# CALCULATION AND EXPERIMENTAL STUDIES ON MINOR ACTINIDES SAMPLES IRRADIATION IN FAST REACTORS

A. Kotchetkov, Yu. Khomiakov, N. Nerozin, E. Smetanin and A. Tsiboulia SSC IPPE, Obninsk, Russia

> **A. Bychkov** and **I. Zhemkov** SSC RIAR, Dimitrovograd, Russia

## Abstract

Review of the experimental work on the material composition variations of different types of fuel and actinide samples under the influence of fast reactor neutron irradiation is presented in the report. Brief characteristics of the experimental methods applied, experimental programmes performed, fuel and actinide samples researched are presented. Statement of problem is given as well as some results of the project on the estimated data bank development maximally accounting the whole set of experimental results obtained in BN-350 and BOR-60 reactor adjusted to conditions of specially developed benchmark models.

## Introduction

Within sequence of years a great number of physical experiments was carried out in BN-350 and BOR-60 reactor. A series of burn-up experiments were carried out with pure actinide samples (Th, Pa, U, Np, Pu, Am, Cm), fuel samples and structure elements irradiated in the reactor core and blanket for the purpose of the further radiochemical research. The experimental data analysis and compilation are currently carried out in order to develop the database supporting the International programmes on MA transmutation and for calculation code and nuclear date verification as well.

#### Measurements in BN-350 reactor

Method of the "needle" detectors irradiated in the inter-element space of the fuel assembly has been developed for the neutron field investigation in standard fuel assemblies of BN-350 reactor with the minimal disturbances. It has been found out that thin stainless steel capillaries can be inserted into the inter-element space of fuel assembly without noticeable deterioration of thermal exchange conditions. That's why the sets of experimental samples of 1.2 mm diameter have been fabricated and consecutively loaded into capillary of 1.6 mm diameter. The capillary was inserted into the interelement gap and fastened in the head part of the fuel assembly for irradiation period. As a rule a sample of high-enriched uranium-235 (90% enrichment) was loaded into capillary and was used as a neutron fluence monitor. In order to determine the control sample location in the fuel assembly the iridium-192 radioactive nuclide was loaded into the bottom part of the pipe. The actinide sample arrangement in the fuel assembly irradiated in the 243<sup>th</sup> cell of reactor is shown on the Figure 1 as an example. This method has become a basic one in the research at BN-350 in the experiments of two types. The first one is the activation measurements by the sample irradiation at low power level described above with the further radiochemical analysis of the induced activity. The other type is longterm irradiation of fuel and actinide samples at standard power level with the further radiochemical analysis of the sample nuclide composition variation. These measurements allow investigation of such neutron reactions which are not determined by the activation method, for example, radiation capture reaction on uranium-235, plutonium isotopes, americium-241, etc.



Figure 1. The scheme of samples location into assembly

Thermal power, MWt	750	
Subassemblies irradiation interval, eff.days	IC	OC*
	395 456	
Interval between reloadings, eff.days	7	9
Number of subassemblies in the core	IC	OC
	109	115
Type of fuel	U	$O_2$
Fuel enrichment, %		
IC	1	7
OC	2	б
Core FSA hexagonal cladding across flats dimensions, mm	96	×2
Hexagonal lattice pitch, mm	9	8
Core subassembly fuel pin diameter, mm	6.9>	<0.4
The number of fuel pins in core subassembly	12	27
Fuel column height, mm	1 0	00
Fuel effective density, g/cm <sup>3</sup>	8.	6
Axial blanket material	Depleted UO	$_{2}(0.4\%^{235}\mathrm{U})$
Fuel column height in upper axial blanket, mm	300	
Fuel column height in lower axial blanket, mm	380	
Effective density of depleted $UO_2$ in axial blanket, g/cm <sup>3</sup>	8.	6
Radial blanket material	Depleted UO	<sub>2</sub> (0.4% <sup>235</sup> U)
Radial blanket fuel pin diameter, mm	14.2	×0.4
The number of fuel pins in radial blanket subassembly	3	7
Fuel column height in radial blanket, mm	1 6	80
Effective density of depleted UO <sub>2</sub> in radial blanket, g/cm <sup>3</sup>	9.	4
The number of radial blanket assemblies	25	6
Including:	5.	
Inner radial blanket	10	)1
Outer radial l blanket	255	
Inner radial blanket subassemblies irradiation interval, eff.days	553	
Outer radial blanket subassemblies irradiation interval, eff.days	1 106	
The number of subassemblies in the in-vessel storage	10	)9
Number of control rods,	1	2
Including:		2
SR – shim rods	6	<u>.</u>
AR – automatic regulator	2	2
TC – temperature reactivity compensators	1	
SA – scram assemblies	3	3

# Table 1. The main BN-350 reactor parameters

\* IC – Inner Core, ITC – Intermediate Core, OC – Outer Core



Figure 2. Reactor map of BN-350

Inner Core subassemblies, 17% enrichment

Outer Core subassemblies, 26% enrichment

Inner Axial Blanket subassemblies

- Outer Axial Blanket subassemblies
- MOX fuel subassemblies
- Control rods: SA, AR, SR, TC

