

National Institute of Standards and Technology

Nuclear Data Verification and Standardization Program

PROGRESS REPORT

USNDP Meeting

Brookhaven National Laboratory

November 11, 2005

Staff :

- Allan Carlson, David Gilliam, and Alan Thompson.
- NIST, independent of DOE funds, supplies about half of the total support for the standards program.
- There is the equivalent of about 1 FTE working on the program.

Nuclear Structure Activities:

- None are supported by DOE funding.
- A modest effort (1 FTE) in structure and decay studies is supported by NIST funds.

Nuclear Reaction Activities: Neutron cross section standards

- Significant improvements have been made in the standard cross section database.
- The standards are the basis for the neutron reaction cross section libraries.
- In response to requests for improvements in the standards:
 - The CSEWG formed a Task Force.
 - The WPEC formed a subgroup.
 - The IAEA formed a Coordinated Research Project (CRP).
 - NIST has maintained a leadership role in each of these groups.

THE NEUTRON CROSS SECTION STANDARDS

Reaction	Energy Range
H(n,n)	1 keV to 200 MeV
³ He(n,p)	thermal to 50 keV
⁶ Li(n,t)	thermal to 1 MeV
¹⁰ B(n,α)	thermal to 1 MeV
¹⁰ B(n,α ₁ γ)	thermal to 1 MeV
C(n,n)	thermal to 1.8 MeV
¹⁹⁷ Au(n,γ)	thermal, 0.2 to 2.5 MeV
²³⁵ U(n,f)	thermal, 0.15 to 200 MeV
²³⁸ U(n,f)	2 to 200 MeV

Recent Standards Evaluation Activities

- Comparisons of R-matrix codes were completed to check for consistency of values of the cross sections, variances and covariances produced when the same database is used for each analysis.
- Changes were made to the Hale hydrogen evaluation.
- The $^{10}\text{B}(n,\alpha)$ and $^{10}\text{B}(n,\alpha,\gamma)$ R-matrix evaluations were completed using both the EDA and RAC codes.
- Final combination of the R-matrix and generalized least squares evaluations was completed.
- Final cross sections and covariance data from the standards evaluation were submitted.
- Documentation of the standards evaluation process is underway.
- Improvements continue to be made to the experimental data in the standards database.

Cross Section Results

•H(n,n)

- A full (complete) ENDF evaluation by Hale up to 20 Mev has been submitted.
- The energy range of the standard is 1 keV to 20 MeV.
- The extension to 200 MeV has not been completed.

³He(n,p)

- This evaluation was not completed. This evaluation will be carried over from ENDF/B-VI.
- The energy range of the standard is thermal to 50 keV.

⁶Li(n,t)

- The evaluation is complete.
- The energy range of the standard is thermal to 1 MeV.
- Users are cautioned about using this as a standard near the resonance at ~240 KeV due to the rapid change of the cross section with energy.

Cross Section Results (cont.)

- $^{10}\text{B}(n,\alpha)$

- This evaluation is complete.
- The energy range of the standard is thermal to 1 MeV.

- $^{10}\text{B}(n,\alpha_1\gamma)$

- This evaluation is complete.
- The energy range of the standard is thermal to 1 MeV.

- $\text{C}(n,n)$

- This evaluation will be carried over from ENDF/B-VI. Very few new measurements have been made of this standard and those that were made agree very well with the ENDF/B-VI evaluation.
- The energy range of the standard is thermal to 1.8 MeV.

- $\text{Au}(n,\gamma)$

- This evaluation is complete.
- The energy range of the standard is thermal and 0.2 MeV to 2.5 MeV.

Cross Section Results (cont.)

•²³⁵U(n,f)

- The evaluation is complete.
- The energy range of the standard is thermal and 0.15 MeV to 200 MeV.

•²³⁸U(n,f)

- This evaluation is complete.
- It was accepted as an ENDF standard at the 2004 CSEWG meeting.
- It was recommended that the lower energy bound for use as a standard be changed to 2 MeV.
- The energy range of the standard is 2 MeV to 200 MeV.

Cross Section Results (cont.)

$^{238}\text{U}(n,\gamma)$

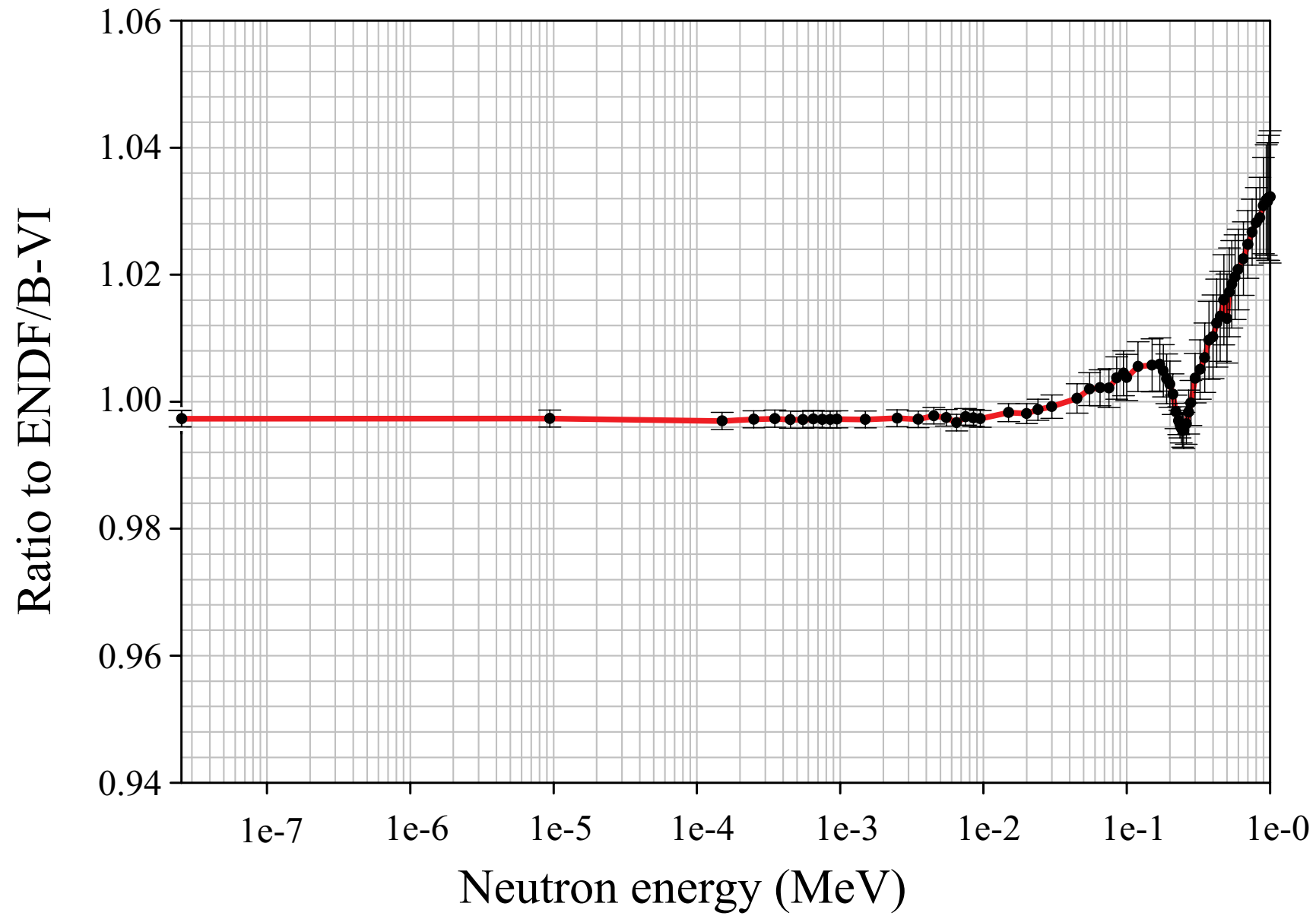
- This evaluation is complete.
- This is not a standard cross section.

