Status of BROND-3 library (May 2006)

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Main Russian activity on nuclear data in the last years was concentrated on a revision of most important neutron data for advanced nuclear reactors and a compilation of a new version of the BROND-3 library.

The following evaluations were performed for the neutron energies below 20 MeV:
i) Files for U-235, U-238, Pu-239 and Pu-241 were revised taking into account the new standards recommended for the fission cross sections of the uranium isotopes. Main problems relate to an estimation of uncertainties for new evaluations and to test of the revised files against the available benchmarks. The present standards have some unrealistic fluctuations for both the cross sections and uncertainties and such fluctuations should be certainly removed from the final version of the standards. The updated files for the above isotopes should be prepared to the end of the year. The final conclusions about uncertainties and the corresponding covariance matrices will be done on the basis of the available microscopic experimental data and the benchmark testing results.
ii) For all fissile nuclei and most important minor actinides the delayed neutron decay parameters and spectra are transformed to the 8-group system. The decay constants are taken in accordance with the recommendations of the Subroup 6 and the energy dependences of the partial DN-spectra components estimated in accordance with the recent IPPE measurements. The corresponding sections of files should be formatted to the end of the year.
iii) A revision of the previous evaluations for most important fission products was continued. Main attention was spent to a comparison with the recent ENDF/B-VI evaluations and a search of criteria for the evaluation selection in the case of scanty experimental data. The evaluations for Sm-151 can be considered as an example of available disagreements. The results of the recent measurements of the capture cross section for this isotope, performed on the nTOF-spectrometer at CERN, compared in Fig. 1 with the evaluations. The BROND-2, JEFF-3.1 and ENDF/B-VI evaluations, which made long before the measurements, agree reasonably with the experimental data at the region of unresolved resonances (<100 keV). Of course, the BROND-3, that takes into account these data, looks preferable for the whole energy region. Other libraries will be adjusted soon to these data. However, the main questions with a selection between evaluations arise for the inelastic scattering (Fig. 2), where there are no experimental data and there is no a hope to obtain them at a reasonable time. Nevertheless, main conclusions about preferable evaluations can be done on the basis of the cross-section systematics for neighboring nuclei. From this point of view agreement the BROND-3, CENDL-3, and ENDF/B-VII should be considered as acceptable ones for the energies above 100 keV, but other evaluations look definitely wrong. A more difficult question relates to the inelastic scattering cross section below 100 keV. The shortcomings of the ENDF/B-VII evaluation relate directly to a missing of any inelastic scattering contribution at the unresolved resonance region. Differences between other evaluations relate to the optical model description of the total and absorption cross sections for low energies. The optical model parameters were adjusted to the available experimental data for neighboring nuclei for the JENDL-3, CENDL-3 and BROND-3 evaluations and the

agreement between these evaluations seems rather good the inelastic scattering evaluations below 100 keV. A similar analysis was performed for about 50 of the most important fission products, we are ready to agree with a preference of the ENDF/B-vi evaluations over the previous ones only for a half of them, while for other we prefer the updated BROND-3 evaluations. The final answer about the evaluations included in the new BROBD-3 library will be done after the comparison of new evaluations with the integral data obtained on the IPPE BFS facilities.

iv) Files for zirconium isotopes were revised and updated. Because such isotopes relates to both the structural materials and fission products, the evaluations of neutron scattering cross sections and spectra are required for zirconium isotopes with higher accuracy than for most fission products. Particularly, the double-differential neutron spectra (MF=6) and gamma-ray production data were included into the new evaluations. For the inelastic scattering and the (n,2n) reactions the new evaluations are compared with previous ones in Fig. 3. The threshold reaction cross sections were tested against some phenomenological systematics, so the BROND-3 evaluations look preferable for cases where contradictions with other evaluations are observed.

