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Title: NEW CALCULATIONS FOR CRITICAL ASSEMBLIES USING MCNP4B

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New Calculations for Critical Assemblies using MCNP4B

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A suite of forty-one criticality benchmarks has been modeled using MCNP™ (version 4B).[1] Most of the assembly specifications were obtained from the Cross Section Evaluation Working Group (CSEWG)[2] and the International Criticality Safety Benchmark Evaluation Project (ICSBEP)[3] compendiums of experimental benchmarks. A few assembly specifications were obtained from experimental papers. The suite contains thermal and fast assemblies, bare and reflected assemblies, and emphasizes ^{233}U, ^{235}U, ^{238}U, and ^{239}Pu.

The values of k_{eff} for each assembly in the suite were calculated using MCNP libraries derived primarily from release 2 of ENDF/B-V and release 2 of ENDF/B-VI. The results show that the new ENDF/B-VI.2 evaluations for H, O, N, B, ^{235}U, ^{238}U, and ^{239}Pu can have a significant impact on the values of k_{eff}. A preliminary discussion of these results has been released[4] and a more detailed discussion will be published in an upcoming Los Alamos National Laboratory Report.

In addition to the integral quantity k_{eff}, several additional experimental measurements were performed and documented for the following CSEWG benchmarks: Godiva (CSEWG:F5), Jezebel-4.5% (CSEWG:F1), Jezebel-20.1% (CSEWG:F21), Bigten

(CSEWG:F20), Flattop-25 (CSEWG:F22), Flattop-Pu (CSEWG:F23), Thor (CSEWG:F25), Jezebel-23 (CSEWG:F19), and Flattop-23 (CSEWG:F24). These experimental measurements include central fission and reaction-rate ratios for various isotopes, and neutron leakage and flux spectra. They provide more detailed information about the accuracy of the nuclear data than can k_{eff}. Comparison calculations were performed using both ENDF/B-V.2 and ENDF/B-VI.2-based data libraries. The purpose of this paper is to compare the results of these additional calculations with experimental data, and to use these results to assess the quality of the nuclear data.

For assemblies with experimentally-measured leakage spectra (Godiva, Jezebel-4.5%, and Jezebel-23), we calculated the neutron flux averaged over the outer surface of the assembly. For the assembly with an experimentally-measured central flux (Bigten) we calculated the flux in a small sphere in the center of the assembly. The experimental and MCNP-calculated spectra were then normalized to unit area and compared. Comparisons were performed by plotting the spectra simultaneously and by calculating the chi-squared difference between the spectra. The comparisons reveal little difference between the ENDF/B-V.2 and ENDF/B-VI.2 libraries for ^{239}Pu, ^{240}Pu, and ^{241}Pu, but show an improvement in the ENDF/B-VI.2 libraries for ^{235}U and ^{238}U. Figure 1 shows a plot of the experimental Godiva leakage spectrum with the calculated ENDF/B-V.2 and ENDF/B-VI.2 leakage spectra.

For CSEWG benchmarks with experimentally-measured central fission and reaction-rate ratios, we used the tally multiplier feature in MCNP to perform the calculations. The CSEWG ratios, with the exception of some Thor values, were with respect to ^{235}U fission. When possible, all CSEWG-reported ratios were calculated using both ENDF/B-

V.2 and ENDF/B-VI.2 data.

Overall, the agreement with experiment was fairly good. The central fission ratios for ^{233}U and ^{239}Pu using both ENDF/B-V.2 and ENDF/B-VI.2 data were within one standard deviation of the CSEWG values for all four assemblies in which these ratios were measured. For ^{238}U and ^{237}Np, most of the fission ratios were within two standard deviations of the CSEWG values. A comparison of the calculated fission ratios for ^{237}Np to the measured CSEWG values for each assembly is shown in Figure 2 for both ENDF/B-V.2 and ENDF/B-VI.2.

The calculated reaction-rate ratios also showed good agreement with experiment. Most ratios were within one or two standard deviations of the experimental values, and there was usually little difference between the ENDF/B-V.2 and ENDF/B-VI.2 results. For reaction-rate ratios measured in several assemblies, the agreement with the MCNP calculations was usually assembly independent. The two exceptions were the activation ratios of ^{59}Co and ^{238}U. The calculated ^{59}Co ratio in Godiva agreed poorly with experiment, while the same ratio in Bigten agreed well with experiment. Likewise, the ^{238}U activation ratio in Thor agreed poorly with experiment, while the same ratio in Bigten agreed well with experiment. Since the neutron spectrum in Bigten is softer than the neutron spectrum in Godiva and Thor, this may suggest the cross-section data for ^{59}Co and ^{238}U are reasonable at lower energies and could be improved at higher energies. Such information cannot be obtained from comparisons of k_{eff} alone.

