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Review and Assessment of Neutron Cross Section and Nubar Covariances for Advanced Reactor Systems

VM Maslov[1, 3] P Obložinský[2] and M Herman[2]

1 Joint Institute for Nuclear and Energy Research
Krasina Street 99, 220109 Minsk-Sosny, Belarus

2 National Nuclear Data Center, Brookhaven National Laboratory
Upton, NY, 11973-5000, USA

3 Guest Scientist at National Nuclear Data Center, Brookhaven National Laboratory, Upton, NY, 11973-5000, USA

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The aim of this report is to review and assess preliminary neutron cross section and nubar covariance data for advanced reactor systems recently produced by the National Nuclear Data Center, BNL. The list of materials includes 19 actinides, the incident neutron energies cover the fast region (above about 1keV) up to 20 MeV and include cross sections for elastic, fission ,inelastic, capture and (n,2n) reaction channels, as well as prompt nubars (average number of emitted neutrons per fission). We focus on the diagonal terms of covariances matrices, that is, on cross section and nubar uncertainties. We found that quite a few of the preliminary BNL uncertainties should be improved and we propose such improved values. We also point out that in several instances, in particular 238-Pu and 242,244-Cm, basic ENDF/B-VII.0 evaluations are fairly poor and should be improved.

DISCLAIMER

Abstract

In January 2007, the National Nuclear Data Center (NNDC) produced a set of preliminary neutron covariance data for the international project "Nuclear Data Needs for Advanced Reactor Systems". The project was sponsored by the OECD Nuclear Energy Agency (NEA), Paris, under the Subgroup 26 of the International Working Party on Evaluation Cooperation (WPEC). These preliminary covariances are described in two recent BNL reports [1, 2]. The NNDC used a simplified version of the method developed by BNL and LANL that combines the recent Atlas of Neutron Resonances, the nuclear reaction model code EMPIRE and the Bayesian code KALMAN with the experimental data used as guidance. There are numerous issues involved in these estimates of covariances and it was decided to perform an independent review and assessment of these results so that better covariances can be produced for the revised version in future.

Reviewed and assessed are uncertainties for fission, capture, elastic scattering, inelastic scattering and (n,2n) cross sections as well as prompt nubars for 15 minor actinides (^{233,234,236}U, ^{237}Np, ^{238,240,241,242}Pu, ^{241,242m,243}Am and ^{242,243,244,245}Cm) and 4 major actinides (^{232}Th, $^{235,\ 238}$U and ^{239}Pu). We examined available evaluations, performed comparison with experimental data, taken into account uncertainties in model parameterization and made use state-of–the-art nuclear reaction theory to produce the uncertainty assessment.

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Chapter I

Introduction

The NNDC produced preliminary uncertainties and correlation matrices for 15 actinides, including $^{233,234,236}U$, ^{237}Np, $^{238,240,241,242}Pu$, $^{241,242m,243}Am$, $^{242,243,244,245}Cm$ [1, 2]. These results are cross-checked by making comparisons with measured cross section data and newly calculated data for fission, capture, elastic, inelastic, (n,2n) cross sections and neutron multiplicities of major (^{232}Th, $^{235,,238}U$, ^{239}Pu) and minor actinides in the unresolved resonance region (URR) and fast neutron energy region.

Notwithstanding the years of experimental and theoretical efforts, the evaluated capture, (n,2n), neutron inelastic and inelastic scattering cross sections of most thoroughly investigated nuclides like ^{232}Th, ^{235}U, ^{238}U or ^{239}Pu in major data libraries differ a lot. Since these cross sections are obtained (or might be obtained) via Hauser-Feshbach model calculations, the part of the differences might be attributed to the unjustified simplifications in modeling excited nucleus (either composite, compound or residual) energy spectra or neutron-nucleus interactions. For fissile target nuclides ^{235}U or ^{239}Pu the spectroscopic properties of the transition states at inner and outer saddles deformations of fissioning ^{236}U or ^{240}Pu nuclides, respectively, are of key importance. Though the relative contributions of transition states to the fission cross section are much affected by the target spin value $I^{\pi}=7/2^{-}$ for ^{235}U and $1/2^{+}$ for ^{239}Pu and relative heights of the inner and outer fission barrier humps [3, 4, 5], the fair description of $^{235}U(n,f)$ ($I^{\pi}=7/2^{-}$) [3], $^{237}U(n,f)$ ($I^{\pi}=1/2^{+}$) [5], $^{233}U(n,f)$ ($I^{\pi}=5/2^{+}$) and $^{239}Pu(n,f)$ ($I^{\pi}=1/2^{+}$) allows to reproduce measured data on capture and inelastic scattering rather reliably. That approach paves the way to prediction of fission, capture, elastic and inelastic scattering cross sections at 1 keV – 5 MeV energy range for fissile minor actinide nuclides.

Major source of discrepancies in case of inelastic scattering on ^{232}Th or ^{238}U targets are the coupling strengths of the deformed optical potential [6, 7]. Experimental data on inelastic neutron scattering are analyzed in a Hauser-Feshbach-Moldauer approach using a coupled channel estimates of the direct inelastic scattering. For the direct excitation of the ^{238}U ground state rotational band levels with $I^{\pi} = 0_1^{+}, 2^{+}, 4^{+}, 6^{+}, 8^{+}$ the rigid rotator model was used, whereas for the direct excitation of members of the β-, γ- ($K^{\pi}=0_2^{+}, 0_2^{+}, 2_2^{+}$) and the first octupole band $K^{\pi}=0^{-}$, a soft-deformable rotator model was used [6, 7]. Quadrupole, octupole, hexadecapole and gamma-deformation parameters were defined by consistent analysis of excited rotational-vibrational band structures and excitation cross section of the relevant excited levels of ^{232}Th or ^{238}U. Structures evident in measured neutron emission spectra for En ~1 - 6 MeV are correlated with excitation of levels of $K^{\pi}=0^-$ and $K^{\pi}=0_2^+$, 0_2^+, 2_2^+ bands. That approach was used for the ^{232}Th and ^{238}U inelastic scattering data analysis. Similar quality of inelastic data description was obtained. That means we have a viable tool for inelastic cross section prediction for even-even target nuclides. While compound scattering component is influenced mainly by the fission competition, in case if high fissility Pu or Cm nuclides the role of direct excitation of vibrational levels will be much enhanced. That should be taken into account when making the uncertainty estimates of the relevant cross sections.

For neutron capture reactions on even-even U, Pu and Cm nuclei in unresolved resonance and fast neutron energy ranges the methods, proven in case of ^{232}Th(n,γ) and ^{238}U(n, γ) [8, 9] data analysis would be used. Advances of the present approach over previous evaluations are due to precise treatment fission and neutron emission competition, which depends on the (Z, N)-composition of the compound nuclei.

^{235}U(n,xn) and ^{238}U(n,xn) reaction cross sections and prompt fission neutron spectra (PFNS) are affected by the emissive fission chances distribution $\beta_x = \sigma(n,xnf)/\ \sigma(n,F)$ of ^{235}U(n,F) [10] and ^{238}U(n,F) [11, 12, 13], respectively. In present approach β_x are based on consistent description of the cross section database and PFNS, they differ a lot from the evaluations of ENDF/B-VII.0 [14] and JEFF-3.1 [15]. That peculiarity influences most the (n, xn) cross section discrepancies. In case of poorly investigated minor actinides the β_x differences defines the (n,xn) cross section differences and relevant uncertainties.

Recently released ENDF/B-VII.0 evaluated data library [14] much contributed to recognition of the need of re-examining the major principal reactions, such as neutron capture on ^{238}U or inelastic scattering on ^{235}U and ^{239}Pu, to tell nothing about prompt fission neutron spectra. The assessment of the preliminary covariance data produced by the NNDC for minor actinides should be based on educated expectations, which are grounded mostly on the accumulated knowledge of major actinide data analyses. It is exemplified in the ENDF/B-VII.0 [14], JENDL-3.3 [16], JEFF-3.1 [15] evaluated data files and data files, produced by Maslov et al. [17-34] (a number of these minor actinide data files are adopted for JENDL-3.3, JEFF-3.1 and ENDF/B-VII.0 data libraries, in case of major fertile nuclides, i.e. ^{238}U and ^{232}Th the evaluations by Maslov et al. [19, 23] were in many respects followed later on in other data libraries) as well as calculations specifically made during that report compilation.

Disentangling of the model deficiencies, when measured data fits are rather poor, and model parameter uncertainties, turned out to be a major problem. The calculations with the EMPIRE code [35], used in [1, 2] were fitted to the evaluated data of ENDF/B-VII.0 [14] data library, except ^{235}U, ^{238}U and ^{239}Pu nuclides. However, in a number of cases these evaluated data are much different from the newest measured data (stemming from direct neutron or surrogate measurements) or calculations, made with the modern theoretical approaches (see Proceedings of the International Conference on Nuclear Data for Science and Technology, Nice, France, 22-27 April 2007). That happens either for poorly investigated nuclides like ^{242,244}Cm, ^{238}Pu or major fissile nuclides like ^{235}U or ^{239}Pu. Though in latter case covariance estimates were adopted from JENDL-3.3 data library, the same conclusion applies for JENDL-3.3 library as well. In a number of cases recent ENDF/B-VII.0 evaluations are much different from those of JENDL-3.3. These peculiarities might influence the realistic estimate of covariances, whatever would be the adopted evaluated data file, however, the deficiencies of the models, used for the specific data evaluation, can not be simulated by enlarging the uncertainties of the model parameters.

For actinide nuclides the most important correlation of the parameters, which is frequently ignored, is imposed by the fission cross-section description constraint. One of the purposes of the present analysis is to clear out the cases, when say ~20% estimate of the relative standard deviations (r.s.d) is claimed for cross sections (or nu-bars), which differ from the experimental data or other evaluations, which seem quite reasonable, by ~50-200%. The important point is that those "other evaluations" are often produced using more refined approaches as compared to those previously used. Similar situation occurs for many minor actinide cross sections. Otherwise, we should assume that r.s.d refers to some virtual "true " cross section. That is the point where the question of model simplification comes into play. For example, there is some systematic for capture cross sections for ^{233}U, ^{235}U and ^{237}U, which is violated in ENDF/B-VII.0 [14] for ^{237}U. Surrogate measurements for ^{237}U(n,γ) and ^{237}U(n,2n)) at LLNL, when available, might provide guidance for similar predictions for Pu and Cm targets.

The review and assessment of relative standard deviations is provided below for the 15-group representation for fission, capture, elastic, inelastic, (n,2n) cross sections and prompt fission neutron multiplicities.

Chapter 2

Elastic scattering

It was a common practice for major actinides not long ago and it still is for some minor actinides (^{244}Cm data file of ENDF/B-VII.0, borrowed from JENDL-3.3, for example) to obtain the elastic cross section as a difference of the total cross section and all partial neutron cross section. In that case the uncertainty of the elastic cross section depends in a rather sophisticated fashion upon the uncertainties of the involved partial cross sections.

In another case, when the elastic scattering cross section is defined as a sum of shape elastic cross section plus a compound elastic scattering cross section, the uncertainty of the evaluated/calculated elastic scattering cross section would be defined by the uncertainties of the calculated elastic cross section and that of the measured elastic scattering data if available. The contribution of the compound elastic scattering cross section much depends on the fissility of the compound nuclides. In case of high fissility Cm even-odd compound nuclides ^{243,245}Cm the contribution of the compound elastic scattering might be relatively low, but it still will impose rather high uncertainty on the lumped inelastic scattering cross section. In summary, it might be argued there is no justification, that the elastic scattering cross section r.s.d of U, Pu of Cm could be more optimistic than those of ^{238}U or ^{232}Th.

^{232}Th: Fig. 2.1 shows, that the uncertainty estimate in the 3d group (first minimum of the elastic scattering cross section) for the data file adopted for ENDF/B-VII.0 [36] should be decreased to the level of 2% (similar to adjacent groups) and increased in some lower energy groups due to uncertainty of the total cross section mostly. In fact, in case of ^{232}Th [19] and ^{238}U [23] there is no robust justification to increase the cross section uncertainty at first minimum (see also [37], as predicted in BNL evaluation [1, 2], though the measured data [38-46] scatter a lot (see Fig. 2.1).

^{238}U: Fig. 2.2 shows, that the elastic scattering cross section uncertainty estimate of JENDL-3.3 data file [16] is much higher than that of ^{232}Th data file, adopted for ENDF/B-VII.0 data library. It should be mentioned that the relevant measured data base for these two nuclides, ^{232}Th [38-46] and ^{238}U [46-52] are rather similar. The compound elastic scattering contribution/uncertainty are similar as well. That means we can impose the r.s.d. at incident neutron energy above 2 keV equal to 2% (see Fig. 2.2).

^{236}U: the r.s.d., shown on the Fig.2.3 gives increased uncertainty in the first minimum around 2 MeV and in the incident neutron energy range of 200-500 keV. Evidently, the r.s.d should be less optimistic than in case of either ^{238}U or ^{232}Th, especially around 100 keV and at lower energies. At this energy range ENDF/B-VII.0 estimate is much discrepant with previous evaluations. The contribution of the compound elastic scattering at 1 keV is just as high as in case of ^{232}Th, i.e. the inelastic/capture cross section uncertainty contributes to the r.s.d. in a similar way (see Fig. 2.3).

^{234}U: the r.s.d. of [1, 2], which is shown on the Fig. 2.4 gives increased uncertainty in the first minimum and around incident neutron energy of 10-50 keV. The r.s.d should be less optimistic than in case of ^{236}U, ^{238}U or ^{232}Th, because there is no precise data on capture and no inelastic scattering data at higher energies to fix the compound contribution to the elastic scattering cross section. At the MeV-energy range the ENDF/B-VII.0 estimate is very similar to previous evaluations of JENDL-3.3 and evaluation by Maslov et al. [21], adopted for JEFF-3.1 [15]. The increased cross section uncertainty at first minimum should be discarded as for other nuclides just considered (see Fig. 2.4).

^{238}Pu: Fig. 2.5 shows that for the incident neutron energies 1-67.4 keV the r.s.d. value for ENDF/B-VII.0 [1, 2] should be increased up to 20 % because of discrepancy of ENDF/B-VII.0 with most recent evaluation by Maslov et al. [32], which is adopted for JENDL-3.3 [16]. The r.s.d of 3 % at higher energy looks reasonable. Discrepancy of JENDL-3.2 data with other evaluations in no way can be perceived as a justification for the increase of the r.s.d. values in the 200 keV – 2 MeV energy range, proposed in BNL covariance evaluation [1, 2] (see Fig. 2.5).

^{240}Pu: in that nuclide case the drop of r.s.d. in the 1st group does not look justified. Here the r.s.d is assumed to be similar to that of ^{234}U (see Fig. 2.6).

^{242}Pu: Fig. 2.7 shows, that in that case the ENDF/B-VII.0 (ENDF/B-VI) evaluation is compatible with most recent evaluation by Maslov et al. [33]. The drop of r.s.d. in 1st and 2nd groups does not look justified, as well as increase of r.s.d. in 3d and 4th groups. The r.s.d is assumed similar to that of ^{234}U. The guidance comes from the ^{238}U elastic scattering analysis [23]. There is no justification, that the r.s.d of ^{242}Pu could be more optimistic than those of ^{238}U or ^{232}Th (see Fig. 2.7).

^{242}Cm: in the 1st group the uncertainty should increased up to 10%, as shown on Fig. 2.8. At lower energies the discrepancy of ENDF/B-VII.0 evaluation with present and BROND estimates give estimates of r.s.d. In the group of 9-2 keV the BNL [1, 2] estimate of r.s.d should be decreased. At these low energies major uncertainty comes from the compound elastic scattering cross section. The compound elastic scattering cross sections of BROND [53] and present calculations are rather close, since they produce similar estimates of the fission cross section in keV-energy range and up to 1 MeV (see Fig. 2.8).

^{244}Cm: JENDL-3.3 evaluation [16] is accepted for the ENDF/B-VII.0 [14] library. Decrease of r.s.d. in the fast neutron energy range from 10% to 5% and eventually 3 % is justified by small discrepancy of JENDL-3.3 data at one hand an BROND and present calculation at the other hand. Evidently, in JENDL-3.3 data file the elastic cross section is obtained as a difference of the total cross section and partial neutron cross sections (see Fig. 2.9).

^{235}U: in case of fissile nuclides the contribution of the compound elastic scattering cross section is much lower than in case of even-even targets, as well as its influence on the r.s.d. values (see Fig. 2.10). The covariances of JENDL-3.3 and data file itself are adopted for BNL report [1, 2]. The discrepancy of JENDL-3.3 data with present calculation and measured data [46, 47, 54-57] scattering and systematic differences, gives guidance to increase the r.s.d. at incident neutron energies higher than 498 keV (see Fig. 2.10).

^{233}U: ENDF/B-VII.0 and present estimates are systematically different in the energy range 1-700 keV, at higher energies both evaluations are consistent with each other and Haouat et al. [46] data within 3% (see Fig. 2.11). The non-smooth shape of the elastic scattering cross section of ENDF/B-VII.0 at E_n<70 keV differs very much from the present estimate. The non-smooth behavior of evaluated cross sections of JENDL-3.3 and ENDF/B-VII.0 seem to be due to normalizations to measured data on competing reactions. Our estimate is based on optical and statistical model fits of total, fission and capture cross sections. The same approach was pursued in case of ^{235}U and ^{239}Pu, in both cases consistent fits were obtained. The r.s.d. values for ENDF/B-VII.0 evaluation should be fixed to 10-12 % in 1 keV-1.5 MeV, while at higher energies 2-3% value looks justified (see Fig. 2.11).

^{239}Pu: in case of ^{239}Pu target nuclide the contribution of the compound elastic scattering cross section around 1 keV is higher than in case of ^{235}U target, as shown on Fig. 2.12. That is due to lower fission cross section of ^{239}Pu in keV energy range. The covariances of JENDL-3.3 and data file itself are adopted for the BNL report [1, 2]. The discrepancy of JENDL-3.3 data with present calculation and measured data [46, 47, 57, 58, 59] gives guidance to decrease the r.s.d., as shown on Fig. 2.12

^{241}Pu: ENDF/B-VII.0 and present estimates are systematically different in the energy range 40-1000 keV, at higher energies both evaluations are roughly consistent with each other, but non-smooth shape is a clear indication, that ENDF/B-VII.0 data were adjusted to be consistent with total and partial cross sections. That means the procedure to estimate the r.s.d. values for ENDF/B-VII.0 data file should be different from that adopted in case of ^{239}Pu. Present r.s.d. estimate is fixed at 10-11% at 1 – 1500 keV energy range and 2-3 % at higher energies (see Fig. 2.13).

^{243}**Cm:** in ENDF/B-VII.0 data file, the evaluation by Maslov et al. [26] was adopted. In JENDL-3.3 [16] basically the same evaluation is adopted, but the fission cross section was deliberately renormalized (increased by approximately 30 %) to Fursov et al. [60] data at 0.1-14.9 MeV energy range, while the elastic scattering was adjusted to be consistent with total and partial cross sections, adopted from Maslov et al. [26] evaluation. That will influence mainly the compound elastic scattering contribution, however recent surrogate measurements of ^{243}Cm(n,F) cross section supported the data by Fomushkin et al. [61, 62], on which the evaluation by Maslov et al. [26] was based. Note, that because of high fissility of ^{244}Cm compound nuclide the influence of the uncertainty of compound elastic scattering on the lumped elastic scattering cross section would be diminished. In fact, there is no other evaluations or experimental data on elastic scattering to be compared with. Values of r.s.d are fixed at 3% in fast neutron energy range. Note, that procedure adopted to estimate the r.s.d. values for ENDF/B-VII.0 data file of ^{243}Cm should be different from that adopted in case of major actinides like ^{235}U or ^{239}Pu. That difference complicates severely the overall reliability of r.s.d. estimates for minor actinides (see Fig. 2.14).

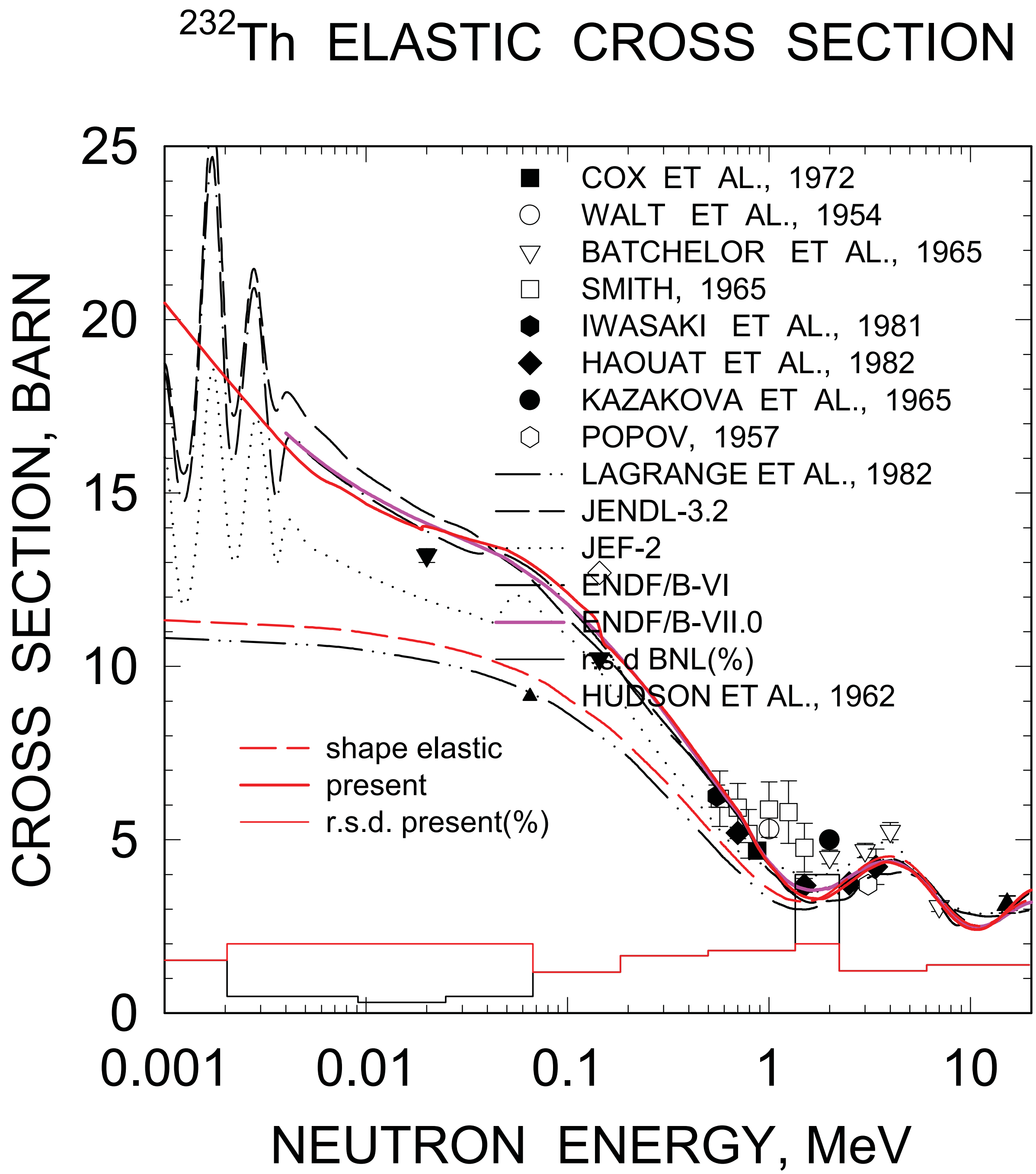
^{245}**Cm:** in ENDF/B-VII.0 data file, the evaluation by Maslov et al. [27] was adopted. In JENDL-3.3 [16] basically the same evaluation is adopted, but the fission cross section was deliberately renormalized (increased by approximately 5 %) to Fursov et al. [60] data at 14.9 MeV, the elastic scattering was adjusted to be consistent with total and partial cross sections, adopted from Maslov et al. [27] evaluation. In fact, there is no other evaluations or experimental data on elastic scattering to be compared with. Values of r.s.d are fixed at 3% in the fast neutron energy range (see Fig. 2.15).

^{237}**Np:** present calculation is compatible with ENDF/B-VII.0 [14] calculations within 2 or 3 % at E_n>100 keV (see Fig. 2.16). At lower energies the 20% difference is observed between present calculation and ENDF/B-VII.0 [14] and JENDL-3.3 [16] evaluations. In the two latter cases the elastic scattering was adjusted to be consistent with total and partial cross sections. That is a questionable procedure, since the evaluated inelastic cross sections of ENDF/B-VII.0 and JENDL-3.3 evaluations is in severe disagreement with measured data by Kornilov et al. [63] on the inelastic scattering of neutrons, while our approach produces consistent description of (n,f), (n,n') and (n,γ) measured data. However, our estimate of the elastic scattering is quite consistent with the estimate for the ^{241}Am target nuclide by Maslov et al. [17]. In case of ^{237}Np and ^{241}Am the compound elastic scattering contributions are rather similar and they should be similar, since the measured databases of competing reactions are quite similar.

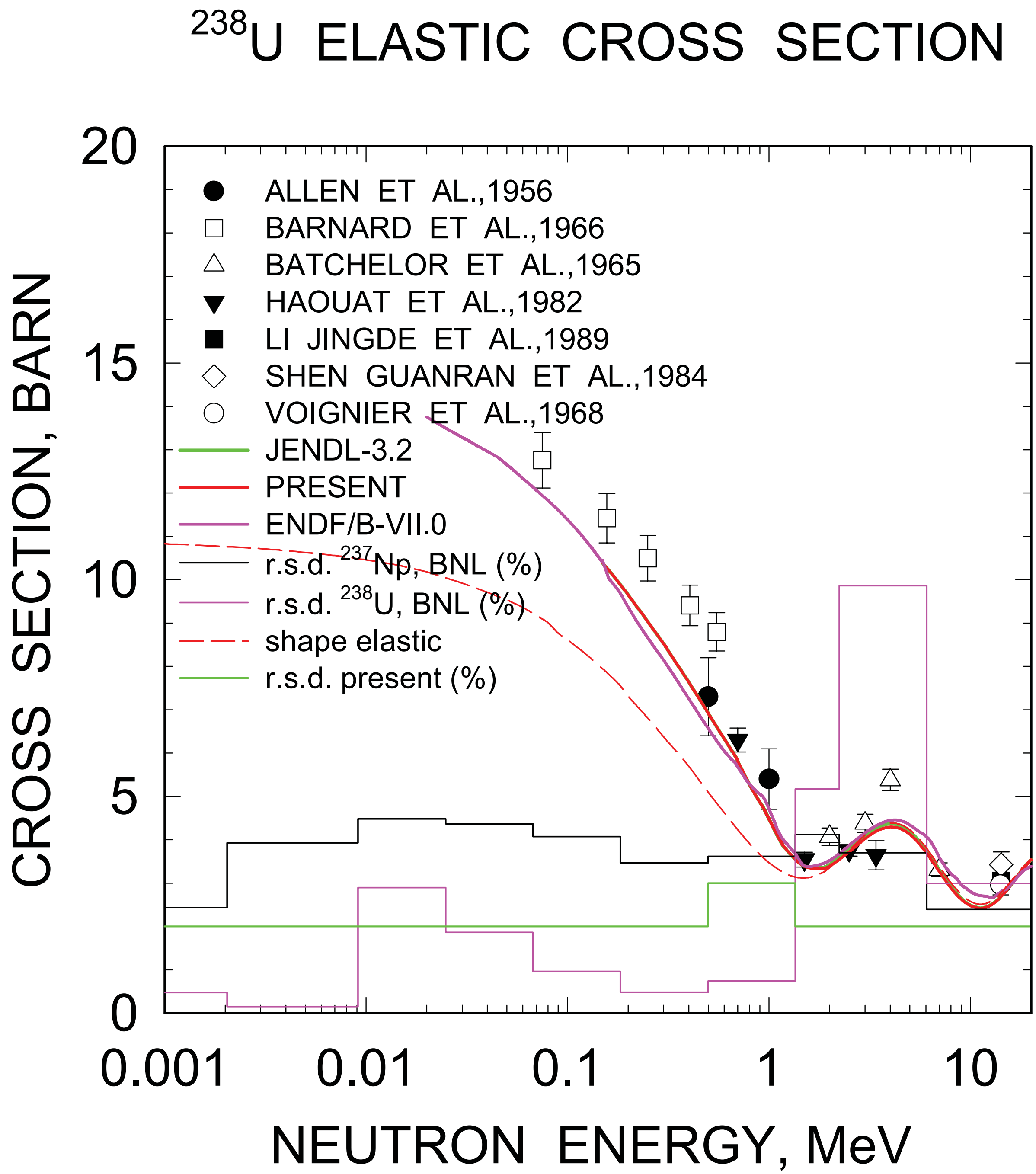
^{241}**Am:** there are signatures of the ENDF/B-VII.0 [14] elastic scattering adjustments to be consistent with total and partial cross sections. The JENDL-3.3 [16] compilers did the same, i.e., the elastic scattering was adjusted to be consistent with total and partial cross sections, adopted from Maslov et al. [17] evaluation, while fission cross section was slightly renormalized. In summary, r.s.d will be fixed at 10 % level in 1 – 100 keV energy range and 2-3 % at higher energies, which is quite similar to ^{237}Np case (see Fig. 2.17).

^{243}**Am:** there are signatures of the ENDF/B-VII.0 [14] elastic scattering adjustments to attain consistency with total and partial cross sections. The JENDL-3.3 [16] compilers did the same, i.e., the elastic scattering was adjusted to be consistent with total and partial cross sections, adopted from Maslov et al. [18] evaluation, while fission cross section was slightly renormalized. In summary, r.s.d will be fixed at 20 % level in 1 – 100 keV energy range and 5 % at higher energies. There is no reasonable explanation for the saw-tooth pattern of the r.s.d. of BNL [1, 2] estimate (see Fig. 2.18).

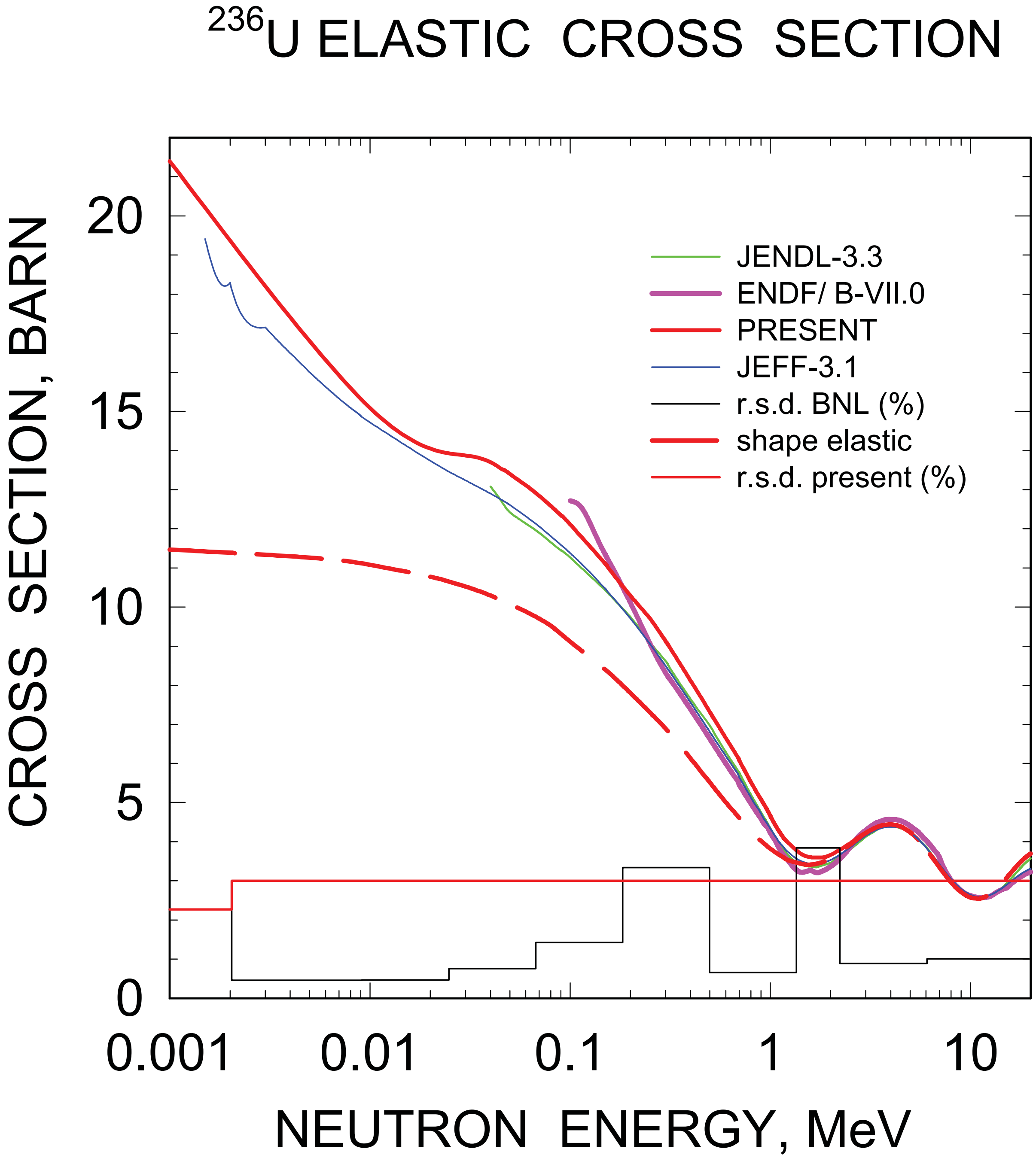
^{242m}**Am:** ENDF/B-VII.0 [14] and present estimates are pretty consistent in the energy range below 1 MeV, at higher energies the 10% discrepancies are noticed in minima and maximum of the cross sections. In summary, r.s.d will be fixed at 1 % level in 1 – 1000 keV energy range and 10 % at higher energies (see Fig. 2.19).



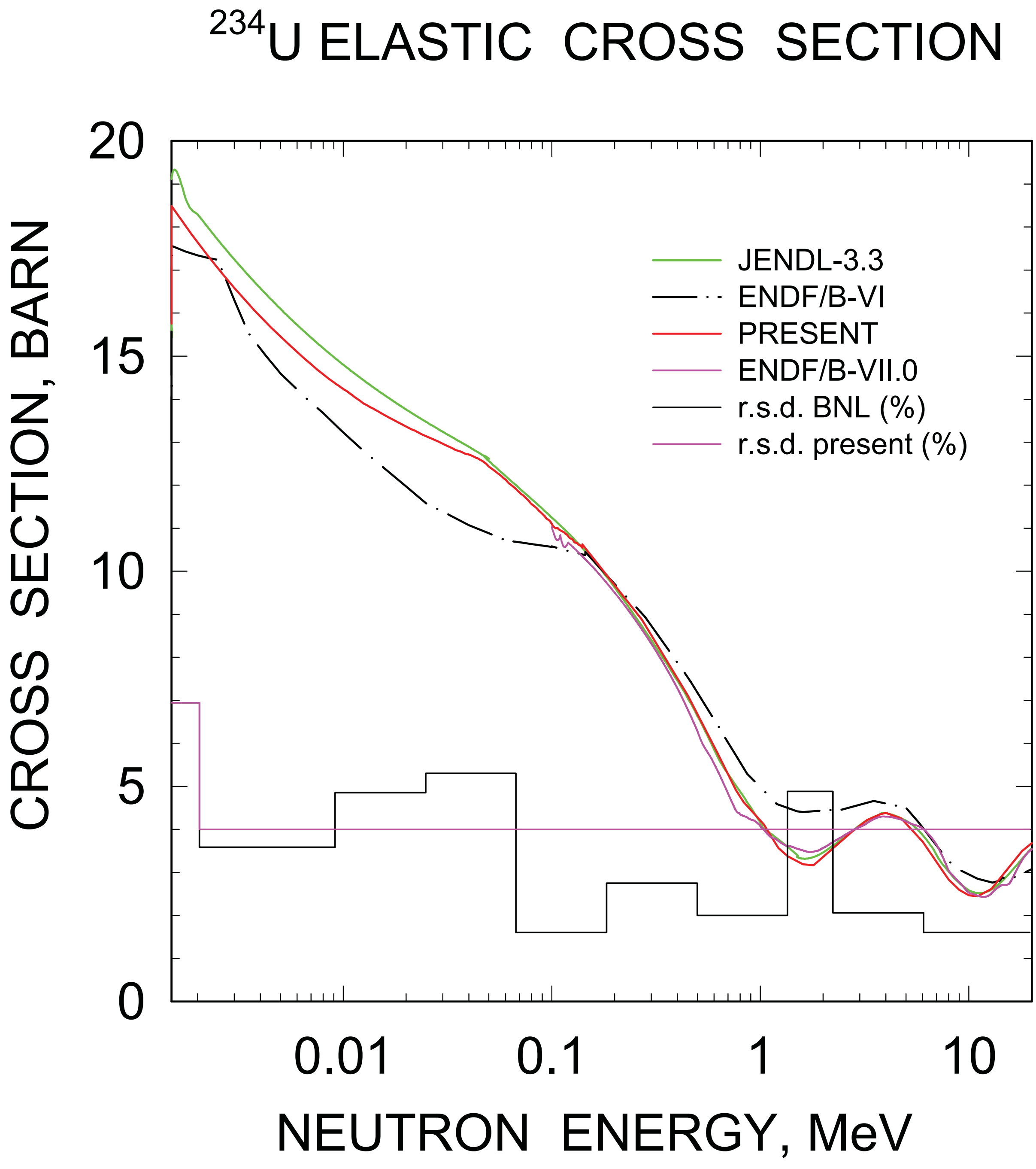
^{232}Th ELASTIC CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
25
20
15
10
5
0
0.001
0.01
0.1
1
10
COX ET AL., 1972
WALT ET AL., 1954
BATCHELOR ET AL., 1965
SMITH, 1965
IWASAKI ET AL., 1981
HAOUAT ET AL., 1982
KAZAKOVA ET AL., 1965
POPOV, 1957
LAGRANGE ET AL., 1982
JENDL-3.2
JEF-2
ENDF/B-VI
ENDF/B-VII.0
r.s.d BNL(%)
HUDSON ET AL., 1962
shape elastic
present
r.s.d. present(%)



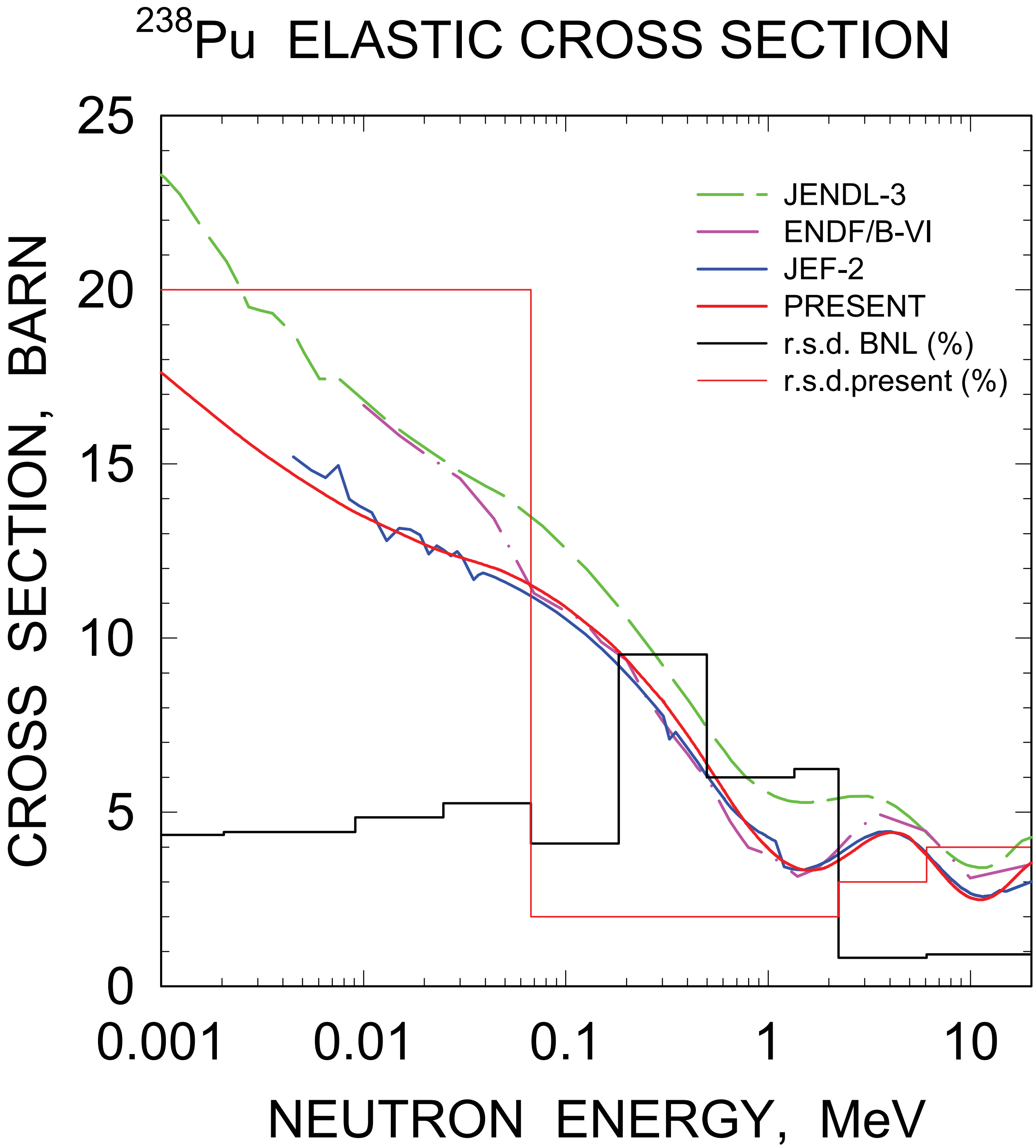
^{238}U ELASTIC CROSS SECTION
ALLEN ET AL.,1956
BARNARD ET AL.,1966
BATCHELOR ET AL.,1965
HAOUAT ET AL.,1982
LI JINGDE ET AL.,1989
SHEN GUANRAN ET AL.,1984
VOIGNIER ET AL.,1968
JENDL-3.2
PRESENT
ENDF/B-VII.0
r.s.d. ^{237}Np, BNL (%)
r.s.d. ^{238}U, BNL (%)
shape elastic
r.s.d. present (%)
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0
5
10
15
20
0.001
0.01
0.1
1
10



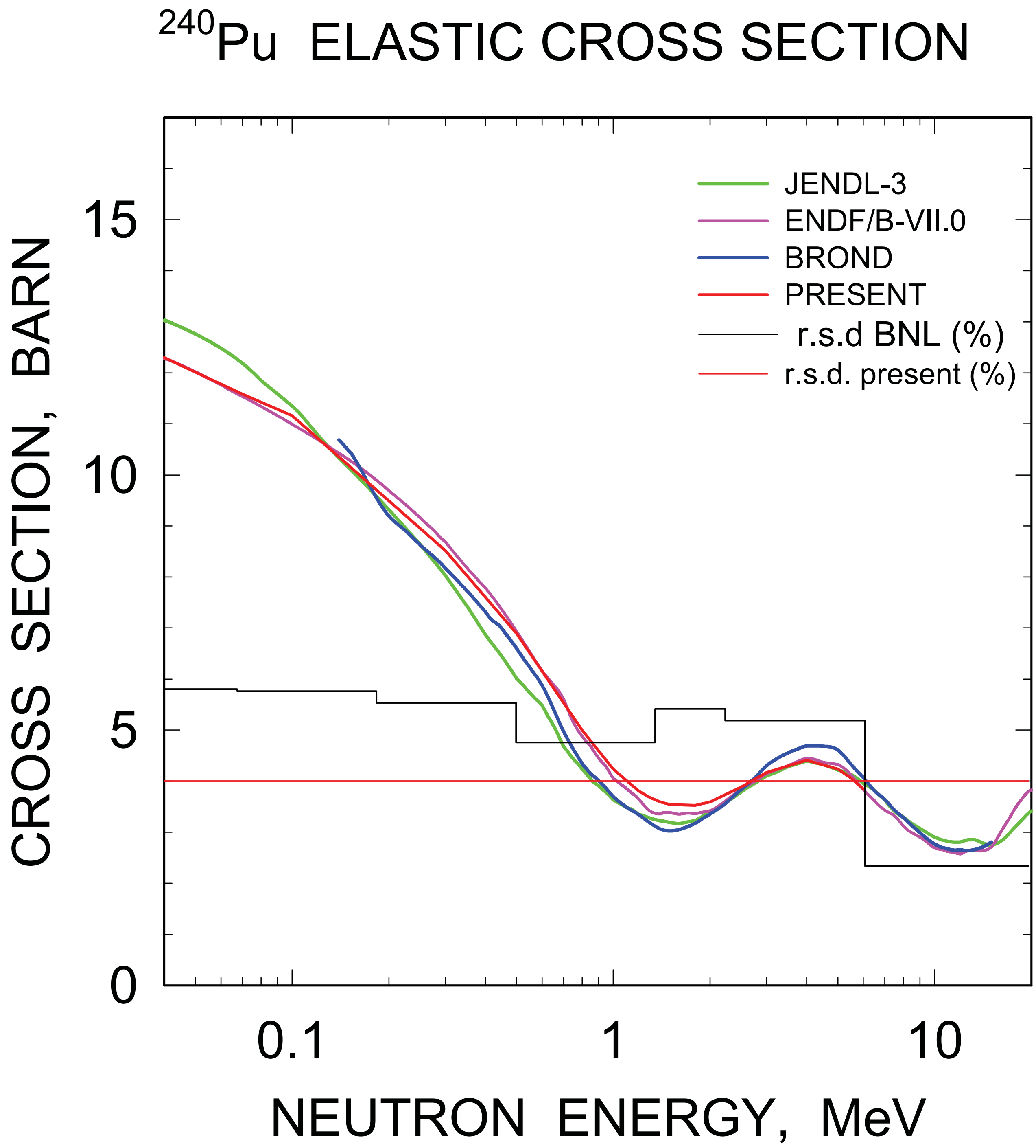
^{236}U ELASTIC CROSS SECTION
JENDL-3.3
ENDF/ B-VII.0
PRESENT
JEFF-3.1
r.s.d. BNL (%)
shape elastic
r.s.d. present (%)
CROSS SECTION, BARN
0
5
10
15
20
0.001
0.01
0.1
1
10
NEUTRON ENERGY, MeV



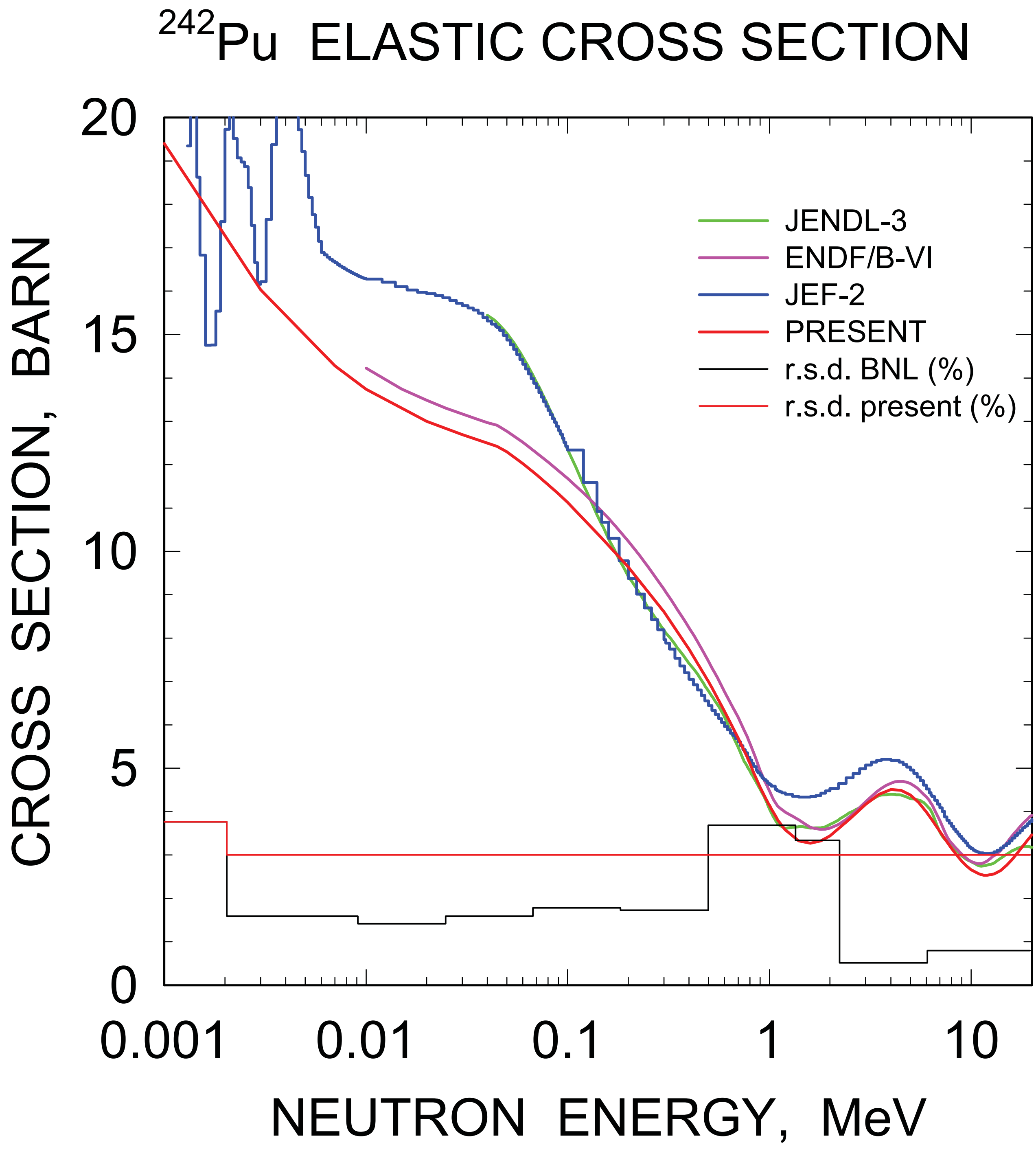
^{234}U ELASTIC CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
JENDL-3.3
ENDF/B-VI
PRESENT
ENDF/B-VII.0
r.s.d. BNL (%)
r.s.d. present (%)
20
15
10
5
0
0.01
0.1
1
10



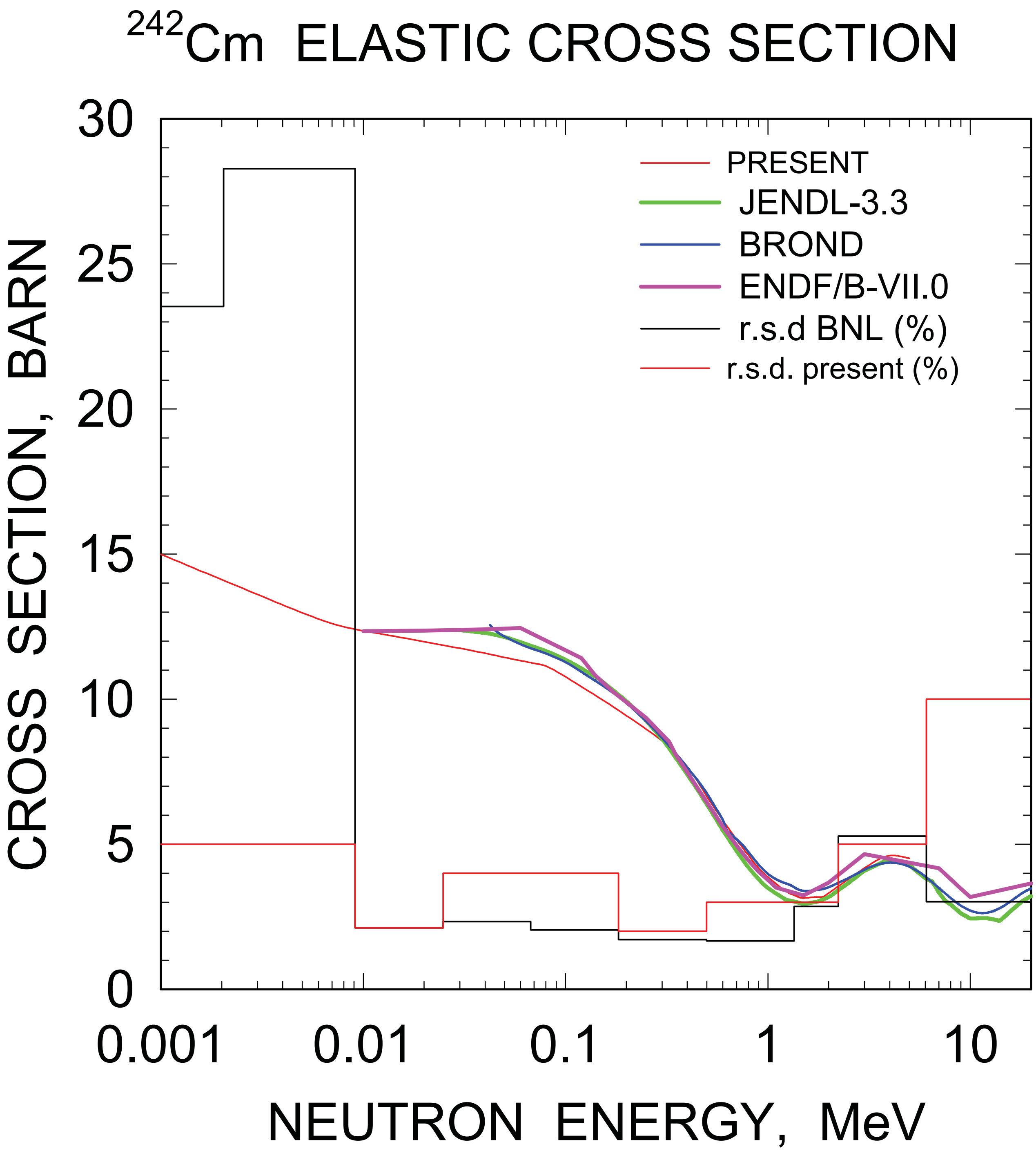
238Pu ELASTIC CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0
5
10
15
20
25
0.001
0.01
0.1
1
10
JENDL-3
ENDF/B-VI
JEF-2
PRESENT
r.s.d. BNL (%)
r.s.d.present (%)



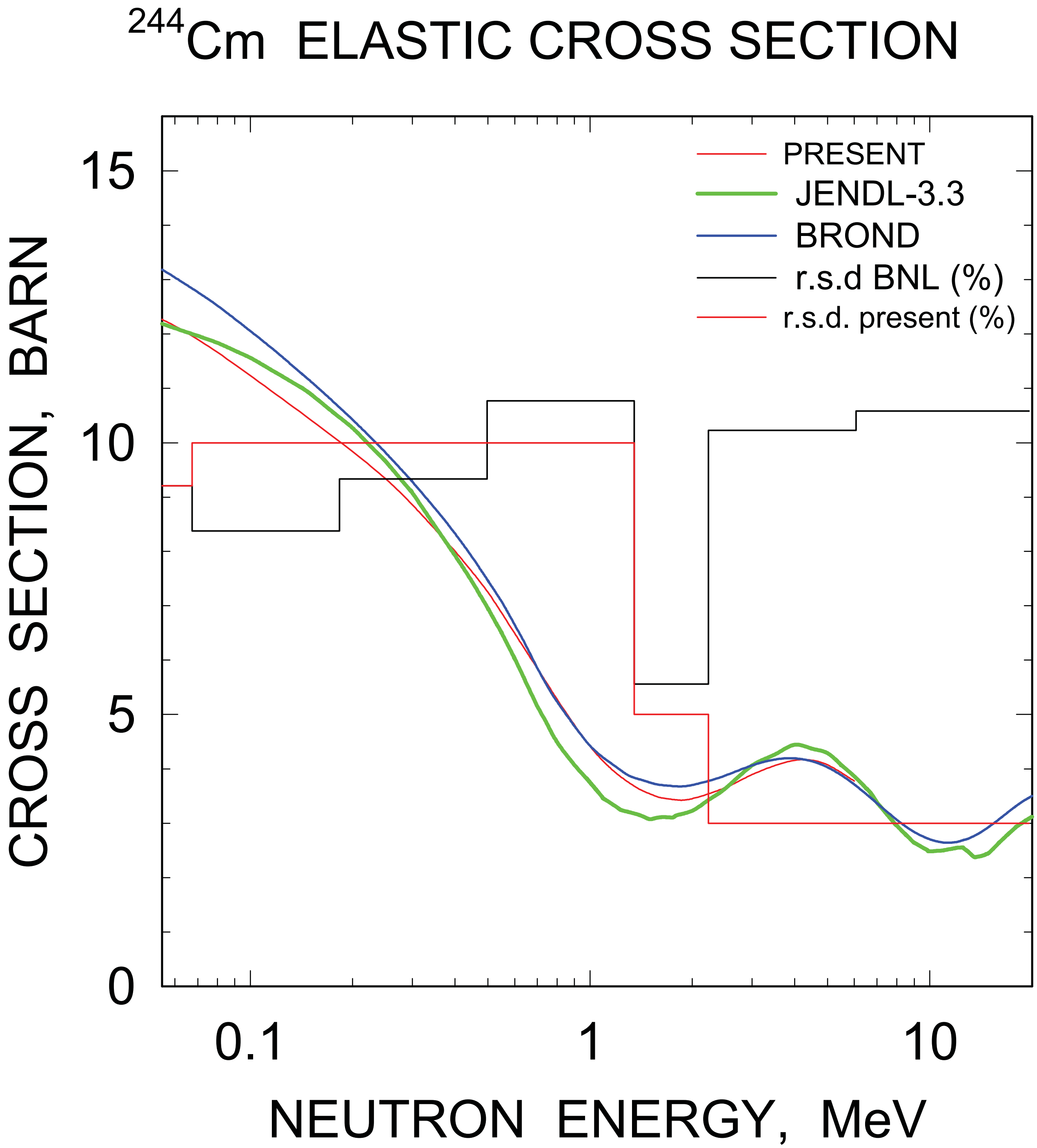
240Pu ELASTIC CROSS SECTION
JENDL-3
ENDF/B-VII.0
BROND
PRESENT
r.s.d BNL (%)
r.s.d. present (%)
CROSS SECTION, BARN
0
5
10
15
0.1
1
10
NEUTRON ENERGY, MeV



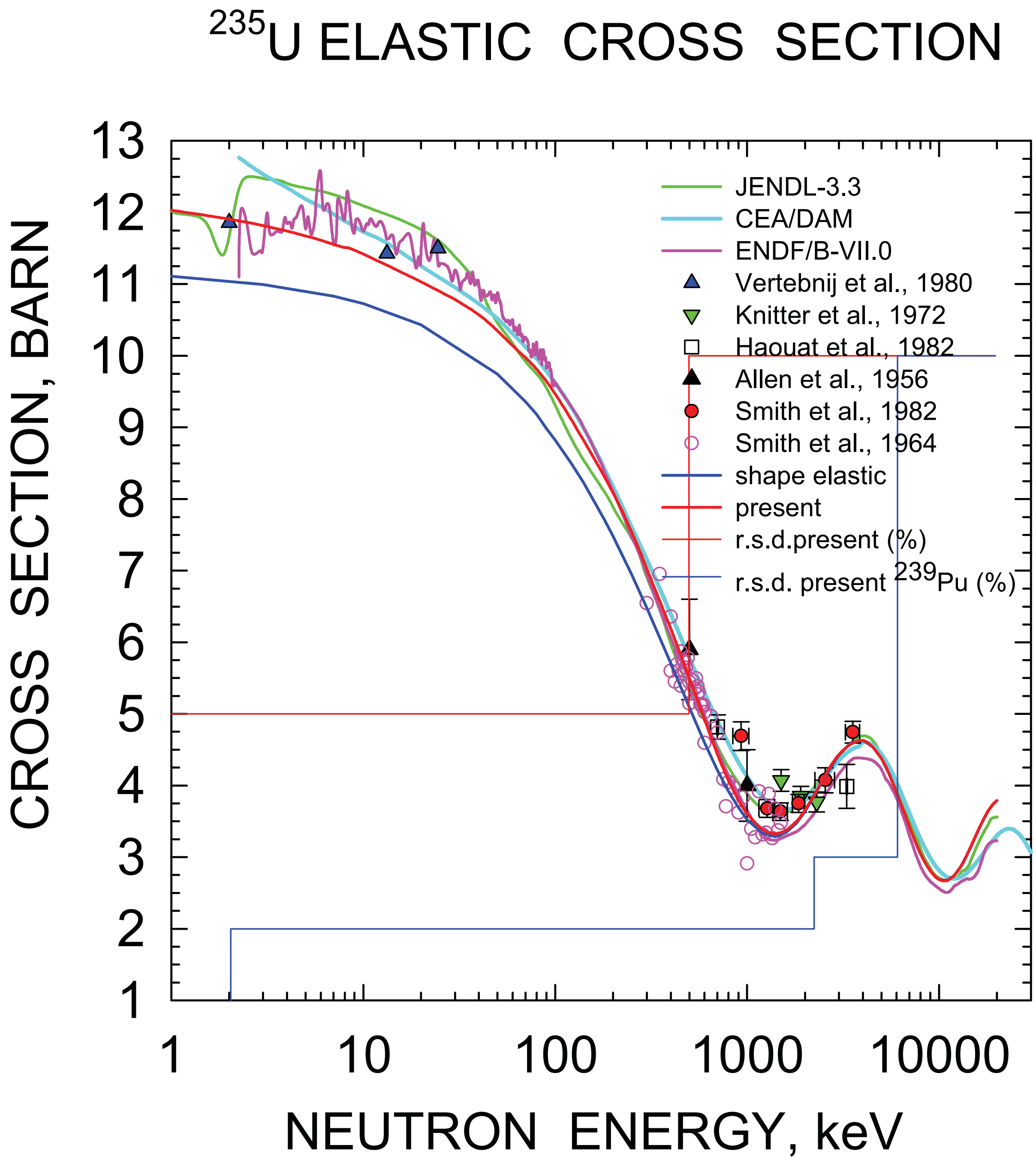
242Pu ELASTIC CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
20
15
10
5
0
0.001
0.01
0.1
1
10
JENDL-3
ENDF/B-VI
JEF-2
PRESENT
r.s.d. BNL (%)
r.s.d. present (%)



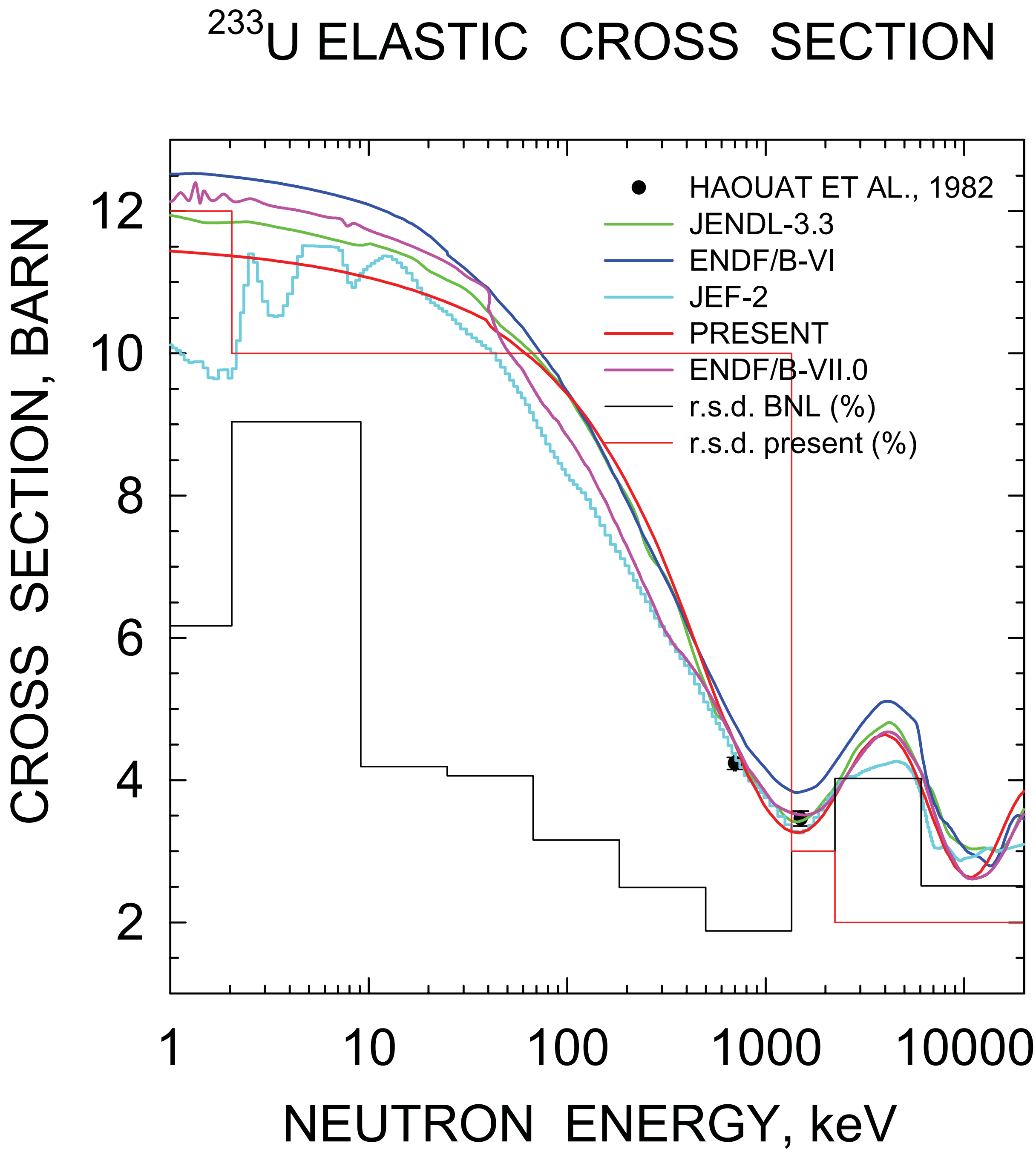
^{242}Cm ELASTIC CROSS SECTION
PRESENT
JENDL-3.3
BROND
ENDF/B-VII.0
r.s.d BNL (%)
r.s.d. present (%)
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0
5
10
15
20
25
30
0.001
0.01
0.1
1
10



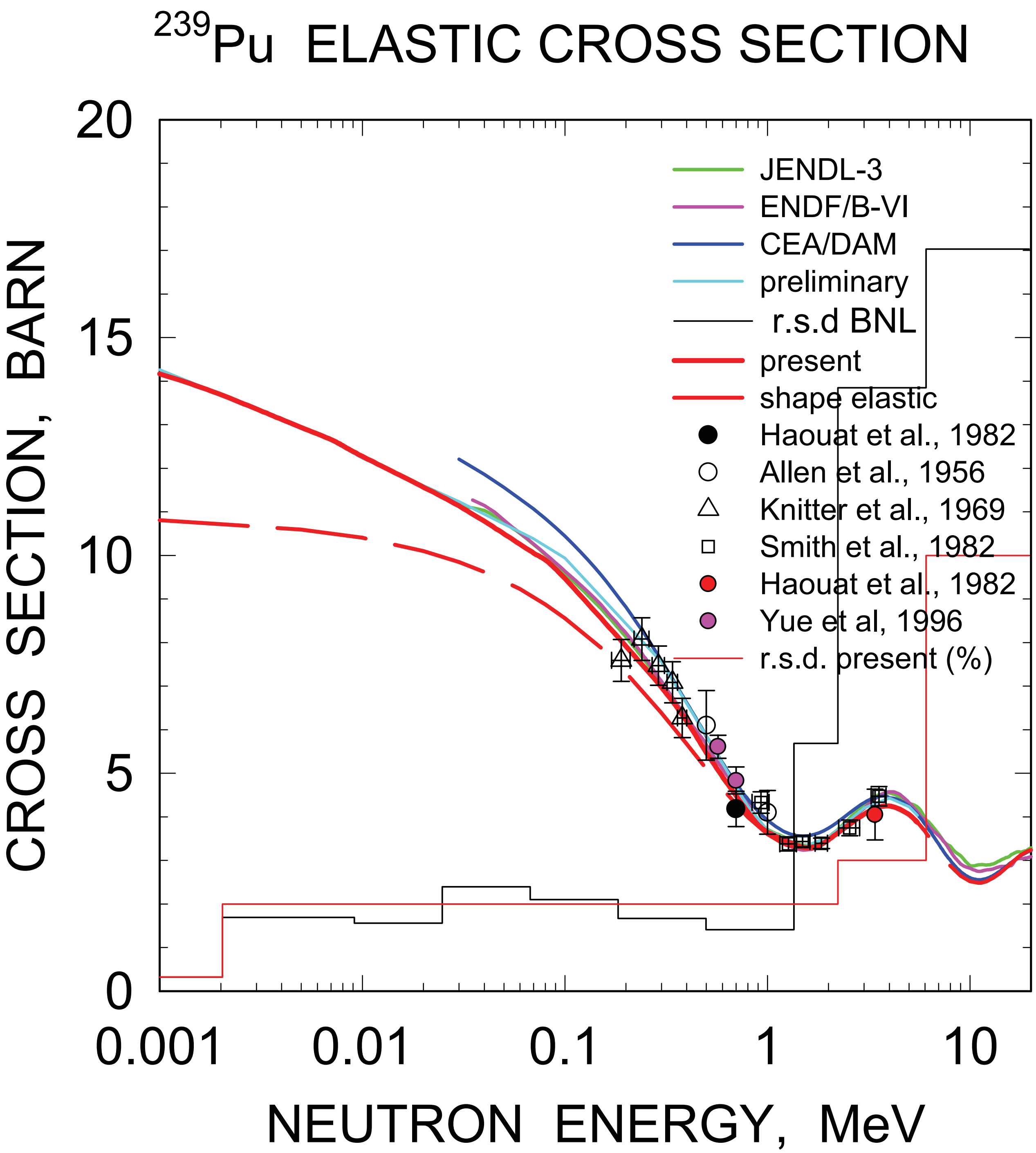
^{244}Cm ELASTIC CROSS SECTION
PRESENT
JENDL-3.3
BROND
r.s.d BNL (%)
r.s.d. present (%)
CROSS SECTION, BARN
0
5
10
15
0.1
1
10
NEUTRON ENERGY, MeV



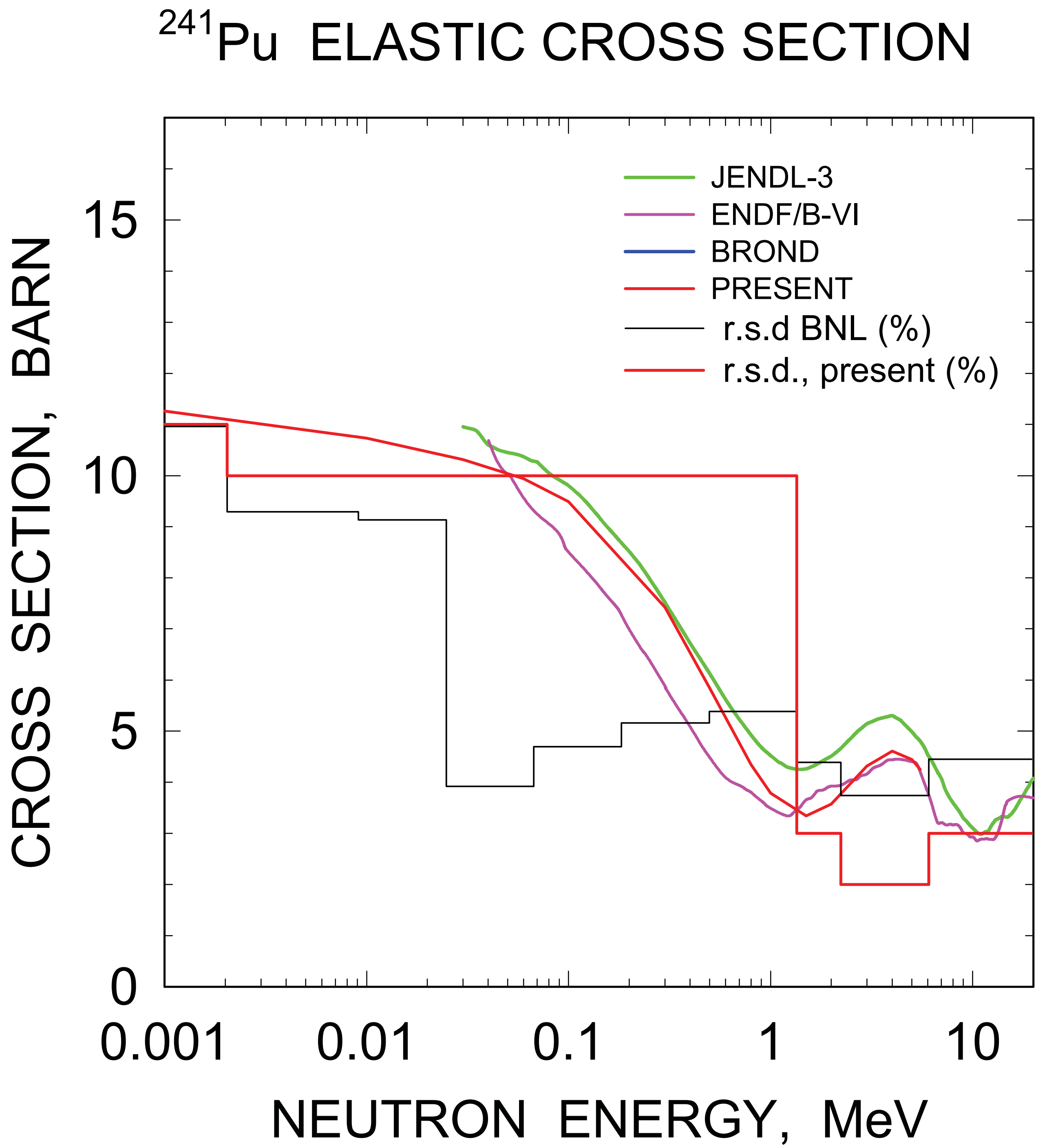
^{235}U ELASTIC CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, keV
JENDL-3.3
CEA/DAM
ENDF/B-VII.0
Vertebnij et al., 1980
Knitter et al., 1972
Haouat et al., 1982
Allen et al., 1956
Smith et al., 1982
Smith et al., 1964
shape elastic
present
r.s.d.present (%)
r.s.d. present ^{239}Pu (%)



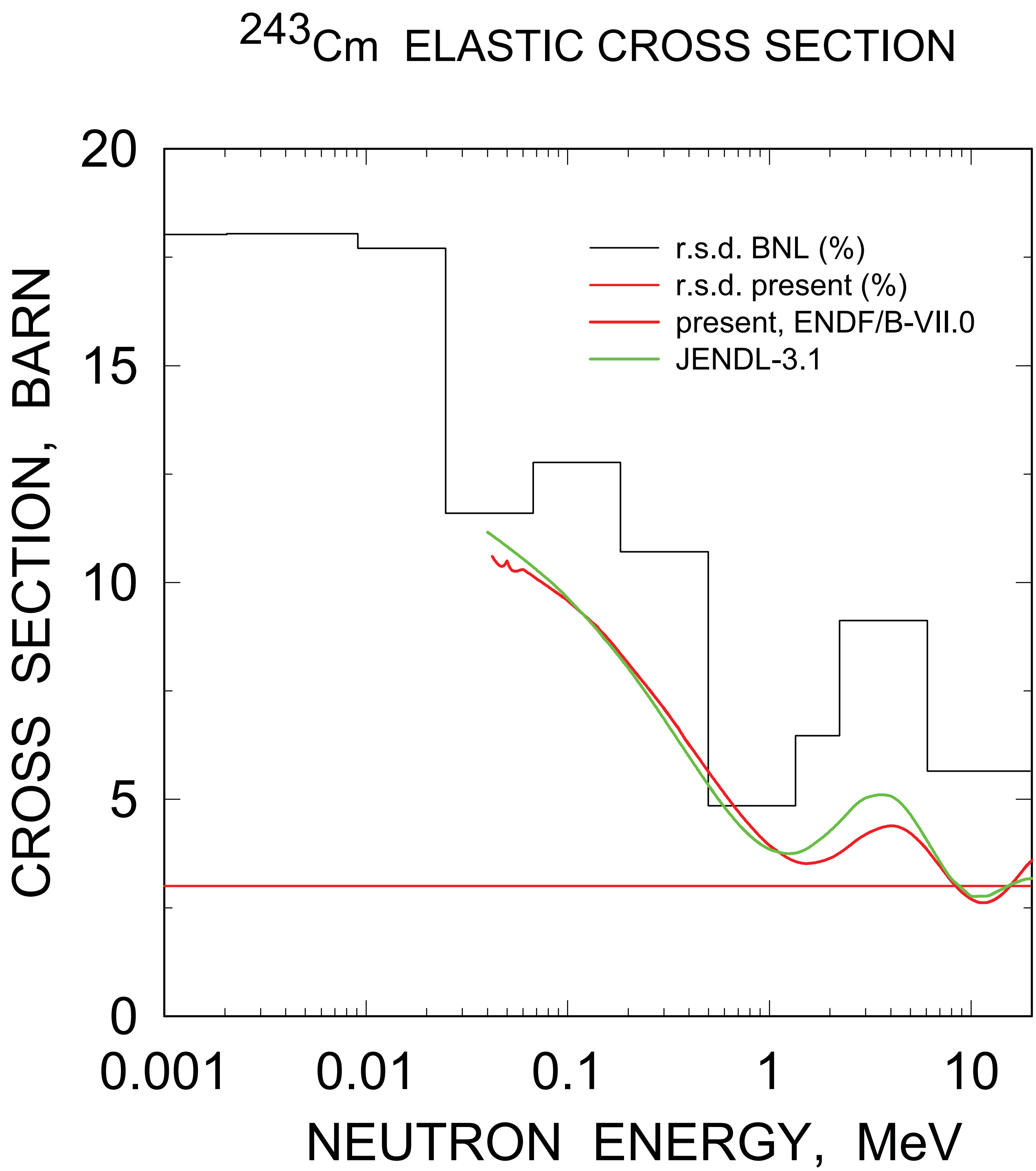
233U ELASTIC CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, keV
2
4
6
8
10
12
1
10
100
1000
10000
HAOUAT ET AL., 1982
JENDL-3.3
ENDF/B-VI
JEF-2
PRESENT
ENDF/B-VII.0
r.s.d. BNL (%)
r.s.d. present (%)



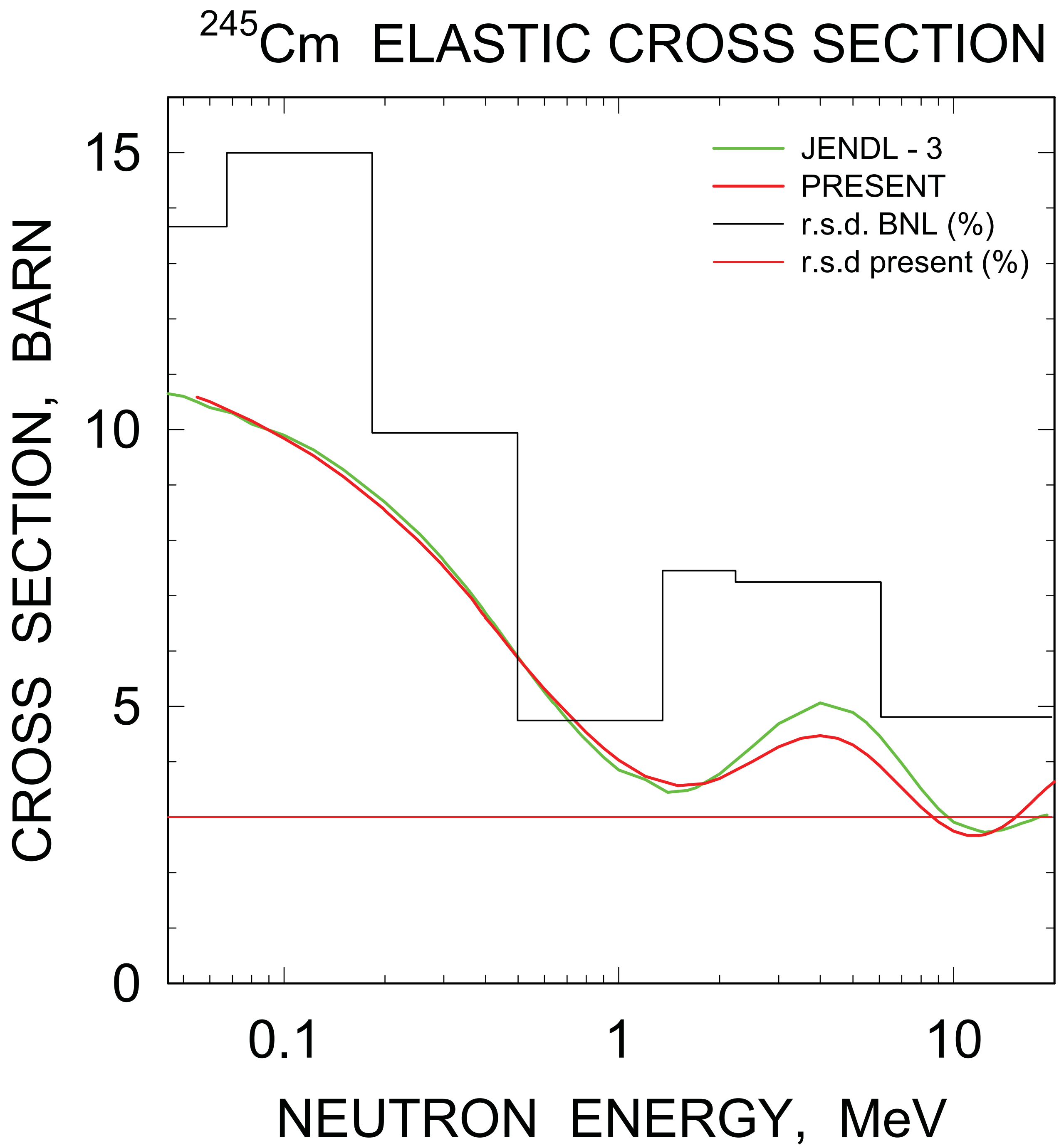
^{239}Pu ELASTIC CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0
5
10
15
20
0.001
0.01
0.1
1
10
JENDL-3
ENDF/B-VI
CEA/DAM
preliminary
r.s.d BNL
present
shape elastic
Haouat et al., 1982
Allen et al., 1956
Knitter et al., 1969
Smith et al., 1982
Haouat et al., 1982
Yue et al, 1996
r.s.d. present (%)



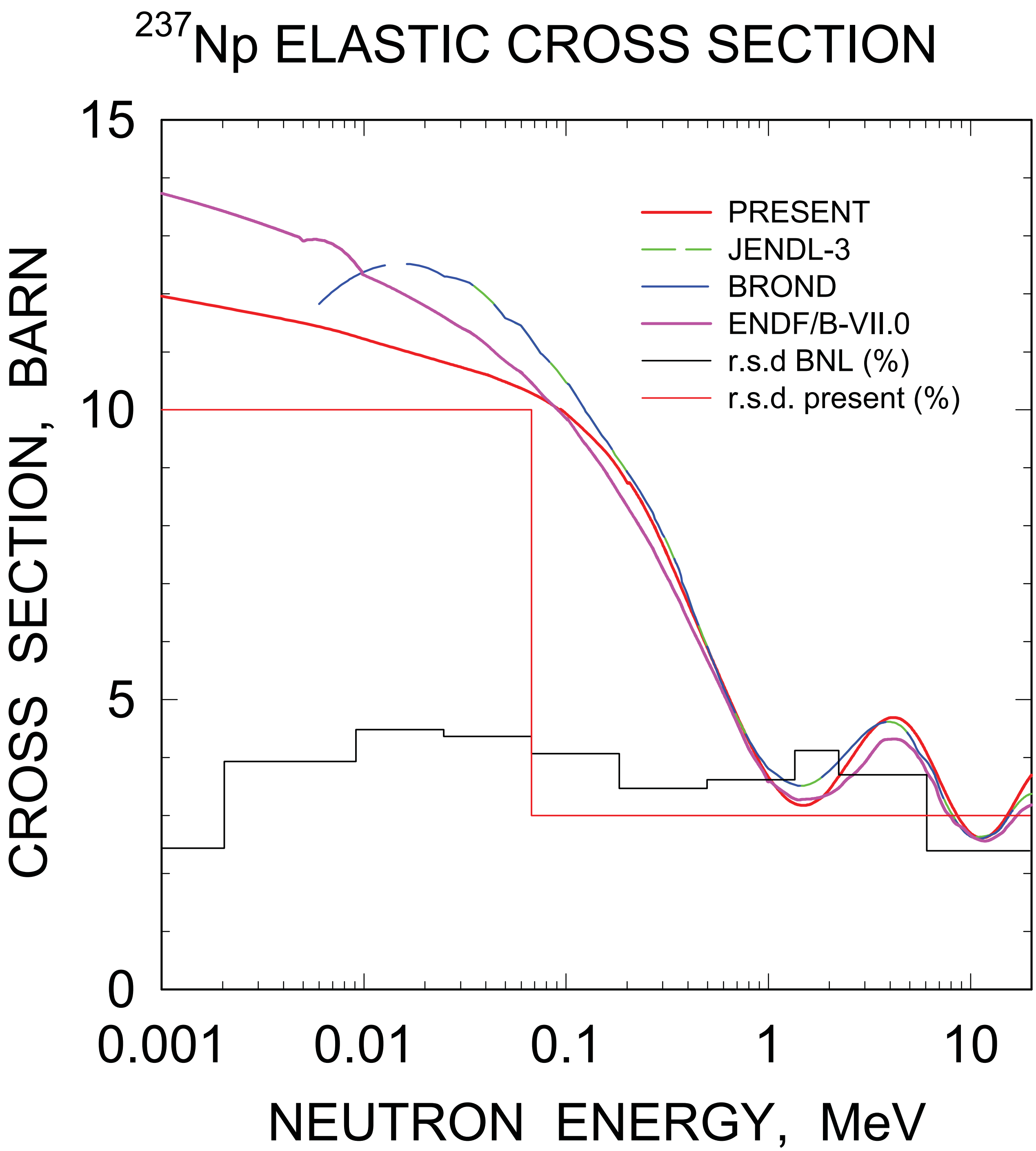
241Pu ELASTIC CROSS SECTION
JENDL-3
ENDF/B-VI
BROND
PRESENT
r.s.d BNL (%)
r.s.d., present (%)
CROSS SECTION, BARN
0
5
10
15
0.001
0.01
0.1
1
10
NEUTRON ENERGY, MeV



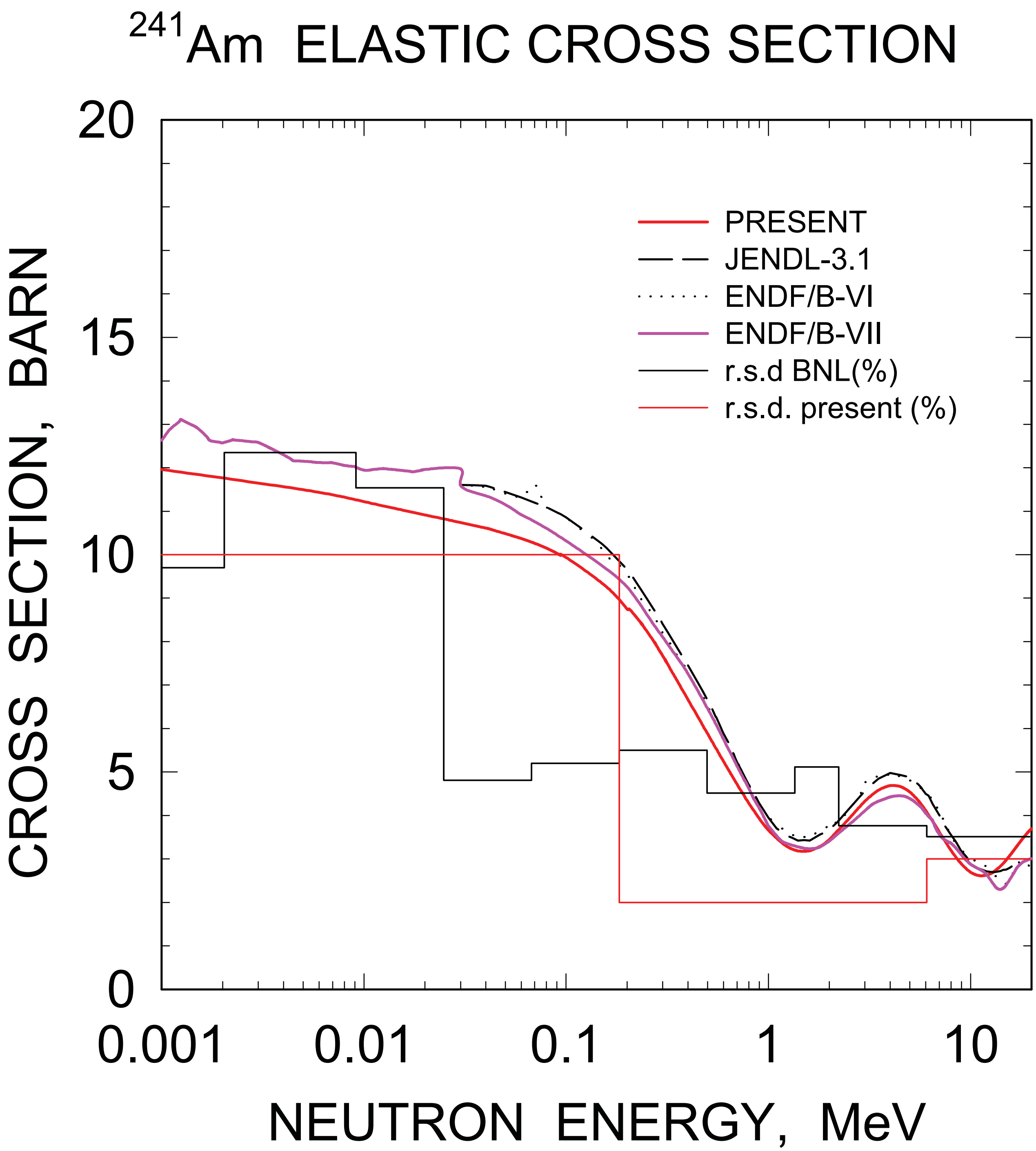
243Cm ELASTIC CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0
5
10
15
20
0.001
0.01
0.1
1
10
r.s.d. BNL (%)
r.s.d. present (%)
present, ENDF/B-VII.0
JENDL-3.1



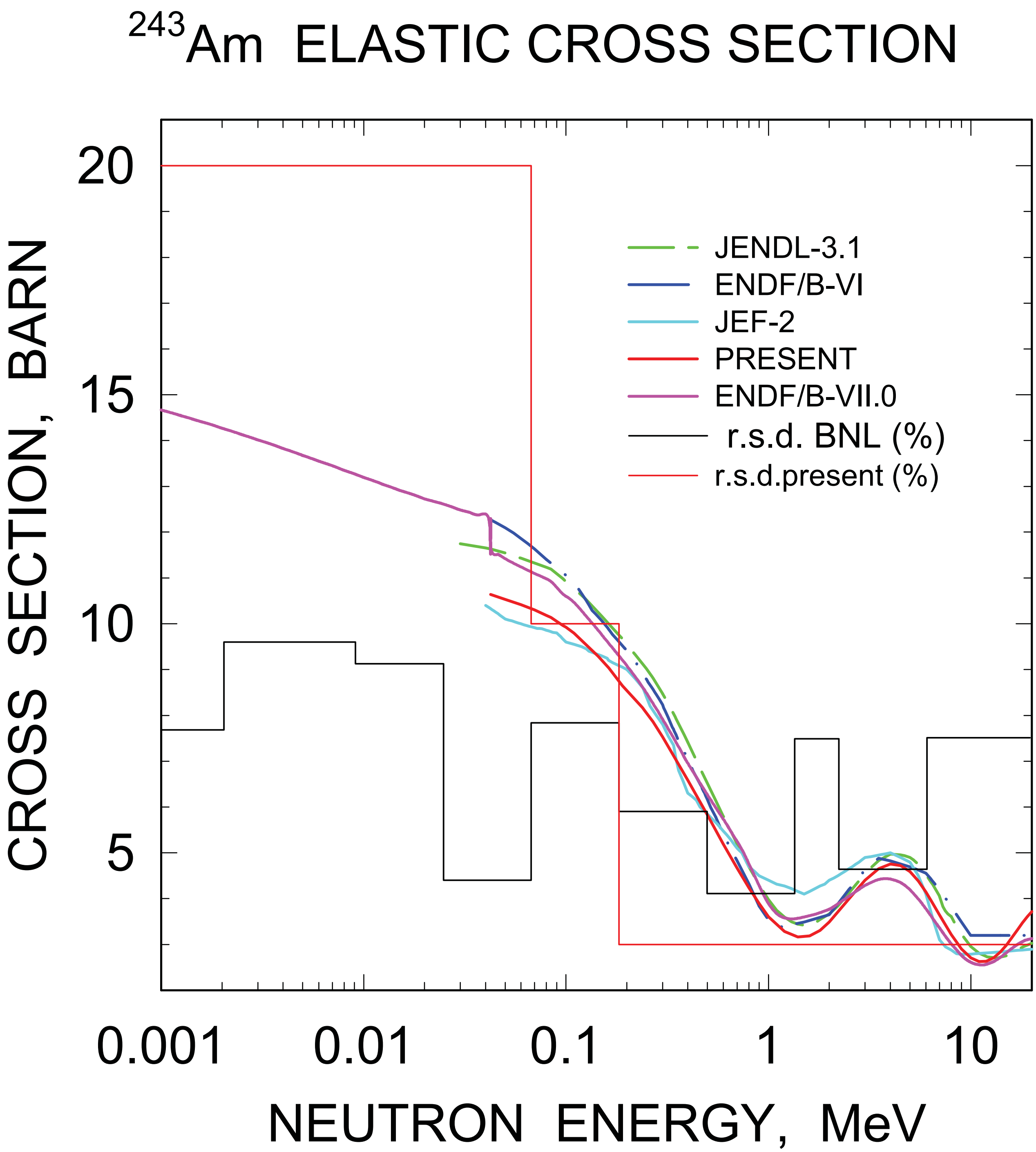
245Cm ELASTIC CROSS SECTION
JENDL - 3
PRESENT
r.s.d. BNL (%)
r.s.d present (%)
15
10
5
0
0.1
1
10
CROSS SECTION, BARN
NEUTRON ENERGY, MeV



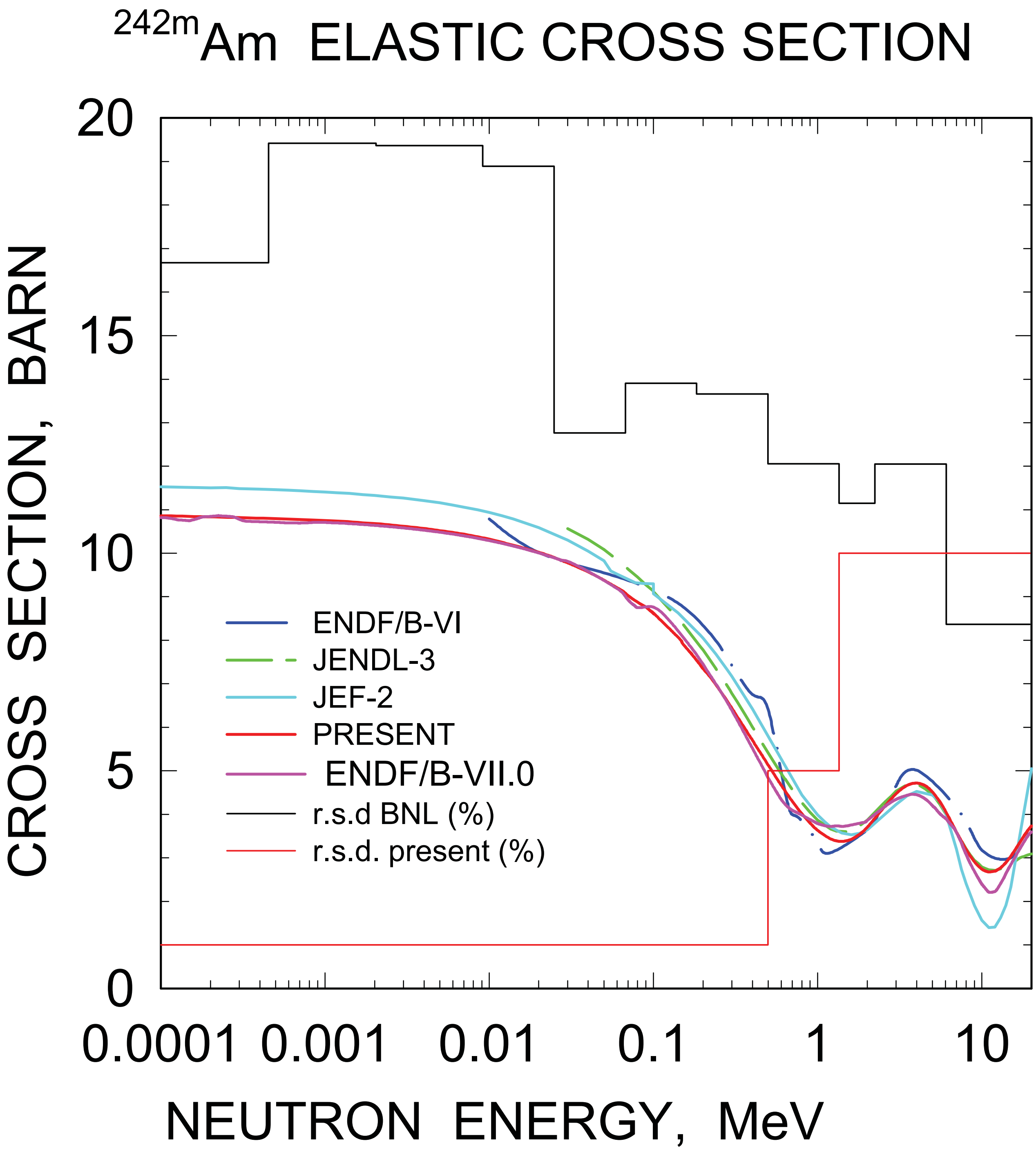
^{237}Np ELASTIC CROSS SECTION
PRESENT
JENDL-3
BROND
ENDF/B-VII.0
r.s.d BNL (%)
r.s.d. present (%)
CROSS SECTION, BARN
15
10
5
0
0.001
0.01
0.1
1
10
NEUTRON ENERGY, MeV



241Am ELASTIC CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0
5
10
15
20
0.001
0.01
0.1
1
10
PRESENT
JENDL-3.1
ENDF/B-VI
ENDF/B-VII
r.s.d BNL(%)
r.s.d. present (%)



^{243}Am ELASTIC CROSS SECTION
JENDL-3.1
ENDF/B-VI
JEF-2
PRESENT
ENDF/B-VII.0
r.s.d. BNL (%)
r.s.d.present (%)
CROSS SECTION, BARN
20
15
10
5
0.001
0.01
0.1
1
10
NEUTRON ENERGY, MeV



242mAm ELASTIC CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0
5
10
15
20
0.0001
0.001
0.01
0.1
1
10
ENDF/B-VI
JENDL-3
JEF-2
PRESENT
ENDF/B-VII.0
r.s.d BNL (%)
r.s.d. present (%)

Chapter 3

Fission cross sections

^{232}Th: in fast energy range (in 1st and 2nd energy groups) r.s.d estimate of BNL should be increased up to 3 %, in accordance with the measured data [64-70] scatter (see Fig. 3.1). In other groups it looks reasonable. In our approach ^{232}Th(n,F) fission cross section was calculated consistently with relevant (n,xn) and (n,f) reaction cross sections and prompt fission neutron spectra with proper description of the surrogate data [71, 72] on the ^{231}Th(n,f) reaction by Maslov [4].

