

## **Status of BROND-3 library (June 2009)**

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Main Russian activity on nuclear data in the last two 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.

### **BROND-3 and ROSFOND-2006**

Nowadays the general purpose BROND-3 library includes about 120 nuclides, evaluations of which differ from other libraries. Almost the same list of nuclides was included in the previous BROND-2 library. For practical applications and for the new group-constant preparation, in particular, other data libraries are used widely for nuclides unavailable in BROND-3. The corresponding files are selected usually on the basis of a consistent description of some integral experiments and, first of all, the well-known criticality benchmarks.

A new version of the compiled library ROSFOND-2006 was assembled at the IPPE in 2006. The library contains 654 nuclides used in various reactor projects. About two thirds of them are the complete general purpose files and a third presents the activation files needed for the analysis of residual activations of reactor material. Additionally the library includes 20 files related to the slow-neutron scattering data for the important composite materials. The heading section of each file contains information about the original library, from which the file was selected, as well as a list of used modifications and the name of a person recommended the file for ROSFOND. More detailed descriptions of reasons for a made selection together with additional recommendations for possible further improvements are presented in the special report for ROSFOND, which is written in Russian and contains more 5000 pages. The library was sent to the IAEA NDS in 2008 and can be readied from the corresponding website.

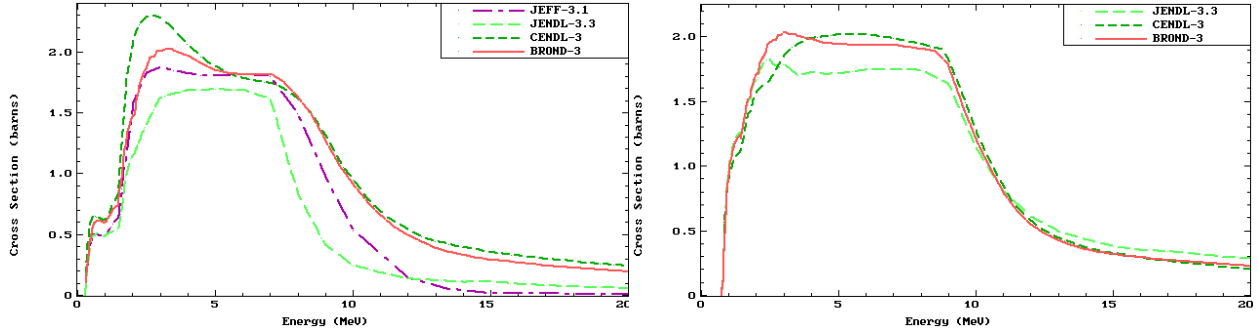
The ROSFOND-2006 files are tested now with a selected set on the national and international benchmarks and the obtained results will be used for further updating the BROND-3 files and a subsequent revision of files included in the ROSFOND library.

