IEC-182

Investigation of Capture Cross Section Differences between JENDL-3.2 and JEF-2.2

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At the previous WPEC meeting at ANL, it was pointed out that the JENDL-3.2 capture cross sections of pseudo fission product were generally smaller than the others of JEF-2.2 and BROND-2. In order to clarify the reason of the discrepancy, we compared the evaluated capture cross sections for 40 highest priority FP nuclides to fast power reactor calculations given in Table 1. In the table, I was surprised, JENDL-3.2 data were larger than JEF-2.2 for about half number of nuclides. Further check of cross sections was made for important 27 nuclides by comparing the JENDL-3.2 with the other evaluated data and the experimental data.

Large discrepancies are observed among the libraries for nuclides such as Sm-151, Ru-103 and Eu-155 whose experimental data is not available in the keV region and contribution to FBR capture rates is high (See Fig.1 for Sm-151). For these nuclides, JENDL-3.2 shows smaller values than JEF-2.2 and BROND-2. It might be pointed out that this discrepancy is due to the difference of parameterization of nuclear model for such nuclides.

The selection of experimental is one of the cause to originate discrepancy between JENDL-3.2 and JEF-2.2. As shown in Figs. 2 and 3 for example of Ag-109 and Sm-149, the JENDL-3.2 evaluation stands on later experimental data of ORNL and JAERI, which were not used for the JEF-2.2 evaluation. The later experiments show a tendency becoming smaller than older ones. New experiments have been made for important nuclides so the difference might affect to the pseudo FP cross sections.

In the lower energy than 1 eV, large difference is observed in the capture cross sections of the pseudo FP between JENDL-3.2 and JEF-2.2 as shown in Fig. 4. The cross sections are mostly contributed by Eu-155. Table 2 compares the resonance parameters for Eu-155: JEF-2.2 adopted artificial ones , I guess, determined so as to reproduce the measured thermal value and resonance integral, but JENDL-3.2 are those evaluated on the basis of the measured resonance data given by Moller et al. (Nucl. Sci. Eng., 8, 183 (1960)), Friesenhahn et al. (Nucl. Phys., A146, 337 (1970)) and Ribon

(CEA-N-1149 (1969)). Moreover, negative resonance was added to JENDL-3.2 so as to reproduce the thermal value and resonance integral for capture of Eu-155 measured by T. Sekine et al. (Appl. Radiat. Isotopes, 38, 513 (1987)). Figure 5 shows a remarkably large difference of cross section below 10 eV between JEF-2 and the other files (JENDLs and ENDF/B-VI).

Besides, the cross sections of JEF-2.2 are those adjusted to the integral data of the STEK experiments. For many nuclides, the C/E values of JENDL-3.2 to the STEK experiments correlate with the cross section ratios of JENDL-3.2 to JEF-2.2 as shown in Table 3 and Fig. 6. The results of integral test for JENDL-3.2 shows a trend of underestimation of reactivity worth by 5% -10% for nuclides having masses more than 130.

Accordingly, it is not strange there is systematic difference between JENDL-3.2 and JEF-2.2.

Additionally, I would like to add the following opinion: Data comparison should be made for originally evaluated data. In statistics of the result of benchmark study, each data should be equally treated not to make a double count. In the present case, ideal benchmark study will be accomplished with that all participants will calculate the quantities of pseudo FP from the common evaluated FP libraries, JEF-2.2, JENDL-3.2, ENDF/B-VI and BROND-2 with their own method. Unfortunately, we did not take such a method and no person has not participate the study from ENDF/B side. I think it is not easy to make a fair conclusion to satisfy all participants.

Participant: T. Nakagawa (JAERI)
T. Watanabe (Kawasaki Heavy Industries, Ltd.)
A. Zukeran (Hitachi Ltd.)
H. Matsunobu (Data EngineeringLtd.)
Y. Nakajima (Research Organization for Information Science & Technology)
M. Kawai (KEK)

Table 1 Status of JENDL-3.2 capture data compared with the 'average' of one group cross sections for 40 high contribution FP nuclides. The table was prepared by referring to only three originally evaluated files: JEF-2.2, JENDL-3.2 and FOND-2.1 (instead of BROND-2). In the following, the difference between JENDL-3.2 and the others (JEF-2.2 and FOND-2.1) are shown with symbol of the sign of plus, minus and asterisk.

