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Measurement Of Electron Induced Showers
With Thermoluminescent Dosimeters

Theodore M. Jenkins, Joseph K. Cobb, Walter R. Nelson,
and Richard C. McCall

Stanford Linear Accelerator Center, Stanford University, Stanford, California

When a high energy electron is stopped in an absorber, an electron-photon cascade or shower is produced. Many authors have contributed to the theory of showers.[1] Experimental measurements of shower propagation have been made using ionization chambers,[2] scintillators,[3] photographic film,[4] spark chambers,[5,6] cloud chambers,[7] nuclear emulsions,[8] Cerenkov counters,[9] and bubble chambers.[10] All of these methods have some disadvantages, especially for measuring radial development of the showers. Some of these disadvantages are limited intensity range of the detector, large energy dependence, large physical size, laborious methods, and disturbance of the shower by the detector. In addition, those methods which make measurements point by point require long machine time and careful monitoring and data normalization to correct for variations in beam intensity.

The recent development of thermoluminescent dosimeters (TLD) seemed to offer an excellent tool for investigation of shower development.[11]

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The TLD using LiF or CaF_2 (Mn) powder have wide range (0.01 to 10^5 rads = 1 to 10^7 ergs/gm), small size (~ 3 mg), and simple readout. The small size and low density, especially of LiF powder, means that there will be negligible disturbance of the shower in materials such as copper or lead. The bulk density of LiF powder is approximately 0.8 gm/cm^3.

A preliminary experiment was performed to examine the feasibility of the TLD method. An iron block was prepared as shown in Fig. 1. The LiF powder was placed in thin-walled polyethylene tubing of inner diameter 0.023 inches and outer diameter of 0.038 inches. Since the TLD responds to the amount of energy deposited in it, this geometry results in a solid state analog of the cavity ionization chamber.[12] The energy deposition of such a device is characteristic of the surrounding medium rather than the device itself; hence energy dependence is not a problem.

The arrangement shown in Fig. 1 was irradiated at the 660 foot point of the Stanford two-mile linear accelerator. The beam energy was 1 GeV and the target was irradiated with approximately 10^{11} electrons. The beam diameter was unknown but at higher currents where it could be observed on an optical detector it was seen to be about 5 mm. The tubing was cut into lengths and the LiF was poured out and weighed in a torsion balance (Sartorius VDF). The LiF was then read out in a commercial reader (Controls for Radiation, Incorporated). In the center of the block the tubing was cut in sections 5 mm long and farther out in sections 1 cm long. This amounted to LiF weights of about 1.5 and 3 mg respectively. Each reading had to be corrected for the actual weight of LiF in the sample. This is a linear correction for weight up to about 80 mg.

The results are shown in Fig. 2. Radial distribution or profile curves are shown for depths of 0.5, 1.5, 3.0, and 5.5 inches. The curve for 1.5 inches is near the shower maximum and was exposed beyond the 10^5 rad limit of the TLD so there is some uncertainty in its height. It also appears that the spatial resolution afforded by the 5 mm sections was not good enough to really define the shower dimensions.

A further experiment is in progress using more refined techniques to obtain better spatial resolution (about 1.5 mm) to follow the shower farther both radially and longitudinally and to extend the measurement to copper and lead.

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FIGURE CAPTIONS

1. An exploded view of the iron block showing the relative positions of the LiF detectors.
2. Typical profile curves showing the shower build-up both longitudinally and radially. Data points are shown for one curve only.