In-vessel storage

Nº	Irradiation date	Number of samples	Composition	Radiation zone	Measurement results	Cross-section ratio derived	
1. Study of uranium oxide fuel of fuel elements of the first loading							
1.1	1973- 1976	9	enriched (26%) <sup>235</sup> U	HEZ	Pu, FP accumulation U, Pu isotopic composition	$\alpha^5 \sigma_c(8)/\sigma_f(5)$	
1.2	1973- 1976	7	enriched (17%) <sup>235</sup> U	LEZ	Pu, FP accumulation U, Pu isotopic composition	$\sigma_{c}(39)/\sigma_{f}(5) \sigma_{n,2n}(39)/\sigma_{f}(5)$	
1.3	1973- 1976	22	depleted uranium	HEZ, LEZ, blanket	Pu, FP accumulation U, Pu isotopic composition		
2. St	udy of ura	nium oxid	le fuel of fuel eler	ments of th	ne second loading a	nd control samples	
irı	radiated in f	uel assem	blies of the second l	oading			
2.1	1978- 1980	3	<sup>235</sup> U (21%)	LEZ	Pu, FP accumulation U, Pu isotopic composition	_	
2.2	1981	1	<sup>235</sup> U (88%)	LEZ	Pu, FP accumulation U, Pu isotopic composition	$\alpha^5$	
2.3	1981	1	<sup>239</sup> Pu (95%)	LEZ	Am, Cm, FP accumulation Pu isotopic composition	$\alpha^9 \\ \sigma_c(40)/\sigma_f(39) \\ \sigma_c(41)/\sigma_f(39)$	
2.4	1981	2	MOX, reactor (WWER) <b>Pu</b> (74% <sup>239</sup> <b>Pu</b> )	LEZ	Am, Cm, FP accumulation Pu isotopic composition	$\begin{array}{c} \sigma_{c}(Am241)/\sigma_{f}(39) \\ \sigma_{n,2n}(39)/\sigma_{f}(39) \\ \omega(^{242m}Am) \end{array}$	
<i>3.</i> <sup>236</sup>	U and <sup>237</sup> Np	sample i	research in order to	determine	<sup>236</sup> Pu accumulation	and (n,2n) reaction	
cr	oss sections	<sup>237</sup> Pu					
3.1	1977- 1978	2	<sup>236</sup> U(99.66%)	blanket	<sup>236</sup> Pu/ <sup>238</sup> Pu	$\sigma_{n,2n}/\sigma_c(^{237}Np)$	
3.2	1977- 1978	4	<sup>237</sup> Np(100%)	HEZ, LEZ, blanket	<sup>236</sup> Pu/ <sup>238</sup> Pu	$\sigma_{n,2n}/\sigma_c(^{237}Np)$	
4. St	udy of mixe	d uraniun	n-plutonium fuel in	the module	of 7 fuel assemblies v	with MOX fuel	
4.1	28.09.82 16.06.83	9	MOX fuel: 21% Pu 79% depleted U	7Pu (LEZ)	Am, Cm, FP accumulation Pu isotopic composition	$\begin{array}{c} \alpha^{9} \\ \sigma_{c}(8)/\sigma_{f}(39) \\ \sigma_{c}(40)/\sigma_{f}(39) \\ \sigma_{c}(41)/\sigma_{f}(39) \\ \sigma_{c}(241)/\sigma_{f}(39) \\ \sigma_{n,2n}(39)/\sigma_{f}(39) \end{array}$	
5. St sa	udy of meta me fuel	llic uranii	um fuel irradiated in	n experimen	ntal fuel radial blank	et assembly with the	
	06.12.87 22.03.88	3	depleted <sup>238</sup> U	LEZ	Pu, FP accumulation U, Pu isotopic composition		

Table 2. The list of actinide samples researched

6. St	6. Study of thorium and uranium-233, -234 samples for thorium fuel cycle substantiation							
6.1	1987- 1988	8	Dioxide <b>Th</b>	Outer radial blanket	U, <sup>233</sup> Pa accumulation U isotopic composition dependence of <sup>232</sup> U accumulation on their location in the blanket	$ \begin{array}{c} \sigma_{c}(^{232}\text{Th})/\sigma_{f}(5) \\ \sigma_{n,2n}(^{232}\text{Th})/\sigma_{f}(5) \\ \sigma_{c}(^{231}\text{Pa})/\sigma_{f}(5) \end{array} $		
6.2	1990- 1992	6	Metal <b>Th</b>	blanket	<sup>233</sup> U, <sup>232</sup> U, FP accumulation			
6.3	1990- 1992	1	Th	LEZ	<sup>233</sup> U, <sup>232</sup> U, FP accumulation			
6.4	1990- 1992	2	<sup>233</sup> U	LEZ	U, FP <sup>*</sup> isotopic composition	$\sigma_c(3)/\sigma_f(3)^*$		
6.5	1990- 1992	1	<sup>234</sup> U	LEZ	U, FP <sup>*</sup> isotopic composition	$\sigma_c(4)/\sigma_f(4)^*$		
7. St tre	tudy of mi ansmutation	nor actin	nide (MA) samples	s for subs	stantiation of the p	possibility of their		
7.1	1990- 1992	1	<sup>237</sup> Np	LEZ	under investigation	$\sigma_c/\sigma_f(^{237}Np)^*$		
7.2	1990- 1992	2	<sup>241</sup> Am	LEZ	under investigation	$\sigma_c\!/\!\sigma_f{(}^{241}Am{)}^*$		
7.3	1990- 1992	1	<sup>238</sup> Pu	LEZ	under investigation	$\sigma_{c}/\sigma_{f}(^{238}Pu)^{*}$		
7.4	1990- 1992	2	<sup>240</sup> Pu	LEZ	under investigation	$\sigma_c/\sigma_f(^{240}Pu)^*$		
7.5	1990- 1992	2	<sup>243</sup> +Cm <sup>244</sup> Cm	LEZ	under investigation	$\sigma_c(^{244}\text{Cm})/\sigma_f(5)^*$		

Table 2. The list of actinide samples researched (contd.)

\* Presumably.

## **Measurements in BOR-60 reactor**

Two pins with eight ampoules in each were irradiated in BOR-60 reactor. These pins are located into experimental assembly having 19 pins (see Figure 3). Studying actinides were set into quartz capsule having follow dimensions: outer diameter -4.5 mm; length -20-21 mm; thickness -0.7-0.8 mm. The set of samples is shown in Table 3.



Figure 3. Map of BOR-60 experimental assembly

Table 3. The initial MA isotope composition into the ampoules

Ampoule marking	The basic isotope	Mass (mkg)	The isotope composition (%)
1	<sup>232</sup> Th	419	$^{232}$ Th $- 100$
2	<sup>237</sup> Np	408	$^{237}Np - 100$
			$^{238}\text{Pu} - 0.36 \\ ^{239}\text{Pu} - 94.80$
3	<sup>239</sup> Pu	115	$^{240}$ Pu - 4.66 $^{241}$ Pu - 0.18 $^{242}$ Pu - <0.01
4	<sup>240</sup> Pu	126	$\begin{array}{r} 2^{238} \mathrm{Pu} - 0.18 \\ 2^{239} \mathrm{Pu} - 1.00 \\ 2^{240} \mathrm{Pu} - 98.82 \end{array}$
5	<sup>242</sup> Pu	127	$^{242}Pu - 99.54$
6	<sup>241</sup> Am	129	$^{241}Am - 100$
7	<sup>243</sup> Am	113	${}^{241}\text{Am}-2.37$ ${}^{243}\text{Am}-97.62$ ${}^{244}\text{Cm}-{<}0.01$
8	<sup>244</sup> Cm	129	$^{244}Cm - 100$

### Integrated gravichemical method of irradiated sample nuclide composition study

This method is the basic one during the research of the sample nuclide composition after longterm irradiation during one or several micro-runs (operation periods). It proposes the recovery of weight amounts of strictly stochoimetric compositions of uranium and plutonium and purification from impurities. Separate isotope amounts are determined by a combination of weighing (the use of the most precise method, if possible), radiometric and mass-spectrometric methods. The methods of alpha-spectrometric (actinides) and gamma-spectrometric (fission fragments) analysis are used. As the irradiated samples and their solutions are highly active the special specimens are prepared for the measurements by small amount sampling and further considerable dilution. Typical errors of  $\alpha$ - and  $\gamma$ measurements are presented in the Table 4. Mass-spectrometric measurements give the most precise results in relative concentration of one or another isotopes (parts of percent). Sometimes these measurements were combined with the method of the isotope dilution.

