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University of California / Livermore, California
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LLL SPECIAL PROJECTS DIVISION RESEARCH IN NEUTRON MEASUREMENTS TECHNIQUES

R. V. Griffith
D. R. Slaughter
T. R. Crites

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LLL SPECIAL PROJECTS DIVISION RESEARCH IN NEUTRON MEASUREMENTS TECHNIQUES*

Richard V. Griffith, Dennis R. Slaughter and Thomas R. Crites

The neutron measurement work done in this Division is primarily in support of the applied health physics program at LLL. Currently the emphasis is on neutron spectrometry and personnel neutron dosimetry.

The spectrometry development is being done to provide spectral measurements of the source-moderator configurations used in our calibration facility. These measurements will be used for studies of dosimeter energy response. In the long run, we intend to assemble a system that can be used for high resolution spectrum measurements at the Laboratory's neutron generation facilities. This information will be used to provide data for neutron shielding problems.

Our spectrometry work includes development of sophisticated, high resolution detector systems as well as refinement of the conventional multisphere moderator techniques. High resolution detectors under study include NE 213 scintillators, ^{6}LiI scintillators, ^{3}He proportional counters and hydrogen proportional counters. The development primarily involves selecting a small set of detectors capable of spectral measurements from 10 keV to 20 MeV, refinement of pulse height analysis electronics for use with these detectors, and development of response function unfolding techniques which can be applied to the assembled system.

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The effort on multisphere detectors has been to provide an array that can be used now to make "field" measurements and will be available after the development of the high resolution systems to provide spectral information below 10 keV. We are currently using a set of polyethylene spheres with a 1.27 cm x 1.27 cm ^{6}LiI detector on loan to LLL from the ERDA Health and Safety Laboratory. The system has been used to make neutron spectrum measurements both in the calibration facility and in working areas. A prototype of a new portable pulse height analyzer is used for most field measurements.

The data is processed with the LOUHI computer code developed at the Lawrence Berkeley Laboratory.[1] The code is capable of unfolding neutron spectra from activation foil measurements with threshold detectors, moderating spheres, and nuclear emulsions.

One interesting aspect of the LOUHI code is that the responses of a detector to "known" spectra can be used by LOUHI to estimate the response function of that detector. That is, if the roles of the spectra and response function are reversed and spectra are provided as input data, the code solves the activation equation for the detector responses. This, of course, requires the availability of a number of different neutron spectra. Our calibration facility has available ^{238}PuBe and ^{252}Cf sources which can be used under ten different moderation conditions. We are beginning measurements with these sources and the LOUHI code to estimate the responses of moderated neutron detectors such as, TLD albedo dosimeters.

The problem of low level neutron spectrometry in pulsed or otherwise varying fields has led to interest in use of a multisphere system using track registration detectors so the spheres can be exposed simultaneously. Our current studies are being done with ^{235}U fission foils and thin films of polycarbonate for spark counting. The immediate problem is establishment of response functions for the various moderators. This will be done by combination of computer calculations using a discrete ordinates code, experimental measurements with monoenergetic neutrons from 10 keV to 20 MeV using LLL accelerators, and LOUHI calculations with our calibration facility measurements. We expect to be able to yield useful spectra at levels of 1 to 5 mRem over exposures of many days.

We are still concerned with the problem of developing a dependable, sensitive and accurate personnel dosimetry system. Our studies involve development of an albedo dosimeter with improved spectral response characteristics and fast neutron dosimeter which could be used to augment albedo dosimeter data for improved accuracy at dose equivalents in excess of a few hundred mRem.

Several variations, using different shield materials, of albedo badges have been examined in an effort to gain dose equivalence information independent of information concerning the incident neutron spectrum. Recent work has concentrated on defining the energy dependence of a simple albedo type dosimeter (TLD-600, 700 pairs on either side of a borated plastic shield) to the variety of source/moderator configurations available at LLL and reported at the last work shop. Preliminary results indicate a predictable energy dependence can be defined with a given source/ moderator combination. Information yielded from the badge is sufficient to determine a calibration factor for a wide range of moderator thicknesses in this case. However, when the initial source or moderator type is changed, then determination of the calibration factor is no longer simple.

There are three potentially useful track registration techniques currently under investigation as fast neutron dosimeters. None of these involve the use of fissionable material.

1. Electro-chemical Etching - In 1970, L. Tommasino[2] reported the use of an alternating electric field current applied across a dielectric during etching to enhance the visibility of tracks from fission fragments and alpha particles. A recent report extended this work to neutron recoil tracks.[3] We have attempted to reproduce these results, however, the unexposed background we have found in various samples of polycarbonate films with thicknesses of .013 cm to .030 cm has been equivalent to a few rem. Annealing overnight at 160°C does not reduce the background level significantly. Although the recoil tracks are enhanced as suggested, the technique could not be used without a method of reducing the background significantly.

2. In 1972, a report was made at the International Conference on Nuclear Photography and Solid State Track Detectors,[4]

suggesting the use of AgCl single crystals for neutron dosimetry. Dr. Charles Childs at the University of North Carolina has been working with silver halide crystals for heavy ion detection in applications such as cosmic ray studies. His technique involves decoration of the tracks by simultaneous application of electric field and U.V. light. The photoelectrons produced combine with silver ions along the particle track to produce free silver which provides a visible track.

We have exposed AgCl crystals doped with different materials to 30 Rem of ^{252}Cf neutrons. The crystals were returned to Dr. Childs for "decoration". He reports no visible tracks in Pb doped crystals, but there appear to be tracks in crystals doped with other materials. The crystals have not yet been returned to us, so we cannot make more definite comments.

3. LR 115 - We have been working with the commercial cellulose nitrate, LR 115,(5) for some time. The material uses a 0.001 cm thick layer of red dyed cellulose nitrate as a particle detector. Holes in the red layer after etching are very visible in a microscope when viewed with green light.

Currently, we are investigating the use of tracks from direct interaction in the film as well as a Be radiator as suggested by Frank and Benton.(6) The light Be recoils are more efficient for track production than the C, N, and O in the cellulose nitrate at fission neutron energies. Because tracks from Be recoils are apt to be seen at lower energies than those from direct recoils, we may be able to obtain some estimate of the neutron spectral quality using data from films with and without Be radiators together with the low and intermediate energy albedo detectors.

There are certainly other potentially useful track registration techniques, such as spark counting of direct recoils in thin films, but we have selected those that seemed most promising to fill our current needs.

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