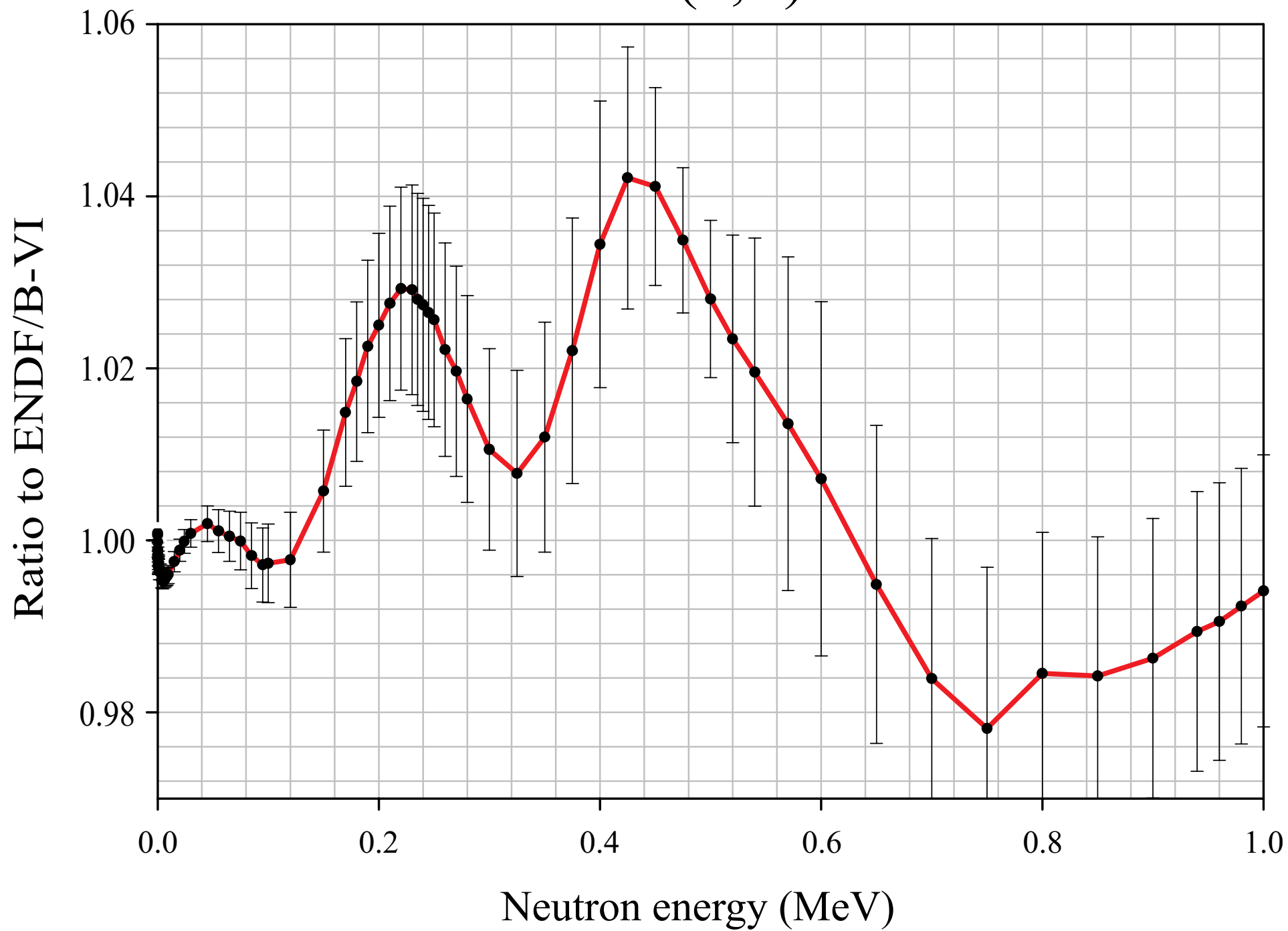
• $^{239}\text{Pu}(n,f)$

- This evaluation is complete
- The evaluation extends to 200 MeV.
- This is not a standard cross section.

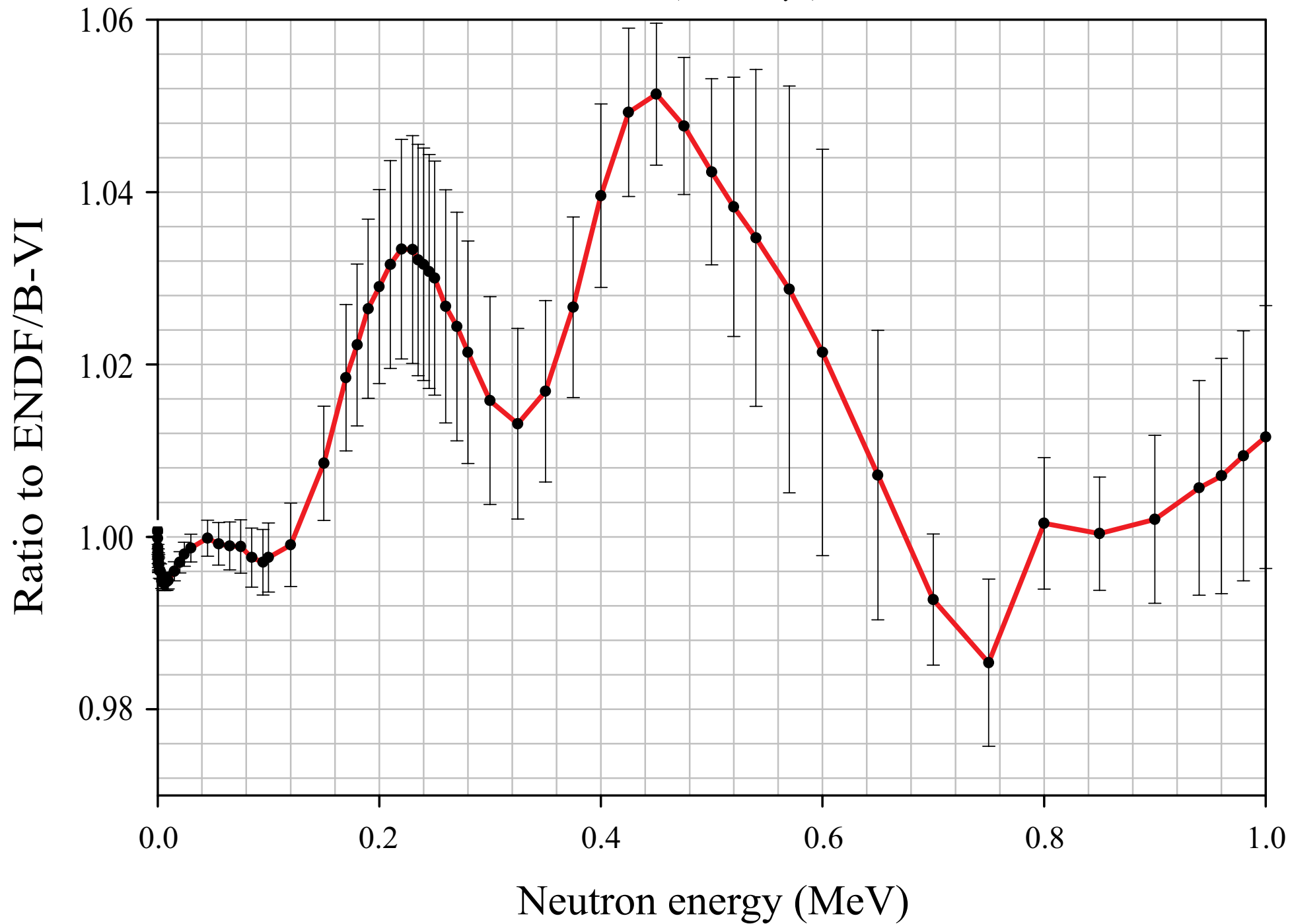
**Comparison of the Standard Cross Sections
obtained from the ENDF/B-VII Standards Evaluation Process
with
the ENDF/B-VI Results**

