Comment to unresolved resonance data in JENDL-3.3

Japan Atomic Energy Research Institute

Chikara KONNO and Yujiro IKEDA

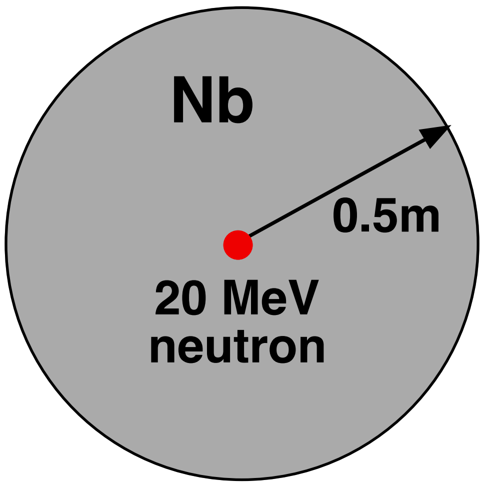
Background - (1)

- ❑ **JENDL (JENDL-3.1 ~ JENDL-3.3) tends to use unresolved resonance data more than other evaluated nuclear data libraries.**
  - Not only heavy nuclei such as uranium, but also fission products such as niobium in JENDL include unresolved resonance data.

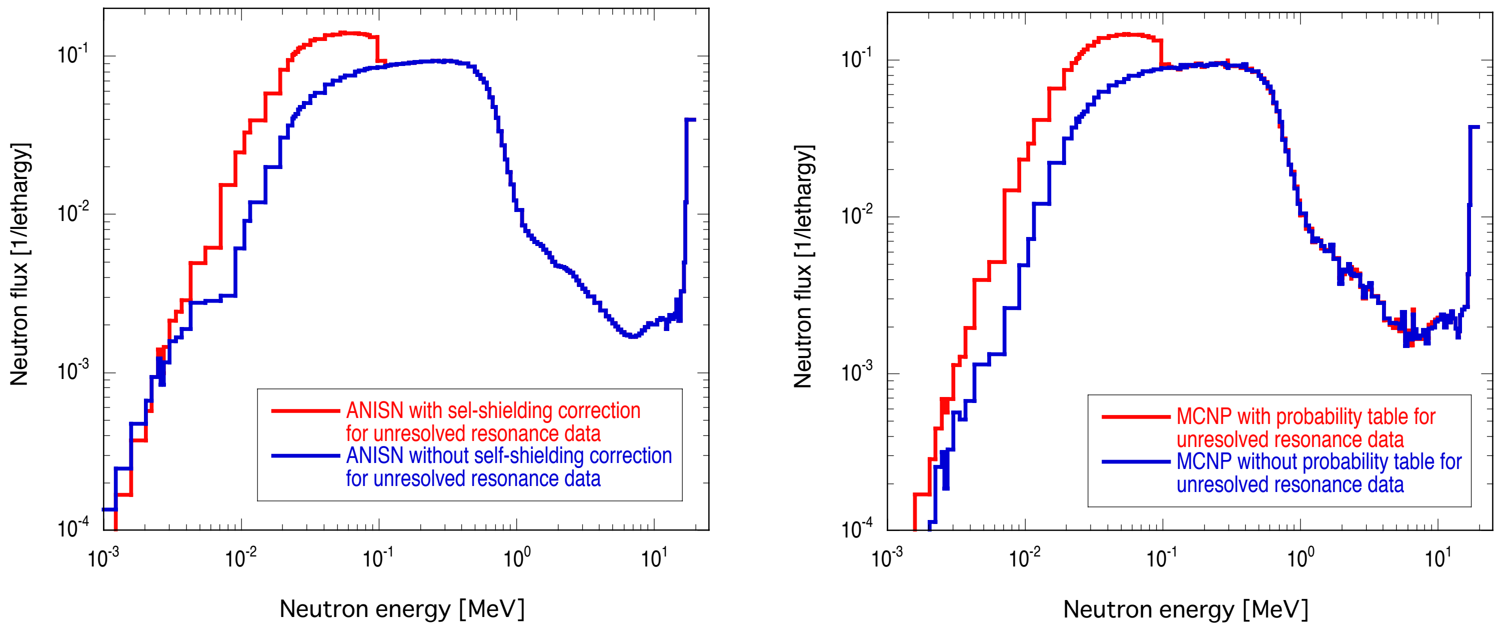
- ❑ **These unresolved resonance data were not often used in neutronics calculations so far, but they will be later.**
  - The NJOY code can make
    ACE libraries with unresolved resonance data and
    multigroup libraries with self-shielding correction for unresolved resonance data.
  - The MCNP4C code can use ACE libraries with unresolved resonances.
  - The Sn codes such as ANISN can use multigroup libraries with self-shielding correction for unresolved resonance data.

