Status of the ^{239}Pu+n Evaluated Data in the Resolved Resonance Region

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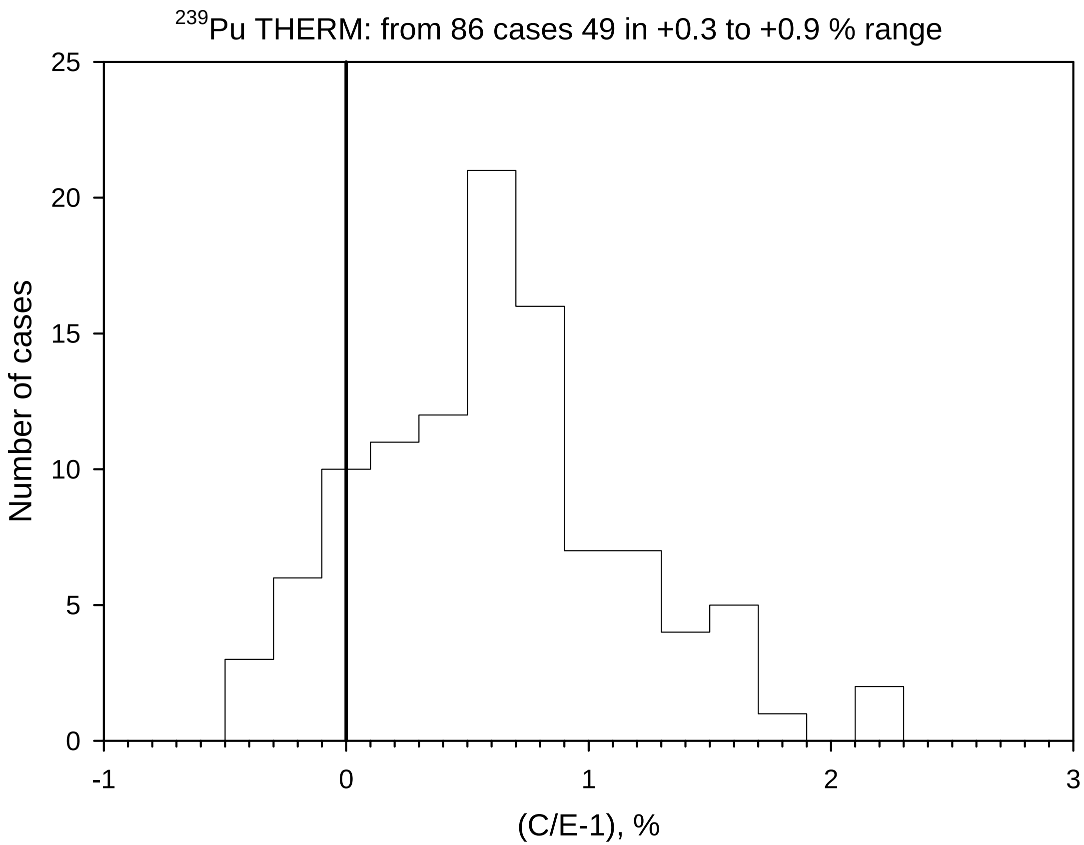
ENDF/B-VII.0 and JENDL-3.1 ^{239}Pu Files

- the files are identical in the resolved resonance region ($E_n < 2.5$ keV)

- the average over-prediction of criticalities for most “clean” thermal Plutonium assemblies is +0.7% (700 pcm)

