[3] J. H. Elliott, private communication.

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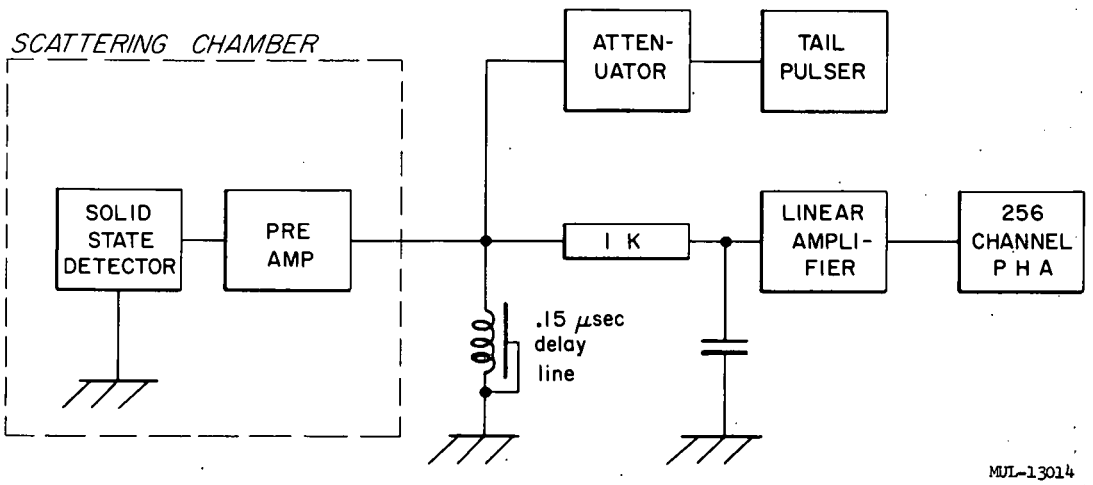

Fig. 1. Block diagram of detector electronics.