Isotone		Total error					
Isotope	Statistics	Dilution	Sample preparation	Irradiation yield	Reference	(%)	
$^{241}Am + ^{238}Pu (\alpha)$	1.0	1.8	2.0	0.5	<0.3	2.9	
<sup>241</sup> Am (γ)	0.4	1.0	2.0	_	2.0	3.0	
$^{238}$ Pu ( $\gamma$ )	3.0	0.4	2.0	1.1	3.0	4.8	
<sup>243</sup> Cm (γ)	1.5	1.0	2.0	2.8	3.0	4.9	
$^{137}Cs$ ( $\gamma$ )	0.9	1.0	2.0	_	2.0	3.1	

Table 4. Characteristic errors of  $\alpha$ - and  $\gamma$ -spectrometric measurements and their main components

## Analysis of experimental results

Calculation analysis of experiments is based on:

- ABBN-93 constant system; [1]
- three-dimension hexagonal geometry code TRIGEX [2] in diffusion approximation for neutron field calculation;
- CARE [3] code for calculation of nuclide composition of the spent fuel and samples.

The following problems are being solved while analysis:

- neutron field precise calculations according to detail description of changing in core configuration in course of fuel reloading and burn-up;
- calculation of nuclide composition of fuel pins or samples;
- comparison of calculation and experimental data on nuclide composition;
- adjustment of neutron fluences according to results of analysis of monitor samples;
- neutron reactions cross sections rates decision according to results of nuclide composition analysis;

- definition of benchmark model of experiments, directed on neutron data precision;
- reducing results of separate measurements to benchmark model conditions and analysis of consistency;
- creation of data base of experiments;
- neutron data precision and adjustment.

Results of comparison of series of cross section rates, obtained in BN-350 experiments are given in Table 5. Tables 6 and 7 show preliminary results of expected changing in nuclide composition of actinide samples, being analysed at present.

Table 5.	Comparison of calculated (C) and experimental (E) data on cross section ratios on
	actinides, $(C - E)/E$ (%)

Isotope	$\sigma_x / \sigma_{f5}$	LEZ*	HEZ**	MOX Sub-zone
<sup>232</sup> Th	Fiss	-1 ± 4	3 ± 7	$5\pm 6$
111	Capt	$5\pm 6$	$-8 \pm 7$	$0\pm7$
<sup>231</sup> Pa	Capt	$2\pm 5$	-	-
<sup>235</sup> U	α	$-2 \pm 3$	$10 \pm 4$	_
236 <b>T</b> T	Fiss	$4\pm 5$	$1\pm 5$	$0\pm 6$
U	Capt	$5\pm 5$	_	_
	Fiss	$3\pm3$	$3\pm 5$	$2\pm4$
<sup>238</sup> U	capt	-1 ± 3	$1\pm3$	$0\pm4$
	n,2n	-5 ± 11	$10 \pm 10$	_
	fiss	$4\pm4$	$-2 \pm 5$	$3\pm 5$
<sup>237</sup> Np	capt	_	$-3 \pm 6$	_
	n,2n	$4\pm 6$	$2\pm 6$	_
	fiss	$1\pm3$	$0\pm 3$	$0\pm 4$
<sup>239</sup> Pu	α	$2\pm4$	$15\pm 6$	$1\pm3$
	n,2n	_	-	$-6\pm7$
<sup>240</sup> Du	fiss	$3\pm 5$	$4\pm 5$	_
ru	capt	$0\pm 5$	_	$9\pm 6$
<sup>241</sup> Pu	α	$-8 \pm 11$	_	$-6\pm 6$
<sup>241</sup> Am	capt	$0\pm 8$	_	$-11 \pm 5$

\* Low enrichment zone

\*\* High enrichment zone

Isotope	Reactor cell	Irradiated time, days	Fluence 10 <sup>23</sup> cm <sup>-2</sup> s <sup>-1</sup>	Basic isotope burn-up (%)	Secondary actinide generation (%)	Total burn-up (%)
<sup>237</sup> Np	89	781	2.0	35	25	10
<sup>238</sup> Pu	89	781	1.8	31	8	23
<sup>240</sup> Pu	110	781	1.7	11	0.5	10.5
<sup>241</sup> Am	89	781	1.9	35	25.5	9.5
<sup>241</sup> Am	243	797	2.0	35	25.7	9.3
<sup>244</sup> Cm	243	797	1.5	25	11	14
<sup>244</sup> Cm	243	797	1.7	31	14	17

Table 6. The calculation estimations of characteristics MA samples, irradiated in BN-350

### Conclusions

- In the BN-350 reactor there have been performed wide investigations of nuclide composition changing of fuel samples and several separate isotopes, which allow to increase accuracy and reliability of nuclide data for basic isotopes, such as U, Pu and some minor actinides.
- Series of experiments has got visible discrepancies between calculation and experimental data, for example, for such isotopes as <sup>240</sup>Pu, <sup>241</sup>Am. As a rule, analysis of U or Pu samples shows the larger accumulation of Cm isotopes in experiment. In the whole, the minor actinides data are still insufficient. At the present time the work on analysis of minor actinides samples, irradiated in BN-530 and BOR-60, is carried out and it is going to give the necessary experimental information.
- Another unsolved problem is that analysis of various experiments was carried out at the different time using different approaches and different nuclear data, that does not allow to carry out complete analysis of obtained data. It is necessary to perform:
- evaluation of experiments carried out in BN-350 and BOR-60;
- creation of benchmarks on the base of these experiments for testing nuclear data and calculation codes and storing it in the unified data base;
- calculation analysis of benchmarks.

## REFERENCES

- A.S. Seregin (1983), Annotation of TRIGEX Code Intended for Low-group Neutron and Physical Reactor Calculation in Hexagonal Geometry. Problems of Atomic Science and Engineering. Series Nuclear Reactor Physics and Engineering. Issue 4(33).
- [2] G.N. Manturov, M.N. Nikolaev, A.M. Tsiboulia (1996), BNAB-93 Group Constant System. Part 1. Nuclear Constants for Neutron and Photon Radiation Field Calculation. Problems of Atomic Science and Engineering. Series Nuclear Constants 1, p. 59.
- [3] A.L. Kochetkov (1995), Preprint IPPE-2431, Obninsk.