^{238}U: Fig. 3.2 shows, that in the fast energy range (in 1st – 4th energy groups) r.s.d estimate of BNL [1, 2] should be increased at least up to 1 %, in other cases it looks reasonable. In our approach ^{238}U(n,F) fission cross section was calculated consistently with relevant (n,xn) and (n,f) reaction cross section [69, 73-75] data and prompt fission neutron spectra with proper description of the 2006'surrogate data [76, 77] on the ^{237}U(n,f) reaction in 2005 [5]. Note drastic discrepancies of partial fission chances contributions to the observed fission cross section of ^{238}U(n, F) reaction for present [11,12, 13] and other [14, 78] approaches. These discrepancy would have a strong influence on the ^{238}U(n,xn) reaction cross section uncertainty estimates.

^{236}U: ENDF/B-VII.0 evaluation and present calculations of ^{236}U(n, F) fission cross sections are quite consistent with each other and measured data base [73, 75, 80], r.s.d are changed only slightly. Nonetheless, drastic discrepancies of partial fission chances contributions to the observed fission cross section of ^{236}U(n,F) reaction for present and other approaches of ENDF/B-VII.0 [14] and JEFF [15] will influence substantially the ^{236}U(n, 2n) reaction cross section estimate (see Fig. 3.3).

^{234}U: Fig. 3.4 shows, that main discrepancies of ENDF/B-VII.0 [11] evaluation and present calculations of ^{234}U(n, F) fission cross sections [73, 81-90], which are the same as those by Maslov et al. [21], are in 1st and 2nd groups, the r.s.d. values are changed only slightly. Drastic discrepancies are noticed between partial fission chances, which should influence the ^{234}U(n, 2n) reaction cross section.

^{238}Pu: as shown on Fig. 3.5 evaluated data file by Maslov et al. [32] describes the deep sub-threshold data by Alam et al. [91] and data by Budtz-Jorgensen et al. [92] up to (n,nf) fission threshold (see Fig. 3.6). Data by Fursov et al. [60] were not available at the moment of data evaluation [32], nonetheless, they are quite compatible with the evaluated curve below and above fission threshold, except 100-500 keV energy range. The discrepancy of the evaluated curve with the measured data by Fursov et al. [60] could be attributed to the erroneously increased contribution of ^{238}Pu(n,nf) reaction to the observed fission cross section ^{238}Pu(n, F). The latter is due to erroneously increased fission probability of ^{238}Pu. In 1996 it was done to decrease the discrepancy of the calculated fission cross section with the data by Budtz-Jorgensen et al. [92]. However, the final conclusion was that the data by Budtz-Jorgensen et al. [92] can not be fitted above the (n,nf) reaction threshold. As in case of ^{243}Am(n,F) reaction (see below) the measured fission cross section data [92] are higher than neutron absorption cross section. Near the ^{238}Pu(n,2nf) reaction threshold the calculated cross section is compatible with data by Ermagambetov and Smirenkin [93, 94] and newest data by Fursov et al. [60], the other data [95-97] are also shown.

New measurements of the ^{238}Pu(n,F) reaction cross section from 10 кeV up to 14 MeV would be rather important, moreover so that most of previous evaluations, including that adopted for ENDF/B-VII.0, are higher than the newest data by Alam et al. [91] in the deep sub-threshold energy range and data by Fursov et al. [60] in the vicinity of (n,nf) reaction threshold. Values of r.s.d. should be strongly increased at low energies.

^{240,242}Pu: as shown on Figs. 3.7, 3.8, 3.9, 3.10 present calculation (^{240}Pu), evaluation (^{242}Pu) and ENDF/B-VII.0 evaluations of ^{240}Pu(n,F) and ^{242}Pu(n,F) fission cross sections are quite consistent, except 1st energy group. However, the discrepancy is well within a data scatter for ^{240}Pu [98-104] and ^{242}Pu [99, 103, 104,105, 106, 107, 108, 109, 110] and there is no need to change r.s.d., defined in BNL report [1, 2].

^{242}Cm: Figs. 3.11, 3.12 show that in case of ^{242}Cm(n,F) the BNL r.s.d. [1, 2], estimated in 15 energy groups needs severe modifications, since ENDF/B-VII.0 [14] evaluation is much discrepant with the measured data at the deep sub-threshold energies [91] and up to 1 MeV [111]. BNL [1, 2] r.s.d. estimates seem to be rather optimistic in both energy ranges, especially in the former one. In case of n+^{242}Cm the ^{242}Cm (n, F) cross section shape predicted by Maslov [112] was supported by the surrogate measurements [113], presented at ND2007 [114]. The key point is the predicted over-threshold quasi-resonance shape, similar to that observed in ^{244}Cm(n,f) reaction [60,115, 116, 117].

^{244}Cm: JENDL-3.3 evaluation is adopted for the ENDF/B-VII.0 data library. Measured sub-threshold data by Maguire et al. [118] are compatible with Fomushkin et. al. [115, 116] data. Newest data by Fursov et al. [60] are systematically higher than data by Fomushkin et. al. [115, 116] and can not be reconciled with sub-threshold data by Maguire et al. [118] within a statistical theory calculations (see Fig. 3.13, 3.14). Present calculation fits sub-threshold data by Maguire et al. [118] and data [115, 116, 119, 120, 121]. We will define the r.s.d based on the discrepancy of ENDF/B-VII.0 (JENDL-3.3 evaluation is adopted) evaluation with present calculation (see appropriate graph).

^{235}U: fission cross section of ^{235}U(n,F) is a standard one. While different evaluations reproduce roughly the same database [75, 122, 123], drastic discrepancies are noticed between partial fission chances, which should influence the (n, 2n) and (n,3n) reaction cross sections, as well as prompt fission neutron spectra [10, 14] (see Fig. 3.15).

^{233}U: fission cross section of ^{233}U(n,F), measured in [124-131], in ENDF/B-VII.0 [11] data file is higher than evaluated data by Maslov et al. [22] by up to 5% in 1st group, r.s.d. should be increased up to 5 % as well, since there are a newest, still unpublished n-TOF data [132] , which support the lower cross section values (see Fig. 3.16). In fact, that means the cross section shape might be different. The partial fission chances contributions in ENDF/B-VII.0 [14] and Maslov et al. [19] data files are rather similar.

^{239}Pu: Figs. 3.17, 3.18 show that fission cross section data [88, 98, 101, 106, 124, 133, 134, 135] could be reproduced almost within errors (r.s.d.) from 1 keV up to 20 MeV. That provides a reliable constraint for capture, inelastic and elastic scattering, and (n, 2n) reaction cross section prediction. Values of r.s.d of JENDL-3.3 [16] look reasonable.

^{241}Pu: fission cross section data [88, 97, 127, 136, 137, 138, 139, 140] could be reproduced almost within errors (r.s.d.) from 1 keV up to 20 MeV (see Fig. 3.19, 3.20). That provides a reliable constraint for capture, inelastic and elastic scattering, and (n, 2n) reaction cross section prediction. Values of r.s.d of BNL in 1st, 2nd and 3d groups could be somewhat decreased.

^{243}Cm: in ENDF/B-VII.0 data file, the evaluation by Maslov et al. [26] was adopted. In JENDL-3.3 [15] basically the same evaluation is adopted, but the fission cross section was deliberately renormalized (increased by approximately 20 %) to Fursov et al. [60] data at 0.1- 14.9 MeV energy range (see Fig. 3.21). Measured data base for ^{243}Cm(n,f), ^{245}Cm(n,f) and ^{247}Cm(n,f) reaction cross sections became much more extensive after data by Fursov et al. [60] became available. Two-quasi-particle states of even fissioning nuclide ^{244}Cm might be pronounced in ^{243}Cm(n,f) data at E_n> 0.05 MeV. That estimate of the two-quasi-particle states excitation threshold E_2 comes from the fission barrier values estimate based on cross section data in first “plateau” region. Unfortunately, at E_n< 0.2 MeV there is no reliable data of ^{243}Cm(n,f) reaction cross section. The four-quasi-particle states of even fissioning nuclide ^{244}Cm influence the fission cross section at E_n =1~3 MeV.

The bomb-shot data by Silbert [141] were used to derive the average resonance parameters. Average fission value $\langle \Gamma_f \rangle$=0.355 eV governs the absolute cross section value in keV-energy range. Calculated ^{243}Cm(n,F) cross section could be fitted to data by Fursov et al. [60], which are are much discrepant with data by Fomushkin et al. [61, 62] in the first plateau region. The shape of the data by Fursov et al. [60] could be reproduced up to (n,nf) reaction threshold, but in that case at lower energies the consistency of the calculated data with measured data by Silbert [114] will be severely deteriorated.

At excitations higher than the emissive fission threshold it is hardly possible to reproduce the shape of measured data by Fursov et al. [60], since the neutron absorption cross section is lower than the observed fission data. The fission probability of ^{243}Cm, fissioning in the reaction ^{243}Cm(n,nf), was defined using data on ^{242}Cm(n,f) [112] (see above).

Fortunately, the ^{243}Cm (n,f) shape predicted by Maslov et al. [26] was supported by the surrogate measurements, presented at ND2007 [114]. At present r.s.d values are severely decreased, as compared with BNL estimate.

^{245}Cm: in ENDF/B-VII.0 data file, the evaluation by Maslov et al. [27] was adopted. In JENDL-3.3 basically the same evaluation is adopted, but the fission cross section was deliberately renormalized (increased by approximately 5 %) to Fursov et al. [60] data at 14.9 MeV (see Fis. 3.22, 3.23). In case of ^{245}Cm(n,F) reaction the measured data in the first plateau region are quite compatible (see data by Fursov et al. [60] and Fomushkin et al. [142], but discrepant with data by Moore et al. [117]. At incident neutron energies higher than E_n ~8 МэВ to reproduce the measured data by White and Browne [143] and Fomushkin et al. [144] is hardly possible. The reason for that are the same as in case of ^{243}Cm(n,F) reaction – measured data at E_n =14 MeV are higher than the neutron absorption cross section. The fission probability of ^{245}Cm, fissioning in the reaction ^{245}Cm(n,nf), was defined using data on ^{244}Cm(n,f) by Fomushkin et al. [115, 116].

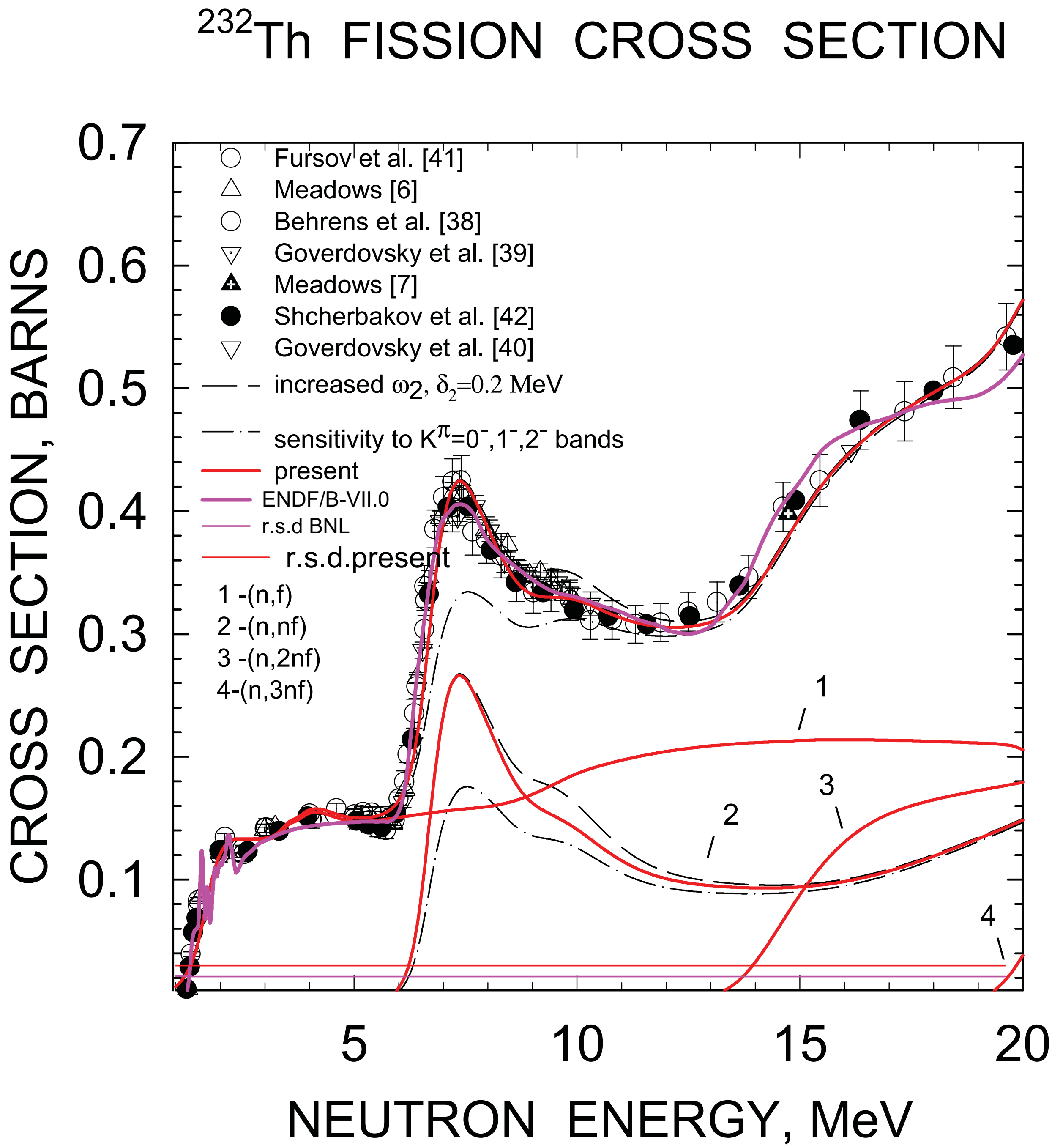
^{237}Np: In case of ^{237}Np(n,f) cross section, for which there are systematic discrepancies in measured data [145-153], which were not removed by recent measurement by Tovesson et al. [153], the estimated r.s.d. is over-optimistic (see Figs. 3.24, 3.25, 3.26). That would influence the estimates of ^{237}Np(n,n') [63] and ^{237}Np(n,2n) r.s.d [154, 155]. The r.s.d. are increased in the first groups almost twice. Present partial chance fission cross sections are much different from those of ENDF/B-VI evaluation, unfortunately, they are not provided for the ENDF/B-VII.0 evaluation.

^{241}Am: Measured data on ^{241}Am(n,F) [120, 156-168] cross section emerging from different experiments are scattering a lot, the systematic differences are also quite appreciable (see Figs. 3.27, 3.28, 3.29).. Data by Dabbs et al. [157] could be easily reproduced within a statistical theory approach from 1 keV up to 20 MeV, except the energy range in the vicinity of the (n,2nf) reaction threshold. The fission probabilities of ^{241}Am and ^{240}Am nuclides, fissioning in ^{241}Am(n,nf) and ^{241}Am(n,2nf) reactions, are defined using nucleon transfer reaction data by Britt et al [113]. The data by Prindle et al. [164] and Fomushkin et al. [120] at E_n =14.8 MeV are consistent with the calculated cross section. Data on the ^{241}Am(n,2n) reaction cross section by Filatenkov et al. [169] are consistent with evaluation by Maslov et al. [17]. That is rather important peculiarity, which is an important evidence of the reliability of the fission chances partitioning. Recent measurement of the ^{241}Am(n,2n) in the energy range of 8.8-11.4 MeV by Perdikakis et al. [170] favors our cross section estimate at E_n <10 MeV and by Vieira et al. [171] strongly support fission cross section estimate by Maslov et al. [17, 172]. The r.s.d. is increased in first groups almost twice.

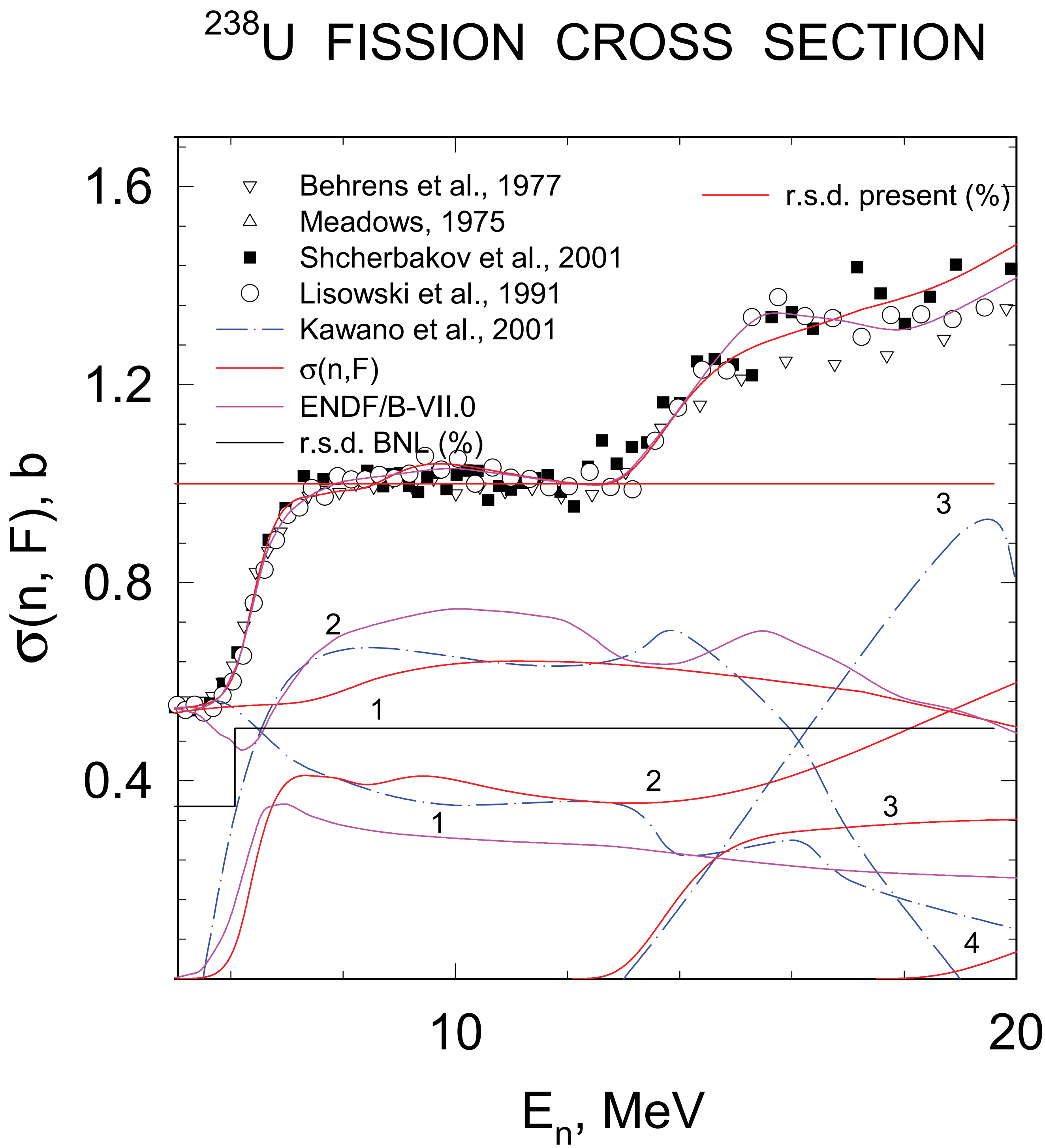
^{243}Am: Measured data [173-182] on ^{243}Am(n,F) cross section emerging from different experiments are scattering much more than in case of ^{241}Am(n,F), the systematic differences are also much higher (see Figs. 3.30, 3.31, 3.32).. We suppose the data by Knitter et al. [174] and Fursov et al. [173], spanning the energy range of 1 keV up to E_n = 7.4 MeV are more reliable than the others. Data by Goverdovskij et al. [175] and Behrens et al. [179] predict a systematically higher cross section values. The fission probabilities of ^{243}Am and ^{242}Am, fissioning in the reactions ^{243}Am(n,nf) and ^{243}Am(n,2nf) were defined by ^{242m}Am(n,f) и ^{241}Am(n,f) data. The contributions of the (n,xnf) emissive fission cross sections to the observed ^{243}Am(n,F) fission cross section predict the cross section values at E_n >7.4 MeV, which are systematically lower than the measured data, including the data by Fomushkin et al. [176] at E_n = 14.5 MeV. However, the recent measurement of the energy dependence of the ratio of ^{243}Am/^{235}U cross sections by Laptev et al. [181] supports our theoretical estimate. The data by Laptev et al. [181], when normalized to the data by Fursov et al. [173] at E_n = 5-6 MeV demonstrate nice consistency of the calculated and measured data on ^{243}Am(n,F) in the E_n =0.1- 20 MeV energy range. The r.s.d. is increased in first groups almost twice.

^{242m}Am: We suppose the data by Browne et al. [182] and Fursov et al. [183], which predict a systematically lower cross section than that observed in other experiment by Dabbs et al. [184] (see Figs. 3.33, 3.34).. The energy dependence of ^{242m}Am(n,F) reaction cross section in the 0.1-20 MeV energy range is stemming from the data by Browne et al. [182] and Dabbs et al. [185]. The fission probability of the ^{242}Am, fissioning in the reaction ^{242m}Am(n,nf), is defined by the ^{241}Am(n,f) data. The calculated cross section is consistent with data by Browne et al. [182] and Fursov et al. [183] up to E_n =

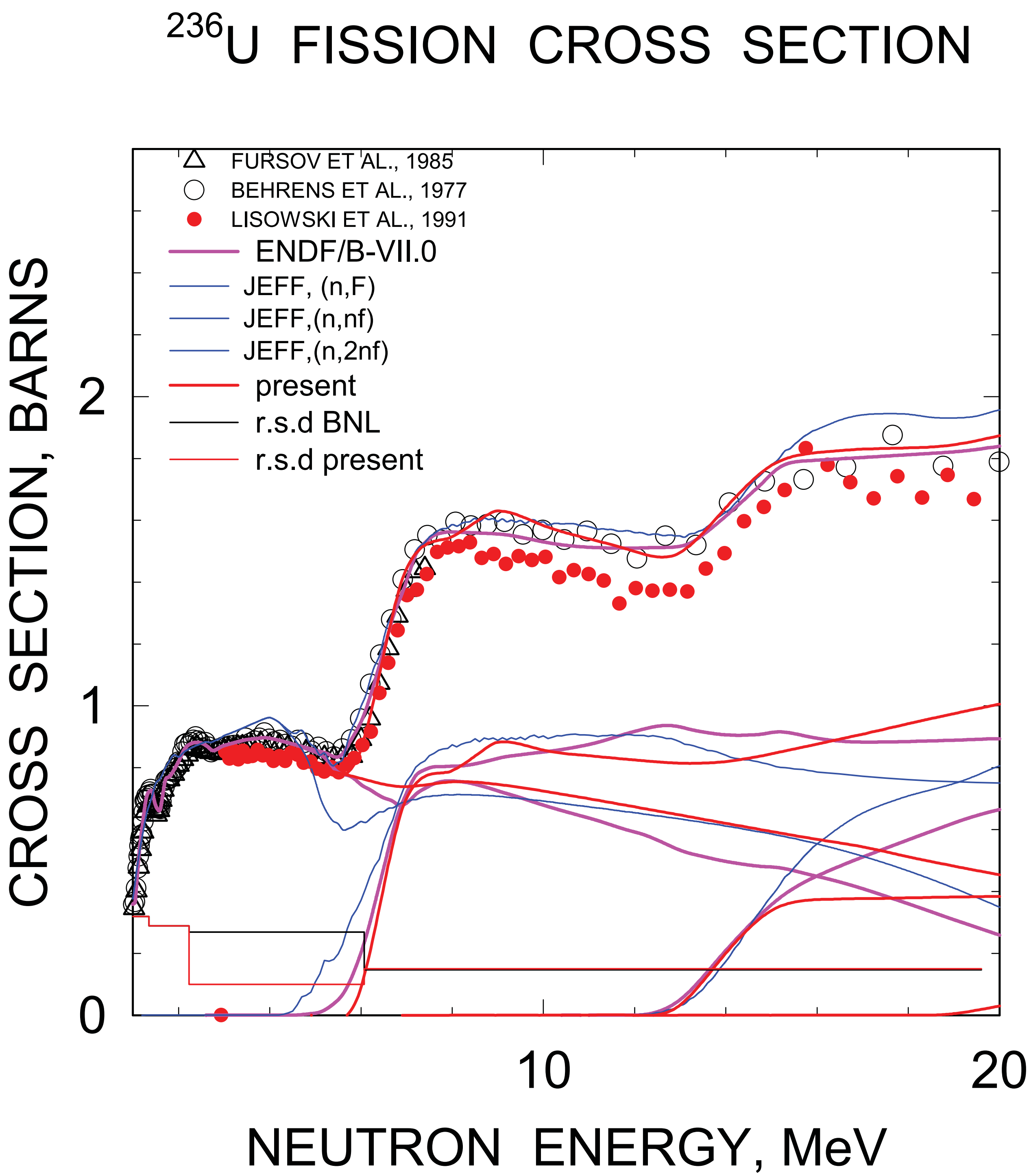
10 MeV, while its energy dependence is consistent with data by Dabbs et al. [184] and Fomushkin et al. [185] at E_n higher than the emissive fission threshold. Summarizing, we argue, that the consistent estimate of the fission probabilities of ^{244}Am, ^{243}Am and ^{242}Am nuclides produces a theoretical estimate of the ^{242m}Am(n,F) reaction cross section, which is different from the data by Browne et al. [182] in the same manner as in case of data by White and Browne et al. [143] on ^{245}Cm(n,F). That is quite important observation, since both measurements were made in similar environments. The r.s.d. is increased in first groups almost twice.



^{232}Th FISSION CROSS SECTION
CROSS SECTION, BARNS
NEUTRON ENERGY, MeV
0.1
0.2
0.3
0.4
0.5
0.6
0.7
5
10
15
20
Fursov et al. [41]
Meadows [6]
Behrens et al. [38]
Goverdovsky et al. [39]
Meadows [7]
Shcherbakov et al. [42]
Goverdovsky et al. [40]
increased ω_2, δ_2=0.2 MeV
sensitivity to K^{π}=0^-,1^-,2^- bands
present
ENDF/B-VII.0
r.s.d BNL
r.s.d.present
1 -(n,f)
2 -(n,nf)
3 -(n,2nf)
4-(n,3nf)
1
2
3
4

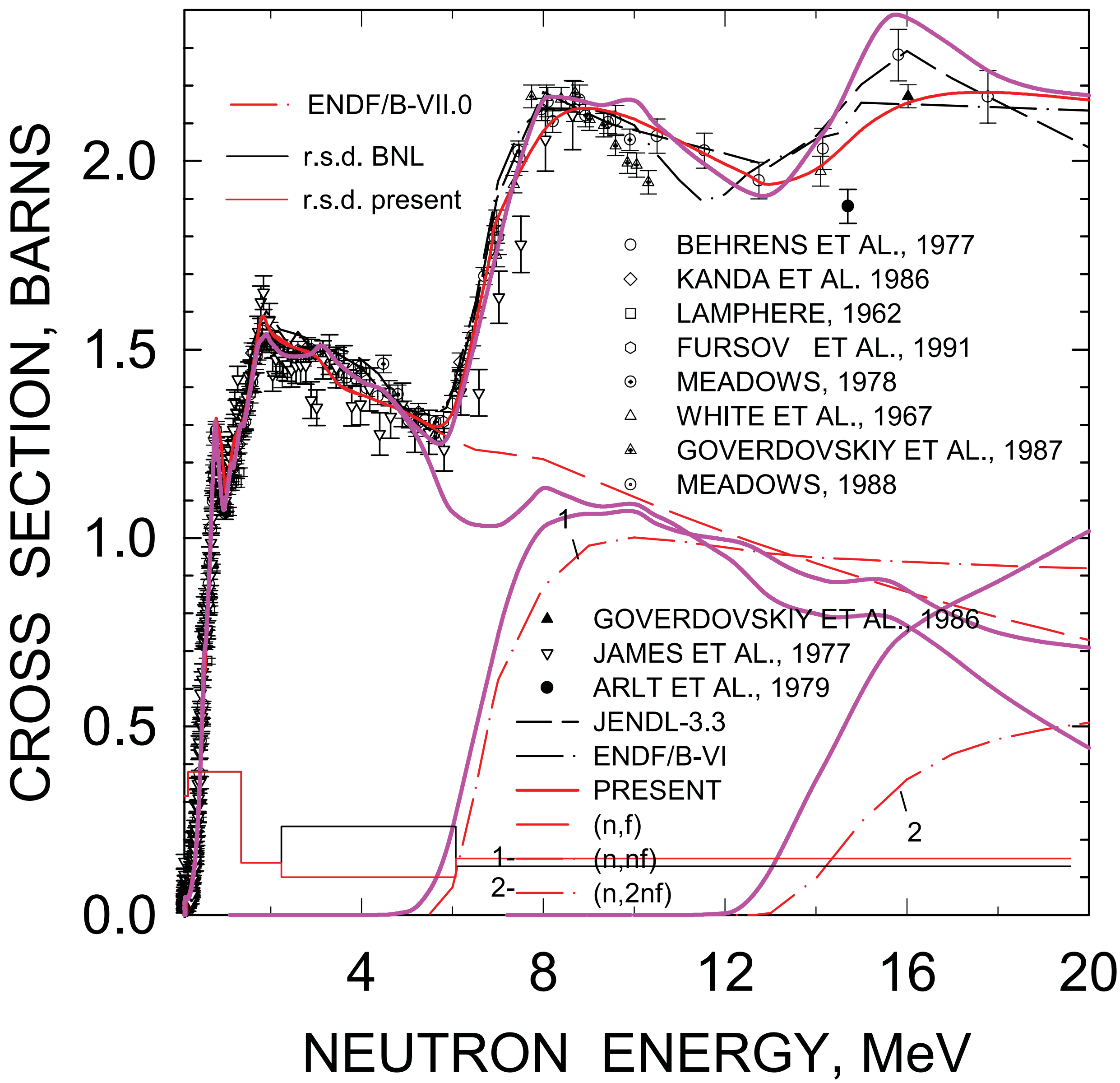


^{238}U FISSION CROSS SECTION
Behrens et al., 1977
Meadows, 1975
Shcherbakov et al., 2001
Lisowski et al., 1991
Kawano et al., 2001
σ(n,F)
ENDF/B-VII.0
r.s.d. BNL (%)
r.s.d. present (%)
σ(n, F), b
1.6
1.2
0.8
0.4
10
20
E_n, MeV
1
2
3
4

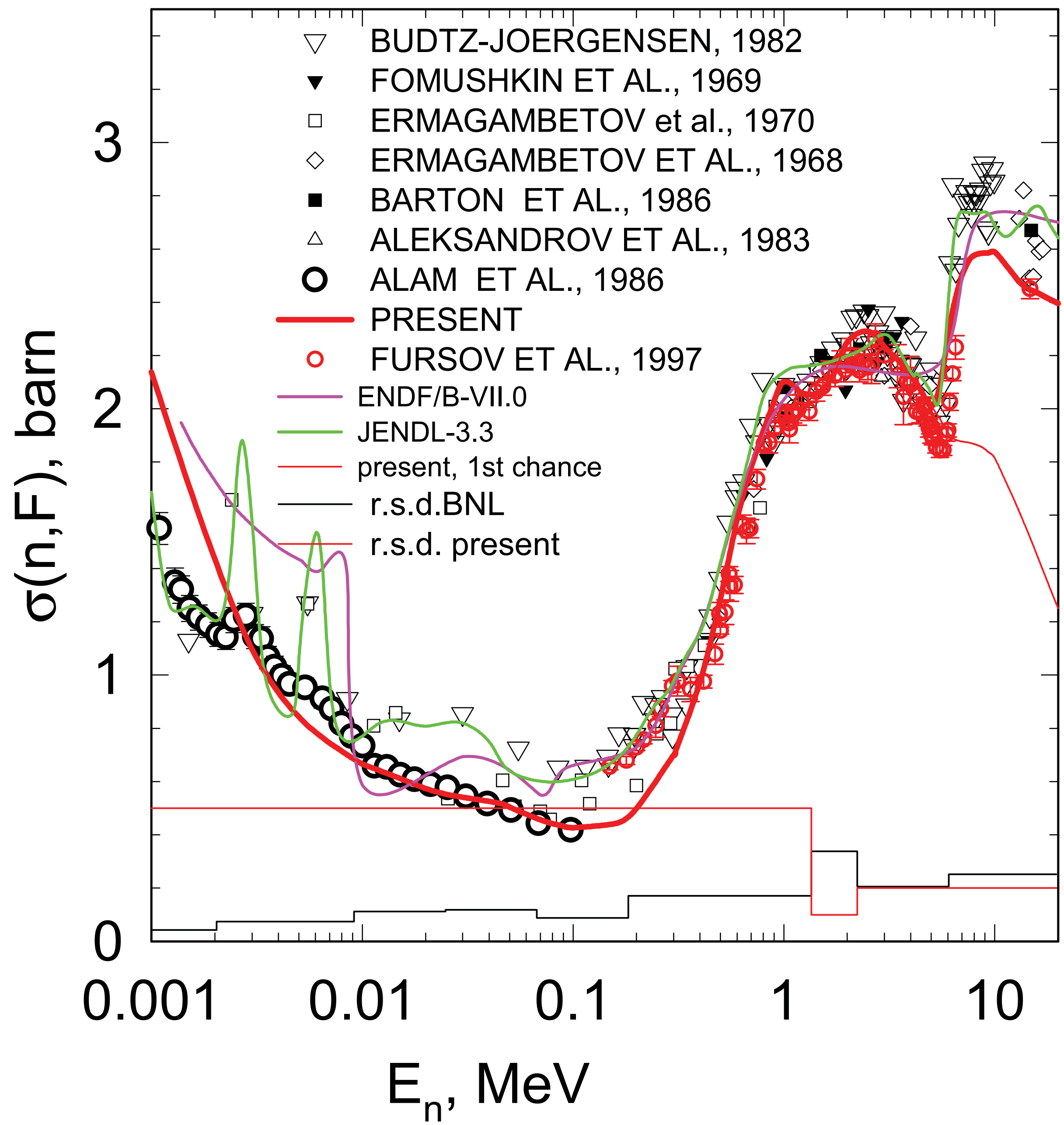


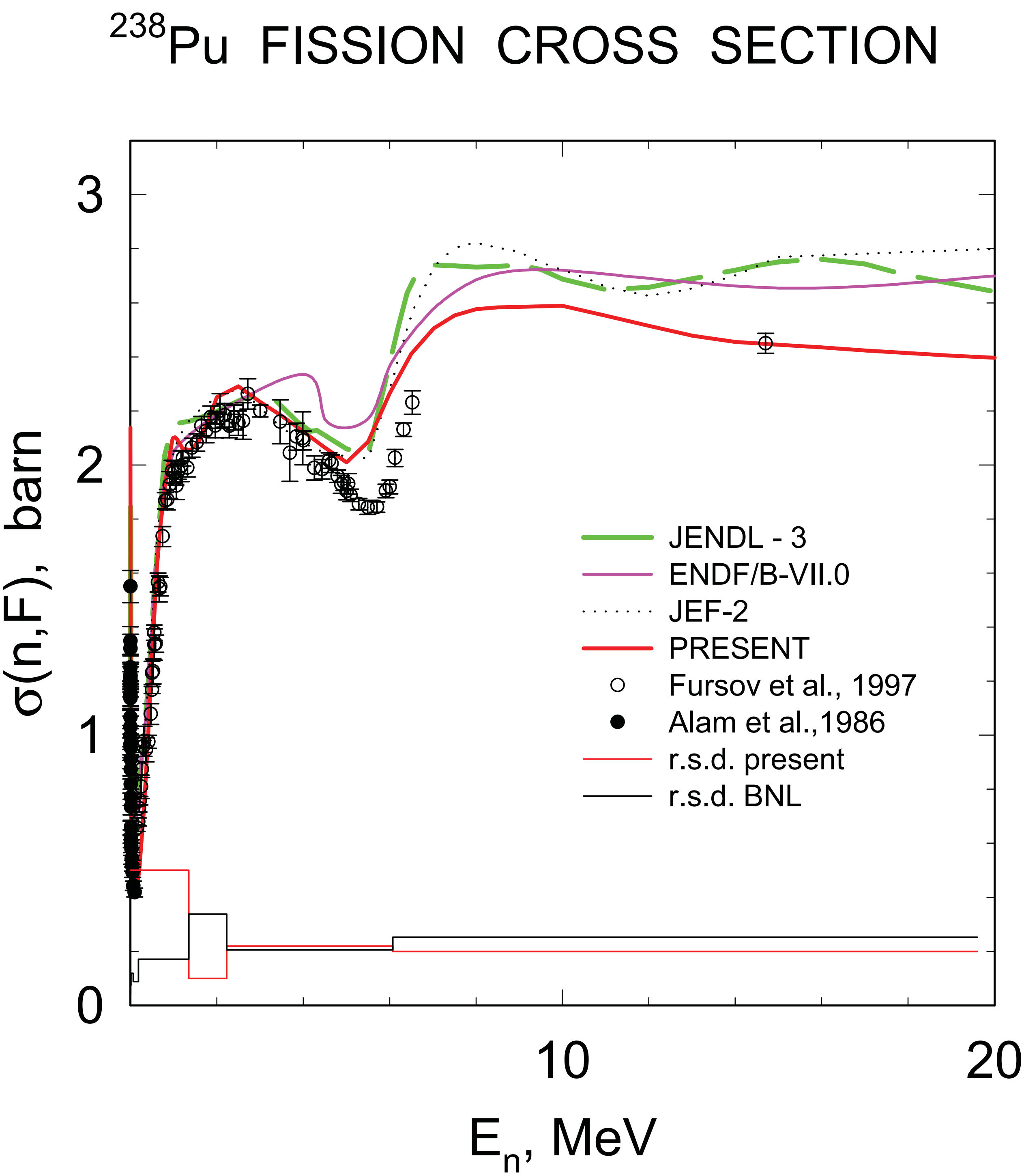
^{236}U FISSION CROSS SECTION
FURSOV ET AL., 1985
BEHRENS ET AL., 1977
LISOWSKI ET AL., 1991
ENDF/B-VII.0
JEFF, (n,F)
JEFF,(n,nf)
JEFF,(n,2nf)
present
r.s.d BNL
r.s.d present
CROSS SECTION, BARNS
0
1
2
10
20
NEUTRON ENERGY, MeV

^{234}U FISSION CROSS SECTION

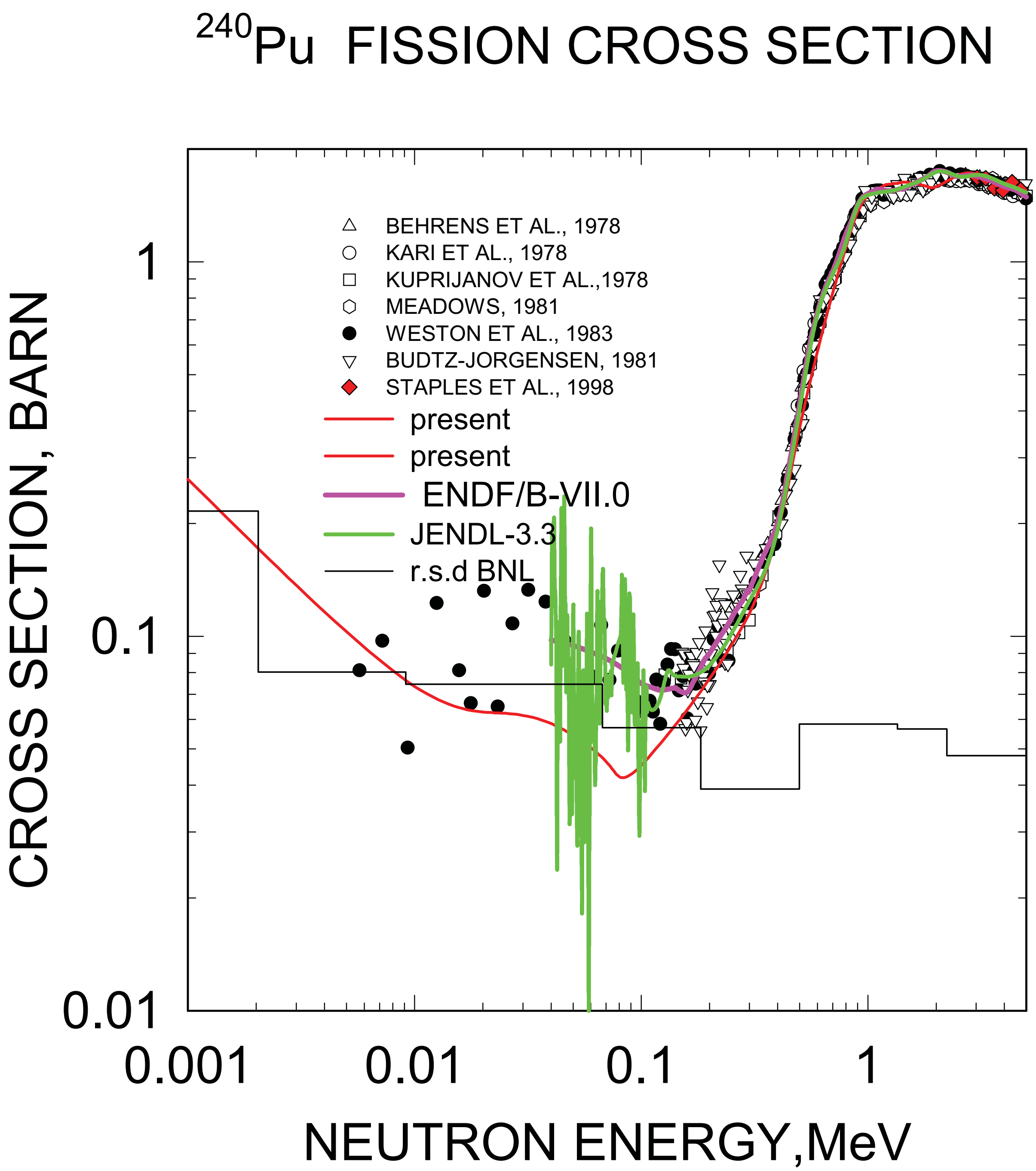


^{238}PU FISSION CROSS SECTION

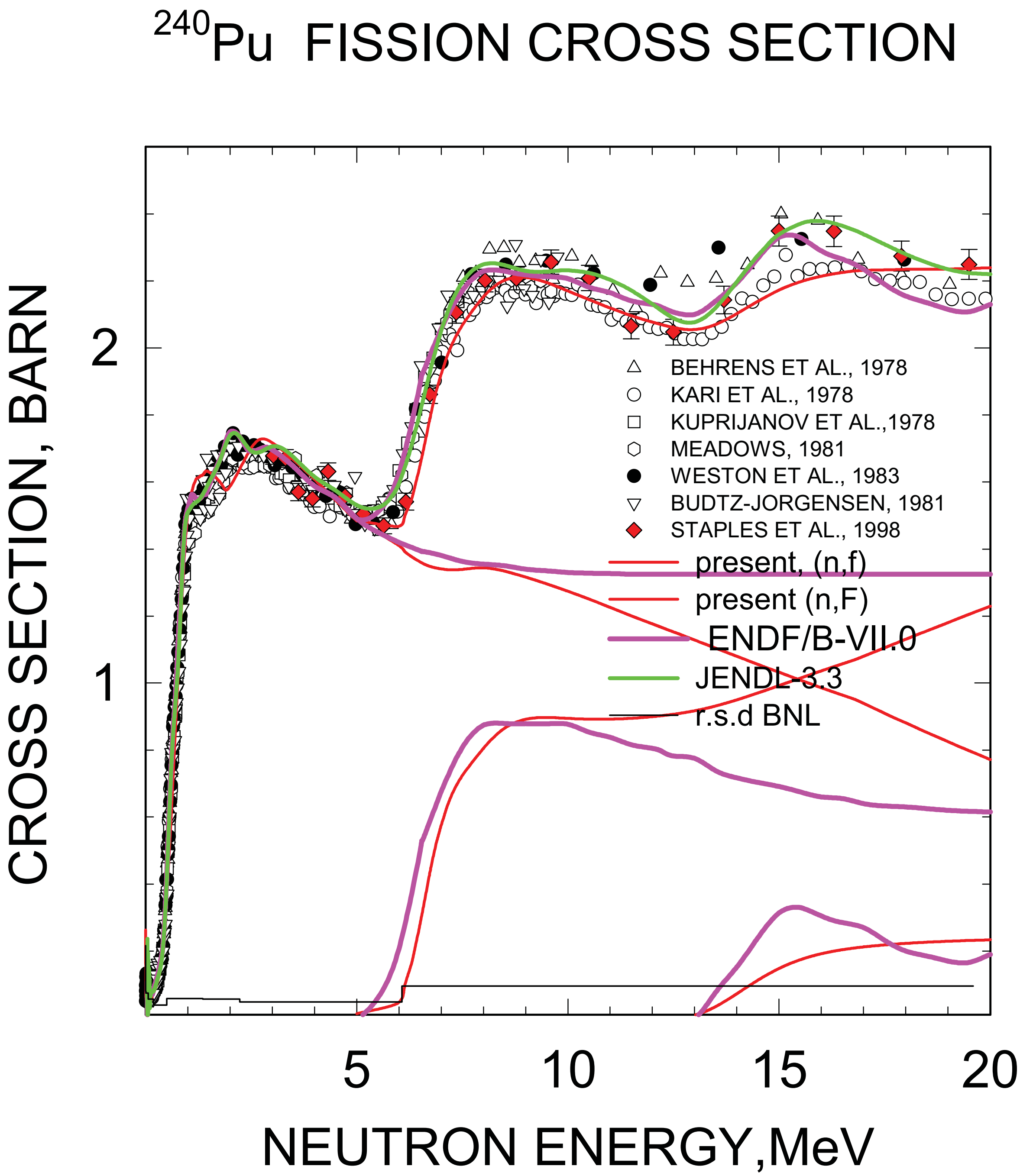




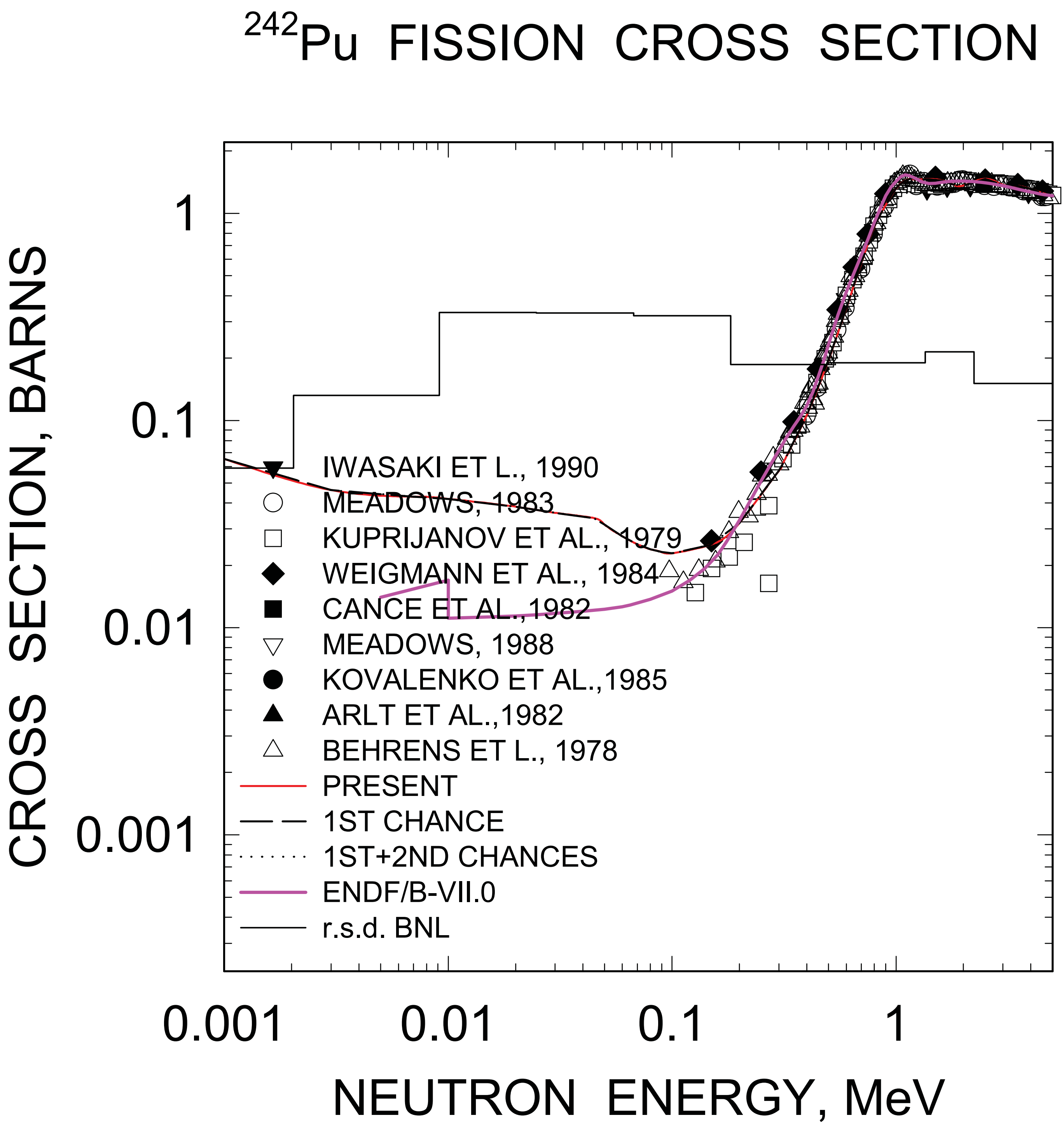
^{238}Pu FISSION CROSS SECTION
σ(n,F), barn
E$_n$, MeV
0
1
2
3
10
20
JENDL - 3
ENDF/B-VII.0
JEF-2
PRESENT
Fursov et al., 1997
Alam et al.,1986
r.s.d. present
r.s.d. BNL



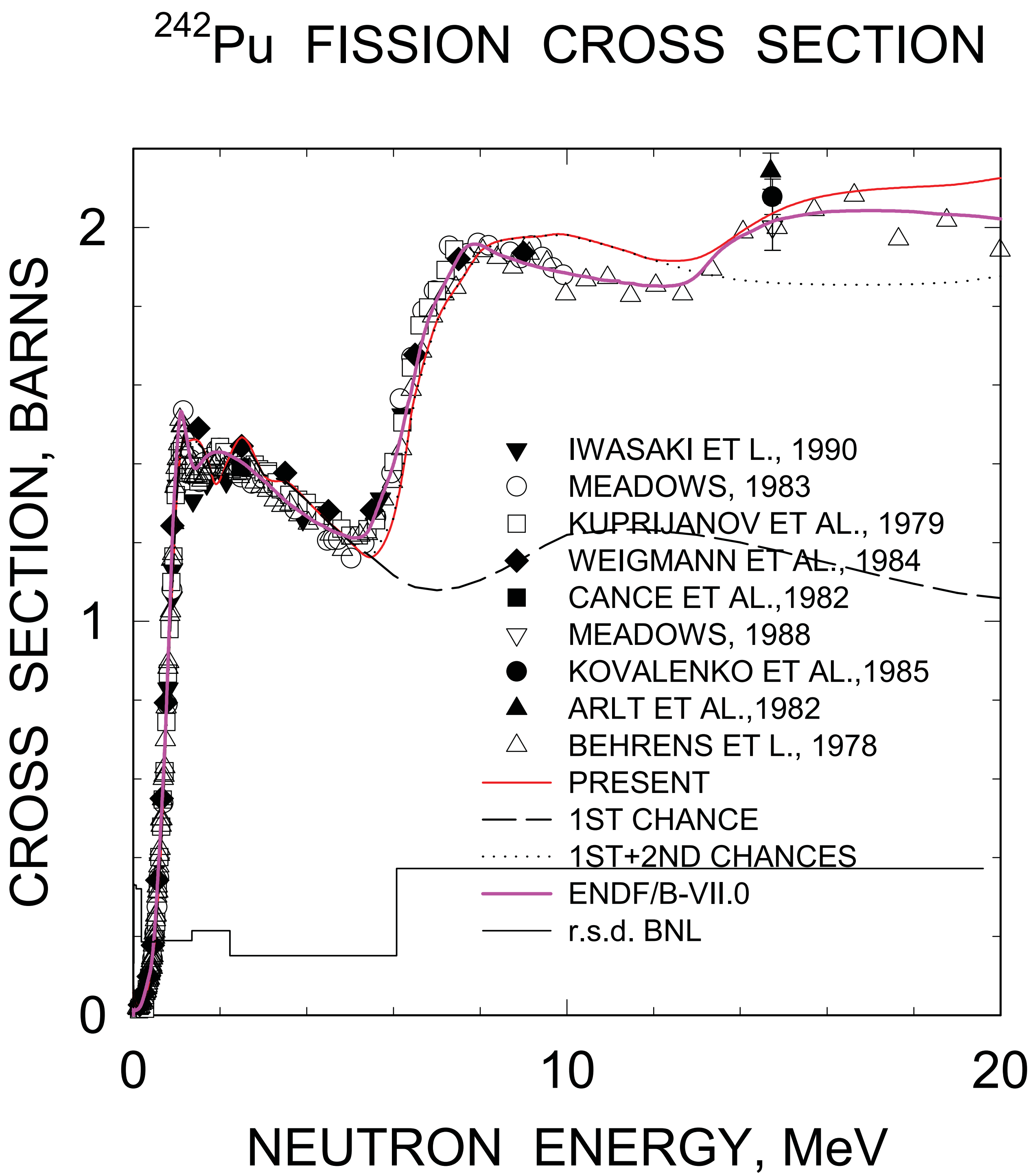
^{240}Pu FISSION CROSS SECTION
BEHRENS ET AL., 1978
KARI ET AL., 1978
KUPRIJANOV ET AL.,1978
MEADOWS, 1981
WESTON ET AL., 1983
BUDTZ-JORGENSEN, 1981
STAPLES ET AL., 1998
present
present
ENDF/B-VII.0
JENDL-3.3
r.s.d BNL
1
0.1
0.01
0.001
0.01
0.1
1
CROSS SECTION, BARN
NEUTRON ENERGY,MeV



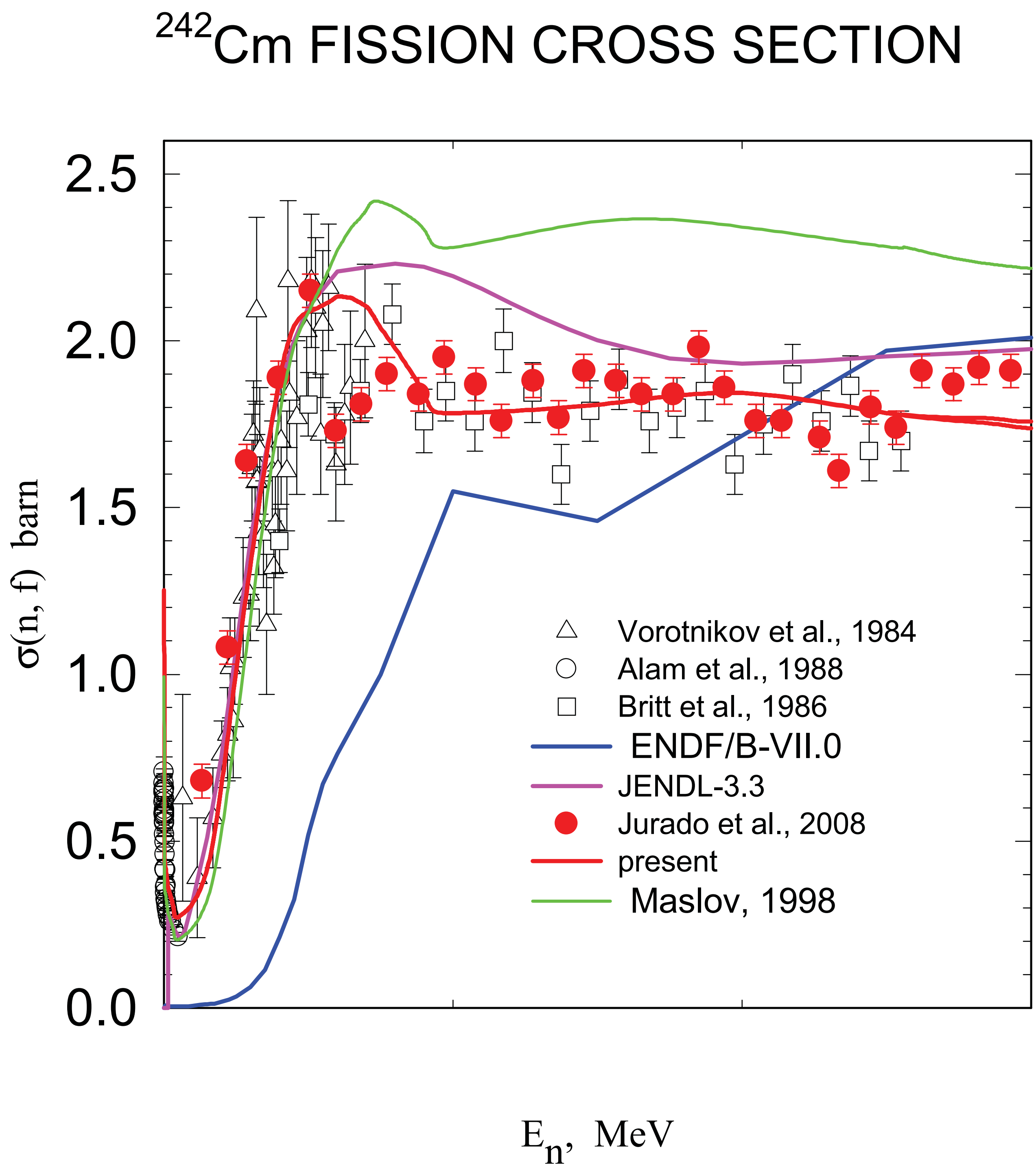
^{240}Pu FISSION CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY,MeV
1
2
5
10
15
20
BEHRENS ET AL., 1978
KARI ET AL., 1978
KUPRIJANOV ET AL.,1978
MEADOWS, 1981
WESTON ET AL., 1983
BUDTZ-JORGENSEN, 1981
STAPLES ET AL., 1998
present, (n,f)
present (n,F)
ENDF/B-VII.0
JENDL-3.3
r.s.d BNL



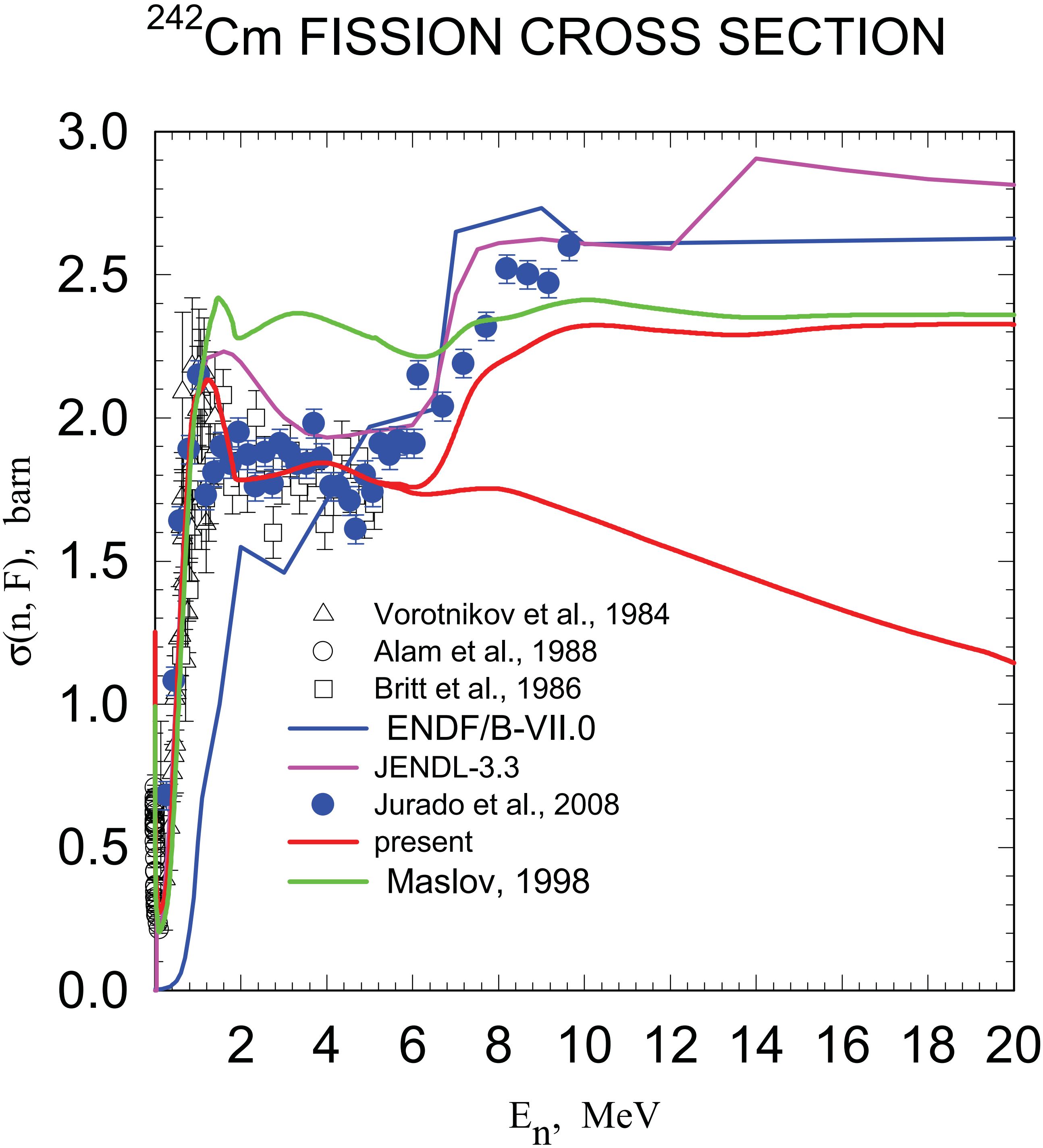
^{242}Pu FISSION CROSS SECTION
CROSS SECTION, BARNS
NEUTRON ENERGY, MeV
1
0.1
0.01
0.001
0.001
0.01
0.1
1
IWASAKI ET L., 1990
MEADOWS, 1983
KUPRIJANOV ET AL., 1979
WEIGMANN ET AL., 1984
CANCE ET AL.,1982
MEADOWS, 1988
KOVALENKO ET AL.,1985
ARLT ET AL.,1982
BEHRENS ET L., 1978
PRESENT
1ST CHANCE
1ST+2ND CHANCES
ENDF/B-VII.0
r.s.d. BNL



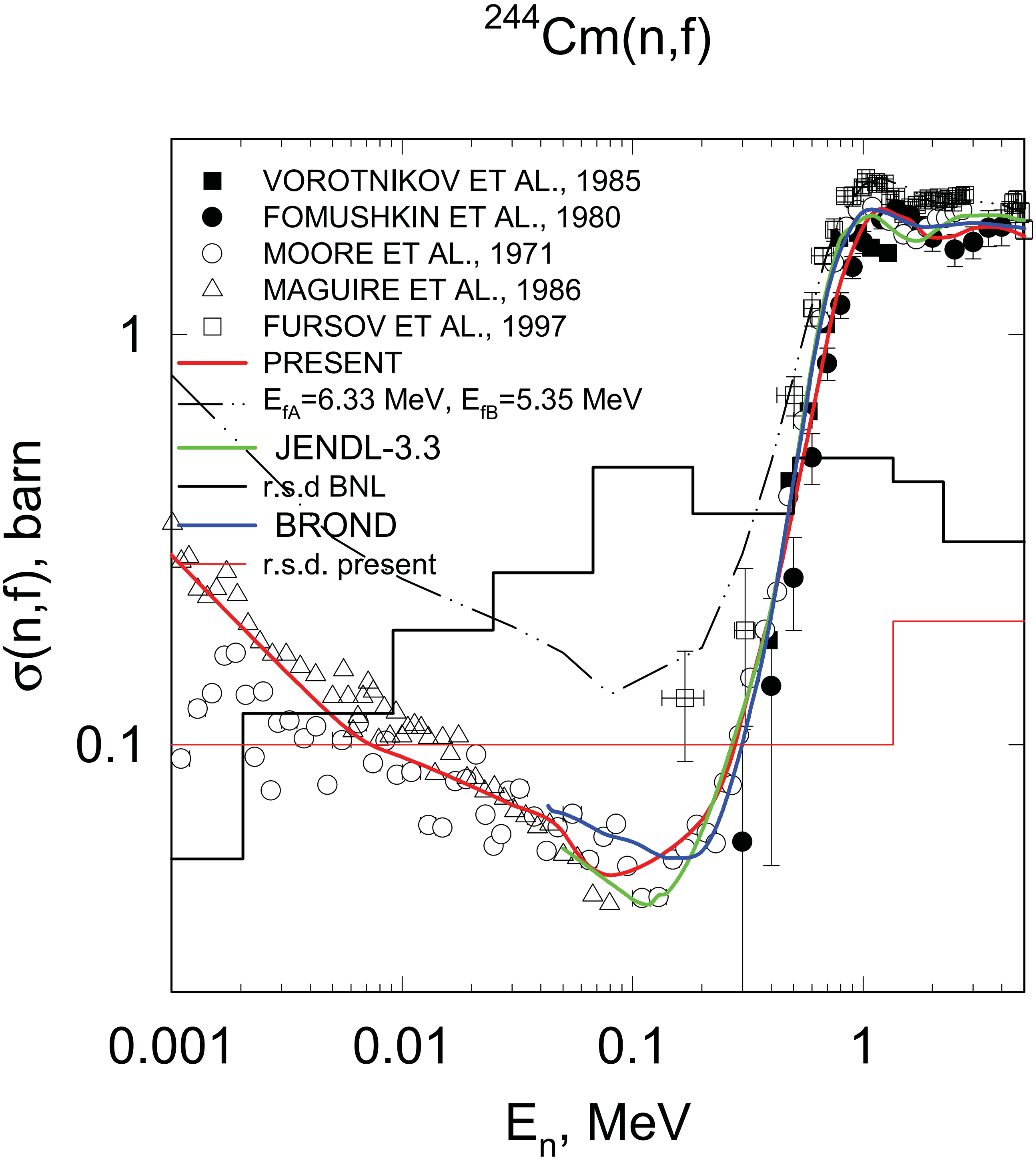
^{242}Pu FISSION CROSS SECTION
CROSS SECTION, BARNS
NEUTRON ENERGY, MeV
0
1
2
0
10
20
IWASAKI ET L., 1990
MEADOWS, 1983
KUPRIJANOV ET AL., 1979
WEIGMANN ET AL., 1984
CANCE ET AL.,1982
MEADOWS, 1988
KOVALENKO ET AL.,1985
ARLT ET AL.,1982
BEHRENS ET L., 1978
PRESENT
1ST CHANCE
1ST+2ND CHANCES
ENDF/B-VII.0
r.s.d. BNL



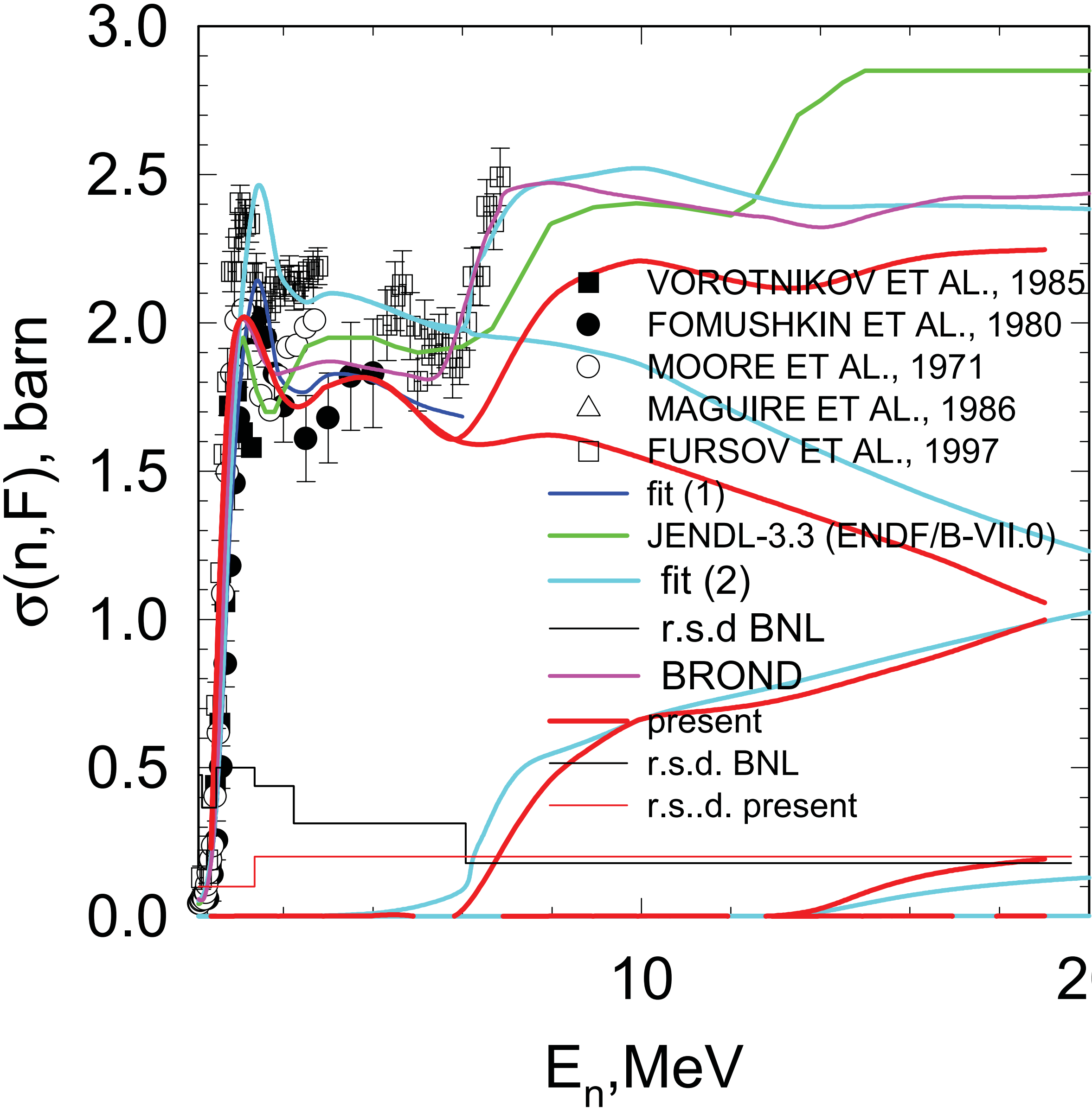
^{242}Cm FISSION CROSS SECTION
2.5
2.0
1.5
1.0
0.5
0.0
σ(n, f) barn
E_n, MeV
Vorotnikov et al., 1984
Alam et al., 1988
Britt et al., 1986
ENDF/B-VII.0
JENDL-3.3
Jurado et al., 2008
present
Maslov, 1998

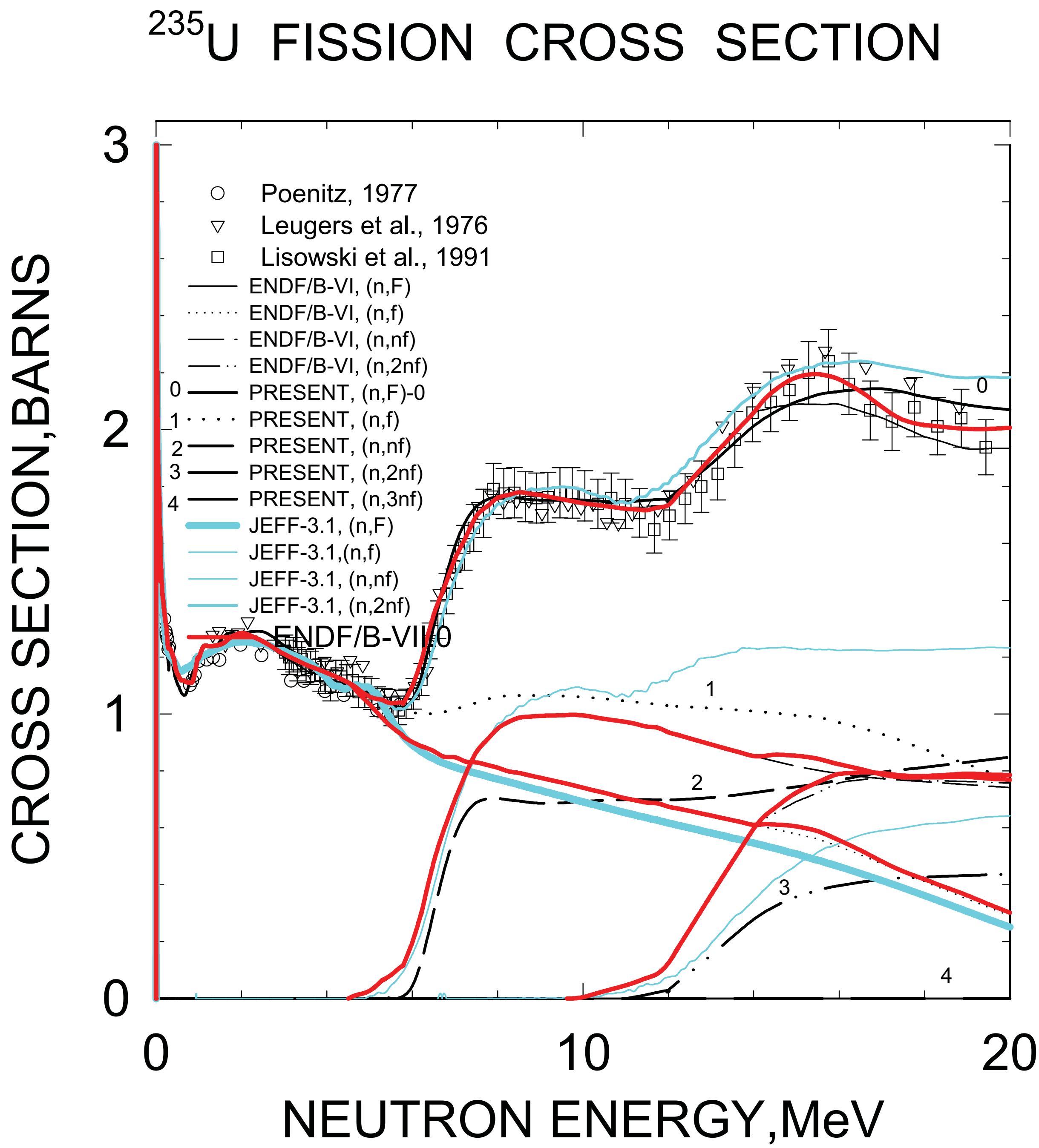


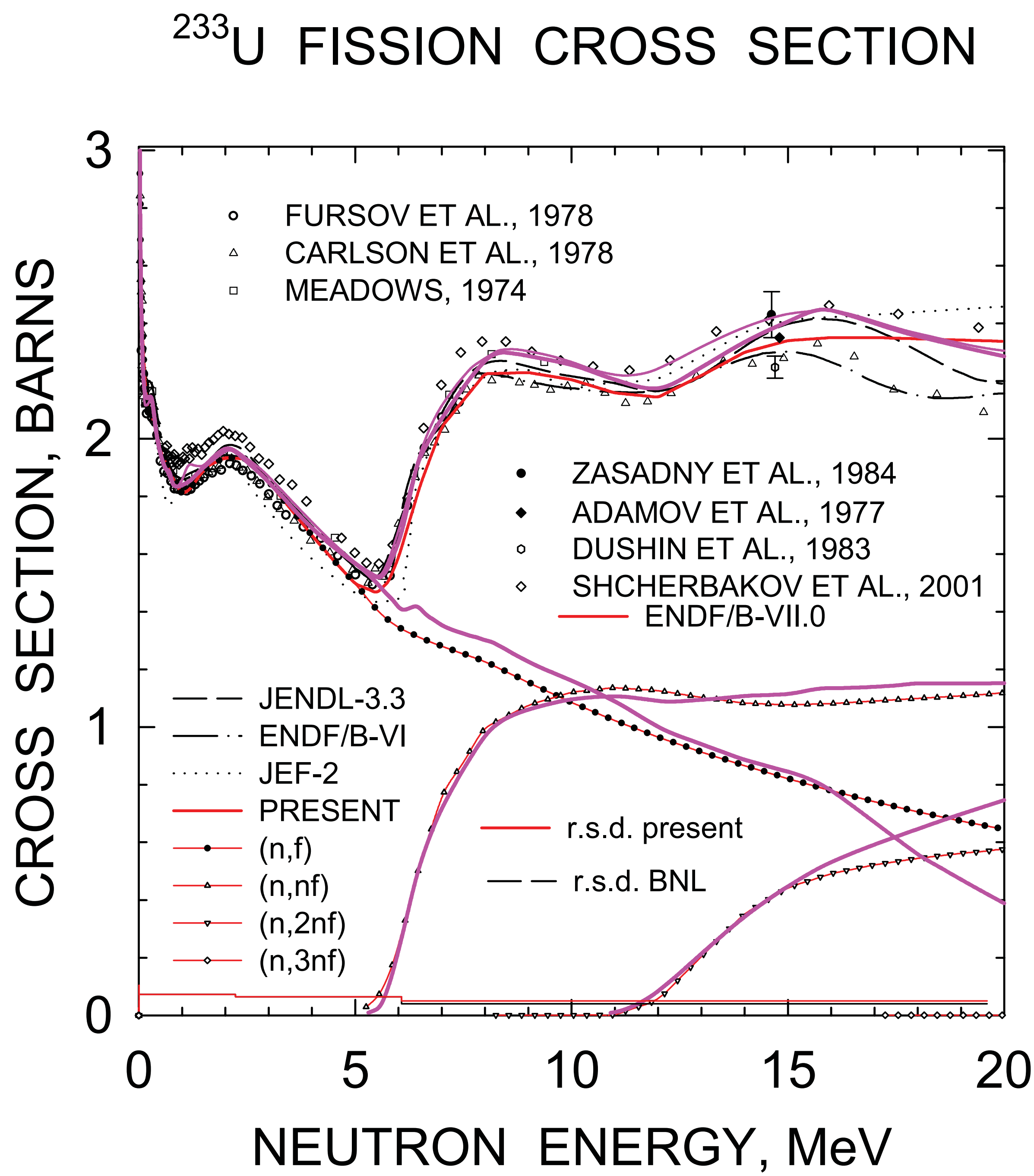
^{242}Cm FISSION CROSS SECTION
σ(n, F), barn
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2
4
6
8
10
12
14
16
18
20
E_n, MeV
Vorotnikov et al., 1984
Alam et al., 1988
Britt et al., 1986
ENDF/B-VII.0
JENDL-3.3
Jurado et al., 2008
present
Maslov, 1998


^{244}Cm(n,f)
VOROTNIKOV ET AL., 1985
FOMUSHKIN ET AL., 1980
MOORE ET AL., 1971
MAGUIRE ET AL., 1986
FURSOV ET AL., 1997
PRESENT
E_{fA}=6.33 MeV, E_{fB}=5.35 MeV
JENDL-3.3
r.s.d BNL
BROND
r.s.d. present
σ(n,f), barn
E_n, MeV
1
0.1
0.001
0.01
0.1
1

