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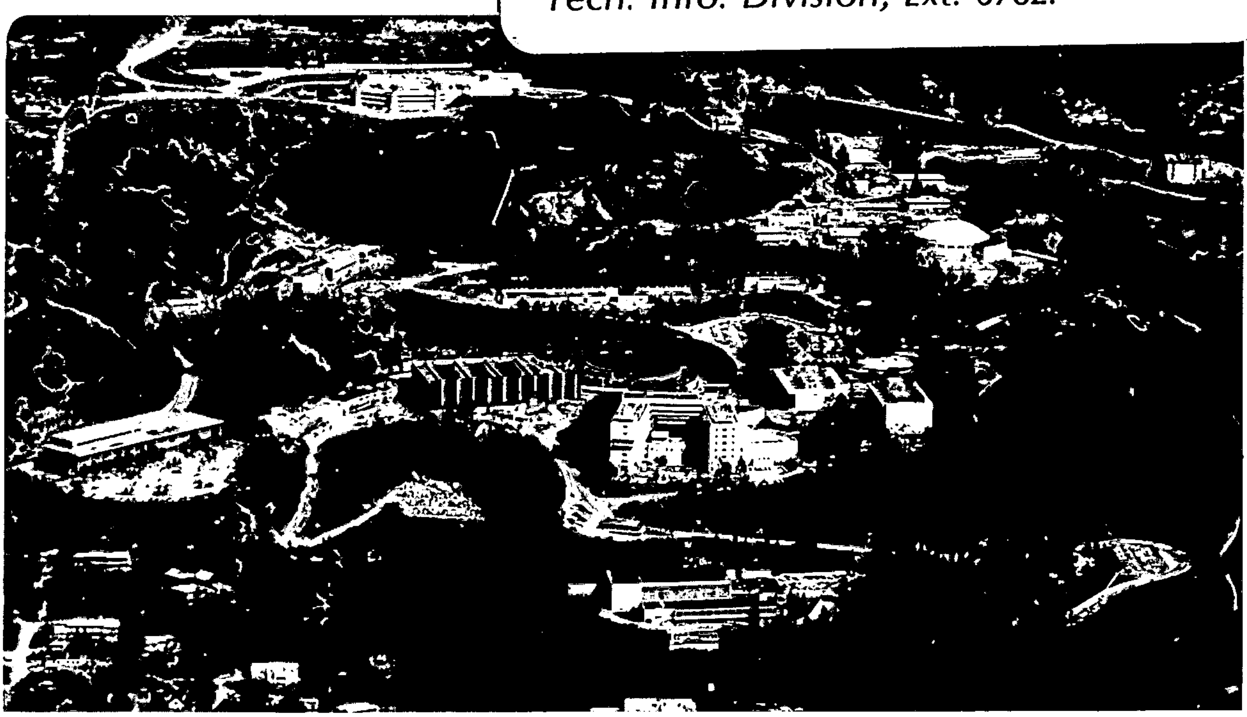

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GROUND SCATTERING CONTRIBUTION IN NEUTRON CALIBRATIONS

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The Editor, Health Physics
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Dear Sir:

Ground Scattering Contribution in Neutron Calibrations

Our attention has been drawn to some comments in a paper by Jenkins entitled "Simple Recipes for Ground Scattering in Neutron Detector Calibration", on the unpublished measurements, made by two of us, of neutron scattering (Mc76, Je80).

Our work referred to by Jenkins concerns measurements of the magnitude of the ground-scattering correction that should be made to typical "Fast-Neutron" detector* calibrations. In calibrating such detectors the assumption is often made that both source and detector are "point-like" and that the only neutrons detected are uncollided neutrons from the source. Under these assumptions the counting rate of the detector is simply related to the source-detector distance by the inverse square law. Neither assumption is true. Both uncollided source neutrons and neutrons scattered by the ground (and, to a much lower extent, air-scattered neutrons) reach the detector. The effect of these collided neutrons, relative to the uncollided fluence, is minimized by reducing the source detector distance. This minimization procedure is limited however. The detector is finite in size and it is consequently not possible to increase detector counting rates by decreasing the source-detector distance below a distance comparable to the detector length, if a sufficiently precise inverse square law relationship is to be maintained.

