14th October, 1997

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Dear Harm,

How are you? I must apologize to delay sending you the comment on the draft of ECN-R-97: Final Report of SWG17 of WPEC because of my new hard job on the system integration of the IFMIF (International Fusion Material Irradiation Facility) Project at JAERI.

The draft sent from you in May was distributed to all members of FP Nuclear Data Working Group in JNDC. After I prepared graphs comparing evaluated capture cross sections in JEF-2.2, JENDL-3.2, ENDF/B-VI and BROND-2 for about thirty highest priority nuclides to fast power rectors with the experimental data, we had a meeting and discussed on causes of the cross section differences mainly between JENDL-3.2 and JEF-2.2. On the basis of the discussions and further investigation, I have reached a conclusion on differences and prepared the comment.

The comment on the final report and the description of cross section comparison for each nucleus are given in the separate sheets together with graphs comparing capture cross sections for the 20 highest priority FP nuclides and 7 nuclides specified by higher RMS than 10% within the second priority (20) nuclides, according to Table I which was prepared by referring to only three originally evaluated files: JEF-2.2, JENDL-3.2 and FOND-2 (instead of BROND-2). The causes of the difference between JEF-2.2 and JENDL-3.2 are also discussed. I would like to ask you to add H. Matsunobu (Data Engineering) and Y. Nakasima (RIST) to the authors list. Besides, our contribution is noted as 'FP Nuclear Data Working Group of Japanese Nuclear Data Committee (abbreviated as JNDC)' in P.10 of the draft of ECN-R-97. Please correct all 'JNDL' in the tables and figures of the draft paper into JNDC.

I hope this comment will be helpful to complete the final report. Thank you very much for your efforts on the activities of both SWG17 and 10.

Sincerely yours,

川合將義

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**Table I Status of JENDL-3.2 capture data compared with the 'average' of one group cross sections for 40 high contribution FP nuclides, given in Table 5.1 of ECN-R-97-Draft**

In the following table, the difference between JENDL-3.2 and the others (ECN-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.

# Status of pseudo fission-product cross sections for fast reactors

# Results of the SWG17

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Heavy Ind.

Could you ask comments from Japanese authors, before I publish it?
Thank you very much!

**The following are my opinion to the final report of SG17.**

**(1) Data comparison should be made for originally evaluated data.**

I think only JEF-2.2, JENDL-3.2, ENDF/B-VI and BROND-2 are adopted as an original evaluation of fission product nuclides for general purpose: FOND-2.1 is a mixed library composed of BROND-2 and others. Since activation files lack some kinds of partial cross sections, comparison between them and the FP libraries may bring a misunderstanding. However, there are no small numbers of nuclides that smooth cross sections of JEF-2.2 and ENDF/B-VI are identical, because they were adopted from ENDF/B-V. Then, to treat each original evaluation without any unequal tendency may be difficult.

**(2) Statistics and evaluation for results**

In Tables 4.1 through 5.3, averaged cross sections and their standard deviation are given. Data counting for statistics should be made with a equal weight per each library. It is good that you have paid an attention not to make a double count of the data in Tables 4.1 and 4.2. Even so, since there are so many data which were not used for average that it is troublesome for us to distinguish the data used for average from them, I think, the confusing data should be omitted. If it is needed to discuss on some kinds of effect on cross section averaging, you can prepare a separate table as like Table 4.3 for spectrum effect, and explain more clearly it without confusing readers. I would also like to point out some misprints of average:

Table 4.1 MAT= 16 1.14 ---> 1.12
MAT= 107 7.8 ---> 6.99 ( 9.87 with considering 21.4 $\mu$ b for JENDL-3.2)
Table 4.2 MAT= 102 -0.567 ----> -0.566
MAT=Total -0.644 ----> -0.642

Besides, since JENDL-3.2 contains all threshold reaction cross sections, the results for them should be added to Table 4.1, i.e., 5.37 $\mu$ b for MT=103 and 21.4 $\mu$ b for MT=107.

In Tables 5.1 to 5.3, the results of JEF-2.2 are doubly counted, although the results for JEF-2.2 were reported from the different organizations. ADL-3 is an activation library. What meaning exists in such statistics? I also wonder why there are not small differences between CEA and ECN results for JEF-2.2. Especially, large differences (about 20% in maximum) are observed in (n, 2n) cross sections. The reason should be discussed in order to clarify problems on the nuclear data and the present benchmarking methodology. Accordingly, in the following table (Table II), I would like to show you the results compared among ECN-JEF-2.2, FOND-2.1 (instead of BROND-2) and JENDL-3.2. In the 8th column, the relative difference between the

JENDL-3.2 and averaged values are given. The difference shown in Table I are adopted from Table II.