Evaluations for intermediate energies

i) The neutron data-file for U-233 in the energy range up to 150 MeV was evaluated on the basis of the same approaches that were used in the previous BROND-3 evaluations for Th-232, U-238, Np-237, Pu-239 and Am-241. For the energy region below 20 MeV the ENDF/B-VII and Minsk evaluations were adopted. As examples of the obtained results the fission cross sections and the prompt-fission neutron multiplicities are compared in Figs. 4 and 5 with the experimental data and other evaluations. Uncertainties and the corresponding covariance matrix were estimated for most important cross sections.

iii) In collaboration with the ITEP (Moscow) and GSI (Darmstadt) we are also working on improvements of the intranuclear cascade model to obtain a consistent description of the observed isotopic yields of spallation and multi-fragmentation reaction products. Available simulation codes for such processes give strongly divergent results and these contradictions of calculations should be removed, if we want to produce reliable evaluations of nuclear data for energies above 150 MeV. This activity should be partially supported by the Project ISTC-3266 that will be started on the nearest months.

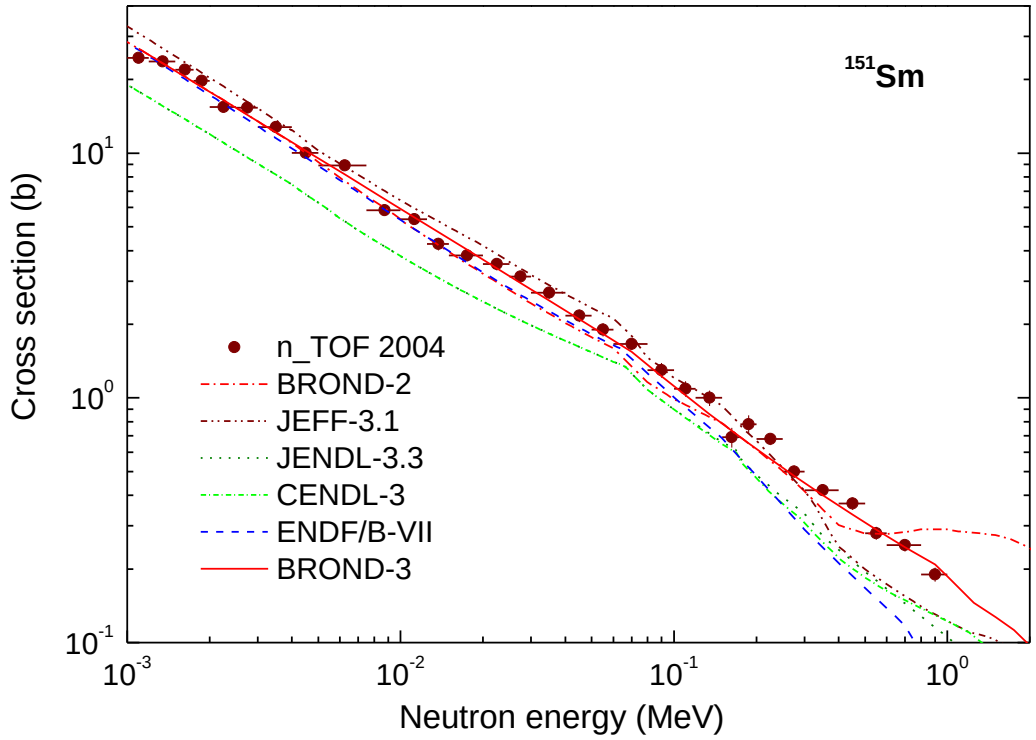

Fig. 1. Comparison of the recent nTOF-data on the neutron capture cross section with the available evaluations