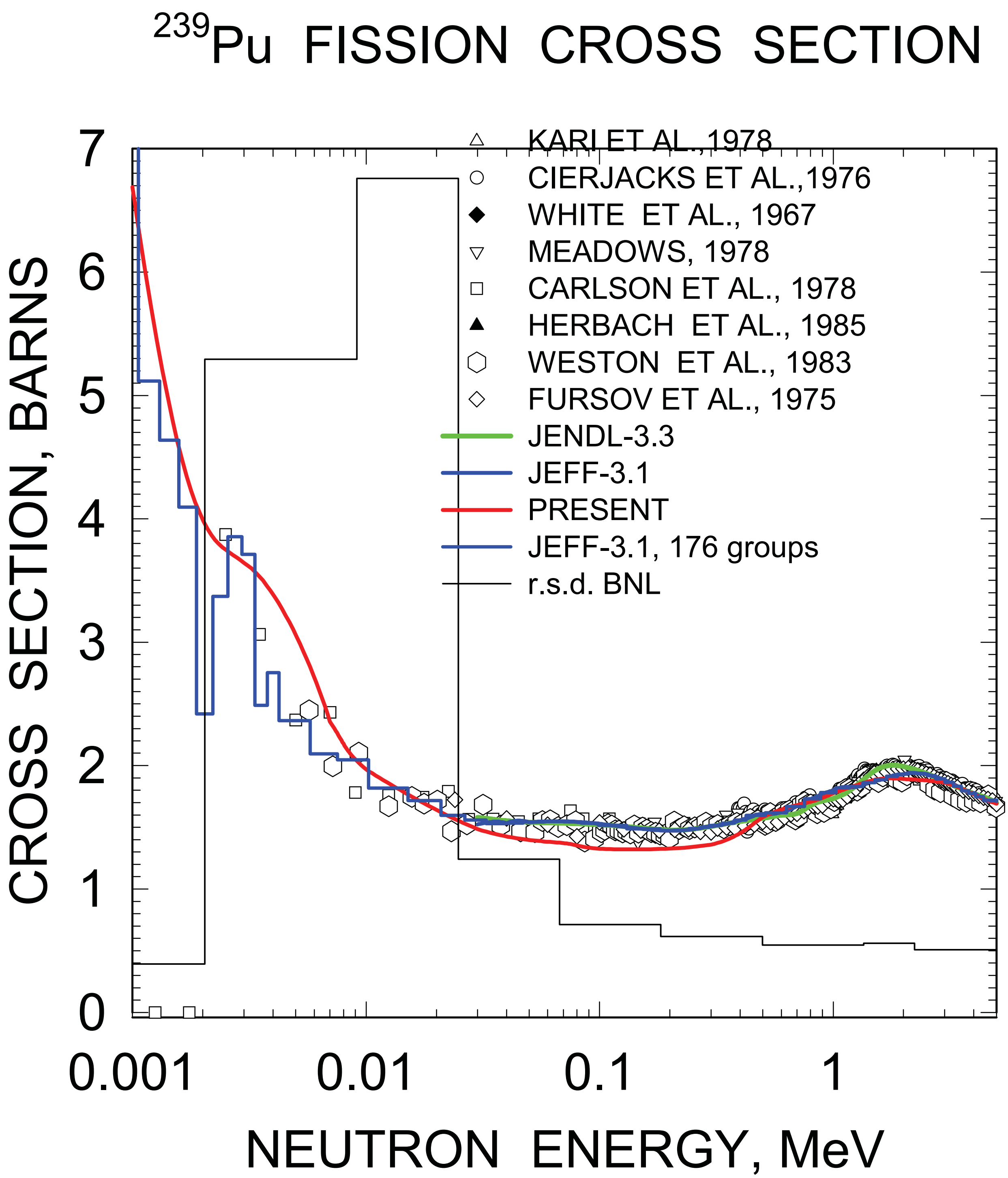
^{244}Cm FISSION CROSS SECTION



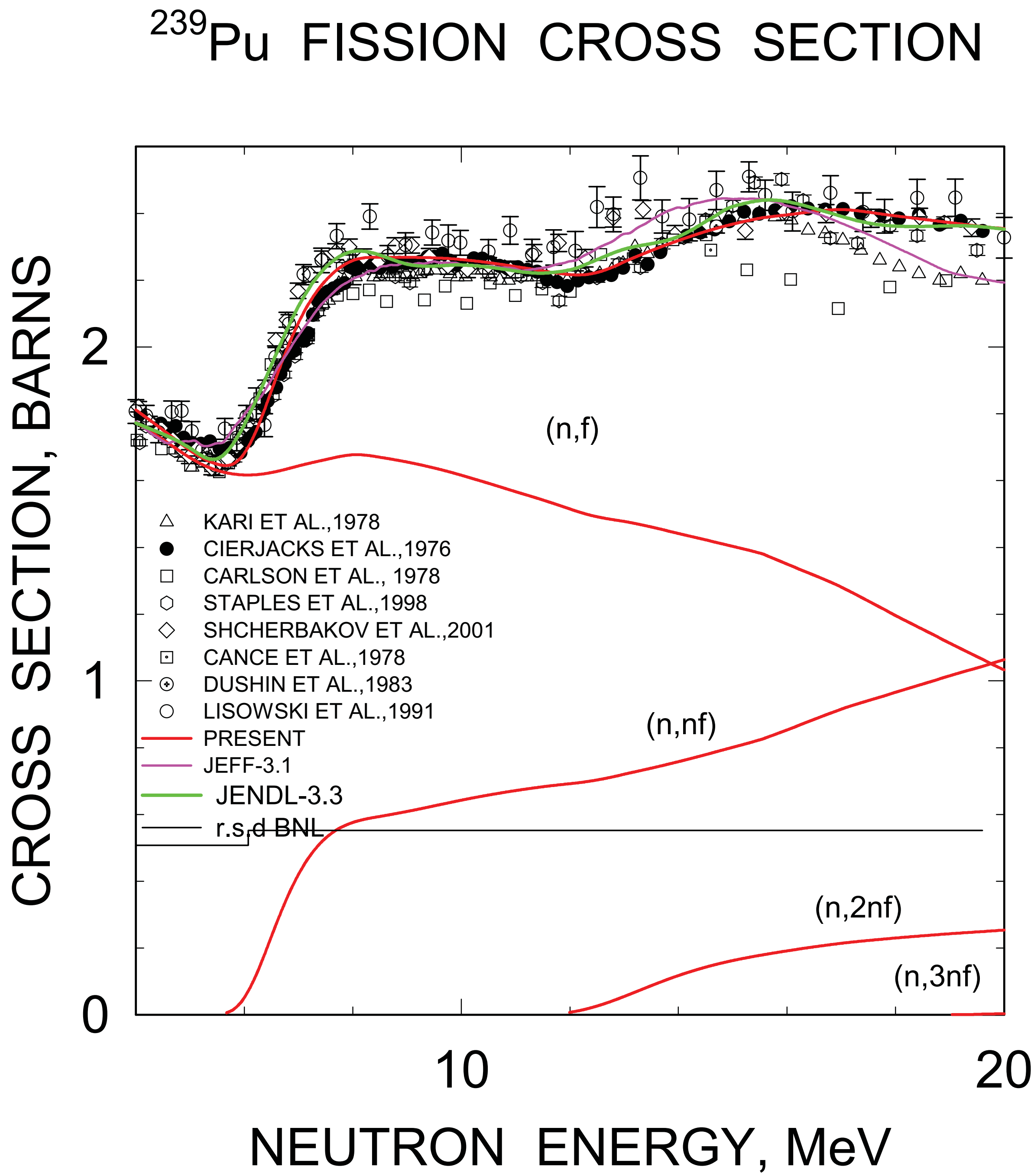

^{235}U FISSION CROSS SECTION
Poenitz, 1977
Leugers et al., 1976
Lisowski et al., 1991
ENDF/B-VI, (n,F)
ENDF/B-VI, (n,f)
ENDF/B-VI, (n,nf)
ENDF/B-VI, (n,2nf)
0 PRESENT, (n,F)-0
1 PRESENT, (n,f)
2 PRESENT, (n,nf)
3 PRESENT, (n,2nf)
4 PRESENT, (n,3nf)
JEFF-3.1, (n,F)
JEFF-3.1,(n,f)
JEFF-3.1, (n,nf)
JEFF-3.1, (n,2nf)
ENDF/B-VII.0
CROSS SECTION,BARNS
NEUTRON ENERGY,MeV



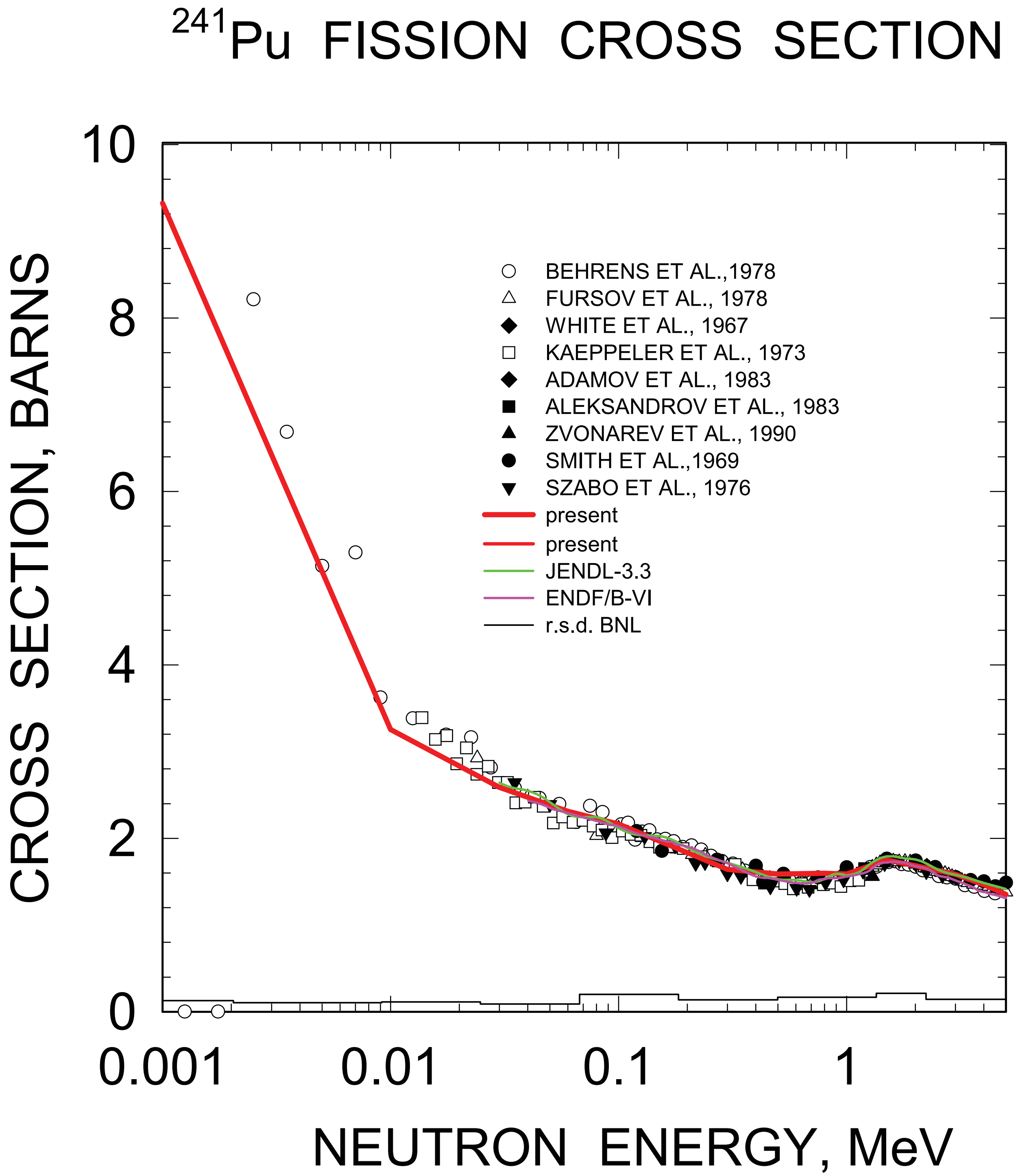
^{233}U FISSION CROSS SECTION
FURSOV ET AL., 1978
CARLSON ET AL., 1978
MEADOWS, 1974
ZASADNY ET AL., 1984
ADAMOV ET AL., 1977
DUSHIN ET AL., 1983
SHCHERBAKOV ET AL., 2001
ENDF/B-VII.0
JENDL-3.3
ENDF/B-VI
JEF-2
PRESENT
(n,f)
(n,nf)
(n,2nf)
(n,3nf)
r.s.d. present
r.s.d. BNL
CROSS SECTION, BARNS
NEUTRON ENERGY, MeV
0
1
2
3
0
5
10
15
20



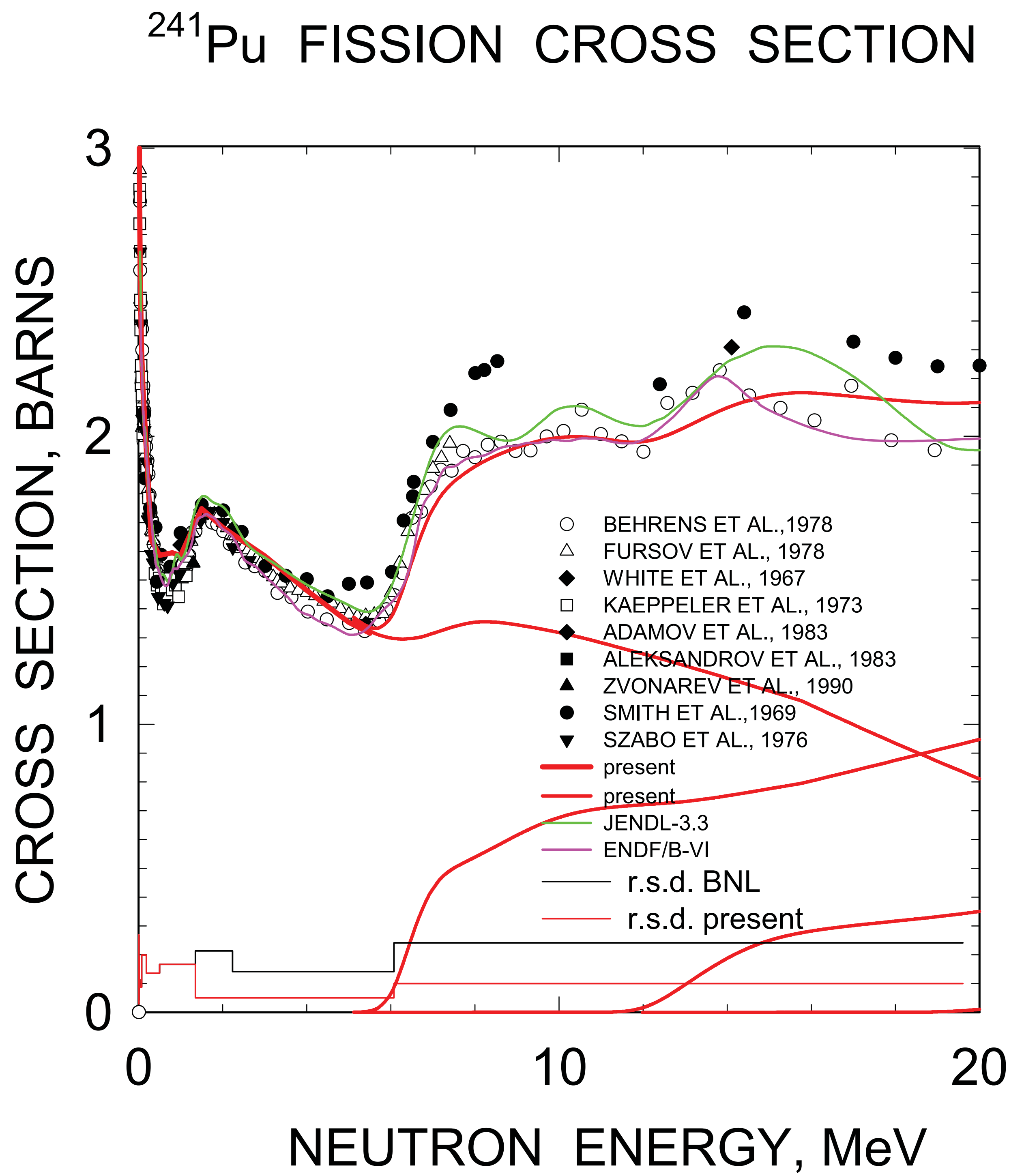
239Pu FISSION CROSS SECTION
KARI ET AL.,1978
CIERJACKS ET AL.,1976
WHITE ET AL., 1967
MEADOWS, 1978
CARLSON ET AL., 1978
HERBACH ET AL., 1985
WESTON ET AL., 1983
FURSOV ET AL., 1975
JENDL-3.3
JEFF-3.1
PRESENT
JEFF-3.1, 176 groups
r.s.d. BNL
CROSS SECTION, BARNS
0
1
2
3
4
5
6
7
0.001
0.01
0.1
1
NEUTRON ENERGY, MeV



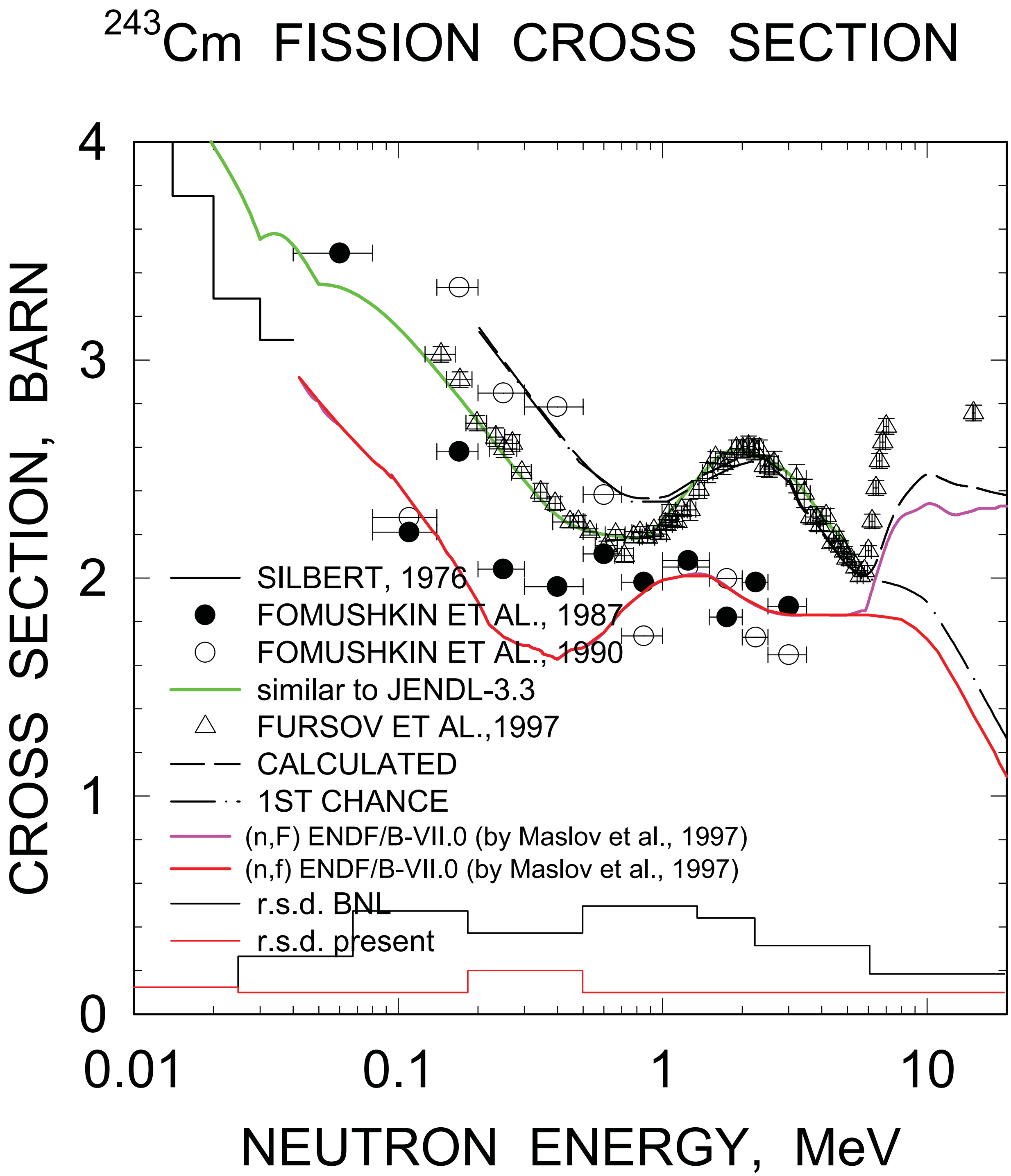
239Pu FISSION CROSS SECTION
CROSS SECTION, BARNS
NEUTRON ENERGY, MeV
0
1
2
10
20
(n,f)
(n,nf)
(n,2nf)
(n,3nf)
KARI ET AL.,1978
CIERJACKS ET AL.,1976
CARLSON ET AL., 1978
STAPLES ET AL.,1998
SHCHERBAKOV ET AL.,2001
CANCE ET AL.,1978
DUSHIN ET AL.,1983
LISOWSKI ET AL.,1991
PRESENT
JEFF-3.1
JENDL-3.3
r.s.d BNL



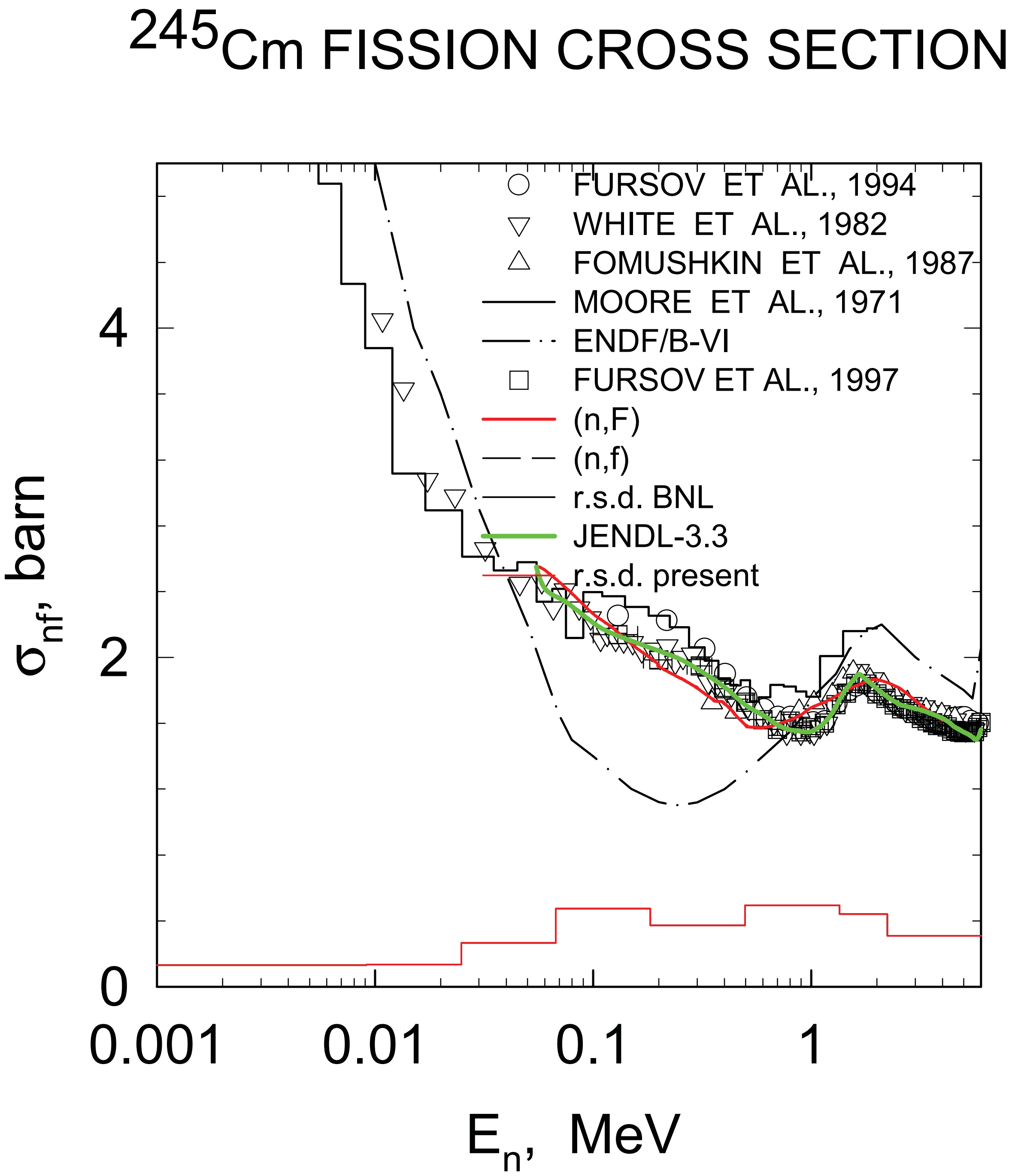
241Pu FISSION CROSS SECTION
CROSS SECTION, BARNS
NEUTRON ENERGY, MeV
0
2
4
6
8
10
0.001
0.01
0.1
1
BEHRENS ET AL.,1978
FURSOV ET AL., 1978
WHITE ET AL., 1967
KAEPPELER ET AL., 1973
ADAMOV ET AL., 1983
ALEKSANDROV ET AL., 1983
ZVONAREV ET AL., 1990
SMITH ET AL.,1969
SZABO ET AL., 1976
present
present
JENDL-3.3
ENDF/B-VI
r.s.d. BNL



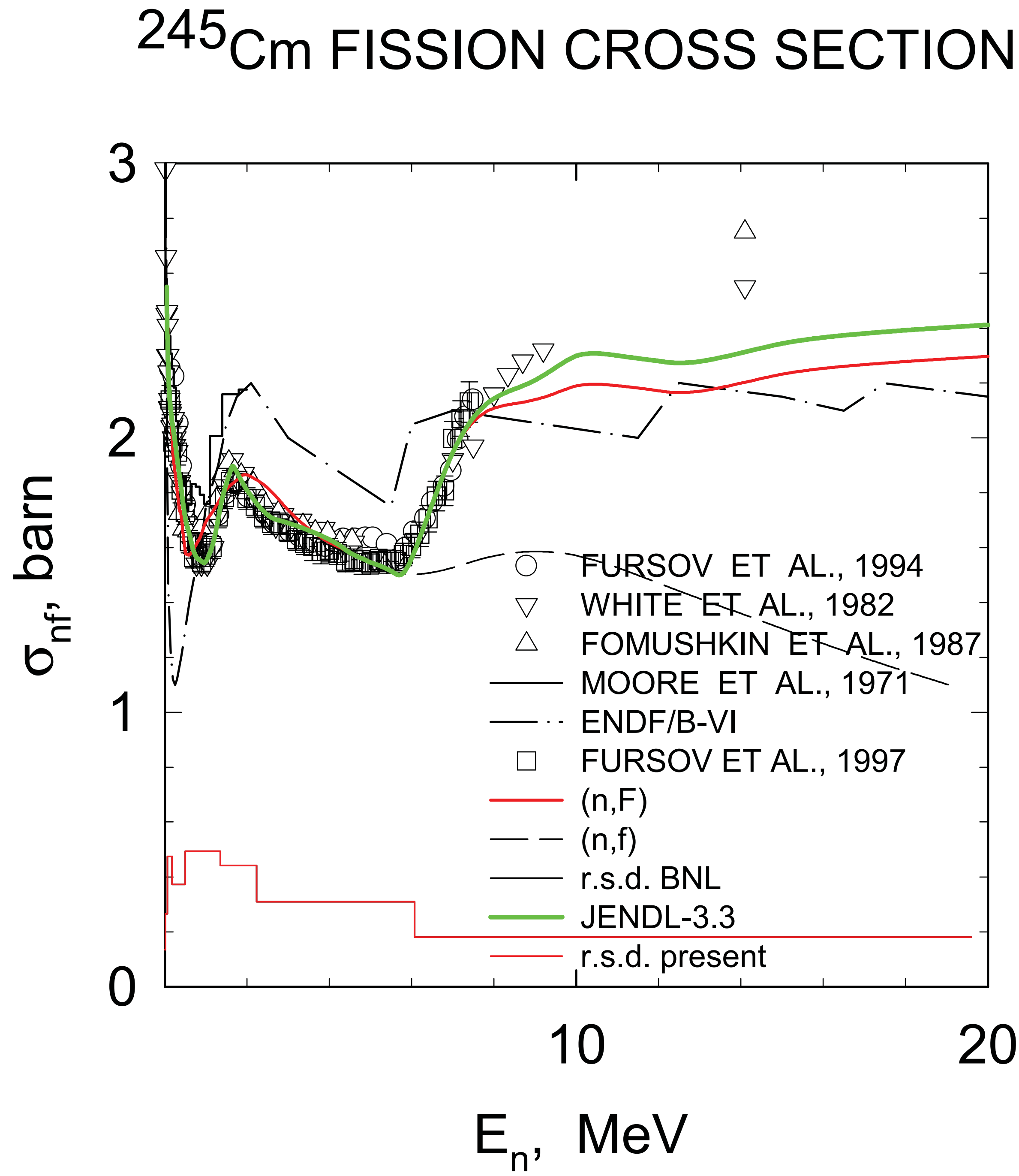
^{241}Pu FISSION CROSS SECTION
CROSS SECTION, BARNS
NEUTRON ENERGY, MeV
0
1
2
3
0
10
20
BEHRENS ET AL.,1978
FURSOV ET AL., 1978
WHITE ET AL., 1967
KAEPPELER ET AL., 1973
ADAMOV ET AL., 1983
ALEKSANDROV ET AL., 1983
ZVONAREV ET AL., 1990
SMITH ET AL.,1969
SZABO ET AL., 1976
present
present
JENDL-3.3
ENDF/B-VI
r.s.d. BNL
r.s.d. present



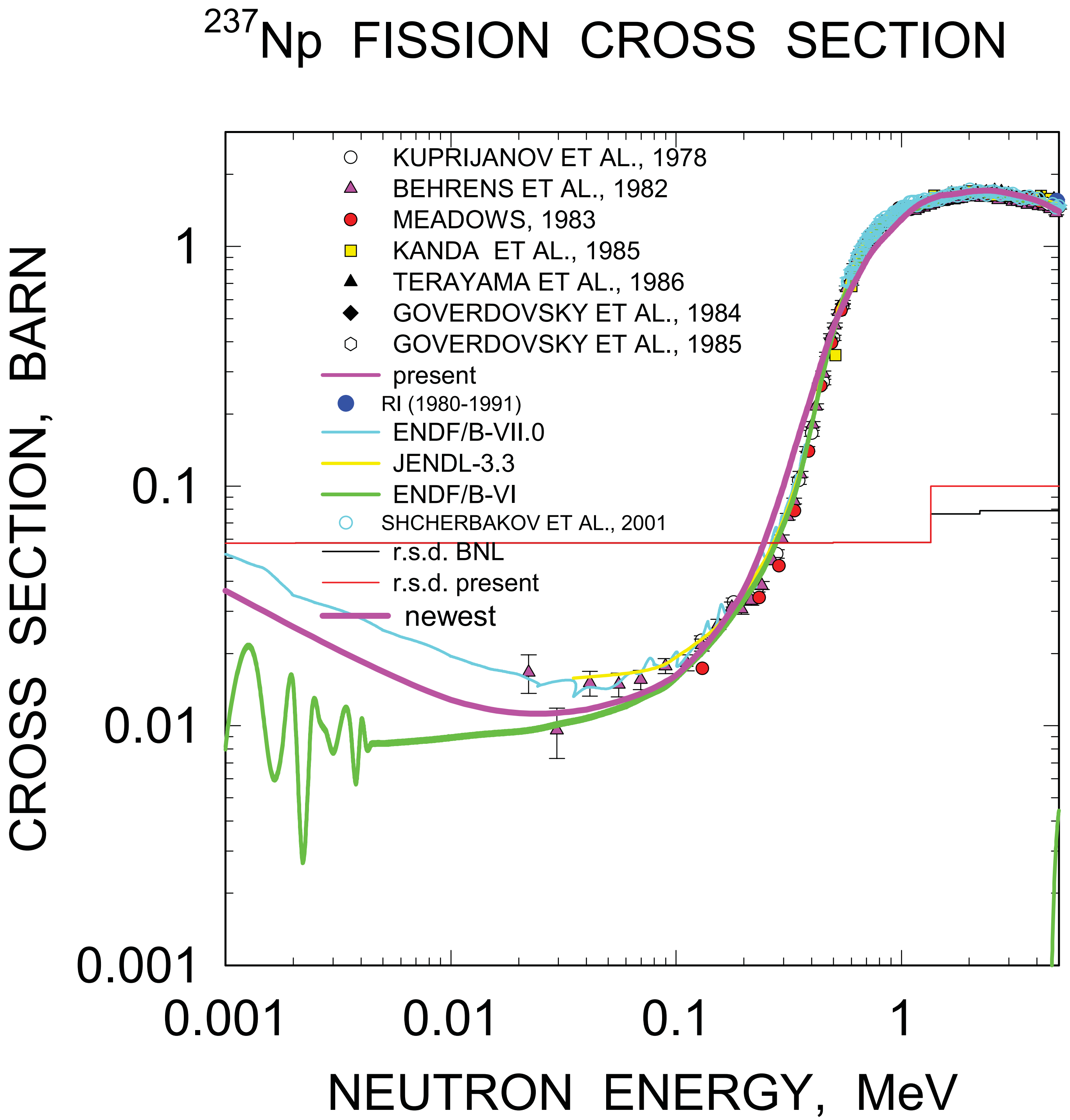
^{243}Cm FISSION CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0
1
2
3
4
0.01
0.1
1
10
SILBERT, 1976
FOMUSHKIN ET AL., 1987
FOMUSHKIN ET AL., 1990
similar to JENDL-3.3
FURSOV ET AL.,1997
CALCULATED
1ST CHANCE
(n,F) ENDF/B-VII.0 (by Maslov et al., 1997)
(n,f) ENDF/B-VII.0 (by Maslov et al., 1997)
r.s.d. BNL
r.s.d. present



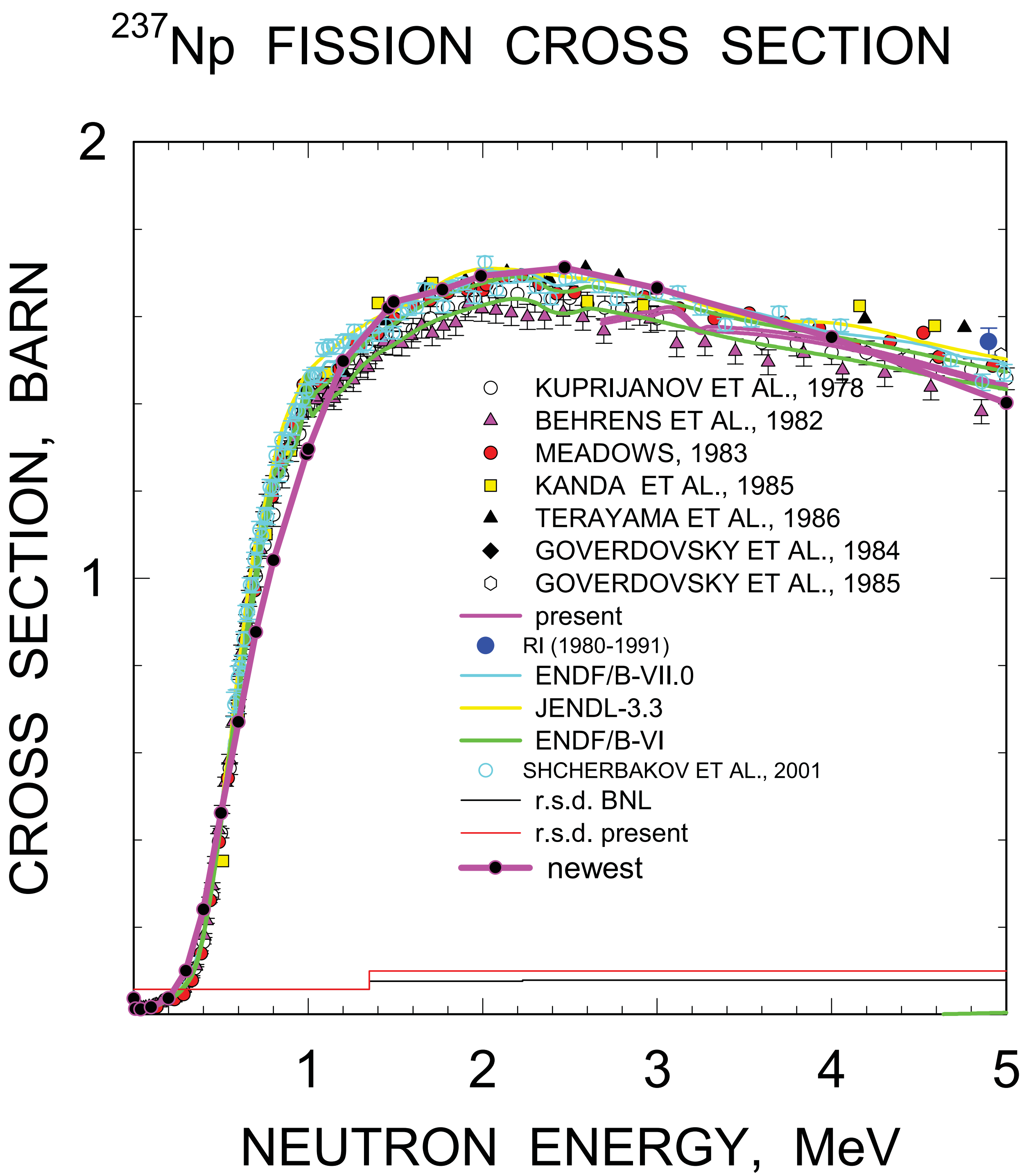
245Cm FISSION CROSS SECTION
FURSOV ET AL., 1994
WHITE ET AL., 1982
FOMUSHKIN ET AL., 1987
MOORE ET AL., 1971
ENDF/B-VI
FURSOV ET AL., 1997
(n,F)
(n,f)
r.s.d. BNL
JENDL-3.3
r.s.d. present
σnf, barn
0
2
4
0.001
0.01
0.1
1
En, MeV



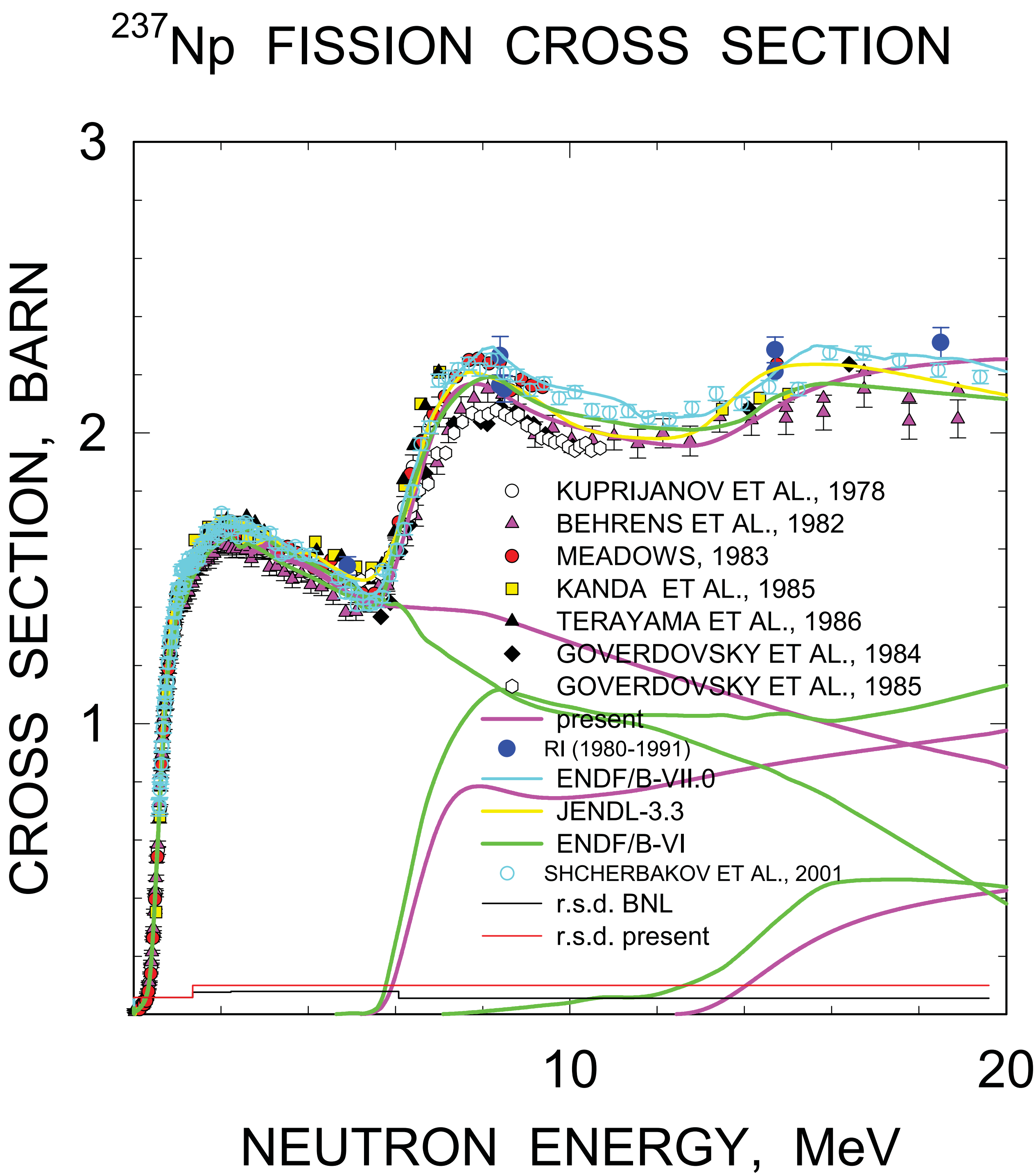
245Cm FISSION CROSS SECTION
3
2
1
0
10
20
σnf, barn
En, MeV
FURSOV ET AL., 1994
WHITE ET AL., 1982
FOMUSHKIN ET AL., 1987
MOORE ET AL., 1971
ENDF/B-VI
FURSOV ET AL., 1997
(n,F)
(n,f)
r.s.d. BNL
JENDL-3.3
r.s.d. present



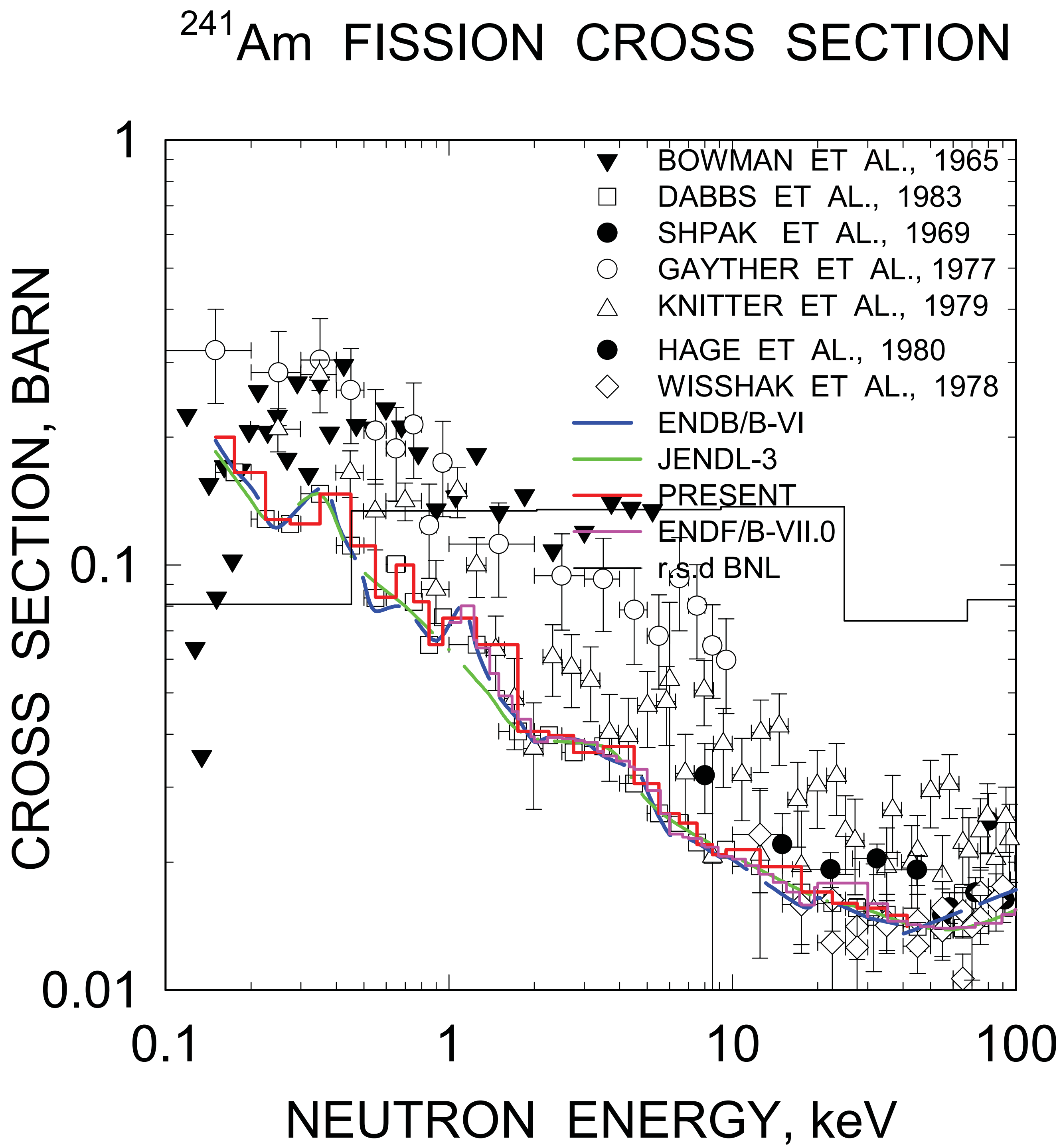
^{237}Np FISSION CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0.001
0.01
0.1
1
KUPRIJANOV ET AL., 1978
BEHRENS ET AL., 1982
MEADOWS, 1983
KANDA ET AL., 1985
TERAYAMA ET AL., 1986
GOVERDOVSKY ET AL., 1984
GOVERDOVSKY ET AL., 1985
present
RI (1980-1991)
ENDF/B-VII.0
JENDL-3.3
ENDF/B-VI
SHCHERBAKOV ET AL., 2001
r.s.d. BNL
r.s.d. present
newest



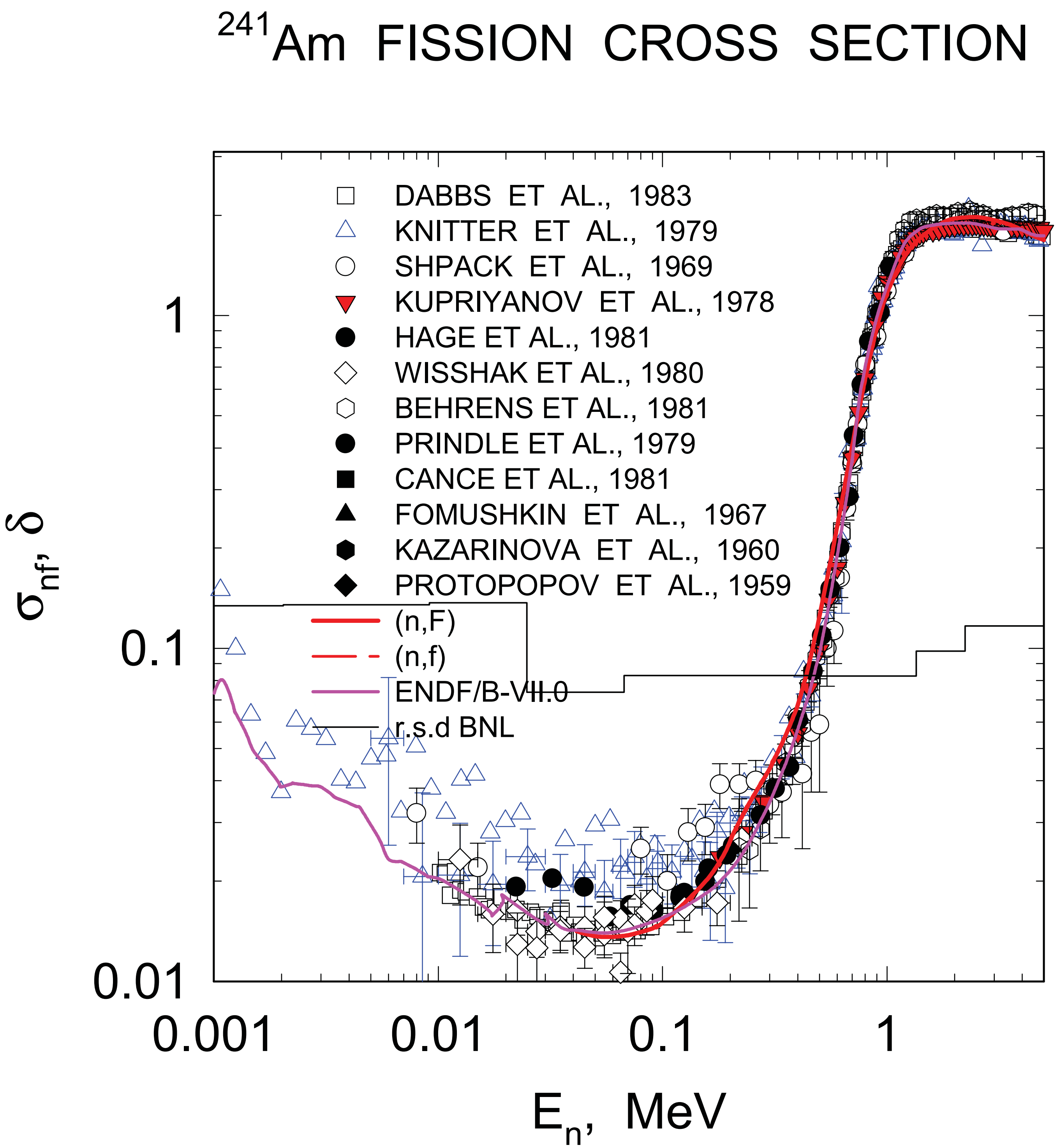
^{237}Np FISSION CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
2
1
1
2
3
4
5
KUPRIJANOV ET AL., 1978
BEHRENS ET AL., 1982
MEADOWS, 1983
KANDA ET AL., 1985
TERAYAMA ET AL., 1986
GOVERDOVSKY ET AL., 1984
GOVERDOVSKY ET AL., 1985
present
RI (1980-1991)
ENDF/B-VII.0
JENDL-3.3
ENDF/B-VI
SHCHERBAKOV ET AL., 2001
r.s.d. BNL
r.s.d. present
newest



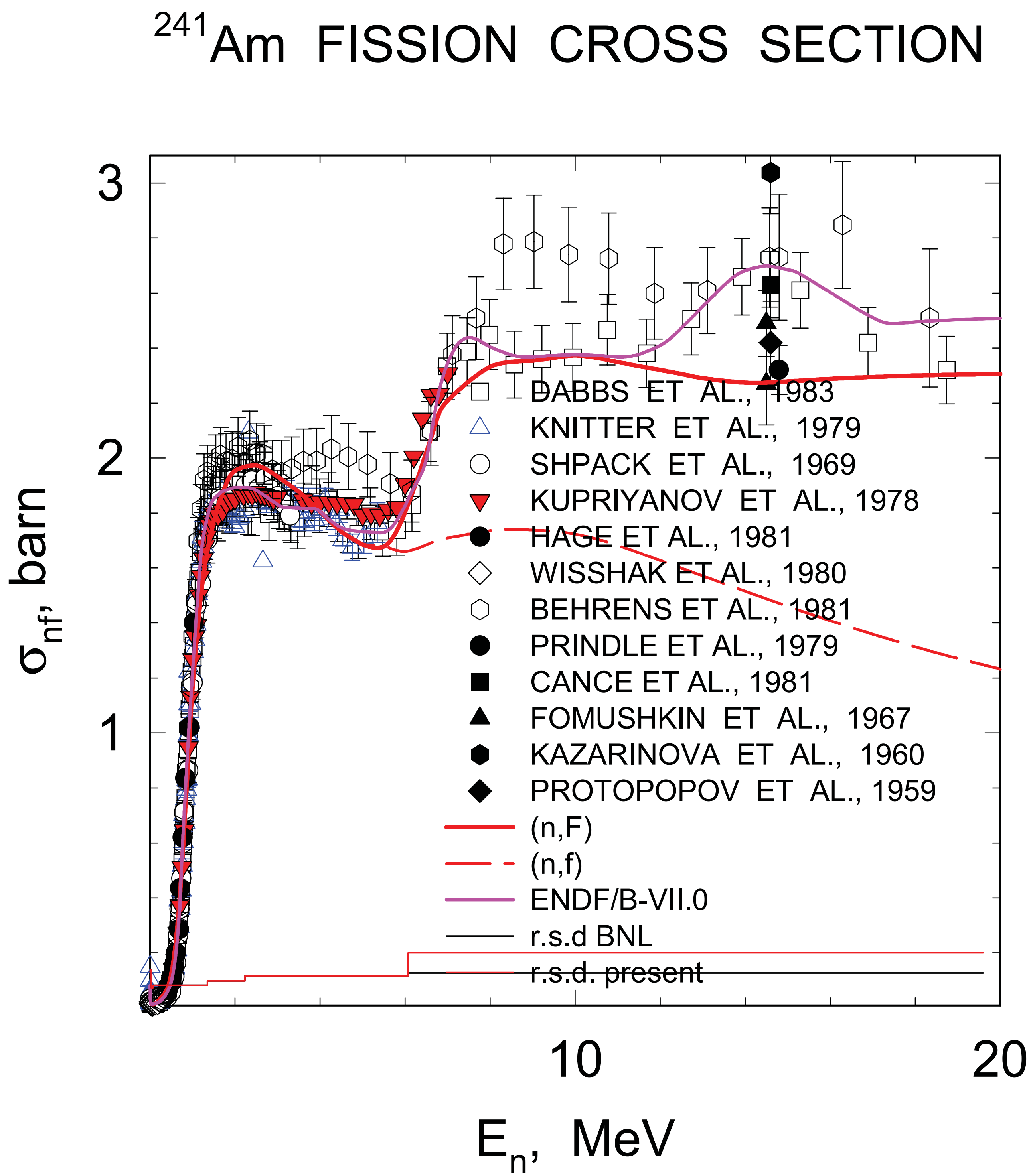
^{237}Np FISSION CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
3
2
1
10
20
KUPRIJANOV ET AL., 1978
BEHRENS ET AL., 1982
MEADOWS, 1983
KANDA ET AL., 1985
TERAYAMA ET AL., 1986
GOVERDOVSKY ET AL., 1984
GOVERDOVSKY ET AL., 1985
present
RI (1980-1991)
ENDF/B-VII.0
JENDL-3.3
ENDF/B-VI
SHCHERBAKOV ET AL., 2001
r.s.d. BNL
r.s.d. present

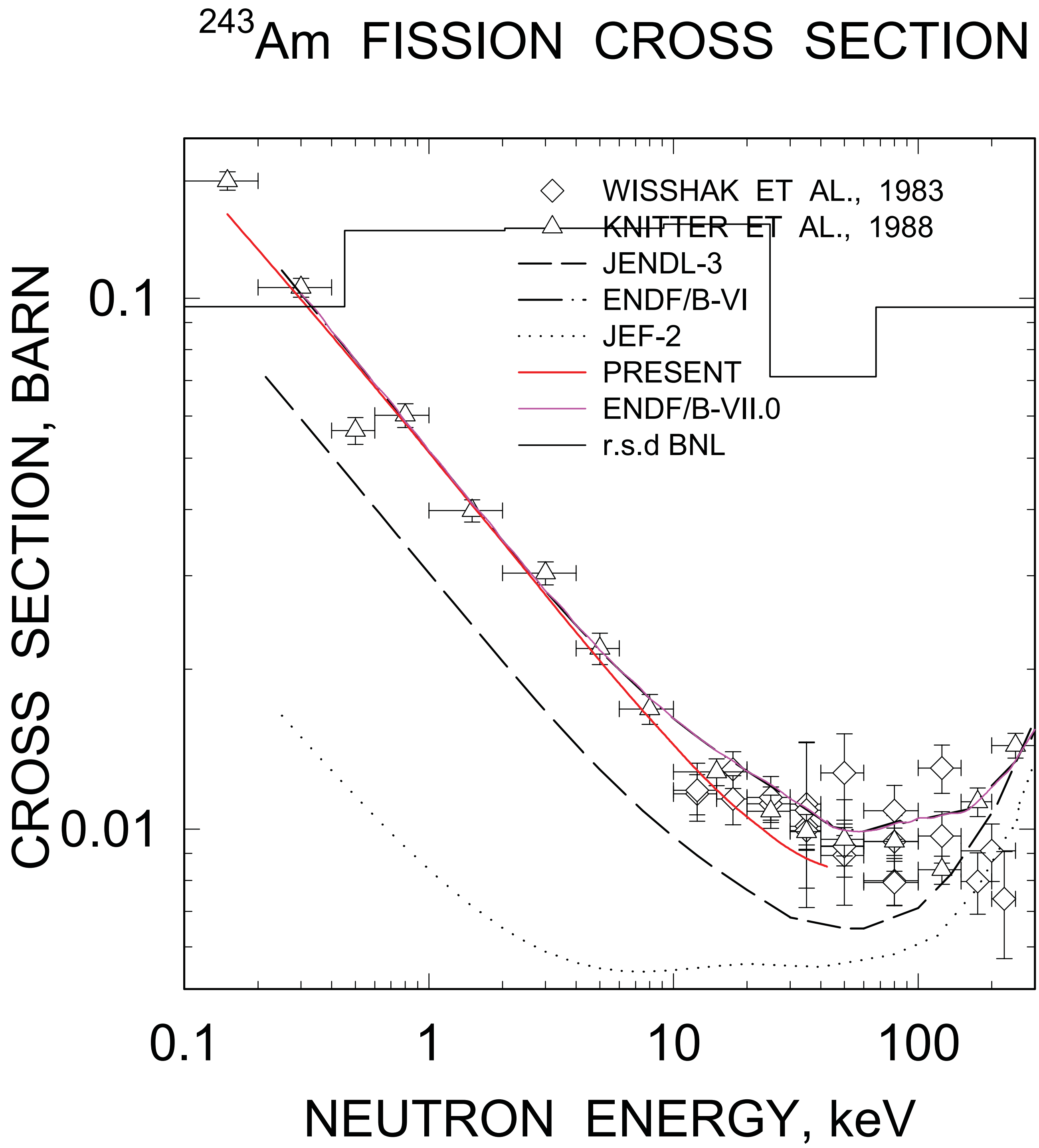


^{241}Am FISSION CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, keV
1
0.1
0.01
0.1
1
10
100
BOWMAN ET AL., 1965
DABBS ET AL., 1983
SHPAK ET AL., 1969
GAYTHER ET AL., 1977
KNITTER ET AL., 1979
HAGE ET AL., 1980
WISSHAK ET AL., 1978
ENDB/B-VI
JENDL-3
PRESENT
ENDF/B-VII.0
r.s.d BNL

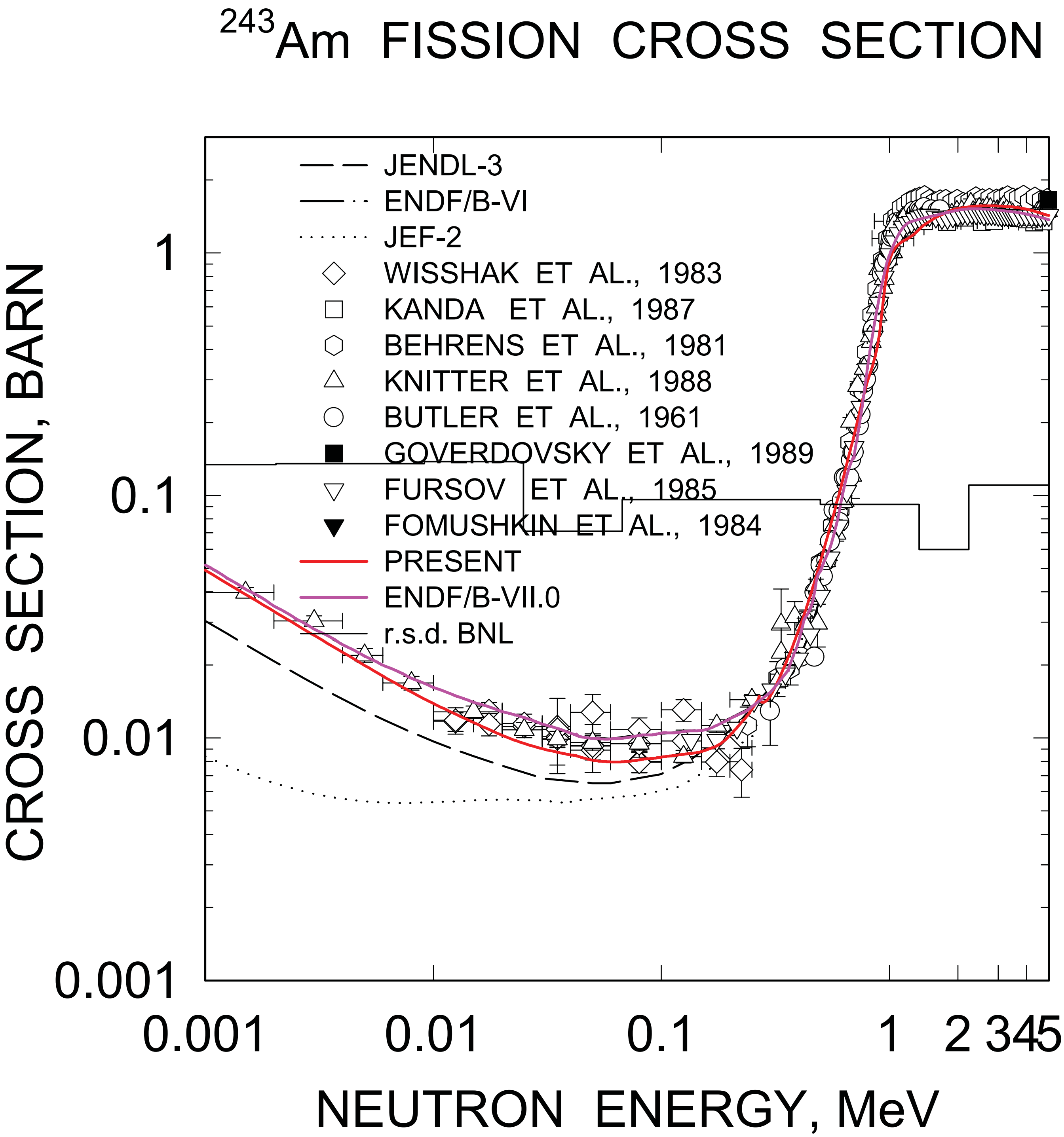


^{241}Am FISSION CROSS SECTION
DABBS ET AL., 1983
KNITTER ET AL., 1979
SHPACK ET AL., 1969
KUPRIYANOV ET AL., 1978
HAGE ET AL., 1981
WISSHAK ET AL., 1980
BEHRENS ET AL., 1981
PRINDLE ET AL., 1979
CANCE ET AL., 1981
FOMUSHKIN ET AL., 1967
KAZARINOVA ET AL., 1960
PROTOPOPOV ET AL., 1959
(n,F)
(n,f)
ENDF/B-VII.0
r.s.d BNL
σ_{nf}, δ
1
0.1
0.01
0.001
0.01
0.1
1
E_n, MeV

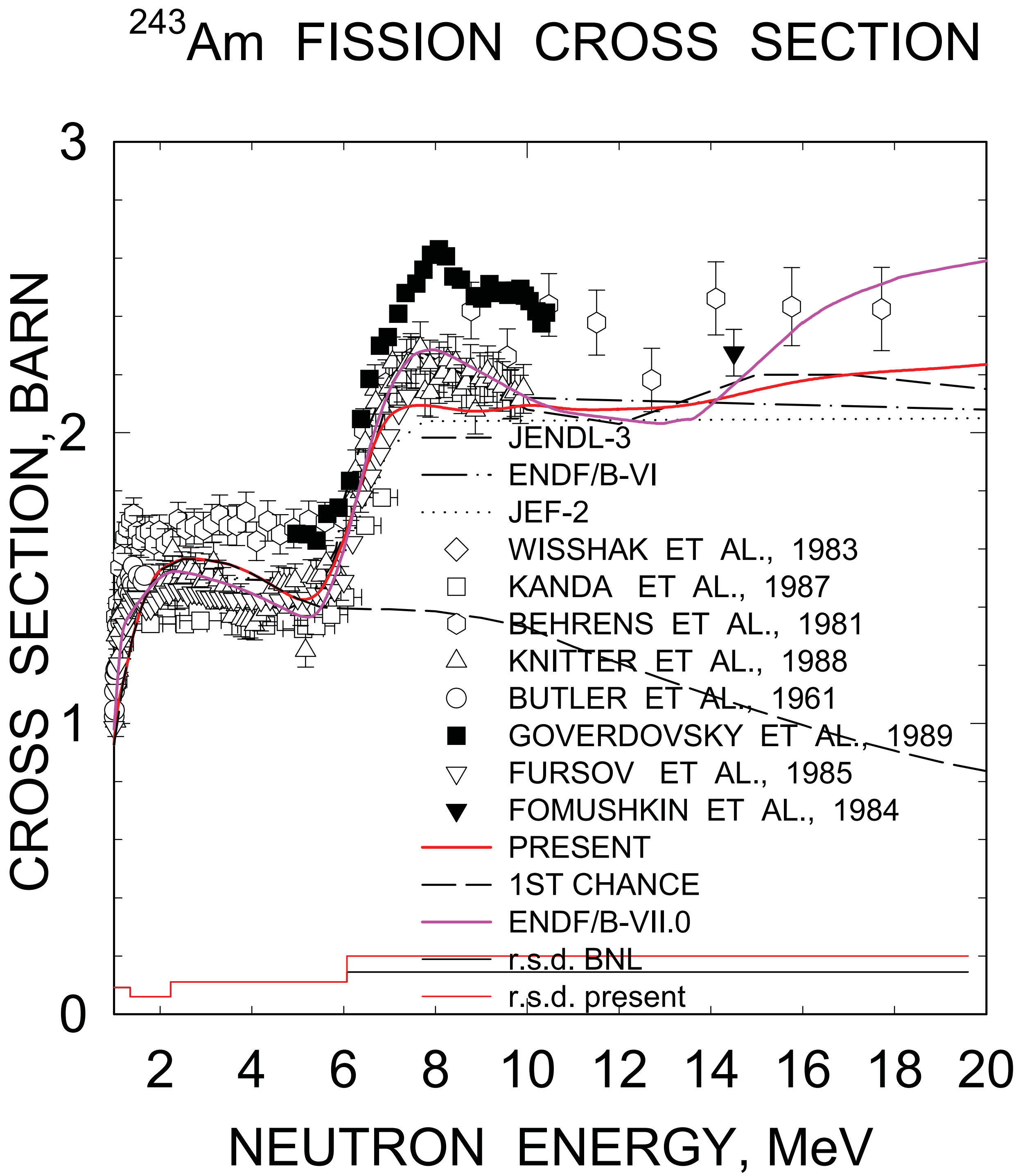

^{241}Am FISSION CROSS SECTION
σ_{nf}, barn
E_n, MeV
3
2
1
10
20
DABBS ET AL., 1983
KNITTER ET AL., 1979
SHPACK ET AL., 1969
KUPRIYANOV ET AL., 1978
HAGE ET AL., 1981
WISSHAK ET AL., 1980
BEHRENS ET AL., 1981
PRINDLE ET AL., 1979
CANCE ET AL., 1981
FOMUSHKIN ET AL., 1967
KAZARINOVA ET AL., 1960
PROTOPOPOV ET AL., 1959
(n,F)
(n,f)
ENDF/B-VII.0
r.s.d BNL
r.s.d. present



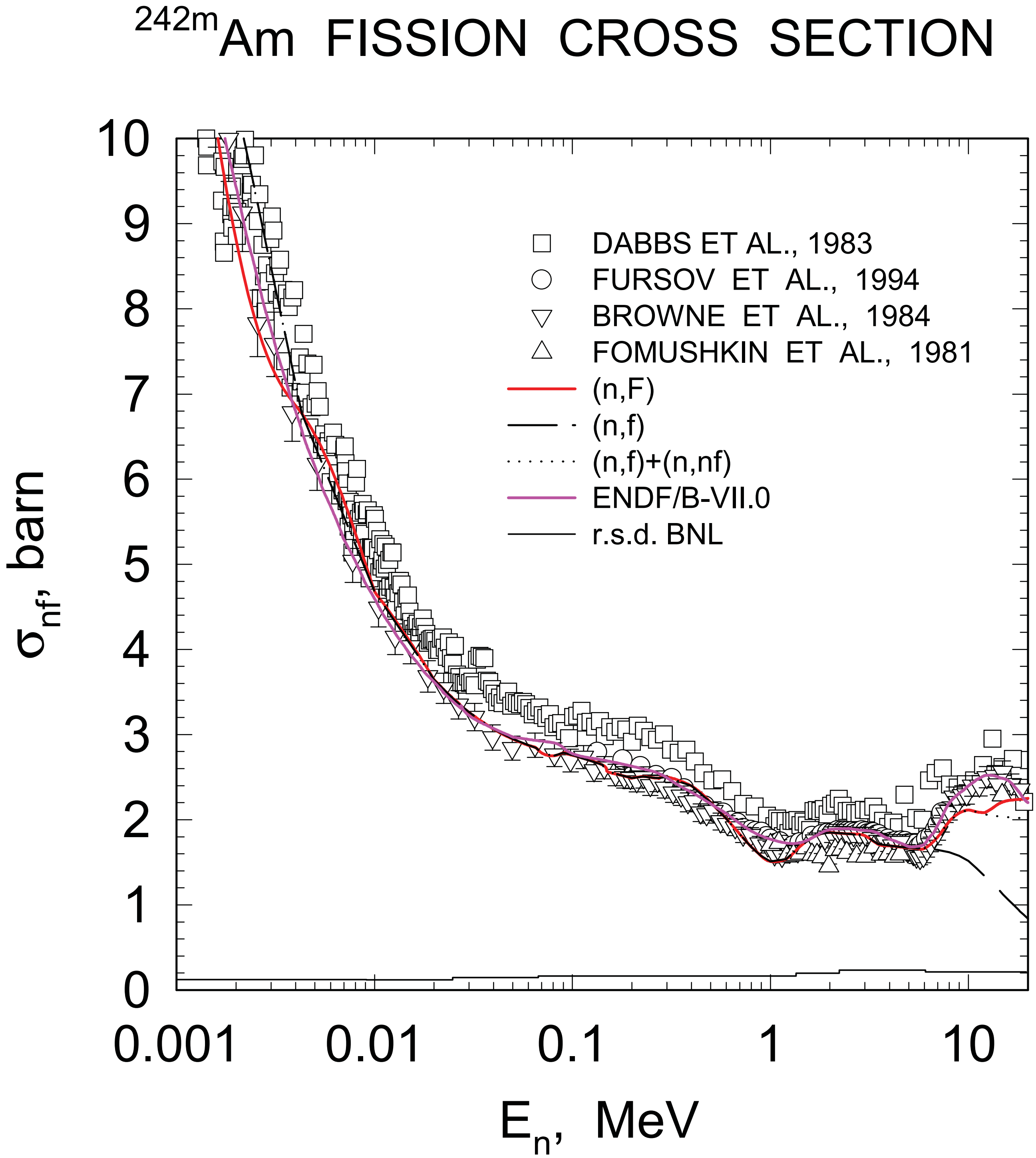
243Am FISSION CROSS SECTION
WISSHAK ET AL., 1983
KNITTER ET AL., 1988
JENDL-3
ENDF/B-VI
JEF-2
PRESENT
ENDF/B-VII.0
r.s.d BNL
CROSS SECTION, BARN
0.1
0.01
0.1
1
10
100
NEUTRON ENERGY, keV



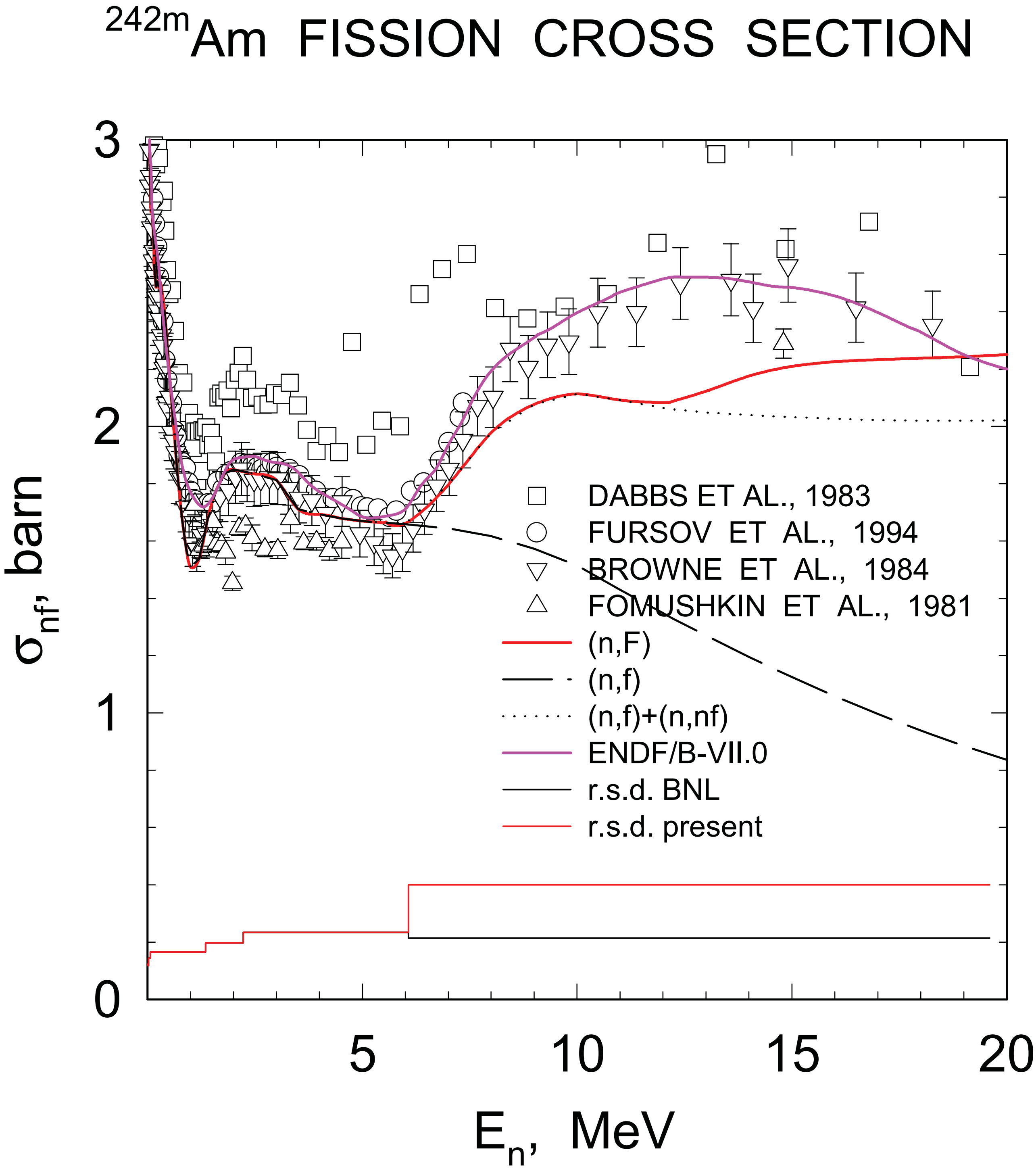
243Am FISSION CROSS SECTION
JENDL-3
ENDF/B-VI
JEF-2
WISSHAK ET AL., 1983
KANDA ET AL., 1987
BEHRENS ET AL., 1981
KNITTER ET AL., 1988
BUTLER ET AL., 1961
GOVERDOVSKY ET AL., 1989
FURSOV ET AL., 1985
FOMUSHKIN ET AL., 1984
PRESENT
ENDF/B-VII.0
r.s.d. BNL
CROSS SECTION, BARN
1
0.1
0.01
0.001
0.001
0.01
0.1
1
2 345
NEUTRON ENERGY, MeV



^{243}Am FISSION CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0
1
2
3
2
4
6
8
10
12
14
16
18
20
JENDL-3
ENDF/B-VI
JEF-2
WISSHAK ET AL., 1983
KANDA ET AL., 1987
BEHRENS ET AL., 1981
KNITTER ET AL., 1988
BUTLER ET AL., 1961
GOVERDOVSKY ET AL., 1989
FURSOV ET AL., 1985
FOMUSHKIN ET AL., 1984
PRESENT
1ST CHANCE
ENDF/B-VII.0
r.s.d. BNL
r.s.d. present



242mAm FISSION CROSS SECTION
DABBS ET AL., 1983
FURSOV ET AL., 1994
BROWNE ET AL., 1984
FOMUSHKIN ET AL., 1981
(n,F)
(n,f)
(n,f)+(n,nf)
ENDF/B-VII.0
r.s.d. BNL
σnf, barn
En, MeV
0
1
2
3
4
5
6
7
8
9
10
0.001
0.01
0.1
1
10



242mAm FISSION CROSS SECTION
3
2
1
0
5
10
15
20
σnf, barn
En, MeV
DABBS ET AL., 1983
FURSOV ET AL., 1994
BROWNE ET AL., 1984
FOMUSHKIN ET AL., 1981
(n,F)
(n,f)
(n,f)+(n,nf)
ENDF/B-VII.0
r.s.d. BNL
r.s.d. present

Chapter 4

Inelastic scattering

^{232}Th: For ^{232}Th(n,n') [57, 186-188] for the first level r.s.d. estimate of ENDF/B-VII.0 seems to reflect poor fit of measured data by Fujita [188] (see Fig. 4.1). That is why it looks very pessimistic, when compared with ^{238}U(n,n') r.s.d., which is much lower, or with ^{234}U(n,n'), which is similar to that of ^{232}Th(n,n') at E_n<1 MeV. The data availability for ^{238}U(n,n') and ^{232}Th(n,n') is quite similar, while for ^{234}U(n,n') there is no measured data. That means better fit of inelastic scattering data for discreet level and their groups, proper direct excitation of vibrational levels [6, 7, 189, 190], might lead to decrease of ^{232}Th(n,n') r.s.d. to a few percent level, claimed for ^{238}U(n,n') at relevant energies. Present values of r.s.d are increased.

^{238}U: Though it is assumed that BNL fits approximately reproduces ENDF/B-VII.0 (or JENDL-3.3) cross sections, it is never shown to which extent. Since in case of inelastic scattering, measured in [57, 191, 192] the main competing channel is fission, its uncertainty much depends upon the fission competition and relative role of direct excitation of vibration levels at excitations of 0.6-1.2 MeV (for even targets). Calculations by H.Wienke et al. [193] of emissive neutron spectra demonstrated once again, that omission or weak direct excitation of these levels as in [14] is incompatible with measured data. Specifically, large value of r.s.d for the 2nd group reflects only the approximation, involved in the evaluation procedures (proper direct excitation of vibrational levels), but not the reliability of the inelastic scattering simulation. R.s.d. values are left as they are (see Fig. 4.2).

^{236}U: The r.s.d. estimates for ^{236}U(n,n') are too pessimistic, relatively over-optimistic for the 2nd and 3rd groups (the range where the direct excitation of vibrational levels is important, but is omitted in ENDF/B-VII.0 evaluation). Values of r.s.d are modified based on the attained level for the ^{238}U(n,n') and comparison with present calculation. The latter calculation takes into account direct excitation of vibrational levels and fission competition to the compound inelastic scattering (see Fig. 4.3).

^{234}U: The r.s.d. estimates for ^{234}U(n,n') are too pessimistic, relatively over-optimistic for the 4th group (the range where the discrete levels are murged with continuum excitation). Values of r.s.d are modified based on the attained level for the ^{238}U(n,n') and comparison with Maslov et al. [21] evaluation. The latter evaluation properly includes direct excitation of vibrational levels and fission competition to the compound inelastic scattering (see Fig. 4.4).

^{238}**Pu:** The r.s.d. estimates for ^{238}Pu(n,n') too optimistic (low) (note the discrepancies of evaluated cross sections with recent reliable measured fission data in these particular case) and missing of direct excitation of rotational and vibrational levels, the latter is missing also in the evaluation named present, of 1998. Values of r.s.d are severely modified (see Fig. 4.5).

^{240}**Pu:** The r.s.d. estimates for ^{240}Pu(n,n') too optimistic, excessively pessimistic in the 1st group (see Fig. 4.6). Values of r.s.d are severely modified, based on comparison of ENDF/B-VII.0 evaluation with present and BROND evaluations. Note that direct excitation of vibrational levels [6, 7] is missing in all calculations.

^{242}**Pu:** The r.s.d. estimates for ^{242}Pu(n,n') too optimistic for 2nd group, but excessively pessimistic for the in the 1st group (see Fig. 4.7). Values of r.s.d are severely modified, based on comparison of ENDF/B-VII.0 evaluation with the evaluation of 1998 by Maslov et al. [33]. Note that direct excitation of vibrational levels [6, 7] is missing in all calculations.

^{242}**Cm:** The r.s.d. estimates for ^{242}Cm(n,n') too optimistic (low) (note the discrepancies of evaluated cross sections with recent reliable measured fission data in sub-threshold energy range and unpublished surrogate data, presented at ND2007 [114] and missing of direct excitation of rotational and vibrational levels [6], the latter is missing also in present calculation. Values of r.s.d are severely modified (see Fig. 4.8).

^{244}**Cm:** The r.s.d. estimates for ^{244}Cm(n,n') are too optimistic (low) (note the discrepancies of JENDL-3.3 (adopted for ENDF/B-VII.0) evaluated fission cross section with measured fission data by Fomushkin et al. [115, 116]. We consider these data most reliable. Note missing of the direct excitation of rotational and vibrational levels [6, 7], the latter is missing also in present calculation. Values of r.s.d are modified (see Fig. 4.9).

^{235}**U:** In case of ^{235}U (n,n') the discrepancies between different evaluations and measured data [57, 191] are rather large (see Fig. 4.10). That discrepancy should not be reflected just in large relative standard deviation, moreover so that the JENDL-3.3 data files of ^{235}U and ^{238}U are not the best fits. In case of other nuclides, when EMPIRE-KALMAN [1, 2] approach is employed, it is said only briefly about the "best fit" parameters for Pu, Am and Cm targets. Values of r.s.d. seem to be similar to those of ^{239}Pu(n,n'), estimated in that report.

^{233}**U:** In case of ^{233}U(n,n') [57] the discrepancies between different evaluations are extremely large at energies below 1 MeV (see Fig. 4.11). That discrepancy should be reflected just as large relative standard deviation, since large cross section in ENDF/B-VII.0 is defined by large direct excitation of rotational levels. Values of r.s.d. seem to be similar to those of ^{239}Pu(n,n'), estimated in that report.

^{239}Pu: In case of ^{239}Pu (n,n'), measured in [194, 195], the discrepancies between different evaluations are larger than in case of ^{235}U (n,n') (see Fig. 4.12). Our calculation provides best fits of fission, elastic scattering and capture cross sections. Present values of r.s.d. are decreased in first two groups, but increased in the remaining groups.

^{241}Pu: In case of ^{241}Pu (n,n') the discrepancies between different evaluations at energies below 1 MeV are even larger than in case of ^{233}U (n,n') (see Fig. 4.13). Our calculation provides best fit of fission cross section. Present values of r.s.d. are decreased in 1st groups, but increased in the remaining groups.

^{243}Cm: in ENDF/B-VII.0 data file, the evaluation by Maslov et al. [26] is adopted. We assume r.s.d. to be similar to those of ^{245}Cm(n,n'), assuming that the fission cross section is defined correctly and no further renormalizations would be required (see Fig. 4.14).

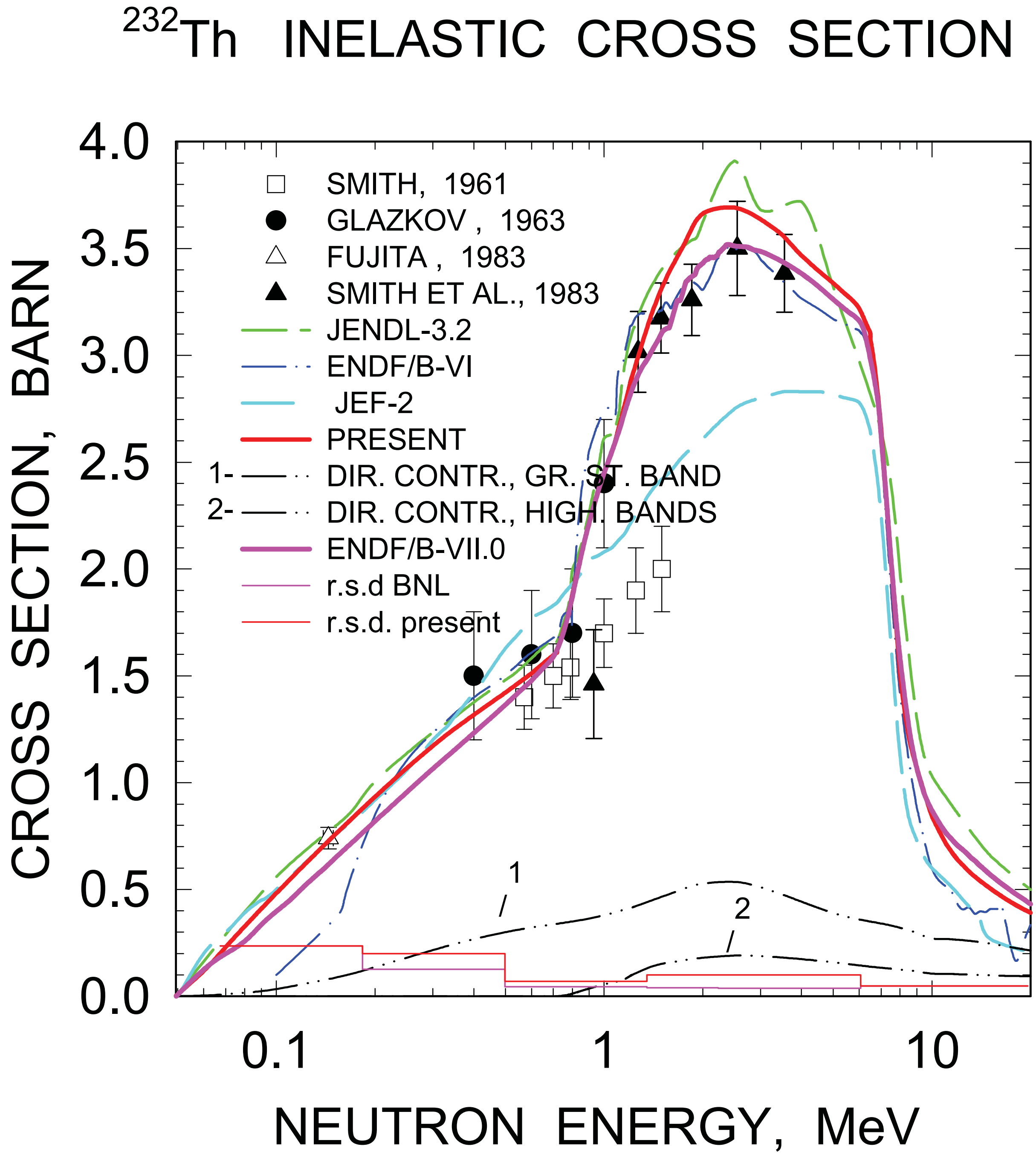
^{245}Cm: in ENDF/B-VII.0 data file, the evaluation by Maslov et al. [27] is adopted. We assume r.s.d. to be similar to those of ^{235}U(n,n') and ^{239}Pu(,.n') (see Fig. 4.15).

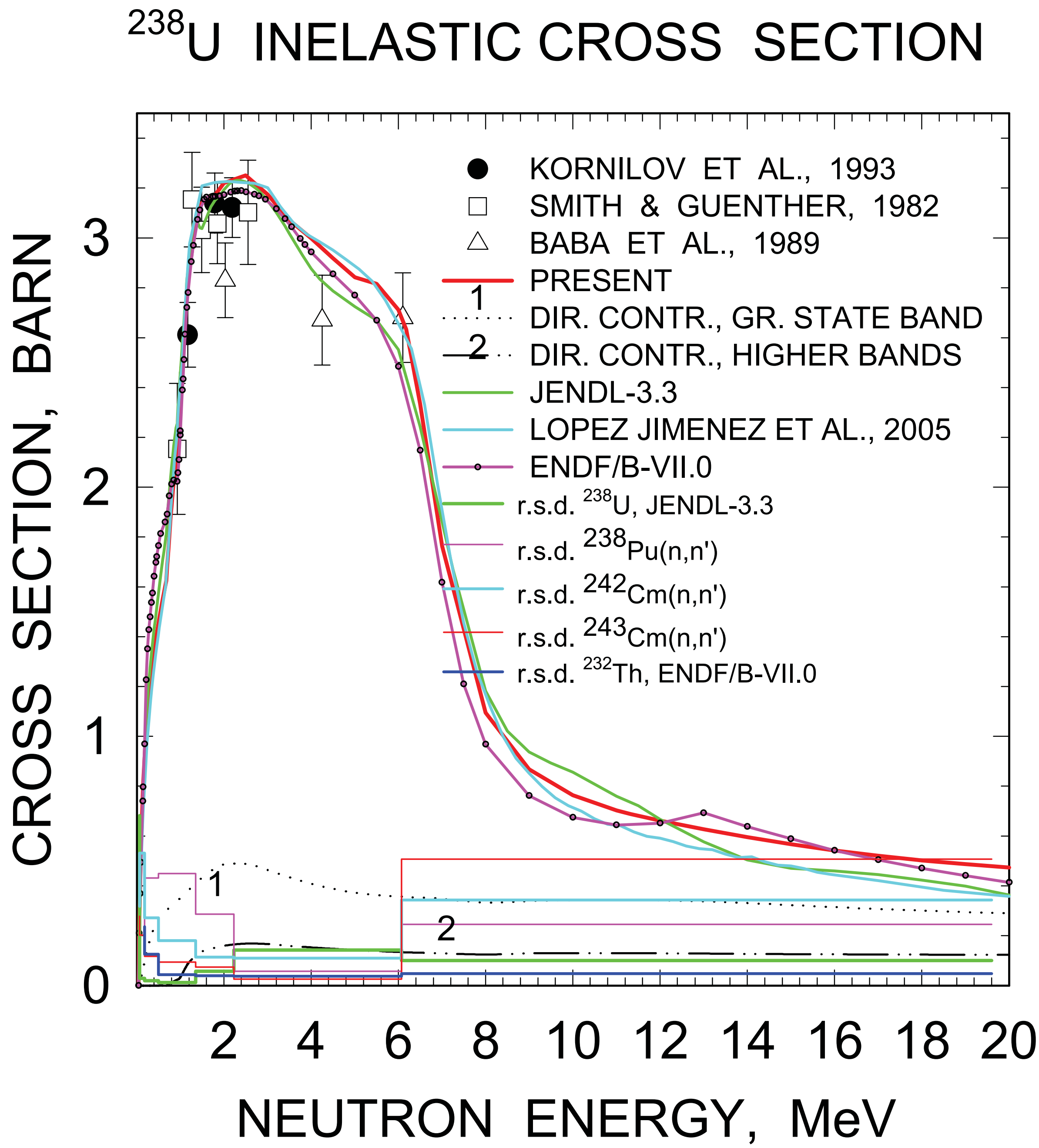
^{237}Np: it seems that 1.5 MeV is a stabilization point of inelastic scattering cross section (see Fig. 4.16). We assume r.s.d to be defined by the deviation of ENDF/B-VII.0 data from present calculation. Present calculation based on the fits of fission and capture cross sections. The evaluated inelastic cross sections of ENDF/B-VII.0 and JENDL-3.3 evaluations are in severe disagreement with measured data by Kornilov et al. [63] on the inelastic scattering of neutrons with excitation of specific groups of levels, while our approach produces consistent description of (n,f), (n,n') and (n,γ) measured data.

^{241}Am: We assume r.s.d to be defined by the deviation of ENDF/B-VII.0 data from Maslov et al. [17] evaluation. It is based on fits of total, fission and capture cross sections. R.s.d. changed in accordance with observed trends for U and Pu target nuclides (see Fig. 4.17).

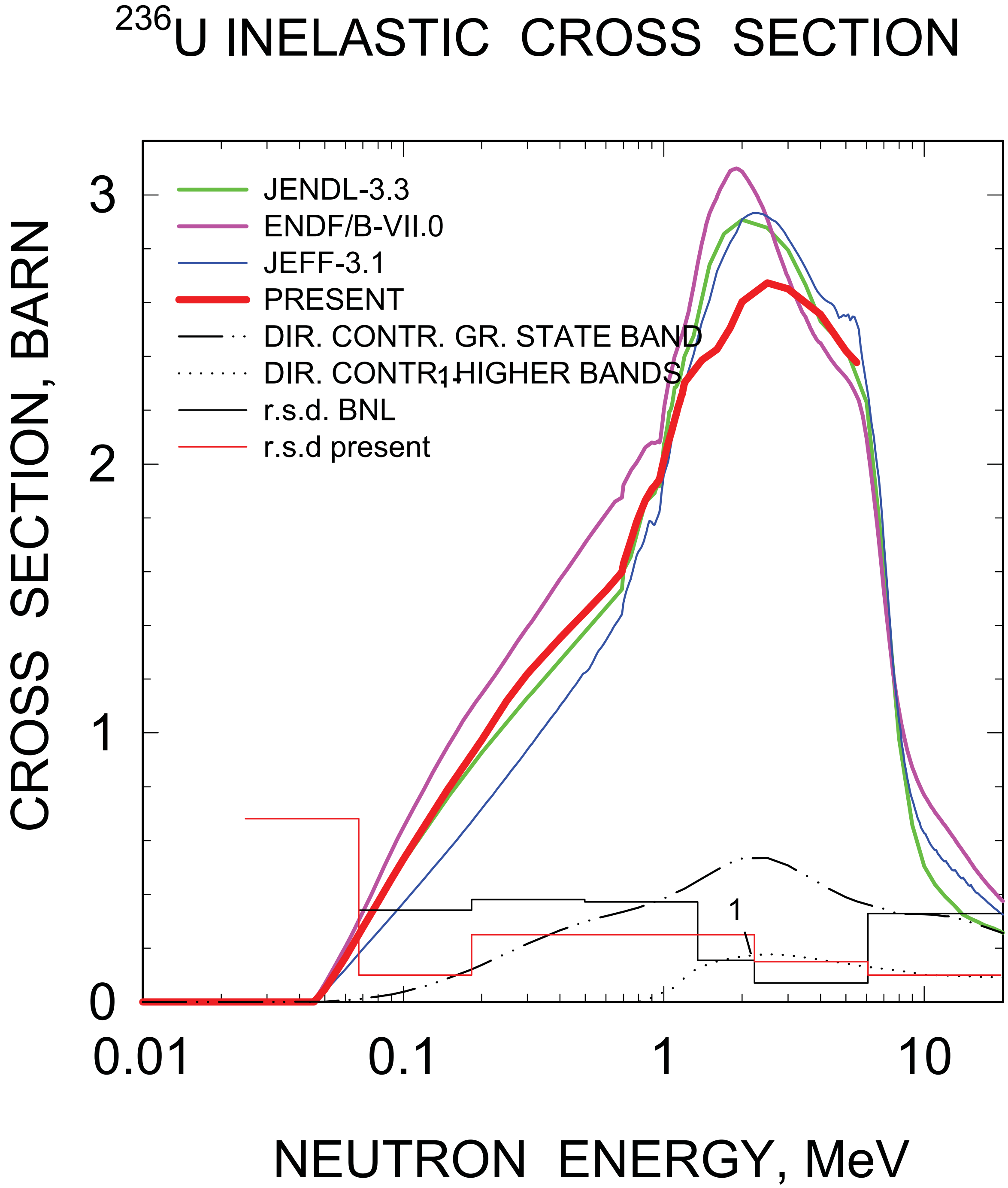
^{243}Am: We assume r.s.d to be defined by the deviation of ENDF/B-VII.0 data from Maslov et al. [18] evaluation, the same values as those of ^{241}Am(n,n') look reasonable (see Fig. 4.18).