239 Th         419         410.6 $^{231}Pa$ 0.051         0.26 $^{233}U$ 6.5         0.045 $^{233}U$ 0.045         0.045 $^{234}U$ 0.045         0.045           Nb 2 $^{237}Np$ 408         360.2         4.7 $^{238}Pu$ 0.39         27.6         4.7 $^{239}Pu$ 0.39         0.39         13.8 $^{240}Pu$ 0.357         13.8 $^{240}Pu$ 0.207         0.57 $^{240}Pu$ 0.0115         0.019 $^{244}Pu$ 0.227         0.19 $^{239}Pu$ 1.26         1.05 $^{244}Pu$ 7.9         5.8 $^{242}Pu$ 0.098         244Am           0.42         117.2         3.8 $^{243}Pu$ 126.42         117.2 $^{244}Pu$ 0.50         5.8 $^{237}Np$ 0.50         2.8 $^{243}Cm^3$ 0.13         4.7 $^{244}Pu$ 1.6         4.7 $^{243}Am$ <t< th=""><th>Sample</th><th>Isotope</th><th>Initial isotope composition, (mkg)</th><th>Isotope composition, after irradiation (mkg)</th><th>Total burn- up (%)</th></t<>	Sample	Isotope	Initial isotope composition, (mkg)	Isotope composition, after irradiation (mkg)	Total burn- up (%)
N₂ 1         231 Pa 233 Pa 233 U 233 U         0.051 0.70         0.26 $2^{23}$ U         0.045         6.5 $2^{24}$ U         0.045         6.5 $2^{24}$ U         0.26         4.7 $2^{28}$ Pu         0.39         2.7.6         4.7 $2^{29}$ Pu         0.39         2.39         0.39         3.8 $2^{240}$ Pu         5.35         7.3         13.8 $2^{240}$ Pu         0.207         0.57         3.8 $2^{249}$ Pu         0.0015         0.009         2.4 $2^{239}$ Pu         0.227         0.19         2.23 $2^{247}$ Pu         0.227         0.19         2.33 $2^{239}$ Pu         1.26         1.05         3.8 $2^{247}$ Pu         0.098         2.4         3.8 $2^{247}$ Pu         0.098         2.4         3.8 $2^{247}$ Pu         0.042         117.2         3.8 $2^{247}$ Pu         0.008         3.8         3.8 $2^{247}$ Pu         0.049         5.7         2.3 $8^{243}$ Cm <sup>4</sup> 0.650         2.3         1.6         4.7		<sup>232</sup> Th	419	410.6	
№ 1 $23^{3}Pa$ $23^{3}U$ 0.001 6.5       0.26 $2^{237}U$ 0.045       0.045         № 2 $2^{237}Np$ $2^{237}Np$ 408       360.2 0.045       4.7 $N^{2} 2$ $2^{237}Np$ $2^{238}Pu$ 0.414       0.36       4.7 $2^{239}Pu$ 0.902       90.8       4.7       4.7 $2^{240}Pu$ 0.535       7.3       13.8 $2^{240}Pu$ 0.207       0.57       13.8 $2^{240}Pu$ 0.207       0.57       13.8 $2^{240}Pu$ 0.227       0.19       4.7 $2^{240}Pu$ 0.227       0.19       5.8 $2^{240}Pu$ 0.227       0.19       5.8 $2^{240}Pu$ 0.0215       109.0       5.8 $2^{240}Pu$ 0.0227       0.19       5.8 $2^{240}Pu$ 0.042       124.51       109.0 $2^{240}Pu$ 0.098       4.3       3.8 $N^{2} 5$ $2^{243}Cm^{3}$ 0.13       5.8 $2^{240}Pu$ 126.42       117.2       3.8 $N^{2} 6$ $2^{240}Pu$ 0.66       4.7         <		<sup>231</sup> Pa	417	0.051	
N₂ 1       2 <sup>33</sup> U       0.10       0.20 $2^{234}U$ 0.045       0.045         N₂ 2 $2^{23}$ Np       408       360.2       4.7 $2^{239}$ Pu       0.39       2.39       0.39       4.7         N₂ 2 $2^{238}$ Pu       0.414       0.36       2.7.6       4.7 $2^{239}$ Pu       109.02       90.8       2.47       4.7 $2^{249}$ Pu       0.207       0.57       13.8 $2^{242}$ Pu       0.0115       0.019       2.47 $2^{242}$ Pu       0.227       0.19       2.32 $2^{243}$ Pu       1.26       1.05       2.6         N₂ 4 $2^{242}$ Pu       0.098       2.41 $2^{242}$ Pu       0.098       2.41 $2^{242}$ Pu       0.098       2.41 $2^{242}$ Pu       0.008       2.42 $2^{242}$ Pu       0.042       117.2 $2^{242}$ Pu       0.008       2.43 $2^{243}$ Cm       0.13       3.8 $2^{243}$ Cm       0.03       3.7 $2^{243}$ Pu       0.60       2.6 $2^{243}$ Pu       0.60       3.3	No 1	<sup>233</sup> Pa		0.70	0.26
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	J12 I	<sup>233</sup> II		65	0.20
$2^{234}$ U       0.360         N≥ 2 $2^{237}$ Np $2^{238}$ Pu       408       360.2 $27.6$ 4.7 $2^{239}$ Pu       0.414       0.39       360.2 $27.6$ 4.7 $2^{239}$ Pu       0.414       0.39       360.2 $27.6$ 4.7 $2^{239}$ Pu       0.414       0.39       360.2 $2138$ Pu       4.7 $2^{249}$ Pu       0.414       0.36 $90.8$ 360.2 $2139$ Pu       4.7 $2^{249}$ Pu       0.0115       0.019 $0.042$ 360.2 $2^{249}$ Pu       0.207       0.57 $0.019$ 3.8 $2^{249}$ Pu       0.215       109.0 $0.042$ 5.8 $2^{249}$ Pu       1.26       1.05 $1.05$ 3.8 $2^{249}$ Pu       1.26       1.05 $1.05$ 3.8 $2^{249}$ Pu       1.26.42       117.2 $0.049$ 3.8 $2^{243}$ Cm 3       0.13       3.8 $2^{243}$ Cm 3       0.50 $0.50$ 3.8 $2^{243}$ Cm 4       129       110.5       3.8 $2^{243}$ Cm 3       0.011       3.3 $N_2$ 6 $2^{249}$ Cm 4       0.011       3.3 $N_2$ 7 $2$		<sup>234</sup> U		0.045	