### **BROND-3 library for fission products**

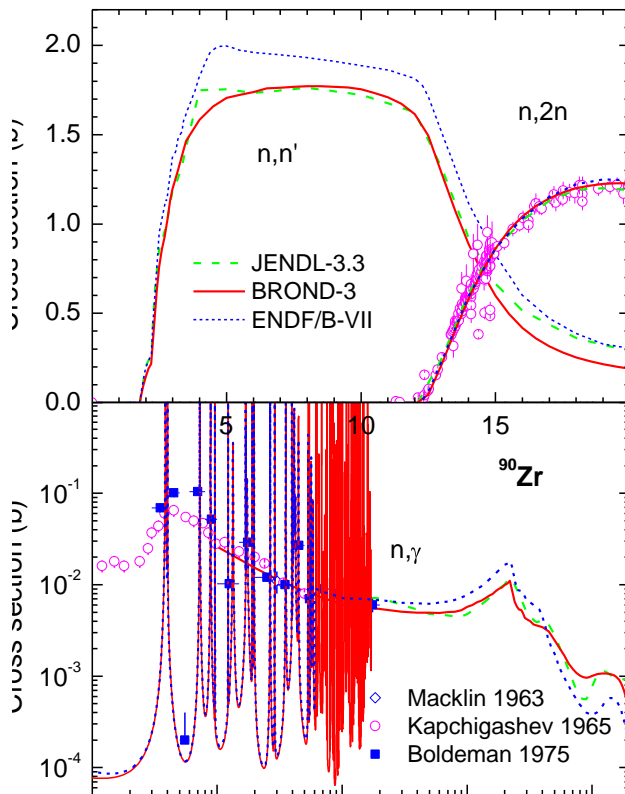
A revision of the previous evaluations for most important fission products was completed during the last year. Main attention was spent to a comparison with the recent ENDF/B-VII.0 evaluations and a search of criteria for the evaluation selection in the case of scanty experimental data. Most questions arise in this case for the inelastic scattering (Fig. 1), where there are no experimental data and there is no a hope to obtain them at a foreseeable future. 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 a reasonable agreement between the recent BROND-3, CENDL-3, and ENDF/B-VII evaluations 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. Differences between evaluations relate to the optical model description of the total and absorption cross sections for low energies, and it seems that the RIPL recommendations, which are quite reasonable for higher energies, are not good enough at low energies. So, the preferable ones at low energies are the optical model parameters describing the available experimental data on the neutron strength functions.

The analysis of recent evaluations was performed for about 40 of the most important fission products. The benchmark experiments on the BFS (IPPE) assemblies were included into consideration. The preference of the new ENDF/B-VII evaluations over the previous ones was confirmed for a half of the analyzed nuclei, while for other the updated BROND-3 evaluations

were preferred. Some examples of a comparison of the various evaluations with experimental data are shown in Figs. 2 and 3. The list of nuclides included in the BROND-3FP library for the mass numbers  $A \geq 89$  is presented in Table 1. For more light fission products the same evaluations as included in the ENDF/B-VII library were adopted in accordance with recommendations of the Subgroup 23.



**Fig. 1.** Evaluations of the inelastic scattering cross sections for  $^{93}\text{Zr}$  (left side) and  $^{98}\text{Mo}$  (right side). The JENDL-3.3 evaluations adopted in ENDF/B-VII for both isotopes and in JEFF-3.1 for  $^{98}\text{Mo}$ .