- the outliers are mostly assemblies with reflectors with different materials

- the C/E displacement distribution looks like the sum of two distributions



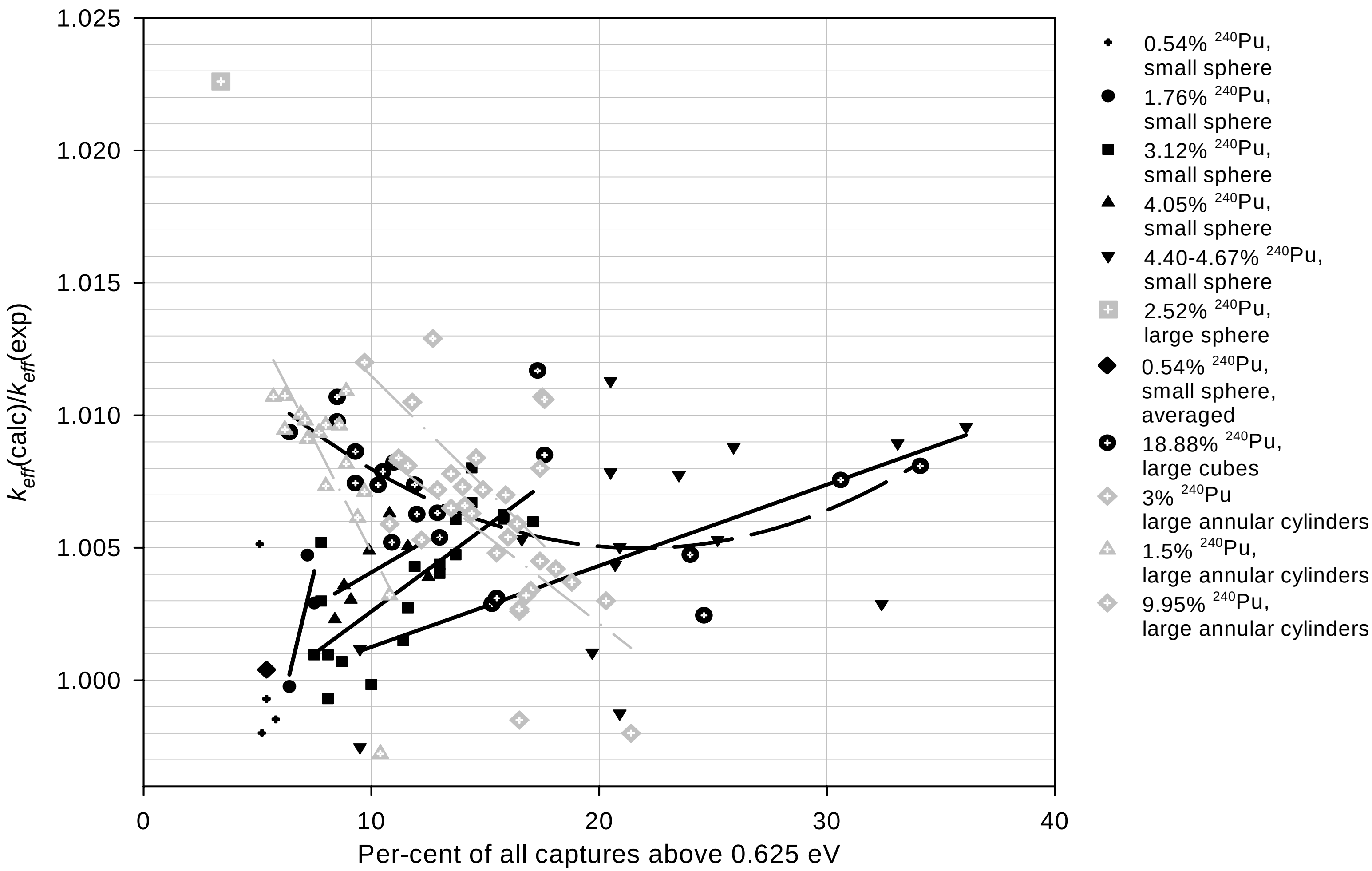
C/E for 86 “clean” thermal plutonium critical assemblies (according to *Van der Marck S.C.* Benchmarking ENDF/B-VII.0 // Nuclear Data Sheets – 2006. – Vol. 107. - P. 3061 – 3117)

If percent of total captures above 0.625 eV is used as an independent variable (parameter) for data presentation:

- C/E displacements are split into 2 groups for low values of the percent of captures above 0.625 eV neutron energy (for thermal spectra)

-small spheres (closed symbols, “large” neutron leakage) and large spheres, large cubes and large cylinders (open symbols, “small” neutron leakage) have on average about 1 % difference in the criticality prediction for assemblies with the softest spectra

- the reason for these differences can be too low a value of the capture cross section (or $\alpha=\sigma_c/\sigma_f$) in the resolved resonance region (0.6 – 1000 eV)



C/E for 86 “clean” thermal plutonium critical assemblies showing dependence on percent of all captures above 0.625 eV:

closed symbols (fits with solid lines) – small spheres.

open symbols (fits with dashed, dot-dashed lines) – large spheres, large cubes and large annular cylinders

^{239}Pu cross sections in the neutron energy range above 0.625 eV:

