# AN ANALYSIS OF SAMPLE REACTIVITY MEASUREMENTS IN ROSSENDORF SEG CONFIGURATIONS USING THE JEF-2 DATA BASE

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The ROSSENDORF SEG-4 and SEG-5 configurations characterized by energy-independent adjoint spectra have been recalculated using the comprehensive scheme JEF2/ECCO/ERANOS.
C/E-values are given for fission product nuclides and structural materials using the results of the sample reactivity measurements at the central position of the RRR/SEG.

## 1. Introduction

According to the recommendations of the NEANSC Working Group on the International Evaluation Cooperation in the OECD countries, the STEK and ROSSENDORF experiments have been proposed as a joint integral data base for the validation and convergence of the latest versions of JEF, ENDF/B and JENDL, especially for capture and inelastic scattering data (subgroup 10) of structural materials and FP nuclides /1/. In CADARACHE, the reanalysis of the ROSSENDORF experiments has started using the comprehensive European scheme JEF2/ECCO/ERANOS.

The ROSSENDORF experiments include sample reactivity measurements at the central position of the fast-thermal coupled system RRR/SEG, well described and documented now in /2/. The measurements are based on the pile-oscillator method developed to a high perfection.

Using a precisely defined combination of pellets in unit cells, fast insertion lattices (SEG) with specially designed adjoint spectra were arranged to check cross-sections and self-shielding data of FP nuclides, structural materials and standards /3,4,5/. In the case of an energy-independent adjoint spectrum (SEG-4,SEG-5), the slowing-down contribution to the sample reactivity worth will disappear and, conversely, in a configuration characterized by a strong energy dependence, e.g. a monotonically rising adjoint spectrum as in SEG-6, the scattering effect in the sample reactivity will be dominant.
In this way, it is possible to check capture or scattering data separately comparing calculated and measured central reactivity worths (CRW) in the different configurations.

Because of its simplicity, the reanalysis was started with the calculation of RRR/SEG-5 /6/. The unit cell of SEG-5 consists only of B-10, B-11, C, Al, U-235, and U-238. The samples were located in graphite containers inserted in the experimental channel which was then filled by graphite bars. In SEG-4, Cadmium (instead of B-10) was used to decrease the adjoint function in the low energy range.

## 2. Calculations

### 2.1. The calculational scheme

The JEF2/ECCO/ERANOS calculations have been performed in a similar way to that decribed in /7/. At first for each region of the RRR/SEG-facility cell calculations with ECCO /8/ were performed using the 1968 or 172 group libraries of JEF-2.2 condensed then to 33 groups /9/ for the ERANOS input. For the outer (subcritical) regions only 33 groups were used. ERANOS /10/ reads the ECCO output files and changes them into EDL's. The calculational scheme is given in Table 1.

The R,Z-geometry was produced in the way described in Fig.1 and Table 2. The calculation of the whole reactor was performed using the diffusion and/or transport code BISTRO (S4 P1 treatment).

The reactivity perturbations of the sample materials at the central position were calculated by specific modules of ERANOS. For this, all sample materials were introduced into the experimental channel as traces with an atomic density of E-10. The resulting calculated reactivities allow the analysis of the experimental information and lead to the C/E-ratios.

Special attention has been focussed on the treatment of the thermal driver zone, the inserted lattice SEG (represented by the unit cells), and the experimental channel. The above described calculational scheme is able to tackle correctly special problems in these regions.

### 2.2. The SEG and experimental channel

The pattern of the SEG loading is shown in Fig.1, the lattice is hexagonal. The pellets are inserted into cylindrical holes in the matrix. The central hole is the experimental channel. According to its geometry, the unit cell has a hexagonal form, filled with cylindrical pellets (Fig. 2). The characteristics of the pellets used in the SEG-4 and SEG-5 unit cells are given in Table 3.

The geometry of the SEG-5 unit cell is shown in Fig.2. This type of geometry is not actually implemented in ECCO but the nearest corresponding type of geometry is the slab geometry. It changes the hexagonal shape of the unit cell and the cylindrical shape of the inner pellets into square shapes preserving the volumes. This 3D cell description is much more accurate than an 1D description.

In order to take into account the fact that the neutrons at the sample position are coming from the inserted fast lattice, the ECCO calculation of the experimental channel was performed for a macrocell consisting of the experimental channel surrounded by the SEG.

In this way, the macrocell consists of the inner graphite zone containing the trace quantities (atomic density E-10) of the sample materials surrounded by the homogenised SEG. The perturbation calculations were performed then for the central position.

This macrocell treatment allows an accurate consideration of the spatial self-shielding interaction between the trace quantity of the sample and the presence of the material in the surrounding region, but also of the slowing-down effect using the subgroup method and the 1968 group scheme. The last point is very important in calculations of SEG-configurations with an energy-dependent adjoint function (SEG-6,SEG-7). In detail, the recalculation of SEG-5 is described in /11/.

## 3. Discussion of the results

### 3.1. SEG-5

The calculated neutron spectrum and the adjoint spectrum at the central position of the RRR/SEG-5 are shown in Fig.3. The adjoint spectrum is nearly energy-independent in the energy range of the neutron spectrum (groups 1...23). When using JEF-2/ECCO/ERANOS, a better flatness was obtained than in former calculations. Consequently, the ratios for the scattering/capture effects are lower, as it is for the individual positive or negative scattering/total scattering effects. Thus, for all strong absorbers (e.g. all FP samples) the slowing-down effect was less than 1% of the capture effect. For Fe, Cr, Ni, Co, Mn these ratios are between 1...8%, but for V it is 30%. The ratios of the positive slowing-down contribution to the total scattering effect amount to 2...14, in most cases they are also smaller than in former calculations.
The C/E-values of CRW's in SEG-5 are compiled in Table 4. The experimental (extrapolated/infinite dilute) CRW's are taken from /2,12,13/.
Discrepancies have been found for Cd, Sm-149, Rh-103, and Mo-95.
Based on the calculated sensitivities for the energy groups, the following recommendations can be given:

- Cd: to decrease the capture cross-section in the energy region 40 eV ... 40 keV,
- Sm-149: to decrease the capture cross-section in the energy region 40 eV ... 20 keV,
- Rh-103: to increase the capture cross-section in the energy region 150 eV ... 300 keV,
- Mo-95: to check the capture data of the 26th group ( 40.1 eV ... 67.9 eV / 29% of the reactivity effect is coming from the resonance in this group) or to decrease the capture cross-section in the energy region 300 eV ... 40 keV.

For Fe, Ni, W, Ag-109, Nd-143, and Eu-153 the C/E-values are near to the error limit. In the case of Fe and Ni, a consistent information about an overestimation of the capture cross-sections in JEF-2 has been deduced in the preliminary analysis of SEG-4. According to the sensitivities for SEG-5, a decrease of about 5% in the energy range 15 keV ... 800 keV (Fe) and 10 keV ... 10 MeV (Ni) is indicated, but the final recommendations will be given after completion the reanalysis of the SEG-4 and SEG-7.
Our results support the recommendations of E.Fort for Fe-56 and Ni-58 /14/.

he value C/E = 1.084 for U-235 is in agreement with the former C/E = 1.09 sing other codes and ABBN-78 data. Our result is consistent with the -235/B-10 discrepancy in sample reactivity measurements (in many reactor configurations the C/E-value of U-235 related to B-10 is overestimated /15/), although in our case this is within the uncertainty.
For U-238 (difficulties in the experimental extrapolation) and V ( 30% of the reactivity effect is due to the slowing-down effect), a further analysis is needed. All other materials under investigation have C/E-values within the error limits.

