NUCLEAR DATA ADJUSTMENT USING SPENT FUEL ANALYSIS : FEEDBACK TO JEFF-3 PROJECT.

Keywords : U238,U235,^{241}AM, ^{242M}AM,SPENT FUEL, Apollo2

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1. INTRODUCTION

Spent fuel analysis (mass spectrometry and chemical analysis) of PWR pins is a major interest to validate nuclear data. These types of measurements complete critical and oscillations experiments. In particular, we can extract accurate trends about radiative capture of majors and minors actinides.
The analysis with Apollo2 code has been given in a preceding meeting (JEF/DOC-646).
The aim of the paper following the later is to present the actual status of nuclear data adjustment using this data base. This study contribute to point out the deficiencies in JEF2.2 and to help to make choices for the JEFF-3 project.
This work is support EDF and FRAMATOME to improve the nuclear library of Apollo2 code which is mainly based on JEF2.2.

2. EXPERIMENTAL DATA BASE

The irradiation of assemblies (4.5% U235 initial enrichment) in the EDF PWR Gravelines up to 60 GWd/t constitutes a somewhat large data base of various isotopic ratios. It contains the analysis of 17 samples for which uranium and plutonium analysis were done.

3. NUCLEAR DATA PARAMETERS IN THIS STUDY

For this adjustment we used six broad groups ranging from thermal to high energy.

group	1	2	3	4	5	6
upper energy (eV)	$19.64\ 10^{6}$	$2.48\ 10^{3}$	91	2.76	0.5	0.1

We considered the following nuclides with fission and capture cross sections.

U235, U238, U236

PU238, PU238, PU239, PU240, PU241, PU242

AM241, AM242M, AM243

NP237

CM242, CM243, CM244, CM245

Fission yield for ND148

4. SENSITIVITY

We can found below different sensitivities versus burnup. These sensitivities served in least mean square minimisation.