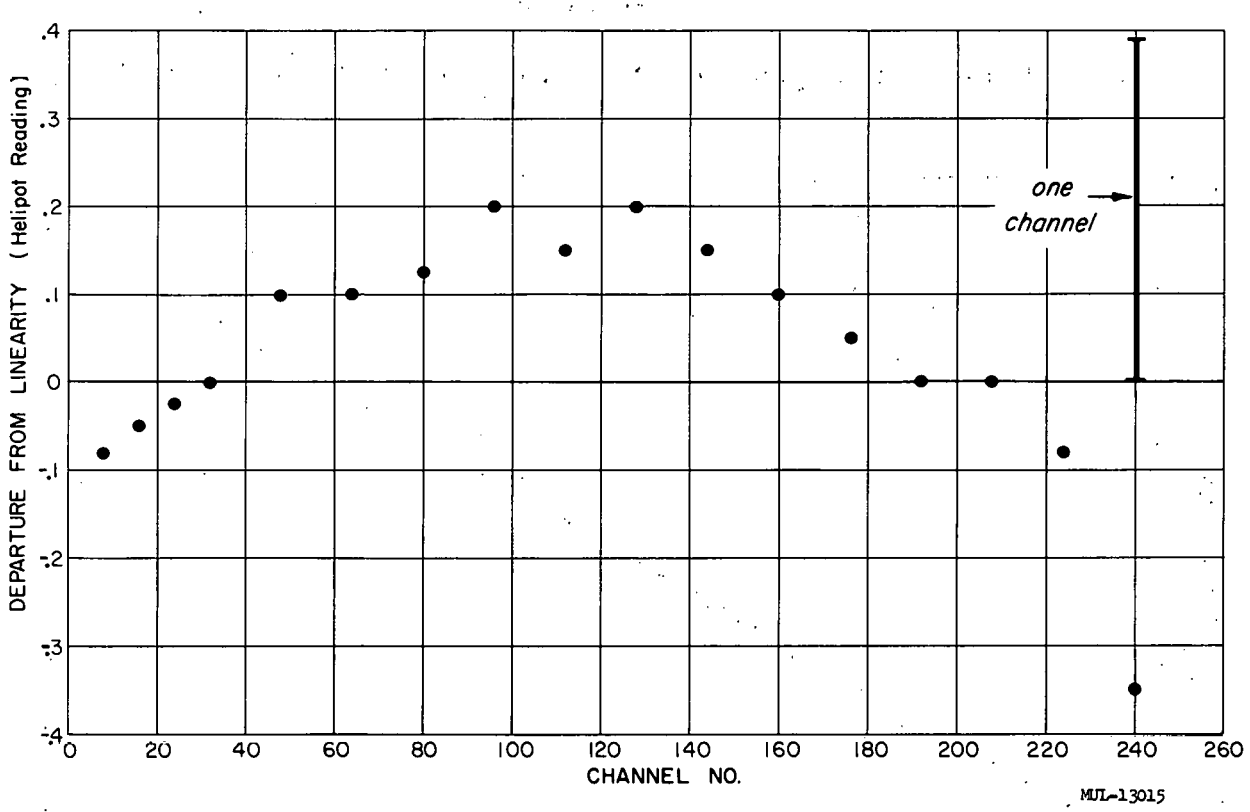

Fig. 2. Linearity check.

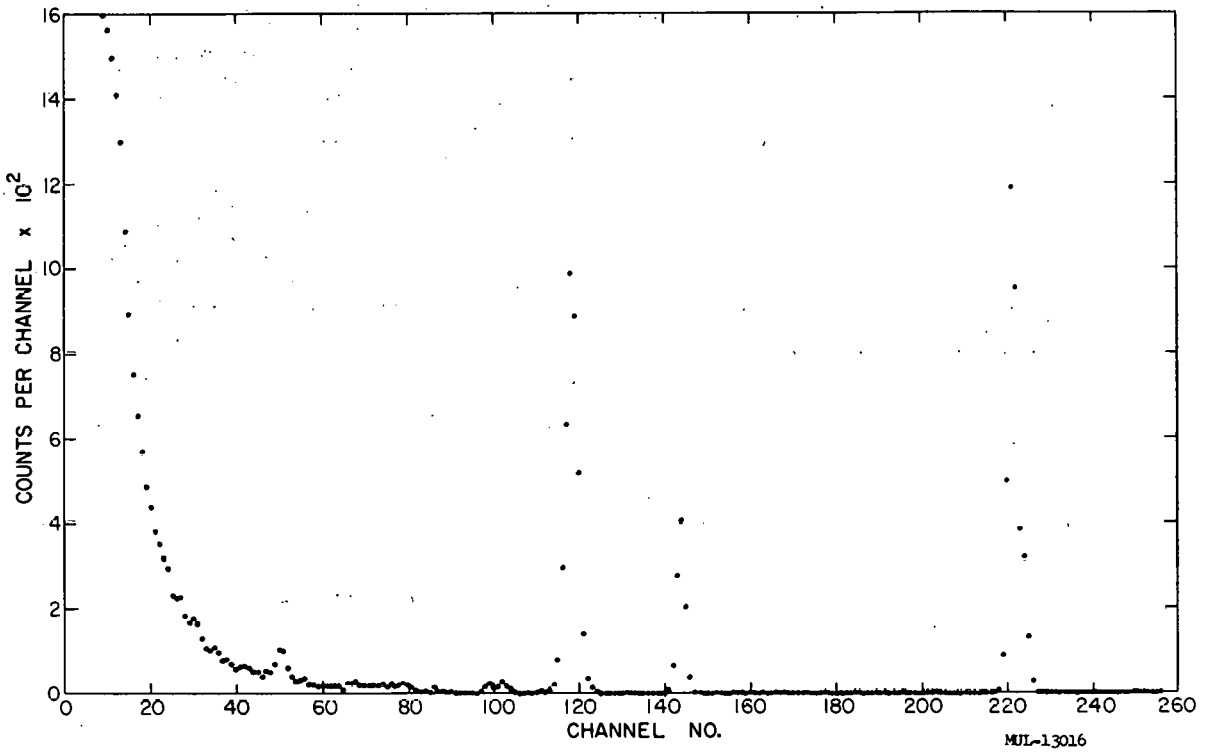

Fig. 3. Pulse height spectrum of protons scattered from mylar (44°).