The calculated sensitivities for SEG-5 are given in Table 5. As example, the sensitivities for Sm-149 are specified in energy groups and given in Table 6.
In Fig.4 the C/E-values of FP nuclides for JEF-2 are compared with former results /12/. The divergence of the C/E-values for Sm-149 is considerable and obviously due to discrepant capture cross-sections in the data sets.

## 3.2. SEG-4

The SEG-4 /16,17/ has been recalculated for two versions: with voided (v) and graphite filled (g) experimental channel. The differencies in the shapes of the spectra are small. But the calculated neutron and adjoint spectra show a strange behaviour in the epithermal energy region (Fig.5), obviously due to the lower capture cross-sections of Cd in this energy region. Consequently, most of the C/E-values in Table 7 are about 10% too low due to the high sensitivity of B-10 (reference material) in this energy range. Nevertheless, the overestimation of Fe, Cr, Ni, U-235, and Sm-149 is evident. A revision of the Cd data in JEF-2 is necessary. The analysis of SEG-4 will be repeated then with the corrected data.
Inaccurate self-shielding data and capture cross-sections of Cd have been found in other data sets, too /18/.

## 4. Conclusions

A calculational scheme has been set up with JEF2/ECCO/ERANOS for the analysis of sample reactivity measurements in the Rossendorf RRR/SEG configurations.

In comparison to former calculations, this scheme resolves the following problems:

- representation in R,Z-geometry,
- upscattering calculation for the thermal driver cell,
- wide resonance treatment with 1968 energy groups,
- anisotropic calculation using P1 matrices,
- spatial self-shielding treatment with the subgroup method,
- accurate slowing-down treatment in a 1968 group calculation.

The new analysis of the RRR/SEG-5 with the full scheme JEF2/ECCO/ERANOS has given a flatter adjoint function than obtained in former calculations. Consequently, the scattering contributions to the sample reactivity are smaller, in the most cases less than 1%. In the case of SEG-4, inaccuracies were found for the Cd data in JEF-2. The analysis will be repeated with revised Cd data.

Most of the calculated sample reactivities are in good agreement with the experimental results. Significant discrepancies have been found only for Cd and Sm-149. The overestimation for U-235, natural Fe, Cr and Ni will be tested also in SEG-7.
The analysis of the other SEG-configurations are under work. Especially the reanalysis of the experiments in SEG-6 /19,20/ are of interest for the validation of the inelastic scattering data of U-238 and for other even-even nuclides.

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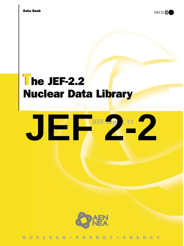