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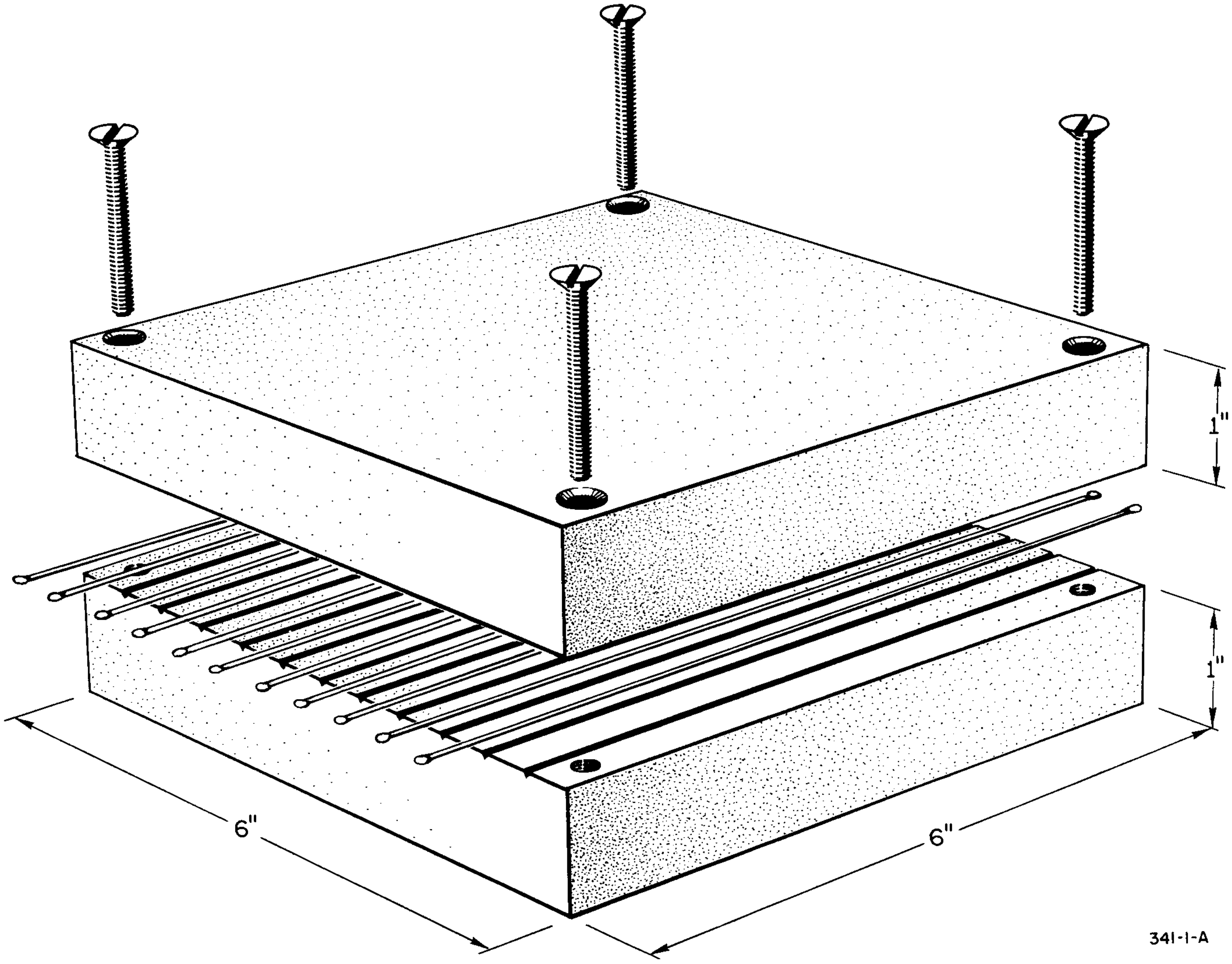

FIG. 1 -- AN EXPLODED VIEW OF THE IRON BLOCK SHOWING THE RELATIVE POSITIONS OF THE LiF DETECTORS.