${}^6\text{Li}(n,t)$

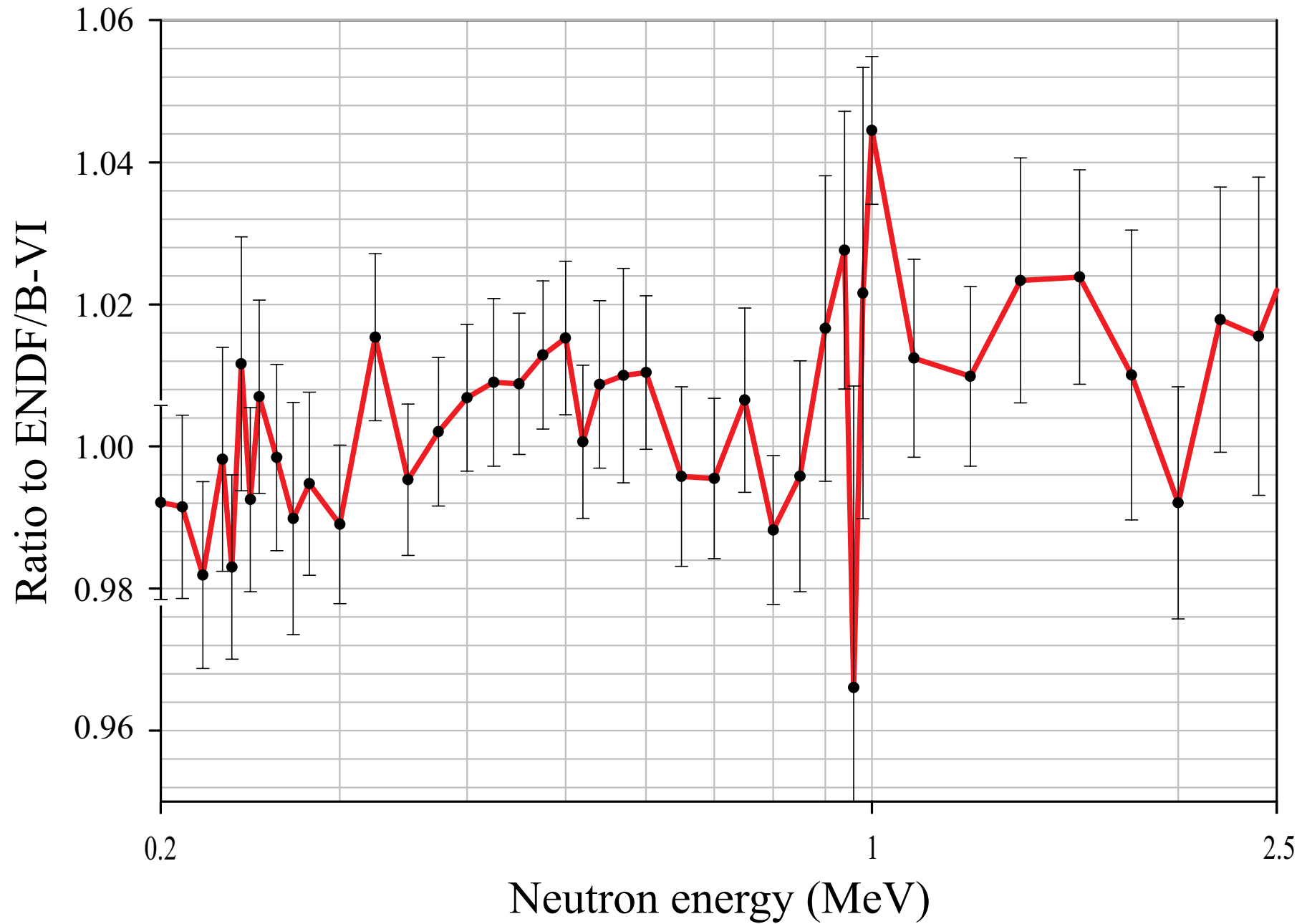


$^{10}\text{B}(n,\alpha)$ 