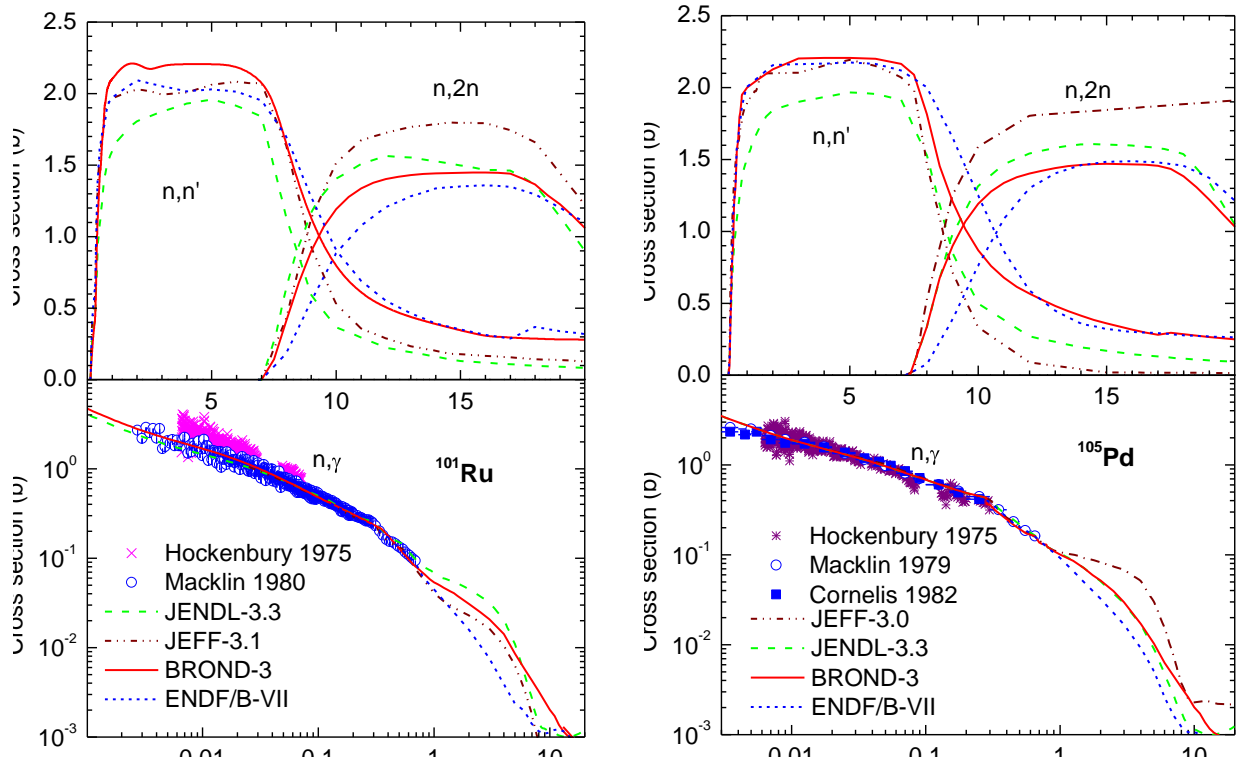


**Fig. 2.** Evaluations of the inelastic scattering,  $(n,2n)$  and capture cross sections for  $^{90}\text{Zr}$  compared with the available experimental data

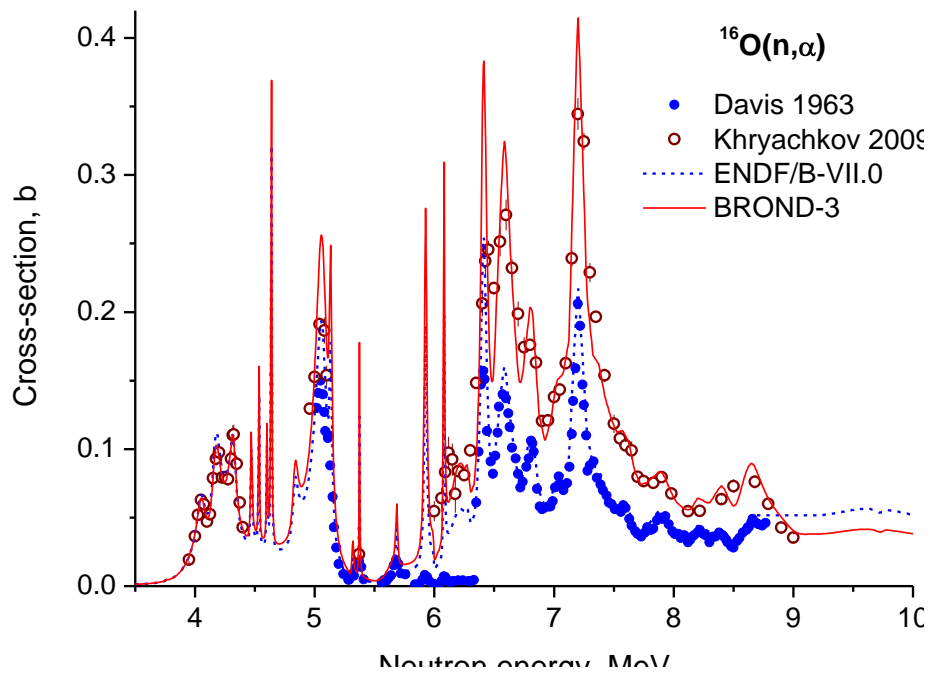
### New evaluations for $^{16}\text{O}$

The precision measurements of the  $^{16}\text{O}(n, \alpha)$  cross section at the neutron energies above 6.3 MeV, performed during the last years at the IRMM (Geel) and independently at the IPPE (Obninsk), demonstrate essential contradictions between the experimental data and the recently ENDF/B-VII evaluation adjusted to experimental data at the energy region from 4 to 6.3 MeV. To remove this contradiction the updated BROND-3 evaluation was prepared during this year by V.Pronyaev, the