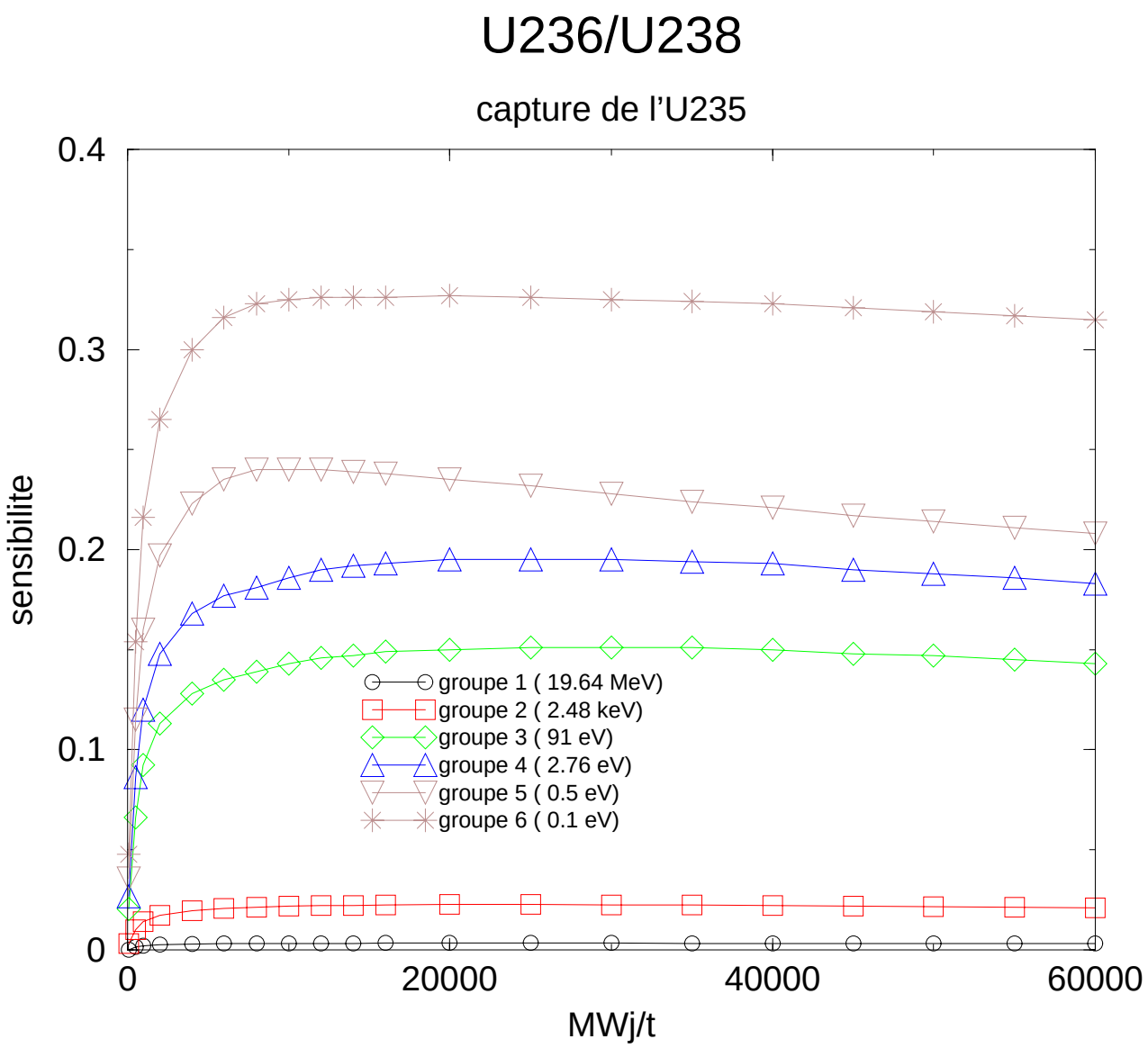

Figure 1 Sensitivity of $^{236}U/^{238}U$ to ^{235}U capture

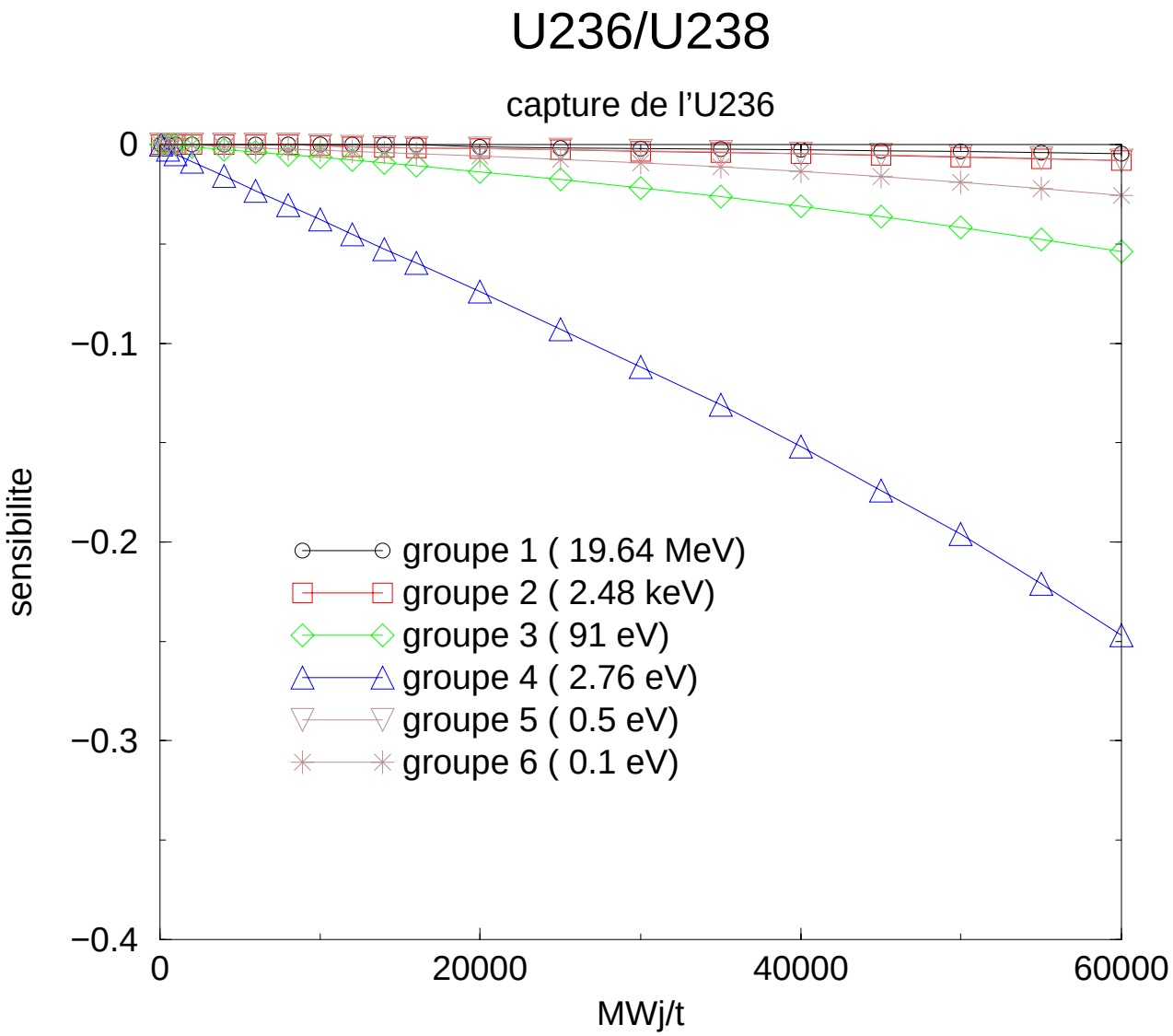

Figure 2 Sensitivity of $^{236}U/^{238}U$ to ^{236}U capture

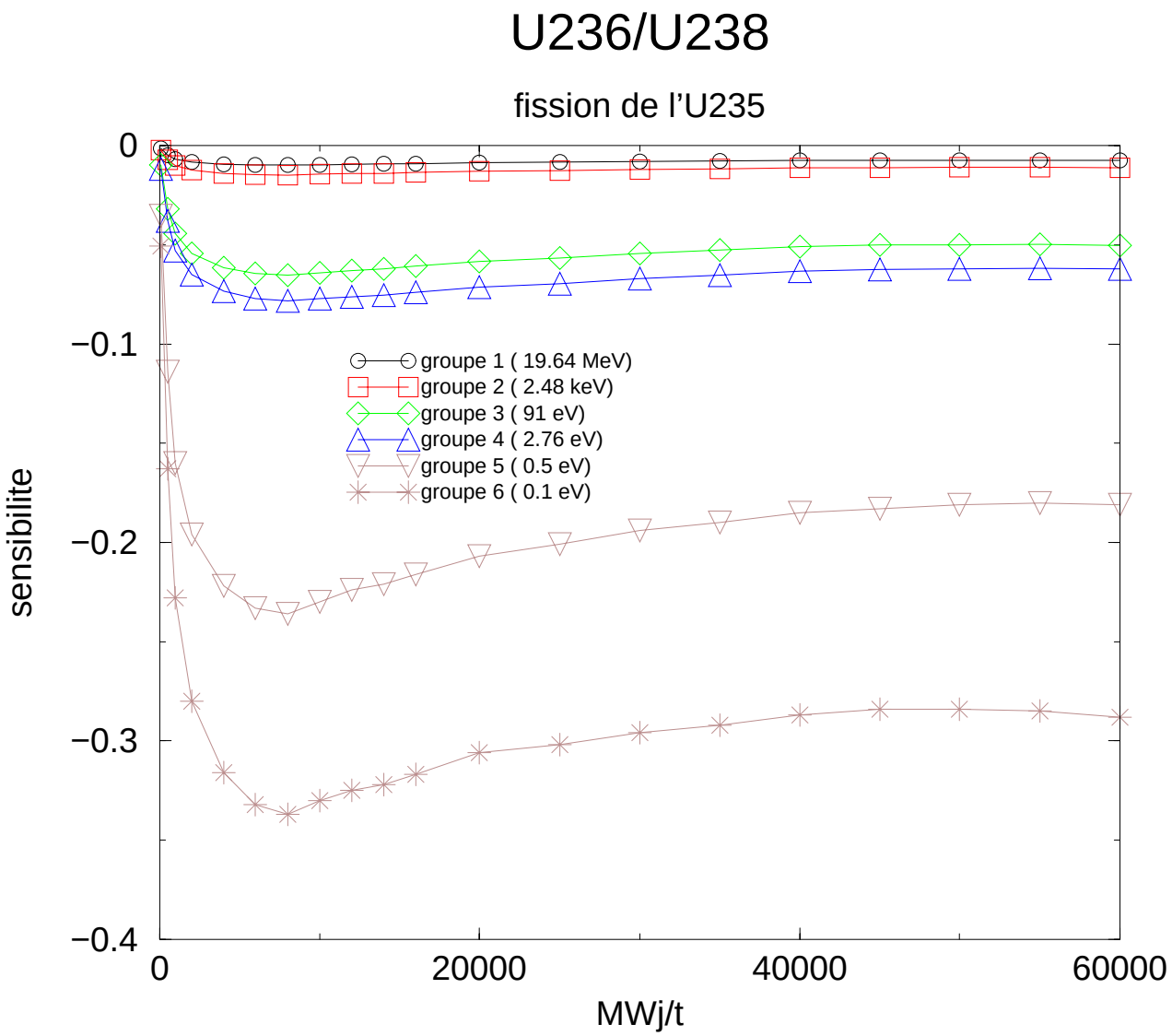

Figure 3 Sensitivity of $^{236}U/^{238}U$ to ^{235}U fission

5. RESULTS

Overview of the adjustments

isotope	thermal		epithermal		comments
	capture	fission	capture	fission	
^{235}U	+0.4	-0.5%	+2 to +9%	-1 to -3%	JEFF-3 or ENDF/B-VI.5 confirmed
^{236}U			-2 to -5%		
^{238}U			-1 to -3%		close to BROND2.2