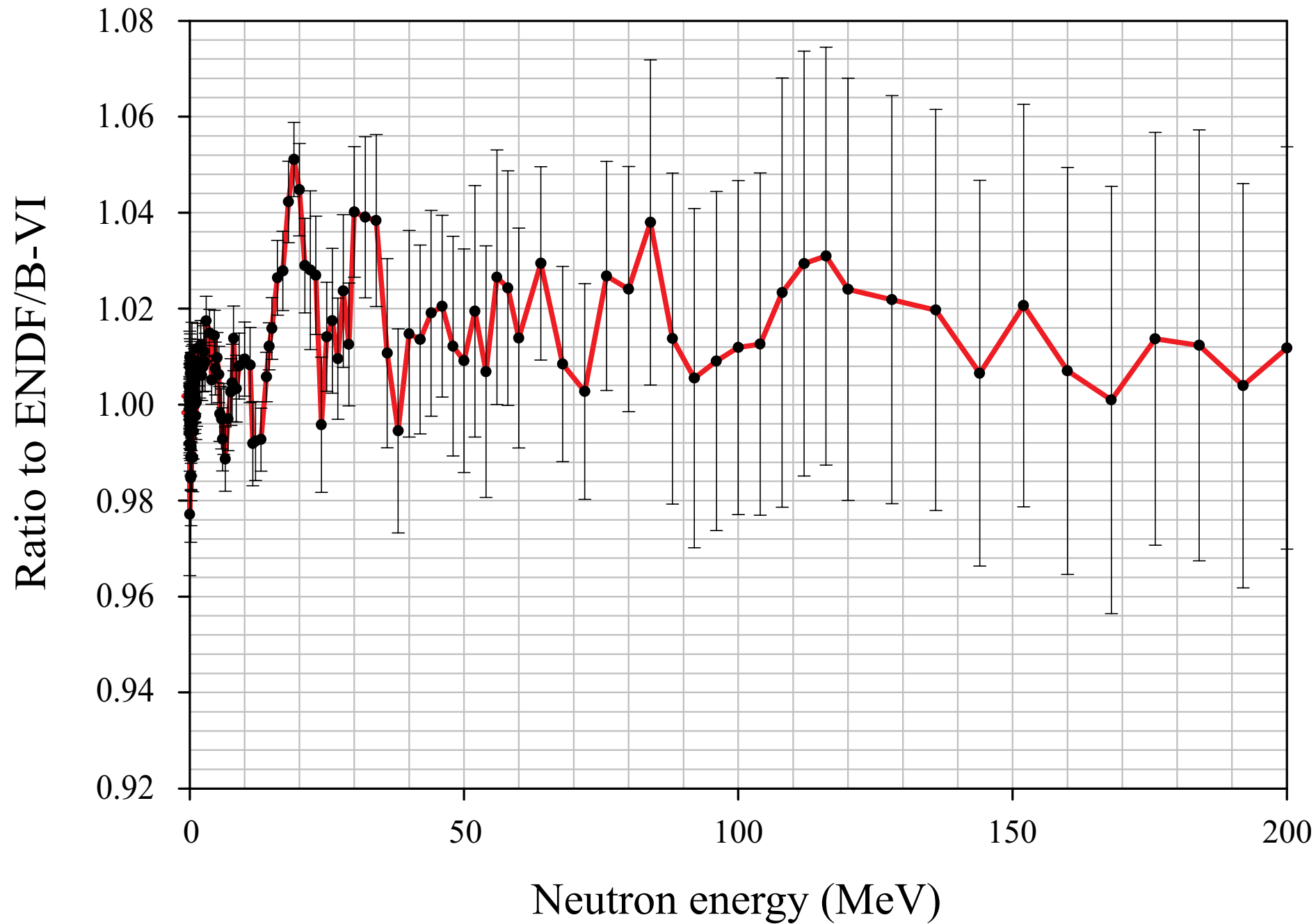
$^{10}\text{B}(n,\alpha_1\gamma)$



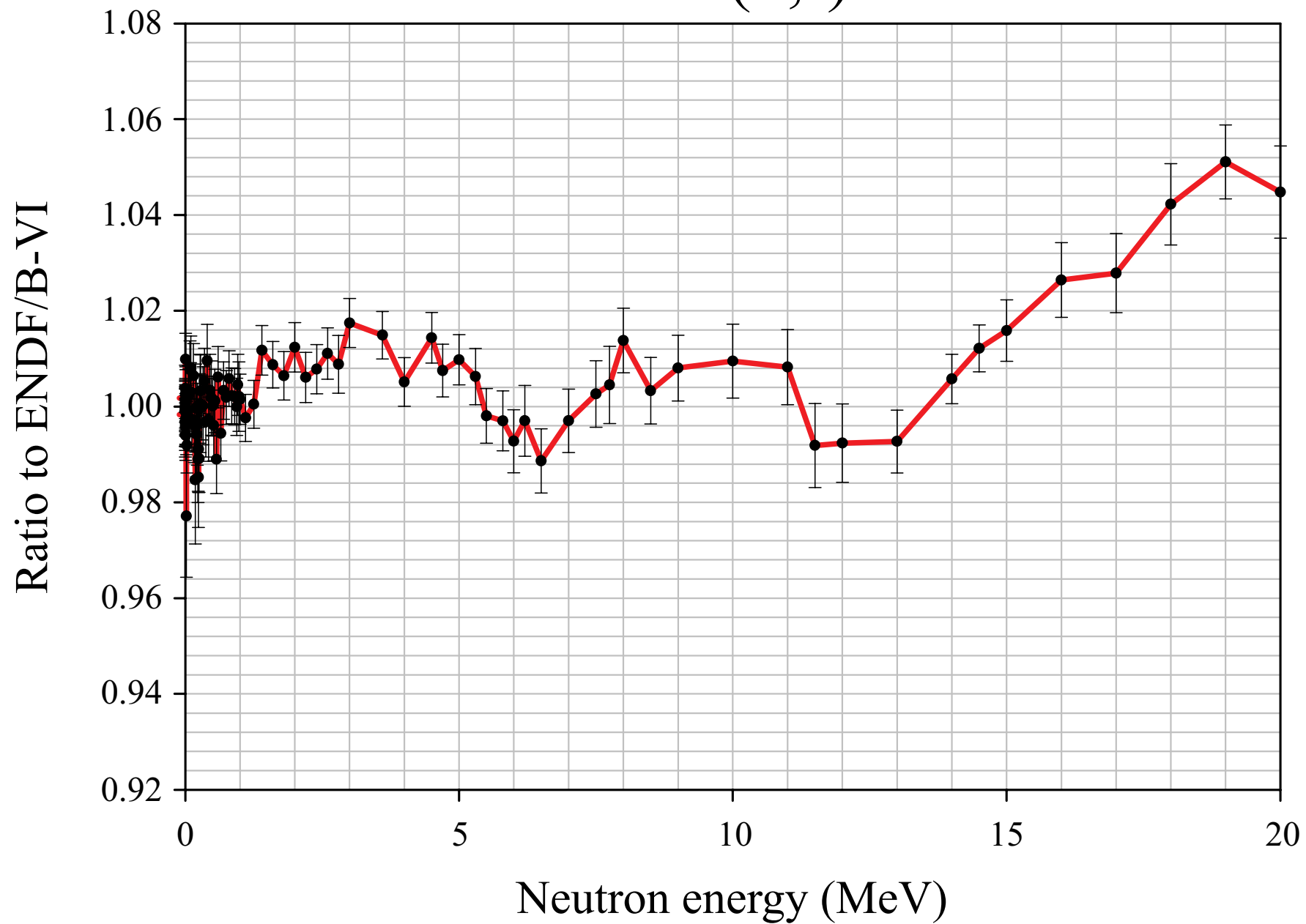
Au(n, γ)