results of which are shown in Fig. 4 together with the experimental data. All threshold reactions were revised in accordance with the changes of the  $(n, \alpha)$  cross section. The new evaluations are tested now against the reactor benchmarks and the status of the updated evaluations will be estimated after the analysis of the obtained results.



**Fig. 3.** The same as in Fig. 2 for  $^{101}\text{Ru}$  and  $^{105}\text{Pd}$ . These nuclides relate to the highest priority in the list of the most important fission products.



**Fig. 4.** New experimental data on the  $^{16}\text{O}(n,\alpha)$  cross section compared with the recent evaluations

### Revision of the activation library

The Russian activation data library ADL-3 was created in 1995 and many of its evaluations were included in the FENDL-2A library and the previous versions of the European activation library. A reduction of the long-lived residual activity of reactor materials requires nowadays revision of many previous evaluations. In accordance with this task the new evaluations more than 500 threshold reactions have been performed by A.Blokhin and V.Manokhin during the last two years. The activation data library BROND-3A is compiling now on the basis of these evaluations. The corresponding updating the RUSFOND library is also planned in the next year.

Table 1. List of the fission product files included in the BROND-3FP library

Nuclide	Original evaluation	Date	Authors of evaluation	MAT
39-Y -89	BROND-3	May06	Ignatyuk, Gai	3925
39-Y -90	ENDF/B-VII	Mar06	Herman,Oblozinsky,Mughabghab	3928
39-Y -91	JENDL-3.3	Mar90	JNDC	3931
40-Zr-90	BROND-3	Dec05	Ignatyuk, Manokhin, Tertychnyi	4025
40-Zr-91	BROND-3	Dec05	Ignatyuk, Manokhin, Tertychnyi	4028
40-Zr-92	BROND-3	Dec05	Ignatyuk, Manokhin, Tertychnyi	4031
40-Zr-93	BROND-3	Dec05	Ignatyuk, Manokhin, Tertychnyi	4034
40-Zr-94	BROND-3	Dec05	Ignatyuk, Manokhin, Tertychnyi	4037
40-Zr-95	BROND-3	Dec05	Ignatyuk, Manokhin, Tertychnyi	4040
40-Zr-96	BROND-3	Dec05	Ignatyuk, Manokhin, Tertychnyi	4043
41-Nb-93	ENDF/B-VII	Dec97	M.Chadwick,P.Young,D.L.Smith	4125
41-Nb-94	JENDL-3.3	Mar90	JNDC	4128
41-Nb-95	JENDL-3.3	Mar90	JNDC	4131
42-Mo-92	BROND-3	Dec05	Ignatyuk, Manokhin, Tertychnyi	4225
42-Mo-94	BROND-3	Dec05	Ignatyuk, Manokhin, Tertychnyi	4231
42-Mo-95	BROND-3	Dec05	Ignatyuk, Manokhin, Tertychnyi	4234
42-Mo-96	BROND-3	Dec05	Ignatyuk, Manokhin, Tertychnyi	4237
42-Mo-97	BROND-3	Dec05	Ignatyuk, Manokhin, Tertychnyi	4240
42-Mo-98	BROND-3	Dec05	Ignatyuk, Manokhin, Tertychnyi	4243
42-Mo-99	BROND-3	Dec05	Ignatyuk, Manokhin, Tertychnyi	4246
42-Mo-100	BROND-3	Dec05	Ignatyuk, Manokhin, Tertychnyi	4249
43-Tc-99	ENDF/B-VII	Sep05	Oblozinsky,Rochman,Herman,Mughab	4325
44-Ru-96	JENDL-3.3	Mar90	JNDC	4425
44-Ru-98	JENDL-3.3	Mar90	JNDC	4431
44-Ru-99	JENDL-3.3	Mar90	JNDC	4434
44-Ru-100	BROND-3	Dec03	Ignatyuk, Tertychnyi	4437
44-Ru-101	BROND-3	Dec03	Ignatyuk, Tertychnyi	4440
44-Ru-102	BROND-3	Dec03	Ignatyuk, Tertychnyi	4443
44-Ru-103	BROND-3	Dec03	Ignatyuk, Tertychnyi	4446
44-Ru-104	BROND-3	Dec03	Ignatyuk, Tertychnyi	4449
44-Ru-105	CENDL-3	Jun00	Qi Chang	4452
44-Ru-106	BROND-3	Dec03	Ignatyuk, Tertychnyi	4455
45-Rh-103	ENDF/B-VII	Feb06	Kim,Herman,Chang,Mughabghab+	4525
45-Rh-105	CENDL-3	Dec99	X.Sun,Z.Zhang,Q.Shen,J.Zhao,W.Su	4531
46-Pd-102	BROND-3	Dec03	Ignatyuk, Tertychnyi	4625
46-Pd-104	BROND-3	Dec03	Ignatyuk, Tertychnyi	4631
46-Pd-105	BROND-3	Dec03	Ignatyuk, Tertychnyi	4634
46-Pd-106	BROND-3	Dec03	Ignatyuk, Tertychnyi	4637

