



METHODOLOGY FOR VALIDATING MINOR ACTINIDE FISSION CROSS SECTIONS

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OVERVIEW

- Introduction
- JAEA Foundational Work
- Work Description
- Results
- Conclusions and Continuing Work



INTRODUCTION

- As the nuclear industry moves towards a closed fuel cycle increased attention has been paid to the accuracy of the current evaluated nuclear data for the minor actinides.
- The purpose of this work was to create a simple method for identifying and predicting potential corrections to the high energy fission cross-sections of Np-237, Pu-238, Pu-242, Am-241, Am-243, and Cm-244.



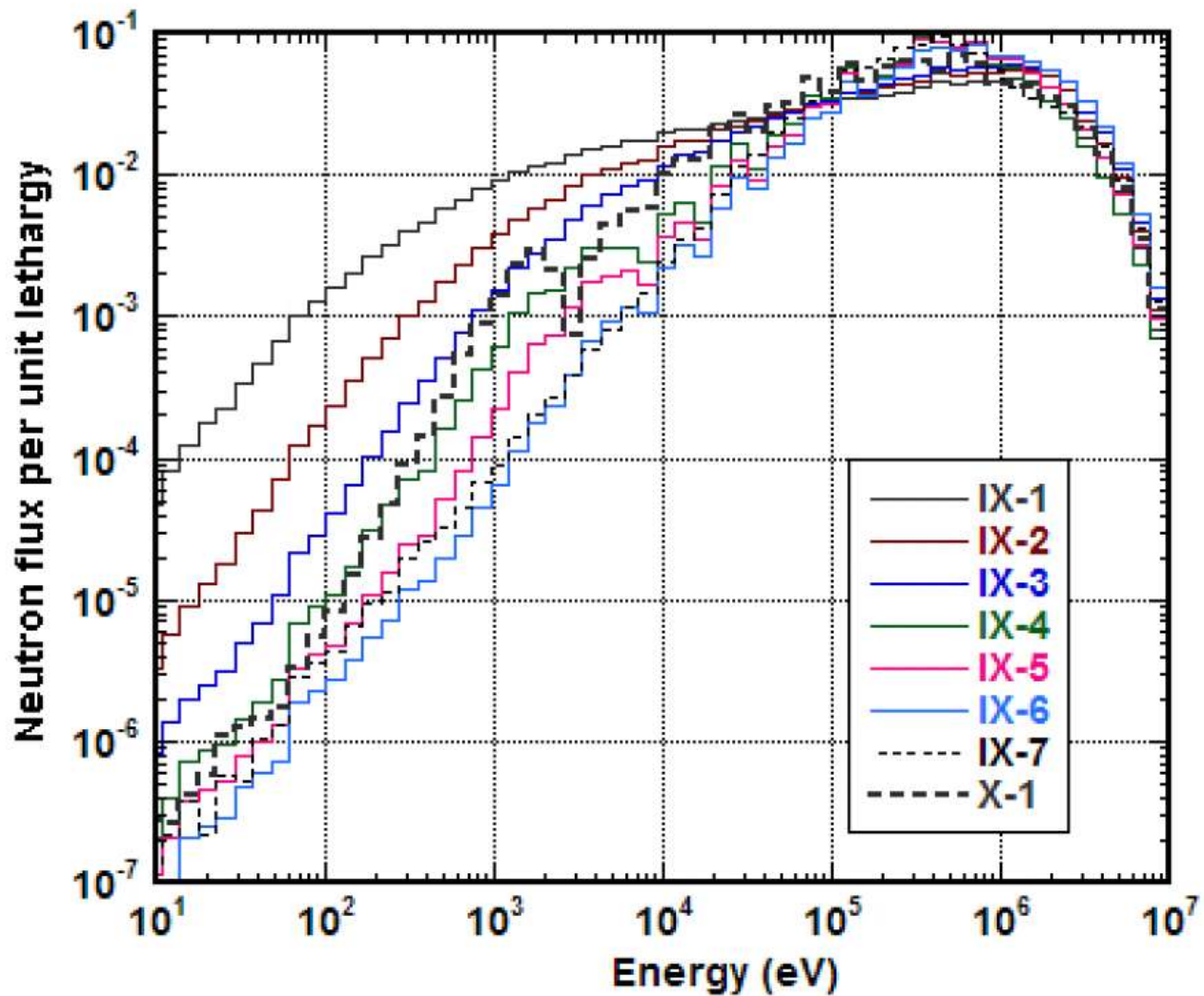
FOUNDATIONAL JAEA EXPERIMENTAL RESULTS

- Undertaken by S. Okajima, M. Fukushima, T. Mukaiyama at the Fast Critical Assembly of the Japan Atomic Energy Agency.
- Eight test cores of varying spectra hardness were constructed. Actinide foil samples were irradiated within these cores, and their fission rates relative to Pu-239 were measured.

- S. OKAJIMA, M. FUKUSHIMA, T. MUKAIYAMA, "Benchmark Test for TRU Nuclear Data by Analysis of Central Fission Rate Ratios Measured at FCA Cores," *International Conference on the Physics of Reactors*, Interlaken, Switzerland, September 14-19, 2008



FCA CORE CALCULATED SPECTRA



WORK DESCRIPTION

- Using ENDF-B/VI.6 and ENDF-B/V data, MCNPX was used to fold the spectra from each core with the fission cross section for each of the minor actinides.
- The MCNPX simulated reaction rates differed from the experimental relative reaction rates by as much as 9.3%. It was desirable to identify the energy groups where erroneous nuclear data was inducing the discrepancy and to estimate the magnitude of the error.



WORK DESCRIPTION

- Tallies were used to compute group averaged fission cross-sections for each minor actinide for the energy ranges 10 eV – 1 keV, 1 keV – 100 keV, 100 keV – 1 MeV, 1 MeV – 10 MeV
- Each group cross-section was multiplied by a constant to be determined, referred to as λ_4 through λ_1 .



WORK DESCRIPTION

$$\min \sum_{j=1}^8 \left(\left[\sum_{i=1}^4 \lambda_i \hat{\sigma}_{i,j} \phi_{i,j} \right] - [RR_j] \right)^2$$