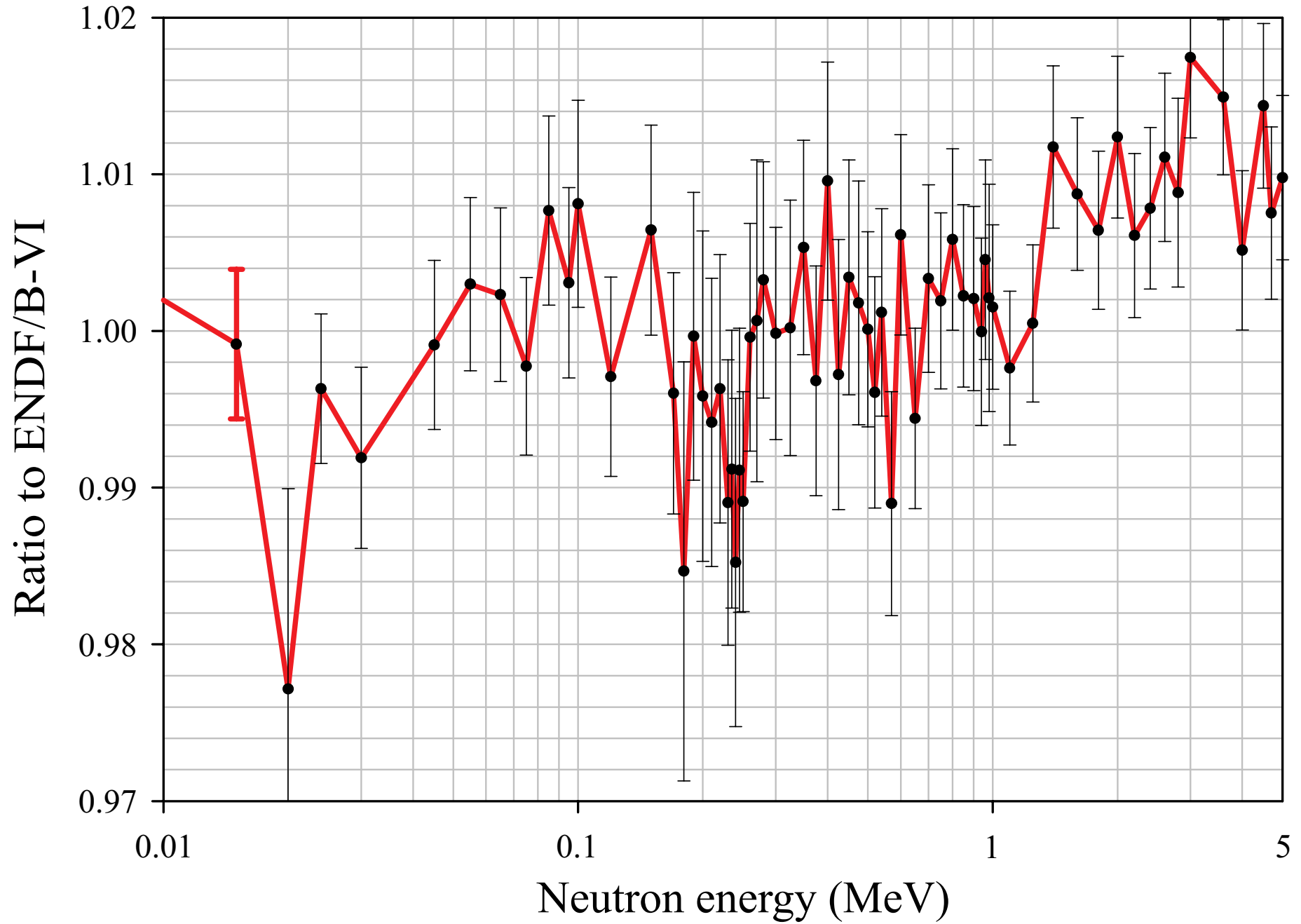
$^{235}\text{U}(n,f)$



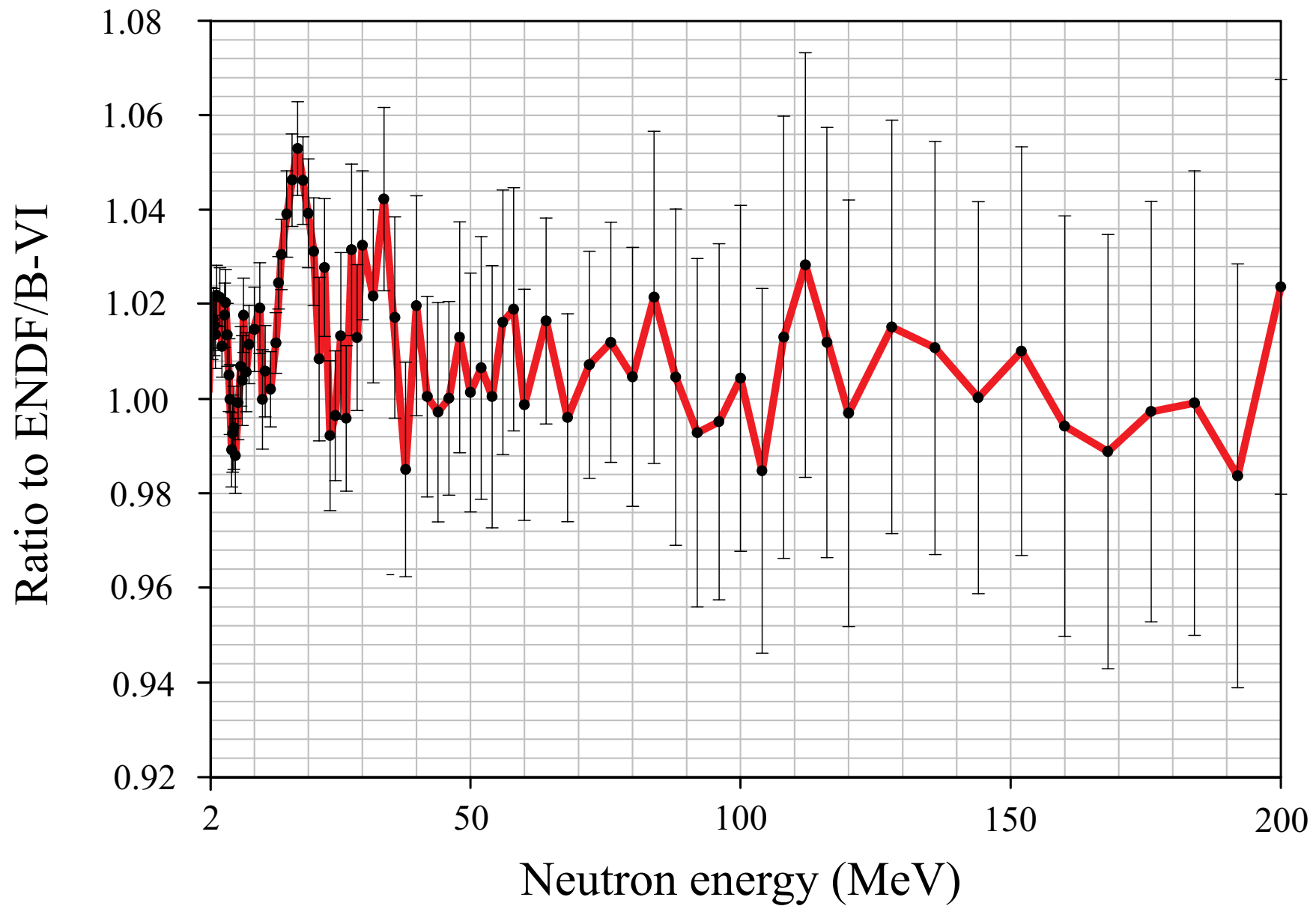
$^{235}\text{U}(n,f)$



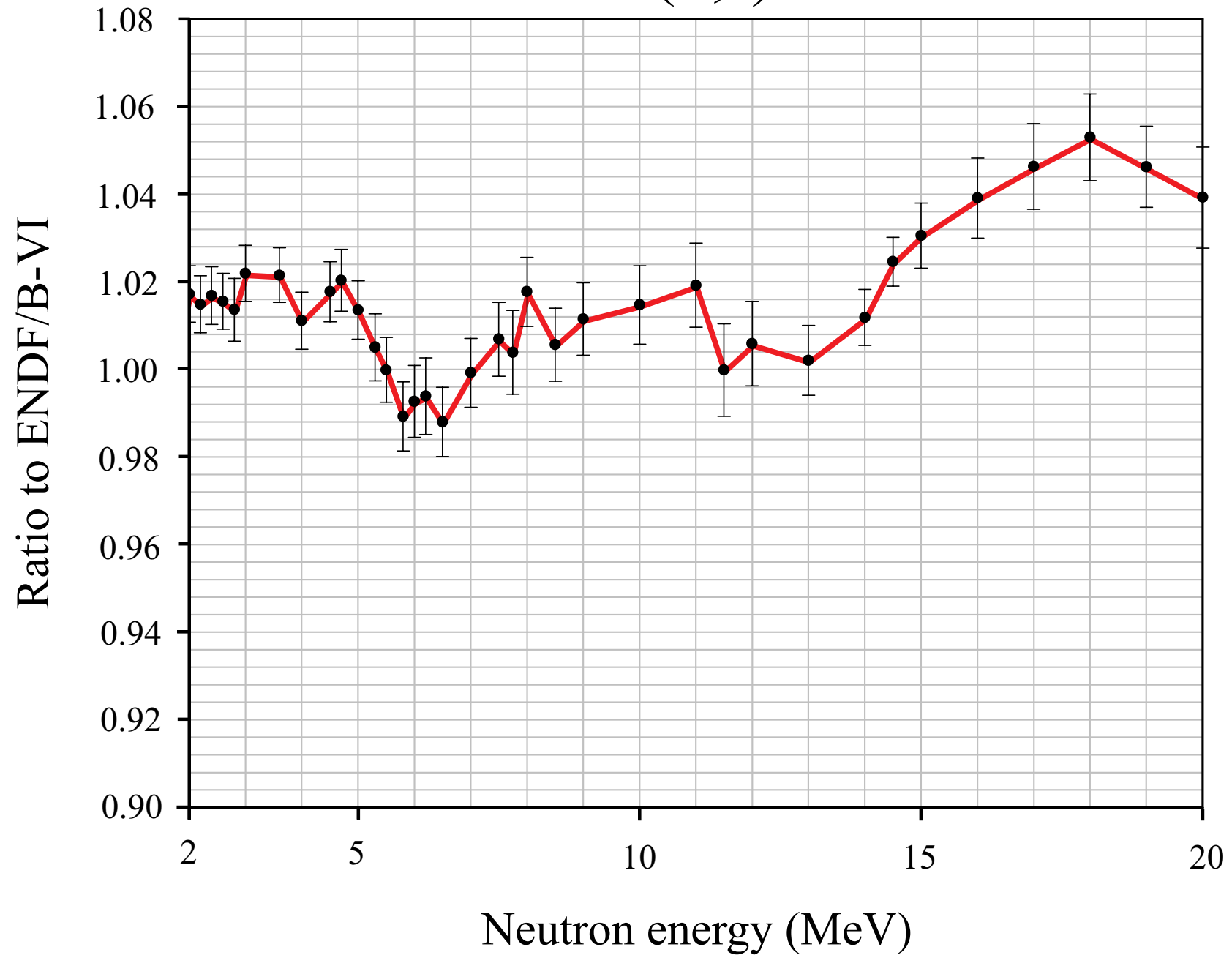