46-Pd-107	BROND-3	Dec03	Ignatyuk, Tertychnyi	4640
46-Pd-108	BROND-3	Dec03	Ignatyuk, Tertychnyi	4643
46-Pd-110	BROND-3	Dec03	Ignatyuk, Tertychnyi	4649
47-Ag-107	ENDF/B-VII	Mar05	Liu+,	4725
47-Ag-109	ENDF/B-VII	Feb06	Kim,Herman,Oh,Mughabghab+	4731
47-Ag-110m	ENDF/B-VII	Mar05	JNDC	4735
47-Ag-111	ENDF/B-VII	Mar06	Herman,Oblozinsky,Mughabghab	4737
48-Cd-106	ENDF/B-VII	Mar05	JNDC	4825
48-Cd-108	ENDF/B-VII	Mar05	J.McCabe,	4831
48-Cd-110	ENDF/B-VII	Mar05	J.McCabe,	4837
48-Cd-111	BROND-3	Dec06	Ignatyuk, Tertychnyi	4840
48-Cd-112	BROND-3	Dec06	Ignatyuk, Tertychnyi	4843
48-Cd-113	BROND-3	Dec06	Ignatyuk, Tertychnyi	4846
48-Cd-114	BROND-3	Dec06	Ignatyuk, Tertychnyi	4849
48-Cd-115M	ENDF/B-VII	Mar06	Herman,Oblozinsky,Mughabghab	4853
48-Cd-116	BROND-3	Dec06	Ignatyuk, Tertychnyi	4855
50-Sn-125	ENDF/B-VII	Mar06	Herman,Oblozinsky,Mughabghab	5064
51-Sb-126	ENDF/B-VII	Mar06	Herman,Oblozinsky,Mughabghab	5140
52-Te-132	ENDF/B-VII	Mar06	Herman,Oblozinsky,Mughabghab	5261
53-I -127	ENDF/B-VII	Jan05	Young+	5325
53-I -129	ENDF/B-VII	Jan05	JNDC	5331
53-I -130	ENDF/B-VII	Mar06	Herman,Oblozinsky,Mughabghab	5334
54-Xe-131	ENDF/B-VII	Feb06	Kim,Herman,Oh,Mughabghab+	5446
55-Cs-133	ENDF/B-VII	Feb06	Kim,Herman,Oh,Mughabghab+	5525
56-Ba-133	ENDF/B-VII	Mar06	Herman,Oblozinsky,Mughabghab	5634
57-La-140	ENDF/B-VII	Mar06	Herman,Oblozinsky,Mughabghab	5731
58-Ce-136	ENDF/B-VII	Mar06	Herman,Oblozinsky,Mughabghab	5825
58-Ce-138	ENDF/B-VII	Mar06	Herman,Oblozinsky,Mughabghab	5831
58-Ce-139	ENDF/B-VII	Mar06	Herman,Oblozinsky,Mughabghab	5834
58-Ce-140	ENDF/B-VII	Jan05	JNDC	5837
58-Ce-141	ENDF/B-VII	Jan05	Zhang+,	5840
58-Ce-142	ENDF/B-VII	Jan05	JNDC	5843