**Table II Average and RMS of 1 Group (n, $\gamma$) Cross Sections for Libraries by 3 Facilities**

| No. | Nuclide | ECN JEF-2.2 | IPPE FOND-2.1 | JNDC JENDL-3.2 | Average | RMS(%) | %Diff.J-3.2 |
|---|---|---|---|---|---|---|---|
| 1 | Ru-101 | 0.7243 | 0.7616 | 0.7523 | 0.746067 | 2.12484 | 0.83549 |
| 2 | Pd-105 | 0.9490 | 0.9161 | 0.9594 | 0.941500 | 1.96023 | 1.90122 |
| 3 | Sm-149 | 2.5437 | 2.8700 | 2.2990 | 2.570900 | 9.09805 | -10.57606 |
| 4 | Tc--99 | 0.6479 | 0.6561 | 0.5923 | 0.632100 | 4.48367 | -6.29647 |
| 5 | Cs-133 | 0.5167 | 0.5184 | 0.4874 | 0.507500 | 2.80390 | -3.96059 |
| 6 | Pd-107 | 1.0700 | 1.0399 | 1.0520 | 1.053967 | 1.17335 | -0.18660 |
| 7 | Rh-103 | 0.6832 | 0.6526 | 0.6774 | 0.671067 | 1.97758 | 0.94377 |
| 8 | Pm-147 | 1.5167 | 1.4309 | 1.2753 | 1.407633 | 7.09808 | -9.40112 |
| 9 | Sm-151 | 3.3998 | 2.9413 | 2.1080 | 2.816367 | 18.98627 | -25.15179 |
| 10 | Ru-103 | 1.1992 | 1.2140 | 0.5047 | 0.972633 | 34.02454 | -48.10994 |
| 11 | Mo--97 | 0.3406 | 0.3568 | 0.3484 | 0.348600 | 1.89763 | -0.05737 |
| 12 | Nd-145 | 0.5700 | 0.5124 | 0.5648 | 0.549067 | 4.73786 | 2.86547 |
| 13 | Xe-131 | 0.2937 | 0.3323 | 0.3461 | 0.324033 | 6.84388 | 6.81000 |
| 14 | Eu-153 | 2.7655 | 2.9288 | 2.5958 | 2.763367 | 4.91991 | -6.06386 |
| 15 | Nd-143 | 0.3550 | 0.3370 | 0.3589 | 0.350300 | 2.72291 | 2.45504 |
| 16 | Ru-102 | 0.1581 | 0.1796 | 0.1642 | 0.167300 | 5.40760 | -1.85296 |
| 17 | Ag-109 | 0.7927 | 0.7203 | 0.6916 | 0.734867 | 5.78877 | -5.88769 |
| 18 | Ru-104 | 0.1546 | 0.1658 | 0.1685 | 0.162967 | 3.69274 | 3.39538 |
| 19 | Cs-135 | 0.2445 | 0.1361 | 0.2284 | 0.203000 | 23.52704 | 12.51232 |
| 20 | Pr-141 | 0.1582 | 0.1540 | 0.1564 | 0.156200 | 1.10145 | 0.12804 |
| 21 | Mo--95 | 0.3204 | 0.3351 | 0.3360 | 0.330500 | 2.16376 | 1.66415 |
| 22 | Mo--98 | 0.1280 | 0.1179 | 0.1194 | 0.121767 | 3.65450 | -1.94361 |
| 23 | Mo-100 | 0.0938 | 0.1011 | 0.1000 | 0.098300 | 3.26909 | 1.72940 |
| 24 | Eu-155 | 2.8428 | 2.9559 | 1.3368 | 2.378500 | 31.02959 | -43.79651 |
| 25 | Pd-108 | 0.1770 | 0.2507 | 0.2358 | 0.221167 | 14.38618 | 6.61643 |
| 26 | Xe-132 | 0.0708 | 0.0755 | 0.0980 | 0.081433 | 14.57696 | 20.34384 |
| 27 | Zr--93 | 0.1335 | 0.1042 | 0.1057 | 0.114467 | 11.76982 | -7.65871 |
| 28 | Sm-152 | 0.4956 | 0.5077 | 0.4799 | 0.494400 | 2.30198 | -2.93285 |
| 29 | Ce-141 | 0.2963 | 0.2960 | 0.2977 | 0.296667 | 0.24973 | 0.34831 |
| 30 | I--129 | 0.3700 | 0.3804 | 0.3840 | 0.378133 | 1.56980 | 1.55148 |
| 31 | Ru-106 | 0.0871 | 0.0946 | 0.0916 | 0.091100 | 3.38332 | 0.54885 |
| 32 | Zr--96 | 0.0358 | 0.0590 | 0.0391 | 0.044633 | 22.95977 | -12.39731 |
| 33 | Pd-106 | 0.2027 | 0.2553 | 0.2772 | 0.245067 | 12.75711 | 13.11208 |
| 34 | I--127 | 0.6199 | 0.6307 | 0.6028 | 0.617800 | 1.85926 | -2.42797 |
| 35 | Nd-146 | 0.0956 | 0.1100 | 0.1076 | 0.104400 | 6.03372 | 3.06513 |
| 36 | Nd-148 | 0.1681 | 0.1636 | 0.1469 | 0.159533 | 5.71671 | -7.91893 |
| 37 | Xe-134 | 0.0360 | 0.0374 | 0.0272 | 0.033533 | 13.46322 | -18.88668 |
| 38 | La-139 | 0.0333 | 0.0390 | 0.0343 | 0.035533 | 6.99362 | -3.47092 |
| 39 | Nb--95 | 0.3496 | 0.2705 | 0.3669 | 0.329000 | 12.75512 | 11.51976 |
| 40 | Zr--95 | 0.0643 | 0.1229 | 0.1489 | 0.112033 | 31.58188 | 32.90687 |
| 41 | Pd-110 | 0.0985 | 0.2189 | 0.1291 | 0.148833 | 34.33054 | -13.25868 |
| 42 | Cd-111 | 0.4665 | 0.4683 | 0.7475 | 0.560767 | 23.54677 | 33.29965 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 43 | Sm-147 | 1.4660 | 1.4183 | 1.2719 | 1.385400 | 5.96112 | -8.19258 |
| 44 | Nd-150 | 0.1748 | 0.1729 | 0.1626 | 0.170100 | 3.15093 | -4.40917 |
| 45 | Eu-154 | 3.1233 | 3.1720 | 3.4503 | 3.248533 | 4.43428 | 6.21101 |
| 46 | Pr-143 | 0.4095 | 0.4206 | 0.1263 | 0.318800 | 42.72066 | -60.38269 |
| 47 | Gd-157 | 1.8389 | 1.6372 | 1.3578 | 1.611300 | 12.24230 | -15.73264 |
| 48 | Zr--92 | 0.0368 | 0.0433 | 0.0418 | 0.040633 | 6.83894 | 2.87121 |
| 49 | Zr--91 | 0.0789 | 0.0790 | 0.0913 | 0.083067 | 7.00881 | 9.91172 |
| 50 | Gd-156 | 0.6156 | 0.7077 | 0.7059 | 0.676400 | 6.35694 | 4.36132 |
| 51 | Zr--94 | 0.0237 | 0.0271 | 0.0258 | 0.025533 | 5.48614 | 1.04439 |
| 52 | Nd-147 | 1.0173 | 0.7995 | 1.2315 | 1.016100 | 17.35708 | 21.19870 |
| 53 | Cs-137 | 0.0280 | 0.0160 | 0.0160 | 0.020000 | 28.28427 | -20.00000 |
| 54 | Ce-142 | 0.0442 | 0.0186 | 0.0252 | 0.029333 | 36.99592 | -14.09091 |
| 55 | Ce-144 | 0.0490 | 0.0337 | 0.0241 | 0.035600 | 28.80275 | -32.30337 |
| 56 | Tb-159 | 1.7482 | 2.0672 | 1.8546 | 1.890000 | 7.01667 | -1.87302 |
| 57 | Sm-154 | 0.2507 | 0.2729 | 0.2471 | 0.256900 | 4.44094 | -3.81471 |
| 58 | Kr--83 | 0.2465 | 0.2422 | 0.2806 | 0.256433 | 6.69895 | 9.42415 |
| 59 | Nd-144 | 0.0807 | 0.0936 | 0.0829 | 0.085733 | 6.57226 | -3.30482 |
| 60 | Te-128 | 0.0416 | 0.1029 | 0.0408 | 0.061767 | 47.09254 | -33.94495 |
| 61 | Pm-148 | 4.1781 | 4.2530 | 3.2167 | 3.882600 | 12.15305 | -17.15088 |
| 62 | Pm-149 | 3.5548 | 3.6200 | 1.2367 | 2.803833 | 39.53339 | -55.89253 |
| 63 | Ce-140 | 0.0135 | 0.0123 | 0.0061 | 0.010633 | 30.49627 | -42.63323 |
| 64 | Cd-116 | 0.1182 | 0.8856 | 0.0823 | 0.362033 | 102.34072 | -77.26729 |