^{242m}Am: The inelastic scattering cross sections of ENDF/B-VII.0 and Maslov et al. [30] evaluations differ very much in 0.5-5 MeV energy range (see Fig. 4.19). The correlated difference of fission cross sections is much less. Obviously, the problem is with the optical potential parameters employed. That leads to the increase of r.s.d in that energy range.

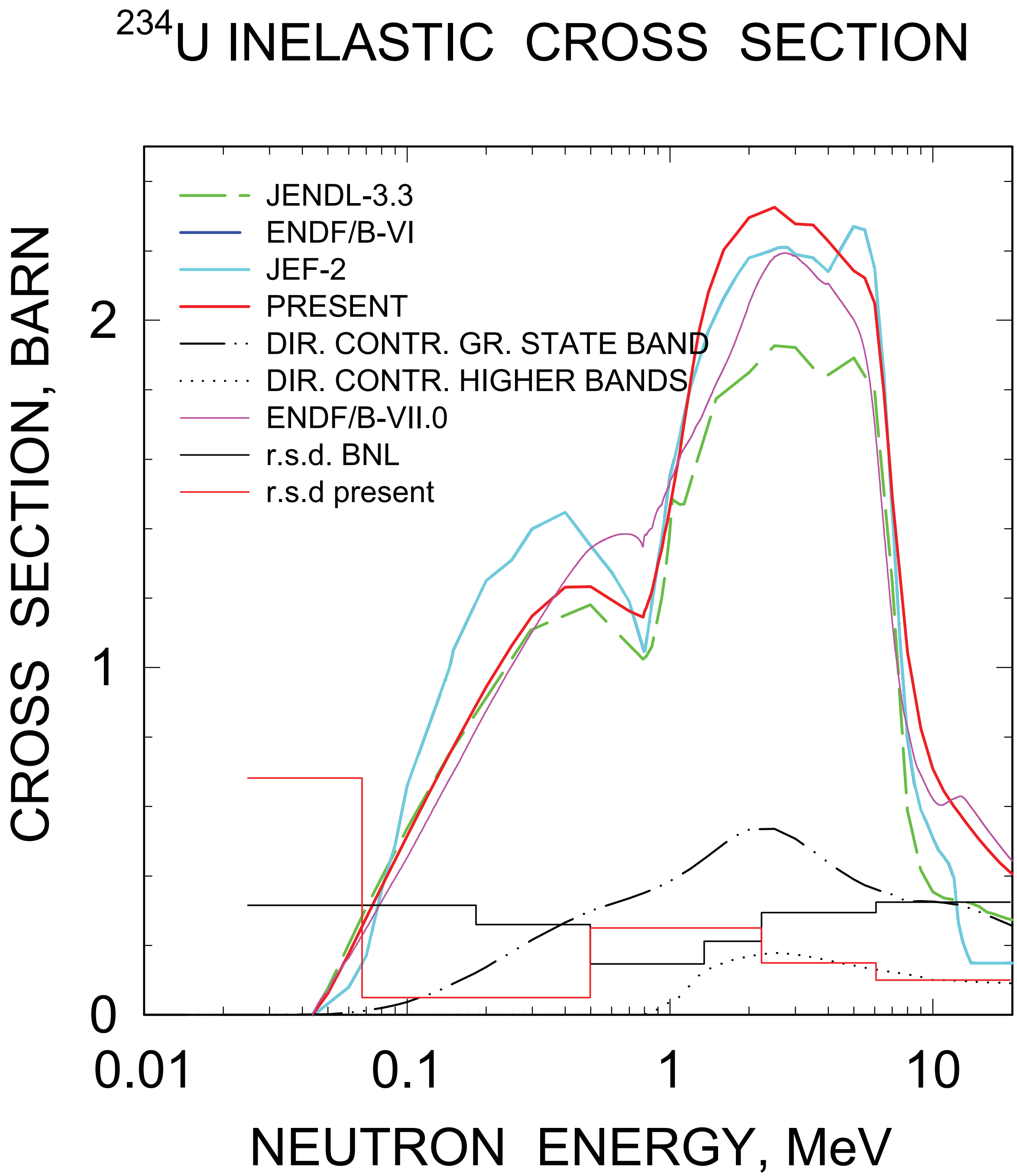

^{232}Th INELASTIC CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
SMITH, 1961
GLAZKOV , 1963
FUJITA , 1983
SMITH ET AL., 1983
JENDL-3.2
ENDF/B-VI
JEF-2
PRESENT
1- DIR. CONTR., GR. ST. BAND
2- DIR. CONTR., HIGH. BANDS
ENDF/B-VII.0
r.s.d BNL
r.s.d. present
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0.1
1
10
1
2



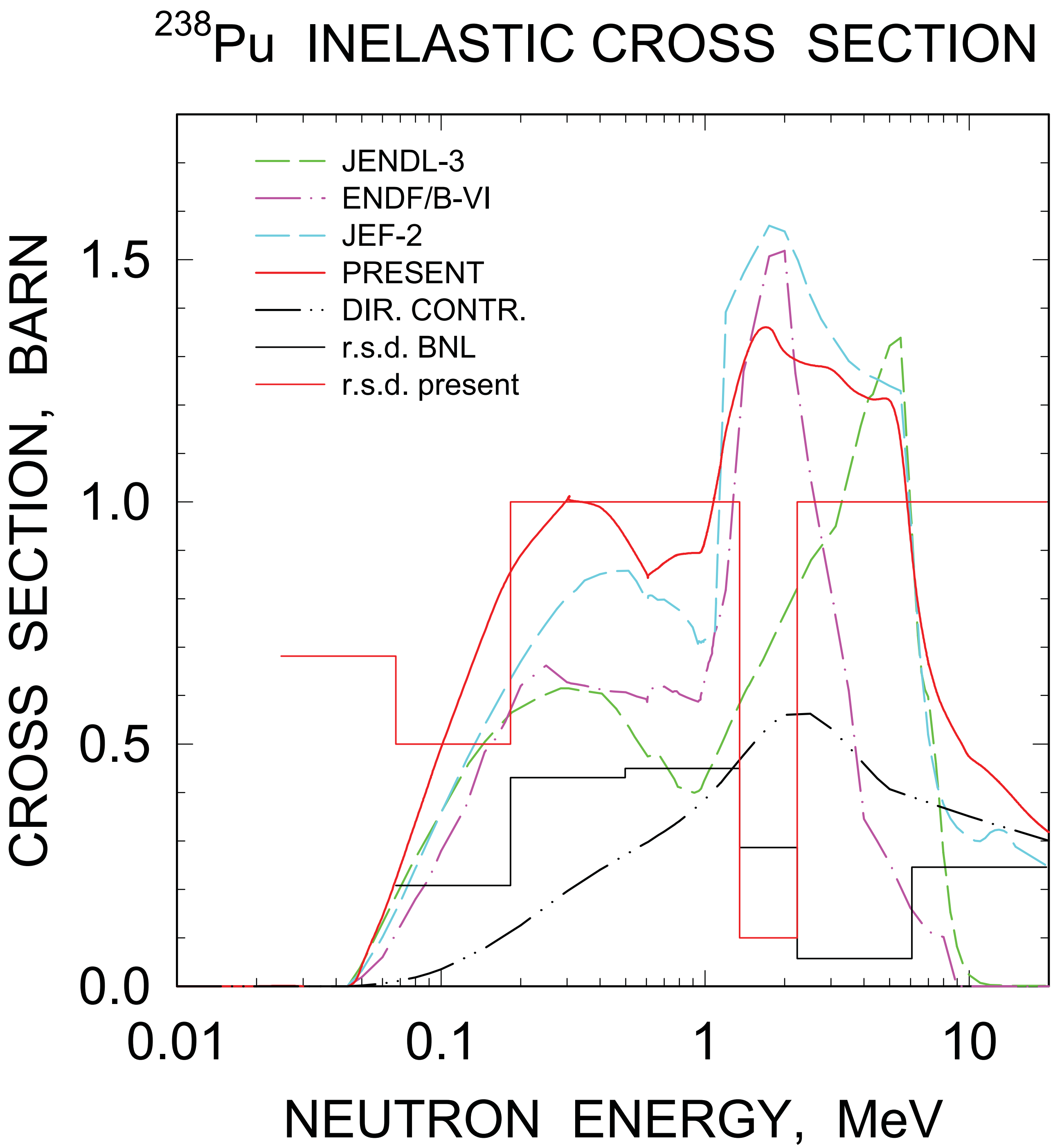
238U INELASTIC CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0
1
2
3
2
4
6
8
10
12
14
16
18
20
KORNILOV ET AL., 1993
SMITH & GUENTHER, 1982
BABA ET AL., 1989
PRESENT
1
DIR. CONTR., GR. STATE BAND
2
DIR. CONTR., HIGHER BANDS
JENDL-3.3
LOPEZ JIMENEZ ET AL., 2005
ENDF/B-VII.0
r.s.d. 238U, JENDL-3.3
r.s.d. 238Pu(n,n')
r.s.d. 242Cm(n,n')
r.s.d. 243Cm(n,n')
r.s.d. 232Th, ENDF/B-VII.0
1
2



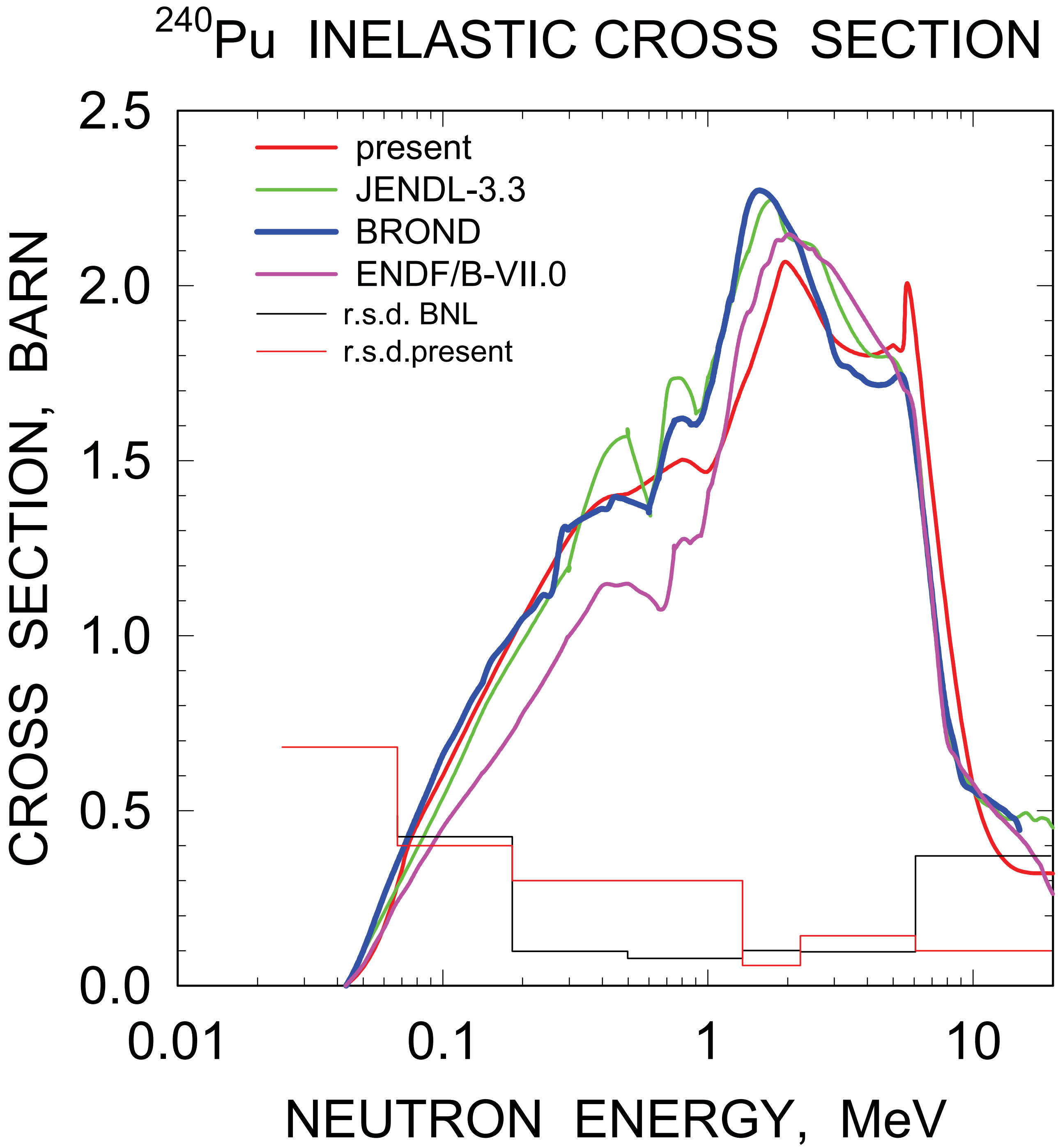
^{236}U INELASTIC CROSS SECTION
JENDL-3.3
ENDF/B-VII.0
JEFF-3.1
PRESENT
DIR. CONTR. GR. STATE BAND
DIR. CONTR. HIGHER BANDS
r.s.d. BNL
r.s.d present
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0
1
2
3
0.01
0.1
1
10



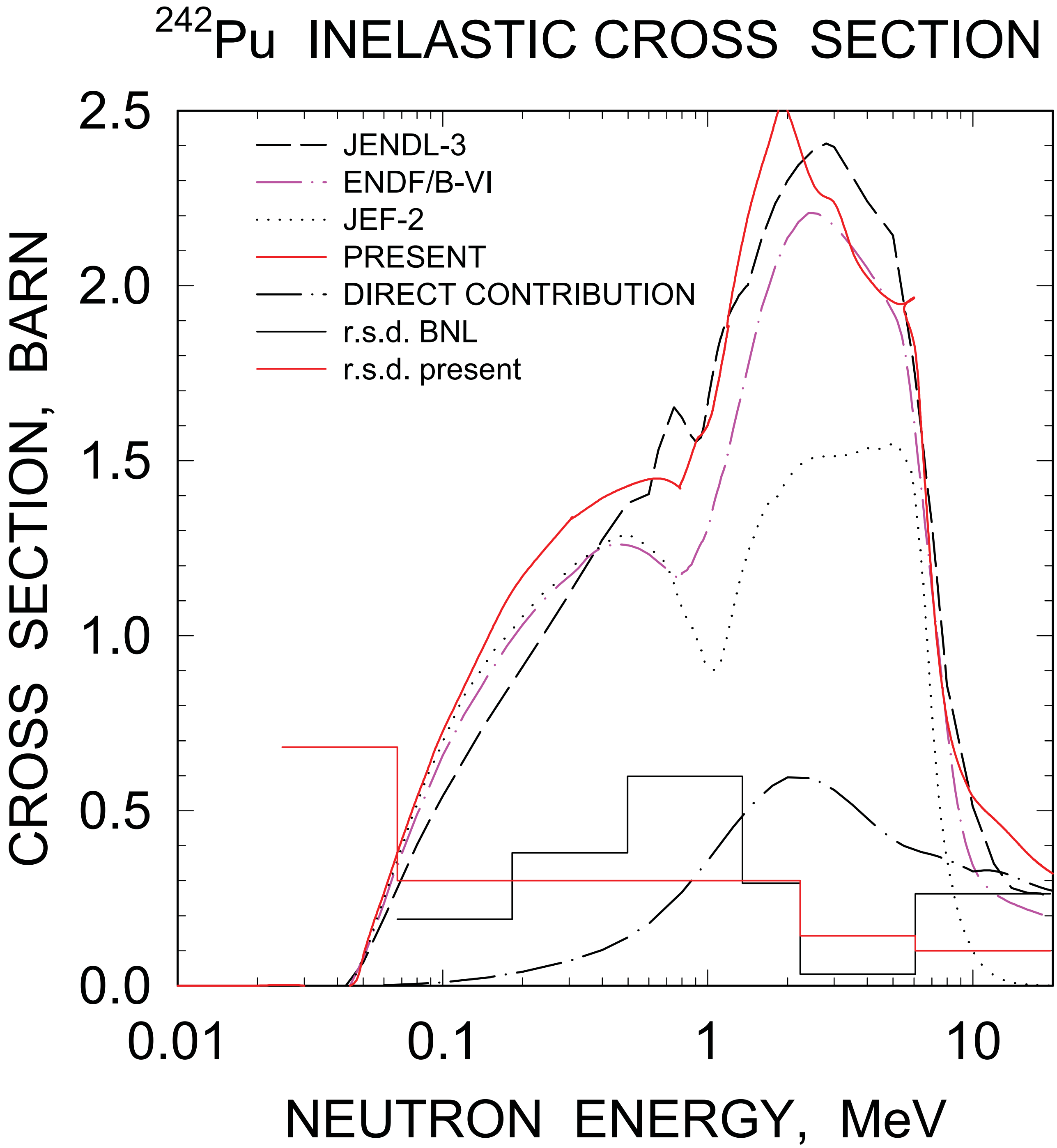
^{234}U INELASTIC CROSS SECTION
JENDL-3.3
ENDF/B-VI
JEF-2
PRESENT
DIR. CONTR. GR. STATE BAND
DIR. CONTR. HIGHER BANDS
ENDF/B-VII.0
r.s.d. BNL
r.s.d present
CROSS SECTION, BARN
0
1
2
0.01
0.1
1
10
NEUTRON ENERGY, MeV



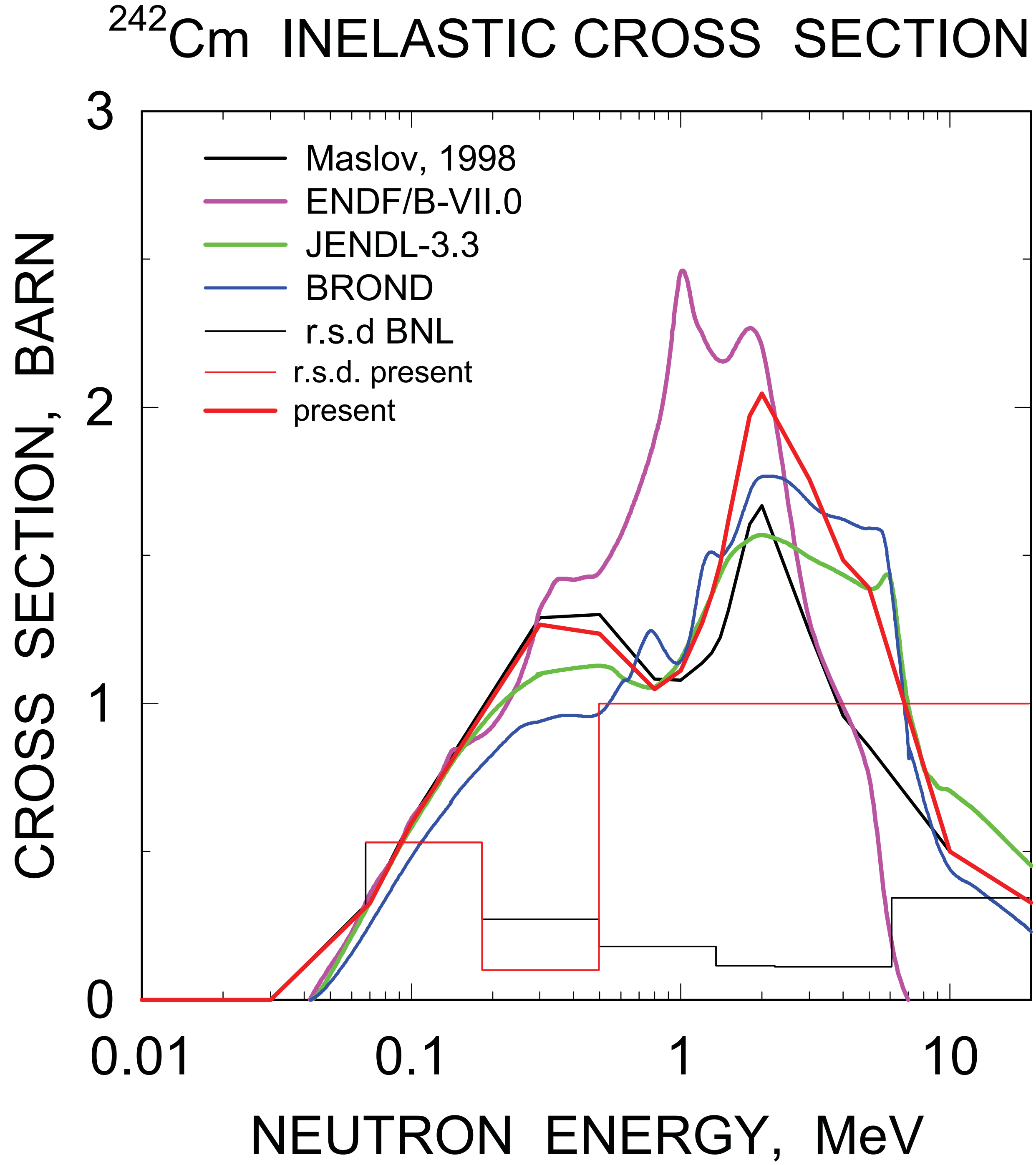
^{238}Pu INELASTIC CROSS SECTION
JENDL-3
ENDF/B-VI
JEF-2
PRESENT
DIR. CONTR.
r.s.d. BNL
r.s.d. present
CROSS SECTION, BARN
0.0
0.5
1.0
1.5
0.01
0.1
1
10
NEUTRON ENERGY, MeV



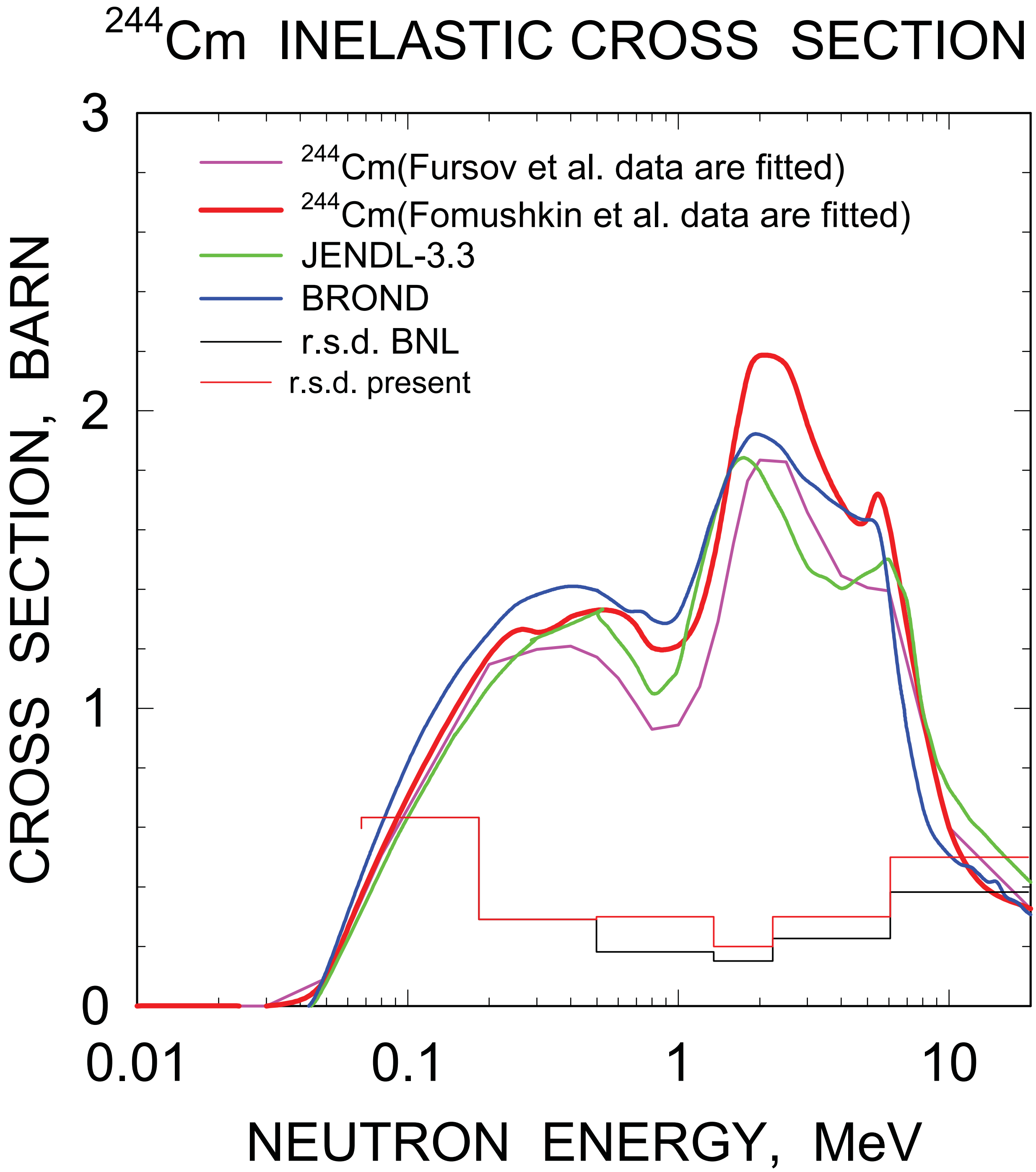
240Pu INELASTIC CROSS SECTION
present
JENDL-3.3
BROND
ENDF/B-VII.0
r.s.d. BNL
r.s.d.present
CROSS SECTION, BARN
2.5
2.0
1.5
1.0
0.5
0.0
0.01
0.1
1
10
NEUTRON ENERGY, MeV



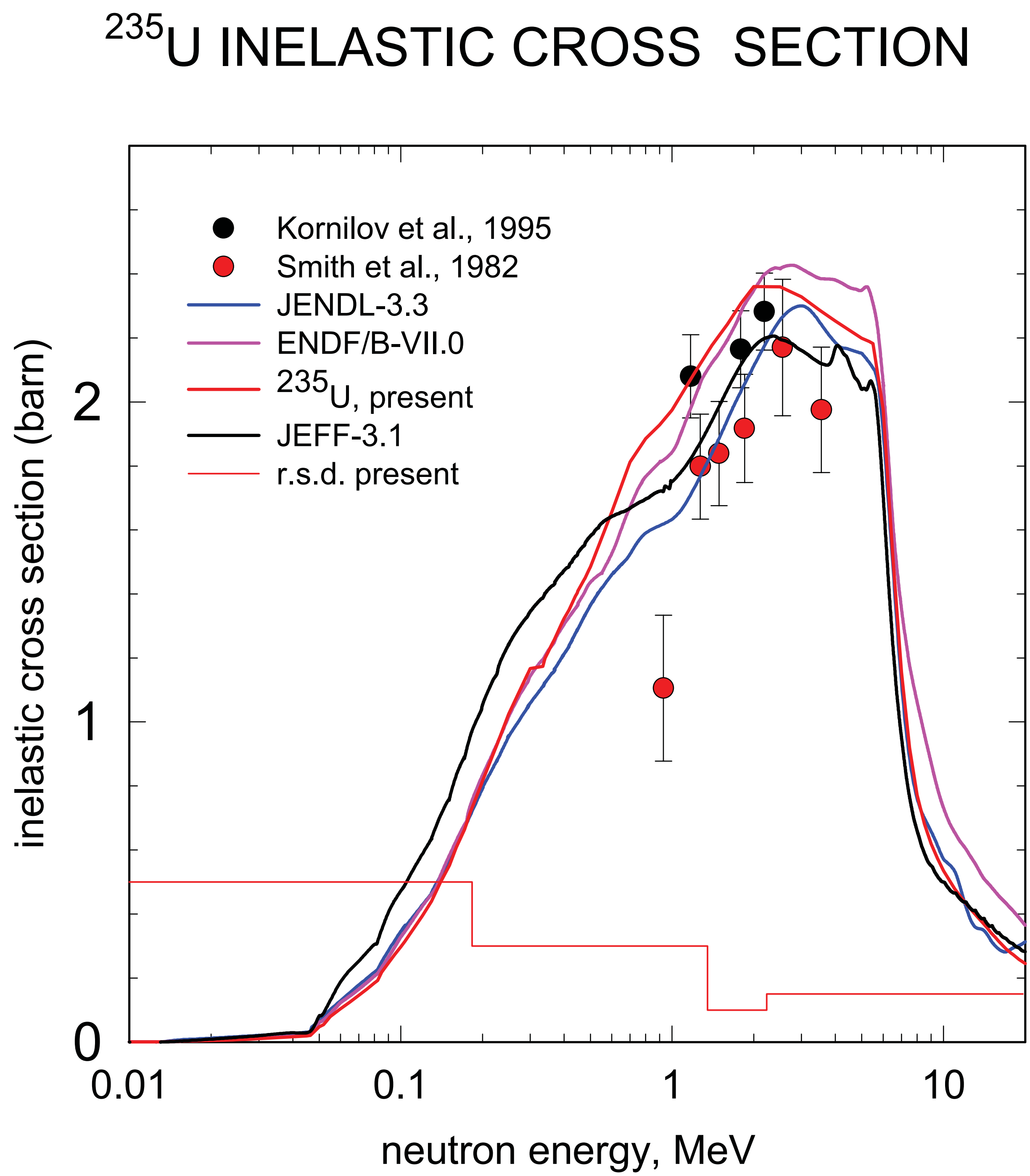
^{242}Pu INELASTIC CROSS SECTION
JENDL-3
ENDF/B-VI
JEF-2
PRESENT
DIRECT CONTRIBUTION
r.s.d. BNL
r.s.d. present
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
2.5
2.0
1.5
1.0
0.5
0.0
0.01
0.1
1
10



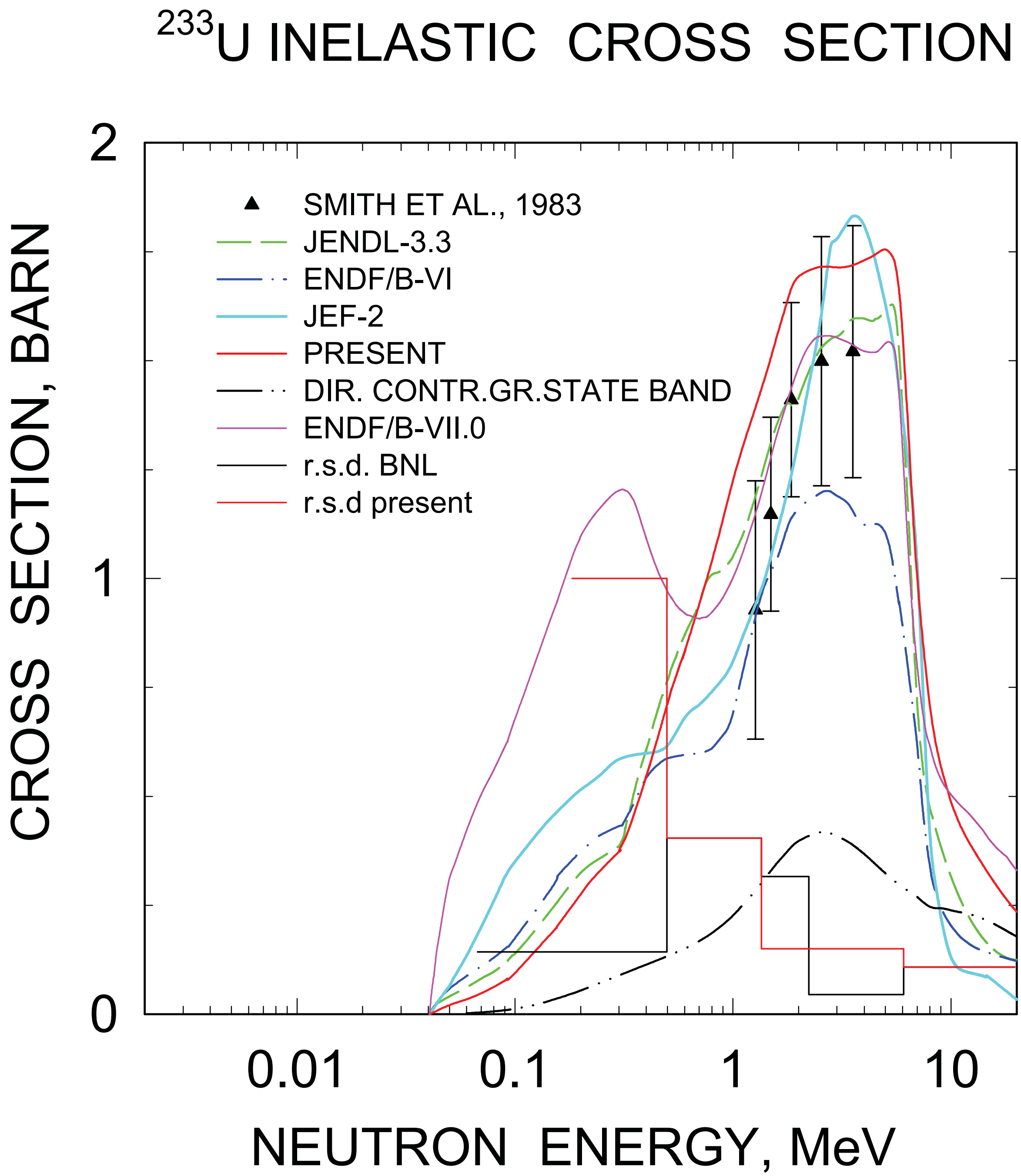
^{242}Cm INELASTIC CROSS SECTION
Maslov, 1998
ENDF/B-VII.0
JENDL-3.3
BROND
r.s.d BNL
r.s.d. present
present
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0
1
2
3
0.01
0.1
1
10



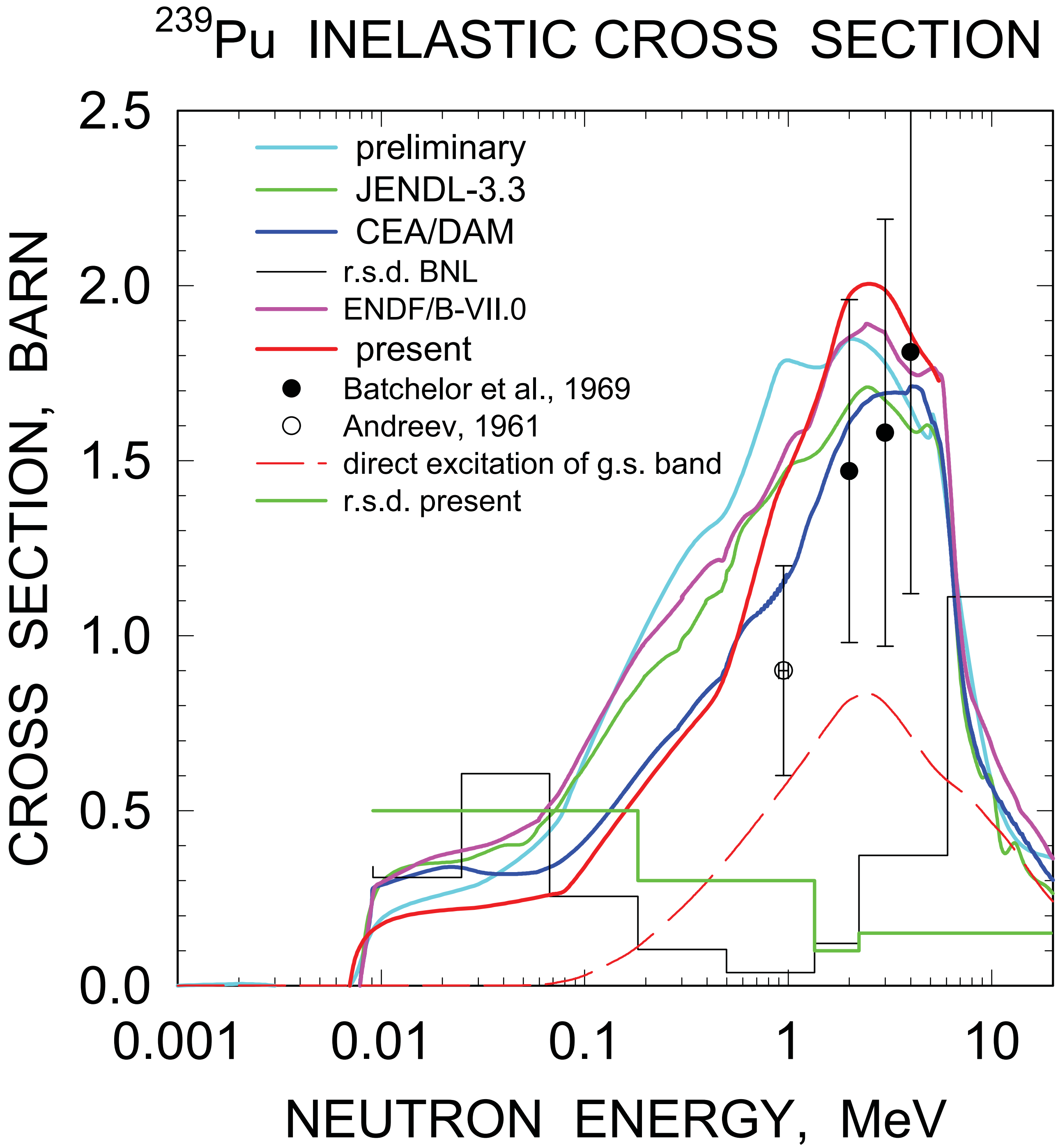
244Cm INELASTIC CROSS SECTION
244Cm(Fursov et al. data are fitted)
244Cm(Fomushkin et al. data are fitted)
JENDL-3.3
BROND
r.s.d. BNL
r.s.d. present
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0
1
2
3
0.01
0.1
1
10



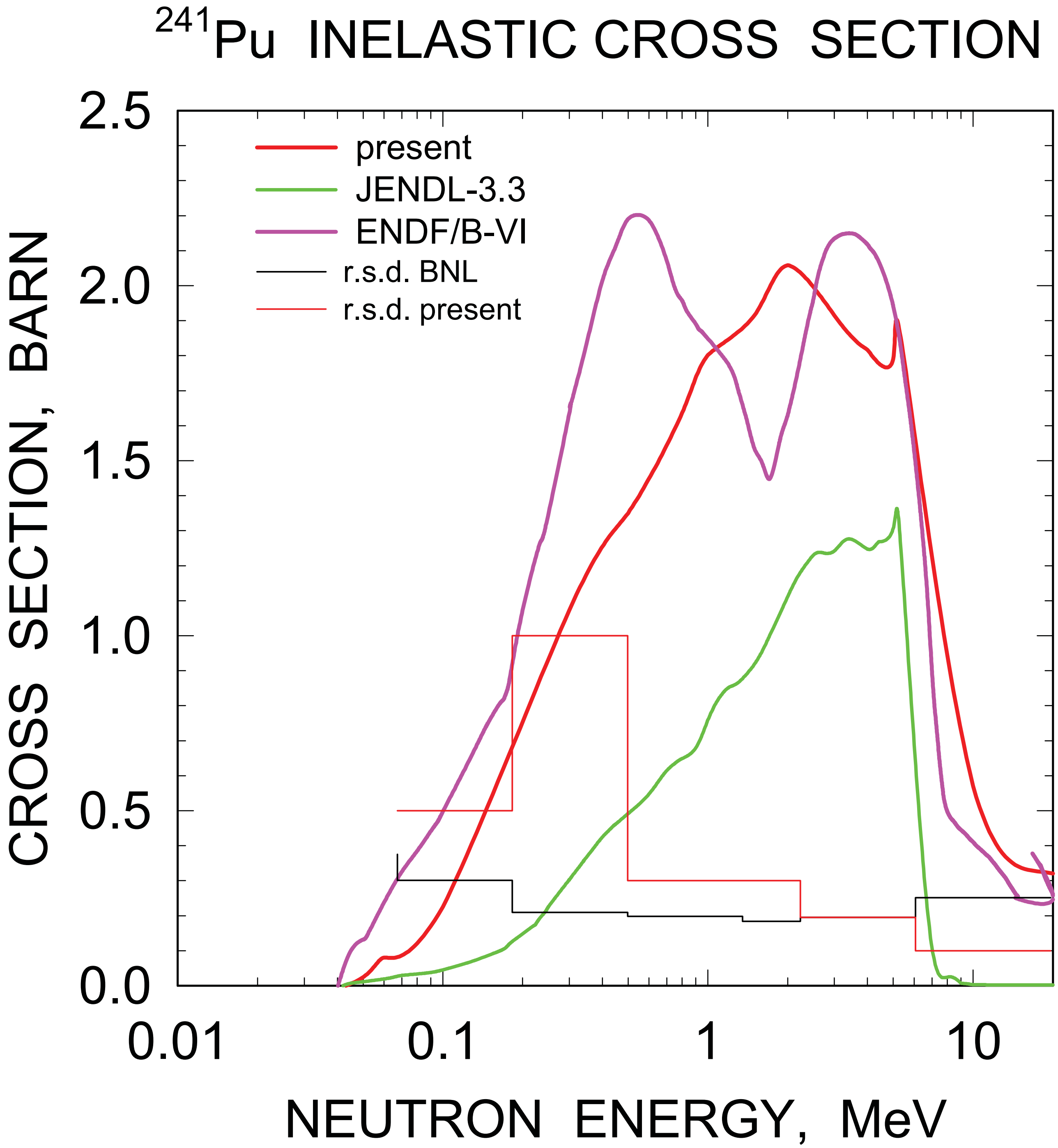
235U INELASTIC CROSS SECTION
Kornilov et al., 1995
Smith et al., 1982
JENDL-3.3
ENDF/B-VII.0
235U, present
JEFF-3.1
r.s.d. present
inelastic cross section (barn)
0
1
2
0.01
0.1
1
10
neutron energy, MeV



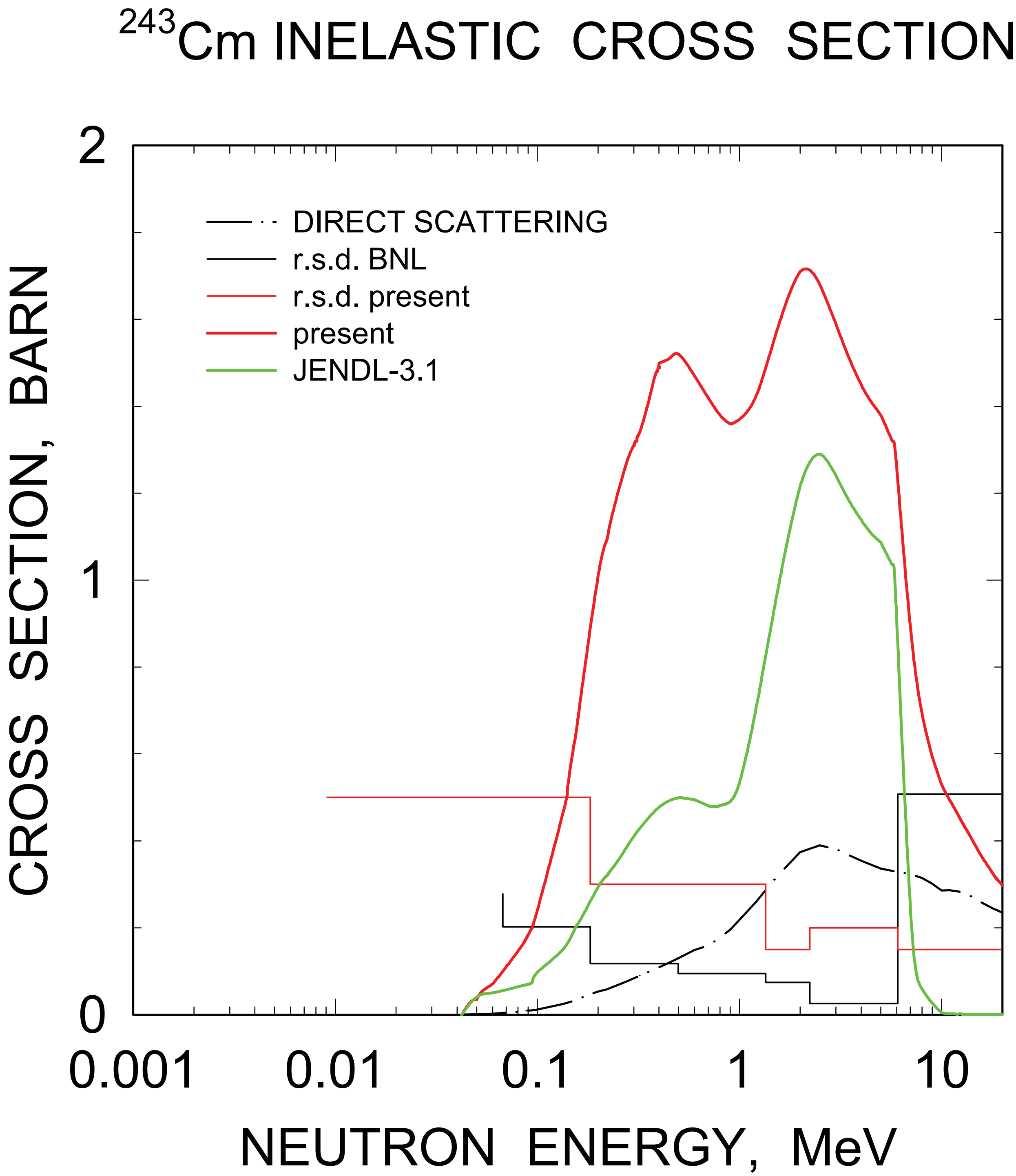
^{233}U INELASTIC CROSS SECTION
SMITH ET AL., 1983
JENDL-3.3
ENDF/B-VI
JEF-2
PRESENT
DIR. CONTR.GR.STATE BAND
ENDF/B-VII.0
r.s.d. BNL
r.s.d present
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0
1
2
0.01
0.1
1
10



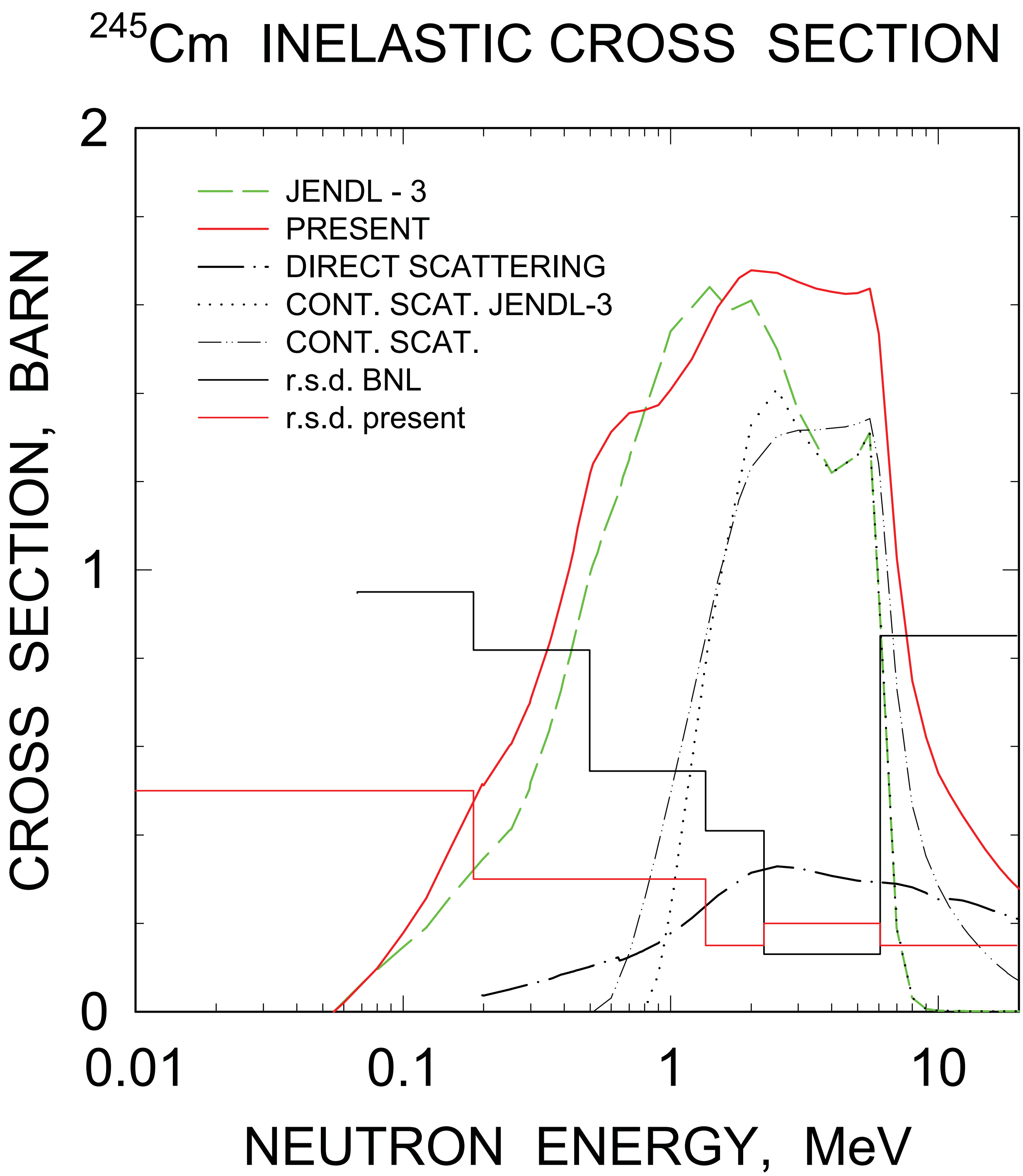
239Pu INELASTIC CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
2.5
2.0
1.5
1.0
0.5
0.0
0.001
0.01
0.1
1
10
preliminary
JENDL-3.3
CEA/DAM
r.s.d. BNL
ENDF/B-VII.0
present
Batchelor et al., 1969
Andreev, 1961
direct excitation of g.s. band
r.s.d. present

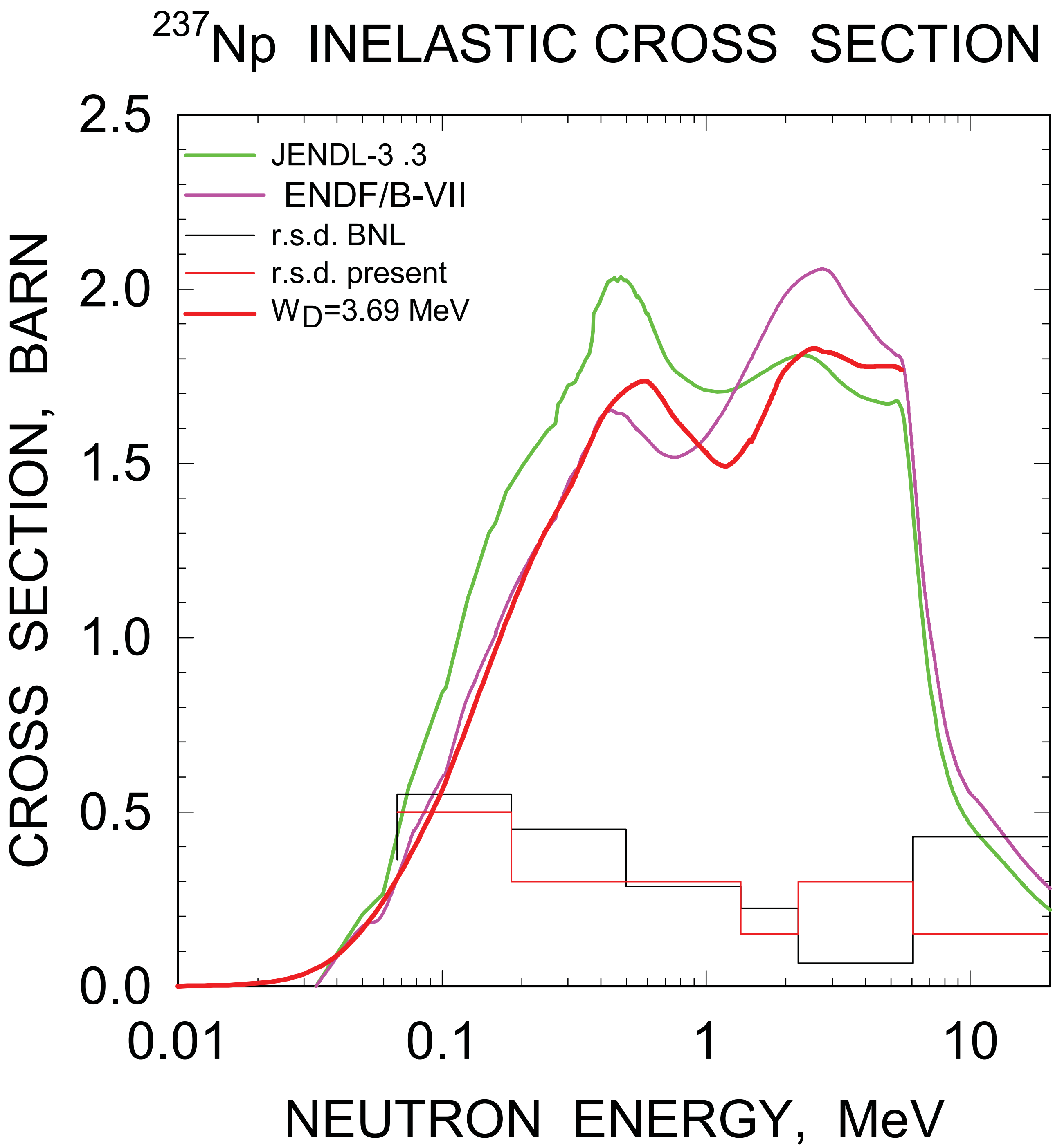


^{241}Pu INELASTIC CROSS SECTION
present
JENDL-3.3
ENDF/B-VI
r.s.d. BNL
r.s.d. present
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0.0
0.5
1.0
1.5
2.0
2.5
0.01
0.1
1
10

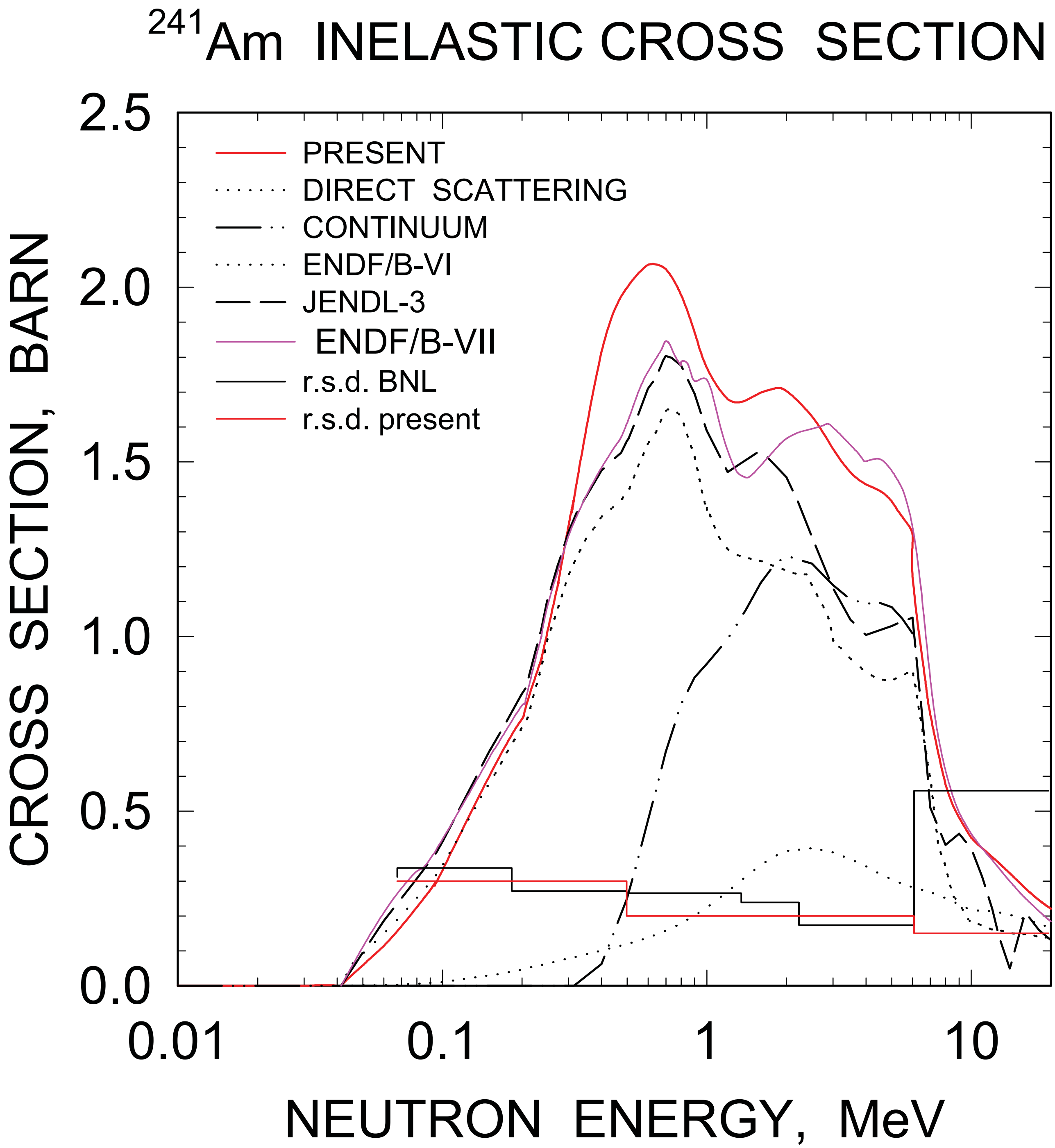


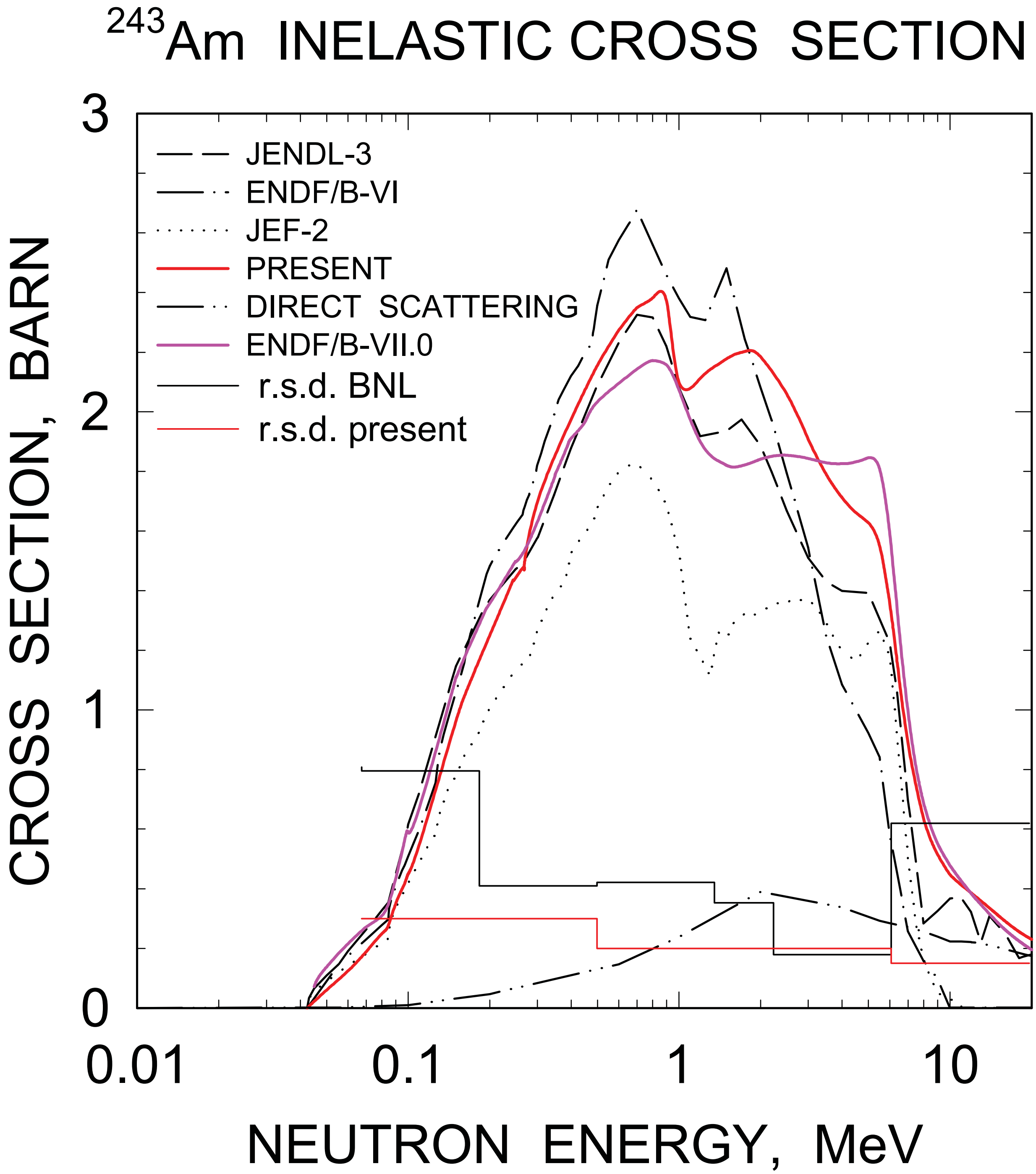
^{243}Cm INELASTIC CROSS SECTION
DIRECT SCATTERING
r.s.d. BNL
r.s.d. present
present
JENDL-3.1
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
2
1
0
0.001
0.01
0.1
1
10


245Cm INELASTIC CROSS SECTION
JENDL - 3
PRESENT
DIRECT SCATTERING
CONT. SCAT. JENDL-3
CONT. SCAT.
r.s.d. BNL
r.s.d. present
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
2
1
0
0.01
0.1
1
10

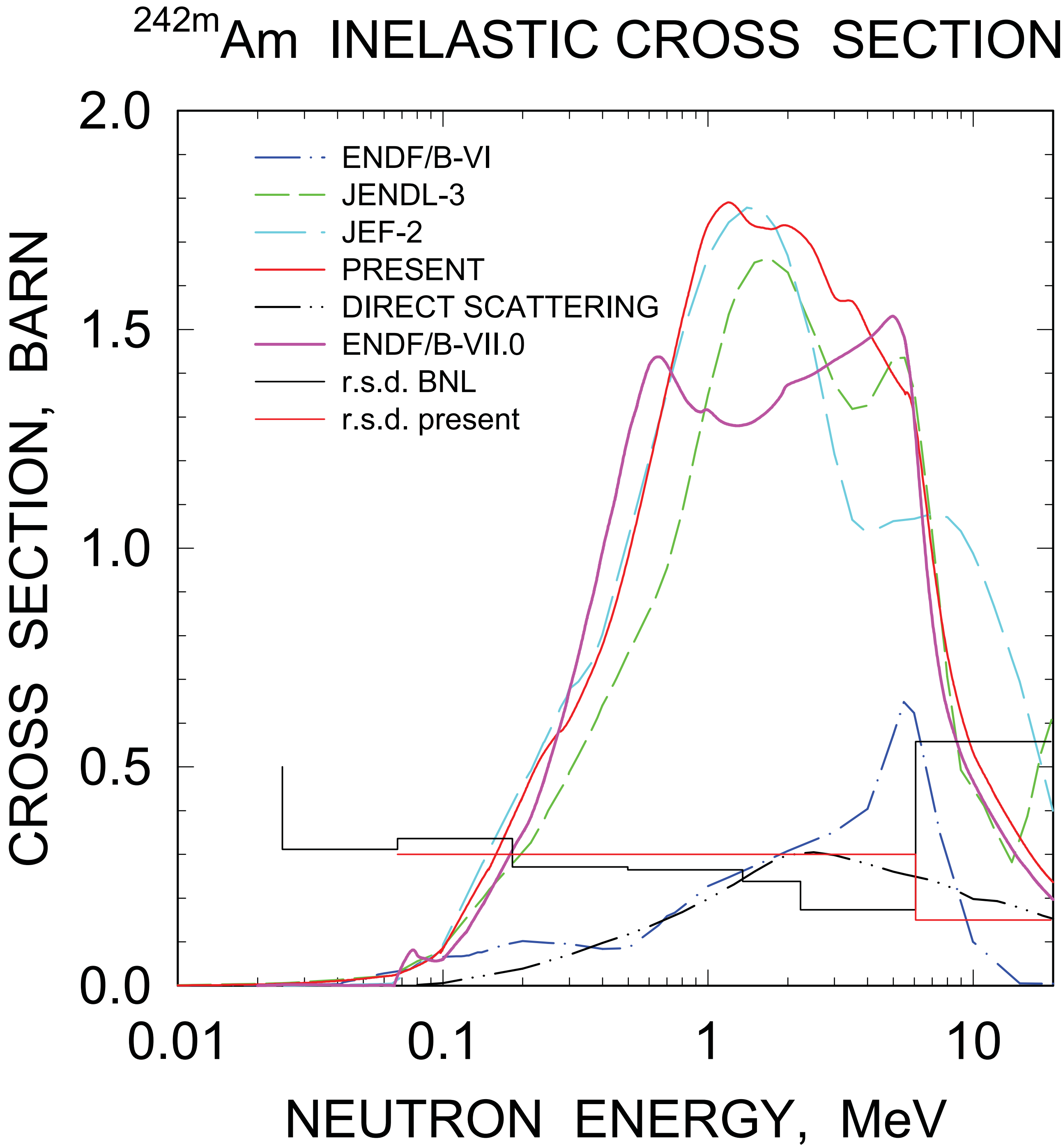


^{237}Np INELASTIC CROSS SECTION
JENDL-3 .3
ENDF/B-VII
r.s.d. BNL
r.s.d. present
W_D=3.69 MeV
CROSS SECTION, BARN
2.5
2.0
1.5
1.0
0.5
0.0
0.01
0.1
1
10
NEUTRON ENERGY, MeV


241Am INELASTIC CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0.0
0.5
1.0
1.5
2.0
2.5
0.01
0.1
1
10
PRESENT
DIRECT SCATTERING
CONTINUUM
ENDF/B-VI
JENDL-3
ENDF/B-VII
r.s.d. BNL
r.s.d. present



^{243}Am INELASTIC CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0
1
2
3
0.01
0.1
1
10
JENDL-3
ENDF/B-VI
JEF-2
PRESENT
DIRECT SCATTERING
ENDF/B-VII.0
r.s.d. BNL
r.s.d. present



^{242m}Am INELASTIC CROSS SECTION
ENDF/B-VI
JENDL-3
JEF-2
PRESENT
DIRECT SCATTERING
ENDF/B-VII.0
r.s.d. BNL
r.s.d. present
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
2.0
1.5
1.0
0.5
0.0
0.01
0.1
1
10

Chapter 5

Capture cross sections

^{232}Th: In case of ^{232}Th(n, γ) cross section, measured in [196-205], present estimate of r.s.d. for ENDF/B-VII.0 data relies on the analysis of the deficiencies of the capture data fits around 50 keV and in the range of 800-1800 keV [206, 207] (see Figs. 5.1, 5.2).

^{238}U: As regards capture cross section, fits of capture data [208-215] in JENDL-3.3 as well as ENDF/B-VII.0 cannot be considered unambiguous, especially in the energy range of 50-1000 keV (see Fig. 5.3). In ENDF/B-VII.0 [14] integral tests the indications of ^{238}U capture under prediction in B-VII.0 by 5-10% in 50 - 1000 keV are revealed. This under prediction in 200-500 keV energy range might be affected by the contribution of the d- and f- partial entrance neutron wave channels, as well as energy dependence of gamma-ray strength function. These effects were noted in case of ^{232}Th capture cross section [207] and are applicable here. That means that r.s.d. in the energy range 50-1000 kev should be increased to at least 7%. Only after getting a calculated ^{238}U capture cross section, which fits Kazakov et al. [215] data in hundreds keV energy range, its uncertainty could be claimed to be 3 % or lower. Combining differential and integral data during the production of covariance data, but not after, implicitly or explicitly, is of the utmost importance.

^{236}U: the deviations between measured data [208, 216-219] and capture cross sections of ENDF/B-VII.0, present and our previous [220] calculations look very similar to those observed for ^{238}U target. We assume the same r.s.d. as for the ^{238}U(n, γ) and ^{232}Th(n, γ) cross section (see Fig. 5.4).

^{234}U: the deviations between capture cross sections of ENDF/B-VII.0 and evaluated data by Maslov et al. [21] are rather large, measured data are scarce [221]. R.s.d. for ENDF/B-VII.0 are somewhat increased to reflect these differences (see Fig. 5.5).

^{238}Pu: the deviations between capture cross sections of ENDF/B-VII.0 and evaluated data by Maslov et al. [32] are extremely large (see Fig. 5.6). It seems to be due to fission and neutron competition differences in calculation procedures. However, in second energy group the relative standard deviation (r.s.d.) is comparable to that of ^{238}U target nuclide, and in 3d group it is even better. R.s.d. for ENDF/B-VII.0 should be severely increased to reflect these differences.

^{240}Pu: calculated ^{240}Pu(n, γ) reaction cross section shape is much similar to that, observed experimentally for the ^{238}U(n, γ) and ^{232}Th(n, γ) reaction cross sections (see Fig. 5.7). Differences are due to fission and neutron emission competition, which depends on the (Z,N)-composition of the compound nuclide. The first Wigner' cusp is observed around first rotation level excitation threshold, another two cusps are due to further increases in neutron and then fission competition. Decreasing trend in Weston and Todd [222] data needs to be checked experimentally. Similar cross section shape is reproduced in JENDL-3.3 data file, absolute differences are due to inherent approximations of evaluation procedures of JENDL-3.3. R.s.d. for ENDF/B-VII.0 should be severely increased at E_n>100 keV to reflect the cross section shape differences.

^{242}Pu: calculated ^{242}Pu(n, γ) [223-225] reaction cross section shape is much similar to that, observed experimentally for the ^{238}U(n, γ) and ^{232}Th(n, γ) reaction cross sections (see Fig. 5.8). It resembles the shape of ^{240}Pu(n, γ) reaction cross section, the differences above 100 keV are due to decreased fission competition. Differences are due to fission and neutron emission competition, which depends on the (Z,N)-composition of the compound nuclide. The first Wigner' cusp is observed around first rotation level excitation threshold, another two cusps, which are more prominent, than in case of ^{240}Pu(n, γ) reaction cross section are due to decreased fission competition. Decreasing trend in Wisshak et al. [224] data needs to be checked experimentally. Similar cross section shape is reproduced in JENDL-3.3 evaluation, absolute differences are due to inherent approximations of evaluation procedures of JENDL-3.3. R.s.d. for ENDF/B-VII.0 should be severely increased at E_n>200 keV to reflect the cross section absolute value and shape differences. Moreover so, that BNL estimate for ^{242}Pu(n, γ) is better than that of ^{238}U(n, γ) in 2nd and 3rd groups.

^{242}Cm: calculated ^{242}Cm(n, γ) reaction cross section shape further demonstrates the influence of the fission competition via (n, γ)/(n, f) and (n, γf) reactions. The cusps are even less pronounced than in case of ^{240}Pu(n, γ) reaction (see Fig. 5.9). JENDL-3.3 and ENDF/B-VII.0 evaluations severely distort the cross section shape, absolute differences are due to inherent approximations of evaluation procedures of JENDL-3.3. R.s.d. for ENDF/B-VII.0 should be severely increased to reflect the cross section absolute value and shape inconsistencies with theoretical estimates, obtained with proven theoretical methods.

^{244}Cm: calculated ^{244}Cm(n, γ) reaction cross section shape further demonstrates the influence of the fission competition via (n, γ)/(n, f) and (n, γf) reactions. The cusps are more pronounced than in case of ^{242}Cm(n, γ) reaction (see Fig. 5.10). JENDL-3.3 evaluation, adopted for ENDF/B-VII.0 data library predict rather exotic cross section shape at E_n>1 MeV. Previous evaluations severely distort the cross section shape, absolute differences are due to inherent approximations of evaluation procedures of JENDL-3.3. R.s.d. for ENDF/B-VII.0 should be severely increased to reflect the cross section absolute value and shape inconsistencies with theoretical estimates, obtained with proven theoretical methods.

^{233}U, ^{235}U, ^{239}Pu: capture cross sections of fissile nuclides demonstrate most vividly the influence of target spin differences, fission transition states spectroscopy and fission/gamma-emission competition on capture cross section shape and absolute values. In all cases the capture cross sections were obtained via consistent description of fission and elastic/inelastic scattering. In case of $^{235}U(n, \gamma)$ [226-231] reasonable values of average resonance parameters support the high values of capture cross section around 10 keV (see Fig. 5.11). In case of $^{233}U(n, \gamma)$ [226, 232] reasonable values of average resonance parameters provide a consistent description of capture data in keV- and MeV-energy ranges (see Fig. 5.12). To explain the biases of $^{233}U(n, \gamma)$ and $^{235}U(n, \gamma)$ evaluations of ENDF/B-VII.0 relative to measured data by Weston et al. [232] and Muradyan et al. [231], respectively, robust argument should be provided. That would make possible to assess the estimates of r.s.d for capture cross sections of other fissile nuclides.

In case of $^{239}Pu(n, \gamma)$ [226, 228, 229, 233, 234, 235] the structure at E_n below 5 keV is defined by fission via 1^+ sub-threshold transition states (see Fig. 5.13). At E_n around 100 keV there are systematic differences in measured data trends.

R.s.d. for $^{235}U(n, \gamma)$ reaction cross section reflects the differences of JENDL-3.3 evaluated data from measured data and present calculation and ENDF/B-VII.0 evaluation.

R.s.d. for $^{233}U(n, \gamma)$ reaction cross section reflects the differences of ENDF/B-VII.0 evaluated data from measured data and present calculation.

R.s.d. for $^{239}Pu(n, \gamma)$ reaction cross section reflects the differences of JENDL-3.3 evaluated data from measured data and present calculation and ENDF/B-VII.0 evaluation.

^{241}Pu: Shape of the calculated $^{241}Pu(n, \gamma)$ capture cross section resemble more closely that of $^{233}U(n, \gamma)$, than that of $^{239}Pu(n, \gamma)$ (see Fig. 5.14). That is the consequence of the target spin differences, fission transition states spectroscopy and fission/gamma-emission competition. JENDL-3.3 evaluated data differ very much from both from ENDF/B-VII.0 evaluation and present calculation in 100 –1000 kev energy range. measured data and present calculation and ENDF/B-VII.0 evaluation. R.s.d. for $^{241}Pu(n, \gamma)$ reaction cross section reflects the differences of ENDF/B-VII.0 evaluation from present calculation, which is based on fission data description.

^{243}Cm: R.s.d. for $^{243}Cm(n, \gamma)$ reaction cross section reflects the differences of JENDL-3.1 evaluated data from data and present calculation adopted for JENDL-3.2 and ENDF/B-VII.0 evaluation (see Fig. 5.15).

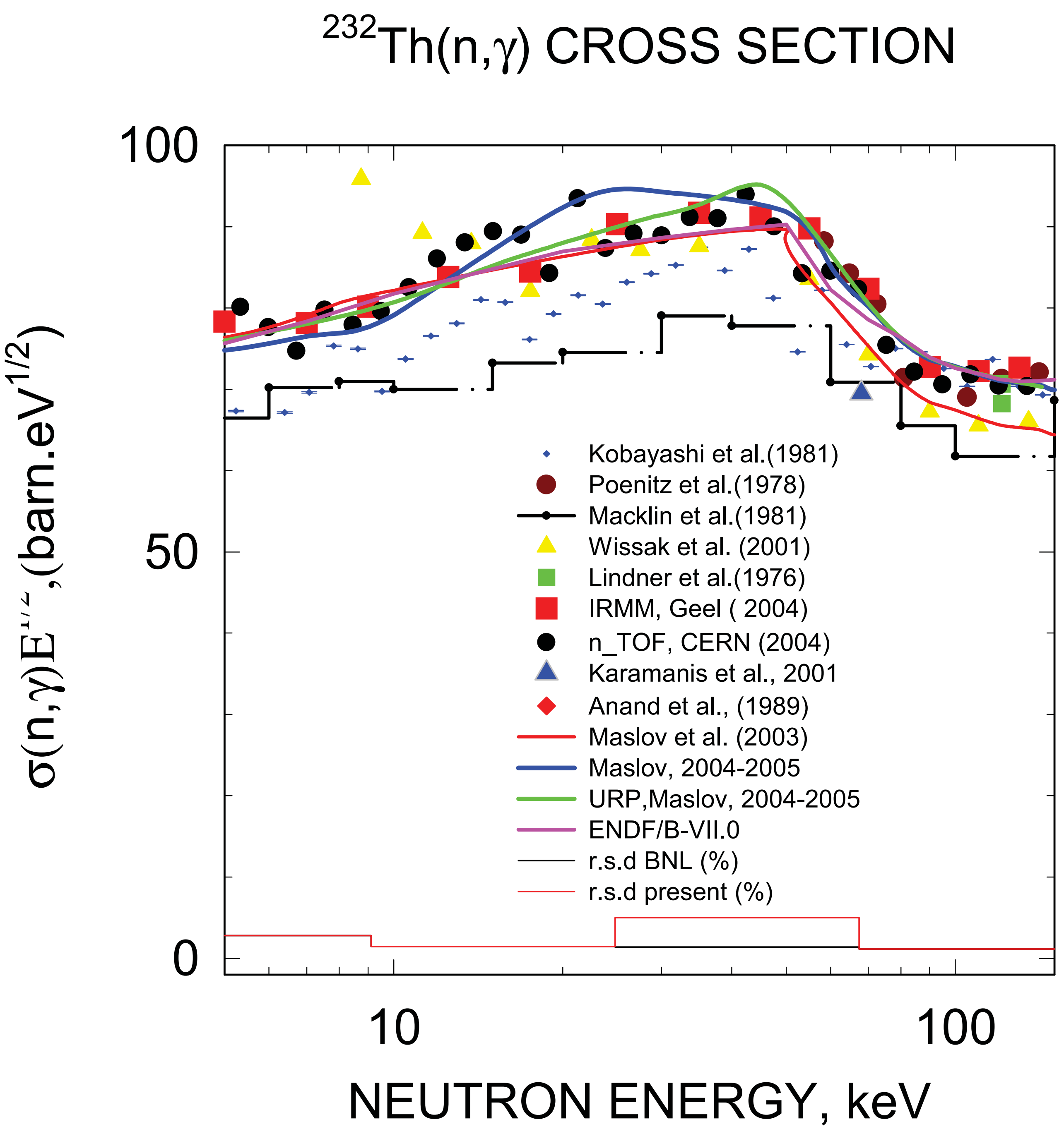
^{245}**Cm:** R.s.d. for ^{245}Cm(n, γ) reaction cross section reflects the differences of JENDL-3.1 evaluated data from data and present calculation adopted for JENDL-3.2 and ENDF/B-VII.0 evaluation (see Fig. 5.16).

^{237}**Np:** R.s.d. for ^{237}Np(n, γ) reaction cross section reflects the differences of ENDF/B-VII.0 evaluated data from measured data [208, 236-239], other evaluated data and present calculation (see Fig. 5.17).

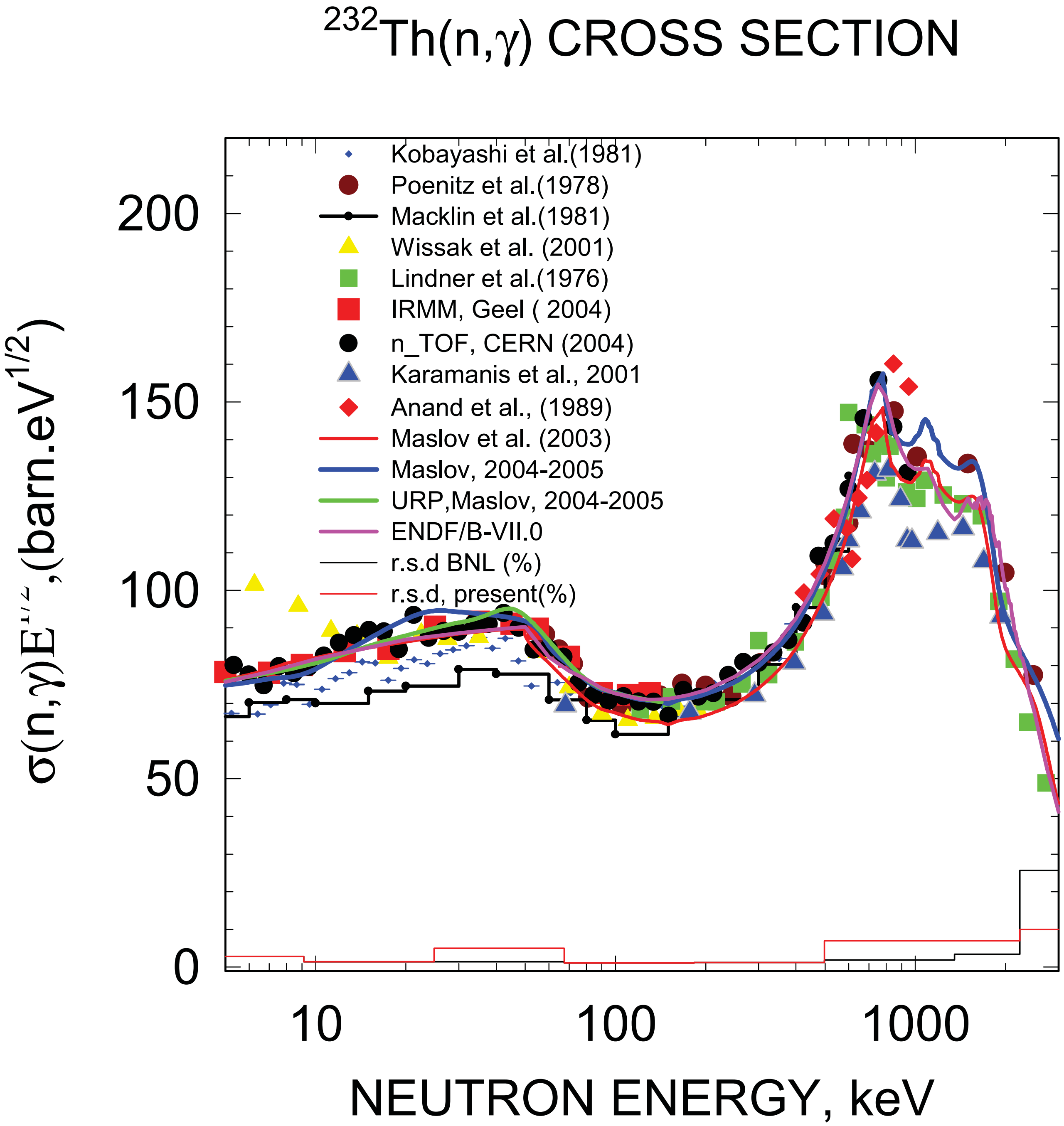
^{241}**Am:** ENDF/B-VII.0 evaluation is quite compatible with evaluation by Maslov et al. [17], though systematic differences are observed in measured data [240-242]. Some differences are observed only in 4-6 groups. R.s.d. for ^{241}Am(n, γ) reaction cross section reflects these differences of ENDF/B-VII.0 evaluated data from evaluation by Maslov et al. [17], much differing from these both early JENDL-2 evaluation was superseded by evaluation by Maslov et al. [17] (see Fig. 5.18).

^{243}**Am:** ENDF/B-VII.0 evaluation is a bit less compatible with evaluation by Maslov et al. [18], than in case of ^{241}Am(n, γ) reaction (see Fig. 5.19). Systematic differences are observed in measured data [243, 244]. Differences are observed in 4-6 groups. R.s.d. for ^{243}Am(n, γ) reaction cross section reflects these differences of ENDF/B-VII.0 evaluated data from evaluation by Maslov et al. [18], much differing from these both early JENDL-2 evaluation was superseded by evaluation by Maslov et al. [18].

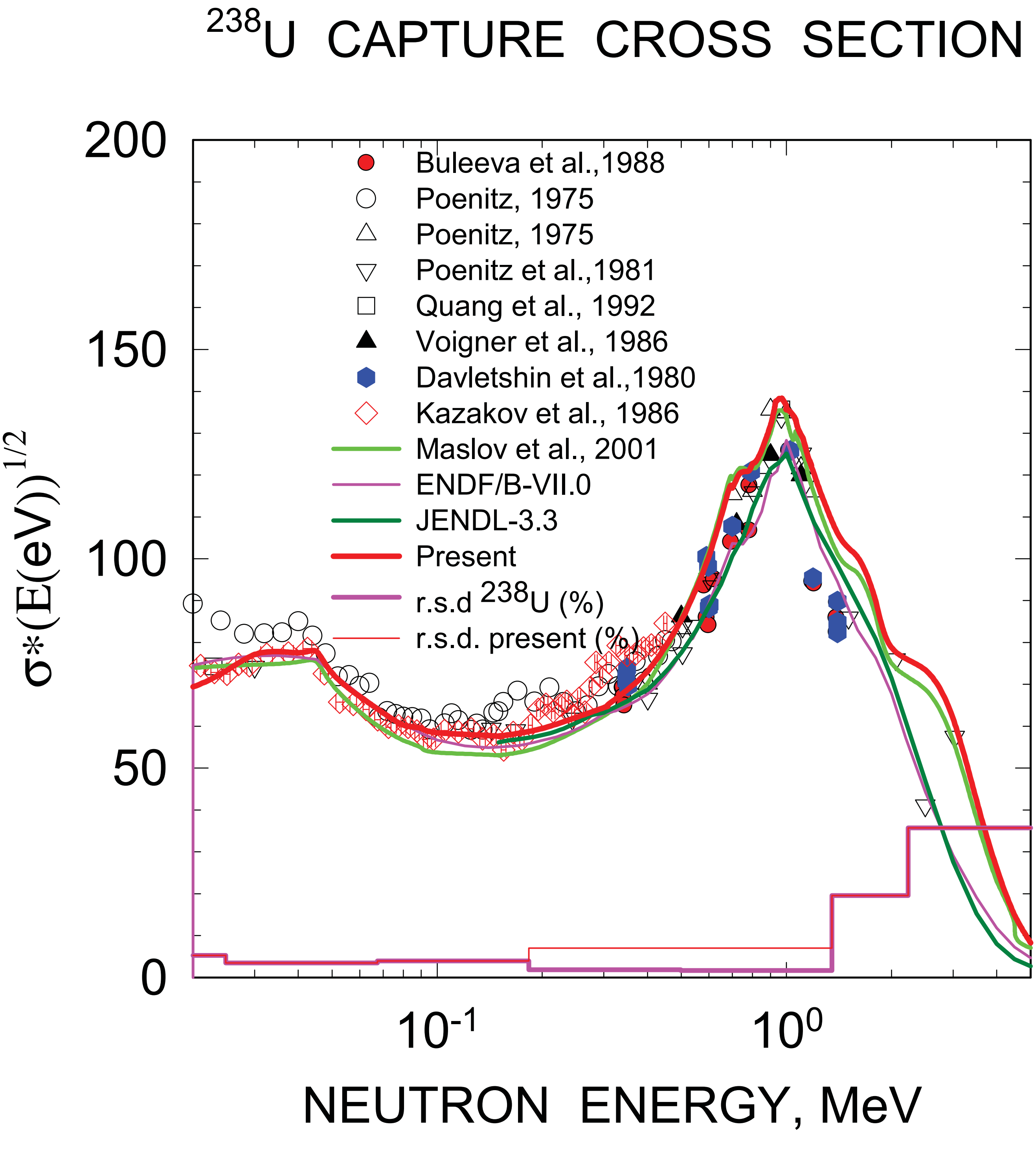
^{242m}**Am:** ENDF/B-VII.0 evaluation is much different from evaluation by Maslov et al. [30], differences are observed from 1 keV to 20 MeV (see Fig. 5.20). R.s.d. for ^{242m}Am(n, γ) reaction cross section reflects these differences of ENDF/B-VII.0 evaluated data from evaluation by Maslov et al. [30], much differing from these both early JENDL-2 evaluation was superseded by evaluation by Maslov et al. [30].



