Tungsten Evaluation Validation

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Introduction

The Grenoble lead-slowing-down experiment is an excellent benchmark for testing nuclear data in the resonance range. Calculations with ENDF/B-VII and with the new IAEA-ORNL evaluations for the tungsten isotopes were performed. The resonance parameters were provided by L. Leal from Oak Ridge National Laboratory (ORNL). They were obtained by refining existing evaluated data from the JENDL-3 library, extending the resonance range and adding covariance information. Thus, they do not present an independent new evaluation. The JENDL-3.2 resonance parameters were propagated into JENDL-3.3, JENDL-4 and JEFF-3.1 libraries. The resonance parameters in ENDF/B-VI.8 and ENDF/B-VII are different.

Results of the analysis

The new ORNL resonance data (blue dotted curve labeled "ib21g" in Figure 1) generally perform better than ENDF/B-VII.0 (green dashed curve in Figure 1). There is a slight discrepancy just above 1 KeV, and above 20 KeV. Refinements of the base ORNL evaluation are discussed below.

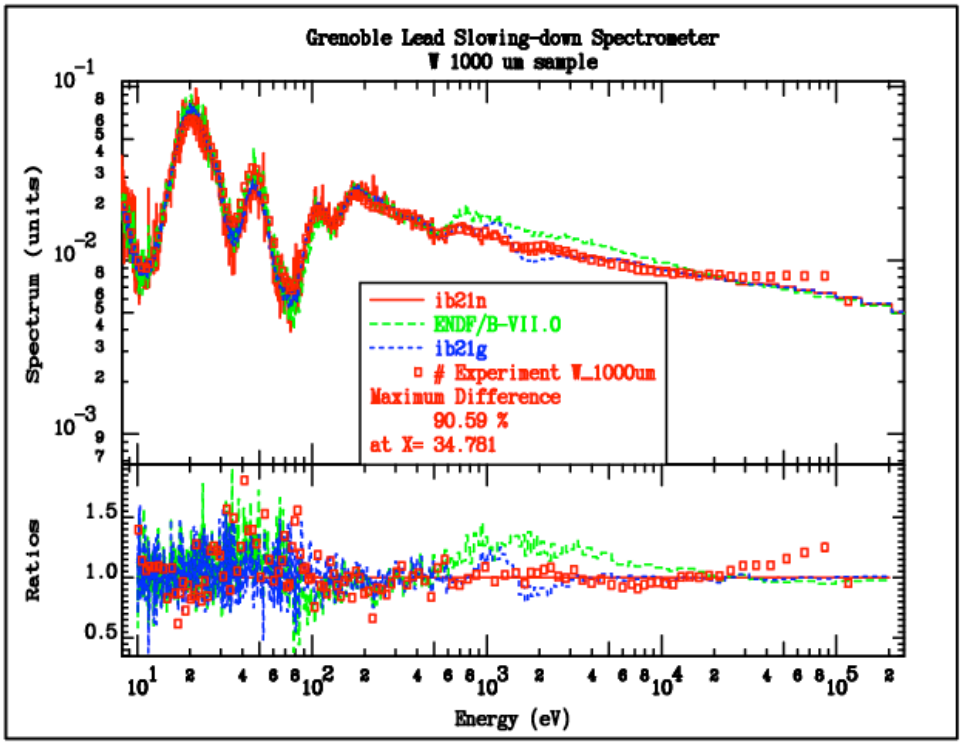

Figure 1: Simulation of the Grenoble lead-slowing-down benchmark experiment with ENDF/B-VII.0 and variants of the Oak Ridge resonance data (labeled ib21g and ib21n).

W-184

The resonance at 1.132 KeV has a gamma width of 6.07 eV. All other gamma-widths for this isotope as well as the value for the resonance at this energy in the ENDF/B-VII library are about 100 times smaller. It is assumed that the exponent in the original JENDL-3.2 evaluation was wrong and was se to "-2". The file with the corrected gamma width is labeled "ib21n".