$^{235}\text{U}(n,f)$



$^{238}\text{U}(n,f)$

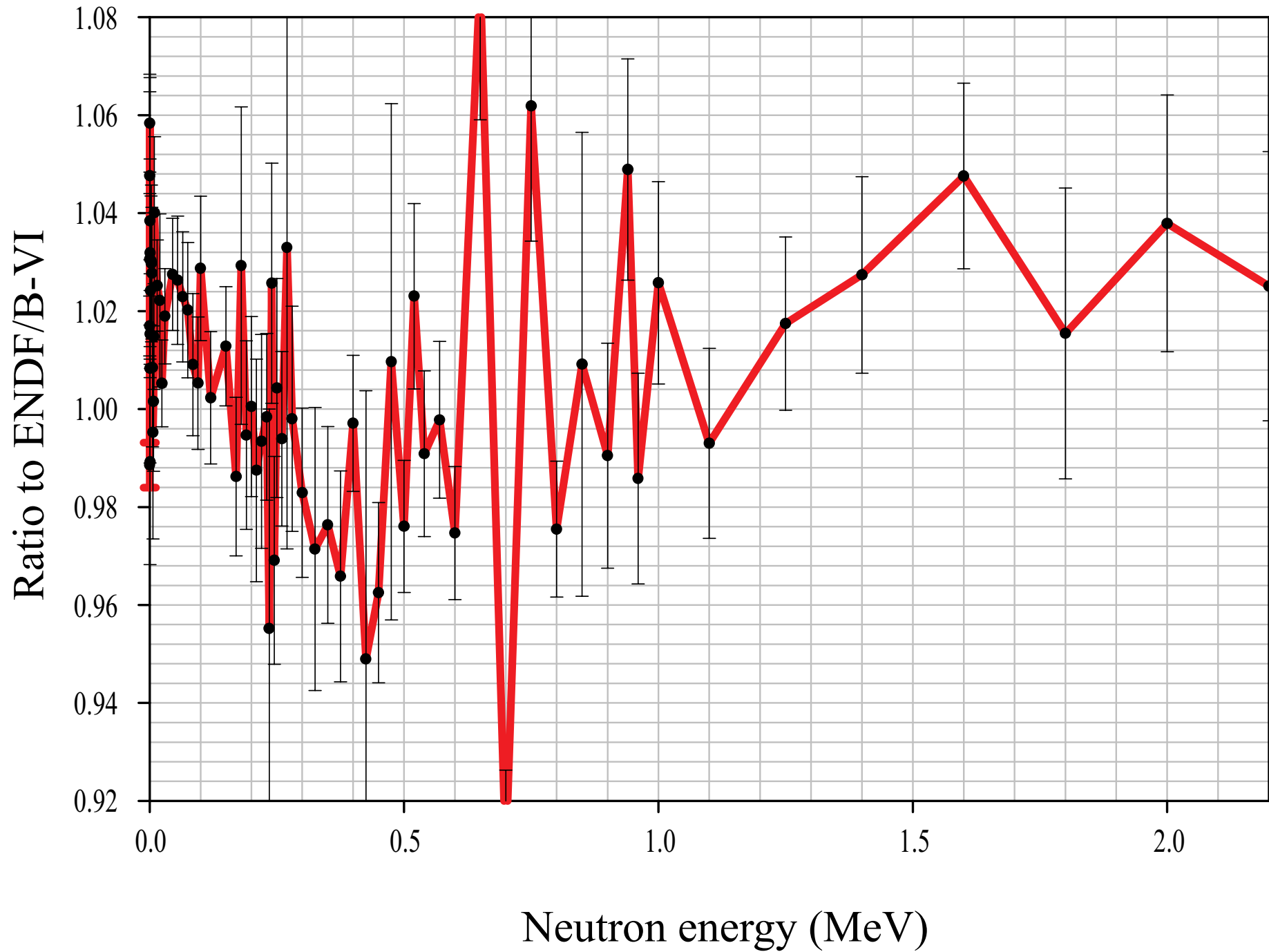


$^{238}\text{U}(n,f)$

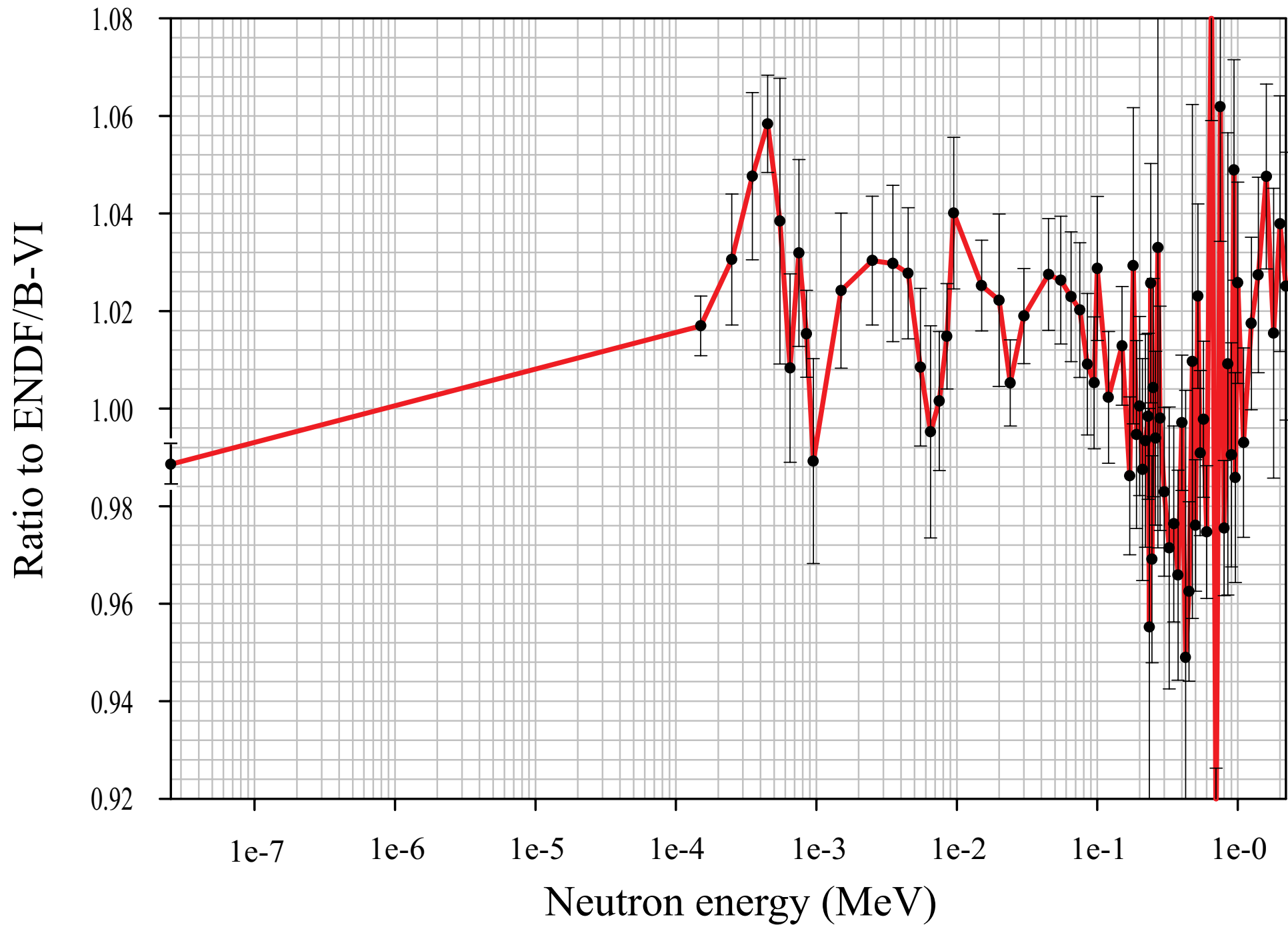