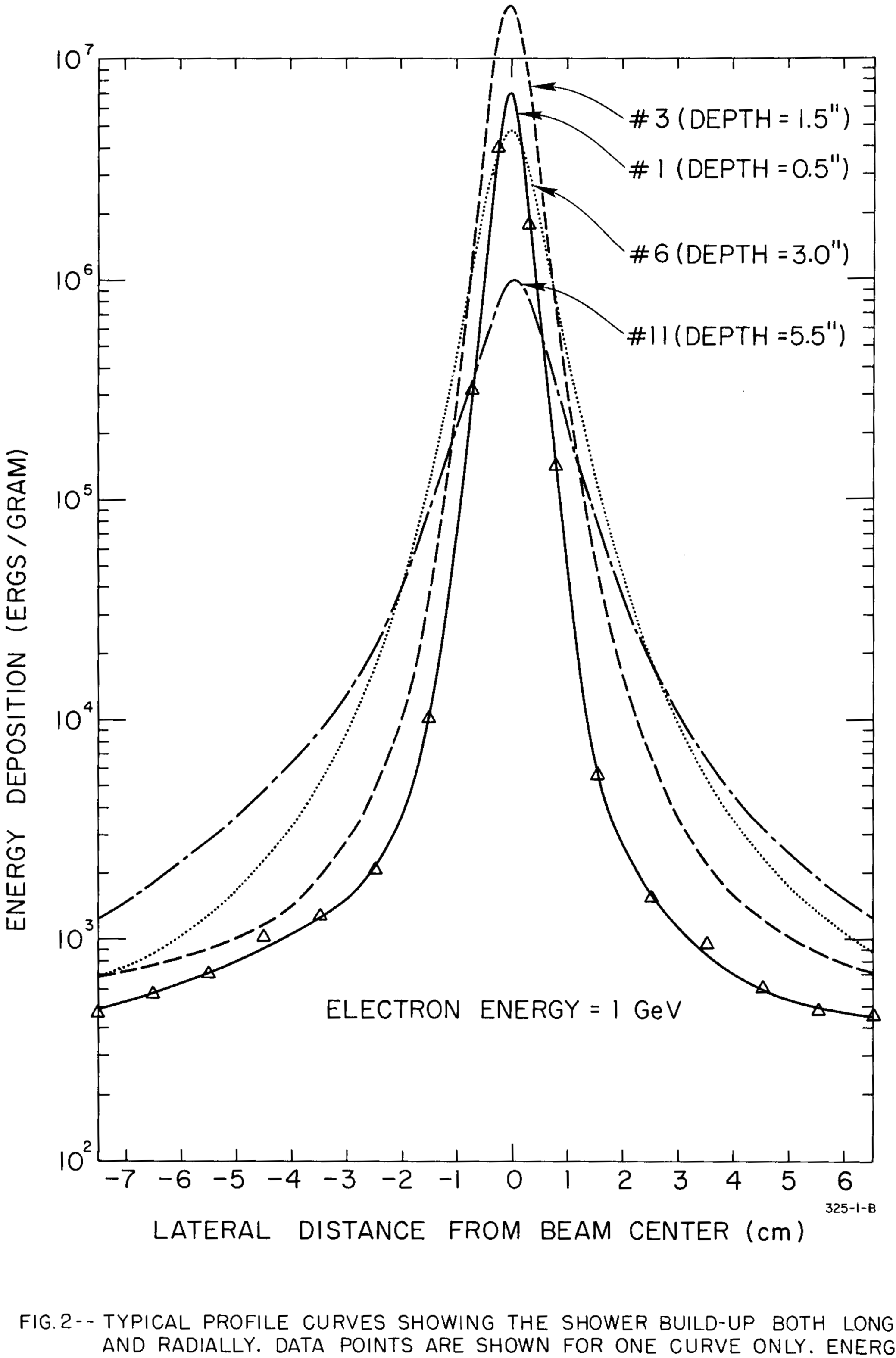

FIG. 2-- TYPICAL PROFILE CURVES SHOWING THE SHOWER BUILD-UP BOTH LONGITUDINALLY AND RADIALLY. DATA POINTS ARE SHOWN FOR ONE CURVE ONLY. ENERGY DEPOSITION ERRORS ARE OF THE ORDER OF ±5%.