Background - (2)

- In ND2001, we pointed out that the leakage neutron spectrum from a natural niobium sphere with a 20 MeV neutron in the center, which was calculated with ANISN, MCNP and JENDL-3.3, had a **large bump around 100 keV**.



Calculation model



Calculated leakage neutron spectra

- **Unresolved resonance data** cause the large bump around 100 keV.

It seems that the large bump is strange.

Objectives

It is considered that the unresolved resonance data in Nb-93 have some problems.

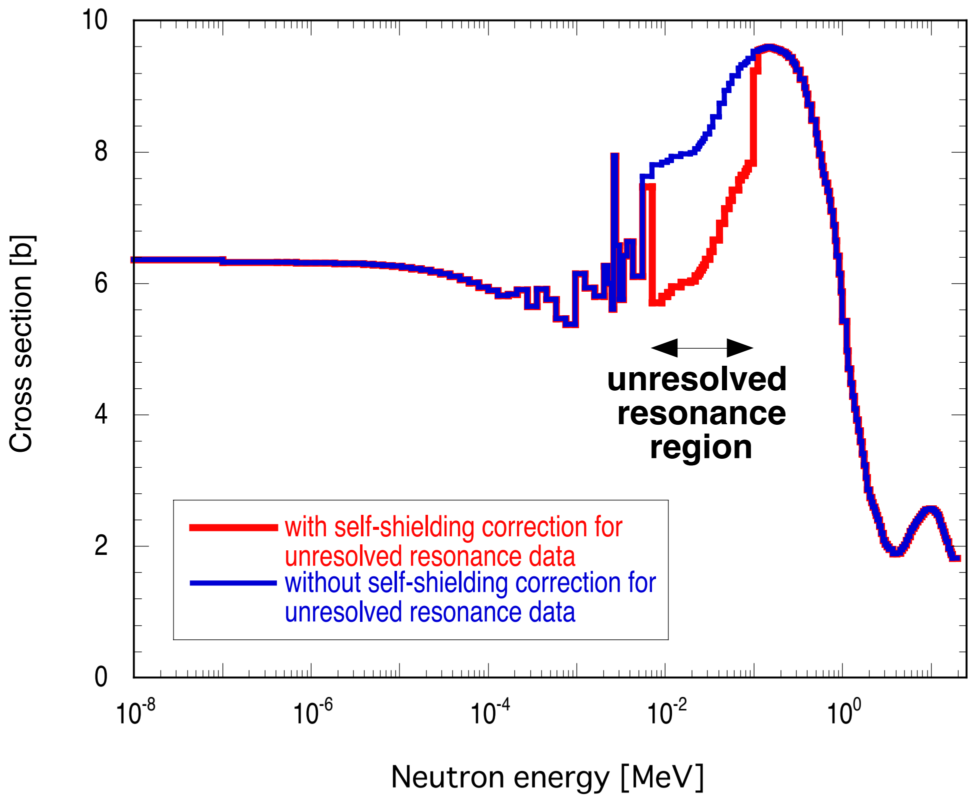
What problems?

How about other nuclei with unresolved resonance data in JENDL-3.3?