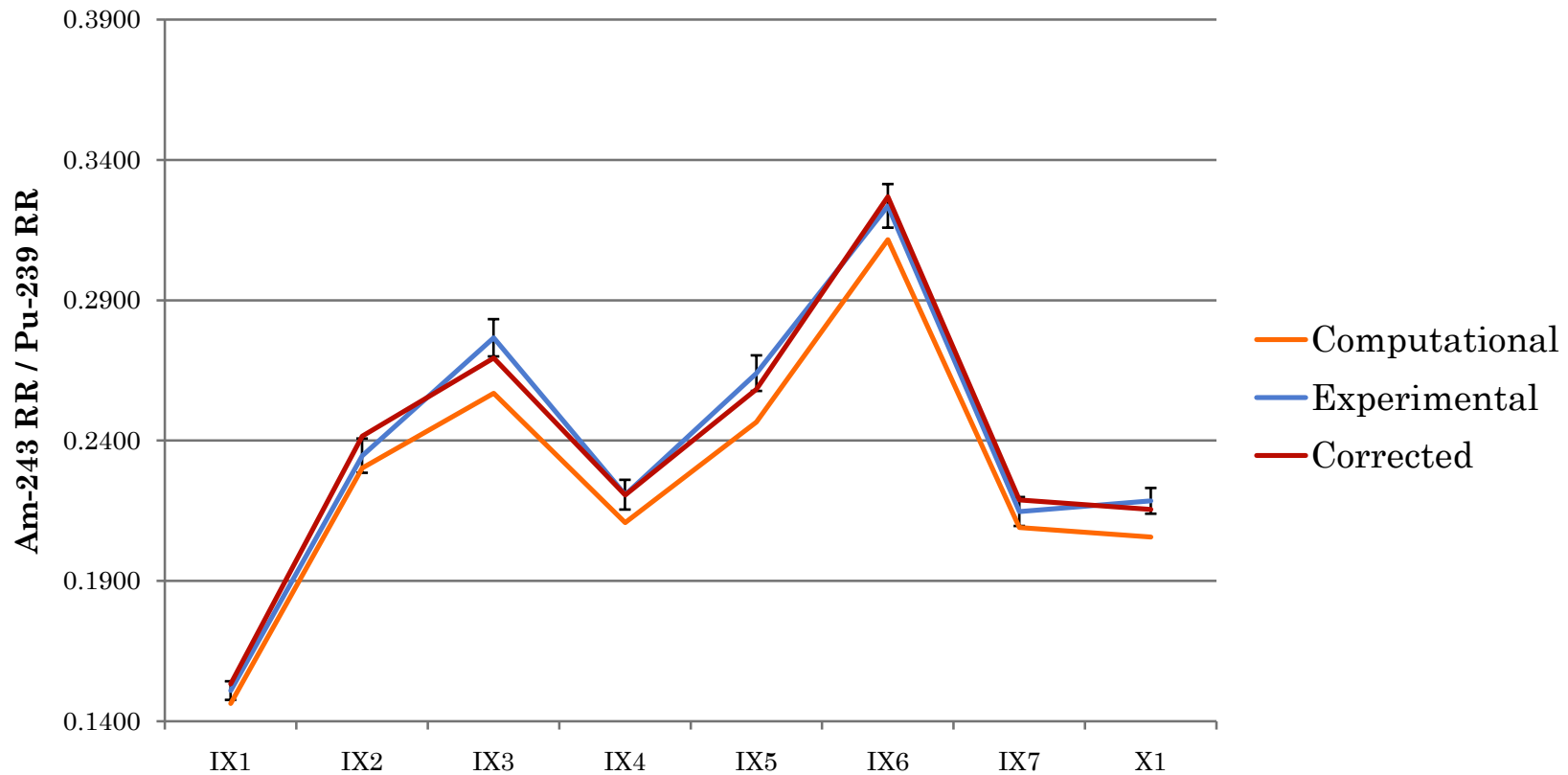
- $\hat{\sigma}_{i,j}$ is the spectrum-weighted cross section obtained via an MCNPX-assisted group collapse of the ENDF data.
- $\phi_{i,j}$ is the i^{th} group flux for the j^{th} experimental trial.
- RR_j is the measured reaction rate reported.