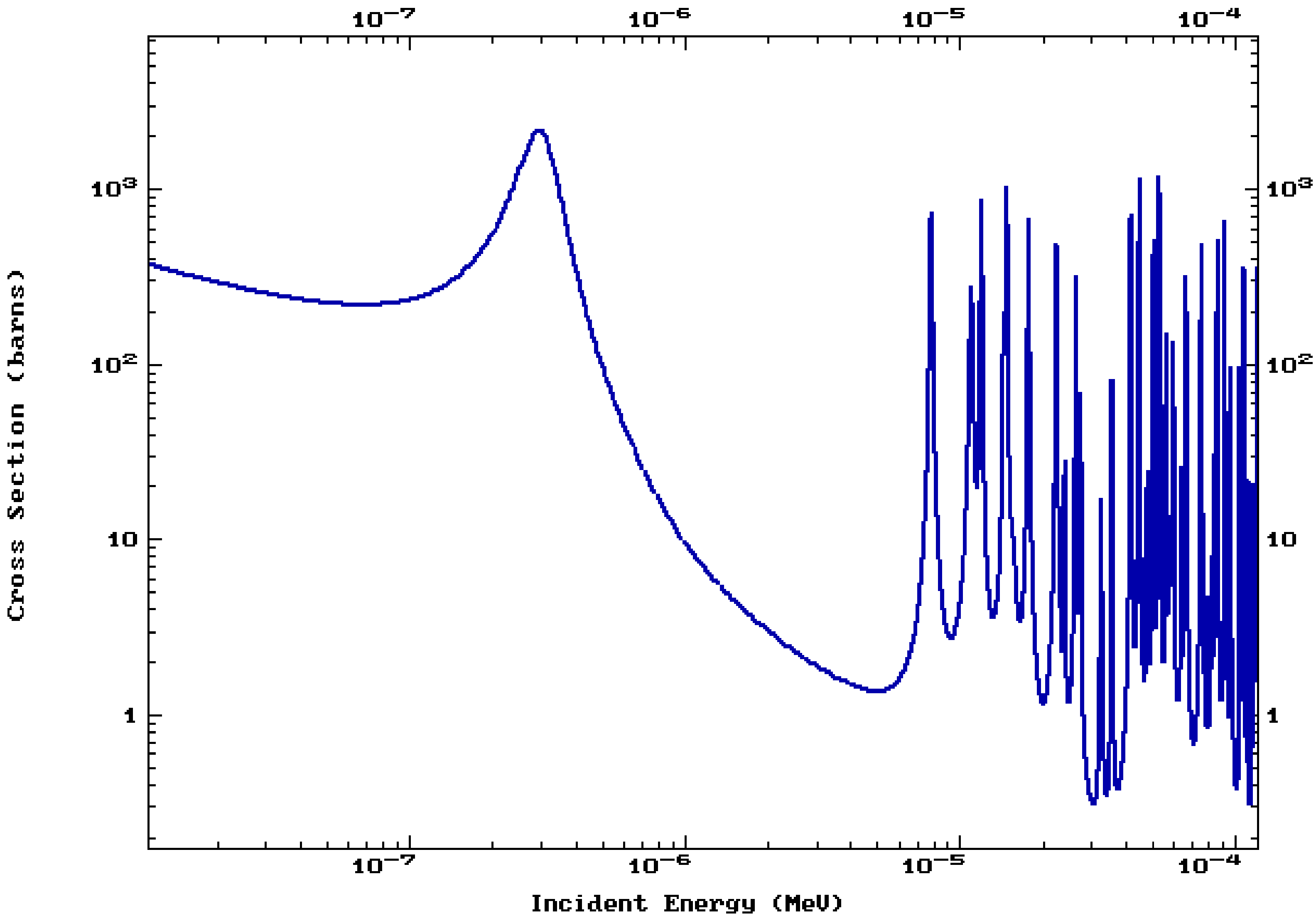
- have a large gap between the first and second resonance (about 7 eV)

- have a maximum total cross section in the resonances of about 2000 barns

- “black resonance” (or thick sample) conditions (e.g., transmission in the maximum less than 0.1) occur if the thickness of the sample is more than 0.001 atoms/barn

- the results of measurements are available for densities of samples of 0.07375, 0.01803, 0.00638 at/barn, transmission, (ORNL, Harvey, 1988); 0.000594 at/barn, transmission (ORNL, Spencer, 1987); 0.000000193 at/barn, absorption (ORNL, Gwin, 1975)