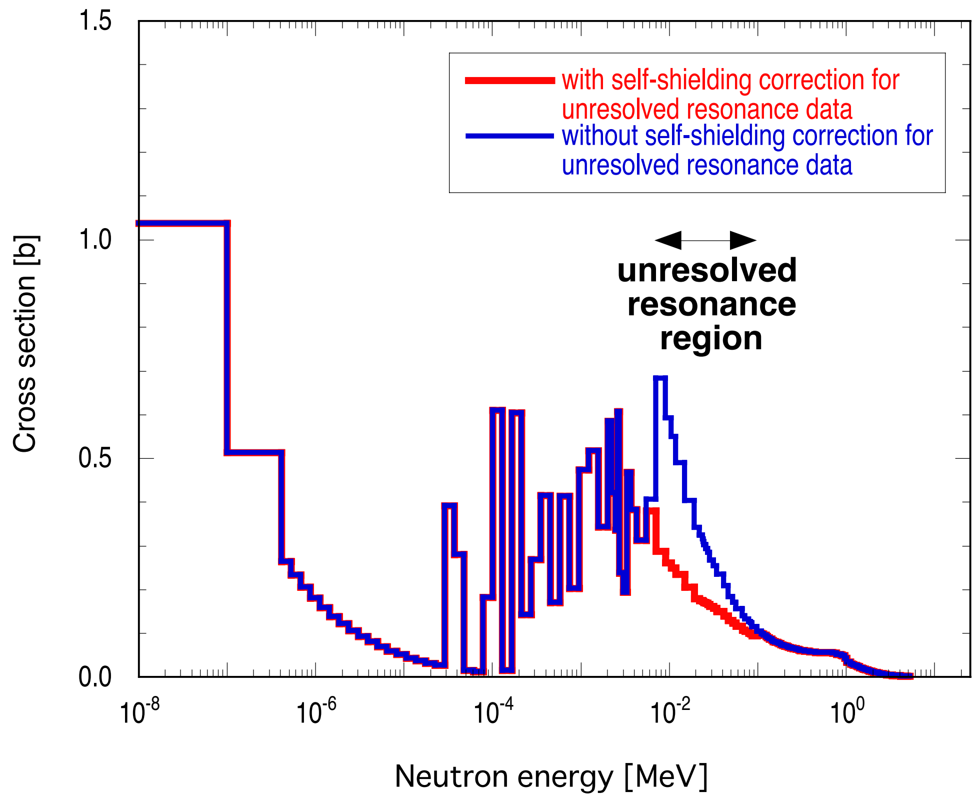
We examined the above issues by using a multigroup library of JENDL-3.3 (MATXSLIB-J33).

Cross section data of Nb-93 in JENDL-3.3

Self-shielding corrected elastic scattering cross section



Self-shielding corrected (n,γ) cross section



The self-shielding correction of unresolved resonances for elastic scattering seems to be too large even around the upper energy of the unresolved resonance region.

It is considered that this large self-shielding correction causes the large bump around 100 keV in the leakage neutron spectra.

Unresolved resonance data in JENDL-3.3 ^{93}Nb

Why is the self-shielding correction too large even around the upper energy [100 keV] of the unresolved resonance region in ^{93}Nb?

↓

Probably the average reduced neutron widths are too large around the upper energy of the unresolved resonance region.

$\overline{\Gamma^{o}}_{n,l=0,j=4}$ = 0.0085323 eV at 7 ～ 100 keV

$\overline{\Gamma^{o}}_{n,l=0,j=5}$ = 0.006981 eV at 7 ～ 100 keV

$\overline{\Gamma^{o}}_{n,l=1,j=3}$ = 0.1832 eV at 7 ～ 100 keV

$\overline{\Gamma^{o}}_{n,l=1,j=4}$ = 0.14249 eV at 7 ～ 100 keV

$\overline{\Gamma^{o}}_{n,l=1,j=5}$ = 0.11658 eV at 7 ～ 100 keV

$\overline{\Gamma^{o}}_{n,l=1,j=6}$ = 0.098646 eV at 7 ～ 100 keV

The larger average reduced neutron widths are required to reproduce average elastic scattering cross sections in the unresolved resonance energy region, but they cause larger self-shielding correction.

Are the averaged reduced neutron widths and/or the upper energy of the unresolved resonance region appropriate?