| 65 | Br--81 | 0.4293 | 0.3892 | 0.2777 | 0.365400 | 17.55274 | -24.00109 |
| 66 | Sb-125 | 0.3217 | 0.3216 | 0.4493 | 0.364200 | 16.52246 | 23.36628 |
| 67 | Dy-161 | 2.5911 | 2.5856 | -------- | 2.588350 | 0.10625 | -------- |
| 68 | Mo-99 | 0.5132 | 0.5176 | 0.3780 | 0.469600 | 13.79810 | -19.50596 |
| 69 | In-115 | 0.4772 | 0.4755 | 0.6084 | 0.520367 | 11.96326 | 16.91756 |
| 70 | Pd-104 | 0.2016 | 0.3311 | 0.2993 | 0.277333 | 19.86877 | 7.92067 |
| 71 | Y---91 | 0.0467 | 0.0472 | 0.0891 | 0.061000 | 32.57500 | 46.06557 |
| 72 | I--131 | 0.1706 | 0.1743 | 0.2808 | 0.208567 | 24.50009 | 34.63321 |
| 73 | Cd-113 | 0.4134 | 0.4128 | 0.5273 | 0.451167 | 11.93239 | 16.87477 |
| 74 | Kr--84 | 0.0699 | 0.0664 | 0.0519 | 0.062733 | 12.42154 | -17.26886 |
| 75 | Cd-112 | 0.2443 | 0.2535 | 0.2084 | 0.235400 | 8.26585 | -11.46984 |
| 76 | Te-129 | 0.1387 | 0.1387 | 0.7658 | 0.347733 | 85.01278 | 120.22623 |
| 77 | Sm-150 | 0.4583 | 0.3408 | 0.4341 | 0.411067 | 12.32373 | 5.60331 |
| 78 | Sb-121 | 0.4707 | 0.4663 | 0.4414 | 0.459467 | 2.80776 | -3.93210 |
| 79 | Ru-100 | 0.1996 | 0.1991 | 0.2067 | 0.201800 | 1.71994 | 2.42815 |
| 80 | Gd-158 | 0.3337 | 0.3356 | 0.3417 | 0.337000 | 1.01268 | 1.39466 |
| 81 | Te-130 | 0.0147 | 0.0149 | 0.0129 | 0.014167 | 6.34858 | -8.94118 |
| 82 | Rh-105 | 0.5988 | 0.6036 | 0.6544 | 0.618933 | 4.06428 | 5.73029 |
| 83 | Ba-140 | 0.0188 | 0.0691 | 0.0024 | 0.030100 | 94.27999 | -92.02658 |
| 84 | Rb--87 | 0.0248 | 0.0248 | 0.0292 | 0.026267 | 7.89662 | 11.16751 |
| 85 | Xe-133 | 0.1287 | 0.1275 | 0.1380 | 0.131400 | 3.57119 | 5.02283 |
| 86 | Cd-114 | 0.2785 | 0.2818 | 0.1882 | 0.249500 | 17.38139 | -24.56914 |
| 87 | Gd-155 | 2.9068 | 2.9057 | 2.6347 | 2.815733 | 4.54626 | -6.42935 |
| 88 | Sm-148 | 0.3686 | 0.3110 | 0.2885 | 0.322700 | 10.45274 | -10.59808 |
| 89 | Sr--90 | 0.0134 | 0.0134 | 0.0100 | 0.012267 | 13.06610 | -18.47826 |
| 90 | La-140 | 0.3788 | 0.3919 | ------- | 0.385350 | 1.69975 | ------- |
| 91 | Xe-136 | 0.0031 | 0.0031 | 0.0011 | 0.002433 | 38.74558 | -54.79452 |
| 92 | Y---89 | 0.0174 | 0.0145 | 0.0178 | 0.016567 | 8.87595 | 7.44467 |
| 93 | Te-127 | 0.4100 | 0.4100 | 0.8786 | 0.566200 | 39.01451 | 55.17485 |
| 94 | Ba-138 | 0.0034 | 0.0036 | 0.0052 | 0.004067 | 19.80827 | 27.86885 |
| 95 | Ag-111 | 0.7936 | 0.8141 | -------- | 0.803850 | 1.27511 | ------ |
| 96 | Pm-148 | 3.9372 | 4.2530 | 1.9922 | 3.394133 | 29.45273 | -41.30460 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 97 | Sn-117 | 0.2228 | 0.2243 | 0.2377 | 0.228267 | 2.93447 | 4.13259 |
| 98 | Ce-143 | 0.3364 | 0.3512 | ------- | 0.343800 | 2.15241 | ------- |
| 99 | Sr--89 | 0.0225 | 0.0226 | 0.0126 | 0.019233 | 24.38814 | -34.48873 |
| 100 | Cd-110 | 0.2714 | 0.2658 | 0.2200 | 0.252400 | 9.12205 | -12.83677 |
| 101 | Sn-118 | 0.1255 | 0.1264 | 0.0890 | 0.113633 | 15.33201 | -21.67791 |
| 102 | Sb-123 | 0.2560 | 0.2558 | 0.2849 | 0.265567 | 5.14785 | 7.28003 |
| 103 | Gd-160 | 0.2236 | 0.1696 | 0.2248 | 0.206000 | 12.49677 | 9.12621 |
| 104 | Se--77 | 0.4126 | 0.3864 | 0.3970 | 0.398667 | 2.69921 | -0.41806 |
| 105 | Sn-123 | 0.1232 | 0.1239 | 0.3672 | 0.204767 | 56.09217 | 79.32606 |
| 106 | Te-125 | 0.4001 | 0.4019 | 0.3783 | 0.393433 | 2.72628 | -3.84648 |
| 107 | Se--80 | 0.0582 | 0.0493 | 0.0422 | 0.049900 | 13.11771 | -15.43086 |
| 108 | Kr--85 | 0.0436 | 0.0066 | 0.0597 | 0.036633 | 60.68424 | 62.96633 |
| 109 | Sn-125 | 0.3681 | 0.3791 | ------- | 0.373600 | 1.47216 | ------- |
| 110 | Sn-119 | 0.0643 | 0.0630 | 0.1847 | 0.104000 | 54.87114 | 77.59615 |
| 111 | Ba-136 | 0.0531 | 0.0505 | 0.0700 | 0.057867 | 14.93947 | 20.96774 |
| 112 | Ba-137 | 0.0649 | 0.0680 | 0.0822 | 0.071700 | 10.50448 | 14.64435 |
| 113 | Sn-124 | 0.0265 | 0.0281 | 0.0150 | 0.023200 | 25.15066 | -35.34483 |
| 114 | Sn-120 | 0.0454 | 0.0454 | 0.0456 | 0.045467 | 0.20736 | 0.29326 |
| 115 | Kr--86 | 0.0039 | 0.0034 | 0.0028 | 0.003367 | 13.35717 | -16.83168 |
| 116 | Cs-136 | 0.3023 | 0.3187 | 0.2535 | 0.291500 | 9.49970 | -13.03602 |
| 117 | Rb--85 | 0.2245 | 0.1979 | 0.2767 | 0.233033 | 14.04561 | 18.73838 |
| 118 | Se--78 | 0.0806 | 0.0682 | 0.0917 | 0.080167 | 11.97346 | 14.38669 |
| 119 | Xe-130 | 0.1265 | 0.1267 | 0.2729 | 0.175367 | 39.32705 | 55.61680 |
| 120 | Xe-128 | 0.1905 | 0.1886 | 0.2600 | 0.213033 | 15.59357 | 22.04663 |
| 121 | Mo--96 | 0.0859 | 0.0901 | 0.0893 | 0.088433 | 2.05903 | 0.98002 |
| 122 | Dy-160 | 2.2301 | 2.2255 | ------- | 2.227800 | 0.10324 | ------- |
| 123 | Se--82 | 0.0093 | 0.0094 | 0.0288 | 0.015833 | 57.90890 | 81.89474 |
| 124 | Sn-126 | 0.0070 | 0.0070 | 0.0085 | 0.007500 | 9.42809 | 13.33333 |
| 125 | Dy-162 | 0.9439 | 0.9456 | ------- | 0.944750 | 0.08997 | ------- |
| 126 | Sn-122 | 0.0234 | 0.0238 | 0.0276 | 0.024933 | 7.59095 | 10.69519 |
| 127 | Sr--88 | 0.0010 | 0.0010 | 0.0041 | 0.002033 | 71.86987 | 101.63934 |
| 128 | Eu-156 | 0.0696 | 0.0713 | 0.7202 | 0.287033 | 106.71091 | 150.91162 |
| 129 | Gd-154 | 1.1355 | 1.3159 | 0.9733 | 1.141567 | 12.25786 | -14.73998 |
| 130 | Ba-134 | 0.1164 | 0.1120 | 0.2081 | 0.145500 | 30.44764 | 43.02405 |