AM-243 RESULTS ENDF-B/VI.6

TABLE I. Am-243 lambda values
for ENDF-B/VI.6

λ_4	1.0000
λ_3	1.0004
λ_2	1.009
λ_1	1.0551

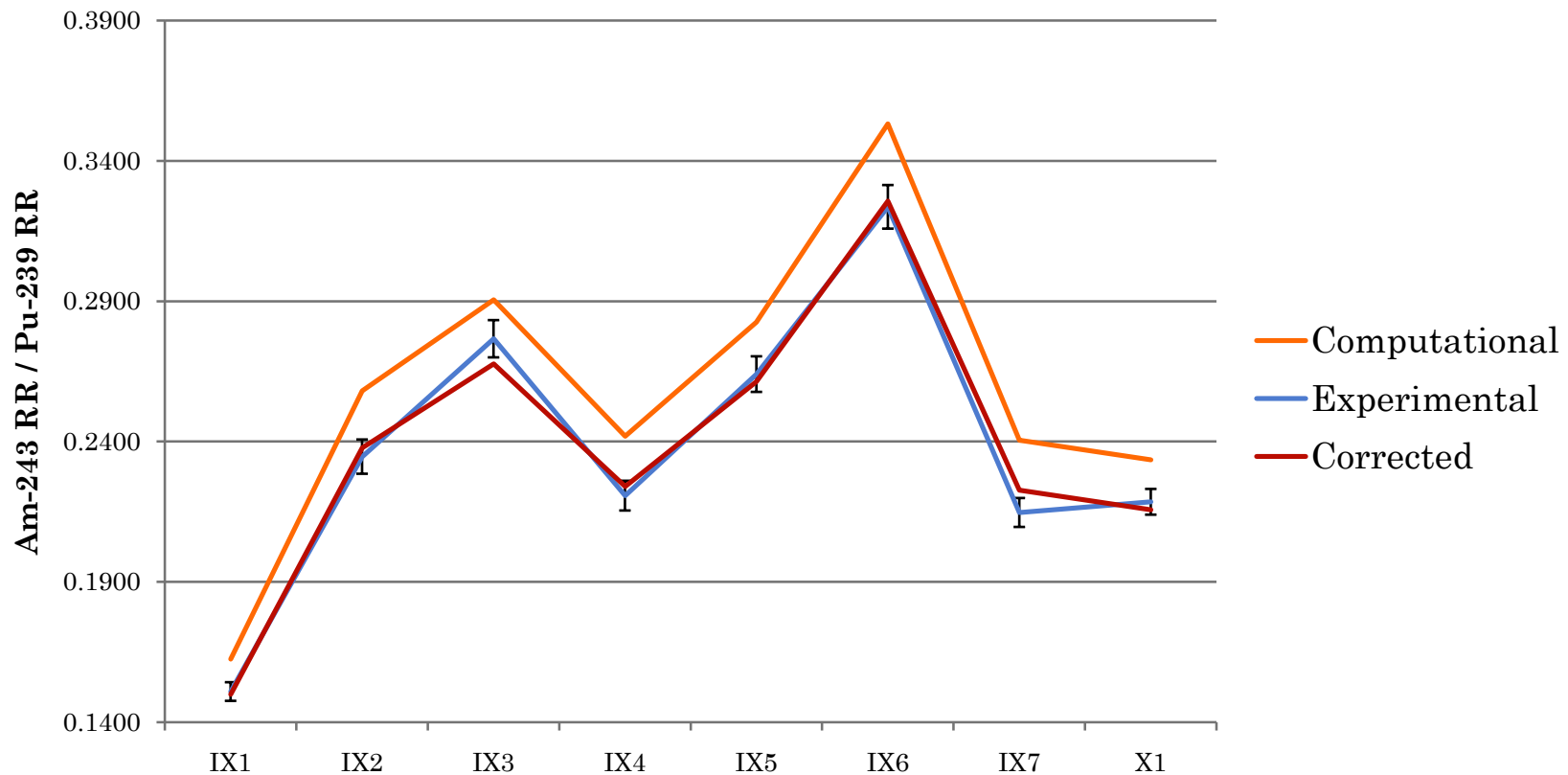


AM-243 RESULTS

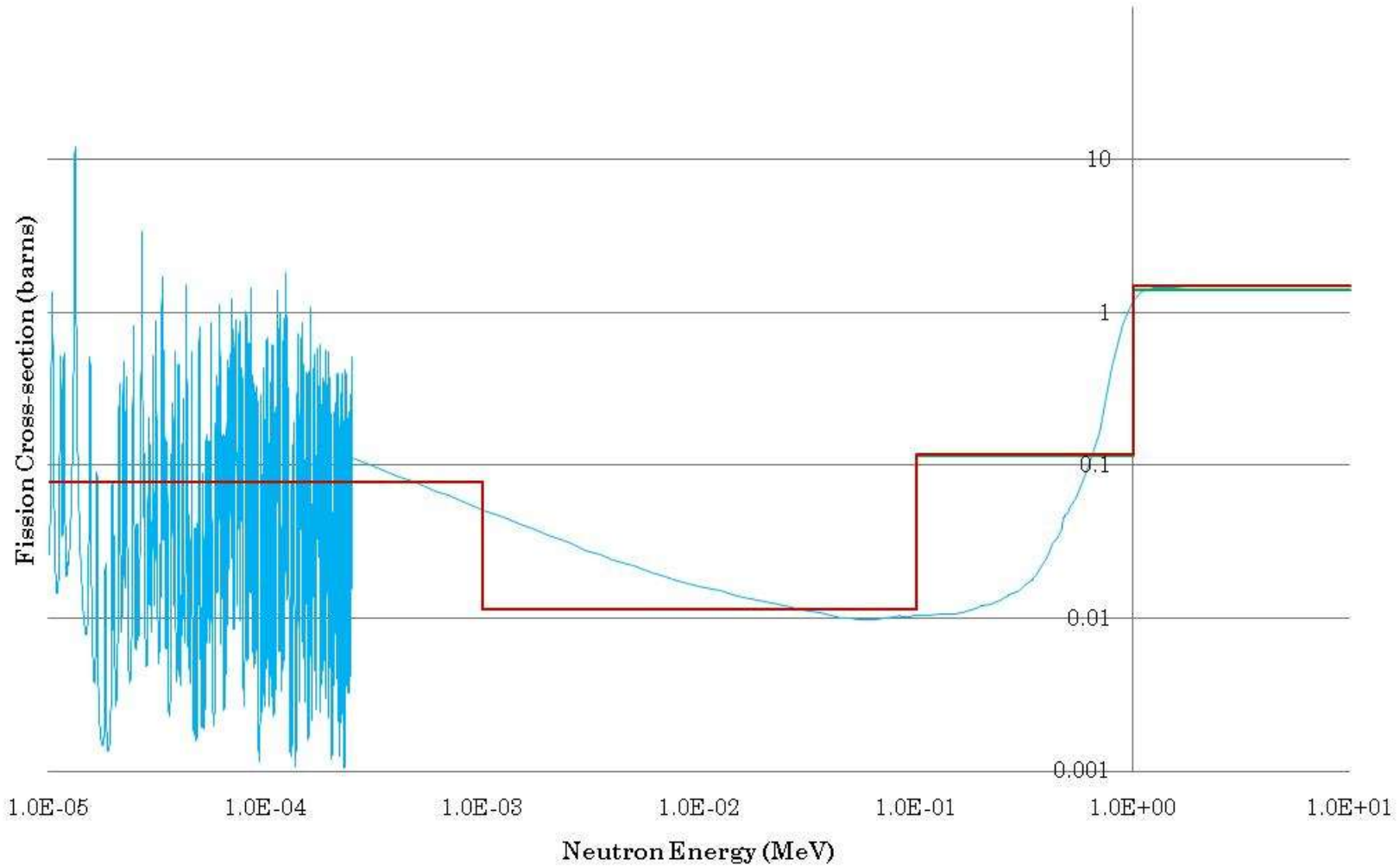
ENDF-B/V

TABLE I. Am-243 lambda values for ENDF-B/V

λ_4	1.0000
λ_3	0.9993
λ_2	0.9812
λ_1	0.9110



AM-243 ENDF-B/VI.6 COLLAPSED CROSS-SECTIONS

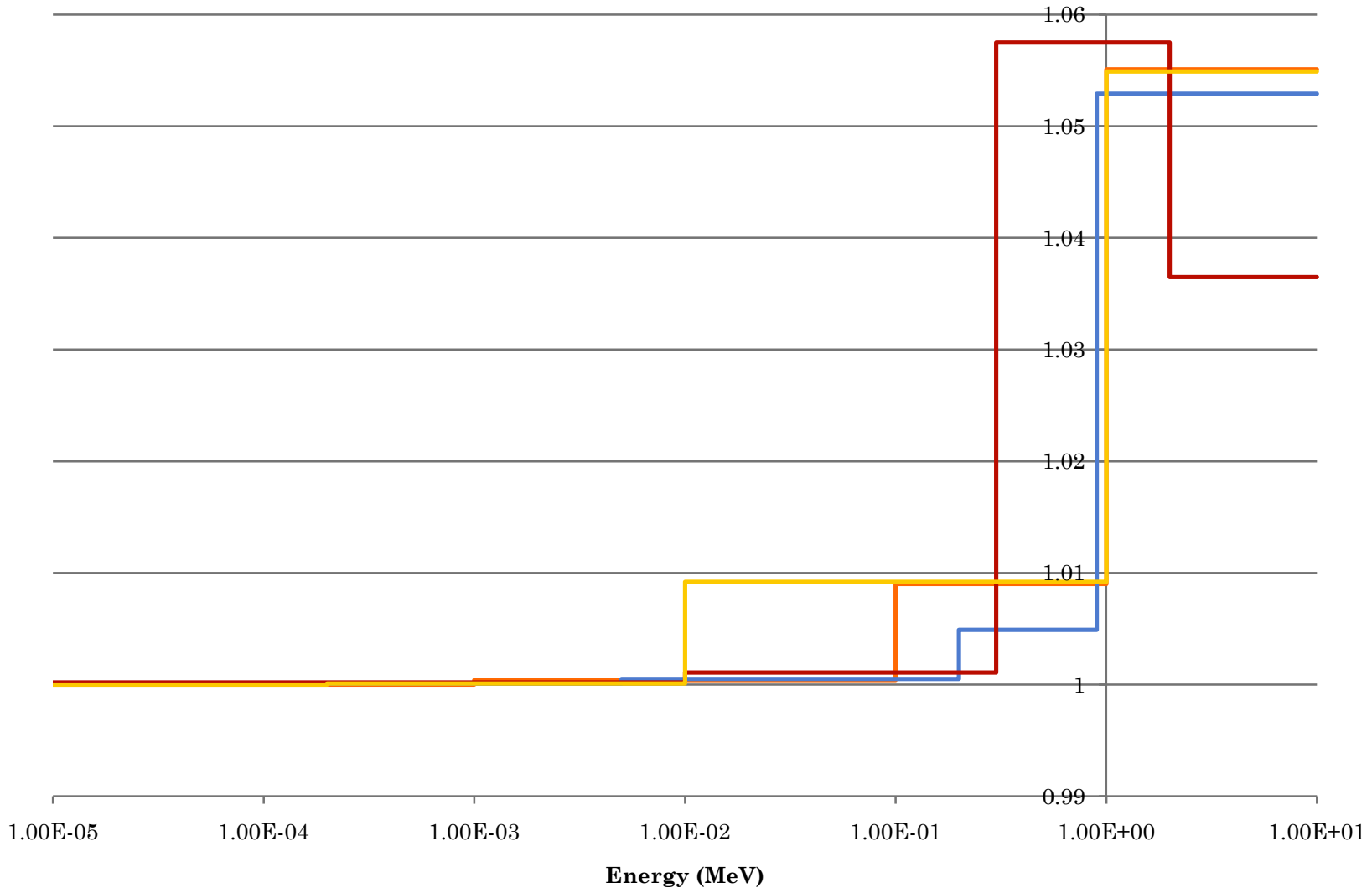


NEXT STEP

- The lambda values calculated are tied to the group structure chosen.
- Therefore, by varying the group structure repeatedly it may be possible to determine more accurately corrections to specific energy ranges.



AM-243 Λ -VALUES FOR VARYING GROUP STRUCTURES



CONCLUSIONS AND CONTINUING WORK

- To within the accuracy of the experimental JAEA data it seems the nuclear data for Np-237 is acceptable.
- The nuclear data for the other actinides appears to be incorrect by between 5% and 10%, especially in the fission threshold region.
- Further work will focus on the possibility of incorrect placement of the fission threshold, as well as the cross-section magnitude following the threshold.



CONCLUSIONS AND CONTINUING WORK

- The methodology described here applies when the use of very small samples of material decouples the flux spectra and the uncertain cross sections.
- Due to the limited number of available data points, the energy binning used in this research was coarse.
- Additionally, this work will be repeated using the ENDF/B-VII data and compared to the ENDF/B-VI.6 results.



○ Questions?