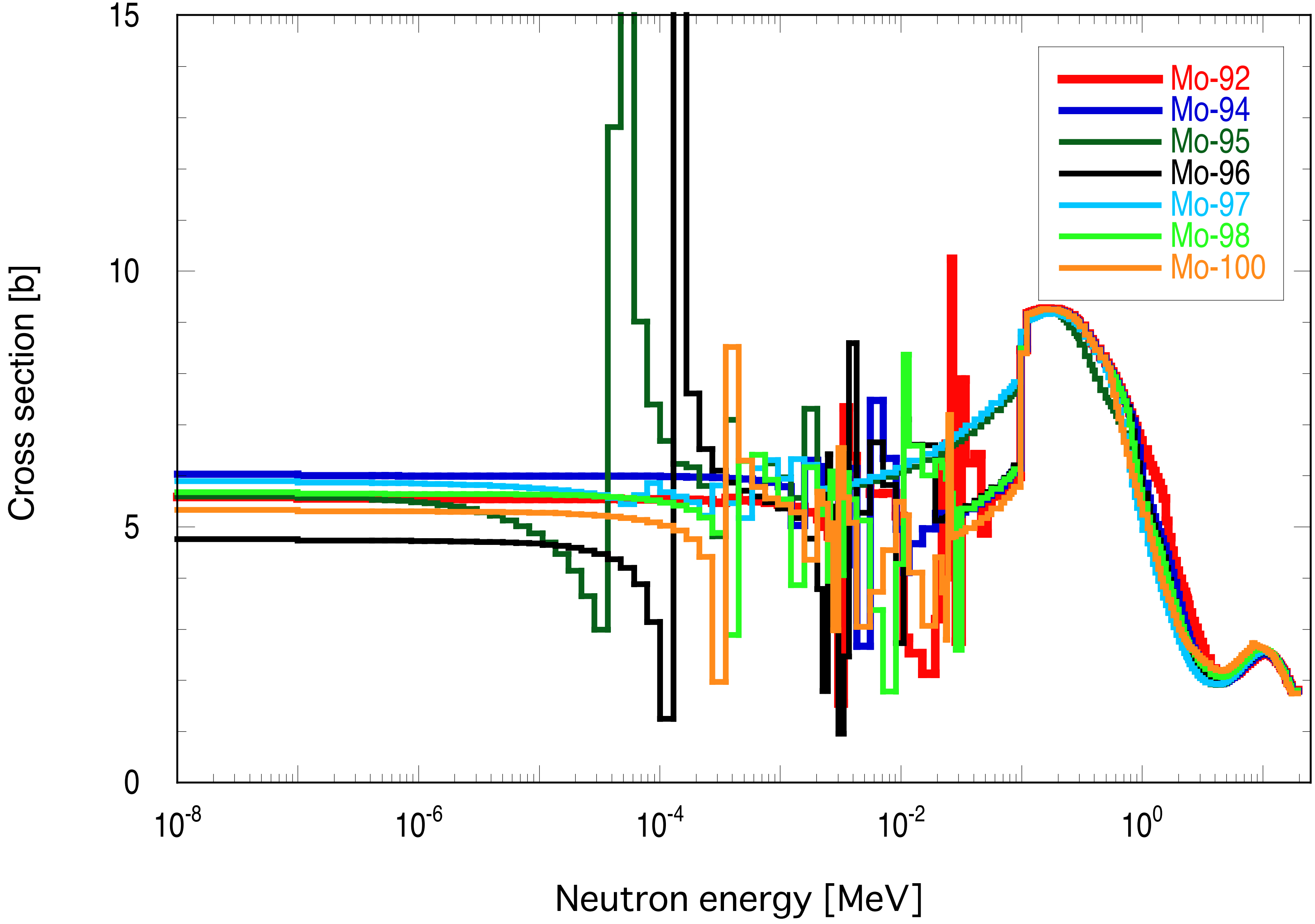
How about other nuclei with unresolved resonance data in JENDL-3.3?

- Self-shielding corrected elastic scattering cross sections were deduced from multigroup libraries of JENDL-3.3 (MATXSLIB-J33).