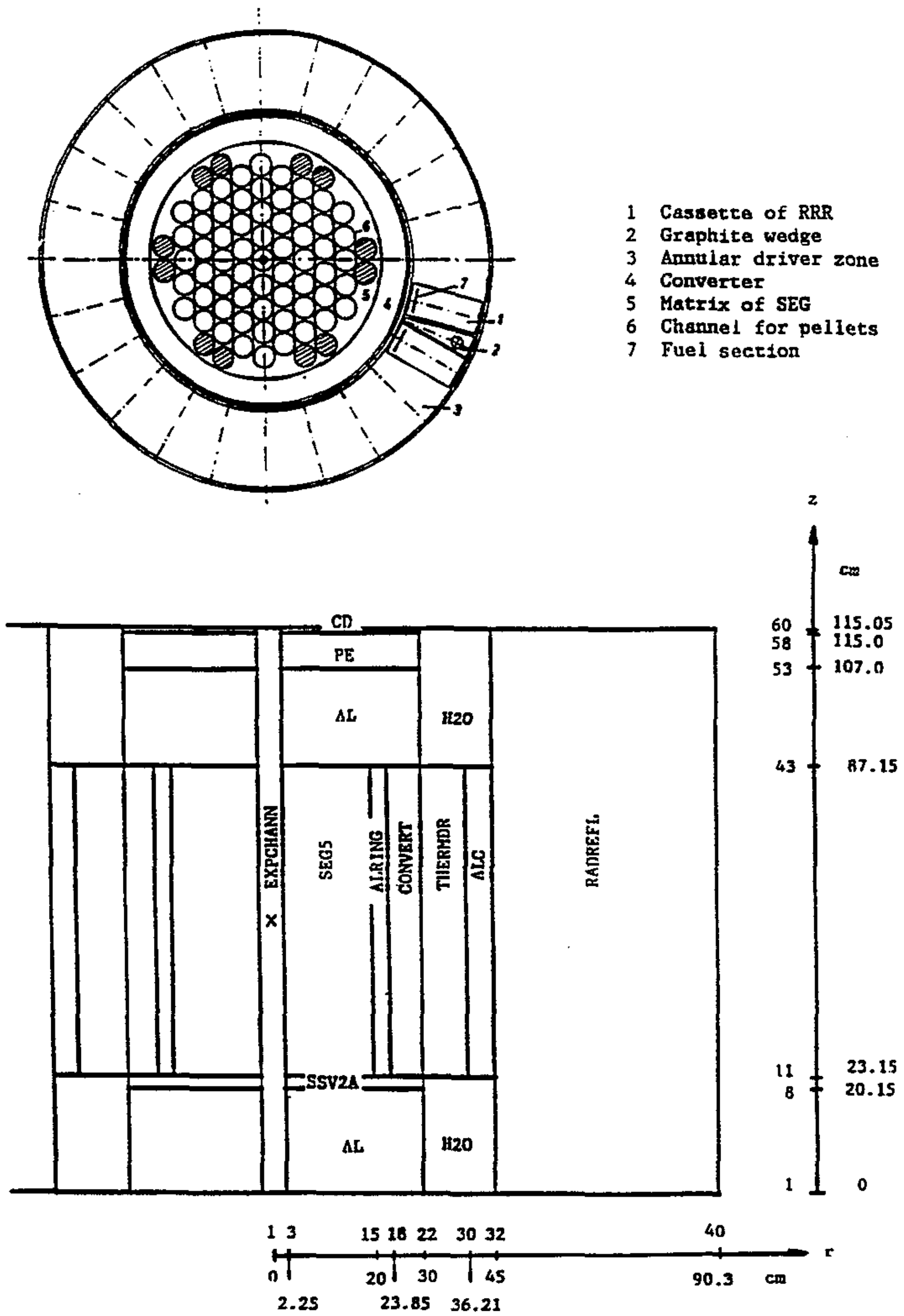


Fig. 1 : Geometrical cross-sections and regions of RRR/SEG-5

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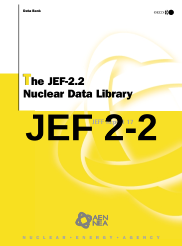
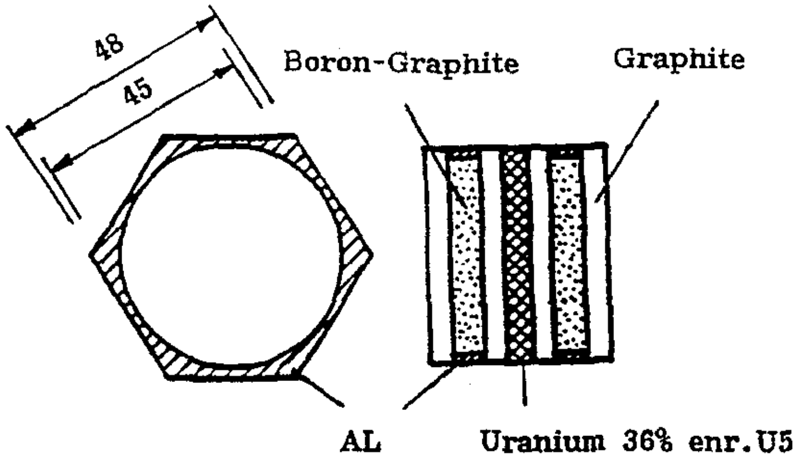
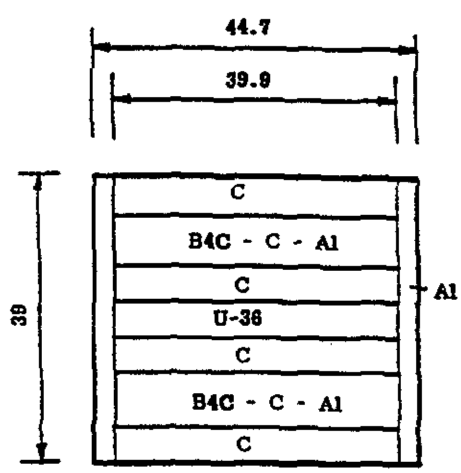



Real unit cell




Unit cell in SLAB geometry for ECCO

**Fig. 2 : Unit cell of SEG-5**

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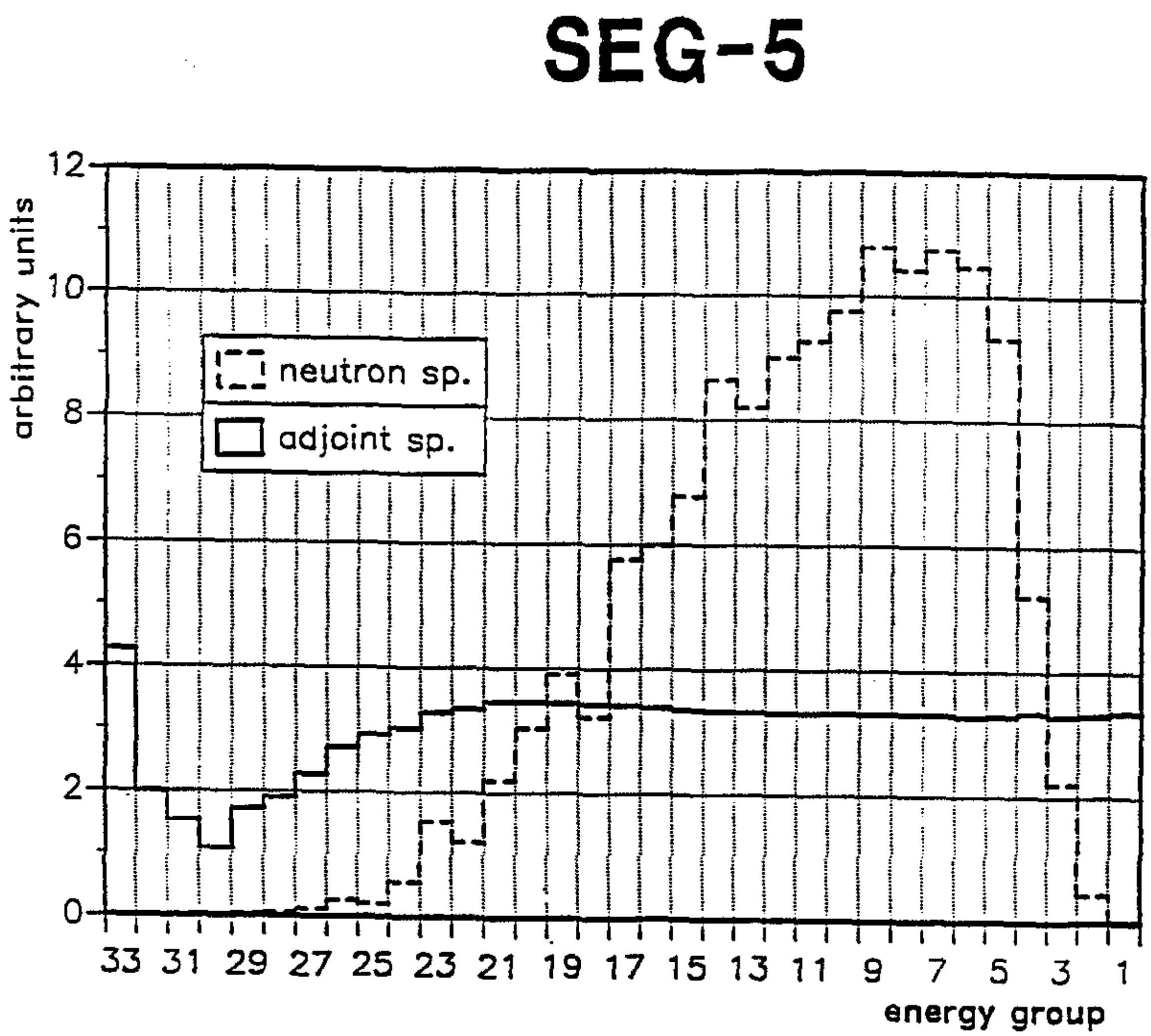
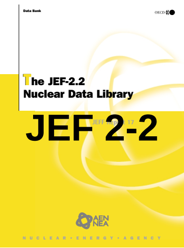