APPENDIX

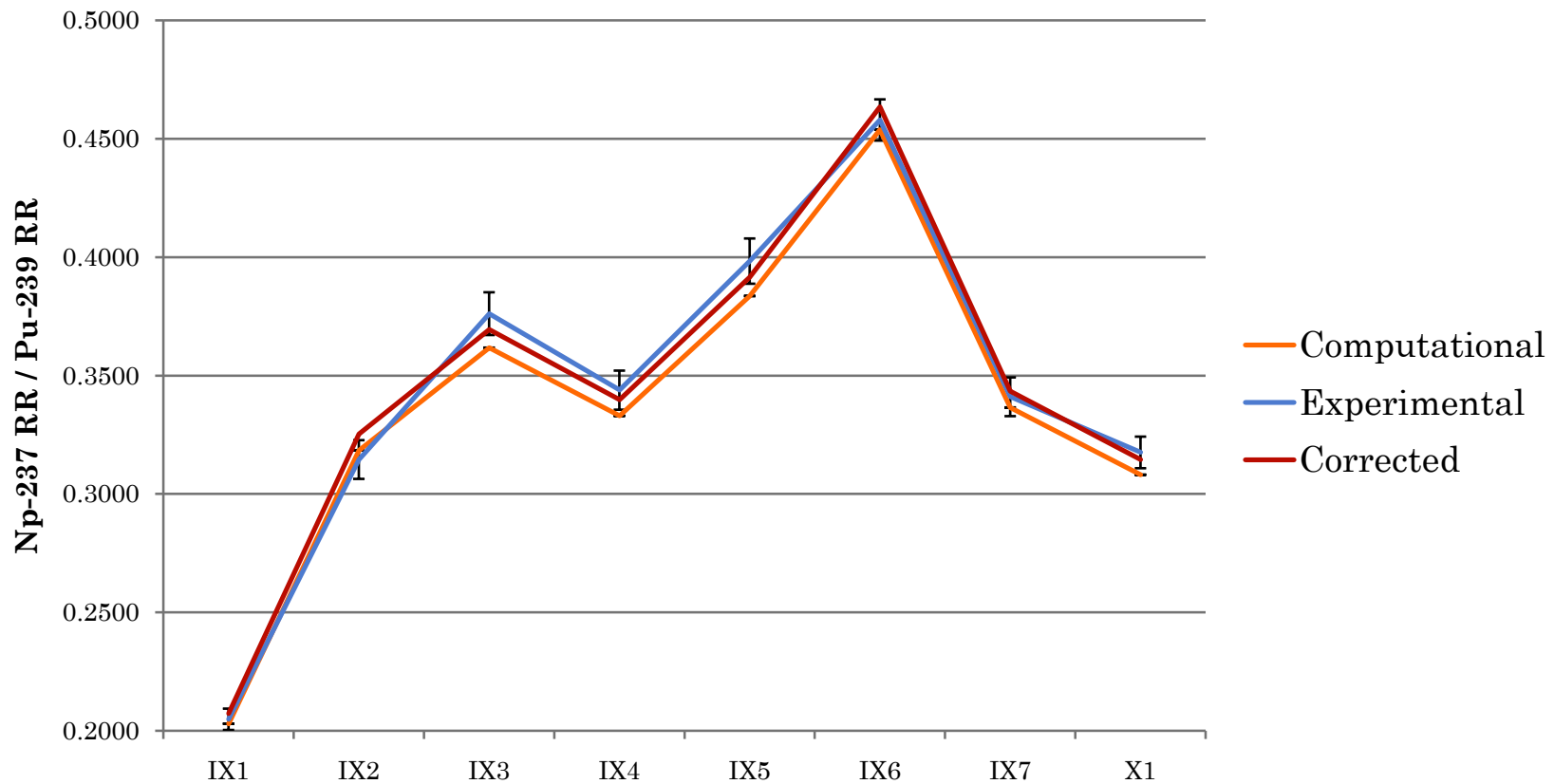
- Complete Results



Np-237 RESULTS ENDF-B/V1.6

TABLE I. Np-237 lambda values
for ENDF-B/V1.6

λ_4	1.0000
λ_3	1.0001
λ_2	1.0151
λ_1	1.0241

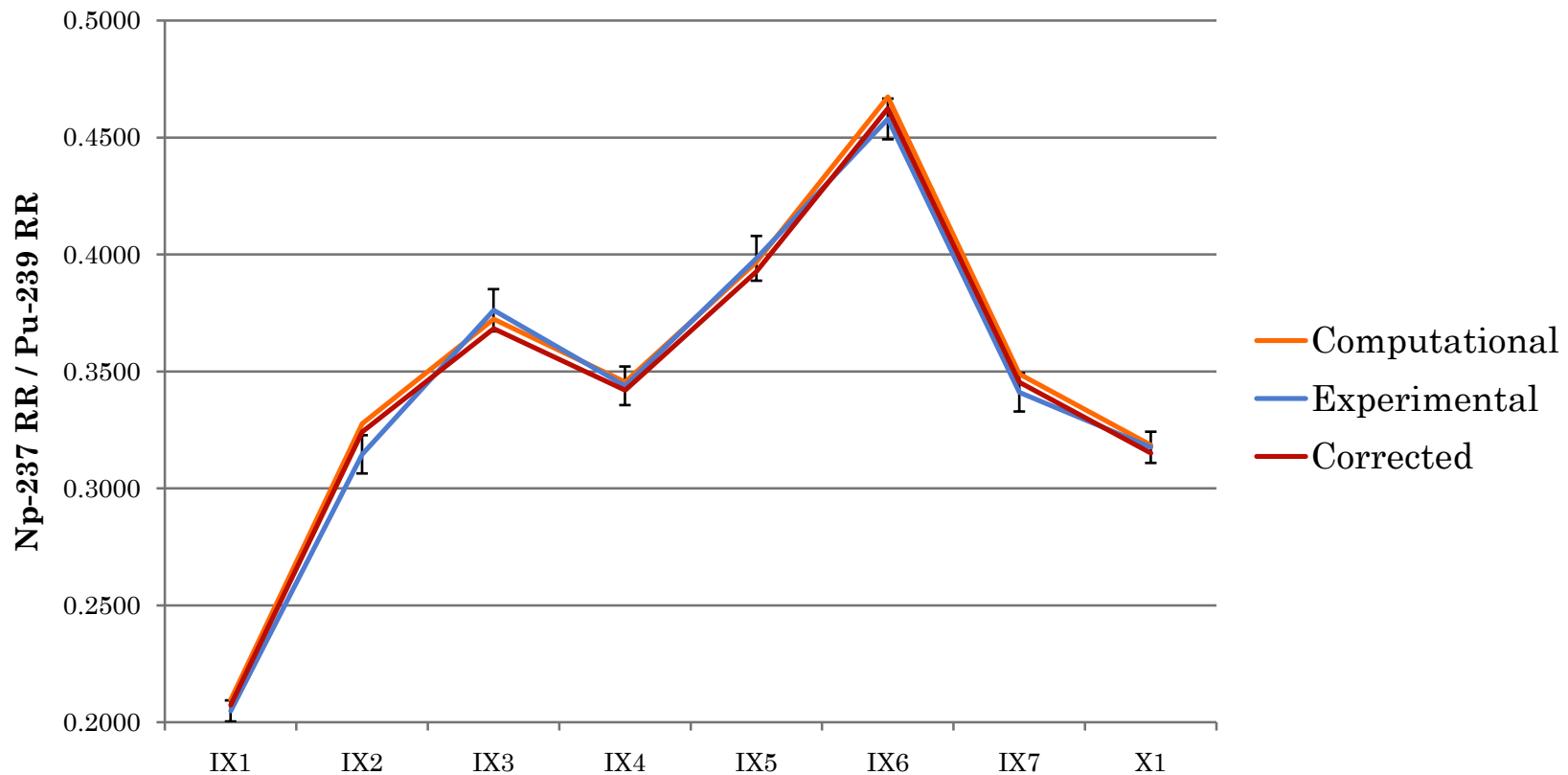


Np-237 RESULTS

ENDF-B/V