Ru101+	Pd105+	Sm149-**	Tc99-*	Cs133-
Pd107-	Rh103+	(Pm147)-*	(Sm151)-**	(Ru103)-**
Mo97-*	Nd145+	(Xe131)+*	Eu153-*	Nd143+
Ru102-	Ag109-*	Ru104+	(Cs135)+**	Pr141+
Mo95+	Mo98-	Mo100+	(Eu155)-**	Pd108+*
Xe132+**	Zr93-*	Sm152-	(Ce141)+	I129+
(Ru106)+	Zr96-**	Pd106+**	I127-	Nd146+
Nd148-*	Xe134-**	La139-	(Nb95)+**	(Zr95)+**

N.B. * Difference> 5% (-: 6 nuclides +: 2 nuclides)
** Difference> 10% (-: 6 nuclides +: 5 nuclides)
-, + JENDL-3.2 is smaller and larger than average, respectively.
( ) No experimental data.

Table 2 Comparison of resonance parameters of Eu-155.

	Er (eV)	J	Γ tot (eV)	Γ n (eV)	Γ γ (eV)
JEF-2.2	1.900000-1	2.000000+0	1.292140-1	2.136000-4	1.290000-1
	1.120000+0	3.000000+0	1.293710-1	3.711400-4	1.290000-1
	2.050000+0	3.000000+0	1.295020-1	5.022900-4	1.290000-1
	2.980000+0	3.000000+0	1.296050-1	6.051400-4	1.290000-1
	3.910000+0	3.000000+0	1.296930-1	6.934300-4	1.290000-1
JENDL-3.2	-5.00000-1	2.00000+0	1.20435-1	1.33500-3	1.19100- 1
	6.02000-1	2.00000+0	9.10800-2	4.08000-3	8.70000- 2
	2.04000+0	3.00000+0	1.00039-1	3.94300-5	1.00000-1
	7.19000+0	3.00000+0	1.00180-1	1.80000-4	1.00000-1
ENDF/B-VI	6.030000-1	3.000000+0	9.850860-2	4.508600-3	9.400000-2
	2.040000+0	2.000000+0	9.405520-2	5.520000-5	9.400000-2
	7.190000+0	3.000000+0	9.418000-2	1.800000-4	9.400000-2

Table 3 C/E values of JENDL-3.2 for STEK experiments and origin of JEF-2.2.

Nuclide	C/E Values	JENDL3.2/JEF2.2	Origin of JEF-2.2	Nuclide	C/E Values	JENDL3.2/JEF2.2	Origin of JEF-2.2
^{101}Ru+	0.94±0.01	1.04	RCN	^{95}Mo	0.99±0.02	1.05	JENDL-1
^{105}Pd+	0.92±0.06	1.01	ENEA/CEA	^{98}Mo*	0.78±0.06	0.93	ENEA/CEA
^{149}Sm-*	0.88±0.06	0.90	RCN	^{100}Mo*	0.45±0.06	1.07	ENEA/CEA
^{99}Tc-	0.80±0.01	0.91	RCN	(^{155}Eu)-**	-	0.47	ENEA/CEA
^{133}Cs-	0.80±0.05	0.94	RCN	^{108}Pd**	1.09±0.11	1.33	RCN
^{107}Pd	0.94±0.01	0.98	RCN	^{132}Xe**	-	1.38	ENDF/B5
^{103}Rh	0.96±0.01	0.99	RCN	^{93}Zr-	0.42±0.44	0.79	ENEA/CEA
(^{147}Pm)-*	0.88±0.05	0.84	RCN	^{152}Sm-	0.85±0.02	0.97	RCN
(^{151}Sm)-**	0.90±0.03	0.62	ENEA	(^{141}Ce)	-	1.00	ENEA/CEA
(^{103}Ru)-**	-	0.42	ENEA/CEA	^{129}I	1.06±0.06	1.04	RCN
^{97}Mo	0.96±0.02	1.02	JENDL-1	(^{106}Ru)	-	1.05	ENDF/B5
^{145}Nd*	0.84±0.02	0.99	RCN	^{96}Zr-**	0.66±0.05	1.09	ENEA/CEA
(^{131}Xe)*	1.00±0.10	1.18	ENDF/B5	^{106}Pd**	1.17±0.09	1.37	RCN
^{153}Eu-*	0.92±0.01	0.94	ENDF/B5	^{127}I-	0.84±0.01	0.97	RCN
^{143}Nd*	0.90±0.01	1.01	ENEA	^{146}Nd*	0.13±0.47	1.13	RCN
^{102}Ru-*	1.07±0.14	1.04	ENDF/B5	^{148}Nd-*	0.79±0.06	0.87	RCN
^{109}Ag-*	0.63±0.16	0.87	RCN	^{134}Xe-**	-	0.76	ENDF/B5
^{104}Ru	1.06±0.14	1.09	ENDF/B5	^{139}La-*	0.70±0.03	1.03	RCN
(^{135}Cs)**	0.88±0.05	0.93	ENEA	(^{95}Nb)*	-	1.05	ENEA/CEA
^{141}Pr*	0.96±0.01	0.99	RCN	(^{95}Zr)**	-	2.32	ENEA/CEA