**Fig. 3 : Calculated neutron spectrum and adjoint spectrum at the central position of RRR/SEG-5**



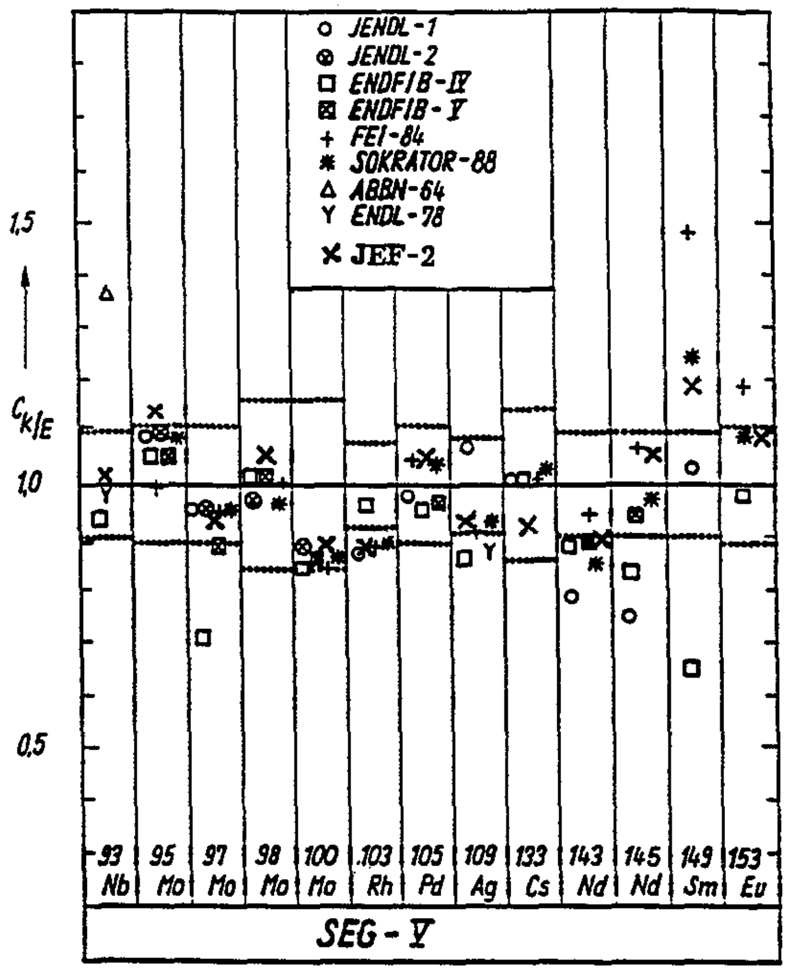
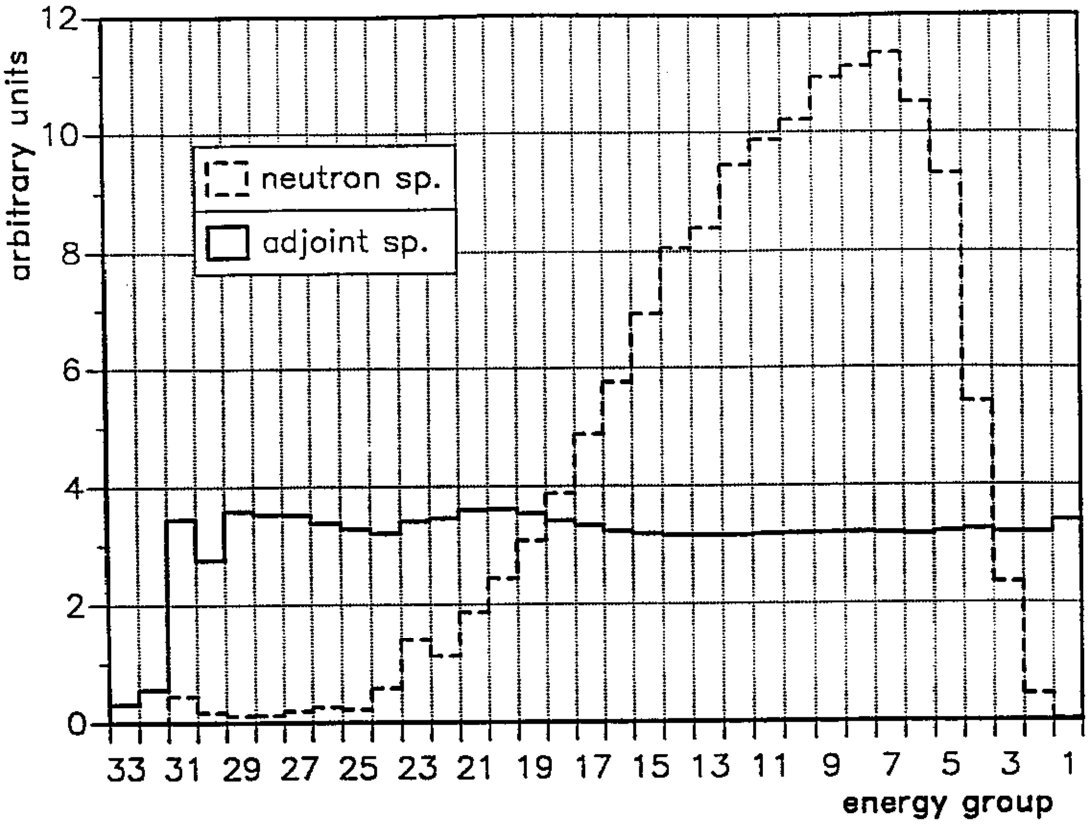




Fig. 4 : C/E-values of FP nuclides in comparison with former results [12]

## SEG-4v




## SEG-4g

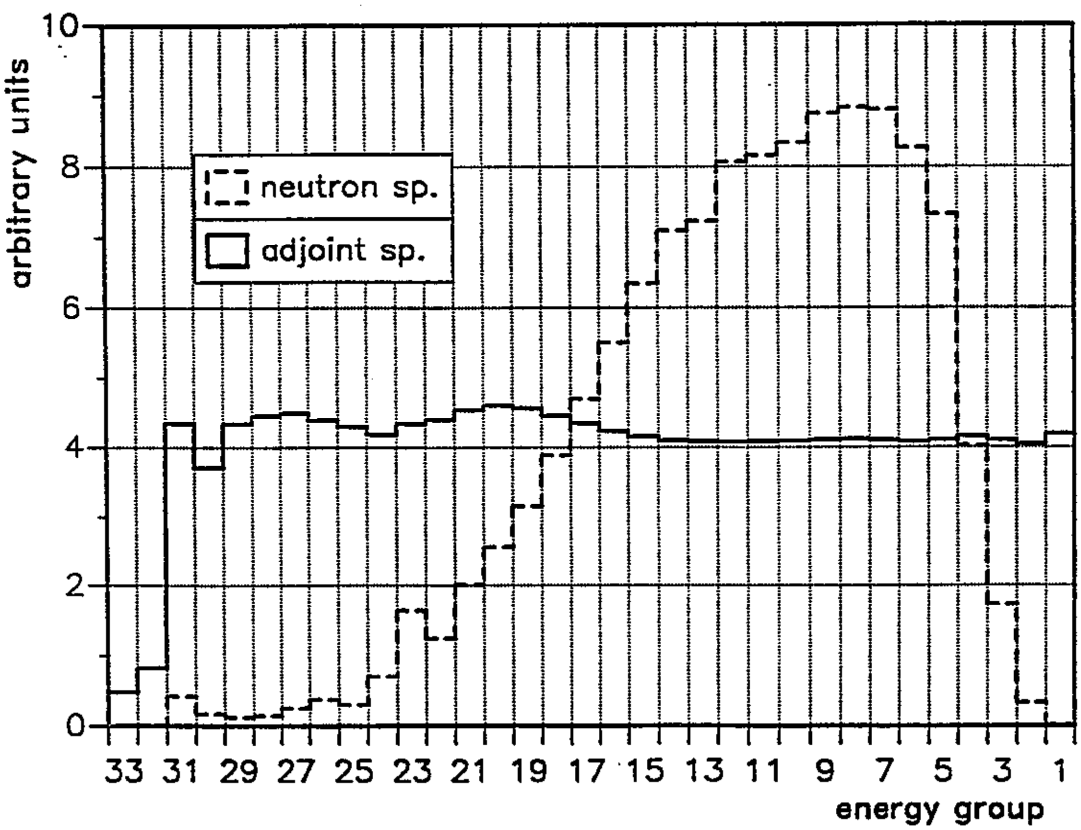



**Fig. 5: Calculated neutron spectra and adjoint spectra of SEG-4.**
**SEG-4v: voided experimental channel**
**SEG-4g: graphite filled channel**