TABLE I. Np-237 lambda values for ENDF-B/V

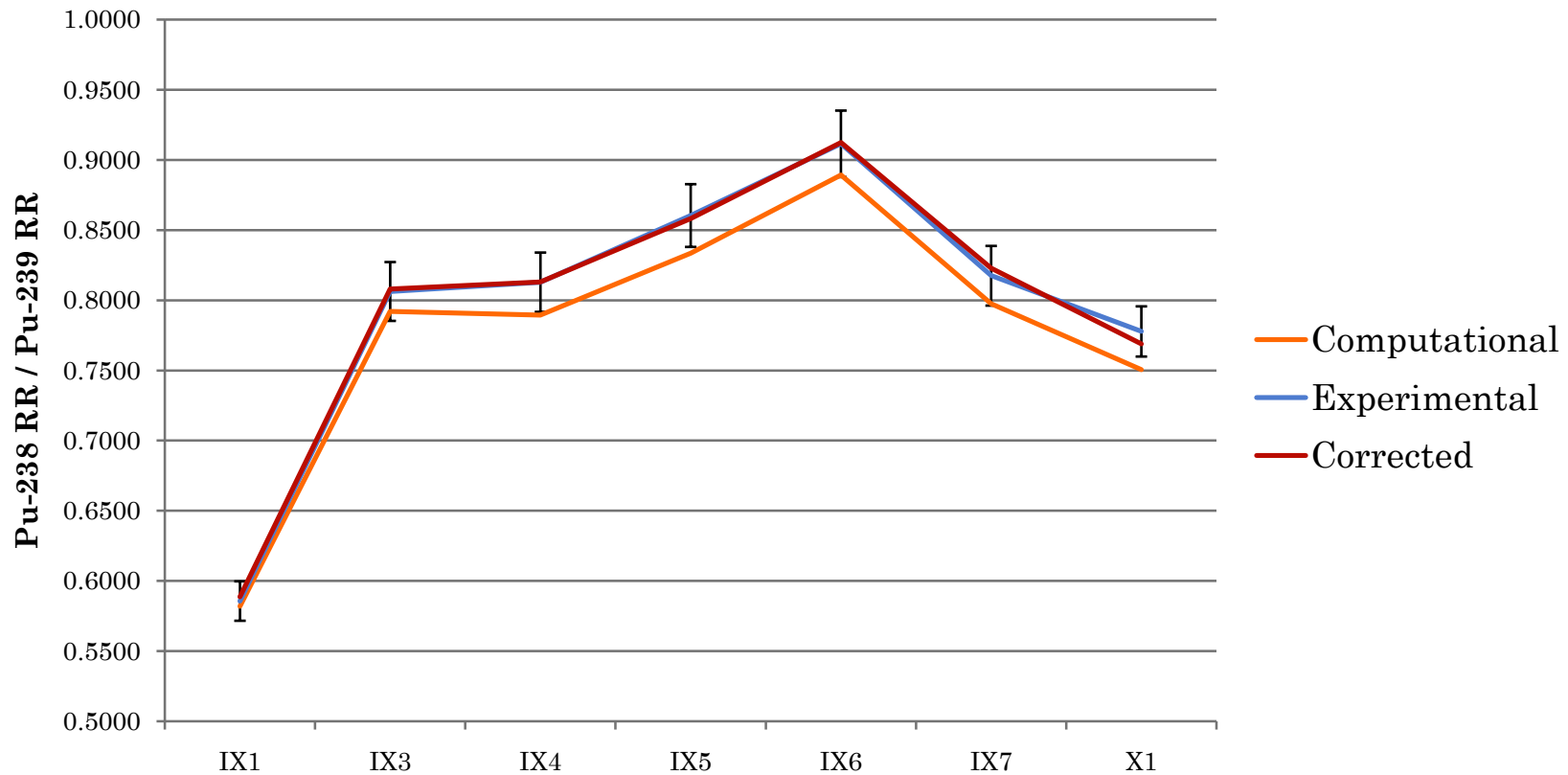
λ_4	1.0000
λ_3	0.9999
λ_2	0.9938
λ_1	0.9873



PU-238 RESULTS ENDF-B/VI.6

TABLE I. Pu-238 lambda values
for ENDF-B/VI.6

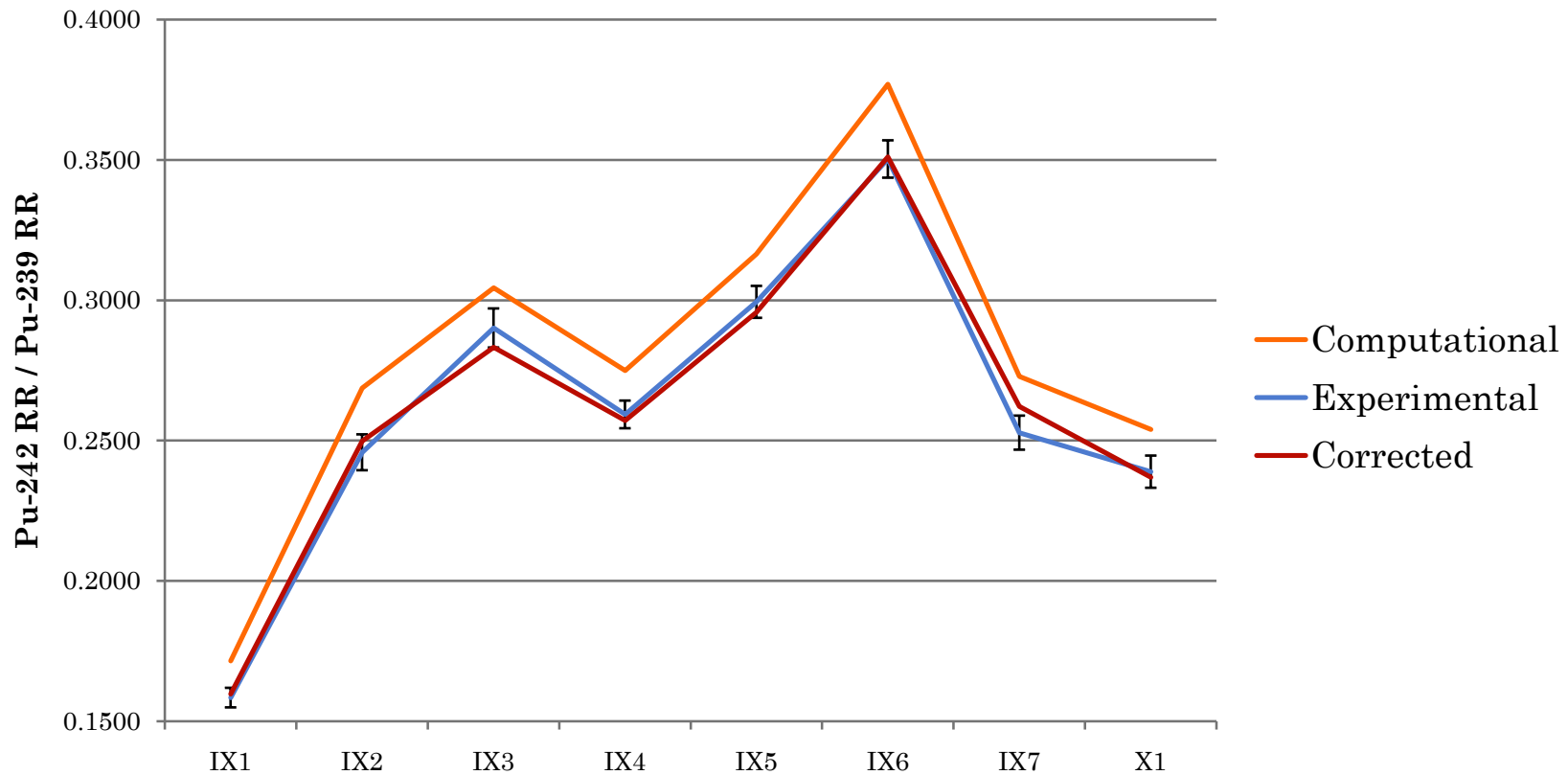
λ_4	0.9820
λ_3	0.9831
λ_2	1.0578
λ_1	0.9979