In summary, a suite of criticality benchmarks has been modeled with MCNP4B. In addition to k_{eff}, several other experimentally-measured quantities have been calculated using both ENDF/B-V.2 and ENDF/B-VI.2 data. Detailed comparisons indicate generally good agreement with experiment using both libraries. However, they also reveal areas needing improvement in the nuclear data.

References

1 J. F. Briesmeister, Ed., "MCNP4B - A General Monte Carlo N-Particle Transport Code," Los Alamos National Laboratory report, LA-12625-M (1997).

2 "Cross Section Evaluation Working Group Benchmark Specifications," Brookhaven National Laboratory report, BNL 19302 and ENDF-202 revised (1991).

3 "International Handbook of Evaluated Criticality Safety Benchmark Experiments," NEA Nuclear Science Committee publication, NEA/NSC/DOC(95)03, Volumes I-VIII, (1996).

4 A. A. Adams, S. C. Frankle, and R. C. Little, "Revised Criticality Benchmarks for MCNP," Los Alamos National Laboratory research note, XTM-RN(U)96-031 (1996).

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ENDF/B-V and ENDF/B-VI F2 Spectra vs. Experimental GODIVA Leakage

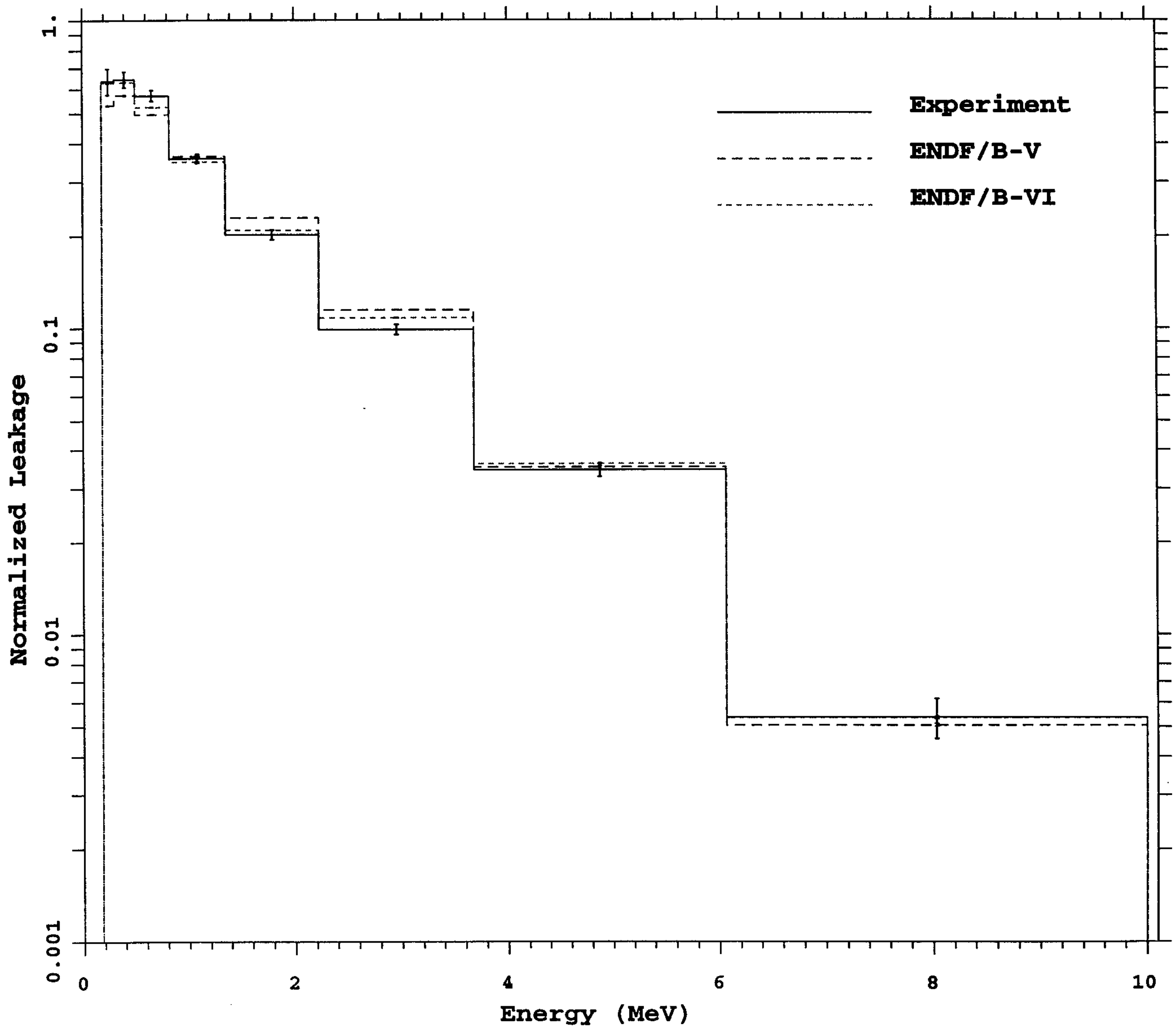
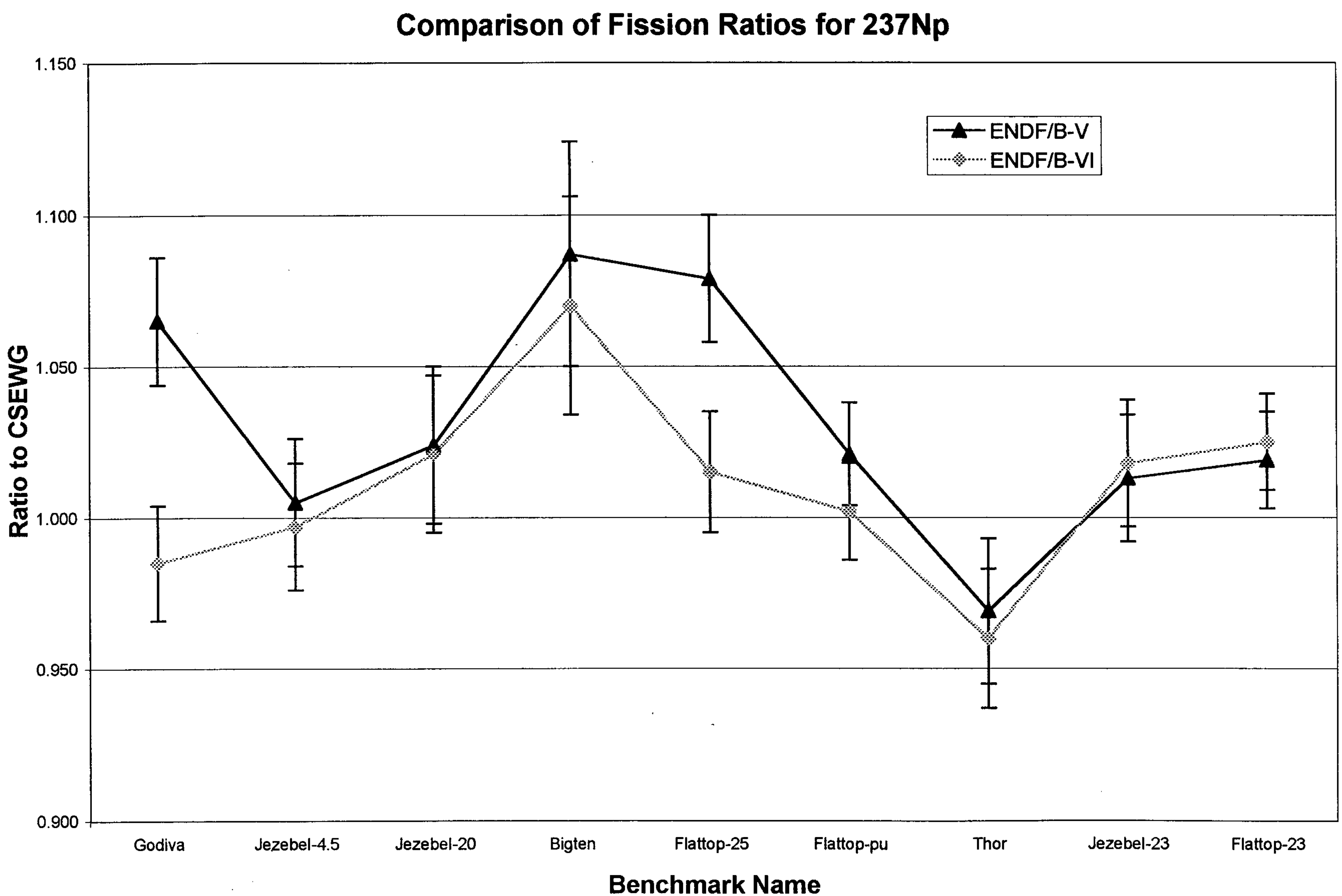


Figure 1

Figure 2



Comparison of Fission Ratios for 237Np
ENDF/B-V
ENDF/B-VI
Ratio to CSEWG
1.150
1.100
1.050
1.000
0.950
0.900
Godiva
Jezebel-4.5
Jezebel-20
Bigten
Flattop-25
Flattop-pu
Thor
Jezebel-23
Flattop-23
Benchmark Name

M97009128

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