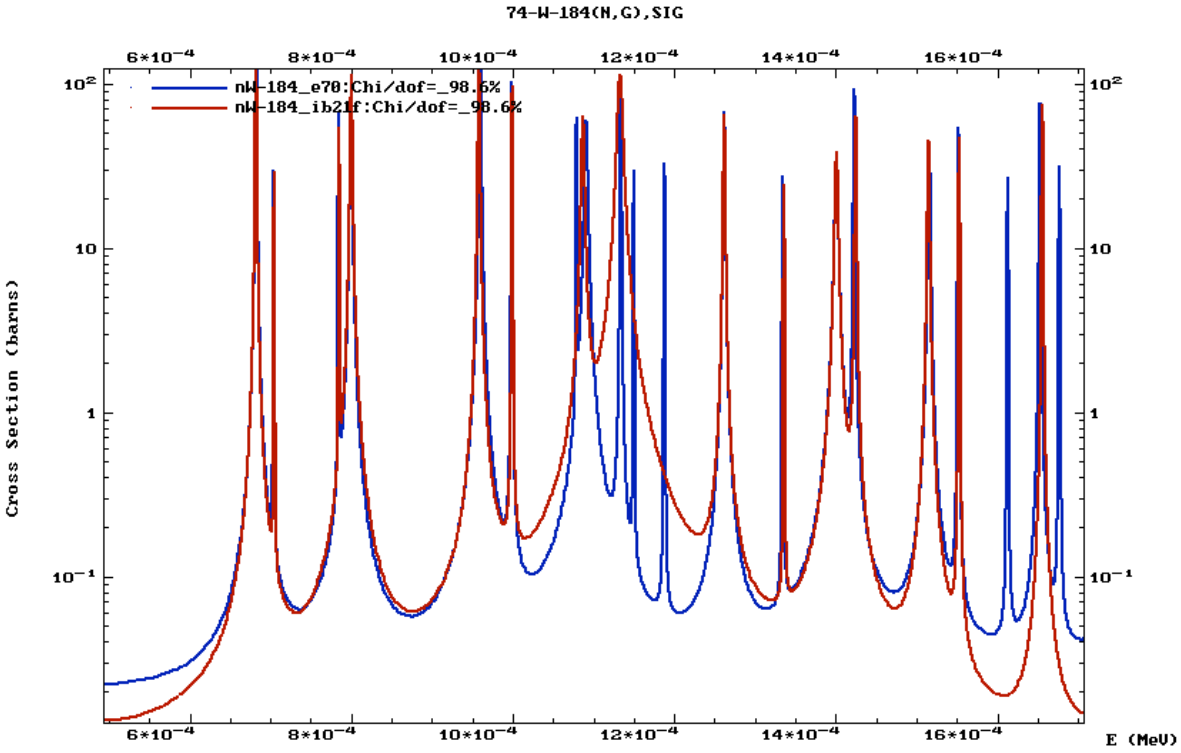

Figure 2: Comparison of the ^{184}W capture cross section in the region of the 1.132 KeV resonance, comparing ENDF/B-VII.0 (blue) and the original ORNL (red) evaluations.

W-183

Cross sections in the 640-group SAND-II structure were generated with the Pre-Pro codes for all isotopes. The capture cross sections between 1 KeV and 1 MeV are shown on Figure 3. The original JENDL-3.2 resolved resonance range for this isotope was defined up to 1 KeV. In the ORNL evaluation the range was extended to 2.2 KeV, but as seen on Figure 3, the capture cross sections in the extended energy range are much lower than the cross sections above this range, which were evaluated based on available experimental data. A background cross section of 1.8 barns was added to the background from 1.2 to 2.2 KeV. The file with the corrected background is labeled "ib21n".