- for comparison, in the case of ^{238}U, transmissions are available for samples with thicknesses in the range of 0.0000028 to 0.16 at/barn

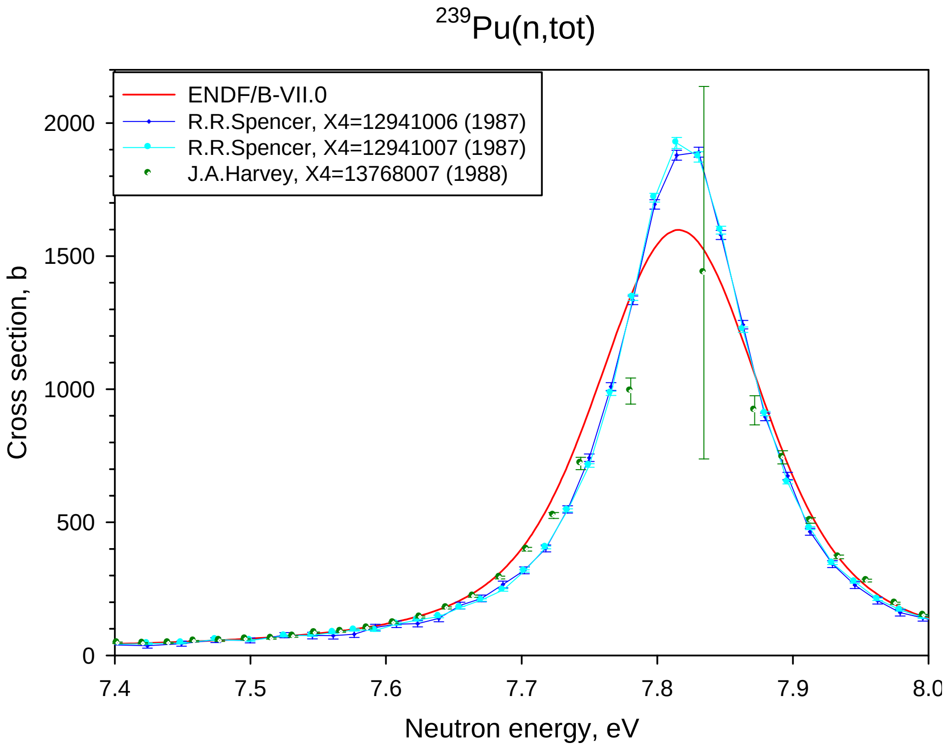


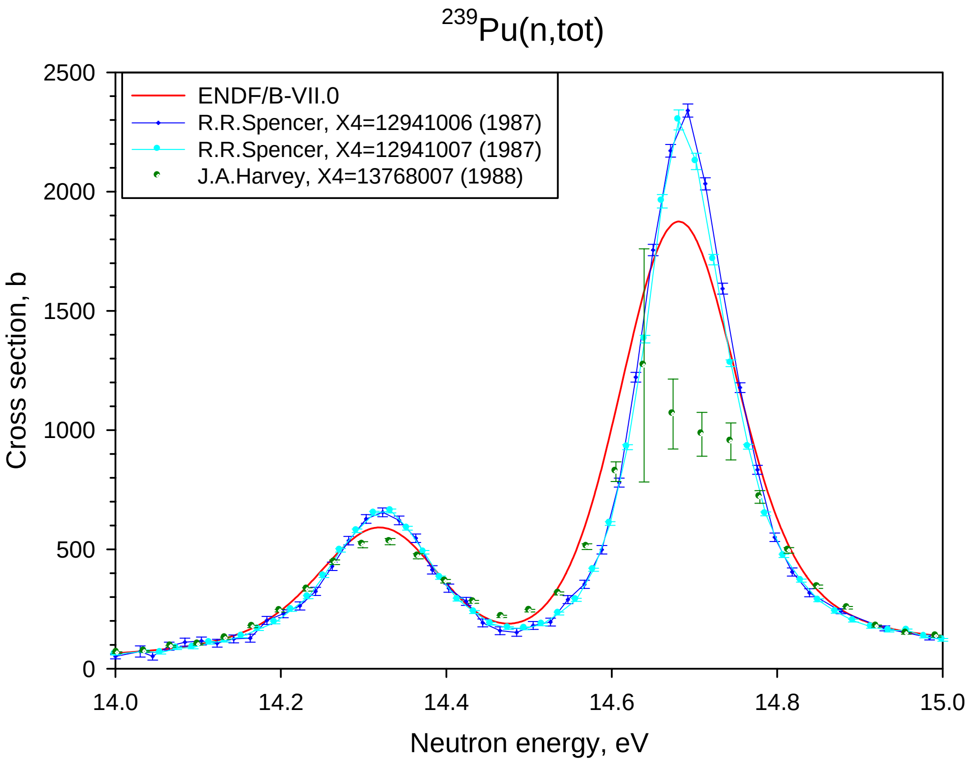
Capture neutron cross section of ^{239}Pu (ENDF/B-VII.0 evaluation.