PU-242 RESULTS ENDF-B/VI.6

TABLE I. Pu-242 lambda values
for ENDF-B/VI.6

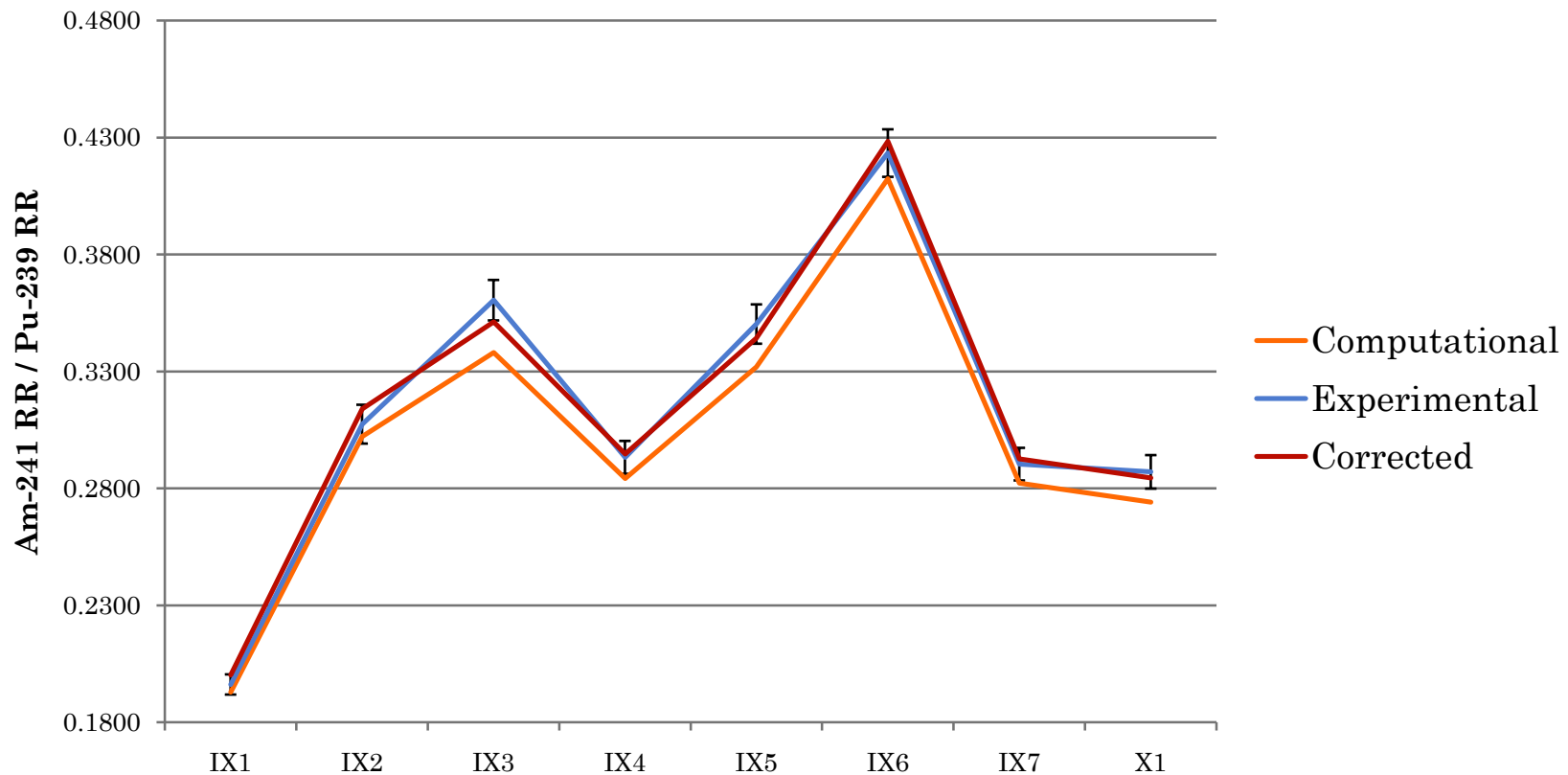
λ_4	0.9999
λ_3	0.9994
λ_2	0.9679
λ_1	0.9166



AM-241 RESULTS ENDF-B/VI.6

TABLE I. Am-241 lambda values
for ENDF-B/VI.6

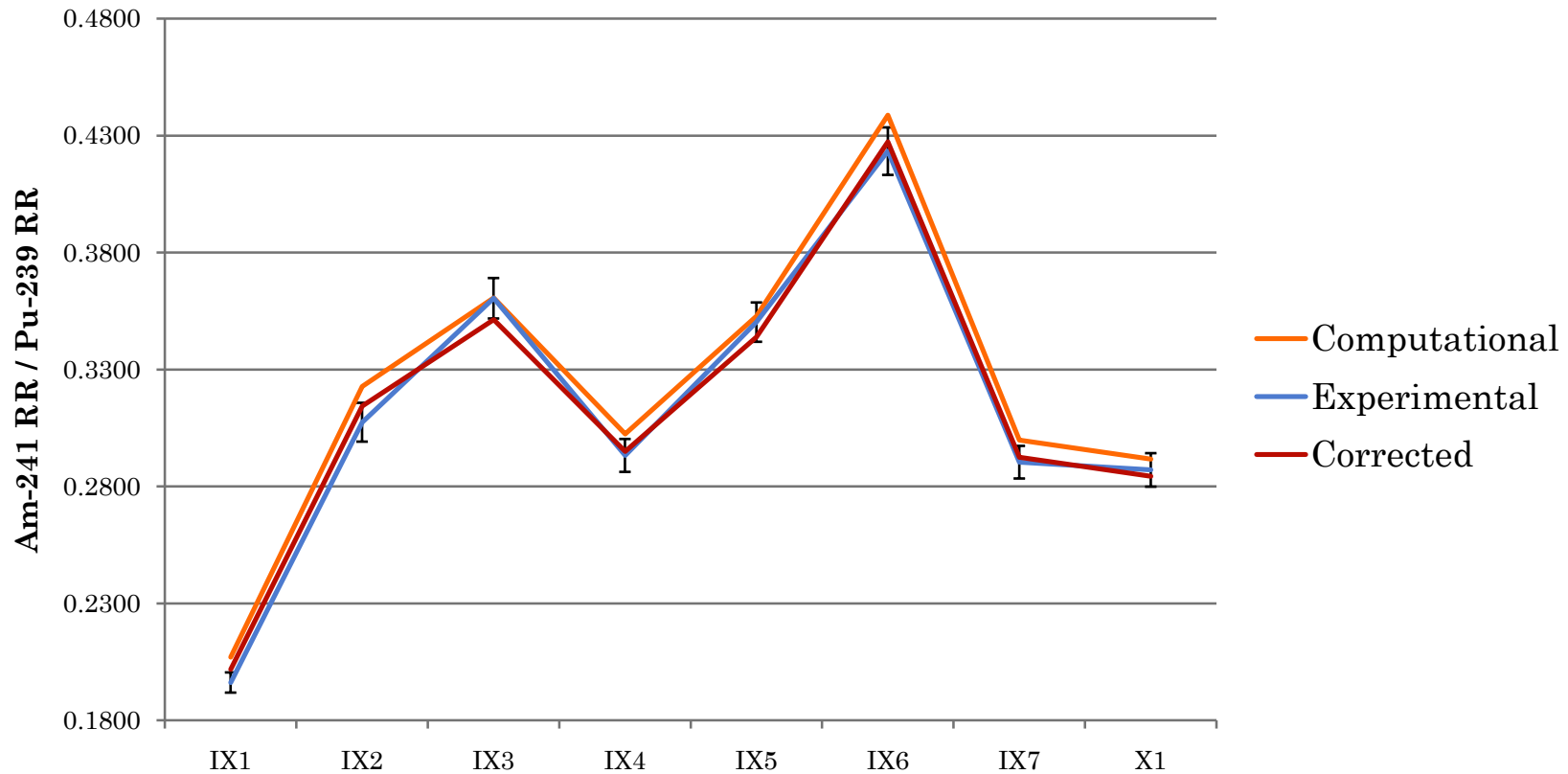
λ_4	1.0000
λ_3	1.0004
λ_2	1.0106
λ_1	1.0447