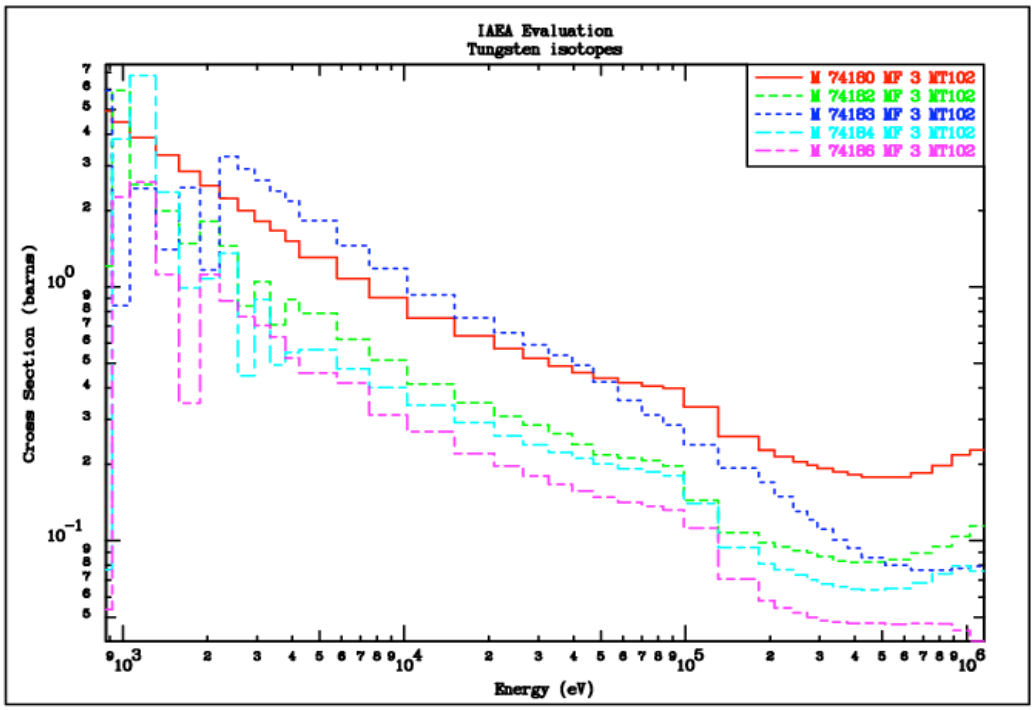

Figure 3: Comparison of capture cross sections for all isotopes of tungsten from the original IAEA-ORNL evaluation.

Other isotopes

There is a dip in the average capture cross sections of ^{186}W at around 2 KeV, visible on Figure 3. The resonances in this energy range are rather widely spaced, as seen from Figure 4, so the valleys between the resonances are more important. An "ad-hoc" addition of 0.032 barns background between 1.2 and 2.5 KeV would bring the capture cross section close to the ENDF/B-VII.0 evaluation, but it would not have a big influence on the overall capture cross section. At present there is no strong justification (and no strong need) for such a change.