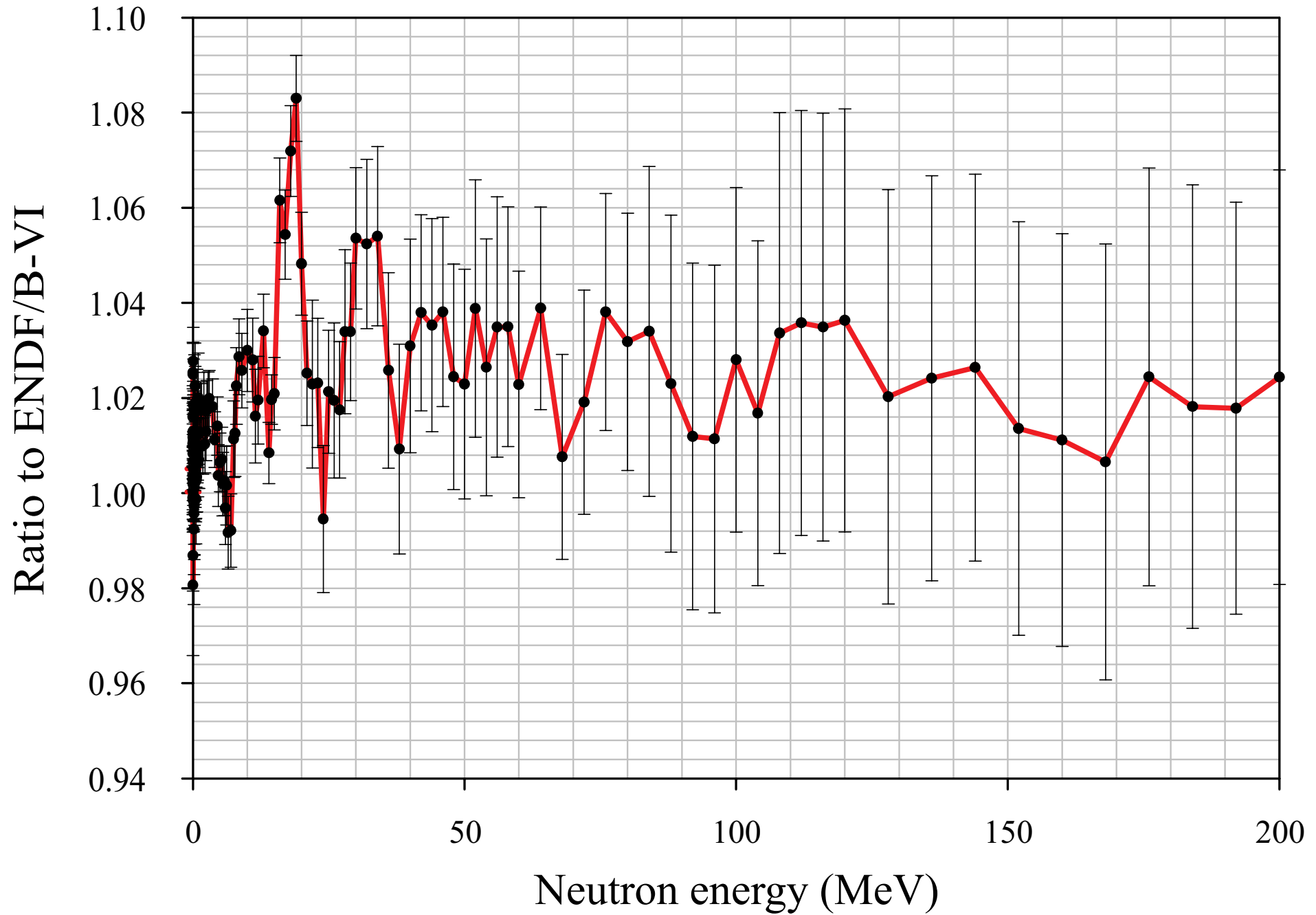
**Comparison of the Cross Sections that are not Standards
obtained from the ENDF/B-VII Standards Evaluation Process
with
the ENDF/B-VI Results**