**(3) Origin of systematic difference for capture cross section between JENDL-3.2 and JEF-2.2**

For nuclides whose experimental data is not available in the keV region, large differences are observed among the libraries. Some part of the differences in cross sections of a pseudo fission product came from the difference of nuclear model parameters for such nuclides. However, there are other reasons than the parameterization.

In the low energy cross section below 10 eV, it can be pointed out that origin of the difference between JENDL-3.2 and JEF-2.2 is the resonance parameters for Eu-155 listed in Table III. The parameters for JEF-2.2 are artificial except for the resonance at 2.05 eV, while those of JENDL-3.2 and ENDF/B-VI are based on the experimental data of Anufriev et al. (Sov. At. Energy, 46, 182 (1979)). For JENDL-3.2, negative resonance was added 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)).

As for smooth cross sections, it should be noted that evaluation of JENDL-3.2 stands on the recent experimental data reported from ORNL and JAERI and statistical model calculation with a spherical optical model. The recent experiments were made for important nuclides and their results have a tendency becoming smaller than previous ones. The data selection must bring a difference between JENDL-3.2 and others.

Besides, the cross sections of JEF-2.2 (taken from the RCN library) are those adjusted to the integral data of the STEK experiments. Our integral test with the STEK experiments showed JENDL-3.2 underestimates sample worth by 5% to 10% for many nuclides having masses larger than 130, as shown in Table IV. Figure 1 shows the correlation between the ratio of JENDL-3.2 to JEF-2.2 and the C/E value for STEK reactivity worth. For RCN data in JEF-2.2 which are generally larger than JENDL-3.2, strong correlation is observed, while the others are weakly correlate with the C/E value. Thus, the RCN data in JEF-2.2 is systematically larger than JENDL-3.2. You can see in the attached description about capture cross sections for 27 nuclides that JEF-2.2 is larger than JENDL-3.2 in many case of C/E<1.0.