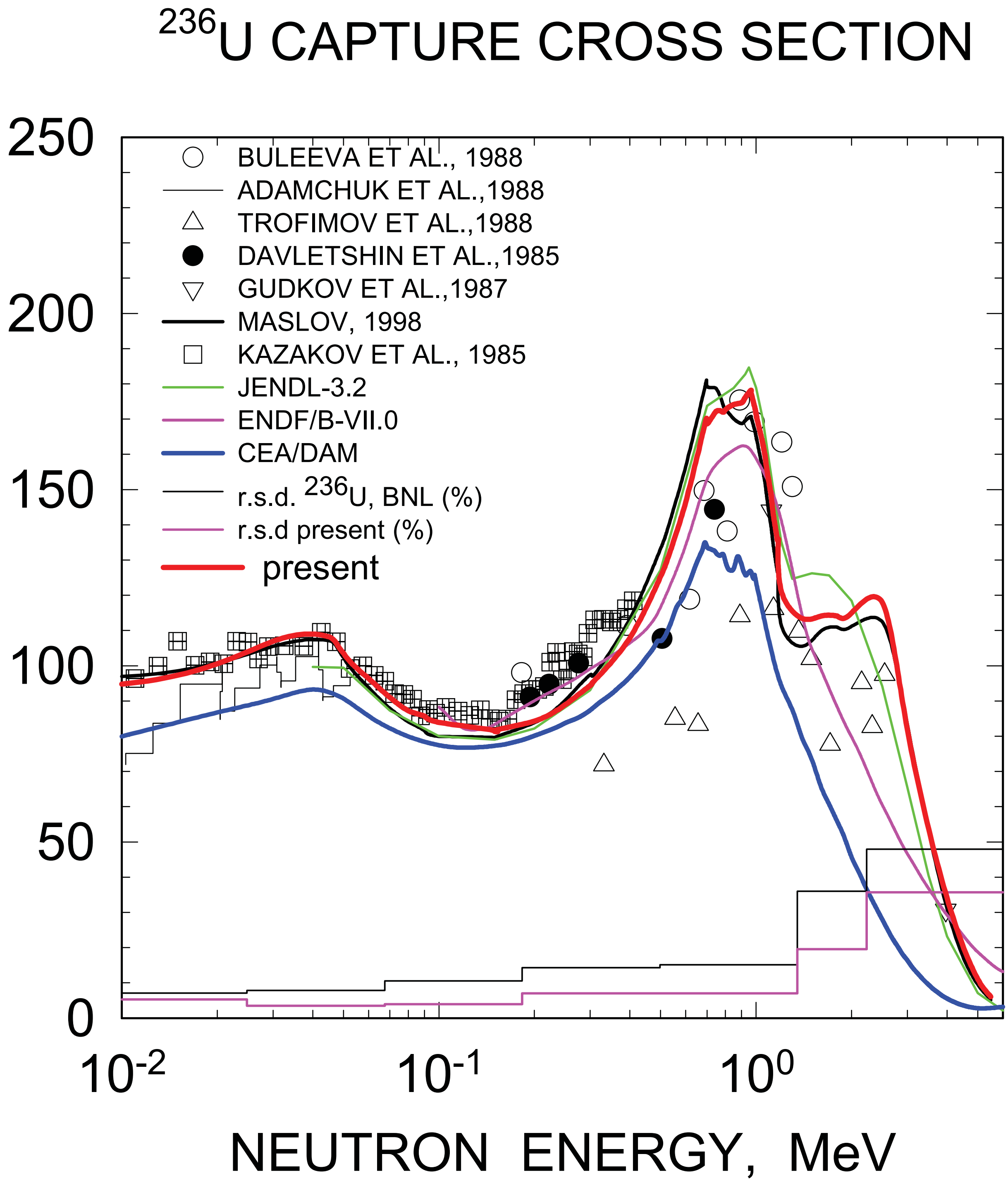
^{232}Th(n,γ) CROSS SECTION
100
50
0
10
100
NEUTRON ENERGY, keV
σ(n,γ)E$^{1/2}$,(barn.eV$^{1/2}$)
Kobayashi et al.(1981)
Poenitz et al.(1978)
Macklin et al.(1981)
Wissak et al. (2001)
Lindner et al.(1976)
IRMM, Geel (2004)
n_TOF, CERN (2004)
Karamanis et al., 2001
Anand et al., (1989)
Maslov et al. (2003)
Maslov, 2004-2005
URP,Maslov, 2004-2005
ENDF/B-VII.0
r.s.d BNL (%)
r.s.d present (%)



^{232}Th(n,γ) CROSS SECTION
Kobayashi et al.(1981)
Poenitz et al.(1978)
Macklin et al.(1981)
Wissak et al. (2001)
Lindner et al.(1976)
IRMM, Geel (2004)
n_TOF, CERN (2004)
Karamanis et al., 2001
Anand et al., (1989)
Maslov et al. (2003)
Maslov, 2004-2005
URP,Maslov, 2004-2005
ENDF/B-VII.0
r.s.d BNL (%)
r.s.d, present(%)
σ(n,γ)E$^{1/2}$,(barn.eV$^{1/2}$)
200
150
100
50
0
10
100
1000
NEUTRON ENERGY, keV

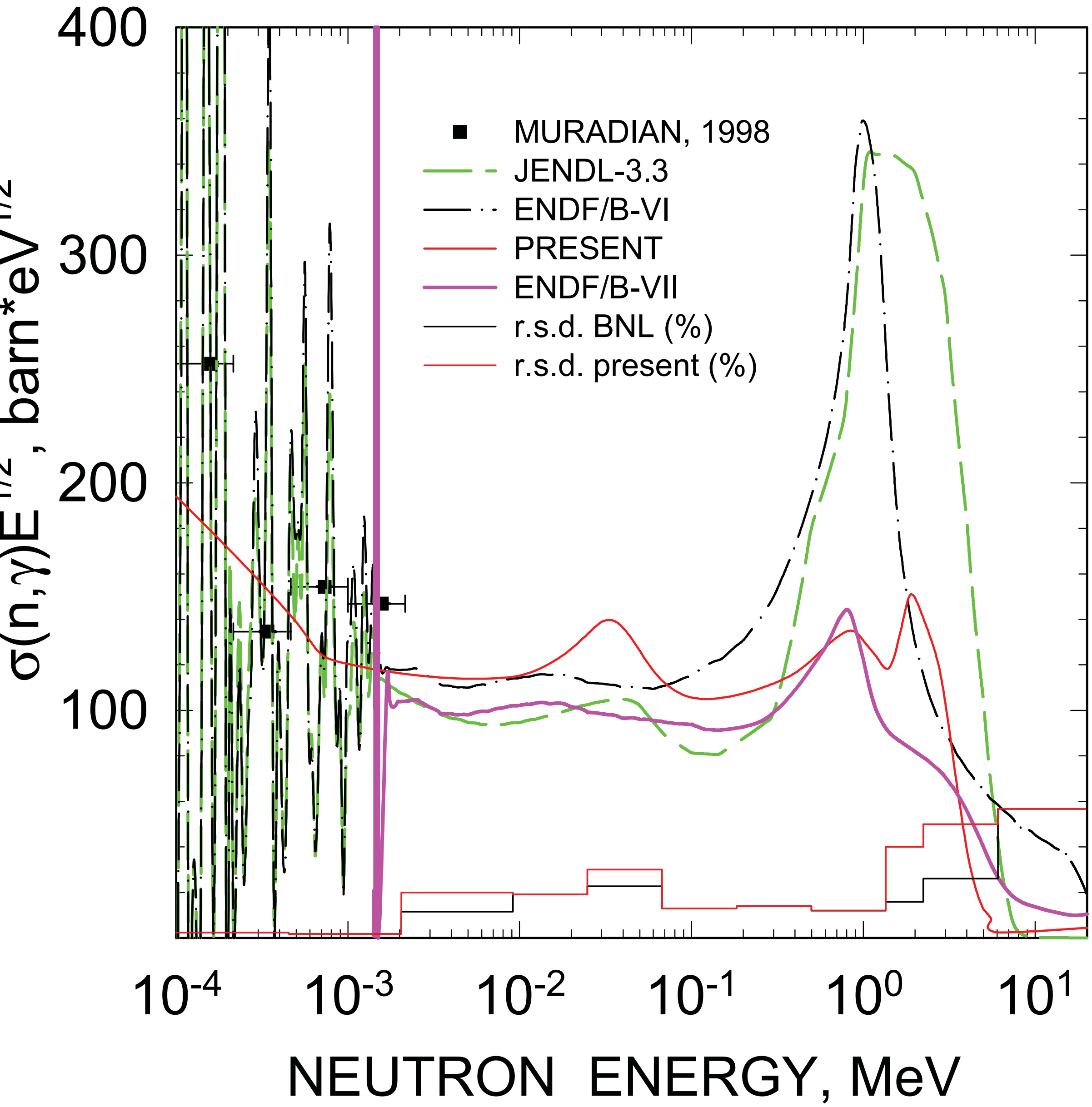


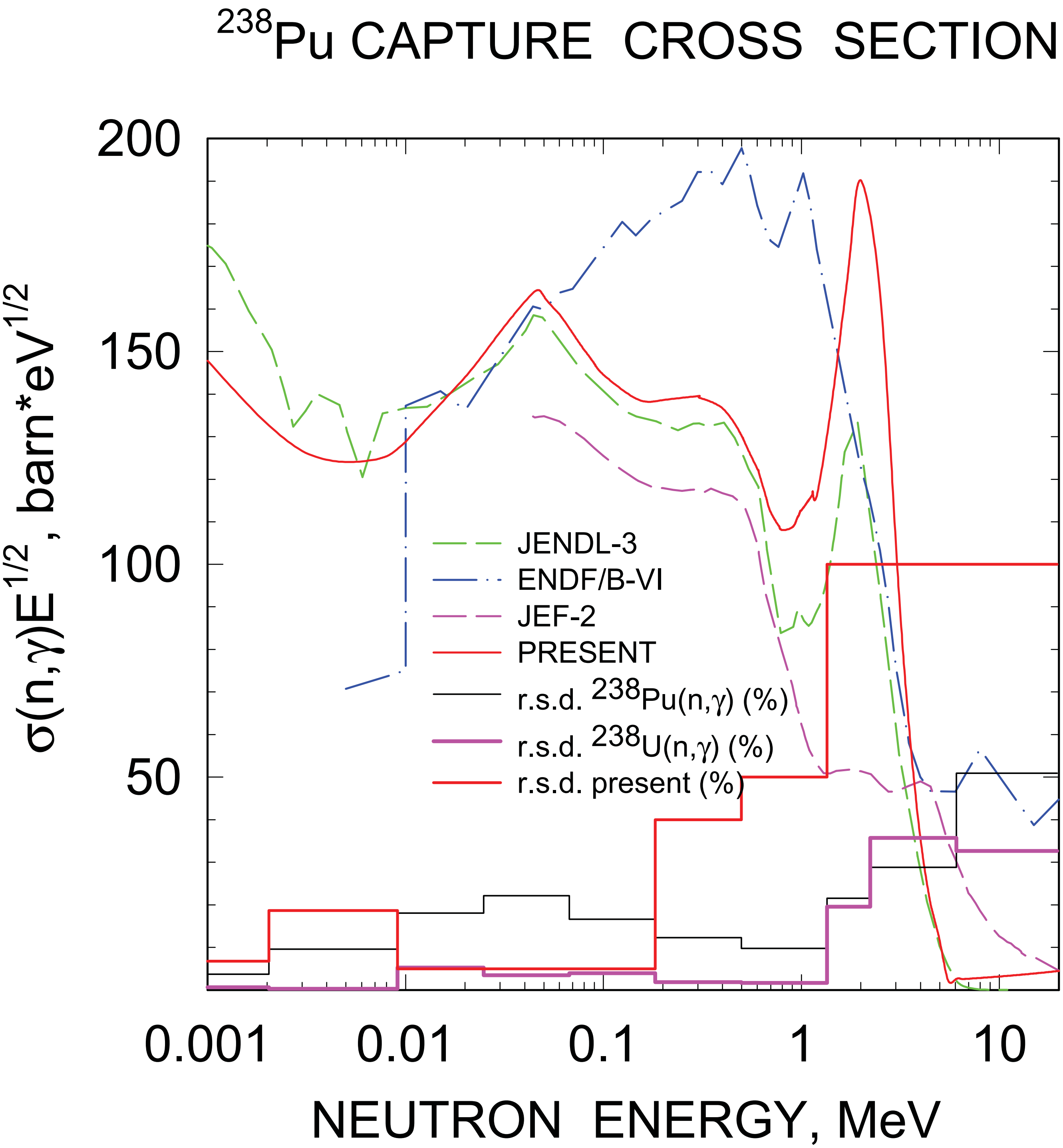
^{238}U CAPTURE CROSS SECTION
200
150
100
50
0
$\sigma*(E(eV))^{1/2}$
Buleeva et al.,1988
Poenitz, 1975
Poenitz, 1975
Poenitz et al.,1981
Quang et al., 1992
Voigner et al., 1986
Davletshin et al.,1980
Kazakov et al., 1986
Maslov et al., 2001
ENDF/B-VII.0
JENDL-3.3
Present
r.s.d ^{238}U (%)
r.s.d. present (%)
10^{-1}
10^{0}
NEUTRON ENERGY, MeV



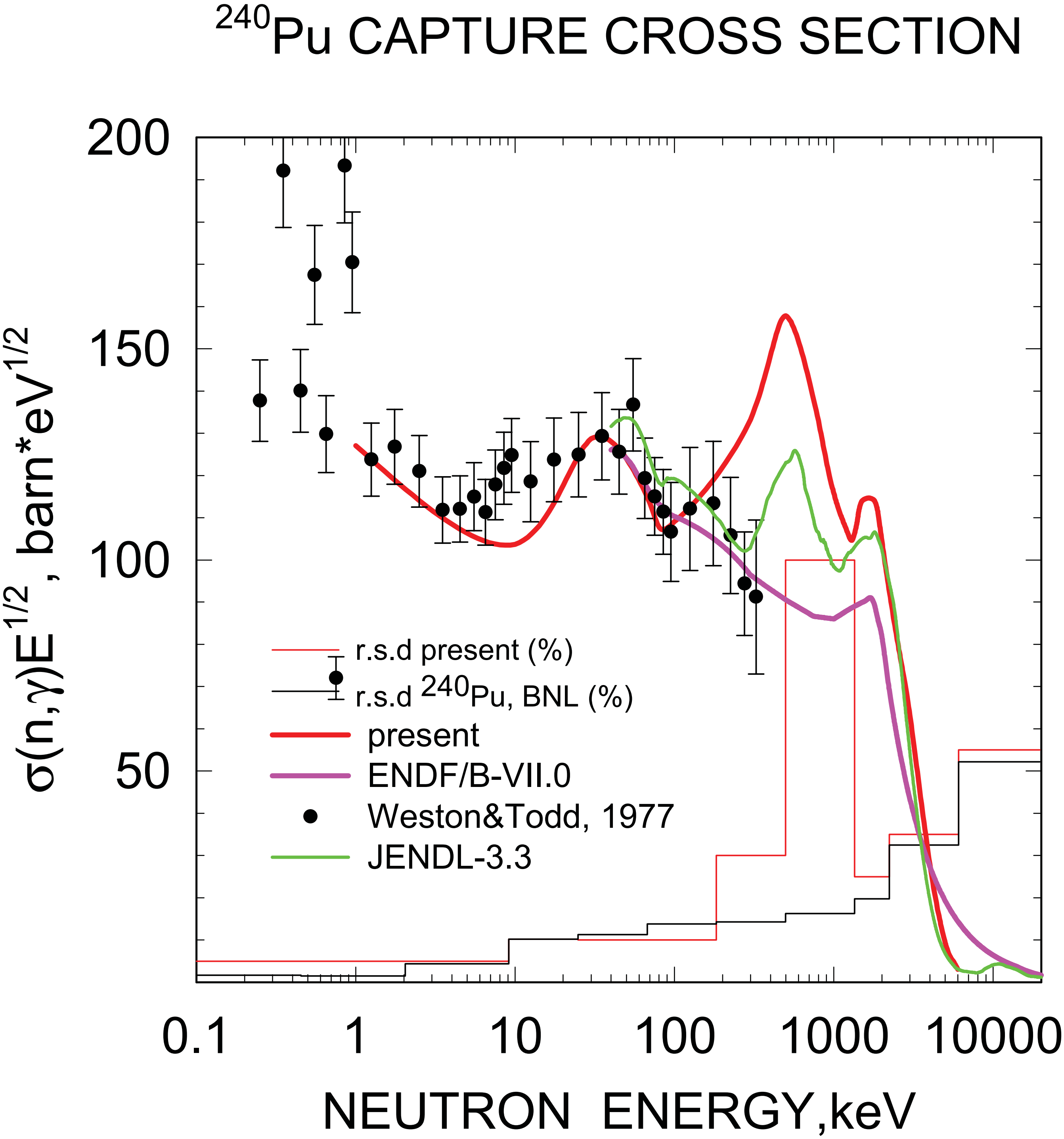
236U CAPTURE CROSS SECTION
250
200
150
100
50
0
BULEEVA ET AL., 1988
ADAMCHUK ET AL.,1988
TROFIMOV ET AL.,1988
DAVLETSHIN ET AL.,1985
GUDKOV ET AL.,1987
MASLOV, 1998
KAZAKOV ET AL., 1985
JENDL-3.2
ENDF/B-VII.0
CEA/DAM
r.s.d. 236U, BNL (%)
r.s.d present (%)
present
10-2
10-1
100
NEUTRON ENERGY, MeV

^{234}U (*n*,γ) CROSS SECTION

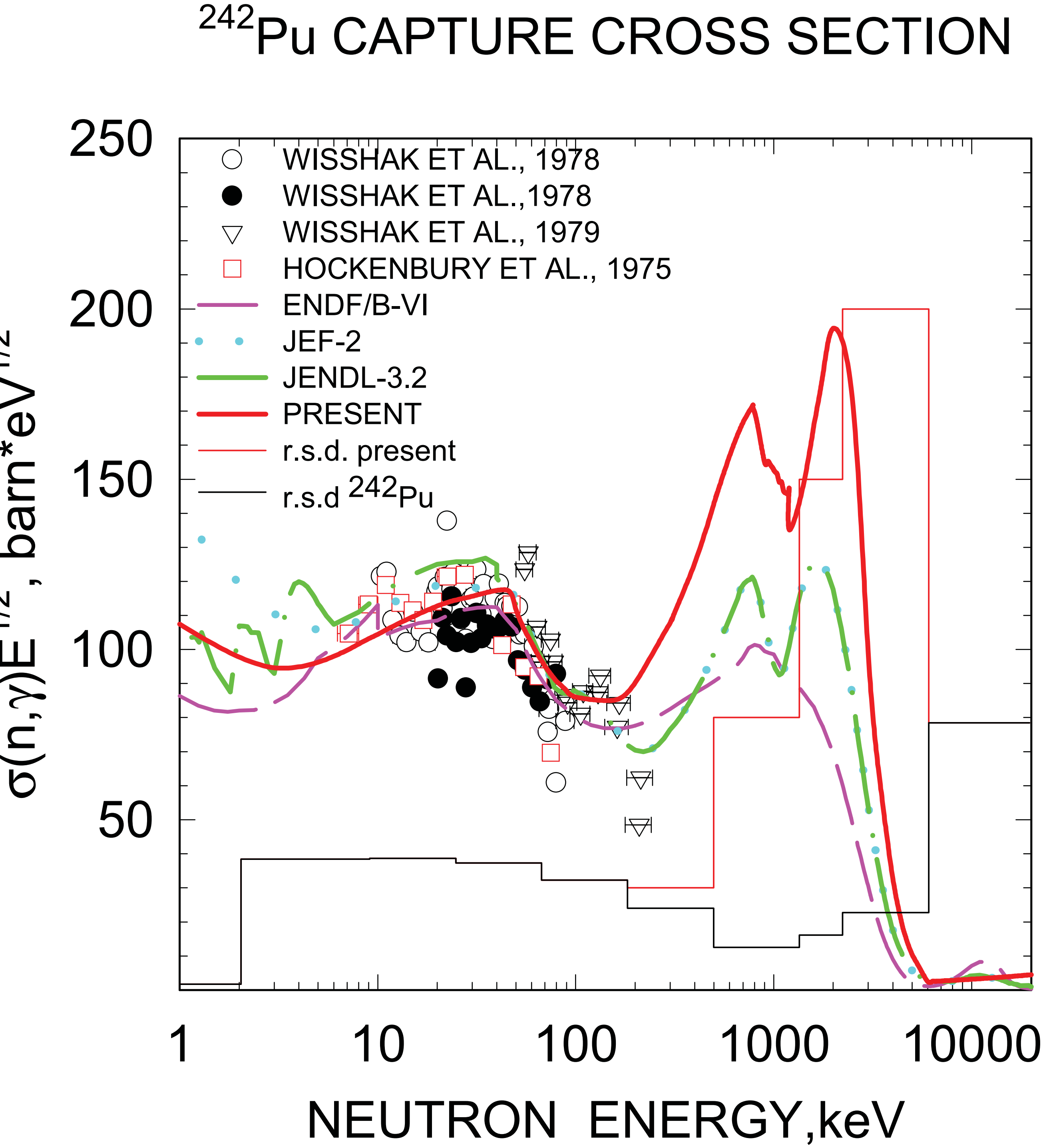




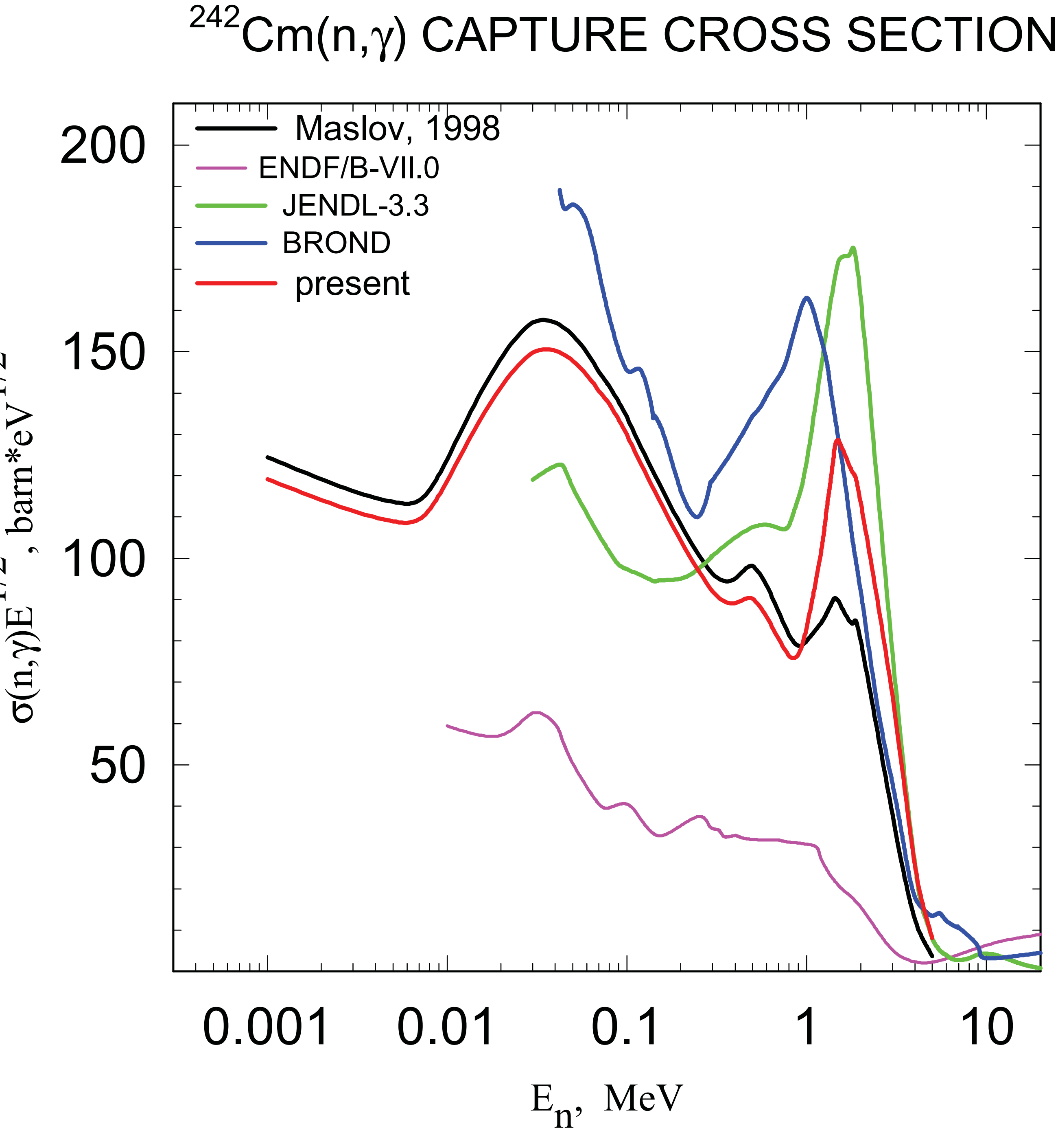
^{238}Pu CAPTURE CROSS SECTION
$\sigma(n,\gamma)E^{1/2}$, barn*eV$^{1/2}$
200
150
100
50
0.001
0.01
0.1
1
10
NEUTRON ENERGY, MeV
JENDL-3
ENDF/B-VI
JEF-2
PRESENT
r.s.d. ^{238}Pu(n,γ) (%)
r.s.d. ^{238}U(n,γ) (%)
r.s.d. present (%)



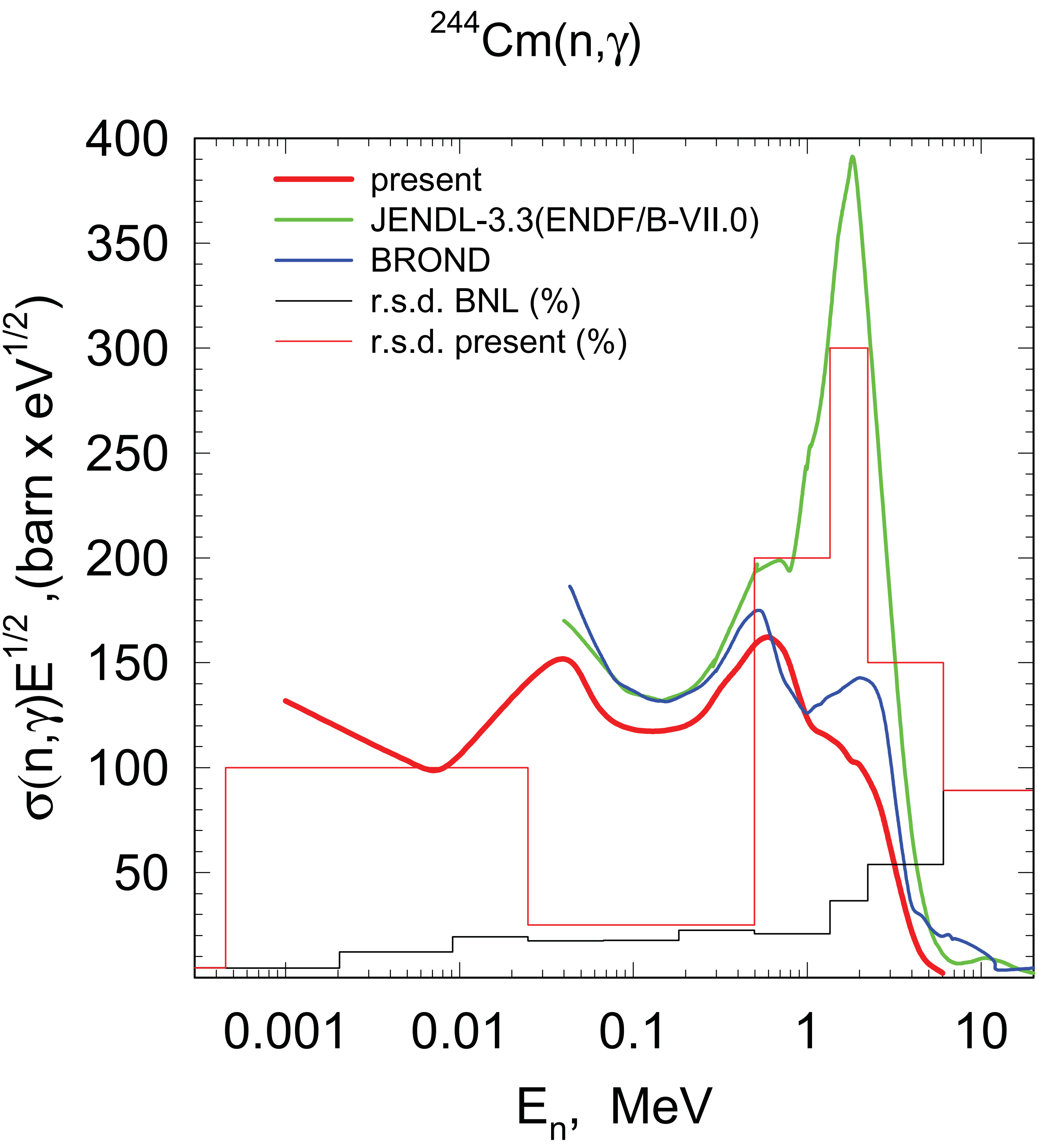
240Pu CAPTURE CROSS SECTION
σ(n,γ)E1/2, barn*eV1/2
200
150
100
50
0.1
1
10
100
1000
10000
NEUTRON ENERGY,keV
r.s.d present (%)
r.s.d 240Pu, BNL (%)
present
ENDF/B-VII.0
Weston&Todd, 1977
JENDL-3.3



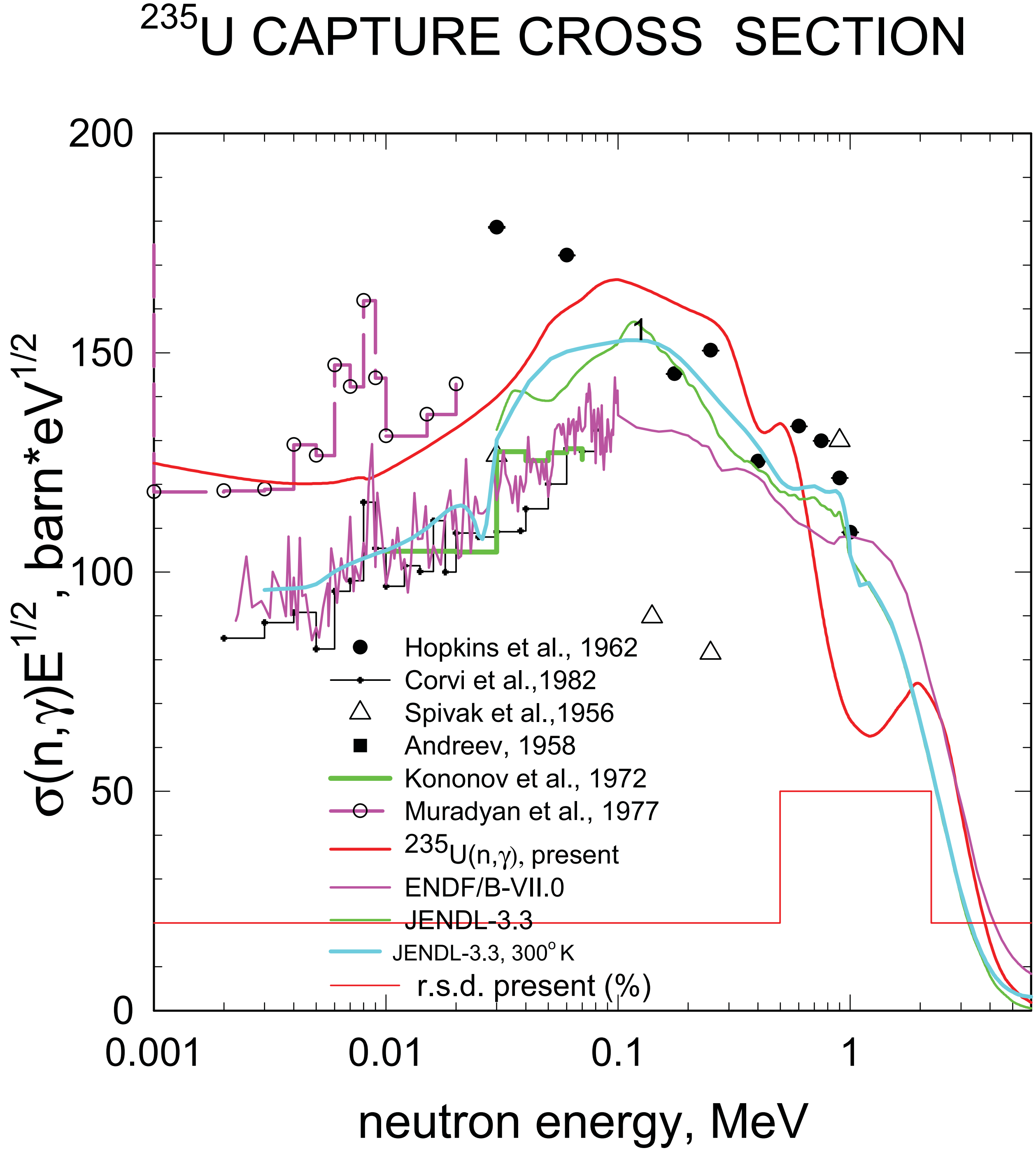
242Pu CAPTURE CROSS SECTION
σ(n,γ)E1/2, barn*eV1/2
NEUTRON ENERGY,keV
WISSHAK ET AL., 1978
WISSHAK ET AL.,1978
WISSHAK ET AL., 1979
HOCKENBURY ET AL., 1975
ENDF/B-VI
JEF-2
JENDL-3.2
PRESENT
r.s.d. present
r.s.d 242Pu
250
200
150
100
50
1
10
100
1000
10000



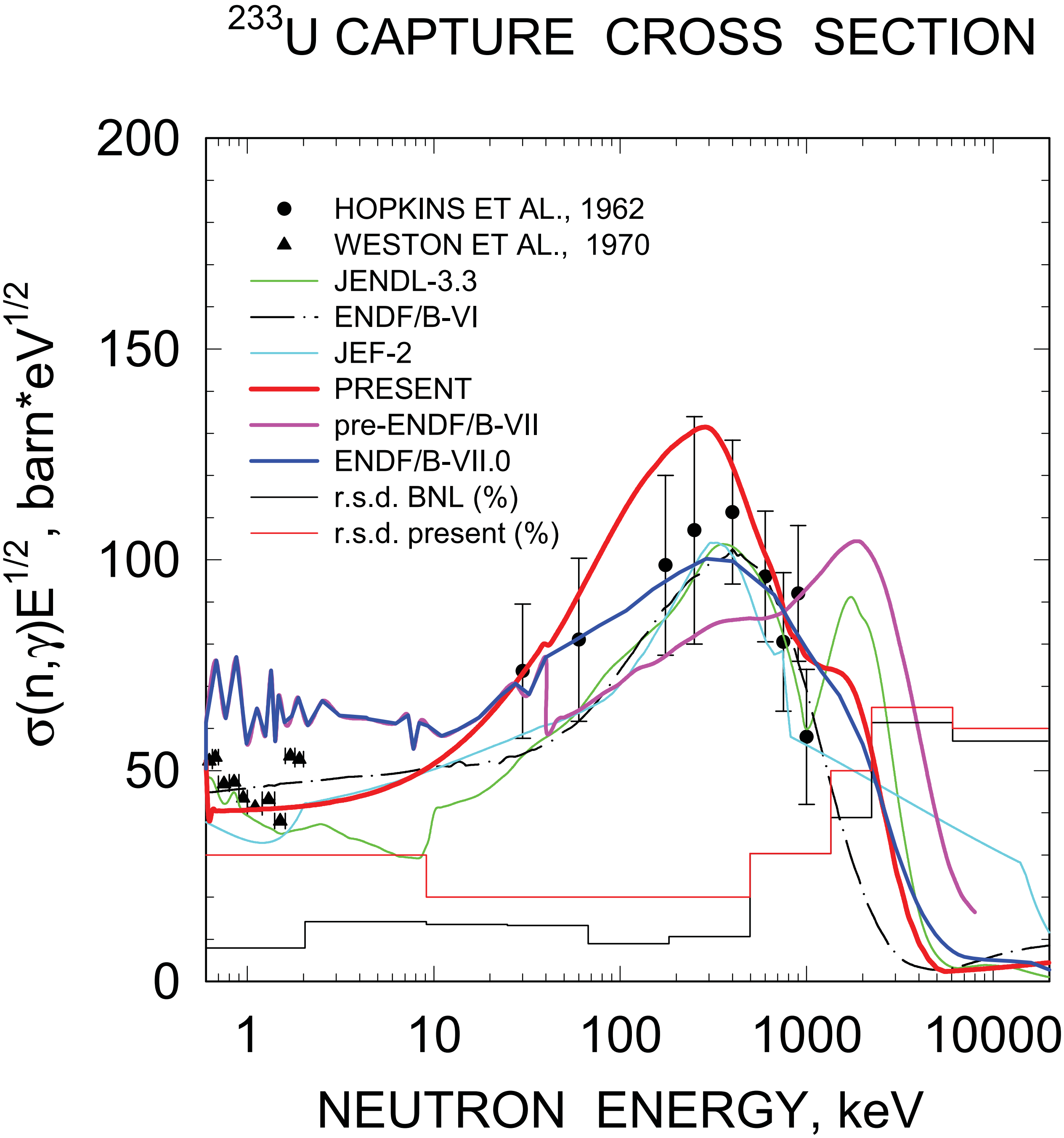
^{242}Cm(n,γ) CAPTURE CROSS SECTION
Maslov, 1998
ENDF/B-VII.0
JENDL-3.3
BROND
present
200
150
100
50
0.001
0.01
0.1
1
10
$\sigma(n,\gamma)E^{1/2}$, barn*eV$^{1/2}$
E_n, MeV



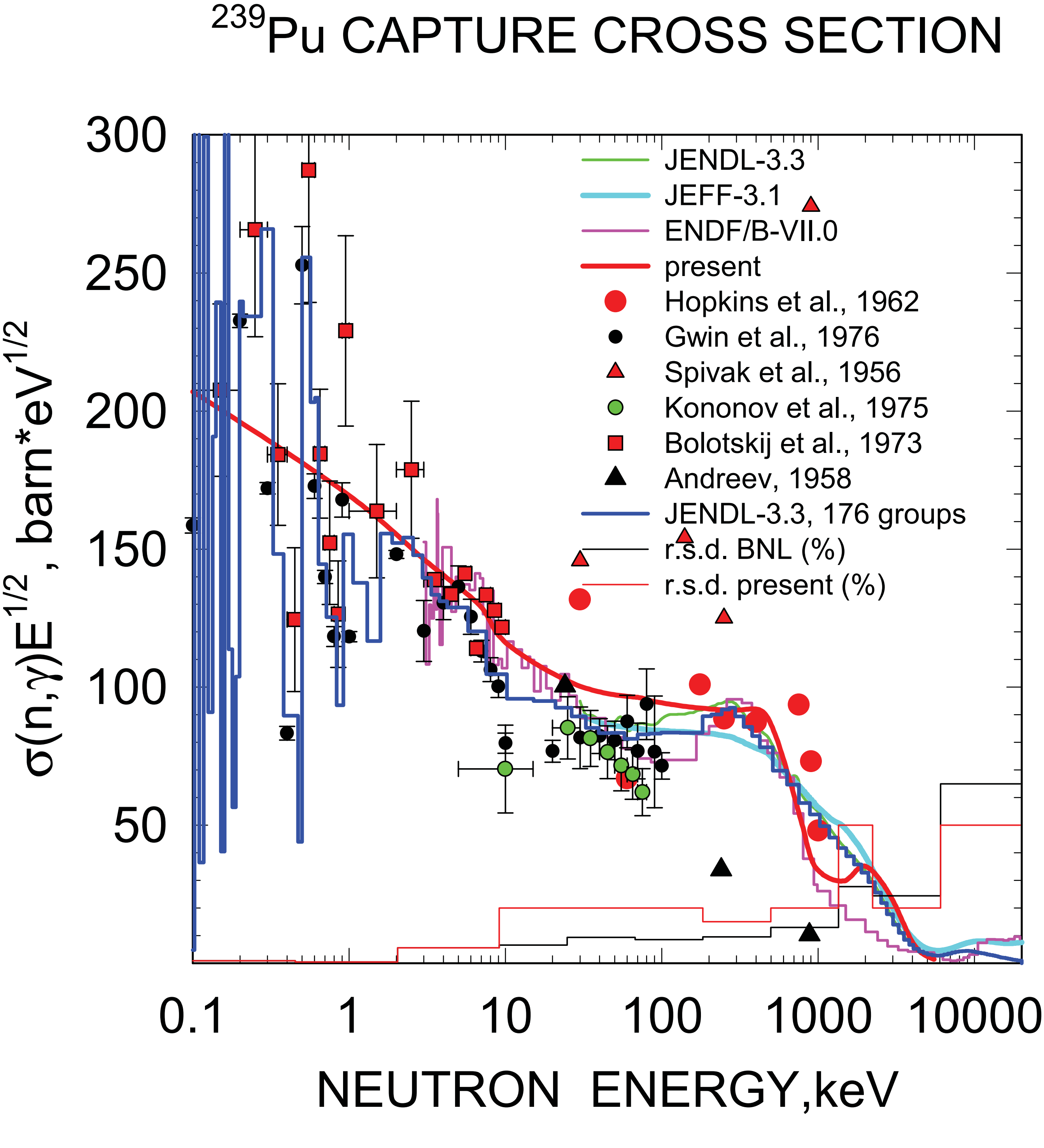
^{244}Cm(n,γ)
present
JENDL-3.3(ENDF/B-VII.0)
BROND
r.s.d. BNL (%)
r.s.d. present (%)
$\sigma(n,\gamma)E^{1/2}$,(barn x eV$^{1/2}$)
400
350
300
250
200
150
100
50
0.001
0.01
0.1
1
10
E_n, MeV



235U CAPTURE CROSS SECTION
σ(n,γ)E1/2, barn*eV1/2
200
150
100
50
0
0.001
0.01
0.1
1
neutron energy, MeV
Hopkins et al., 1962
Corvi et al.,1982
Spivak et al.,1956
Andreev, 1958
Kononov et al., 1972
Muradyan et al., 1977
235U(n,γ), present
ENDF/B-VII.0
JENDL-3.3
JENDL-3.3, 300° K
r.s.d. present (%)

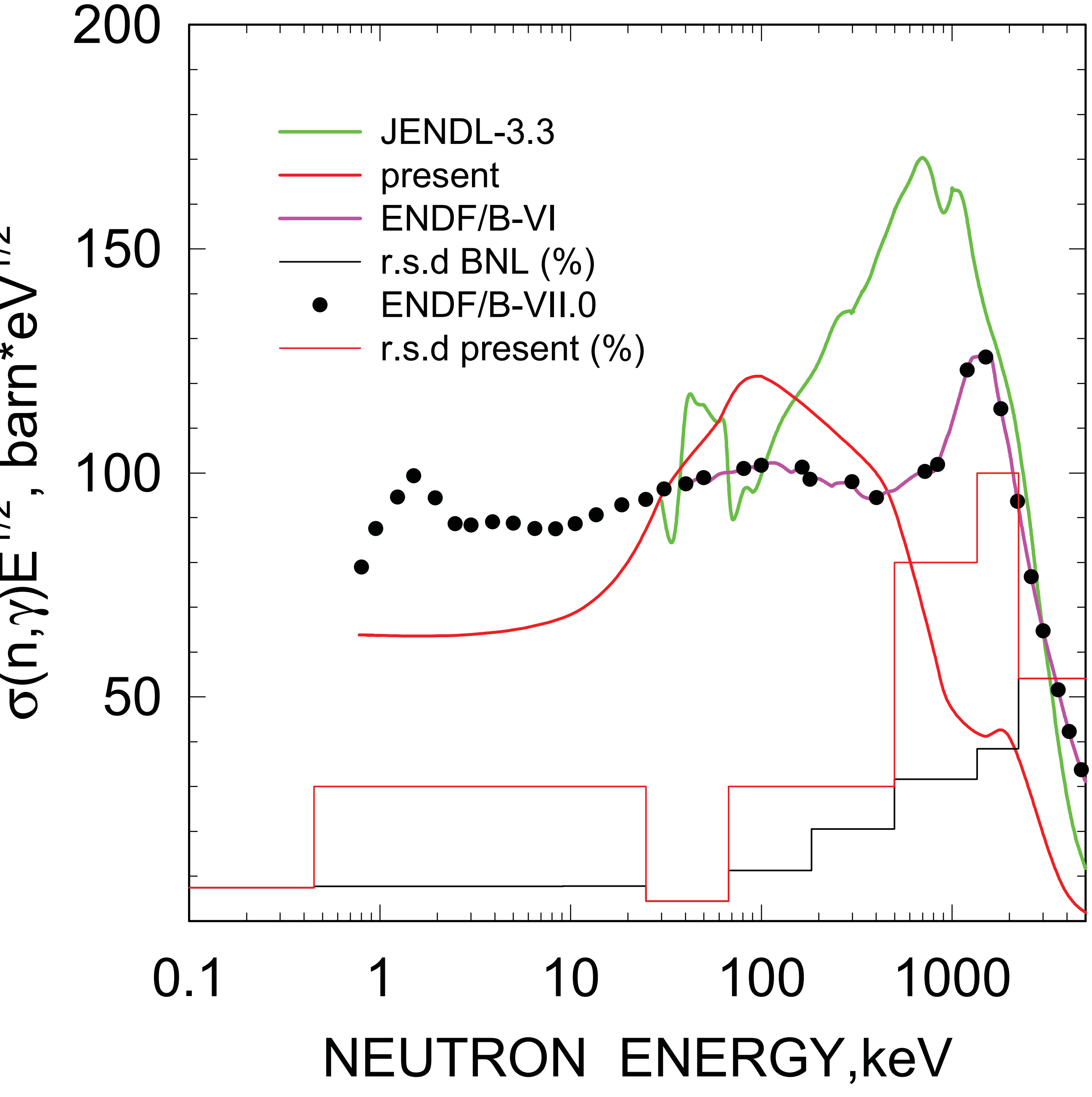


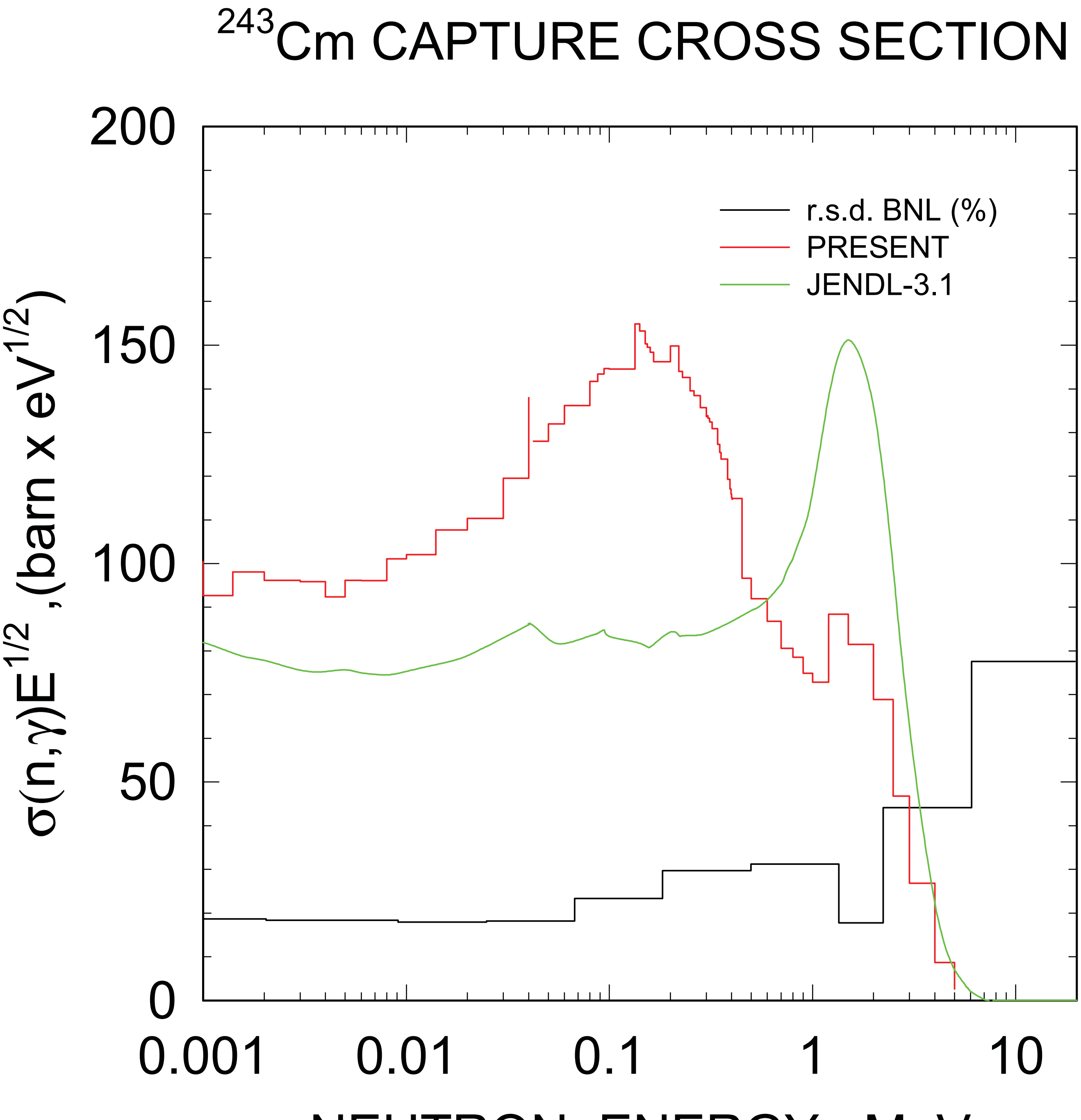
^{233}U CAPTURE CROSS SECTION
HOPKINS ET AL., 1962
WESTON ET AL., 1970
JENDL-3.3
ENDF/B-VI
JEF-2
PRESENT
pre-ENDF/B-VII
ENDF/B-VII.0
r.s.d. BNL (%)
r.s.d. present (%)
200
150
100
50
0
1
10
100
1000
10000
$\sigma(n,\gamma)E^{1/2}$, barn*eV$^{1/2}$
NEUTRON ENERGY, keV



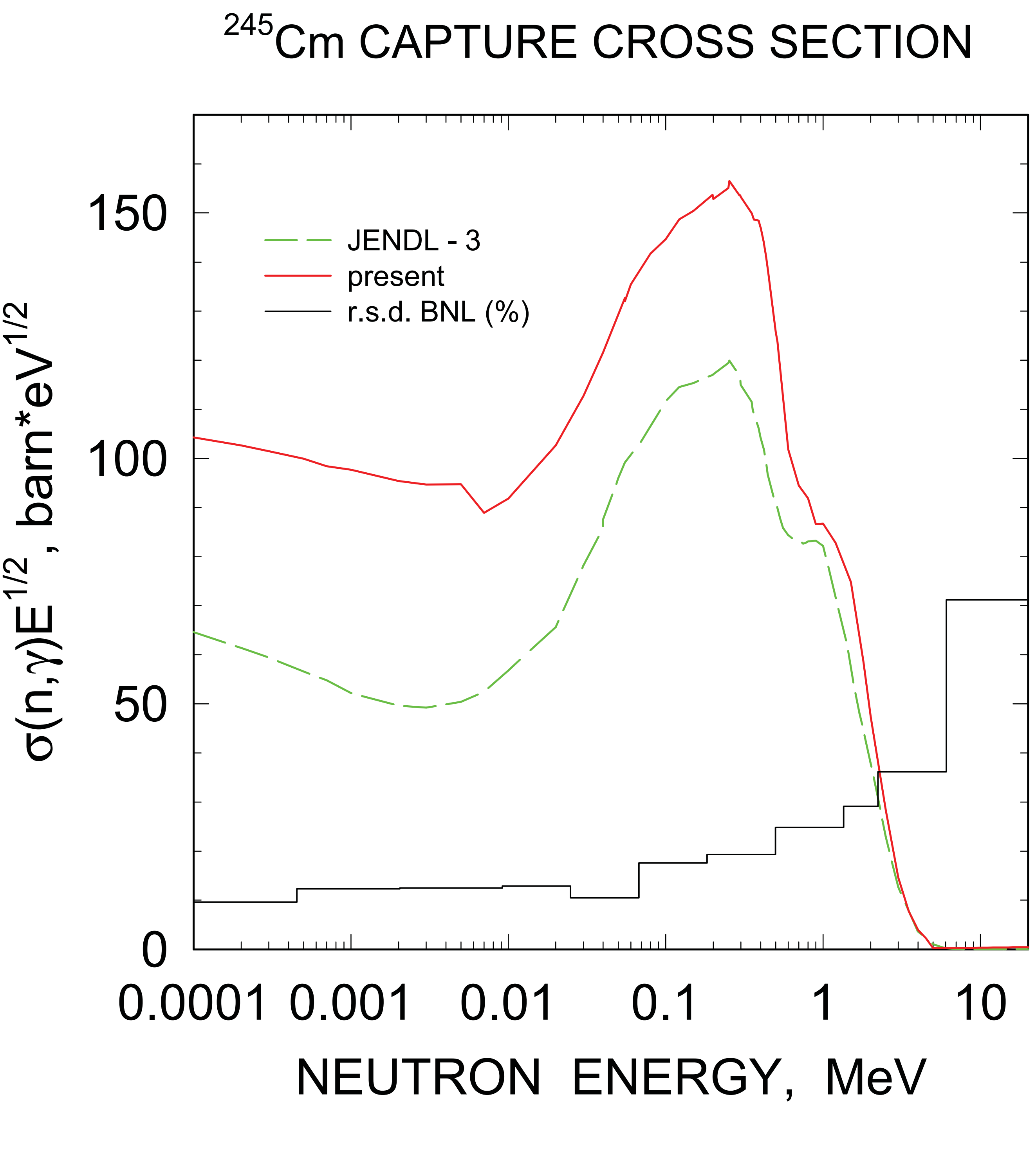
^{239}Pu CAPTURE CROSS SECTION
JENDL-3.3
JEFF-3.1
ENDF/B-VII.0
present
Hopkins et al., 1962
Gwin et al., 1976
Spivak et al., 1956
Kononov et al., 1975
Bolotskij et al., 1973
Andreev, 1958
JENDL-3.3, 176 groups
r.s.d. BNL (%)
r.s.d. present (%)
σ(n,γ)E$^{1/2}$, barn*eV$^{1/2}$
300
250
200
150
100
50
0.1
1
10
100
1000
10000
NEUTRON ENERGY,keV

^{241}Pu CAPTURE CROSS SECTION

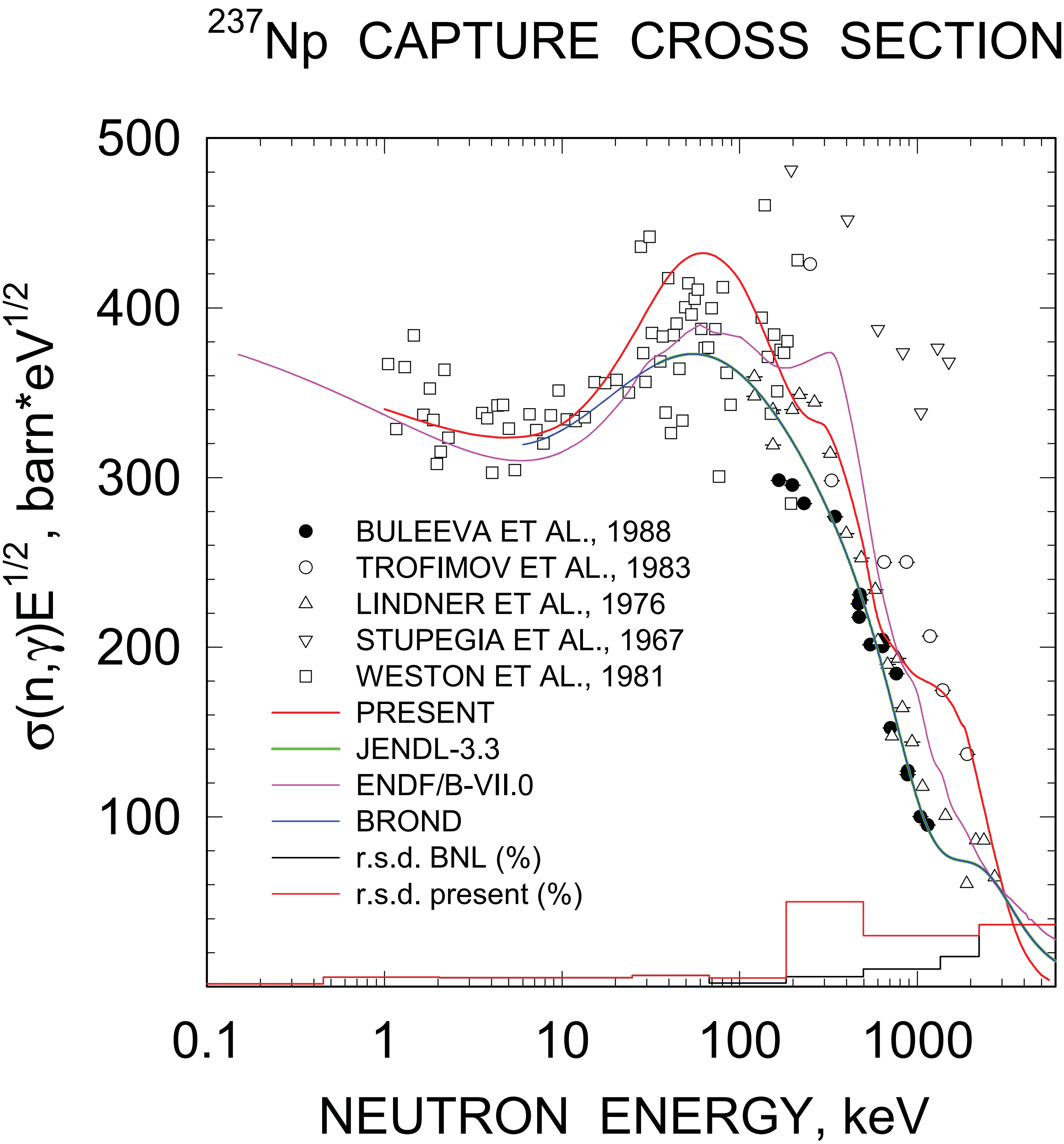




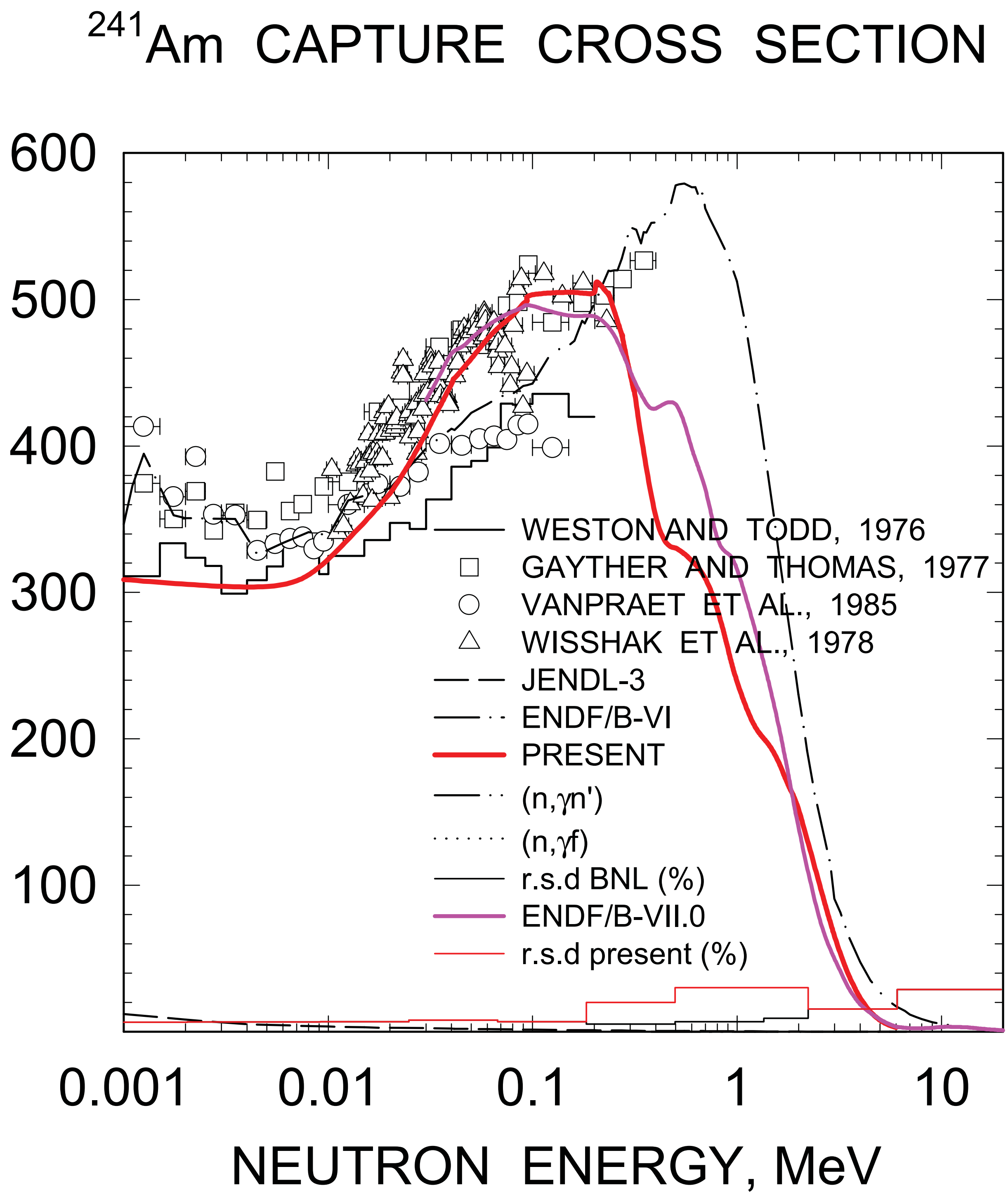
^{243}Cm CAPTURE CROSS SECTION
r.s.d. BNL (%)
PRESENT
JENDL-3.1
σ(n,γ)E$^{1/2}$,(barn x eV$^{1/2}$)
0
50
100
150
200
0.001
0.01
0.1
1
10
NEUTRON ENERGY, MeV



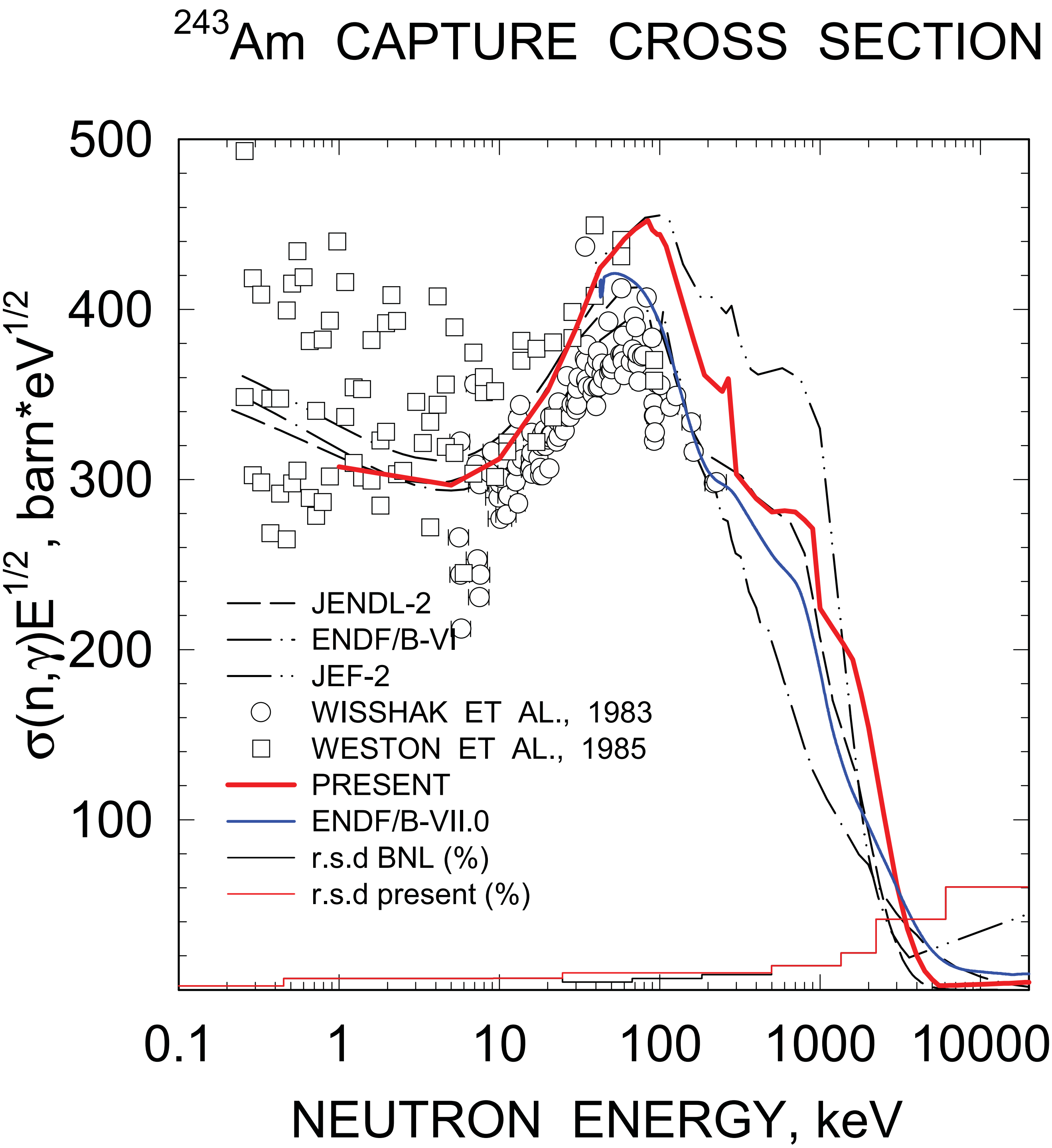
^{245}Cm CAPTURE CROSS SECTION
JENDL - 3
present
r.s.d. BNL (%)
σ(n,γ)E$^{1/2}$, barn*eV$^{1/2}$
0
50
100
150
0.0001
0.001
0.01
0.1
1
10
NEUTRON ENERGY, MeV



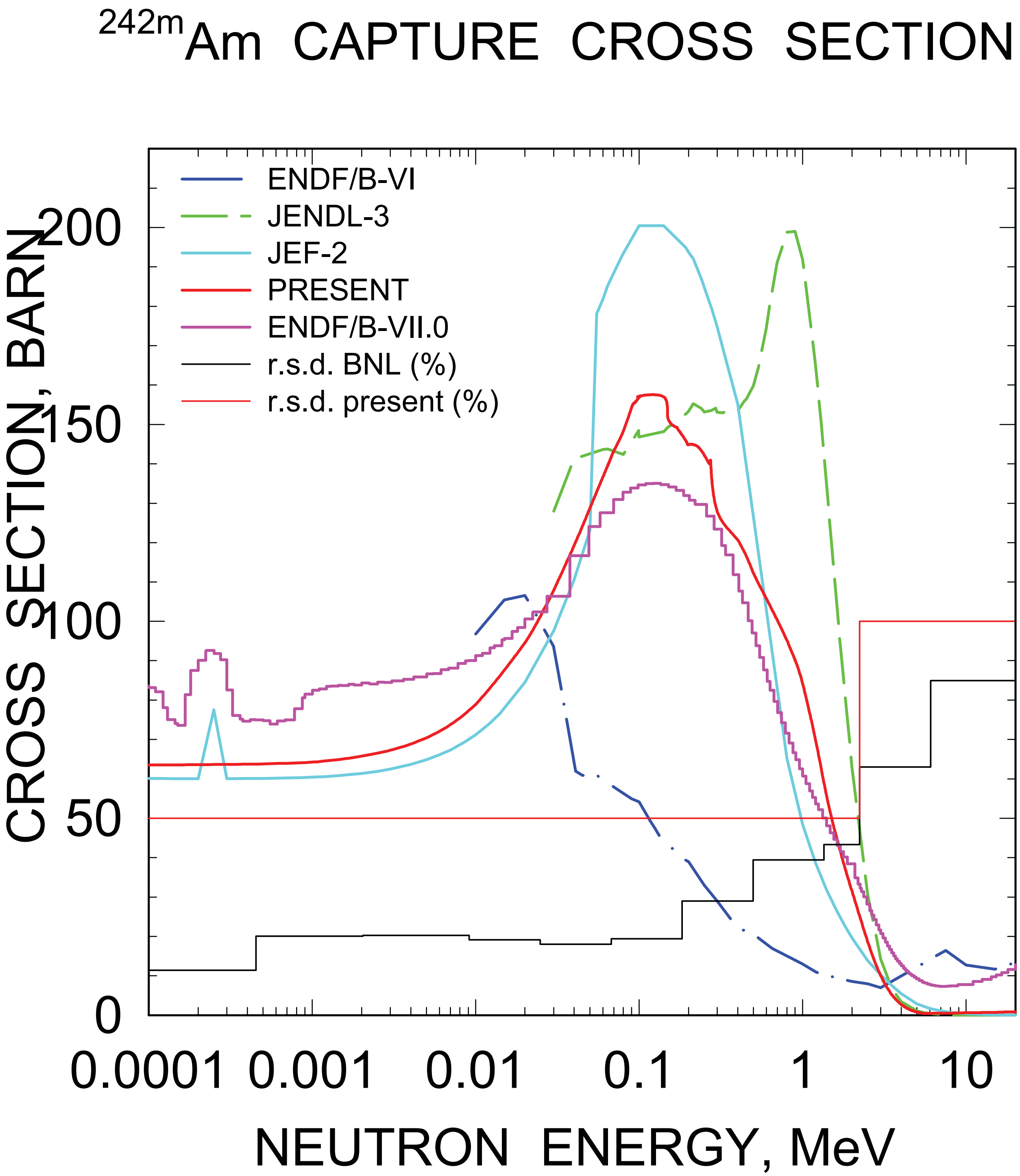
237Np CAPTURE CROSS SECTION
σ(n,γ)E1/2, barn*eV1/2
NEUTRON ENERGY, keV
500
400
300
200
100
0.1
1
10
100
1000
BULEEVA ET AL., 1988
TROFIMOV ET AL., 1983
LINDNER ET AL., 1976
STUPEGIA ET AL., 1967
WESTON ET AL., 1981
PRESENT
JENDL-3.3
ENDF/B-VII.0
BROND
r.s.d. BNL (%)
r.s.d. present (%)



241Am CAPTURE CROSS SECTION
σ(n,γ)E1/2, barn*eV1/2
600
500
400
300
200
100
0.001
0.01
0.1
1
10
NEUTRON ENERGY, MeV
WESTON AND TODD, 1976
GAYTHER AND THOMAS, 1977
VANPRAET ET AL., 1985
WISSHAK ET AL., 1978
JENDL-3
ENDF/B-VI
PRESENT
(n,γn')
(n,γf)
r.s.d BNL (%)
ENDF/B-VII.0
r.s.d present (%)



^{243}Am CAPTURE CROSS SECTION
$\sigma(n,\gamma)E^{1/2}$, barn*eV$^{1/2}$
NEUTRON ENERGY, keV
JENDL-2
ENDF/B-VI
JEF-2
WISSHAK ET AL., 1983
WESTON ET AL., 1985
PRESENT
ENDF/B-VII.0
r.s.d BNL (%)
r.s.d present (%)



242mAm CAPTURE CROSS SECTION
ENDF/B-VI
JENDL-3
JEF-2
PRESENT
ENDF/B-VII.0
r.s.d. BNL (%)
r.s.d. present (%)
CROSS SECTION, BARN
0
50
100
150
200
0.0001
0.001
0.01
0.1
1
10
NEUTRON ENERGY, MeV

Chapter 6

(n,2n) cross sections

^{232}Th: R.s.d. for ^{232}Th(n, 2n) reaction cross section are left unchanged, since ENDF/B-VII.0 does not differ much from newest measured data [245-256] and Maslov et al.[19] evaluation (see Fig. 6.1). Both are much differing from early JEFF and JENDL-3.3 evaluations.

^{238}U: For that nuclide covariances in BNL report were adopted from JENDL-3.3 data file. For this nuclide (n,2n) cross sections is much different from that of ENDF/B-VII.0 and Maslov et al. [23] data file and newest measured data [169, 257-263] (see Fig. 6.2). R.s.d. for ^{238}U(n, 2n) reaction cross section is increased up to 30 %.

^{236}U: R.s.d. for ^{236}U(n, 2n) reaction cross section is left unchanged, since ENDF/B-VII.0 does not differ much from present calculation (see Fig. 6.3). However, both are much different from JEFF-3.1 and JENDL-3.3 evaluations.

^{234}U: R.s.d. for ^{234}U(n, 2n) reaction cross section is left unchanged, since ENDF/B-VII.0 does not differ much from Maslov et al. [21] evaluation (see Fig. 6.4). However, both are much different from ENDF/B-VI and JENDL-3.3 evaluations.

^{238}Pu: R.s.d. for ^{238}Pu(n, 2n) reaction cross section is increased up to 100 %, since the ENDF/B-VII.0 differ much from Maslov et al. [32] evaluation, almost by an order of magnitude. However, both are much different from JEFF and JENDL-3.1 evaluations (see Fig. 6.5).

^{240}Pu: R.s.d. for ^{240}Pu(n, 2n) reaction cross section is decreased down to 10 %, since the ENDF/B-VII.0 data, present calculation and JEFF and JENDL-3.3 evaluations are not much different from each other (see Fig. 6.6).

^{242}Pu: R.s.d. for ^{242}Pu(n, 2n) reaction cross section is left unchanged, it corresponds to differences of ENDF/B-VII.0 data from Maslov et al. [33] evaluation (see Fig. 6.7). Shape of the cross section in ENDF/B-VII.0 data should be updated strongly.

^{242}Cm: R.s.d. for ^{242}Cm(n, 2n) reaction cross should be increased 10 times, since the ENDF/B-VII.0 orders of magnitude different from present calculation, which reliably predicts fission cross section. The latter is confirmed by surrogate fission data [114], presented at ND2007 conference. Both are much different from JEFF and JENDL-3.3 evaluations (see Fig. 6.8).

^{244}Cm: R.s.d. for ^{244}Cm(n, 2n) reaction cross should be decreased to 30 %, to reflect actual differences of present calculation, which reliably predicts fission cross section, from JENDL-3.3 data, adopted for ENDF/B-VII.0 (see Fig. 6.9).

^{235}U, ^{239}Pu: For two nuclides – ^{235}U [263-265] and ^{239}Pu [263, 265, 266, 267] - covariances in BNL report were adopted from JENDL-3.3. For these nuclides (n,2n) cross sections are different from those of ENDF/B-VII.0 and Maslov [10, 268] calculations and measured data as well (see Figs. 6.10, 6.12). Without understanding the uncertainties of relatively well-investigated (n,2n) cross sections, only next to nothing could be said about poor investigated nuclides. However, it should be stated that mild consistency of different evaluations does not reflect the predictive powers of different approaches, since predicted fission chances contributions differ very much. In a number of cases, predicted r.s.d. is over-conservative (^{233}U(n,2n), ^{234}U(n,2n), for example) or over-optimistic (^{242}Cm(n,2n), for example)). R.s.d for ^{235}U and ^{239}Pu are fixed at 10% and 29% level, respectively.

^{233}U: R.s.d. for ^{233}U(n, 2n) reaction cross is left unchaged, it reflects the consistency between ENDF/B-VII.0 and Maslov et al. [22] evaluations, other evaluations should be severely modified (see Fig. 6.11).

^{241}Pu: R.s.d. for ^{241}Pu(n, 2n) reaction cross is left un-changed, it reflects the differences between present calculation and previous evaluations, which should be severely modified (see Fig. 6.13).

^{245}Cm: R.s.d. for ^{245}Cm(n, 2n) reaction cross section is left unchanged, since Maslov et al. [27] evaluation is adopted for JEFF, JENDL-3.3 and ENDF/B-VII.0 data libraries and there is no modern data files to compare with. However, it is much different from early JENDL evaluation (see Fig. 6.14).

^{243}Cm: R.s.d. for ^{243}Cm(n, 2n) reaction cross section is left unchanged, since Maslov et al. [26] evaluation is adopted for JEFF, JENDL-3.3 and ENDF/B-VII.0 data libraries and there is no modern data files to compare with (see Fig. 6.15). However, it is much different from the early JENDL evaluation.

^{237}Np, ^{241}Am, ^{243}Am: There are a number of (n,2n) cross sections, which might be of minor importance, but they give one a confidence that the whole pipe-line is working properly, since extensive measured data are available only for ^{237}Np(n,2n)^{236l}Np reaction [269-274] (see Figs. 6.16, 6.17, 6.18). One of them is ^{241}Am(n,2n) [275-277], its newest measurement, reported at ND2007 by Vieira et al. [171], nicely confirmed older evaluation by Maslov et al. [17], that data file afterwards was accepted for JENDL-3.3(2). As regards ^{243}Am(n,2n) feeding ^{242m}Am(J=5) (141 y) and ^{242g}Am(J=1) (16 h) there is a measurement by Gancarz [278] referred by Chadwick et al. [14]. Unfortunately, the exact reference to that measurement is missing. However, the quoted Gancarz [278] data point gives the yield of ^{242g}Am(J=1) (16 h) at 15 MeV as 0.2 barn. It would be quite compatible with estimate of ^{243}Am(n,2n)$^{242(m+g)}$Am of 0.3 barn, granted that branching ratio of m/g or (long-lived-to-short/lived) is similar to that in ^{237}Np(n,2n) reaction. Only in that case the r.s.d. of ^{243}Am(n,2n) cross section could be claimed to be equal to 30% or even to that of ^{241}Am(n,2n), otherwise it should increased to 100 %. In ENDF/B-VII.0 there is some misunderstanding with the ^{243}Am(n,2n) and ^{243}Am(n,F) data, if Gancarz [278] measurement is activation/radiochemistry and not the mass-spectroscopy and gives the yield of ^{242g}Am(J=1). Besides all, it would be a strong constraint for the ^{243}Am(n,F) fission cross section estimates, which are quite controversial. In case of ^{243}Am(n,2n) in Maslov et al. [18] and ENDF/B-VII.0 evaluation the cross sections are very different. The problem is with the branching ratio of g.s./m.s. It should be like in case ^{237}Np(n,2n), that is quite evident, while in ENDF/B-VII.0 [14] case it is much different. Gaussian random sampling would not produce reasonable estimate of r.s.d. in that case.

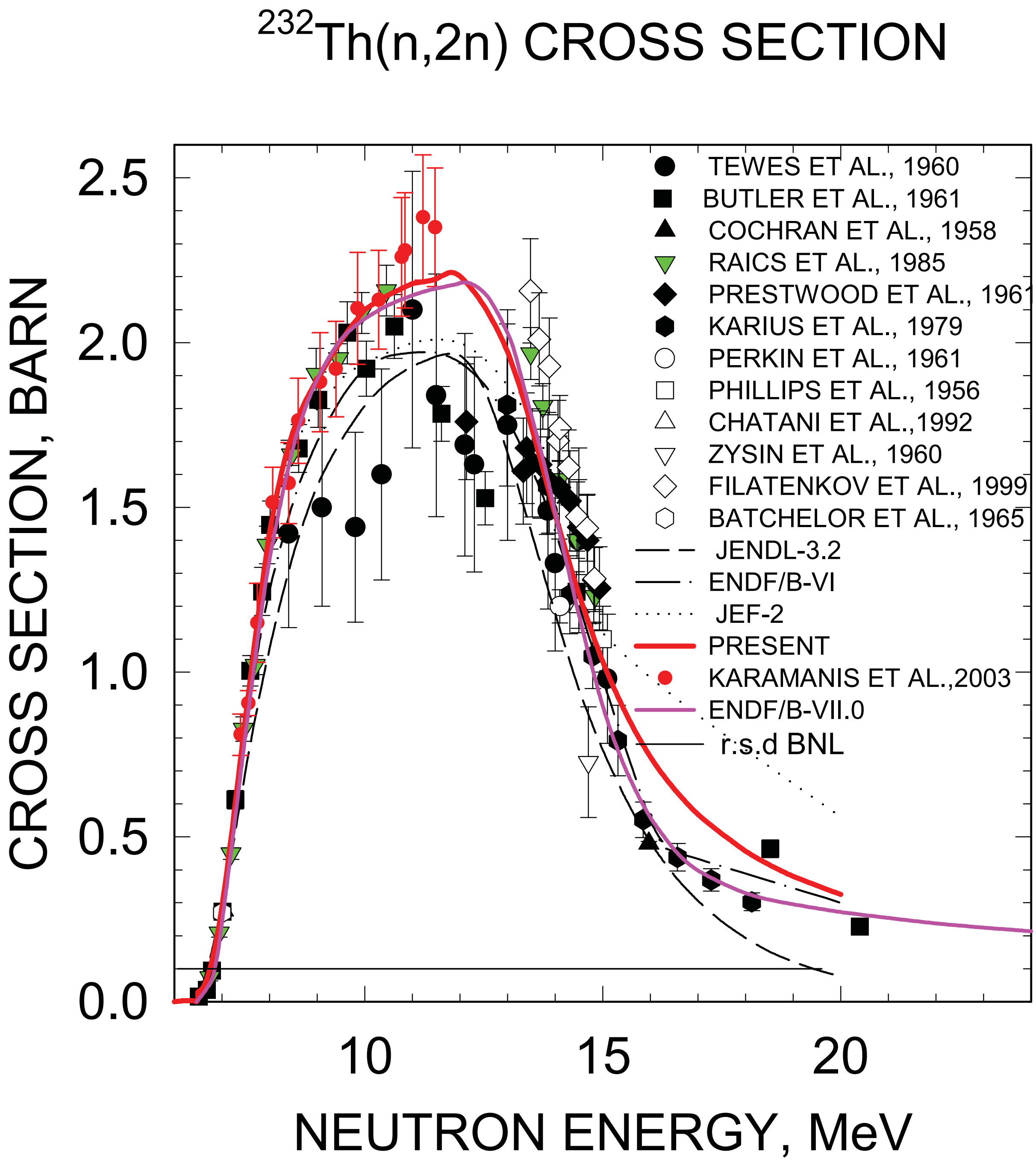
We did in 1987 (Ignatyk et al. [154]) the analysis for ^{237}Np(n, 2n), feeding short-lived ^{236}Np (J=1) with a branching ratio of long-lived(J=6)-to-short-lived(J=1) at 14 MeV of 0.35 (measured data by Myers et al. [279] fitted as well as near-threshold ^{237}Np(n,2n) ^{237s}Np high-precision data measured by Kornilov et al. [272]. In case of ^{237}Np(n,2n)^{236s}Np reaction, where there are precise data in a threshold region, i.e. r.s.d. can not be 3 times worse than at 14 MeV [155].

R.s.d. for ^{237}Np(n, 2n) reaction cross section should be increase to 20% to reflect the differences of ENDF/B-VII.0 evaluated data from measured data and present calculation.

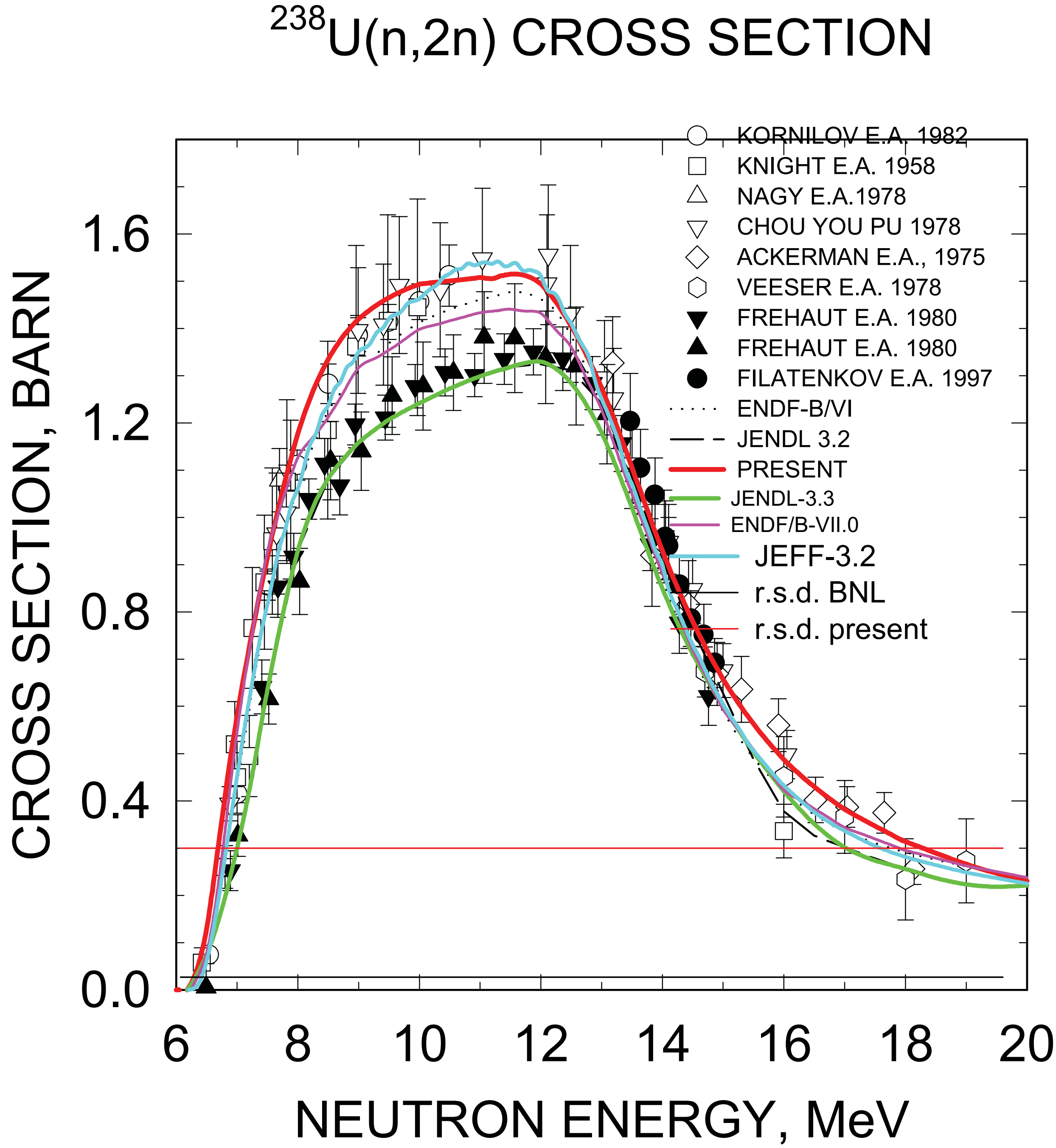
R.s.d. for ^{241}Am(n, 2n) reaction cross section reflects the differences of ENDF/B-VII.0 evaluated data from measured data and evaluation by Maslov et al. [17] and is left unchanged.

R.s.d. for ^{243}Am(n, 2n) reaction cross section is increased to 50 % to reflect the differences of ENDF/B-VII.0 evaluated data from evaluation by Maslov et al. [18] and proper treatment of measured data in that latter evaluation.

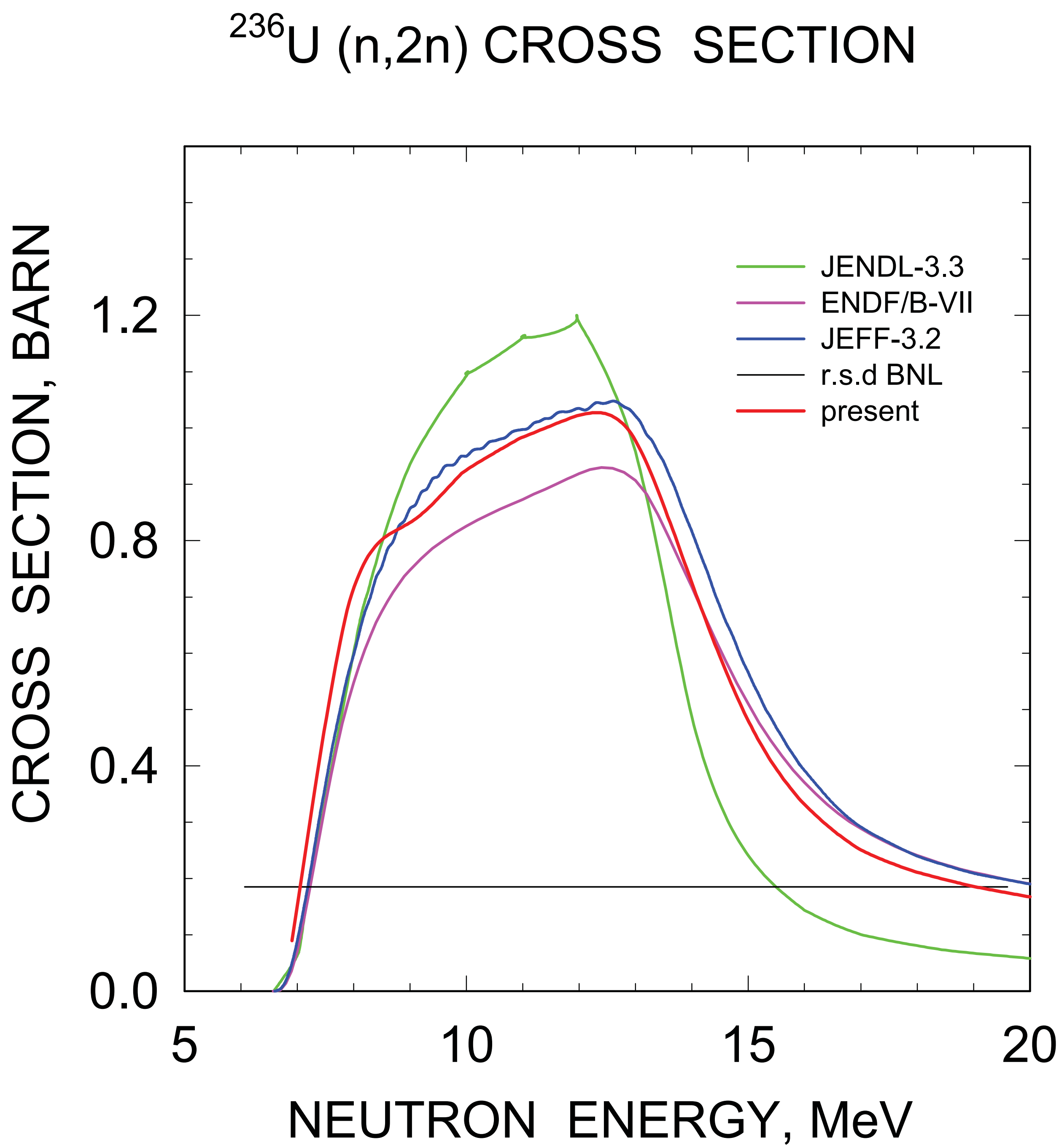
^{242m}Am: R.s.d. for ^{242}Am(n, 2n) reaction cross section reflects the differences of ENDF/B-VII.0 evaluated data from measured data and evaluation by Maslov et al. [30] and is left unchanged (see Fig. 6.19).