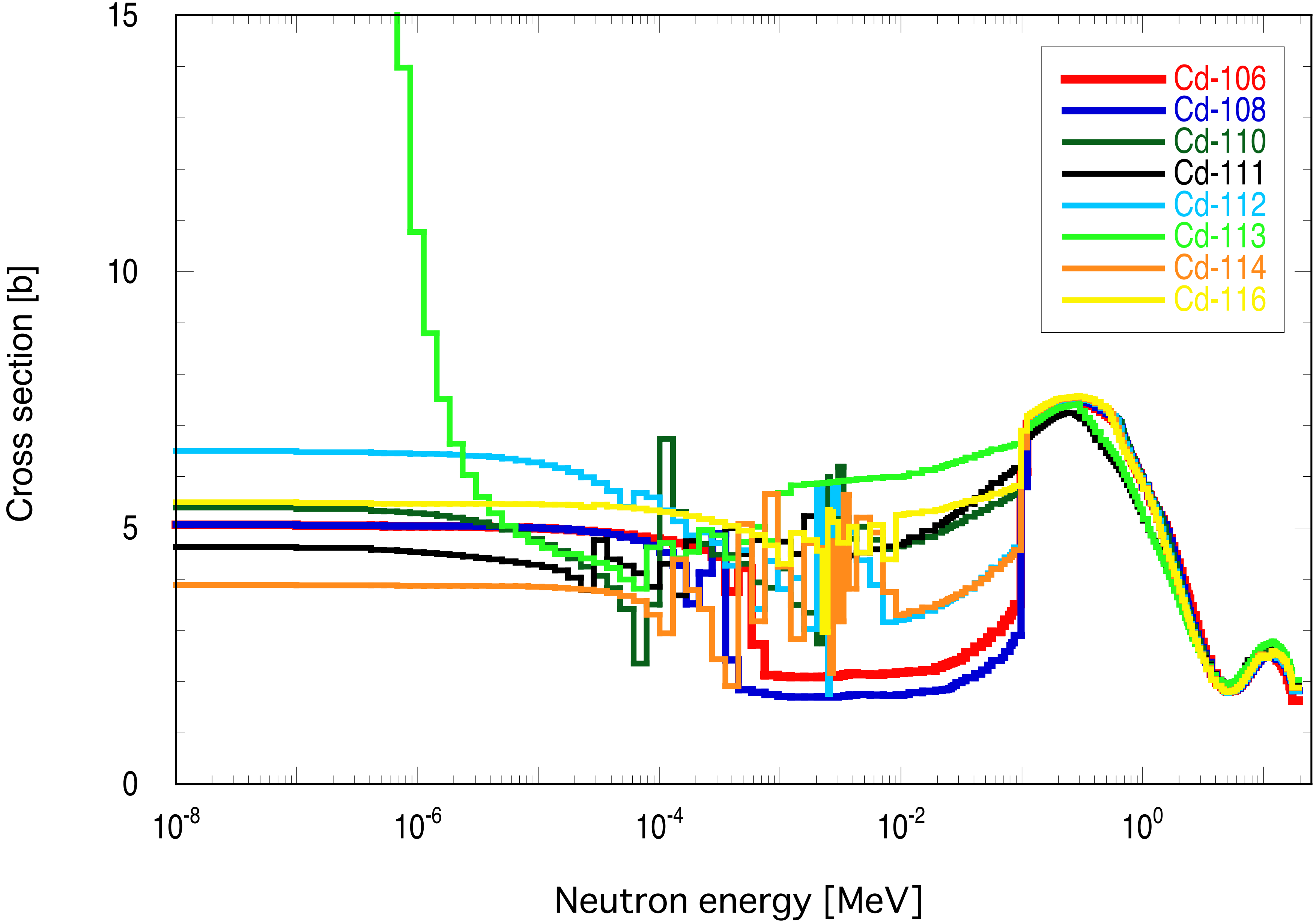
As-75, Se-74, -76, -77, -78, -79, -80, -82, Br-79, Br-81, Kr-78, -80, -82, -83, -84, -85, Rb-85, -87, Sr-86, -87, -89, -90, Y-89, -91, Zr-91, -92, -93, -94, -95, Nb-93, -94, -95, Mo-92, -94, -95, -96, -97, -98, -100, Tc-99, Ru-96, -98, -99, -100, -101, -102, -103, -104, -106, Rh-103, -105, Pd-102, -104, -105, -106, -107, -108, -110, Ag-107, -109, Cd-106, -108, -110, -111, -112, -113, -114, -116, In-113, -115, Sn-112, -114, -115, -116, -117, -118, -119, -120, -122, -123, -124, -126, Sb-121, -123, -124, -125, Te-120, -122, -123, -124, -125, -126, -128, -130, I-127, -129, -131, Xe-124, -126, -128, -129, -130, -131, -132, -133, -134, -135, Cs-133, -134, -135, -136, -137, Ba-130, -132, -134, -135, -136, -137, -140, La-138, -139, Ce-141, -142, -144, Pr-141, -143, Nd-142, -143, -144, -145, -146, -147, -148, -150, Pm-147, -148, -149, Sm-144, -147, -148, -149, -150, -151, -152, -153, -154, Eu-151, -152, -153, -154, -155, -156, Gd-152, -154, -155, -156, -157, -158, -160, Tb-159, Er-167, Hf-174, -176, -177, -178, -179, -180, Ta-181, Pa-231, 233, U-233, -234, -235, -236, -237, -238, Np-237, Pu-236, -238, -239, -240, -241, -242, Am-241, -242, -243, Cm-240, -241, -242, -243, -244, -245, -246, -247, -248, -249, -250, Bk-249, -250, Cf-249, -250, -251, -252

Red : Strange gap appeas in the elastic scattering cross sections.