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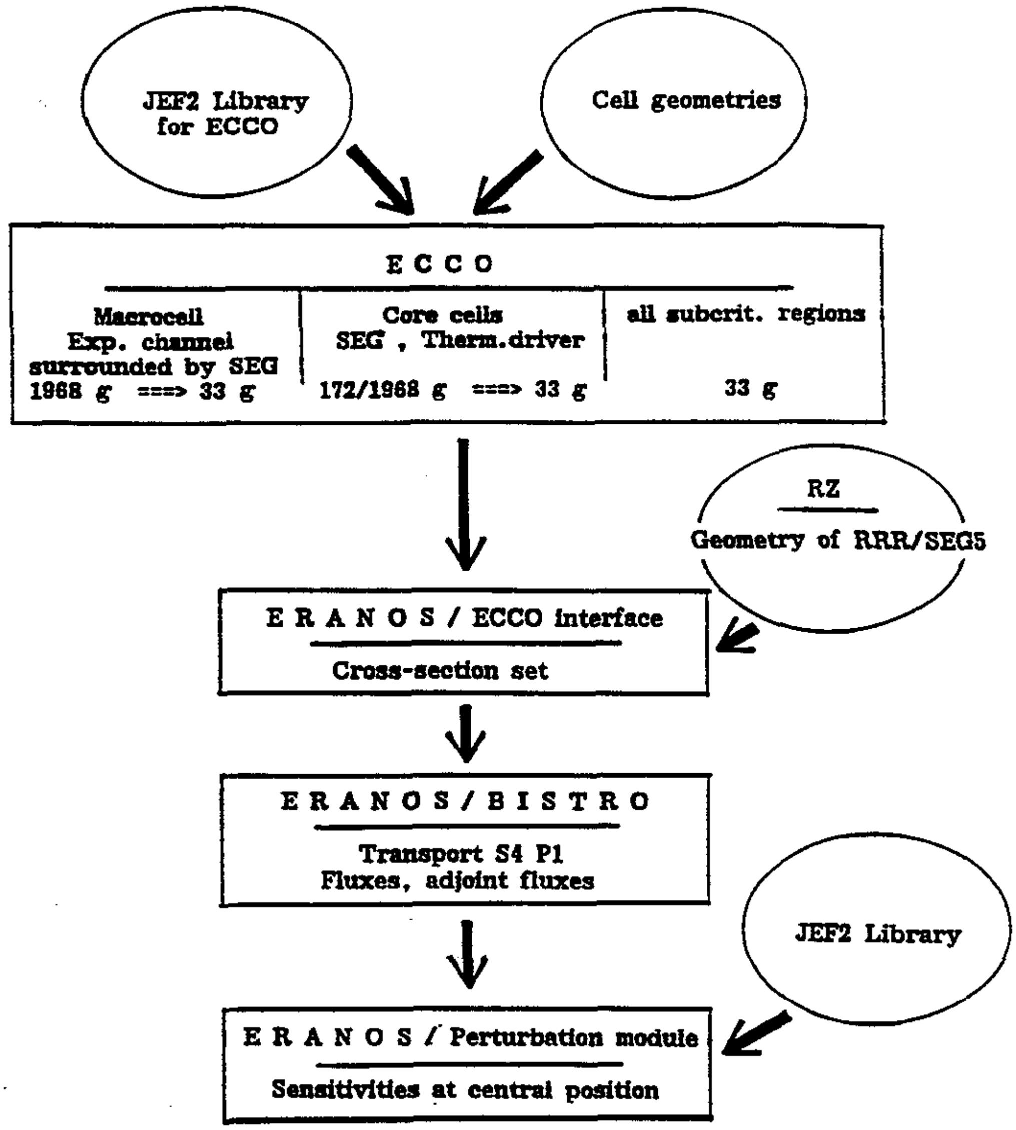


**Table 1 : Calculational scheme used for the analysis of the sample reactivity measurements in RRR/SEG-5**

```
ROSSENDORF CELL SEG5 for ECCO4 USING SLAB GEOMETRY
 REFERENCE DATA 1 8192
 GEOMETRY DATA
 SLAB
 4.47    7
 .50000 3.99
 .70000 3.99
 .50000 3.99
 .50000 3.99
 .50000 3.99
 .70000 3.99
 .50000 3.99
 REGION 1 'C'     COMP 2 300
 REGION 2 'BG'    COMP 3 300
 REGION 3 'C'     COMP 2 300
 REGION 4 'U-36'  COMP 1 300
 REGION 5 'C'     COMP 2 300
 REGION 6 'BG'    COMP 3 300
 REGION 7 'C'     COMP 2 300
 REGION 8 'AL'    COMP 4 300
 REGION 9 'AL'    COMP 4 300
 REGION 10 'AL'   COMP 4 300
 REGION 11 'AL'   COMP 4 300
 REGION 12 'AL'   COMP 4 300
 REGION 13 'AL'   COMP 4 300
 REGION 14 'AL'   COMP 4 300
 REFLECTION
& SPECIFY COMPOSITIONS
 COMPS
 1
   U235         0.016084
   U238         0.028527
 2
   C            0.07815
 3
   C            0.08450
   B10          0.001224
   B11          0.004756
   A1           0.006045
 4
   A1           0.06030
 END OF CELL DESCRIPTION
 END OF GEOMETRY DATA
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EOF
cat <<'EOF'>DATA
|         ****************************************************
|         *                  GEOMETRIE RZ                    *
|         *             pour le coeur SEG 5                  *
|         ****************************************************

PROC ->TOTO

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     REPERAGE  CYLINDRIQUE  RZ
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                      36.21  30  45.0  32  90.3  40
     COORDONNEE   Z   0.  1  20.15  8  23.15  11  87.15  43
                      107.0  53  115.0  58  115.05  60
     SECTION
           'LOWERAL'    1   40    1   60
           'SSV2A'      3   22    8   11
           'UPPERAL'    3   22   43   53
           'PE'         3   22   53   58
           'CD'         3   22   58   60
           'EXPCHANN'   1    3    1   60
           'SEG5'       3   15   11   43
           'ALRING'    15   18   11   43
           'CONVERTE'  18   22   11   43
           'THERMOR'   22   30   11   43
           'ALC'       30   32   11   43
           'RADREFL'   32   40    1   60
           'H2OLOW'    22   32    1   11
           'H2OUP'     22   32   43   60
  LIMITE
 RINF DERIVEE_NULLE
 RSUP VIDE
 ZINF VIDE
 ZSUP VIDE
   LAPLACIEN 0.0
  ;

 ARCHIVE REMPLACER (GEO)
 GEORZ SEG5 ;
```

**Table 2 : Input data for the R. Z-geometry model of RRR/SEG-5**

| Pellet Designation | Thickness mm | Weight g | Compositions E+24/cm3 | | Comment |
|---|---|---|---|---|---|
| U enr.36% U36 | 5.0 | 148.7 | U235<br>U238 | 0.016084<br>0.028527 | Ni cladding 20um,0.68g<br>U235: 53.3g |
| Graphite C | 5.0 | 14.3 | C | 0.07815 | Reactor graphite |
| Cadmium Cd | 0.5 | 6.87 | Cd | 0.04640 | Cd pure |
| Boron-Graphite BG | 7.0 | 22.3 | B10<br>B11<br>C<br>Al | 0.001224<br>0.004756<br>0.08450<br>0.006045 | Mixture of graphite (17g type M96) and boron carbide (1.4g grannulation K6), pressed into 3.87g Al rings (AlMgSi1) |

Diameter of the pellets: 45.0 + 0.1 mm

Table 3:
Characteristics of the pellets used in SEG-4 and SEG-5.