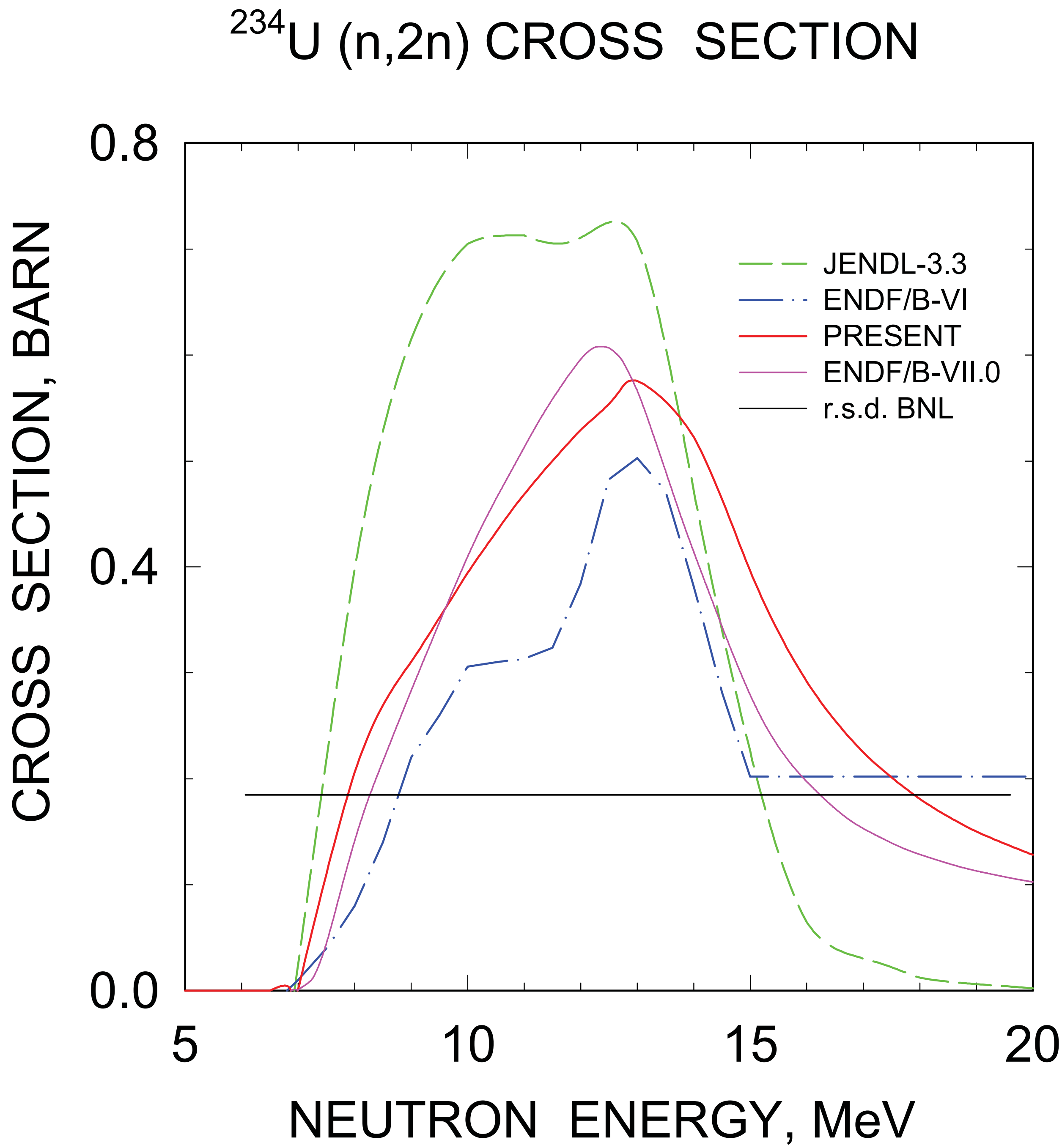
^{232}Th(n,2n) CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0.0
0.5
1.0
1.5
2.0
2.5
10
15
20
TEWES ET AL., 1960
BUTLER ET AL., 1961
COCHRAN ET AL., 1958
RAICS ET AL., 1985
PRESTWOOD ET AL., 1961
KARIUS ET AL., 1979
PERKIN ET AL., 1961
PHILLIPS ET AL., 1956
CHATANI ET AL.,1992
ZYSIN ET AL., 1960
FILATENKOV ET AL., 1999
BATCHELOR ET AL., 1965
JENDL-3.2
ENDF/B-VI
JEF-2
PRESENT
KARAMANIS ET AL.,2003
ENDF/B-VII.0
r.s.d BNL



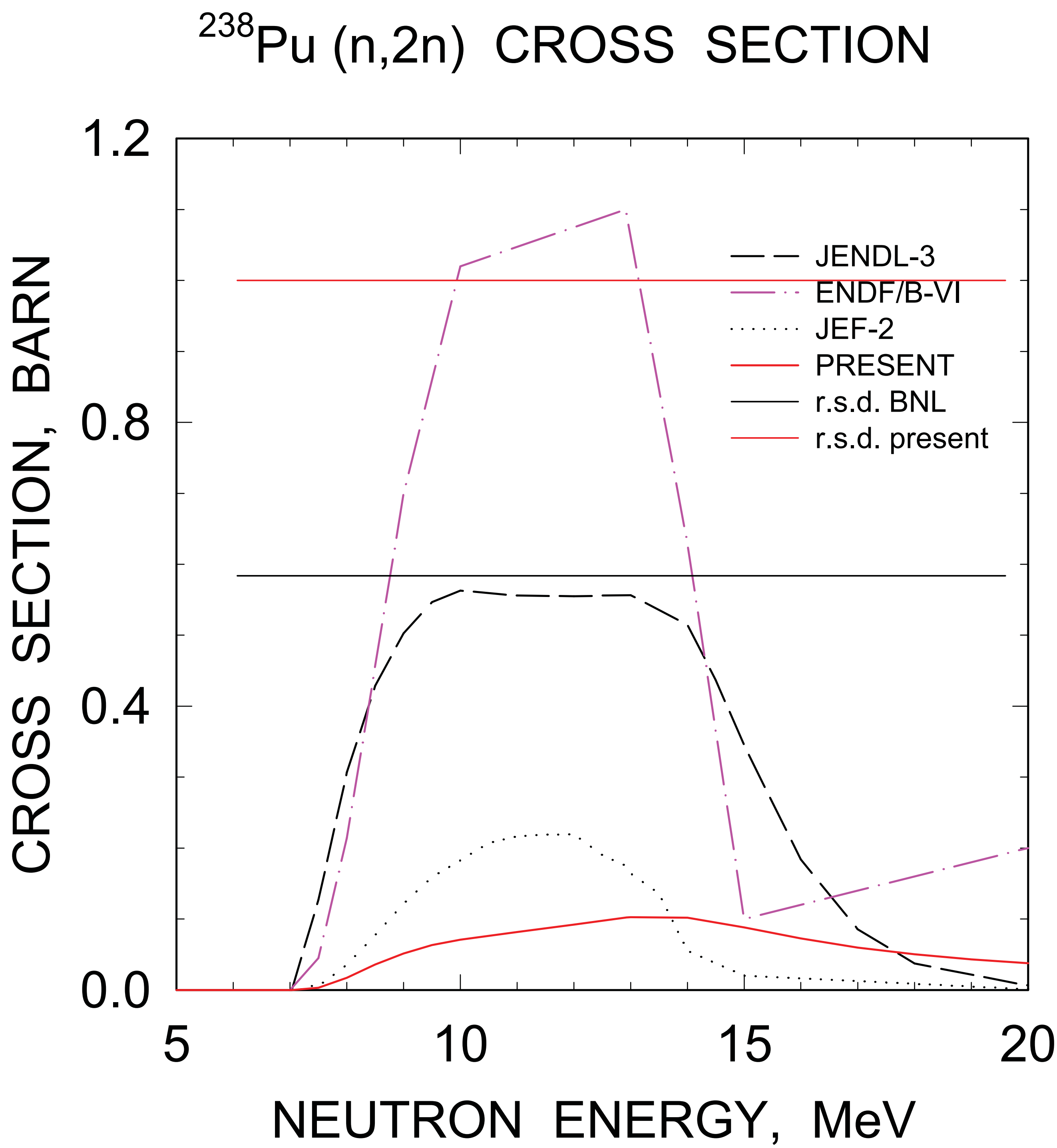
$^{238}U(n,2n)$ CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0.0
0.4
0.8
1.2
1.6
6
8
10
12
14
16
18
20
KORNILOV E.A. 1982
KNIGHT E.A. 1958
NAGY E.A.1978
CHOU YOU PU 1978
ACKERMAN E.A., 1975
VEESER E.A. 1978
FREHAUT E.A. 1980
FREHAUT E.A. 1980
FILATENKOV E.A. 1997
ENDF-B/VI
JENDL 3.2
PRESENT
JENDL-3.3
ENDF/B-VII.0
JEFF-3.2
r.s.d. BNL
r.s.d. present



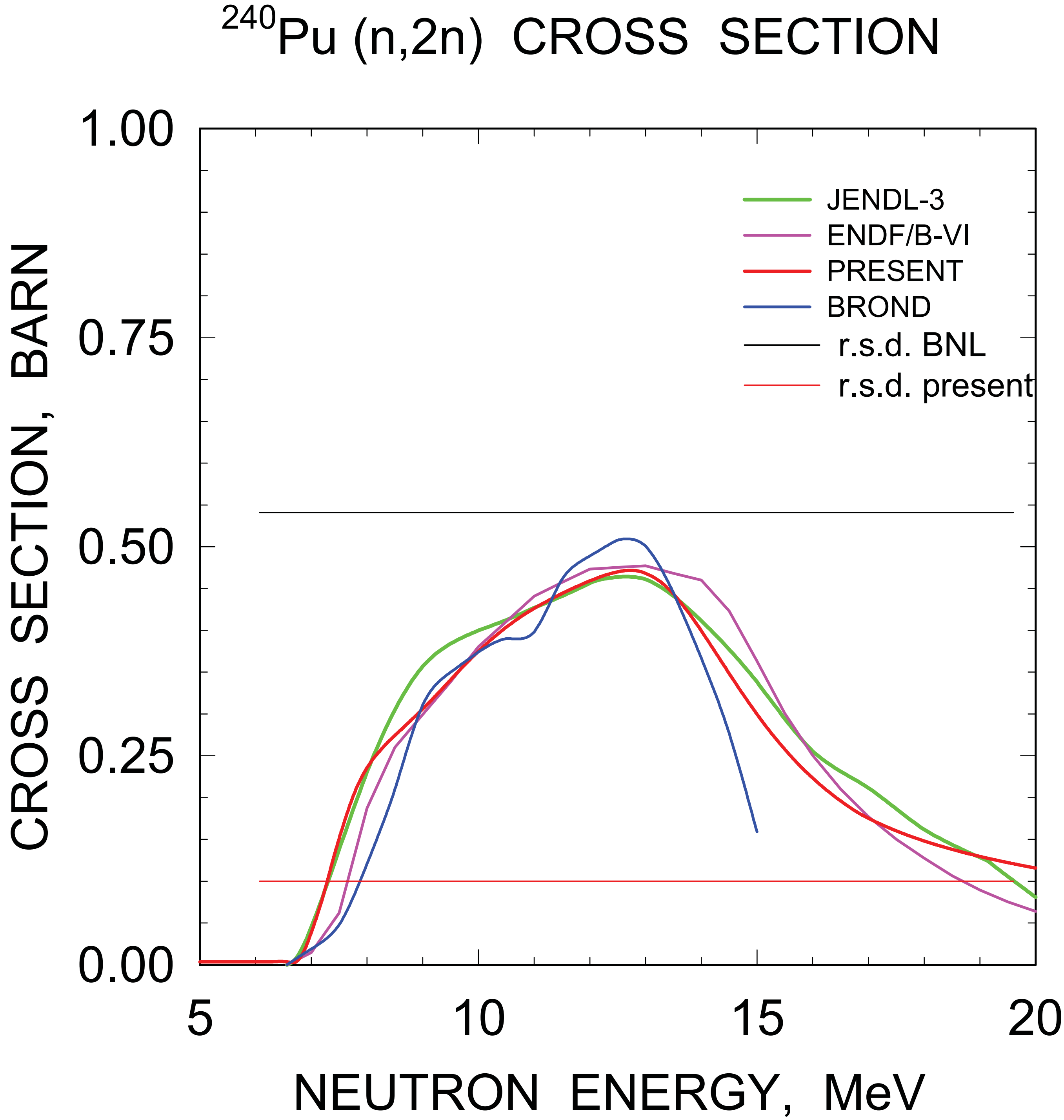
^{236}U (n,2n) CROSS SECTION
JENDL-3.3
ENDF/B-VII
JEFF-3.2
r.s.d BNL
present
CROSS SECTION, BARN
1.2
0.8
0.4
0.0
5
10
15
20
NEUTRON ENERGY, MeV



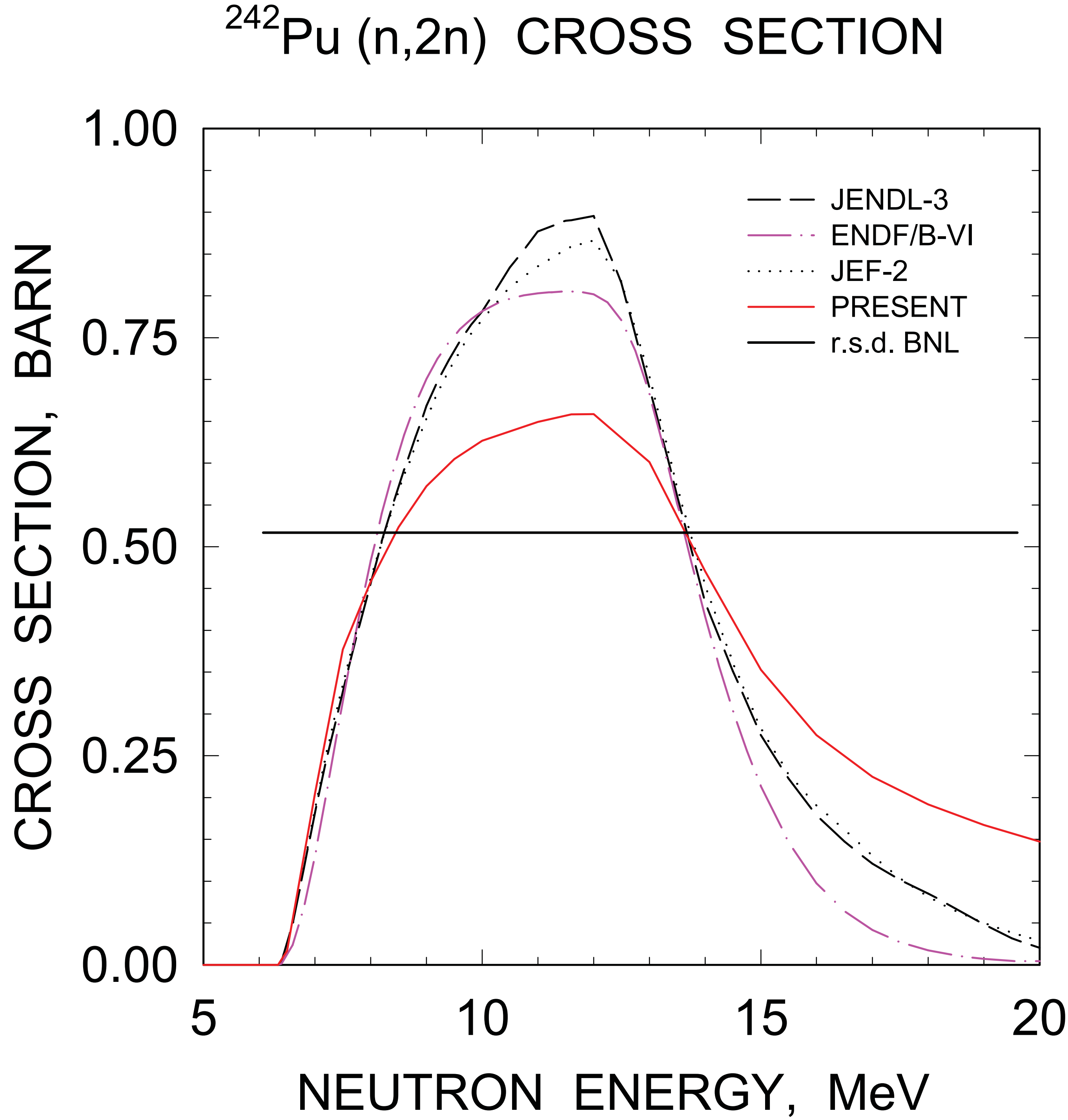
^{234}U (n,2n) CROSS SECTION
0.8
0.4
0.0
5
10
15
20
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
JENDL-3.3
ENDF/B-VI
PRESENT
ENDF/B-VII.0
r.s.d. BNL



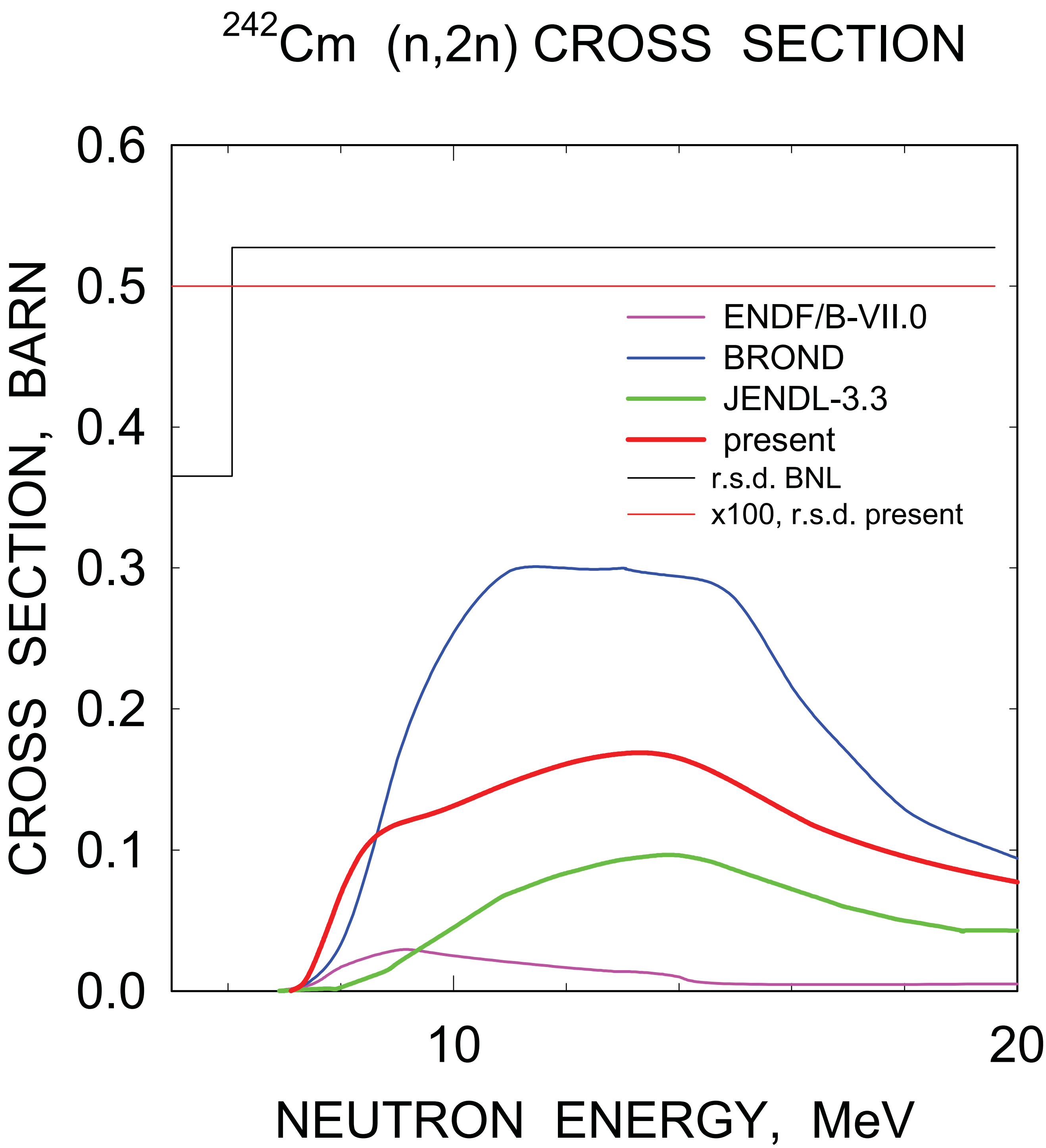
^{238}Pu (n,2n) CROSS SECTION
1.2
0.8
0.4
0.0
5
10
15
20
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
JENDL-3
ENDF/B-VI
JEF-2
PRESENT
r.s.d. BNL
r.s.d. present



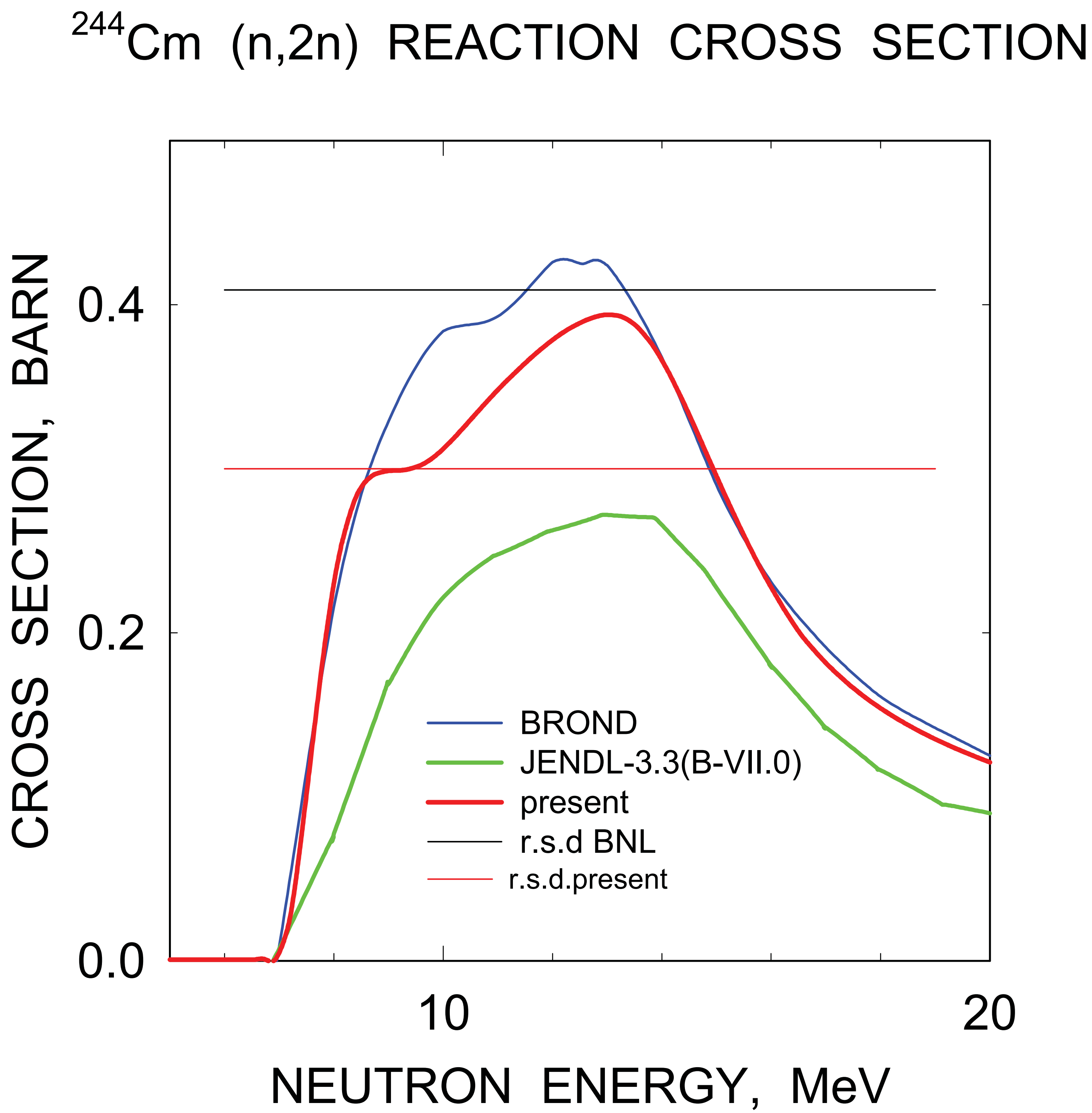
^{240}Pu (n,2n) CROSS SECTION
1.00
0.75
0.50
0.25
0.00
5
10
15
20
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
JENDL-3
ENDF/B-VI
PRESENT
BROND
r.s.d. BNL
r.s.d. present

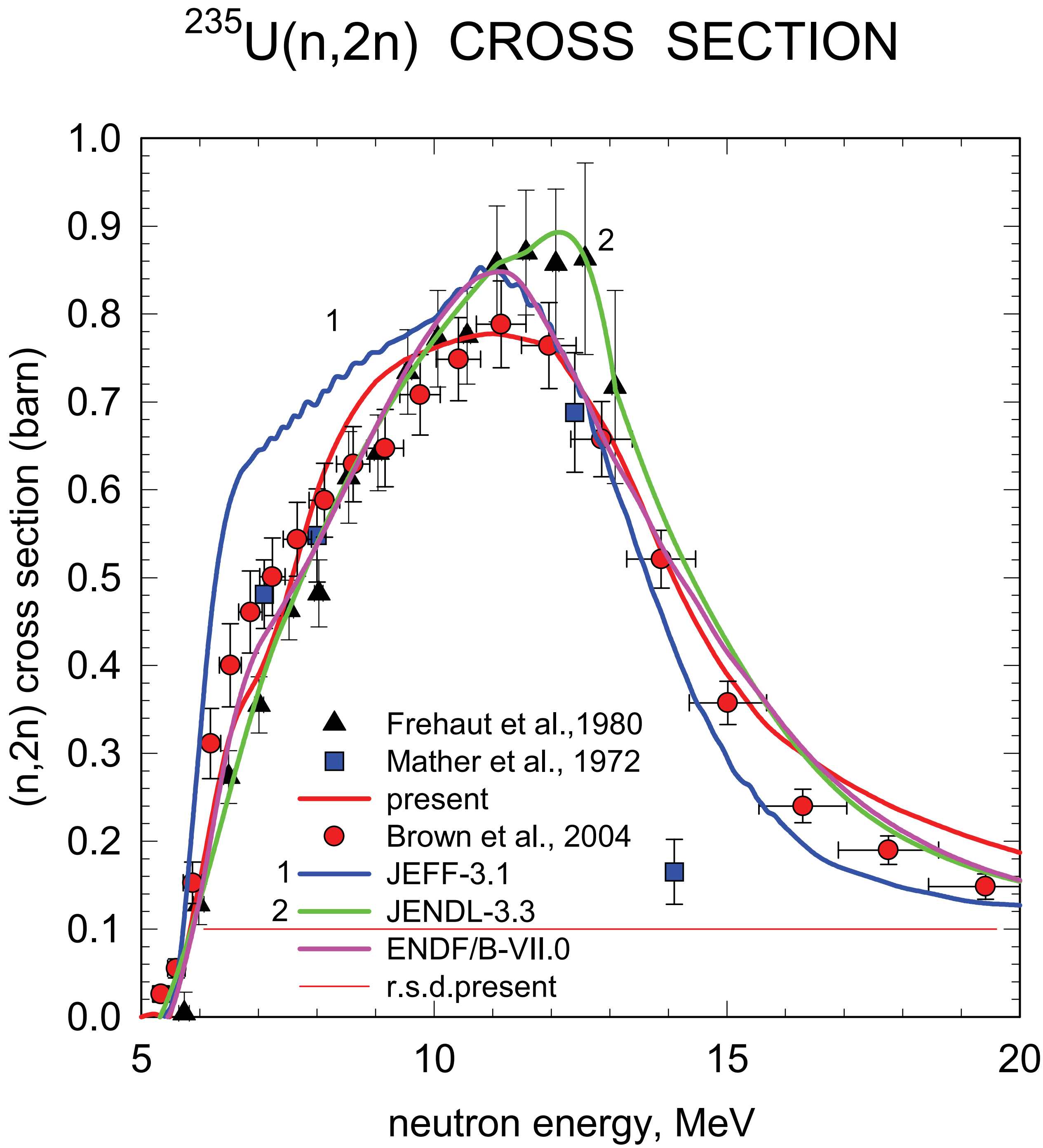


242Pu (n,2n) CROSS SECTION
1.00
0.75
0.50
0.25
0.00
5
10
15
20
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
JENDL-3
ENDF/B-VI
JEF-2
PRESENT
r.s.d. BNL

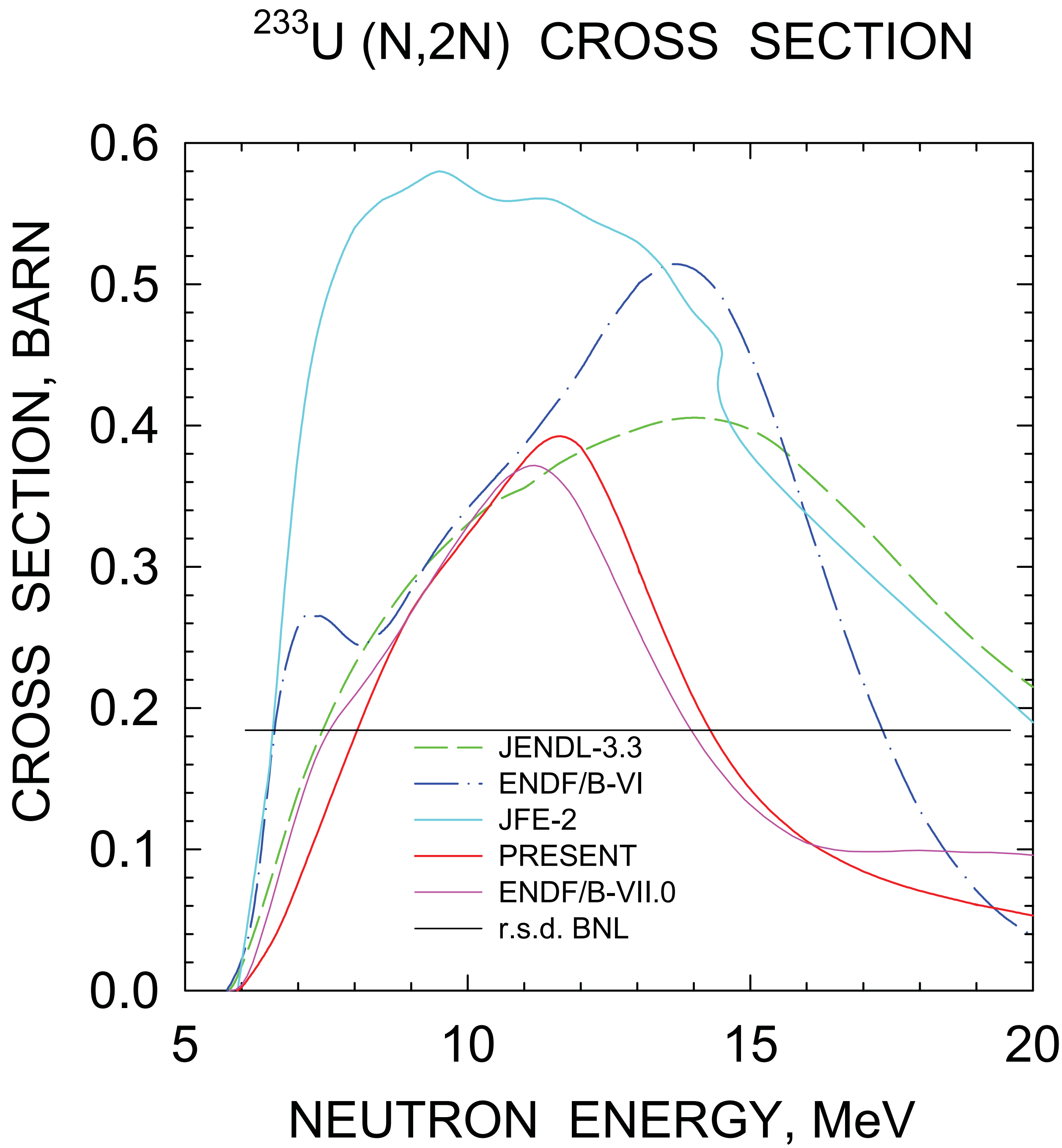


242Cm (n,2n) CROSS SECTION
0.6
0.5
0.4
0.3
0.2
0.1
0.0
CROSS SECTION, BARN
10
20
NEUTRON ENERGY, MeV
ENDF/B-VII.0
BROND
JENDL-3.3
present
r.s.d. BNL
x100, r.s.d. present

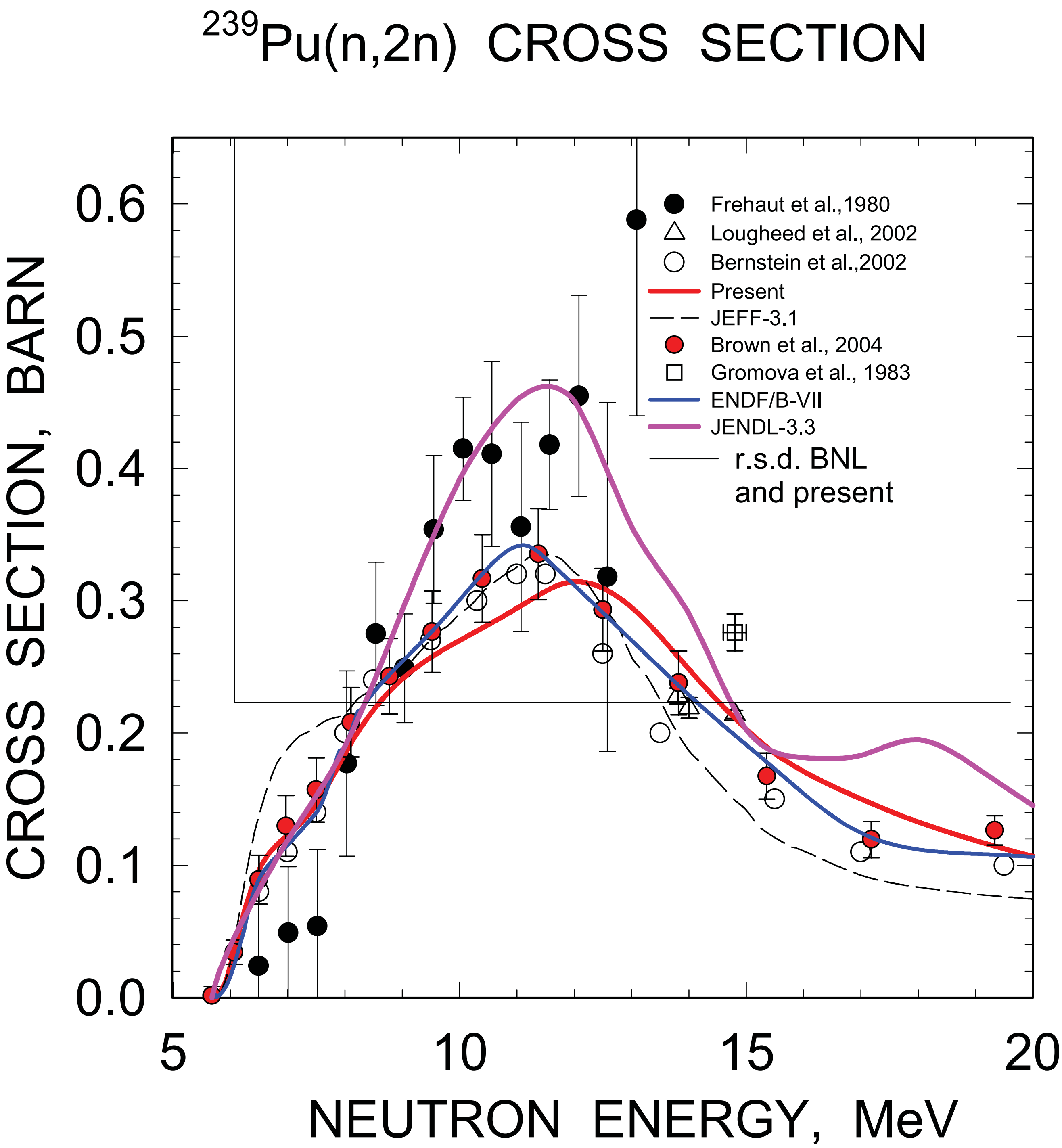

^{244}Cm (n,2n) REACTION CROSS SECTION
CROSS SECTION, BARN
0.0
0.2
0.4
10
20
NEUTRON ENERGY, MeV
BROND
JENDL-3.3(B-VII.0)
present
r.s.d BNL
r.s.d.present



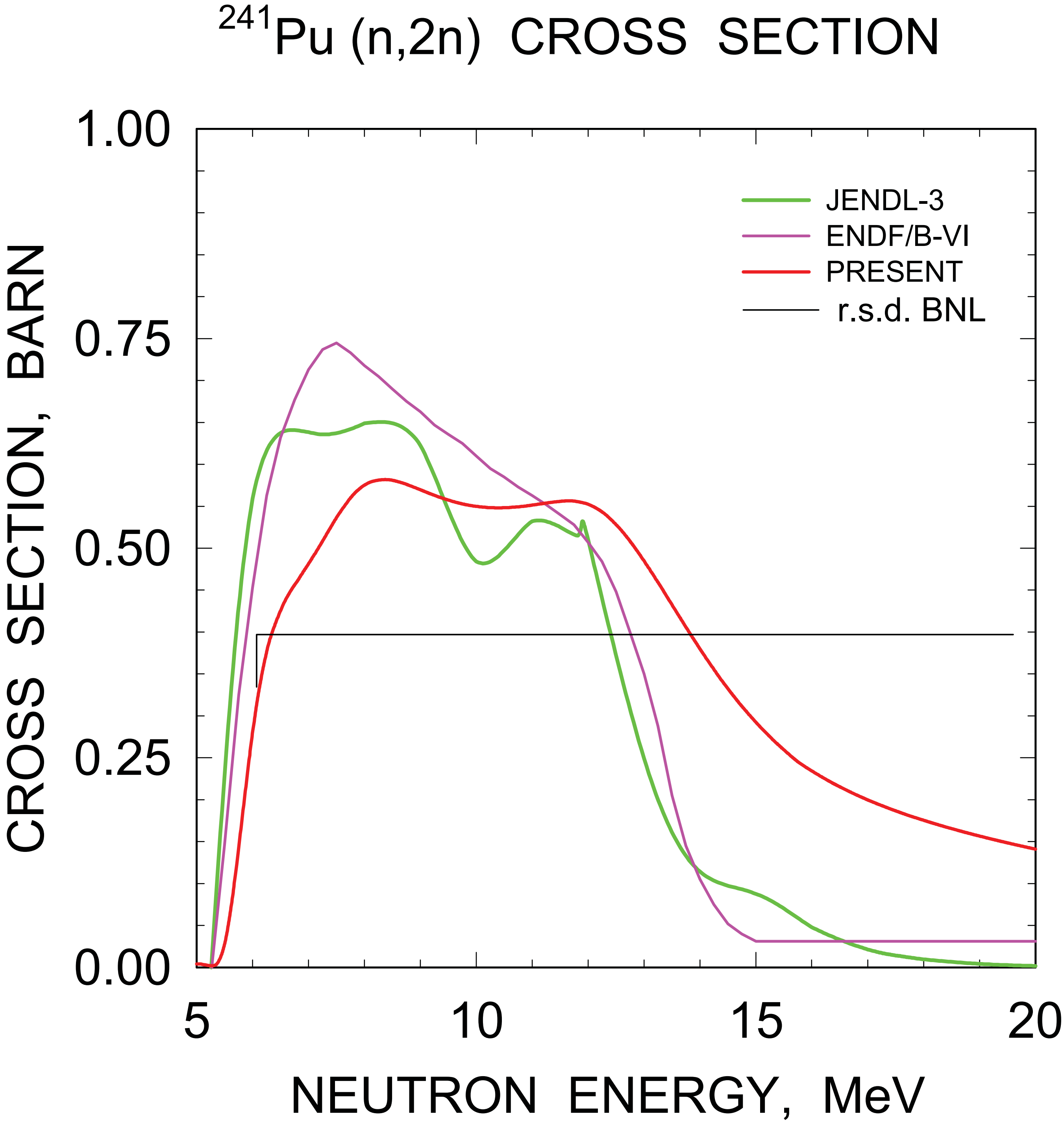
^{235}U(n,2n) CROSS SECTION
(n,2n) cross section (barn)
neutron energy, MeV
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
5
10
15
20
1
2
Frehaut et al.,1980
Mather et al., 1972
present
Brown et al., 2004
1 JEFF-3.1
2 JENDL-3.3
ENDF/B-VII.0
r.s.d.present



^{233}U (N,2N) CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0.0
0.1
0.2
0.3
0.4
0.5
0.6
5
10
15
20
JENDL-3.3
ENDF/B-VI
JFE-2
PRESENT
ENDF/B-VII.0
r.s.d. BNL

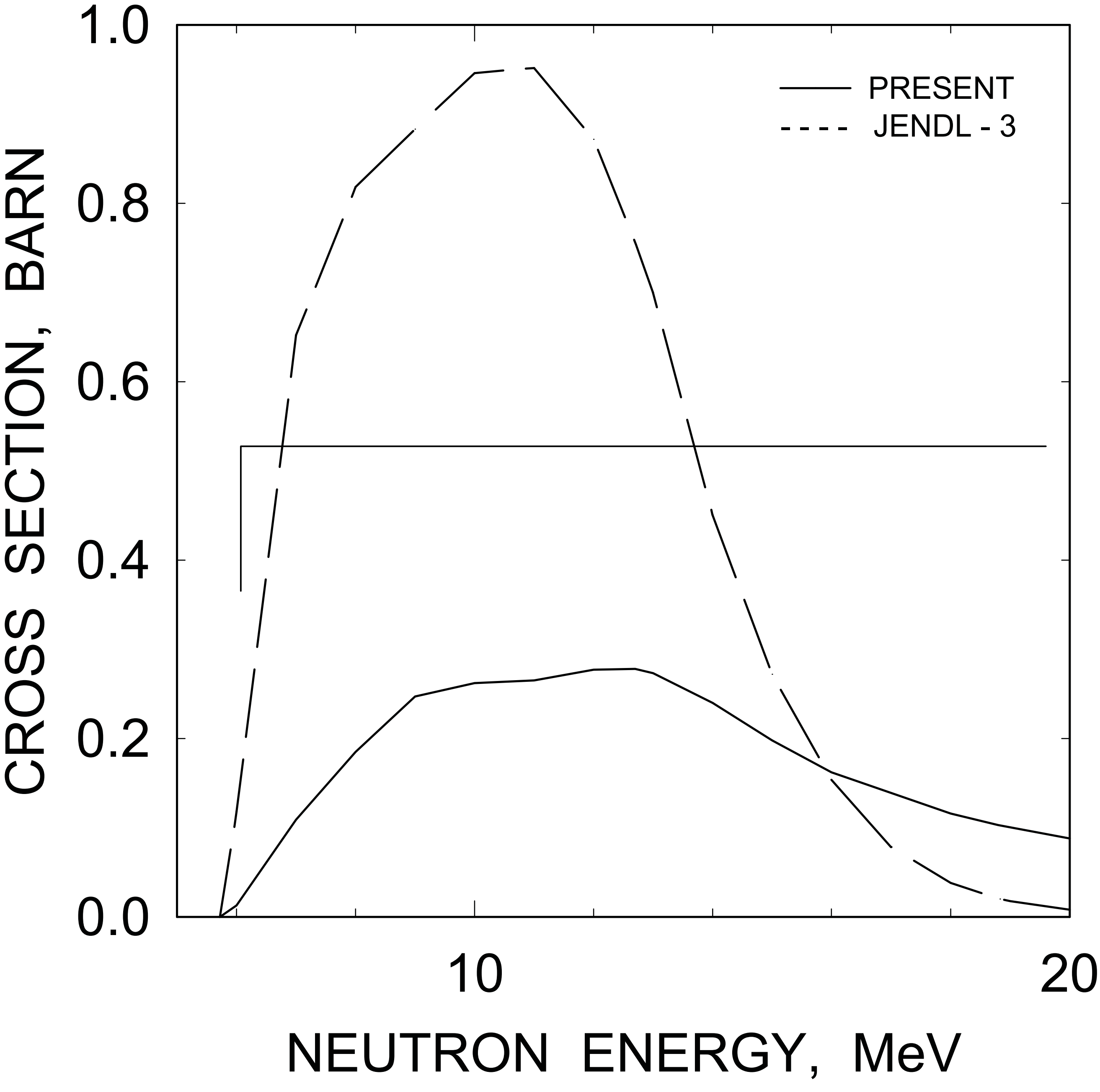


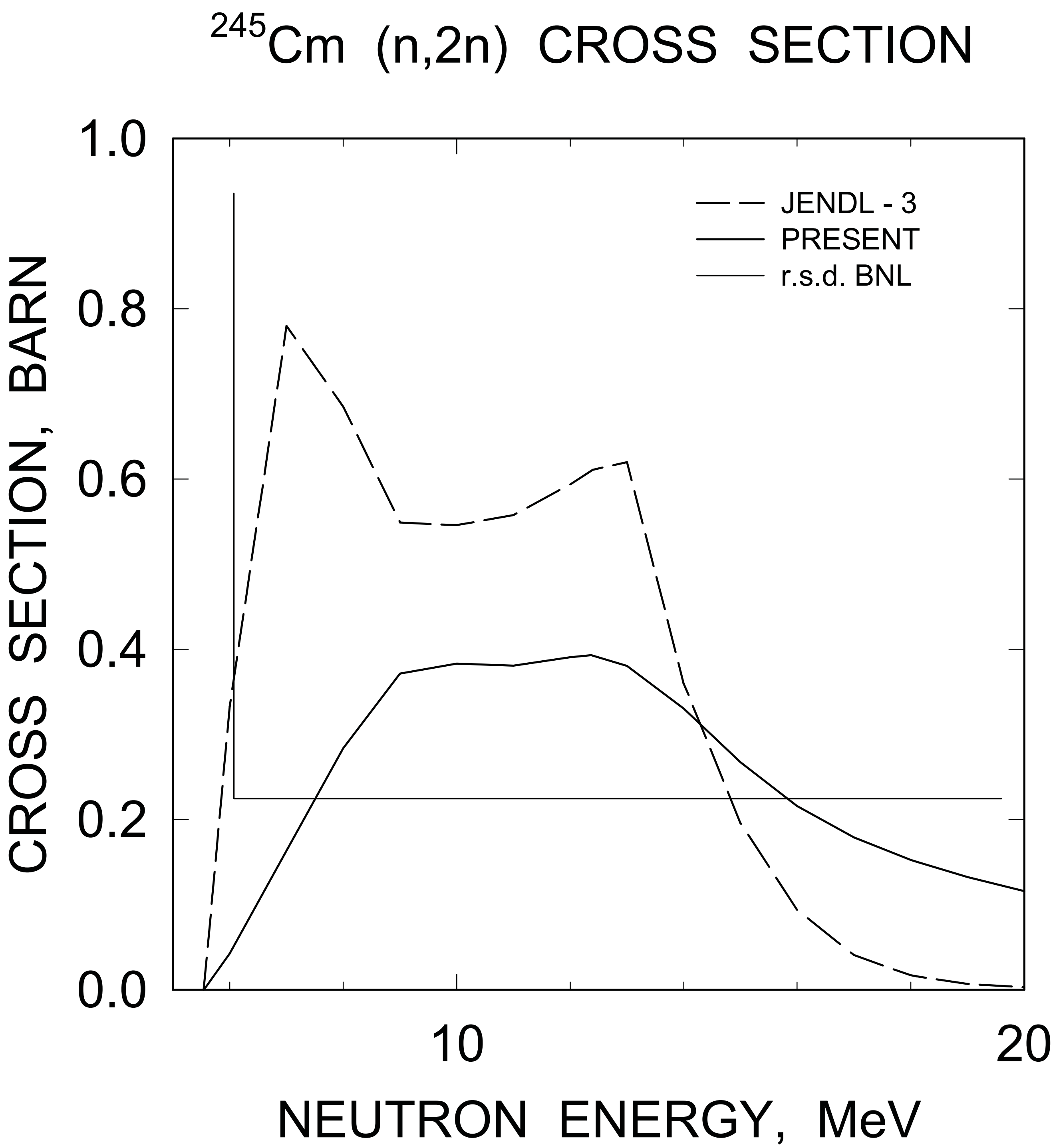
^{239}Pu(n,2n) CROSS SECTION
CROSS SECTION, BARN
NEUTRON ENERGY, MeV
0.0
0.1
0.2
0.3
0.4
0.5
0.6
5
10
15
20
Frehaut et al.,1980
Lougheed et al., 2002
Bernstein et al.,2002
Present
JEFF-3.1
Brown et al., 2004
Gromova et al., 1983
ENDF/B-VII
JENDL-3.3
r.s.d. BNL
and present



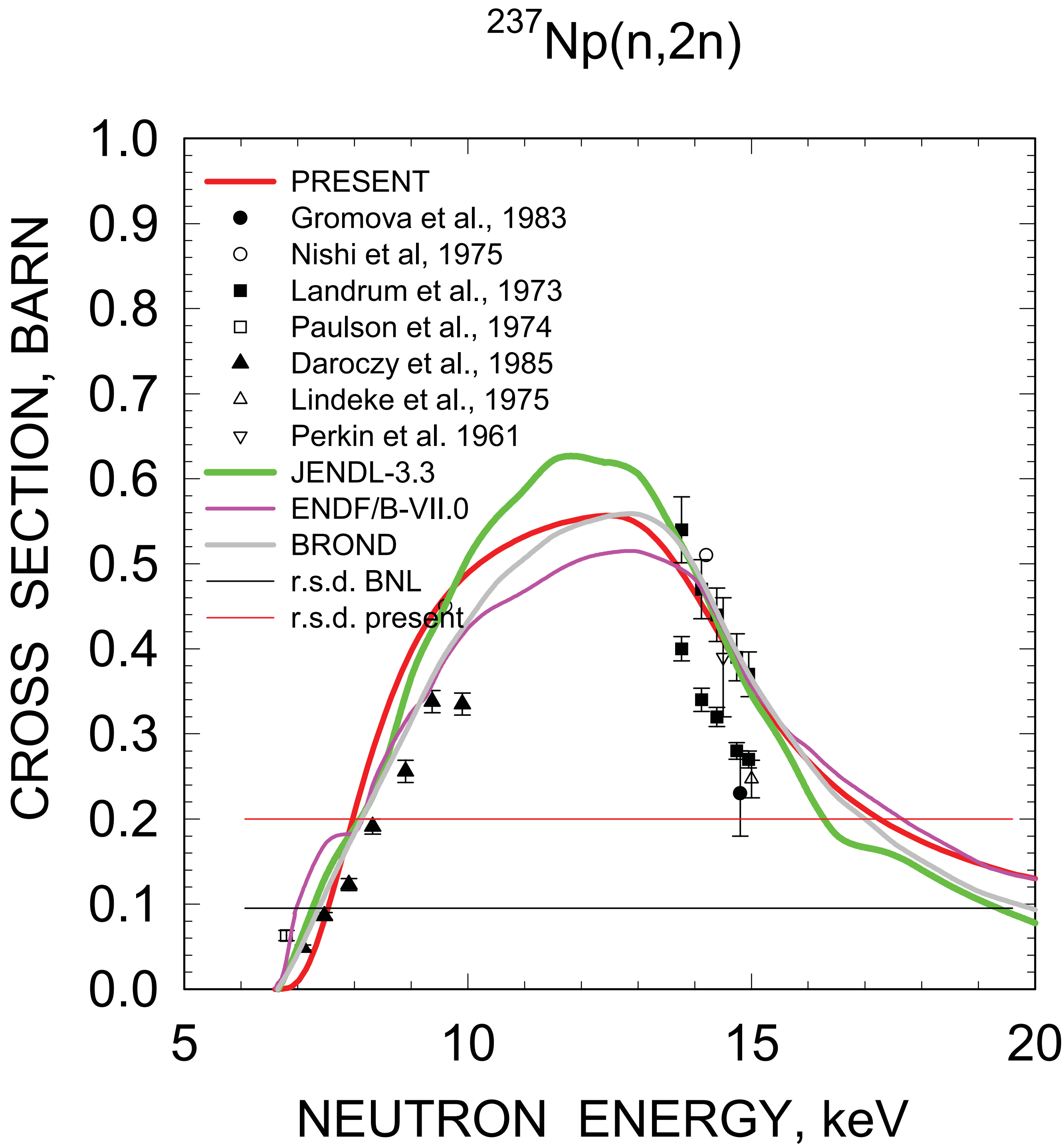
^{241}Pu (n,2n) CROSS SECTION
CROSS SECTION, BARN
1.00
0.75
0.50
0.25
0.00
5
10
15
20
NEUTRON ENERGY, MeV
JENDL-3
ENDF/B-VI
PRESENT
r.s.d. BNL

^{243}Cm (n,2n) REACTION CROSS SECTION

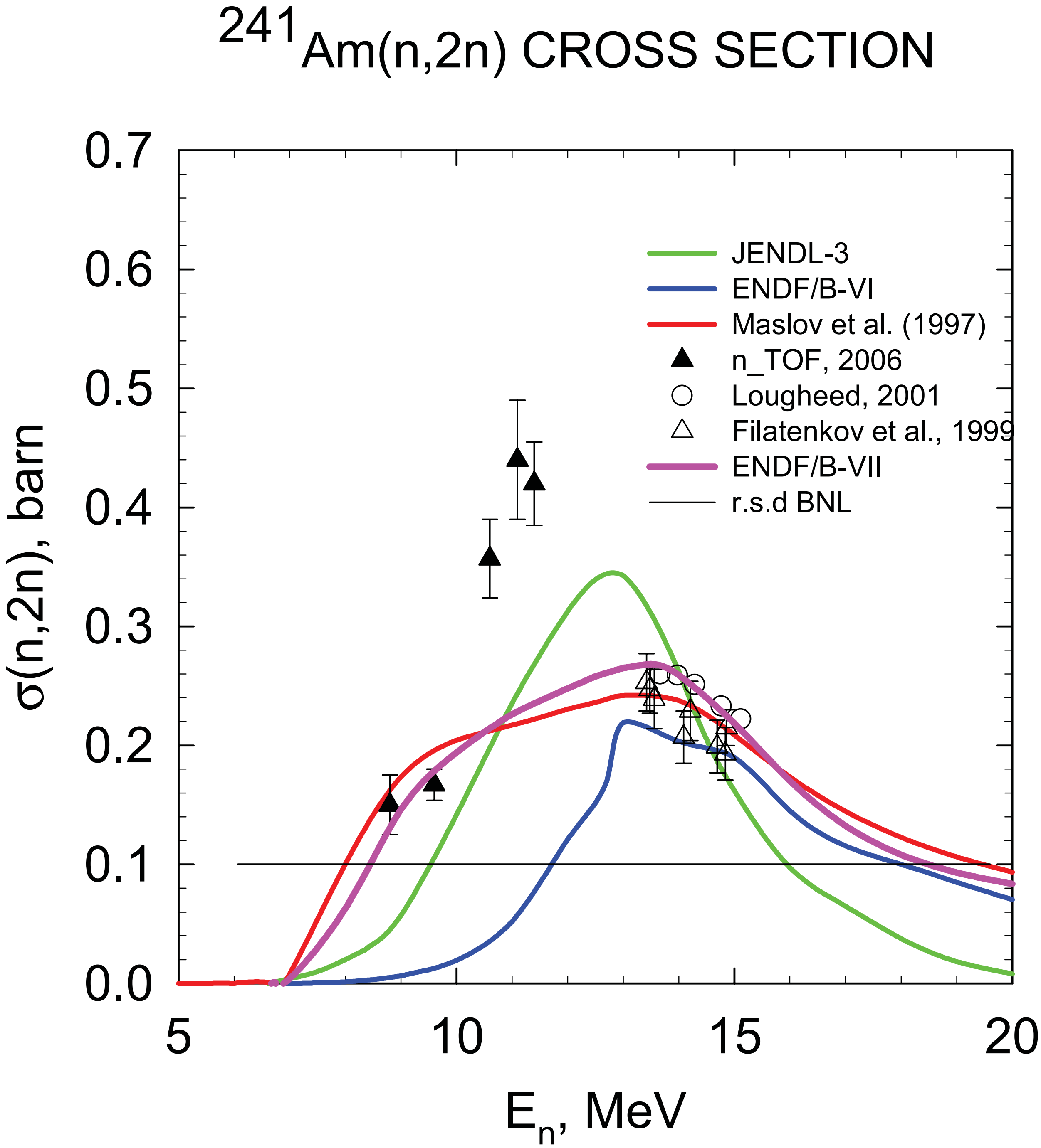


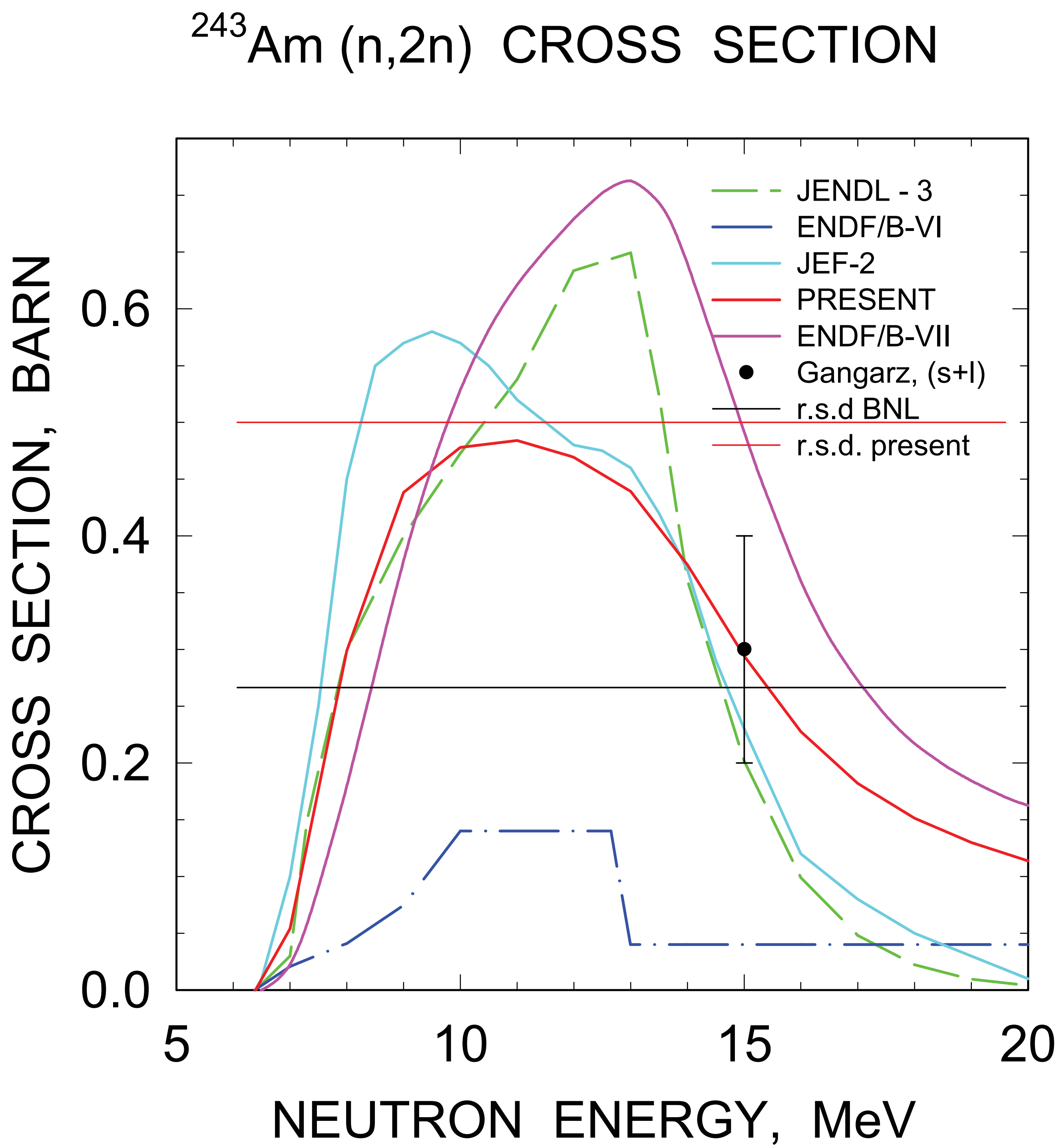


^{245}Cm (n,2n) CROSS SECTION
1.0
0.8
0.6
0.4
0.2
0.0
CROSS SECTION, BARN
JENDL - 3
PRESENT
r.s.d. BNL
10
20
NEUTRON ENERGY, MeV



^{237}Np(n,2n)
PRESENT
Gromova et al., 1983
Nishi et al, 1975
Landrum et al., 1973
Paulson et al., 1974
Daroczy et al., 1985
Lindeke et al., 1975
Perkin et al. 1961
JENDL-3.3
ENDF/B-VII.0
BROND
r.s.d. BNL
r.s.d. present
CROSS SECTION, BARN
NEUTRON ENERGY, keV
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
5
10
15
20


241Am(n,2n) CROSS SECTION
σ(n,2n), barn
En, MeV
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
5
10
15
20
JENDL-3
ENDF/B-VI
Maslov et al. (1997)
n_TOF, 2006
Lougheed, 2001
Filatenkov et al., 1999
ENDF/B-VII
r.s.d BNL



^{243}Am (n,2n) CROSS SECTION
JENDL - 3
ENDF/B-VI
JEF-2
PRESENT
ENDF/B-VII
Gangarz, (s+l)
r.s.d BNL
r.s.d. present
CROSS SECTION, BARN
0.0
0.2
0.4
0.6
5
10
15
20
NEUTRON ENERGY, MeV

Chapter 7

Prompt fission neutron multiplicities

In some cases, described in BNL reports [1, 2], the prompt fission neutron multiplicities (nu-bars) relative standard deviations, based on linear [280] or more complex fits of measured data are too optimistic. Present analysis would be based on the energy balance model, which takes into account the pre-fission (n, xnf) neutron emission in an approximate, but explicit way. The prompt neutron multiplicity ν_p covariance, just as that of fission cross sections, should be strictly "correlated" with the underlying absolute values. That means both ν_p and r.s.d of ν_p for neighboring nuclides should be self-consistent. To follow that "rule" one should interpret the variation of the slope $d\nu_p/dE$ as dependent on (Z,N)-composition of the fissioning nuclides and E_n of the incident neutron. Since the linear approximation of $d\nu_p/dE$=const is often employed in evaluated data files, one should understand the nature of various violations of that simple linear behavior. One of them is encountered in case of ^{232}Th(n,F) reaction [281-296]. Bump in ν_p around 7 MeV is due to the (n,nf) pre-fission neutrons of second-chance fission reaction. Of similar nature, but less pronounced, effect is anticipated in case of ^{243}Am(n,F) reaction, while it is missing in case of ^{238}U(n,F) [297-301] or ^{236}U(n, F) [298, 302-303] reactions.

The pre-equilibrium emission of the (n,nf) pre-fission neutrons of second-chance fission at higher incident neutron energies leads to general decrease of $d\nu_p/dE$, that conclusion is supported by the multiplicity data base, as opposed to Howerton [280] systematic. This effect is important for the error propagation with the incident neutron energy increase. In case of ^{238,240,242}Pu nuclides, ^{240}Pu data are adopted for the BNL covariance files [1, 2] from JENDL-3.3, the r.s.d. in first, second and some lower groups is rather low, since they are compatible with measured data by Khokhlov et al. [304]. For the ^{242}Pu nuclide r.s.d. is even lower, while the discrepancies with measured data of JENDL-3.3 evaluations, which are based on liner extrapolation from low to higher energies, tend to increases. In case of ^{238}Pu nuclide, in JENDL-3.3 Maslov et al. [32] evaluation is adopted, similar approach provides good fit in case of ^{242}Pu as well (Maslov et al. [33]). These fits are attained by taking into account pre-equilibrium emission of the (n,nf) pre-fission neutrons of second-chance fission. The conclusion is that with increase of the incident neutron energy the r.s.d estimates for ^{238,240,242}Pu nuclides should be correlated with the measured data fits and systematic. The analysis of evaluated curves discrepancies with each other, at high energies and at lower energies, may lead to wrong estimates of r.s.d. for neighbor even nuclides.

In case of ^{242,243,244,245}Cm nuclei, the estimate of r.s.d. for ^{243}Cm seem to be too optimistic, as compared with that of ^{245}Cm. The calculated slope of $d\nu_p/dE = 0.135$ for ^{243}Cm is considerably lower than that of Howerton [280] systematic prediction. However, it is consistent with $d\nu_p/dE$ for neighboring nuclei. The Madland-Nix [305] model calculations, used in Maslov et al. [26, 27] evaluation predict non-linear shape of $\nu_p(E)$ above emissive fission threshold. The influence of pre-equilibrium pre-fission neutrons manifests in additional appreciable decrease of $d\nu_p/dE$ above 12 MeV.

For ^{238,242}Pu, ^{241,242m,243}Am, ^{243,245}Cm our previous analysis (Maslov et al. [23, 24]) was based on Madland-Nix [305] model calculations with pre-equilibrium pre-fission neutron in the exit channel, new analysis, based on the refined treatment of pre-fission neutron emission and energy balance model would be of interest.

In case of ^{241,242m,243}Am nuclides the r.s.d. estimates also seem to be rather optimistic, having in mind data scatter and increase of the model parameter uncertainties with incident neutron energy increase.

^{232}Th: r.s.d are increased in 1st and 2nd groups up to 3 and 5%, respectively, to reflect the differences of ENDF/B-VII.0 evaluated data from measured data and evaluation by Maslov et al. [19] (see Fig. 7.1).

^{238}U: r.s.d are left unchanged, since they reflect the differences of ENDF/B-VII.0 evaluated data with measured data and evaluation by Maslov et al. [23] (see Fig. 7.2).

^{236}U: r.s.d are fixed as those of ^{238}U, except 1st, 2nd and 3rd groups, where 3 % values are assumed. That reflect the differences of ENDF/B-VII.0 evaluated data with measured data and previous evaluations (see Fig. 7.3).

^{234}U: r.s.d are fixed as those of ^{236}U, except 1st, 2nd and 3rd groups, where 3 % values are assumed (see Fig. 7.4). That reflects the differences of ENDF/B-VII.0 evaluated data with previous evaluations of JENDL-3.3 and by Maslov et al. [21]. Data by Mather et al. [285] cover only the first chance fission energy range.

^{238}Pu: r.s.d are increased in 1st group to 5 % values, but decreased in other groups. That reflect the differences of ENDF/B-VII.0 evaluated data with evaluation by Maslov et al. [32] (see Fig. 7.5).

^{240}Pu: r.s.d are left unchanged, since they reflect the differences of ENDF/B-VII.0 evaluated data with measured data and previous evaluations (see Fig. 7.6).

^{242}Pu: r.s.d are increased in 1^{st} and 2^{nd} groups, where 10% and 3 % values are assumed, respectively (see Fig. 7.7). That increase reflects the differences of ENDF/B-VII.0 evaluated data with measured data and previous evaluations.

^{242}Cm: r.s.d are increased roughly up to 10 %, to reflect the differences of ENDF/B-VII.0 evaluated data with previous evaluations (see Fig. 7.8).

^{244}Cm: r.s.d are increased roughly up to 10 %, to reflect the differences of ENDF/B-VII.0 evaluated data with previous evaluations (see Fig. 7.9).

^{235}U: nu-bar data [286, 306-309] are fitted with an energy balance model by Maslov et al. [10, 11], the partial contributions of (n, xnf) fission chances are distinguished (see Fig. 7.10). The perfect fit above (n, xnf) fission thresholds might be obtained by fine-tuning of nu-bars for the relevant emissive fission chances. That might be helpful for prediction of nu-bars of poorly investigated nuclides. R.s.d. values are left as they are.

^{233}U: nu-bar data [297, 310-320] is fitted with an energy balance model by Maslov et al. [10, 11, 22], the partial contributions of (n, xnf) fission chances are distinguished and compared with those of ^{235}U(n, F) (see Fig. 7.11). R.s.d. values are left as they are.

^{239}Pu: nu-bar data [308] are described with an energy balance model by Maslov et al. [10, 11], the partial contributions of (n, xnf) fission chances are distinguished (see Fig. 7.12). The first iteration curve is shown on the graph. The perfect fit above (n, xnf) fission thresholds might be obtained by fine-tuning of nu-bars for emissive fission chances. That would be helpful for fitting nu-bar of ^{239}Pu(n, f) above emissive fission threshold by slight increase of $d\nu_p/dE$ for ^{239}Pu fissioning nuclide. R.s.d. values are left as they are.

^{241}Pu: R.s.d. values, based on [308] data fit, are left as they are (see Fig. 7.13).

^{243}Cm: The Madland-Nix [305] model calculations, used in Maslov et al. [26] evaluation, predict non-linear shape of $\nu_p(E)$ above emissive fission threshold, similar to that, predicted for ^{245}Cm(n,F) (see Fig. 7.14). The influence of pre-equilibrium pre-fission neutrons manifests in additional appreciable decrease of $d\nu_p/dE$ above 12 MeV. R.s.d. values are left as they are.

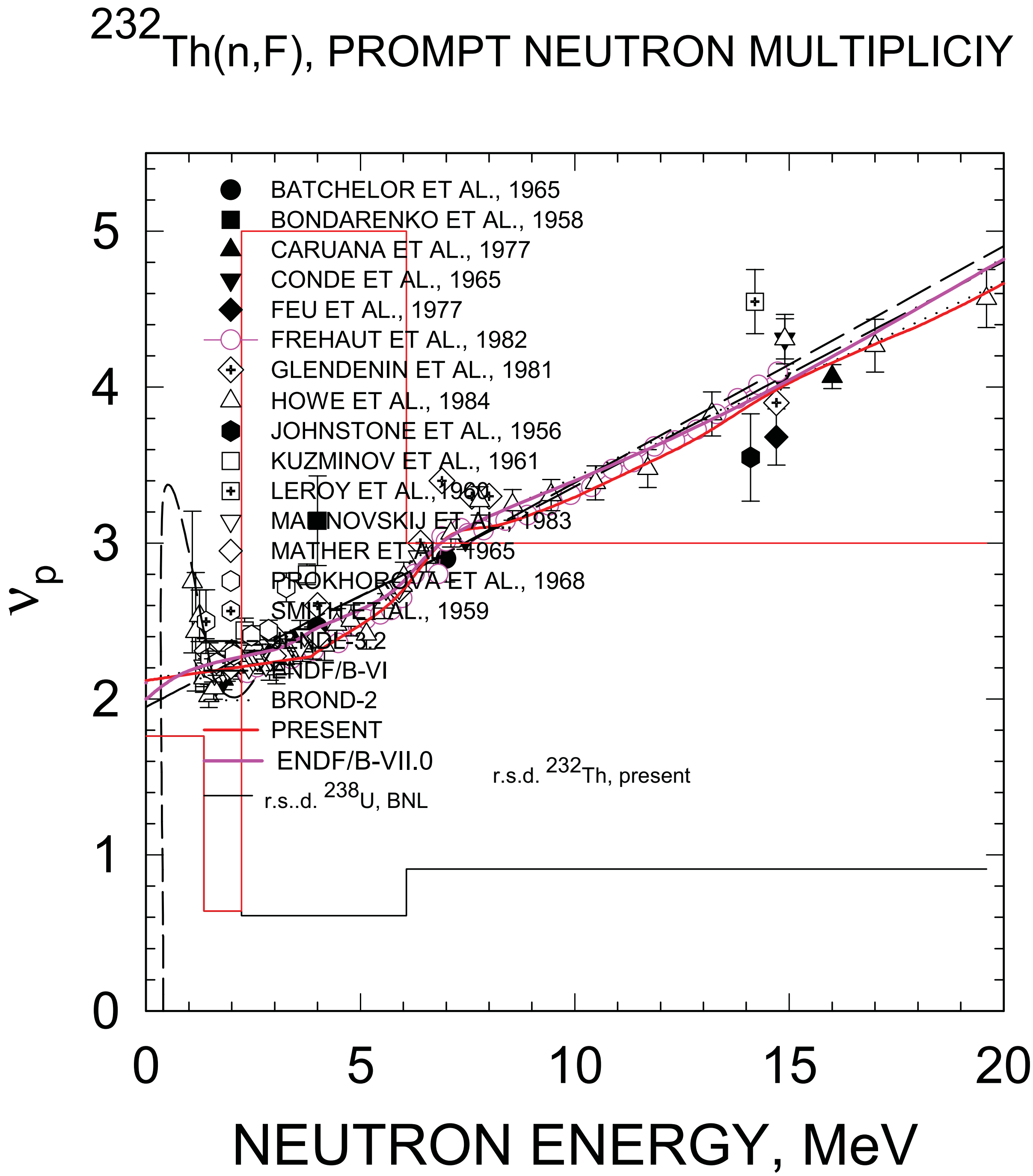
^{245}Cm: The Madland-Nix [305] model calculations, used in Maslov et al. [27] evaluation of measured data [304, 321-323] predict non-linear shape of $\nu_p(E)$ above emissive fission threshold (see Fig. 7.15). The influence of pre-equilibrium pre-fission neutrons manifests in additional appreciable decrease of $d\nu_p/dE$ above 12 MeV. R.s.d. values are left as they are.

^{237}**Np:** nu-bar data [304, 306, 289, 325] are roughly reproduced with an energy balance model [10, 11], the partial contributions of (n, xnf) fission chances are distinguished (see Fig. 7.16). Better fit might be obtained by fine-tuning of nu-bars for emissive fission chances. R.s.d. values are increased in the first group to reflect the non-linear slope of nu-bar.

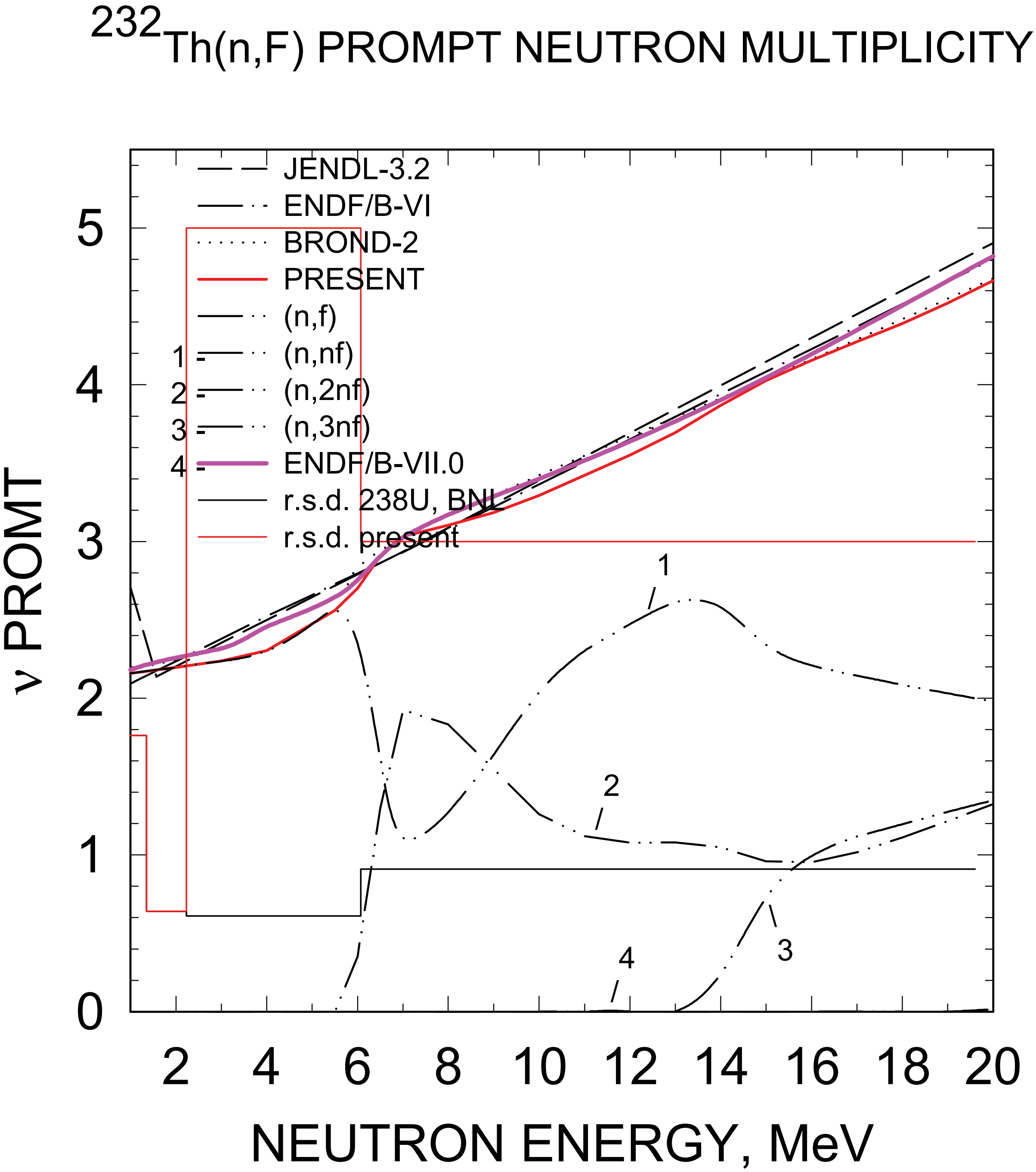
^{241}**Am:** nu-bar data [304, 322, 324] is reproduced with an energy balance model by [10, 11], the partial contributions of (n, xnf) fission chances are distinguished (see Fig. 7.17). Better fit might be obtained by fine-tuning of nu-bars for emissive fission chances. Present fit it rather different from the previous evaluation by Maslov et al. [17]. R.s.d. values should be assumed equal to 3% over the whole energy range to reflect the non-linear slope of nu-bar and data spread.

^{243}**Am:** nu-bar of ENDF/B-VII.0 is quite compatible with Maslov et al. evaluation [18] and measured data by Frehaut er al. [326], revealing the systematic error in Khohlov et al. [304] in ^{241}Am(n,F) reaction as well (see Fig. 7.18). R.s.d. values are left as they are.

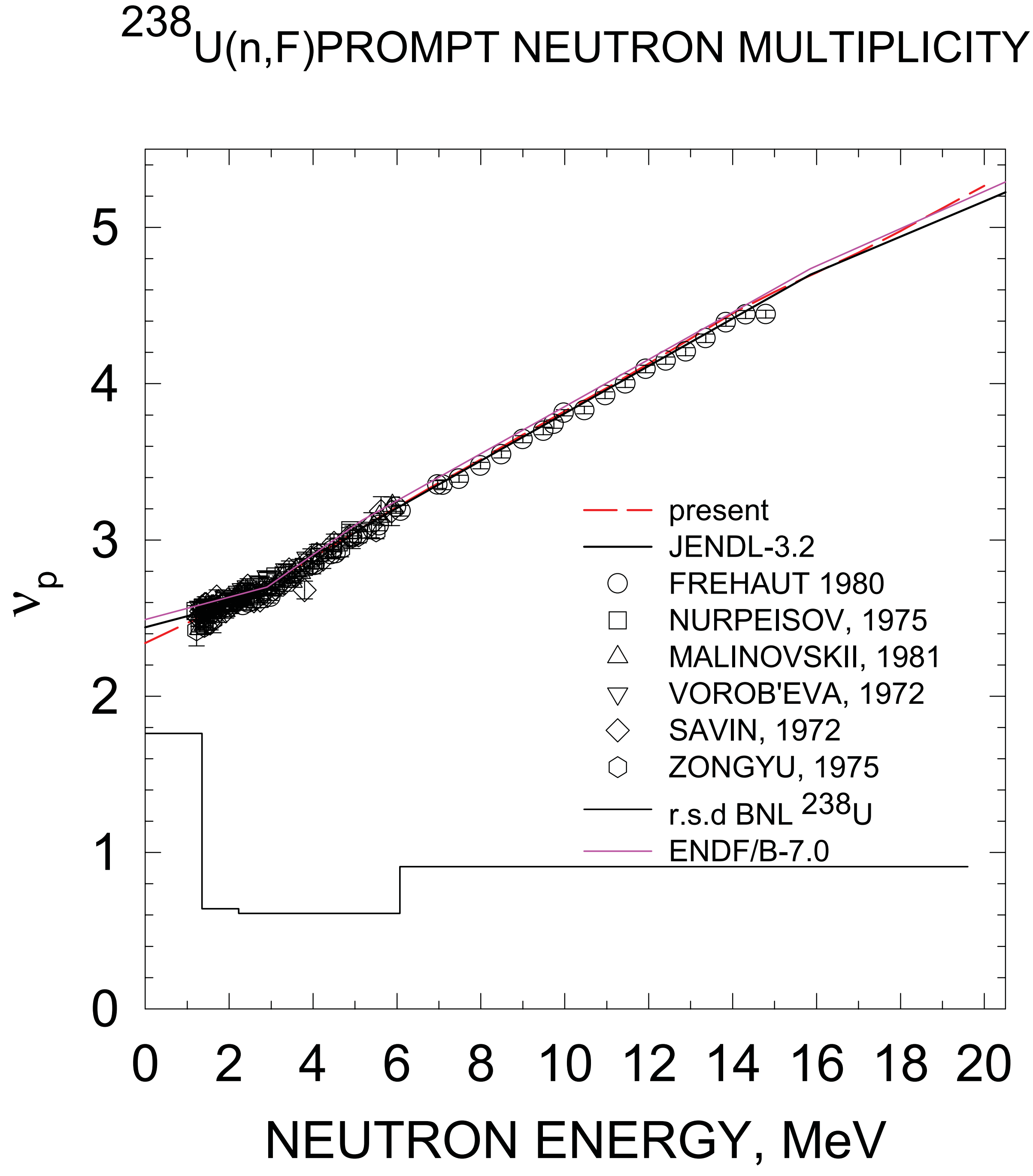
^{242m}**Am:** nu-bar of ENDF/B-VII.0 is adopted from the evaluation by Maslov et al. evaluation [30], which is based on [321, 322, 327, 328] data description (see Fig. 7.19). R.s.d. values are left as they are.