239Pu cross sections in the neutron energy range above 0.625 eV: (cont.)

- The present evaluation of the ^{239}Pu cross sections is based exclusively on thick sample measurements by Harvey (1988)

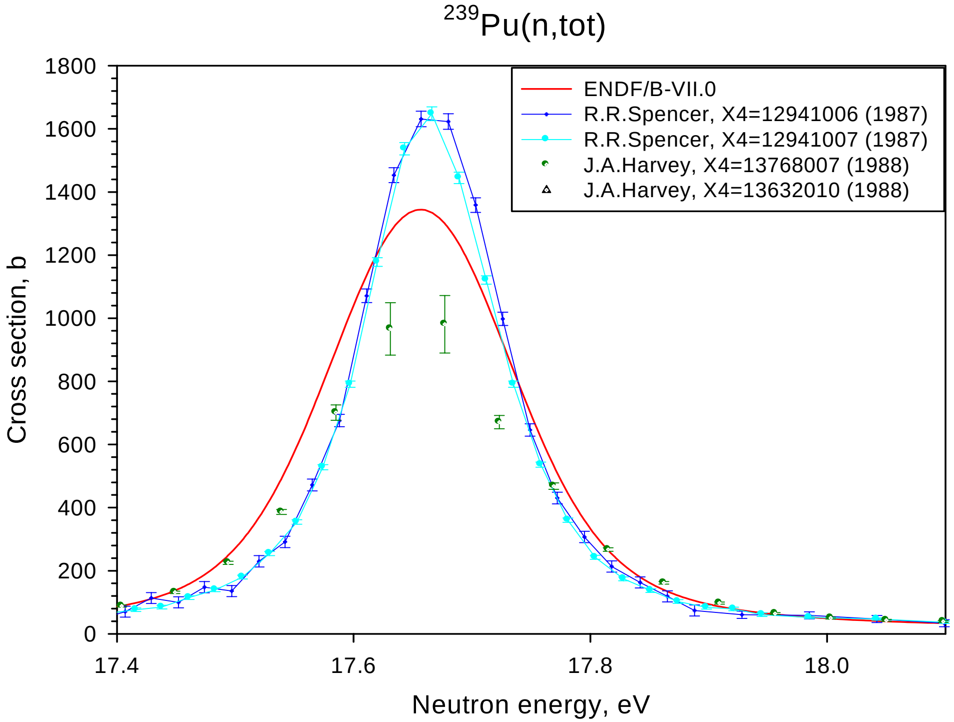
- The last revision of the resonance parameters (as in ENDF/B-VII.0 now) led to an increase of the fission cross section in the RRR (0.1 – 1 keV) of about 3% to make the fission cross section consistent with values obtained in the standards (ENDF/B-VI standard) evaluation and in re-analysis of the Weston & Todd fission measurements. This led to a reduction in the capture cross section since the total cross section was not changed since it was obtained from thick target measurements