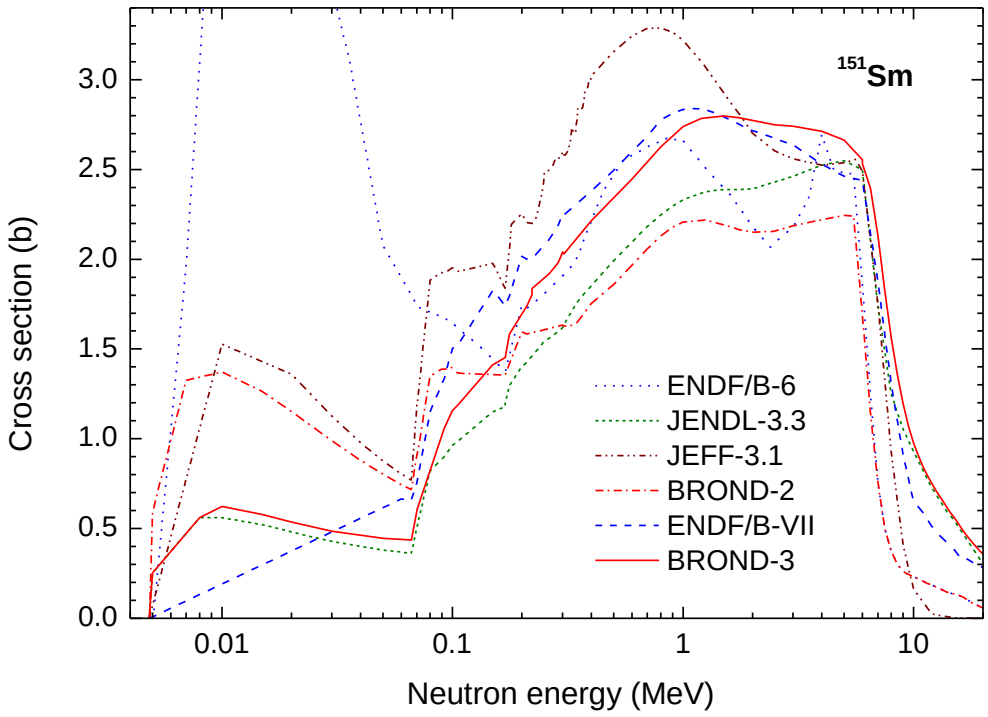

Fig. 2. Comparison of the neutron inelastic scattering evaluations

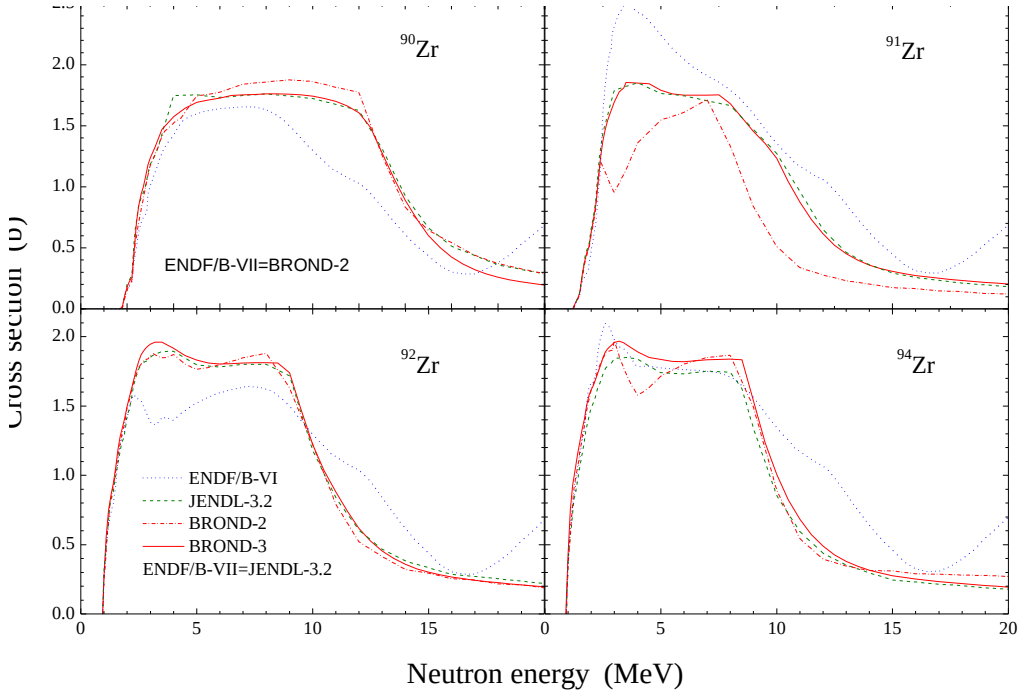

Fig. 3. Comparison of the neutron inelastic scattering evaluations for zirconium isotopes