№ 2 $\frac{237}{238}$ Pu       408 $360.2$ 4.7 $\frac{239}{238}$ Pu       0.414       0.39       0.39         № 3 $\frac{239}{238}$ Pu       0.414       0.36       4.7 $\frac{239}{249}$ Pu       109.02       90.8       3 $\frac{240}{249}$ Pu       5.35       7.3       13.8 $\frac{240}{242}$ Pu       0.0115       0.019       3 $\frac{240}{242}$ Pu       0.207       0.19       3 $\frac{239}{249}$ Pu       1.26       1.05       3 $\frac{240}{242}$ Pu       124.51       109.0       5.8 $\frac{240}{242}$ Pu       0.098       3       3 $\frac{240}{242}$ Pu       126.42       117.2       3 $\frac{243}{242}$ Pu       0.042       4.3       3.8 $\frac{243}{242}$ Pu       0.049       3       3 $\frac{239}{243}$ Pu       126.42       117.2       3       3.8 $\frac{239}{243}$ Pu       0.049       3.8       4.7 $\frac{243}{245}$ Cm <sup>8</sup> 0.11       4.7       4.7 $\frac{243}{242}$ Pu       0.068       4.7       4.7 $\frac{243}{242}$ Cm       2.6       2.6       2.6       2.6		<sup>234</sup> LI		0.045	
№ 2 $23^{5}P_{u}$ $300$ $300^{-6}$ $4.7$ $2^{239}P_{u}$ 0.414         0.39         0.39 $2^{239}P_{u}$ 0.000         90.8 $300^{-6}$ $4.7$ $2^{239}P_{u}$ 0.000         90.8 $300^{-6}$ $300^{-6}$ $2^{24}P_{u}$ 0.207         0.57 $13.8$ $2^{242}P_{u}$ 0.0115         0.019 $300^{-6}$ $2^{242}P_{u}$ 0.227         0.19 $300^{-6}$ $2^{242}P_{u}$ 0.227         0.19 $300^{-6}$ $2^{242}P_{u}$ 126         1.05 $300^{-6}$ $2^{242}P_{u}$ 0.098 $300^{-6}$ $300^{-6}$ $2^{242}P_{u}$ 0.098 $3.8$ $3.8$ $2^{242}P_{u}$ 0.0049 $3.8$ $3.8$ $2^{243}Am$ 4.3 $3.8$ $3.8$ $2^{243}P_{u}$ 126.42         117.2 $3.8$ $2^{243}Am$ 0.13 $3.8$ $2^{24}$ $N_2 6$ $\frac{2^{24}}{34m}$ 129 $100.5$ $4.7$		<sup>237</sup> Nn	408	360.2	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	<u>№</u> 2	<sup>238</sup> Pu	400	27.6	4.7
N₂ 3 $2^{28}$ Pu $2^{39}$ Pu $2^{40}$ Pu $2^{41}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{41}$ Pu $2^{42}$ Pu $2^{41}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{43}$ Am $2^{43}$ Cm <sup>8</sup> 109.0 $1.26$ 5.8       N₂ 5 $2^{43}$ Am $2^{43}$ Cm <sup>8</sup> 0.027 0.098     0.098 $0.098$ N₂ 5 $2^{43}$ Am $2^{43}$ Cm <sup>8</sup> 0.13       N₂ 6 $2^{42}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{43}$ Am $2^{43}$ Cm <sup>8</sup> 0.049 $5.7$ N₂ 6 $2^{42}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2^{42}$ Pu $2.6$ 3.3       N₂ 6 $2^{42}$ Pu $2^{44}$ Cm $2^{44}$ Cm $2^{44}$ Cm     0.011 $2.6$ N₂ 7 $2^{43}$ Am 110.31 $100.9$ 3.3       N₂ 8 $2^{44}$ Cm $2^{44}$ Cm     0.025		<sup>239</sup> Pu		0.39	
№ 3 $\frac{239}{240}$ Pu     109.02 109.02     90.8 90.8 7.3     13.8 $\frac{240}{240}$ Pu     5.35 241Pu     0.207 0.57     0.57     13.8 $\frac{242}{242}$ Pu     0.0115     0.019     0.042 $\frac{243}{240}$ Pu     1.26     1.05     1.05 $\frac{240}{240}$ Pu     1.26     1.05     1.09.0 $\frac{240}{240}$ Pu     124.51     109.0     5.8 $\frac{240}{242}$ Pu     0.098     241 $\frac{242}{242}$ Pu     0.098     3.8 $\frac{242}{242}$ Pu     0.098     3.8 $\frac{243}{241}$ Am     0.42     117.2 $\frac{243}{243}$ Cm <sup>×</sup> 0.13     3.8 $\frac{243}{243}$ Cm <sup>×</sup> 0.50     5.7 $\frac{238}{243}$ Cm <sup>×</sup> 0.50     5.7 $\frac{238}{243}$ Cm <sup>×</sup> 0.50     5.7 $\frac{238}{243}$ Cm <sup>×</sup> 0.008     4.7 $\frac{242}{243}$ Am     129     110.5 $\frac{242}{242}$ Cm     2.6     2.6 $\frac{243}{243}$ Am     2.678     2.32 $\frac{243}{245}$ Cm     0.011     3.3 $\frac{244}{241}$ Am     2.678     2.32 $\frac{244}{245}$ Cm     0.0084 $\frac{244}{245}$ Cm     0.084 $\frac{244}{245}$ Cm     0.025		<sup>238</sup> Pu	0.414	0.36	
№ 3 $\frac{2^{40}Pu}{2^{41}Pu}$ $0.535}{0.207}$ $7.3$ $13.8$ $\frac{2^{41}Pu}{2^{42}Pu}$ $0.207$ $0.57$ $0.042$ $\frac{2^{35}Pu}{2^{42}Pu}$ $0.0115$ $0.019$ $0.042$ $\frac{2^{35}Pu}{2^{42}Pu}$ $0.227$ $0.19$ $0.042$ $\frac{2^{42}Pu}{2^{42}Pu}$ $1.26$ $1.05$ $0.098$ $\frac{2^{42}Pu}{2^{42}Pu}$ $0.098$ $0.42$ $0.42$ $\frac{2^{42}Pu}{2^{41}Am}$ $126.42$ $117.2$ $3.8$ $\frac{2^{42}Pu}{2^{43}Cm^3}$ $0.0098$ $0.42$ $0.098$ $\frac{2^{42}Pu}{2^{42}Pu}$ $126.42$ $117.2$ $3.8$ $\frac{2^{42}Pu}{2^{43}Cm^3}$ $0.0049$ $0.50$ $5.7$ $\frac{2^{39}Pu}{2^{239}Pu}$ $0.008$ $4.7$ $4.7$ $\frac{2^{23}Pu}{2^{42}Pu}$ $0.008$ $4.7$ $4.7$ $\frac{2^{24}Qu}{2^{42}Pu}$ $1.6$ $4.7$ $4.7$ $\frac{2^{42}Pu}{2^{42}Pu}$ $1.6$ $4.7$ $2.6$ $\frac{2^{42}Cm}{2^{42}Cm}$ $0.011$ $2.6$ $2.6$ $3.3$ $N_{2} 7$ $\frac{2^{43}Cm}{2^{42}Cm}$ $0.011$ $2.6$		<sup>239</sup> Pu	109.02	90.8	