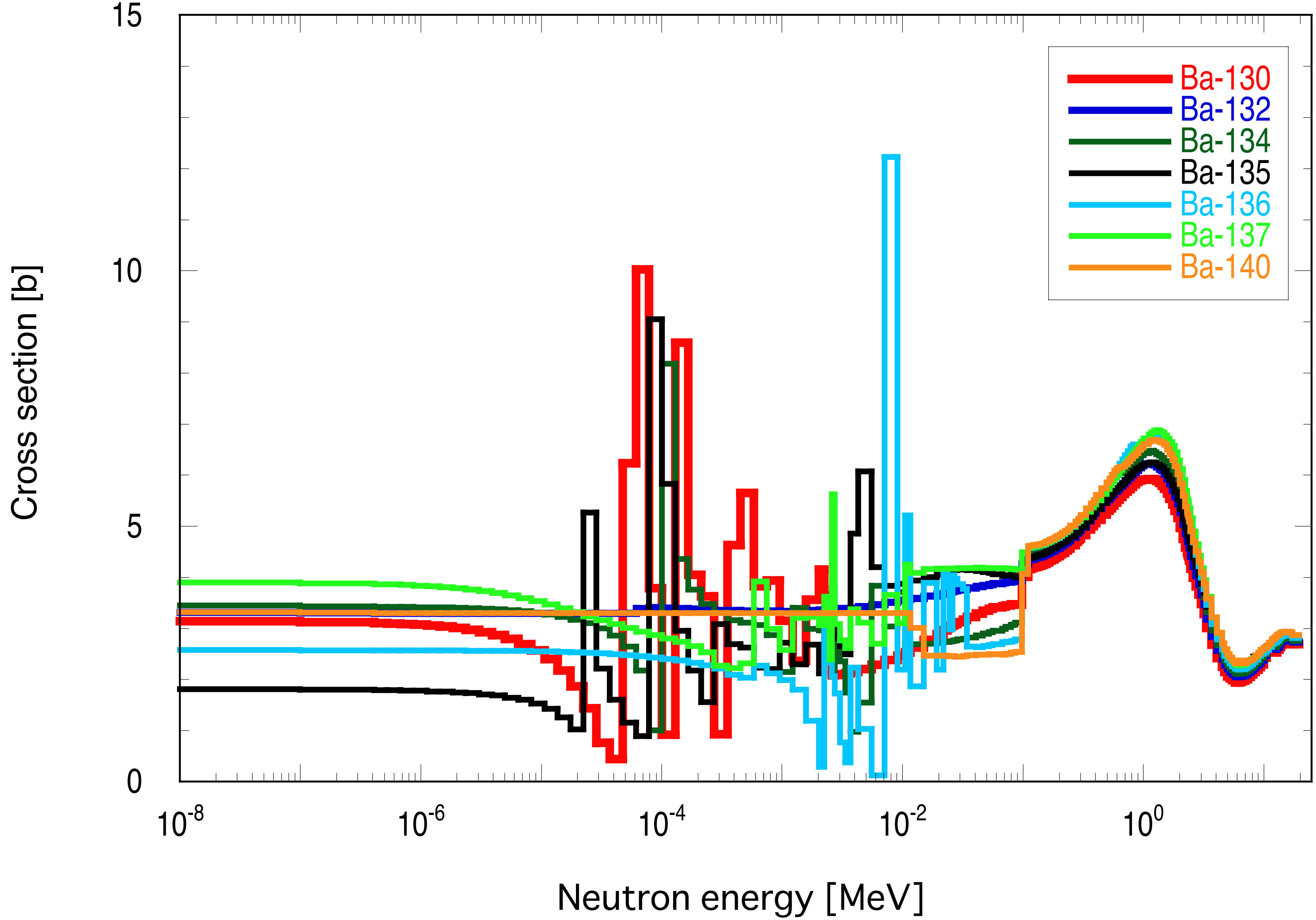
Self-shielding corrected elastic scattering cross section data of Mo isotopes in JENDL-3.3