N.B. As for Zr, Nd and Sm isotopes, reactivity worth was measured for oxide sample, i.e., ZrO2, Nd_2O_3 and Sm_2O_3. For these oxide samples, there is a trend of underestimation of worths, perhaps due to underestimating scattering worth of oxygen.

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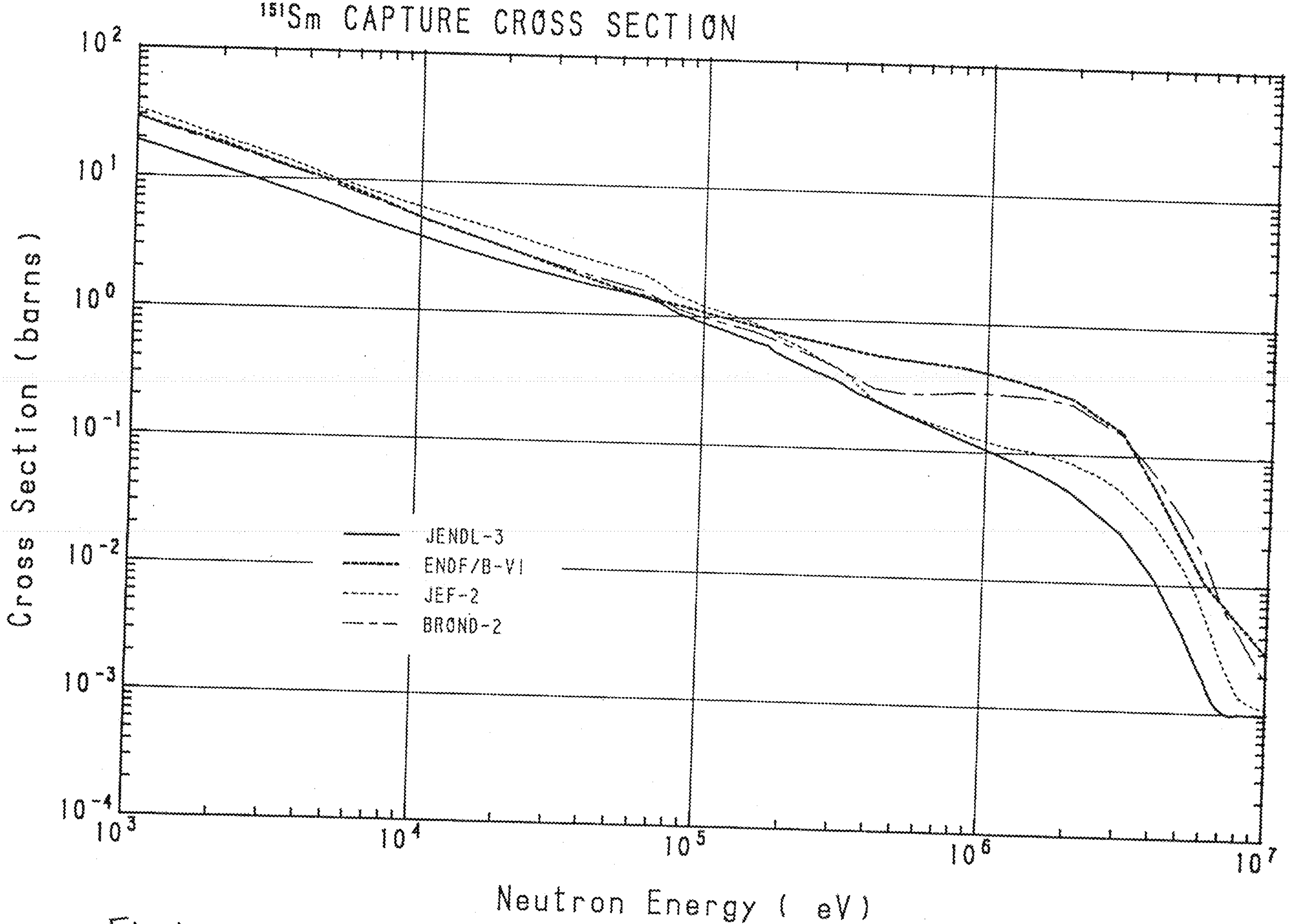