^{239}Pu	+1%		+1 %		
^{240}Pu			+1 %		
^{241}Pu	+1%		+1 to 2%		
^{242}Pu			+3%		close to JENDL-3.2
^{241}Am	+3%		+9%		close to Maslov evaluation, JENDL-3.2 et ENDF/B-VI
^{242m}Am	-60%	-4%	-5%		close to Maslov evaluation, JENDL-3.2 et ENDF/B-VI
^{243}Am					
^{237}Np			-0.3%		
^{242}Cm	+17%		+8 à14%.		No evaluation found sustaining this trend
^{243}Cm	-0.4%	-0.5%	-0.8%	-2%	
^{244}Cm			-3%		
^{245}Cm	+2%	-1%	+1%		

CROSS SECTION ADJUSTEMENTS

father nuclide	adjustment in %
U235	-0.85

FISSION YIELD ND148

6. CONCLUSIONS

U235 choice in JEFF-3.0 (ENDF/B-VI.5) confirmed

	JEF2.2	JEFF-3.0	PRESENT ADJUSTMENT
I_γ/I_f	0.476	0.517	0.524

U238 choice of BROND-2.2 would be better for capture

	JEF2.2	BROND-2.2	PRESENT ADJUSTMENT
I_γ	278.05	275.98	275.4

Actually in JEF-2.2, we have probably reactivity compensation between U235 and U238 in a restrict class of critical experiments (2-3% U235). It would be worst to change only U235 without considering U238.

U238 evaluation needed (ENDF/B-VI.5 ?)

=>a slight diminution of Γ_n (-3%)and Γ_γ (-2%) for the first five levels.