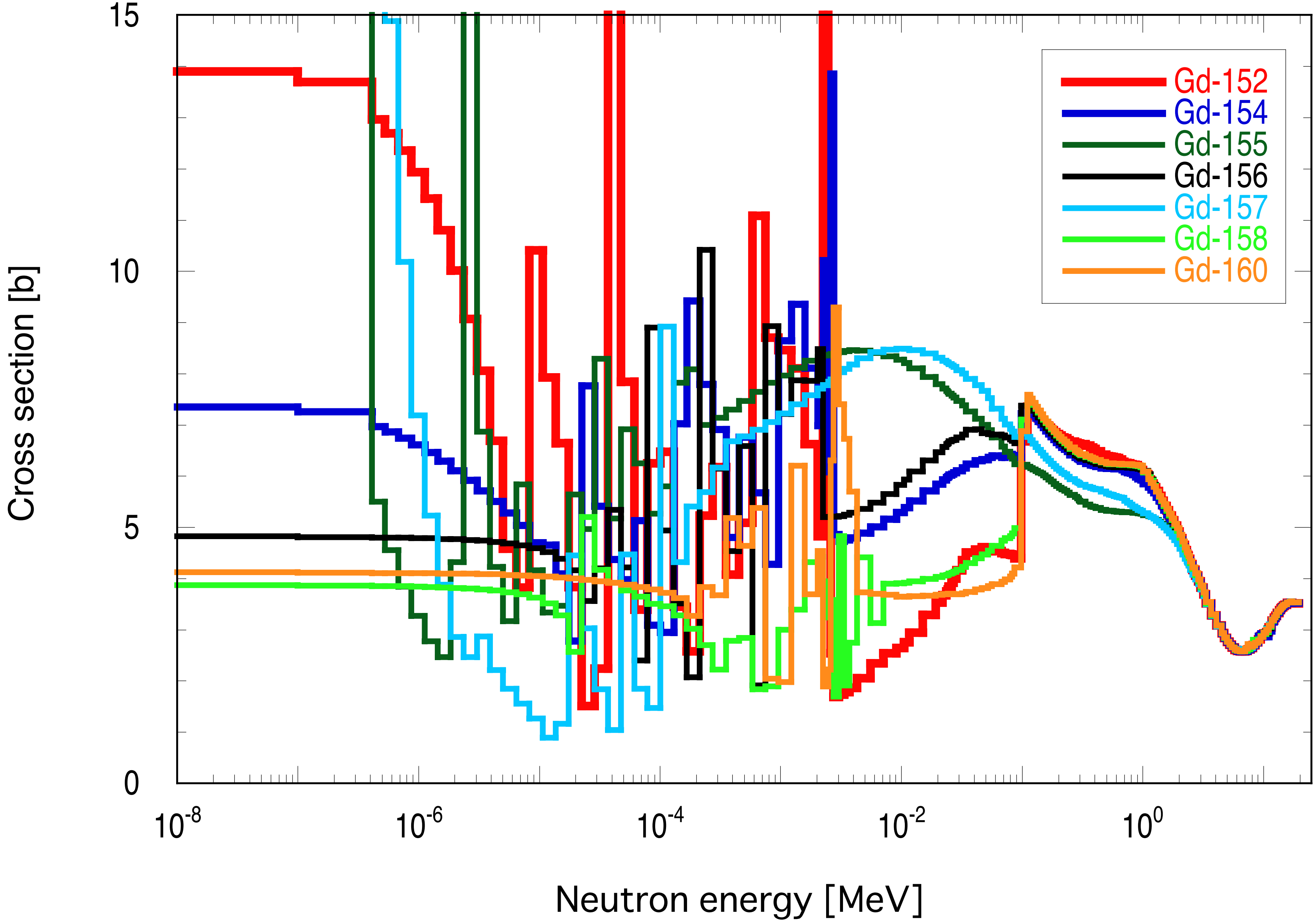
Self-shielding corrected elastic scattering cross section data of Cd isotopes in JENDL-3.3