^{151}Sm CAPTURE CROSS SECTION
Cross Section (barns)
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}
Neutron Energy (eV)
JENDL-3
ENDF/B-VI
JEF-2
BROND-2

Fig. 1

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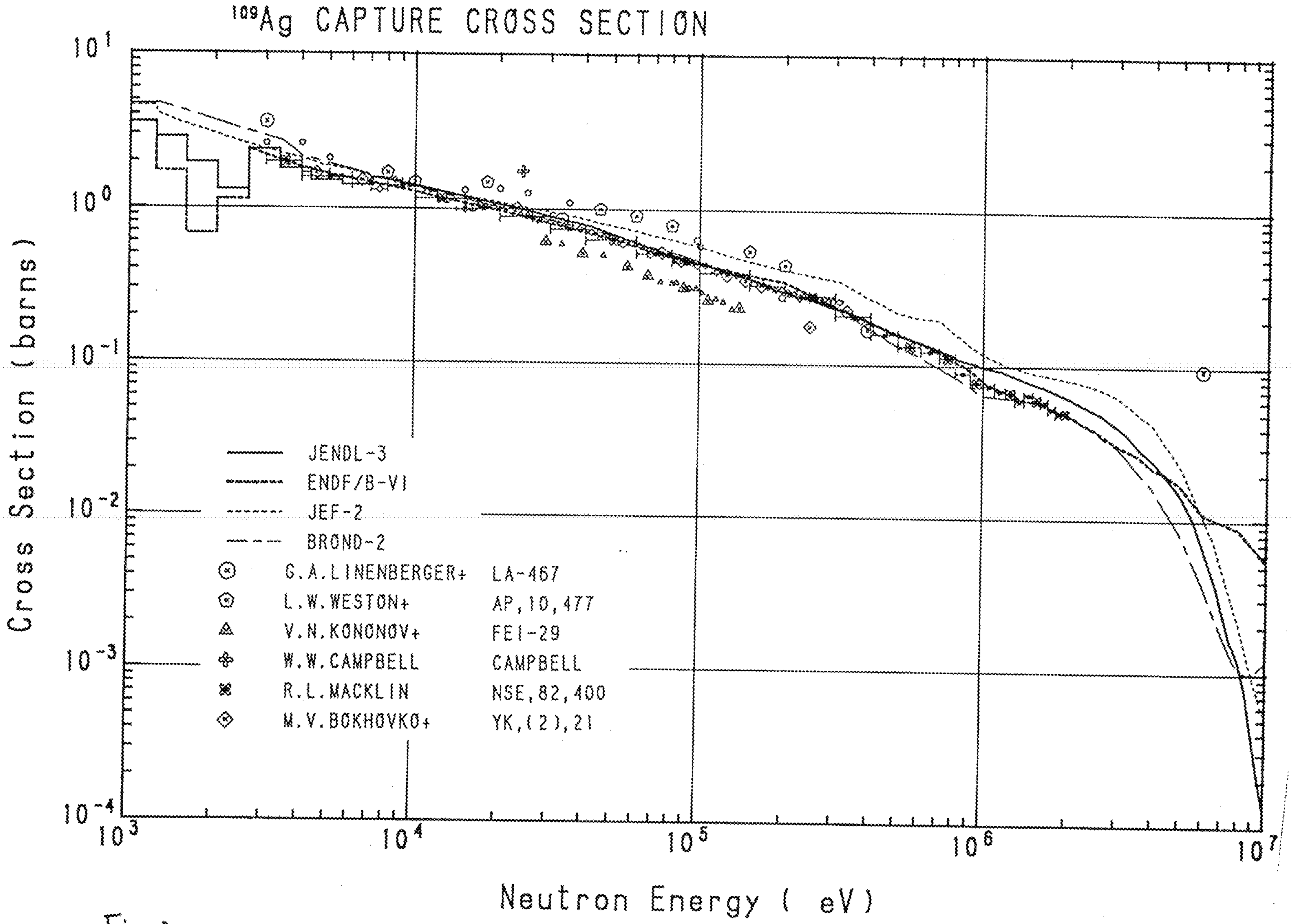
^{109}Ag CAPTURE CROSS SECTION
Cross Section (barns)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{3}
10^{4}
10^{5}
10^{6}
10^{7}
Neutron Energy (eV)
JENDL-3
ENDF/B-VI
JEF-2
BROND-2
G.A.LINENBERGER+ LA-467
L.W.WESTON+ AP,10,477
V.N.KONONOV+ FEI-29
W.W.CAMPBELL CAMPBELL
R.L.MACKLIN NSE,82,400
M.V.BOKHOVKO+ YK,(2),21