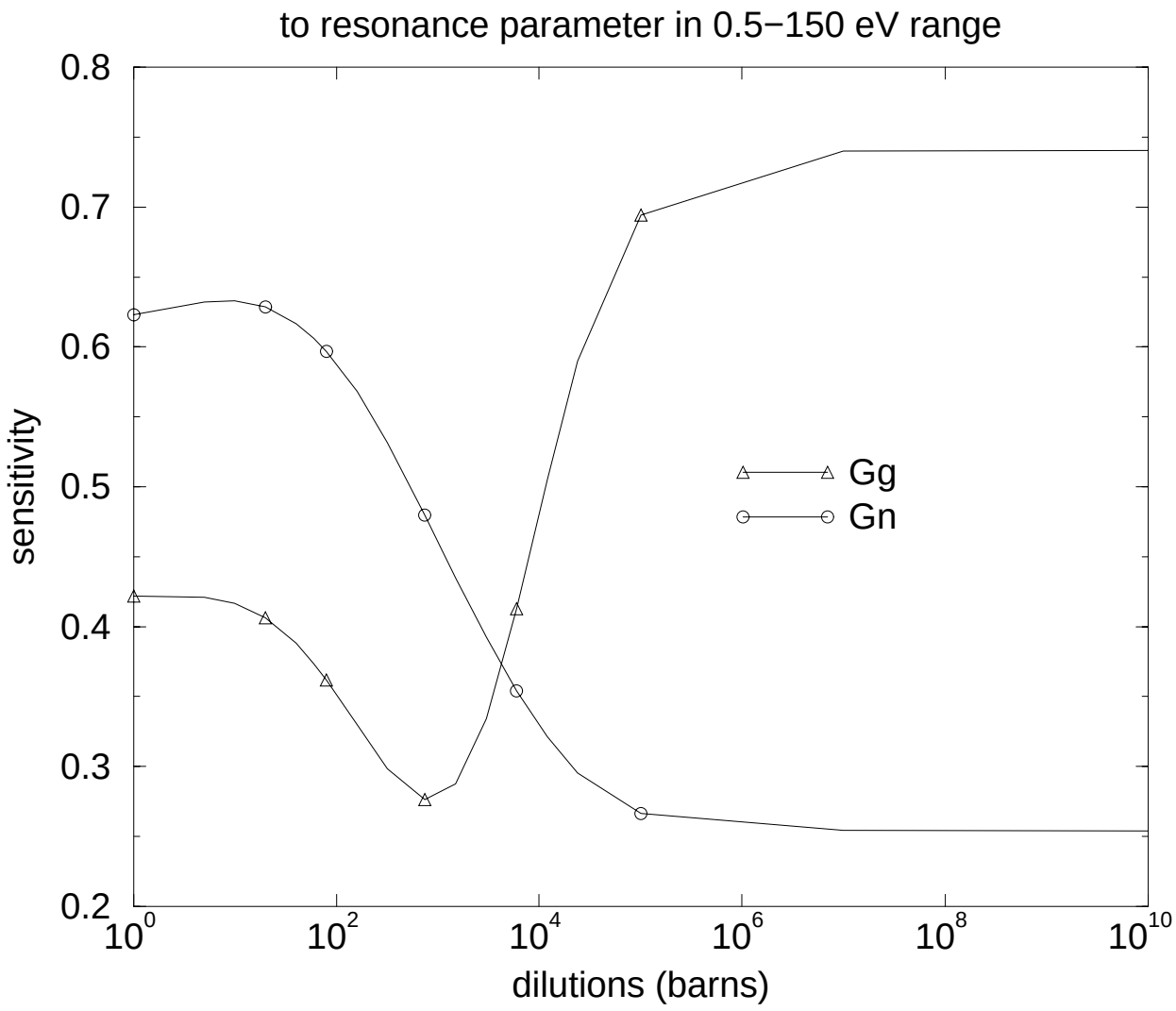

Figure 4 Sensitivity of self-shielded capture to resonance parameter in range 0.5-150 eV

7. APPENDIX

JEF2.2 resonance integrals 0.5 eV-20 MeV

Isotope	SIGA	SIGF	CAPTURE	ALPHA
U235	4.1151E+02	2.7884E+02	1.326700E+02	4.757926E-01
U236	3.5470E+02	7.7274E+00	3.469726E+02	4.490160E+01
U238	2.8005E+02	1.9933E+00	2.780567E+02	1.394957E+02
PU239	4.8321E+02	2.9850E+02	1.847100E+02	6.187940E-01
PU240	8.4630E+03	1.0044E+01	8.452956E+03	8.415926E+02
PU241	7.5032E+02	5.7994E+02	1.703800E+02	2.937890E-01
PU242	1.1223E+03	6.2600E+00	1.116040E+03	1.782812E+02
AM241	1.4625E+03	1.6004E+01	1.446496E+03	9.038340E+01
AM242M	1.9038E+03	1.6415E+03	2.623000E+02	1.597929E-01
CM242	1.2811E+02	1.2296E+01	1.158140E+02	9.418835E+00
CM243	2.0692E+03	1.7850E+03	2.842000E+02	1.592157E-01
CM244	6.5359E+02	1.9681E+01	6.339090E+02	3.220919E+01
CM245	8.8286E+02	7.5930E+02	1.235600E+02	1.627288E-01