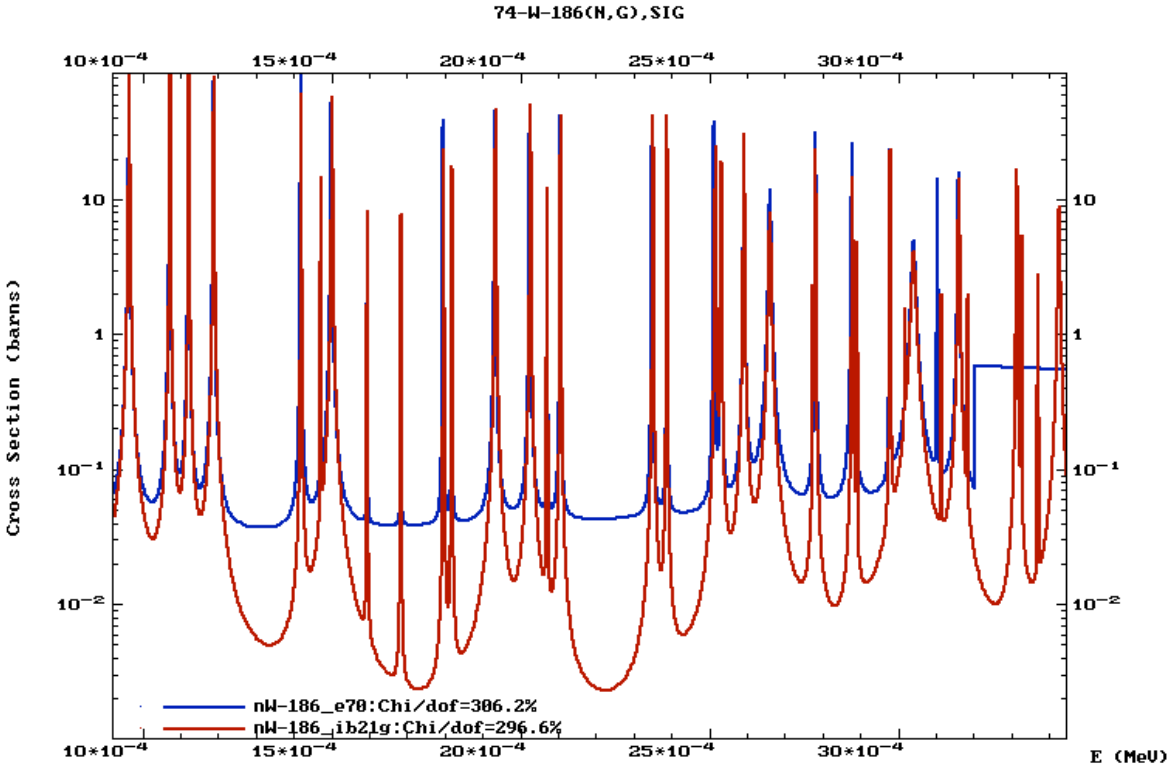

Figure 4: Comparison of the ^{186}W capture cross section between the ENDF/B-VII.0 and the IAEA-ORNL evaluation between 1 and 3 KeV.

On Figure 1 there is a discrepancy between measurements and calculations above 10 KeV with all data libraries. To force better agreement the capture cross sections of one or more isotopes would need to be increased significantly. There is considerable scatter of experimental data in the EXFOR library for the capture cross section in natural tungsten, but the discrepancies seem to be mainly systematic (see Figure 5). Comparison with isotopic data leads to the same conclusion (see Figures 6-9), therefore the discrepancy at energies above 10 KeV in the Grenoble lead-slowing-down experiment is ignored.