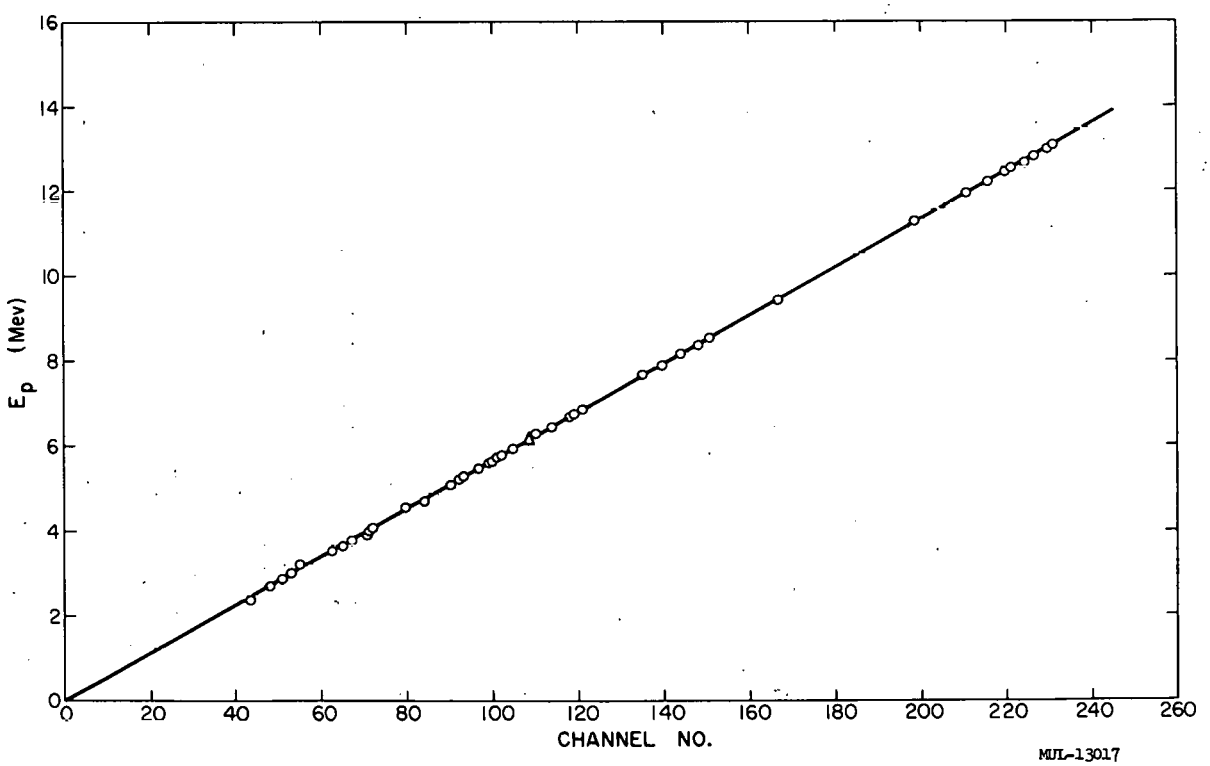

Fig. 4. Response curve for lithium-drifted detector, 500-v bias.