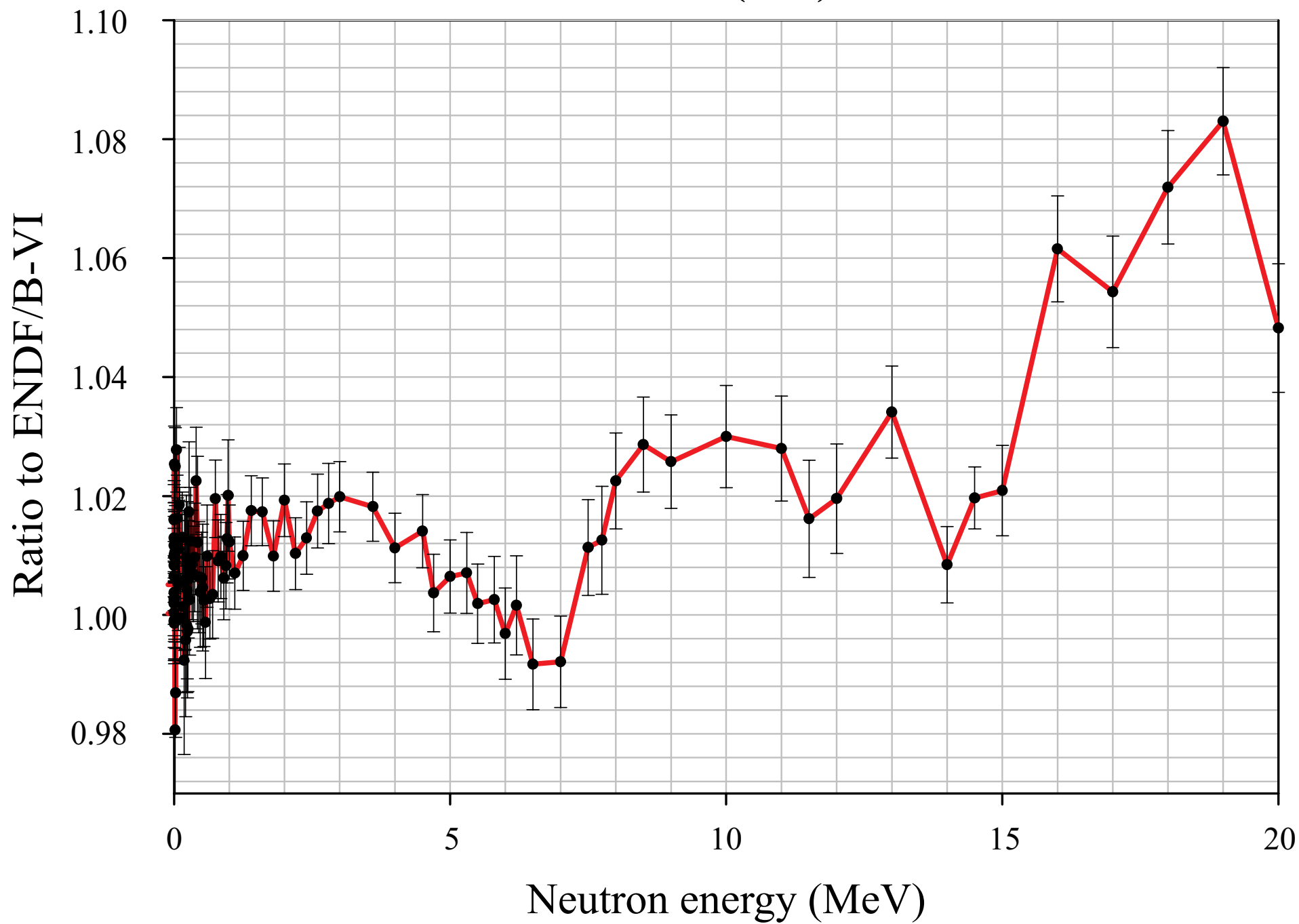
$^{238}\text{U}(n,\gamma)$



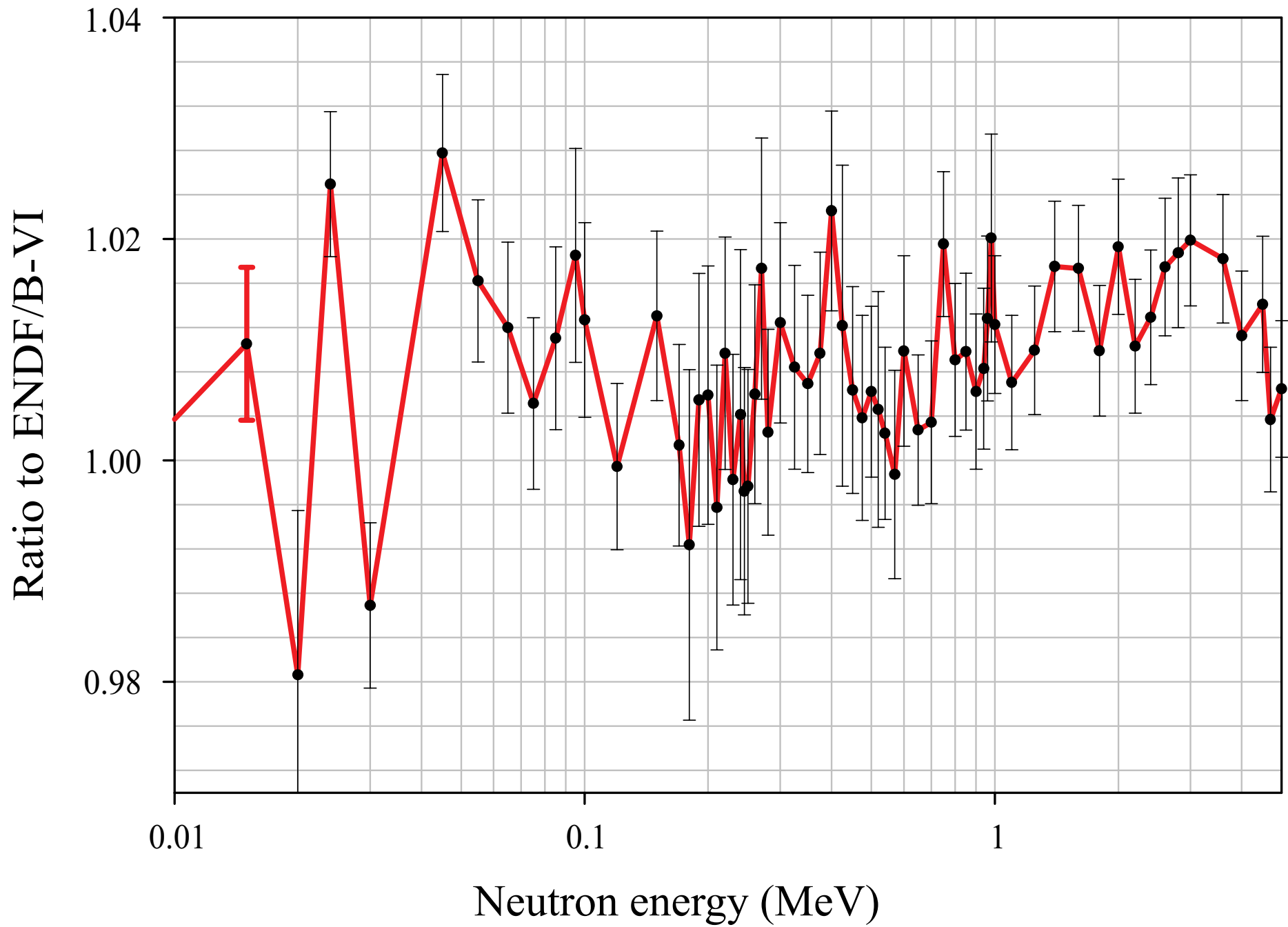
$^{238}\text{U}(n,\gamma)$



$^{239}\text{Pu}(n,f)$ 

$^{239}\text{Pu}(n,f)$ 

$^{239}\text{Pu}(n,f)$



Experimental and other work

- Hydrogen scattering angular distribution data at 15 MeV neutron energy have been obtained and data accumulation continues. Initial analysis is underway. (collaboration with Ohio University and LANL)
- The NIST National Repository for Fissionable Isotope Mass Standards continues to acquire and monitor samples.
- n-H and n-³He coherent scattering length work that is used in the evaluations of the H(n,n) and ³He(n,p) cross sections has been published. An experiment is being setup for measurements of the spin-dependent portion of the n-³He coherent scattering length. Also work is underway to measure the n-³H coherent scattering length.
- Improvements continue on a measurement of the ⁶Li(n,t) cross section standard at ~ 4 meV neutron energy. The emphasis is on improved fluence determinations using methods based on calorimetry, nu-bar of ²⁵²Cf and α - γ coincidences using the ¹⁰B(n, α , γ) reaction.

Recommendations

- Though the ENDF/B-VII standards evaluation has been completed, there are still important standards activities that need to be continued.
 - Completion of the $^3\text{He}(n,p)$ evaluation.
 - Extension of the H(n,n) standard to 200 MeV.
 - Re-evaluation of the standards based on the new hydrogen standard since so many standards have been measured relative to that standard.
 - Maintaining and improving the standards database and codes.
 - Maintaining an experimental program to improve the standards.
- These activities could be done under an approved IAEA nuclear data development project “maintenance of the neutron cross section standards”. This project will continually update the standards so they are available for new versions of a library. New experiments will be encouraged and the experimental results obtained will be carefully investigated so that an improved database will be available for the next evaluation. Also standards evaluation codes will be maintained and improved. Maintaining a close relationship with the WPEC and CSEWG communities will make this a more effective project.