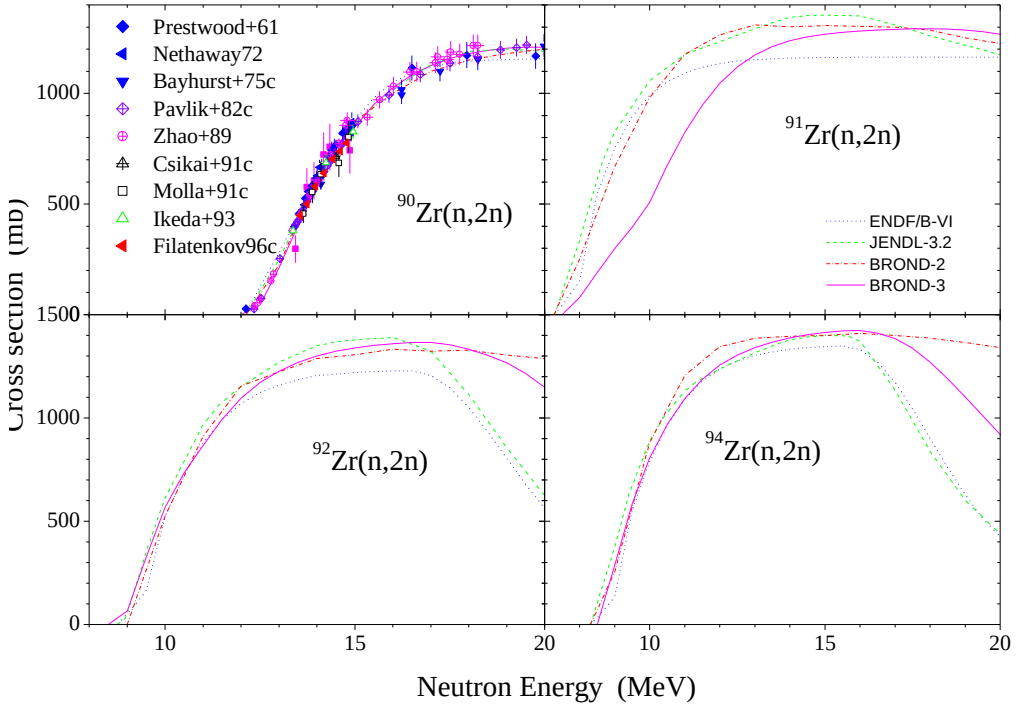

Fig. 4. Comparison of the (n,2n) reaction evaluations for zirconium isotopes with the available experimental data