**Table III Comparison of resonance parameters of Eu-155.**

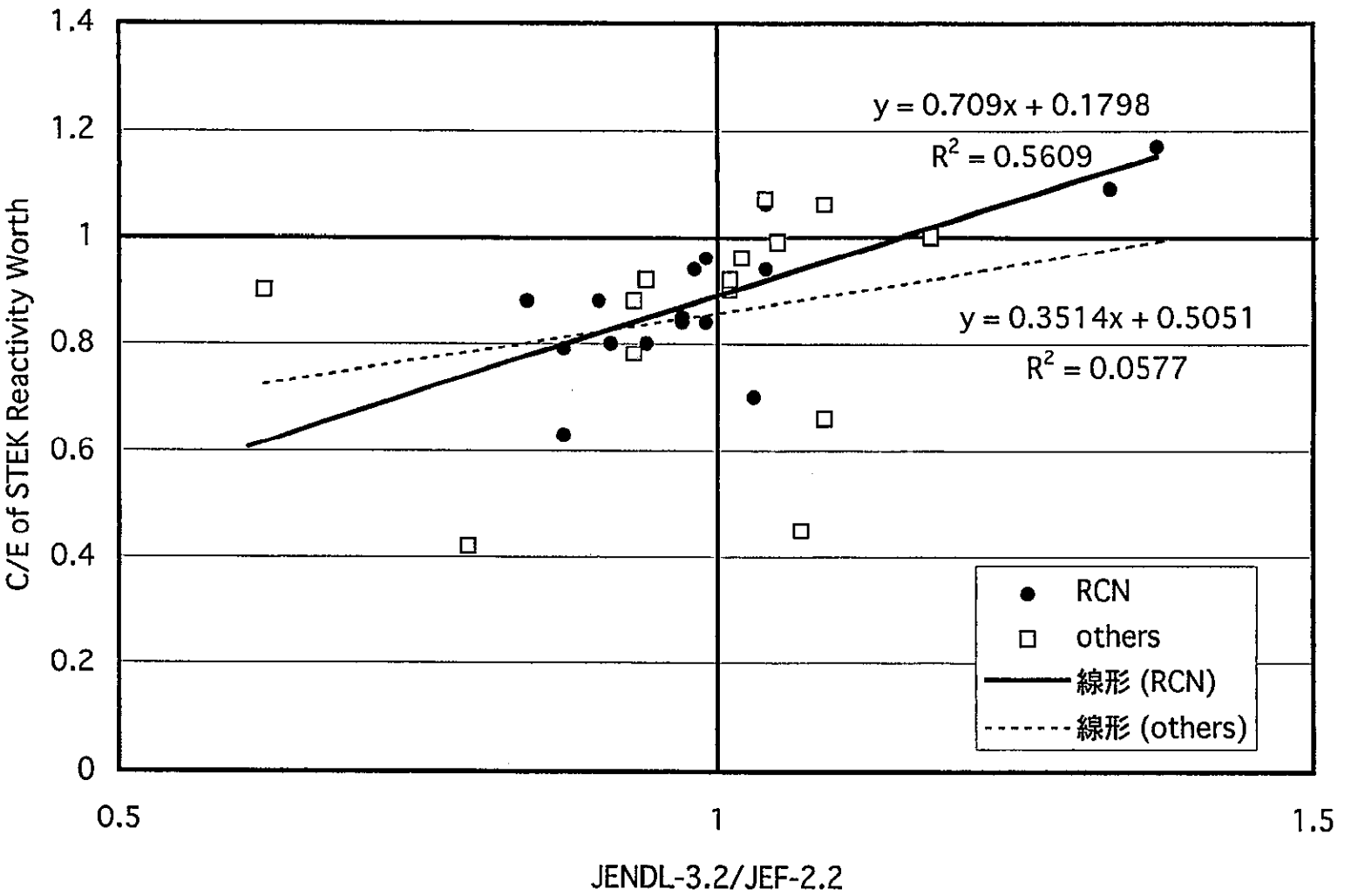
| | Er (eV) | J | Γ tot (eV) | Γ n (eV) | Γ γ (eV) |
|---|---|---|---|---|---|
| JEF-2.2 | 1.900000-1 | 2.000000+0 | 1.292140-1 | 2.136000-4 | 1.290000-1 |
| | 1.120000+0 | 3.000000+0 | 1.293710-1 | 3.711400-4 | 1.290000-1 |
| | 2.050000+0 | 3.000000+0 | 1.295020-1 | 5.022900-4 | 1.290000-1 |
| | 2.980000+0 | 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 IV C/E values of JENDL-3.2 for STEK experiments and ratio of JENDL-3.2 to JEF-2.2.**

| Nuclide | C/E Values | JENDL3.2/JEF 2.2 | Origin of JEF-2.2 | Nuclide | C/E Values | JENDL3.2/JEF 2.2 | 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.

Fig.1 Correlation between JENDL3.2/JEF2.2 and C/E for STEK Worth



**(4) Inelastic scattering cross sections**

As for inelastic scattering, comparison only between JEF-2.2 and JENDL-3 is given in Table V, because I have no information about BROND-2. For high priority nuclides in FP region, JENDL-3.2 shows a trend of lower than JEF-2.2 but it becomes not clear for on the whole.

It can be said from the present benchmarks made in SWG-17 that inelastic scattering cross sections and the other threshold reaction cross sections give tiny contribution to reactivity worth in fast power reactor. Accordingly, I could not agree with the following presentation in the introduction of the draft: "Another component of the reactivity effect of fast power reactors is due to elastic and particularly inelastic scattering. In this case the important contributions (10 to 15%) to the total reactivity effect result from the lowest levels excited by inelastic scattering." Moreover, I would like to emphasize that JENDL-3.2 took into account of direct inelastic scattering with the DWBA method which might be applicable for cross section estimation of inelastic scattering to one-phonon transition states for most nuclei. Only one problem on the inelastic scattering for nuclei having mass around 100 remains and is now studied as one of the activities of SWG10 at JAERI. However, as long as we discuss the effect of lumped FP cross sections on reactor performances, the detailed description about direct inelastic scattering cross sections might be off the point in the activities of SWG17.