232Th(n,F), PROMPT NEUTRON MULTIPLICIY
BATCHELOR ET AL., 1965
BONDARENKO ET AL., 1958
CARUANA ET AL., 1977
CONDE ET AL., 1965
FEU ET AL., 1977
FREHAUT ET AL., 1982
GLENDENIN ET AL., 1981
HOWE ET AL., 1984
JOHNSTONE ET AL., 1956
KUZMINOV ET AL., 1961
LEROY ET AL., 1960
MALINOVSKIJ ET AL., 1983
MATHER ET AL., 1965
PROKHOROVA ET AL., 1968
SMITH ET AL., 1959
JENDL-3.2
ENDF/B-VI
BROND-2
PRESENT
ENDF/B-VII.0
r.s.d. 232Th, present
r.s..d. 238U, BNL
ν p
NEUTRON ENERGY, MeV
0
1
2
3
4
5
0
5
10
15
20

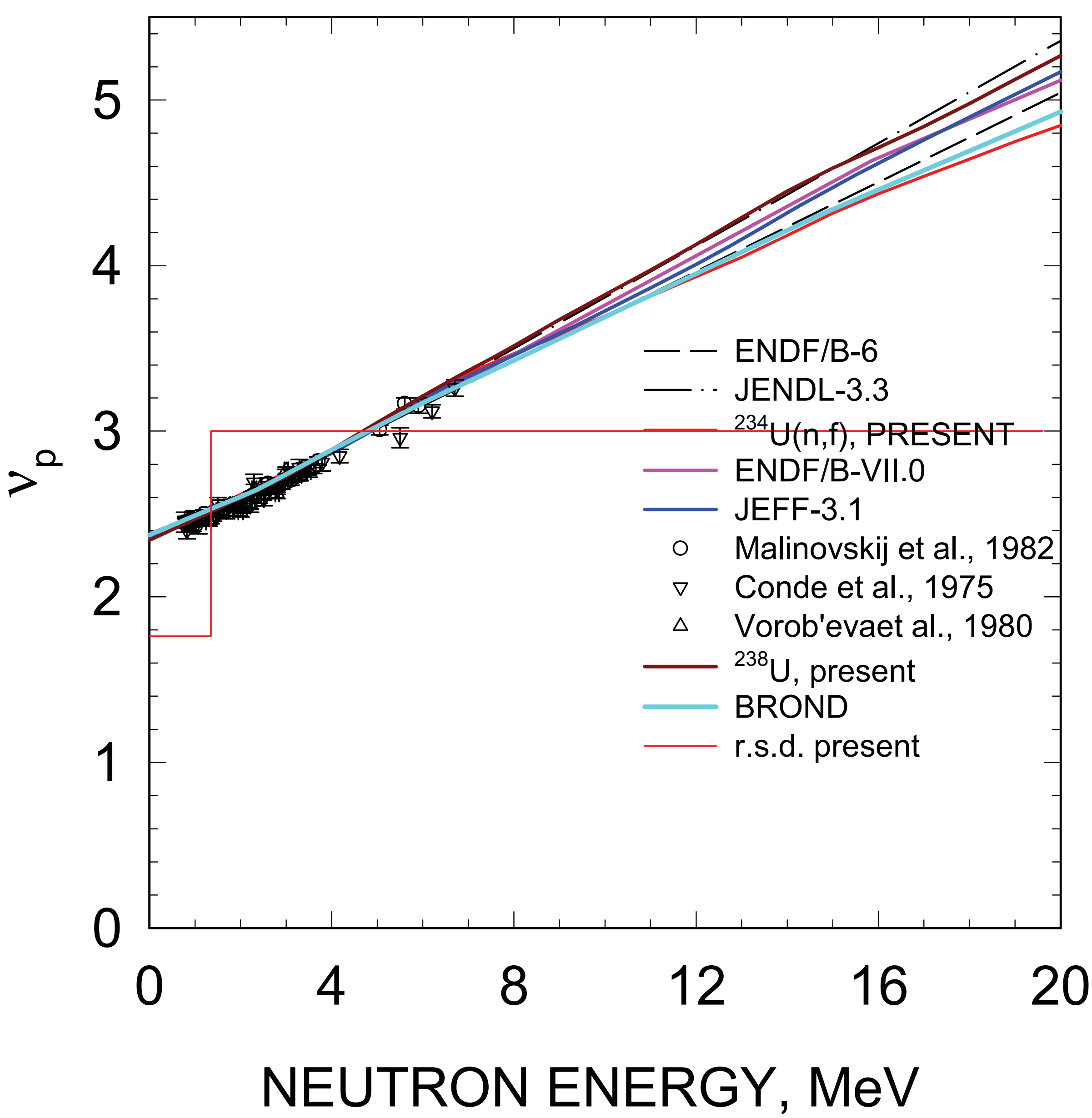


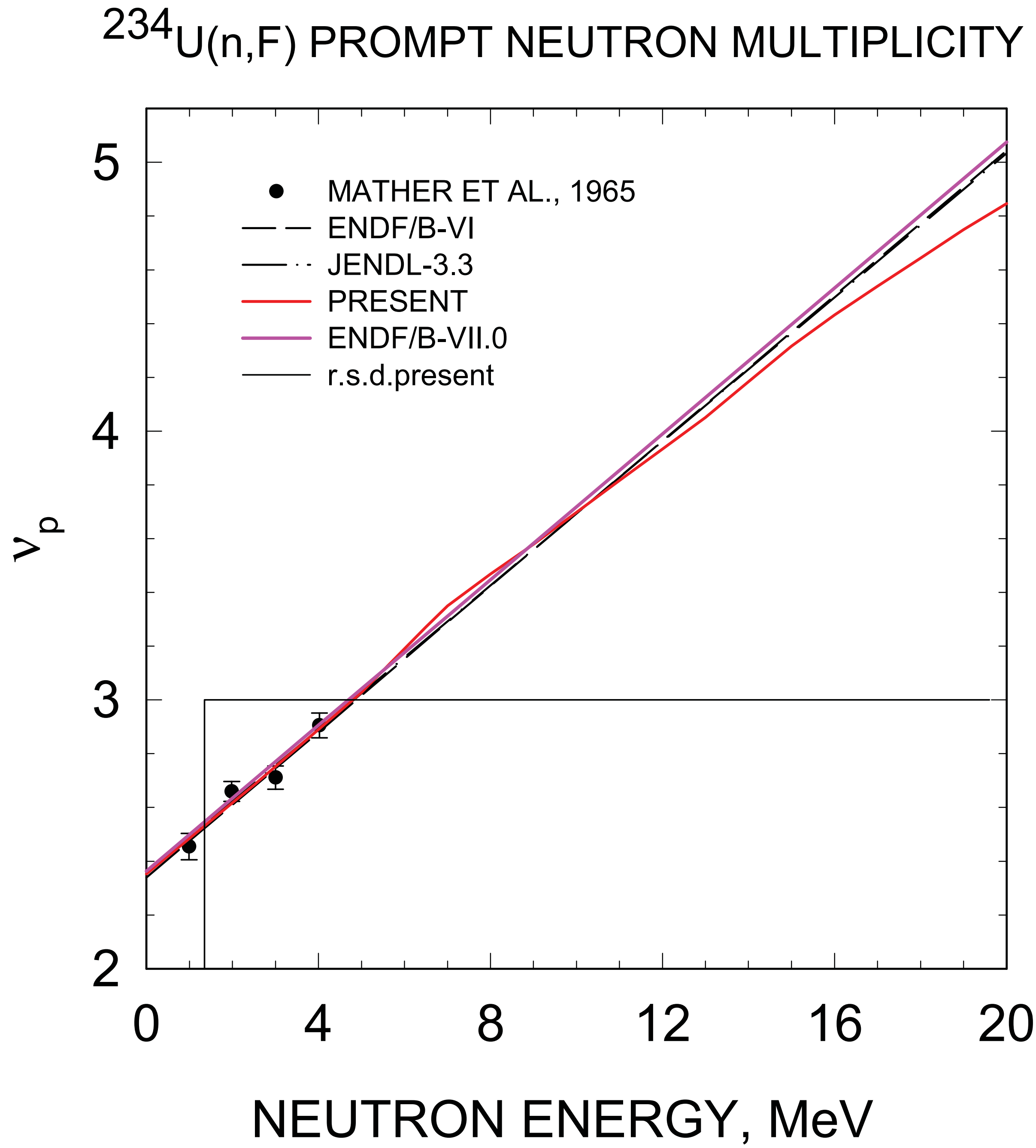
232Th(n,F) PROMPT NEUTRON MULTIPLICITY
JENDL-3.2
ENDF/B-VI
BROND-2
PRESENT
(n,f)
1 - (n,nf)
2 - (n,2nf)
3 - (n,3nf)
4 - ENDF/B-VII.0
r.s.d. 238U, BNL
r.s.d. present
ν PROMT
NEUTRON ENERGY, MeV
0
1
2
3
4
5
2
4
6
8
10
12
14
16
18
20
1
2
3
4



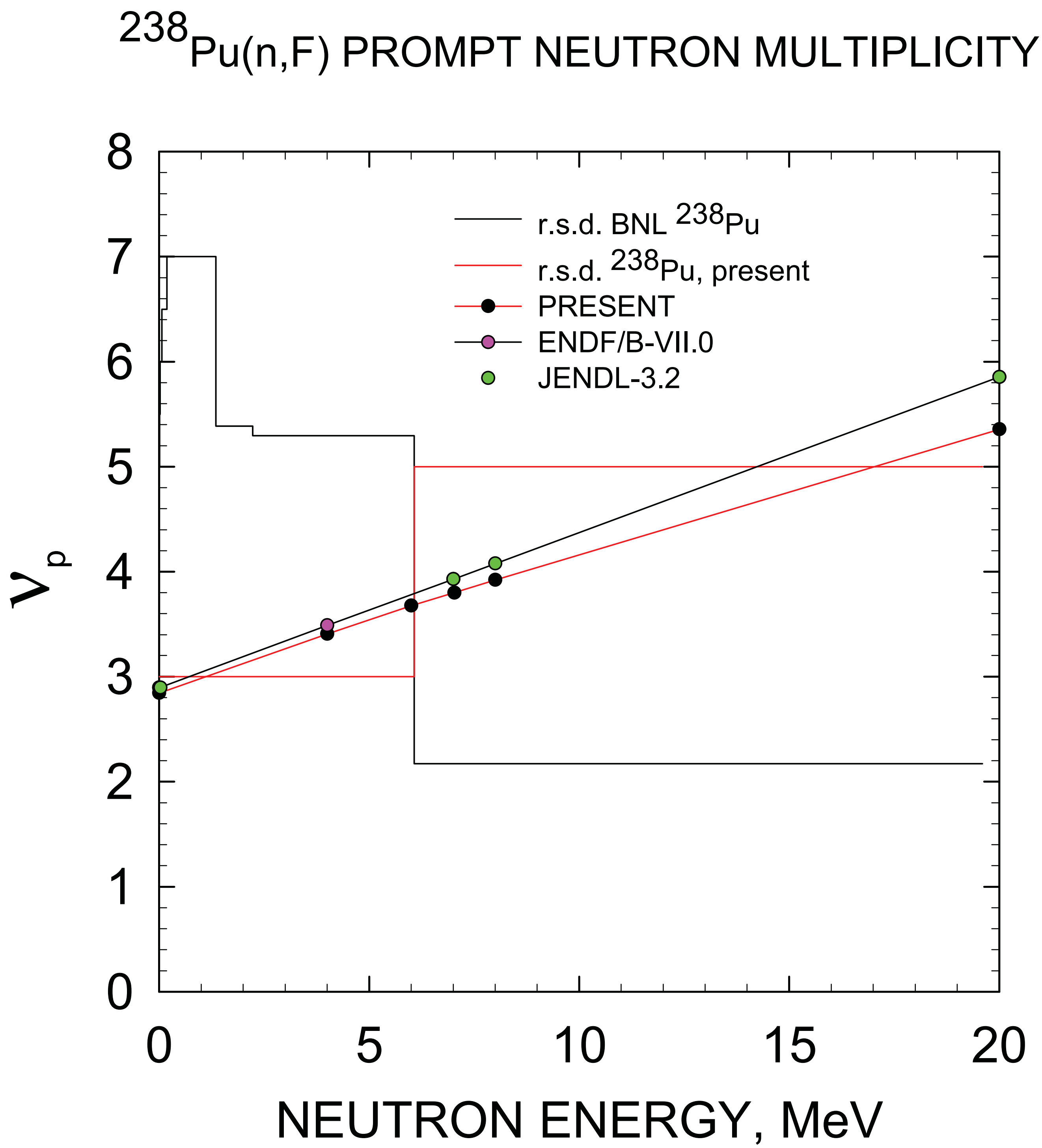
^{238}U(n,F)PROMPT NEUTRON MULTIPLICITY
ν_p
NEUTRON ENERGY, MeV
0
1
2
3
4
5
0
2
4
6
8
10
12
14
16
18
20
present
JENDL-3.2
FREHAUT 1980
NURPEISOV, 1975
MALINOVSKII, 1981
VOROB'EVA, 1972
SAVIN, 1972
ZONGYU, 1975
r.s.d BNL ^{238}U
ENDF/B-7.0

^{236}U(n,F) PROMPT NEUTRON MULTIPLICITY

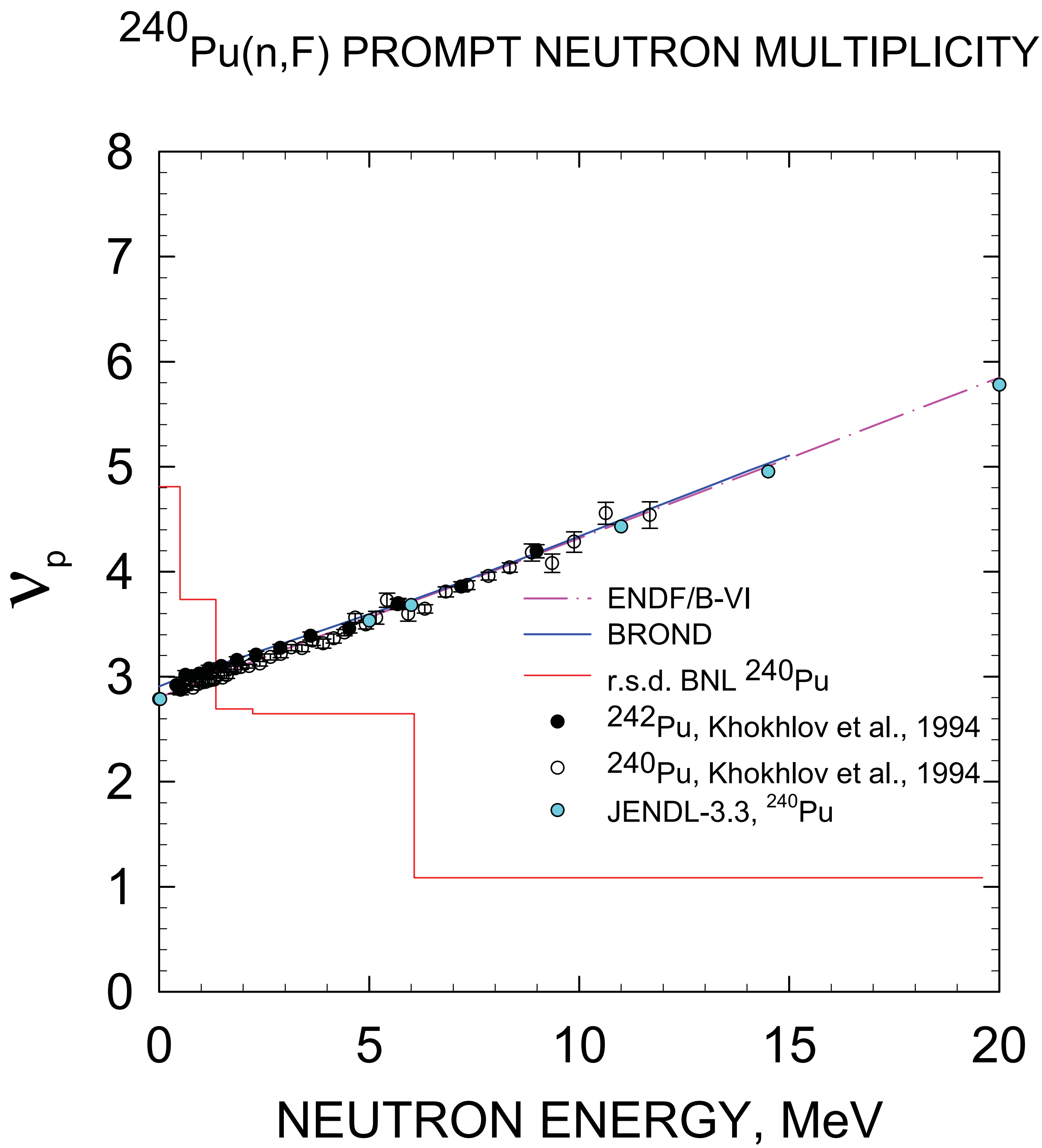




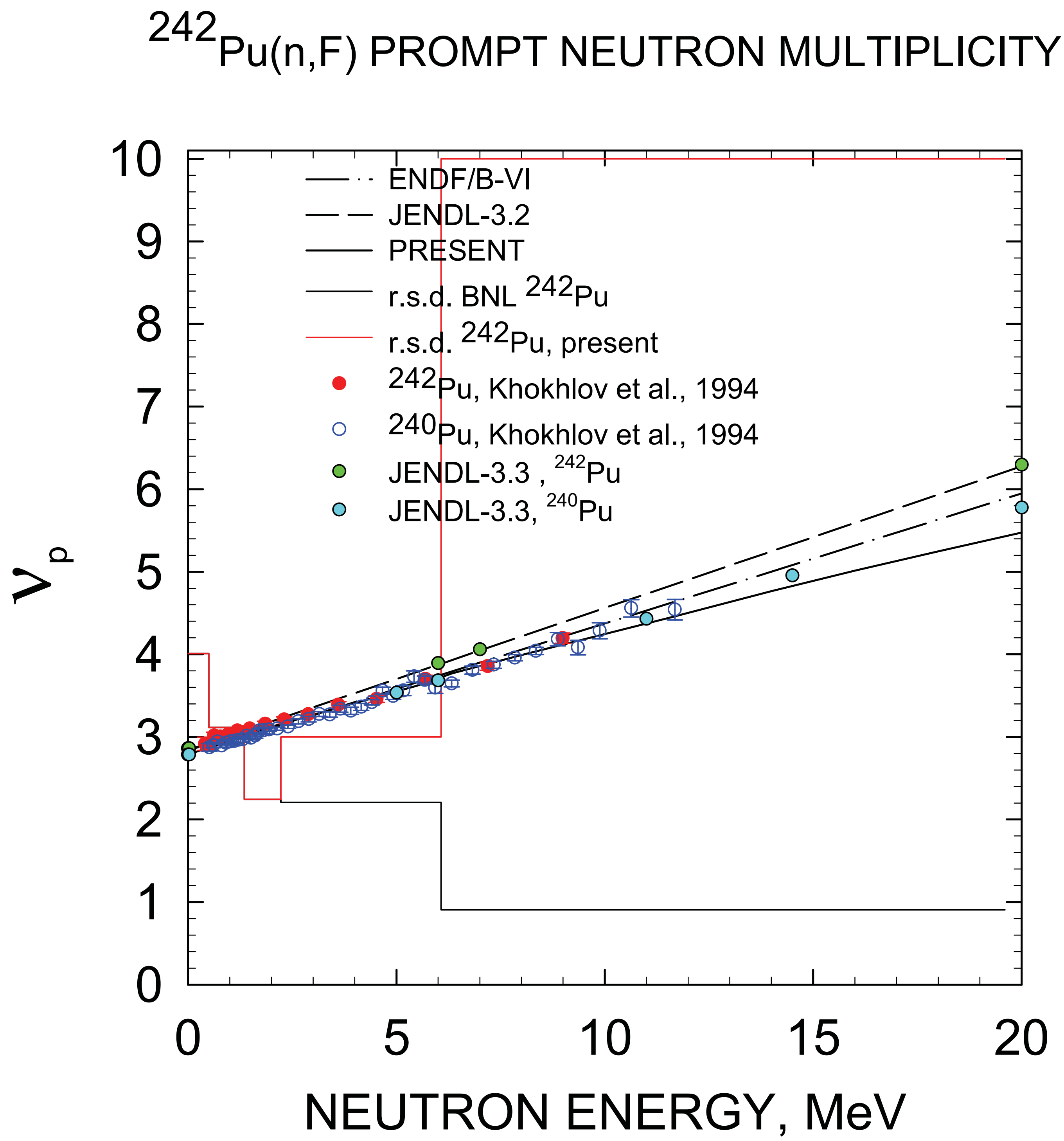
^{234}U(n,F) PROMPT NEUTRON MULTIPLICITY
MATHER ET AL., 1965
ENDF/B-VI
JENDL-3.3
PRESENT
ENDF/B-VII.0
r.s.d.present
ν_p
2
3
4
5
0
4
8
12
16
20
NEUTRON ENERGY, MeV



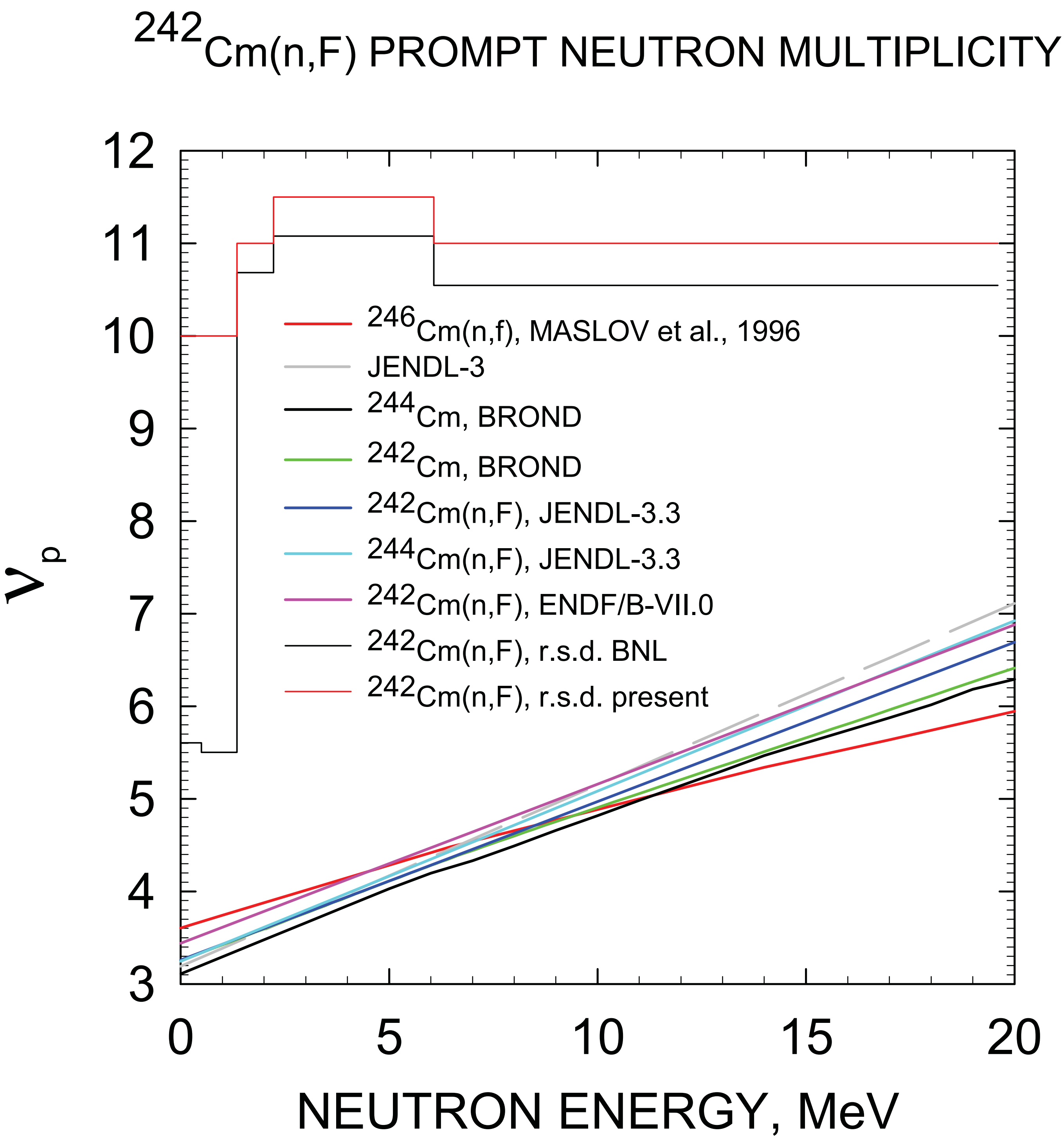
^{238}Pu(n,F) PROMPT NEUTRON MULTIPLICITY
r.s.d. BNL ^{238}Pu
r.s.d. ^{238}Pu, present
PRESENT
ENDF/B-VII.0
JENDL-3.2
ν_p
NEUTRON ENERGY, MeV
0
5
10
15
20
0
1
2
3
4
5
6
7
8



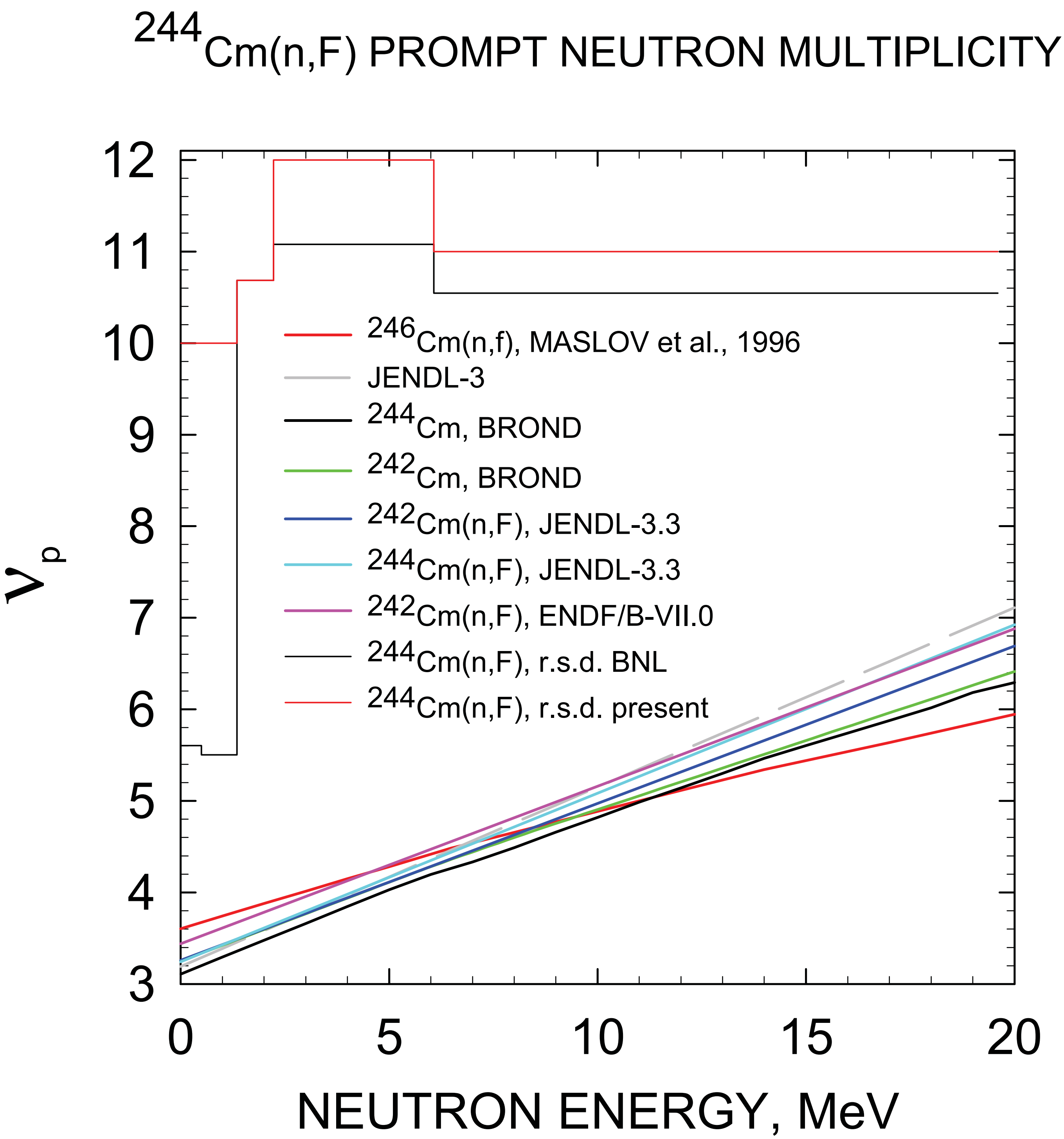
^{240}Pu(n,F) PROMPT NEUTRON MULTIPLICITY
ν_p
NEUTRON ENERGY, MeV
0
1
2
3
4
5
6
7
8
0
5
10
15
20
ENDF/B-VI
BROND
r.s.d. BNL ^{240}Pu
^{242}Pu, Khokhlov et al., 1994
^{240}Pu, Khokhlov et al., 1994
JENDL-3.3, ^{240}Pu



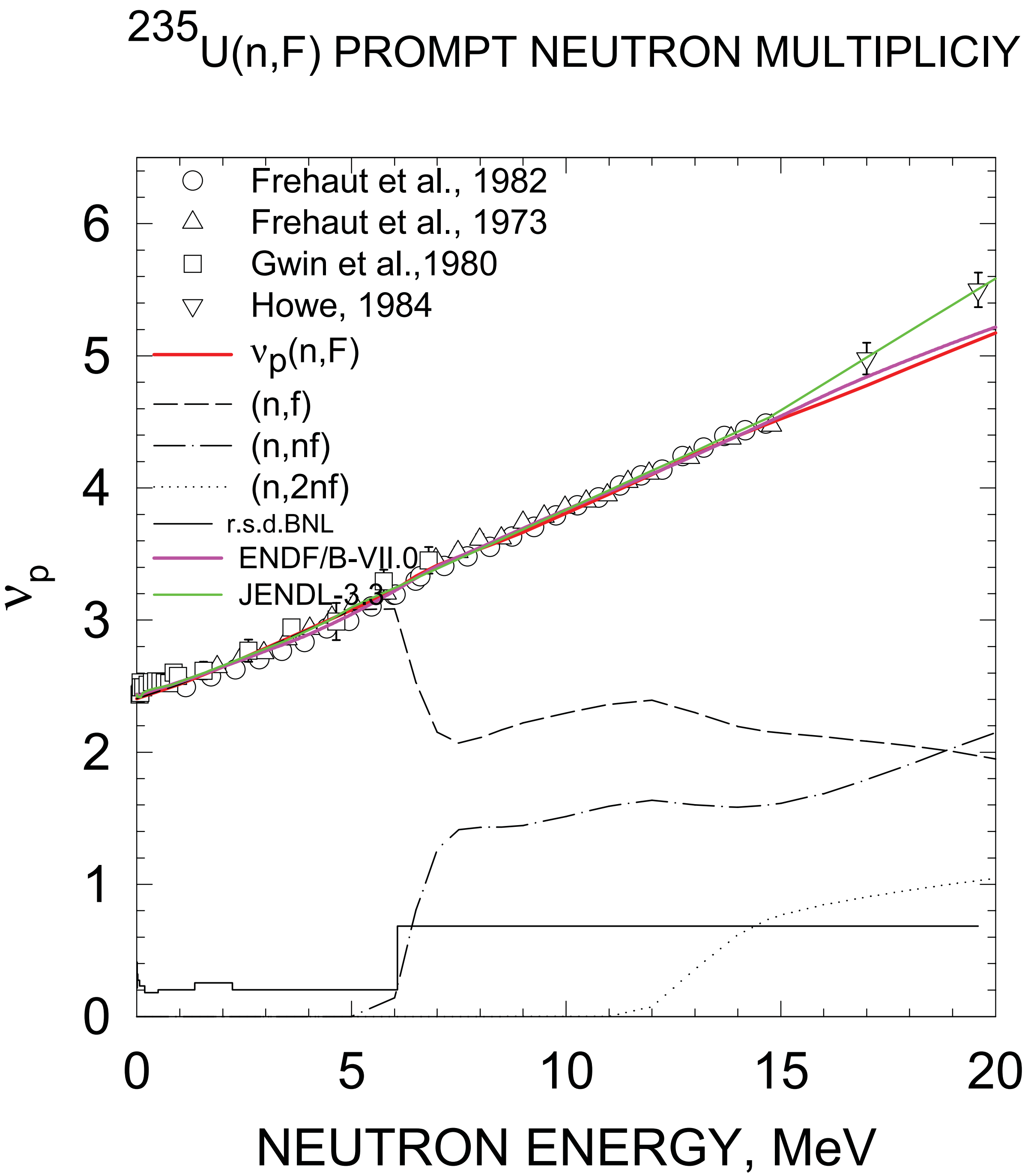
242Pu(n,F) PROMPT NEUTRON MULTIPLICITY
ENDF/B-VI
JENDL-3.2
PRESENT
r.s.d. BNL 242Pu
r.s.d. 242Pu, present
242Pu, Khokhlov et al., 1994
240Pu, Khokhlov et al., 1994
JENDL-3.3 , 242Pu
JENDL-3.3, 240Pu
νp
NEUTRON ENERGY, MeV
0
5
10
15
20
1
2
3
4
6
7
8
9



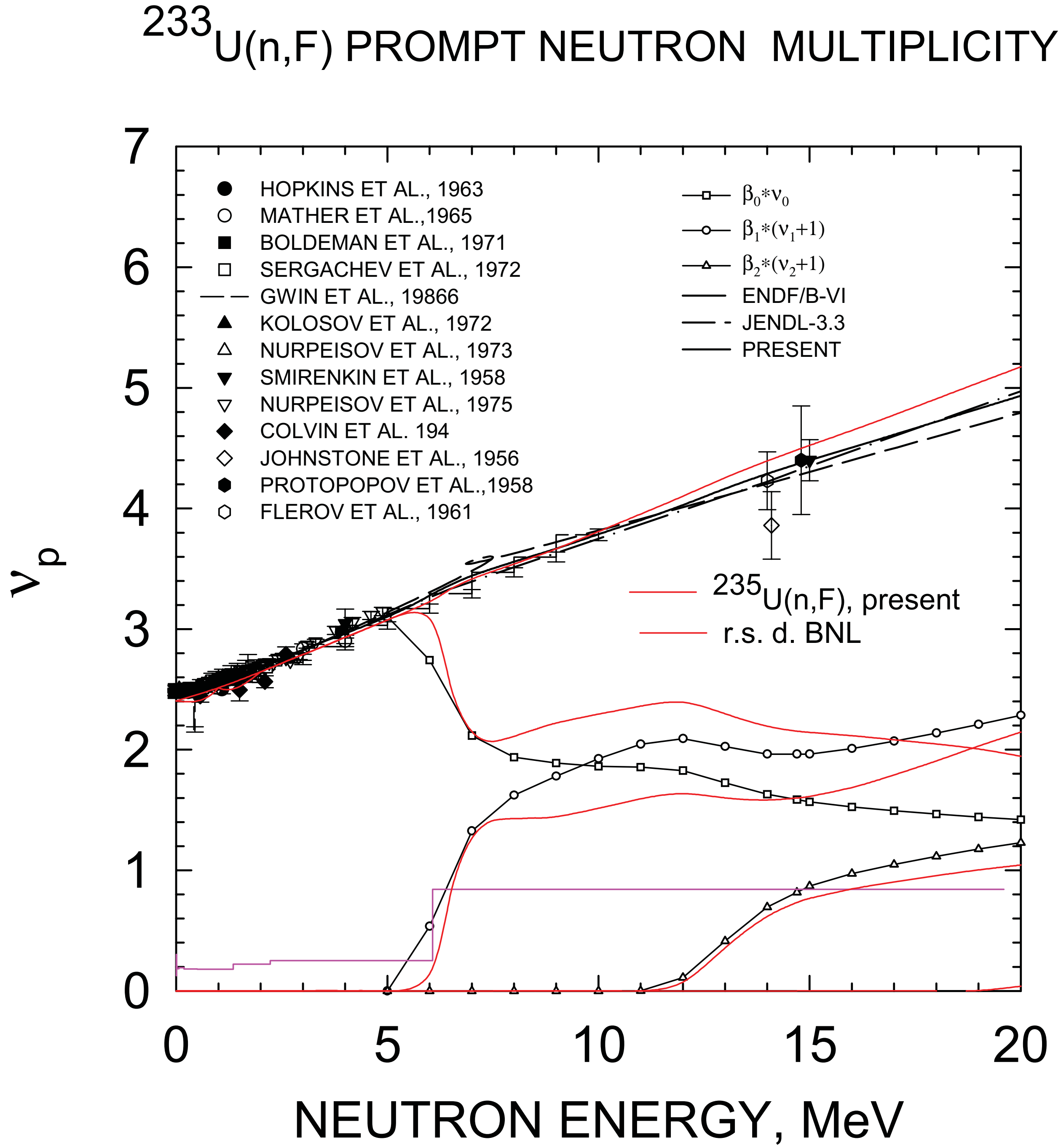
242Cm(n,F) PROMPT NEUTRON MULTIPLICITY
12
11
10
9
8
7
6
5
4
3
0
5
10
15
20
νp
NEUTRON ENERGY, MeV
246Cm(n,f), MASLOV et al., 1996
JENDL-3
244Cm, BROND
242Cm, BROND
242Cm(n,F), JENDL-3.3
244Cm(n,F), JENDL-3.3
242Cm(n,F), ENDF/B-VII.0
242Cm(n,F), r.s.d. BNL
242Cm(n,F), r.s.d. present



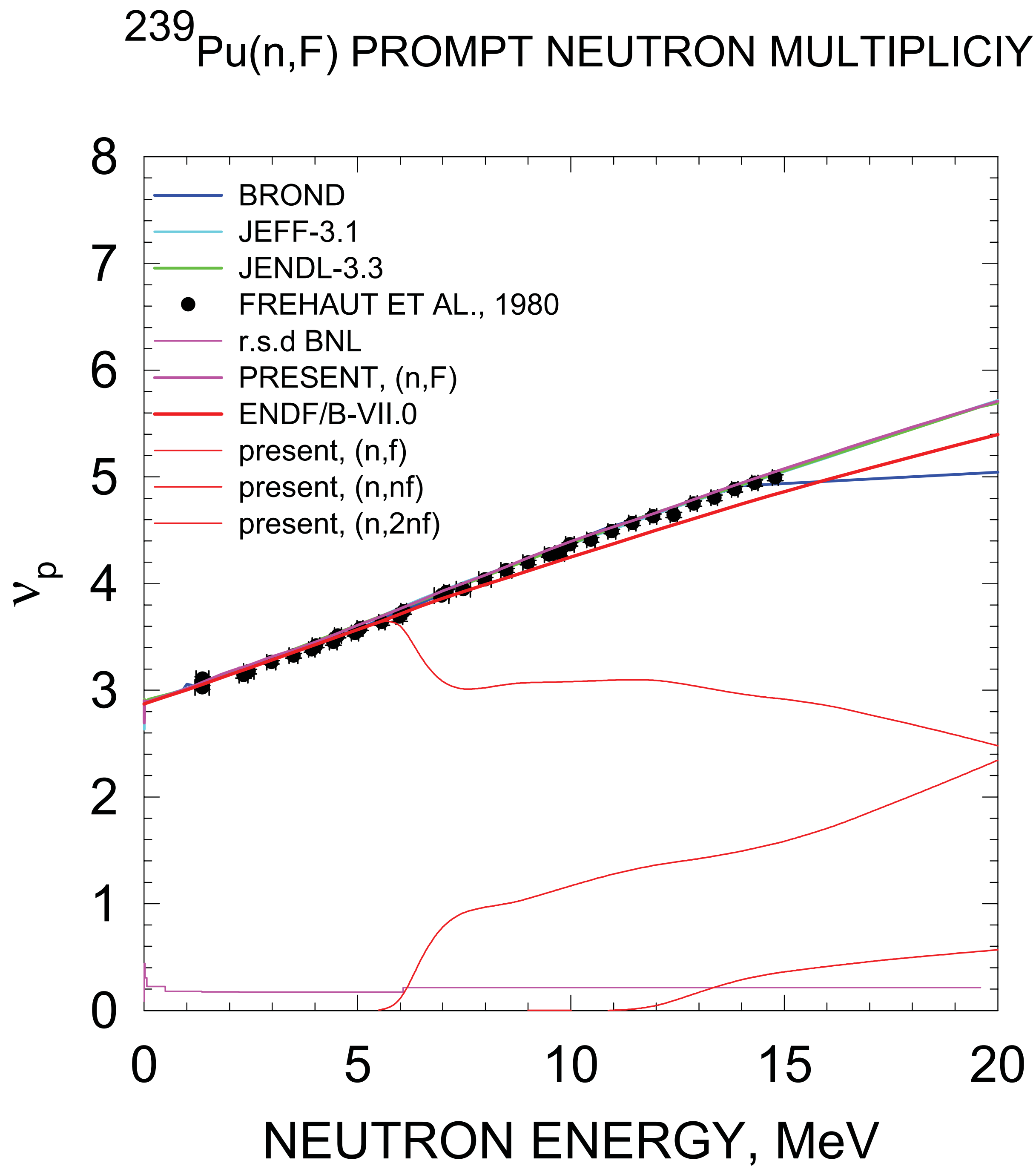
^{244}Cm(n,F) PROMPT NEUTRON MULTIPLICITY
ν_p
NEUTRON ENERGY, MeV
^{246}Cm(n,f), MASLOV et al., 1996
JENDL-3
^{244}Cm, BROND
^{242}Cm, BROND
^{242}Cm(n,F), JENDL-3.3
^{244}Cm(n,F), JENDL-3.3
^{242}Cm(n,F), ENDF/B-VII.0
^{244}Cm(n,F), r.s.d. BNL
^{244}Cm(n,F), r.s.d. present



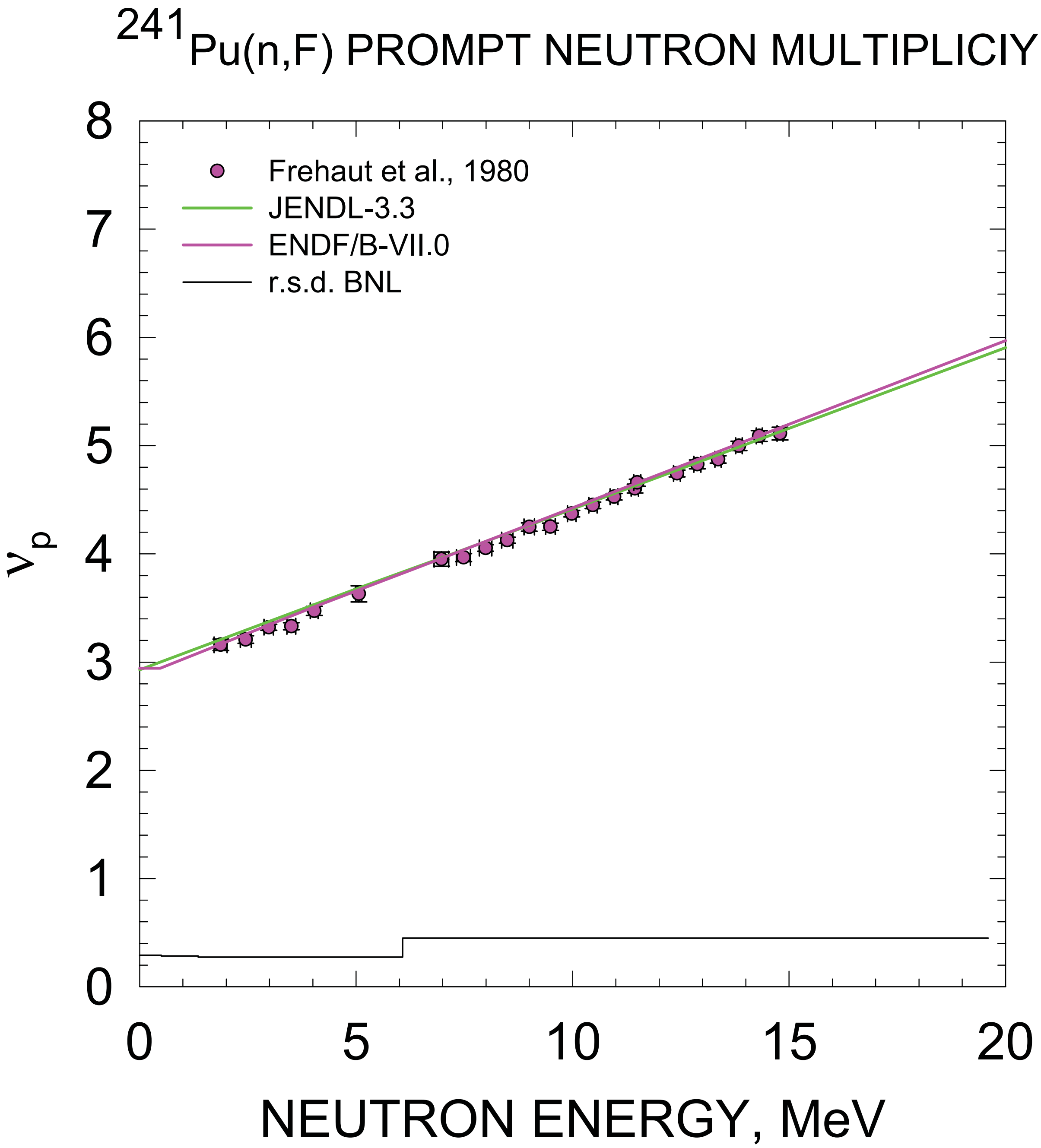
^{235}U(n,F) PROMPT NEUTRON MULTIPLICIY
Frehaut et al., 1982
Frehaut et al., 1973
Gwin et al.,1980
Howe, 1984
ν_p(n,F)
(n,f)
(n,nf)
(n,2nf)
r.s.d.BNL
ENDF/B-VII.0
JENDL-3.3
ν_p
0
1
2
3
4
5
6
0
5
10
15
20
NEUTRON ENERGY, MeV



233U(n,F) PROMPT NEUTRON MULTIPLICITY
HOPKINS ET AL., 1963
MATHER ET AL.,1965
BOLDEMAN ET AL., 1971
SERGACHEV ET AL., 1972
GWIN ET AL., 19866
KOLOSOV ET AL., 1972
NURPEISOV ET AL., 1973
SMIRENKIN ET AL., 1958
NURPEISOV ET AL., 1975
COLVIN ET AL. 194
JOHNSTONE ET AL., 1956
PROTOPOPOV ET AL.,1958
FLEROV ET AL., 1961
β0*ν0
β1*(ν1+1)
β2*(ν2+1)
ENDF/B-VI
JENDL-3.3
PRESENT
235U(n,F), present
r.s. d. BNL
νp
NEUTRON ENERGY, MeV
0
1
2
3
4
5
6
7
10
15
20

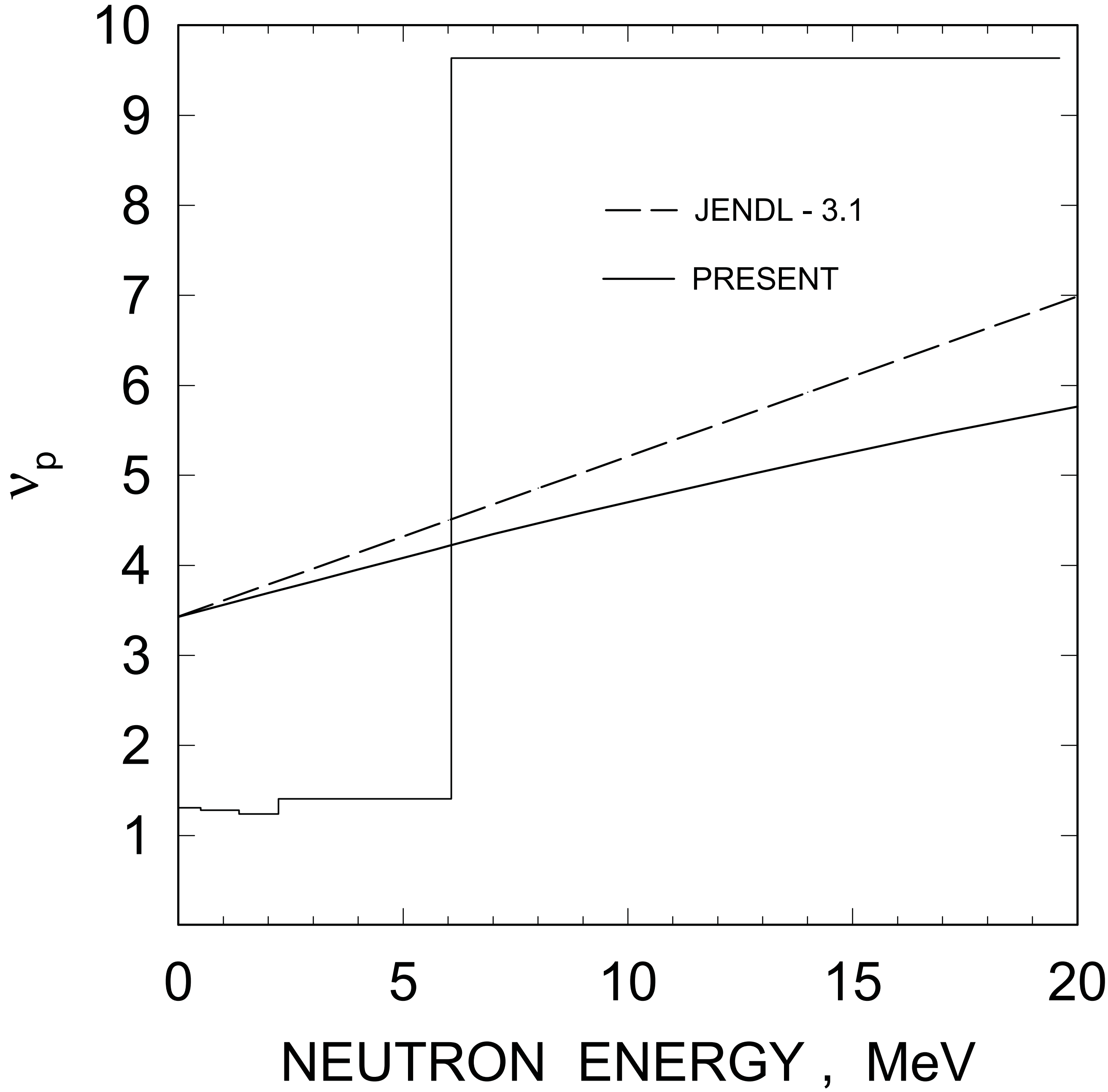


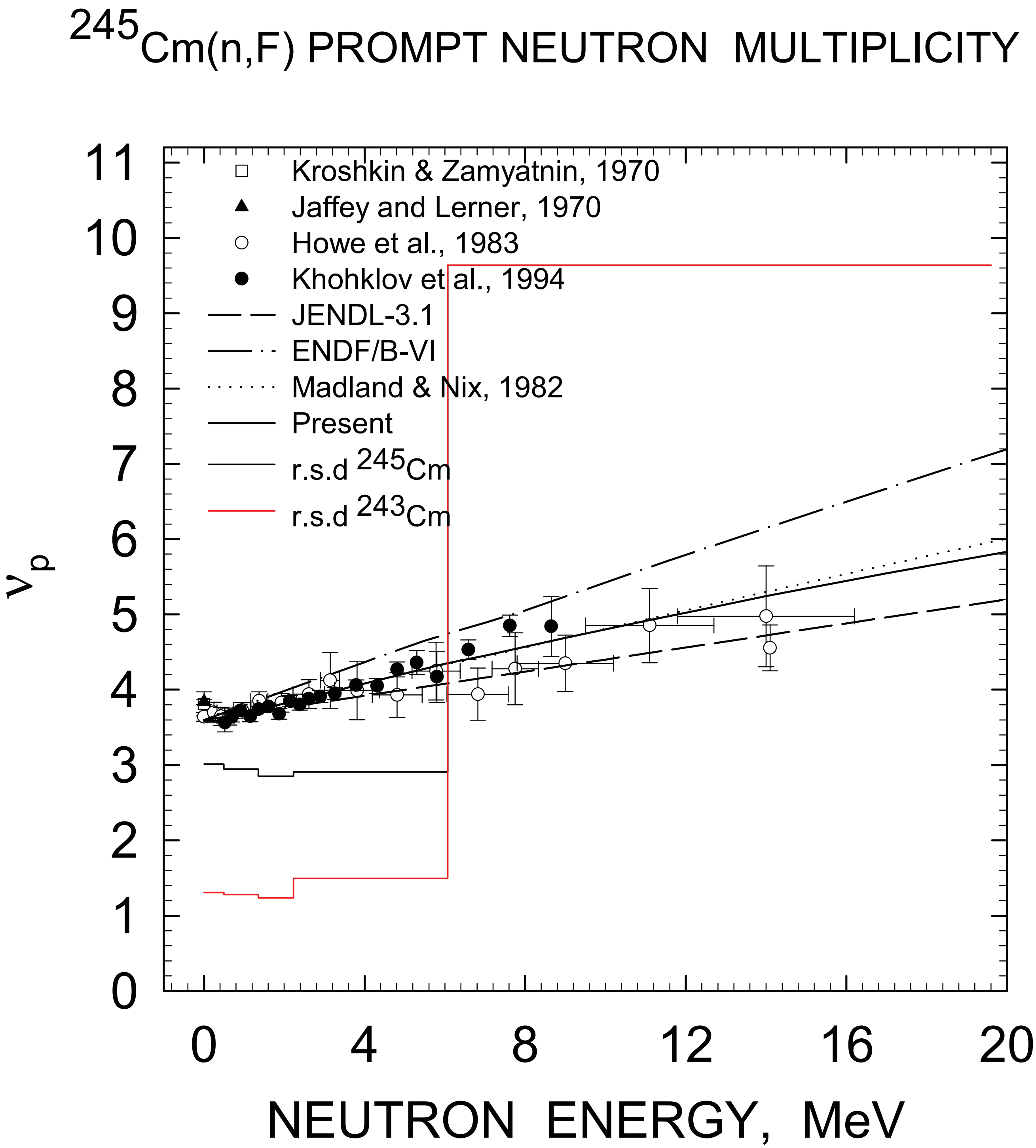
239Pu(n,F) PROMPT NEUTRON MULTIPLICIY
BROND
JEFF-3.1
JENDL-3.3
FREHAUT ET AL., 1980
r.s.d BNL
PRESENT, (n,F)
ENDF/B-VII.0
present, (n,f)
present, (n,nf)
present, (n,2nf)
νp
NEUTRON ENERGY, MeV
0
5
10
15
20
0
1
2
3
4
5
6
7
8



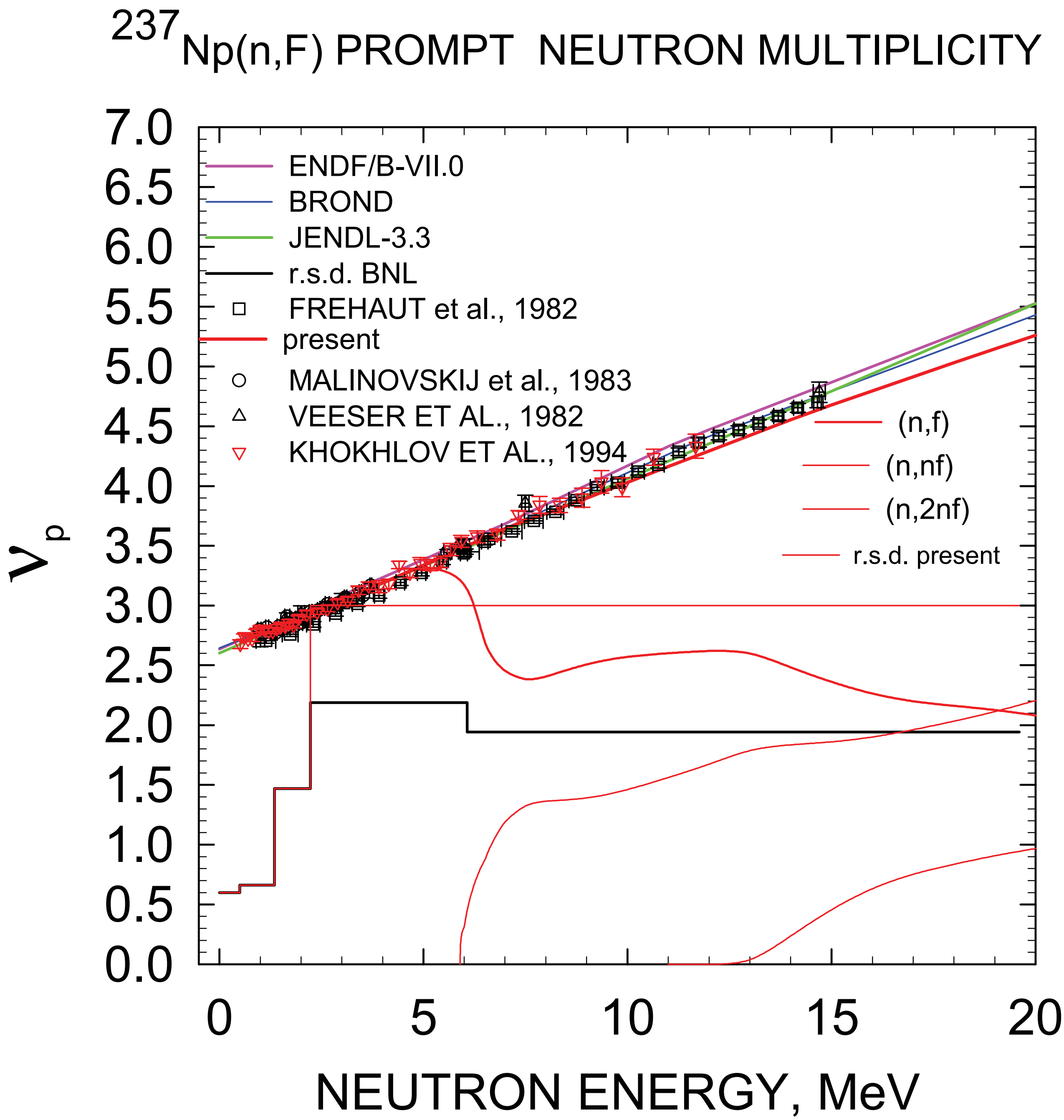
^{241}Pu(n,F) PROMPT NEUTRON MULTIPLICIY
Frehaut et al., 1980
JENDL-3.3
ENDF/B-VII.0
r.s.d. BNL
ν_p
0
1
2
3
4
5
6
7
8
0
5
10
15
20
NEUTRON ENERGY, MeV

$^{243}Cm(n,F)$ PROMPT NEUTRON MULTIPLICITY

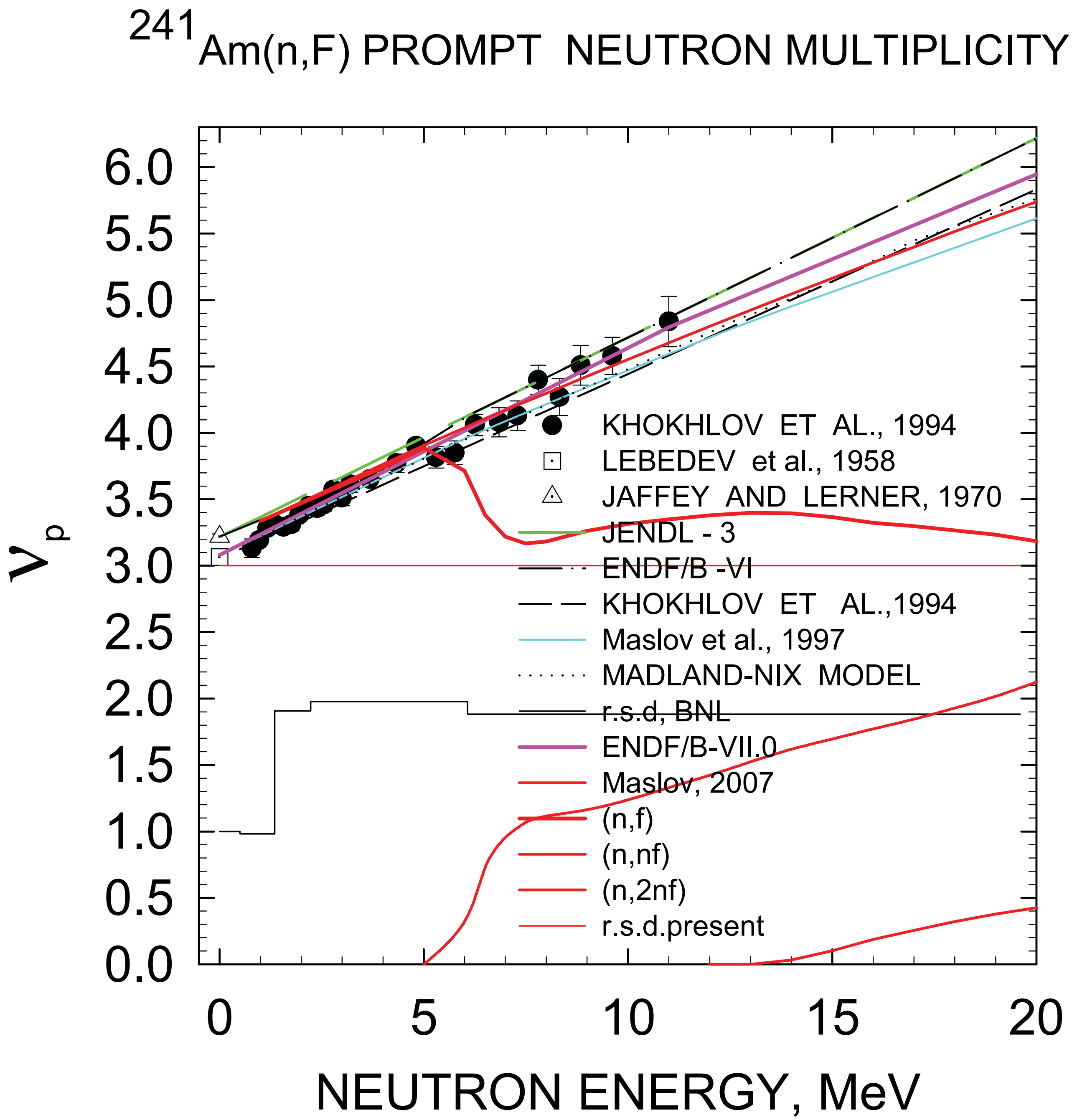




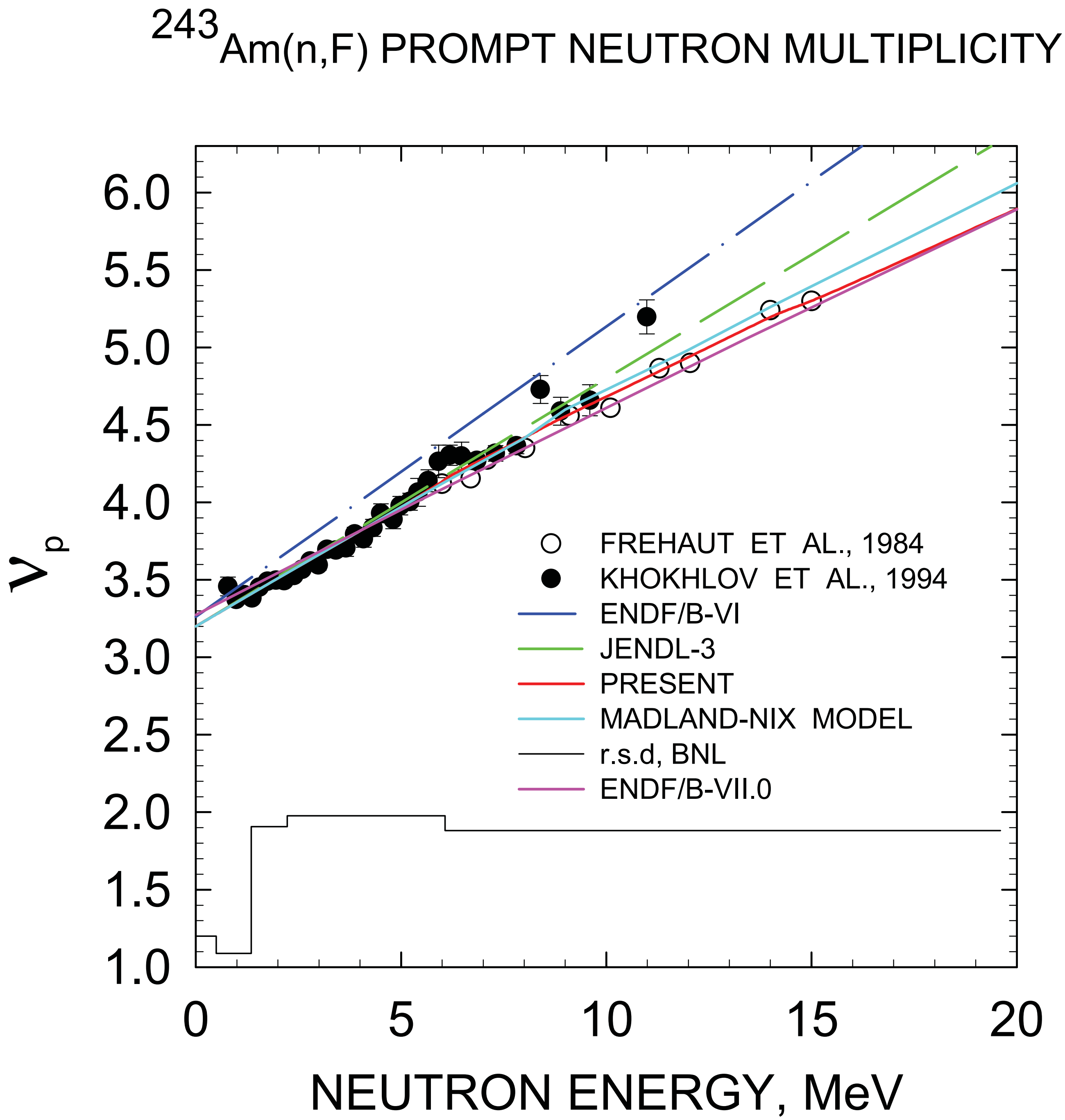
245Cm(n,F) PROMPT NEUTRON MULTIPLICITY
Kroshkin & Zamyatnin, 1970
Jaffey and Lerner, 1970
Howe et al., 1983
Khohklov et al., 1994
JENDL-3.1
ENDF/B-VI
Madland & Nix, 1982
Present
r.s.d 245Cm
r.s.d 243Cm
νp
NEUTRON ENERGY, MeV
0
1
2
3
4
5
6
7
8
9
10
11
0
4
8
12
16
20



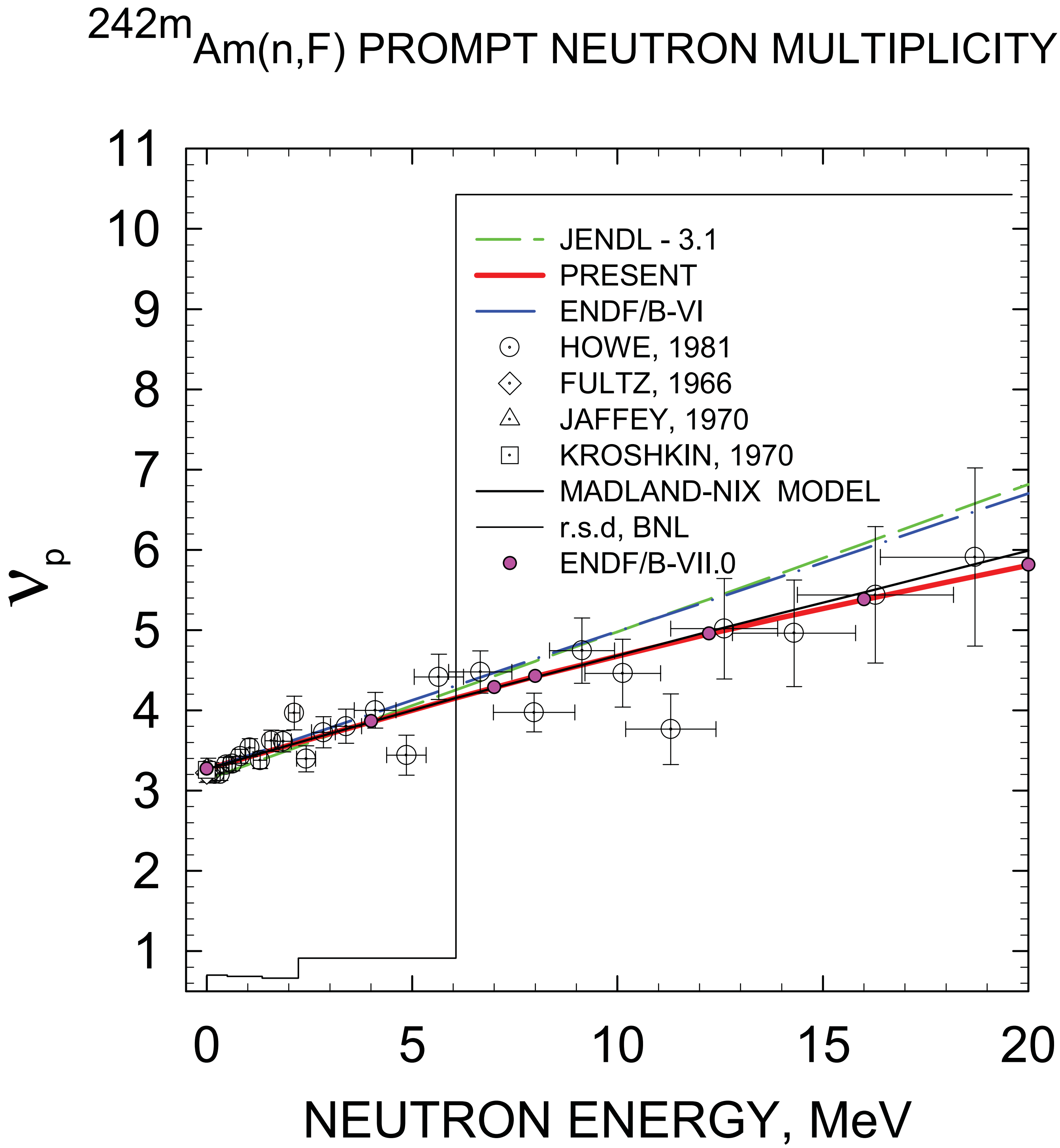
^{237}Np(n,F) PROMPT NEUTRON MULTIPLICITY
ENDF/B-VII.0
BROND
JENDL-3.3
r.s.d. BNL
FREHAUT et al., 1982
present
MALINOVSKIJ et al., 1983
VEESER ET AL., 1982
KHOKHLOV ET AL., 1994
(n,f)
(n,nf)
(n,2nf)
r.s.d. present
ν_p
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
NEUTRON ENERGY, MeV



^{241}Am(n,F) PROMPT NEUTRON MULTIPLICITY
ν_p
NEUTRON ENERGY, MeV
0
5
10
15
20
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
KHOKHLOV ET AL., 1994
LEBEDEV et al., 1958
JAFFEY AND LERNER, 1970
JENDL - 3
ENDF/B -VI
KHOKHLOV ET AL.,1994
Maslov et al., 1997
MADLAND-NIX MODEL
r.s.d, BNL
ENDF/B-VII.0
Maslov, 2007
(n,f)
(n,nf)
(n,2nf)
r.s.d.present



^{243}Am(n,F) PROMPT NEUTRON MULTIPLICITY
ν_p
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0
5
10
15
20
NEUTRON ENERGY, MeV
FREHAUT ET AL., 1984
KHOKHLOV ET AL., 1994
ENDF/B-VI
JENDL-3
PRESENT
MADLAND-NIX MODEL
r.s.d, BNL
ENDF/B-VII.0



242mAm(n,F) PROMPT NEUTRON MULTIPLICITY
JENDL - 3.1
PRESENT
ENDF/B-VI
HOWE, 1981
FULTZ, 1966
JAFFEY, 1970
KROSHKIN, 1970
MADLAND-NIX MODEL
r.s.d, BNL
ENDF/B-VII.0
ν p
NEUTRON ENERGY, MeV
11
10
9
8
7
6
5
4
3
2
1
0
5
10
15
20

Chapter 8
Conclusions

The improvements of the nuclear reaction modeling and nuclear parameter systematic, developed based on neutron data description of major actinides ^{232}Th, ^{233}U, ^{235}U, ^{238}U and ^{239}Pu is shown to provide a sound basis for critical assessment of the fission, capture, inelastic scattering, (n,xn) reaction cross sections of minor actinides. The main reasons of improvements are justified by: a) refined treatment of the spectra of collective states at equilibrium and saddle deformations; b) consistent description of (n,F) as a superposition of (n, f) and (n, xnf) reactions, (n,xn) reaction cross sections and prompt fission neutron spectra of ^{235}U, ^{238}U and ^{232}Th; c) refined treatment of the collective and intrinsic excitations influence on the level densities at equilibrium and saddle deformations; d) calculation of the exclusive neutron spectra of (n,xn) and (n,xnf) reactions. Conclusive evidence of the reliability of the approach employed comes from the confirmation of the predicted ^{237}U(n,F) reaction cross section [7] by the surrogate measurements of the ratio of ^{238}U/^{236}U fission probabilities [77].

For neutron capture reactions on even-even U, Pu and Cm nuclei in unresolved resonance and fast neutron energy ranges the methods, proven in case of ^{232}Th(n,γ) and ^{238}U(n, γ) data analysis were used. For example, calculated ^{240}Pu(n, γ) reaction cross section shape is much similar to that, observed for the ^{238}U(n, γ) and ^{232}Th(n, γ) reaction cross sections. Differences are due to fission and neutron emission competition, which depends on the (Z, N)-composition of the compound nucleus. The first Wigner' cusp is observed around first rotation level excitation threshold, another two cusps are due to further increases in neutron and then fission competition. Decreasing trend in Weston and Todd [222] data needs to be further checked experimentally. Similar cross section shape is reproduced in JENDL-3.3 evaluation, absolute differences are due to inherent approximations of evaluation procedures of JENDL-3.3.

For fissile targets ^{239}Pu, ^{233}U, ^{235}U capture cross sections of fissile nuclides demonstrate most vividly the influence of target spin differences, fission transition states spectroscopy and fission/gamma-emission competition on capture cross section shape and absolute values. In all cases the capture cross sections were obtained via consistent description of fission and elastic/inelastic scattering, (n, γf) reaction being included. In case of ^{239}Pu(n, γ) the structure at E_n below 5 keV is defined by fission via 1^+ sub-threshold transition states. At E_n around 100 keV there are systematic differences in measured $^{239}Pu(n, \gamma)$ data trends. In case of $^{235}U(n, \gamma)$ reasonable values of average resonance parameters support the high values of capture cross section around 10 keV, the measured data inconsistencies should be addressed. In case of $^{233}U(n, \gamma)$ reasonable values of average resonance parameters provide a consistent description of capture data in keV- and MeV-energy ranges. To explain the biases of $^{233}U(n, \gamma)$ and $^{235}U(n, \gamma)$ evaluations of ENDF/B-VII.0 relative to measured data by Weston et al. [232] and Muradyan et al. [231], respectively, robust argument should be found.

Fission cross section of $^{242}Cm(n,F)$ was predicted based on the sub-threshold neutron data and surrogate data at higher excitation energies. Fission cross section of $^{238}Pu(n,F)$ was be predicted based on the neutron data in the non-emissive fission domain and surrogate data for $^{237}Pu(n,f)$ at excitation energies higher than emissive fission threshold. The latest $^{238}Pu(n,F)$ data by Fursov et al. [60] discards the previous extremely high fission cross section estimates in E_n=6-20 MeV range. The same problem of inconsistency we are facing for Cm targets, where the (n, F) reaction data are higher than the modern estimates of the neutron absorption cross section.

Fission cross section fits serve as a constraint for the (n,xn) reaction prediction. One of them is $^{241}Am(n,2n)$, its measurement, reported at ND2007 by Vieira et al. [171], nicely confirmed the older evaluation by Maslov et al. [17] of 1997, evaluated data file afterwards was accepted for JENDL-3.3. As regards $^{243}Am(n,2n)$ reaction feeding $^{242m}Am(J=5)$ (141 y) and $^{242g}Am(J=1)$ (16 h) there is a measurement by Gangarz referred by Chadwick et al. [14]. The quoted Gancarz data point gives the yield of $^{242g}Am(J=1)$ (16 h) at 15 MeV as 0.2 barn. It would be quite compatible with estimate of $^{243}Am(n,2n)^{242(m+g)}Am$ of 0.3 barn, granted that branching ratio of m/g or (long-lived-to-short/lived) is similar to that in $^{237}Np(n,2n)$ reaction. Only in that case the uncertainty of $^{243}Am(n,2n)$ cross section could be claimed to be equal to 30% or even to that of $^{241}Am(n,2n)$, otherwise it should increased to 100%. Disentangling of the model deficiencies, when measured cross section and nubar data fits are rather poor, and model parameter uncertainties, turned out to be a major problem. Realistic assessment of the relative standard deviations is provided based on use of state-of–the-art nuclear reaction theory.

The state-of –the-art of minor actinide data files ($^{233,234,236}U$, ^{237}Np, $^{238,240,241,242}Pu$, $^{241,242m,243}Am$, $^{242,243,244,245}Cm$) dictates that their improvement based on new measured neutron data, either direct or surrogate) and advanced nuclear reaction modeling and nuclear parameter systematic will provide a sound basis for critical assessment of the fission, capture, inelastic scattering, (n,xn) reaction cross sections and relevant uncertainties. That will largely help to avoid substituting possible model deficiency uncertainties by enlarging the uncertainties of conventional nuclear model parameters. In a number of minor actinides the uncertainty estimation of cross sections and prompt fission neutron spectra should be preceded with the robust neutron data re-evaluation. Otherwise, in case of poorly investigated Np, Pu, Am, Cm targets the artificially large cross section uncertainty estimates will be unavoidable.

The following tables summarize the possibility to use the available ENDF/B-VII.0 evaluated data files of minor actinides for the estimation of current uncertainties in evaluated nuclear data, as accomplished in [1, 2]. Sign '-' means that the uncertainties of (n,el) (n,f) (n,n') (n, γ) (n,2n) ν_p are unacceptable, notwithstanding they are overoptimistic or too conservative, or evaluated data are inexplainable, sign "+" means the uncertainties of [1, 2] quite correspond to the actual knowledge database. In fact, a score of 5 or 4 "-" in case of ^{238}Pu, ^{242}Cm, ^{244}Cm nuclides means the data files should be replaced. Other nuclides should be considered on a case-by-case basis, for example, ^{237}Np with a score of five "-" needs severe modification. The prompt fission spectra representation in all data files needs severe modification, as described in [3, 10, 11, 12, 13]. That is inforced by the high sensitivity of the core neutronics to the prompt fission neutron spectra, as mentioned by M. Salvatores (see [329] and references therein).

Table 8.1. Status of the uncertainty estimates for 15 minor actinides produced for Subgroup 26. Sign '-' means poor quality, sign '+' indicates good quality. The present report proposed improvements for all estimates of type '-' as well as small adjustments of estimates '+'. It should be noted that basic ENDF/B-VII.0 evaluations for ^{238}Pu, ^{242}Cm, ^{244}Cm **are very poor and must be improved.**

Material	(n,el)	(n,f)	(n,n')	(n, γ)	(n,2n)	ν_p
^{233}U	-	+	-	-	+	+
^{234}U	-	+	-	-	+	-
^{236}U	-	+	-	-	+	-
^{237}Np	-	+	-	-	-	-
^{238}Pu	-	-	-	-	-	-
^{240}Pu	-	+	-	-	-	+
^{241}Pu	-	-	-	-	+	+
^{242}Pu	-	+	-	-	+	-
^{241}Am	-	-	+	-	+	-
^{242m}Am	-	-	-	-	+	+
^{243}Am	-	-	-	+	-	+
^{242}Cm	-	-	-	-	-	+
^{243}Cm	-	-	-	+	+	+
^{244}Cm	-	-	-	-	-	+
^{245}Cm	-	+	-	+	+	+

Table 8.2. Status of the uncertainty estimates for the ENDF/B VII.0 evaluations of major actinides. For explation see the table above.

Material	(n,el)	(n,f)	(n,n')	(n, γ)	(n,2n)	ν
^{232}Th	+	+	+	-	+	-
^{235}U	-	+	+	-	+	+
^{238}U	-	-	+	-	-	+
^{239}Pu	-	+	-	-	+	+

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Apendix A

In the following, numerical tables for the relative cross section uncertainties (relative standard deviations) and correlations (normalized to 1000), borrowed from [1, 2} are given in a 15-group representation

Tables of cross section and certainties and covariances, borrowed from [1, 2]

Definition of the 15-energy groups

Group no.	Energy Max (eV)	Energy Min (eV)
1	19.6 E+07	6.07 E+06
2	6.07 E+06	2.23 E+06
3	2.23 E+06	1.35 E+06
4	1.35 E+06	4.98 E+05
5	4.98 E+05	1.83 E+05
6	1.83 E+05	6.74 E+04
7	6.74 E+04	2.48 E+04
8	2.48 E+04	9.12 E+03
9	9.12 E+03	2.04 E+03
10	2.04 E+03	4.54 E+02
11	4.54 E+02	2.26 E+01
12	2.26 E+01	4.00 E+00
13	4.00 E+00	5.40 E-01
14	5.40 E-01	1.00 E-01
15	1.00 E-01	1.00 E-05

232Th(n,el)

group	rel.s.d.															
1	1.3888E-02	1000	189	74	74	102	101	0	0	0	0	0	0	0	0	0
2	1.2163E-02	189	1000	124	100	132	133	0	0	0	0	0	0	0	0	0
3	2.0000E-02	74	124	1000	290	217	164	0	0	0	0	0	0	0	0	0
4	1.7999E-02	74	100	290	1000	262	171	0	0	0	0	0	0	0	0	0
5	1.6491E-02	102	132	217	262	1000	212	0	0	0	0	0	0	0	0	0
6	1.1832E-02	101	133	164	171	212	1000	170	168	54	0	0	0	0	0	0
7	2.0000E-02	0	0	0	0	0	170	1000	991	322	0	0	0	0	0	0
8	2.0000E-02	0	0	0	0	0	168	991	1000	335	0	0	0	0	0	0
9	2.0000E-02	0	0	0	0	0	54	322	335	1000	-25	-4	-56	-105	-110	-112
10	1.5258E-02	0	0	0	0	0	0	0	0	-25	1000	5	-64	-118	-124	-126
11	3.8154E-02	0	0	0	0	0	0	0	0	-4	5	1000	-275	-450	-464	-468
12	1.5349E-02	0	0	0	0	0	0	0	0	-56	-64	-275	1000	505	496	492
13	8.6288E-03	0	0	0	0	0	0	0	0	-105	-118	-450	505	1000	990	983
14	8.0601E-03	0	0	0	0	0	0	0	0	-110	-124	-464	496	990	1000	999
15	7.9245E-03	0	0	0	0	0	0	0	0	-112	-126	-468	492	983	999	1000

232Th(n,n')

group	rel.s.d.	----	----	----	----	----	----
1	4.8492E-02	1000	549	192	51	28	13
2	1.0000E-01	549	1000	267	54	-41	-43
3	1.0000E-00	192	267	1000	163	-83	-102
4	7.0000E-02	51	54	163	1000	149	15
5	2.0000E-01	28	-41	-83	149	1000	206
6	2.3602E-01	13	-43	-102	15	206	1000

232Th(n,2n)

group	rel.s.d.	----
1	1.0000E-01	1000

232Th(n,f)

group	rel.s.d.	----	----	----	----	----	----
1	3.0000E-02	1000	983	980	960	16	8
2	3.0000E-02	983	1000	991	970	16	9
3	3.0000E-02	980	991	1000	974	16	9
4	3.0000E-02	960	970	974	1000	17	10
5	9.5167E-01	16	16	16	17	1000	217
6	4.6917E-01	8	9	9	10	217	1000

232Th(n,gamma)

group	rel.s.d.	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
1	1.7397E-01	1000	36	5	11	9	5	0	0	0	0	0	0	0	0	0
2	1.0000E-01	36	1000	36	43	43	26	0	0	0	0	0	0	0	0	0
3	7.0000E-02	5	36	1000	306	218	125	0	0	0	0	0	0	0	0	0
4	7.0000E-02	11	43	306	1000	402	229	0	0	0	0	0	0	0	0	0
5	1.2432E-02	9	43	218	402	1000	342	0	0	0	0	0	0	0	0	0
6	1.1407E-02	5	26	125	229	342	1000	515	309	109	0	0	0	0	0	0
7	5.0000E-02	0	0	0	0	0	515	1000	939	310	0	0	0	0	0	0
8	1.4553E-02	0	0	0	0	0	309	939	1000	336	0	0	0	0	0	0
9	2.7999E-02	0	0	0	0	0	109	310	336	1000	0	0	0	2	1	1
10	3.3534E-02	0	0	0	0	0	0	0	0	0	1000	0	0	3	3	2

11	2.2069E-02	0	0	0	0	0	0	0	0	0	0	1000	1	130	110	102
12	3.2750E-02	0	0	0	0	0	0	0	0	0	0	1	1000	7	5	5
13	1.8986E-02	0	0	0	0	0	0	0	0	2	3	130	7	1000	902	838
14	1.3095E-02	0	0	0	0	0	0	0	0	1	3	110	5	902	1000	991
15	1.2506E-02	0	0	0	0	0	0	0	0	1	2	102	5	838	991	1000

233U(n,el)

group	rel.s.d.	--														
1	2.0000E-02	1000	979	391	15	193	-16	-131	-137	0	0	0	0	0	0	0
2	2.0000E-02	979	1000	543	-16	205	119	44	37	0	0	0	0	0	0	0
3	3.0000E-02	391	543	1000	-20	144	666	809	807	0	0	0	0	0	0	0
4	1.0000E-01	15	-16	-20	1000	102	-116	-159	-159	0	0	0	0	0	0	0
5	1.0000E-01	193	205	144	102	1000	148	88	85	0	0	0	0	0	0	0
6	1.0000E-01	-16	119	666	-116	148	1000	785	784	0	0	0	0	0	0	0
7	1.0000E-01	-131	44	809	-159	88	785	1000	1000	0	0	0	0	0	0	0
8	1.0000E-01	-137	37	807	-159	85	784	1000	1000	0	0	0	0	0	0	0
9	1.0000E-01	0	0	0	0	0	0	0	0	1000	317	332	340	356	276	66
10	1.2000E-01	0	0	0	0	0	0	0	0	317	1000	997	996	961	658	155
11	6.0022E-02	0	0	0	0	0	0	0	0	332	997	1000	998	964	665	157
12	5.6089E-02	0	0	0	0	0	0	0	0	340	996	998	1000	972	680	166
13	4.1560E-02	0	0	0	0	0	0	0	0	356	961	964	972	1000	758	276
14	2.1388E-02	0	0	0	0	0	0	0	0	276	658	665	680	758	1000	251
15	5.3372E-02	0	0	0	0	0	0	0	0	66	155	157	166	276	251	1000

233U(n,n')

group	rel.s.d.	------------------------				
1	1.0788E-01	1000	-741	-35	64	0
2	1.5000E-01	-741	1000	43	-95	0
3	1.5000E-01	-35	43	1000	980	0
4	4.0461E-01	64	-95	980	1000	139
5	1.0000E-00	0	0	0	139	1000

233U(n,2n)

group	rel.s.d.	----
1	1.8435E-01	1000

233U(n,f)

group	rel.s.d.															
1	5.0000E-02	1000	795	291	291	291	291	291	291	291	3	0	0	0	0	0
2	6.4367E-02	795	1000	718	718	718	718	718	718	718	8	0	0	0	0	0
3	7.2612E-02	291	718	1000	1000	1000	1000	1000	1000	1000	11	0	0	0	0	0
4	7.2612E-02	291	718	1000	1000	1000	1000	1000	1000	1000	11	0	0	0	0	0
5	7.2612E-02	291	718	1000	1000	1000	1000	1000	1000	1000	11	0	0	0	0	0
6	7.2612E-02	291	718	1000	1000	1000	1000	1000	1000	1000	11	0	0	0	0	0
7	7.2612E-02	291	718	1000	1000	1000	1000	1000	1000	1000	11	0	0	0	0	0
8	7.2612E-02	291	718	1000	1000	1000	1000	1000	1000	1000	11	0	0	0	0	0
9	7.2612E-02	291	718	1000	1000	1000	1000	1000	1000	1000	11	0	0	0	0	0
10	1.0351E-01	3	8	11	11	11	11	11	11	11	1000	17	-3	1	1	1
11	4.4903E-02	0	0	0	0	0	0	0	0	0	17	1000	21	1	4	2
12	2.2291E-02	0	0	0	0	0	0	0	0	0	-3	21	1000	30	55	51
13	5.0252E-02	0	0	0	0	0	0	0	0	0	1	1	30	1000	148	146
14	1.4606E-02	0	0	0	0	0	0	0	0	0	1	4	55	148	1000	948
15	1.0329E-02	0	0	0	0	0	0	0	0	0	1	2	51	146	948	1000

233U(n,gamma)

group	rel.s.d.															
1	6.0000E-01	1000	409	458	498	498	-104	-297	-303	-317	-16	0	0	0	0	0
2	6.5000E-01	409	1000	988	953	767	-451	-726	-732	-750	-37	0	0	0	0	0
3	5.0000E-01	458	988	1000	988	839	-405	-712	-719	-740	-36	0	0	0	0	0
4	3.0000E-01	498	953	988	1000	872	-391	-714	-723	-745	-37	0	0	0	0	0
5	2.0000E-01	498	767	839	872	1000	104	-289	-301	-332	-18	0	0	0	0	0
6	2.0000E-01	-104	-451	-405	-391	104	1000	922	917	903	42	0	0	0	0	0
7	2.0000E-01	-297	-726	-712	-714	-289	922	1000	1000	999	47	0	0	0	0	0
8	2.0000E-01	-303	-732	-719	-723	-301	917	1000	1000	999	47	0	0	0	0	0
9	3.0000E-01	-317	-750	-740	-745	-332	903	999	999	1000	48	0	0	0	0	0
10	3.0000E-01	-16	-37	-36	-37	-18	42	47	47	48	1000	21	1	0	0	0
11	4.2773E-02	0	0	0	0	0	0	0	0	0	21	1000	5	0	0	0
12	3.0200E-02	0	0	0	0	0	0	0	0	0	1	5	1000	40	14	0
13	9.0560E-02	0	0	0	0	0	0	0	0	0	0	0	40	1000	114	-57
14	2.5871E-02	0	0	0	0	0	0	0	0	0	0	0	14	114	1000	-706
15	4.2279E-02	0	0	0	0	0	0	0	0	0	0	0	0	-57	-706	1000

234U(n,el)

group	rel.s.d.															
1	4.0000E-02	1000	-244	181	-20	-188	-75	0	0	0	0	0	0	0	0	0
2	4.0000E-02	-244	1000	255	-6	-51	-16	0	0	0	0	0	0	0	0	0
3	4.0000E-02	181	255	1000	25	-708	-289	0	0	0	0	0	0	0	0	0

4	4.0000E-02	-20	-6	25	1000	125	33	0	0	0	0	0	0	0	0	0
5	4.0000E-02	-188	-51	-708	125	1000	309	0	0	0	0	0	0	0	0	0
6	4.0000E-02	-75	-16	-289	33	309	1000	929	925	898	0	0	0	0	0	0
7	4.0000E-02	0	0	0	0	0	929	1000	996	967	0	0	0	0	0	0
8	4.0000E-02	0	0	0	0	0	925	996	1000	972	0	0	0	0	0	0
9	4.0000E-02	0	0	0	0	0	898	967	972	1000	3	2	1	30	30	30
10	6.9420E-02	0	0	0	0	0	0	0	0	3	1000	5	2	54	55	54
11	2.3161E-01	0	0	0	0	0	0	0	0	2	5	1000	-5	-25	-13	-11
12	1.7123E-01	0	0	0	0	0	0	0	0	1	2	-5	1000	44	43	43
13	2.3248E-02	0	0	0	0	0	0	0	0	30	54	-25	44	1000	983	969
14	2.0174E-02	0	0	0	0	0	0	0	0	30	55	-13	43	983	1000	998
15	1.9753E-02	0	0	0	0	0	0	0	0	30	54	-11	43	969	998	1000

234U(n,n')

group	rel.s.d.						
1	1.0000E-01	1000	-953	-971	-169	-164	-163
2	1.5000E-01	-953	1000	995	-82	-84	-84
3	2.5000E-01	-971	995	1000	9	1	-1
4	2.5000E-01	-169	-82	9	1000	995	992
5	5.0000E-02	-164	-84	1	995	1000	1000
6	5.0000E-02	-163	-84	-1	992	1000	1000

234U(n,2n)

group	rel.s.d.	
1	3.4847E-01	1000

234U(n,f)

group	rel.s.d.															
1	1.5000E-01	1000	314	243	7	7	7	0	0	0	0	0	0	0	0	0
2	1.0000E-01	314	1000	978	944	944	937	0	0	0	0	0	0	0	0	0
3	1.3834E-01	243	978	1000	921	921	915	0	0	0	0	0	0	0	0	0
4	3.7974E-01	7	944	921	1000	1000	993	0	0	0	0	0	0	0	0	0
5	3.7974E-01	7	944	921	1000	1000	993	0	0	0	0	0	0	0	0	0
6	3.1605E-01	7	937	915	993	993	1000	122	122	119	2	0	0	0	0	0
7	2.2840E-01	0	0	0	0	0	122	1000	999	976	18	0	0	0	0	0
8	1.9411E-01	0	0	0	0	0	122	999	1000	981	18	0	0	0	0	0
9	1.3692E-01	0	0	0	0	0	119	976	981	1000	17	0	0	0	0	0
10	1.4972E-01	0	0	0	0	0	2	18	18	17	1000	15	0	2	1	1
11	5.1074E-02	0	0	0	0	0	0	0	0	0	15	1000	0	1	1	1

12	1.7489E-01	0	0	0	0	0	0	0	0	0	0	0	1000	51	18	17
13	2.1849E-01	0	0	0	0	0	0	0	0	0	2	1	51	1000	998	998
14	2.4671E-01	0	0	0	0	0	0	0	0	0	1	1	18	998	1000	1000
15	2.4806E-01	0	0	0	0	0	0	0	0	0	1	1	17	998	1000	1000

234U(n,gamma)

group	rel.s.d.															
1	5.6740E-01	1000	710	404	149	4	20	0	0	0	0	0	0	0	0	0
2	5.0000E-01	710	1000	784	304	-42	29	0	0	0	0	0	0	0	0	0
3	4.0000E-01	404	784	1000	584	76	223	0	0	0	0	0	0	0	0	0
4	1.1992E-01	149	304	584	1000	837	768	0	0	0	0	0	0	0	0	0
5	1.3981E-01	4	-42	76	837	1000	764	0	0	0	0	0	0	0	0	0
6	1.2921E-01	20	29	223	768	764	1000	559	559	558	385	0	0	0	0	0
7	3.0000E-01	0	0	0	0	0	559	1000	1000	998	688	0	0	0	0	0
8	1.9156E-01	0	0	0	0	0	559	1000	1000	999	689	0	0	0	0	0
9	2.0000E-01	0	0	0	0	0	558	998	999	1000	696	0	0	0	0	0
10	1.8562E-02	0	0	0	0	0	385	688	689	696	1000	7	0	0	0	0
11	2.4153E-02	0	0	0	0	0	0	0	0	0	7	1000	2	6	14	12
12	1.3763E-02	0	0	0	0	0	0	0	0	0	0	2	1000	949	679	538
13	9.3406E-02	0	0	0	0	0	0	0	0	0	0	6	949	1000	768	631
14	3.0754E-02	0	0	0	0	0	0	0	0	0	0	14	679	768	1000	981
15	2.9278E-02	0	0	0	0	0	0	0	0	0	0	12	538	631	981	1000

235U(n,el), non-diagonal terms are those of 233U

group	rel.s.d.															
1	1.0000E-01	1000	979	391	15	193	-16	-131	-137	0	0	0	0	0	0	0
2	3.0000E-02	979	1000	543	-16	205	119	44	37	0	0	0	0	0	0	0
3	2.0000E-02	391	543	1000	-20	144	666	809	807	0	0	0	0	0	0	0
4	2.0000E-02	15	-16	-20	1000	102	-116	-159	-159	0	0	0	0	0	0	0
5	2.0000E-02	193	205	144	102	1000	148	88	85	0	0	0	0	0	0	0
6	2.0000E-02	-16	119	666	-116	148	1000	785	784	0	0	0	0	0	0	0
7	2.0000E-02	-131	44	809	-159	88	785	1000	1000	0	0	0	0	0	0	0
8	2.0000E-02	-137	37	807	-159	85	784	1000	1000	0	0	0	0	0	0	0
9	2.0000E-02	0	0	0	0	0	0	0	0	1000	317	332	340	356	276	66
10	3.2229E-03	0	0	0	0	0	0	0	0	317	1000	997	996	961	658	155
11	9.4190E-03	0	0	0	0	0	0	0	0	332	997	1000	998	964	665	157
12	1.8648E-02	0	0	0	0	0	0	0	0	340	996	998	1000	972	680	166
13	3.1444E-02	0	0	0	0	0	0	0	0	356	961	964	972	1000	758	276
14	3.4417E-02	0	0	0	0	0	0	0	0	276	658	665	680	758	1000	251
15	6.6491E-02	0	0	0	0	0	0	0	0	66	155	157	166	276	251	1000

235U(n,n')

group	rel.s.d.					
1	1.5000E-01	1000	-741	-35	64	0
2	1.5000E-01	-741	1000	43	-95	0
3	1.0000E-01	-35	43	1000	980	0
4	3.0000E-01	64	-95	980	1000	139
5	3.0000E-00	0	0	0	139	1000
6	5.0000E-00					
7	5.0000E-00					
8	5.0000E-00					

235U(n,2n)

group	rel.s.d.	
1	1.0000E-01	1000

235U(n,f)

235U(n,gamma)

group	rel.s.d.															
1	5.0000E-01	1000	409	458	498	498	-104	-297	-303	-317	-16	0	0	0	0	0
2	2.0000E-01	409	1000	988	953	767	-451	-726	-732	-750	-37	0	0	0	0	0
3	5.0000E-01	458	988	1000	988	839	-405	-712	-719	-740	-36	0	0	0	0	0
4	5.0000E-01	498	953	988	1000	872	-391	-714	-723	-745	-37	0	0	0	0	0
5	2.0000E-01	498	767	839	872	1000	104	-289	-301	-332	-18	0	0	0	0	0
6	2.0000E-01	-104	-451	-405	-391	104	1000	922	917	903	42	0	0	0	0	0
7	2.0000E-01	-297	-726	-712	-714	-289	922	1000	1000	999	47	0	0	0	0	0
8	2.0000E-01	-303	-732	-719	-723	-301	917	1000	1000	999	47	0	0	0	0	0
9	2.0000E-01	-317	-750	-740	-745	-332	903	999	999	1000	48	0	0	0	0	0
10	2.0000E-01	-16	-37	-36	-37	-18	42	47	47	48	1000	21	1	0	0	0
11	0.8767E-02	0	0	0	0	0	0	0	0	0	21	1000	5	0	0	0
12	2.1341E-02	0	0	0	0	0	0	0	0	0	1	5	1000	40	14	0
13	1.7530E-01	0	0	0	0	0	0	0	0	0	0	0	40	1000	114	-57
14	2.8745E-02	0	0	0	0	0	0	0	0	0	0	0	14	114	1000	-706
15	2.1209E-02	0	0	0	0	0	0	0	0	0	0	0	0	-57	-706	1000

236U(n,el)

group	rel.s.d.	--

1	3.0000E-02	1000	998	1000	-994	-1000	-985	0	0	0	0	0	0	0	0	0
2	3.0000E-02	998	1000	998	-999	-999	-985	0	0	0	0	0	0	0	0	0
3	3.0000E-02	1000	998	1000	-994	-1000	-985	0	0	0	0	0	0	0	0	0
4	3.0000E-02	-994	-999	-994	1000	996	982	0	0	0	0	0	0	0	0	0
5	3.0000E-02	-1000	-999	-1000	996	1000	986	0	0	0	0	0	0	0	0	0
6	3.0000E-02	-985	-985	-985	982	986	1000	168	168	75	0	0	0	0	0	0
7	3.0000E-02	0	0	0	0	0	168	1000	1000	449	0	0	0	0	0	0
8	3.0000E-02	0	0	0	0	0	168	1000	1000	449	0	0	0	0	0	0
9	3.0000E-02	0	0	0	0	0	75	449	449	1000	274	160	146	128	120	118
10	2.2647E-02	0	0	0	0	0	0	0	0	274	1000	170	163	149	140	139
11	5.9574E-02	0	0	0	0	0	0	0	0	160	170	1000	173	191	188	187
12	2.3485E-02	0	0	0	0	0	0	0	0	146	163	173	1000	840	833	833
13	4.7682E-02	0	0	0	0	0	0	0	0	128	149	191	840	1000	1000	999
14	4.9096E-02	0	0	0	0	0	0	0	0	120	140	188	833	1000	1000	1000
15	4.8916E-02	0	0	0	0	0	0	0	0	118	139	187	833	999	1000	1000

236U(n,n')

group	rel.s.d.						
1	1.0000E-01	1000	216	-330	-379	-396	-399
2	1.5000E-01	216	1000	136	-136	-315	-496
3	2.5000E-01	-330	136	1000	963	897	793
4	2.5000E-01	-379	-136	963	1000	983	928
5	2.5000E-01	-396	-315	897	983	1000	980
6	1.0000E-01	-399	-496	793	928	980	1000

236U(n,2n)

group	rel.s.d.	
1	1.8490E-01	1000

236U(n,f)

group	rel.s.d.															
1	1.5000E-01	1000	-189	-217	-216	-216	-211	0	0	0	0	0	0	0	0	0
2	1.0000E-01	-189	1000	995	990	990	969	0	0	0	0	0	0	0	0	0
3	2.8876E-01	-217	995	1000	999	999	978	0	0	0	0	0	0	0	0	0
4	3.1965E-01	-216	990	999	1000	1000	979	0	0	0	0	0	0	0	0	0
5	3.1965E-01	-216	990	999	1000	1000	979	0	0	0	0	0	0	0	0	0
6	1.6471E-01	-211	969	978	979	979	1000	206	206	66	0	0	0	0	0	0
7	7.6244E-02	0	0	0	0	0	206	1000	1000	319	0	0	0	0	0	0
8	6.6765E-02	0	0	0	0	0	206	1000	1000	320	0	0	0	0	0	0

9	3.5008E-02	0	0	0	0	0	66	319	320	1000	11	243	130	0	0	0
10	3.2973E-02	0	0	0	0	0	0	0	0	11	1000	899	767	0	0	0
11	1.3702E-02	0	0	0	0	0	0	0	0	243	899	1000	1	9	9	9
12	2.5696E-02	0	0	0	0	0	0	0	0	130	767	1	1000	132	107	106
13	1.5788E-01	0	0	0	0	0	0	0	0	0	0	9	132	1000	999	999
14	1.9584E-01	0	0	0	0	0	0	0	0	0	0	9	107	999	1000	1000
15	1.9863E-01	0	0	0	0	0	0	0	0	0	0	9	106	999	1000	1000