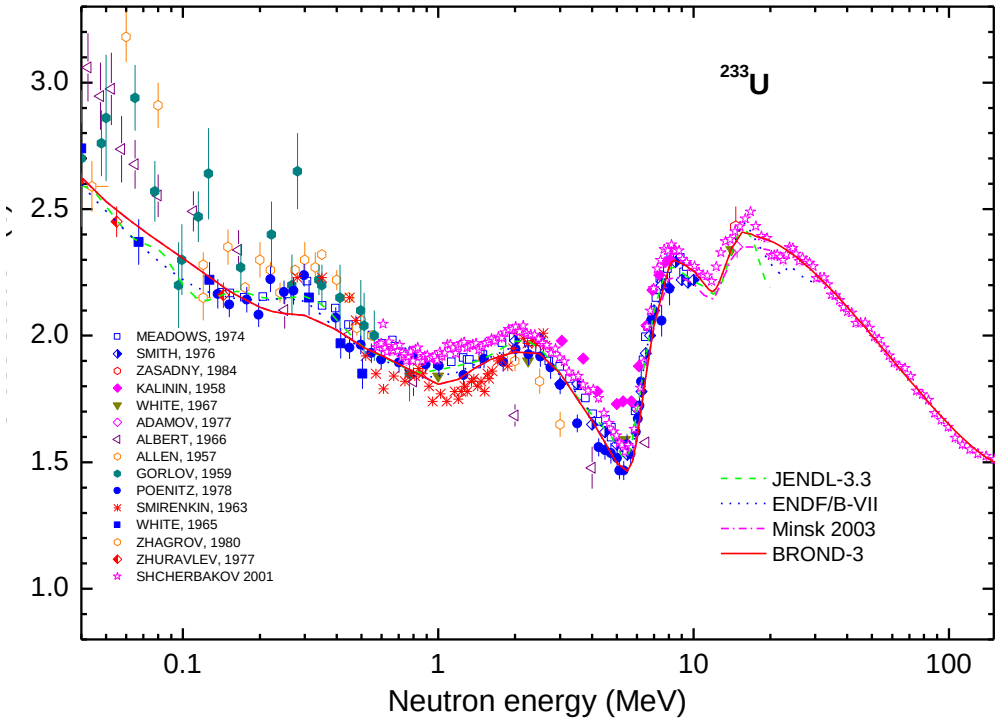

Fig. 5. Experimental data on the fission cross section of ^{233}U in comparison with evaluations

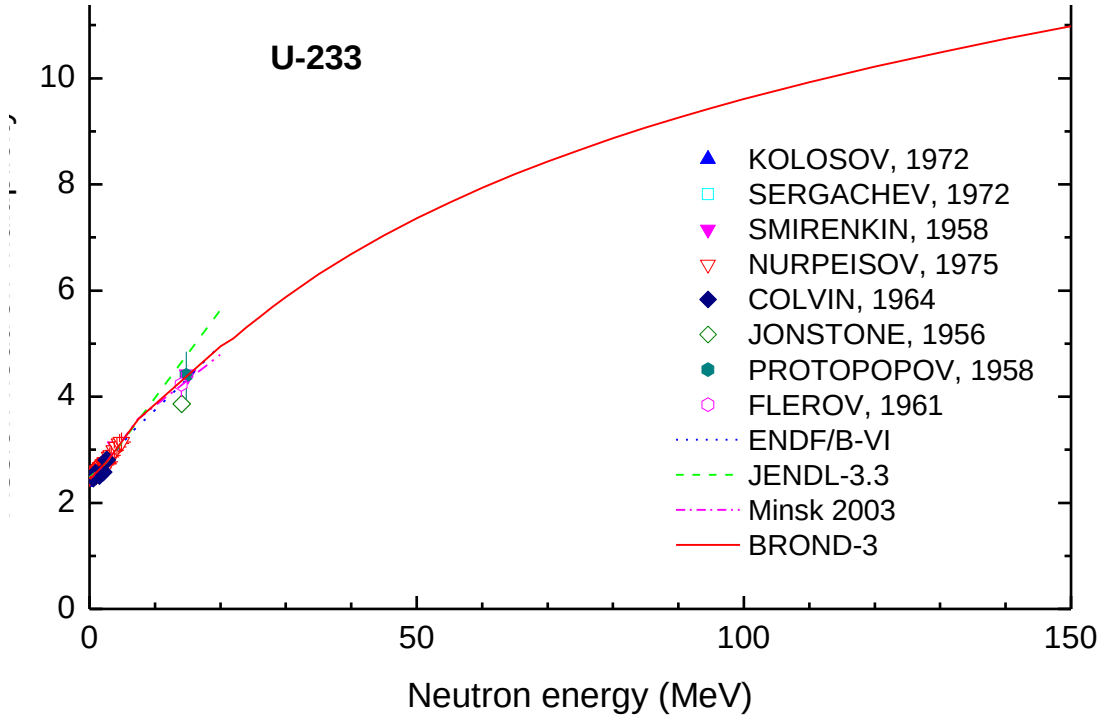

Fig. 6. Experimental data on the prompt fission-neutron multiplicity for ^{233}U in comparison with evaluations