AM-241 RESULTS ENDF-B/V

TABLE I. Am-241 lambda values
for ENDF-B/V

λ_4	0.9999
λ_3	0.9996
λ_2	0.9936
λ_1	0.9700



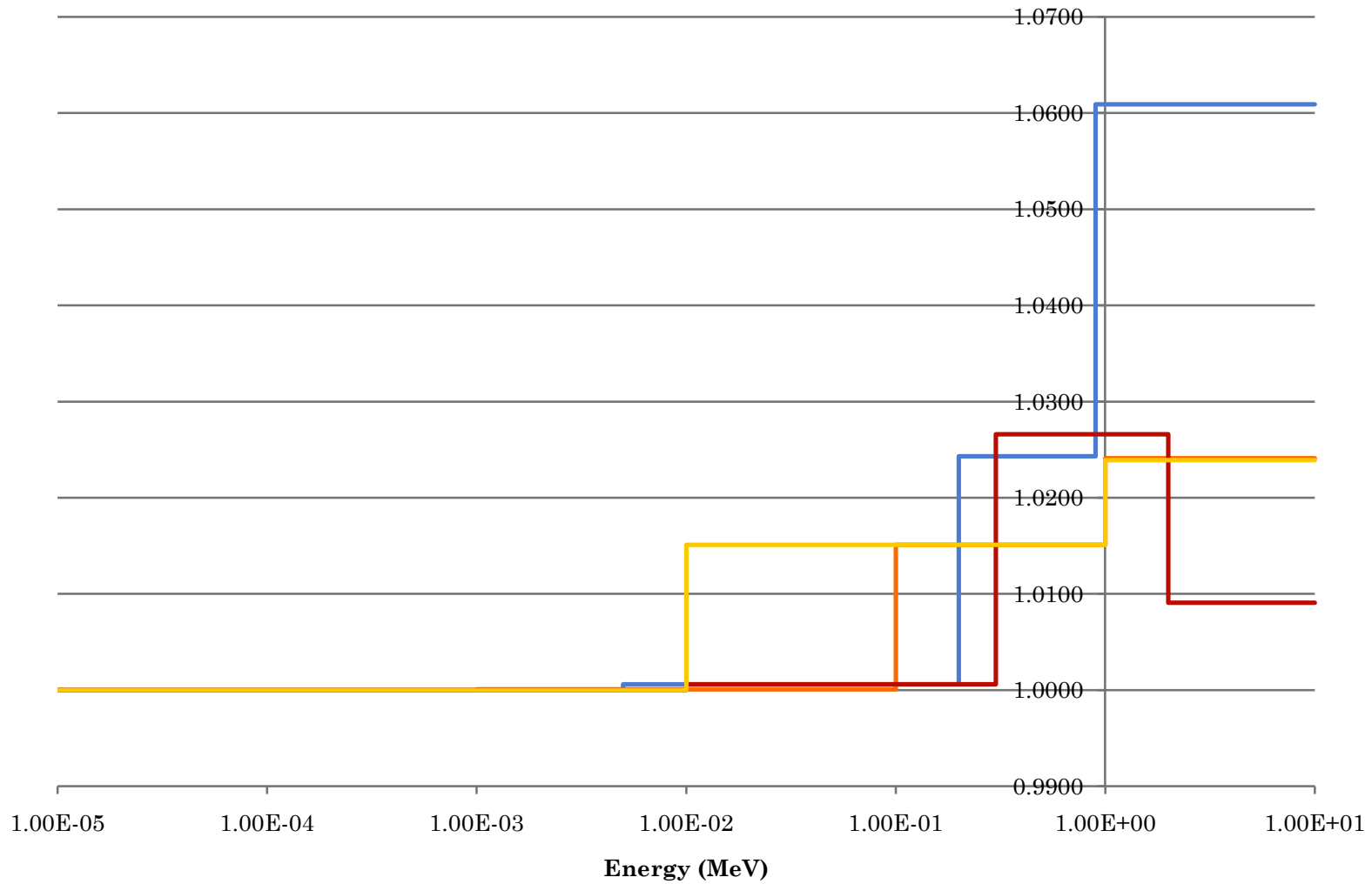
CM-244 RESULTS ENDF-B/V1.6

TABLE I. Cm-244 lambda values
for ENDF-B/V1.6

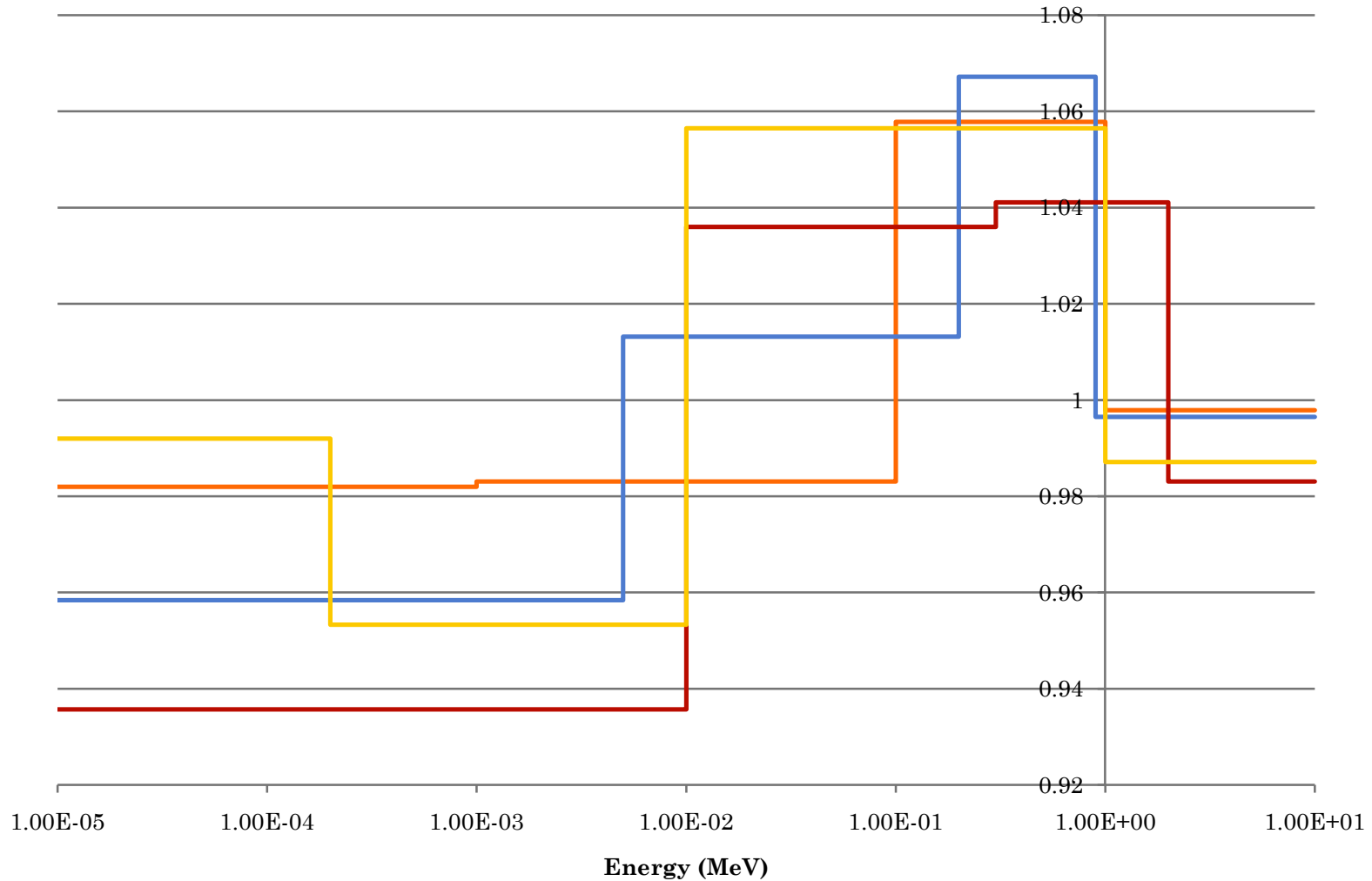
λ_4	1.0000
λ_3	0.9989
λ_2	0.9642
λ_1	0.9381