Fig. 2

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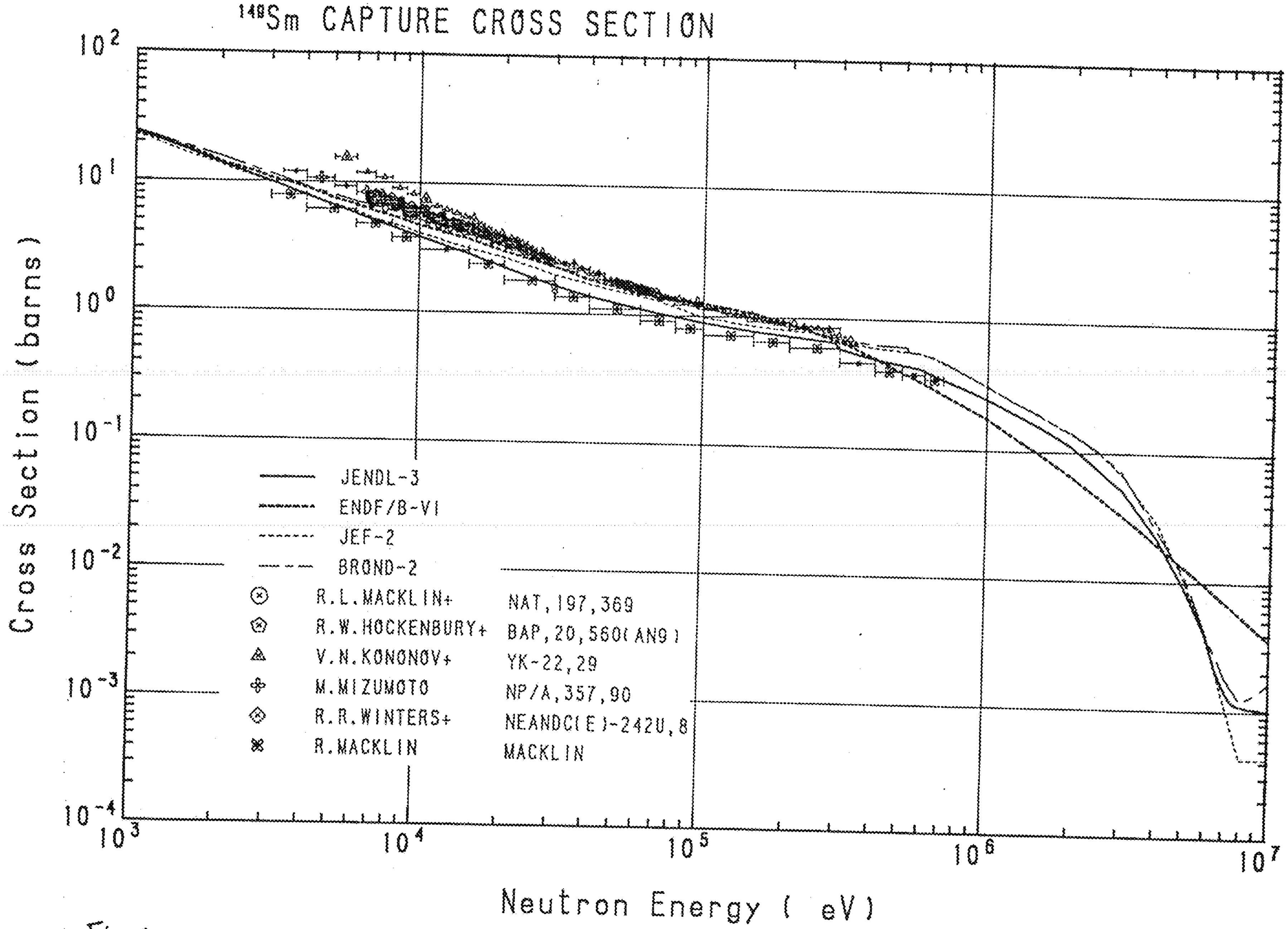
^{148}Sm CAPTURE CROSS SECTION
Cross Section (barns)
Neutron Energy (eV)
10^2
10^1
10^0
10^-1
10^-2
10^-3
10^-4
10^3
10^4
10^5
10^6
10^7
JENDL-3
ENDF/B-VI
JEF-2
BROND-2
R.L.MACKLIN+ NAT,197,369
R.W.HOCKENBURY+ BAP,20,560(AN9)
V.N.KONONOV+ YK-22,29
M.MIZUMOTO NP/A,357,90
R.R.WINTERS+ NEANDC(E)-242U,8
R.MACKLIN MACKLIN