**Table V Average and RMS of 1 Group (n, n') Cross Sections for Libraries of 2 Facilities**

| No. | Nuclide | ECN JEF-2.2 | JNDC JENDL-3.2 | Average | RMS(%) | %Diff.J-3.2 |
|---|---|---|---|---|---|---|
| 1 | Ru-101 | 0.6012 | 0.4748 | 0.53800 | 11.74721 | -11.747212 |
| 2 | Cs-133 | 0.4576 | 0.4411 | 0.44935 | 1.83599 | -1.835985 |
| 3 | Tc--99 | 0.4487 | 0.3599 | 0.40430 | 10.98194 | -10.981944 |
| 4 | Rh-103 | 0.4028 | 0.4041 | 0.40345 | 0.16111 | 0.161110 |
| 5 | Cs-135 | 0.2998 | 0.2615 | 0.28065 | 6.82345 | -6.823446 |
| 6 | Ru-104 | 0.2072 | 0.2919 | 0.24955 | 16.97055 | 16.970547 |
| 7 | Pd-105 | 0.4970 | 0.3870 | 0.44200 | 12.44344 | -12.443439 |
| 8 | Mo-100 | 0.2641 | 0.2852 | 0.27465 | 3.84125 | 3.841253 |
| 9 | Ru-102 | 0.1884 | 0.2426 | 0.21550 | 12.57541 | 12.575406 |
| 10 | Pr-141 | 0.3448 | 0.3577 | 0.35125 | 1.83630 | 1.836299 |
| 11 | Nd-145 | 0.4985 | 0.5236 | 0.51105 | 2.45573 | 2.455728 |
| 12 | Ru-103 | 1.0630 | 0.9858 | 1.02440 | 3.76806 | -3.768059 |
| 13 | Mo--97 | 0.2549 | 0.2947 | 0.27480 | 7.24163 | 7.241630 |
| 14 | Xe-131 | 0.4955 | 0.3559 | 0.42570 | 16.39652 | -16.396523 |
| 15 | Pd-107 | 0.4961 | 0.4284 | 0.46225 | 7.32288 | -7.322877 |
| 16 | Sm-149 | 0.9174 | 0.9073 | 0.91235 | 0.55352 | -0.553516 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 17 | La-139 | 0.2693 | 0.1850 | 0.22715 | 18.55602 | -18.556020 |
| 18 | Mo--98 | 0.1880 | 0.1956 | 0.19180 | 1.98123 | 1.981230 |
| 19 | Ru-106 | 0.2792 | 0.3048 | 0.29200 | 4.38356 | 4.383562 |
| 20 | Cs-137 | 0.1685 | 0.1565 | 0.16250 | 3.69231 | -3.692308 |
| 21 | Xe-134 | 0.1656 | 0.1268 | 0.14620 | 13.26949 | -13.269494 |
| 22 | Sm-151 | 1.9303 | 1.1939 | 1.56210 | 23.57083 | -23.570834 |
| 23 | Ce-142 | 0.2064 | 0.1706 | 0.18850 | 9.49602 | -9.496021 |
| 24 | Xe-132 | 0.2054 | 0.1559 | 0.18065 | 13.70053 | -13.700526 |
| 25 | Pm-147 | 0.5027 | 0.4834 | 0.49305 | 1.95721 | -1.957205 |
| 26 | Zr--93 | 0.2301 | 0.2062 | 0.21815 | 5.47788 | -5.477882 |
| 27 | Nd-146 | 0.3060 | 0.3054 | 0.30570 | 0.09814 | -0.098135 |
| 28 | Mo--95 | 0.3319 | 0.3328 | 0.33235 | 0.13540 | 0.135399 |
| 29 | Nd-148 | 0.3695 | 0.3943 | 0.38190 | 3.24692 | 3.246923 |
| 30 | Ag-109 | 0.4218 | 0.4105 | 0.41615 | 1.35768 | -1.357684 |
| 31 | Zr--94 | 0.1368 | 0.1543 | 0.14555 | 6.01168 | 6.011680 |
| 32 | Xe-136 | 0.1144 | 0.0924 | 0.10340 | 10.63830 | -10.638298 |
| 33 | Pd-108 | 0.2547 | 0.2531 | 0.25390 | 0.31508 | -0.315085 |
| 34 | Nd-150 | 0.5902 | 0.5478 | 0.56900 | 3.72583 | -3.725835 |
| 35 | Ce-144 | 0.4433 | 0.2091 | 0.32620 | 35.89822 | -35.898222 |
| 36 | Nd-143 | 0.1554 | 0.1380 | 0.14670 | 5.93047 | -5.930470 |
| 37 | Sm-152 | 0.7364 | 0.6112 | 0.67380 | 9.29059 | -9.290591 |
| 38 | Zr--92 | 0.1310 | 0.1510 | 0.14100 | 7.09220 | 7.092199 |
| 39 | Ba-138 | 0.1076 | 0.0849 | 0.09625 | 11.79221 | -11.792208 |
| 40 | Zr--96 | 0.0874 | 0.0838 | 0.08560 | 2.10280 | -2.102804 |
| 41 | Zr--96 | 0.0874 | 0.0838 | 0.08560 | 2.10280 | -2.102804 |
| 42 | I--129 | 0.4605 | 0.4174 | 0.43895 | 4.90944 | -4.909443 |
| 43 | Ce-140 | 0.0676 | 0.0780 | 0.07280 | 7.14286 | 7.142857 |
| 44 | Eu-153 | 1.0051 | 0.7759 | 0.89050 | 12.86917 | -12.869175 |
| 45 | Pd-110 | 0.2838 | 0.2884 | 0.28610 | 0.80391 | 0.803915 |
| 46 | Te-130 | 0.1145 | 0.1292 | 0.12185 | 6.03201 | 6.032007 |
| 47 | Sr--90 | 0.1047 | 0.1303 | 0.11750 | 10.89362 | 10.893617 |
| 48 | Pd-106 | 0.2208 | 0.2036 | 0.21220 | 4.05278 | -4.052780 |
| 49 | Sm-154 | 0.4997 | 0.6552 | 0.57745 | 13.46437 | 13.464369 |
| 50 | I--127 | 0.5089 | 0.4693 | 0.48910 | 4.04825 | -4.048252 |
| 51 | Rb--87 | 0.1840 | 0.1813 | 0.18265 | 0.73912 | -0.739119 |
| 52 | Nd-144 | 0.2071 | 0.2132 | 0.21015 | 1.45134 | 1.451344 |
| 53 | Kr--83 | 0.6619 | 0.5107 | 0.58630 | 12.89442 | -12.894423 |
| 54 | Pr-143 | 0.3895 | 0.4662 | 0.42785 | 8.96342 | 8.963422 |
| 55 | Zr--95 | 0.1083 | 0.0956 | 0.10195 | 6.22854 | -6.228543 |
| 56 | Y---91 | 0.1713 | 0.1875 | 0.17940 | 4.51505 | 4.515050 |
| 57 | Zr--91 | 0.0845 | 0.0913 | 0.08790 | 3.86803 | 3.868032 |
| 58 | Eu-155 | 0.7078 | 0.6595 | 0.68365 | 3.53251 | -3.532509 |
| 59 | Cd-111 | 0.4014 | 0.3348 | 0.36810 | 9.04645 | -9.046455 |
| 60 | Cs-134 | 0.7546 | 0.8764 | 0.81550 | 7.46781 | 7.467811 |
| 61 | Ce-141 | 0.1421 | 0.1078 | 0.12495 | 13.72549 | -13.725490 |
| 62 | Nd-147 | 0.6295 | 0.8092 | 0.71935 | 12.49044 | 12.490443 |
| 63 | Te-128 | 0.1506 | 0.1433 | 0.14695 | 2.48384 | -2.483838 |
| 64 | Nb--95 | 0.1794 | 0.1316 | 0.15550 | 15.36977 | -15.369775 |
| 65 | Y---89 | 0.1013 | 0.0827 | 0.09200 | 10.10870 | -10.108696 |
| 66 | Gd-156 | 0.5773 | 0.5054 | 0.54135 | 6.64081 | -6.640805 |
| 67 | Gd-157 | 0.8158 | 0.8253 | 0.82055 | 0.57888 | 0.578880 |
| 68 | Sr--88 | 0.0404 | 0.0505 | 0.04545 | 11.11111 | 11.111111 |
| 69 | Sm-147 | 0.5452 | 0.5243 | 0.53475 | 1.95418 | -1.954184 |
| 70 | Mo--99 | 0.4874 | 0.6881 | 0.58775 | 17.07359 | 17.073586 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 71 | Kr--84 | 0.1638 | 0.1147 | 0.13925 | 17.63016 | -17.630162 |
| 72 | Ba-140 | 0.1311 | 0.1522 | 0.14165 | 7.44794 | 7.447935 |
| 73 | I--131 | 0.2646 | 0.2820 | 0.27330 | 3.18332 | 3.183315 |
| 74 | Kr--86 | 0.1114 | 0.0655 | 0.08845 | 25.94686 | -25.946863 |
| 75 | Xe-133 | 0.1925 | 0.2571 | 0.22480 | 14.36833 | 14.368327 |
| 76 | Gd-158 | 0.5067 | 0.5507 | 0.52870 | 4.16115 | 4.161150 |
| 77 | Br--81 | 0.2173 | 0.3164 | 0.26685 | 18.56848 | 18.568484 |
| 78 | Sr--89 | 0.0366 | 0.0790 | 0.05780 | 36.67820 | 36.678201 |
| 79 | Te-129 | 0.1390 | 0.1850 | 0.16200 | 14.19753 | 14.197531 |
| 80 | Sn-119 | 0.5773 | 0.6247 | 0.60100 | 3.94343 | 3.943428 |
| 81 | Kr--85 | 0.0537 | 0.0620 | 0.05785 | 7.17373 | 7.173725 |
| 82 | Sm-150 | 0.3243 | 0.3734 | 0.34885 | 7.03741 | 7.037409 |
| 83 | Se--82 | 0.1211 | 0.1439 | 0.13250 | 8.60377 | 8.603774 |
| 84 | Sb-121 | 0.4348 | 0.4908 | 0.46280 | 6.05013 | 6.050130 |
| 85 | Ru-100 | 0.1609 | 0.2071 | 0.18400 | 12.55435 | 12.554348 |
| 86 | Sn-126 | 0.0667 | 0.1018 | 0.08425 | 20.83086 | 20.830861 |
| 87 | Cd-113 | 0.3776 | 0.3305 | 0.35405 | 6.65160 | -6.651603 |
| 88 | Sb-125 | 0.1714 | 0.1819 | 0.17665 | 2.97198 | 2.971978 |
| 89 | Tb-159 | 0.9638 | 0.6133 | 0.78855 | 22.22434 | -22.224336 |
| 90 | Cd-112 | 0.1457 | 0.1849 | 0.16530 | 11.85723 | 11.857229 |
| 91 | Pd-104 | 0.2035 | 0.1922 | 0.19785 | 2.85570 | -2.855699 |
| 92 | Eu-154 | 0.8918 | 0.4550 | 0.67340 | 32.43243 | -32.432432 |
| 93 | Eu-156 | 1.3320 | 1.1121 | 1.22205 | 8.99718 | -8.997177 |
| 94 | Sn-117 | 0.3214 | 0.3463 | 0.33385 | 3.72922 | 3.729220 |
| 95 | Sm-148 | 0.1982 | 0.2462 | 0.22220 | 10.80108 | 10.801080 |
| 96 | Rh-105 | 0.2806 | 0.4240 | 0.35230 | 20.35197 | 20.351973 |
| 97 | Cd-114 | 0.1390 | 0.2030 | 0.17100 | 18.71345 | 18.713450 |
| 98 | Gd-160 | 0.5105 | 0.5664 | 0.53845 | 5.19083 | 5.190826 |
| 99 | Se--80 | 0.1235 | 0.1525 | 0.13800 | 10.50725 | 10.507246 |
| 100 | Cd-116 | 0.1597 | 0.2119 | 0.18580 | 14.04736 | 14.047363 |
| 101 | Pm-149 | 0.4923 | 0.6892 | 0.59075 | 16.66526 | 16.665256 |
| 102 | Sn-124 | 0.0645 | 0.1035 | 0.08400 | 23.21429 | 23.214286 |
| 103 | In-115 | 0.1177 | 0.1393 | 0.12850 | 8.40467 | 8.404669 |
| 104 | Ba-136 | 0.1298 | 0.1353 | 0.13255 | 2.07469 | 2.074689 |
| 105 | Te-127 | 0.1215 | 0.2295 | 0.17550 | 30.76923 | 30.769231 |
| 106 | Sm-153 | 1.4055 | 1.3639 | 1.38470 | 1.50213 | -1.502130 |
| 107 | Pm-148 | 0.5942 | 0.4980 | 0.54610 | 8.80791 | -8.807911 |
| 108 | Ba-137 | 0.1851 | 0.1415 | 0.16330 | 13.34966 | -13.349663 |
| 109 | Sb-123 | 0.2208 | 0.2576 | 0.23920 | 7.69231 | 7.692308 |
| 110 | Cd-110 | 0.1255 | 0.1674 | 0.14645 | 14.30522 | 14.305224 |
| 111 | Gd-155 | 0.7726 | 0.7637 | 0.76815 | 0.57931 | -0.579314 |
| 112 | Sn-122 | 0.0727 | 0.0983 | 0.08550 | 14.97076 | 14.970760 |
| 113 | Sn-120 | 0.0670 | 0.1002 | 0.08360 | 19.85646 | 19.856459 |
| 114 | Te-125 | 0.5385 | 0.5546 | 0.54655 | 1.47288 | 1.472875 |
| 115 | Sn-118 | 0.0608 | 0.0959 | 0.07835 | 22.39949 | 22.399489 |
| 116 | Sn-123 | 0.0907 | 0.1487 | 0.11970 | 24.22723 | 24.227235 |
| 117 | Se--78 | 0.1294 | 0.1652 | 0.14730 | 12.15207 | 12.152071 |
| 118 | Se--77 | 0.3267 | 0.4345 | 0.38060 | 14.16185 | 14.161850 |
| 119 | Mo--96 | 0.1160 | 0.1833 | 0.14965 | 22.48580 | 22.485800 |
| 120 | Rb--85 | 0.2403 | 0.3057 | 0.27300 | 11.97802 | 11.978022 |
| 121 | Xe-130 | 0.2370 | 0.1742 | 0.20560 | 15.27237 | -15.272374 |
| 122 | Pm-148 | 0.5942 | 0.7662 | 0.68020 | 12.64334 | 12.643340 |
| 123 | Cs-136 | 0.1827 | 0.3319 | 0.25730 | 28.99339 | 28.993393 |
| 124 | Nd-142 | 0.0744 | 0.0974 | 0.08590 | 13.38766 | 13.387660 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 125 | Xe-128 | 0.2641 | 0.2022 | 0.23315 | 13.27472 | -13.274716 |
| 126 | Ba-134 | 0.1694 | 0.1688 | 0.16910 | 0.17741 | -0.177410 |
| 127 | Te-126 | 0.1412 | 0.1532 | 0.14720 | 4.07609 | 4.076087 |
| 128 | Zr--90 | 0.0501 | 0.0590 | 0.05455 | 8.15765 | 8.157654 |
| 129 | Kr--82 | 0.1753 | 0.1342 | 0.15475 | 13.27948 | -13.279483 |
| 130 | Sn-115 | 0.1916 | 0.2001 | 0.19585 | 2.17003 | 2.170028 |