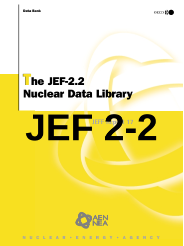



**Table 4 : C/E-values of standards, structural materials and fission product nuclides measured in SEG-5, related to the C/E-value of boron-10.**

The error consists of the experimental error for the CRW of the material and of the accuracy of the C/E-value for boron-10.

| MAT | CRW (mcent/g) | C/E (JEF-2) | Error (%) |
|---|---|---|---|
| B-10 | - 1230 ± 20 | 1.000 | 2 |
| Ta | - 31.5 ± 1.0 | 0.956 | 7 |
| U-235 | + 31.2 ± 2.0 | 1.084 | 10 |
| Mo | - 7.4 ± 0.5 | 0.964 | 10 |
| Mn | - 12.0 ± 0.5 | 0.952 | 7 |
| Cd | - 10.0 ± 0.5 | 1.215 | 9 |
| Nb | - 10.0 ± 0.6 | 1.022 | 9 |
| Cu | - 4.5 ± 0.5 | 1.119 | 14 |
| Zr | - 1.05 ± 0.1 | 1.032 | 13 |
| W | - 10.0 ± 0.5 | 1.085 | 8 |
| Fe | - 0.7 ± 0.06 | 1.084 | 11 |
| Cr | - 0.8 ± 0.06 | 1.032 | 10 |
| Ni | - 1.3 ± 0.1 | 1.073 | 10 |
| Co | - 20.0 ± 1.5 | 0.992 | 10 |
| B-10 | - 1174 ± 20 | 1.000 | 2 |
| Mo-95 | - 14.5 ± 1.0 | 1.133 | 10 |
| Mo-97 | - 14.0 ± 1.0 | 0.954 | 10 |
| Mo-98 | - 5.0 ± 0.6 | 1.061 | 15 |
| Mo-100 | - 4.1 ± 0.5 | 0.888 | 16 |
| Rh-103 | - 27.0 ± 1.0 | 0.901 | 7 |
| Pd-105 | - 30.2 ± 1.0 | 1.064 | 7 |
| Ag-109 | - 31.5 ± 1.5 | 0.929 | 8 |
| Cs-133 | - 19.5 ± 2.0 | 0.926 | 13 |
| Nd-143 | - 16.0 ± 1.0 | 0.896 | 9 |
| Nd-145 | - 18.0 ± 1.0 | 1.066 | 9 |
| Sm-149 | - 83 ± 5 | 1.191 | 9 |
| Eu-153 | - 75 ± 5 | 1.091 | 10 |

SENSIBILITE

REACTEUR

TOTAL SUR LES GROUPES

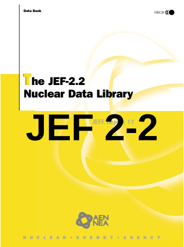
| CORPS | CAPTURE | FISSION | TRANSPORT | SCATTERING $g \rightarrow g'$ $g'=g+2,3,\ldots$ | $g'=g+1$ | NU | TOTAL |
|---|---|---|---|---|---|---|---|
| U238 | -4.084453E-13 | 6.353093E-14 | 2.332466E-17 | 3.651863E-16 | 1.443316E-16 | 0.000000E+00 | -3.443815E-13 |
| U235 | -6.499369E-13 | 2.454169E-12 | 2.148613E-17 | 4.194056E-16 | 8.067102E-17 | 4.128679E-12 | 6.033423E-12 |
| B10 | -2.946860E-12 | 0.000000E+00 | 4.623108E-18 | -2.023133E-17 | 3.599146E-16 | 0.000000E+00 | -2.946606E-12 |
| B11 | -2.774739E-17 | 0.000000E+00 | 4.210294E-18 | -7.975542E-18 | 2.388638E-16 | 0.000000E+00 | 2.073612E-16 |
| Zr | -2.373753E-14 | 0.000000E+00 | 1.561162E-17 | -1.763705E-16 | 2.251058E-16 | 0.000000E+00 | -2.367319E-14 |
| Mo | -1.636531E-13 | 0.000000E+00 | 1.522811E-17 | -4.314069E-17 | -1.728531E-16 | 0.000000E+00 | -1.638539E-13 |
| Mn | -1.457499E-13 | 0.000000E+00 | 3.332034E-18 | -9.870174E-17 | -4.620880E-15 | 0.000000E+00 | -1.503661E-13 |
| Fe56 | -8.916399E-15 | 0.000000E+00 | 6.060497E-19 | -8.260611E-17 | -2.262172E-16 | 0.000000E+00 | -9.224717E-15 |
| Fe54 | -2.445809E-14 | 0.000000E+00 | 1.571389E-18 | -1.826291E-16 | 1.673360E-15 | 0.000000E+00 | -2.295879E-14 |
| Fe57 | -3.595682E-14 | 0.000000E+00 | 1.473986E-18 | 2.007736E-15 | 2.229469E-15 | 0.000000E+00 | -3.272814E-14 |
| Fe58 | -1.454076E-14 | 0.000000E+00 | 1.327803E-18 | -1.139861E-16 | 9.933691E-16 | 0.000000E+00 | -1.366006E-14 |
| Cr50 | -3.301728E-14 | 0.000000E+00 | 1.818211E-18 | -2.002176E-17 | 4.830997E-15 | 0.000000E+00 | -2.820449E-14 |
| Cr52 | -6.825561E-15 | 0.000000E+00 | 1.054901E-18 | -2.173329E-16 | 1.944420E-17 | 0.000000E+00 | -7.022386E-15 |
| Cr53 | -3.688706E-14 | 0.000000E+00 | 1.526376E-18 | -1.743860E-16 | 4.194696E-15 | 0.000000E+00 | -3.286522E-14 |
| Cr54 | -1.801699E-15 | 0.000000E+00 | 9.493714E-19 | -6.601516E-17 | 4.085184E-17 | 0.000000E+00 | -1.845913E-15 |
| Ni58 | -2.417554E-14 | 0.000000E+00 | 4.547243E-19 | -1.983107E-16 | 1.790425E-15 | 0.000000E+00 | -2.258297E-14 |
| Ni60 | -1.275710E-14 | 0.000000E+00 | 1.302868E-18 | -2.599678E-16 | 1.262154E-15 | 0.000000E+00 | -1.176380E-14 |
