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Improving the LLNL Pulsed Sphere Experiments Database and MCNP Models

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INTRODUCTION

During the last 33 years, numerous high-energy pulsed-sphere experiments[1-4] have been performed in which small, medium, and large spheres of 32 different materials were pulsed with a burst of high-energy neutrons. Measured time-dependent detector responses at distant locations provide a benchmark by which various neutron transport codes and cross-section libraries may be judged.

Figure 1 shows a simple but typical sphere. Others are made with multiple layers of steel-clad hemispherical shells. Various types of neutron detectors were located in the 26°, 30°, and 120° beamlines, outboard of the 2-m-thick concrete vault walls, with flightpaths ranging from 7.23 to 9.77 meters. Time-of-flight neutron measurements were typically made in 2-ns time bins from about 100 to several hundred nanoseconds after a pulse.

The most comprehensive sets of results from these measurements thus far have been included in the EXPTDATA[5] and DISP93IN[4] datafiles from LLNL. Unfortunately, both are incomplete and partially overlapping, with the latter including some more recent re-measurements of earlier experiments.

PRESENT WORK — PART 1

The first phase of the present work was to carefully go through both datafiles and extract the most reliable set of results for each experiment (experimental parameters and neutron count rates vs time) and create a well-documented master library with results from 145 experiments. In some cases, results from one or the other datafile were rejected if the data were known to be flawed. In other cases, a particular datafile may have been selected if it spanned a broader range of measurement times. In still other cases, the header record information in the two datafiles describing the experimental parameters was not consistent and an effort was made to resolve these discrepancies.

The new master library contains information on 145 such experiments. A companion library of 145 text files gives additional information about each of the experiments. The first section of the text files includes comments on the original EXPTDATA and DISP93IN datafiles -- such as why one was chosen as opposed to the other, and how any discrepancies in the experimental parameters were resolved. The second section includes supplemental information regarding the MCNP model.

PRESENT WORK — PART 2

The second phase of the present work is to create an MCNP model for at least one sphere of each material, and to make comparisons of the measured time-dependent spectra (and/or energy-dependent spectra) against the spectra calculated using the ENDL92, the ENDF60, and the newest ENDF66 libraries. Results for the NE213-A detector in the 120° beamline in combination with the 0.7 mean-free-path Pu-239 pulsed sphere are, for example, shown in Fig. 1.

Before converging on a common set of features to be included in each of these models, a series of investigatory calculations and comparisons were made involving several new features:

1. Results with Marchetti and Hedstrom s new source specifications[6] were compared against measurements and the results using the traditional source specifications for 13 different cases. This new source consistently gave results that were in much better agreement with the measurements in the high-energy range (11 to 15 MeV), and virtually equivalent everywhere else. Thus, the new source specifications were adopted.

2. The air inside the target room and beamlines has traditionally been included in all models, but in previous calculational models,[7,8,9] the 2-m concrete walls were ignored and the beamlines were not collimated. For the Pu-239 sphere, the collimating effect of the wall around the beamline was found to be very important. Whether the collimating material was concrete or a black absorber made some difference, but not much. Comparison plots show that the effect of neutron reflection back to the sphere from the concrete walls was totally negligible in the timeframe of the measurements. Thus, the black absorber model was adopted.