236U(n,gamma)

group	rel.s.d.															
1	3.2677E-01	1000	998	999	523	337	-217	0	0	0	0	0	0	0	0	0
2	3.5693E-01	998	1000	996	479	289	-264	0	0	0	0	0	0	0	0	0
3	1.9559E-01	999	996	1000	560	378	-175	0	0	0	0	0	0	0	0	0
4	7.0000E-02	523	479	560	1000	979	686	0	0	0	0	0	0	0	0	0
5	7.0000E-02	337	289	378	979	1000	810	0	0	0	0	0	0	0	0	0
6	3.9424E-02	-217	-264	-175	686	810	1000	271	271	269	0	0	0	0	0	0
7	3.4607E-02	0	0	0	0	0	271	1000	1000	994	0	0	0	0	0	0
8	5.2580E-02	0	0	0	0	0	271	1000	1000	994	0	0	0	0	0	0
9	2.9760E-03	0	0	0	0	0	269	994	994	1000	4	0	0	0	0	0
10	6.3700E-03	0	0	0	0	0	0	0	0	4	1000	20	0	1	2	2
11	8.2960E-03	0	0	0	0	0	0	0	0	0	20	1000	1	18	42	42
12	4.0519E-02	0	0	0	0	0	0	0	0	0	0	1	1000	327	271	254
13	2.7286E-02	0	0	0	0	0	0	0	0	0	1	18	327	1000	759	722
14	1.9606E-02	0	0	0	0	0	0	0	0	0	2	42	271	759	1000	998
15	1.8877E-02	0	0	0	0	0	0	0	0	0	2	42	254	722	998	1000

238U(n,el)

group	rel.s.d.															
1	2.0000E-02	1000	468	80	116	51	-9	-2	0	0	0	0	0	0	0	0
2	2.0000E-02	468	1000	686	6	37	7	3	0	0	0	0	0	0	0	0
3	2.0000E-02	80	686	1000	156	44	3	1	0	0	0	0	0	0	0	0
4	2.0000E-02	116	6	156	1000	420	38	9	0	0	0	0	0	0	0	0
5	2.0000E-02	51	37	44	420	1000	170	12	0	0	0	0	0	0	0	0
6	2.0000E-02	-9	7	3	38	170	1000	762	585	0	0	0	0	0	0	0
7	2.0000E-02	-2	3	1	9	12	762	1000	953	0	0	0	0	0	0	0
8	2.0000E-02	0	0	0	0	0	585	953	1000	0	0	0	0	0	0	0
9	2.0000E-02	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0
10	2.0000E-02	0	0	0	0	0	0	0	0	0	1000	10	-2	-3	-4	-4
11	1.5274E-02	0	0	0	0	0	0	0	0	0	10	1000	-633	444	423	420
12	3.0734E-01	0	0	0	0	0	0	0	0	0	-2	-633	1000	-963	-962	-961
13	8.5536E-03	0	0	0	0	0	0	0	0	0	-3	444	-963	1000	999	999
14	7.2937E-03	0	0	0	0	0	0	0	0	0	-4	423	-962	999	1000	1000
15	7.1430E-03	0	0	0	0	0	0	0	0	0	-4	420	-961	999	1000	1000

238U(n,n')

group	rel.s.d.							
1	1.0006E-01	1000	525	70	40	-90	-149	-11
2	1.4271E-01	525	1000	691	-21	18	23	18
3	5.7474E-02	70	691	1000	123	-43	-40	5
4	1.2202E-02	40	-21	123	1000	47	-106	73
5	1.9820E-02	-90	18	-43	47	1000	908	108
6	2.9219E-02	-149	23	-40	-106	908	1000	247
7	6.8172E-01	-11	18	5	73	108	247	1000

238U(n,2n)

group	rel.s.d.	
1	3.0000E-01	1000

238U(n,f)

group	rel.s.d.															
1	1.0000E-02	1000	516	365	271	80	9	0	0	0	0	0	0	0	0	0
2	1.0000E-02	516	1000	555	416	123	14	0	0	0	0	0	0	0	0	0
3	1.0000E-02	365	555	1000	456	139	16	0	0	0	0	0	0	0	0	0
4	1.0000E-02	271	416	456	1000	229	23	0	0	0	0	0	0	0	0	0
5	3.1619E-02	80	123	139	229	1000	-55	0	0	0	0	0	0	0	0	0
6	1.0366E-01	9	14	16	23	-55	1000	0	0	0	0	0	0	0	0	0
7	1.0000E-01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	1.7604E-05	0	0	0	0	0	0	0	1000	0	0	0	0	0	0	0
9	1.8774E-02	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0
10	3.8972E-04	0	0	0	0	0	0	0	0	0	1000	-3	-3	82	107	110
11	6.6799E-03	0	0	0	0	0	0	0	0	0	-3	1000	-400	-270	-210	-194
12	2.2304E-01	0	0	0	0	0	0	0	0	0	-3	-400	1000	794	634	588
13	1.1961E-02	0	0	0	0	0	0	0	0	0	82	-270	794	1000	963	945
14	9.2888E-03	0	0	0	0	0	0	0	0	0	107	-210	634	963	1000	998
15	8.9256E-03	0	0	0	0	0	0	0	0	0	110	-194	588	945	998	1000

238U(n,gamma)

group	rel.s.d.															
1	3.2677E-01	1000	28	0	0	0	0	0	0	0	0	0	0	0	0	0
2	3.5693E-01	28	1000	394	0	0	0	0	0	0	0	0	0	0	0	0
3	1.9559E-01	0	394	1000	4	0	0	0	0	0	0	0	0	0	0	0
4	7.0000E-02	0	0	4	1000	15	1	0	0	0	0	0	0	0	0	0
5	7.0000E-02	0	0	0	15	1000	21	0	0	0	0	0	0	0	0	0
6	3.9424E-02	0	0	0	1	21	1000	568	-75	0	0	0	0	0	0	0
7	3.4607E-02	0	0	0	0	0	568	1000	513	0	0	0	0	0	0	0
8	5.2580E-02	0	0	0	0	0	-75	513	1000	0	0	0	0	0	0	0
9	2.9764E-03	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0
10	6.3700E-03	0	0	0	0	0	0	0	0	0	1000	-1	1	-1	-1	-1
11	8.2962E-03	0	0	0	0	0	0	0	0	0	-1	1000	31	121	35	25
12	4.0519E-02	0	0	0	0	0	0	0	0	0	1	31	1000	356	312	305
13	2.7286E-02	0	0	0	0	0	0	0	0	0	-1	121	356	1000	990	988
14	1.9606E-02	0	0	0	0	0	0	0	0	0	-1	35	312	990	1000	1000
15	1.8877E-02	0	0	0	0	0	0	0	0	0	-1	25	305	988	1000	1000

237Np(n,el)

group	rel.s.d.															
1	3.0000E-02	1000	970	197	173	702	329	182	93	237	0	0	0	0	0	0
2	3.0000E-02	970	1000	270	128	671	355	217	130	255	0	0	0	0	0	0
3	3.0000E-02	197	270	1000	-150	435	815	794	774	302	0	0	0	0	0	0
4	3.0000E-02	173	128	-150	1000	394	-212	-290	-321	106	0	0	0	0	0	0
5	3.0000E-02	702	671	435	394	1000	694	563	487	526	0	0	0	0	0	0
6	3.0000E-02	329	355	815	-212	694	1000	978	952	630	0	0	0	0	0	0
7	1.0000E-01	182	217	794	-290	563	978	1000	995	693	0	0	0	0	0	0
8	1.0000E-01	93	130	774	-321	487	952	995	1000	701	0	0	0	0	0	0
9	1.0000E-01	237	255	302	106	526	630	693	701	1000	31	33	33	33	33	33
10	1.0000E-01	0	0	0	0	0	0	0	0	31	1000	926	926	923	917	912
11	2.4133E-02	0	0	0	0	0	0	0	0	33	926	1000	1000	996	990	984
12	2.3148E-02	0	0	0	0	0	0	0	0	33	926	1000	1000	996	991	985
13	2.2347E-02	0	0	0	0	0	0	0	0	33	923	996	996	1000	994	990
14	2.1817E-02	0	0	0	0	0	0	0	0	33	917	990	991	994	1000	998
15	2.0343E-02	0	0	0	0	0	0	0	0	33	912	984	985	990	998	1000

237Np(n,n')

group	rel.s.d.							
1	1.5000E-01	1000	-772	-398	-267	-124	-143	-359
2	3.0000E-01	-772	1000	547	313	44	8	138
3	1.5000E-01	-398	547	1000	950	809	744	576
4	3.0000E-01	-267	313	950	1000	947	907	737

5	3.0000E-01	-124	44	809	947	1000	990	832
6	5.0000E-01	-143	8	744	907	990	1000	895
7	5.0000E-01	-359	138	576	737	832	895	1000

237Np(n,2n)

group	rel.s.d.	----
1	2.0000E-01	1000

237Np(n,f)

group	rel.s.d.															
1	1.0000E-01	1000	212	-238	-326	-349	-349	-349	-349	-349	-307	0	0	0	0	0
2	1.0000E-01	212	1000	853	764	733	733	733	733	733	645	0	0	0	0	0
3	1.0000E-01	-238	853	1000	986	976	976	976	976	976	859	0	0	0	0	0
4	5.8154E-02	-326	764	986	1000	999	999	999	999	999	878	0	0	0	0	0
5	5.7859E-02	-349	733	976	999	1000	1000	1000	1000	1000	879	0	0	0	0	0
6	5.7859E-02	-349	733	976	999	1000	1000	1000	1000	1000	879	0	0	0	0	0
7	5.7859E-02	-349	733	976	999	1000	1000	1000	1000	1000	879	0	0	0	0	0
8	5.7859E-02	-349	733	976	999	1000	1000	1000	1000	1000	879	0	0	0	0	0
9	5.7859E-02	-349	733	976	999	1000	1000	1000	1000	1000	879	0	0	0	0	0
10	5.7735E-02	-307	645	859	878	879	879	879	879	879	1000	1	1	0	0	0
11	7.5377E-02	0	0	0	0	0	0	0	0	0	1	1000	110	5	5	34
12	4.6415E-02	0	0	0	0	0	0	0	0	0	1	110	1000	25	5	36
13	5.5804E-02	0	0	0	0	0	0	0	0	0	0	5	25	1000	52	65
14	1.4743E-01	0	0	0	0	0	0	0	0	0	0	5	5	52	1000	277
15	4.5504E-02	0	0	0	0	0	0	0	0	0	0	34	36	65	277	1000

237Np(n,gamma)

group	rel.s.d.															
1	4.1465E-01	1000	444	425	368	331	-178	-267	-167	61	156	0	0	0	0	0
2	3.6484E-01	444	1000	983	869	732	-421	-606	-444	2	211	0	0	0	0	0
3	3.0000E-01	425	983	1000	946	840	-495	-719	-543	-33	211	0	0	0	0	0
4	3.0000E-01	368	869	946	1000	962	-588	-859	-669	-81	207	0	0	0	0	0
5	5.0000E-01	331	732	840	962	1000	-551	-874	-648	-13	283	0	0	0	0	0
6	5.0000E-02	-178	-421	-495	-588	-551	1000	874	853	487	220	0	0	0	0	0
7	6.6594E-02	-267	-606	-719	-859	-874	874	1000	899	367	49	0	0	0	0	0
8	5.2450E-02	-167	-444	-543	-669	-648	853	899	1000	737	476	0	0	0	0	0
9	5.2484E-02	61	2	-33	-81	-13	487	367	737	1000	935	0	0	0	0	0
10	5.5373E-02	156	211	211	207	283	220	49	476	935	1000	1	0	0	0	0
11	1.6955E-02	0	0	0	0	0	0	0	0	0	1	1000	47	3	3	26
12	5.5020E-03	0	0	0	0	0	0	0	0	0	0	47	1000	-36	32	284

13	6.9900E-03	0	0	0	0	0	0	0	0	0	0	3	-36	1000	117	102
14	2.4108E-02	0	0	0	0	0	0	0	0	0	0	3	32	117	1000	279
15	1.5534E-02	0	0	0	0	0	0	0	0	0	0	26	284	102	279	1000

238Pu(n,el)

group	rel.s.d.															
1	4.0000E-02	1000	656	971	-266	-561	-240	0	0	0	0	0	0	0	0	0
2	3.0000E-02	656	1000	545	-600	-679	-290	0	0	0	0	0	0	0	0	0
3	2.0000E-02	971	545	1000	-189	-508	-217	0	0	0	0	0	0	0	0	0
4	2.0000E-02	-266	-600	-189	1000	940	402	0	0	0	0	0	0	0	0	0
5	2.0000E-02	-561	-679	-508	940	1000	427	0	0	0	0	0	0	0	0	0
6	2.0000E-02	-240	-290	-217	402	427	1000	897	881	867	760	0	0	0	0	0
7	2.0000E-01	0	0	0	0	0	897	1000	985	971	848	0	0	0	0	0
8	2.0000E-01	0	0	0	0	0	881	985	1000	998	848	0	0	0	0	0
9	2.0000E-01	0	0	0	0	0	867	971	998	1000	842	0	0	0	0	0
10	2.0000E-01	0	0	0	0	0	760	848	848	842	1000	112	9	19	19	19
11	2.0005E-01	0	0	0	0	0	0	0	0	0	112	1000	-3	2	3	2
12	1.0108E-01	0	0	0	0	0	0	0	0	0	9	-3	1000	472	474	472
13	5.7862E-02	0	0	0	0	0	0	0	0	0	19	2	472	1000	999	995
14	5.1029E-02	0	0	0	0	0	0	0	0	0	19	3	474	999	1000	999
15	4.6944E-02	0	0	0	0	0	0	0	0	0	19	2	472	995	999	1000

238Pu(n,n')

group	rel.s.d.					
1	1.0000E-00	1000	-636	-783	-839	-135	0
2	1.0000E-00	-636	1000	950	855	131	0
3	1.0000E-01	-783	950	1000	974	152	0
4	1.0000E-00	-839	855	974	1000	159	0
5	1.0000E-00	-135	131	152	159	1000	987
6	5.0000E-01	0	0	0	0	987	1000

238Pu(n,2n)

group	rel.s.d.	
1	1.0000E-00	1000

238Pu(n,f)

group	rel.s.d.															
1	2.0000E-01	1000	123	-7	-11	-11	-5	0	0	0	0	0	0	0	0	0
2	2.0000E-01	123	1000	930	605	605	258	0	0	0	0	0	0	0	0	0
3	1.0000E-01	-7	930	1000	548	548	233	0	0	0	0	0	0	0	0	0
4	5.0000E-01	-11	605	548	1000	1000	426	0	0	0	0	0	0	0	0	0
5	5.0000E-01	-11	605	548	1000	1000	426	0	0	0	0	0	0	0	0	0
6	5.0000E-01	-5	258	233	426	426	1000	895	894	876	777	0	0	0	0	0
7	5.0000E-01	0	0	0	0	0	895	1000	999	980	870	0	0	0	0	0
8	5.0000E-01	0	0	0	0	0	894	999	1000	986	889	0	0	0	0	0
9	5.0000E-01	0	0	0	0	0	876	980	986	1000	949	0	0	0	0	0
10	5.0000E-01	0	0	0	0	0	777	870	889	949	1000	10	0	0	0	0
11	8.0000E-01	0	0	0	0	0	0	0	0	0	10	1000	1	36	9	4
12	1.8975E-01	0	0	0	0	0	0	0	0	0	0	1	1000	27	6	3
13	4.5674E-02	0	0	0	0	0	0	0	0	0	0	36	27	1000	545	529
14	4.6265E-02	0	0	0	0	0	0	0	0	0	0	9	6	545	1000	998
15	4.8675E-02	0	0	0	0	0	0	0	0	0	0	4	3	529	998	1000

238Pu(n,gamma)

group	rel.s.d.															
1	1.0000E-00	1000	630	624	278	-161	-19	0	0	0	0	0	0	0	0	0
2	1.0000E-00	630	1000	996	409	-300	-35	0	0	0	0	0	0	0	0	0
3	1.0000E-00	624	996	1000	478	-228	-27	0	0	0	0	0	0	0	0	0
4	5.0000E-01	278	409	478	1000	738	87	0	0	0	0	0	0	0	0	0
5	4.0000E-01	-161	-300	-228	738	1000	118	0	0	0	0	0	0	0	0	0
6	5.0000E-02	-19	-35	-27	87	118	1000	988	987	982	866	0	0	0	0	0
7	5.0000E-02	0	0	0	0	0	988	1000	1000	994	877	0	0	0	0	0
8	5.0000E-01	0	0	0	0	0	987	1000	1000	996	882	0	0	0	0	0
9	1.8668E-01	0	0	0	0	0	982	994	996	1000	911	0	0	0	0	0
10	6.7513E-01	0	0	0	0	0	866	877	882	911	1000	76	0	0	0	0
11	4.5526E-02	0	0	0	0	0	0	0	0	0	76	1000	1	2	6	3
12	3.6984E-02	0	0	0	0	0	0	0	0	0	0	1	1000	5	15	6
13	3.2510E-01	0	0	0	0	0	0	0	0	0	0	2	5	1000	52	42
14	3.9233E-01	0	0	0	0	0	0	0	0	0	0	6	15	52	1000	999
15	4.0774E-01	0	0	0	0	0	0	0	0	0	0	3	6	42	999	1000

239Pu(n,el)

group	rel.s.d.															
1	1.0000E-01	1000	805	-338	-126	383	357	329	155	7	0	0	0	0	0	0
2	3.0000E-02	805	1000	-441	-116	244	251	259	134	6	0	0	0	0	0	0

3	2.0000E-02	-338	-441	1000	458	-262	-223	-177	-76	-3	0	0	0	0	0	0
4	2.0000E-02	-126	-116	458	1000	197	42	-56	-69	-3	0	0	0	0	0	0
5	2.0000E-02	383	244	-262	197	1000	879	676	251	10	0	0	0	0	0	0
6	2.0000E-02	357	251	-223	42	879	1000	905	385	16	0	0	0	0	0	0
7	2.0000E-02	329	259	-177	-56	676	905	1000	558	80	0	0	0	0	0	0
8	2.0000E-02	155	134	-76	-69	251	385	558	1000	837	0	0	0	0	0	0
9	2.0000E-02	7	6	-3	-3	10	16	80	837	1000	0	0	0	0	0	0
10	3.2285E-03	0	0	0	0	0	0	0	0	0	1000	11	10	20	21	21
11	9.4185E-03	0	0	0	0	0	0	0	0	0	11	1000	17	50	55	64
12	1.8648E-02	0	0	0	0	0	0	0	0	0	10	17	1000	554	567	535
13	3.1444E-02	0	0	0	0	0	0	0	0	0	20	50	554	1000	958	981
14	3.4417E-02	0	0	0	0	0	0	0	0	0	21	55	567	958	1000	936
15	6.6491E-02	0	0	0	0	0	0	0	0	0	21	64	535	981	936	1000

239Pu(n,n')

group	rel.s.d.									
1	1.5000E-01	1000	811	-343	-138	408	390	343	276	268
2	1.5000E-01	811	1000	-445	-125	256	271	269	238	234
3	1.0000E-01	-343	-445	1000	475	-284	-250	-189	-135	-129
4	3.0000E-01	-138	-125	475	1000	168	31	-66	-130	-139
5	3.0000E-01	408	256	-284	168	1000	904	703	471	440
6	5.0000E-01	390	271	-250	31	904	1000	923	737	709
7	5.0000E-01	343	269	-189	-66	703	923	1000	934	917
8	5.0000E-01	276	238	-135	-130	471	737	934	1000	999
9	5.0000E-01	268	234	-129	-139	440	709	917	999	1000

239Pu(n,2n)

group	rel.s.d.		
1	2.2319E-01	1000	299
2	7.2530E+00	299	1000

239Pu(n,f)

group	rel.s.d.															
1	5.5216E-03	1000	791	684	677	585	489	233	0	0	0	0	0	0	0	0
2	5.0775E-03	791	1000	807	800	695	580	276	0	0	0	0	0	0	0	0
3	5.6025E-03	684	807	1000	831	713	592	281	0	0	0	0	0	0	0	0
4	5.4610E-03	677	800	831	1000	801	664	317	0	0	0	0	0	0	0	0
5	6.1655E-03	585	695	713	801	1000	692	325	0	0	0	0	0	0	0	0
6	7.1258E-03	489	580	592	664	692	1000	331	0	0	0	0	0	0	0	0

7	1.2416E-02	233	276	281	317	325	331	1000	816	740	0	0	0	0	0	0
8	6.7595E-02	0	0	0	0	0	0	816	1000	949	0	0	0	0	0	0
9	5.2934E-02	0	0	0	0	0	0	740	949	1000	0	0	0	0	0	0
10	3.9323E-03	0	0	0	0	0	0	0	0	0	1000	-11	2	-15	16	11
11	9.9794E-03	0	0	0	0	0	0	0	0	0	-11	1000	2	2	0	1
12	2.6346E-02	0	0	0	0	0	0	0	0	0	2	2	1000	193	-202	-44
13	2.0256E-01	0	0	0	0	0	0	0	0	0	-15	2	193	1000	-942	-35
14	4.7989E-02	0	0	0	0	0	0	0	0	0	16	0	-202	-942	1000	167
15	1.4841E-02	0	0	0	0	0	0	0	0	0	11	1	-44	-35	167	1000

239Pu(n,gamma)

group	rel.s.d.															
1	6.0000E-01	1000	408	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2.0000E-01	408	1000	820	659	162	35	23	0	0	0	0	0	0	0	0
3	5.0000E-01	0	820	1000	804	197	43	28	0	0	0	0	0	0	0	0
4	2.0000E-01	0	659	804	1000	354	77	50	0	0	0	0	0	0	0	0
5	1.5000E-01	0	162	197	354	1000	221	91	0	0	0	0	0	0	0	0
6	2.0000E-01	0	35	43	77	221	1000	820	0	0	0	0	0	0	0	0
7	2.0000E-01	0	23	28	50	91	820	1000	121	116	0	0	0	0	0	0
8	2.0000E-01	0	0	0	0	0	0	121	1000	986	0	0	0	0	0	0
9	5.5706E-02	0	0	0	0	0	0	116	986	1000	0	0	0	0	0	0
10	4.4079E-03	0	0	0	0	0	0	0	0	0	1000	0	1	1	-1	1
11	8.7665E-03	0	0	0	0	0	0	0	0	0	0	1000	-4	13	-8	5
12	2.1341E-02	0	0	0	0	0	0	0	0	0	1	-4	1000	65	-87	-13
13	1.7530E-01	0	0	0	0	0	0	0	0	0	1	13	65	1000	-965	-315
14	2.8745E-02	0	0	0	0	0	0	0	0	0	-1	-8	-87	-965	1000	525
15	2.1209E-02	0	0	0	0	0	0	0	0	0	1	5	-13	-315	525	1000

240Pu(n,el)

group	rel.s.d.															
1	4.0000E-02	1000	917	442	427	816	638	243	-23	-86	0	0	0	0	0	0
2	4.0000E-02	917	1000	709	634	941	850	524	276	138	0	0	0	0	0	0
3	4.0000E-02	442	709	1000	856	798	950	949	861	610	0	0	0	0	0	0
4	4.0000E-02	427	634	856	1000	844	906	901	787	548	0	0	0	0	0	0
5	4.0000E-02	816	941	798	844	1000	942	706	478	292	0	0	0	0	0	0
6	4.0000E-02	638	850	950	906	942	1000	892	732	496	0	0	0	0	0	0
7	4.0000E-02	243	524	949	901	706	892	1000	959	693	0	0	0	0	0	0
8	4.0000E-02	-23	276	861	787	478	732	959	1000	744	0	0	0	0	0	0
9	4.0000E-02	-86	138	610	548	292	496	693	744	1000	-13	0	7	-2	11	15
10	1.2591E-02	0	0	0	0	0	0	0	0	-13	1000	38	25	14	8	7
11	1.6361E-02	0	0	0	0	0	0	0	0	0	38	1000	49	16	24	26
12	3.2532E-02	0	0	0	0	0	0	0	0	7	25	49	1000	164	168	169
13	4.8438E-03	0	0	0	0	0	0	0	0	-2	14	16	164	1000	988	986
14	4.5762E-02	0	0	0	0	0	0	0	0	11	8	24	168	988	1000	1000

15	5.6449E-02	0	0	0	0	0	0	0	0	15	7	26	169	986	1000	1000

240Pu(n,n')

group	rel.s.d.							
1	1.0000E-01	1000	608	559	-740	-539	-661	-597
2	1.4270E-01	608	1000	978	-846	-870	-972	-858
3	5.7500E-02	559	978	1000	-757	-795	-927	-825
4	3.0000E-01	-740	-846	-757	1000	908	930	809
5	3.0000E-01	-539	-870	-795	908	1000	949	807
6	4.0000E-01	-661	-972	-927	930	949	1000	873
7	6.8170E-01	-597	-858	-825	809	807	873	1000

240Pu(n,2n)

group	rel.s.d.	
1	1.0000E-01	1000

240Pu(n,f)

group	rel.s.d.															
1	9.5597E-02	1000	741	-204	-344	-337	-577	-594	-594	-205	0	0	0	0	0	0
2	4.8001E-02	741	1000	-374	-594	-582	-941	-962	-962	-331	0	0	0	0	0	0
3	5.6532E-02	-204	-374	1000	965	969	581	454	454	156	0	0	0	0	0	0
4	5.8233E-02	-344	-594	965	1000	1000	774	672	672	231	0	0	0	0	0	0
5	3.9098E-02	-337	-582	969	1000	1000	764	661	661	227	0	0	0	0	0	0
6	5.7007E-02	-577	-941	581	774	764	1000	989	989	341	0	0	0	0	0	0
7	7.4510E-02	-594	-962	454	672	661	989	1000	1000	344	0	0	0	0	0	0
8	7.4510E-02	-594	-962	454	672	661	989	1000	1000	344	0	0	0	0	0	0
9	8.0144E-02	-205	-331	156	231	227	341	344	344	1000	20	45	4	1	-1	-1
10	2.1617E-01	0	0	0	0	0	0	0	0	20	1000	357	24	6	16	18
11	4.7157E-02	0	0	0	0	0	0	0	0	45	357	1000	40	13	-31	-30
12	8.9123E-02	0	0	0	0	0	0	0	0	4	24	40	1000	8	-21	-21
13	1.2186E-02	0	0	0	0	0	0	0	0	1	6	13	8	1000	559	478
14	2.9756E-01	0	0	0	0	0	0	0	0	-1	16	-31	-21	559	1000	995
15	4.8464E-01	0	0	0	0	0	0	0	0	-1	18	-30	-21	478	995	1000

240Pu(n,gamma)

group	rel.s.d.															
1	5.5000E-01	1000	655	464	413	411	411	393	393	380	0	0	0	0	0	0
2	3.5000E-01	655	1000	848	734	661	641	581	584	571	0	0	0	0	0	0
3	2.5000E-01	464	848	1000	971	917	904	836	838	814	0	0	0	0	0	0
4	1.0000E-00	413	734	971	1000	983	975	934	935	900	0	0	0	0	0	0
5	3.0000E-01	411	661	917	983	1000	997	977	977	935	0	0	0	0	0	0
6	1.0000E-01	411	641	904	975	997	1000	972	970	930	0	0	0	0	0	0
7	1.0000E-01	393	581	836	934	977	972	1000	1000	948	0	0	0	0	0	0
8	1.0211E-01	393	584	838	935	977	970	1000	1000	948	0	0	0	0	0	0
9	5.0000E-02	380	571	814	900	935	930	948	948	1000	1	0	0	0	0	0
10	5.0000E-02	0	0	0	0	0	0	0	0	1	1000	1	0	0	0	0
11	5.0000E-02	0	0	0	0	0	0	0	0	0	1	1000	5	1	5	5
12	5.4970E-02	0	0	0	0	0	0	0	0	0	0	5	1000	2	23	25
13	4.3621E-03	0	0	0	0	0	0	0	0	0	0	1	2	1000	7	58
14	3.2338E-02	0	0	0	0	0	0	0	0	0	0	5	23	7	1000	962
15	4.7875E-02	0	0	0	0	0	0	0	0	0	0	5	25	58	962	1000

241Pu(n,el)

group	rel.s.d.															
1	3.0000E-02	1000	768	-24	45	9	-14	-9	0	0	0	0	0	0	0	0
2	2.0000E-02	768	1000	240	-562	-86	174	111	0	0	0	0	0	0	0	0
3	3.0000E-02	-24	240	1000	-411	-253	88	86	0	0	0	0	0	0	0	0
4	1.0000E-01	45	-562	-411	1000	423	-34	-68	0	0	0	0	0	0	0	0
5	1.0000E-01	9	-86	-253	423	1000	872	397	0	0	0	0	0	0	0	0
6	1.0000E-01	-14	174	88	-34	872	1000	488	0	0	0	0	0	0	0	0
7	1.0000E-01	-9	111	86	-68	397	488	1000	870	857	0	0	0	0	0	0
8	1.0000E-01	0	0	0	0	0	0	870	1000	992	0	0	0	0	0	0
9	1.0000E-01	0	0	0	0	0	0	857	992	1000	12	12	12	12	12	11
10	1.1000E-01	0	0	0	0	0	0	0	0	12	1000	1000	994	976	925	885
11	1.0873E-01	0	0	0	0	0	0	0	0	12	1000	1000	994	976	925	885
12	1.0658E-01	0	0	0	0	0	0	0	0	12	994	994	1000	948	905	868
13	1.1489E-01	0	0	0	0	0	0	0	0	12	976	976	948	1000	957	912
14	9.9124E-02	0	0	0	0	0	0	0	0	12	925	925	905	957	1000	939
15	1.1318E-01	0	0	0	0	0	0	0	0	11	885	885	868	912	939	1000

241Pu(n,n')

group	rel.s.d.							
1	1.0000E-01	1000	555	474	-704	-482	-619	-417
2	1.9469E-01	555	1000	965	-859	-852	-969	-638
3	3.0000E-01	474	965	1000	-742	-748	-907	-603
4	3.0000E-01	-704	-859	-742	1000	907	942	611
5	1.0000E-01	-482	-852	-748	907	1000	935	591

6	5.0000E-01	-619	-969	-907	942	935	1000	651
7	5.0000E-01	-417	-638	-603	611	591	651	1000

241Pu(n,2n)

group	rel.s.d.	---------	
1	3.9684E-01	1000	827
2	3.3427E-01	827	1000

241Pu(n,f)

group	rel.s.d.	------														
1	1.0000E-01	1000	-75	-98	-82	-71	-78	-71	0	0	0	0	0	0	0	0
2	5.0000E-02	-75	1000	444	170	152	227	214	0	0	0	0	0	0	0	0
3	5.0000E-02	-98	444	1000	956	928	858	670	0	0	0	0	0	0	0	0
4	1.6621E-01	-82	170	956	1000	979	878	675	0	0	0	0	0	0	0	0
5	1.3538E-01	-71	152	928	979	1000	951	756	0	0	0	0	0	0	0	0
6	1.9872E-01	-78	227	858	878	951	1000	839	0	0	0	0	0	0	0	0
7	8.7402E-02	-71	214	670	675	756	839	1000	526	525	0	0	0	0	0	0
8	1.1285E-01	0	0	0	0	0	0	526	1000	1000	0	0	0	0	0	0
9	1.0435E-01	0	0	0	0	0	0	525	1000	1000	0	0	0	0	0	0
10	1.2679E-01	0	0	0	0	0	0	0	0	0	1000	7	137	-233	158	424
11	1.9379E-01	0	0	0	0	0	0	0	0	0	7	1000	233	-80	49	176
12	4.2051E-02	0	0	0	0	0	0	0	0	0	137	233	1000	339	134	26
13	2.6831E-01	0	0	0	0	0	0	0	0	0	-233	-80	339	1000	165	-771
14	2.9394E-02	0	0	0	0	0	0	0	0	0	158	49	134	165	1000	63
15	3.2656E-02	0	0	0	0	0	0	0	0	0	424	176	26	-771	63	1000

241Pu(n,gamma)

group	rel.s.d.	------														
1	5.5385E-01	1000	585	561	536	583	588	390	0	0	0	0	0	0	0	0
2	5.4101E-01	585	1000	931	814	744	691	445	0	0	0	0	0	0	0	0
3	1.0000E-00	561	931	1000	969	928	882	573	0	0	0	0	0	0	0	0
4	8.0000E-01	536	814	969	1000	986	953	624	0	0	0	0	0	0	0	0
5	3.0000E-01	583	744	928	986	1000	986	654	0	0	0	0	0	0	0	0
6	3.0000E-01	588	691	882	953	986	1000	676	0	0	0	0	0	0	0	0
7	4.4279E-02	390	445	573	624	654	676	1000	733	730	730	608	0	0	0	0
8	3.0000E-02	0	0	0	0	0	0	733	1000	999	998	831	0	0	0	0
9	3.0000E-02	0	0	0	0	0	0	730	999	1000	1000	833	0	0	0	0
10	3.0000E-02	0	0	0	0	0	0	730	998	1000	1000	833	0	0	0	0

11	7.4258E-02	0	0	0	0	0	0	608	831	833	833	1000	225	67	148	-235
12	8.3828E-02	0	0	0	0	0	0	0	0	0	0	225	1000	264	398	-407
13	6.3663E-02	0	0	0	0	0	0	0	0	0	0	67	264	1000	636	319
14	6.8424E-02	0	0	0	0	0	0	0	0	0	0	148	398	636	1000	-6
15	3.5907E-02	0	0	0	0	0	0	0	0	0	0	-235	-407	319	-6	1000

242Pu(n,el)

group	rel.s.d.	--														
1	3.0000E-02	1000	160	967	196	-363	0	0	0	0	0	0	0	0	0	0
2	3.0000E-02	160	1000	-2	-351	-141	0	0	0	0	0	0	0	0	0	0
3	3.0000E-02	967	-2	1000	293	-328	0	0	0	0	0	0	0	0	0	0
4	3.0000E-02	196	-351	293	1000	432	0	0	0	0	0	0	0	0	0	0
5	3.0000E-02	-363	-141	-328	432	1000	762	92	0	0	0	0	0	0	0	0
6	3.0000E-02	0	0	0	0	762	1000	121	0	0	0	0	0	0	0	0
7	3.0000E-02	0	0	0	0	92	121	1000	993	708	0	0	0	0	0	0
8	3.0000E-02	0	0	0	0	0	0	993	1000	711	0	0	0	0	0	0
9	3.0000E-02	0	0	0	0	0	0	708	711	1000	591	558	627	96	627	627
10	3.7640E-02	0	0	0	0	0	0	0	0	591	1000	827	936	143	936	936
11	2.2909E-02	0	0	0	0	0	0	0	0	558	827	1000	884	136	884	884
12	5.9371E-02	0	0	0	0	0	0	0	0	627	936	884	1000	169	998	998
13	4.6823E-02	0	0	0	0	0	0	0	0	96	143	136	169	1000	118	120
14	7.1901E-02	0	0	0	0	0	0	0	0	627	936	884	998	118	1000	1000
15	6.9903E-02	0	0	0	0	0	0	0	0	627	936	884	998	120	1000	1000

242Pu(n,n')

group	rel.s.d.	------------------------------					
1	1.0000E-01	1000	-519	-804	-838	-363	0
2	1.4270E-01	-519	1000	865	785	315	0
3	3.0000E-01	-804	865	1000	989	418	0
4	3.0000E-01	-838	785	989	1000	428	0
5	3.0000E-01	-363	315	418	428	1000	903
6	6.8170E-01	0	0	0	0	903	1000

242Pu(n,2n)

group	rel.s.d.	----
1	5.1701E-01	1000

242Pu(n,f)

group	rel.s.d.														
1	3.7238E-01	1000	-366	-37	-32	-16	0	0	0	0	0	0	0	0	0	0
2	1.5095E-01	-366	1000	592	497	253	0	0	0	0	0	0	0	0	0	0
3	2.1418E-01	-37	592	1000	981	500	0	0	0	0	0	0	0	0	0	0
4	1.8982E-01	-32	497	981	1000	510	0	0	0	0	0	0	0	0	0	0
5	1.8630E-01	-16	253	500	510	1000	860	103	0	0	0	0	0	0	0	0
6	3.2071E-01	0	0	0	0	860	1000	120	0	0	0	0	0	0	0	0
7	3.3058E-01	0	0	0	0	103	120	1000	992	680	0	0	0	0	0	0
8	3.3187E-01	0	0	0	0	0	0	992	1000	682	0	0	0	0	0	0
9	1.3227E-01	0	0	0	0	0	0	680	682	1000	0	0	0	0	0	0
10	5.8878E-02	0	0	0	0	0	0	0	0	0	1000	2	7	0	5	5
11	1.9567E-02	0	0	0	0	0	0	0	0	0	2	1000	32	0	13	15
12	6.4611E-02	0	0	0	0	0	0	0	0	0	7	32	1000	337	477	477
13	7.6041E-02	0	0	0	0	0	0	0	0	0	0	0	337	1000	708	706
14	5.2357E-02	0	0	0	0	0	0	0	0	0	5	13	477	708	1000	1000
15	5.0918E-02	0	0	0	0	0	0	0	0	0	5	15	477	706	1000	1000

242Pu(n,gamma)

group	rel.s.d.														
1	7.8469E-01	1000	369	230	42	0	0	0	0	0	0	0	0	0	0	0
2	2.00000-00	369	1000	936	188	-12	0	0	0	0	0	0	0	0	0	0
3	1.5000E-00	230	936	1000	345	9	0	0	0	0	0	0	0	0	0	0
4	8.0000E-01	42	188	345	1000	159	0	0	0	0	0	0	0	0	0	0
5	3.0000E-01	0	-12	9	159	1000	986	66	0	0	0	0	0	0	0	0
6	3.2281E-01	0	0	0	0	986	1000	67	0	0	0	0	0	0	0	0
7	3.7256E-01	0	0	0	0	66	67	1000	998	997	0	0	0	0	0	0
8	3.8632E-01	0	0	0	0	0	0	998	1000	999	0	0	0	0	0	0
9	3.8452E-01	0	0	0	0	0	0	997	999	1000	0	0	0	0	0	0
10	1.7004E-02	0	0	0	0	0	0	0	0	0	1000	4	0	0	0	0
11	2.2263E-02	0	0	0	0	0	0	0	0	0	4	1000	12	0	10	11
12	7.4046E-02	0	0	0	0	0	0	0	0	0	0	12	1000	66	97	98
13	3.7810E-02	0	0	0	0	0	0	0	0	0	0	0	66	1000	688	705
14	7.0974E-02	0	0	0	0	0	0	0	0	0	0	10	97	688	1000	1000
15	6.8893E-02	0	0	0	0	0	0	0	0	0	0	11	98	705	1000	1000

241Am(n,el)

group	rel.s.d.														
1	3.0000E-02	1000	-57	-244	-61	-6	-7	-9	0	0	0	0	0	0	0	0
2	2.0000E-02	-57	1000	465	53	-317	-342	-329	0	0	0	0	0	0	0	0
3	2.0000E-02	-244	465	1000	562	-155	-191	-182	0	0	0	0	0	0	0	0

4	2.0000E-02	-61	53	562	1000	700	670	639	0	0	0	0	0	0	0	0
5	1.0000E-01	-6	-317	-155	700	1000	999	952	0	0	0	0	0	0	0	0
6	1.0000E-01	-7	-342	-191	670	999	1000	953	0	0	0	0	0	0	0	0
7	1.0000E-01	-9	-329	-182	639	952	953	1000	302	299	127	0	0	0	0	0
8	1.0000E-01	0	0	0	0	0	0	302	1000	991	421	0	0	0	0	0
9	1.0000E-01	0	0	0	0	0	0	299	991	1000	434	0	0	0	0	0
10	1.0000E-01	0	0	0	0	0	0	127	421	434	1000	886	886	885	885	885
11	1.4527E-01	0	0	0	0	0	0	0	0	0	886	1000	1000	998	998	998
12	1.4030E-01	0	0	0	0	0	0	0	0	0	886	1000	1000	998	998	998
13	1.4204E-01	0	0	0	0	0	0	0	0	0	885	998	998	1000	996	996
14	1.3810E-01	0	0	0	0	0	0	0	0	0	885	998	998	996	1000	1000
15	1.3033E-01	0	0	0	0	0	0	0	0	0	885	998	998	996	1000	1000

241Am(n,n')

group	rel.s.d.							
1	1.5000E-01	1000	-20	-67	-275	-375	-151	-103
2	2.0000E-01	-20	1000	953	889	-305	-798	-718
3	2.0000E-01	-67	953	1000	884	-409	-884	-788
4	2.0000E-01	-275	889	884	1000	61	-564	-538
5	3.0000E-01	-375	-305	-409	61	1000	787	629
6	3.0000E-01	-151	-798	-884	-564	787	1000	855
7	3.0000E-01	-103	-718	-788	-538	629	855	1000

241Am(n,2n)

group	rel.s.d.	
1	1.0034E-01	1000

241Am(n,f)

group	rel.s.d.															
1	2.0000E-01	1000	293	-126	-71	-75	-75	-72	0	0	0	0	0	0	0	0
2	1.1665E-01	293	1000	632	409	331	331	320	0	0	0	0	0	0	0	0
3	9.8086E-02	-126	632	1000	921	882	882	852	0	0	0	0	0	0	0	0
4	8.2530E-02	-71	409	921	1000	996	996	962	0	0	0	0	0	0	0	0
5	8.2853E-02	-75	331	882	996	1000	1000	966	0	0	0	0	0	0	0	0
6	8.2853E-02	-75	331	882	996	1000	1000	966	0	0	0	0	0	0	0	0
7	7.3868E-02	-72	320	852	962	966	966	1000	258	258	258	225	0	0	0	0
8	1.3709E-01	0	0	0	0	0	0	258	1000	1000	1000	874	0	0	0	0
9	1.3507E-01	0	0	0	0	0	0	258	1000	1000	1000	874	0	0	0	0
10	1.3410E-01	0	0	0	0	0	0	258	1000	1000	1000	874	0	0	0	0
11	8.0804E-02	0	0	0	0	0	0	225	874	874	874	1000	0	0	0	0
12	5.1451E-02	0	0	0	0	0	0	0	0	0	0	0	1000	-4	1	12

13	6.7239E-02	0	0	0	0	0	0	0	0	0	0	0	-4	1000	57	131
14	8.9340E-02	0	0	0	0	0	0	0	0	0	0	0	1	57	1000	884
15	3.0203E-02	0	0	0	0	0	0	0	0	0	0	0	12	131	884	1000

241Am(n,gamma)

group	rel.s.d.															
1	2.8826E-01	1000	391	321	246	253	156	105	0	0	0	0	0	0	0	0
2	1.5384E-01	391	1000	935	753	240	-204	-370	0	0	0	0	0	0	0	0
3	3.0000E-01	321	935	1000	932	416	-104	-329	0	0	0	0	0	0	0	0
4	3.0000E-01	246	753	932	1000	618	100	-148	0	0	0	0	0	0	0	0
5	2.0000E-01	253	240	416	618	1000	843	677	0	0	0	0	0	0	0	0
6	6.7913E-02	156	-204	-104	100	843	1000	957	0	0	0	0	0	0	0	0
7	7.9615E-02	105	-370	-329	-148	677	957	1000	122	122	122	121	0	0	0	0
8	6.8538E-02	0	0	0	0	0	0	122	1000	1000	1000	996	0	0	0	0
9	6.6629E-02	0	0	0	0	0	0	122	1000	1000	1000	997	0	0	0	0
10	6.5925E-02	0	0	0	0	0	0	122	1000	1000	1000	997	0	0	0	0
11	3.6682E-02	0	0	0	0	0	0	121	996	997	997	1000	0	0	0	0
12	1.8169E-02	0	0	0	0	0	0	0	0	0	0	0	1000	-157	0	-1
13	5.5364E-02	0	0	0	0	0	0	0	0	0	0	0	-157	1000	32	80
14	1.2581E-02	0	0	0	0	0	0	0	0	0	0	0	0	32	1000	320
15	1.8013E-02	0	0	0	0	0	0	0	0	0	0	0	-1	80	320	1000

242mAm(n,el)

group	rel.s.d.															
1	1.0000E-01	1000	972	100	959	908	654	306	0	0	0	0	0	0	0	0
2	1.0000E-01	972	1000	322	998	977	804	507	0	0	0	0	0	0	0	0
3	1.0000E-01	100	322	1000	367	490	797	952	0	0	0	0	0	0	0	0
4	5.0000E-02	959	998	367	1000	987	835	551	0	0	0	0	0	0	0	0
5	1.0000E-02	908	977	490	987	1000	909	666	0	0	0	0	0	0	0	0
6	1.3909E-01	654	804	797	835	909	1000	909	0	0	0	0	0	0	0	0
7	1.2761E-01	306	507	952	551	666	909	1000	153	138	136	20	0	0	0	0
8	1.8887E-01	0	0	0	0	0	0	153	1000	930	922	136	0	0	0	0
9	1.9364E-01	0	0	0	0	0	0	138	930	1000	997	147	0	0	0	0
10	1.9423E-01	0	0	0	0	0	0	136	922	997	1000	151	4	4	4	4
11	1.6677E-01	0	0	0	0	0	0	20	136	147	151	1000	989	987	921	984
12	1.9950E-01	0	0	0	0	0	0	0	0	0	4	989	1000	998	932	994
13	2.0611E-01	0	0	0	0	0	0	0	0	0	4	987	998	1000	944	994
14	1.7644E-01	0	0	0	0	0	0	0	0	0	4	921	932	944	1000	943
15	2.1783E-01	0	0	0	0	0	0	0	0	0	4	984	994	994	943	1000

242mAm(n,n')

group	rel.s.d.								
1	1.5000E-01	1000	-300	-403	-468	-444	-387	-328	0
2	3.0000E-01	-300	1000	960	874	691	399	207	0
3	3.0000E-01	-403	960	1000	926	756	460	254	0
4	3.0000E-01	-468	874	926	1000	938	754	576	0
5	3.0000E-01	-444	691	756	938	1000	927	768	0
6	3.0000E-01	-387	399	460	754	927	1000	913	0
7	3.0000E-01	-328	207	254	576	768	913	1000	332
8	3.0000E-01	0	0	0	0	0	0	332	1000

242mAm(n,2n)

group	rel.s.d.		
1	3.1766E-01	1000	186
2	3.7230E-01	186	1000

242mAm(n,f)

group	rel.s.d.															
1	4.0000E-01	1000	358	-148	-82	-85	-85	-84	0	0	0	0	0	0	0	0
2	2.3363E-01	358	1000	645	390	343	343	341	0	0	0	0	0	0	0	0
3	1.9701E-01	-148	645	1000	904	880	880	876	0	0	0	0	0	0	0	0
4	1.6514E-01	-82	390	904	1000	998	998	995	0	0	0	0	0	0	0	0
5	1.6571E-01	-85	343	880	998	1000	1000	996	0	0	0	0	0	0	0	0
6	1.6571E-01	-85	343	880	998	1000	1000	996	0	0	0	0	0	0	0	0
7	1.4431E-01	-84	341	876	995	996	996	1000	87	87	87	8	0	0	0	0
8	1.1797E-01	0	0	0	0	0	0	87	1000	1000	1000	91	0	0	0	0
9	1.2360E-01	0	0	0	0	0	0	87	1000	1000	1000	91	0	0	0	0
10	1.2197E-01	0	0	0	0	0	0	87	1000	1000	1000	92	0	0	0	0
11	1.0393E-01	0	0	0	0	0	0	8	91	91	92	1000	23	0	0	0
12	1.0377E-01	0	0	0	0	0	0	0	0	0	0	23	1000	5	2	2
13	6.9997E-02	0	0	0	0	0	0	0	0	0	0	0	5	1000	159	149
14	8.8316E-02	0	0	0	0	0	0	0	0	0	0	0	2	159	1000	979
15	8.0613E-02	0	0	0	0	0	0	0	0	0	0	0	2	149	979	1000

242mAm(n,gamma)

group	rel.s.d.															
1	1.00000-00	1000	426	431	370	349	378	320	0	0	0	0	0	0	0	0
2	1.0000E-00	426	1000	960	822	757	661	376	0	0	0	0	0	0	0	0
3	5.0000E-01	431	960	1000	939	897	830	551	0	0	0	0	0	0	0	0
4	5.0000E-01	370	822	939	1000	994	928	655	0	0	0	0	0	0	0	0
5	5.0000E-01	349	757	897	994	1000	949	701	0	0	0	0	0	0	0	0
6	5.0000E-01	378	661	830	928	949	1000	881	0	0	0	0	0	0	0	0

7	5.0000E-01	320	376	551	655	701	881	1000	118	118	118	22	0	0	0	0
8	5.0000E-01	0	0	0	0	0	0	118	1000	1000	999	187	0	0	0	0
9	5.0000E-01	0	0	0	0	0	0	118	1000	1000	1000	188	0	0	0	0
10	5.0000E-01	0	0	0	0	0	0	118	999	1000	1000	190	0	0	0	0
11	5.0000E-01	0	0	0	0	0	0	22	187	188	190	1000	25	2	1	1
12	1.3246E-01	0	0	0	0	0	0	0	0	0	0	25	1000	47	5	5
13	1.3573E-01	0	0	0	0	0	0	0	0	0	0	2	47	1000	326	268
14	1.9867E-01	0	0	0	0	0	0	0	0	0	0	1	5	326	1000	988
15	1.9597E-01	0	0	0	0	0	0	0	0	0	0	1	5	268	988	1000

243Am(n,el)

group	rel.s.d.															
1	3.0000E-02	1000	160	-142	-61	-73	-138	-72	0	0	0	0	0	0	0	0
2	3.0000E-02	160	1000	222	538	510	232	82	0	0	0	0	0	0	0	0
3	3.0000E-02	-142	222	1000	914	938	989	472	0	0	0	0	0	0	0	0
4	3.0000E-02	-61	538	914	1000	982	923	429	0	0	0	0	0	0	0	0
5	3.0000E-02	-73	510	938	982	1000	954	445	0	0	0	0	0	0	0	0
6	1.0000E-01	-138	232	989	923	954	1000	476	0	0	0	0	0	0	0	0
7	2.0000E-01	-72	82	472	429	445	476	1000	879	866	0	0	0	0	0	0
8	2.0000E-01	0	0	0	0	0	0	879	1000	989	0	0	0	0	0	0
9	2.0000E-01	0	0	0	0	0	0	866	989	1000	5	5	5	3	5	5
10	2.0000E-01	0	0	0	0	0	0	0	0	5	1000	949	929	648	952	954
11	8.9578E-02	0	0	0	0	0	0	0	0	5	949	1000	963	672	986	987
12	8.2168E-02	0	0	0	0	0	0	0	0	5	929	963	1000	663	963	965
13	7.0028E-02	0	0	0	0	0	0	0	0	3	648	672	663	1000	609	623
14	1.2409E-01	0	0	0	0	0	0	0	0	5	952	986	963	609	1000	1000
15	1.1444E-01	0	0	0	0	0	0	0	0	5	954	987	965	623	1000	1000

243Am(n,n')

group	rel.s.d.							
1	1.5000E-01	1000	208	-8	-15	-16	-20	-24
2	2.0000E-01	208	1000	533	609	647	666	657
3	2.0000E-01	-8	533	1000	978	911	784	667
4	2.0000E-01	-15	609	978	1000	977	895	805
5	3.0000E-01	-16	647	911	977	1000	970	911
6	3.0000E-01	-20	666	784	895	970	1000	981
7	3.0000E-01	-24	657	667	805	911	981	1000

243Am(n,2n)

group	rel.s.d.	
1	5.0000E-01	1000

243Am(n,f)

group	rel.s.d.															
1	2.0000E-01	1000	129	70	-13	-19	-19	-10	0	0	0	0	0	0	0	0
2	1.1028E-01	129	1000	682	-170	-223	-223	-117	0	0	0	0	0	0	0	0
3	5.9739E-02	70	682	1000	550	486	486	255	0	0	0	0	0	0	0	0
4	9.1842E-02	-13	-170	550	1000	995	995	522	0	0	0	0	0	0	0	0
5	9.6178E-02	-19	-223	486	995	1000	1000	525	0	0	0	0	0	0	0	0
6	9.6178E-02	-19	-223	486	995	1000	1000	525	0	0	0	0	0	0	0	0
7	7.1171E-02	-10	-117	255	522	525	525	1000	851	851	851	844	0	0	0	0
8	1.3789E-01	0	0	0	0	0	0	851	1000	1000	1000	992	0	0	0	0
9	1.3540E-01	0	0	0	0	0	0	851	1000	1000	1000	992	0	0	0	0
10	1.3408E-01	0	0	0	0	0	0	851	1000	1000	1000	992	0	0	0	0
11	9.6353E-02	0	0	0	0	0	0	844	992	992	992	1000	1	0	0	0
12	5.9527E-02	0	0	0	0	0	0	0	0	0	0	1	1000	1	13	12
13	4.8053E-02	0	0	0	0	0	0	0	0	0	0	0	1	1000	381	240
14	2.2488E-02	0	0	0	0	0	0	0	0	0	0	0	13	381	1000	905
15	2.1229E-02	0	0	0	0	0	0	0	0	0	0	0	12	240	905	1000

243Am(n,gamma)

group	rel.s.d.															
1	6.0422E-01	1000	353	246	128	145	147	72	0	0	0	0	0	0	0	0
2	4.1502E-01	353	1000	948	725	529	-31	-171	0	0	0	0	0	0	0	0
3	2.1658E-01	246	948	1000	899	728	-40	-243	0	0	0	0	0	0	0	0
4	1.4183E-01	128	725	899	1000	930	26	-256	0	0	0	0	0	0	0	0
5	1.0000E-01	145	529	728	930	1000	299	-67	0	0	0	0	0	0	0	0
6	1.0000E-01	147	-31	-40	26	299	1000	698	0	0	0	0	0	0	0	0
7	1.0000E-01	72	-171	-243	-256	-67	698	1000	652	652	652	613	0	0	0	0
8	6.7704E-02	0	0	0	0	0	0	652	1000	1000	1000	939	0	0	0	0
9	6.6441E-02	0	0	0	0	0	0	652	1000	1000	1000	939	0	0	0	0
10	6.5778E-02	0	0	0	0	0	0	652	1000	1000	1000	940	0	0	0	0
11	2.3065E-02	0	0	0	0	0	0	613	939	939	940	1000	5	0	1	1
12	1.7412E-02	0	0	0	0	0	0	0	0	0	0	5	1000	3	14	20
13	3.4319E-02	0	0	0	0	0	0	0	0	0	0	0	3	1000	707	754
14	3.7452E-02	0	0	0	0	0	0	0	0	0	0	1	14	707	1000	942
15	3.5761E-02	0	0	0	0	0	0	0	0	0	0	1	20	754	942	1000

242Cm(n,el)

group	rel.s.d.															
1	1.0000E-01	1000	995	996	-26	-430	-627	-880	-917	0	0	0	0	0	0	0
2	5.0000E-02	995	1000	985	-123	-516	-701	-923	-920	0	0	0	0	0	0	0
3	3.0000E-02	996	985	1000	51	-362	-569	-842	-906	0	0	0	0	0	0	0
4	3.0000E-02	-26	-123	51	1000	906	787	496	109	0	0	0	0	0	0	0
5	2.0000E-02	-430	-516	-362	906	1000	973	805	463	0	0	0	0	0	0	0
6	4.0000E-02	-627	-701	-569	787	973	1000	920	634	0	0	0	0	0	0	0
7	4.0000E-02	-880	-923	-842	496	805	920	1000	846	0	0	0	0	0	0	0
8	2.1149E-02	-917	-920	-906	109	463	634	846	1000	359	358	225	0	0	0	0
9	5.0000E-02	0	0	0	0	0	0	0	359	1000	999	627	0	0	0	0
10	5.0000E-02	0	0	0	0	0	0	0	358	999	1000	629	0	0	0	0
11	5.0000E-02	0	0	0	0	0	0	0	225	627	629	1000	412	412	403	401
12	1.8182E-01	0	0	0	0	0	0	0	0	0	0	412	1000	986	968	963
13	1.9871E-01	0	0	0	0	0	0	0	0	0	0	412	986	1000	995	992
14	1.9673E-01	0	0	0	0	0	0	0	0	0	0	403	968	995	1000	1000
15	1.9679E-01	0	0	0	0	0	0	0	0	0	0	401	963	992	1000	1000

242Cm(n,n')

group	rel.s.d.							
1	1.0000E-00	1000	-780	-464	-221	-193	-83	-103
2	1.0000E-00	-780	1000	129	-230	-446	-550	-533
3	1.0000E-00	-464	129	1000	930	607	504	518
4	1.0000E-00	-221	-230	930	1000	809	747	755
5	1.0000E-01	-193	-446	607	809	1000	991	993
6	5.3151E-01	-83	-550	504	747	991	1000	1000
7	3.1726E-01	-103	-533	518	755	993	1000	1000

242Cm(n,2n)

group	rel.s.d.	
1	5.0000E-01	1000

242Cm(n,f)

group	rel.s.d.															
1	5.0000E-01	1000	991	870	356	138	-42	788	778	0	0	0	0	0	0	0
2	1.0000E-00	991	1000	917	467	259	78	845	819	0	0	0	0	0	0	0
3	1.0000E-00	870	917	1000	743	551	318	837	807	0	0	0	0	0	0	0
4	1.0000E-00	356	467	743	1000	965	834	715	609	0	0	0	0	0	0	0
5	1.0000E-00	138	259	551	965	1000	944	621	487	0	0	0	0	0	0	0
6	1.0000E-00	-42	78	318	834	944	1000	553	381	0	0	0	0	0	0	0
7	1.0000E-00	788	845	837	715	621	553	1000	871	0	0	0	0	0	0	0
8	1.0000E-00	778	819	807	609	487	381	871	1000	460	368	82	0	0	0	0

9	1.0000E-00	0	0	0	0	0	0	0	460	1000	870	202	0	0	0	0
10	1.0000E-00	0	0	0	0	0	0	0	368	870	1000	264	0	0	0	0
11	1.0000E-00	0	0	0	0	0	0	0	82	202	264	1000	1	8	4	3
12	1.0000E-00	0	0	0	0	0	0	0	0	0	0	1	1000	11	7	7
13	1.0000E-00	0	0	0	0	0	0	0	0	0	0	8	11	1000	996	995
14	1.0000E-00	0	0	0	0	0	0	0	0	0	0	4	7	996	1000	1000
15	5.0000E-01	0	0	0	0	0	0	0	0	0	0	3	7	995	1000	1000

242Cm(n,gamma)

group	rel.s.d.															
1	5.2782E-01	1000	898	696	187	93	-43	-218	-342	0	0	0	0	0	0	0
2	2.0000E-00	898	1000	891	398	300	148	-59	-212	0	0	0	0	0	0	0
3	2.0000E-00	696	891	1000	767	696	574	392	243	0	0	0	0	0	0	0
4	2.0000E-00	187	398	767	1000	994	965	890	807	0	0	0	0	0	0	0
5	2.0000E-00	93	300	696	994	1000	988	933	864	0	0	0	0	0	0	0
6	2.0000E-00	-43	148	574	965	988	1000	978	932	0	0	0	0	0	0	0
7	2.0000E-00	-218	-59	392	890	933	978	1000	986	0	0	0	0	0	0	0
8	2.0000E-00	-342	-212	243	807	864	932	986	1000	59	56	12	0	0	0	0
9	2.0000E-00	0	0	0	0	0	0	0	59	1000	960	206	0	0	0	0
10	2.0000E-00	0	0	0	0	0	0	0	56	960	1000	230	0	0	0	0
11	2.0000E-00	0	0	0	0	0	0	0	12	206	230	1000	3	11	5	5
12	2.0000E-00	0	0	0	0	0	0	0	0	0	0	3	1000	29	21	20
13	2.0000E-00	0	0	0	0	0	0	0	0	0	0	11	29	1000	996	995
14	2.0000E-00	0	0	0	0	0	0	0	0	0	0	5	21	996	1000	1000
15	2.0000E-00	0	0	0	0	0	0	0	0	0	0	5	20	995	1000	1000

243Cm(n,el)

group	rel.s.d.															
1	3.0000E-02	1000	976	19	536	589	281	47	0	0	0	0	0	0	0	0
2	3.0000E-02	976	1000	135	636	686	391	139	0	0	0	0	0	0	0	0
3	3.0000E-02	19	135	1000	846	808	941	806	0	0	0	0	0	0	0	0
4	3.0000E-02	536	636	846	1000	998	953	714	0	0	0	0	0	0	0	0
5	3.0000E-02	589	686	808	998	1000	934	686	0	0	0	0	0	0	0	0
6	3.0000E-02	281	391	941	953	934	1000	807	0	0	0	0	0	0	0	0
7	3.0000E-02	47	139	806	714	686	807	1000	558	558	557	545	0	0	0	0
8	3.0000E-02	0	0	0	0	0	0	558	1000	1000	999	976	0	0	0	0
9	3.0000E-02	0	0	0	0	0	0	558	1000	1000	1000	976	0	0	0	0
10	3.0000E-02	0	0	0	0	0	0	557	999	1000	1000	976	0	0	0	0
11	1.5540E-01	0	0	0	0	0	0	545	976	976	976	1000	216	214	215	214
12	1.8809E-01	0	0	0	0	0	0	0	0	0	0	216	1000	988	989	984
13	1.9530E-01	0	0	0	0	0	0	0	0	0	0	214	988	1000	973	970
14	2.4913E-01	0	0	0	0	0	0	0	0	0	0	215	989	973	1000	998
15	2.3411E-01	0	0	0	0	0	0	0	0	0	0	214	984	970	998	1000

243Cm(n,n')

group	rel.s.d.							
1	1.5000E-01	1000	478	-488	-672	-695	-589	-510
2	2.0000E-01	478	1000	208	143	107	87	50
3	1.5000E-01	-488	208	1000	896	711	454	249
4	3.0000E-01	-672	143	896	1000	938	742	578
5	3.0000E-01	-695	107	711	938	1000	922	821
6	5.0000E-01	-589	87	454	742	922	1000	975
7	5.0000E-01	-510	50	249	578	821	975	1000

243Cm(n,2n)

group	rel.s.d.		
1	5.2753E-01	1000	948
2	3.6532E-01	948	1000

243Cm(n,f)

group	rel.s.d.															
1	1.0000E-01	1000	756	633	64	64	64	62	0	0	0	0	0	0	0	0
2	1.0000E-01	756	1000	967	663	663	663	652	0	0	0	0	0	0	0	0
3	1.0000E-01	633	967	1000	723	723	723	711	0	0	0	0	0	0	0	0
4	1.0000E-01	64	663	723	1000	1000	1000	983	0	0	0	0	0	0	0	0
5	2.0000E-01	64	663	723	1000	1000	1000	983	0	0	0	0	0	0	0	0
6	1.0000E-01	64	663	723	1000	1000	1000	983	0	0	0	0	0	0	0	0
7	1.0000E-01	62	652	711	983	983	983	1000	184	184	184	181	0	0	0	0
8	1.2387E-01	0	0	0	0	0	0	184	1000	1000	1000	988	0	0	0	0
9	1.2206E-01	0	0	0	0	0	0	184	1000	1000	1000	988	0	0	0	0
10	1.2188E-01	0	0	0	0	0	0	184	1000	1000	1000	988	0	0	0	0
11	8.0417E-02	0	0	0	0	0	0	181	988	988	988	1000	2	0	0	1
12	3.3438E-02	0	0	0	0	0	0	0	0	0	0	2	1000	59	33	72
13	6.4408E-02	0	0	0	0	0	0	0	0	0	0	0	59	1000	168	349
14	1.9522E-01	0	0	0	0	0	0	0	0	0	0	0	33	168	1000	855
15	1.0526E-01	0	0	0	0	0	0	0	0	0	0	1	72	349	855	1000

243Cm(n,gamma)

group	rel.s.d.															
1	7.7568E-01	1000	979	-37	-158	507	5	-330	0	0	0	0	0	0	0	0
2	4.4117E-01	979	1000	-87	-204	509	-30	-381	0	0	0	0	0	0	0	0
3	1.7742E-01	-37	-87	1000	986	763	987	862	0	0	0	0	0	0	0	0
4	3.1194E-01	-158	-204	986	1000	714	983	889	0	0	0	0	0	0	0	0

5	2.9719E-01	507	509	763	714	1000	828	483	0	0	0	0	0	0	0	0
6	2.3358E-01	5	-30	987	983	828	1000	836	0	0	0	0	0	0	0	0
7	1.8181E-01	-330	-381	862	889	483	836	1000	402	402	401	399	0	0	0	0
8	1.7967E-01	0	0	0	0	0	0	402	1000	999	997	992	0	0	0	0
9	1.8375E-01	0	0	0	0	0	0	402	999	1000	999	996	0	0	0	0
10	1.8701E-01	0	0	0	0	0	0	401	997	999	1000	998	0	0	0	0
11	1.4520E-01	0	0	0	0	0	0	399	992	996	998	1000	1	0	0	0
12	5.1162E-02	0	0	0	0	0	0	0	0	0	0	1	1000	51	18	15
13	7.9878E-02	0	0	0	0	0	0	0	0	0	0	0	51	1000	136	101
14	1.5497E-01	0	0	0	0	0	0	0	0	0	0	0	18	136	1000	708
15	1.6379E-01	0	0	0	0	0	0	0	0	0	0	0	15	101	708	1000

244Cm(n,el)

group	rel.s.d.															
1	3.0000E-02	1000	488	569	274	322	234	65	0	0	0	0	0	0	0	0
2	3.00000-02	488	1000	852	87	198	44	-224	0	0	0	0	0	0	0	0
3	5.0000E-02	569	852	1000	594	680	551	213	0	0	0	0	0	0	0	0
4	1.0000E-01	274	87	594	1000	993	988	750	0	0	0	0	0	0	0	0
5	1.0000E-01	322	198	680	993	1000	971	716	0	0	0	0	0	0	0	0
6	1.0000E-01	234	44	551	988	971	1000	739	0	0	0	0	0	0	0	0
7	9.2095E-02	65	-224	213	750	716	739	1000	586	586	572	0	0	0	0	0
8	1.4933E-01	0	0	0	0	0	0	586	1000	999	976	0	0	0	0	0
9	1.4039E-01	0	0	0	0	0	0	586	999	1000	975	0	0	0	0	0
10	7.7188E-02	0	0	0	0	0	0	572	976	975	1000	136	17	160	160	160
11	3.6106E-02	0	0	0	0	0	0	0	0	0	136	1000	77	706	706	706
12	7.7538E-02	0	0	0	0	0	0	0	0	0	17	77	1000	5	26	28
13	6.6248E-02	0	0	0	0	0	0	0	0	0	160	706	5	1000	999	999
14	6.1634E-02	0	0	0	0	0	0	0	0	0	160	706	26	999	1000	1000
15	6.1192E-02	0	0	0	0	0	0	0	0	0	160	706	28	999	1000	1000

244Cm(n,n')

group	rel.s.d.							
1	5.0000E-01	1000	-562	-570	-282	-50	37	-66
2	3.0000E-01	-562	1000	859	412	43	-138	42
3	2.0000E-01	-570	859	1000	737	241	29	132
4	3.0000E-01	-282	412	737	1000	788	642	656
5	2.9094E-01	-50	43	241	788	1000	976	973
6	6.3307E-01	37	-138	29	642	976	1000	978
7	5.9718E-01	-66	42	132	656	973	978	1000

244Cm(n,2n)

group rel.s.d. ----

group	rel.s.d.	
1	3.0000E-01	1000

244Cm(n,f)

group	rel.s.d.															
1	2.0000E-01	1000	752	628	58	58	58	55	0	0	0	0	0	0	0	0
2	2.0000E-01	752	1000	967	663	663	663	633	0	0	0	0	0	0	0	0
3	2.0000E-01	628	967	1000	725	725	725	693	0	0	0	0	0	0	0	0
4	1.0000E-01	58	663	725	1000	1000	1000	955	0	0	0	0	0	0	0	0
5	1.0000E-01	58	663	725	1000	1000	1000	955	0	0	0	0	0	0	0	0
6	1.0000E-01	58	663	725	1000	1000	1000	955	0	0	0	0	0	0	0	0
7	1.0000E-01	55	633	693	955	955	955	1000	298	297	222	0	0	0	0	0
8	1.0000E-01	0	0	0	0	0	0	298	1000	997	745	0	0	0	0	0
9	1.00000-01	0	0	0	0	0	0	297	997	1000	767	0	0	0	0	0
10	1.0000E-01	0	0	0	0	0	0	222	745	767	1000	-162	0	0	0	0
11	5.7020E-02	0	0	0	0	0	0	0	0	0	-162	1000	13	9	5	5
12	1.7085E-01	0	0	0	0	0	0	0	0	0	0	13	1000	42	20	18
13	2.1993E-01	0	0	0	0	0	0	0	0	0	0	9	42	1000	997	996
14	2.6401E-01	0	0	0	0	0	0	0	0	0	0	5	20	997	1000	1000
15	2.7178E-01	0	0	0	0	0	0	0	0	0	0	5	18	996	1000	1000

244Cm(n,gamma)

group	rel.s.d.															
1	8.9189E-01	1000	928	832	247	112	-142	-169	0	0	0	0	0	0	0	0
2	1.5000E-00	928	1000	967	470	331	57	-22	0	0	0	0	0	0	0	0
3	3.0000E-00	832	967	1000	647	483	229	130	0	0	0	0	0	0	0	0
4	2.0000E-00	247	470	647	1000	946	870	732	0	0	0	0	0	0	0	0
5	2.5000E-01	112	331	483	946	1000	959	804	0	0	0	0	0	0	0	0
6	2.5000E-01	-142	57	229	870	959	1000	864	0	0	0	0	0	0	0	0
7	2.5000E-01	-169	-22	130	732	804	864	1000	482	481	340	0	0	0	0	0
8	1.0000E-00	0	0	0	0	0	0	482	1000	999	705	0	0	0	0	0
9	1.0000E-00	0	0	0	0	0	0	481	999	1000	711	0	0	0	0	0
10	1.0000E-00	0	0	0	0	0	0	340	705	711	1000	-366	0	0	0	0
11	4.6026E-02	0	0	0	0	0	0	0	0	0	-366	1000	1	4	5	5
12	6.6427E-02	0	0	0	0	0	0	0	0	0	0	1	1000	821	639	590
13	1.1793E-01	0	0	0	0	0	0	0	0	0	0	4	821	1000	903	862
14	1.2159E-01	0	0	0	0	0	0	0	0	0	0	5	639	903	1000	996
15	1.2506E-01	0	0	0	0	0	0	0	0	0	0	5	590	862	996	1000

245Cm(n,el)

group	rel.s.d.															
1	3.0000E-02	1000	898	246	715	457	214	33	0	0	0	0	0	0	0	0
2	3.0000E-02	898	1000	541	903	690	479	128	0	0	0	0	0	0	0	0

3	3.0000E-02	246	541	1000	790	864	902	312	0	0	0	0	0	0	0	0
4	3.0000E-02	715	903	790	1000	933	808	258	0	0	0	0	0	0	0	0
5	3.0000E-02	457	690	864	933	1000	961	327	0	0	0	0	0	0	0	0
6	3.0000E-02	214	479	902	808	961	1000	353	0	0	0	0	0	0	0	0
7	3.0000E-02	33	128	312	258	327	353	1000	934	934	933	911	0	0	0	0
8	3.0000E-02	0	0	0	0	0	0	934	1000	1000	999	975	0	0	0	0
9	3.0000E-02	0	0	0	0	0	0	934	1000	1000	1000	976	0	0	0	0
10	3.0000E-02	0	0	0	0	0	0	933	999	1000	1000	977	0	0	0	0
11	5.0000E-02	0	0	0	0	0	0	911	975	976	977	1000	213	213	213	213
12	2.0251E-01	0	0	0	0	0	0	0	0	0	0	213	1000	999	999	999
13	2.1778E-01	0	0	0	0	0	0	0	0	0	0	213	999	1000	999	999
14	2.0779E-01	0	0	0	0	0	0	0	0	0	0	213	999	999	1000	1000
15	1.9438E-01	0	0	0	0	0	0	0	0	0	0	213	999	999	1000	1000

245Cm(n,n')

group	rel.s.d.							
1	1.5000E-01	1000	-853	-603	-711	-402	-304	-271
2	2.0000E-01	-853	1000	509	721	528	464	449
3	1.5000E-01	-603	509	1000	861	362	121	-44
4	3.0000E-01	-711	721	861	1000	762	590	460
5	3.0000E-01	-402	528	362	762	1000	968	905
6	5.0000E-01	-304	464	121	590	968	1000	982
7	5.0000E-01	-271	449	-44	460	905	982	1000

245Cm(n,2n)

group	rel.s.d.		
1	2.2433E-01	1000	165
2	9.3532E-01	165	1000

245Cm(n,f)

group	rel.s.d.															
1	1.8111E-01	1000	748	634	58	58	58	57	0	0	0	0	0	0	0	0
2	3.0961E-01	748	1000	971	666	666	666	652	0	0	0	0	0	0	0	0
3	4.4171E-01	634	971	1000	720	720	720	706	0	0	0	0	0	0	0	0
4	4.9428E-01	58	666	720	1000	1000	1000	980	0	0	0	0	0	0	0	0
5	3.7220E-01	58	666	720	1000	1000	1000	980	0	0	0	0	0	0	0	0
6	4.7447E-01	58	666	720	1000	1000	1000	980	0	0	0	0	0	0	0	0
7	2.6531E-01	57	652	706	980	980	980	1000	198	198	198	191	0	0	0	0
8	1.3474E-01	0	0	0	0	0	0	198	1000	1000	1000	965	0	0	0	0

9	1.3177E-01	0	0	0	0	0	0	198	1000	1000	1000	965	0	0	0	0
10	1.3026E-01	0	0	0	0	0	0	198	1000	1000	1000	965	0	0	0	0
11	8.6603E-02	0	0	0	0	0	0	191	965	965	965	1000	5	1	1	1
12	3.8941E-02	0	0	0	0	0	0	0	0	0	0	5	1000	29	17	12
13	6.2109E-02	0	0	0	0	0	0	0	0	0	0	1	29	1000	321	164
14	5.1220E-02	0	0	0	0	0	0	0	0	0	0	1	17	321	1000	773
15	3.8175E-02	0	0	0	0	0	0	0	0	0	0	1	12	164	773	1000

245Cm(n,gamma)

group	rel.s.d.															
1	7.1207E-01	1000	622	485	371	361	359	128	0	0	0	0	0	0	0	0
2	3.6169E-01	622	1000	955	877	863	858	308	0	0	0	0	0	0	0	0
3	2.9122E-01	485	955	1000	980	965	960	345	0	0	0	0	0	0	0	0
4	2.4824E-01	371	877	980	1000	988	983	354	0	0	0	0	0	0	0	0
5	1.9317E-01	361	863	965	988	1000	999	366	0	0	0	0	0	0	0	0
6	1.7559E-01	359	858	960	983	999	1000	367	0	0	0	0	0	0	0	0
7	1.0498E-01	128	308	345	354	366	367	1000	929	929	928	922	0	0	0	0
8	1.2886E-01	0	0	0	0	0	0	929	1000	1000	999	993	0	0	0	0
9	1.2486E-01	0	0	0	0	0	0	929	1000	1000	1000	994	0	0	0	0
10	1.2317E-01	0	0	0	0	0	0	928	999	1000	1000	994	0	0	0	0
11	9.6045E-02	0	0	0	0	0	0	922	993	994	994	1000	1	0	0	0
12	7.8749E-02	0	0	0	0	0	0	0	0	0	0	1	1000	57	24	10
13	1.1787E-01	0	0	0	0	0	0	0	0	0	0	0	57	1000	136	72
14	7.4618E-02	0	0	0	0	0	0	0	0	0	0	0	24	136	1000	966
15	8.3869E-02	0	0	0	0	0	0	0	0	0	0	0	10	72	966	1000

Apendix B

In the following, numerical tables for the relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar borrowed from [1, 2] are given in a 15-group representation

1	19.6 E+06	6.07 E+06
2	6.07 E+06	2.23 E+06
3	2.23 E+06	1.35 E+06
4	1.35 E+06	4.98 E+05
5	4.98 E+05	1.83 E+05
6	1.83 E+05	6.74 E+04
7	6.74 E+04	2.48 E+04
8	2.48 E+04	9.12 E+03
9	9.12 E+03	2.04 E+03
10	2.04 E+03	4.54 E+02
11	4.54 E+02	2.26 E+01
12	2.26 E+01	4.00 E+00
13	4.00 E+00	5.40 E-01
14	5.40 E-01	1.00 E-01
15	1.00 E-01	1.00 E-05

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 232Th
no-diagonal terms are those of 238U

group	rel.s.d.															
1	3.0000E-02	1000	411	349	308	308	308	308	308	308	308	308	308	308	308	308
2	5.0000E-02	411	1000	923	278	278	278	278	278	278	278	278	278	278	278	278
3	0.6402E-02	349	923	1000	550	550	550	550	550	550	550	550	550	550	550	550
4	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
5	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
6	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
7	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
8	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
9	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
10	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
11	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
12	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
13	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
14	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
15	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 233U

group	rel.s.d.															
1	8.4211E-03	1000	37	38	55	62	61	68	62	68	43	28	32	35	35	33
2	2.5122E-03	37	1000	385	268	232	213	229	206	225	139	122	187	204	204	193
3	2.2163E-03	38	385	1000	347	309	267	278	246	270	166	160	261	284	284	269
4	1.7977E-03	55	268	347	1000	445	390	415	369	404	254	210	299	324	324	307
5	1.8181E-03	62	232	309	445	1000	465	457	412	451	282	212	280	305	305	289
6	1.9268E-03	61	213	267	390	465	1000	615	417	457	280	192	247	268	268	254
7	1.8345E-03	68	229	278	415	457	615	1000	956	722	313	206	252	274	274	259
8	2.0560E-03	62	206	246	369	412	417	956	1000	715	287	185	221	240	240	227
9	1.8495E-03	68	225	270	404	451	457	722	715	1000	580	202	243	264	264	250
10	3.0187E-03	43	139	166	254	282	280	313	287	580	1000	820	145	158	158	149
11	2.4814E-03	28	122	160	210	212	192	206	185	202	820	1000	443	415	415	401

12	1.3557E-03	32	187	261	299	280	247	252	221	243	145	443	1000	919	919	891
13	1.2690E-03	35	204	284	324	305	268	274	240	264	158	415	919	1000	1000	946
14	1.2690E-03	35	204	284	324	305	268	274	240	264	158	415	919	1000	1000	946
15	1.3294E-03	33	193	269	307	289	254	259	227	250	149	401	891	946	946	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 235U

group	rel.s.d.															
1	6.8355E-03	1000	132	80	74	67	50	41	35	54	51	23	0	0	0	0
2	2.0161E-03	132	1000	429	360	368	279	230	195	298	284	131	0	0	0	0
3	2.5371E-03	80	429	1000	419	353	250	204	171	268	254	117	0	0	0	0
4	2.0122E-03	74	360	419	1000	550	347	287	246	369	359	175	0	0	0	0
5	1.7967E-03	67	368	353	550	1000	492	358	304	465	445	208	0	0	0	0
6	2.3035E-03	50	279	250	347	492	1000	319	268	385	370	164	0	0	0	0
7	2.7486E-03	41	230	204	287	358	319	1000	235	325	319	152	0	0	0	0
8	3.2002E-03	35	195	171	246	304	268	235	1000	293	275	121	0	0	0	0
9	2.1589E-03	54	298	268	369	465	385	325	293	1000	435	186	0	0	0	0
10	2.2034E-03	51	284	254	359	445	370	319	275	435	1000	359	0	0	0	0
11	4.1079E-03	23	131	117	175	208	164	152	121	186	359	1000	58	53	53	53
12	3.1620E-03	0	0	0	0	0	0	0	0	0	0	58	1000	916	916	916
13	3.1200E-03	0	0	0	0	0	0	0	0	0	0	53	916	1000	1000	1000
14	3.1200E-03	0	0	0	0	0	0	0	0	0	0	53	916	1000	1000	1000
15	3.1200E-03	0	0	0	0	0	0	0	0	0	0	53	916	1000	1000	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 234U
no-diagonal terms are those of 238U

group	rel.s.d.															
1	3.0000E-02	1000	411	349	308	308	308	308	308	308	308	308	308	308	308	308
2	3.0000E-02	411	1000	923	278	278	278	278	278	278	278	278	278	278	278	278
3	3.0000E-03	349	923	1000	550	550	550	550	550	550	550	550	550	550	550	550
4	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
5	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
6	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
7	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
8	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
9	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
10	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
11	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
12	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
13	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
14	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
15	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 236U
no-diagonal terms are those of 238U

group	rel.s.d.															
1	3.0000E-02	1000	411	349	308	308	308	308	308	308	308	308	308	308	308	308
2	3.0000E-02	411	1000	923	278	278	278	278	278	278	278	278	278	278	278	278
3	3.0000E-02	349	923	1000	550	550	550	550	550	550	550	550	550	550	550	550
4	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
5	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
6	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
7	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
8	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
9	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

10	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
11	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
12	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
13	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
14	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
15	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 238U

group	rel.s.d.															
1	9.1066E-03	1000	411	349	308	308	308	308	308	308	308	308	308	308	308	308
2	6.1098E-03	411	1000	923	278	278	278	278	278	278	278	278	278	278	278	278
3	6.4020E-03	349	923	1000	550	550	550	550	550	550	550	550	550	550	550	550
4	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
5	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
6	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
7	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
8	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
9	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
10	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
11	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
12	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
13	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
14	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
15	1.7627E-02	308	278	550	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 237Np

group	rel.s.d.															
1	3.0000E-02	1000	132	27	0	0	0	0	0	0	0	0	0	0	0	0
2	3.0000E-02	132	1000	511	197	71	71	71	71	71	71	71	71	71	71	71
3	1.4704E-02	27	511	1000	605	76	76	76	76	76	76	76	76	76	76	76
4	6.6175E-03	0	197	605	1000	818	818	818	818	818	818	818	818	818	818	818
5	6.0000E-03	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
6	6.0000E-03	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
7	6.0000E-03	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
8	6.0000E-03	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
9	6.0000E-03	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
10	6.0000E-03	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
11	6.0000E-03	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
12	6.0000E-03	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
13	6.0000E-03	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
14	6.0000E-03	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
15	6.0000E-03	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 238Pu

group	rel.s.d.															
1	5.0000E-02	1000	672	138	0	0	0	0	0	0	0	0	0	0	0	0
2	3.0000E-02	672	1000	625	390	303	303	303	303	303	303	303	303	303	303	303
3	3.0000E-02	138	625	1000	508	309	309	309	309	309	309	309	309	309	309	309
4	3.0000E-02	0	390	508	1000	975	975	975	975	975	975	975	975	975	975	975
5	3.0000E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
6	3.0000E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
7	3.0000E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
8	3.0000E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
9	3.0000E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

10	3.0000E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
11	3.0000E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
12	3.0000E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
13	3.0000E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
14	3.0000E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
15	3.0000E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 239Pu

group	rel.s.d.															
1	2.1524E-03	1000	740	513	334	217	217	79	26	26	26	21	25	21	35	35
2	1.7031E-03	740	1000	914	588	382	382	134	41	41	41	34	42	35	58	59
3	1.7340E-03	513	914	1000	640	415	415	143	42	42	42	36	45	37	61	63
4	1.7900E-03	334	588	640	1000	550	550	185	51	51	52	29	36	29	48	49
5	2.2400E-03	217	382	415	550	1000	1000	303	58	58	58	18	22	18	31	31
6	2.2400E-03	217	382	415	550	1000	1000	303	58	58	58	18	22	18	31	31
7	3.0540E-03	79	134	143	185	303	303	1000	969	969	969	6	8	6	11	11
8	4.3980E-03	26	41	42	51	58	58	969	1000	1000	1000	2	2	2	3	3
9	4.3980E-03	26	41	42	51	58	58	969	1000	1000	1000	2	2	2	3	3
10	4.3509E-03	26	41	42	52	58	58	969	1000	1000	1000	6	5	4	5	5
11	1.5633E-03	21	34	36	29	18	18	6	2	2	6	1000	730	447	521	485
12	1.3122E-03	25	42	45	36	22	22	8	2	2	5	730	1000	585	640	595
13	1.2082E-03	21	35	37	29	18	18	6	2	2	4	447	585	1000	531	492
14	9.1368E-04	35	58	61	48	31	31	11	3	3	5	521	640	531	1000	819
15	8.5168E-04	35	59	63	49	31	31	11	3	3	5	485	595	492	819	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 240Pu

group	rel.s.d.															
1	1.0857E-02	1000	672	138	0	0	0	0	0	0	0	0	0	0	0	0
2	2.6479E-02	672	1000	625	390	303	303	303	303	303	303	303	303	303	303	303
3	2.6926E-02	138	625	1000	508	309	309	309	309	309	309	309	309	309	309	309
4	3.7373E-02	0	390	508	1000	975	975	975	975	975	975	975	975	975	975	975
5	4.8100E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
6	4.8100E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
7	4.8100E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
8	4.8100E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
9	4.8100E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
10	4.8100E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
11	4.8100E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
12	4.8100E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
13	4.8100E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
14	4.8100E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
15	4.8100E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 241Pu

group	rel.s.d.															
1	4.4976E-03	1000	581	531	358	288	288	288	288	288	288	288	288	288	288	288
2	2.7245E-03	581	1000	998	968	946	946	946	946	946	946	946	946	946	946	946
3	2.7345E-03	531	998	1000	981	964	964	964	964	964	964	964	964	964	964	964
4	2.8414E-03	358	968	981	1000	997	997	997	997	997	997	997	997	997	996	996
5	2.9154E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
6	2.9154E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
7	2.9154E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
8	2.9154E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
9	2.9154E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999

10	2.9154E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
11	2.9154E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
12	2.9154E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
13	2.9146E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
14	2.9154E-03	288	946	964	996	999	999	999	999	999	999	999	999	1000	1000	1000
15	2.9154E-03	288	946	964	996	999	999	999	999	999	999	999	999	1000	1000	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 242Pu

group	rel.s.d.															
1	1.0000E-01	1000	672	138	0	0	0	0	0	0	0	0	0	0	0	0
2	3.0000E-02	672	1000	625	390	303	303	303	303	303	303	303	303	303	303	303
3	2.2439E-02	138	625	1000	508	309	309	309	309	309	309	309	309	309	309	309
4	3.1144E-02	0	390	508	1000	975	975	975	975	975	975	975	975	975	975	975
5	4.0083E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
6	4.0083E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
7	4.0083E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
8	4.0083E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
9	4.0083E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
10	4.0083E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
11	4.0083E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
12	4.0083E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
13	4.0083E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
14	4.0083E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
15	4.0083E-02	0	303	309	975	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 241Am

group	rel.s.d.															
1	3.0000E-02	1000	132	27	0	0	0	0	0	0	0	0	0	0	0	0
2	3.0000E-02	132	1000	511	197	71	71	71	71	71	71	71	71	71	71	71
3	3.0000E-02	27	511	1000	605	76	76	76	76	76	76	76	76	76	76	76
4	3.0000E-03	0	197	605	1000	818	818	818	818	818	818	818	818	818	818	818
5	3.0000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
6	3.0000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
7	3.0000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
8	3.0000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
9	3.0000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
10	3.0000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
11	3.0000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
12	3.0000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
13	3.0000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
14	3.0000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
15	3.0000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 242mAm

group	rel.s.d.															
1	1.0428E-01	1000	581	531	358	288	288	288	288	288	288	288	288	288	288	288
2	9.1295E-03	581	1000	998	968	946	946	946	946	946	946	946	946	946	946	946
3	6.6162E-03	531	998	1000	981	964	964	964	964	964	964	964	964	964	964	964
4	6.8430E-03	358	968	981	1000	997	997	997	997	997	997	997	997	997	996	996
5	6.9995E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
6	6.9995E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
7	6.9995E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
8	6.9995E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
9	6.9995E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999

10	6.9995E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
11	6.9995E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
12	6.9995E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
13	6.9965E-03	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
14	6.9995E-03	288	946	964	996	999	999	999	999	999	999	999	999	1000	1000	1000
15	6.9995E-03	288	946	964	996	999	999	999	999	999	999	999	999	1000	1000	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 243Am

group	rel.s.d.															
1	1.8823E-02	1000	132	27	0	0	0	0	0	0	0	0	0	0	0	0
2	1.9772E-02	132	1000	511	197	71	71	71	71	71	71	71	71	71	71	71
3	1.9067E-02	27	511	1000	605	76	76	76	76	76	76	76	76	76	76	76
4	1.0880E-02	0	197	605	1000	818	818	818	818	818	818	818	818	818	818	818
5	1.2000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
6	1.2000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
7	1.2000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
8	1.2000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
9	1.2000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
10	1.2000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
11	1.2000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
12	1.2000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
13	1.2000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
14	1.2000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
15	1.2000E-02	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 242Cm

group	rel.s.d.															
1	1.1000E-01	1000	132	27	0	0	0	0	0	0	0	0	0	0	0	0
2	1.1500E-01	132	1000	511	197	71	71	71	71	71	71	71	71	71	71	71
3	1.1000E-01	27	511	1000	605	76	76	76	76	76	76	76	76	76	76	76
4	1.0000E-01	0	197	605	1000	818	818	818	818	818	818	818	818	818	818	818
5	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
6	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
7	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
8	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
9	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
10	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
11	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
12	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
13	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
14	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
15	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 243Cm

group	rel.s.d.															
1	9.6361E-02	1000	581	531	358	288	288	288	288	288	288	288	288	288	288	288
2	1.4075E-02	581	1000	998	968	946	946	946	946	946	946	946	946	946	946	946
3	1.2378E-02	531	998	1000	981	964	964	964	964	964	964	964	964	964	964	964
4	1.2802E-02	358	968	981	1000	997	997	997	997	997	997	997	997	997	996	996
5	1.3095E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
6	1.3095E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
7	1.3095E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
8	1.3095E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
9	1.3095E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999

10	1.3095E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
11	1.3095E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
12	1.3095E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
13	1.3089E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
14	1.3095E-02	288	946	964	996	999	999	999	999	999	999	999	999	1000	1000	1000
15	1.3095E-02	288	946	964	996	999	999	999	999	999	999	999	999	1000	1000	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 244Cm

group	rel.s.d.															
1	1.1000E-01	1000	132	27	0	0	0	0	0	0	0	0	0	0	0	0
2	1.2000E-01	132	1000	511	197	71	71	71	71	71	71	71	71	71	71	71
3	1.0000E-01	27	511	1000	605	76	76	76	76	76	76	76	76	76	76	76
4	1.0000E-01	0	197	605	1000	818	818	818	818	818	818	818	818	818	818	818
5	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
6	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
7	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
8	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
9	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
10	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
11	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
12	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
13	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
14	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
15	1.0000E-01	0	71	76	818	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

Relative uncertainty (relative standard deviation) and correlation (normalized to 1000) for nu-bar for 245Cm

group	rel.s.d.															
1	9.6361E-02	1000	581	531	358	288	288	288	288	288	288	288	288	288	288	288
2	2.9088E-02	581	1000	998	968	946	946	946	946	946	946	946	946	946	946	946
3	2.8496E-02	531	998	1000	981	964	964	964	964	964	964	964	964	964	964	964
4	2.9473E-02	358	968	981	1000	997	997	997	997	997	997	997	997	997	996	996
5	3.0147E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
6	3.0147E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
7	3.0147E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
8	3.0147E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
9	3.0147E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
10	3.0147E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
11	3.0147E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
12	3.0147E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	999	999
13	3.0134E-02	288	946	964	997	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
14	3.0147E-02	288	946	964	996	999	999	999	999	999	999	999	999	1000	1000	1000
15	3.0147E-02	288	946	964	996	999	999	999	999	999	999	999	999	1000	1000	1000