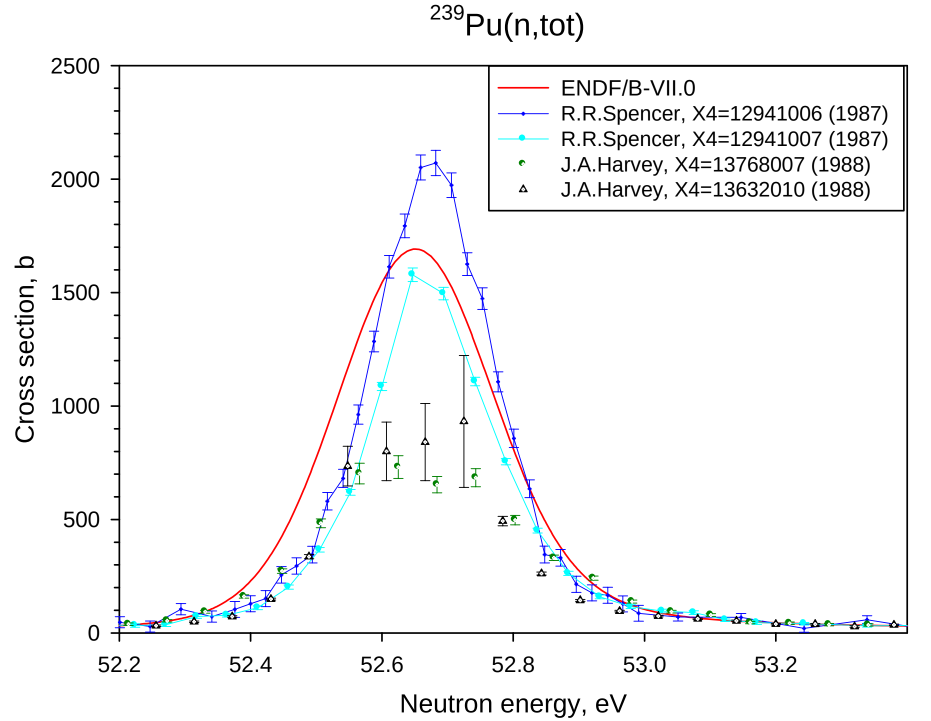




ENDF/B-VII evaluation compared with experimental total cross sections obtained from transmissions without taking into account the “black” resonance effect:

thin sample – Spencer (1987); **thick sample** – Harvey (1988)





ENDF/B-VII evaluation compared with experimental total cross sections obtained from transmissions without taking into account the “black” resonance effect:

thin sample – Spencer (1987); **thick sample** – Harvey (1988)

- transmission data by Spencer (thin sample) and absorption data by Gwin were not used in the resonance parameter fit

- the use of thin and thick sample data allows values in the minima and maxima of the cross sections to be determined with better accuracy

The α-values in present ENDF/B-VII evaluation are discrepant with Gwin’s experimental results (taken from ENDF-B-VII.0 free text description):

Energy (eV)	Cross Sections (barn) calc. values (293 K)			Gwin data			
	CAPT	ABSORP	ALPHA	CAPT	ABSORP	ALPHA	Gwin/B-7 α
7.3- 16.0	76.61	196.04	0.64	88.45	208.00	0.74(*)	1.16
16.0- 37.5	20.51	44.55	0.85	21.9	46.50	0.89(*)	1.05
37.5- 50.0	48.72	70.00	2.29	62.4	83.15	2.96(*)	1.19
50.0-100.0	33.60	92.13	0.57	35.9	92.84	0.63	1.11
00.0-200.0	15.58	34.29	0.83	15.17	33.66	0.87	1.05
00.0-300.0	15.85	33.68	0.89	16.79	34.69	0.94	1.06
00.0-400.0	9.69	18.01	1.16	9.83	18.31	1.16	1.00
00.0-500.0	3.96	13.56	0.41	4.16	13.56	0.44	1.07
00.0-600.0	10.87	26.30	0.70	11.08	26.54	0.72	1.03
00.0-700.0	6.53	10.90	1.49	7.02	11.57	1.54	1.03
00.0-800.0	4.95	10.47	0.90	5.18	10.52	0.97	1.08
00.0-900.0	3.65	8.50	0.75	4.20	9.30	0.82	1.09
00.0-999.9	5.06	13.51	0.60	5.40	13.23	0.70	1.17

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(*) Gwin 1971 data

Solution to the Problem:

- new transmission measurements with thin samples (0.0005 – 0.0001 atoms/barn) should be made and used in the R-matrix analysis

- or as minimum, all thin target measurements should be used in new R-matrix analyses and fits.

JEFF-3.1.1 Approach to the Problem

A technical solution was used in the JEFF-3.1.1 file for ^{239}Pu, to improve agreement with the criticality benchmarks:

- starting with the same set of parameters as in the ENDF/B-VII.0 file, an artificial small negative resonance was added to increase the capture below 0.0253 eV without changing the cross section at 0.0253 eV

- nu-prompt was reduced by about 1% comparing with the standards (thermal constants) evaluation