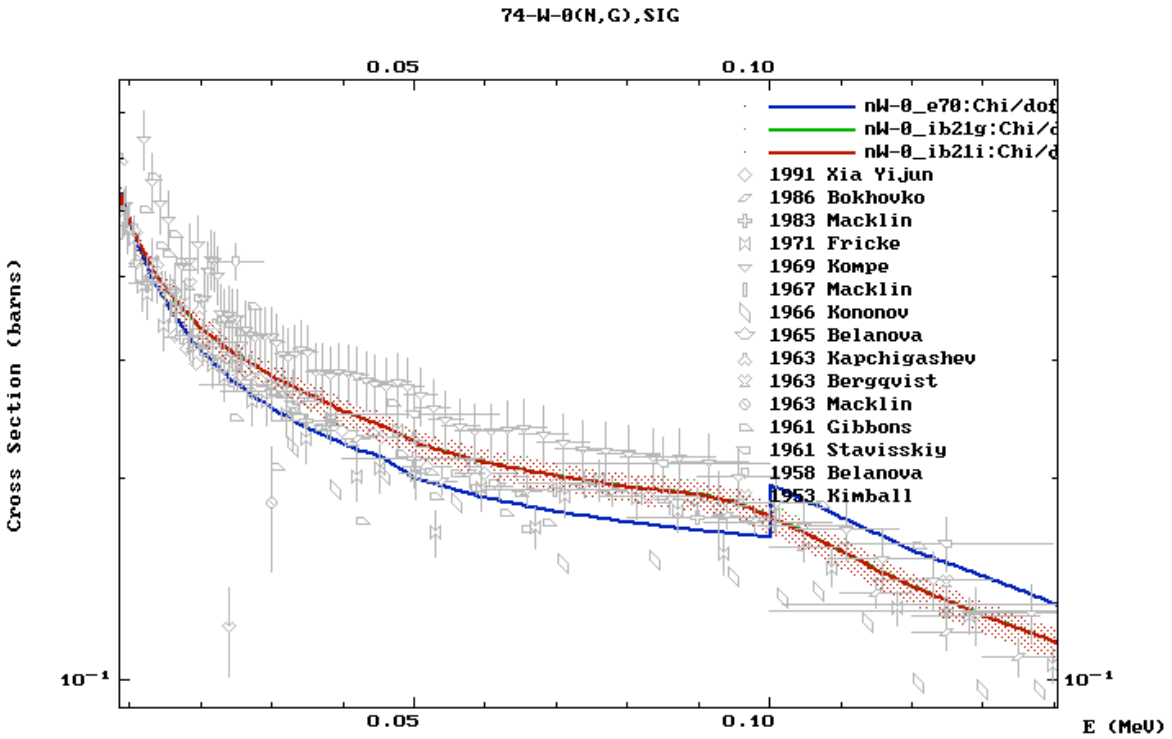

Figure 5: Capture cross sections of natural tungsten comparing the ENDF/B-VII evaluation (labeled nW-0_e70) and IAEA-ORNL evaluation (labeled nW-o_ib21i).

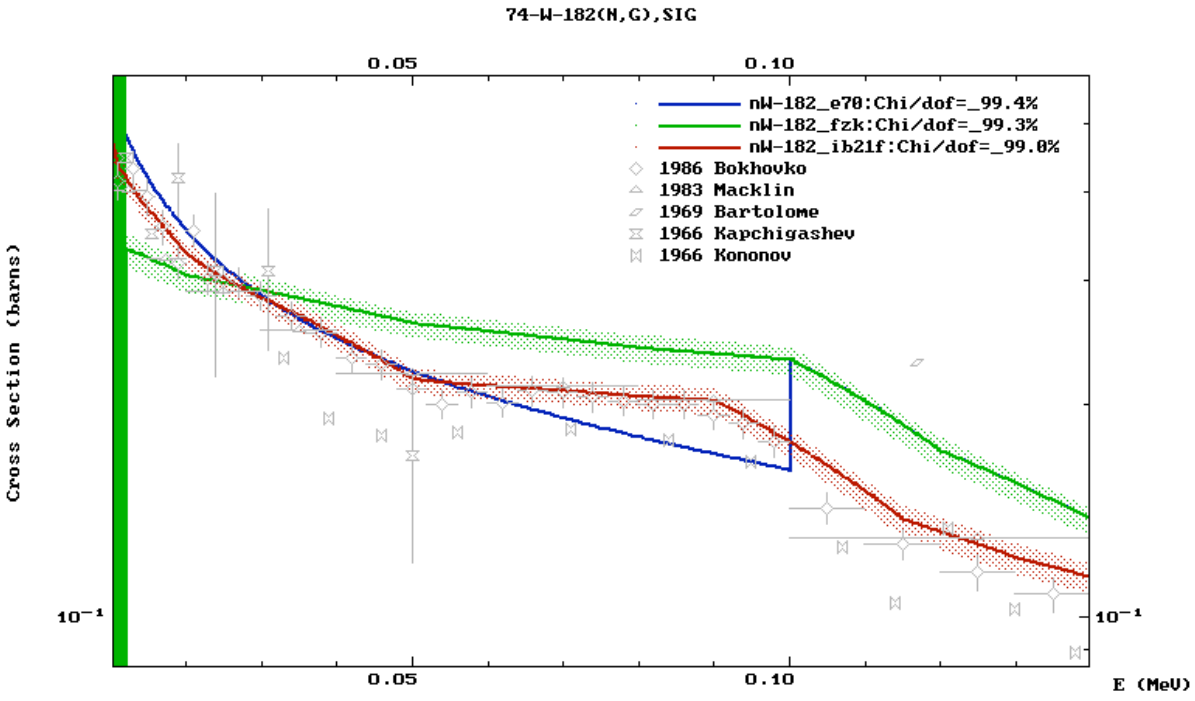

Figure 6:

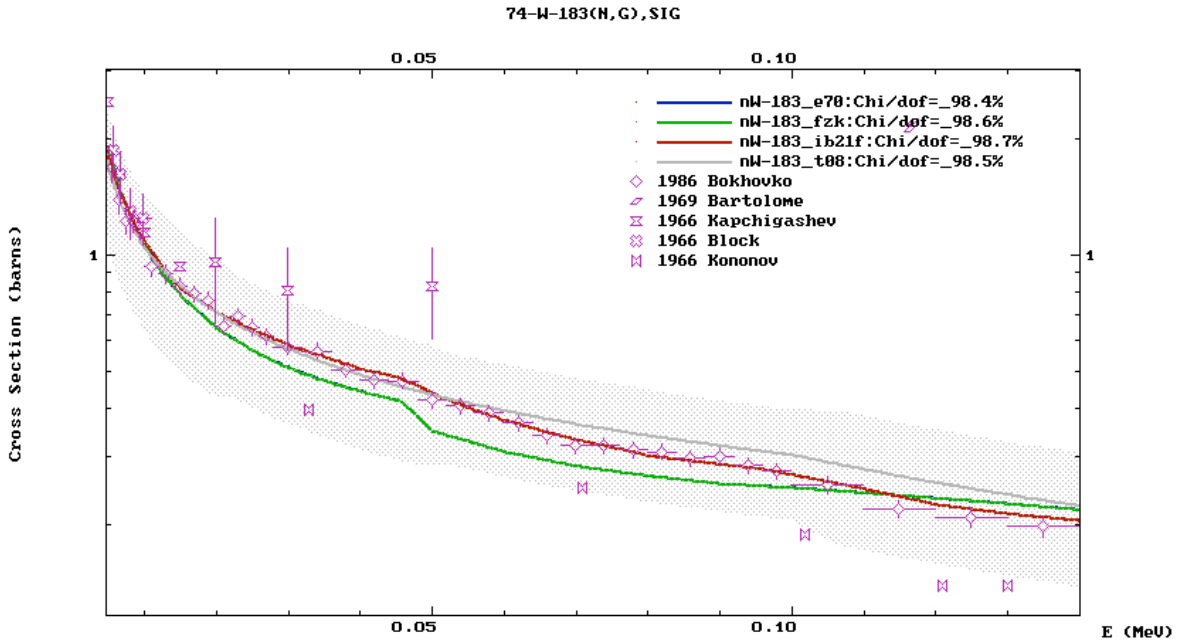

Figure 7:

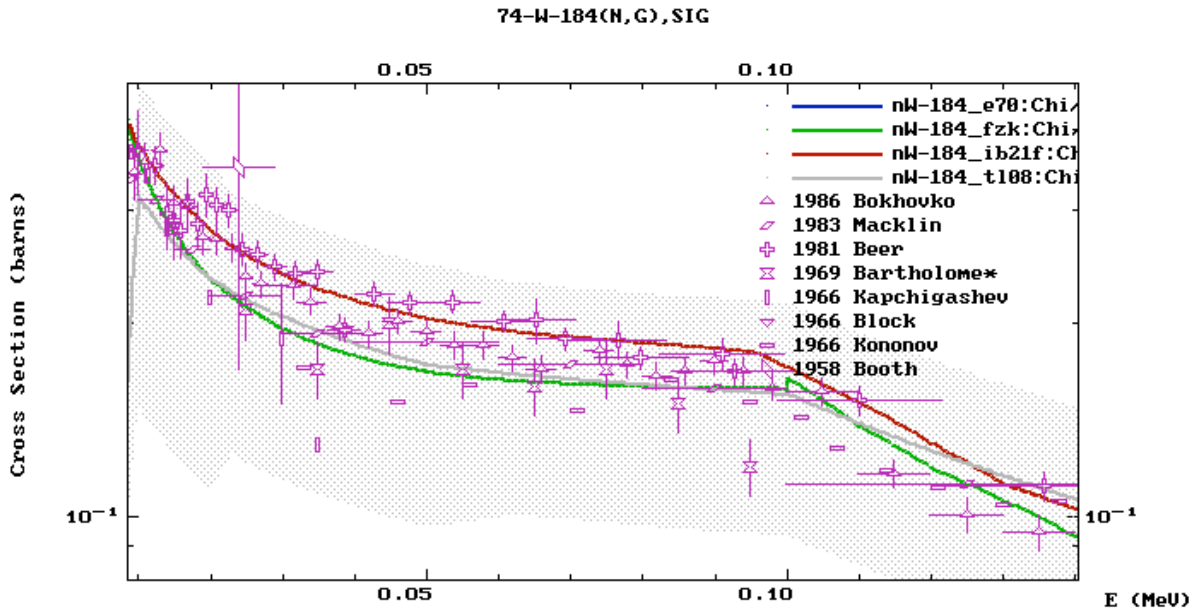

Figure 8:

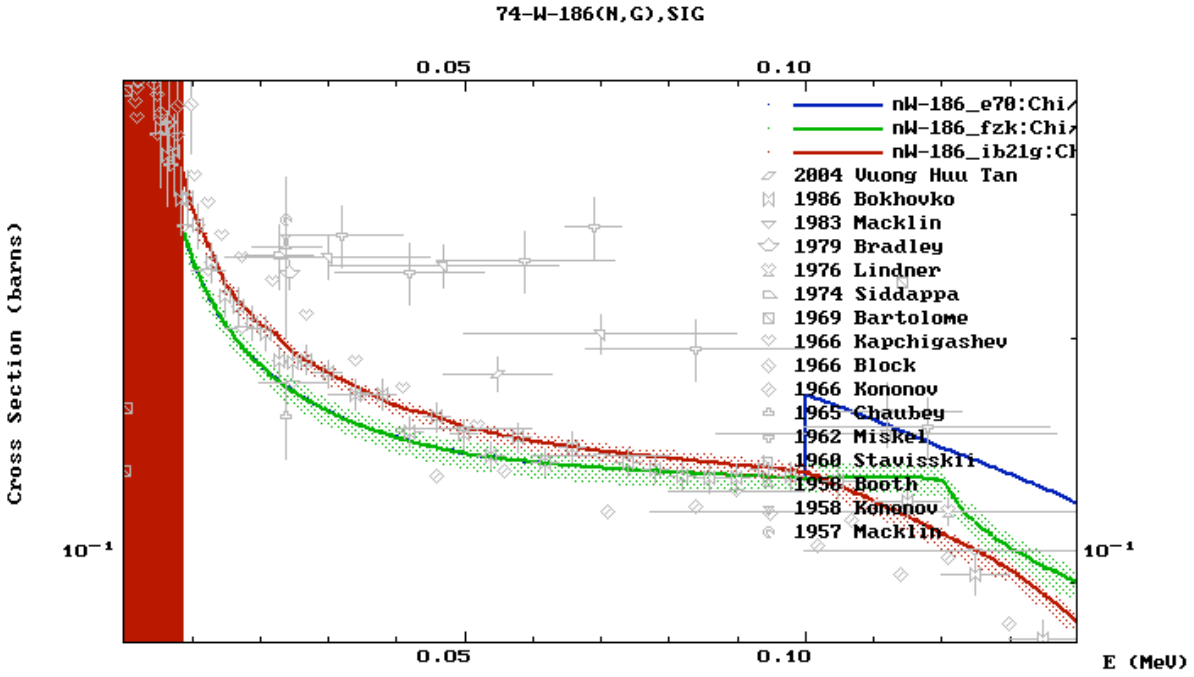

Figure 9:

Conclusions

The results of the analysis of the Grenoble lead-slowing-down experiment helped to identify two small problems in the resonance evaluations of the tungsten isotopes, one of them originating from the JENDL-3.2 evaluation and also found in JEFF-3.1 and JENDL-4. The corrected files are proposed for the new release of the ENDF/B-VII.1 library.