(Appendix)

**Table 5.1R 5FPNGRMS.DAT September 12, 1997 (Matsunobu)**

**Average and RMS of 1 Group (n, $\gamma$) Cross Sections for Libraries by 5 Facilities**

| No. | Nuclide | CEA JEF-2.2 | ECN JEF-2.2 | IPPE FOND-2.1 | IPPE ADL-3 | JNDC JENDL-3.2 | Average | RMS(%) | %Diff.J3 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Ru-101 | 0.7143 | 0.7243 | 0.7616 | 0.7141 | 0.7523 | 0.733320 | 2.7085 | 2.5882 |
| 2 | Pd-105 | 0.9369 | 0.9490 | 0.9161 | 0.8568 | 0.9594 | 0.923640 | 3.9401 | 3.8716 |
| 3 | Sm-149 | 2.5398 | 2.5437 | 2.8700 | 2.6540 | 2.2990 | 2.581300 | 7.1740 | -10.9363 |
| 4 | Tc--99 | 0.6301 | 0.6479 | 0.6561 | 0.6152 | 0.5923 | 0.628320 | 3.6487 | -5.7327 |
| 5 | Cs-133 | 0.5072 | 0.5167 | 0.5184 | 0.4715 | 0.4874 | 0.500240 | 3.6204 | -2.5668 |
| 6 | Pd-107 | 1.0569 | 1.0700 | 1.0399 | 0.9840 | 1.0520 | 1.040560 | 2.8715 | 1.0994 |
| 7 | Rh-103 | 0.6751 | 0.6832 | 0.6526 | 0.6124 | 0.6774 | 0.660140 | 3.9440 | 2.6146 |
| 8 | Pm-147 | 1.5064 | 1.5167 | 1.4309 | 1.3335 | 1.2753 | 1.412560 | 6.7219 | -9.7171 |
| 9 | Sm-151 | 3.3618 | 3.3998 | 2.9413 | 2.6922 | 2.1080 | 2.900620 | 16.4271 | -27.3259 |
| 10 | Ru-103 | 1.1828 | 1.1992 | 1.2140 | 1.1416 | 0.5047 | 1.048460 | 26.0339 | -51.8627 |
| 11 | Mo--97 | 0.3351 | 0.3406 | 0.3568 | 0.3159 | 0.3484 | 0.339360 | 4.0744 | 2.6638 |
| 12 | Nd-145 | 0.5657 | 0.5700 | 0.5124 | 0.4755 | 0.5648 | 0.537680 | 6.9939 | 5.0439 |
| 13 | Xe-131 | 0.2917 | 0.2937 | 0.3323 | 0.3018 | 0.3461 | 0.313120 | 7.0255 | 10.5327 |
| 14 | Eu-153 | 2.7363 | 2.7655 | 2.9288 | 2.4251 | 2.5958 | 2.690300 | 6.3062 | -3.5126 |
| 15 | Nd-143 | 0.3592 | 0.3550 | 0.3370 | 0.3080 | 0.3589 | 0.343620 | 5.7003 | 4.4468 |
| 16 | Ru-102 | 0.1558 | 0.1581 | 0.1796 | 0.1732 | 0.1642 | 0.166180 | 5.4247 | -1.1915 |
| 17 | Ag-109 | 0.7846 | 0.7927 | 0.7203 | 0.6705 | 0.6916 | 0.731940 | 6.6938 | -5.5114 |
| 18 | Ru-104 | 0.1517 | 0.1546 | 0.1658 | 0.1572 | 0.1685 | 0.159560 | 4.0695 | 5.6029 |
| 19 | Cs-135 | 0.2379 | 0.2445 | 0.1361 | 0.2269 | 0.2284 | 0.214760 | 18.5563 | 6.3513 |
| 20 | Pr-141 | 0.1553 | 0.1582 | 0.1540 | 0.1360 | 0.1564 | 0.151980 | 5.3348 | 2.9083 |
| 21 | Mo--95 | 0.3180 | 0.3204 | 0.3351 | 0.3096 | 0.3360 | 0.323820 | 3.1595 | 3.7613 |
| 22 | Mo--98 | 0.1233 | 0.1280 | 0.1179 | 0.1067 | 0.1194 | 0.119060 | 5.9643 | 0.2856 |
| 23 | Mo-100 | 0.0933 | 0.0938 | 0.1011 | 0.0862 | 0.1000 | 0.094880 | 5.6544 | 5.3963 |
| 24 | Eu-155 | 2.8163 | 2.8428 | 2.9559 | 2.6783 | 1.3368 | 2.526020 | 23.7979 | -47.0788 |
| 25 | Pd-108 | 0.1778 | 0.1770 | 0.2507 | 0.2352 | 0.2358 | 0.215300 | 14.6032 | 9.5216 |
| 26 | Xe-132 | 0.0689 | 0.0708 | 0.0755 | 0.0804 | 0.0980 | 0.078720 | 13.2512 | 24.4919 |
| 27 | Zr--93 | 0.1349 | 0.1335 | 0.1042 | 0.0924 | 0.1057 | 0.114140 | 14.9118 | -7.3944 |
| 28 | Sm-152 | 0.4951 | 0.4956 | 0.5077 | 0.4768 | 0.4799 | 0.491020 | 2.3072 | -2.2647 |
| 29 | Ce-141 | 0.2970 | 0.2963 | 0.2960 | 0.2754 | 0.2977 | 0.292480 | 2.9268 | 1.7847 |
| 30 | I--129 | 0.3644 | 0.3700 | 0.3804 | 0.3566 | 0.3840 | 0.371080 | 2.7196 | 3.4817 |
| 31 | Ru-106 | 0.0922 | 0.0871 | 0.0946 | 0.0887 | 0.0916 | 0.090840 | 2.9180 | 0.8366 |
| 32 | Zr--96 | 0.0343 | 0.0358 | 0.0590 | 0.0550 | 0.0391 | 0.044640 | 23.0483 | -12.4104 |
| 33 | Pd-106 | 0.1994 | 0.2027 | 0.2553 | 0.1959 | 0.2772 | 0.226100 | 14.8495 | 22.6006 |
| 34 | I--127 | 0.6168 | 0.6199 | 0.6307 | 0.5806 | 0.6028 | 0.610160 | 2.8281 | -1.2062 |
| 35 | Nd-146 | 0.0947 | 0.0956 | 0.1100 | 0.0911 | 0.1076 | 0.099800 | 7.5546 | 7.8156 |
| 36 | Nd-148 | 0.1703 | 0.1681 | 0.1636 | 0.1609 | 0.1469 | 0.161960 | 5.0756 | -9.2986 |
| 37 | Xe-134 | 0.0361 | 0.0360 | 0.0374 | 0.0292 | 0.0272 | 0.033180 | 12.4912 | -18.0229 |
| 38 | La-139 | 0.0339 | 0.0333 | 0.0390 | 0.0320 | 0.0343 | 0.034500 | 6.9007 | -0.5797 |
| 39 | Nb--95 | 0.3469 | 0.3496 | 0.2705 | 0.3311 | 0.3669 | 0.333000 | 9.9850 | 10.1802 |
| 40 | Zr--95 | 0.0651 | 0.0643 | 0.1229 | 0.0586 | 0.1489 | 0.091960 | 40.0991 | 61.9182 |
| 41 | Pd-110 | 0.0970 | 0.0985 | 0.2189 | 0.0920 | 0.1291 | 0.127100 | 37.5473 | 1.5736 |
| 42 | Cd-111 | 0.4605 | 0.4665 | 0.4683 | 0.4350 | 0.7475 | 0.515560 | 22.6129 | 44.9880 |
| 43 | Sm-147 | 1.4571 | 1.4660 | 1.4183 | 1.3243 | 1.2719 | 1.387520 | 5.5183 | -8.3329 |
| 44 | Nd-150 | 0.1728 | 0.1748 | 0.1729 | 0.1668 | 0.1626 | 0.169980 | 2.6868 | -4.3417 |
| 45 | Eu-154 | 3.0951 | 3.1233 | 3.1720 | 2.9430 | 3.4503 | 3.156740 | 5.2439 | 9.2995 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 46 | Pr-143 | 0.4094 | 0.4095 | 0.4206 | 0.3847 | 0.1263 | 0.350100 | 32.1381 | -63.9246 |
| 47 | Gd-157 | 1.8214 | 1.8389 | 1.6372 | 1.4989 | 1.3578 | 1.630840 | 11.3596 | -16.7423 |
| 48 | Zr--92 | 0.0365 | 0.0368 | 0.0433 | 0.0425 | 0.0418 | 0.040180 | 7.2738 | 4.0319 |
| 49 | Zr--91 | 0.0796 | 0.0789 | 0.0790 | 0.0720 | 0.0913 | 0.080160 | 7.7693 | 13.8972 |
| 50 | Gd-156 | 0.6203 | 0.6156 | 0.7077 | 0.6631 | 0.7059 | 0.662520 | 6.0025 | 6.5477 |
| 51 | Zr--94 | 0.0229 | 0.0237 | 0.0271 | 0.0262 | 0.0258 | 0.025140 | 6.2873 | 2.6253 |
| 52 | Nd-147 | 1.0075 | 1.0173 | 0.7995 | 0.9482 | 1.2315 | 1.000800 | 13.9049 | 23.0516 |
| 53 | Cs-137 | 0.0274 | 0.0280 | 0.0160 | 0.0264 | 0.0160 | 0.022760 | 24.3547 | -29.7012 |
| 54 | Ce-142 | 0.0436 | 0.0442 | 0.0186 | 0.0196 | 0.0252 | 0.030240 | 37.6308 | -16.6667 |
| 55 | Ce-144 | 0.0493 | 0.0490 | 0.0337 | 0.0470 | 0.0241 | 0.040620 | 24.7918 | -40.6696 |
| 56 | Tb-159 | 0.0000 | 1.7482 | 2.0672 | 1.6488 | 1.8546 | 1.829700 | 8.4843 | 1.3609 |
| 57 | Sm-154 | 0.2479 | 0.2507 | 0.2729 | 0.2514 | 0.2471 | 0.254000 | 3.7749 | -2.7165 |
| 58 | Kr--83 | 0.0000 | 0.2465 | 0.2422 | 0.2232 | 0.2806 | 0.248125 | 8.3418 | 13.0882 |
| 59 | Nd-144 | 0.0800 | 0.0807 | 0.0936 | 0.0758 | 0.0829 | 0.082600 | 7.2174 | 0.3632 |
| 60 | Te-128 | 0.0418 | 0.0416 | 0.1029 | 0.0387 | 0.0408 | 0.053160 | 46.8289 | -23.2506 |
| 61 | Pm-148 | 4.1510 | 4.1781 | 4.2530 | 5.8795 | 3.2167 | 4.335660 | 19.8443 | -25.8083 |
| 62 | Pm-149 | 3.5314 | 3.5548 | 3.6200 | 3.3688 | 1.2367 | 3.062340 | 29.9300 | -59.6158 |
| 63 | Ce-140 | 0.0138 | 0.0135 | 0.0123 | 0.0142 | 0.0061 | 0.011980 | 25.1051 | -49.0818 |
| 64 | Cd-116 | 0.0000 | 0.1182 | 0.8856 | 0.1139 | 0.0823 | 0.300000 | 112.7935 | -72.5667 |
| 65 | Br--81 | 0.0000 | 0.4293 | 0.3892 | 0.4048 | 0.2777 | 0.375250 | 15.4846 | -25.9960 |
| 66 | Sb-125 | 0.3184 | 0.3217 | 0.3216 | 0.0000 | 0.4493 | 0.352750 | 15.8069 | 27.3707 |
| 67 | Dy-161 | 0.0000 | 2.5911 | 2.5856 | 2.4223 | 0.0000 | 2.533000 | 3.0915 | 0.0000 |
| 68 | Mo-99 | 0.5052 | 0.5132 | 0.5176 | 0.4907 | 0.3780 | 0.480940 | 10.8700 | -21.4039 |
| 69 | In-115 | 0.4711 | 0.4772 | 0.4755 | 0.4540 | 0.6084 | 0.497240 | 11.2994 | 22.3554 |
| 70 | Pd-104 | 0.0000 | 0.2016 | 0.3311 | 0.1921 | 0.2993 | 0.256025 | 23.5630 | 16.9026 |
| 71 | Y---91 | 0.0461 | 0.0467 | 0.0472 | 0.0445 | 0.0891 | 0.054720 | 31.4583 | 62.8289 |
| 72 | I--131 | 0.1686 | 0.1706 | 0.1743 | 0.1613 | 0.2808 | 0.191120 | 23.5662 | 46.9234 |
| 73 | Cd-113 | 0.4092 | 0.4134 | 0.4128 | 0.3865 | 0.5273 | 0.429840 | 11.5685 | 22.6736 |
| 74 | Kr--84 | 0.0000 | 0.0699 | 0.0664 | 0.0629 | 0.0519 | 0.062775 | 10.7508 | -17.3238 |
| 75 | Cd-112 | 0.2421 | 0.2443 | 0.2535 | 0.2399 | 0.2084 | 0.237640 | 6.4532 | -12.3043 |
| 76 | Te-129 | 0.0000 | 0.1387 | 0.1387 | 2.7649 | 0.7658 | 0.952025 | 113.1818 | -19.5609 |
| 77 | Sm-150 | 0.4543 | 0.4583 | 0.3408 | 0.3237 | 0.4341 | 0.402240 | 14.4156 | 7.9206 |
| 78 | Sb-121 | 0.4657 | 0.4707 | 0.4663 | 0.4467 | 0.4414 | 0.458160 | 2.5688 | -3.6581 |
| 79 | Ru-100 | 0.0000 | 0.1996 | 0.1991 | 0.1886 | 0.2067 | 0.198500 | 3.2534 | 4.1310 |
| 80 | Gd-158 | 0.0000 | 0.3337 | 0.3356 | 0.3126 | 0.3417 | 0.330900 | 3.3155 | 3.2638 |
| 81 | Te-130 | 0.0143 | 0.0147 | 0.0149 | 0.0137 | 0.0129 | 0.014100 | 5.1534 | -8.5106 |
| 82 | Rh-105 | 0.5905 | 0.5988 | 0.6036 | 0.0000 | 0.6544 | 0.611825 | 4.0900 | 6.9587 |
| 83 | Ba-140 | 0.0000 | 0.0188 | 0.0691 | 0.0185 | 0.0024 | 0.027200 | 92.2219 | -91.1765 |
| 84 | Rb--87 | 0.0247 | 0.0248 | 0.0248 | 0.0213 | 0.0292 | 0.024960 | 10.0547 | 16.9872 |
| 85 | Xe-133 | 0.1351 | 0.1287 | 0.1275 | 0.1184 | 0.1380 | 0.129540 | 5.2522 | 6.5308 |
| 86 | Cd-114 | 0.0000 | 0.2785 | 0.2818 | 0.2611 | 0.1882 | 0.252400 | 15.0123 | -25.4358 |
| 87 | Gd-155 | 0.0000 | 2.9068 | 2.9057 | 2.6694 | 2.6347 | 2.779150 | 4.5946 | -5.1976 |
| 88 | Sm-148 | 0.0000 | 0.3686 | 0.3110 | 0.2907 | 0.2885 | 0.314700 | 10.2738 | -8.3254 |
| 89 | Sr--90 | 0.0131 | 0.0134 | 0.0134 | 0.0126 | 0.0100 | 0.012500 | 10.2700 | -20.0000 |
| 90 | La-140 | 0.3773 | 0.3788 | 0.3919 | 0.3507 | 0.0000 | 0.374675 | 3.9932 | 0.0000 |
| 91 | Xe-136 | 0.0031 | 0.0031 | 0.0031 | 0.0029 | 0.0011 | 0.002660 | 29.4675 | -58.6466 |
| 92 | Y---89 | 0.0000 | 0.0174 | 0.0145 | 0.0225 | 0.0178 | 0.018050 | 15.8864 | -1.3850 |
| 93 | Te-127 | 0.0000 | 0.4100 | 0.4100 | 3.1977 | 0.8786 | 1.224075 | 94.3913 | -28.2234 |
| 94 | Ba-138 | 0.0033 | 0.0034 | 0.0036 | 0.0034 | 0.0052 | 0.003780 | 18.9592 | 37.5661 |
| 95 | Ag-111 | 0.0000 | 0.7936 | 0.8141 | 0.7389 | 0.0000 | 0.782200 | 4.0579 | 0.0000 |
| 96 | Pm-148 | 0.0000 | 3.9372 | 4.2530 | 3.9542 | 1.9922 | 3.534150 | 25.4393 | -43.6300 |
| 97 | Sn-117 | 0.0000 | 0.2228 | 0.2243 | 0.2129 | 0.2377 | 0.224425 | 3.9334 | 5.9151 |
| 98 | Ce-143 | 0.0000 | 0.3364 | 0.3512 | 0.3144 | 0.0000 | 0.334000 | 4.5267 | 0.0000 |
| 99 | Sr--89 | 0.0000 | 0.0225 | 0.0226 | 0.0214 | 0.0126 | 0.019775 | 21.0830 | -36.2832 |

