# Alpha spectroscopy in the world today

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## INTRODUCTION

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The $S_N$ equations were also developed by Carlson [1]. Another paper is cited here [2].

## RESULTS AND ANALYSIS

The results were interesting, blah blah blah.

### Depletion

The depletion region is where the electric field inside the semiconductor detector grows, "depleting" the region of free carriers increasing the spatial charge. Before the detector is fully depleted, the depletion width $d$ can be roughly described as

$$d = \left(\frac{2\varepsilon V}{e_0 N}\right)^{1/2},$$

where $V$ is the voltage, $N$ is the dopant concentration, $e_0$ is the electron charge, and $\varepsilon$ is the dielectric constant of the detector.

Fig. 1 shows the variation of pulse height as measured by the oscilloscope and centroid channel (which should be directly proportional to the pulse height, although less accurate) by varying the voltage across the detector. The discontinuity between 25 and 30 V was a result of re-pumping the vacuum from 27 to 28.5 inHg (inches of mercury) relative to atmosphere. Aside from that discontinuity, the curve behaves about as expected. Because the centroid peak channel is still increasing, the detector is probably not saturated.

Incidentally, the unusual detector output when exposed to room light suggests that the detector is a "surface barrier" detector, which according to Knoll [3, p. 377] are particularly sensitive to light.

### Measured range

The primary alpha particle released from Am-241 has an energy of 5485 keV and a yield is 84.8%. Another alpha with a smaller yield of 13.1% has an energy of 5443 keV, which is practically the same and in this problem is neglected. The first formula gives an alpha range

$$R = 1.24(5.48) - 2.62 = 4.18\,\text{cm},$$

and the second formula gives

$$R = (0.005(5.48) + 2.85)(5.48)^{1.5} = 36.9\,\text{mm},$$

so we should expect a range of about 4 cm.

## CONCLUSIONS

We found by extrapolating the alpha's peak energy down to zero that the range of the 5.5-MeV alpha particles is roughly 4.6 to 5.0 cm. This is only roughly in agreement with the empirically estimated range of 3.6 to 4.2 cm.

Plotting a curve of the total alpha attenuation should have given us a plot of the range, but the inability of the vacuum pressure to hold at near-atmospheric levels and the geometrical aberrance prevented a useful curve from being measured.

Finally, looking the width of the spread in alpha energies by measuring the FWHM of the alpha peak as the pressure in the chamber changed results in a straggling curve. As expected, the range in alpha energies increased with the amount of material between the source and detector.

There is an abundance of sources of error in this experiment. The temperature in the room, which affects the air density, was not at all under control. Furthermore, the instrumentation measuring the vacuum chamber, and the chamber itself, were

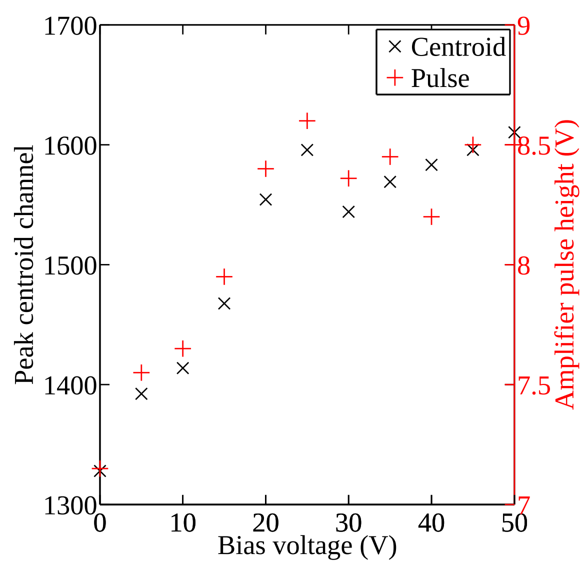


Fig. 1: Variation of pulse height out of the amplifier with voltage.

shaky at best. Another source of error was the lack of precision in the measurement of source-detector separation; the measured distances could be off by several millimeters at least. Finally, as is shown in Fig. 1, the detector was not operated in a fully saturated, fully depleted region. That will introduce some error into the measured MCA spectra, since as the detector was not operated in a "plateau" region, the pulse height is sensitive to changes in the high voltage bias. In fact, because the high voltage supply is usually operated at a factor of ten to thirty higher than in this lab, its accuracy at low voltages is questionable.

## REFERENCES


1. B. G. CARLSON, "Solution of the Transport Equation by $S_n$ Approximations," Tech. Rep. LA-1599, Los Alamos Scientific Laboratory (1953).
2. E. W. LARSEN and A. B. WOLLABER, "A Quantitative Theory of Angular Truncation Errors in Three-Dimensional $S_N$ Calculations," *Nuclear Science and Engineering*, **160**, 3, 267–283 (2008).
3. G. F. KNOLL, *Radiation Detection and Measurement*, John Wiley & Sons, Inc., 3rd ed. (2000).