| Ni61 | -4.105746E-14 | 0.000000E+00 | 8.647568E-19 | 3.104933E-17 | 2.984979E-16 | 0.000000E+00 | -4.072704E-14 |
| Ni62 | -2.140732E-14 | 0.000000E+00 | 7.446325E-19 | -2.360030E-16 | 3.564700E-15 | 0.000000E+00 | -1.807788E-14 |
| Ni64 | -7.371482E-15 | 0.000000E+00 | 1.575752E-18 | -2.402256E-16 | 2.260076E-15 | 0.000000E+00 | -5.350056E-15 |
| Ag109 | -8.009447E-13 | 0.000000E+00 | 5.203330E-19 | 3.336352E-16 | -9.288717E-17 | 0.000000E+00 | -8.007034E-13 |
| Co59 | -2.742082E-13 | 0.000000E+00 | -3.155574E-18 | -3.074143E-16 | -6.638128E-15 | 0.000000E+00 | -2.801669E-13 |
| Cu | -7.709756E-14 | 0.000000E+00 | 9.682933E-19 | -1.842101E-16 | 6.531270E-16 | 0.000000E+00 | -7.652767E-14 |
| Nb93 | -2.276206E-13 | 0.000000E+00 | 8.787644E-19 | -1.328748E-16 | 2.385916E-16 | 0.000000E+00 | -2.276140E-13 |
| Ta181 | -1.305768E-12 | 0.000000E+00 | 2.812726E-19 | 5.049864E-16 | -2.649238E-16 | 0.000000E+00 | -1.305618E-12 |
| Ti | -9.528809E-15 | 0.000000E+00 | 1.574627E-18 | -2.200947E-16 | 3.163331E-15 | 0.000000E+00 | -6.583998E-15 |
| V | -1.340277E-14 | 0.000000E+00 | 1.657019E-18 | -1.719152E-16 | 4.115492E-15 | 0.000000E+00 | -9.457639E-15 |
| W182 | -4.821758E-13 | 0.000000E+00 | 1.098419E-19 | -2.618798E-16 | -1.445923E-16 | 0.000000E+00 | -4.825821E-13 |
| W183 | -1.009919E-12 | 0.000000E+00 | -1.024540E-19 | 4.537256E-16 | -3.981191E-16 | 0.000000E+00 | -1.009864E-12 |
| W184 | -2.860593E-13 | 0.000000E+00 | -2.609534E-19 | -1.372805E-16 | -1.525936E-15 | 0.000000E+00 | -2.877227E-13 |
| W186 | -4.107261E-13 | 0.000000E+00 | -2.071294E-19 | -1.007996E-16 | -5.154800E-17 | 0.000000E+00 | -4.108786E-13 |
| Bi209 | -7.371744E-15 | 0.000000E+00 | 5.883473E-19 | -3.280587E-16 | 1.443336E-16 | 0.000000E+00 | -7.554880E-15 |
| Mo95 | -3.891915E-13 | 0.000000E+00 | -5.504576E-19 | 1.151370E-16 | -2.634611E-15 | 0.000000E+00 | -3.917115E-13 |
| Mo97 | -3.254746E-13 | 0.000000E+00 | 7.943690E-19 | 2.806779E-16 | 1.185964E-16 | 0.000000E+00 | -3.250745E-13 |
| Mo98 | -1.304895E-13 | 0.000000E+00 | 7.236400E-19 | 3.698305E-17 | -4.692409E-17 | 0.000000E+00 | -1.304987E-13 |
| Cd | -3.275588E-13 | 0.000000E+00 | 6.649671E-19 | 3.829446E-16 | 5.858998E-17 | 0.000000E+00 | -3.271166E-13 |
| Eu153 | -3.140836E-12 | 0.000000E+00 | 3.560533E-19 | 2.374504E-16 | -7.105548E-17 | 0.000000E+00 | -3.140668E-12 |
| Mo100 | -9.147832E-14 | 0.000000E+00 | 6.435601E-19 | 2.557173E-16 | -1.434459E-16 | 0.000000E+00 | -9.136541E-14 |
| Cs133 | -6.026529E-13 | 0.000000E+00 | 5.912982E-19 | 5.401849E-17 | 1.196641E-16 | 0.000000E+00 | -6.024886E-13 |
| Rh103 | -6.290636E-13 | 0.000000E+00 | 8.130383E-19 | 3.163093E-16 | 1.067496E-16 | 0.000000E+00 | -6.286397E-13 |
| Sm149 | -3.696496E-12 | 0.000000E+00 | -7.746088E-19 | 1.031738E-15 | -1.635465E-15 | 0.000000E+00 | -3.697101E-12 |
| Nd143 | -5.094479E-13 | 0.000000E+00 | -1.770123E-18 | -5.668207E-16 | -4.640119E-15 | 0.000000E+00 | -5.146686E-13 |
| Nd145 | -6.929911E-13 | 0.000000E+00 | -2.764752E-18 | -1.229397E-17 | -5.610969E-15 | 0.000000E+00 | -6.986171E-13 |
| Pd105 | -8.477100E-13 | 0.000000E+00 | 6.865127E-19 | 5.303238E-16 | 6.285330E-17 | 0.000000E+00 | -8.471161E-13 |
| C | -6.657949E-08 | 0.000000E+00 | 2.848666E-09 | -3.762112E-09 | 3.362360E-07 | 0.000000E+00 | 2.697431E-07 |
| PARTIE >0 | 0.000000E+00 | 2.517690E-12 | 2.848666E-09 | 7.357024E-16 | 3.362361E-07 | 4.128679E-12 | 3.390974E-07 |
| PARTIE <0 | -6.660029E-08 | 0.000000E+00 | -9.586052E-18 | -3.762116E-09 | -2.771868E-14 | 0.000000E+00 | -6.936243E-08 |
| TOTAL | -6.660029E-08 | 2.517690E-12 | 2.848666E-09 | -3.762109E-09 | 3.362360E-07 | 4.128679E-12 | 2.697289E-07 |