№ 3 $2^{241}Pu$ 0.007       0.57       13.8 $2^{42}Pu$ 0.0115       0.019       0.042 $2^{41}Am$ 0.042       0.042 $2^{238}Pu$ 0.227       0.19 $2^{39}Pu$ 1.26       1.05 $2^{41}Am$ 7.9       5.8 $2^{42}Pu$ 0.098 $2^{42}Pu$ 0.098 $2^{42}Pu$ 0.098 $2^{41}Am$ 0.42 $2^{42}Pu$ 0.098 $2^{41}Am$ 0.42         Ne 5 $2^{43}Am$ 0.43 $2^{42}Pu$ 126.42       117.2         Ne 5 $2^{43}Am$ 0.13 $2^{37}Np$ 0.50       5.7 $2^{39}Pu$ 0.008       4.7 $2^{42}Pu$ 1.6       4.7 $2^{42}Mm$ 129       110.5 $2^{42}Mm$ 0.05       2.6 $2^{42}Cm$ 2.6       2.6 $2^{42}Cm$ 0.011       3.3 $2^{42}Cm$ 0.0113       5.48 $2^{44}Cm$ 0.0113       5.48 $2^{45}Cm$		<sup>240</sup> Pu	5 35	73	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	<u>№</u> 3	<sup>241</sup> Pu	0.207	0.57	13.8
$2^{41}$ Am       0.0113       0.042 $2^{238}$ Pu       0.227       0.19 $2^{39}$ Pu       1.26       1.05 $2^{40}$ Pu       124.51       109.0 $2^{41}$ Pu       7.9       5.8 $2^{42}$ Pu       0.098       241 $2^{42}$ Pu       0.042       109.0 $2^{42}$ Pu       0.098       241 $2^{42}$ Pu       0.098       241 $2^{42}$ Pu       126.42       117.2 $N^{\underline{2}}$ 5 $2^{243}$ Am       4.3       3.8 $2^{243}$ Cm <sup>x</sup> 0.13       0.049 $2^{237}$ Np       0.50       5.7 $2^{39}$ Pu       0.068       4.7 $2^{39}$ Pu       0.068       4.7 $2^{42}$ Am       129       110.5 $2^{42}$ Ma       1.6       4.7 $2^{42}$ Am       0.05       242 $2^{42}$ Am       0.05       242 $2^{42}$ Am       0.011       5.4 $2^{42}$ Am       0.0113       5.48 $2^{42}$ Cm       0.013       5.48 $2^{42}$ Cm       0.084 $2^{42}$ Cm       0.084 <td></td> <td><sup>242</sup>Pu</td> <td>0.0115</td> <td>0.019</td> <td></td>		<sup>242</sup> Pu	0.0115	0.019	
N≥ 4 $2^{38}$ Pu $2^{39}$ Pu $2^{39}$ Pu 1.26       0.19 $1.05$ N≥ 4 $2^{240}$ Pu $2^{41}$ Pu $2^{41}$ Pu       124.51       109.0 $7.9$ 5.8         N≥ 5 $2^{42}$ Pu $2^{41}$ Am       0.098 $0.42$ 5.8         N≥ 5 $2^{243}$ Pu $2^{243}$ Cm <sup>×</sup> 126.42       117.2 $0.13$ 3.8         N≥ 5 $2^{243}$ Cm <sup>×</sup> 0.13       3.8         N≥ 6 $2^{242}$ Pu $2^{243}$ Cm <sup>×</sup> 0.0049 $0.008$ 4.7         N≥ 6 $2^{242}$ Pu $2^{242}$ Pu $2^{239}$ Pu $2^{422}$ Pu       0.008 $1.6$ 4.7         N≥ 6 $2^{242}$ Mam $2^{42}$ Pu $2^{42}$ Pu       0.013       3.3         N≥ 6 $2^{243}$ Am $2^{42}$ Pu $2^{42}$ Pu       0.011 $2^{42}$ Pu $2^{42}$ Cm       3.3         N≥ 7 $2^{38}$ Pu $2^{42}$ Cm $2^{45}$ Cm       0.0113 2.678       5.48 2.32 $2.32$ 3.3         N≥ 7 $2^{43}$ Am $2^{45}$ Cm $2^{45}$ Cm       129       107.6 0.084       4.5		$^{241}$ A m	0.0115	0.017	
№ 4 $\frac{2^{39}}{2^{40}}$ Pu       1.26       1.05         1240       124.51       109.0       5.8         241Pu       7.9       5.8         242Pu       0.098       0.42         241Am       0.42       117.2         Ne 5       243Am       4.3       3.8         242Pu       0.042       117.2         Ne 5       243Am       0.13       3.8         243Cm <sup>x</sup> 0.13       0.13         243Pu       0.049       5.7         237Np       0.50       5.7         239Pu       0.08       4.7         237Np       0.008       4.7         237Np       0.50       5.7         238Pu       5.7       3.8         242Pu       1.6       4.7         242mAm       1.7       243Am         242mAm       0.05       2.6         242mAm       2.678       2.32         242Mam       0.0113       5.48         243Cm       0.0113       5.48         243Cm       0.0113       5.48         245Cm       0.084       0.084		<sup>238</sup> Pu	0.227	0.042	
№ 4 $\frac{240}{24}$ Pu       1.20       1.00       5.8         № 4 $\frac{241}{2}$ Pu       124.51       109.0       5.8 $\frac{242}{2}$ Pu       0.098       0.42       0.42         № 5 $\frac{243}{2}$ Am       0.42       117.2       3.8         № 5 $\frac{243}{2}$ Cm <sup>x</sup> 0.13       3.8 $\frac{243}{2}$ Cm <sup>x</sup> 0.13       0.13       100.99 $\frac{233}{2}$ U       0.0499       5.7       3.8 $\frac{237}{23^3}$ Pu       0.50       5.7       3.8 $\frac{239}{2^{39}$ Pu       0.08       4.7       4.7 $\frac{242}{2}$ Cm       110.5       4.7       4.7 $\frac{242}{24^3}$ Am       129       110.5       4.7 $\frac{242}{2}$ MAm       2.66       2.6       3.3         № 7 $\frac{238}{243}$ Pu       0.011       3.3 $\frac{242}{24}$ Cm       0.0113       5.48       3.3         № 7 $\frac{243}{4}$ Am       100.9       3.3         № 8 $\frac{244}{245}$ Cm       0.084       4.5         № 8 $\frac{244}{245}$ Cm       2.9       4.5		<sup>239</sup> Pu	1.26	1.05	