Adjusted resonance integrals 0.5 eV -20 MeV

Isotope	SIGA	SIGF	CAPTURE	ALPHA
U235	4.1835E+02	2.7442E+02	1.439300E+02	5.244880E-01
U236	3.4046E+02	7.7274E+00	3.327326E+02	4.305880E+01
U238	2.7744E+02	1.9862E+00	2.754538E+02	1.386838E+02
PU239	4.8617E+02	2.9897E+02	1.872000E+02	6.261498E-01
PU240	8.6225E+03	1.0044E+01	8.612456E+03	8.574727E+02
PU241	7.5924E+02	5.7726E+02	1.819800E+02	3.152479E-01
PU242	1.1001E+03	6.2600E+00	1.093840E+03	1.747348E+02
AM241	1.5625E+03	1.6004E+01	1.546496E+03	9.663184E+01
AM242M	1.8838E+03	1.6334E+03	2.504000E+02	1.532999E-01
AM243	1.8215E+03	6.4818E+00	1.815018E+03	2.800176E+02
CM242	1.4127E+02	1.2296E+01	1.289740E+02	1.048910E+01
CM243	2.0317E+03	1.7495E+03	2.822000E+02	1.613032E-01
CM244	6.3517E+02	1.9681E+01	6.154890E+02	3.127326E+01
CM245	8.8064E+02	7.5595E+02	1.246900E+02	1.649448E-01

U235			
CAPTURE			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	0.000E-01	1.000E+01	1.000E+01
2	1.897E+00	6.958E+00	7.000E+00
3	9.467E+00	4.762E+00	6.000E+00
4	8.298E+00	3.762E+00	5.000E+00
5	3.781E-01	9.883E-01	1.000E+00
6	3.912E-01	7.870E-01	8.000E-01
FISSION			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	-2.724E-02	1.999E+00	2.000E+00
2	-1.327E-01	1.998E+00	2.000E+00
3	-1.445E+00	2.911E+00	3.000E+00
4	-1.847E+00	2.869E+00	3.000E+00
5	-6.458E-01	9.592E-01	1.000E+00
6	-1.430E-01	3.955E-01	4.000E-01

U236			
CAPTURE			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	3.269E-01	2.497E+01	2.500E+01
2	-4.488E+00	1.471E+01	1.500E+01
3	-2.315E+00	3.909E+00	4.100E+00
4	-4.549E+00	3.155E+00	4.100E+00
5	1.974E-02	4.100E+00	4.100E+00
6	-2.813E-01	4.095E+00	4.100E+00

U238			
CAPTURE			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	-2.255E-01	2.991E+00	3.000E+00
2	-9.054E-01	2.403E+00	2.500E+00
3	-2.630E+00	1.593E+00	2.500E+00
4	-2.792E-01	9.747E-01	1.000E+00
5	-4.365E-02	6.990E-01	7.000E-01
6	-6.012E-02	6.977E-01	7.000E-01

PU239			
CAPTURE			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	0.000E-01	1.000E+01	1.000E+01
2	-3.403E-02	5.999E+00	6.000E+00
3	2.010E+00	5.851E+00	6.000E+00
4	9.373E-01	3.943E+00	4.000E+00
5	2.016E+00	9.367E-01	1.600E+00
6	2.650E-01	9.820E-01	1.000E+00
FISSION			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	2.034E-01	3.998E+00	4.000E+00
2	4.504E-02	3.999E+00	4.000E+00
3	9.761E-02	2.996E+00	3.000E+00
4	1.931E-01	2.988E+00	3.000E+00
5	2.013E-01	9.536E-01	1.000E+00
6	5.795E-02	4.981E-01	5.000E-01

PU240			
CAPTURE			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	0.000E-01	2.000E+01	2.000E+01
2	0.000E-01	1.000E+01	1.000E+01
3	3.382E+00	8.684E+00	9.000E+00
4	1.866E+00	1.527E+00	3.000E+00
5	1.157E-01	9.966E-01	1.000E+00
6	7.818E-02	6.981E-01	7.000E-01

PU241			
CAPTURE			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	0.000E-01	2.000E+01	2.000E+01
2	5.182E-01	9.996E+00	1.000E+01
3	2.574E+00	9.886E+00	1.000E+01
4	7.940E+00	8.554E+00	1.000E+01
5	1.629E+00	1.726E+00	2.000E+00
6	5.831E-01	1.349E+00	1.400E+00
FISSION			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	0.000E-01	5.000E+00	5.000E+00
2	-6.748E-02	4.996E+00	5.000E+00
3	-2.339E-01	2.992E+00	3.000E+00
4	-5.579E-01	2.957E+00	3.000E+00
5	-3.388E-01	9.622E-01	1.000E+00
6	-9.501E-02	5.936E-01	6.000E-01