58-Ce-143	ENDF/B-VII	Mar06	Herman,Oblozinsky,Mughabghab	5846
58-Ce-144	JENDL-3.3	Mar90	JNDC	5849
59-Pr-141	ENDF/B-VII	Feb06	Kim,Mughabghab,Herman,Oblozinsky	5925
59-Pr-142	ENDF/B-VII	Mar06	Herman,Oblozinsky,Mughabghab	5928
59-Pr-143	ENDF/B-VII	Jan05	JNDC	5931
60-Nd-142	BROND-3	Dec05	Ignatyuk, Tertychnyi	6025
60-Nd-143	BROND-3	Dec05	Ignatyuk, Tertychnyi	6028
60-Nd-144	BROND-3	Dec05	Ignatyuk, Tertychnyi	6031
60-Nd-145	BROND-3	Dec05	Ignatyuk, Tertychnyi	6034
60-Nd-146	BROND-3	Dec05	Ignatyuk, Tertychnyi	6037
60-Nd-147	BROND-3	Dec05	Ignatyuk, Tertychnyi	6040
60-Nd-148	BROND-3	Dec05	Ignatyuk, Tertychnyi	6043
60-Nd-150	BROND-3	Dec05	Ignatyuk, Tertychnyi	6049
61-Pm-147	JENDL-3.3	Mar90	JNDC	6149
61-Pm-148	JENDL-3.3	Mar90	JNDC	6152
61-Pm-148M	CENDL-3	Sep01	You-Xiang	6153
61-Pm-149	JENDL-3.3	Mar90	JNDC	6155
61-Pm-151	ENDF/B-VII	Mar06	Herman,Oblozinsky,Mughabghab	6161
62-Sm-144	BROND-3	Dec05	Ignatyuk, Tertychnyi	6225
62-Sm-147	BROND-3	Dec05	Ignatyuk, Tertychnyi	6234
62-Sm-148	BROND-3	Dec05	Ignatyuk, Tertychnyi	6237
62-Sm-149	BROND-3	Dec05	Ignatyuk, Tertychnyi	6240
62-Sm-150	BROND-3	Dec05	Ignatyuk, Tertychnyi	6243

62-Sm-151	BROND-3	Dec05	Ignatyuk, Tertychnyi	6246
62-Sm-152	BROND-3	Dec05	Ignatyuk, Tertychnyi	6249
62-Sm-153	BROND-3	Dec05	Ignatyuk, Tertychnyi	6252
62-Sm-154	BROND-3	Dec05	Ignatyuk, Tertychnyi	6255
63-Eu-151	ENDF/B-VII	Jan05	Ge+,	6325
63-Eu-152	ENDF/B-VII	Mar05	JNDC	6328
63-Eu-153	ENDF/B-VII	Sep02	Oblozinsky,Herman,Rochman,Chang+	6331
63-Eu-154	ENDF/B-VII	Jan05	Ge+,	6334
63-Eu-155	CENDL-3	Feb99	You-Xiang	6337
63-Eu-156	JENDL-3.3	Mar90	JNDC	6340
63-Eu-157	ENDF/B-VII	Mar06	Herman,Oblozinsky,Mughabghab	6343