No 4       10       124.51       100.00       5.8 $2^{41}Pu$ 7.9       0.098       0.098 $2^{41}Am$ 0.42       0.42         No 5       243 Am       4.3       3.8 $2^{42}Pu$ 126.42       117.2       3.8         No 5       243 Am       4.3       3.8 $2^{43}Cm^x$ 0.13       0.049 $2^{37}Np$ 0.50       5.7 $2^{39}Pu$ 0.08       4.7 $2^{242}Cm$ 110.5       4.7 $2^{242}Mam$ 129       110.5 $2^{42}Mam$ 129       110.5 $2^{42}Cm$ 2.6       2.6         No 7 $2^{38}Pu$ 0.11       3.3 $2^{42}Cm$ 2.6       3.3         No 7 $2^{38}Pu$ 0.11       3.3 $2^{44}Cm$ 0.0113       5.48       3.3 $No 7$ $2^{43}Am$ 110.31       100.9       3.3 $No 8$ $2^{44}Cm$ 0.0113       5.48       3.45 $No 8$ $2^{44}Cm$ 0.025       3.45		<sup>240</sup> <b>P</b> 1	124 51	1.05	
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	<u>N</u> ⁰ 4	<sup>241</sup> <b>D</b> u	124.31	7 0	5.8
$2^{41}$ Am       0.600 $2^{42}$ Pu       126.42       117.2 $N_{2}$ 5 $2^{43}$ Am       4.3       3.8 $2^{43}$ Cm <sup>x</sup> 0.13       0.13 $2^{34}$ U       0.049       3.8 $2^{37}$ Np       0.50       5.7 $2^{39}$ Pu       5.7       3.8 $2^{242}$ Pu       1.6       4.7 $2^{42}$ Pu       1.6       4.7 $2^{42}$ Pu       1.6       4.7 $2^{42}$ Mm       129       110.5 $2^{42}$ Mm       2.6       2.6 $2^{42}$ Am       2.678       2.32 $N_{2}$ 7 $2^{43}$ Am       2.678       2.32 $N_{2}$ 7 $2^{43}$ Am       110.31       100.9       3.3 $N_{2}$ 7 $2^{43}$ Am       0.0113       5.48 $2^{44}$ Cm       0.0113       5.48       3.45 $N_{2}$ 8 $2^{45}$ Cm       0.084       4.5		<sup>242</sup> Pu		0.098	
N₂ 5 $2^{42}$ Pu       126.42       117.2         N₂ 5 $2^{43}$ Am       4.3       3.8 $2^{43}$ Cm <sup>x</sup> 0.13       0.13 $2^{34}$ U       0.049       0.50 $2^{37}$ Np       0.50       5.7 $2^{39}$ Pu       0.08       4.7 $2^{242}$ Pu       1.6       4.7 $2^{42}$ Pu       1.6       4.7 $2^{42}$ Pu       1.6       4.7 $2^{42}$ Pu       1.6       4.7 $2^{42}$ Mm       129       110.5 $2^{42}$ Cm       2.6       2.6 $2^{42}$ Cm       0.011       3.3         N₂ 7 $2^{38}$ Pu       0.011 $2^{41}$ Am       2.678       2.32         N₂ 7 $2^{34}$ Am       110.31       100.9       3.3 $2^{42}$ Cm       0.0113       5.48       3.4 $2^{45}$ Cm       0.084       3.4       3.4         N₂ 8 $2^{45}$ Cm       2.9       4.5		$^{241}$ A m		0.098	
№ 5 $^{243}Am$ 4.3       3.8 $^{243}Cm^x$ 0.13       0.13 $^{234}U$ 0.049       0.50 $^{238}Pu$ 5.7       0.08 $^{239}Pu$ 0.08       4.7 $^{242}Pu$ 1.6       4.7 $^{242}Mm$ 10.5       4.7 $^{242}Mm$ 1.6       4.7 $^{242}Mm$ 1.6       4.7 $^{242}Mm$ 1.6       4.7 $^{242}Mm$ 2.6       2.6 $^{242}Cm$ 2.6       3.3 $^{242}Cm$ 0.011       3.3 $^{242}Cm$ 0.011       3.3 $^{242}Cm$ 0.0113       100.9       3.3 $^{241}Am$ 2.678       2.32       3.3 $^{242}Cm$ 0.0113       5.48       3.4 $^{245}Cm$ 0.084       4.5       3.45 $^{242}Cm$ 129       107.6       4.5 $^{245}Cm$ 2.9       4.5       3.45		<sup>242</sup> Pu	126.42	117.2	
$3 \frac{2}{2}$ 3 $2^{43} Cm^x$ $0.13$ $2^{234} U$ $0.049$ $2^{37} Np$ $0.50$ $2^{38} Pu$ $5.7$ $2^{39} Pu$ $0.08$ $2^{242} Pu$ $1.6$ $2^{42} Pu$ $1.6$ $2^{42} Mm$ $1.6$ $2^{42} Mm$ $1.6$ $2^{42} Mm$ $1.7$ $2^{42} Mm$ $2.6$ $2^{42} Cm$ $2.6$ $2^{42} Cm$ $0.11$ $2^{43} Am$ $0.05$ $2^{42} Cm$ $0.11$ $2^{42} Cm$ $0.011$ $2^{42} Cm$ $0.011$ $2^{41} Am$ $2.678$ $2.32$ $N_{\mathfrak{P}$ 7 $2^{38} Pu$ $0.011$ $2^{44} Cm$ $0.0113$ $5.48$ $2^{44} Cm$ $0.013$ $5.48$ $2^{45} Cm$ $0.084$ $0.025$	No 5	$^{243}\Delta m$	120.42	/ 3	38
N≥ 6 $2^{34}$ U       0.049 $2^{37}$ Np       0.50 $2^{38}$ Pu       5.7 $2^{39}$ Pu       0.08 $2^{42}$ Pu       1.6 $2^{42}$ Mm       129 $10.5$ 4.7 $2^{42}$ MAm       1.7 $2^{43}$ Am       0.05 $2^{42}$ Cm       2.6 $2^{41}$ Am       2.678 $2^{43}$ Am       0.011 $2^{43}$ Am       110.31 $2^{43}$ Cm       0.084 $2^{44}$ Cm       0.0113 $2^{44}$ Cm       0.0113 $2^{44}$ Cm       129 $0.084$ 4.5 $N$ 8 $2^{245}$ Cm $2.9$ 4.5	512 5	$^{243}Cm^{X}$		0.13	5.0
N≥ 6 $2^{37}$ Np       0.0049 $2^{38}$ Pu       0.50 $2^{39}$ Pu       5.7 $2^{39}$ Pu       0.08 $2^{39}$ Pu       1.6 $2^{42}$ Pu       1.6 $2^{42}$ Pu       1.6 $2^{42}$ Pu       1.7 $2^{42}$ Rm       0.05 $2^{42}$ Cm       2.6 $2^{42}$ Cm       0.11 $2^{41}$ Am       2.678 $2^{42}$ Cm       0.11 $2^{41}$ Am       2.678 $2^{42}$ Cm       0.011 $2^{42}$ Cm       0.0113 $2^{42}$ Cm       0.0113 $2^{44}$ Cm       0.0113 $2^{44}$ Cm       0.0113 $2^{44}$ Cm       0.025		<sup>234</sup> L1		0.15	