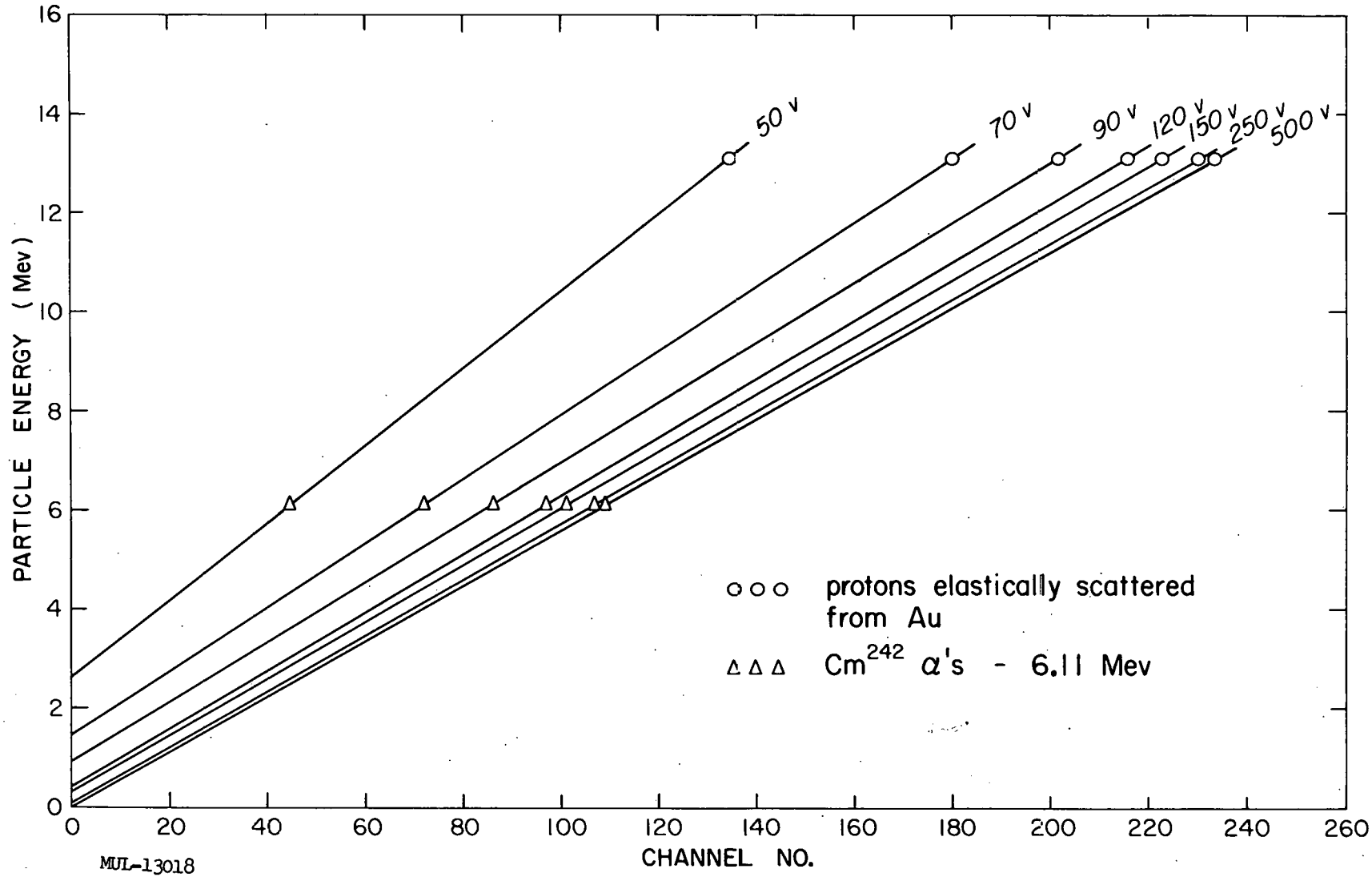

Fig. 5. Effect of bias voltage on response curve.