Fig. 3

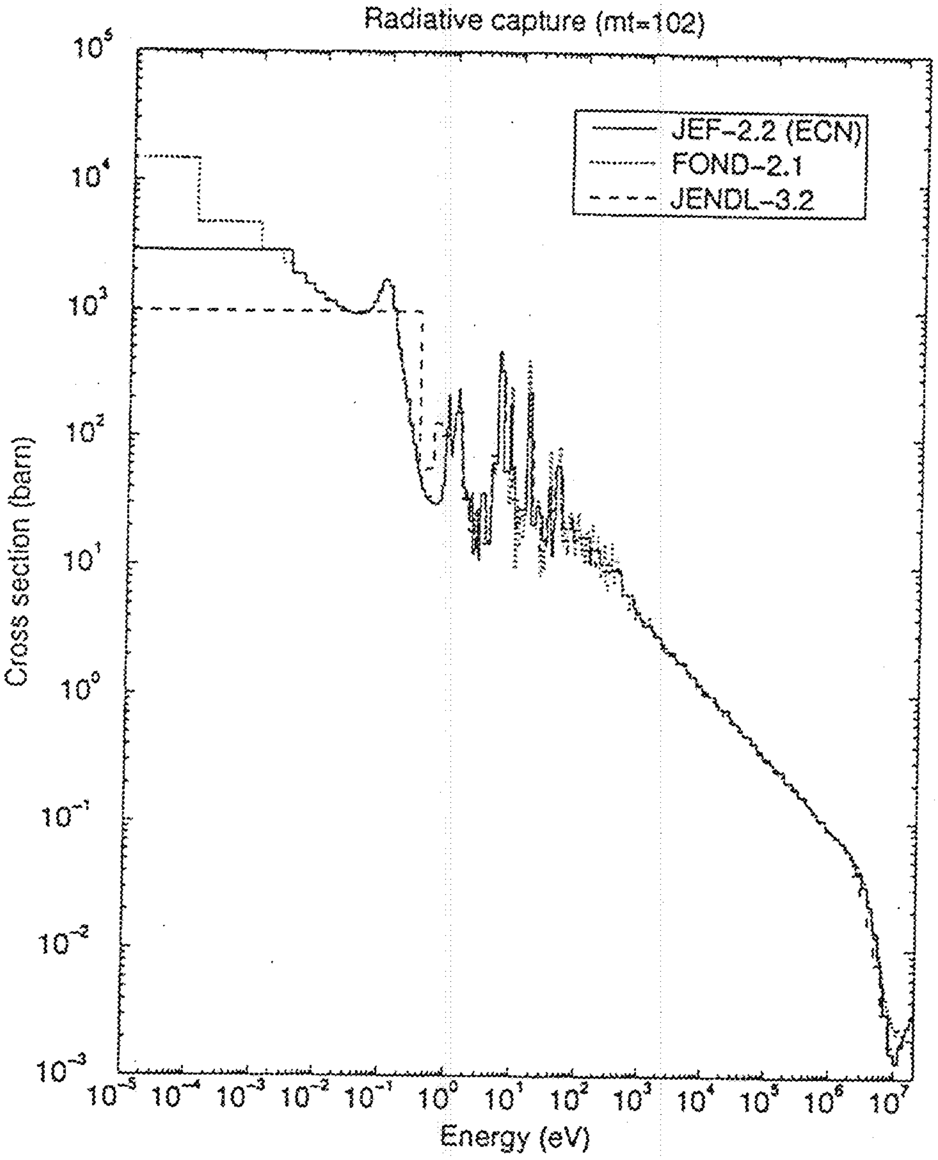

Figure 4.1 *The radiative capture cross section of the lumped nuclide as a function of the energy. Above 1 keV, the pseudo fission product behaves as a 1/v nuclide. The EAF-4.2 results are not shown because they are very close to JEF-2.2. The BROND-2 results are shown in Appendix C where a full comparison is given. The ADL-3 results are not available.*