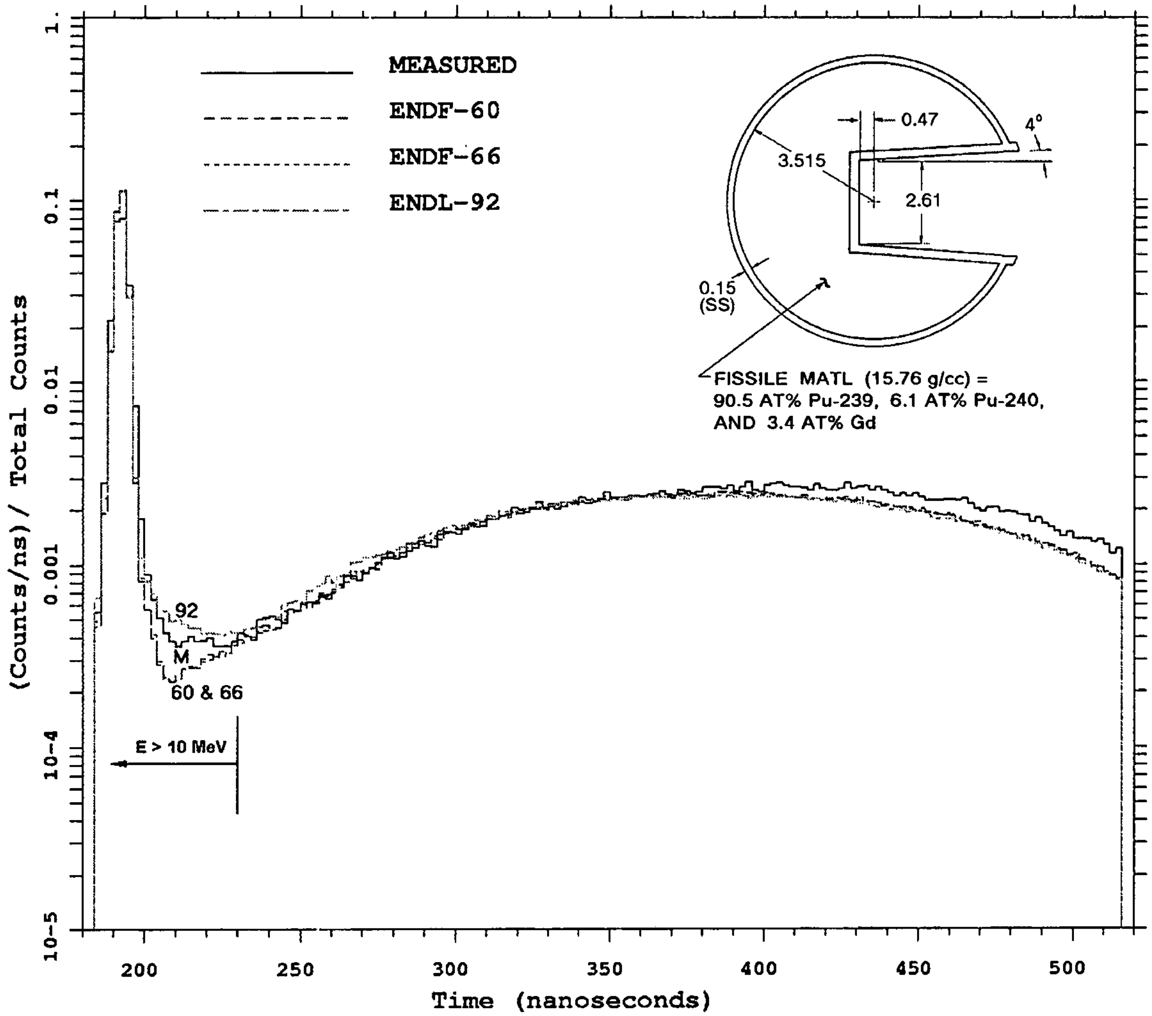

Fig.1. Results for the NE213-A neutron detector in the 120-deg beamline in combination with the 0.7 mfp Pu-239 pulsed sphere. Dimensions of sphere are in cm.

3. Lastly, the target assembly shown in Fig. 6 of Ref. 1 was included in all of the new MCNP models. Historically this has been ignored for light materials.

CONCLUSION

With these new features in place, ENDL92, ENDF60, and ENDF66 comparison calculations have thus far been performed for 76 detector measurements involving 38 pulsed spheres made of 20 different materials. From the MCNP comparisons to date, two general observations may be made: (1) The ENDF66 results are slightly closer to the measured values than the ENDF60 results, but not significantly different in most cases. (2) The ENDL92 results frequently appear to be significantly closer to the measured high-energy results (E > 10 MeV) corresponding to very short times, especially for the Pu-239 and U-235 spheres, whereas the ENDF data is frequently slightly better at lower energies and longer times.

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