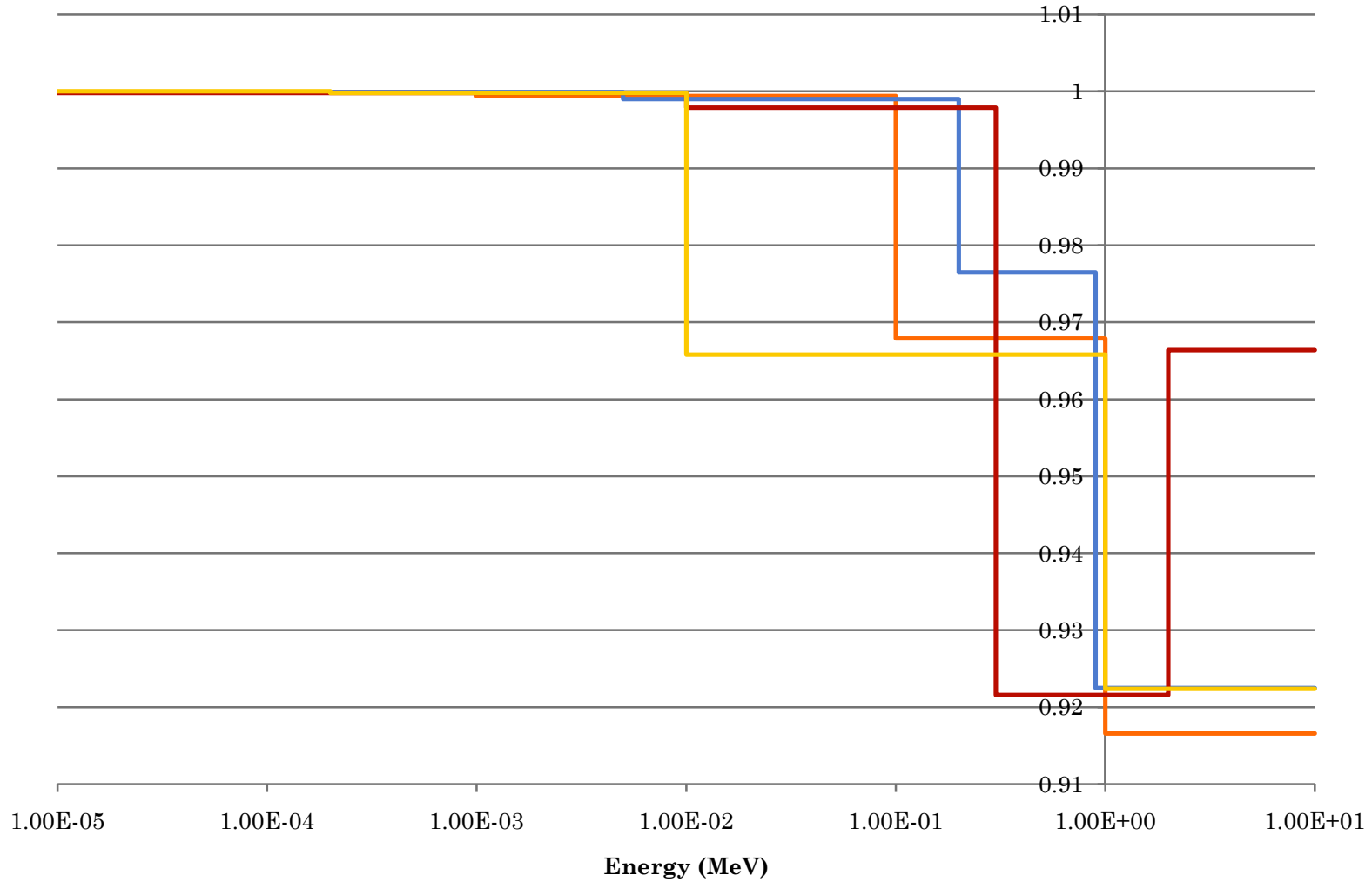
NP-237 Λ -VALUES FOR VARYING GROUP STRUCTURES



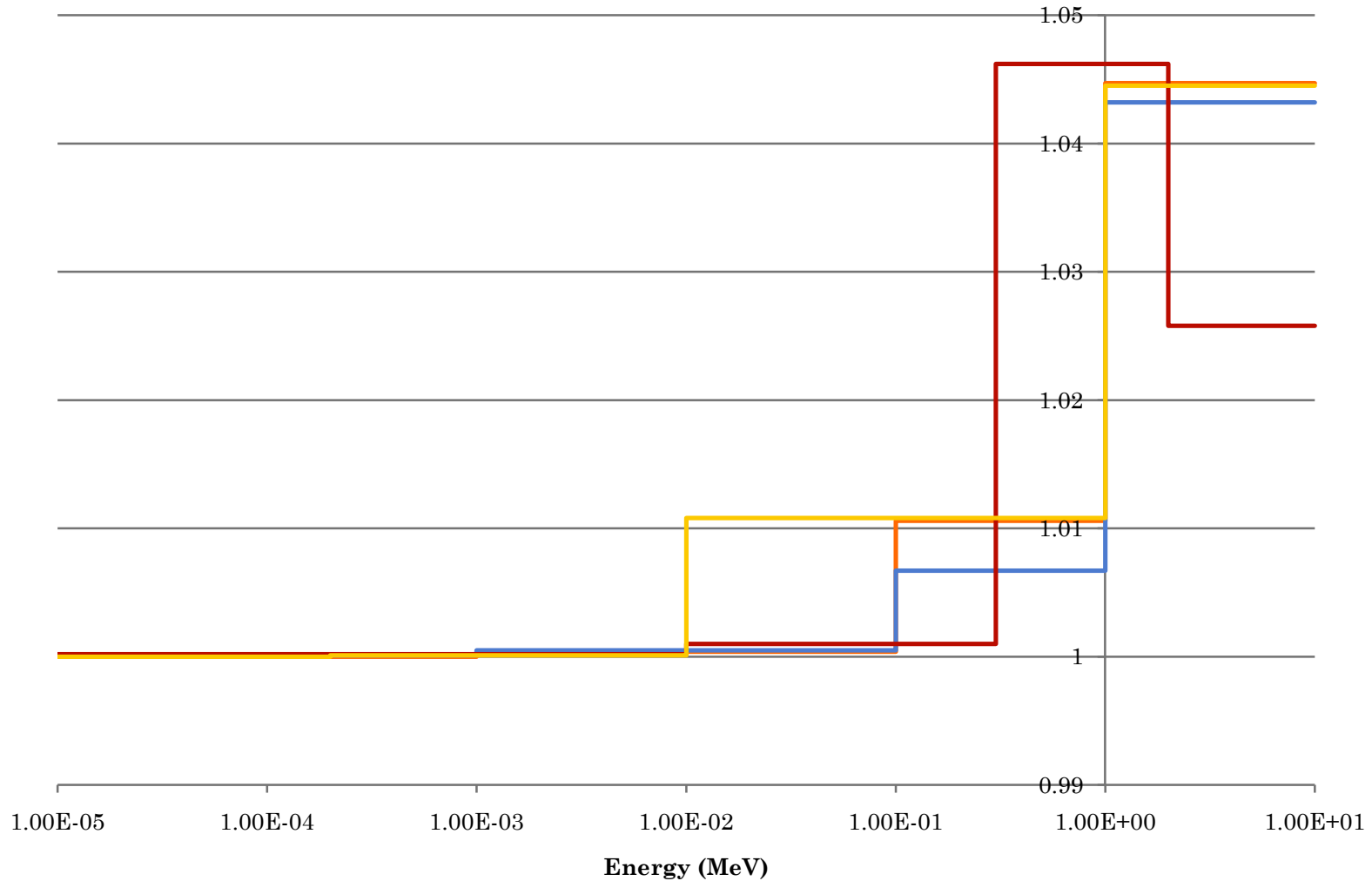
PU-238 Λ -VALUES FOR VARYING GROUP STRUCTURES



PU-242 Λ -VALUES FOR VARYING GROUP STRUCTURES



AM-241 Λ -VALUES FOR VARYING GROUP STRUCTURES



CM-244 Λ -VALUES FOR VARYING GROUP STRUCTURES