Fig. 4

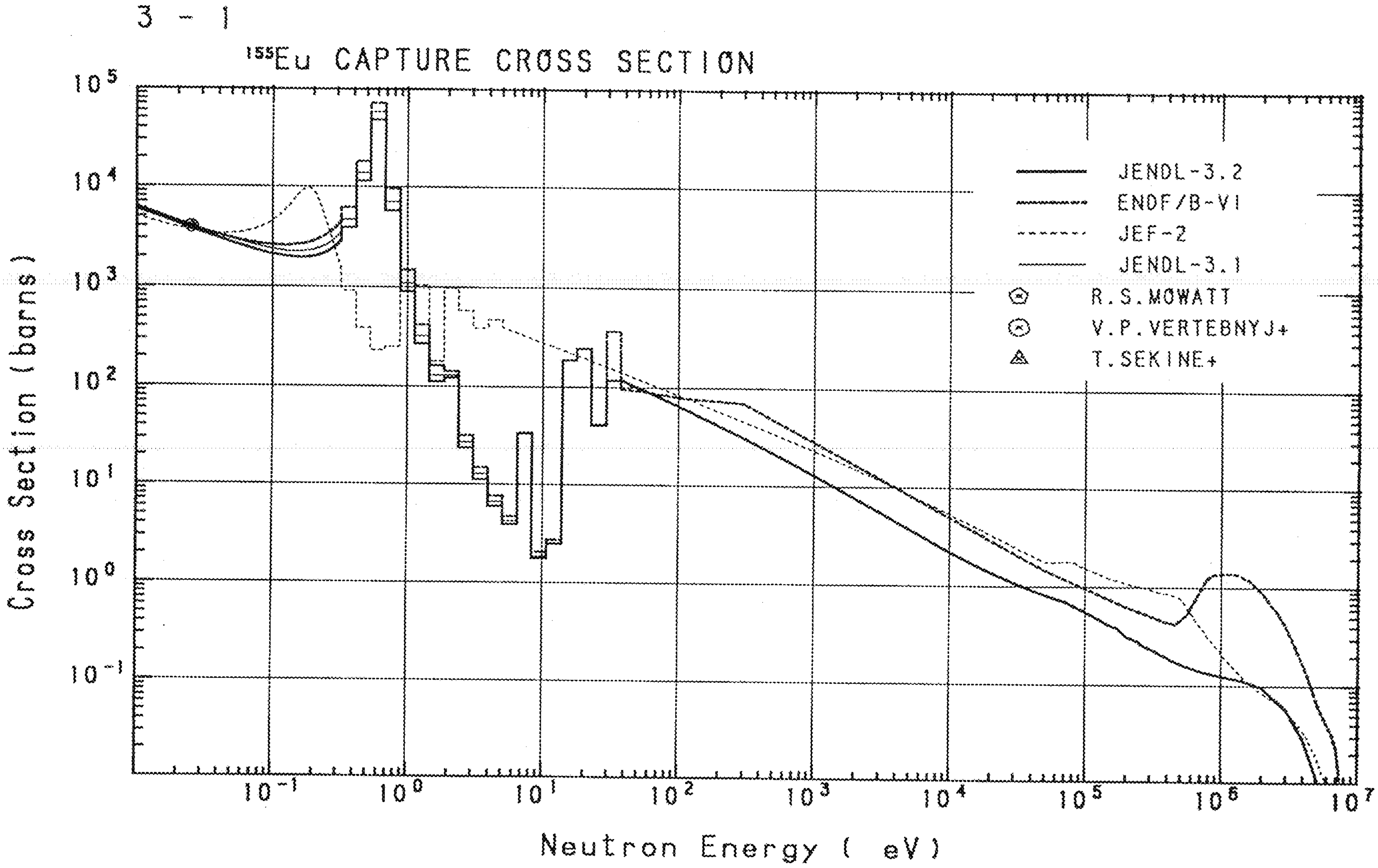
3 - 1
^{155}Eu CAPTURE CROSS SECTION
JENDL-3.2
ENDF/B-VI
JEF-2
JENDL-3.1
R.S.MOWATT
V.P.VERTEBNYJ+
T.SEKINE+
Cross Section (barns)
10^5
10^4
10^3
10^2
10^1
10^0
10^-1
10^-1
10^0
10^1
10^2
10^3
10^4
10^5
10^6
10^7
Neutron Energy (eV)