**Table 5 : Sensitivities of sample materials (traces of atomic density E-10) in the central position of SEG-5**

CORPS Sm149

| GROUPE | CAPTURE | FISSION | TRANSPORT | SCATTERING $g \rightarrow g'$ $g'=g+2,3,\ldots$ | $g'=g+1$ | NU | TOTAL |
|---|---|---|---|---|---|---|---|
| 1 | -4.873766E-19 | 0.000000E+00 | 3.531284E-21 | -9.266231E-18 | -3.608038E-19 | 0.000000E+00 | -1.011058E-17 |
| 2 | -3.715568E-18 | 0.000000E+00 | 2.580160E-20 | -3.637082E-17 | -1.824710E-18 | 0.000000E+00 | -4.188628E-17 |
| 3 | -1.882026E-16 | 0.000000E+00 | 4.436478E-20 | 2.961119E-17 | 1.644107E-17 | 0.000000E+00 | -1.421059E-16 |
| 4 | -1.873215E-15 | 0.000000E+00 | 1.448135E-19 | -8.704842E-16 | -5.874074E-17 | 0.000000E+00 | -2.802295E-15 |
| 5 | -6.614120E-15 | 0.000000E+00 | 1.508651E-19 | 3.210561E-17 | -3.784161E-17 | 0.000000E+00 | -6.619705E-15 |
| 6 | -1.334928E-14 | 0.000000E+00 | 9.072077E-20 | 1.224717E-15 | 4.824130E-17 | 0.000000E+00 | -1.207823E-14 |
| 7 | -2.288522E-14 | 0.000000E+00 | 8.097120E-20 | 3.203326E-16 | 3.059590E-17 | 0.000000E+00 | -2.251421E-14 |
| 8 | -2.721168E-14 | 0.000000E+00 | 4.671072E-20 | -2.518879E-17 | 5.564229E-19 | 0.000000E+00 | -2.723628E-14 |
| 9 | -3.554316E-14 | 0.000000E+00 | 2.615577E-20 | 1.367381E-17 | -8.528559E-18 | 0.000000E+00 | -3.553798E-14 |
| 10 | -3.631693E-14 | 0.000000E+00 | 3.377148E-20 | -9.777714E-18 | -1.034414E-17 | 0.000000E+00 | -3.633701E-14 |
| 11 | -4.400967E-14 | 0.000000E+00 | 3.551336E-20 | -5.627480E-19 | -4.046361E-19 | 0.000000E+00 | -4.401060E-14 |
| 12 | -5.743064E-14 | 0.000000E+00 | 2.801676E-20 | 8.407246E-17 | 2.927923E-17 | 0.000000E+00 | -5.731716E-14 |
| 13 | -6.907514E-14 | 0.000000E+00 | 2.715208E-20 | 2.624205E-16 | 5.653021E-17 | 0.000000E+00 | -6.876616E-14 |
| 14 | -1.037463E-13 | 0.000000E+00 | 2.077157E-20 | 1.645539E-17 | 1.247610E-16 | 0.000000E+00 | -1.036041E-13 |
| 15 | -1.121776E-13 | 0.000000E+00 | 3.774904E-20 | 0.000000E+00 | 1.038996E-16 | 0.000000E+00 | -1.120737E-13 |
| 16 | -1.369526E-13 | 0.000000E+00 | 3.477626E-20 | 0.000000E+00 | 1.246163E-16 | 0.000000E+00 | -1.368280E-13 |
| 17 | -1.927168E-13 | 0.000000E+00 | -2.122194E-20 | 0.000000E+00 | 4.560351E-17 | 0.000000E+00 | -1.926712E-13 |
| 18 | -1.570789E-13 | 0.000000E+00 | 4.615816E-20 | 0.000000E+00 | 4.582470E-17 | 0.000000E+00 | -1.570331E-13 |
| 19 | -2.875991E-13 | 0.000000E+00 | -7.893801E-21 | 0.000000E+00 | 8.217616E-17 | 0.000000E+00 | -2.875169E-13 |
| 20 | -3.117973E-13 | 0.000000E+00 | -4.762383E-20 | 0.000000E+00 | 1.973212E-17 | 0.000000E+00 | -3.117776E-13 |
| 21 | -3.264213E-13 | 0.000000E+00 | -2.374603E-19 | 0.000000E+00 | -3.016961E-16 | 0.000000E+00 | -3.267233E-13 |
| 22 | -2.423448E-13 | 0.000000E+00 | -1.384758E-19 | 0.000000E+00 | -1.578520E-16 | 0.000000E+00 | -2.425028E-13 |
| 23 | -4.278948E-13 | 0.000000E+00 | -2.250038E-19 | 0.000000E+00 | -3.774375E-16 | 0.000000E+00 | -4.282724E-13 |
| 24 | -3.518347E-13 | 0.000000E+00 | -2.032040E-19 | 0.000000E+00 | -2.581662E-16 | 0.000000E+00 | -3.520930E-13 |
| 25 | -1.885250E-13 | 0.000000E+00 | -4.053916E-19 | 0.000000E+00 | -4.476523E-16 | 0.000000E+00 | -1.889781E-13 |
| 26 | -3.170832E-13 | 0.000000E+00 | -3.999284E-19 | 0.000000E+00 | -5.954821E-16 | 0.000000E+00 | -3.176791E-13 |
| 27 | -6.067621E-14 | 0.000000E+00 | -1.067531E-20 | 0.000000E+00 | -3.331582E-18 | 0.000000E+00 | -6.067955E-14 |
| 28 | -1.465465E-14 | 0.000000E+00 | -4.466499E-21 | 0.000000E+00 | -5.956829E-18 | 0.000000E+00 | -1.466061E-14 |
| 29 | -1.919868E-14 | 0.000000E+00 | -6.110142E-20 | 0.000000E+00 | -1.018613E-16 | 0.000000E+00 | -1.930059E-14 |
| 30 | -4.092763E-15 | 0.000000E+00 | -2.271463E-22 | 0.000000E+00 | 1.199396E-19 | 0.000000E+00 | -4.092644E-15 |
| 31 | -2.241412E-15 | 0.000000E+00 | 1.523781E-23 | 0.000000E+00 | 4.081167E-21 | 0.000000E+00 | -2.241408E-15 |
| 32 | -2.334792E-14 | 0.000000E+00 | 1.959501E-20 | 0.000000E+00 | 3.583489E-18 | 0.000000E+00 | -2.334431E-14 |
| 33 | -1.014320E-13 | 0.000000E+00 | 8.041243E-20 | 0.000000E+00 | 8.041243E-20 | 0.000000E+00 | -1.014318E-13 |
| PARTIE >0 | 0.000000E+00 | 0.000000E+00 | 9.780661E-19 | 1.983388E-15 | 7.320467E-16 | 0.000000E+00 | 2.716412E-15 |
| PARTIE <0 | -3.696496E-12 | 0.000000E+00 | -1.752674E-18 | -9.518505E-16 | -2.367611E-15 | 0.000000E+00 | -3.699817E-12 |
| TOTAL | -3.696496E-12 | 0.000000E+00 | -7.746088E-19 | 1.031738E-15 | -1.635465E-15 | 0.000000E+00 | -3.697101E-12 |

***Table 6 : Sensitivities of Sm-149 (trace of E-10) in the central position of SEG-5***




Preliminary results of the analysis for SEG-4 using JEF-2/ECCO/ERANOS

$$C/E = \frac{Ci \quad E10 \quad 10}{Ei \quad C10 \quad Ai}$$

SEG-4g: Graphite filled exp. channel
SEG-4v: Voided experimental channel

dcrit= 7.14 cm, keff= 0.99999

| MAT | Ai | Ei(mcent/g) | C/E | ERROR | COMMENT | capt/tot |
|---|---|---|---|---|---|---|
| B-10 | 10 | -1326 +- 20 | 1.000 | 2% | C10: 0.5% diff.to ABBN-78 | 1.0003 |
| U-235 | 235 | + 31.2 +-2 | 0.965 | 10% | Rossendorf analysis: C/E= 1.25 | |
| U-238 | 238 | -7.2 +-0.5 | 1.056 | 10% | | |
| Mo-95 | 95 | -18 +- 1 | 0.913 | 10% | | 1.0024 |
| Mo-97 | 97 | -11 +- 0.5 | 0.952 | 9% | | 1.0009 |
| Mo-98 | 98 | -5.3 +- 0.4 | 0.773 | 12% | | 1.0007 |
| Mo-100 | 100 | -3.5 +- 0.3 | 0.803 | 13% | | 0.9885 |
| Rh-103 | 103 | -35 +- 3 | 1.056 | 12% | | 1.0002 |
| Pd-105 | 105 | -30.5 +- 5 | 0.882 | 19% | | 1.0002 |
| Ag-109 | 109 | -65 +- 5 | 0.809 | 12% | | 1.0001 |
| Cs-133 | 133 | -22 +- 2 | 1.038 | 13% | | 1.0001 |
| Sm-149 | 149 | -105 +- 5 | 1.094 | 9% | | 1.0002 |
| Eu-153 | 153 | -93 +- 5 | 1.108 | 10% | | 1.0000 |
| Ta | 180.95 | -37 +- 2 | 0.851 | 8% | | 0.9996 |
| Mo | 95.95 | -6.2 +- 0.5 | 0.906 | 12% | | 0.9950 |
| Nb | 92.91 | -8.5 +- 0.5 | 0.889 | 10% | | 0.9972 |
| Mn | 54.94 | -8.3 +- 0.6 | 0.957 | 11% | | 1.0480 |
| Fe | 55.85 | -0.52 +- 0.07 | 1.086 | 12% | | 1.2014 |
| Cr | 52.01 | -0.50 +- 0.03 | 1.076 | 10% | | 1.5925 |
| Ni | 58.71 | -1.00 +- 0.08 | 1.091 | 11% | | 1.2464 |
| Cd | 112.4 | -7.5 +- 0.5 | 1.046 | 10% | present in SEG-4 | 0.9967 |
| Cu | 63.54 | -4.2 +- 0.3 | 0.878 | 11% | | 1.0458 |
| Zr | 91.22 | -0.90 +- 0.08 | 0.911 | 12% | | 0.9980 |
| W | 183.86 | -15 +- 1 | 0.896 | 10% | | 0.9986 |

**Table 7: As Table 4, for SEG-4.**