№ 6 $2^{38}$ Pu       5.7 $2^{39}$ Pu       0.08 $2^{39}$ Pu       0.08 $2^{32}$ Pu       1.6 $2^{42}$ Pu       1.6 $2^{41}$ Am       129 $2^{42m}$ Am       1.7 $2^{42}$ Cm       2.6 $2^{42}$ Cm       0.11 $2^{42}$ Cm       0.11 $2^{42}$ Cm       0.11 $2^{42}$ Cm       0.011 $2^{42}$ Cm       0.011 $2^{42}$ Cm       0.0113 $2^{42}$ Cm       0.0113 $2^{43}$ Am       110.31 $0.084$ 0.084 $2^{44}$ Cm       129 $N_{2}$ 8 $2^{44}$ Cm $2^{44}$ Cm       0.0113 $5.48$ 2.9 $0.084$ 4.5		<sup>237</sup> Np		0.049	
№ 6 $2^{39}$ Pu       0.08       4.7 $2^{42}$ Pu       1.6       4.7 $2^{41}$ Am       129       110.5 $2^{42m}$ Am       1.7       0.05 $2^{42}$ Cm       2.6       2.6 $2^{42}$ Cm       0.11       1.7 $2^{42}$ Cm       2.678       2.32 $N^{b}$ 7 $2^{38}$ Pu       0.11 $2^{41}$ Am       2.678       2.32 $N^{b}$ 7 $2^{43}$ Am       110.31       100.9       3.3 $2^{42}$ Cm       0.0113       5.48       3.3 $2^{45}$ Cm       0.084       4.5         N^{b} 8 $2^{42}$ Cm       129       107.6 $N^{b}$ 8 $2^{45}$ Cm       2.9       4.5		<sup>238</sup> Pu		5 7	
№ 6 ${}^{242}$ Pu       1.6       4.7 ${}^{241}$ Am       129       110.5       4.7 ${}^{242m}$ Am       1.7       0.05       4.7 ${}^{242}$ Mm       2.6       0.05       4.7 ${}^{242}$ Cm       2.6       0.05       4.7 ${}^{242}$ Cm       2.6       0.05       4.7 ${}^{242}$ Cm       2.6       3.3       3.3 ${}^{241}$ Am       2.678       2.32       3.3 ${}^{241}$ Cm       0.0113       100.9       3.3 ${}^{244}$ Cm       0.0113       5.48       4.5 ${}^{244}$ Cm       129       107.6       4.5 ${}^{244}$ Cm       2.9       4.5       4.5 ${}^{245}$ Cm       0.025       4.5		<sup>239</sup> Pu		0.08	
$3^{12}$ 0 $2^{41}$ Am       129       110.5 $2^{42m}$ Am       129       110.5 $2^{42m}$ Am       1.7 $2^{43}$ Am       0.05 $2^{42}$ Cm       2.6 $2^{42}$ Cm       0.11 $2^{42}$ Cm       2.6 $2^{42}$ Cm       0.11 $2^{42}$ Am       110.31 $2^{43}$ Am       110.31 $2^{44}$ Cm       0.0113 $2^{45}$ Cm       0.084         N₂ 8 $2^{44}$ Cm $2^{44}$ Cm       129         107.6       2.9         4.5	No 6	<sup>242</sup> Pu		1.6	47
$^{242m}Am$ 123       110.3 $^{242m}Am$ 1.7 $^{243}Am$ 0.05 $^{242}Cm$ 2.6 $^{242}Cm$ 0.11 $^{242}Am$ 2.678 $^{242}Am$ 100.9 $^{243}Am$ 110.31 $^{243}Am$ 110.31 $^{244}Cm$ 0.0113 $^{244}Cm$ 0.0113 $^{245}Cm$ 0.084 $^{244}Cm$ 129 $N_{2} 8$ $^{245}Cm$ $^{244}Cm$ 0.025	512 0	<sup>241</sup> Am	129	110.5	/
$2^{43}$ Am       0.05 $2^{42}$ Cm       2.6 $2^{42}$ Cm       0.11 $2^{41}$ Am       2.678       2.32 $2^{43}$ Am       110.31       100.9       3.3 $2^{44}$ Cm       0.0113       5.48 $2^{44}$ Cm       0.0113       5.48 $2^{45}$ Cm       0.084       4.5         № 8 $2^{45}$ Cm       2.9       4.5		$^{242m}\Delta m$	127	17	
$^{242}Cm$ $2.6$ $^{242}Cm$ $2.6$ $^{242}Am$ $0.11$ $^{241}Am$ $2.678$ $2.32$ $^{243}Am$ $110.31$ $100.9$ $3.3$ $^{244}Cm$ $0.0113$ $5.48$ $^{245}Cm$ $0.084$ $0.084$ № 8 $^{245}Cm$ $2.9$ $4.5$		$^{243}\Delta m$		0.05	
N≥ 7 $2^{38}$ Pu $2^{41}$ Am $2^{41}$ Am $2^{42}$ Am $2^{43}$ Am $2^{43}$ Cm $2^{44}$ Cm $2^{44}$ Cm $2^{45}$ Cm $2^{44}$ Cm $2^{44}$ Cm $2^{44}$ Cm $2^{45}$ Cm $2^{44}$ Cm $2^{45}$ Cm $2^{45}$ Cm 2.32 $3.3$ N≥ 8 $2^{44}$ Cm $2^{45}$ Cm $2^{45}$ Cm 2.9 $4.5$		<sup>242</sup> Cm		2.6	
№ 7 $^{241}Am$ 2.678     2.32 $^{243}Am$ 110.31     100.9     3.3 $^{244}Cm$ 0.0113     5.48 $^{245}Cm$ 0.084 $^{244}Cm$ 129 $^{244}Cm$ 2.9 $^{244}Cm$ 0.025		<sup>238</sup> P11		0.11	
№ 7 $^{243}Am$ 110.31     100.9     3.3 $^{244}Cm$ 0.0113     5.48     0.084 $^{245}Cm$ 0.084     0.084       № 8 $^{244}Cm$ 129     107.6 $^{245}Cm$ 2.9     4.5 $^{246}Cm$ 0.025		<sup>241</sup> Am	2 678	2 32	
$^{244}Cm$ $^{245}Cm$ $^{10001}$ $^{10001}$ $^{10001}$ $^{244}Cm$ $^{0.0113}$ $^{5.48}$ $^{245}Cm$ $^{0.084}$ № 8 $^{245}Cm$ $^{245}Cm$ $^{246}Cm$ $^{2.9}$ $^{4.5}$	<b>№</b> 7	<sup>243</sup> Am	110 31	100.9	33
245 Cm         0.0110         0.084           244 Cm         129         107.6           № 8 <sup>245</sup> Cm         2.9         4.5           246 Cm         0.025         0.025         0.025		<sup>244</sup> Cm	0.0113	5 48	
№ 8         244 Cm         129         107.6           245 Cm         2.9         4.5		<sup>245</sup> Cm	0.0115	0.084	
<b>№ 8</b> $\begin{bmatrix} 245 \text{Cm} \\ 246 \text{Cm} \\ 246 \text{Cm} \end{bmatrix}$ <b>127 107.0 4.5</b>		<sup>244</sup> Cm	129	107.6	
$\frac{240}{246}$ Cm 0.025	No 8	<sup>245</sup> Cm	127	29	45
	J1≌ O	<sup>246</sup> Cm		0.025	

Table 7. The calculation estimations of characteristics MA samples, irradiated in BOR-60