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|---|---|---|---|---|---|---|---|---|---|
| 100 | Cd-110 | 0.0000 | 0.2714 | 0.2658 | 0.2640 | 0.2200 | 0.255300 | 8.0542 | -13.8269 |
| 101 | Sn-118 | 0.0000 | 0.1255 | 0.1264 | 0.1204 | 0.0890 | 0.115325 | 13.3276 | -22.8268 |
| 102 | Sb-123 | 0.0000 | 0.2560 | 0.2558 | 0.2471 | 0.2849 | 0.260950 | 5.4749 | 9.1780 |
| 103 | Gd-160 | 0.0000 | 0.2236 | 0.1696 | 0.1726 | 0.2248 | 0.197650 | 13.4453 | 13.7364 |
| 104 | Se--77 | 0.0000 | 0.4126 | 0.3864 | 0.3936 | 0.3970 | 0.397400 | 2.4091 | -0.1007 |
| 105 | Sn-123 | 0.0000 | 0.1232 | 0.1239 | 0.1179 | 0.3672 | 0.183050 | 58.0958 | 100.6009 |
| 106 | Te-125 | 0.0000 | 0.4001 | 0.4019 | 0.3696 | 0.3783 | 0.387475 | 3.5834 | -2.3679 |
| 107 | Se--80 | 0.0000 | 0.0582 | 0.0493 | 0.0545 | 0.0422 | 0.051050 | 11.7699 | -17.3359 |
| 108 | Kr--85 | 0.0000 | 0.0436 | 0.0066 | 0.0413 | 0.0597 | 0.037800 | 51.2118 | 57.9365 |
| 109 | Sn-125 | 0.0000 | 0.3681 | 0.3791 | 0.3539 | 0.0000 | 0.367033 | 2.8105 | 0.0000 |
| 110 | Sn-119 | 0.0000 | 0.0643 | 0.0630 | 0.0587 | 0.1847 | 0.092675 | 57.3737 | 99.2986 |
| 111 | Ba-136 | 0.0000 | 0.0531 | 0.0505 | 0.0453 | 0.0700 | 0.054725 | 16.9125 | 27.9123 |
| 112 | Ba-137 | 0.0000 | 0.0649 | 0.0680 | 0.0642 | 0.0822 | 0.069825 | 10.4353 | 17.7229 |
| 113 | Sn-124 | 0.0000 | 0.0265 | 0.0281 | 0.0288 | 0.0150 | 0.024600 | 22.7842 | -39.0244 |
| 114 | Sn-120 | 0.0000 | 0.0454 | 0.0454 | 0.0585 | 0.0456 | 0.048725 | 11.5838 | -6.4135 |
| 115 | Kr--86 | 0.0000 | 0.0039 | 0.0034 | 0.0040 | 0.0028 | 0.003525 | 13.5125 | -20.5674 |
| 116 | Cs-136 | 0.0000 | 0.3023 | 0.3187 | 0.2888 | 0.2535 | 0.290825 | 8.2559 | -12.8342 |
| 117 | Rb--85 | 0.2193 | 0.2245 | 0.1979 | 0.2063 | 0.2767 | 0.224940 | 12.2392 | 23.0106 |
| 118 | Se--78 | 0.0000 | 0.0806 | 0.0682 | 0.0706 | 0.0917 | 0.077775 | 11.9418 | 17.9042 |
| 119 | Xe-130 | 0.0000 | 0.1265 | 0.1267 | 0.1461 | 0.2729 | 0.168050 | 36.3323 | 62.3921 |
| 120 | Xe-128 | 0.0000 | 0.1905 | 0.1886 | 0.2026 | 0.2600 | 0.210425 | 13.8394 | 23.5595 |
| 121 | Mo--96 | 0.0000 | 0.0859 | 0.0901 | 0.0873 | 0.0893 | 0.088150 | 1.8735 | 1.3046 |
| 122 | Dy-160 | 0.0000 | 2.2301 | 2.2255 | 2.1165 | 0.0000 | 2.190700 | 2.3965 | 0.0000 |
| 123 | Se--82 | 0.0000 | 0.0093 | 0.0094 | 0.0092 | 0.0288 | 0.014175 | 59.5700 | 103.1746 |
| 124 | Sn-126 | 0.0000 | 0.0070 | 0.0070 | 0.0071 | 0.0085 | 0.007400 | 8.5999 | 14.8649 |
| 125 | Dy-162 | 0.0000 | 0.9439 | 0.9456 | 0.8971 | 0.0000 | 0.928867 | 2.4194 | 0.0000 |
| 126 | Sn-122 | 0.0000 | 0.0234 | 0.0238 | 0.0231 | 0.0276 | 0.024475 | 7.4412 | 12.7681 |
| 127 | Sr--88 | 0.0000 | 0.0010 | 0.0010 | 0.0011 | 0.0041 | 0.001800 | 73.8074 | 127.7778 |
| 128 | Eu-156 | 0.0000 | 0.0696 | 0.0713 | 0.0650 | 0.7202 | 0.231525 | 121.8642 | 211.0679 |
| 129 | Gd-154 | 0.0000 | 1.1355 | 1.3159 | 1.2452 | 0.9733 | 1.167475 | 11.0688 | -16.6320 |
| 130 | Ba-134 | 0.0000 | 0.1164 | 0.1120 | 0.1038 | 0.2081 | 0.135075 | 31.3920 | 54.0626 |