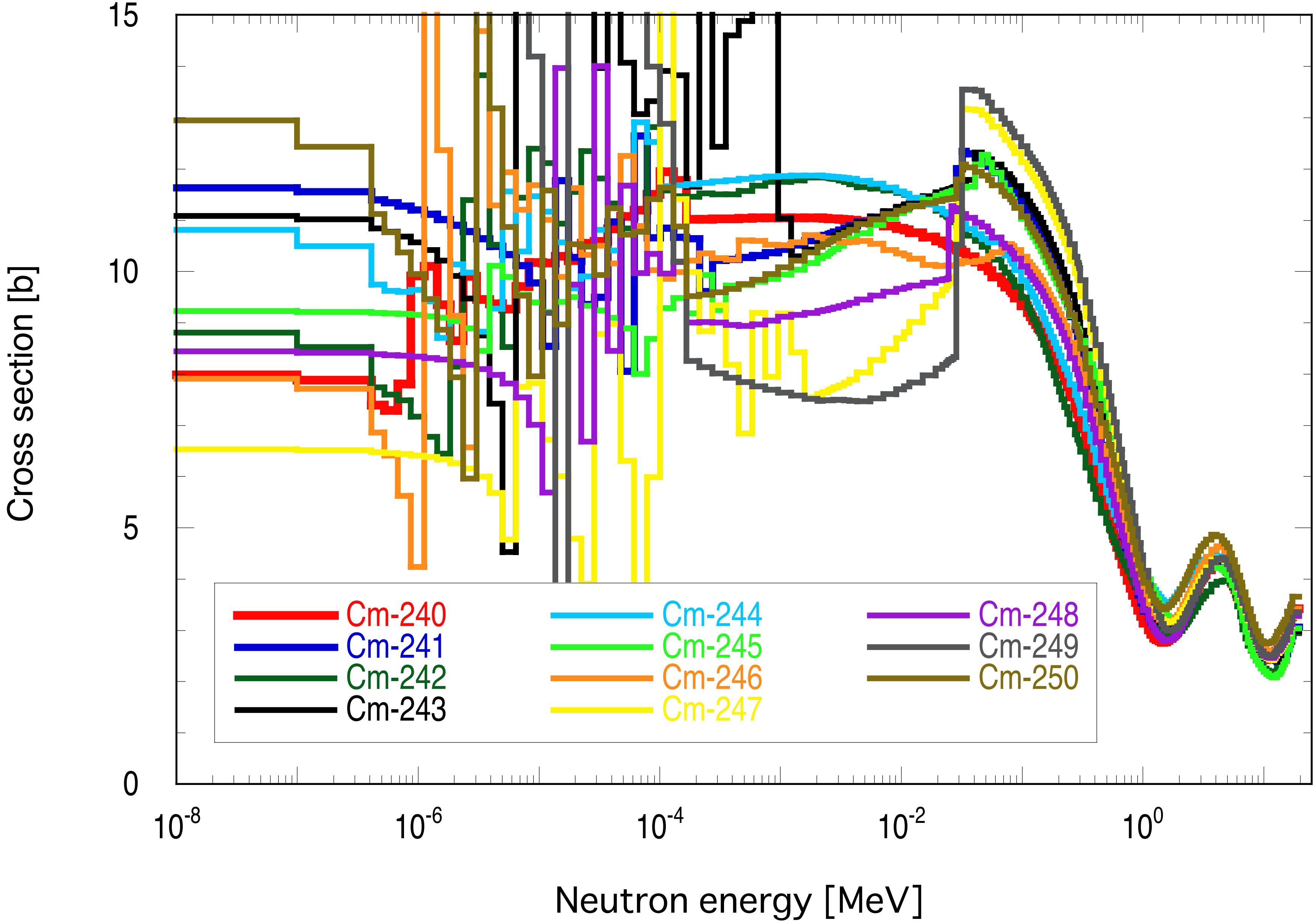
Self-shielding corrected elastic scattering cross section data of Ba isotopes in JENDL-3.3



Self-shielding corrected elastic scattering cross section data of Gd isotopes in JENDL-3.3



Self-shielding corrected elastic scattering cross section data of Cm isotopes in JENDL-3.3



Summary

- The self-shielding correction for the unresoved resonaces is too large around the upper energy of the unresolved resonance region in ^{93}Nb of JENDL-3.3. The following reasons for this problem are pointed out.
  - The average reduced neutron widths seem to be larger around the upper energy of the unresolved resonance region.

  and/or

  - The upper energy of the unresolved resonance region seems to be smaller.

- The above problem appears for many nuclei with unresolved resonance data in JENDL-3.3.

- All the unresolved resonance data in JENDL-3.3 should be rechecked and revised by considering self-shielding correction in the next JENDL.

- Other nuclear data libraries such as ENDF/B-VI may also have the same problem for unresolved resonance data as JENDL-3.3.