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*e.g. de Pangher counters (De59), Stephens and Smith Detectors (St58); Hankin's Sphere (Ha62).

In practice a compromise based on experience is achieved at the Lawrence Berkeley Laboratory by using a source detector distance of 1 meter, with an elevation of 1.50 meters above the ground (Mc76). With this configuration it is our estimate that ground-scattered neutrons increase the detector counting rate by about 15 percent.

In order to accurately determine this ground-scattered contribution we at Berkeley undertook two sets of measurements (Mc76): the first at the low-scatter cell of the Lawrence Livermore National Laborarartory, (LLNL), (Bo69) and the second at the Ames Research Center of the National Aeronautical and Space Administration (Mc76). It is these measurements that Jenkins refers to in his paper.

The measurements at the Livermore facility quickly revealed it not to be sufficiently "scatter-free" for calibration purposes and our work was therefore largely devoted to determining the magnitude of the wall-scatter contribution using a ^{239}Pu-Be Neutron Source ($\bar{E}$ = 4.2 MeV). It is not therefore correct that, as Jenkins states, we "assumed no scattering inside the room". In fact, we attempted to determine the scattered fraction by using the deviation from inverse square as an indication of the amount of scattering. After the magnitude of the wall scattering contribution had been determined we concluded: "In the standard (calibration) position above a concrete floor..... the (ground) scattering contribution ---- from the LLL experiment is then computed to be 12.1 percent".

Because this estimate was of limited accuracy a second set of measurements was made at the NASA - Ames Research Center. Here a source detector assembly, with a fixed source detector distance of 1 meter, was raised above the earth using an aircraft service gantry. It was found that the ground-scattered contribution to the detector counting rate became vanishing small at a height of 8m above the ground. These measurements showed that, using a ^{238}Pu Be neutron source ($\bar{E}$ = 2.4 MeV), the ground scattered contribution at the calibration position was (15.5 $\pm$ 0.1)%.

It is of some interest to compare our measurements with the values calculated by Jenkins. In computing values for the LLNL facility Jenkins shows that quite good agreement is obtained with the measurement made by McCaslin and Stephens, provided it is assumed that there is scattering from all six walls of the concrete enclosures. (See Fig. 10 in Je80).

In comparing his calculations with our NASA/Ames measurements Jenkins has plotted our data together with a theoretical curve using an equation assume a simple energy-independent scattering term:

$$R = \frac{\text{Total Fluence}}{\text{Uncollided Fluence}} = 1 + \left[\frac{1.26\rho}{1 + \rho^3}\right] \quad (1)$$

Where the parameter ρ as defined in the original paper is the ratio of the distance from the detector to the image of the source below the ground plane, to the direct distance from the detector to the source. Jenkins shows only fair agreement between calculated values of ratio R and our NASA Ames measurements as a function of ρ . This comparison is, however, is not expected to yield good agreement because, whereas the calculations reported were made for source and detector lying parallel to the horizontal ground plane, the measurements were made with the source and detector lying in a plane perpendicular to the ground and with the detectors intersecting the perpendicular line from the source to the ground.*

Nevertheless, the NASA-Ames experimental data may be quite correctly used to test experimentally equation (1) at one value of ρ. Since the NASA-Ames experiment was designed to provide an essentially ground-scatter-free detector calibration we are able to infer, with good accuracy, that in the LBL standard calibration position (source to detector distance 1 meter; source and detector ground distance 1.5 meters) that the ratio, R, of total fluence to uncollided fluence with a source, detector height of 1.5m above a concrete floor, is 1.155. The corresponding value of R calculated from Eqn. 1 is 1.12 (ρ = 3.16).

Thus in our analysis, both sets of our measuremens are in good agreement with Jenkin's simple recipes for ground scattering in neutron detector calibration. This agreement gives suport for the accuracy of the Morse calculations upon which the recipes are based. Although this agreement is indicated by Jenkins it is not clearly stated and, in our opinion, the reader might be misled in believing there to be disagreement where none exists. The purpose of this letter is to emphasize the degree of this agreement.

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* *[In fact the measured values of R shown in Fig. 9 in Je80 are misplotted but a correct plot only slightly improves the agreement between calculated and measured values]*

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