Fig. 5

Fig.~~4~~6 Correlation between JENDL3.2/JEF2.2 and C/E for STEK Worth

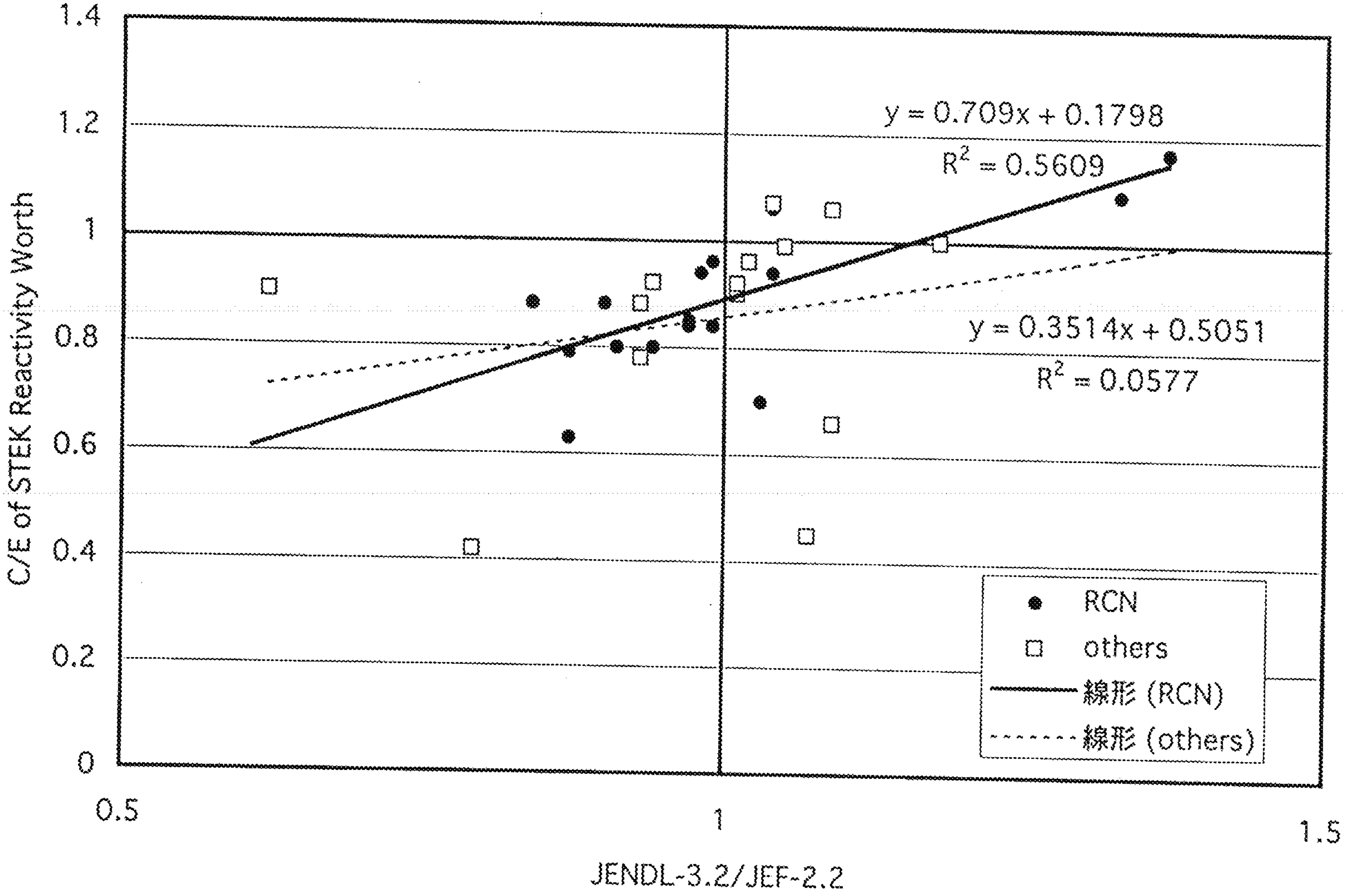

Fig. 6