PU242			
CAPTURE			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	0.000E-01	1.500E+01	1.500E+01
2	1.173E-01	1.000E+01	1.000E+01
3	-5.609E-01	7.986E+00	8.000E+00
4	-2.059E+00	3.073E+00	8.000E+00
5	-1.760E-02	2.200E+00	2.200E+00
6	-1.652E-02	1.800E+00	1.800E+00

AM241			
CAPTURE			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	0.000E-01	1.000E+01	1.000E+01
2	-1.242E-01	9.998E+00	1.000E+01
3	8.591E-01	9.957E+00	1.000E+01
4	7.621E+00	7.004E+00	1.000E+01
5	2.853E+00	4.437E+00	5.000E+00
6	2.392E-01	2.088E+00	2.100E+00

AM242M			
CAPTURE			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	0.000E-01	3.000E+01	3.000E+01
2	0.000E-01	3.000E+01	3.000E+01
3	0.000E-01	3.000E+01	3.000E+01
4	-5.073E+00	2.997E+01	3.000E+01
5	-4.814E+01	2.750E+01	3.000E+01
6	-6.268E+01	2.555E+01	3.000E+01
FISSION			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	0.000E-01	1.000E+01	1.000E+01
2	0.000E-01	1.000E+01	1.000E+01
3	-8.571E-02	4.000E+00	4.000E+00
4	-5.489E-01	3.998E+00	4.000E+00
5	-3.928E+00	3.880E+00	4.000E+00
6	-4.586E+00	3.832E+00	4.000E+00

AM243			
CAPTURE			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	0.000E-01	2.500E+01	2.500E+01
2	-1.003E-02	1.500E+01	1.500E+01
3	-5.091E-02	3.998E+00	4.000E+00
4	-1.355E-01	3.832E+00	4.000E+00
5	-3.440E-02	4.000E+00	4.000E+00
6	-2.508E-02	2.400E+00	2.400E+00

CM242			
CAPTURE			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	0.000E-01	2.500E+01	2.500E+01
2	8.835E-01	1.497E+01	1.500E+01
3	1.425E+01	1.228E+01	1.800E+01
4	7.709E+00	1.665E+01	1.800E+01
5	2.504E+00	1.789E+01	1.800E+01
6	1.757E+01	2.892E+01	3.100E+01

CM243			
CAPTURE			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	0.000E-01	2.500E+01	2.500E+01
2	0.000E-01	1.500E+01	1.500E+01
3	-2.857E-01	9.999E+00	1.000E+01
4	-7.704E-01	9.295E+00	9.300E+00
5	-2.840E-01	9.299E+00	9.300E+00
6	-3.858E-01	7.699E+00	7.700E+00
FISSION			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	0.000E-01	1.000E+01	1.000E+01
2	-4.745E-01	1.500E+01	1.500E+01
3	-2.772E-01	6.399E+00	6.400E+00
4	-2.176E+00	6.340E+00	6.400E+00
5	-6.779E-01	6.395E+00	6.400E+00
6	-2.739E-01	3.198E+00	3.200E+00

CM244			
CAPTURE			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	0.000E-01	2.500E+01	2.500E+01
2	-4.900E-01	1.499E+01	1.500E+01
3	-2.170E-01	4.572E+00	4.600E+00
4	-3.168E+00	1.556E+00	4.600E+00
5	-4.592E-02	4.599E+00	4.600E+00
6	1.679E-01	7.878E+00	7.900E+00

CM245			
CAPTURE			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	0.000E-01	2.500E+01	2.500E+01
2	9.141E-02	7.900E+00	7.900E+00
3	6.473E-01	7.895E+00	7.900E+00
4	1.023E+00	7.867E+00	7.900E+00
5	2.090E+00	7.814E+00	7.900E+00
6	1.982E+00	4.434E+00	4.600E+00
FISSION			
group	adjustment in %	final standard deviation in %	initial standard deviation in %
1	0.000E-01	1.000E+01	1.000E+01
2	0.000E-01	4.700E+00	4.700E+00
3	-1.887E-01	4.697E+00	4.700E+00
4	-5.257E-01	4.678E+00	4.700E+00
5	-1.219E+00	4.597E+00	4.700E+00
6	-1.276E+00	2.526E+00	2.700E+00